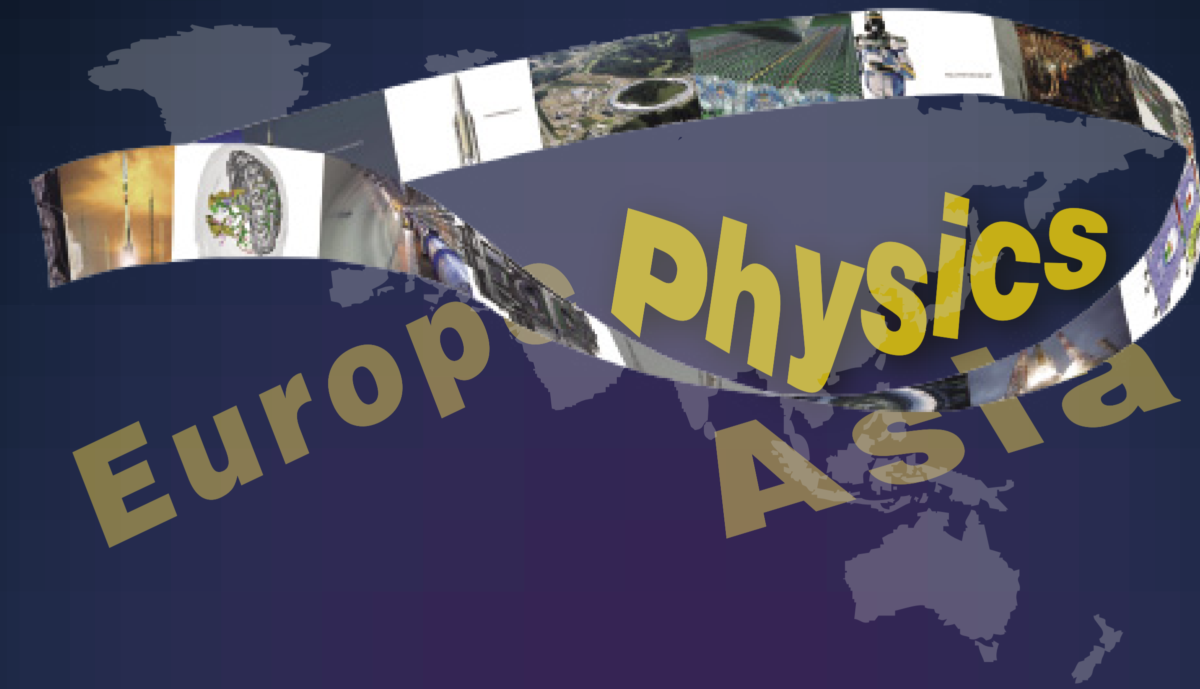
http://aseps.kek.jp

Contributions to Poster Session

ASEPS2010



Contributions to Poster Session

First Asia-Europe Physics Summit

March 24-26, 2010

aseps

ASia Europe Physics Summit

EPOCHAL Tsukuba, Ibaraki (Japan)

Preface

Welcome to the Asia-Europe Physics Summit, ASEPS.

Although a lot of international projects in physics research have been conducted, although a variety of cooperative programs have been devised and carried out by governments/funding agencies, academies and physical societies, the ASEPS is the first attempt for relevant players promoting physical sciences to get together in one place to discuss common issues and future prospects of physics research.

From 30 countries/regions, both from developed and developing countries/regions, about 200 participants have registered and 100 posters have been submitted.
This booklet is a compilation of the submitted posters, which will help you surveying physics research and related activities in Asia and Europe.

We wish the ASEPS series will help promoting and strengthening Asia-Europe cooperation in physics research by providing a long lasting platform for discussions towards mutual benefit between Asia and Europe, between researchers and governments, and between developed and developing countries.

On behalf of the ASEPS organizers, co-chairs (DPG and MN) acknowledge JSPS (Japan Society for Promotion of Science), CNRS (Centre National pour Recherche Scientifique) and KEK (High Energy Accelerator Research Organization) for their substantial support.

We express our thanks to AAPPS (Association of Asia Pacific Physical Societies) and EPS (European Physical Society) for endorsing this project and for their leading role in carrying out the Summit and to JPS (Physical Society of Japan) for its firm commitment in the organization. We also thank all our friends in Asia and Europe whose cooperation was essential establishing this Eurasia network.

Co-chairs of the ASEPS organizing committee

Mitsuaki Nozaki (KEK)
Denis Perret-Gallix (IN2P3/CNRS)

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Organization/Institute/Cooperation

JSPS

Japan Society for the Promotion of Science

http://www.jsps.go.jp/english/index.html

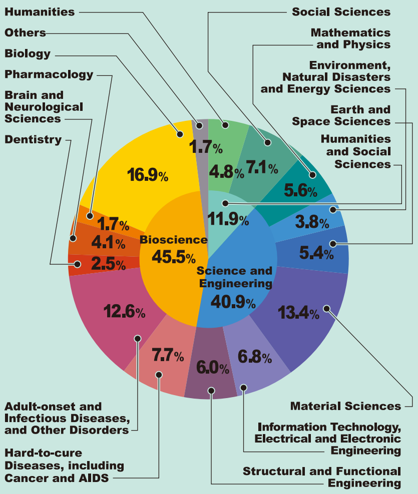
JSPS's 4 MAIN PROGRAM PILLARS

The Japan Society for the Promotion of Science (JSPS) is an independent administrative institution, established by way of a national law for the purpose of contributing to the advancement of science in all fields of the natural and social sciences and the humanities. JSPS plays a pivotal role in the administration of a wide spectrum of Japan's scientific and academic programs.
JSPS has established a variety of funding systems to support research that advances science on a level of excellence anticipated to generate new knowledge assets and matrices.

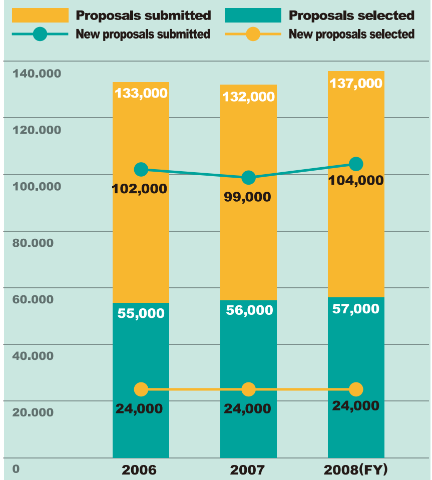
1 Supporting Research Initiatives

Grants-in-Aid for Scientific Research, or "KAKENHI", are awarded to promote creative and pioneering research across a wide spectrum of scientific fields, ranging from the humanities and social sciences to the natural sciences. More than 40% of Japan's competitive funding is provided by way of Grants-in-Aid for Scientific Research.

FY2008 Grants-in-Aid for Scientific Research by Research Field (percentage based on amount of funding)



Number of Proposals for Grants-in-Aid for Scientific Research



2 Fostering Next Generation of Researchers

Research Fellowship for Young Scientists

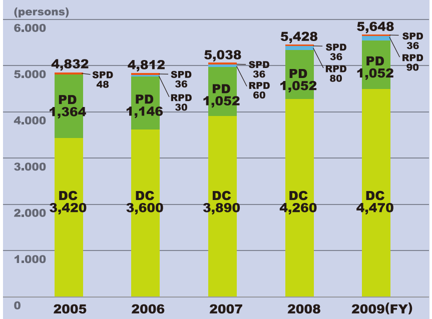
Strong emphasis is placed on doctoral and postdoctoral fellowship programs designed to foster and secure excellent young researchers.

Postdoctoral Fellowship for Research Abroad

This fellowship helps to foster and secure talented young Japanese researchers endowed rich international perspectives.

No limitation is placed on their selections of research topics or host institutions.

Total Number of Fellowships



Terms of Research of Fellowships

CATEGORY	Doctoral Students	Postdocs	Restart Postdocs	Superlative Postdocs	Postdoctoral Fellowships for Research Abroad
TENURE (years)	2-3	3	2 (-FY2009) 3 (FY2010-)	3	2

3 Advancing International Collaborations

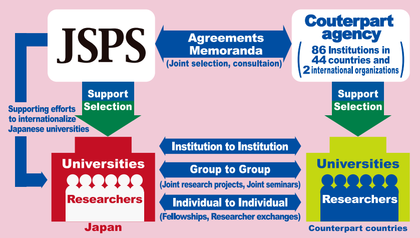
JSPS also focuses on international scientific exchanges that advance cutting-edge research in partnership with overseas science-promotion agencies.

We have to date formed cooperative relationships with 86 counterpart science-promotion institutions in 44 countries and two international organizations.
By way of these partnerships, JSPS offers a wide array of programs to support and advance international exchange and collaboration.

Five Components of International Programs

1. Support for collaboration with North/South American, European and Oceanian countries
2. Support for collaboration with Asian and African countries
3. Support for university internationalization
4. International training for young researchers
5. Fellowships for overseas researchers

Implementation System



4 Supporting University Reform

Together with the Ministry of Education, Culture, Sports, Science and Technology (MEXT), JSPS supports university reform through a variety of programs: Global COE Program; Program for Enhancing Systematic Education in Graduate Schools; Program for Promoting University Education Reform; Project for Establishing Core Universities for Internationalization ("Global 30"); World Premier International Research Center Initiative; Program for Area Studies Based on Needs of Society; Program for Promoting Social Science Research Aimed at Solutions of Near-Future Problems.

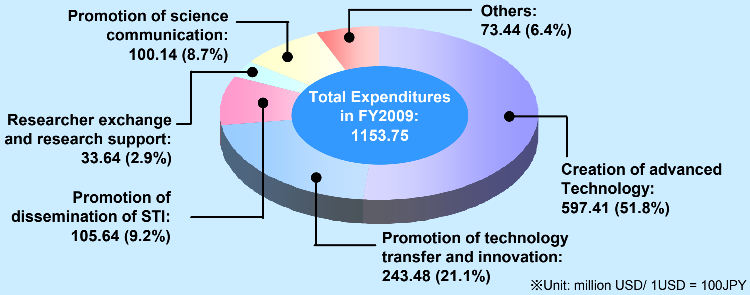
Japan Science and Technology Agency (JST)

JST is a core funding agency to implement the Japanese Science and Technology Basic Plan under the Ministry of Education, Culture, Sports, Science and Technology (MEXT). Our long term mission is to promote science and technology for the future in order to advance national welfare and prosperity.

JST's Vision:
1. To promote innovation based on science and technology.
2. To support the development of an environment for all people who advance and utilize science and technology.
3. To promote science and technology for sustainable development, and contribute Japanese leadership in international collaborations.

JST's Activities:

Creation of advanced technology	Promotes basic research to achieve the strategic objectives set by the government.
Promotion of technology transfer and innovation	Links universities and corporations to promote society reduction of research results.
Promotion of the dissemination of scientific and technological information	Provides useful information to researchers and supports research activities.
Promotion of science communication	Promotes S&T related educational support and communication. Integrated hub for information transmission and reception.
Researcher exchange and research support	Supports international research exchange activities.



※Unit: million USD/ 1USD = 100JPY

Strategic International Cooperative Program (SICP)
Based upon intergovernmental talks and other agreements on cooperation in S&T fields, MEXT designates certain countries and field as especially important in order for Japan and its counterpart countries to promote cooperation. On such designation, JST, with SICP, and its counterpart country jointly make further advances in research exchanges from both countries. Specifically, JST supports joint researches and research exchanges among research teams, dispatching and hosting researchers and organizing symposia and seminars. (http://www.jst.go.jp/inter/english/index.html)

Science and Technology Research Partnership for Sustainable Development (SATREPS)
JST supports international joint research cooperation between Japan and developing countries for resolving global issues such as environment/energy, bioresources, natural disaster prevention, and infectious diseases control. Such research cooperation is conducted in collaboration with JICA, an organization that implements ODA technical cooperation. (http://www.jst.go.jp/global/english/index.html)

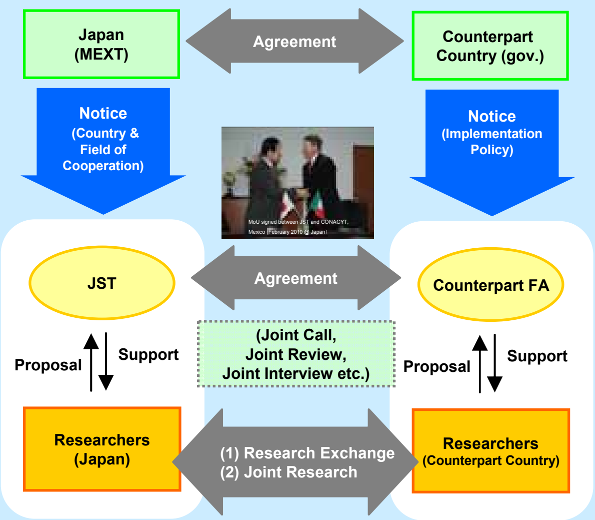
Strategic International Cooperative Program (SICP)

I. Programs

(1) Research Exchange Type
(since FY 2003)
- International research exchanges in equal partnership
- Budget for Japanese side: 5-10 million JPY (50,000 USD -100,000 USD) / project / year (for 3 years)
- Ongoing 190 projects with 22 countries and regions (as of February 22, 2010)

(2) Joint Research Type
(since FY 2009)
- International joint researches in equal partnership (medium to large scale)
- Budget for Japanese side: up to 100 million JPY (approx. 1million USD) / project / year (for 3 – 5 years)
- Ongoing cooperation with Germany (Nanoelectronics) and France (ICT)

II. Program Scheme



Workshop with Tekes and AF, Finland
(May 2009 @ Finland)

Workshop with NSFC, China
(June 2009 @ Japan)

III. International Cooperation under the SICP Framework

Country/ Region	Field of Cooperation	Counterpart Organization
Australia	Marine Science	DIISR
Brazil	Biomass and Biotechnology	CNPq
China	S&T for Environmental Conservation and Construction of a Society with Less Environmental Burden	NSFC
		MOST
	Climate Change	
China-Korea	Materials Science	(China) NIM (Korea) KRISS
	Global issues and important issues in Northeast Asian region	(China) MOST (Korea) NRF
Croatia	Materials Science	MSES
Denmark	Clinical Research	DASTI
England	(1) Bionanotechnology, (2) Structural Genomics and Proteomics, (3) Systems Biology	BBSRC
	Advanced Materials	EPSRC
EU	Environment	EC- DGR
Finland	Functional Materials	AF, TEKES
France	Life Science (Marine Genome & Marine Biotechnology)	CNRS
	ICT including Computer Science	
		ANR
Germany	Nanoelectronics	DFG
India	Multidisciplinary ICT	DST
Israel	Life Sciences	MOST
Korea	Biosciences	NRF
Mexico	Life Sciences	CONACYT
New Zealand	Bioscience and Biotechnology	FRST
Singapore	Functional Applications in Physical Sciences	A*STAR
South Africa	Life Sciences	NRF
Spain	Materials Science	MICINN
Sweden	Multidisciplinary Bio	VINNOVA
Switzerland	Life Sciences	ETHZ
Thailand	Biotechnology	NSTDA
USA	S&T for a Secure and Safe Society	NSF

Physics in Korea

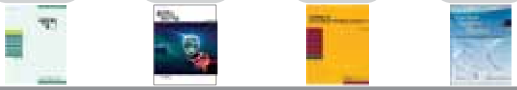
Overview of the Korean Physical Society

❖ Founded in 1952
❖ 12,378 members
❖ 11 divisions, 7 regional chapters, 17 committees
❖ Semiannual meetings
- April and October
- Approximately 1,000 papers each time

❖ 4 periodicals published
❖ Korean Physics Olympiad
- Competition for middle school & high school students
- 6,800 participants in 2009

KPS Journals

New Physics	Physics and High Technology	Journal of the Korean Physical Society	Current Applied Physics
▪Monthly ▪Research journal ▪Korean	▪Monthly ▪News magazine for non specialists ▪Korean	▪Monthly ▪Research journal ▪English ▪SCI	▪Bi-monthly ▪Research journal ▪English ▪SCI ▪Published by Elsevier



Expanding Frontiers

External Cooperation

❖ Alliance with Other Societies in Korea
- Federation of Basic Science Societies
- Federation of Physics-Related Societies

❖ International Cooperation
- Physical Society of Japan (1986)
- Japan Society of Applied Physics (1987)
- German Physical Society (1991)
- American Physical Society (1993)
- Australian Institute of Physics (1994)
- Chinese Physical Society (1995)
- Institute of Physics (1997)
- Association of American Physics Teachers(2001)
- Indonesian Physical Society(2005)
- Myanmar Physical Society(2005)
- Vietnamese Physical Society(2005)

Physics Research Institutions in Korea

Korea Research Institute of Standards and Science (KRISS)

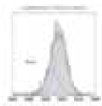
❖ Established in 1975
❖ Mission of KRISS
- Establishment and Maintenance of National Measurement Standards
- R&D on Metrology
- Dissemination of NMS

<Mesa-gate pump>

❖ Next generation measurement standards
- Quantum current standards(SAW-induced electron pump)
  - Objective: 1 nA, uncertainty of 10-8
- Frequency standards based on an optical lattice clock
  - Objective: uncertainty below 10-17
- Noise thermometry
  - Shot noise thermometry, Jonson noise thermometry
- Quantum-based force standards
  - Objective: sub-pN

❖ Nano-quantum based extreme measurement technologies
- Generation and entanglement of single photon
  - Objective: 10 qubits quantum computing
- High-resolution spectroscopy with low-temperature detectors
  - Objective: energy resolution of 1 eV@6 keV
- Nanoscale thermal energy transport and conversion
- Nanoelectromechanical systems for quantum detection
  - Objective: GHz resonating for quantum detection

<Metallic magnetic calorimeter>



<6-qubit quantum computer>

Pohang Light Source (PLS) | PLS Beamlines

Pohang Light Source

❖ Construction Budget(1988~1994)
- ~US $200 million

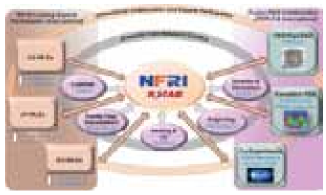
❖ Operating Budget(2008)
- Government $18.5 M+Endowment&other $5.2M

❖ User Statistics(2007)

	University	R&D Lab	Industry	Foreign	Total
Experiments	704	70	48	15	837
Institutes	45	11	10	5	71
Users	2,199	207	103	44	2,553

National Fusion Research Institute (NFRI)

KSTAR(Korea Superconducting Tokamak Advanced Research)



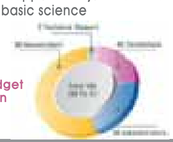
Korea Institute for Advanced Study (KIAS)

❖ Founded in 1996
❖ Mission
- Research in theoretical basic sciences
- Training young scientists
- Leading Korea's basic sciences

❖ Activities
- Training research fellows through research activities
- Inviting visiting scholars and hosting international conferences and workshops

Korea Basic Science Institute (KBSI)

❖ Mission
- Perform R&D support and joint research to promote basic science



❖ State-of-the-Art Facilities at KBSI

KPS 한국물리학회 The Korean Physical Society | Tel : +82-2-556-4737 FAX : +82-2-554-1643
http://www.kps.or.kr/home/kor E-mail : office@kps.or.kr


ADVANCED MATERIALS FOR ENERGY AND HEALTH APPLICATION IN BATAN INDONESIA
NATIONAL NUCLEAR ENERGY AGENCY (BATAN), PUSPIPTEK SERPONG, TANGERANG, INDONESIA
STRATEGIC PLANNING OF INDONESIA IN SCIENCE & TECHNOLOGY
indonesia innovations
Indonesia as one of the G20 members has shown its commitment on Science and Technology development, especially on the Innovative Research towards the industrial application. To bridge the gap, the Indonesian Government through the Ministry of Research and Technology since 2008 has launched an annual program of 100 Indonesian Innovators of the year. The government has also a plan to form a National Innovation System (SIN). As for the National Research Agenda, the priority programs are in Agriculture, Energy, Information Technology, Transportation, Defense, Health and Development of Advanced Materials.
NATIONAL NUCLEAR ENERGY AGENCY (BATAN), INDONESIA
NEUTRON SCATTERING LABORATORY
NSH
The main duties of BATAN are to conduct research, development and the beneficial applications of nuclear science and technology in accordance with the laws and regulations.
TECHNOLOGY CENTER FOR NUCLEAR INDUSTRY MATERIALS, BATAN
INDONESIAN INTERNATIONAL JOINT RESEARCH PROGRAM
The research on electrode and electrolyte materials for Lithium battery components, has generated wide spread interest in this system as the power source with a variety of applications, including RFID. The research has been funded by the International Joint Research Program (RUTI) from the Ministry Research and Technology. The program has brought out the Indonesian research activities into the International forum, which is the key for bridging the science and technology in developing country with the Asian-Europe community. Other international activities have been shown by promoting the science into the international joint experiments at the neutron world class laboratory, such as ISIS, UK; ANSTO, Australia; KEK and JPARC: Japan; BENSC, Germany, and many other laboratories/ universities worldwide.
Preliminary RUT,RUTI,BG
International Networking
Industrial Application
Technology Center for Nuclear Industry Materials (PTBIN) is one of the centers of competences at BATAN for developing new materials for alternative energy and health.
The center is not only facilitated by different laboratories, equipped by different instruments for material characterizations (XRD, HRSEM/EDS, DTA/DSC, VSM, etc), but also has a neutron scattering laboratories.
DEVELOPMENT OF NANO MATERIALS FOR DIAGNOSTIC
Contact person : Dr. Evvy Kartini ; kartini@batan.go.id
Contact person: mujamilah@batan.go.id

FUNDAMENTAL AND APPLIED PHYSICS RESEARCHES IN VIETNAM: A LANDSCAPE OF THE PROJECTS GRANTED BY STATE PROGRAMS FOR 2009-2011 PERIOD

Nguyen Xuan Phuc

Vietnam Physical Society (VPS), NAFOSTED,
and Vietnam Academy of Science and Technology (VAST),
18 Hoang Quoc Viet, Cau Giay, Hanoi, Vietnam, phucnx@ims.vast.ac.vn

I. Aim: *Ptesentation of the curent physics research situation in Vietnam*

II. Natural Science Research Program in Vietnam: a Brief History

- Proposal on a National Program in Fundamental research launched in 1991, proposed by Vietnam Academy of Science (now Vietnam Academy of Science and Technology).
- Since 1996 -2008: official State Programme on Basic Research in Natural Sciences, run by Ministry of Science and Technology (MOST).
- Sciences covered: Mathematics, Computer sciences, Physics, Chemistry, Earth science, Biology.

Budget: very little at the beginning and increased with time.

- Achievement:
  + Research in physics and other natural sciences survived through the hard time just after the collapse of Soviet Union, and increased a step.
  + Scientific capacity distribution has changed significantly: new research groups established in Universities.
- 2004-2005: Additional subprogram on 2 priority sciences: Nanotechnoloy and Molecular Biology

III. National Foundation for Science and Technology Development of Vietnam (NAFOSTED)

- Established based on PM decision No. 122/2003/ ND-CP, 22/10/ 2003.
- Inauguration: 2008
- Announcement on calling for research proposal: Dec. 2008
- Principal condition for a project PI:
  + Currently working in a research unit, if not must have a one to be applied via, and managed by.
  + Scientific degree at least a PhD, and scientific achievement at least a SCI paper during the last 5 years. New condition!!!
- Basic output requirement:
  At least 1-2 SCI paper/project. New condition!!!
- Recruitment councils:
  Founded based mainly on the recent reasearch achievement (SCI papers) of scientists, and voted among the list of 50 best researchers. New approach!!!

- Approved projects for 2009-11:

Mathematics:	16
Information and computer sciences:	18
Physics:	83 (30%)
Chemistry:	57
Earth sciences:	38
Life sciences:	60
Mechanics:	19

- Physics Council: 11 members

Chair: Prof. Nguyen Xuan Phuc

Aged:	45 - 60
Member's background distribution:	
+ Condensed Matter Physics (Exp.):	5
+ Condensed Matter Physics (Theoretical):	4
+ High Energy Physics (Theoretical):	1
+ Nuclear Physics (Theoretical):	1

IV. Physics NAFOSTED grants for 2009-2011

-Statistics of proposals and granted projects:
+ No. of submitted proposals: 111
+ No. of considered projects:105
+ No. of approved projects: 83 (75%)
Rejected: 25% : much higher than before NAFOSTED (5%)

- Budget:
  + Total budget proposed by the Council: 36,000,000,000 VND (2 mil. USD): Principle of suggestion: 8 k$US/1 SCI paper (theoretical), + 20% for experimental SCI paper and/or 70% for experimental patent.
  + Total budget allocated by NAFOSTED: around 1.5 mil. USD).
- List of approved projects:

1. Simulation of molecular dynamics, Prof.Vo Van Hoang,TU HCMC
2. Quantum information theory,Assoc. Prof Nguyen Ba An,IP/VAST, Hanoi
3.Transport mechanism in multiferrolics,Assoc. Prof.Le Van Hong,,IMS/VAST, Hanoi
4.Manganite nanocomposite,Assoc. Prof,Nguyen V.Khiem,HDU, Thanh Hoa
5. Lepton and baron particles.Prof..Hoang N. Long.IP/VAST Hanoi.
6..Intermetal. hard magnetic nanomaterials.Assoc. Prof.Nguyen H.Dan.IMS/VAST Hanoi
7.Mutilayer magnetic GMI : materials and devise.PhD.Le Anh Tuan .HUT, Hanoi
8.TM based Nanostructured Materials.Prof..Nguyen H. Luong.VNU Hanoi
9.Multiferroics for magnetic sensor.Prof..Nguyen Huu Duc.VNU Hanoi
10. Ferrite nanoparticles.Assoc. Prof.Nguyen P. Duong.HUT, Hanoi
11. Nano graphene: electron struclture.Prof..Nguyen Van Lien.IP/VAST, Hanoi
12. Amorphous magnetic materials by sonochem.Assoc. Prof.Nguyen H.Hai.VNU Hanoi
13. ZnO, MgxZn1-xO films by (MOVCD).PhD.Nguyen Thanh Binh.IP/VAST, Hanoi
14. Proton, alpha, ion scattering at low &medium energy.As. Prof.Dao TKhoa.NTI,Hanoi
15. Raman spectra of nanostr. perovskites.Assoc. Prof.Nguyen V. Minh.HUEHanoi
16.Temp and presure influence on X absorption.Prof..Vu Van Hung.HUE, Hanoi
17. Nanoliquids and application.Assoc. Prof.Hoang Nam Nhat.VNU Hanoi
18. 2D system of ZnO and III-group nitride Prof..Doan N. Quang. IP/VAST, Hanoi
19. Multimorphosm of SiO2-Al2O3…..Assoc. Prof.Pham K.Hung.HUT Hanoi
20. Higgs physics in unified model.Prof..Dang Van Soa.HUE, Hanoi
21. CNT-enhan.thermal dissipation in devices.As.. Prof.Phan N. Minh.IMS Hanoi
22. Electron correlation in advanced materials.As.. Prof.Tran Minh Tien.IP Hanoi
23. Energy band curving in 2D systems.Assoc. Prof.Nguyen H. Tung.HUT, Hanoi
24. Accelators researching of new nuclei.Assoc. Prof.Le H. Khiem.IP/VAST, Hanoi
25. Semicon films of ZnO doped with C and graphene.PhD.Do VNam.HUT, Hanoi
26. Phase transition in 2 component systems.Prof..Tran Huu Phat.NTI, Hanoi
27. Size dependence in some nano systems.Prof..Bach Thanh Cong.VNU, Hanoi
28. Optical properties of ZnO colloisals.PhD.Ngo Thu Huong.VNU, Hanoi
29. Si and Ge-based Quantum dots and wire.PhD.Nguyen Huu Lam.HUT, Hanoi
30. Inicio Principle in Low D systems.Assoc. Prof.Vu Ngoc Tuoc.HUT, Hanoi
31. Correlation accumul. In polaron densed system.Prof.Tran T.D. Bao.IP HCMC
32. Oscil. and emission from 1D electron system.As. Prof.Tran C.Phong.HUE Hue
33. Spin interaction in nano systems.Assoc. Prof.Nguyen Anh Tuan.HUT, Hanoi
34. Theoretical models in nano, bio systems.Prof.Nguyen Ai Viet.IP/VAST, Hanoi
35. Fluor.and Raman in nanotetrap. CdSe/CdS/Assoc. Prof N.X.Nghia. IMS Hanoi
36. Ferroelectric nano film on Si substrate.PhDPham Duc Thang.VNU Hanoi
37.Nuclear reactions by optical neutrons.Prof.Nguyen Van Do.IP/VAST, Hanoi
38.Polariz. labeling in molecular NaLi structure.PhDNguyen Huy Bang. Vinh Univ
39.1D functional materials based on ZnS, TiO2.As. Prof.Pham T Huy.HUT Hanoi
40.Analysis using superclean semicon detectors.As. Prof.Ngo Q.Huy.VNU HCMC
41.Correlation effects in layr structure.Assoc. Prof.Nguyen Q. Khanh VNU HCMC
42.Charge exchange reaction on accelarator.Prof.Tran Duc Thiep.IP/VAST, Hanoi
43.Nano composite based on collosal CdSe..As. Prof.Pham T.Nga.IMS, Hanoi
44.Nanostruc. of InP, ZnS, PbS metals and perovskit As. Prof.Le V.Vu.VNU Hanoi
45.Superfast optical reactions in 2D nano systems.Dr.Sc.Hoang N.Cam IP, Hanoi
46.Solar cell of new generation CIGS,Assoc. Prof.Pham Hong Quang.VNU Hanoi
47.Forced emission in Er-enhanced Opal 2D, 3D.As. Prof.Pham V.Hoi IMS, Hanoi
48.Nanocomp. for photoelectronics and photonics.Prof.Nguyen N.Dinh.VNU Hanoi
49.Optical labeling for use in cancer D&T.Assoc. Prof.Tran H. Nhung.IP, Hanoi
50.Thermodyn. and temperature analysis .Prof.Nguyen Van Hung.VNU Hanoi
51.Low D semicon systems: theoretical research,Prof.Nguyen Q.Bau.VNU Hanoi
52. Au nanpoparticle for lasering of short pulse.PhD .Do Quang Hoa IP, Hanoi
53.Density functional of monomolecular magnet. PhD.Nguyen A.Tuan.VNU Hanoi
54.Up-conv. nanophosp. for biome. optical labeling.PhD. Nguyen Vu.IMS Hanoi
55.Electron properties of low D semosond..Assoc. Prof.Nguyen H. Quang.IP Hanoi
56.Hybrid device of metallic magnetic /semicon.As.Prof.Phi H.Binh.IMS, Hanoi
57.Strong correlaton systems.Assoc. Prof.Hoang Anh Tuan.IP/VAST, Hanoi
58.Laser physics of all-solid systems.Prof..Nguyen Dai Hung.IP/VAST, Hanoi
59.Magneto-electrical prop.of nano perovkite.As.Prof.Dang Le Minh.VNU Hanoi
60. Yang-Mills theory for unified basic interactions.Prof.Nguyen V.Tho.HUT, Hanoi
61.Monitor. chem Dynam.by ultrafast pulse laser.As.Prof.Le V.Hoang.HUE HCMC
62.Magn. nanopart. for diagnosis & treatment.As.Prof.Tran H.Hai. IP HCMC
63.Chemical biosensors for virus detection.PhD.Mai Anh Tuan.HUT, Hanoi
64.Rich Si nanosilica for photonic device.PhD.Bui Huy.IMS/VAST, Hanoi
65.Solar cell based on oxide nanosemicond.As.Prof.Pham V.Nho.VNU Hanoi
66.SiC nanostructures.Prof.Dao Tran Cao.IMS/VAST, Hanoi
67.Ener. transfer of opt. centers nanosystems.As.Prof.Pham H.Duong.IMS Hanoi
68.Gas sensitivity of perovskite/cond.polymer.As. Prof.Nguyen N.Toan.IMS, Hanoi
69.Material modeling of SiO2 and(Al2O3)x(SiO2)1-x.PhD.Le T.Vinh.Vinh Univ
70.Energy storage and transfer in metallic oxides.PhD.Pham D.Long.IMS Hanoi
71.Negative index materials.PhD. Vu Dinh Lam.IMS/VAST, Hanoi
72.Dark matter and energy.PhD.Nguyen Quynh Lan.HUE, Hanoi
73.Q dynamics in BE condensate in semic. Wells.PhD.Cao H.Thien.IP HCMC
74. SnO2, A2B6 nanostructures.PhD.Pham Van Vinh.HUE, Hanoi
75. TiO2 nanotubes by sono-micriwav- hydrolis.PhD.Truong Van Chuong.US, Hue
76.Surface interaction of polymer/CNTs.Assoc. Prof.Duong N. Huyen HUT Hanoi
77. Spectroscopy of RE cont. oxyfluoratates.Prof.Vu X.Quang.IMS/VAST, Hanoi
78.Tb3+ and Eu3+ Nanorods for biomed. Labeling.PhD.Tran T.Huong IMS, Hanoi
79.Conducting films by jet printing techniques.As. Prof.Dang M.Chien VNU HCMC
80.Organ/inorgan hybrid for device used in biomed.As. Prof.Le Q.Minh.IMS, Hanoi
81.Heating in nanoparticle systems.Prof.Nguyen X. Phuc. IMS/VAST Hanoi
82.Optical processes in II-VI, III-V, I-III-VI2 substances.As. Prof.Nguyen Q. Liem IMS Hanoi
83.Electronic device based on semicond. Wires.Assoc. Prof.Nguyen V. Hieu HUT, Hanoi

- Distribution of the granted projects:
  Speciality distribution:
  + Condensed Matter Physics (Ex): 45
  + Theoretical Physics: 30
  + Laser and Spectroscopy: 6
  + Nuclear & Hi Energy Physics: 4

Research Institute / University: 39/ 44
(before 1991: Univ. only < 10%),
:+ Youngest PI: 32,+ Oldest PI:72
+ PIs below 40: 22%
(Before NAFOSTED: only 5%)

(MOST) application-oriented grants:
MOST support, besides, a limit of so called 'application oriented physics grants'.
- Goal: To master a few new future technology.
- Output requirement: attention paid less on quantity of SCI papers but more on application perspectives.
- For 2009-2011: 7 projects on nanotechnology;

V. Discussion and conclusion remarks:

- Official state research program on physical sciences: 20 years, short time compared with developed countries.
- Physics research center map: increase in University, and sustainable in National research c¥block.
- Establishment and first activities of NAFOSTED: a big change to promote research quality following international standard.
- Research potential fields: Condensed Matter (Materials Physics) and Theoretical Physics.
- Need more strategy (2010-2020) efforts to develop physics in Vietnam in general and research in particular.

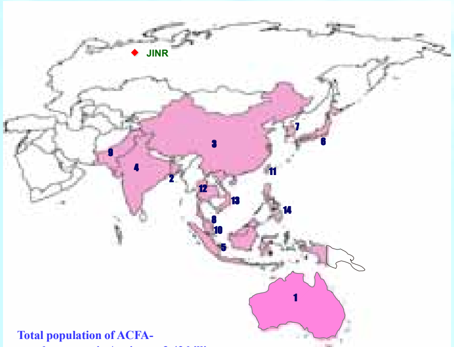
Acknowledgement:
Prof. Acad. Nguyen Van Hieu, Honorary president of VPS, for his enormous contributions for physics research and education in Vietnam

Reference:
1. Nguyen Van Hieu, A half century of development of natural sciences in Vietnam, Journal: Scientific Activity, MOST , No. 10 (2009) *(in Vietnamese).*
2. Webpage www.nafosted.vn *(in Vietnamese)*

ACFA
Asian Committee for Future Accelerators

ACFA is officially established in the First Plenary ACFA meeting held in 1996 at POSTECH, Korea
ACFA covers Asia and Oseania
ACFA is composed by 14 countries/regions and 1 international organization (JINR, Russia)

ACFA Members



Total population of ACFA-member countries/regions = 3.42 billion (53.8% of the world population)

1. Australia
2. Bangladesh
3. China
4. India
5. Indonesia
6. Japan
7. Korea
8. Malaysia
9. Pakistan
10. Singapore
11. Taiwan
12. Thailand
13. Vietnam
14. Philippines

Purpose

The primary purpose of ACFA shall be to strengthen regional collaboration in accelerator-based sciences. In particular, ACFA seeks cooperative ways:

- ◆To facilitate efficient utilization of existing human and material resources.
- ◆To bring up accelerator scientists of the next generation.
- ◆To encourage future accelerator projects in Asia and to make recommendations for them to governments.

Business

ACFA will carry out its business according to the following guiding principles:

- ◆ACFA is open to any active region in Asia which is willing to contribute to the advancement of accelerator-based science.
- ◆ACFA is not intended to displace or supersede any existing organization.
- ◆ACFA will closely cooperate with ICFA (International Committee for Future Accelerators).

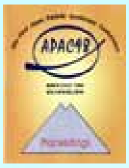
Activities

ACFA can engage in the following activities:

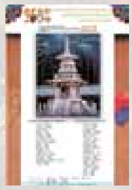
- ◆regular meetings of the Plenary ACFA
- ◆schools, symposia, workshops, and conferences sponsored or organized by ACFA, or jointly with other organizations
- ◆study groups for special issues, set up by ACFA, or jointly with other organizations

Particle Accelerators in Asia

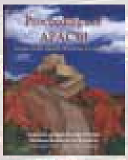
APAC98, KEK, Japan



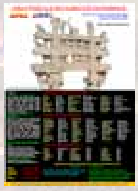
APAC04, PAL, Korea



APAC01, IHEP, China



APAC07, RRCAT, India

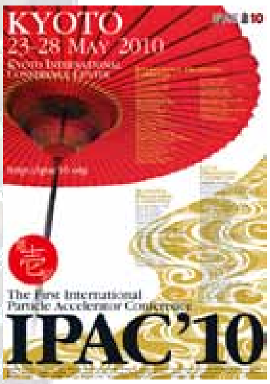


Working Group

- ◆Network Working Group
- ◆Electronic Publication Working Group
- ◆HPPA Group Working Group
- ◆LC Physics/Detector Working Group
- ◆Advanced Accelerator Working Group
- ◆Asia Linear Collider Steering Committee

Asian Accelerator Network

- ◆to establish the Asian accelerator science community
- ◆to promote exchange of accelerator scientists/students
- ◆to coordinate cooperative research programs
- ◆to coordinate strategic planning based on common interests
- ◆to plan/support symposia, workshops, and schools in Asia
- ◆the Network is not limited to HEP programs, but extends to accelerator science in general science using light sources or neutron sources, medical/industrial application, innovative technologies (accelerator/detector)



www.kek. jp/ACFA/

Asia-Europe Physics Summit

Tsukuba, Ibaraki 305-0801, Japan, March 24 ~ 26, 2010

SCIENCE AND INNOVATION POLICY IN FLANDERS | BELGIUM

Department of Economy, Science and Innovation
www.ewi-vlaanderen.be

The Department of Economy, Science and Innovation (EWI) of the Flemish government is charged with the **preparation, monitoring and evaluation of policy concerning economy, science and innovation** in Flanders.

Furthermore, the Department coordinates the cooperation between the different agents of the Flemish government regarding economic, scientific and innovative domains.

Transforming Flanders to one of the most advanced and prosperous regions in Europe, is the most important strategic goal. International cooperation is one of the corner stones of the science and innovation policy that is designed to stimulate:

- excellent scientific research;
- an appealing and sustainable climate for investments;
- an open, creative, innovative and entrepreneurial society.

The science and innovation **policy** of Flanders is **implemented by agencies**.

Agency for Innovation by Science and Technology (IWT)
www.iwt.be

This agency supports innovation in Flanders by:
- **Funding.** Innovative projects of companies, research centres, organizations and individuals are financed through assignments set by the Flemish government. In 2008, 297 million € were paid out to Flemish innovative projects.

- **Advice and services.** All Flemish companies and research centres are supported. They are helped during their applications and technological advice is provided during their innovative projects. IWT is the national contact point for European funding programmes and assists in transferring technologies throughout Europe via the Enterprise Europe Network (EEN).

- **Coordination and networking.** Collaboration is stimulated by bringing innovative companies and research centres in contact with Flemish intermediate organizations that stimulate innovation. This is done via the Flemish Innovation Network.

- **Policy development.** IWT supports the Flemish government in its innovation policy. Among other things, the effectiveness of the Flemish innovation initiatives are studied and evaluated.

Research Foundation Flanders (FWO)
www.fwo.be

Research Foundation – Flanders (FWO) finances **basic research** which is aimed at moving forward the frontiers of knowledge in all disciplines. Basic research is carried out in the Flemish universities and in affiliated research institutes. Therefore FWO is Flanders' main instrument to support and stimulate fundamental research based on scientific inter-university competition.

FWO supports:
- individual researchers and research teams by financing both talented recently graduated students to obtain a doctoral thesis (Ph.D.) as well as Postdoctoral Fellows;
- young researchers at the start of their academic career;
- research by supplying personnel, equipment and consumables for top priority research proposals.

National and international mobility of researchers is promoted by:
- establishing Scientific Research Networks to promote coordination, national and international contacts at postdoctoral level;
- attracting junior and senior Visiting Postdoctoral Fellowships to join a FWO research project or network bringing in additional expertise;
- providing grants for active participation of researchers in international congresses;
- providing grants for study and training periods abroad;
- bilateral agreements and participation in international corporate projects;
- sabbatical leaves;
- providing grants for organising international congresses in Belgium;
- mobility allowances for FWO-Postdoctoral Fellows.

FWO also participates in European research organisations like ESF, EUROHORCs, DUBBLE at ESRF, CECAM, EUPRO,... and awards scientific prizes to distinguished researchers.

Hercules Foundation
www.herculesstichting.be

The Hercules Foundation was set up in 2007 by the Flemish government as a **structural funding instrument for investments in (large) research infrastructure**.

The Foundation is intended to support fundamental and basic strategic research in Flanders.

Bilateral cooperation between Flanders and Asian countries

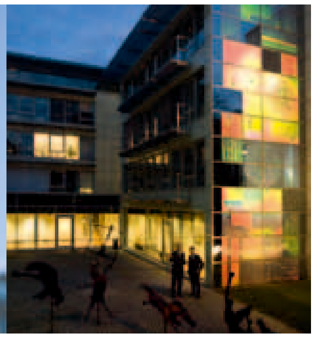
Universities in Flanders are obliged to spend 3% of the Special Research Fund (BOF) for international cooperation. Most of the universities have dedicated programs for collaboration with Asian countries, in particular with China, India and Vietnam.

Besides this, FWO spends 1.5 million € per year dedicated for bilateral basic research projects. Vietnam and China have been selected among the Asian countries as preferential partners since already for a long time cooperation existed in previous government programmes.

With **Vietnam** the cooperation is organised through NAFOSTED (National Foundation for Science and Technology Development) and at present 5 bilateral projects are funded.

With **China** an active bilateral programme exists consisting of a researcher exchange programme run by FWO and the Chinese National Natural Science Foundation and a programme run by FWO and the Chinese Ministry of Science and Technology with a focus on agronomy, biotechnology and micro-electronics.

Deutsche Forschungsgemeinschaft (DFG)

The Deutsche Forschungsgemeinschaft (German Research Foundation) is the central, self-governing research funding organisation that promotes research at universities and other publicly financed research institutions in Germany.

The DFG serves all branches of science and the humanities by funding research projects and facilitating cooperation among researchers.

The Deutsche Forschungsgemeinschaft (German Research Foundation) encourages international cooperation between scientists and academics in all its programmes.

The DFG promotes...

- ▶ **international project cooperation**
- ▶ **international mobility of scientists and researchers**
- ▶ **the internationalisation of German universities**

The DFG is also represented as an institution in various scientific and science policy organisations and bodies at an international and a European level.

Contact

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DFG Office Japan
Dr. Iris Wieczorek (Director)

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Fax +81 (03) 3589-2509

japan@dfg.de
www.dfg.de/japan

DFG

PHYSICS in CSIC

Spanish National Research Council

MINISTERIO DE CIENCIA E INNOVACIÓN

The *Agencia Estatal Consejo Superior de Investigaciones Científicas* (CSIC) is the largest public multidisciplinary research organisation in Spain. It has a staff of more than 12.000 employees, including 3000 scientists and 4000 pre and postdoctoral researchers, working in 130 Institutes and centres distributed across Spain. Its annual budget is close to 900 M euros.

Physical Science and Technology Area

RESEARCH LINES IN PHYSICS	
Astrophysics and Space Sciences	ASTRO
Physical Technologies	TEC
Mathematics	MATH
Particle Physics, Astroparticles and Nuclear Physics	FPAN
Atomic and Molecular Physics	MOL
Optics	OPT
Complex Systems and Statistical Physics	QFISES
Nanoscience and Nanotechnology	NANO
Integrated Micro and Nano Systems	MICRO
Computing Sciences and Technologies	ICT

BILATERAL AGREEMENTS	
COUNTRY	INSTITUTION
China	Chinese Academy of Sciences (CAS)
	National Natural Science Foundation of China (NSFC)
Korea	Korea Science and Engineering Foundation (KOSEF)
Japan	Japan Society for the Promotion of Science (JSPS)
Taiwan	National Science Council (NSC)
Vietnam	Vietnamese Academy of Science and Technology (VAST)

CSIC INSTITUTES IN THE AREA OF CIENCIAS Y TECNOLOGÍAS FÍSICAS					
CAB	Centro de Astrobiología (Mixto INTA) – *Madrid*	ASTRO	IMB	Instituto de Microelectrónica de Barcelona	NANO MICRO
IAA	Instituto de Astrofísica de Andalucía *Granada*	ASTRO	IMM	Instituto de Microelectrónica de Madrid	NANO
ICE	Instituto de Ciencias del Espacio (Mixto IECC) – *Barcelona*	ASTRO	IMSE	Instituto de Microelectrónica de Sevilla	MICRO
ICMAT	Instituto de Ciencias Matemáticas (Mixto UAM-UC3-UCM) - *Madrid*	MATH	IO	Instituto de Óptica – *Madrid*	OPT NANO
IEM	Instituto de Estructura de la Materia *Madrid*	MOL FPAN QFISES OPT ASTRO NANO	IRI	Instituto de Robótica e Informática Industrial (Mixto UPC) – *Barcelona*	TEC ICT
IFCA	Instituto de Física de Cantabria (Mixto UC) - *Santander*	ASTRO FPAN ICT QFISES	LITEC	Laboratorio de Investigación en Tecnologías de (Mixto UZ, DGA) – *Zaragoza*	TEC
IFIC	Instituto de Física Corpuscular (Mixto UV) - *Valencia*	FPAN	CAR	Centro de Automática y Robótica (Mixto UPM) – *Madrid*	TEC ICT
IFISC	Instituto de Física Interdisciplinar y Sistemas Complejos (Mixto UIB) – *Palma de Mallorca*	QFISES OPT	CAA-END	Centro de Acústica Aplicada y Evaluación No Destructiva (Mixto UPM) – *Madrid*	TEC
IFT	Instituto de Física Teórica (Mixto UAM) - *Madrid*	FPAN QFISES	IA	Instituto de Acústica *Madrid*	TEC
IIIA	Instituto de Inteligencia Artificial *Barcelona*	ICT	IFA	Instituto de Física Aplicada *Madrid*	TEC OPT ICT
IFF	Instituto de Física Fundamental *Madrid*	MOL QFISES	IAI	Instituto de Automática Industrial- *Madrid*	TEC ICT

LARGE SCIENTIFIC FACILITIES IN THE AREA			
Centre	Infrastructure	Place	Type
SB-CNM	Sala Blanca del Centro Nacional de Microelectrónica *(Clean Room at the National Centre in Microelectronics)*	Barcelone	ICTS UUHH CSIC
CAHA	Centro Astronómico Hispano Alemán (Calar Alto) *(Astronomic Center Spain-Germany)*	Madrid	ICTS Joint CSIC-MPG
CNA	Centro Nacional de Aceleradores *(National Centre for Accelerators)*	Sevilla	ICTS Joint CSIC-US-JA

The fundamental mission of the CSIC's Physical Science and Technology Area is the advancement of science by addressing new challenges, ranging from the basic approach provided by models and theories in physics and mathematics, through to the experimental and technological perspective where it serves as a complement to engineering.

Relevant ongoing projects with international dimension

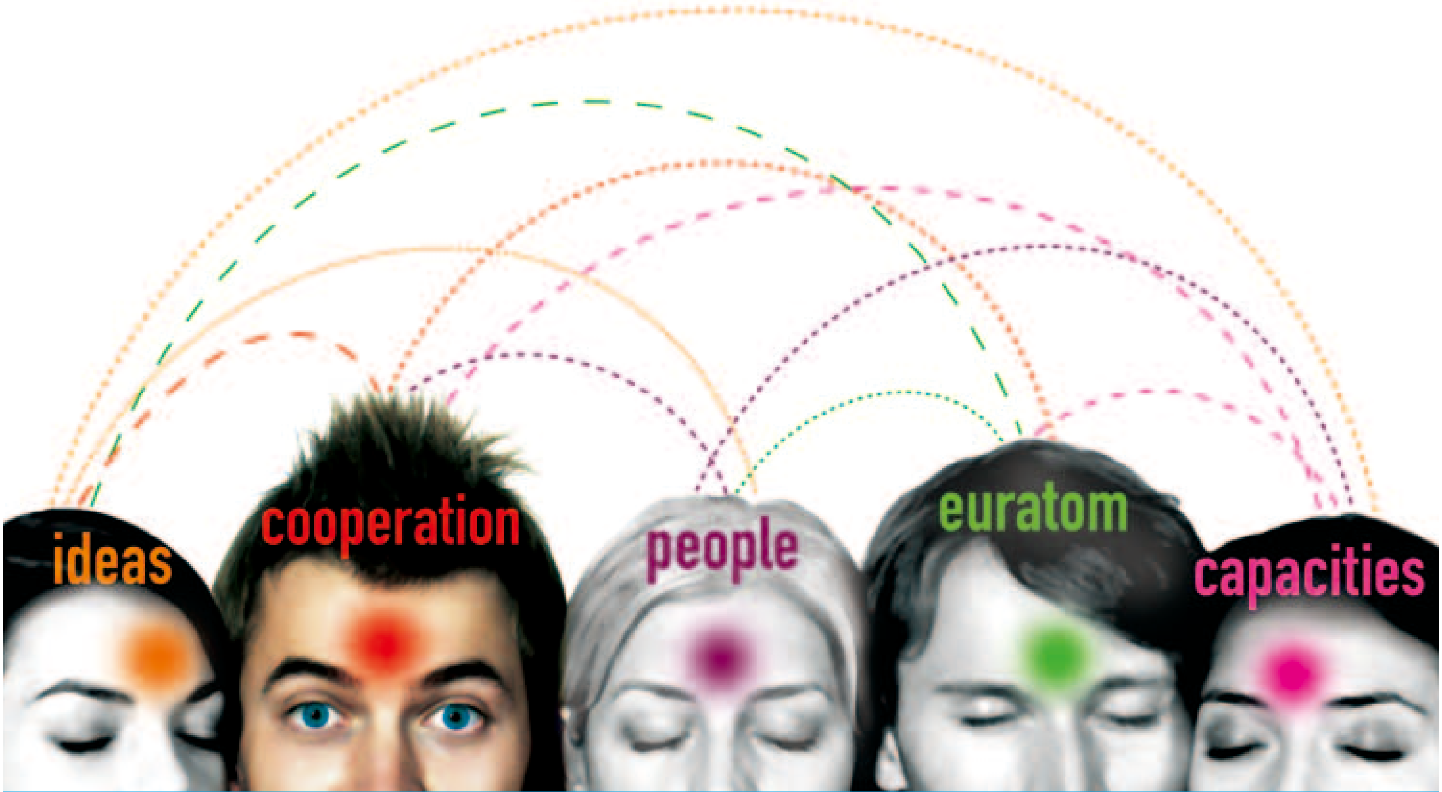
-ESA missions: XMM, Planck, Herschel, COROT, Integral, Solar missions.
-ESO observatories: ALMA, VLT
-CERN: LHC (ATLAS & CMS);
-ILC, CDF
-FAIR, SPIRAL-2
-EELT, CTA, KM3NET
-EGI

New initiatives on instrumentation and energy

-Cryogenic technology for space
-Hard radiation sensors for high multiplicity
-Optical fibers, microlenses, adaptive optics
-Biomed photonics & neural imaging
-Social robotics
-High efficiency photovoltaic pannels
-Fuel cells

http://www.csic.es

EUROPEAN COMMISSION / European Research Area / 7th Framework Programme



FP7*...
get connected!!

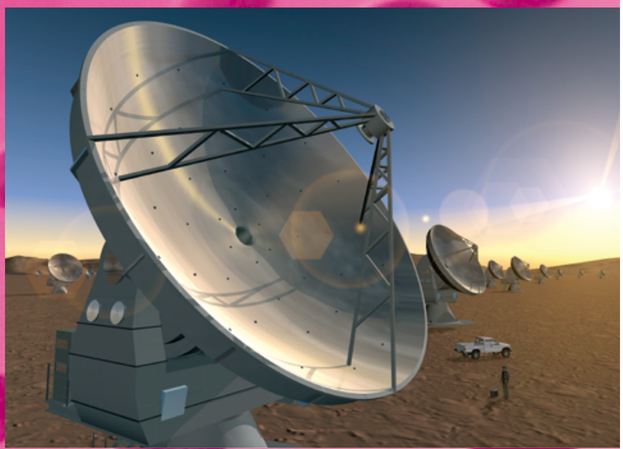
SEVENTH FRAMEWORK PROGRAMME

www.ec.europa.eu/research/fp7

* EU's funding instrument for research

EUROPEAN COMMISSION / European Research Area / 7th Framework Programme

Top Facilities for top scientists



This scheme puts Europe's research and innovation 'Capacities' to optimal use. It covers, for example, research infrastructures, regions of knowledge issues, research for SMEs, science in society aspects, and it backs up policy-making and the 'Cooperation' programme.

'Capacities' in FP7*

www.ec.europa.eu/research/fp7

* EU's funding instrument for research

CAPACITIES

Brief Introduction of Institute of High Energy Physics (IHEP)

The Institute of High Energy Physics (IHEP) is the biggest and comprehensive fundamental research center in China. IHEP is staffed with 1131 people, including over 826 physicists and engineers. In addition, there are 413 graduate students and post-doctors in IHEP. The current director is Prof. Chen Hesheng.

The major research fields of IHEP are particle physics, accelerator physics and technologies, radiation technologies and application, including the following leading research areas:

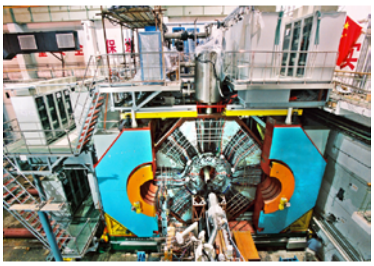
- Particle physics experiments: BESIII, neutrino experiments, experiments at LHC and B-factories…
- Theoretical Physics: particle physics, medium and high energy nuclear physics, cosmology, field theory…
- Particle astrophysics: cosmic ray, astrophysics experiments…
- Accelerator physics and technology: high luminosity e^+e^- collider, high power proton accelerator, accelerator applications…
- Synchrotron radiation: technology and application;
- Nuclear analytical technique and application;
- Multiple Discipline Research;
- Free electron laser;
- Nuclear detector and fast electronics;
- Computing and network application;
- Radiation safety.

The main research facilities at IHEP are:

- Beijing Electron Positron Collider (BEPCII)
- Beijing Spectrometer (BESIII)
- Beijing Synchrotron Radiation Facility (BSRF)
- Yangbajing International Cosmic Ray Observatory in Tibet
- Daya Bay Reactor Neutrino Experiment
- China Spallation Neutron Source (CSNS) (under construction)

IHEP has extensive cooperation with many national laboratories and participates in many important particle physics experiments in the world.

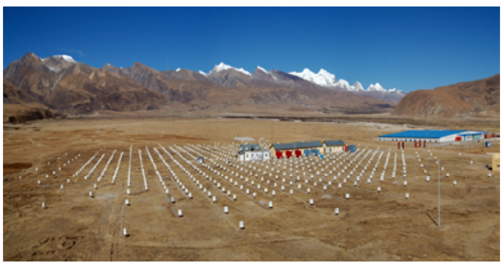
BEPCII



BESIII

BSRF

Daya Bay Reactor Neutrino Experiment



Yangbajing International Cosmic Ray Observatory in Tibet

CSNS

http://www.ihep.ac.cn Telephone: +86 10 88233093, Fax: +86 10 88233374

Mail address: P.O Box 918, 19 Yuquanlu Road, Beijing 100049, P. R. China

Optics in the Institute of Physics, Chinese Academy of Sciences
—— from Terawatts to Single Photons

The Institute of Physics, Chinese Academy of Sciences, was established in 1950 through the merging of two older institutes dating back to 1928. Now also known as the Beijing National Laboratory for Condensed Matter Physics, with more than 200 research staff and 600 graduate students, it conducts basic and applied research on condensed matter, optics, atomic and molecular physics, plasma physics, and theoretical physics, with cross-disciplines related to materials, information, energy and life science. International collaboration, involving 400 visits/events annually, is a vital facet of the institute.

Research in the Key Laboratory of Optical Physics embraces novel optical materials, laser physics, photonic crystals, nonlinear optics, strong field physics, ultrafast processes, quantum optics, and applications to biological systems. Facilities include pulsed ns, ps and fs lasers, with powers up to terawatts, tunable cw lasers, and so forth, with wavelengths ranging from x-ray to THz. Light detection instruments include uv, ir, and visible spectrometers, boxcars, single-photon detectors, broadband oscilloscopes, and other electronic equipment.

Intense Laser-Matter Interactions

- **High energy density physics**
  - **Generation of fast electrons and ions with solid targets**
  - **Laser wakefield electron acceleration**
- **Novel laser-based radiation sources (THz, X-rays, X-ray lasers)**
- **Propagation of fs laser pulses in air**
- **Laboratory astrophysics**
- **Future energy science**

Contact: Jie Zhang (jzhang@aphy.iphy.ac.cn) or Yutong Li (ytli@aphy.iphy.ac.cn)
http://highfield.iphy.ac.cn

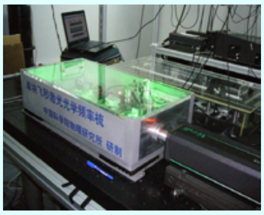
Ultrahigh Intensity fs Laser System Xtreme-Light (XL-III)

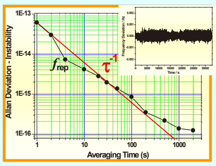
XL-III is a high power Ti:sapphire laser system based on chirped pulse amplification, capable of delivering 30fs pulses with an energy of 22J (= peak power 700TW)

Target Chamber

Monolithic Frequency Comb

A compact frequency comb based on difference frequency generation and our free fiber new design can run with long-term superstability and precision. It can be used for coherent control of atom and molecule dynamics, frequency metrology, optical clocks, measurement of fundamental constants, etc.

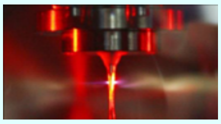




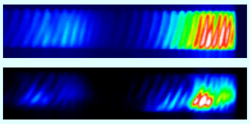
CEO fluctuations after locking

CEP Controlled fs Laser and Attosecond Science

The output pulse from an fs Ti:sapphire laser can be compressed to sub-5fs with an energy of about 0.5mJ, repetition rate 1kHz, and CEP locked within a fluctuation of <53mrad.
Coherent ultrafast X-rays of sub-10nm wavelengths can be generated for research on attsecond science and ultrafast X-ray spectroscopy.



Driving high order harmonics



Coherent X-rays with (upper) and without (lower) CEP locking

Supercomputer Facilities

Dawning-4000
CPU: 276GHz (31 nodes), Memory: 170GB

KLAP -1D, 2D, 3D PIC codes + field and collision ionization etc.
Laser beam transport code
Hydrodynamic code: Medusa
Radiation transport: NIMP
Ray tracing codes
Atomic data packages
Fokker-Planck code

Also available: Shenteng 6800: 1200CPU
Computation Center, CAS

International Collaboration

Country	Institution	Subject
UK	Rutherford Appleton Laboratory, CCLRC	Ultrashort intense laser interaction with matters
Italy	Dipartimento di Fisica "G.Occhialini", Università di Milano Bicocca	Generation and transport of fast electrons
Japan, Korea	Advanced Photon Research Center, JAERI, Japan Kwangju Institute of Science and Technology	China-Japan-Korea trilateral collaboration on ultrashort intense laser development and applications
Japan	Institute of Laser Engineering, Osaka University	Laboratory astrophysics by intense laser pulses.

8 international conferences, workshops and summer schools have been organized during the past 6 years

Quantum Optics

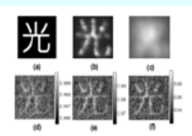
- **Intensity correlation "ghost" imaging and interference with thermal light**
- **Generation and applications of entangled light**
- **Generation and applications of single photons**
- **Quantum cryptography**

International Collaboration:
Previous collaboration with France, Russia, and USA

High-visibility high-order lensless ghost imaging with thermal light *

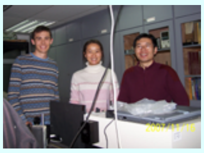
Xi-Hao Chen, Ivan N. Agafonov, Kai-Hong Luo, Qian Liu, Rui Xian, Maria V. Chekhova, and Ling-An Wu (to appear in *Optics Letters*)

High-visibility *N*-th-order ghost imaging with thermal light has been realized by only recording the intensities in two optical paths in a lensless setup. The visibility is dramatically enhanced as the order *N* increases



Reconstructed 2nd, 10th and 20th order ghost images
(b) and (c): Projection images obtained by CCD1 alone, averaged over 20,000 frames, for (b) z_3 = 20 mm, (c) z_3 = 70mm
(d) 2nd order (N = 2, n = 1)
(e) 10th order (N = 10, n = 9)
(f) 20th order (N = 20, n = 19), 140,000 frames

- **Visibiilty improves as N increases**
- **Only 2 detectors required**



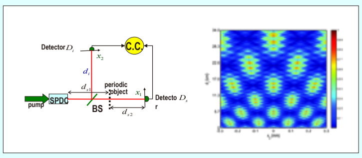
Russian student Ivan working in our lab

* Collaborative project with Russia, supported by a Joint Grant from NNSFC and RFBR

Second-order Talbot effect with entangled photon pairs *

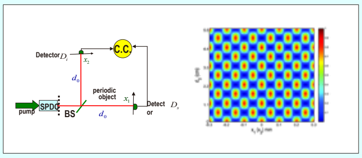
Kai-Hong Luo, Jianming Wen, Xi-Hao Chen, Qian Liu, Min Xiao, and Ling-An Wu, *Phys. Rev. A* 80, 043820 (2009)

The second-order Talbot effect for a periodic object illuminated by entangled photon pairs may be observed, without any focusing lens. Self-images of the object that may or may not be magnified can be observed nonlocally in the photon coincidences but not in the singles count rate. In the quantum lithography setup the second-order Talbot length is half that of the classical first-order case, thus the resolution may be improved by a factor of 2.



Talbot carpet in quantum imaging

D_s fixed, D_i scanned



Talbot carpet in quantum lithography

D_s or D_i fixed in the transverse direction
D_s and D_i scanned synchronously along the *z* direction

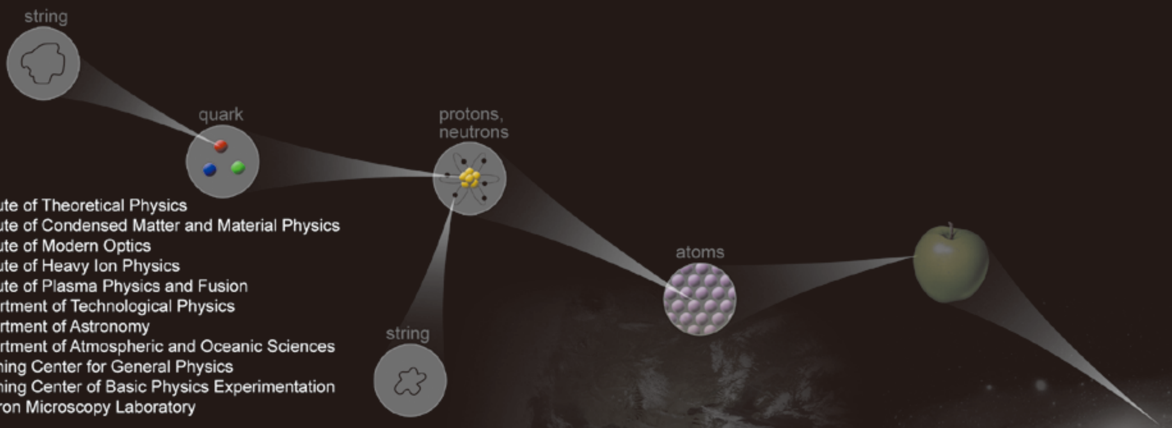
* Collaborative project with Arkansas Univ, USA

Physics Now at Peking University

北京大学物理学院

The Peking University School of Physics has its origins of the "Lixue Ke" (science) at the Imperial University of Peking. In 1913, the "WuLi Men" (physics division) was established, and this was later renamed the Department of Physics in 1919. With the reorganization of the Chinese system of higher education in 1952, the new Physics Department of Peking University, created from the merger of the physics departments of Peking University, Tsinghua University and Yenching University, became the premier center for physics in China. The School of Physics was established in 2001, and includes not only the traditional fields of study in physics, but also related physical sciences. Today, the School of Physics includes Physics, Astronomy, and Atmospheric & Oceanic Sciences and consists of eleven divisions and six research institutes, including the State Key Laboratory for Artificial Microstructure and Mesoscopic Physics and the State Key Laboratory of Nuclear Physics and Technology.

It has been nearly 100 years since Peking University established its Department of Physics. The Department's founding in 1913 was not only an announcement of the importance that Peking University placed on the physical sciences, but also a milestone in the development of modern science in China. One hundred years on, the School has made distinguished contributions to the nation and to the world in both education and academics. As it embarks on its second century, the Peking University School of Physics extends a warm welcome to distinguished scholars and outstanding young students from China and abroad who wish to join its ranks.



- Institute of Theoretical Physics
- Institute of Condensed Matter and Material Physics
- Institute of Modern Optics
- Institute of Heavy Ion Physics
- Institute of Plasma Physics and Fusion
- Department of Technological Physics
- Department of Astronomy
- Department of Atmospheric and Oceanic Sciences
- Teaching Center for General Physics
- Teaching Center of Basic Physics Experimentation
- Electron Microscopy Laboratory

- State Key Laboratory for Artificial Microstructure and Mesoscopic Physics
- State Key Laboratory of Nuclear Physics and Technology
- Beijing Key Laboratory of Medical Physics and Engineering
- Center for High Energy Physics
- International Center for Quantum Materials
- Kavli Institute for Astronomy and Astrophysics

Faculty

Today, the School of Physics has about 200 faculty and staff, including 15 Academicians of Chinese Academy of Sciences, 4 "Qianren" Scholars, 10 "Cheung Kong" Scholars and 12 National Distinguished Young Scholars. There are 3 innovative research groups sponsored by the National Natural Science Foundation of China (NSFC): QCD & Hadron Physics, Femtosecond Optical Physics & Mesoscopic Optics, and Biological Networks.

Teaching

The School of Physics grants Bachelor of Science, Master of Science, and Doctor of Philosophy degrees. Around 200 undergraduate students and 200 graduate students are admitted each year by the School of Physics (100 for PhD degrees and 100 for Master degrees). Most undergraduate students pursue advanced studies after finishing their Bachelor degrees, and about one-third of them go to leading international universities for their advanced study.

The School of Physics has a tradition of teaching excellence in both graduate and undergraduate courses. Faculty members have received one grand, four first-class, and five second-class National Teaching Awards, and more than 30 teaching awards at provincial and ministerial levels. Scholars in the School of Physics have published more than one hundred textbooks and monographs since 1991.

Research

Research in the School of Physics is devoted not only to the frontiers of fundamental physics but also to the innovation of advanced technology. The School plays a leading role in planning and executing regional, national, and international scientific research programs. Major research fields include: high energy physics， astrophysics and cosmology, radioactive nuclear physics, high energy-density physics, key technology for advanced light sources and particle beams, interaction of particle beams with materials, mesoscopic semiconductor light emission and laser physics, ultra-fast physics, optical properties of artificial microstructures and mesoscopic devices, electro-magnetic properties of mesoscopic functional systems, mesoscopic theory and material computation, high-temperature superconductivity physics and devices, nano-material and devices, near-field optics, quantum materials and quantum manipulation, soft condensed matter physics, biophysics， medical physics and imaging, atmospheric physics and the environment, meteorology and climate change, and many others. Scholars in the School were awarded three National Prizes and two National Science & Technology Progress Awards in the past five years. During this period, the School has more than 300 on-going and completed research projects, including five national basic research programs ("973" projects), seven national high technology research and development programs ("863" projects) and more than 20 key projects of the NSFC. Research funding in the School has progressively increased in recent years.

International Cooperation

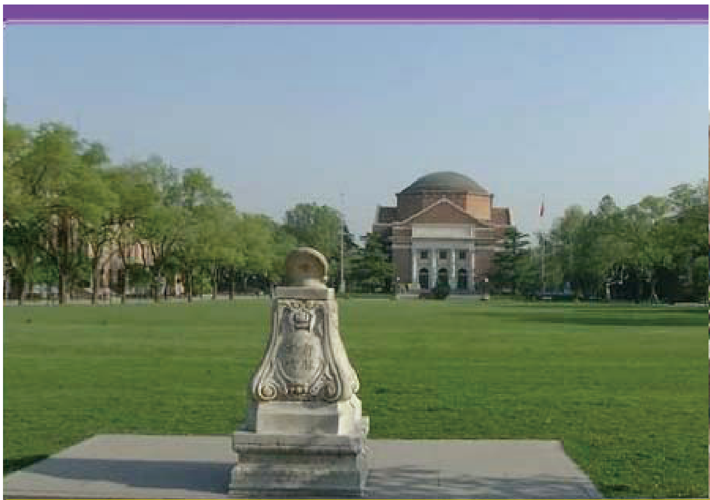
The School is involved in a wide range of international activities. A number of faculty members serve as committee members in many international scientific organizations and as editors for international leading journals. Peking University participates in many international collaborations, in particular the world's largest high-energy physics project, LHC-CMS, as well as a number of other projects, such as RIKEN and KEK in Japan, GSI and DESY in Germany, and JLab and ANL in the United States. The School of Physics organizes various international conferences and international summer schools and seminars.

Facility and Equipment

There has been rapid improvement in the facilities and equipment for scientific research in recent years, with a total expenditure of more than 200 million RMB. This has resulted in a number of flagship instruments, including a seven-femtosecond CE-phase-stabilized laser amplifier system, a molecular beam epitaxy system, a metal-organic chemical vapor deposition system, a focused ion beam workstation, and four electrostatic ion accelerators.

School of Physics，Peking University
http://www.phy.pku.edu.cn/

Physics Department in Tsinghua University



2009年物理系年终总结会合影（昌平军都旅游度假村）

Full Prof. 49; Associate Prof. 24; Assistant Prof. 12.
Of them 10 members of Chinese Academy of Sciences
33 Supporting Staffs

- **Physics Department Established in 1926 by Professor Qi-sun Ye (Ch'i-Sun Yeh， 叶企孙), soon earned a reputation as the best Physics Departments in China;**
- **First 10 years: Among 71 graduates, 21 Members of CAS, 1 Member of NAS and 1 Member of NAE.**

What is "AIST"?

Ken-ichi Watabe

National Institute of Advanced Industrial Science and Technology (AIST), Japan

Overview

The National Institute of Advanced Industrial Science and Technology (AIST) is one of the largest public research institutions in Japan in the field of science and technology. 2,500 researchers are working for cutting-edge R&D in wide areas of industrial technology. In good cooperation with companies and universities, AIST creates new industries, and initiates R&D projects collaborating with companies. The supreme goal of our efforts is to establish a sustainable society.

AIST's Targets and Research Areas

Targets:

(A) To create new industries from innovative research seeds, and to stimulate industrial competence and innovation

(B) To establish intellectual infrastructure to support the whole industry

(C) To establish a sustainable society

Research Areas:

(1) "Life Science & Technology" toward a society for health and long life

(2) "Information Technology & Electronics" for secure, safe and comfortable life

(3) "Environment & Energy" to solve pressing global problems in these areas

(4) "Nanotechnology, Materials & Manufacturing" to create manufacturing technology for sustainable development

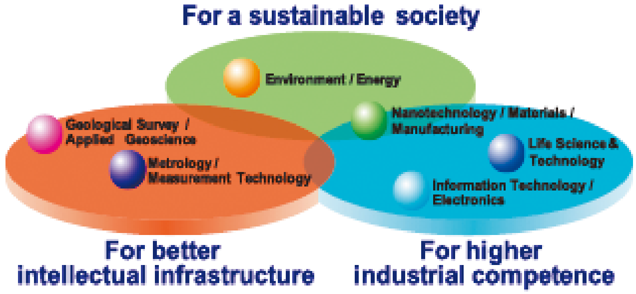
(5) "Geological Survey and Applied Geoscience" to intellectual infrastructure for efficient use of lands

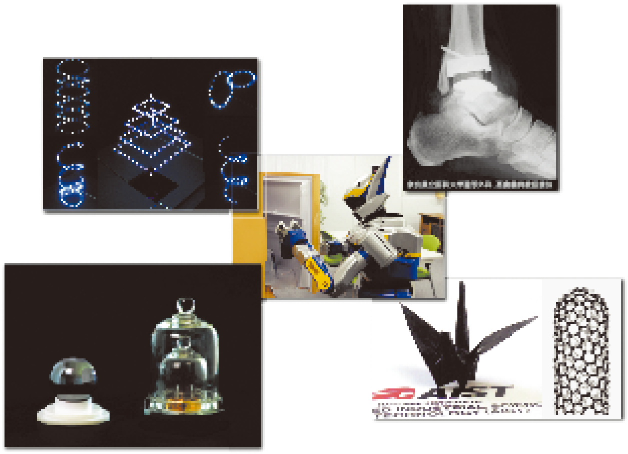
(6) "Metrology and Measurement Technology" to promote industrial infrastructure

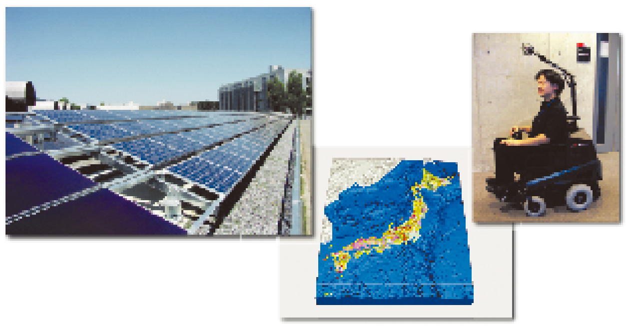
AIST covers almost all the engineering areas.

AIST's International Partnership

AIST has agreements for research cooperation with major organizations in 40 countries, and works to form together a Network of Excellence. Also, international joint researches are being promoted by researchers exchange, human resources development, joint projects, and so on.







International Activities of National Institute for Materials Science

Masahiro TAKEMURA　Kazunari KOIKE

National Institute for Mareials Science (NIMS)

What is NIMS?

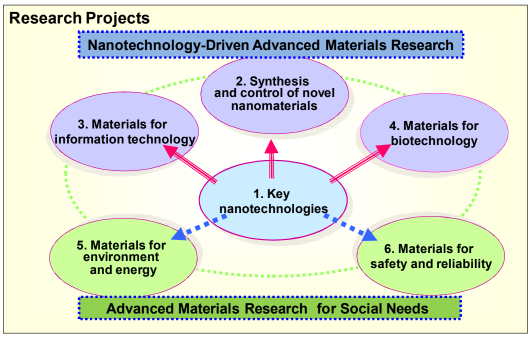
National Research Institute for Metals (since 1956)

National Institute for Research in Inorganic Materials (since 1966)

Independent Administrative Institution
National Institute for Materials Science
Since April 2001

Budget : ~$200 million
Personnel : ~420 tenured researchers
~300 post-docs & students
~400 overseas researchers & students

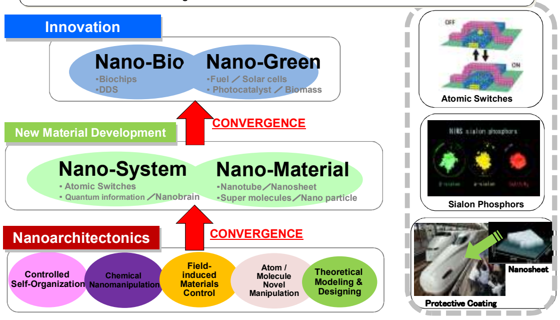
Six Major Research Areas



Exploratory Research　Infrastructural Development

WPI International Center for Materials Nanoarchitectonics (MANA)

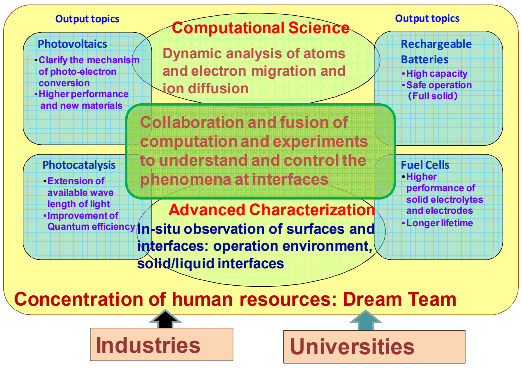
To develop novel materials and create epoch-making innovations by converging 5 key technologies of **Nanoarchitectonics** by intentionally controlling the arrangement of individual nanostructures and extracting ultimate functions.



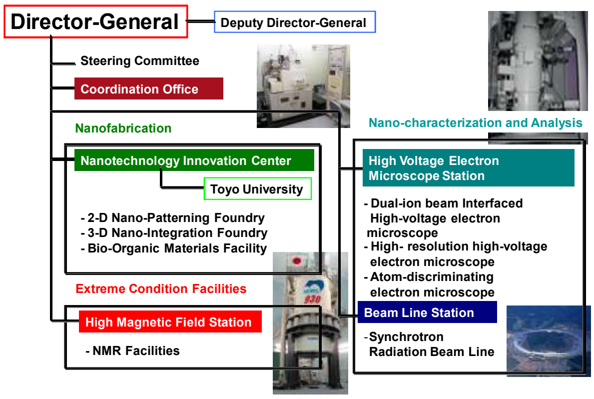
(Five key technologies)

Innovative Center of Nanomaterials Science for Environment and Energy (ICNSEE)

MEXT Program for Develop. Environ. Tech. utilizing Nanotech. (200 M Yen for FY2009)



International Center for Nanotechnology Network



World Materials Research Institute Forum (WMRIF)

•1st: 2005, Tsukuba, Japan
2nd: 2007, Berlin, Germany
3rd: 2009, Washington D.C., USA
4th: 2011, Shenyang, China

•44 Material research institutes from 21 countries of 5 continents

•President : Teruo Kishi , NIMS

•Communication and Cooperation for common issues of national institutes

•Working groups
- Research resource mapping
- Material science outlook
- Global database
- Materials for sustainable energy technology
- Materials reliability
- Materials simulation

3rd WMRIF 2009 at NIST

(America) ORNL, LLNL, NIST, AMES, EWI, BNL, INMETRO

(Europe & Africa) BAM, KIT, HZB, MPI-MF, NPL, VTT, CNRS-NEEL, LNE, RAS-GISC, RAS-NIIC, CSIC-ICMAB, CSIC-ICMM, EMPA, KFKI, INMAT, SP, MINTEK, U. of Sheffield,

(Asia) NIMS,AIST, CAS-IOP, CAS-IMR, CAS-SIC, FJIRSM, CISRI, KAIST, KIMS, KIST, IMRE, JNCASR, IGCAR, NEERI, BARC, ITRI, MIRDC, MTEC, VAST

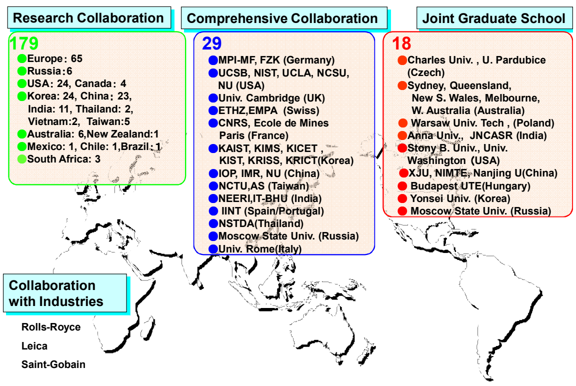
International Center for Young Scientists

Program for postdoctoral researchers since 2003.

86 Researchers are working now.

http://www.nims.go.jp/eng

MOU for Bilateral Collaboration



RIKEN

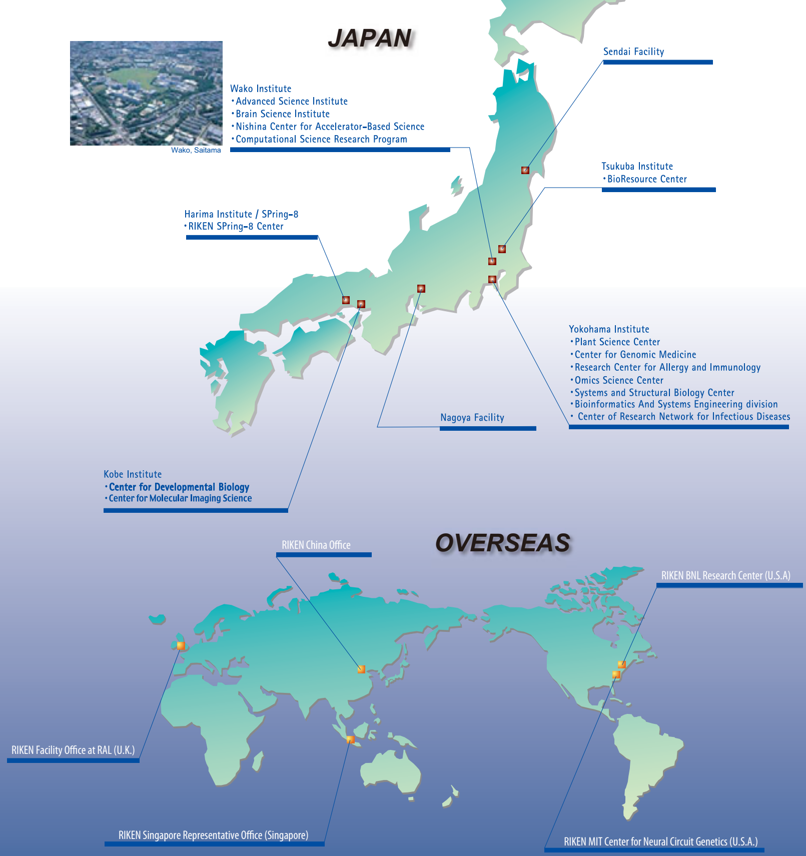
Established in 1917 and headed by Nobel laureate Noyori Ryoji, RIKEN is Japan's premier research institute devoted to basic and applied reserch.

With its 13 reserch centers, seven additional reserch facilities, and 350 labs, RIKEN is globally recognized as the leading research institution in Japan.

The Japanese government has put RIKEN in charge of the development and operation of a number of its strategic projects, among them the SPring-8 synchrotron, one of the largest in the world, the Next-Generation Supercomputer, expected to be the world's most advanced computer when it is completed, and the X-ray Free Electron Laser (XFEL) facility now under construction and scheduled to begin shared use in 2011.

In biological and medical research, RIKEN scientists are working in fields ranging from bio-resource management, allergies, and immunology to genomic medicine and basic research in structural and developmental biology. RIKEN research teams are also exploring the frontiers of brain science, plant science, chemical biology, emergent materials, and extreme photonics. Our mission in every field is producing cutting-edge research and maximizing its benefits to society.

RIKEN Facilities



Research Activities in
Physics Department of University of Malaya

Swee-Ping Chia
Physics Depart, University of Malaya
50603 Kuala Lumpur, Malaysia
spchia@um.edu.my

APPLIED MATERIALS
Abdul Kariem Hj Mohd Arof

SOLID STATE PHYSICS
Muhamad Rasat Muhamad

PHOTONICS
Harith Ahmad

PLASMA & PULSED TECHNOLOGY RESEARCH
Wong Chiow San

APPLIED OPTICS, LASER PHYSICS & OPTOELECTRONICS
Kwek Kuan Hiang

SPACE PHYSICS
Mohd Zambri Zainuddin

MATERIALS SCIENCE & POLYMER PHYSICS
Zurina Osman

APPLIED RADIATION
Rosli Hj Mahat

ELEMENTARY PARTICLE PHYSICS
Wan Ahmad Tajuddin Wan Abdullah

COMPUTATIONAL PHYSICS & MICROPROCESSOR
Wan Ahmad Tajuddin Wan Abdullah

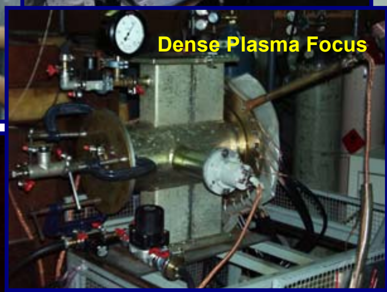
CENTER FOR THEORETICAL & COMPUTATIONAL PHYSICS
Chia Swee Ping

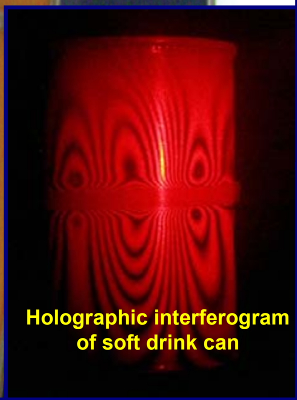
THEORETICAL PHYSICS
Hasan Abu Kassim


Polymer Ni-MH Cell


Deposition of Nano-Si by RF PECVD

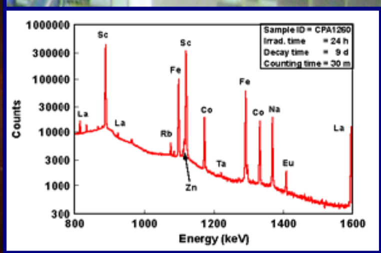

Facility for EDFA Test and Measurement


Dense Plasma Focus


Holographic interferogram of soft drink can

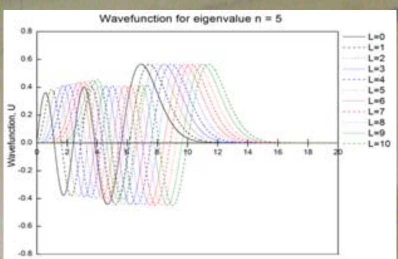

Celestron CG-14 and Paramount GT 1100-ME


Polymer Electrolytes Films

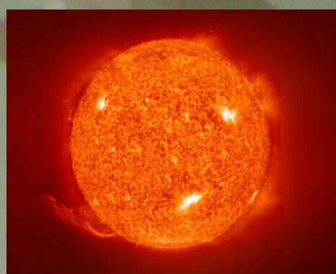



ZEUS team
http://zms.desy.de/images/content/e8/e72/

One of the participating institution of the ZEUS Collaboration at the Hadron-Electron Ring Accelerator (HERA) facility in Germany



UNIVERSITI MALAYA
KUALA LUMPUR



Ghent University

Faculties

- 11 faculties
- 133 departments

Faculty of Arts and Philosophy
Faculty of Law
Faculty of Sciences
Faculty of Medicine and Health Sciences
Faculty of Engineering
Faculty of Economics and Business Administration
Faculty of Veterinary Medicine
Faculty of Psychology and Educational Sciences
Faculty of Bioscience Engineering
Faculty of Pharmaceutical Sciences
Faculty of Political and Social Sciences

Students

33,000
3,000 foreign students

- Bachelor
- Master
- PhD
- Postdoc

Doctoral Schools

Arts, Humanities and Law
Social and Behavioural Sciences
Natural Sciences
(Bioscience) Engineering
Life Sciences and Medicine

Ghent University Association

Ghent University
University College Ghent
Artevelde University College
University College of West Flanders

Internationalisation

www.international.ugent.be

- ECTS label
- international masters (http://www.opleidingen.ugent.be/studiekiezer/nl/brochure/int_masters.pdf)

Education
EU programmes
- Lifelong Learning Programme
- Tempus
- Alfa
- Atlantis-EU-Canada-Australia-New Zealand
- Erasmus Mundus Action 1 (EMMC)
- Erasmus Mundus Action 2 (formerly EMECW):

UGent is coordinator of 2 programmes:
  - With China (since 2009): **LISUM**
  - With Western Balkan (since 2007): **BASILEUS**
- Edulink

Other
- 74 interuniversity bilateral agreements with Asia:
  - China: 29
  - India: 10
  - Japan: 6
  - Taiwan: 7
  - Vietnam: 6
- International educational cooperation projects (Flemish Community)
- Networks: e.g. Santander Group
- **CHINA PLATFORM** (www.ugent.be/china): central point of contact within Ghent University for all matters relating to China, creating a synergy between the academic, political and economic world in order to establish a common China strategy
  - Initiatives: different scholarship programmes
  - Cofunding for 7 CSC PhD students
  - Tuition fee voucher for all PhD students
  - Reimbursement of APS screening costs for all Chinese students
- **INDIA PLATFORM** (http://www.india-platform.org/)

Research
- 6 ERC grants (excellent researchers funded by European Commission)
- 9 Methusalem & 6 Odysseus I grant holders (excellent researchers funded by Flemish Government)
- FP6 and FP7 project coördinator in the fields of nanotechnology, ICT, immunology, biotechnology and aquaculture
- Member of international organizations: IMHE, UKRO, U4,…
- Selected for CHE Excellence ranking in fields of Biology & Psychology
- In top-100 of research-intensive universities (Leiden world ranking)

Development Cooperation
Possibilities for several cooperation programs: www.vliruos.be

UNIVERSITEIT GENT

www.UGent.be

IPPS (SWEDEN) PHYSICS SUPPORT TO VAST (VIETNAM): AN EXAMPLE OF FRUITFUL COLLABORATION BETWEEN A DEVELOPED EUROPIAN COUNTRY AND A DEVELOPING ASIAN COUNTRY

Nguyen Xuan Phuc and Le Van Hong

Vietnam Academy of Science and Technology (VAST),

18 Hoang Quoc Viet, Cau Giay, Hanoi, Vietnam, phucnx@ims.vast.ac.vn

I. Problem: *How to conduct fruitfully a collaboration between a developed and a developing country in experimental physics?*

II. Colaborating institutions: IPPS and VAST

A side :. IPPS as a project donor:
International Programme in the Physical Sciences (IPPS) Supported research areas
The IPPS focuses its activities on providing assistance to create viable and independent research teams of an international standard. In the countries with which IPPS has co-operation, physics is very weak and in a stage of capacity building. Therefore, most of the Research groups supported by the IPPS are located at university departments. This means that in the project support given, the IPPS also assists the departments in creating or strengthening their MSc and/or PhD programmes. IPPS also has attached groups, which means groups not receiving regular support but who can apply for grants for minor expences of urgent needs.
All research to be supported are proposed by the groups in the respective countries and should be in line with the plans of the department/institution/faculty/university.

B side: VAST as a project acceptor:
Vietnam Academy of Science and Technology (VAST) is the scientific institution under the direct management of the Government with the function to conduct the research and implementation of the natural sciences and technology in the key directions of the State.
The missions of VAST are to organize and implement the natural science and technology research activities according to the key directions fixed by the State, to create and implement the advanced technologies. The objectives of which are to better serve the country's policy in science and technology development for the most benefit of the society in general and of science & technology in particular.
Physics are done in the following institutes of VAST:
- Institute of Physics
- *Institute of Materials Science (IMS)*
- Institute of Geophysics
- Institute of Space Technology
- HCMC Institute of Physics
- Institute of Applied Materials Science
- Nha Trang Institute of Technology Research and Application
- Institute of Applied Physics and Scientific Instruments

III. Role of a long term research project: a skeleton of the collaboration

-Project title: *Rare Earth Metal*
-Project length: *2+1/2 phase = 10 year from 1991-2001*
-Total project budget: *1,1 USD, (including training sandwich PhD)*
-Budget source: *SAREC/Sida (Sweden),*
-Swedish budget manager: *IPPS*
-Swedish physics laboratory: *Angstrom Laboratory of Uppsala University*
-Vietnam budget manager: *Vietnam Academy of Science and Technology,*
-Vietnam physics laboratory: *Magnetic Materials Laboratory of Institute of Materials Science, (IMS of VAST)*

IV. Recipient Labo: Status (then and now) of (IMS) Laboratory of Magnetic Materials Physics :

a) Facility: (installed in) and beneficial for:
1. Arc melting (1996): 3 PhD& 5 MSc thesis, 5 SCI papers, 2. Ball milling (2001): 2 PhD& 3 MSc thesis, 4 SCI papers, 3. HiT (1600oC) furnace (2000): 2 PhD& 3 MSc thesis, 5 SCI papers, 4.Sputtering (2001):1 PhD& 3 MSc thesis, 3 SCI papers, 5.Vibrating Sample Magnetometer (VSM) (1991): 7 PhD& 10 MSc thesis, 15 SCI papers, 6.Closed Cycle Refregirator (1994): 4 PhD& 8 MSc thesis, 12 SCI papers, 7. Hi Field Pulsed Magnetometer (1998): 2 PhD& 5 MSc thesis, 4 SCI papers, 8.Rapid quenching* (2001), 9- PPMS*(2006) , 10. XRD* (1993), 11. FE-SEM* (2005)- 12. Pulsed Laser Abelation (2004)- *) Non-IPPS

b) Education:
- Sandwich PhD theses: 3 (Vu Van Hong, Dao Nguyen Hoai Nam and Le Viet Bau)
- Other theses completed with benifit of project research facilities:
+ 8 PhD and 20 MSc.

c) Publication:
+ Swedish-Vietnamese co-author: 20 SCI papers,
+ Other papers with benifit of project equipment: 30 SCI papers.

d) Significant research results:
Research fields of the Laboratory: Physics and materials aspects of various magnetic materials such as: Magnetoresistive ceramics, Spintronic materials, Bulk amorphous materials, and Magnetic nanoparticle.
Especially regarding magnetoresistive materials, collaboration resulted in the following physical phenomena:
+ Glassy Magnetism of Manganites and Cobaltites
+ Temperature Memory Effects of Electrical Resistance in $La_{0.7}Sr_{0.3}Mn_{0.925}Ti_{0.075}O_3$
+ Selective Dilution for Detection of Interactions in $La_{0.7}Sr_{0.3}MnO_3$ and $La_{0.7}Ca_{0.3}MnO_3$
+ No Double Exchange Between Co and Mn
+ Room temperature Magnetocaloric Effect in $La_{0.7}Sr_{0.3}Mn_{1-x}M_xO_3$ (M=Al or Ti)

e) Publication:
1. D.N.H.Nam et al.. J. Mag. Mag.., Mat. 177-181(1998) 1135-1136.
2. D.N.H.Nam et al., Phys. Rev. B, Vol.59, No 6, (1999) 4189-4194.
3. D.N.H.Nam et al Phys. Rev. B, Vol. 62 (2000) 1027-1032.
4. D.N.H.Nam et al. Phys.Rev.B, Vol. 62 (2000) 8989-8995.
5. R.Mathieu et al. Phys. Rev. B, Vol. 63 (2001) 1744051-1744056.
6. D.N.H.Nam et al. J. Mag. Mag. Mat226-230 (2001) 1335-1337.
7. D.N.H.Nam et al. J. Mag. Mag. Mat., 226-230 (2001) 1340-1342.
8. M. Tseggai et al. Journal of Solid State Chemistry 178 (2005) 1203–1211,
9. L.V. Bau et al. J. Mag. Mag. Mat (2005).
10. D.N.H.Nam et al. Phys. Rev. B 73, 184430 (2006).
11. N.V.Dai et al. Phys. Rev. B, (2008) accepted 03/2008,,Code: LM11637BJ.
12. D.N.H. Nam et al. J. Applied Physics, 103 (2008) 043905.
13. DNH Nam, et al. Phys. Rev. B, Accepted May 17, 2008.
14. DNH Nam et al. Phys. Rev. B, code LN 11513B
15. L.V. Bau et al. J. Mag. Mag. Mat., …. (2010)

VSM 1991

PPMS 2006

Arch melting 1996

FE-SEM 2005

V. Discussion and conclusion remarks:

- How to choose in capacity building:
Equipment but what?
Machine for sample fabrication + 1 (research interested) physical property characterization.
Better choice: not commercially ready made, but composing of component equipments of advanced electronics.
Expert education but when?
Sandwich education of PhD
The student must master the support research equipment, as a part of the his/her thesis content.

- Knowledge required for the recipient to master:
First phase: A side to B side: 'Tell me what is it, I will tell you why it is so"
Next phase: A side to B side: 'Tell what is it, we'll see why',
- Collaboration to continue: what here and where else: B side (VAST) contributions also to South-South collaborations

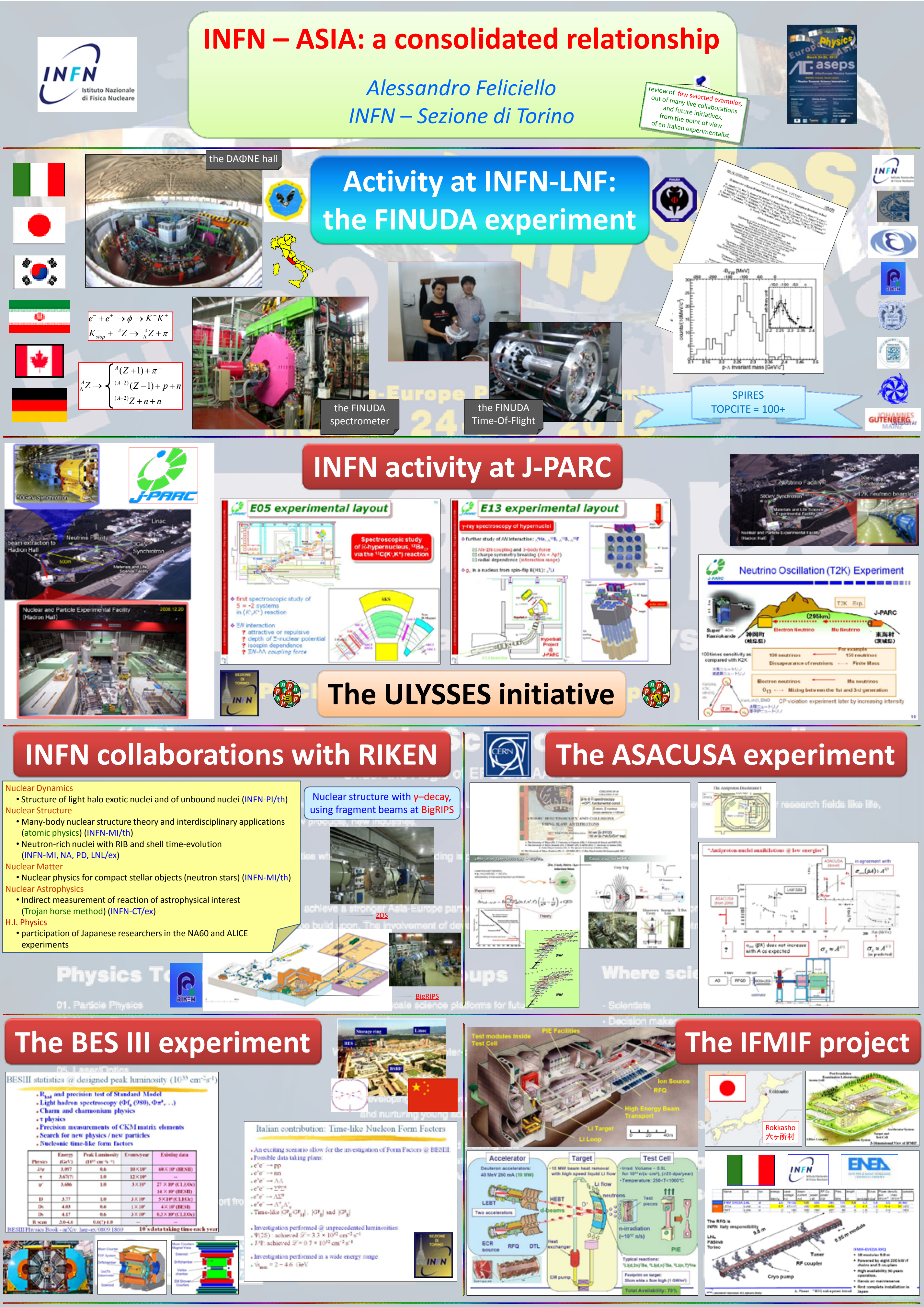
Scientific Workshop in Bangladedh

Training Workshop in Laos

Acknowledgement: *Prof. Nguyen Van Hieu and Prof. Dang Vu Minh (VAST) and Prof. Lennart Hasselgren (IPPS) for their contributions to the collaboration*

Reference:

1. ISP Report, International Programme in the Physical Sciences, Project Catalogue 2002, Uppsala University, Tabergstryken AB, 2004.
2. ISP Report, Annual Report for International Science Programme, Universitetstryckeret, Uppsala 2009
3. Vietnam Academy of Science and Technology, Annual Report 2008, Hanoi-March 2009.6



INFN – ASIA: a consolidated relationship
Alessandro Feliciello
INFN – Sezione di Torino
review of few selected examples, out of many live collaborations and future initiatives, from the point of view of an Italian experimentalist
Istituto Nazionale di Fisica Nucleare
the DAΦNE hall
Activity at INFN-LNF: the FINUDA experiment
$e^- + e^+ \to \phi \to K^- K^+$
$K^-_{stop} + {}^{A}Z \to {}^{A}_{\Lambda}Z + \pi^-$
${}^{A}_{\Lambda}Z \to \{ {}^{A}(Z+1) + \pi^- ;\ {}^{(A-1)}(Z-1) + p + n ;\ {}^{(A-2)}Z + n + n$
the FINUDA spectrometer
the FINUDA Time-Of-Flight
SPIRES TOPCITE = 100+
INFN activity at J-PARC
E05 experimental layout
E13 experimental layout
Neutrino Oscillation (T2K) Experiment
The ULYSSES initiative
INFN collaborations with RIKEN
Nuclear Dynamics
• Structure of light halo exotic nuclei and of unbound nuclei (INFN-PI/th)
Nuclear Structure
• Many-body nuclear structure theory and interdisciplinary applications (atomic physics) (INFN-MI/th)
• Neutron-rich nuclei with RIB and shell time-evolution (INFN-MI, NA, PD, LNL/ex)
Nuclear Matter
• Nuclear physics for compact stellar objects (neutron stars) (INFN-MI/th)
Nuclear Astrophysics
• Indirect measurement of reaction of astrophysical interest (Trojan horse method) (INFN-CT/ex)
H.I. Physics
• participation of Japanese researchers in the NA60 and ALICE experiments
Nuclear structure with γ–decay, using fragment beams at BigRIPS
ZDS
BigRIPS
The ASACUSA experiment
"Antiproton-nuclei annihilations @ low energies"
The BES III experiment
BESIII statistics @ designed peak luminosity (10^{33} cm^{-2}s^{-1})
Italian contribution: Time-like Nucleon Form Factors
The IFMIF project
Rokkasho
六ヶ所村
Accelerator
Target
Test Cell


EUROPEAN COMMISSION
European Research Area
Human resources & mobility
MARIE CURIE ACTIONS
International research careers
> Fellowships
> Training Networks
> Staff exchange
> Reintegration
www.ec.europa.eu/mariecurieactions
PEOPLE


EUROPEAN COMMISSION
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euraxess
RESEARCHERS IN MOTION
New Funding Booklet
*** AVAILABLE ***
www.ec.europa.eu/euraxess/links/japan

Woman in physics and Education

Efforts of the Chinese Physical Society to Promote Women in Physics in China

中国物理学会 Chinese Physical Society

Asia-Europe Physics Summit
Tsukuba, Japan, March 24 ~ 26, 2010

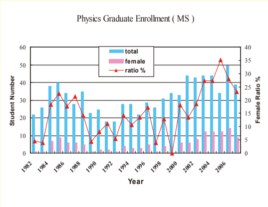
Chinese Physical Society, Beijing, China

Funding in China is increasing year by year so prospects for physicists are bright, though not so much so for women. The ratio of women physicists in China is less than 25%, dropping at senior levels due to the "leaky pipeline" effect and the forced retirement of female professionals below the rank of associate professor at age 55 compared to 60 for men.. Paradoxically, the number of female graduate students has increased in recent years, but this is due to the new trend of employment discrimination against women as the country evolves towards a market economy.

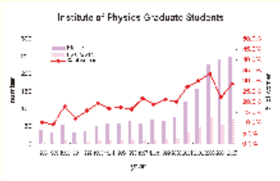
Since the formation of the Chinese Physical Society's Working Group on Women in Physics in 2002, much effort has been made to reverse this trend and to promote the image of women physicists. Statistical data are collected; a special session is held on gender issues at the Society's annual meeting; each March issue of Physics magazine has articles devoted to women in physics; the Xie Xi-De Physics Prize for Women was established and first awarded in 2007; special prizes for girls are awarded at provincial Physics Olympiads. However, much still remains to be done.

Increasing job discrimination leads to Increase in ratio of female graduate students, as they seek higher qualifications

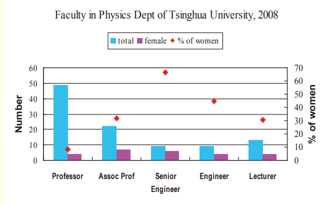
Graduate Students in Fudan University, Shanghai

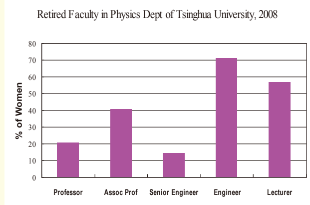


Graduate Students in Institute of Physics, Chinese Academy of Sciences



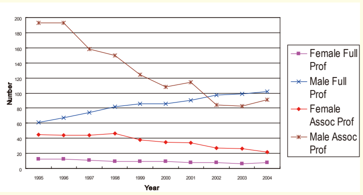
Enforced early retirement leads to high ratio of retired/current female professors





Although the current faculty has the usual "scissors" gender distribution, amongst the retirees there is a disproportionately high ratio of senior ranked women.
This indicates that they had to retire earlier with a lower rank than their male colleagues, or that they live longer, or both!

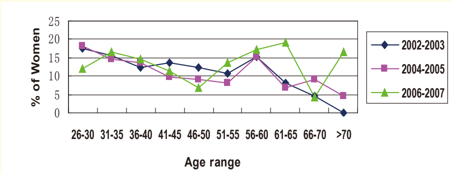
Number of senior research staff in the Institute of Physics, Chinese Academy of Sciences, 1995-2004



The ratio of senior female physicists is slowly decreasing

Ratio of Women Awarded NNSF of China Grants in Physics, Ranked by Age

Age distribution of women awarded regular NNSF grants in physics, averaged over every two years from 2002 to 2007.



Note the 2 dips in the age distribution, where
1) Women in their mid-forties are too burdened with family cares?
2) More women over 60 are retired.

Ratio of Women Awarded Major NNSFC Grants Ranked by Age

Age	2001		2002		2003		2004		2005		2006		2007	
	Total No	% Fem	Total No	% Fem	Total No	% Fem	Total No	% Fem	Total No	% Fem	Total No	% Fem	Total No	% Fem
26--30	1	0	2	0	0	0	1	0	0	0	0	0	0	0
31--35	5	0	11	0	7	0	12	1	2	0	2	0	2	0
36--40	37	3	47	1	70	3	55	3	5	0	7	2	9	0
41--45	29	0	25	0	32	0	58	2	12	0	9	1	17	0
46--50	0	0	6	1	8	1	16	2	2	0	3	0	4	0
51--55	5	0	0	0	2	0	2	0	0	0	1	0	1	0
56--60	7	0	10	1	12	1	9	0	3	0	0	0	1	0
61--65	12	2	16	3	15	0	12	0	2	1	4	0	1	0
66--70	4	0	4	0	5	0	9	0	0	0	2	0	2	0
>70	0	0	2	0	3	0	3	0	0	0	2	0	0	0
	100	5	123	4.88	154	3.25	177	4.52	26	3.85	30	10	37	0

Women awarded major grants are still very few

Actions of the Working Group

- Xie Xi-De Physics Prize for Women established, awarded in 2007, 2009
- Special March issue of *Physics* magazine each year on WiP
- Special girl's prize in provincial Physics Olympiads
- Round table meeting to discuss women issues at annual CPS meetings
- 2005 World Year of Physics — reaching out
- Networking at home and abroad
- ....

Xie Xi-De Prize awarded in 2007

2005 World Year of Physics Posters commemorating Women in Physics

Future Tasks

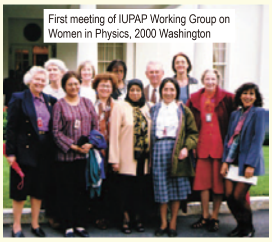
- Increase awareness of problem at all levels
- Increase popularization of physics
- Implement equity, not just equality
  - Grant application requirements relaxed for childbirth
  - Equal retirement age for men and women
  - Equal employment standards enforced

International Cooperation

- Attendance at international conferences
- Foreign visitors invited to attend domestic round-table meetings


Chinese delegation at IUPAP International Conf. on Women in Physics, Paris 2002

First International Workshop on Asian Women in Physics organized by AAPPS Working Group on Women in Physics, Pohang 2005


First meeting of IUPAP Working Group on Women in Physics, 2000 Washington

Mexico, 2009 International Physics Olympiad highest score won by a girl for the first time

SHI Handuo of China won highest overall score, highest experimental score

WU Ling-An gives talk at IUPAP International Conf. on Women in Physics, Rio de Janeiro 2005


Visiting professor speaks at 2007.9 CPS Round table meeting

Peter Melville of Inst of Physics, UK, speaks at 2006 CPS Round table meeting

Seminar at CAS Inst of Phys, 2005

Women in Physics in India

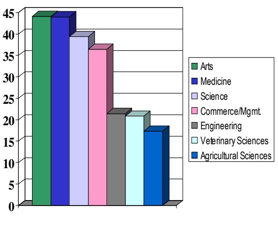
Shobhana Narasimhan

shobhana@jncasr.ac.in

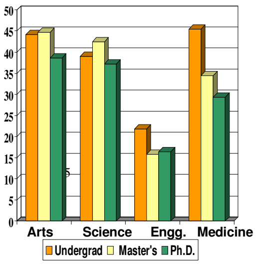
Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore 560064, India

- Everywhere in the world, women in physics are a minority. India is no exception. But the nature of the problem varies from country to country…

- In India, roughly 1/3 of science students are women, right up to the PhD level:

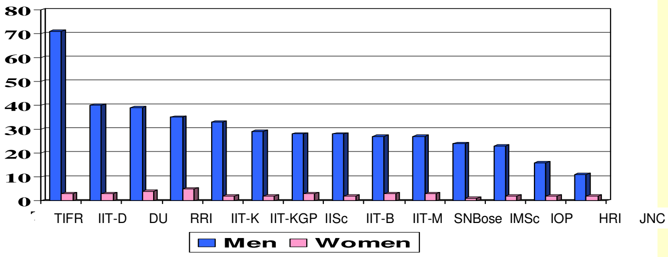


Source: UGC Report



Though not much rigorous data is available, anecdotal evidence suggests that the stereotype that women cannot do physics is NOT as widely prevalent in India as it is in some "developed" countries.

- But after doing their PhD's, most of these women "disappear"! e.g., consider the data on the physics faculty at some elite institutions in India:



- So unlike the "leaky pipeline" observed elsewhere, in India the main problem is after the PhD
- This represents a huge loss of highly trained (wo)manpower!
- The problem: societal expectations that women should function primarily as wives & mothers.

- Most prestigious science prize (Bhatnagar) has never been awarded to a woman in physics!
- Few (or no) women in high-profile positions, selection committees, etc.

What are Governmental Institutions & Academies doing to help?

➢ Department of Science & Technology, Government of India:

- Has a division: Science for Equity, Empowerment & Development
- Created "women scientists' scheme": 3 year research grant, specifically for women who have had a break in career and want to return to science (hundreds of fellowships awarded).
- Established "Task Force on Women in Science" which held meetings all over India, evaluated situation and made long list of recommendations recently.
- Minister of S&T (P. Chavan) invited women scientists to meet him and talk to him.
- Ministers for S&T have made various announcements to help ameliorate the situation (flexitime, funds for creche & daycare, planned establishment of Standing Committee, etc.)
- Institutions encouraged to have programmes dealing with gender equity.

➢ Indian National Science Academy & Indian Academy of Sciences:

- Committees to discuss issues related to women's participation in science
- "Lilavati's Daughters": book of autobiographical essays by 97 women scientists.
- Surveys commissioned to gather more data, including information about why women have left science.

One continuing problem in search of a solution (any ideas?!) :

How can we convince men that this is not a "women's issue" and get them involved in the movement to increase the participation of women in physics in India ??!!

Activities of the Physical Society of Japan (JPS) for the Promotion of Gender Equality

JPS Gender Equality Promotion Committee

Y. Matsuo, Chair of JPS-GEP (RIKEN)

N. Arimitsu (Yokohama Ntnl. U.) T. Kagayama (Osaka U.) K. Kaki (Shizuoka U.) R. Kadono (KEK) M. Kuwata-Gonokami (U.Tokyo) M. Sasao (Tohoku U.) Y. Torii (U.Tokyo) M. Nakashima (Shinshu U.) M. Ninomiya (Okayama IQP) F. Matsushima (Toyama U.) I. Yonenaga, Vice-chair (IMR, Tohoku U.)

About JPS

The Physical Society of Japan (JPS) is an organization of over 18,000 physicists, researchers as well as educators, and engineers.

The primary purposes of the JPS are to publish research reports of its members and to provide its members with facilities relating to physics.

The JPS was founded in 1877 as the first society in natural science in Japan.

The JPS has concluded reciprocal agreements with seven physical societies such as the American Physical Society, German Physical Society and Korean Physical Society so that the members of one society can participate in the activities of the other on an equal partner basis. (http://wwwsoc.nii.ac.jp/jps/)

About JPS-GEP

Gender Equality Promotion Committee of the Physical Society of Japan (JPS) has been established after the IUPAP International Conference on Women in Physics held at Paris in 2002 to realize the resolution of the conference. The committee aims at

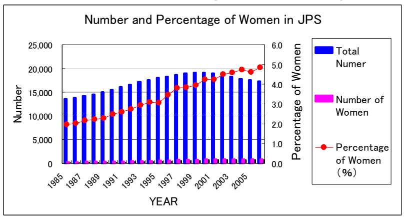
(1) Discussing the significance of gender equality promotion and taking actions for the achievement,

(2) Developing the next generation human resources in science including female scientists,

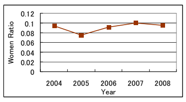
(3) Surveys and improvement of the environment for men and women in science.

The committee also takes part in a number of international collaboration activities such as IUPAP International Conference on Women in Physics.

The number and the percentage of women in JPS during the last 20 years



The women ratio in the graduate students of JPS members



Symposia in the JPS Annual Meetings

The JPS organized symposia on subjects relating to promote the gender equality in the JPS annual meetings, since 2002.

1. "Women in Physics: Survey Results of JPS Members and Report on the Paris Conference", 2002.
2. "Promotion of the Gender Equality: Balancing Childcare and Physics ", 2003.
3. "Evaluation of Researchers", 2004. This was organized by the Survey Analysis Committee.
4. "Promotion of the Gender Equality: on the Occasion of the revision of the Basic Plan for Science and Engineering", 2005.
5. "Governmental Supports for Career Development of Women Scientists and Engineers", 2006
6. "Gender Equal Participation in Research and Development – Present Status and Future Prospect of the Governmental Supporting Policy to Support Career Development of Women Researchers", 2007
7. "Gender Equal Participation in Research and Development – Booming Governmental Supporting Policy to Support Career Development of Women Researchers and Future Prospect", 2009
8. "Positive Action – Governmental Supporting Policy to Accelerate Career Development of Women Researchers and Future Prospect", 2010

Recommendations

Based on the JPS member survey results, the JPS has advanced two recommendations to the governmental authorities, academic related institutes and organizations; one for the flexible childcare supports and the other for improvement of the research granting systems for the post-doctoral fellows and part-time researchers in May and August 2003 respectively.

Publications

Publishing seven "News from the JPS Gender Equality Promotion Committee" in the JPS membership journal BUTSURI since 2007.

Public Relations

Activities of the JPS for the Gender Equality Promotion

- Symposia in the JPS Annual Meetings
- Collaborating with the Other Associations in Science and Engineering
- International Collaboration
- Girls Science Camp
- Surveys of JPS members
- Public Relations of the JPS Gender Equality Promotion Committee
- Childcare Supports during the JPS meeting

International Collaboration

1. Chairing the Round Table Discussion on Women in Physics, in Asia Pacific Physics Conference, October, 2004.Chair H. Fukuyama, Presentation E. Torikai
2. Participating the Round Table Discussion on Women in Physics, in the Summit of Asia Pacific Physics Society, January 2005,Taiwan. Presentation S. Tajima.
3. Participating the Round Table Discussion on Women in Physics, IUPUP, April 2007,Bad Honef, Germany. Presentation A. Maeda.
4. Giving 2 invited talks in APPC10, August, Pohang. Invited Presentations M. Bando and E. Torikai
5. Participating the 3rd International Conference on Women in Physics in Physics, IUPAP, October 2008, Seoul, Korea. Presentation S. Tajima, A. Maeda, E. Hiyama.
6. Participating the Round Table Discussion on Women in Physics, IUPUP, July 2009, Berlin, Germany. Presentation S. Tajima.

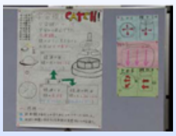
Girls Science Camp 1

To attract girls into science and engineering, the JPS has been co-organizing the Girls Science Summer Camp, held in August 2005, 2006, 2007, 2008, and 2009 in collaboration with the National Women Education Center in Saitama and the EPMEWSE (the Japan Inter-Society Liaison Association Committee for Promoting Equal Participation of Men and Women in Science and Engineering).



Girls Science Camp 2

To attract girls into science and engineering, the JPS has been co-organizing the Girls Science Spring Camp, held in March 2007, 2008, and 2009 in Kansai area in collaboration with the EPMEWSE.


Future Prospect of the JPS Gender Equality Promotion Committee

- The goal of the committee would be seeing the society where such a committee is not necessary.
- There is still a long way to go, in particular, in the field of science in Japan.
- Recently, the governmental supporting policy to support career development of women researchers started to move on, including a sort of positive actions.
- The committee will continuously work on this issue from the viewpoint of what this large academic society (where the ratio of the male members is 95%) can contribute to overcome the current status.

Activities by the Japan Society of Applied Physics for the Promotion of Equal Participation of Men and Women

The Committee for Diversity Promotion in Science and Technology in the Japan Society of Applied Physics
Yukari TANIKAWA (AIST), Kazue ISHIKAWA (Sophia Univ.), Madoka TAKAI (Univ. of Tokyo), Kikue SHIMOKAWA (JETO), Hanako IIJIMA (JSAP), Kayoko ITO (JSAP), Jun NAKAMURA (Univ. of Electro-Communications), Kashiko KODATE (Japan Women's Univ.)

The Committee for Diversity Promotion in Science and Technology

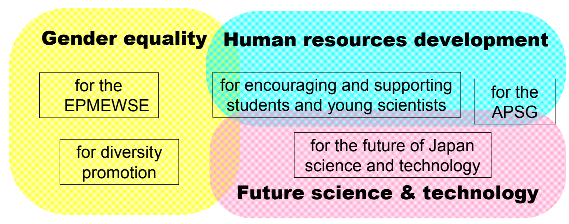
What is JSAP?

The Japan Society of Applied Physics (JSAP) serves as an academic interface between science and engineering and an interactive platform for academia and the industry. JSAP is a "conduit" for the transfer of fundamental concepts to the industry for development and technological applications.
To this end, the JSAP holds annual conferences; publishes scientific journals; actively sponsors events, symposia, and festivals related to science education; and compiles information related to state-of-the-art technology for the public.
The activities as the society started in July 1932, when the monthly journal "OYO BUTSURI" (Applied Physics) was published. JSAP was established as an official academic society in 1946.
JSAP has about 25,000 members, 45% of them belonging to private companies.
JSAP offers the following grades of memberships :
Student member, Member, Fellow, Emeritus member, and Honorary member.

Our committee

The Committee for Diversity Promotion in Science and Technology in the Japan Society of Applied Physics (JSAP) will aim to promote gender equality and human resources development. Our committee has worked on the activities related to the promotion of gender equality, both intra-/inter- academic societies and in society as a whole, and development of human resources since 2001.

Our activity

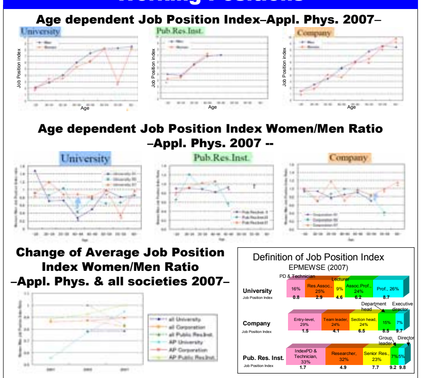


Results of Questionnaire Survey in EPMEWSE (2007)

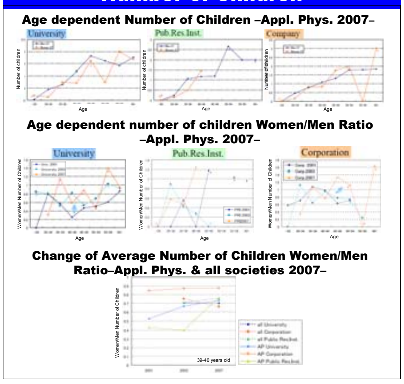
EPMEWSE

EPMEWSE
(Japan Inter-Society Liaison Association Committee for Promoting Equal Participation of Men and Women in Science and Engineering)
Field: Mathematics, Electronics & Information, Physics, Chemical & Material Eng., Life science & Biology, Civil Eng., Others
Members : 37 Academic Societies
The Japan Society of Applied Physics, The Society of Chemical Engineers,Japan, Ecological Society of Japan, The Society of Polymer Science,Japan, The Institute of Electronics, Information and Communication Engineers, Japanese Society for Biological Sciences in Space, The Chemical Society of Japan, The Japanese Forest Society, Atomic Energy Society of Japan, Japan Society for Cell Biology, The Society of Japanese Women Scientists, The Japanese Society of Plant Physiologists, The Mathematical Society of Japan, Bioimaging Society, The Japanese Biochemical Society, The Biophysical Society of Japan, Physiological Society of Japan, Protein Science Society of Japan, Astronomical Society of Japan, The Zoological Society of Japan, The Japanese Society of Developmental Biologist, The Japan Society for Comparative Endocrinology, The Physical Society of Japan, The Molecular Biology Society of Japan, The Japan Neuroscience Society, Society of Geomagnetism and Earth, Planetary and Space Sciences, The Crystallographic Society of Japan, The Japanese Society of Carbohydrate Research, Japanese Society of Breeding, Japan Geoscience Union, The Japanese Society of Animal Reproduction, The Society of Eco-Engineering, The Genetics Society of Japan, Japan Society of Coordination Chemistry, Society of Evolutionary Studies, Japan, Architectural Institute of Japan, The Society for the Study of Species Biology
Observer : 29 Academic Societies

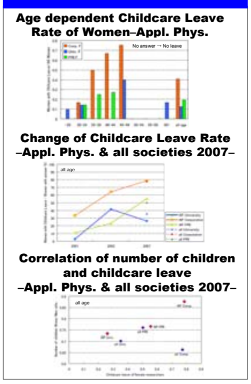
Working Positions



Number of Children



Childcare Leave



The Activities of the committee

For diversely promotion

Symposia

"Science and technology human resources development for the coming 20 years" (Mar. 19, 2010, Tokai Univ.).
The total number of the symposia was 7 since 2001, and the average number of the participants was approximately 120 persons per the symposium.

Childcare facilities

Establishment of childcare facilities at biannual JSAP conferences since 2005.
The total number of the children who received a day-care at the facility was111 until today.

Activities abroad

Presentation and discussion at "The 3rd International Union of Pure and Applied Physics (IUPAP) Conference on 'Women in Physics' (ICWIP)", which was held in Seoul, Oct. 7-10, 2008.

For encouraging and supporting students and young scientists

Career-explorer mark

The logo illustrated for pre- and post-docs has circulated in the JSAP community as a "career-explorer mark".
"Logo offers physicists a system for hire education" :Nature 448, 739 (2007).
・An employment bureau for job offers and applications has been established toward the closure of job-scarcity problems for post-docs.

Consultation meeting

"A tutorial for young scientists by the JSAP -for drawing a career-design by themselves-",(Mar. 17, 2010, Tokai Univ.).
The total number of the symposia was 7 since 2001, and the average number of the participants was approximately 120 persons per the symposium.

The activity of the APSG

APSG : Applied Physics Social Service Group

Informal meeting

" Why don't you use your experience and talents for the society ?" (Mar. 29, 2008, Nihon Univ.).
"Let's utilize your scientific experience and skill of applied physics for the Social contribution"
(Sep. 4, 2008, Chubu Univ.).

The educational road-map

Educational road-map in line with the JSAP vision for the scientists of tomorrow

"The educational road-map in line with the JSAP vision for the scientists of tomorrow", which is one of 'the academic road-maps' was planned and constructed. This aims to draw a way to the bright future for the scientists and engineers where they can lead the field of science and technology on a global level.

Contact information

The Committee for Diversity Promotion in Science and Technology in the Japan Society of Applied Physics

E-mail: gender@jsap.or.jp
<gender@jsap.or.jp>

homepage:
http://www.jsap.or.jp/activities/gender/index.html

RIKEN's Programs for Young Researchers

Welcome to RIKEN

Noyori Ryoji
2001 Nobel Laureate in Chemistry
President, RIKEN

Why do we pursue science?
Because we have an instinctive desire to understand our natural environment.
Knowledge – including scientific knowledge – is fundamental to culture, and technology enriches society.
RIKEN offers the best research environment in the world. Come join us in cutting-edge research, pushing forward the frontiers of science and technology.
Together we can do great things.

Advances you can be part of –won't you join us?

For Doctoral Candidates

If you are a doctoral candidate, your research may qualify you for an International Program Associate (IPA) position at RIKEN. We are looking for research that advances work now underway at RIKEN and for non-Japanese researchers to help us create a borderless, interdisciplinary research environment. IPAs carry out their research under the joint supervision of their graduate school and RIKEN.

IPAs are expected to bring fresh thinking to research in physics, chemistry, biology, medicine, or engineering and to take full advantage of the RIKEN research environment through collaboration and use of shared equipment and facility.

For Postdoctoral Researchers

If you have completed your doctorate, consider joining the researchers who are making RIKEN a stimulating interdisciplinary research environment that knows no borders. Candidates for the Foreign Postdoctoral Researcher Program (FPR) are internationally active scientists who can contribute their own thinking to the research underway at RIKEN.

FPRs apply their innovative ideas, under the direction of their laboratory head, to research currently being carried out at RIKEN. RIKEN will assist in the selection of a mentor and provide guidance on laboratory and administrative procedures.

For Leaders in Their Fields

Is your goal to become a world-class researcher? RIKEN's Initiative Research Unit (IRU) program could be the opportunity you seek. The IRU provides funding opportunities for promising young scientists who, as unit leaders, will contribute to advances in RIKEN-designated research fields in an environment that develops world-class researchers. IRU unit leaders will independently draw up and carry out a detailed research proposal, making full use of the RIKEN research environment, including applying for funding, establishing collaborative relationships, and using shared equipment and facilities.

Diversity at RIKEN

By attracting the most talented scientists from Japan and abroad, RIKEN activity promotes a research environment that fosters the very best of international research. Diversity among personnel is a vital factor contributing to RIKENS's success and RIKEN has set ambitious targets for increasing the number of international scientists.

Europe	194
China	114
Asia	94
Korea	54
North America	37
Oceania	11
Central & South America	5
Africa	2

International Researchers by Countries and Regions (including visiting researchers, as of October 2008)

Curiosity knows no borders

RIKEN is growing not only in numbers, but also in scope. RIKEN actively supports young researchers, collaboration with overseas organizations, and the exchange of personnel with overseas universities and institutions. The map below, with the number of joint projects and programs in parentheses, shows the countries engaged in such collaborations and agreements between RIKEN and research organizations and universities aroung the world.

The number of joint projects and programs in parentheses (as of March 2009)

Please visit our booth backside for more information!

RIKEN

Fostering Practical Engineers Through Cooperative Problem-Based Learning with Students from Overseas Universities

Sasebo Nat'l College Tech.: H. Kawasaki, Y. Suda, K. Morishita, K. Nakashi, T. Shigematsu, T. Yamasaki, M. Inoue

Introduction

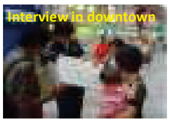
Sasebo National College of Technology (SNCT) and Xiamen University of Technology (XUT) cooperatively launched a mutual student exchange program in 2005. One of the aims of this program is to educate and train young Japanese engineers who can apply their knowledge and skills fully to work in factories in China. The other aim is to educate and train young Chinese engineers who will acquire not only technological knowledge and skills but also an understanding of the organizational structure and cultural background of Japanese companies. In order to achieve these aims, three main activities have been planned as follows.(1)Exchange program between SNCT and XUT. (2)SNCT faculty visiting Chinese University and Japanese factories operating in China. (3).Holding international forums and students' reporting sessions

Exchange program between SNCT and XUT

2005, 4 XUT students and 2 faculty visited SNCT for three weeks.
2006, 6 XUT students and 2 faculty visited SNCT for three weeks.
2007-9, 6 XUT students and 3 faculty visited SNCT for three weeks.

Staying in the SNCT dormitory each year, XUT students and faculty joined classes, visited factories, laboratories and historical sights in northern Kyushu, Japan.



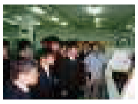


SNCT faculty held special training seminars for XUT students to become familiar with advanced technology using highly sensitive experimental instruments. They also did internship program in Tuji Co. for 3 days, in 2007.
6 SNCT students had their internship at Xiamen FDK Co. in 2006 ~ 2008 for four days. Though this internship term was short, 6 SNCT students reported that they learned a lot about factories in China.

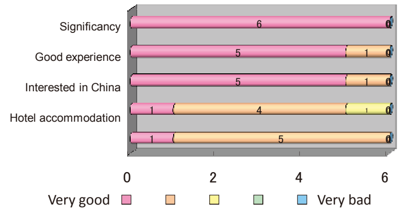
2005: 4 SNCT students and 3 faculty visited XUT
2006-8: 6 SNCT students and 3 faculty visited XUT


Staying in XUT guest houses for three weeks each year, SNCT students also attended classes and visited cultural and historical sights in Xiamen City. They also had opportunities to learn Chinese traditional arts, such as calligraphy, the tea ceremony and tai-chi. Though they had these experiences for the first time, SNCT students really enjoyed these activities and were impressed by how splendid they were. Although the SNCT students and faculty just had an introductory seminar at that time, these experiences surely helped them to deepen their understanding of Chinese culture.

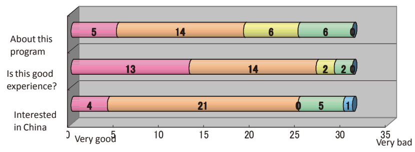
The fourth grade students of SNCT performed the factory tour of Shanghai and Xiamen in 2007.
They also visited to Xiamen University of Technology. (First time overseas factory tour)




Questionnaires about student exchange program



Questionnaires about fourth graders' factory tour in 2007



Future Plan

- Working cooperatively with factories to create new products
- Demanding environmentally friendly and energy saving products
- Crossover industries based on various fields

- High evaluation of graduates as practical engineers
- Low evaluation of graduates' use of English
- New trial to introduce a course system in which students can pursue their interests further

【Huis Ten Bosch in Sasebo】
Theme park in which people can learn about energy and ecology

【Sasebo National College of Tech.】
High evaluation of starting student-exchange program with Xiamen Univ.

The combination of high level of technology, idea and manufacture
⇒ the innovation to promote international manufacture and service value
⇒ graduates who can play major parts as leaders in overseas factories

The International Engineer Course

Sweden / China / Korea
Using English as a major communication tool

Mutual exchange , WEB, Skype, e-mail

Providing concrete themes as tasks (solar cell, windmill, battery, hydrogen, ・・・

Int'l communication lab., International Engineers' Nets

Cooperative project on environment and energy by engineering students working on the same task overseas

The use of the most advanced equipment + Internship in foreign countries

Nagasaki Next Generation Theme Park in Huis Ten Bosch, Sasebo, Japan (presentation, exhibition)

Presentation at conference

Evaluating the program / Evaluating students' performance

Certification of International Engineer Course

The approved students are
- the ones who can play active roles as leaders in overseas factories
- the ones who can develop products and its service value worldwide
- the ones who can work cooperatively with other engineers internationally

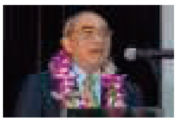
International forum

Because the number of students who can join this program was limited, off-campus international forums and in-school reporting sessions were planned.

The first , second and fourth Sasebo-China international forum was held in Sasebo, Japan, in 2005, 2006 and 2008.

The third international forum was held in Xiamen, China in November, 2007.

One of the guest speakers at that time is Mr. Mitsutake, the ex-Mayor of Sasebo, Japan. Around 250 people attended this forum and discussed how we could improve this program in the following years.

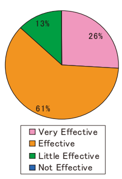
After the forum, we obtain the information by means of questionnaires about our program.

(1) Effect for Fostering young practical engineer in Japan

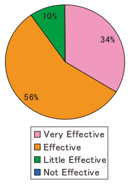
(2) Effect for a mutual friendship between Japan and China

All results of these questionnaire survey suggest that this program is highly admired for educating Japanese and Chinese students.

Questionnaires about our program



(1) Effect for Fostering young practical engineer in Japan



(2)Effect for a mutual friendship between Japan and China

Final evaluation on this program

The final evaluation on this program was carried out on Feb. 9, 2009. The evaluation committee consisted of a total of eight persons (3 SNCT teachers, 1 external technical college teacher, 4 external knowledge persons.) The results of four year trial were as follows. Generally speaking, this program was highly evaluated.

(1)Acceptance enterprise	4.8/5.0
(2)Dispatch enterprise	4.9/5.0
(3)Intership activity	4.9/5.0
(4)Forth grader's factory tour	4.5/5.0

(Maximal point 5.0)

Conclusions

It is expected that each participant makes the most of available opportunities which this program will supply them with, so that he or she can deepen and broaden understanding of each country. It is also expected that the participants' experiences are widely reported to society so as to influence those who don't have any chance to join this student exchange program personally. By continuing this student exchange program taking hands in hands with colleges and Universities in China, SNCT will make every effort to help young future engineers to learn about Chinese and Japanese working environments and culture respectively, and to build friendships over the ocean.

Collaboration between enterprises and research physicist - A measure to boost in physics research in Vietnamf.c.c and b.c.c

The First Asia - Europe Physics Summit, Tsukuba, March 24 -26, 2010

Nguyen Thanh Hai

Department of Theoretical Physics, Institute of Engineering Physics, Hanoi University of Technology,hai@mail.hut.edu.vn

And

Vietnam Youth Academy, Viet Nam Central Youth Union

Introduction

Enterprises linking model with scientific research in universities or research institute have developed strongly in many countries. This problem has also been much interested in Vietnam in the last few years and obviously it is much beneficial for both scientists and business. In Vietnam, an annual state budget allocates to the scientific research in all fields at universities and research institutes, many research has been very successful and as result published in several well-known international journals. Many research results can continue develop or apply in the fields of technology, production at enterprises. However many obstacles also occur by many reasons, such as: shortage of funding to continue research, no appropriate mechanism for technology transfer, or simply no exchange of information between businesses and scientists. Recently, the collaboration between business and universities in research has been started to deploy in some university such as Hanoi University of Technology, University of Technology although it often concentrated only in the sectors of information technology, biotechnology, ...

In physics, currently the companies have not much interested in investing in research results (theoretical and experimental). Therefore the development of this model for studying the physical results are very necessary and is considered as an important method to attract more fund for physics research so that it may improve the quality of research study physics. Models, measures and concrete statistical data is gently mentioned as follows

Problems approach

1. Cooperation between universities, research institutions with enterprises in scientific research and the interests of the parties

1.1 For enterprises

✐Cooperation with the universities, institutes is considered as attractive investment channel for enterprises to improve quality of the product.

✐- Base on idea, innovation of the researchers in the universities and institutes, the enterprises may quickly produce and introduce the new product to the market

✐Giving supplementary "artificial capital" to the researchers. It also their the grey matter

✐ Providing the chance for enterprise to promote its business activity and implement the social obligation.

1.2 For Universities, research institutions

✐ Supplementing the budget for the research activities

✐Increasing the financial self control right in researcher activities.

- Quick putting the research results into the practice

In general, the cooperation bring the beneficial for all involved parties

2. The question is how this collaboration really effective

✐ Cooperation can not play unilaterally. All concerned parties must actively look to the other, promote, expand and diversify their relations

✐Enterprises must actively set all issues to study and be solved in practice by researchers

✐Scientists need to actively inform their research results to enterprise. The results of this study can be applied immediately in practice. In some case, it may require additional funding from the business

✐ Beside businesses and scientists, it is good idea if we could involve specialist advice on legal, appraisal value of scientific research, drafting the contract, to ensure mutual benefits to all parties and the most important thing is to keep the long and reliable cooperation between businesses and scientists (the services of science, technology transfer)

3. Actual situations in Viet Nam

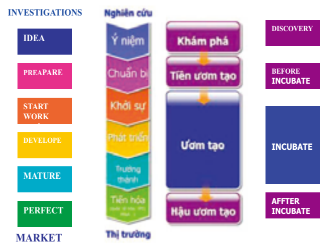
✐Investment, low risk but get high profit and can quick recover its capital). Many enterprises have funded to a researching the university and institutes. Most of the research results gotten from the governmental funded projects and were applied to businesses. Obviously it has brought many benefits to the entire society.

✐For industry, or basic and applied scientific research such as research in physics (condensed matter physics, material physics, physical electronics, biomedical physics, high energy physics,...) often face difficulties due to the expense of investment in research in this field is big but high-risk and long-time capital withdrawal. Most research in physics now Vietnam is expect to those funds granted either by the government or by the foreign research institutes, universities (in practice, the foreign research institutes and universities often focus on investment of the training in Vietnam, but they are very little interest in investment research)

Proposed Models

1. Technology incubator

✐Technology incubator is division belong to the universities or research institutions (universities and enterprises investment funding), activities to support technology viable ideas become product configured. After the nursery can make the output of products which business can apply to organizations production.



2. Technology business incubator

✐Technology business incubator is a division belongs to the universities or research institutions activities to support establish enterprises based on the ideas or technology platform. After the nursery, its output products may apply in the technology sector.

3. Part-time staff in enterprise

✐The researcher in the universities, institutes spend from 1 to 3 months per year to work in the enterprises and fully understand the demand of the social and enterprises. Base on it, the researcher determine their scientific activities in the coming time

4.Establish universities and research institutions of enterprises

5. Seek investment funding from the business associations or Fund development of science,...

Conclusions

The development of this model for studying the physical results are very necessary and is considered as an important method to attract more fund for physics research so that it may improve the quality of research study physics.

Acknowlegements

It is pleasure to express my sincerely thank to Organizing Committee ASEPS and The High Eenergy Accelerator Research Organization (KEK), who gives me a nice chance to attend this conference. Thanks for so much for all support from Local Organizing

For discussion

Research Project

Accelerator

Particle and Nuclear Physics

Astronomy and Astrophysics

Neutron Science

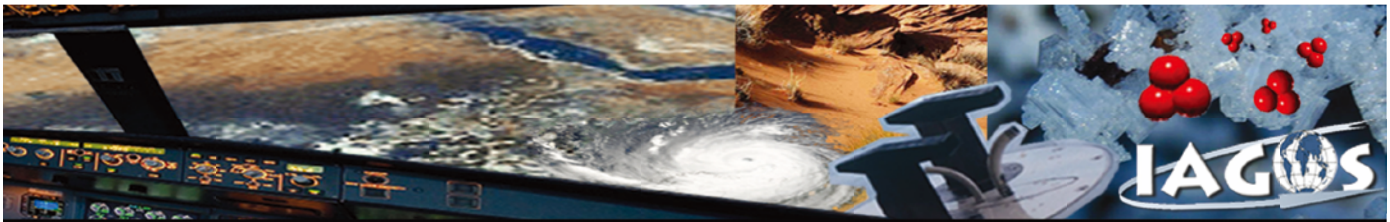
Nano Science

Metrology

Computational Science

Biology and Biophysics

Miscellaneous



In-service Aircraft for a Global Observing System

The Consortium

IAGOS-ERI builds on 15 years of scientific and technological experience gained in the research projects MOZAIC (Measurement of Ozone and Water Vapour on Airbus in-service Aircraft) and CARIBIC (Civil Aircraft for the Regular Investigation of the Atmosphere Based on an Instrument Container).

The Partnership

JÜLICH, CNRS, METEO FRANCE, MANCHESTER 1824, ift, UNIVERSITY OF CAMBRIDGE, BRITISH AIRWAYS, Lufthansa, NATURAL ENVIRONMENT RESEARCH COUNCIL, MPI-BGC Jena, enviscope, DLR, AIRBUS, cnes, ECMWF, WMO

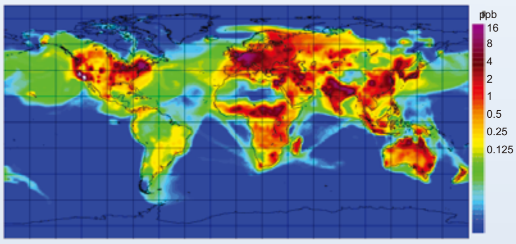
Associated Airlines

Lufthansa, BRITISH AIRWAYS, CHINA AIRLINES, QANTAS, AIR FRANCE, Austrian, Air Namibia, IBERIA, CATHAY PACIFIC, Philippine Airlines, SOUTH AFRICAN AIRWAYS

The Science

The need for routine aircraft observations at the global scale is driven by:

- The scientific communities engaged in modelling of
  - Climate Change
  - Air Quality
  - Carbon Cycle
  - Impact of Aviation
- The Task Force on Hemispheric Transport of Air Pollutants (HTAP)
- The GMES Atmosphere Service (GAS)
- The scientific community engaged in improving satellite data

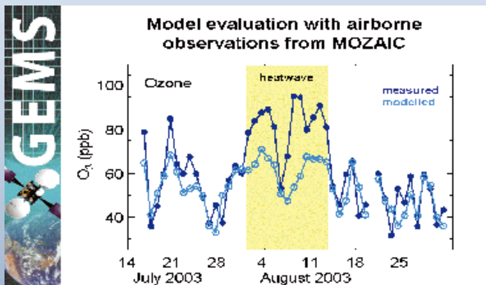


ECMWF/GEMS Forecast of Surface NOx for 26.11.2008 (http://gems.ecmwf.int)

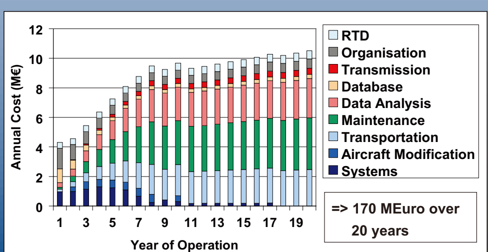
The Users

IAGOS-ERI provides data for users in science and policy, including:

- Modelling of climate change and global air quality
- Air quality forecasting in the GMES Atmospheric Service.
- Verification of CO_2 emissions and Kyoto monitoring
- Numerical weather prediction
- Validation of satellite data products

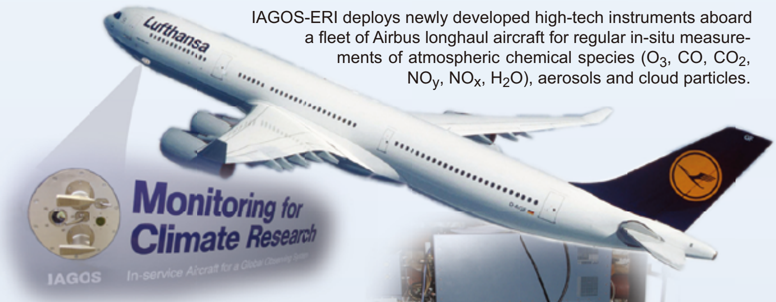


The Costs



The Technical Approach

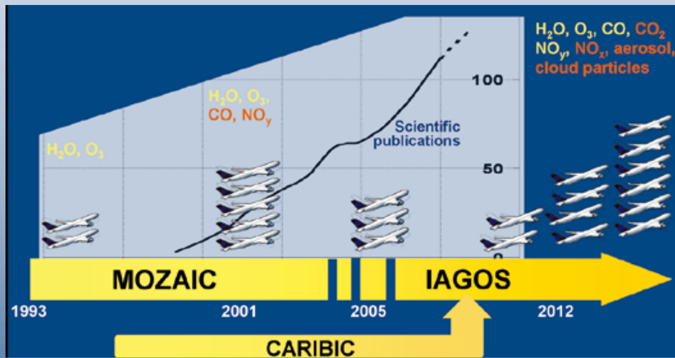
IAGOS-ERI deploys newly developed high-tech instruments aboard a fleet of Airbus longhaul aircraft for regular in-situ measurements of atmospheric chemical species (O_3, CO, CO_2, NO_y, NO_x, H_2O), aerosols and cloud particles.



IAGOS instruments are permanently installed in the avionic compartment.

In CARIBIC, a cargo container is deployed as a flying laboratory aboard one aircraft. A special multi-functional inlet system allows optical measurements and accurate sampling for aerosol and trace gases.

The Timeline



Coordinator: A.Volz-Thomas, Institut für Chemie und Dynamik der Geosphäre 2, Forschungszentrum Jülich, Germany, *a.volz-thomas@fz-juelich.de*

www.iagos.org

EMFL – Plans for a European High Magnetic Field Facility

O. Portugall[1], G. Rikken[1], J. K. Maan[2] and J. Wosnitza[3]

[1] LNCMI Grenoble & Toulouse, France
[2] HFML Nijmegen, The Netherlands [3] HLD Dresden, Germany

Science in high fields

Magnetic fields act on charges and spins. Their capability to influence matter reversibly, without intrusion, makes them a useful tool to

- **manipulate** (deflection, levitation, separation, alignment, acceleration),
- **probe** (nuclear magnetic resonance, electron spin and cyclotron resonance, Hall-effect and magneto-resistance),
- **induce new fundamental states** (field-induced supraconductivity, normal state of superconductors, magnetic phases).

High magnetic fields have played an essential role in discoveries rewarded by 15 Nobel prizes.

High-field X-ray scattering setup (LNCMI-ESRF).

High magnetic field generation

The generation of high magnetic fields is technically limited by several physical phenomena.

- **Critical field of superconductors:** 25 T limit for generating magnetic fields dissipationless.
- **Joule heating of electrical conductors:** 36 T limit for static fields (resistive only). 45 T limit for static fields (hybrid).
- **Lorentz forces:** 90 T limit for non-destructive pulsed fields.
- **Magnetic flux diffusion:** 300 T limit for destructive single-turn coils, 700 T limit for in-door flux compression.

Capacitor bank for pulsed field generation.

User facilities worldwide

The technical difficulty of generating high magnetic fields has given rise to a centralization of research activities in a few large user facilities that are based on four corner stones:

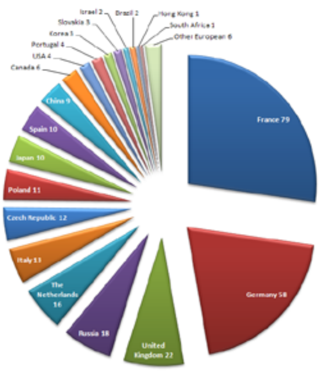
- the development of cutting-edge magnet technology,
- the development of suitable experimental techniques,
- an extensive in-house research programm,
- the accommodation of external users on a regular basis.

*User facilities for pulsed (red) and static (yellow) magnetic fields. Installations marked by * are under construction.*

The EuroMagNET consortium

EuroMagNET (www.euromagnet2.eu) comprises the 4 largest European magnet facilities as core-partners. Installations are open to external users whose projects have been validated by an international selection committee. Calls for proposals are issued twice a year. Financial support for European users is provided through the Transnational Access (TNA) programme.

- **HLD Dresden, Germany** – pulsed magnetic fields up to 87 T; access to the THz-FEL ELBE; project for a 100 T non-destructive magnet.
- **HFML Nijmegen, The Netherlands** – static magnetic fields up to 33 T; constructions of a THz-FEL and 44 T hybrid magnet underway.
- **LNCMI Grenoble, France** – static magnetic fields up to 35 T; 43 T hybrid magnet under construction.
- **LNCMI Toulouse, France** – pulsed fields up to 80 T, ultra-short 300 T fields and mobile generators for experiments at other large facilities.



Project proposals per country received by EuroMagNET in 2009. Asia represents the second largest user group after Europe.

Eurasian perspectives

The EuroMagNET partners maintain collaborations with high-field facilities in China and Japan as well as other laboratories in Asia. These need to be intensified to counterbalance the American supremacy and to cope efficiently with issues related to the operation of large-scale installations. Some issues to be addressed are:

- **Joint scientific projects** – make use of the complementarity of experimental techniques available in different facilities.
- **Joint technological development** – avoid redundancy and limit the individual investment in cost-intensive areas.
- **Outsourcing** – identify industrial partners to take over tasks of routine production; enhance prototype development in exchange.
- **Purchasing** – coordinate the acquisition of raw materials so as to improve industrial partnerships.

The EMFL project

EuroMagNET is funded on a 4-year basis by the European Commission. In order to consolidate and improve the free access to high magnetic fields for the international user community, it is planned that the existing network will evolve into a distributed infrastructure, the European Magnetic Field Laboratory (EMFL).

As of 2008, the EMFL project has been integrated in the ESFRI roadmap for European large installations. The corresponding preparatory phase proposal is under evaluation.

Contact

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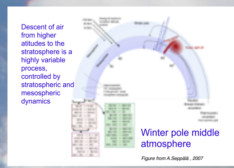
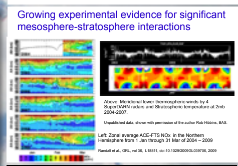
EISCAT_3D: A European Three-Dimensional Imaging Radar for Atmospheric and Geospace Research

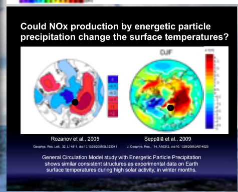
Esa Turunen, EISCAT Scientific Association, Box 812, SE-981 28 Kiruna, Sweden

EISCAT_3D will be Europe's next-generation radar for the study of the high-latitude atmosphere and geospace. The facility will be located in northern Fenno-Scandinavia, with capabilities going well beyond anything currently available to the international research community. Several very large active phased-array antenna transmitter/receiver arrays, and multiple passive sites will be located across three countries. EISCAT_3D will be comprised of tens of thousands, up to more than 100000, individual antenna elements.

EISCAT_3D combines several key attributes which have never before been available together in a single radar, such as volumetric imaging and tracking, aperture synthesis imaging, multistatic configuration, improved sensitivity and transmitter flexibility. The use of advanced beam-forming technology allows the beam direction to be switched in milliseconds, rather than the minutes which it can take to re-position dish-based radars. This allows very wide spatial coverage to be obtained, by interleaving multiple beam directions to carry out quasi-simultaneous volumetric imaging. It also allows objects such as satellites and space debris to be tracked across the sky. At the passive sites, the design allows for at least five simultaneous beams at full bandwidth, rising to over twenty beams if the bandwidth is limited to the ion line, allowing the whole range of the transmitted beam to be imaged from each passive site, using holographic radar techniques.







The Science Objectives

- **What is the influence of natural variability in the solar-terrestrial system on climate?**
- How are atmospheric layers coupled?
- Support for space-borne science studies.
- Space weather monitoring.
- Space surveillance.
- Orbital element determination of space debris, meteors and asteroids.
- Effects of meteoritic deposit on atmospheric chemistry.
- Magnetospheric and ionospheric plasma physics.
- Mapping of near-Earth objects.
- Solar wind and solar coronal measurements.
- Development of radar and information technology.

Contact us:
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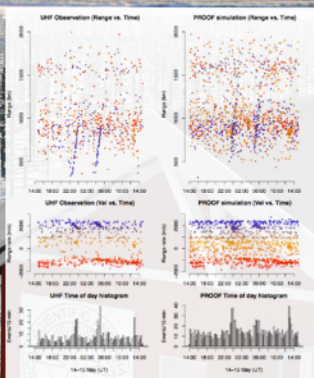
Dr Ian McCrea, Rutherford Appleton Lab., UK, ian.mccrea@stfc.ac.uk

Concept of the Design Study

- at least 4 remotes and 1 core site
- resolution at 100 km 1s/100m
- 3D coverage: stratosphere - 800 km
- core site range up to 2000 km



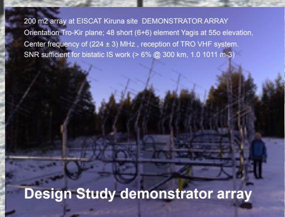
Space debris detected using the EISCAT UHF system on May 14-15th 2009, afew months after the Iridium-Cosmos satellite collision.The Iridium cloud orbital plane passes are visible at about 00:00 and 13:00 UT; and the Cosmos cloud pass at about 00:00 and 06:00 UT. The figure also compares the measurement with a statistical debris model called PROOF.

Differences show that the model could be improved by using the EISCAT measurements.

(from J. Vierinen et al., 2009)

The time line:

- 2005-2009: Design Study, completed
- 2010-2013: Preparatory Phase
- 2014-2015: Construction
- 2015-2045: Operation



Design Study demonstrator array

SCALE: 10's of thousands of antennas
RESOLUTION: 10 times better time and spatial resoution than present radars
CAPABILITY: EISCAT_3D will be a volumetric radar capable of imaging an extended spatial area with simultaneous full-vector drift velocities, having continuous operation modes, short baseline interferometry capability for imaging sub-beamwidth scales, real-time data access for applications and extensive data archiving facilities.
EISCAT_3D is open to Global and Asian participitation
During the preparatory phase 2010-2013 the development of technical concepts according to science criteria will be done via user community workshops and dedicate work groups.
If your institute is interested to use EISCAT_3D, please send us a request to be included as an Associate Partner. Associate partners are invited to user meetings and workgroups.
NEXT USER MEETING: 19-21 MAY, 2010, UPPSALA, SWEDEN
See handout document at http://www.eiscat3d.se/drupal/material

EISCAT_3D has a modular configuration, which allows an active array to be split into smaller elements to be used for aperture synthesis imaging. The result will be an entirely new data product, consisting of range-dependent images of small sub-beamwidth scale structures, with sizes down to 20 m. EISCAT_3D will be the first phased array incoherent scatter radar to use a multistatic configuration. A minimum of five radar sites, consisting of two pairs located around 120 km and 250 km from the active site respectively, on baselines running East and South from the active core, is envisaged. This provides an optimal geometry for calculation of vector velocities in the middle and upper atmosphere. The gain of the EISCAT_3D antennas and the large size of the active site arrays will deliver an enormous increase in the figure-of-merit relative to any of EISCAT's existing radars. An active site of 5,000 elements would already exceed the performance of the current EISCAT VHF system, while an active site comprising 16,000 elements, as suggested in the Design Study carried out from 2005 to 2009, will exceed the sensitivity of the present VHF radar by an order of magnitude. Each transmitter unit will have its own signal generator, allowing the generation and transmission of arbitrary waveforms, limited only by the available transmission bandwidth and spectrum allocation by the frequency management authorities.

Implementation of all currently used and envisaged modulation schemes and antenna codings (such as polyphase alternating codes, array tapering, orbital angular momentum beams) is possible, as well as adaptation to any kind of future codes. In addition, it will allow advanced clutter mitigation strategies such as adaptive null steering and null shaping.

The science case of EISCAT_3D is versatile, ranging from global change related studies of the atmospheric energy budget and coupling of atmospheric regions to space plasma physics with both small-scale structures and large-scale processes, as well as planetary and meteor radar applications. Additional societal value is in opportunities for continuous geo-space environment monitoring and possible service applications to users needing information on space debris and space weather.

Modular construction, several sites

ESFRI Roadmap project

- The Swedish Research Council proposed EISCAT_3D on the ESFRI Roadmap
- ESFRI accepted the proposal in December 2008.
- The ESFRI EISCAT_3D proposal emphasizes modular construction of a large distributed radar facility with a possibility to have several active sites

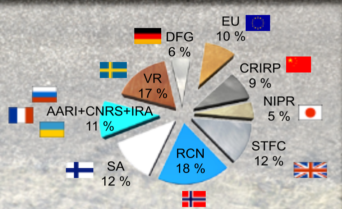
Operation 2015-2045
Estimated costs: Preparation: 6 MEUR
Construction: 60 MEUR one active site
250 MEUR all sites
Operation: 4-10 MEUR/year
Decomissioning: 10-15% of construction

Website: http://www.eiscat3d.se/

***EISCAT** is an International Association with current members from China, Finland, Germany, Japan, Norway, Sweden, and Great Britain, as well as supporting partners from France, Russia and Ukraine.*

EU funding of mobility and development is essential.

EISCAT Scientific Association



2009 Budget 34 MSEK / 3.3 MEUR

EISCAT Scientific Association operates currently three incoherent scatter radars in Northern Scandinavia. The current facilities include the 2-dish monostatic radar at 500Mhz at Longyearbyen, Svalbard, the 224 MHz monostatic VHF radar in Tromsø, Norway, a tristatic UHF radar at 930 Mhz with transmitter/receiver in Tromsø and receivers in Kiruna, Sweden and Sodankylä, Finland, a high-power HF heating facility in Tromso, as well as 2 dynasondes in Tromso and at Svalbard.

Incoherent scatter radar (ISR) is known to be the most versatile ground-based remote sensing method of the upper atmosphere and near-Earth space, being able to measure 4 parameters, electron density, electron temperature, ion temperature and line-of-sight plasma velocity simultaneously. With assumptions, even more parameters can be deduced. Also weak coherent targets, such as meteors and very small space debris can be measured since the ISR is essentially a high-power, large-aperture radar.

EISCAT Incoherent Scatter radars

A new experience in clustering teams of physicists: *Triangle de la Physique* in the south of Paris

Christian Colliex*, Elisabeth Bouchaud, Anna da Costa,
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TRIANGLE DE LA PHYSIQUE

an Advanced Research Cluster in Physics

from basic to applied *(optics, lasers, nanosciences, condensed matter, statistical physics, complexity…)* of more than **1000 permanent physicists** (researchers, professors and engineers…) attached to **40 laboratories.**

Our goals

- Improve the **international global visibility and attractiveness** of a critical number of expert and recognized physicists working on top level equipment, gathered on a restricted geographic area (south of Paris) but belonging to different science organizations, universities and engineering schools;
- Create a new dynamics among the scientific population to **generate ambitious and innovative projects**, transgressing the administrative affiliations;
- Promote a world-wide recognized **scientific label**.

Our tools

To foster international attractiveness:

- grants for consolidated **senior chairs**
  - **S. Svensson**, 2007, University of Uppsala, Sweden
  - **Lev Ioffe**, 2007, Rutgers University, USA
  - **Jörg Wrachtrup**, 2008, University of Stuttgart, Germany
  - **Léon Sanche**, 2009, University of Sherbrooke, Canada
- grants for welcoming visiting foreign professors and researchers, as well as post-doctoral (about and Ph.D. positions
- support for sabbatical visits of French staff and of students into foreign labs

To promote emerging novel research themes:

- grants for consolidated **junior chairs** with equipment and running costs
  - **Corinna Kollath**, 2007; **Laurie Calvet**, 2008; **Viatcheslav Kokoouline**, 2008; **Andrea Fioretti**, 2009; **Mikkhail Zvonarev**, 2009
- support for hiring dedicated post-docs (57 in 3 years) and Ph. D. students

To upgrade the common scientific and technical substrate of equipment:

- finance prioritary common equipment for experiments and computing, to be shared by several users
  - **Appeal** (2007), **FemtoArpes** (2008), **Frachet** (2009)

To encourage diffusion towards the socio-economical neighbourhood:

- select and promote a few proposals for transfer of technology, for innovation in education and teaching

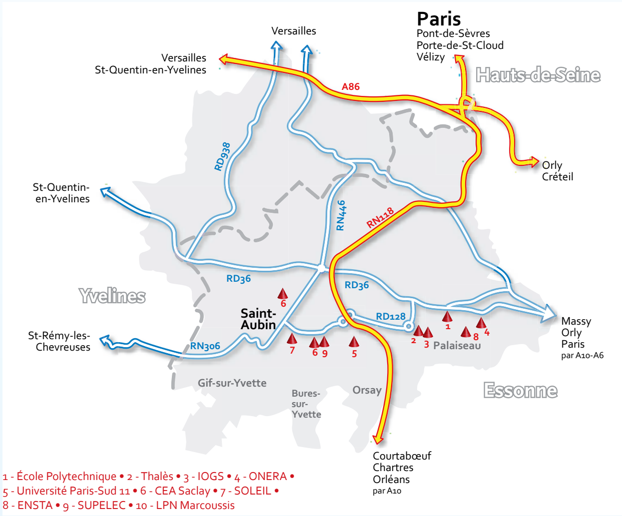
Our scientific themes

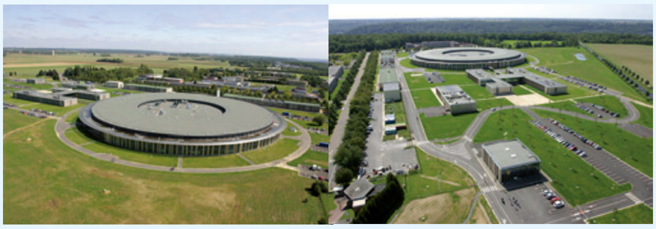
Federative Themes…

1. Coherence and quantum entanglement: from atoms to mesoscopic systems
2. Matter out of equilibrium: from molecules to nanoparticles
3. Complex matter: systems, materials and dynamics
4. Strongly correlated materials
5. Spintronics
6. Extreme light pole
7. Nanophotonics

… relying on a common substrate of:

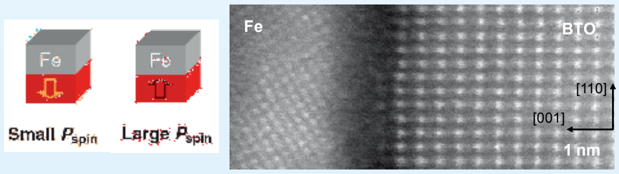
A. Instrumentation at its limits
B. Theory from statistical physics to ab initio modelization
C. Synthesis of new objects for study
D. Innovation and transfer of technology





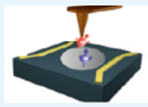
Synchrotron SOLEIL

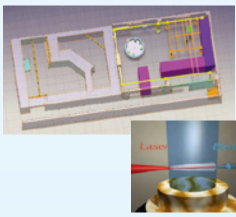
Copyright : C.Kermarrec/SOLEIL



Scheme of electrical control of spin polarization at a Fe/BaTiO3 interface and atomically resolved image of its structure
OxiSpintronics project 2008, see Ferroelectric control of spin polarization by V. Garcia et al. Science 327 (2010) 1106

Magnetic probe using the echo of spin of a center colored in a nanocrystal of diamond
B-Diamant project, 2008 Senior Chair J. Wrachtrup





A targeted joint project to promote the use in physics, chemistry and biology, of short electron pulses generated by ultra-short laser beams. Perform advanced experiments in radiolysis and in radiotherapy.
Appeal project, 2007

Our founders: CNRS, Université Paris-Sud 11, CEA, École Polytechnique, Institut d'Optique, Supélec, ENSTA ParisTech, ONERA

Our partners: ENS Cachan, Centrale Paris

http://www.triangledelaphysique.com
contact@triangledelaphysique.fr

Japanese Contribution to the ITER Project

Japan Domestic Agency of the ITER Project

Japan Atomic Energy Agency, Naka, Ibaraki 311-0193 Japan

ITER Project to demonstrate the feasibility of fusion energy

Expectations for ITER

Utilization of fusion energy is one of the most attractive solutions to a future long-term energy source and global warming which respond to a common demand of mankind. The overall programmatic objective of ITER (originally the International Thermonuclear Experimental Reactor) is to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes. Technical objectives of ITER can be summarized as follows:

Plasma Performance

- Extended burn in inductively driven plasmas with the ratio of fusion power to auxiliary heating power, Q, of at least 10 with a duration sufficient to achieve stationary conditions on the timescales characteristic of plasma processes.
- Demonstrating steady-state operation using non-inductive current drive with the ratio of fusion power to input power for current drive of at least 5.
- Possibility of controlled ignition should not be precluded.

Engineering Performance and Testing

- Demonstrating the availability and integration of technologies essential for a fusion reactor (such as superconducting magnets and remote maintenance).
- Testing components for a future reactor (such as systems to exhaust power and particles from the plasma).
- Testing tritium breeding module concepts that would lead in a future reactor.

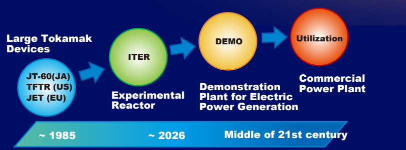
Domestic Agencies' contribution

The idea for ITER originated from the Geneva Superpower Summit in 1985 and is a research cooperation using international resources and expertise toward the practical realization of fusion energy.

The ITER Agreement was signed by Japan, USA, Russia, European Union (EU), China, Korea, and India in 2006. The ITER project is managed by the ITER Organization, based in Cadarache, in the South of France. Japan Atomic Energy Agency was designated as a domestic agency of ITER Project in Japan, and procures the equipments and devices such as the superconducting coils and plays a role as the contact points of a personnel contribution of Japan to the ITER Project.

Cost sharing for construction of host (EU) is 45.46 % and other 6 parties are 9.09 %. In-kind procurement (construction and secondment of human resources to the ITER Organization) is 78 % and cash contribution is 22 %.

A Way Towards Practical Use of Fusion Energy



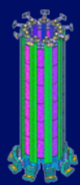
ITER is a bridge from the Large Tokamak Devices toward demonstrating the feasibility of a large-scale reactor for electrical power production, called DEMO. DEMO will lead the way to the first commercial fusion power plant.

Schedule of ITER

The ITER project is planned to last for 30 years – 10 for construction and 20 years of operation.

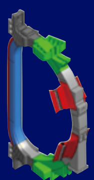
In-kind Procurement by Japan

Japan contributes to the construction of ITER by producing major components in collaboration with the ITER Organization and Participating Parties.



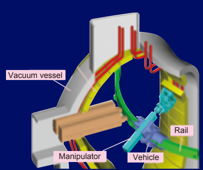
Central Solenoid Coils

Superconducting coils for controlling the start up, fusion burning and shut down of the plasma. Japan shall procure all conductors for Central Solenoid Coils.



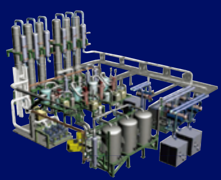
Toroidal Field Coils

Superconducting coils for confinement of the high temperature plasma. Japan shall procure 25% conductors, nine windings, all structures and nine coils for Toroidal Field Coils.



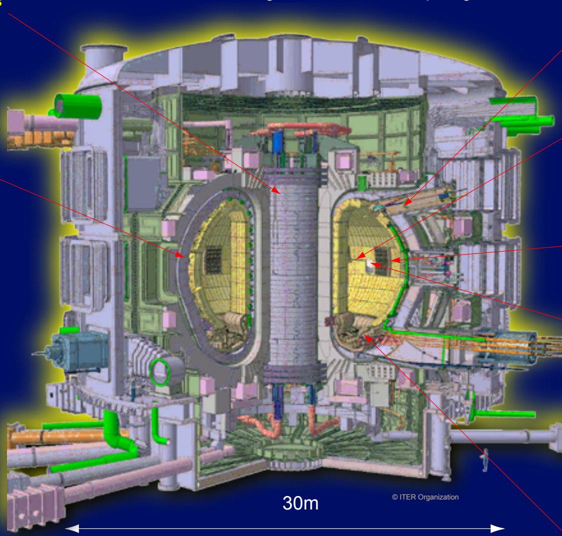
Remote Handling Equipment

Remote handling equipment for shield blanket maintenance and replacement.



Tritium Plant

A tritium separation, purification and re-fueling facility. Japan shall procure Air Detritiation System.

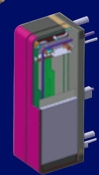


Main Parameters of ITER

Total fusion power	500 MW
Plasma major radius	6.2 m
Plasma minor radius	2.0 m
Plasma Current	15 MA
Toroidal field at 6.2 m radius	5.3 T
Plasma inductive burn time	300 - 500 s

Diagnostics

Devices for measuring the temperature and density of ions and electrons in plasma and the distribution of impurities and neutrons.



Test Blanket Module

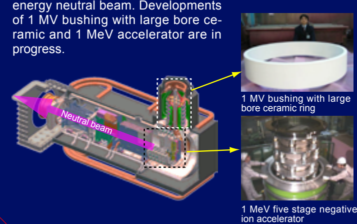
Test Blanket module will lead to a DEMO reactor blanket through the experimental operations in ITER . This is prepared for the test at the ITER, and outside of the scope of in-kind procurement.

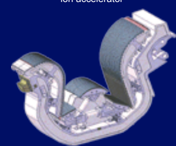
Electron Cyclotron Radio Frequency Resonance Heating System

Plasma heating device using electromagnetic waves in the electron cyclotron wave range.

Neutral Beam Injector

Plasma heating device using high energy neutral beam. Developments of 1 MV bushing with large bore ceramic and 1 MeV accelerator are in progress.



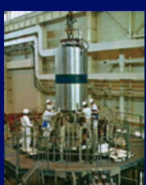


Divertor

In-vessel components for heat removal and exhaust of helium ash and impurities.

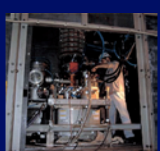
Fusion Research Test Facility for ITER Procurement

JADA pursues the procurement of ITER components through R&D and testing in these existing facilities in use for fusion research in JAEA.



Superconducting Coil Test Facility

Testing of superconducting magnets.



Gyrotron Test Facility

Testing of the RF heating system

Tritium Process Laboratory

A series of demonstration tests for the tritium removal system has been carried out to provide the data related to licensing of ITER.

Diagnostics Test Facility

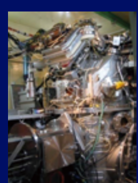
Developing a high-energy-output (5 J) and high-repetition-rate (100 Hz) YAG laser for edge Thomson scattering system.

Remote Handling Test Facility

Testing of remote handling equipment.

MeV Class Ion Source Test Facility

Testing of a 1 MeV accelerator for the neutral beam injection system.



High Heat Flux test Facility

High heat flux testing of the test blanket module and divertor.

Fusion Neutronics Source Facility

Testing using 14 MeV neutrons.

Current Status of ITER Broader Approach Activities within the Framework of Japan-EU Collaboration

- IFMIF/EVEDA & IFERC Projects in Rokkasho and Satellite Tokamak JT-60SA Project in Naka –

The Implementing Teams of IFMIF/EVEDA and IFERC, and the JT-60SA Team

Mission: The Earliest Realization of Fusion Energy

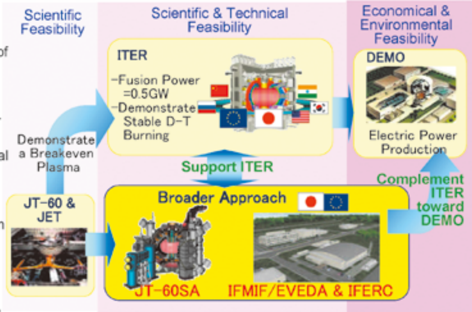
The Broader Approach (BA) is a Japan-EU collaborative project aiming at supporting the ITER Project and complementing developments toward a fusion DEMO reactor on the same period of ITER construction.

The major objective of ITER validate the scientific and engineering feasibility of fusion energy, by demonstrating a stable D-T burning operation. This, however, is considered insufficient for the earliest achievement of fusion energy.

In parallel with the ITER project, additional and supplemental R&Ds are considered necessary as follows: (a) fusion materials development and their irradiation tests, (b) conceptual design and engineering assessments for the DEMO, (c) engineering developments of the breeding blanket including materials for tritium bleeding, neutron multiplier, and also (d) research and developments of plasma to support ITER with exploring advanced tokamak scenarios.

On such a mutual understanding of fusion energy R&D strategy common to both Japan and EU, they agreed to initiate the BA Activities together with the ITER project.

Strategy toward Fusion Power



Management Structure for Broader Approach

EU Implementing Agency: F4E (Fusion for Energy)

BA Agreement between Japan and EU

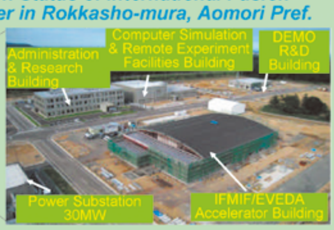
Japan Implementing Agency: JAEA (Japan Atomic Energy Agency)

Steering Committee
Overall direction and supervision of the Implementation of the BA activities

Three Projects in BA:

1) Engineering Validation and Engineering Design Activities for the International Fusion Materials Irradiation Facility (IFMIF/EVEDA)
2) International Fusion Energy Research Center (IFERC),
 a) DEMO Design and R&D Coordination Center
 b) Computer Simulation Center
 c) ITER Remote Experiment Center
3) Satellite Tokamak Program
 Participation to Upgrade of JT-60 Tokamak to JT-60SA and Its Exploitation to Contribute to the Earliest Realization of Fusion Energy by Addressing the Key Physics Issues in ITER and DEMO.

Building Construction Status of International Fusion Energy Research Center in Rokkasho-mura, Aomori Pref.



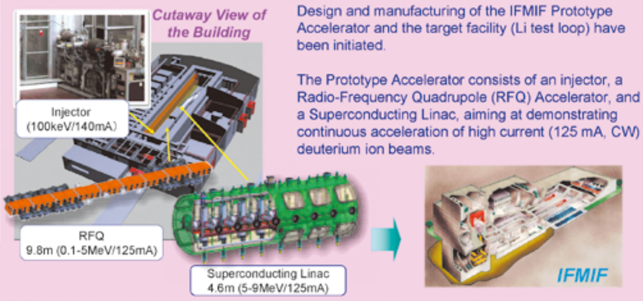
IFMIF/EVEDA Project

10 Experts

5 Experts and 6 Support Staffs (January, 2010)

Design and manufacturing of the IFMIF Prototype Accelerator and the target facility (Li test loop) have been initiated.

The Prototype Accelerator consists of an injector, a Radio-Frequency Quadrupole (RFQ) Accelerator, and a Superconducting Linac, aiming at demonstrating continuous acceleration of high current (125 mA, CW) deuterium ion beams.



IFERC Project

DEMO Design and R&D Coordination Center

Computer Simulation Center & ITER Remote Experiment Center

For DEMO design and R&D activities, the first three years of 2007-9 as the first phase have been devoted to workshops and preparation for activities.
The following years will be planned for full-fledged activities in collaborative design and R&D works.
- Establish Common Conceptual DEMO Design (Assumption, Cost, Time Schedule, Safety Concept)
- Physics and Engineering Issues in R&D should be identified, and Preliminary R&D (Low Activated Materials, Breeding Blanket, Tritium Management, etc.)

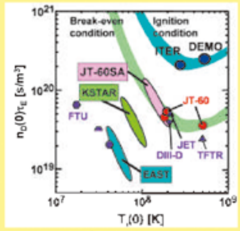
For the Computer Simulation Center, selection of the high performance computer (the next-generation supercomputer) is now going for operation of early in 2012.
- D-T burning plasma simulation for ITER
- Advanced plasma behavior simulation for JT-60SA
- DEMO reactor design
- Advanced material simulation

The Remote Experiment Center will be tested in 2015 using JT-60SA, after design, manufacturing, and installation in 2012-2015.

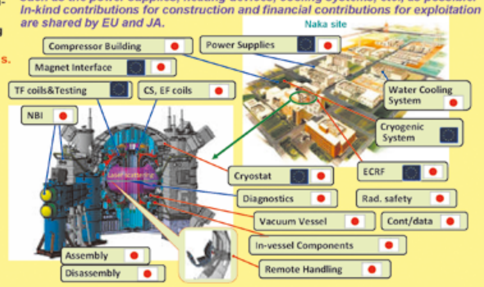
Satellite Tokamak JT-60SA Project

The mission of JT-60SA is capable of confining breakeven-equivalent class, high-pressure deuterium plasmas with the max. plasma current of 5.5 MA, superconducting toroidal (2.26 T) and poloidal field coils. 34 MW of NB and 7 MW of ECRF for up to 100 s.

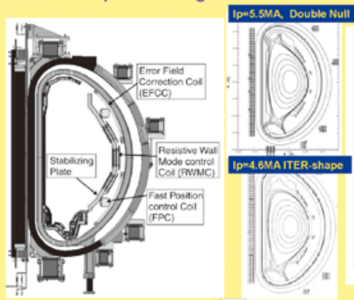
Complete reconfiguration of the JT-60 by reusing as many existing infrastructure such as the power supplies, heating devices, cooling systems, etc., as possible. In-kind contributions for construction and financial contributions for exploitation are shared by EU and JA.



Plasma Operation Regime



Japan-EU Sharing of Tokamak Facilities in Naka

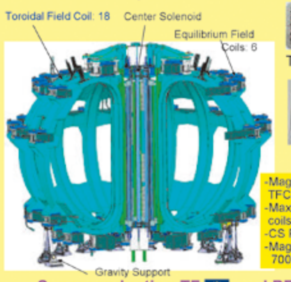


Typical Plasma Parameters

Parameter	DN Low A	ITER-shape	High-β_N full-CD
Plasma Major Radius R (m)	2.96	2.93	2.97
Plasma Minor Radius a (m)	1.18	1.14	1.11
Plasma Current I_p (MA)	5.5	4.6	2.3
Toroidal Field B_t (T)	2.25	2.28	1.71
Plasma Aspect Ratio A	2.5	2.6	2.7
Plasma Elongation κ_x, κ_{95}	1.95, 1.77	1.81, 1.70	1.92, 1.83
Plasma Triangularity δ_x, δ_{95}	0.53, 0.42	0.43, 0.33	0.51, 0.41
Shape Parameter S	6.7	5.7	6.9
Safety Factor q_{95}	3.2	3.2	5.7
Plasma Volume (m³)	132	122	124
Heating Power (MW)	41	34	37
Assumed HH-factor	1.3	1.1	1.3
Normalized Beta β_N	3.1	2.8	4.3
Thermal Energy Confinement Time τ_E (s)	0.54	0.52	0.26
Electron Density n_e (10^{20}/m³)	0.63	0.91	0.50
Greenwald Density $n_{Greenwald}$ (10^{20}/m³)	1.3	1.1	0.59
Normalized Plasma Density $n_e/n_{Greenwald}$	0.5	0.8	0.86
Flattop Flux (Vs) (li=0.73-0.75)	~9	~17	- (full CD)
Bootstrap current fraction	0.29	0.30	0.66
Discharge flattop duration (s)	100	100	100

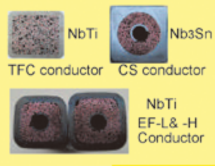
ITER-shape: same κ and δ but lower A than ITER.

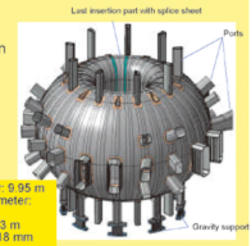
In-vessel Components



-Magnetic Energy in TFC: 1.5 GJ
-Max Field in TFC coils: 5.8 T
-CS Peak Field: 8.9 T
-Magnet Weight 700 tons (4K)

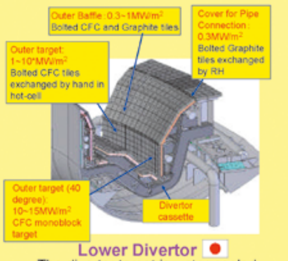
Superconducting TF and PF Coils





Outside diameter: 9.95 m
Inboard Side diameter: 2.86 m
Torus height: 6.63 m
Shell thickness 18 mm
Weight~150 ton
One-turn resistance:19 μΩ
Normal operation Temp.:50 degC
(Boric acid water between shells)

Vacuum Vessel (Low Co SUS316L)



Lower Divertor

The divertor target is water-cooled, resistant against the heat flux of 15 MW/m².

Naka Fusion Institute

PF Coil Manufacturing Building

PF SC Conductor Manufacturing Building (700m in length)

VV Welding Test

Manufacturing Activities

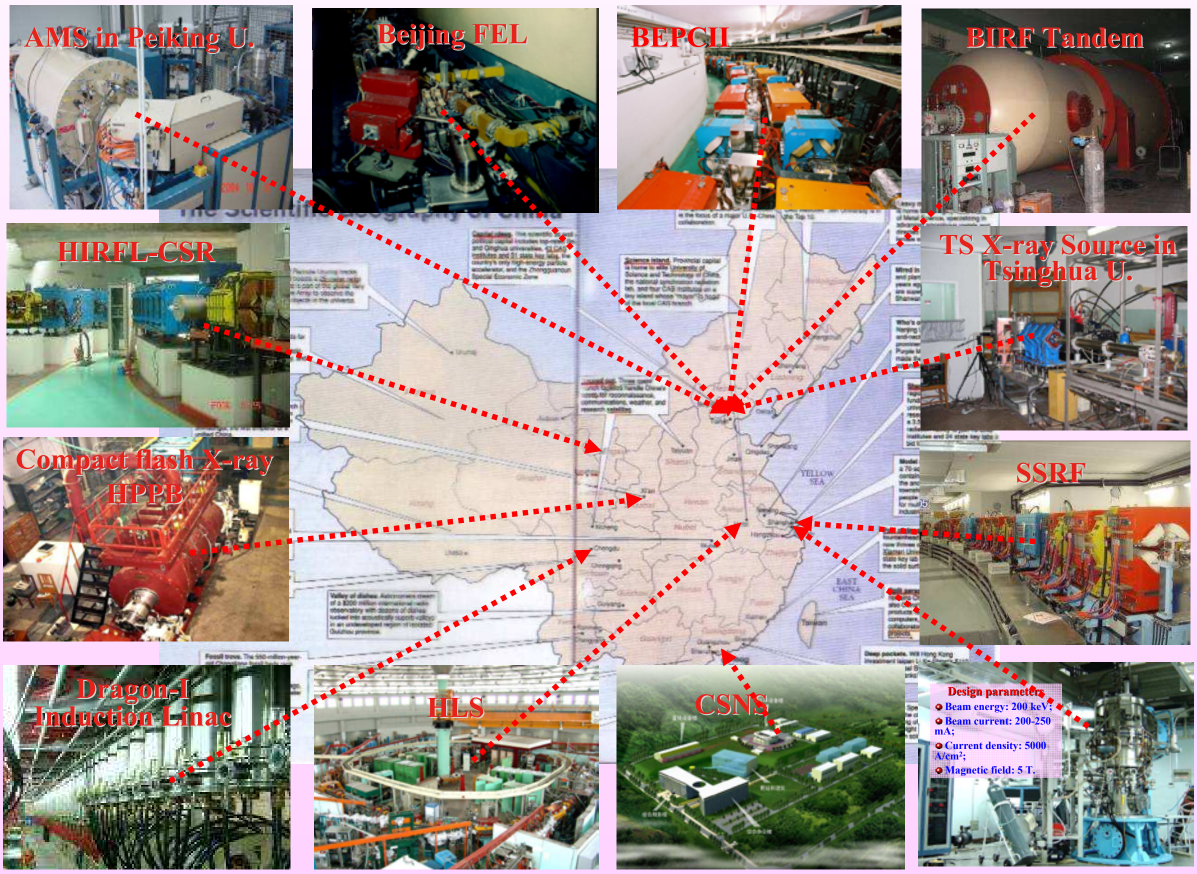
ITER Broader Approach

ITER BA Activities, IFMIF/EVEDA, IFERC, and Satellite Tokamak JT-60SA, are now being implemented within a tight active collaboration between Japan and EU, toward the earliest realization of fusion energy for human beings.

Particle Accelerators in China

Particle Accelerator Branch, Chinese Physics Society
The China Association for Science and Technology
P.O. Box 918, Beijing 100049, China

In China, there are Beijing Electron-Positron Collider (BEPC) and its major upgrade BEPCII for charm and τ physics research; Heavy Ion Research Facility in Lazhou (HIRFL) and its Cooling Storage Ring (HIRFL-CSR), and Beijing Radioactive Ion Facility (BIRF) for nuclear physics research; Beijing Synchrotron Radiation Facility (BSRF), Hefei Light Source (HLS), Shanghai Synchrotron Radiation Facility (SSRF) and China Spallation Neutron Source (CSNS) for researches of atomic and molecular scale. In the meantime, numbers of low energy accelerators have been constructed and applied in scientific research, irradiation, medicine and nondestructive testing. International collaboration in accelerator field is actively promoted.



BEPCII : Major Upgrade of the Beijing Electron-Positron Collider

BEPCII Team

Institute of High Energy Physics, Chinese Academy of Sciences
P.O. Box 918, Beijing 100049, China

The major upgrade of the Beijing Electron-Positron Collider (BEPCII) is one of China's key projects. It is a double ring e^+-e^- collider as well as a synchrotron radiation (SR) source with its outer ring, or SR ring. Construction of BEPCII started in the beginning of 2004. Installation of the storage ring components completed in October 2007. The commissioning of BEPCII started in June 2008 together with BESIII detector. The luminosity increased step by step and reached 1/3 of design value in May 2009. The collider has been in routine operation since November 2009.

Beam energy range	1–2.1 GeV
Optimized beam energy	1.89GeV
Luminosity @ 1.89 GeV	1×10^{33} $cm^{-2}s^{-1}$
Injection from linac	Full energy injection: E_{inj}=1.55–1.89GeV Positron injection rate > 50 mA/min
Dedicated SR operation	250 mA @ 2.5 GeV

Strategy of luminosity upgrade

- Double-ring: multi-bunch, k_b=1 ➔ 93
- Choose large ε_x & optimum param.: I_b=9.75mA, ξ_y=0.04

$$L(cm^{-2}s^{-1}) = 2.17\times10^{34}(1+R)\xi_y \frac{E(GeV)k_b I_b(A)}{\beta_y^*(cm)}$$

- Micro-β: β_y^* =5cm ➔ 1.5 cm, SC insertion quads
- Reduce impedance +SC RF, σ_z =5cm ➔ <1.5cm

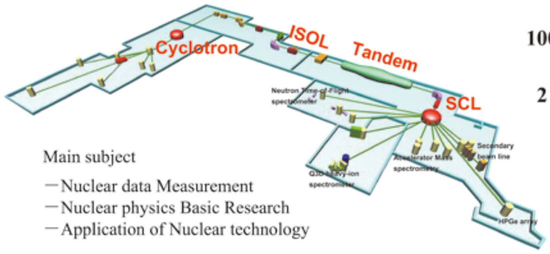
$(L_{BEPCII}/L_{BEPC})_{D.R.}=(5.5/1.5)\times93\times9.8/35=96$

$L_{BEPC}=1.0\times10^{31}$ $cm^{-2}s^{-1}$ ➔ $L_{BEPCII}=1\times10^{33}$ $cm^{-2}s^{-1}$

Progress of Beijing Tandem Accelerator National Lab

China Institute of Atomic Energy (CIAE)

About Tandem Lab



Main subject

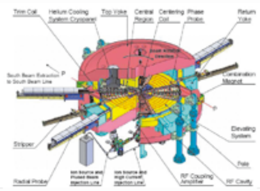
—Nuclear data Measurement
—Nuclear physics Basic Research
—Application of Nuclear technology

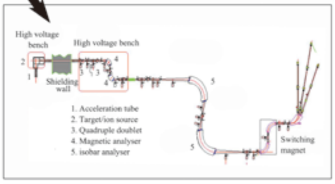
Main Experimental Facilities

—Neutron Time-of-Flight spectrometer
—Q3D heavy-ion spectrometer
—Accelerator Mass spectrometry
—Secondary beam line
—Heavy-ion Micro beam facility

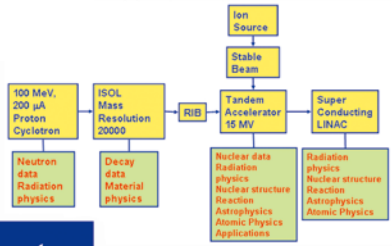
HI-13 Tandem Accelerator

100 MeV 200 mA compact proton cyclotron, 20000 mass resolution ISOL, 2 MeV/q Super-Conducting LINAC (SCL)

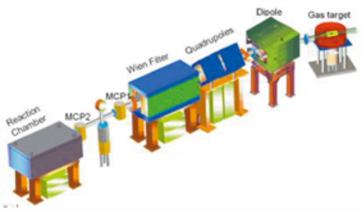




Beijing Radioactive Ion-beam

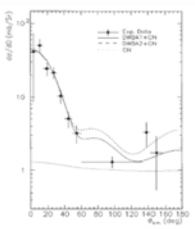


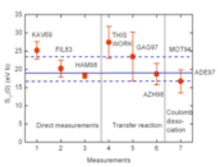
Nuclear Astrophysics Experiments



An unstable nuclear beam facility (GIRAFFE) at the Beijing Tandem accelerator lab was used for producing low energy secondary beams. GIRAFFE was designed for studying reactions of astrophysical interest and the structure of unstable nuclei. It comprises a primary reaction chamber, a dipole-quadrupole doublet (D-Q-Q) beam transport system and a secondary reaction chamber. At the end of 2004, a major upgrading of this facility will be taken place by inserting a velocity filter after its focal quadrupole doublet; this upgrading will greatly enhance the beam purity of secondary beam. Up to now, we have carried out measurement of astrophysical interest, including $^{7}Be(d,n)^{8}B$, $^{11}C(d,n)^{12}N$, $^{8}Li(d,n)^{9}Be$ and $^{8}Li(d,p)^{9}Li$ etc.

Angular Distribution for the $^{7}Be(d, n)^{8}B$ Reaction at $E_{c.m.} = 5.8$ MeV and the $S_{17}(0)$ Factor for the $^{7}Be(p, \gamma)^{8}B$ Reaction

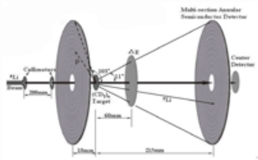


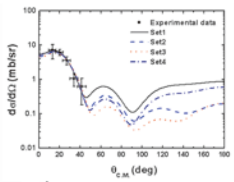


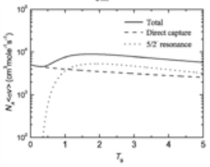
The angular distribution of $^{7}Be(d, n)^{8}B$ reaction has been measured in the experiment for the first time, from which the $S_{17}(0)$ factor for the $^{7}Be(d, n)^{8}B$ reaction was derived. Our $S_{17}(0)$ value (27.4±4.4 eV b) is shown together with the currently adopted value (22.4 ±2.1 eV b), the experimental results, and the calculations. As a result of an independent experimental approach, the present $S_{17}(0)$ value supports the missing solar neutrino found in the Kamiokande and Homestake experiments. Further experiments along this direction, e.g., the study of the $^{7}Be(^{10}B, ^{9}Be)^{8}B$ reaction, are under consideration..

W. Liu et al. PRL77(1996)611 & NPA 616(1997)131c

Cross section for $^{8}Li(d, p)^{9}Li$ reaction and $^{8}Li(n, \gamma)^{9}Li$ reaction rate

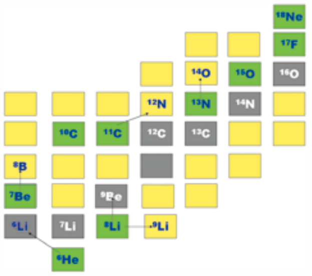






We have measured the angular distribution of $^{8}Li(d, p)^{9}Li$g.s. reaction at $E_{c.m.} = 7.8$ MeV, through coincidence detection of ^{9}Li and recoil proton, for the first time, and obtained the cross section and astrophysical S-factor.. By using ANC deduced from the $^{8}Li(d, p)^{9}Li_{g.s.}$ angular distribution, we have successfully derived the $^{8}Li(n,\gamma)^{9}Li_{g.s.}$ direct capture cross section and astrophysical reaction rate. We also plan to carry out an experiment at lower energies by upgrading our secondary beam facility and using a thinner DE detector.

Phys. Rev. C 71 (2005) 052801(R)



Main Works on GIRAFFE:

Secondary beam	Studied reaction	Scientific motivation	Publication
^{7}Be	$^{2}H(^{7}Be, ^{8}B)n$	S factor of the $^{7}Be(p,\gamma)^{8}B$ reaction	Phys. Rev. Lett.,77(1996)611, Nucl. Phys. A 616(1997)131c
^{6}He	$^{1}H(^{6}He, ^{6}Li)n$	Neutron-Proton Halo Structure for the 3.563 MeV 0+ State in 6Li	Phys. Lett. B 527 (2002) 50
^{11}C	$^{2}H(^{11}C, ^{12}N)n$	S factor and reaction rate of $^{11}C(p,\gamma)^{12}N$	Nucl. Phys. A 728(2003)275
^{8}Li	$^{2}H(^{8}Li, ^{9}Li)p$	the astrophysical reaction rate of $^{8}Li(n,\gamma)^{9}Li$	Phys. Rev. C 71 (2005) 052801R
^{8}Li	$^{2}H(^{8}Li, ^{9}Li)p$	astrophysical reaction rate of $^{8}B(p,\gamma)^{9}C$	Nucl. Phys. A 761 (2005) 162
^{13}N	$^{2}H(^{13}N, ^{14}O)n$	the astrophysical $^{13}N(p, \gamma)^{14}O$ Reaction Rate	Phys. Rev. C 74 (2006) 035801.
^{13}N	$^{1}H(^{13}N,p)^{13}N$	^{14}O resonance levels	Phys. Rev. C77(2008)044304

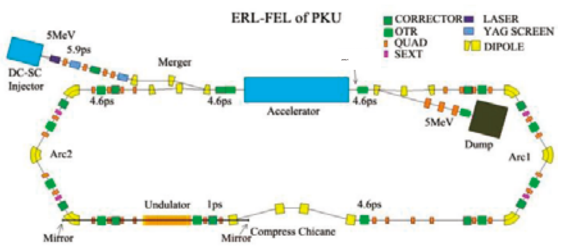
The SRF ERL Based FEL Test Facility at Peking University

SRF Physics & Technology Team

State Key Lab. of Nuclear Physics & Technology at Peking University, Beijing 100871, China

To provide coherent radiations with high luminosity, high RF efficiency and low waste, the construction of a SRF (Superconducting RF) ERL (Energy Recovery Linac) test facility (PKU-SETF) was initiated by the PKU-SRF group in 2005 as a mid-term goal. The PKU-SETF consists of mainly a 5 MeV DC-SRF injector, a cryomodule of 9-cell TESLA cavity for accelerating electrons to ~20 MeV and an energy recovery beam transport loop with two arcs matching with the main accelerator. An undulator and a chicane compressor are inserted in the loop to produce FEL with 4-8 micron wave length. The PKU-SETF might be realized in 3 steps. First the 5 MeV beam from the DC-SRF injector will be injected directly to an undulator to produce THz radiations. After the main accelerator and the energy recovery loop are accomplished, an ERL Compton Backscattering (CBS) device will be constructed to produce high flux X-ray of ~10 keV. Finally with an 11.5 m long optical cavity, an IR high brightness laser can be obtained. A 900 m^2 experimental area was completed last year, the layout of PKU-SETF is shown in the poster. The cryomodule and the cryogenic system is in position. The 1st beam from the injector is hopeful this year.

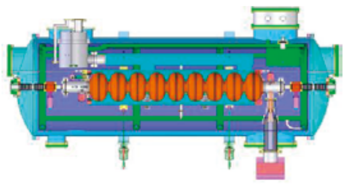
Schematic layout of PKU-SETF

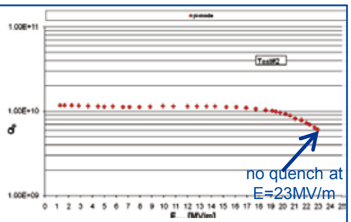


Main parameters of PKU-SETF

Injection Energy	~5 MeV
Output Energy	~20 MeV
Bunch Frequency	81.25 MHz
Bunch Charge	-60 pc
Bunch Length at the entrance of Undulator	~1 ps
Macro Pulse Length	2 ms
Rep. Frequency of Macro Pulse	10 Hz
Energy Spread (rms)	0.24 %
Transverse Emmittance (rms, n)	~3 mm-mrad
Length of Undulator	1.5 m
Period of Undulator	3 cm
K of Undulator	0.5-1.4
Optical Cavity Length	11.52 m
Wave Length of FEL	4.7-8.3 μm

Main SRF Accelerator

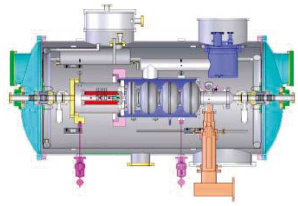


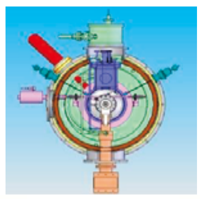


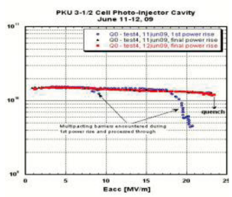
RF frequency	1.3 GHz
Field gradient	15-20MV/m
Q_0	1×10^{10}
Peak Current	20~50 A
Bunch Charge	20~50 pC
Average Current	1.6~4.0 mA
External Q	$0.2\sim1\times10^7$
Cryogenic losses	12W@2K

DC-SRF photoinjector

- 100 KV Pierce gun
- renewable photocathode
- 3.5-cell large grain Nb cavity
- working at 2K

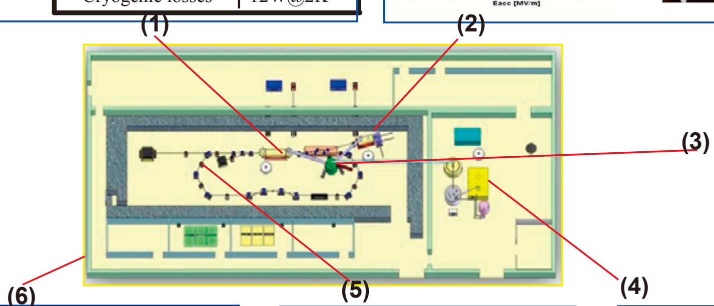






PKU-SETF

(1) Main Accelerator
(2) DC-SRF Photoinjector
(3) 2K Cold Box
(4) Cryogenic System
(5) ERL Beam line loop
(6) 900 m^2 SRF Laboratory



The Beam Test of a Separated Function RFQ Accelerator at Peking University

RFQ Group, PKU

State Key Lab. of Nuclear Physics & Technology, Peking University, Beijing 100871, China

Introduction

In a traditional RFQ ions are accelerated and focused simultaneously by related field components generated by surface modulation of the quadrupole electrodes. Since a large part of the RF voltage is used for beam focusing, the accelerating efficiency is rather limited. While ions in a Separated Function RFQ (SFRFQ) are accelerated by fields between a series of gaps generated by diaphragm pairs loaded periodically onto the special pair of quadrupole electrodes and focused by the quadrupole field separately so that the overall accelerating efficiency is remarkably enhanced. In the following you will see the structure and merits of the SFRFQ comparing with the traditional RFQ.

Field and Structures of RFQ & SFRFQ

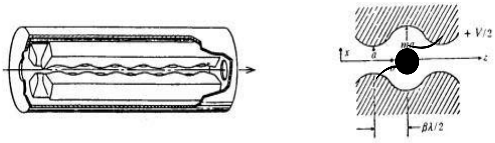


Fig 1: Schematic structure of conventional RFQ

For a conventional RFQ, we have

$E_z = (kAV/2)\cdot I_0(kr)\cdot \sin kz\cdot \sin(\omega t+\phi)$ (1)

$Er = [-(FV/a^2)\cdot r\cdot \cos(2\psi) - (kAV/2)\cdot I_1(kr)\cdot \cos kz]\cdot \sin(wt+\phi)$ (2)

$A = (m^2-1)/[m^2\cdot I_0(ka)+I_0(mka)]$ (3)

$F = 1 - A\cdot I_0(ka)$ (4)

V: accelerating voltage ; m: Depth of surface modulation

A : accelerating factor ; F : Focusing factor

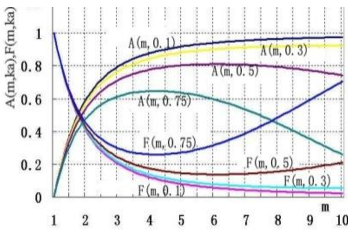


Fig 2: A & F versus m

We can see from fig. 2, A & F limited with each other, and the energy gain from one cell is:

$\Delta W = q\cdot T\cdot AV\cos(\phi_s)$, where T transit time factor $T \approx \pi/4$, while $A\approx(0\sim0.65)$ in general .

The schematic structure of a SFRFQ is as in the fig.3, the accelerating field inside the diaphragms makes A=1, and time transit factor T~1. While in the quadrupole field, we have F=1. However, at the backside of a diaphragm, there is a field of deacceleration. In order to minimize this effect, we have to enhance alternatively the length of one diaphragm to nearly βλ/4 as can be seen in the figure 4.

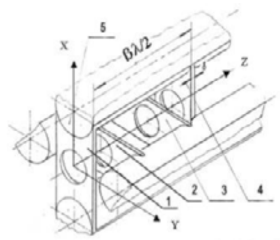


Fig 3: Diaphragms in SFRFQ

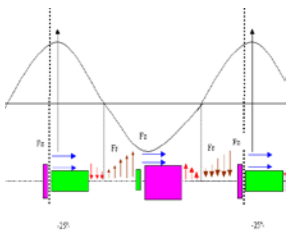


Fig 4: Asymmetry diaphragm system

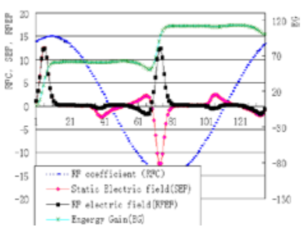


Fig. 5 Energy gain in SFRFQ

Fig.6 A SFRFQ model

The longitudinal field distribution & energy gain in such an asymmetry periodical diaphragm system and the practical structure model are shown in figures 5 &6.To verify the feasibility and merits of this new idea, a code called SFRFQCODE was developed specially for SFRFQ cavity design and beam dynamics simulation , which shows that for accelerating O^+ to 5 MeV for the same 1 MeV input energy and the same vane voltage of 70 KV of 26 MHz , the total length of a SFRFQ can be 80% shorter than that of a RFO. (See table below).

	SFREQ	RFQ
Number of cells	82	132
Average energy gain (keV) per cell	48.8	30.3
Synchronous Phase	-25^o	-25^o
Resonator Length (m)	10.3	18.5
Beam aperture (mm)	6.2	6.2
Beam transport efficiency	96%	96%

Full Power Test of SFRFQ with O^+ Beam

To verify the feasibility of the SFRFQ structure, a prototype cavity of about ~1m long was constructed. It goes through full power test without beam and with O^+ beam injected at1 MeV as following.

Input power(kW)	Vane voltage(kV)
16. 2	65. 81
20. 7	73. 16
23. 4	78. 06
28. 8	86. 22
33. 3	91. 02

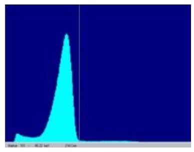


Fig. 7 X-ray spectrum of full power test with 26 MHz RF power source without beam

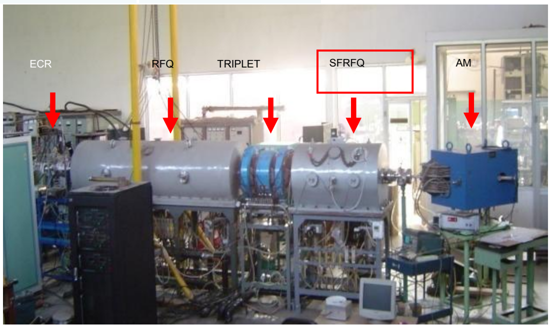


Fig. 8 The Layout of the SFRFQ beam test

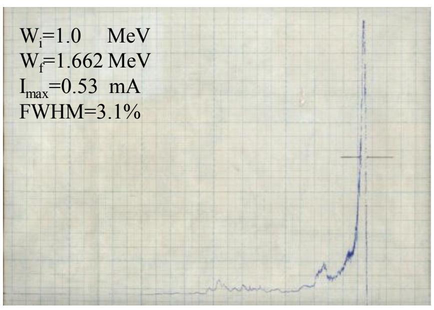


Fig. 9 Output Energy Spectrum of the O^+ beam

The result of the beam test shows the cavity length is 50% shorter than that of traditional RFQ even a part of cavity is used for rebunching. The enhancement of accelerating efficiency for SFRFQ is proved.

Mono-energetic ion beam generation in Phase Stable Acceleration (PSA) with circularly polarized laser

Laser driven ion acceleration team

State Key Lab. of Nuclear Physics & Technology, Peking University, Beijing 100871, China

Introduction

Ultrahigh-intensity lasers can produce accelerating fields of 10 TV/m, surpassing those in conventional accelerators for ions by six orders of magnitude [1]. Remarkable progress has been made in producing laser-driven ultra-bright MeV proton and ion beams in a very compact fashion compared to conventional RF accelerators. These beams have been produced up to several MeV per nucleon with outstanding properties in terms of transverse emittance and current, but typically suffer from exponential energy distributions. Recently a new ion acceleration method, namely **Phase-Stable Acceleration (PSA)** [2], is proposed by our group, which uses circularly-polarized laser pulses in order to decrease the energy spread and generate a high-intensity mono-energetic ion beam. In the first experiment the quasi-monoenergetic carbon beams driven by a circularly polarized laser with particle energies of 30MeV and energy spread of 15% were observed [3]. At a laser intensity of 7×10^{21} W/cm^2, self-focusing nano-Coulomb GeV proton bunches can be generated from laser foil interaction in PSA regime [4].

Phase Stable Acceleration

Why a CP laser can generate a mono-energetic ion beam in the interaction with a foil [2]?

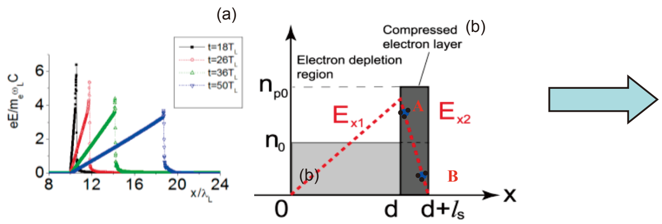


Fig.1 (a) Snapshots of the spatial distribution of the electrostatic field; (b) density profile in PSA model (laser intensity $6*10^{19}$W/cm^2)

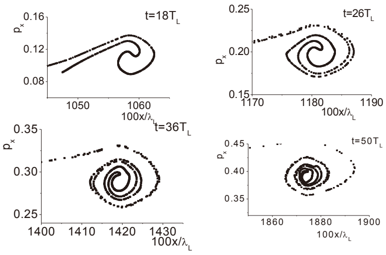


Fig.2 Phase Oscillation

Proof of principle experiments

The first proof of principle experiment was done at Max Born Institute and Munich University, Germany. The laser intensity is $5*10^{19}$W/cm^2, pulse duration 45fs. Diamond like carbon (DLC) target with thickness of 5nm(Fig.5b) was used. In the first experiment the quasi-mono-energetic carbon beams with particle energies of 30MeV and energy spread of 15% were observed. It shows the Phase Stable acceleration can generate quasi-mono-energetic ion beam.

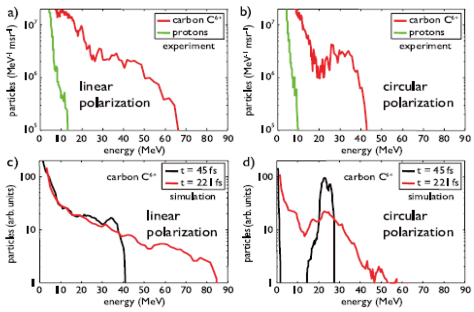


Fig.3 Energy spectrum in experiments and simulations

Self-organizing nano-Coulomb GeV proton

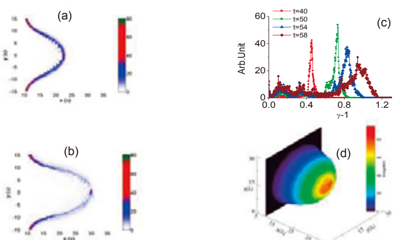


Fig.4 (a,b) Foil density evolution; (c) evolution of energy spectrum for beam ions located inside the central clump ; (d) energy distribution of protons (the colour bar gives ion energy in MeV). [laser intensity $7*10^{21}$W/cm^2, pulse duration 66 fs (FWHM)]

Table top proton therapy machine

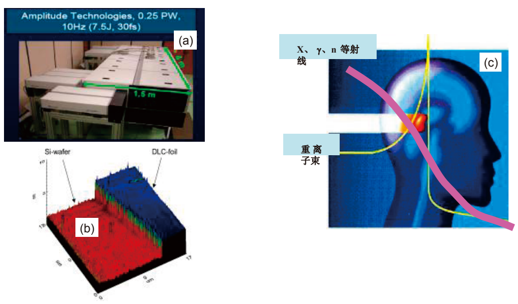


Fig.5 (a) Amplitude laser; (b) Diamond Like Carbon foil of 5nm thickness; (c) ion therapy

References

1. B. M. Hegelich et al., Nature (London) 439, 441 (2006).
2. X. Q. Yan et al., Phys. Rev. Lett. 100, 135003 (2008)
3. A. Henig et al., Phys. Rev. Lett. 103, 245003 (2009)
4. X. Q. Yan et al., Phys. Rev. Lett. 103, 135001 (2009)

Affluent Future with Advanced Accelerator Science & Technology

The Advanced Accelerator Association Promoting Science & Technology (AAA) has been established to facilitate industry-government-academia collaboration, not only to obtain scientific findings in the field of particle physics but also to promote and seek various industrial applications of advanced accelerators and technologies derived from R&D on such accelerators. The AAA has designated the International Linear Collider (ILC) as its model project: with advanced accelerator science and technology the association aims to exploit the "intellectual horizon" of humanity on various research fields (such as space, elementary particles, material and life science), takes on new global-level assignments (such as medical applications, energy and environment), and strengthens international competitiveness in advanced science and technology. The Goal of the AAA is to establish a new form of system to gain strategic cooperation from the multilateral collaborations among industry, academia and government.

Observing Tiny Objects

An accelerator is a big microscope. An electron microscope is also a type of accelerator that uses an electron beam to illuminate a specimen and creates a highly-magnified image.

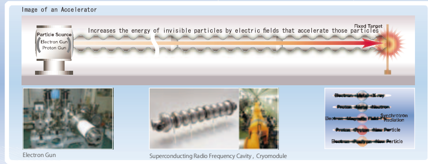
Creating New Drugs

We can study protein structures by utilizing synchrotron radiation technologies. Scientific elucidation of their structures would lead us to epochal drug discoveries.

Examining Inner Conditions

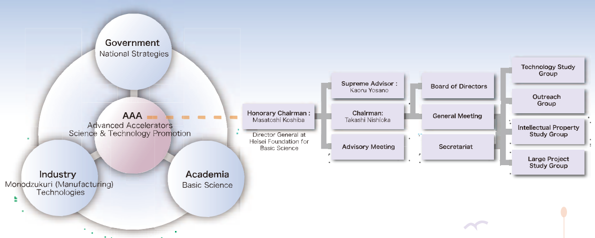
X-rays and neutron beams allow us to investigate conditions of cracks inside walls and pipes, or inner structure of an engine in operation.

Image of an Accelerator



Electron Gun

Superconducting Radio Frequency Cavity, Cryomodule

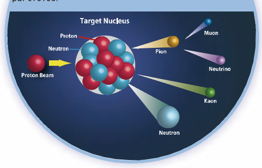


Protecting Our Lives

Accelerators manufacture diagnostic medicines for PET (Positron Emission Tomography) technologies. X-rays or particle beams emitted from accelerators are also used for cancer treatments.

Discovering Scientific Facts

We believe that new particles will be discovered when ultra-high energy collisions occur among protons or between electrons and positrons. We are expecting to reveal remarkable scientific discoveries by studying those yet to be discovered particles.



Promoting Advanced Accelerator Science & Technology with the Industry-Government-Academia Collaboration

- Worldwide outreach about all the possibilities and significant developments advanced accelerator technologies have to offer.
- Seek directionalities on advanced accelerator R&D and proper ways to handle intellectual property with the "ILC Project" as an underlying model.
- Gather "Monodzukuri (manufacturing) technologies" from a variety of industrial fields to create innovative scientific technologies.

Japan, the Leading Nation in Accelerator Technology

Japan is recognized as the leading nation in the fields of particle physics and accelerators worldwide. Japan has had several Nobel Prize Laureates in Physics; Dr. Hideki Yukawa, Dr. Sin-Itiro Tomonaga and Dr. Masatoshi Koshiba. And in 2008 three researchers were added to the list; Dr. Yoichiro Nambu, Dr. Toshihide Maskawa and Dr. Makoto Kobayashi. This latest news about Japanese physicists receiving Triple Crown Nobel Prize still sounds fresh to us.

KEKB remains the most powerful (high luminosity) Electron-Positron (e^+e^-) accelerator in the world. KEK also had the proton accelerator which successfully completed neutrino oscillation experiments for the first time.

Spring-8 is one of the three largest synchrotron radiation facilities in the world. J-PARC is also the world's strongest multi-purpose proton beam facility. Today Japan has a variety of accelerators that offer highly competitive performances in the world. Besides building those excellent machines in Japan, the latest Japanese manufacturing technologies have contributed fully to construct the world's biggest accelerator, the Large Hadron Collider (LHC) at the European Center for Nuclear Research (CERN) in Geneva, Switzerland.

Image of the International Science City:
ILC will form an international science city filled with brilliant scientists, engineers and their families from all around the world.

International Linear Collider (ILC)

The International Linear Collider (ILC) will be the world's largest and strongest high energy accelerator. The ILC will be an extremely precise system stretching approximately 40km in length inside a linear tunnel deep underground. An accelerator hurls electrons and their anti-particles, positrons, into a series of vacuumed superconducting accelerator cavities that are surrounded by very precise devices, and then accelerates them to nearly the speed of light toward the detectors; finally, particles collide face to face at the center of the machine. The International Linear Collider will give a new cosmic doorway to make discoveries on new philosophy of nature and to provide answers to fundamental questions of all time by researching the origins of mass for all elementary particles called "Higgs boson," unknown substance which composes 23% of the total mass of the Universe, "dark matter," and "extra dimensions" of space and time beyond four dimensions we are living in.

Advanced Accelerators and Our Future

The quality of our lives would dramatically increase when compact and more efficient accelerators are put into practical uses in research, industrial and medical fields. One day in very near future advanced accelerator technologies would produce improved, compact and higher-performance machines, bringing us better lives.

XFEL Project

X-ray Free Electron Laser
Pioneering a new generation of sciences for the 21st century

http://www.riken.jp/XFEL/

XFEL Heralds the Dawn of a New Era in Science

RIKEN established the SPring-8 Joint Project for XFEL to construct an X-ray free electron laser (XFEL) in collaboration with JASRI*. The XFEL will enable major progress in the structural analysis of proteins and the development of new materials, helping create new fields of science.

*Japan Synchrotron Radiation Research Institute

Milestones

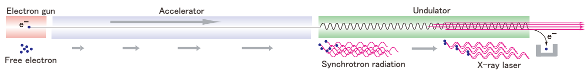
- 2005 Manufacture of the 250 MeV prototype begins
- 2006 Success in laser oscillation of 49 nm UV rays in the prototype
- 2007 XFEL facility construction begins
- 2008 XFEL User Promotion Projects and User Projects open to the Public

Future Plans

- 2009 Complete construction of the building housing the light source and all related equipment
- 2010 Complete construction of experiment/research building
- 2010-2011 Achieve XFEL laser oscillation Open facility for use

What is an X-ray Free Electron Laser?

To date, it has been difficult to reach the short X-ray wavelengths needed for microscopic observation at atomic resolution with conventional lasers using stimulated emission or higher harmonics generated by non-linear processes. One way of reaching the X-ray region is to use free electrons in an accelerator to produce coherent X-ray photons from electron-photon interactions in a long undulator.



A beam of electrons is accelerated to 8 GeV - near the speed of light - and passes through a series of permanent magnets with alternating polarity called undulators. These sinusoidally deflect the electrons' path with their magnetic fields, generating light. This light and the electron beam then repeatedly reinteract in the undulator, generating the free electron laser beam.

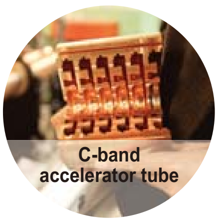
The SCSS test accelerator, a prototype for the XFEL

Technologies for a Compact XFEL

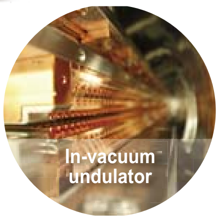
A compact XFEL has been attained by new technologies developed in Japan. These technologies will also contribute to its stable operation. Smaller facilities are generally more cost-effective and take less time to complete.

Although XFEL facilities are under construction in the United States and Europe, the length of the Japanese XFEL, 700 m, is 1/3-1/4 of theirs. This reduction in size was made possible with three unique technologies developed in the RIKEN SPring-8 Center : a single crystal CeB6 thermionic electron gun, a high-frequency (C-band) accelerator, and an in-vacuum undulator.

Thermionic electron gun



C-band accelerator tube



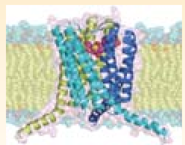
In-vacuum undulator

XFEL New Sciences and Technologies to Create

Protein Structure Analysis

Structure analysis of protein molecules at atomic resolution clarifies their function, thus creating products with new functions in biology and pharmacy.

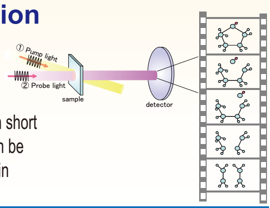
In particular, XFEL will have a capability of imaging atoms as a microscope, and it will show structuresof proteins which are difficult to crystallize.



Ultra-fast Observation

Femtosecond XFEL pulses can probe ultra-fast movement of materials.

Chemical reactions can be filmed with short pulses from XFEL. These pictures can be used to better understand processes in fuel and solar cells.

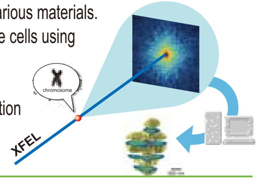


Imaging Technology

Coherent X-ray imaging using XFEL is a promising tool for atomic-level resolution microscopy for various materials.

Our goal is high resolution imaging of live cells using the extreme intensity and coherence of the XFEL.

It will also be a powerful tool for observation of specific cells, such as cancer.



RIKEN

Nishina Center for Accelerator-Baced Science

Research Locations

RIKEN BNL Research Center

polarized proton beam colliding
High- speed lattice QCD computing

RIKEN Nishina Center

RI Beam Factory
most intense exotic RI beam

Center for Nuclear Study,
The university of Tokyo

RIKEN RAL Facility Office

intense muon beam

RI Beam Factory

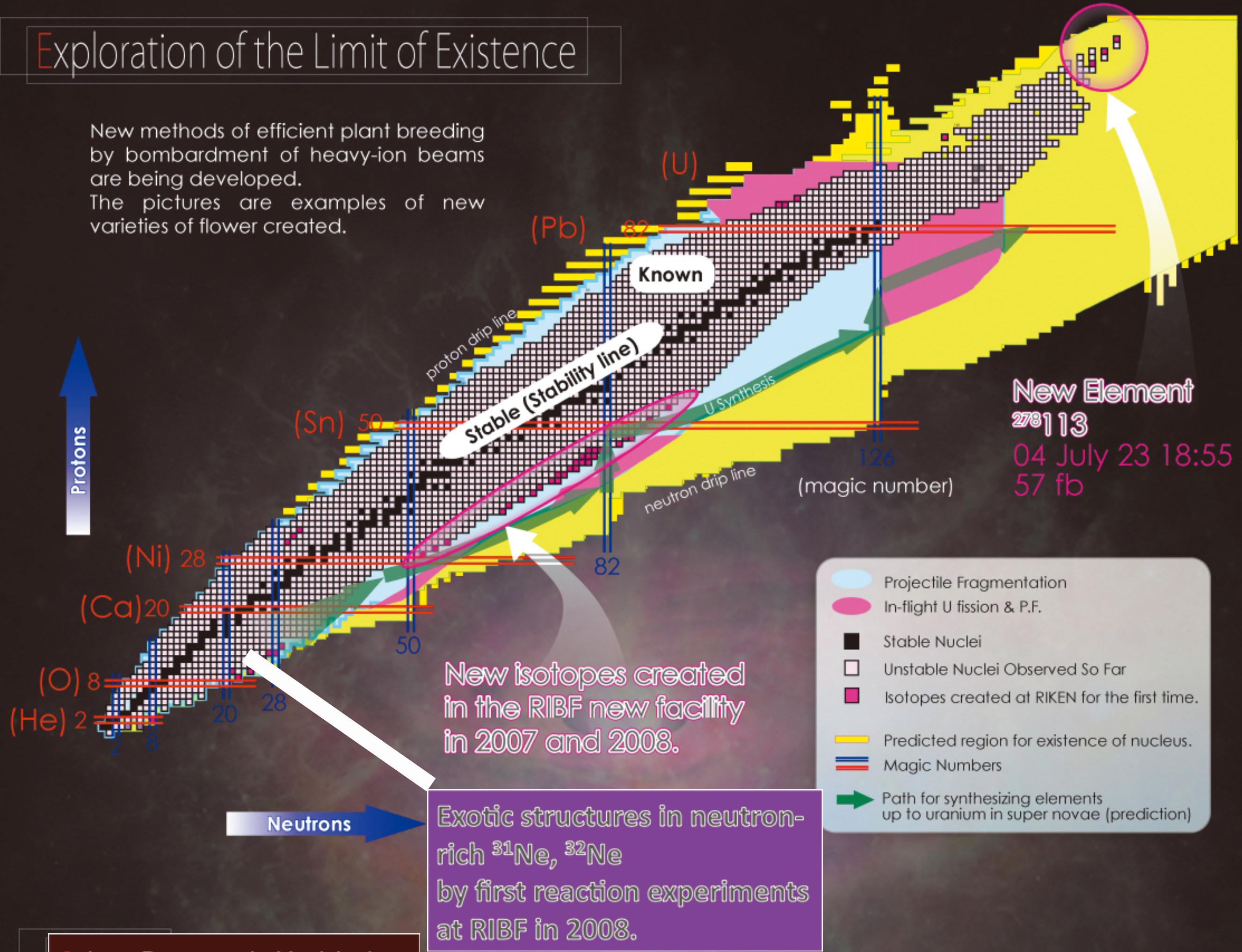
RI Beam Factory provides opportunities to study the nature of unstable nuclei in a wide range up to Uranium. Its multi-step acceleration enables acceleration of high-intensity heavy-ion beams, and hence produces secondary beams of unstable nuclei in a great variety. The last cyclotron, SRC, weighs 8,300 ton, which is heaviest in the world. The RI Beam factory has currently highest capability of producing beams of unstable nuclei.

RIKEN NISHINA CENTER
http://www.nishina.riken.jp/

RIKEN RI Beam Factory – providing beams of unstable nuclei with world-highest intensity

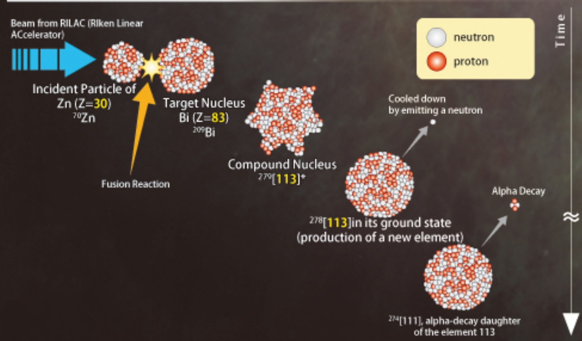
Exploration of the Limit of Existence

New methods of efficient plant breeding by bombardment of heavy-ion beams are being developed. The pictures are examples of new varieties of flower created.



Other Research Highlights

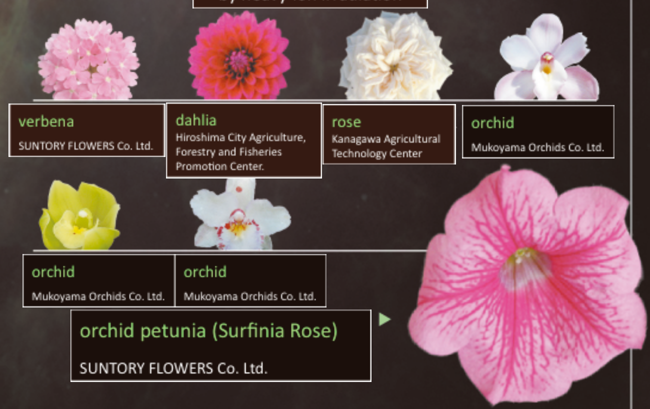
Production of the new element 113



The new element with the atomic number 113 has been found among reaction products created by the $^{70}Zn + ^{209}Bi$ interaction. We are claiming the right to name the elements.

New flowers

by heavy-ion irradiation



New methods of efficient plant breeding by bombardment of heavy-ion beams are being developed. The pictures are examples of new varieties of flower created. Recent development is for rice growing in salty water.

RIKEN NISHINA CENTER
http://www.nishina.riken.jp/

J-PARC Hadron Facility

Megumi Naruki for the Hadron Facility Team

J-PARC 50GeV Main Ring

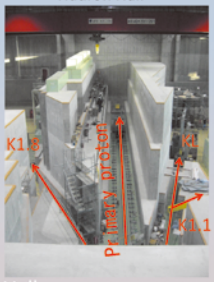
Introduction

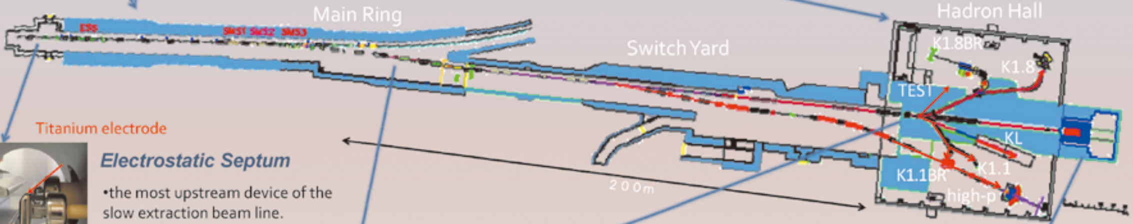
J-PARC (Japan Proton Accelerator Research Complex) is a new accelerator facility to produce MW-class high power proton beams at both 3 GeV and 50 GeV. The Main Ring (MR) of J-PARC can extract beams to the neutrino beam line and the slow-extraction beam line for Hadron Experimental Facility (Hadron Hall). Civil construction of Hadron Hall was completed in June, 2007.

Slow-extraction beam line

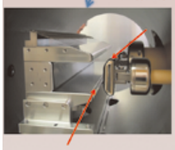
The slow-extraction beam line handles the beams of 3x10^{14} protons extracted "slowly" in about 2 second duration per 6 second accelerator cycle. The extracted beams are transported to Hadron Hall and irradiated on the production target (T1) to produce secondary particles (kaons and pions). The secondary beams are transported to experimental area for nuclear and particle physics experiments. The beam "Switch Yard" has capabilities to separate a small portion (2% loss) of the primary beam and place a production target (0.2% loss) that can provide test beams for future extensions.

Hadron Hall





Titanium electrode



ribbon

Electrostatic Septum

- the most upstream device of the slow extraction beam line.
- "shave" the proton beam under a high electric field(170kV/25mm) between the titanium electrode and tungsten ribbon

Radiation Hardness

- To handle the high intensity proton beam, beam line components are designed to have enough radiation hardness.
- Design of working spaces, remote maintenance system and quick connection system have been developed.

Radiation-hard Magnet

- Made of fully inorganic materials.
- Lifting tackle which automatically locks
- "Knife switch" – electrical connection system; up to 3000A
- Quick coupler

Lifting

Water Connection

- no bolt
- 2 inch. diameter
- operation with 2 MPa

Vacuum Connection

- all metal
- remote handling
- leak rate: 10^{-11}Pa·m³/s
- large diameter: 500mm

Electrical Connection

Max. 3000A

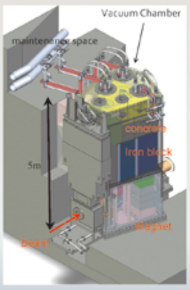
Production Target & Central Vacuum Chamber

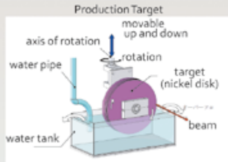
The production target(T1) :

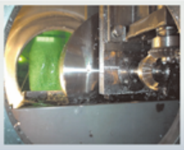
- nickel disks
- diameter is 36cm
- thickness is 54mm(corresponds to 30% loss)
- rotating in a water tank to remove the heat deposit ion of the primary beam . (85rpm)

Vacuum Chamber:

- storage for magnets
- no beam duct
- water pipes and power cables are drawn out to the maintenance space.

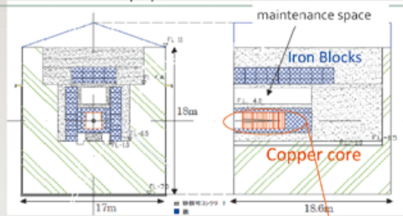


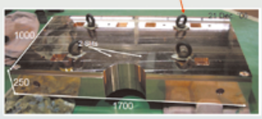




Beam Dump

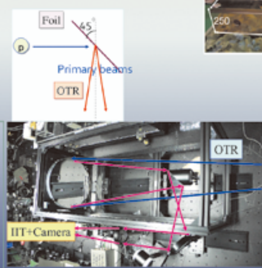
- Located at the end of the primary beam line.
- Absorb beam power of 750kW safely.
- Core part consists of 40 oxygen free copper blocks(1000 tons).
- The copper core is cooled by water to reduce the temperature rise up to 200 Celsius.
- Surrounding materials are concrete and iron blocks.
- Movable on rails – keep up with an extension of the hall at Phase II



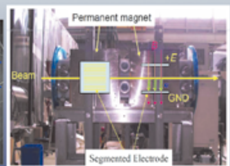


Beam Monitor

- Measure profile and intensity of the primary proton beam
- OTR(Optical Transition Radiation monitor) measures 2-dimensional profile images by detecting transition radiation generated on the surface of a thin metallic foil.
- Residual Gas Ionization Profile Monitor measures X/Y profile by detecting ionization electrons of residual gas in the beam pipe with no beam loss.

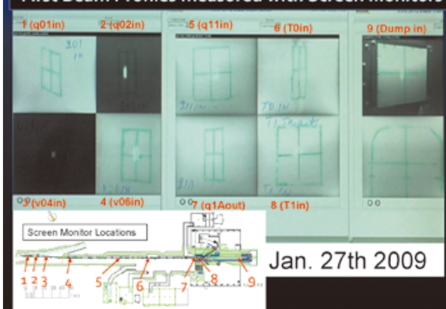


RGIPM

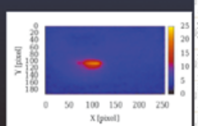


Resent Results

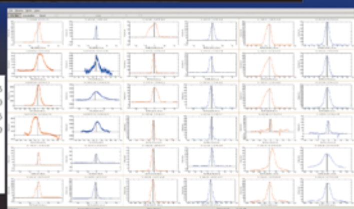
First Beam Profiles measured with Screen Monitors



TYPICAL BEAM PROFILES



OTR Profile (Oct. 2009)



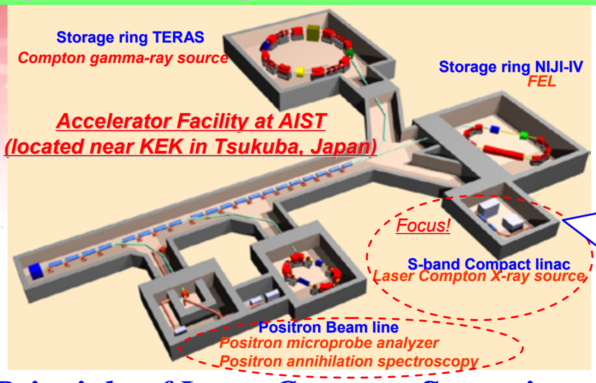
RGIPM Profile

The first beam from the Main Ring was successfully extracted on 27th. January 2009. The beam profiles are measured with the OTR and RGIPM.

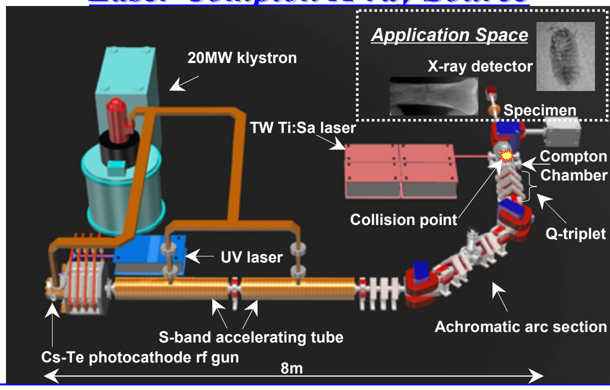
Laser Compton Scattering X-ray Source at AIST

Ryunosuke Kuroda
National Institute of Advanced Industrial Science and Technology (AIST), Japan

Infrastructure for Accelerator Science



Laser Compton X-ray Source



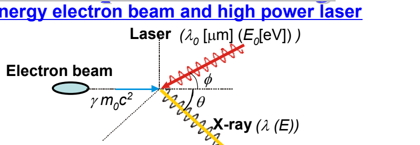
Principle of Laser Compton Scattering

Interaction between high energy electron beam and high power laser

- Max. Energy(θ=0)

$E=2\gamma^2 E_0$ (ϕ=90)

$E=4\gamma^2 E_0$ (ϕ=0)



LCS X-ray source
- Short pulse
- Energy tunability
- Quasi- monochromatic
- Small source size
- Good directivity
- Good polarization
- Compact system …etc

Many benefits!

Scattered X-ray energy

$$E = \frac{(1+\beta\cos\phi)E_0}{1-\beta\cos\theta+(1+\cos(\theta+\phi))\dfrac{E_0}{\gamma m_0 c^2}}$$

TW Ti:Sa Laser beam (CPA)

Wave length	800 nm
Energy/pulse	140 mJ
Pulse width (FWHM)	100 fs
Beam size (σ_x/σ_y)	30 μm

Electron beam

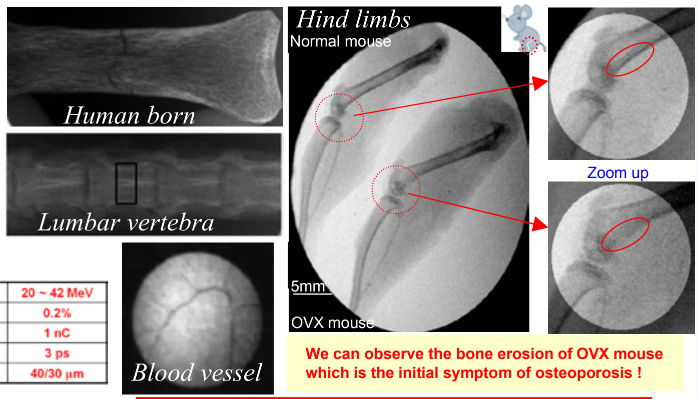
Electron Energy	20 ~ 42 MeV
Energy spread	0.2%
Bunch charge/bunch	1 nC
Bunch length (rms)	3 ps
Beam size (σ_x/σ_y)	40/30 μm

Beam Status

Quasi-monochromatic X-ray

Collision angle (ϕ)	Photon energy	Pulse width	Number of Photons
90	~20 keV (max)	150 fs (rms)	~10^6 /s (max) @10Hz
0	~ 40 keV (max)	3 ps (rms)	~10^7 /s (max) @10Hz

Biological & Medical Uses



We can observe the bone erosion of OVX mouse which is the initial symptom of osteoporosis !

Application to biological and medical research
in-line phase contrast imaging, K-edge imaging
(because of quite small size of X-ray source about 30~40 μm)

Global Communication for Development of Accelerator Technologies

Laser Compton Scattering Technology

I suggest the ASIA group should make many relations in the development of LCS X-ray source and Superconducting Accelerator technology with Europe group.

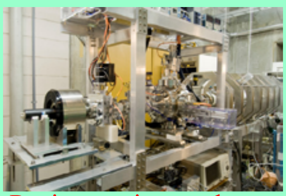
Advanced Key Technology

Superconducting Accelerator Technology

Suggestion **International relationship**

Europe		JAPAN
DESY	ILC	KEK
Daresbury	ERL	JAEA
INFN	LCS-X	AIST *New*
…	e-source	…

Under development!



Positron microprobe analyzer at AIST

X

High duty electron source

Asia-Europe Physics Summit 23-28 March 2010

Optics Labs & CERN : Chance Encounter in 1998

A CERN team visiting PINSTECH (Pak. Instt. of Nuclear Science and Technology), Islamabad in October 1998. The Team was looking for partners who could contribute to the design and fabrication of parts and modules for the CMS Detector.

The Team had some spare time. So they were also taken for a visit to Optics Labs next door…..

Collaboration became possible because Optics Labs had some clear expertise

- It is the only dedicated and integrated laser lab of the country, with considerable expertise in lasers, optics, and electronics. It is involved in research, teaching and production for over 35 years.
- It houses excellent infrastructure in designing and fabrication of opto-mechanica,-electronics components and modules

Hence a Natural Partner for CMS

Profile of the Laser Programme in Pakistan

Pakistan started a modest programme in lasers in June 1969 at the Atomic Energy Centre, Lahore. This has grown over the years to become first…. “Optics Labs, “ ...which itself has given birth to (NILOP) National Instt. of Lasers and Optics in Islamabad

>> over 600 professionals <<

- Build A Wide Array Of Complete Laser Systems
  - –UV to IR (Solid State, Metal Vapour, Liquid, Gas)
  - –Pulsed (psec - nsec), Moderate Rep rates
  - –Fixed Frequency / tunable
- Design and Fabricate:
  - –Optical Components / Modules / Systems
  - –Optical Coatings
  - –Precision Mechanics / Electronics

- Grow Laser Crystals / YAG / Saphire / GaN
- Atomic / Molecular Spectroscopy ; LIS
- Atomic Clocks, BEC
- Laser Land Levelers for Farmers

SOME CLIENTS:
Universities and Industry in Pakistan
Europe (IFCA Spain; RWTH, Aachen, Germany)

12 Years of Collaboration with CERN

Some Contribution of Optics Labs :

- Position Monitoring System of Detectors in the Tracker, + work on Link with End Caps / Muon Chambers:
  - Process Feasibility
  - Testing of Components for Radiation Damage
  - Fabricated / Tested Prototypes for Performance
  - Convergence between the various proposals from Germany, Hungary, Spain, Portugal and Pakistan
  - Have Supplied and Integrated 40 Modules
- Assembly of the Tracker Outer Barrel RODs (TOB RODs) which are a self-contained assembly
  - Design of Test Jigs /Processes for Individual Modules and RODs
- Installation, Validation, and Testing at CERN

Optical Compnents

- Only Rad-Hard materials usable.
- n fluence: $4x10^{14}$; γ rays : 10 MegaRad ;Used the 10 MW Pinstech Reactor
- Studied 13 Diff. Glasses; 3 Diff. Opt.Cements; HR / AR / Metallic Coating [Some glasses / coatings /cements had not been studied previously]
- Tests of adhesion / abrasion of coatings.
- Stability of a large distribution

LASER RESEARCH IN PAKISTAN AND CMS / CERN

Dr. Shaukat Hameed Khan
Executive Director, SOPREST/GIKI Pakistan
Former Chief Scientist / DG Optics Labs, PAEC

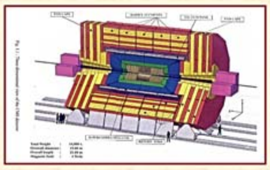
FOUR MAJOR CONTRIBUTIONS

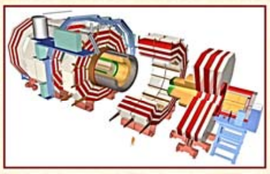
- Magnet Feet for CMS (Fabrication only)
- Resistive Plate Chambers (Assembly & Test)
- Assembly and Test of Carbon Frames and RODS for TOBs
- Laser Based Position Monitoring System for Tracker of CMS (design, fabrication, installation)
- Part of Int. Data Processing - GRID

The Tracker has 40 laser based Position Monitoring Modules from Optics Labs, Pakistan.

2007: Loading The Tracker inside CMS.

In 2000, CMS COLLABORATION HAD : 36 NATIONS; 160 INSTITUTIONS; 2008 Sc. / Eng.






Total Weight : 12,500 Tons; Total Length :~22 m
Diameter : ~15 m ; Magnet : 4 Tesla
SC cable: 4.2°K, 20 kilo Amps, 27,000A/mm^2

- CMS is designed for high momentum resolution of muons.
- Places a very stringent demand upon the spatial resolution and therefore the detector alignments.
- Need to know where the detectors are w.r.t each other

Scale of the Problem

Tracker Max. distortion @ R=1.2m : - 0.314 mm (top & bottom			
Required Precision			
Vert. Position mm	R (µm)	R ϕ (µm)	Z (µm)
200	100	15	500
700	300	15	500
1200	600	50	2000

The Laser Position Monitoring System was tested at CERN;
Can give precision of ~2 micron

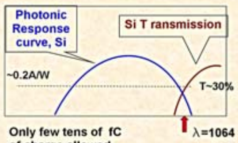
Tracker Performance: Heart Of The CMS

TRACKER PERFORMANCE depends as much on
- Intrinsic Detector Capability
- Stability of the Structure (Design… Materials … Stiffness / Stability)
  Very Very Heavy /LargeStructure. It moves / distorts due to: Gravity, Magnetic field, Temperature Gradients, Differential Expansions (e.g, Si, Steel, Al, CF, quartz) ,

Features of the Position Monitoring System

The laser pulse produces photo-electrons in the Si .

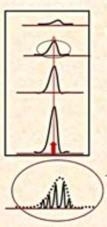
Laser also transmitted to other detectors if correct λ. Electronic read-out system same for high energy particles as well as the laser



Only few tens of fC of charge allowed

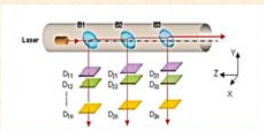
Fire the laser:

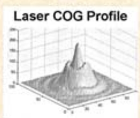
Read the Laser's Centre of Gravity (COG)



- Read the signal / laser position (c.o.g.) from each detector in turn
- One shot gives relative positions of many detectors at the same instant
- Repeat the sequence
  Thus Relative Positions can be continuously Monitored

Diffraction from detector strips



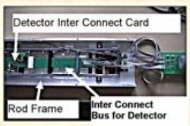


- Specs. of Optical Components
- Fabricated & Tested Prototypes
- Produced the Final Modules

From Pakistan

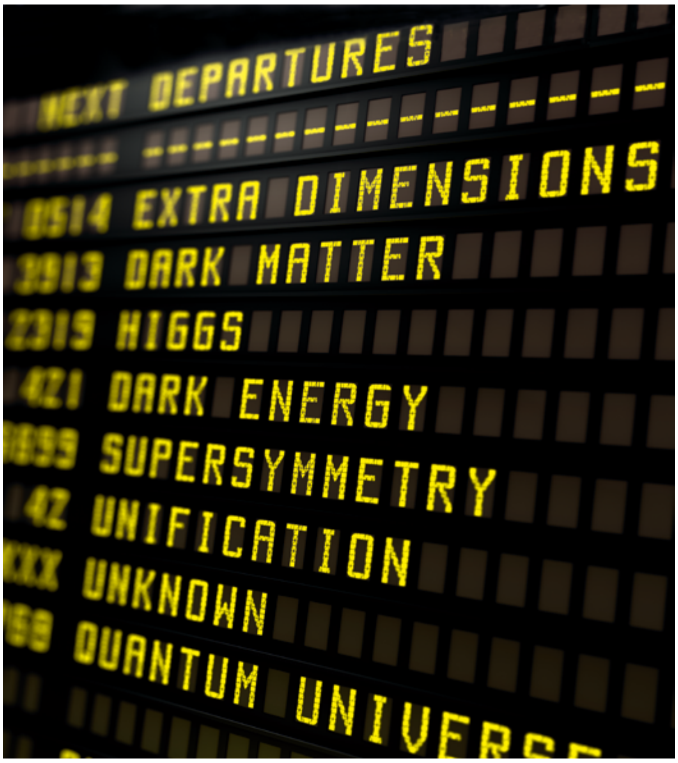
Assembly and Test Setup For Integrated Rods

Production, Assembly and Testing of RODs at CERN



Electrical Test Setup for Assembled Rods of CMS Tracker

Completely assembled Rod: 6 Det. Modules Under Test.



The International Linear Collider

Witness a scientific revolution! The *International Linear Collider* (ILC), a proposed new particle accelerator, promises to radically change our understanding of the universe – revealing the origin of mass, uncurling hidden dimensions of space, and even explaining the mystery of dark matter. Advanced superconducting technology will accelerate and collide particles to incredibly high energies down tunnels that span more than 30 kilometres in length. State-of-the-art detectors will record the collisions at the centre of the machine, opening a new gateway into the Quantum Universe, an unexplored territory where the very small answers questions about the very large. From young graduate students to university professors, more than a thousand scientists worldwide are collaborating today to design and build the particle accelerator of tomorrow.

ILC-HiGrade: Towards the International Linear Collider

ILC-HiGrade or *International Linear Collider and High Gradient Superconducting RF-Cavities* produces a small series of accelerating cavities, superconducting components made of pure niobium for the International Linear Collider. It also plans a possible organisation and governance structure for the ILC as well as measures to prepare for the construction of the machine, including a detailed study on possible sites in Europe.

Participating Institutes:

- DESY (Germany)
- CEA (France)
- CERN (European Organization for Nuclear Research)
- CNRS/IN2P3 (France)
- INFN (Italy)
- Oxford University (United Kingdom)

The ILC – a step-by-step guide

How does the ILC work? Like any complex machine, the 31 kilometre-long accelerator is made up of several systems – each one an essential component for launching particles at close to the speed of light. This step-by-step guide explains how the ILC works.

The linacs

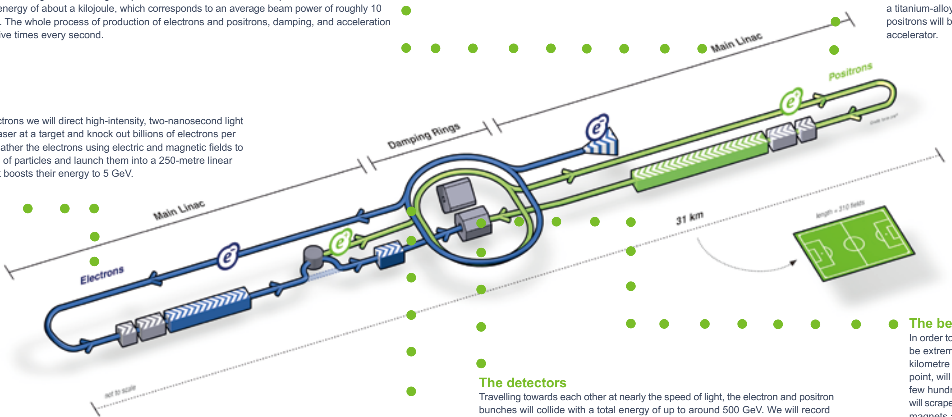
Two main linear accelerators (called linacs), one for electrons and one for positrons, each 12 kilometres long, will accelerate the bunches of particles toward the collision point. Each accelerator consists of hollow structures called superconducting cavities, nestled within a series of cooled vessels known as cryomodules. The modules use liquid helium to cool the cavities to –271 °C, only slightly above absolute zero, to make them superconducting. Electromagnetic waves fill the cavities to 'push' the particles, accelerating them to energies up to 250 GeV. Each electron and positron bunch will then contain an energy of about a kilojoule, which corresponds to an average beam power of roughly 10 mega-watts. The whole process of production of electrons and positrons, damping, and acceleration will repeat five times every second.

Positrons

Positrons, the antimatter partners of electrons, do not exist naturally on Earth. To produce them, we will send the high-energy electron beam through an undulator, a special arrangement of magnets in which electrons are sent on a 'roller coaster' course. This turbulent motion will cause the electrons to emit a stream of X-ray photons. Just beyond the undulator the electrons will return to the main accelerator, while the photons will hit a titanium-alloy target and produce pairs of electrons and positrons. The positrons will be collected and launched into their own 250-metre 5-GeV accelerator.

Electrons

To produce electrons we will direct high-intensity, two-nanosecond light pulses from a laser at a target and knock out billions of electrons per pulse. We will gather the electrons using electric and magnetic fields to create bunches of particles and launch them into a 250-metre linear accelerator that boosts their energy to 5 GeV.



The damping rings

When created, neither the electron nor the positron bunches are compact enough to yield the high density needed to produce copious collisions inside the detectors. Two 6.7 kilo-metre-circumference damping rings, one for electrons and one for positrons, will solve this problem. In each ring, the bunches will repeatedly traverse a series of wigglers, devices that causes the beam trajectories to 'wiggle' in a way that makes the bunches more compact. Each bunch will spend approximately two tenths of a second in its damping ring, circling roughly 10,000 times before being kicked out. Magnets will keep the particles on track and focused in their circular orbits around the ring. Upon exiting the damping rings, the bunches will be a few millimetres long and thinner than a human hair.

The detectors

Travelling towards each other at nearly the speed of light, the electron and positron bunches will collide with a total energy of up to around 500 GeV. We will record the spectacular collisions in two interchangeable giant particle detectors. These work like gigantic cameras, taking snapshots of the fleeting particles produced by the electron-positron collisions. The two detectors will incorporate different but complementary state-of-the-art technologies to capture this precious information about every particle produced in each interaction. Having these two detectors will allow vital cross-checking of the potentially subtle physics discovery signatures.

The beam delivery systems

In order to maximise the luminosity, the bunches of particles must be extremely small. A series of magnets, arranged along two 2-kilometre beam delivery systems on each side of the collision point, will focus the beams to a few nanometres in height and a few hundred nanometres in width. The beam delivery systems will scrape off stray particles in the beams and protect the sensitive magnets and detectors. Magnets will steer the electrons and positrons into head-on collisions.

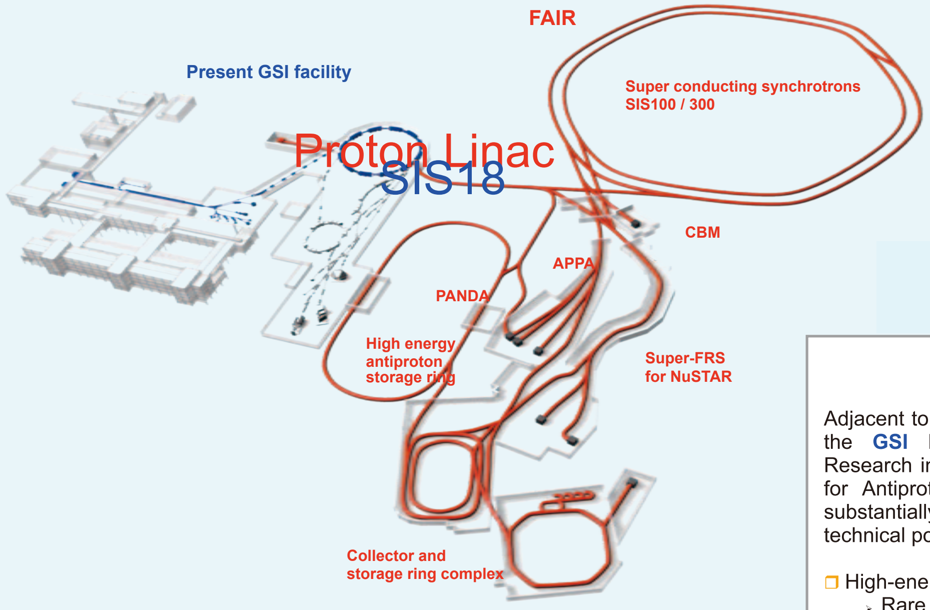
Find out more: www.linearcollider.org, www.ilc-higrade.eu

SEVENTH FRAMEWORK PROGRAMME

Facility for Antiproton and Ion Research

FAIR

The Universe in the Laboratory



The Facility

Adjacent to the existing accelerator complex of the **GSI** Helmholtz Centre for Heavy-Ion Research in Darmstadt / Germany, the Facility for Antiproton and Ion Research **FAIR** will substantially expand research goals and technical possibilities.

- High-energy and high-intensity beams of
  - Rare isotopes
  - Cooled antiprotons
  - Heavy ions
- First beams expected in 2016
- 3,000 scientists from 45 countries
- 16 member countries
- 1.2 billion € construction costs
- 18 hectare site area

Research Programme

The research programme of **FAIR** includes 14 initial experiments, which form the four scientific pillars of FAIR:

APPA - Atomic Physics, Plasma Physics and Applied Sciences
High-energy atomic physics, plasma physics, material research, and bio (medical) science

The Compressed Baryonic Matter Experiment CBM
Experiments on dense, strongly interacting matter in high-energy and high-intensity nucleus-nucleus- ollisions

NuSTAR - Nuclear Structure, Astrophysics and Reactions
Nuclear structure and reactions, nuclear astrophysics using high-intensity radioactive ion beams

The PANDA Experiment: Antiproton Annihilation in Darmstadt
Hadron structure and spectroscopy using cooled precision beams of antiprotons

Fundamental Questions
The FAIR Science Case

How does the complex structure of matter at all levels arise from the basic building blocks and the fundamental interactions?

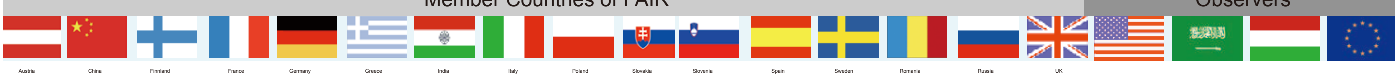
How can the structure of hadronic matter be deduced from the strong interaction? In particular, what is the origin of the hadron masses?

What is the structure of matter under the extreme conditions of temperature and density found in astrophysical objects?

What was the evolution and the composition of matter in the early Universe?

What is the origin of the elements in the Universe?

Member Countries of FAIR | Observers



Proposal for a new international beam instrumentation conference

T. MITSUHASHI, KEK and H. Tanaka, RIKEN/SPring8

Our Proposal

We propose the establishment of a new International Beam Instrumentation Conference (IBIC). Currently there are two major workshops on beam instrumentation, the Beam Instrumentation Workshop (BIW) in North America, and the European Workshop on Beam Diagnostics and Instrumentation (DIPAC) in Europe. Herein, we present a proposal for a new international beam instrumentation conference, and introduce recent discussions at KEK and SPring-8.

Workshops on beam instrumentation in US and Europe

There are currently two workshops, the Beam Instrumentation Workshop (BIW) in North America, and the European Workshop on Beam Diagnostics and Instrumentation for Particle Accelerators (DIPAC) in Europe. The BIW was established in 1989, and has been held 14 times so far in the US. The BIW includes invited and contributed talks, poster sessions, tutorials and discussion sessions. DIPAC was established in 1993, and has been held 10 times so far. DIPAC includes invited and contributed talks, poster sessions, and topical discussion sessions. Traditionally, extra discussion sessions are organized after the oral sessions. Currently, the above two workshops are held on alternate years in North America (BIW) and Europe (DIPAC).

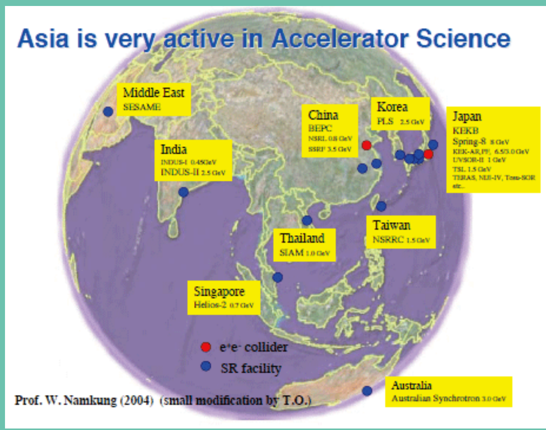
Workshop on Advanced Beam Instrumentation in KEK in 1991

The Workshop on Advanced Beam Instrumentation (ABI) was held in 1991 in Tsukuba, Japan. This workshop commemorated the sixtieth anniversary of Prof. Shibata, and was not intended to be a series but a short discussion meeting to help planning future KEK projects such as the B-factory and linear collider. However, in the foreword to the proceedings, Prof. Mizumachi, the chairman of the workshop, wrote, "It would be very nice if some other organization could continue this workshop in the future".

Why propose IBIC, including Asia?

Beam instrumentation is a very active, hot field in Asia.

Active accelerator facilities in Asia:



To accommodate the growing needs of Asian researchers within the larger international beam instrumentation community, we have begun discussing the creation of IBIC, which rotates among the geographic regions of Asia, Europe, and the Americas on a three-year cycle.

Recent discussions at KEK and SPring8

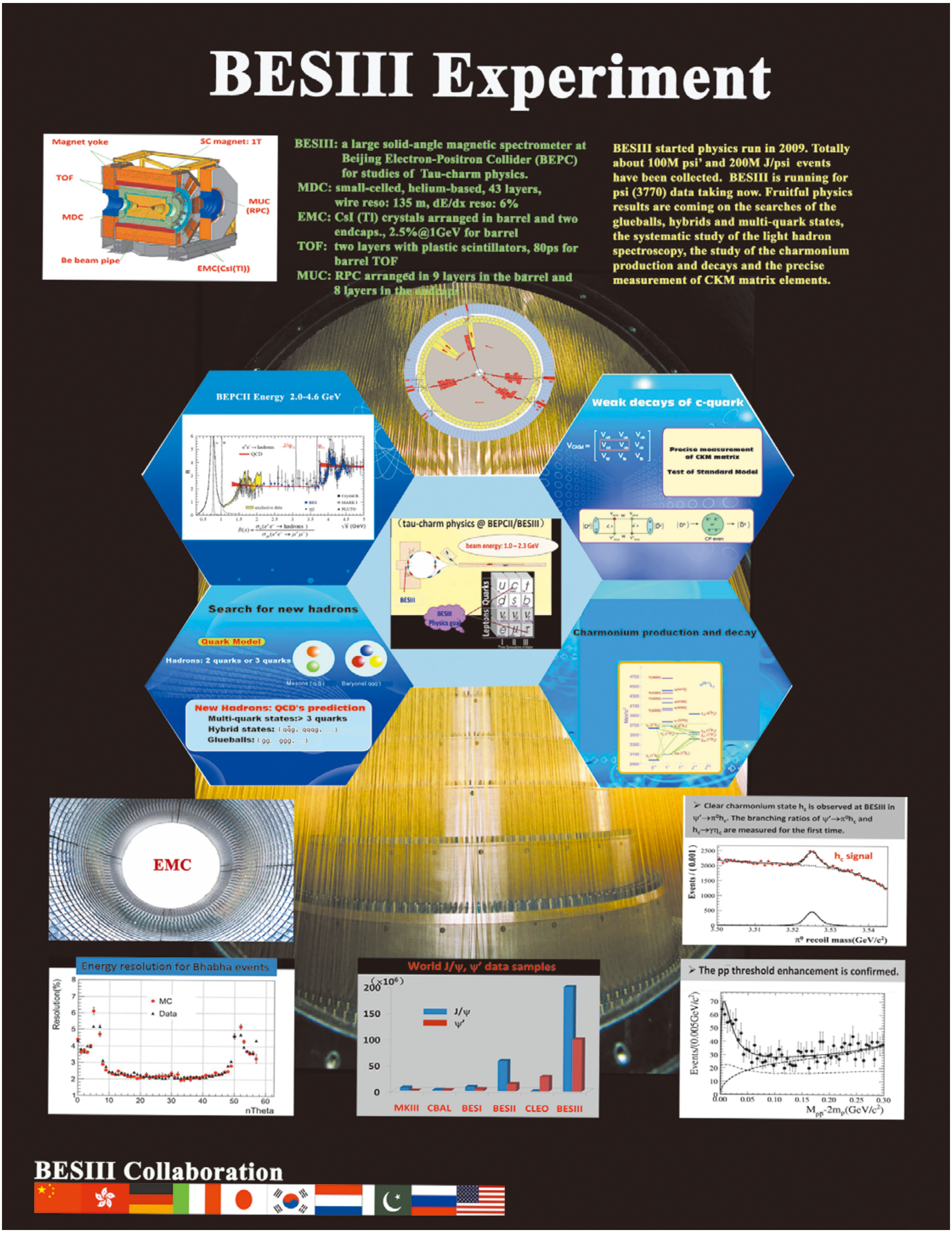
In late 2009, the DIPAC and BIW committees began discussing the addition of an Asian instrumentation workshop and the creation of an international conference.

KEK and SPring8 have accordingly initiated IBIC organization activities. KEK and SPring8 held meeting on the IBIC via video conference. We agreed on the following items:

1. KEK and SPring 8 should actively promote the establishment of the IBIC.
2. KEK and SPring 8 should cooperate with ACFA to promote the IBIC.
3. KEK and SPring8 will circulate a proposal for the IBIC among Asian accelerator facilities.

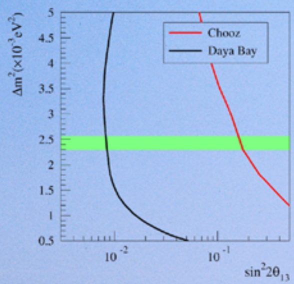
Following these discussions, we have discussed with the IHEP beam instrumentation group joint promotion of the IBIC in February, 2010.

We propose that the first IBIC should be held in Asia in 2013.

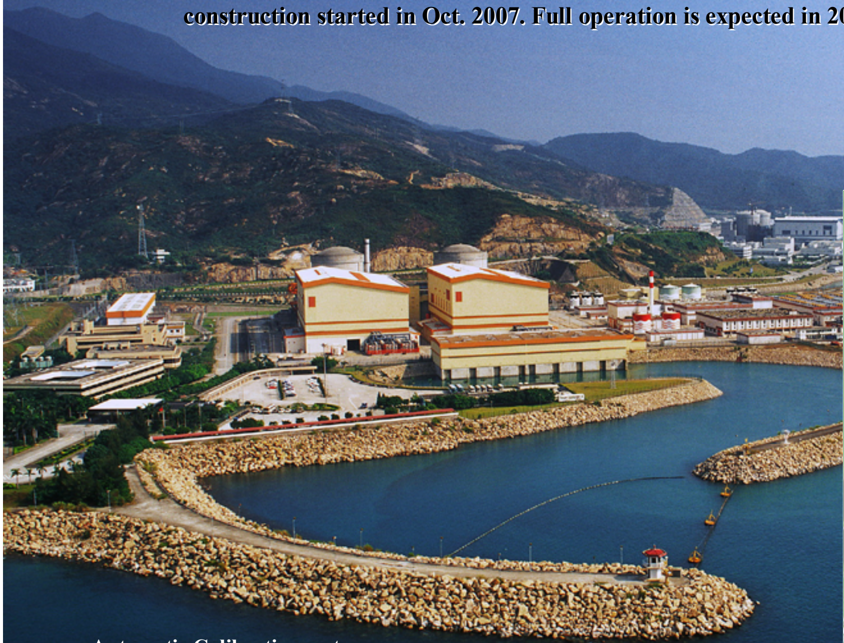

BESIII Experiment
Magnet yoke
SC magnet: 1T
TOF
MUC (RPC)
MDC
Be beam pipe
EMC(CsI(Tl))
BESIII: a large solid-angle magnetic spectrometer at Beijing Electron-Positron Collider (BEPC) for studies of Tau-charm physics.
MDC: small-celled, helium-based, 43 layers, wire reso: 135 m, dE/dx reso: 6%
EMC: CsI (Tl) crystals arranged in barrel and two endcaps., 2.5%@1GeV for barrel
TOF: two layers with plastic scintillators, 80ps for barrel TOF
MUC: RPC arranged in 9 layers in the barrel and 8 layers in the endcaps
BESIII started physics run in 2009. Totally about 100M psi' and 200M J/psi events have been collected. BESIII is running for psi (3770) data taking now. Fruitful physics results are coming on the searches of the glueballs, hybrids and multi-quark states, the systematic study of the light hadron spectroscopy, the study of the charmonium production and decays and the precise measurement of CKM matrix elements.
BEPCII Energy 2.0-4.6 GeV
Weak decays of c-quark
Precise measurement of CKM matrix
Test of Standard Model
(tau-charm physics @ BEPCII/BESIII)
beam energy: 1.0 – 2.3 GeV
Search for new hadrons
Quark Model
Hadrons: 2 quarks or 3 quarks
New Hadrons: QCD's prediction
Multi-quark states:> 3 quarks
Hybrid states:
Glueballs:
Charmonium production and decay
EMC
Clear charmonium state h_c is observed at BESIII in $\psi'\to\pi^0 h_c$. The branching ratios of $\psi'\to\pi^0 h_c$ and $h_c\to\gamma\eta_c$ are measured for the first time.
h_c signal
Events / (0.001)
π^0 recoil mass(GeV/c^2)
Energy resolution for Bhabha events
Resolution(%)
MC
Data
nTheta
World J/ψ, ψ' data samples
(×10^6)
J/ψ
ψ'
MKIII CBAL BESI BESII CLEO BESIII
The pp threshold enhancement is confirmed.
Events/(0.005GeV/c^2)
$M_{pp}-2m_p$(GeV/c^2)
BESIII Collaboration

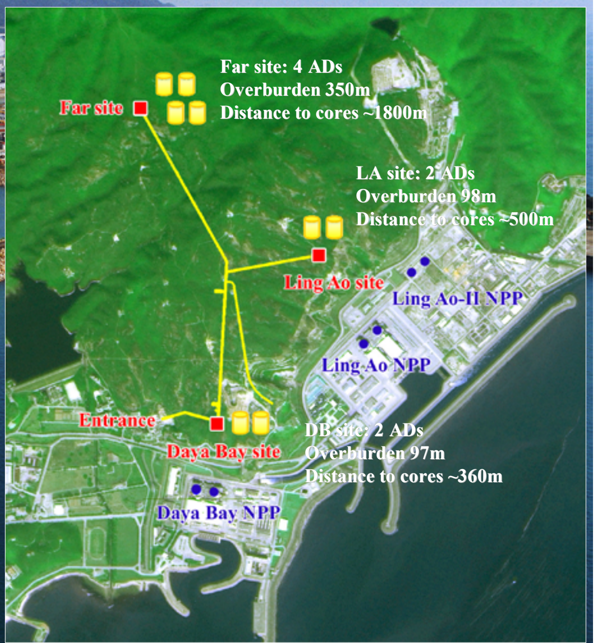
Daya Bay Reactor Neutrino Experiment

Daya Bay Reactor Neutrino Experiment is a neutrino oscillation experiment to determine the neutrino mixing angle θ_{13}. Daya Bay and Ling Ao Nuclear Power Plants in southern China have four 2.9-GW_{th} cores running. Another two will operate in 2011. The cores are very close to mountains, providing an excellent site for neutrino experiment. Civil construction started in Oct. 2007. Full operation is expected in 2011.

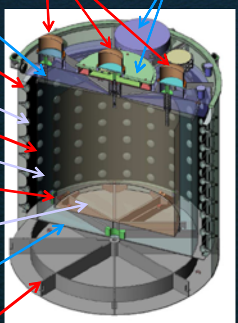


Sensitivity in $\sin^2 2\theta_{13}$ will be better than 0.01 at 90% CL with 3 years' full operation, an order better than existing limit. Green band shows the Δm^2 at 90% CL measured by MINOS.

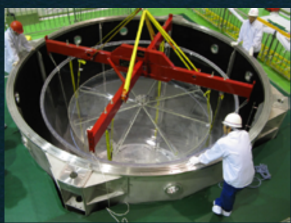




Near-far relative measurement greatly reduces systematic errors. Identical ADs will be put at 3 sites, which are connected by horizontal tunnel in the mountains.

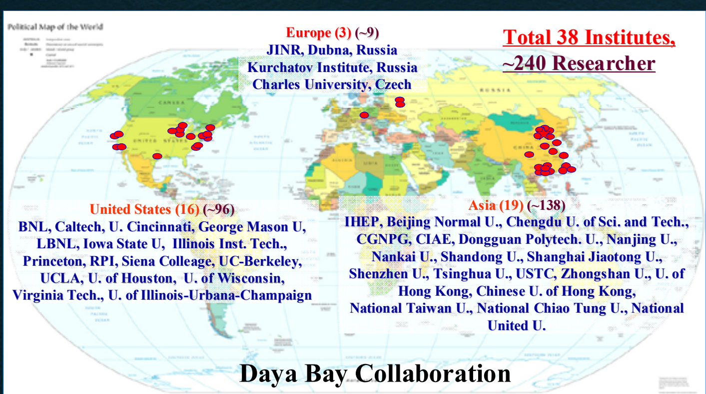


Antineutrino Detector under construction in the clean room of Surface Assembly Building

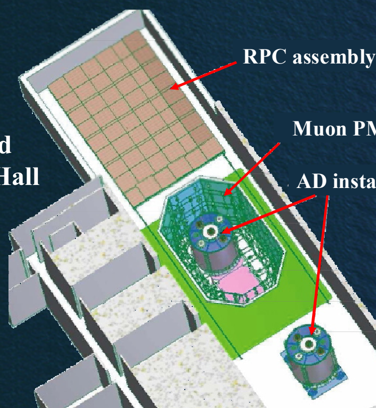


Antineutrino Detector (AD) is a 5mX5m cylinder, filled with 3 different liquids separated by acrylic vessels (AV). Gadolinium-doped liquid scintillator (Gd-LS) is used as neutrino target. Each AD weighs ~110 ton.

ADs are shielded by 2.5m thick water in a pool filled with deionized water. Muon System consists of water cherenkov detector and resistance plate chambers (RPC). The combined muon efficiency is 99.5%



Underground Experimental Hall

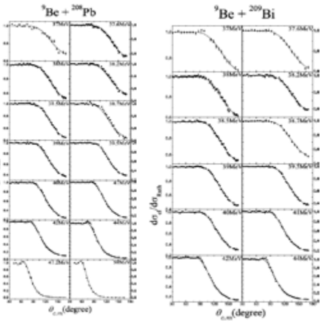


Studies of Heavy Ion Reactions around Coulomb Barrier

Part I. The breakup threshold anomaly of ^{9}Be+^{208}Pb,^{209}Bi.

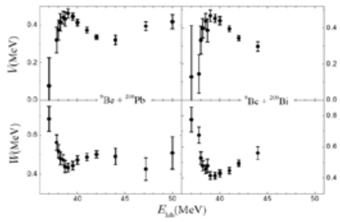
The threshold anomaly (TA) comes from the coupled-channels (CC) effects and plays an important role in heavy ion reactions at the energies around Coulomb barrier.

How does the breakup of the weakly bound projectile affect the TA ?



Elastic scattering angular distributions for the ^{9}Be+^{208}Pb,^{209}Bi systems and the optical model fit with PTOLEMY.

The breakup/unusual threshold anomaly



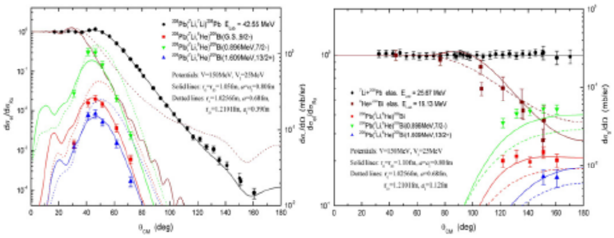
The real and imaginary parts of optical potential for the two systems.

Part II. An indirect method to extract the optical potential

- ♠ optical potential parameter OMP
- ♠ unknown for unstable nuclei
- ♠ hard to extract from elastic scattering

Reaction
^{208}Pb(^{7}Li,^{6}He)^{209}Bi
^{16}O(^{14}N,^{13}C)^{17}F
^{11}B(^{7}Li,^{6}He)^{12}C

Fit ^{208}Pb(^{7}Li,^{6}He)^{209}Bi angular distribution, extract OMP for ^{6}He+^{209}Bi

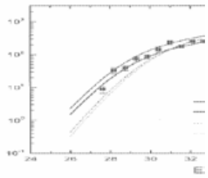


Agree with the result extracted from direct elastic scattering

Part III . The breakup effect on the ^{6,7}Li+^{208}Pb,^{209}Bi reactions.

1) Dynamics of both fusion and elastic scattering are influenced by coupling to direct reaction channels (including breakup if the projectile and/or target nuclei are weakly bound);
2) These couplings generate a distribution of potential barriers;
3) Barrier distributions can be derived from the excitation functions of fusion and quasielastic/elastic scattering.

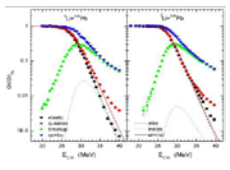
Fusion suppression due to the breakup of ^{6}Li above the Coulomb barrier.

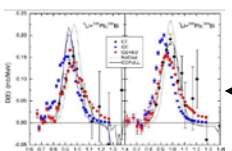


Y.W. Wu *et al*., Phys. Rev. C **68**, 044605 (2003)

Breakup effect of weakly bound nuclei — ^{6,7}Li+^{208}Pb barrier distribution.

Excitation function →





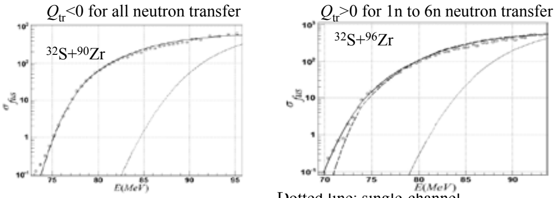
^{6,7}Li+^{208}Pb quasi barrier distribution
— blue: T=1-R
— red: T=1-R-B
^{6,7}Li+^{209}Bi full fusion, black

C.J. Lin *et al*. Nucl. Phys. **A787**, 281c (2007)

Barrier distribution is a probe for reaction dynamics and nuclear structure

Part IV. Sub-barrier fusion enhancement of ^{32}S+^{90,96}Zr at subbarrier energies due to positive Q_{tr} value neutron transfers.

Q_{tr}<0 for all neutron transfer — Q_{tr}>0 for 1n to 6n neutron transfer

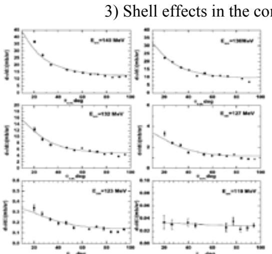


Dotted line: single-channel
Solid line: coupled to inelastic states

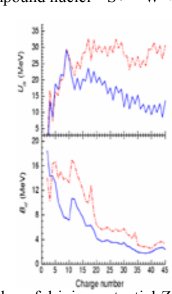
Dotted line: single-channel
Dashed line: coupled to inelastic states
Solid line: coupled to inelastic states + neutron transfer

Part V. Competition between fusion-fission and quasi-fission in ^{32}S+^{184}W reaction

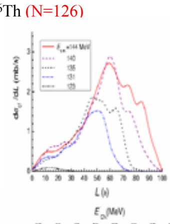
1) Fusion-fission dynamics – Quasi-fission, Pre-equilibrium fission ……
2) Deformation effects in the entrance channels
3) Shell effects in the compound nuclei ^{32}S+^{184}W -> ^{216}Th (N=126)

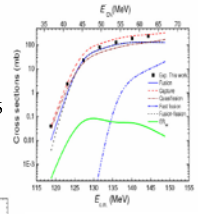


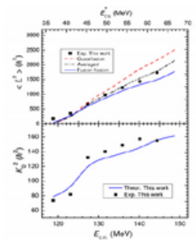
The fission fragments angular distributions of ^{32}S+^{184}W



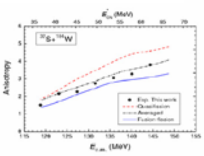
The value of driving potential Z=16 for the small orientation angle 15 ° (solid line) and 45 ° (dashed line).







The fraction of fusion-fission and quasi-fission:



The relative intensities for fusion-fission and quasi-fission as a function of the bombarding energy.

Part VI. Two-proton emission from ^{29}S excited states after Coulomb excitation.

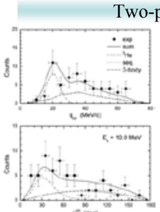
Two-proton radioactivity: 1) Two-body sequential emission; 2) Three-body simultaneously democratic emission; 3) ^{2}He cluster emission and following breakup.

Experiment → ***Decay Dynamics of two-proton emission from excited states*** ← **Theory**

Invariant Mass,
q_{pp}=|p_1-p_2|/2,the relative momentum,
θ_{pp}^{cm} ,the opening angle,
the relative energy,
....

Three body models,
The extended *R*-matrix theory,
The Faddeev equations,
....

Two-proton correlation for 10.0MeV state of ^{29}S

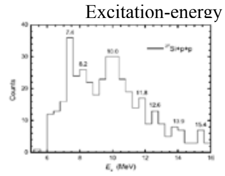


9.6<E_x<10.4MeV

The enhanced peaks at q_{pp}=20MeV/c and θ_{pp}=35° According to MC simulations (for *three-body democratic decay, no* FSI) the branching ratio of ^{2}He emission is 29 $^{+10}_{-11}$ % .

C.J. Lin *et al*. Phys. Rev. C **80**, 014310 (2009)

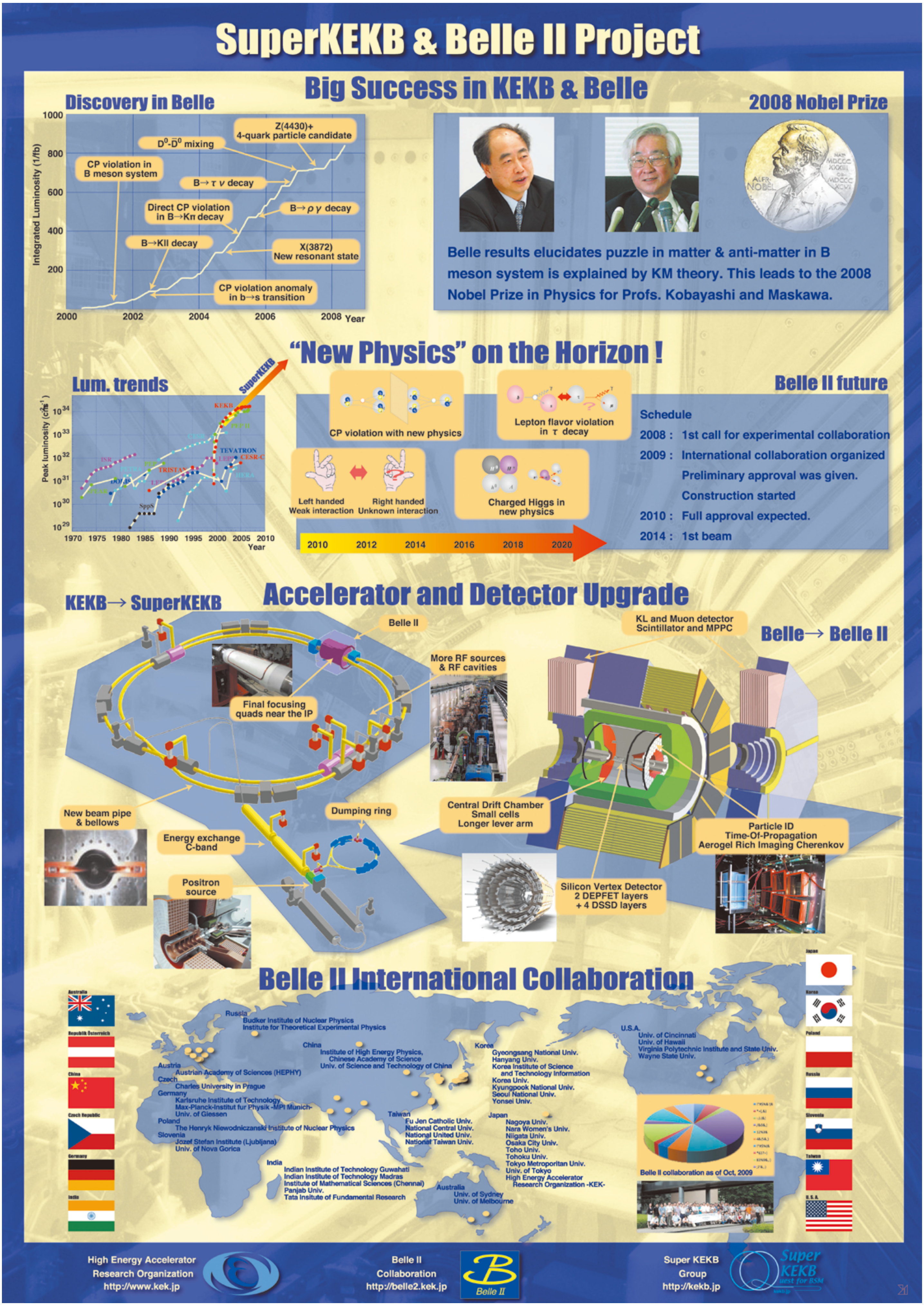
Excitation-energy spectrum of ^{29}S reconstructed from ^{27}Si+p+p events



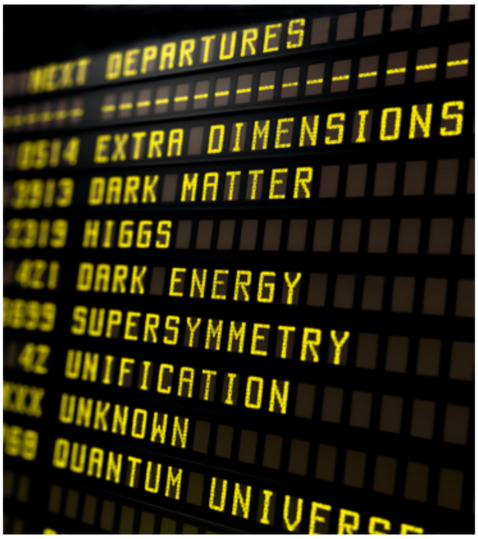
$$E^{*} = \sqrt{(\sum E_i)^2 - (\sum P_i c)^2} - M_{gr}$$

where E_i and P_i are the total energy and the momentum of each fragment including heavy ions and light protons, M_{gr} is the ground-state mass of mother nuclei.

The configurations (J^{π}) of these levels are still unknown and information is not available in the literature at all. The experimental excitation-energy resolution was estimated as 400 keV.



SuperKEKB & Belle II Project
Big Success in KEKB & Belle
Discovery in Belle
Integrated Luminosity (1/fb)
Z(4430)+
4-quark particle candidate
D0-D̄0 mixing
CP violation in
B meson system
B→τν decay
Direct CP violation
in B→Kπ decay
B→ργ decay
B→Kll decay
X(3872)
New resonant state
CP violation anomaly
in b→s transition
Year
2008 Nobel Prize
Belle results elucidates puzzle in matter & anti-matter in B meson system is explained by KM theory. This leads to the 2008 Nobel Prize in Physics for Profs. Kobayashi and Maskawa.
"New Physics" on the Horizon !
Lum. trends
Peak luminosity
SuperKEKB
KEKB
TEVATRON
CESR-C
TRISTAN
Year
CP violation with new physics
Lepton flavor violation
in τ decay
Left handed
Weak interaction
Right handed
Unknown interaction
Charged Higgs in
new physics
2010
2012
2014
2016
2018
2020
Belle II future
Schedule
2008 : 1st call for experimental collaboration
2009 : International collaboration organized
Preliminary approval was given.
Construction started
2010 : Full approval expected.
2014 : 1st beam
KEKB→ SuperKEKB
Accelerator and Detector Upgrade
Belle II
Final focusing
quads near the IP
More RF sources
& RF cavities
New beam pipe
& bellows
Energy exchange
C-band
Dumping ring
Positron
source
KL and Muon detector
Scintillator and MPPC
Belle→ Belle II
Central Drift Chamber
Small cells
Longer lever arm
Particle ID
Time-Of-Propagation
Aerogel Rich Imaging Cherenkov
Silicon Vertex Detector
2 DEPFET layers
+ 4 DSSD layers
Belle II International Collaboration
Russia
Budker Institute of Nuclear Physics
Institute for Theoretical Experimental Physics
China
Institute of High Energy Physics,
Chinese Academy of Science
Univ. of Science and Technology of China
Austria
Austrian Academy of Sciences (HEPHY)
Czech
Charles University in Prague
Germany
Karlsruhe Institute of Technology
Max-Planck-Institut fur Physik -MPI Munich-
Univ. of Giessen
Poland
The Henryk Niewodniczanski Institute of Nuclear Physics
Slovenia
Jozef Stefan Institute (Ljubljana)
Univ. of Nova Gorica
India
Indian Institute of Technology Guwahati
Indian Institute of Technology Madras
Institute of Mathematical Sciences (Chennai)
Panjab Univ.
Tata Insitute of Fundamental Research
Taiwan
Fu Jen Catholic Univ.
National Central Univ.
National United Univ.
National Taiwan Univ.
Korea
Gyeongsang National Univ.
Hanyang Univ.
Korea Institute of Science
and Technology Information
Korea Univ.
Kyungpook National Univ.
Seoul National Univ.
Yonsei Univ.
Japan
Nagoya Univ.
Nara Women's Univ.
Niigata Univ.
Osaka City Univ.
Toho Univ.
Tohoku Univ.
Tokyo Metroporitan Univ.
Univ. of Tokyo
High Energy Accelerator
Research Organization -KEK-
Australia
Univ. of Sydney
Univ. of Melbourne
U.S.A.
Univ. of Cincinnati
Univ. of Hawaii
Virginia Polytechnic Institute and State Univ.
Wayne State Univ.
Belle II collaboration as of Oct, 2009
High Energy Accelerator
Research Organization
http://www.kek.jp
Belle II
Collaboration
http://belle2.kek.jp
Super KEKB
Group
http://kekb.jp



ilc

Physics
Machine
Detector

The International Linear Collider

Witness a scientific revolution! The International Linear Collider (ILC), a proposed new particle accelerator, promises to radically change our understanding of the universe - revealing the origin of mass, uncurling hidden dimensions of space, and even explaining the mystery of dark matter. Advanced superconducting technology will accelerate and collide particles to incredibly high energies down tunnels that span more than 30 kilometres in length. State-of-the-art detectors will record the collisions at the centre of the machine, opening a new gateway into the Quantum Universe, an unexplored territory where the very small answers questions about the very large. From young graduate students to university professors, more than a thousand scientists worldwide are collaborating today to design and build the particle accelerator of tomorrow.

The ILC - the key components

Like any complex machine, the 31 kilometre-long accelerator is made up of several systems - each one an essential component for launching particles at close to the speed of light. These key components are being developed and tested at various facilities.

The linacs

Two main linear accelerators (called linacs), one for electrons and the other for positrons, each 12 kilometres long, will accelerate the bunches of particles toward the collision point. Each accelerator consists of ***superconducting cavities***, nestled within a series of cryomodules. Electromagnetic waves fill the cavities to accelerate the particles to energies up to 250 GeV.

STF - Superconducting RF Test Facility

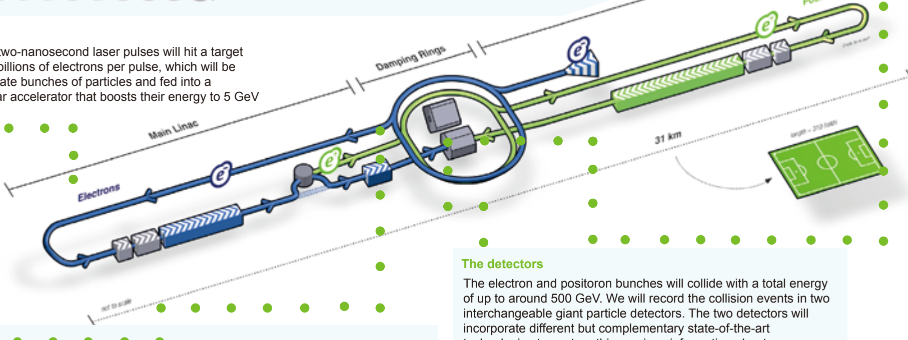
KEK's Superconducting radiofrequency Test Facility (STF) is the Japanese research base for developing and testing the superconducting cavities and cryomodules.

Positrons

The high-energy electron beam will go through ***undulator*** magnets, which will cause the electrons to emit a stream of X-ray photons. Just beyond the undulator the electrons will return to the main accelerator, while the photons will hit a titanium-alloy target and produce pairs of electrons and positrons. The positrons will be collected and launched into their own 250-metre 5-GeV accelerator.

Electrons

High-intensity, two-nanosecond laser pulses will hit a target and knock out billions of electrons per pulse, which will be gathered to create bunches of particles and fed into a 250-metre linear accelerator that boosts their energy to 5 GeV



The beam delivery sysyems

A series of magnets, arranged along two 2-kilometre ***beam delivery systems*** on each side of the collision point, will focus the beams to a few nanometres in height and a few hundred nanometres in width and steer the electrons and positrons into head-on collisions.

ATF2 at KEK

ATF2 is a prototype of the ILC beam delivery systems to test and develop the optics to produce ***the nanobeam*** and the technologies to stabilise it to a nano-metre level.

The detectors

The electron and positoron bunches will collide with a total energy of up to around 500 GeV. We will record the collision events in two interchangeable giant particle detectors. The two detectors will incorporate different but complementary state-of-the-art technologies to capture this precious information about every particle produced in each interaction.

ILD

SiD

The damping rings

When created, neither the electron nor the positron bunches are compact enough to yield the high density needed to produce copious collisions inside the detectors. Two 6.7 kilo-metre-circumference ***damping rings***, one for electrons and the other for positrons, will make them more compact. Each bunch will circle roughly 10,000 times before being kicked out. Upon exiting the damping rings, the bunches will be a few millimetres long and thinner than a human hair.

ATF - Accelerator Test Facility

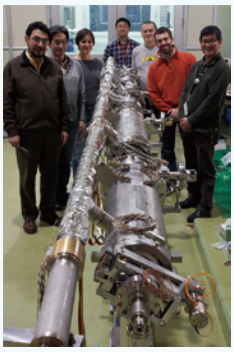
KEK's ATF aims to establish techniques to produce stable ***ultra-low emittance*** beams.

LC-TPC Large Prototype Test at DESY

A large prototype of the Time Projection Chamber (TPC) for tracking the charged particles is now being tested at the test beam facility at DESY. The TPC technology has been as adopted by the ILD detector concept group.

International Collaborations: Towards the International Linear Collider

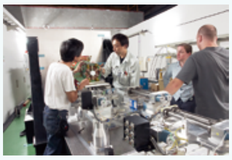
International Accelerator R&D Collaboration



• *S1 Global*

The object of S1 global is the demonstration of two connected four-cavity ***cryomodules*** operating at an average accelerating gradient of 31.5 Megavolts per metre (MV/m), the design gradient for the ILC. Each cryomodule will contain four dressed ***superconducting cavities*** stringed together, coming from around the globe; two from Europe (DESY), two from the Americas (Fermilab and the Thomas Jefferson Lab National Accelerator Facility), and four from Asia (KEK).

• *ATF/ATF2 International Collaboration*



25 overseas institutes, KEK, and 6 Japanese universities are participating in the collaboration.

International Physics and Detector R&D Collaboration

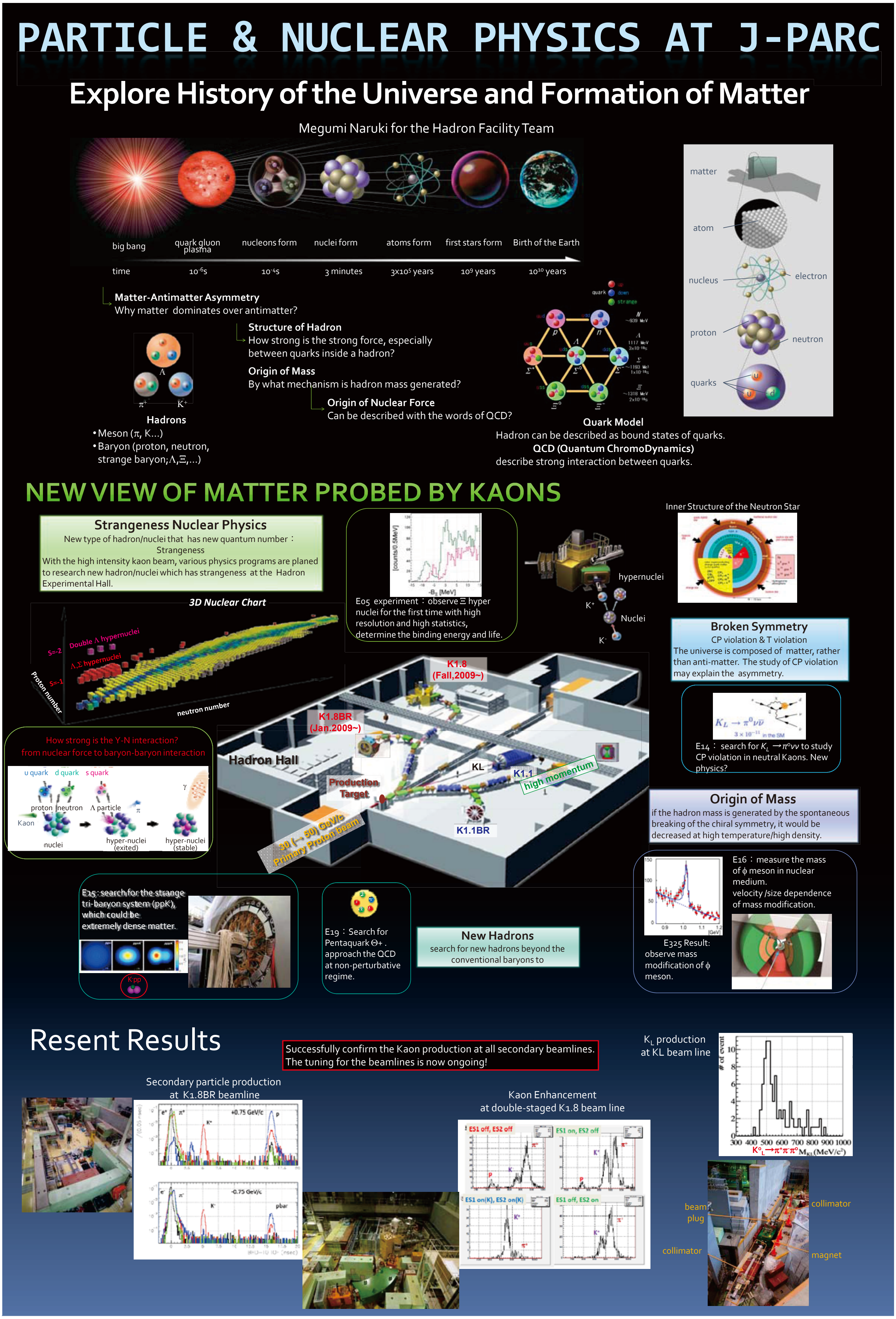
• *LC-TPC Collaboration*

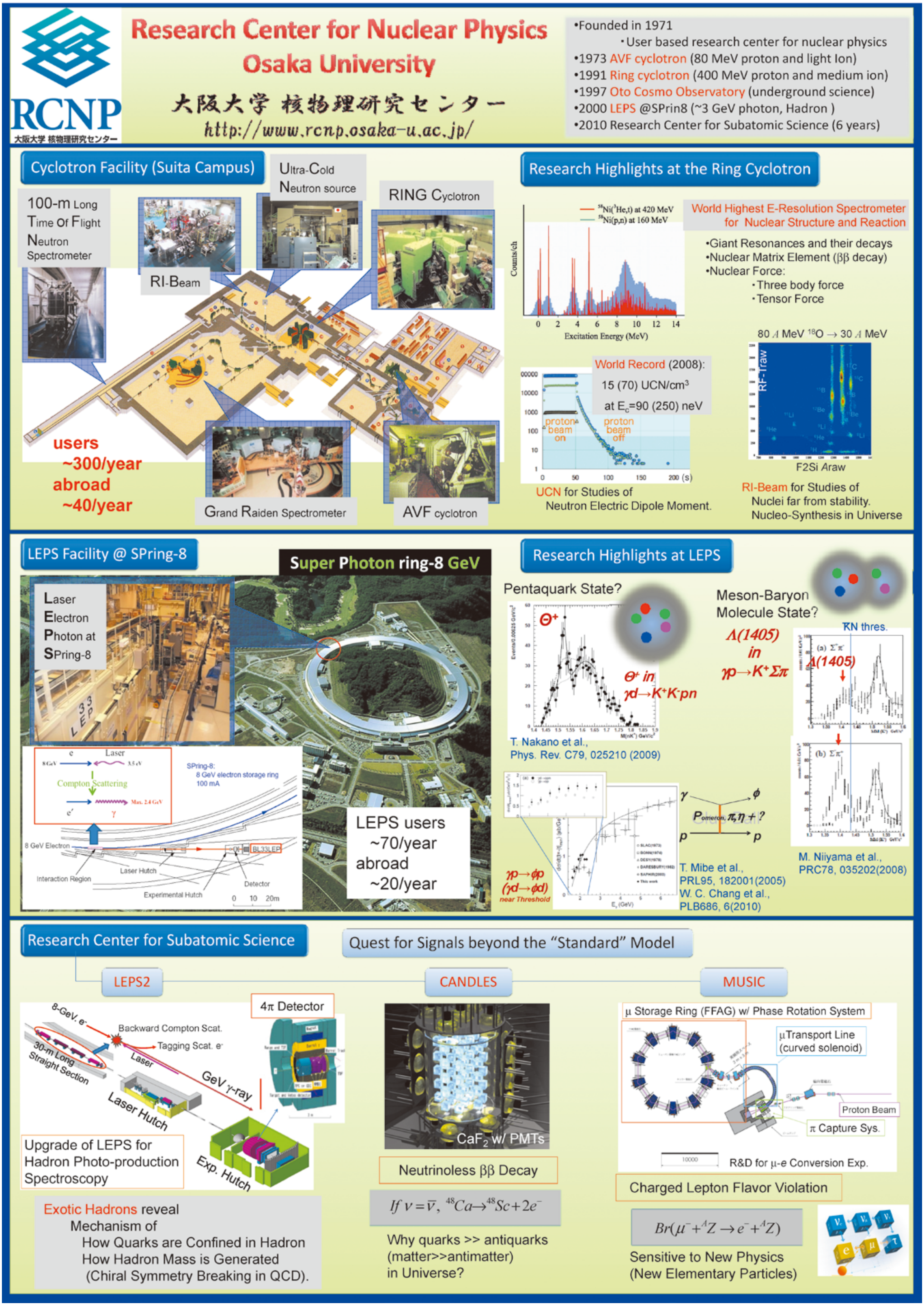
29 overseas institutes, KEK, JAXA, and 7 Japanese universities are participating in the R&D of the ILC TPC.

• *ILD Concept Team*

About 700 people from 32 countries and regions have signed up the ILD Letter of Intent (LoI).

Find out more: http://www.linearcollider.org


PARTICLE & NUCLEAR PHYSICS AT J-PARC
Explore History of the Universe and Formation of Matter
Megumi Naruki for the Hadron Facility Team
big bang
quark gluon plasma
nucleons form
nuclei form
atoms form
first stars form
Birth of the Earth
time
10⁻⁶s
10⁻⁴s
3 minutes
3x10⁵ years
10⁹ years
10¹⁰ years
matter
atom
nucleus
electron
proton
neutron
quarks
Matter-Antimatter Asymmetry
Why matter dominates over antimatter?
Structure of Hadron
How strong is the strong force, especially between quarks inside a hadron?
Origin of Mass
By what mechanism is hadron mass generated?
Origin of Nuclear Force
Can be described with the words of QCD?
Hadrons
•Meson (π, K...)
•Baryon (proton, neutron, strange baryon;Λ,Ξ,...)
Quark Model
Hadron can be described as bound states of quarks.
QCD (Quantum ChromoDynamics)
describe strong interaction between quarks.
NEW VIEW OF MATTER PROBED BY KAONS
Strangeness Nuclear Physics
New type of hadron/nuclei that has new quantum number : Strangeness
With the high intensity kaon beam, various physics programs are planed to research new hadron/nuclei which has strangeness at the Hadron Experimental Hall.
E05 experiment : observe Ξ hyper nuclei for the first time with high resolution and high statistics, determine the binding energy and life.
hypernuclei
Nuclei
Inner Structure of the Neutron Star
3D Nuclear Chart
Double Λ hypernuclei
Λ,Σ hypernuclei
Proton number
neutron number
Broken Symmetry
CP violation & T violation
The universe is composed of matter, rather than anti-matter. The study of CP violation may explain the asymmetry.
K1.8 (Fall,2009~)
K1.8BR (Jan.2009~)
Hadron Hall
Production Target
KL
K1.1
high momentum
K1.1BR
30 (→ 50) GeV/c Primary Proton beam
How strong is the Y-N interaction?
from nuclear force to baryon-baryon interaction
u quark
d quark
s quark
proton
neutron
Λ particle
Kaon
nuclei
hyper-nuclei (exited)
hyper-nuclei (stable)
E14 : search for K_L → π⁰νν to study CP violation in neutral Kaons. New physics?
Origin of Mass
if the hadron mass is generated by the spontaneous breaking of the chiral symmetry, it would be decreased at high temperature/high density.
E16 : measure the mass of ϕ meson in nuclear medium.
velocity /size dependence of mass modification.
E325 Result: observe mass modification of ϕ meson.
E15 : search for the strange tri-baryon system (ppK), which could be extremely dense matter.
E19 : Search for Pentaquark Θ+ . approach the QCD at non-perturbative regime.
New Hadrons
search for new hadrons beyond the conventional baryons to
Resent Results
Successfully confirm the Kaon production at all secondary beamlines.
The tuning for the beamlines is now ongoing!
Secondary particle production at K1.8BR beamline
+0.75 GeV/c
-0.75 GeV/c
pbar
Kaon Enhancement at double-staged K1.8 beam line
ES1 off, ES2 off
ES1 on, ES2 off
ES1 on(K), ES2 on(K)
ES1 off, ES2 on
K_L production at KL beam line
beam plug
collimator
collimator
magnet


Research Center for Nuclear Physics
Osaka University
大阪大学 核物理研究センター
http://www.rcnp.osaka-u.ac.jp/
RCNP
大阪大学 核物理研究センター
•Founded in 1971
•User based research center for nuclear physics
•1973 AVF cyclotron (80 MeV proton and light Ion)
•1991 Ring cyclotron (400 MeV proton and medium ion)
•1997 Oto Cosmo Observatory (underground science)
•2000 LEPS @SPrin8 (~3 GeV photon, Hadron)
•2010 Research Center for Subatomic Science (6 years)
Cyclotron Facility (Suita Campus)
100-m Long Time Of Flight Neutron Spectrometer
RI-Beam
Ultra-Cold Neutron source
RING Cyclotron
Grand Raiden Spectrometer
AVF cyclotron
users ~300/year
abroad ~40/year
Research Highlights at the Ring Cyclotron
World Highest E-Resolution Spectrometer for Nuclear Structure and Reaction
•Giant Resonances and their decays
•Nuclear Matrix Element (ββ decay)
•Nuclear Force:
•Three body force
•Tensor Force
Counts/ch
Excitation Energy (MeV)
World Record (2008):
15 (70) UCN/cm³
at E=90 (250) neV
proton beam on
proton beam off
UCN for Studies of Neutron Electric Dipole Moment.
80 A MeV ¹⁸O → 30 A MeV
RF - Traw
F2Si Araw
RI-Beam for Studies of Nuclei far from stability.
Nucleo-Synthesis in Universe
LEPS Facility @ SPring-8
Super Photon ring-8 GeV
Laser Electron Photon at SPring-8
Laser
Compton Scattering
SPring-8: 8 GeV electron storage ring 100 mA
8 GeV Electron
Interaction Region
Laser Hutch
Experimental Hutch
Detector
LEPS users ~70/year
abroad ~20/year
Research Highlights at LEPS
Pentaquark State?
Θ⁺
Θ⁺ in γd→K⁺K⁻pn
T. Nakano et al., Phys. Rev. C79, 025210 (2009)
Meson-Baryon Molecule State?
Λ(1405) in γp→K⁺Σπ
K̄N thres.
(a) Σ⁺π⁻
(b) Σ⁻π⁺
Λ(1405)
M. Niiyama et al., PRC78, 035202(2008)
γp→φp
(γd→φd)
near Threshold
γ
φ
Pomeron, π,η + ?
p
T. Mibe et al., PRL95, 182001(2005)
W. C. Chang et al., PLB686, 6(2010)
Research Center for Subatomic Science
Quest for Signals beyond the “Standard” Model
LEPS2
CANDLES
MUSIC
8-GeV e⁻
Backward Compton Scat.
Tagging Scat. e⁻
Laser
30-m Long Straight Section
GeV γ-ray
Laser Hutch
Exp. Hutch
4π Detector
Upgrade of LEPS for Hadron Photo-production Spectroscopy
Exotic Hadrons reveal Mechanism of
How Quarks are Confined in Hadron
How Hadron Mass is Generated
(Chiral Symmetry Breaking in QCD).
CaF₂ w/ PMTs
Neutrinoless ββ Decay
$If\ \nu=\bar{\nu},\ {}^{48}Ca \to {}^{48}Sc + 2e^-$
Why quarks >> antiquarks (matter>>antimatter) in Universe?
μ Storage Ring (FFAG) w/ Phase Rotation System
μ Transport Line (curved solenoid)
Proton Beam
π Capture Sys.
R&D for μ-e Conversion Exp.
Charged Lepton Flavor Violation
$Br(\mu^- + {}^AZ \to e^- + {}^AZ)$
Sensitive to New Physics (New Elementary Particles)

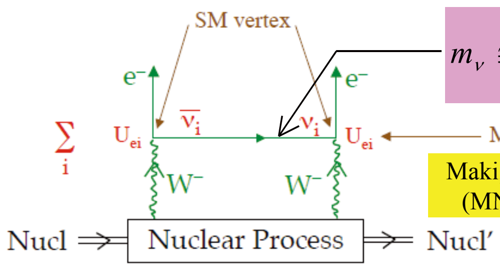
Neutrinoless Double Beta Decay Experiments and Leptogenesis Scenario of Early Universe

Nobuhiro Ishihara, for the DCBA collaboration
Institute of Particle and Nuclear Studies (IPNS), KEK, High Energy Accelerator Research Organization
1-1 Oho, Tsukuba-city, Ibaraki, 305-0801 Japan *E-mail: nobuhiro.ishihara@kek.jp*

Abstract: Neutrinoless double beta decay (0νββ) takes place only when neutrinos are Majorana neutrinos that have the nature of no distinction between particles and their own anti-particles. Majorana neutrino plays important role in the theory called Seesaw Mechanism, in which a left-handed Majorana neutrino (LMN) can obtain its mass independently of a right-handed Majorana neutrino (RMN). The product of two masses of LMN and RMN is equal to a Dirac particle mass squared. Therefore, when the mass of RMN is extremely large, the one of LMN naturally becomes very small. The LMN is considered as known neutrino weakly interacting. In the Leptogenesis scenario, heavy RMNs have been produced in early universe. The heavy RMNs can asymmetrically decay to leptons over anti-leptons. This is the reason why the present universe is filled with matter without anti-matter. Observation of 0νββ would be evidence of Seesaw Mechanism and Leptogenesis. The R&D of tracking detectors for 0νββ are developed at KEK and in Europe under the program of France Japan Particle Physics Laboratory (FJPPL).

Neutrinoless Double Beta Decay (0νββ)

Lepton Number Violation Process
ΔL=2



A: Mass number
Z: Atomic number
(From Boris Kayser at APS – JPS meeting at Hawaii, Oct. 13, 2009)

$\nu = \bar{\nu}$

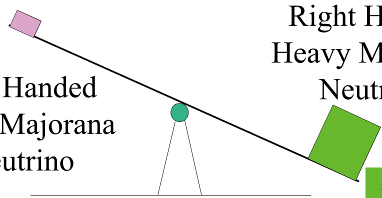
$m_\nu \cong \frac{m_D^2}{m_N} < 0.4$ eV

Maki, Nakagawa, Sakata (MNS Matrix) (1962)

$T_{1/2}^{0\nu} \propto \frac{1}{m_{\beta\beta}^2} \approx 10^{26}$ y

Effective neutrino mass: $m_{\beta\beta} = \left|\sum m_i U_{ei}^2\right| \approx 0.05\text{eV}$

Seesaw Mechanism



Left Handed Light Majorana Neutrino

Right Handed Heavy Majorana Neutrino

$N = \bar{N}$

Yanagida
Gell-Mann, Ramond, Slansky (1979)
Mohapatra, Senjanovic
Minkowski

$m_N \approx \frac{m_{top}^2}{m_\nu(\approx 0.05\text{eV})} \approx 10^{15}$ GeV

Leptogenesis

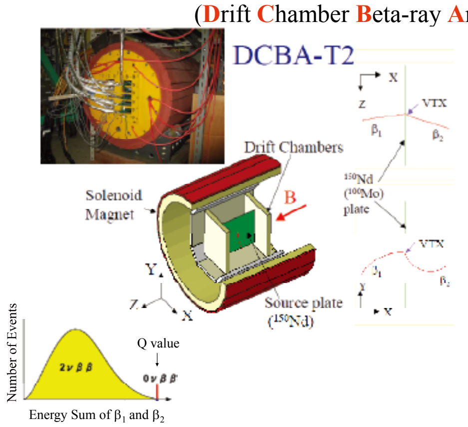
N would have been made in the hot Big Bang

$\Gamma(N \to l^- H^+) \neq \Gamma(N \to l^+ H^-)$

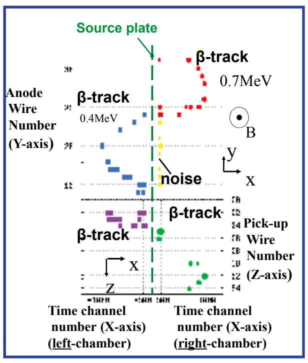
Fukugita, Yanagida (1986)

0νββ Experiment DCBA at KEK

(Drift Chamber Beta-ray Analyzer)



2νββ event



Baryon Asymmetry

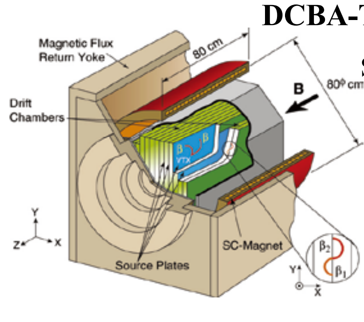
The Standard-Model ***Sphaleron*** process,
which does not conserve Baryon Number *B*,
or Lepton Number *L*, but does conserve *B* – *L*, acts.

Initial state from N decays

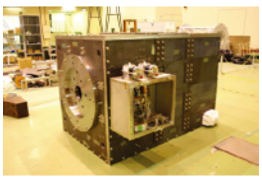
Final state

(From Boris Kayser at APS – JPS meeting at Hawaii, Oct. 13, 2009)

DCBA-T3

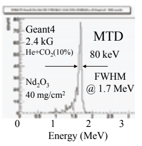


Super Conducting Magnet



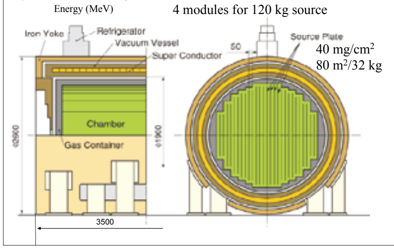
Under construction

R&D of Future Tracking Detectors for 0νββ under France Japan Particle Physics Laboratory (FJPPL)



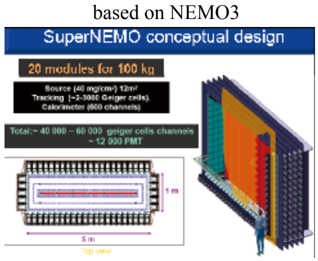
Magnetic Tracking Detector (MTD) based on DCBA

4 modules for 120 kg source



40 mg/cm²
80 m²/32 kg

SuperNEMO in Europe based on NEMO3



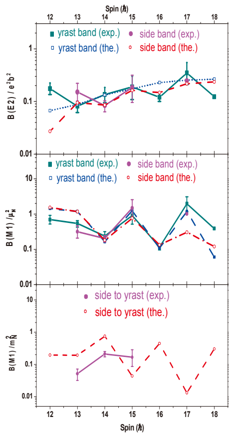
China Institute of Atomic Energy

Nuclear Structure at High Spins

Nuclear structure at high spins possesses many new features. Among them the quasi-particle alignment, magnetic rotation, coexistence of electric, magnetic and chiral rotations, chirality, critical point symmetry, etc are of particular interest. We have performed a series of experiments at the HI-13 tandem accelerator in CIAE to investigate the nuclear structure at high spins. Here some examples are presented.

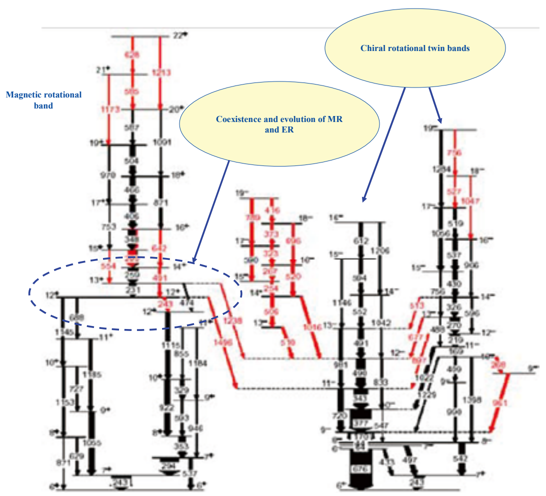
1. Electromagnetic properties of chiral twin bands in ^{130}Cs

The lifetimes of high spin states of the chiral twin bands in ^{130}Cs populated by the reaction ^{124}Sn (^{11}B,5n) ^{130}Cs were measured using Doppler Shift Attenuation method (DSAM). The reduced transition probabilities B(M1) and *B*(*E2*) were extracted as shown in the figure. Besides the identical level energies, the *B*(*M1*) and *B*(*E2*) values of both side and yrast bands are identical and consistent with the ones calculated with a Particle-Rotor Model including chiral rotation, indicating good chirality of the two bands at high spins in ^{130}Cs.



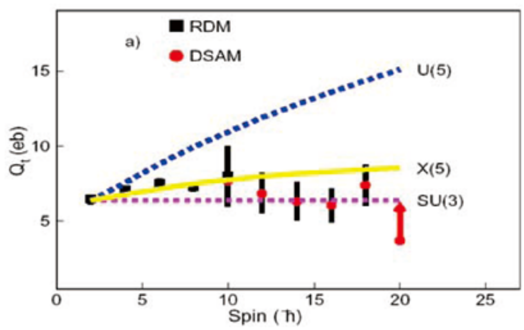
2. Coexistence of electric, magnetic and chiral rotations in ^{106}Ag

The high spin states in ^{106}Ag were populated via the reaction ^{100}Mo(^{11}B,5n)^{106}Ag and more than 30 new γ transitions were observed and assigned as shown in the figure. The electric, magnetic and chiral bands were observed simultaneously, illustrating the coexistence of electric, magnetic and chiral rotations in ^{106}Ag. The yrast and yrare bands are possibly the chiral twin bands.



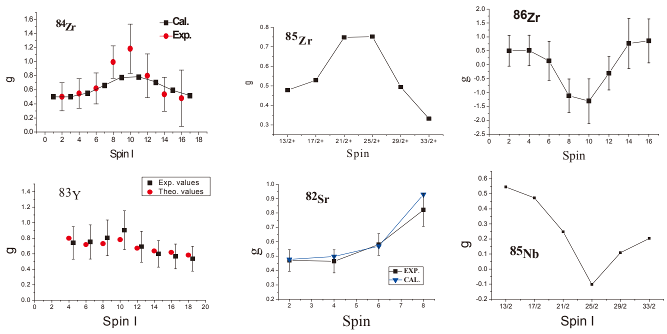
3. X(5) critical point symmetry in ^{176}Os

^{176}Os is a good candidate nuclide with X(5) critical point symmetry. The lifetimes of the spin above 10+ states in ^{176}Os populated by the reaction ^{152}Sm(^{28}Si,4n)^{176}Os were measured by DSAM. The figure shows the transitional quadrupole moments Q_t deduced from the presently measured lifetimes and the lifetimes of the spin below 10+ states measured previously by RDDS together with the Q_t calculated based on the X(5) prediction and the IBM U(5) and SU(3) limits. It could be concluded that ^{176}Os nucleus keeps an X(5) critical point symmetry until 10$^+$ state. Above the 10$^+$ state the transitional quadruple moments suddenly drop and are saturated at the values of the IBM SU(3) limit, indicating that ^{176}Os behaves as an axially symmetric rotor as the spin increases.



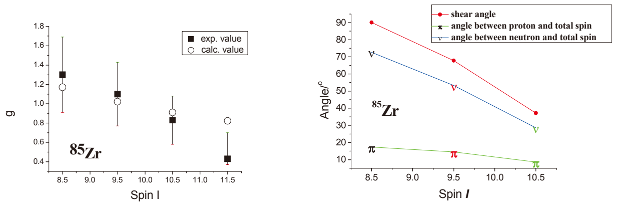
4. Quasi-particle alignment

Quasi-particle alignment was investigated at high spins in a mass region of A=80 by g-factor measurements using the TMF-IMPAD technique. The high spin states of the ground state rotational band in ^{82}Sr, ^{83}Y, $^{84-86}$Zr and ^{85}Nb were populated by the fusion-evaporation reactions. The Cranking shell model and the particle-rotor model were also used to calculate the g-factors for ^{84}Zr and ^{83}Y and for ^{82}Sr, respectively. Proton and/or neutron alignments were observed in these nuclides, which lead to different patterns of g-factor variation with spin as shown in the figures. It can be seen that the quasi-particle alignment depends on the proton and neutron numbers. For the nuclides of Z=40 neutron alignment follows proton alignment in ^{84}Zr and ^{85}Zr, while proton alignment follows neutron alignment in ^{86}Zr and ^{85}Nb. For the nuclides of N=44 the proton aligns only in ^{82}Sr and neutron alignment follows proton alignment in ^{83}Y and ^{84}Zr.



5. Magnetic rotation

Magnetic rotation, a novel mode of nuclear rotation occurring in nearly spherical nuclei, was studied through g-factors measured by the TMF-IMPAD technique for the magnetic rotational band built on the 17/2$^-$ state in ^{85}Zr. The figure illustrates the measured g-factors together with the calculated g-factors and shears angles θ between the proton and neutron angular momentum vectors and the angles θπ and θν of the proton and neutron angular momentum vectors with respect to the total angular momentum vector, respectively. The calculation was performed based on the independent particle angular momentum coupling assumption. The decreasing of both g-factors and shears angles with the spin increase clearly demonstrates the shears mechanism of step-by-step alignment of valence protons & neutrons in magnetic rotation.



Her Royal Highness Princess Maha Chakri Sirindhorn

Nuclear and Particle Physics Research in Thailand

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**School of Physics, Institute of Science, Suranaree University of Technology, Nakhon Ratchasima, 30000, Thailand*

†Thailand Center of Excellence in Physics, Commission on Higher Education, Bangkok, 10400, Thailand

Abstract

The Nuclear and Particle Physics Research Unit was founded by the school of physics, Suranaree University of Technology (SUT) in year 2000. Later in 2007, our group has joined the Research Center in Computational and Theoretical Physics which is financed by the Thailand Center of Excellence in Physics (ThEP Center). Suranaree University of Technology is one of the nation's leading research universities with particular strengths in science and technology. The school of physics was ranked first among all universities in Thailand by the Thailand Research Fund (TRF) in year 2008. Our unit itself is located in the north-eastern part of Thailand, about 250 km from Bangkok with the main interests as follows:

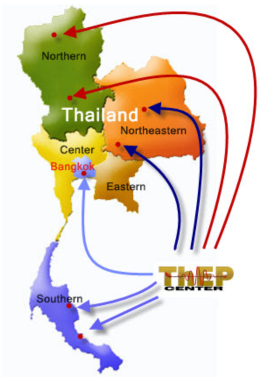
1. **Hadron physics which include hadron interaction, exotic atoms, chiral perturbation theory and chiral quark models. In this area, we have collaborated with groups from University of Tübingen, GSI from Germany, TRIUMF from Canada and Institute of High Energy Physics (IHEP), China.**
2. **Heavy ion collision based on the QMD and UrQMD model to study hypernuclei, kaon and sigma meson production with exchange visits from Johann Wolfgang Goethe Universität, Germany and China Institute of Atomic Energy (CIAE) Beijing, China.**
3. **Lattice QCD to extract information about gluon and ghost propagator in Coulomb gauge at zero and finite temperature. In this topic we have collaborated with a group from University of Tübingen, Germany.**

Past Activities

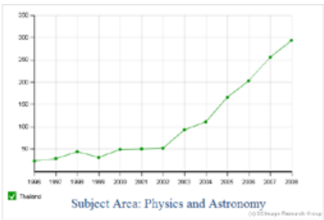
We hosted the third Asia-Pacific Conference on Few-Body Problems in Physics (APFB05) from July 26 to 30, 2005. Over 100 physicists from around the world participated in this program.

Pictures from CERN PhotoLab

Her Royal Highness Princess Maha Chakri Sirindhorn of Thailand has visited CERN 3 times in year 2000, 2003 and 2009. Her interests have led to the selection of Thai teachers and students to participate in CERN's summer student programme and physics high school teacher programme. Her gracious patronage has been appreciated by physics community in Thailand.



Suranaree University of Technology (SUT) is Thailand's first autonomous state university. SUT has served as one of the nation's leading research universities with particular strengths in science and technology. The university campus is located in Nakhon Ratchasima province, only 250 km from Bangkok. The school of physics was ranked first among all universities in Thailand by the Thailand Research Fund (TRF) in year 2008. The research group in physics currently being conducted at SUT are Condensed Matter Physics, Nuclear and Particle Physics, Synchrotron Radiation Physics, and Lasers Technology.



The Thailand Center of Excellence in Physics, ThEP Center, is a collaboration of more than 12 Thai universities around the country. Evidently, there has been substantial growth of physics research in Thailand since 2003. The center aim is to enhance the quality of teaching and research in physics among Thai universities and support local industries with a supply of well-prepared graduates and innovative ideas.

APFB 2005

The Third Asia-Pacific Conference on Few-Body Problems in Physics

Nakhon Ratchasima, Thailand

July 25-29, 2005

Past Activities: The third Asia-Pacific Conference on Few-Body Problems in Physics (APFB05) was held from July 26 to 30, 2005 in Nakhon Ratchasima, Thailand, with School of Physics, Suranaree University of Technology (SUT) as its host. Over 100 physicists from around the world participated in this program.

The Nuclear and Particle Physics Research Unit was founded in year 2000. Later in 2007, our group has joined the Research Center in Computational and Theoretical Physics which is financed by the Thailand Center of Excellence in Physics (ThEP Center). We have strong collaborations with forefront physics institutes in Europe, North America, and China. The following is a list of the research projects currently being conducted.

1. Hadron physics which include hadron interaction, exotic atoms, chiral perturbation theory and chiral quark models. In this area, we have collaborated with groups from University of Tübingen, GSI from Germany, TRIUMF from Canada and Institute of High Energy Physics (IHEP), China.

   Eberhard Karls Universität Tübingen GSI TRIUMF

2. Heavy ion collision based on the QMD and UrQMD model to study hypernuclei, kaon and sigma meson production with exchange visits from Johann Wolfgang Goethe Universität, Germany and China Institute of Atomic Energy (CIAE) Beijing, China.

   Johann Wolfgang Goethe Universität Frankfurt am Main

3. Lattice QCD to extract information about gluon and ghost propagator in Coulomb gauge at zero and finite temperature. In this topic we have collaborated with a group from University of Tübingen, Germany.

   Eberhard Karls Universität Tübingen

Cherenkov Telescope Array

A global endeavor for astronomy and particle astrophysics with very high energy (VHE) gamma rays

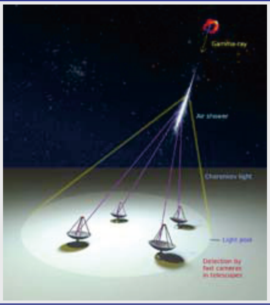
Astronomy and particle astrophysics with very high energy (VHE) gamma rays

The universe is a unique laboratory to study fundamental physical processes at extreme energies, well beyond any energy scale that can ever be reached with accelerators on Earth. Gamma-ray astronomy at Tera-electronvolt (TeV) energies uses this laboratory, to address issues such as

- Investigation of *the most energetic processes in the Universe*
- Understanding the *cosmic particle accelerators*
- Mapping the *energy density of cosmic rays* in the Galaxy
- Probing the *environment of black holes* and *neutron stars*
- *Cosmology* and the history of galaxy formation
- Probing the validity of *fundamental physics* laws at extreme energies
- What is the *origin of Dark Matter* ?

Detecting VHE gamma rays

When highly energetic cosmic particles hit the atmosphere, cascades of relativistic particles are generated. They emit faint flashes of Cherenkov light with nanosecond duration. Large telescopes focus the light onto fast photosenor arrays. Stereoscopic observation with several telescopes is the state of the art. They allow the determination of the properties of the primary particles with high accuracy. Gamma rays coming from sources can be identified and used to investigate the source properties.



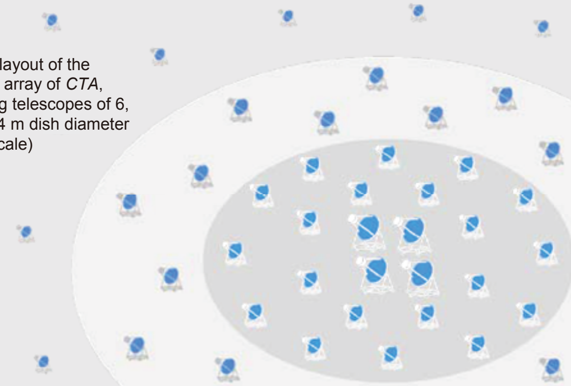
CTA : a quantum step for particle astrophysics

The great success of the current generation instruments (H.E.S.S., MAGIC, CANGAROO and VERITAS) has demonstrated the great potential of the young field of TeV gamma-ray astrophysics. In order to fully exploit this potential, the next generation instrument *CTA* aims for providing a significant improvement in all performance characteristics:

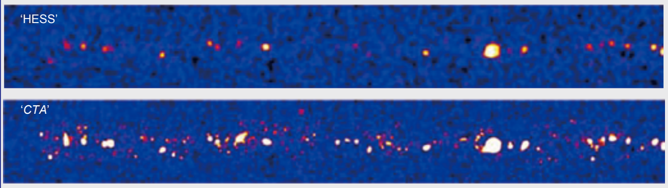
- Factor 10 higher sensitivity at TeV energies
- Energy range extending from some 10 GeV to some 100 TeV
- Improved angular resolution down to 1-2 arcmin
- Factor 5 - 10 higher detection rates
- Improved survey capability and full-sky coverage

In order to achieve the envisaged performance, about 50-100 telescopes of different sizes, distributed over an area of >1 km^2 will be needed. The array design has to be optimized for reliability and remote robotic operation.

Possible layout of the Southern array of *CTA*, combining telescopes of 6, 12 and 24 m dish diameter (not to scale)



The Galaxy viewed in gamma rays



CTA will have by far the best angular resolution of any type of gamma-ray instrument. It will therefore for the first time allow to resolve structures of Galactic emission regions on parsec scales and act like a “microscope” for cosmic accelerators. (Figures: sky-map of the inner part of a simulated Galactic plane as it would be visible with current instruments and with *CTA*). It is expected that *CTA* will discover more than 1000 TeV-gamma-ray sources - galactic and extra-galactic - a factor of >10 more than are detected with current instruments.

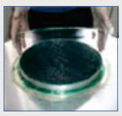
CTA as an observatory with full-sky coverage will have two sites, one in the Northern and one in the Southern hemisphere. They will be jointly constructed and operated by one international consortium and use the same technology.

CTA design: facing the challenges

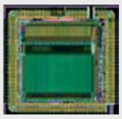
The development of cost effective, high performance components for the *CTA* telescope array is a major technological challenge. Examples are:

- Construction of 50 – 100 optical telescopes with dish sizes of ~6, ~12 and ~24 m for robotic operation with maximum reliability
- Production of ~ 70 m^2 photo sensitive area with nanosecond response
- Development of high speed cameras with >100 000 electronics channels to be operated in a rough environment
- Development of production techniques for 10 000 m^2 focusing mirrors
- Data handling of up to 50 GByte/sec

The *CTA* consortium currently meets these challenges in a *Design Study* that is jointly performed by all major European groups, together with Japanese and other international groups, and in cooperation with industry.



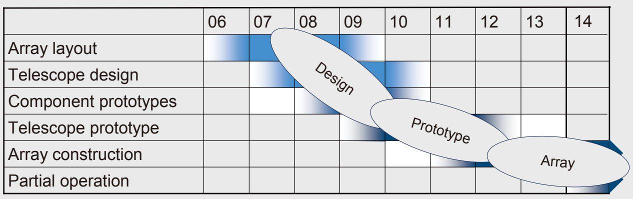
Development of new production techniques for mirrors



Development of micro-electronics and photon detectors

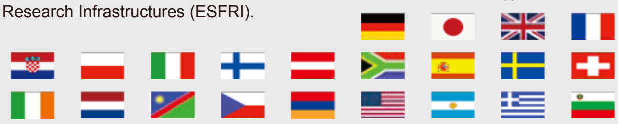
Design of telescope structures; concepts for safety and robotics

Tentative timeline towards the *CTA* observatory



CTA as a global endeavor

The *CTA observatory as world-class research infrastructure* will be open to the scientific community. The project directly involves more than 500 scientists from over 120 institutes worldwide. *CTA* is top ranked in the roadmaps of ASPERA and ASTRONET for future projects in particle astrophysics and astronomy. *CTA* is included in the 2008 update of the roadmap of the European Strategy Forum on Research Infrastructures (ESFRI).



Institute of High Energy Physics (IHEP),CAS
Center for Space Science and Applied Research,CAS
China Meteorological Administration
Hebei Normal University
Institute of Disaster Prevention Science and Technology
Shandong University
Southwest Jiaotong University
Tibet University and Yunnan University
Tsinghua University

Hirosaki University
ICRR, University of Tokyo
Nagoya University
National Institute of Information
Nihon University
Kanagawa University
Konan University
RIKEN
Saitama University
Sakushin Gakuin University
Shibaura Institute of Technology
Shinshu University
Shonan Institute of Technology
Tokyo Metropolitan College of Aeronautical Engineering
Utsunomiya University
Waseda University
Yokohama National University

YangBaJing International Cosmic Ray Observatory

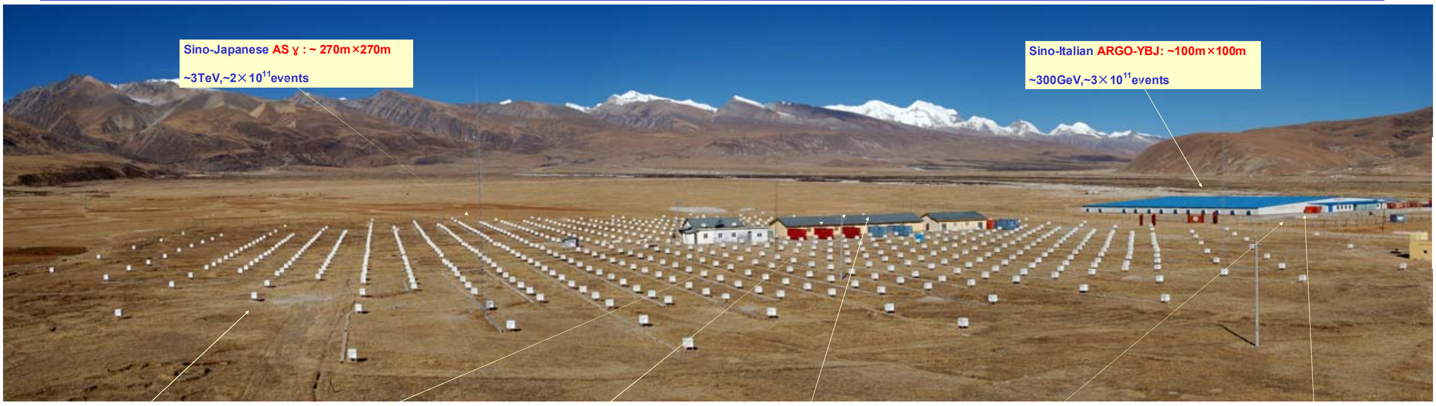
Institute of High Energy Physics, CAS
Hebei Normal University
Shandong University
Southwest Jiaotong University
Tibet University
Yunnan University

INFN and Lecce University
INFN and Napoli University
INFN Section of Napoli and University of Salerno
INFN Section of Napoli and University of Sonnio, Benevento
INFN and University Roma "Tor Vergata"
INFN and University "Roma Tre" Roma
INFN and Institute of Cosmogeo Physics of CNR, Torino
INFN Section of Catania and Institute of Physics of Cosmic
IFCA/CNR,Palerno and INFN Section of Pavia

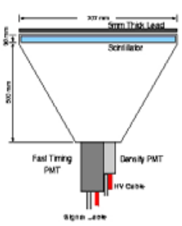
The observatory is located at 90°26'E and 30°13'N in Yangbajing (YBJ) valley of Tibetan highland, about 90KM NW of Lhasa, the capital city of Tibet, China. Currently, the YBJ observatory hosts two cosmic ray experiments. One is a Sino-Japanese collaboration called ASɣ, a sampling detector with 400 m² sensitive area covers an effective area of about 40,000m² and has been operating since 1990. Another one is a Sino-Italian experiment called ARGO-YBJ, a "full coverage" carpet detector with a very large sensitive area of about 6700m², and has been in operation since 2006.

ASɣ uses scintillation counters and ARGO-YBJ uses resistive plate chambers (RPCs) to detect the arrival times and number densities of the secondary particles, with which the original direction and energy of the cosmic rays can be determined. Both experiments study the origin and acceleration of cosmic rays by measuring the spectrum and anisotropy of cosmic rays, by observing the TeV ɣ rays emission etc. As a sampling detector, ASɣ has a threshold energy of a few TeV while ARGO-YBJ can significantly decrease the threshold energy down to a few hunderd GeV. The two experiments have the advantages of high duty cycle and large field of view, which make them particularly suitable for sky surveys and observations of sporadic sources.

In addition, YBJ observatory is equipped with a neutron monitor system, a neutron telescope and a multi-directional muon telescope for solar cosmic rays observation. Various sensors are installed for thunderstorms, meterologic and seismological studies. Recently, one sub-mm telescope from Delingha observatory in QingHai has been moved to the site for astronomic observation. It is also planned to install a second telescope, coming from Germany.



ASɣ scintillation counter



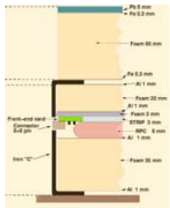
Solar neutron telescope (IHEP, Nagoya University,RIKEN)

Neutron monitor (IHEP, Nagoya University,RIKEN)

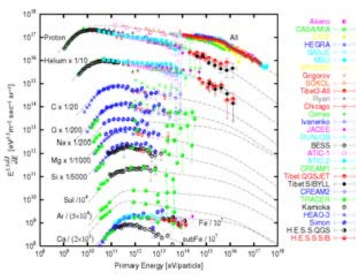
Multi-directional muon telescope and sandwich neutron system (IHEP)

ARGO hall with carpet of RPCs

Resistive Plate Chamber



Proton/Helium spectra and sharp knee by ASɣ (Phys. Lett. B 632, 58-64 (2006); ApJ, 678 1165-1179 (2008))

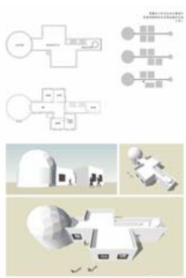


Corner reflector for crust deformation monitoring (IHEP & China Earthquake Administration)

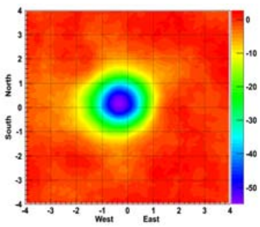
Sub-mm telescope from Delingha observatory (IHEP & MPO)

Instruments for atmospheric and meterologic observations (IHEP & Institute of Atmospheric Physics,CAS)

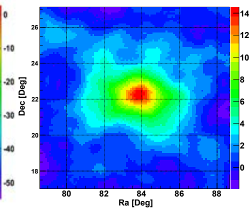
The KOSMA 3m Sub-millimeter telescope will be installed at YBJ observatory (IHEP&NAOC)



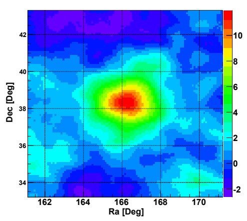
ARGO-YBJ images moon's shadow



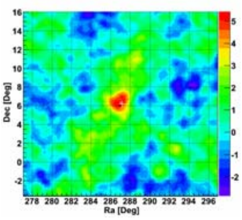
TeV ɣ rays from the crab nebula as observed by ARGO-YBJ



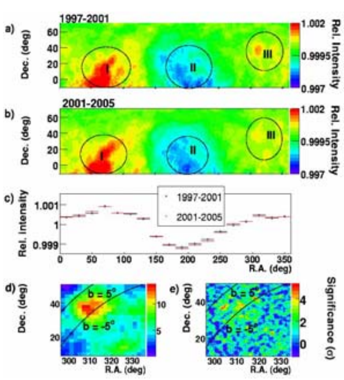
TeV ɣ rays emission from the extragalactic source Mrk421

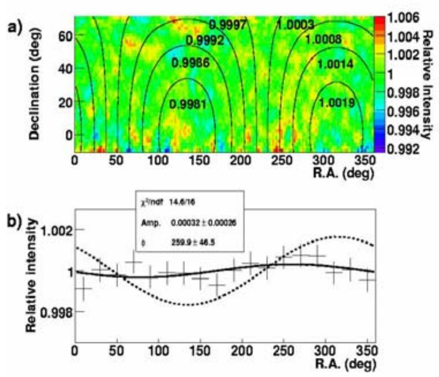


TeV ɣ rays emission from the MGRO 1908+06

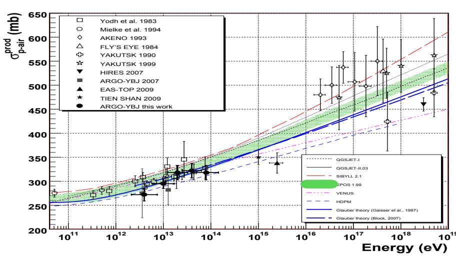


Anisotropy and Corotation of Galactic Cosmic Rays by Tibet ASɣ (Science314:439-443,2006)





Proton-Air cross section measurements by ARGO-YBJ (Phys. Rev. D 80 (2009) 092004)



ALMA

Atacama Large Millimeter/submillimeter Array

Astronomical Observatory Closest to the Universe

ALMA (Atacama Large Millimeter/submillimeter Array) is under construction in the Atacama Desert at an altitude of approximately 5000 meters in northern Chile. The annual rainfall of the area is less than 100 mm, and the sky is always clear almost throughout the year. In the Atacama Desert at high altitudes, incoming radio waves are less susceptible to absorption by terrestrial water vapor and thus we can observe radio waves at relatively shorter wavelengths (at higher frequencies). Combination of these favorable conditions opens the way for the submillimeter observations with ALMA. A flat and wide space of the Chajnantor Plateau is also perfect for the construction of a large-scale array.

ALMA Telescope
–Gigantic Eyes Looking Far Out into the Universe-

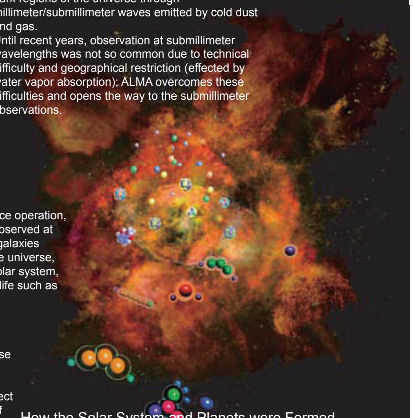
ALMA is a gigantic radio interferometer array with 66 parabola antennas. ALMA consists of fifty 12-m antennas and "Atacama Compact Array (ACA)" which is composed of four 12-m antennas and twelve 7-m antennas.

By spreading these transportable antennas over the distance of up to 18.5 km, ALMA achieves the resolution equivalent to a telescope of 18.5 km in diameter, as a telescope with the world's highest sensitivities and resolutions at millimeter and submillimeter wavelengths.

ALMA started its construction in 2002, and will start its regular science operation from 2012.
"ALMA" means "soul" in Spanish (the official language of Chile).

Millimeter and Submillimeter Waves

Electromagnetic waves are divided into several classes according to their wavelengths. Light visible to our eyes is a kind of electromagnetic waves called "visible light." Radio wave closest to infrared rays (at the shortest wavelengths) is called "submillimeter wave" (wavelength: 1 mm to 0.1 mm, frequency: 300 GHz to 3 THz) and the second shortest radio wave after submillimeter is called "millimeter wave" (wavelength: 10 mm to 1mm, frequency: 30 GHz to 300 GHz). Subaru Telescope observes the universe at infrared and optical wavelengths.
We cannot observe dust and gas in the universe with optical telescopes because they are very cold (down to -260?C) and do not emit visible or infrared emission. However, with a radio telescope, we can observe such dark regions of the universe through millimeter/submillimeter waves emitted by cold dust and gas.
Until recent years, observation at submillimeter wavelengths was not so common due to technical difficulty and geographical restriction (effected by water vapor absorption); ALMA overcomes these difficulties and opens the way to the submillimeter observations.



Global Collaboration

ALMA is a global collaboration among the National Astronomical Observatory of Japan on behalf of East Asia, National Radio Astronomy Observatory on behalf of North America, and European Southern Observatory on behalf of Europe. The Republic of Chile (host country) also participates in the ALMA project by providing land and cooperation for the construction and operations of ALMA.

The ALMA Project was launched in April 2001 by uniting three different projects of three institutes.

Developing three projects into one global partnership led the way to the joint construction and operation of a high-precision gigantic telescope that is difficult to complete for a single institute in terms of resources and costs. Also, cooperation among East Asia, Europe, and North America, sharing tasks in their respective field of expertise, brought about enhanced performance of the telescope.

Japanese Contributions

In global partnership among three parties, Japan is responsible for the development of 16 ultrahigh-precision antennas, collectively called "ACA (Atacama Compact Array)" which is located near the center of the 66 antennas, as well as that of three receiver bands (frequency bands) including submillimeter band (terahertz band) whose development is supposed to be especially difficult.

ALMA is capable of observing millimeter/submillimeter waves at wavelengths from 0.3 mm to 10 mm, and we will manufacture receivers covering this frequency range, which is divided into 10 frequency bands.

Band 4, 8, and 10 Superconducting Receivers

Radio waves collected by an antenna are transmitted to seven superconducting receivers (to be increased to 10 in the future) corresponding to a certain frequency band. The development of seven receiver cartridges is shared by Japan, Europe, and North America.

To achieve unprecedented high performance of ALMA, receivers need to meet very high level of requirements. These requirements will be only satisfied with high development capabilities: unified standards jointly agreed among three parties; extremely low-noise design realized by installing the receivers in a cryogenically-cooled tank at the absolute temperature of 4 K (-269 degrees C); and robust structure with low failure rate for 30-year operation. In spite of such strict requirements, Japan is engaged in the development of multiple receiver bands, and successfully developed three superconducting receivers for Band 4, 8, and 10.

Developing receivers at shorter wavelengths requires higher manufacturing techniques. Though the development of the Band 10 receiver at the shortest wavelengths was thought to be the most difficult among ALMA frequency bands, the Band 10 receiver developed by NAOJ has successfully achieved the world' s best noise performance.

What We Can See

When ALMA starts its regular science operation, we can see what has never been observed at optical wavelengths, such as protogalaxies formed in the very early years of the universe, birth of stars and planets like our solar system, and matters related to the origin of life such as organic molecules.

How the First Galaxy was Formed after the Big Bang

Subaru Telescope is capable of observing the universe dating back about 8 billion years after the birth of the universe, but optical telescopes are unable to observe the universe prior to this point due to the effect of the redshift. On the other hand, in the spectrum of millimeter/submillimeter waves, redshifted galaxies appear brighter and dust in galaxies emitting millimeter/submillimeter waves is also observable. With ALMA, we may be able to observe the birth of the galaxies that occurred just after the cosmic "Dark Ages."

It is expected that ALMA will be a key to solving mysteries of the formation of galaxies just after the Dark Ages.

Clue to the Origin of Life

Is the beginning of life a mere result of chemical reactions that occurred only on the Earth? Did our planetary system have the seed of life when it was formed? Did the space hold any materials that could be an origin of life? There are various theories about the beginning of life. Obtaining a clue to the origin of life is one of the main goals of ALMA.

How the Solar System and Planets were Formed

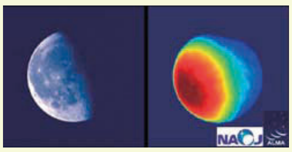
How were the planetary systems like our solar system formed? Since the discovery of the first planet outside the solar system in 1995, about 4000 planets were found directly or indirectly outside the solar system so far. Study results on these planets showed that planetary systems have a wide variety of forms. To explore their formation process, it is necessary to observe the birth of the planetary system, but ingredients of planets (e.g. gas and dust) are too cold to be observed by optical telescopes.

However, with millimeter/submillimeter telescopes, we can observe gas and dust before evolving into stars and planetary systems. Though existing radio telescopes are only capable of seeing object structures vaguely due to lack of angular resolution, ALMA that has a resolution far better than previous radio telescopes is capable of observing with unimaginable clarity the formation process of fixed stars as well as that of planetary systems. The aim of ALMA is to probe unexplored regions of the universe that have not been reached by previous telescopes.

== Latest Progress in ALMA Construction ==

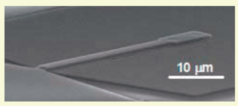
Mar 18, 2008
Result of the Initial Testing of the Japanese ACA 12-m Antenna for ALMA

Japan constructs sixteen parabolic antennas for the Atacama Compact Array (ACA) as part of the ALMA, and three of them were assembled in Chile in the latter half of last year.
One of these three antennas (12 m in diameter) was equipped with a Japanese receiver and was used to obtain the first radio image of the moon at a wavelength of 2 mm (140 GHz). The obtained image shows clearly the temperature distribution of the moon and weak radio emission from the right half of the moon, which is dark in the optical image. This is the first radio image of the celestial object taken with Japanese ACA 12-m Antenna in Chile.

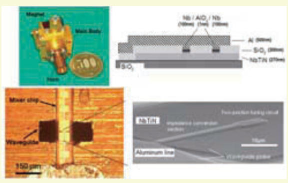


Jun 16, 2009 NAOJ successfully developed the Band 10 receiver

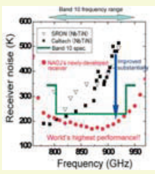
NAOJ successfully developed the Band 10 receiver covering the frequency band from 787 GHz to 950 GHz, whose development was thought to be the most difficult among ten receiver bands to be installed in ALMA. This low-noise receiver is based on a superconductive integrated circuit designed and fabricated using a high-quality film made of compound superconductive material NbTiN (niobium-titanium nitrides). The performance test was conducted with this circuit installed in the newly-developed receiver. As a result of the test, it was proved that the world's highest performance low-noise receiver was successfully developed.
The picture shows the superconductive integrated circuit micrographed by an electron microscope.



Jun 16, 2009 World's Highest Performance Submillimeter (terahertz) Receiver
- Band 10, the highest frequency receiver in ALMA, was successfully developed -



Submillimeter (terahertz) receiver system using NbTiN (upper left).Superconductive integrated circuit using NbTiN, micrographed by an electron microscope (lower right) and its cross section structure (upper right).



Previously, the world's highest performance of the 750 to 950 GHz receiver (operation temperature at 4K) was achieved by the California Institute of Technology, and SRON (Netherlands Institute for Space Research: one of the major research institutes in Europe). NAOJ research team has succeeded in improving the performance substantially with its newly-developed receiver.

Jan 05, 2010 Successful Three-Antenna Interferometry at ALMA 5000-meter Site

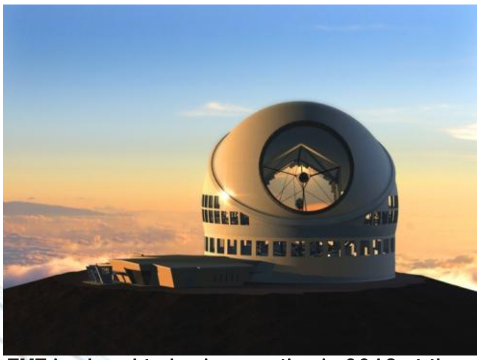
ALMA has passed a key milestone crucial to producing the high-quality images that will be the trademark of this revolutionary new tool for astronomy. A team of astronomers and engineers successfully linked three of the observatory's antennas at the 5000-meter elevation observing site in northern Chile. The three antennas observing in unison for the first time allowed the ALMA team to correct errors that can arise when only two antennas are used, thus paving the way for precise images of the cool Universe at unprecedented resolution.
On 20 November 2009 the third antenna for the ALMA observatory was successfully installed at the Array Operations Site, the observatory's "high site" on the Chajnantor plateau, at an altitude of 5000 meters in the Chilean Andes. After complex technical tests over the subsequent weeks, astronomers and engineers were able to observe the first signals from an astronomical source making use of all three 12-meter diameter antennas linked together.

National Astronomical Observatory of Japan
ALMA Project Office
2-21-1 Osawa, Mitaka, Tokyo, 181-8588, JAPAN
http://alma.mtk.nao.ac.jp

Physics and Astronomy with the Thirty Meter Telescope (TMT)

M. Iye, T. Yamashita, H. Akitaya, N. Ohshima, W. Aoki, N. Kahikawa, T. Kodama, M. Imanishi, T. Usuda, H. Takami, N. Takato, J. Nishikawa, T Sasaki

TMT is the next generation ground-based telescope having a 30-meter diameter mirror. The first light of the telescope is planed in 2018. The telescope with adaptive optics will achieve much higher resolving power and sensitivity than those with currently largest telescopes. The targets of the telescope not only cover almost all fields of astronomy, but will also extend to physics and biology by measuring the expansion of the Universe and investigating the atmospheres of extra-solar planets. TMT will be constructed by the collaboration between universities and institutes in USA, Canada and Asian countries. National Astronomical Observatory of Japan is planning to participate this project. Technical and Scientific cooperation with European Extremely Large Telescope will open new observational astronomy.



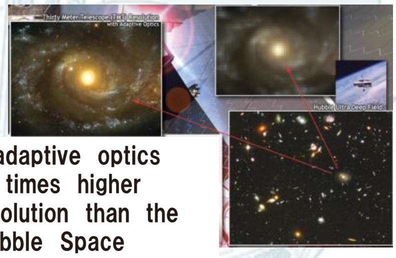
TMT is planed to begin operation in 2018 at the summit of Mauna Kea in Hawaii.

Primary Mirror	30m aperture (492 segments)
First Light	October 2018
Site	4100m, Mauna Kea, Hawaii
Construction cost	~ 1000M$
Partners	Caltech, Univ. California, ACURA
Potential Partners	Japan (NAOJ), China (NAOC), India,Brazil, Taiwan

July 2009	Mauna Kea site chosen
	Fund raising
Feb.2011	Construction Permit
Oct. 2011	Begin Construction
Oct. 2018	First light

•TMT's resolution and light collecting power:

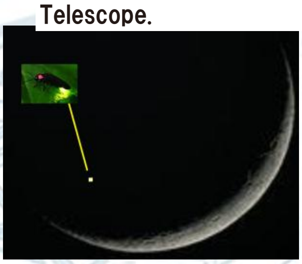
TMT will enable high resolution imaging with its adaptive optics system, 4 times sharper than current 8m-class telescopes (12 times sharper than Hubble Space Telescope [HST]). The light collecting power of TMT is 13 times larger than 8m-class telescopes (150 times larger than HST) and enables detection of extremely faint object.



TMT with adaptive optics offers 13 times higher spatial resolution than the current Hubble Space Telescope.

•Japan's contribution plan:

NAOJ is planning to contribute to the construction of TMT by providing its 574 aspheric mirror segments for the primary mirror, support structures for the secondary and tertiary mirrors, and scientific instruments. The Japanese 8m telescope Subaru at Mauna Kea will contribute to the science with TMT by its survey capability provided by the prime focus camera and spectrograph.



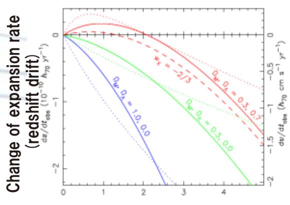
TMT's detection limit is 33 magnitude, which is approximately the brightness of a firefly on the moon.

•Collaborations with other next generation telescopes

Another extremely large telescope is planed by European countries, called E-ELT. Technical and scientific collaborations between TMT and E-ELT will promote new astronomy and astrophysics.

•Direct measurements of the Universe's expansion history

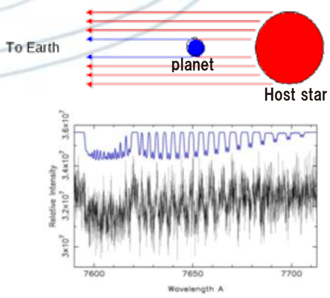
The changes of the Universe's expansion rate can be measured by redshift drift for distant objects. Redshift changes of the order of 10^{-10} per year are expected for high redshift objects. 10 year-measurements for Ly-alpha clouds for redshift of 2-4 will provide a direct test for the acceleration of the Universe's expansion reported previously from measurements of distant type Ia supernovae.



Cosmology models with different combinations of dark matter and dark energy predict different expansion history, which is distinguishable by measurements of redshift drift for distant objects. (adapted from Liske et al. 2008, MNRAS 386, 1192)

•Searches for signature of life in extra-solar planets

Atmospheres of extra-solar planets can be investigated by spectroscopy for stellar light during the planet's transit. Detection oxygen (O2 molecule) is challenging, but is a strong signature of life in the atmosphere of the planet.



Absorption spectra of O2 molecule (simulation: adapted from Webb & Wormleaton 2001, PASA 18, 252)

HINODE

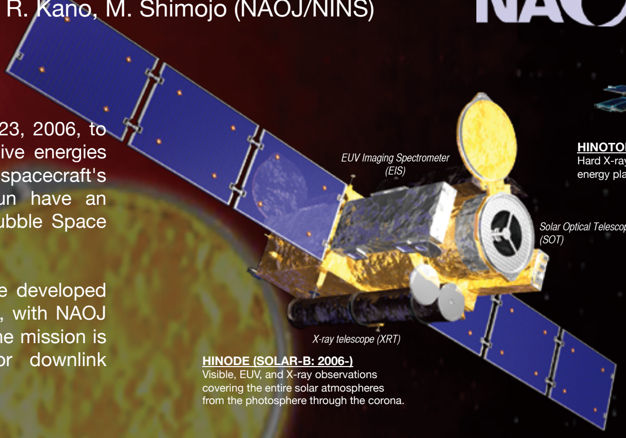
Space Mission to Investigate the Sun

Y. Katsukawa, S. Tsuneta (NAOJ/NINS) T. Sakao, T. Shimizu, K. Matsuzaki (ISAS/JAXA)
T. Watanabe, Y. Suematsu, T. Sekii, H. Hara, R. Kano, M. Shimojo (NAOJ/NINS)

HINODE Mission

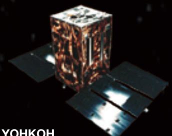
HINODE, Japanese for "sunrise," was launched Sept. 23, 2006, to study the Sun's magnetic fields and how their explosive energies propagate through the different atmospheric layers. The spacecraft's uninterrupted high-resolution observations of the Sun have an impact on solar physics comparable to that of the Hubble Space Telescope on astronomy.

The three advanced telescopes onboard HINODE were developed through international collaboration between ISAS/JAXA, with NAOJ as domestic partner, and NASA (US) and STFC (UK). The mission is operated by these agencies with contributions for downlink connections from ESA.



HINODE (SOLAR-B: 2006-)
Visible, EUV, and X-ray observations covering the entire solar atmospheres from the photosphere through the corona.

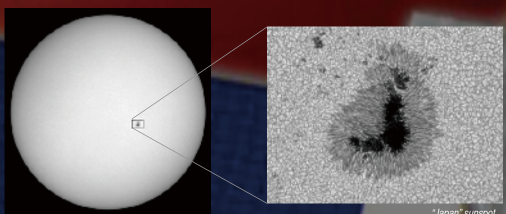
HINOTORI (ASTRO-A: 1981-1982)
Hard X-ray and γ-ray observations of high energy plasma produced by solar flares.



YOHKOH (SOLAR-A: 1991-2001)
Soft and hard X-ray observations provided pieces of evidence of "magnetic reconnection" as the energy converter of flares.

Microscopic Observations of the Sun

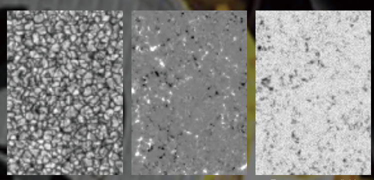
The Solar Optical Telescope (SOT) onboard HINODE provides continuous observations of the Sun's surface with unprecedented resolution free from the influence of the Earth's atmosphere, which allows us to study how magnetic fields emerge and evolve on the surface, and how they give rise to magnetic structures like a sunspot.



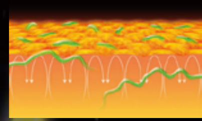
"Japan" sunspot

Ubiquitous Horizontal Magnetic Fields

HINODE discovered a new type of magnetic fields covering the Sun thanks to its high polarimetric sensitivity. These magnetic fields are called Transient Horizontal Magnetic Fields, and their properties are completely different from those of sunspots. Because total magnetic energies carried by the fields are enormous, the fields may play a crucial role in heating and acceleration in the outer atmosphere.



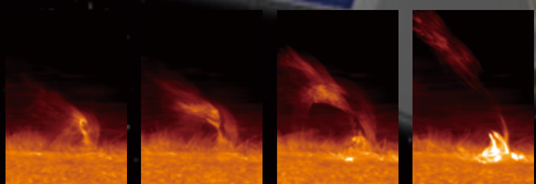
Continuum intensity / Longitudinal mag. field / Transverse mag. field



Artist's view of solar convection (granules) and horizontal magnetic fields.

Plasma Ejections in the Chromosphere

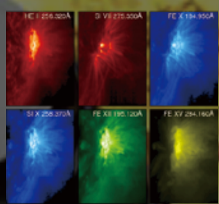
The chromosphere is the interface atmospheric layer between the photosphere and the corona. HINODE has detected plasma ejections over various spatial and temporal scales in the chromosphere. It has also witnessed signatures of magneto-hydrodynamic waves there. These phenomena are essential to understand how the magnetic energy is liberated and transferred in the solar atmosphere.

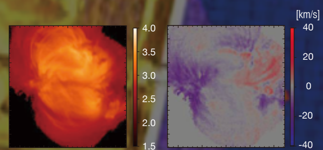


Dynamic plasma ejection in the chromosphere

Structures and Flows in the Corona

For understanding the physics of coronal heating and solar wind acceleration, it is crucial to measure temperatures, densities, and velocities using spectroscopic observations of emission lines from coronal plasma in the extreme-UV (EUV). HINODE discovered upflows near the roots of coronal loops for the first time, which indicate there are sources of heating and acceleration near the base of the corona.



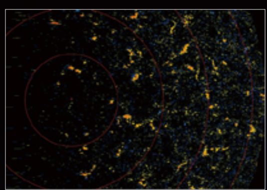


Intensities and Doppler shifts in an active region corona

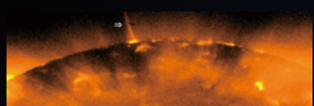
Active region corona seen in various EUV emission lines

Sun's Pole

Magnetic configuration of the Sun's poles was poorly observed so far because of projection shortening in spite of its importance in acceleration of high-speed solar winds. HINODE found polar fields consisting of magnetic patches of kilogauss field concentration. There are also field emergences taking place frequently in the polar regions, which produce bright points and jets seen in X-rays.



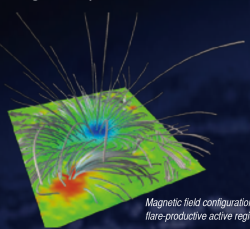
Magnetic landscape of the Sun's pole



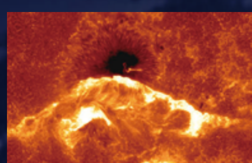
X-ray jet in a polar coronal hole

Origin of Massive Flares

Precise measurements of magnetic fields in the photosphere are a key to understand how enormous magnetic energies are stored and how the energies are suddenly released in a solar flare. Solar flares eventually trigger magnetic storms and aurora activity around the Earth. Solar observations with HINODE have helped progress toward realizing the space weather forecast.



Magnetic field configuration of a flare-productive active region.



Flare ribbons caused by electron beam bombardment of the chromosphere.

Overview of VSOP-2 (ASTRO-G) Project

T. Umemoto, Y. Hagiwara, H. Kobayashi (NAOJ), Y. Murata, M. Tsuboi, Y. Saito (JAXA),
and VSOP-2/ASTRO-G Project Team

ABSTRACT: VSOP-2/ASTRO-G Project

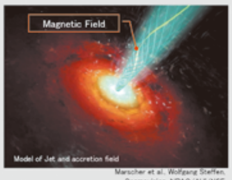
VSOP-2 (VLBI Space Observatory Programme 2) is a successor to VSOP/HALCA in which Japan plays a leading role. The space radio telescope (ASTRO-G) will be launched by Japan Aerospace Exploration Agency (JAXA) and will be operated as a single radio telescope with a 35,000km diameter, combined with ground radio telescopes. VSOP-2 will attain the angular resolution of about 40 micro-arcseconds at 43 GHz, 2,000 times better than the Hubble Space Telescope, and reveal the relativistic phenomena such as jets around super-massive black holes at the centers of galaxies, and the dynamics in galaxies and stars by observations of masers. VSOP-2 project is now proceeding through the cooperation of the National Astronomical Observatory of Japan (NAOJ) and universities and institutes in Japan and all over the world, e.g., Europe, USA, Korea, China, Taiwan. NAOJ is expected to play vital roles in organizing the ground VLBI arrays and upgrading the ground facilities in the east-Asian region, East-Asian VLBI Network (EAVN), and construction and operation of science operation center to maximize science output.

Information of VSOP-2 Project

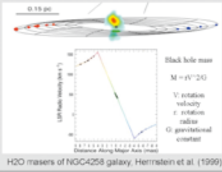
- JAXA/ISAS Space VLBI WG
  http://www.vsop.isas.jaxa.jp/
- NAOJ SpaceVLBI Project
  http://vsop.mtk.nao.ac.jp/vsop2/

VSOP-2 Science Goals

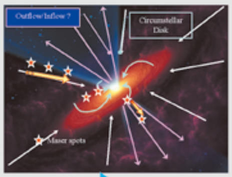
- Imaging of Accretion disks around super-massive black holes
- Imaging of Relativistic Jets from the accretion disks, with the polarization information
- Dynamics in galaxies and stars by observations of cosmic masers

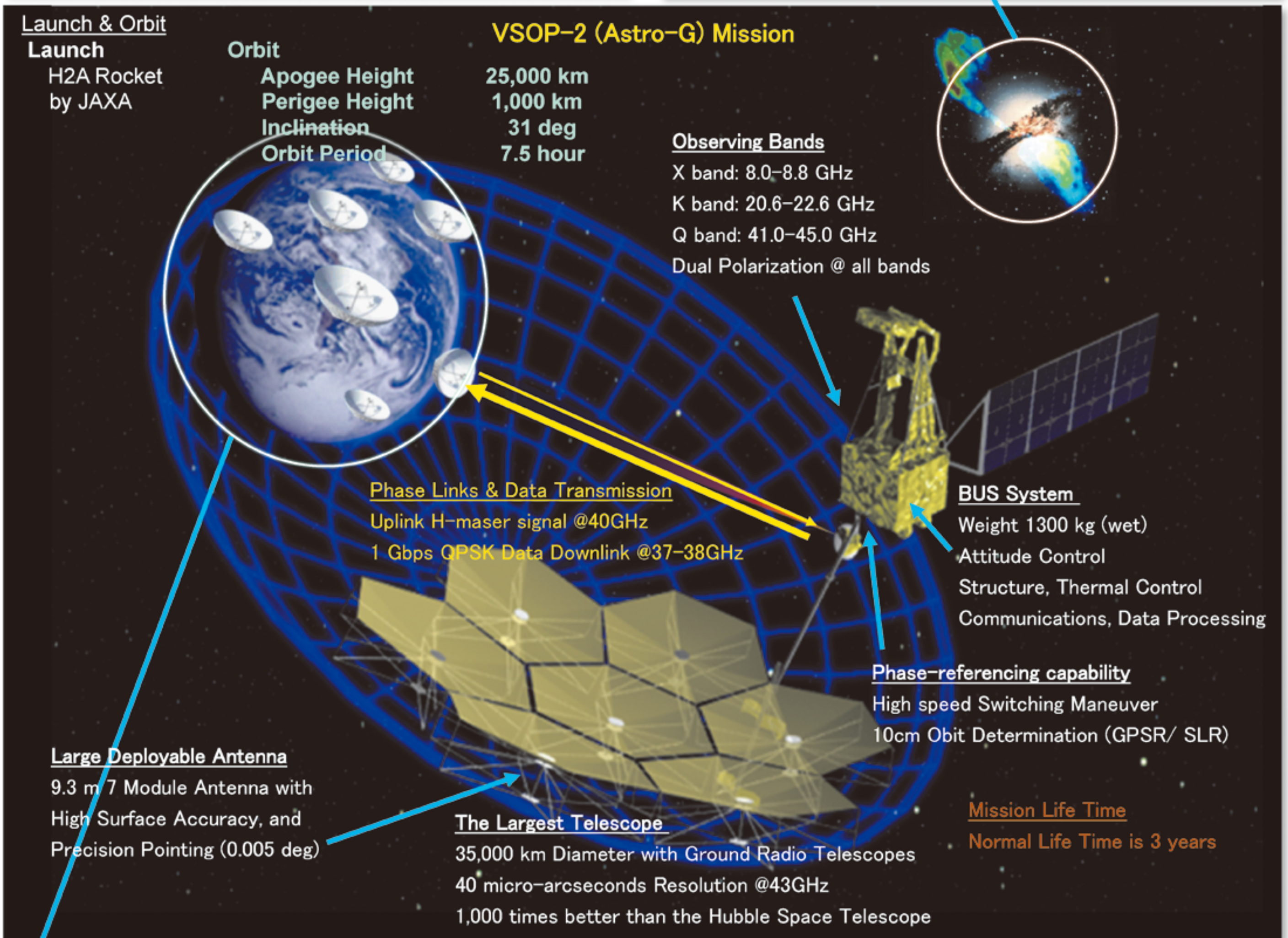


Marscher et al., Wolfgang Steffen, Cosmovision, NRAO/AUI/NSF



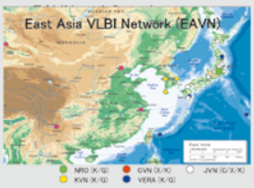
H2O masers of NGC4258 galaxy, Herrnstein et al. (1999)

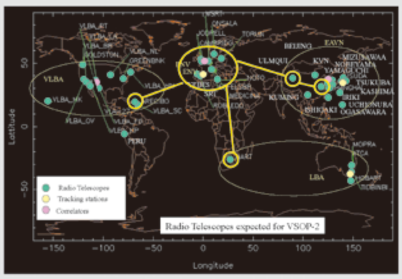




International Collaborations of Ground Facilities

- Ground VLBI Telescopes/Arrays (East Asia VLBI Network, European VLBI Network, etc)
- Tracking Stations (Japan: Usuda, Spain: Yebes, and other)
- Correlators (ex., Korea-Japan Joint VLBI Correlator)
- Role of NAOJ is organization of ground VLBI arrays & update of

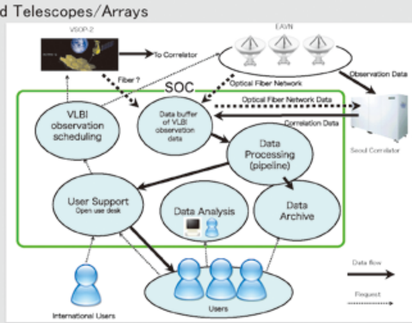




Science Operation Center (SOC) @Mitaka NAOJ

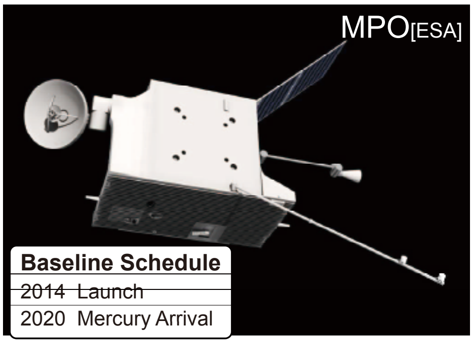
Role of SOC is Point of Contact for VSOP-2 Users

- Scheduling of Space & Ground Telescopes/Arrays
- Open use desk, Announce of Opportunity
- Management & Processing of science data to provide for users (pipeline processing, data archive and database)
- User Support for proposal & data analysis
- Correlator control & support
- Education & public outreach
- International cooperation



BepiColombo: Mission to Mercury

Hajime HAYAKAWA (ISAS/JAXA)
Hironori MAEJIMA (ISAS/JAXA)
BepiColombo Project Team



Baseline Schedule

~~2014 Launch~~

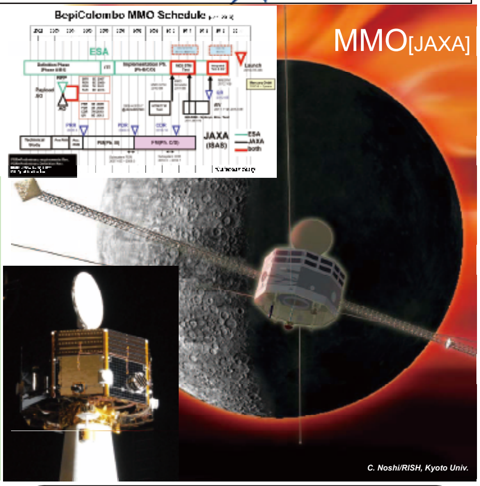
2020 Mercury Arrival

First full-scale Euro-Japan joint mission

Two orbiters (MPO & MMO) will observe Mercury simultaneously with instruments developed by Euro-Japan joint research teams.

MMO（Mercury Magnetospheric Orbiter）
is a spin-stabilized spacecraft. The MMO will study magnetic field, atmosphere, magnetosphere, and inner interplanetary space. Comparison of magnetic field & Magnetosphere with Earth will provide the new vision for space physics.

MPO（Mercury Planetary Orbiter)
is a three-axis stabilized spacecraft. The MPO will study geology, composition, inner structure and the exosphere. Abnormal structure and composition of Mercury will provide the keys for the planetary formation in the inner solar system.



BepiColombo Science Team

Project Scientist: J. Benkhoff (ESA/ESTEC)

MPO Science Sub-Group

[Altimeter]
BELA (Laser Altimeter)
Co-PI: N. Thomas (U. Bern, Switzerland)
T. Spohn (DLR, Germany)

[Radio Science]
ISA (Accelerometer)
PI: V. Iafolla (CNR-IFSI, Italy)
MORE (Ka-band trans.)
PI: L. Iess (Univ. Rome, Italy)
Co-PI: S. Asmar(JPL,USA)

[Magnetic field]
MERMAG (Magnetometer)
PI: K.H. Glassmeier (TU-BS, Germany)
Deputy PI: C.M. Carr (ICL, UK)

[Image & V-NIR Spectrum]
SIMBIO-SYS
PI: E. Flamini (ISA, Italy)
Co-PI: F. Capaccioni (INAF-IASF, Italy)
L. Colangeli (INAF-OAdC, Italy)
G. Cremonese (INAF-OAdP, Italy)
A. Doressoundiram (LESIA, France)
O. Forni (IAS, France)
J. L. Josset (SPACE-X, Switzerland)

[IR]
MERTIS-TIS
PI: E.K. Jessberger (U. Munster, Germany)

[γ & neutron]
MGNS
PI: I. Mitrofanov (IKI, Russia)

[X-ray]
MIXS (spectrometer)
PI: G. Fraser (Univ. Leicester, UK)
Co-PI: K. Muinonen (U. Helsinki, Finland)
SIXS (Solar monitor)
PI: J. Huovelin (Univ. Helsinki, Finland)
Co-PI: M. Grande (RAL, UK)

[UV]
PHEBUS (spectrometer)
PI: E. Chassefiere (SA/IPSL,France)
Co-PI: S. Okano (Tohoku Univ.)
O. Korablev (IKI, Russia)

[Neutral / Ion particles]
SERENA
PI: S. Orsini (CNR-IFSI, Italy)
Co-PI: S. A. Livi (JHU, USA)
S. Barabash (IRF, Sweden)
K. Torkar (SRI, Graz, Austria)

Complete study of 'unknown planet' near the Sun

The innermost planet Mercury was already known in the ancient days, but it was visited only by the Mariner 10 spacecraft 3 decades ago. Mercury is still "unknown" and provides important keys to the solar system sciences.

History of Inner Solar System
Mercury's high density and composition tell us the initial stage of the innermost solar system.

Origin & Structure of Magnetic Field
Why do planets have magnetic field? Mercury provides the first chance to compare the magnetic field with Earth.

Magnetosphere: Similar or Different ?
Mercury's special magnetosphere without thick atmosphere will provide another view of the planetary magnetosphere.

MMO Science Sub-Group

Project Scientist: M. Fujimoto (ISAS/JAXA, Japan)
(Deputy) Y. Kasaba(Tohoku Univ. Japan),
T. Takashima (ISAS/JAXA, Japan)

MGF Magnetic Field Investigation (2 sensors)
studies magnetic field from the planet, magnetosphere, and interplanetary solar wind.
PI: W. Baumjohann (IWF, Austria)
Co-PI: H. Matsuoka (ISAS/JAXA, Japan)
Members: Japan, Austria, Germany, UK, USA

MPPE Mercury Plasma Particle Experiment (7 sensors)
studies plasma & neutral particles from the planet, magnetosphere, and interplanetary solar wind.
PI: Y. Saito (ISAS/JAXA, Japan)
Co-PI: J.-A. Sauvaud (CESR-CNRS, France), M. Hirahara (Rikkyo Univ., Japan),
S. Barabash (IRF, Sweden)
Members: Japan, France, Sweden, UK, Italy, Czech, Belgium, Germany, Switzerland
USA, Taiwan

PWI Plasma Wave Investigation (7 sub-instruments)
studies electric field, electromagnetic waves, and radio waves from magnetosphere and solar wind.
PI: Y. Kasaba (Tohoku Univ., Japan)
Co-PI: J.-L. Bougeret (LESIA, France), L. Blomberg (KTH, Sweden),
H. Kojima (RISH, Kyoto Univ.), S. Yagitani (Kanazawa Univ.)
Members: Japan, France, Sweden, Norway, Finland, Hungary, ESA

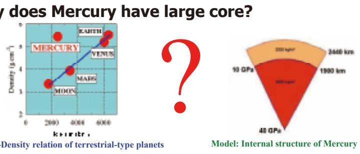
MSASI Sodium Atmosphere Spectral Imager
studies thin sodium atmosphere of Mercury.
PI: I. Yoshikawa (Univ. Tokyo, Japan)
Co-PI: O. Korablev (IKI, Russia)
Members: Japan, Russia, Italy, USA

MDM Mercury Dust Monitor
studies dust from the planet and interplanetary & interstellar space.
PI: K. Nogami (Dokkyo Univ., Japan)
Members: Japan, Germany

Science

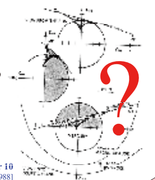
Magnetic Field & Internal structure

Internal structure
What does internal structure look like?
Why does Mercury have large core?

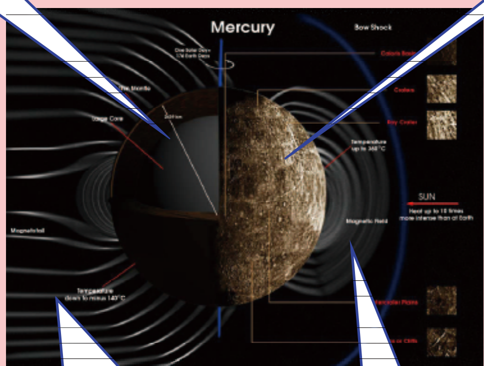


Fact: Radius-Density relation of terrestrial-type planets
Model: Internal structure of Mercury

Magnetic field
Structure: Dipole or Multi-pole?
Origin: Dynamo or Crust?

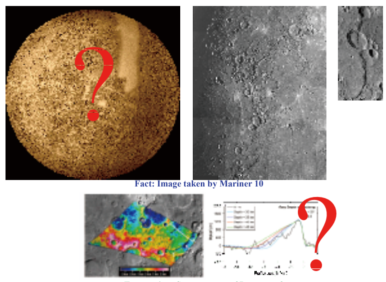


Fact: Magnetic field observation at 3rd Flyby of Mariner 10 [Connerney and Ness, 1988]



Surface

Structure & Composition
When and how did the crust form?
Unknown region: Ice on the pole? Volcano?

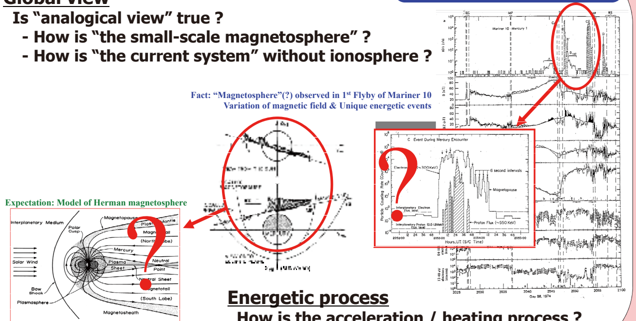


Fact: Image taken by Mariner 10
Expectation: Spectroscopy of Lunar surface

Surface / Exosphere / Magnetosphere / Heliosphere interactions
How are the relationship between them through photon, fields, particles, dusts, etc.?

Magnetosphere & Inner Heliosphere

Global view
Is "analogical view" true ?
- How is "the small-scale magnetosphere" ?
- How is "the current system" without ionosphere ?

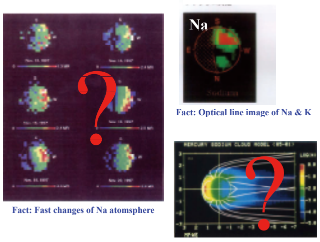


Fact: "Magnetosphere"(?) observed in 1st Flyby of Mariner 10
Variation of magnetic field & Unique energetic events
Expectation: Model of Herman magnetosphere

Energetic process
How is the acceleration / heating process ?
How is the scale effects?

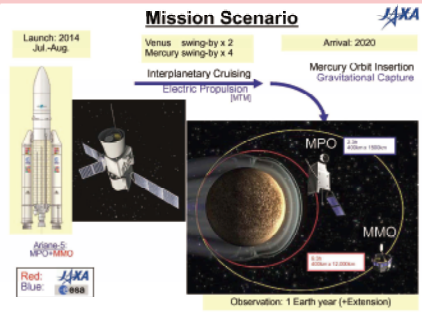
Exosphere

Structure & Composition
What is the origin ?
How and why is the fast variability ?



Fact: Optical line image of Na & K
Fact: Fast changes of Na atomsphere
Expectation: Spatial distribution of Na

Mission Scenario



JAXA/BepiColombo Project Office: http://www.stp.isas.jaxa.jp/mercury/

The Next-Generation Infrared Astronomy Mission

SPICA

Space Infrared Telescope for Cosmology and Astrophysics

Takao Nakagawa (JAXA) and SPICA Pre-project Team

SPICA Specifications

•Mission Goals	Revealing the origins of planets and galaxies with observation of high sensitivity and resolution in mid- to far-infrared regions
•Telescope dia.	3-m class (3.5m in the current design)
•Telescope temp.	<6K(－268℃)
•Total mass	～4t
•Orbit	Halo orbit around libration point S-E L_2
•Launch year	2018 (target)

SPICA Telescope

SPICA is a next-generation infrared astronomy mission. With its cooled (<6K) large (3-m class) telescope, **SPICA** will be able to achieve superior sensitivity and high spatial resolution.

SPICA, a Cool Mission !

Warm telescopes (≫20 K) on other missions emit infrared radiation much stronger than astronomical diffuse radiation. This self-emitted infrared radiation hinders high-sensitivity infrared observations .
With a cryogenically-cooled (< 6K), large (3-m class) telescope on **SPICA**, self-emitted infrared radiation is reduced by a factor of a million, and SPICA is expected to achieve superior sensitivity (2 orders of magnitude of improvement). **SPICA** employs a completely new cooling system, which

Europe-Japan Collaborative Mission

SPICA is planned based on the scientific heritage of previous infrared missions. It is a JAXA-led mission with essential contributions from ESA and a European consortium. Other international collaborations are also under discussion.

Recent Progress

•Since **SPICA** pre-project team was officially established in July, 2008, technical reviews and development for the mission have been underway.
•European participation in SPICA under the framework of ESA Cosmic Vision was proposed in June 2007, and SPICA was selected as a future candidate mission in October, 2007. Following this, European team has been conducting full assessment study.
•The communit-based SPICA Task Force was organized in 2008 in the aim of incorporating opinions of the Japanese communities into the project. Since then STF has been a forum for active discussions on the project, mainly on science matter.

JAXA
esa

STATUS OF CHINA SPALLATION NEUTRON SOURCE (CSNS)

中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

CSNS Team

The China Spallation Neutron Source (CSNS) facility is designed to provide multidisciplinary platforms for scientific research. The site of CSNS has been selected at Dongguan, Guangdong Province. In the Phase I of the project, the facility comprises an 80-MeV H^- linac, a 1.6-GeV proton rapid cycling synchrotron (RCS), beam transport lines, a solid tungsten target station, and 3 initial instruments for the pulsed spallation neutron applications. The RCS provides a beam power of 100 kW with a repetition rate of 25 Hz. The beam power can be further increased to 200 kW in the Phase II. A series of R&D for major components have being performed since 2006. The project design proposal was approved by the Chinese central government in September 2008. The preliminary site geological survey has been completed. The groundbreaking is planned in 2010.

Key Milestones

Feb. 2001	idea of CSNS discussed
Jun. 2005	project proposal approved in principle by central government
Jan. 2006	CAS funded (30M CNY) for R&D 1
Jul. 2007	Guangdong funded (40M CNY) for R&D 2
Dec. 2007	project proposal review
Sep. 2008	project proposal approved by central government
Oct. 2009	project feasibility study review
May 2010	expect to start project construction (ground breaking)

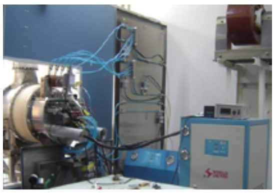
Schedule

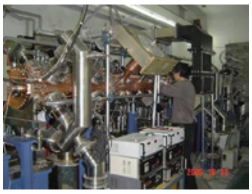
Prototyping R&D	Jan. 2006 – Jul. 2010
Construction start	May 2010
Civil construction	May 2010 – May 2013
Component fabrication	May 2010 – May 2014
Installation & tests	Jan. 2013 – Jan. 2015
Integrated system commissioning	May 2014 – Nov. 2015
1st beam on target	Nov. 2015
Project complete/operation start	Nov. 2016

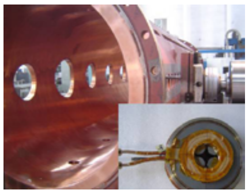
Design Goal

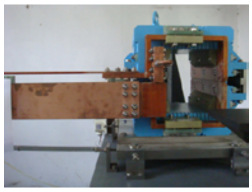
Beam power (kW)	Repetition rate (Hz)	Beam current (μA)	Energy (GeV)	Max neutron flux* ($n/cm^2/s$)	Number of instruments
100	25	63	1.6	10^6	3

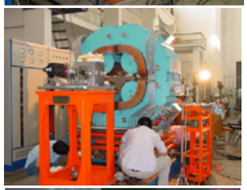
R&D and prototyping work has been carried out since 2006. Over 30 prototyping items (covering most key technologies) have been completed and in the test process.

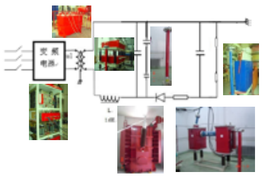

H^- ion source

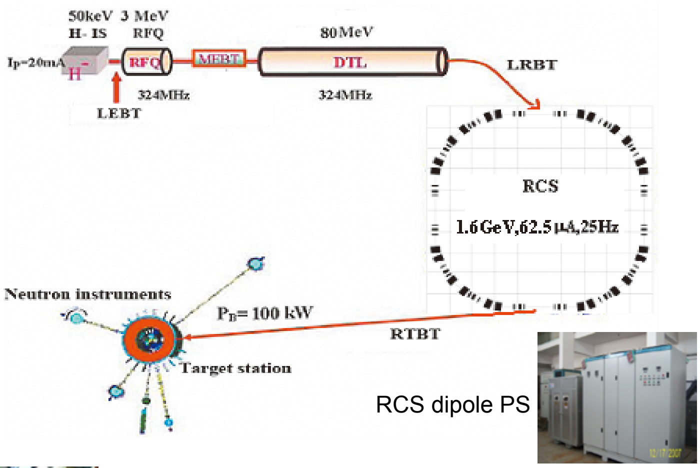

RFQ


DTL


Injection bumper

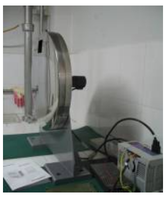


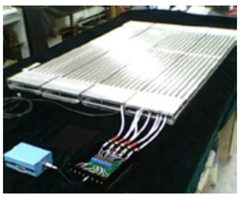

Linac RF




Target mockup test stand

RCS dipole PS


Chopper


^{3}He Neutron Detector


Extraction kicker and PS


RCS RF cavity

China Advanced Research Reactor

The China Advanced Research Reactor (CARR) at China Institute of Atomic Energy (CIAE) is expected to become critical in 2010, which is a tank-in-pool inverse neutron trap type reactor equipped with a liquid hydrogen cold source.

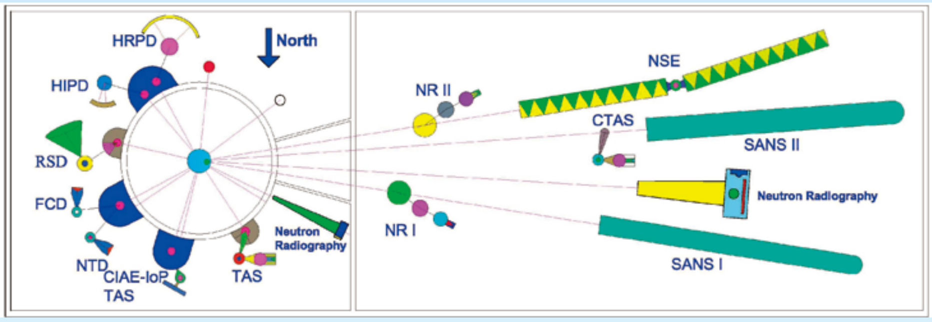
Key Parameters of CARR

Power (MW)	60
Max undisturbed thermal neutron flux ($n \cdot cm^{-2} \cdot s^{-1}$)	8×10^{14} (at heavy-water reflector)
horizontal beam tubes	9
vertical channels	25
U^{235} enrichment/ (wt%)	19.75

Multipurpose Research Reactor

□Neutron scattering---*the major research program at CARR.*

1) Instrument:



Layout of Experimental Channels

PHASE I (under construction):		PHASE II (future):
Diffractometer	Industrial Application	NSE Spin Echo Spectrometer
HRPD/HIPD Powder diffractometer	RSD Residual stress diffractometer	CTAS Cold triple-axis spectrometer
FCD Four-circle diffractometer	NTD Texture diffractometer	BS Backscattering spectrometer
Large-scale structure diffractometer	Neutron imaging	
SANS Small-angle neutron scattering	Spectrometer	
NR Neutron reflectometer	TAS Triple-axis spectrometer	

2) Sample environment (under construction): top loading CCR (0-500K), high temperature furnace(0-1600℃), magnet(0-300K,7 T) and high pressure (200MPa)

□Radioisotopes production

Vertical channels with different diameters and different neutron flux levels and the automatic and processing transportation systems can be used for production of radio-isotopes in industrial scale.

□Neutron transmutation doping (NTD) silicon

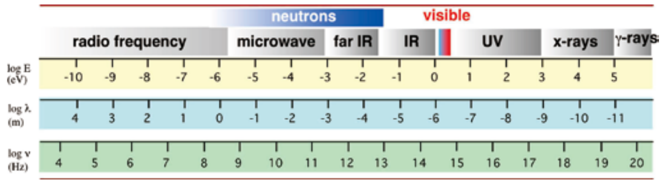
□Neutron activation analysis (NAA) etc

NAA will reach the sensitivity up to $10^{-6} \sim 10^{-9}$ gram for most chemical elements.

中国原子能科学研究院
CHINA INSTITUTE OF ATOMIC ENERGY

Neutron Instruments for Fundamental Scientific Research at China Advanced Research Reactor (CARR)

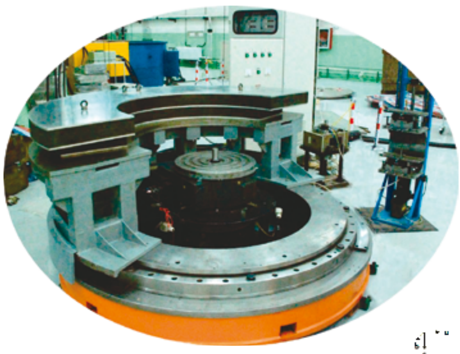
The neutron can be a particle or a wave compared to electromagnetic spectrum.

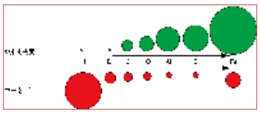


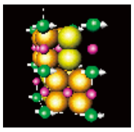
The neutrons beam features the ***wavelength*** comparable with the interatomic distance in crystals and sensitive to different isotopes that neutrons can be used to yield the information about the crystal structures and atomic positions. Apart from that, neutron has a magnetic moment that undergoes a dipole-dipole interaction with magnetic moments of unpaired electrons and can be used to determine magnetic structures. THAT is famous "WHERE ARE THEY?"

In CARR, both a high resolution powder diffractometer and four circle diffractometer will be built to involve in crystal and magnetic structure research.

High Resolution Powder Diffractometer

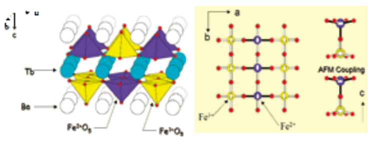






Instrument details:

Resolution: $\Delta d/d=2\times10^{-3}$
Flux at sample position: $>10^{6}$n/cm^{2}·s
Monochromator: Vertical focusing Ge(115)
Monochromator take-off angle: 120º
Wavelength: 1.886Å
Collimation: C1: 10´,20´,open; C2: 40´; C3: 10´
Detectors: 64 ^{3}He
Monochromator to Sample distance: 2.4m
Sample to detector distance: 0.94m

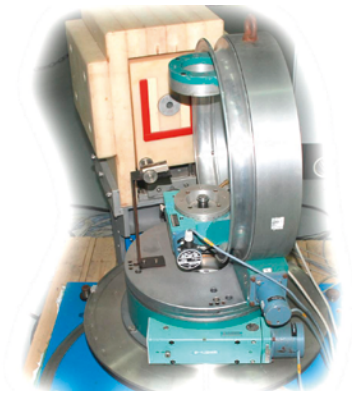


Crystal structure and magnetic structure of $TbBaFe_2O_5$

The HRPD is designed and constructed completely by CIAE staff and all the instrument components are ready for installation. The instrument is planned to be assembled around April of 2010 and expected to be put into service next half of 2010.

CARR welcomes your involvement as neutron users, scientific collaborations, or instrumentation co-developers. Neutron Scattering Laboratory will seek advice from international experts in the field of neutron scattering on user programs, operation safety, and instrument upgrade.

Four Circle Neutron Diffractometer



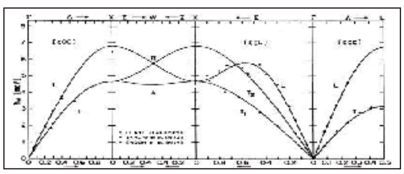
Instrument details:

Beam size: 40mm×100mm(H×V)
Flux at sample position: $>10^{6}$n/cm^{2}·s
Monochromator: Cu(220)
Monochromator take-off angle: 40º
Wavelength: 0.87Å
Collimation: 15´,30´,open
Detectors: ^{3}He

The FCD with all the mechanical parts maintained and electronics renewed is relocated from Juelich Center for Neutron Science and expected to work when CARR is critical.

Thermal neutron has the energy comparable to most excitations in condensed matter, which makes neutrons an ideal probe to measure excitations. That is neutron's another ability to yield "**What they are doing?**"

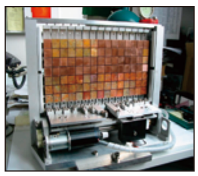
The triple axis spectrometer is the most versatile and useful instrument for use in inelastic scattering for the permission to probe nearly any coordinates in energy and momentum space in a precisely controlled manner.

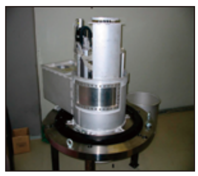


Phonon dispersion curve of Ne

H. Bilz and W. Kress, Phonon Dispersion Relation in Insulators, Springer Verlag, Berlin Heidelberg New-York(1979)

Thermal neutron triple axis spectrometer





Instrument details:

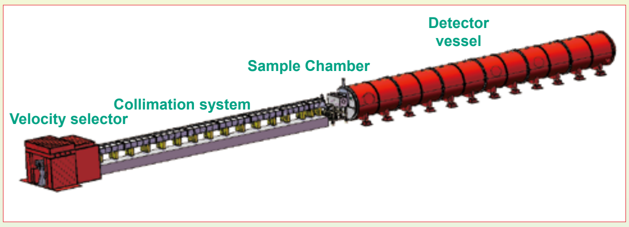
Monochromators: Double focusing PG(002), Cu(200)
Monochromator take-off angle: 13.4°, 20.7°, 37.2°
Incident neutron energy (mev): 5, 14.6, 17.2, 33.9, 49.9, 117
Analyzer: Double focusing PG(002),
Collimation: 20', 40', 60'
Neutron filter: PG, Erbium
Incident beam cross section: 90×140mm^{2}, 90×100mm^{2}, 70×100mm^{2}

Neutron Reflectometer and SANS Instrument at CARR

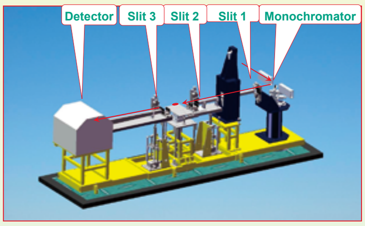
A vertical scattering geometry neutron reflectometer (NR) and a 30m Small Angle Neutron Scattering (SANS) instrument are being built at China Advanced Research Reactor (CARR) by Institute of Chemistry, Chinese Academy of Sciences (ICCAS) and China Institute of Atomic Energy (CIAE). The project is sponsored by Ministry of Science and Technology (MOST) as one part of the "national science & technology infrastructure center".

Both instruments are being installed in the guide hall, which will use cold neutrons transferred by CNGD neutron guide from the reactor, as shown in the following pictures.

Three-dimensional design of SANS



Three-dimensional design of NR



In the 30m x.60m guide hall, three neutron guides CNGA,CNGB and CNGD have been installed. The SANS and NR will be the first two cold neutron instruments there.

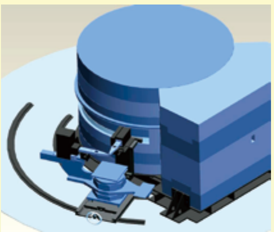
At present, the installation is almost done and the instruments are being adjusted with their motion and control systems. The instruments will be open to both domestic and international users in the near future.

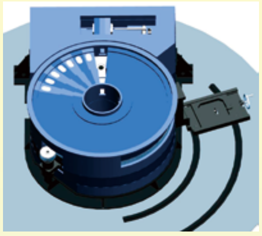
SANS instrument Specifications:
Beam cross section: 50 mm×50 mm
Monochromator: mechanical velocity selector
Wavelength Range: λ=4.0 -20.0 Å, Δλ/λ =10% to 22%
Source-to-Sample Distance : 4 to 16 m
Sample-to-Detector Distance:1.0 to 15 m
Collimation: Circular pinhole collimation or focusing lenses
Sample Size:Φ5 mm to Φ25 mm
Q-range:0.0008 to 0.7 $Å^{-1}$
Size Regime:10 to 5000 Å

Neutron reflectometer Specifications:
Vertical scattering geometry
Monochromator: pyrolytic graphite
Incident neutron wavelength : λ = 4.75 Å, Δλ/λ ~ 2 %
Beam size: 0.01 mm x 50 mm to 30mm x 50 mm
Q range: 0.003 ~ 0.4 $Å^{-1}$
Q resolution: Variable with slits from .02 to .15 Δ Q/Q
Monochromator-to-sample distance: 2m
Sample-to-detector distance : 2m
Sub Å thickness resolution

NR and SANS are very useful in studies on structures on the scale of 1 to several 100 nanometers. Due to the unique properties of neutron, these techniques play important roles in a wide research fields ranging from polymers and colloids to biological structure. While SANS is powerful in measuring structures in solution or in the solid state, NR is dedicated to structures in very thin films or at surfaces/interfaces.

Industrial Applications of Neutron Residual Stress, Texture and Imaging Techniques





The Specification of Residual Stress Diffractometer

Monochromator: Double focusing Si(311); Cu(220)

Take off angle: 41°～109°

Wavelength: 0.895 Å ～ 2.666Å

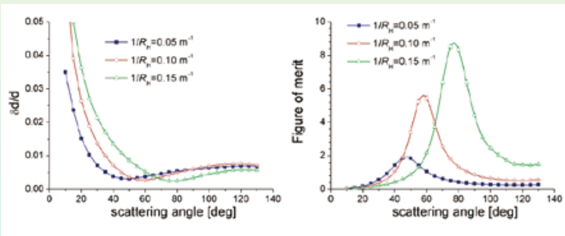
Detector: ORDELA 1128N

Monochromator to Sample: 190 cm ～ 220 cm

Sample to Detector: 60 cm ～ 110 cm

Sample table: 200 kg load capacity

Relative resolution of the diffractometer when wavelength is 1.76Å



$2\theta_M=65°$, $\lambda=1.76$ Å

Studying residual stresses due to manufacturing processes such as welding, heat treatment, casting, coldworking and etc.

The Specification of Neutron Texture Diffractometer

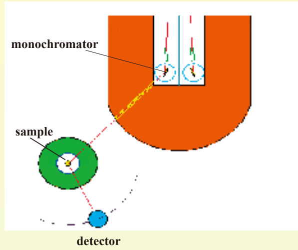
Collimator：10′，30′，open

Monochromator：Cu（200）

Take off angle：40º

Wavelength： 1.24Å

Detector： ^{3}He counter

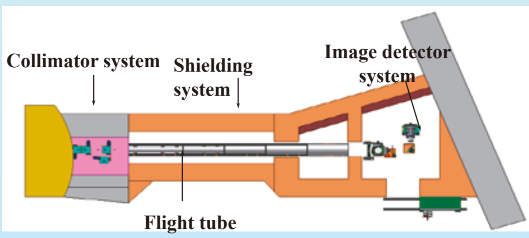


Mainly studying the texture in the industrial materials such as deep-drawing materials, shape memory alloy, tyre wires and second generation high-temperature superconducting wires.

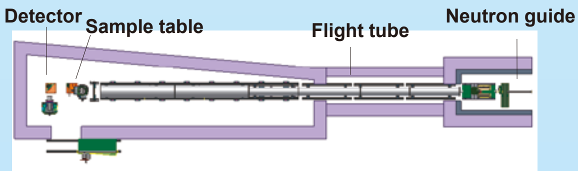
At present, the residual stress and texture diffractometers are being installed in the reactor hall and will be finished at the middle of 2010, then will start to adjust and test their motion and control systems. The instruments will be open to public in the near future.

The conceptional and physical design have been finished for the Thermal and Cold Neutron Imaging Facility, which will be constructed and assembled completely before 2012.

Setup of the Thermal Neutron Imaging Facility



Setup of the Cold Neutron Imaging Facility



Key Designed Parameters of Neutron Imaging Facility

	Thermal	Cold
Aperture D (cm)	4, 2, 1, 0.5	5, 4, 2, 1
Experimental position (cm)	850 and 1140	800 and 1600 (from aperture)
L/D	212~2280	160~1600
Neutron beam (cm²)	22×40.6	30×30
n/γ (n cm^{-2} · mR^{-1})	>1.0×10^{6}	>1.0×10^{6}
Cd-ratio	>100	>100
Desired resolution (mm)	0.15	0.12

The thermal and cold neutron imaging will be widely used in the following fields: nuclear fuel element, two-phase flow, small combustion engine, plants, fuel cells, concrete etc.

NEUTRON SCATTERING RESEARCH IN INDIA

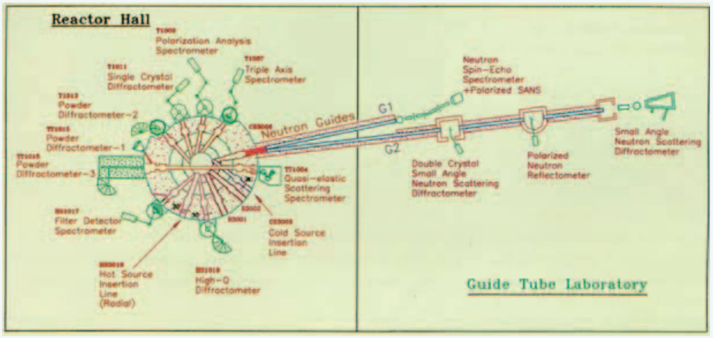
S.L. Chaplot and R. Mukhopadhyay

Solid State Physics Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400085, INDIA

The National Facility for Neutron Beam Research is regularly utilized in collaboration with about 200 users from universities and other academic institutions.

There are at present 30 universities' projects running under the aegis of UGC-DAE CSR. School/Workshops are arranged regularly since 1990 for awareness of neutron scattering.

In addition, India has contributed to significant international cooperation (through IAEA-RCA and others) involving supply of neutron spectrometers and research collaboration with major neutron scattering laboratories abroad.



Experimental Facilities at Dhruva Reactor

Facility includes

Diffraction (Structure)

- **Small-angle scattering** (large molecules, thin films)
- **Wide-angle scattering** (crystals, strain distribution)
- **Very-large angle scattering** (glasses, liquids)
- **Reflectometry** (surfaces, interfaces, thin films)
- **Neutron polarization analysis**

Spectroscopy (Dynamics)

- **Inelastic scattering**
- **Quasielastic scattering**

- **Fundamental Quantum Physics - Neutron Optics**
- **Neutron Imaging - Tomography/Radiography**

Neutron Beam Research

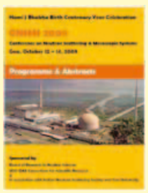
Structure, Dynamics and Magnetism of a wide variety of materials have been investigated.

- **Technological and industrial materials**: Magnetic materials, High-T_c superconductors, Macro emulsion, Ferrofluids, Polymers, Maraging steel, Cement, Catalysts, Negative Thermal Expansion Materials, Nanomaterials, Porous Materials, Minerals etc
- **Amorphous & glassy systems**: Phosphate glasses, Ge-Se glasses, Hydrogen bonding in deuterated alcohol.
- **Thin Films and Multilayers**: Magnetic moment density in semiconductor - metal multilayers, surface morphology of metallic thin films.
- **Applied work**: Neutron radiography of two phase coolant flow in coolant channels and Zirconium hydride blisters.
- **Fundamental Physics**: First neutronic observation of non-cyclic phases, First neutron interferrometric separation of Geometric and Dynamical phases.

Recent Schools and International Conferences in India

International Symposium on Neutron Scattering held at BARC, Mumbai, January 15-18, 2008.

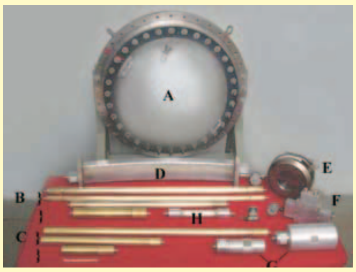
School and Conference on Neutron Scattering & Mesoscopic Systems held at Mumbai and Goa, October 5-14, 2009



Neutron Beam Instrumentation

- In-house development of neutron spectrometers.
- Self reliance in design and fabrication, control and data acquisition systems, etc.
- Development of neutron detectors.
- Novel technologies for beam tailoring.
- International Collaboration with Rutherford Appleton Laboratory, UK at the spallation neutron source ISIS. Contribution towards IRIS and OSIRIS spectrometers.
- Several instruments exported to Korea, Indonesia, Phillipines and Bangladesh through the aegis of IAEA.

Development of various Detectors



A : 2-D PSD for neutrons
B : 1-D PSD for neutrons
C : Neutron Proportional Counters,
D : 1-D Curvilinear PSD for neutrons
E : 2-D PSD for x-ray
F : Microstrip Detector for x-rays and neutrons
G : X-ray Proportional counters
H : 1-D PSD for x-ray

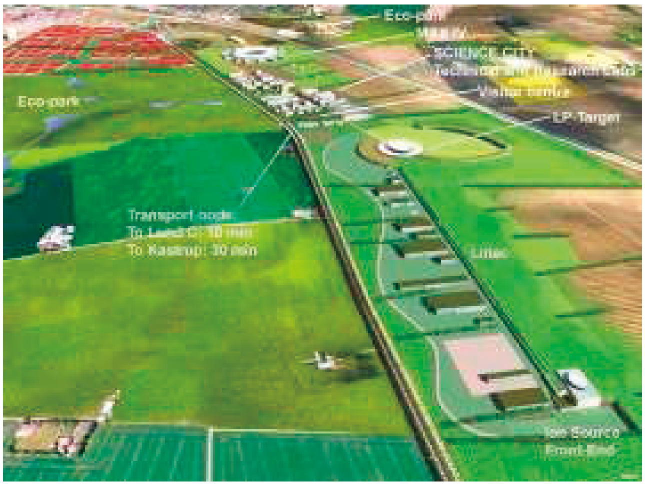
International Collaboration

- Tripartite agreement between India, Philippines and IAEA during sixties (RCA-IAEA). Later, India collaborated with Korea, Indonesia, Bangladesh and other countries.
- Neutron instruments built in BARC were installed and used in some of these countries. Asian collaborative programs with BARC have been supported by IAEA.
- BARC has been collaborating with ISIS facility, Rutherford Appleton Laboratory, UK since early Eighties. We have been a regular user of the ISIS facility for carrying out neutron experiments since 1985.
- Researchers from India availed advanced sources at UK, USA, Germany, France, Switzerland, Japan and other countries to carry out front line research.

The European Spallation Source Project

F. Mezei [1] for the ESS Collaboration, Lund, Sweden
[1]Hungarian Academy of Sciences, SzFKI, Budapest, Hungary

ESS is the next generation European neutron source, to be built at Lund in Sweden. It entered its pre-construction phase as a Collaboration of by now 14 countries: Denmark, Estonia, France, Germany, Hungary, Iceland, Italy, Latvia, Lithuania, Norway, Poland, Spain, Sweden and Switzerland.



Artists conception of ESS on a green field site outside the university town Lund. It will consist of a linear proton accelerator, a target station as the neutron beam source and a host of neutron scattering instruments at 15 – 100 m distance from the target.

Pulsed Spallation Sources: the most energy/costs efficient way to produce neutron beam

40 MeV proton beam energy per fast neutron produced (cf. 190 MeV for fission in conventional reactors)

Equally efficient slowing down of MeV neutrons to the sub-eV range for neutron scattering research

Pulsed sources produce monochromatic neutrons at the instruments at any instant of time, due to the energy dependent neutron flight times (principal neutron velocity range 200 – 2000 m/s)

Most powerful neutron sources today:
ILL (Gernoble, France: 58 MW reactor)
SNS (Oak Ridge, US: 1.4 MW pulsed spallation s.)
J-PARC (Tokai, Japan: 0.5 MW pulsed spallation s.)

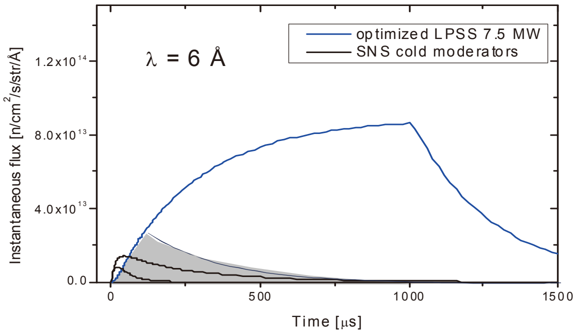
ESS: new concept in pulsed spallation source design for increased beam power at lower costs

Conventional short pulse spallation sources:
~1 μs proton pulses → ring accelerator needed, very high instantaneous power on target (~ 10 GW)

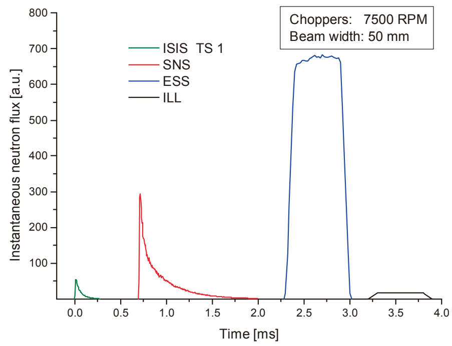
New concept: LONG PULSE Spallation Source:
~1 ms long proton pulses can deliver 10 times more protons (i.e. neutrons) per pulse at 100 times less instantaneous power on target

Simplified accelerator and target system :
- only linear accelerator is needed
- higher neutron beam performance at comparable costs and technical challenges
- 5 MW (and more) proton beam power feasible

Compared to the conventional short pulse spallation sources, here SNS, Oak Ridge, USA, the Long Pulse concept of ESS offers a simplified accelerator system: H^+ linear accelerator without accumulator ring reduces technical challenges (injection, space charge, target fatigue) and offers superior neutron beam performance by more neutrons /pulse.

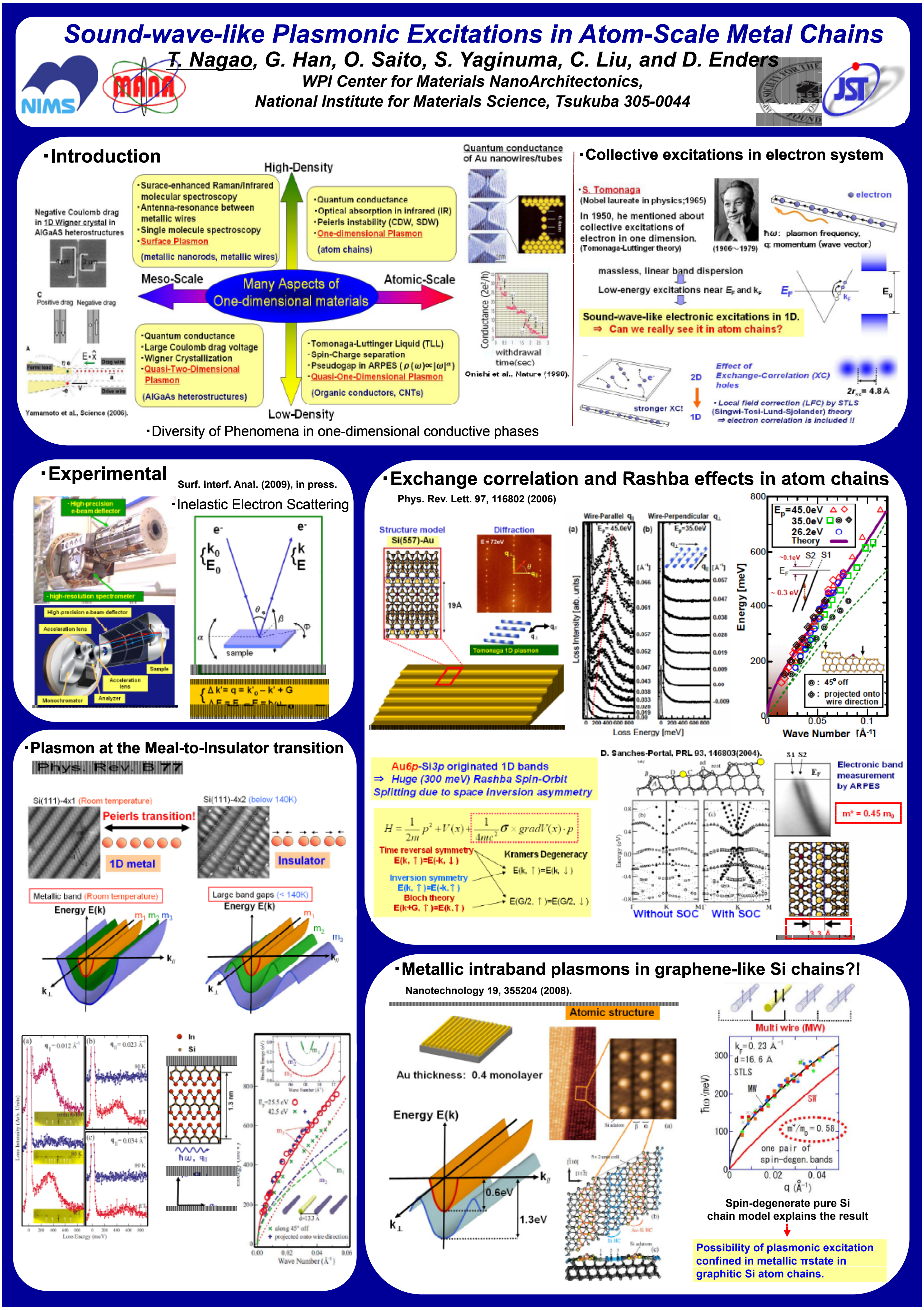


A linac driven long pulse source can emulate with proton pulses of ~ 100 μs duration the slow neutron pulses of a short pulses source (grey area vs. black lines), and produce order of magnitude more neutrons per pulse with higher peak brilliance with proton pulse lengths in the ms range.



Innovative fast rotating mechanical neutron chopper systems allow us to cut out shorter pulses for better definition of the neutron velocity (energy) from the long ESS pulses. The area of the pulses gives in the figure in this example the performance gain of ESS compared to the existing most powerful neutron sources (J-PARC is about equivalent to SNS).

Conclusion: With its innovative Long Pulse approach, using a high power, state-of-the-art linear proton accelerator and novel neutron instrument concepts to shape the neutron pulse lengths to individual user needs, the 5 MW beam power ESS will offer – at comparable costs – an order of magnitude enhanced scientific opportunities relative to existing neutron scattering facilities worldwide.


Sound-wave-like Plasmonic Excitations in Atom-Scale Metal Chains
T. Nagao, G. Han, O. Saito, S. Yaginuma, C. Liu, and D. Enders
WPI Center for Materials NanoArchitectonics,
National Institute for Materials Science, Tsukuba 305-0044
・Introduction
High-Density
Low-Density
Meso-Scale
Atomic-Scale
Many Aspects of One-dimensional materials
・Surace-enhanced Raman/Infrared molecular spectroscopy
・Antenna-resonance between metallic wires
・Single molecule spectroscopy
・Surface Plasmon
(metallic nanorods, metallic wires)
・Quantum conductance
・Optical absorption in infrared (IR)
・Peierls instability (CDW, SDW)
・One-dimensional Plasmon
(atom chains)
・Quantum conductance
・Large Coulomb drag voltage
・Wigner Crystallization
・Quasi-Two-Dimensional Plasmon
(AlGaAs heterostructures)
・Tomonaga-Luttinger Liquid (TLL)
・Spin-Charge separation
・Pseudogap in ARPES
・Quasi-One-Dimensional Plasmon
(Organic conductors, CNTs)
Negative Coulomb drag in 1D Wigner crystal in AlGaAS heterostructures
Yamamoto et al., Science (2006).
Quantum conductance of Au nanowires/tubes
Conductance (2e²/h)
withdrawal time(sec)
Onishi et al., Nature (1998).
・Diversity of Phenomena in one-dimensional conductive phases
・Collective excitations in electron system
・S. Tomonaga
(Nobel laureate in physics;1965)
In 1950, he mentioned about collective excitations of electron in one dimension.
(Tomonaga-Luttinger theory)
(1906～1979)
electron
ħω: plasmon frequency, q: momentum (wave vector)
massless, linear band dispersion
Low-energy excitations near E_F and k_F
Sound-wave-like electronic excitations in 1D.
⇒ Can we really see it in atom chains?
2D
1D
stronger XC!
Effect of Exchange-Correlation (XC) holes
2r_xc = 4.8 Å
・Local field correction (LFC) by STLS (Singwi-Tosi-Lund-Sjolander) theory
⇒ electron correlation is included !!
・Experimental
Surf. Interf. Anal. (2009), in press.
・Inelastic Electron Scattering
High-precision e-beam deflector
high-resolution spectrometer
Acceleration lens
Sample
Monochromator
Analyzer
sample
Δk' = q = k'_0 − k' + G
ΔE = E_0 − E = ħω
・Exchange correlation and Rashba effects in atom chains
Phys. Rev. Lett. 97, 116802 (2006)
Structure model
Si(557)-Au
Diffraction
19Å
Tomonaga 1D plasmon
Wire-Parallel q_∥
Wire-Perpendicular q_⊥
Loss Intensity [arb. units]
Loss Energy [meV]
E_p=45.0eV
35.0eV
26.2eV
Theory
Energy [meV]
Wave Number [Å⁻¹]
45° off
projected onto wire direction
Au6p-Si3p originated 1D bands
⇒ Huge (300 meV) Rashba Spin-Orbit Splitting due to space inversion asymmetry
Time reversal symmetry E(k, ↑)=E(-k, ↓)
Inversion symmetry E(k, ↑)=E(-k, ↑)
Bloch theory E(k+G, ↑)=E(k, ↑)
Kramers Degeneracy
D. Sanches-Portal, PRL 93, 146803(2004).
Without SOC
With SOC
Electronic band measurement by ARPES
m* = 0.45 m_0
・Plasmon at the Meal-to-Insulator transition
Si(111)-4x1 (Room temperature)
Si(111)-4x2 (below 140K)
Peierls transition!
1D metal
Insulator
Metallic band (Room temperature)
Large band gaps (< 140K)
Energy E(k)
Loss Energy (meV)
Wave Number (Å⁻¹)
・Metallic intraband plasmons in graphene-like Si chains?!
Nanotechnology 19, 355204 (2008).
Atomic structure
Au thickness: 0.4 monolayer
Energy E(k)
0.6eV
1.3eV
Multi wire (MW)
k_F=0.23 Å⁻¹
d=16.6 Å
STLS
m*/m_0 = 0.58
one pair of spin-degen. bands
q (Å⁻¹)
Spin-degenerate pure Si chain model explains the result
Possibility of plasmonic excitation confined in metallic π state in graphitic Si atom chains.

MONTE CARLO STUDY OF COLLECTIVE BEHAVIOR OF MAGNETIC NANOPARTICLE SYSTEMS

Tran Nguyen Lan, Tran Hoang Hai

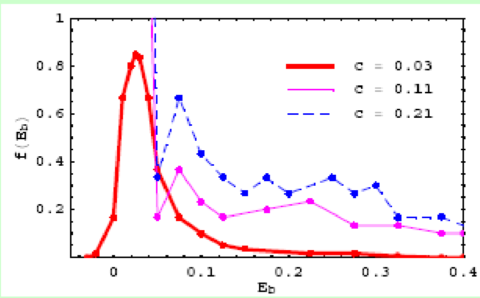
Ho Chi Minh City Institute of Physics, Viet Nam

Energy of Magnetic Nanoparticle Sytems

$$E^{(i)} = -K_u V_i \left(\frac{\boldsymbol{\mu}_i . \mathbf{n}_i}{|\boldsymbol{\mu}_i|} \right)^2 - \boldsymbol{\mu}_i \mathbf{H} + g \sum_{j \neq i}^{N} \left(\frac{\boldsymbol{\mu}_i . \boldsymbol{\mu}_j}{r_{ij}^3} - 3 \frac{(\boldsymbol{\mu}_i . \mathbf{r}_{ij})(\boldsymbol{\mu}_j . \mathbf{r}_{ij})}{r_{ij}^5} \right)$$

The first term in Eq.3 is the anisotropy energy, n_i is the direction of the anisotropy axis, $|n_i| = 1$. The second term is the Zeeman energy, H is the external field. The last time is the dipolar energy between two particles i and j separated by r_{ij}, and constant $g = \mu_0/4\pi$.

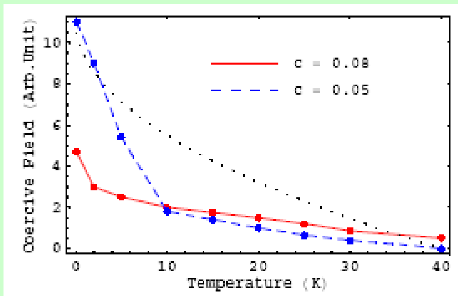
Barrier Distribution



In the dilute sample, the barrier distribution responds to the size distribution, namely log-normal distribution, however, with increasing the concentration, the barrier distribution shifts to the large-energy and the relation disappears and the distribution peaks appears at the lower energy and the high energy tails become longer.

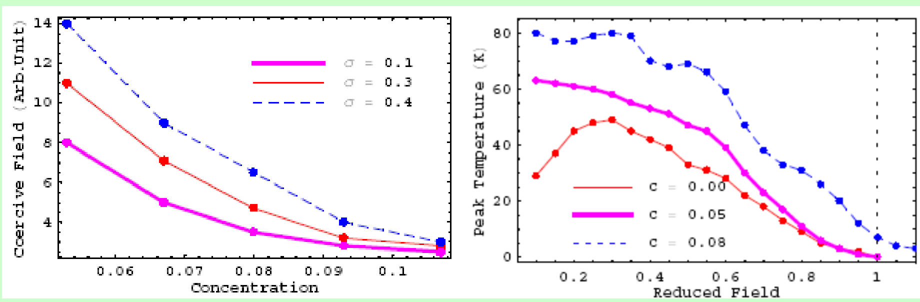
This result has an importance significant to show the role of the size distribution and the dipolar interaction. The size distribution plays dominant role in the non-interacting sample, and with increasing the concentration it is replaced by the dipolar interaction.

Temperature Dependence of Coercive Field



At the low temperature, the coercive fields completely separate, and as saw in Fig.2a, the coercive field decreases along with the increase of the concentration, however, at the certain temperature, about 10 K in our case, the coercive field starts to increase. This temperature is called the glass translation, T_g, or super-ferromagnetic (SFM) translation temperature, T_c. It is worth commenting that the temperature dependence of coercive field does not follow the classical theoretical prediction, $H_c \sim 1 - (T/T_B)^{1/2}$, as represented by dot line. The temperature T_g (T_c) raises as the dipolar interaction is strong, and it can exceed the blocking temperature if the sample is very dense

Collective Behavior At The Low and The High Temperature



The dipolar energy is minimal as the moments parallel together. Therefore, the rotation of a moment can excite the rotation of another. The dipolar interaction deduces the decrease of the coercive field below the translation temperature T_g (or T_c) and the increase of blocking temperature. The field dependence of the peak temperature changes from the bell-like shape to the plateau-like shape as the interacting strength increases. Under the influence of the dipolar interaction, the magnetic nanoparticle system has properties responding to spin glass material at the low temperature and to the multi-domain wall material at the high temperature, however, with the greater properties.

Nanostructured thermoelectric generators

Marisol Martin-Gonzalez and Fernando Briones
IMM-Instituto de Microelectrónica de Madrid (CNM-CSIC), Isaac Newton 8, PTM, E-28760 Tres Cantos, Madrid, Spain.
Email: marisol@imm.cnm.csic.es

Providing a sustainable supply of energy to the world's population will become a major societal problem for the 21st century. Thermoelectric materials, whose combination of thermal, electrical, and semiconducting properties, allows them to convert waste heat into electricity, are expected to play an increasingly important role in meeting the energy challenge of the future. Recent work on the theory of thermoelectric devices has led to the expectation that their performance could be enhanced if the diameter of the wires could be reduced to a point where quantum confinement effects increase charge-carrier mobility (thereby increasing the Seebeck coefficient) and reduce thermal conductivity. The predicted net effect of reducing diameters to the order of tens of nanometers would be to increase efficiency or ZT index by a factor of 3.

Our work in the thermoelectricity has been recently funded by the European ERC program "IDEAS" under ERC contract 240497, granted to Dr. Marisol Martin at IMM-CSIC, and also by a bilateral collaboration (NANO-THERMA) within the Spanish team and a NIMS group in Japan.

Its main objective is to investigate and optimize nanostructures influencing ZT in order to achieve a power conversion efficiency >20%. For that, nanowire arrays of state of art n and p-type semiconductor materials will be prepared by cost-effective mass-production electrochemical methods and fabricate devices with a ZT >2 for applications in energy scavenging and as cooler/heating devices. Three lines of research are followed:

a) determination of the best materials for each temperature range (n and p type) optimizing composition, microstructure, shapes (core/shell nanowires, surface texture, heterostructures), interfaces and orientations,

b) advanced characterization, device development and modeling will be used iteratively during nanostructures and materials optimization, and

c) nano-engineering less conventional thermoelectric like "cage compounds" by electrodeposition methods.

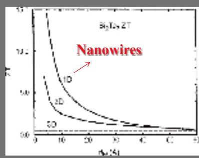
Theory of Low-dimensional Thermoelectrics

$$ZT=\frac{S^2\sigma}{\kappa}T$$

Effects of reduced dimensionality

- Increase in S
  - quantum confinement effect
- Decrease in κ
  - introduction of interphases

Theoretical investigation



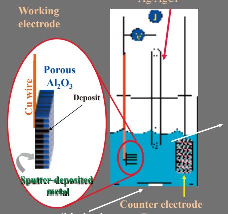
Dependence of $Z_{3D}T$ and $Z_{1D}T$ on quantum-well and quantum-wire widths d_W for bismuth

From L.D. Hicks & M.S. Dresselhaus, MIT

Low dimensionality should improve the properties of thermoelectric materials

Fabrication of Nanowires by electrodeposition

Electrochemical Cell



Nanowire Arrays

Bi_2Te_3

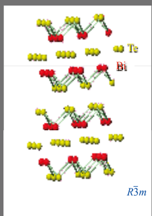
Why?

- Commercially used ZT~1 at 300K

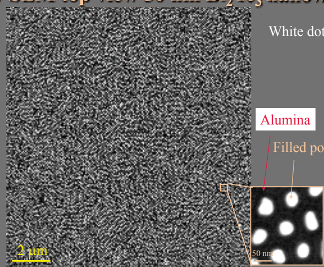
S ≈ -240 μV/K
σ ≈ 10 μΩ•m
κ ≈ 2.02 W/m•K

- It can be electrodeposit (Takahashi *et al.*, 1993)
- Anisotropy

Structure



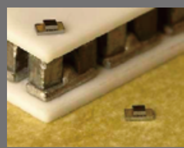
FE-SEM top view 50 nm Bi_2Te_3 nanowire

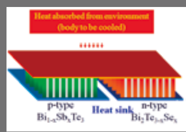


Well ordered, >90% Nucleation

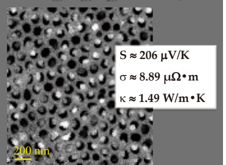
Bi_2Te_3 wires fill the pores completely → wetting effect

Thin film Peltier element.

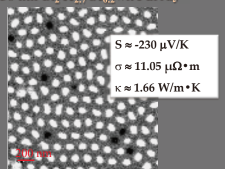




50 nm $Bi_{0.7}Sb_{1.4}Te_{2.9}$ wire array



50 nm $Bi_2Te_{2.7}Se_{0.3}$ wire array



$Bi_{1-x}Sb_x$

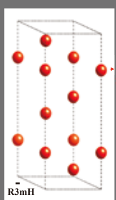
Why?

- Solid solution
- Best low temperature thermoelectric *ZT ~ 0.88 at 12% Sb and 80K*

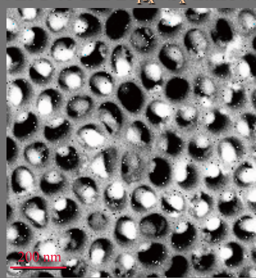
S ≈ -160 μV/K
σ ≈ 1.5 μΩ•m
κ ≈ 2.4 W/m•K

- Calculations by Dresselhaus *et al.* suggest a ZT ~ 1.25-1.5, diameters of ~40 nm, x ~0.13

Structure

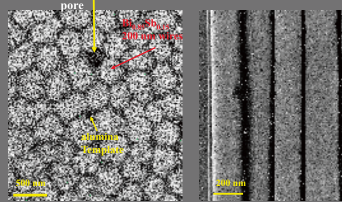


FE-SEM 40 nm $Bi_{1-x}Sb_x$ nanowire array



- The wire diameter is smaller than the pore diameter
- The wire grows concentrically in the pore but does not wet the alumina walls

FE- SEM of 200 nm $Bi_{0.85}Sb_{0.15}$ nanowires



- The pores can be filled by doing the process more slowly but non wetting effects are still observed

$CoSb_3$

Cage Compound

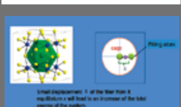
Why?

- Part of the Skutterudite ($CoAs_3$) family
- **ZT ≈ 1.47 at 573K**

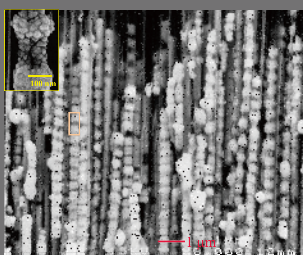
S ≈ 220 μV/K
σ ≈ 10 μΩ•m
κ≈ 3.2 W/m•K

- Separation:
  - electronic structure
  - thermal conductivity
- Isotropic

Rattler type Structure



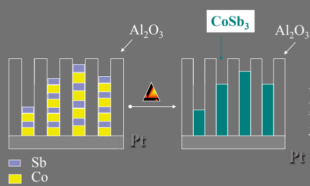
$CoSb_3$: Post-annealed *Morphology*



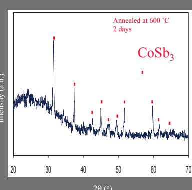
- Co layer wet alumina walls while Sb layer do not.
- There is also a reduction in volume after heating.
- All that gives a very interesting periodic constriction along the length of the wire

$CoSb_3$: Electrodeposition sequence

Multilayer deposition into 200 nm Al_2O_3 templates



XRD



Deposition: 8 to 30 multilayers, 50°C

Conclusions:

➤**Nanowire arrays of thermoelectric materials like Bi_2Te_3, $Bi_{2-x}Sb_xTe_3$ $Bi_2Te_{3-x}Se_x$, $Bi_{1-x}Sb_x$ and $CoSb_3$ have been successfully prepared.**

➤***Because of the "wetting/non-wetting" effects between the porous alumina and the material inside the pore different and technologically interesting nanostructures can be found!!!!***

References::
(a) M.S. Dresselhaus, et al. Microscale Thermophysical Engineering 3 (1999) 89
(b) Martin, C. R., *Adv. Mater.* **1999**, *3*, 457.
(c) Martin, C. R., *Science* **1994**, *266*, 1961.
(d) Amy L. Prieto, Melissa S. Sander, Marisol S. Martín-González, et al. *J. Am. Chem. Soc.*, **123**, 7160 -7161, 2001.
(e) Marisol S. Martín-González, *et al. J. Electrochem. Soc.*, 2002, 149, C546-C554
(f) Marisol S. Martín-González, *et al. Chem. Mater.*, 2003; 15, 1676-1681.
(g) **M.S. Martín-González**, *et al. Adv. Mater.*, 2003, 15, 1003-1006
(h) **M.S. Martín-González**, *et al. Nano Letters.*, 2003, 3, 973-977.
(i) A.L. Prieto, **M.S. Martín-González**, *et al. J. Am. Chem. Soc*, 2003, 125, 2388.
(j) D.-A. Borca-Tasciuc, G. Chen, A. Prieto, **M. S. Martín-González**, *et al. Appl. Phys. Lett.* 2004, 85: 6001-6003

Frequency metrology at NMIJ and possible collaborations with Europe

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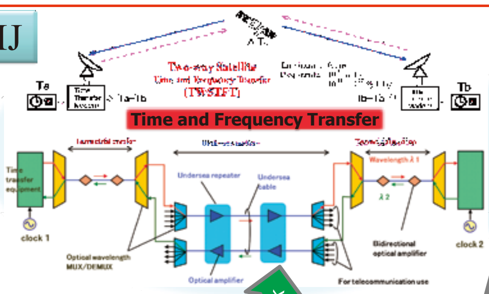
National Institute of Advanced Industrial Science and Technology (AIST), Japan

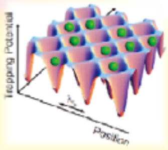
Frequency metrology at NMIJ

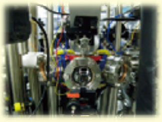


Time and Frequency Transfer

Link

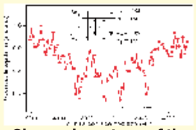
Yb Optical Lattice Clock: A candidate for the next frequency standard



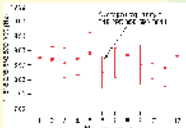


Vacuum chamber for trapping atoms

Ultracold Yb atoms in the MOT



Observed spectrum of the clock transition in ^{171}Yb



Absolute frequency measurement of the clock transition in ^{171}Yb

Source of uncertainty	Bias (Hz)	Uncertainty (Hz)
Blackbody radiation	+1.32	0.13
Gravitation	-1.19	0.03
2nd order Zeeman	+0.4	0.05
Scalar light shift	0	14
Clock laser light shift	-0.04	<0.01
Paper lock error	0	23
UTC(NMIJ)	0	5
Total	+0.49	27

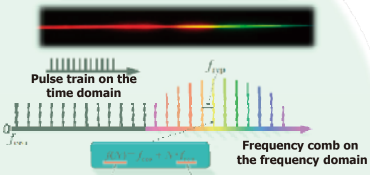
Frequency biases and uncertainties in NMIJ Yb optical lattice clock

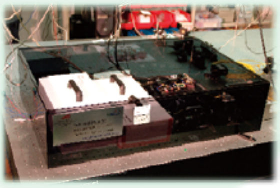
(Very small corrections!)

Our value was listed up in the *Mise en pratique* list of recommended radiations to realize meter (C2-2009).

Link & Interactions

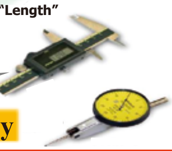
Optical Frequency Comb: Frequency linker between optical and microwave





Japanese National Standard of "Length"

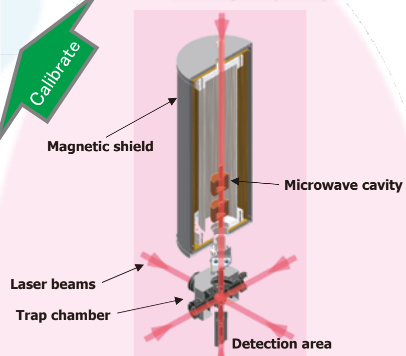
Calibrate

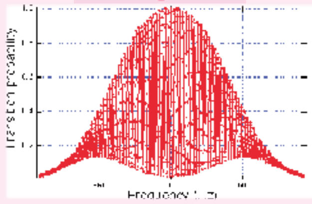


Length metrology

Cs fountain: Primary frequency standard

Calibrate





Ramsey fringe of NMIJ-F1

Source of uncertainty	Bias	Uncertainty
2nd order Zeeman	185	0.5
Black body radiation	-17.8	1.4
Gravitation	1.6	0.1
Cold collisions	0.0	3.3
Distributed Cavity Phase	0.0	1.2
Microwave power dependence	0.0	0.7
Total	168.8	3.9

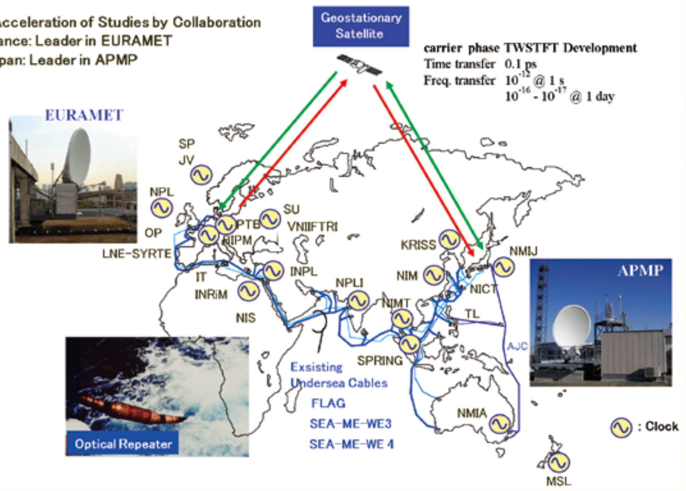
Frequency biases and uncertainties in NMIJ-F1(typical)

Establishment of a global scheme is required to accelerate collaboration between EURAMET and APMP in the frame of the Metre Convention.

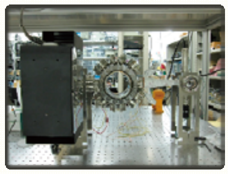
Possible collaboration with Europe (1) Construction of time and frequency transfer system between Europe and Japan

- Global T&F Transfer by Satellites and Undersea Cables
- Acceleration of Studies by Collaboration
  France: Leader in EURAMET
  Japan: Leader in APMP

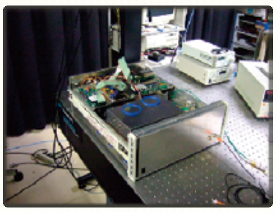
carrier phase TWSTFT Development
Time transfer 0.1 ps
Freq. transfer 10^{-12} @ 1 s
10^{-16} - 10^{-17} @ 1 day



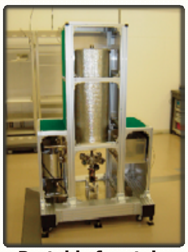
Possible collaboration with Europe (2) International comparison using "portable" standards



Portable optical lattice clock
Intercontinental frequency comparison
Space clock



Portable optical frequency comb
Intercontinental comb comparison



Portable fountain
Intercontinental frequency comparison

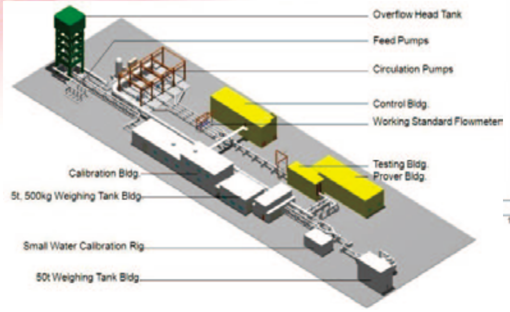
http://www.aist.go.jp AIST NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE AND TECHNOLOGY (AIST)

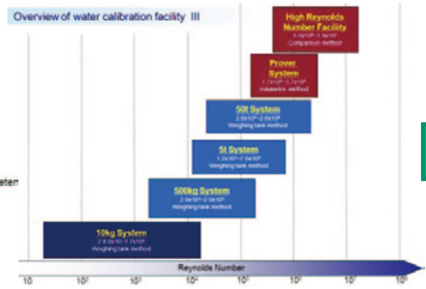
Infrastructure for Flow Metrology Standards and International Collaborations

Yoshiya Terao

National Institute of Advanced Industrial Science and Technology (AIST), Japan

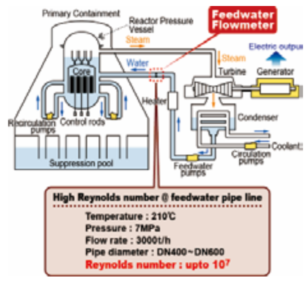
Water Flow



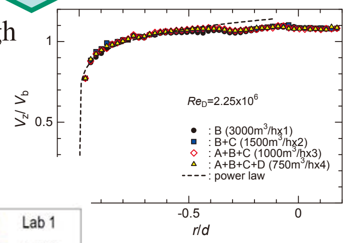


Very wide range of Reynolds number

Power Uprate of Nuclear Power Plant



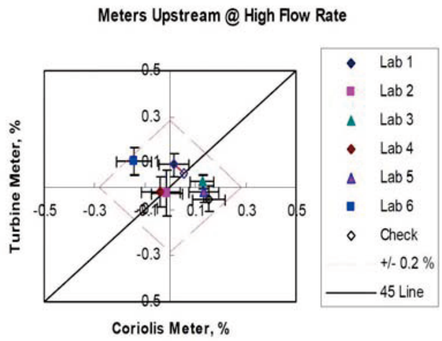
Fluid Dynamics at High Reynolds number

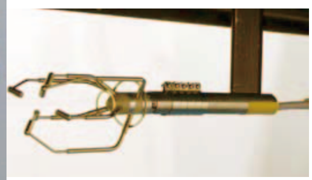


CO_2 Reduction

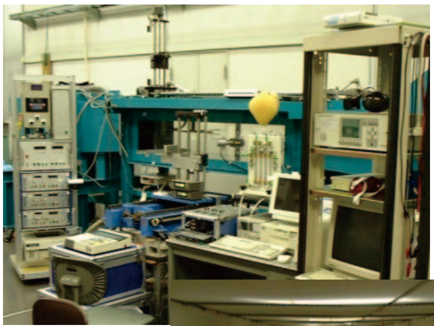
CO_2

International comparison program

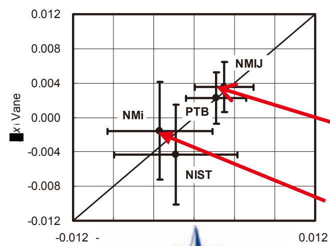




Air Speed



International comparison program



Establishment of Linkage

PTB, Germany

NMi, Netherlands

World Meteorological Organization

Weather • Climate • Water

Environmental Research

GRID COMPUTING AND ITS PROSPECTS FOR MALAYSIAN NUCLEAR PHYSICS & ENGINEERING RESEARCH

Abdul Aziz Mohamed[1], Saliza Hassan[2], Saliza Hassan Wan Mohd Hikam Kauthary Hassan[2], Faridah Md Idris[1], Azraf Azman[1], Megat Harun Al Rashid Megat Ahmad[1], and Julia Abdul Karim[1]

[1] Reactor Interest Group - RIG (Neutron Beam Applications), Malaysia Nuclear Agency, 43000 Kajang, Malaysia.

[2] Grid Computing, MIMOS Berhad, Technology Park Malaysia, 57000 Kuala Lumpur, Malaysia.

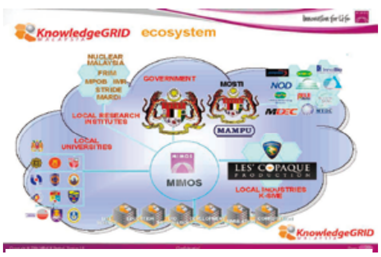
Abstract

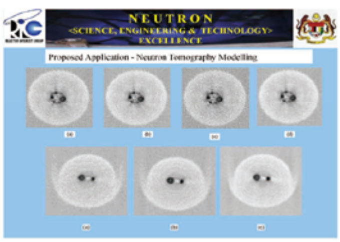
Grid computing in principle provides all the needed facilities, software, hardware, high speed internet, communication interface and secure environment for collaboration of research activities and projects around the scientific and engineering communities. It provides fast compute engine for those engaged in highly technical research projects and business/commercial purposes which are required heavily compute intensive and/or process huge amount of data. Grid computing also offers a possibility of using a very advanced and sophisticated methodologies, simulation models, expert system and treasure of knowledge available around the research and business world under the umbrella of knowledge sharing. Quantum and nuclear researches are expensive and dangerous (i.e. risk of ionizing radiations, hazardous materials, extreme condition such as cryogenic etc.). Thus, grid computing makes possible for quantum and nuclear including related areas of R&D to be designed in the most details and complex configurations. The problems can be modeled and simulated with incorporation of vast information and knowledge available around the globe. It also provides optimal safety prediction and analysis for each new research requirements. This poster describes some issues and beneficial prospects in utilising grid computing power for Malaysian quantum and nuclear physics and engineering research communities in pursuing the related science, engineering and technology, in particular in areas of high-energy physics and quantum science and engineering.

Summary

1)The QuantumGRID has great importance
2)Heterogeneous, supports the joint of different types of clusters and supercomputers
3)Gives a high-performance and high-throughput Grid for the parallel applications as well as sequential modes
4)Software licensing needs to be resolved
5)MIMOS-MOSTI need to provide stable nodes linked to QuantumGRID RIG members

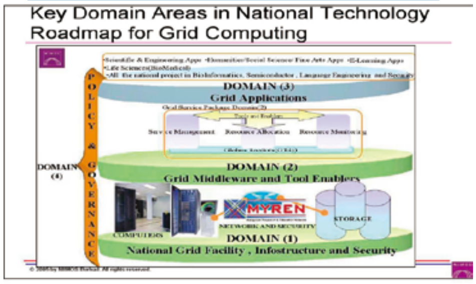
About MIMOS

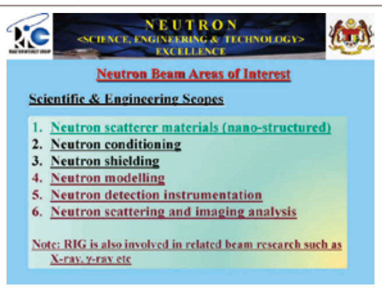


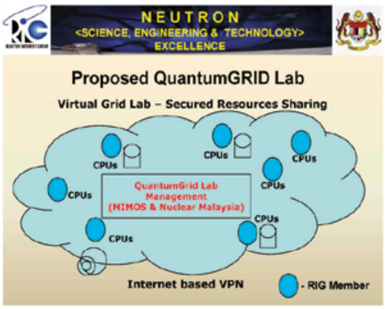


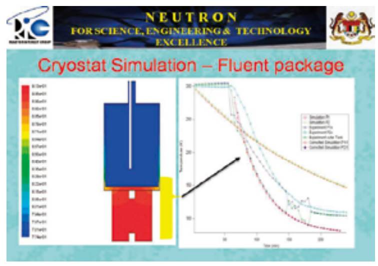
QuantumGRID powered by RIG

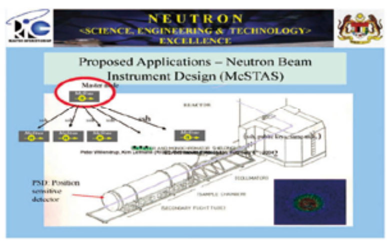
Quantum R&D – Neutron /related rays











Presented at - The First Asia-Europe Physics Summit, Epochal International Congress Center (Tsukuba), March 24-26, 2010

"Physics towards Science Innovations"

Conformational Alphabets in the Study of Protein Structure

Wei-Mou Zheng (zheng@itp.ac.cn, zhengwm@genomics.org.cn)
Institute of Theoretical Physics, Academia Sinica, Beijing, China

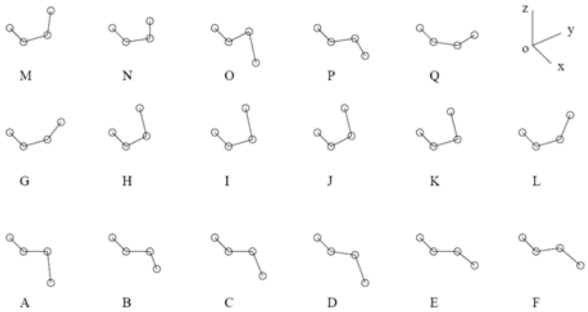
Introduction

Life science, bringing us ever-growing unexplained data, is attracting increasing interest from physicists. Protein structure is a good subject for physicists to study, being simple enough yet, at the same time, complex enough.

Conformational alphabets

Conformational alphabets (CAs) provide discrete representation for the protein local structure. We have proposed an alphabet:

a letter = a *cluster of combinations of three angles* formed by C$_\alpha$ pseudobonds of four contiguous residues (obtained by *clustering* according to the probability distribution) = a discretized state of 3D segmental conformations, and constructed its substitution matrix CLESUM (Conformational LEtter SUbstitution Matrix), which measures similarity between fragmental states.



Centers of 17 conformational letters

	J	H	I	K	N	Q	L	G	M	B	P	A	O	C	E	F	D
J	37																
H	13	23															
I	16	18	23														
K	13	5	21	49													
N	-2	-34	-11	28	90												
Q	-44	-87	-62	-24	32	90											
L	-32	-62	-41	-1	8	26	74										
G	-21	-51	-34	-13	-8	8	29	69									
M	16	-4	1	12	7	-7	5	21	61								
B	-57	-96	-74	-50	-11	12	-12	13	-13	51							
P	-34	-60	-49	-36	-3	7	-12	5	8	42	66						
A	-23	-45	-31	-19	10	16	-11	-6	-2	20	35	73					
O	-24	-55	-34	5	15	-13	-4	-1	5	-12	4	25	104				
C	-43	-77	-56	-33	-5	29	0	-4	-12	7	4	13	3	53			
E	-93	-127	-108	-84	-43	-6	-21	-22	-47	15	-5	-25	-48	3	36		
F	-73	-107	-88	-69	-32	3	-16	-5	-33	7	0	-20	-30	20	26	50	
D	-88	-124	-105	-81	-44	14	-22	-31	-49	13	-10	-17	-42	21	22	21	52

evolutionary
+ geometric

Similarity between conformational letters

Conformational alphabets in the study of protein structure

We have succeeded in developing a fast alignment tool for multiple protein structures by means of our CA called BLOMAPS, which is faster than other tools by 2 to 3 orders. Multiple alignment carries significantly more information than pairwise alignment, and hence is a much more powerful tool for classifying proteins, detecting evolutionary relationship and common structural motifs, and assisting structure/function prediction.

Such conformational alphabets, bridging the secondary and 3D structures, facilitate computations for protein structures. Our focus is on the development of a reliable statistical potential function using CAs, and improving structure prediction.

This is a rich territory for collaboration amongst physicists, computer scientists, mathematicians, and biologists.

References

1, WM ZHENG and X LIU, *A protein structural alphabet and its substitution matrix CLESUM*, in Lecture Notes in Bioinformatics **3680**, pp. 59-67, Springer, Berlin, 2005.

2, S Wang and WM Zheng, *Fast multiple alignment of protein structures using conformational letter blocks*, The Open Bioinformatics J., **3** (2009) 69-83.

On-going Project between Europe and China

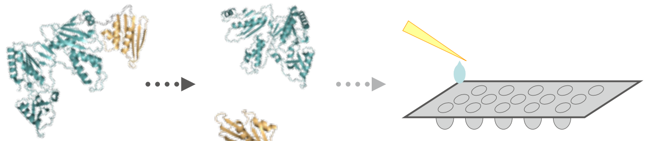
of Metagenomic sequencing of gut microbiomes (conducted in Beijing Genomics Institute, Shenzhen) within the frame of the European Commission funded program MetaHIT (Metagenomics of the Human Intestinal Tract).

An SVM-Domain Linker Prediction Trained with Optimized Features Selected by Random Forest and Stepwise Selection

Teppei Ebina[1], Hiroyuki Toh[2] and Yutaka Kuroda[1]

1 Department of Biotechnology and Life Science, Tokyo University of Agriculture and Technology.
2 Medical Institute of Bioregulation, Kyushu University.

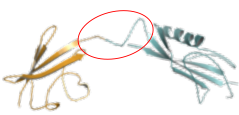
Introduction



The prediction of structural domains has practical implication because large proteins often need to be dissected into structurally independent domains, which are usually easier to express, purify and characterize than whole proteins. Our specific goal is to develop an accurate domain linker prediction method & improve their prediction performances.

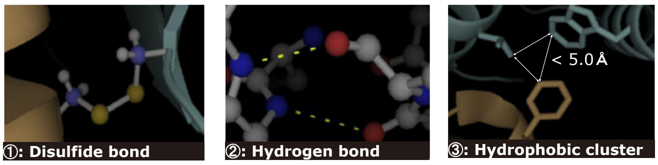
Methods

Target: Domain linker



- Loop regions between two structural domains
- Easier to predict than domain regions

Structural domain



Domains having no inter-domain interactions

Predictor construction

SCOP: 40000~ Proteins → Structural Domains: 2532 Proteins → 182 Proteins, 216 Linkers: Linker Dataset (for Training & Evaluation)

Features

- 544 Amino Acid Indices
- PSSM Elements
- Probability of Secondary Structure
- α-Helix & β-Sheet Core
- Sequence Hydrophobic Core
- Sequence Complexity
- Similarity in Amino Acid Composition
  - between Domain
  - between Linker
  - Ratio of the Similarity Scores

Vector Coding

1, 11, 21, 31 or 41 residue window

···DTO···FHFFKQNVM···

Target Sequences

Vector Data: 2870 dimensional vectors

Feature Selection – 1st Step

Random Forest Classification

Random Selection
200 domain & 200 linker data

Perform 100 times

Random Forest

Features with Z-Score of MDGI > 2.0 were selected as optimal feature candidates.

47 Optimal Feature Candidates

Feature Selection – 2nd Step

Backward Selection

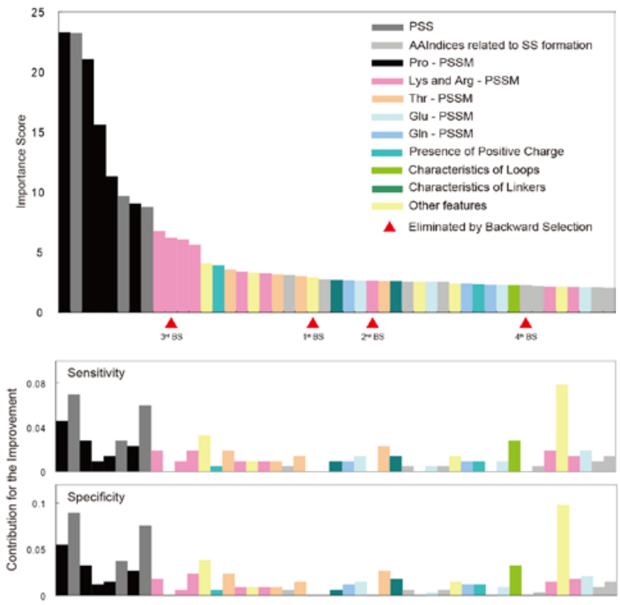
Repeat until no improvement was observed by eliminating features

SVM
Assess the performance

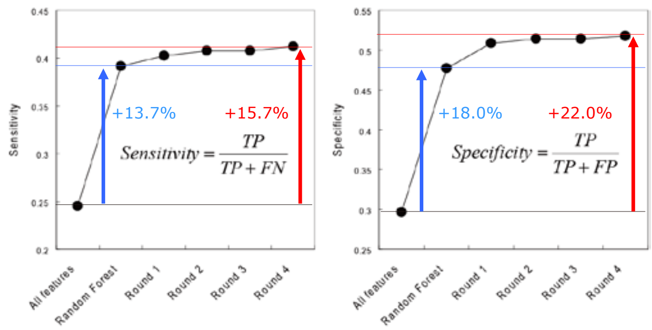
In each round of this selection, a candidate that most worsened the performances was eliminated from the feature set.

Results

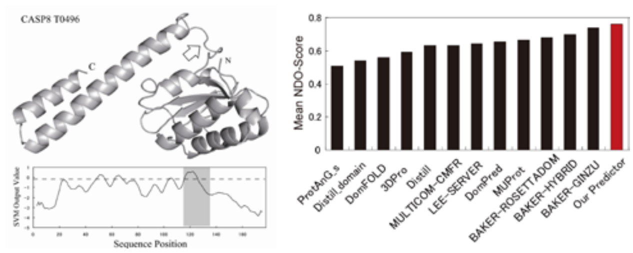
Importance score of the feature candidates



Improvement by feature selections



Compare with CASP8 servers



Computational Time of the Feature Selection

	Runing Time (hour)	Feature Total	hours/Feature
Random Forest	20	2870	0.007
Backward Selection	100	47	2.128

Conclusion

- The combination of random forest & backward selection efficiently determined the optimal features.
- The prediction performances of our predictor improved by over 15% by the feature selection.

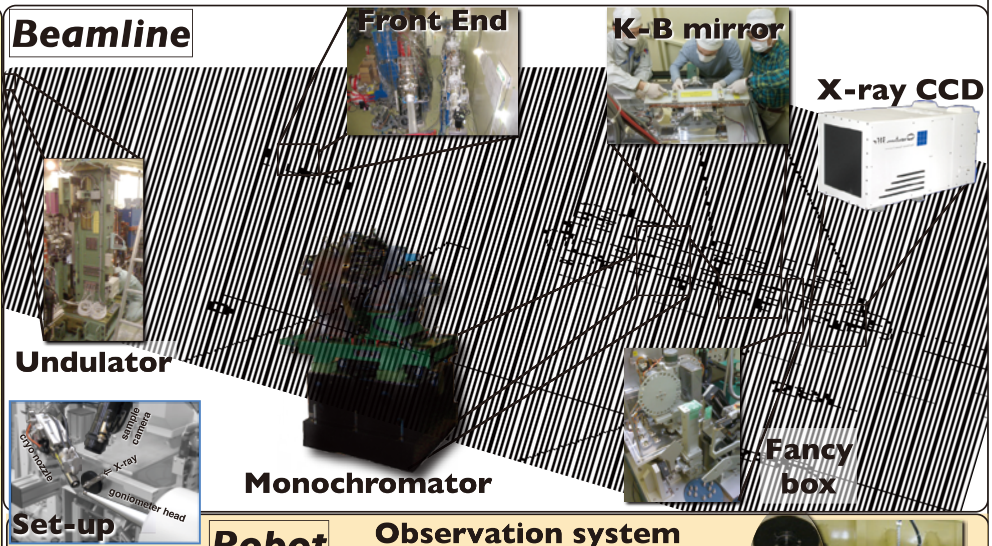
Structural Biology at the Photon Factory

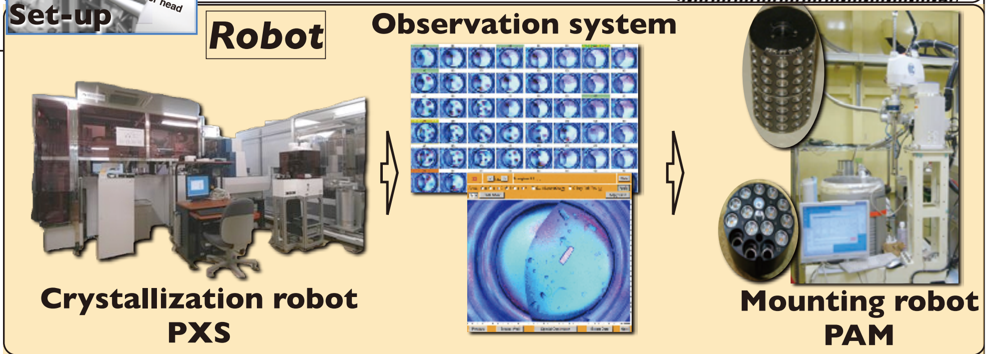
L.M.G. Chavas, N. Matsugaki, Y. Yamada, M. Hiraki, M. Kawasaki, N. Igarashi, R. Kato, S. Wakatsuki

Institute of Material Structure Sciences, Structural Biology Research Center, Photon Factory, High Energy Research Organization (KEK)

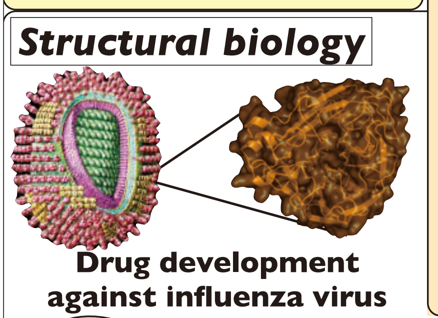
305-0801 Tsukuba Oho 1-1 (Japan)

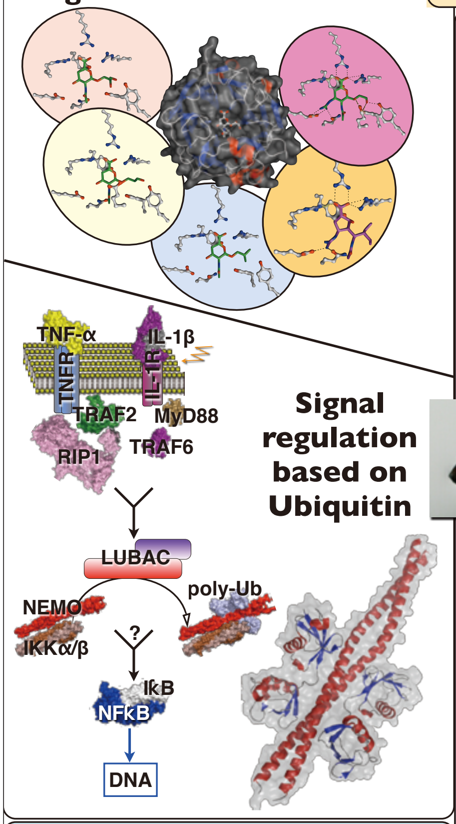
At the Photon Factory (PF), the Structural Biology Research Center (SBRC) currently operates five beamlines dedicated to protein crystallography, including four insertion device (BL-5A, BL-17A, AR NW12A, AR NE3A) and one bending magnet beamlines (BL-6A). The optic for three of the beamlines was designed to provide monochromatic beam of energies from 6 to 17 keV, in an environment ideal for high-throughput crystal screening, data collection and analysis. These beamlines, BL-5A, AR NW12A and the newly built AR NE3A, deliver a measured flux ranging from 1.5 x 10^{11} to 8.0 x 10^{11} photons/sec of 12 keV photons on the sample. Together with improvements in the automation of the beamline control, notably through the implementation of sample exchange systems and automatic sample centering, a fully automated data collection and processing system was optimized to allow data acquisition of more than 150 data sets per day in a routinely manner. To complement BL-17A as an additional microfocus beamline, the short-gap undulator beamline BL-1A is now under construction and will be opened for users in April 2010. BL-1A will deliver brilliant lower energy beam at around 4-5 keV, ideally optimized for sulphur single-wavelength anomalous dispersion (S-SAD) experiments. In this poster, I will present a brief summary of the beamline designs and the challenges facing the new developments, some innovation highlights, and I will try to emphasize through case studies the impact that have such state-of-the art beamlines on the biological studies at SBRC.

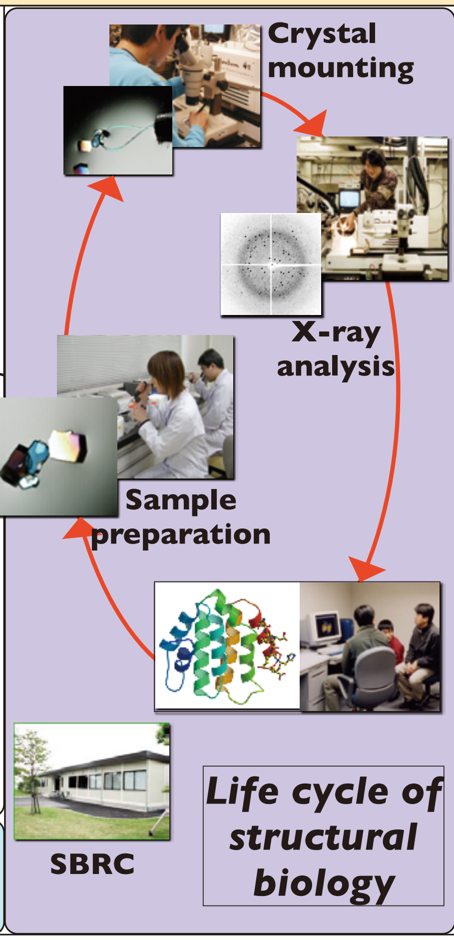


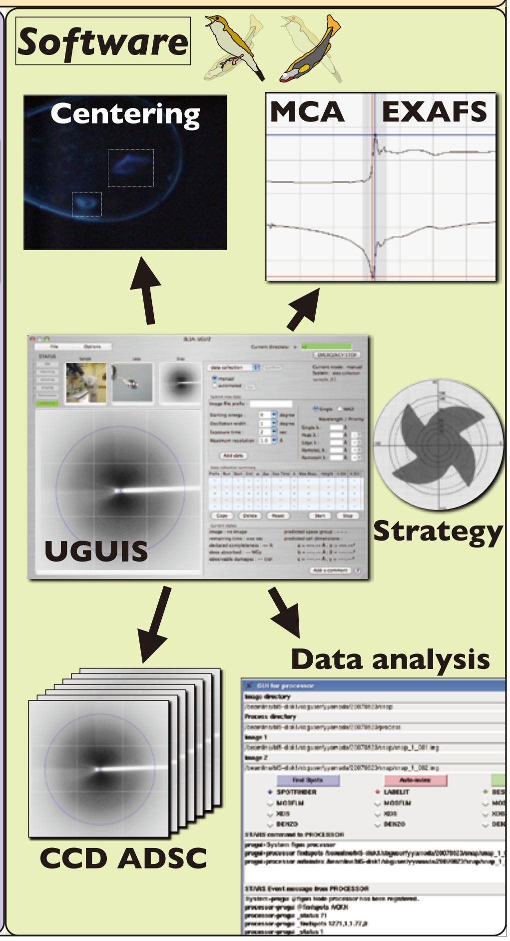


Structural biology









For further readings:

Structure 18, 138–147 (2010)

J Mol Biol (2009)

Cell 136, 1098–109 (2009) ...

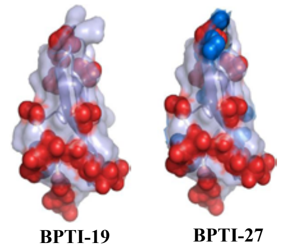
X-Ray Crystal Structures of Extensively Simplified BPTI Variants Determined Using the KEK Photon Factory Facility

Mohammad Monirul Islam, Shihori Sohya, Keiichi Noguchi, Masafumi Yohda and Kuroda Yutaka
Department of Biotechnology and Life Sciences, Tokyo University of Agriculture and Technology (TUAT)

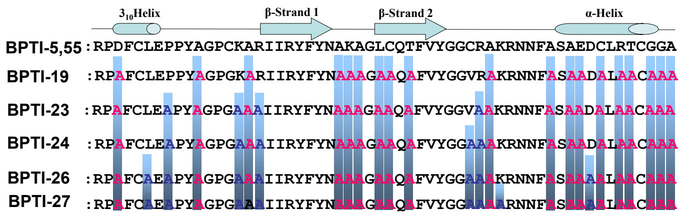
□ Introduction

Protein stabilization is very difficult to rationalize as it often results from multiple mutations, whose effects are intertwined. Rather, it is worth investigating the 3-D structures of proteins differed by a single and/or a few amino acid substitutions, followed by their thermodynamic studies to elucidate the stabilization mechanism. Here, we report the X-ray crystal structures of several BPTI variants containing 19 to 23 alanines (out of 58 residues) that were determined using the Photon Factory synchrotron radiation source at KEK. All extensively simplified BPTI variants retained almost perfectly the wild-type BPTI structure. However, pair wise RMS deviations at Cα atoms indicated that small local structural fluctuations, found in the wild-type structure (7PTI), were significantly reduced in the simplified BPTI structures. The temperature factors (main chain, side chain and average temperature factors) were also significantly reduced at and/or around the alanine substitution sites. Moreover, new hydration structures (protein water interaction) were observed at/around the substitution sites that could contribute to rigidify the native structure.

□Methods



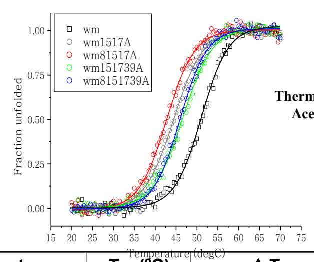
Surface representation of BPTI variants. Alanines are in red while alanines present BPTI-27 but not in BPTI-19 are in blue.



Sequences of BPTI variants. BPTI-[5-55] contains only the [5-55] bond, and four wild type SS bonding cysteines substituted to alanines. BPTI-19 to 27 contains 19 to 27 alanines, respectively

□Results

□ Thermal stability by circular dichroism

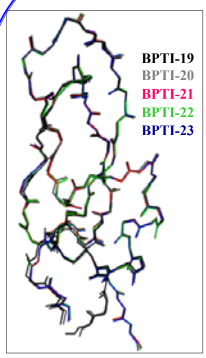


Thermal stabilities measured in 20mM Acetate (pH4.7) at 10 μM protein concentration.

Mutants	*Tm* (°C)	△*Tm* (experimental)	△*Tm* (estimated)
BPTI-19	51.35	-	-
BPTI-21	44.33	-7.02	-4.50
BPTI-22a	42.81	-8.54	-7.00
BPTI-22b	46.56	-4.79	-4.50
BPTI-23	46.68	-4.67	-7.00

What are the effects of alanine substitutions to the protein structures and stability?

□ Structure determination: X-ray crystallography

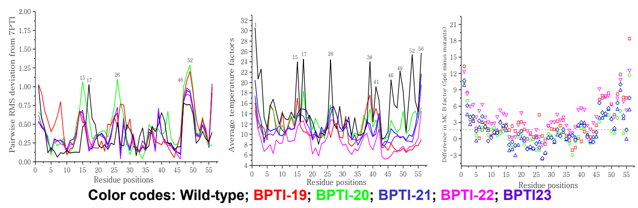


Refinement statistics

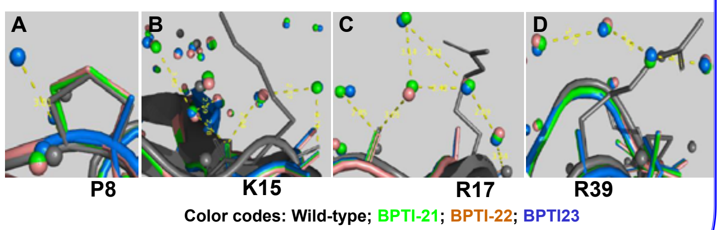
Parameters	BPTI-19	BPTI-20	BPTI-21	BPTI-22	BPTI-23
Space group	C2	$P2_12_12_1$	$C2_12_12_1$	$C2_12_12_1$	$C2_12_12_1$
Matthews coefficient	2.15	2.14	2.16	2.18	2.27
Solvent content	43.5%	42%	43.1%	43.1%	45.2%
Reflection used	49171	38836	12300	23855	13898
Max. resolution (Å)	1.00	1.391	1.99	1.60	1.90
Rfactor/Rfree	0.14/0.16	0.156/.20	0.17/0.23	0.18/0.23	0.18/0.21
Ramachandarn plot statistics					
Res in most favored	90.4%	90.7%	89.4%	90.7%	88.0%

Backbone RMS Deviations at Cα Atoms

Template structures	Simplified BPTIs				
	BPTI-19	BPTI-20	BPTI-21	BPTI-22	BPTI-23
BPTI-[5,55]	0.364	0.484	0.386	0.374	0.378
4PTI	0.420	0.429	0.336	0.312	0.306



Structural fluctuations in wild-type and mutant BPTI structures. Left: Pair wise RMS deviations at Cαatoms from 7PTI; Middle: average temperature factors; and Right: difference in main chain temperature factors (5PTI minus simplified BPTIs).



New hydration structures at and/or around the alanine substitution sites in the wild-type and mutant BPTI structures. (A) P8A; (B) K15A; (C) R17A; and (D) R39A substitution sites. 7PTI is used as the wild-type BPTI structure.

□Conclusions

- All extensively simplified BPTI variants retained almost perfectly the wild-type BPTI structures.
- Pair wise RMS deviations at Cα atoms indicated small local structural fluctuations, found in the wild-type, were significantly reduced in the simplified structures.
- The temperature factors (main chain, side chain and average) were also significantly reduced at and/or around the alanine substitution sites.
- New hydration structures (protein water interactions) were observed at/around the substitution sites that could contribute to rigidify the native structures.

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e-Science and Technology Infrastructure for Biodiversity Data & Observatories

LIFEWATCH

While we are exploring other planets, it is surprising how little we still know about our own planet Earth. This is certainly true for our understanding of the living world, the biological diversity of species, and their genes and the ecosystems in which they occur. We only know a fraction of the probably millions of species, especially of the insects, microorganisms and other small species which are in different ways crucial for goods and services such as pollination, health or biotechnology. Scientific developments have already generated knowledge about some components of biodiversity, but the research community absolutely needs a new methodological approach to understand the biodiversity system.

LifeWatch will construct and bring into operation the facilities, hardware, software and governance structures for research on the protection, management and sustainable use of biodiversity.

Components

- facilities for data generation and processing; a network of observatories
- facilities for data integration and interoperability
- virtual laboratories offering a range of analytical and modelling tools
- a Service Centre providing special services for scientific and policy users, including training & research opportunities for young scientists.

The architecture allows for dynamic linkages to other resources and associated infrastructures. As such, LifeWatch will be the first example of a new generation of research infrastructures that form a cooperating fabric.

The LifeWatch infrastructure for biodiversity research addresses the huge gaps we face in our understanding of life on Earth. Its innovative design supports a large-scale methodological approach to data resources, advanced algorithms and computational capability. LifeWatch will not only serve to support the scientific research, but will also be an essential tool for local and global policy makers in the understanding and the rational management of our ecosystems.

Features & benefits

- A single portal for pure and applied researchers, policy makers, industries and the public at large
- Discovery of biodiversity data: habitats, species and DNA sequences, geographical, climatological and ecological data; visualisation of temporal and spatial distribution
- Modelling tools to analyse statistical relationships between, among others, species occurrence data and environmental factors; creation and integration of geographic information system (GIS) map layers
- Facilitation of data access and proper citation; on-line / off-line user support
- Structuring the science community with opportunities for large-scale projects
- Accelerating data capture with new technologies and institutional support; identifying priorities and knowledge gaps
- Close cooperation with existing infrastructures and facilities

SEVENTH FRAMEWORK PROGRAMME

International cooperation

Successfully implementing LifeWatch is only possible through international cooperation. The sheer size of the infrastructure with respect to costs, functionalities and user communities requires large-scale collaboration. The European Strategy Forum on Research Infrastructures (ESFRI) identified LifeWatch as an essential facility to be supported by European countries.

The preparatory phase runs from Feb. 1st 2008 to Feb. 1st 2011. It brings together – and aims to expand – a group of interested EU member and associated states in order to prepare a cooperation agreement on the construction and long term maintenance of the LifeWatch infrastructure. A Policy and Science Board - composed of the representatives of more than 18 interested partner countries and 8 scientific networks, oversees process progress.

2010 International Year of Biodiversity

LifeWatch national partners are aiming at starting construction in the 2010 International Year of Biodiversity.

Executive participants: Universiteit van Amsterdam | Netherlands Institute of Ecology | Norwegian Institute for Nature Research | Consejo Superior de Investigaciones Científicas | Freie Universität Berlin, Botanischer Garten und Botanisches Museum Berlin-Dahlem | Fraunhofer Institute IAIS | Cardiff University | Naturhistoriska Riksmuseet | Centre for Ecology and Hydrology | University of the West of England, Bristol | Comunità Ambiente | Muséum National d'Histoire Naturelle | HealthGrid | Research Institute for Nature and Forest | Sven Lovén Centre for Marine Sciences, University of Gothenburg | Swedish Research Council | Finnish Environment Institute | National Research Institute for Mathematics and Computer Science in the Netherlands | The Natural History Museum in London || Countries: Austria | Belgium | Denmark | Finland | France | Greece | Hungary | Italy | Netherlands | Norway | Poland | Portugal | Romania | Slovak Republic | Slovenia | Spain | Sweden | Turkey | United Kingdom ||
Scientific Networks: AlterNET | BioCASE | EDIT | ENBI | EurOceans | MarBef | Marine Genomics | SYNTHESYS

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www.lifewatch.eu

Are spin-polarized atoms clustering ?

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1. Introduction

The interplay between spin and structure is a problem of interest in the field of nanomagnetism and cluster/surface physics. While this effect is less dominant in bulk materials, the ground state physical properties (including the geometry) of finite systems like clusters are strongly influenced by the spin, and different optimal ground state geometries are possible for different spin states of size-specific clusters (spin isomers). Further, the nature of bonding in finite systems is strongly influenced by the spin states of the constituent atoms. Of particular interest in finite systems is the question of what we can expect if a small number of spin-polarized atoms are placed on a plane, and allowed to assemble (or disassemble). Would clustering or self-assembling occur?

If spin-polarized atoms are clustering, they will exhibit a spin-dependent functional property which is applicable for a quantum device. In such a system, observation of the atomic arrangement will give information on spin arrangement and vice versa.

For the experimental clarification, spin-polarized cold atoms of cesium are soft-landed randomly on a van der Waals solid and spin clusters of cesium are expected to form through self-assembly. Solid argon is selected as a candidate of the ideal substrate , because the non-wetting phenomena of argon observed on cesium suggests negligibly small interaction between them.

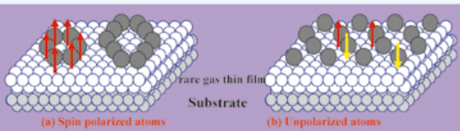


Fig. 1 Concept of the free clustering of (a) spin-polarzed atoms, and (b) unpolarized atoms.

2. Magneto-optical Trapping of Cold Cs Atoms

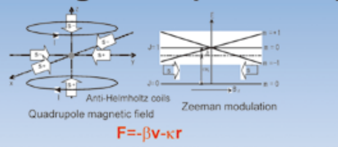


Fig. 3 Principle of the magneto-optical trapping in the two level system.

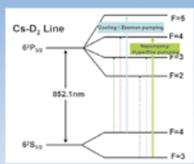


Fig. 4 Energy Scheme of Cs-D2 Line.

* Theoretical modeling of the structures and spin states of Cs_n clusters suggests that low- and high-spin states are competitive for n . 4, 5 and 6. For these sizes, planar geometries are favored for the low-spin states, while compact 3-D geometries are favorable for the high-spin states of Cs_5 and Cs_6. Spin states higher than the triplet are not energetically favorable. High spin states are not favored for Cs_2 and Cs_3.

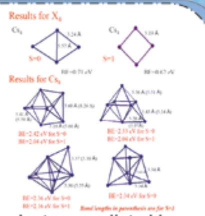
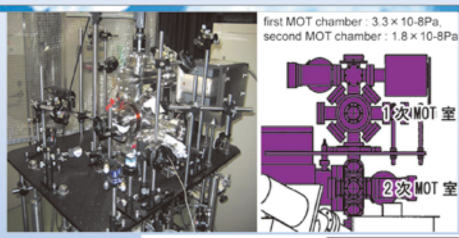


Fig. 2 Examples of the low-lying structures of Cs_n clusters predicted by the density functional model. (J.M.M.M 310(2007) 2390.)

3. Experimental Procedure

Cesium atoms are cooled and trapped in the magneto-optical trap(MOT) and spin-polarized by the successive hyperfine and Zeeman pumping method. Spin-polarized molasses are dropped onto the solid argon substrate and form clusters. We used double MOT to increase the number density of the cold atoms of the order of 10^{10} [cm^{-3}].

(a) top view



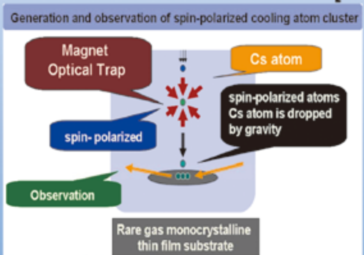
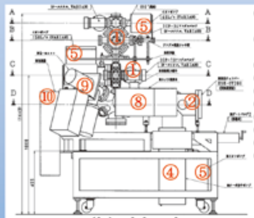


Fig. 5 Image of the experimental procedure.



(b) side view

① Double MOT Chamber(stacked)
② Spin-cluster Observation Chamber
③ Scroll Pumps(not seen)
④ Turbo Molecular Pumps
⑤ Ion Pumps
⑥ Ion Gauges
⑦ RHEED
⑧ CCD Camera for RHEED
⑨ Q mass Spectrometer
⑩ Helium Refrigerator(GM-type)

Fig. 6 Experimental Setup.

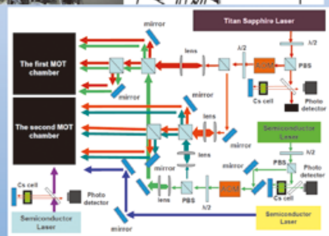


Fig. 7 Laser system for double MOT and optical pumping.

4. Current Result: Cold Molasses Trapped by Double MOT

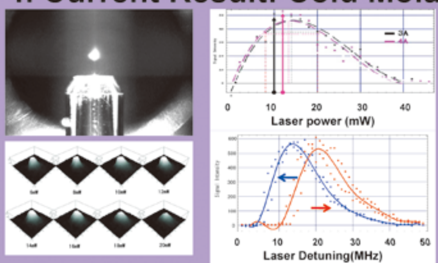


Fig. 8 Luminescence of cold Cs atoms trapped in the 1-st MOT observed by the infrared sensitive CCD camera(upper left), and their intensity profiles depending on the cooling laser power(lower left). Laser power dependence(upper right) and the detuning-frequency dependence(lower right) of the number density of atoms trapped in arbitrary units.

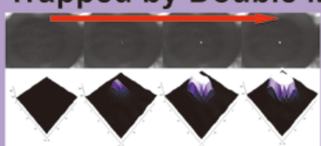


Fig. 9 luminescence of cold Cs atoms trapped in the 2-nd MOT. The intensity increases with repeating drops of molasses from the 1-st MOT.

- Optimization of laser for higher number density of cold molasses in the 1-st MOT:
  laser power: 10～12mW
  detuning : 13 MHz on increasing freq.
- Cold atoms are trapped successfully in the 2-nd MOT by laser-off, further detuning of laser frequency, or magnetic field turning off in the 1-st MOT after trapping.
- Luminescence of the 2-nd MOT increases by repetition of laser-off in the 1-st MOT after trapping.
- Measurement of the temperature and absolute number densities are now under execution.

5. Summary

In order to understand the interplay between spin arrangement and atomic arrangement that are originated from the exchange interaction, we are performing the experimental study on the nature of clustering of spin-polarized Cs atoms. Cold atoms are trapped successfully and ready for the experiment for free clustering.

From double-slit experiments with single electrons to two-electron entanglement in space-time: A Europe-Asia Physics Project

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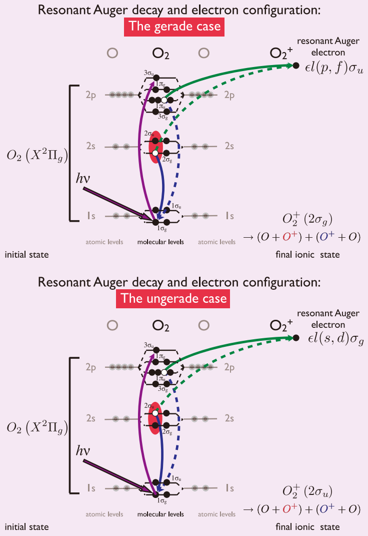
During the last decade a sneaking paradigm change has been taken place regarding the compatibility of quantum physics, in particular its consequences for entangled pairs of particles [1], and special relativity. Tim Maudlin of Rutgers University wrote a book on "quantum non-locality and relativity" in 1994 [2] which highlighted that the compatibility of non-locality and special relativity was a much more subtle question than the traditional arguments based on instantaneous messages would have us believed. He shows that special relativity is compatible with a variety of faster-than-light transmission mechanisms, however, they would have to fulfill certain requirements. What is in last consequence uncanny about the way quantum objects can non-locally influence one another is the fact that it does not depend on the particles spatial arrangements and their intrinsic physical characteristics, but only on whether or not the particles in question are quantum mechanically entangled with one another. Hence the kind of non-locality seems to call for an absolute simultaneity, which would pose a very real and ominous threat to special relativity.

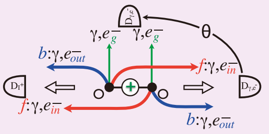
Two new ideas have emerged from this situation in the past few years. The first one was a paper by Roderich Tomulka from Rutgers University [3] who showed, that a non-local modification of Ghirardi-Rimini-Weber (GRW) theory, a theory promoting a philosophical realistic way to subsume the predictions of quantum mechanics, would provide a peaceful coexistence between quantum mechanical non-locality and special relativity. The price for this coexistence is however, that one has to introduce a new variety of non-locality into the laws of nature, a non-locality not merely in space but in time. The other approach to solve the conflict between quantum-mechanical non-locality and special relativity is concentrated on the character of quantum mechanical wave functions in the sense of a "many world" interpretation of our reality [4,5].

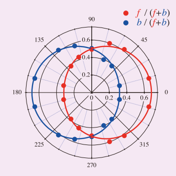
We present here results supporting the first scenario of interpretation of our reality. The experimental data obtained from angle resolved coincident detection of photo- and Auger electrons in the molecule frame of homonuclear diatomic molecules, here N_2, prove that the corresponding emitted electrons are indeed spatially entangled [6]. This entanglement is based on the spatial properties of the parity eigenstates *gerade* and *ungerade* which constitute dichotomic variables of the continuous variable position. These eigenstates are distinguished by their non-degenerate energy values giving rise to an energy difference specific tunneling time. The parity and hence energy eigenstates g and u have as complementary system concerning their entanglement the eigenfunctions of the Fourier integral of energy, which is nothing else than time. Hence our results are the first proof of entanglement between two particles based on time, which means a proof of non-locality of time! This non-locality means that two entangled particles have the same clock starting from the same origin in space independently of their separation in space. This would make quantum mechanical non-locality and special relativity compatible to each other, providing an unexpected peaceful solution to the famous controversy between the two most contradictory opponents of the interpretation of our physical reality in the last century, Albert Einstein and Nils Bohr.

Resonant Auger decay and electron configuration: The gerade case / The ungerade case

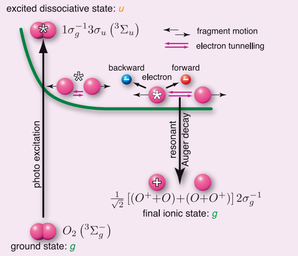


Which way information versus interference pattern

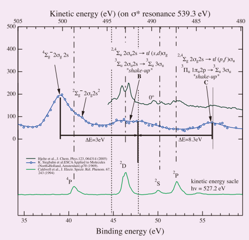




Electron emission in dissociating O_2

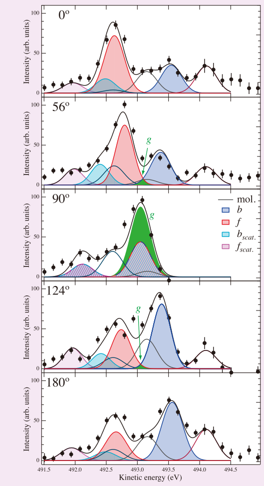


Resonant Auger decay follwoing core electron excitation to the discociative $1\sigma_g^{-1}3\sigma_u\,(^3\Sigma_u)$ state.



Comparison between regular photoelectron and resonant Auger decay spectrum .

Measured coincident electron spectra

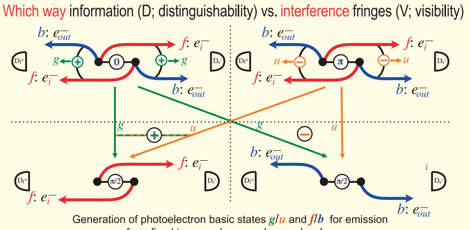


Measured resonant Auger spectra in dependence of the molecular axis

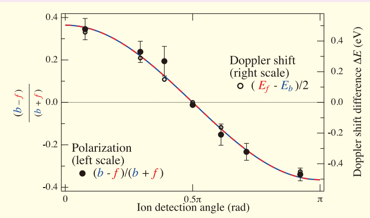
References:

[1] A. Einstein, B. Podolsky,N. Rosen, *P ys. Rev.* **47**, 777-780 (1935).
[2] T. Maudlin, *Quantum Non-Locality and Relativity: metaphysical intimations of modern physics.* (Oxford: Basil Blackwell, 1994).
[3] R. Tumulka, *J. Statist. Phys.* **125**, 825 (2006).
[4] H. Everett, *The Theory of the Universal Wave Function*, in *The Many-Worlds Interpretation of Quantum Mechanics* by B. S. DeWitt, R. N. Graham, eds, Princeton Series in Physics, (Princeton University Press, 1973), pp 3-140.
[5] D. Albert and R. Galchen, Scient. Am. **300**, 32 (2009).
[6] Schöffler *et al.*, Science **320**, 920 (2008).

Which way information (D; distinguishability) vs. interference fringes (V; visibility)

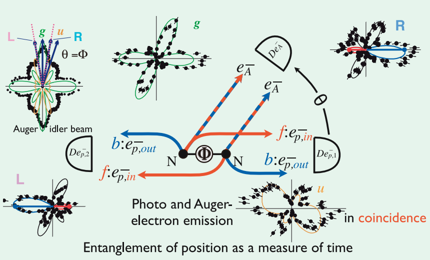


Generation of photoelectron basic states *g*/*u* and *f*/*b* for emission from fixed in space homonuclear molecules



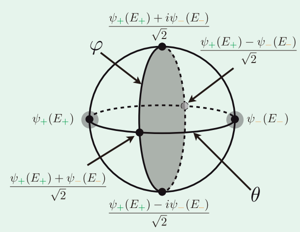
The emitter site polarization (*b*-*f*)/(*b*+*f*), respectively, in dependence of the molecular axis direction. In the resonant Auger case this corresponds to the ion detection angle.

Two-fold double slit experiment: The molecular version of EPR's idea to prove the completeness of QM

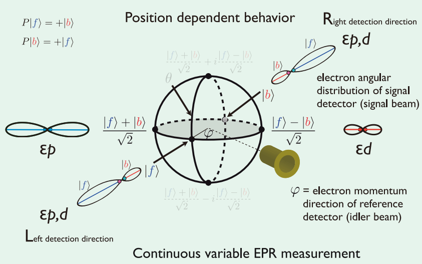


Entanglement of position as a measure of time

Poincaré sphere of energy and its Fourier integral time

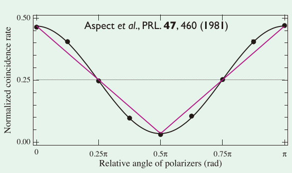


Position based EPR experiment described in momentum space on the *f*/*b*-Poincaré sphere

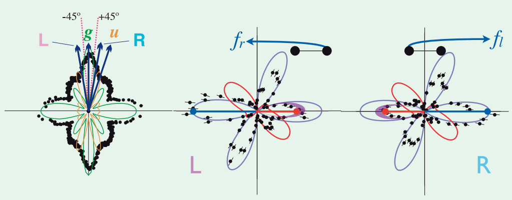


Continuous variable EPR measurement

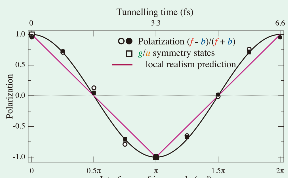
Polarization correlations in spin space revealed by photon-photon coincidence measurements



Auger electron-Photoelectron coincidences: Evidence for a violation of Bell's inequality.



Polarization correlations in momentum space revealed by electron-electron coincidence measurements:



Asia-Europe Physics Summit, 24-26 March 2010, Tsukuba, Japan

On thermodynamics of irreversible transitions in the oceanic general circulation

By Shinya Shimokawa [1] and Hisashi Ozawa [2]
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[2] Hiroshima University, Japan

1. Introduction

In this study, we focus on a thermodynamic variational principle of maximum entropy production (**MEP**, Sawada,1981); a nonlinear non-equilibrium system tends to evolve to a state with maximum entropy production. This principle has been confirmed to be valid for various nonlinear fluid systems (e.g., Paltridge, 1975).

The ocean system can be seen as an open dissipative system connected with its surroundings mainly via heat and salt fluxes, and has been known to possesses multiple steady states under the same boundary conditions (Fig. 1). In this study, we examine MEP for the transition among multiple steady states of the oceanic general circulation (Shimokawa and Ozawa, 2001, 2002, 2007).

2. Model and Method

The numerical model used in this study is the Geophysical Fluid Dynamics Laboratory's Modular Ocean Model. The model domain is a rectangular basin with a cyclic path, representing an idealized Atlantic Ocean. A series of multiple steady states under the same boundary conditions (four Southern Sinking Circulations (**SSC**): S1–S4; and three Northern Sinking Circulations (**NSC**): N1–N3, Fig. 2) are obtained by adding salinity perturbation to the north of 46° N.

3. Results

The results are summarized in Fig. 2. Starting from S3, the system moves to S4 with higher entropy production, regardless of the sign of the perturbation (**r14 and r15**). Starting from S4, the system does not return to S3, but remains in S4, regardless of the sign of the perturbation (**r18 and r19**). **These transitions are irreversible in the increase direction of entropy production rate, and support MEP.** In r14, negative salt perturbation applied to S3 strengthens SSC (Fig. 3c). In fact, the system moves to a stronger SSC, S4, after the perturbation is removed. **This is a natural transition caused by the perturbation and is consistent with MEP.** In r15, positive salt perturbation applied to S3 weakens SSC (i.e. strengthens NSC). In fact, a NSC is developed temporarily (Fig. 3d). But, the system moves to S4 after the perturbation is removed. **This is positive evidence in support of MEP.**

Starting from N1 with negative perturbation, the system moves to S1 (**r12**). Starting from S1 with positive perturbation, the system moves to N1 (**r06**). **These transitions are irrelevant to the entropy production rate, and appear to be contradicted MEP.** In oceanic circulation, sinking occurs in the narrow polar region, and upwelling occurs in other broad regions. Therefore, a positive (negative) salt perturbation applied to a sinking region should effectively strengthen (suppress) the circulation when compared with a negative (positive) salt perturbation applied to an upwelling region. In r06, a positive salt perturbation is applied to northern high latitude region in a southern sinking (upwelling region). In this case, the SSC co-exists with a newly developed NSC, and then changes into the NSC (Fig. 3b). **The perturbation acts only as a trigger for the transition. This transition is a spontaneous transition independent of the perturbation and is consistent with MEP.** In r12, a negative salt perturbation is applied to northern high latitude region in a northern sinking (sinking region) (Fig. 3a). In this case, the NSC collapses completely, and then changes into a newly developed SSC. **The perturbation acts as a forcing to the initial circulation. This transition is an enforced transition controlled by the strong perturbation and is independent of MEP.**

4. Conclusions

The results can be explained in a consistent manner by a conceptual figure (Fig. 4a). A small perturbation can trigger the transition to a state with higher entropy production, regardless of its sign. In the situations, the entropy production rate plays a similar role to a thermodynamic potential in classical thermodynamics (Fig. 4b).

Summary

・The mechanism of transitions among multiple steady states under the same set of boundary conditions is investigated by using an numerical model of the oceanic general circulation.

・The results suggest that the transition is consistent with MEP except when the perturbation destroys the initial circulation altogether.

・ These results can be explained in a consistent manner by a conceptual figure which regards the rate of entropy production as a kind of thermodynamic potential in classical thermodynamics.

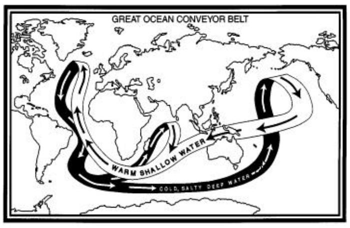

Figure 1 Conceptual figure of the oceanic general circulation at the present state of climate. The state of the circulation can be changed drastically by the state of climate, which affects on heat and fresh water (salt) fluxes.

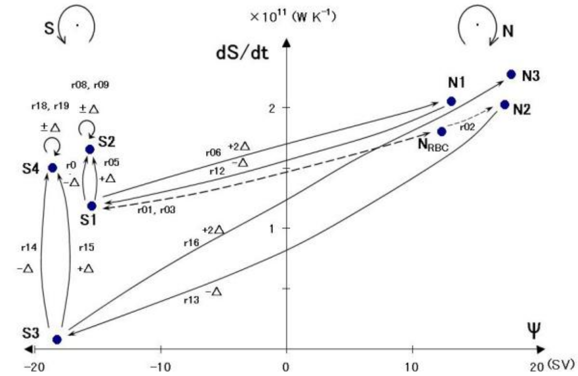

Figure 2 Summary of the results obtained from the numerical simulations: the relationship between transitions among multiple steady states and rates of entropy production. The y axis (dS/dt) indicates the rate of entropy production (W K^{-1}), and the x axis (Ψ) shows the maximum value of the zonally integrated meridional stream function for the main circulation (SV = 10^6 m^3 s^{-1}). The dots correspond to the steady states (initial and final states) of each experiment (e.g., N1). The arrows show the direction of the transitions. The symbols beside the arrows show the experiment number and the perturbation used in the experiment (e.g. r04 and −Δ). The standard salinity perturbation, Δ is 2×10^{-7} kg m^{-2} s^{-1}, which is applied north of 46° N. N_{RBC} is a unique solution under another boundary conditions. The dashed lines show the transition from or to N_{RBC} with the changes of boundary conditions.

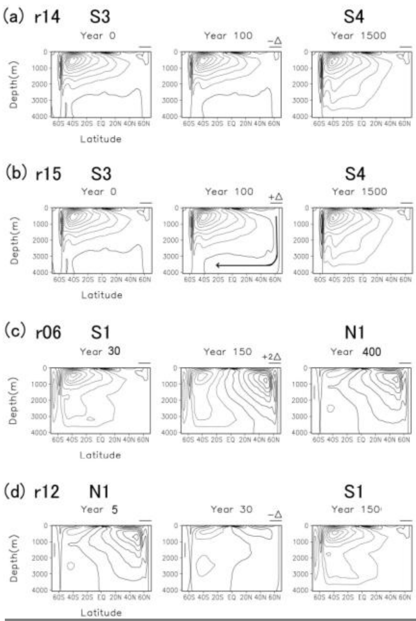

Figure 3 Evolution of the zonally integrated meridional stream function in five experiments: (a) r14; (b) r15; (c) r06; (d) r12. The contour interval is 2.0 SV (10^6 m^3 s^{-1}). The arrow in the middle of (b) indicates the development of the NSC (see left text).

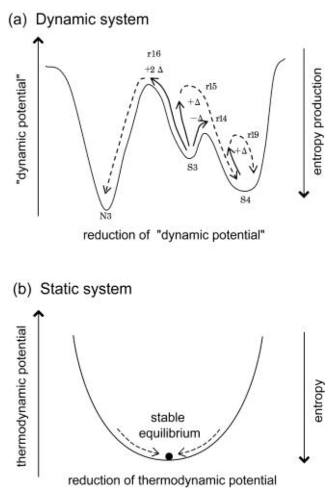

Figure 4 Schematic diagrams showing the stability of (a) a dynamic system and (b) a static system. The most stable steady state corresponds to a minimum in the dynamic potential (i.e., MEP) in (a) and a minimum in the thermodynamic potential (i.e., maximum entropy) in (b).

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A Study on Dosimetry of Gynaecological Cancer and Quality Assurance of HDR Brachytherapy in BPKMCH, Nepal

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ABSTRACT

Brachytherapy is the treatment of malignant lesion using radioactive isotopes near or inside the tumor. Brachytherapy is useful to deliver high radiation dose to the tumor and minimum possible to normal surrounding organs/tissue. The intention of this study was to do quality assurance of the cases that have undergone for the treatment in dept of radiation oncology, B.P.Koirala memorial cancer Hospital (BPKMCH) since last five year. The most practiced cases in our center are carcinoma of cervix and oesophagus in HDR Brachytherapy. Only Intracavitary brachytherapy (ICBT) cases were taken for this study. In total number 1341 patients has received ICBT from 2005 to 2009; out of them 1296 patients completed the treatments. Total 3941 applications were held during this period of study.

Key words— High Dose Rate Brachytherapy, ICRU-38 report, Remote after loading.

1. INTRODUCTION

Brachytherapy is a method of treatment in which sealed radioactive sources are used to deliver radiation at a short distance by interstitial, intracavitary, or surface application. With this mode of therapy a high radiation dose can be delivered locally to the tumor with rapid fall-off in the surrounding normal tissue. The history of Brachytherapy began in Paris in 1897.Shortly after Marie and Pierre Curie discovered radium in 1898, brachytherapy was first performed successfully to treat facial skin cancer[1]. This was done by directly applying a radioactive material such as radium, radon to the affected site. Within five years, radioactive sources were being used internally via an applicator inserted into the body. Since the technology is gradually progressing, the after loading methods were developed during 1959 and 1960 which offered protection from the radiation hazard to radiation workers performing Brachytherapy and there was greater flexibility of source geometry as well as improved reproducibility of treatment and comparatively shorter treatment time.[2] After the introduction of artificial isotopes, remote after loading devices, it has advantages of energy, source flexibility, source size, half life, reduced personal exposure. Three types of Brachytherapy are defined as dose rate: Low dose rate: 0.4 to 2 Gray/hr. Medium dose rate: 2 to 12 Gray/hr. High dose rate (HDR): more that 12 Gray/hr.[3] 137Cs (Cesium) is commonly used in LDR where as 192Ir (Iridium) and 60Co (Cobalt) are used in HDR brachytherapy. The use of Iridium for brachytherapy was developed though clinical experience in the treatment of uterine cervix, prostate, head and neck, oesophagus and skin cancer.

The use of HDR brachytherapy for cervical carcinoma is the result of technologic development in the manufacture of high intensity radioactive source, computerized remote after loading devices and treatment planning sysytem.[3] Optimization is used in various types such as dose point, dwell time, geometry based dose, volume time and equal time etc.[4]

External beam radiotherapy therapy and Brachytherapy are two main ways of delivering radiotherapy for cervical cancer. Usually external therapy is followed by Intracavitary brachytherapy. In the early stage of the disease only brachytherapy may be sufficient. External therapy is used to treat whole pelvis and the parametrium including lymph nodes. The aim of the study was to do quality assurance of the cases that have under gone for the treatment of carcinoma of cervix by HDR brachytherapy.

2. MATERIALS AND METHODS

Brachytherapy treatment has started with Varian Varisource HDR remote after loading (RAL) machine since 17 September 2002 in B.P.Koirala memorial cancer hospital (BPKMCH) in Bharatpur, Nepal. Varisource RAL device is a single source HDR after loading machine with a built in inactive wire called dummy wire which tests all connections before an actual treatment run is allowed. The maximum distal position of Varisource RAL is 150-cm, minimum step size is 4 mm, 20 cm continuous treatment and 1.5 cm minimum radius of curvature at 80 cm wire[5].After loader shielding material is Tungsten with maximum of 12 Curies Ir-192 shielding capacity.[10] Ir-192 is a solid single radioisotope of 5 mm length, 0.348 mm diameter, emits gamma rays of 380 KeV and a short half life of 73.83 days.

For carcinoma of cervix, we have delivered 40 Gy in 20 fraction(2Gy/# one fraction a day, 5 days in a week) the 10 Gy in 5 fraction with Mid Line Block (MLB) of external radiotherapy followed by 3 application of Intracavitary Radiotherapy (ICR) 7 Gy per fraction, one week interval between the ICRs. The Gynae- brachy table is used to for application in application room. Foley's catheter was inserted aseptically and 7 ml of radio opaque dye (urograffin) pushed into balloon that helped to locate bladder reference points. Rectal probe was inserted into rectum to identify rectum position on AP/LAT orthogonal films. The uterine sound was inserted in the uterine cavity to assess the length and position of the cavity. Uterine tandem was placed according to the length of uterine cavity and flange was fixed to remain at the external Os. Largest possible ovoid were placed in lateral fornices and fixed with the uterine tandem .The vaginal packing was done adequately with ribbon gauge. The Fletcher Suit Delclos FSD type of applicator was used for treatment of uterine cervix with intact uterus and vaginal cylinder for postoperative cases.[5]

Figure 1. Preparation of patients for external RT (left) and Brachytherapy (right)

Patient was shifted in simulator room to take orthogonal films. Applicators, bladder rectum position was observed and made needful adjustment before take the films.

Orthogonal films are taken in simulator room scanned through Vidar film digitizer scanner for planning the case in brachyvision treatment planning system. References points such as point A(2cm superior to external cervical Os and 2 cm lateral to cervical canal6), Bladder points, rectum points and point B (3 cm lateral to point A) were taken according to ICRU-38 reports.[2] Plan was done required dose to point A and as low as reasonably possible to rectum and bladder. Isodose curve shape, rectum, bladder dose was discussed. HDR Brachytherapy source calibration was done at the time of replacement of source wire. Before delivering the dose to patients the following Quality Assurance have been performed per day [7, 8, and 9]

We used Standard Imaging Inc electrometer CDX model and HDR 1000 plus well type ionization chamber with a volume 245 cm^3 source calibration. Current was noted at every source positioning in the well chamber.

Figure 2. Position verification (left) and source calibration (right)

3. RESULTS AND DISCUSSION:

Varisource Treatment Day QA Check lists

Perform door interlock test **Pass,** Perform door stop test **Pass**
Perform consol Stop test **Pass,** Perform consol key test **Pass**
Perform after loader key test **Pass,** Perform radiation monitor test **Pass**
Perform applicator inspection test **Pass,** Perform treatment room radiation test **Pass**
Perform obstruction detection test **Pass,** Perform catheter Misconnect test **Pass**
Perform position verification test, **Pass** Perform decay test **Pass**

The catheter position verification was done frequently with camscale and its deviation is within 0.01%.

Varisource strength calibration.

All new sources were calibrated to check source strength specified by the vendor.

Source strength = peak current reading x Ktp x calibration factor.

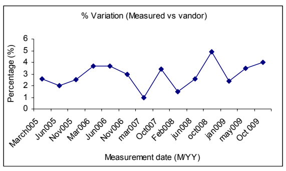

Figure 3 Source strength difference in vendor and site measured of different sources.

The difference, in percentage, between source strength measured at site and provided by varisource has calculated. Site measurement activities of different sources are seems similar to the vendor activities as shown in fig.3 and is within acceptable limit.

During the period of study 2005 to 2009, total 1341 intracavitary Brachytherapy (ICBT) patients, out of whom 1296 patients completed the treatments. Twenty eight received two and seventeen patients received only one Brachytherapy. In total, 3941 ICBT were held during the period of this study.

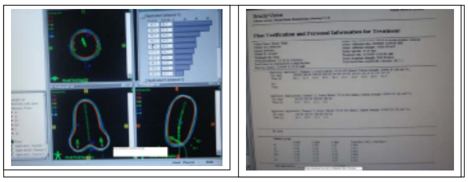

Figure 4 Isodose curves of ICBT planning (left) and dose at different points (right)

Bladder and Rectal dose

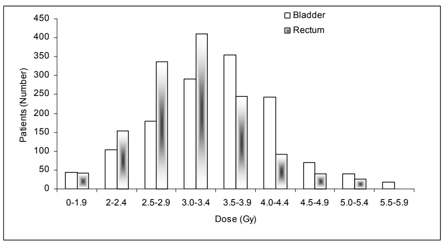

Figure 5. Bladder and rectal (centrally shaded) dose received by patients

1296 patients received all 3 cycle of treatments. Seven Gray was given in each ICBT. Maximum patients 888 (66.22%) are getting bladder dose between 3 to 4.4 Gy per treatment. 26.47 percentage patients has received dose to bladder in range of 3.5 to 3.9Gy . The bladder dose 72.5 percentage patients is less than 55.7 percentage of point A dose in each treatment.. Similarly; In case of rectum dose, total 1186 (89.2%) pts has received rectal dose less than 55.7 percentage of seven gray per cycle. 3.06 pts has rectal dose less than 2Gy and none have more than 5.5 Gy as in fig.5, centrally shaded chart. The peak of chart is 410 (30.58%) between 3-3.4 Gy which is less than 50 percentage of A point dose. The AP view of isodose curve is pear shaped. Most common stages of cervical cancer in our centre are of IIB and IIIB.[11] Higher the dose to bladder and rectum may cause of complication.

During the period of study new sources were calibrated in different dates. The variation between site measured and varisource sources strengths are in acceptable limit within five percentage.

4. CONCLUSION

The Most common malignancy in women in our dept of radiation oncology is cervical cancer. Radiotherapy has been considered an established effective treatment modality for all stage carcinoma of cervix. There is individualized treatment planning for every patient. Maximum patients were treated with bladder and rectal dose less than 55 and 50 percentages respectively of Point A dose with satisfactory pear shape. Normal organ dose should minimise, however, it should not produce a significant reduction in disease control.

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Equilibrium Configuration of LiH and Li_2

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The present work describes the equilibrium configuration of the lithium hydride (LiH) and lithium dimer (Li_2) calculated using the Hartree-Fock procedure implemented by the Gaussian 03 set of programs. We have also calculated the ground state energy of the lithium atom and ions using the single-center expansion method with the Gaussian shell orbitals. The ground state energies for the lithium atom and ions calculated using the single-center expansion method and the HF procedure agree to each other within 3%. The ground state energy for the lithium atom has been estimated to be -7.432 a.u. and that for Li^+ and Li^{++} ions to be -7.236 a.u. and -4.494 a.u., respectively. With these HF values of energy for the lithium atom and ions, we have estimated the first and second ionization potentials for the lithium atom to be 5.34 eV and 79.95 eV, respectively, which are in close agreement to the previously reported experimental values within 1%. We have also performed calculations using configurations interaction (CI) method and the density functional theory (DFT) to study the equilibrium configurations of LiH and Li2. The ground state energies for LiH and Li_2 obtained using the DFT calculation are lower than that obtained with the CI method, which, in turn, are lower than that obtained with the HF approximation. With the DFT calculation we have estimated the binding energy of LiH to be 242.81 kJ/mol, which is in close agreement with the previously reported experimental value of 238.049 kJ/mol within 2%. However, in case of Li_2 the DFT value of binding energy is less than the corresponding CI value by around 9%. The binding energy of Li_2 using the CI calculation has been estimated to be 94.99 kJ/mol, which is close to the previously reported experimental value of 98.98 kJ/mol within 4%. We have also studied the variation of energy with distance between the constituent atoms of LiH and Li_2. From the energy versus distance curves we have estimated the bond lengths for Li-H and Li-Li to be 1.59 Å and 2.70Å, respectively, which are in close agreement with the previously reported experimental values within 1%.

Key words: HF approximation, CI, DFT, binding energy, bond length.

I. INTRODUCTION

The first-principles approaches are being widely used to study the electronic structure and to determine the various physical properties (e.g., ground state energy, dipole moment, ionization potential, polarizability, nuclear quadruple moment etc) of many-electron systems [1]. These approaches can be classified into three main categories: Hartree-Fock (HF) approximation, density functional theory (DFT) and quantum Monte Carlo method. Here the calculations are carried out using only HF and DFT methods. Since Hartree-Fock approximation can not calculate the correlation between electrons of opposite spin, the correlation methods like Møller-Plesset perturbation (MP_2) and configuration interaction (CI) considers the mixing of wave function from the ground state configuration are taken. The CI method, in principle, has many of the desirable features being well defined, size-consistant and variational [2]. Møller-Plesset perturbation theory adds higher excitations to HF theory as a non-iterative correction and are variational. So there is a possibility of overcorrecting the energy values [3].

In another first-principles approach- DFT, in which the electronic orbitals are solution to a Schrodinger equation which depends on the electron density rather than on individual electron orbitals, the exchange-correlation potential not only includes exchange effects arising from the antisymmetric of the wave functions but also correlation effects due to the motions of the individual electrons (dynamic correlation effects). In this method exchange and dynamic correlation effects are in practice treated approximately [1]. HF, MP_2, CI and DFT methods can be used to study the electronic structure and to calculate the various physical properties of many electron systems with the aid of the Gaussian 03 set of programs [3].

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II. GROUND STATE ENERGY OF Li ATOM USING GAUSSIAN SHELL ORBITALS (GSO)

The first principle calculations to study the equilibrium configuration of many-electron systems have been performed using the basis sets like Slater type orbitals (STO), Gaussian type orbitals (GTO) and single-center Gaussian shell orbitals (GSO) [4]. The Gaussian shell orbitals (GSO) are defined [4] as

$$\Phi(n,l,m,\alpha,\rho;r) = \mathbf{N}\, r^{\,n-1}\, e^{-\alpha(r-\rho)^2}\, Y_{l,m}(\theta,\phi)$$

where r, θ, ϕ are the spherical polar coordinates describing the electronic configuration, n, l and m are the principal, the orbital and magnetic quantum numbers respectively, N is the normalization constant and α and ρ gives the distance from the center to variationally scaled spherical shell. The optimazitation of the variational parameters (α, ρ) of Gaussian shell orbitals has been done by minimizing the following energy expression

$$E = \frac{\langle\phi|H|\phi\rangle}{\langle\phi|\phi\rangle} \qquad (1)$$

where H is the Hamiltonian which consists of the kinetic energy of the electrons relative to the stationary nucleus, the energy due to the Columb attraction of the electron and nucleus and the energy due to electron-electron repulsion and Φ is single-center Gaussian shell orbitals. As different combinations of the variational parameters α and ρ satisfy the condition of energy minimization, we have used the virial theorem to optimize the value of α and ρ.

Actually the Gaussian shell orbitals are hybrids of Gaussian and Slater orbitals [4].

The STO is linear exponential functions of the radius r and can be write as

$$\chi(n,l,m,\tau;r) = A\, r^{\,n-1}\, e^{-\tau r}\, Y_{l,m}(\theta,\phi)$$

where τ is the variatiional parameter and A is the normalization constant. And the Gaussian type orbital (GTO) is the quadratic exponential function of r

$$\xi(n,l,m,\alpha;r) = B\, r^{\,n-1}\, e^{-\alpha r^2}\, Y_{l,m}(\theta,\phi)$$

where α is variational parameter and B is the normalization constant. Using error functions [5] we can solve the Eq. (1).

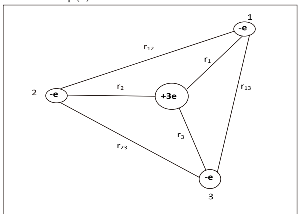

Fig. 1. Lithium atom in the ground state

The non-relativistic Hamiltonian of the lithium atom (Z=3) within the Born-Oppenheimer approximation in atomic units (i.e., e=1, h=1,m=1) can be expressed as

$$H = -\frac{1}{2}\left(\nabla_1^2+\nabla_2^2+\nabla_3^2\right) - \left(r_1^{-1}+r_2^{-1}+r_3^{-1}\right) + \left(r_{12}^{-1}+r_{13}^{-1}+r_{23}^{-1}\right)$$

where the first, second and third term represent the kinetic energy of the electrons relative to stationary nucleus, the energy due to Columbic attraction of the electron and the nucleus and the energy due to Columbic repulsion between the electrons respectively.

In the ground state of the lithium atom, there are two electrons in the 1s orbital and one electron in the 2s orbital. For the electrons in 1s state n=1, l=0 and m=0, the wave functions in terms of the Gaussian shell orbital can be expressed as

$$\Phi_1 = \frac{1}{\sqrt{4\pi G_2}}\, e^{-\alpha(r_1-\rho)^2}$$

and $\Phi_2 = \frac{1}{\sqrt{4\pi G_2}}\, e^{-\alpha(r_2-\rho)^2}$

And for the electrons in 2s state n=2, l=0 and m=0, the wave functions in terms of the Gaussian shell orbital can be expressed as

$$\Phi_3 = \frac{1}{\sqrt{4\pi G_4}}\, e^{-\alpha(r_3-\rho)^2}$$

Using Schrodinger time independent wave equation, normalized wave function Φ and Eq. (1), we get

$$E = \langle\phi|H|\phi\rangle \qquad (2)$$

$= KE_1+KE_2+KE_3+PE_1+PE_2+PE_3+(IEPE)_{12}+(IEPE)_{13}+(IEPE)_{23}$

Where $KE_1 = KE_2 = \frac{3}{2}\alpha - \alpha\rho\frac{G_1}{G_2}$ $\qquad KE_3 = \frac{1}{2}\alpha + \frac{G_2}{2G_4}$

$G_n = \int r^n e^{-\alpha(r-\rho)^2}dr$ $\qquad PE_1 = PE_2 = -\frac{3G_1}{G_2}$

$PE_3 = -\frac{3G_3}{G_4}$ $\qquad (IEPE)_{12} = \langle\phi|r_{12}^{-1}|\phi\rangle$

$\phi = \phi_1\phi_2$

wave function for $(IEPE)_{13} = \frac{1}{\sqrt{2}}\left(\phi_{100}(1)\phi_{200}(3) - \phi_{200}(1)\phi_{100}(3)\right)$ (3)

wave function for $(IEPE)_{23} = \frac{1}{\sqrt{2}}\left(\phi_{100}(2)\phi_{200}(3) + \phi_{200}(2)\phi_{100}(3)\right)$ (4)

The choice of ϕ as given in Eqs. (3) and (4) is due to the fact that the Pauli principle requires that the orbital part of the wave function be antisymmetric/symmetric for electrons with parallel/antiparallel spins [6].

III. HATRTREE-FOCK APPROXIMATION

Hartree-Fock theory is well established approach to obtain an approximate solution of the many-electron Schrodinger equation by writing the total (electronic) wave function of the system as a single Slater determinant containing one-electron orbitals [7]. In Hartree-Fock self-consistent method for calculating the electronic states of many-electron systems, we have also explained the Hartree-Fock Roothaan variational procedure and the Møller-Plesset perturbation theory (MP_2). In Hartree's self-consistent field (SCF) approximation, for many electron system, it is assumed that the motion of each electron in a central field, produced by the nucleus , and the spherically averaged potential fields of each other electron is governed by a one-electron Schrodinger wave equation. Self-consistency of electronic charge distribution with its own electronic field leads to a set of coupled integro-differential equations (Hartree's equation) for N one-electron wave functions. Slater and Fock improved a formalism which represents the atomic wave function by a determinant built of atomic spin orbitals and is thereby consistent with the Pauli principle. Taking the wave function of many-electron system as Slater determinant, the missing term in Hartree's SCF model (i.e., exchange interaction) can be taken into account in the Hartree-Fock approximation. Application of the variational principle to a Slater determinant leads to a set of N coupled equations, known as Hartree-Fock equations [8]. As the anti-symmetric product of one-electron wave functions is used in the Hartree-Fock approximation, it takes into account of the correlation arising due to electrons of the same spin, however , the motion of the electrons of opposite spin remains uncorrelated. In general, the spin orbital restricted closed-shell formulation; by replacing the spin orbitals with a set of restricted closed-shell spin orbitals. Then a basis set is introduced and it converts the spatial integro-differential closed-shell Hartree-Fock equations to a set of algebraic equations, known as Roothaan equations [2].

Hartree product does not satisfy the antisymmetric principle. In order to fulfil the antisymmetic principle, the wave function for N-electron system is taken in the form of Slater determinant [9] as follows,

$$\Psi(x_1,x_2,\ldots x_N) = \frac{1}{\sqrt{N!}}\begin{vmatrix}\chi_1(r_1) & \chi_2(r_1) & \cdots & \chi_N(r_1)\\ \chi_1(r_2) & \chi_2(r_2) & \cdots & \chi_N(r_2)\\ \vdots & \vdots & \ddots & \vdots\\ \chi_1(r_N) & \chi_2(r_N) & \cdots & \chi_N(r_N)\end{vmatrix} \qquad (5)$$

or, $\Psi(x_1,x_2,\ldots x_N) = |\chi_1\chi_2\cdots\chi_a\chi_b\cdots\chi_N\rangle$

where, $\frac{1}{\sqrt{N!}}$ is a normalization constant.

$\chi(x) = \Psi(\mathbf{r})\alpha(\omega)$

and $\chi(x) = \Psi(r)\beta(\omega)$

the Hamiltonian for N electron and M nuclei system can be written as,

$$H = -\sum_{i=1}^{N}\frac{1}{2}\nabla_i^2 - \sum_{A=1}^{M}\frac{1}{2M_A}\nabla_A^2 - \sum_{i=1}^{N}\sum_{A=1}^{M}\frac{Z_A}{r_{iA}} + \sum_{i=1}^{N}\sum_{j>i}^{N}\frac{1}{r_{ij}} + \sum_{A=1}^{M}\sum_{B>A}^{M}\frac{Z_A Z_B}{r_{AB}} \qquad (6)$$

where, M_A is the ratio of the mass of the nucleus A to the mass of an electron, and Z_A is the atomic number of nucleus A. The first and the second terms in Eq. (6) represents the kinetic energy of the electrons and nuclei, respectively, the third term represents the Coulomb attraction between electrons and nuclei, and the fourth and fifth terms represent the repulsion between electrons and between nuclei, respectively. Using the Born-Oppenheimer approximation, the Hamiltonian of the system is given to be,

$$H = -\sum_{i=1}^{N}\frac{1}{2}\nabla_i^2 - \sum_{i=1}^{N}\sum_{A=1}^{M}\frac{Z_A}{r_{iA}} + \sum_{i=1}^{N}\sum_{j>i}^{N}\frac{1}{r_{ij}} \qquad (7)$$

The last term of Eq.(6) is neglected because the addition of a constant term does not change the eigen function.

Hartee-Fock method looks for those orbitals χ_i that minimize the variational energy integaal Eq. (1) and each orbital is taken to be normalized i.e., $\langle\phi|\phi\rangle = 1$. Then using Eq. (1) and Eq. , we get

$$E = \langle\Psi|H|\Psi\rangle = \sum_{a=1}^{N}h_{aa} + \frac{1}{2}\sum_{a=1}^{N}\sum_{b>a}^{N}(J_{ab} - K_{ab}) \qquad (8)$$

where, $h_{aa} = \langle\chi_a|h(1)|\chi_a\rangle$

$= \int dr_1 \Psi_a^*(r_1)\left(-\frac{1}{2}\nabla_1^2 - \frac{Z}{r_1}\right)\Psi_a(r_1)$, is the average kinetic and nuclear attraction energy of the electron described by the wave function $\Psi_a(r_1)$;

$J_{ab} = \langle\chi_a\chi_b|\chi_a\chi_b\rangle$

$= \int dr_1 dr_2 |\Psi(r_2)|^2 \frac{1}{r_{12}}$; is the classical repulsion between the charge clouds $|\Psi_a(r_1)|^2$ and $|\Psi_b(r_2)|^2$, and is called the Coulomb integral or the electrostatic repulsion potential which arises due to electron b when its position is averaged over the space.

$K_{ab} = \langle\chi_a\chi_b|\chi_b\chi_a\rangle$

$= \int dr_1 dr_2 \Psi_a(r_1)\Psi_b(r_2)\frac{1}{r_{12}}\Psi_b(r_2)\Psi_a(r_1)$; is called the exchange integral, which arises due to the asymmetry of the total wave function, and requires the spin of electrons a and b to be parallel.

For atoms and molecules with the closed shell configuration, the energy expression Eq. (8) can be written as,

$$E = 2\sum_a h_{aa} + \sum_{a=1}\sum_{b=1}(2J_{ab} - K_{ab})$$

Minimizing $E[\{\chi_a\}]$ with respect the spin orbitals, subject to the constraint that the spin orbitals remain orthogonal.

$$F(1)|\chi_a(1)\rangle = \sum_{b=1}^{N}\varepsilon_{ba}|\chi_a(1)\rangle \qquad (9)$$

where, $F(1) = h(1) + \sum_{b=1}^{N}\{J_b(1) - K_b(1)\}$ is known as the Fock operator. Eq. (9) are known as the Hartree-Fock equations. Using Hartree-Fock orbitals $\psi_i = \sum_\mu C_{\mu i}\varphi_\mu$

where $i = 1,2,\ldots k$ and spatial integro-differential equation, we get

$$\sum_\mu F_{\nu\mu}C_{\mu i} = \varepsilon_i \sum_\mu S_{\nu\mu}C_{\mu i}: \qquad i=1, 2, \ldots k \qquad (10)$$

where,

$S_{\nu\mu} = \int dr_1\, \varphi_\nu(1)\varphi_\mu(1)$, & $\qquad F_{\nu\mu} = \int dr_1\, \varphi_\nu(1)F(1)\varphi_\mu(1)$

Eq. (10) are known as Roothan equations.

IV. CORRELATION METHODS

The Møller-Plesset (MP) perturbation theory adds higher excitations to the Hartree-Fock theory as a non-iterative correction. It begins with the dividing the Hamiltonian (H) of the system into two different parts [3, 10], as presented below

$$\hat{H} = \hat{H}_0 + \hat{V} \qquad (11)$$

where, $\hat{H}_0$ is the unperturbed Hamiltonian which has exact solution and $\hat{V}$ is a small perturbation applied to $\hat{\mathbf{H}}_0$, which can be expanded in terms of some real perturbation parameter λ as,

$$\hat{V} = \lambda\hat{H}^{(1)} + \lambda^2\hat{H}^{(2)} + \lambda^3\hat{H}^{(3)} + \ldots \qquad (12)$$

The assumption that $\hat{V}$ is a small perturbation to $\hat{H}_0$, suggests that the perturbed wave function and energy can be expressed as a power series in terms of the parameter λ, due to the addition of the small correction terms, i.e.

$$\Psi = \Psi^{(0)} + \lambda^1\Psi^{(1)} + \lambda^2\Psi^{(2)} + \lambda^3\Psi^{(3)} + \ldots \qquad (13)$$

$$E = E^{(0)} + \lambda^1E^{(1)} + \lambda^2E^{(2)} + \lambda^3E^{(3)} + \ldots \qquad (14)$$

Substituting the perturbed wave function and energy into the time independent Schröndinger wave equation,

$$\hat{H}\Psi = E\Psi \qquad (15)$$

we get,

$$(\hat{H}_0 + \hat{V})\Psi = E\Psi$$

or,

$$(\hat{H}_0 + \hat{V})(\Psi^{(0)} + \lambda^1\Psi^{(1)} + \lambda^2\Psi^{(2)} + \ldots) = (E^{(0)} + \lambda^1E^{(1)} + \lambda^2E^{(2)} + \ldots)(\Psi^{(0)} + \lambda^1\Psi^{(1)} + \lambda^2\Psi^{(2)} + \ldots) \qquad (16)$$

Equating the coefficients for equal power of λ, on both sides of Eq.5 we obtain the following relations,

Zero order:

Theoretical analysis of material constants in thermopiezoelasticity

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Abstract

Materials with thermopiezoelastic properties have both theoretical and practical significance in solid-state physics and materials science. Thermopiezoelastic media exhibit coupling among the thermal, electric and elastic fields. Strain, electric displacement and entropy can be written in terms of stress, electric field and temperature. Investigation is concerned with the analysis of nonlinear thermopiezoelasticity using thermodynamic functions. Strain, electric displacement and entropy are expanded into Taylor series. Zeroth to eighth rank tensors are derived for describing material constants. Relationship of material constants of strain, electric displacement and entropy are obtained in thermopiezoelasticity. Due to intrinsic coupling behavior, thermopiezoelastic materials are widely used as sensors and actuators in sensing, actuation, and control of smart structures. Mathematical expressions of material constants may be useful for future investigation of the mechanics and physics of nonlinear thermopiezoelasticity.

Introduction

Mechanical, electrical, and thermal fields are coupled in thermopiezoelasticity. Nonlinear analysis of thermopiezoelasticity has been made for determining their material constants. In the previous studies, Bao and co-workers (1998) introduced static, dynamic, and control characteristics of a nonlinear piezoelectric laminated beam subjected to mechanical, temperature, and electric excitations. Wang et al. (1999) studied the nonlinear electromechanical behavior piezoelectric ceramic in a wide electric field and frequency range. Zhou and Tzou (2000) developed nonlinear electromechanics and active control of piezoelectric laminated circular spherical shallow shells. Hall (2001) gave an overview of experimental evidence and understanding of nonlinear dielectric, elastic and piezoelectric relationships in piezoelectric ceramics.

Furthermore, Altay and Dokmeci (2002) described a nonlinear rod theory for high-frequency vibrations of thermopiezoelectric materials. Warkusz and Linek (2003) analyzed material constants from zeroth to sixth rank tensors in nonlinear mechanical, electrical and thermal phenomena in piezoelectric crystals. Wagner (2004) presented nonlinear longitudinal vibrations of non-slender piezoceramic rods. Mukherjee and Chaudhuri (2005) deduced a generalized formulation for nonlinear dynamic analysis of piezoelectric structures. Blackburn and Cain (2006) examined nonlinear piezoelectric resonance.

Among some recent works, Balakina (2007) deduced analytical expressions for the pyro- and piezoelectric coefficients of nonlinear optical polymer electrets. Grigoriev et al. (2008) discussed nonlinear piezoelectricity in epitaxial ferroelectrics at high electric fields. Xia and Shen (2009) proposed an analysis with the nonlinear vibration and dynamic response of a shear deformable functionally graded material (FGM) plate with surface-bonded piezoelectric fiber reinforced composite actuators (PFRC) in thermal environments. Yiqi and Yiming (2010) considered nonlinear dynamic response and active vibration control of the piezoelectric functionally graded plate.

Present analysis deals with thermodynamic Gibbs function. Strain, electric displacement and entropy are produced simultaneously by stress, electric field and temperature change. In order to derive material constants from zeroth to eighth rank tensors, thermodynamic Gibbs function is expressed in Taylor series up to fourth order differentiation.

Thermopiezoelasticity and thermodynamics

In thermopiezoelastic materials, thermodynamics Gibbs function G (or the Gibbs potential) can be written as

$$G = U - \varepsilon_{ij}\sigma_{ij} - E_m D_m - TS \qquad (1)$$

In equation (1), U, T and S are internal energy, temperature change and entropy, respectively. Subscripts indices i, j, m are ranging 1 to 3. It is noted that all other subscripts indices denoting in other equations range from 1 to 3 unless otherwise specified. Strain, stress, electric field and electric displacement are denoted by ε_{ij}, σ_{ij}, E_m and D_m. Following Einstein's summation convention, the summation sign $\sum$ is omitted. For example, its detail can be found in Weber, Balashova and Kizhaev (2000).

Differential form of Gibbs function is expressed as

$$dG = dU - \varepsilon_{ij}d\sigma_{ij} - \sigma_{ij}d\varepsilon_{ij} - E_m dD_m - D_m dE_m - SdT - TdS \qquad (2)$$

As far as the first and second law of thermodynamics are concerned, differential form of internal energy is represented by

$$dU = \sigma_{ij}d\varepsilon_{ij} + E_m dD_m + TdS \qquad (3)$$

It follows from equations (2) and (3) that

$$dG = -\varepsilon_{ij}d\sigma_{ij} - D_m dE_m - SdT. \qquad (4)$$

Strain, electric displacement and entropy can be written in the following forms

$$\varepsilon_{ij} = f(\sigma_{kl}, E_n, T) \qquad (5)$$

$$D_m = f(\sigma_{kl}, E_n, T) \qquad (6)$$

$$S = f(\sigma_{kl}, E_n, T) \qquad (7)$$

Further, thermodynamics Gibbs function can be written as

$$dG = \left.\frac{\partial G}{\partial \sigma_{ij}}\right|_{E,T} d\sigma_{ij} + \left.\frac{\partial G}{\partial E_m}\right|_{\sigma,T} dE_m + \left.\frac{\partial G}{\partial T}\right|_{\sigma,E} dT \qquad (8)$$

In equation (8), indices in the lower part of vertical line on the partial derivatives indicate the variable that must be held constant during differentiation.

Also, equations (4) and (8) yield

$$\varepsilon_{ij} = -\left.\frac{\partial G}{\partial \sigma_{ij}}\right|_{E,T} \qquad (9)$$

$$D_m = -\left.\frac{\partial G}{\partial E_m}\right|_{\sigma,T} \qquad (10)$$

$$S = -\left.\frac{\partial G}{\partial T}\right|_{\sigma,E} \qquad (11)$$

Material constants are obtained by the thermodynamic Gibbs function. Strain, electric displacement and entropy are expanded into Taylor Series.

Nonlinear equations in thermopiezoelasticity

Up to third order differentiation, Strain, electric displacement and entropy can be expressed in Taylor Series as follows:

$$\varepsilon_{ij} = \Big(\frac{\partial \varepsilon_{ij}}{\partial \sigma_{kl}} + \frac{1}{2!}\frac{\partial^2 \varepsilon_{ij}}{\partial \sigma_{kl}\partial \sigma_{pq}}\sigma_{pq} + \frac{1}{2!}\frac{\partial^2 \varepsilon_{ij}}{\partial \sigma_{kl}\partial E_n}E_n + \frac{1}{2!}\frac{\partial^2 \varepsilon_{ij}}{\partial \sigma_{kl}\partial T}T$$

$$+\frac{1}{3!}\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}}\sigma_{pq}\sigma_{rs} + \frac{1}{3!}\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n}\sigma_{pq}E_n + \frac{1}{3!}\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\sigma_{pq}T\Big)\sigma_{kl}$$
$$+\Big(\frac{\partial \varepsilon_{ij}}{\partial E_n} + \frac{1}{2!}\frac{\partial^2 \varepsilon_{ij}}{\partial E_n\partial \sigma_{kl}}\sigma_{kl} + \frac{1}{2!}\frac{\partial^2 \varepsilon_{ij}}{\partial E_n\partial E_t}E_t + \frac{1}{2!}\frac{\partial^2 \varepsilon_{ij}}{\partial E_n\partial T}T$$
$$+\frac{1}{3!}\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{pq}\partial E_n\partial E_t}\sigma_{pq}E_t + \frac{1}{3!}\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{pq}\partial E_n\partial T}\sigma_{pq}T\Big)E_n$$
$$+\Big(\frac{\partial \varepsilon_{ij}}{\partial T} + \frac{1}{2!}\frac{\partial^2 \varepsilon_{ij}}{\partial \sigma_{kl}\partial T}\sigma_{kl} + \frac{1}{2!}\frac{\partial^2 \varepsilon_{ij}}{\partial E_n\partial T}E_n + \frac{1}{2!}\frac{\partial^2 \varepsilon_{ij}}{\partial T^2}T$$
$$+\frac{1}{3!}\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{pq}\partial E_n\partial T}\sigma_{pq}E_n + \frac{1}{3!}\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{kl}\partial T^2}\sigma_{kl}T\Big)T \qquad (12)$$

$$D_m = \Big(\frac{\partial D_m}{\partial \sigma_{kl}} + \frac{1}{2!}\frac{\partial^2 D_m}{\partial \sigma_{kl}\partial \sigma_{pq}}\sigma_{pq} + \frac{1}{2!}\frac{\partial^2 D_m}{\partial \sigma_{kl}\partial E_n}E_n + \frac{1}{2!}\frac{\partial^2 D_m}{\partial \sigma_{kl}\partial T}T$$
$$+\frac{1}{3!}\frac{\partial^3 D_m}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}}\sigma_{pq}\sigma_{rs} + \frac{1}{3!}\frac{\partial^3 D_m}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n}\sigma_{pq}E_n + \frac{1}{3!}\frac{\partial^3 D_m}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\sigma_{pq}T\Big)\sigma_{kl}$$
$$+\Big(\frac{\partial D_m}{\partial E_n} + \frac{1}{2!}\frac{\partial^2 D_m}{\partial \sigma_{kl}\partial E_n}\sigma_{kl} + \frac{1}{2!}\frac{\partial^2 D_m}{\partial E_n\partial E_t}E_t + \frac{1}{2!}\frac{\partial^2 D_m}{\partial E_n\partial T}T$$
$$+\frac{1}{3!}\frac{\partial^3 D_m}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}\frac{\partial^3 D_m}{\partial \sigma_{pq}\partial E_n\partial E_t}\sigma_{pq}E_t + \frac{1}{3!}\frac{\partial^3 D_m}{\partial \sigma_{pq}\partial E_n\partial T}\sigma_{pq}T\Big)E_n$$
$$+\Big(\frac{\partial D_m}{\partial T} + \frac{1}{2!}\frac{\partial^2 D_m}{\partial \sigma_{kl}\partial T}\sigma_{kl} + \frac{1}{2!}\frac{\partial^2 D_m}{\partial E_n\partial T}E_n + \frac{1}{2!}\frac{\partial^2 D_m}{\partial T^2}T$$
$$+\frac{1}{3!}\frac{\partial^3 D_m}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}\frac{\partial^3 D_m}{\partial \sigma_{pq}\partial E_n\partial T}\sigma_{pq}E_n + \frac{1}{3!}\frac{\partial^3 D_m}{\partial \sigma_{kl}\partial T^2}\sigma_{kl}T\Big)T \qquad (13)$$

$$S = \Big(\frac{\partial S}{\partial \sigma_{kl}} + \frac{1}{2!}\frac{\partial^2 S}{\partial \sigma_{kl}\partial \sigma_{pq}}\sigma_{pq} + \frac{1}{2!}\frac{\partial^2 S}{\partial \sigma_{kl}\partial E_n}E_n + \frac{1}{2!}\frac{\partial^2 S}{\partial \sigma_{kl}\partial T}T$$
$$+\frac{1}{3!}\frac{\partial^3 S}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}}\sigma_{pq}\sigma_{rs} + \frac{1}{3!}\frac{\partial^3 S}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n}\sigma_{pq}E_n + \frac{1}{3!}\frac{\partial^3 S}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\sigma_{pq}T\Big)\sigma_{kl}$$
$$+\Big(\frac{\partial S}{\partial E_n} + \frac{1}{2!}\frac{\partial^2 S}{\partial \sigma_{kl}\partial E_n}\sigma_{kl} + \frac{1}{2!}\frac{\partial^2 S}{\partial E_n\partial E_t}E_t + \frac{1}{2!}\frac{\partial^2 S}{\partial E_n\partial T}T$$
$$+\frac{1}{3!}\frac{\partial^3 S}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}\frac{\partial^3 S}{\partial \sigma_{pq}\partial E_n\partial E_t}\sigma_{pq}E_t + \frac{1}{3!}\frac{\partial^3 S}{\partial \sigma_{pq}\partial E_n\partial T}\sigma_{pq}T\Big)E_n$$
$$+\Big(\frac{\partial S}{\partial T} + \frac{1}{2!}\frac{\partial^2 S}{\partial \sigma_{kl}\partial T}\sigma_{kl} + \frac{1}{2!}\frac{\partial^2 S}{\partial E_n\partial T}E_n + \frac{1}{2!}\frac{\partial^2 S}{\partial T^2}T$$

$$+\frac{1}{3!}\frac{\partial^3 S}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}\frac{\partial^3 S}{\partial \sigma_{pq}\partial E_n\partial T}\sigma_{pq}E_n + \frac{1}{3!}\frac{\partial^3 S}{\partial \sigma_{kl}\partial T^2}\sigma_{kl}T\Big)T \qquad (14)$$

Material constants obtained from strain ε_{ij}

Taking equation (9), expressions of material constants can be obtained as

Second order elasticity constant (fourth rank tensor)

$$\left.\frac{\partial \varepsilon_{ij}}{\partial \sigma_{kl}}\right|_{E,T} = \frac{\partial}{\partial \sigma_{kl}}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^2 G}{\partial \sigma_{kl}\partial \sigma_{ij}}\right|_{E,T} = s^{E,T}_{ijkl} \qquad (15a)$$

In equation (15a) and all other equations of material constants, superscript indices are constant. It should be noted that superscripts indices are not taken as powers.

Second order piezoelectric constant (third rank tensor)

$$\left.\frac{\partial \varepsilon_{ij}}{\partial E_n}\right|_{T} = \frac{\partial}{\partial E_n}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^2 G}{\partial E_n\partial \sigma_{ij}}\right|_{T} = d^T_{ijn} \qquad (15b)$$

Second order piezo-calorific constant (second rank tensor)

$$\left.\frac{\partial \varepsilon_{ij}}{\partial T}\right|_{\sigma,E} = \frac{\partial}{\partial T}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^2 G}{\partial T\partial \sigma_{ij}}\right|_{E} = \alpha^E_{ij} \qquad (15c)$$

Third order elasticity constant (sixth rank tensor)

$$\left.\frac{\partial^2 \varepsilon_{ij}}{\partial \sigma_{kl}\partial \sigma_{pq}}\right|_{E,T} = \frac{\partial^2}{\partial \sigma_{kl}\partial \sigma_{pq}}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{ij}}\right|_{E,T} = s^{E,T}_{ijklpq} \qquad (15d)$$

Third order piezoelectric constant (fifth rank tensor)

$$\left.\frac{\partial^2 \varepsilon_{ij}}{\partial \sigma_{kl}\partial E_n}\right|_{T} = \frac{\partial^2}{\partial \sigma_{kl}\partial E_n}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial E_n\partial \sigma_{ij}}\right|_{T} = d^T_{ijkln} \qquad (15e)$$

Third order piezo-calorific constant (fourth rank tensor)

$$\left.\frac{\partial^2 \varepsilon_{ij}}{\partial \sigma_{kl}\partial T}\right|_{E} = \frac{\partial^2}{\partial \sigma_{kl}\partial T}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial T\partial \sigma_{ij}}\right|_{E} = \alpha^E_{ijkl} \qquad (15f)$$

Fourth order elasticity constant (eighth rank tensor)

$$\left.\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}}\right|_{E,T} = \frac{\partial^3}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}\partial \sigma_{ij}}\right|_{E,T} = s^{E,T}_{ijklpqrs} \qquad (15g)$$

Fourth order piezoelectric constant (seventh rank tensor)

$$\left.\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n}\right|_{T} = \frac{\partial^3}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n\partial \sigma_{ij}}\right|_{T} = d^T_{ijklpqn} \qquad (15h)$$

Fourth order piezo-calorific constant (sixth rank tensor)

$$\left.\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\right|_{E} = \frac{\partial^3}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T\partial \sigma_{ij}}\right|_{E} = \alpha^E_{ijklpq} \qquad (15i)$$

Third order electrostriction constant (fourth rank tensor)

$$\left.\frac{\partial^2 \varepsilon_{ij}}{\partial E_n\partial E_t}\right|_{\sigma,T} = \frac{\partial^2}{\partial E_n\partial E_t}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^3 G}{\partial E_n\partial E_t\partial \sigma_{ij}}\right|_{T} = o^T_{ijnt} \qquad (15j)$$

Third order electro-thermo-elastic constant (third rank tensor)

$$\left.\frac{\partial^2 \varepsilon_{ij}}{\partial E_n\partial T}\right|_{\sigma} = \frac{\partial^2}{\partial E_n\partial T}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^3 G}{\partial E_n\partial T\partial \sigma_{ij}}\right| = k_{ijn} \qquad (15k)$$

Fourth order electrostriction constant (sixth rank tensor)

$$\left.\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{pq}\partial E_t\partial E_n}\right|_{T} = \frac{\partial^3}{\partial \sigma_{pq}\partial E_t\partial E_n}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{pq}\partial E_t\partial E_n\partial \sigma_{ij}}\right|_{T} = o^T_{ijpqtn} \qquad (15l)$$

Fourth order electro-thermo-elastic constant (fifth rank tensor)

$$\left.\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{pq}\partial E_n\partial T}\right| = \frac{\partial^3}{\partial \sigma_{pq}\partial E_n\partial T}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{pq}\partial E_n\partial T\partial \sigma_{ij}}\right| = k_{ijpqn} \qquad (15m)$$

Third order thermal expansion constant (second rank tensor)

$$\left.\frac{\partial^2 \varepsilon_{ij}}{\partial T^2}\right|_{\sigma,E} = \frac{\partial^2}{\partial T^2}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^3 G}{\partial T^2\partial \sigma_{ij}}\right|_{E} = r^E_{ij} \qquad (15n)$$

Fourth order thermal expansion constant (fourth rank tensor)

$$\left.\frac{\partial^3 \varepsilon_{ij}}{\partial \sigma_{kl}\partial T^2}\right|_{E} = \frac{\partial^3}{\partial \sigma_{kl}\partial T^2}\left(-\frac{\partial G}{\partial \sigma_{ij}}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial T^2\partial \sigma_{ij}}\right|_{E} = r^E_{ijkl} \qquad (15o)$$

Material constants obtained from electric displacement D_m

Considering equation (10), the material constants can be derived as

Second order piezoelectric constant (third rank tensor)

$$\left.\frac{\partial D_m}{\partial \sigma_{kl}}\right|_{E,T} = \frac{\partial}{\partial \sigma_{kl}}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^2 G}{\partial \sigma_{kl}\partial E_m}\right|_{T} = d^T_{klm} \qquad (16a)$$

Second order permittivity constant (second rank tensor)

$$\left.\frac{\partial D_m}{\partial E_n}\right|_{\sigma,T} = \frac{\partial}{\partial E_n}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^2 G}{\partial E_n\partial E_m}\right|_{\sigma,T} = \eta^{\sigma,T}_{mn} \qquad (16b)$$

Second order electric heat constant (first rank tensor)

$$\left.\frac{\partial D_m}{\partial T}\right|_{\sigma,E} = \frac{\partial}{\partial T}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^2 G}{\partial T\partial E_m}\right|_{\sigma} = p^\sigma_m \qquad (16c)$$

Third order piezoelectric constant (fifth rank tensor)

$$\left.\frac{\partial^2 D_m}{\partial \sigma_{kl}\partial \sigma_{pq}}\right|_{E,T} = \frac{\partial^2}{\partial \sigma_{kl}\partial \sigma_{pq}}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_m}\right|_{T} = d^T_{klpqm} \qquad (16d)$$

Third order electrostriction constant (fourth rank tensor)

$$\left.\frac{\partial^2 D_m}{\partial \sigma_{kl}\partial E_n}\right|_{T} = \frac{\partial^2}{\partial \sigma_{kl}\partial E_n}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial E_n\partial E_m}\right|_{T} = o^T_{klmn} \qquad (16e)$$

Third order electro-thermo-elastic constant (third rank tensor)

$$\left.\frac{\partial^2 D_m}{\partial \sigma_{kl}\partial T}\right|_{E} = \frac{\partial^2}{\partial \sigma_{kl}\partial T}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial T\partial E_m}\right| = k_{klm} \qquad (16f)$$

Fourth order piezoelectric constant (seventh rank tensor)

$$\left.\frac{\partial^3 D_m}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}}\right|_{E,T} = \frac{\partial^3}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}\partial E_m}\right|_{T} = d^T_{klpqrsm} \qquad (16g)$$

Fourth order electrostriction constant (sixth rank tensor)

$$\left.\frac{\partial^3 D_m}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n}\right|_{T} = \frac{\partial^3}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n\partial E_m}\right|_{T} = o^T_{klpqnm} \qquad (16h)$$

Fourth order electro-thermo-elastic constant (fifth rank tensor)

$$\left.\frac{\partial^3 D_m}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\right|_{E} = \frac{\partial^3}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T\partial E_m}\right| = k_{klpqm} \qquad (16i)$$

Third order permittivity constant (third rank tensor)

$$\left.\frac{\partial^2 D_m}{\partial E_n\partial E_t}\right|_{\sigma,T} = \frac{\partial^2}{\partial E_n\partial E_t}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^3 G}{\partial E_n\partial E_m\partial E_t}\right|_{\sigma,T} = \eta^{\sigma,T}_{mnt} \qquad (16j)$$

Third order electric heat constant (second rank tensor)

$$\left.\frac{\partial^2 D_m}{\partial E_n\partial T}\right|_{\sigma} = \frac{\partial^2}{\partial E_n\partial T}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^3 G}{\partial E_n\partial T\partial E_m}\right|_{\sigma} = p^\sigma_{mn} \qquad (16k)$$

Fourth order electro-elastic constant (fifth rank tensor)

$$\left.\frac{\partial^3 D_m}{\partial \sigma_{pq}\partial E_t\partial E_n}\right|_{T} = \frac{\partial^3}{\partial \sigma_{pq}\partial E_t\partial E_n}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{pq}\partial E_t\partial E_n\partial E_m}\right|_{T} = \Gamma^T_{pqtnm} \qquad (16l)$$

Fourth order electro-thermo-electro-elastic constant (fourth rank tensor)

$$\left.\frac{\partial^3 E_m}{\partial \sigma_{pq}\partial E_n\partial T}\right| = \frac{\partial^3}{\partial \sigma_{pq}\partial E_n\partial T}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{pq}\partial E_n\partial T\partial E_m}\right| = \beta_{pqnm} \qquad (16m)$$

Third order pyroelectric constant (first rank tensor)

$$\left.\frac{\partial^2 D_m}{\partial T^2}\right|_{\sigma,E} = \frac{\partial^2}{\partial T^2}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^3 G}{\partial T^2\partial E_m}\right|_{\sigma} = u^\sigma_m \qquad (16n)$$

Fourth order thermo-electro-elastic constant (third rank tensor)

$$\left.\frac{\partial^3 D_m}{\partial \sigma_{kl}\partial T^2}\right|_{E} = \frac{\partial^3}{\partial \sigma_{kl}\partial T^2}\left(-\frac{\partial G}{\partial E_m}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial T^2\partial E_m}\right| = \omega_{klm} \qquad (16o)$$

Material constants obtained from entropy S

Using equation (11), the material constants can be expressed as

Second order piezo-calorific constant (second rank tensor)

$$\left.\frac{\partial S}{\partial \sigma_{kl}}\right|_{E,T} = \frac{\partial}{\partial \sigma_{kl}}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^2 G}{\partial \sigma_{kl}\partial T}\right|_{E} = \alpha^E_{kl} \qquad (17a)$$

Second order electric heat constant (first rank tensor)

$$\left.\frac{\partial S}{\partial E_n}\right|_{\sigma,T} = \frac{\partial}{\partial E_n}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^2 G}{\partial E_n\partial T}\right|_{\sigma} = p^\sigma_n \qquad (17b)$$

Second order thermal capacity constant (zeroth rank tensor)

$$\left.\frac{\partial S}{\partial T}\right|_{\sigma,E} = \frac{\partial}{\partial T}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^2 G}{\partial T^2}\right|_{\sigma,E} = \xi^{\sigma,E} \qquad (17c)$$

Third order piezo-calorific constant (fourth rank tensor)

$$\left.\frac{\partial^2 S}{\partial \sigma_{kl}\partial \sigma_{pq}}\right|_{E,T} = \frac{\partial^2}{\partial \sigma_{kl}\partial \sigma_{pq}}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\right|_{E} = \alpha^E_{klpq} \qquad (17d)$$

Third order electro-thermo-elastic constant (third rank tensor)

$$\left.\frac{\partial^2 S}{\partial \sigma_{kl}\partial E_n}\right|_{T} = \frac{\partial^2}{\partial \sigma_{kl}\partial E_n}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial E_n\partial T}\right| = k_{k\ln} \qquad (17e)$$

Third order thermal expansion constant (second rank tensor)

$$\left.\frac{\partial^2 S}{\partial \sigma_{kl}\partial T}\right|_{E} = \frac{\partial^2}{\partial \sigma_{kl}\partial T}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial T^2}\right|_{E} = r^E_{kl} \qquad (17f)$$

Fourth order piezo-calorific constant (sixth rank tensor)

$$\left.\frac{\partial^3 S}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}}\right|_{E,T} = \frac{\partial^3}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}\partial T}\right|_{E} = \alpha^E_{klpqrs} \qquad (17g)$$

Fourth order electro-thermo-elastic constant (fifth rank tensor)

$$\left.\frac{\partial^3 S}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n}\right|_{T} = \frac{\partial^3}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n\partial T}\right| = k_{klpqn} \qquad (17h)$$

Fourth order thermal expansion constant (fourth rank tensor)

$$\left.\frac{\partial^3 S}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\right|_{E} = \frac{\partial^3}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T^2}\right|_{E} = r^E_{klpq} \qquad (17i)$$

Third order electric heat constant (second rank tensor)

$$\left.\frac{\partial^2 S}{\partial E_n\partial E_t}\right|_{\sigma,T} = \frac{\partial^2}{\partial E_n\partial E_t}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^3 G}{\partial E_n\partial E_t\partial T}\right|_{\sigma} = p^\sigma_{nt} \qquad (17j)$$

Third order pyroelectric constant (first rank tensor)

$$\left.\frac{\partial^2 S}{\partial E_n\partial T}\right|_{\sigma} = \frac{\partial^2}{\partial E_n\partial T}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^3 G}{\partial E_n\partial T^2}\right|_{\sigma} = u^\sigma_n \qquad (17k)$$

Fourth order electro-thermo-electro-elastic constant (fourth rank tensor)

$$\left.\frac{\partial^3 S}{\partial \sigma_{pq}\partial E_t\partial E_n}\right|_{T} = \frac{\partial^3}{\partial \sigma_{pq}\partial E_t\partial E_n}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{pq}\partial E_n\partial E_t\partial T}\right| = \beta_{pqnt} \qquad (17l)$$

Fourth order thermo-electro-elastic constant (third rank tensor)

$$\left.\frac{\partial^3 S}{\partial \sigma_{pq}\partial E_n\partial T}\right| = \frac{\partial^3}{\partial \sigma_{pq}\partial E_n\partial T}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^4 G}{\partial \sigma_{pq}\partial E_n\partial T^2}\right| = \omega_{pqn} \qquad (17m)$$

Third order thermal capacity constant (zeroth rank tensor)

$$\left.\frac{\partial^2 S}{\partial T^2}\right|_{\sigma,E} = \frac{\partial^2}{\partial T^2}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^3 G}{\partial T^3}\right|_{\sigma,E} = P^{\sigma,E} \qquad (17n)$$

Fourth order thermo-elastic (second rank tensor)

$$\left.\frac{\partial^3 S}{\partial \sigma_{kl}\partial T^2}\right|_{E} = \frac{\partial^3}{\partial \sigma_{kl}\partial T^2}\left(-\frac{\partial G}{\partial T}\right) = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial T^3}\right|_{E} = \mu^E_{kl} \qquad (17o)$$

Relationship of thermopiezoelastic material constants

Considering equations (15a) to (17o), the material constants can be further written as

Second order piezoelectric constant (third rank tensor)

$$\left.\frac{\partial \varepsilon_{kl}}{\partial E_n}\right|_{\sigma,T} = \left.\frac{\partial D_n}{\partial \sigma_{kl}}\right|_{E,T} = -\left.\frac{\partial^2 G}{\partial \sigma_{kl}\partial E_n}\right|_{T} = d^T_{klm} \qquad (18a)$$

Second order piezo-calorific constant (second rank tensor)

$$\left.\frac{\partial \varepsilon_{kl}}{\partial T}\right|_{\sigma,E} = \left.\frac{\partial S}{\partial \sigma_{kl}}\right|_{E,T} = -\left.\frac{\partial^2 G}{\partial \sigma_{kl}\partial T}\right|_{E} = \alpha^E_{kl} \qquad (18b)$$

Third order piezoelectric constant (fifth rank tensor)

$$\left.\frac{\partial^2 \varepsilon_{kl}}{\partial \sigma_{kl}\partial E_n}\right|_{\sigma,T} = \left.\frac{\partial^2 D_m}{\partial \sigma_{kl}\partial \sigma_{pq}}\right|_{E,T} = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_m}\right|_{T} = d^T_{klpqm} \qquad (18c)$$

Third order piezo-calorific constant (fourth rank tensor)

$$\left.\frac{\partial^2 \varepsilon_{kl}}{\partial \sigma_{pq}\partial T}\right|_{E} = \left.\frac{\partial^2 S}{\partial \sigma_{kl}\partial \sigma_{pq}}\right|_{E,T} = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\right|_{E} = \alpha^E_{klpq} \qquad (18d)$$

Fourth order piezoelectric constant (seventh rank tensor)

$$\left.\frac{\partial^3 \varepsilon_{kl}}{\partial \sigma_{pql}\partial \sigma_{rs}\partial E_m}\right|_{T} = \left.\frac{\partial^3 D_m}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}}\right|_{E,T} = -\left.\frac{\partial^r G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}\partial E_m}\right|_{T} = d^T_{klpqrsm} \qquad (18e)$$

Fourth order piezo-calorific constant (sixth rank tensor)

$$\left.\frac{\partial^3 \varepsilon_{kl}}{\partial \sigma_{pq}\partial \sigma_{rs}\partial T}\right|_{E} = \left.\frac{\partial^3 S}{\partial \sigma_{kl}\partial \sigma_{pq}\partial \sigma_{rs}}\right|_{E,T} = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T\partial \sigma_{rs}}\right|_{E} = \alpha^E_{klpqrs} \qquad (18f)$$

Third order electrostriction constant (fourth rank tensor)

$$\left.\frac{\partial^2 \varepsilon_{kl}}{\partial E_n\partial E_t}\right|_{\sigma,T} = \left.\frac{\partial^2 D_m}{\partial \sigma_{kl}\partial E_t}\right|_{T} = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial E_n\partial E_t}\right|_{T} = o^T_{k\ln t} \qquad (18g)$$

Third order electro-thermo-elastic constant (third rank tensor)

$$\left.\frac{\partial^2 \varepsilon_{kl}}{\partial E_n\partial T}\right|_{\sigma} = \left.\frac{\partial^2 D_n}{\partial \sigma_{kl}\partial T}\right|_{E} = \left.\frac{\partial^2 S}{\partial \sigma_{kl}\partial E_n}\right|_{T} = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial E_n\partial T}\right| = k_{k\ln} \qquad (18h)$$

Fourth order electrostriction constant (sixth rank tensor)

$$\left.\frac{\partial^3 \varepsilon_{kl}}{\partial \sigma_{pq}\partial E_t\partial E_n}\right|_{T} = \left.\frac{\partial^3 D_n}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_t}\right|_{T} = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n\partial E_t}\right|_{T} = o^T_{klpqnt} \qquad (18i)$$

Fourth order electro-thermo-elastic constant (fifth rank tensor)

$$\left.\frac{\partial^3 \varepsilon_{kl}}{\partial \sigma_{pq}\partial E_n\partial T}\right| = \left.\frac{\partial^3 D_n}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\right|_{E} = \left.\frac{\partial^3 S}{\partial \sigma_{kl}\partial \sigma_{pq}\partial E_n}\right|_{T} = -\left.\frac{\partial^4 G}{\sigma_{kl}\partial \sigma_{pq}\partial E_n\partial T}\right| = k_{klpqn} \qquad (18j)$$

Third order thermal expansion constant (second rank tensor)

$$\left.\frac{\partial^2 \varepsilon_{kl}}{\partial T^2}\right|_{\sigma,E} = \left.\frac{\partial^2 S}{\partial \sigma_{kl}\partial T}\right|_{E} = -\left.\frac{\partial^3 G}{\partial \sigma_{kl}\partial T^2}\right|_{E} = r^E_{kl} \qquad (18k)$$

Fourth order thermal expansion constant (fourth rank tensor)

$$\left.\frac{\partial^3 \varepsilon_{kl}}{\partial \sigma_{pq}\partial T^2}\right|_{E} = \left.\frac{\partial^3 S}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T}\right|_{E} = -\left.\frac{\partial^4 G}{\partial \sigma_{kl}\partial \sigma_{pq}\partial T^2}\right|_{E} = r^E_{klpq} \qquad (18l)$$

Second order electric heat constant (first rank tensor)

$$\left.\frac{\partial D_n}{\partial T}\right|_{\sigma,E} = \left.\frac{\partial S}{\partial E_n}\right|_{\sigma,T} = -\left.\frac{\partial^2 G}{\partial E_n\partial T}\right|_{\sigma} = p^\sigma_n \qquad (18m)$$

Third order electric heat constant (second rank tensor)

$$\left.\frac{\partial^2 D_m}{\partial E_n\partial T}\right|_{\sigma} = \left.\frac{\partial^2 S}{\partial E_n\partial E_m}\right|_{\sigma,T} = -\left.\frac{\partial^3 G}{\partial E_n\partial E_m\partial T}\right|_{\sigma} = p^\sigma_{nm} \qquad (18n)$$

Fourth order electro-thermo-electro-elastic constant (fourth rank tensor)

$$\left.\frac{\partial^3 E_m}{\partial \sigma_{pq}\partial E_n\partial T}\right| = \left.\frac{\partial^3 S}{\partial \sigma_{pq}\partial E_m\partial E_n}\right|_{T} = -\left.\frac{\partial^4 G}{\partial \sigma_{pq}\partial E_n\partial E_m\partial T}\right| = \beta_{pqmn} \qquad (18o)$$

Third order pyroelectric constant (first rank tensor)

$$\left.\frac{\partial^2 D_n}{\partial T^2}\right|_{\sigma,E} = \left.\frac{\partial^2 S}{\partial E_n\partial T}\right|_{\sigma} = -\left.\frac{\partial^3 G}{\partial T^2\partial E_n}\right|_{\sigma} = u^\sigma_n \qquad (18p)$$

Fourth order thermo-electro-elastic constant (third rank tensor)

$$\left.\frac{\partial^3 D_m}{\partial \sigma_{kl}\partial T^2}\right|_{E} = \left.\frac{\partial^3 S}{\partial \sigma_{kl}\partial E_m\partial T}\right| = -\left.\frac{\partial^4 G}{\sigma_{kl}\partial E_m\partial T^2}\right| = \omega_{klm} \qquad (18q)$$

By using equations (15a) to (17o) into equations (12) to (14), this results nonlinear thermopiezoelastic equations

$$\varepsilon_{ij} = \Big(s^{E,T}_{ijkl} + \frac{1}{2!}s^{E,T}_{ijklpq}\sigma_{pq} + \frac{1}{2!}d^T_{ijk\ln}E_n + \frac{1}{2!}\alpha^E_{ijkl}T$$
$$+\frac{1}{3!}s^{E,T}_{ijklpqrs}\sigma_{pq}\sigma_{rs} + \frac{1}{3!}d^T_{ijklpqn}\sigma_{pq}E_n + \frac{1}{3!}\alpha^E_{ijklpq}\sigma_{pq}T\Big)\sigma_{kl}$$
$$+\Big(d^T_{ijn} + \frac{1}{2!}d^T_{ijk\ln}\sigma_{kl} + \frac{1}{2!}o^T_{ijnt}E_t + \frac{1}{2!}k_{ijn}T$$
$$+\frac{1}{3!}d^T_{ijklpqn}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}o^T_{ijpqtn}\sigma_{pq}E_t + \frac{1}{3!}k_{ijpqn}\sigma_{pq}T\Big)E_n$$
$$+\Big(\alpha^E_{ij} + \frac{1}{2!}\alpha^E_{ijkl}\sigma_{kl} + \frac{1}{2!}k_{ijn}E_n + \frac{1}{2!}r^E_{ij}T$$
$$+\frac{1}{3!}\alpha^E_{ijklpq}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}k_{ijpqn}\sigma_{pq}E_n + \frac{1}{3!}r^E_{ijkl}\sigma_{kl}T\Big)T \qquad (19)$$

$$D_m = \Big(d^T_{klm} + \frac{1}{2!}d^T_{klpqm}\sigma_{pq} + \frac{1}{2!}o^T_{klmn}E_n + \frac{1}{2!}k_{klm}T$$
$$+\frac{1}{3!}d^T_{klpqrsm}\sigma_{pq}\sigma_{rs} + \frac{1}{3!}o^T_{klpqnm}\sigma_{pq}E_n + \frac{1}{3!}k_{klpqm}\sigma_{pq}T\Big)\sigma_{kl}$$
$$+\Big(\eta^{\sigma,T}_{mn} + \frac{1}{2!}o^T_{klmn}\sigma_{kl} + \frac{1}{2!}\eta^{\sigma,T}_{mnt}E_t + \frac{1}{2!}p^\sigma_{mn}T$$

$$+\frac{1}{3!}o^T_{klpqnm}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}\Gamma^T_{pqtnm}\sigma_{pq}E_t + \frac{1}{3!}\beta_{pqnm}\sigma_{pq}T\Big)E_n$$
$$+\Big(p^\sigma_m + \frac{1}{2!}k_{klm}\sigma_{kl} + \frac{1}{2!}p^\sigma_{mn}E_n + \frac{1}{2!}u^\sigma_m T$$
$$+\frac{1}{3!}k_{klpqm}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}\beta_{pqnm}\sigma_{pq}E_n + \frac{1}{3!}\omega_{klm}\sigma_{kl}T\Big)T \qquad (20)$$

$$S = \Big(\alpha^E_{kl} + \frac{1}{2!}\alpha^E_{klpq}\sigma_{pq} + \frac{1}{2!}k_{k\ln}E_n + \frac{1}{2!}r^E_{kl}T$$
$$+\frac{1}{3!}\alpha^E_{klpqrs}\sigma_{pq}\sigma_{rs} + \frac{1}{3!}k_{klpqn}\sigma_{pq}E_n + \frac{1}{3!}r^E_{klpq}\sigma_{pq}T\Big)\sigma_{kl}$$
$$+\Big(p^\sigma_n + \frac{1}{2!}k_{k\ln}\sigma_{kl} + \frac{1}{2!}p^\sigma_{nt}E_t + \frac{1}{2!}u^\sigma_n T$$
$$+\frac{1}{3!}k_{klpqn}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}\beta_{pqnt}\sigma_{pq}E_t + \frac{1}{3!}\omega_{pqn}\sigma_{pq}T\Big)E_n$$
$$+\Big(\xi^{\sigma,E} + \frac{1}{2!}r^E_{kl}\sigma_{kl} + \frac{1}{2!}u^\sigma_n E_n + \frac{1}{2!}P^{\sigma,E}T$$
$$+\frac{1}{3!}r^E_{klpq}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}\omega_{pqn}\sigma_{pq}E_n + \frac{1}{3!}\mu^E_{kl}\sigma_{kl}T\Big)T \qquad (21)$$

Nonlinearity and linearity of thermopiezoelasticity

It is convenient to write nonlinear constitutive equations (19) to (21) in matrix form as

$$\begin{bmatrix}\varepsilon_{ij}\\ D_m\\ S\end{bmatrix} = \begin{bmatrix}A & D & E\\ D & B & F\\ E & F & C\end{bmatrix}\begin{bmatrix}\sigma_{kl}\\ E_n\\ T\end{bmatrix} \qquad (22)$$

In equation (22), A, B, C are basic effects, and D, E, F are conjugate effects, respectively. The basic and conjugate effects are given by

$$A = s^{E,T}_{ijkl} + \frac{1}{2!}s^{E,T}_{ijklpq}\sigma_{pq} + \frac{1}{2!}d^T_{ijk\ln}E_n + \frac{1}{2!}\alpha^E_{ijkl}T$$
$$+\frac{1}{3!}s^{E,T}_{ijklpqrs}\sigma_{pq}\sigma_{rs} + \frac{1}{3!}d^T_{ijklpqn}\sigma_{pq}E_n + \frac{1}{3!}\alpha^E_{ijklpq}\sigma_{pq}T \qquad (23a)$$

$$B = \eta^{\sigma,T}_{mn} + \frac{1}{2!}o^T_{klmn}\sigma_{kl} + \frac{1}{2!}\eta^{\sigma,T}_{mnt}E_t + \frac{1}{2!}p^\sigma_{mn}T$$
$$+\frac{1}{3!}o^T_{klpqnm}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}\Gamma^T_{pqtnm}\sigma_{pq}E_t + \frac{1}{3!}\beta_{pqnm}\sigma_{pq}T \qquad (23b)$$

$$C = \xi^{\sigma,E} + \frac{1}{2!}r^E_{kl}\sigma_{kl} + \frac{1}{2!}u^\sigma_n E_n + \frac{1}{2!}P^{\sigma,E}T$$
$$+\frac{1}{3!}r^E_{klpq}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}\omega_{pqn}\sigma_{pq}E_n + \frac{1}{3!}\mu^E_{kl}\sigma_{kl}T \qquad (23c)$$

$$D = d^T_{ijn} + \frac{1}{2!}d^T_{ijk\ln}\sigma_{kl} + \frac{1}{2!}o^T_{ijnt}E_t + \frac{1}{2!}k_{ijn}T$$
$$+\frac{1}{3!}d^T_{ijklpqn}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}o^T_{ijpqtn}\sigma_{pq}E_t + \frac{1}{3!}k_{ijpqn}\sigma_{pq}T \qquad (23d)$$

$$E = \alpha^E_{ij} + \frac{1}{2!}\alpha^E_{ijkl}\sigma_{kl} + \frac{1}{2!}k_{ijn}E_n + \frac{1}{2!}r^E_{ij}T$$
$$+\frac{1}{3!}\alpha^E_{ijklpq}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}k_{ijpqn}\sigma_{pq}E_n + \frac{1}{3!}r^E_{ijkl}\sigma_{kl}T \qquad (23e)$$

$$F = p^\sigma_m + \frac{1}{2!}k_{klm}\sigma_{kl} + \frac{1}{2!}p^\sigma_{mn}E_n + \frac{1}{2!}u^\sigma_m T$$
$$+\frac{1}{3!}k_{klpqm}\sigma_{kl}\sigma_{pq} + \frac{1}{3!}\beta_{pqnm}\sigma_{pq}E_n + \frac{1}{3!}\omega_{klm}\sigma_{kl}T \qquad (23f)$$

In absence of higher order material constants (higher rank tensors), equations (19) to (21) reduce to

$$\varepsilon_{ij} = s^{E,T}_{ijkl}\sigma_{kl} + d^T_{ijn}E_n + \alpha^E_{ij}T \qquad (24)$$

$$D_m = d^T_{klm}\sigma_{kl} + \eta^{\sigma,T}_{mn}E_n + p^\sigma_m T \qquad (25)$$

$$S = \alpha^E_{kl}\sigma_{kl} + p^\sigma_n E_n + \xi^{\sigma,E}T \qquad (26)$$

It is obvious that equations (24) to (26) are linear constitutive equations of thermopiezoelasticity.

Conclusion

Nonlinear thermopiezoelasticity problem has been studied. Employing thermodynamic Gibbs function and Taylor series, material constants are derived from zeroth to eighth rank tensors. If higher order material constants (higher rank tensors) are neglected in nonlinear equations, linear equations are obtained. Nonlinear and linear equations of thermopiezoelasticity constitute system of symmetry with basic effects and conjugate effects. All the derivations obtained in this analysis are convenient to be used in solving complicated problems in thermopiezoelastic materials. Further investigation may be carried out considering the work of Fumi (1952), Fieshi and Fumi (1953) and Abrahams (1994).

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