Development and cooperation on γ-spectroscopy instruments

LI Guang-shun
for the
gamma instrumentation collaboration

2023-07-13

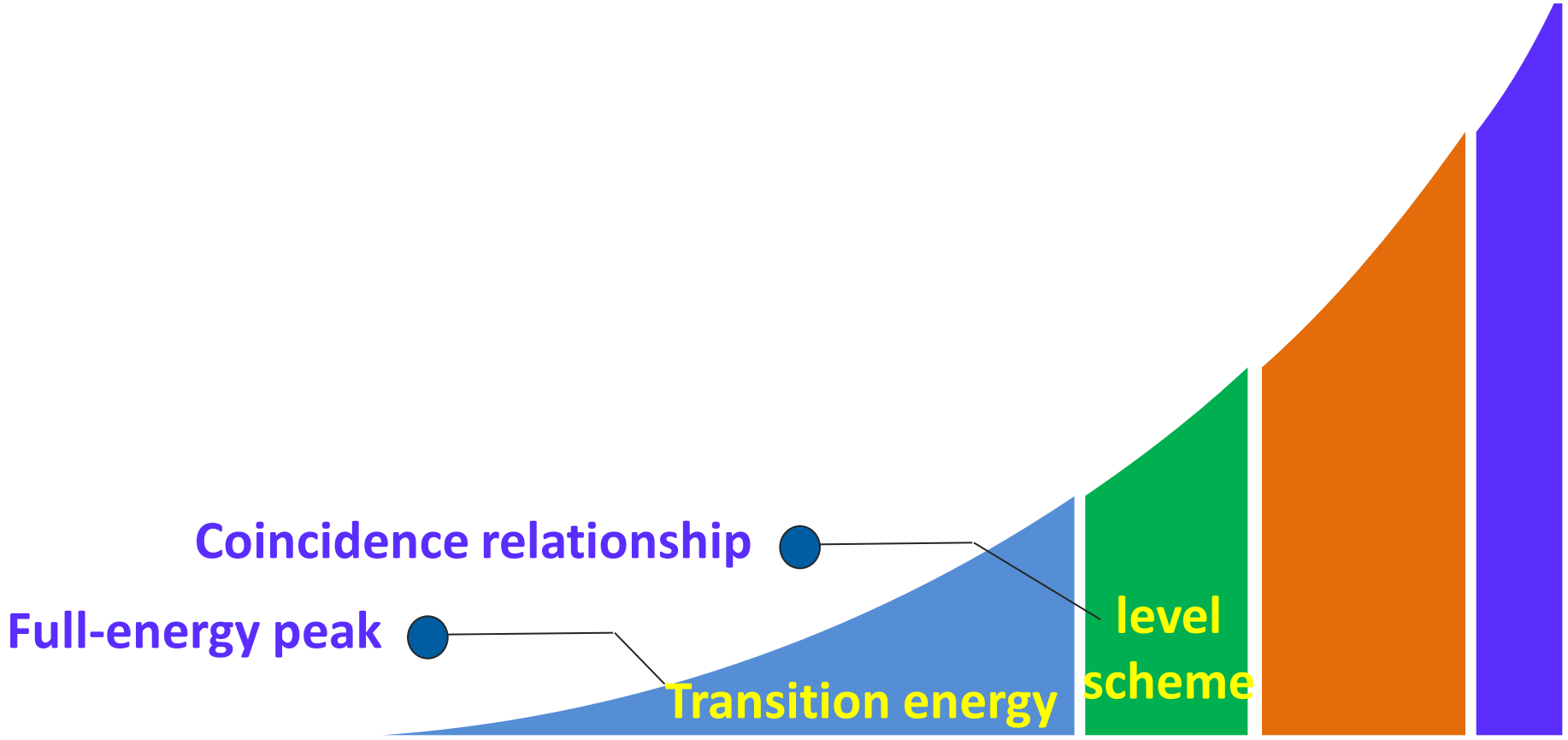
Institute of Modern Physics (IMP), Chinese Academy of Sciences (CAS)

Contents

目录
CONTENTS

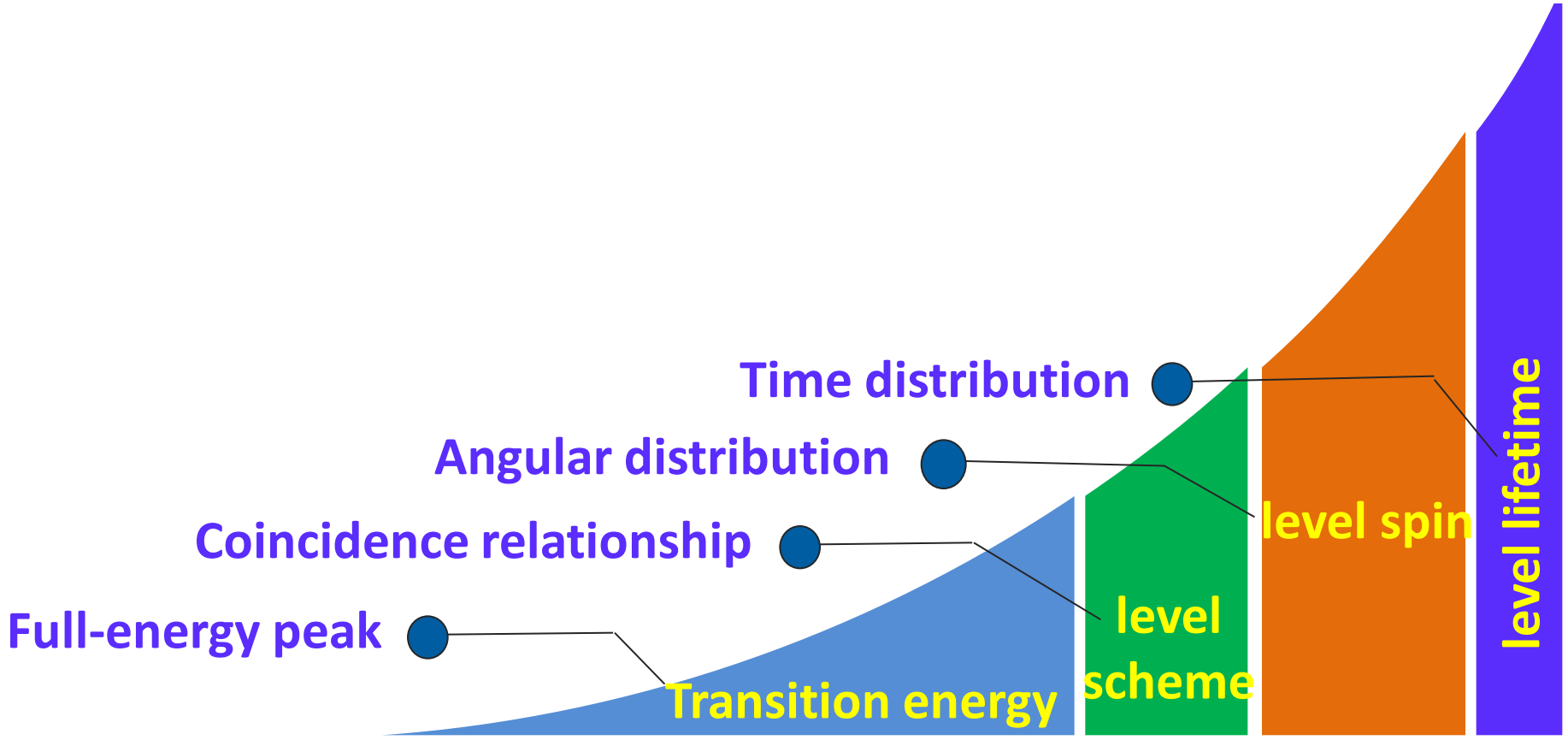
γ-ray detector array as a cornerstone

The basic information of nuclear excited states



γ-ray detector array as a cornerstone

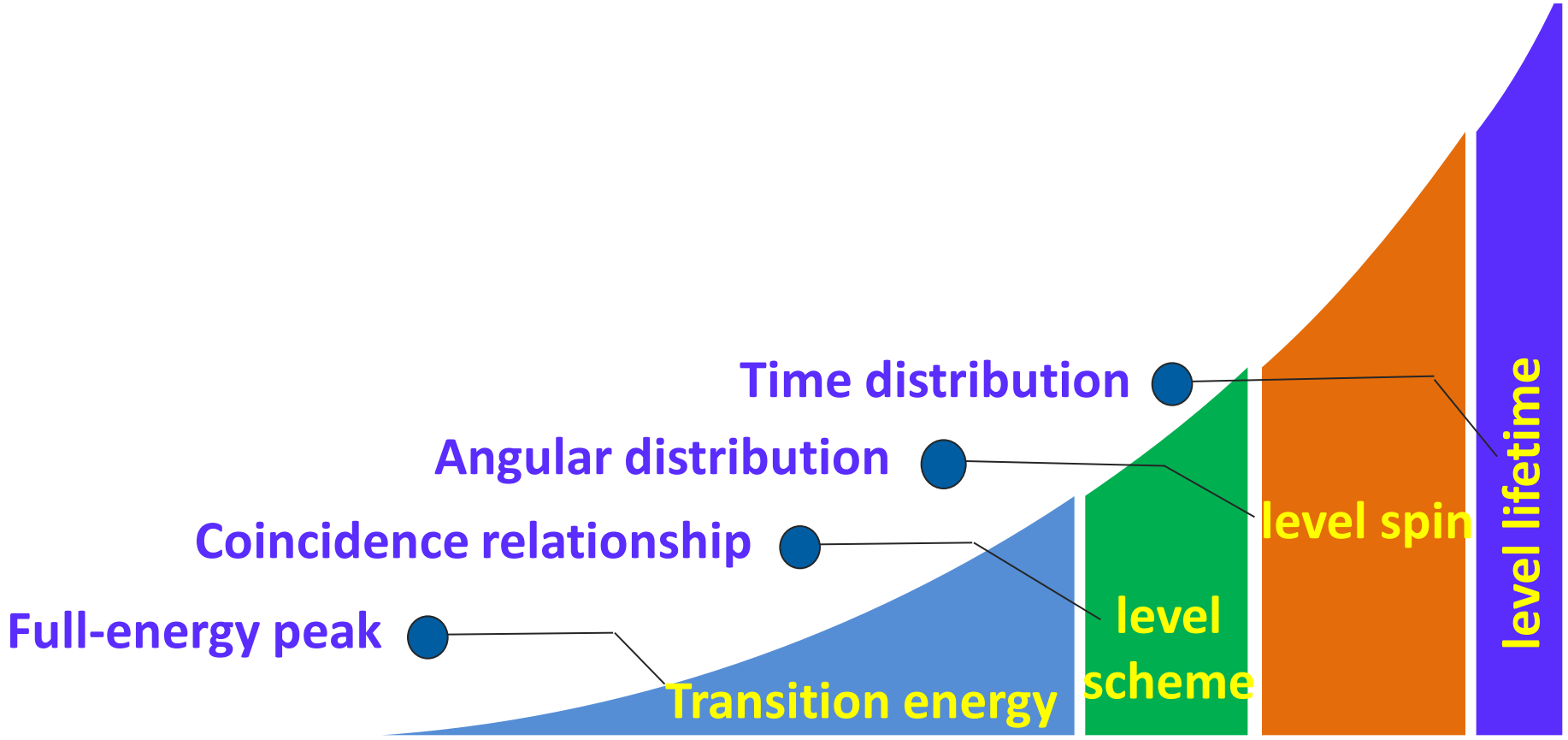
The basic information of nuclear excited states



γ-ray detector array as a cornerstone

The basic information of nuclear excited states

- **Large is still unknown, especially the exotic nuclei near drip line**



γ-ray detector array as a cornerstone

The basic information of nuclear excited states

- **Large is still unknown, especially the exotic nuclei near drip line**

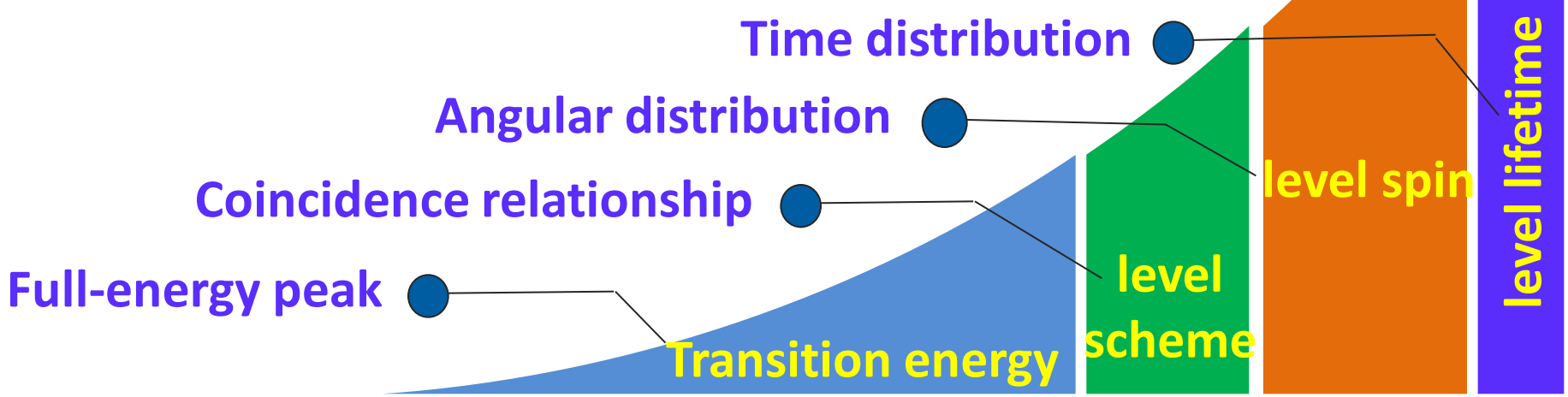
Requirements:

γ-ray detector array as a cornerstone

The basic information of nuclear excited states

- **Large is still unknown, especially the exotic nuclei near drip line**

Requirements:

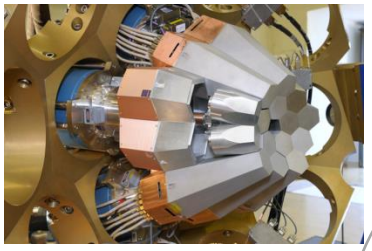


Examples of the γ detector arrays in the world

Partially covered ONLY …

Europe

- AGATA
- FATIMA
- JUROGAM
- ROSPHERE
- …

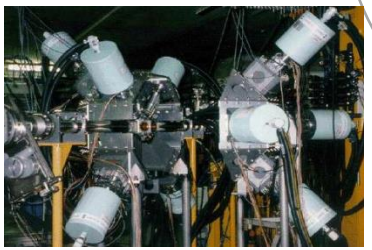


America

- GRETINA
- TIGRESS
- GAMMASPHERE
- GRIFFIN
- …

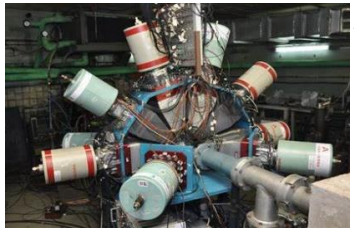
Africa

- AFRODITE
- …



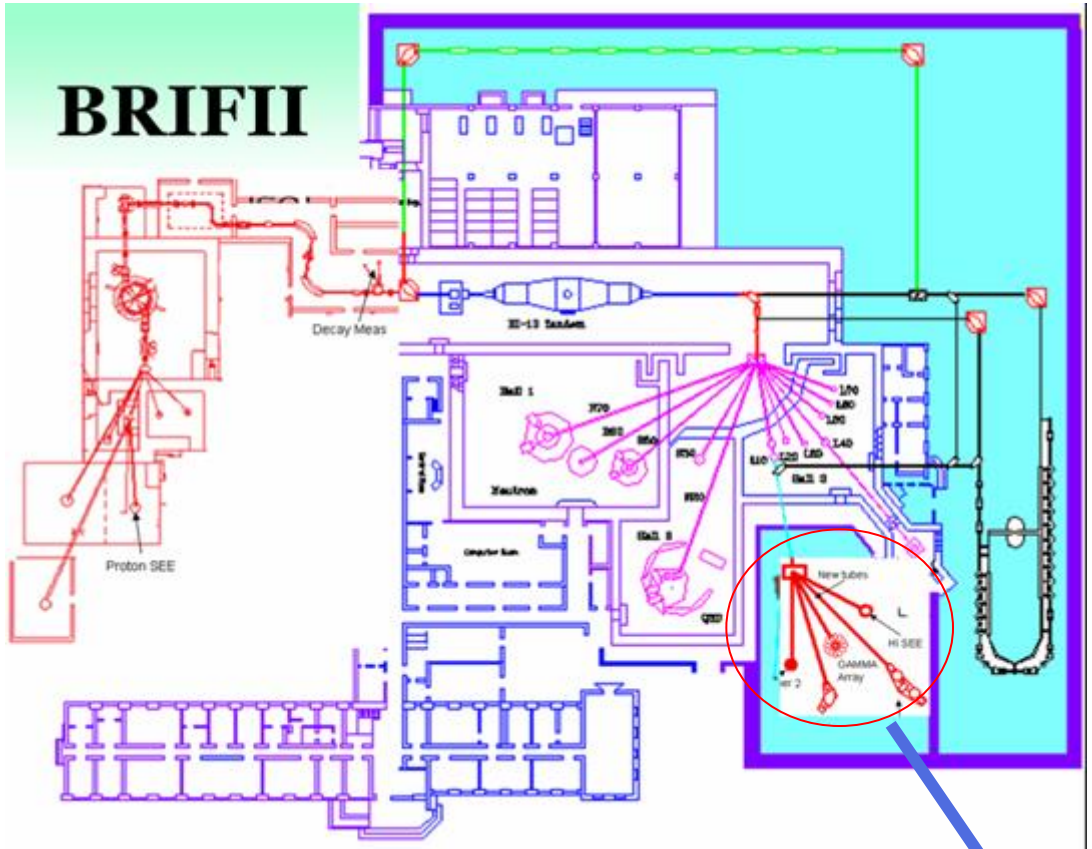
Asia

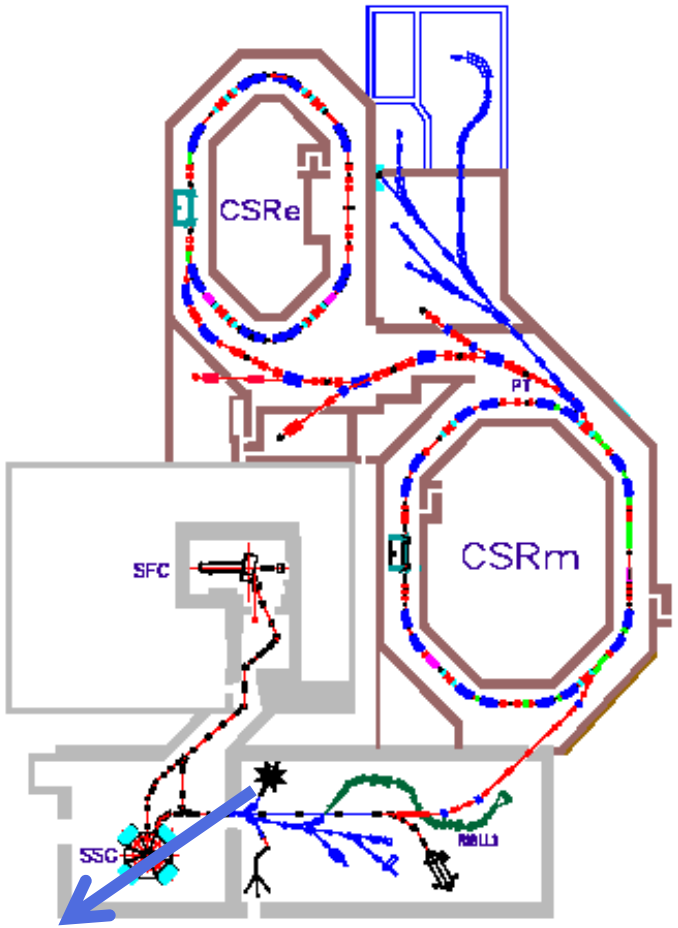
- INGA
- …



We would also like to contribute to the fundamental studies …

Main facilities depend on …



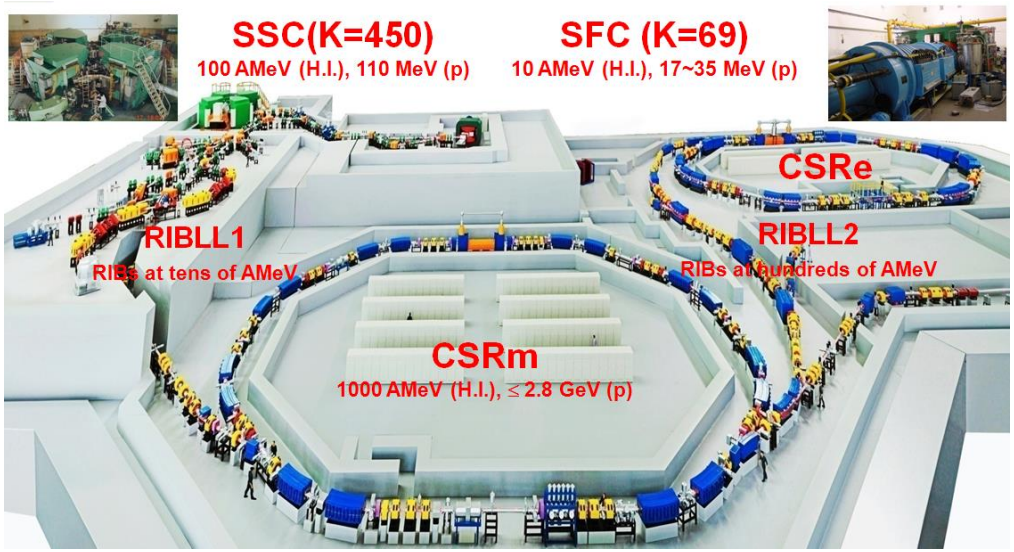


γ-spectroscopy studies

Beijing, HI-13 tandem

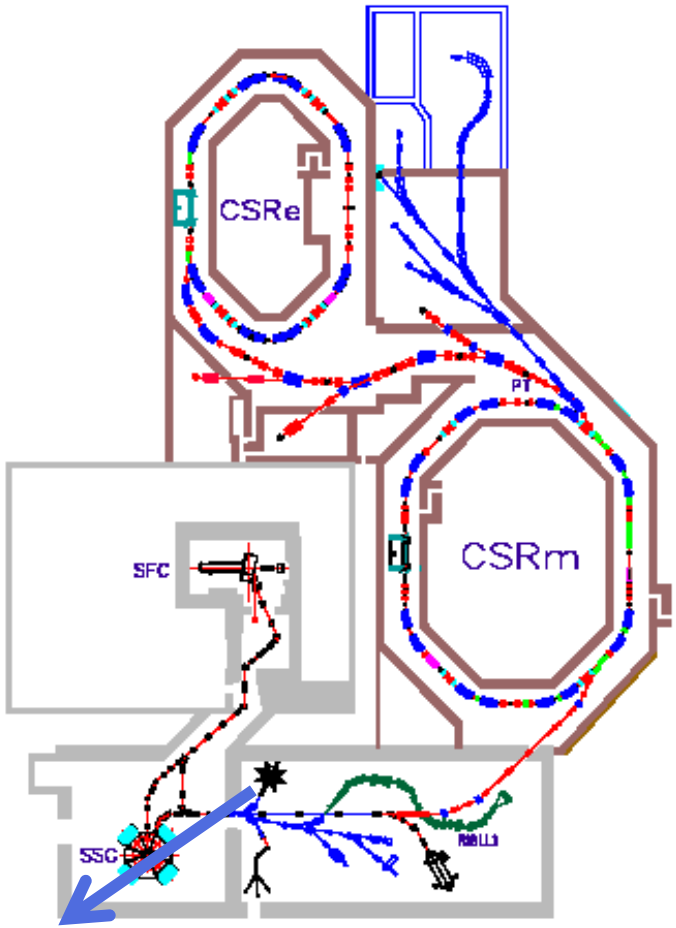
Lanzhou, HIRFL

Facility @ IMP



HIRFL

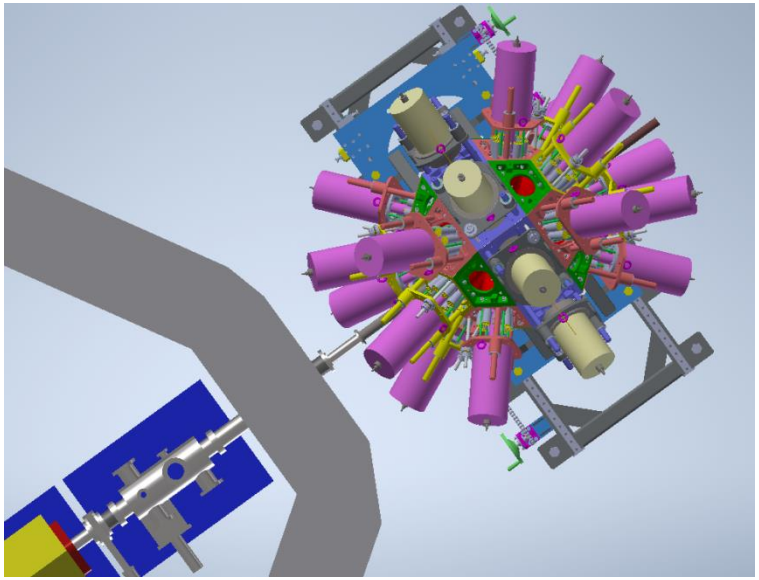
Picture of gate



γ-spectroscopy studies

Lanzhou, HIRFL

HPGe array @ IMP

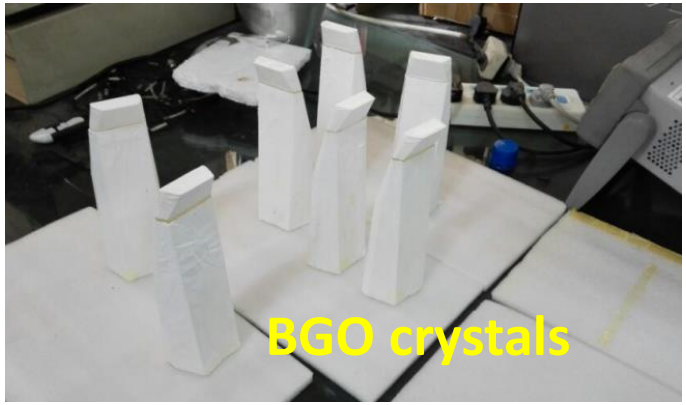


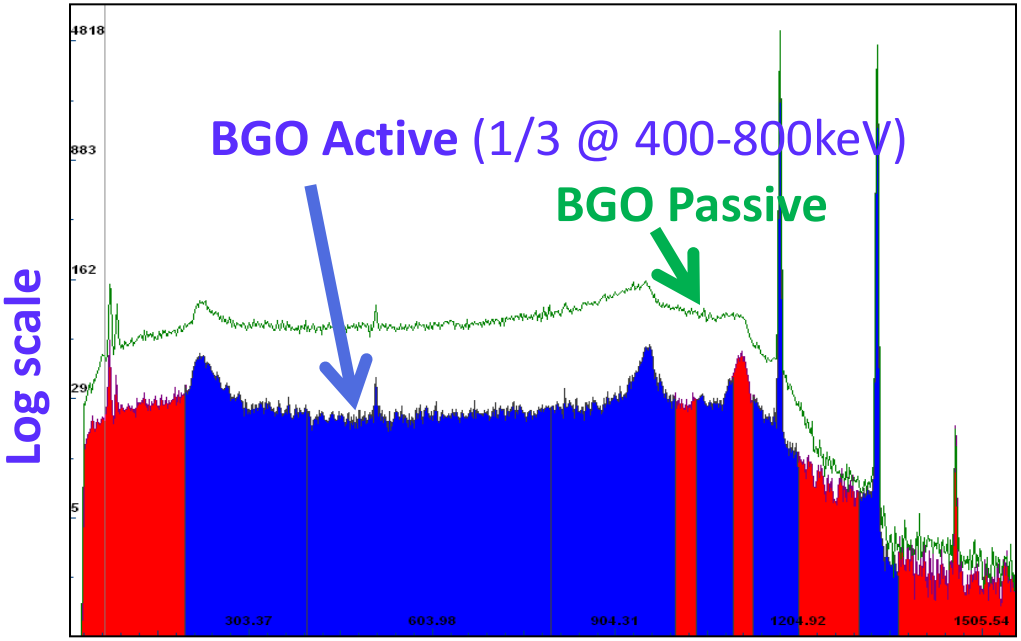
16 coaxial HPGes (70%)

8 Clover HPGes (160%)

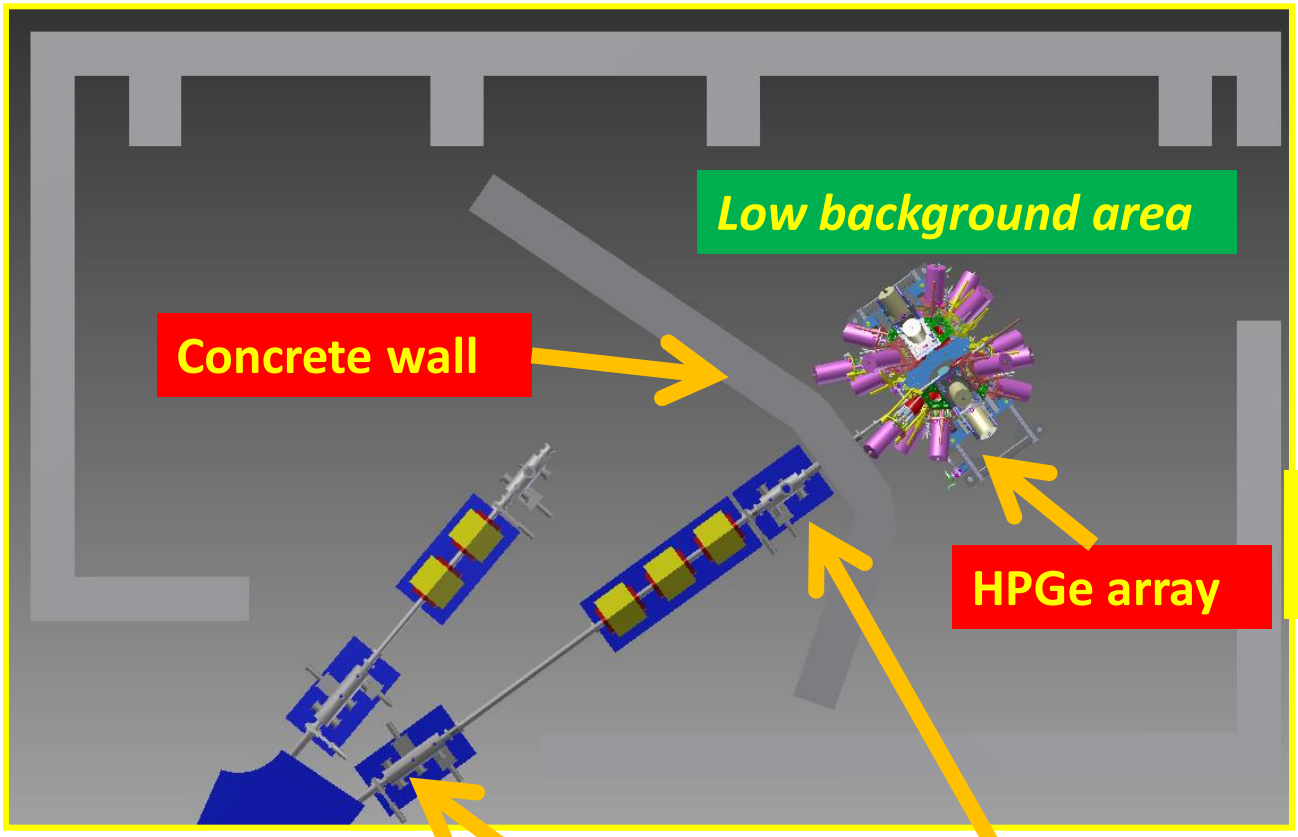
Dedicated supporting frame

BGO Anti-Compton shields @ IMP





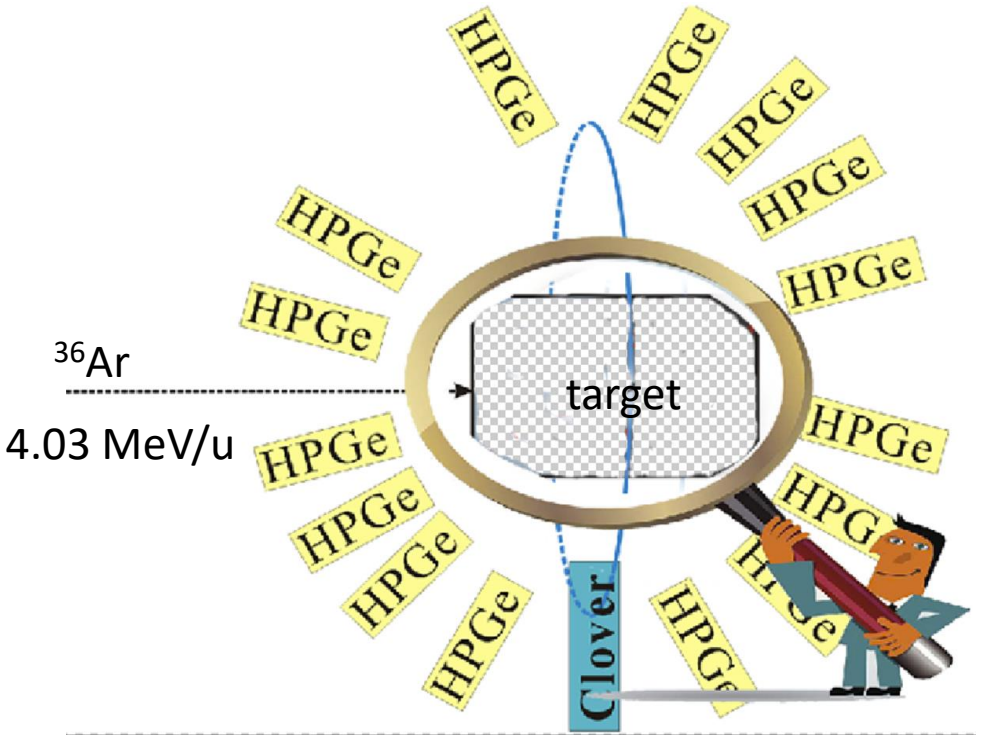
Low energy beam line @ IMP



Beam spot:
< phi 3 mm

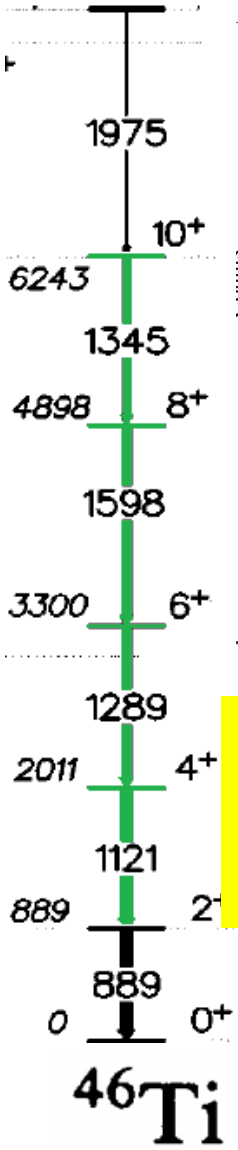
Commissioning run @ IMP

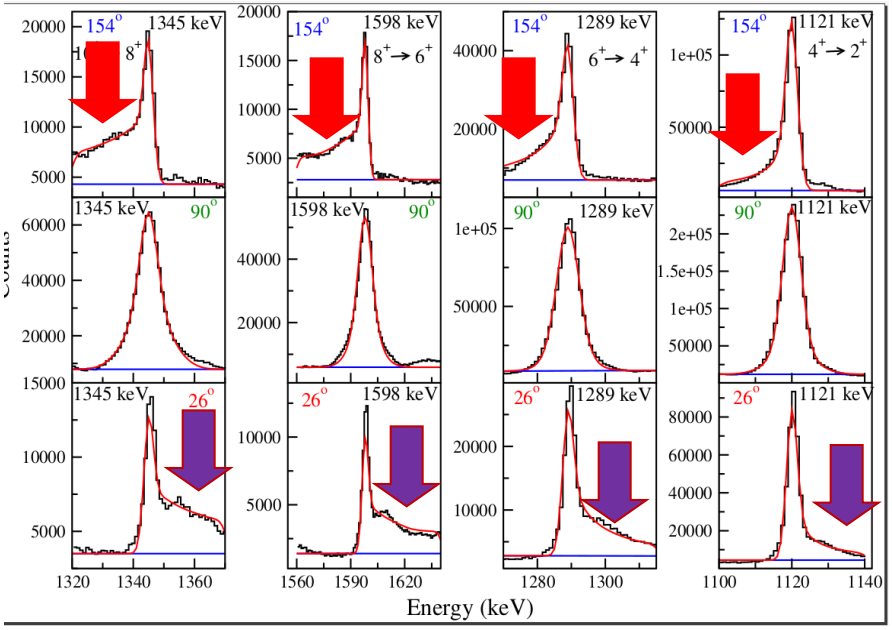
Lifetime measurement of nuclear excited state via DSAM method



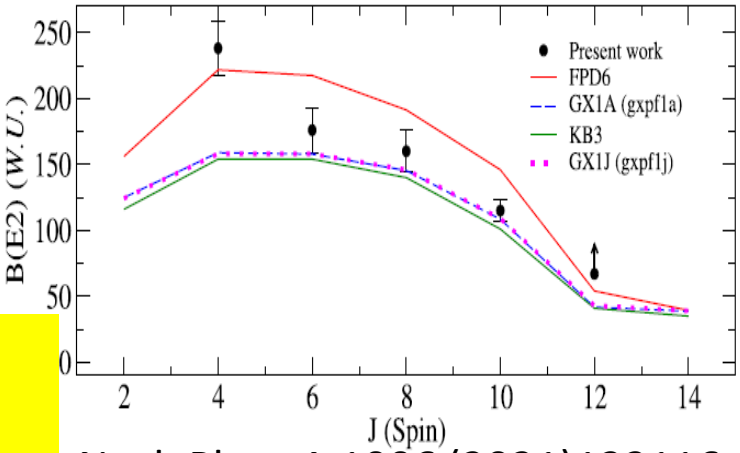
15 HPGe + 6Clover

Experimental data of ^{46}Ti





^{36}Ar + ^{12}C
- → ^{46}Ti (46mb)
- → ^{45}Ti (358mb)
- → ^{45}Sc (115mb)

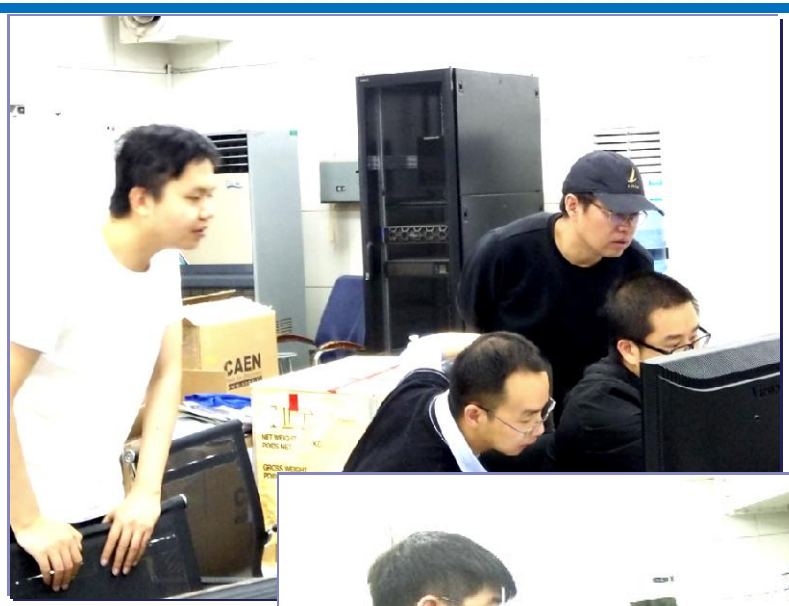


Nucl. Phys. A 1006 (2021)122116

- Improve the lifetime precision
- Update the B(E2) values
- Clarify the configuration mixing issue

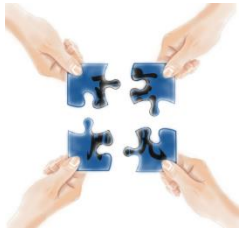
Courtesy: Dr. Aman Rohilla (data analysis)

Participants from domestic collaborations @2021



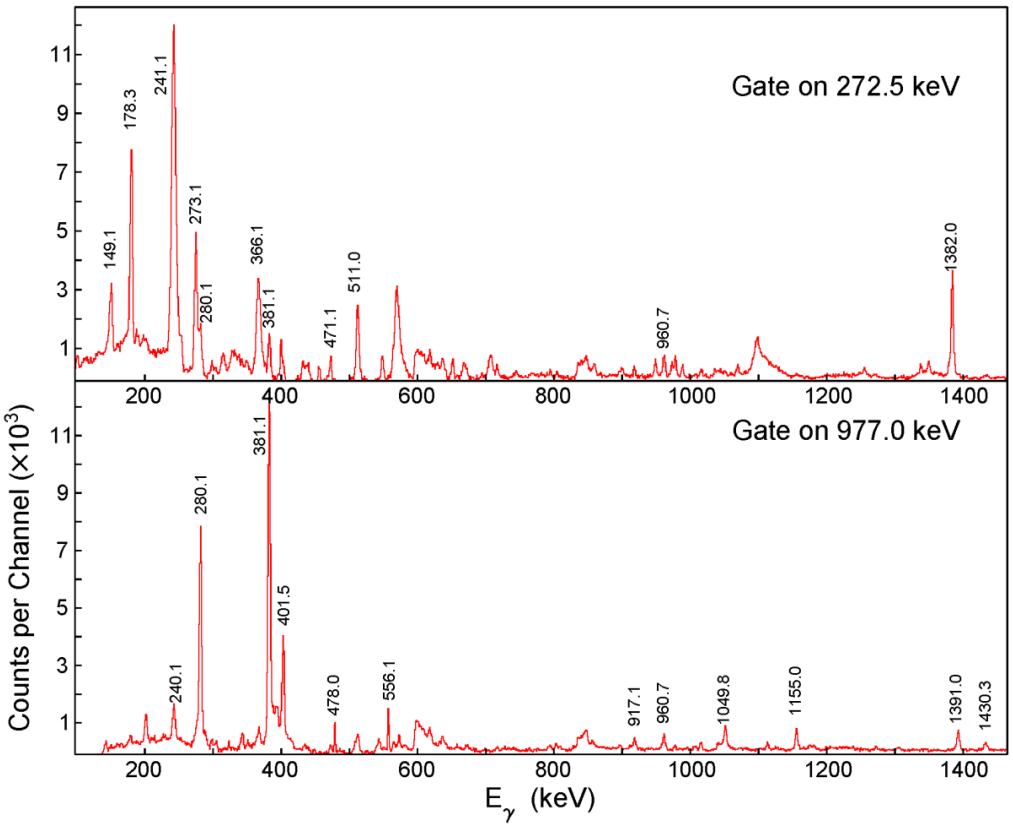
- IMP - Institute of Modern Physics, CAS
- PKU - Peking University
- SDU - Shandong University
- CIAE - China Institute of Atomic Energy
- etc.

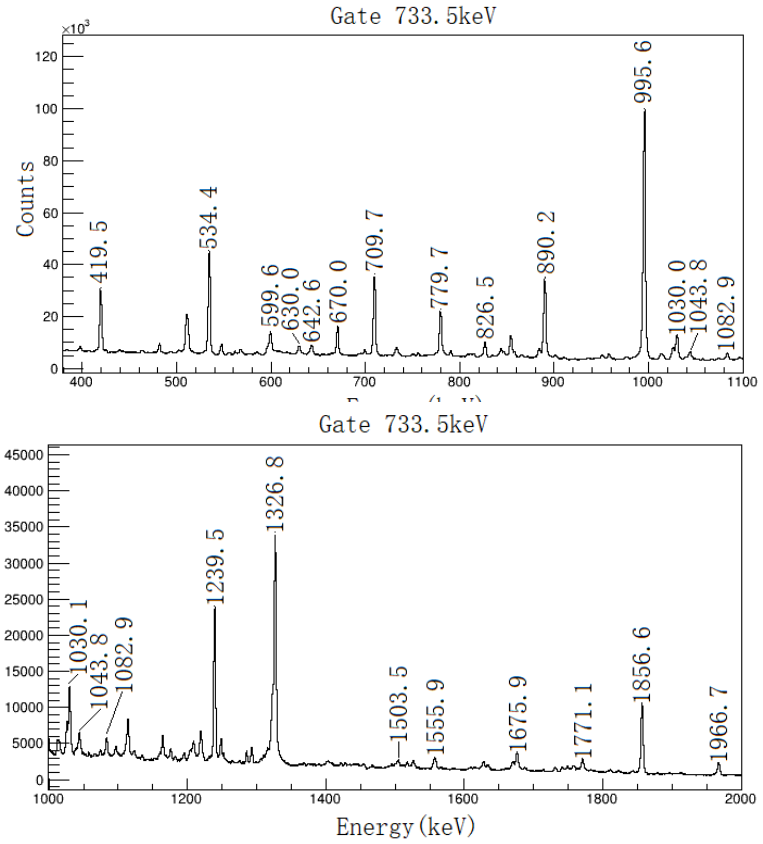
More than 600 hours beam time



First collaborative run within Chinese collaboration

Experimental data of 2021

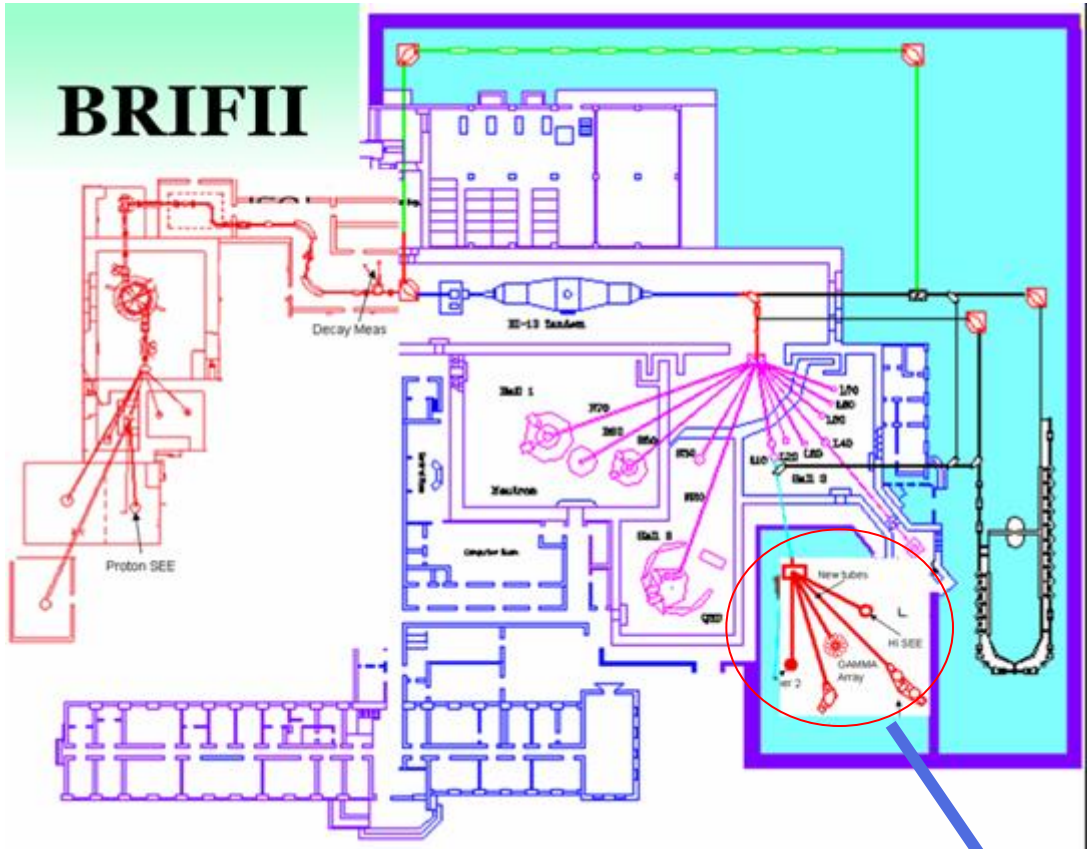




Typical gated spectra from the HPGe array

Data is still in analysis …

Main facilities depend on …



γ-spectroscopy studies

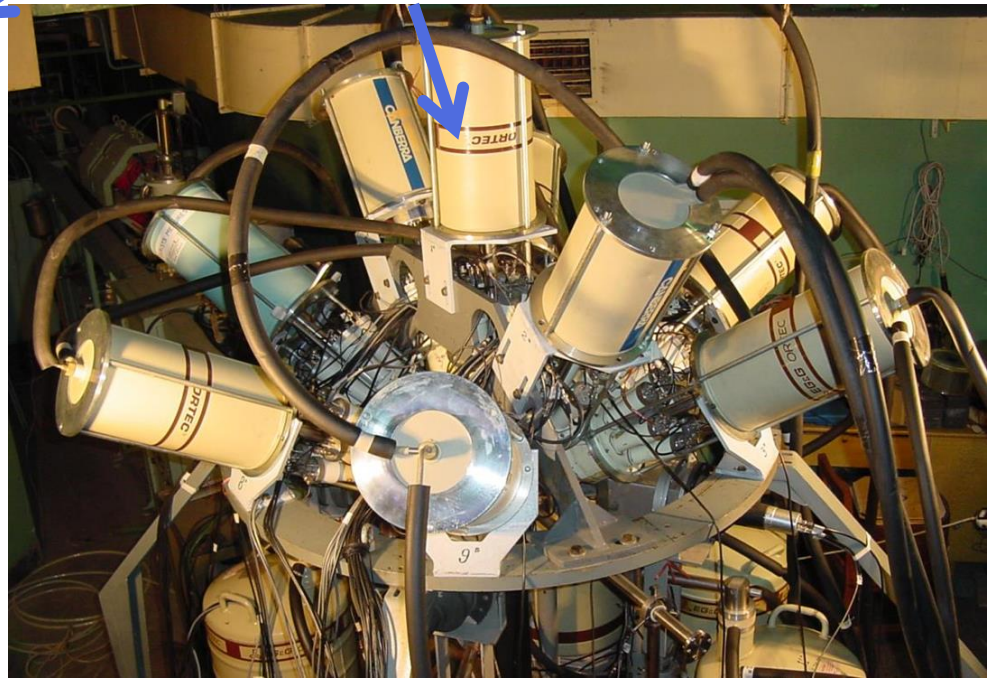
Beijing, HI-13 tandem

Lanzhou, HIRFL

Facility @ CIAE

HI-13 tandem accelerator

HPGe array



Picture of gate

Anti-Compton shield (AC)

Courtesy: Dr. Zheng Yun (CIAE)

Photos during experiment @ CIAE

Collaborations among universities and institutes

Courtesy: Dr. Zheng Yun (CIAE)

Cooperation of new era

➢Available γ-ray detectors:

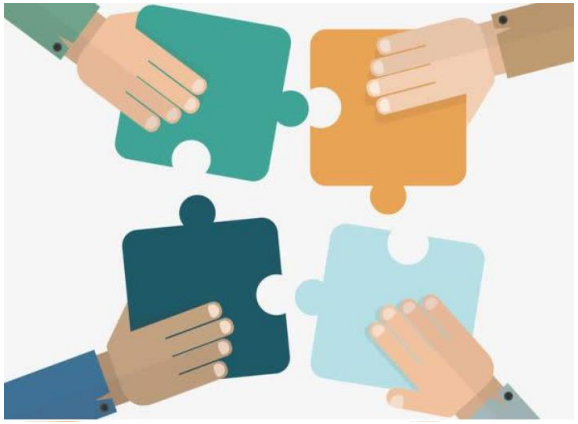
IMP (Lanzhou): HPGe > 16; Clover > 8; $LaBr_3$ > 4

CIAE (Beijing): HPGe > 10; $LaBr_3$ > 5

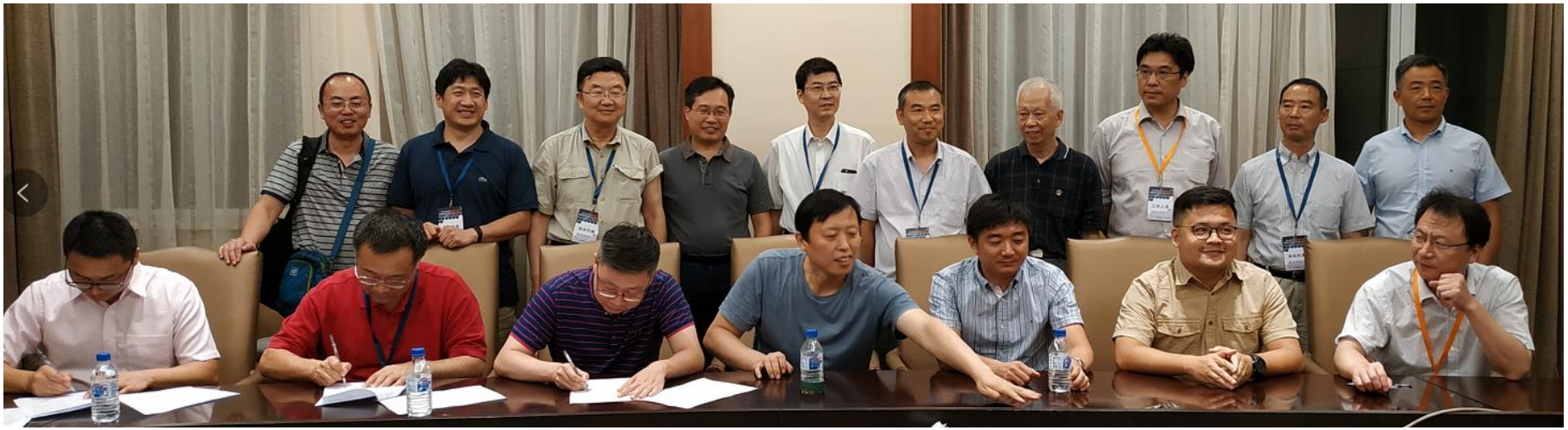
Shandong U. (Weihai): HPGe + $LaBr_3$ > 10

Beihang U. (Beijing): Clover + $LaBr_3$ > 6

… …

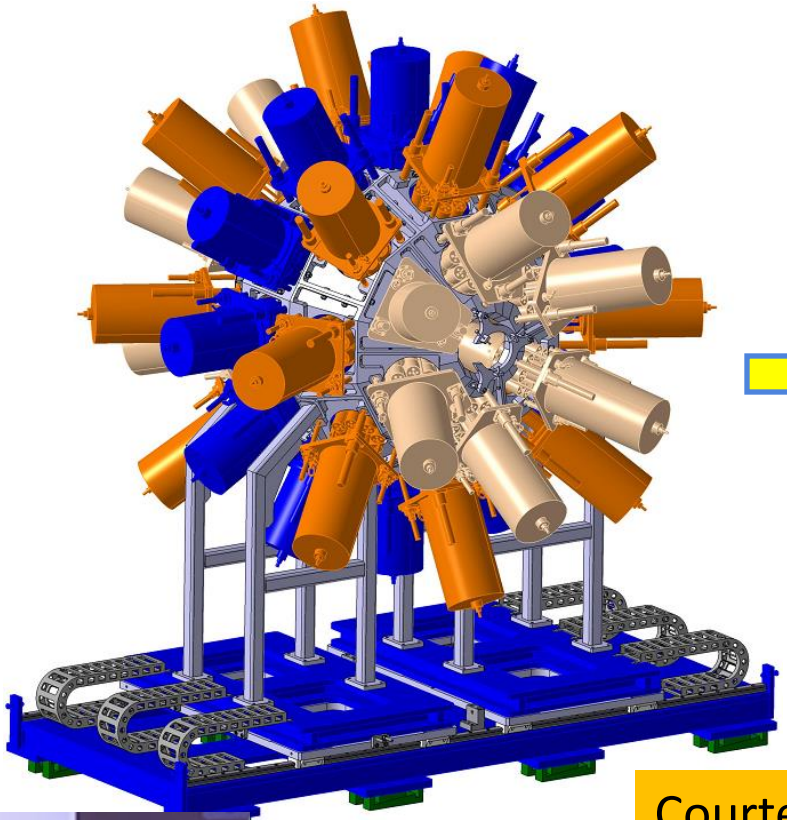


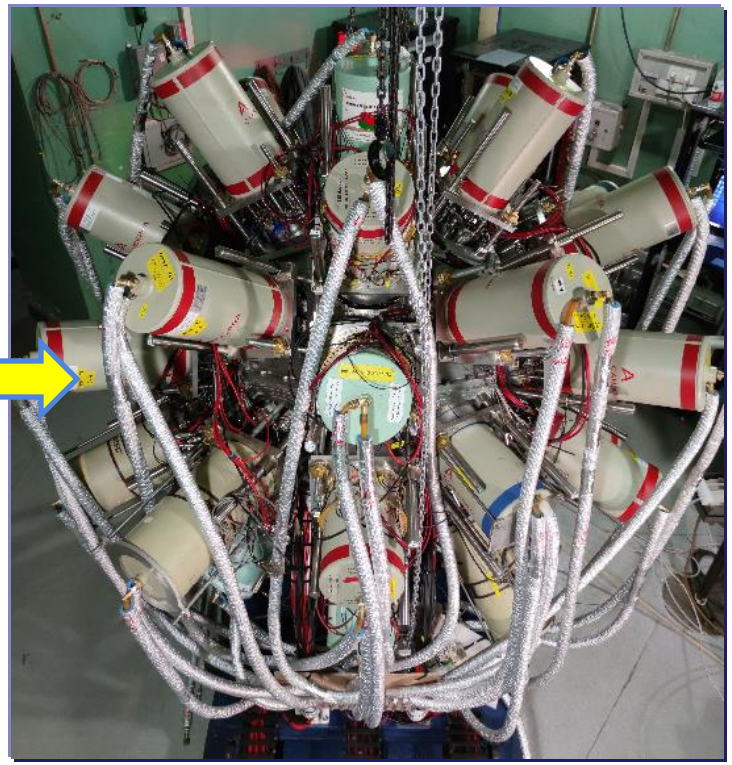
➢New cooperative agreement (2019)

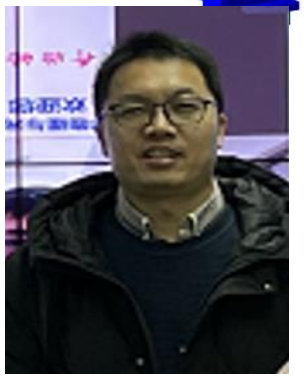


To form a gamma pool in China…

China conjoint gamma array







Courtesy: Dr. Zheng Yun (CIAE)

16 coaxial HPGes (70%)-IMP

8 Clover HPGes (160%)-IMP

7 coaxial HPGes (35%)-CIAE

2 coaxial HPGes (70%)-CIAE

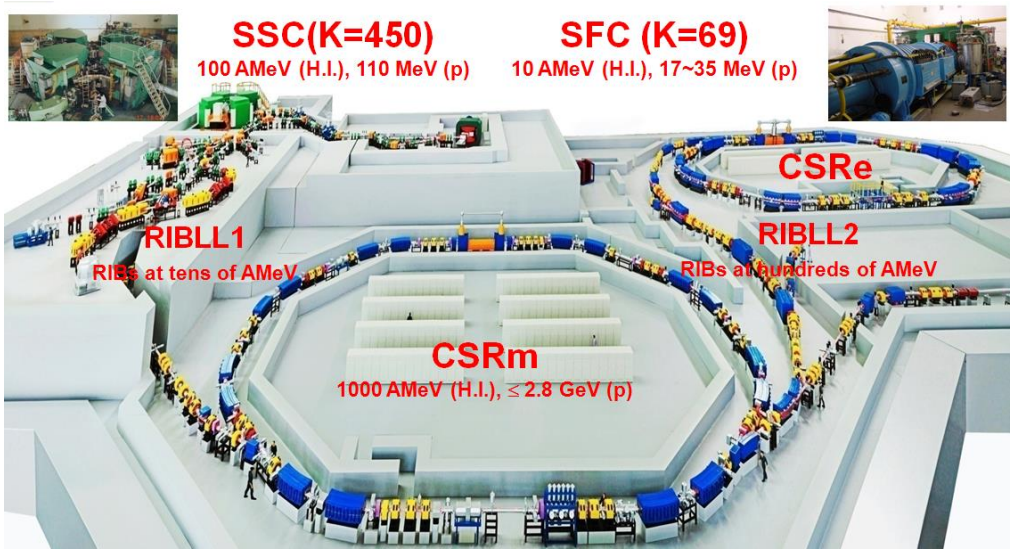
1 Clover HPGe（120%）-BUAA

2 coaxial HPGes (30%)-SDU

Experimental campaign at 2021 - 2022

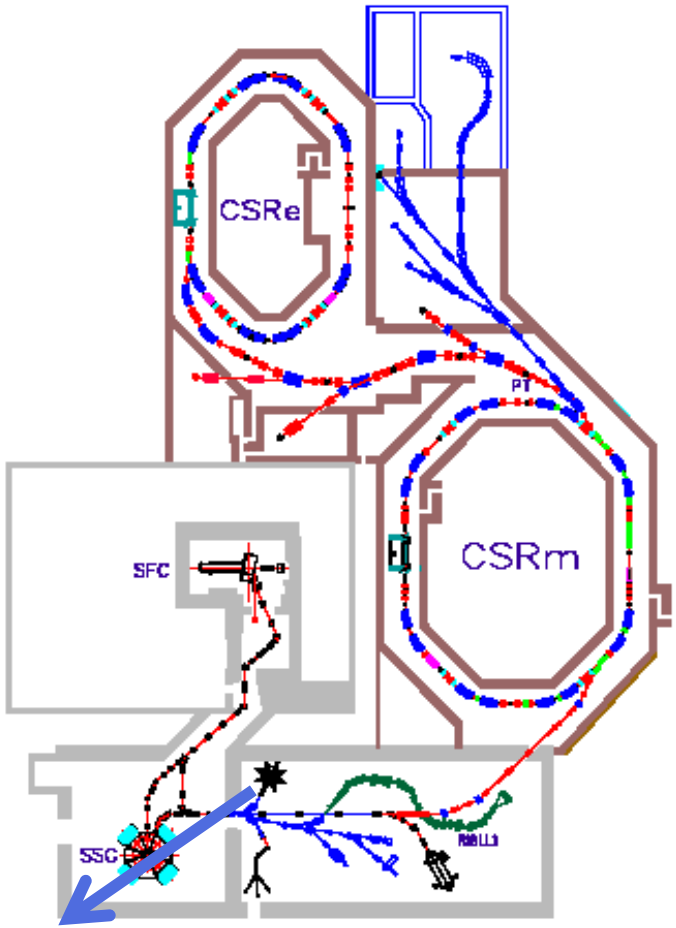
Courtesy: Dr. Zheng Yun (CIAE)

Facility @ IMP



HIRFL

Picture of gate

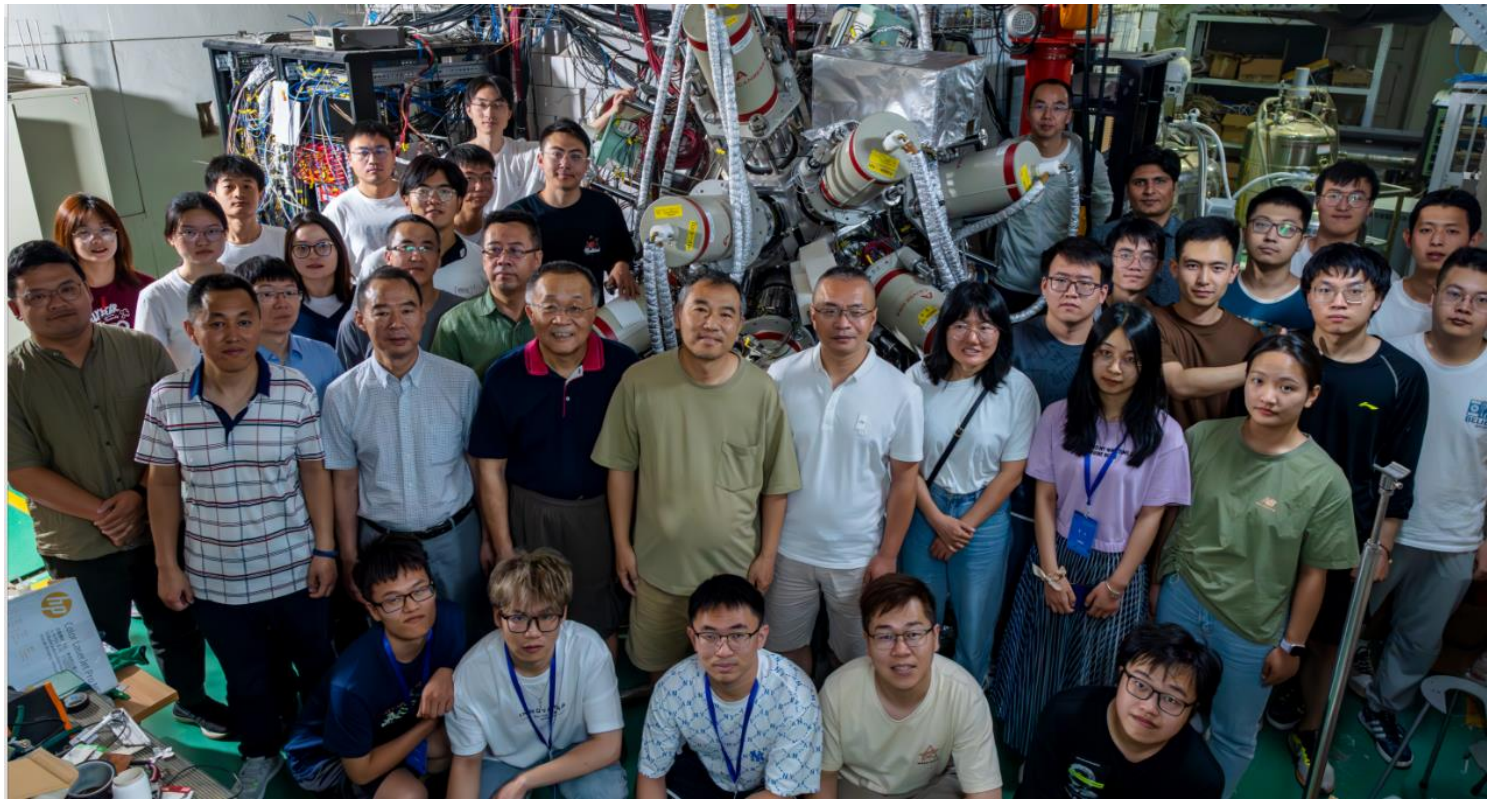


γ-spectroscopy studies

Lanzhou, HIRFL

Gamma campaign @2023

Gamma campaign @2023

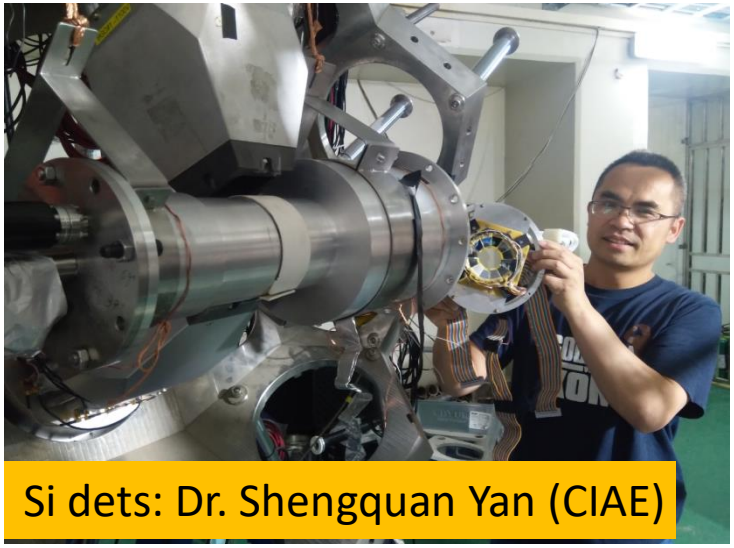


16 Coaxial HPGe
5 Clover HPGe
10 LaBr3
Si telescope
CsI ball

- IMP - Institute of Modern Physics, CAS
- CIAE - China Institute of Atomic Energy
- PKU - Peking University
- SYU - Sun Yat-sen University
- SZU – Shenzhen University
- etc.

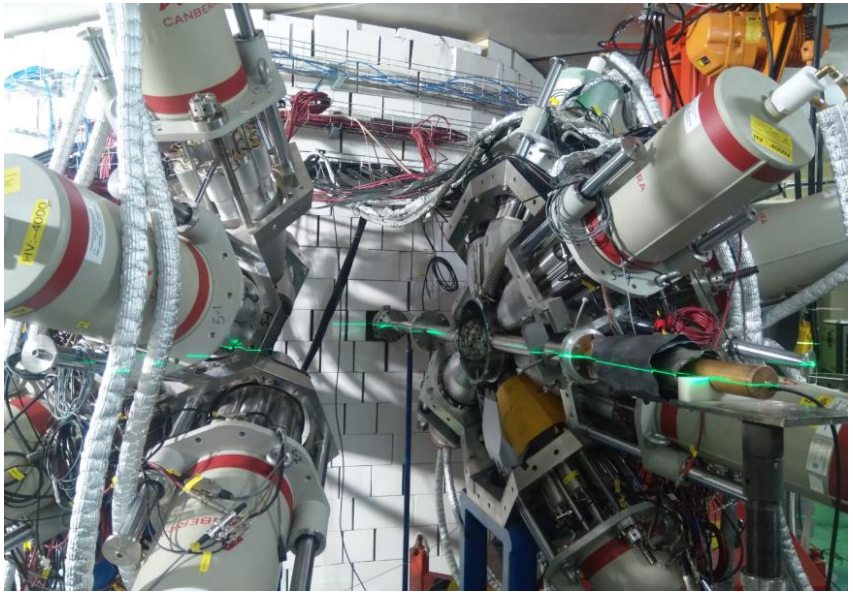
More than 500 hours beam time

Gamma campaign @2023

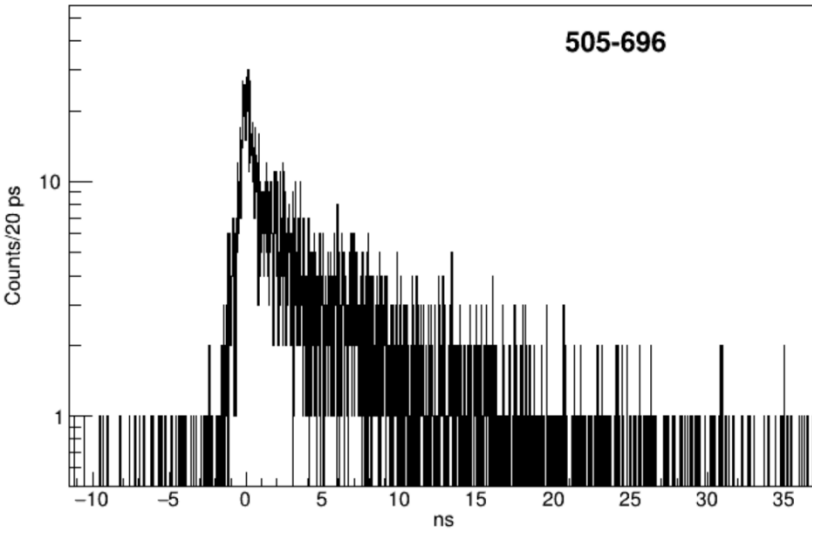


Si dets: Dr. Shengquan Yan (CIAE)

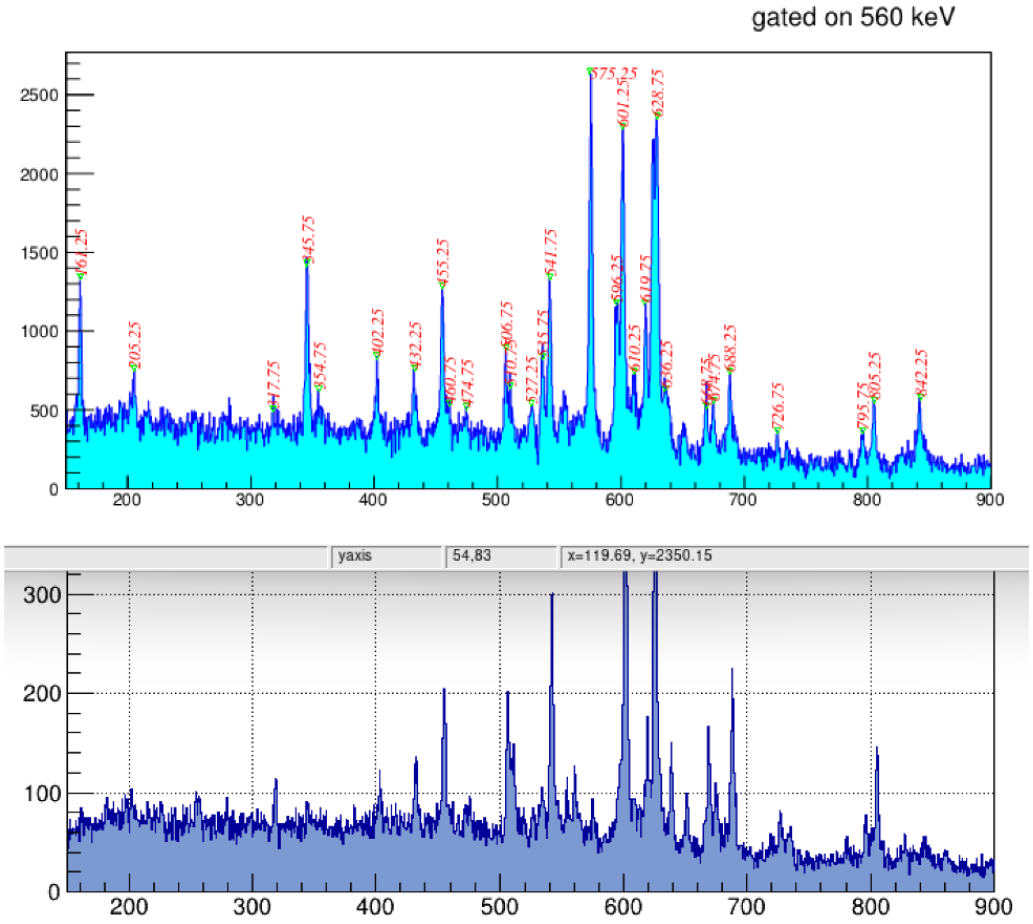
CsI dets: Dr. Yongde Fang (IMP)



Gamma campaign @2023

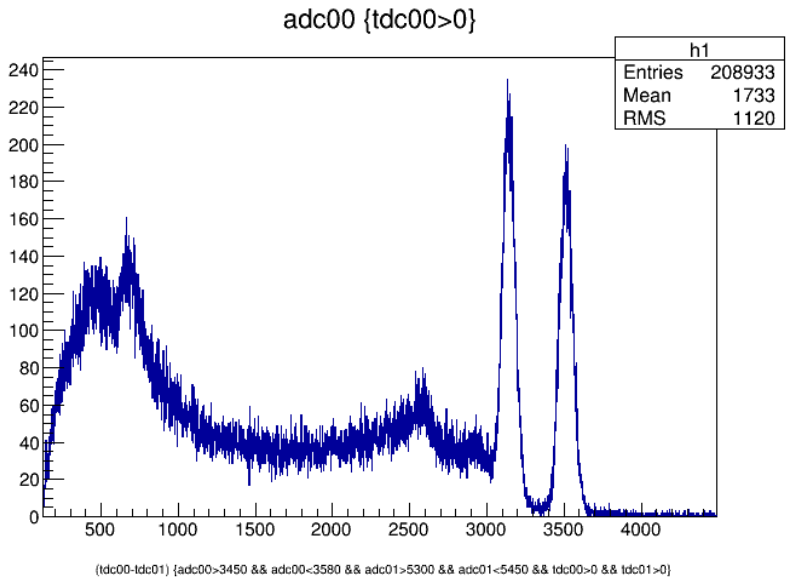


Time spectrum from LaBr3



Gamma spectra w and w/o particle coincidence

$LaBr_3$ detector development @ IMP



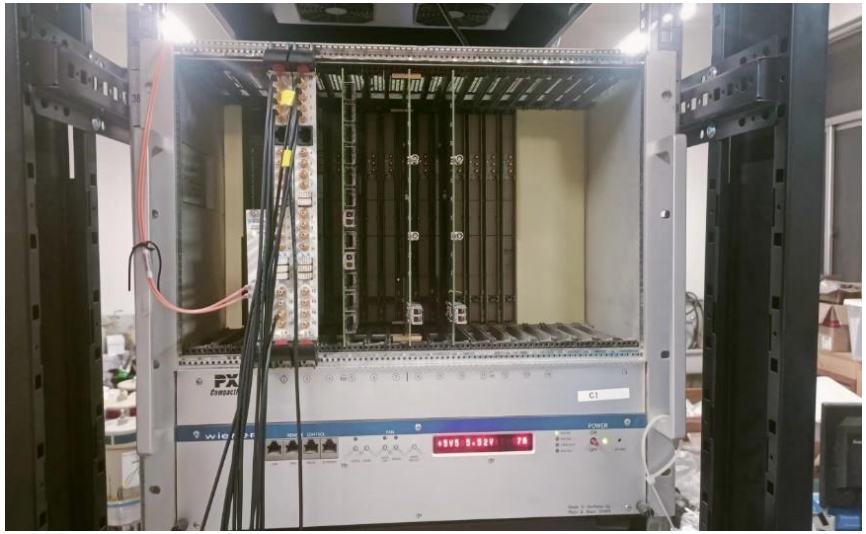
$LaBr_3$(Ce) detector

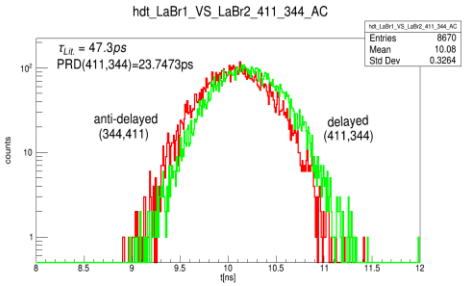
NO.	NAME	VALUE	ERROR
1	Constant	3.96314e+02	9.93133e+00
2	Mean	-1.54411e+02	1.01790e-01
3	Sigma	5.14260e+00	7.90737e-02

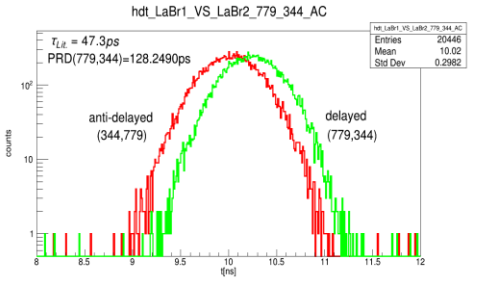
```
root [7] 5.14260e+00*24.414*2.36
(const double)2.96301389903999961e+02
```

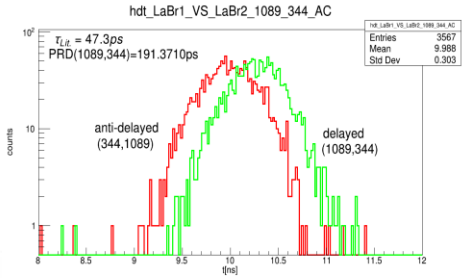
Time resolution:296 ps (FWHM)

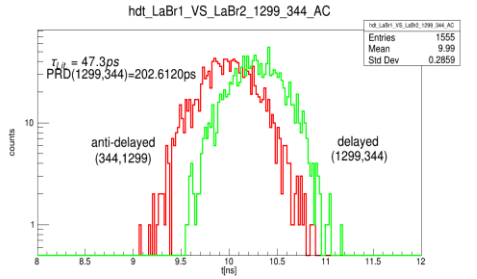
$LaBr_3$ detector development @ IMP

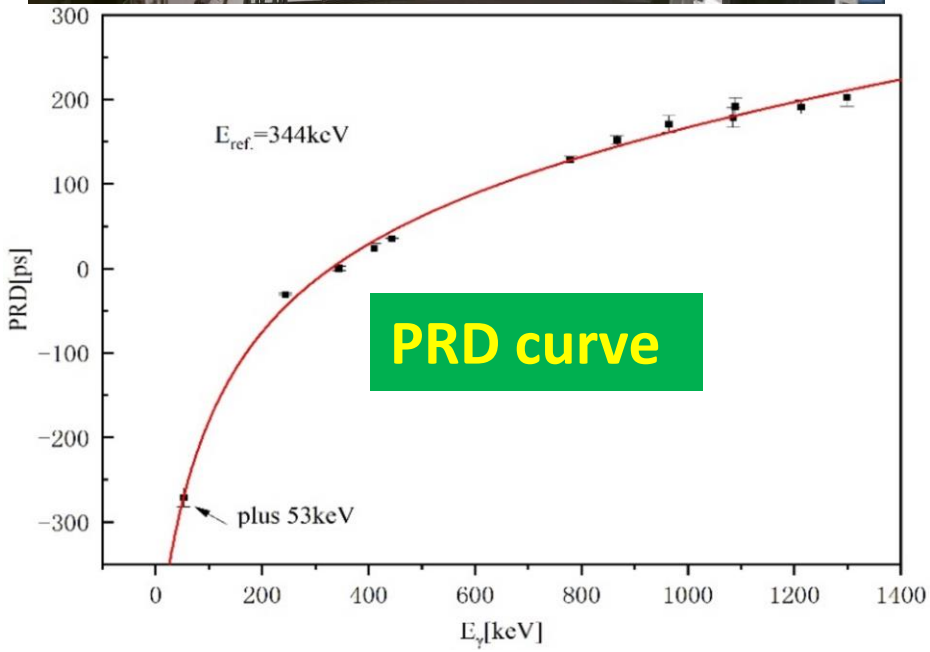


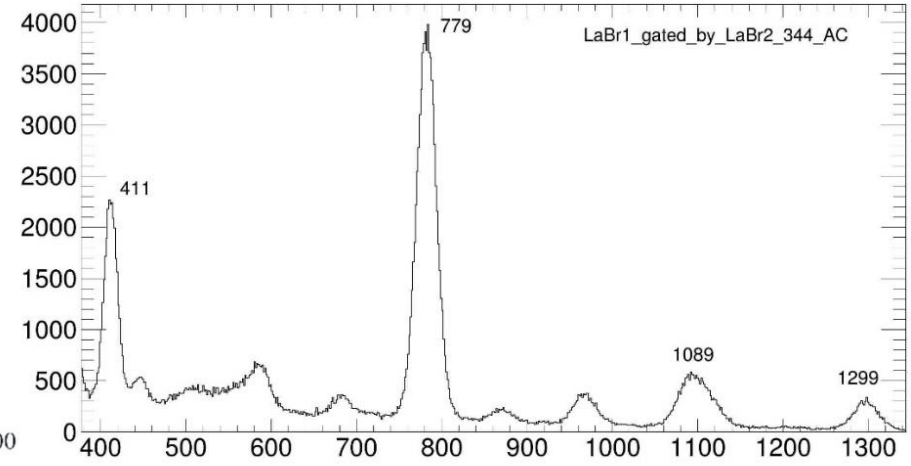




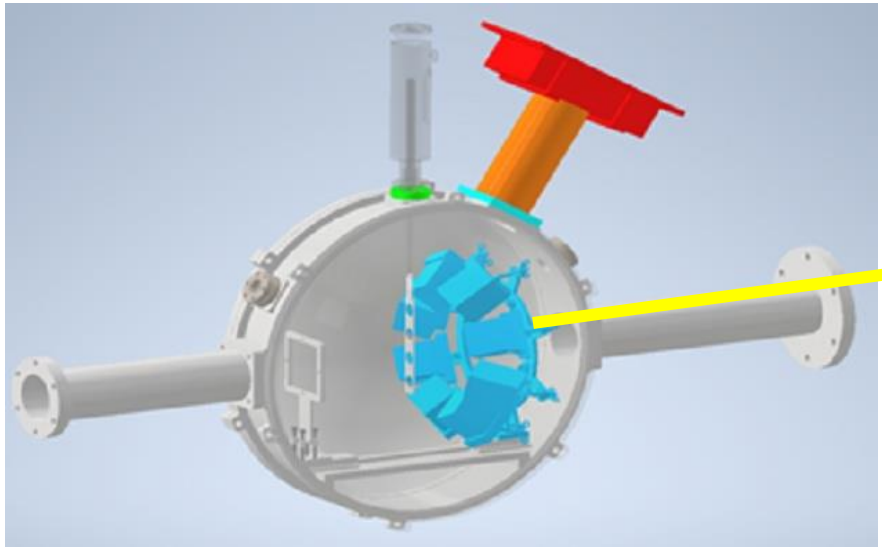


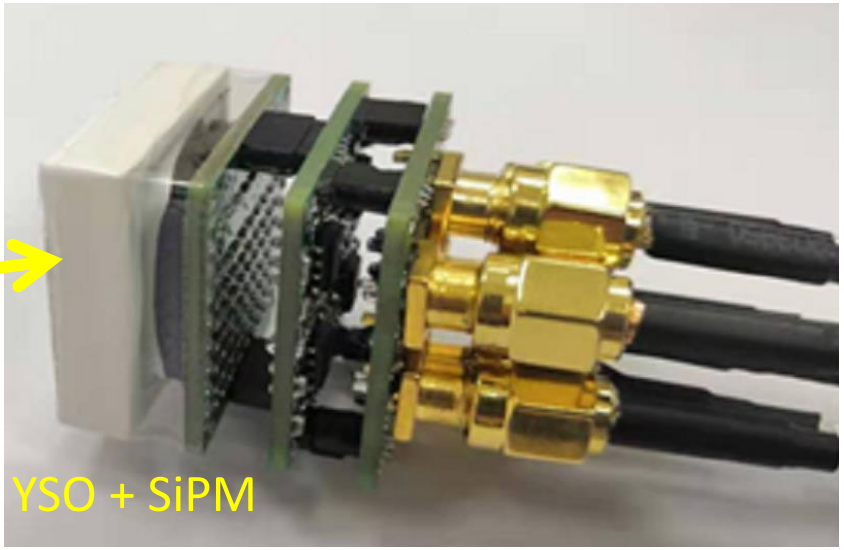


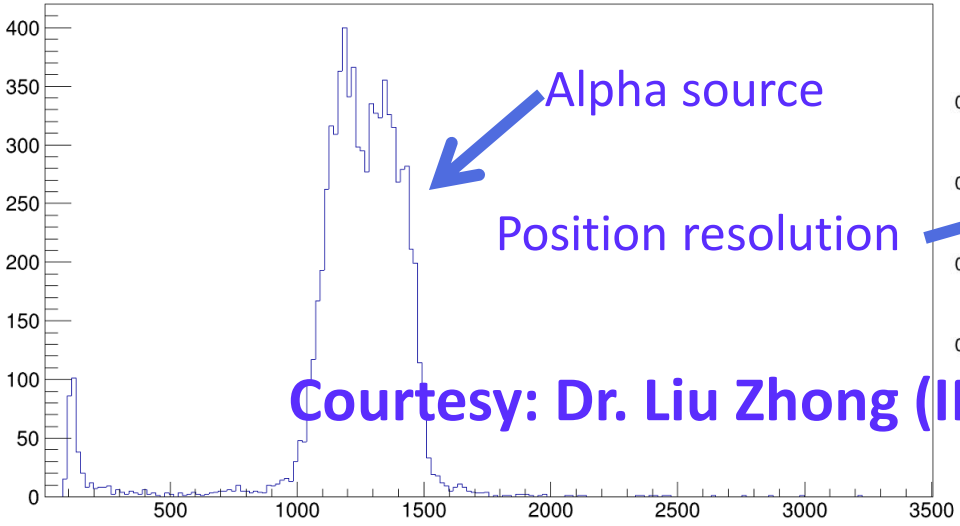


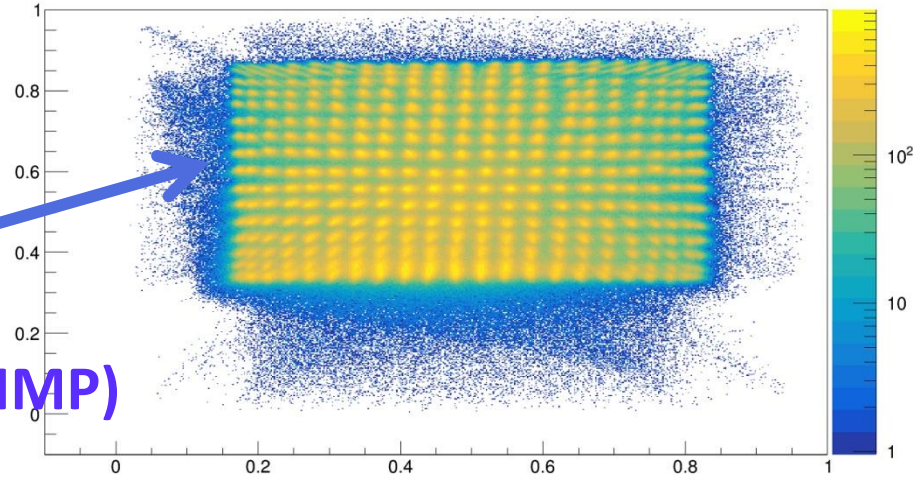


YSO array development @ IMP

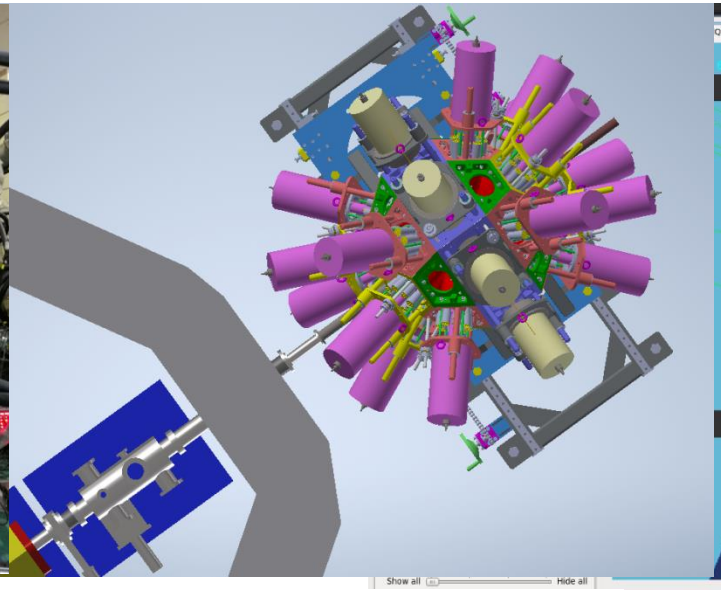


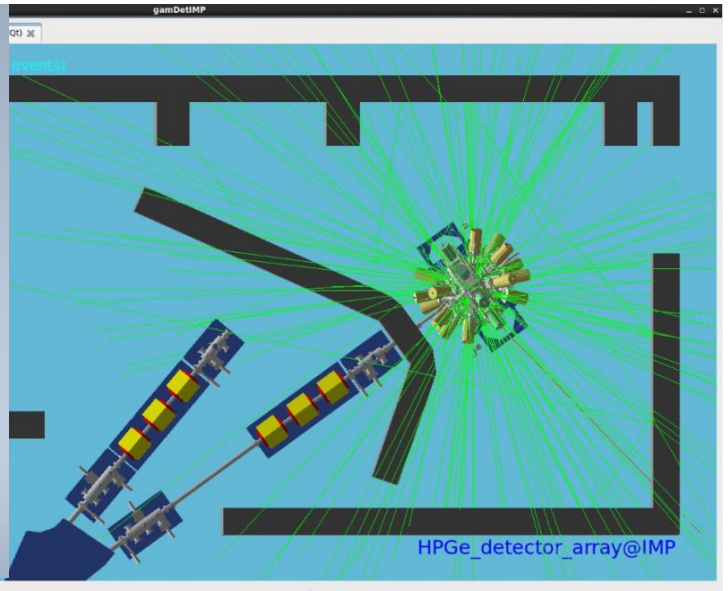


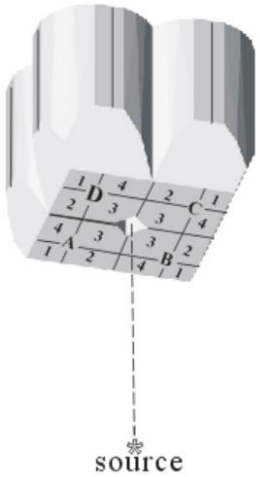


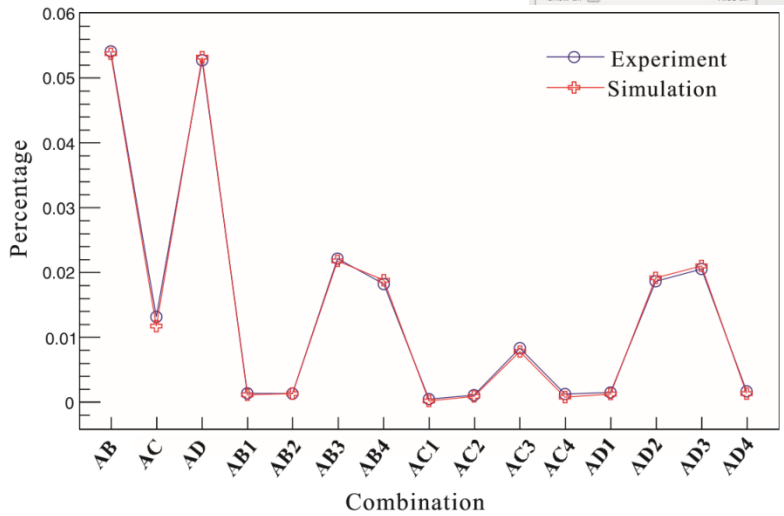


Simulation tools development @ IMP





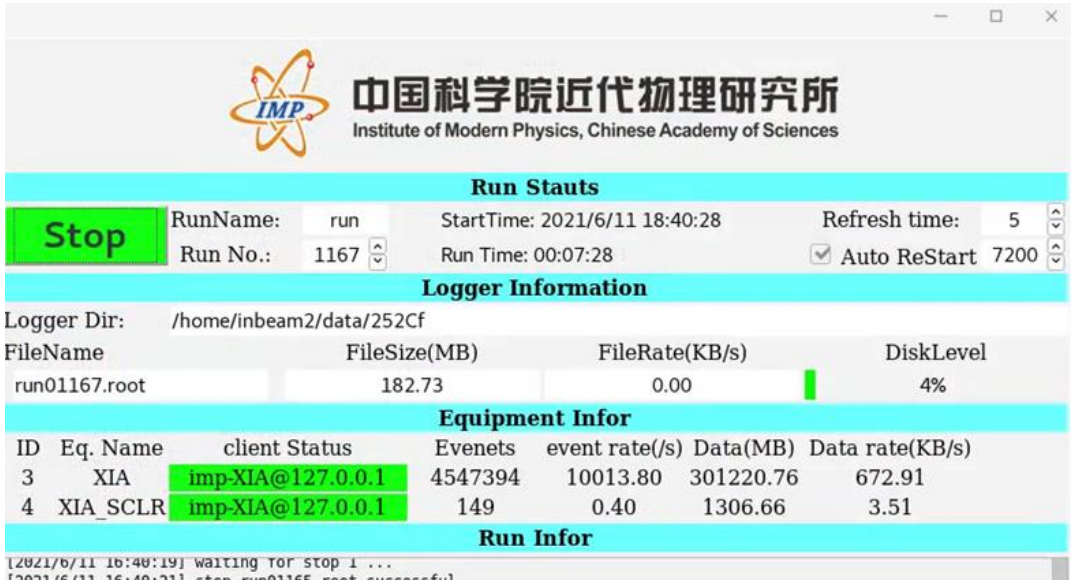


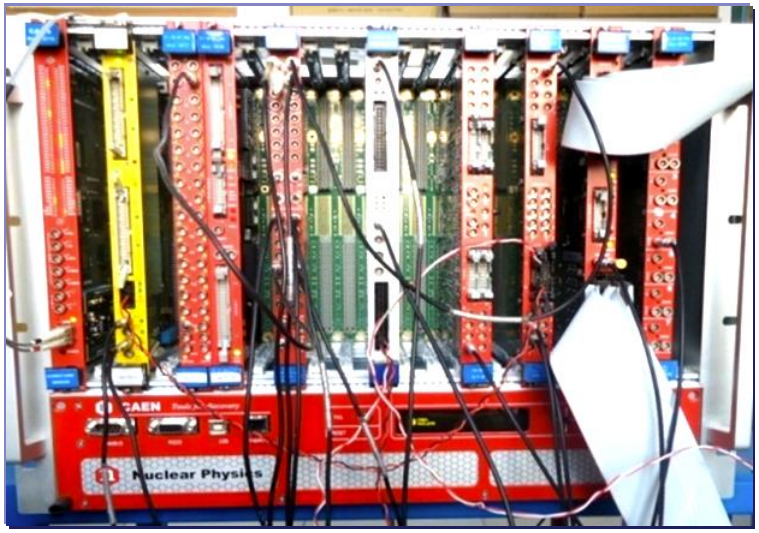


Comparison between Exp. & Sim.

Geant4 simulation frameworks are available, not only for single detector, but for the full array…

High speed/stable DAQ system @ IMP





VME based & Digitizer based DAQ systems are also available from IMP

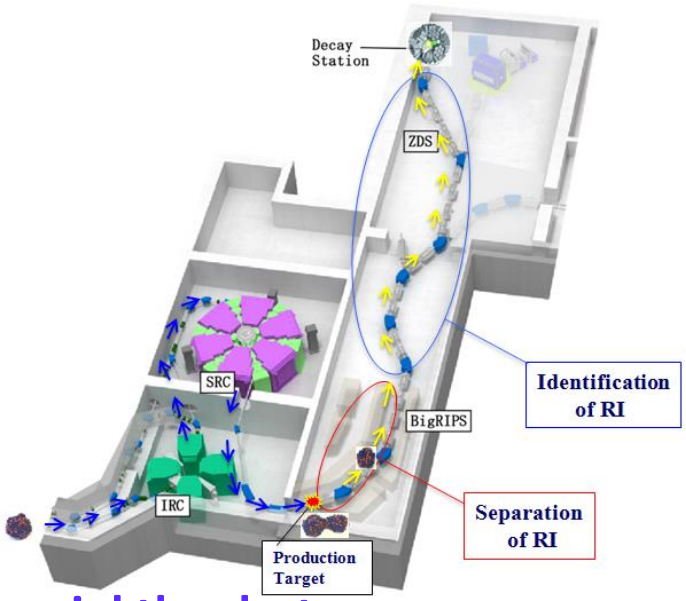
Courtesy: Dr. Wang Jianguo (IMP)

Contents

目录
CONTENTS

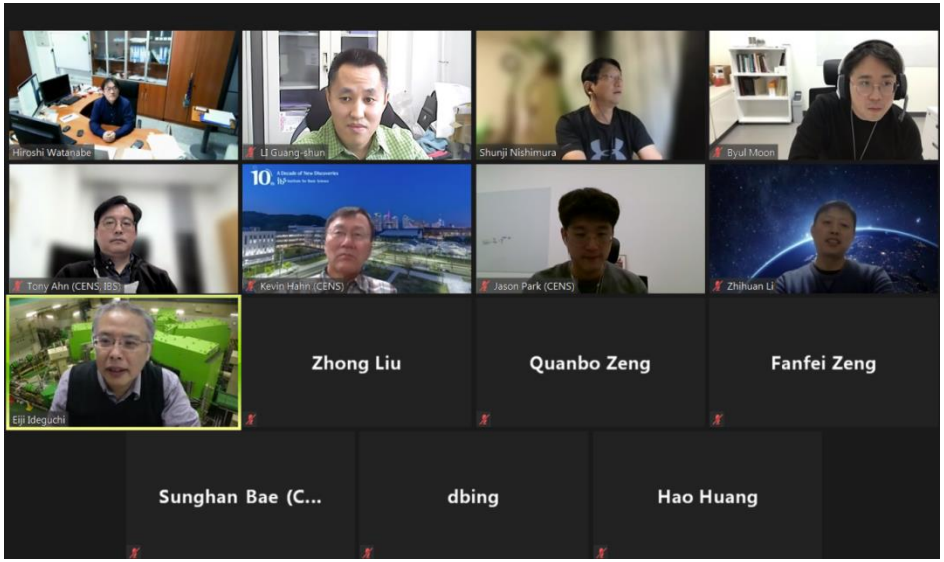
Collaborators from the A3 countries

Conclusion: there is a variety of post-EURICA physical cases



Special thanks to:

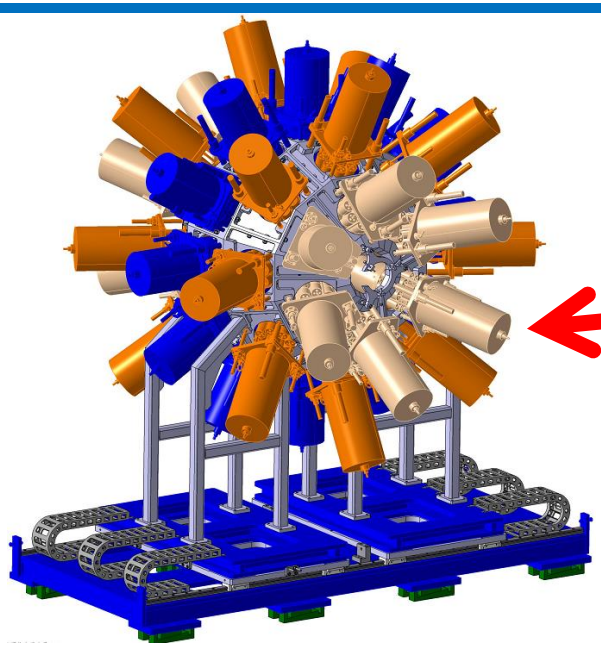
BAUU: H. Watanabe, B.H. Sun, et al.
RIKEN: S. Nishimura, et al.
IBS: T. Ahn, B. Moon, et al.
IMP: G.S. Li, Z. Liu, et al.
RCNP, CIAE, PKU, SDU …



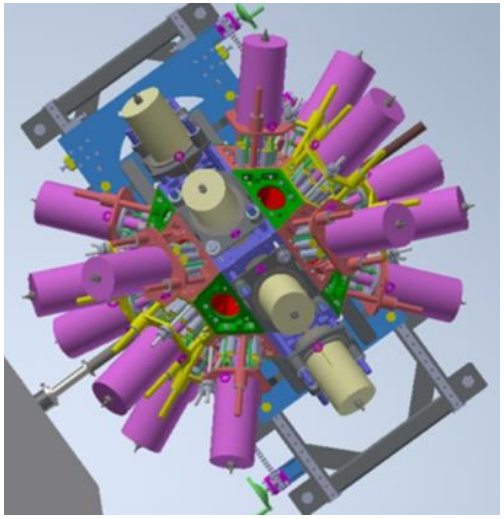
Online meeting at October, 2021

Online meeting at July, 2021

Two candidates to be employed at BigRIPS



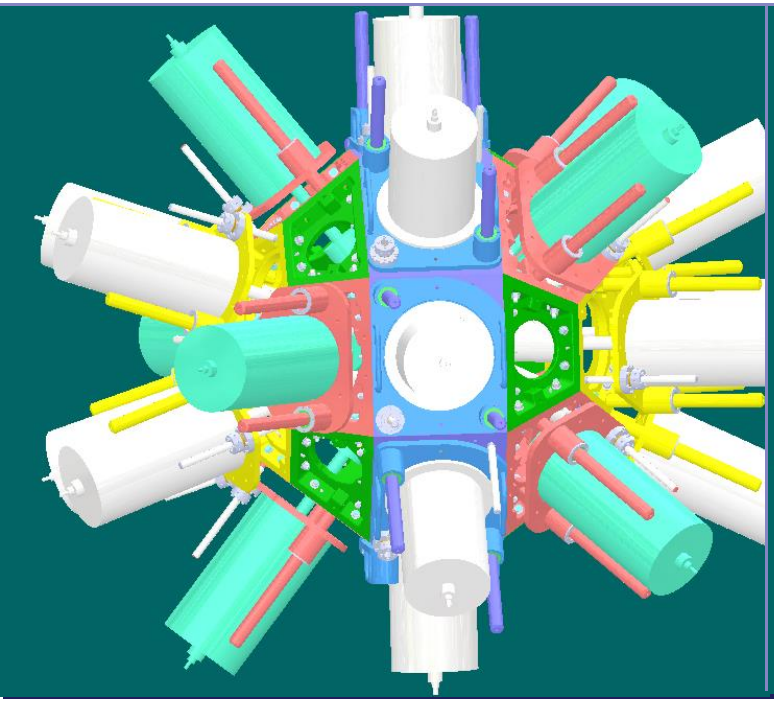
In the model of CIAE, the radius of the basic ball-shell is around 600 mm



In the model of IMP, the radius of the basic ball-shell is around 490 mm

Example of simulations with the IMP frame

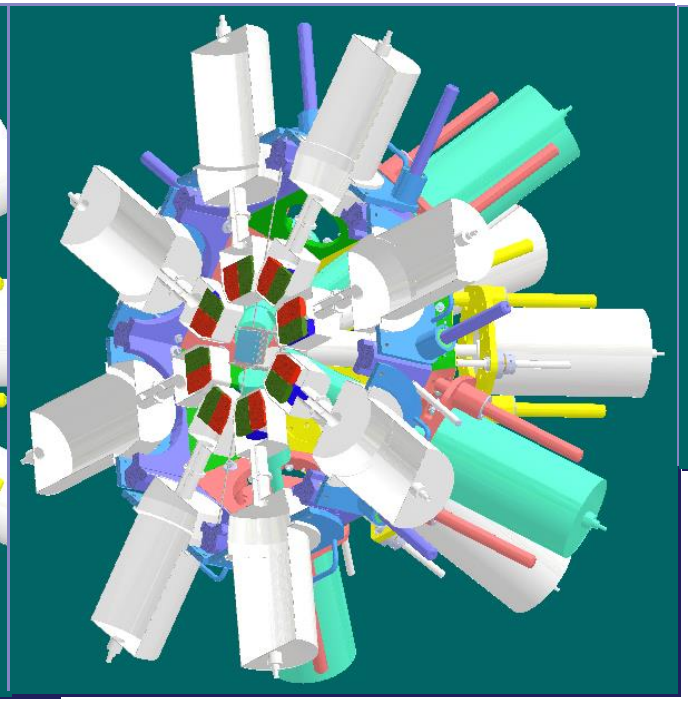
distance	Small angle (HPGes)	Middle angle (HPGes)	90 degree (Clovers)
IMP Closest model	140 mm	93 mm	129 mm



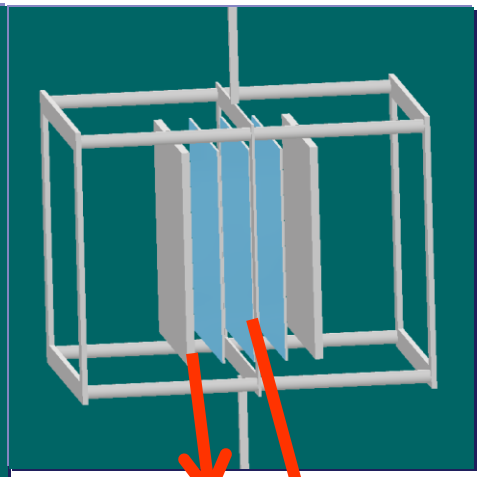
16 coaxial HPGes (70%)

8 Clover HPGes (160%)

4 of the 8 are from Korea



Half –view of the array

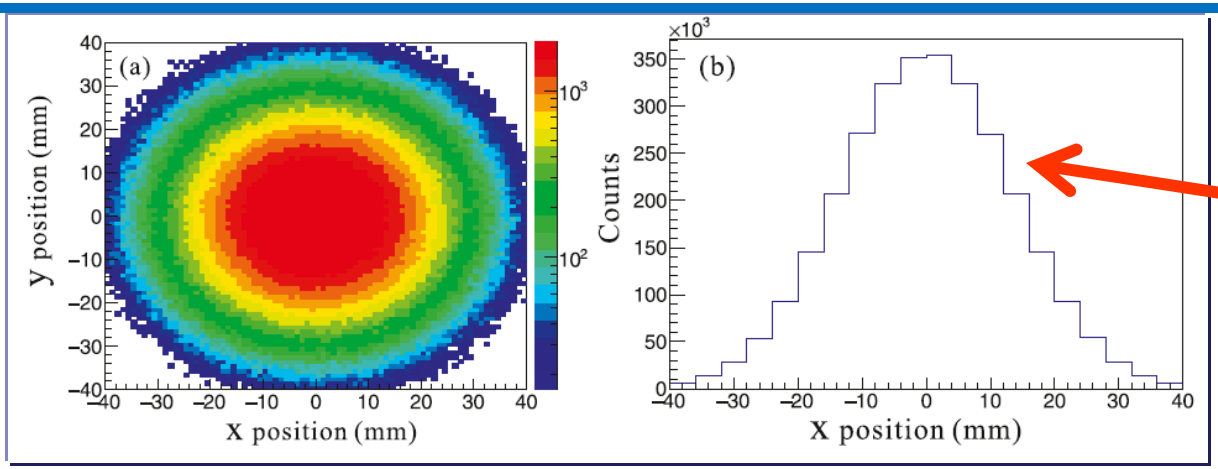


3 mm C9H10 of 2 layers

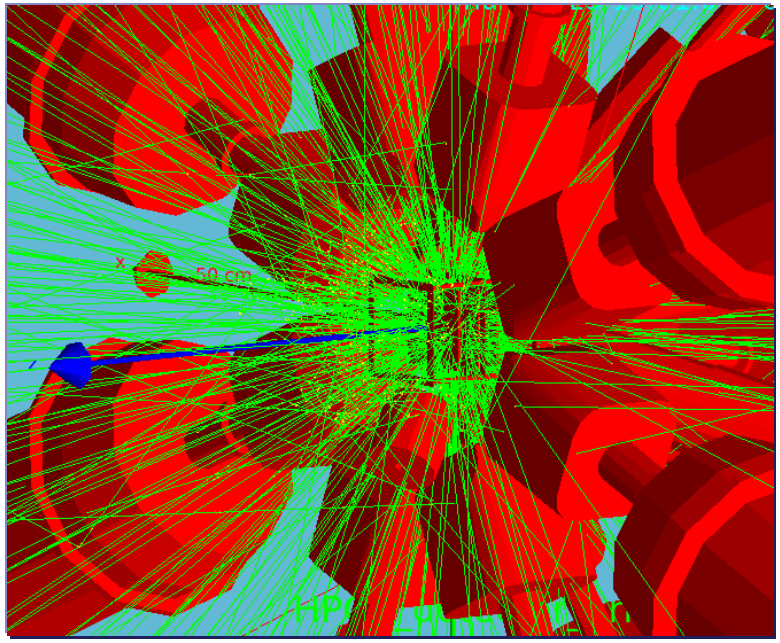
1 mm Si of 3 layers

Si: 78 mm x 78 mm

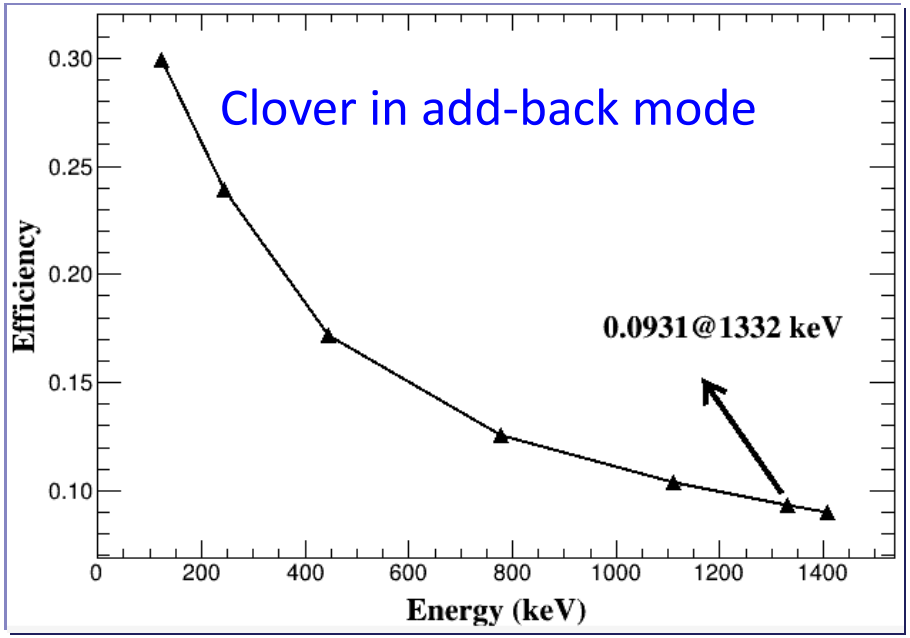
Example of simulations with the IMP frame



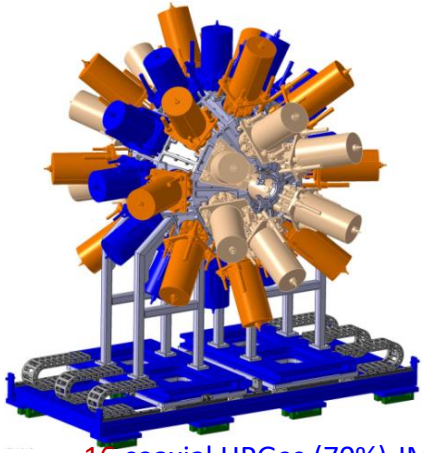
Gamma source distribution at middle Si detector



2 mm Al casings included DSSSDs and bPlasts included

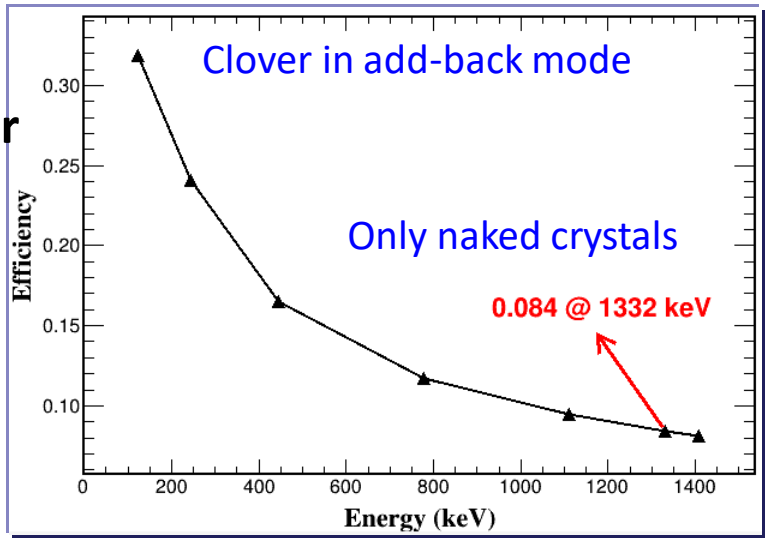


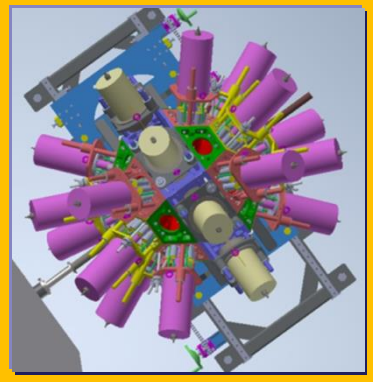
Comparison on the efficiencies



- 40 detectors considered
- Larger distance to the center
- Better granularity

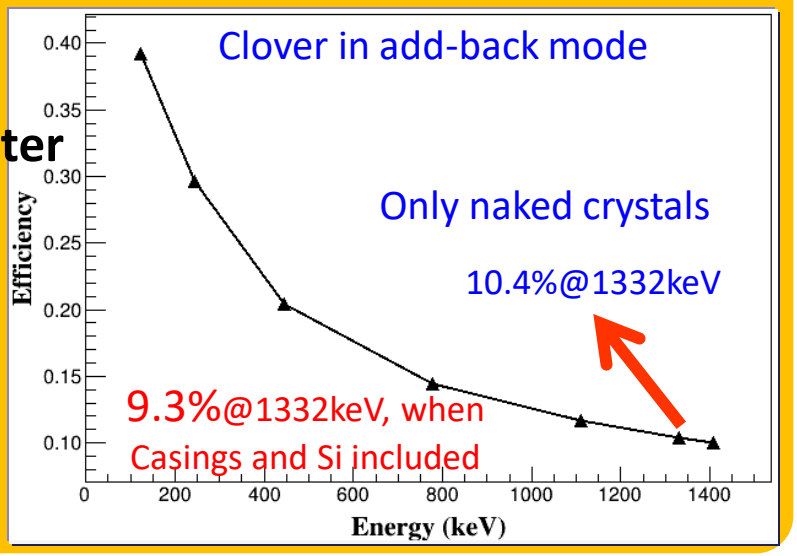
16 coaxial HPGes (70%)-IMP
8 Clover HPGes (160%)-IMP
4 Clover HPGe (Super) -Korea
2 coaxial HPGes (70%)-CIAE
7 coaxial HPGes (35%)-CIAE
3 coaxial HPGes (30%)-SDU





- 24 detectors considered
- Smaller distance to the center
- Worse granularity

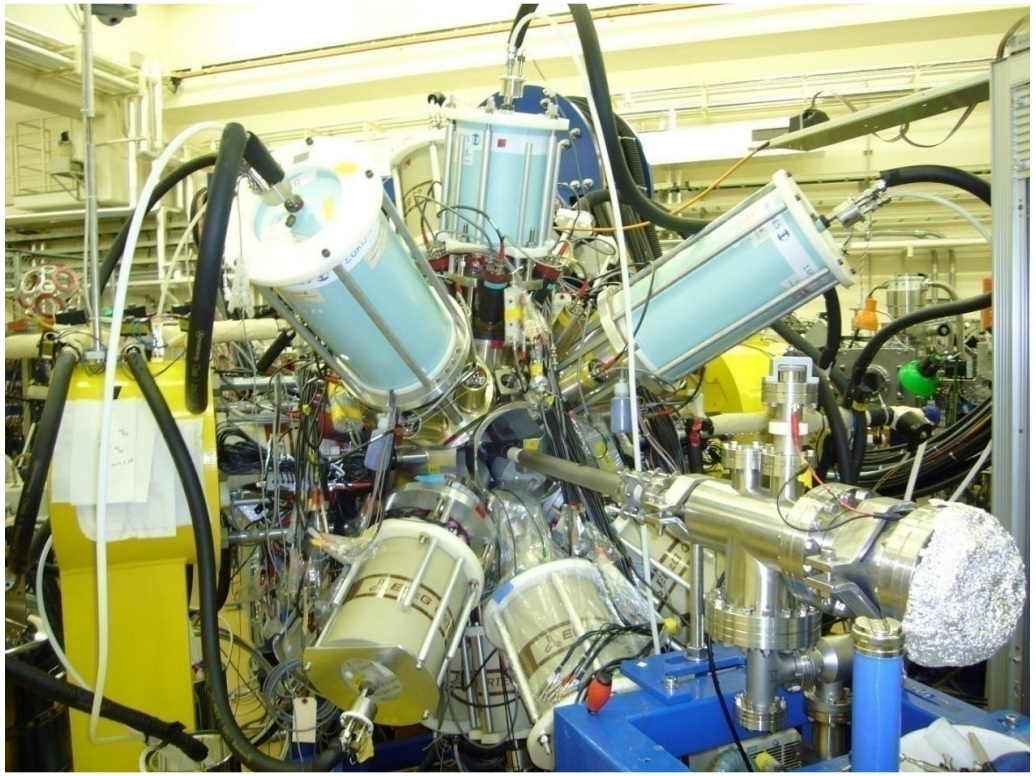
16 coaxial HPGes (70%)-IMP
4 Clover HPGes (160%)-IMP
4 Clover HPGe (Super) -Korea
2 coaxial HPGes (70%)-CIAE
7 coaxial HPGes (35%)-CIAE
3 coaxial HPGes (30%)-SDU



Contents

目录
CONTENTS

Successful collaboration with JAEA



Special thanks to:

JAEA: M. Oshima, Y. Toh, *et al.*

IMP: Zhang. Y. H, Zhou. X. H, *et al.*

GEMINI, Japan Atomic Energy Agency (JAEA)

14 HPGe's with AC shields

Many publications from this collaboration !!

Selected results …

Selected research results

IOP PUBLISHING JOURNAL OF PHYSICS G: NUCLEAR AND PARTICLE PHYSICS

J. Phys. G: Nucl. Part. Phys. **38** (2011) 095105 (9pp) doi:10.1088/0954-3899/38/9/095105

Signature inversion in the $7/2^-[503]$ band of ^{185}Pt

PHYSICAL REVIEW C **75**, 034314 (2007)

Band properties of the transitional nucleus ^{187}Pt

PHYSICAL REVIEW C **80**, 034303 (2009)

Properties of the rotational bands in the transitional nucleus ^{189}Pt

PHYSICAL REVIEW C **89**, 054303 (2014)

In-beam γ spectroscopy of the even-even nucleus ^{190}Pt

High spin states in the Pt isotopes are further systematically studied

Selected results …

Selected research results

IOP PUBLISHING — JOURNAL OF PHYSICS G: NUCLEAR AND PARTICLE PHYSICS

J. Phys. G: Nucl. Part. Phys. **38** (2011) 095105 (9pp) doi:10.1088/0954-3899/38/9/095105

Signature inversion in the $7/2^-[503]$ band of ^{185}Pt

PHYSICAL REVIEW C **75**, 034314 (2007)

Band properties of the transitional nucleus ^{187}Pt

PHYSICAL REVIEW C **80**, 034303 (2009)

Properties of the rotational bands in the transitional nucleus ^{189}Pt

PHYSICAL REVIEW C **89**, 054303 (2014)

In-beam γ spectroscopy of the even-even nucleus ^{190}Pt

High spin states in the Pt isotopes are further systematically studied

S. Guo, *et al.,* Phys.Rev. C 86, 014323 (2012)

H. X. Wang, *et al.,* Phys.Rev. C 86, 044305 (2012)

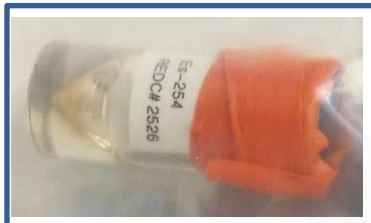
Y. D. Fang, *et al.*, Phys.Rev. C 82, 064303 (2010)

… …

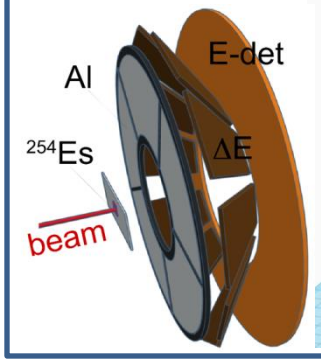
Successful collaboration with JAEA

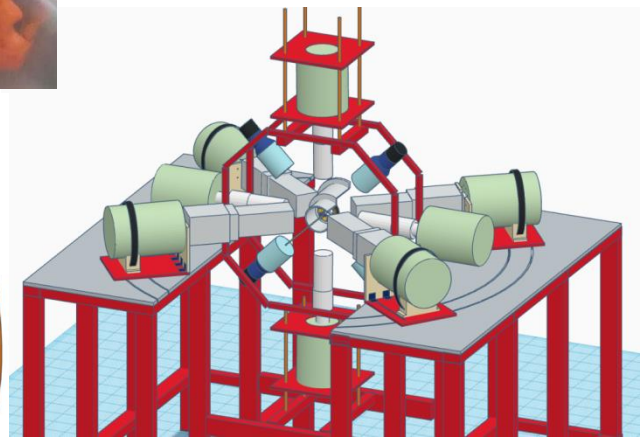
Nuclear structure study on ^{256,258}No

$^{10}B+^{254}Es \longrightarrow {}^{256,258}No+\alpha xn$



^{254}Es(Z=99) liftime: 276sdays





MOU协议

For the Advanced Science Research Center,
Japan Atomic Energy Agency
(ASRC/JAEA)

Prof. Dr. Sadamichi Maekawa
Director General

Date: Jan. 15, 2018

For Institute of Modern Physics,
Chinese Academy of Sciences
(IMP/CAS)

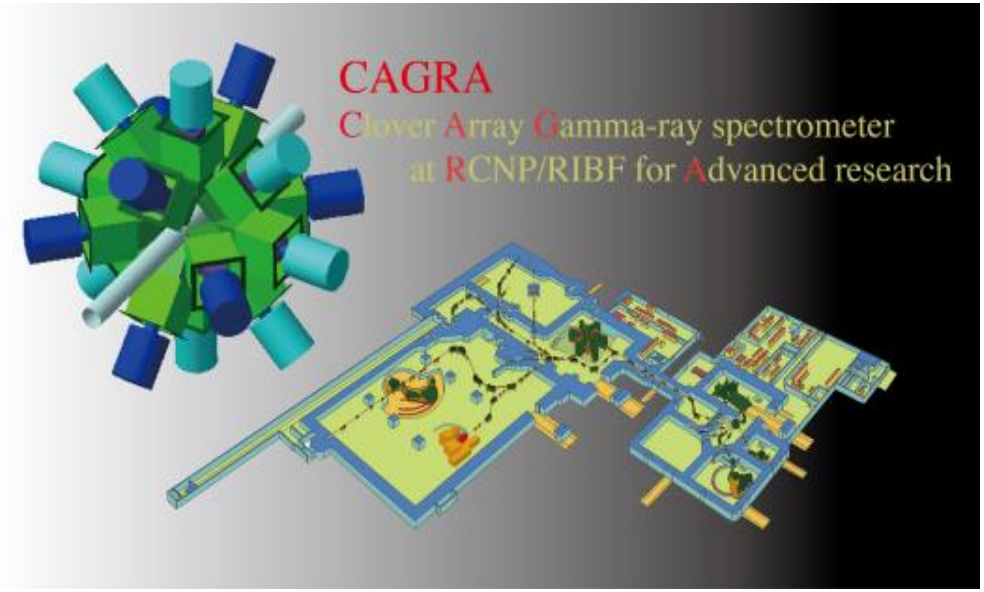
Dr. Guoqing Xiao
Director

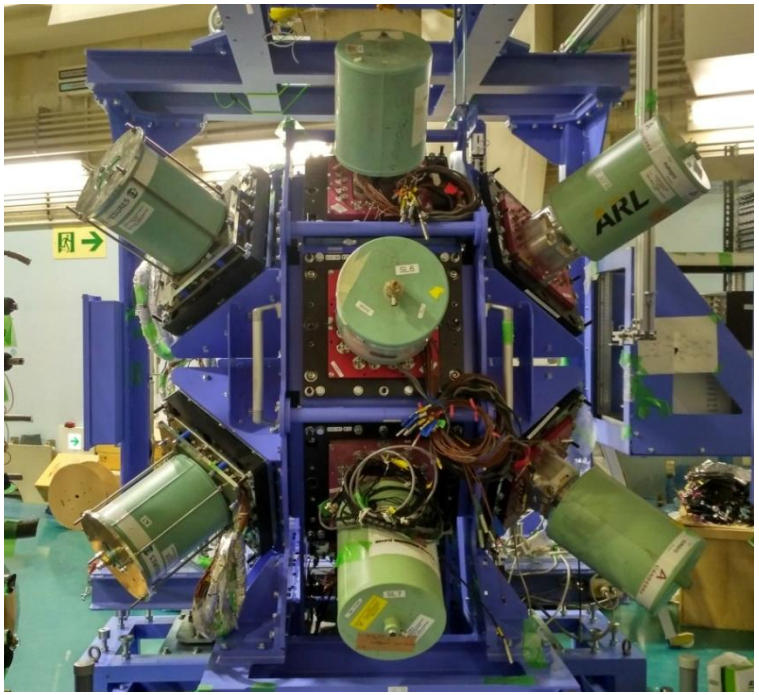
Date: Jan. 29, 2018

JAEA: Dr. Katsuhisa Nishio, *et al.*
IMP: Dr. Fang. Y. D, *et al.*

4 Clover detectors were employed in the project

Successful collaboration with RCNP





Collaboration: USA, Japan, China

16 Clover detectors + Acs, 2 from IMP

Performed experiment (2017):

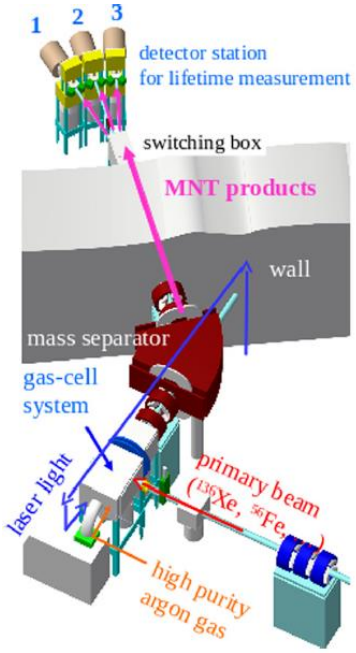
High-Spin States in ^{91}Y, ^{93,94}Nb and ^{94}Zr, by Dr. Liu. M. L *et al.*

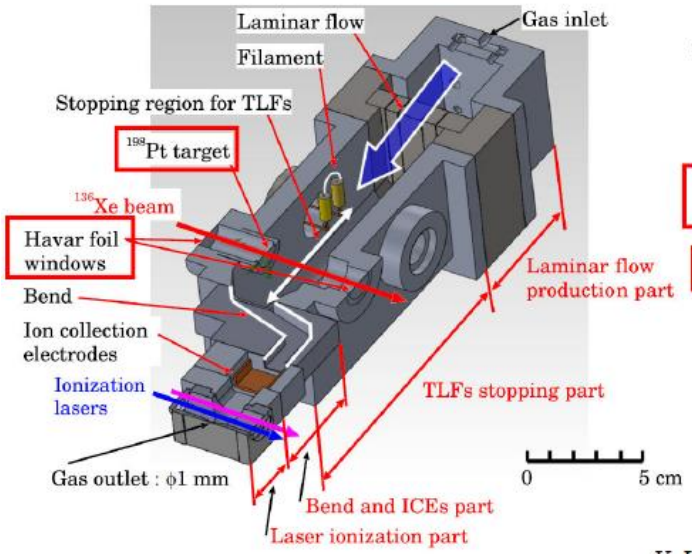
Approved beam time:

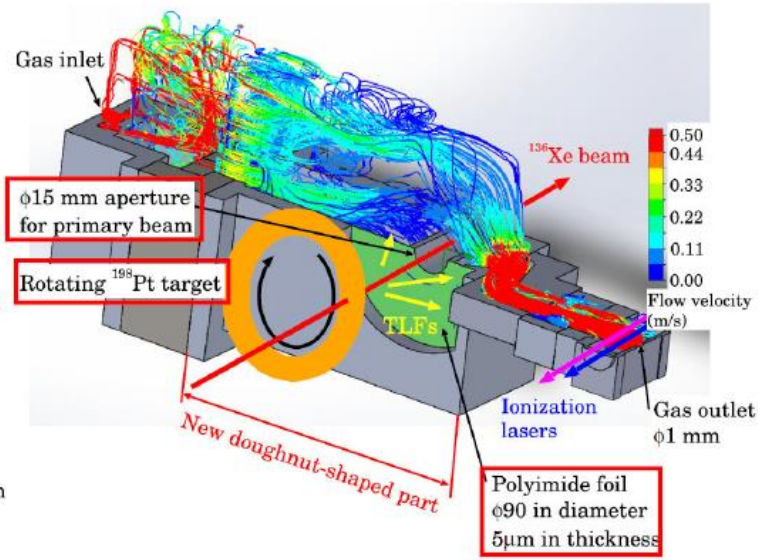
Linear Polarization Measurement in Wobbling Bands, by Dr. Guo. S *et al.*

On going collaboration with KEK

The KISS project







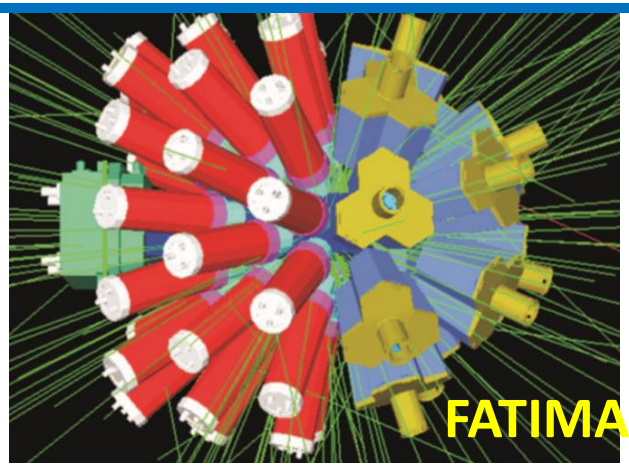
Y. Hirayama et al., Nucl. Instrum. and Meth. B 412, 11 – 18 (2017).

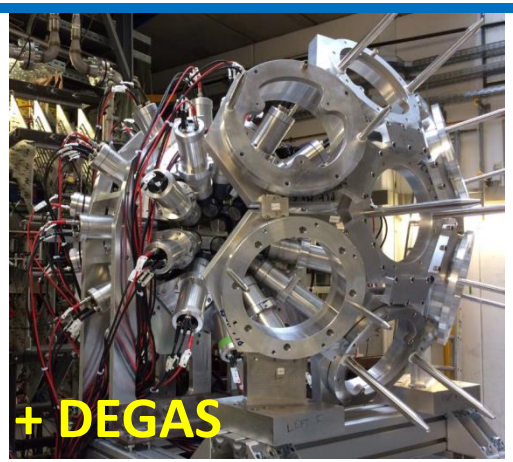
4 IMP Clover detectors were employed for the project at 2020

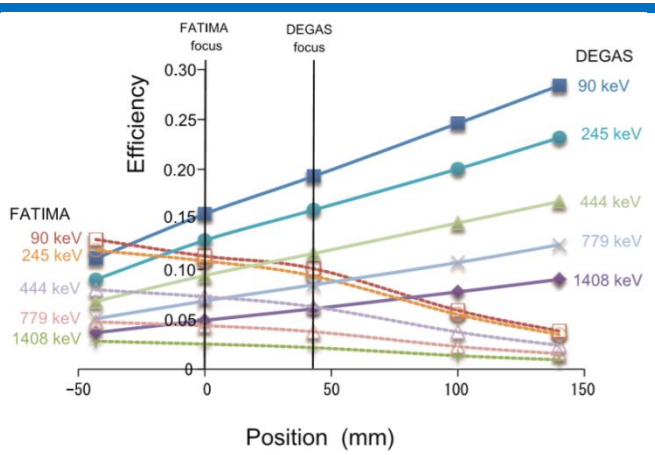
They will be employed again for the project at 2023

WNSC: Dr. Yutaka Watanabe, *et al.*

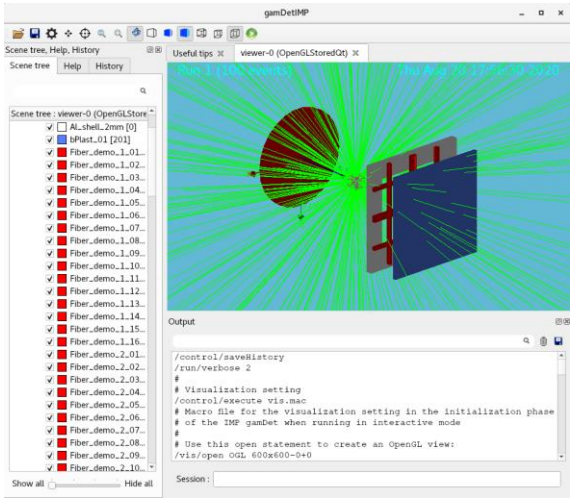
On going collaboration with GSI

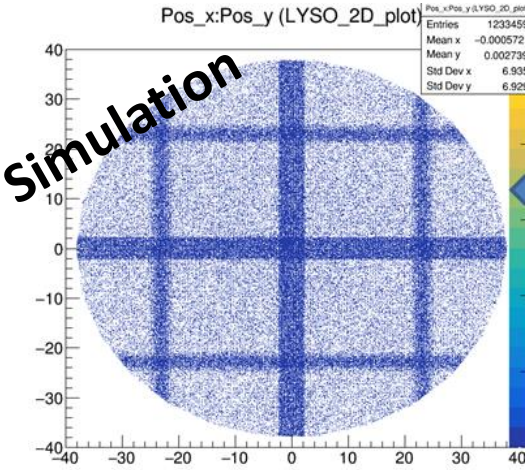


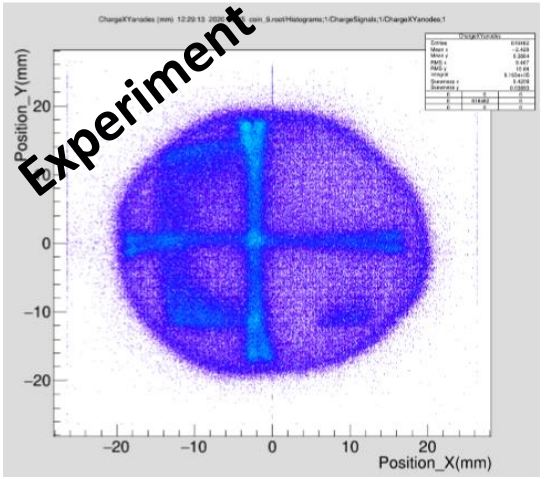




G. S. Li, R. Lozeva, *et al.*, NIM A, 987, 164806 (2021)

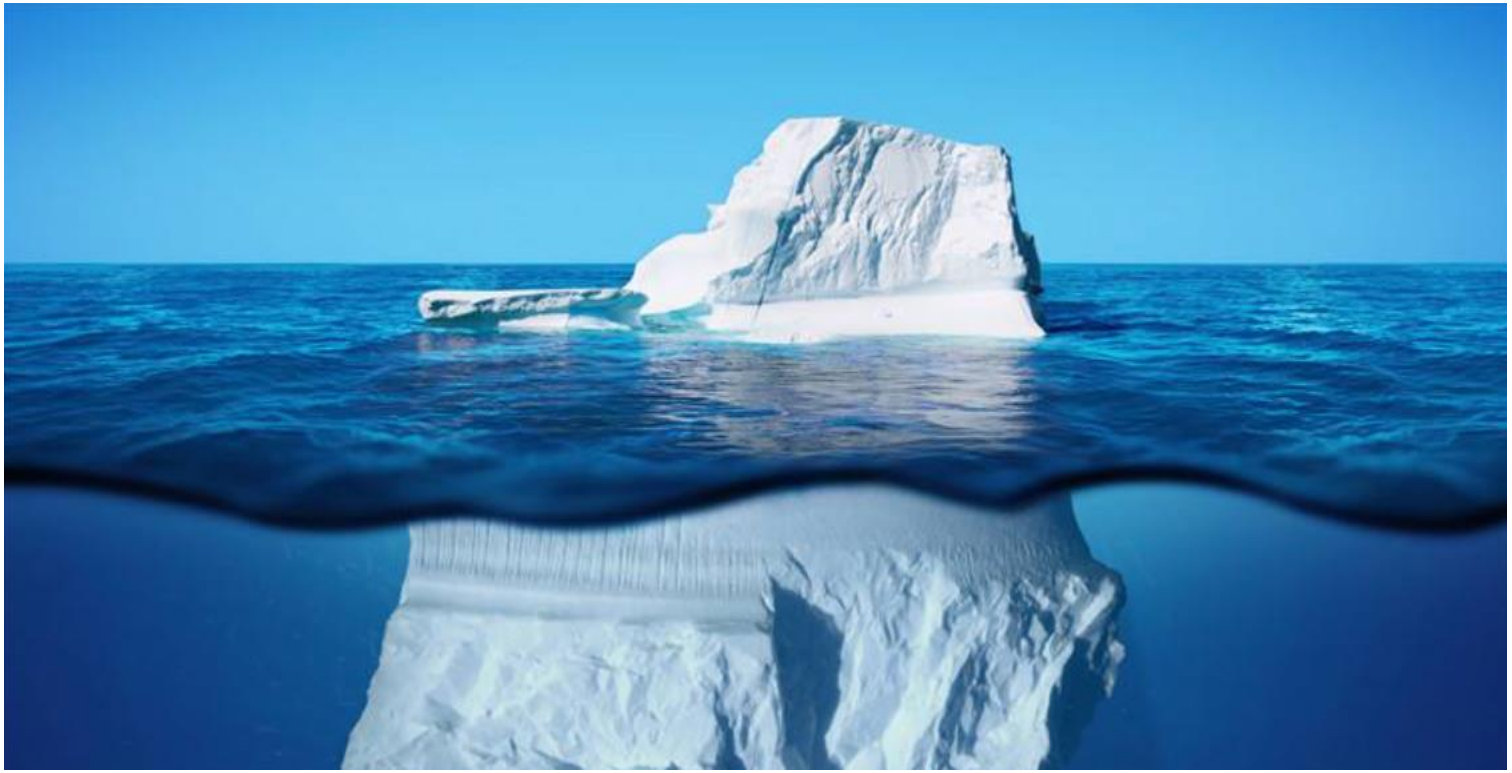






NUSTAR/DESPEC project

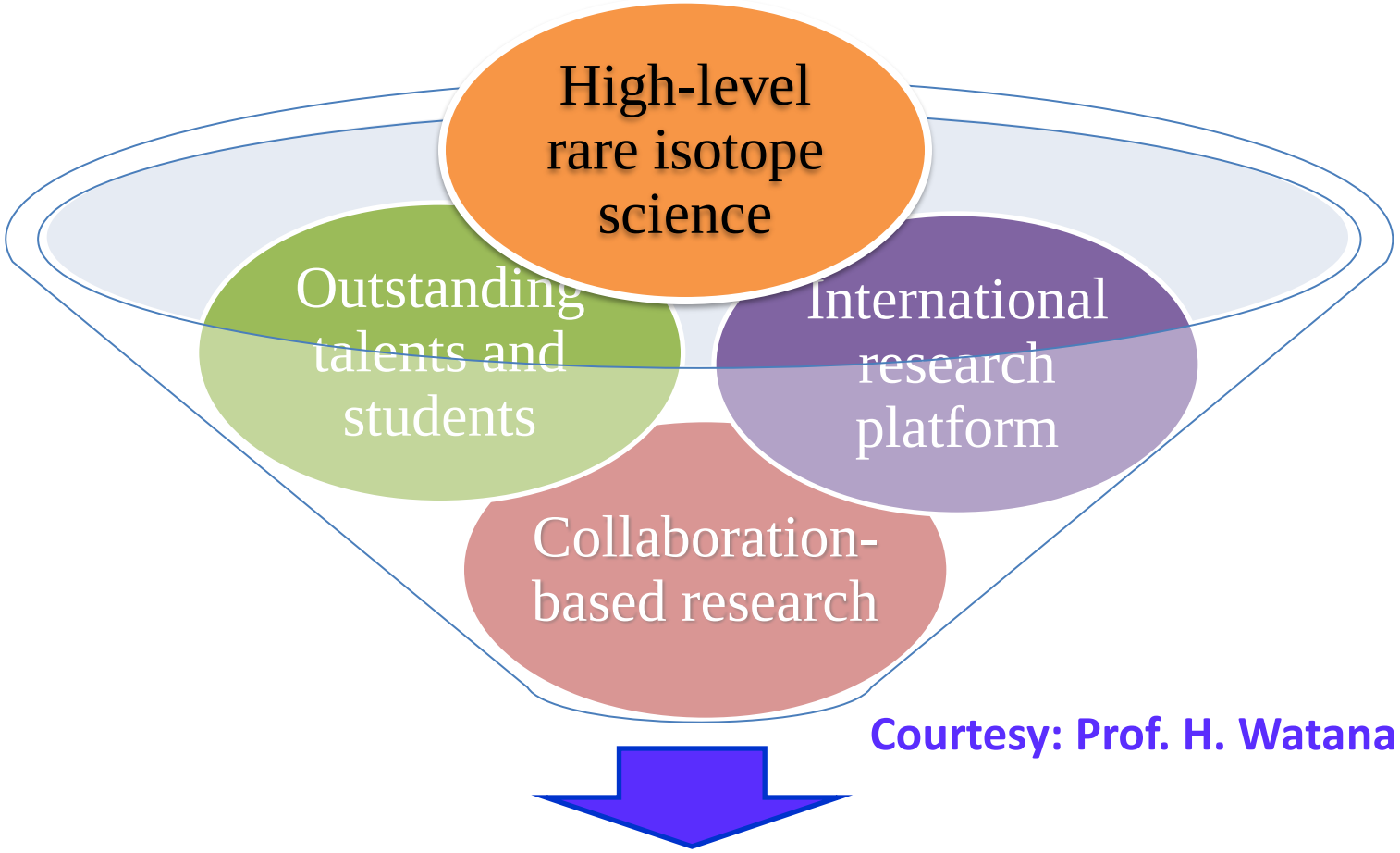
A tip of the iceberg



The sharing of the instrumentations are only partially covered in this talk!

Outlook

Contribution to the (inter)national interest in the community



Courtesy: Prof. H. Watanabe(BUAA)

- **Maximize scientific outputs and impact of the community**
- **Foster researchers who will bare the future of Nuclear Physics**

Outlook

- Strengthen the collaboration, share the instrumentations
- We will have more bright future

Thank you for your attention!