

Spanish roadmap

Federico Sánchez



Outline

- Spanish neutrino community
- Topics:
 - Neutrino oscillation (Dooble Chooz, T2K, SuperKamiokande, Neutrino Factory &)
 - Double beta decay (NEXT, BIPO, Ge detectors)
 - Astroparticle neutrinos.
 - Theory

Funding

- Ministry of Science with two programs.
 - Standard 3 year funding calls.
 - Consolider Ingenio 2010. Funding projects of excellence.
- New Spanish network of Particle physics funding via the Consolider program.
- European funding.
- Little support from Autonomous Communities: mainly man power & pocket money.

Spanish ν community



Oscillation physics

Oscillation physics

- Spanish groups have contributed in the past to both the theory and experiment of neutrino oscillations:
 - K2K/SciBoone (IFAE Barcelona / IFIC Valencia)
 - HARP for hadroproduction (IFIC)
 - NOMAD (IFIC Valencia)
 - MiniBoone (IFIC Valencia)
 - Neutrino factory and Beta Beams (U.Valencia/IFIC, U.A.Madrid/IFT, U.Barcelona, IFAE)
 - Neutrino–Nucleus interactions (U.Valencia/IFIC, U.Granada, U.Salamanca, U.Sevilla).

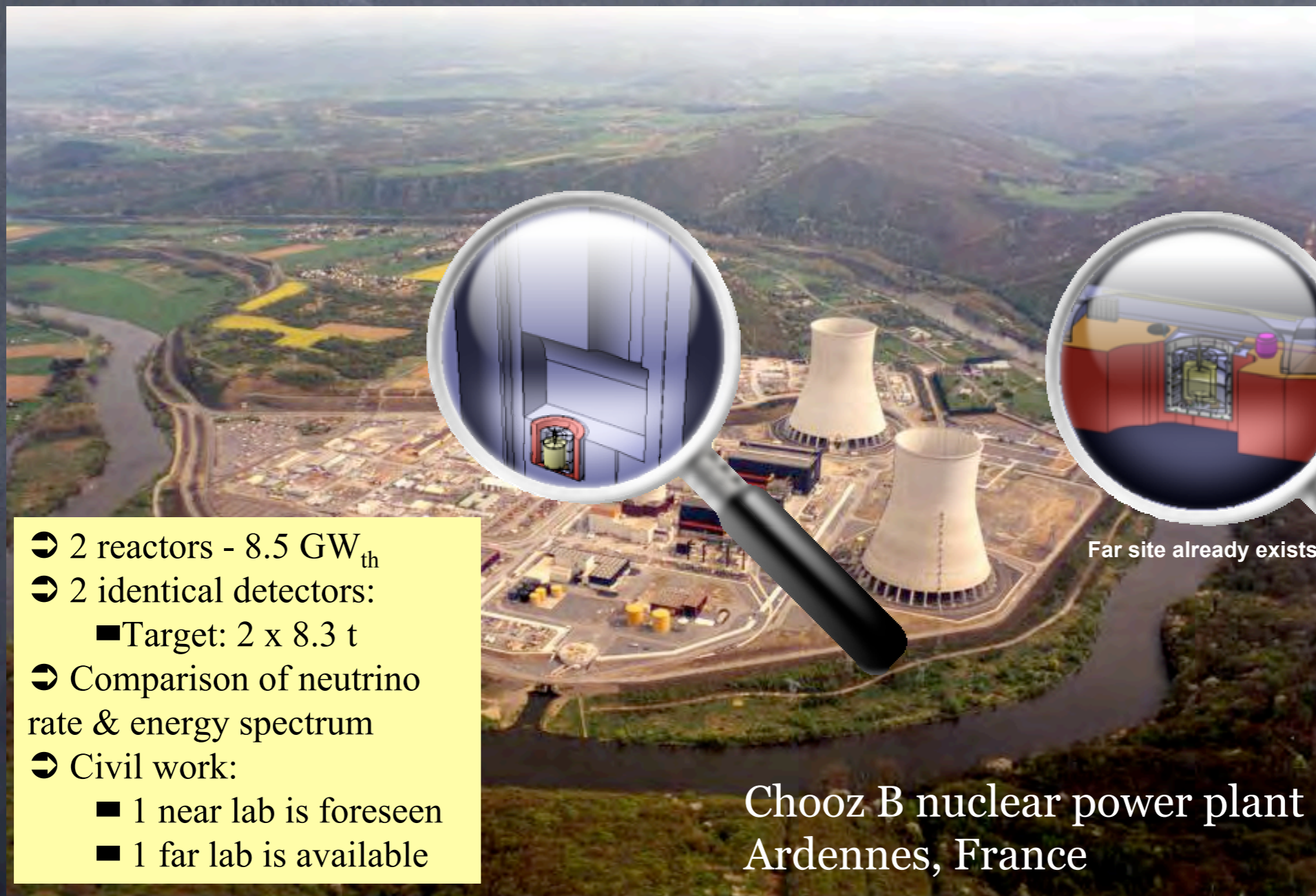
Oscillation physics

- The spanish groups are involved in several aspects of current and future experiments:
 - Double-Chooz
 - T2K (+SciBoone)
 - SuperKamiokande
 - Neutrino Factory including Laguna.



Double Chooz

Ciemat
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Energéticas, Medioambientales
y Tecnológicas



- ⇒ 2 reactors - 8.5 GW_{th}
- ⇒ 2 identical detectors:
 - Target: 2 x 8.3 t
- ⇒ Comparison of neutrino rate & energy spectrum
- ⇒ Civil work:
 - 1 near lab is foreseen
 - 1 far lab is available

Far site already exists

Chooz B nuclear power plant
Ardennes, France



Double Chooz

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▣ HV splitter system

- ◆ Design, manufacturing, installation on site and commissioning

▣ PMT mechanical structure

- ◆ Design, manufacturing, installation on site and commissioning

▣ PMT magnetic shielding

- ◆ Design, tests, realization, installation on site and commissioning

▣ Mechanical assembly of PMTs

▣ PMT integration on site

▣ Mechanical tools for acrylics vessels

- ◆ Manufacturing of tools for transportation and installation of acrylic vessels

Close collaboration with APC/Paris & Saclay



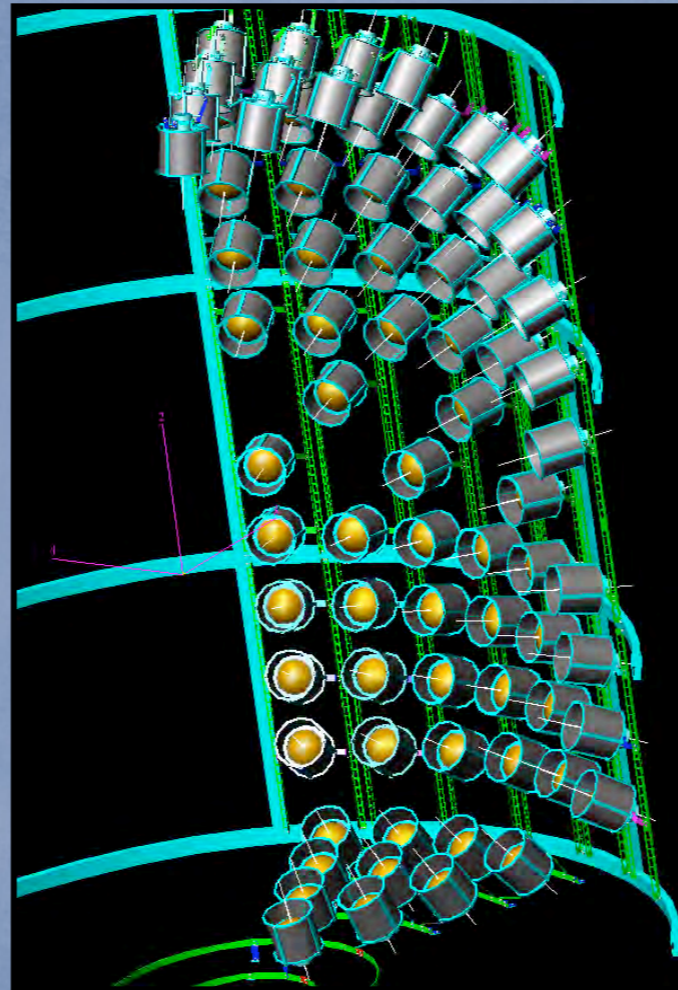
Double Chooz



Low background glass
10'' R7081 Hamamatsu PMTs



PMT geometry baseline
(390 PMTs/detector)



PMT mechanical support
& magnetic shield





Double Chooz



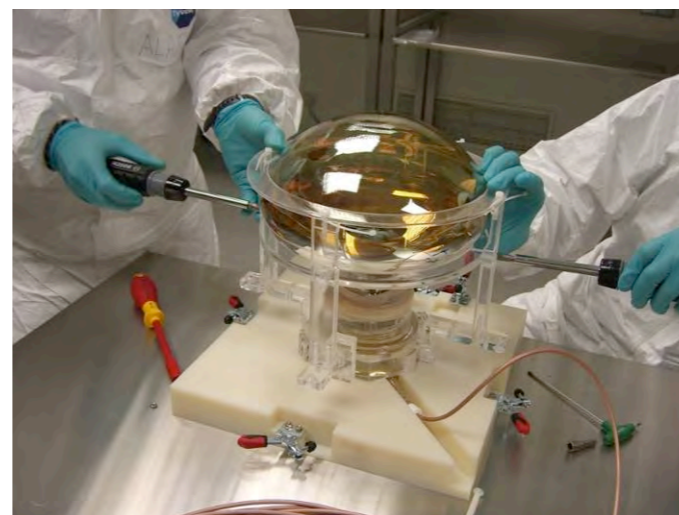
Magnetic tests
@ CIEMAT



PMT testing finished



PMT assembly almost finished



Installation of PMT's in CHOOZ starting 2nd week of May,



Double Chooz



Target vessel tools



Engineers from Saclay



Gamma-catcher vessel tool



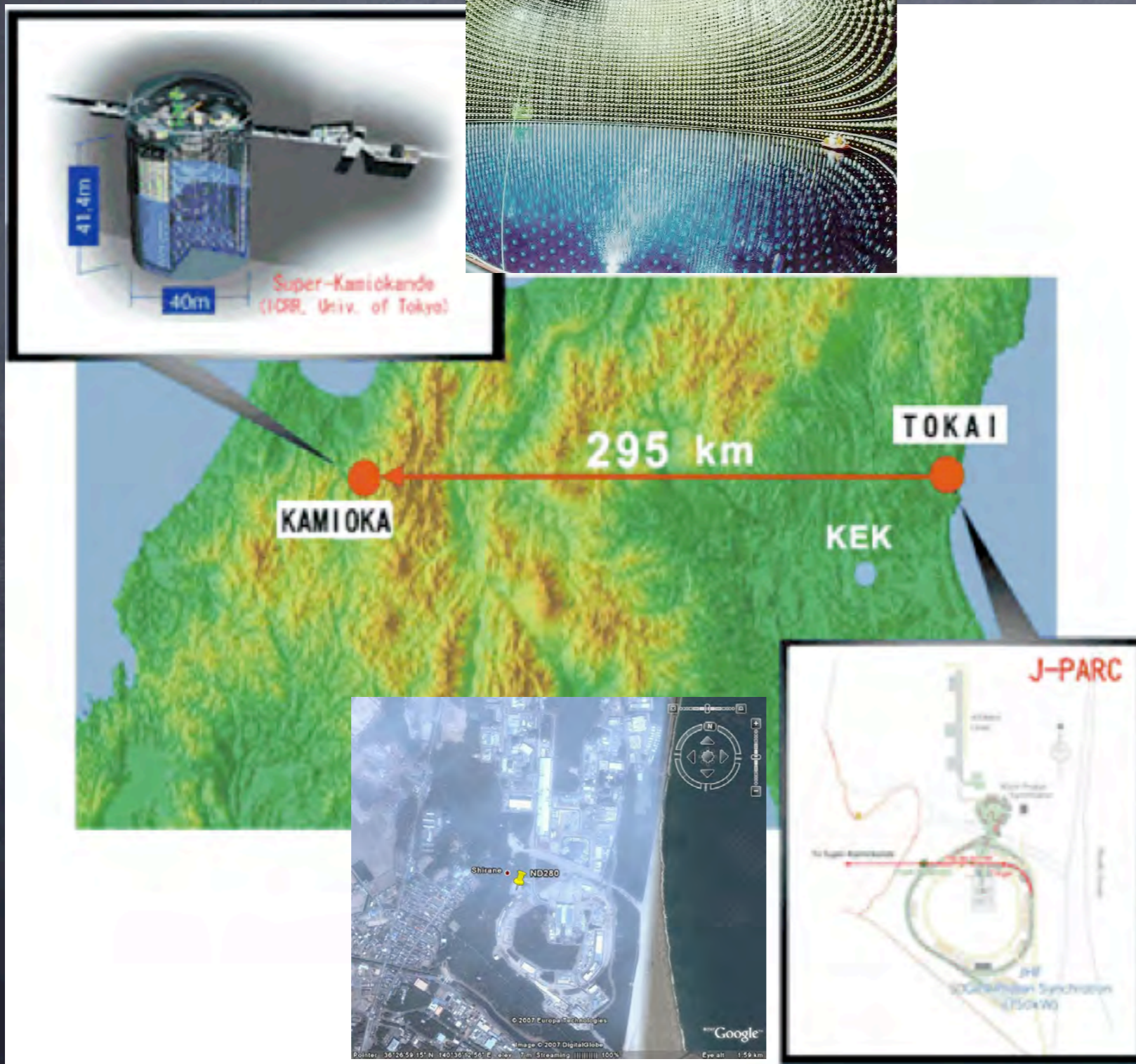


Double Chooz



- Contribution to the software & analysis efforts:
 - PMT simulation.
 - Uniformity response studies.
 - Pulse reconstruction.
 - Online data quality.
 - Accidental background.
 - Oscillation analysis.

T2K

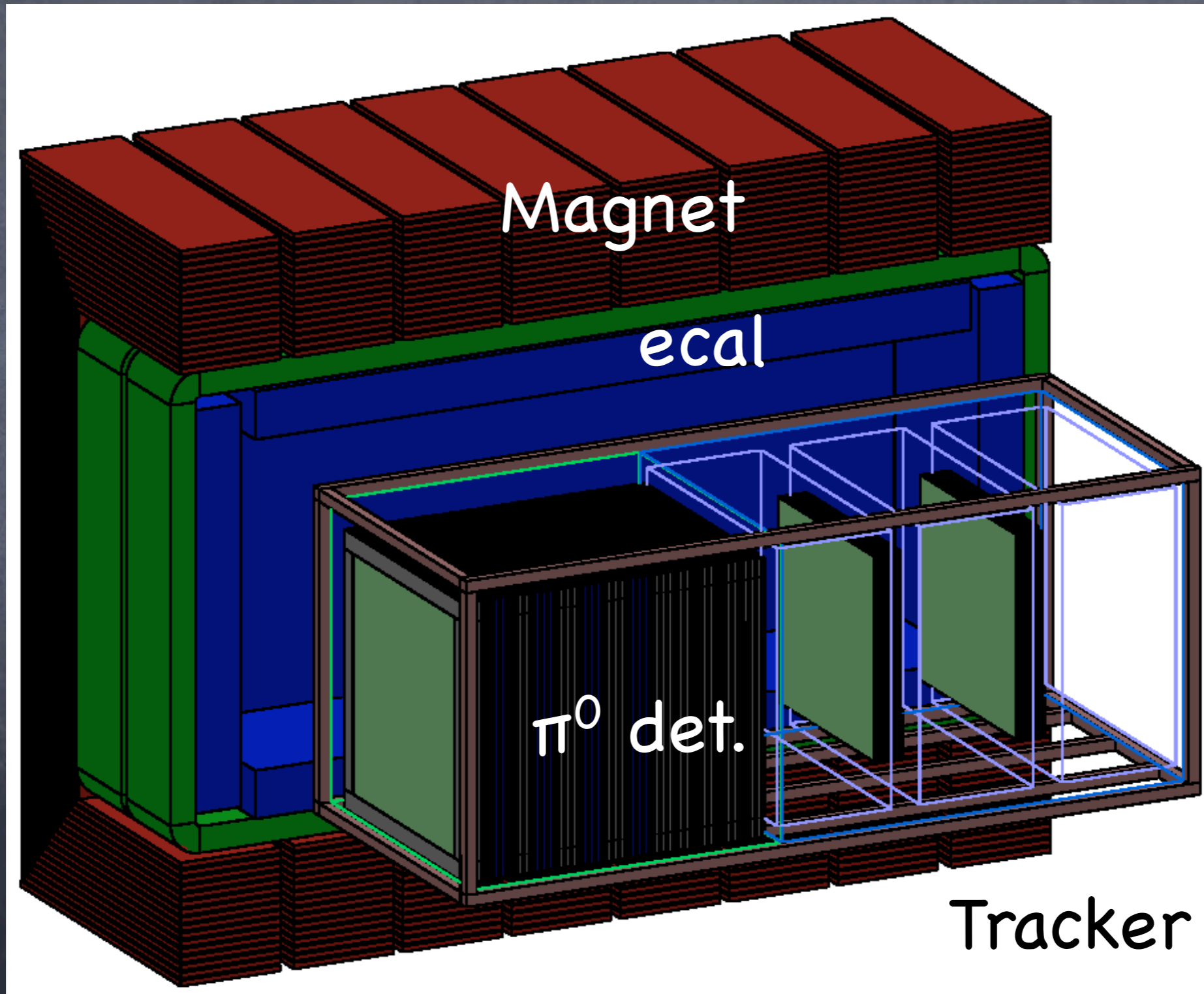


JPARC is a new high power 30 GeV proton accelerator complex (700 kW) in Japan for nuclear and particle physics research.

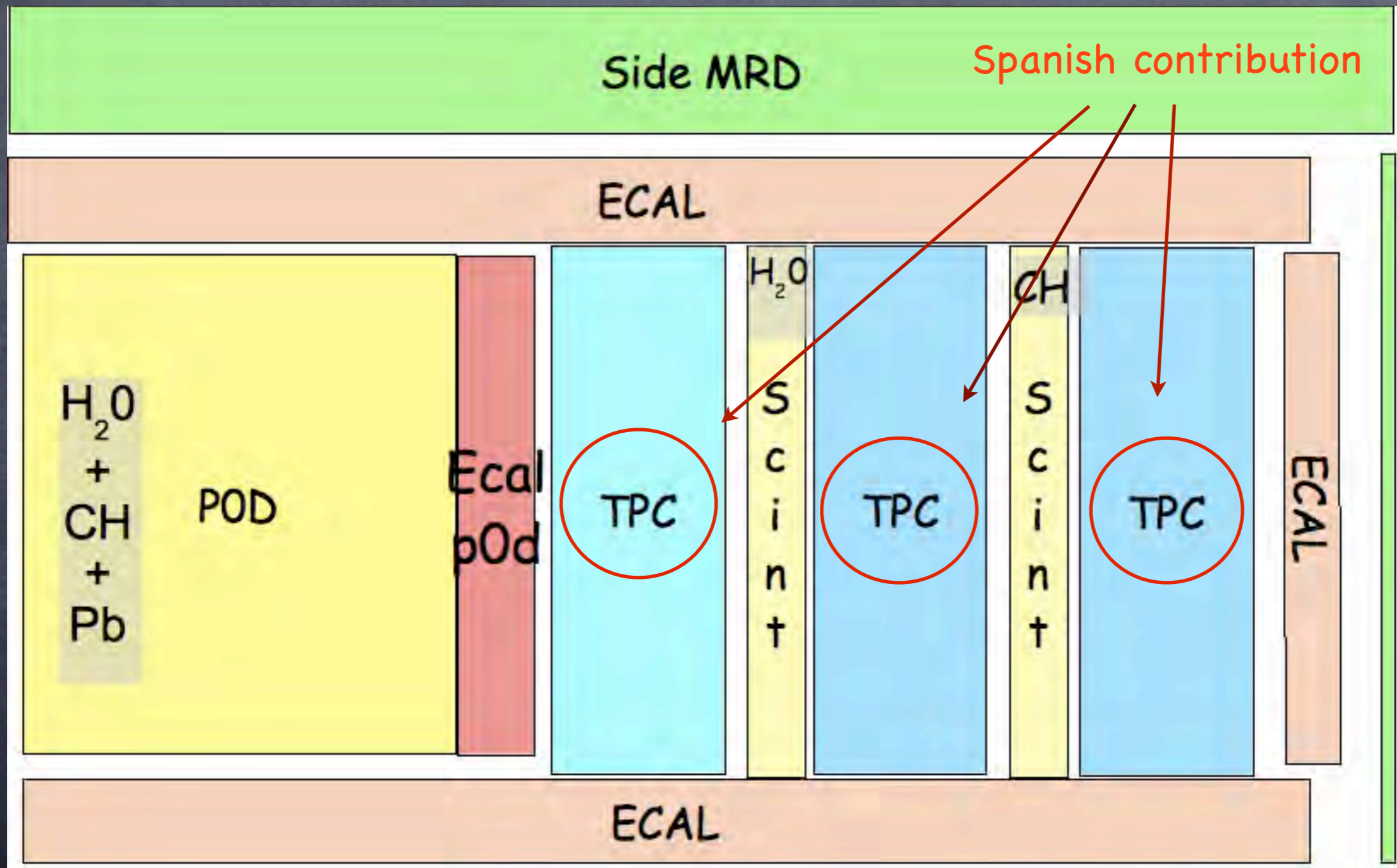
JPARC accelerator and neutrino beam line are under construction, first beam in April 2009.

IFIC & IFAE groups were members of K2K & SciBoone and has long tradition of neutrino-nucleus interaction studies @ 1Gev.

Near detector: ND280



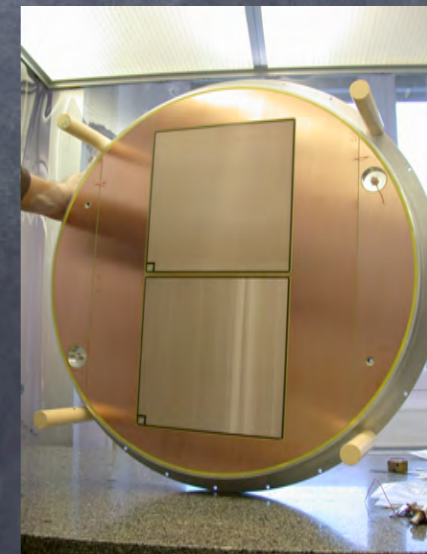
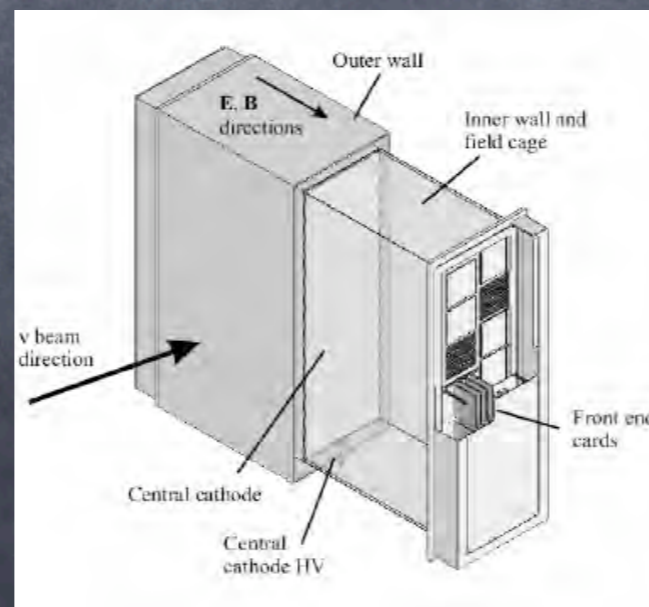
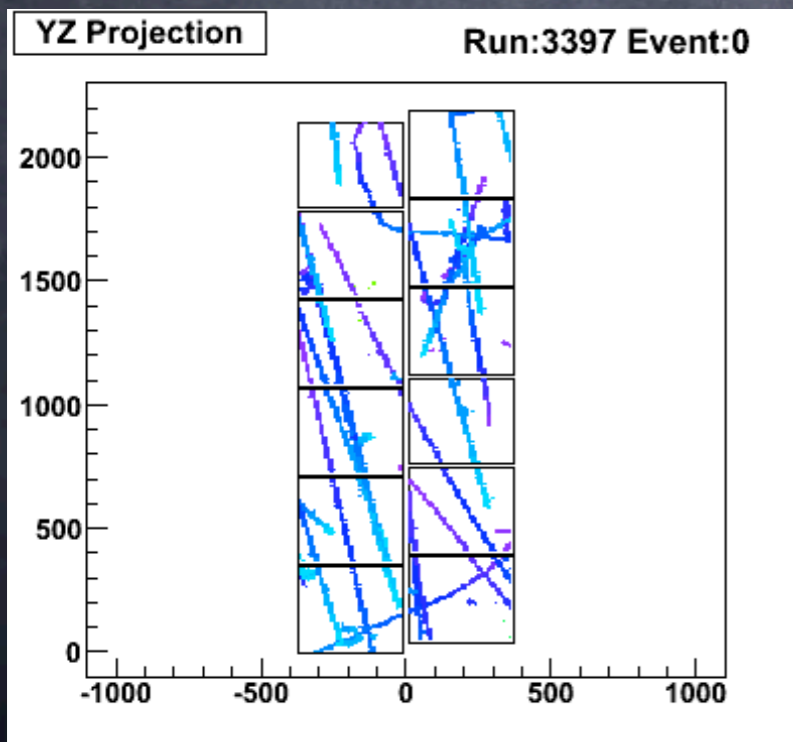
Near detector ND280



ND280 TPC

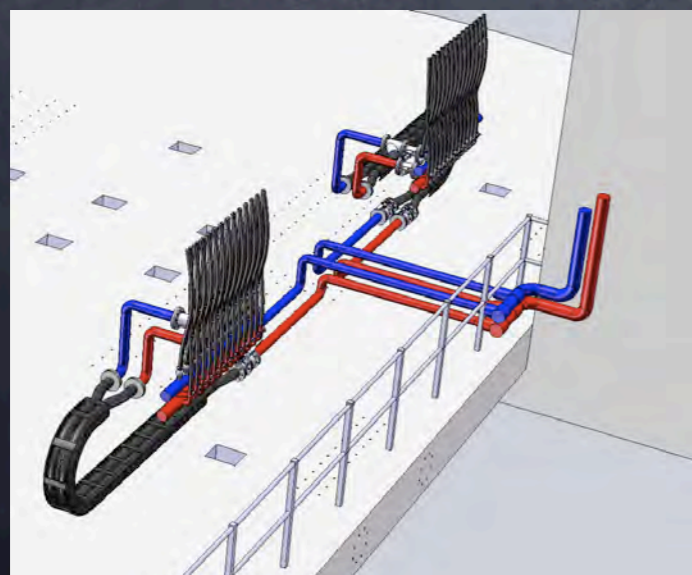


- TPC readout with MicroMegas.
- Spain contributes to:
 - MM production quality assessment.
 - DAQ.
 - Electronics of tests.
 - Reconstruction & Calibration software.



Close collaboration with Saclay & LPNHE

ND280 Magnet

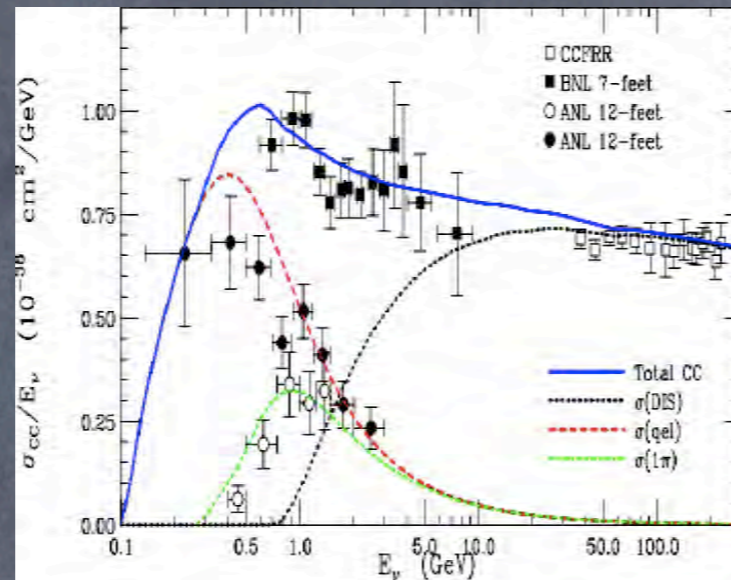


- Donated from CERN to T2K european groups.
- Old magnet from UA1 and NOMAD.
- IFAE contributes to the water cooling system:
 - slow control.
 - water manifolds.
 - refurbishing and shipment.
- The system will be installed in May 2009.

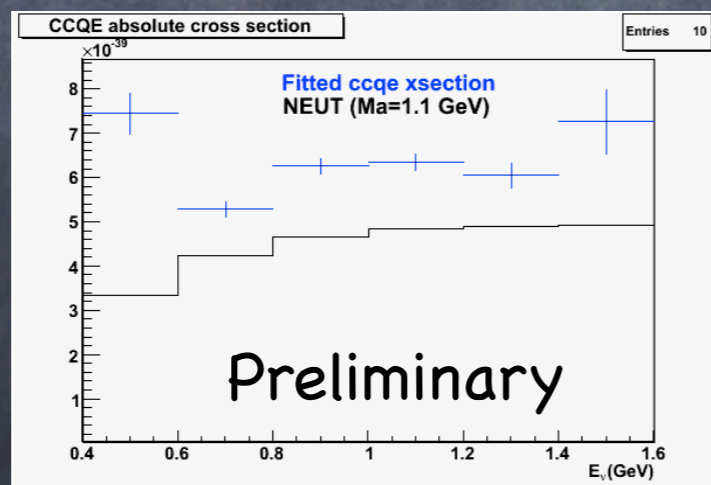
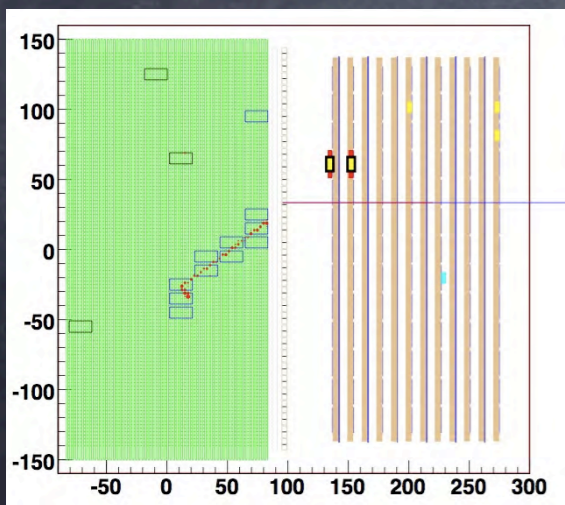
T2K

- Contribution to software & analysis:
 - reconstruction: TPC, Kalman filter, global reconstruction, etc...
 - Calibration framework & Online to Offline decoding.
 - Charged current analysis: CCQE, CC1 π , etc...
 - ν_{μ} disappearance studies.

Close collaboration with Saclay & LPNHE

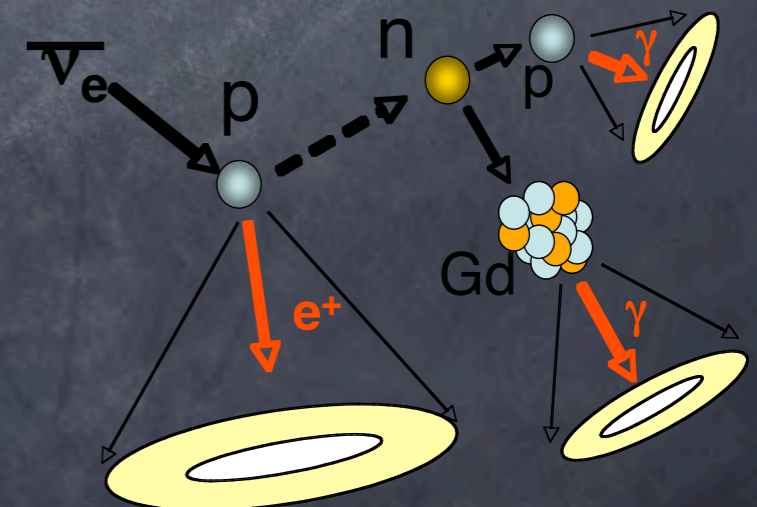
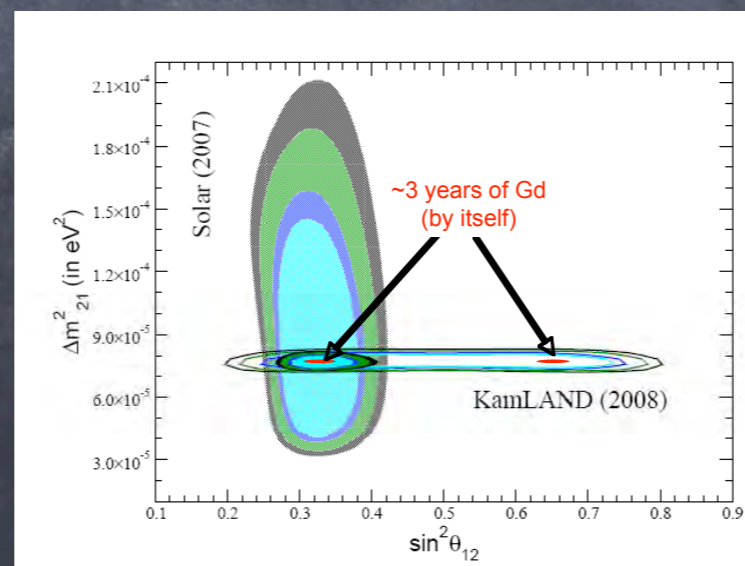
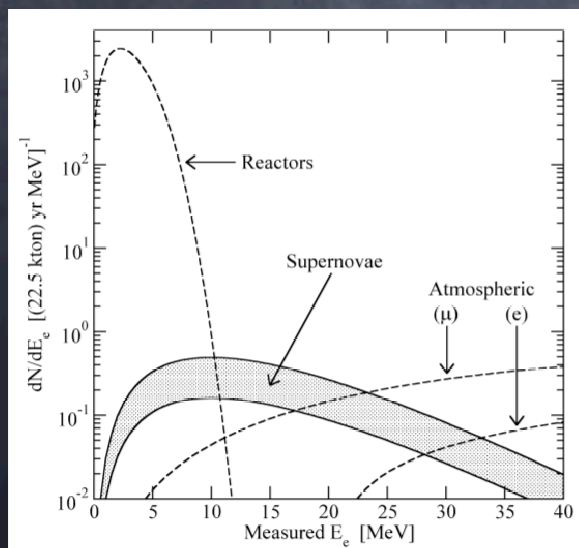


- The old SciBar detector from K2K was moved to the MiniBoone beam.
- IFAE/IFIC were member of the SciBar group and was invited to participate:
 - Software framework.
 - Reconstruction tools.
 - Analysis of neutrino interactions: CCQE & CC π^0
- Detector started in June 2007 and stopped taking data summer 2008.
- Useful physics studies for T2K neutrino interactions.



SuperKamiokande

- The group from U.A.Madrid has joined SuperKamiokande recently. It is not yet fully funded but it has good prospects.
- The main goal is to contribute to the Gd dopant for neutron tagging:
 - SN relic neutrinos, reactor neutrinos (a la Kamland).
- Main contribution: measure the thermal neutron background in the Canfranc underground facility.





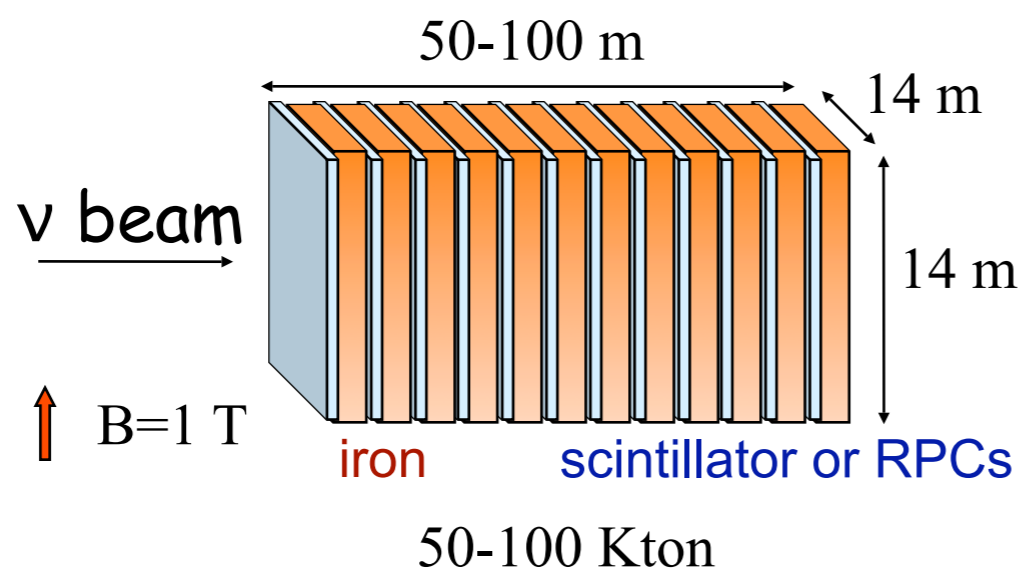
Neutrino Factory



- The long tradition of theoretical and phenomenological studies is continued in the optimization of the MIND detector.
- The main goal is the optimization of detector and algorithm to improve efficiencies at low energies ($\sim 5\text{GeV}$)

The golden detector: MIND

3



- based in known technology: MINOS
- easy to magnetise
- Ideal to identify muons and measure their charge

the energy threshold is high

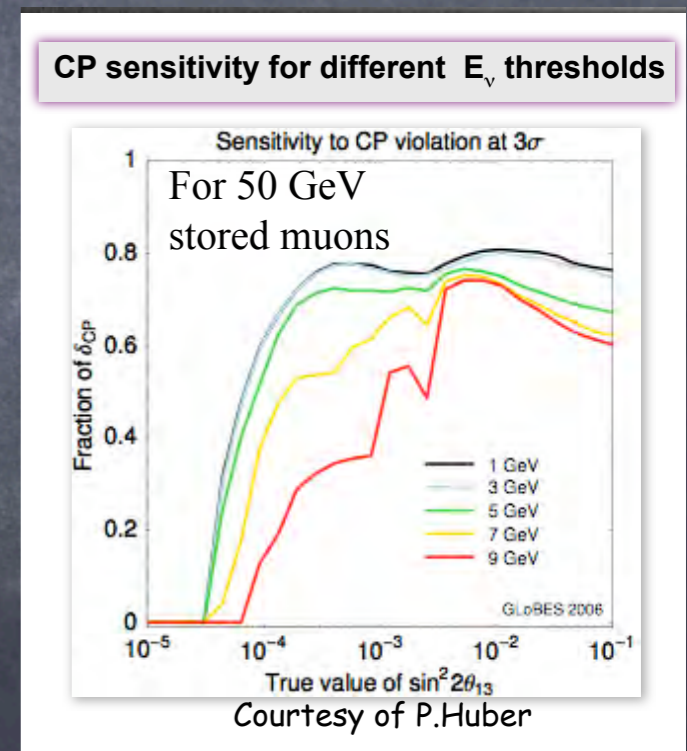
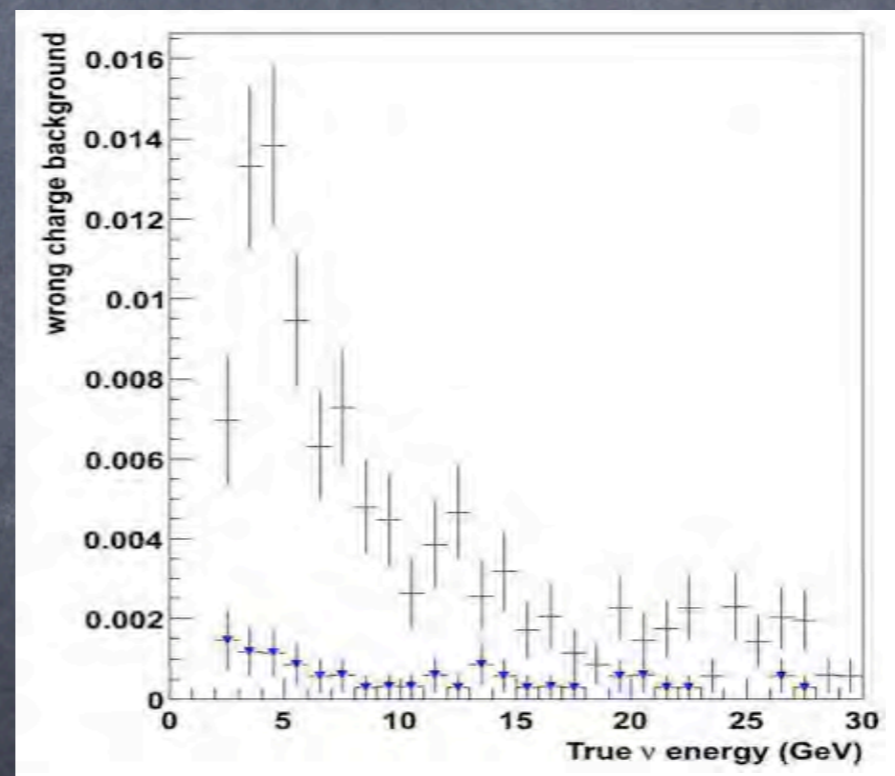
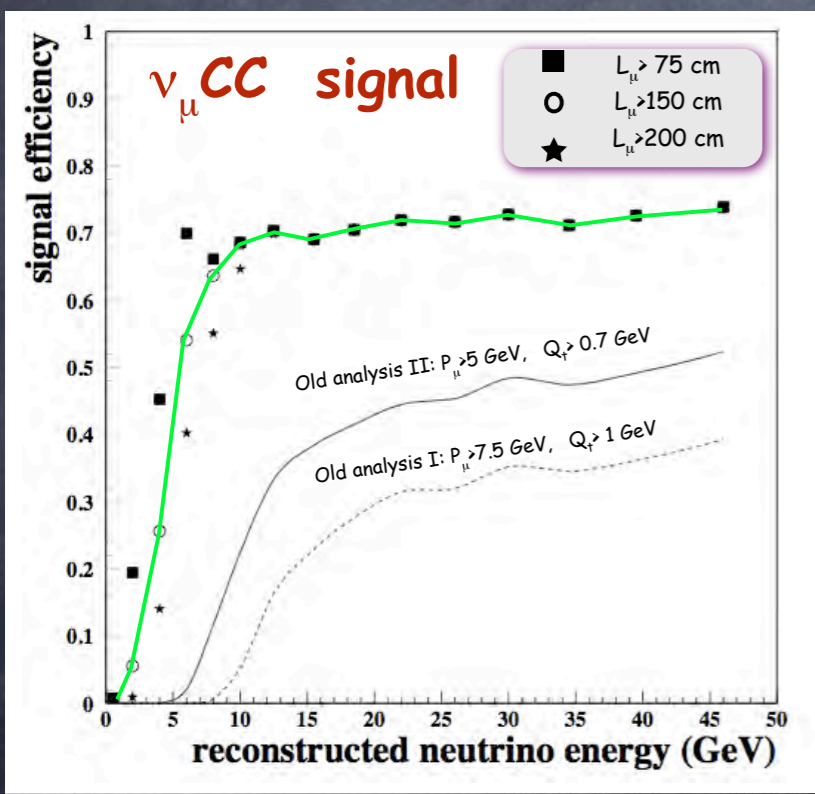
cannot detect electrons or taus



Neutrino Factory



- Sensitivity saturates for $E_\nu > 3$ GeV.
- The detector should be optimized to match this requirement keeping good wrong charge assignment.



$2\beta 0\nu$ Experiments

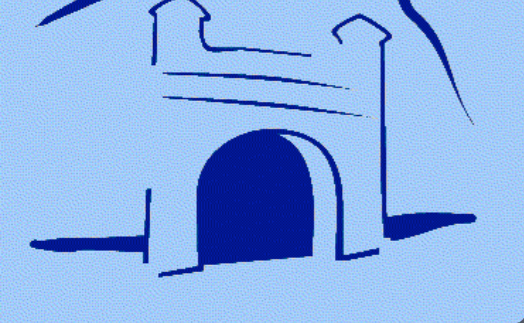
$2\beta 0\nu$ Experiments

- Long tradition of $2\beta 0\nu$ at the Univ. of Zaragoza that was operating with strong international collaboration a Ge detector (IGEX) from 1988 @ Canfranc Laboratory.
- The Canfranc laboratory was upgraded recently to a larger facility and a new institution "Laboratorio Subterraneo de Canfranc" (LSC) was formed.
- The new LSC triggered new activities in this field in Spain related to neutrino physics:
 - BIPO
 - NEXT
 - Exploring the future of Ge detectors for $2\beta 0\nu$.

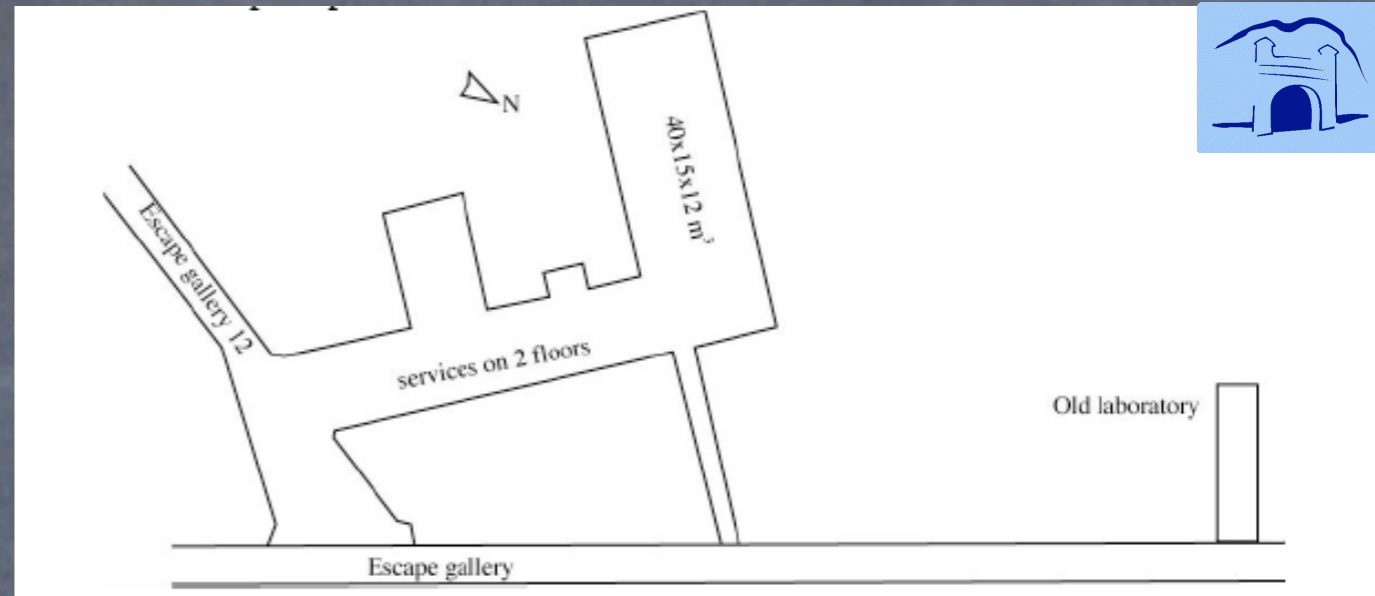


Laboratorio Nacional de Canfranc main Hall





Laboratorio Nacional de Canfranc



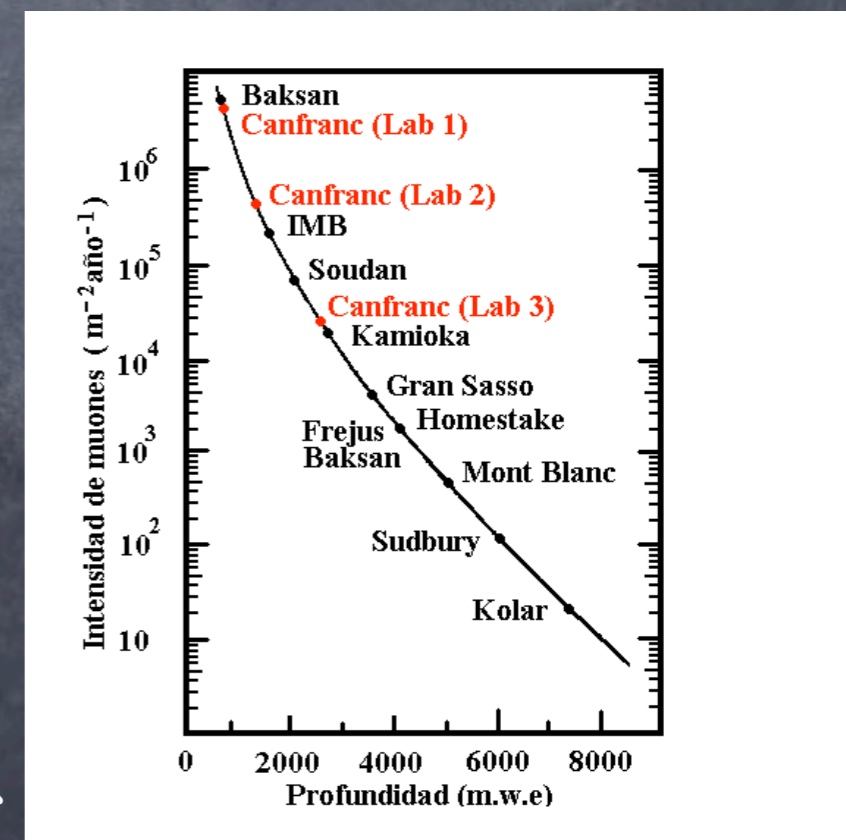
Profiting from a new road between Spain and France.



Service building



Under the "Tobazo" peak

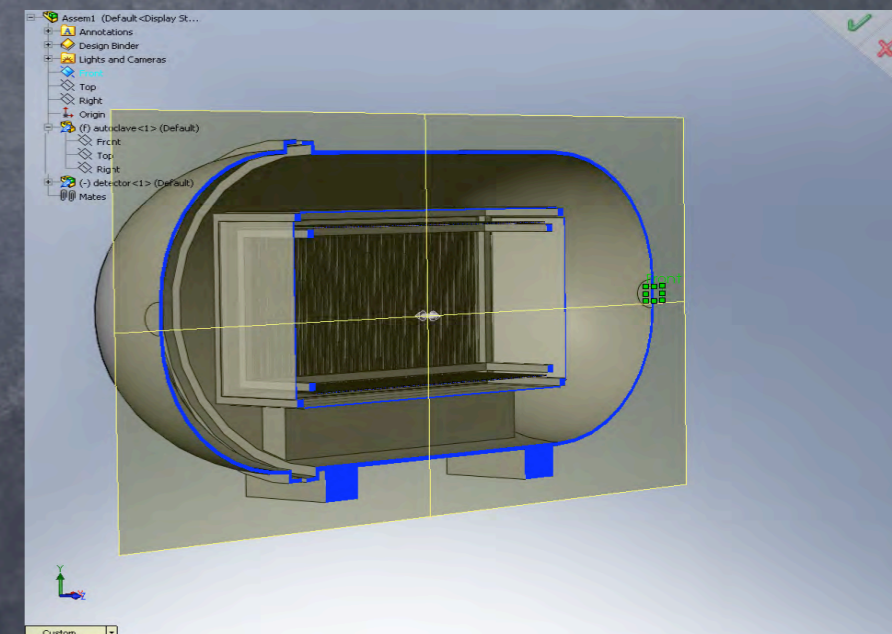
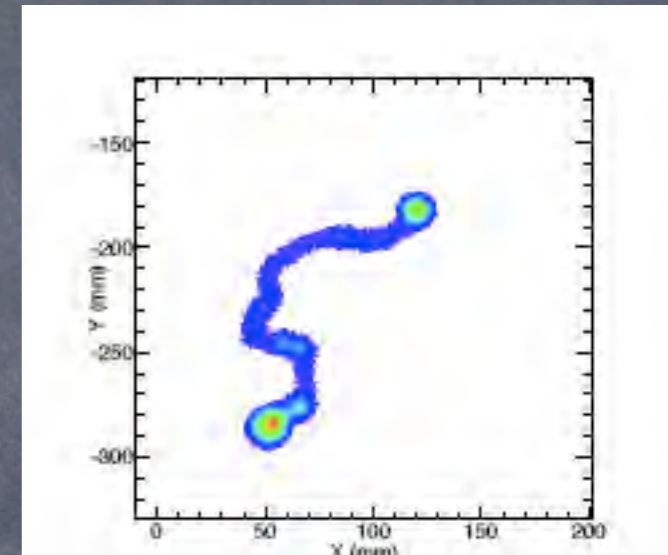




NEXT



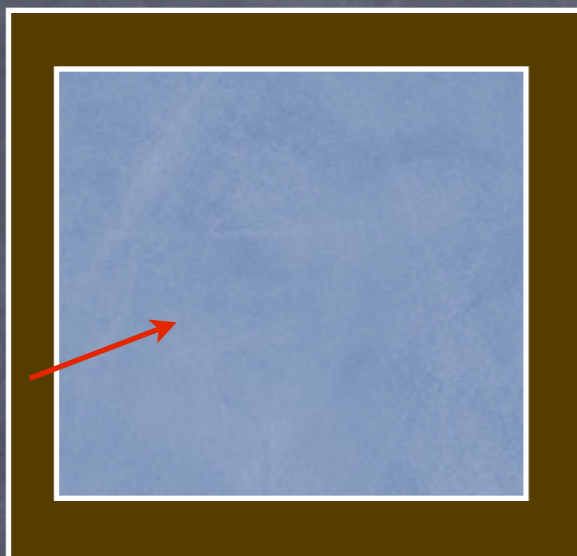
- Neutrino Xenon TPC (NEXT) is a new enriched Xenon gas TPC proposal for $2\beta 0\nu$ searches.
- High pressure for compactness and containment.
- Gas for extended topologies & background rejection.
- Measurement of prompt light for T_0 .
- Energy resolution at $^{136}\text{Xe} Q_{\beta\beta} < 1\%$ FWHM.
- Electron readout via electroluminescence.
- ~100 kg in a first phase.



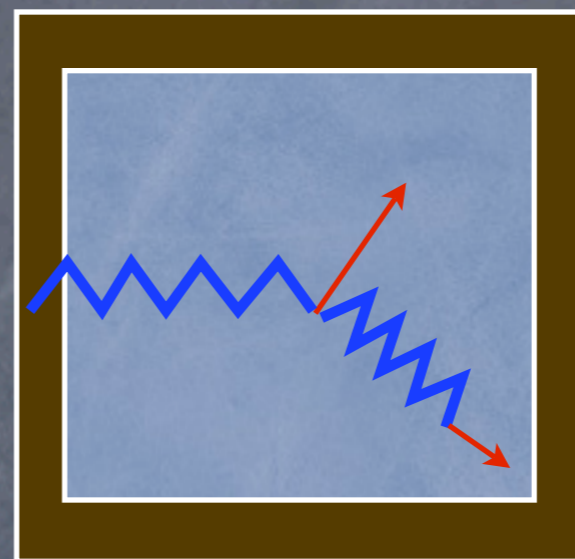


NEXT bkg

1)



External charged

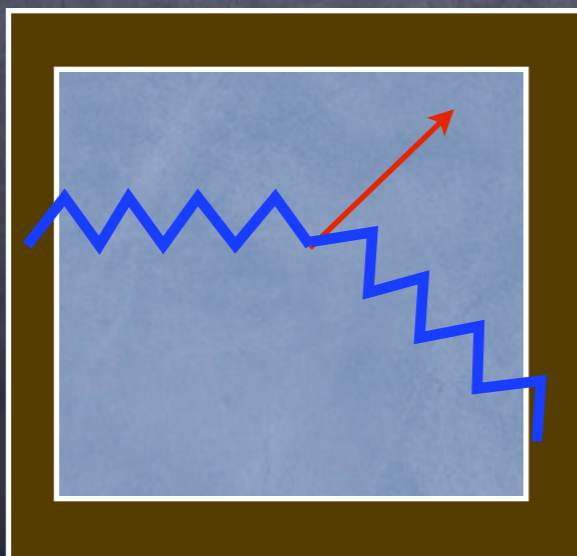


Double Compton internal

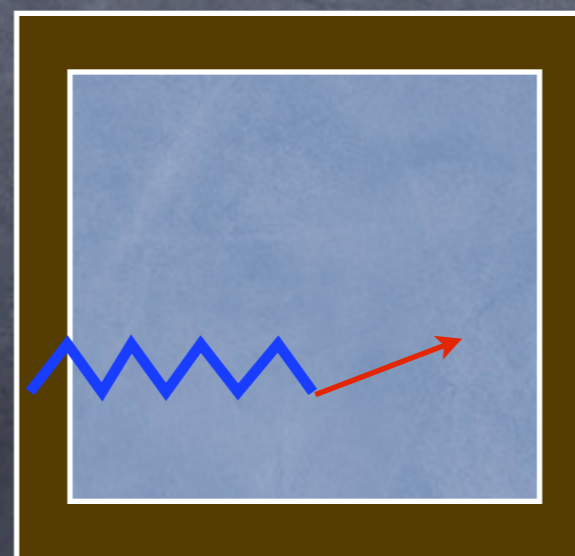
Handles

Event
topology

2)



Compton internal



Photoelectric internal

Event
energy &
topology



NEXT

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IFIC
INSTITUT DE FÍSICA
CORPUSCULAR



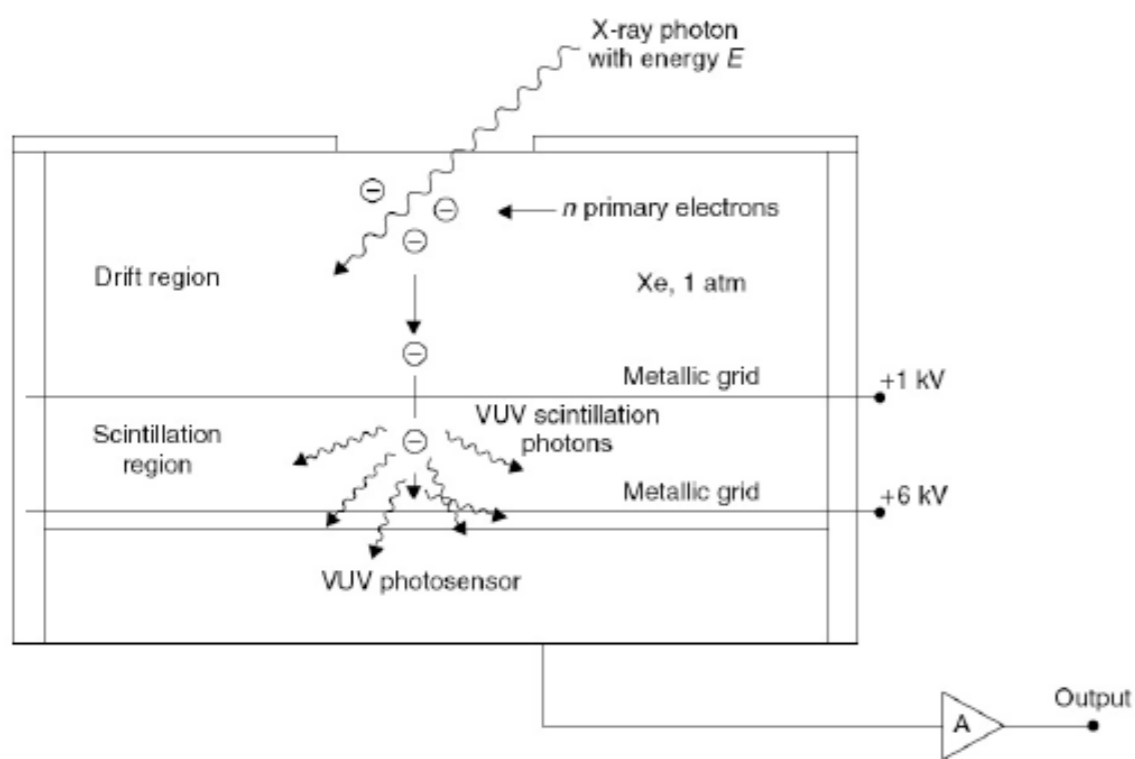
Universidad
de Zaragoza
<http://www.unizar.es>



Electroluminescence is a process to produce scintillating light when a charged particle cross a material at certain velocity.

It is proportional scintillating light emission:

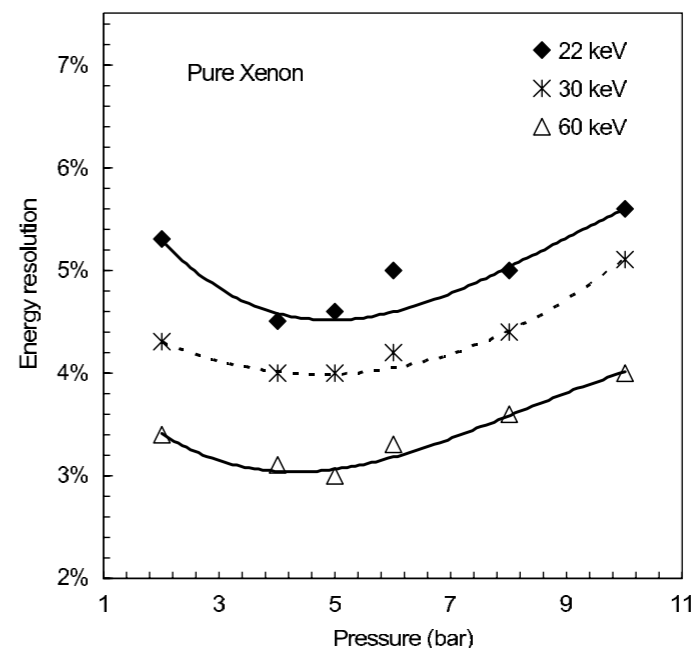
- ☑ Linear process: $N_Y = \alpha N_e$
- ☑ Abundant light produced: $\sim 1000\gamma/e^-/cm.$
- ☑ Small sensitivity to high pressure.
- ☐ The light is in the deep ultraviolet ($\sim 180nm$)
- ☐ Need to apply large voltages (V)



FWHM 3% @ 60 KeV

0.4% @ 2.5 MeV!!!

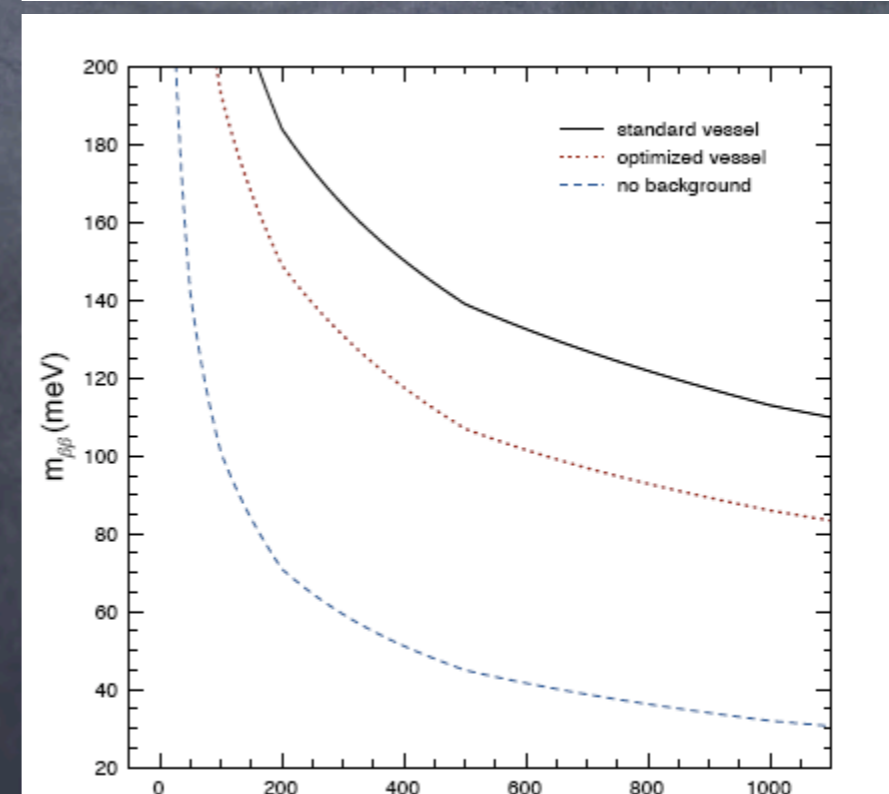
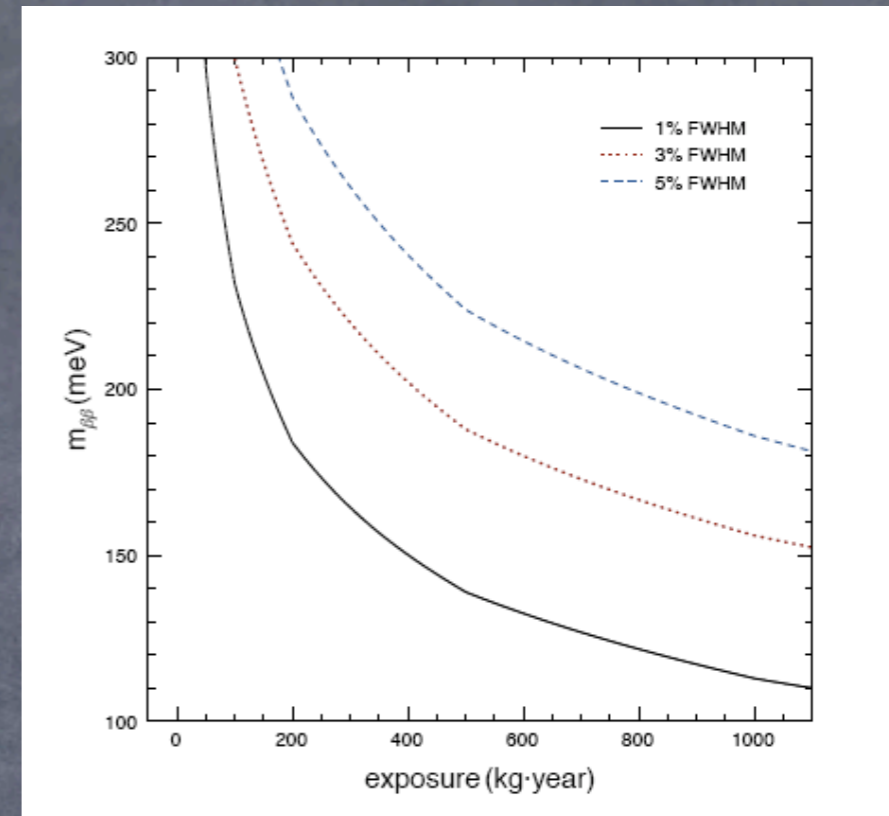
L.C.C. Coelho et al. NIM A 575 (2007) 444-448





NEXT

- Realistic MC simulation.
- Full (conservative) background included.
- Dominated by vessel background.
- Expected sensitivity of < 150 meV in 5 years.





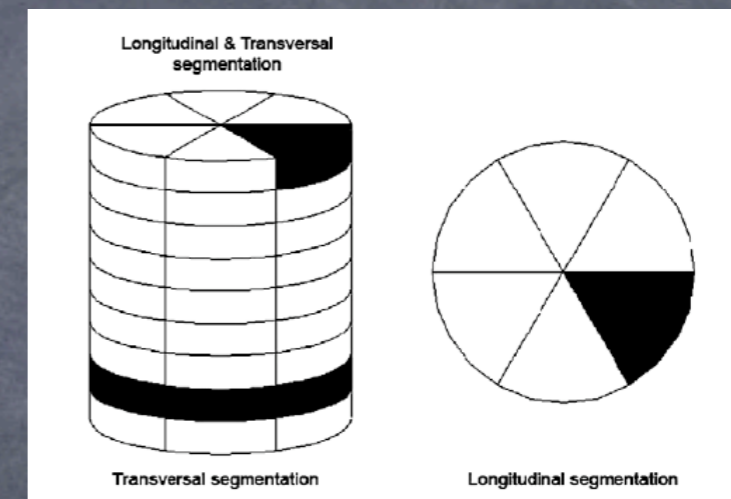
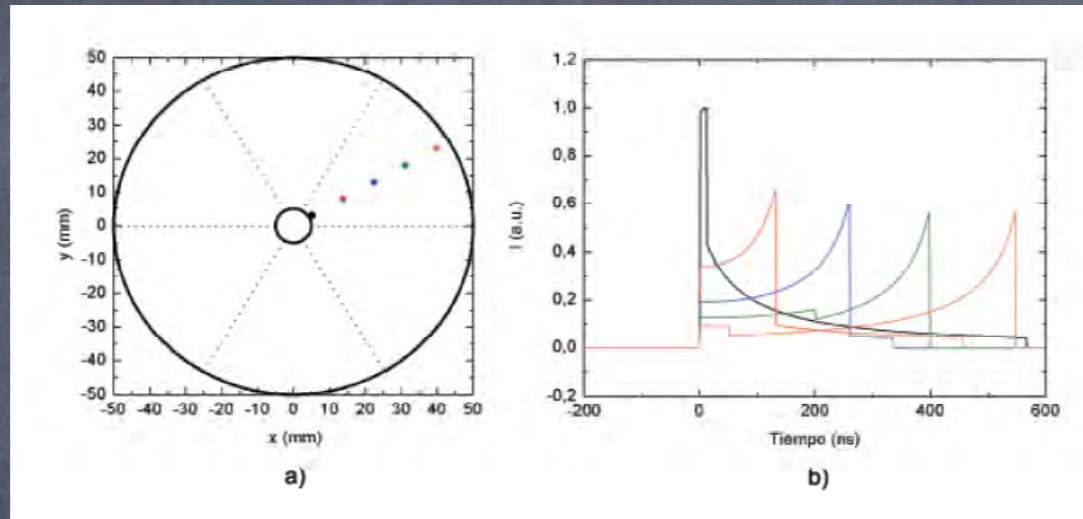
NEXT



- The project has funding of 5+1 million euros in 5 years for the construction of a 100kg device in Canfranc. Funding is independent of standard funding from Ministry of Science.
- Almost all experimental neutrino groups in Spain are involved in this effort.
- Several institutions from Italy, Portugal and USA have joined the project.
- The Canfranc scientific committee has approved NEXT project based on an early EoI submitted in April 2008 depending on the correct development of the project.
- Recently the collaboration has presented a Letter of Intent to the scientific panel of Canfranc that is being evaluated.

$2\beta 0\nu$ with Ge

- Following the long tradition of Zaragoza Univ. and Canfranc on Ge detectors (IGEX). The group is involved in the development of novel techniques for future $2\beta 0\nu$ Ge experiments. Goal \rightarrow 40 meV.
- Studies of background rejection based on anticoincidence and pulse analysis.



	MT (kg year)	b (c $\text{keV}^{-1} \text{kg}^{-1} \text{year}^{-1}$)	ϵ (%)	F_D (10^{26} year)	$\langle m_\nu \rangle$ (meV)
No rejection	100	0.022	93.8	1.6	149
6×11 segmentation	100	0.0019	80.3	4.7	88
PSA (3 mm resolution)	100	0.0011	85.4	6.5	74
No rejection	1000	0.022	93.8	5.1	84
6×11 segmentation	1000	0.0019	80.3	15	49
PSA (3 mm resolution)	1000	0.0011	85.4	21	42

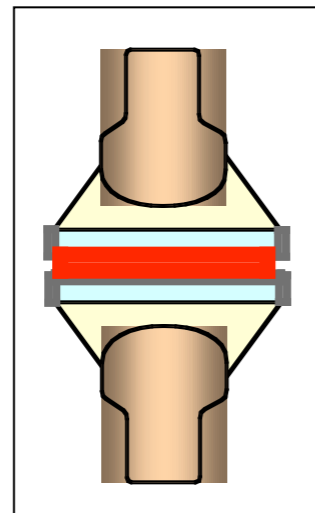
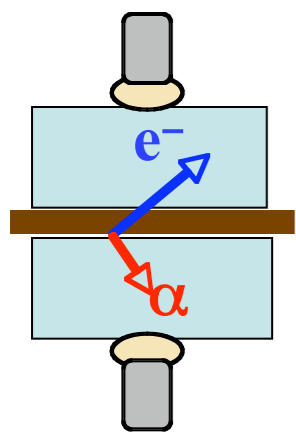
BiPo

Related to activities in SuperNemo

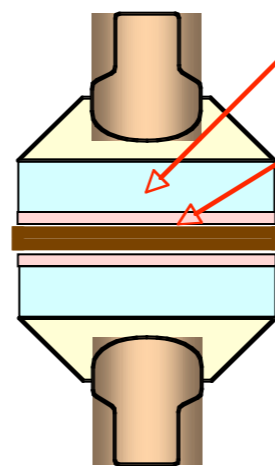
The BiPo detector has been designed to measure the radio-purity in ^{208}Tl and ^{214}Bi of the double beta sources of SuperNEMO detector with a required sensitivity of

$^{214}\text{Bi} < 10 \mu\text{Bq/kg}$ $^{208}\text{Tl} < 2 \mu\text{Bq/kg}$ For a time exposure of : **1 month/ 5 kg**

It is also a general facility for the measurement of ultra-low activity in ^{208}Tl and ^{214}Bi of the surface of other materials in use in underground experiments.

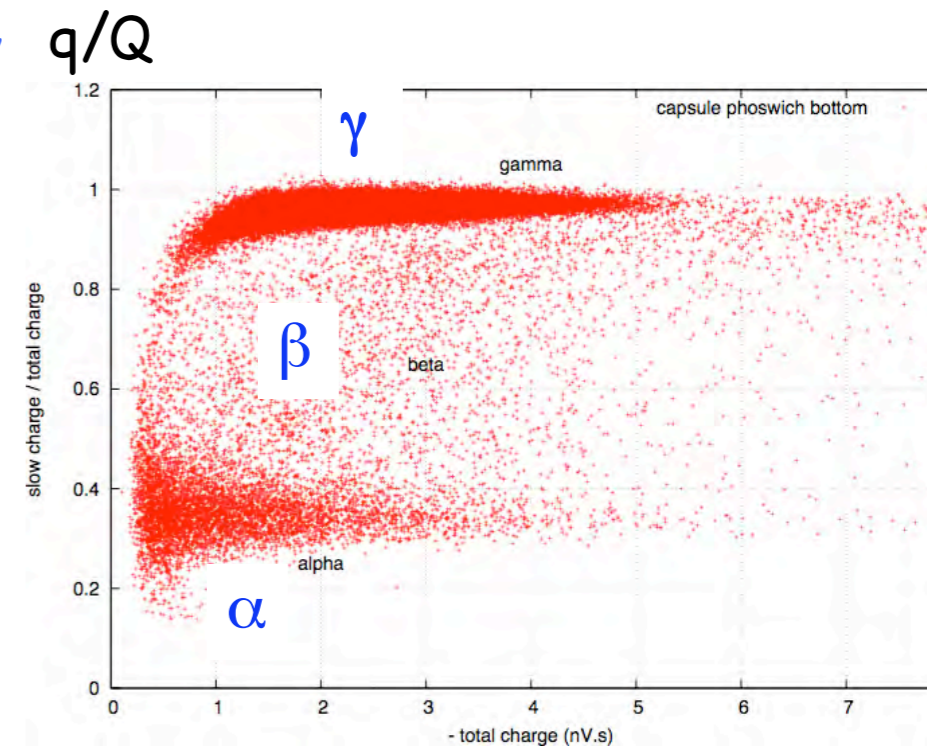


NEMO3 scintillators :
Polystyrene- based
Aluminized front-face



Phoswich scintillators :
Fast-slow assembly. PVT based
(BC400-BC444 Saint-Gobain)
Aluminized front-face

Slow $\rightarrow \beta, \gamma$
Fast $\rightarrow \alpha$

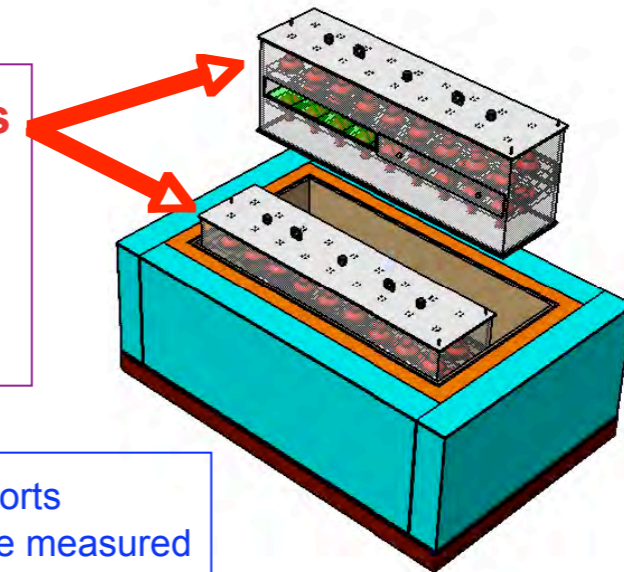


BiPo

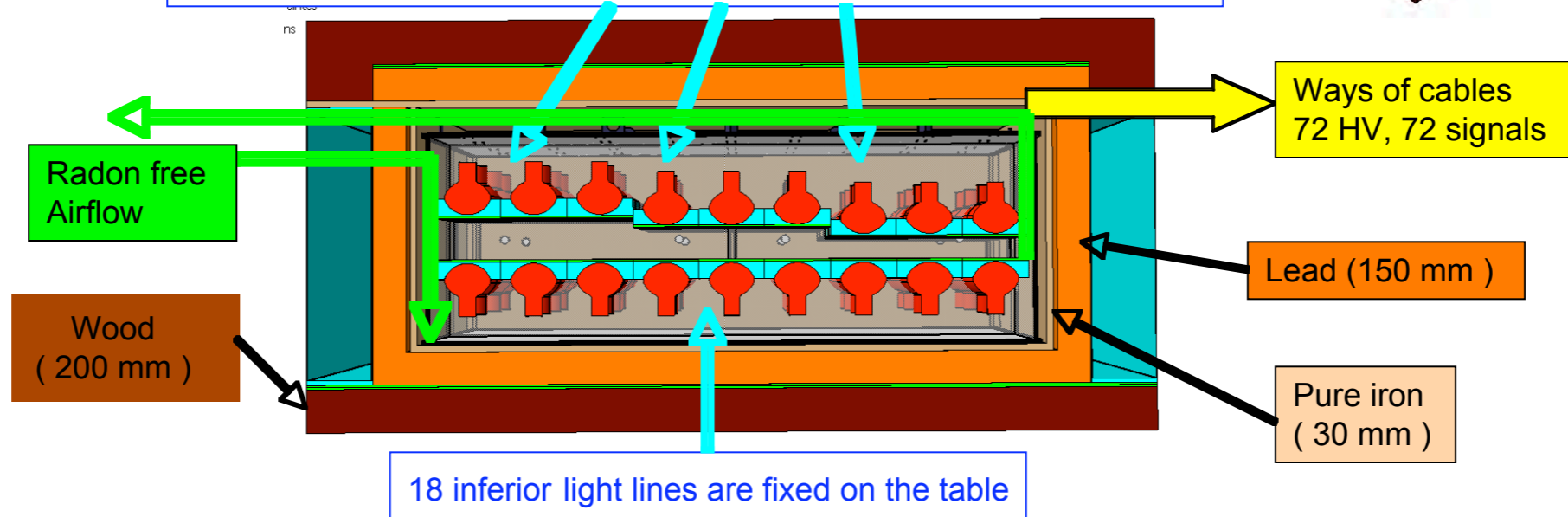
2 modules composed of 2 rows of 9 scintillator pairs (face-to-face, $30 \times 30 \text{ cm}^2$) coupled to 5" PMTs.

Total number of PMT channels : 72

Surface of measurement : $0.3 \times 0.3 \times (18 \times 2) = 3.24 \text{ m}^2$

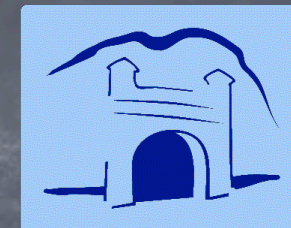


3 x 6 superior light lines are fixed on 3 moving supports
Maximum opening up is 200 mm for loading the source to be measured

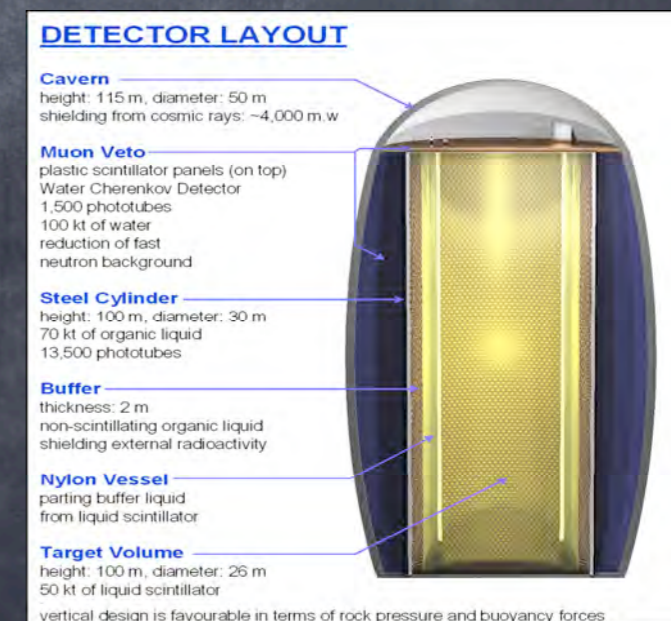
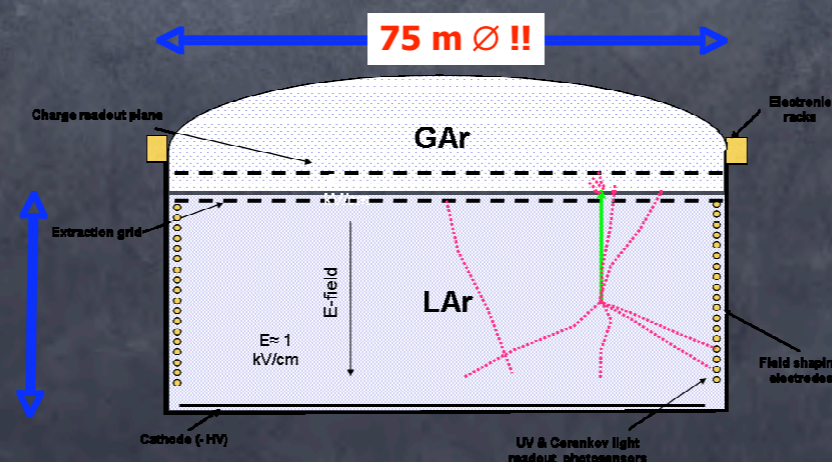
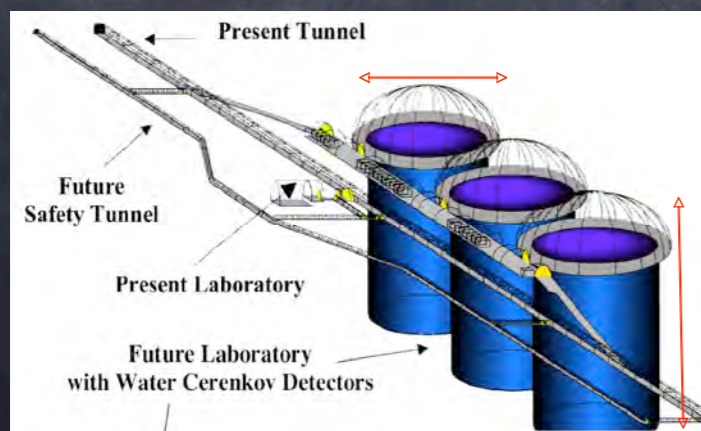


First Bipo will be installed in Canfranc in 2011

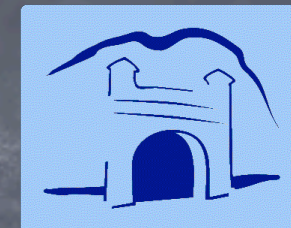
Laguna & Canfranc



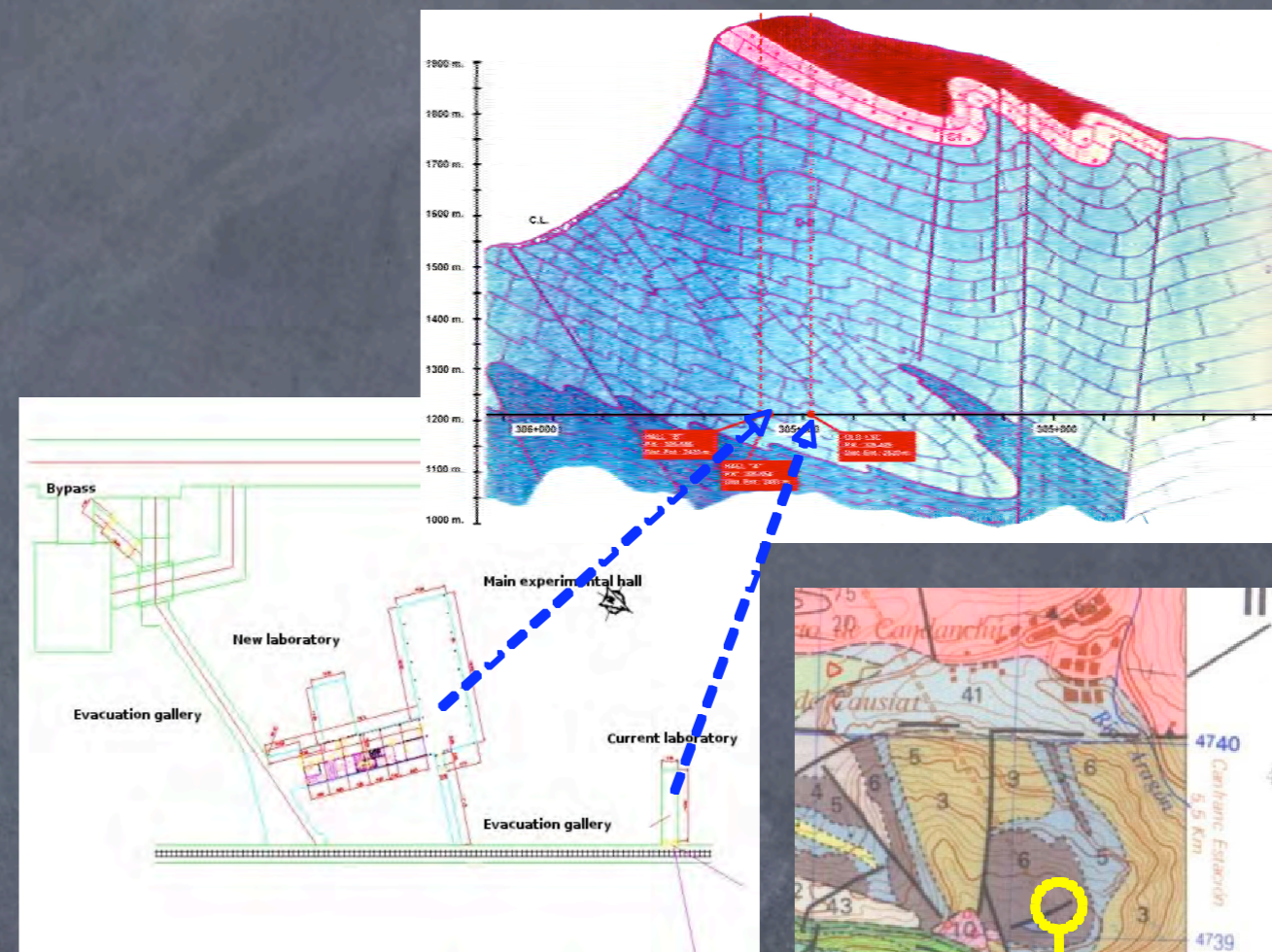
- Laguna is a common european initiative for the next liquid p-decay & neutrino detector.
- Seven location candidates.
- 3 detector technologies:
 - water cherenkov
 - Ar Liq.
 - Liquid Scintillator.



Laguna & Canfranc



- Feasibility study started.
- Main design companies contracted (Iberinsa, STMR)
 - supported by ITASCA Spain, OSSA, small consulting.
- Feasibility + cost document expected by December 2009



Some work done by the team 1/3

LAGUNA Canfranc feasibility study

Aldeadavila (Spain)

31/03/2009 LAGUNA Canfranc 15

Some work done by the team 2/3

LAGUNA Canfranc feasibility study

Ralco (Chile)

31/03/2009 LAGUNA Canfranc

Some work done by the team 3/3

LAGUNA Canfranc feasibility study

Artist conceptual image of the Tindaya Cavern. Fuerteventura (Canary Islands) Chillida design

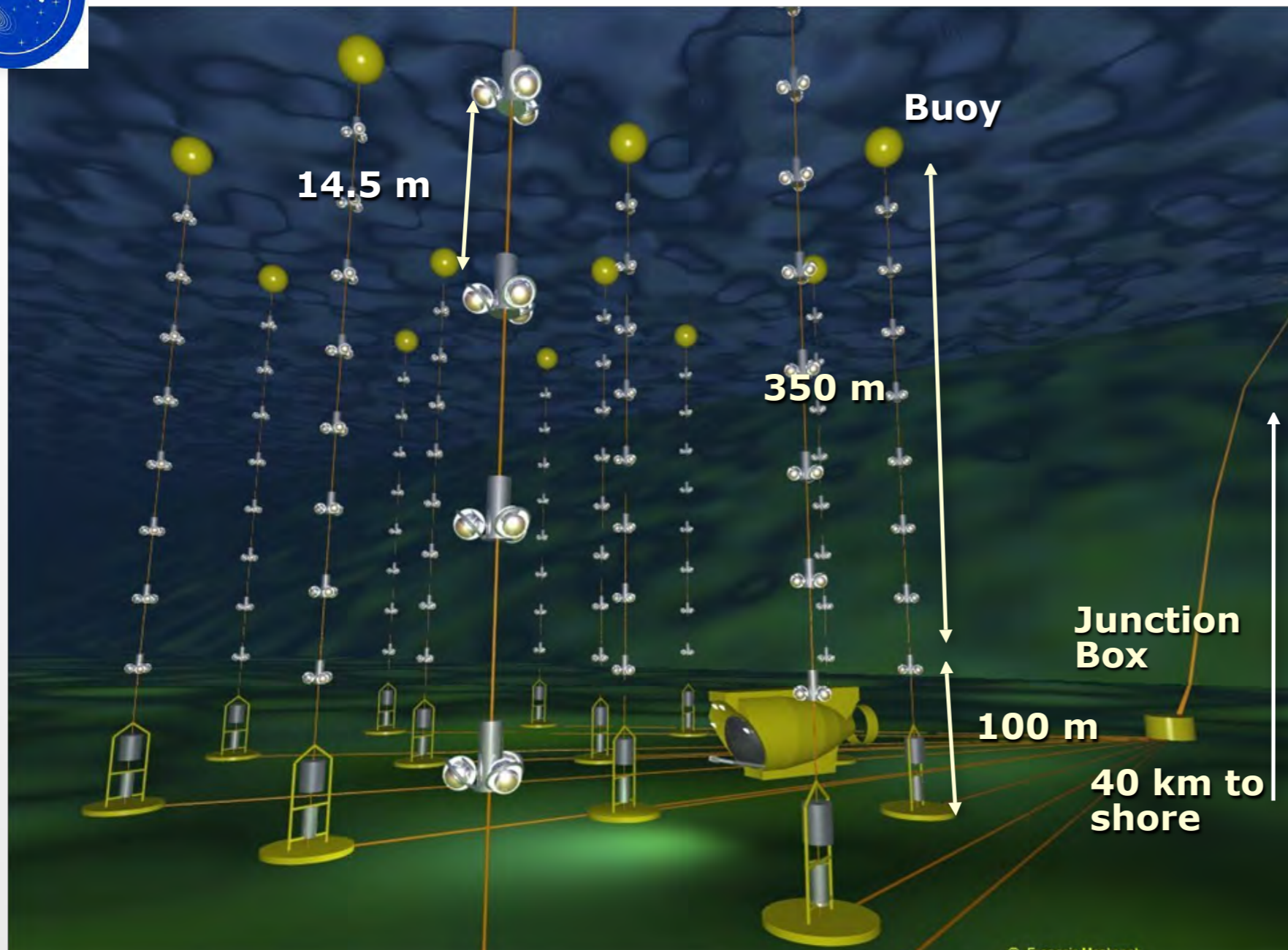
Scale is given by man.

31/03/2009 LAGUNA Canfranc 17

possible place for LAGUNA

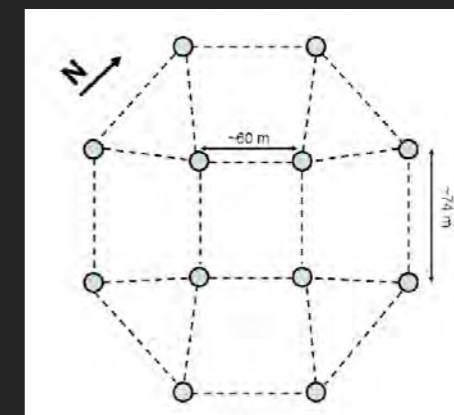
Neutrino astrophysics

The Antares Telescope



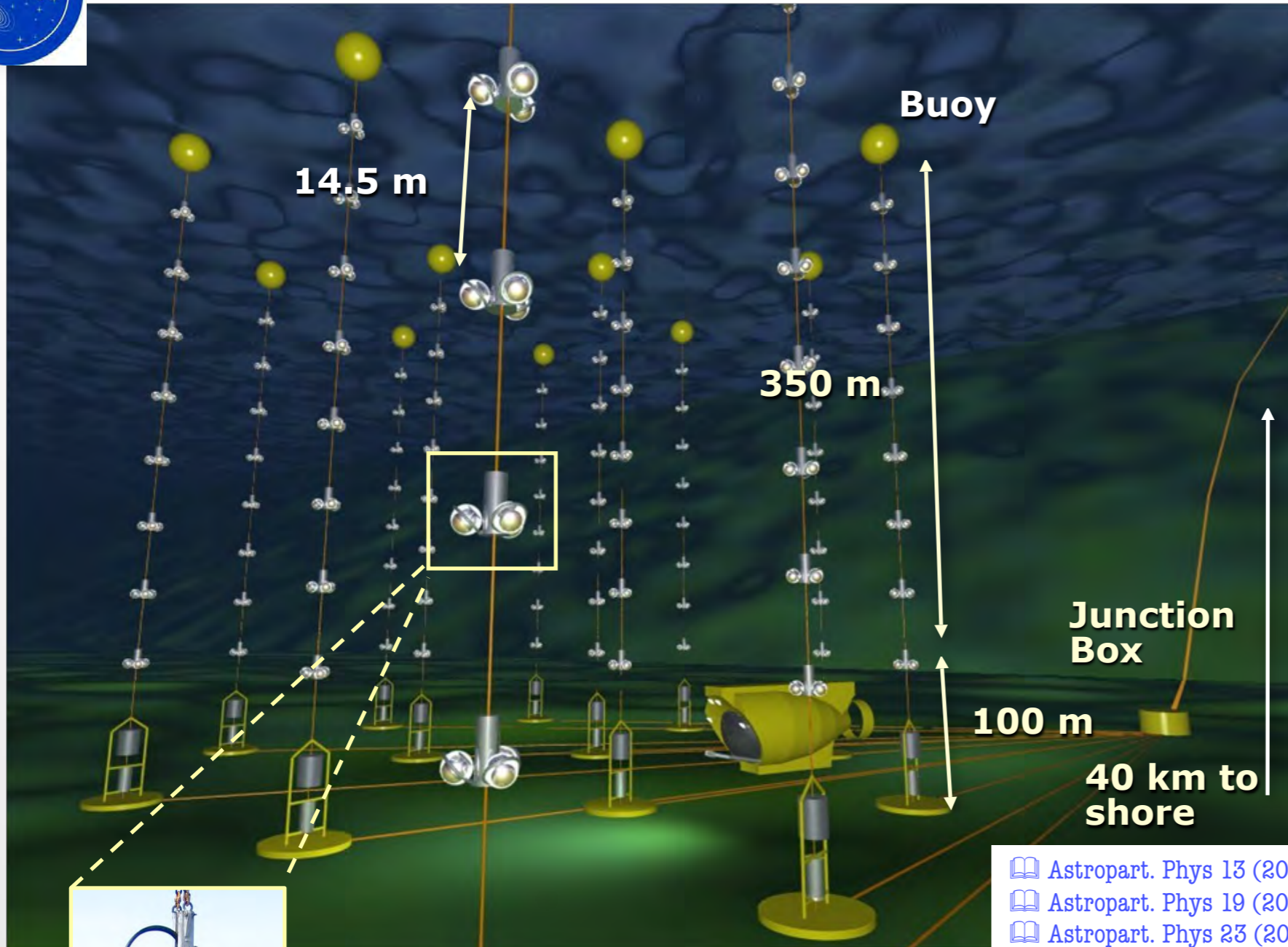
- 12 lines (900 PMTs)
- 25 storeys / line
- 3 PMTs / storey

Horizontal layout



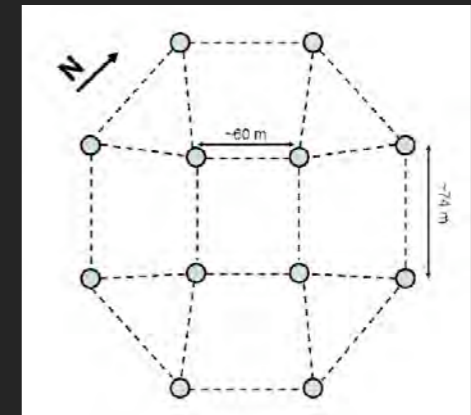


The Antares Telescope



- 12 lines (900 PMTs)
- 25 storeys / line
- 3 PMTs / storey

Horizontal layout



- 📖 Astropart. Phys 13 (2000) 127-136 (Background light)
- 📖 Astropart. Phys 19 (2003) 253-267 (Sedimentation & Fouling)
- 📖 Astropart. Phys 23 (2005) 131-155 (Light transmission)

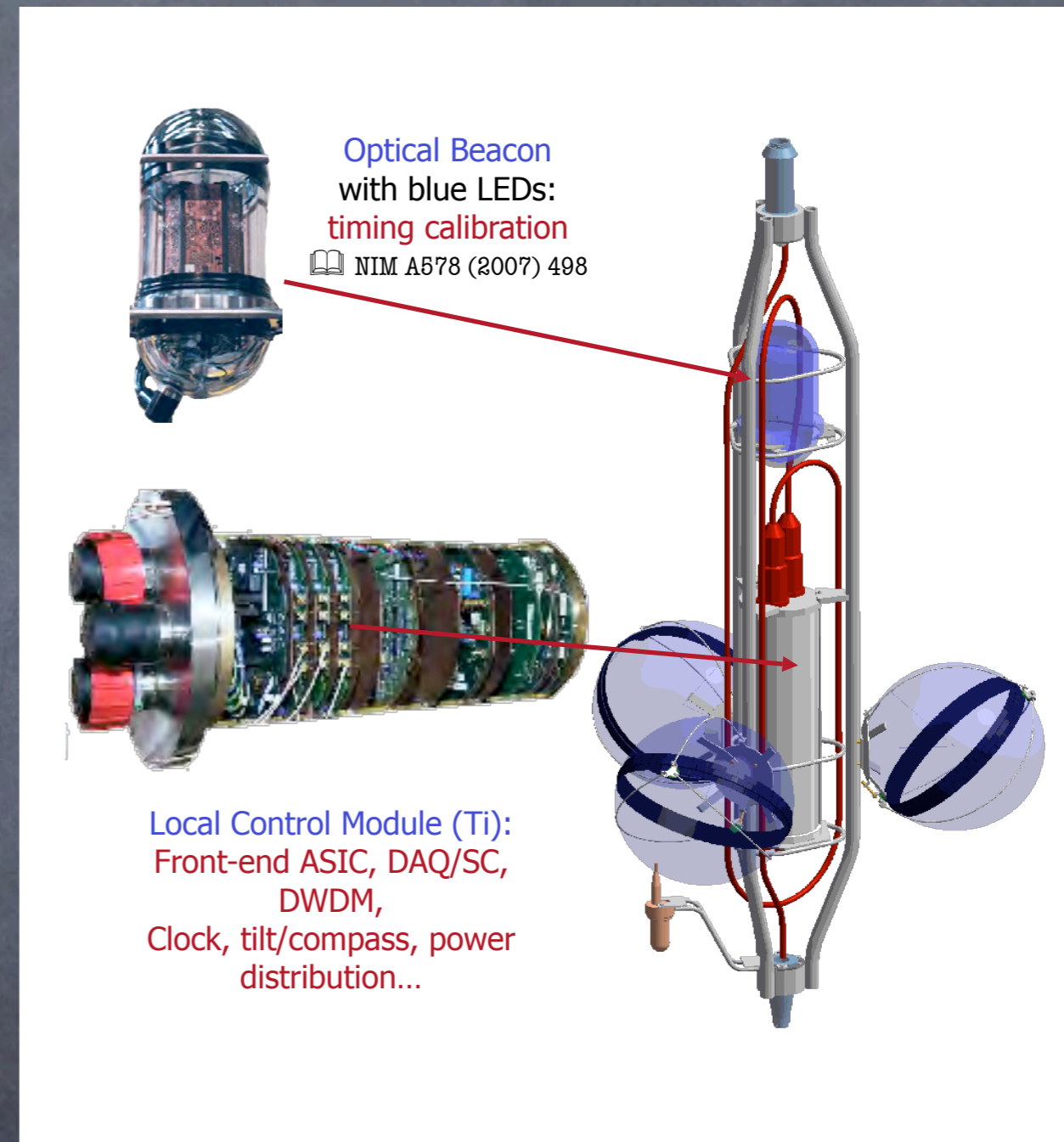
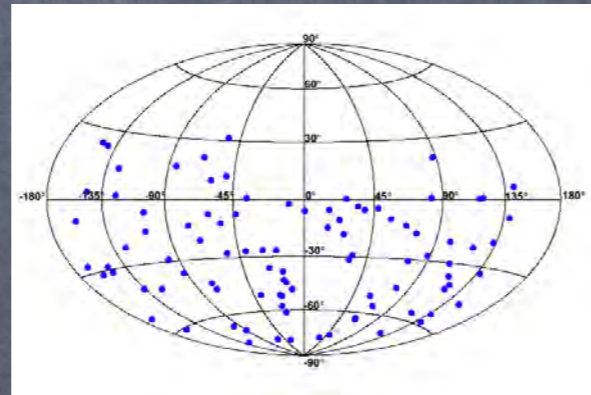


The detector is located in the Mediterranean Sea ($42^{\circ}50'N$, $6^{\circ}10'E$) at **2500 m** depth, in the south coast of Toulon (France).



Antares

- The Spanish groups were in charge of the time calibration and the sensor location location using tiltmeters and compasses.
- The Spanish groups are at the moment the leading group searching point-like sources.

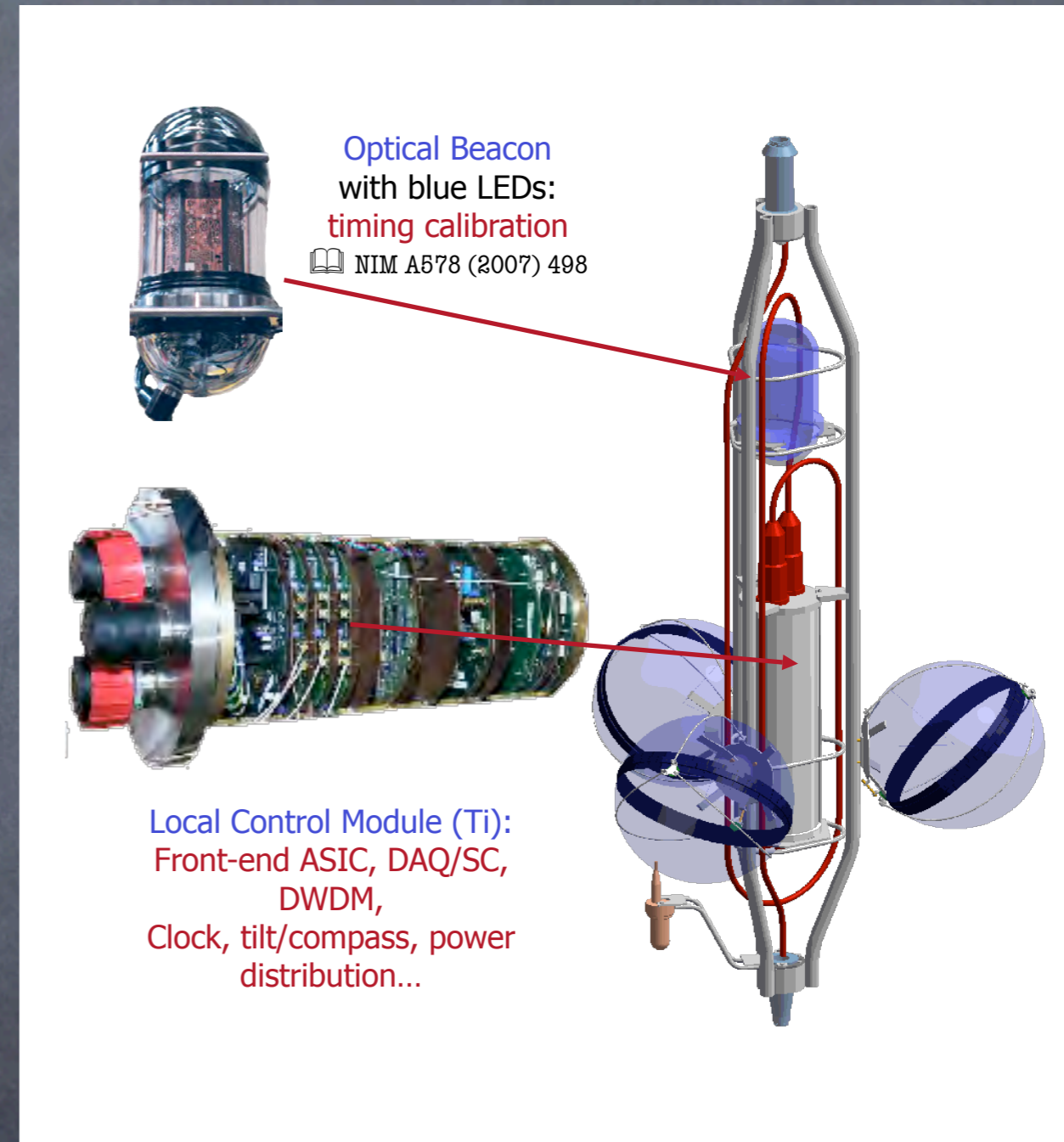
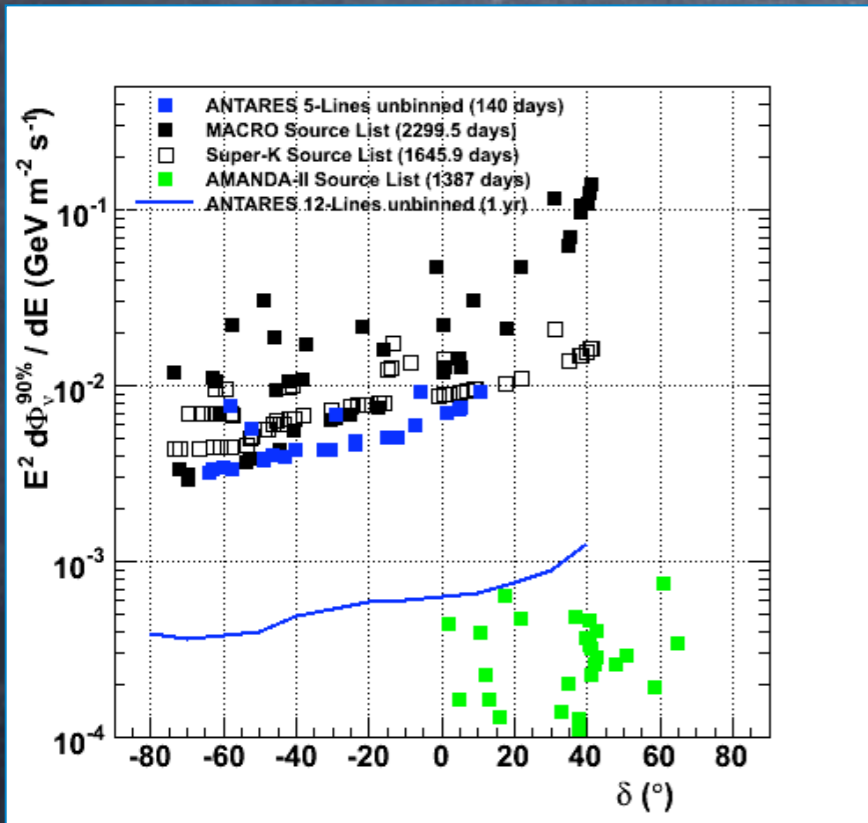




Antares



- The Spanish groups were in charge of the time calibration and the sensor location using tiltmeters and compasses.
- The Spanish groups are at the moment the leading group searching point-like sources.

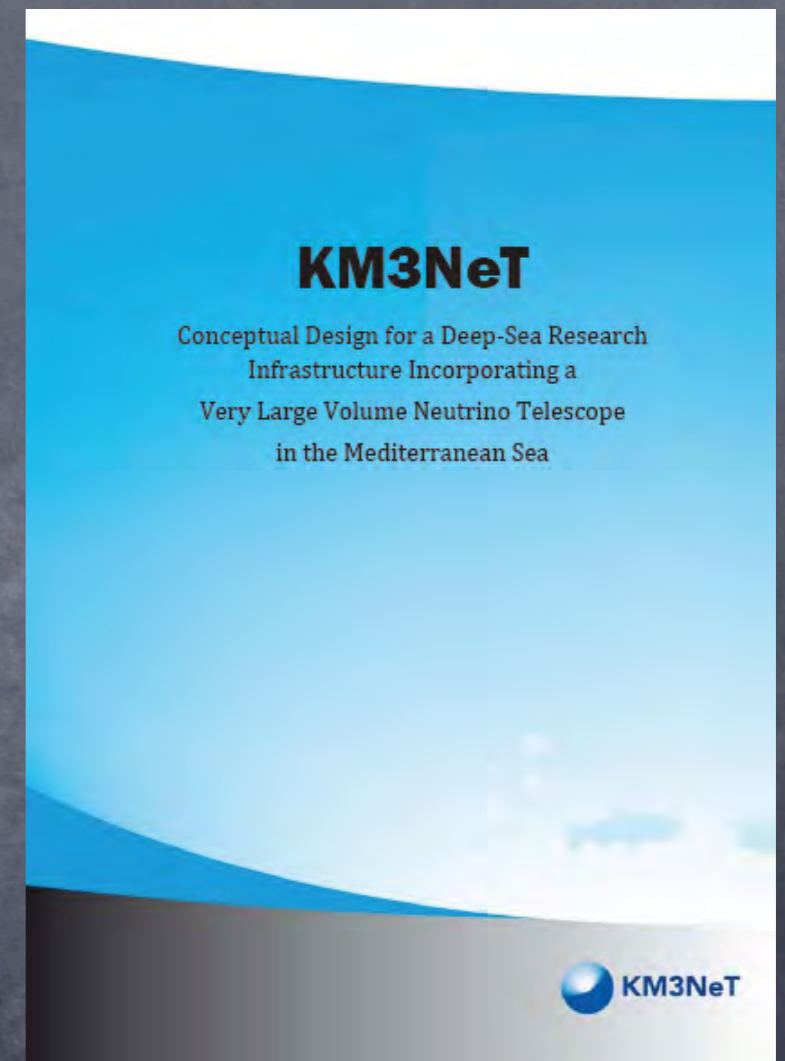




KM3



- Spanish groups are also involved in the preparatory phase for Km3 with other 40 european institutions:
 - Sensitivity studies
 - geolocalization & calibration.
- Three Spanish groups (2 from Valencia & 1 from Barcelona). 2 technical institutions interested in geoscience.



Theory

UAM/IFT (Madrid)



- Lepton flavour violation (B.Gavela, A.Casas, M.J.Herrero)
- Experimental data fits, astroneneutrinos & sterile neutrinos. (M.Maltoni)
- Future facilities (A.Donini)
- SuperNova neutrinos (B.Gavela)

- Large, long tradición (J.Valle, P. Bernabeu, ...)
- Future facilities (J.Bernabeu, P.Hernandez, O.Mena)
- Low energy lagrangians (A.Santamaria, N.Rius, C.Peña Garay)
- Astroneutrinos (O.Mena, S.Pastor)
- Solar neutrinos experimental fits (C.Peña Garay)
- Neutrino-nucleus interactions (J.Nieves, M.J.Vicente-Vacas)

U.Granada

- Heavy neutrinos in LHC (F.del Aguila, A. Aguilar Saavedra).
- Neutrino-nucleus interactions (J.E.Amaro)

U.Murcia

- Neutrino-nucleus interactions (L.Alvarez Ruso)

U.Salamanca

- Neutrino-nucleus interactions (E.Hernandez)

Review

- Spanish neutrino groups are involved in almost all aspects of neutrino physics nowadays.
- Contribution to 3 leading oscillation neutrino experiments in the near future (T2K, D.Chooz, SK)
- Involved in the neutrino factory design.
- Involved in the european initiatives for new experiments: LAGUNA @ Canfranc.

Review

- New underground facility available:
 - New $2\beta 0\nu$ experiment lead by Spanish institutions: NEXT.
 - Contribution to the upgrade of SuperKamiokande with Gd.
 - Hosting BiPo for low activity measurements.
- Contribution to neutrino astrophysics experiments: Antares & Future Km³.

Review

- (almost) All experiments are established in the funding profile of HEP.
- Strong theoretical community involved in:
 - Neutrino–Nucleus interaction models at low energies.
 - Neutrino oscillation phenomenology.
 - Future facilities
 - Astroneutrinos (mainly SuperNovas)

09 NUINT

May 18th-22nd 2009 Sitges(Spain)

6th International Workshop on Neutrino-Nucleus Interactions in the Few-GeV Region

Confronting theory, models & data
Electron scattering and its connections to neutrino-nucleus interactions
Current and future neutrino experiments
CC and NC quasi-elastic scattering
Single pion production
Deep and not-so-deep inelastic scattering
The path forward: theory vs. experiments needs

Local Organizing Committee

L. Alvarez-Ruso
A. Cervera
F. Sánchez (chair)
M. Sorel (co-chair)
M.J. Vicente Vacas

Scientific Program Organizing Committee

J. Beacom	S. Boyd	R. Bradford	A. Butkevich	J.A. Caballero
F. Cavanna	S. Choubey	E. Christy	S. Dytman	E. Fernández
H. Gallagher	Y. Hayato	S. Kumano	K. McFarland	M. Mezzetto
J. Morfin	T. Nakaya	J. Nieves	S. Palomares	C. Pöly
R. Tayloe	T. Sato	M. Sakuda	S. Singh	J. Sobczyk
C. Walter	M. Wascko	S. Zeller		

Information and registration at <http://nuint09.ifae.es/>

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