INFN

National Institute for Nuclear Physics

U.Dosselli

The origins

- Born in 1951 out of four founding Institutes of Physics in Milano, Padova, Rome and Torino
- A nation wide effort toward the creation of a center for physics with accelerators

The mission

- Basic research in
  - subnuclear,
  - nuclear and
  - astroparticle physics
- Dissemination of scientific culture
- Training of young reserchers
- Fertilizing the process of cutting edge technology transfer to industries

The sites

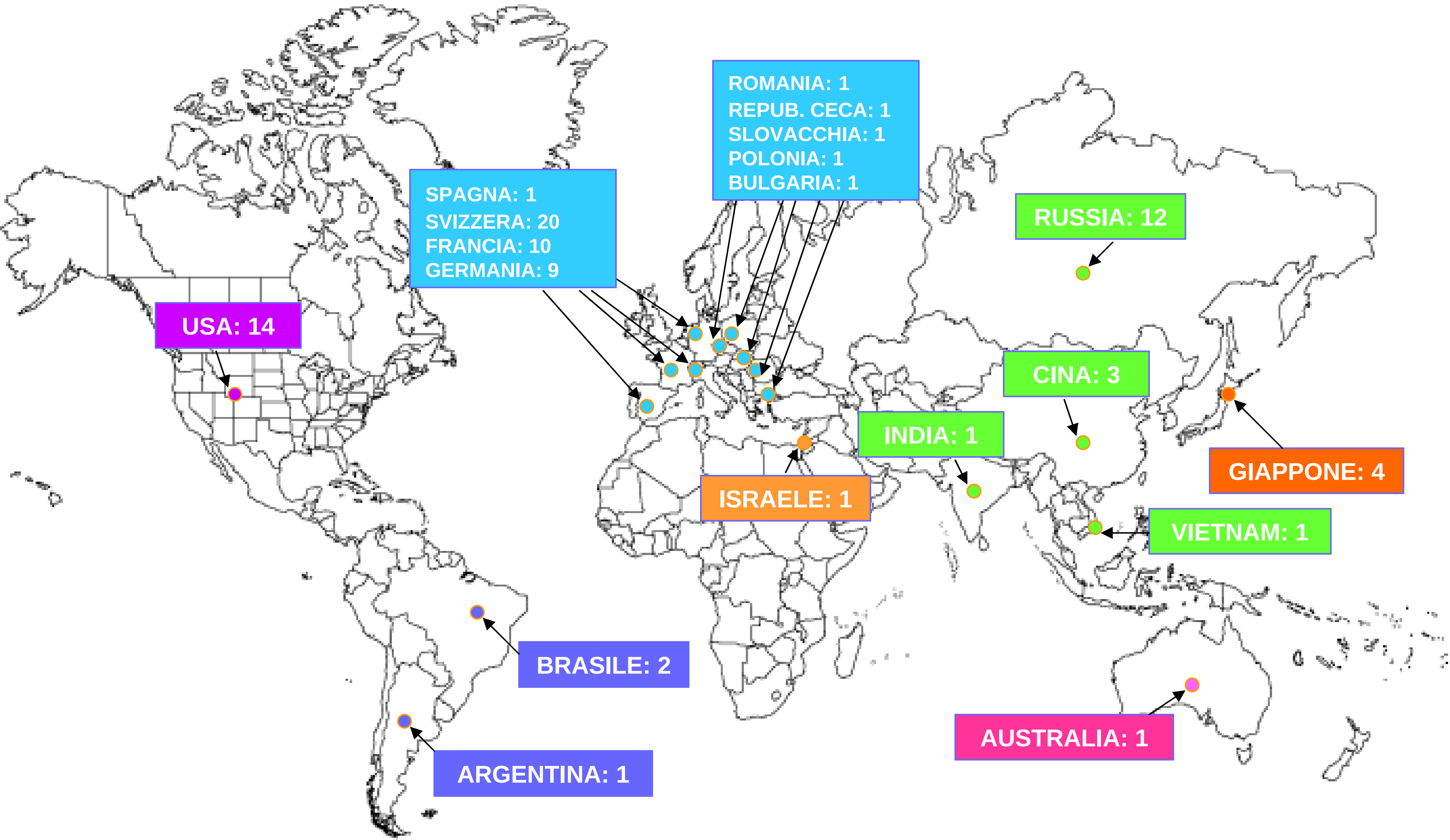
- 4 Laboratories
- 20 Sections
- 1 Computing Centre
- 11 Groups
- 2000 employees
- 3000 associate university scientists

The governing bodies

- The board of Directors (Directors, the Executive Board, representatives from research Institutions) led by the President
- The Executive Board (two Vicepresidents two members and the President)

promotes ad hoc memoranda both scientific and for the dissemination of the scientific culture with international institutions

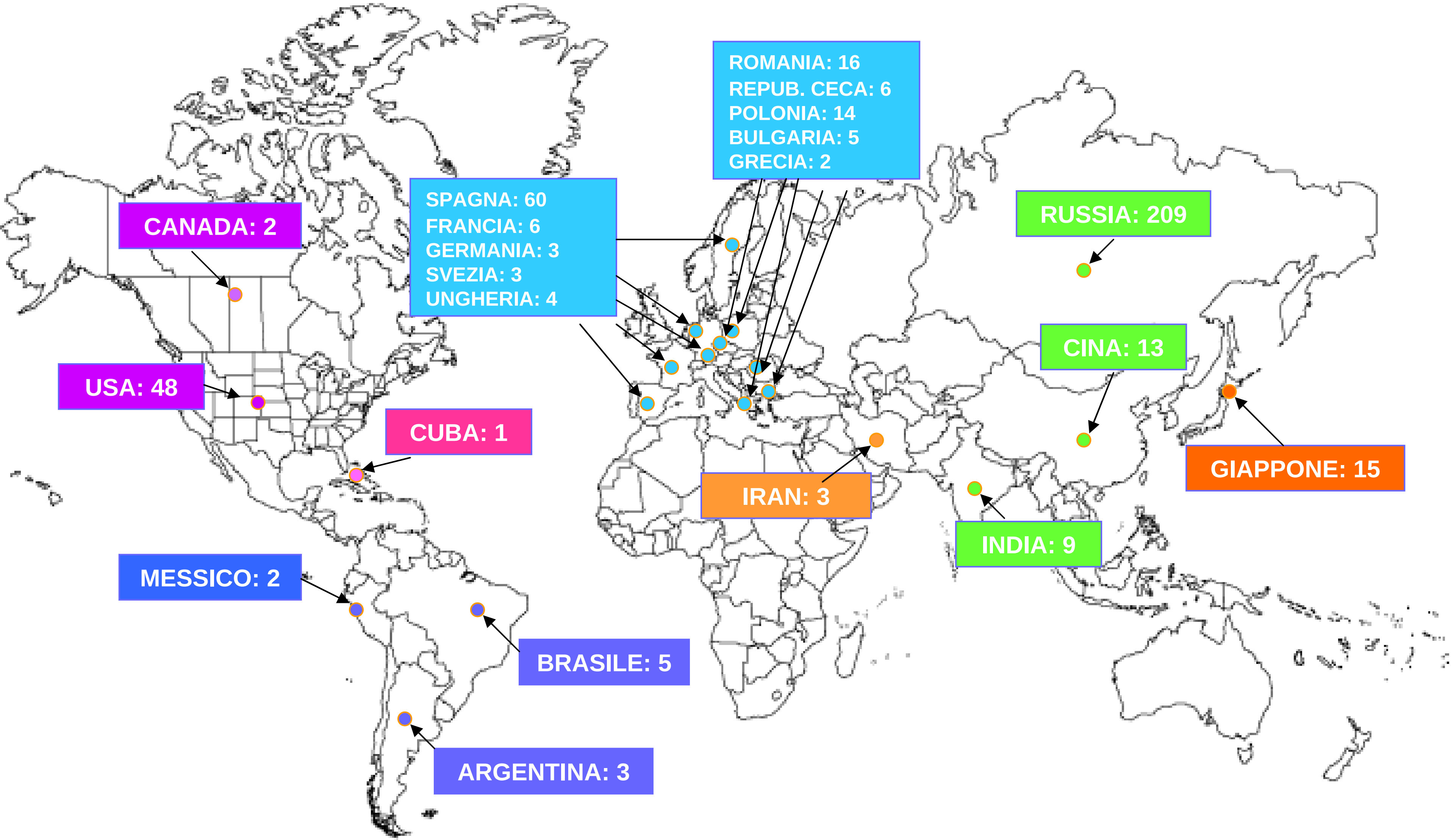
INFN – BILATERAL AND MULTILATERAL MoU ESTABLISHED WITH FOREIGN SCIENTIFIC INSTITUTIONS



with a specific budget (INFN Fund for International Matters), foreign researchers inside its departments foreign researchers are invited

INFN – FOREIGN RESEARCHERS GUESTS IN INFN STRUCTURES (FAI)

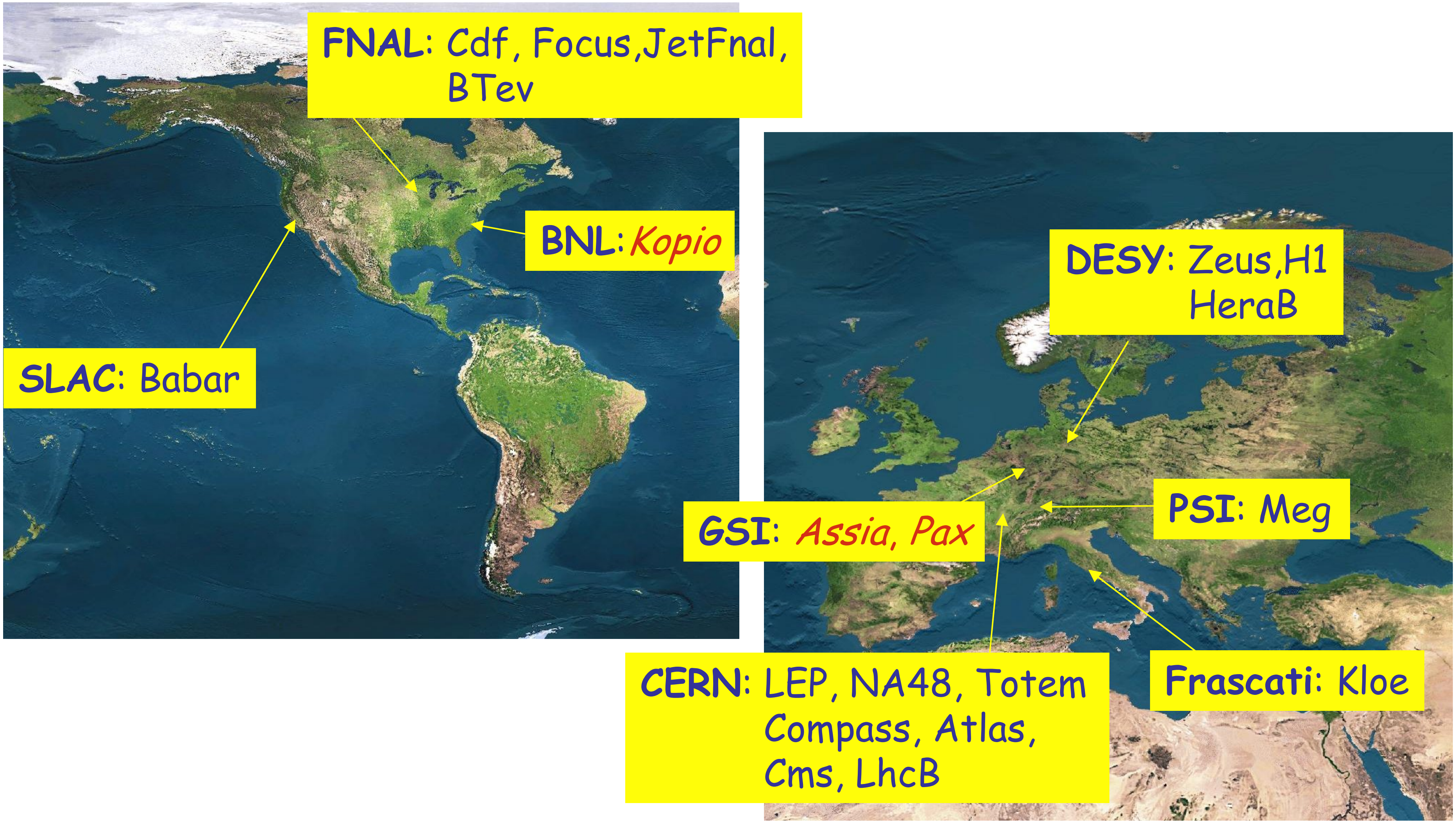
(data from 1st semester 04, 420)



The scientific evaluation

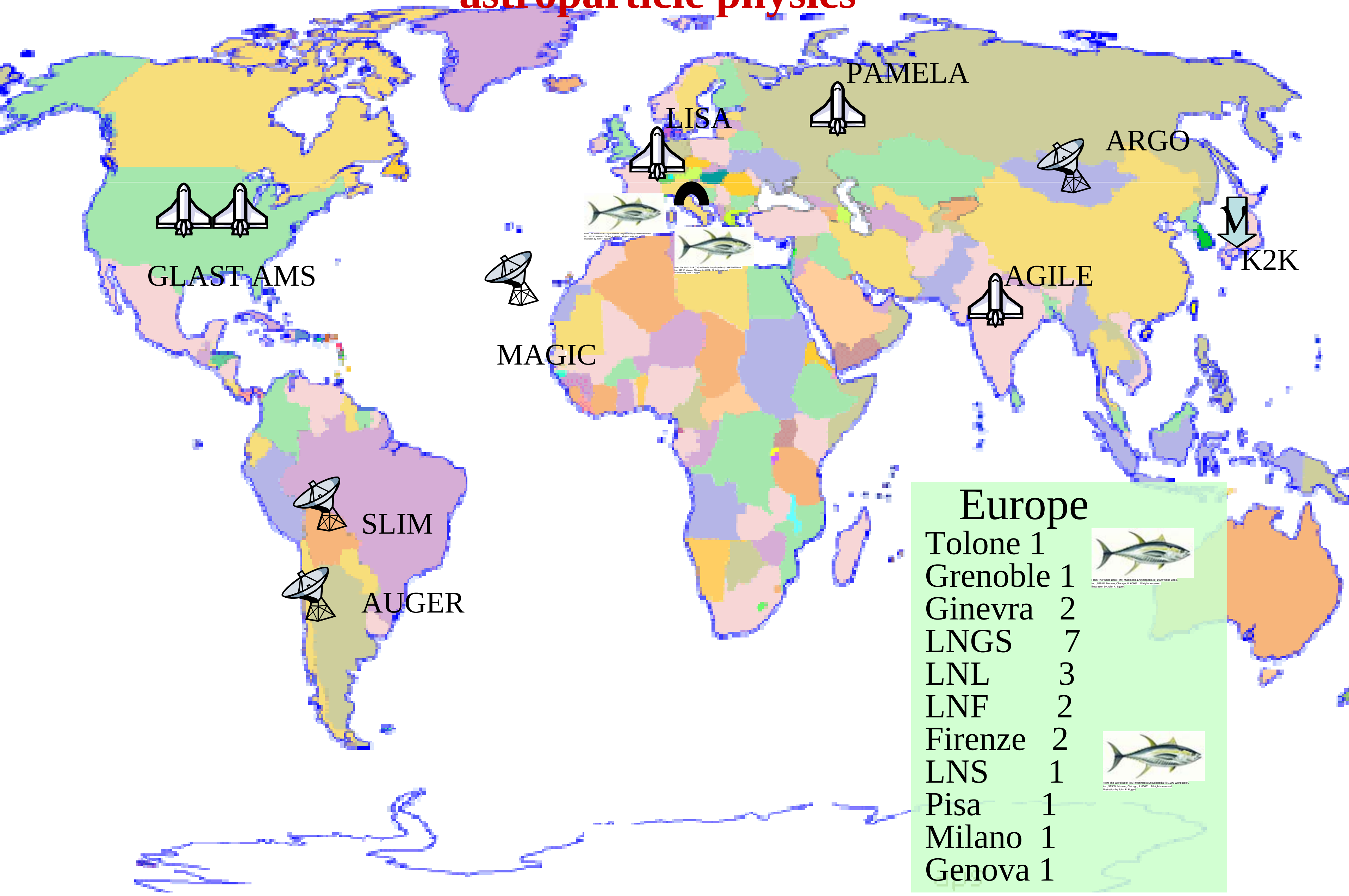
- Five scientific committees:
  - Subnuclear physics
  - Astroparticle physics
  - Nuclear physics
  - Theory
  - Technological developments

INTERNATIONAL COLLABORATIONS
subnuclear physics

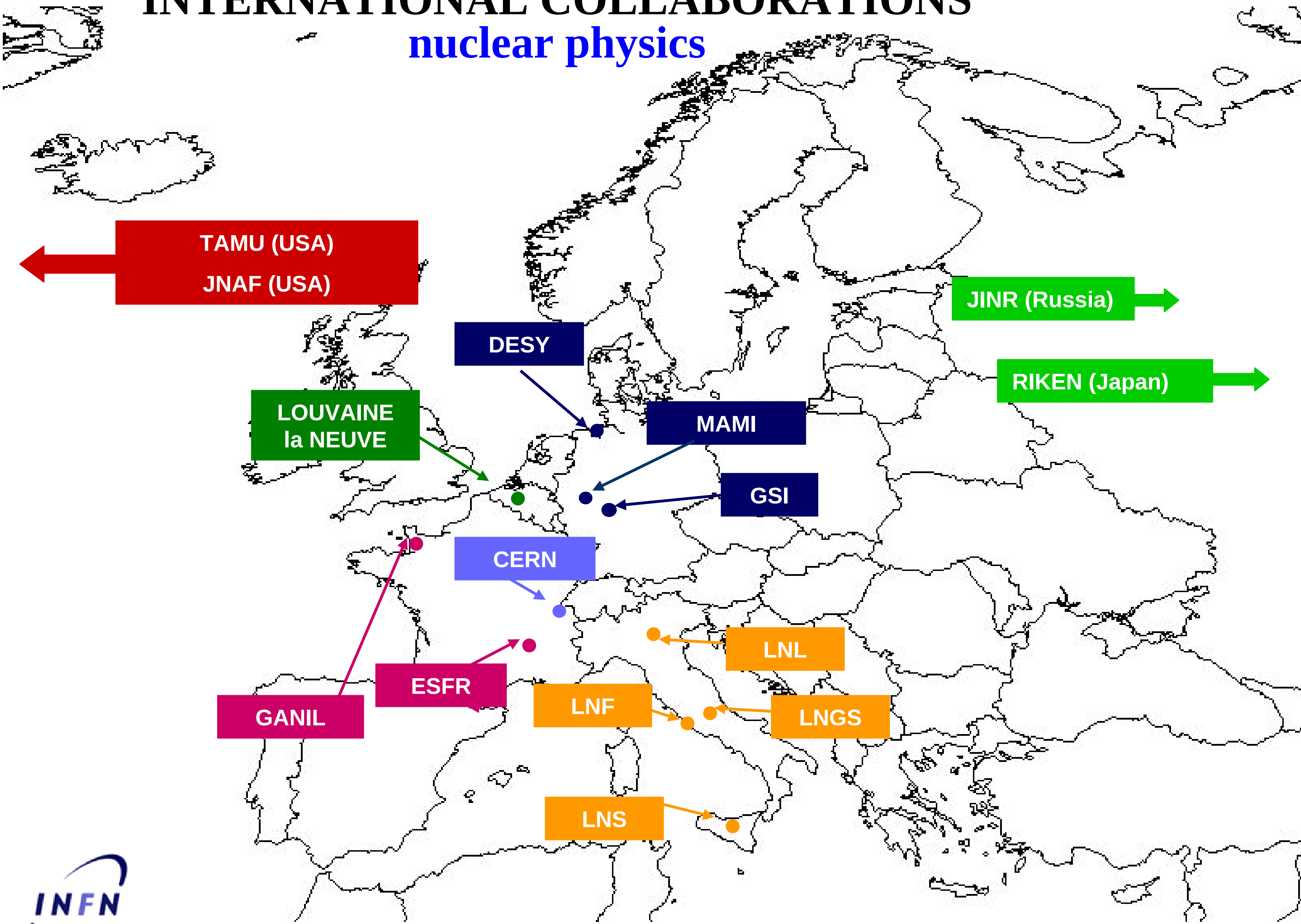


INTERNATIONAL COLLABORATIONS

astroparticle physics



INTERNATIONAL COLLABORATIONS
nuclear physics



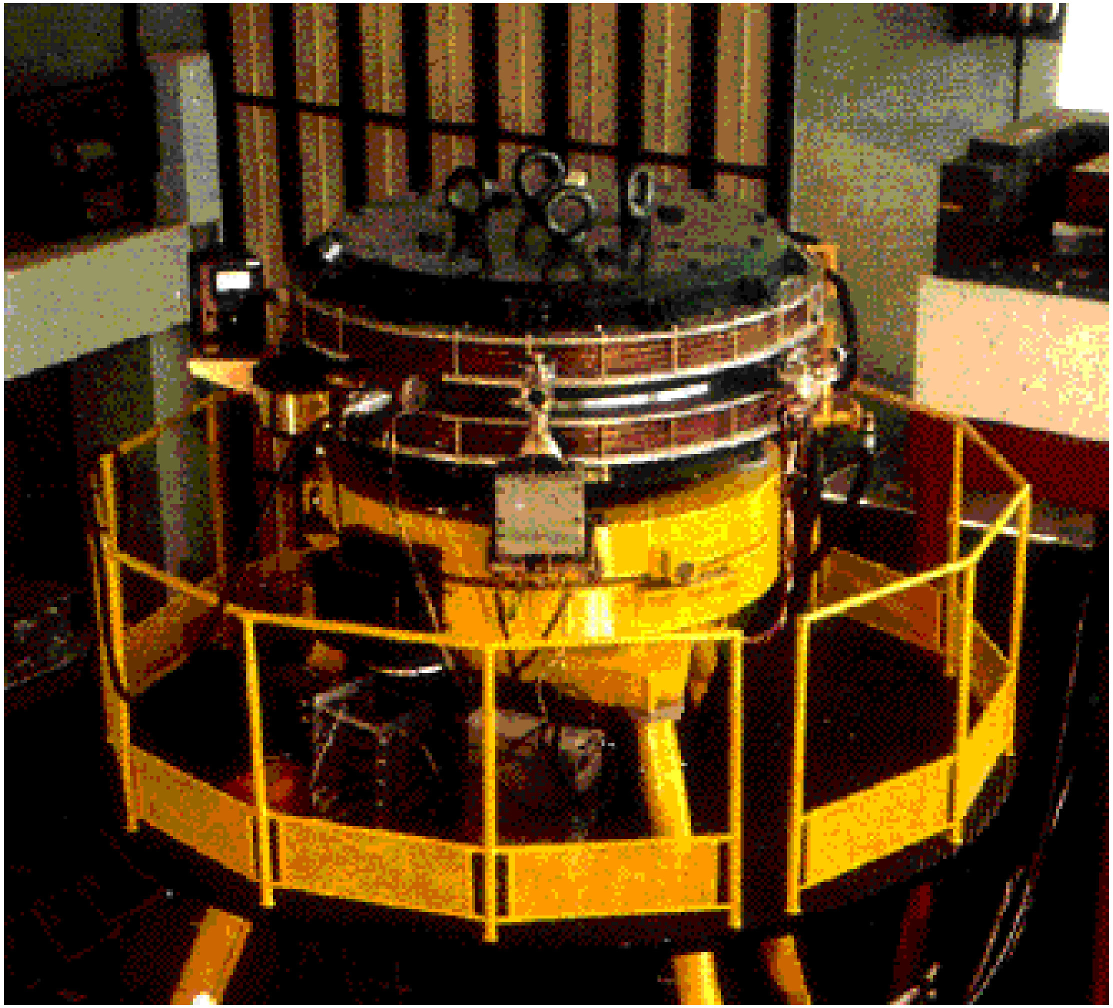
Subnuclear physics

- The study of strong and electroweak interactions:
  - Flavour physics and CP violation
  - The Higgs particle
  - Supersymmetry at the TeV scale
  - Hidden spatial dimensions at the TeV scale (strong gravity?)

Infrastructures for subnuclear physics

- The Frascati National lab (where the e+ e- was born…) and in particular Dafne
- International labs: CERN, Desy, Fermilab, Slac

Ada



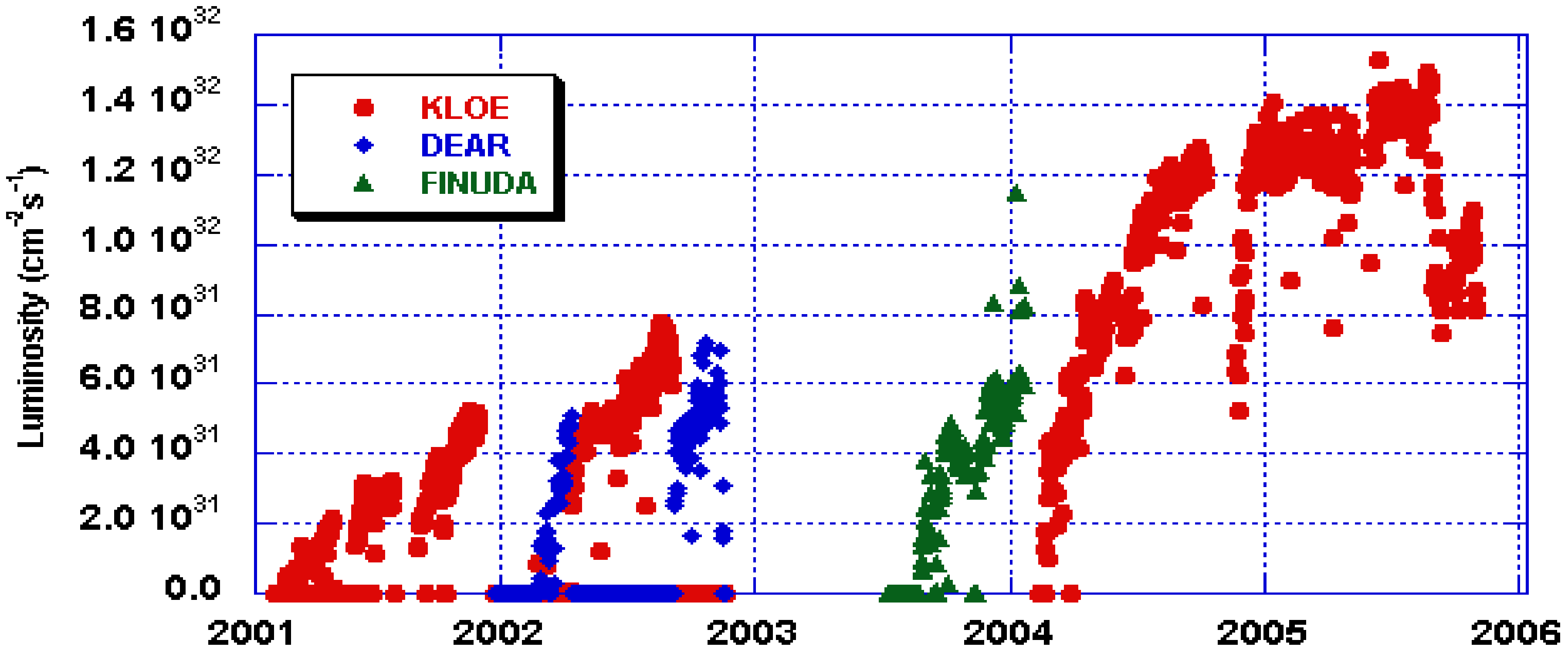
dafne

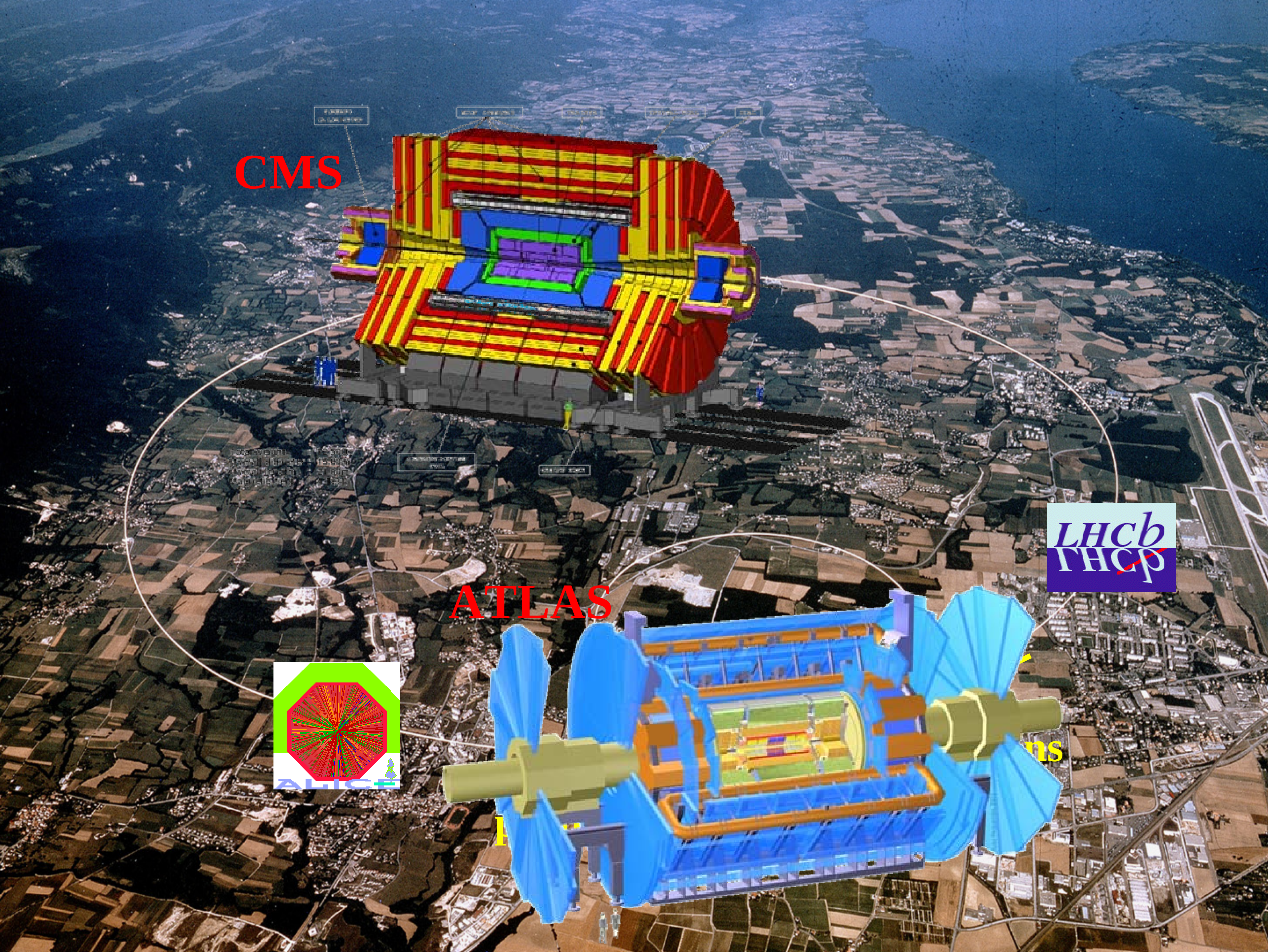
dafne

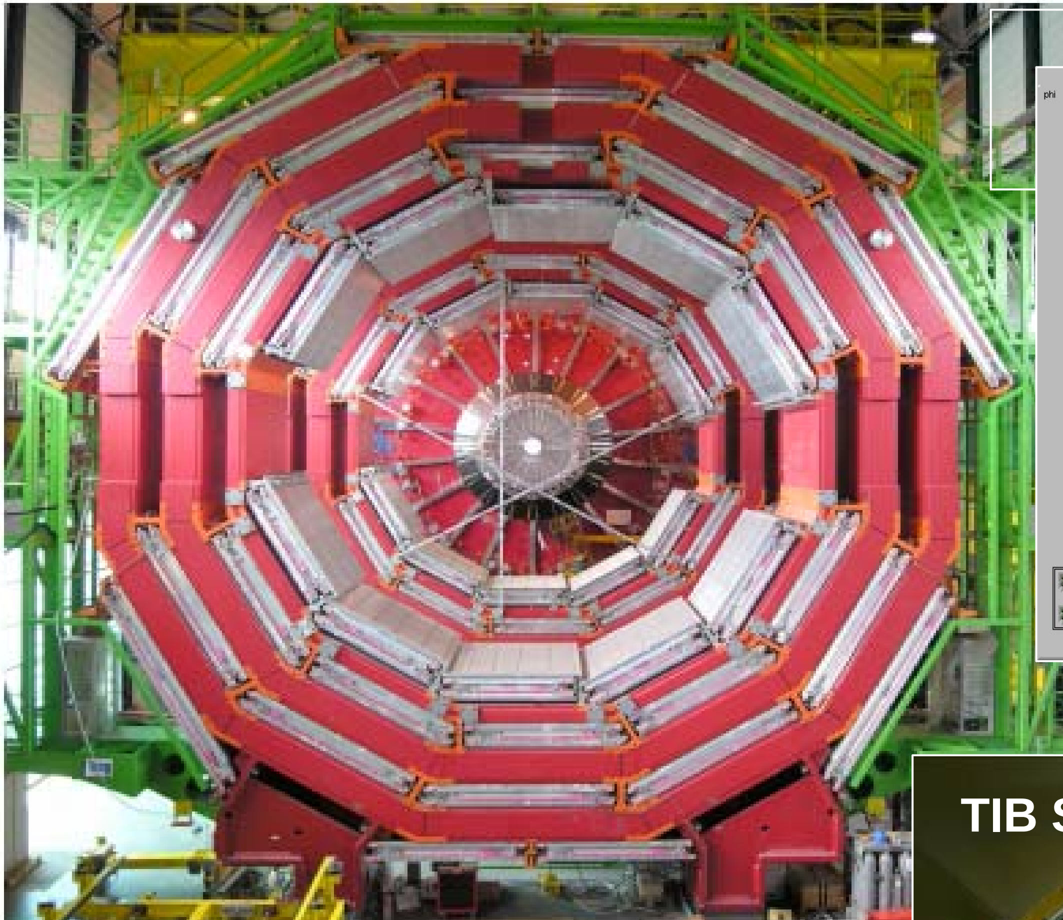
KLOE @ Φ PEAK $\int\mathcal{L} = 2.5\ fb^{-1}$ $\mathcal{L}_{peak}=1.5\times10^{32}\ cm^{-2}s^{-1}$

@ 1000 MeV $\int\mathcal{L} = 250\ pb^{-1}$ $\mathcal{L}_{peak}=1.0\times10^{32}\ cm^{-2}s^{-1}$

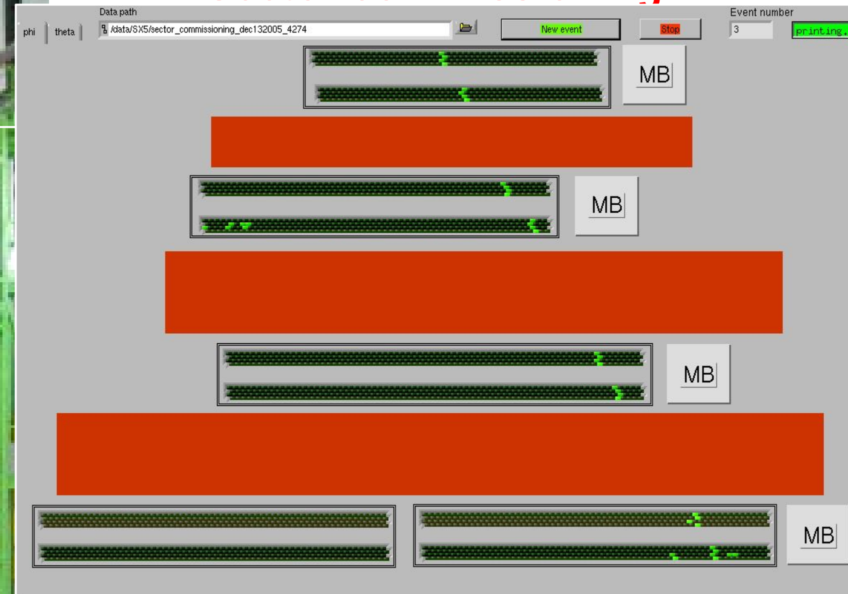
DAΦNE

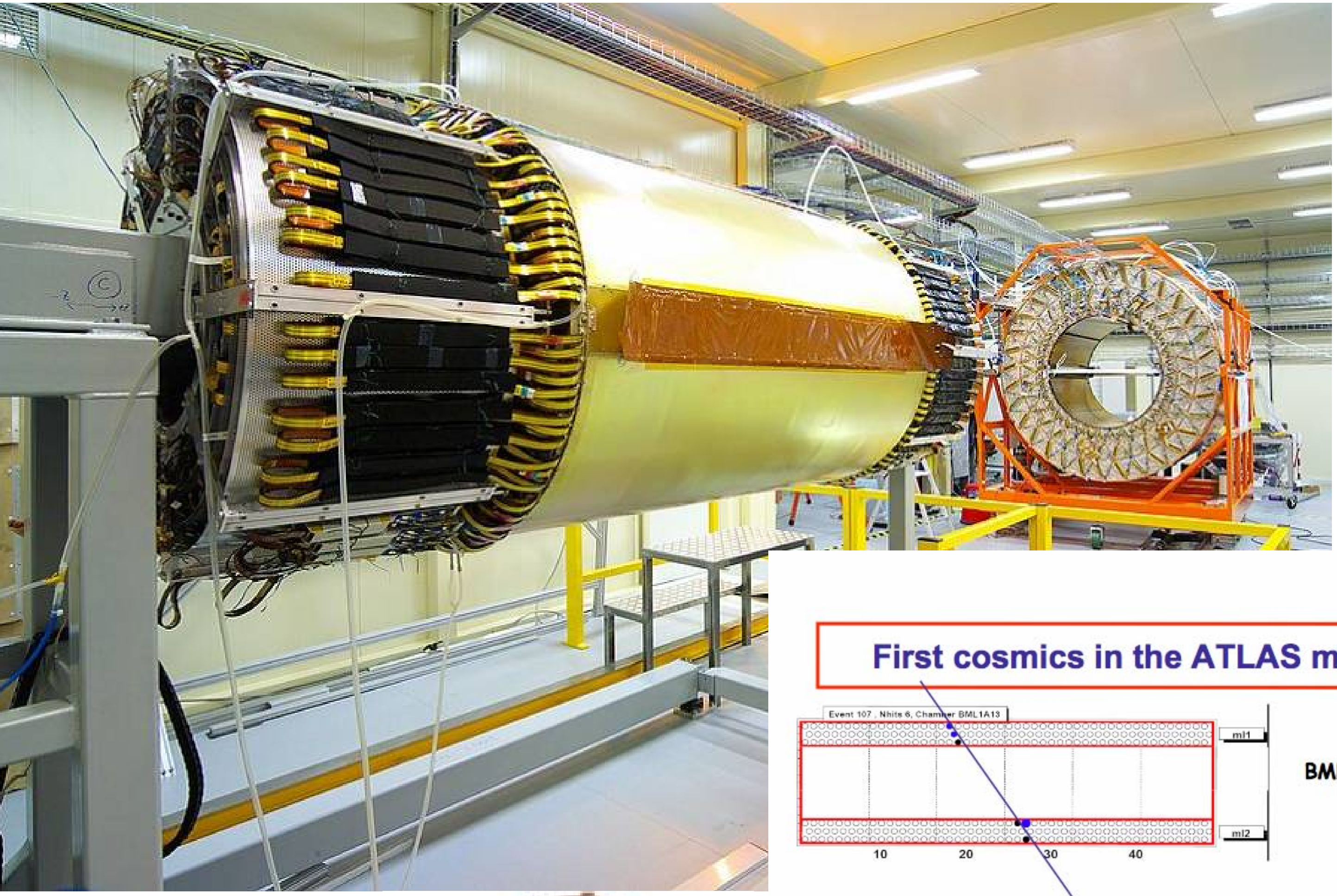



CMS
ATLAS
LHCb
ALICE

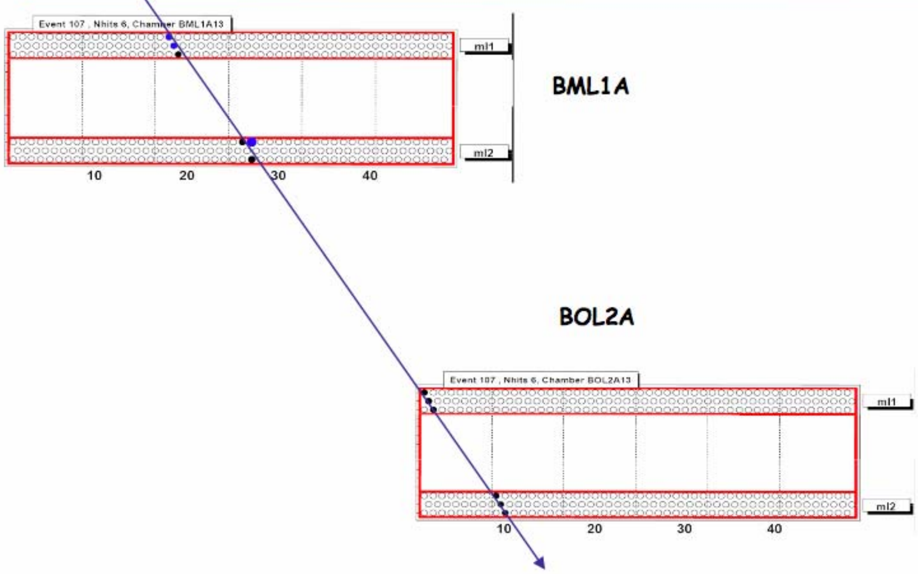


Sector commissioning



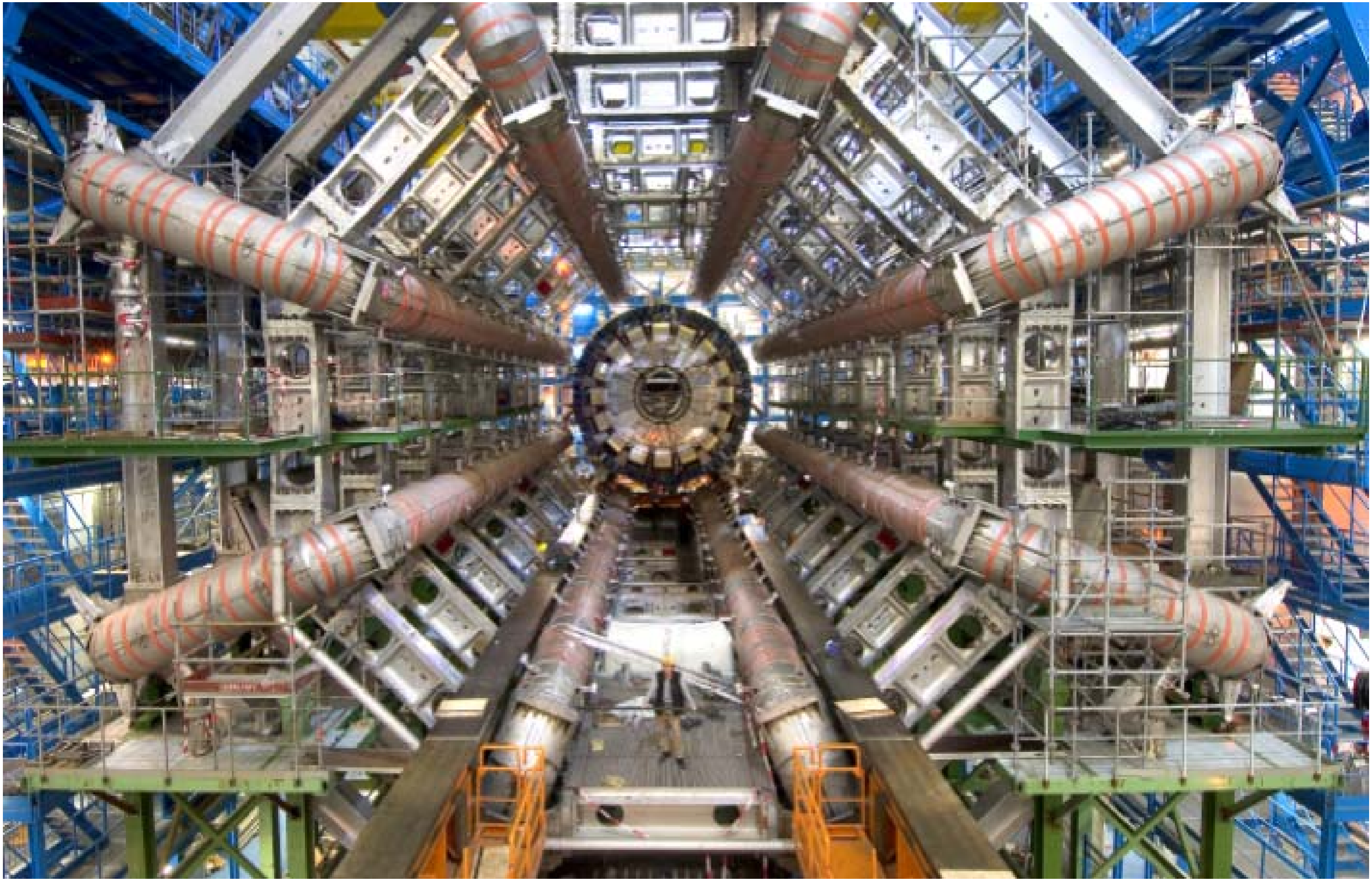


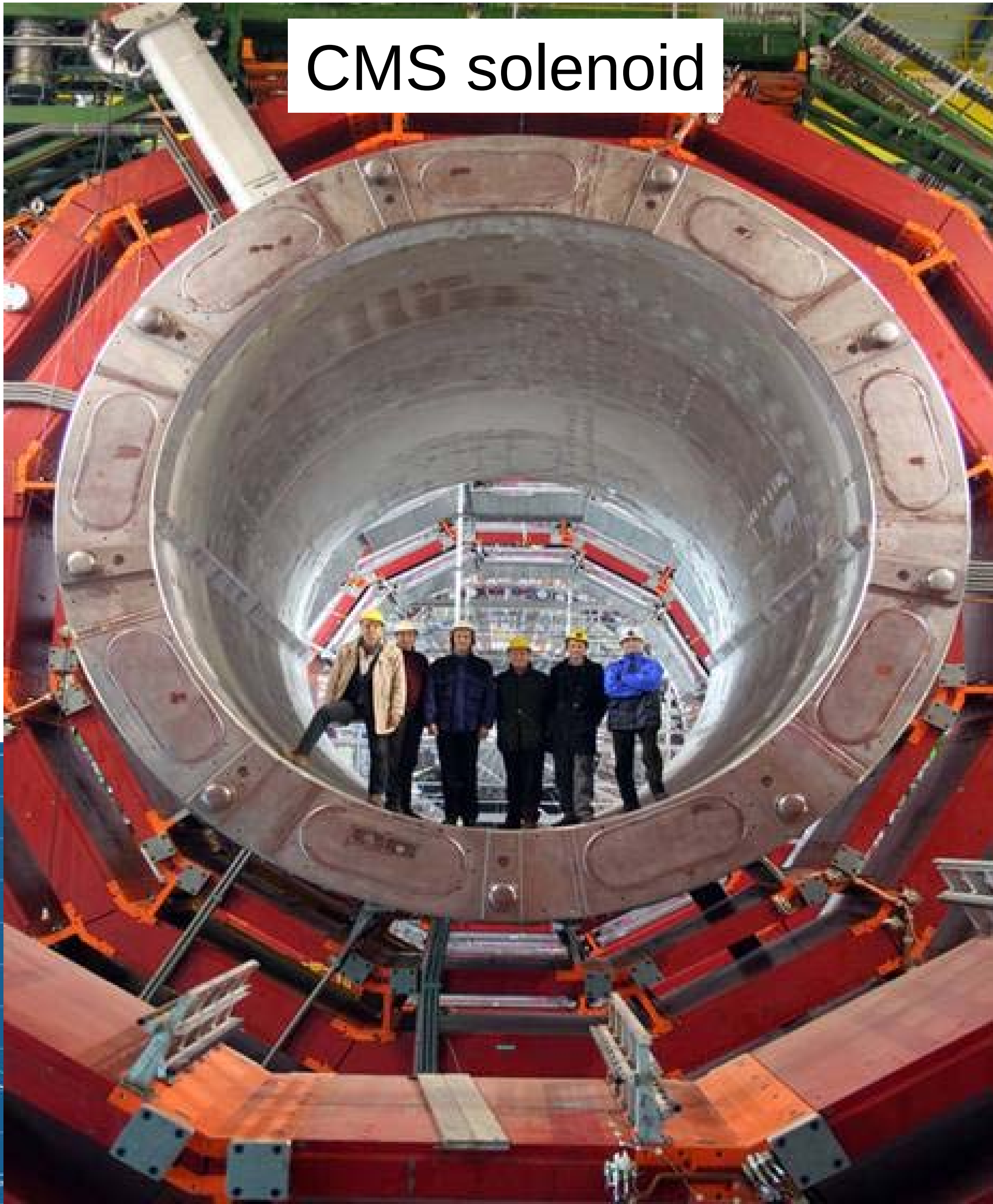
First cosmics in the ATLAS muon spectrometer



ATLAS

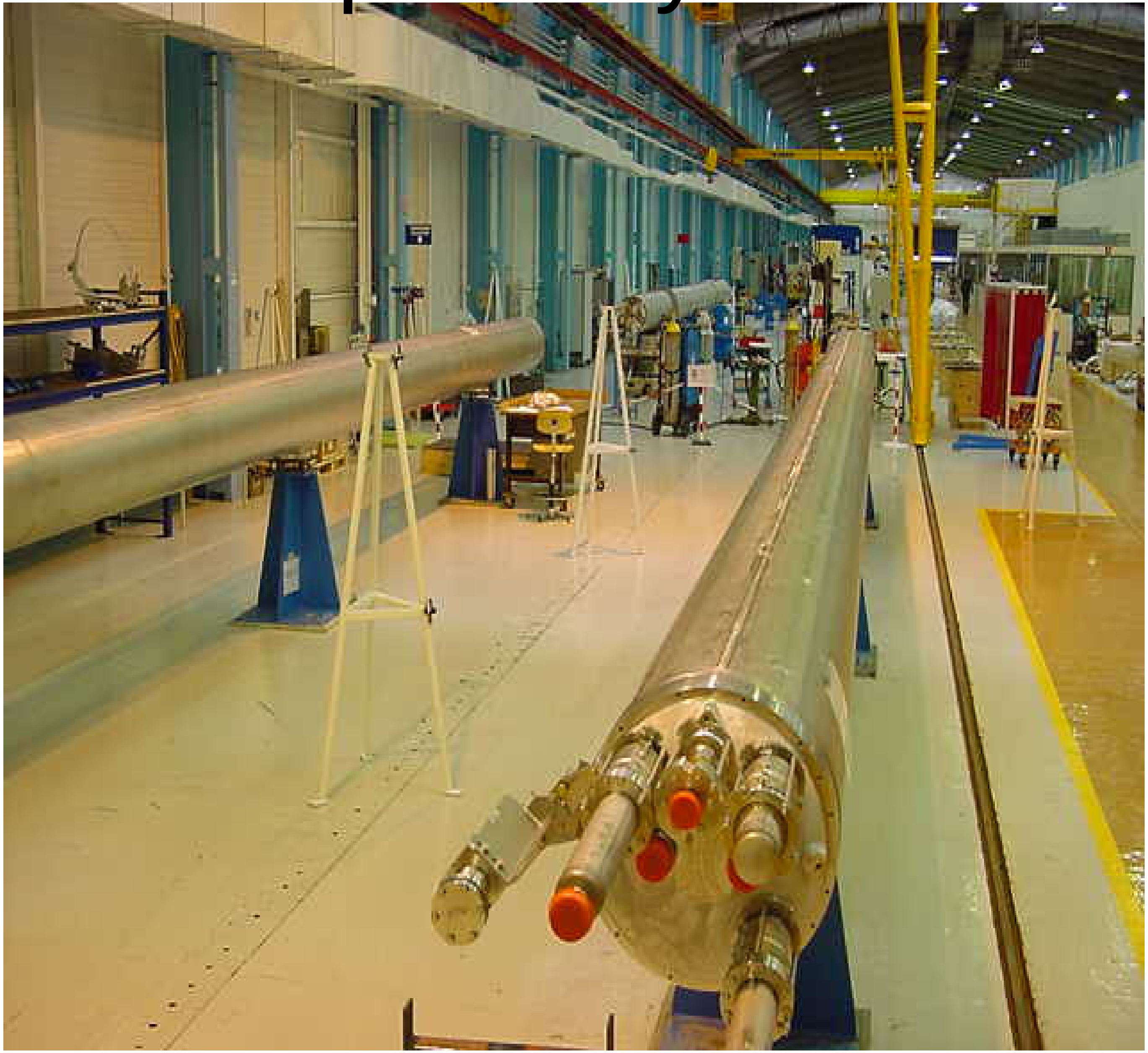
ATLAS 8 barrel toroids coils




CMS solenoid


is at
4 K !

Lhc dipoles by Ansaldo



GOAL: limit BR $\mu \rightarrow e \gamma < 10^{-13}$ ⟺ MEG

Switzerland

Drift Chambers,
Readout & DAQ

Russia

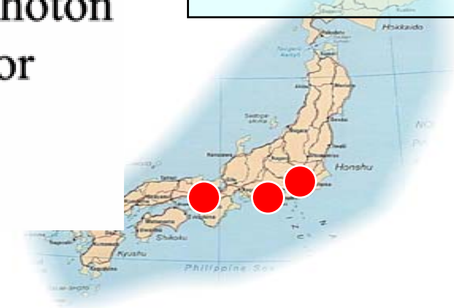
Manpower
Muons transport
solenoid

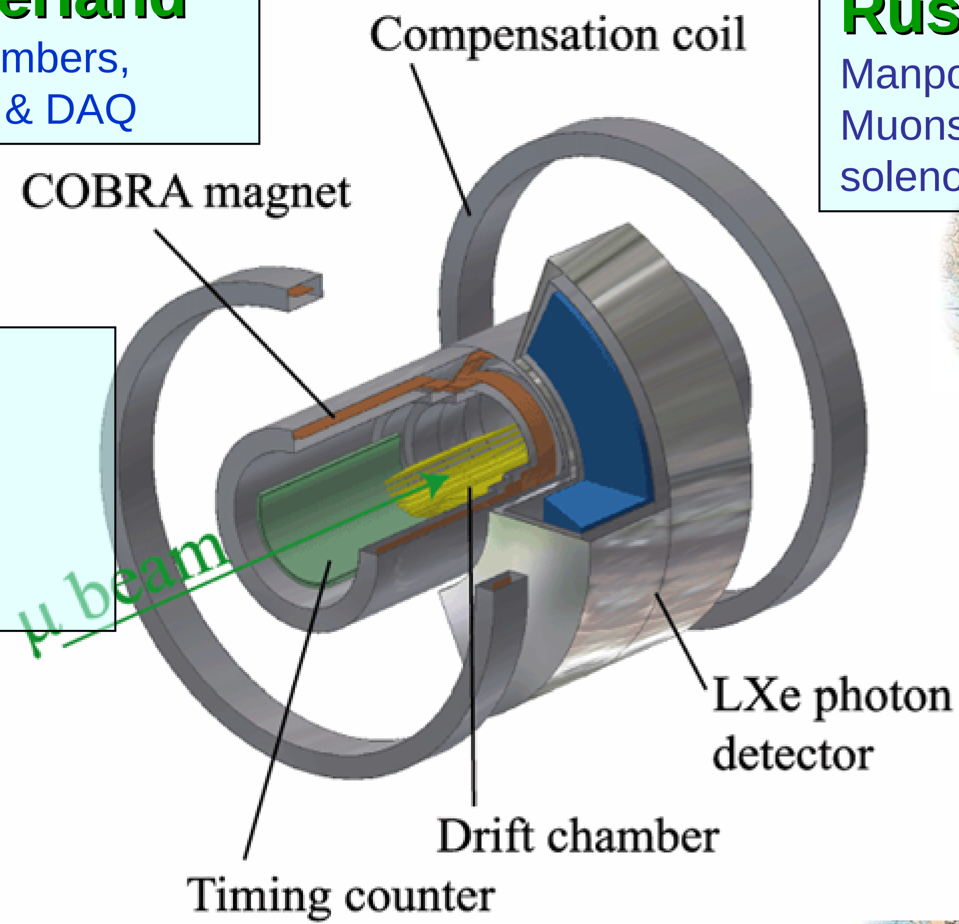
Italy

e+ counter
Trigger
Splitter
LXe Calorimeter

Japan

LXe Calorimeter,
Superconducting
Solenoid





Points of excellence of subnuclear physics

- CP violation (NA48, Babar, Kloe)
- Accelerator technology:
  - Dafne (high luminosity at low energy)
  - Clic (R&D for a compact linear collider)
  - ILC (R&D for the international linear collider, strong role in the TESLA collaboration)
  - SparX (X-fel)
- Grid middleware (LHC)
- Large scale detectors and silicon trackers

Astroparticle physics

- Particle messengers of Cosmo evolution
  - Dark matter and dark energy
  - Proton decay and unification
  - Majorana Neutrinos and the see saw mechanism
  - Gravitational waves: relics and stellar collapses
  - Gamma rays and neutrino astronomy
  - Relic neutrinos
  - Galactic antimatter abundance

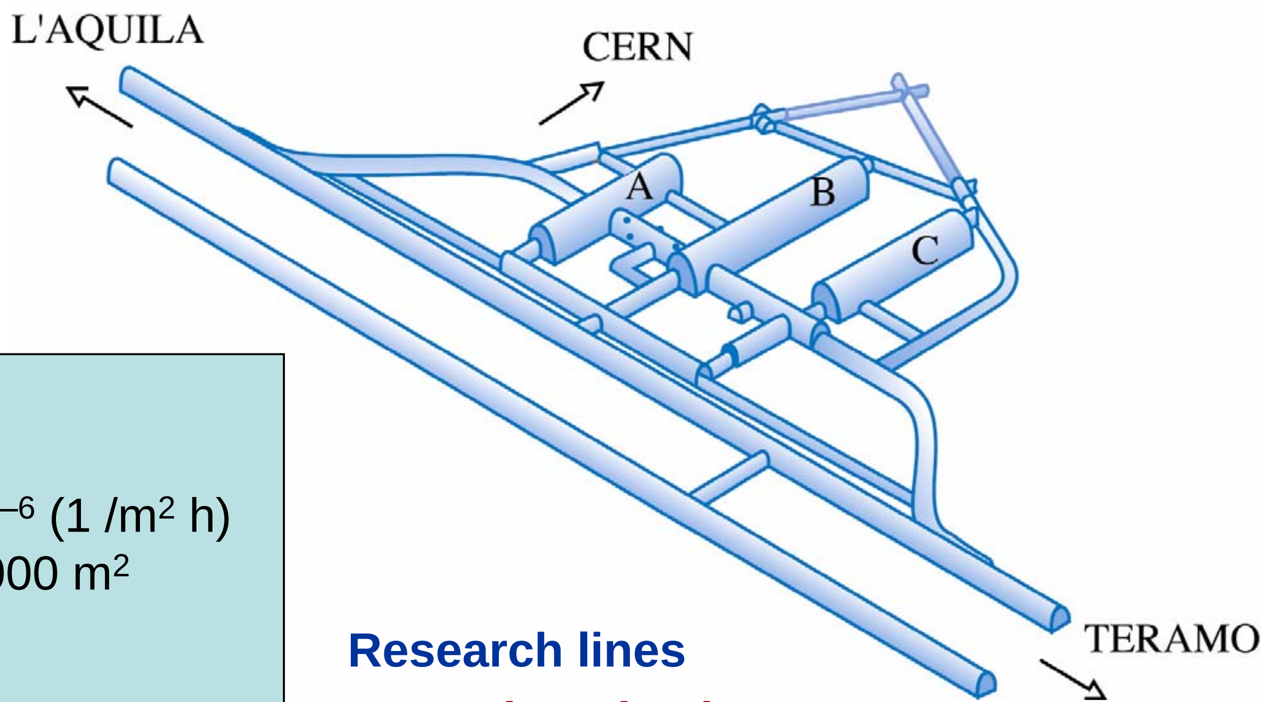
Infrastructures for astroparticle physics

- Low threshold solar neutrino telescopes
- Deep water large acceptance telescopes
- Gravitational antennas and interferometers
- Large area gamma detectors
- Space borne experiments


Gran Sasso Labs

LABORATORI NAZIONALI DEL GRAN SASSO - INFN

Largest underground laboratory for particle and astroparticle physics



1400 m rock coverage
cosmic μ reduction= 10^{-6} (1 /m^2 h)
underground area: 18 000 m^2
external facilities
easy access
756 scientists from 24 countries
Permanent staff = 70 positions

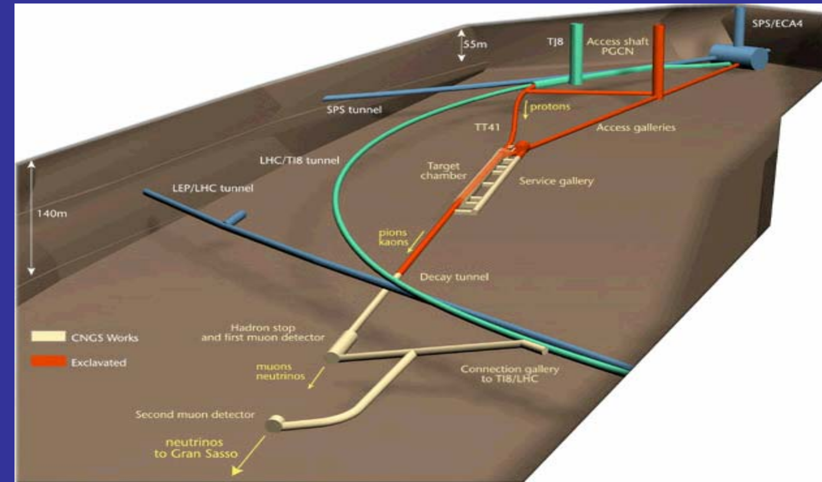
Research lines

- **Neutrino physics**
  (mass, oscillations, stellar physics)
- **Dark matter**
- **Nuclear reactions of astrophysics interest**
- **Gravitational waves**
- **Geophysics**
- **Biology**

ν beam from CERN:

OPERA

ICARUS



Gravitational Waves

Lisa test

Fundamental physics

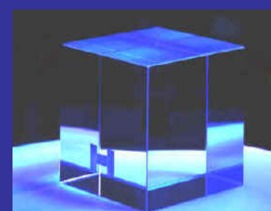
VIP

PRESENT EXPERIMENTS

$\beta\beta$ decay and rare events

Cuoricino

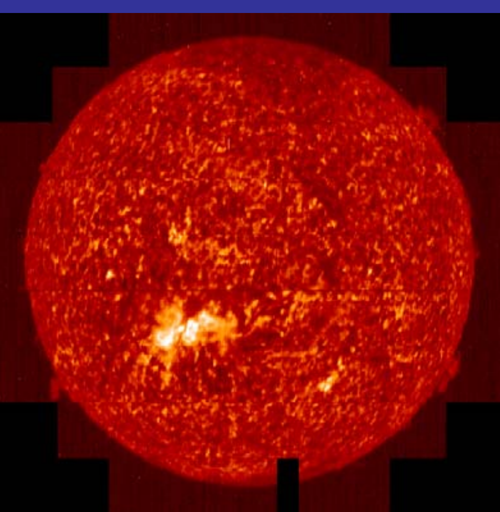
CUORE; GERDA



Dark Matter

DAMA/LIBRA; CRESST

WARP; Xenon test



Solar ν

Luna

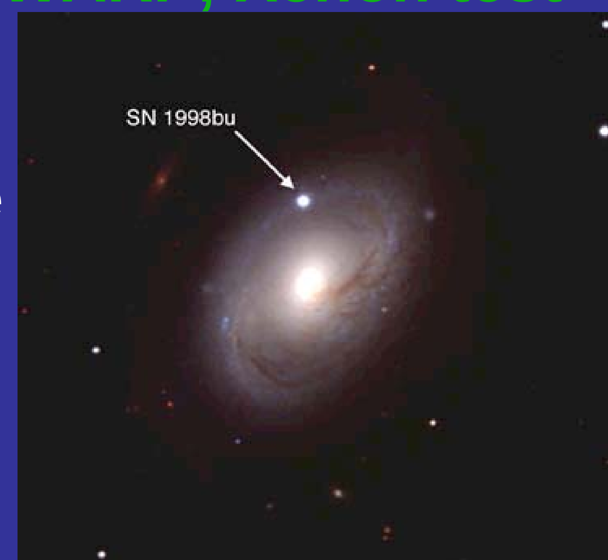
Borexino

ν from Supernovae

LVD

Borexino

ICARUS

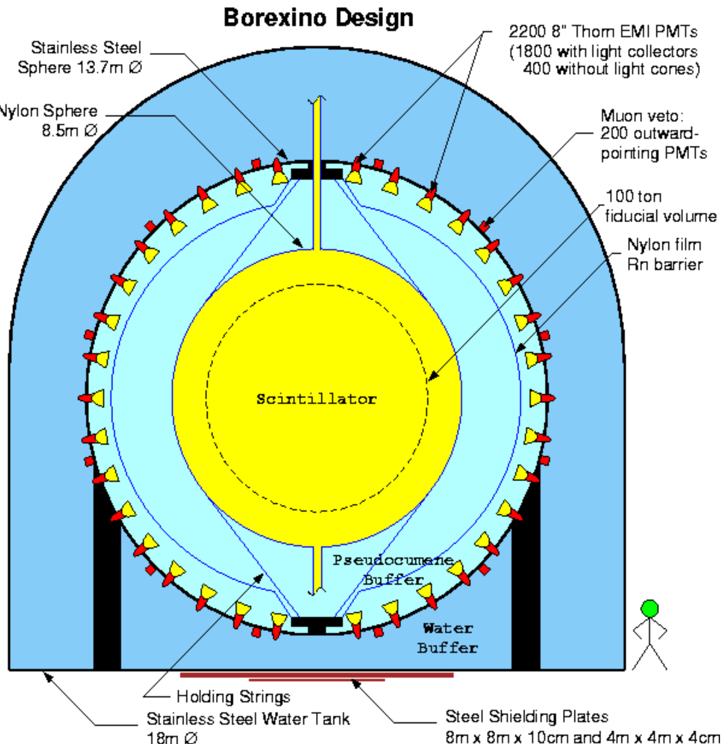


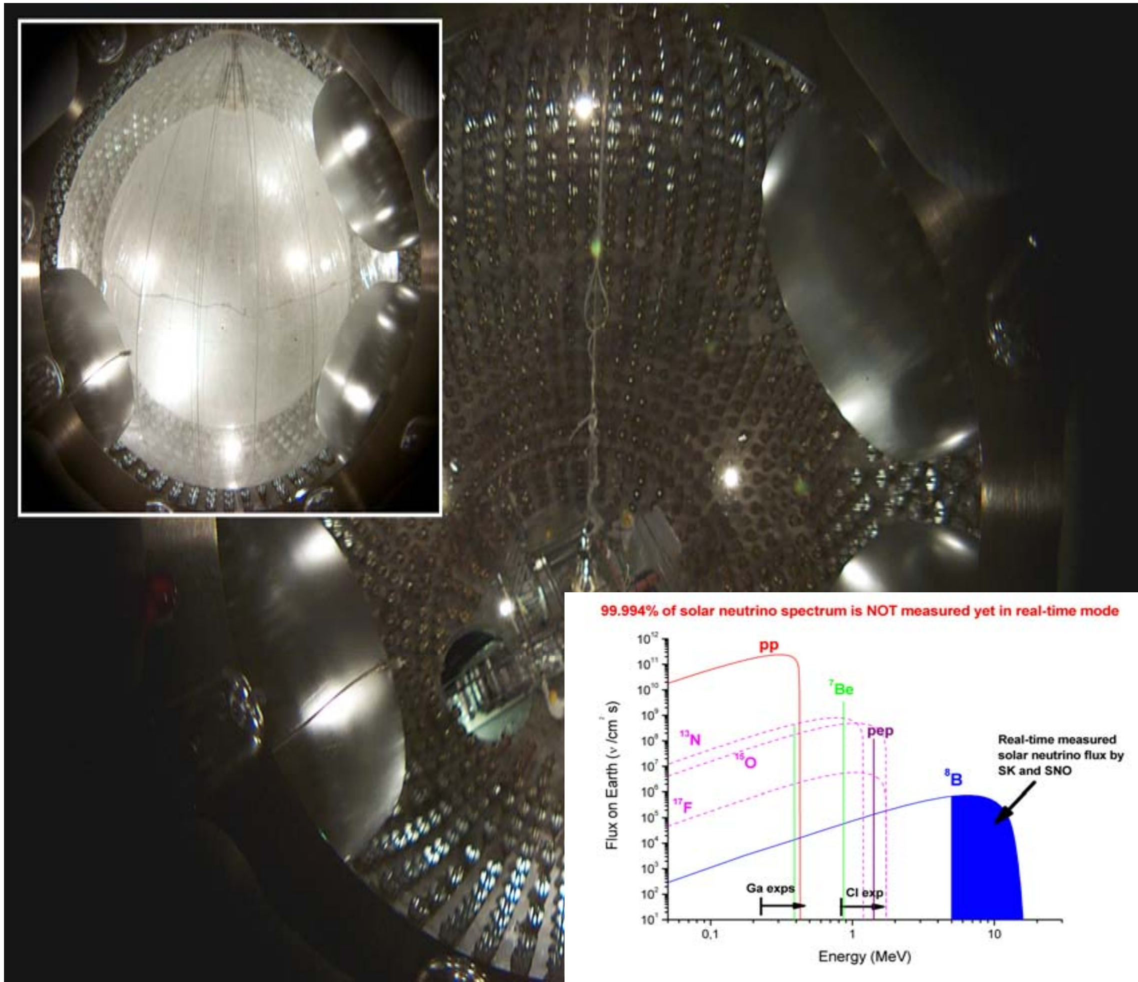
LNGS

Borexino: how LNGS can search for low-energy solar neutrinos (only ^{7}Be and pep)

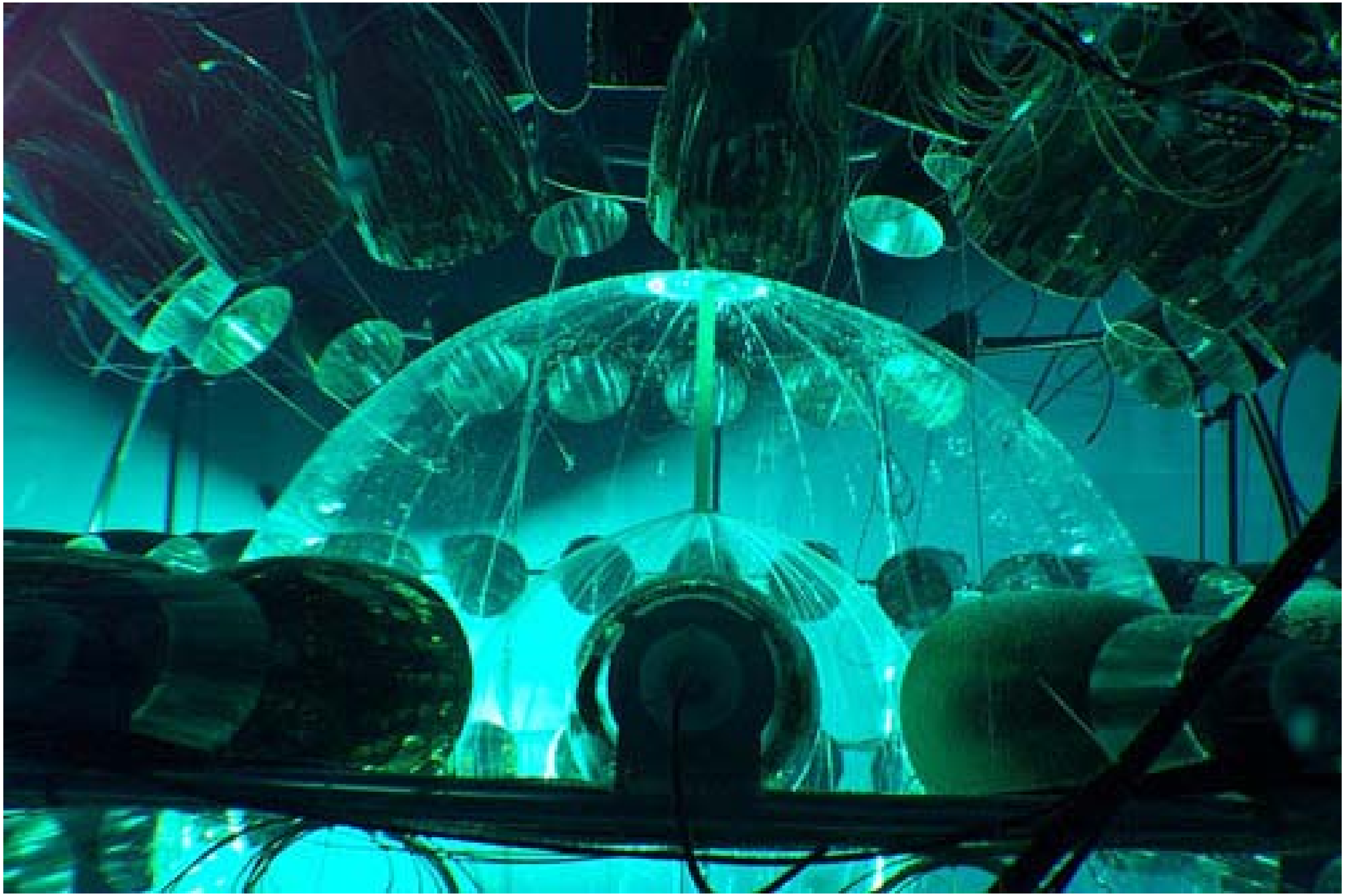
- **The possibility worldwide to measure low-energy solar neutrinos in the next 2-4 yr relies on Borexino (^{7}Be and pep) and KamLAND (only ^{7}Be)**

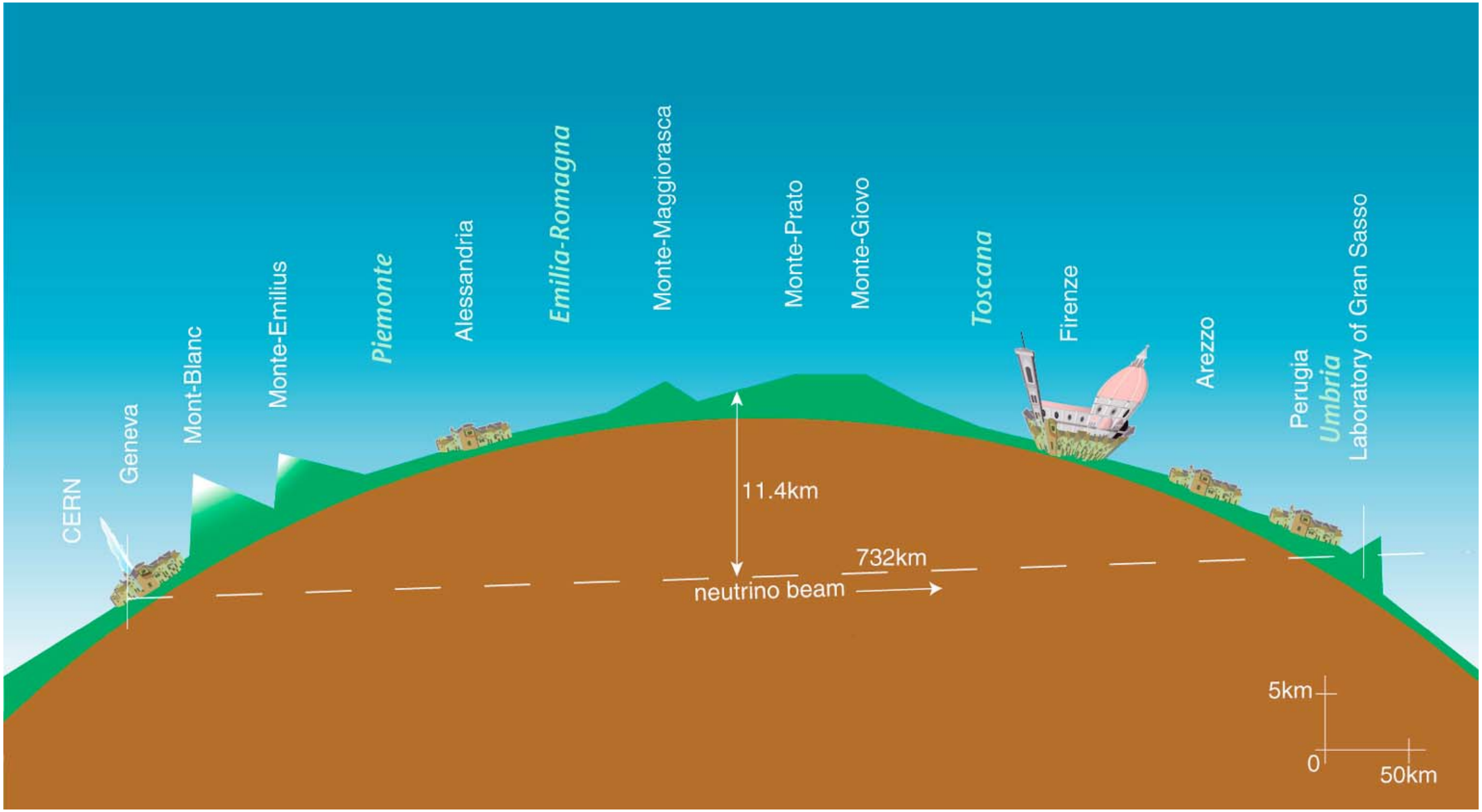
- **With a 10% measu. of ^{7}Be the pp flux will be known at the level of 1%!**





Borexino





CERN
Geneva
Mont-Blanc
Monte-Emilius
Piemonte
Alessandria
Emilia-Romagna
Monte-Maggiorasca
Monte-Prato
Monte-Giovo
Toscana
Firenze
Arezzo
Perugia
Umbria
Laboratory of Gran Sasso
11.4km
732km
neutrino beam
5km
0
50km

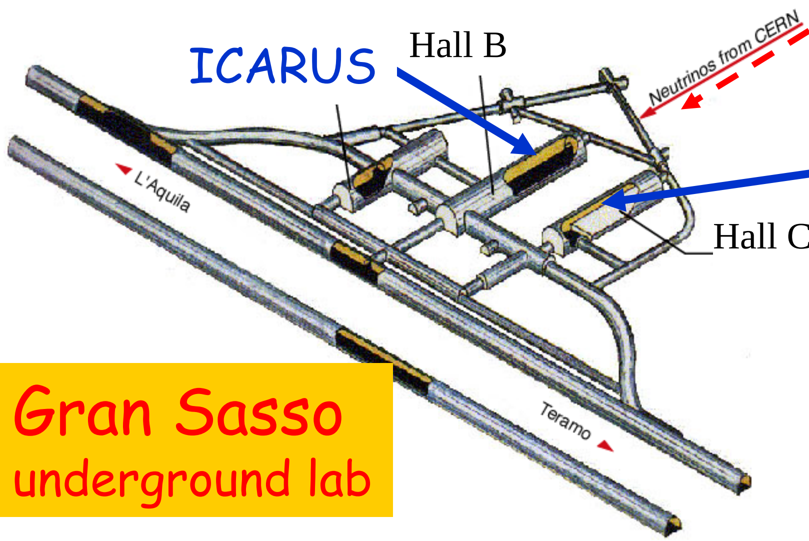
The OPERA Experiment

- Search for ν_τ appearance in the ν_μ CNGS beam to validate the $\nu_\mu \rightarrow \nu_\tau$ hypothesis in the atmospheric sector
- Search for $\nu_\mu \rightarrow \nu_e$ subleading channel

CERN
(731 km)

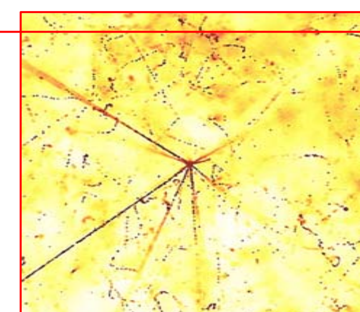
ν

OPERA
(CNGS1)

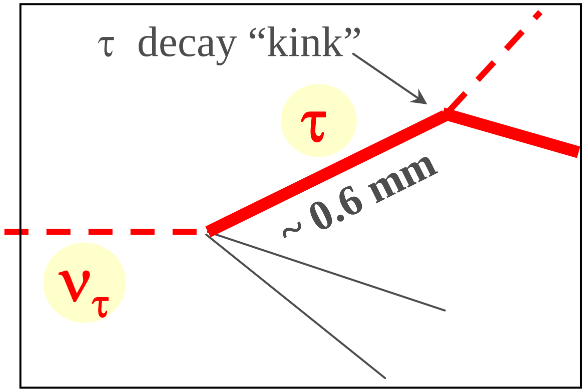


Gran Sasso
underground lab

Topological signature
of the τ decay
by using nuclear emulsions



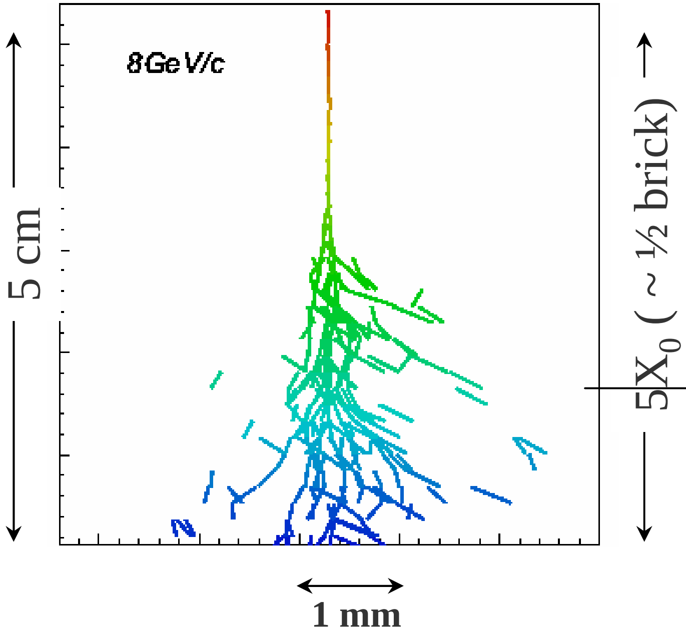
OPERA : ν_τ ν_e appearance



“Lead Emulsion Cloud Chamber”
(ECC)

QuickTime™ e un
decompressore TIFF (LZW)
sono necessari per visualizzare quest'immagine.

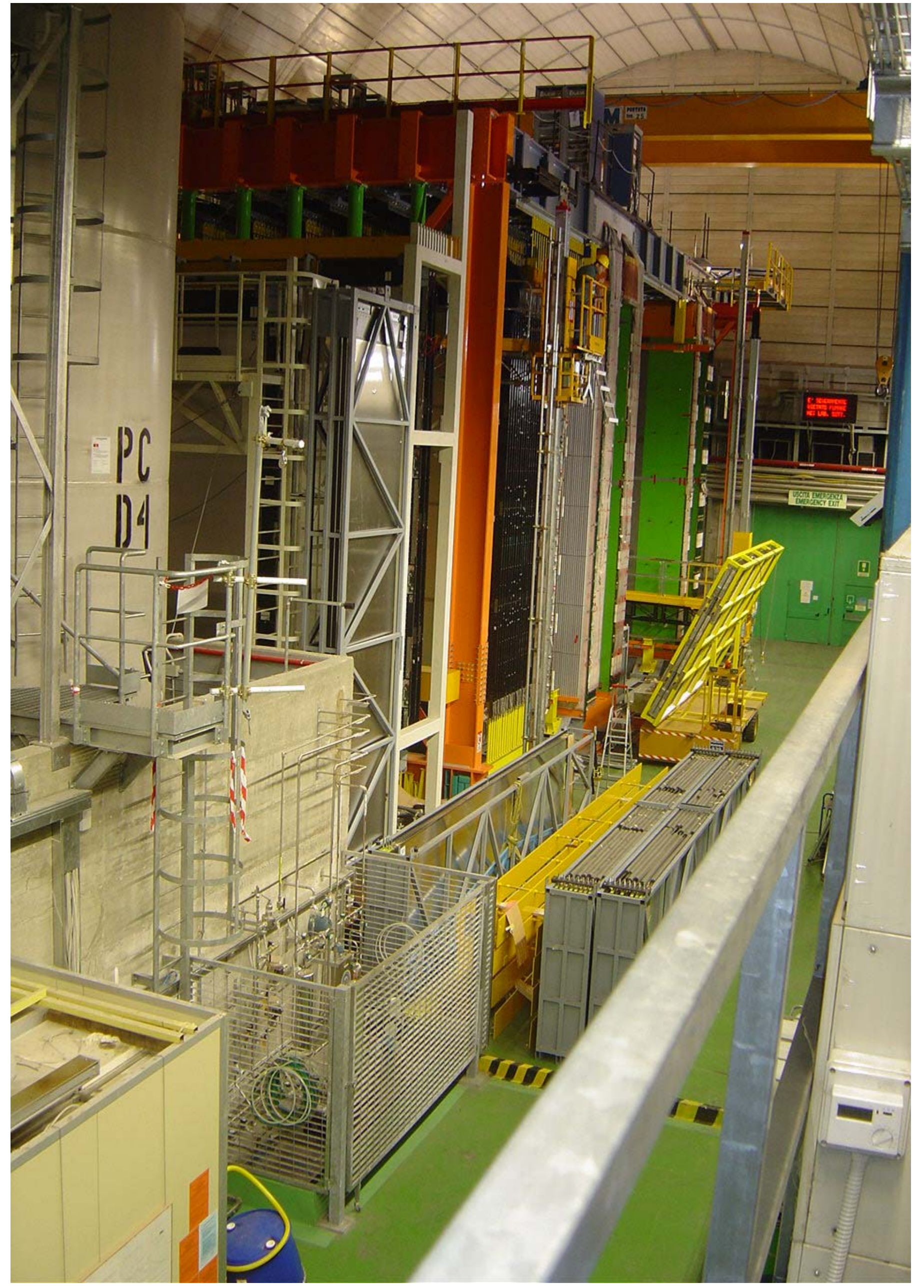
(momentum from multiple coulomb scattering)



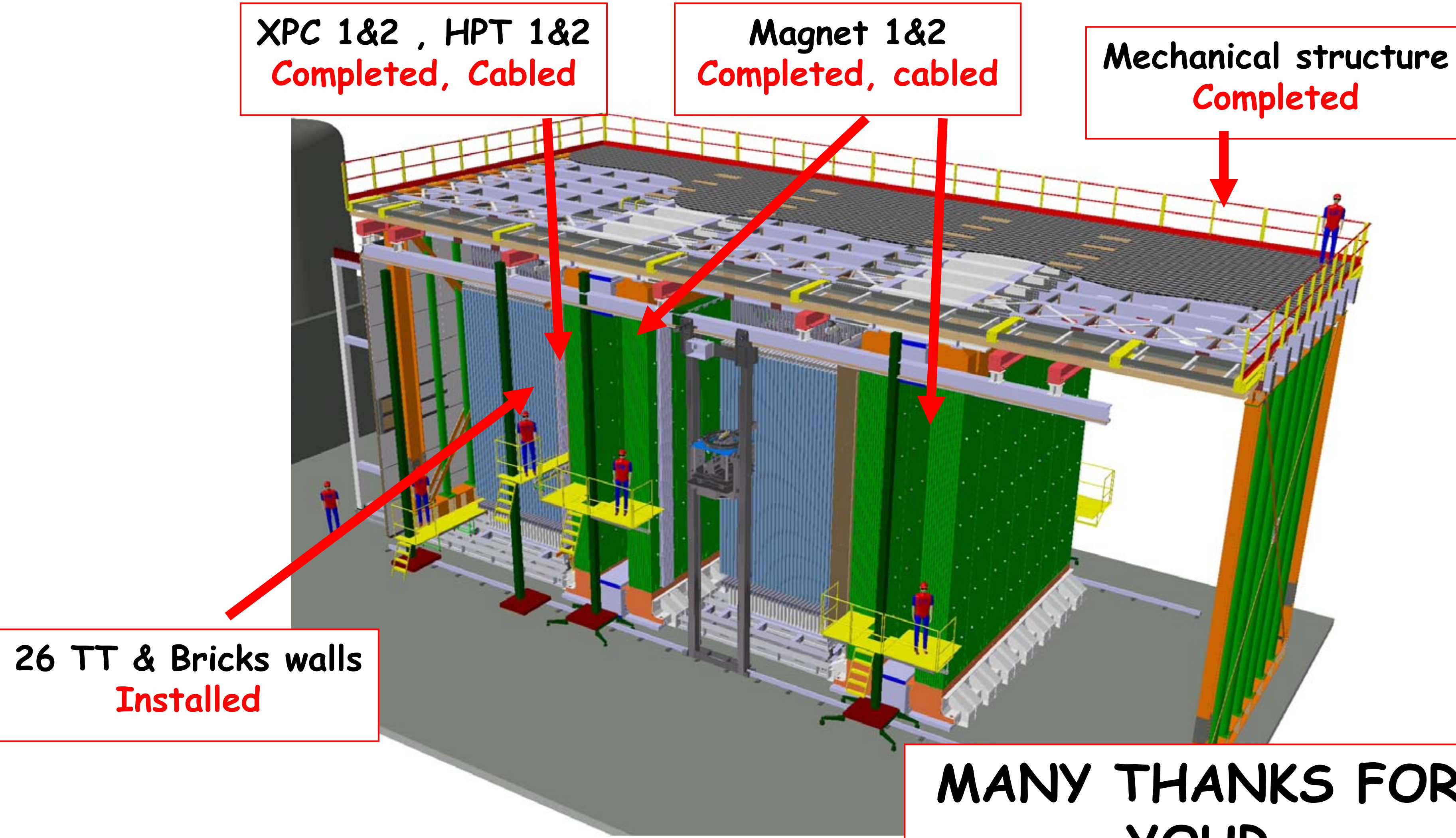
Electrons detection

- $\tau \rightarrow e$
- $\nu_\mu \rightarrow \nu_e$ appearance


NACANCO


PC
D4

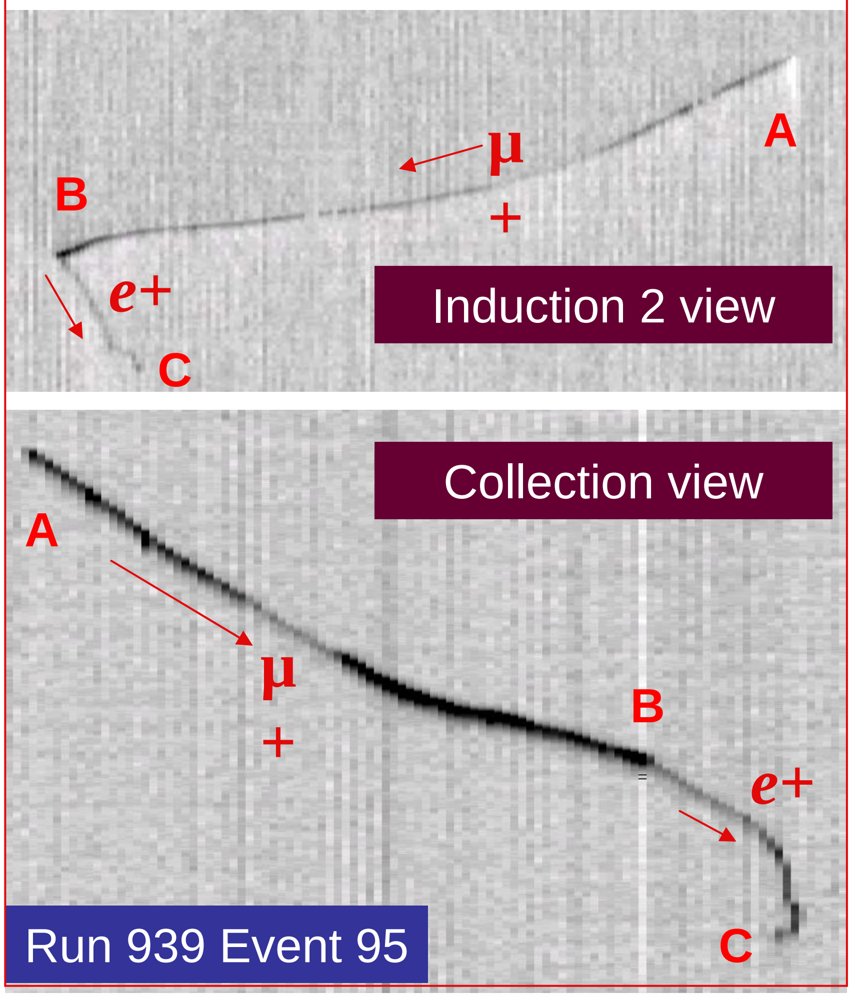
Status of the installation



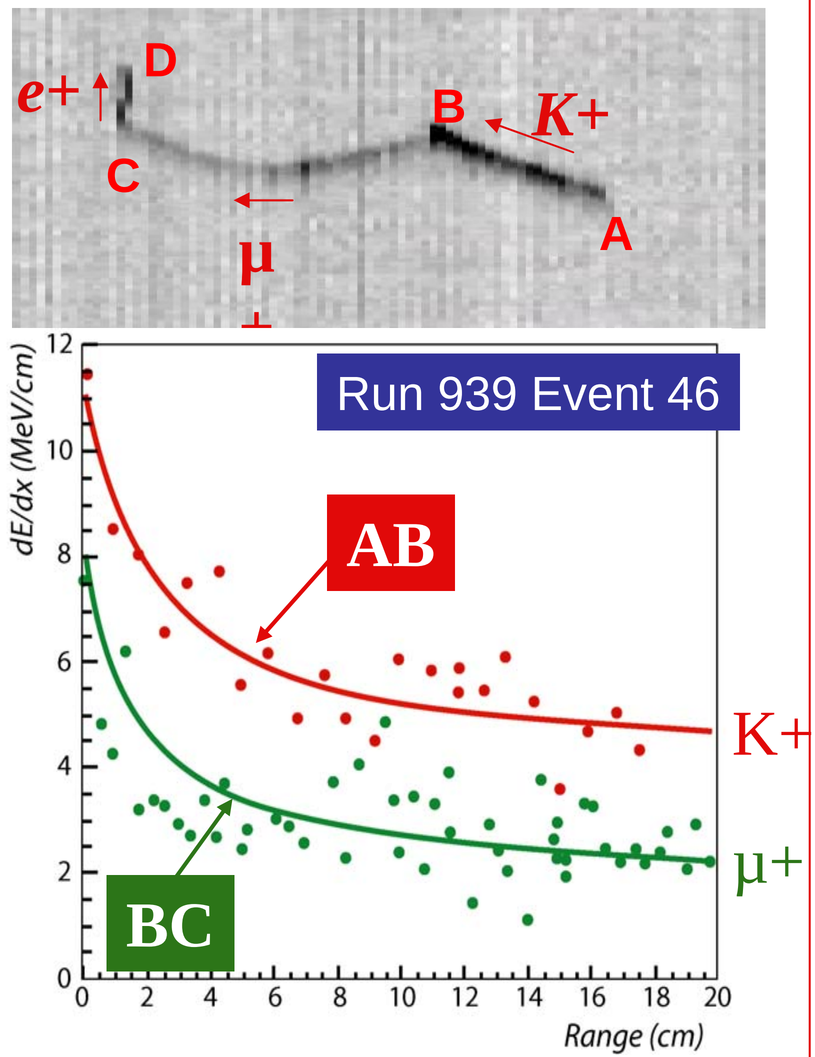
MANY THANKS FOR YOUR COLLABORATION !!!

ICARUS T300 Detector's performance

$$\mu^{+}[AB] \rightarrow e^{+}[BC]$$



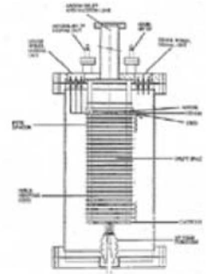
$$K^{+}[AB] \rightarrow \mu^{+}[BC] \rightarrow e^{+}[CD]$$



The path to larger liquid Argon detectors

24 cm drift wires chamber

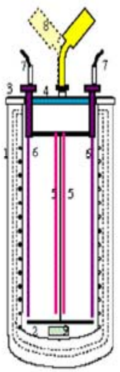
CERN 1



1987: First LAr TPC. Proof of principle. Measurements of TPC performances.

2

3 ton prototype



1991-1995: First demonstration of the LAr TPC on large masses. Measurement of the TPC performances. TMG doping.

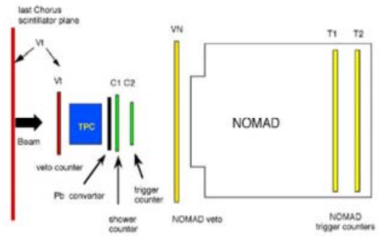
CERN

Laboratory work

50 litres prototype 1.4 m drift chamber

CERN

3



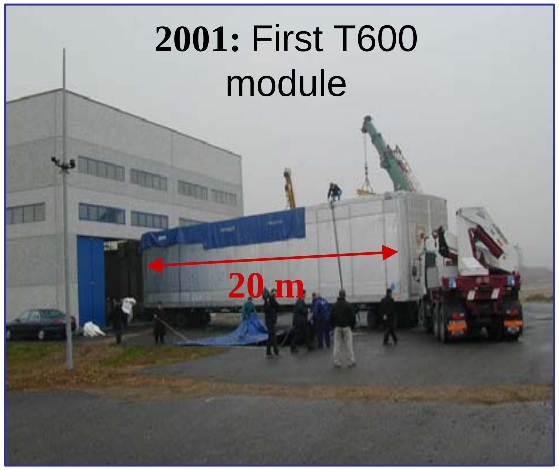
1997-1999: Neutrino beam events measurements. Readout electronics optimization. MLPB development and study. 1.4 m drift test.

4

10 m3 industrial prototype

1999-2000: Test of final industrial solutions for the wire chamber mechanics and readout electronics.

T600 detector



5

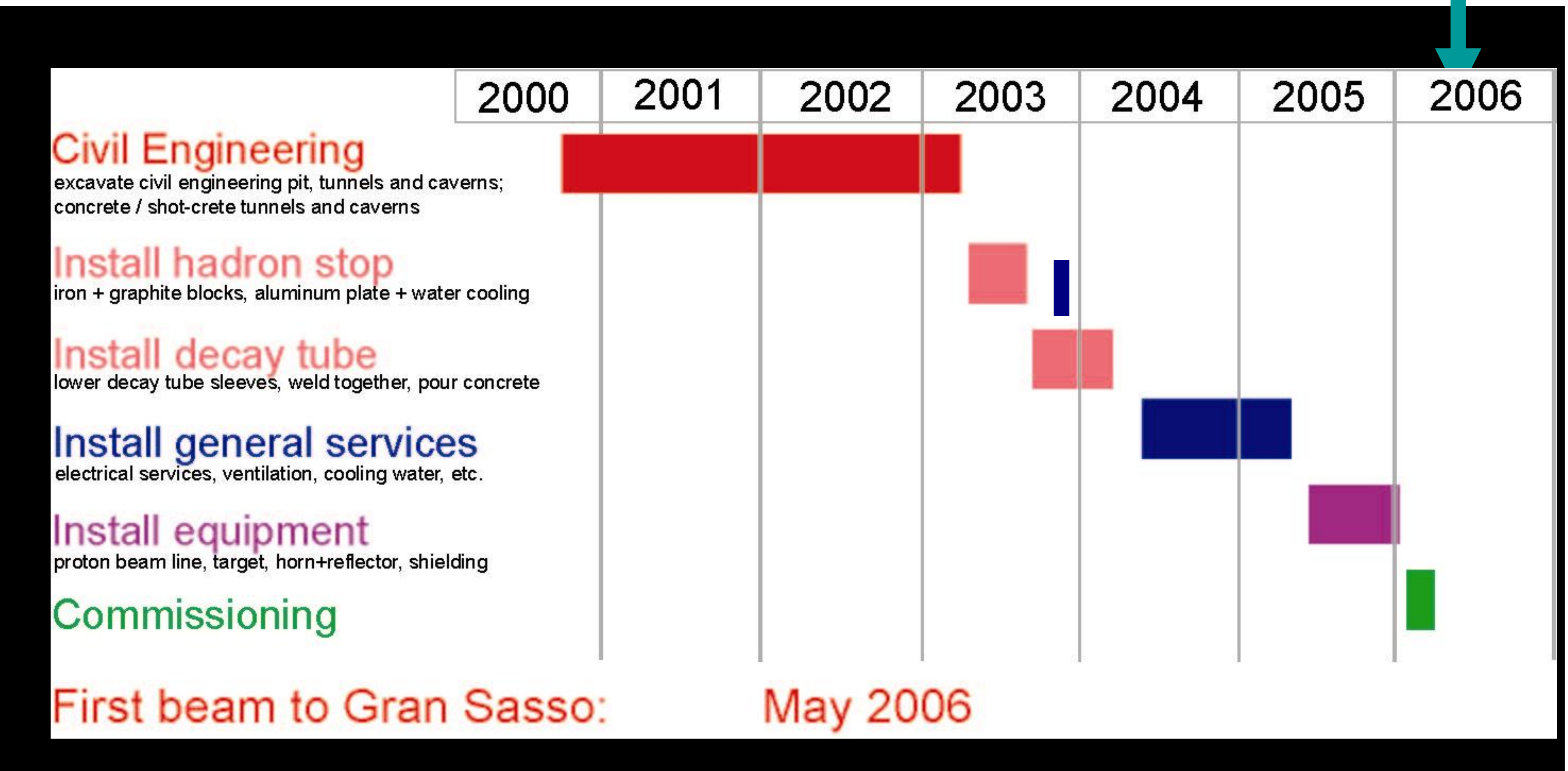
Cooperation with industry

Neutrino Beam CERN-Gran Sasso

CNGS schedule

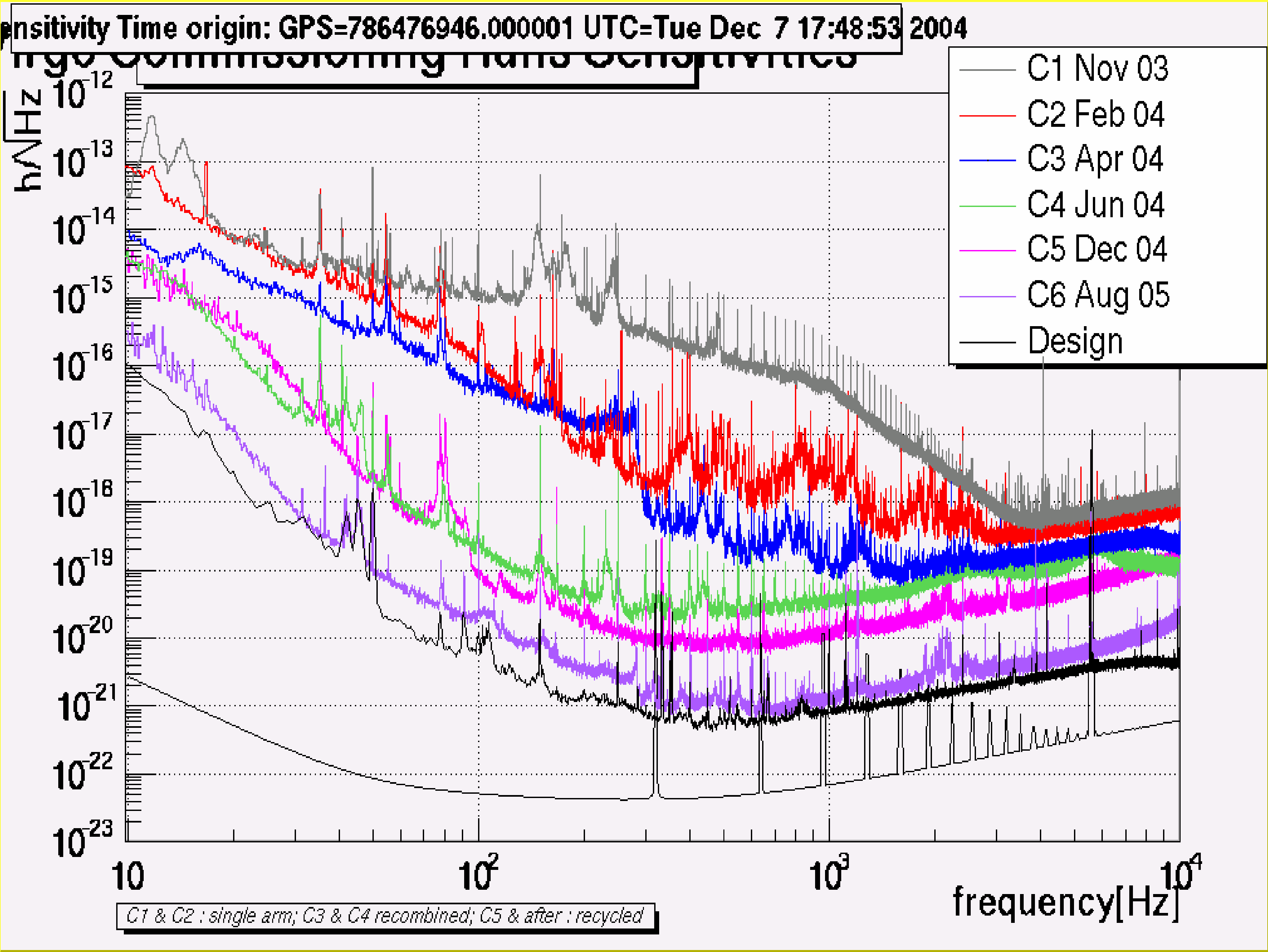
(schematic, simplified version)

"today"



Argo in Tibet: gamma astronomy

Virgo

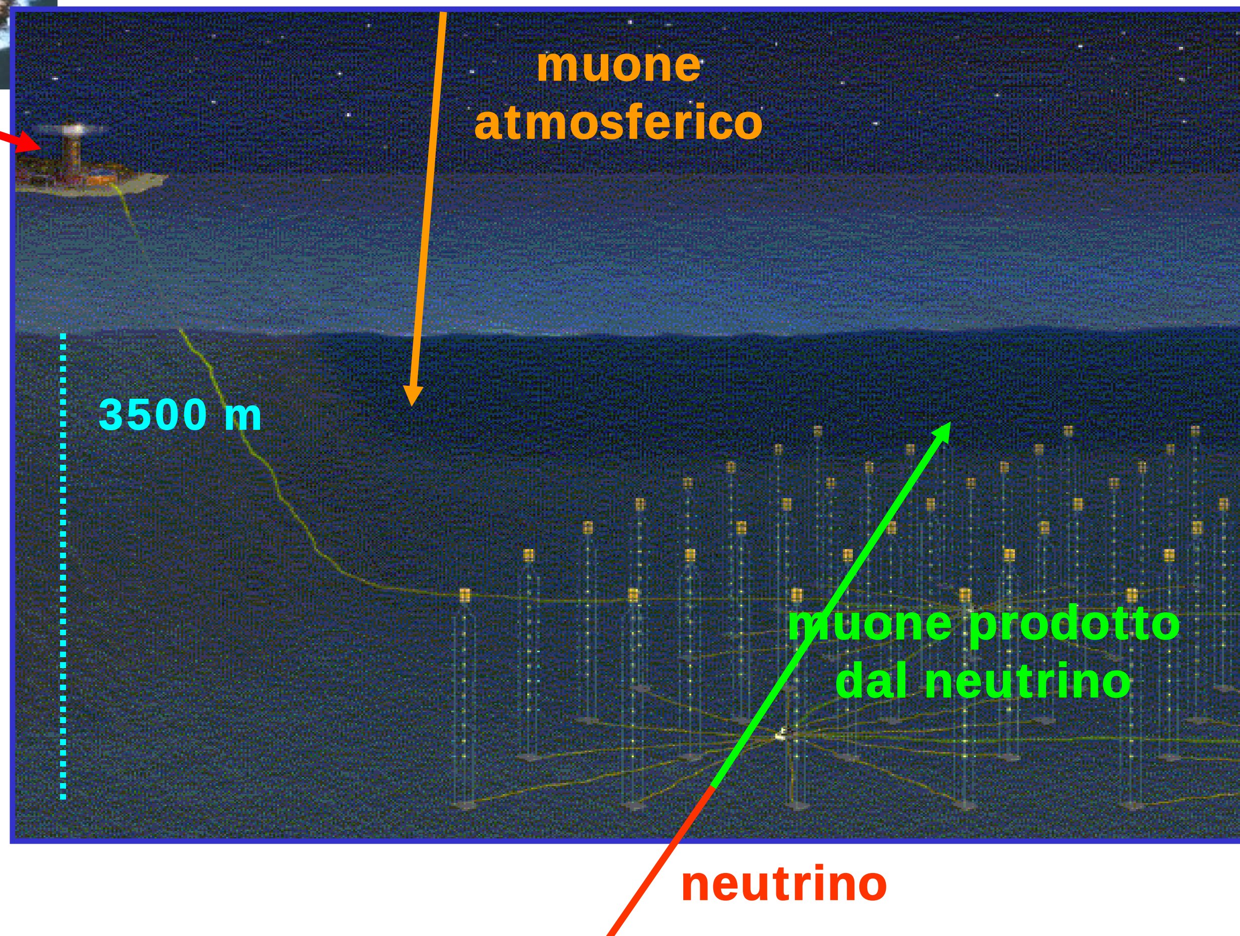

ensitivity Time origin: GPS=786476946.000001 UTC=Tue Dec 7 17:48:53 2004
h/√Hz
C1 Nov 03
C2 Feb 04
C3 Apr 04
C4 Jun 04
C5 Dec 04
C6 Aug 05
Design
10^-12
10^-13
10^-14
10^-15
10^-16
10^-17
10^-18
10^-19
10^-20
10^-21
10^-22
10^-23
10
10^2
10^3
10^4
frequency[Hz]
C1 & C2 : single arm; C3 & C4 recombined; C5 & after : recycled

Progetto NEMO

INFN Istituto Nazionale di Fisica Nucleare

Capo Passero

Layout of a km³ underwater telescope for high energy astrophisicals ν's

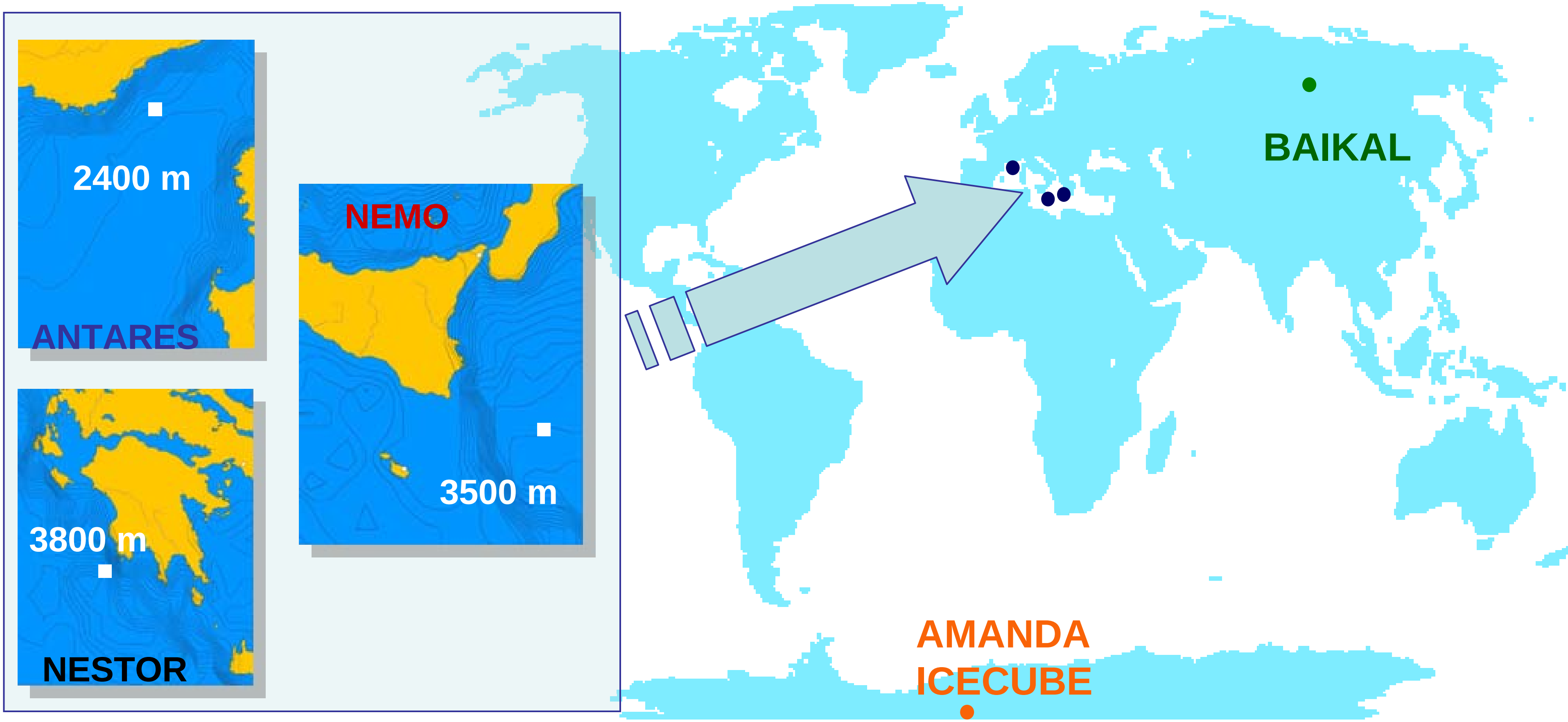


International status

BAIKAL, AMANDA: data taking

NESTOR, ANTARES, NEMO R&D: in construction

ICECUBE: in costruction, complete in 2010

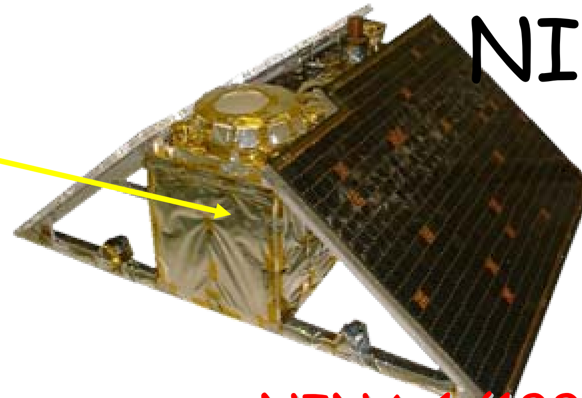


Cosmic radiation in space - antimatter

PAMELA-WiZard group (first INFN group in space)

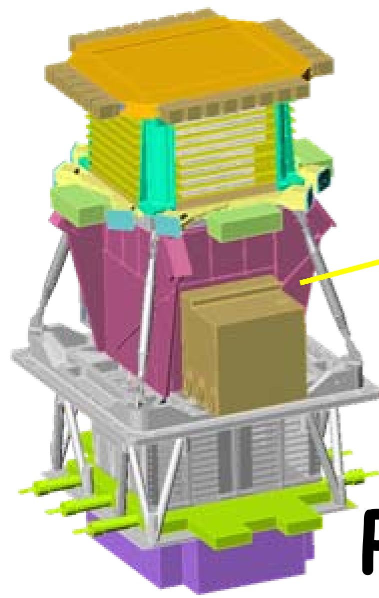
Balloons

- ✓ MASS-1 (1989)
- ✓ MASS-2 (1991)
- ✓ TrampSI (1993)
- ✓ CAPRICE (1994)
- ✓ CAPRICE (1997)
- ✓ CAPRICE (1998)
- ✓ CAPRICE



NINA

- ✓ NINA-1 (1998)
- ✓ NINA-2 (2000)

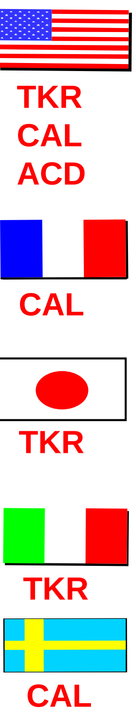


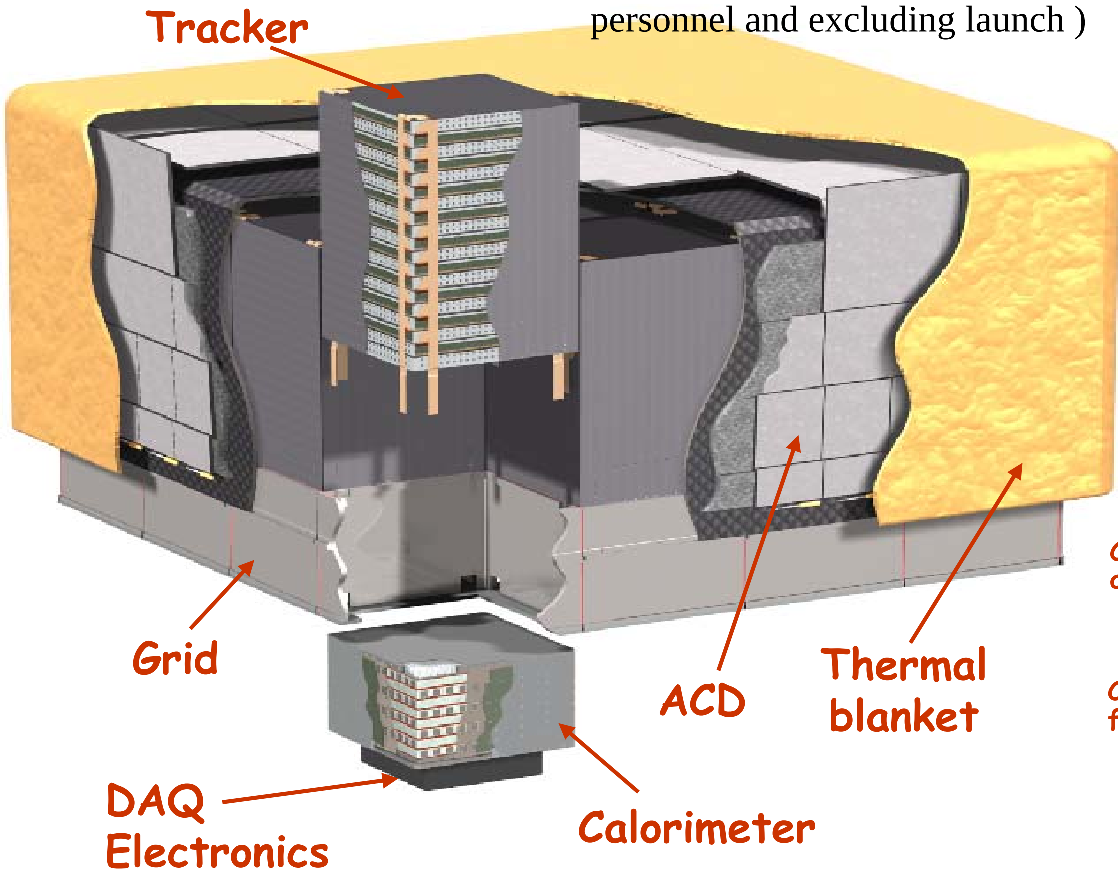
PAMELA

Cosmic rays space - γ astronomy GLAST

Main detector in GLAST : Large Area Telescope

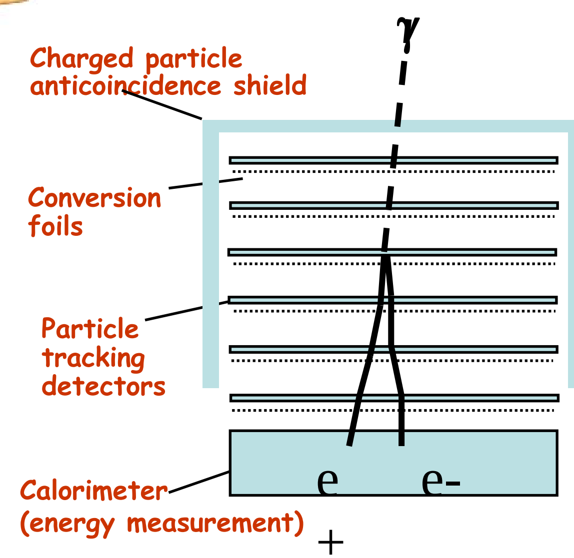
INFN 5.0 Meuro ASI 5.0 Total 183 MEURO (including personnel and excluding launch)





TKR (self-triggering)
- 16 towers
- 83m² total Si
- 11500 SSD, ~ 1M channels

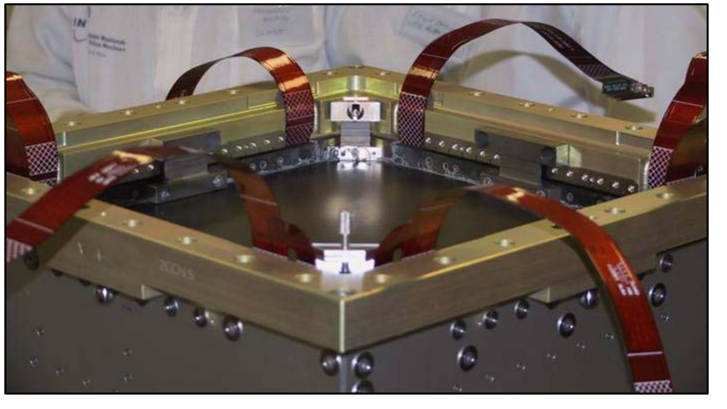
CAL (imaging)
- 96 CsI crystals / touer
- 8 layers of 12 crystals each
- each layer tilted 90°



GLAST uses modern technologies tested in particle physics : Silicon detectors and CsI crystals for electromagnetic calorimeters

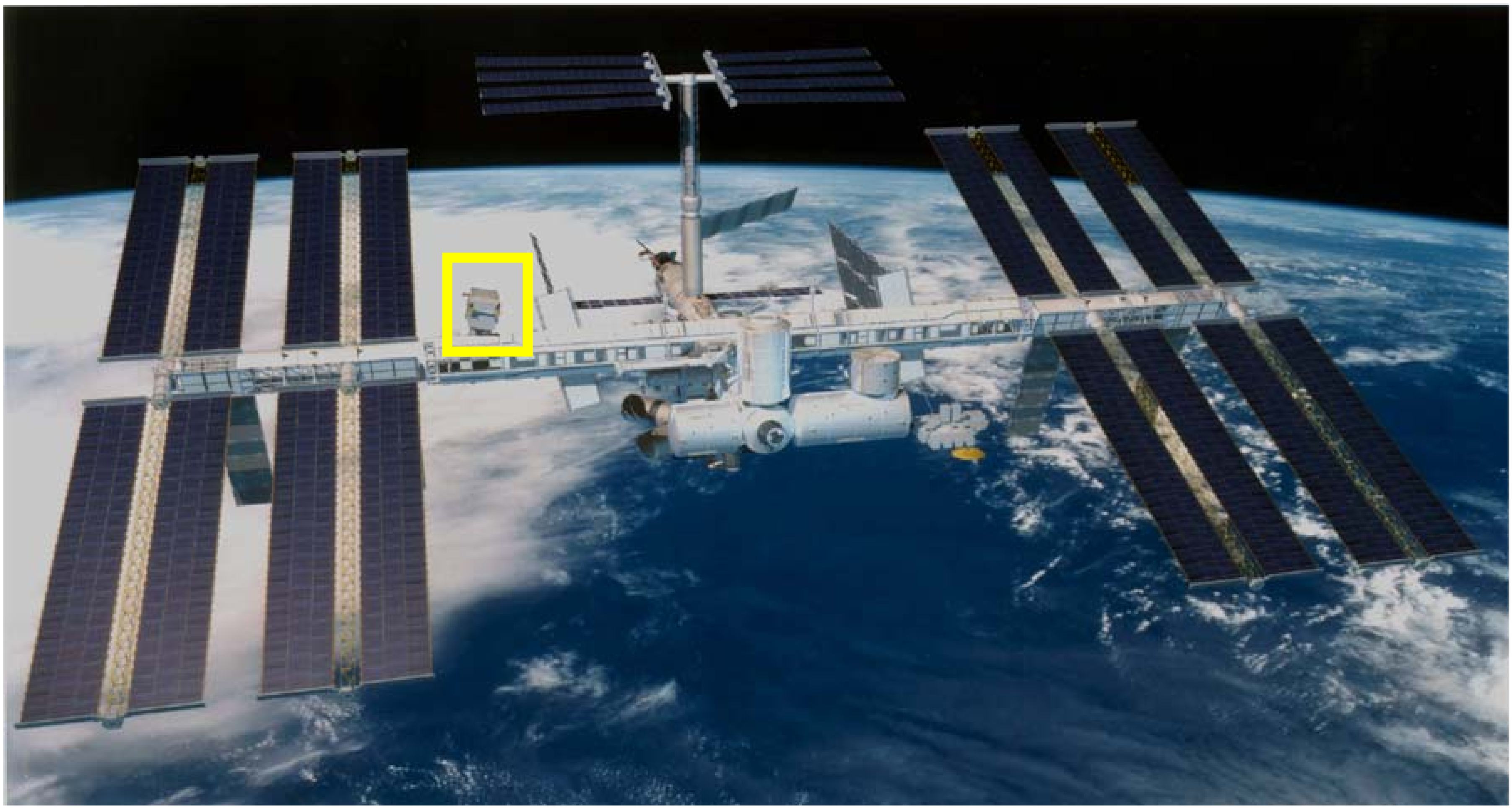
Launch 2007

GLAST:Tower assembly at INFN-Pisa



All towers built, shipped to SLAC and integrated in detector

AMS experiment on the ISS



Points of excellence of astroparticle physics

- Appearance oscillation experiment
- Liquid argon “electronic bubble chambers”
- Low noise detectors for neutrinoless double beta decays
- Cryogenic resonators for gravitational wave detection
- Deep water electro-mechanical experience
- Extensive areas gas counter deployments
- Silicon detectors for space missions

Nuclear physics

- Quark gluon plasma
- Nuclear matter in extreme conditions
- Radioactive ions: away from the stability region
- The nucleon spin structure functions
- Nuclear astrophysics

Infrastructures for nuclear physics

- Legnaro national Laboratory (SPES)
- Southern national Laboratory (Excyt)
- Underground nuclear astrophysics
- Alice-LHC
- Jefferson lab

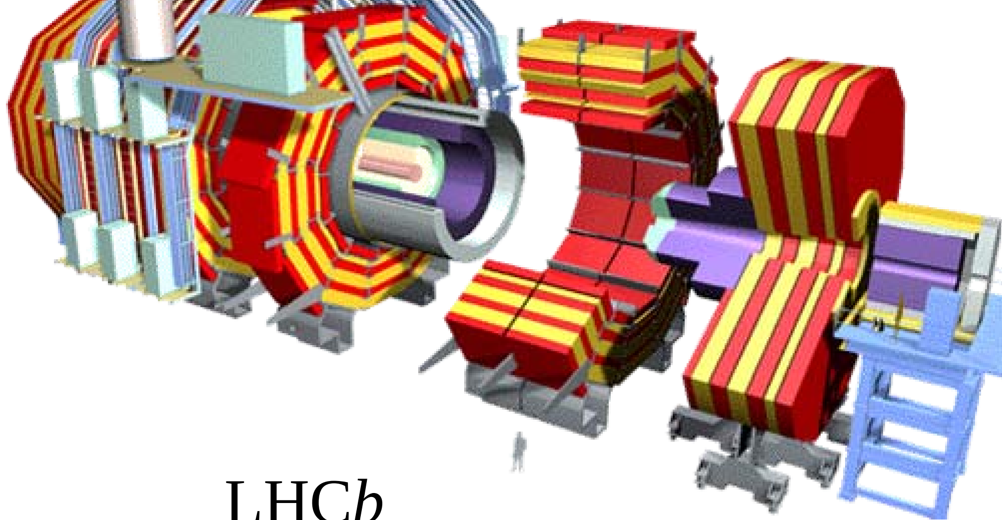
LNL

Laboratori di Legnaro

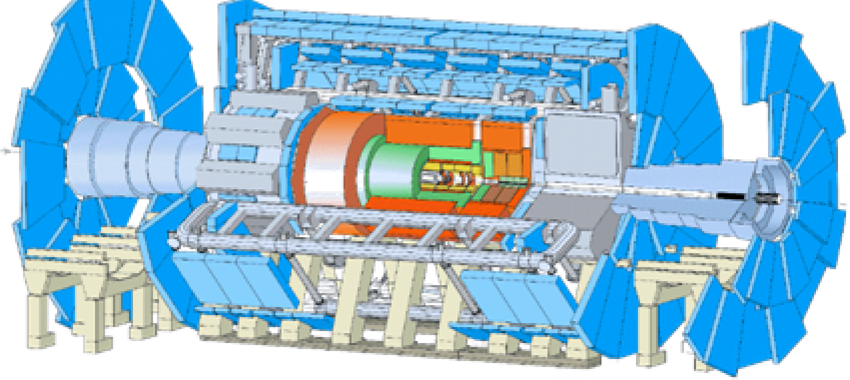
Superconducting Cyclotron

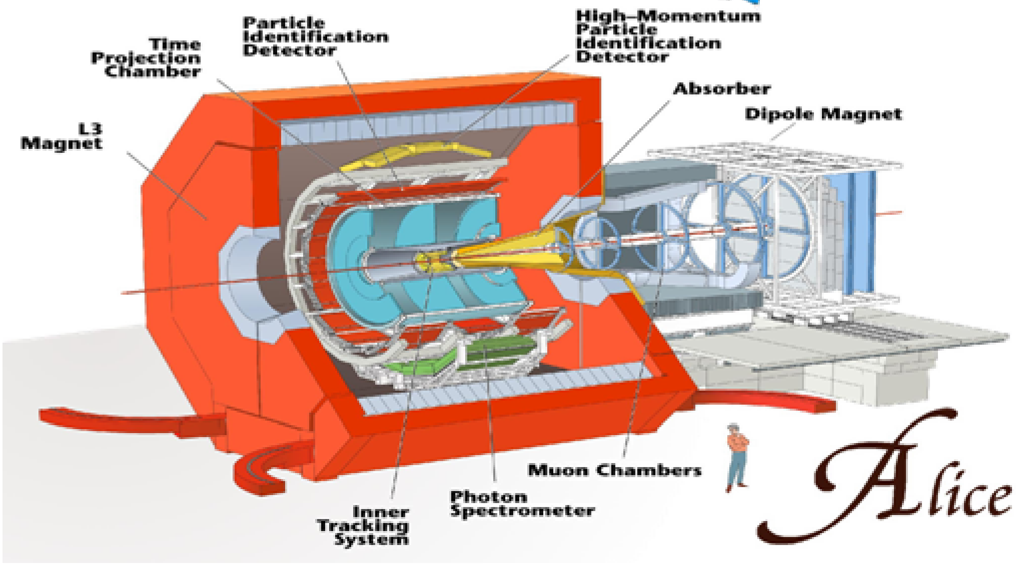
LHC Experiments

CMS

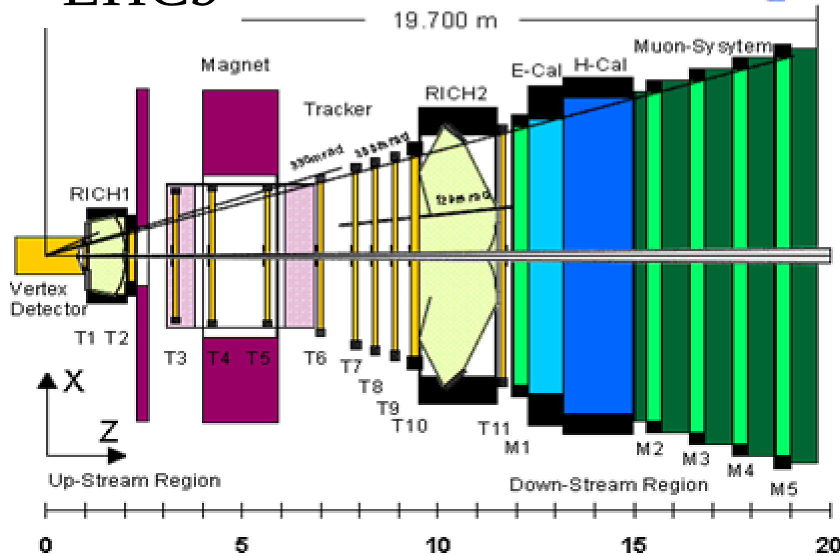


ATLAS

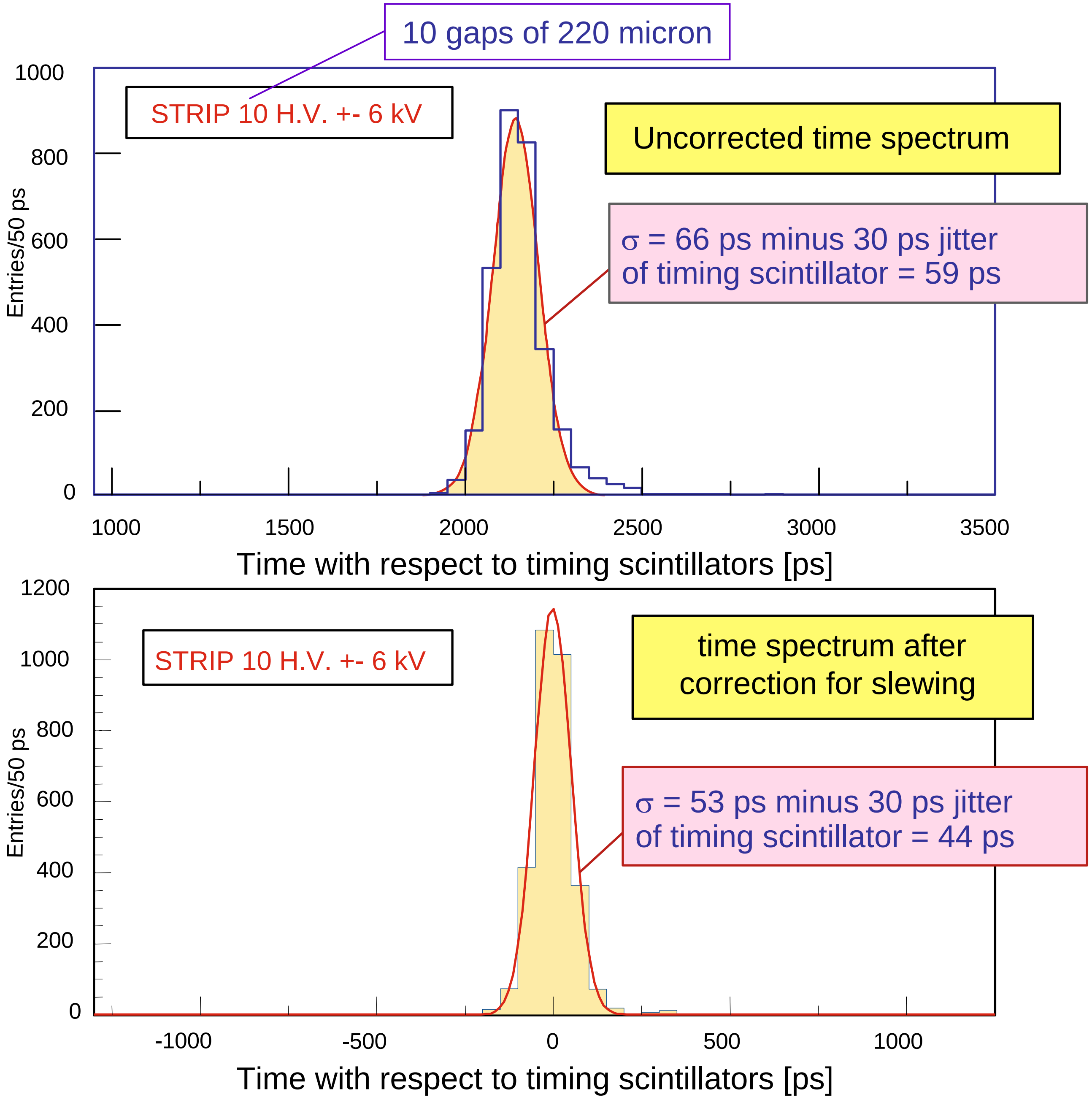




LHC*b*



The MRPC


10 gaps of 220 micron
STRIP 10 H.V. +- 6 kV
Uncorrected time spectrum
σ = 66 ps minus 30 ps jitter of timing scintillator = 59 ps
Entries/50 ps
Time with respect to timing scintillators [ps]
STRIP 10 H.V. +- 6 kV
time spectrum after correction for slewing
σ = 53 ps minus 30 ps jitter of timing scintillator = 44 ps
Entries/50 ps
Time with respect to timing scintillators [ps]

Points of excellence of nuclear physics

- Radioactive ion beams
- Precision measurements of low energy processes in stellar evolution
- Multigap RPC
- Application of nuclear physics to medicine and environment

The technology transfer

- The fifth scientific committee
- The TT committee

The fifth scientific committee

- Cutting edge technological research dedicated to:
  - Accelerators
  - Detectors
  - Interdisciplinary fields

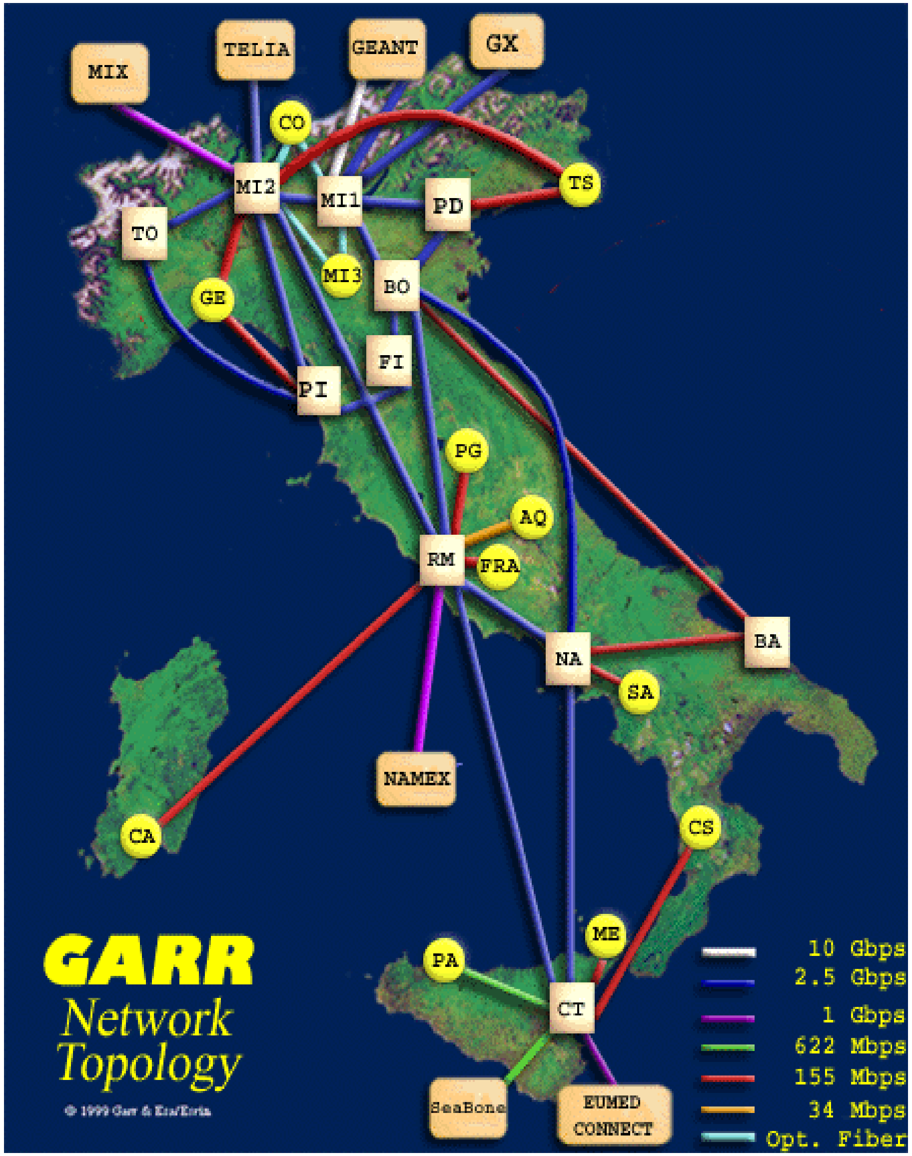
The committee for external education and technological transfer (TT)

- Mandate:
  - To promote the technology education (Masters)
    - Microelectronics
    - Surface treatments
    - Nuclear methods for cultural heritage
    - Informatics
    - Cancer therapy with accelerators
  - To assist the process of technology transfer
    - Patents
    - Contracts
  - To make the portfolio of INFN developments accessible to the industries

The main roads

- **Detectors**
  - Sensors
  - Dosimetry
  - Detectors for mammography, PET
- **Information technology**
  - GRID
  - Computer Aided Detection
  - Simulation codes for radiation damage (FLUKA)
  - High end computers (APE)

Research and Academic Networks



- INFN has been always at the forefront of network developments, building in past years GARR-B that aggregated Italian Universities and Research Centres at 5 Gbit/s
- Outstanding contribution for the fibre optic metropolitan nets, allowing researchers in the Southern regions to contribute more effectively to large-scale scientific programs
  - Important opportunities offered also to Countries facing the Mediterranean Sea
- Active participation in EU 5th and 6th Framework programs
- Now INFN operates within the Consortium GARR, with a backbone at 50 Gbit/s and connection to the Pan-European Network GEANT at 10 Gbit/s
- Extremely beneficial to academic and research communities for participating to international projects

The main roads

- **Accelerators**
  - X_FEL, monochromatic X rays
  - Gantries
  - Cultural heritage
  - Pollution
  - hadrontherapy

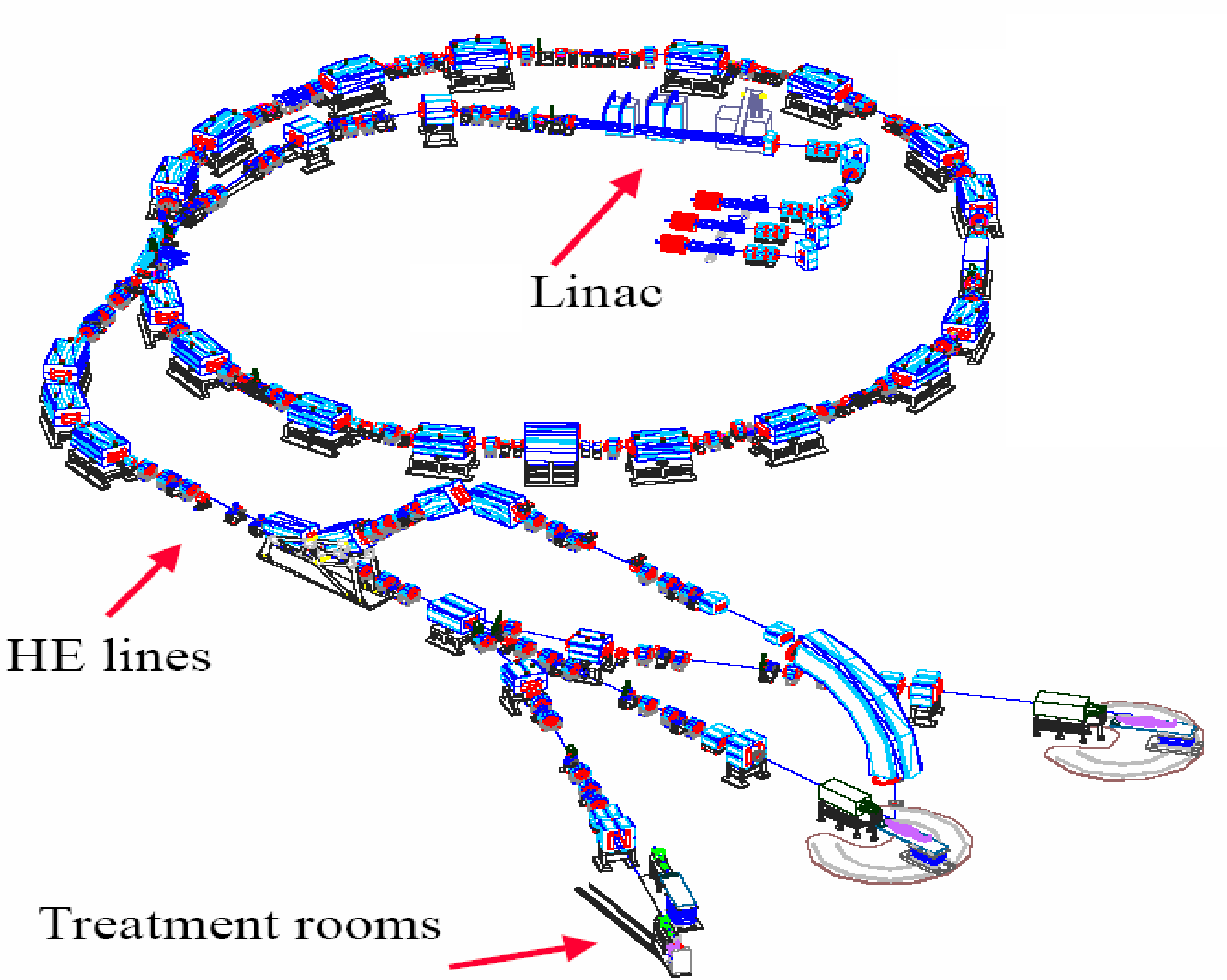
hadrontherapy

- The CATANA experience
  - 79 treated patients with uval melanoma
  - First definition of the cost of a hadrontherapy session
  - An experience at a physics lab, the INFNnational southern laboratory

CATANA from april 2005.

The CNAO facility in Pavia

- A ion machine based on a synchrotron
- The basic project from TERA
- INFN heavily involved in its realization (co-direction with CNAO and responsability of many tasks)
- Support form other scientific institutions (CERN, GSI)
- The current european solution for fully operating light ions machines


Linac
HE lines
Treatment rooms

Innovative options

- Dosimetry
- Gantry
- Beam scanning
- A new multiparticle cyclotron

High end computing

- APE: custom parallel machines for computer simulations
  - Last generation: apeNEXT
    - 12 Teraflops peak speed installation
    - Skills in computer architectures
  - APEnet: a new PC communication card based on ape_custom 3-d architecture
- *Petaflop* project under study

Special labs

- Labec: the laboratory for cultural heritage preservation
- EGO: the international european gravitational observatory
- Galileo Galilei Institute in Florence: an “italian summer” institute for theoretical physics

The perspectives: the INFN roadmap recommandations

- **sees the full exploitation of LHC as a first priority in the coming years**. It also encourages and **supports discussions on possible second phase upgrades of the machine**, either in luminosity and/or in energy.

- **the Institute supports the current global effort toward a technical design for the International Linear Collider Project**

Roadmap recommandations

- The detection of rare events, and in particular of flavour changing neutral currents, may then lead to information complementary to that coming from high energy accelerators. **INFN supports an activity in this field, by encouraging the design of new flavour factories and of very intense proton beams**

Roadmap recommandations

- **INFN prepares for a new generation machine at Frascati**,
- **INFN strongly encourages feasibility studies of flavour factories embodying ILC technology** from which an even more ambitious strategy for Frascati may arise.

Roadmap recommandations

- **INFN sees further collaborations with existing projects intimately related to the development at Gran Sasso of the prototypes of the new generation cryogenic detectors. The nature of neutrino will be also investigated by the forthcoming large mass experiment dedicated to the detection of a double beta decay without neutrinos, relying on an internationally recognised leadership in this field**

Roadmap recommandations

- **The current strategy on gravitational wave detection involves a partnership collaboration with the Ligo US interferometer and points in the next few years to a powerful upgrade for a goal sensitivity of Virgo at low frequencies unique in the world. A concurrent development of new concepts of resonating antennas is also foreseen in the next five years that may reach the future interferometer sensitivity levels**

Roadmap recommandations

- Besides a large effort currently deployed on large array earth based detectors to detect messengers from the space, a novel sector is expected to born, the one of neutrino astronomy, based on large mass of water monitored by impressive arrays of underwater photo multipliers. The goal is a mass coverage of a cubic kilometre of sea water and **INFN bids for the future location of such an European infrastructure in Sicily**, nearby Capo Passero, fully supported by the INFN Southern National Laboratory.

Roadmap recommandations

- **The detection at the LHC of the quark gluon plasma**,
- the study of neutron enriched nuclei, away from the stability valley brings to **the project of constructing** in the National laboratory of Legnaro, near Padua**, a high intensity proton beam of 40 MeV to create radioactive beams after scattering on thin targets**

Roadmap recommandations

- **INFN will host the new projects of a superconducting multi ion cyclotron accelerator for cancer therapy and of a free electron laser**.

Fields of activity of common interest with Japan

- Accelerator technology: ILC, flavour factories, high intensity frontier
- Astroparticle physics: oscillation experiments, cryogenic detectors
- Numerical simulations: lattice gauge theory

- INFN supports wide international collaborations and the exchange of scientists within specific agreements
- We look forward to further developments of global cooperation

Thank you!

Grazie!