
Laboratori Nazionali del Gran Sasso
Princeton 10/15/2013
Stefano Ragazzi LNGS Director

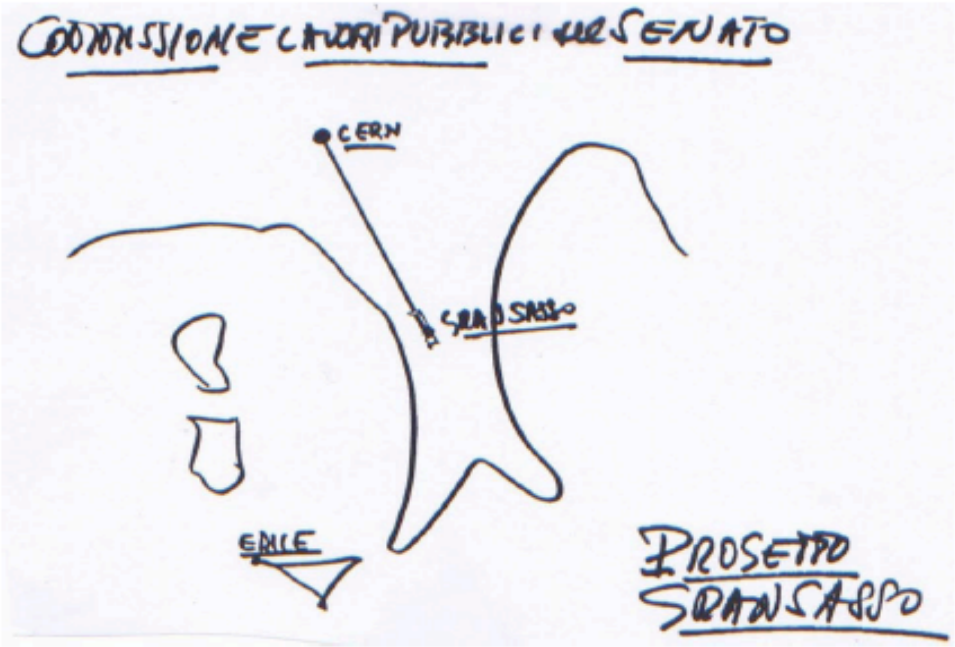
many thanks to

- Italian Consulate in Newark
- Princeton University and Physics Department
- All organizers
- All participants

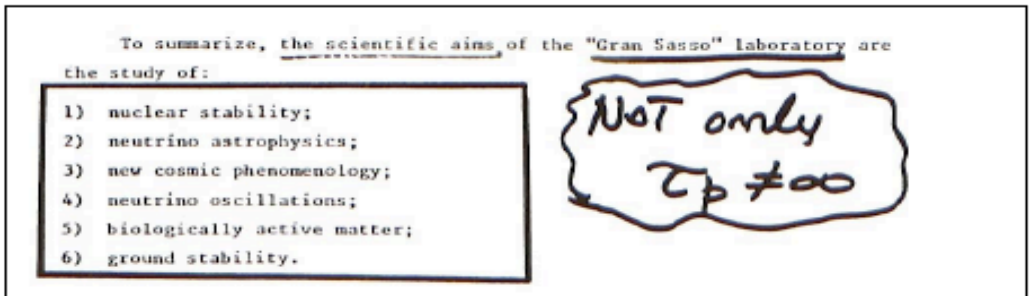
for organizing supporting and making this meeting possible

LNGS – early history

- 1979: proposal by A. Zichichi to Italian Parliament
- 1982: Approval of LNGS construction
- 1987: construction completed
- 1989: Start data taking of first large experiment (MACRO)



Note manoscritte di A. Zichichi presentate nella Seduta della Commissione Lavori Pubblici del Senato convocata con urgenza dal Presidente del Senato per discutere la proposta del Progetto Gran Sasso (1979).

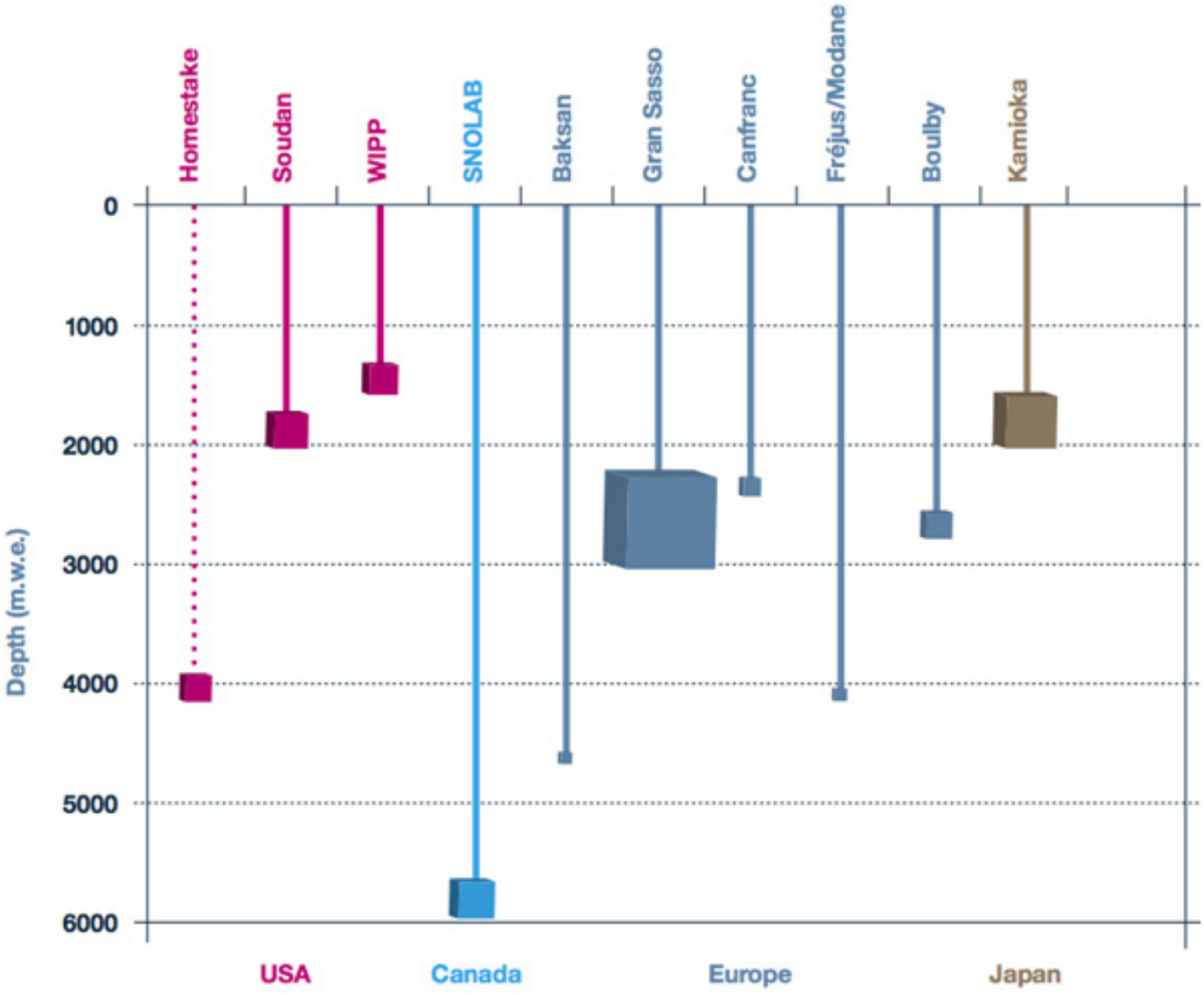


LNGS

design and construction

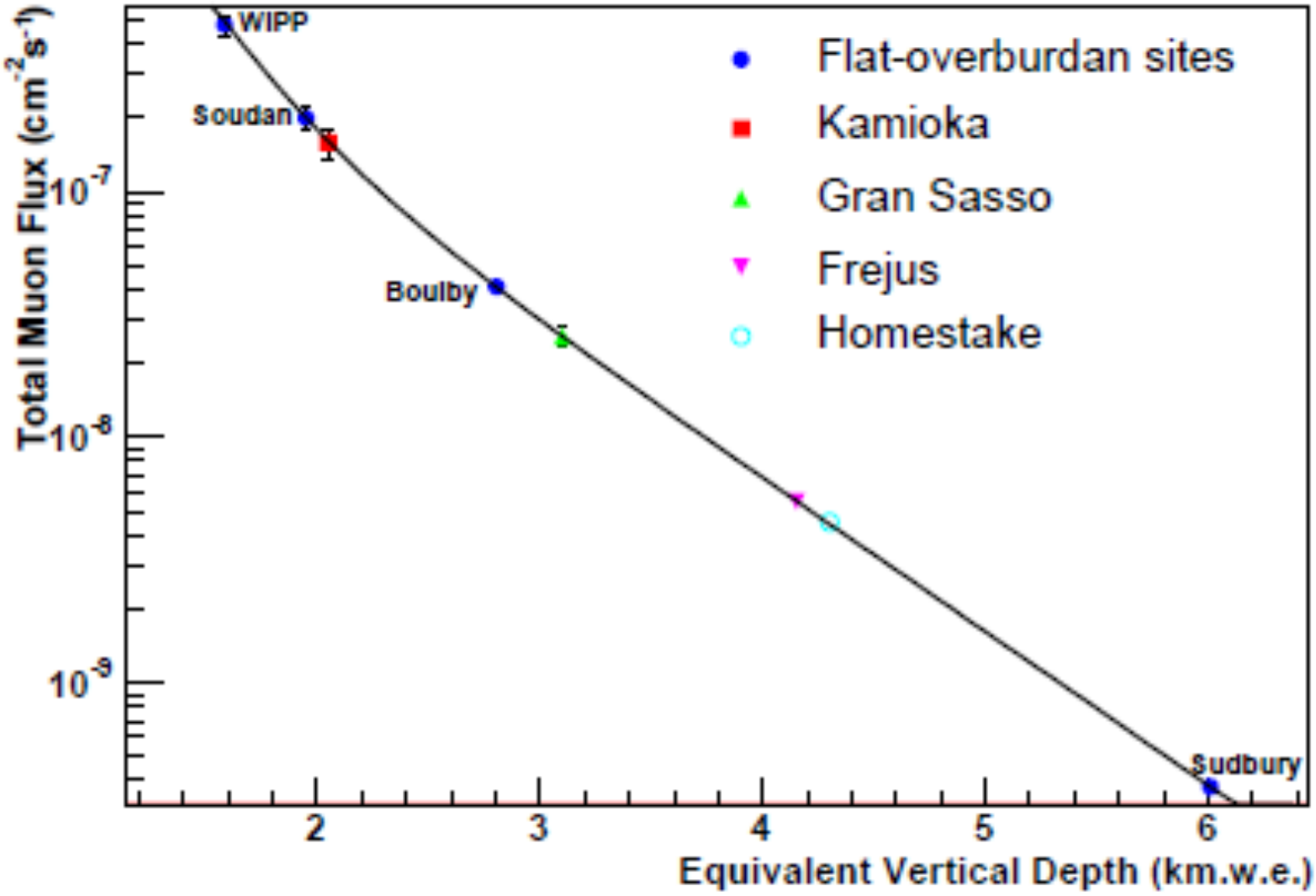
Underground Science Laboratories

- LNGS
  - largest
  - easiest to access



Plot adapted from http://www.deepscience.org/contents/facilities.shtml

Muon Flux versus depth



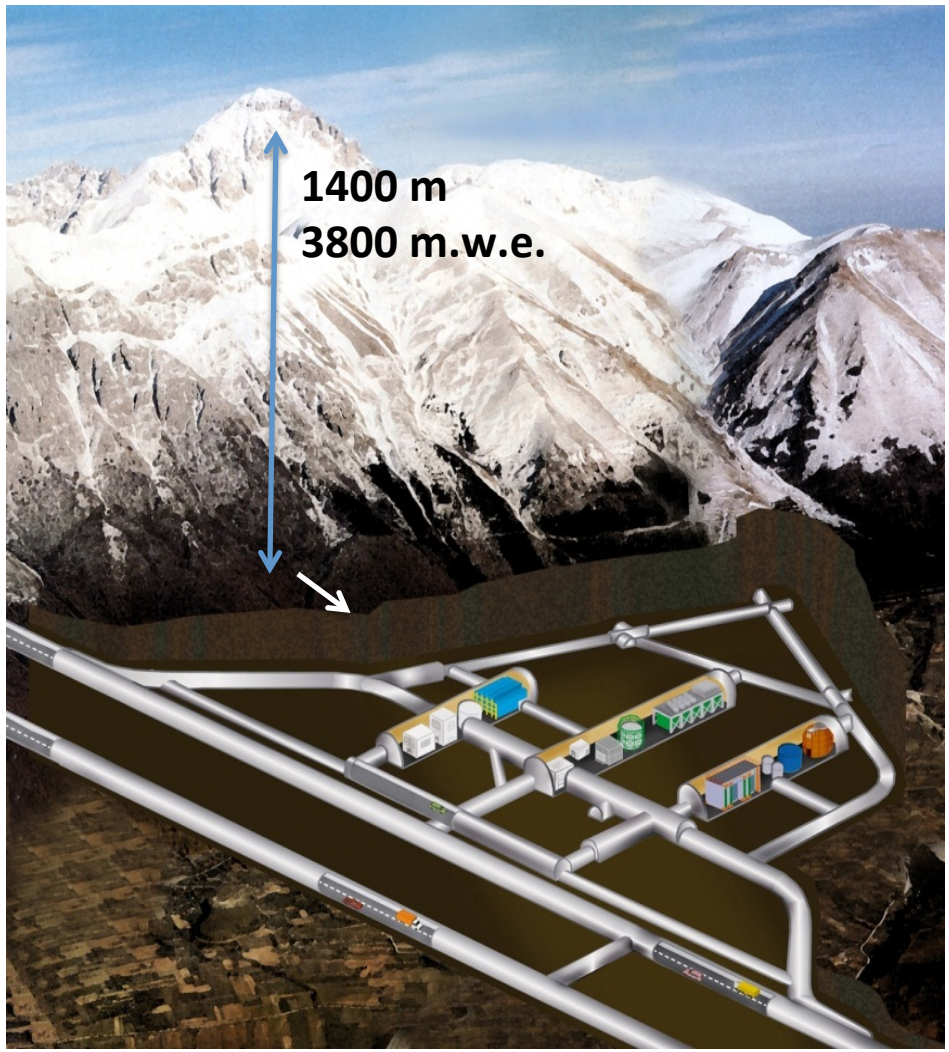
Hime and Mei, Phys.Rev. D73 (2006) 053004

The LNGS Laboratory

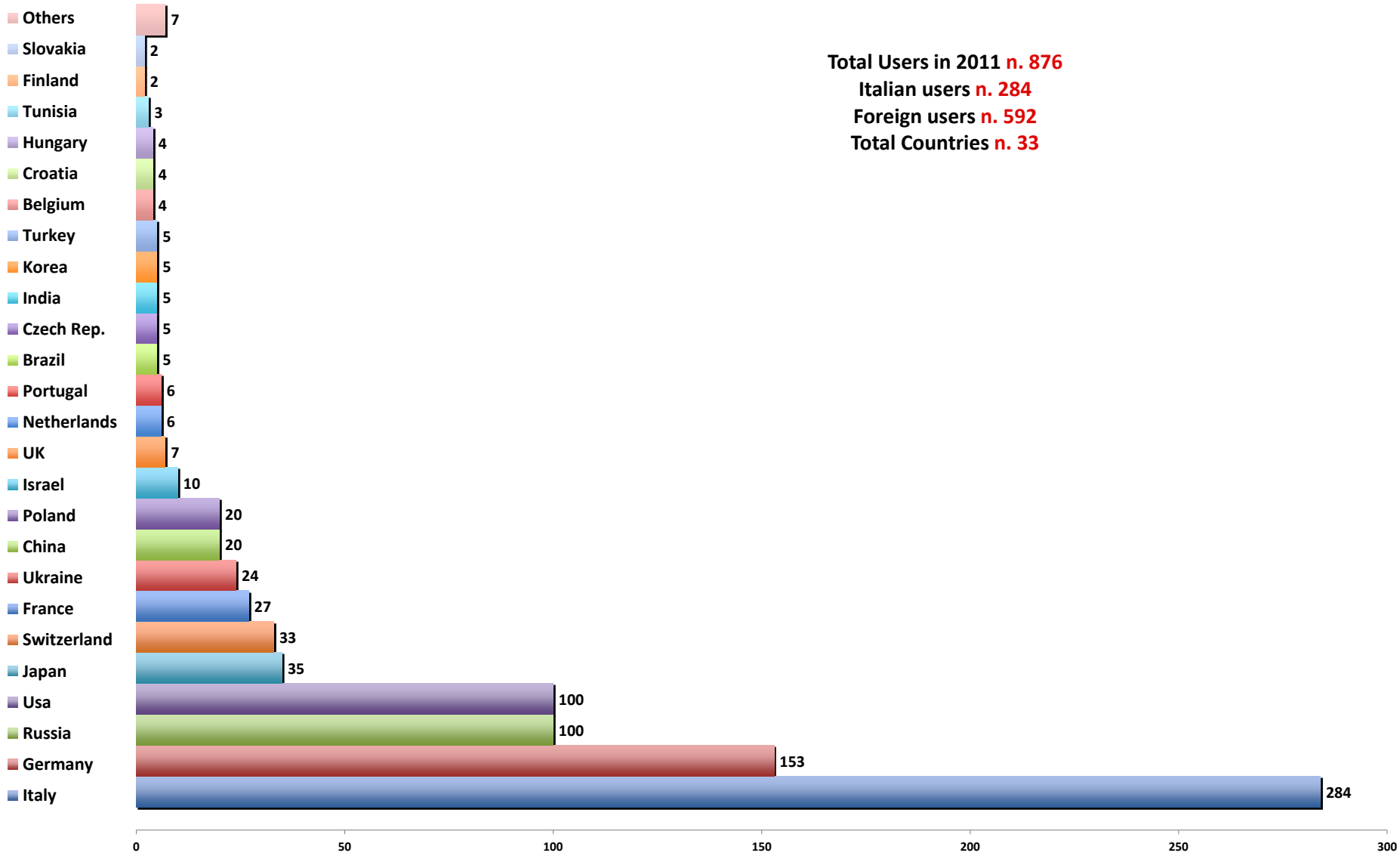
SHIELDING is the main facility

- Muon flux: 3.0 10^{-4} $m^{-2}s^{-1}$
- Neutron flux:
  - 2.92 10^{-6} $cm^{-2}s^{-1}$ (0-1 keV)
  - 0.86 10^{-6} $cm^{-2}s^{-1}$ (> 1 keV)
- Rn in air: 20-80 Bq m^{-3}
- Surface: 17 800 m^2
- Volume: 180 000 m^3
- Ventilation: 1 vol / 3 hours

Effective allocation of underground areas is essential



An International Laboratory



Total Users in 2011 n. 876
Italian users n. 284
Foreign users n. 592
Total Countries n. 33

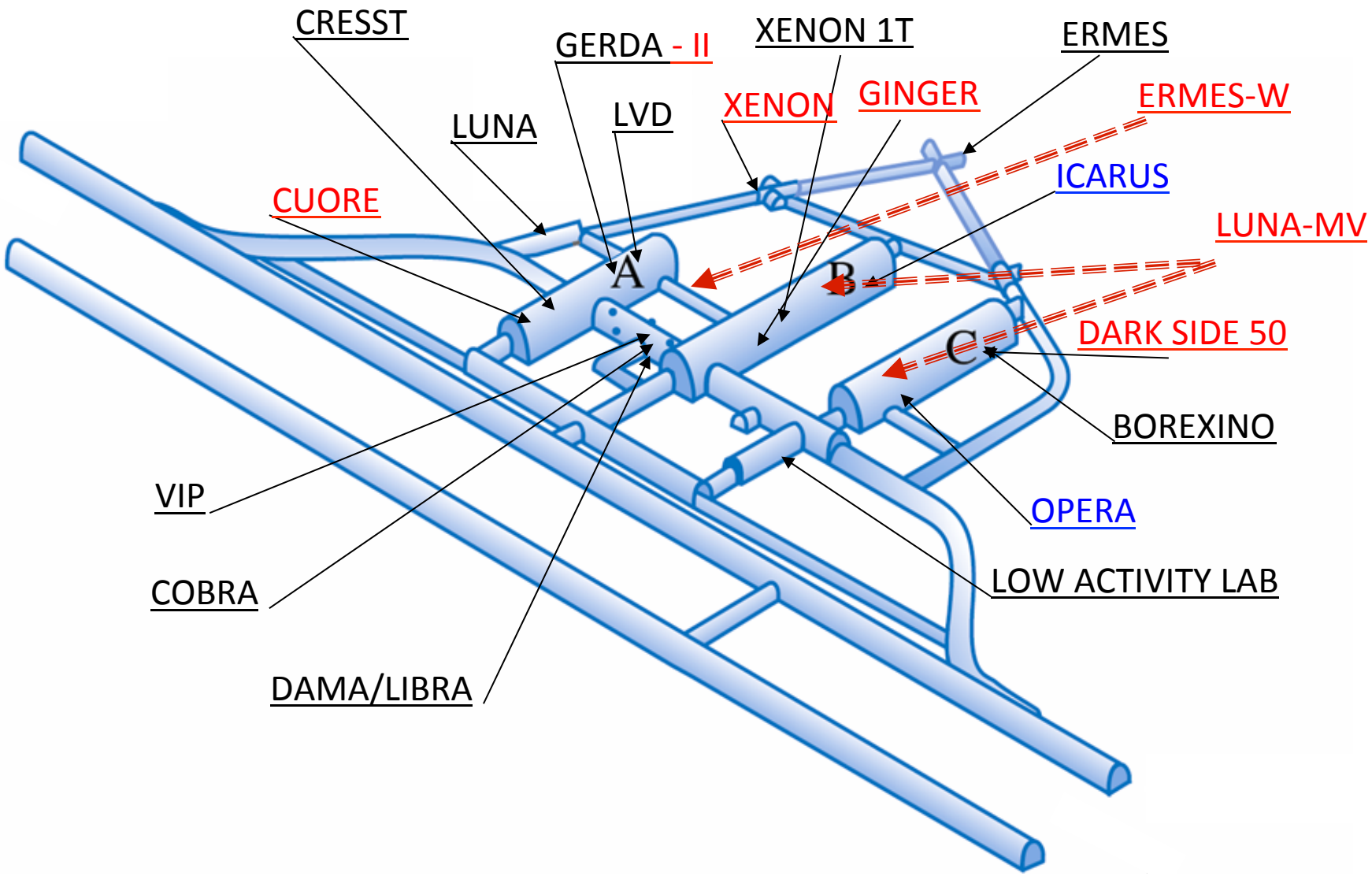
Personnel

- Research
  - 10 permanent staff (- 3 on leave)
  - 7 limited time staff
  - 10 post-doc fellowships (8 INFN, 2 POR)
  - 8 graduate and undergraduate fellowships
- Technology and Engineering
  - 15 permanent staff (- 1 on leave)
  - 6 limited-time staff
  - 2 post-doc fellowships
  - 10 graduate and undergraduate fellowships
- Technicians
  - 24 permanent staff
  - 3 limited time staff
  - 2 fellowships
- Administration
  - 19 permanent staff
  - 3 limited time staff
  - 1 fellowship
- Other support staff
  - 7 permanent

LNGS – 25 years

- In 25 years LNGS evolved
  - from: UG space tailored around a few experiments
  - to: a multi purpose UG science facility

Busy laboratory

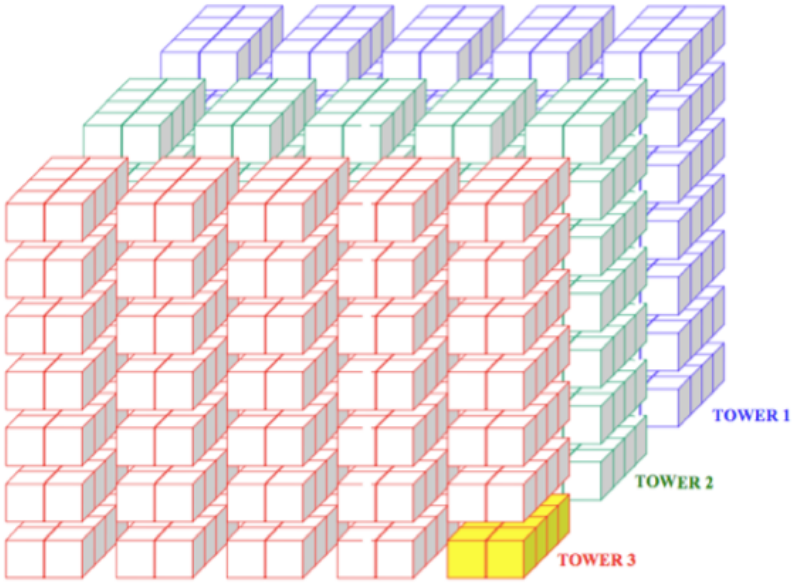


Neutrino physics

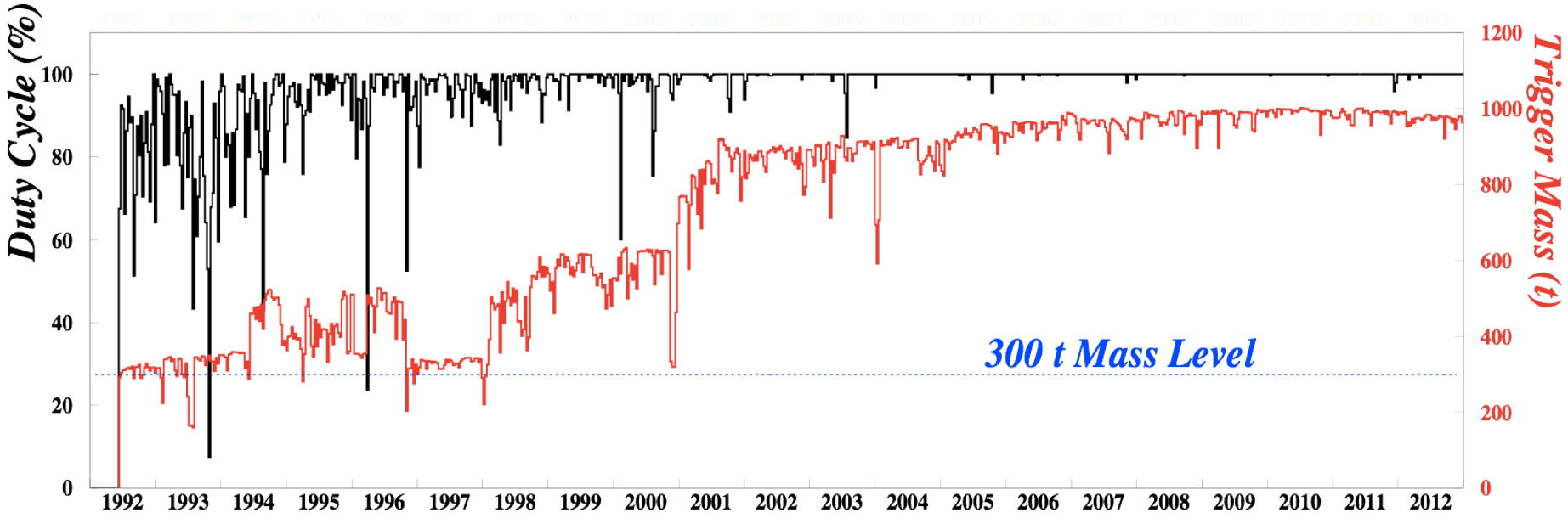
- neutrino oscillations
  - Opera, Icarus: the recent past
  - Borexino-SOX: the future
- solar physics
  - Borexino
- cosmogenic and geo neutrinos
  - LVD, Borexino
- double beta decay
  - GERDA: phase-I completed, phase-II in preparation *(Macolino)*
  - COBRA
  - CUORICINO, CUORE (2015)
  - LUCIFER R&D

LVD

- A survivor of the first-generation LNGS experiments: waiting for a Supernova

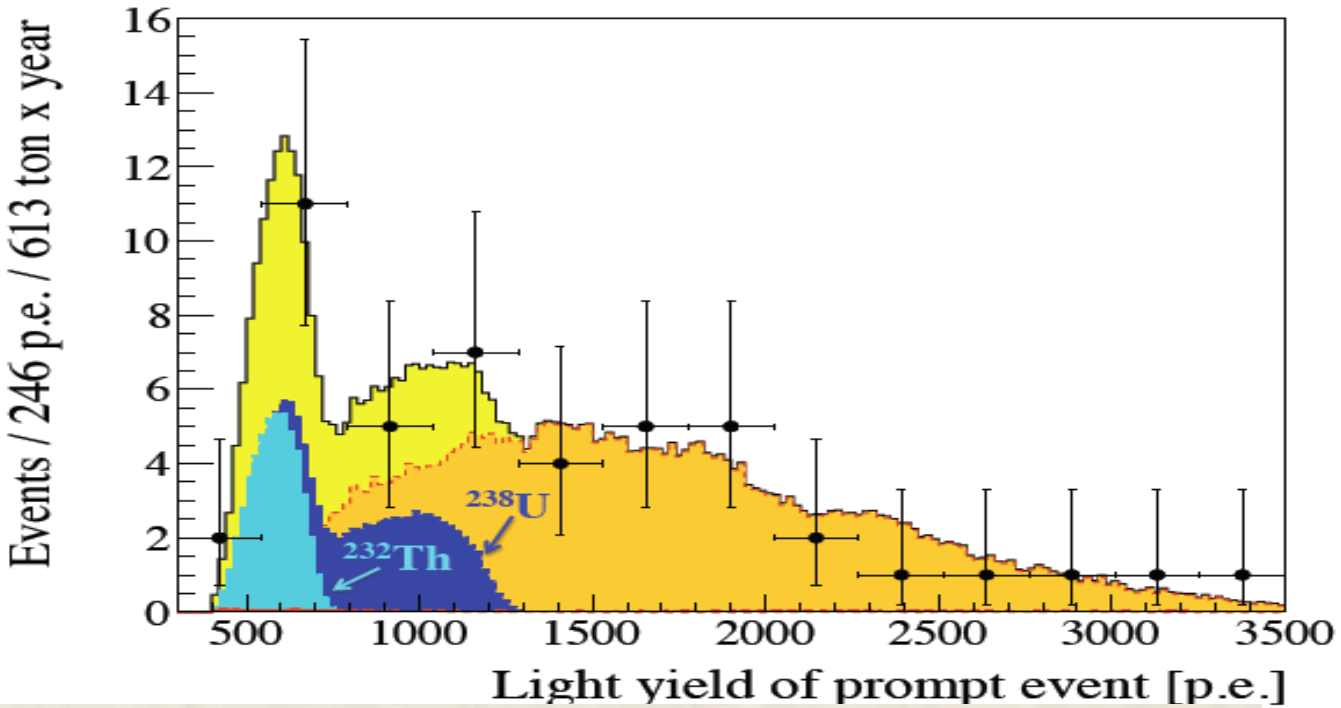


LVD Duty factor



- Large mass
  - 1 kT
- Need high availability
  - ~100%

Geo Neutrinos with Borexino



$^{238}U \quad ^{206}Pb + 8\,\alpha + 8\,e^- + \mathbf{6}\,\nu_e + 51.7\ MeV$

$^{232}Th \quad ^{208}Pb + 6\,\alpha + 4\,e^- + \mathbf{4}\,\nu_e + 42.8\ MeV$

$^{40}K \quad ^{40}Ca + e^- + \mathbf{1}\,\nu_e + 1.32\ MeV$

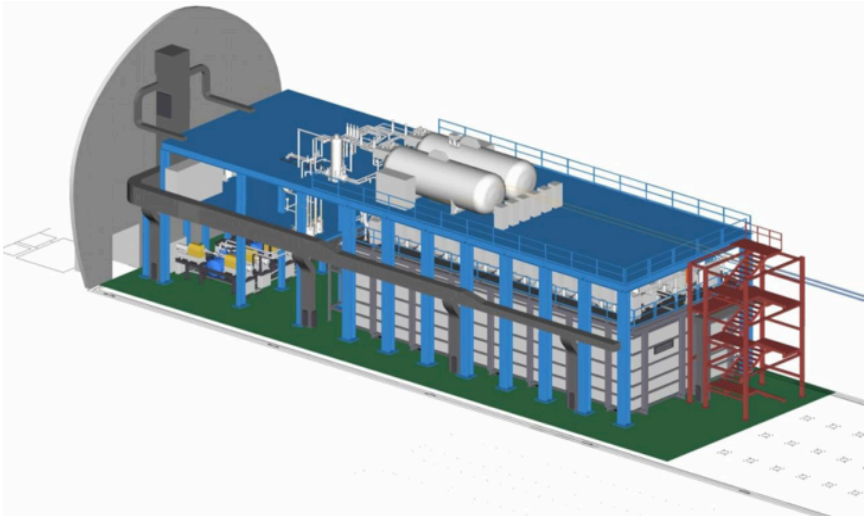
Purification level: U ~ 1.6 10^{-19} g/g

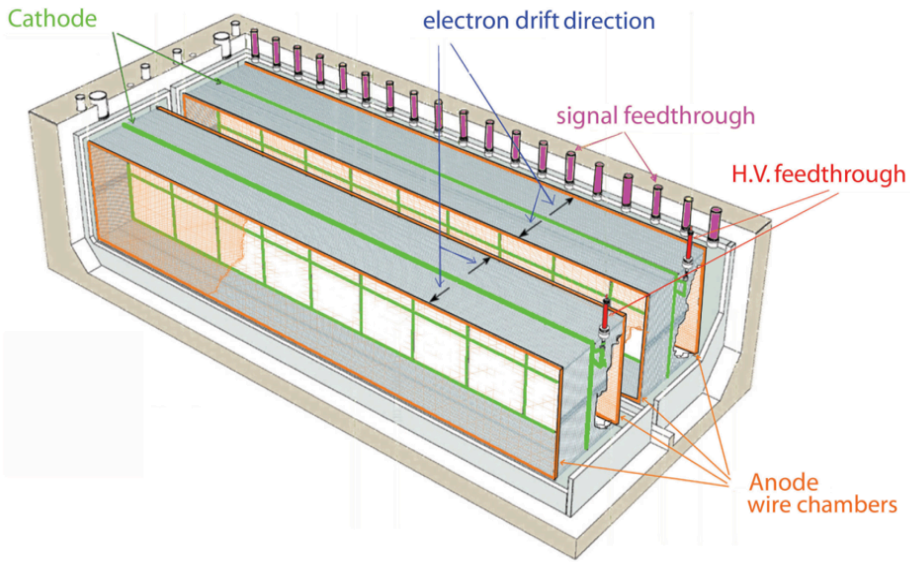
Th < 1.2 10^{-18} g/g

-> ***applied*** neutrino physics

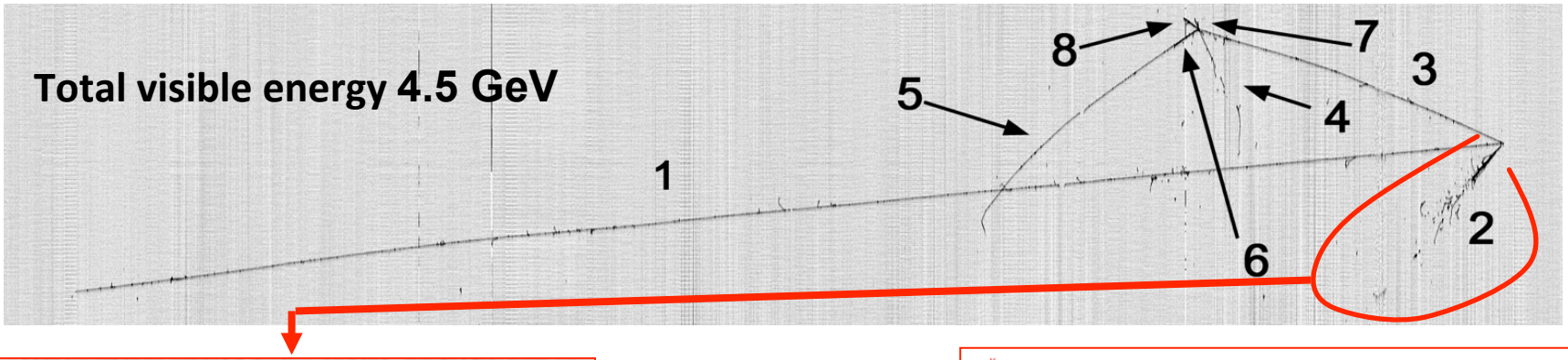
ICARUS-T600 @ LNGS

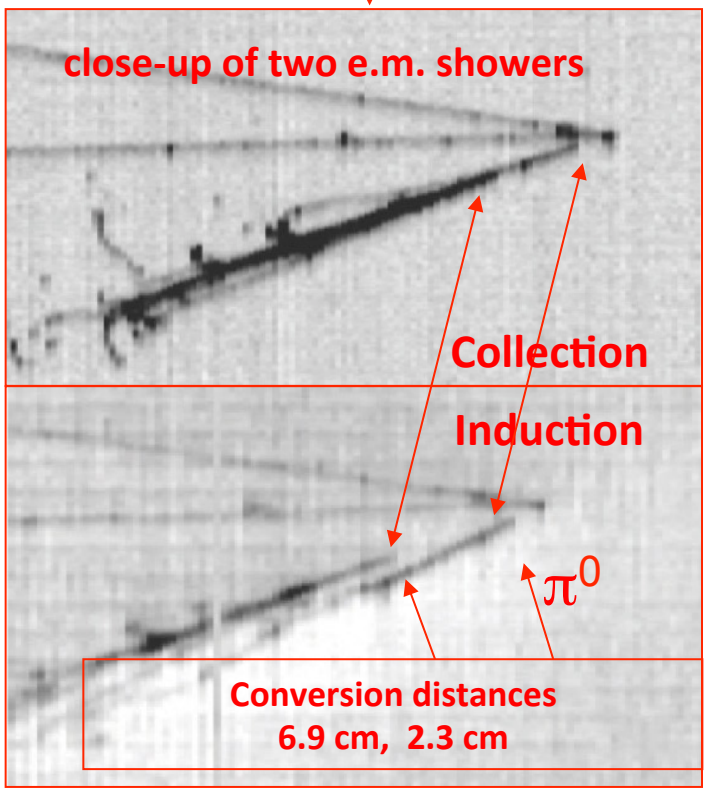
0.77 kton LAr-TPC

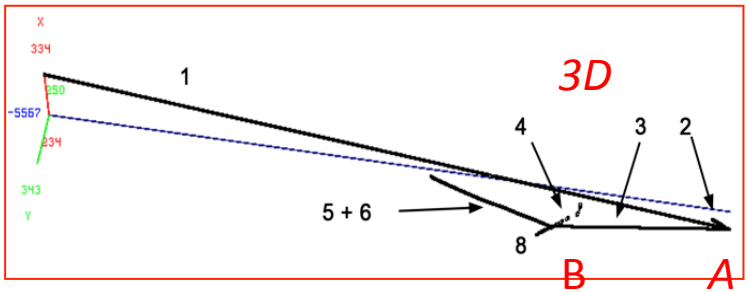




The LAR-TPC: the electronic bubble chamber







Primary vertex (A):

very long μ (1), e.m.cascades(2), π (3)

Secondary vertex (B):

longest track (5) is a μ from stopping K (6)
μ decay is observed

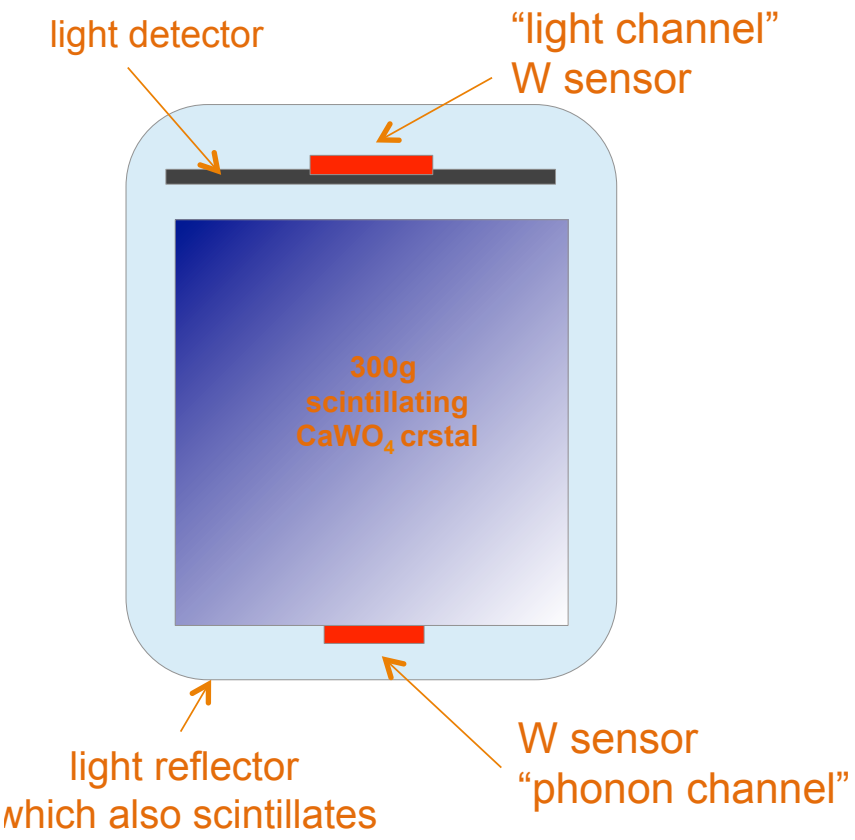
ICARUS T600 timeline

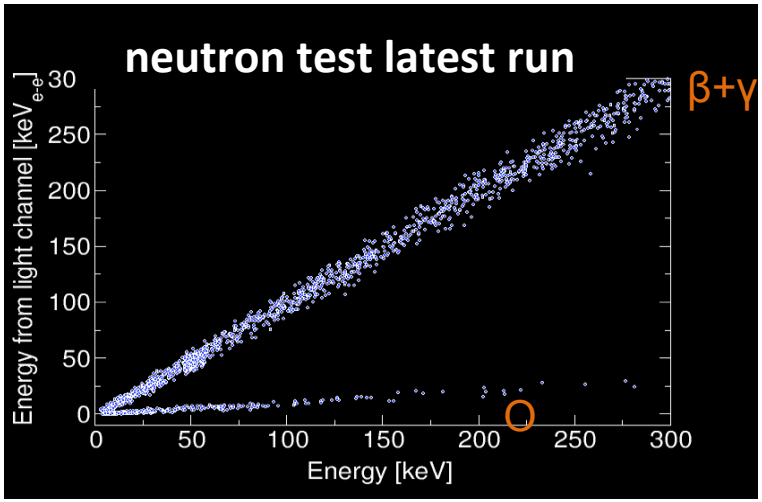
- 2010: Successful assembly and commissioning of ICARUS-T600:
  - May 28th : first CNGS neutrino
  - October: start of physics runs
- 2011 – Dec 3rd, 2012:
  - T600 data-taking with CNGS beam and cosmic rays
    - 2800 CC + 900 NC
    - Muons from upstream GS rock ≈ 12000 ev (≈ 8200 on TPC front face)
    - Intrinsic beam νe CC ≈ 26 ev
    - ν_μ -> ν_τ with kinematic ν_τ -selection (~2 event τ ->e) ν_μ -> ν_e (θ_{13}) from e-like CC events
    - excess at E < 20 GeV (~5 events CC)
    - Search for ν_s in LSND parameter space, studying e-like CC events at E > 10 GeV
  - Nov. 2011 & March 2012: bunched beam for ν velocity measurement
- Dec.2012 – June 2013:
  - Data-taking with cosmic rays
  - From June: decommissioning
- **2014 onward**
  - **ICARUS at CERN – R&D to prepare for a *future beam***

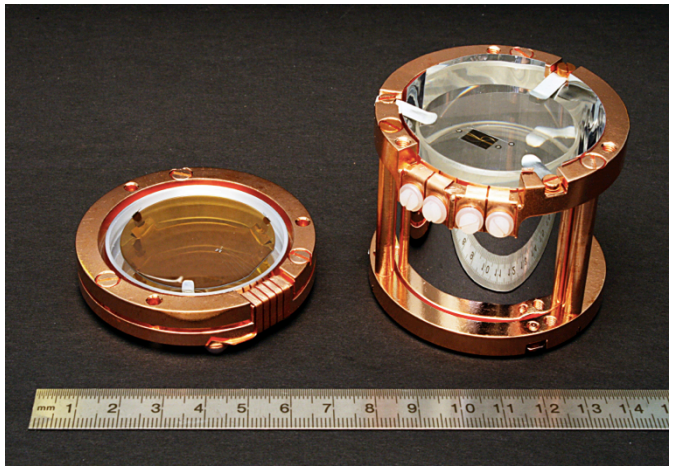
Dark Matter

- DAMA/LIBRA
- Cresst
- Xenon family
- DarkSide *(family)*

CRESST-II







→ phonon channel provides precise measurement of deposited energy

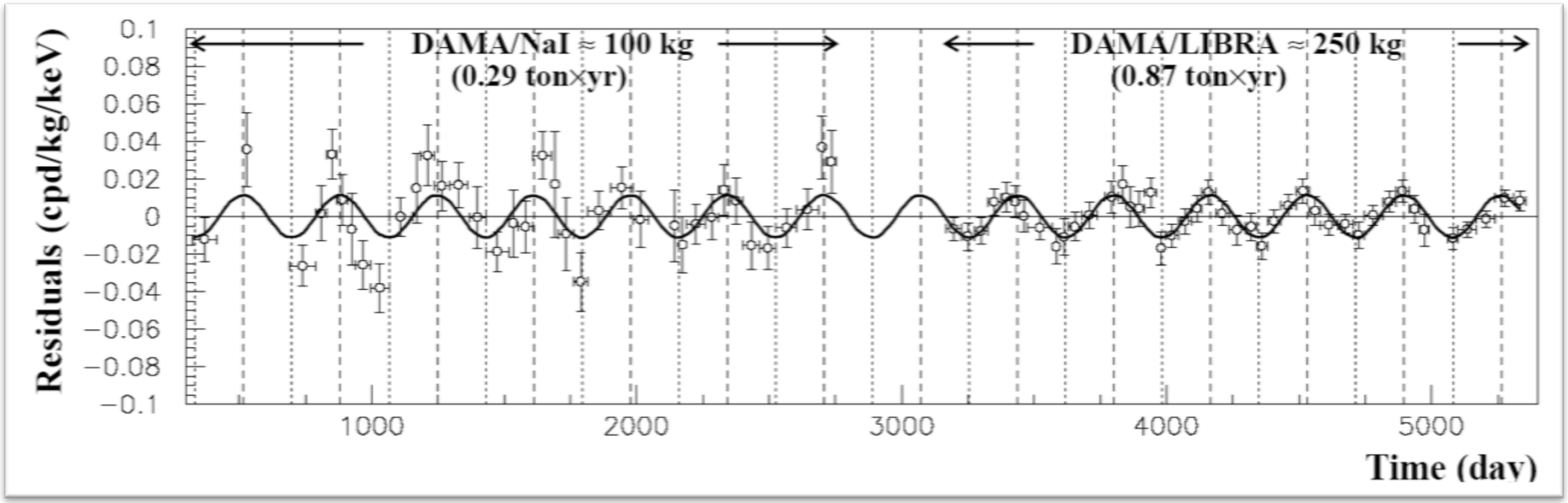
→ Light channel distinguishes types of interaction

→ Types of recoiling nuclei distinguished by different slopes in light energy plane

DAMA/LIBRA

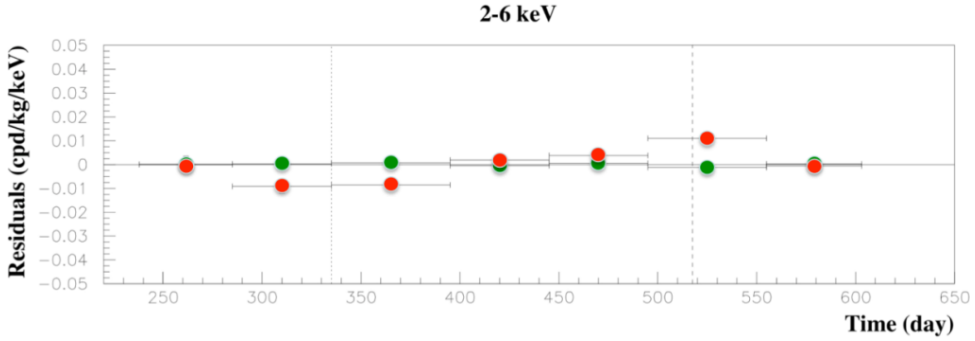
- Ultrapure Na(Tl)
- Residual contamination
  - ^{232}Th, ^{238}U ~ 10 ppt
  - ^{40}K ~ 20 ppb

DAMA/LIBRA – annual modulation



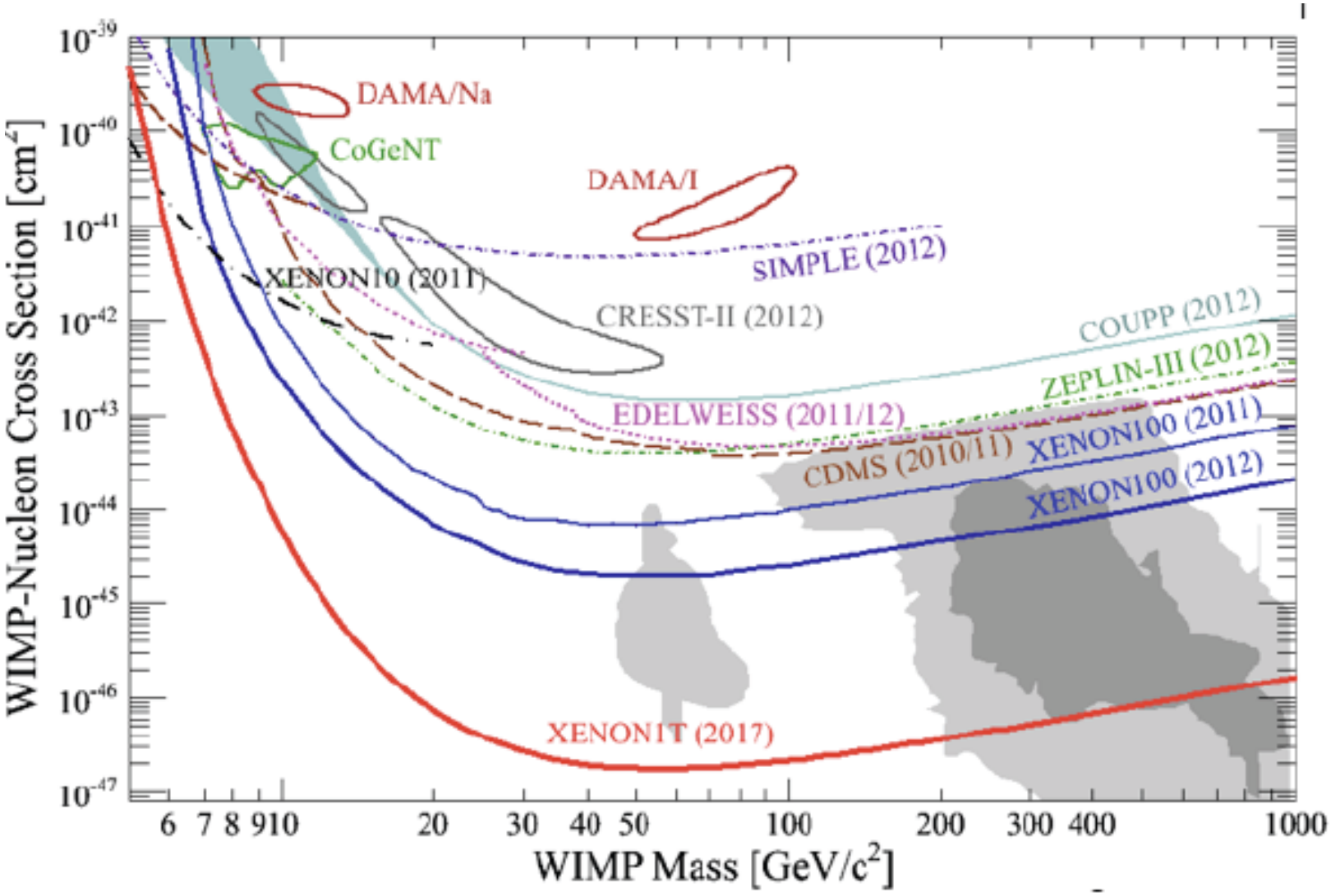
Comparison between **single hit residual rate (red points)** and **multiple hit residual rate (green points)**;
A=-(0.0006±0.0004) cpd/kg/keV

Multiple hits events = Dark Matter particle "switched off"



DM searches

- no general consensus on DM detection by lab experiments
- **origin of Dama/Libra modulation MUST be clarified**



And more

- Test of fundamental principles
  - VIP: Pauli exclusion principle
  - Ginger (G-Gransasso) : Gyrolaser for General Relativity test: Earth gravitomagnetic effect (Lens-Thirring)
- Applications of trace elements measurements to environmental & earth sciences
  - ERMES-W
- Study of biologial effects of low-doses on mammals
  - Cosmic Silence: testing the linear no-threshold hypothesis
- Outreach

OPEN DAY @ LNGS:1.500-2.000 visitors/year

European Researchers Night 2013 @ Galileium: 1.500 visitors

Educational Laboratories:
500-1000 students/years

Competition for schools: 1700 students/years

Visits at LNGS:

8000 visitors/year

Summer Schools for students and teachers

Theatre performance in the underground facilities was followed by 2.5 Million people on a national TV channel.

Physics and Archaeology

Many thanks to strong winds (or Alberto's ancestors?) which sunk the ship

Several tons (~6) of roman lead for shielding Cuore

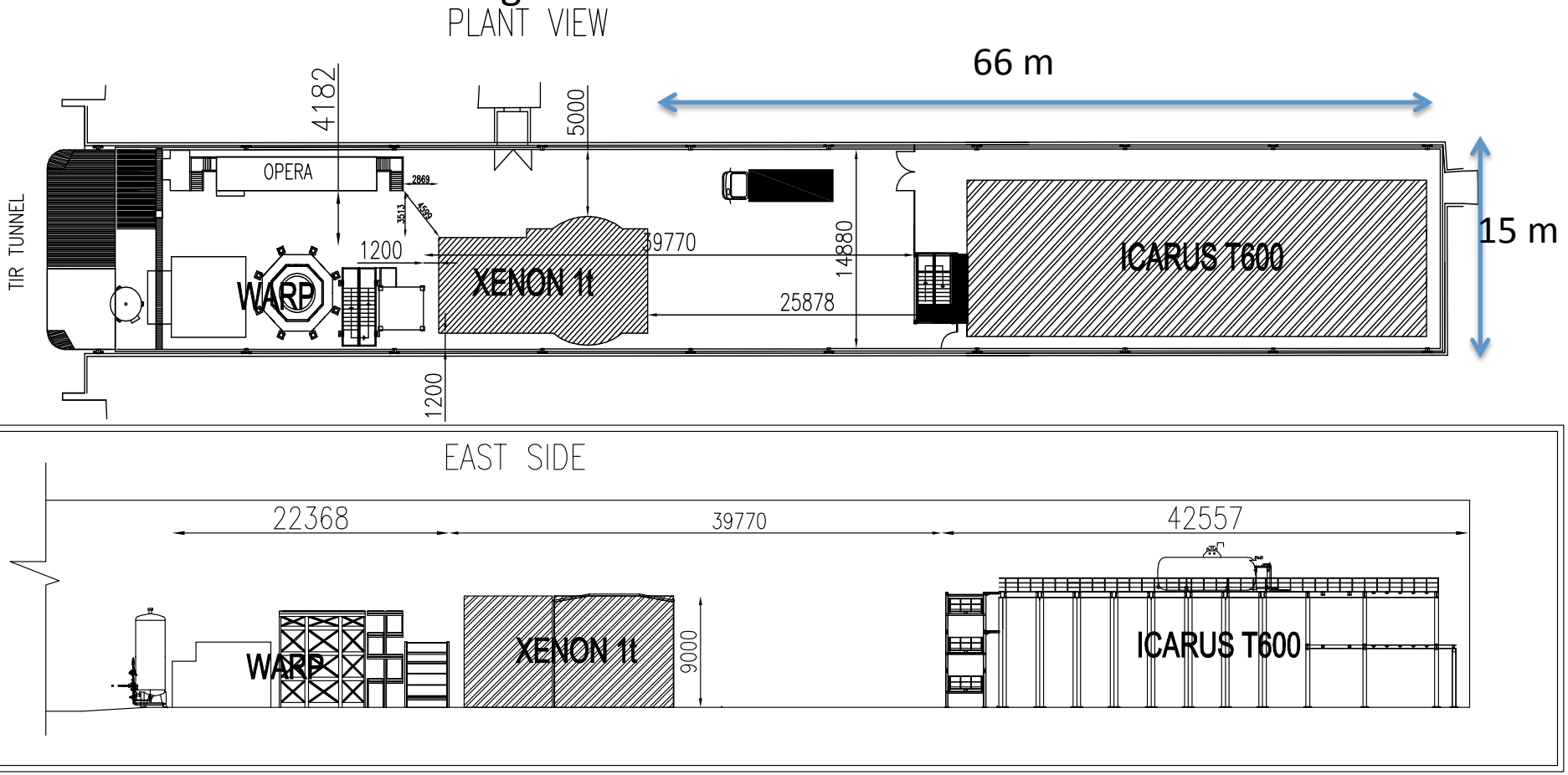
2000 years old lead: free of ^{210}Pb (Romans effectively removed ^{238}U)

LNGS

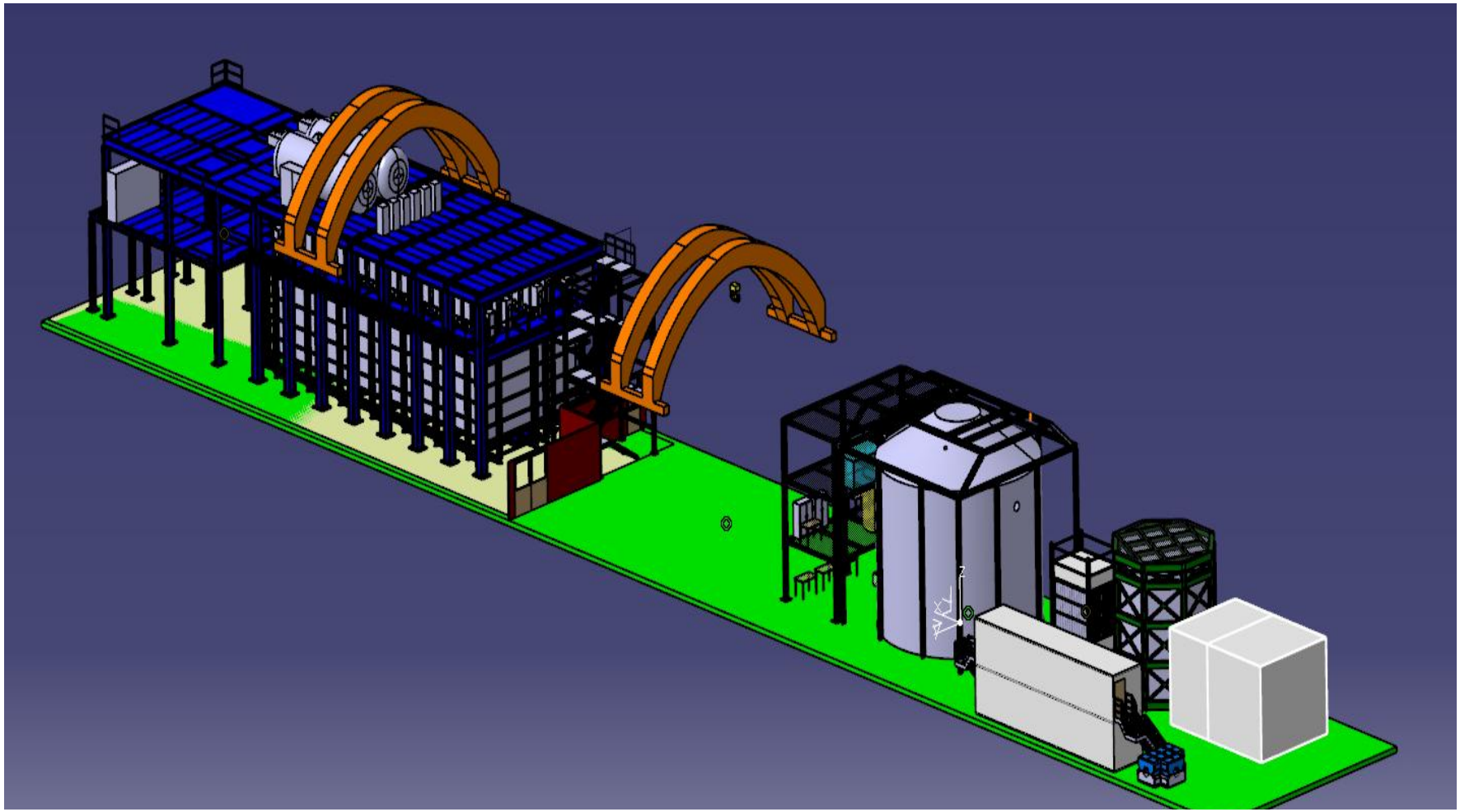
- Room is being made free for new experiments

Hall b

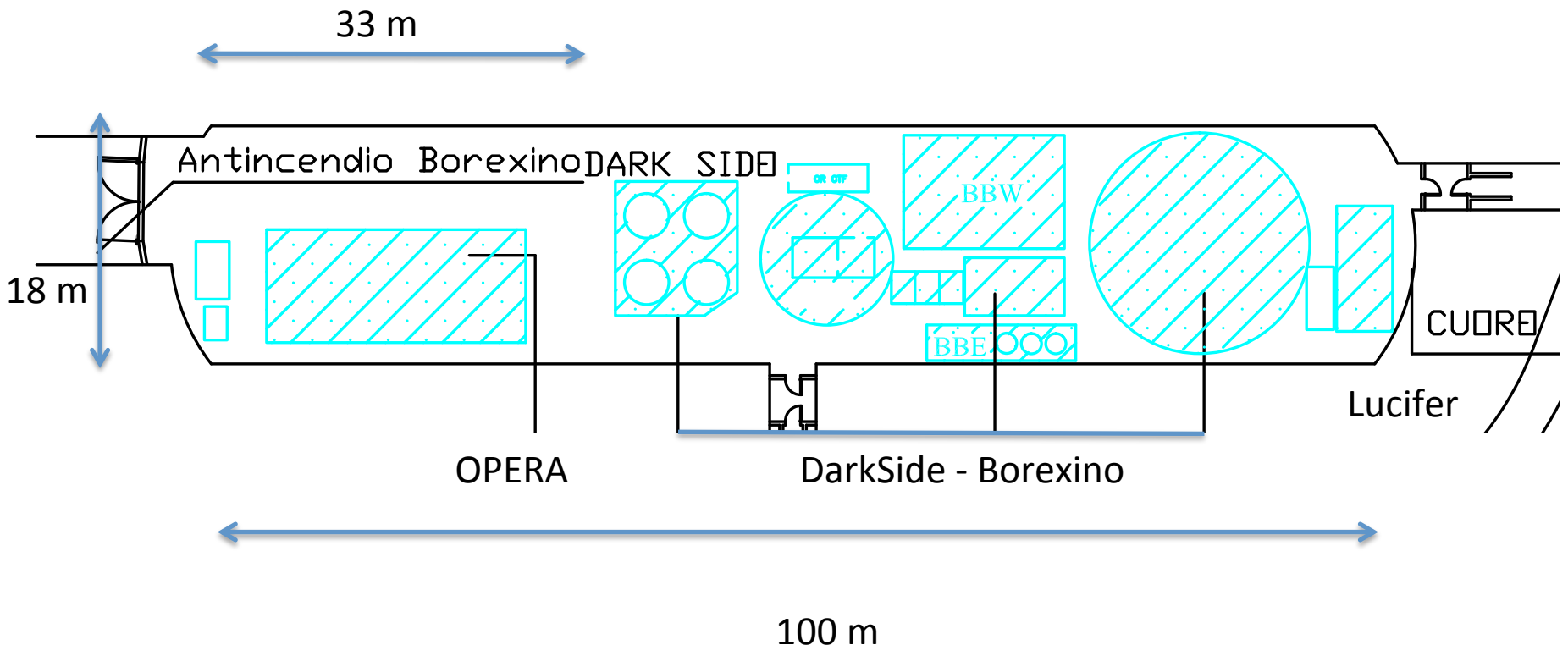
- Warp area allocated to GINGER (G-Gransasso: Gyrolaser in General Relativity)
- Icarus decommissioning: June 2013 -> October 2014



Hall B



Hall C – present status



Which future?

- 3rd generation $\beta\beta$ (IH region) and DM
  - Technique? new xtals? Xenon?
  - Size?
  - Bkg reduction?
  - Can the existing active shieldings be considered as facilities for future experiments?
    - Can/should LNGS invest on a general-purpose active shielding?
- What else?
  - Ginger takes advantage of tremendous reduction of seismic noise underground: more experiments/measurements?
  - Great expertise in ultra purification and measurement of trace elements -> look for applications

Prepare the future

- Stimulate international initiatives and attract international investment
  - e.g. Gerda, Xenon, DarkSide …
- LNGS is a key research facility in the world
  - open to international access with transparent and unbiased procedures
- Coordination and synergies with other UG labs
  - EUROPE: EULAB-ERIC an important (fundamental) step

ERIC

- Ongoing discussions to constitute a distributed European Research Infrastructure Consortium including (most of) European UG labs
- Consistent savings on taxes
- European procurement/tendering rules simpler than Italian PA rules
- Most important: **hire personnel**

Conclusions

- A national lab and international asset
- Room is being made available for the equivalent of > 3 Xenon-1T experiments

- **Science Proposals renewing and strengthening a long standing and successful INFN-US collaboration are welcome**