The INFN perspective on HEP and APP

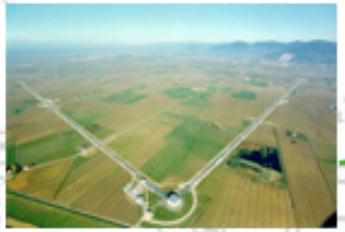
Fernando Ferroni
INFN & Sapienza University-Roma

IoP HEPP and APP joint meeting- Queen Mary, University of London- April 2, 2012

INFN geographically

Legnaro

Gran Sasso



VIRGO-EGO

European

Gravitational

Observatory

Laboratori del Sud

(Catania)

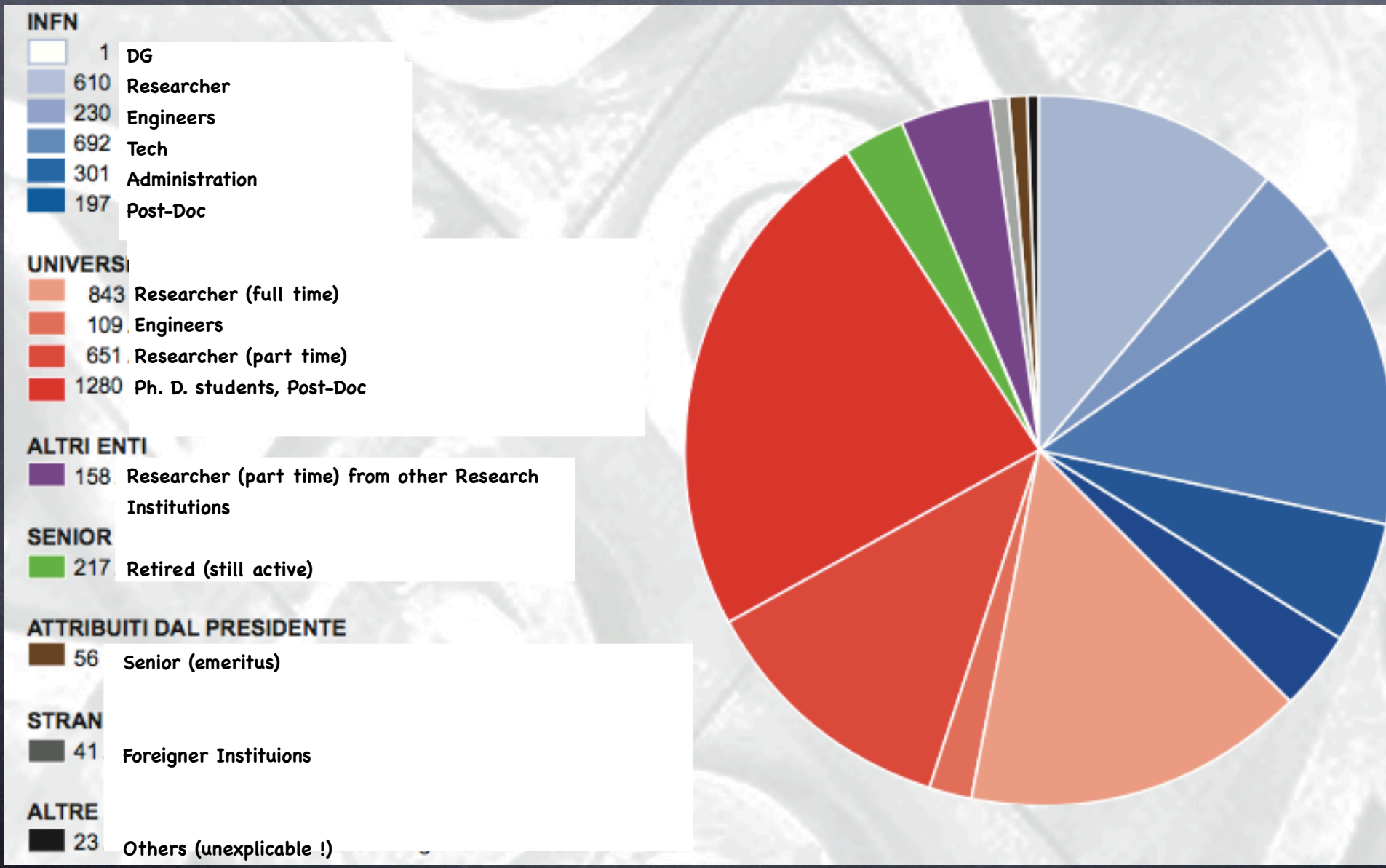
Trento
Udine
Trieste
Padova
Milano
Torino
Pavia
Brescia
L.N.L
Alessandria
Parma
Ferrara
Bologna
Genova
C.N.A.F
Firenze
Siena
Pisa
Perugia
L'Aquila
L.N.G.S
Roma1
Roma2
Roma3
Sanita'
L.N.F
Bari
Napoli
Salerno
Lecce
Cosenza
Cagliari
Messina
Catania
L.N.S

19 Sezioni

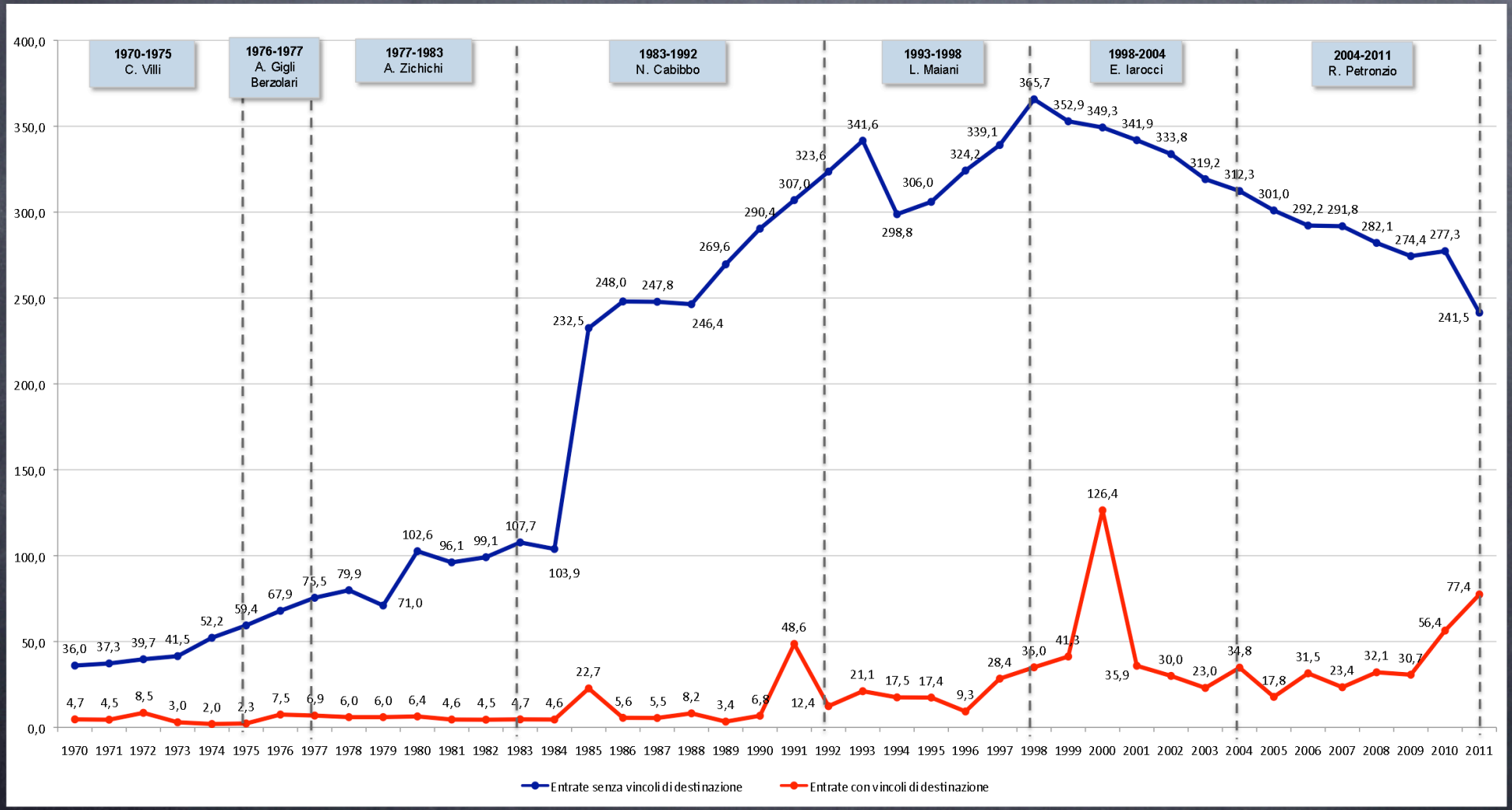
11 Gruppi collegati

4 Laboratori Nazionali

INFN-humanly



INFN financially



The today's menu is:

- Appetizer: LNGS physics
- Main Course: Super-B
- Dessert: KM3Net

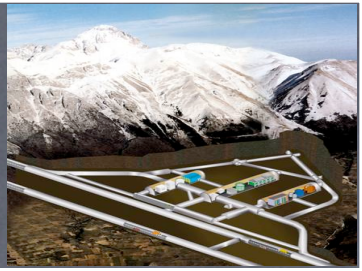
some of you know that 'appetizer' in italian often means a sequence of little dishes (that could just fill you up !)

INFN
Istituto Nazionale
di Fisica Nucleare
Laboratori Nazionali del Gran Sasso

INFN-GRAN SASSO NATIONAL LABORATORY

INFN
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali del Gran Sasso

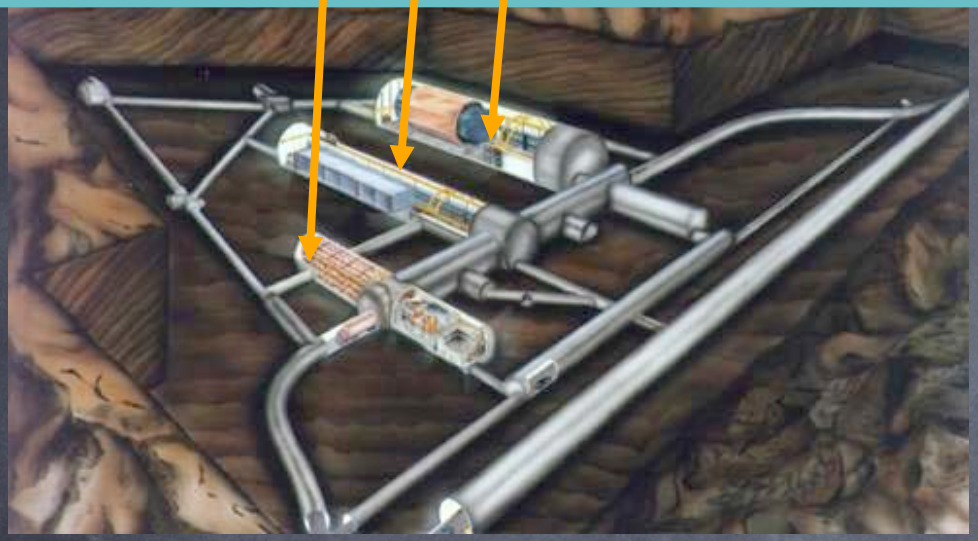
Gran Sasso Laboratory

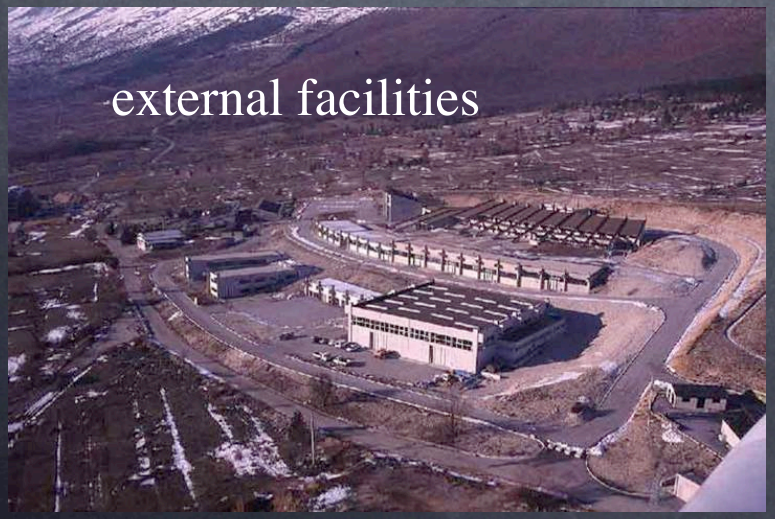


- **Largest** underground laboratory in the world
  - Run by **INFN** under the Gran Sasso Mountain, Italy
  - 120 km far from Rome, completed 1987
  - International scientific community (1000 users per year)
  - Permanent staff: 82 + 19 temporary positions

Gran Sasso Laboratory

3 main halls A B C ~100 x 20 m² (h 20 m)





Muon Flux
$3.0\ 10^{-4}$ μ $m^{-2}\ s^{-1}$

Neutron Flux	
$2.92\ 10^{-6}$ n $cm^{-2}\ s^{-1}$	(0-1 keV)
$0.86\ 10^{-6}$ n $cm^{-2}\ s^{-1}$	(> 1 keV)

Depth: 1400 m **(3800 m w.e.)**

Surface: 17800 m^2

Volume: **180000** m^3

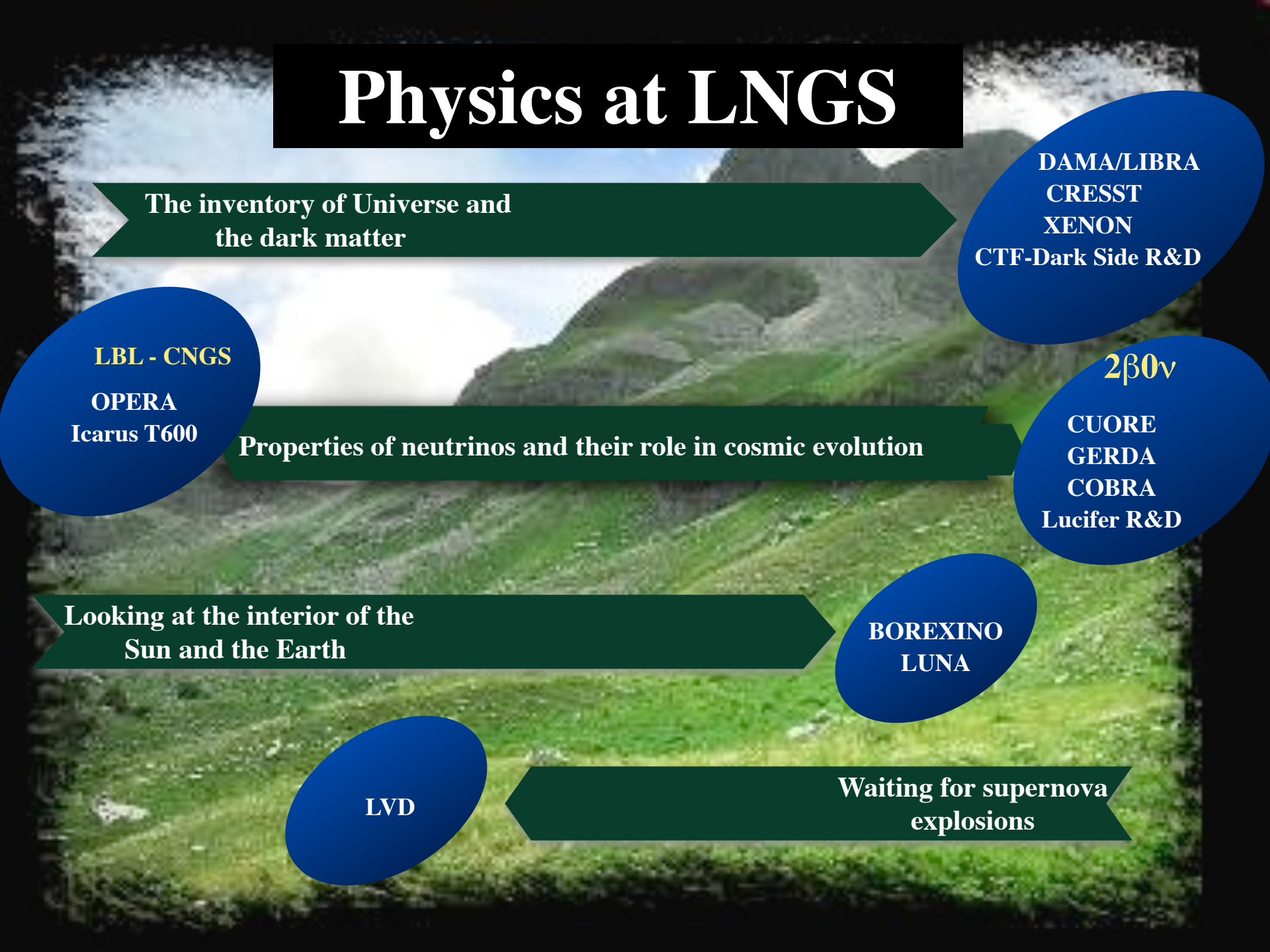
Rn in air: 20-80 Bq/m^3

ISO 14001

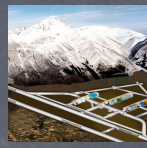
Ventilation: 1 Lab volume/3 h

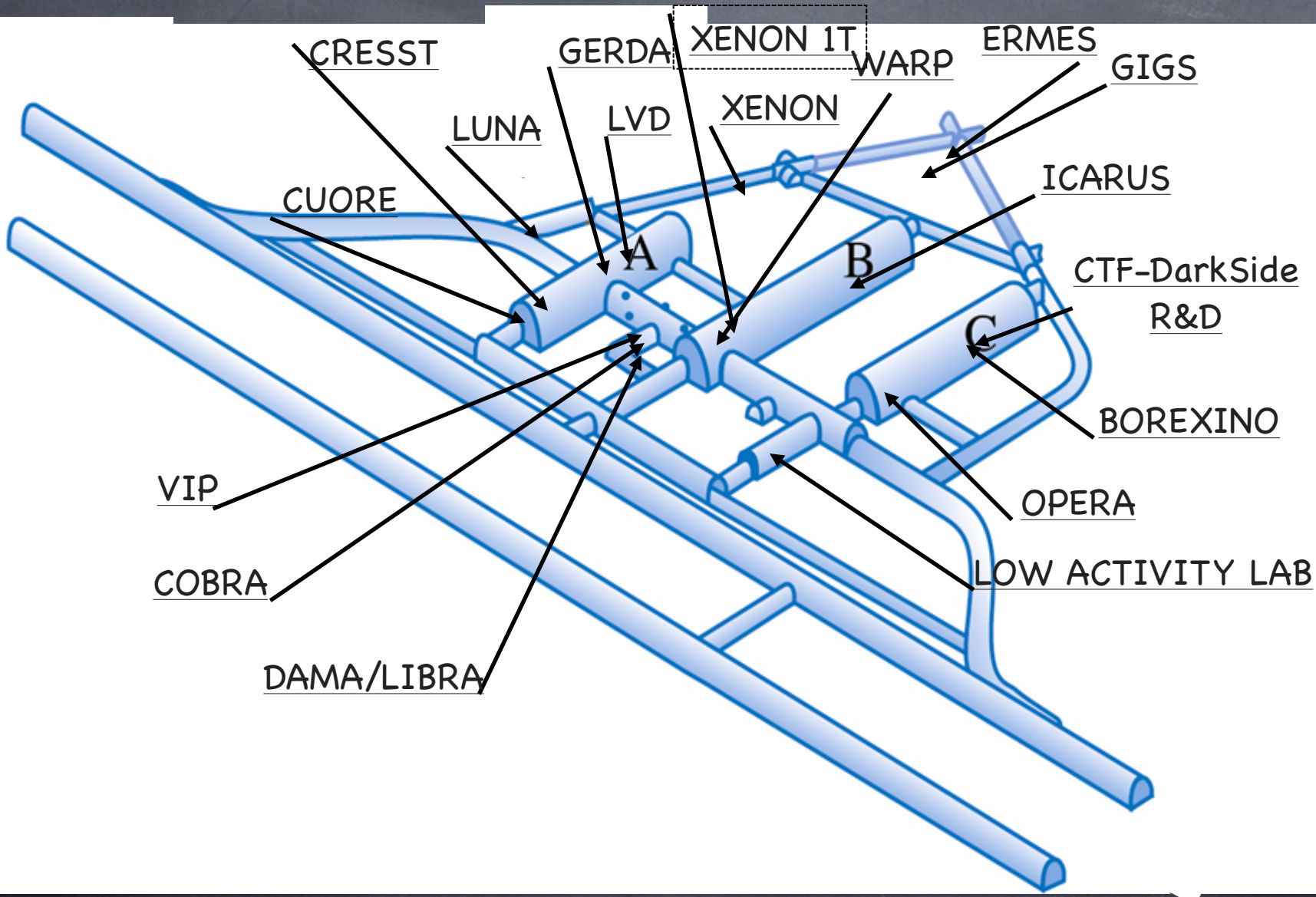
Electrical power: 1300 kW

Access: horizontal


Physics at LNGS
The inventory of Universe and the dark matter
DAMA/LIBRA
CRESST
XENON
CTF-Dark Side R&D
LBL - CNGS
OPERA
Icarus T600
Properties of neutrinos and their role in cosmic evolution
2β0ν
CUORE
GERDA
COBRA
Lucifer R&D
Looking at the interior of the Sun and the Earth
BOREXINO
LUNA
LVD
Waiting for supernova explosions

Pretty crowded





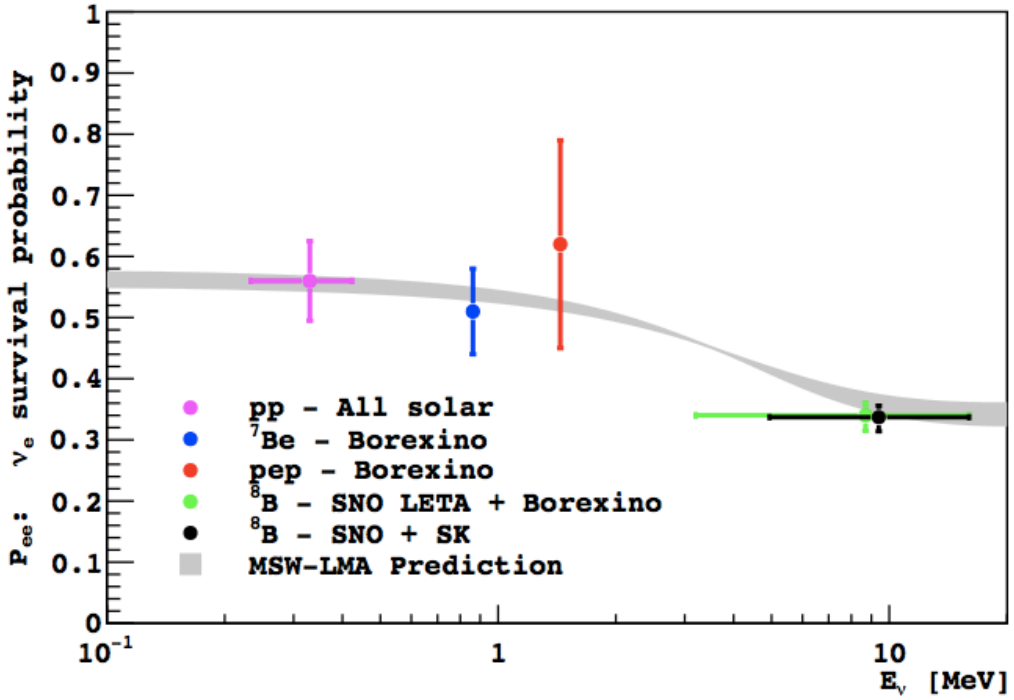

BOREXINO:
a real time liquide scintillator detector
for solar neutrinos

NEW: BX pep and CNO measurements

pep ν measurement motivations

pep neutrino **flux predicted** with **high precision**: 1.2% SSM uncertainty

pep neutrino energy (1.44 MeV) in P_{ee} **transition region,** sensitive to Physics beyons Standard Model



Geo-ν: a unique direct probe of the Earth interior

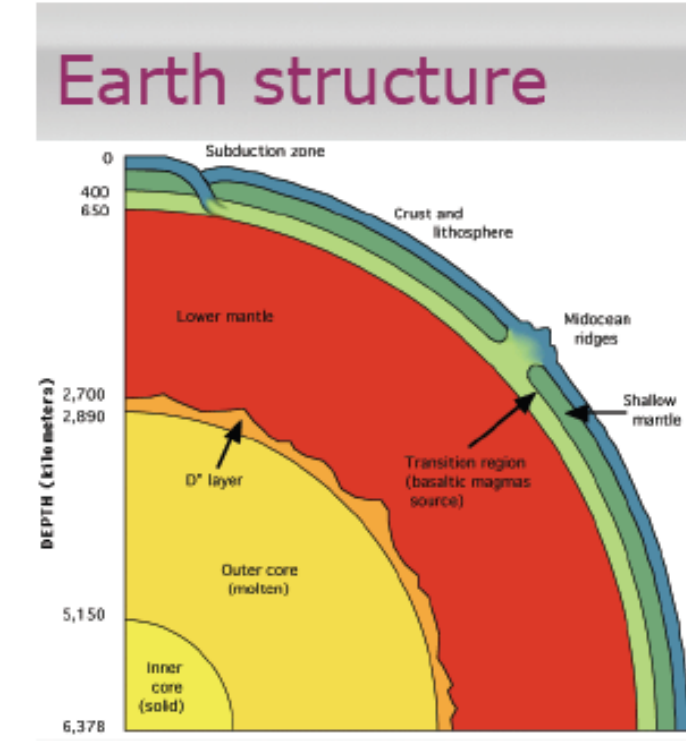
The radioactive isotopes inside the Earth generate heat.

The Earth shines in anti-ν

$^{238}U \rightarrow {}^{206}Pb + 8\,\alpha + 8\,e^- + 6\,\bar{\nu}_e + 51.7$ MeV

$^{232}Th \rightarrow {}^{208}Pb + 6\,\alpha + 4\,e^- + 4\,\bar{\nu}_e + 42.8$ MeV

$^{40}K \rightarrow {}^{40}Ca + e^- + 1\,\bar{\nu}_e + 1.32$ MeV



Only two detectors (Kamland, Borexino) are presently able to detect Geo-ν

Relevance of geoneutrinos study: A new probe of the Earth interior

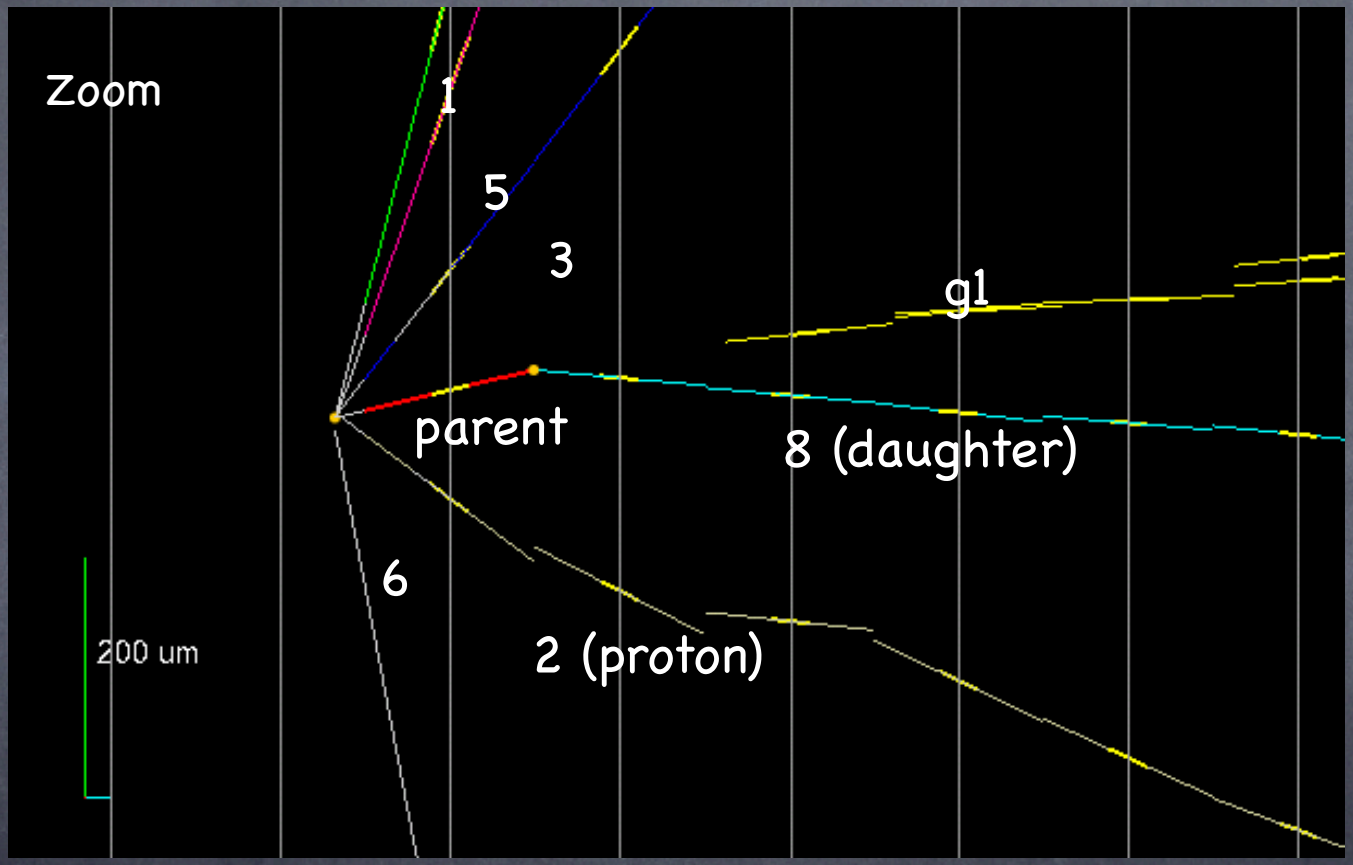
The movement of the heat within the Earth is central in the theory of plate tectonics

- What is radiogenic contribution to the Earth energy budget (50%??)?
- What is the distribution of the radiogenic elements?
- How much in the crust and how much in the mantle?

CNGS

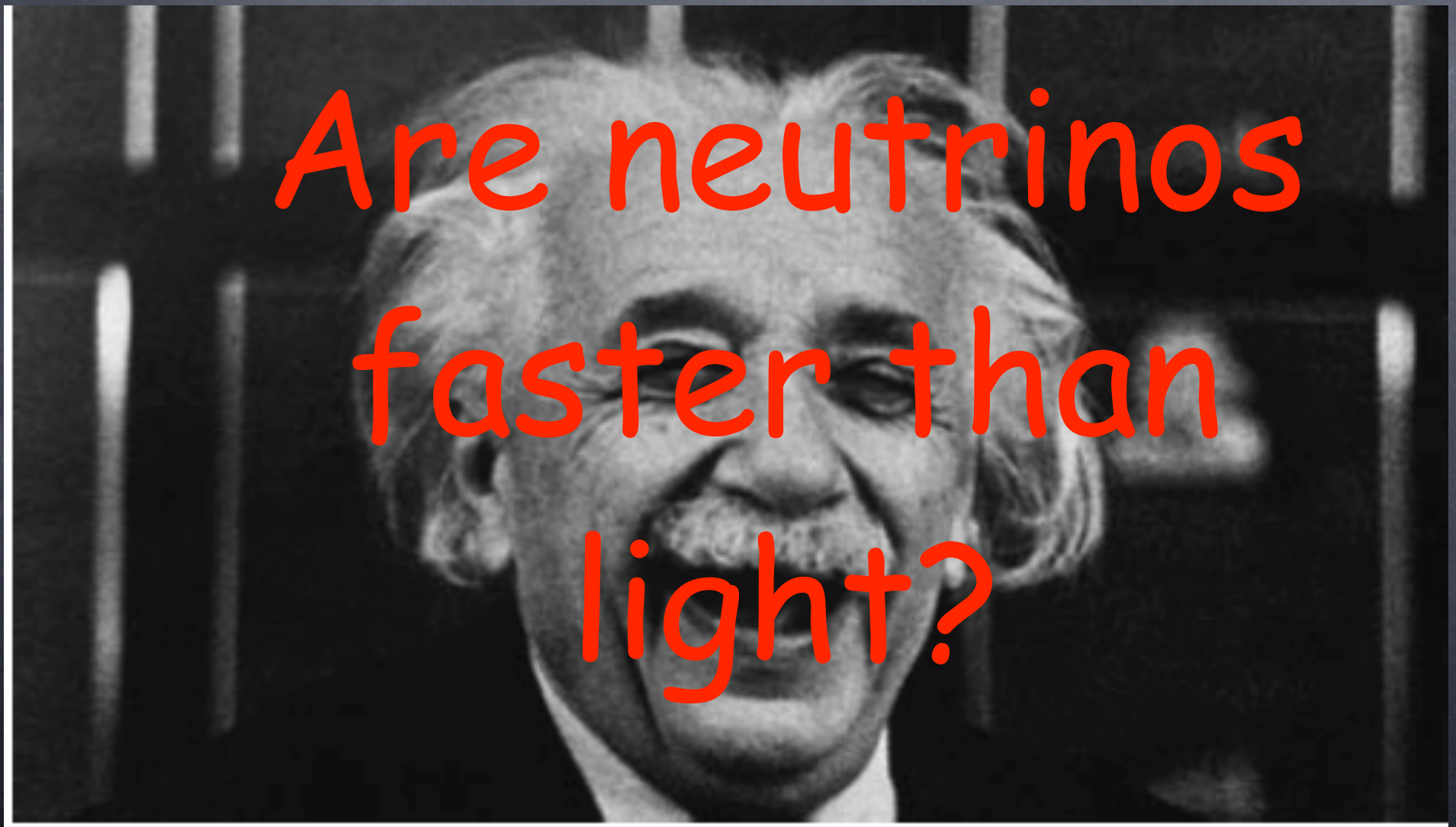
the (in)famous tunnel from CERN to GS

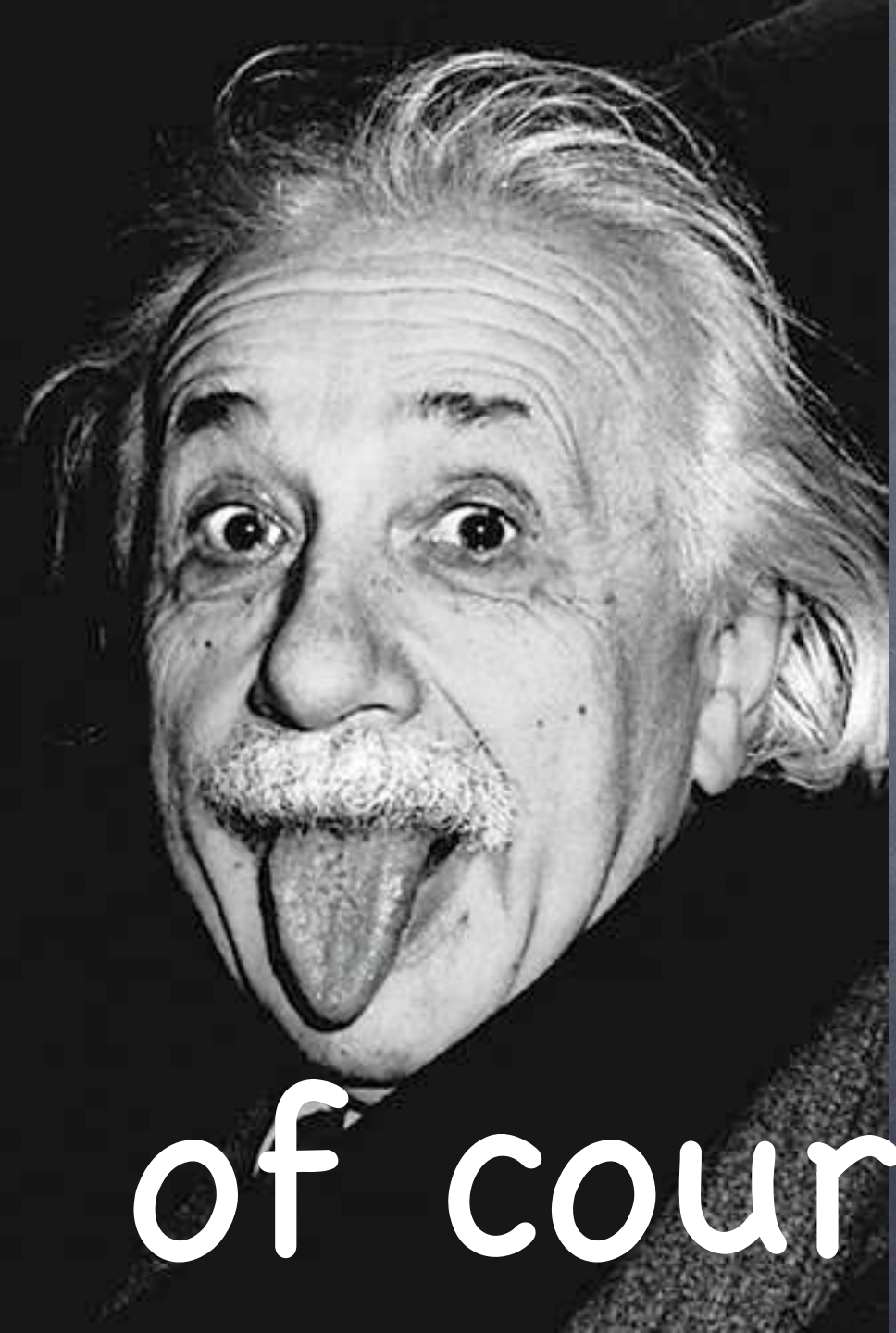
The appearance !

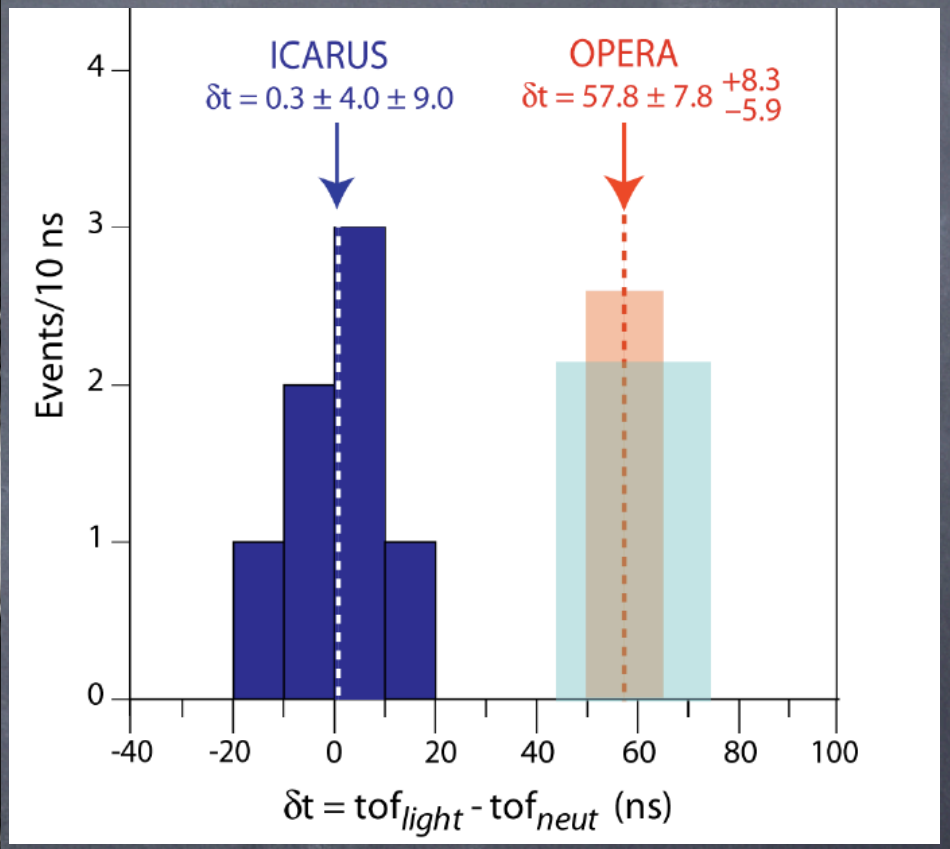


of a tau neutrino transmuted along the way

OPERA: surprising news



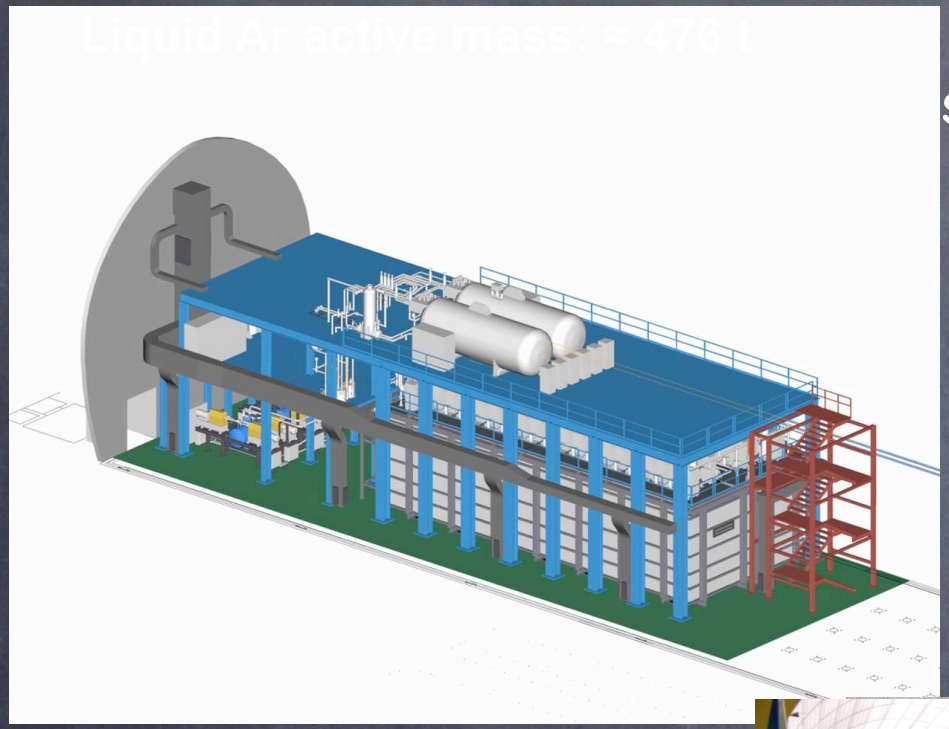




# of course not !

ICARUS T600 in LNGS Hall B

Two identical modules
3.6 x 3.9 x 19.6≈ 275 m^3 each
Liquid Ar active mass: ≈ 476 t

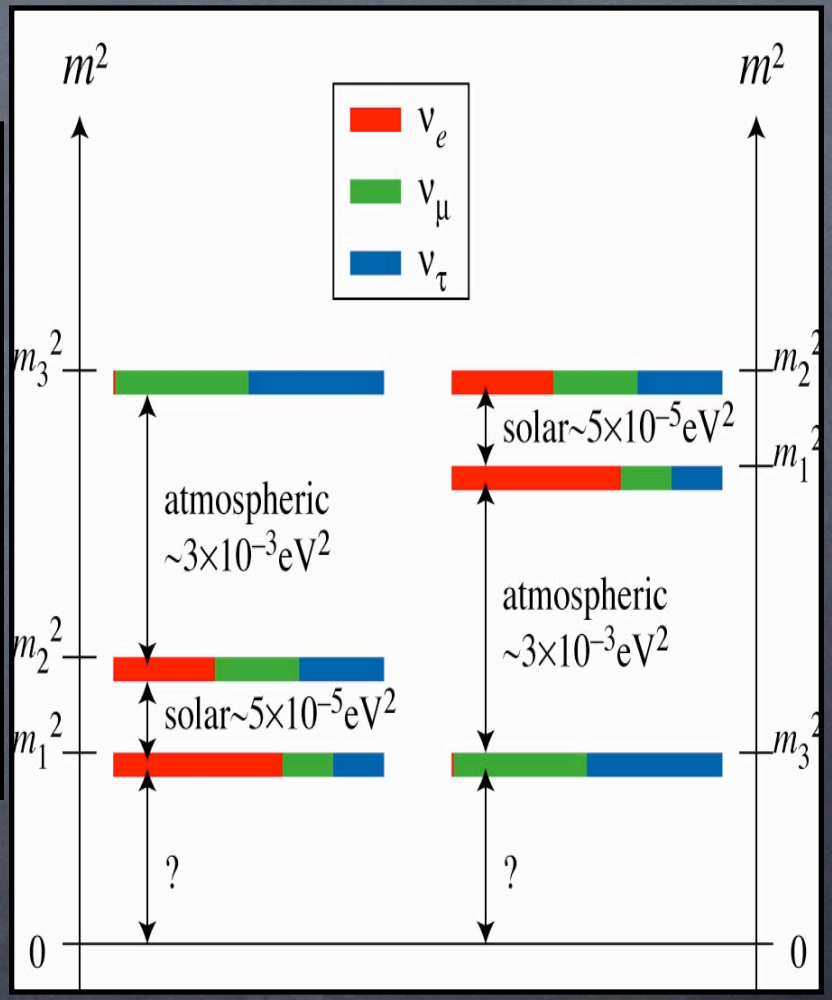


Multi-purpose detector:
atmospheric, solar (>8 Mev), supernovae neutrinos, nucleon decay searches in "exotic" channels, CNGS beam
Milestone towards a multi-kton LAr detector with unique imaging capability, and spatial/calorimetric resolutions

Neutrino open questions

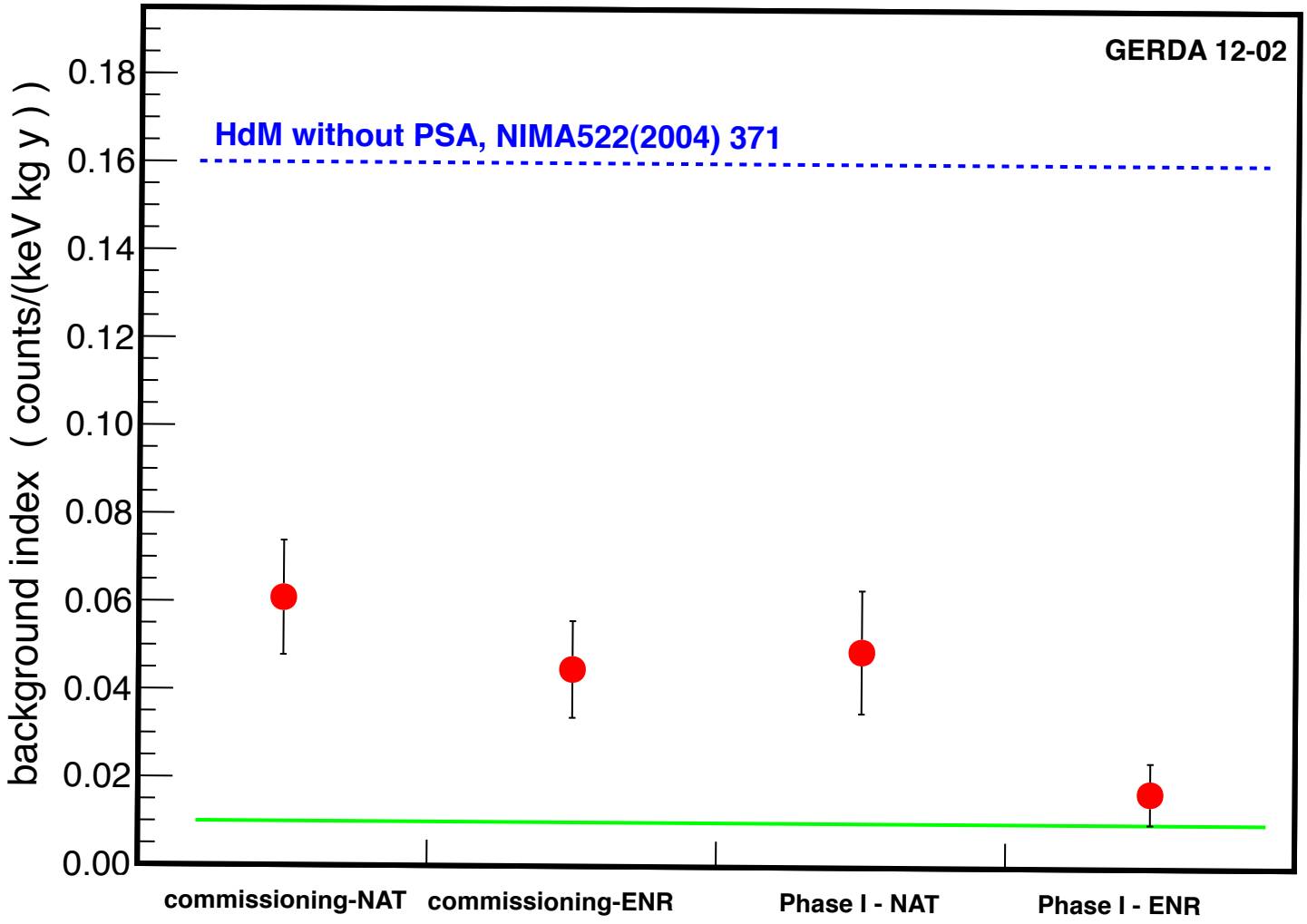
Missing information:

1. The full measurement of the leptonic mixing matrix
2. are neutrinos Dirac or Majorana particles?
3. what is the absolute mass scale and mass hierarchy?



$0\nu\beta\beta$ experiments can answer to 2. and 3.

on the right track !



Roman lead for CUORE @LNGS

- 120 ingots of Roman Lead (4 tons) from an ancient ship that sunk off the Sardinia coast

The dark side of the Universe...

Dark matter @ LNGS

Different methods and techniques towards a "smoking gun" signature

Ionization

Scintillation

Heat

Noble liquids

XENON100
CTF-DarkSide R&D

Crystals NaI 250 kg

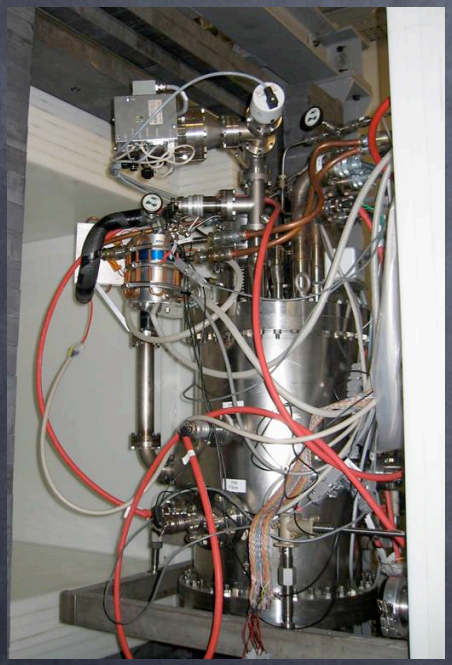
DAMA/LIBRA

Bolometric
Cryogenic $CaWO_4$

CRESST

The XENON Dark Matter Program

past (LNGS) (2005 - 2007)	current (LNGS) (2008-2011)	future (2011-2015)



XENON10

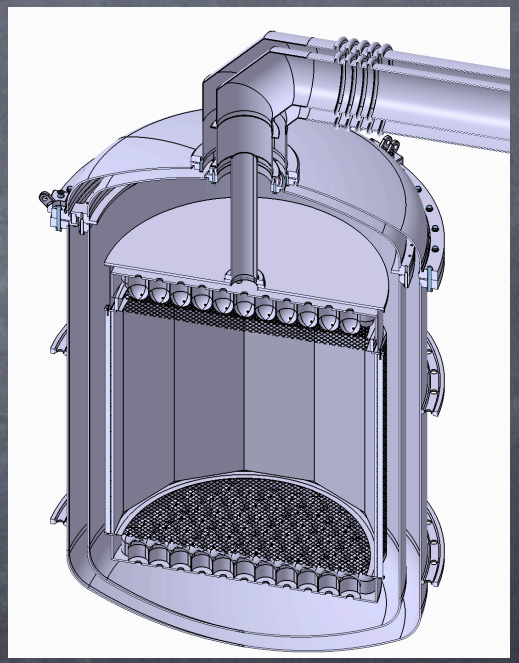
Achieved (2007)

σ_{SI}=8.8 x10^{-44} cm^2

XENON100

Achieved (2011)

σ_{SI}~7x10^{-45} cm^2



XENON1T

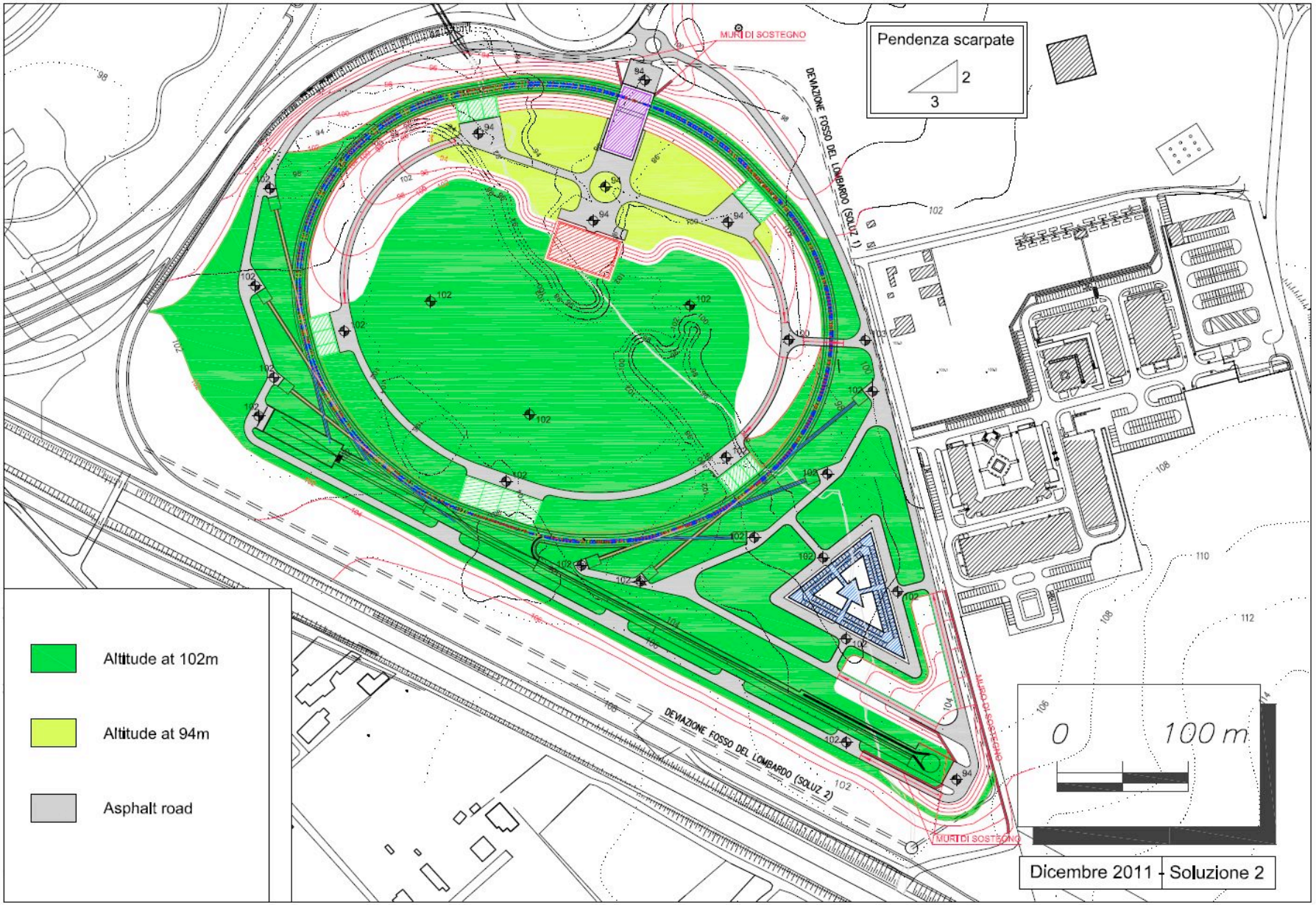
Projected (2015) σ_{SI} ~10^{-47} cm^2

LNGS now and then

- extremely rich program now
- looking for new experiments when OPERA and ICARUS finish in a couple of years
- Mission centered on Dark Matter and Double Beta Decay

Super-B

SuperB@ToV


MURI DI SOSTEGNO
Pendenza scarpate
2
3
DEVIAZIONE FOSSO DEL LOMBARDO (SOLUZ 1)
DEVIAZIONE FOSSO DEL LOMBARDO (SOLUZ 2)
MURI DI SOSTEGNO
Altitude at 102m
Altitude at 94m
Asphalt road
0
100 m
Dicembre 2011 - Soluzione 2


CABIBBO LAB
Laboratorio Nicola Cabibbo

SuperB Physics

- The LHC is homing in on the SM Higgs, hope to find it this year: then there is a planned shutdown for the machine.
- No sign of physics beyond the SM (yet):
  - Naturalness arguments motivated theorists to expect NP at Λ_{NP}~1TeV.
  - But no data pointing to an energy scale accessible to the LHC.
    - Can combine observables measured at SuperB to place model dependent upper bounds on Λ_{NP} if nothing found by the time we start taking data.
    - Otherwise constrain model parameters BSM.
  - The interplay between NP and observables can help to unlock the potential of the global HEP programme.

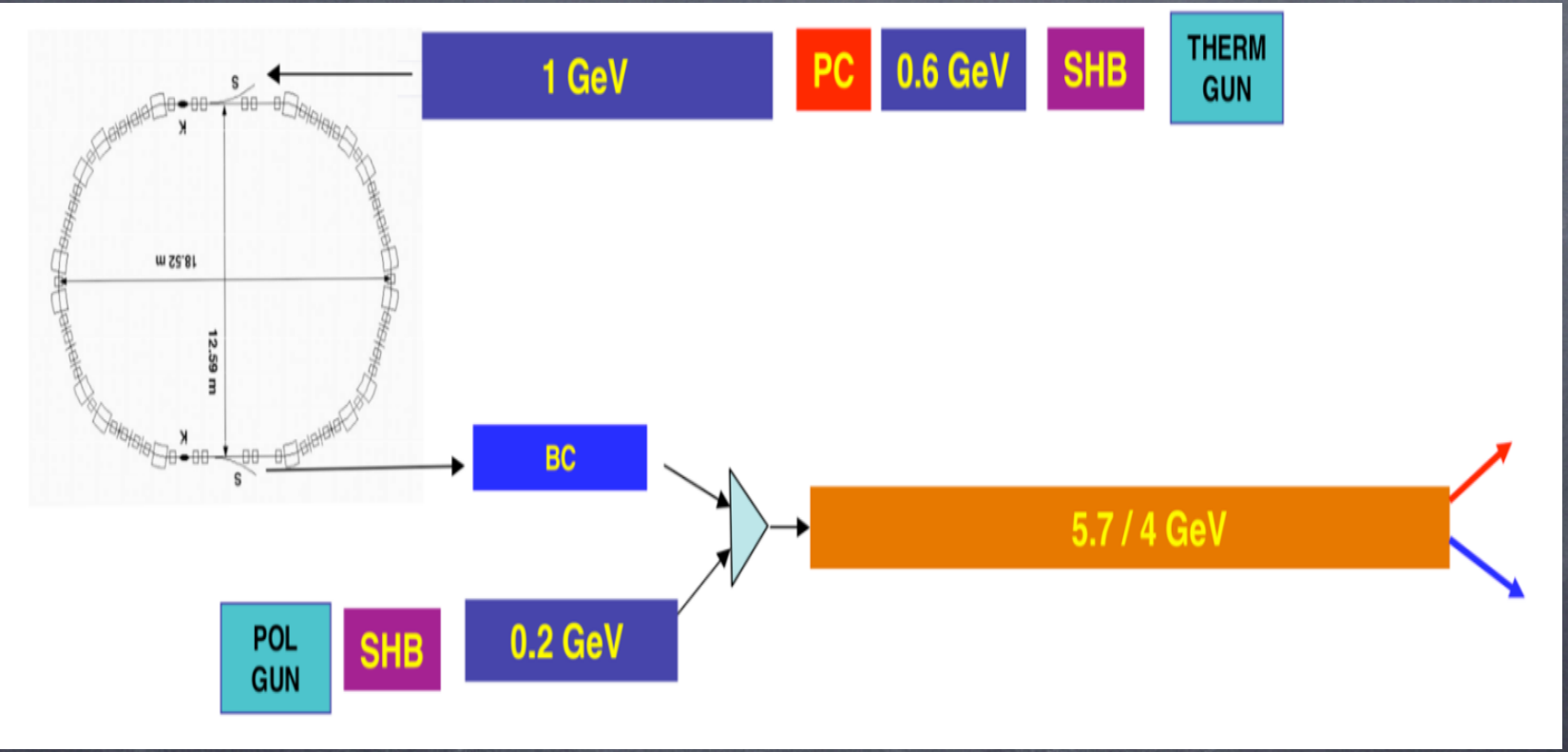
The project

- Phase 1 (by october/november)
  - Site preparation
  - Preliminary project
- Phase 2 (onward)
  - The “target law”
  - Clearing permits
  - Tender for the whole infrastructure
  - Executive project (by may 2013)
  - Start excavation (middle 2013)

Milestones

- Integrating the team
- Costing by end of june
- Lattice completion
- Basic civil engineering inputs for the preliminary project
- MAC assessment
- Finance committee assessment (CRUCIAL – The Ministry will run the show here)
- The freezing of SLAC donation
- Linac
  - The dual option
  - The supplier
  - The order
- General agreement on the money expenditure profile with the Ministery of Research and with the Economy Ministery

SuperB injector options



e- beam quality at the beginning of the Linac defined by the polarised gun100 Hz S-band Linac (options to have it C-band)

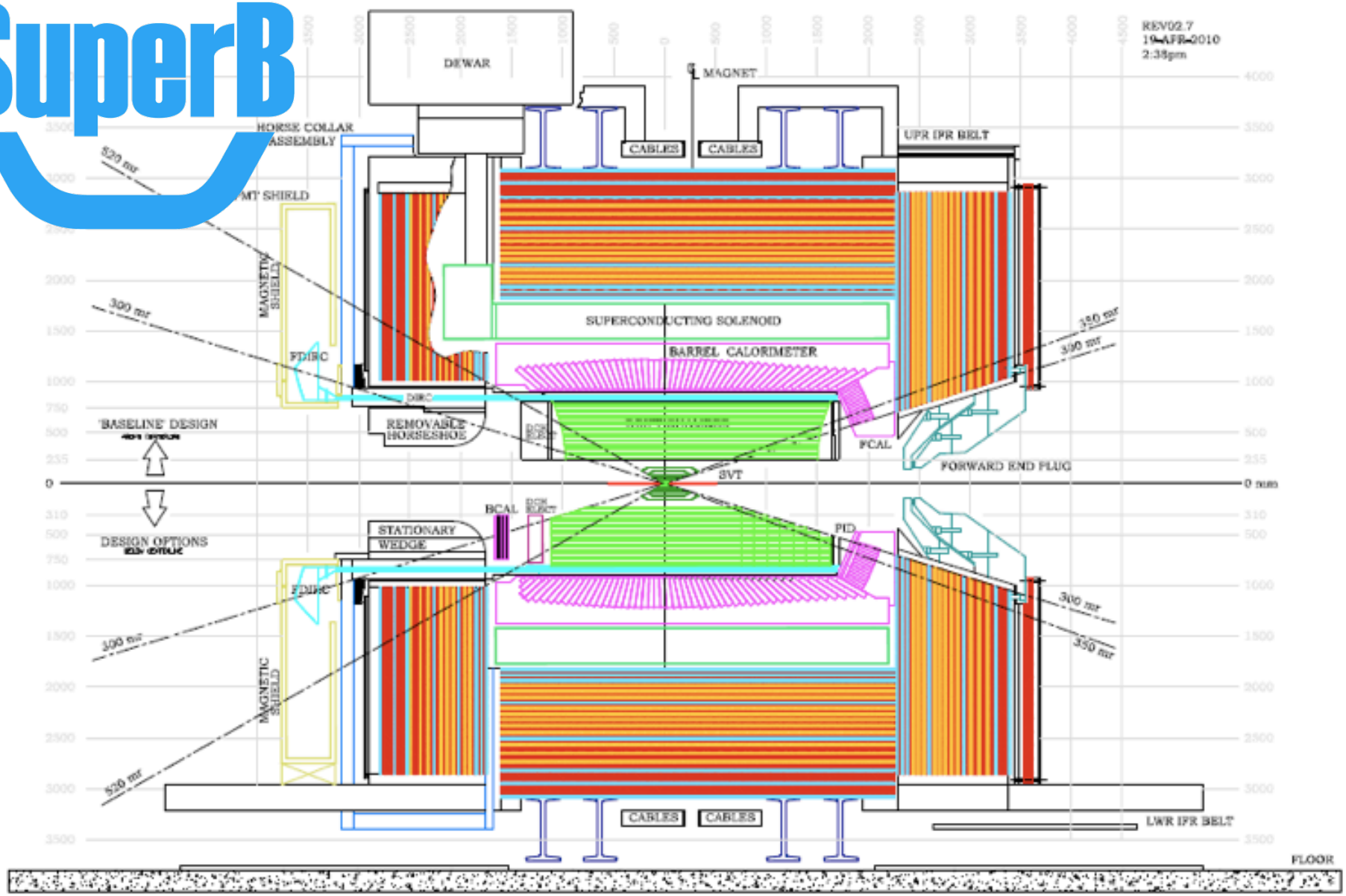
SuperB as SASE XFEL source

- Possibility to use the 6 GeV Linac for a SASE XFEL rather than SR beamlines from MR is appealing for the possibility to have a time sharing that does not compromize collisions
- Discussion with experts from SPARCLAB was very fruitful
- Found a way of operation that can satisfy both the collider and the FEL
- 3 documents to be produced asap:
  - CDR of the time-shared FEL operation in the superb LINAC
  - CDR of the FEL (baseline parameters and performances)
  - CDR of the source for the FEL (baseline parameters and performances)

Machine team in place

- Walter Scandale (formerly CERN) supervising
- Alessandro Variola (IN2P3) as machine head
- Eugeni Levycheff (BINP) and his team
- SLAC on board as well
- LNF AccDiv committed

a detector in progress



detector timeline

TDR process and timeline

- The Technical Design Report is an essential step to get funding and get the detector built.
- Conflicting requirements
  - Essential to enlarge the collaboration, define institutional responsibilites and find resources for designing and building the detector
  - Essential that collaboration members, institutions and countries take ownership of the design and fabrication
- Funding and schedule
  - The TDR must contain an initial definition of funding and resource availability
  - Open question about how to incorporate funding agencies intentions and committments into the TDR:
    - → Proposal to have a separate financial document to detail the agencies contributions

Timeline

- June-July: setup SVN repository + initial outline
- September 2011
  - Detailed outline with page count + editorial responsibilities
  - Tentative institutional matrix of responsibilities and money allocation
- ~~December 2011~~ → March 2012
  - First (in)complete draft,
  - Decision about what is in and what is out
  - ~~Updated budget and schedule for construction~~
- ~~February 2012~~ → June 2012
  - Complete draft into final editing
  - Final readers identified
- July 2012
  - Updated budget and schedule for construction
- September 2012: Publish

in a few words

- Injector also as XFEL machine
- Super-B parameters frozen
- Detector options being narrowed down
- Scheduling and costing review for final green light

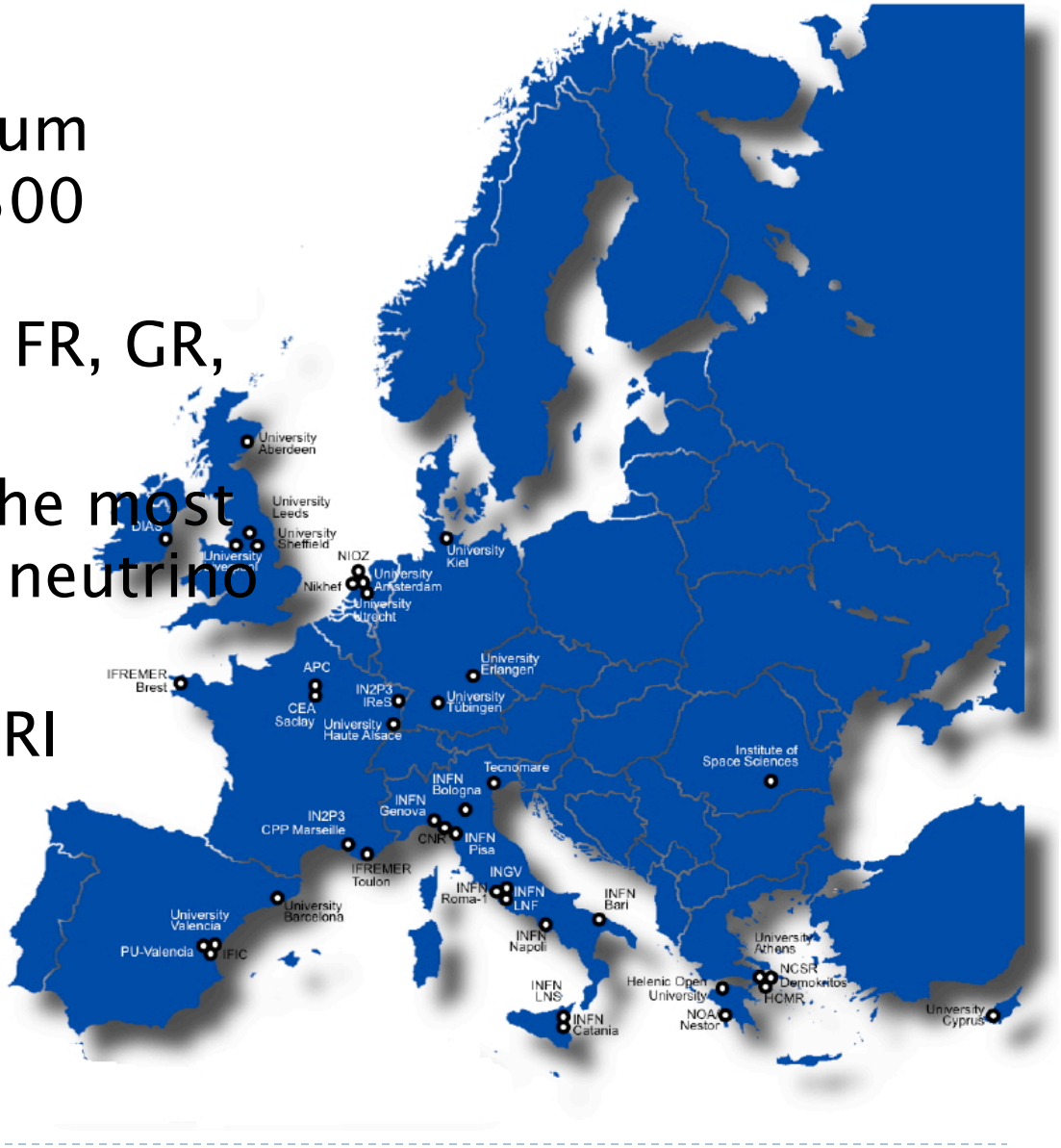
KM3Net

KM3NeT

International consortium involving more than 300 scientists from 10 EU countries (CY, DE, ES, FR, GR, IE, IT, NL, RO, UK)

One objective: build the most sensitive high energy neutrino telescope

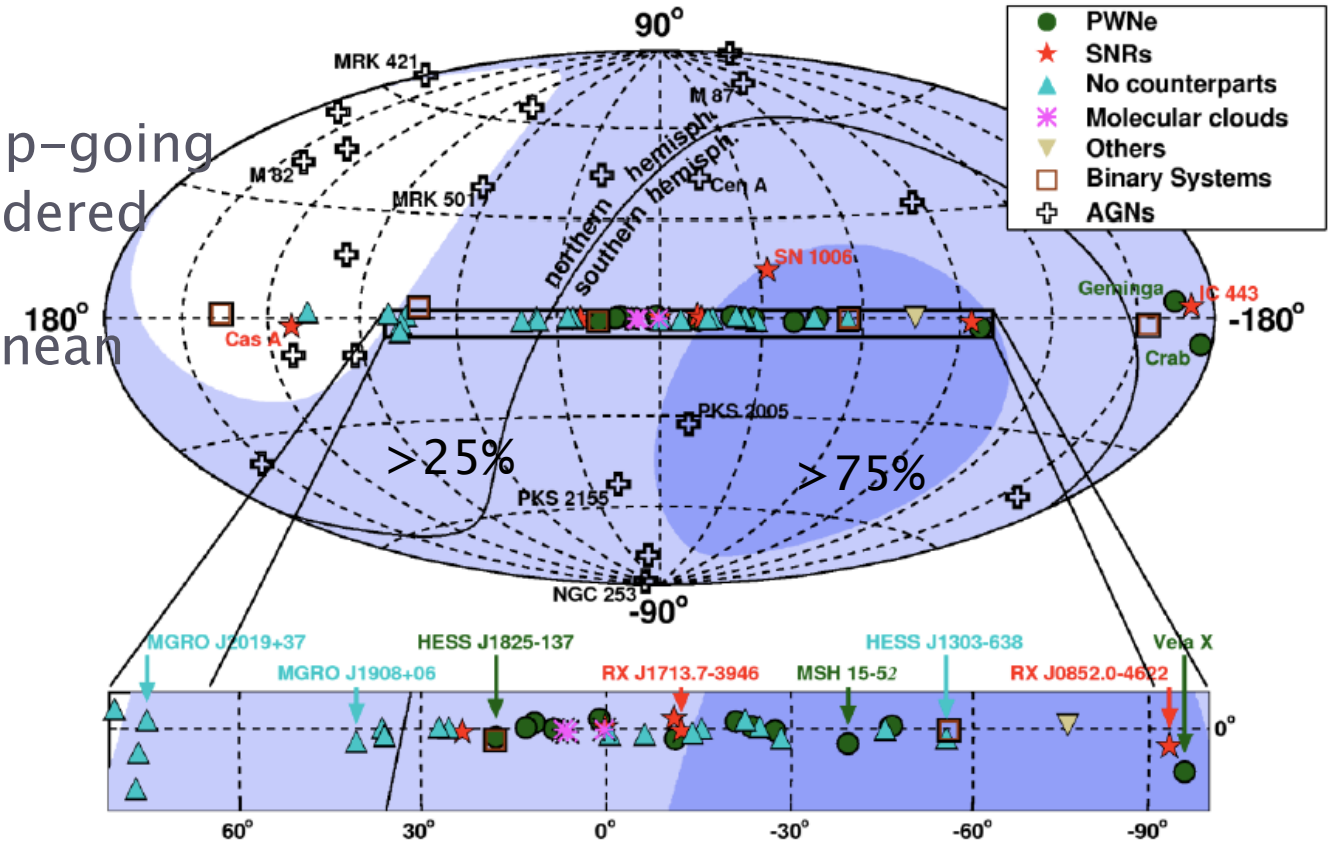
KM3NeT is on the ESFRI roadmap since 2006



The KM3NeT sky view

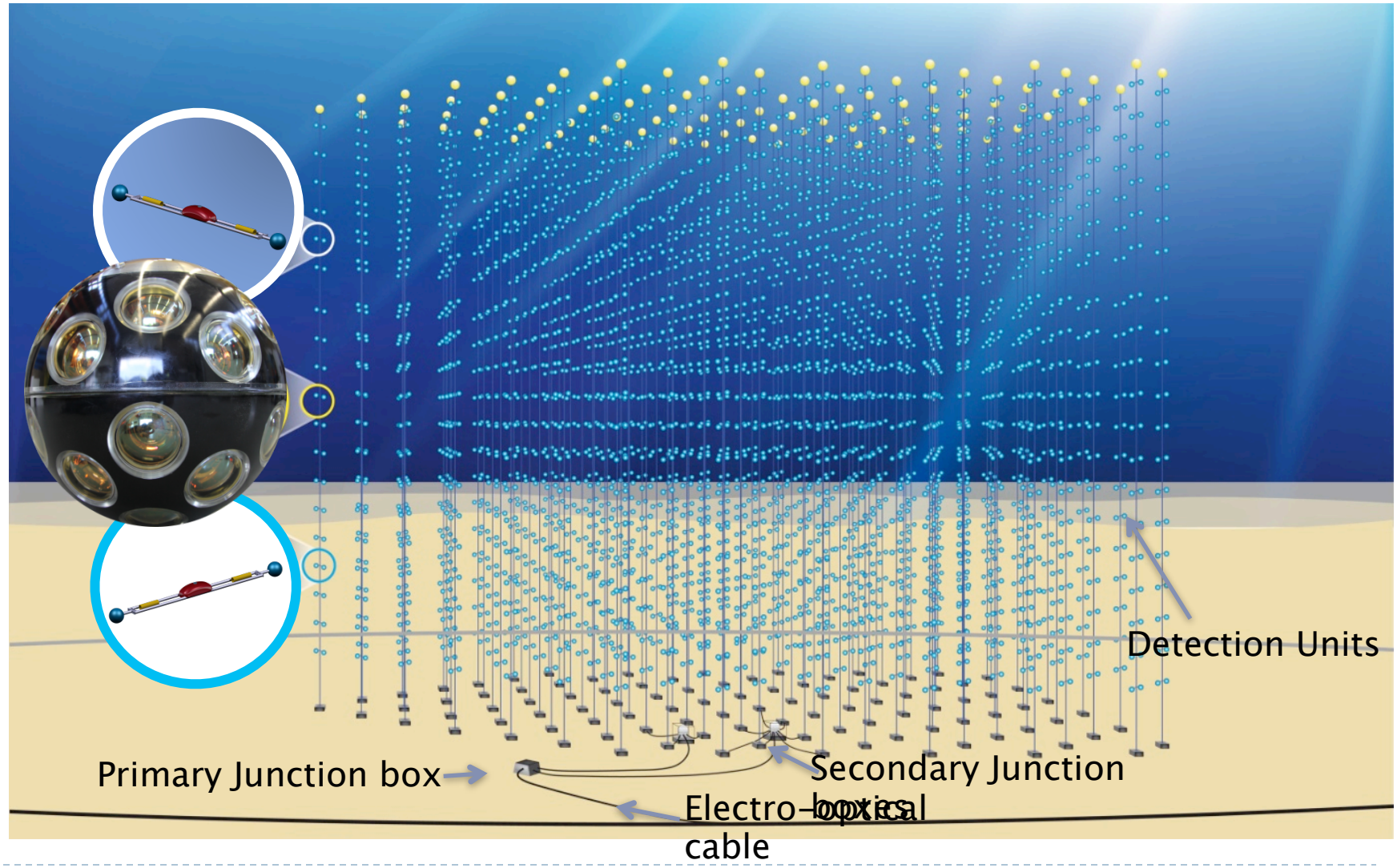
Sensitivity for up-going neutrinos considered

From Mediterranean 24h per day visibility up to about δ= -50°

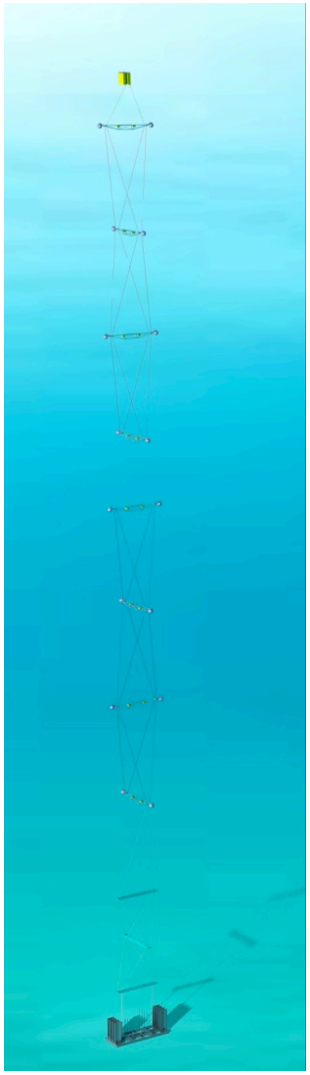


- KM3NeT complements the IceCube field of view
- KM3NeT observes a large part of the sky (~3.5π)

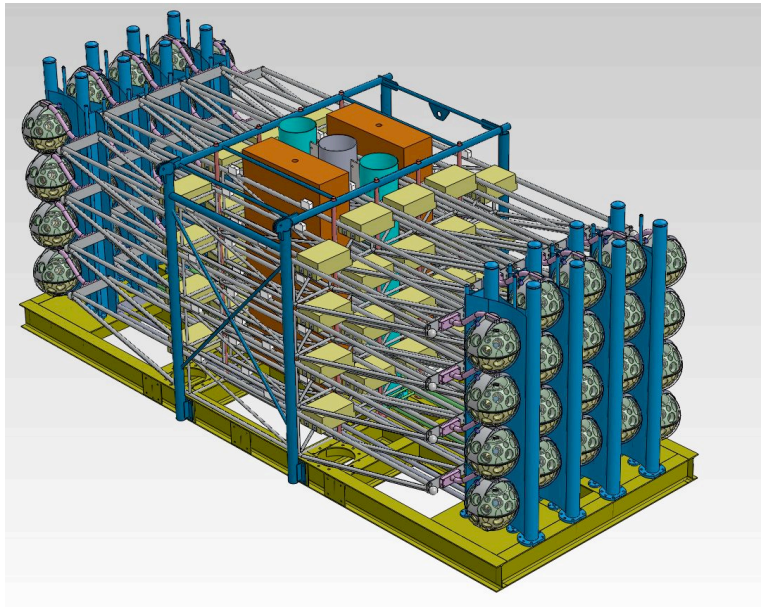
An artists impression of KM3NeT



The technology



Digital Optical Module
31 small PMTs in one 17" glass sphere
Photon counting



Detection Unit with 20 storeys
6 m bar length
DOM on either end
40 m inter-storey distance

Funding

ITALY
20.8 M€ from structural funds (PON 2007-2013)
2 M€ allocated by the Ministry for Research (MIUR)
"Site-linked" Infrastructures
shore station and cable realized by INFN (7 M€)
ROV acquired together with INGV (1.5 M€)

GREECE
50 M€ allocated for KM3NeT (25% of total investment)
Spending frame 7FP
"Site-linked"
Shore Station in Pylos
Surface vessel

FRANCE
8 M€ allocated for new infrastructures in Toulon and a few prototype DUs
"Site-linked"

ROMANIA
Funding up to 2.5 M€

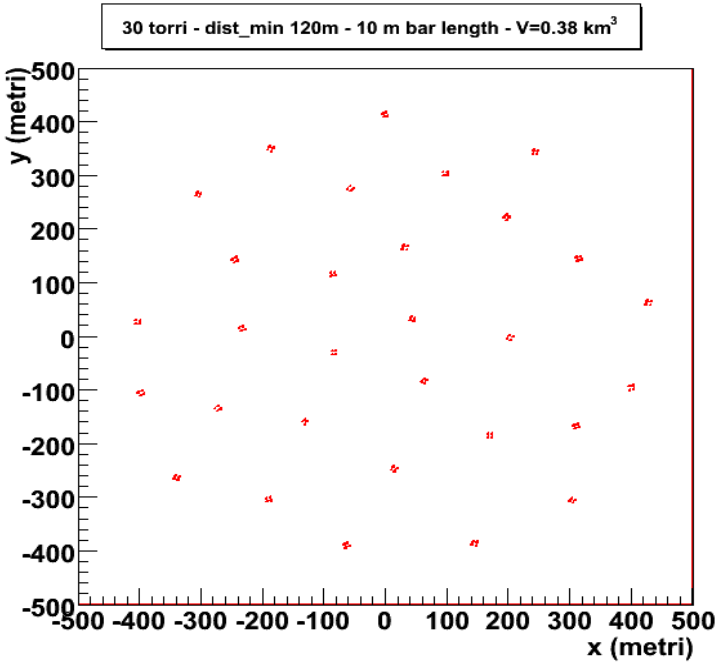
THE NETHERLANDS
7 M€ available for construction
1 M€ to set up KM3NeT headquarters in Amsterdam
Further request for an additional 7 M€ funding will be presented after MoU signature

The constrain of site-linking is a mixed blessing

Overall about 40 M€ are presently available to start construction (≈20% of the estimated cost of full KM3NeT)

KM3NeT-Italia

- Recently funded by the Italian Ministry of Reserach (MIUR) with a 20.8 M€ grant under the PON 2007-2013 (structural funds)
- Program is to build at Capo Passero a first part of the Italian node of a distributed KM3NeT



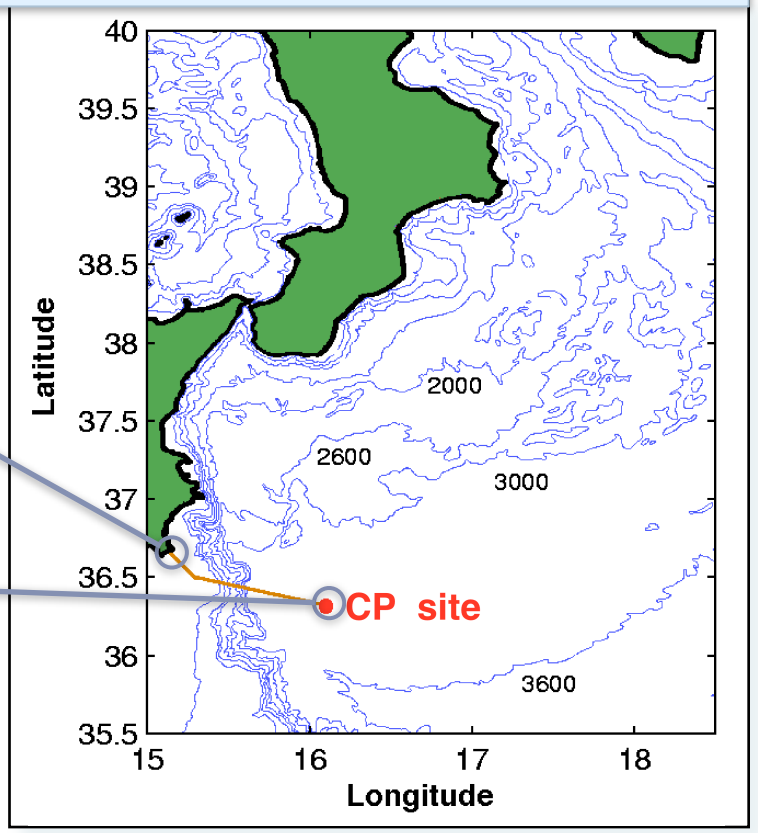
KM3NeT-Italia
- 30 KM3NeT detection units
- Average separation between Dus ~180m
- Total volume 0.38 km^3

The Capo Passero site

Capo Passero is one of the candidate sites for the installation of KM3NeT
Deep sea site studied and fully characterized in the past 12 years
Already existing infrastructure with to be upgraded for KM3NeT-Italia

Present infrastrucures

- Deep-sea 10 kW DC/ DC converter
- Main 100 km electro-optical cable
- Power feeding system
- Shore station
- High bandwidth (1 Gbps) connection to LNS



New funding scheme emerging

- LNGS activities on 'core' INFN funding with some addition from Regional funds
- Super-B on Ministry of Research funding under the National Plan of Research
- KM3Net mainly on Regional funds with some INFN contribution

We have not yet adapted to live with this !

Conclusion

- INFN is still healty and up to the glorious past
- Need an adjustment with new financing scheme
- Need to increase level of capture of EU funding (Horizon2020)