

Physics from Gran Sasso



Laboratori Nazionali del Gran Sasso

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Gran Sasso Science Institute, INFN

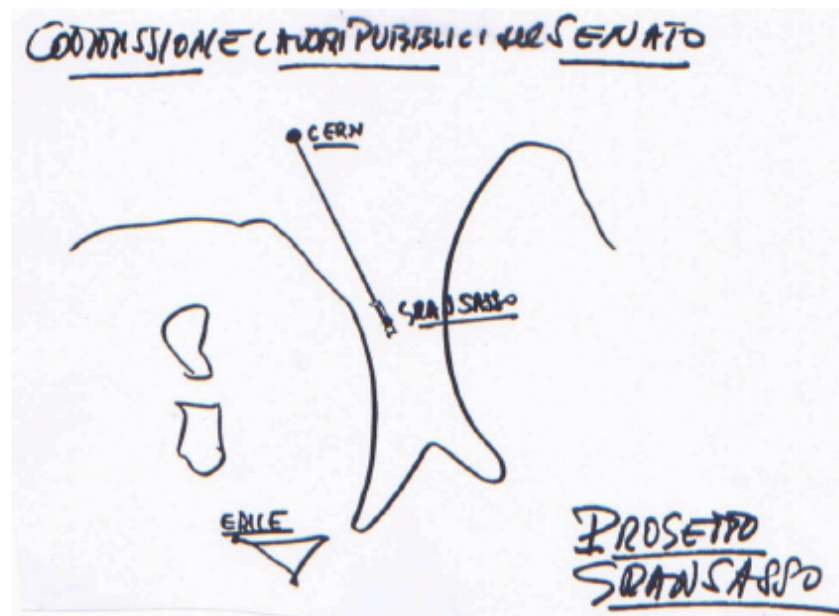
and U. of Rome Tor Vergata

Thanks to Stefano Ragazzi

Cashmorefest
Oxford - June 30, 2015

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).

To summarize, the scientific aims of the "Gran Sasso" laboratory are the study of:

- 1) nuclear stability;
- 2) neutrino astrophysics;
- 3) new cosmic phenomenology;
- 4) neutrino oscillations;
- 5) biologically active matter;
- 6) ground stability.

Not only
 $\tau_p \neq \infty$

Thanks to Stefano Ragazzi

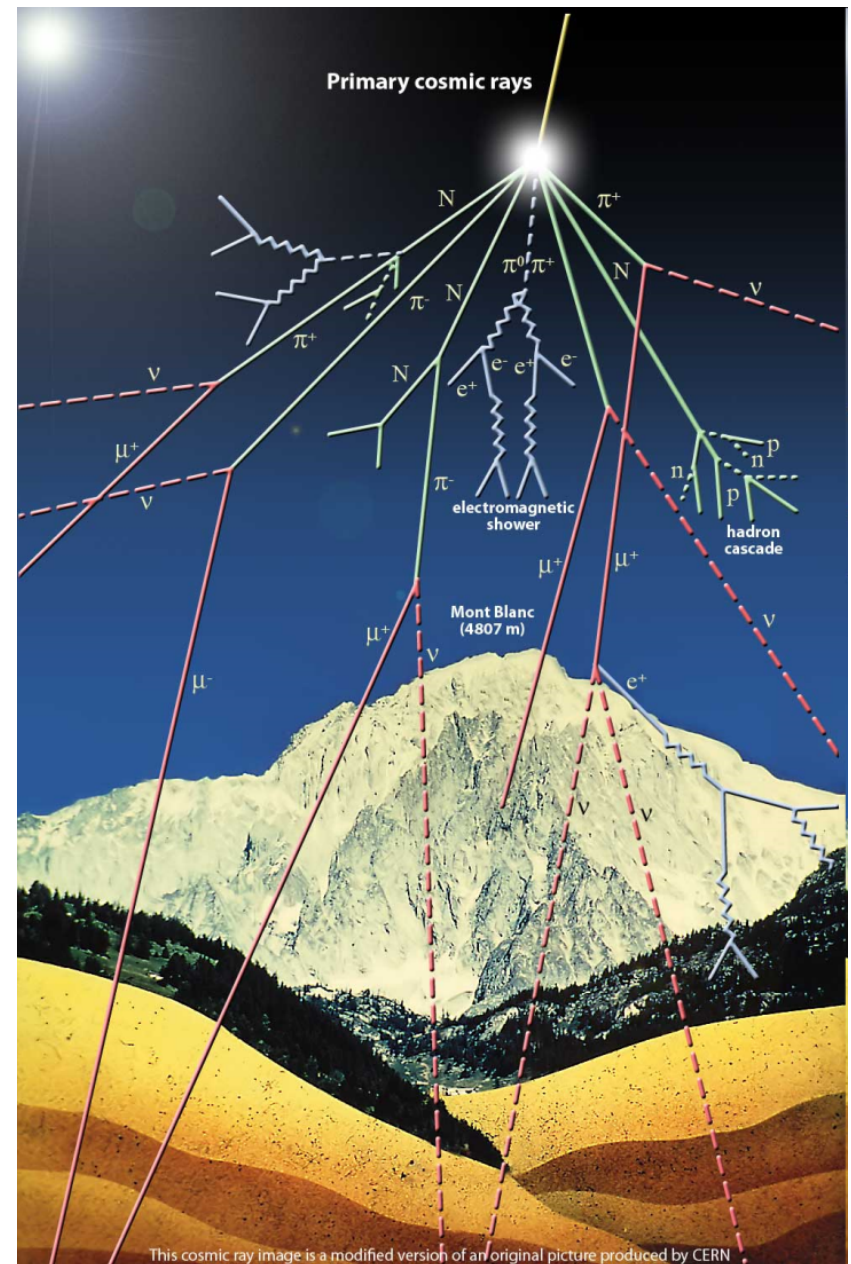
Underground labs: why?

**rare events <-> weak signals
=> low radiation environment**

- E.g: dose to human body in *normal* environment:
 - a. $\sim 1/3$ internal (^{40}K)
 - b. $\sim 1/3$ local radioactivity
 - c. $\sim 1/3$ cosmic ray muons: highly penetrating particles

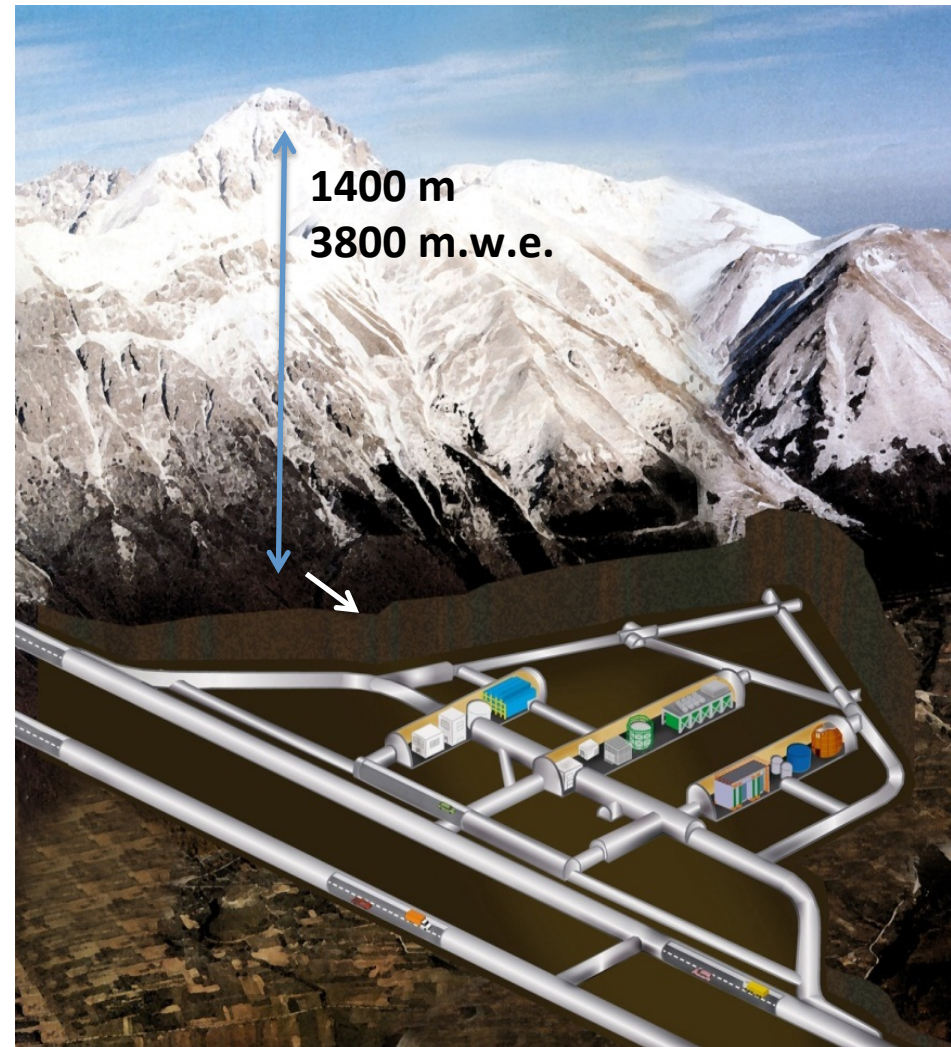
Reduction of radiation background in rare events searches:

- a. Ultrapure detector materials
- b. Ultrapure heavy shielding
- c. **Deep underground laboratories**
=> muon reduction at LNGS $1/10^6$

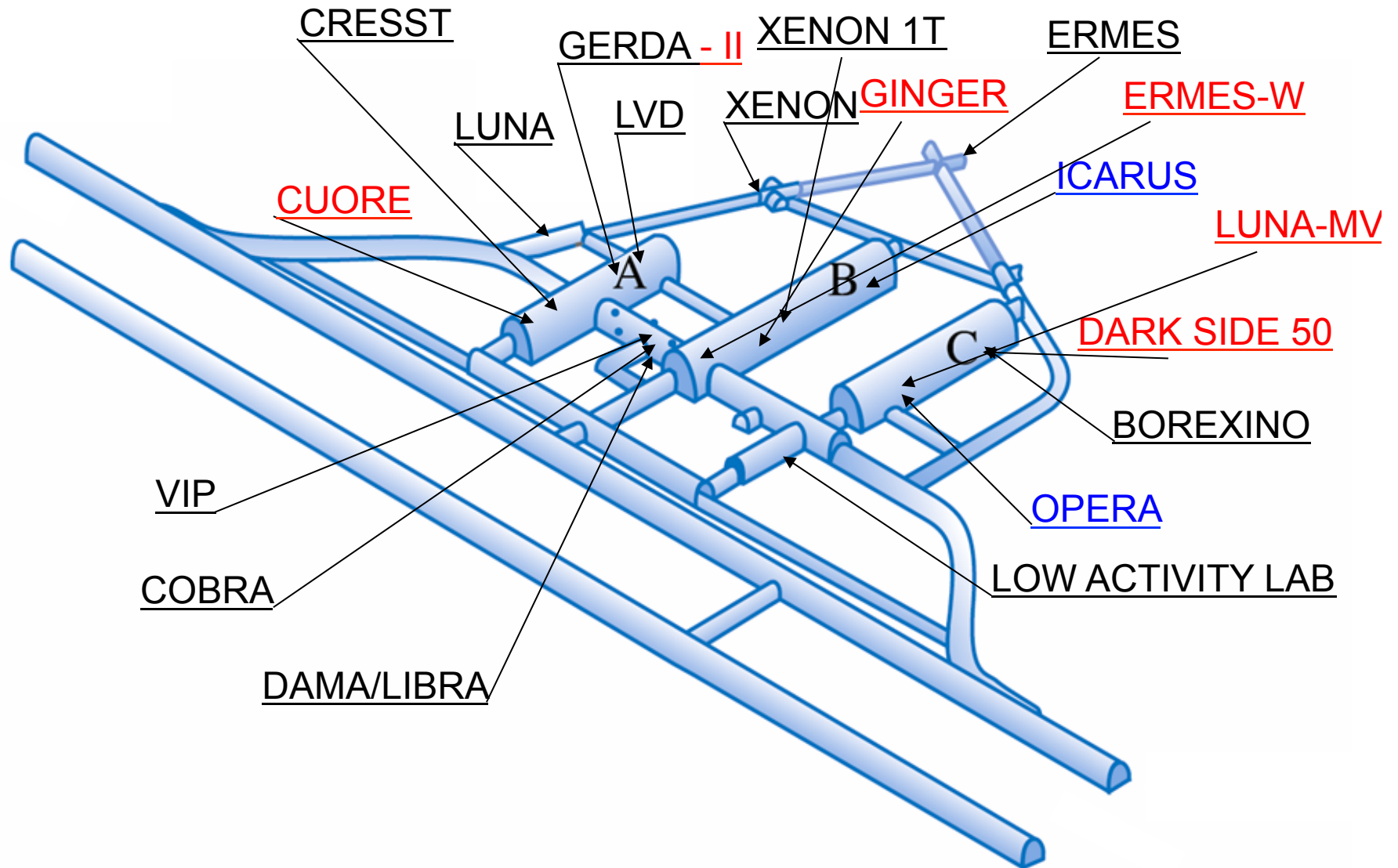


The LNGS Laboratory

- 1400 m (3800 m.w.e. vertical depth)
- Surface: 17 800 m²
- Volume: 180 000 m³
- Ventilation: 1 vol / 3 hours
- **World's largest UG laboratory**
- **Easy access trough highway tunnel**

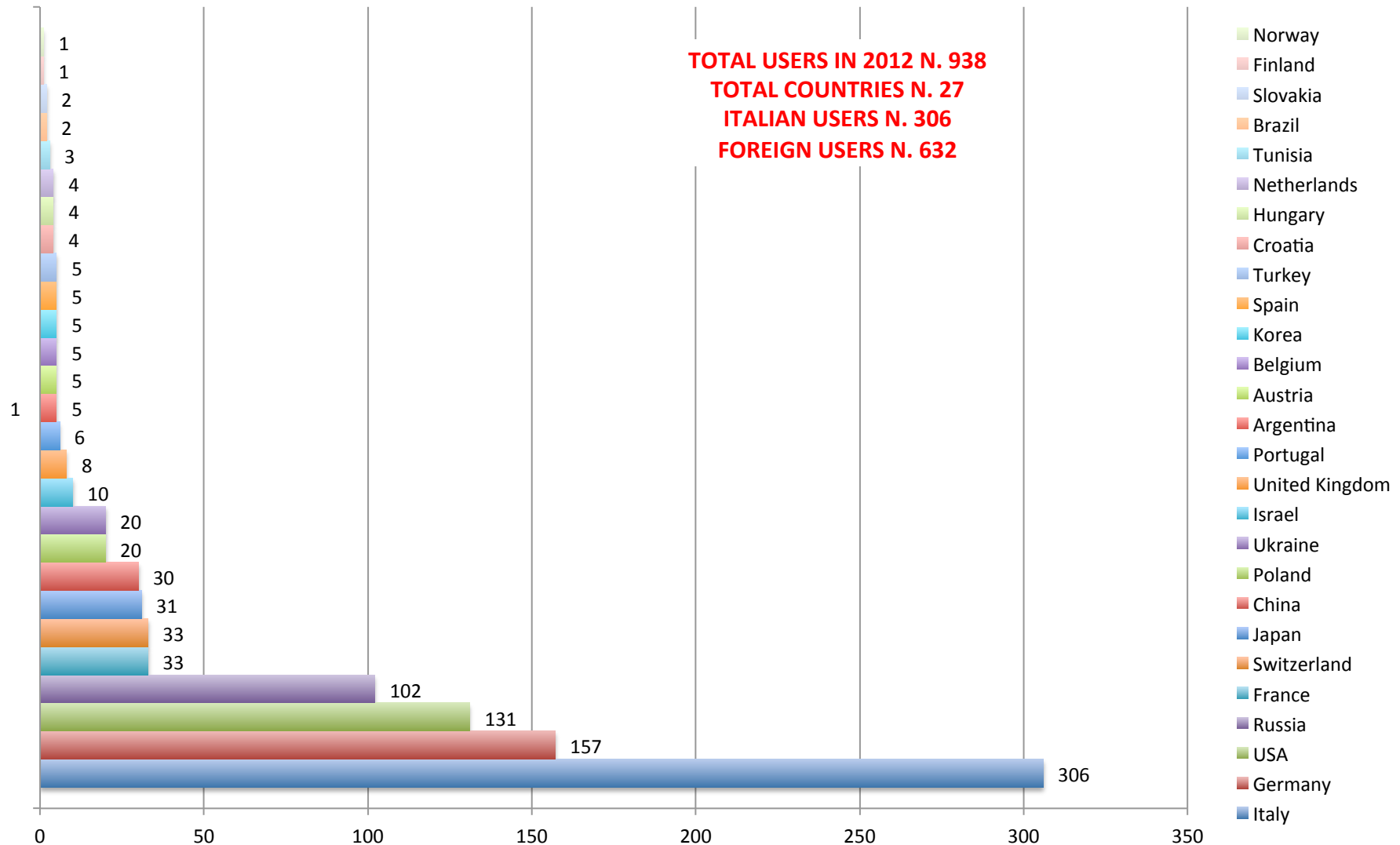


Busy laboratory



An International Laboratory

Main users: Italy, Germany, USA, Russia



Access

- Open access, excellence driven
- Proposals are peer-reviewed by the **Scientific Committee**
- An International **Scientific Committee** :
 - Present composition: 9 members, 3 of them from Italian Institutions
 - Chair: Ken Peach
 - Recommends proposals for approval, monitors progress of experiments

LNGS main research activities

- Neutrino Astrophysics
- Neutrino Physics
- Dark Matter searches: particle physics, astrophysics, cosmology
- Nuclear Astrophysics:
 - Study of Nuclear reactions relevant to Big Bang Nucleosynthesis and Star Nucleosynthesis

Virtual visits

- From Google Street View

- www.google.it/maps/@42.4538978,13.5746863,3a,75y,266.25h,74.88t/data=!3m5!1e1!3m3!1sU33rehgicSpsBNVVJXXT_w!2e0!3e5



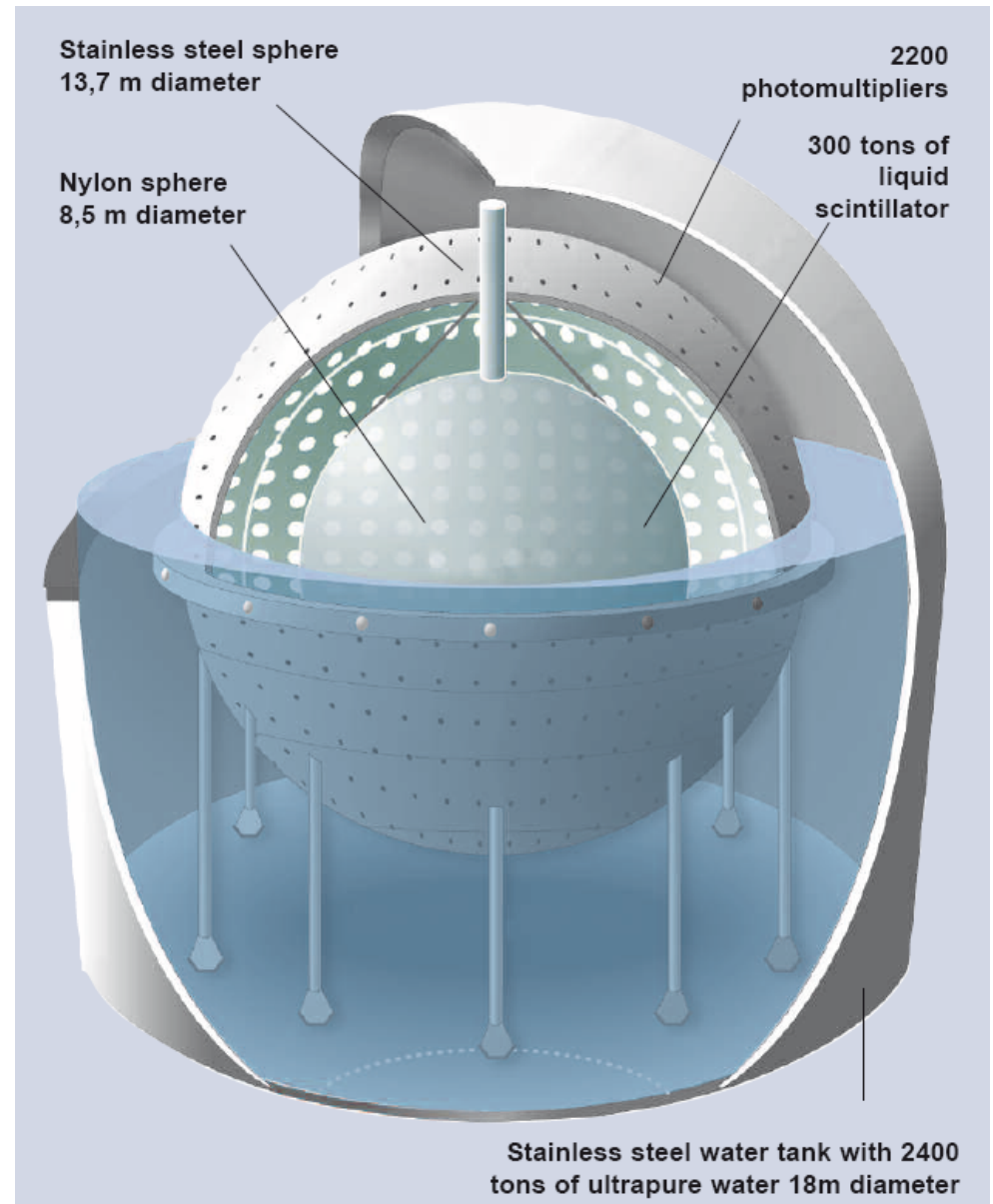
BOREXINO: real time detector of solar neutrinos

300 tons liquid scintillator in a nylon bag
2200 photomultipliers
2500 tons ultrapure water

- **The sun is an intense neutrino source:** 60 Billions neutrinos per second per cm^2 at the Earth surface
- **Neutrinos** produced in the core of the sun reach the Earth in 8 min.
- **Light** produced in Sun's core takes $>100,000$ years to reach the Sun surface
- Aug. 2014: Borexino reported first measurement of neutrinos produced from the primary p-p reaction

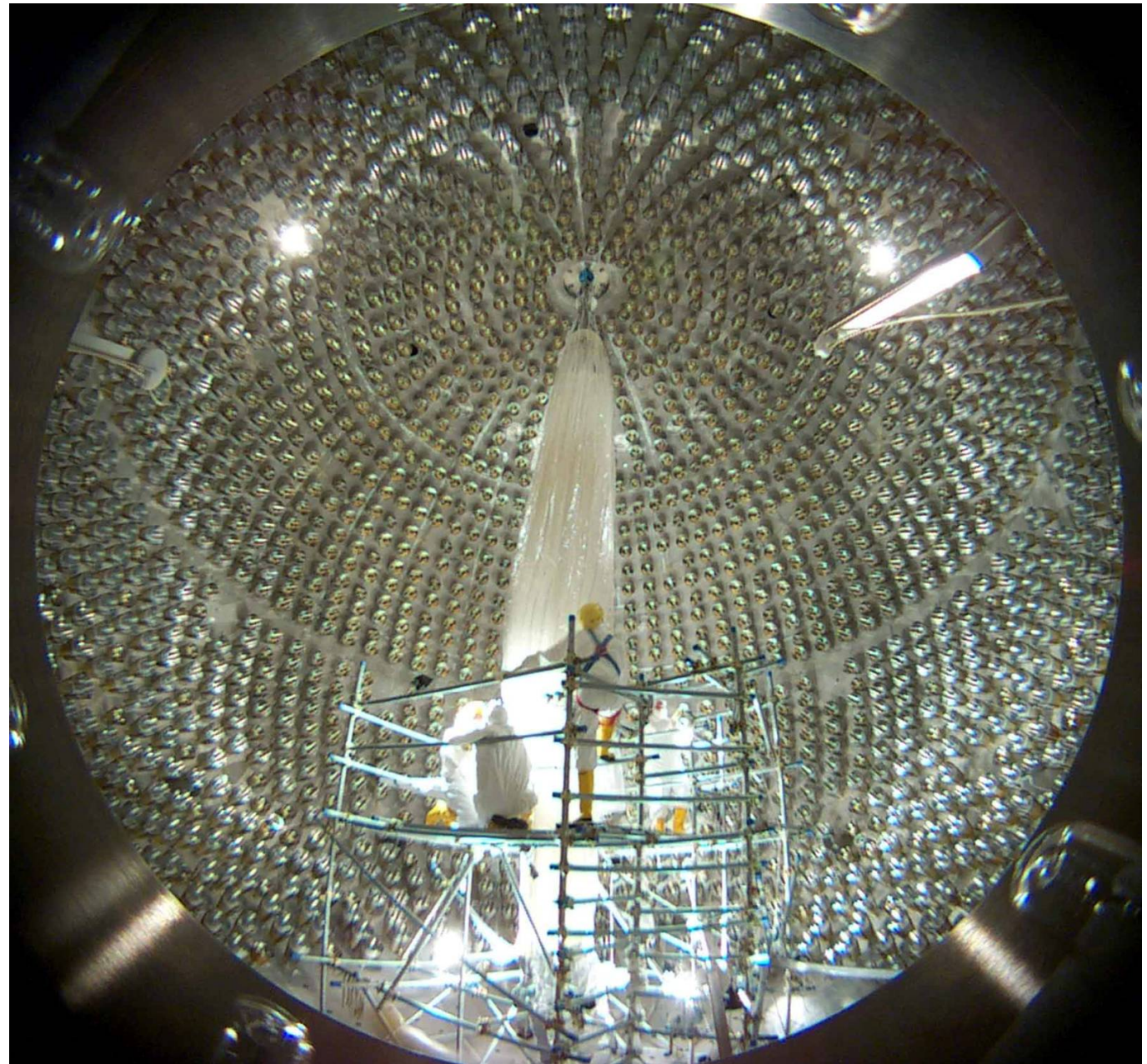


Physics World: 2014 Top
Ten Physics Breakthrough



Can't be seen during visits...

Borexino during
construction



Liquid scintillator: residual $^{238}\text{U} < 2 \times 10^{-19} \text{ g/g}$

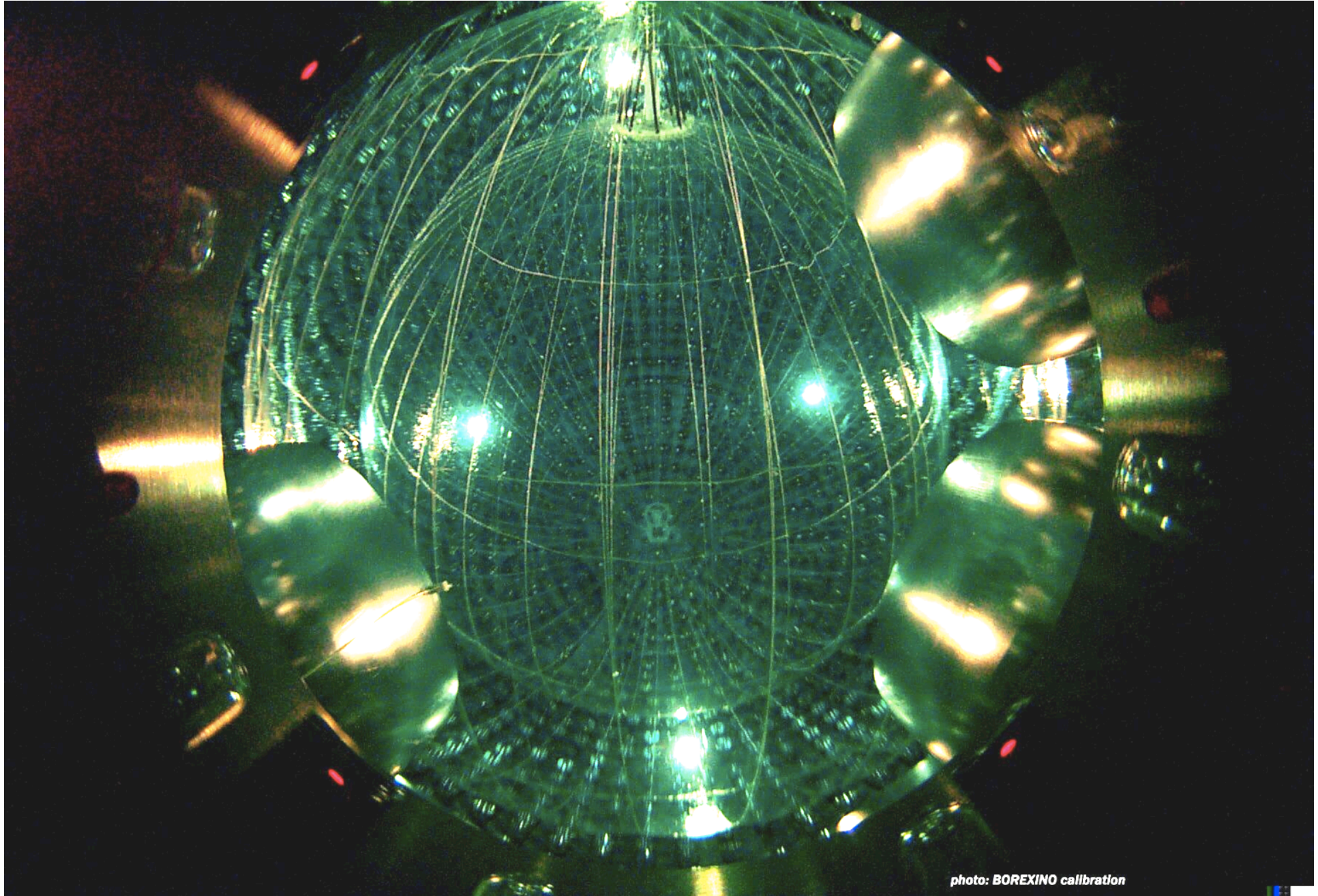


photo: BOREXINO calibration

Sep 3, 2003

Gran Sasso puts its troubles in order

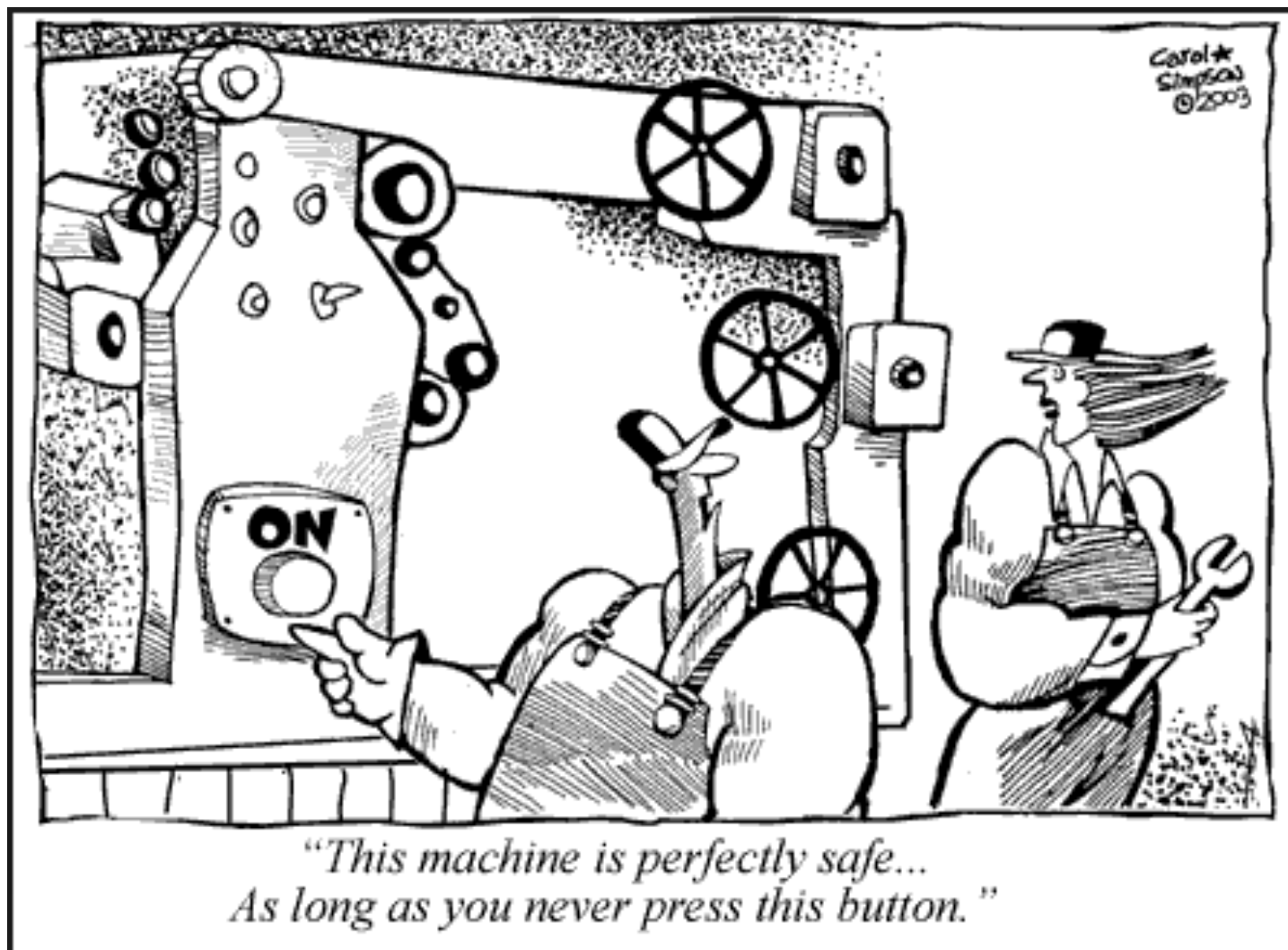


Gran Sasso

After a difficult year, it seems that an air of optimism is back in the INFN laboratories at Gran Sasso. On 17 June the competent court of the city of Teramo agreed to certain scientific activities starting up again in Hall C, as requested by INFN.

In particular, the installation of the OPERA experiment in Hall C, which began in March 2003 but was suspended in early June, will be able to resume. This decision is a sign that the competent authorities recognize the importance of the research being done at the Gran Sasso Laboratories and on the CERN Neutrinos to Gran Sasso (CNGS) programme in particular.

The problems began on 16 August 2002 when, following a series of unfortunate errors in Hall C, the team from the BOREXINO experiment caused 50 litres of trimethylbenzene to be discharged into the environment. The accident occurred at the very moment when a local debate on a safety tunnel designed to provide the underground laboratory complex with access independent from the adjacent road tunnel - very necessary in case of a disaster in the road tunnel - was beginning to become acrimonious. In such a tense atmosphere, even though no damage was caused by the accident, the fact that it could have done was enough to trigger a judicial enquiry.



*"This machine is perfectly safe...
As long as you never press this button."*

In October 2002, the BOREXINO detector was therefore placed under a sequestration order by the Teramo public prosecutor. Subsequently, as the release of information by the regional government cast serious doubts on the water-tightness of the Gran Sasso Laboratories' drainage system, INFN took the precautionary measure of suspending all activities requiring the handling of any kind of fluid throughout the underground laboratories on 5 June 2003. INFN then requested the immediate intervention of the competent government authorities, and at the same time, undoubtedly for the same reasons, the whole of Hall C was placed under a sequestration order.

Rapid and effective action from the Civil Defence Department is now awaited following the Italian government's decision on 27 June 2003 to declare a state of environmental emergency with regard to the entire Gran Sasso facility, that is, the laboratories, the road tunnels, the environment in general and the water system in particular. This intervention by the government should allow the laboratory's activities to return to normal and guarantee the complete safety of the citizens of the region of Abruzzo. These measures are fundamental to ensure that all of Gran Sasso's activities can begin again in an atmosphere of complete trust between the scientists and the local population.





XXII meeting of the Gran Sasso Scientific Committee (SC)
October 14-15-16 2004

List of Participants:

Prof. F. Bobisut

Prof. R. Cashmore (Chairman)

Prof. E. Coccia

Prof. F. Ferroni

Prof. T. Kirsten

Prof. J. Lefrancois

Prof. A. Masiero

Prof. J. Panman

Prof. V. Patera

Prof. A. Scaramelli

Secretary: Dott. R. Aloisio

Laboratory and Committee issues:

The SC congratulates the Laboratory management for the great progresses in solving the operation problems and safety issues of the underground Laboratory. Since August 2004 all the areas in the Laboratory are free of restrictions. The works needed for the upgrade of the LNGS infrastructures are already started and the time schedule of these works is almost respected. The SC took note of the great efforts made in order to reconcile these works with the scientific programme of the Laboratory.

XXX meeting of the Gran Sasso Scientific Committee (SC)

November 4 – 5 2008

List of Participants

Prof. A. Baldini

Prof. C. Brogгинi

Prof. R. Cashmore (Chairman)

Prof. E. Coccia

Prof. P. Lipari

Prof. E. Lisi

Prof. D. Vignaud

Apologies: Prof. F. Linde and Prof. M. Lindner.

Laboratory and Committee issues:

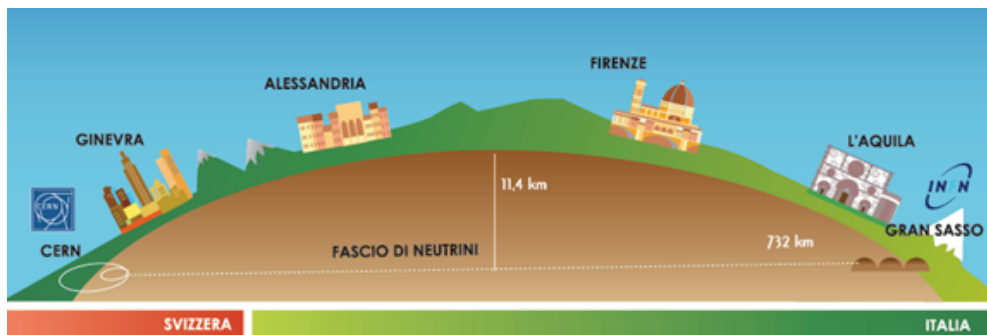
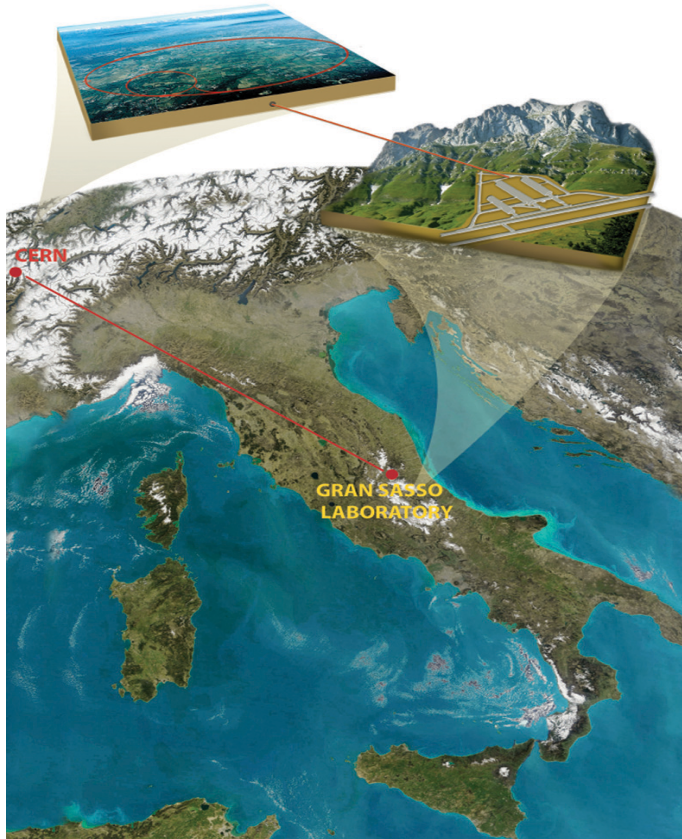
The SC was pleased to note the continued improvement of the Laboratory infrastructures: in the last six months a new ventilation system and a new fire-fighting system were installed underground. The SC congratulates the Laboratory management also for the important renewal of environmental certification recently obtained by LNGS and for the inauguration of the Physics Museum in Teramo, managed by INFN. The SC reiterates its view that the next years in the life of the Laboratory are of paramount importance in continuing and increasing the international status of LNGS. To achieve its important scientific goals the Laboratory needs a substantial increase in its permanent staff in the scientific and technical divisions to give adequate support for its excellent experimental programme.

Neutrino Oscillations

CNGS: Neutrinos generated at CERN (muon neutrinos) sent to LNGS, 732 km away.

A fraction of mu-neutrinos transforms into tau-neutrinos

A phenomenon related to neutrinos mass



OPERA and ICARUS
detectors

Oscillation Project with Emulsion tRacking Apparatus



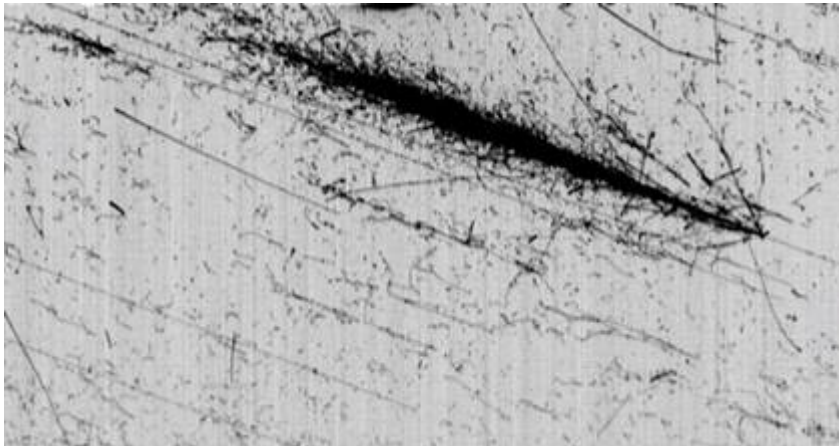
OPERA: take “photographs” on emulsions of tau-neutrino

Imaging Cosmic And Rare Underground Signals



ICARUS:

- world largest liquid argon detector
- takes 3-d electronic photos of neutrino interactions



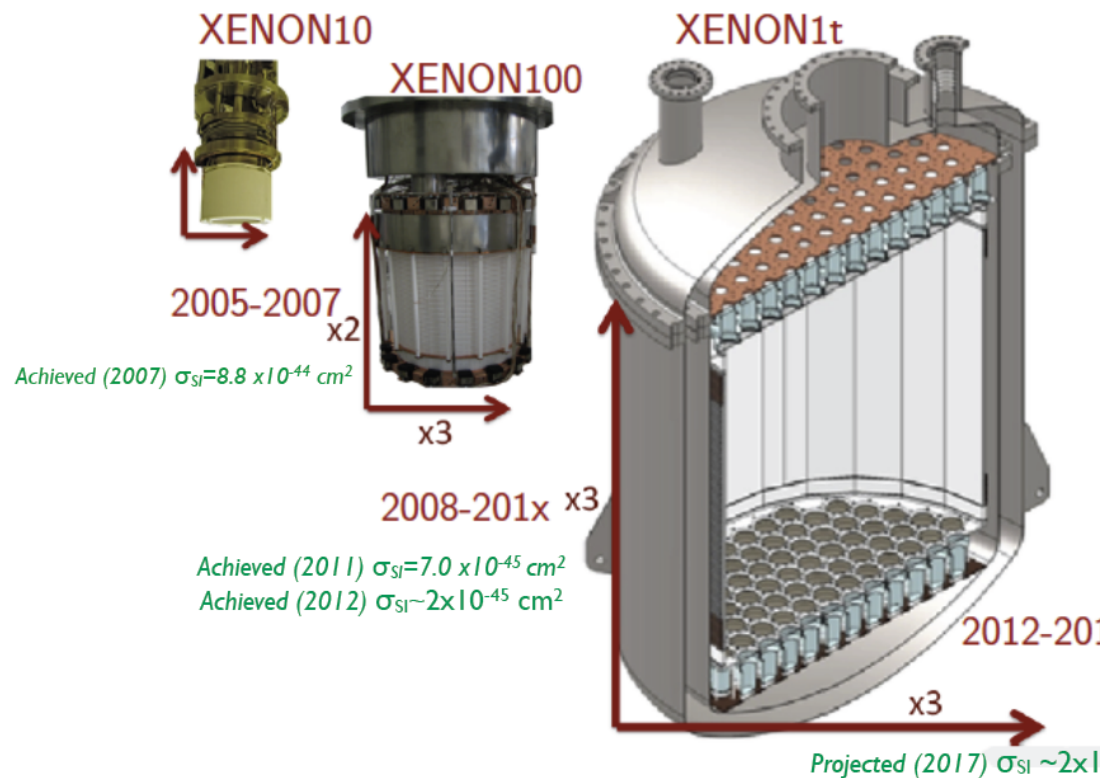
Out and In

- Icarus 1st module passes by Xenon-1T while leaving Hall-B, heading to CERN, on Nov. 10
- Icarus 2nd module left LNGS on Dec. 9
- Xenon1T will start data taking during summer 2015

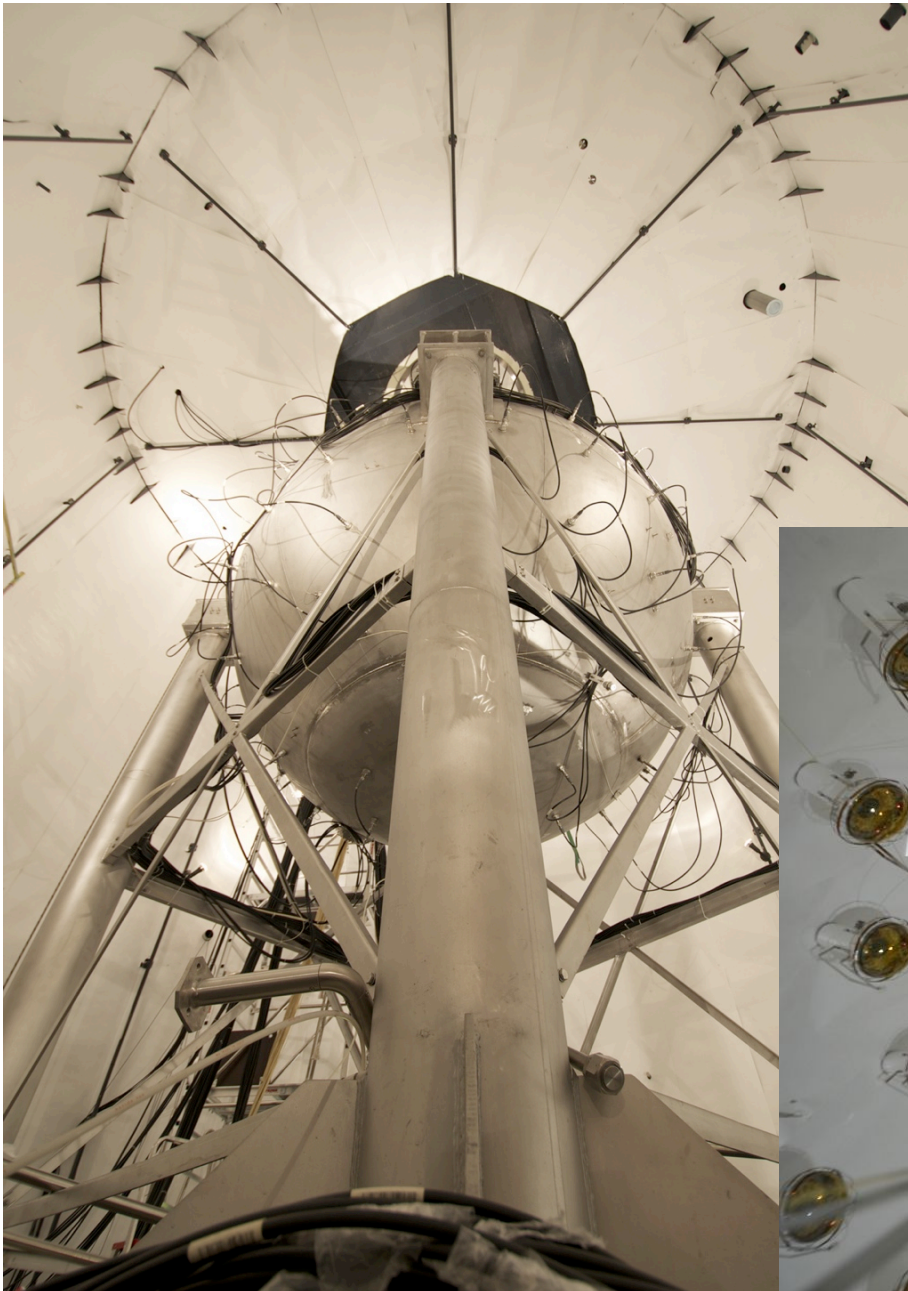


Dark Matter searches

The Xenon family



DarkSide-50 with active neutron veto



Double Beta decay experiments



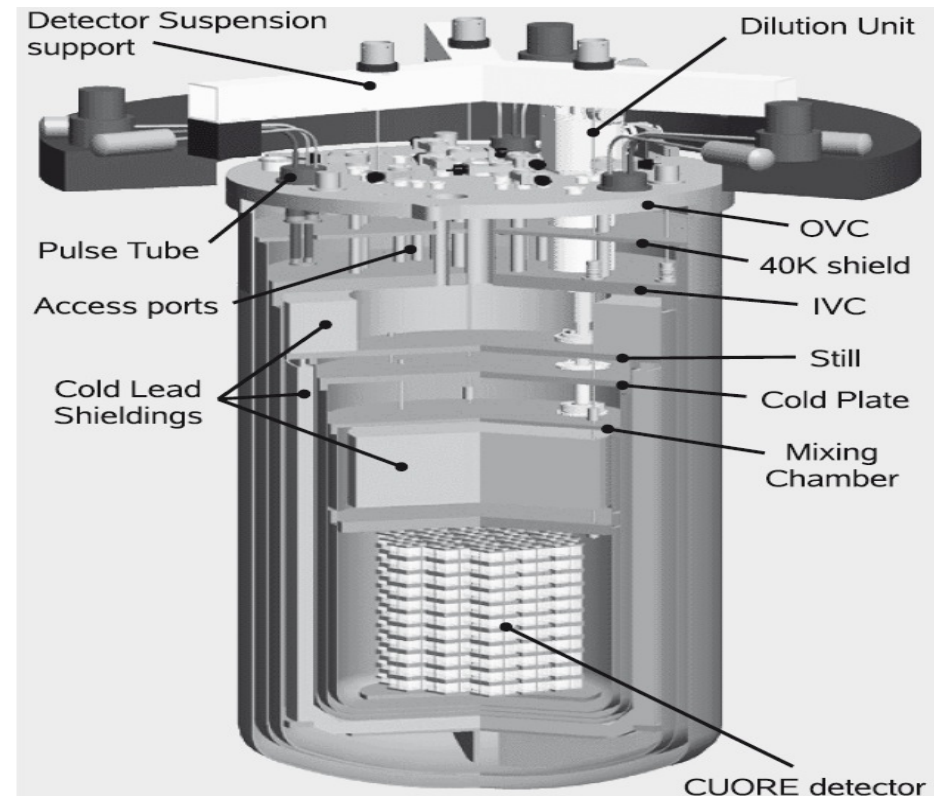
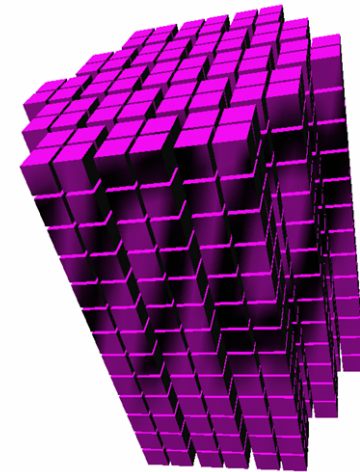
Gerda Experiment

...unfortunately only the outer tank will be visible

CUORE experiment

The CUORE experiment is able to detect $\beta\beta$ decay of ^{130}Te by using cryogenic detectors made of TeO_2 crystals. The prototype CUORICINO, already installed at LNGS, demonstrated the feasibility of the large scale detector CUORE.

@ 6 mK: the coldest m³ in the Universe



Outreach & Education



- 8000 visitors/year
- 1500-2000 visitors at LNGS open day
- 2014 European researcher's night with GSSI and L'Aquila University: 15,000 participants in L'Aquila
- Educational activities at several levels: from youngest to post-Doc and Physics teachers
- 3 education and high-education projects with Abruzzo Region on EU funds 2007-2013: **5.4 M€**



6 April 2009
L'Aquila earthquake



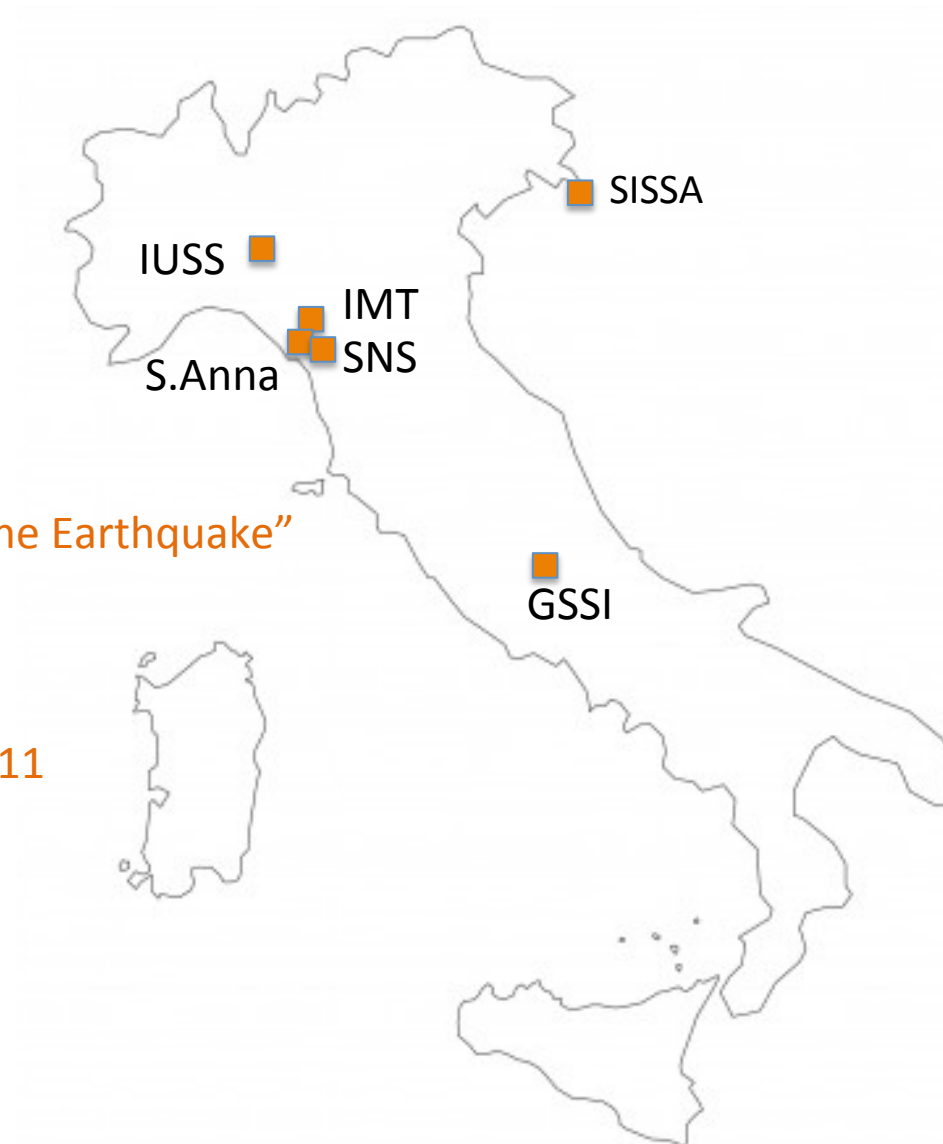
Some History

Initial project of an International PhD
School presented at:

OECD – MEF Meeting “L’Aquila after the Earthquake”
Rome 3.7.2009

Endorsed by the Report from
OECD-University of Groningen – 2010/11

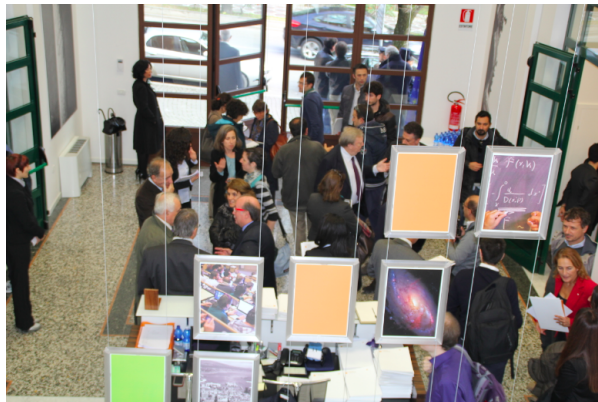
Supported by:
Abruzzo Region
INFN



OECD Report: SPREADING THE EAGLE'S WINGS SO IT MAY FLY:
RELAUNCHING THE ECONOMY OF L'AQUILA REGION, GOV/TDPC/RD(2009)8

<http://www.oecd.org/dataoecd/0/36/43307733.pdf>

The INFN center for advanced study and international PhD school *Gran Sasso Science Institute* has started its educational and scientific activities in 2013, and is now in its third year of life.



4 courses:

- *Astroparticle Physics*
- *Mathematics in Natural, Social and Life Science*
- *Computer Science*
- *Urban Studies*

36 PhD students selected in the first year 2013-2014

40 PhD students selected for the second year 2014-2015

40 PhD students under selection for the third year 2015-2016

Also appointed: 16 Post-docs with two-years research grants

Director: E. Coccia

Coordinators: F. Vissani, P. Marcati, R. De Nicola, A. Calafati

Scientific Committee: F. Barca (MEF, Italy, Chair); R. Barbieri (SNS, Italy); B. Barish (Caltech, USA); S. Iammarino (LSE, UK); A. Quarteroni (Politech. Losanna, CH); A. S. Vincentelli (Berkley, USA). **2° meeting April 17, 2015**

www.gssi.infn.it

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GRAN SASSO
SCIENCE INSTITUTE

CENTER FOR ADVANCED STUDIES
Istituto Nazionale di Fisica Nucleare

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IN N

An international PhD school and a center for advanced studies in physics, mathematics, computer science and social sciences.

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Search...



La vie Lumière - Spettacolo-dialogo "I ragazzi di via Panisperna"

Mercoledì 6 Maggio, ore 20:30 sala rossa del GSSI. Spettacolo-dialogo "I ragazzi di via Panisperna". Con l'ausilio di sequenze del film di Gianni Amelio, verrà raccontata la storia del gruppo di giovani fisici le cui ricerche, negli anni '30 del secolo scorso, sotto la guida di Enrico Fermi, ebbero una straordinaria influenza sulla Fisica italiana e mondiale.

OLDER NEWS

La Vie Lumière: science, culture and cinema in a film festival

500 Applicants for 12 Postdoctoral positions at the GSSI

Eugenio Coccia appointed among CEPR experts

GSSI Professor top-cited author

Open Doors at the GSSI

Forum L'Aquila del futuro. Progetti per la cultura, la scienza, la società.

ANNOUNCEMENTS

PhD call for applications 2015/16 - Deadline May 15, 2015 »

SEMINARS&EVENTS

Regularity of free boundaries in anisotropic capillarity problems and the validity of the Young's law

Guido De Philippis

April 16, 3 pm - Main Lecture Hall

Local volume-constrained minimizers in anisotropic capillarity problems develop free boundaries on the walls of their containers. We prove the regularity of the free boundary outside a small set, showing in...

Measurement-based Performance Problem Detection and Diagnosis

Dr. André van Hoorn, University of Stuttgart, Germany

Tuesday April 21, 2015 11 a.m. - Main Lecture Hall

AbstractApplication performance monitoring (APM) is getting more and more common in practice. The APM data obtained from the monitored application systems - ranging from aggregated response time and resource utilization...

Control of Partial Differential Equations @GSSI

many speakers

April 22-24 - GSSI

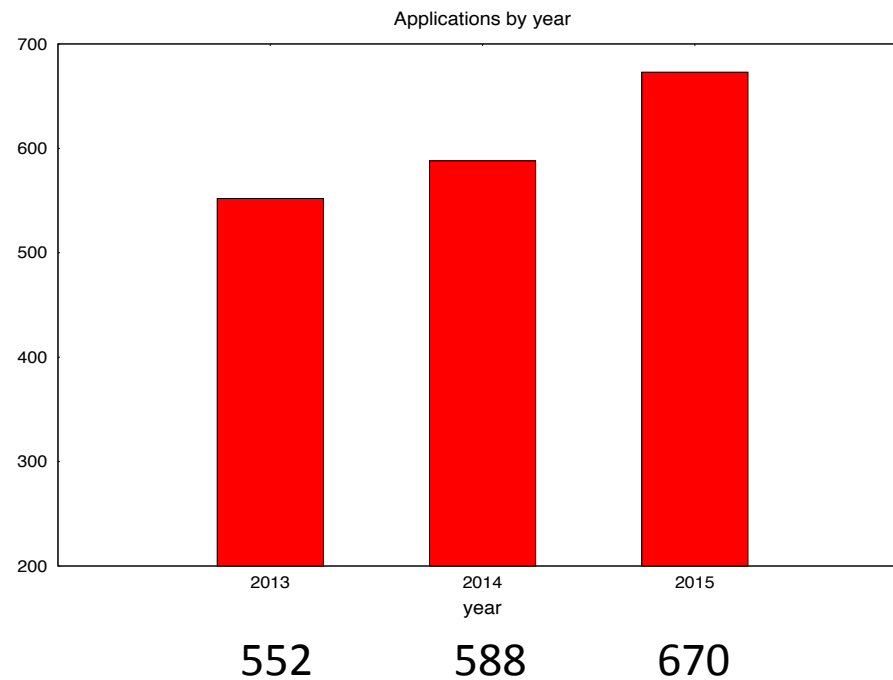
This meeting is aimed to offer an updated view of the current research of interest to the GDRE CONEDP to the large and active community operating at GSSI and to...

ASTROPARTICLE

MATHEMATICS

COMPUTER SCIENCE

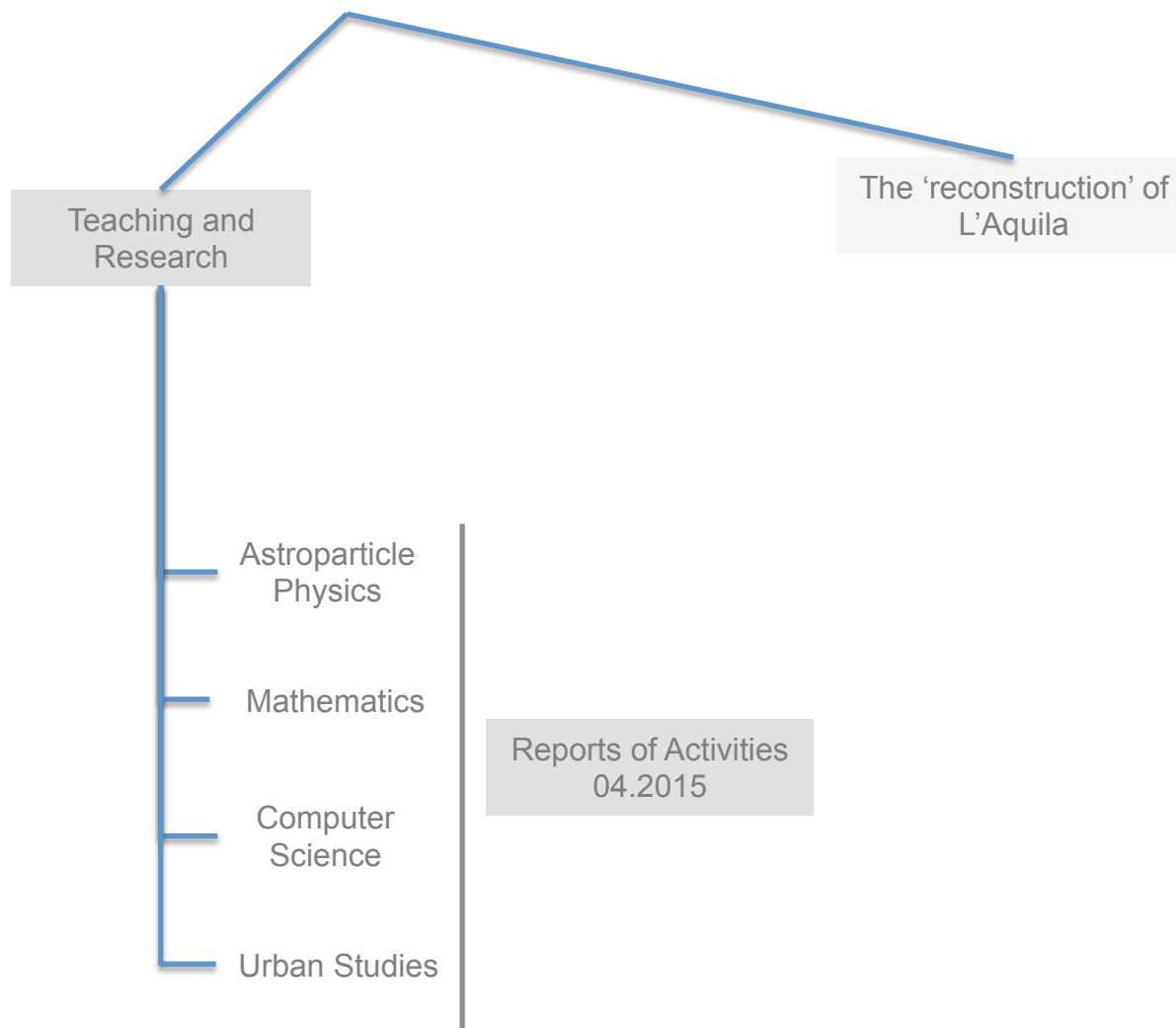
URBAN STUDIES



let me shortly point to what we regard as a key indicator of the progresses GSSI is making.

The application process to the 31th Cycle is currently open and so far we have received a remarkable number of applications. There has been a steady growth in the number of applications (and applications are not yet closed).

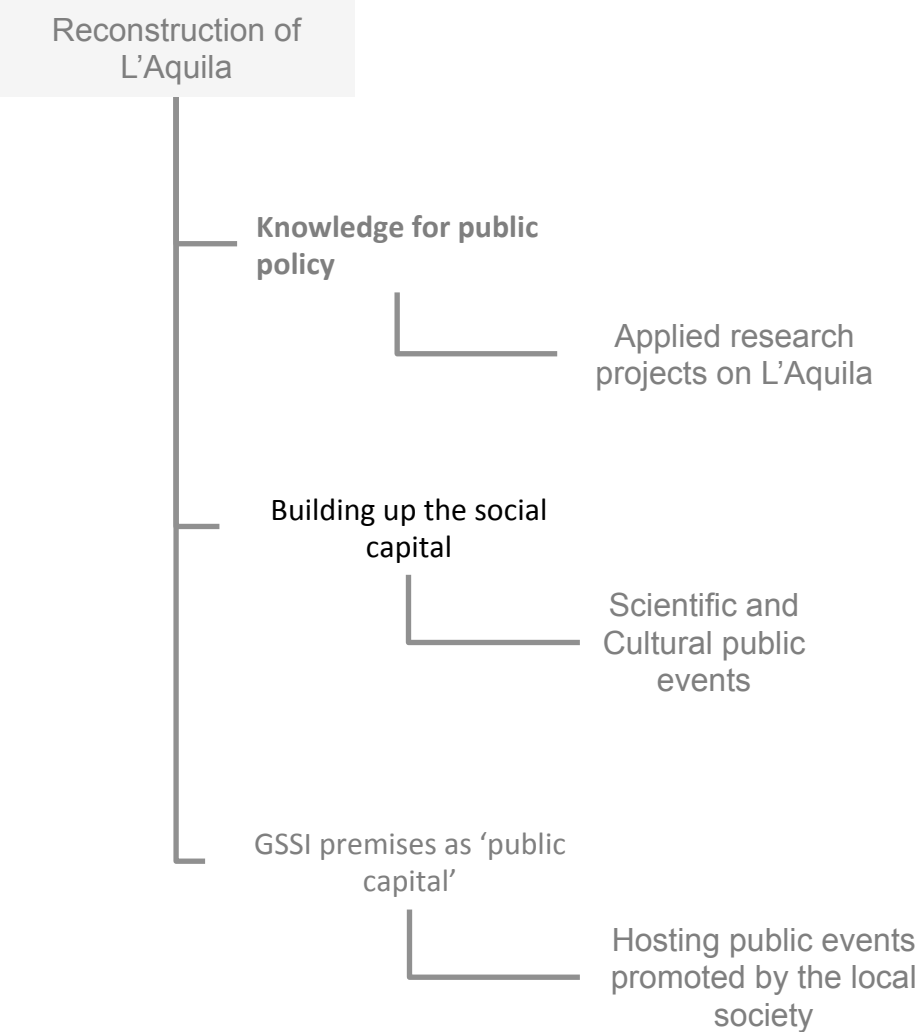
Gran Sasso Science Institute



GSSI mission is in the field of 'teaching and researching',

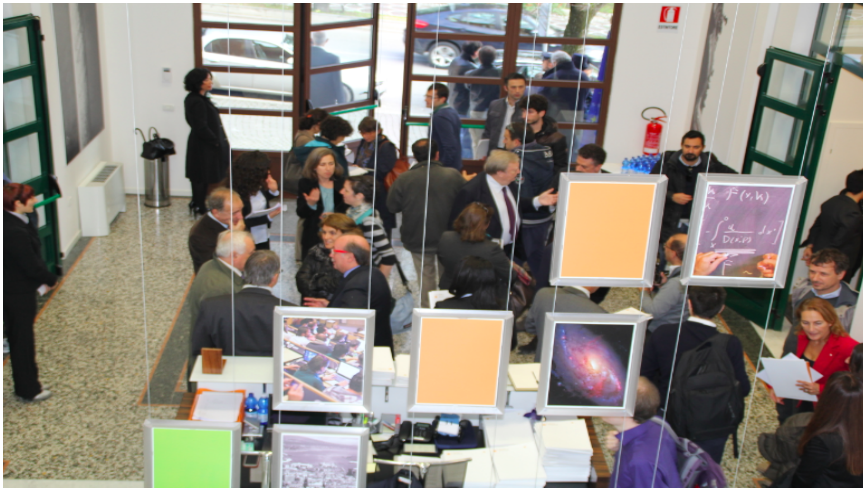
contributing to the reconstruction of L'Aquila.

with precise responsibility of contributing to consolidate L'Aquila as a 'knowledge city' in the Italian, European and global space.



These activities have established the GSSI as a key actor in the reconstruction of L'Aquila (within the limits of a scientific institution).

The research projects recently launched have not yet produced relevant outputs. But they will do it very soon, and before the summer vacation they will be presented to the public.



forming high level human capital,
integrating education and research in a
lively interdisciplinary environment



Roger has been the Chair of the Scientific Committee of the Gran Sasso Laboratories in its most delicate moment.

The moral of the community was very low and the Lab could have been abandoned. We came out of this situation also thanks to the wisdom and influence of Roger.

From the Gran Sasso Lab a new project of higher education in Italy arised after the earthquake.

Thank you Roger, from Gran Sasso

