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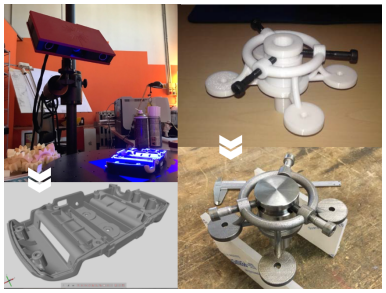
The Gran Sasso National Laboratory

INFN LNGS

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali del Gran Sasso

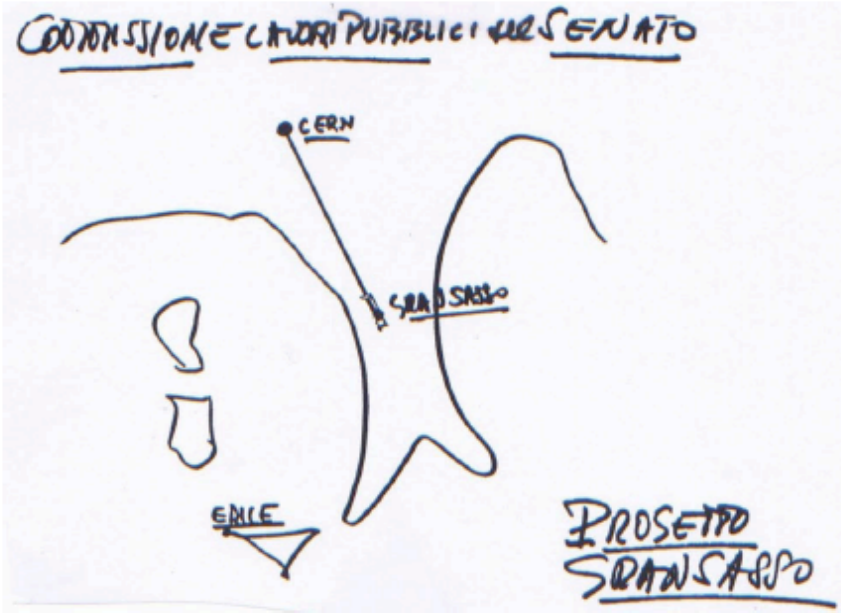
Matthias Laubenstein



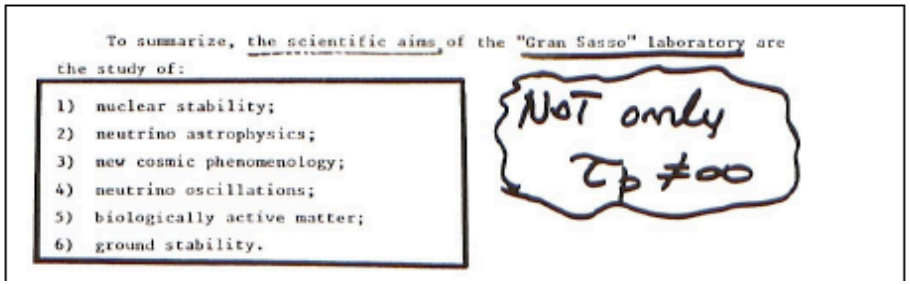
LNGS overview

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 $\tau_p \neq \infty$

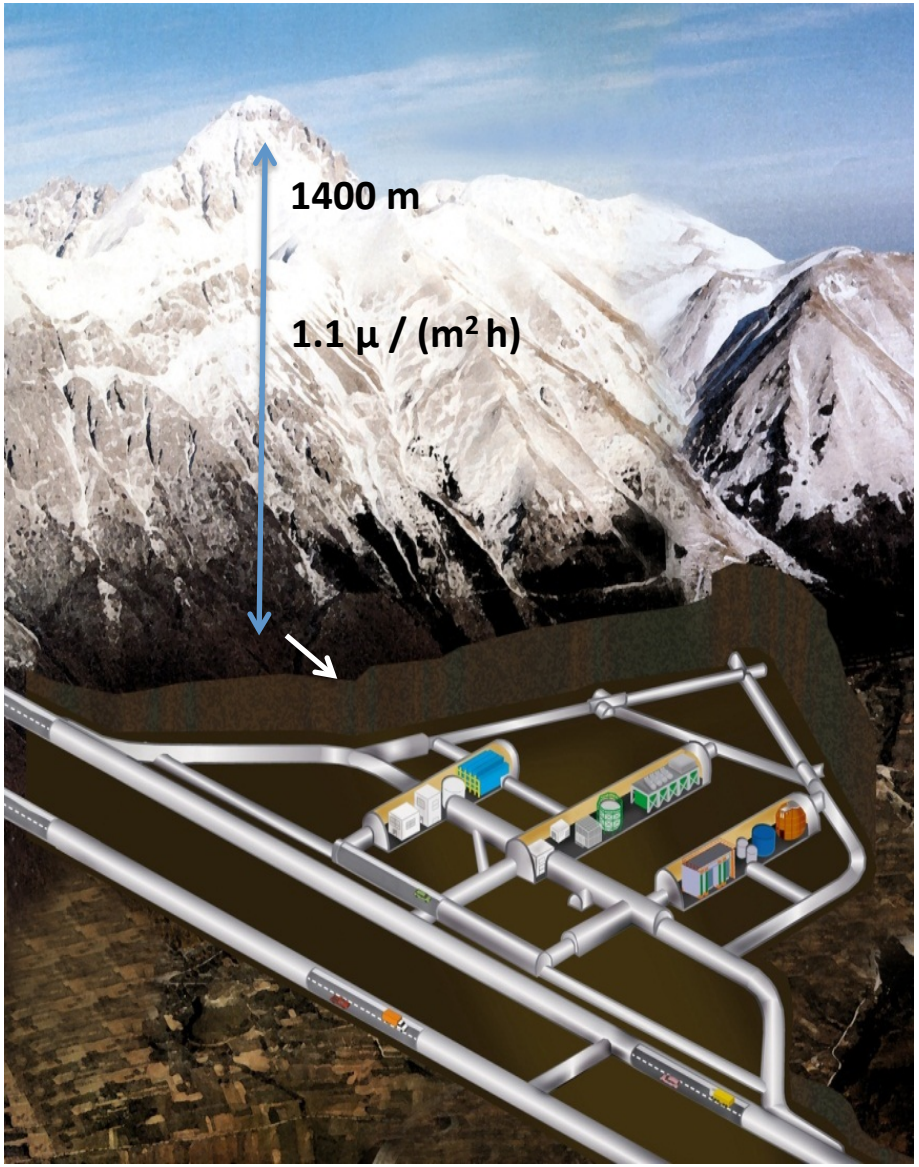
LNGS Characteristics

- Surface: 17 800 m^2
- Volume: 180 000 m^3
- Ventilation: 1 vol / 3.5 hours
- Rn in air: 20-80 Bq m^{-3}
- Muon flux: 3.0 10^{-4} $m^{-2}s^{-1}$
- Neutron flux:

  2.92 10^{-6} $cm^{-2}s^{-1}$ (0-1 keV)

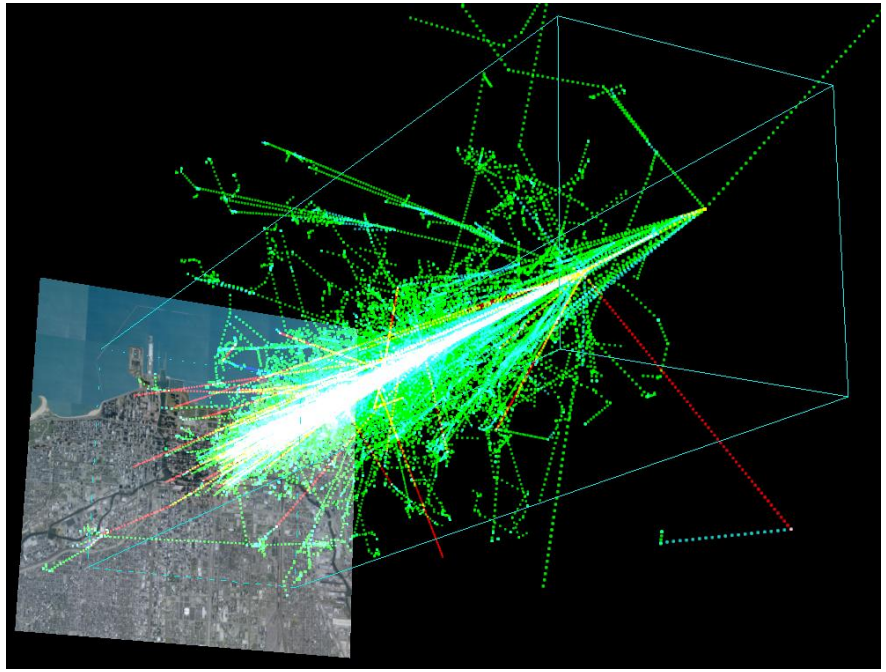
  0.86 10^{-6} $cm^{-2}s^{-1}$ (> 1 keV)

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



Background sources

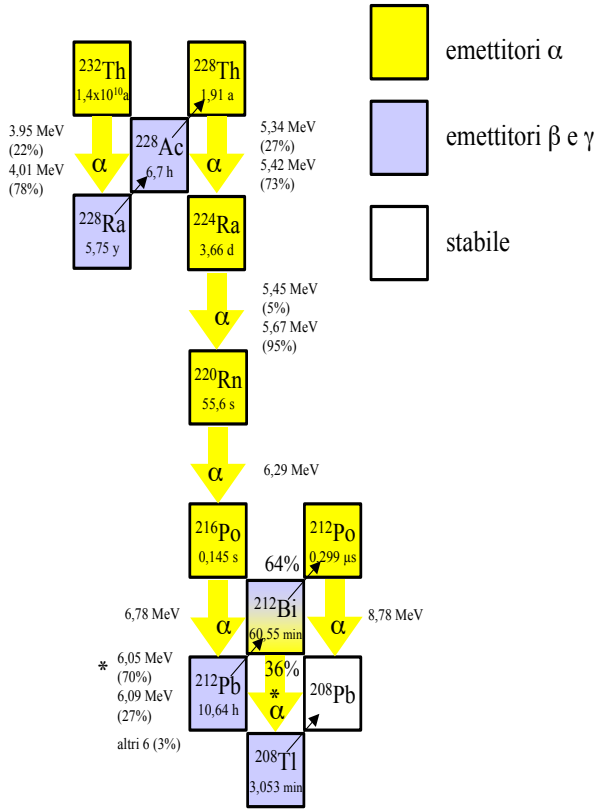
Cosmic rays



http://astro.uchicago.edu/cosmus/projects/aires/

Primary cosmic rays: mostly protons
Create showers of secondary particles
in atmosphere
in the end muons and neutrons reach surface

Natural radioactivity



Natural decay chains: Thorium & Uranium series
Potassium-40
Radon (from decay chains): gaseous

LNGS Users Support and Facilities

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- Ultra-low background techniques
- Chemistry lab and service
- Mechanics workshop
- Mechanics design & 3D-printing lab
- Electronics
- IT
- Technical Division

LNGS research in a nutshell

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Mission: enable and attract frontier astroparticle research and science requiring low-background environment

Our playground

Neutrino Physics

Dark Matter searches

Neutrino Astrophysics

Nuclear Astrophysics

Trace radioactivity measurements

Inductively coupled plasma mass spectrometry (ICP MS)

Material screening In radiopurity assay

Ultra Low-level Gamma ray Spectrometry

Develop analytical procedures
- matrix separation
- analyte pre-concentration
- background and contamination reduction
- increase of sensitivity

Use of suitable shielding to suppress the environmental radioactivity around the detector (i.e. lead, copper, PE)

Ultra-low level radioactivity counting facilities

STELLA (SubTErranean Low Level Assay)

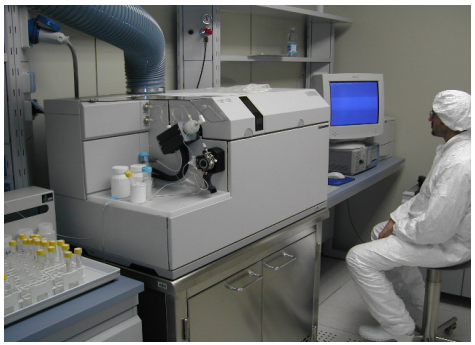
- γ spectrometry (High-Purity Ge Detectors)
- 15 detectors installed

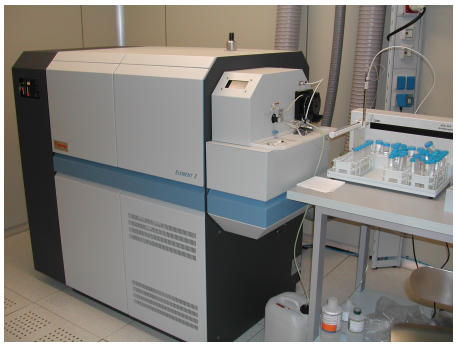
Sensitivity (U/Th):

commercial LB detectors (mBq/kg)
commercial ULB detector (0.5 mBq/kg)
custom ULB detector (MPIK/LNGS) (50 μBq/kg)

- α spectrometry (Silicon PIPS detectors)
- liquid scintillation counters

Inductively coupled plasma mass spectrometry (ICP-MS)





Courtesy: S.Nisi

- 7500a Agilent quadrupole ICP-MS
- Element2 Thermo Double Focusing High Resolution ICP-MS
- Class 1000 clean room
- Sub boiling distillation system for reagent purification

ICP-MS main activity

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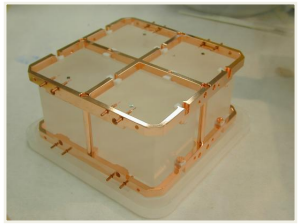
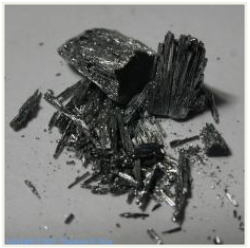
Material screening for low background physics applications (K, Pb, Th U)

- ≈ 200 samples/year (complex matrices)
- few hundreds samples/year (reagents and water)



Cu, TeO_2 and reagents
-CUORE-

Printed Circuit Board (PCB)
-GERDA-



Metals and alloys
-GERDA, XENON, DARKSIDE-

Al-Mylar insulating foils
-XENON, DARKSIDE-

Courtesy: S.Nisi

Access to LNGS RI resources

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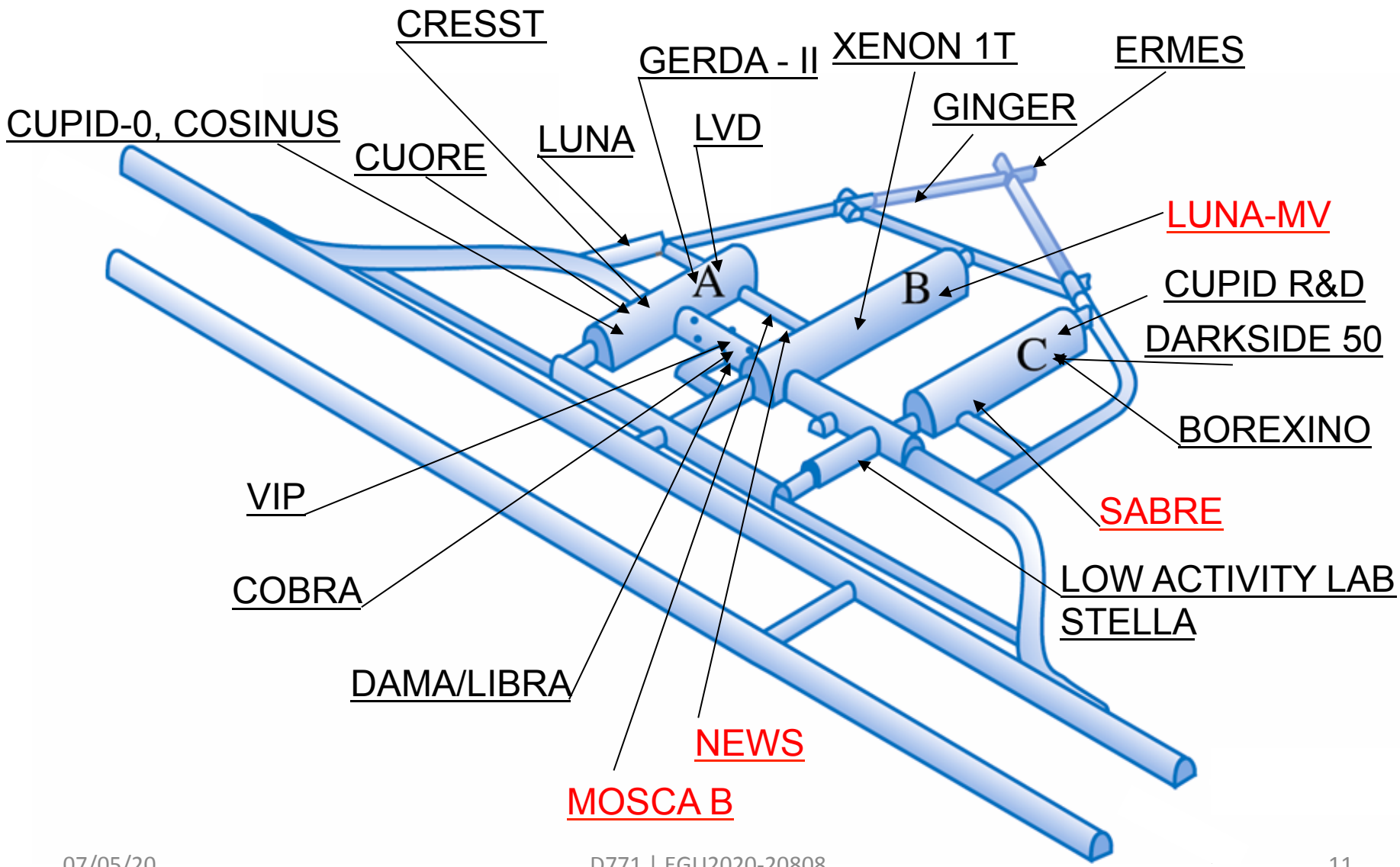
- Open access, excellence driven
- Proposals are peer-reviewed by the **Scientific Committee**
- International **Scientific Committee** :
  - Present composition: 9 members, 4 of them from Italian Institutions
  - Recommends proposals for approval, monitors progress of experiments

LNGS Activities



LNGS & Innovation

- LNGS is a reference player in Regional S3 (Smart Specialization Strategy)
- Access to “Regional” funds for innovation
- Partnership with innovative regional companies
  - Technology transfer to regional companies in order to build up a major LNGS resource

Nuova Officina Assergi

(head of NOA Dr. A.Ianni)

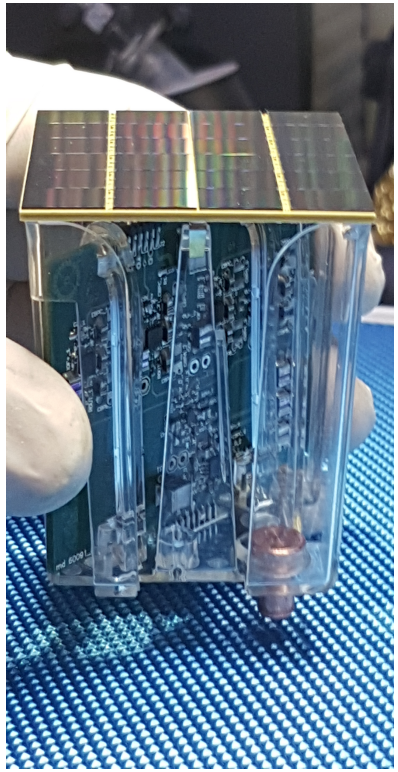
- A new infrastructure for testing and packaging photo-detectors based on SiPM

- ISO6 with a small sector ISO5 radon-free
  - ~250 m^2 and 750 m^3 inside an existing building
  - One main Air Handling Unit (4000 m^3/h) and four AHU for recirculation
  - Can operate with 20 working people inside at the same time

- Ready by end of 2020.
  - First user: production of photo-detector-modules for DarkSide-20k
  - Interest to use the facility from other experiments (CTA, CMS, JUNO, …) under discussion

Preparation of Photo-Detector-Modules

- **Tiles assembling**:
  - SiPM preparation and flip-chip bonding on selected substrate
- **Tiles test**:
  - Low temperature test on samples
- **Mounting Front End Boards** :
  - Room and low temperature test on samples
- **PDM assembling**:
  - SiPM tile + FEB + plastic support
  - ~ 8000
- **Mother Board assembling**
  - each MB with 25 PDMs

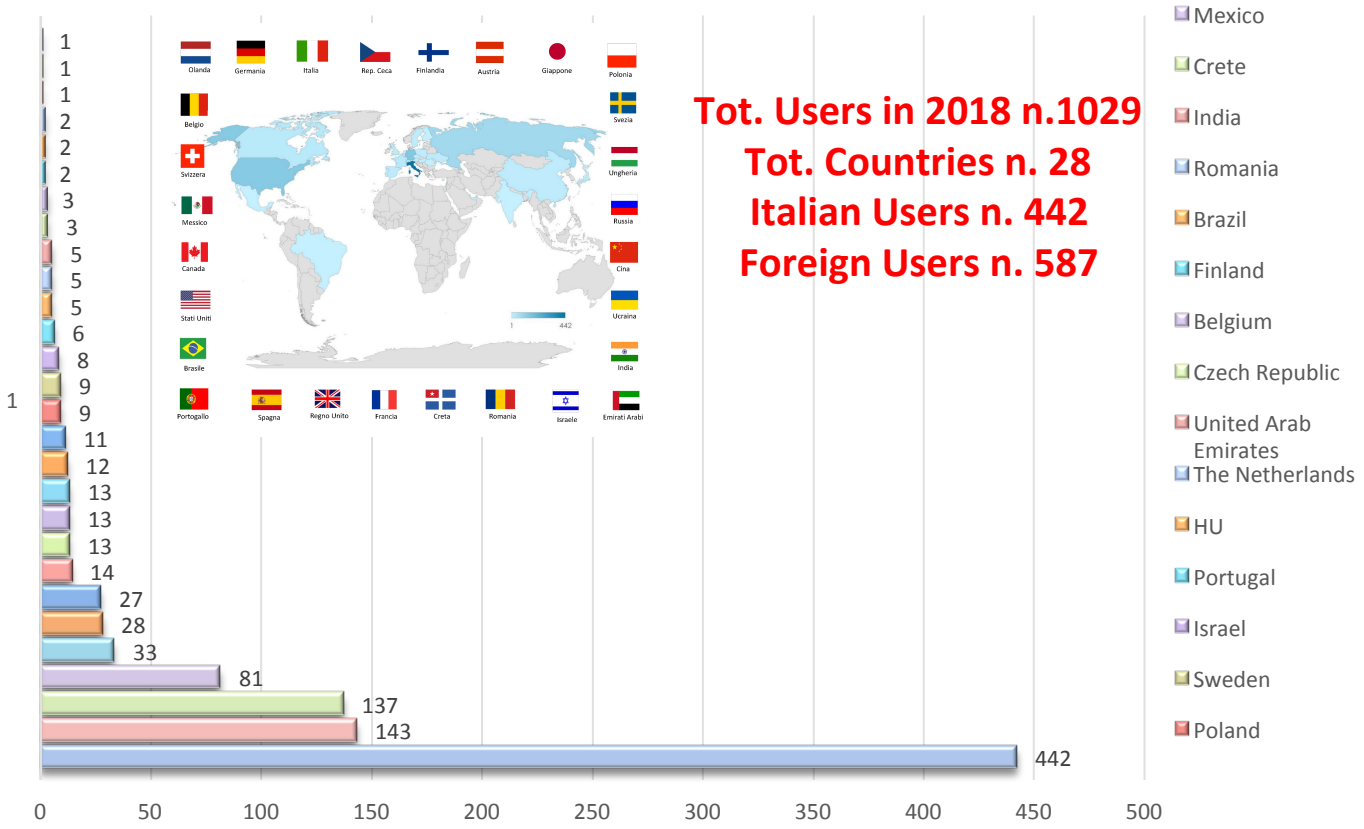


PDM for DS-20k

30 years of operation
UG-GRI next step

Users

- Users constitute the life of the RI



- Drive them through best practices

UnderGround Global Research Infrastructure

- Proposed by LNGS and SNOLAB following an initiative by the Group of Senior Officials (GSO) of the G8+5

- GSO was proposing to bring it to the G20

https://ec.europa.eu/research/infrastructures/index_en.cfm?pg=gso
https://www.gsogri.org/
http://www.gsogri.org/wp-content/uploads/2019/12/gso_progress_report_2017.pdf

UnderGround Global Research Infrastructure

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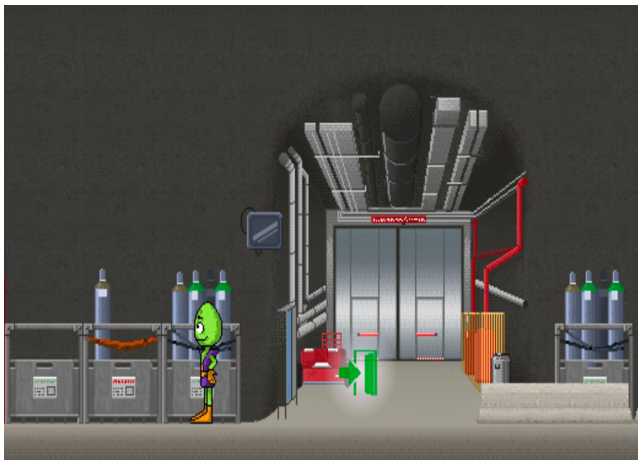
- Build a reference global infrastructure for underground science
  - serve the scientific community of the world
  - accommodate in an efficient manner the needs of new experiments and the planning of novel upgrades and needs
  - enable worldwide science and spread innovation
  - UG-labs that share common challenges (maintenance and continuous upgrade, share and spread best practices, transnational access)

Outreach and Dissemination

Conferences and events 2017-2018

30° Anniversario LNGS with Italian President Mattarella
FameLab : 200 students
PINT OF SCIENCE (Atom to Galaxy) : 250 attendances
SCIENZA, GENERE E NUOVE GENERAZIONI :200 students
OPENDAY : 2000 visits
PHOTOWALK SHARPER: 30.000 visits

Dissemination in the schools 2017-2018

GRAN SASSO VIDEOGAME MIUR project (tested with 350 students)
Alternanza Scuola Lavoro activated 9 stages
ANCH'IO SCIENZIATO : about 2000 students
Concorso Nazionale (INFN-CNR)
"Donne e Fisica: Stereotipi e Pregiudizi"
300 students
Conference/events SHARPER : 1800 students