European Underground Laboratories

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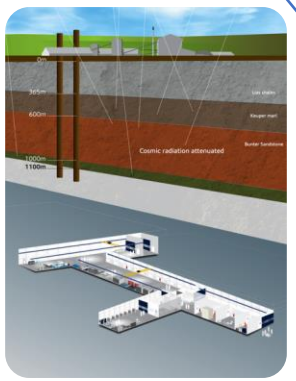
Laboratori Nazionali del Gran Sasso

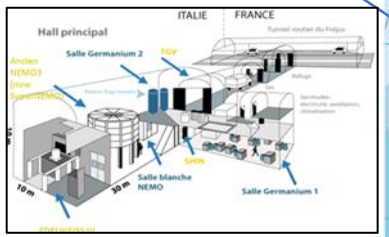
INFN

European Deep Underground Laboratories

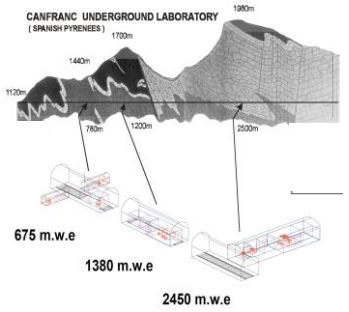
Boulby (UK)



LSM (F)



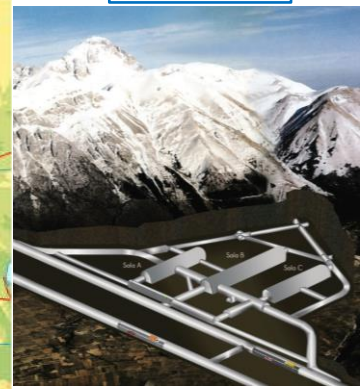
LSC (ES)



CallioLab (FI)

Baksan (RU)

LNGS (IT)



E. Previtali INFN

Double Beta Decay Experiments in Europe

Boulby (UK)

CallioLab (FI)

LSM (F)

SuperNEMO
CUPID-Mo

Baksan (RU)

LNGS (IT)

CUORE
LEGEND-200
CUPID-0
CUPID-R&D
COBRA

LSC (ES)

NEXT
CROSS

Double Beta Decay APPEC Committee Report

Recommendation 5.
The European underground laboratories should provide the required space and infrastructure for next generation double beta decay experiments. A strong level of coordination is required among European laboratories for radiopurity material assays and low background instrumentation development in order to ensure that the challenging sensitivities of the next generation experiments can be achieved on competitive timescales.

In order to establish a multi-technology and multi-isotope DBD0 physics program, extensive underground space to host the DBD0-experiments and related R&Ds activities is necessary. ***In Europe the Gran Sasso underground laboratory has the required depth and could host all currently proposed next generation DBD0 European experiments****.* ***At the same time all other underground laboratories must be strongly involved in the present DBD0 strategy to support various R&D phases for detector development and to guarantee sufficient resources for material selection and detector design****. Pilot experiments will be needed to implement complex and costly experimental apparatus and onsite expertise in low-background techniques is necessary for an effective and timely implementation of the experimental programs. In order to pursue the next generation of neutrinoless double beta decay experiments, a close coordination between the European underground laboratories in the areas of low-background instrumentation development, detector prototyping and radiopurity screening is therefore mandatory.*

Supporting Facilities

Material selection and screening
- HPGe facilities
- Alpha counting
- ICP-MS

Clean materials production and treatments
- Cu electro-forming
- Advanced additive manufacturing
- Ultra-pure water and gas

Cu electro-forming@ LSC


HPGe detectors @ LNGS


HPGe detectors @ Boulby

Clean environments for detector constructions
- Radon abatement systems (1000x Rn reduction)
- Clean rooms (ISO5, ISO6)

Radon-free clean rooms


Radon-free clean room for DS-50 @LNGS

Environmental monitoring e control
- Sensitive radon detectors (<mBq/m^3)
- Monitoring blanket

Engineering support for
- Infrastrutture design and installation
- General supporting facilities (power supply, water, cryogenics, …)

Gran Sasso DUL

Shielded by 1400 m (3800 m.w.e.) of rock (Gran Sasso Mountains)

Total Muon flux 3 10^{-8} cm^{-2} s^{-1}

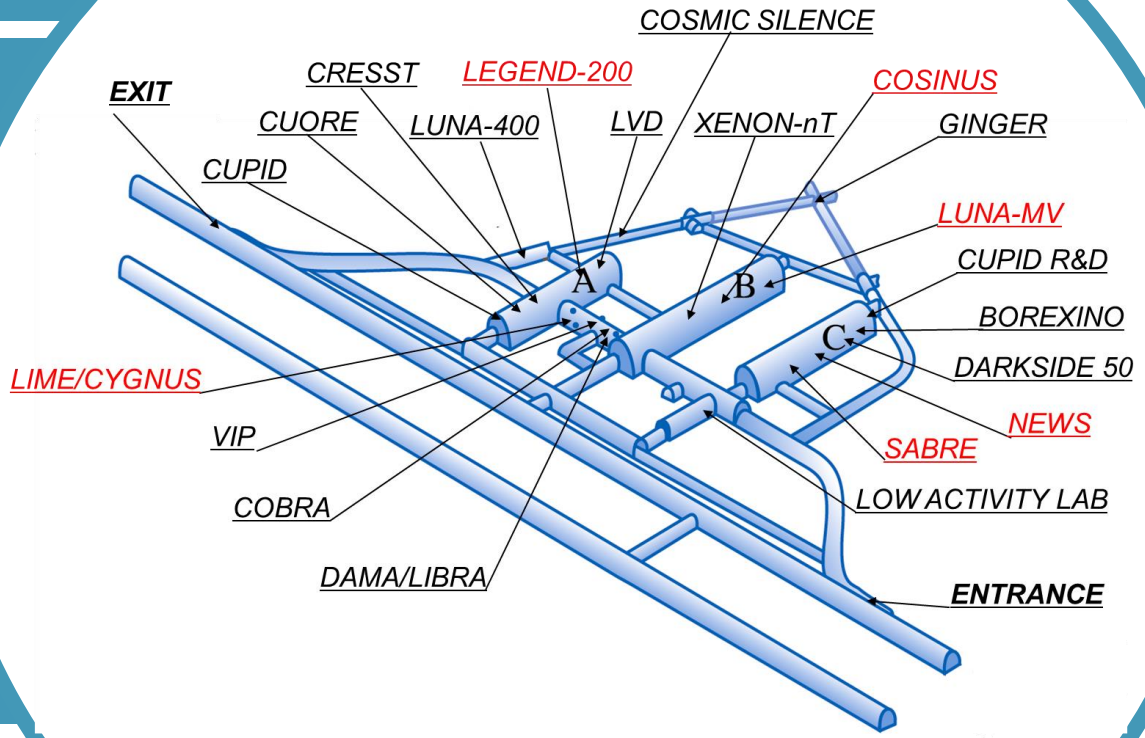
Easy access directly from the A24 highway

3 main experimental halls
100 m long, 20 m width and 18 m hight

Many small tunnels for lab facilities and small experiments

Actually there are 22 experiments in data taking or under construction

Very sensitive laboratory for very low radioactivity measurements



Area: 17.800 m^2

Volume: 180.000 m^3

Gran Sasso Laboratory

External Buildings

Underground Site

Gran Sasso Community

110 staff personnel

- Researchers - 14
- Engineers - 35
- Technical - 38

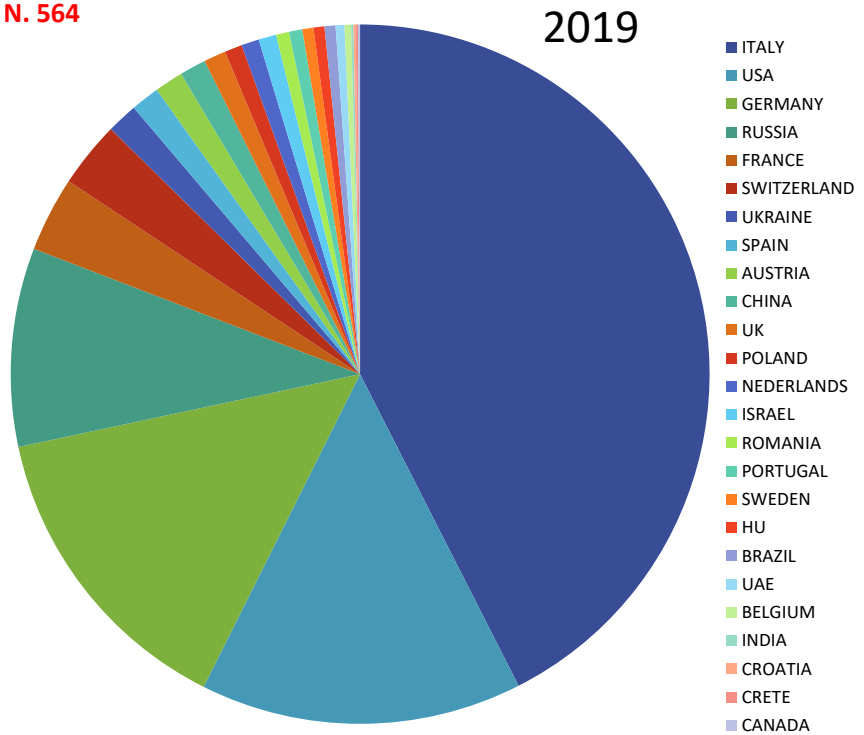
Direct connection with LNGS for associated members:

Gran Sasso Science Institutes (doctorate school)

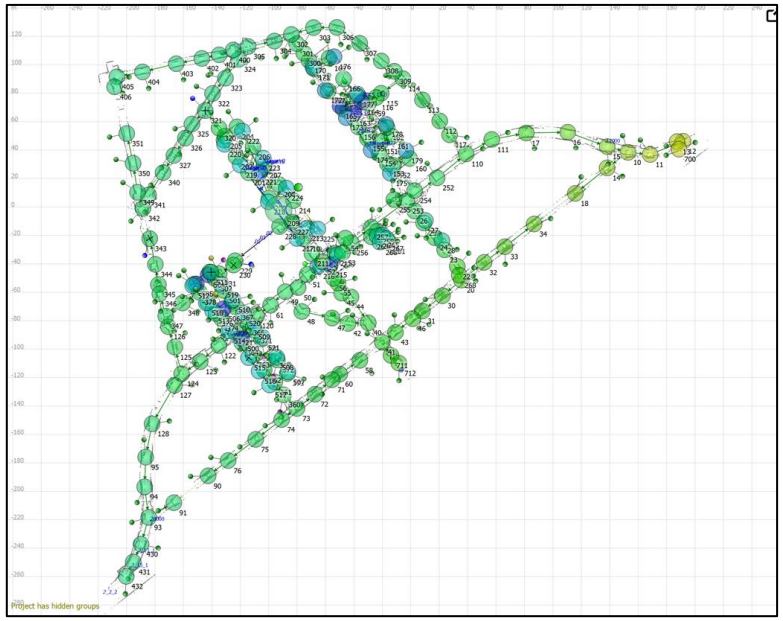
University of L'Aquila

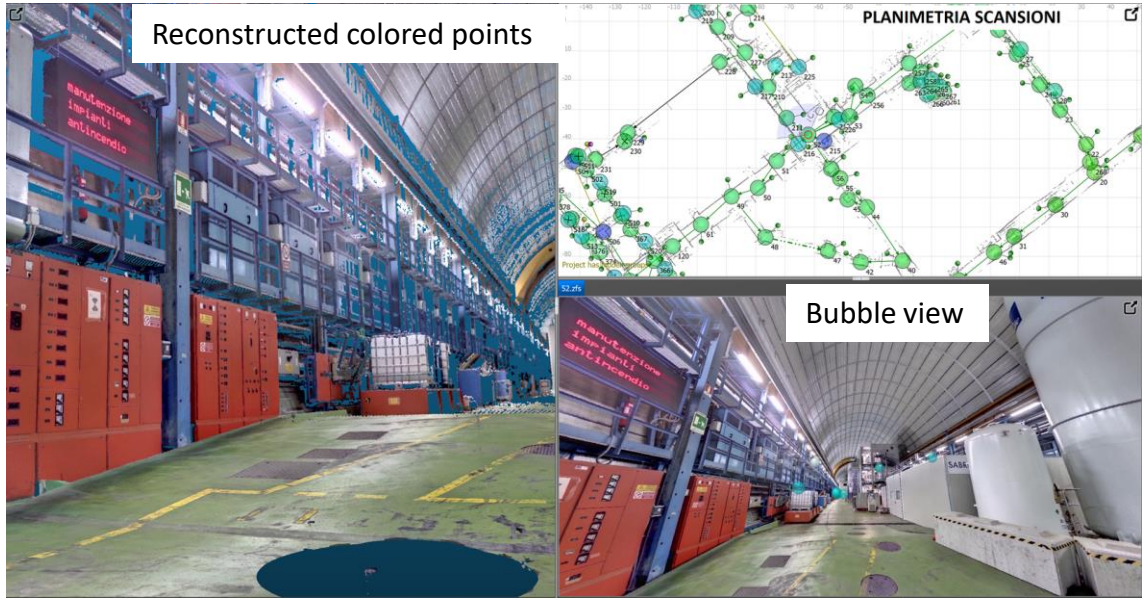
LNGS involved people 215 (110 staff + 95 associated)

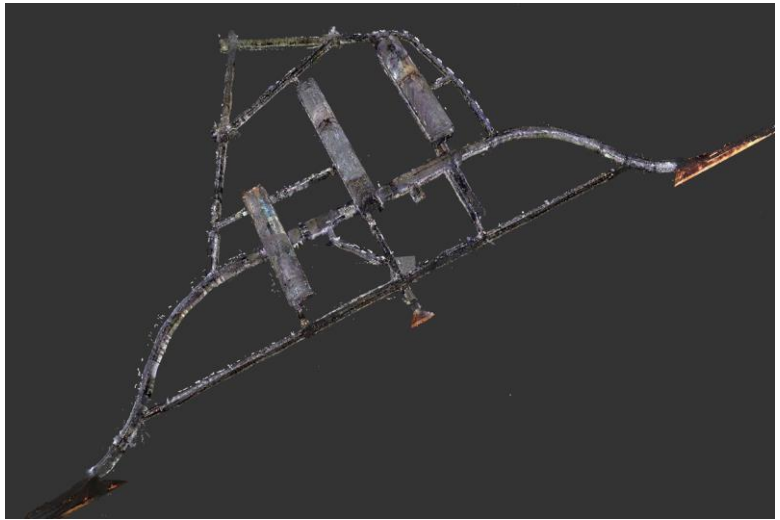
TOTAL USERS: N. 981
ITALIAN USERS: N. 417
FOREIGN USERS: N. 564



Laser Scanning of DUL @ LNGS





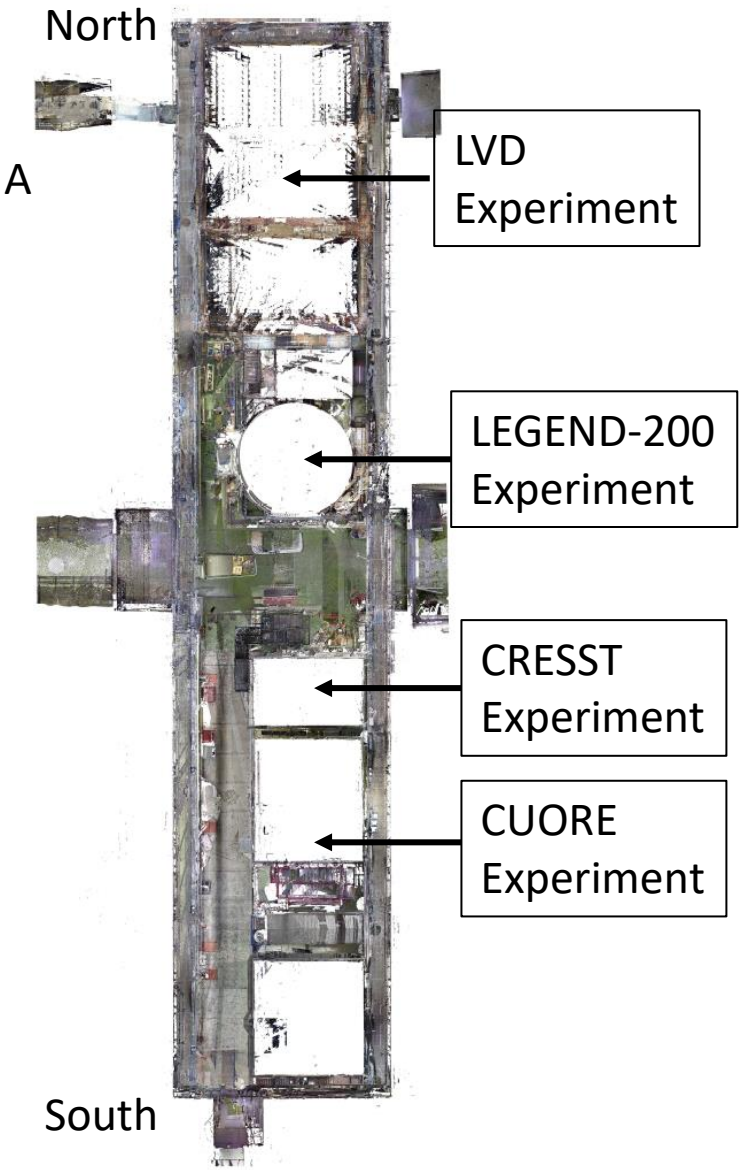


3D scanning of the underground site will allow the complete reconstruction of all the infrastructures installed in the lab.

Using 3 georeferenced points it was possible to orient LNGS halls respect to the cardinal points

Mean deviation obtained in the reconstructed frames is 5 mm over 500 m.

Hall A @ LNGS



LVD decommissioning phase will start during 2022
All the area will be completely free for new experiments during 2023

LEGEND-200 will start the data taking soon
It will be an important test also for the future

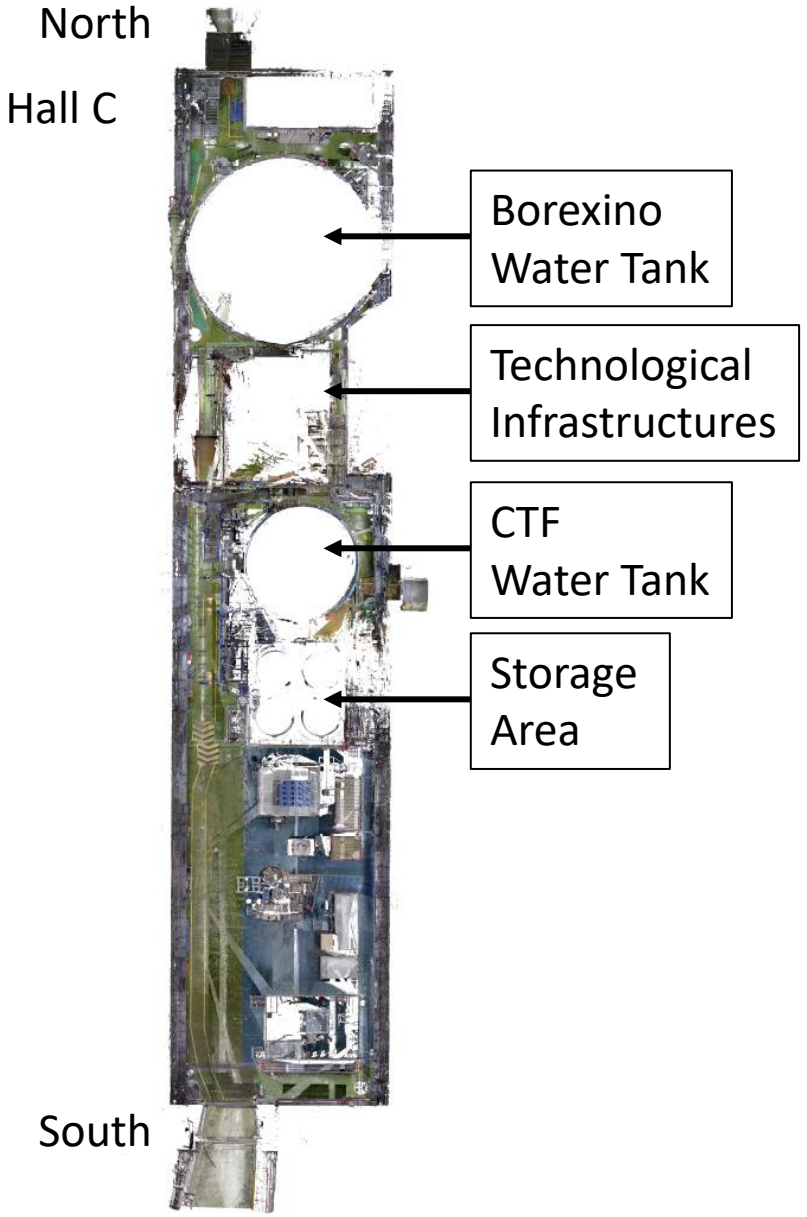
CUORE experiment is in stable data taking
The infrastructure is suitable, with minor changes, to CUPID experiment

Technical division of the LNGS is working to evaluate:

- Possible refurbishing of the LVD area
- Evaluating a time profile and costs
- Support all the engineering aspects for new experiment

One of the proposed DBD experiment could be installed in the LVD area

Hall C @ LNGS



Borexino decommissioning will start next week
An underground area will be available for new experiment

It will be possible also to recover the Borexino infrastructures

- Water tank is equipped with photomultipliers
- Ultra pure water production is operative
- Water pipes and recirculation systems are installed
- Clean rooms could be refurbished and partially available
- Electronics, DAQ and other instrumentation could be useful
- ……

LNGS managements received some requests to reallocate this infrastructures

LNGS supported a study to reallocate Borexino infrastructure for LEGEND-1000

- ✓ Borexino refurbishment and reconfiguration costs around 4 MEuro
- ✓ Time profile for the complete reconfiguration around 32 months

LNGS technical division could also support the installation of experiments

New CryPlatform @ LNGS

New cryogenic setup conceived to perform measurements of detectors and devices at very low temperatures

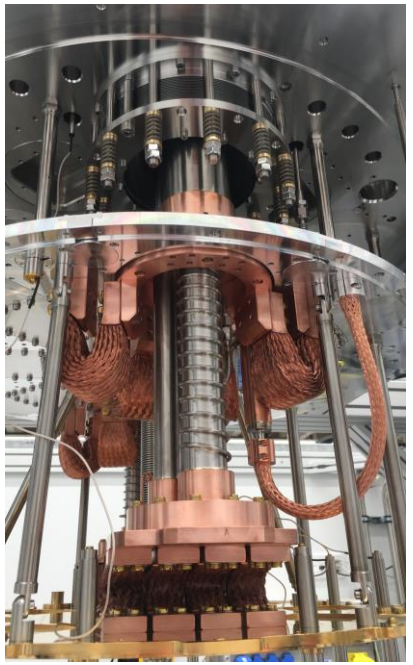
- dry ^{3}He/^{4}He dilution refrigerator
- Large experimental space: Ø 50 cm, h 75 cm
- Base temperature < 10 mK
- Low radioactivity & low vibration environment
- *Funded by INFN, BMBF and SQMS*

Useful for low-background tests of

- Cryogenic detectors equipped with TES, NTD, …
- Qubits

The Cryo-Platform facility will be available in 2023

Access procedures approved by a PAC

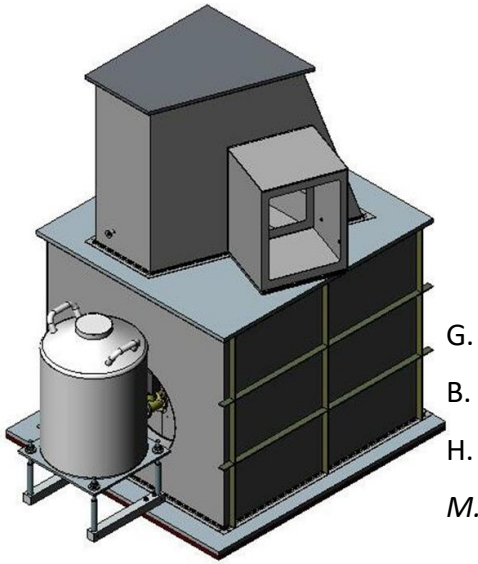


A new LN liquefier with a total power of around 50 kW@77 K will be installed underground
Dedicated cryogenic distribution lines will be designed for each experiment

Material screening @ LNGS

STELLA (SubTErranean Low Level Assay)

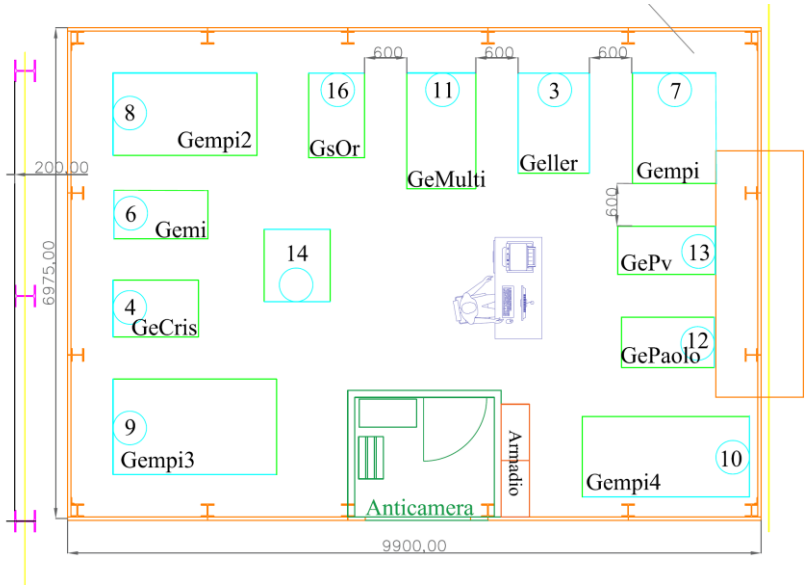
GeMPI type configuration
Custom made, Ultra Sensitive



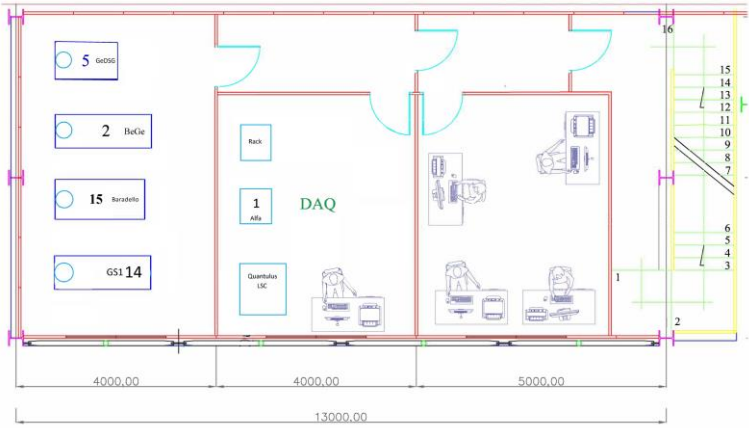
G. Heusser
B. Prokosch
H. Neder
M. Laubenstein

New facility for radio assay

- 16 HPGe detectors
  - Sensitivity few tens of µBq/kg
  - Possibility for large mass sample
- High sensitive alpha spectrometry
- Liquid scintillator counters



Stella design completed
Construction will start beginning 2022



New HPGe detectors will be designed:

- Improving sensitivities
- Increase sample rates

(Agreement between LNGS-INFN and BMBF)

Other European underground labs could be involved in material screening

Material screening @ LNGS

High sensitive ICP-MS laboratories.

Chemical labs for Ultra-Trace Analysis will be equipped with:

- New ICP MS quadrupole instrument
- Magnetic Sector ICP MS instrument
- TIMS for isotopic measurements
- New Laser Ablation ICP MS (LNGS-INFN and BMBF agreement)

Infrastructure is organized with:

- Clean Room of ISO6 Class
- Instrumentation for chemical treatments

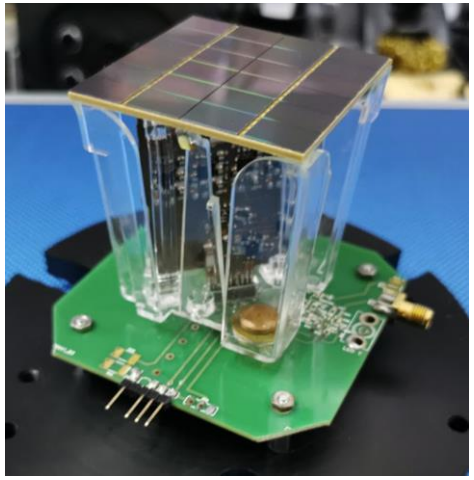
Achieved sensitivities on U and Th around 1 µBq/kg

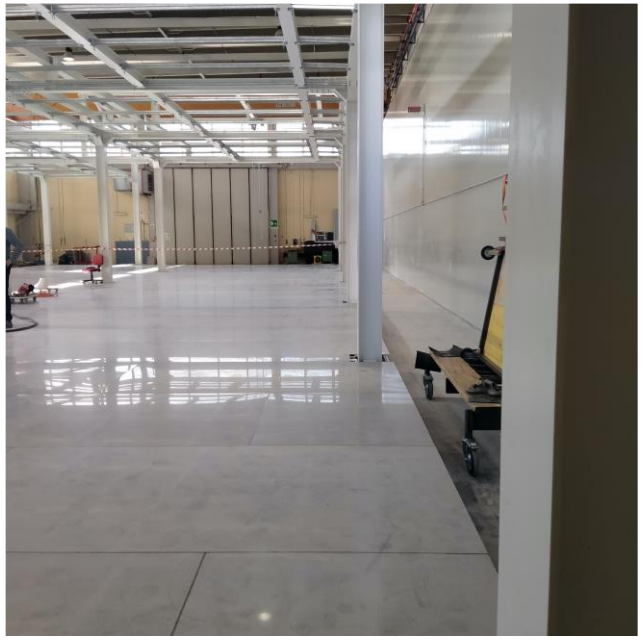
Synergic plans with other European underground labs are ongoing

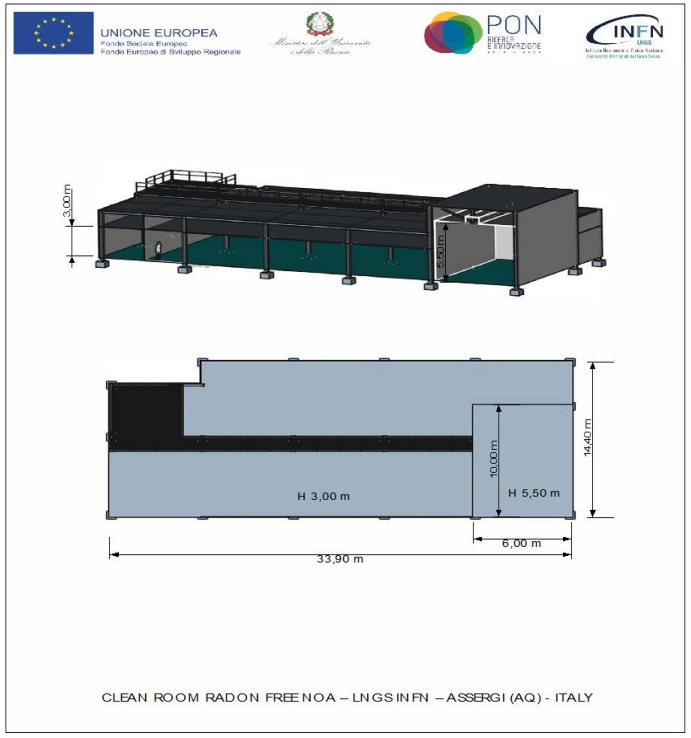
Nuova Officina Assergi (NOA) Clean Room

NOA will be an advanced clean room Radon free facility

- 450 m^2 Clean Room suitable for Radon Free operation
- Detector instrumentation for
  - Bonding
  - Dicing
  - Thermo-compression/epoxy bonding
  - Wire bonding
- PCB preparation
  - Advanced and radio-clean reflow system
- Testing capabilities
  - Performances characterization at cryogenic temperature
- Production
  - 1st production starting in 2022 for DS20k: ~ 20 m^2 SiPM







Dedicated facilities @ LNGS

Advanced Workshops

- Engineering design of custom components
- CAD/CAM advanced software support
- Advanced Additive Manufacturing (Copper 3D printing)
  - e-formed copper produced at LSC
  - copper atomized and 3D printing at LNGS
  - screening to assay radio-purity level both LNGS and LSC
- New cutting machines for faster productions
- New workshop will be installed underground (LNGS-INFN and BMBF agreement)

Laboratories for electronics

- Direct support for electronics design
- CAD/CAE advanced software support
- Instrumentation for PCB testing

New computer center will be installed in the esternal labs (HPC, storage, ….)

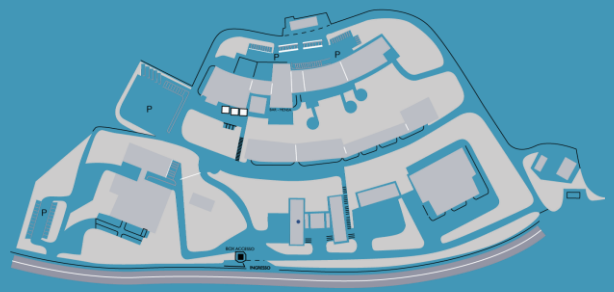
LNGS technical division could also support engineering for experiments

LNGS will support the requested authorization for new experiments

Conclusions

- European underground labs could strongly support the next generation DBD experiments
- Facilities for dedicated material screening will guaranty high measurement sensitivities and high throughputs
- LNGS could host new DBD experiments also of big sizes with the decommissioning of LVD and Borexino
- Dedicated studies for refurbishing the Borexino infrastructures were successfully done
- The infrastructure used by the CUORE experiment could be easily reconfigured for CUPID
- Many facilities (clean rooms, workshops, electronic and chemical labs) are ready to support DBD experiments
- Established and future collaborations between all the underground labs could help in develop optimized strategies
- LNGS could dedicates specific resources for a successfully construction of next generation DBD experiments

Prof. Enrico “Puccio” Bellotti
1940 - 2021
1st director of LNGS
President of Astroparticle Physics committee of INFN
Great scientist and great expert in DBD



Thank you