

Gran Sasso National Laboratory



Ezio Previtali - LNGS

Facilities

External buildings



Underground laboratory



Why underground?

Underground laboratories are shielded by layers of rock and offer the unique possibility of studying rare phenomena in an environment where cosmic ray background is strongly reduced

Features of underground laboratory

- **1400 m** of rock overhead
- Cosmic ray flux reduction: **1.000.000**
- 3 experimental halls **100 m** length, **20 m** width and **18 m** height

Underground Surface: **17800 m³**

Underground Volume: **180000 m³**

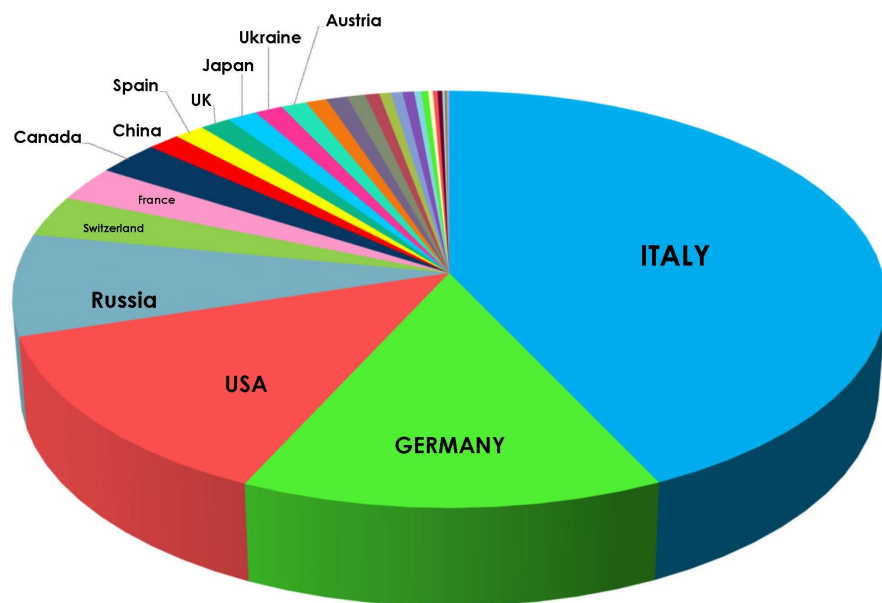


Gran Sasso National Laboratory users

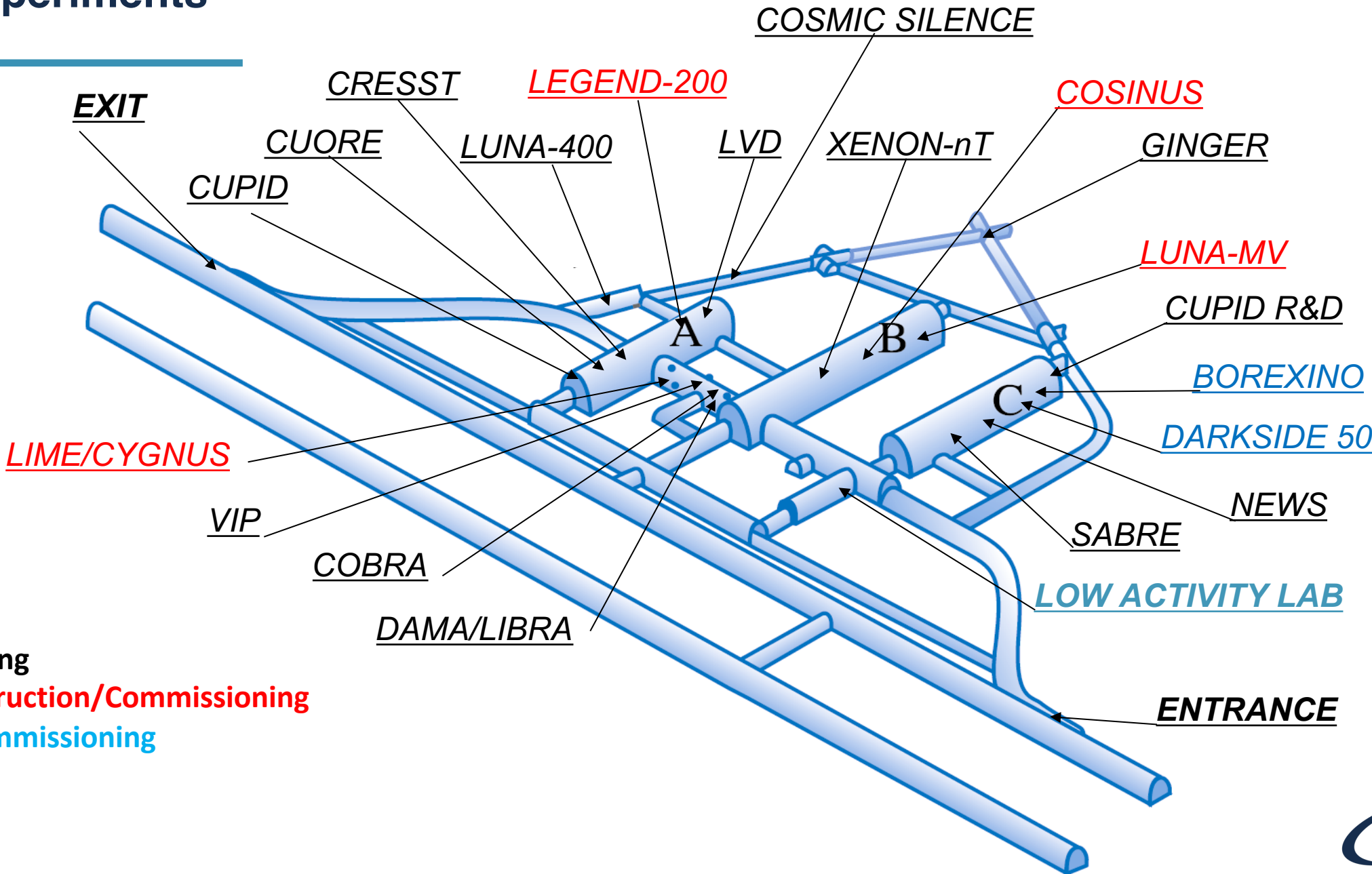
Total users: N. 981

Italian users: N. 417

Foreign users: N. 564



LNGS Experiments



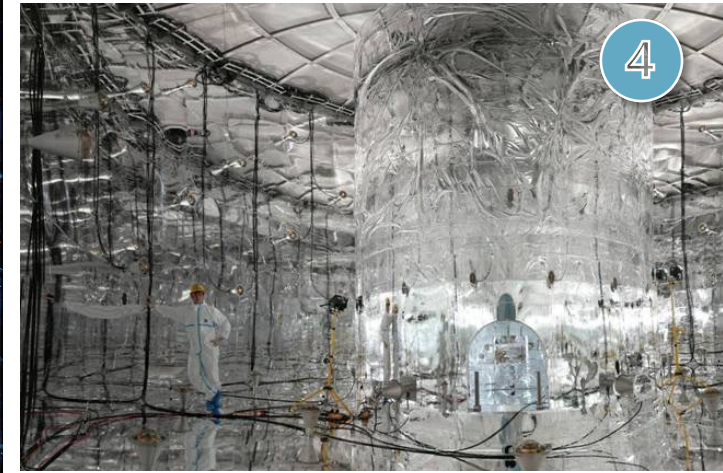
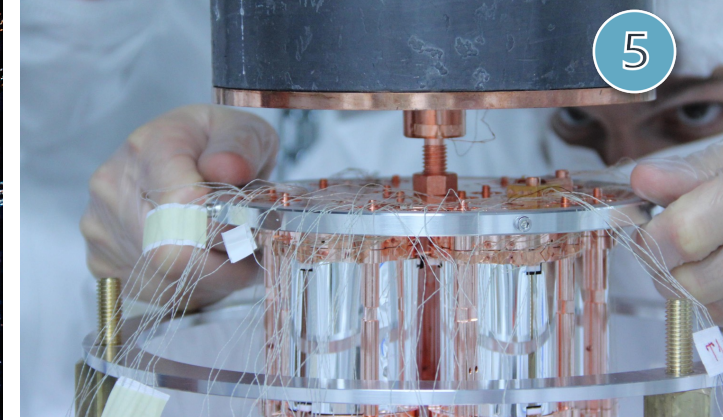
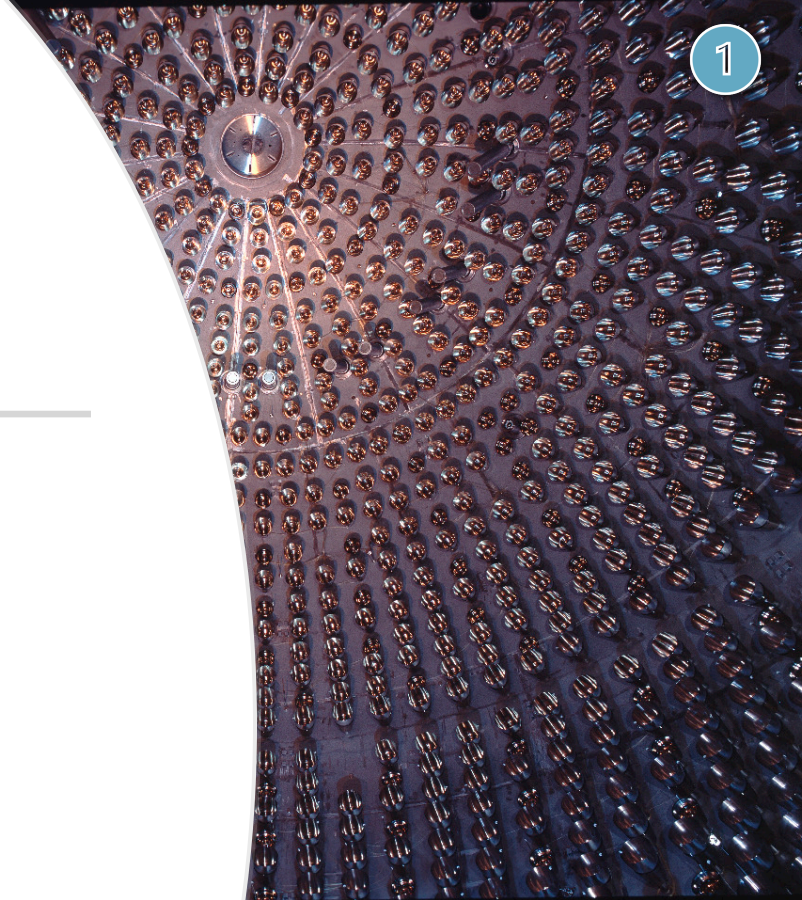
- Running
- Construction/Commissioning
- Decommissioning

Main research topics: **Neutrinos**

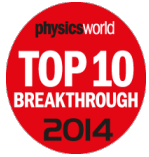
- The messengers of the Universe
- Unique behavior in the particle landscape (Majorana neutrino, neutrino mass,)
- They could explain the prevalence of matter over antimatter in the Universe

Neutrino experiments

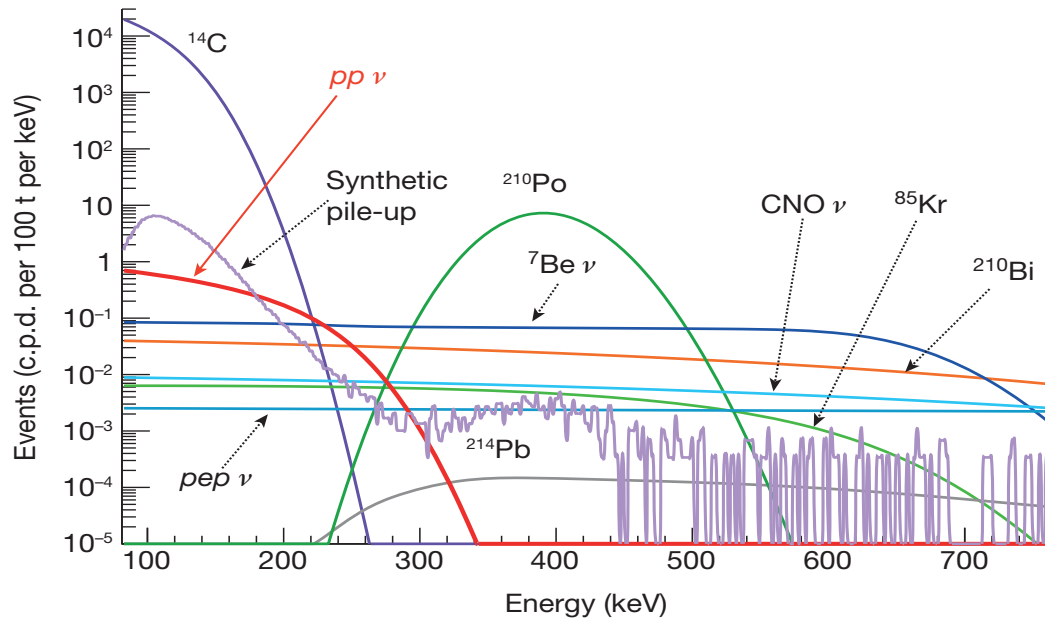
- ① **BOREXINO**
- ② **LVD**
- ③ **CUORE**
- ④ **GERDA/LEGEND**
- ⑤ **CUPID**



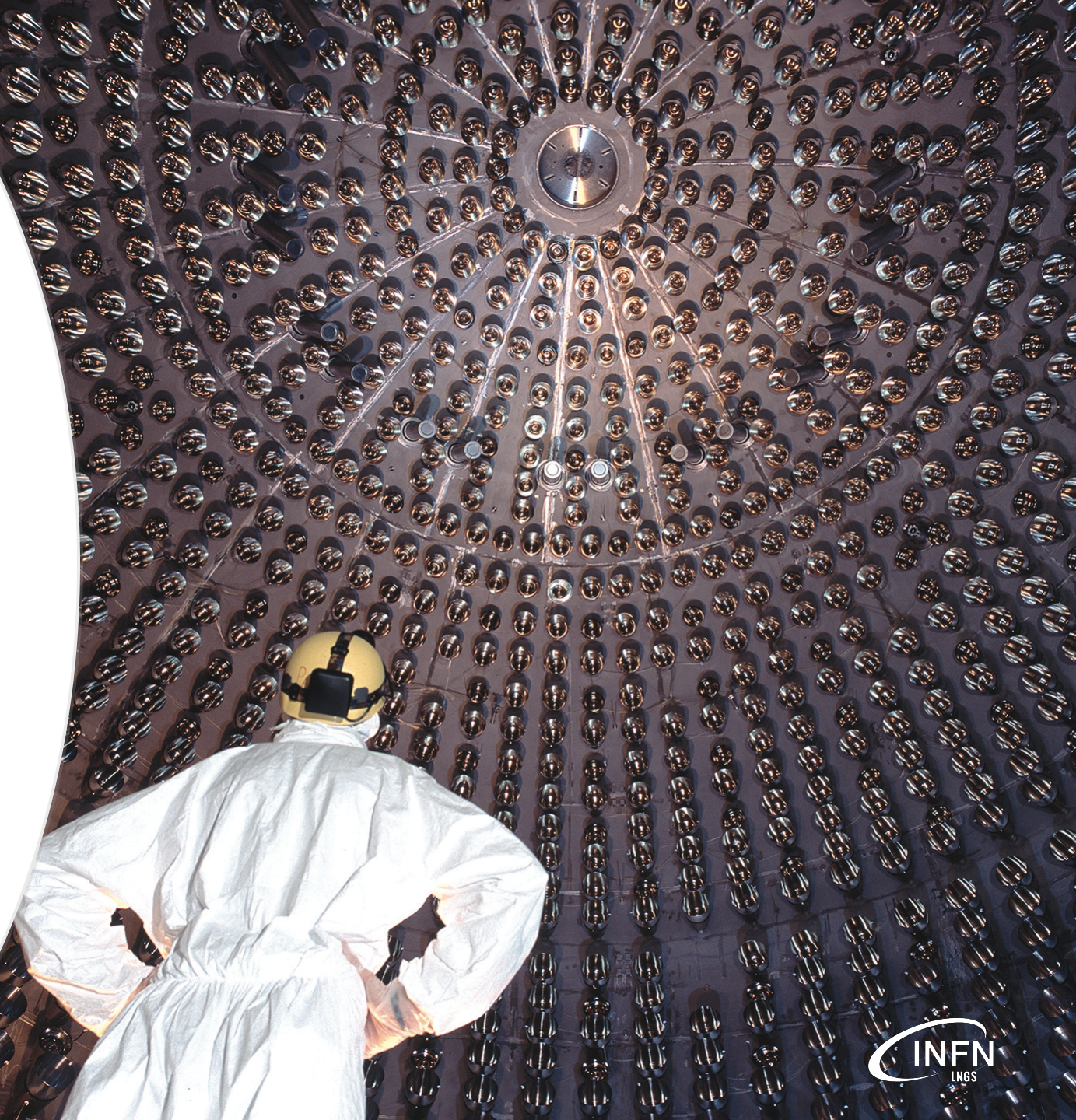
Borexino



Real time neutrino (all flavours) detector
Real-time measurement of pp neutrino



Real-time measurement of Geo-neutrinos



Neutrinoless Double Beta Decay



$T_{1/2} > 10^{24}$ y 90% C.I.
restricted club

GERDA $T_{1/2} > 1.8 \times 10^{26}$ y
Phys. Rev. Lett. 125, 252502 (2020)

KamLAND-Zen 400 $T_{1/2} > 1.07 \times 10^{26}$ y
Phys. Rev. Lett. 117, 082503 (2016)

EXO-200 $T_{1/2} > 3.5 \times 10^{25}$ y
Phys. Rev. Lett. 123, 161802 (2019)

MAJORANA dem. $T_{1/2} > 2.7 \times 10^{25}$ y
Phys. Rev. C 100, 025501

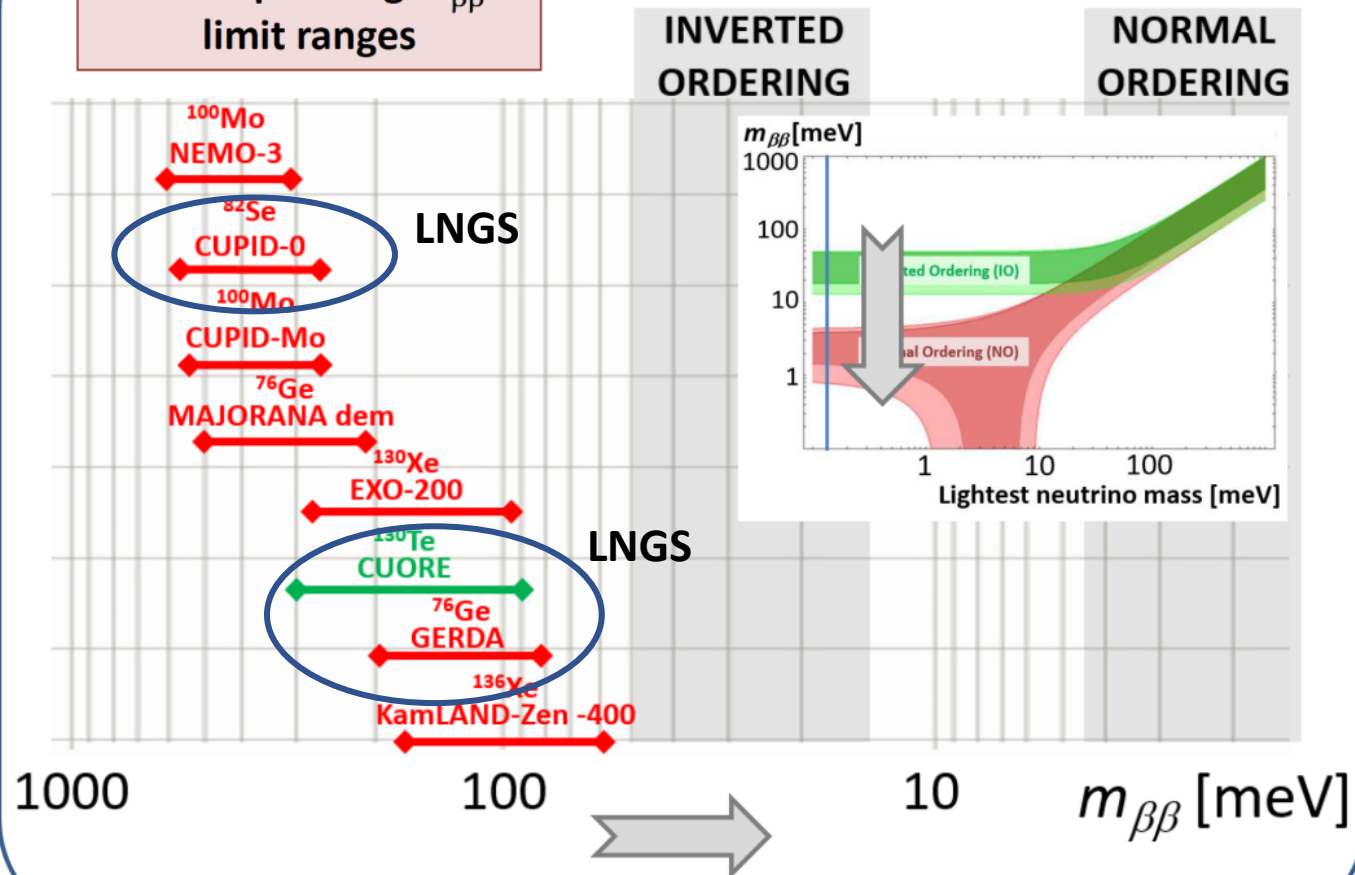
CUORE $T_{1/2} > 2.2 \times 10^{25}$ y
arXiv:1907.09376

CUPID-0 $T_{1/2} > 4.7 \times 10^{24}$ y
L. Pagnanini, TAUP 2021

CUPID-Mo $T_{1/2} > 1.8 \times 10^{24}$ y
B. Welliver, TAUP 2021

NEMO-3 $T_{1/2} > 1.1 \times 10^{24}$ y
Phys. Rev. D 92, 072011 (2015)

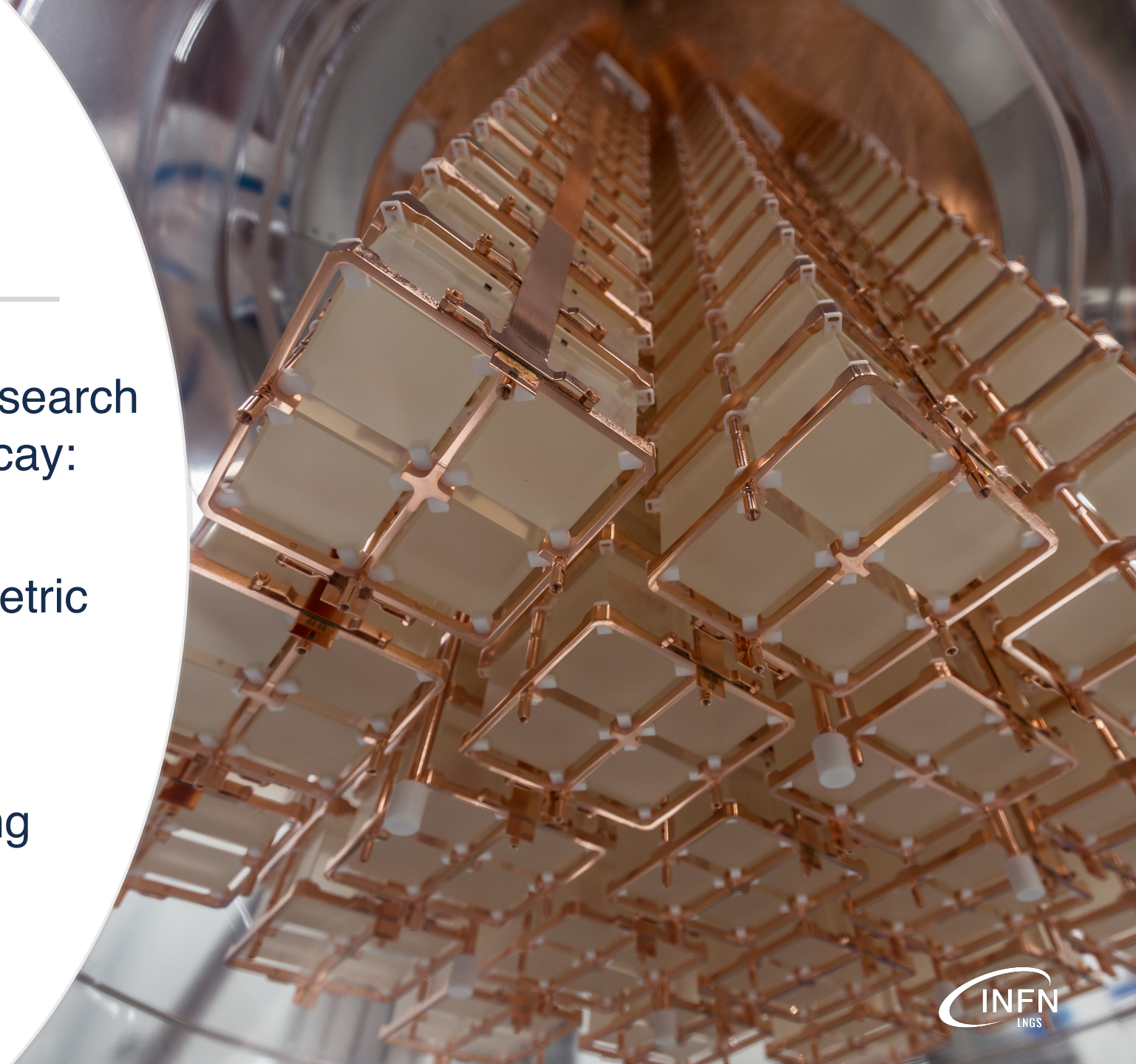
Corresponding $m_{\beta\beta}$
limit ranges



CUORE/CUPID

Massive cryogenic detector to search for Neutrinoless Double Beta Decay:

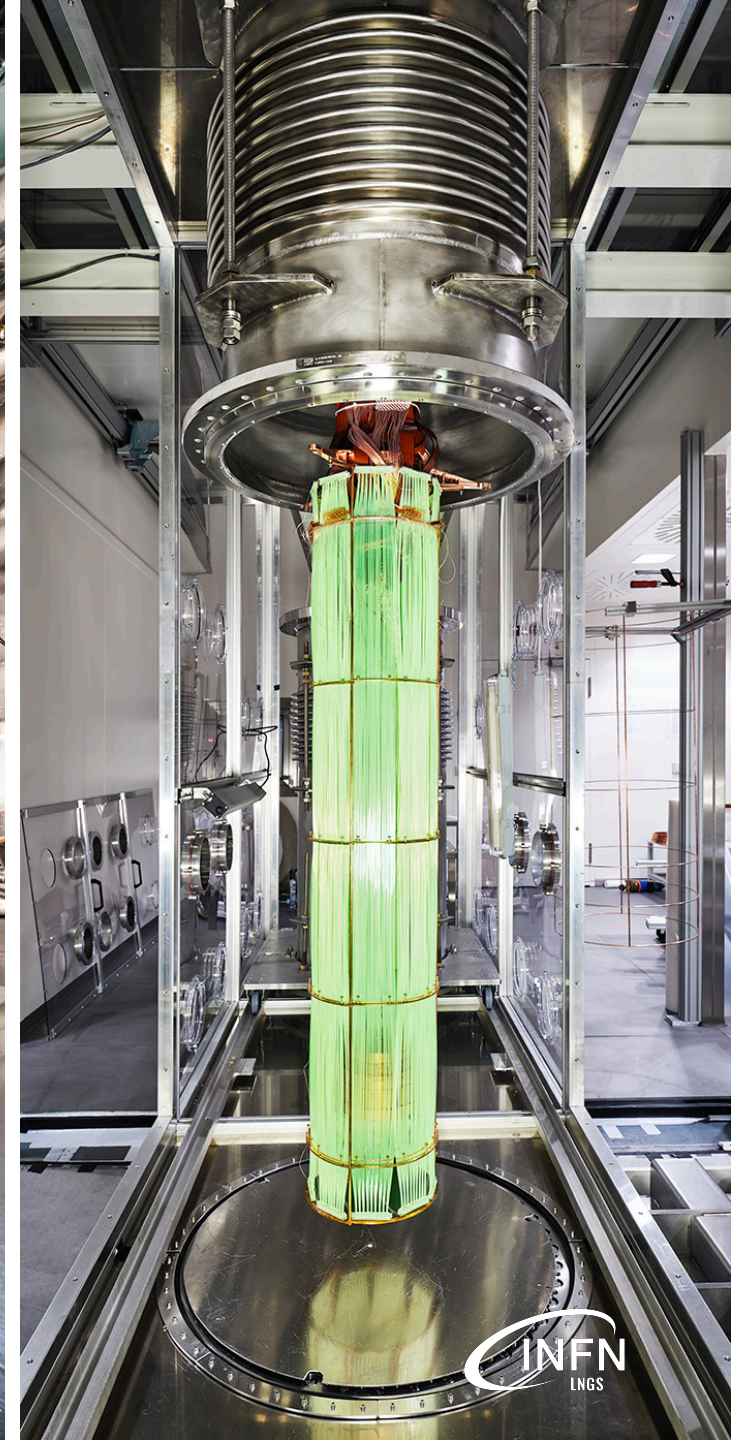
- ① ^{130}Te using 988 TeO_2 bolometric detectors (CUORE)
- ② ^{100}Mo using LMO scintillating bolometers (CUPID)



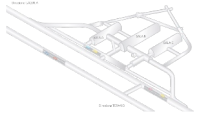
LEGEND-200

Search for Neutrinoless Double Beta Decay of ^{76}Ge with new 200 kg ultrapure enriched germanium detectors deploying more than.

Experiment is in commissioning phase in Hall A



Future Strategies on Double Beta Decay



North American and European funding agencies meeting

- Selection of future DBD experiments
 - Experimental sensitivities*
 - Budget requested for each experiment*
 - International collaborations*
- Selection of possible underground laboratories
 - SNOLab/SURF – North America*
 - LNGS – Europe (with other European labs)***
- All three experiments will be supported
 - Two in Europe (in principle)***

	$T_{1/2}$ (10^{28} years)		$m_{\beta\beta}$ (meV) 3σ Discovery	
	Excl. Sens.	3σ Discovery	Median	Range
CUPID	0.14	0.10	15	12 to 20
LEGEND-1k	1.60	1.30	12	9 to 21
nEXO	1.35	0.74	11	7 to 32



Prosecutor of CUORE

Main research topics: **Dark Matter**

Ordinary matter is less than **5%**

About **27%** of the Universe is
dark matter

More than **68%**, is dark energy



Dark Matter Experiments

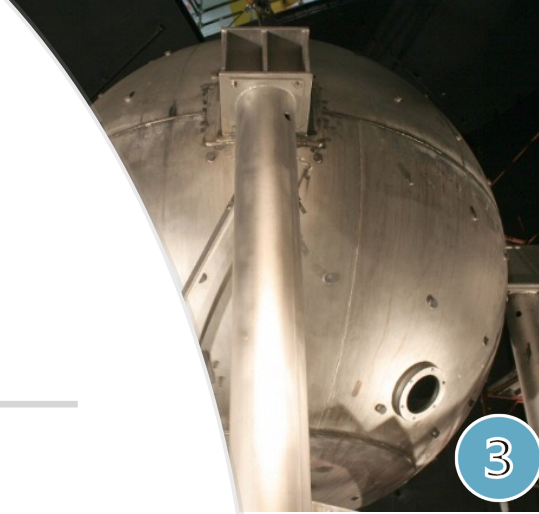
① CRESST

② DAMA

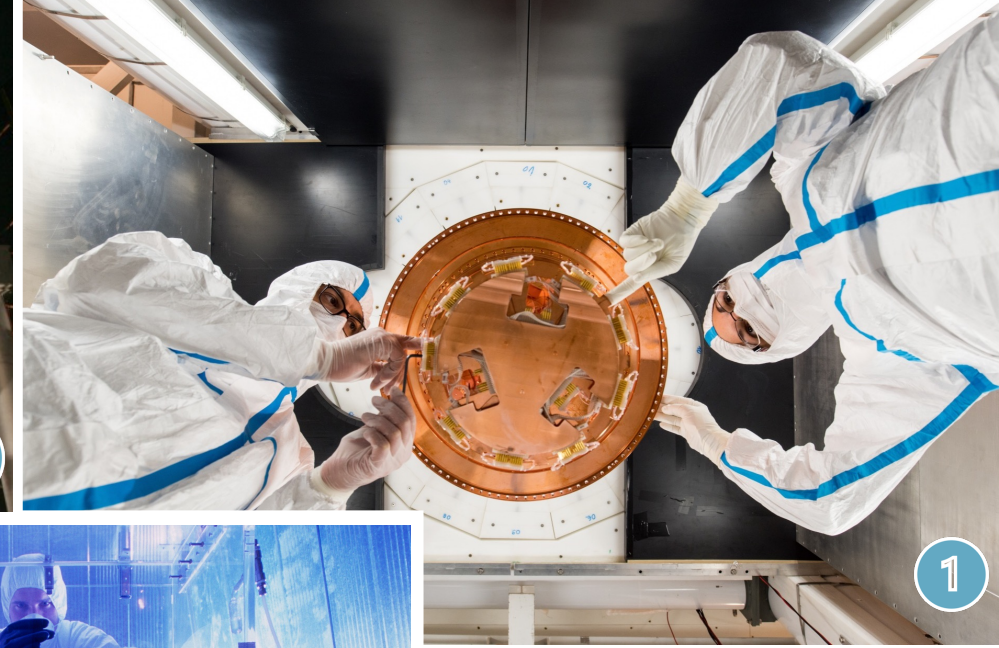
③ DarkSide

④ XENON

COSINUS, CYGNO, NEWS, SABRE



3



1



2

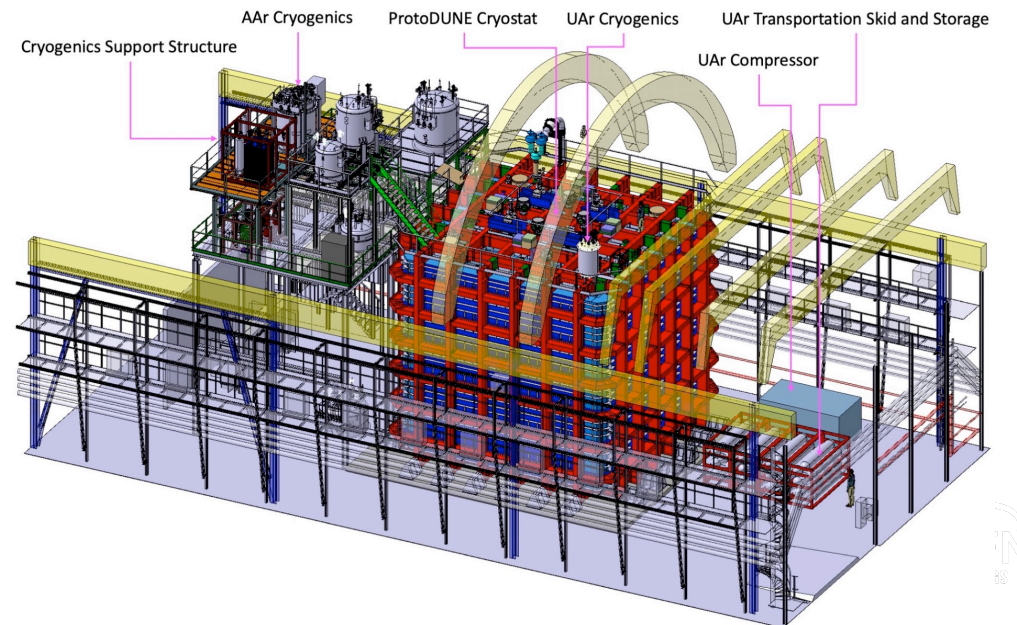
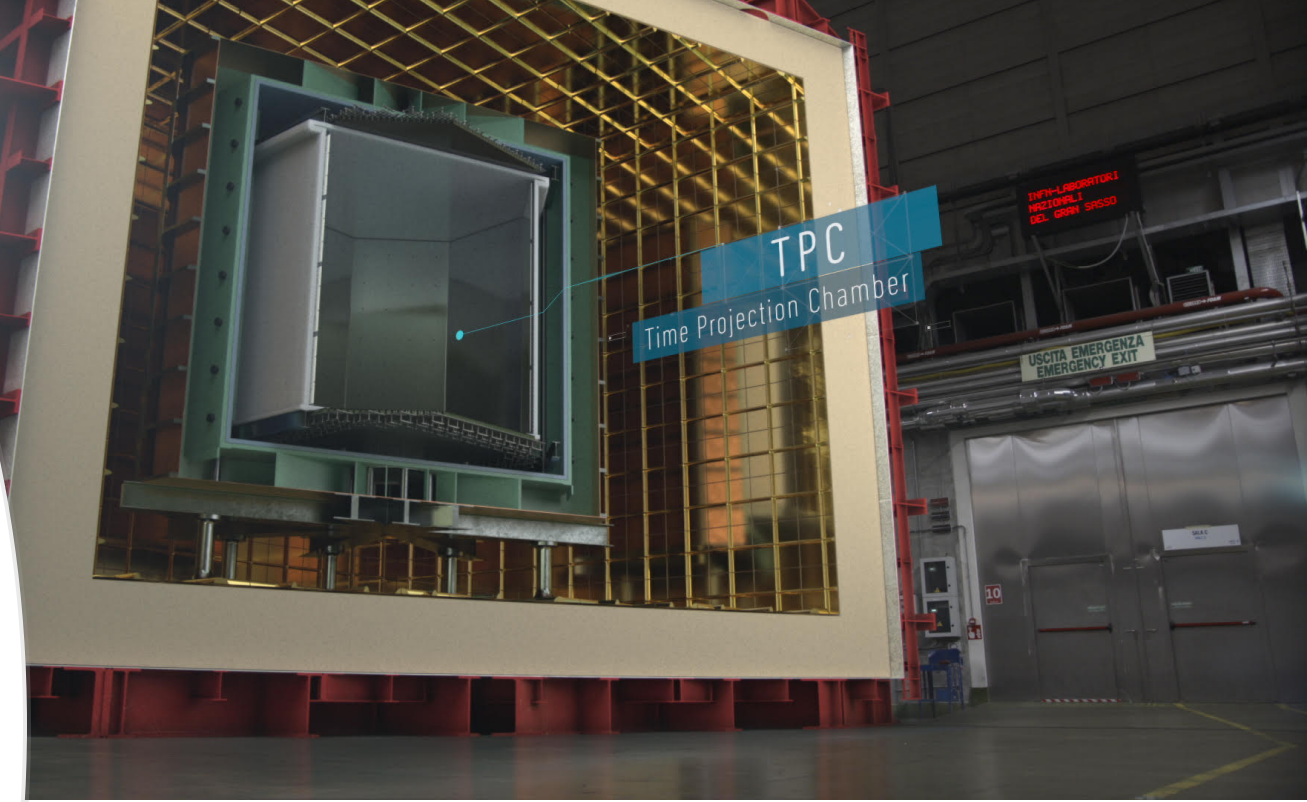


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DarkSide-20K

20 Ton (fiducial volume) **liquid underground Argon TPC**

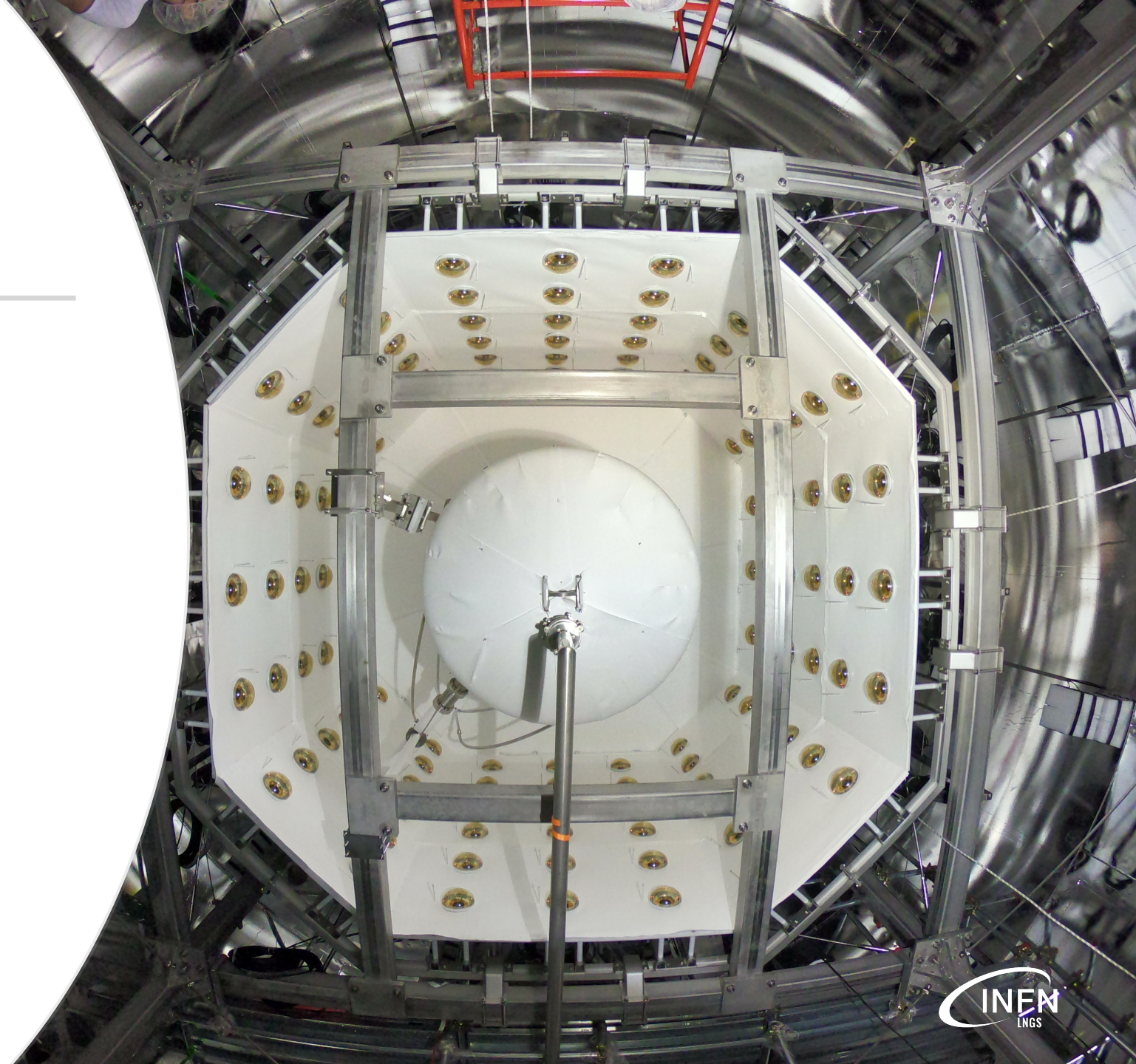
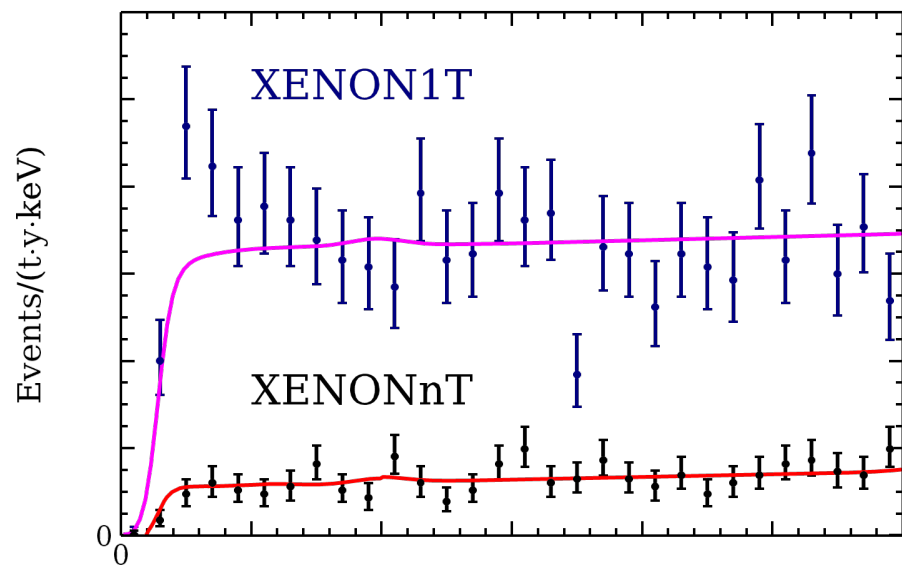
Detector is under construction in **Hall C of LNGS**



XENON/nT

8.3 tonnes of highly radiopure liquid xenon

Direct comparison with the XENON1T results



Main research topics: **Nuclear Astrophysics**

Studying the heart of the stars in underground facilities

- How was star born?
- How does it evolve?
- How are produced the elements?

Nuclear Astrophysics

Two accelerators installed underground

① **LUNA 400 kV**

② **LUNA MV**



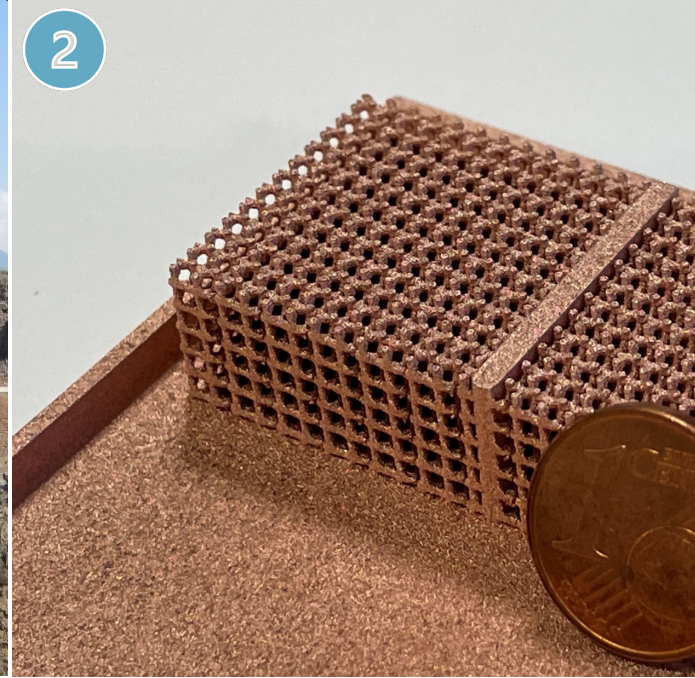
LNGS Users Support and Facilities

- ① Ultra-low background techniques
- ② Chemistry lab and service
- ③ Mechanics workshop
- ④ Mechanics design & 3D-lab
- ⑤ Electronics
- ⑥ IT
- ⑦ Clean Rooms



Multidisciplinary applications

- ① Roman Lead
- ② Additive Manufacturing
- ③ CHNet: study of Cultural Heritage
- ④ Biology
- ⑤ Geophysics



INFN

LNGS

