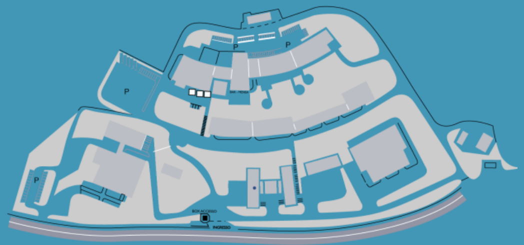
ETTORE MAJORANA FOUNDATION AND CENTRE FOR SCIENTIFIC CULTURE

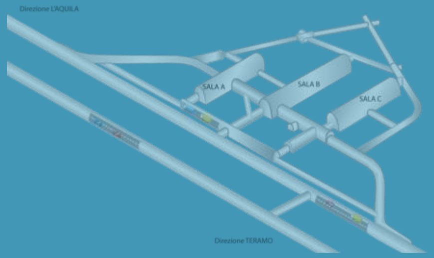
TO PAY A PERMANENT TRIBUTE TO ARCHIMEDES AND GALILEO GALILEI, FOUNDERS OF MODERN SCIENCE AND TO ENRICO FERMI, THE "ITALIAN NAVIGATOR", FATHER OF THE WEAK FORCES

WORLD FEDERATION OF SCIENTISTS — Founded in Erice — Beijing Geneva Moscow New York

INFN LNGS



Highlights from Gran Sasso



Prof. Antonio Zoccoli

Istituto Nazionale di Fisica Nucleare

Università degli Studi di Bologna

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External Buildings

Undergound Site

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Why are we going Undeground?

Why don’t we see stars during the day?

To see a very weak signal (light of a star) we need to avoid interference from other light sources (like the sun).

To study rare nuclear events, we need an environment in which all the possible interferences are minimized.

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Why are we going Undeground?

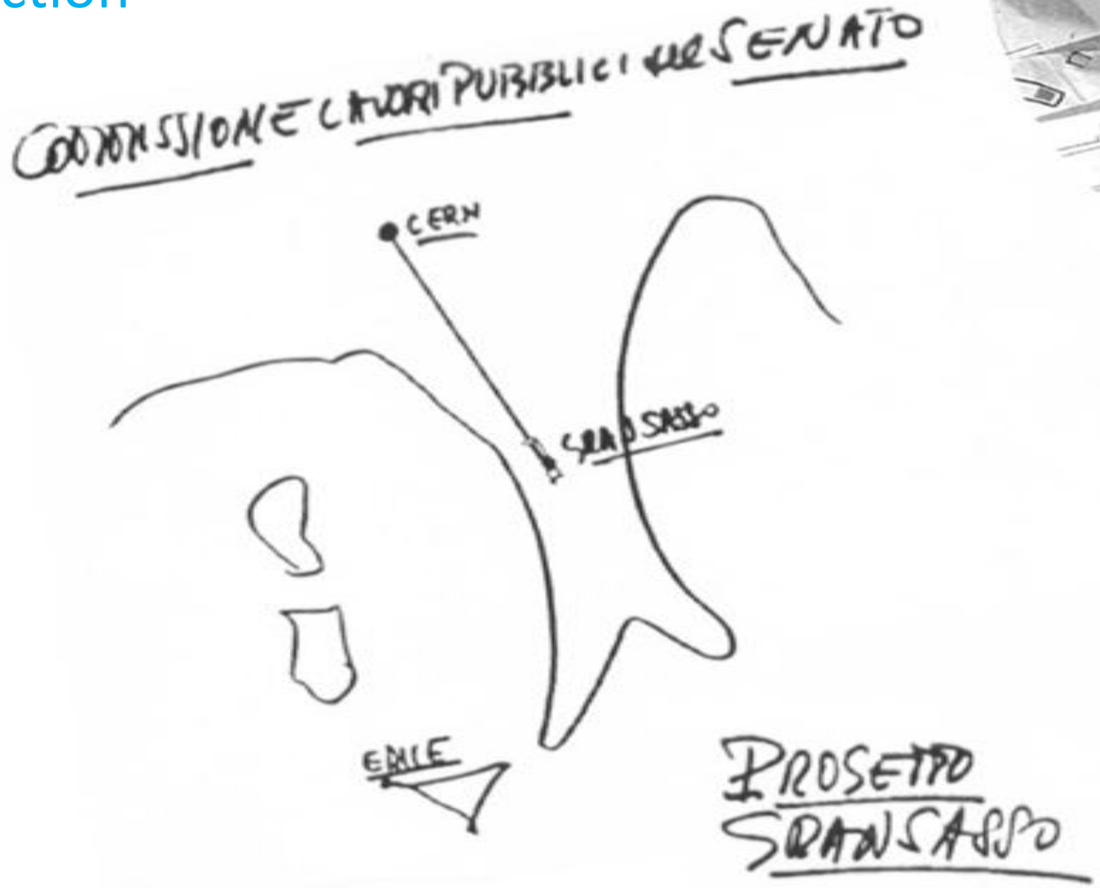
Every second, at sea level, something around 200 particles (muons) per m^2 will interact with Earth.

In this conditions, Cosmic Rays become an unavoidable “noise” for every nuclear detector placed on the Earth surface.

Going underground we strongly suppress such interferences produced by Cosmic Rays on our apparatus.

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)
- 1991: GALLEX
- ……….



LNGS characteristics

The largest and most important underground laboratory in operation

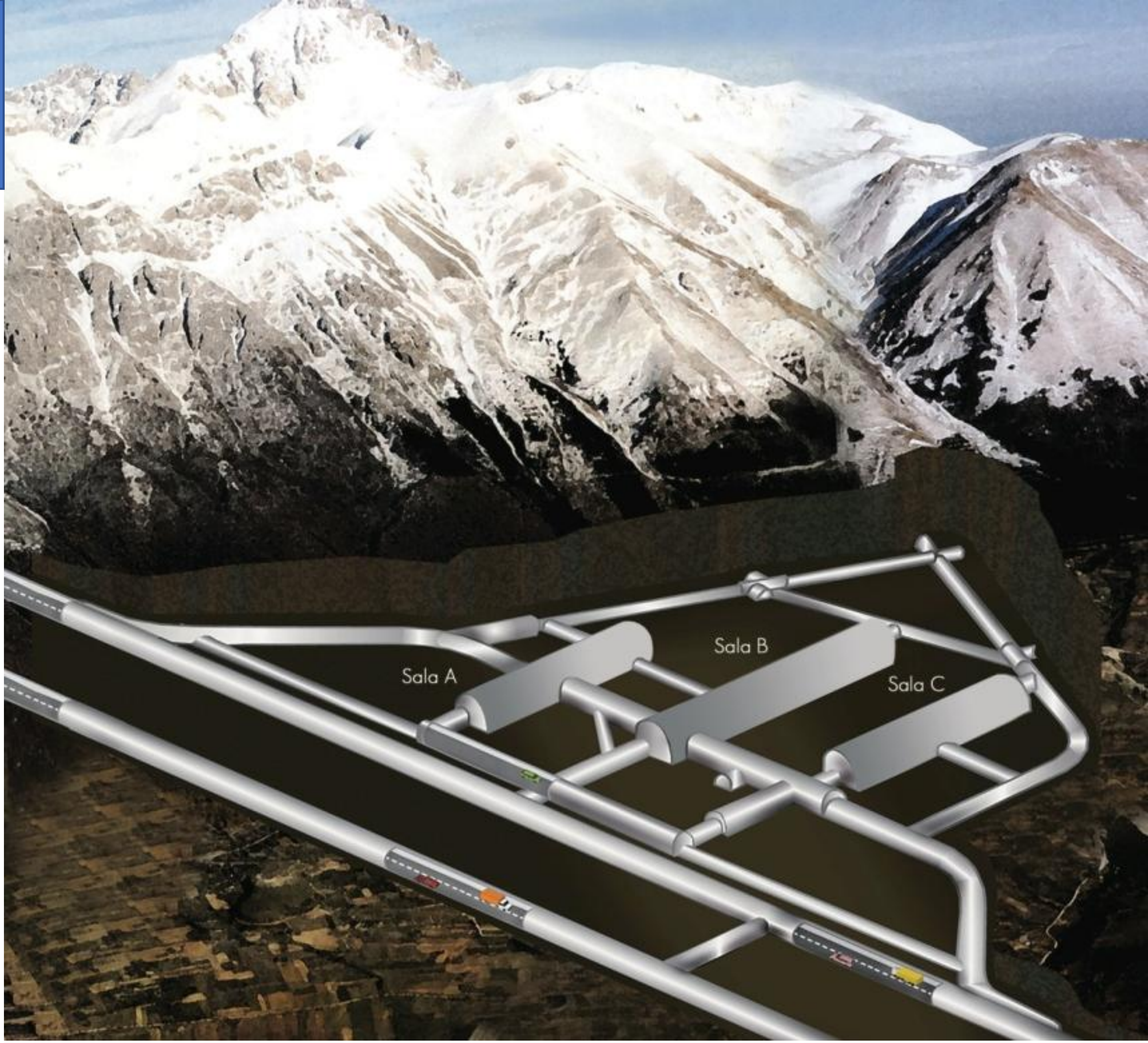
Shielded by **1400 m (3800 m.w.e.)** of rock (Gran Sasso Mountains)

Muon flux reduction respect to sea level **10^6**

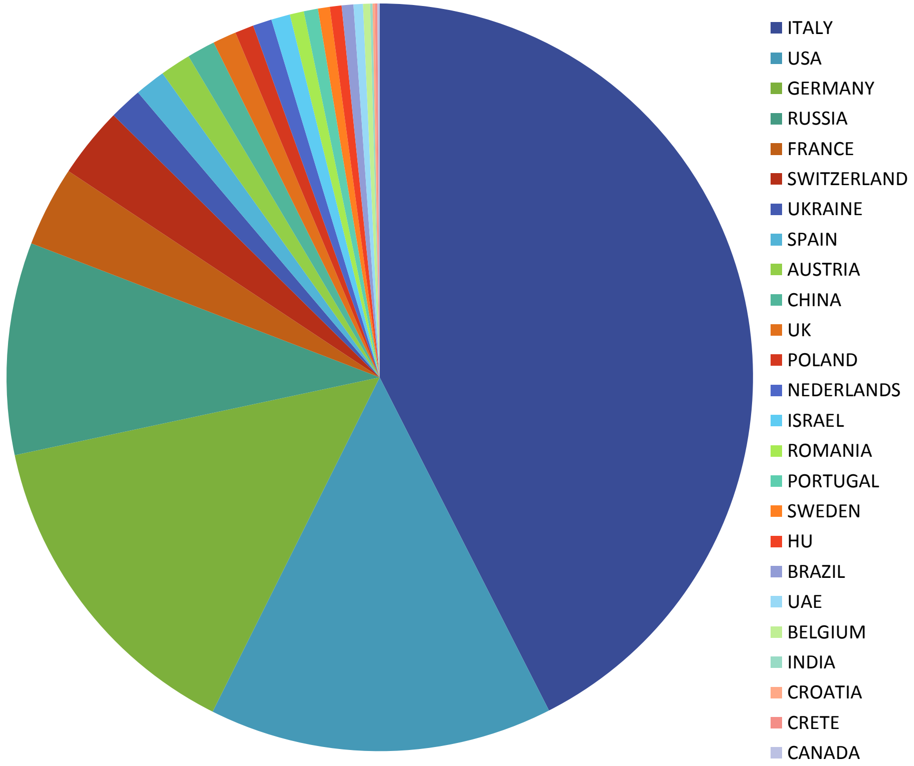
Easy access directly from the **A24 highway**

Area: 17.800 m^2

Volume: 180.000 m^3



An International Lab



TOTAL USERS: N. 981

ITALIAN USERS: N. 417

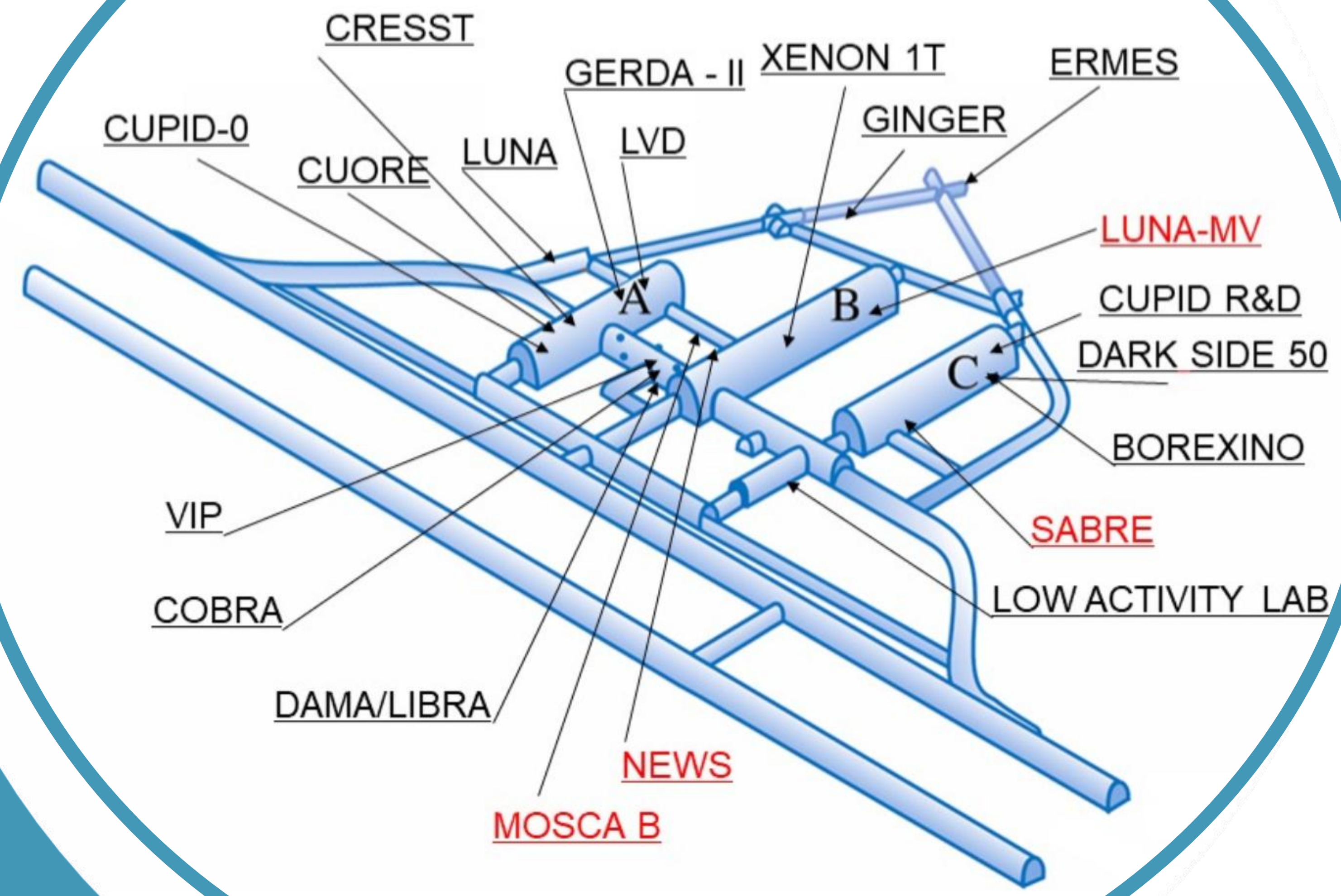
FOREIGN USERS: N. 564

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

The most sensitive laboratory for very low radioactivity measurements



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LNGS experiments

Fundamental physics

- **Neutrino astrophysics**
  - Solar neutrinos
  - Geo-neutrinos
  - Supernova neutrinos
- **Nuclear astrophysics**
  - Astrophysical nuclear processes
- **Neutrino properties**
  - Neutrinoless Double Beta Decay
  - Search for relic neutrinos
- **Dark Matter**
  - Direct interaction of WIMPs with Nuclei

…… but also

- **Test on quantum mechanics**
  - Study on Planck invariance
  - Electron decay
- **Radiobiology**
  - Biological effects of low radioactive environment
- **Geophysics**
  - Earthquacke monitoring and study
  - Analysis of water resources
- **Ultra Trace elemental analysis**
  - Low radioactivity tests and measurements
  - Cultural Heritage analysis
  - Advanced additive manufacturing

KEY words

- Rare events
- Background
  - Radiopurity
  - Screening

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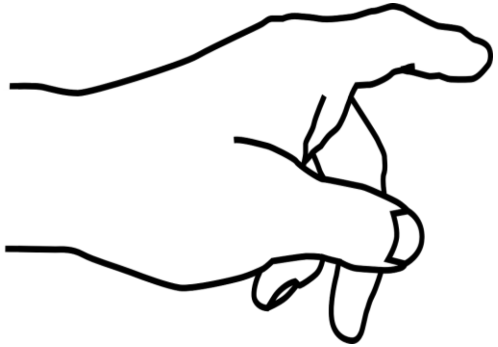
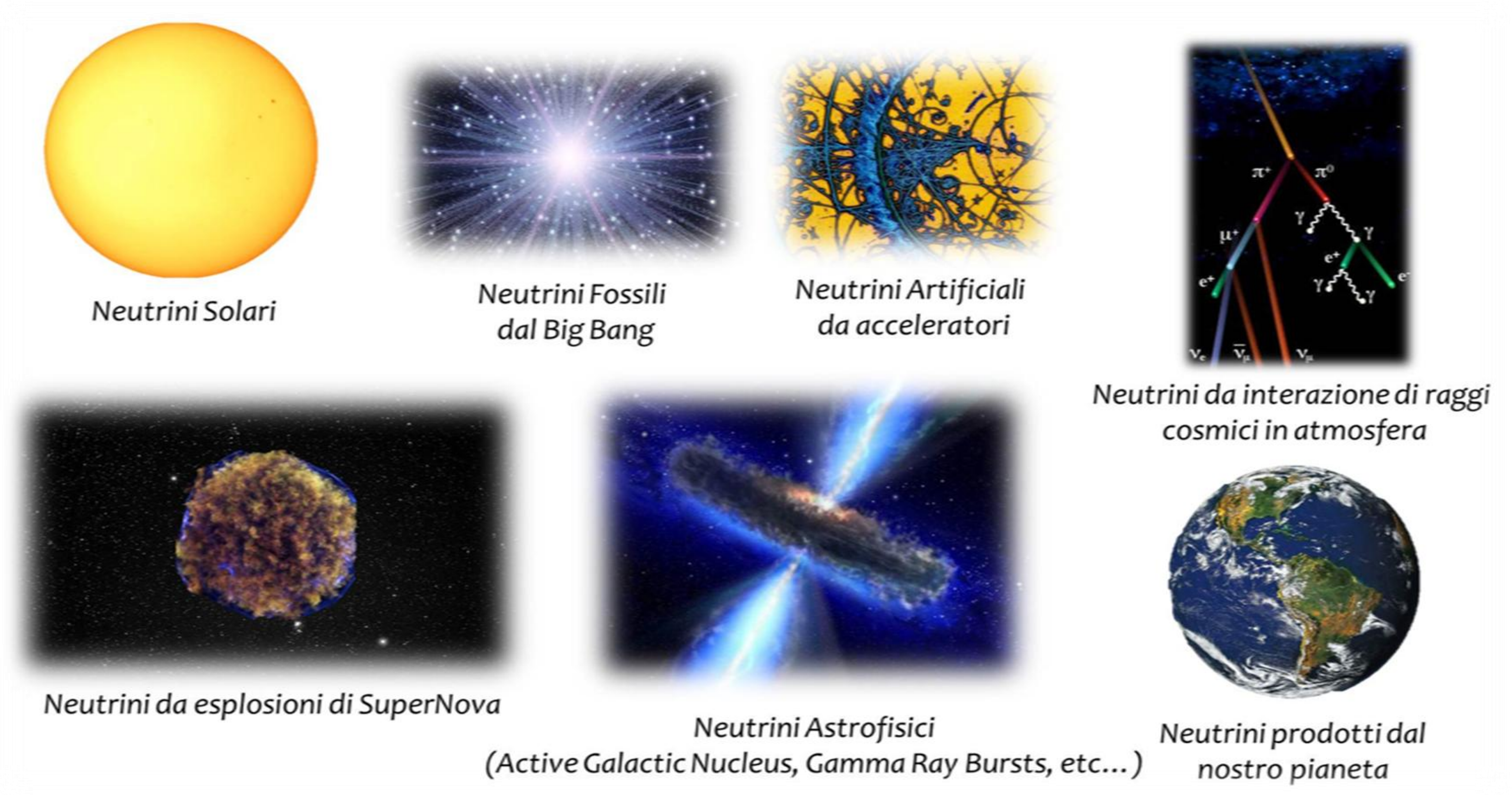
Neutrino AstroPhysics



Every second our fingers are crossed by around **60 Billions** of neutrinos
Produced by many different sources



Neutrino Astrophysics Experiments

- **BOREXINO**

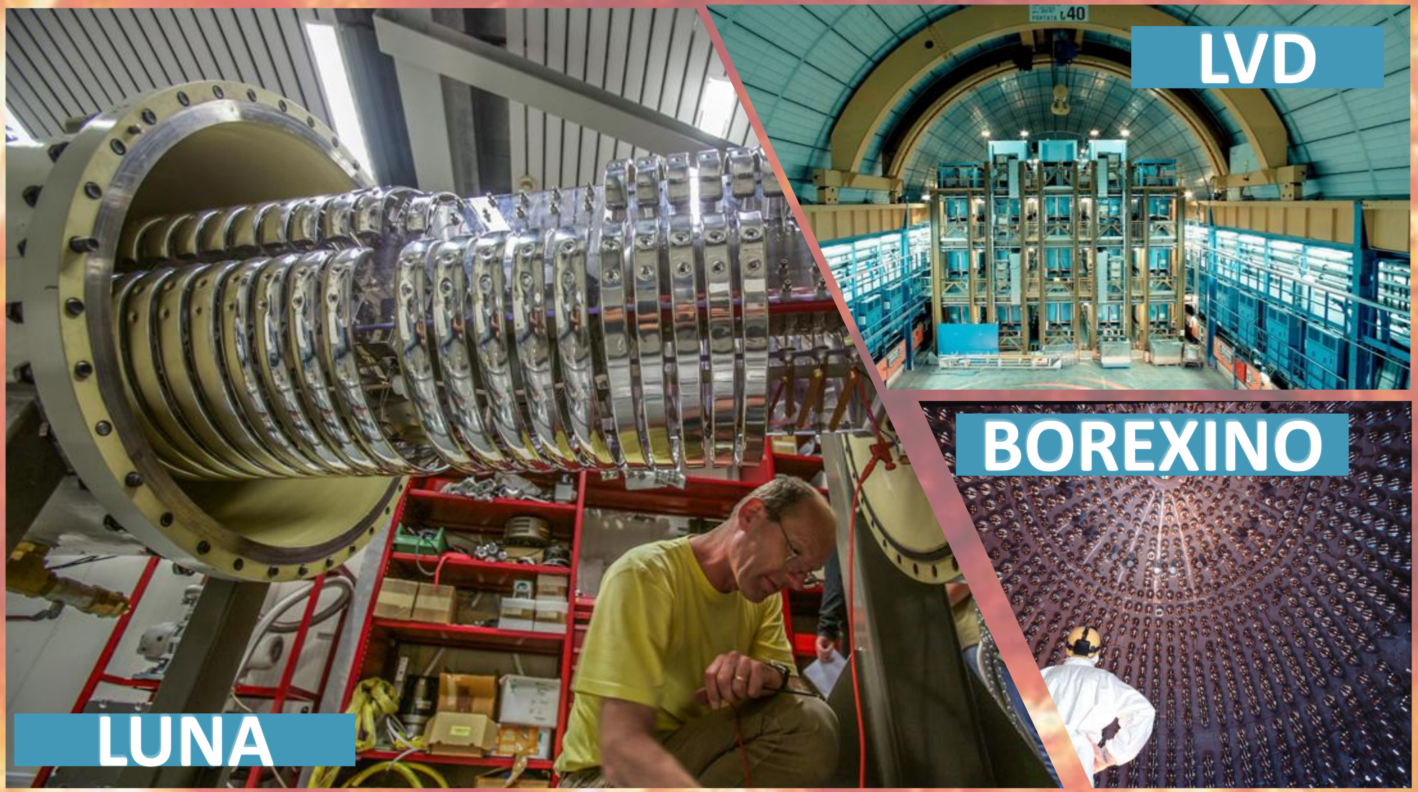
  solar neutrinos
  geo-neutrinos
  SN neutrinos

- **LVD**

  SN neutrinos

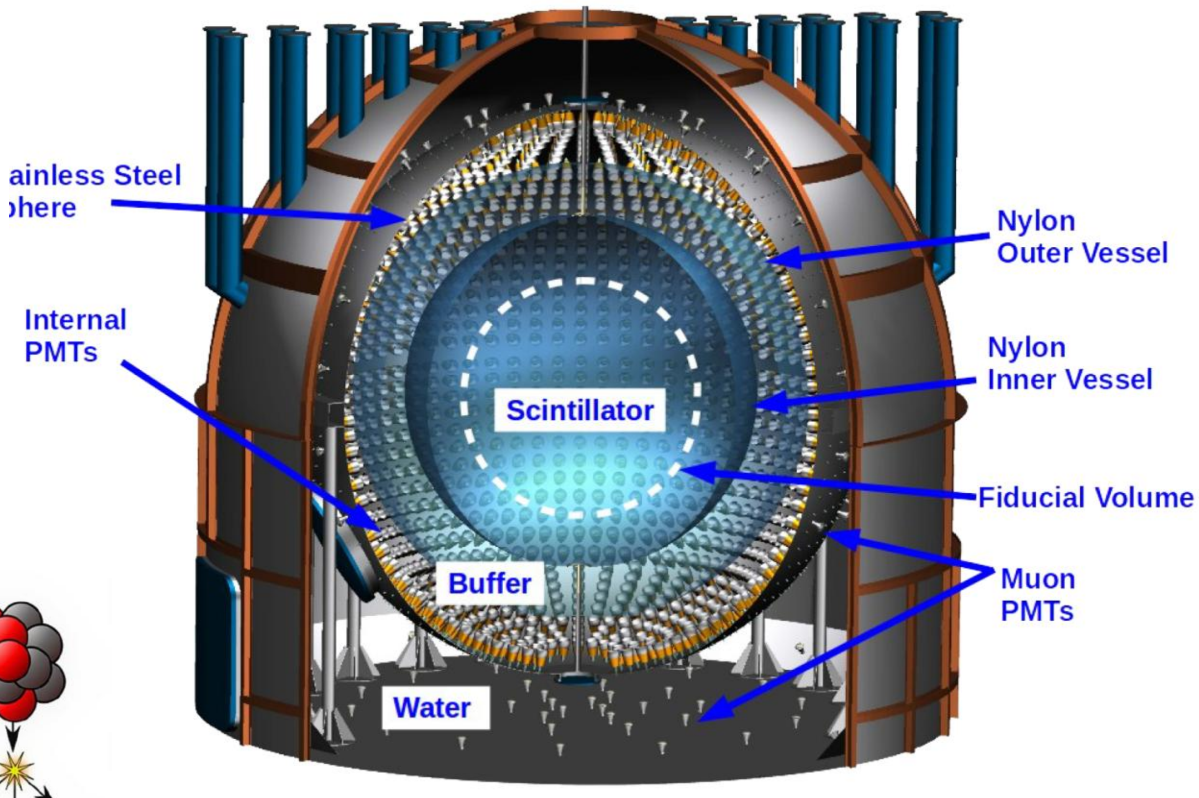
- **LUNA**

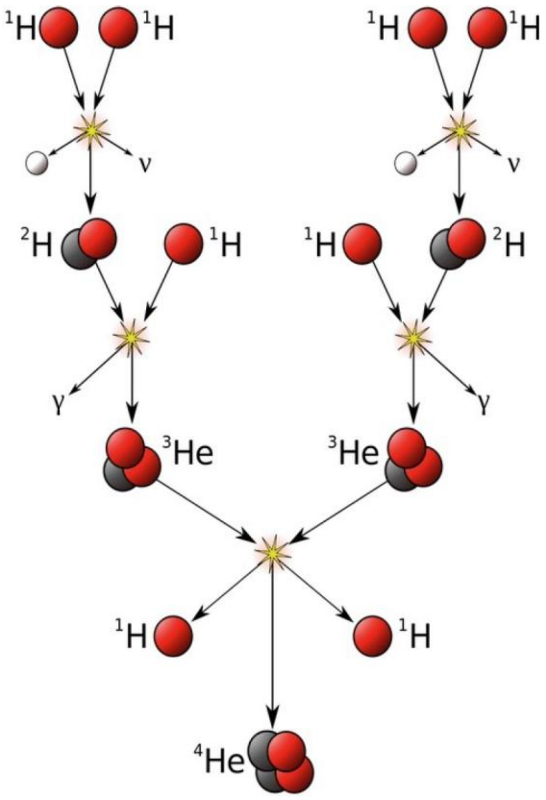
  Nuclear Astophysics



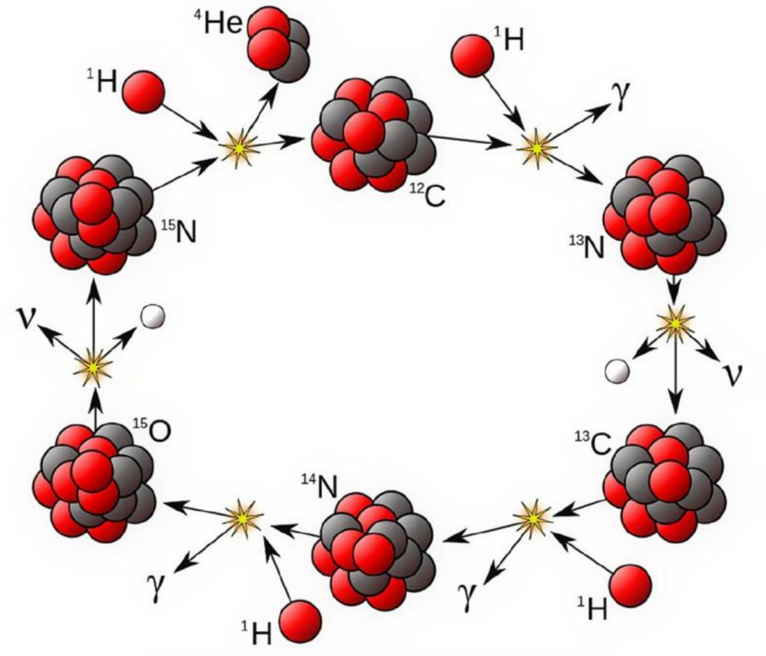
Borexino detector

Nuclear Fusion Processes in the Sun





pp chain (99%)



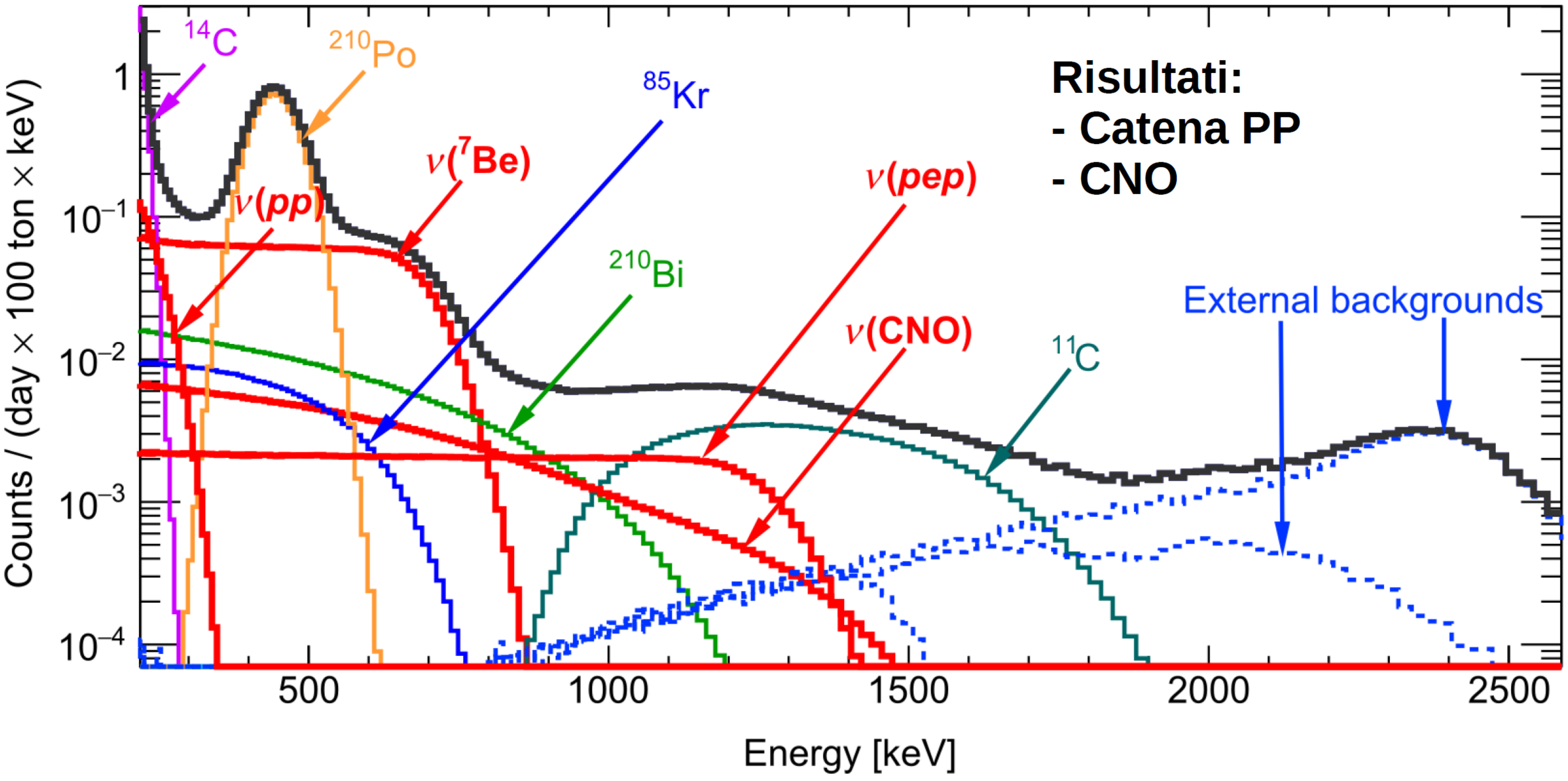
CNO cycle (1%)

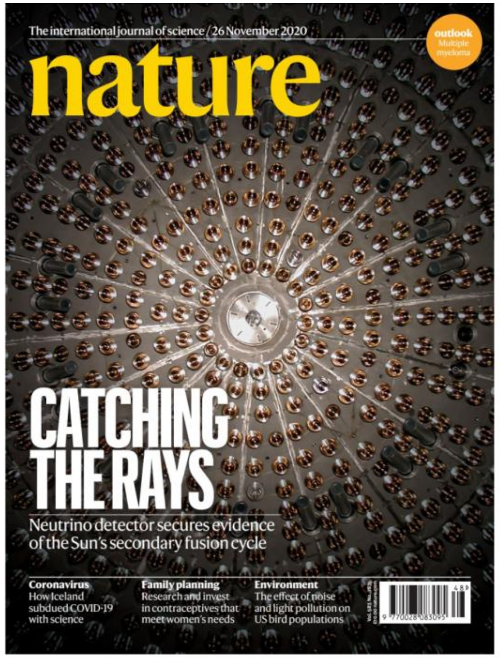
Borexino detector

- Liquid scintillator
- Very high purity materials
- Very low radioactive background
  - U and Th ~$\mathbf{10^{-19}}$-$\mathbf{10^{-20}}$ **g/g**

Borexino results

Reconstruction of the **Solar Neutrino Spectrum**





physicsworld TOP 10 BREAKTHROUGH 2020

Cocconi Prize 2021

Supernovae neutrinos

The most powerful scintillator telescope

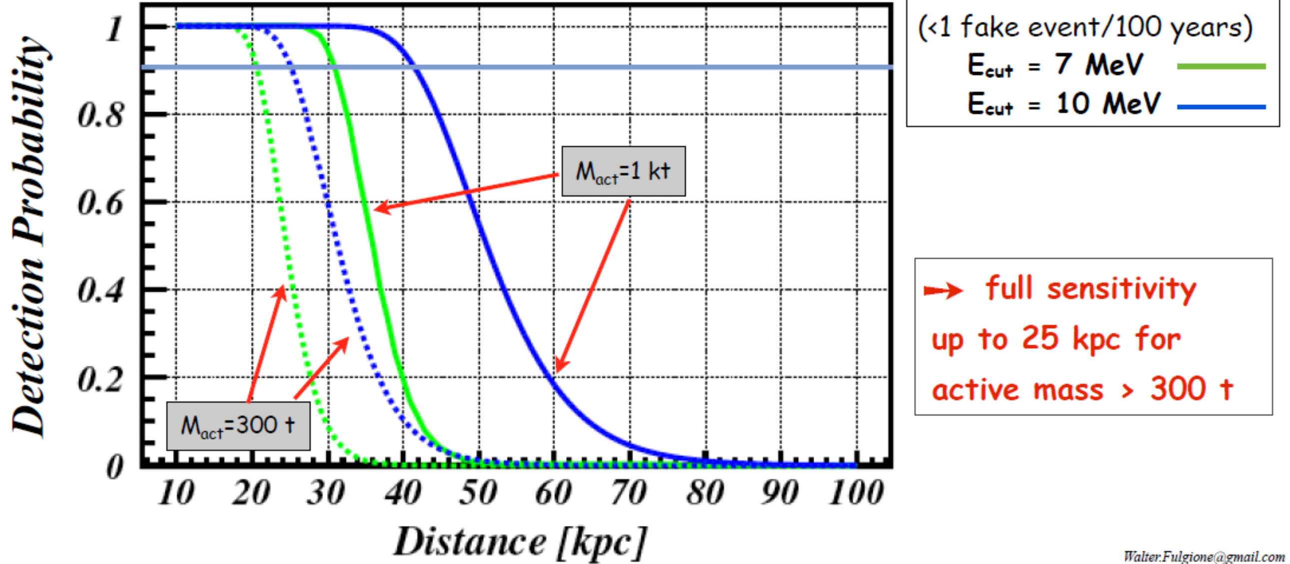
Main features:

Liquid Scintillator: C_nH_{2n+2} <n>=9.6 + 1g/l PPO + 0.03g/l POPOP, ρ=0.8 g/cm^3 **total 1 kt**

840 stainless steel, 1.5 m^3, counters **total 0.85 kt**

(FEU49b or FEU125) 15 cm diameter **2520 PMTs**

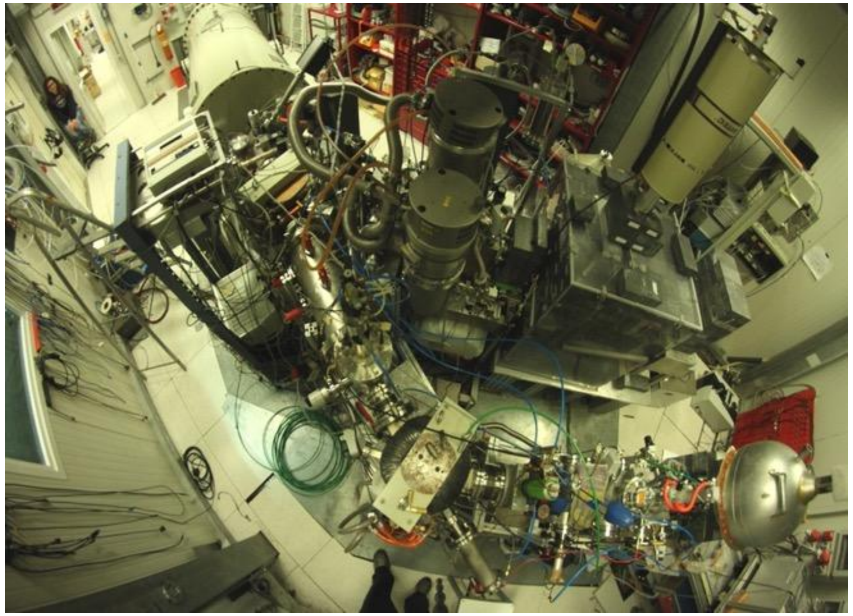
LVD Collaboration, "On-line recognition of supernova neutrino bursts in the LVD detector", Astropart. Phys. 28, 516-522 (2008) [arXiv:0710.0259].

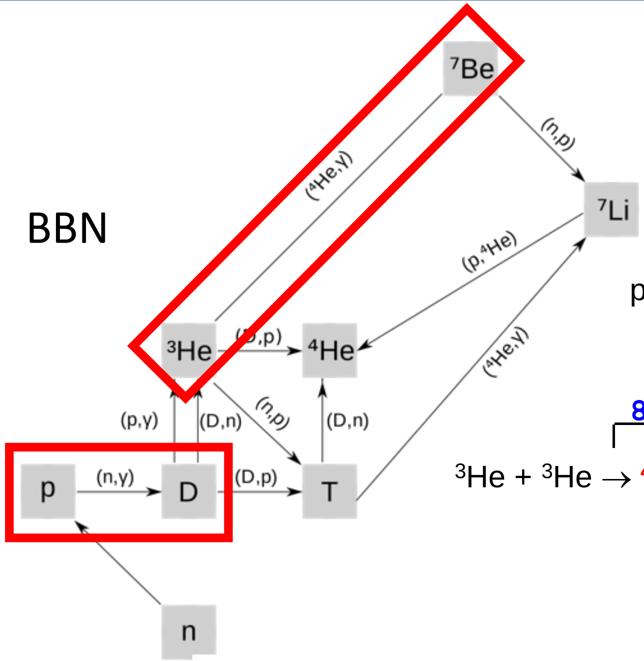


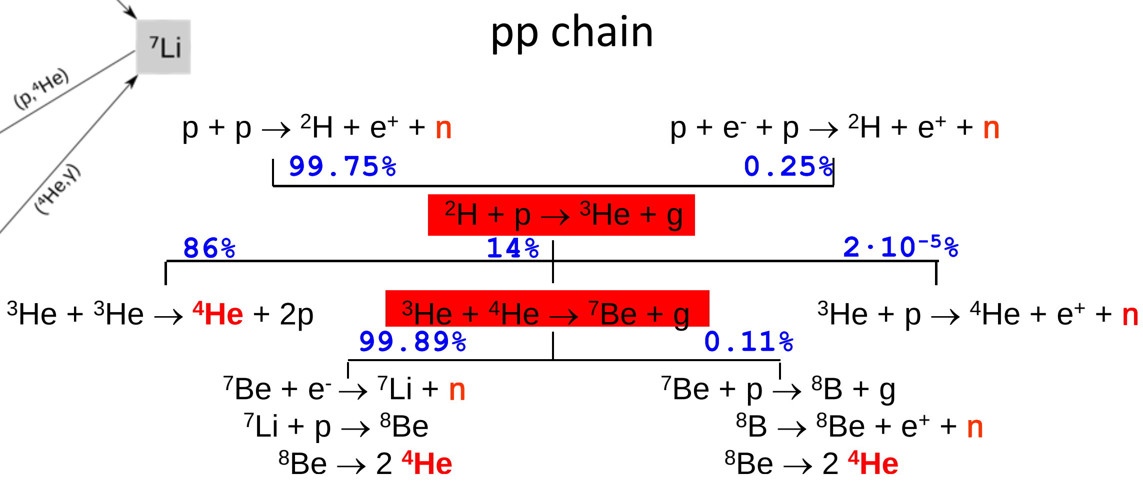
→ full sensitivity up to 25 kpc for active mass > 300 t

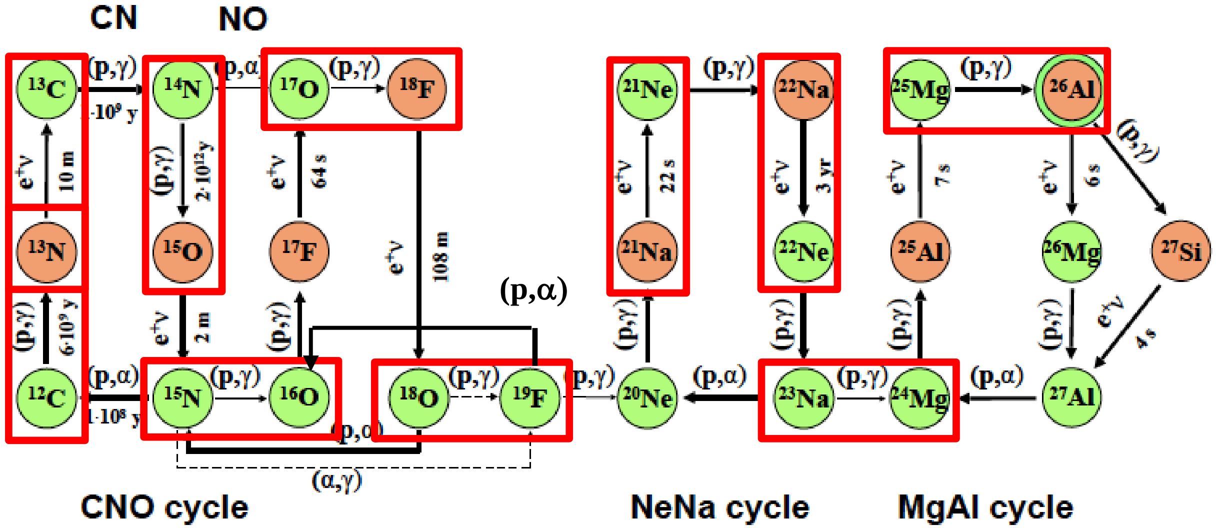
Walter.Fulgione@gmail.com

Nuclear Astrophysics - LUNA400

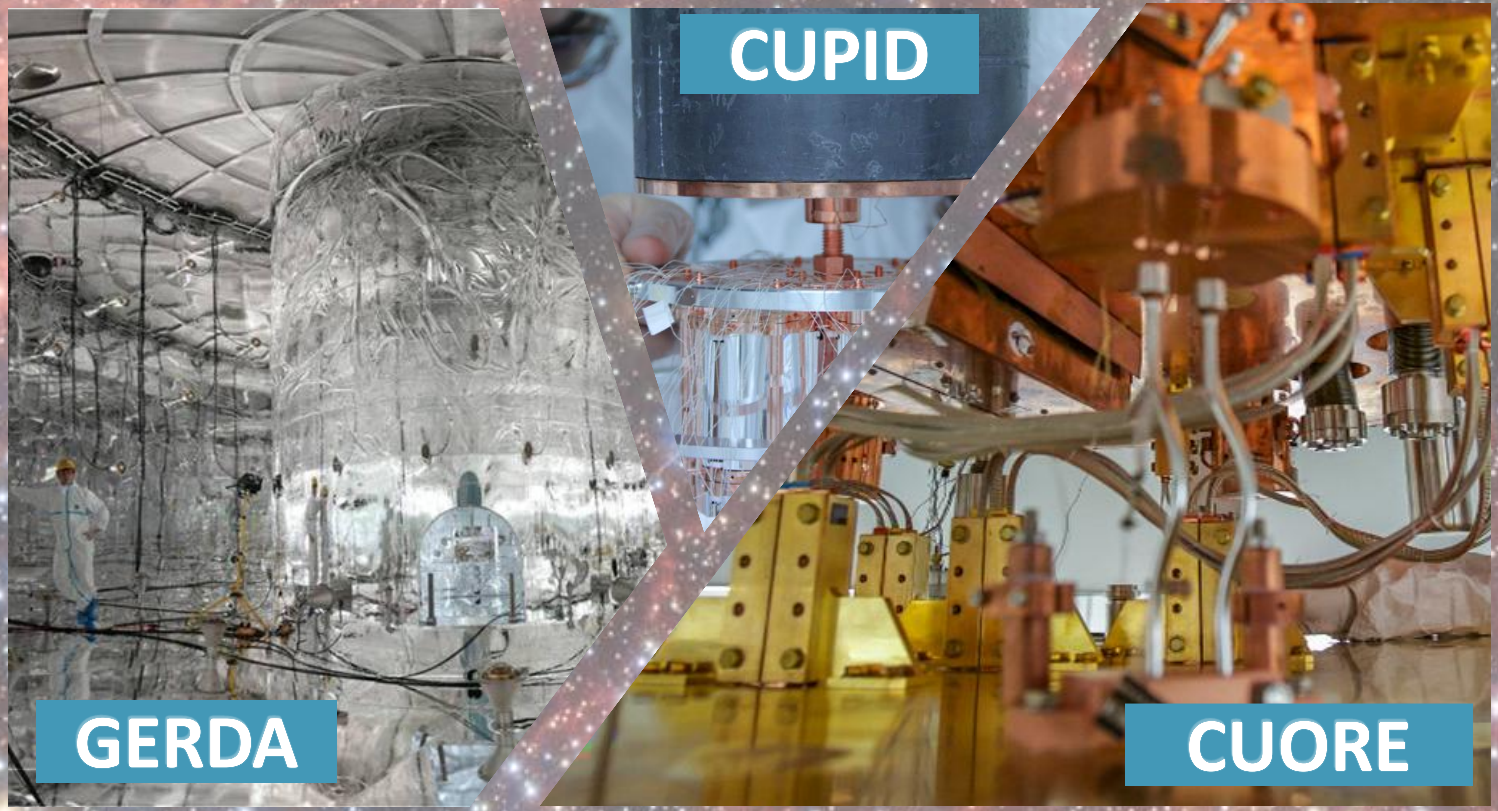








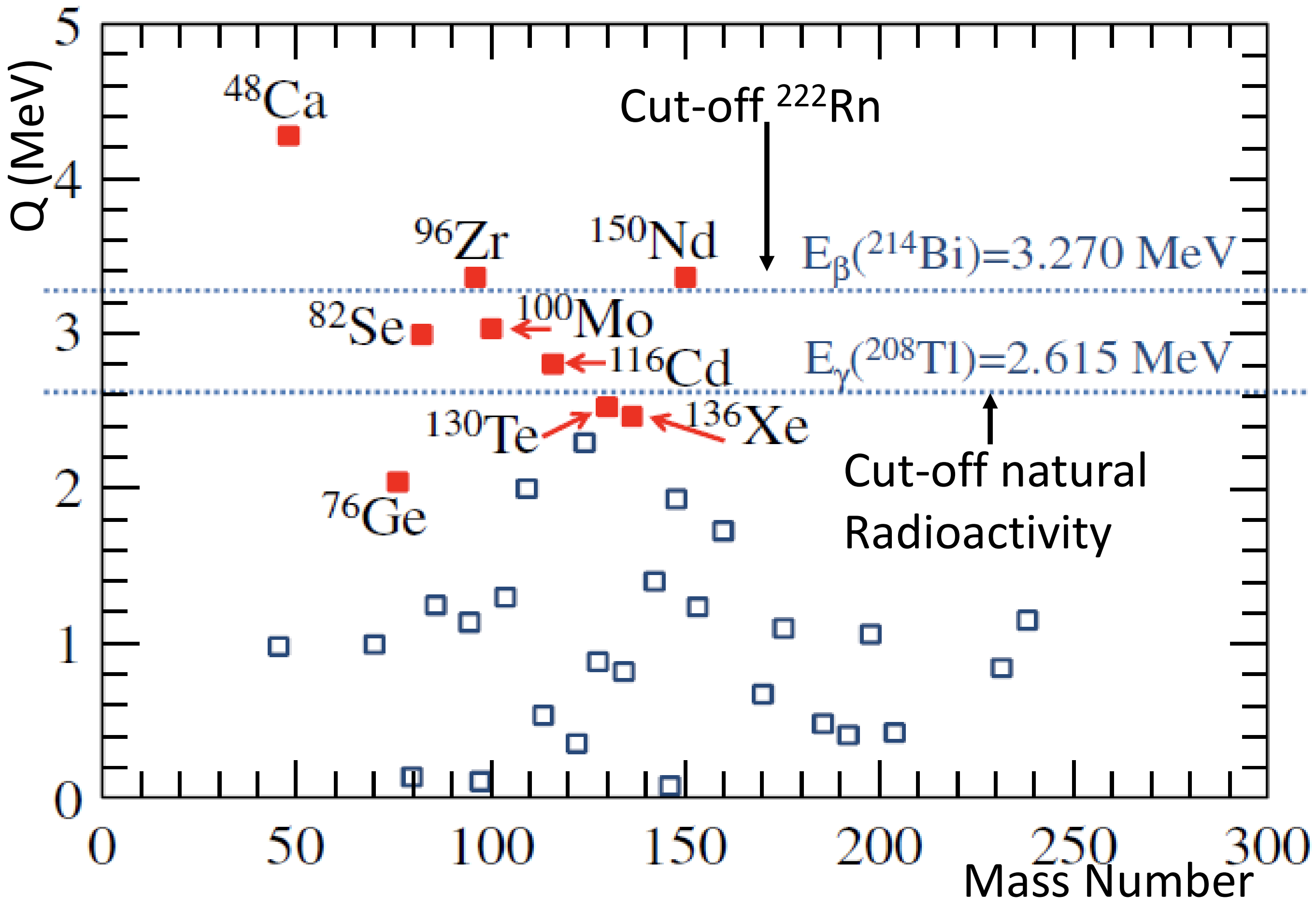
Neutrinoless Double Beta Decay

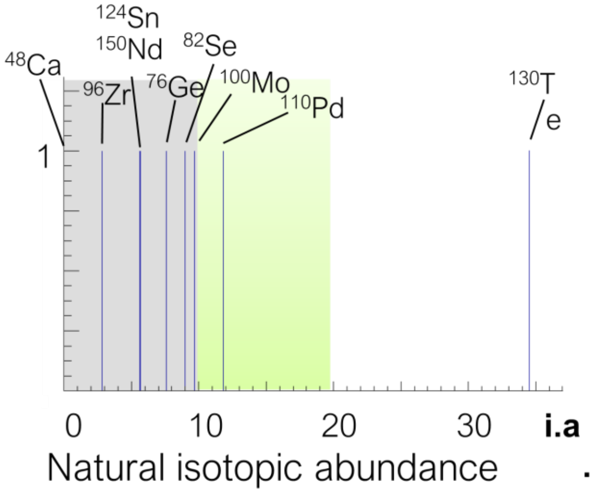


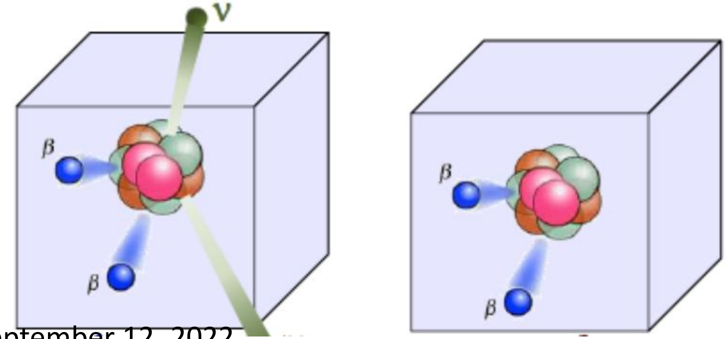
Isotope selection

From the Table of Isotopes

- 35 isotopes with double beta decay transitions
- 9 promising for sensitive measurements
- most promising candidates: $Q_{\beta\beta}$ > 2-3 MeV
- isotope enrichments are needed







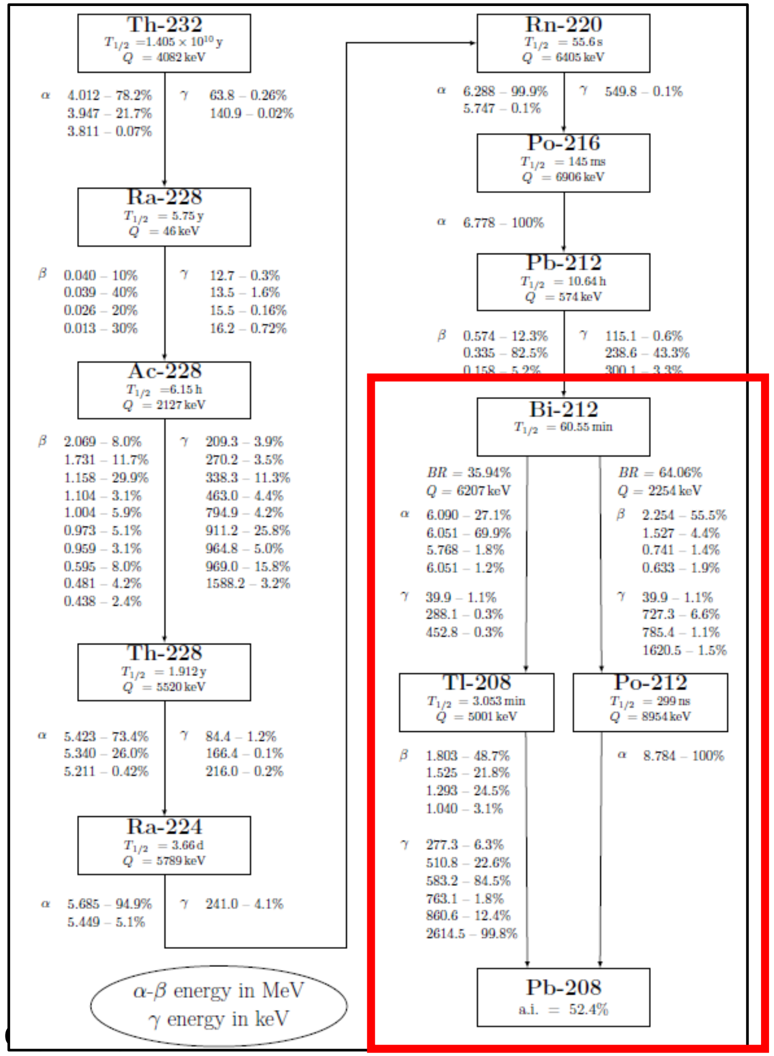
Considering a calorimetric approach (**Source == Detector**)

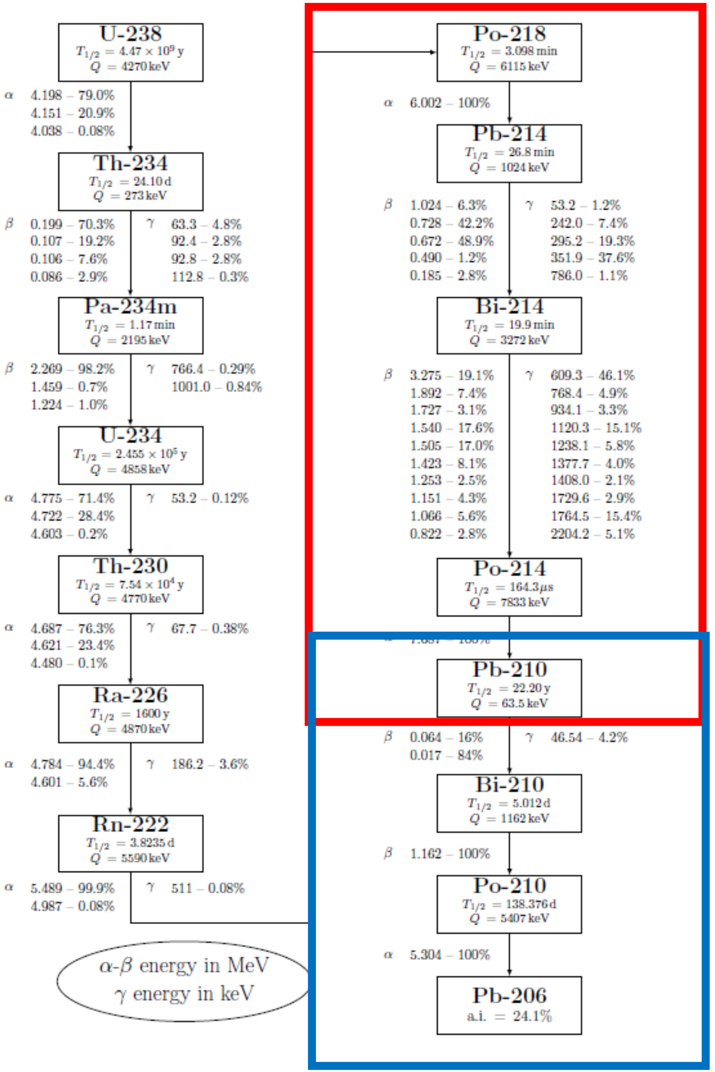
- **isotope enrichments** are needed
- **very clean materials** have to be identified

Background interferences

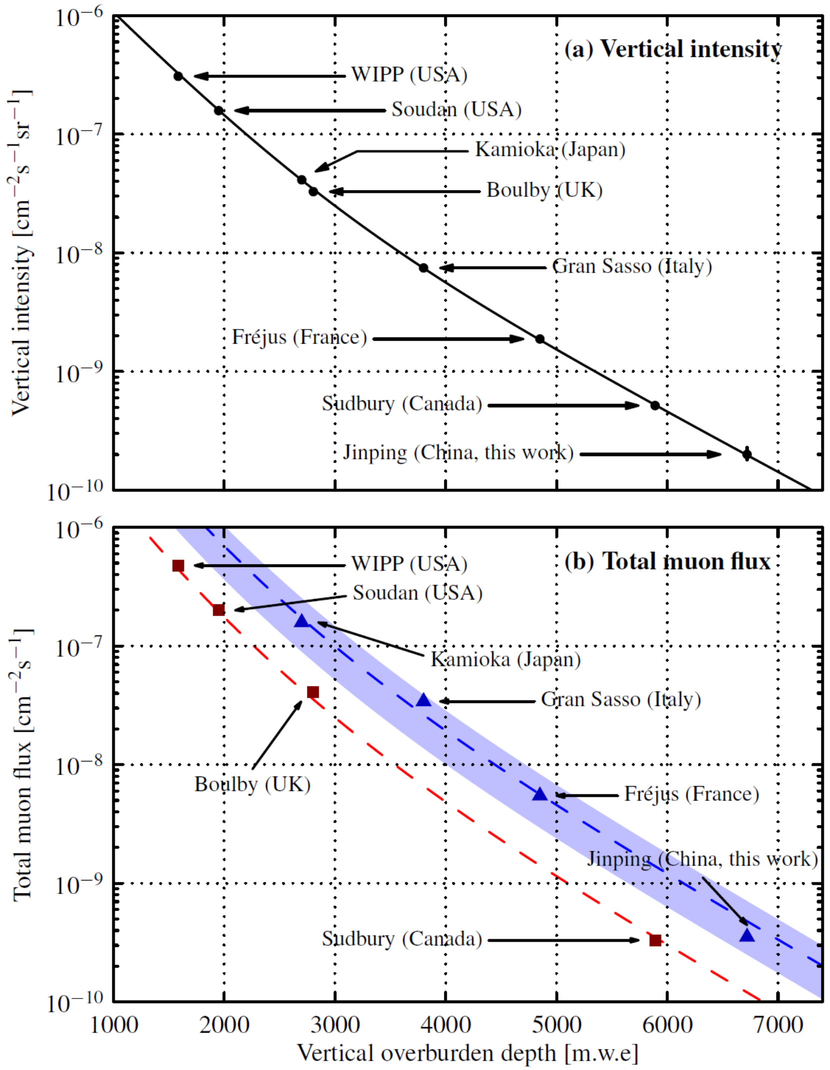
It is necessary to strongly reduce background events:

- Cosmic Rays
- Radioactivity





Guo et al., Chinese Physics **C45** (2021) 025001, arXiv:2007.15



E. Previtali

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Possible Calorimetric Approaches

Fluid or diluted in a fluid ← **Source** → Integral part of a crystal

- Container size
- Concentration of the source

← **Scalability** →

- Size of a single crystal
- Number of crystals

Large volumes of fluid
- Diluted source in liquid scintillatol →
  - Without balloon (SNO+)
  - With balloon (**KamLAND-Zen**)
  - With balloon+Cherenkov (Theia)
  - Opaque scintillator (LiquidO)
- TPC
  - High-pressure gas →
    - Cylindrical(Xe: Next, PandaX, Axel; SeF6:N\nuDEx)
    - Spherical(R2D2)
  - Liquid →
    - Single phase (Xe: EXO-200, **nEXO**)
    - Double phase (Xe: Darwin, LZ)

Crystal arrays
- Inorganic Scintillators (Candles)
- Semiconductor detectors
  - Germanium diodes →
    - Immersed in LAr (**GERDA, LEGEND**)
    - Conventional cryostats (MJD)
  - CCD to Se (SELENA)
  - CdZnTe (COBRA)
- Bolometers →
  - Pure bolometers (**CUORE**)
  - Scintillating bolometers (**CUPID, AMORE**)
  - PSD (CROSS)

Present and Future experiments

	Experiment	Isotope	Status	Laboratory	Moles of isotope	Isotopic abundance	B (events/kg$_{iso}$/keV/yr)	Fiducial isotope mass (kg)	Active fraction (%)	Eficiency	FWHM (keV)
High-purity Ge detectors	GERDA-II	^{76}Ge	completed	LNGS	450	0.87	6.00E-04	30	88	0.7189	3.29
	MJD	^{76}Ge	completed	SURF	240	0.88	4.74E-03	16	90	0.8099	2.585
	LEGEND-200	^{76}Ge	construction		2400	0.9	2.10E-04	166	91	0.819	2.585
	LEGEND-1000	^{76}Ge	proposed		12000	0.91	1.00E-05	839	92	0.828	2.585
Xenon TPC's	EXO-200	^{136}Xe	completed	WIPP	1200	0.81	1.99E-03	75	46	0.84	72.85
	nEXO	^{136}Xe	proposed	SNOLAB	34000	0.9	2.10E-06	2959	64	0.66	47
	NEXT-100	^{136}Xe	construction	LSC	640	0.9	4.90E-04	77	88	0.3724	23.5
	NEXT-HD	^{136}Xe	proposed		7400	0.9	5.80E-06	956	95	0.3916	18.095
	PandaX-III-200	^{136}Xe	construction	CJPL	1300	0.9	1.20E-04	136	77	0.481	72.85
	LZ-nat	^{136}Xe	construction	SURF	4700	0.09	1.22E-03	90	14	0.8	58.75
	LZ-enr	^{136}Xe	proposed	SURF	46000	0.9	1.20E-04	876	14	0.8	58.75
	Darwin	^{136}Xe	proposed		27000	0.09	4.10E-05	477	13	0.9	47
Large liquid scintillators	KLZ-400	^{136}Xe	completed	Kamioka	2500	0.91	3.80E-04	150	44	0.97	267.9
	KLZ-800	^{136}Xe	data taking	Kamioka	5000	0.91	5.30E-05	394	58	0.97	267.9
	KL2Z	^{136}Xe	proposed	Kamioka	6700	0.91	2.20E-05	729	80	0.97	141
	SNO+I	^{130}Te	construction	SNOLAB	10000	0.348	3.00E-04	272	20	0.97	188
	SNO+II	^{130}Te	proposed	SNOLAB	51000	0.348	3.00E-04	1873	27	0.97	133.95
Cryogenic calorimeters	CUORE	^{130}Te	data taking	LNGS	1585	0.348	5.38E-02	206	100	0.8096	7.52
	CUPID-0	^{82}Se	completed	LNGS	62	0.96	5.95E-03	5	100	0.6966	19.975
	CUPID-Mo	^{100}Mo	completed	LSM	23	0.97	7.82E-03	2.3	100	0.6916	7.52
	CROSS	^{100}Mo	construction	LSC	48	0.96	1.71E-02	5	100	0.675	4.935
	CUPID	^{100}Mo	proposed	LNGS	2500	0.96	1.70E-04	250	100	0.711	4.935
	AMORE	^{100}Mo	proposed	Yemilab	1100	0.96	1.70E-04	110	100	0.7462	4.935
Tracking calorimeters	NEMO-3	^{100}Mo	completed	LSM	690	0.9	2.18E-03	69	100	0.11	347.8
	SuperNEMO-D	^{82}Se	construction	LSM	850	0.9	1.10E-04	70	100	0.28	195.05
	SuperNEMO	^{82}Se	proposed	LSM	1200	0.9	3.20E-05	98	100	0.28	169.2

Completed
Data taking

Current situation

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

GERDA $T_{1/2} > 1.8\times10^{26}$ y
Phys. Rev. Lett. 125, 252502 (2020)

KamLAND-Zen 400 $T_{1/2} > 1.07\times10^{26}$ y
Phys. Rev. Lett. 117, 082503 (2016)

EXO-200 $T_{1/2} > 3.5\times10^{25}$ y
Phys. Rev. Lett. 123, 161802 (2019)

MAJORANA dem. $T_{1/2} > 2.7\times10^{25}$ y
Phys. Rev. C 100, 025501

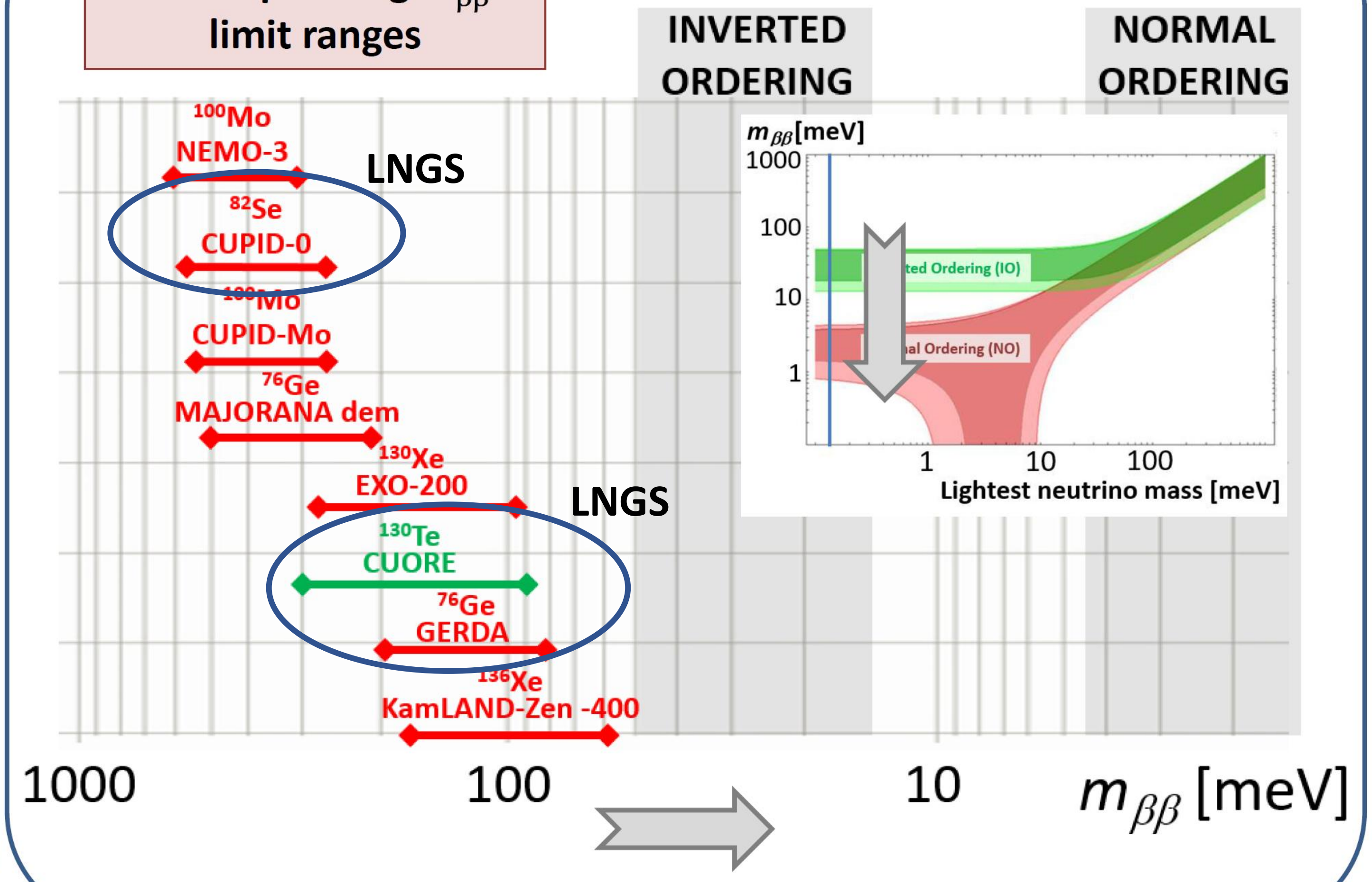
CUORE $T_{1/2} > 2.2\times10^{25}$ y
arXiv:1907.09376

CUPID-0 $T_{1/2} > 4.7\times10^{24}$ y
L. Pagnanini, TAUP 2021

CUPID-Mo $T_{1/2} > 1.8\times10^{24}$ y
B. Welliver, TAUP 2021

NEMO-3 $T_{1/2} > 1.1\times10^{24}$ y
Phys. Rev. D 92, 072011 (2015)

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



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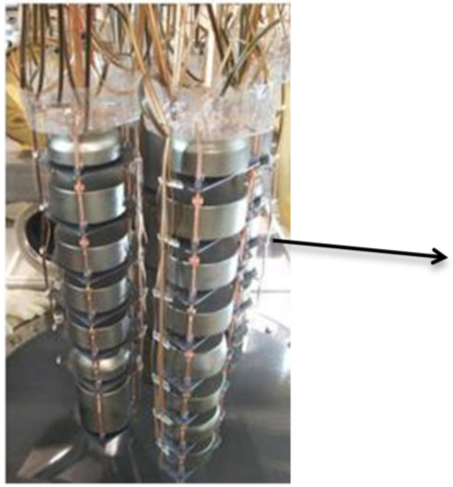
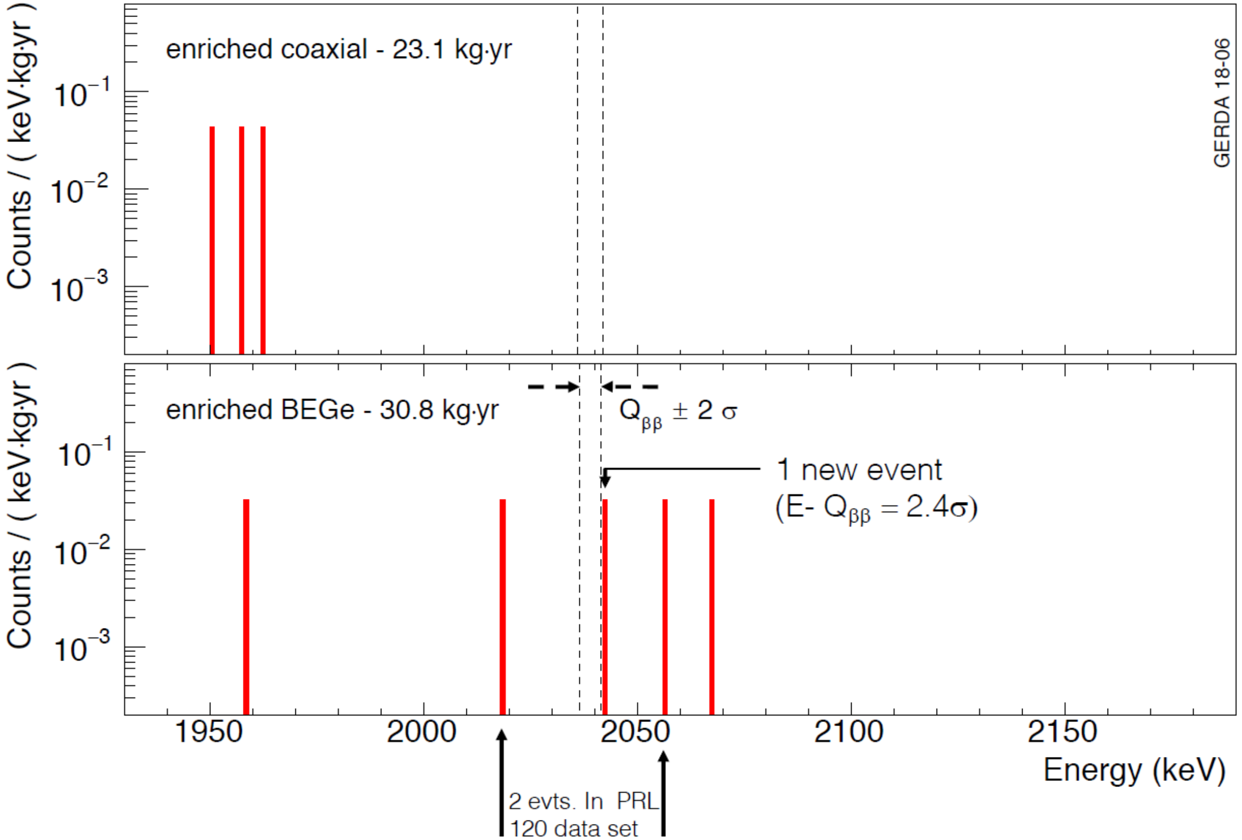
Gerda Results

GERDA experiment operates in a real
0 background conditions

High purity germanium diodes immersed in LAr

- ΔE < 3 Kev FWHM @ Qββ
- Pulse shape analysis: multi/single site vs.
- anticoincidence with LAr
  - scintillating fibers (WLS) coupled to SIPMS
  - PMT above and below the detector





Background index*:

$(5.7^{+4.1}_{-2.6} \cdot 10^{-4})$ counts/(keV·kg·yr)

$(5.6^{+3.4}_{-2.4} \cdot 10^{-4})$ counts/(keV·kg·yr)

*: in 1930-2190 keV excluding ±5 keV at $Q_{\beta\beta}$ and lines at 2104 keV and 2119 keV.

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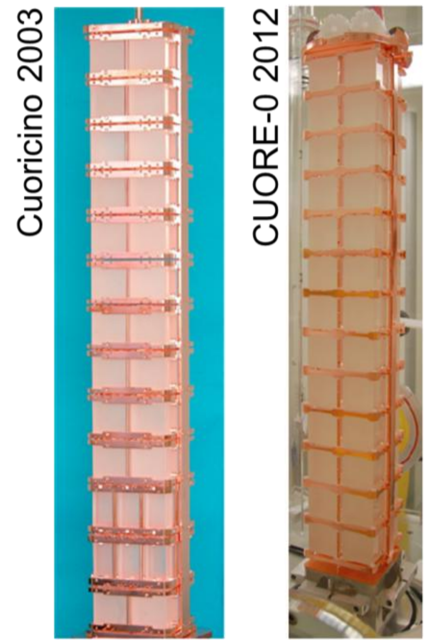
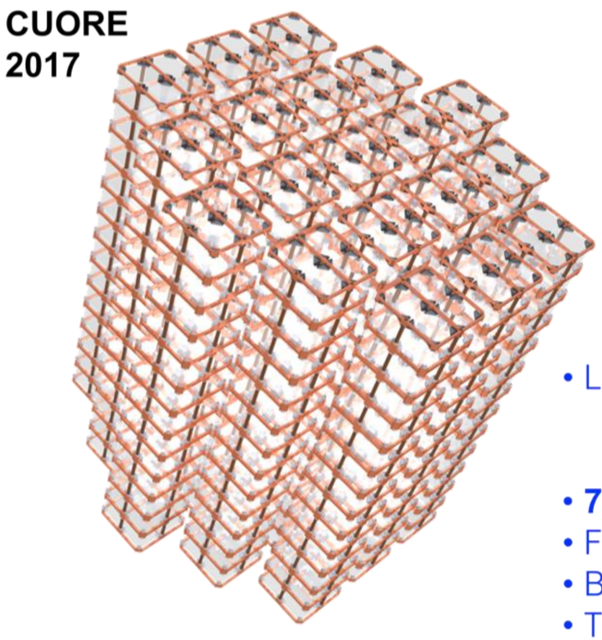
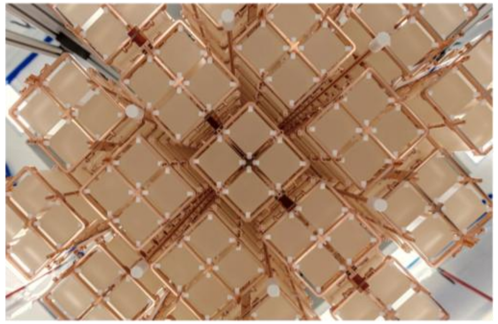
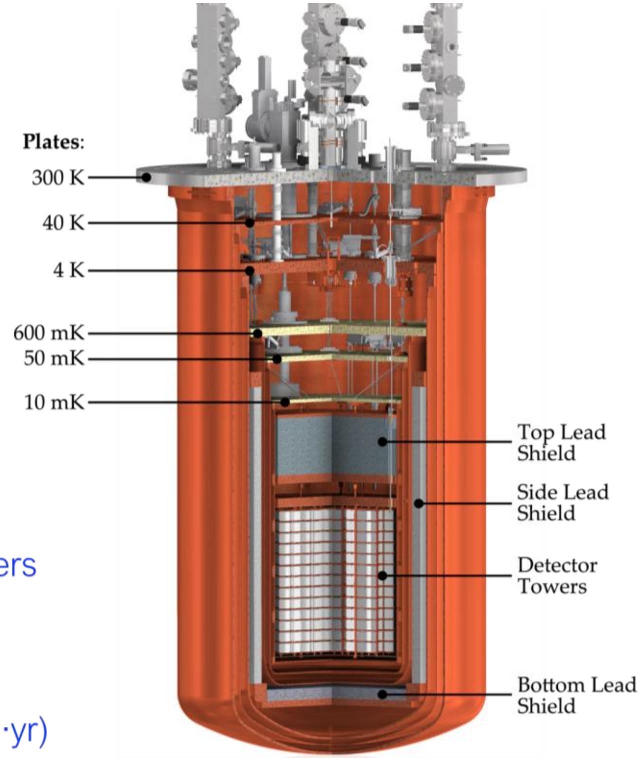
CUORE

Largest cryogenic particle detector ever realized

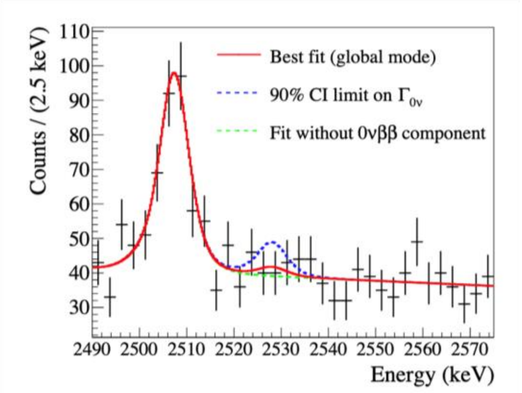








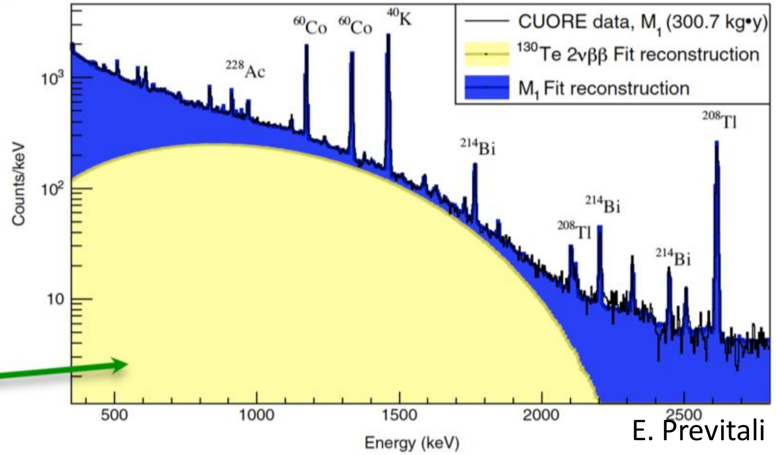
- LNGS
  - 988 TeO_2 crystals arranged on 19 towers
  - dedicated "dry" cryostat
- **742 kg** di $^{natural}TeO_2$ (206 kg of ^{130}Te)
- FWHM: **7.7 keV** FWHM (ROI)
- Background: **$(1.4 \pm 0.2)\cdot 10^{-2}$** cnts/(keV·kg·yr)
- Total exposure: 1.8 tonne (TeO_2)·yr



- $\beta\beta 0\nu$ result (1038.4 kg yr TeO_2, 288 kg yr ^{130}Te): :
  - **$T_{1/2}(0\nu) > 2.2\cdot 10^{25}$ yr (90%C.L.)**
  - **$m_{\beta\beta} < 90\text{–}305$ meV**

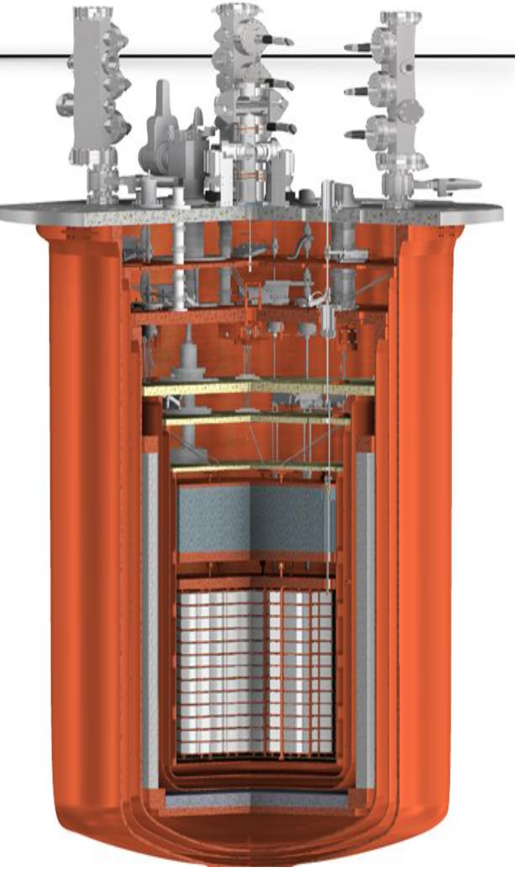
Adams D. et al. (CUORE collaboration), *Nature* 604 (2022) 7904, 53-58
https://www.nature.com/articles/s41586-022-04497-4

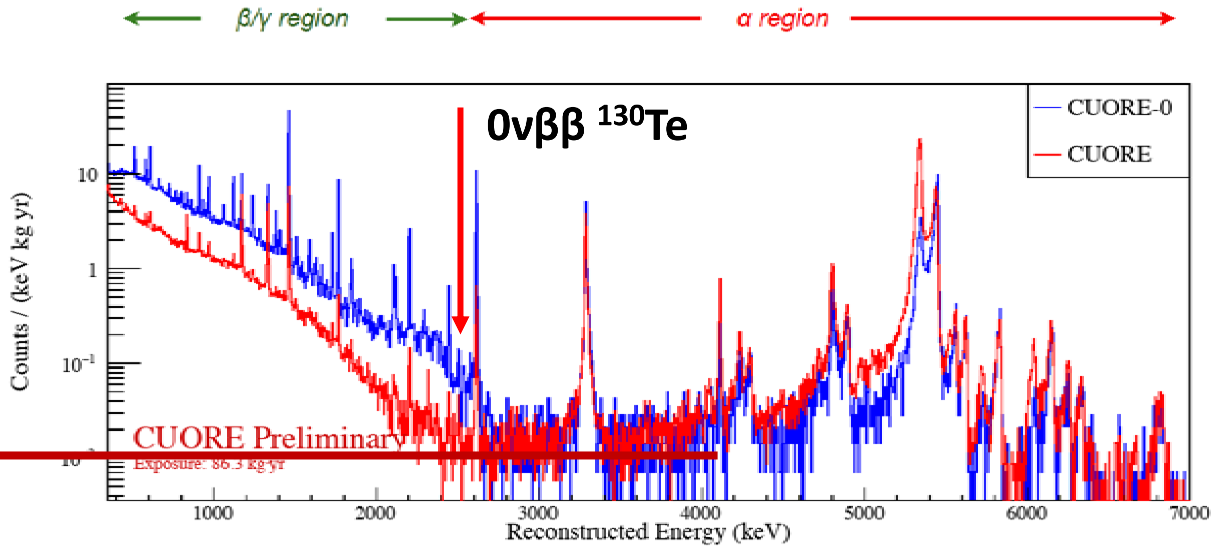
- $T_{1/2}(2\nu) = [7.71(^{+0.08}_{-0.06}(stat.)^{+0.12}_{-0.15}(syst.)]\cdot 10^{20}$ yr



CUORE/CUPID

- CUORE cryostat: **most powerful cryostat** ever realized
- **Tens of ton of materials** cooled at 10 mK
- Cryogenic detectors are **reliable**



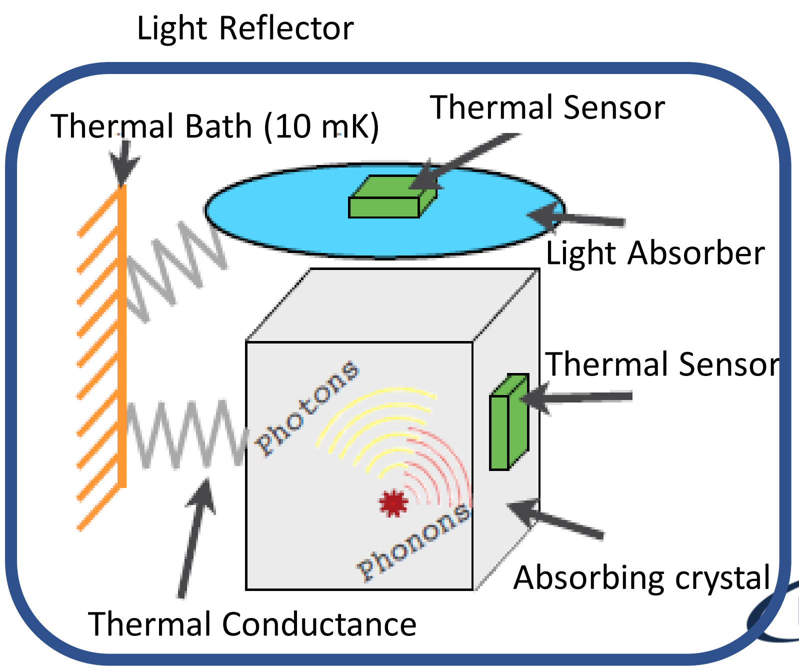


CUORE alpha background
BI ~ 10^{-2} counts/(keV kg years)

CUPID - scintillating bolometers detector

Simultaneous read-out of **Photons and Phonons**

High energy resolution: **as bolometer**
High discrimination capability: **as scintillator**



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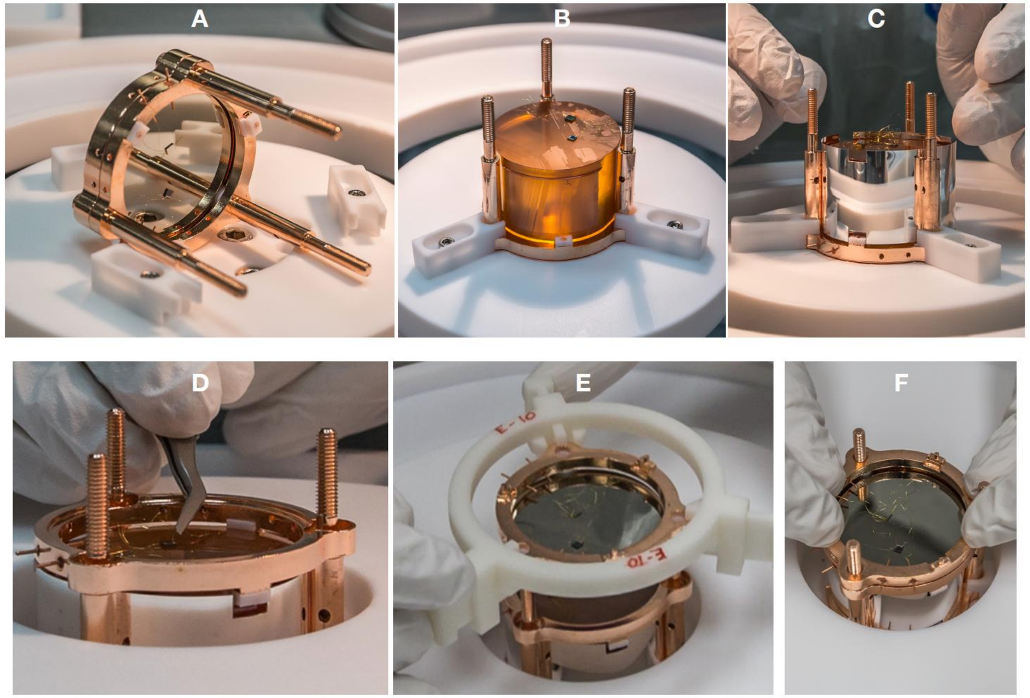
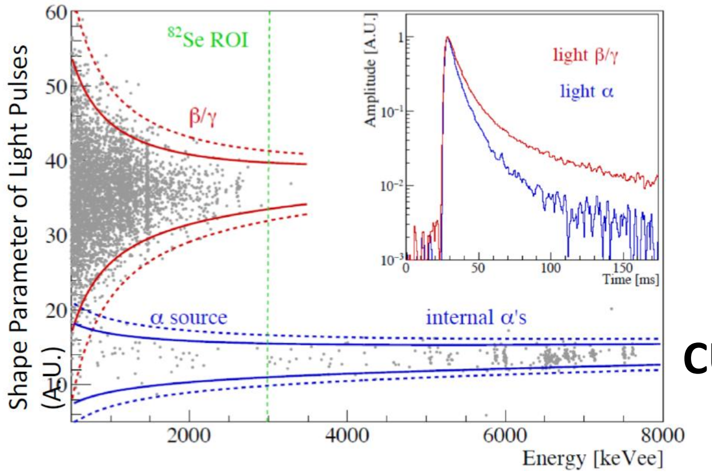
CUPID detector

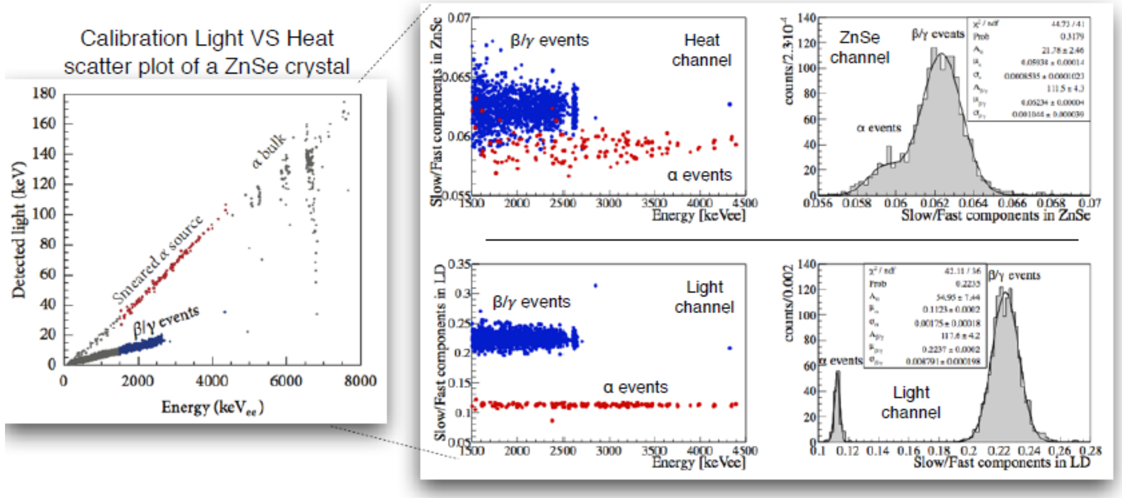
- Scintillating crystals and light detectors operated @ 10 mK
- Grown from **various ββ emitters** (multi-isotope approach)
- **Excellent energy resolution** @$Q_{\beta\beta}$ (<1%)
- Possibility to high $Q_{\beta\beta}$ (3 MeV) for **^{82}Se and ^{100}Mo**
- **$LY_{\alpha} \neq LY_{\beta/\gamma}$** ➜ Particle ID
- **$LShape_{\alpha} \neq LShape_{\beta/\gamma}$** ➜ Particle ID
- **$HShape_{\alpha} \neq HShape_{\beta/\gamma}$** ➜ Particle ID





CUPID-0 Data

Particle identification using Pulse Shape Parameters (decay time)



Discrimination potential @ ROI:

$$DP(E) = \frac{|\mu_{\alpha}(E) - \mu_{\beta\gamma}(E)|}{\sqrt{\sigma^2_{\alpha}(E) + \sigma^2_{\beta\gamma}(E)}}$$

Heat channel
DP@ROI = 2

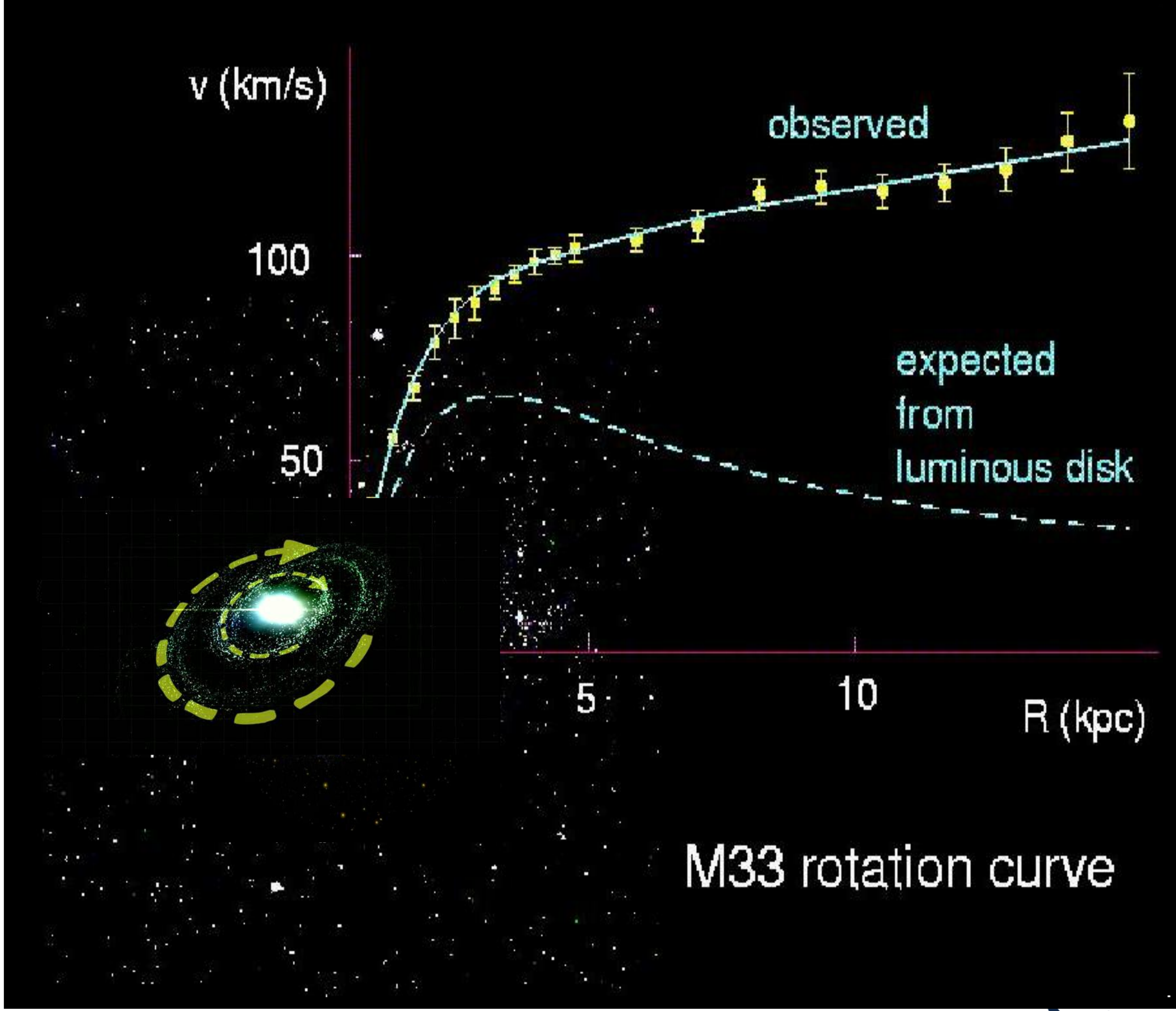
Light channel
DP@ROI = 11

Full rejection of α events shapeHEAT+shapeLIGHT+light

Cosmological studies @ LNGS

Dark Matter Searches

...large part of our Universe is completely unknown...



Dark Matter Search Experiments@ LNGS

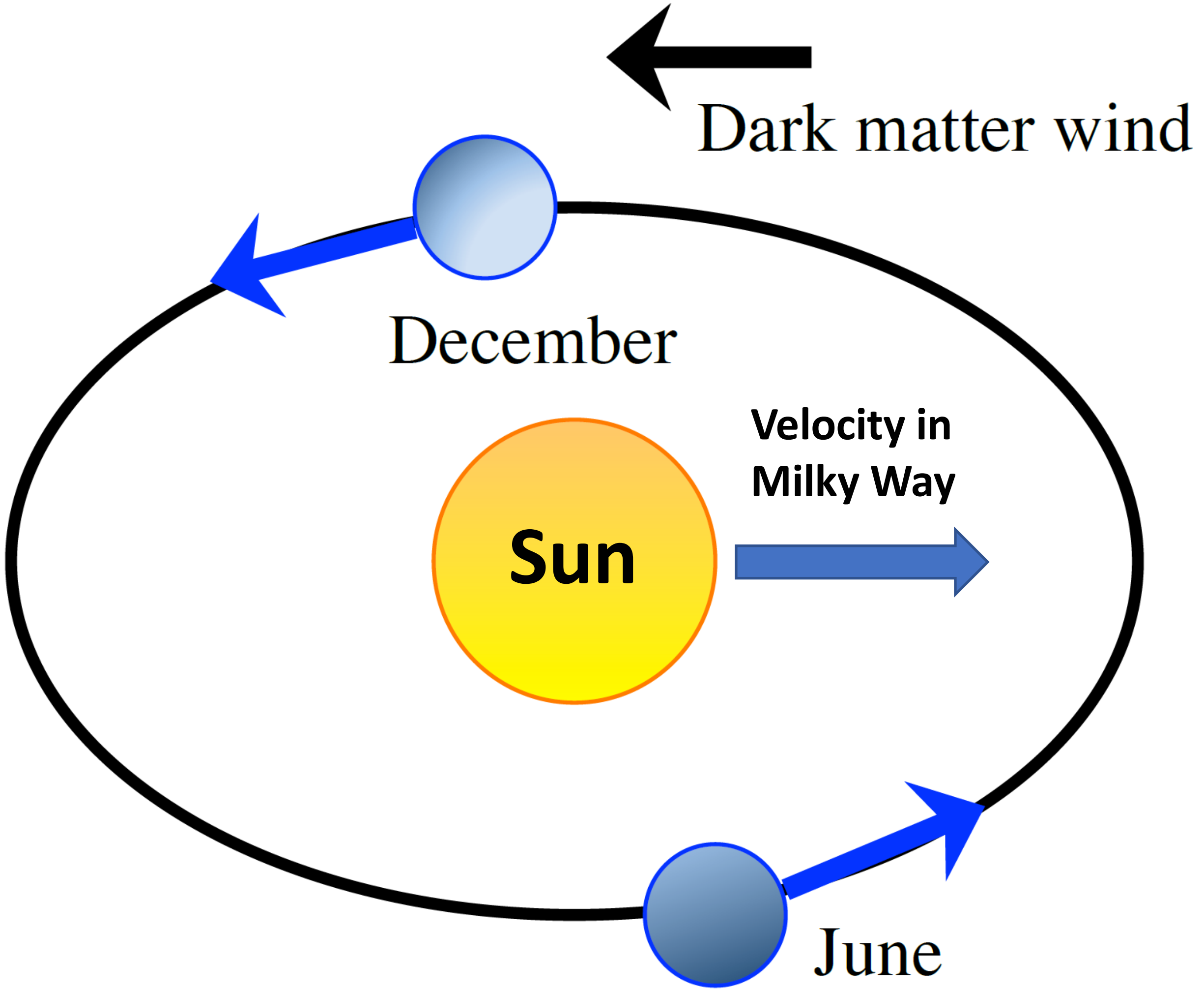
Cryogenic Liquids
- XENON
- Dark Side

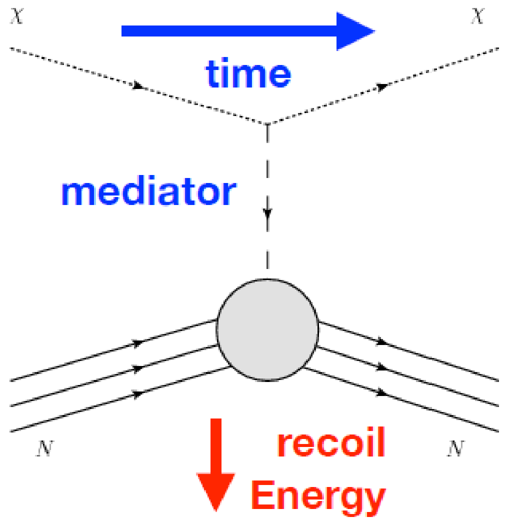
Bolometers
- CRESST

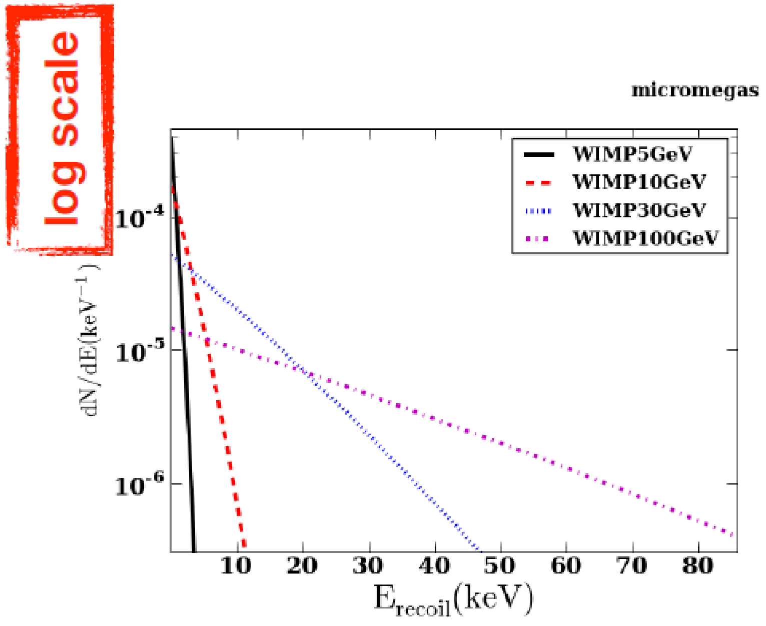
Ultrapure Scintillator
- DAMA/LIBRA
- SABRE

INFN

Dark Matter Searches

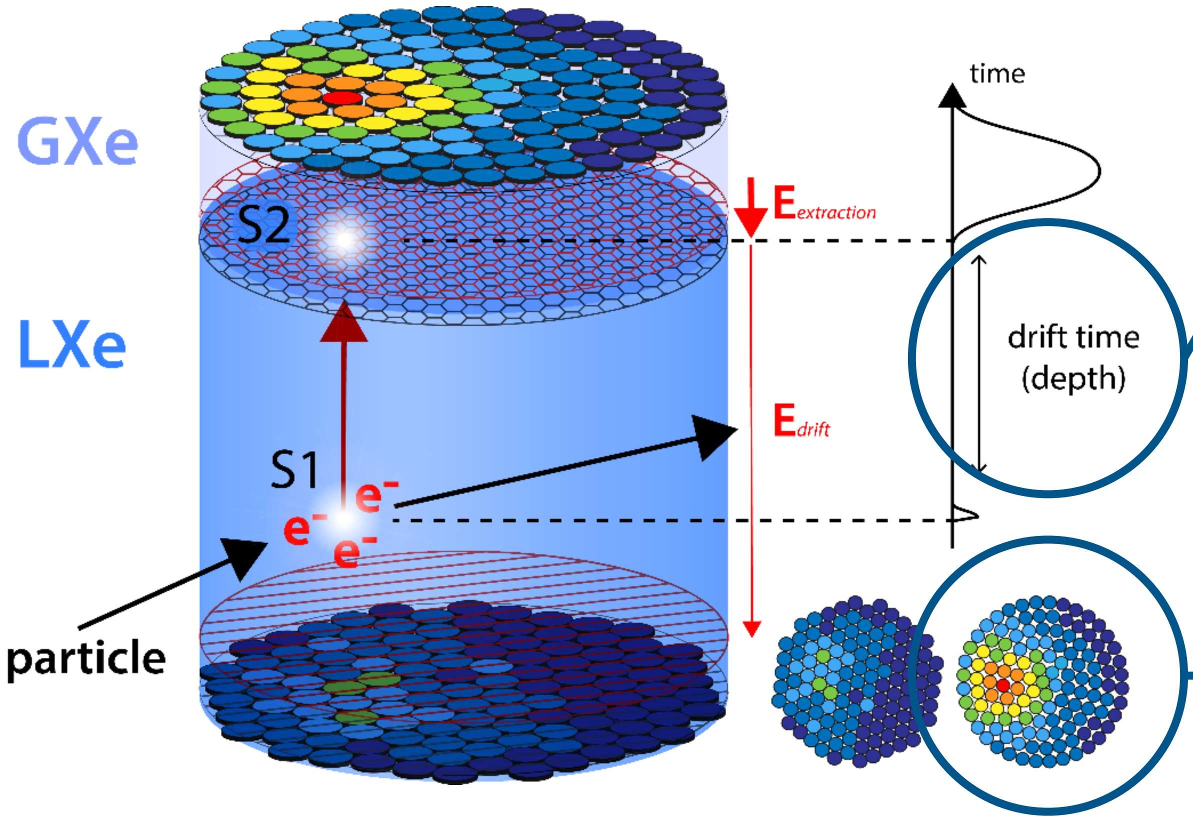






WIMP - ^{78}Ge nucleon scattering

Dual Phase TPC



Thanks C. Weinheimer

Drift time:

$$\Delta t = t_{S2} - t_{S1}$$

Drift velocity:

$$v \approx 2 \, {}^{mm}/_{\mu s} \approx 7200 \, {}^{km}/_{h}$$

Depth (z - position):

$$z = v \cdot \Delta t$$

+

Concentric PMT array on top
→ S2 signal local
→ **x - and y - position**

=

→ **3D position reconstruction**
→ **Self - shielding**
→ **Inner + radio-pure volume**

Dual Phase TPC

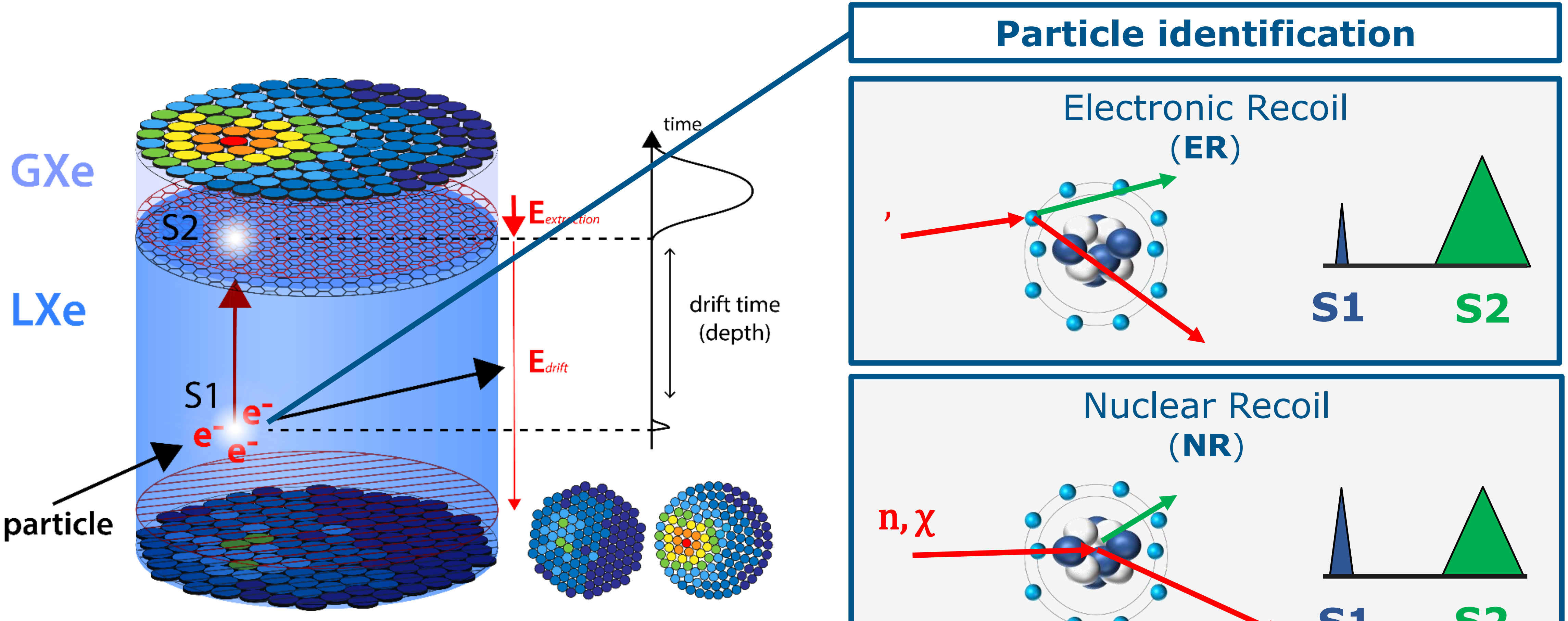


Figure in courtesy: L. Althüser

Thanks C. Weinheimer

Xenon TPC

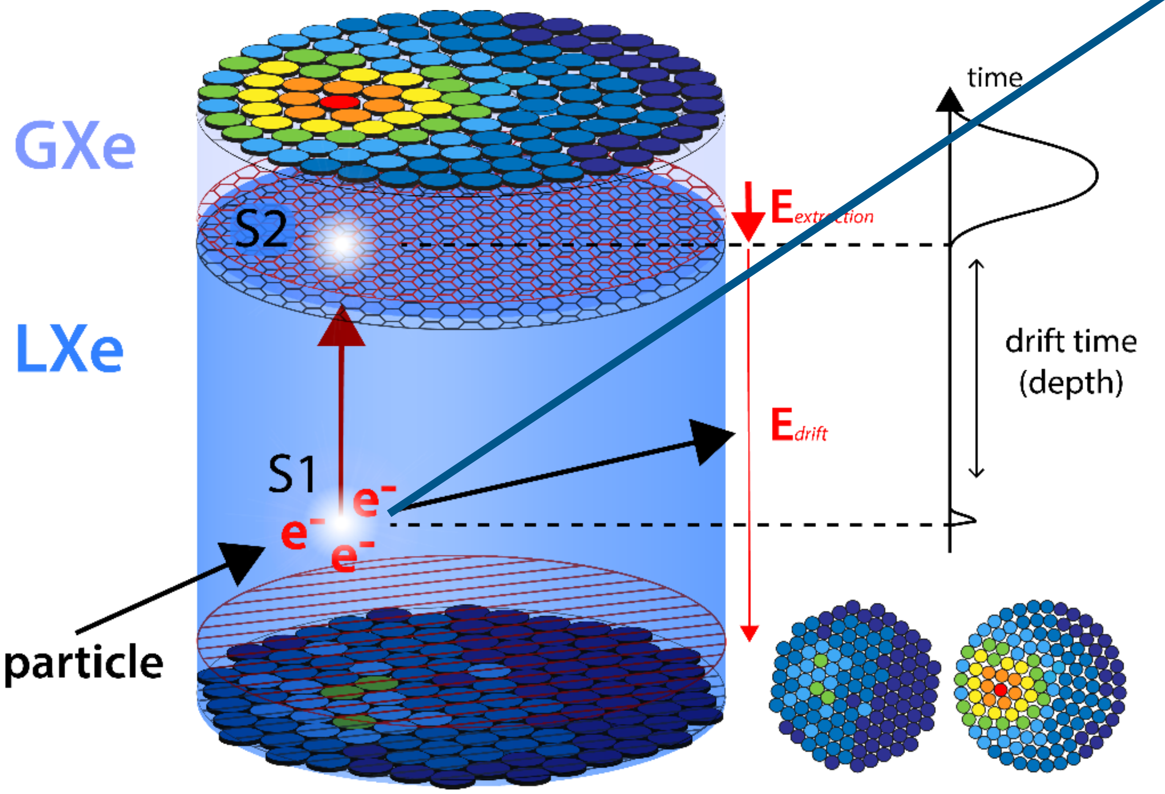
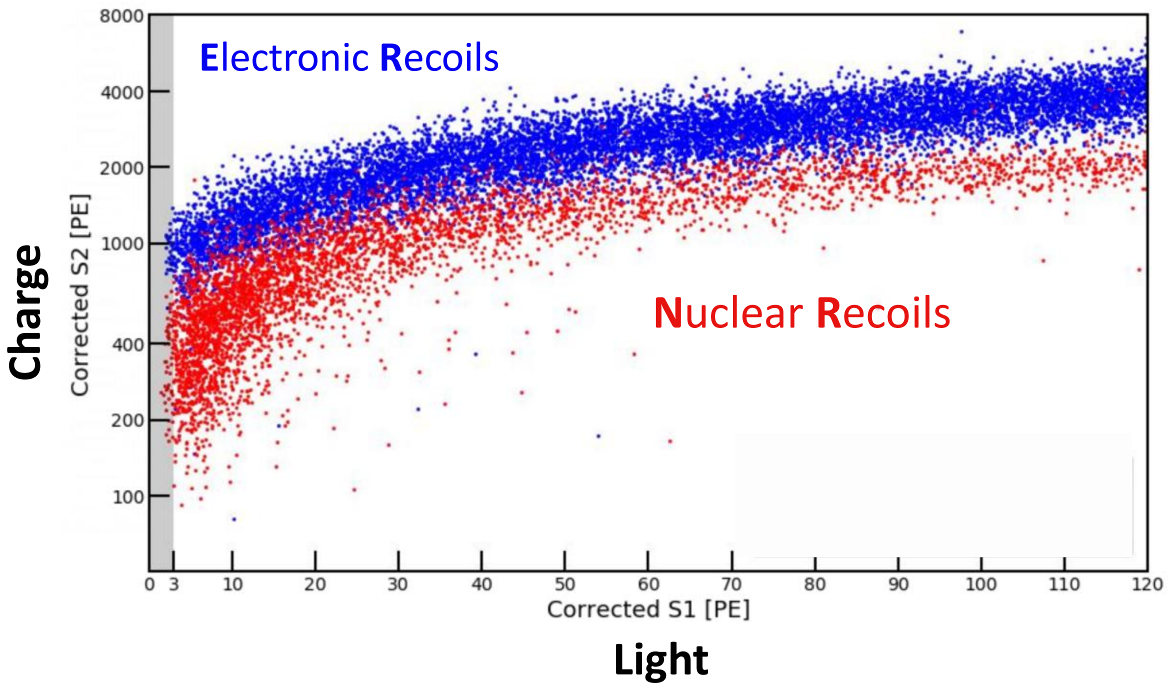


Figure in courtesy: L. Althüser

Particle identification



Reduction of ER-induced background up to 99.75% at 50% NR acceptance

Thanks C. Weinheimer

INFN

Xenon @ LNGS

Dark Matter Searches

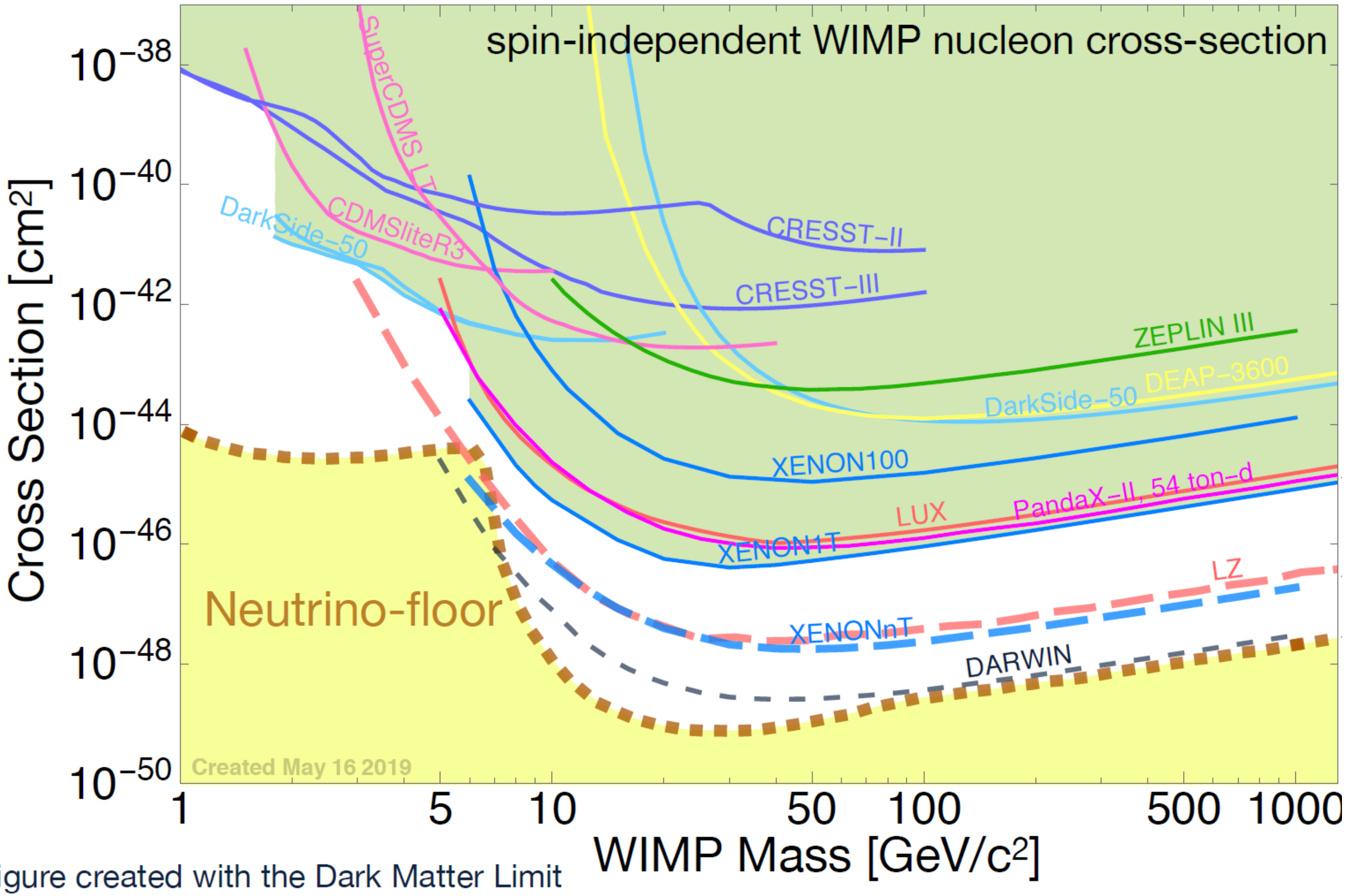


Figure created with the Dark Matter Limit Plotter by T. Saab and E. Figueroa

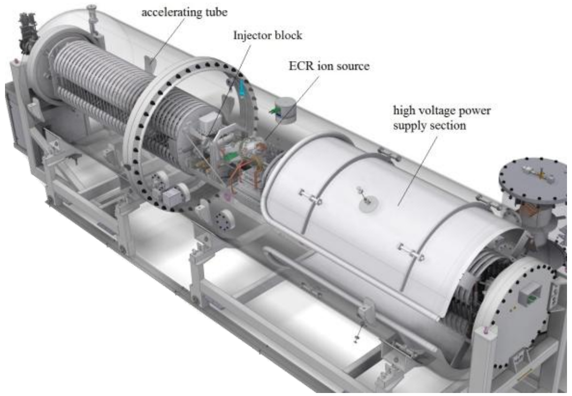
Possible future experiments @ LNGS

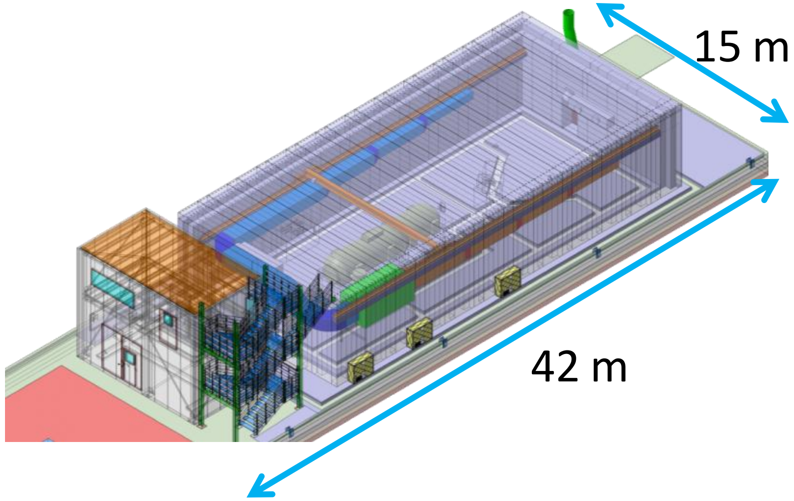
Nuclear Astrophysics - LUNA-MV @ LNGS

Maximum beam intensity on target at different terminal voltage

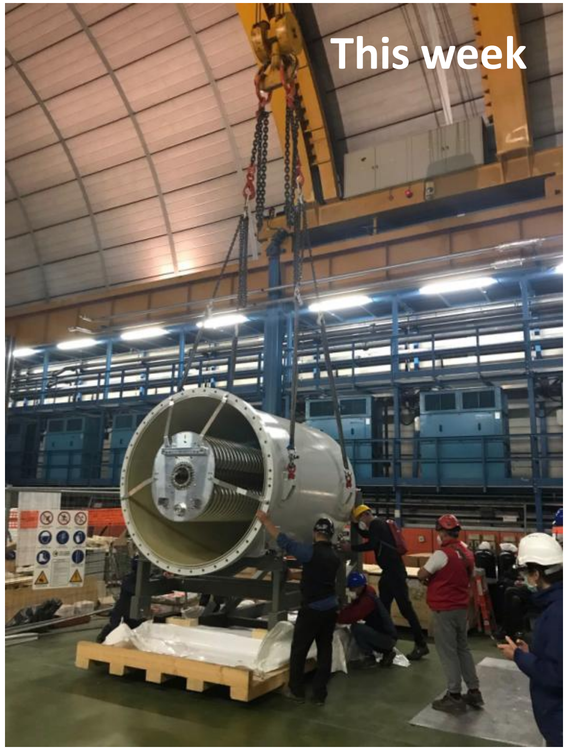
Ion specie	Terminal Voltage 0.3 MV – 0.5 MV	Terminal Voltage 0.5 MV - 3.5 MV
$^{1}H^{+}$	500 μA	1000 μA
$^{4}He^{+}$	300 μA	500 μA
$^{12}C^{+}$	100 μA	150 μA
$^{12}C^{+2}$	60 μA	100 μA
Number of Beam Lines		2
Beam time / year		7400h (308d)
Max. admitted neutron flux at target		2000 n/s
Neutron level outside shielding		Below natural underground neutron flux at LNGS

Literature reference:
Sen, A., NIM B https://doi.org/10.1016/j.nimb.2018.09.016



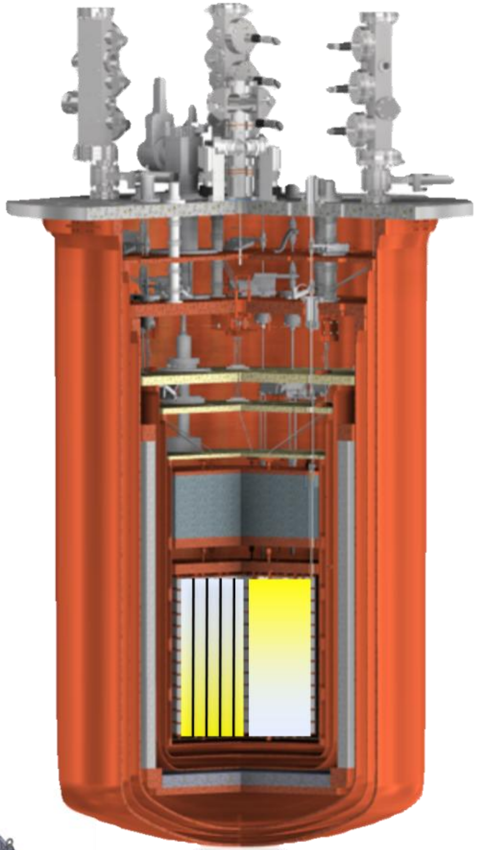


LUNA-MV mainly funded with a national grants

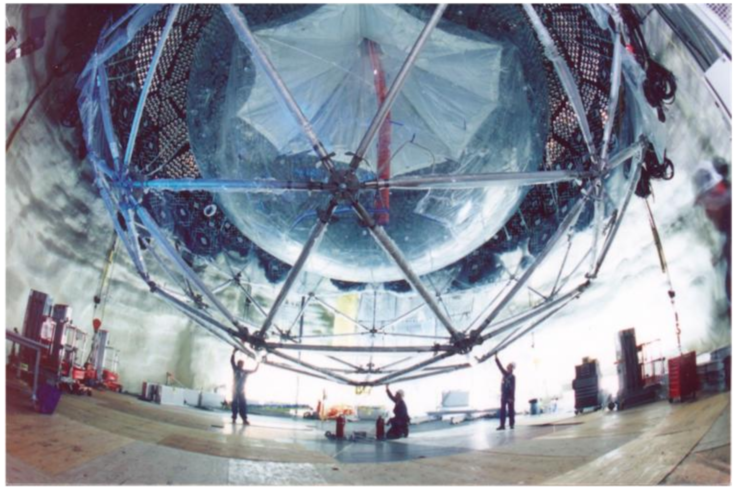


Double Beta Decay : Next Generation Experiments

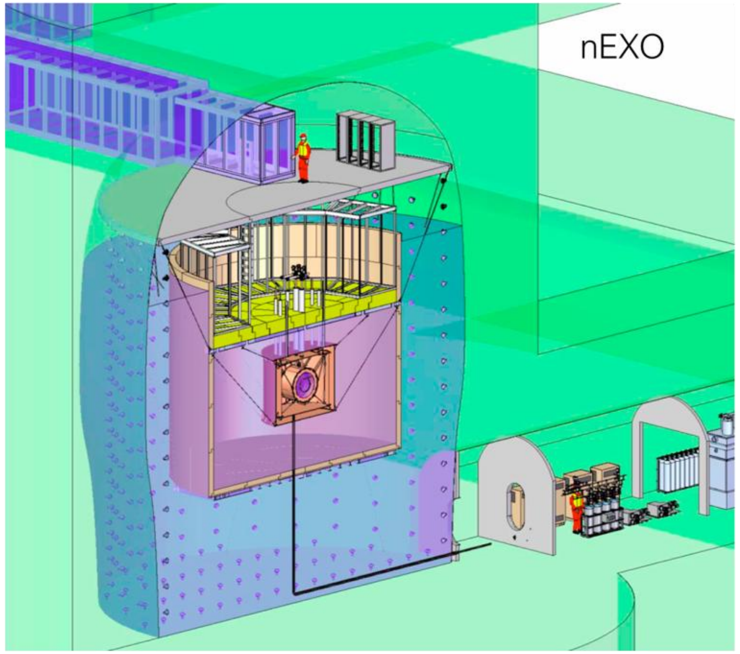
CUPID



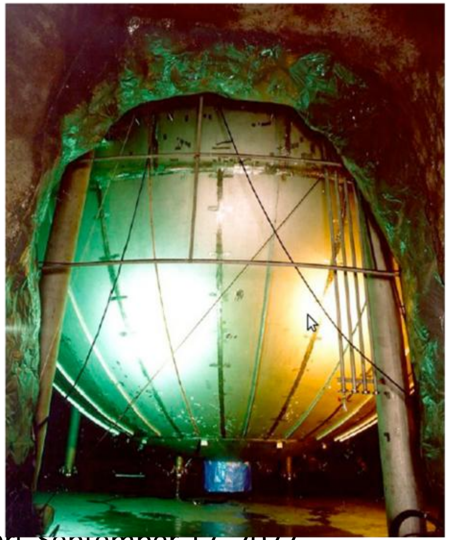
SNO+



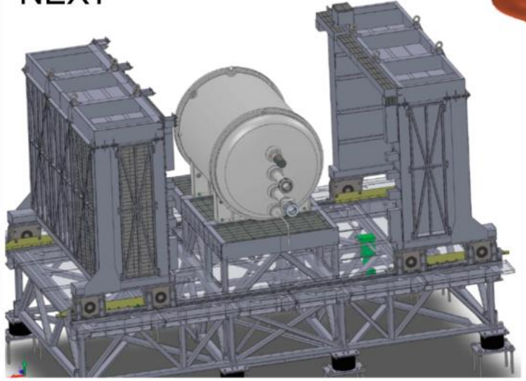
nEXO



KamLAND-ZEN



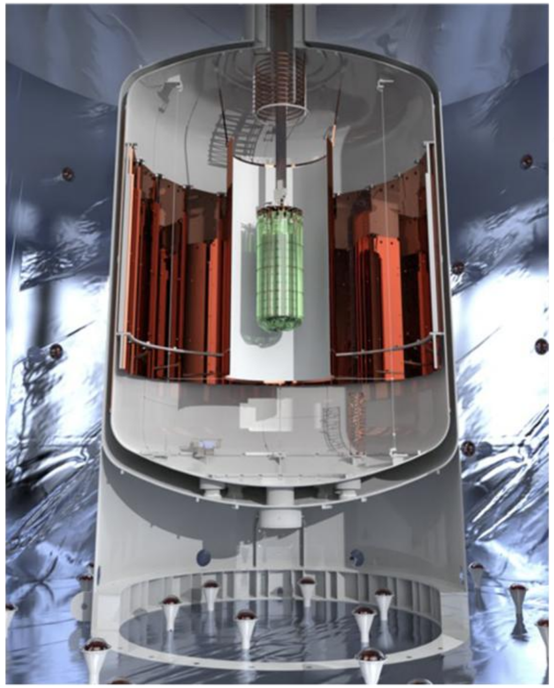
NEXT

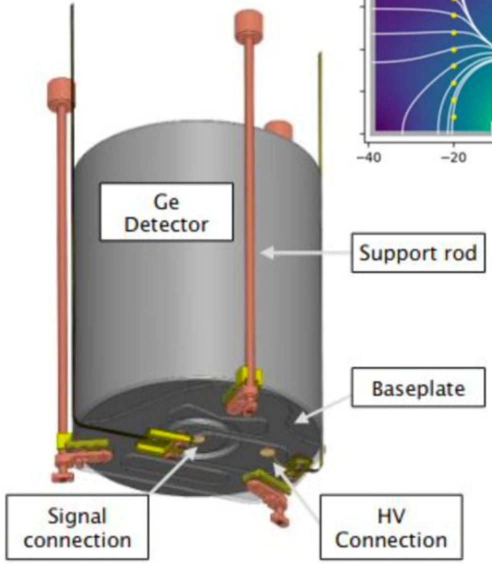


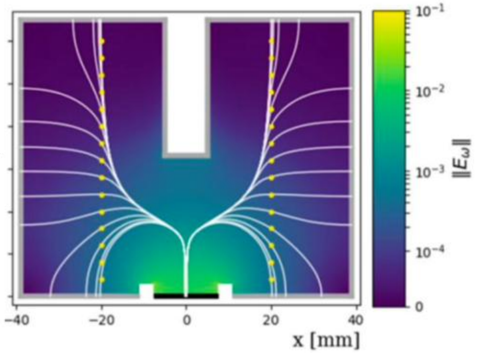
LEGEND

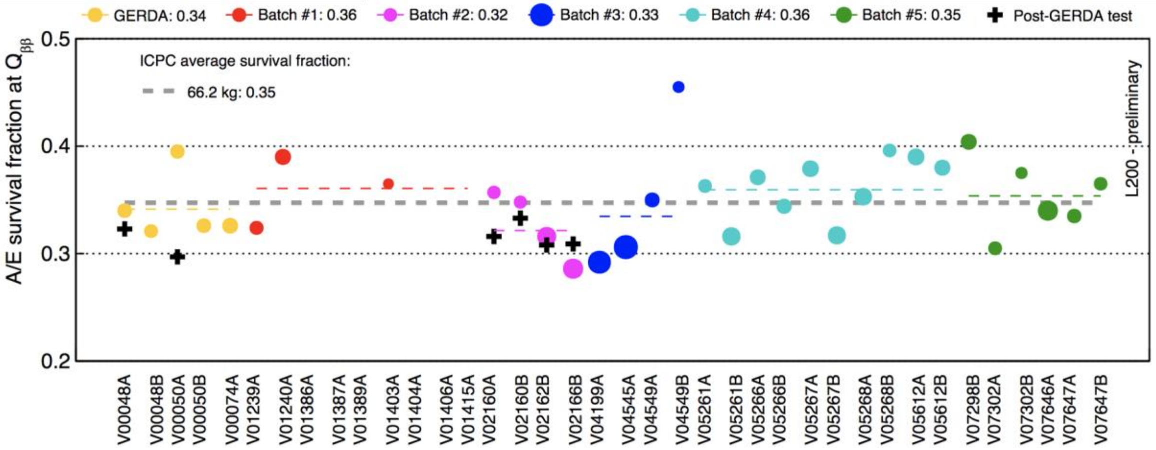
LEGEND-200

- Natural evolution of the GERDA principle
- Combines the best of Gerda and MJD
  - ▸ from GERDA:
    - detector configuration
    - infrastructure@ LNGS
    - system improvements
  - ▸ from MJD
    - selection of radio-pure materials
    - electronics
    - low threshold1
- ^{76}Ge:
  - ▸ 35 kg from GERDA
  - ▸ 30 kg from MJD
  - ▸ 140 kg new materials
- New type of detector, already tested in GERDA
  - ▸ ICPC m > 2 kg (0.7-0.9 kg previously)
  - ▸ same energy resolution and PSD capability









Double Beta Decay Experiments

Meeting between North American and European funding agencies

- Selection of future DBD experiments
  - Experimental sensitivities
  - Budget requested for each experiment
  - International collaborations
- Selection of possible undegroud laboratories
  - SNOLab/SURF – North America
  - LNGS - Europe

	$T_{1/2}$ (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 (CUPID)

← Prosecutor of GERDA (LEGEND-1k)

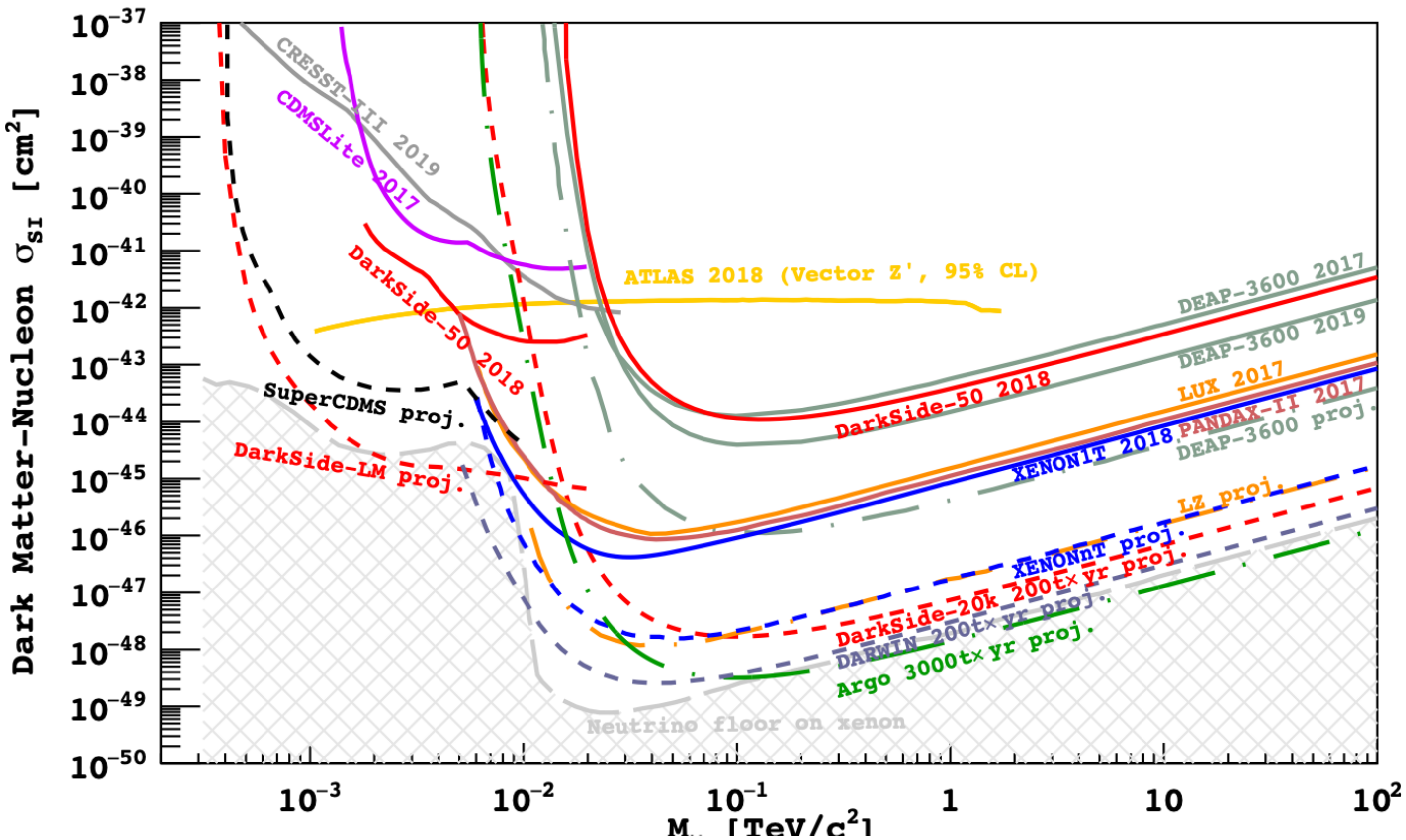
Dark Matter search experiments

A rich experimental program is actually in preparation:

- XENONnT
- Dark Side 20k
- COSINUS
- SABRE
- LIME/CYGNO
- ……

Specific LNGS facilities are under preparation

- NOA Clean Room for detector assembly
- New cryogenic plant for large LN production
- Screening facility for material selection
- ……

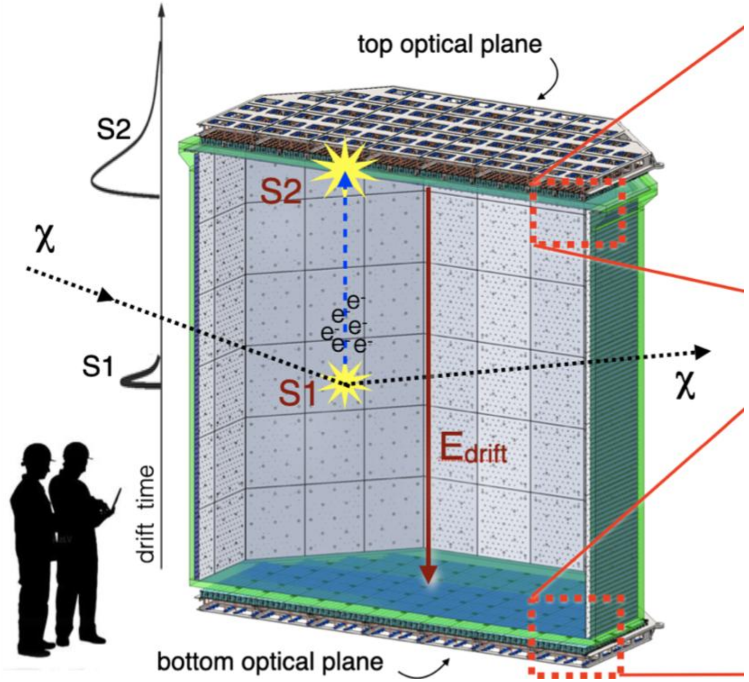


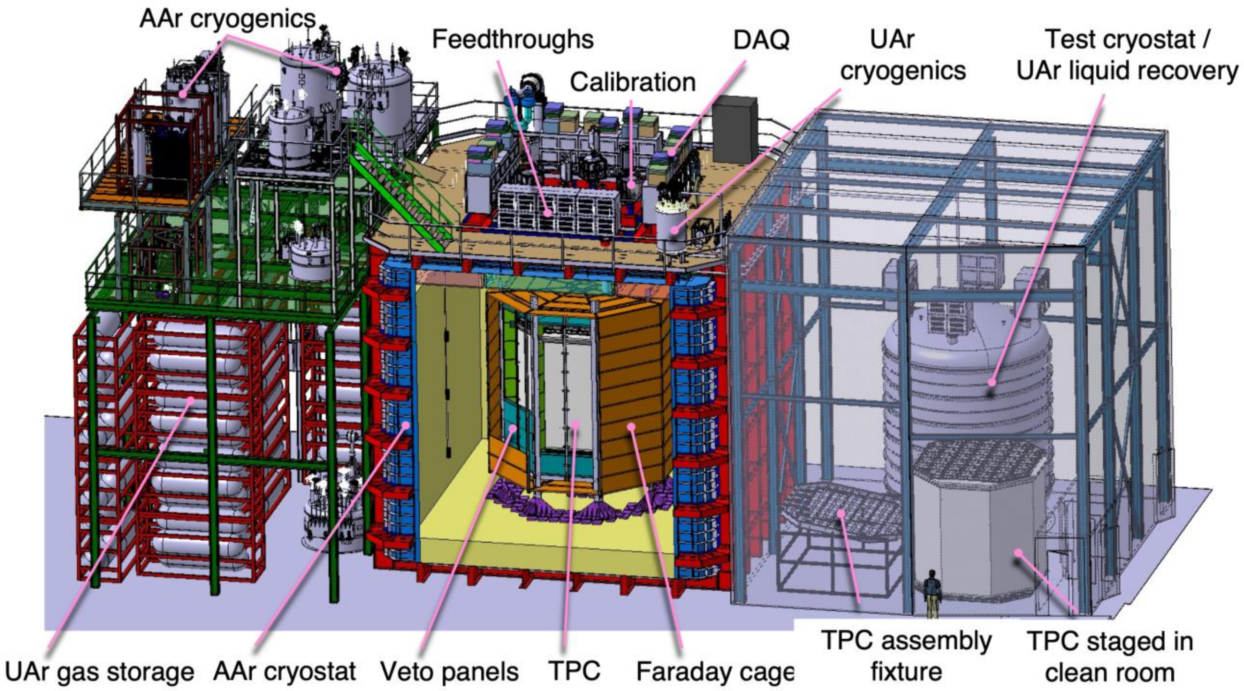
Medium/Long term activities on Dark Matter experiments are ongoing

Some LoIs for future experiments (Darwin, …) were received by LNGS

A 5/10 years plan on Dark Matter experiments is practically well established

Dark Matter search – Darkside 20k

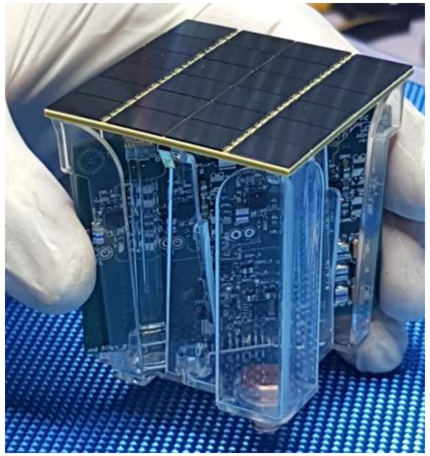




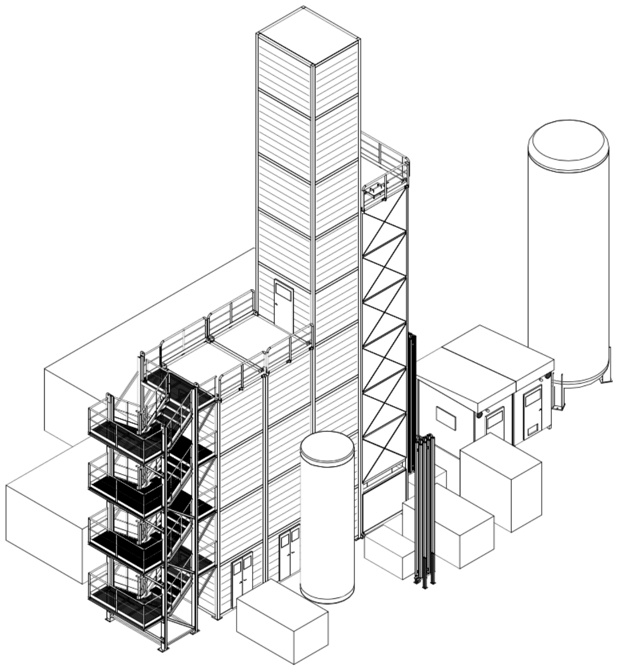
A 20-tonnes fiducial argon detector filled with underground argon

TPC acrylic vessel surrounded by AAr + Gd-loaded acrylic shell as a neutron veto

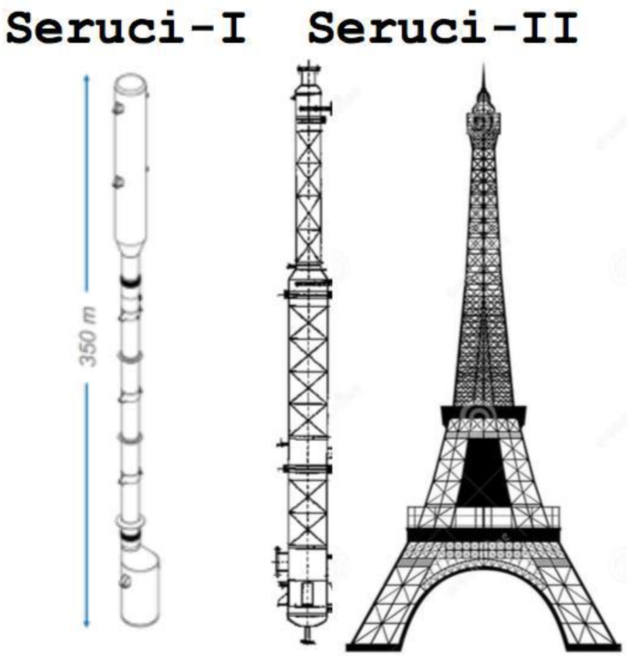
21 m2 of Cryogenic Silicon based Photo-Multipliers



URANIA



- Procurement of 50 tonnes of UAr from same Colorado source as for DS-50
- Extraction of 250 kg/day, with 99.9% purity
- UAr transported to Sardinia for final chemical purification at Aria



ARIA

- Big cryogenic distillation column in Seruci, Sardinia
- Final chemical purification of the UAr
- Can process O(1 tonne/day) with 10^3 reduction of all chemical impurities
- Ultimate goal is to isotopically separate ^{39}Ar from ^{40}Ar (at the rate of 10 kg/day in Seruci-I)

Cutting Edge Technologies

Advanced Additive Manufacturing
Copper 3D printing

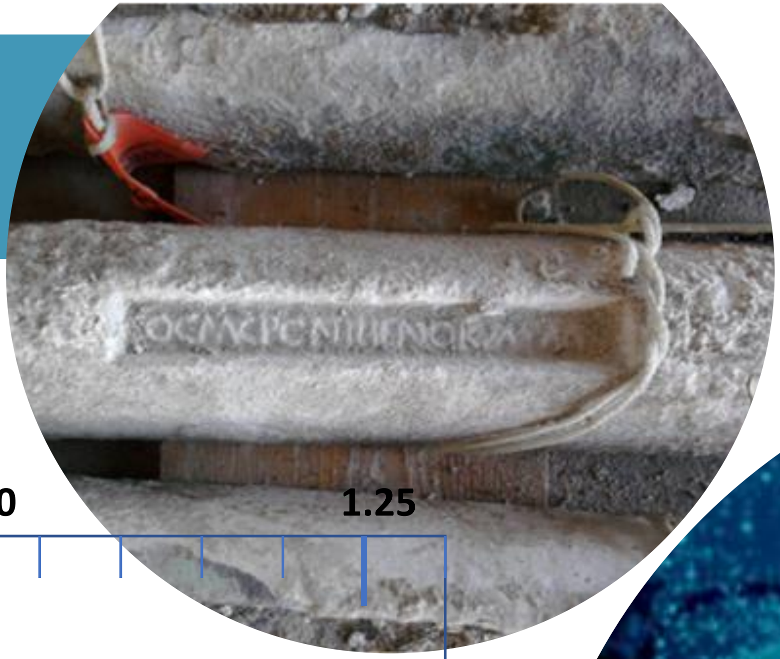
Ultra-Trace elemental and isotopical analysis
Cultural Heritage
Environmetal Studies
High Purity Material
.....

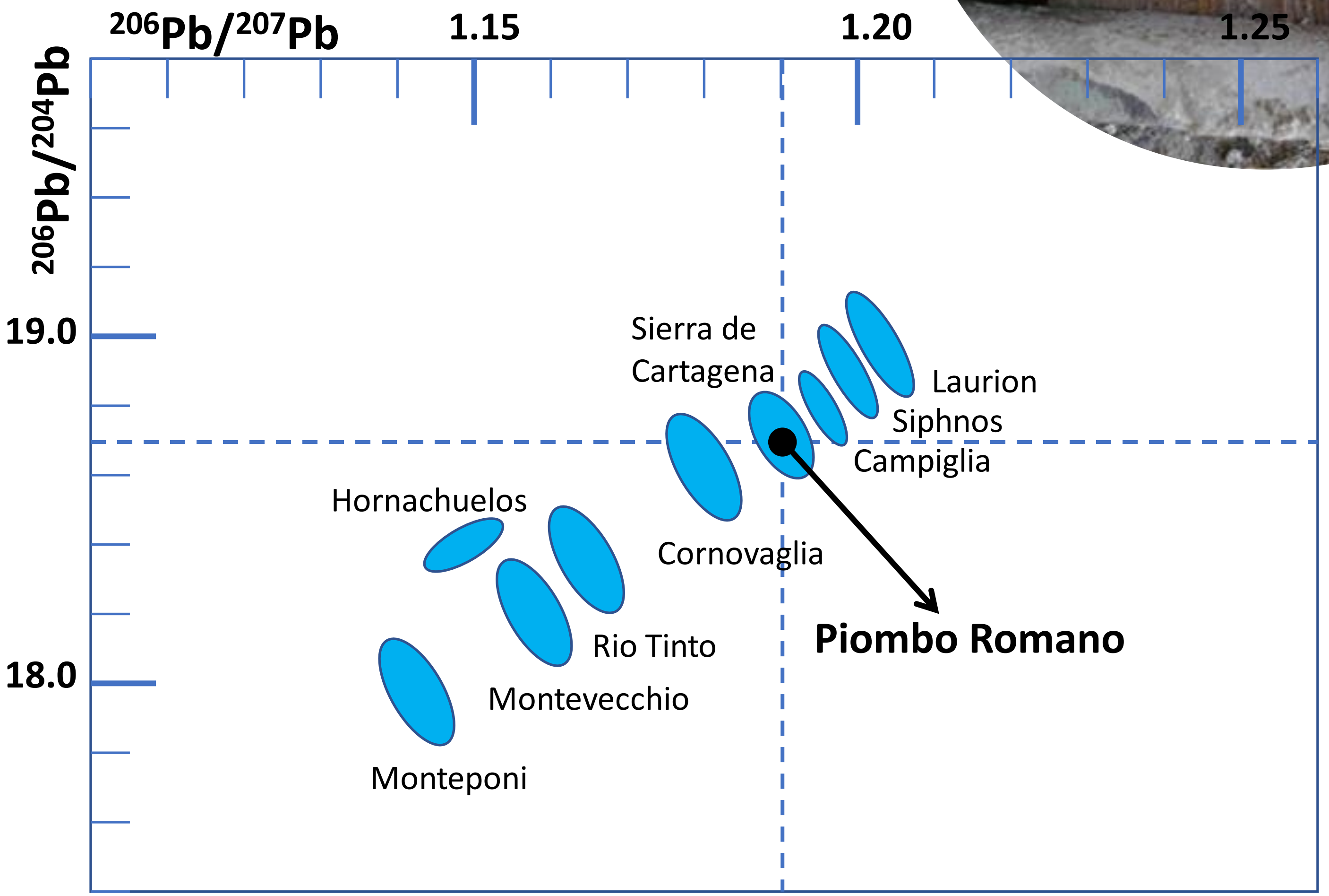
Quantum Technology
Quantum Computing
Quantum Communication

Multidisciplinarity

Archeological Study

Ancient Roman Lead recovered from a Ship sunked in Sardegna **(I century b. C.)**

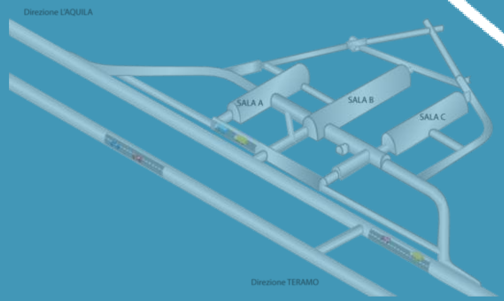




Conclusions

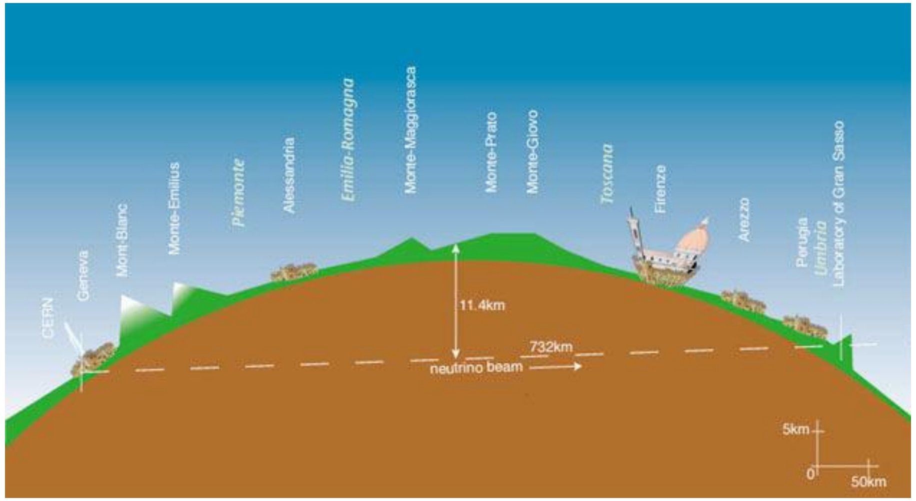
- @LNGS a large number of experiments are actually taking data or are under construction
- LNGS international community involve many country around the world and large number of researchers
- LNGS play a leading role in many different field of researches (DBD, DM, NA …)
- Future scientific programs are under discussion at international level:

Thank you



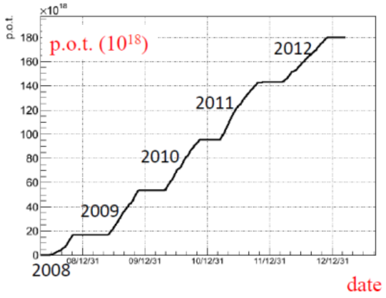
Prof. Enrico “Puccio” Bellotti
1940 - 2021
1st director of LNGS
President of Astroparticle Physics committee of INFN
Great scientist and great expert in DBD

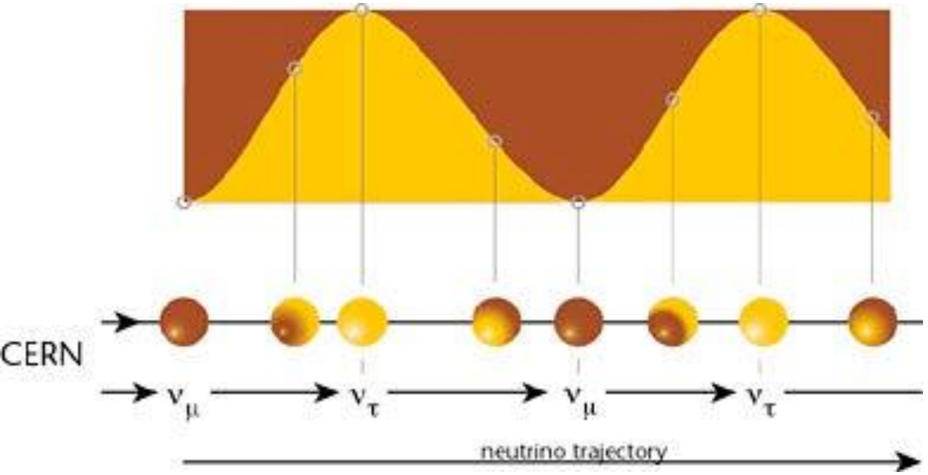
Neutrino Oscillation



The CNGS beam along its five years of operation 2008 ÷ 2012

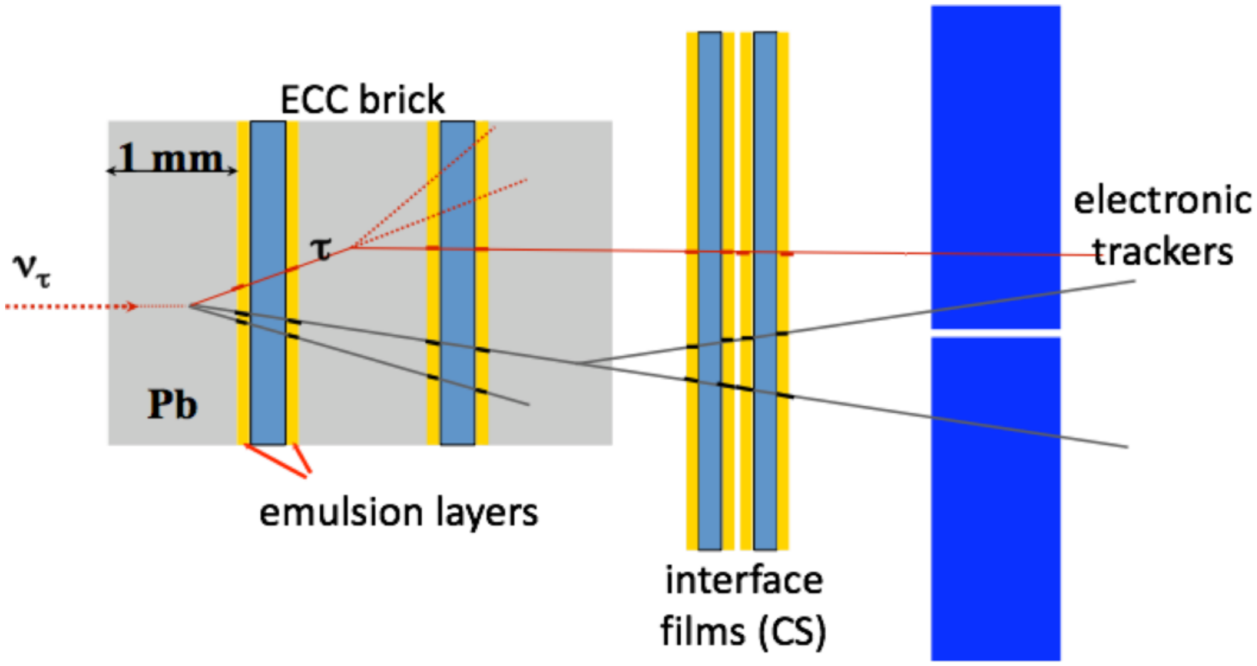
Year	Beam days	P.O.T. (10^{19})
2008	123	1.74
2009	155	3.53
2010	187	4.09
2011	243	4.75
2012	257	3.86
Total	**965**	**17.97**





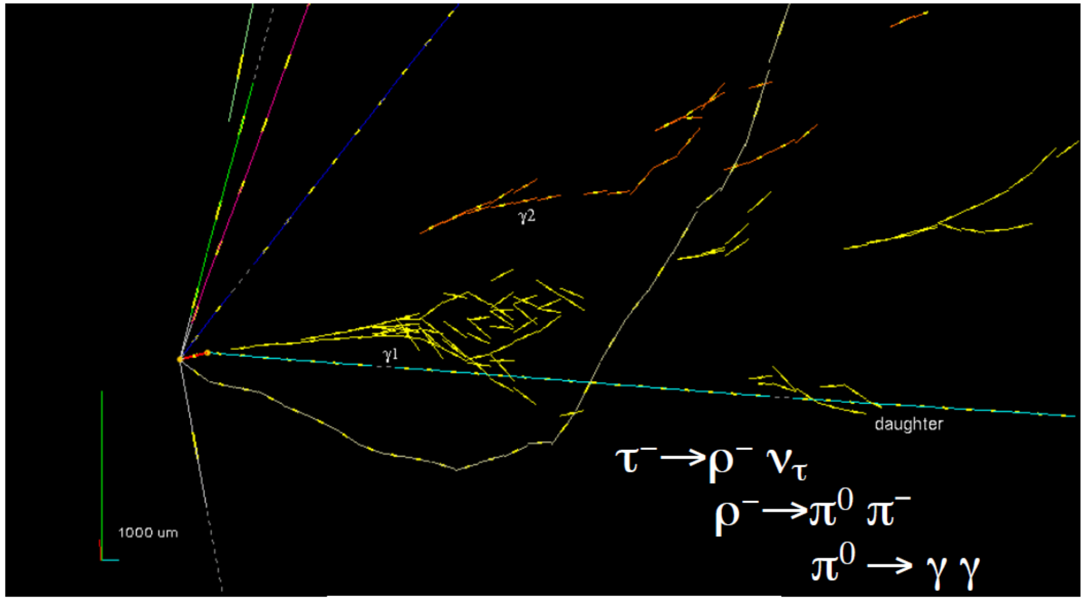
Neutrino Oscillation

$\nu_\mu \rightarrow \nu_\tau + N \rightarrow \tau^- + X$

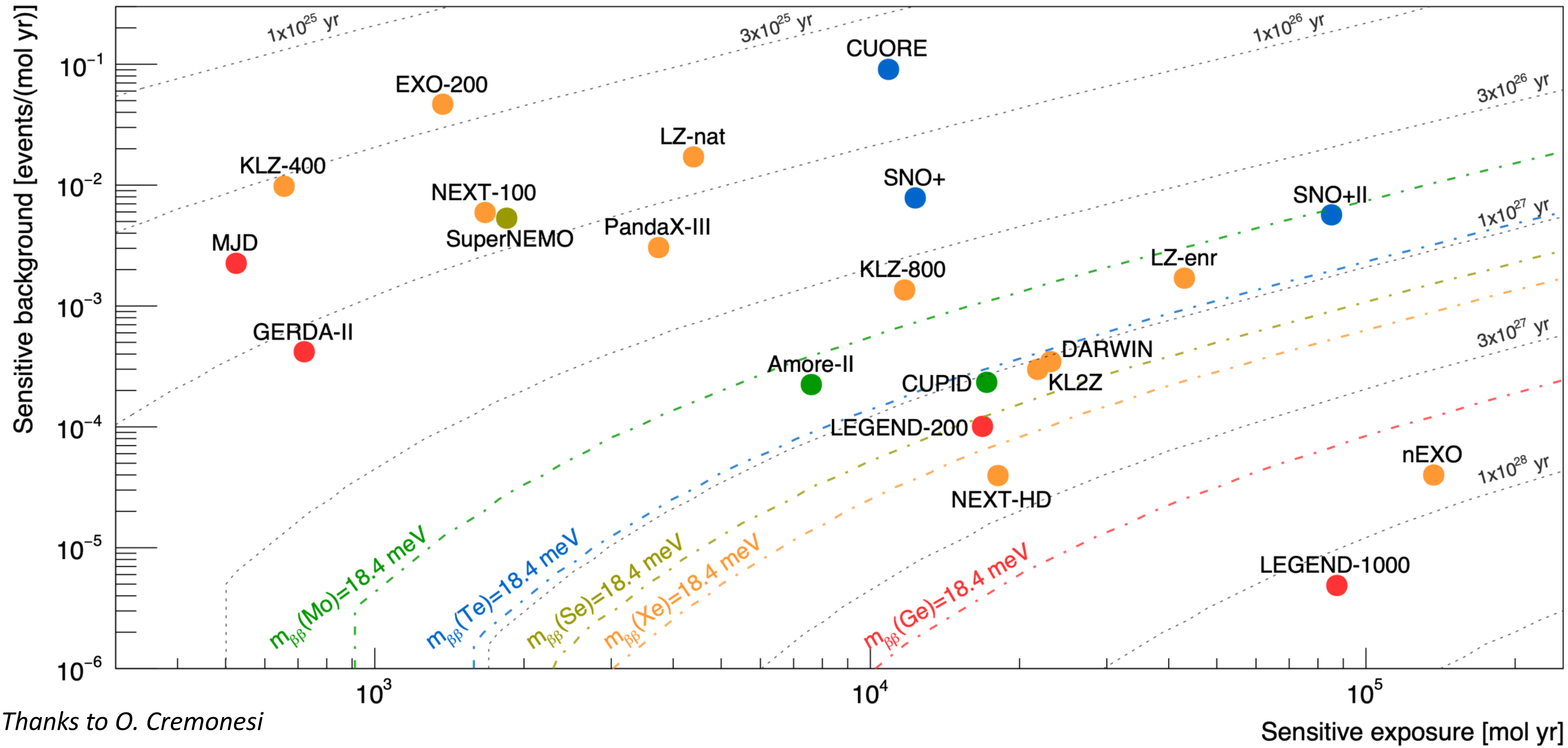


THE FIRST ν_τ CANDIDATE

in the brick



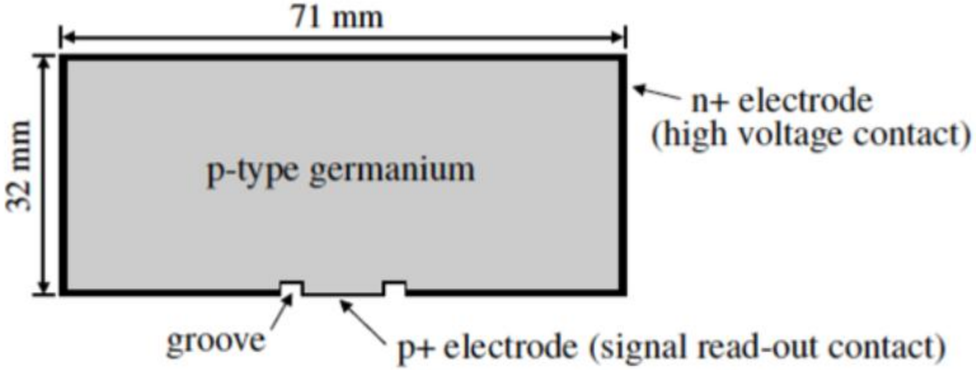
Sensitivities: a different view

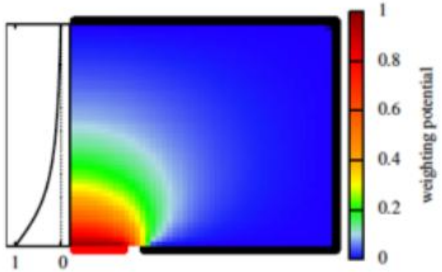


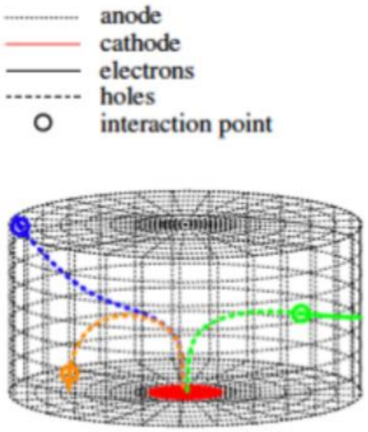
Thanks to O. Cremonesi

Gerda/Legend

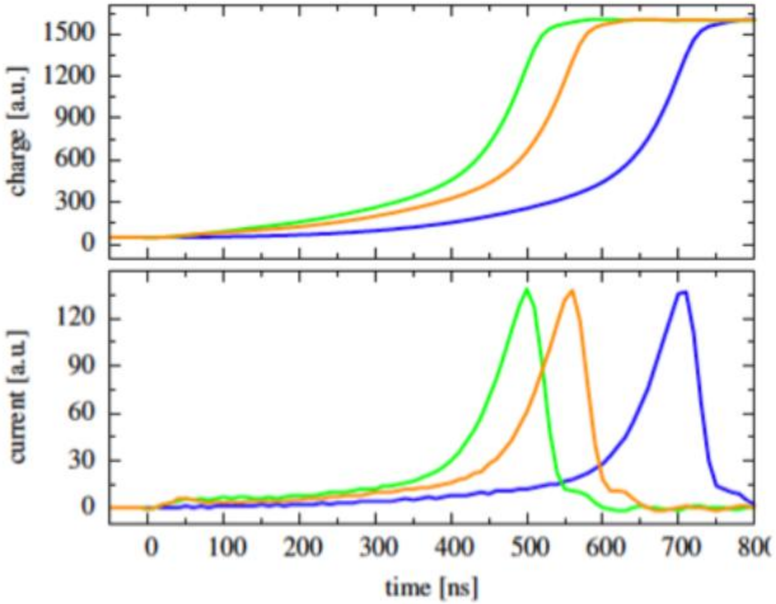
Novel HPGe detectors allow for efficient PID







(a) Trajectories

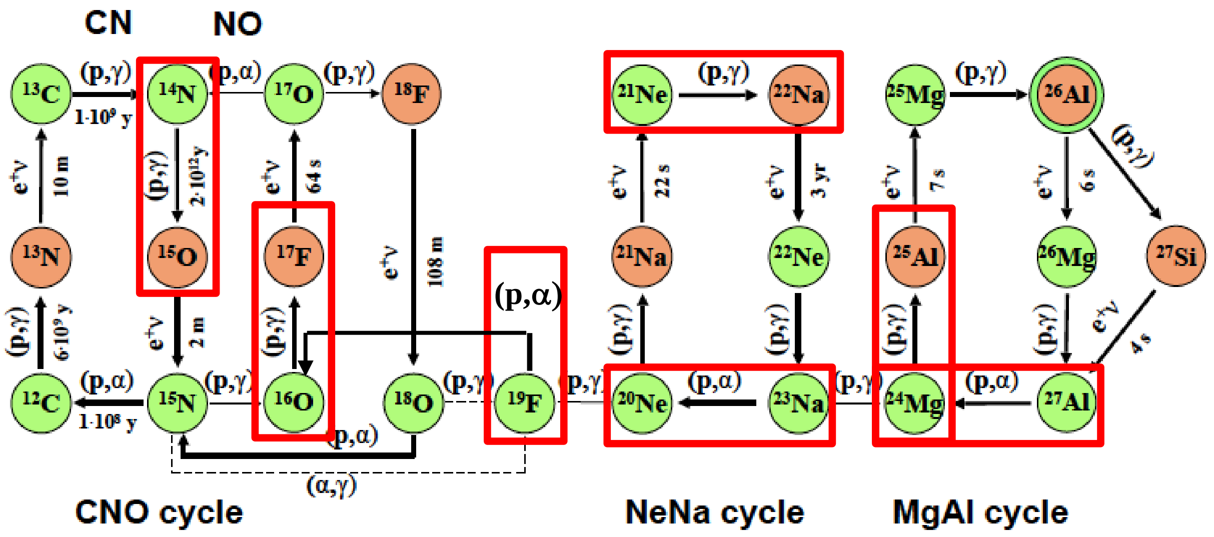


(b) Charge and current pulses

Thanks Prof. S. Shoenert

LUNA400: what can still be done

- $^{14}N(p,\gamma)^{15}O$ to decrease the uncertainty at solar temperature;
- $^{16}O(p,\gamma)^{17}F$ to determine the $^{16}O/^{17}O$ abundance ratio in red giant stars;
- $^{19}F(p,\alpha)^{16}O$ to constrain AGB star nucleosynthesis and to investigate spectroscopy of self-conjugate ^{20}Ne nucleus;
- $^{21}Ne(p,\gamma)^{22}Na$ to determine the production of ^{22}Na in Novae and Supernovae
- $^{23}Na(p,\alpha)^{20}Ne$ to understand the ^{23}Na production during H-burning both in stellar cores and shells;
- $^{24}Mg(p,\gamma)^{25}Al$ which is crucial to understand MgAl anticorrelation;
- $^{27}Al(p,\alpha)^{24}Mg$ which significantly affects the Mg and Al production;
- ……



LUNA400 2022-2024 new program

- $^{16}O(p,\gamma)^{17}F$ will be done using the solid target beam line setup together with the γ detectors available, only minimal modifications are foreseen;
- $^{21}Ne(p,\gamma)^{22}Na$ will be done using the gas target beam line setup together with the γ detectors available, only gas enriched in ^{21}Ne is needed;
- $^{23}Na(p,\alpha)^{20}Ne$ & $^{27}Al(p,\alpha)^{24}Mg$ Edinburgh group will develop the α particle detection setup.