

The Modane Underground Laboratory

*LSM Strategic Plan and its
Implementation*

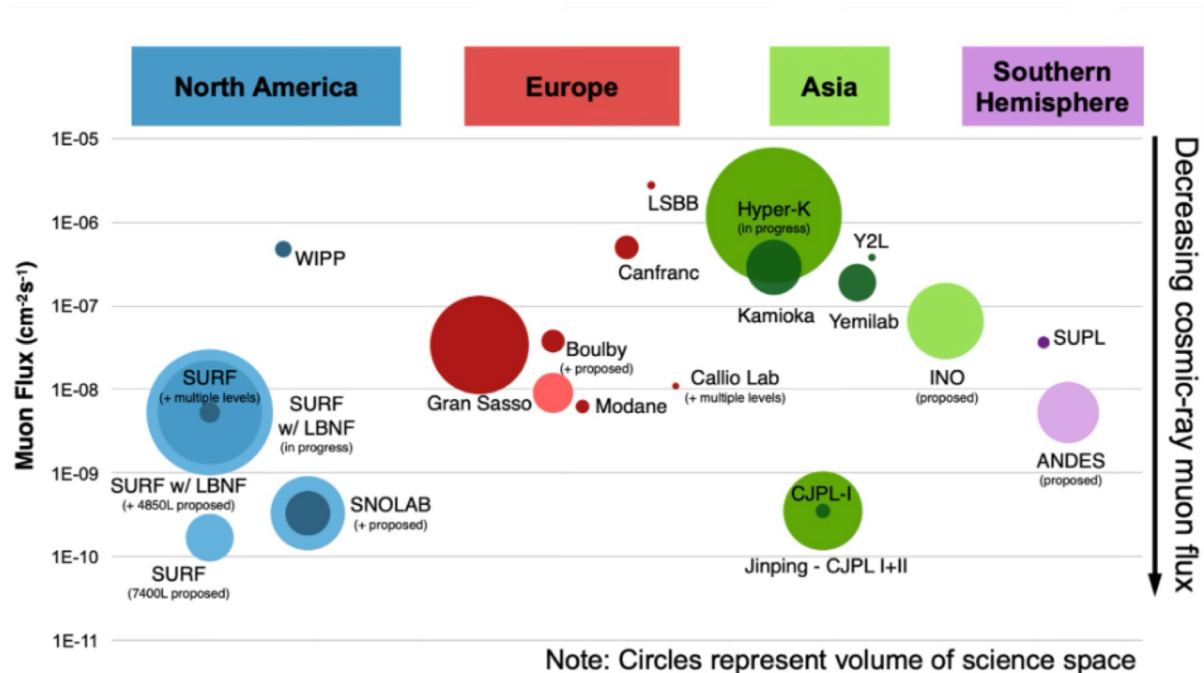
Current Activities

Silvia Scorza (LPSC)



Worldwide Underground Laboratory

Underground facilities provide unique environments for astroparticle and multidisciplinary research with the main feature to be the overburden protection from cosmic-ray muons



The LSM Underground Laboratory



The **LSM** is a **French National Research Infrastructure**

- Experimental site midway in the 13km France/Italy highway road tunnel
- Surface lab (*office, garage, small museum*)

- **Deepest site** in Europe dedicated to astroparticle, nuclear & particle physics
- 4800 m.w.e: **muon flux reduced** by $>10^6$ relative to surface
- **Flexible access** (hall accessible to trucks up to 9m);
- Natural radioactivity due to radon of about $10\text{-}15 \text{ Bq/m}^3$



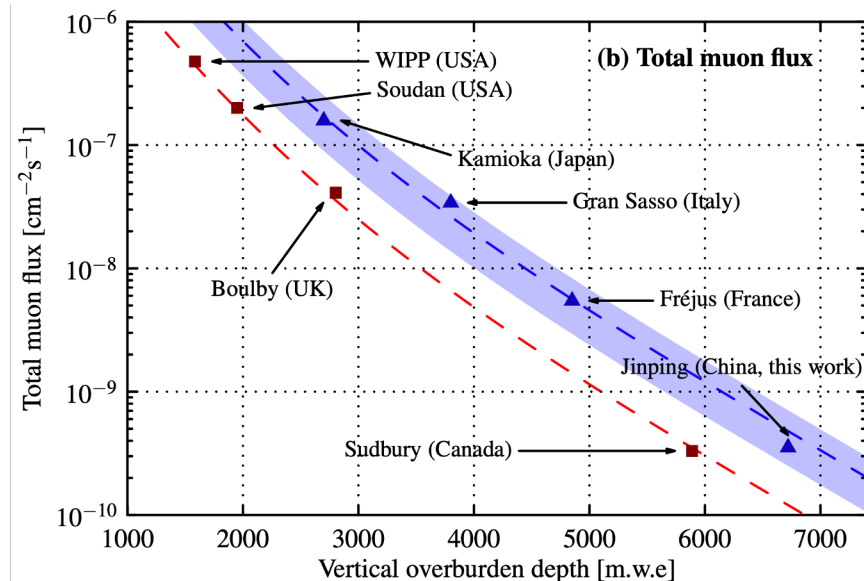
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LSM Scientific Policy

Until 2018: Independent laboratory of IN2P3 and CEA

Since 2019: “*National Platform of IN2P3*”

IN2P3 National Platforms Management Plan:

- The **LSM is administratively attached to the LPSC**. Its activities, budget, and resources are reviewed annually by a management committee (IN2P3, University, and LPSC).
- LSM operations **are funded by IN2P3** and through **own resources** via a new pricing system (towards its final implementation)
- **Experiment and research funding** provided by French and international partners
- IN2P3 has mandated an **International Strategic Committee** to provide annual recommendations on the LSM's scientific program and overall strategy.
- The Scientific Director is appointed directly by IN2P3 (in consultation with LPSC) to ensure that the **LSM's scientific program aligns with IN2P3's national and international objectives**.

The LSM Organization

Laboratoire de Physique Subatomique et de Cosmologie

Directeur de l'Unité : Laurent Derome

Adjoints à la direction : Fabienne Ledroit-Gillon ; RA : Alain Retailleau ; RT: Christophe Vescovi

Laboratoire Souterrain de Modane

Direction

Directrice de la Plateforme (DP)

Silvia Scorza

Directrice Opérationnelle (DO)

Nadine Sauzet

Chargés de Mission

Communication (CMC)

Guillaume Warot

Ali Dastgheibi-Fard

Service Ultra Basse Radioactivité

Responsable de Service

Guillaume Warot

Membres

Ali Dastgheibi-Fard (PCR)

Jean-Louis Margueron

Eric Pailla

Christian Ranieri

Aurélian Rojas-Harillo

Thierry Zampieri

Comités

Comité Stratégique Externe

Aldo Ianni

Marie Davidkova

Sean Paling

Stefan Schönert

Nigel Smith

- LNGS

- NPI CAS

- Boulby

- TUM

- TRIUMF

CoDir

DAS Astroparticules, DAS Nucléaire, DAS Interdisciplinaire, DAT

Représentant Pôle PAGE

DU, DP, DO

- IN2P3

- UGA

- LPSC/LSM

Service Techniques

Service Administratif et Financier

Valérie Favre

Service Informatique

LSM Science Programme

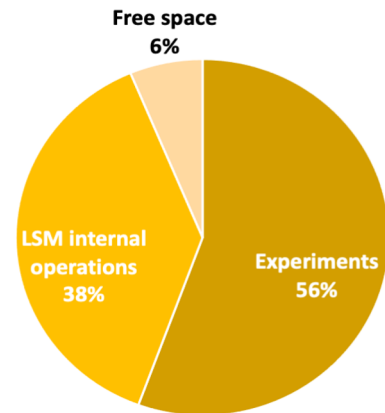
Experiment	Focus	Technology	Description
SuperNEMO	$0\nu\beta\beta$	Tracking-calorimeter	$0\nu\beta\beta$ demonstrator tracking-calorimetry technique, aiming at improving the sensitivity on the $0\nu\beta\beta$ ($T_{1/2} > 6 \times 10^{24}$ y with 6.3 kg of ^{82}Se). Its scientific scope includes detailed studies of the $2\nu\beta\beta$, single-state vs higher-state dominance discrimination, and the constraining of gA.
BINGO	$0\nu\beta\beta$	Cryogenic	$0\nu\beta\beta$ R&D focusing on developing innovative technologies to achieve a very low background index, of the order of 10^{-5} counts/(keV kg yr) in the region of interest.
Obelix ^{82}Se	ECEC 2ν	Ge ionisation	Counting of 6kg enriched ^{82}Se sample from LNGS started in January 2022: ECEC 2ν to excited states.
DAMIC-M	DM	Si CCD	DARK MATTER IN CCDs at Modane experiment employs thick, fully depleted silicon charged-coupled devices (CCDs) to search for dark matter particles with a target exposure of 1 kg-year.
MIMAC	DM	TPC	An original prototype detector based on the direct coupling of a large pixelated micromegas with a special developed fast self-triggered electronics showing the feasibility of a new generation of directional detectors.
RAMURE	Bio		Bio experiment on the long-term impact of natural radioactivity on living organisms, in particular those inhabiting aquatic ecosystems.
CELL STEM	Bio		Cryopreservation of stem cell in absence of radioactivity background.
AQURA	Quantum Clocks		Study on the impact of natural radioactivity on modern atomic quantum clocks.
PARTAGe	Low Background Counting	HPGe	LSM is developing a low background centre of excellence, which will incorporate the local expertise and capitalises on the low background HPGe detectors currently a LSM while adding additional hardware to this suite.

Science programme adapted to LSM size:

- Low-mass Dark Matter Experiments
- $0\nu\beta\beta$ demonstrators & technologies
- HPGe array for low-radioactivity

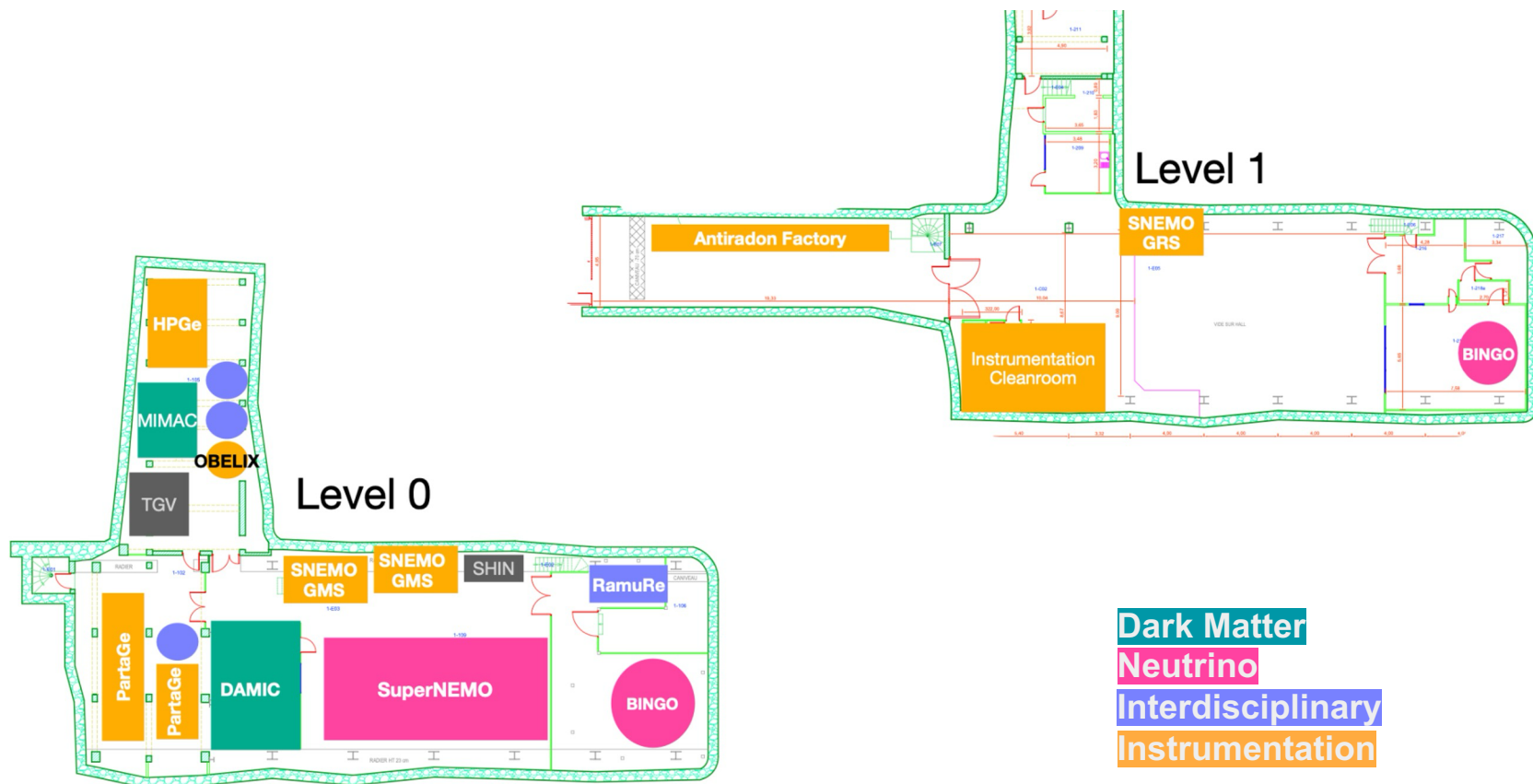
Tight occupation of the available 640m²

***Perspective:** design study to possibly install ~150m² mezzanine level (over the crane access) above experimental level (CPER project)*



Space repartition underground

LSM Layout 2025



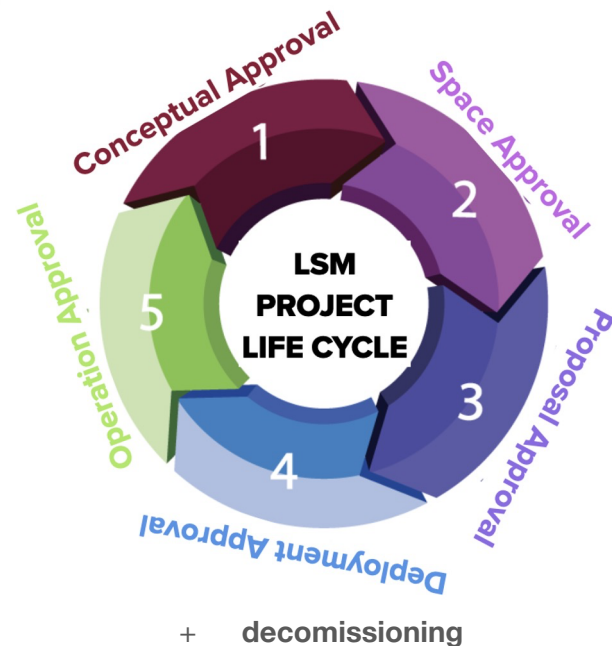
LSM Strategic Plan

- **Enhance the laboratory visibility** at the forefront of nuclear and astroparticle physics by delivering world-class science and boosting its scientific leadership (objective 1);
- Maintain a **strong focus on the delivery of science**, and support to the continued progress of current and future experiments (objective 2);
- Continue to **develop and improve internal project and programme management capacity** to enable and optimise its impact on the effective and efficient development and implementation of science experiments (objective 3);
- **Strengthen its global partnerships with European and international laboratories** to further consolidate the role of France and IN2P3 in world-class physics research in the domain of deep underground physics (objective 4).

LSM Project Life Cycle

New formalisation of the Experiment Life Cycle at LSM

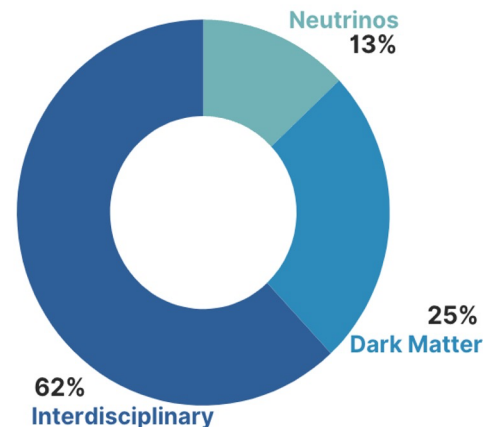
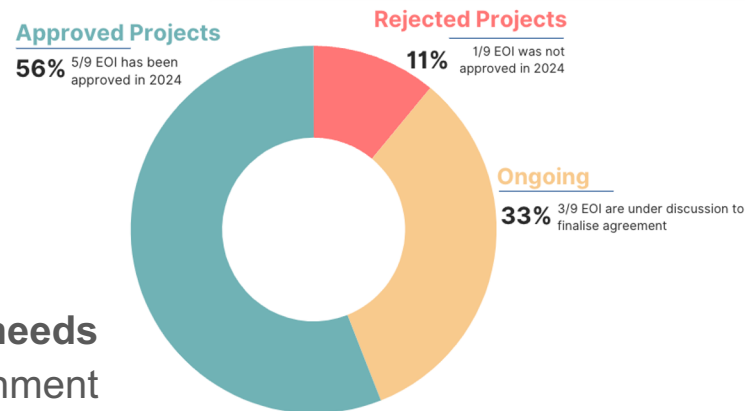
- Definition of the LSM responsibilities
- Definition of the Experiment responsibilities
- Agreement on the **occupied footprint and LSM facility needs** (timeline, surface, fluids, mechanical interfaces, environment constraints,...)
- Agreement on the **operations process**: technical review and analysis, list of documents required (risk assessment, prevention plan, review report).
- **Contracts** regularization in progress / new contracts for new experiments hosting



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LSM Framework

LSM user guide

It is a short document meant to help users navigate the current LSM logistics, especially for shipments, shifts, badges, LSM rooms and meeting room booking.

Two new mailing lists are available for :

- Booking rooms: booking-lsm@lpsc.in2p3.fr
- Radioactive sources: crp-lsm@lpsc.in2p3.fr

A new form for network access requests has been implemented through a web interface

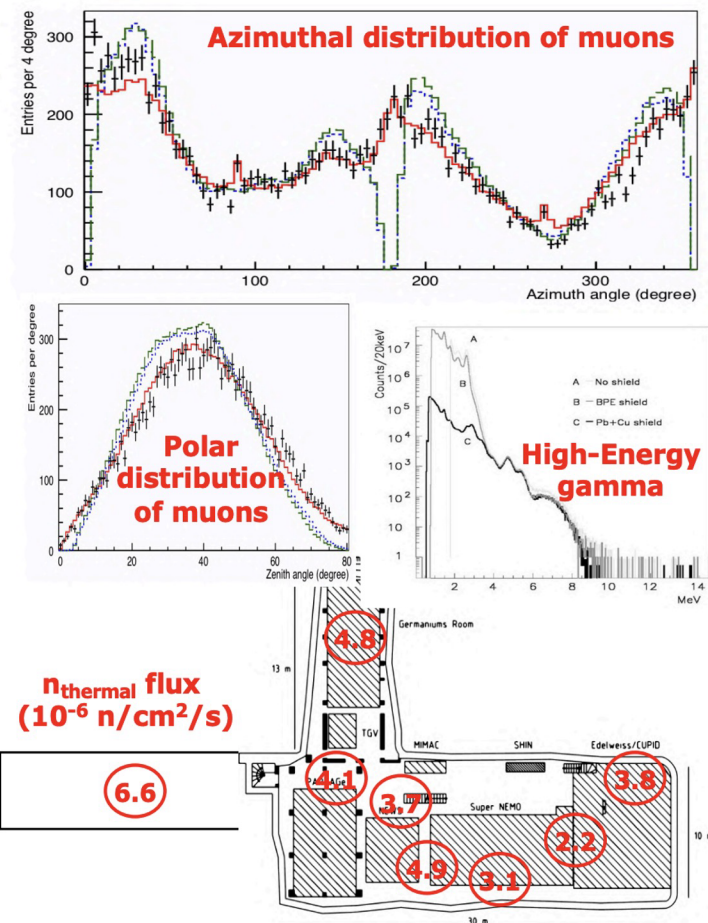
LSM code of conduct

The purpose of the Modane Underground Laboratory (LSM) Code of Conduct is to affirm the ethical environment of LSM's workplace by providing guidance on workplace standards of conduct in the performance of their duties and relationships with others and reporting violations of the Code of Conduct. The Code of Conduct policy applies to all employees, contractors, users and visitors. As of July 2024

LSM Background Measurements

Since 1983, large corpus of measurements of various LSM backgrounds by experiments

- Muons: total flux ($4.5 \mu\text{m}^2/\text{d}$), and angular map
[Rhode, PhD Thesis (Ruppertal, 1993) + Schmidt et al, Astrop. Phys. 44 (2013) 28]
- High-energy gamma rays.
[Ohsumi et al, NIMA 482 (2002) 832]
- Fast neutrons ($1.6 \times 10^{-6} \text{ n/cm}^2/\text{s}$)
[Armengaud et al, Astrop. Phys. 47 (2013) 1]
- Thermal neutrons
[Rozov et al, BRAS 74 (2012) 464; arXiv:1001.4383]
- Radon ($\sim 15 \text{ Bq/m}^3$)
[Hodak et al, J. Phys. G 46 (2019) 11 + E. Armengaud et al, JINST 12 (2017) P08010]



Screening and Material Assay Platform

Wide-range program for Astroparticles, Earth Sciences (sediment and ice core sample datation), environmental safety (CEA), biology, etc...

- HPGe gamma spectroscopy
- Alpha surface contamination via the XIA-UltraLo1800 counter
 - Commissioning at LPSC (surface cleanroom)
- Material assays for experiments based at LSM (SuperNEMO, EDELWEISS, CUPID-Mo, DAMIC-M), and also for other experiments (ex: JUNO, RICOCHET, Q-BITS Canada)
- Agreement with LNGS for long term (~ year) measurement of ECEC decay of ^{82}Se (6 kg) to excited state on large (600 cc) Obelix HPGe.

HPGe Obelix at LSM



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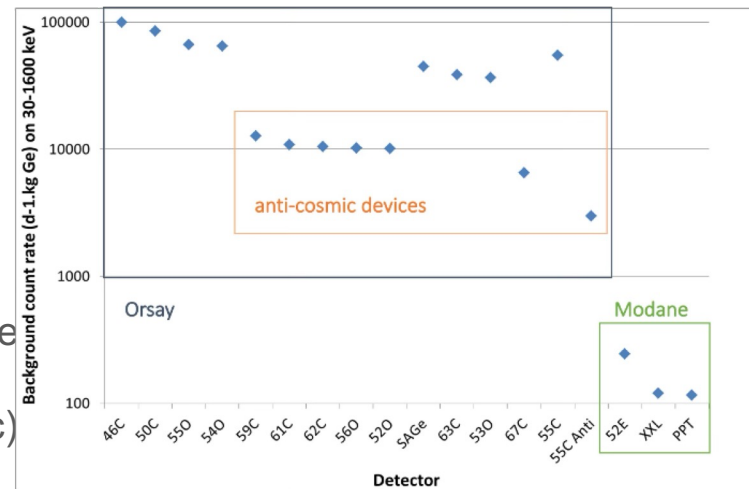
HPGe gamma spectroscopy

Pluri-disciplinary program open to academic and industrial users and partners

Covering very lowest-rate background end of their measurements

France: IRSN, CEA, CENBG, IP2I, LSCE (Université Paris-Saclay, CEA, CNRS), EDYTEM (CNRS, U. Savoie Mont-Blanc)

International: UTEF Prague and SURO (Czech Republic)



Screening and Assay Facilities

Gamma bulk (HPGe):

- 25 detectors in hands at LSM
- 15 installed in PARTAGe
- 5 detectors belonging to LSM
- ~1000 samples/year

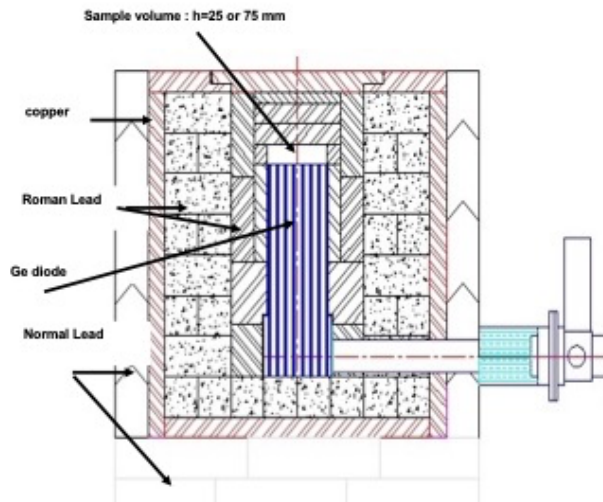
Year	#Samples	HPGe in Partage
2018	579	0
2019	669	0
2020	810	0
2021	1253	5
2022	1251	12
2023	1119	15
2024	1150	15

Alpha Surface:

- New capabilities: surface contamination
- XIA-UltraLo1800
- Commissioning at LPSC (surface cleanroom)



The HPGe for astroparticle screening measurements



Gentiane

Available for Edelweiss collaboration since November 1997

High Purity Ge diode 210cm³ n-type

- Closed-ended coaxial detector
- Ultra-low background cryostat
- Archeological lead shielding
- Nitrogen flux 150cc/min

Sensitivities

- Background counting rate <6.3cts/hr [0-3MeV]
- ~mbq/kg [0.1-0.2 ppb for U/Th]
- 10/muBq/kg [⁶⁰Co in Cu]



The HPGe for astroparticle screening measurements



JASMIN

Available for NEMO collaboration

High Purity Ge diode 400cm³

- Ultra-low background cryostat
- Archeological lead shielding
- Nitrogen flux 150cc/min

Sensitivities

- Background counting rate <250cts/d [0.05-3MeV]
- ~mbq/kg

XIA - UltraLo1800

Alpha spectrometer for large surface screening: specialized ionization counter comprising an active volume filled with boiled-off argon, a lower grounded electrode that is a conductive tray (holds sample), and an upper pair of positively charged electrodes.



- Empty tray monitoring (*in-fieri*)
- Detector characterization via electroformed Cu tray (courtesy of SNOLAB) (*in-fieri*)
- First sample: Rn implanted copper lids of Ge semiconductor detectors to study the background discrimination power.
- Commissioning of gas recycling system (developed by CPPM - Marseille)
- Relocation underground at LSM (summer/fall 2025)

Infrastructure Upgrade

Anti-radon system

- Complete system installation done by LSM
- Start of the continuous operation of the system on October 2025
- Nominal features of the deradonized compressed air at the system outlet: 4.6 bars and 115 to 250 Nm³/h



Shared clean room for instrument prototyping

- A home-made modular design, based on aluminum profiles, polycarbonate panels and 13 Fan Filter Units.
- ISO 5 classification
- Currently used for CCD testing and Low-Background Chamber acquisition within the DAMIC-M project



Underground lab supervision system

- Ongoing renovation with a new architecture and Programmable Logic Controllers



LSM Interdisciplinary Focus

LSM hosts small experiments that can benefit from the exceptional low-radioactivity environment and the staff expertise in this domain (ex: biology, earth sciences..)

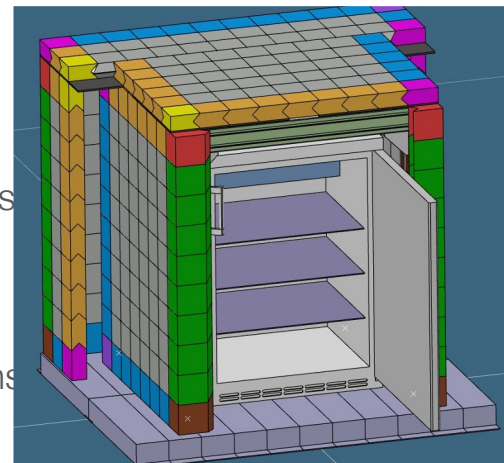
Stem cells storage underground

Allowed to test a stem cell storage shielded from natural radioactivity and terrestrial cosmic rays

- CellTEREO startup (France)
- Cell cryopreservation under extremely low radiation background (CVUT)

RAMUR project

- Funded by CNRS interdisciplinary mission
- Study of the long-term impact of natural radioactivity on living organisms in particular those inhabiting aquatic ecosystems (three species of diatoms).
- Reduced radiation levels lead to various physiological consequences, such as growth inhibition and increased sensitivity to chemical mutagens



International Network of Deep Underground Laboratories (DULs)

- **Stronger collaboration between underground laboratories** to improve support for the scientific community
- DUL creation of joint working groups
 - Sharing of good practices
 - Development in operational matters, Health and Safety, experience management, etc.
 - Low background counting/analysis (“Low Radioactivity Techniques” workshop series), shared databases
- **DULIA Network**
- **iDMEU** <https://www.idmeu.org/> [Initiative for Dark Matter in EUrope and beyond]
- **DMInfraNet** <https://arxiv.org/abs/2504.01688> [Enhancing European Cooperation in the Search for Dark Matter]
- **ISAPP Network** (LSM participating in SC since 06.06.2025)
- Coordination of the response of underground laboratories to European calls for tenders
 - **MSCA-SE** February 2025 - NEXUS
 - **EU INFRADEV** → change of panorama

NEXUS: North-south EXchange for Underground Science

Consortium: EU(CNRS,INFN,LSC,UKRI, SKAO), SNOLAB, SURF, UoMelbourne, UoAdelaide, ZA(SU,UWC,UNISA,Wits)

Project Coordinator: [F. Malek](#) (CNRS DR11-IN2P3)


Grant amount: 771 540.00 EUR

Project duration: 48 months

Project Start: 1st January 2026

[5 Working packages \(WP\):](#)

- 1- Low background Technologies: [S. Scorza](#) (CNRS)
- 2- Muons and radiation Measurements: [N. D'ambrosio](#) (INFN)
- 3- Modelling and Computing: [L. Mantile](#) (UNISA,ZA)
- 4- Quantum science and Technology: [J. Hall](#) (SNOLAB)
- 5- Education, Training, Communication: [C. Oana](#) (INFN)

	EUROPEAN COMMISSION	Evaluation Summary
	Horizon Europe Framework Programme (HORIZON)	Report - Staff Exchanges
Call:	HORIZON-MSCA-2024-SE-01	
Type of action:	HORIZON-TMA-MSCA-SE	
Proposal number:	101236929	
Proposal acronym:	NEXUS	
Duration (months):	48	
Proposal title:	North-south EXchange for Underground Science	
Activity:	PHY	

N.	Proposer name	Country	Total eligible costs	%	Grant Requested	%
1	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	FR	210,420	27.27%	210,420	27.27%
2	ISTITUTO NAZIONALE DI FISICA NUCLEARE	IT	350,700	45.45%	350,700	45.45%
3	CONSORCIO PARA EL EQUIPAMIENTO Y EXPLOTACION DEL LABORATORIO SUBTERRANEO DE CANFRANC	ES	0	0.00%	0	0.00%
4	THE SQUARE KILOMETRE ARRAY OBSERVATORY	UK	10,020	1.30%	10,020	1.30%
5	STELLENBOSCH UNIVERSITY	ZA	110,220	14.29%	110,220	14.29%
6	UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG	ZA	10,020	1.30%	10,020	1.30%
7	UNIVERSITY OF THE WESTERN CAPE	ZA	55,110	7.14%	55,110	7.14%
8	QUEEN'S UNIVERSITY AT KINGSTON	CA	0	0.00%	0	0.00%
9	THE UNIVERSITY OF ADELAIDE	AU	0	0.00%	0	0.00%
10	UNIVERSITY OF MELBOURNE	AU	0	0.00%	0	0.00%
11	UNITED KINGDOM RESEARCH AND INNOVATION	UK	0	0.00%	0	0.00%
12	UNIVERSITY OF SOUTH AFRICA	ZA	25,050	3.25%	25,050	3.25%
13	South Dakota Science &Technology Authority	US	0	0.00%	0	0.00%

The End

thanks