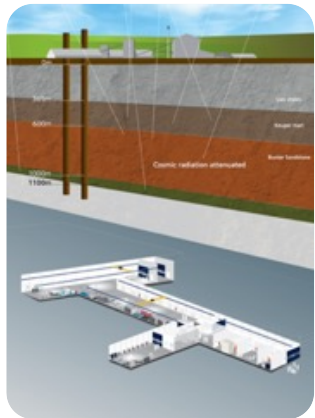


Overview of European Deep Underground Science Facilities

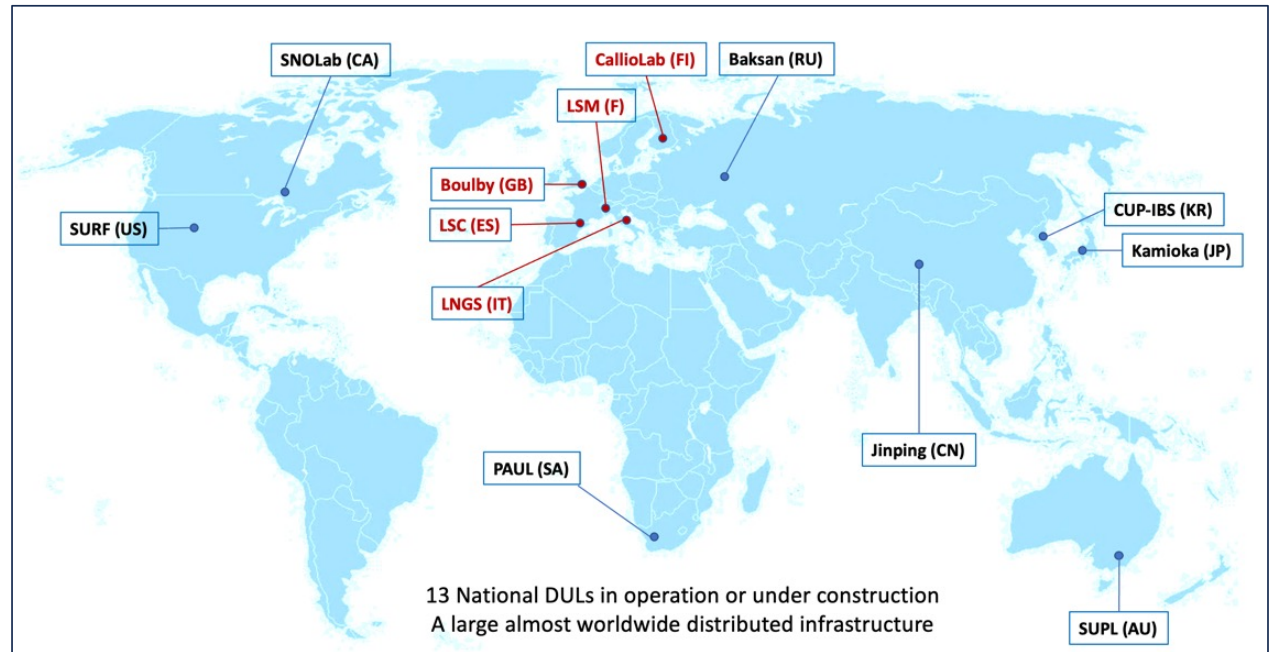


Boulby Underground Laboratory (UK)



LNGS (Italy)

World Underground Labs



Sean Paling
STFC Boulby Underground Laboratory

Why go underground?

Deep Underground Science Themes

Low Background Particle / Astroparticle Physics

- Direct dark matter searches
- Atmospheric, solar & supernova neutrinos
- Reactor and accelerator neutrinos
- Neutrino-less double beta decay
- Nuclear astrophysics / stellar reactions
- Misc. rare-decay processes

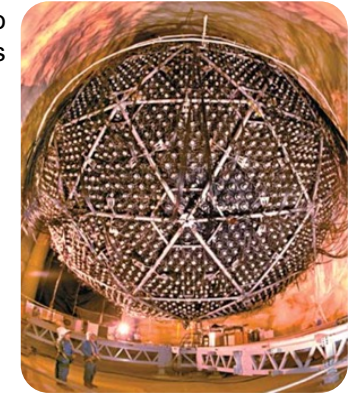
Other 'Multi-disciplinary' studies

- Pure and applied cosmic ray studies,
- Misc. low background studies, Gamma spectroscopy
- Misc. Earth and Environmental Sciences
- Geo-microbiology & life in extreme environs
- Astrobiology and planetary exploration
- Quantum sensors, quantum computing
- Etc...

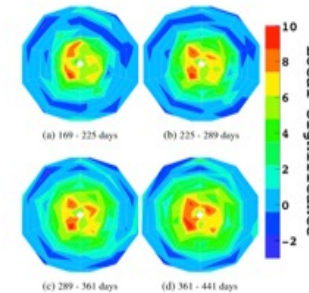
Dark Matter Studies



Neutrino Studies

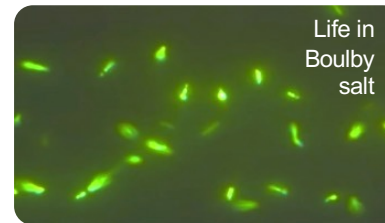


Geology & geophysics



ULB Gamma spectroscopy

Biology, astrobiology and more.



Boulby Underground Laboratory

What's needed from an underground lab? (1)

Experimental Space with... Low Backgrounds...

Cosmic ray Muons...

- Deep underground facilities provide rock overburden & commensurate reduction in c.r. flux & spallation induced products (neutrons)

Go underground...

Neutrons...

Production from

- c.r. muon spallation
- U/Th fission
- α , n reactions

Radon....

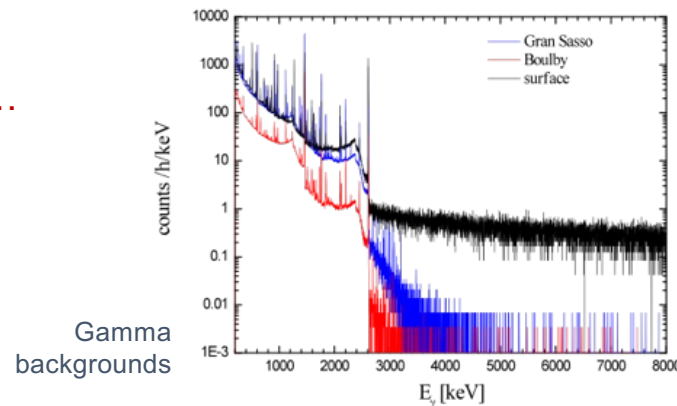
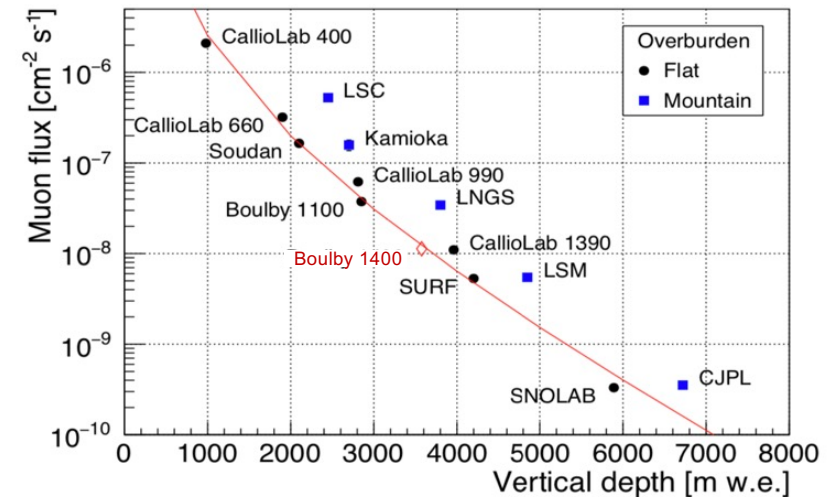
- Dependent on local geology & ventilation

Choose low background rock...

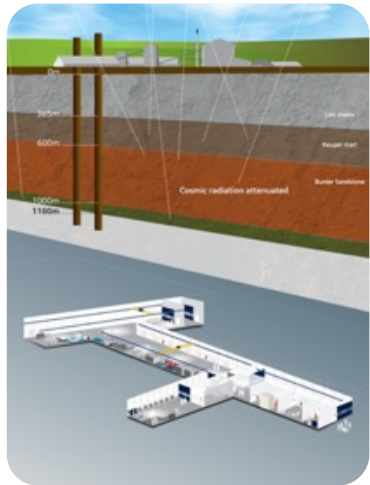
Gammas....

- Reduction in γ -ray background at higher energies from c.r. and neutron reduction
- Below 3.5MeV dependent on local geology

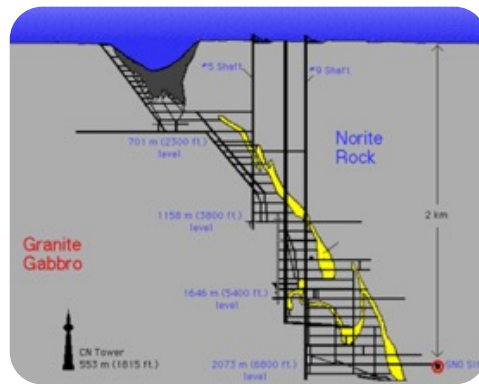
Muon Flux vs. Depth



Underground Labs around the world....

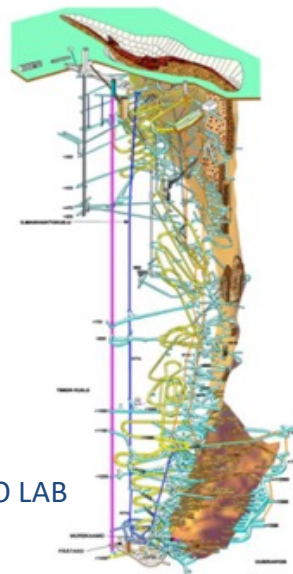
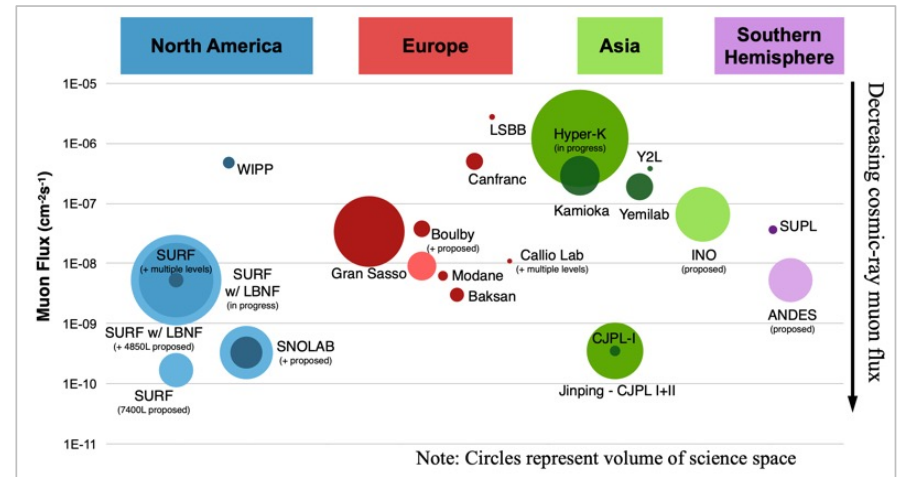


Boulby



SNOLAB

In mines and under mountains

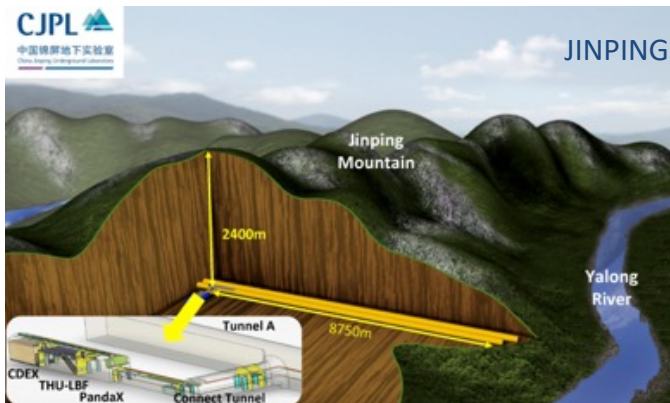


CALLIO LAB

LNGS



SURF



JINPING

What's needed from an underground lab? (2)

Other Factors:

Science and operations support:

- Good surface & underground infrastructure & support facilities
- Reliable utilities: power, ventilation, heat management, water, gases/liquids
- Good Health & Safety and security systems for underground use
- Scientific support personnel: design, construction, operation/analysis
- Infrastructure support and personnel: workshops, chemical labs, IT etc.
- Good ancillary science support facilities: low background assay, clean rooms etc...

'A hole in the ground is not a facility!'



Other Facility Characteristics:

- Size (monolithic or distributed; Space available)
- Ease of Access (vertical or horizontal); Max installation size limitations
- Location (neutrino flux from beam/reactor, Earth, ease of access, quality of life)
- Cleanliness and radiological interference
- **Suitable geology / environmental characteristics**

Other non infrastructure-based things are very important too

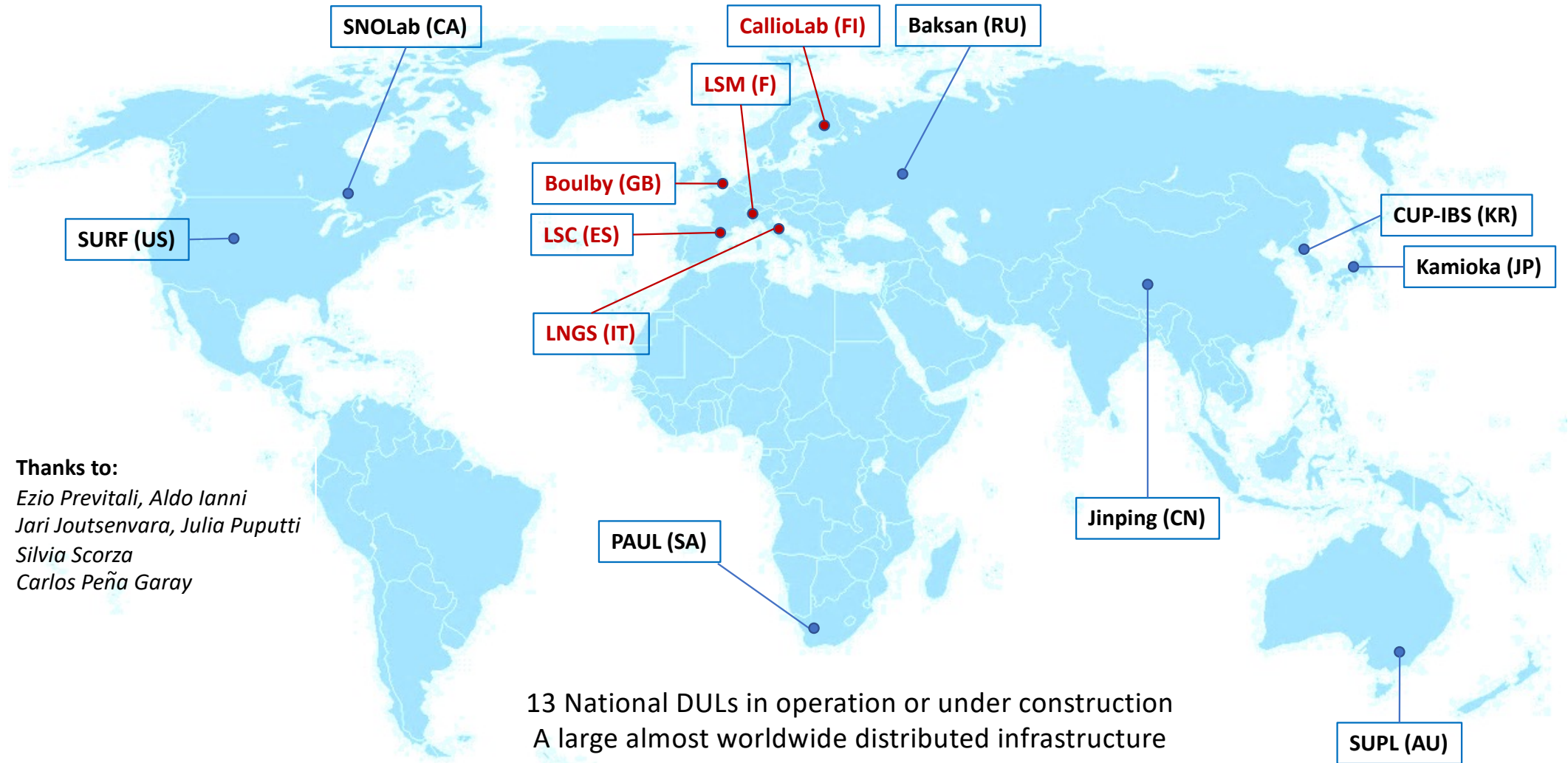


Local Politics & funding: multi-year budgets, solid host nation support, local support /engagement in the facility and the science. Science community networking.



Boulby Underground Laboratory

World Deep Underground Science Labs



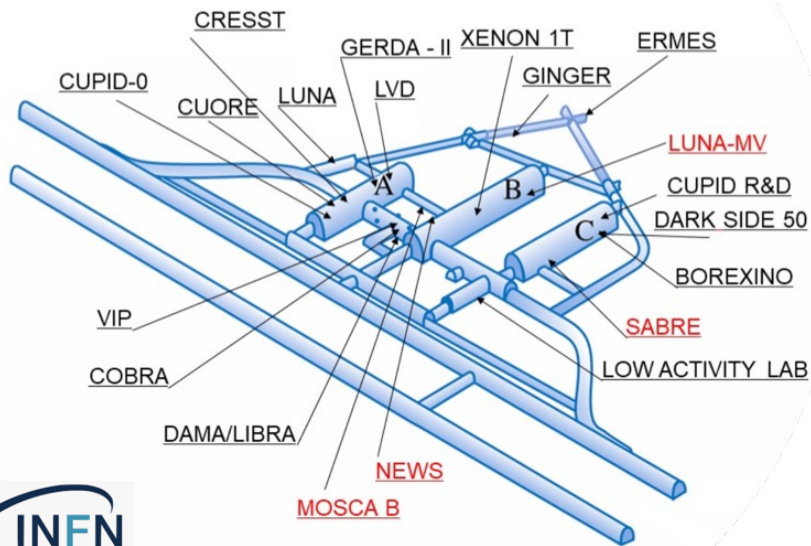
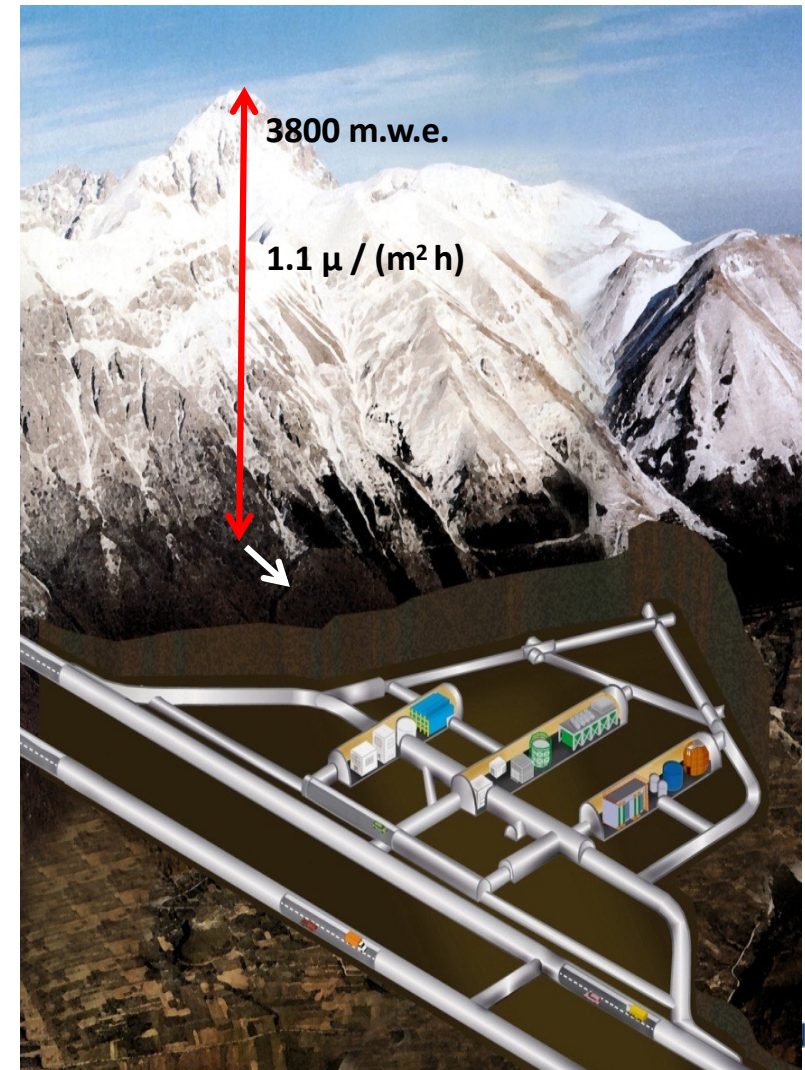
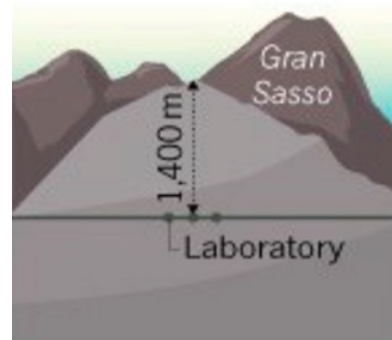
Thanks to:
*Ezio Previtali, Aldo Ianni
Jari Joutsenvara, Julia Puputti
Silvia Scorza
Carlos Peña Garay*

13 National DULs in operation or under construction
A large almost worldwide distributed infrastructure

LNGS / Gran Sasso Deep Underground Lab

- Italy. Under Gran Sasso Mountains (<2hr frm Rome)
- Shielded by 1400 m (3800 m.w.e.) of rock
- Total Muon flux $3 \cdot 10^{-8} \text{ cm}^{-2} \text{ s}^{-1}$
- Radon $i \sim 100 \text{ Bq/m}^3$ with 5-8 air changes/day
- Largest lab in Europe
- 3 main experimental halls:
~100 m long, 20 m width and 18 m height
- Established 1980s
- 22 experiments data taking or under construction

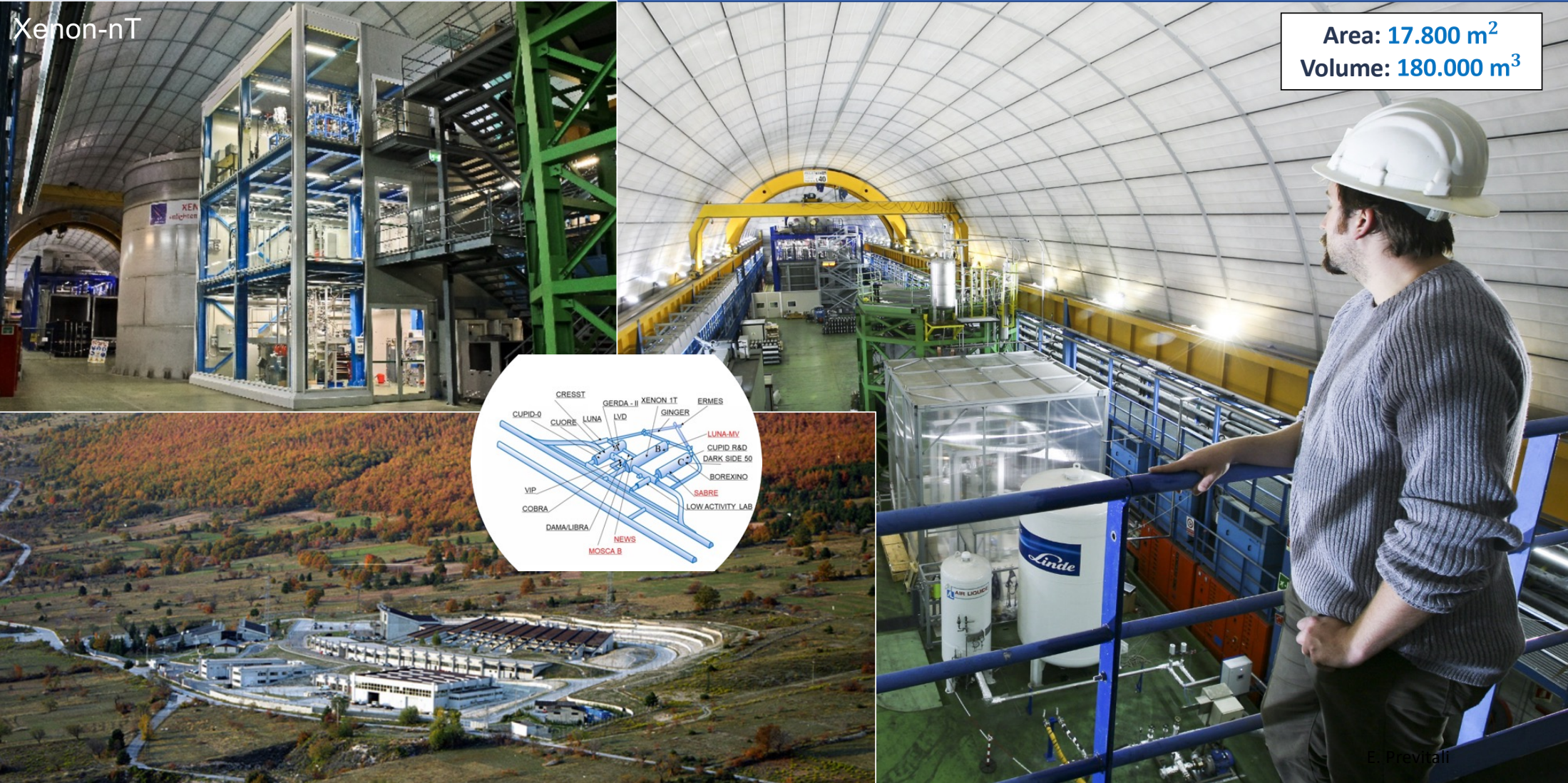
Area: **17.800 m²**
Volume: **180.000 m³**



LNGS / Gran Sasso Deep Underground Lab

Xenon-nT

Area: 17.800 m²
Volume: 180.000 m³



E. Previtali

Gran Sasso Science

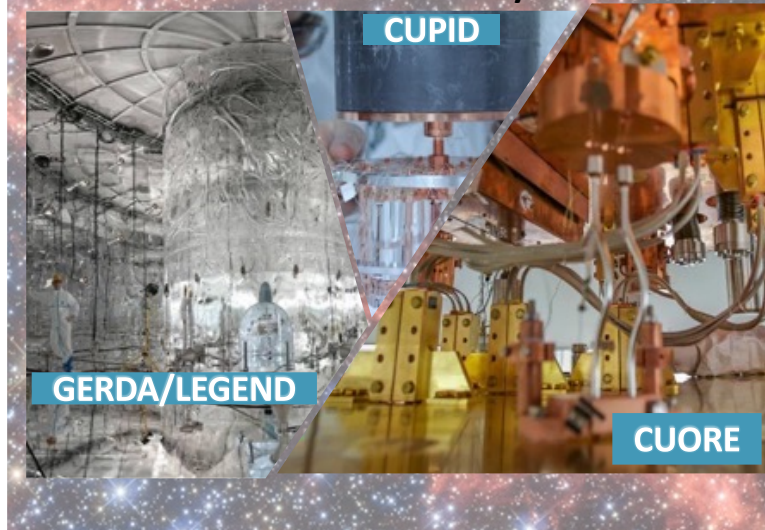
Neutrino Astrophysics



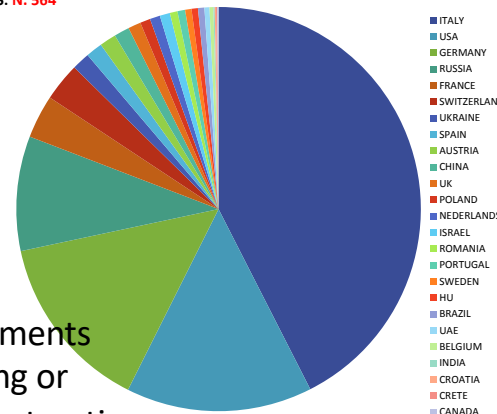
Nuclear Astrophysics



Neutrinoless Double Beta Decay



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



22 experiments
 data-taking or
 under construction

..... but also

- **Test on quantum mechanics**
 - Study on violation of Pauli's exclusion principle
 - Electron decay
- **Radiobiology**
 - Biological effects of low radioactive environment
- **Geophysics**
 - Earthquake monitoring and study
 - Analysis of water resources
- **Ultra Trace elemental analysis**
 - Low radioactivity tests and measurements
 - Cultural Heritage analysis
 - Advanced additive manufacturing

Gran Sasso Status

Bellotti Ion Beam Facility – now in use:

New user facility since June 2023
3.5 MV accelerator for light ions (H, He, C)
call for proposals: <https://l.infn.it/Bellotti>

Borexino decommissioning underway

Liquid scintillator and water removed
Refurbishing of the underground spaces underway
Availability of existing infrastructures for new experiments
(inc **LEGEND-1000**, **G3-XeDM** etc)

New STELLA facility for mat screening (16 HPGe, alpha counting, Liq scint)

Reburishment of new area completed
Improved shielding and cleanliness
Improved samples treatment area
Detector installation in progress

NOA ultra-clean facility for SiPM photosensors production, testing, packaging

Currently in operation for DarkSide-20k

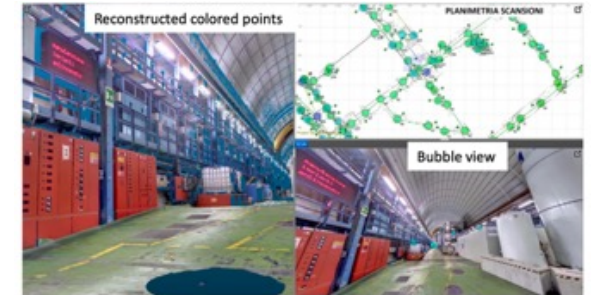
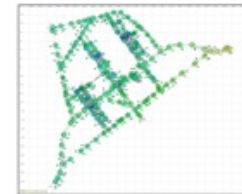
New underground Cryo test facility for low temperature devices

Commissioning scheduled for late 2024

Enlarging the lab workshop and of the 3D printing facility

A dedicated new underground workshop will be installed

Facility 3D-Scanning



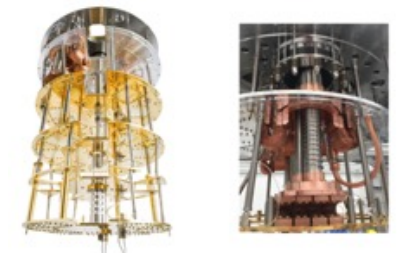
STELLA (SubTERRanean Low Level Assay)



High sensitivity ICP-MS.



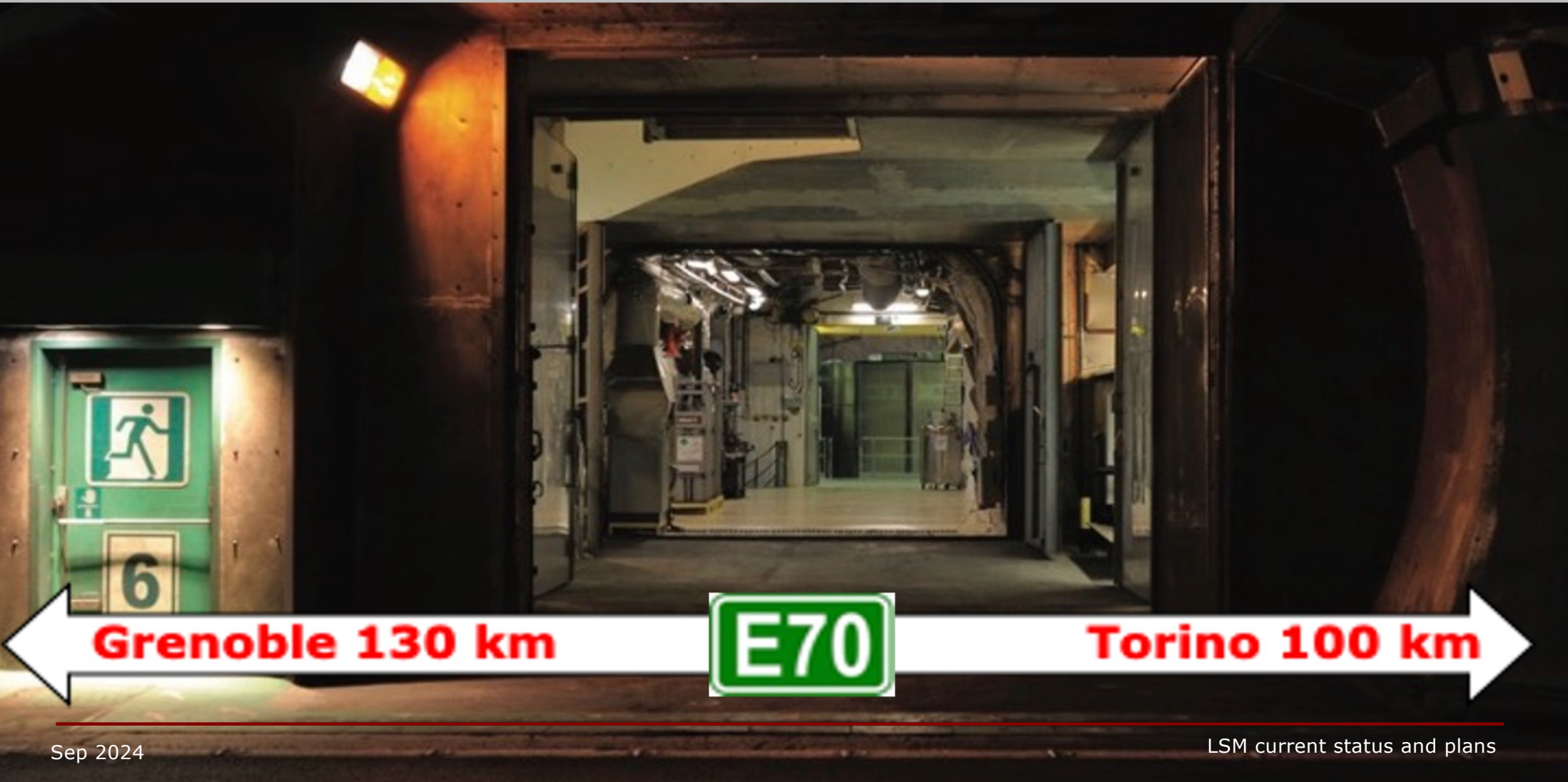
NOA clean room assembly facility



Cryo-facility for testing of low temp devices



LSM Modane Underground Laboratory



LSM Modane 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*)

Modane:

- 130 km from Grenoble
- 200 km from Lyon
- 100 km from Torino
- Volume 3500m³
- **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 10-15 Bq/m³



LSM Science Programme

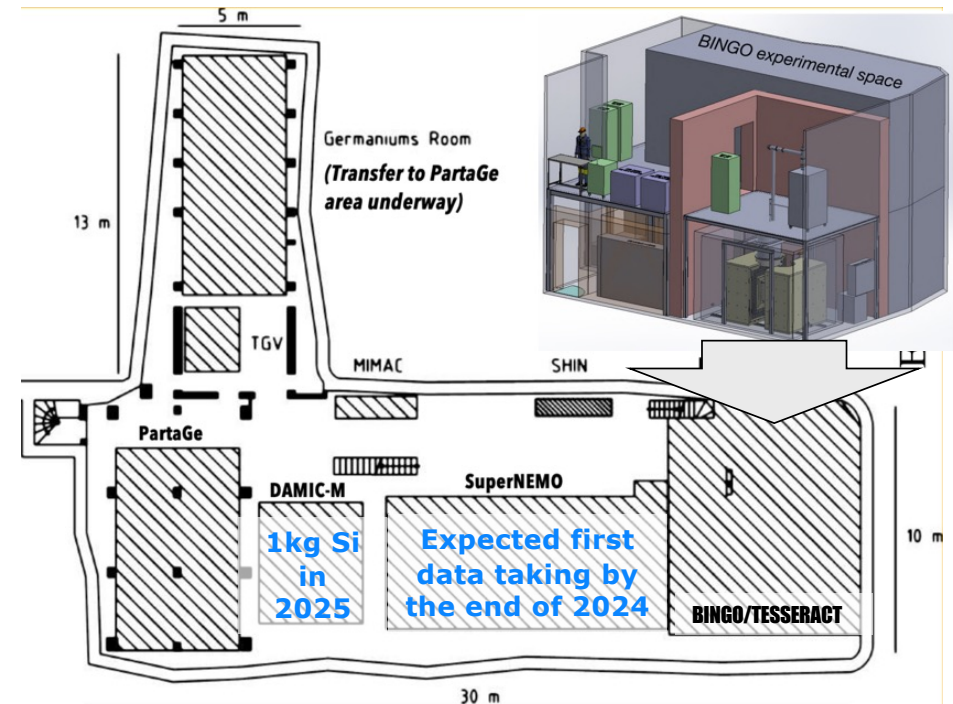
Science programme adapted to LSM size:

- Low-mass Dark Matter Experiments
- $0\nu\beta\beta$ demonstrators & technologies
- HPGe array for low-radioactivity
- Volume 3500m³



Current experimental activities

Experiment	Focus	Technology	Activities in 2024
SuperNEMO	$0\nu\beta\beta$	Tracking-calorimeter	Commissioning and final shielding installation are ongoing. Physics data taking from summer 2024.
BINGO	$0\nu\beta\beta$	Cryogenic	Cryostat integration underground. Commissioning in summer 2024.
Obelix 82Se	ECEC2 ν	Ge ionisation	Counting of 6kg enriched 82Se sample from LNGS started in January 2022: ECEC2 ν to excited states. Renewal of agreement <i>in fieri</i> .
TGV	$0\nu\beta\beta$	Ge ionisation	Detector upgrade delayed.
DAMIC-M	DM	Si CCD	Test chamber Physics run in 2022. Installation of kg-stage from September 2024.
MIMAC	DM	TPC	Detector upgrades with commissioning planned in 2025.



LSM 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)
- 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.

PARTAGe: Footprint optimization for HPGe screen detectors

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



HPGe Obelix at LSM



First PARTAGe detector row

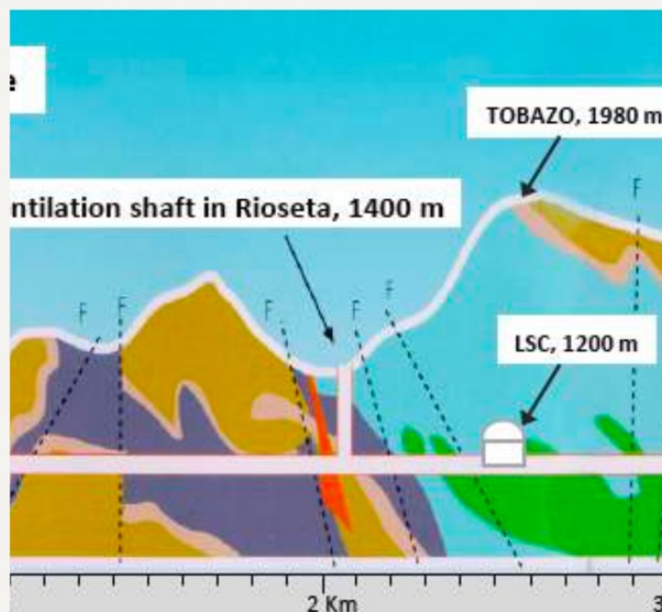
Canfranc Underground Lab

Located in Spanish-French Pyrenees border. Two-way access tunnels: abandoned train tunnel and operative road tunnel.

First experiments (IGEX, ...) since 1986. Modern lab, 1600 m², operative since 2010. 260 scientists from 50 institutions.

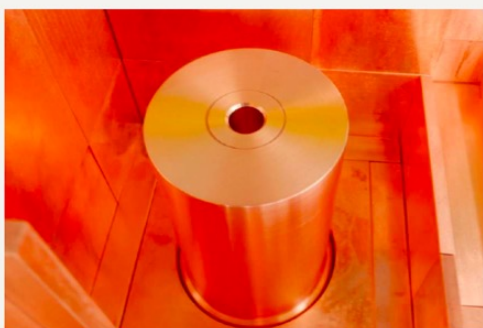
800 meters (v) of rock - muon flux is $5 \times 10^{-7} \text{ cm}^{-2}\text{s}^{-1}$; neutron flux ($E < 10 \text{ MeV}$) is $3.5 \times 10^{-6} \text{ cm}^{-2}\text{s}^{-1}$; gamma flux is $2 \text{ cm}^{-2}\text{s}^{-1}$

Radon abatement system: 220 m³/h radon-reduced air at 1 mBa/m³





Good progress since last LRT meeting



HPGe detector GeRysy



ICPMS-QQQ underground



EFCu: DAMIC lids



ANAIS Experiment

GeRysy: **New** lowest background **record** in **HPGe** gamma screening with (**<10**) **$\mu\text{Bq/kg}$ sensitivity** (led by **G. Zuzel**).

ICPMS-QQQ: in ISO5 clean room underground: **2 (20) ppq** sensitivity in $^{238}\text{U}(^{232}\text{Th})$, **ppb** in ^{40}K (See [L. Cid's talk](#))

EFCu: New installation running in clean room underground. (See [S. Borjabad's talk](#))

ANAIS and next generation NaI experiment: **Last (8th) year** of data taking. LRT work in NaI with SABRE

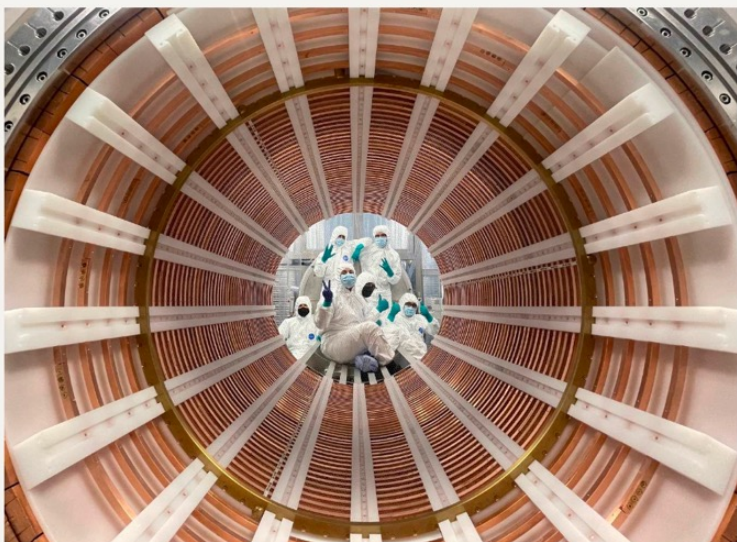
HyperKamiokande: Coordination of the Spanish contribution to the construction of HK (20400 PMT covers to cancel chain reaction, ventilation and geomagnetic compensation systems, 1000 Data Processing Blocks, calibration, ...).

NEXT-100 & NEXT-HD experiments

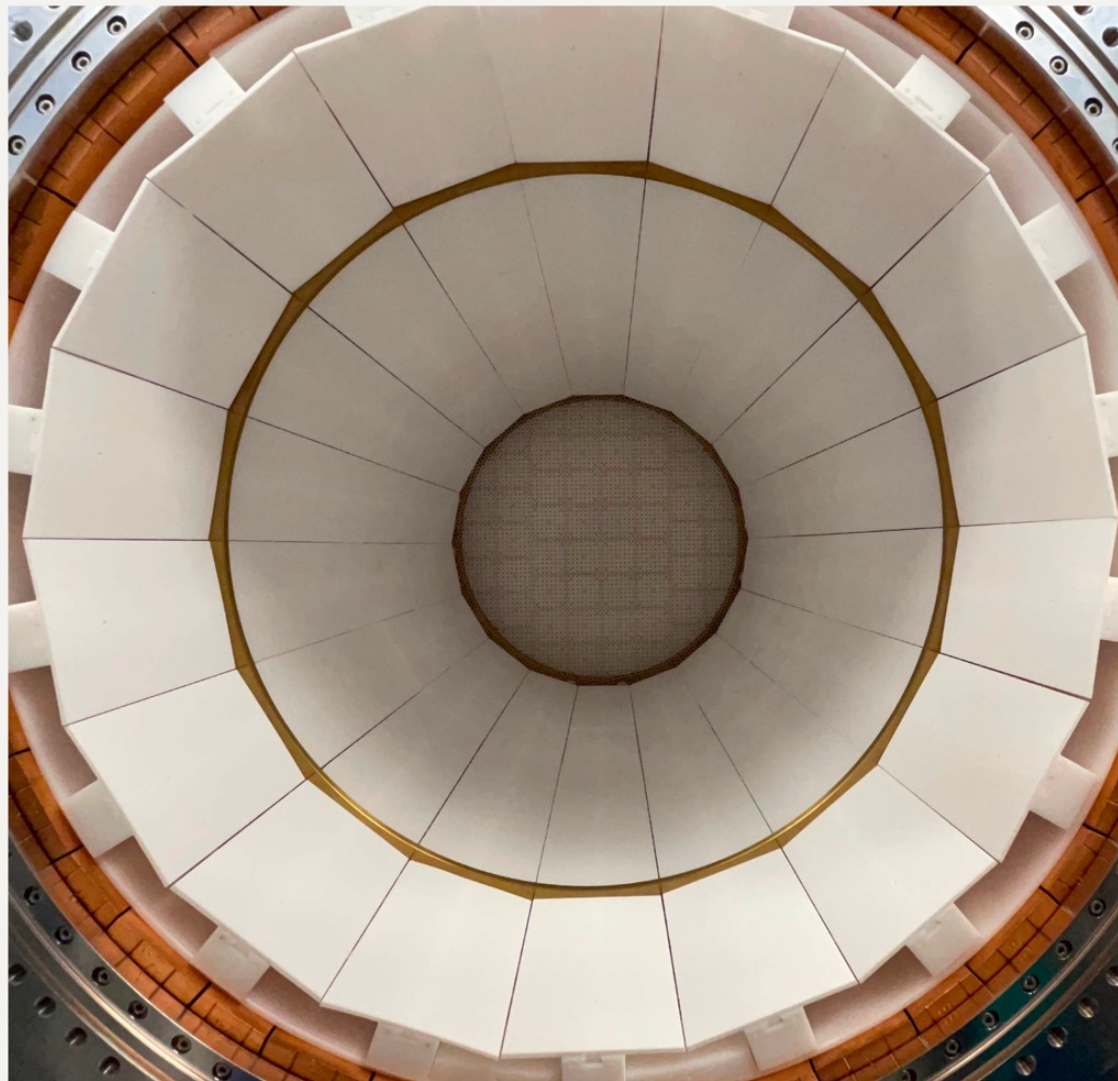


Flagship experiment at LSC:

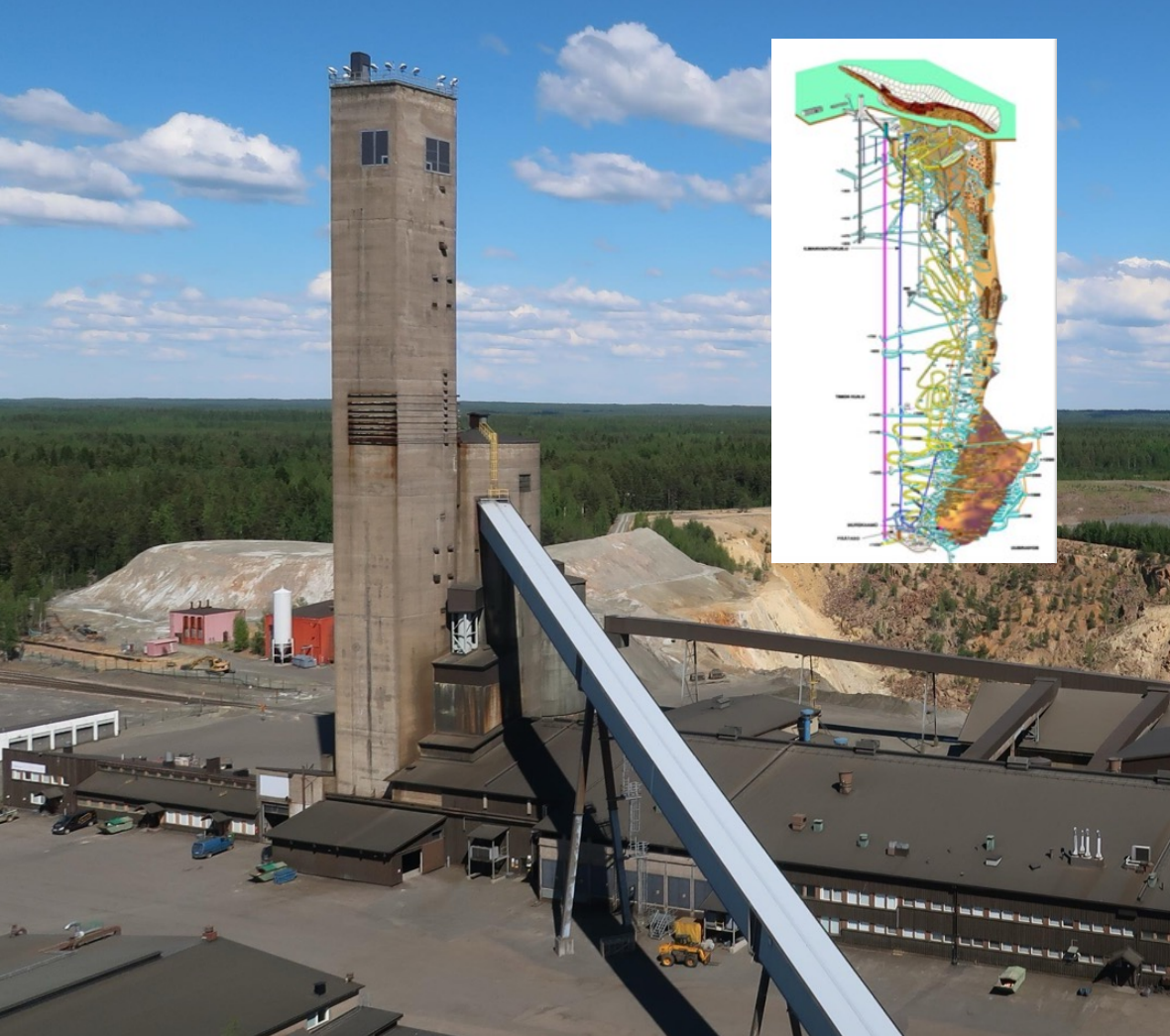
NEXT-100 experiment - TPC with 100 kg of Xe-136 at high pressure - installed @LSC to search for neutrinoless double beta decay. In operation since December 2023.



NEXT-HD - TPC with 1 ton of Xe-136 at high pressure will start construction plans in 2025. Already working on LRT for the ton-scale experiment: higher purity copper shielding, light extraction with fibers,...



CALLIO LAB at the Pyhäsalmi Mine, in Pyhäjärvi Finland



About the Pyhäsalmi mine:

- Underground mining since 1967 (Cu, Zn & pyrite)
- 1.4 km (~4100 mwe) flat overburden
- Access via incline (12 km) or elevator
- Mining ceased in 2022
- Transitioning from mine to repurposing
- **Owned by** Pyhäsalmi Mine Oy
- **Post-mining activities** coordinated by the Pyhäjärvi town-owned Callio- Mine for Business
- Science activities coordinated by the University of Oulu Callio Lab



Basic information:

- Benefits From The Whole Mine Site And Infrastructure
- **Project-based Operations – Low Operational Costs**
- Research Activities At Callio Lab Coordinated By The Kerttu Saalasti Institute, University Of Oulu

- An EPOS Research Infrastructure (ESFRI, 2020)
- A FIN-EPOS Infrastructure (FIRI, 2020)
- Member of DULIA network and collaborating with CELLAR network
- Founding member of European Underground Laboratories Association (EUL, BSUIN projects) Undergroundlabs.network

We offer coordination, cooperation, networking and facilitation



Education and training



Mining & tunnelling



Mine reuse



Geothermal research



Working environment



Underground H&S



Future food & Underground farming



SpaceLab



Earth Observation and remote sensing



Deep underground low background facility



Particle physics & muography



Something new?



Science and
Technology
Facilities Council

Boulby Underground Laboratory: Status and plans for the UK's deep underground science facility.

Sean Paling
Boulby Underground
Laboratory, UK

UKRI Science and Technology Facilities Council

UKRI Science and Technology Facilities Council
Boulby Underground Laboratory

Sean Paling
STFC Boulby Underground Science Facility

Astroparticle physics & ultra low background studies

The search for Dark Matter & beyond

Earth and environmental science, Astrobiology and planetary exploration

Boulby Underground Laboratory:
The UK's deep underground science facility. Current status and future plans

Underground lab @ Boulby

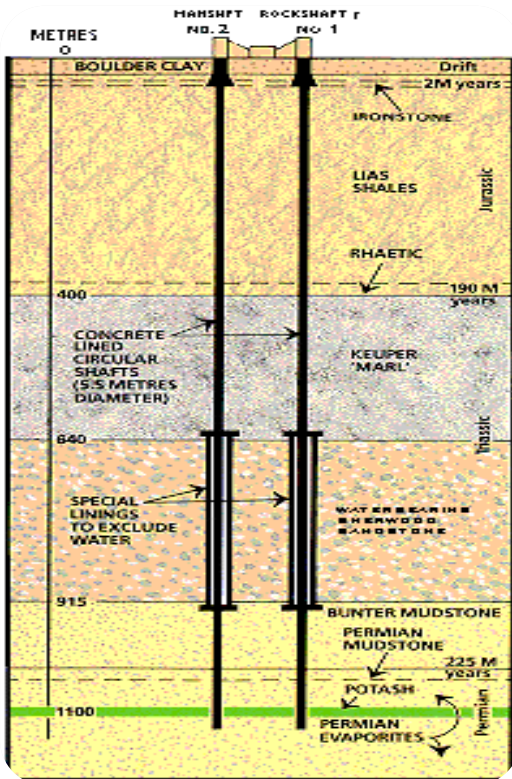
Sean Paling. Boulby Underground Lab. 2024

Boulby Geology & Mining

Excavations are in Salt (NaCl), Potash (KCl) and Polyhalite ($K_2Ca_2Mg(SO_4)$). Permian evaporite layers left over from the Zechstein Sea (250m.yrs past).

Over 40 kms of tunnel mined each year (now >1,000kms), the long-lived roadways being cut in the lower NaCl layer.

Britain's deepest mine.
1.1 to 1.3km deep.
>1000kms tunnel



Polyhalite



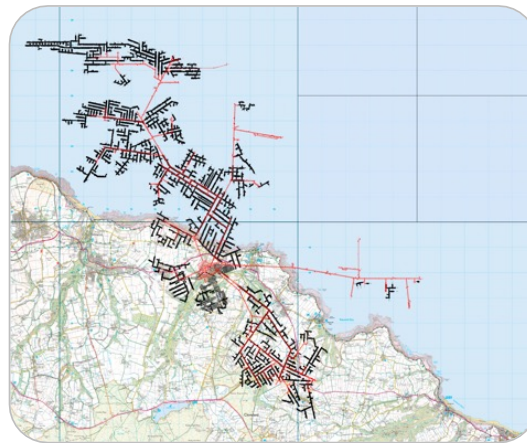
Potash



Rock-Salt



Low activity salt
U ~67 ppb,
Th ~125 ppb



Boulby Geology



Typical Boulby Salt Roadway



Zechstein Sea



Boulby Underground Laboratory

Office space, chemistry & clean prep lab, storage and staging space, IT room, conference room,

Supported access to surrounding geology & UG environs. Power, wifi/internet.



Surface support and staging building

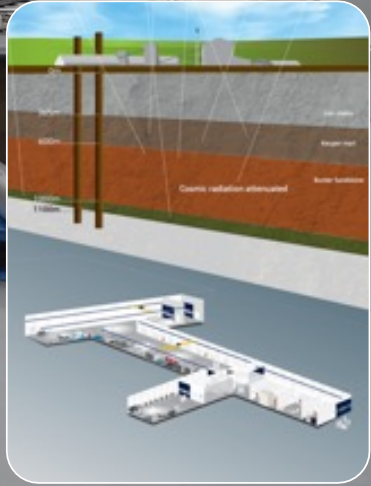


3000m³ Outside Experimentation Area



BUGS Material screening

Boulby Underground Lab Facilities 2023: >4000m³ class 1k & 10k (ISO 6 & 7) clean room lab space. 10Gb Internet. AC, air filtration, 5T & 10T lifting, LN generation, fume hood & clean prep space. 3000m³ Outside Experimentation Area (OEA) with power & internet. Supported access to wider mine environs.



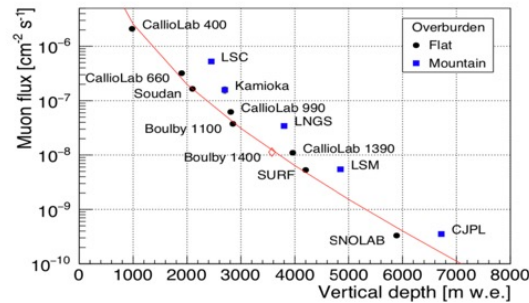
Boulby Underground Laboratory (UK)



Boulby Facility Details...



- The UK's deep underground science facility. One of 5 in Europe, <15 in the world.
- Supports work of >10 collaborative projects (astrophysics to climate, geology, environment etc), >40 institutions, >170 scientists & students.
- Facility funded and operated by the Science & Technology Facilities Council (STFC).



- Operations, H&S & science programme managed by 22 onsite staff and supported by Rutherford Appleton Lab (PPD).
- Mine operators ICL-UK provide wide-ranging operational & high level support.

How does Boulby Compare?

- Low Radon levels (3 Bq/m³)
- Diverse science programme.
- Science and Industry partnership



Science Programme Status & Plans.

- Astroparticle & Low Background Science
- Earth & Environmental Science
- Astrobiology & Planetary Exploration Studies
- Quantum Sensors and Computing
- Outreach & Education

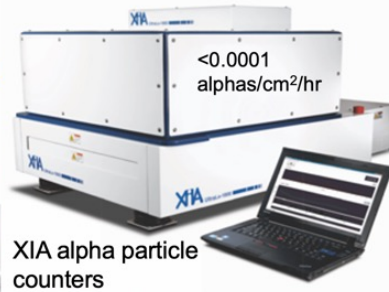
Boulby Underground Laboratory 2024

Find out more:
@BoulbyLab
www.stfc.ac.uk/boulby
f in t y

Boulby Science Now & Future

Particle physics and ultra-low background studies

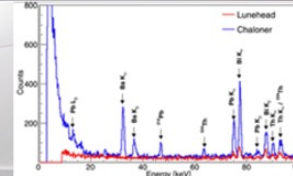
BUGS



XIA alpha particle counters



8 ULB Ge detector systems, 2 XIA alpha counters, Rn emanation (2), ICPMS-QQQ



BUGS (Boulby UnderGround Screening). World-class material screening for current and future ULB experiments. Towards PPT sensitivity for G3 DM and Neutrino experiments



See contributions here @ LRT 2024 by: *Sid Ahmed Maouloud, Beth Green, Sophie Carroll, Jemima Tranter*

Boulby Dark Matter Studies...

Boulby has hosted **Dark Matter** search studies for over two decades. Including the **NAIAD**, **DRIFT** & **ZEPLIN** experiment programmes.

Boulby now hosts **CYGNUS** directional DM programme, **NEWS-G/Dark-Sphere** R&D and providing ULB material screening for other studies, inc **LUX-ZEPLIN (LZ)**

Galactic rotation curves

ZEPLIN-II & III: The world's first 2-phase Xenon dark matter detectors (Finished 2011)

World DM particle search limits and future projections

ZEPLIN-III @ Boulby

NEWS-G

Spherical Proportional Counter (SPC) studies @ Boulby

k. Nikolopoulos, J. Katsioulas, P. Knights, T. Needs, R. Ward
University of Birmingham
And wider NEWS-G Collab.

SPC concept: Variable target Low E_{th} , Low mass sensitivity

Purpose-made gas filter

11-anode sensor

SPC Sensitivities

Direction of R&D at Boulby

- Instrumentation development alongside NEWS-G at SNOLAB
 - Multi-anode sensor
 - Gas mixtures & filtration
- Working towards scaled-up detector at Boulby, 3m diam. **DarkSPHERE**
- Establishing **Electro-forming Capability** at Boulby for Dark SPHERE and beyond (J. Katsioulas, This conf.)

Simulation study of neutron interactions in the S30 at Boulby

Neutron Beam 4 MeV

Multi-disciplinary Science

Applied particle physics, Earth and environmental studies, Astrobiology & Planetary exploration.

Atmospheric monitoring for nuclear security

Astrobiology & planetary exploration

MINAR VII & VIII. 2018 - 2021

NASA-JPL
Signatures of life studies

Lulea University
KORE rover 3D area mapping

LA Nat Hist. Museum
Fluid inclusions in salts

Edinburgh University
MUFFHINS water activity monitoring payload

Coord. X

1.587891

1.281006

0.974121

0.667236

0.360352

0.053467

-0.253418

-0.560303

-0.867188

-1.174072

-1.480957

-1.787842

-2.094727

-2.401611

-2.708496

-3.015381

-3.322266

RECON: CTBT Atmospheric Radionuclide Monitoring

Improving the sensitivity of Nuclear Test Monitoring
A V Davies, R Britton
AWE, Aldermaston, Reading, Berkshire, RG7 4PR

International Monitoring System Sites

Improving the accuracy & sensitivity of atmospheric radionuclide monitoring for international Comprehensive Test Ban Treaty (CTBT) verification

Nuclide	Single MDA	Gate Energy	Projected Peak	RIMMER Factor	Background Counts (projected)	Ir Currie	Ir Poisson	MDA Currie	MDA Poisson	Ratio to singles
CS-134	3.38E-07	604.721	796.00	2.02E-01	2	9	6	4.85E-08	0.143	
BA-133	4.41E-07	30.625	356.00	7.10E-01	54	37	49	8.47E-10	0.002	
AG-109m	4.76E-07	24.013	434.00	2.37E-01	61	39	75	2.68E-06	5.632	
CO-60	5.14E-07	3173.13	1330.00	8.78E-04	1	7	3	5.63E-08	0.109	
AG-110m	4.33E-07	667.76	885.00	1.04E-01	3	11	7	1.09E-07	0.253	
EU-152	8.23E-07	40.118	245.00	2.08E-02	40	32	52	2.52E-08	0.011	
SB-125	1.99E-06	27.322	408.00	9.02E-01	34	30	45	5.40E-08	0.037	
SC-46	4.71E-07	889.277	1120.00	1.31E-01	1	7	3	3.73E-08	0.079	
Rh-102	1.08E-06	21.836	475.00	1.64E-04	30	28	41	2.81E-06	2.603	
FE-59	9.00E-07	192.343	1200.00	1.81E-04	9	17	16	1.44E-06	1.600	
LA-140	1.15E-06	108.762	487.00	1.06E-01	11	18	18	2.71E-07	0.235	
CS-136	1.30E-06	31.817	1240.00	1.82E-01	7	15	13	1.16E-07	0.090	
SB-126	1.01E-06	414.7	666.00	1.81E-01	5	13	10	8.99E-08	0.089	

Sustainable energy storage R&D

Renewable Energy StORage in UnderGround CavErns (RESOURCE)

NERC Grant Proposal 2020
British Geological Survey
Boulby Underground Lab
U. Cambridge & U. Manchester

STFC Boulby Mine, BGS and the University of Cambridge

Low Carbon Technologies

- Engineering solutions have been devised to store energy whilst production is high and feed it into the grid when production is low (e.g. CAES, hydrogen storage)
- Helps to regulate the production of renewable energy

Plan for In-situ Testing at Boulby Mine

Boulby Mine Gallery

1.8 m
Cored borehole (diameters = 75mm)
Plug hole

20 m
Borehole spacing

5 m
Stressed region (due to gallery opening)

15 m
Full depth of hauler = 20 m

Additional 5 m max

Pilot hole cored to 21 m

→ Sensor arrays at 120° intervals around caverns A and B

Mid-scale rock engineering tests of gas containment in salt cavities for energy storage

- Drill and core pilot hole. Study fabric, chemistry and mechanical properties of core. Also drill and core testing holes. Study core and run dissolution tests.
- Drill and core intermediate hole to 8m and deep hole to 15m. Study and compare core. Case holes and form solution-mined caverns. Seal holes and pressure cycle.
- Drill and core shallow hole to 3m. Case hole, cement casing and form solution-mined cavern.

Future facilities & science @ Boulby...

Boulby Activities Now and in the Future

		Now	
		Current Projects	Status
Particle Physics & Low Background		CYGNUS - DM R&D	E/P
		News-G - DM R&D	A
		BUGS: Ge, XIA, RnEm - Material Screening	A
		RECON - Nuclear Security R&D	A
		BUTTON - Nuclear security R&D	A
Earth & Environmental		Muon Tomog – CCS & undersea Geomaging R&D	A
		RESOURCE – Energy store R&D	A
		Seismology/AION R&D	A
Astrobiology & Planetary Exploration		BISAL – Biology/Astrobiology	A
		MINAR – Planetary Exploration Tech development	A
		Misc. Other. SELLR, C14, Adrok, BIO-SPHERE...	A/P
		Outreach/ Education - Misc events, progs, Remote3...	A

Status: A = Active, P = Paused, E = End, I = Interest confirmed

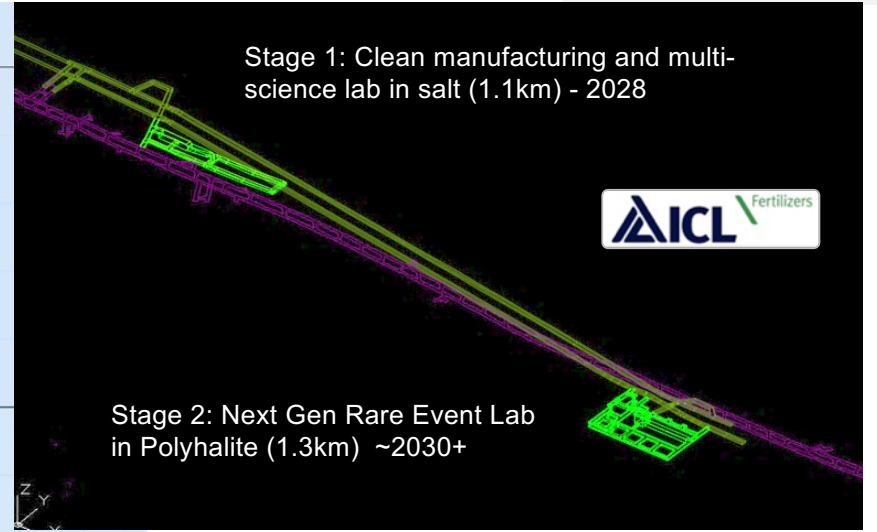
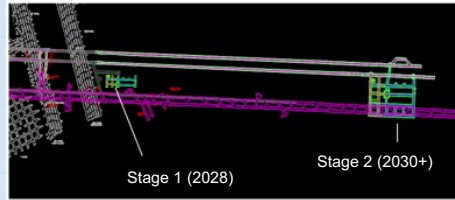
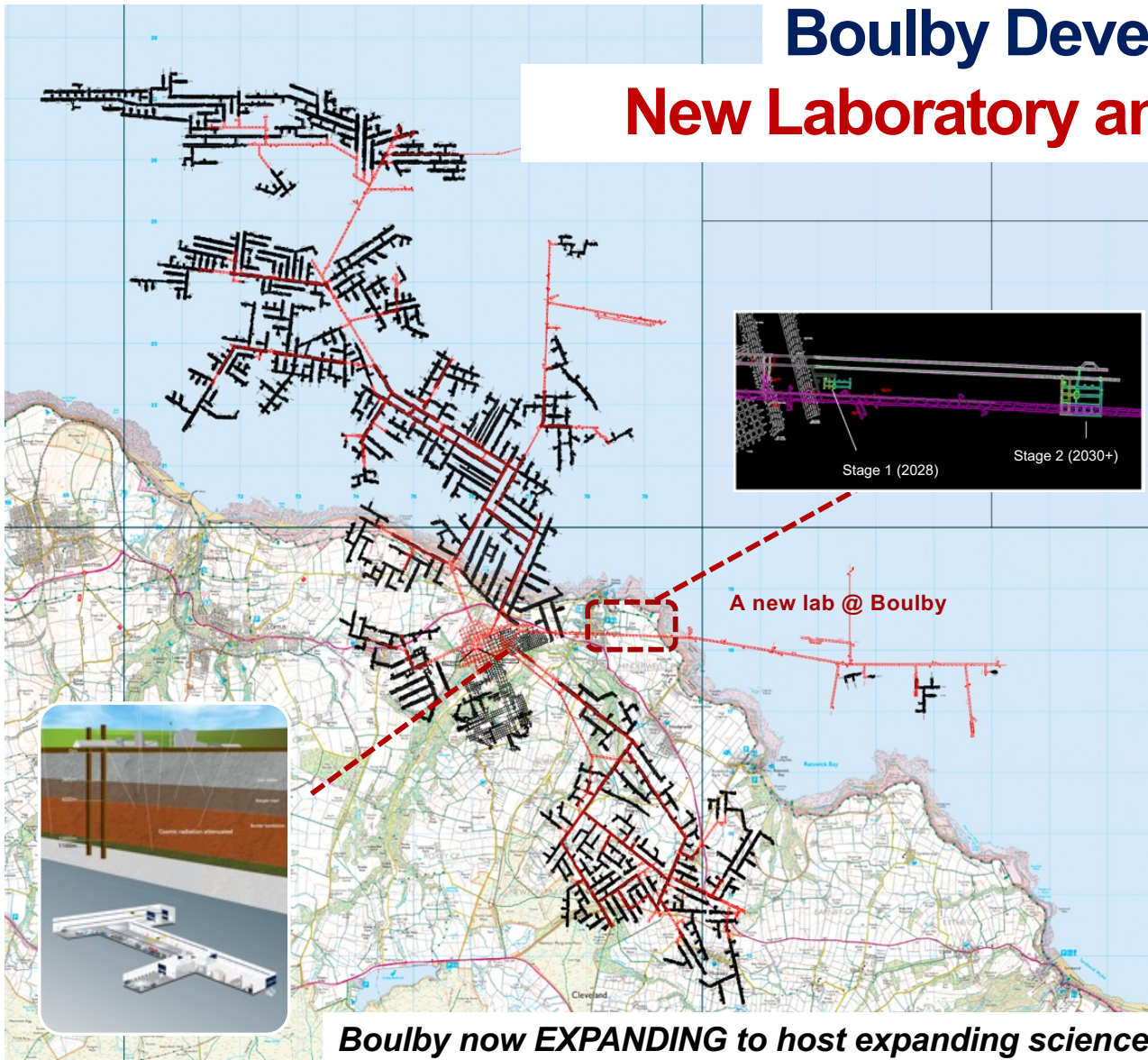
2023-2030	
Medium Term (Current Lab + mods)	Status
BUGS: Ge, XIA, RnEm, ICPMS - Material Screening	A
BUTTON-30 – Nuclear security R&D	A
RECON+ - Nuclear Security R&D	A/I
DarkSPHERE, SOLAIRE, ULT, Quantum Technologies – DM Search	I
DATUM – Neutrino Tech R&D	I
SoLAr – Neutrino R&D	I
AION-100 & 1000 R&D	I
Seismology Array – Geosurvey R&D	I
RESOURCE+ – Energy store R&D	A/I
Muon Tomog – CCS & undersea Geomaging R&D	A/I
BISAL+ – Biology/Astrobiology	A/I
MINAR+ – Planetary Exploration Tech development	A/I
Misc. Other. Quantum Computing Tech R&D?	-
Outreach/ Education: General Public, Schools +	A

2030-2040+
Long Term (Current lab plus major new lab)
<p>Particle Physics and Low Background Science: Dark Matter: Major Next Gen Experiments:</p> <ul style="list-style-type: none"> Xenon (XLZD) Argon (SOLAIRE+) Gas (DarkSPHERE+) ULT technologies for DM Quantum Technologies for DM <p>Neutrinos:</p> <ul style="list-style-type: none"> BUTTON-100+ DATUM (LEGEND Support), SoLAR +.... <p>Mat screening & LB Techniques: A world's best facility:</p> <ul style="list-style-type: none"> Ge, XIA, RnEm, ICPMS, Cleanlines & Engineering R&D <p>Misc Other:</p> <ul style="list-style-type: none"> AION-100 / AION-1000 Nuclear Security Gamma spec Quantum Computing Technology R&D?
<p>Earth & Environmental Science:</p> <ul style="list-style-type: none"> Sustainable Energy R&D Seismology Observatory Geological Repositories R&D Misc geology / Geophysics R&D
<p>Astrobiology & Planetary Exploration:</p> <ul style="list-style-type: none"> Extremophile R&D Astrobiology / life beyond Earth R&D Human habitation R&D Planetary exploration technology development Robotics and AI Mining and industry application development.
<p>Outreach and Education:</p> <ul style="list-style-type: none"> A National Centre for Science and technology outreach and education.

Target projects for a major new UK underground facility / campus

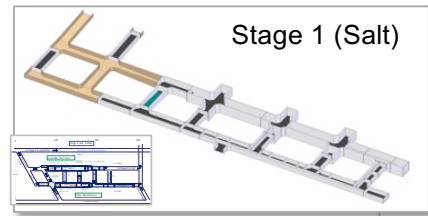
Boulby Development Project

New Laboratory and New Science.

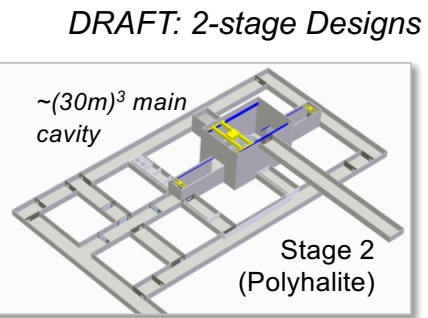


Stage 1: Clean manufacturing and multi-science lab in salt (1.1km) - 2028

Stage 2: Next Gen Rare Event Lab in Polyhalite (1.3km) ~2030+



Stage 1 (Salt)



DRAFT: 2-stage Designs

~(30m)³ main cavity

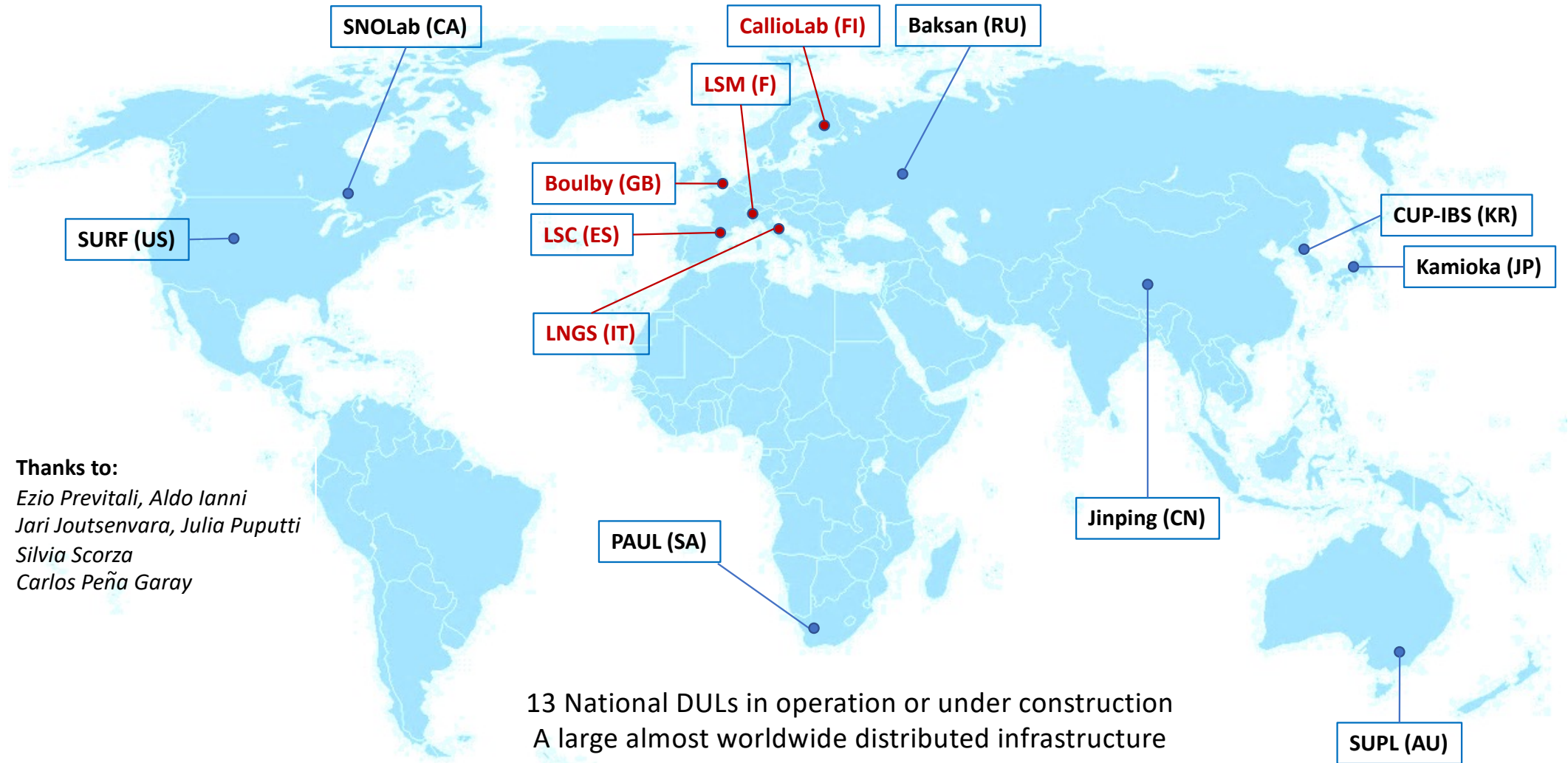
Stage 2 (Polyhalite)

Total volume (Stage 1 + stage 2) ~120,000m³

Boulby now EXPANDING to host expanding science

Excavations for stage 1 now underway

World Deep Underground Science Labs



Thanks to:
*Ezio Previtali, Aldo Ianni
Jari Joutsenvara, Julia Puputti
Silvia Scorza
Carlos Peña Garay*

13 National DULs in operation or under construction
A large almost worldwide distributed infrastructure

Overview of European Deep Underground Science Facilities

Summary

- A busy and exciting time in the international underground laboratory world.
- Many interesting and significant experiments now operating, under construction or planned – many needing better than ever for Low Radiation Techniques and devices.
- Europe has a number of important, historic and diverse underground facilities - each with low background radiation research capabilities and exciting/ambitious plans for the future.

Sean Paling
STFC Boulby Underground Laboratory

Back-Up Slides

BAKSAN Neutrino Observatory (Russia)



DULIA-BIO 2024 – Bio Sciences in Deep Underground Laboratories,
Aug 19 – 22, 2024 Gullfahl, York

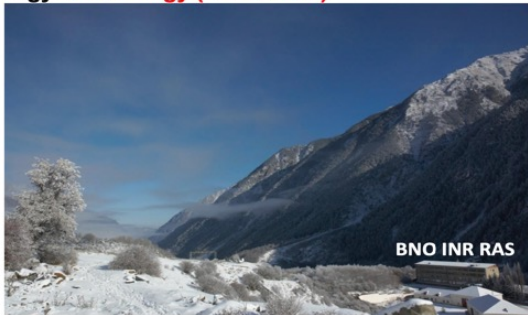
Biological researches at the deep underground low radiation background laboratory (DULB-4900) and tunnel of Baksan Neutrino Observatory: biophysics and microbiology

Zarubin Mikhail¹, Kravchenko Elena¹, Gangapshev Albert²

¹Joint Institute for Nuclear Research, Dubna, Russia
²Institute for Nuclear Research, Moscow, Russia
mzarubin@jinr.ru

Baksan Neutrino Observatory

BNO (INR RAS) was founded in the late 60-80th in the Neutrino Village (1700 m.a.s.l.) located 22 km from the highest European mountain Elbrus (5642 m, dormant volcano) under the peak of Andyrchy mountain (3937 m). Main scientific goals of BNO are related to fields of astrophysics, particle physics and nuclear physics. Moreover newer topics of interdisciplinary research are linked to geophysics, geology and biology (since 2019)



DLNP JINR Sector of Molecular Genetics of the Cell

Baksan Large Neutrino Telescope Project: Prototypes and Perspectives

Show affiliations

Lukanov, A. D.; Budzinskaya, A. A.; Gangapshev, A. N.; Gavrin, V. N.; Fazlakhmetov, A. N.; Ibragimova, T. V.; Kazalov, V. V.; Kuzminov, V. V.; Lubсандорзиев, B. K.; Malyshekin, Yu. M.; Nanzanov, D. A.; Novikova, G. Ya.; Petkov, V. B.; Shikhin, A. A.; Sidorenkov, A. Yu.; Smirnov, O. Yu.; Ushakov, N. A.; Veretenkin, E. P.; Voronin, D. M.; Yanovich, E. A.

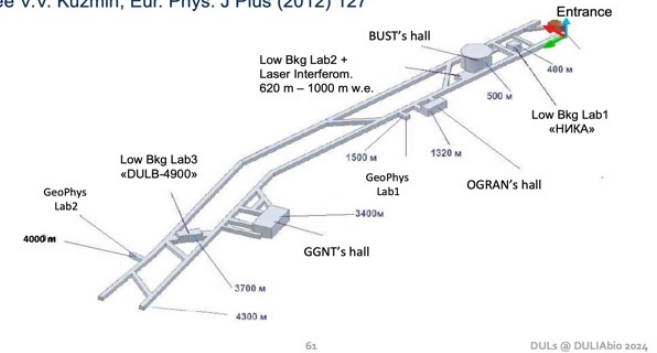
The article reports on the current status of the Baksan Large Neutrino Telescope project and describes some selective results of the first stage of the project, a detector prototype with a liquid scintillator mass of 0.5 tons. The results of the second stage of the project, a prototype with liquid scintillator mass of 5 tons, and project prospects also presented.

Publication: Physics of Atomic Nuclei, Volume 86, Issue 6, p.1380-1384
Pub Date: February 2024
DOI: [10.1134/S1063778823060182](https://doi.org/10.1134/S1063778823060182)
Bibcode: 2024PAN...86.1380L

<https://indico.stfc.ac.uk/event/1058/>

Laboratory structure at Baksan

See V.V. Kuzmin, Eur. Phys. J Plus (2012) 127



Scientific program at Baksan: highlights

- + BUST (Baksan Underground Scintillation Telescope)
 - study of cosmic rays with surface and underground detectors
 - gravitational collapse supernova rate < 0.07/year (90% CL)
- + GGNT (Gallium-Germanium Neutrino Telescope)
 - Solar neutrinos observatory
 - BEST (Baksan Experiment on Sterile Transitions) with ⁵¹Cr source (3.4 Mci) and 0.6-1m baseline
- + LBR (Low Background Researches)
 - Investigation of rare decay processes (DBD and DM)
- + LGG (Laboratory for Geophysics)
 - Geophysics and gravitational waves
- + New:
 - cryogenic laboratory for bolometers (Mo-based DBD)
 - long term: 5kt scale Borexino-like detector (prototype stage)

Misc Sources...