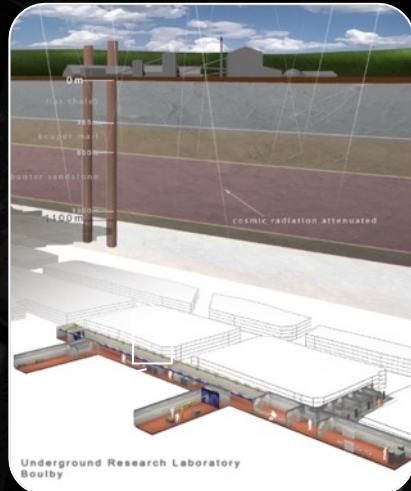




Developments in the World's Deep Underground Laboratories



Sean Paling
STFC Boulby Underground Science Facility



Developments in the World's Deep Underground Laboratories

Overview of status & future plans of (some of) the world's underground facilities...



Europe

- Gran Sasso
- Modane
- Canfranc
- Boulby

Asia

- Kamioka
- Jinping
- Yangyang
- INO

North America

- SNOLAB
- SURF
- Soudan
- WIPP

Southern Hemisphere

- Andes
- Stawell

Lots going on. Many and varied science projects and laboratories progressing and emerging.

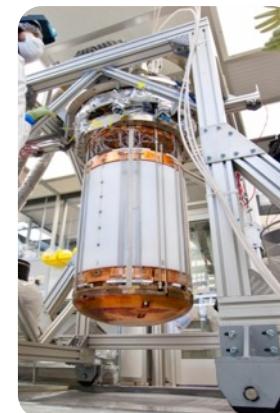


Deep Underground Science

Why go to Underground Laboratories?...

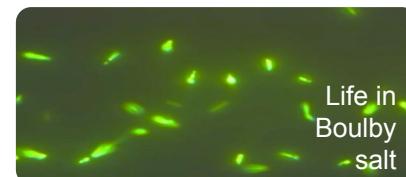
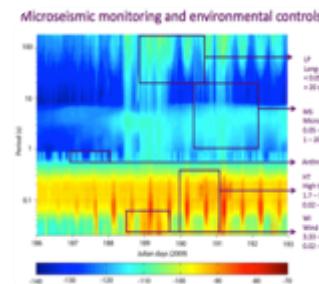
Low Background Particle / Astroparticle Physics

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



Other 'Multi-disciplinary' studies

- Cosmic rays studies
- ULB Gamma counting & spectroscopy
- Misc. Geology/geophysics
- Geo-microbiology & life in extreme environments
- Astrobiology
- Etc...



What Makes a Good Underground Laboratory?

Low Backgrounds...

Cosmic ray Muons...

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

Neutrons...

Production from

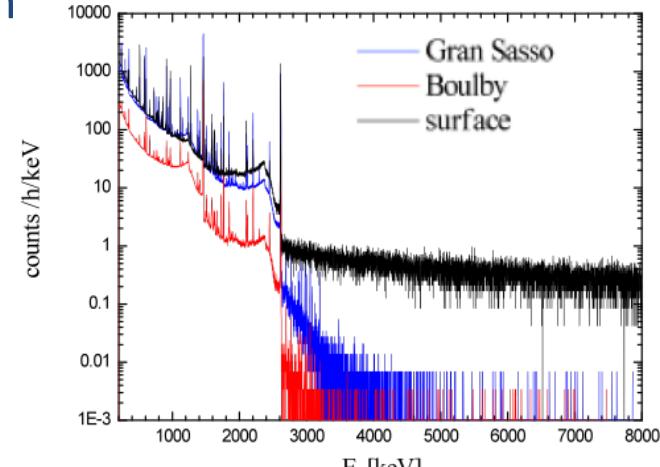
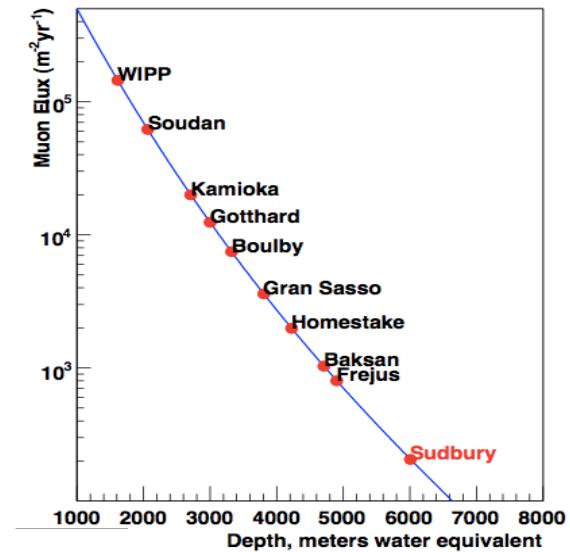
- c.r. muon spallation
- U/Th fission
- α , n reactions

Gammas....

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

Radon....

- Dependent on local geology & ventilation





What Makes a Good Underground Laboratory?

Other Factors

Science and operations support:

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

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

Other Facility Characteristics:

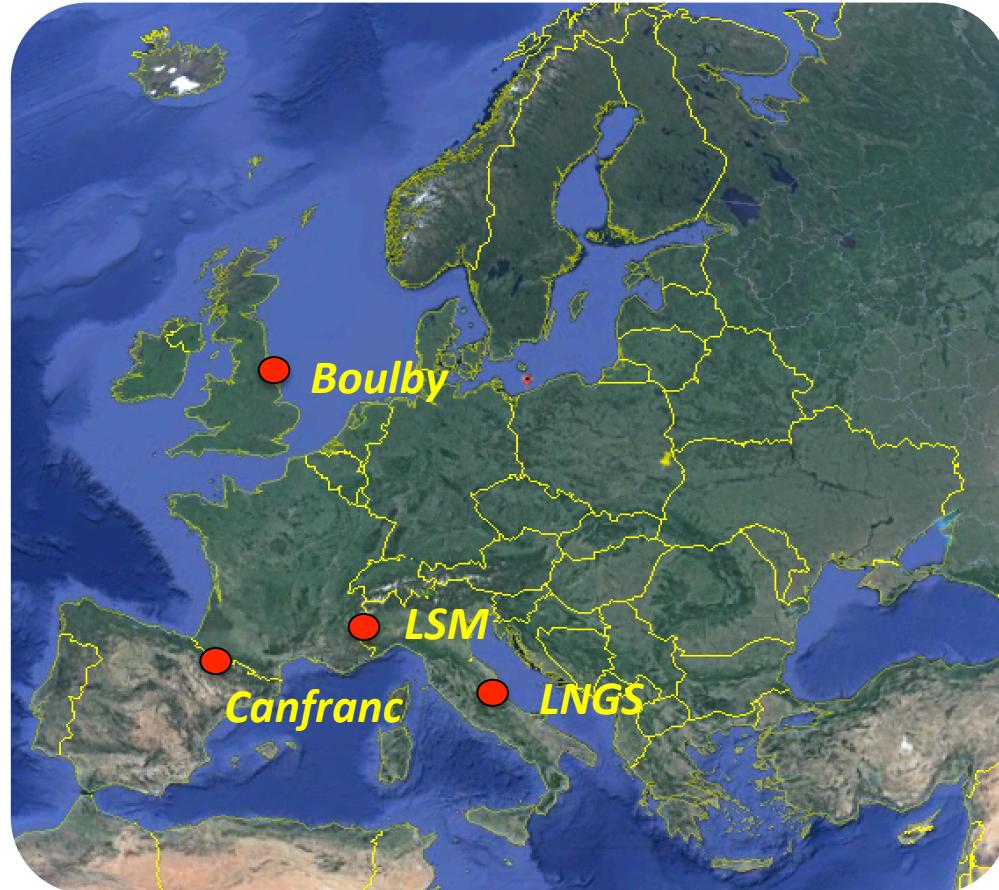
- Size (monolithic or distributed; Space available)
- Ease of Access (vertical or horizontal); Max installation size limitations
- Location (neutrino flux from beam, reactor, Earth, ease of access, quality of life)
- Cleanliness and radiological interference
- Suitability of geology etc

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



European Labs

- *Boulby*
- *Modane (LSM)*
- *Canfranc*
- *Gran Sasso (LNGS)*



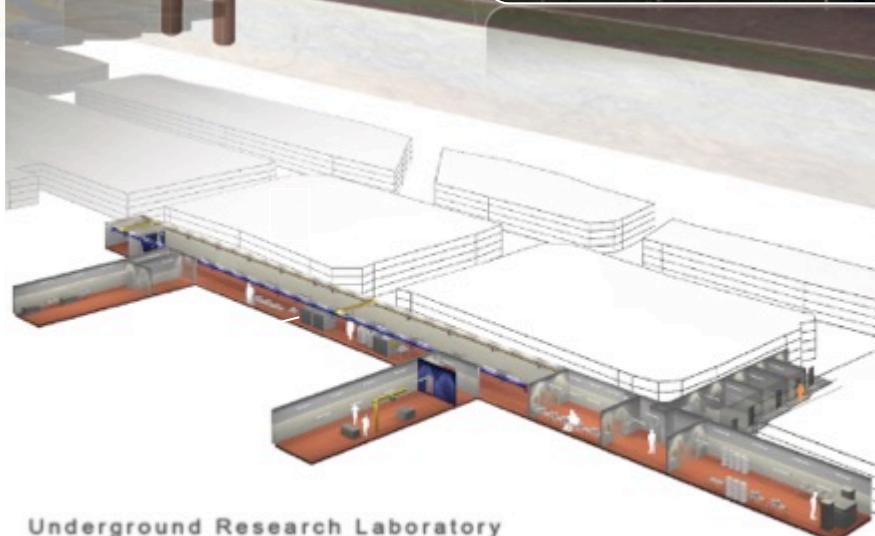


Boulby Underground Laboratory

The UK's deep underground science facility operating in a working potash and salt mine.

Operated by the UK's Science & Technology Facilities Council (STFC) in partnership with the mine operators ICL

1.1km depth (2805 mwe).
Cosmic ray muon flux reduced
by factor ~1 Million



Underground Research Laboratory
Boulby



Boulby Palmer lab. >1000m² floor space.
Operating since 2001

S.M.Paling - Boulby@stfc.ac.uk

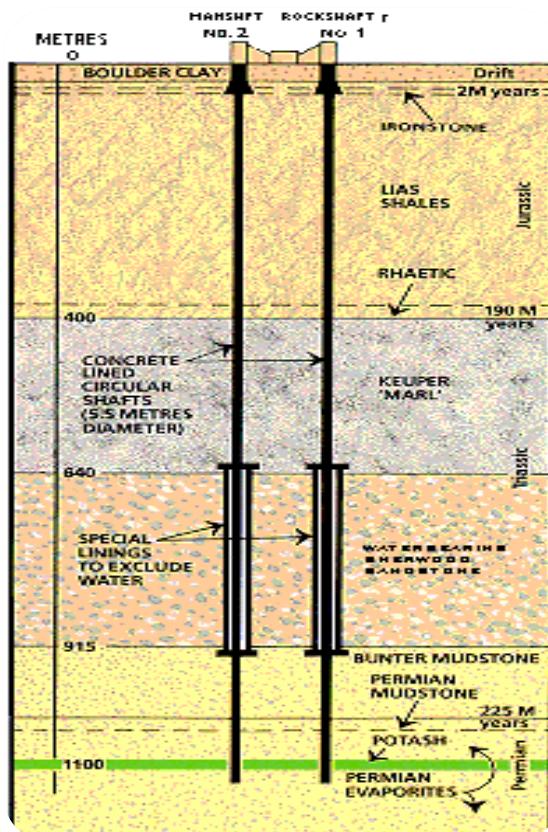




Boulby Geology & Mining

Excavations are in Salt (NaCl) & Potash (KCl) Permian evaporite layers left over from the Zechstein Sea.

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



Boulby
Geology

U: 67 ± 6 ppb
Th: 125 ± 10 ppb
Low γ & n backgrounds
Low Rn (<3 Bqm $^{-3}$)

Rock-Salt



Potash



Underground Science @ Boulby Mine

- DRIFT: Directional Dark Matter Search
- DM Ice: NaI(Tl) Dark Matter detector
- Ultra-low background material screening
- Deep Carbon: Muon Tomography for CCS (etc)
- ERSaB: Environmental gamma spectroscopy
- BISAL: Geomicrobiology / Astrobiology studies
- MINAR: Space Exploration Tech. Development
- Misc. Geology / Geoscience
- Misc. Low-background support projects
- Etc... (More to come).

A growing **multi-disciplinary** science programme:
from astro-particle physics to studies of geology,
climate, the environment, life on Earth & beyond.





Boulby Dark Matter Studies

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

Boulby now hosts two on-site dark matter studies (**DRIFT & DM-Ice**) & provides ULB material screening for other studies, inc **LUX-ZEPLIN**

ZEPLIN: *The world's first 2-phase Xenon dark matter detector (Finished 2011)*



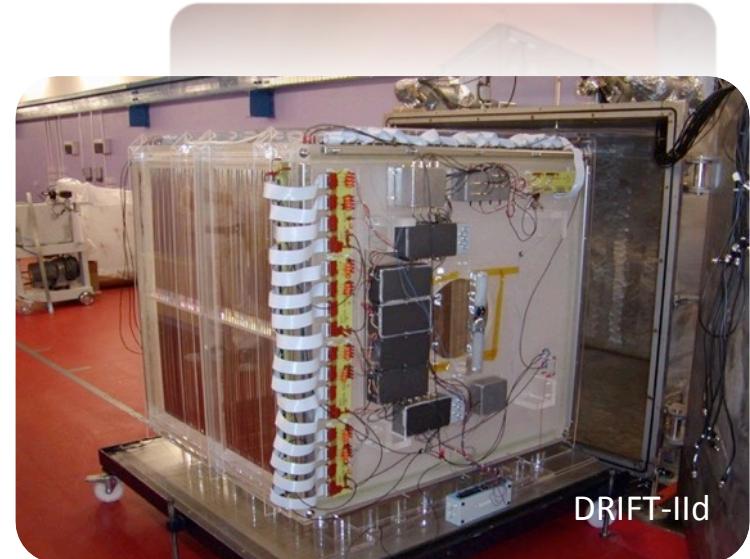
ZEPLIN-III @ Boulby



DM-Ice: R&D for NaI(Tl) array for studying WIMP annual modulation



Wisconsin, Yale,
FNAL, Illinois,
Alberta, Sheffield,
Boulby



DRIFT-III

DRIFT: Negative Ion drift low pressure TPC
directional dark matter detector

Occidental College, New Mexico, Colorado State, Hawaii,
Wesley Coll. Sheffield, Edinburgh, Boulby
Tokyo May 2016



ULB Material Screening

Growing suite ('BUGS') of Ultra-Low-Background germanium detector systems to support Dark Matter & misc 'rare-event' studies...



Boulby Underground
Germanium Suite (BUGS)



Activity testing steel
samples

- Ortec 2kg Coax (90% eff).
- 2 Canberra BEGe detectors
- Canberra SAGe Well-type

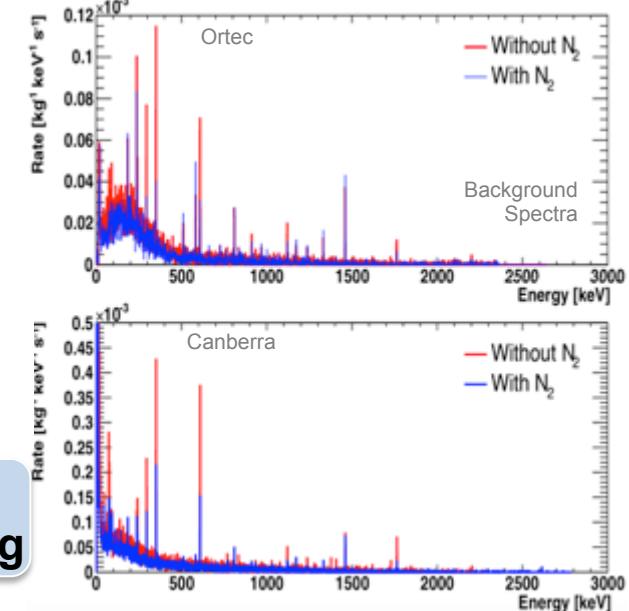
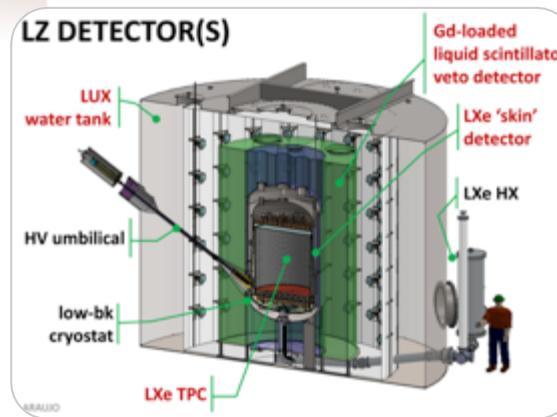
Sensitivity down to <50ppt
U/Th per sample, & improving

ULB counting studies supporting
UK DM studies (**LZ**, **DRIFT**) &
others (**Super-K**, **SuperNEMO**).

Now **EXPANDING** low BG
counting capabilities to meet
international demand.

Working in collaboration with
UCL, Oxford, STFC-RAL

Boulby undertaking major role in material
selection for **LUX-ZEPLIN** d labs



Sean.Paling@stfc.ac.uk, kng@stfc.ac.uk

Tokyo May 2016



Expanding Multi-Disciplinary Studies



ERSaB: Gamma spectroscopy & low background counting environmental radioactivity studies

*Boulby, Scottish Universities Env.
Research Ctr (SUERC)*

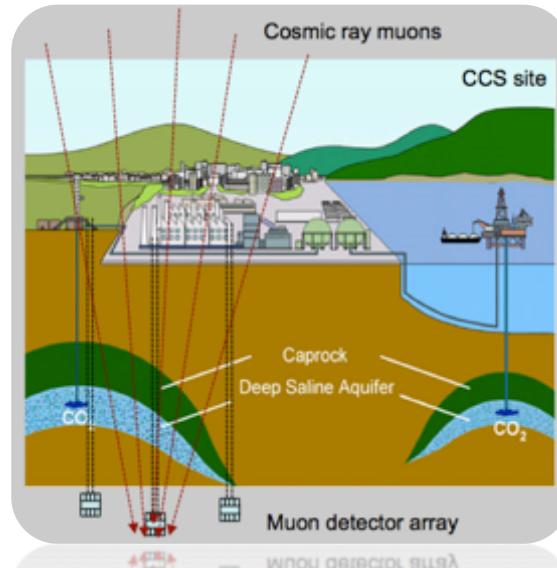


S.M.Paling - Boulby@stfc.ac.uk

DEEP-Carbon: Muon Tomography for deep geological mapping applications including CCS



*Boulby, Durham,
Sheffield, Bath,
Premier Oil, CPL.*



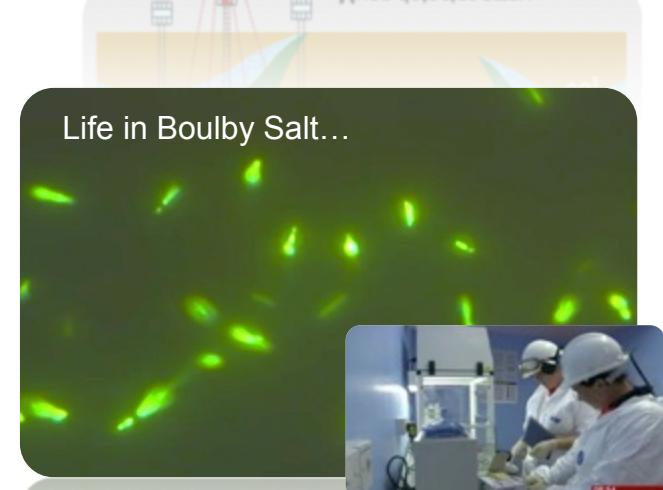
**From astrophysics to climate,
geology, the environment,
life on Earth & beyond...**

MINAR: Space Technology Development

*Boulby,
Edinburgh, NASA,
DLR, CPL etc.*

Plus Misc. Geology &
Geoscience (& more to
come)...

Life in Boulby Salt...

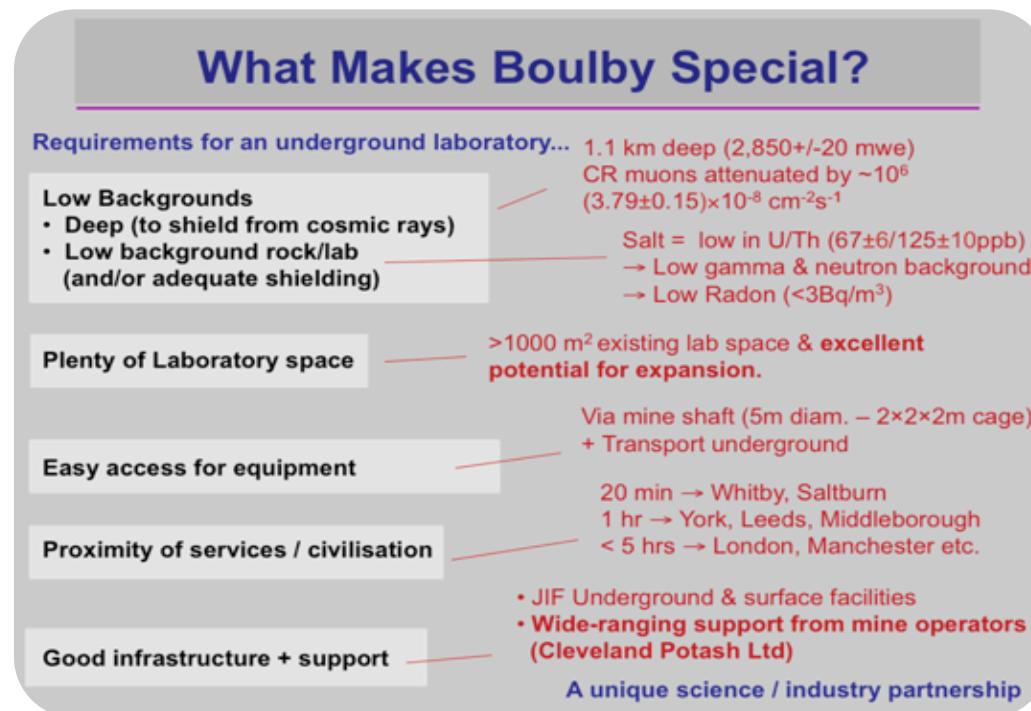


BISAL: Astrobiology / Geo-microbiology. Studies of life in salt, life on Earth & beyond

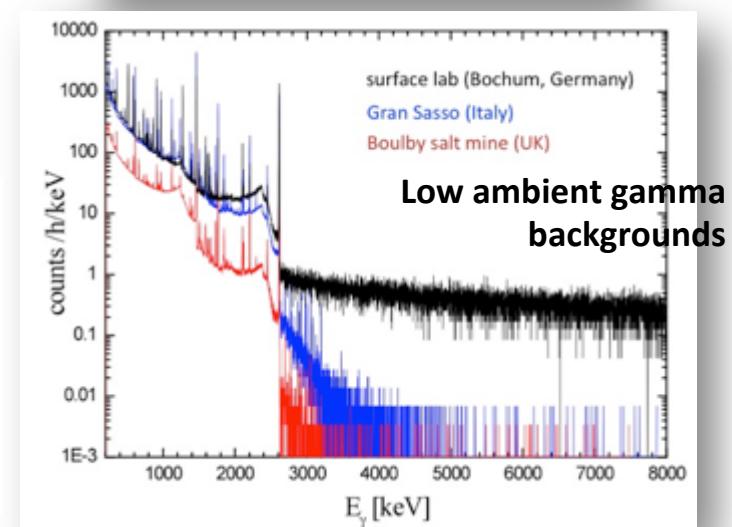
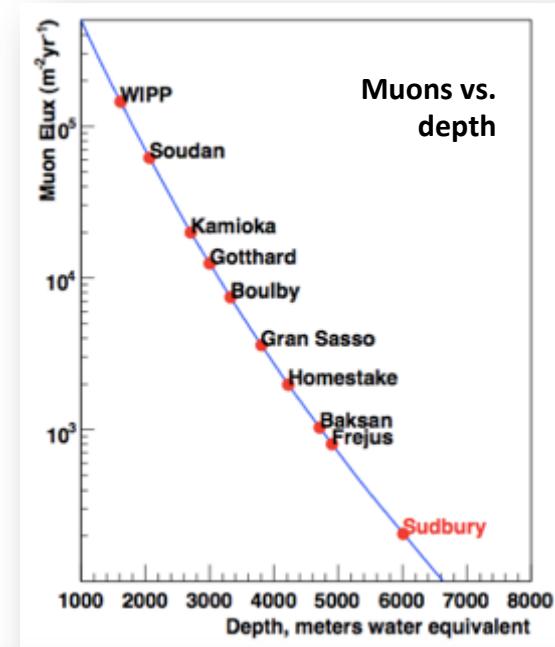


How does Boulby compare?

- 7 onsite staff supporting 70 users from 20 UK & international universities and research institutes



- **VERY low ambient Radon background:** <3 Bq/m³
- **Good location (close to cities / services)**
- **Interesting geology: diverse science programme**
- **Good potential for expansion...**

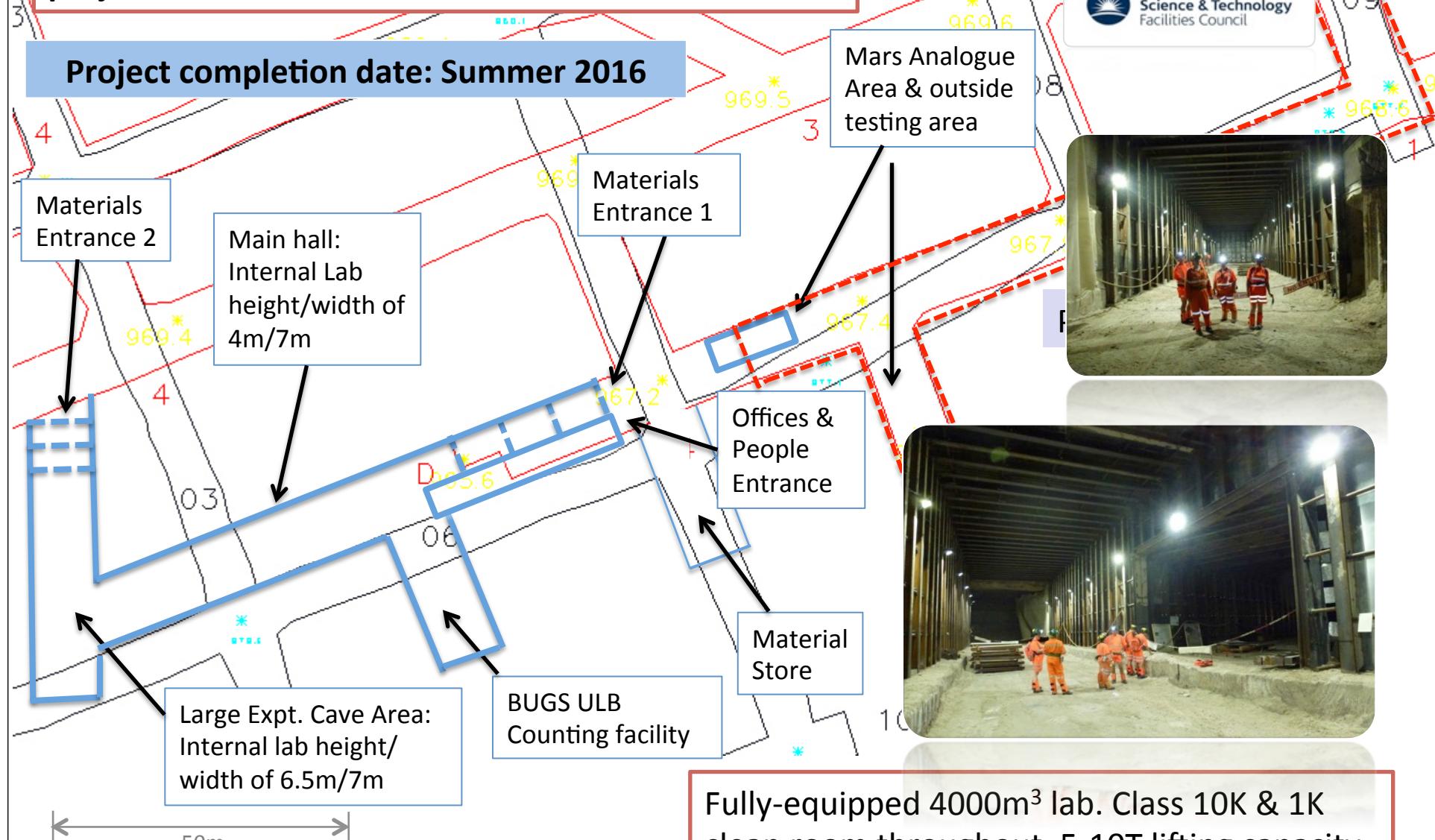


A NEW LABORATORY now being built at Boulby

To replace current facility and host **planned & new projects** for the next decade and more...



Project completion date: Summer 2016



Fully-equipped 4000m³ lab. Class 10K & 1K clean room throughout. 5-10T lifting capacity.

Sean Paling – sean.paling@stfc.ac.uk

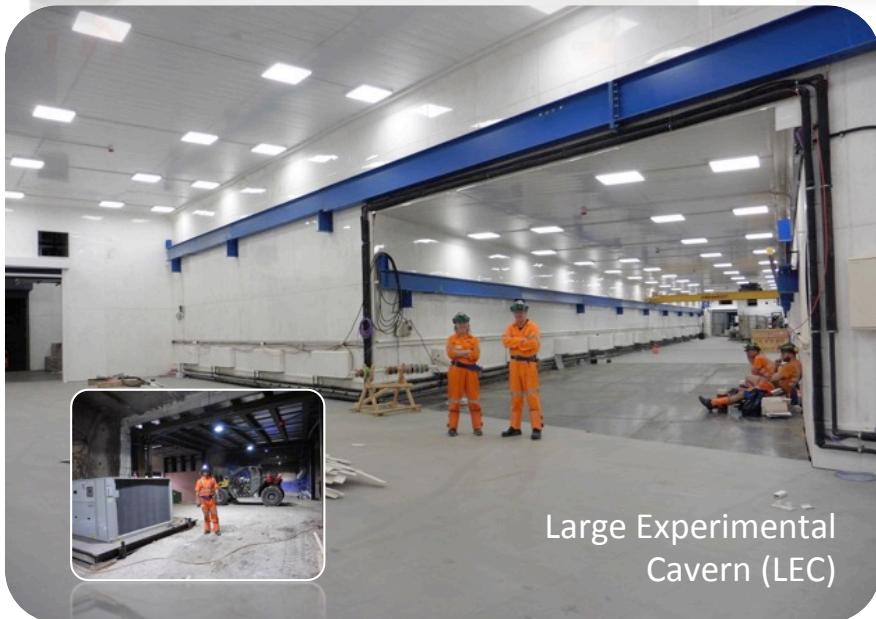


Main Experimental Hall



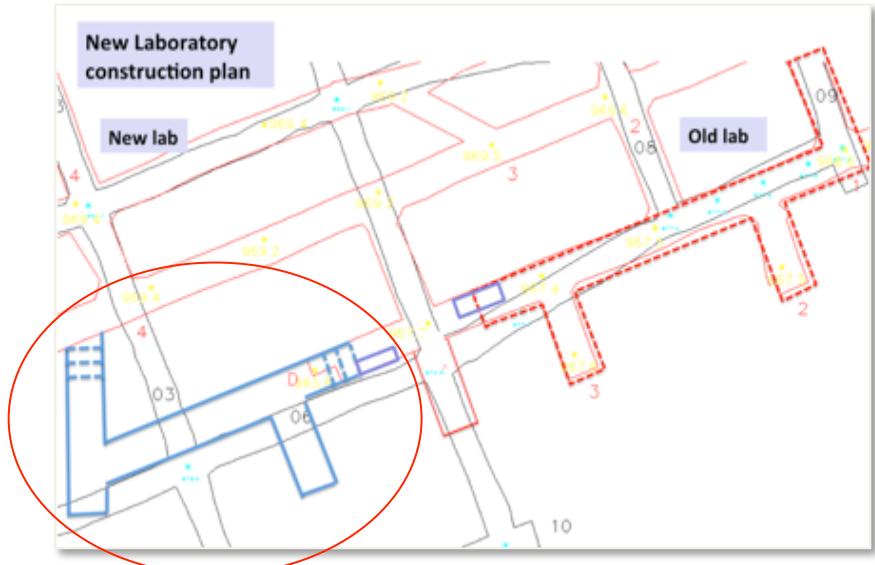
Boulby New Lab
Construction
March 2016

> 4500m³ of well supported class 1,000 and
class 10,000 clean room experimental space



Large Experimental Cavern (LEC)

Air conditioning, HEPA filtration, internet / comms, 5 & 10 Tonne lifting capacity.



Beginning to move experiments in Jan 2016



Laboratoire Souterrain de Modane

Road tunnel under Alps
between France & Italy

Access: **Horizontal**. Drive

Depth: 4800 m.w.e.

Muon flux: $4 \cdot 10^{-5} \mu\text{m}^{-2}\cdot\text{s}^{-1}$

Neutrons:

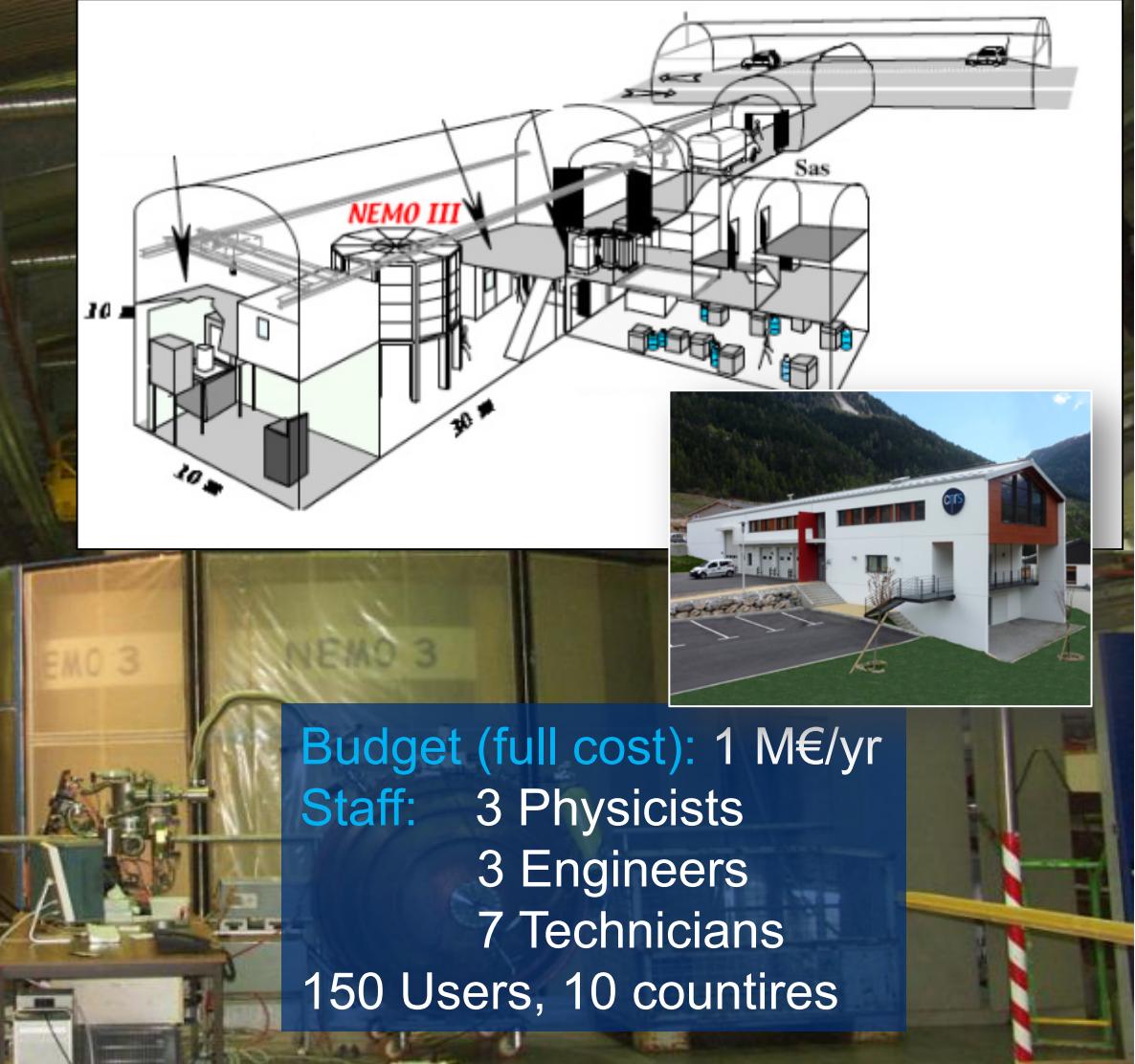
Fast flux: $4 \cdot 10^{-2} \text{n.m}^{-2}\cdot\text{s}^{-1}$

Thermal flux: $1.6 \cdot 10^{-2} \text{n.m}^{-2}\cdot\text{s}^{-1}$

Radon: 15 Bq/m^3

UG Lab Volume : 3500 m^3

Surface: 400 m^2



Budget (full cost): 1 M€/yr

Staff: 3 Physicists

3 Engineers

7 Technicians

150 Users, 10 countries

International associated laboratory agreement with JINR Dubna (Russia) and
CTU Prague (Czech Republic)

Modane UG Laboratory

From a particle physics experiment to a multi-science platform

1979 - 1981

1982- 1990

1990- 2000

2000 -



Construction

τ_p Experiment

Prototypes

Experiments

Fundamental physics:

- Neutrino: double beta decay
(NEMO3->SuperNEMO)
- Dark matter (EDELWEISS,
SEDINE, MIMAC)
- Nuclear structure (TGV, SHIN)

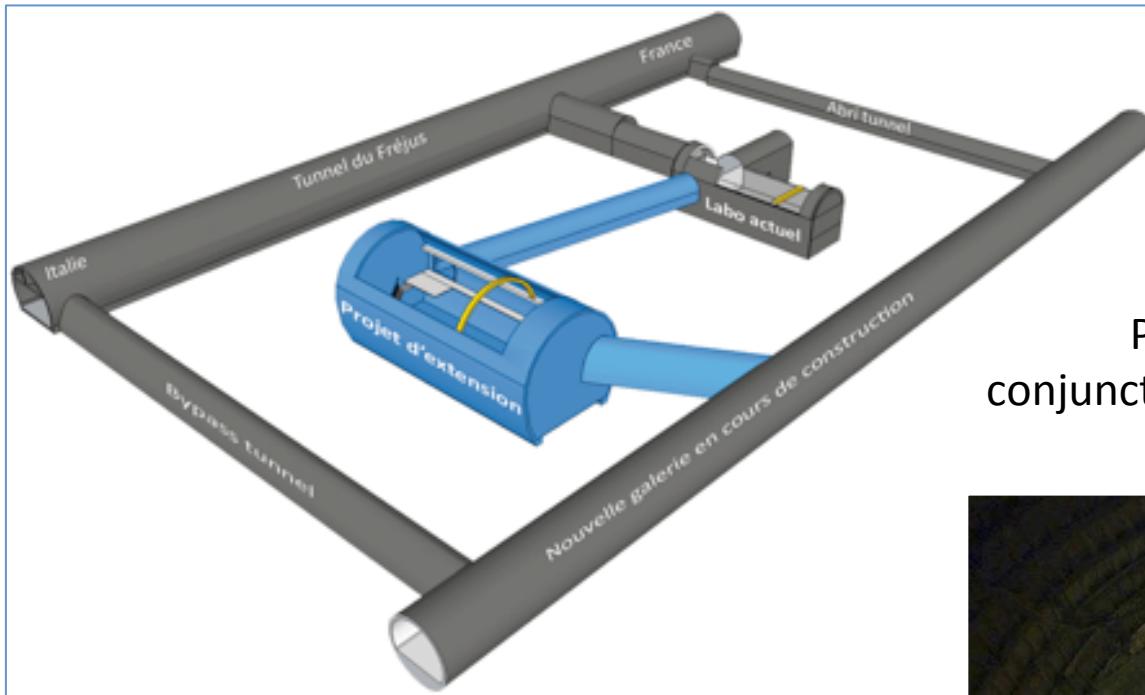
Multidisciplinary activities

- Ultra low radioactivity measurements
Environmental sciences, applications, expertises
- Logical test failures in nano/micro-électronics
- Biology



LSM Extension Project: DOMUS

DOMUS extension project 14 000 m³ (X4 present LSM)



Proposed New Cavity:
Length 40 m, width 18 m,
height 16 m . 12,000m³
(4x current lab)

Proposed work to be undertaken in conjunction with funded (nearly complete) excavation of new roadway

Detailed studies funded by Savoie department and Rhône-Alpes Region

Agreement from Ministry and CNRS for the project

Funding almost secured (85% already obtained
CNRS, Region Rhône-Alpes, FEDER funds)





Laboratorio Subterráneo de Canfranc

Horizontal access
laboratory in road and rail
tunnel between Spain &
France

Overburden: ~2450 mwe
Muon Flux: $2 \times 10^{-3} \text{ m}^2\text{s}^{-1}$
Neutrons (>1 MeV): $3.5 \times 10^{-3} \text{ m}^2\text{s}^{-1}$
Radon: 50-100 Bq.m⁻³

UG Lab vol: 10,000m³
Personnel: 10
Budget: ≈ 1.6 M€/yr
Users: 275 (19 countries)





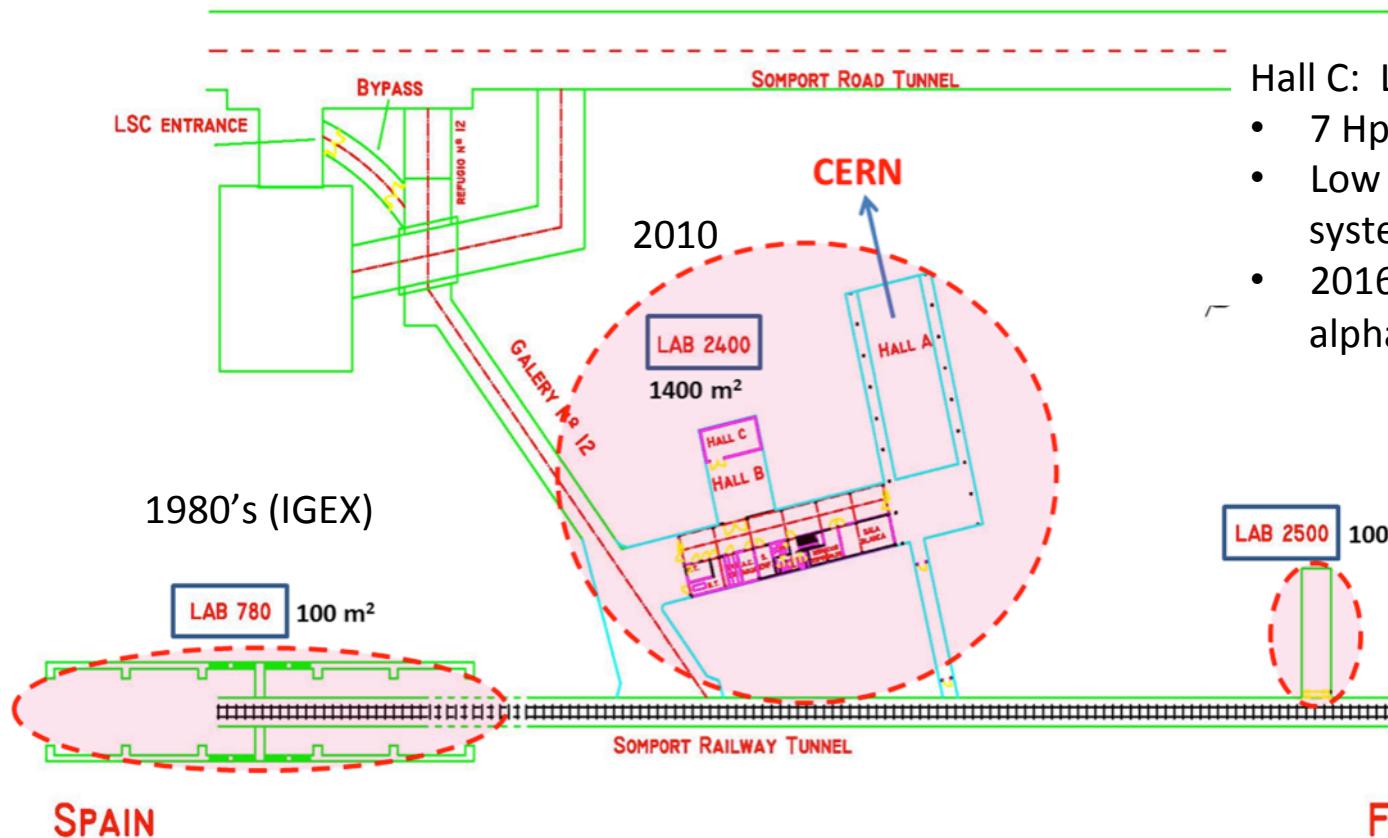
LSC Underground

Two main Halls

- Hall A (length: 40 m, width 15 m, height: 12 m)
- Hall B (length: 15 m, width 10 m, height: 8 m)

Total Volume: 10,000 m³

Hall A



Hall C: LB Screening facility:

- 7 HpGe with a few mBq/kg
- Low background α/β counting system
- 2016: SAGe well detector & an alpha spectrometer



FRANCE

LSC Experiments

- Experiments:

- ✓ **ANALIS** DM (NaI, Annual modul.)
- ✓ **ArDM** DM (2phase Ar TPC) 800 kg
- ✓ **NEXT** $0\nu 2\beta$ (Enr ^{136}Xe gas TPC)
- ✓ **BiPo** $0\nu 2\beta$ (screening for S-NEMO)
- ✓ **SuperK-Gd** Ge screening for Super-K-Gd
- ✓ **GEODYN** Geodynamics, seismic studies

NEXT 10kg demonstrator enr. ^{136}Xe gas TPC



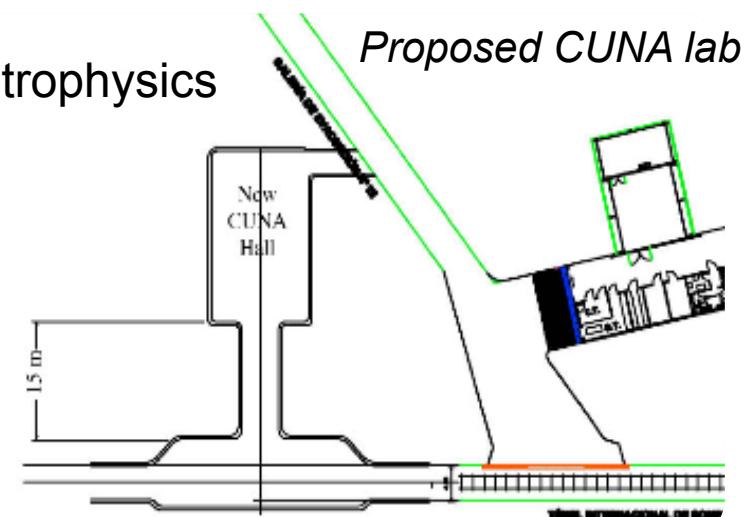
-Expressions of Interest

- ✓ **CUNA** 3MeV accelerator for nuclear astrophysics
- ✓ **GOLLUM** Subterranean bacteria studies

Lab Space available....

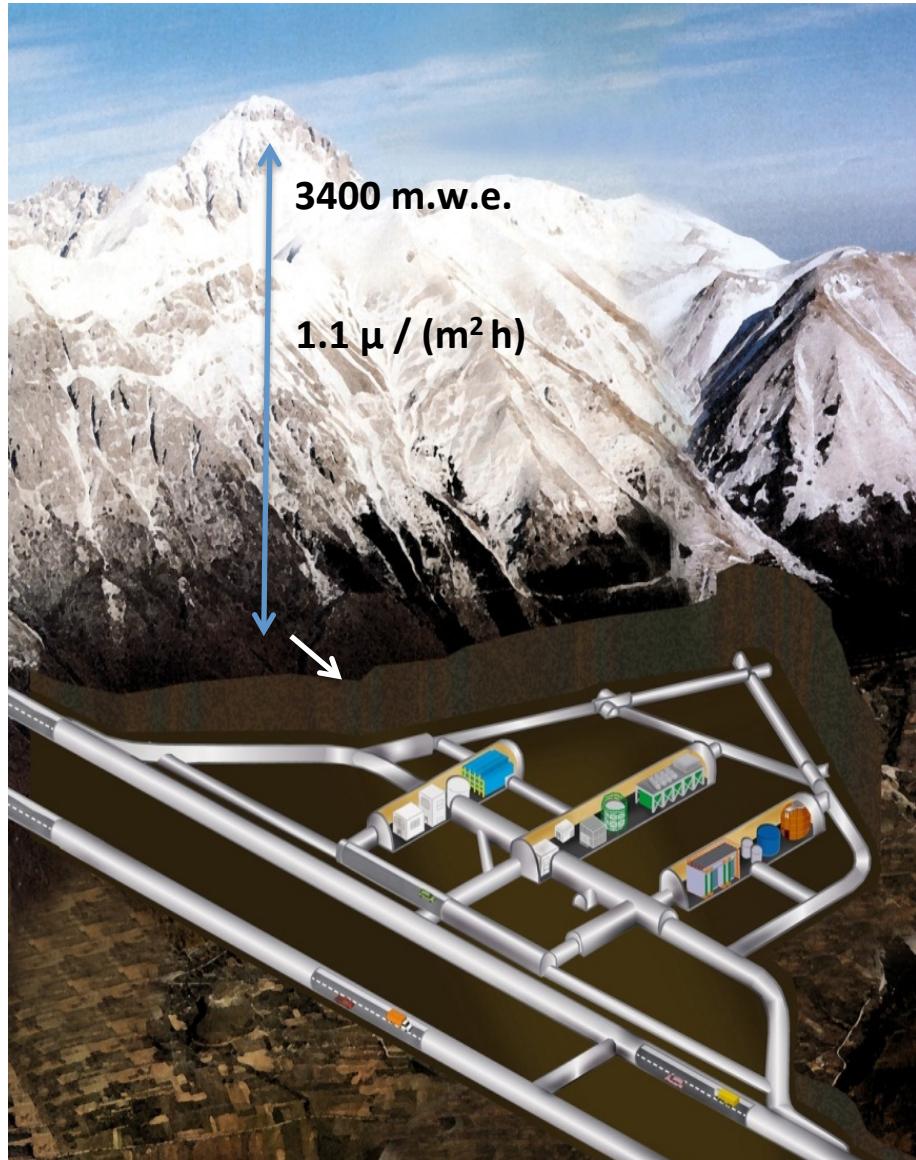
1/3 of Hall A, ½ of Hall B

**New 2300m³ lab proposed for CUNA
(2016-2020?)**



Laboratori Nazionali del Gran Sasso

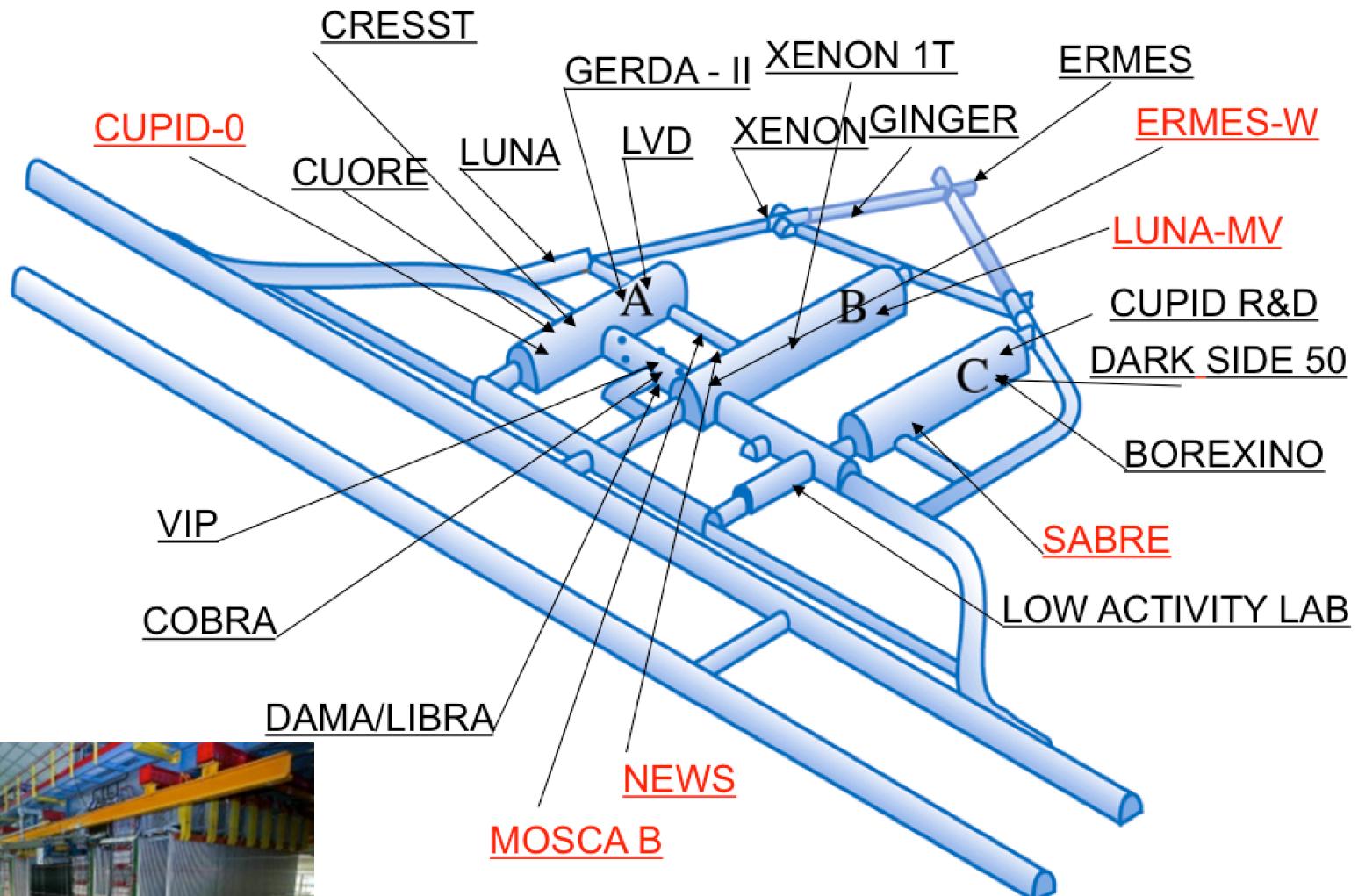
- **Horizontal access**
- **Volume: 180 000 m³**
- **Overburden 3400 m.w.e**
- Muon flux: $3.0 \cdot 10^{-4} \text{ m}^{-2}\text{s}^{-1}$
- Neutron flux:
 - $2.92 \cdot 10^{-6} \text{ cm}^{-2}\text{s}^{-1}$ (0-1 keV)
 - $0.86 \cdot 10^{-6} \text{ cm}^{-2}\text{s}^{-1}$ ($> 1 \text{ keV}$)
- Rn in air: $20\text{-}80 \text{ Bq m}^{-3}$
- Ventilation: 1 vol / 3.5 hours
- **~ 100 Staff**
- **> 900 users from 29 countries**
- 225 avg. daily presence in 2014
- **~ 8000 visitors/yr**
- **Virtual tour via Street View**





LNGS Activities

Overburden
3400 m.w.e



Hall C (~100x20x18m)

Total Lab Volume: 180 000 m³

LNGS Neutrino Studies

- SN neutrino:
 - **LVD** 1 kton liquid scint. Waiting for SN since 1992
- Solar Neutrino:
 - **Borexino**: real-time measurement of pp neutrino, Geo-neutrinos
- Double Beta Decay
 - **Gerda / Gerda-II**: ^{76}Ge
 - **CUORE** – *the coldest m³ in the world*: ^{130}Te
 - **Cobra**: ^{116}Cd
 - **LUCIFER**: R&D phase
- Sterile Neutrino
 - Borexino-SOX (CeSOX first)





LNGS Plans...

No facility expansion plans.

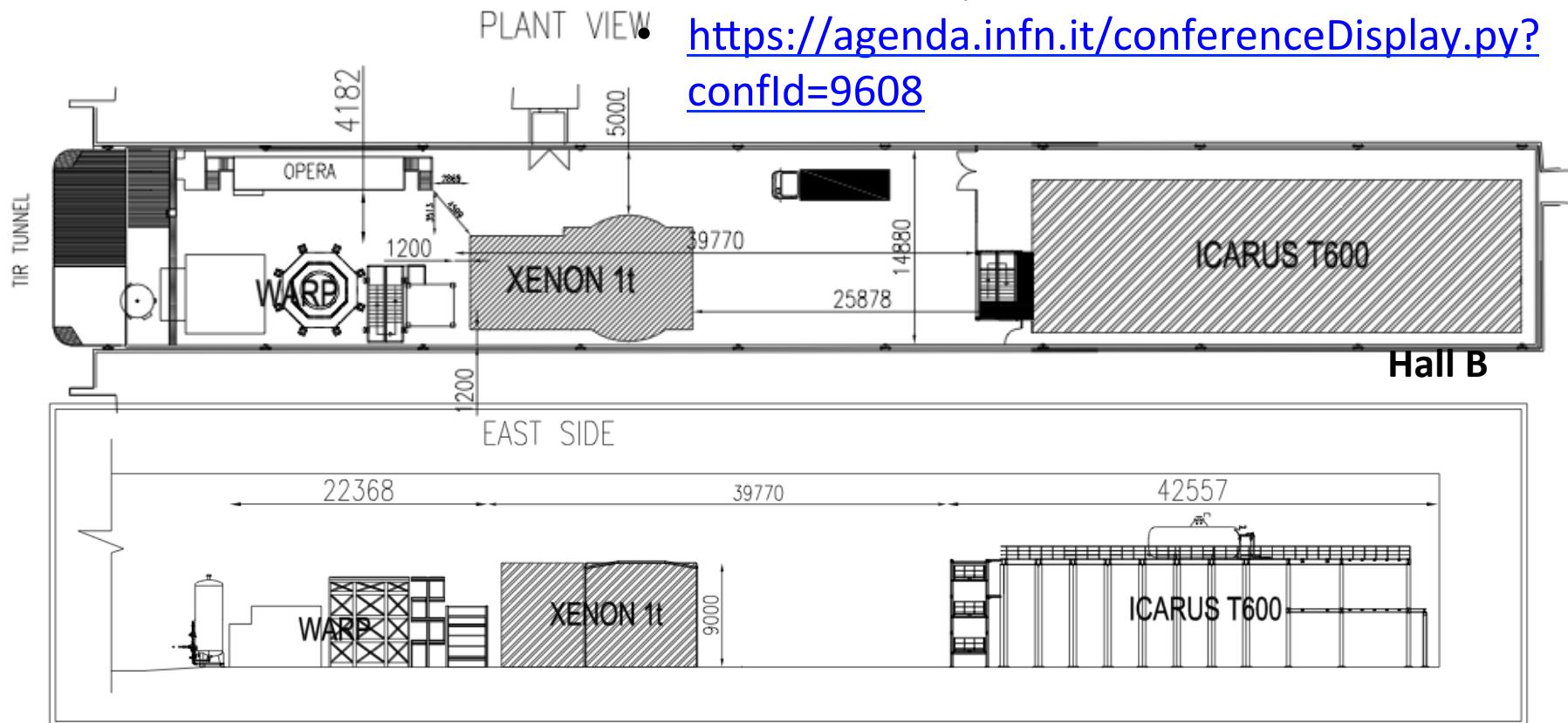
Space available?

- Two free areas in Hall-B
 - "Icarus" 65 m x 15 m
 - "Warp" 22 m x 10 m

Future activity – 2020 and beyond

- Planned extension of screening facilities
- Active Shielding in part of hall B?
- Considering locations and plans for future (post 2020) expts of Xenon-nT, Darkside, DARWIN, Solar Neutrinos, LUNA-MV etc...

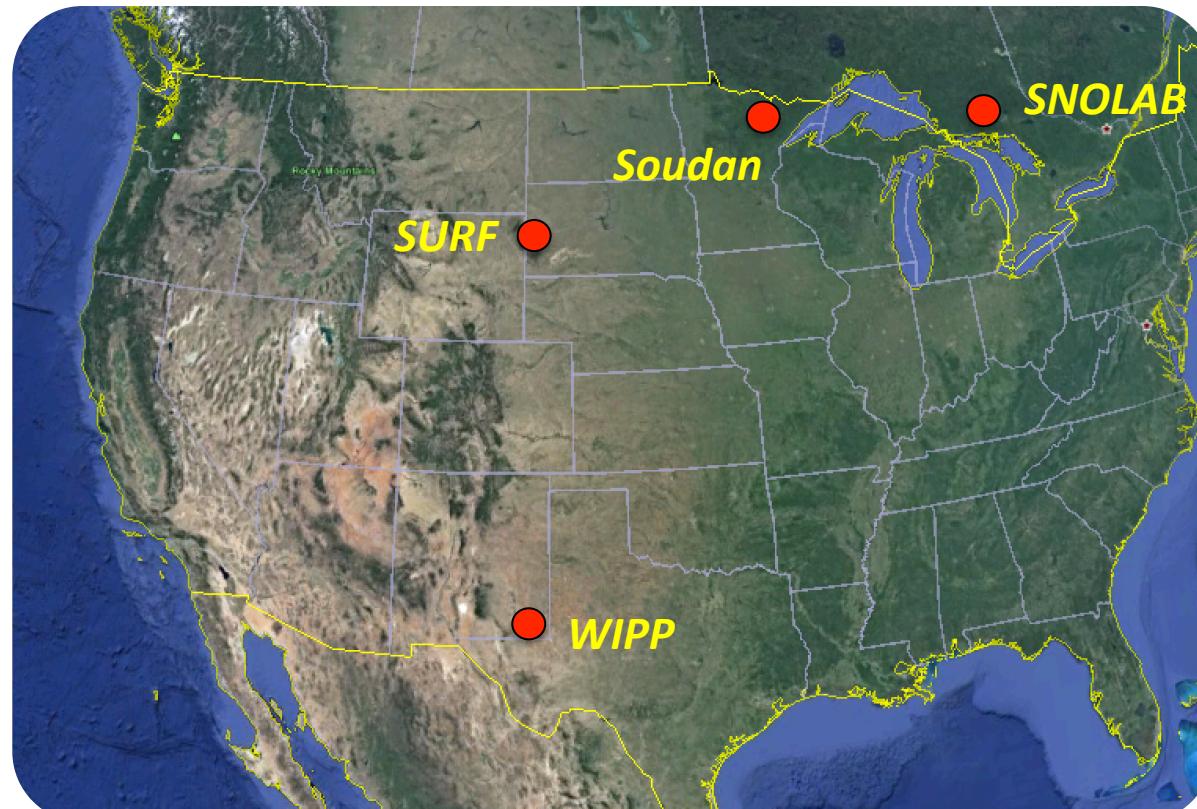
• [https://agenda.infn.it/conferenceDisplay.py?
confId=9608](https://agenda.infn.it/conferenceDisplay.py?confId=9608)





North America Labs

- *SNOLAB*
- *SURF*
- *Soudan*
- *WIPP*





SNOLAB Status Update

Nigel J.T. Smith
Director, SNOLAB

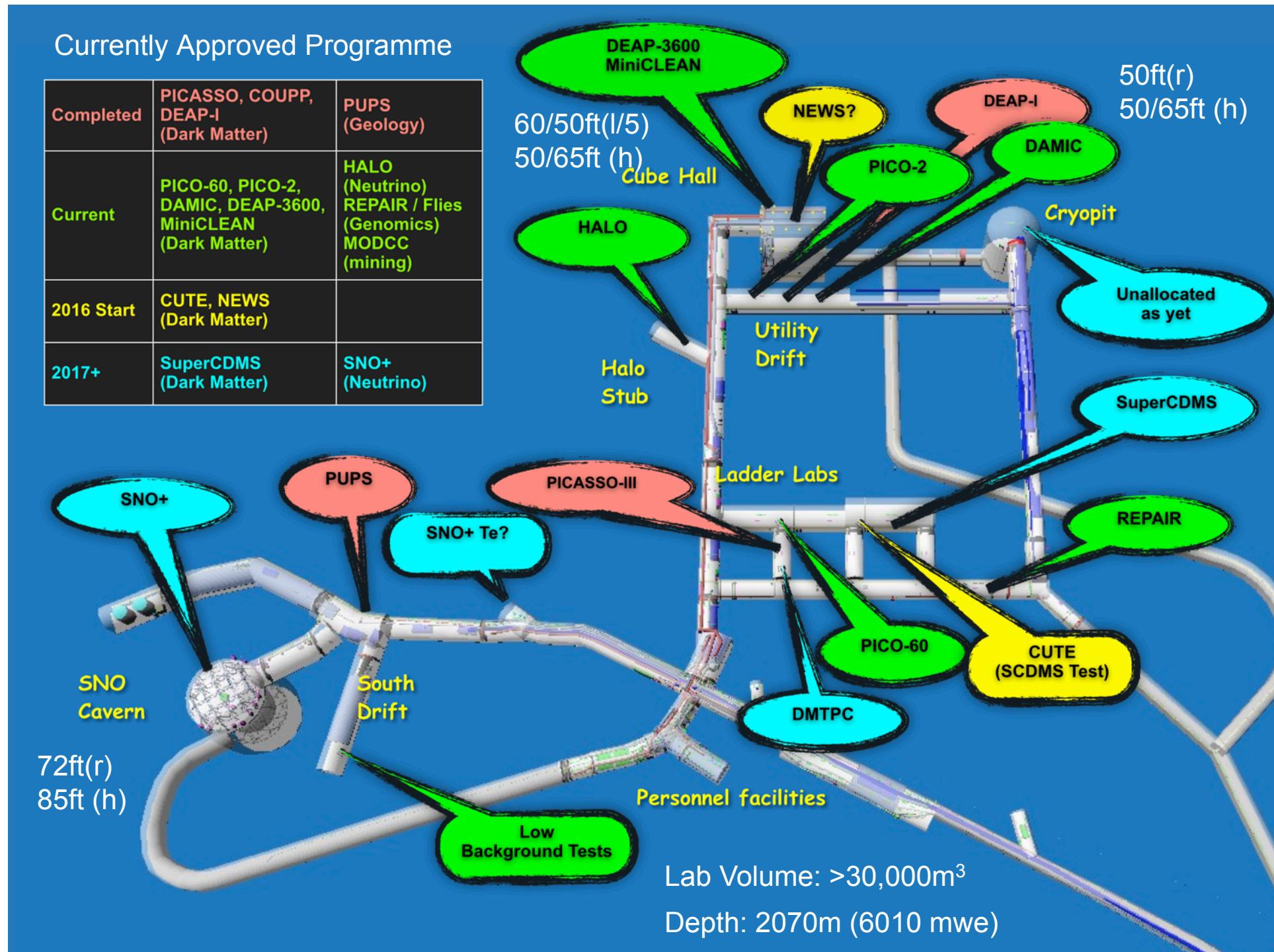


Deep Underground Science Laboratory
Vale's Creighton mine, Sudbury
Northern Ontario, Canada
2070m (6010mwe)



Currently Approved Programme

Completed	PICASSO, COUPP, DEAP-I (Dark Matter)	PUPS (Geology)
Current	PICO-60, PICO-2, DAMIC, DEAP-3600, MiniCLEAN (Dark Matter)	HALO (Neutrino) REPAIR / Flies (Genomics) MODCC (mining)
2016 Start	CUTE, NEWS (Dark Matter)	
2017+	SuperCDMS (Dark Matter)	SNO+ (Neutrino)



Current Programme

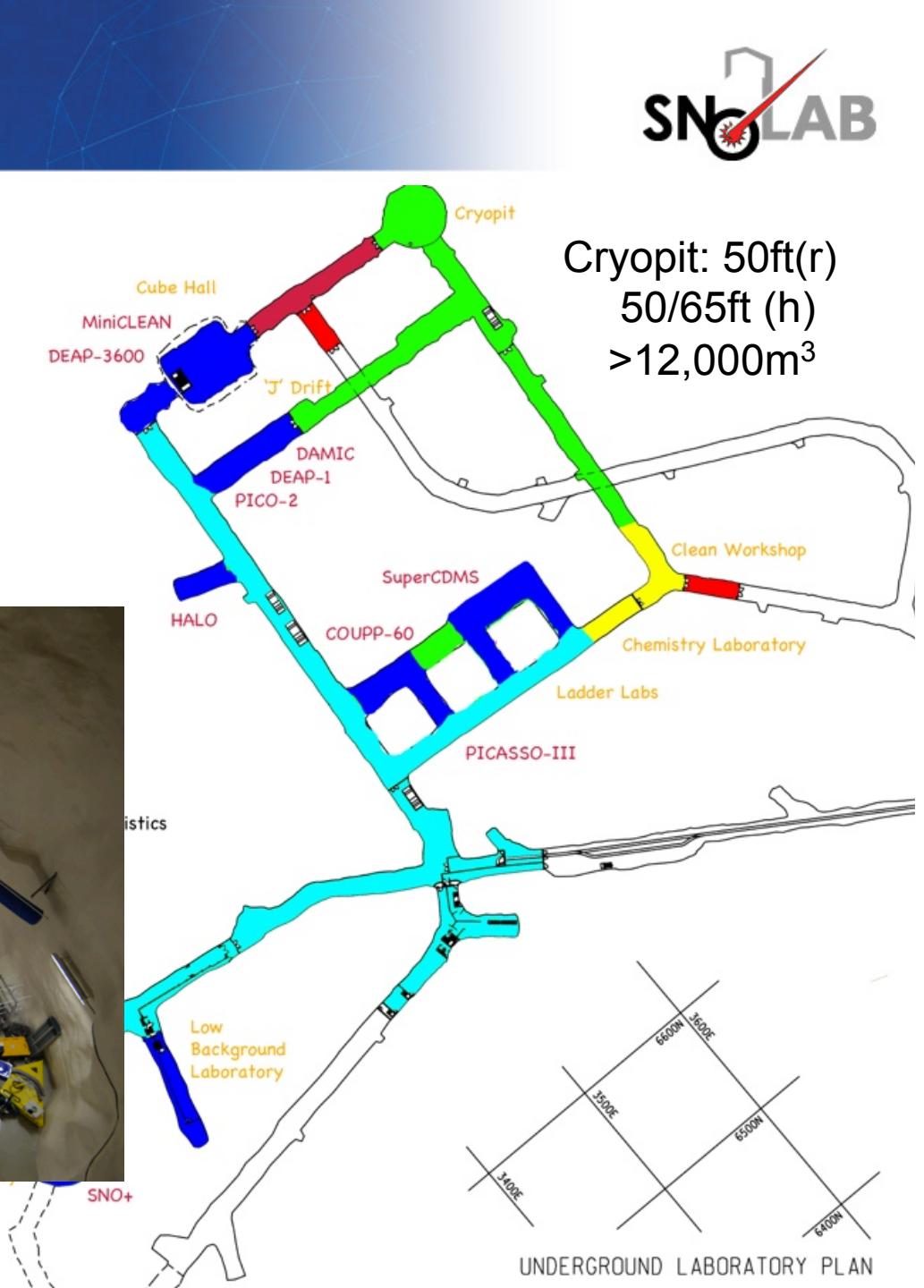
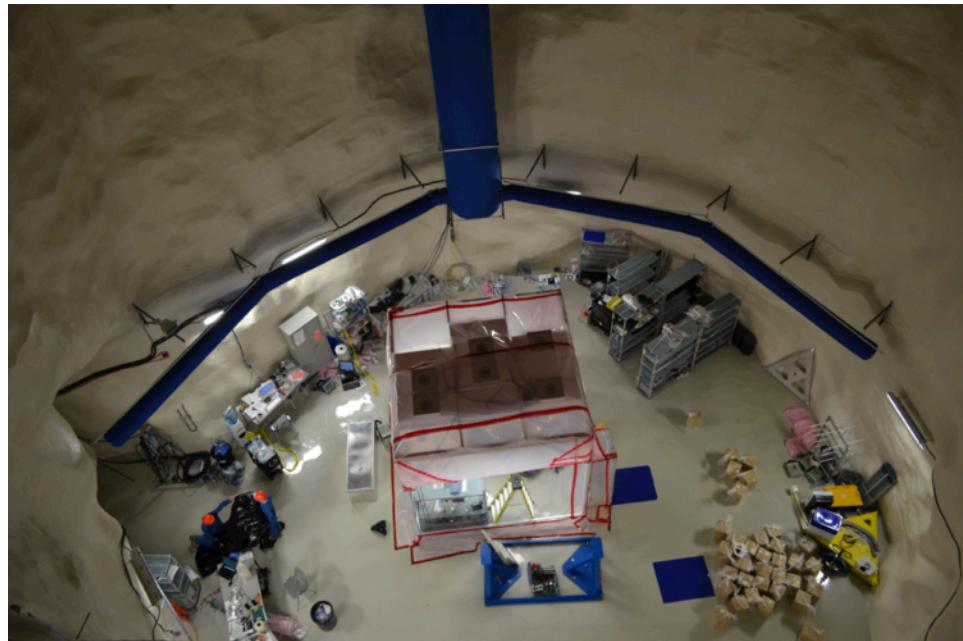


Experiment	Neutrino	Dark Matter	Other	Space allocated	Status
COUPP-4		✓		"J"-Drift	Completed
CUTE		✓	Test Facility	Ladder Labs	In Preparation
DAMIC		✓		"J"-Drift	Operational
DEAP-1		✓		"J"-Drift	Completed
DEAP-3600		✓		Cube Hall	Commissioning
DEAP-50T/CLEAN		✓		Cube Hall	Letter of Intent
DMTPC		✓		Ladder Labs	Concept Phase
DUST			Test Facility	Ladder Labs	Letter of Intent
Flies in a Mine			Genomics	External Drifts	Operational
Ge-1T	✓			Cryopit	Letter of Intent
nEXO	✓			Cryopit	Concept Phase
nEXO Shield	✓			Cryopit	Concept Phase
HALO	✓			Halo Stub	Operational
MiniCLEAN		✓		Cube Hall	Commissioning
MODCC			Mining Data Centre	Surface Facility	Operational
NEWS		✓		Cube Hall	In Preparation
PICASSO-III		✓		Ladders Labs	Completed
PICO-2L		✓		"J"-Drift	Operational
PICO-60		✓		Ladder Labs	Operational
PICO-500		✓		Ladder Labs	Letter of Intent
PUPS			Seismicity	Various	Completed
REPAIR			Genomics	Chem Labs	Operational
SuperCDMS		✓		Ladder Labs	In Preparation
SNO+	✓			SNO Cavern	Commissioning

Space is still available



- **Cryopit**
 - Currently unallocated
 - Future projects planning underway
 - Next generation 0vBB expts: nEXO, Ge-1T, Majorana?

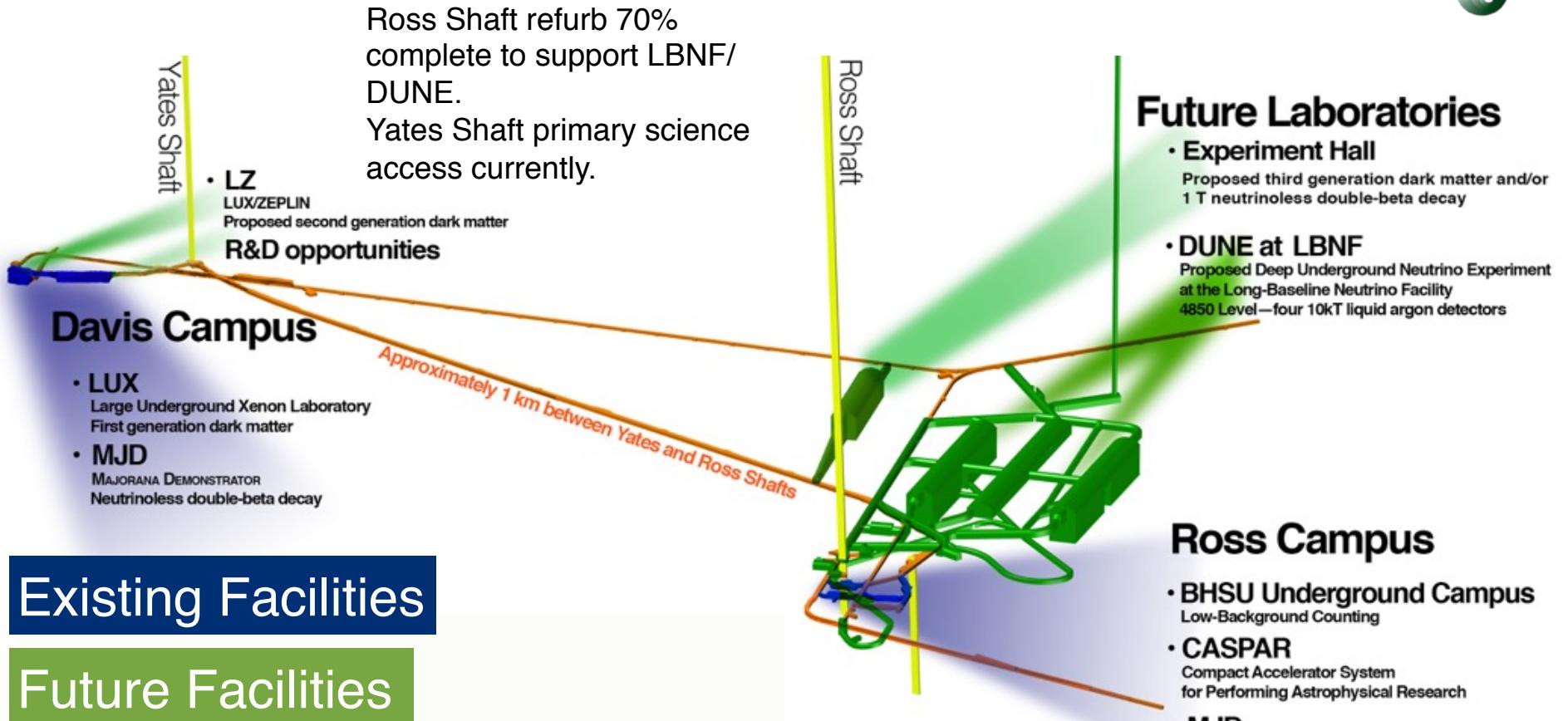


Sanford underground Research Facility



Homestake Gold Mine
Lead, South Dakota
4850ft (4300 m.w.e)

SURF 4850L Physics Laboratories



SURF is a dedicated science facility, created with the support of the NSF, UCB, South Dakota, and Private Donations. Since 2012, supported by DOE HEP and continued exceptionally strong support by South Dakota and Philanthropist T. Denny Sanford

Heise, AIP Conf. Proc. **1604** 331 (2014);
also arXiv:1401.0861v1 (2014)

Lesko, Euro Phys J Plus **127**, 107 (2012)

Current Underground Physics Program



MAJORANA DEMONSTRATOR (MJD):

Multi-Ge detector experiment studying neutrino mass & the imbalance of matter/antimatter in the universe.

First module (29 detectors) installed in the lead/copper shield. Module 2 nearing completion. Physics data in 2016.

Large Underground Xenon (LUX):

Direct detection of dark matter. 2-Phase LXe
300-day data run recently completed.

LZ G2 detector to deploy in Davis Campus after LUX.



Compact Accelerator System for Performing Astrophysical Research (CASPAR):

Studying nuclear reactions in stars.

Accelerator assembly in process. Operations in 2016.

Black Hills State Univ. Underground Campus:

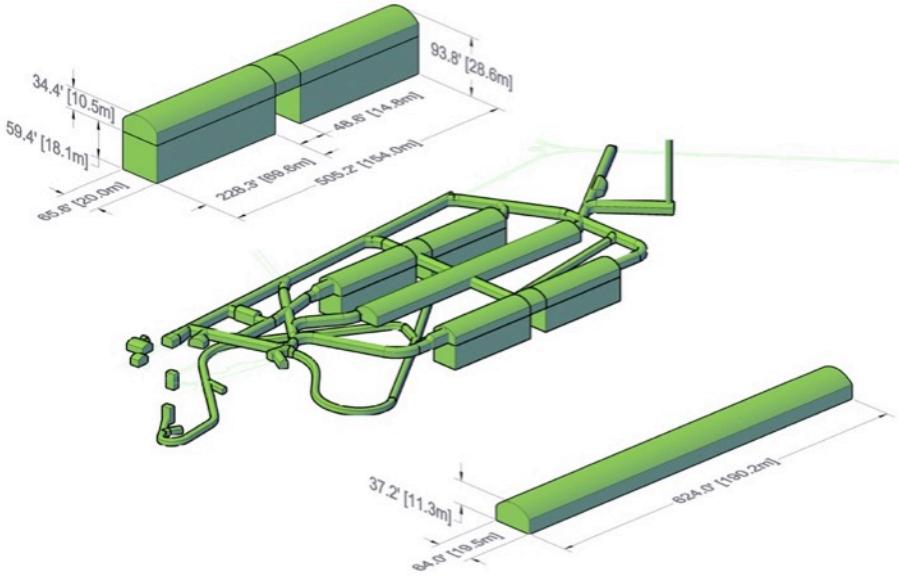
Low Background Assay and Measurement.

3 LBCs operating. Additional counters planned.

LBNF/DUNE Project Status



- US aggressively developing plans to host a world-class neutrino program.
- Aligned with US P5 Report and European Strategy (CERN). Fermilab leading project.
- Collaboration includes over 800 members, 150 institutions, 28 countries.
- **Key goal install the first of four 10kt LAr detectors by 2021**
- DOE CD-1 refresh approved Nov 2015.
- **DOE CD-3a IPR for LBNF work at SURF held Dec 2015. Approval being considered by DOE.**
- **Goal is to begin “pre-excavation” construction in 2017 and excavation in 2018.**
- Test blast program completed March 2016 to inform facility designs and construction plans
- **Prototype LAr cryostat and detector program (ProtoDUNE) underway at CERN being led by DOE, CERN, and DUNE collaboration.**



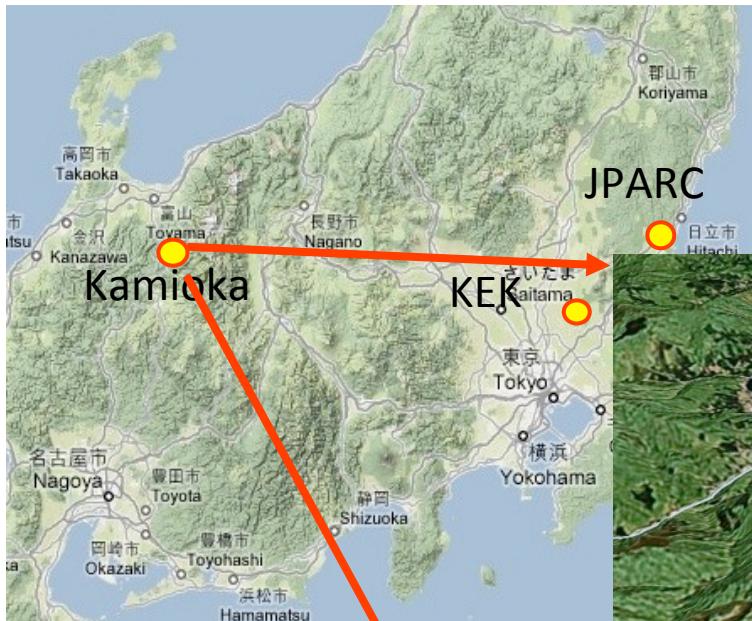
Test Blasting



Asia Labs

- Kamioka
- Jinping
- Yangyang (Y2L)
- INO



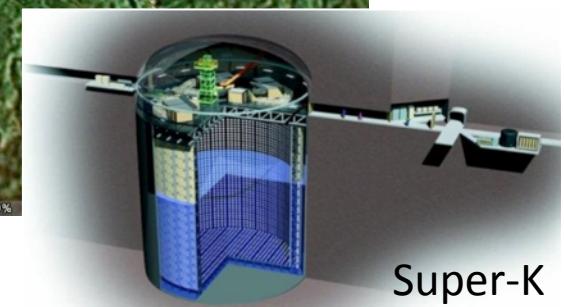
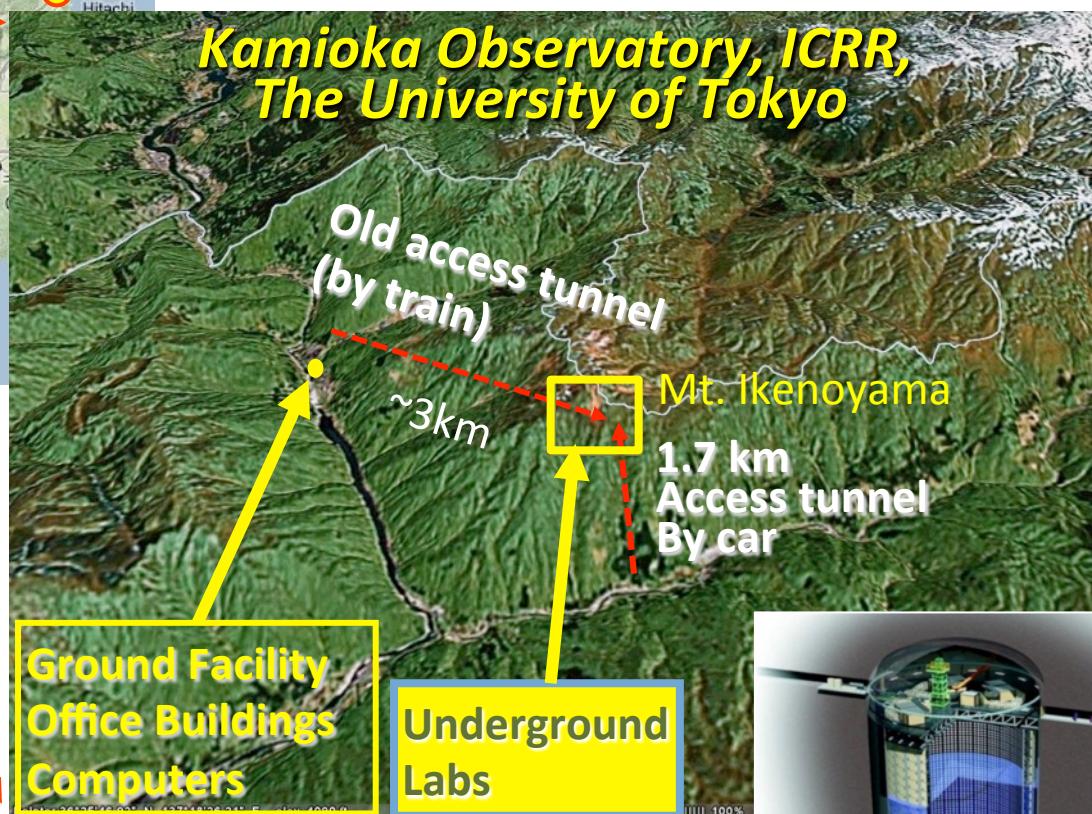


- 1000 m underground
- 2700 m.w.e
- Horizontal access
- 24 hours access by car
- 10 minutes from ground facility

Kamioka Observatory

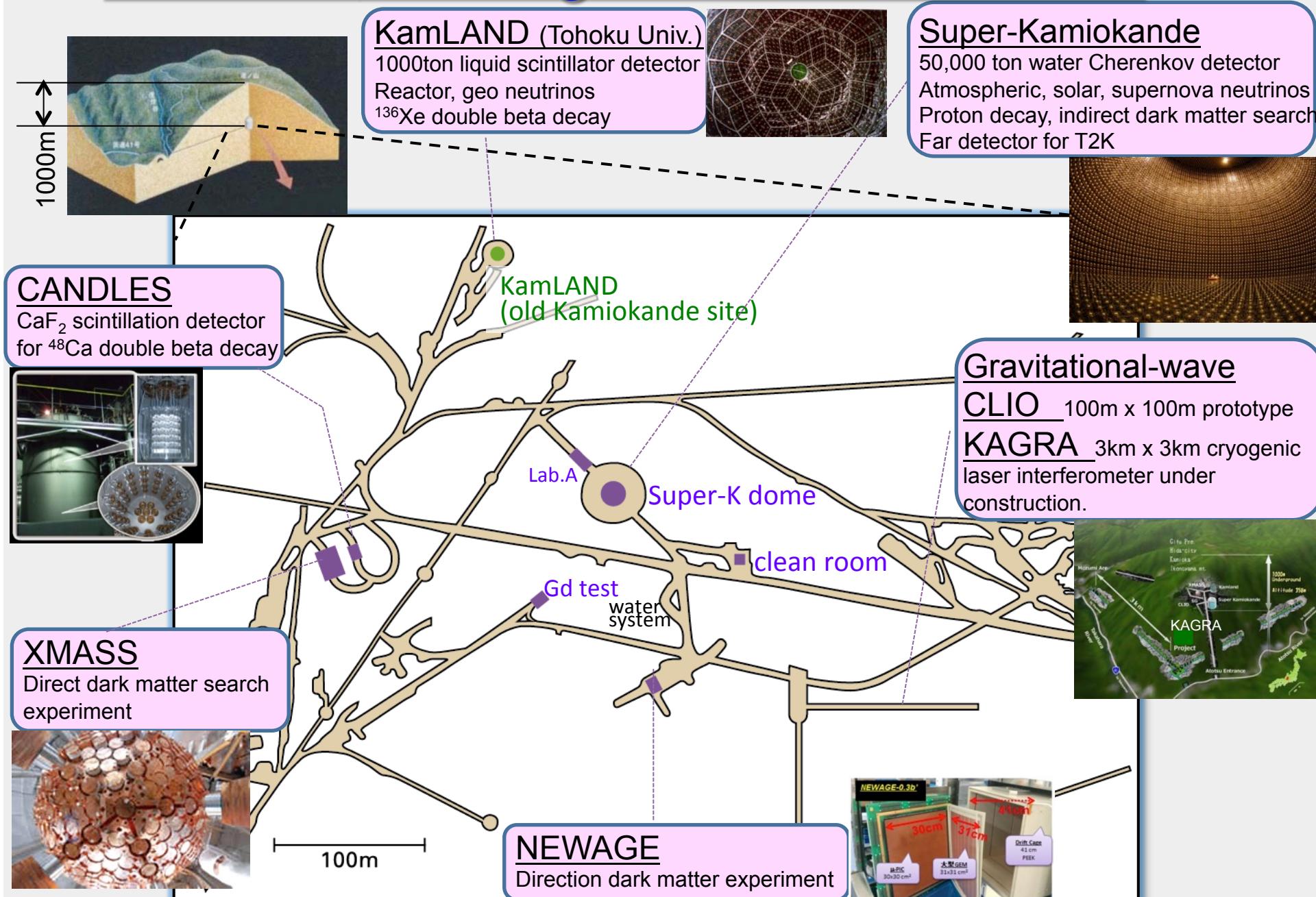
Location

- Mozumi Zinc Mine
- Northen part of Gifu pref. in Japan
- 40 minutes drive from Toyama airport, where is 1 hour flight from Tokyo Airport



Super-K

Kamioka Underground Laboratories





Current Experiments in Kamioka

Center for Gravitational Wave (Op. by Univ. of Tokyo)

- KAGRA (Large Cryogenic Gravitational-wave Telescope)
 - Under construction.
 - Test run in 2016 spring.
 - Cryogenic run from 2017.

Neutrino Science Center (Op by Tohoku Univ.)

- KamLAND (reactor & geo v)
- KamLAND-ZEN (double beta decay of ^{136}Xe)
- **Increasing Xe136 content**

Kamioka Observatory (Op. by Univ. of Tokyo)

- Super-Kamiokande
 - Precise oscillation studies by atmospheric and solar neutrinos.
 - Evidence for ν_e appearance (T2K)
 - **Dissolve 0.1% Gd for anti-neutrino physics in future.**
- XMASS (Dark Matter: liq. Xenon)
 - 1st phase detector completed
 - **Improvement of the detector**
- CANDLES (Double beta)
 - Detector completed
 - Commissioning
- NewAGE (Dark Matter)
 - Directionality
- CLIO (prototype of KAGRA)
- Geo-physics
 - Laser strain meter
 - Superconductive gravity meter

KAGRA



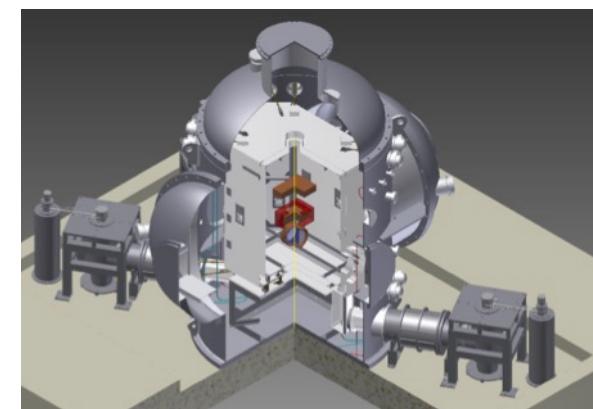
Schedule

- Installation of the major equipment completed by March 2015.
- Normal temperature operation has started at 2016 spring.
- Cryogenic operation from the end of FY2017.

Photo of center area



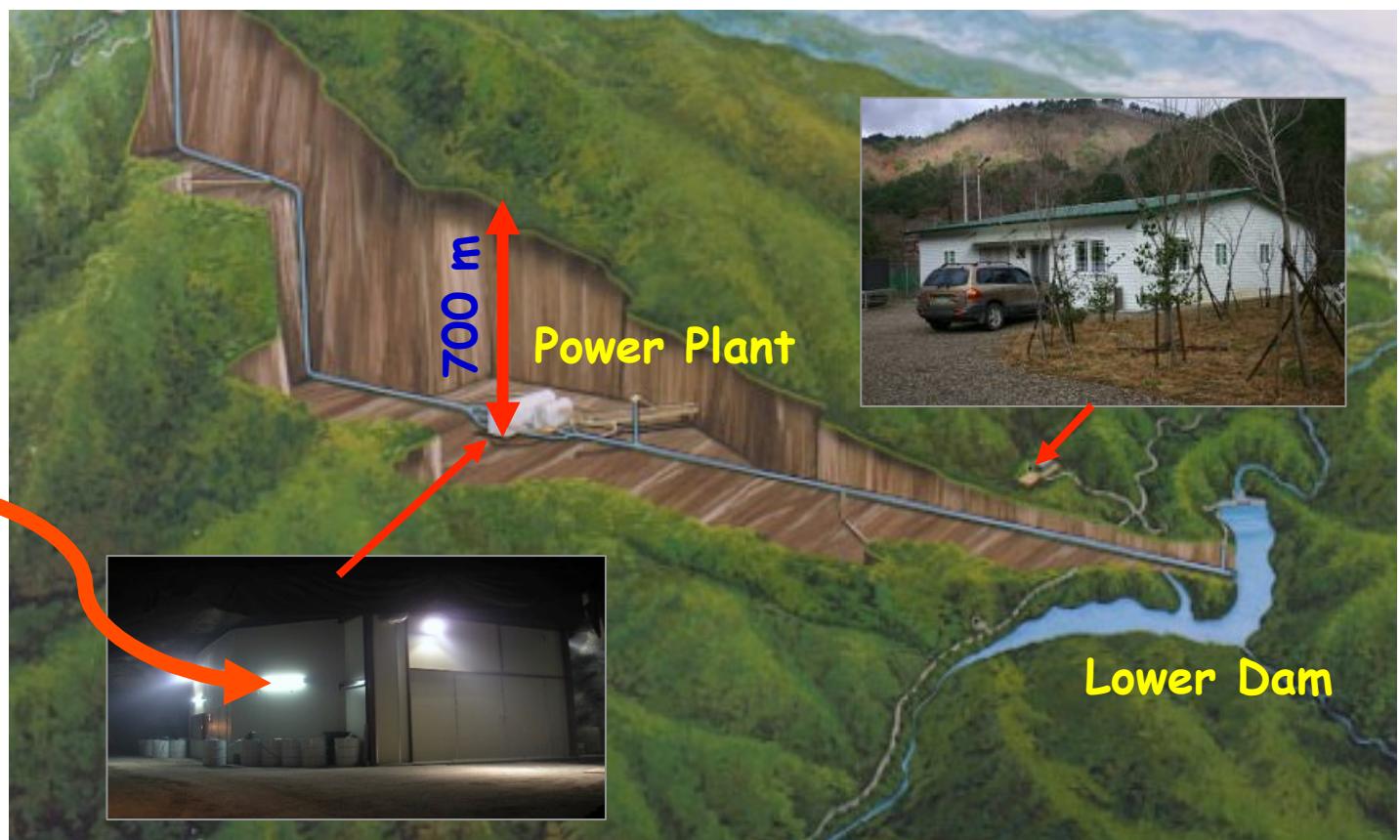
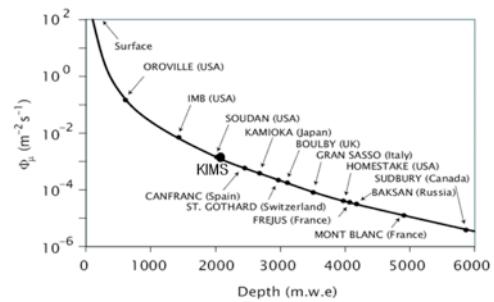
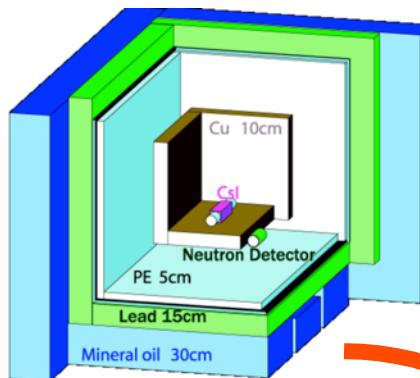
Outline of cryostat





Yangyang Underground Laboratory (Y2L)

- ◎ Hardware facilities with a depth of **700 m**, with a space of **100 m²** was established in 2003.
- ◎ Accessible to the lab by car. (~ 2 km)



Yangyang Pumped Storage Power Plant

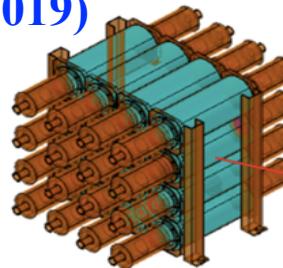
Scientific Programs & activities at Y2L

1. COSINE-100 (Collaboration Of Sodium IodiNe Experiments)

- DM-ICE group + KIMS-NaI group → Exp. at Y2L.
- 200 kg NaI(Tl) crystals inside liquid scintillator active veto.
- Phase I experiment (100 kg) will begin June, 2016.
- Further purification → Phase II exp. (2017-2019)



2. AMoRE $\beta\beta$ experiment



^{100}Mo double beta decay experiment.

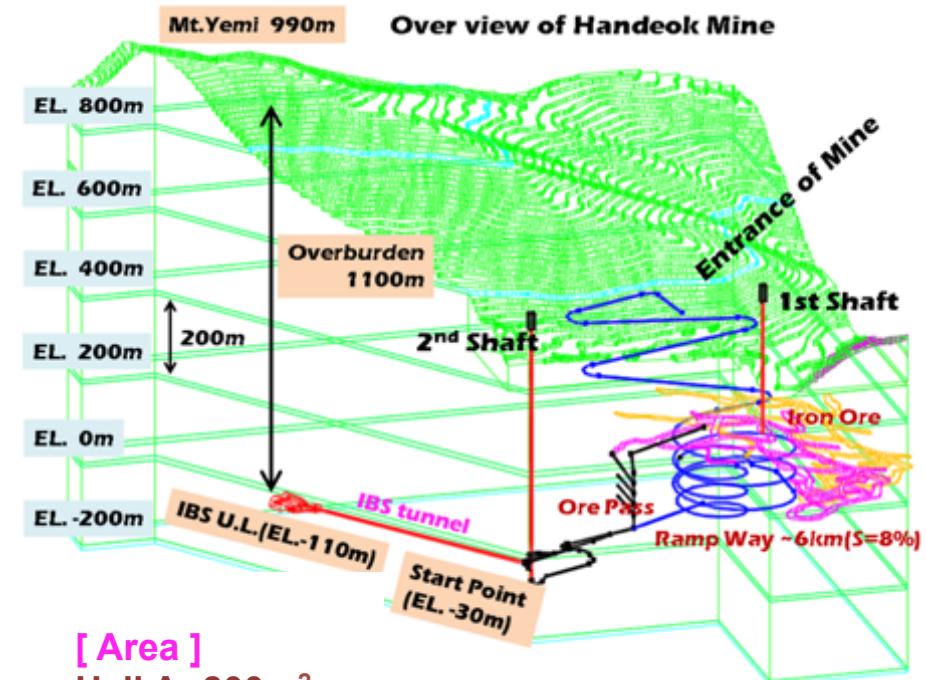
- R&D for CaMoO_4 , LiMoO_4 , ZnMoO_4 , Na_2MoO_4
- AMoRE-Pilot : 1.5 kg crystals running (2017)
- AMoRE-I : 5kg crystals (2018)
- AMoRE-II : 200 kg of (X) $^{100}\text{MoO}_4$ crystals. (2019-2022)
- Chemical purification & Crystal growing is going on at CUP.

 **CUP** (Center for Underground Physics) in Korea approved by
IBS (Institute for Basic Science) in 2013

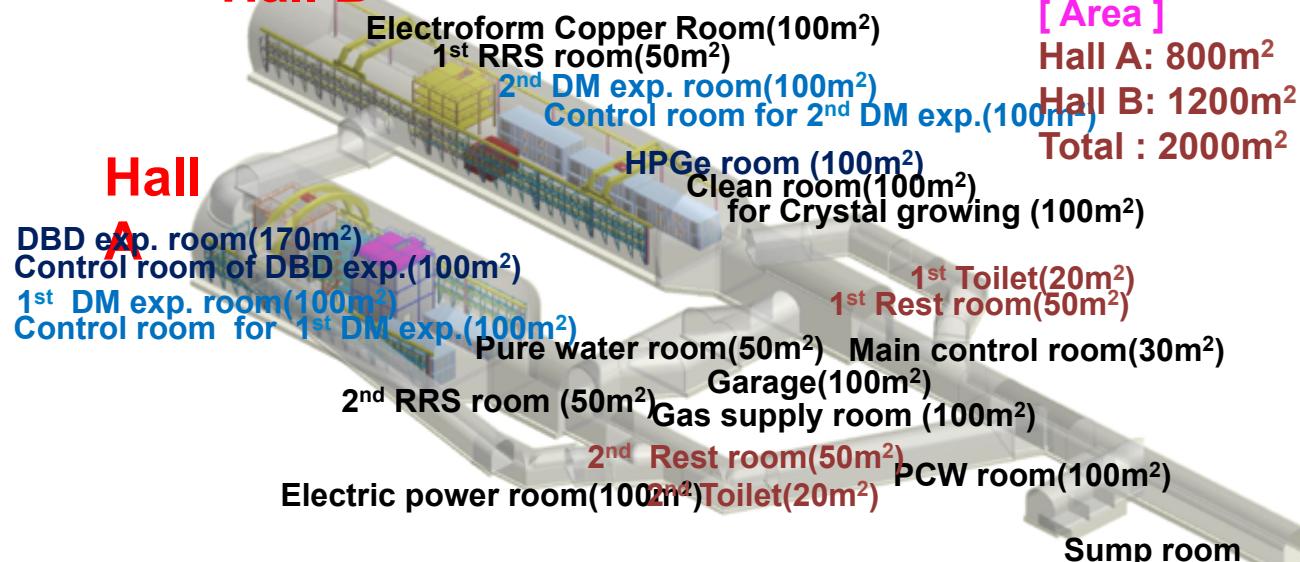
New underground lab.

42

- Active iron mine.
- 600 m vertical tunnel + 800 m new tunnel. (\rightarrow 1100 m depth)
- 2000 m² area for Dark matter and DBD experiments.
- Construction 2017-2019.

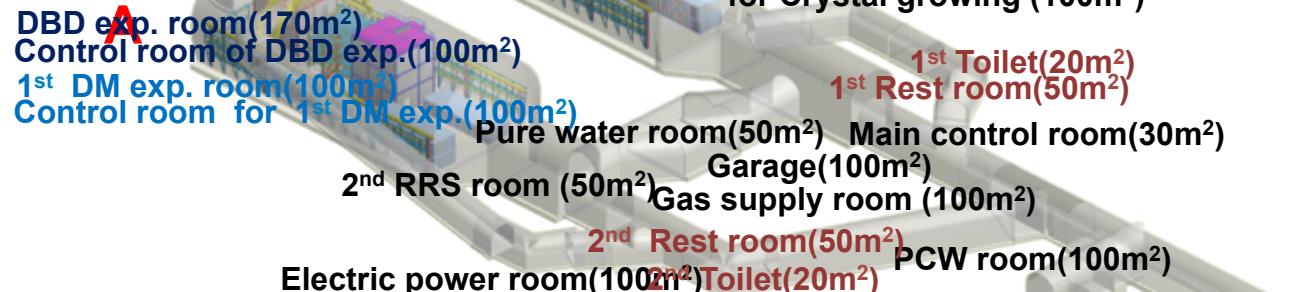


Hall B

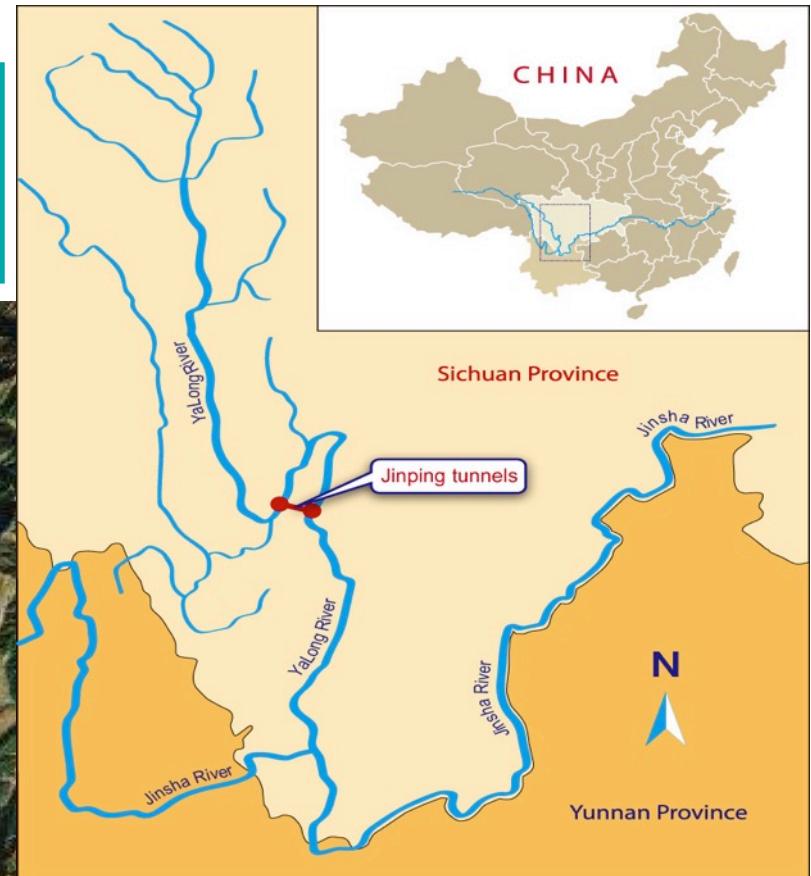
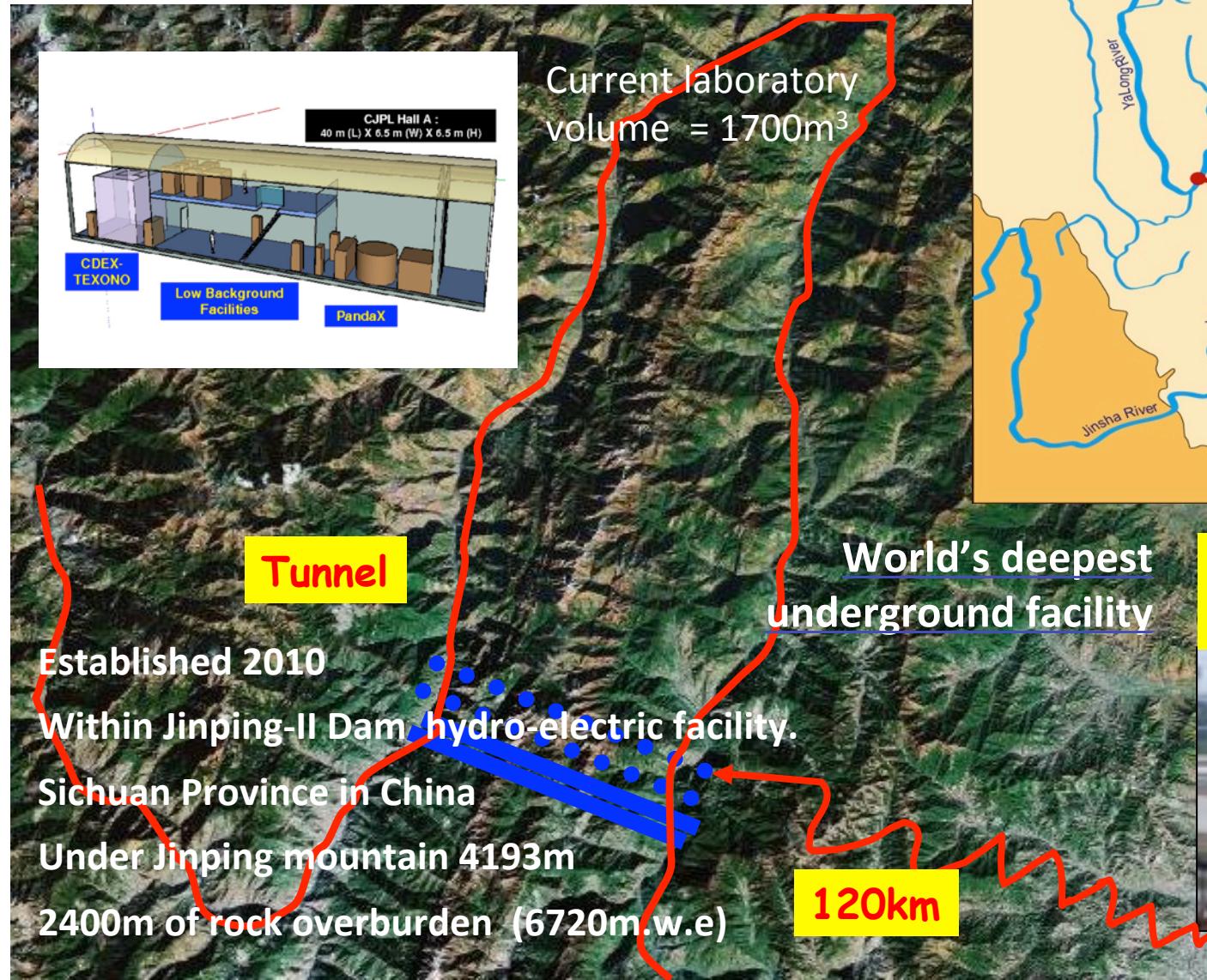


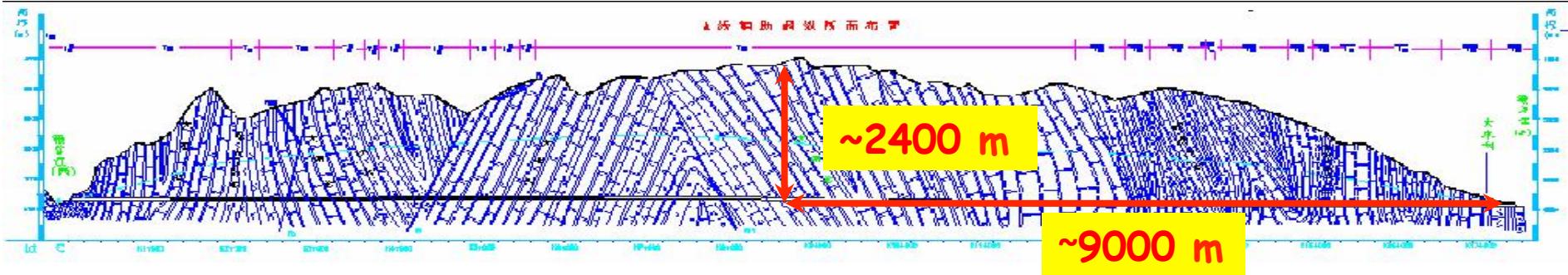
[Area]
 Hall A: 800m²
 Hall B: 1200m²
 Total : 2000m²

Hall
A

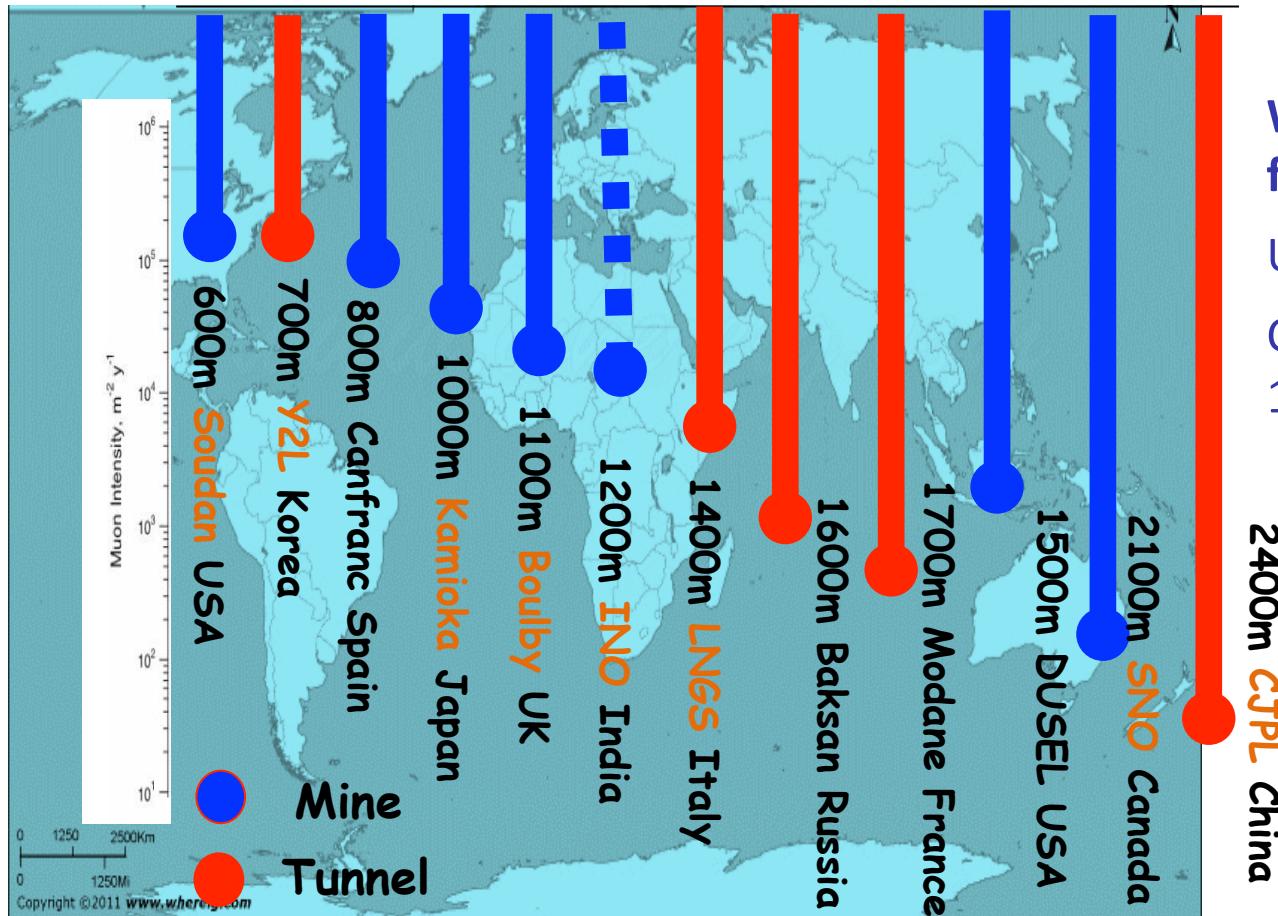


China Jin-Ping Underground Laboratory (CJPL) Site





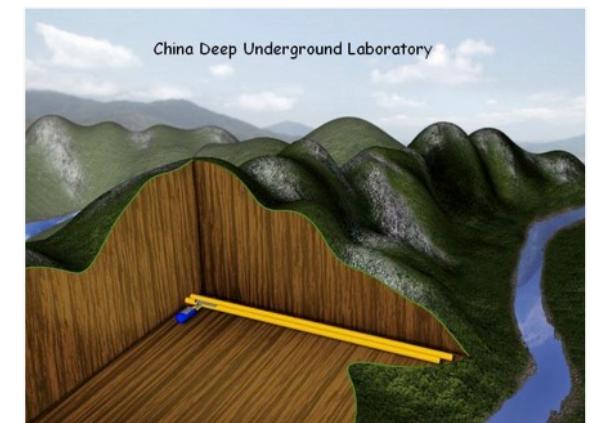
◎ 2400+ m rock overburden, drive-in road tunnel access



World's deepest underground facility @2400m (6720 m.w.e)

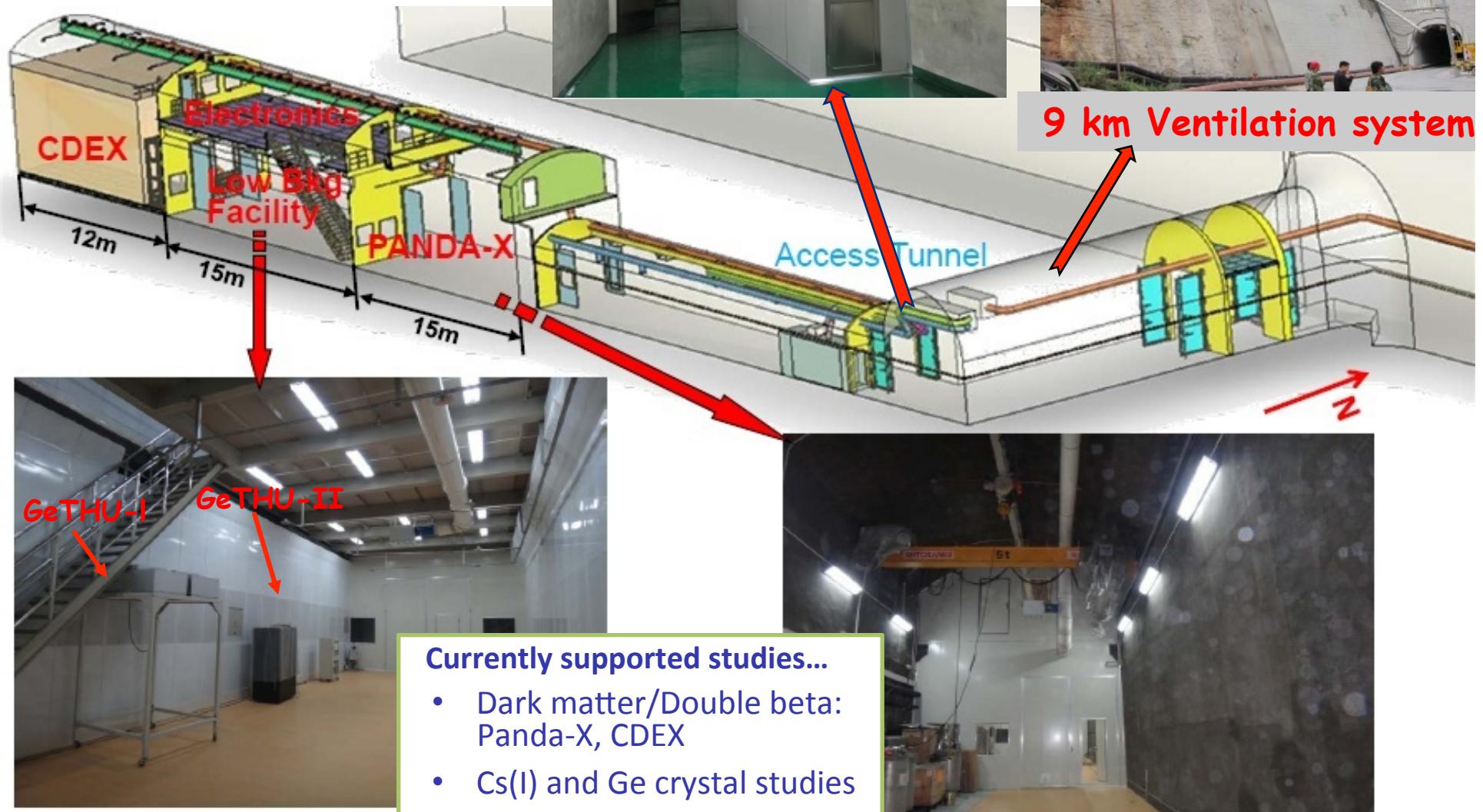
Under Jinping mountain 4193m

Current laboratory volume = 1700m³



Shin-Ted Lin Aug 2015

Internal layout of CJPL-1 (6m×6m×40m)



Currently supported studies...

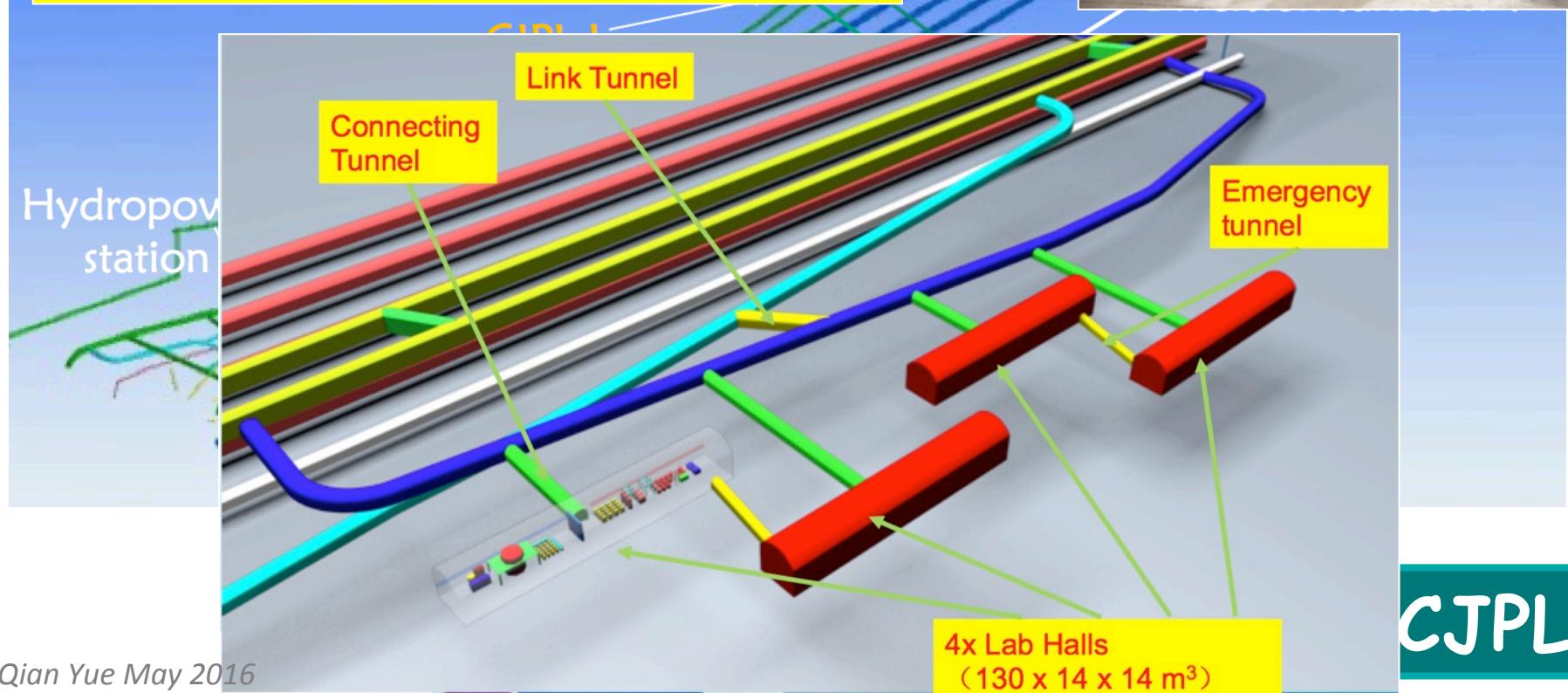
- Dark matter/Double beta: Panda-X, CDEX
- Cs(I) and Ge crystal studies
- Geological studies

Shin-Ted Lin Aug 2015

Plan of CJPL-II

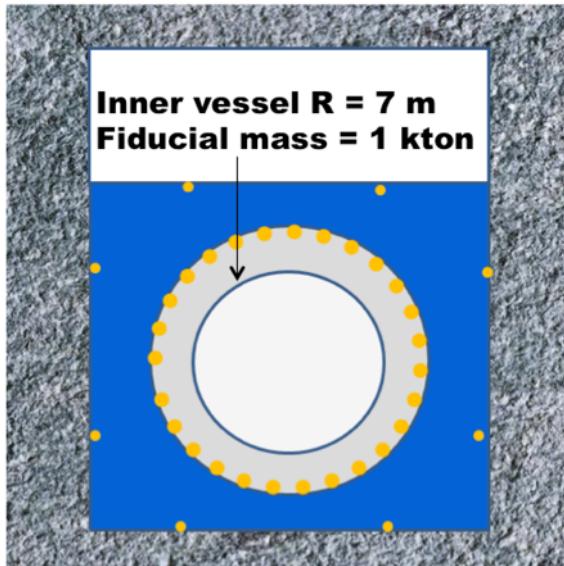
The deepest (& one of largest) underground Labs in the World

Four 14m*14m*130m tunnels OK;
Expansion of two sites OK;
(φ 18m*H32m and L27m*W14m*H28m);
Ventilation system, Power, and other facilities are under construction, plan to ready by the end of 2016.



CJPL-II possible users

- CDEX-1T (Ge DM+DBD Exp.)
- PandaX-1T (Xe DM Exp.)
- LAr dark matter experiment
- Nuclear astroparticle physics
- Solar neutrino experiment
- rock mechanics
-



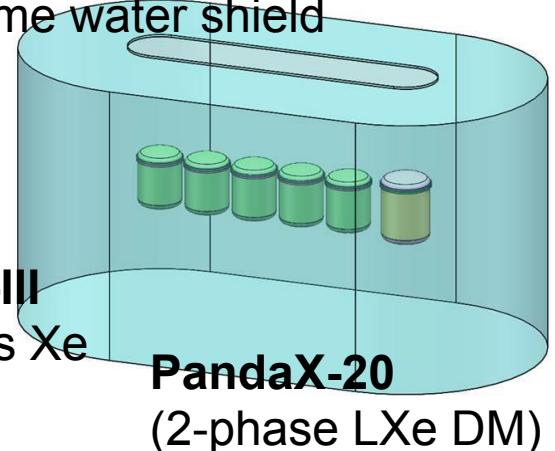
Jinping Neutrino Experiment.

Two modules 1kT
liquid scintillator
detectors

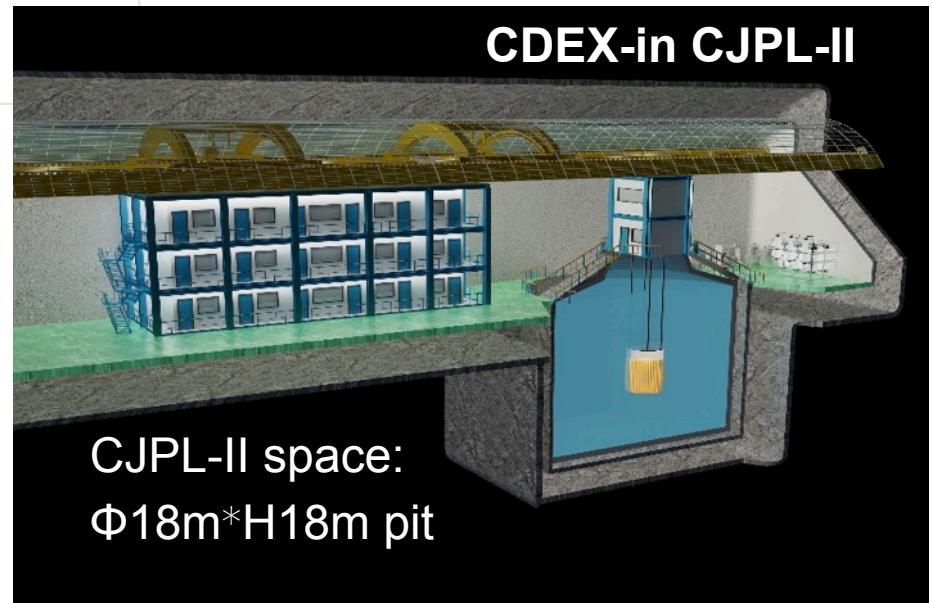
Qian Yue May 2016

Panda-X

Multiple xenon TPC deployed
in the same water shield



CDEX-in CJPL-II



Southern Hemisphere Labs

- Andes
- Stawell



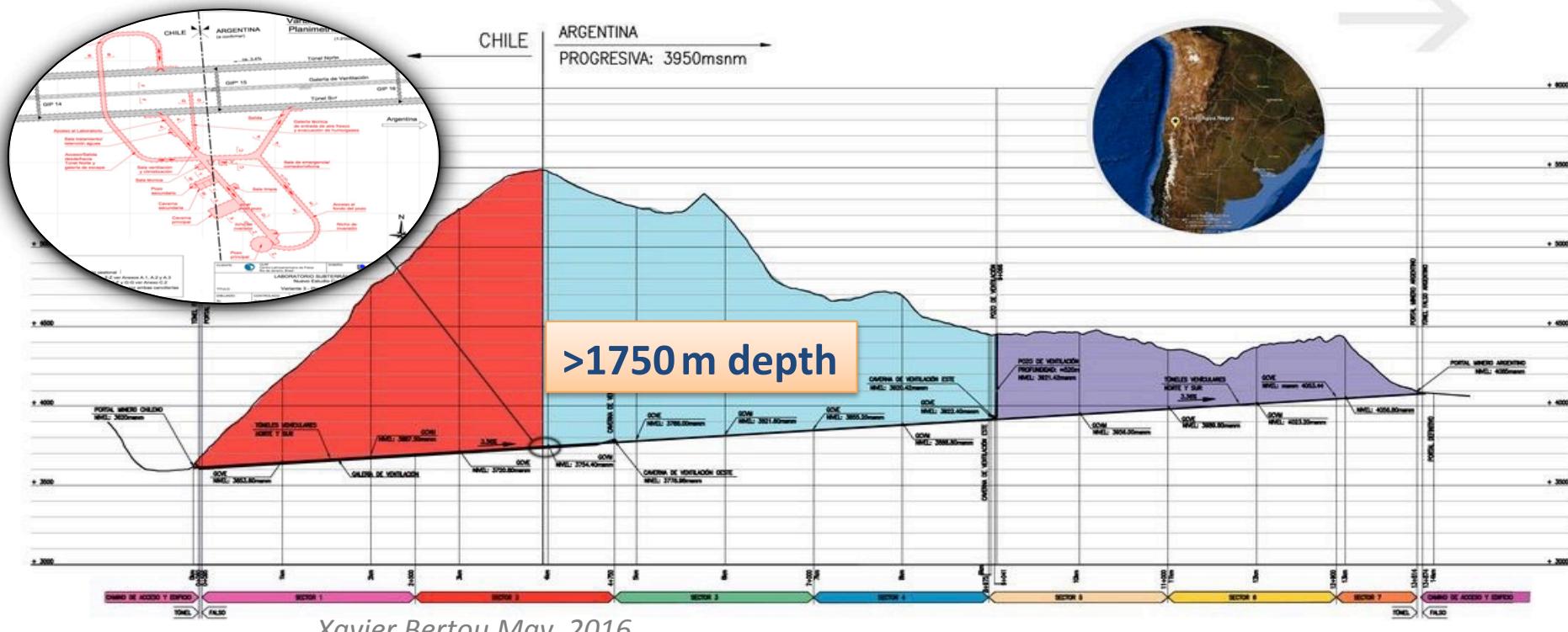
ANDES

The Agua Negra deep underground laboratory



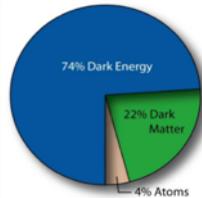
- Agua Negra tunnel between Argentina and Chile, linking MERCOSUR to Asia
- Laboratory location as deep as Modane
- Tunnel financed by Inter-American Development Bank; construction: 2017-2024
- Horizontal access, size of ~4 000 m² and ~70 000 m³ in 8 halls and pits

Large and deep underground laboratory in the southern hemisphere

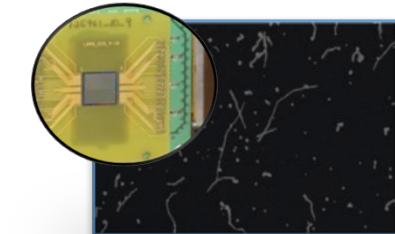
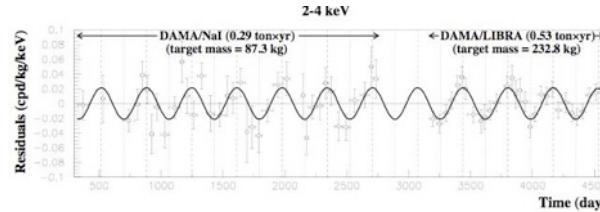


Xavier Bertou May 2016

ANDES: Agua Negra Deep Experiment Site

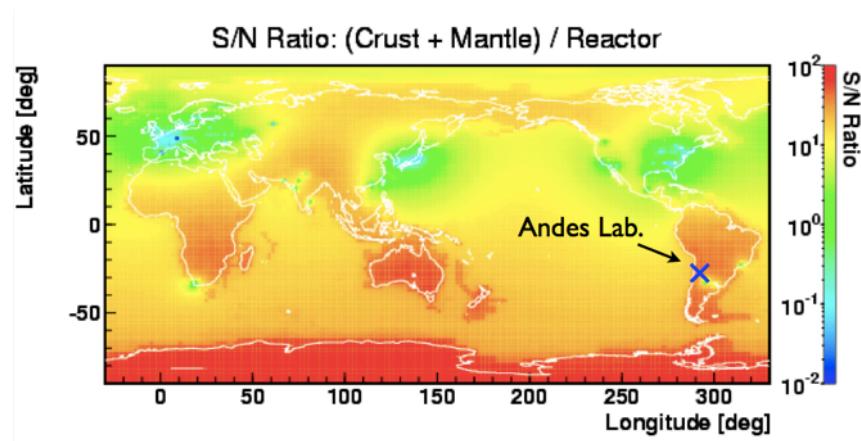


Dark Matter



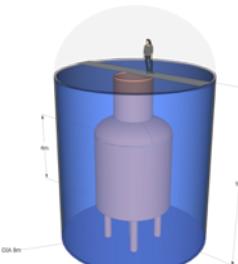
Host 3rd generation DM experiment

Study new particle detection techniques, ex: CCD

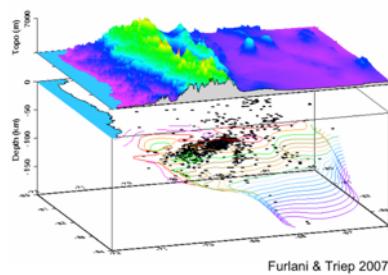


Neutrinos

- Geo-neutrinos (benefit from unique location)
- Build a low energy Latin American neutrino detector
- Host experiments for Mass & Nature (ex: host part of SuperNEMO?)



Ultra low radiation pit
Environmental measurements, material selection...



Geophysics laboratory
Local active region, Seismograph network junction (Argentina+Chile), Magnetic and Gravimetric studies

ANDES: Agua Negra Deep Experiment Site

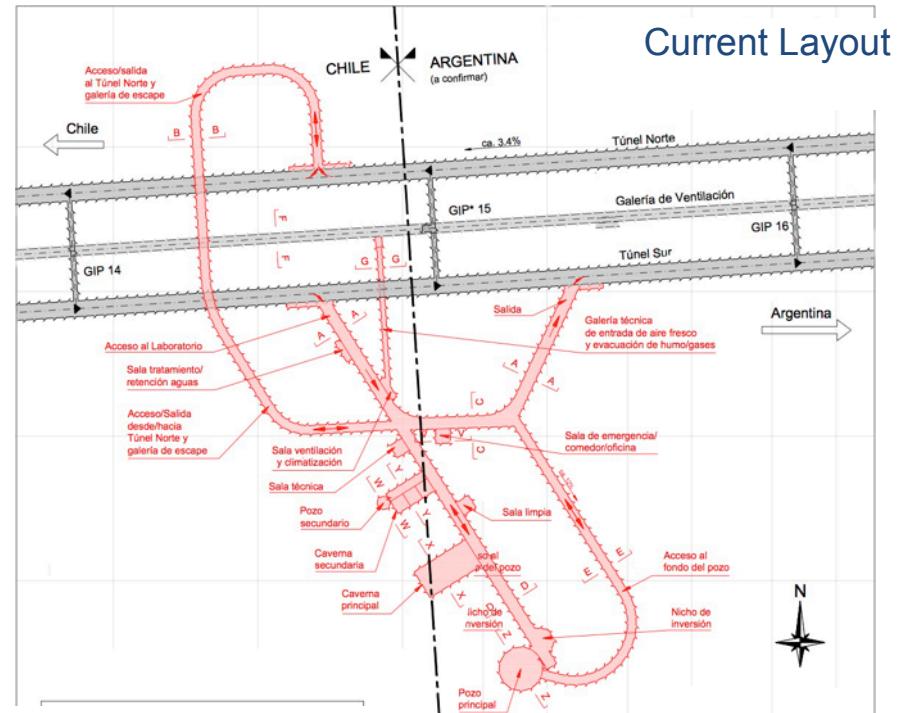
- Main hall
(21 m x 23 m x 50 m)
- Secondary hall
(16 m x 14 m x 40 m)
- Offices and small labs
- Low radiation pit
- Large single experiment pit
(~ Ø 30 m, 30 m tall)
- Vertical depth: 1775 m,
omnidirectional: 1675 m
- Total: 70 000 m³ laboratory volume
(+ 35 000 m³ access tunnels)

Rock Studies
(from test samples
~600 m deep)



Preliminary data (Bq/kg)

	Basalt	Andesite	Rhyolite 1	Rhyolite 2
²³⁸ U	2.6 ± 0.5	9.2 ± 0.9	14.7 ± 2.0	11.5 ± 1.3
²³² Th	0.94 ± 0.09	5.2 ± 0.5	4.5 ± 0.4	4.8 ± 0.5
⁴⁰ K	50 ± 3	47 ± 3	57 ± 3	52 ± 3



- ✓ Final exact location to be determined once geology is better known
- ✓ Proposed as an International laboratory within Latin America
- ✓ Conceptual study finished by Lombardi in January 2015
- ✓ Detailed engineering ongoing
- ✓ **Tunnel fully approved by new Gov.**

More information at <http://andeslab.org/>

SUPL: Stawell Underground Physics Laboratory

Stawell gold mine ~240 km west of Melbourne... In 2017 will host the first ready to be used underground laboratory in the Southern hemisphere.



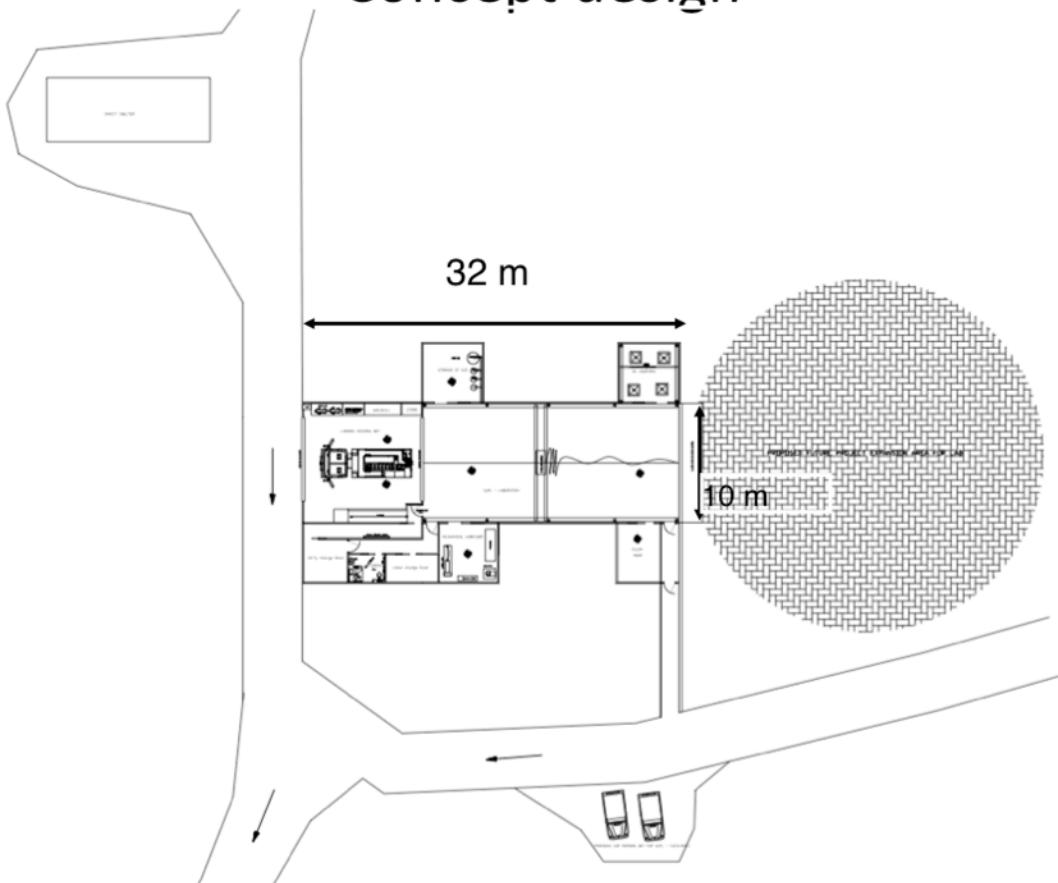
Chose a site at 1.02 km underground, ~3 km water equivalent



Decline gold mine mine, 1.6 km deep, with all caverns served with electricity, optical fibre, reached by car/truck. The mine is operational.

SUPL: Stawell Underground Physics Laboratory

Concept design



In 2017 will host the first ready-to-be-used underground laboratory in the Southern hemisphere.

Time line

2014	Lab proposed (Sep)
2015	Funding secured (May) Call for tenders for final design (Aug) Complete design (Nov) Design Review (Dec/Jan)
2016	Start construction (Jan/Feb) Facility ready (Dec)
2017	Lab ready to be use (Jan/Feb) Planned experiments: SABRE (~2017) – to check DAMA results, paired with Gran Sasso Directional Dark Matter (later date) Non HEP: Astrobiology

Developments in the World's Deep Underground Laboratories

Overview of status & future plans of (some of) the world's underground facilities...



Europe

- Gran Sasso
- Modane
- Canfranc
- Boulby

Asia

- Kamioka
- Jinping
- Yangyang
- INO

North America

- SNOLAB
- SURF
- Soudan
- WIPP

Southern Hemisphere

- Andes
- Stawell

Lots going on. Many and varied science projects and laboratories progressing and emerging.



Boulby Underground Laboratory

Deep Underground Science Workshop

Coming Soon (early 2017)



Sean Paling
STFC Boulby Underground Science Facility