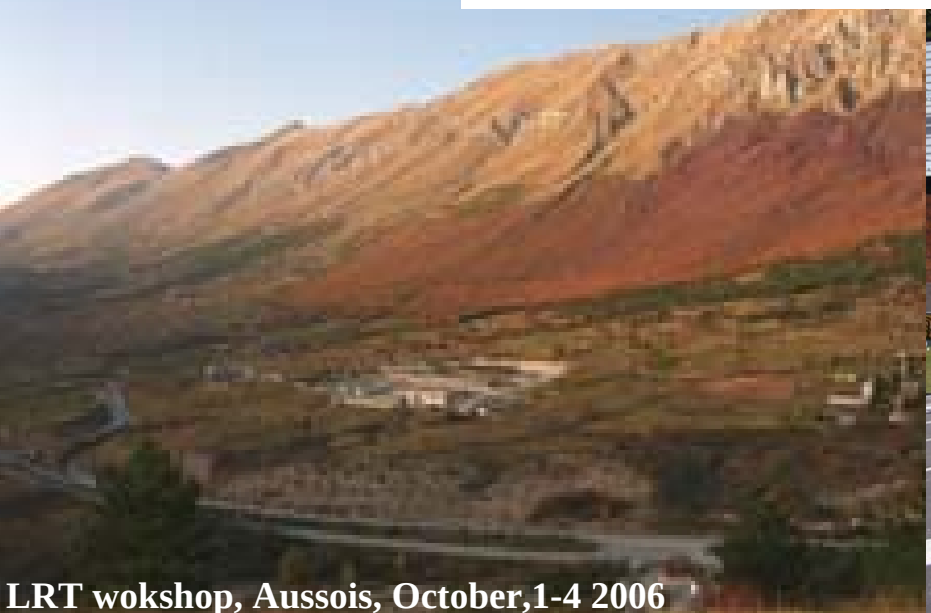
European Underground Laboratories and ILIAS

F. Piquemal (CENBG and LSM)

Acknowlegement to N. Spooner (USFD and Boulby) , J. Morales, (Zaragoza and Canfranc) and G. Gerbier (CEA Saclay and LSM), for their slides



Integrated Large Infrastructures for Astroparticle Science

www.ilias.in2p3/fr

Neil Spooner - University of Sheffield

Aim: to help establish long term integration of Astroparticle Physics in Europe

EU contribution: €7.5 M **Participants: ~1500 scientists, 140 institutes, 23 countries**

3 prime areas: gravitational waves, dark matter, double beta decay

3 types of activity:

Networking Activities

- (N2) Deep Underground science laboratories
- (N3) Direct dark matter detection
- (N4) Search on double beta decay
- (N5) Gravitational wave research
- (N6) Theoretical astroparticle physics

Joint Research Activities (R&D Projects)

- (JRA1) Low background techniques underground
- (JRA2) Double beta decay European observatory
- (JRA3) Study of noise in gravitational wave detectors

Transnational Access Activities

- (TA1) Access to the EU Deep Laboratories

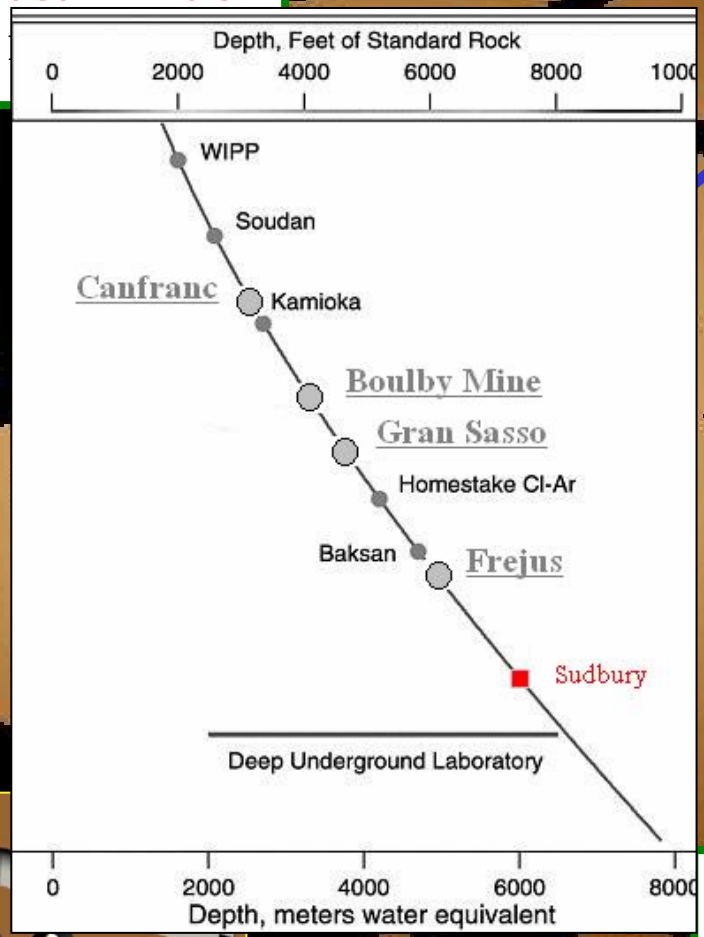
Coordination of European deep underground labs

Deep Underground Labs Tunnels and Mines

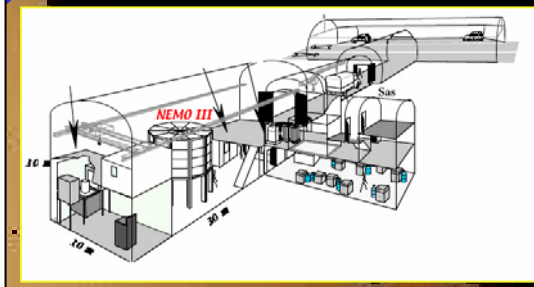
JRA 1, A1
N 2

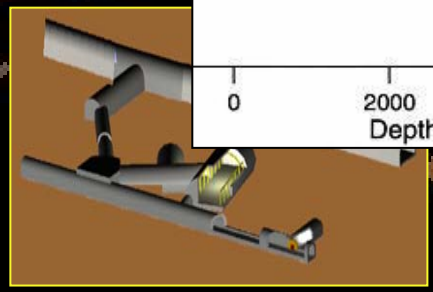
Pyhasalmi lab

Boulby (UK)



Frejus (France)



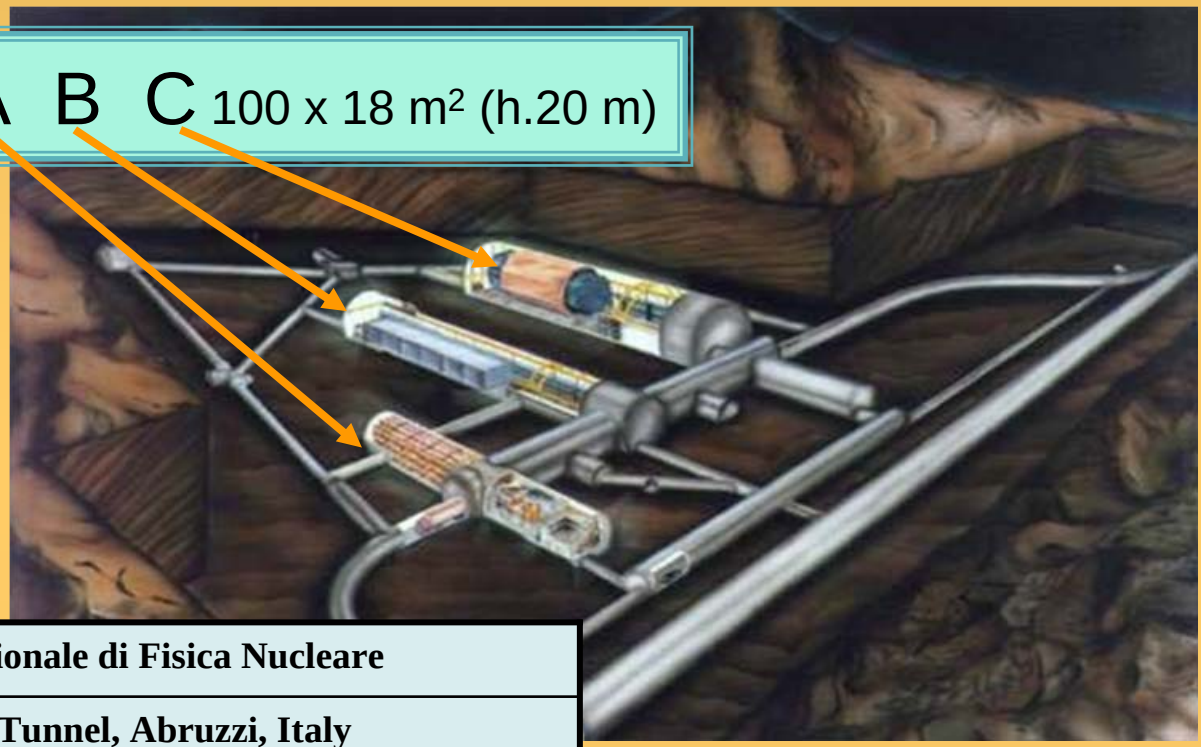


Canfranc (Spain)

Gran Sasso (Italy)

Laboratori Nazionali del Gran Sasso

3 main halls A B C 100 x 18 m² (h.20 m)



Operating Institution	**Istituto Nazionale di Fisica Nucleare**
Location	**Gran Sasso Tunnel, Abruzzi, Italy**
Excavation	**1987**
Underground area	**3 halls (100m x 18m x 20m) + service tunnels**
Depth	**1400 m (3800 mwe)**
Total volume, surface	**180000 m^3, >6000 m^2**
Permanent staff	**66 (physicists, technicians, administration)**
Scientists users	**450**

LNGS backgrounds and facilities

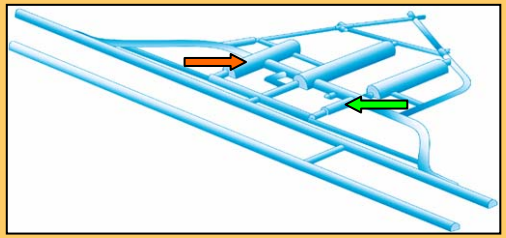
Muon Flux
1.1 μ m^{-2} h^{-1}

Neutron Flux	
1.08 10^{-6} n cm^{-2} s^{-1}	(0-0.05 eV)
1.84 10^{-6} n cm^{-2} s^{-1}	(0.05 eV- 1 keV)
0.54 10^{-6} n cm^{-2} s^{-1}	(1 keV-2.5 MeV)
0.32 10^{-6} n cm^{-2} s^{-1}	(> 2.5 MeV)

Primordial Radionuclides			
^{238}U	6.8 ppm	Rock	(Hall A)
	0.42 ppm	Rock	(Hall B)
	0.66 ppm	Rock	(Hall C)
	1.05 ppm	Concrete	All Halls
^{232}Th	2.167 ppm	Rock	(Hall A)
	0.062 ppm	Rock	(Hall B)
	0.066 ppm	Rock	(Hall C)
	0.656 ppm	Concrete	All Halls
K	160 ppm	Rock	

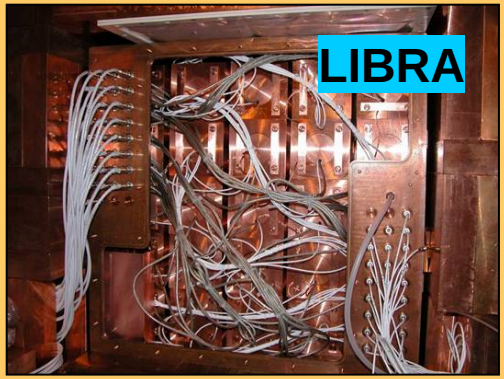
LABORATORY FOR LOW-LEVEL RADIOACTIVITY MEASUREMENTS

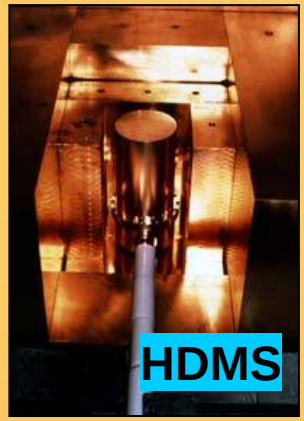
Present: 32 m^2 on one floor in service tunnel
Future: 60 m^2 distributed on three floors in hall A

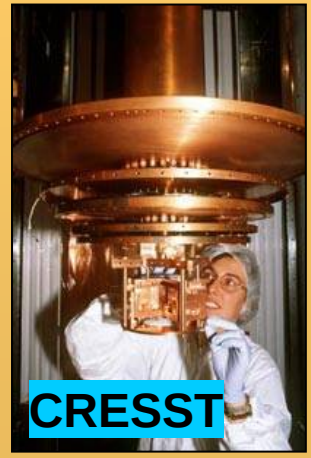


LNGS running experiments

DBD	Cuoricino	(~ 41 kg TeO_2 crystals)
Dark Matter	CRESST	(Sapphire & $CaWO_4$ cryodetector)
Dark Matter	LIBRA	(~ 250 kg NaI crystals)
DBD	HDMS / Genius-TF	(Ge detector ^{73}Ge enriched)
Supernova neutrinos	LVD	(Streamer tubes + Liquid scintillator)
Nuclear astrophysics	LUNA	(Accelerator)

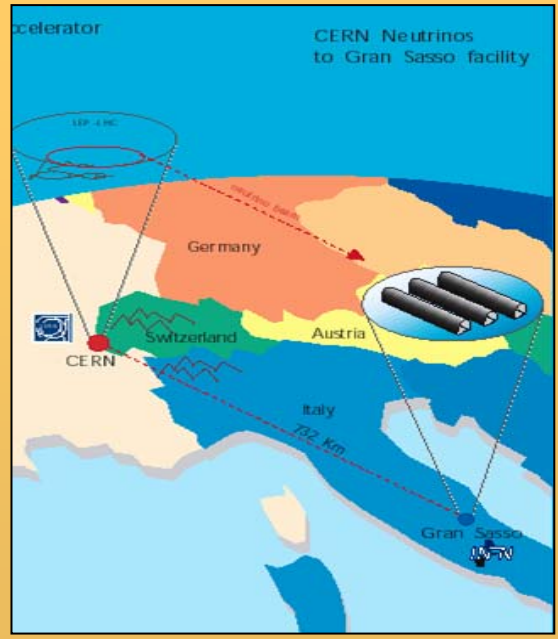






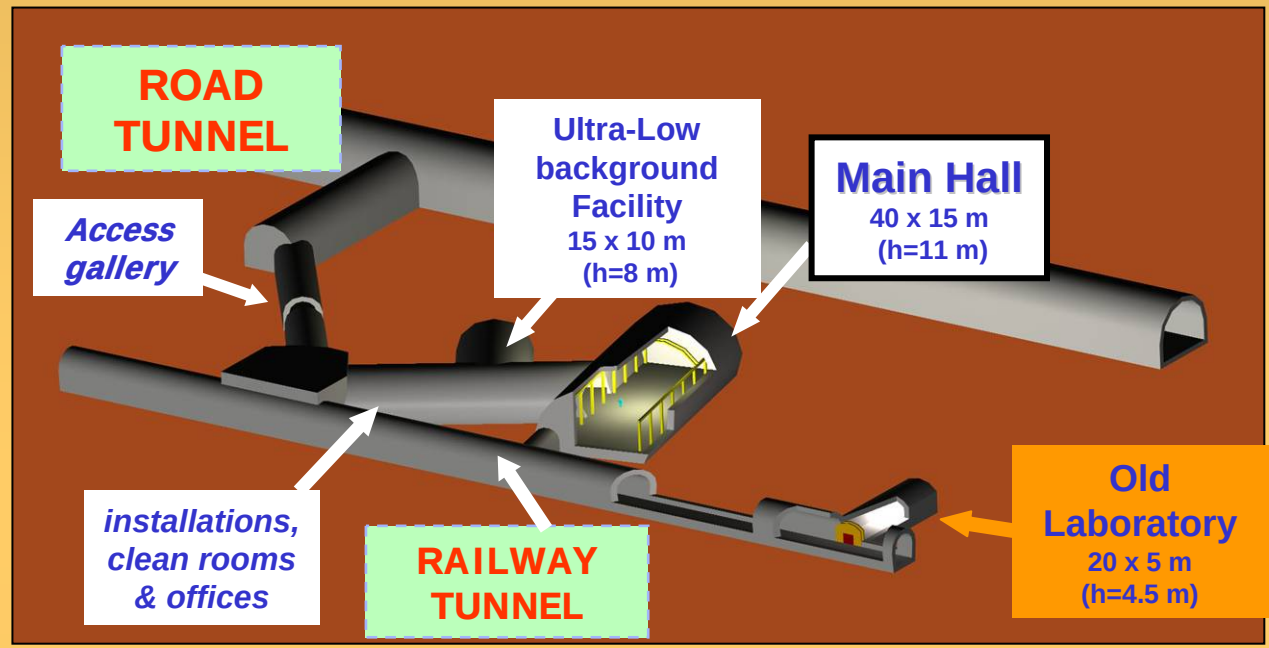
Experiments - running, construction, planned

CERN-GS beam	OPERA (emulsion)
CERN-GS beam	ICARUS (~ 600 T Lq. Ar)
Solar Neutrinos	Borexino (~ 300 T Lq. scint.)
DBD	CUORE (~ 750 kg $Te0_2$)
DBD	GERDA (^{76}Ge)
Nuclear astrophysics	LUNA-III
Gravitational waves	LISA R&D
Dark matter	XENON Lq. Xe / Lq. Ar



LSC Canfranc new lab

The new underground Laboratory is finished



Characteristic of the new LSC	
Depth	900 m (2450 mwe)
Main experimental hall	600 m^2 (oriented to CERN)
Low background lab	150 m^2
Clean room	45 m^2 (100/1000 type)
General services	135 m^2
Offices	80 m^2

-BiPo
- SuperNEMO
- ……

LNGS new space and expansion

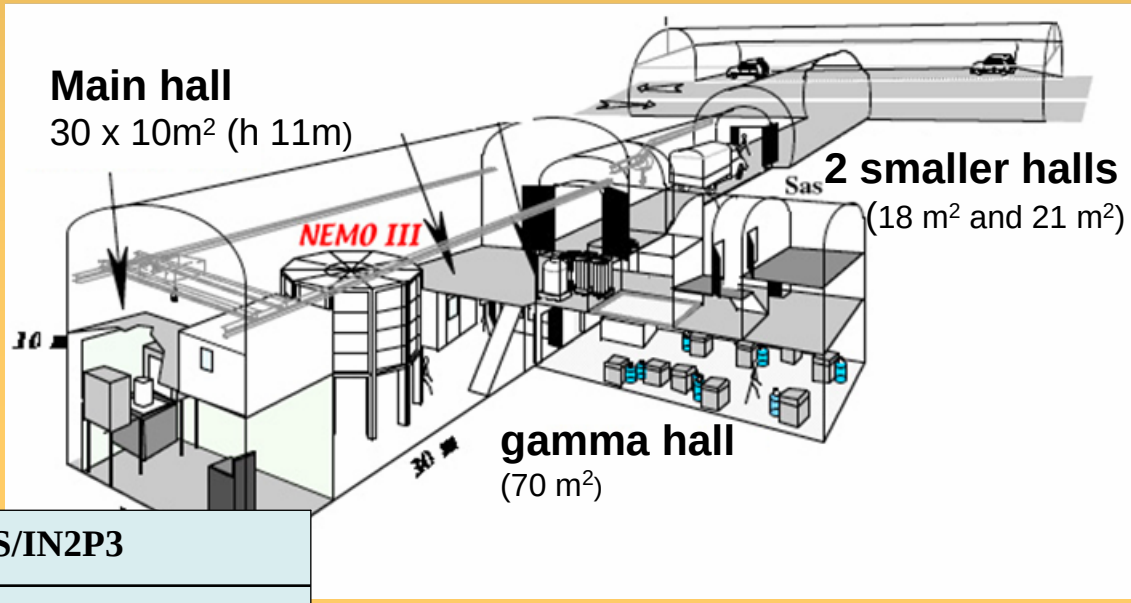
- Extensive improvements underway
- containment/bund
- new ventilation system
- new access road

- No new excavation likely

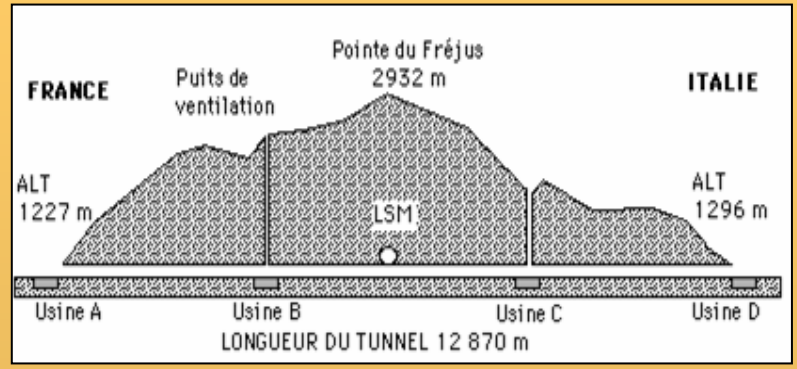
Hall A: FULL - GERDA, LVD, CRESST, Cuoricino
Hall C: FULL - Borexino, Opera
Hall B: probably FULL - (was Macro), ICARUS (600T, + scale-up test?)

bipass tunnels: some minor space - Cobra, Luna, Libra, Dama?..

Laboratoire Souterrain de Modane



Operators	**CEA/DSM & CNRS/IN2P3**
Location	**Fréjus Tunnel (Italian-French border)**
Excavation	**1983**
Underground area	**1 main hall (30m x 10m x 11m) + gamma spectroscopy hall (70 m²) + 2 secondary halls of 18 m² and 21 m²**
Depth	**1700 m (4800 mwe)**
Surface	**> 400 m²**
Permanent staff	**8**
Scientists users	**100**



LSM backgrounds and facilities

Muon Flux
0.17 μ m^{-2} h^{-1}

Neutron Flux	
1.6 10^{-6} n cm^{-2} s^{-1}	(0-0.63 eV)
4 10^{-6} n cm^{-2} s^{-1}	(2-6 MeV)

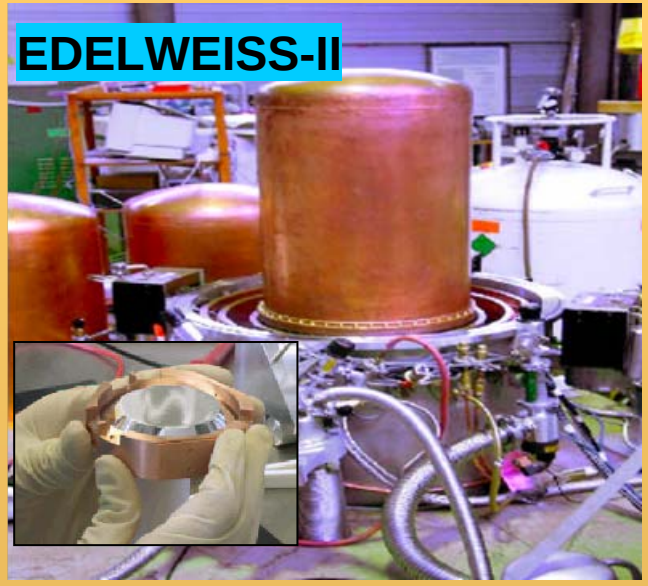
Primordial Radionuclides		
^{238}U	0.84 ppm	Rock
	1.9 ppm	Concrete
^{232}Th	2.45 ppm	Rock
	1.4 ppm	Concrete
K	213 Bq/kg	Rock
	77 Bq/kg	Concrete

LSM = deepest in Europe

13 HPGe from 6 different laboratories of CNRS and CEA are available at LSM

Experiments - running, construction, planned

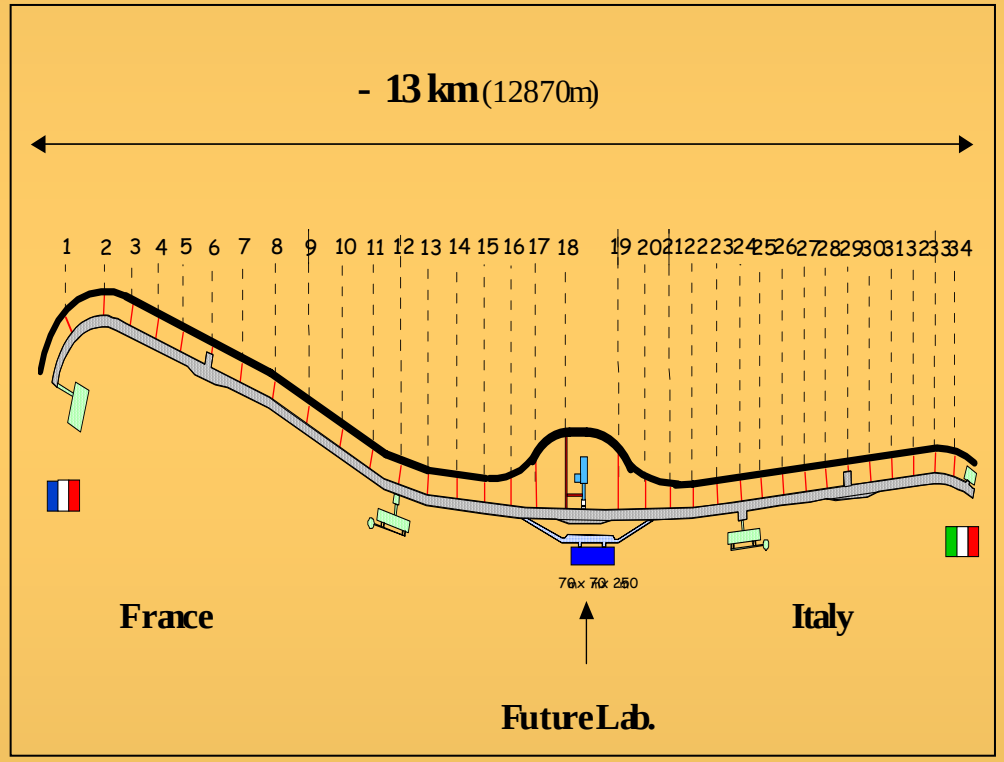
D e⁻ cap	TGV-II	(Ge with sheets of DBD candidates)
DBD	NEMO-III	(tracking + calorimeter - ^{100}Mo)
Heavy elemts	SHIN	*(*super heavy elements in nature + s/c, Z=108, A=230)
Dark Matter	EDELWEISS-II	(10 to 35 kg Ge heat+ion - 9kg in 2005)
DBD	SuperNemo	(tracking + calorimeter 10 000 m^3)
Dark Matter	Eureca DM	(Ge heat+ion 2000 m^3)
Dark Matter	ArDM, LXe	(10 000 m^3)
Neutrino coherent detection		(1 000 m^3)



LSM new space and expansion

2 projets?
new excavation ??

New safety galery besides Fréjus road tunnel 2006-2009



(1) 15,000 m³
volume = 1/3 of one LNGS hall

- middle size projects for deep site
- third generation DBD and DM searches (100 kg to 1T)
- low level radioactive environment
- small size neutrino detectors

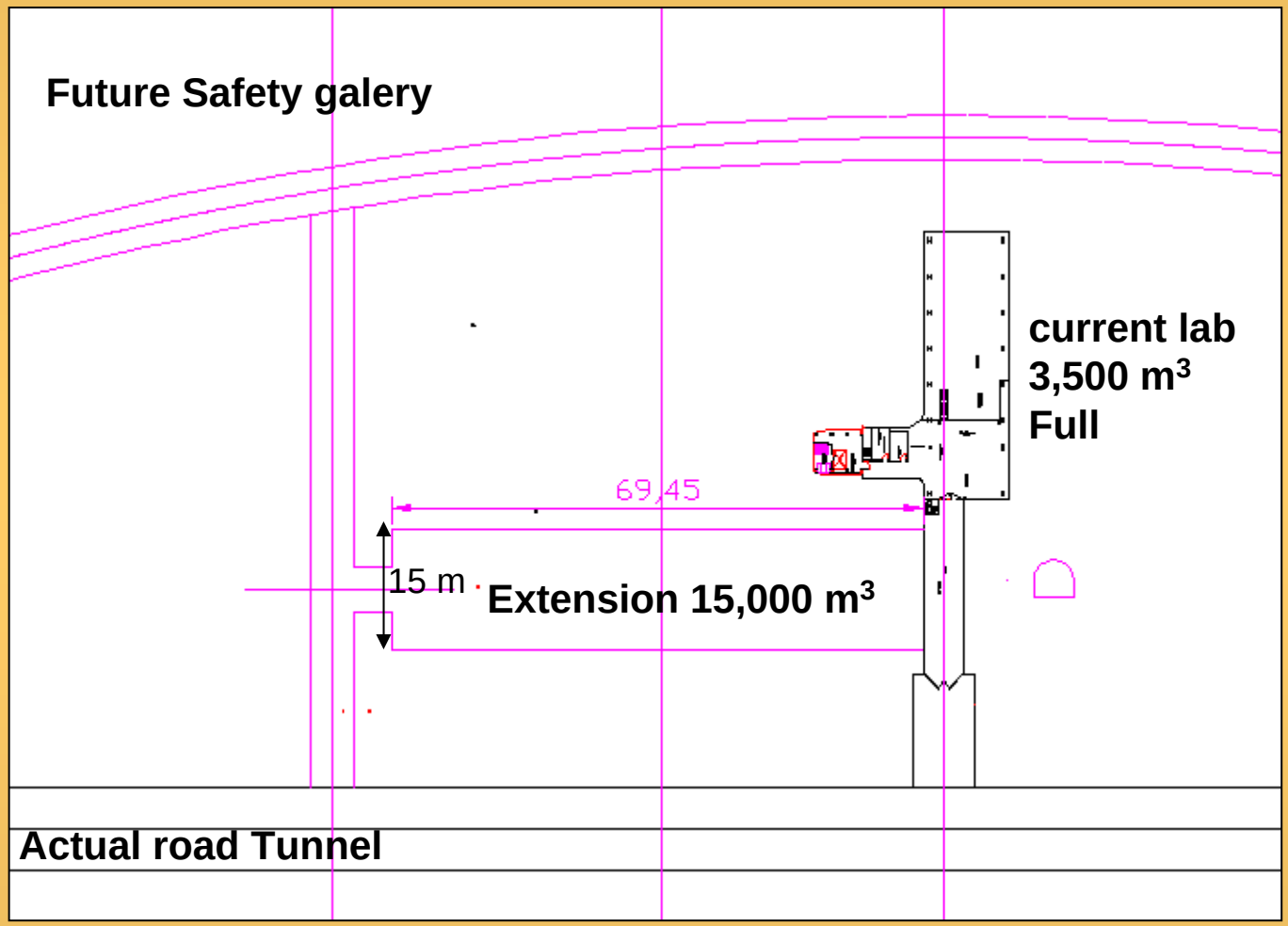
(2) 1,000,000 m³
major international laboratory

- neutrino properties
- proton decay - MEMPHYS
- supernovae

LSM limited expansion (1)

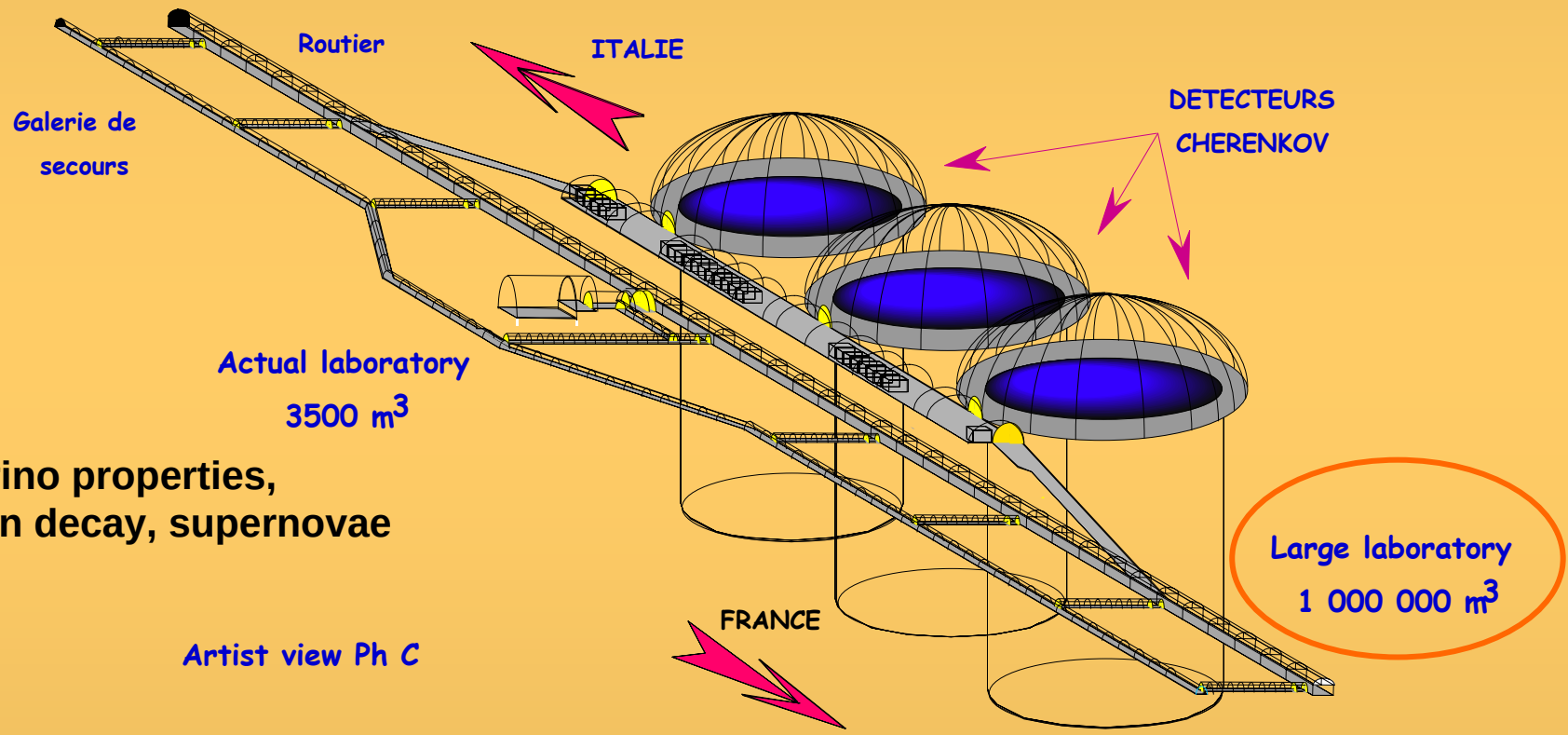
Mid 2009 : the two digging machines meet at LSM location

=>possibility of digging
15-20,000 m³
15x15x(70-100) m



Benefits of infrastruture for digging and excavating
Little impact on total excavation (< 7 %) => low cost

LSM megaton expansion (2)

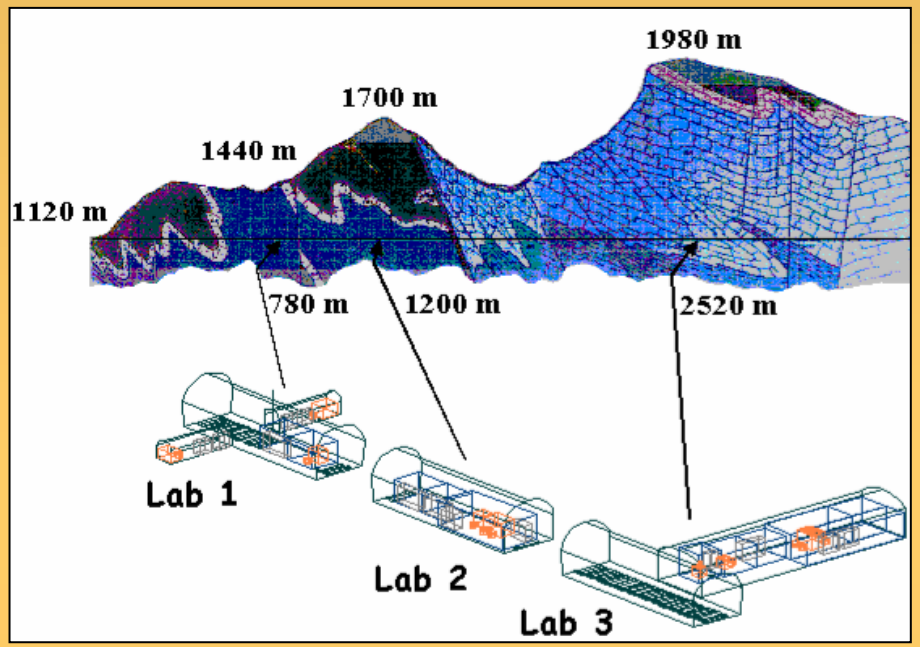


Neutrino properties,
proton decay, supernovae

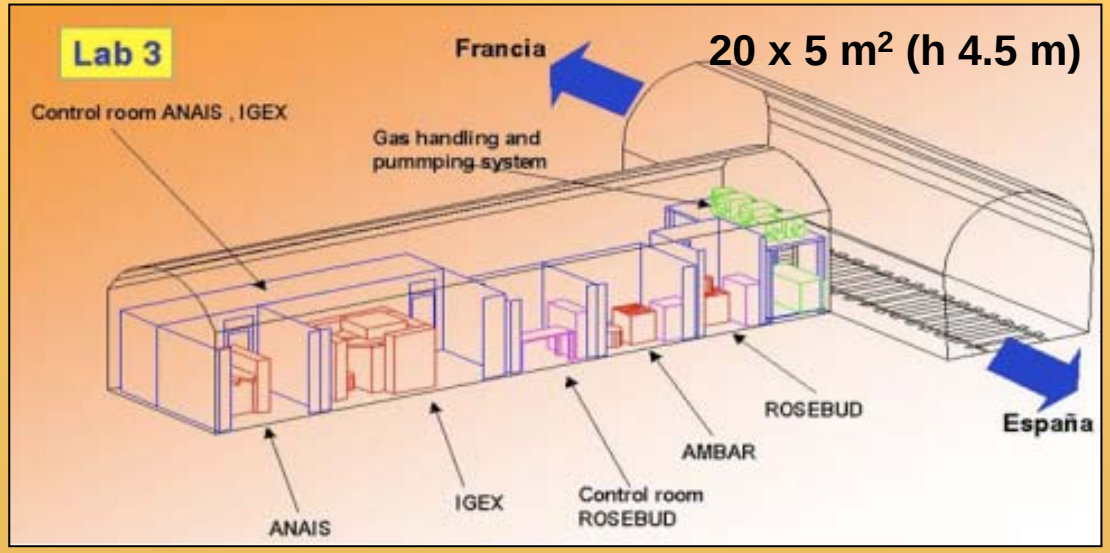
« Pre-study » nearly finished
=> shaft shape preferred

Neutrinos from CERN
SPL, beta beam (few 100 MeV)

Laboratorio Subterraneo de Canfranc



Operators	**Zaragoza University**
Location	**Somport tunnel, Pyrenes 7.5 km**
Excavation	**1986 [lab1] – 1994 [lab3]**
Area	**2 small halls [lab1] + Main hall**
Depth	**200 m (675 mwe) [lab1] – 900 m (2450 mwe) [lab3]**
Surface	**36 m² [lab1] – 118 m² [lab3]**
Permanent staff	**7**
Scientists users	**35**



LSC backgrounds and facilities

Muon Flux

$7.2\ \mu\ m^{-2}\ h^{-1}$

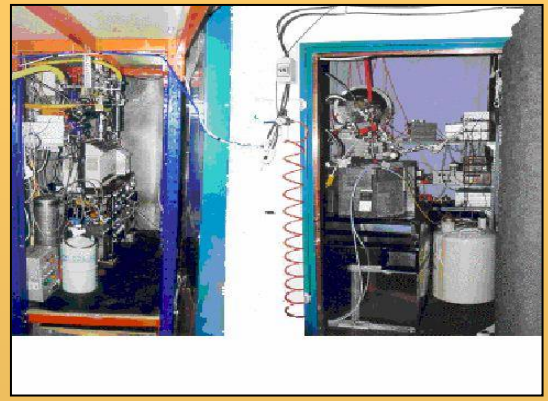
Neutron Flux

$3.82\ 10^{-6}$ n $cm^{-2}\ s^{-1}$	[integrated] (neutrons from radioactivity)
$1.73\ 10^{-9}$ n $cm^{-2}\ s^{-1}$	[integrated] (muon-induced neutrons in rock)

Gamma Flux

$2 \cdot 10^{-2}\ \gamma\ cm^{-2}\ s^{-1}$

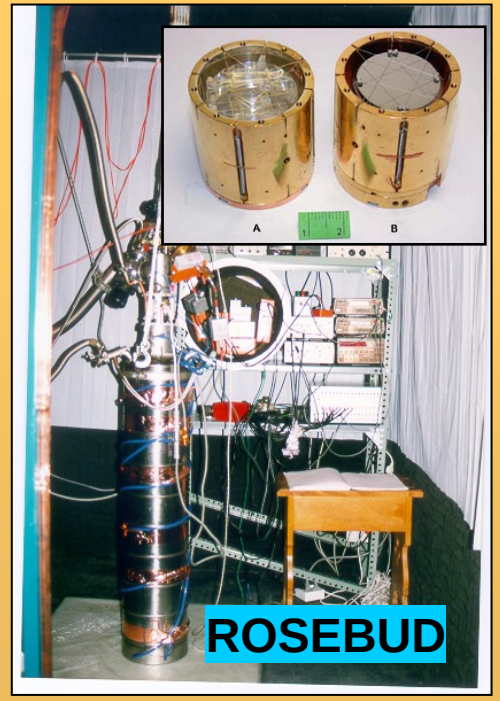
AMBAR for measuring radioactive contaminants in materials intended for low-background experiments



Low temperature installation with the 2x2x3 m^3 Faraday cage located at Lab 3

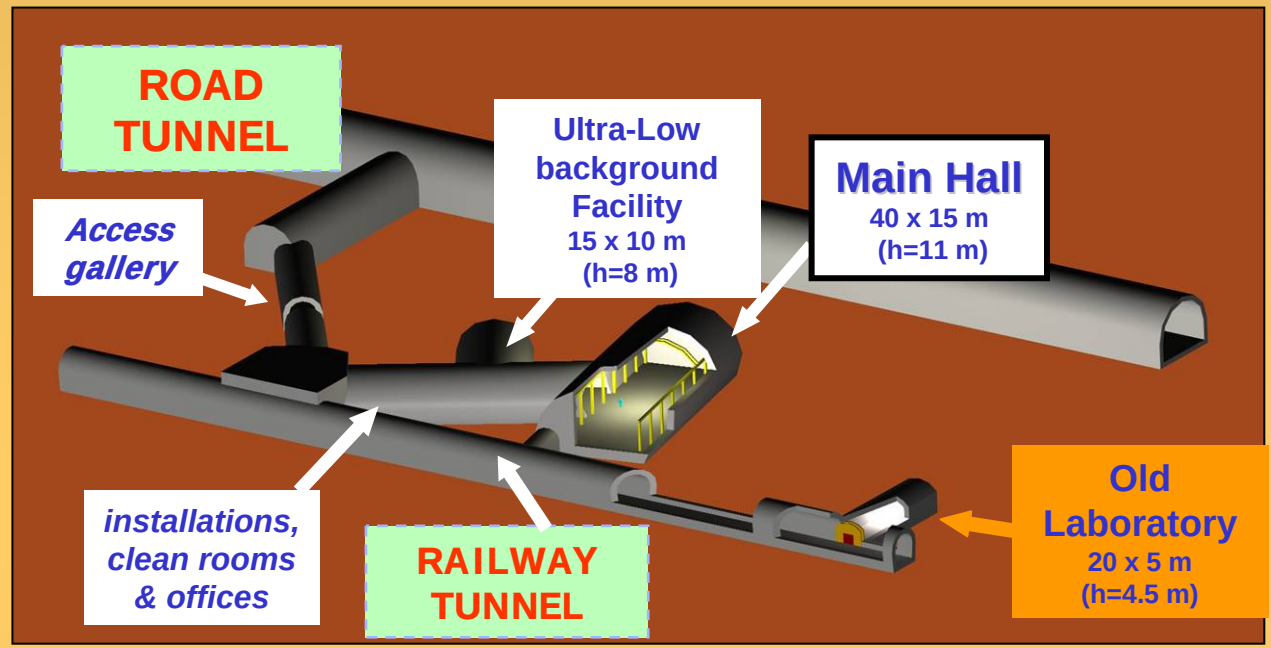
Experiments - running, construction, planned

DBD	IGEX-2	(~ 9 kg enriched Ge detectors)
Dark Matter	IGEX-DM	(~ 2 kg enriched Ge detectors)
	COSME	(small Ge detectors)
	NaI32 / ANAIS	(NaI Crystals)
	ROSEBUD	(Bolometers: Sapphire, Ge, BGO, $CaW0_4$)
DBD	GEDEON	
Dark Matter	ROSEBUD II	



LSC Canfranc new lab

The new underground Laboratory is about finished (Nov 2005)



Characteristic of the new LSC	
Depth	900 m (2450 mwe)
Main experimental hall	600 m^2 (oriented to CERN)
Low background lab	150 m^2
Clean room	45 m^2 (100/1000 type)
General services	135 m^2
Offices	80 m^2

-BiPo
-SuperNEMO
-- Dark matter
-- ....

LSC MAIN CHARACTERISTICS

- HALL A :

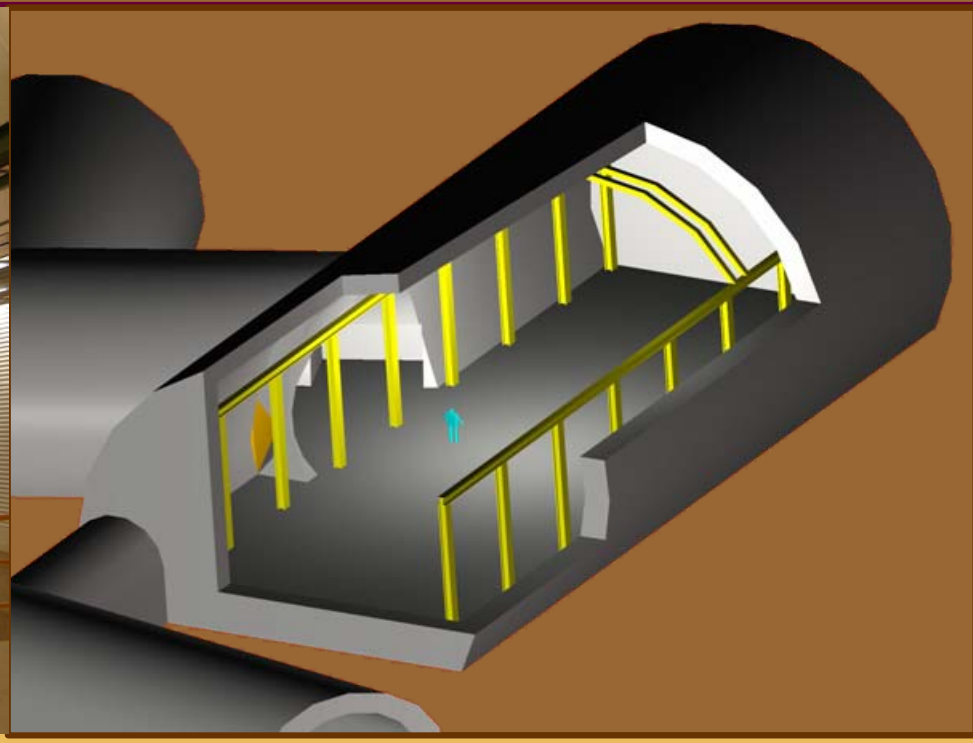
  600 m^2, 40 m x 15 m, 12 m high. (s: 142 m^2, v: 5760 m^3)

  10T overhead crane

  floor: 25 cm concrete;

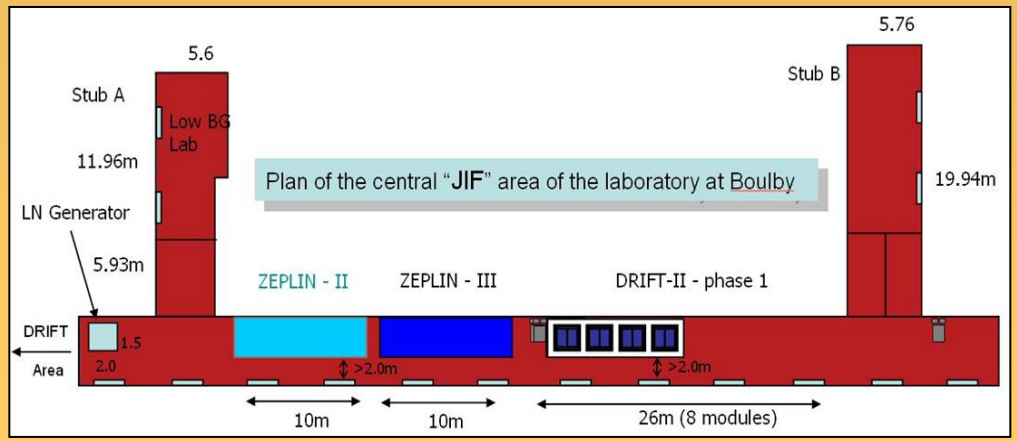
  wall: 20 cm concrete + polyethylene + steel plate;

  main axis oriented to CERN (800 km);

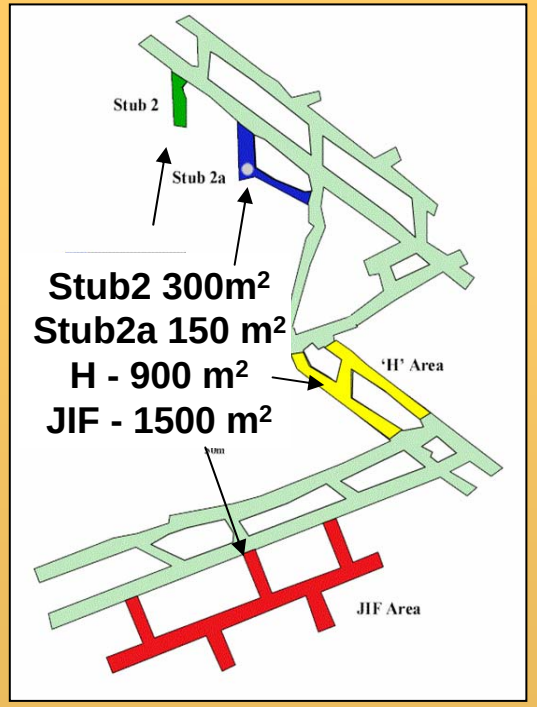


Boulby

Boulby Underground Laboratory



Owners and Operators	Institute for Underground Physics University of Sheffield, RAL
Location	Potash mine, Boulby (UK)
Excavation	1988 (Stub 2) – 1995 (Stub 2a) – 1998 (H area) – 2003 (JIF area)
Depth	1100 m (minimum vertical)
Surface	3000 m^2
Lab staff	2
Users	30



Boulby

Boulby backgrounds and facilities

Muon Flux

1.5 μ m^{-2} h^{-1}

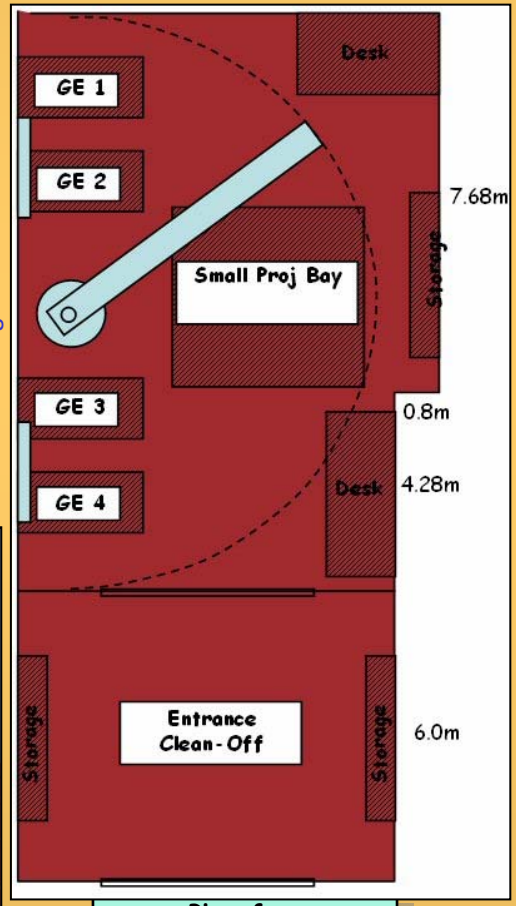
Neutron Flux

2.8 10^{-6} n cm^{-2} s^{-1}	(> 100 keV)
1.3 10^{-6} n cm^{-2} s^{-1}	(> 1 MeV)

Primordial Radionuclides

^{238}U	70 ppb	Rock
^{232}Th	125 ppb	Rock
K	1130 ppm	Rock

new low background facility
(located in the JIF area)



Plan for
JIF Low Background
Lab

Ultra Low HPGe - a 2 kg (400cc) Germanium detector, used for material radiopurity measurements sensitive to samples at the level of 0.1- 0.2 ppb U/Th

Ultra Low Nal - A NaI crystal from the NaIAD experiment will be installed in the clean room low background facility for bulk tests of activity

Radon/gamma environment monitoring

Experiments - running, construction, planned

Dark Matter	NaIAD (50kg NaI array)
	ZEPLIN-I(4 kg LXe)
	DRIFT-I (CS_2 1 m^3 TPC)
Dark Matter	ZEPLIN-II (30 kg LXe two phase)
	ZEPLIN-III (6 kg LXe two phase)
	DRIFT-II (CS_2 10 m^3 TPC)

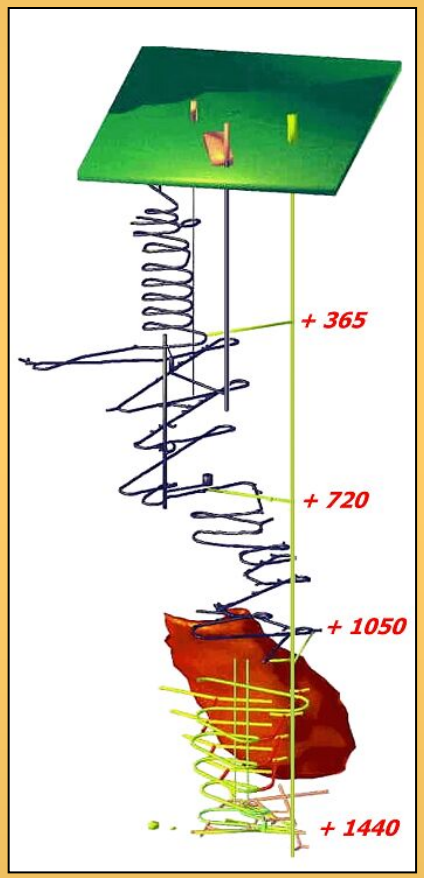
Boulby

Boulby new space and expansion?

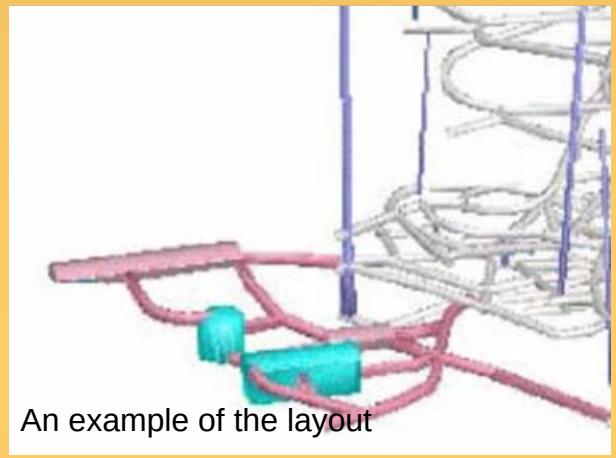
Now over 1000 miles of tunnel at Boulby

Pyhäsalmi Underground Laboratory

CUPP - **C**entre for **U**nderground **P**hysics in **P**yhäsalmi (Finland) started in 1993



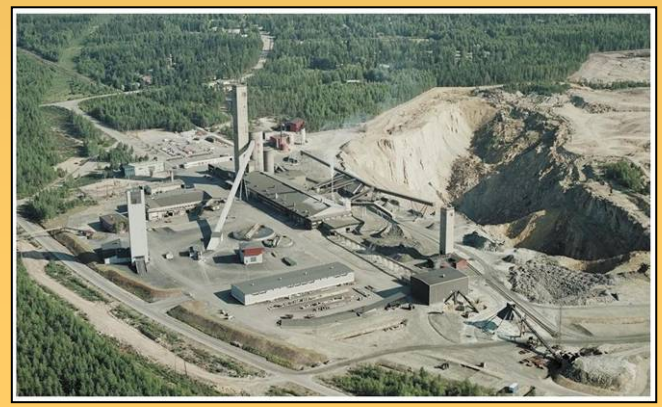
The old part of the mine:
There will be plenty of free space to host and storage experiments



An example of the layout

The new mine started to operate in July 2001. It extends to the depth of 1440 m (4000 mwe).

The largest cavern that can be easily constructed is 100 x 15 x 20 m³.



Preliminary study of backgrounds and rock analysis undertaken

^{238}U	27.8 – 44.5 Bq/m³
^{232}Th	4.0 - 18.7 Bq/m³
^{226}Ra	9.9 – 26.0 Bq/m³
^{40}K	267 – 625 Bq/m³
Rn	10 to 148 Bq/m³

ILIAS progress and the EU labs


new caverns - Canfranc


new low back lab - Boulby


new radon control - Frejus

- ILIAS assists new infrastructure at the underground labs
- ILIAS pushes new technology, new background tests and new visitors


new materials - Canfranc


neutron monitoring - Boulby


new visitors - Frejus

Summary

Significant pressure on available underground space is developing
e.g. LENA, SuperNEMO, GERDA, EURICA, CERN-beams, LAr/LXe....+++

- **European labs are trying to respond - contact us**

  Canfranc - new area - 40 x 15 x11m @ 2450 mwe - new call for SOI

  (contact J. Morales)

(N2) Review of space vs. demand this year (starting at TAUP)

(N2) Further science coordination of the European labs

(contact G. Gerbier)

- **Prospects for new European labs**

  CUPP - Centre for Underground Physics in Pyhäsalmi (Finland)

  (contact J. Peltoniemi)

Principles of « ILIAS next »

- Build on success of ILIAS
- Deepen coordination and synergy of DUL's
- Make Network and Joint Research Activities more oriented to general support to community rather than to specific expts

- Side issues
  - Beware of overlaps DS / ILIAS next
  - Link with HEAPnet, Radio, Astronomy…
  - To be better defined with ApPEC/ASPERA

N2 ILIAS-NEXT

- Network dedicated to the Underground Science Laboratories.
- Continuation of the ILIAS-FP6 N2
- Intensification of the cooperation between the deep european underground laboratories:Boulby (UK),Canfranc (Spain), Gran sasso (Ita
  Modane (France), Pyhasalmi (Finland).

- Scientific coordination
- Improvement of existing laboratories
- Studies of small and large extensions
- Safety and accident prevention
- Public communication
- Cooperation with the shallow underground laboratories (HADES),
- Exchange with non-european underground laboratories
- Relations with the industry,….