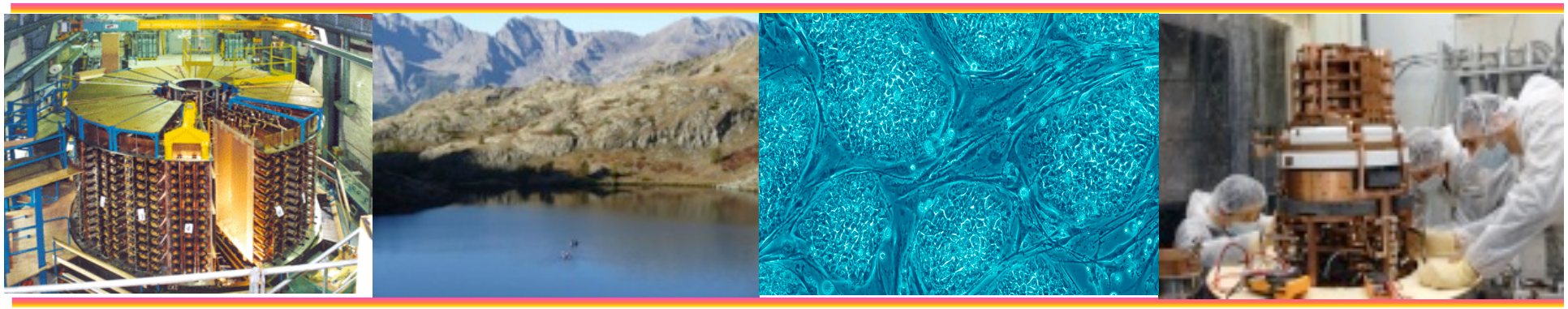
Laboratoire Souterrain de Modane



F. Piquemal

LSM (CNRS/IN2P3 et UGA)

Laboratoire souterrain de Modane

The history of LSM

First laboratory in the world digged for a particle physics experiment (CNRS and CEA)

To host Taup experiment to test grand unification theory

1979 - 1981

Building

1982- 1990

t_p Experiment

1990- 2000

Prototypes ⟶

Dark matter

Double beta decay

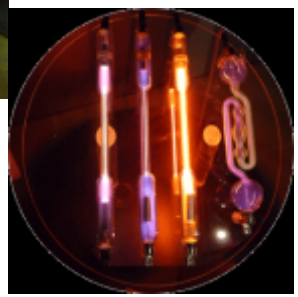
2000 - ….

Experiments

The external building

Offices, workshop, chemistry room, outreach space and guest rooms

Permanent exhibition for general public



The LSM in few words

Operated by: CNRS/IN2P3 and Grenoble-Alpes University since January 2016

The LSM staff is composed of 12 persons including a research team of 5 people (M. Chapellier, A. Dastgheibi-Fard, F. Piquemal, G. Warot, M. Zampaolo)

About 200 users from 40 laboratories (France, Russia, Czesch Rep., Germany,UK ,USA, Japan, Slovakia,…)

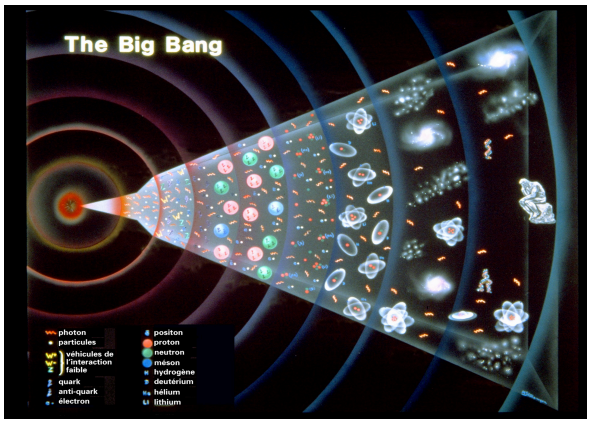
LSM is a member of the Laboratory of Excellence ENIGMASS with LAPP Annecy, LPSC Grenoble and LAPTh Annecy

LSM has an agreement of International Associated Laboratory JOULE with JINR Dubna (Russia), CTU Prague and Comemius University since 2005 . This agreement plays a major role in scientific activities of LSM

Member of the Common Laboratory supported by ANR P2R (Particle Physics for Radioprotection) : CENBG, LSM, CPPM and Carmelec company

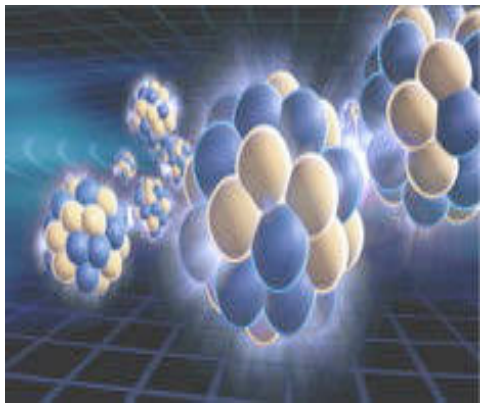
3 500 visitors per year in the LSM outreach space for general public

Scientific activities at LSM



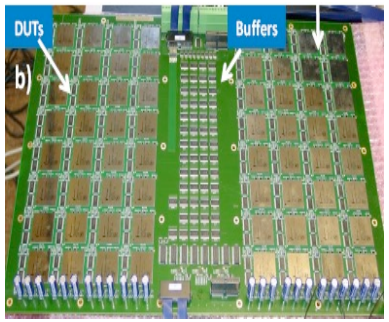
Neutrino physics
SuperNEMO, TGV,CUPID, R2D2

Search of dark matter
EDELWEISS, SEDINE, NEWS-G, MIMAC



Nuclear physics
TGV, OBELIX, SHIN

Environmental sciences



Nano-electronics

Biology

Applications

climatology, oceanography, effects of human activity on the environment, glaciology, archaeology,....

The LSM cavity

Depth: **4800 m.w.e.**

Surface: **400 m2**

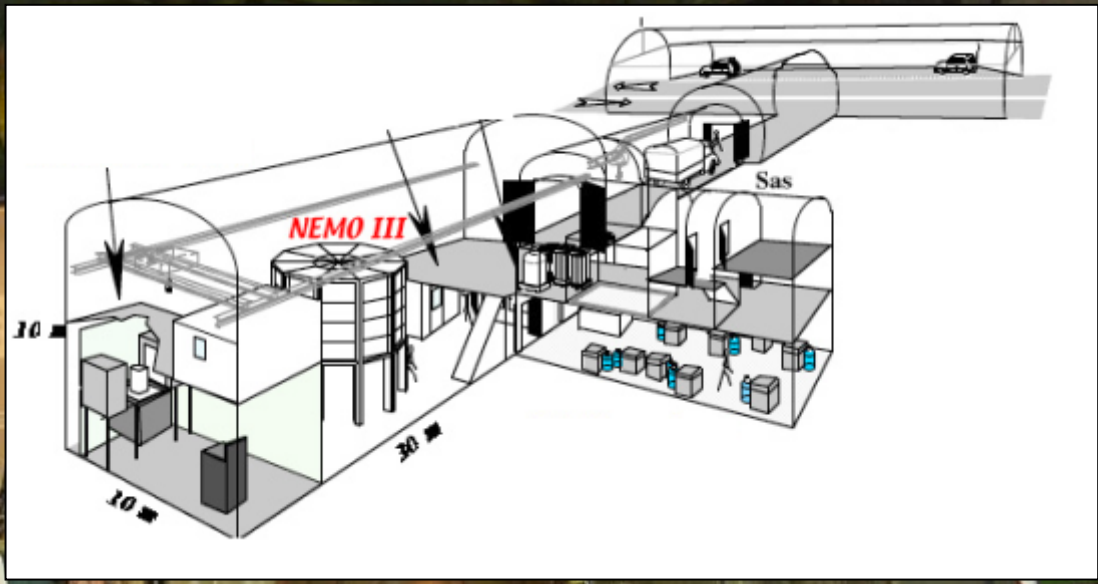
Volume : **3500 m^3**

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

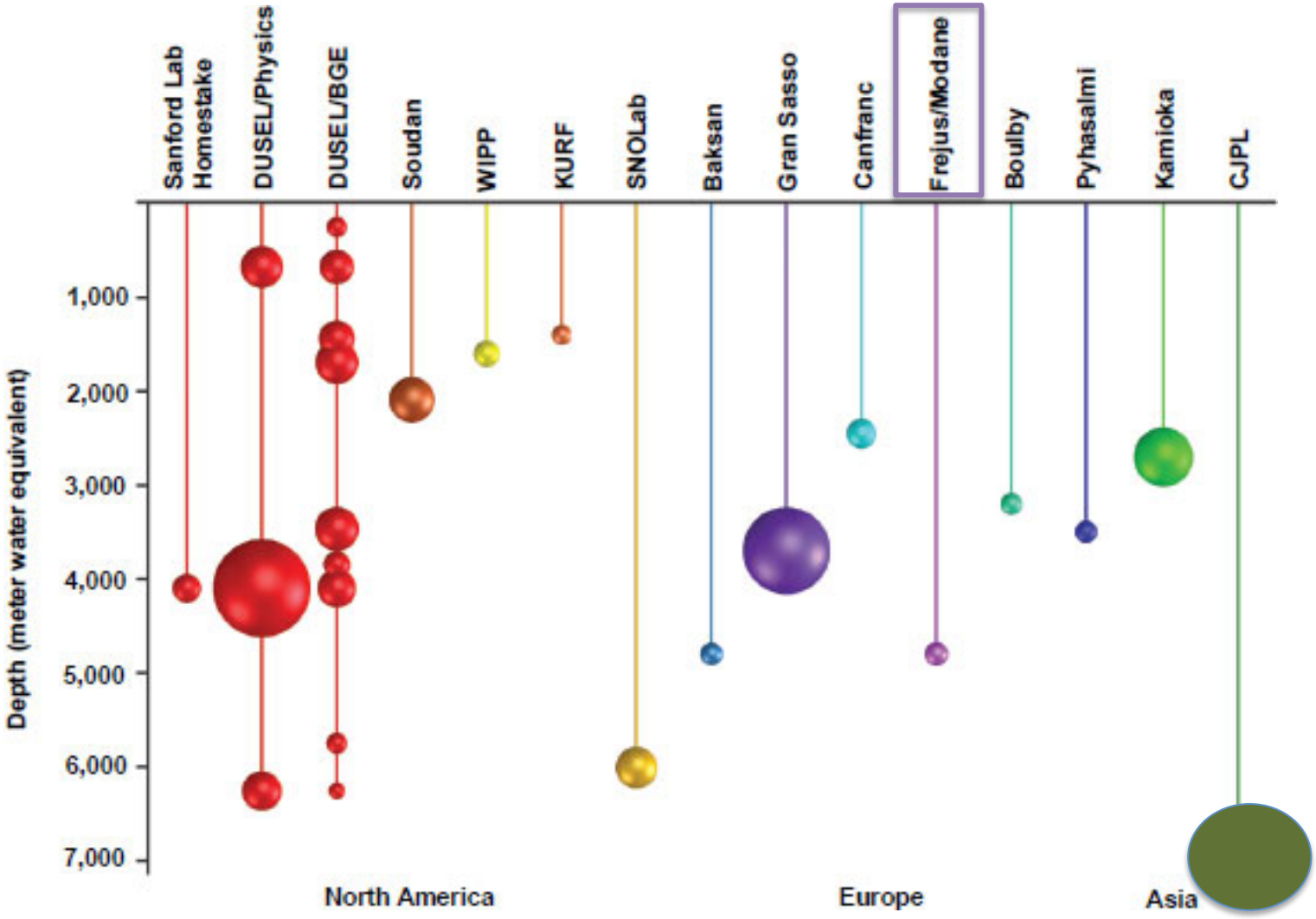
Neutrons:
Fast flux: 4 10^{-2} $n.m^{-2}.s^{-1}$
Thermal flux: 1.6 10^{-2} $n.m^{-2}.s^{-1}$

Radon: **15 Bq/m^3**

Access : **horizontal**

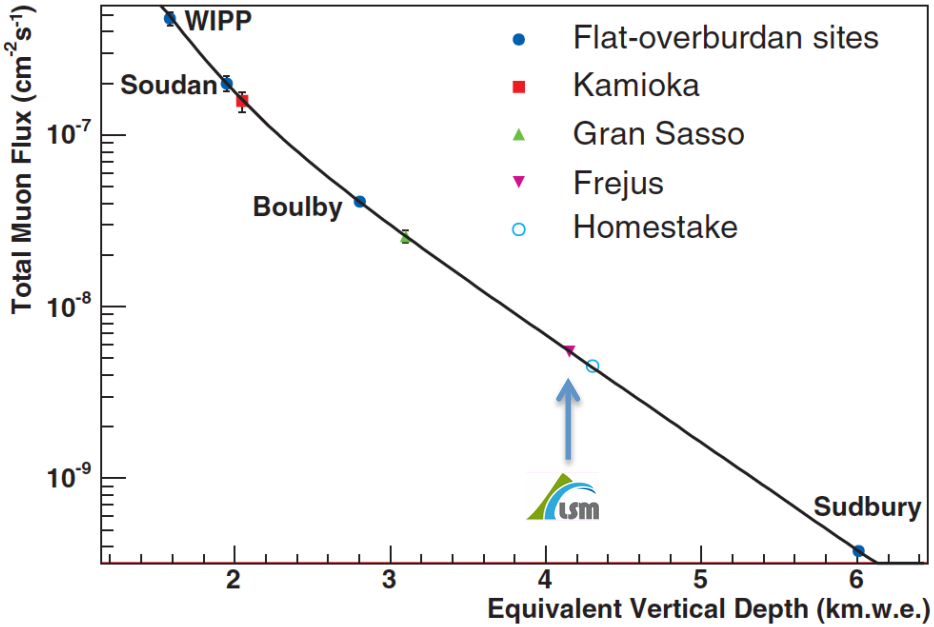


The LSM caracteristics vs other DUL



The LSM caracteristics vs other DUL

Mei and Himes PHYSICAL REVIEW D 73, 053004 (2006)



Site	Total flux $cm^{-2}sec^{-1}$	Depth km.w.e.
WIPP	$(4.77 \pm 0.09) \times 10^{-7}$ [4]	1.585 ± 0.011
Soudan	$(2.0 \pm 0.2) \times 10^{-7}$ [5]	1.95 ± 0.15
Kamioka	$(1.58 \pm 0.21) \times 10^{-7}$ [12]	2.05 ± 0.15^{a}
Boulby	$(4.09 \pm 0.15) \times 10^{-8}$ [6]	2.805 ± 0.015
Gran Sasso	$(2.58 \pm 0.3) \times 10^{-8}$ (this work)	3.1 ± 0.2^{a}
	$(2.78 \pm 0.2) \times 10^{-8}$ [9]	3.05 ± 0.2^{a}
	$(3.22 \pm 0.2) \times 10^{-8}$ [10]	2.96 ± 0.2^{a}
Fréjus	$(5.47 \pm 0.1) \times 10^{-9}$ [11]	4.15 ± 0.2^{a}
	$(4.83 \pm 0.5) \times 10^{-9}$ (this work)	4.2 ± 0.2^{a}
Homestake	$(4.4 \pm 0.1 \times 10^{-9})$ (this work)	4.3 ± 0.2
Sudbury	$(3.77 \pm 0.41) \times 10^{-10}$ [7]	6.011 ± 0.1

[a]Equivalent vertical depth with a flat overburden determined by the measured total muon flux.

Note: the mean LSM depth is 1780 m corresponding to 4850 m.w.e.
(Phys Rev D40 2163 (1989))
On this plot authors renormalized the depth to an equivalent flat surface.

Neutrons

Neutrons flux measured by V. Chazal et al. (Astroparticle Physics 9 (1998) 163-172)

Fast neutrons > 1 MeV : (4.0 ± 1.0) 10^{-6} n.cm^{-2}.s^{-1} ((1.1 ± 0.1) 10^{-6} R. Lemrani and G. Gerbier)
Thermal neutrons : (1.6 ± 0.1) 10^{-6} n.cm^{-2}.s^{-1}

More precise studies by A. Rolov, E. Yakushev et al. : arXiv 1001.4383 (2010)

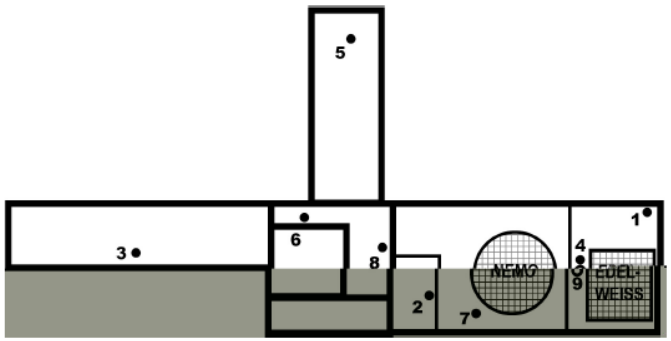


Table 2. Thermal neutron fluxes (10^{-6} /cm^2/sec) at different locations at LSM. See Fig. 3 for details. Errors are statistical only, systematic uncertainties are listed in Table 3.

Point	Run time	Results		
	Days	Counting rate at ROI, cpd	Flux[1]	Flux[2]
1[3]	35.6	76.8±1.5	3.64±0.07	3.90±0.07
1[4]	52.7	74.3±1.2	3.52±0.06	3.77±0.06
2	1.13	96.9±9.3	4.6±0.4	4.9±0.5
3	0.89	130.7±12.1	6.2±0.6	6.6±0.6
4	2.75	43.3±4.0	2.0±0.2	2.2±0.2
5	1.00	94.7±9.7	4.5±0.5	4.8±0.5
6	1.17	81.8±8.4	3.9±0.4	4.1±0.4
7	0.91	60.4±8.1	2.9±0.4	3.1±0.4
8	0.83	72.2±9.3	3.4±0.4	3.7±0.5

Daily check of thermal neutron flux

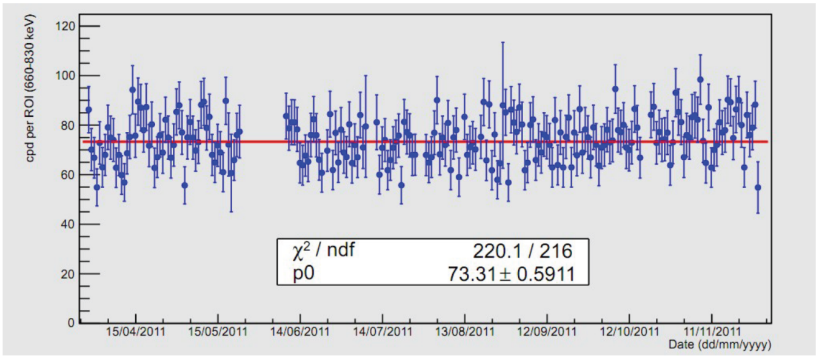


Fig. 24: *Day by day data registered by detector of thermal neutrons in LSM in 2011.*

Gamma-ray flux

The γ-ray fluxes in the LSM. The unit of flux is 10^{-6} cm^{-2} s^{-1}. Errors in the present measurements are about 30%. The results of similar measurements made at the Broken Hill underground facility are also shown (see text)

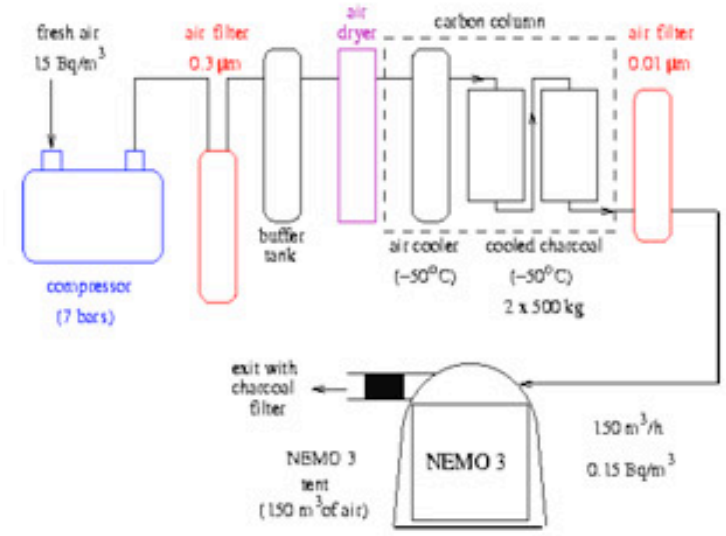
Energy interval (MeV)	LSM (present measurement)	Broken Hill (Ref. [12])
4.0–6.0	3.8	22.5
6.0–7.0	1.5	3.7
7.0–8.0	1.6	0.8
8.0–9.0	0.07	0.14
9.0–10.0	0.05	0.03
> 10.0	0.01	≃ 0.004

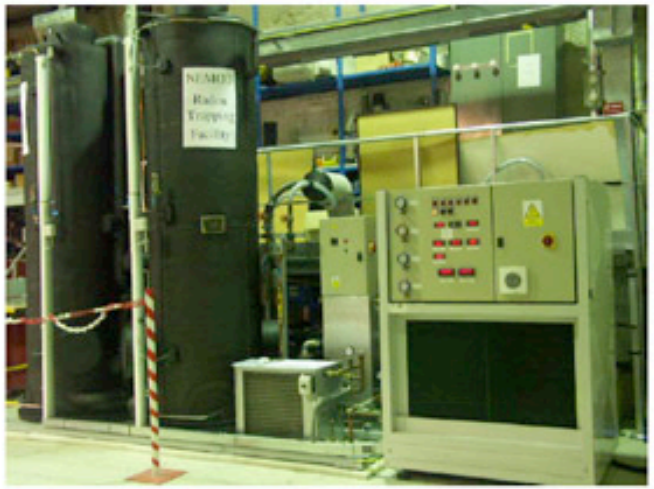
Radon-free air facility

Running since Oct. 4th, 2004
in Fréjus Underground Lab.

1 ton charcoal @ -50°C, 7 bars

Flux: 150 m³/h
Activity of ^{222}Rn :
Before Facility = 15 Bq/m³
After Facility < 15 mBq/m³

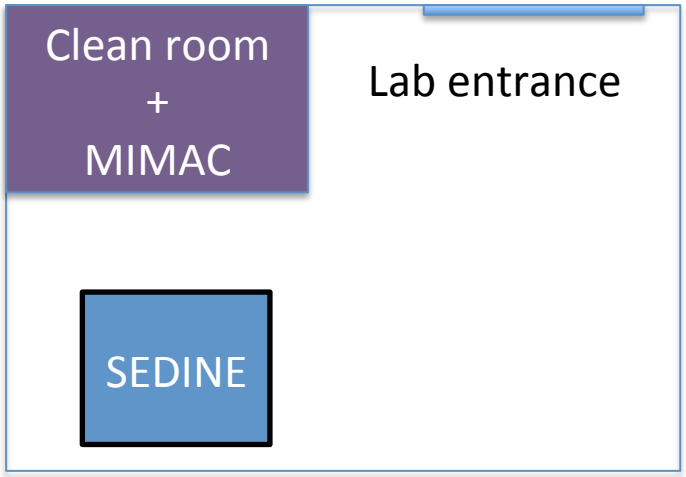


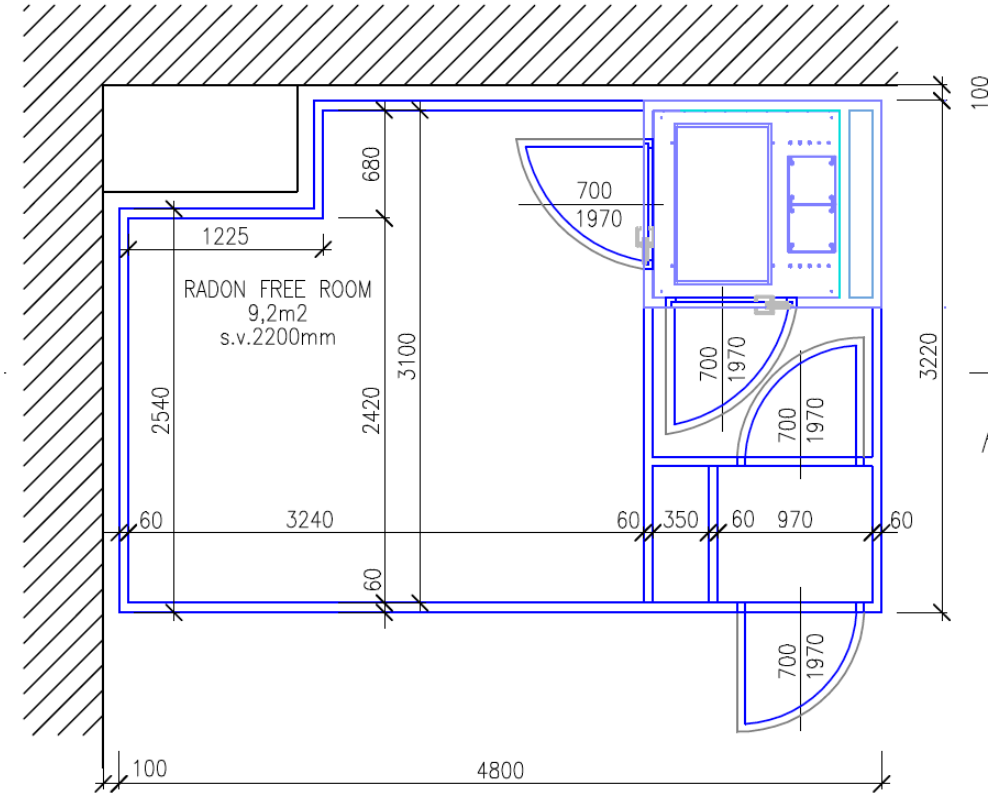


+ 2 radon detectors from JINR Dubna (one on EDELWEISS) sensitivity 17 mBq/m³.d
+ 1 radon detector (CENBG) sensitivity ~ 1 mBq/m³.d

New clean room facility

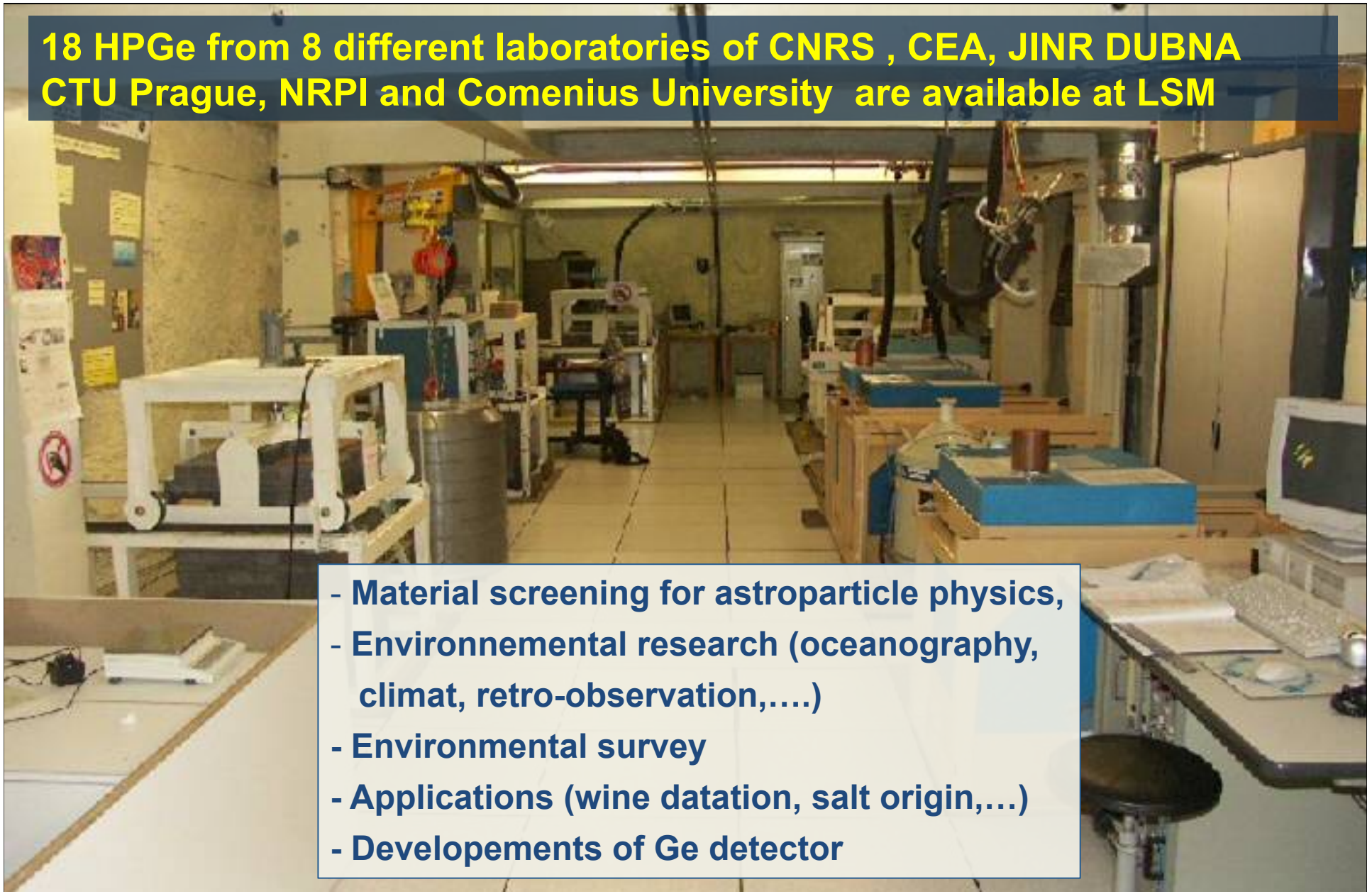
A deradonized clean room class 100 (ISO 5) funded by CTU Prague will available beginning 2018.





It will be used for the biological activities but it will be also open to the users requiring a deradonized clean room for some works

Germanium spectroscopy

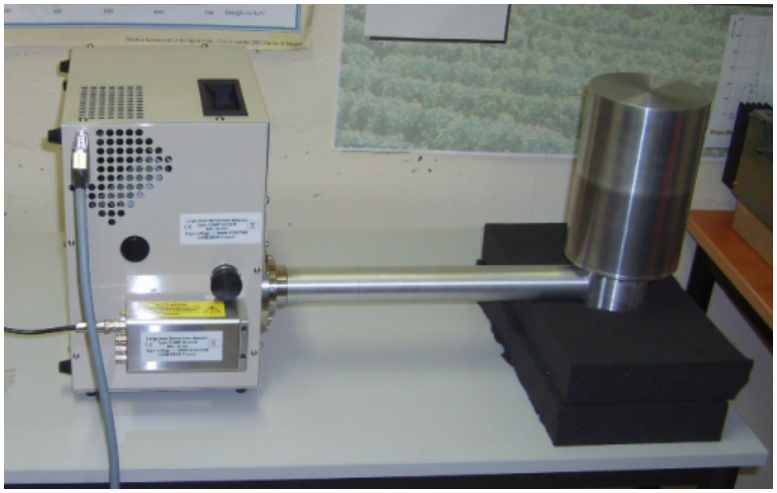


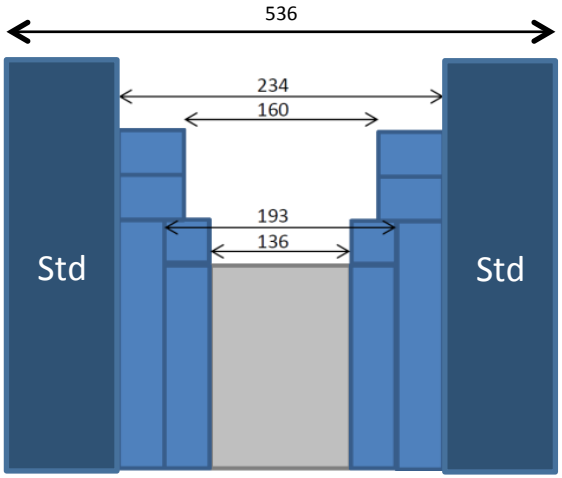
Germanium spectroscopy

LSM has several HPGe detectors to offer material screening to the users

Detector	Size	Type	owner
Mafalda	150 cc	Planar	LSM
Idéfix	600 cc	Co-axial P	Dubna, Prague, LSM
Obélix	600 cc	Co-axial P	Dubna, Bratislave, LSM
Hellaz	200 cc	Co-axial P	LSM
ZZtop	80 cc	N -planar	LSM
Abyme	980 cc	Puit	LSM

Mafalda detector





Silicon wafer measurement
700 000s 650 g

Nucleide		Bq/kg
210Pb	<	1,58E-02
^{226}Ra	<	1,27E-03
238U	<	6,27E-03
228Ra	<	3,82E-03
228Th	<	8,66E-04

Dimensions and performances

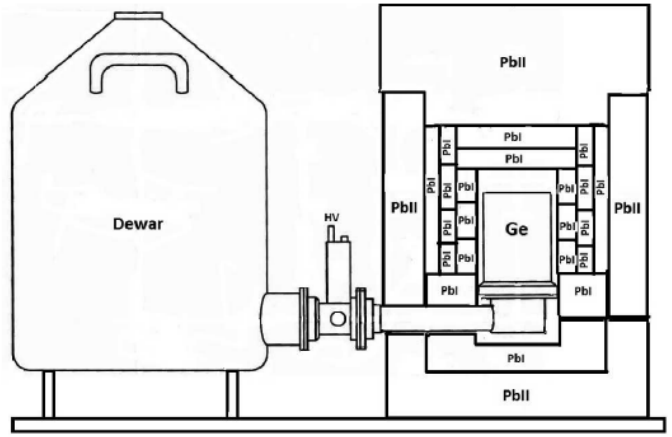
Size 150 cc – 43,1%

Φ 80mm h 31,7mm

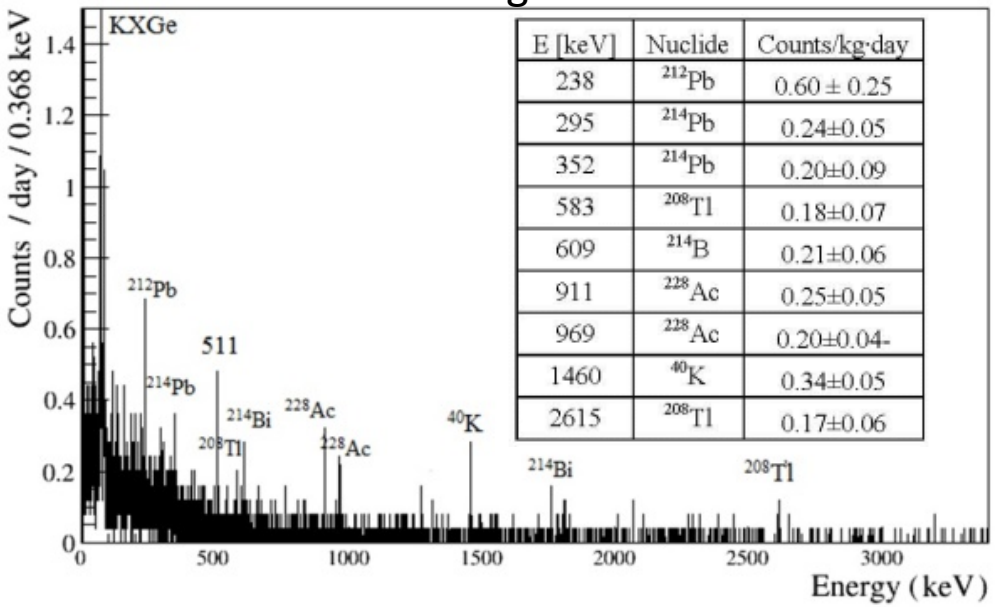
Energy resolution 122 keV 920 eV
1,33MeV 1,97keV

Background: Integral 115 ? 3,5 count/day
46,5 keV 1,49 ? 0,37 c/d[210Pb]
75 keV 3,6 ? 0,62c/d [Pb]

OBELIX detector



Background



E [keV]	Nuclide	Counts/kg·day
238	^{212}Pb	0.60 ± 0.25
295	^{214}Pb	0.24±0.05
352	^{214}Pb	0.20±0.09
583	^{208}Tl	0.18±0.07
609	^{214}B	0.21±0.06
911	^{228}Ac	0.25±0.05
969	^{228}Ac	0.20±0.04-
1460	^{40}K	0.34±0.05
2615	^{208}Tl	0.17±0.06

OBELIX

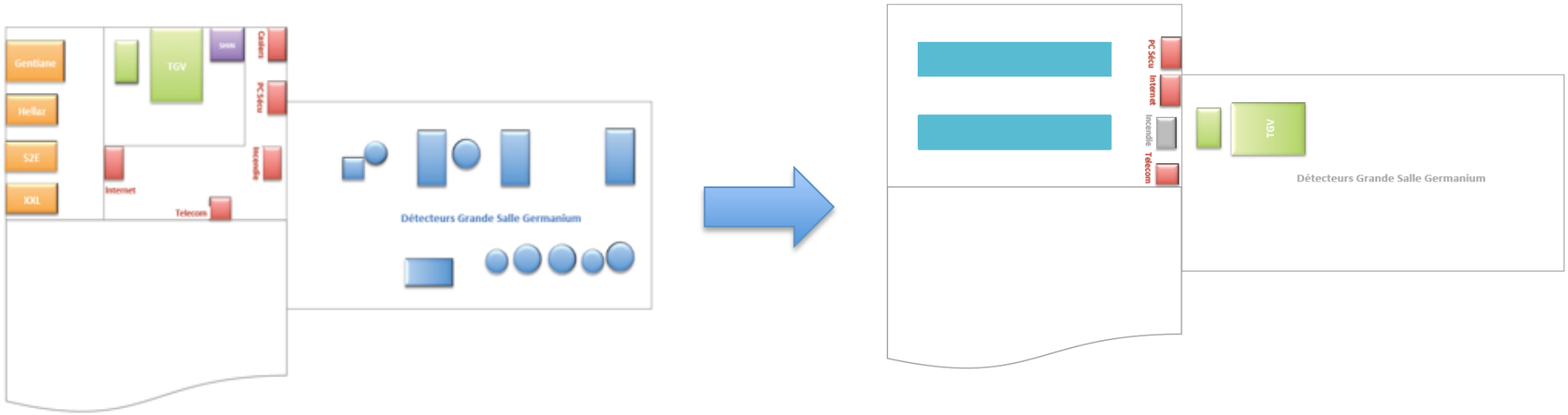
Volume : 600 cc

Efficiency: 160 %

Background: 96 cps/kg.d

PARTAGe project

Presently 18 HPGe detectors at LSM Request for 7 additionnal detectors in 2018-2019
No more place in the spectroscopy rooms

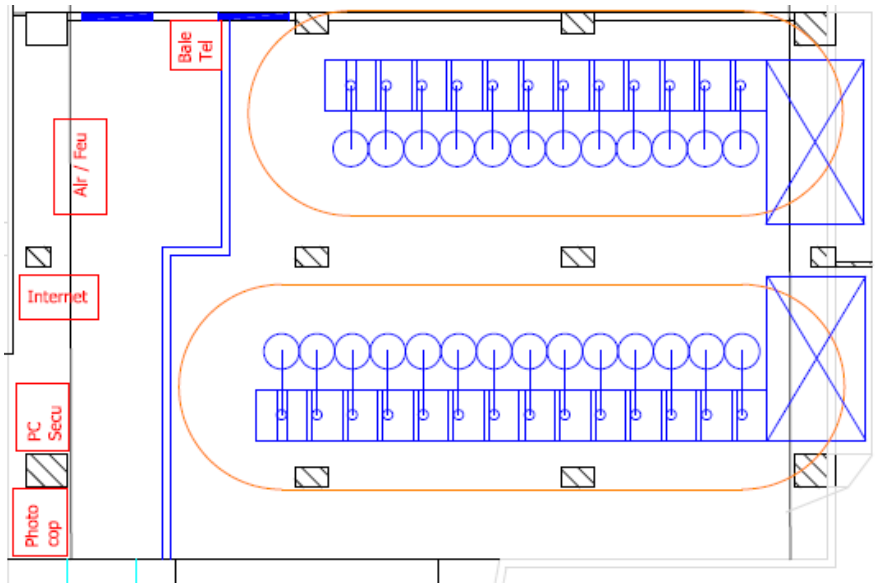


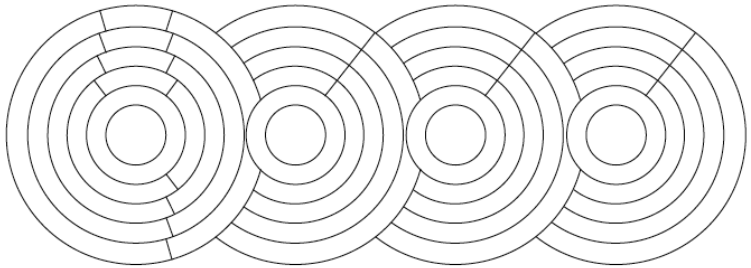
Funding: IDEX Grenoble 140 k€, Université Grenoble-Alpes 150 k€, IN2P3 150 k€
CTU Prague: 120 k€

Additonnal demands Region 200 k€, Département Savoie 200 k€

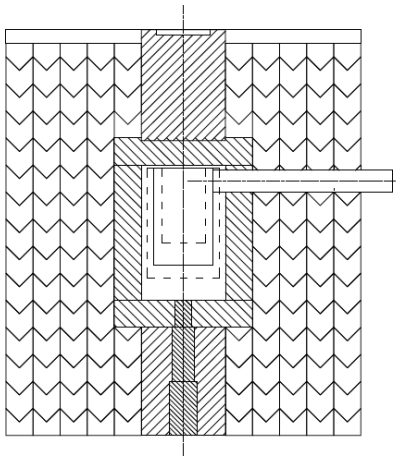
Expected to be completed end summer 2018

PARTAGe project





Top view



Side view

Common shielding

+ anti-radon system

+ study for robot
to change samples

Outlook

PARTAGe Project:

- To optimize the space in the lab in order to host new experiments
- New deradonized clean room
- New room for gamma spectroscopy
- We will try to minimize effects on the other experiments

Collaboration with LAPP to improve the slow control of the laboratory to provide more Information to the experiment using industrial standards

Creation of a startup at LSM for applications in biology supported by the LinkSyum SATT

Fusion of LSM and LPSC in a new institute.
The new institute will have two sites Modane and Grenoble. The brand « LSM » will stay as requested by the CNRS and UGA.
This fusion is essential to continue to develop LSM research activities and support to users

Transition in 2018 (Spring 2018, LSM staff will be transferred to the new institute).
LSM UMR will be stopped December,31 2018.

It will be almost transparent for the users