Low background facilities in LSM

Overview of the germaniums and available at LSM

Germanium

- Germanium hosted in LSM
- Example of detector
- Sample management
- Partage project
- Comparison to mass spectrometry

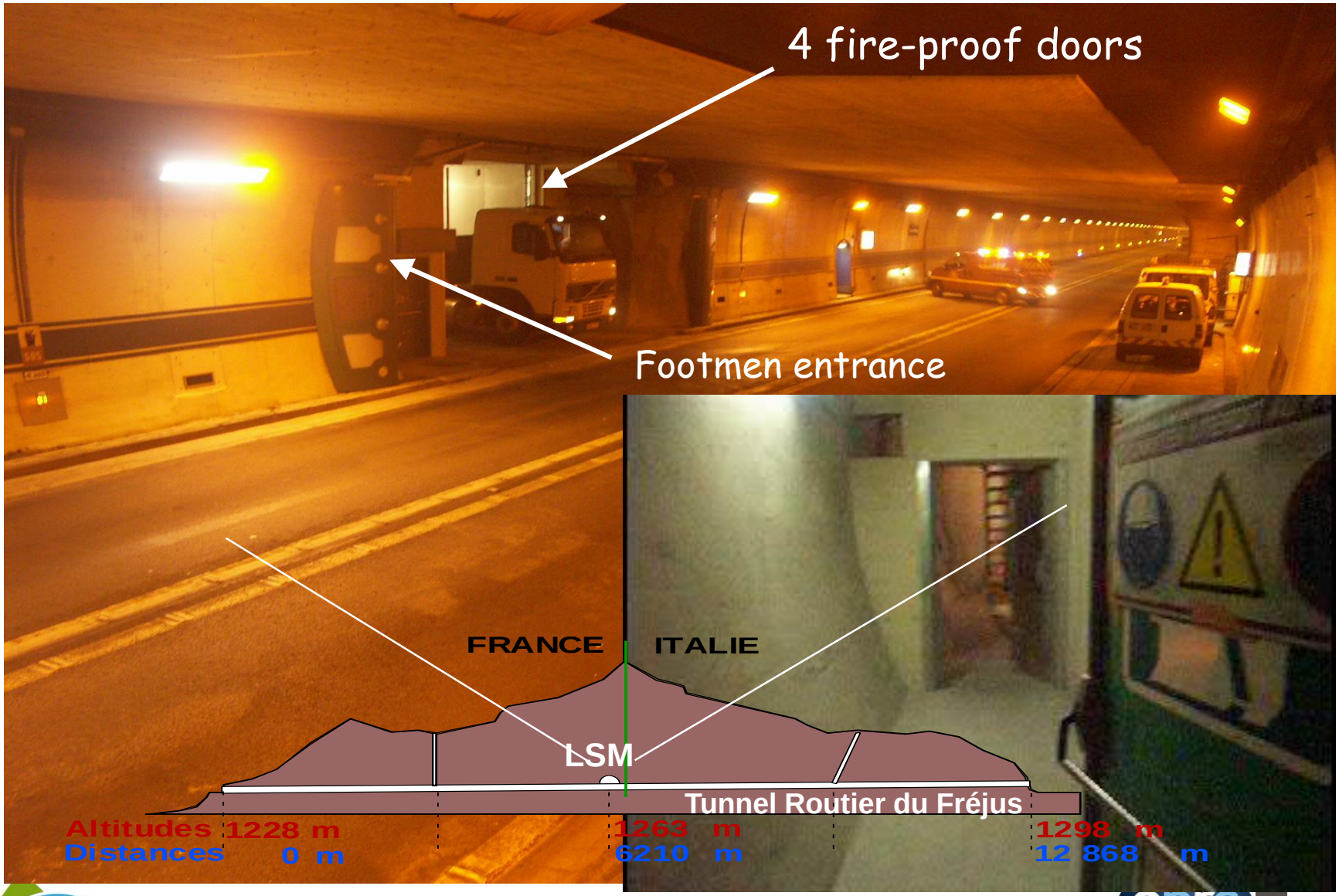
Laboratoire Souterrain de Modane

- Located in Modane
- 12 permanents
- 1000 visitors days per year
- Wide range of interdisciplinary topics
- Astroparticles, nuclear physic, environment, electronics, radioactivity measurement, biology

Laboratoire Souterrain de Modane

- Merger with Laboratoire de Physique Subatomique & Cosmologie (LPSC-IN2P3) in Grenoble
  - 70 researchers, 90 Engineers & technicians
  - Covering fields in particle & nuclear physics, astroparticle and cosmology
- LSM now becomes a « national facility » as labelled by the CNRS
  - National facility for IN2P3 / CNRS
- LSM as an national experimental facility for :
  - Fundamental Physics
    - Neutrino property determination
    - Direct Dark matter search
  - Gamma spectrometry measurement
    - 14 detectors measuring continuously
    - Open to geosciences, materials, biology and medecine
      - Actually 1000 samples measured per year
    - PARTAGe project to automatize measurments
      - Increase significantly the scope of the LSM

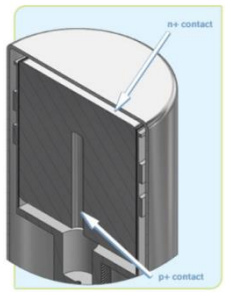
Location and access



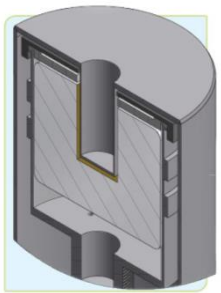
Germanium basics

- Sample at room temperature
- Sensitive to gammas from 20keV up to 3MeV
- Non destructive measurement
- Sensitive to muons and cosmic activation

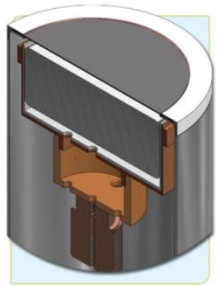
Coax

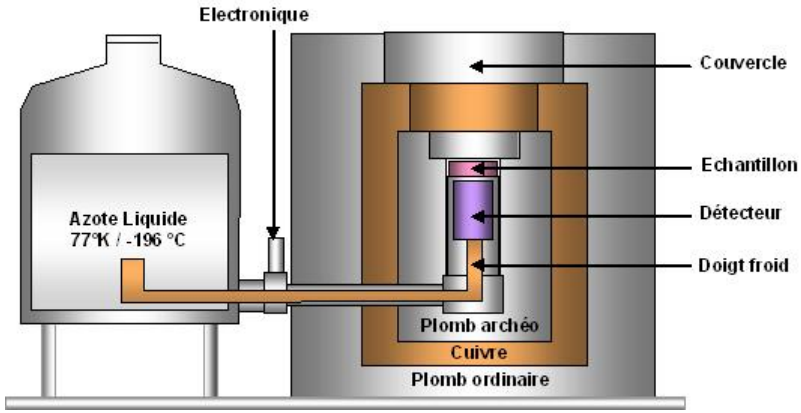


Well



Planar

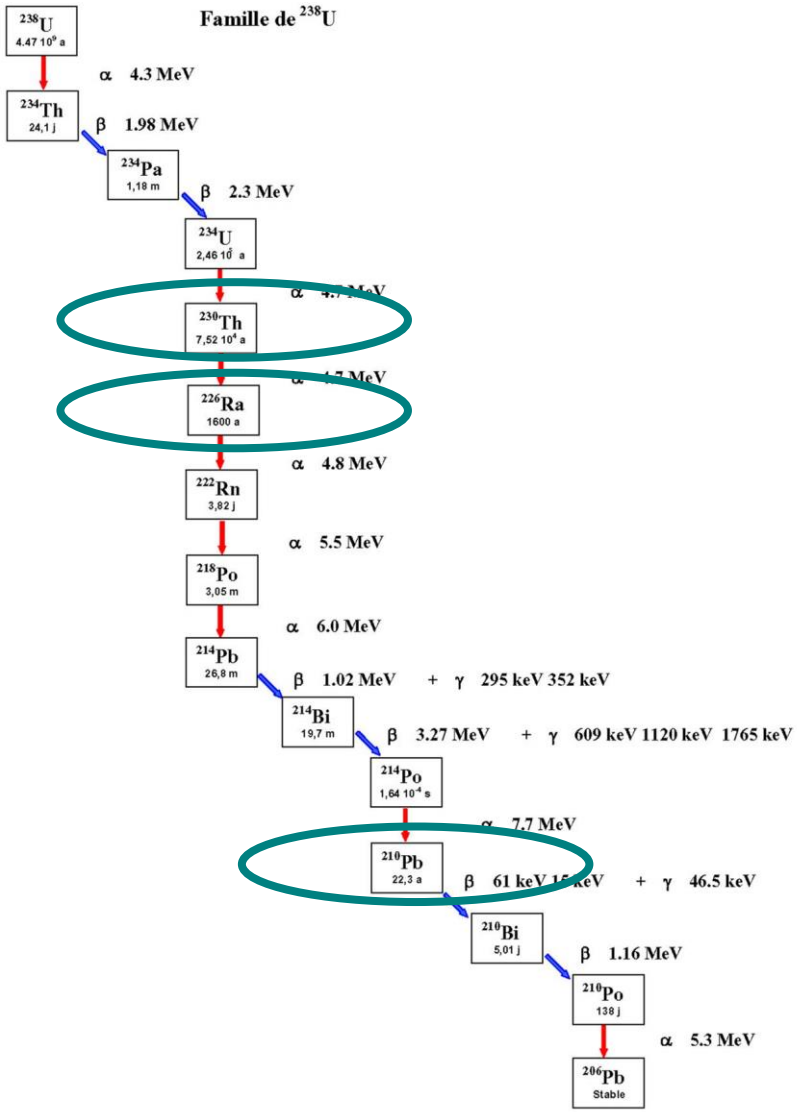


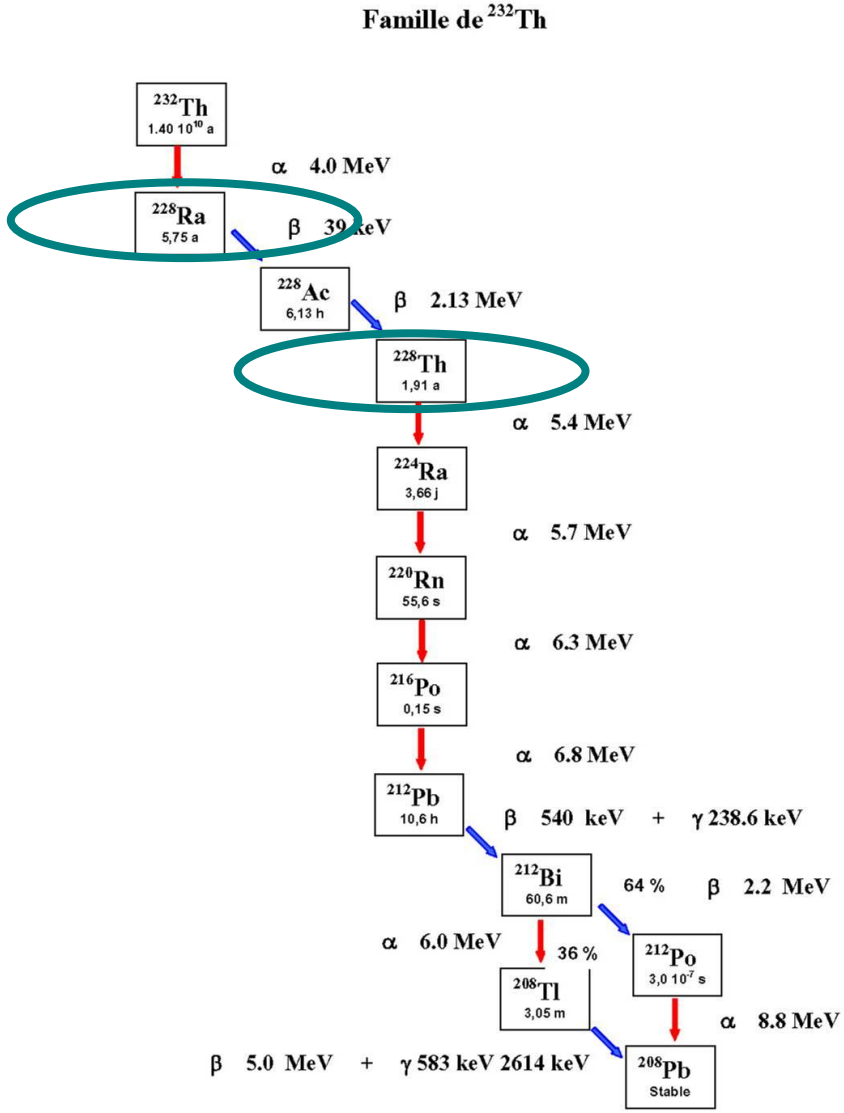


Germanium facility

- LSM hosts currently 18 ultra low background Germanium this number is expected to grow to 24 in the next years
- Different shape and sizes are available.
- The detector should be chosen accordingly to the sample nature
- The gamma measurement allow to search for contamination (month scale measurement)
- Detector fight radons different way. Pure nitrogen, boil off the dewars or radonless air.

Main contaminants





Germanium facility

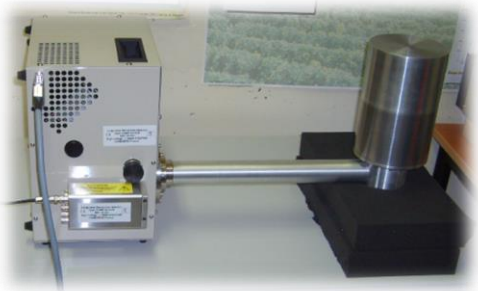
- Example of detection limits

Mafalda : (our swiss army knife)

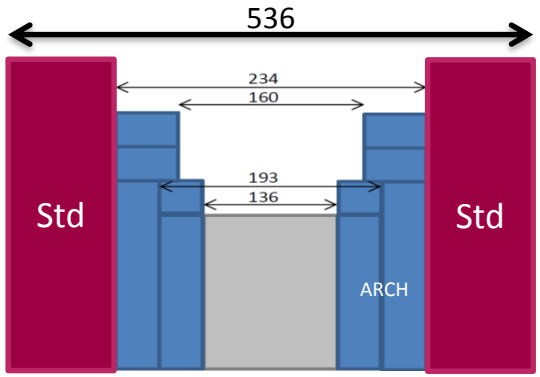
- Size 150 cc – 43,1%
- Resolution
  - Φ 80mm h 31,7mm
  - 122 keV 920 eV
  - 1,33MeV 1,97keV
- Background
  - Integral 115±3,5 count/day
  - 133 c/kg
  - Peaks
  - 46,5 keV 1,49 ± 0,37 c/d [210Pb]
  - 75 keV 3,6 ± 0,62c/d [Pb]

$$\text{limit (Bq)} = \frac{1{,}43 + 2{,}36\sqrt{1{,}36 + bdf \times t}}{\varepsilon(m)\, m\, t}$$

$$\varepsilon = \frac{detected}{emitted}$$



Shielding



Silicon wafer measurement
700 000s 650g

Nucleide		Bq/kg
^{210}Pb	<	1,58E-02
^{226}Ra	<	1,27E-03
^{238}U	<	6,27E-03
^{228}Ra	<	3,82E-03
^{228}Th	<	8,66E-04
^{230}Th	<	1,42E-01

Guillaume Warot

Germanium facility

- Improving detection limit :
  - Imply choices :

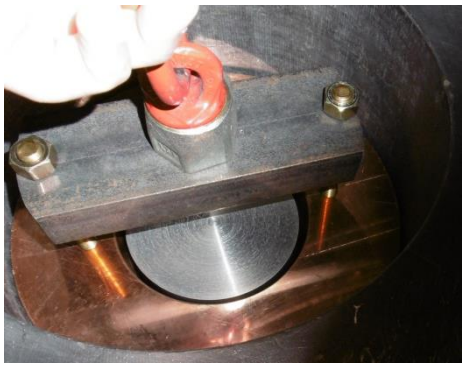
This detector can welcome much bigger sample but the low energy gamma are stopped by the dead layer around the detector.

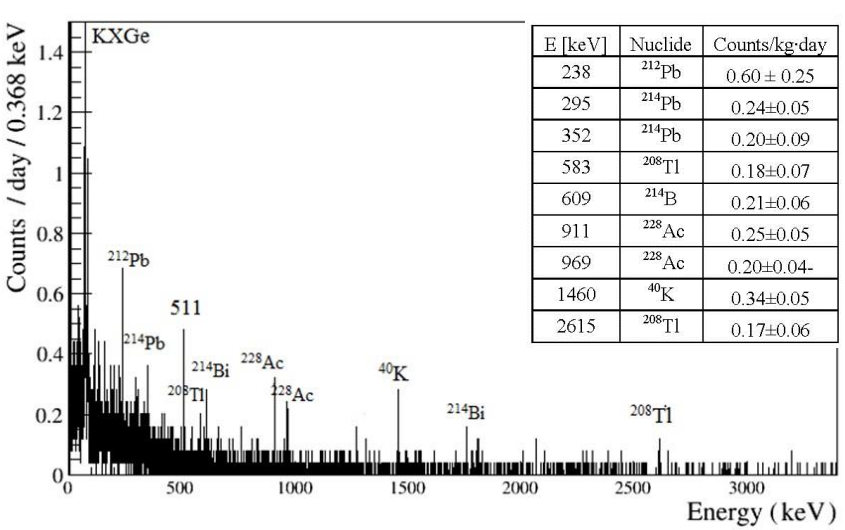
Theoretical sample of 1kg for 500000s

Nucleide		Bq/kg
210Pb		NA
^{226}Ra	<	4,96^{E}-4
238U		NA
228Ra	<	1,78E-03
228Th	<	4,37E-04

Obélix :

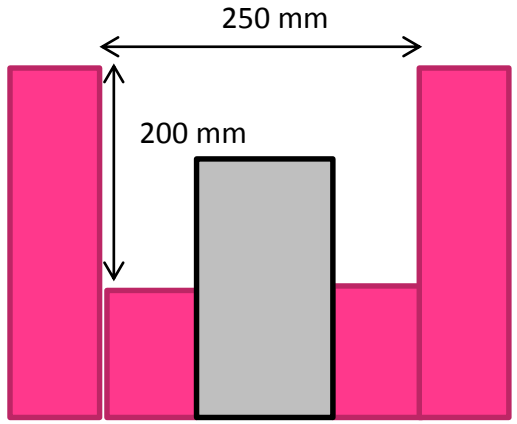
- Size
  - 600cc-160%
- Background
  - 95 counts/kg.d
- Resolution
  - 122 keV 1,1 keV
  - 1,33MeV 2keV





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

Sample Chamber



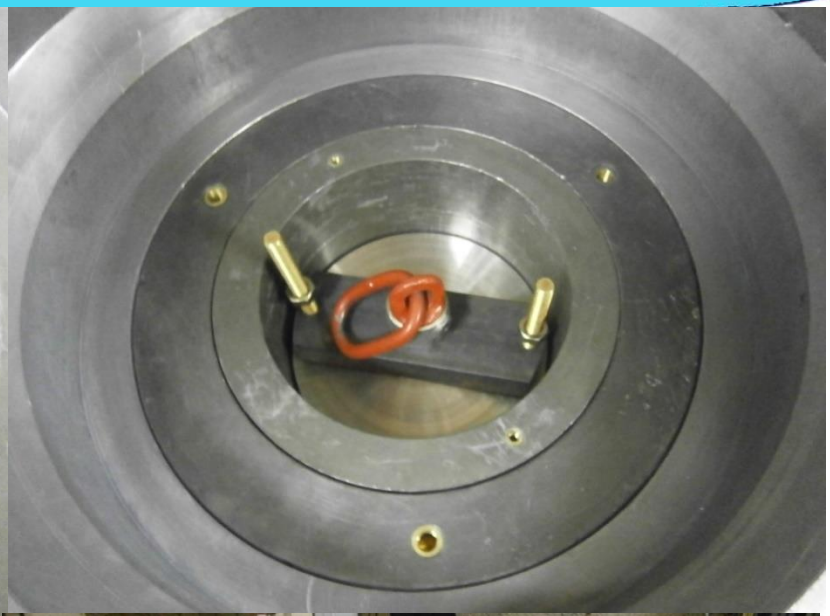
Sample management

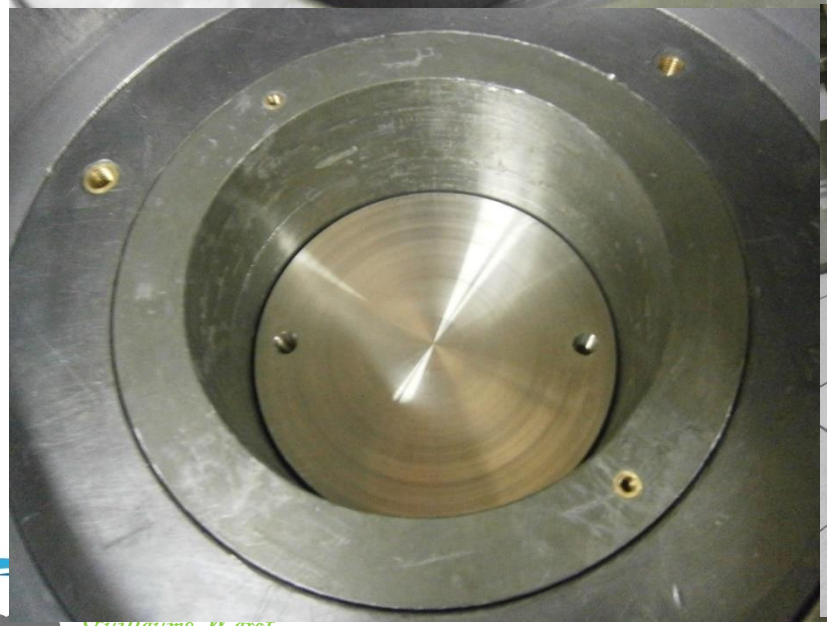
- Priority between measurement and quality checks
- Necessity to define the level of contamination aimed for the experiment on every considered nucleides
- Necessity to define the nucleides of interest especially 210Pb and 238U
- Influence of (α,n) on the background and contamination level associated

Sample management

- Database foreseen to agregate the measures?
- Modane has its sample management system called BaDGe
- Used to centralize measurements and track the samples
- Possibility to merge the systems?
- Naming rules no space, no special characters less than 16 letters and only upper letter

Nickel 58





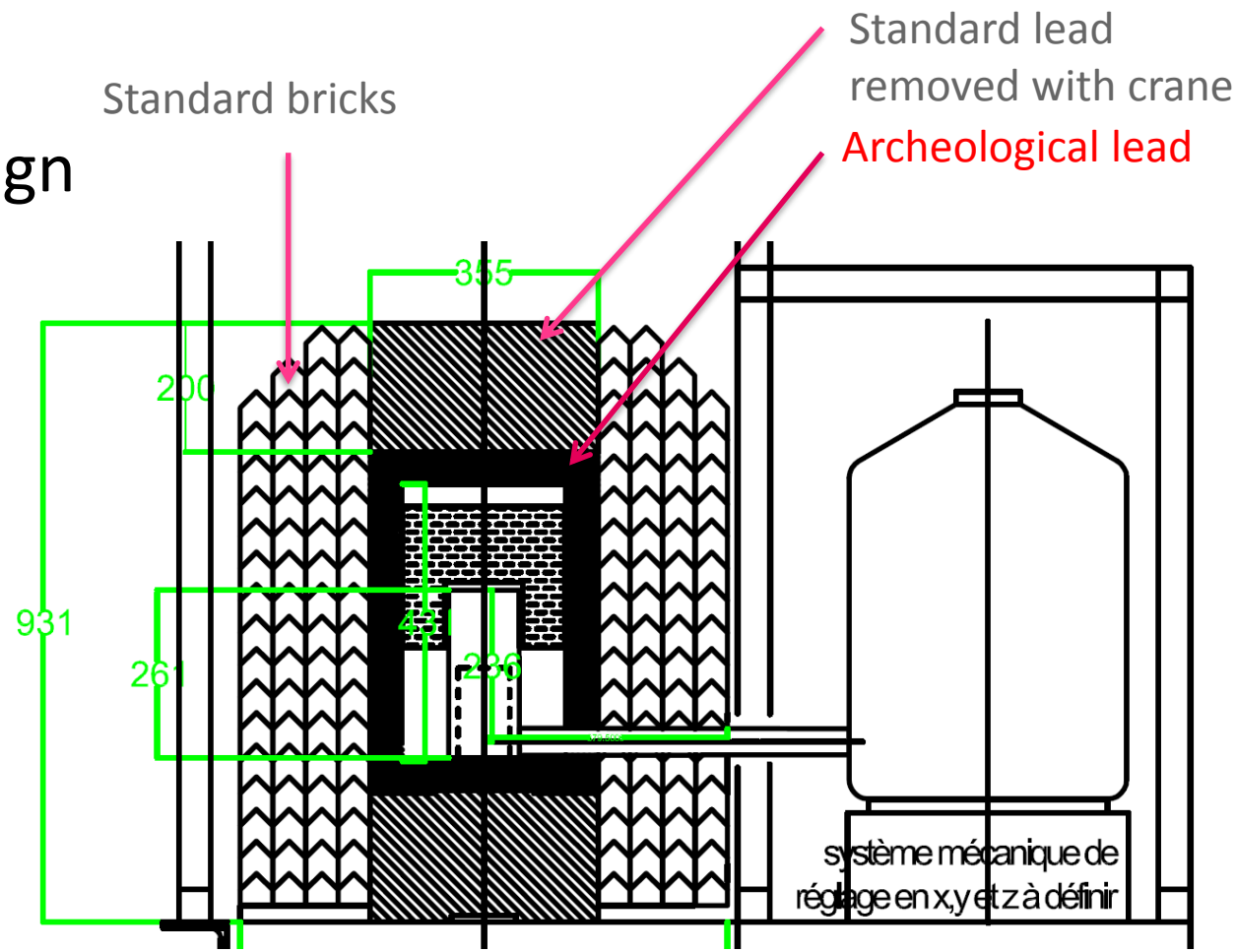
Partage project

- Reduce footprint of Germanium detectors
- Free space for more detectors
- Keep the same level of shielding
- Improve radon mitigation
- March toward robotisation

Lead shield for marinelli

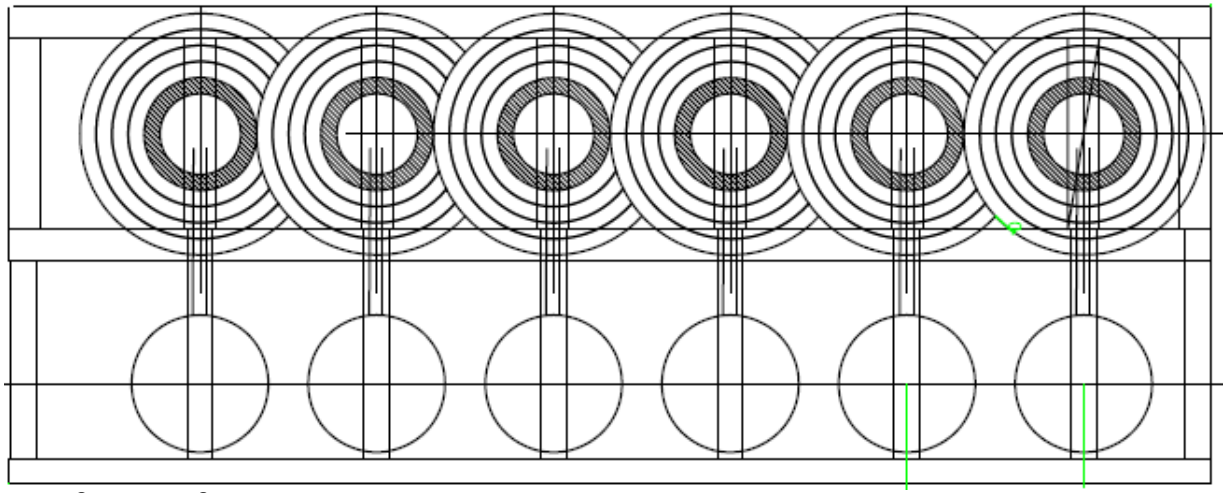
- Global doctrine : 20 cm standard lead 5cm archeological
- No specific design
- All shield are

the same



Future of germanium at LSM

- PARTAGe project
  - Combining shields in common walls

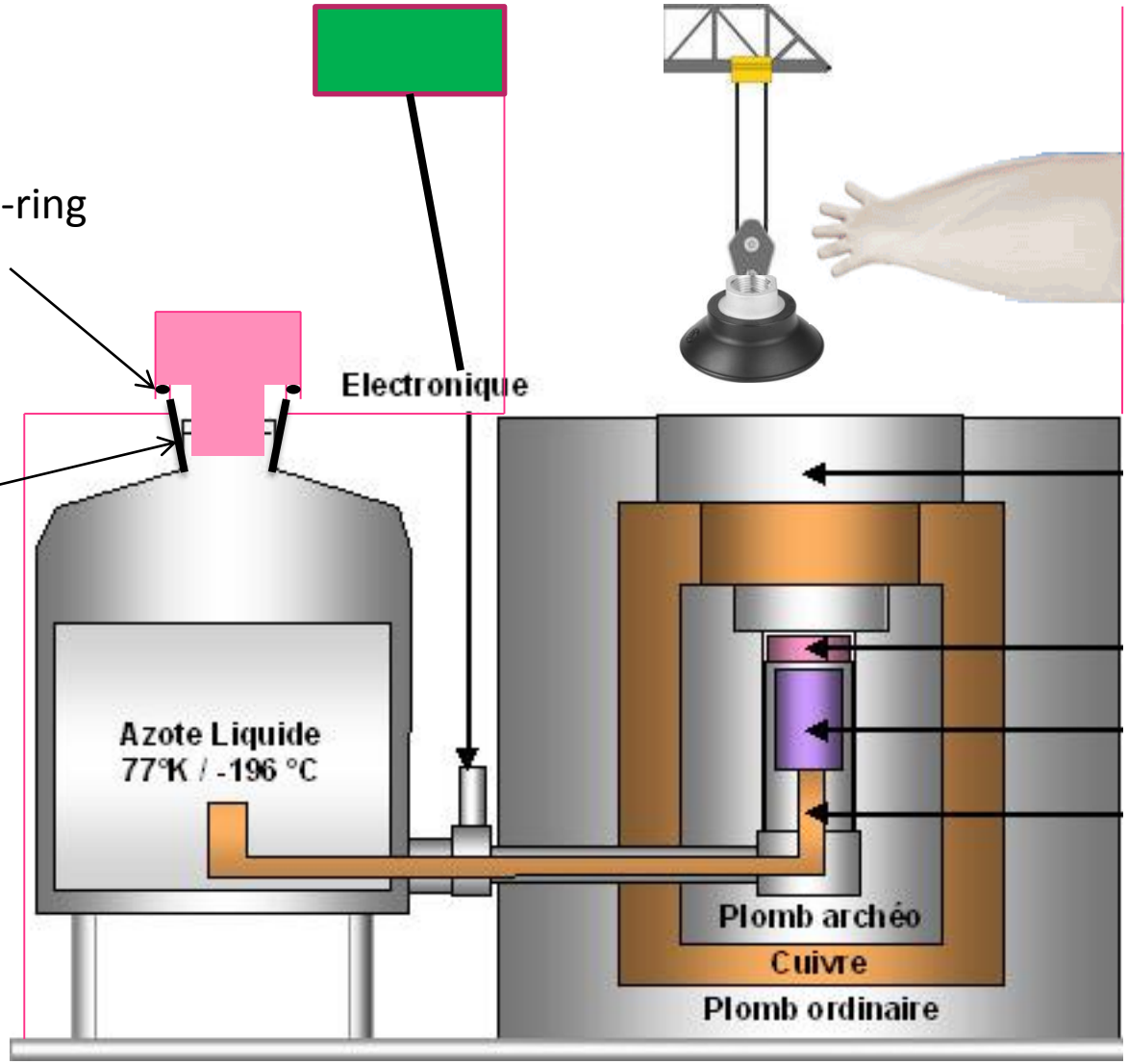


- Robotisation
- Optimisation of measurement time based on the radiopurity objectives

Radon tent

- 10m3 inlet max
- 2,1m3 boil off nitrogen <1mBq/m3

Tent


O-ring
Metalic enveloppe + pressure vent
Electronique
Azote Liquide
77°K / -196 °C
Plomb archéo
Cuivre
Plomb ordinaire

Cosmogenic inside crystal

- Detector mafalda
- Integral background 0,27/min may 2008

énergie	intégrale	Coups par jour	Identification
46.5	51	1.7	Pb210
66.9	33	1.1	Th-230
143.8	78	3.57	Co-57
238.6	20	0.57	Pb-212
1124.5	60	2.73	Zn-65
1460	7	0.36	K-40

- **Integral now : 0,086 cnts /min**
- **only 210Pb =1,5 cnts/min**
- **40K =0,47cnts**

Mass spectrometry

- Conversion from mass to activity considering 1 ppt as LD

	T1/2	1ppt en Bq/g	LD en Bq/kg
238U	4,47E+09	1,24E-08	1,24E-05
230Th	7,52E+04	7,64E-04	7,64E-01
226Ra	1600	3,66E-02	3,66E+01
210Pb	22,3	2,82E+00	2,82E+03
232Th	1,40E+10	4,07E-09	4,07E-06
228Ra	5,75E+00	1,01E+01	1,01E+04
228Th	1,91E+00	3,04E+01	3,04E+04

Consider analysing a standard lead sample

Conclusions

- Deciding the number of sample that must be measured and detection limits required
- Choose the right combination of techniques for optimum results (Analyse Pb with ICP-MS)
- Germaniums measurements have a life ahead
- More demands to put germanium in LSM more fields to explore …