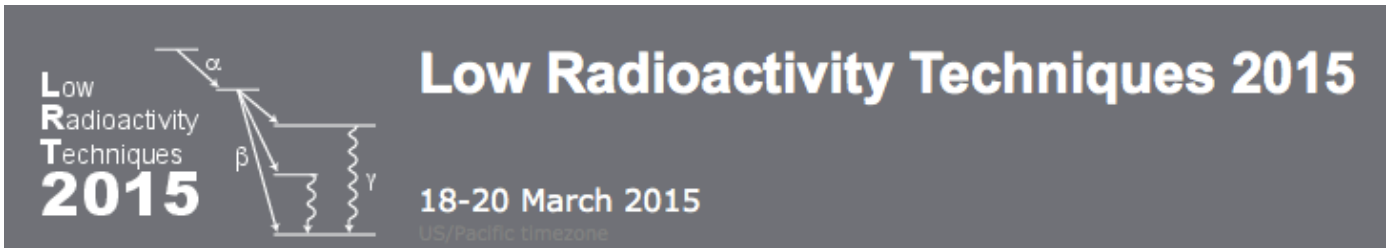
Background reduction of a spherical gaseous detector



E.Bougamont[1], P. Colas[1], J. Derré[1], I. Giomataris[1], G. Gerbier[2], M. Gros[1], P. Loaiza[3], J.Galan[1], D.Jourde[1], P. Magnier[1], J. P. Mols[1], X.F. Navick[1], B.Paul[1], F. Piquemal[3], I. Savvidis[4], G. Tsiledakis[1], J. D. Vergados[5]

1: IRFU Saclay, 3: Queen's University (Canada), 3: LSM Modane, 4:Univ. of Thessaloniki, 5: Univ. of Ioannina,

Ali DASTGHEIBI FARD

Laboratoire Souterrain de Modane

CNRS/CEA FRANCE

Laboratoire Souterrain de Modane

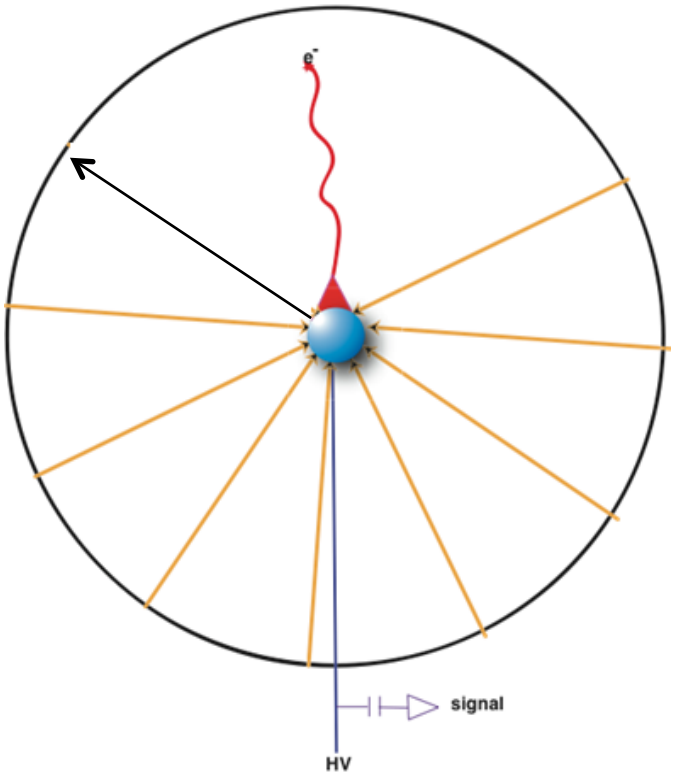
Outline

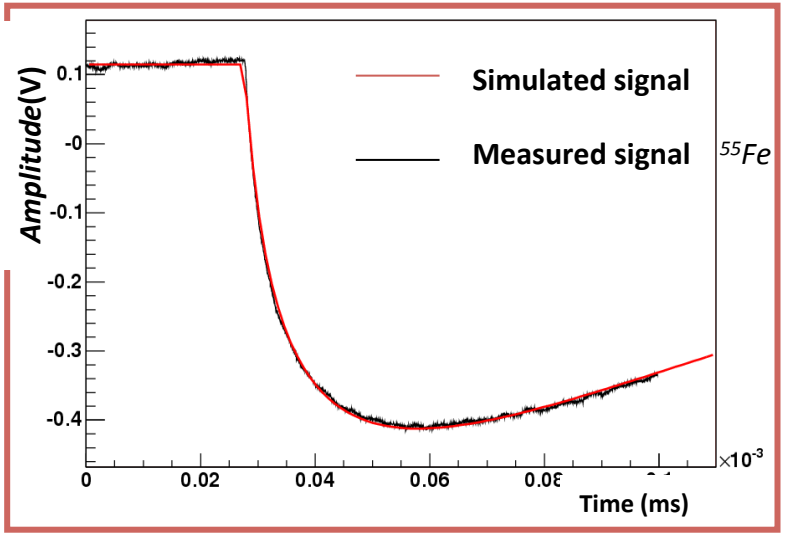
- **Spherical Proportional Counter (SPC)**
  - **Principle of the detection**
  - **Detector design**
  - **Detector calibrations**
- **SEDINE at Laboratoire Souterrain de Modane**
  - **SEDINE background**
  - **Background reduction**
  - **Result for detection of the Light-WIMP's**
- **Summary**

Principle of the detection

Radial Electric field
Ball radius = 1-16 mm
Spherical radius = 7.5-65 cm

$$E \propto \frac{1}{r^2}$$



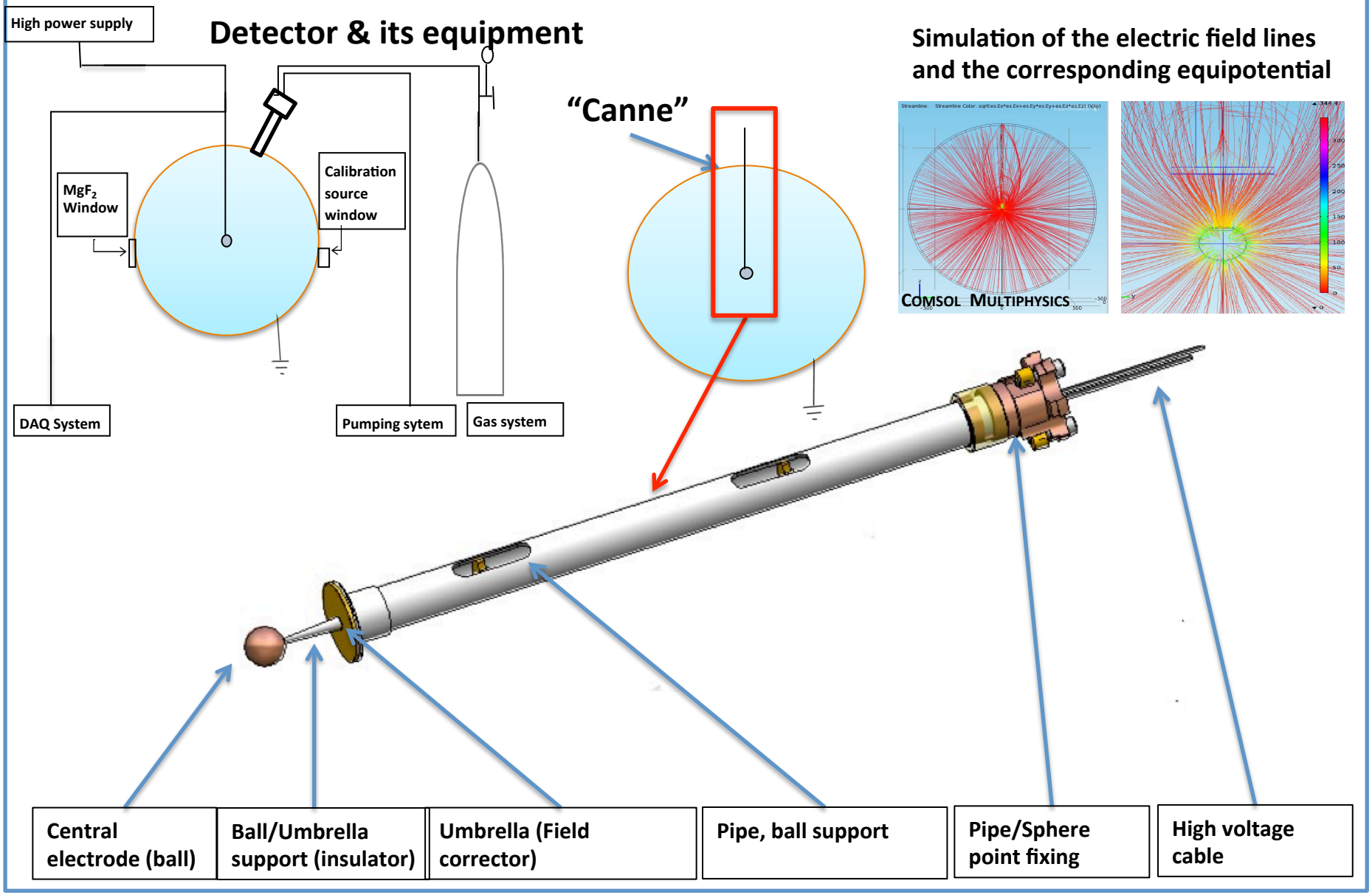


A Novel large-volume Spherical Detector with Proportional Amplification read-out, I. Giomataı
JINST :P09007,2008

Main characteristics

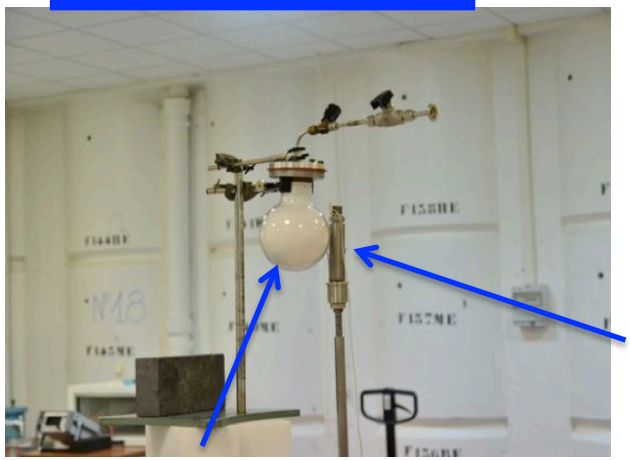
- Low capacitance < *0.1 pF*
- Low energy threshold (≈ 50 eV)
- Good energy resolution
- A single measurement channel for a large volume
- Flexibility : gas, pressure
- Robust, simple and cheap

Detector design



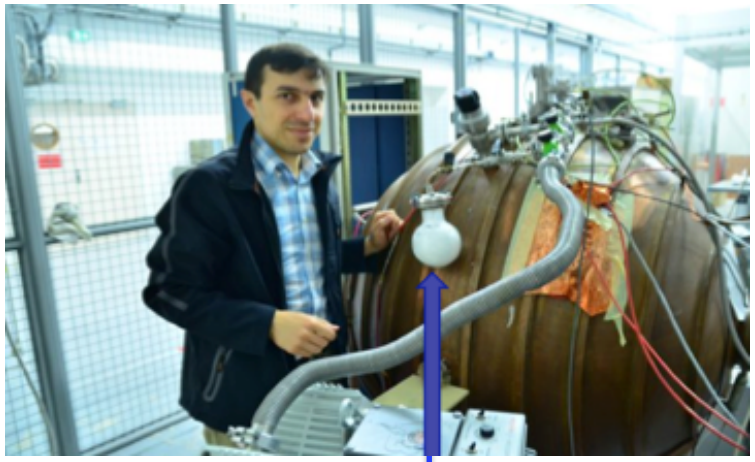
Detector calibrations

$^{40}Ca + n \rightarrow {}^{37}Ar + \alpha$



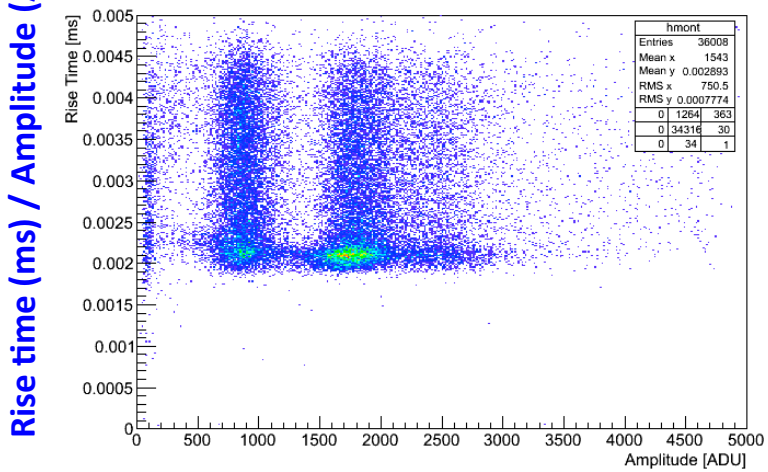
Powder ^{40}Ca , 14 days irradiation

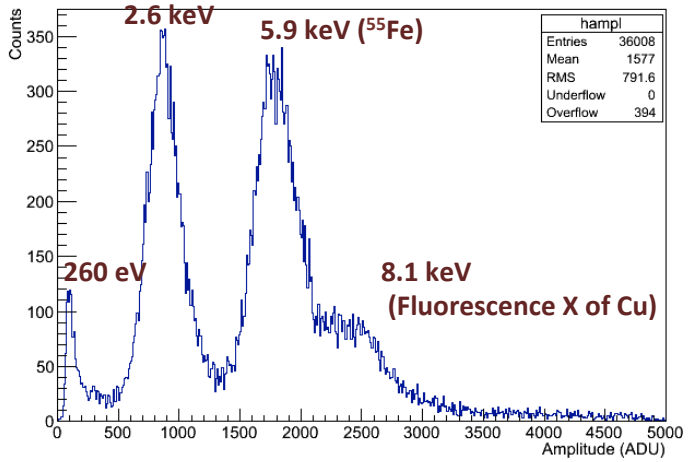
Neutron source
7x 10^6 neutron/s



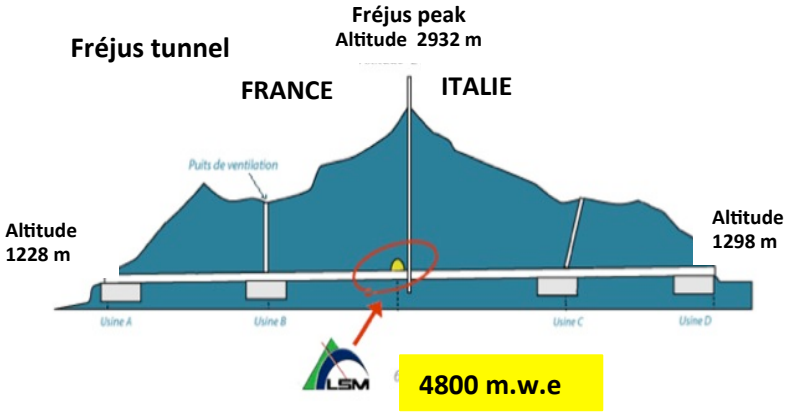
^{37}Ar , $T_{1/2}$ = 35 days, K_a 2.6 keV et L_b 260 eV

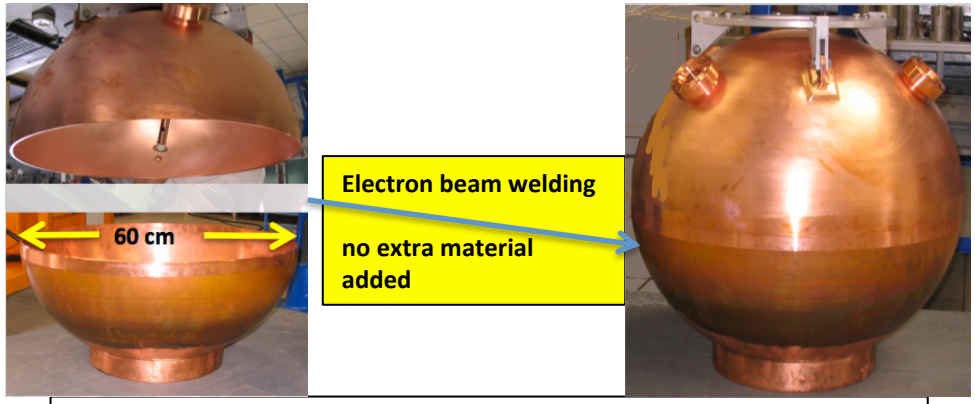
P = 50 mbar, Ar + CH4 (2%), sources of calibration : ^{55}Fe + ^{37}Ar, Saclay





SEDINE Low background, D.M. spherical detector @ Laboratoire Souterrain de Modane

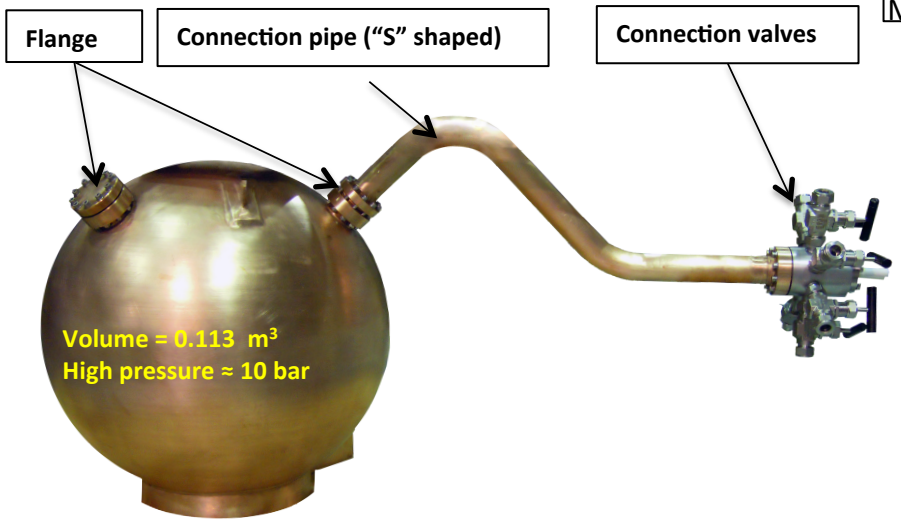




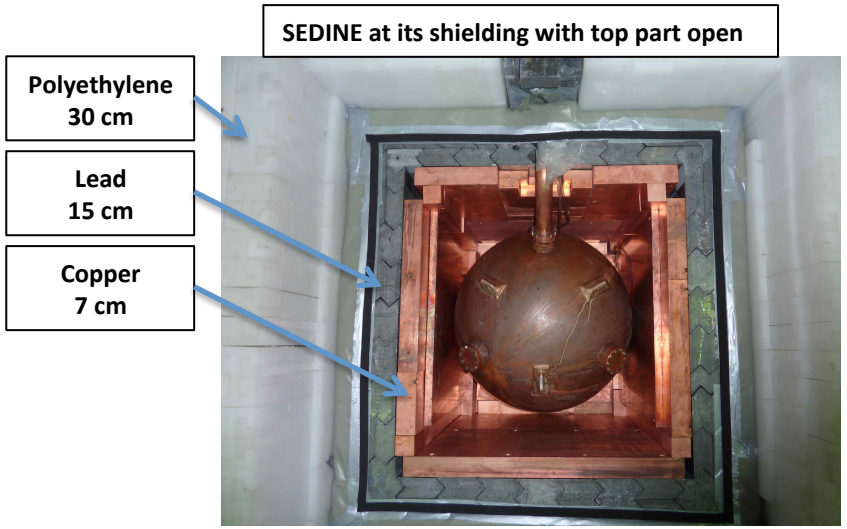
- NOSV Copper (µBq/Kg) : . ^{226}Ra < 16
  . ^{228}Th < 12
  . ^{40}K < 110
  . ^{60}Co < 18

Measured @ LNGS

M. Laubenstein et al., Applied Radiation and Isotopes 61 (2004) 167

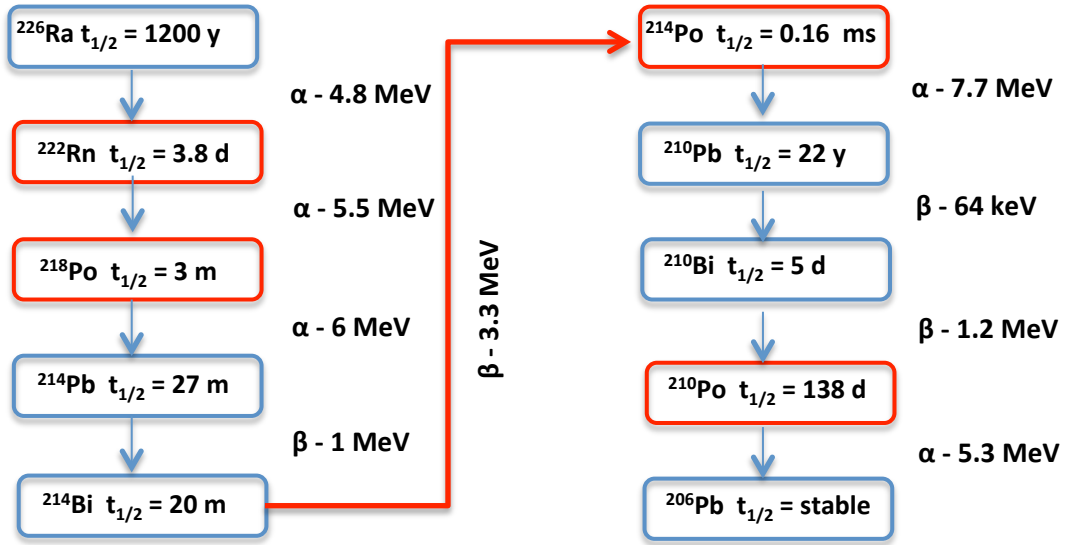


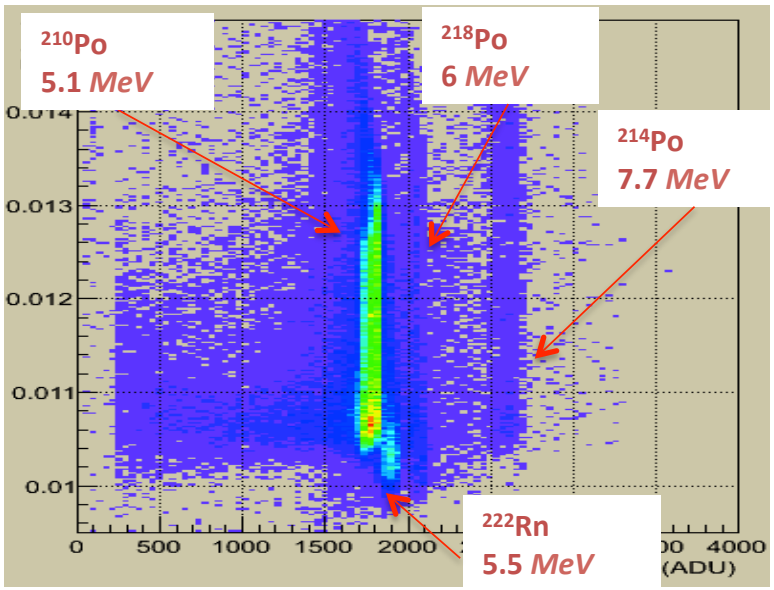
SEDINE at its shielding with top part open

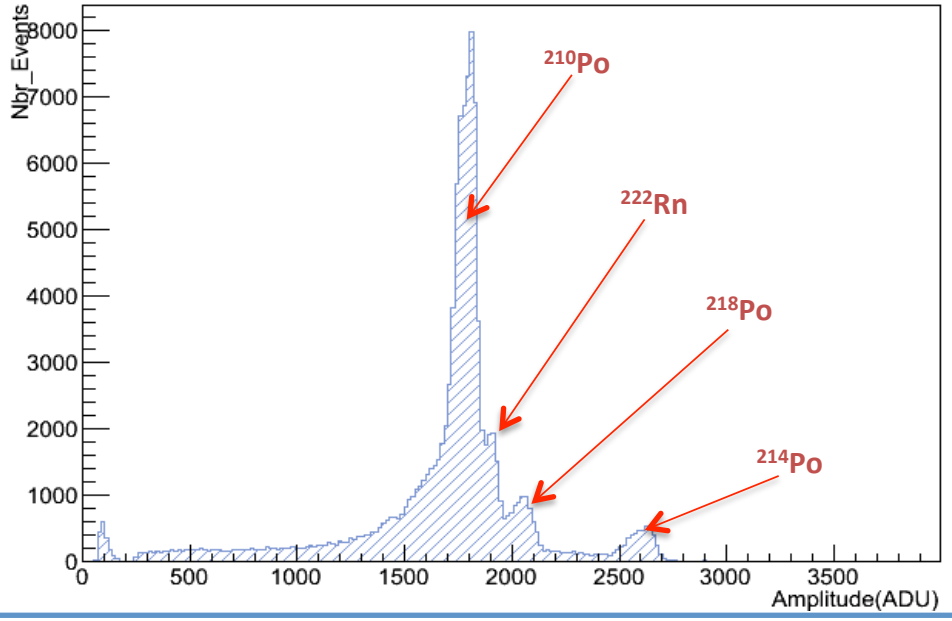


SEDINE Background
Internal contamination

Contamination inside of the sphere

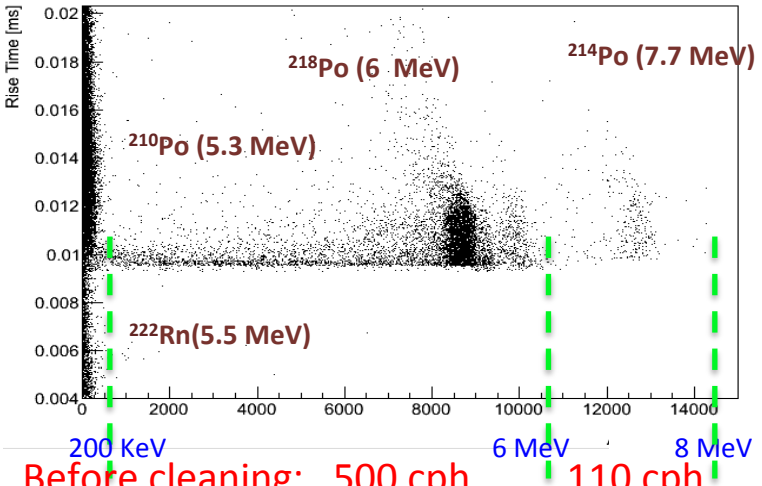






Internal contamination: 1st chemical cleaning of the sphere

Ar + CH_4 (2%) P = 300 mbar

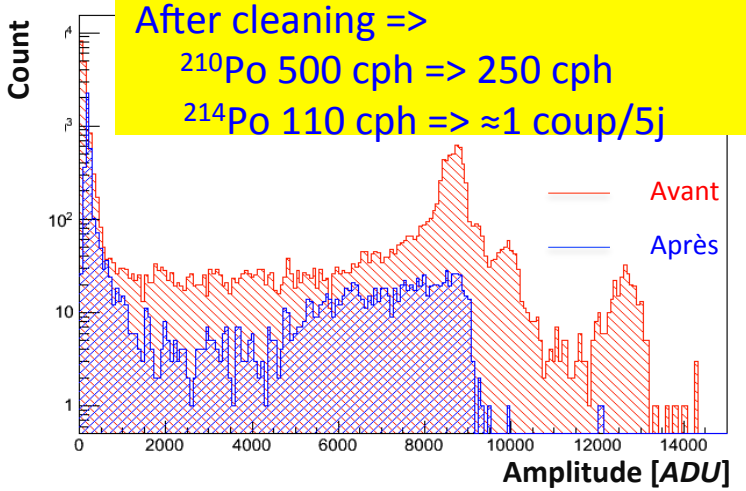


Before cleaning: 500 cph 110 cph

Conditions :

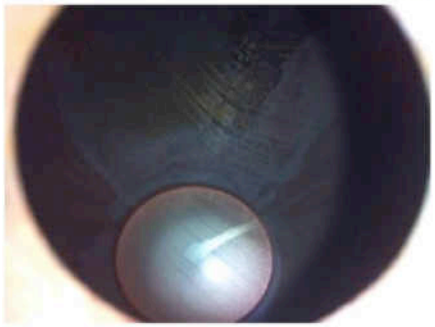
- Nitric acid (17 %)
- T≈ 10° *C*
- Cleaning by the filling of the **spherical cavity**
- Washing by the purified water
- Drying with hot nitrogen

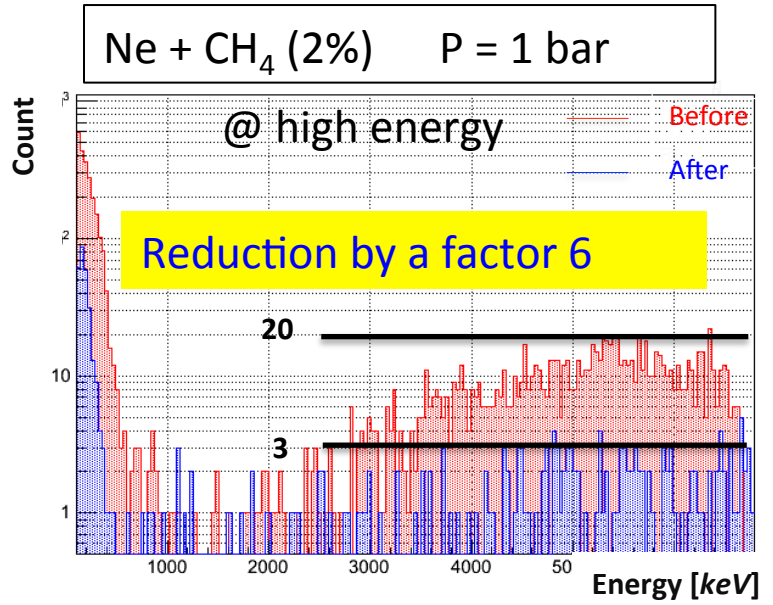
After cleaning =>
^{210}Po 500 cph => 250 cph
^{214}Po 110 cph => ≈1 coup/5j

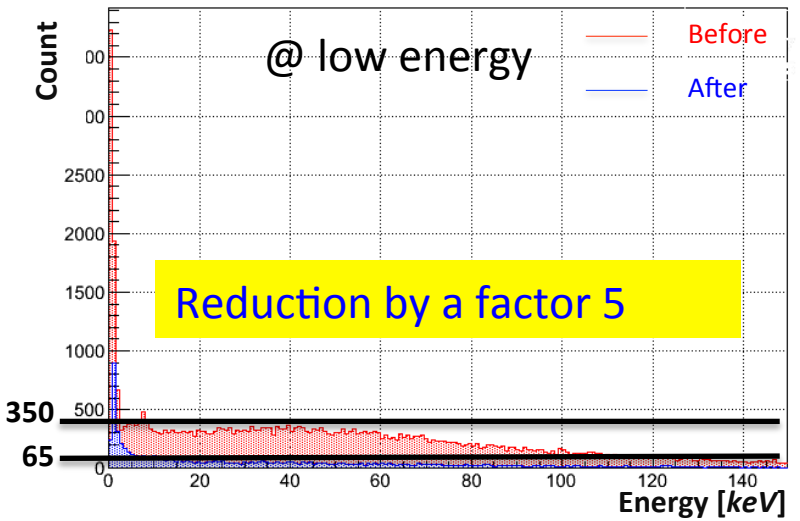


Residual deposit of ^{210}Pb on the surface of cavity

Internal contamination: 2nd chemical cleaning of the sphere



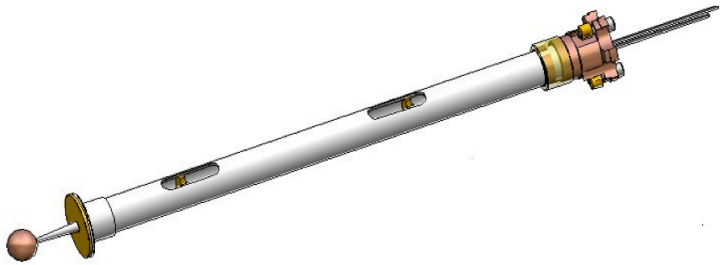




Conditions :

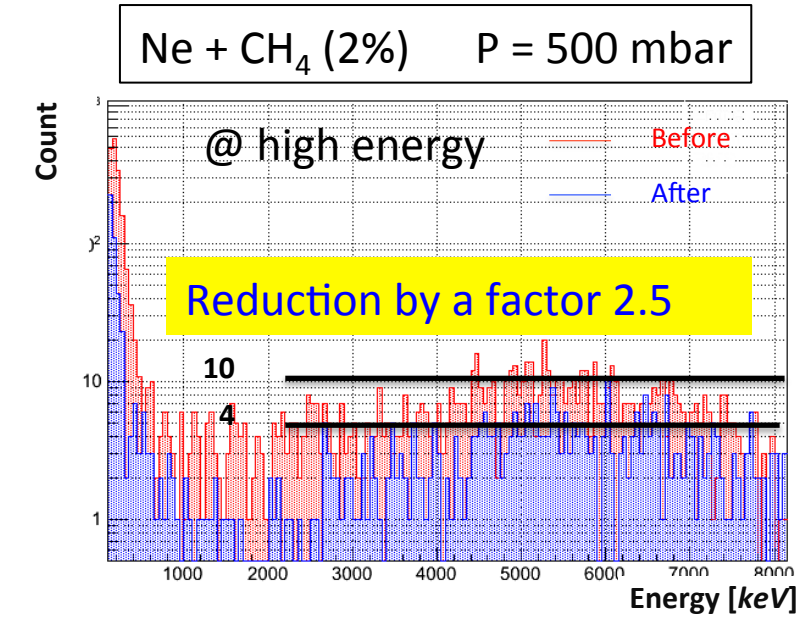
- Nitric acid (30 %)
- T≈ 30° *C*
- Cleaning by the spraying the internal/ external surface of the **spherical cavity**
- Washing by the purified water
- Drying with hot nitrogen

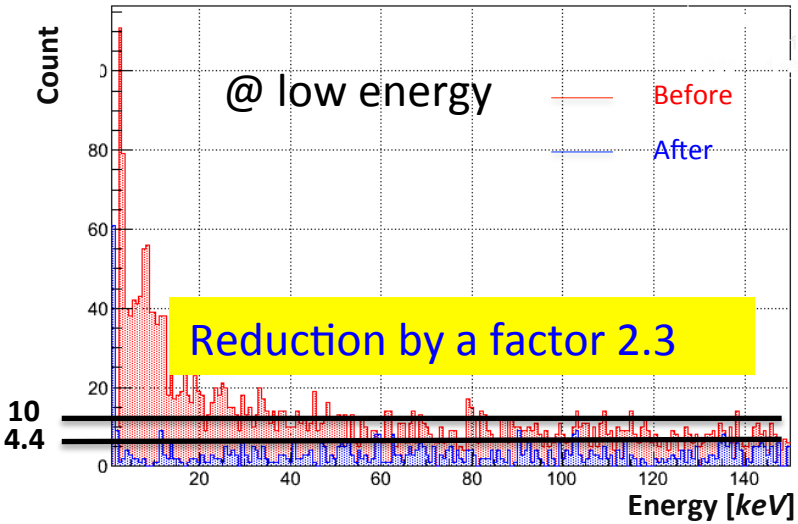
Internal contamination: chemical cleaning of the sensor



Conditions :

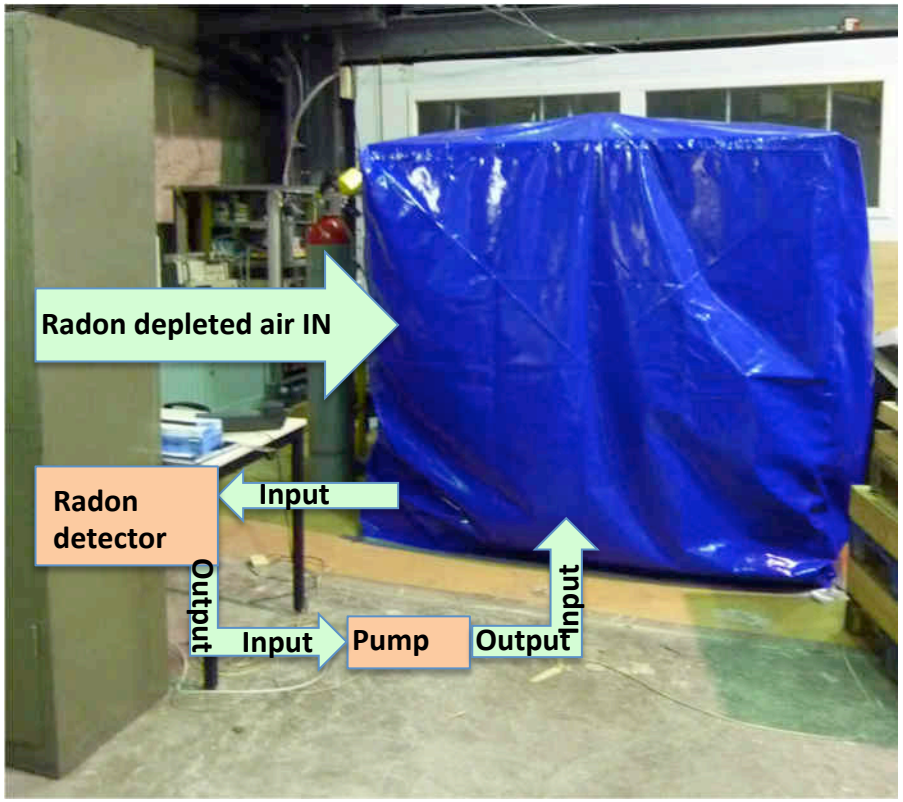
- Nitric acid (30 %)
- T≈ 30° *C*
- Cleaning by the drop of the **sensor**
- Washing by the purified water
- Drying with hot nitrogen



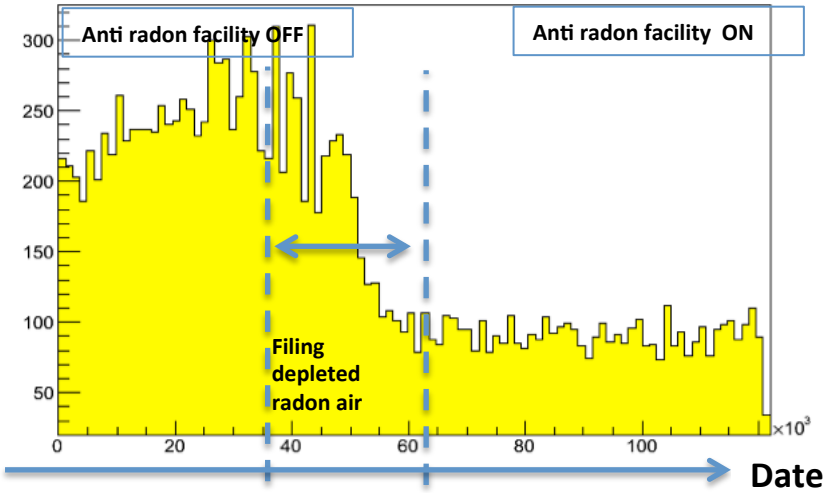


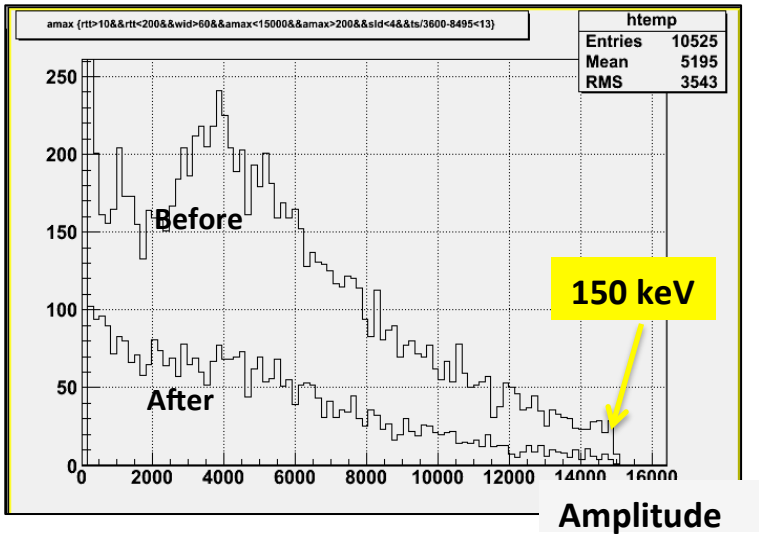
External contamination

Anti radon protection (tent)



Ne (2 bar) + He (1 bar) + CH_4 (2%)





Radon rate:

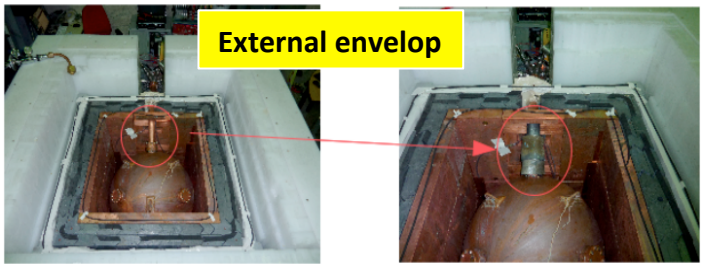
- @LSM ≈ 15 Bq/m^3
- After radon trapping factory ≈ 20 mBq/m^3

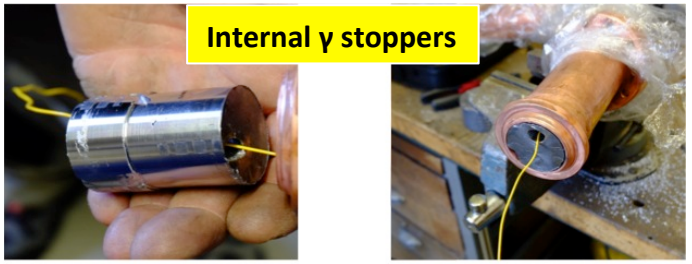
Other plausible contaminations

- ^{14}C containing in the gas

  β spectrum from ^{14}C was not observed ✗

- Pipe connection (“S” shaped)

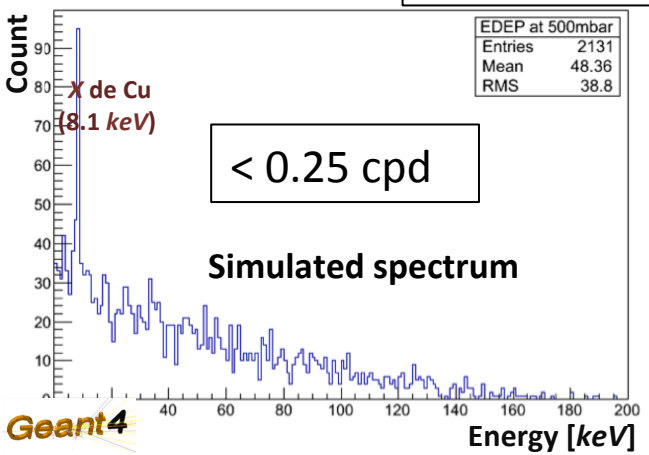


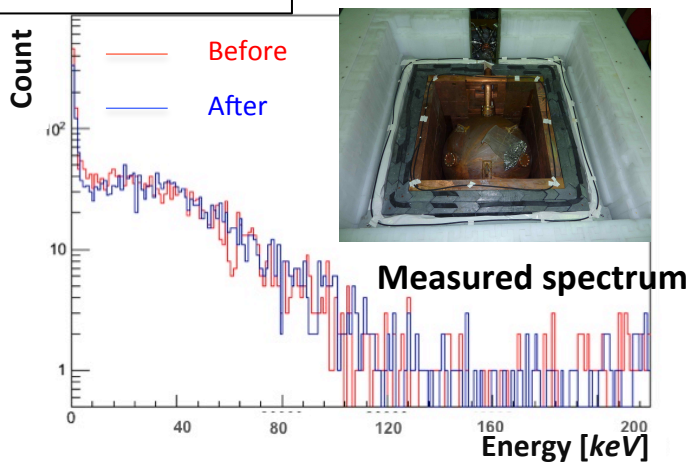


✗

- Screw used on the detector

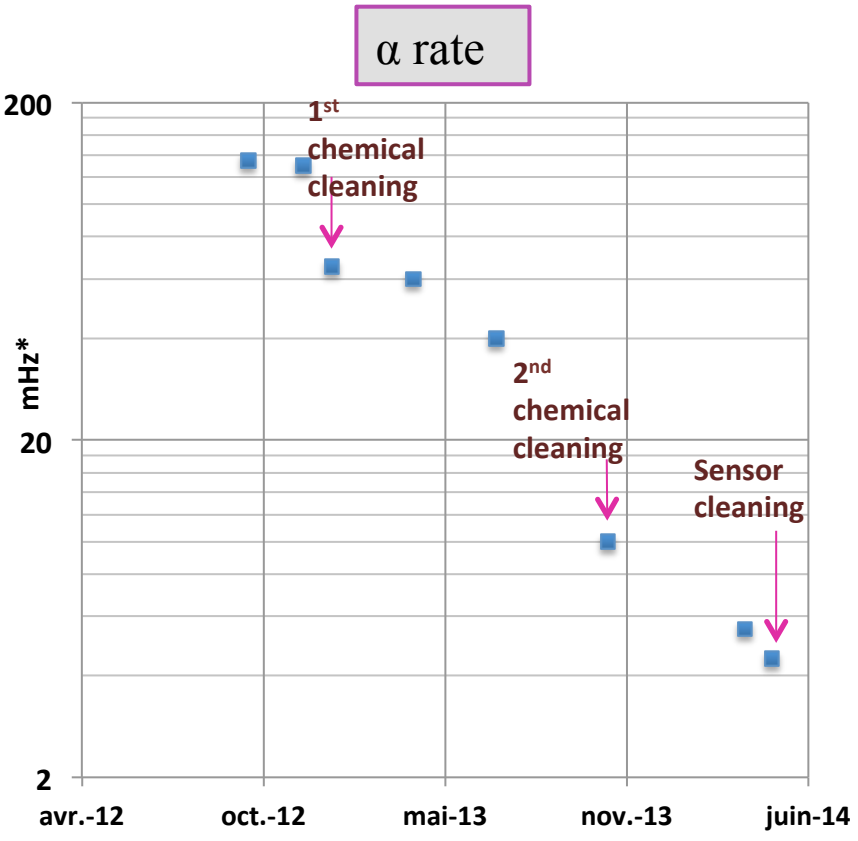
Ne + CH_4 (2%) ; P = 500 mbar

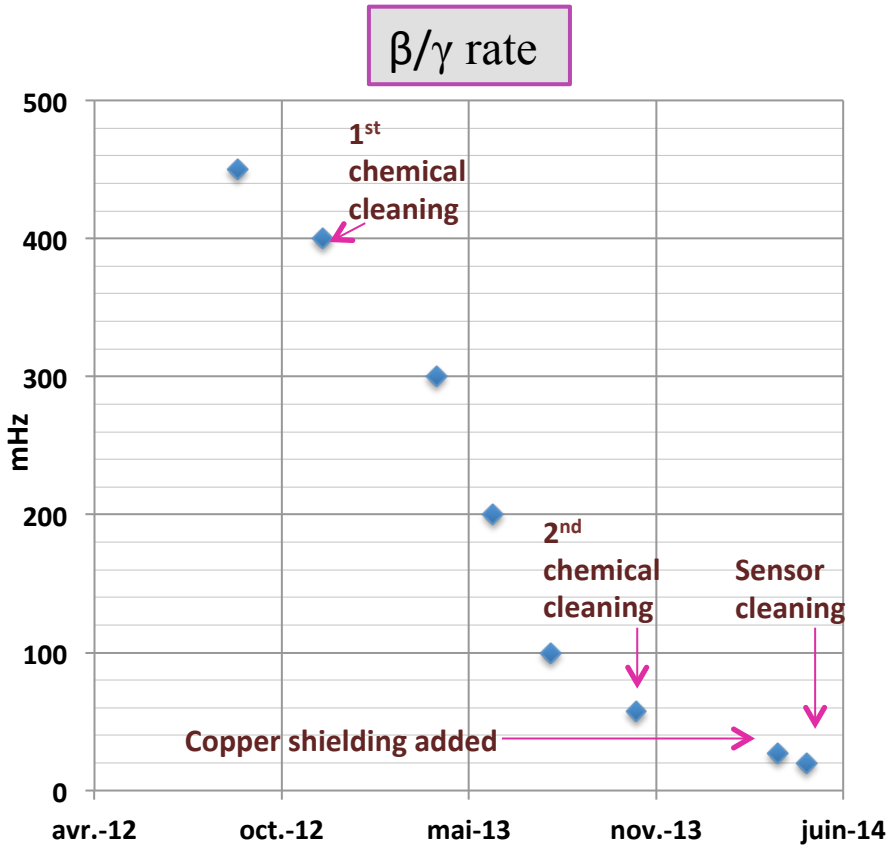




✗

Summary





Reduction by a factor 45
180 *mHz** => 4 *mHz*

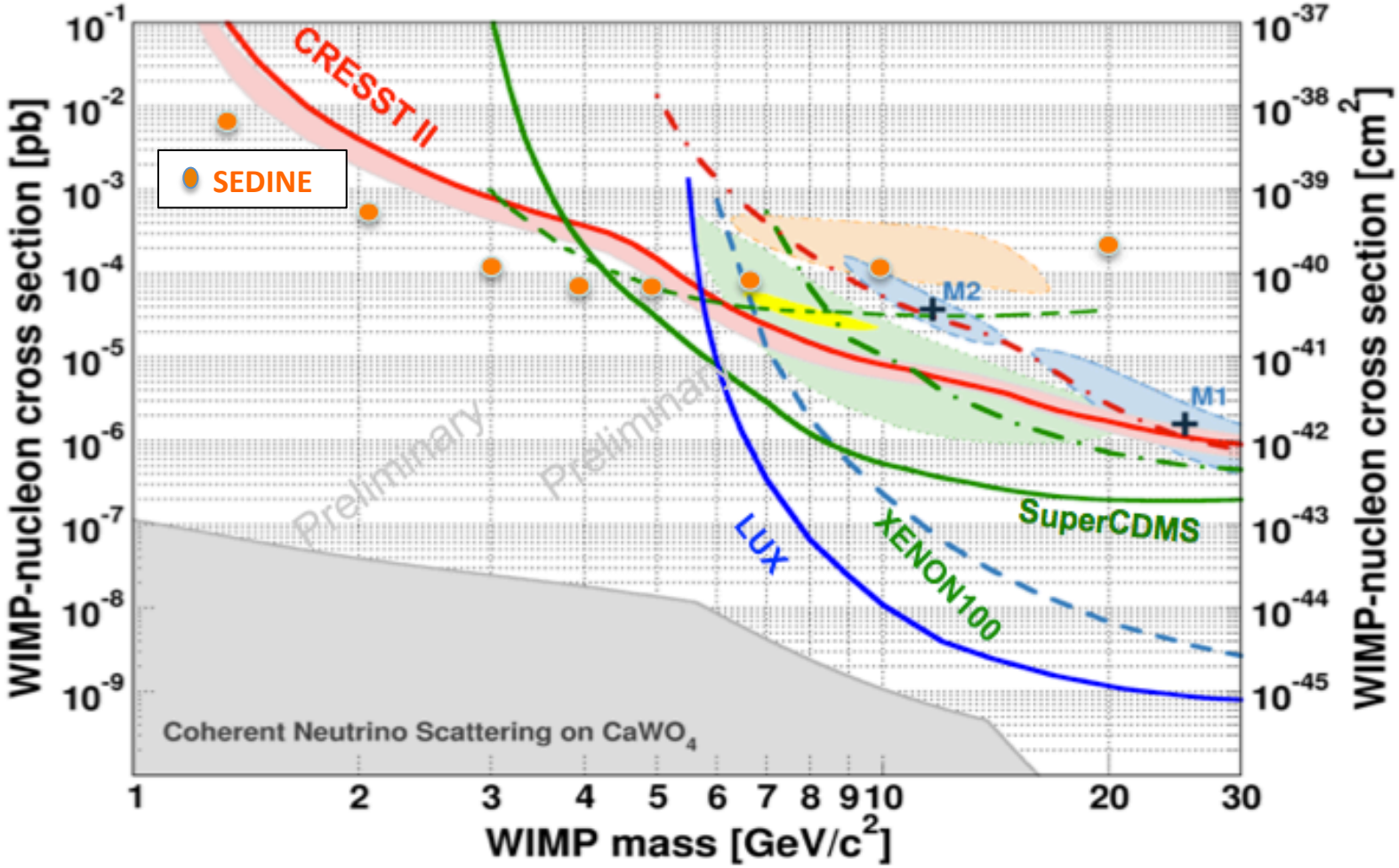
Reduction by a factor 20
400 *mHz* => 20 *mHz*

* 1 mHz = 10^{-3} cps

Dastgheibi-Fard, A., et al. (2014). Background optimization for a new spherical gas detector for very light WIMP detection. *TIPP conf. proceeding*

SEDINE sensitivity for detection of the Light WIMPs
After background reductions

Limits from SEDINE on Neon target assume 100 % cuts eff



Summary

- A novel type of gaseous detector, spherical proportional counter (SPC) :
  - ✓ Good energy resolution, low energy threshold ≈ 50 eV, low capacitance < 0.1 pF, signal discrimination by the Rise-time

- SEDINE, low background SPC, installed at LSM
  - ✓ Reduction of the internal contaminations (^{210}Pb) by several chemical cleaning
  - ✓ Reduction of the external contamination (radon) by adding of a anti-radon tent
  - ✓ Testing of the others sources: ^{14}C, pipe connection (“S” formed) and screw used on the detector

- Sensitivity of the SEDINE for detection of the Light-WIMPs

Perspective

- Improvements of the shielding
- Cleaning of the copper shielding close to detector
- Making and cleaning of a new sensor at LSM
- Building a very large SPC $\Phi \approx 1.4$ -2m for Light WIMPs detection @ SNOLAB (NEWS network)

Thank you

Maybe, an other application of sphere

Banquet @ Ivar's Salmon house