NEWS

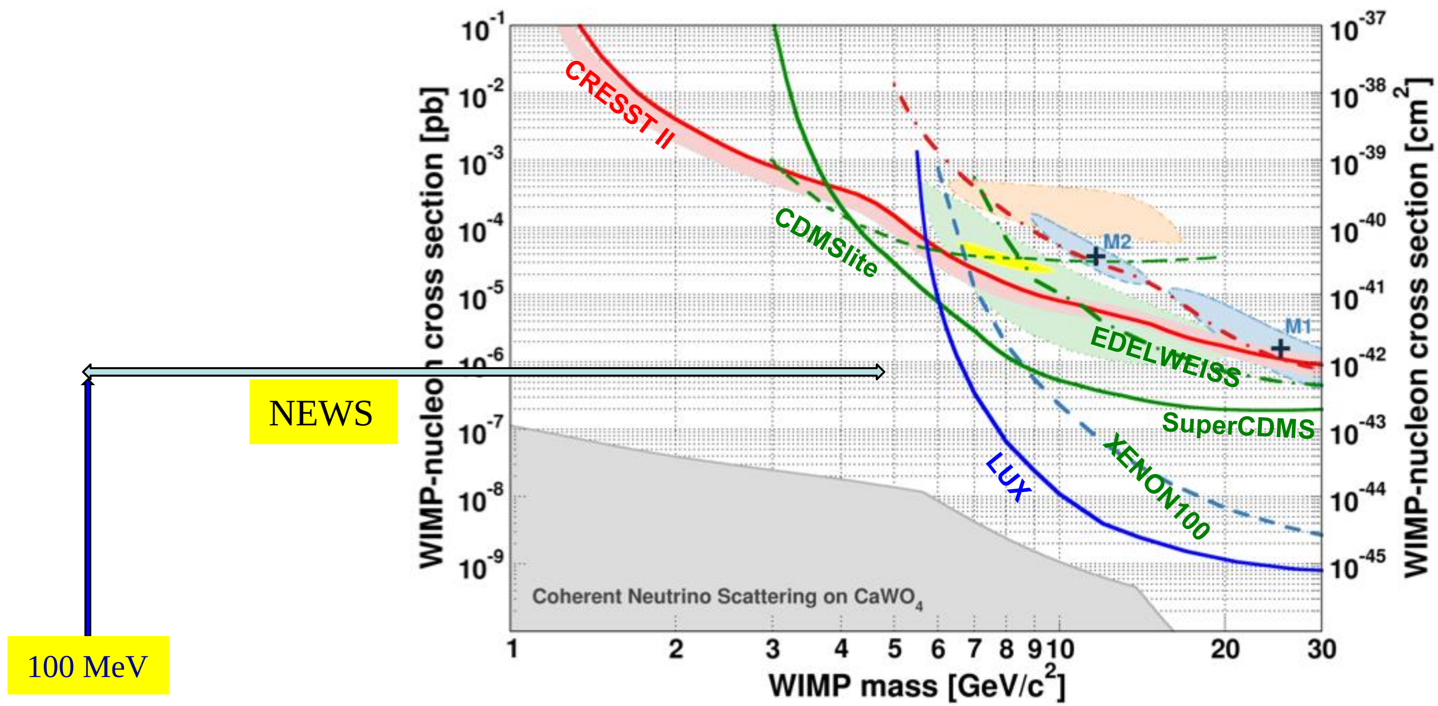
Light dark matter search using the spherical detector

I. Giomataris, CEA-Irfu-France

GOAL: EXPLORE DM MASSES DOWN TO 100 MEV

Motivated by:

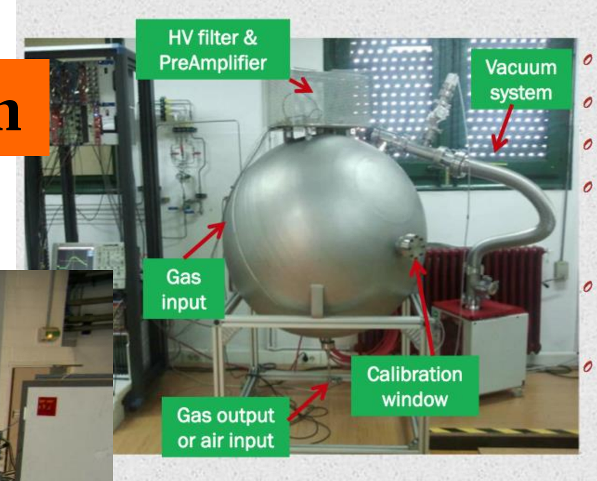
- **Sub-keV energy threshold of the detector**
- **Versatility of the low-Z target (H, He, Ne)**
- **Low background capability of this design**



Spherical detector propagation

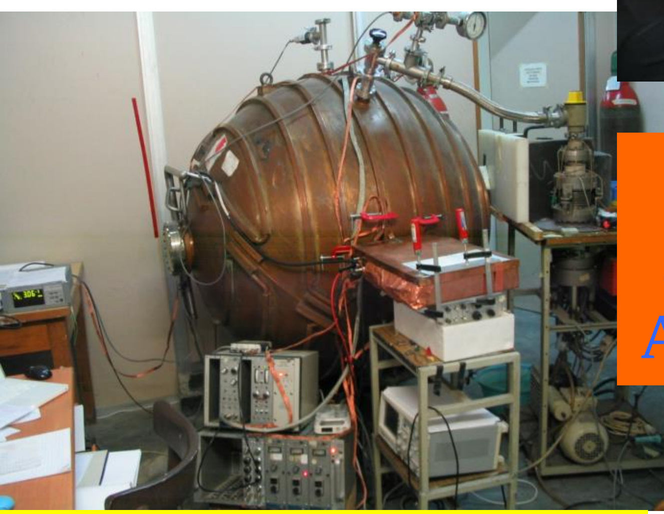
Low background detector d=60 cm p=10 bar

University of Saragoza detector



Basic R@D detector in Saclay

Future project
2m detector will be developed
At SNOLAB (G. Gerbier et al.)



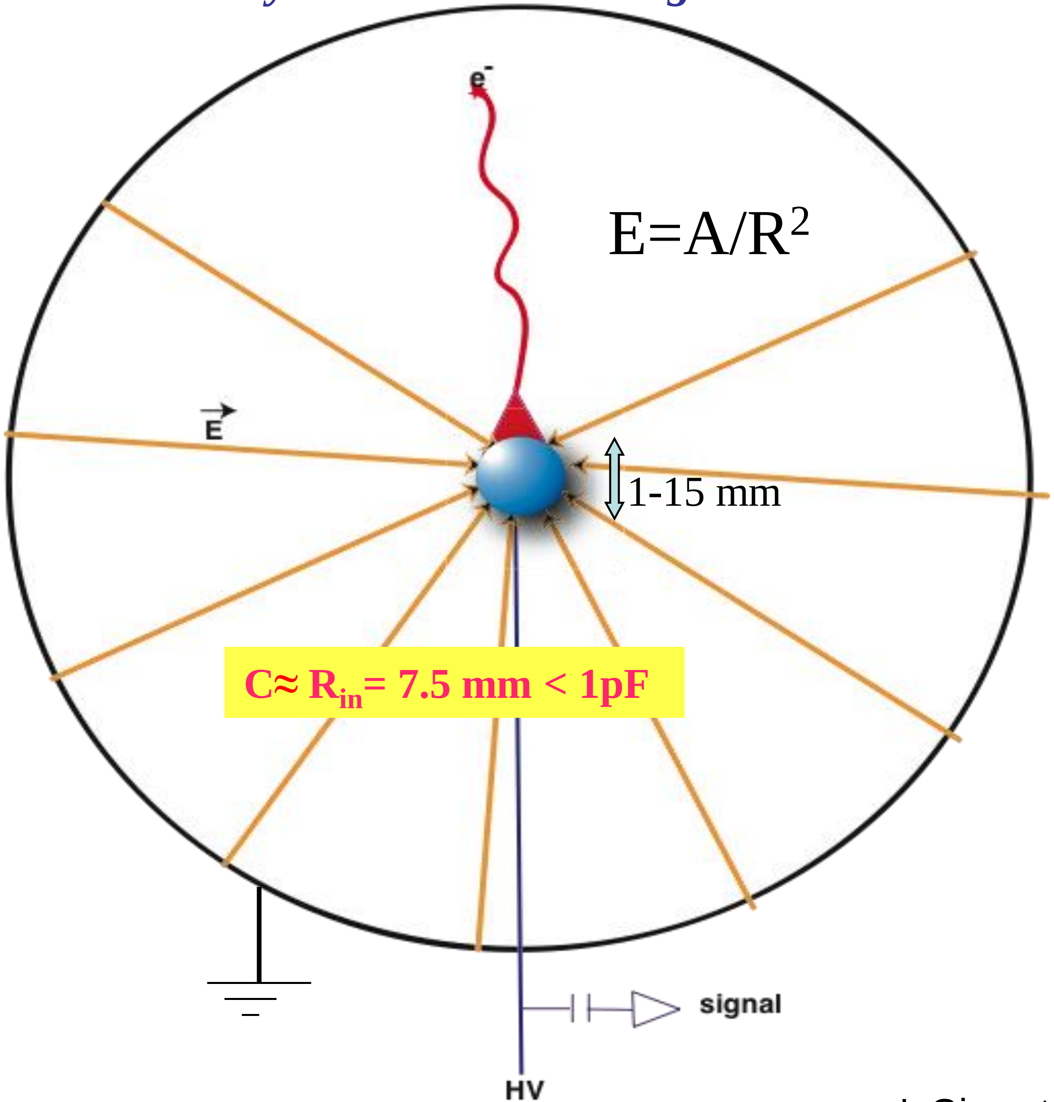
University of Thessaloniki detector

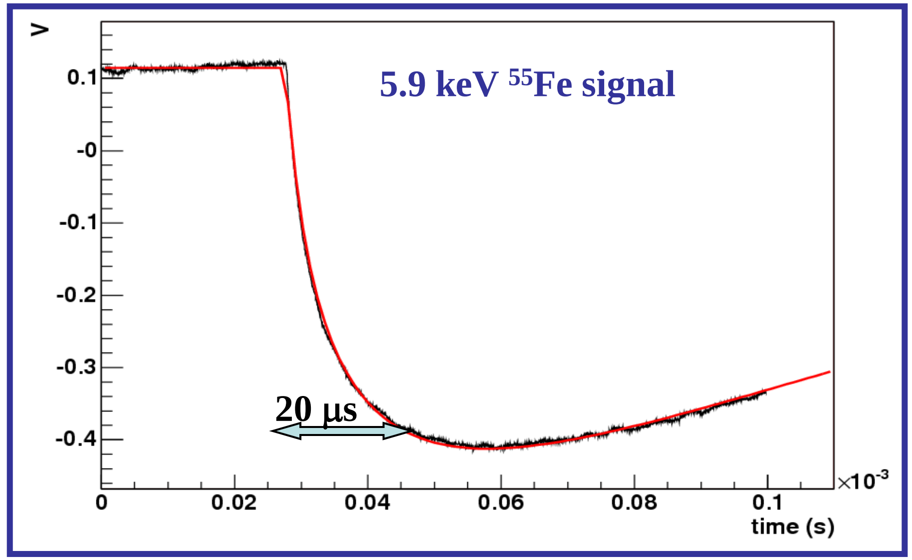
University of Tsinghua - HEP detector

Radial TPC with spherical proportional counter read-out

Saclay-Thessaloniki-Saragoza

A Novel large-volume Spherical Detector with Proportional Amplification read-out, I. Giomataris *et al.*, JINST 3:P09007,2008



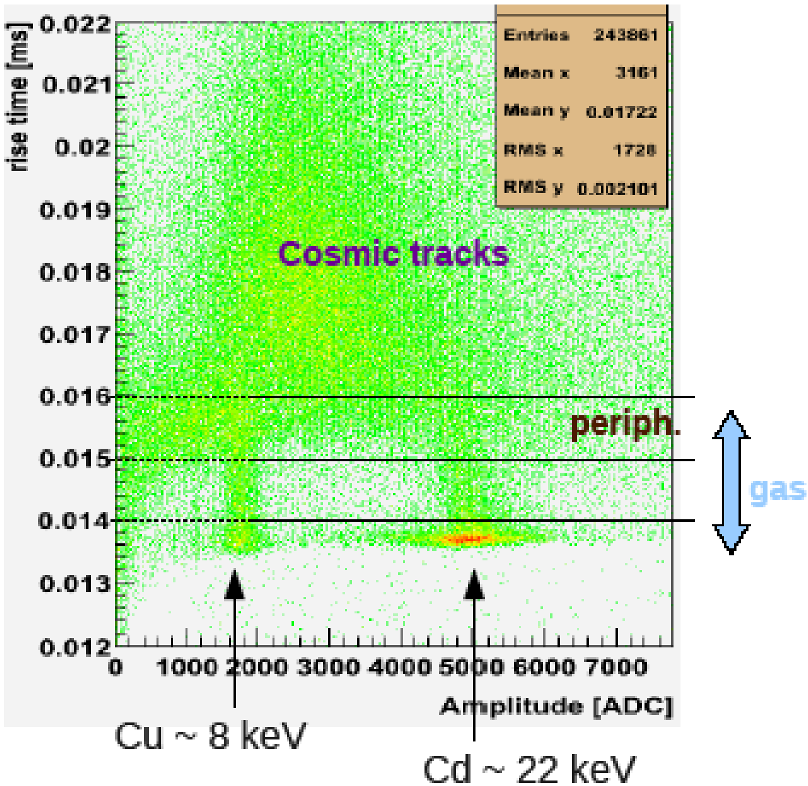


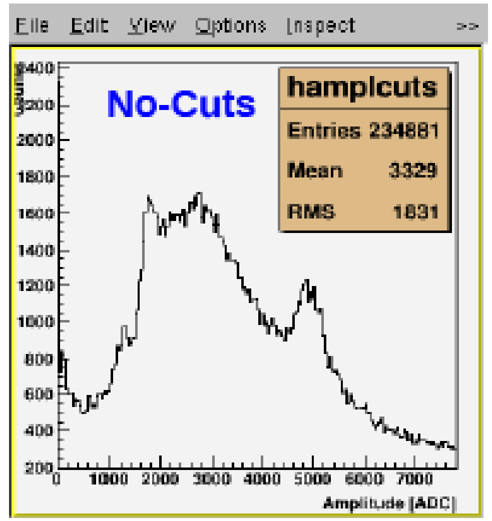
I. Giomataris

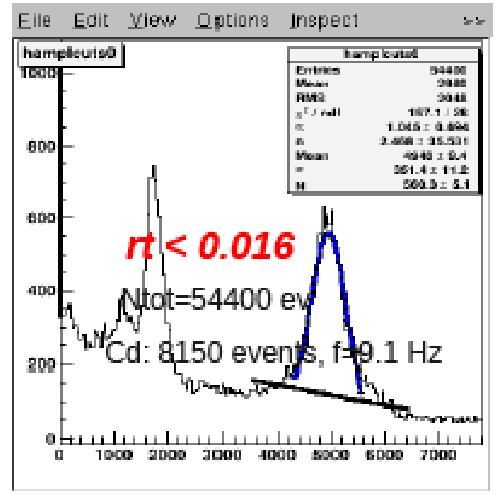
- Simple and cheap
- Large volume
- single read-out
- Robustness
- Good energy resolution
- Low energy threshold
- Efficient fiducial cut

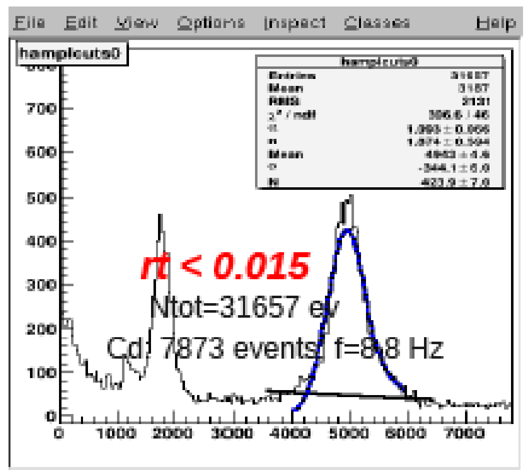
Fiducial cuts-rejection power

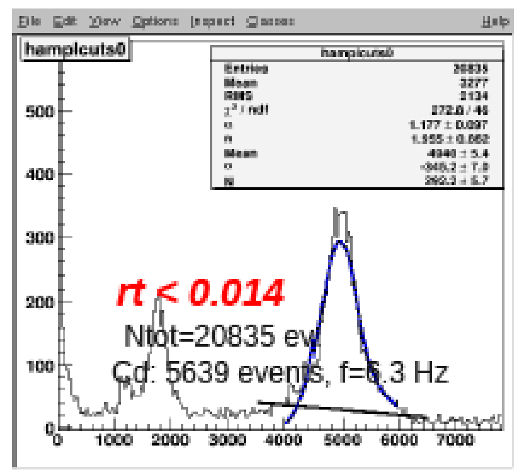
Using Cd-109 source – December 2009
Irradiate gas through 200µm Al window
P = 100 mb, Ar-CH_4 (2%)











If rt ~ 0.0155 ms ==> R = 65 cm
0.014 ms ==> ~70% of signal

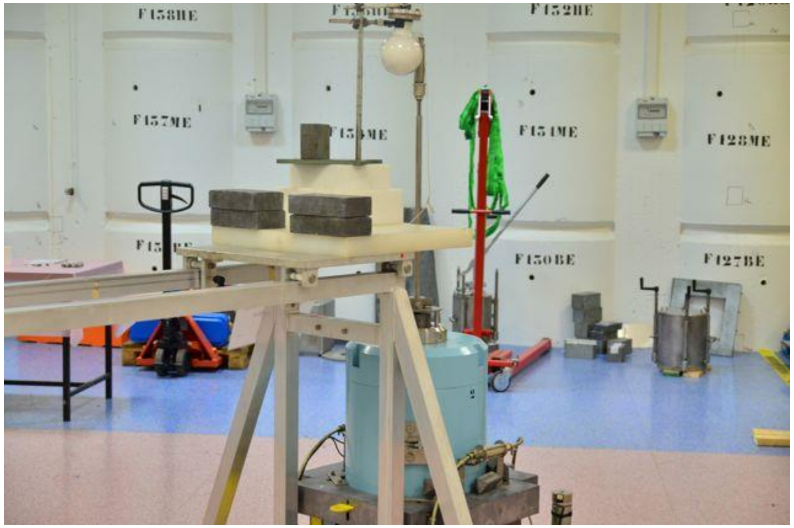
Efficiency of the cut in rt ==> ~ 70% signal (Cd peak)

Severe background reduction

Energy resolution ~ 6 % and 9 % for Cu and Cd

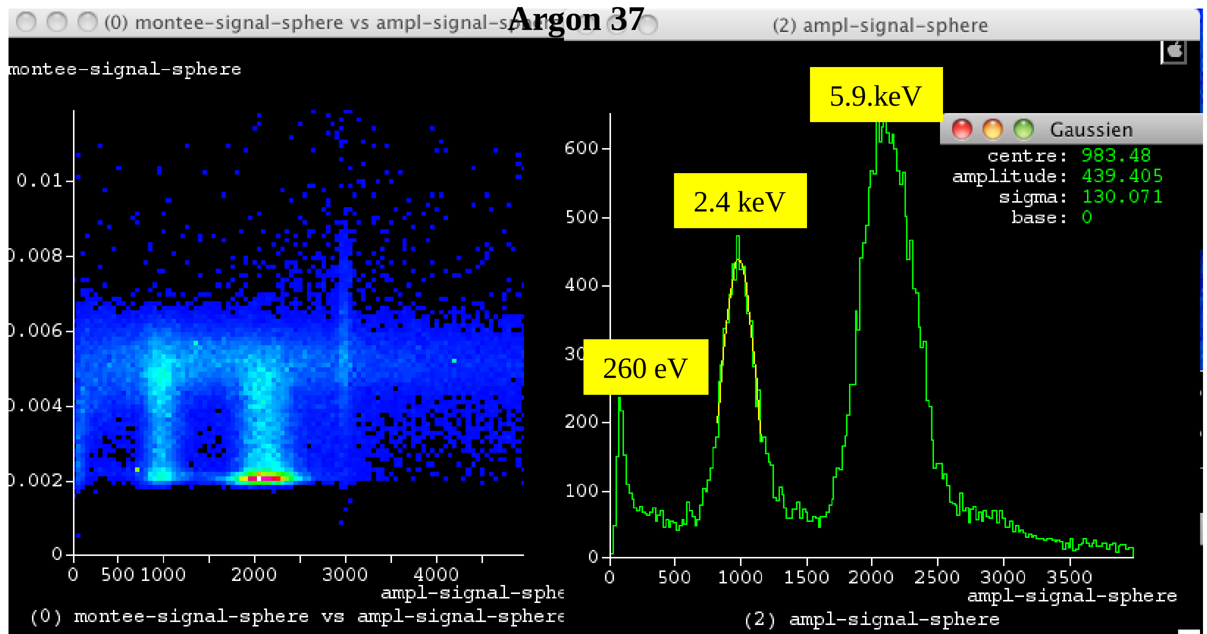
New low-energy calibration source *Argon-37*

Home made Ar-37 source: irradiating Ca-40 powder with fast neutrons 7x10^{6}neutrons/s
Irradiation time 14 days. Ar-37 emits K(2.6 keV) and L(260 eV) X-rays (35 d decay time)



Argon 37

First measurement
with Ar-37 source
Total rate 40 hz
in 250 mbar gas, 8 mm ball
260 eV peak clearly seen
A key result for light dark matter search

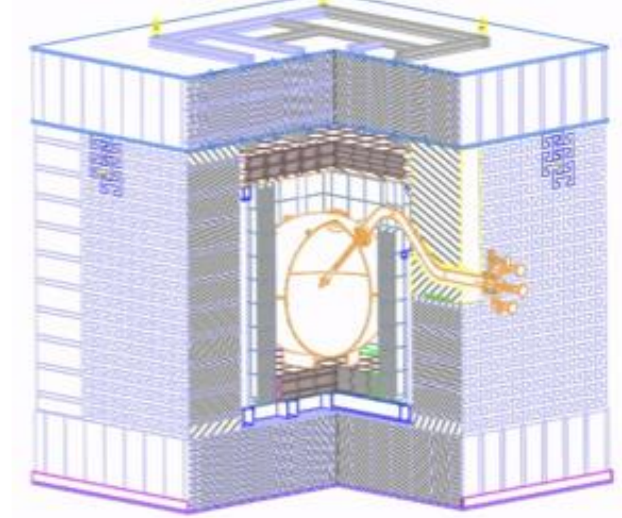


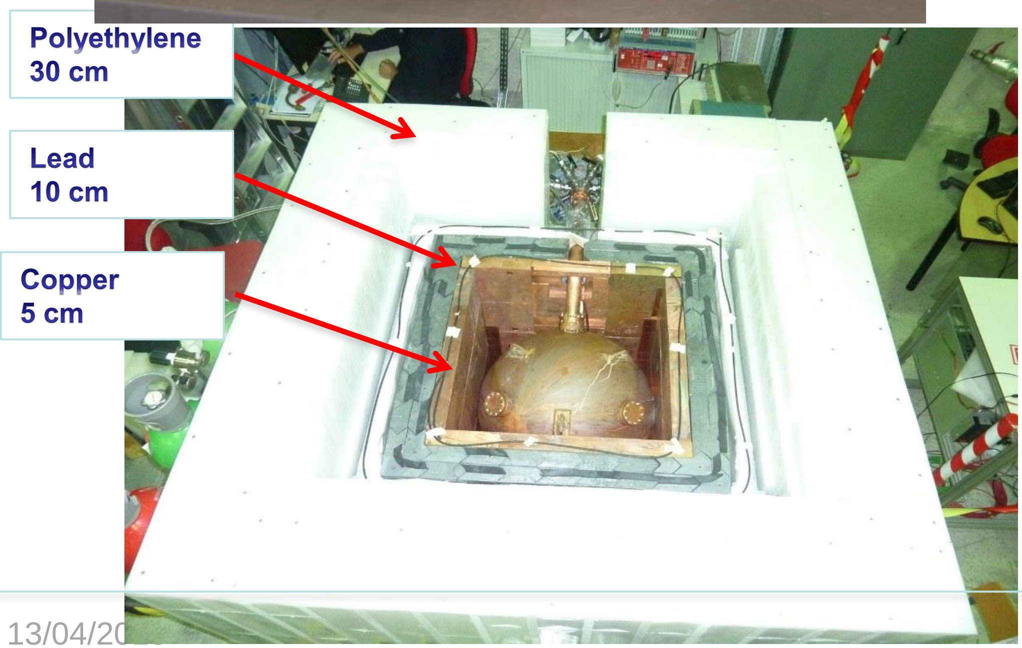
Search for light dark matter

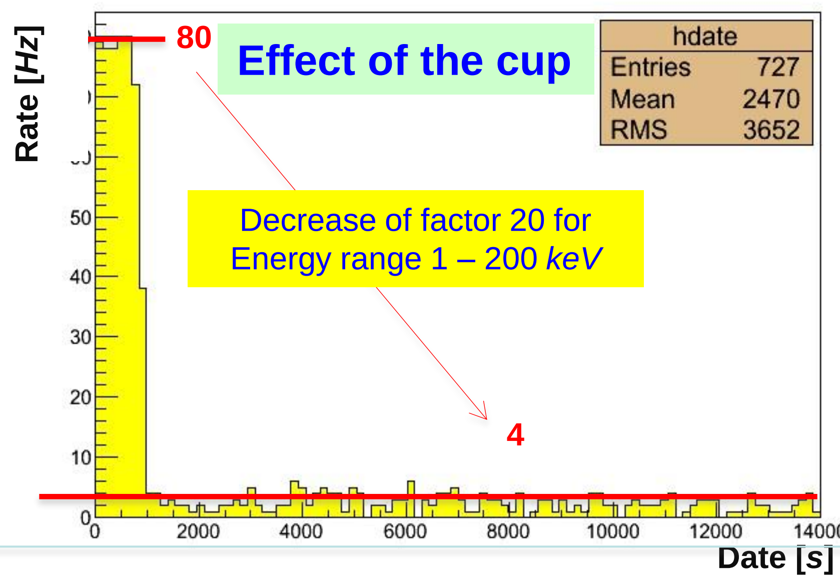
Detector installed at LSM end 2012: 60 cm, Pressure = up to 10 bar

Gas targets: Ar, Ne, He, CH4

Detector inside shield







Internal contamination cleaning

Goal: remove Po-210, Pb-210

1st chemical cleaning of sphere

Conditions :

- Nitric acid (17 %)
- Temperature 10° C
- Cleaning by filling the spherical cavity
- Washing by pure water
- Drying by hot nitrogen

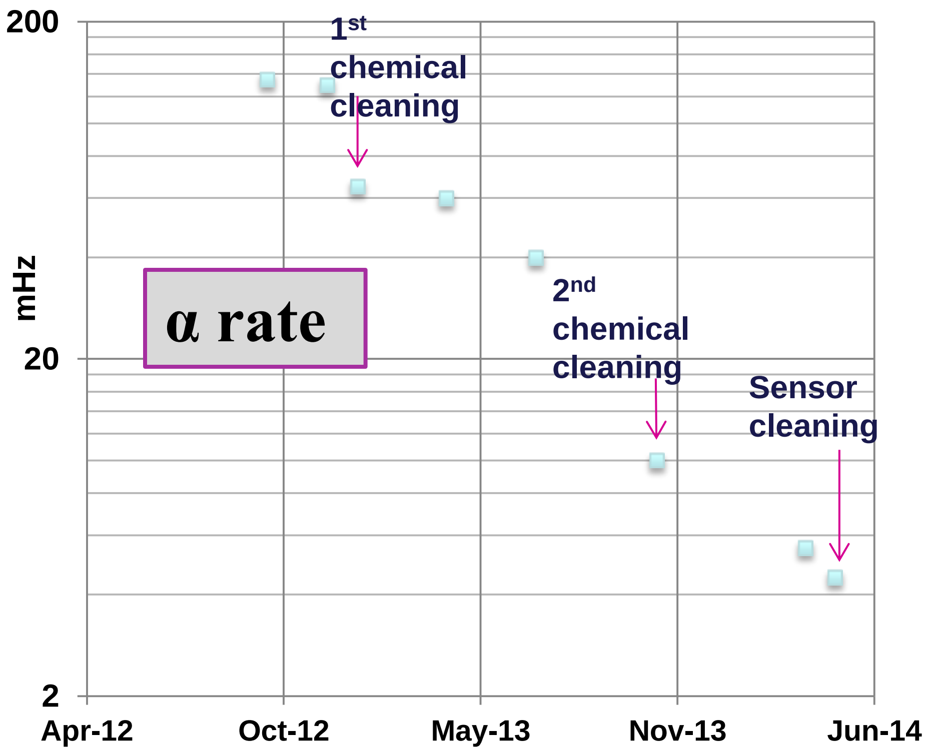
2nd chemical cleaning of sphere

Conditions :

- Nitric acid (30 %)
- Temperature 30° C
- Cleaning by spray
- Washing by pure water
- Drying by hot nitrogen

Backround evolution of the detector

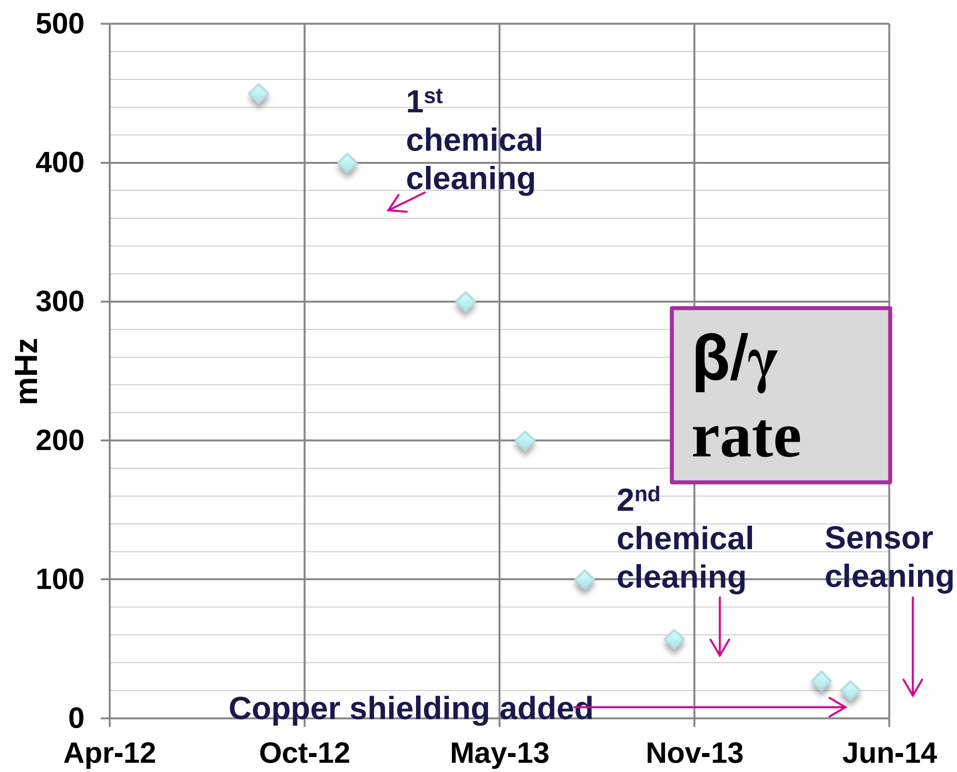
Alpha rate evolution



Decreasing factor = 45

180 *mHz* => 4 *mHz*

β/γ rate evolution



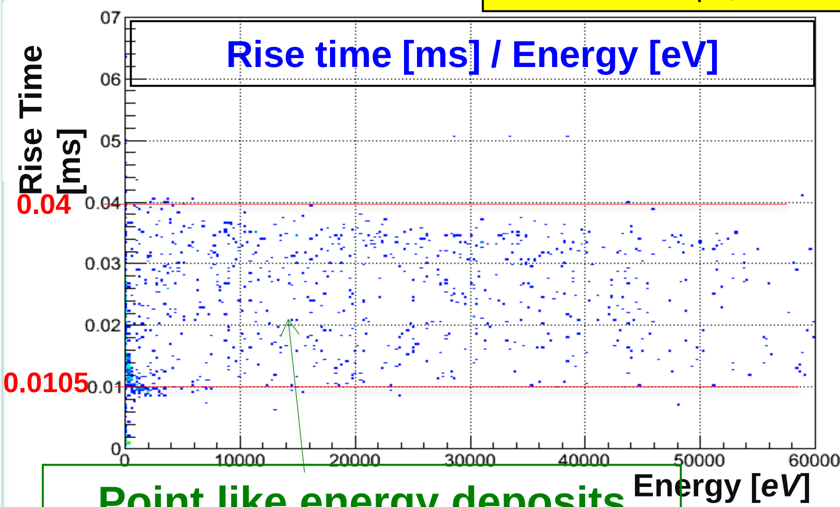
Decreasing factor = 20

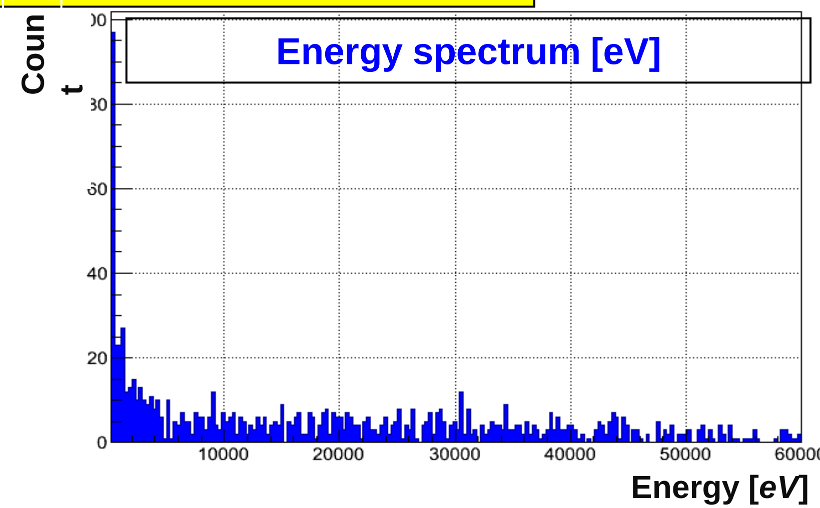
400 *mHz* => 20 *mHz*

Analysis – optimization of cuts

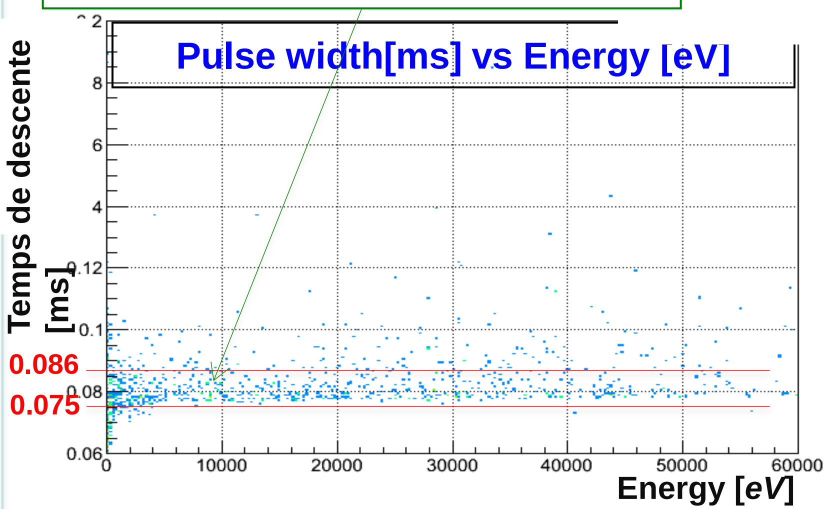
Calibration with neutrons (^{241}Am-Be) source

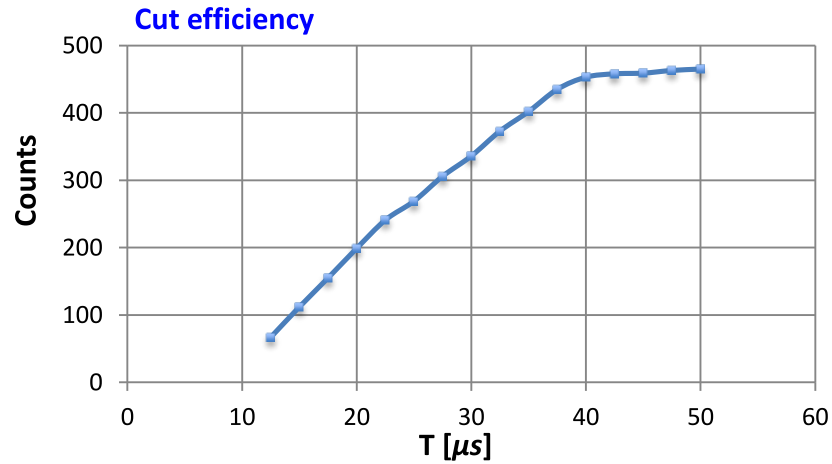
Ne + CH_4 (0.7 %) P = 3 bar T = 4455 s





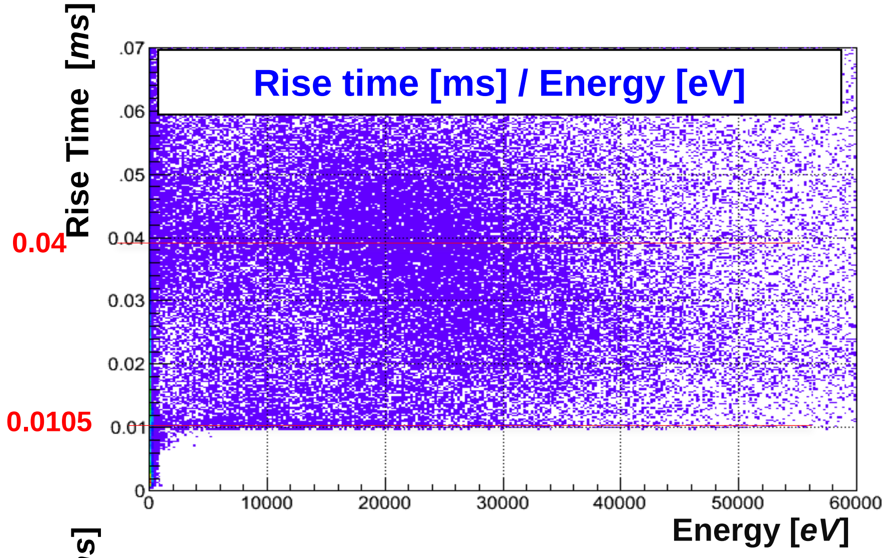
Point like energy deposits

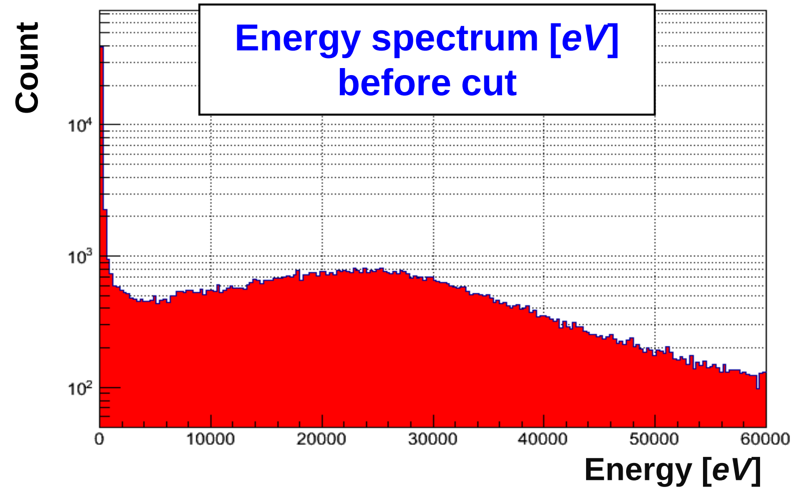


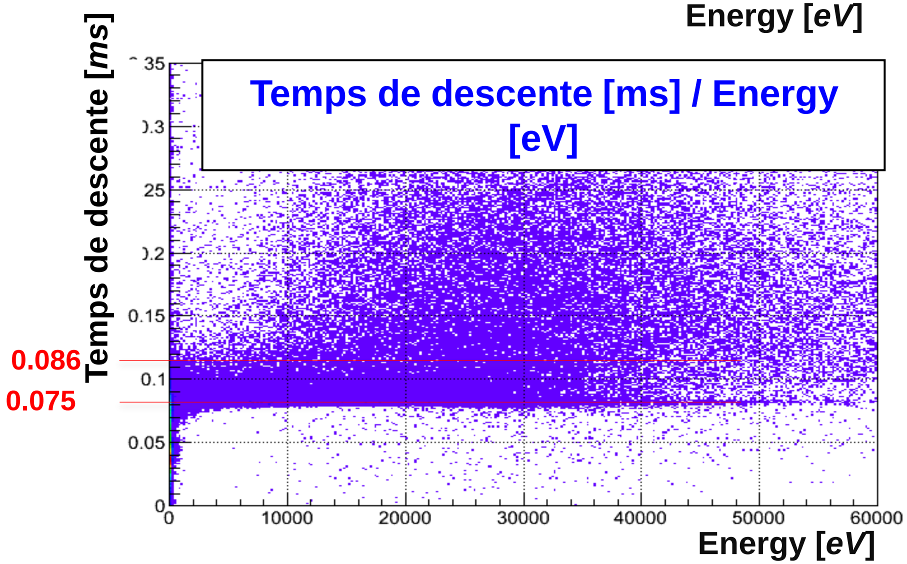


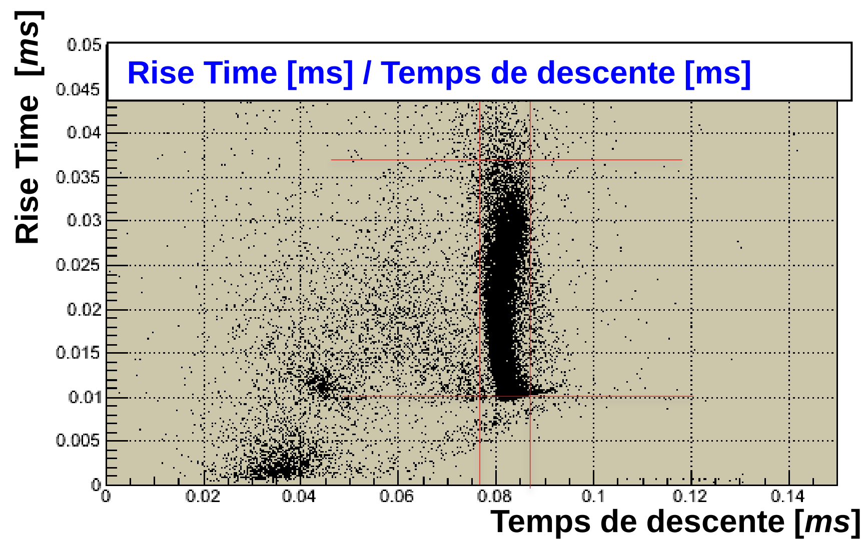
Physic run (light-WIMPs research)

Ne + CH_4 (0.7 %)   P = 3 bar   T = 30.5 jours

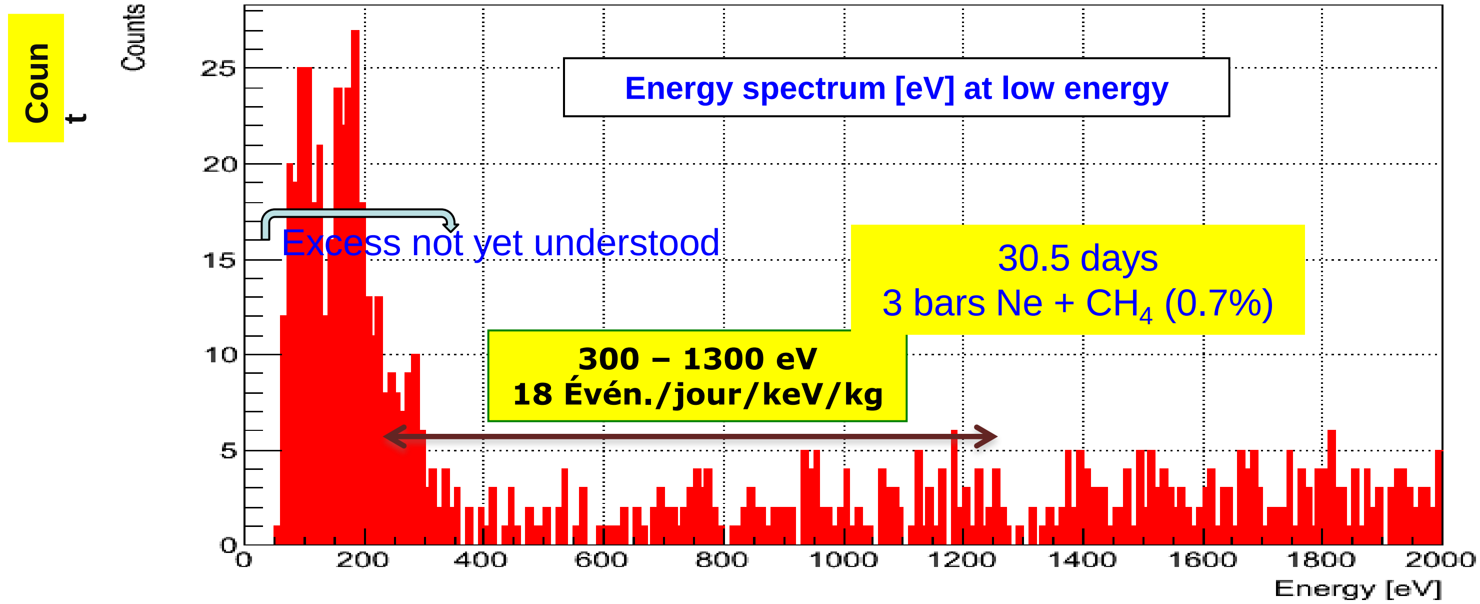


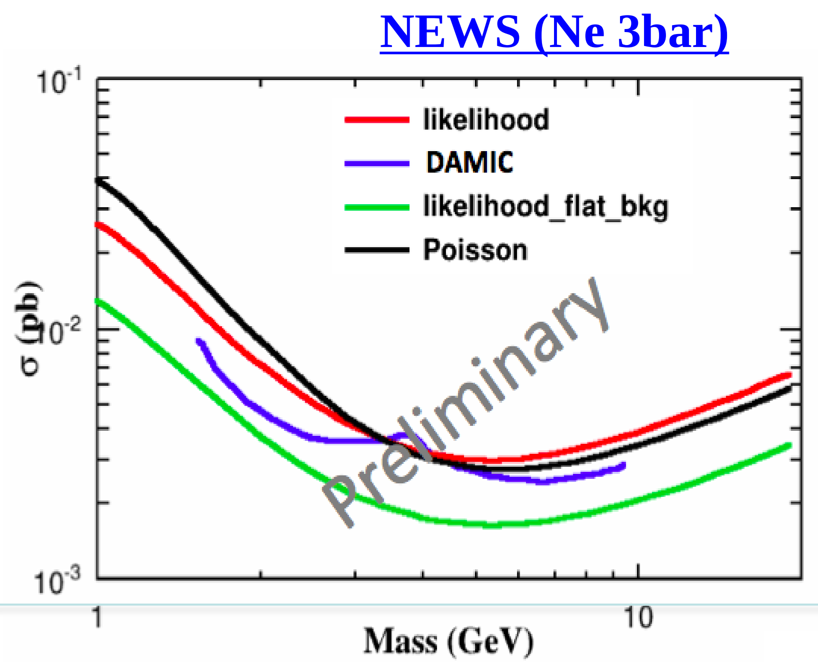






Light WIMP search results



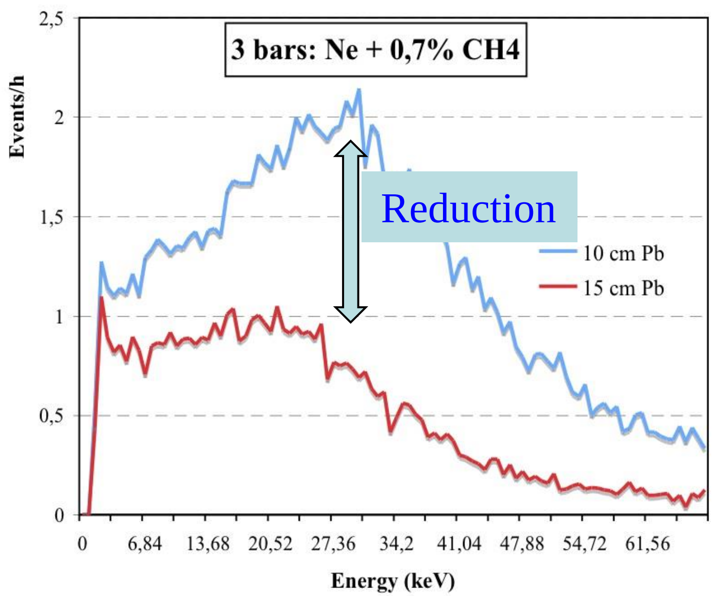


Shield improvement

During last month intervention

- New platform fabricated and installed to carry detector and shield
- Chemical cleaning of internal copper shield plates
- Total lead thickness = 15 cm (from 10cm)
- Total copper thickness= 7 cm (from 5 cm)
- Improved anti-radon tent

Physics run has started last week (Ne at 3 bar)



Summary: background level among the best experiments

Achieved with modest budget and manpower

Combined with the low energy threshold and low-Z targets:

Sensitivity for very-light WIMPs of this experiment is out of competition

NEWS-SNOLAB project

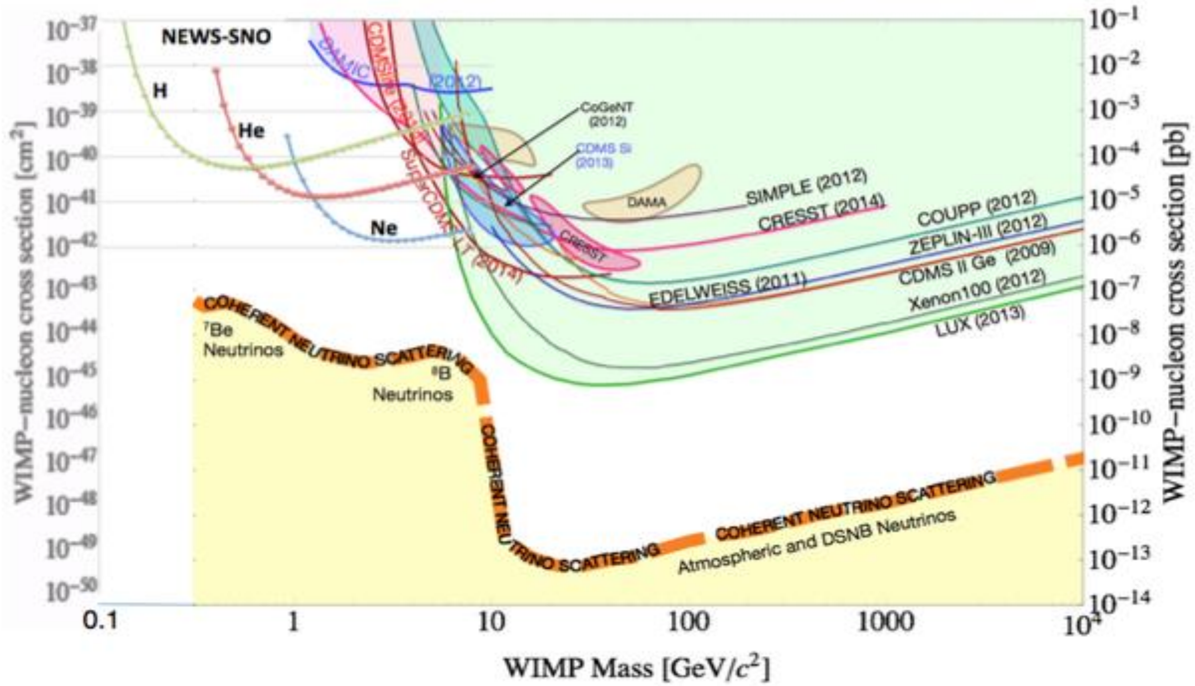
Kingston, Saclay, Grenoble, LSM, Thessaloniki…..

2 m detector at 10 bar

Pure water shield

Funded by Canadian grant of excellence

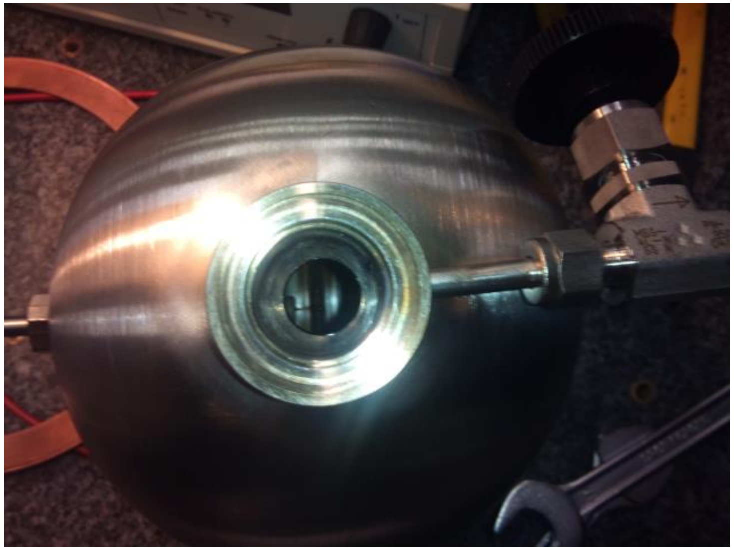
LOI recently approved by SNOLAB committee

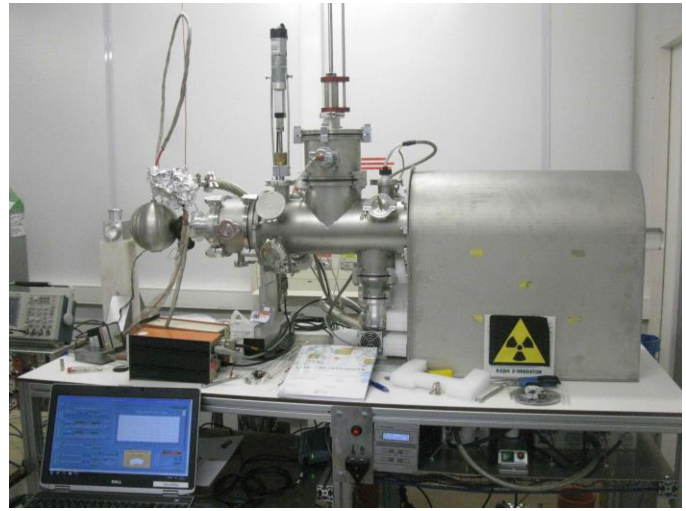


I. Giomataris

Quenching factor measurements

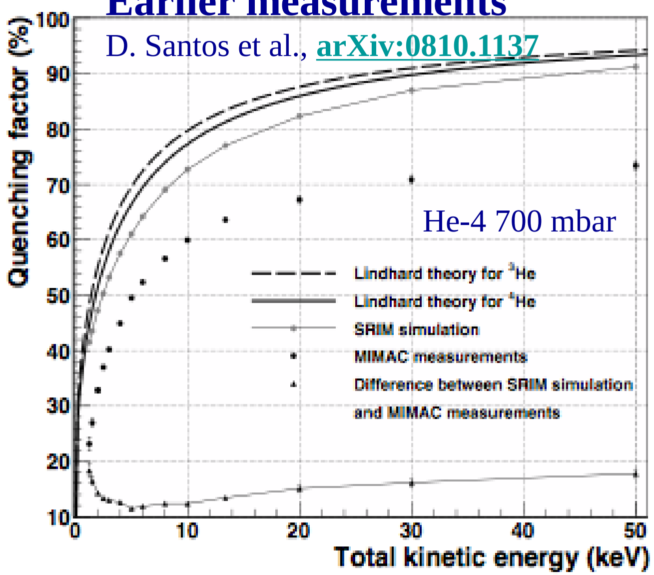
Goal: measure QF down to 500 eV ion energy using the Grenoble MIMAC facility for H, He, Ne, CF4, Ar, Xe at various pressures





Earlier measurements

D. Santos et al., arXiv:0810.1137



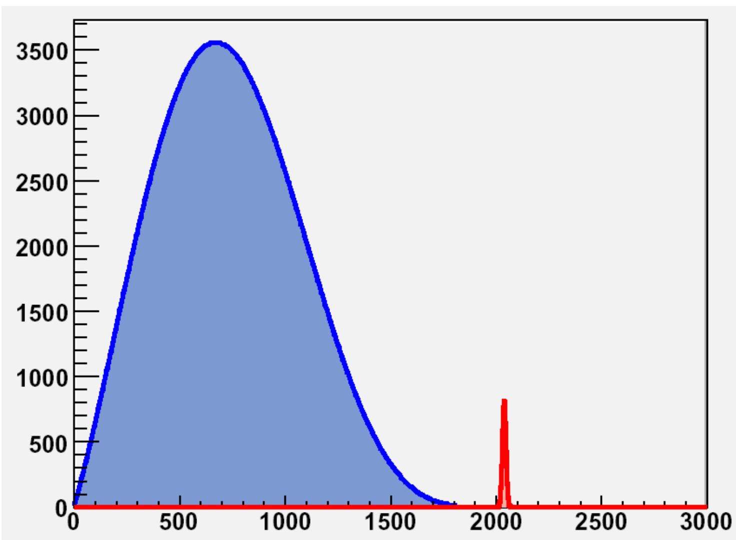
Recent investigations with a 15 cm sphere show the capability to measure 500 eV He-4 ions with an estimated QF of about 25%

Saclay, Grenoble, Thessaloniki, Queen's-Kingston

0-ν ββ Decay

- If 0-ν decays occur, then:
  - Neutrino mass ≠0
  - Decay rate measures effective mass $\langle m_\nu \rangle$
  - Neutrinos are Majorana particles
  - Lepton number is not conserved
- Physics impact is great.

Target >> 1000 Kgr and zero background



- Xenon is relatively safe and easy to enrich
- Natural abundance of ^{136}Xe is ~ 8%
- EXO and NEXT have 200 kg highly enriched in ^{136}Xe
- Low cost
- Pressure variation

High density is desirable to contain event
But there is an upper limit! □ < 0.55 g/cm^3
Beyond this density, □E/E deteriorates rapidly!

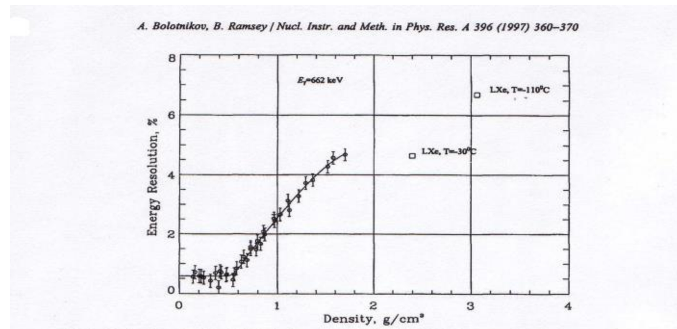
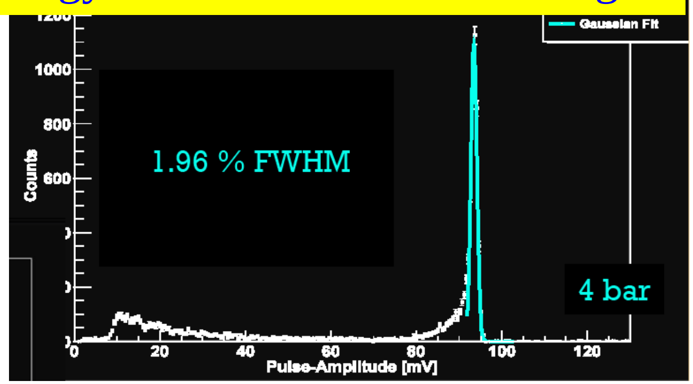


Fig. 5. Density dependencies of the intrinsic energy resolution (%FWHM) measured for 662 keV gamma-rays.

Energy resolution with Micromegas



Double beta decay experiment with the spherical detector

Advantages: Simple and cost effective

Very-low background capability

Scaling up :

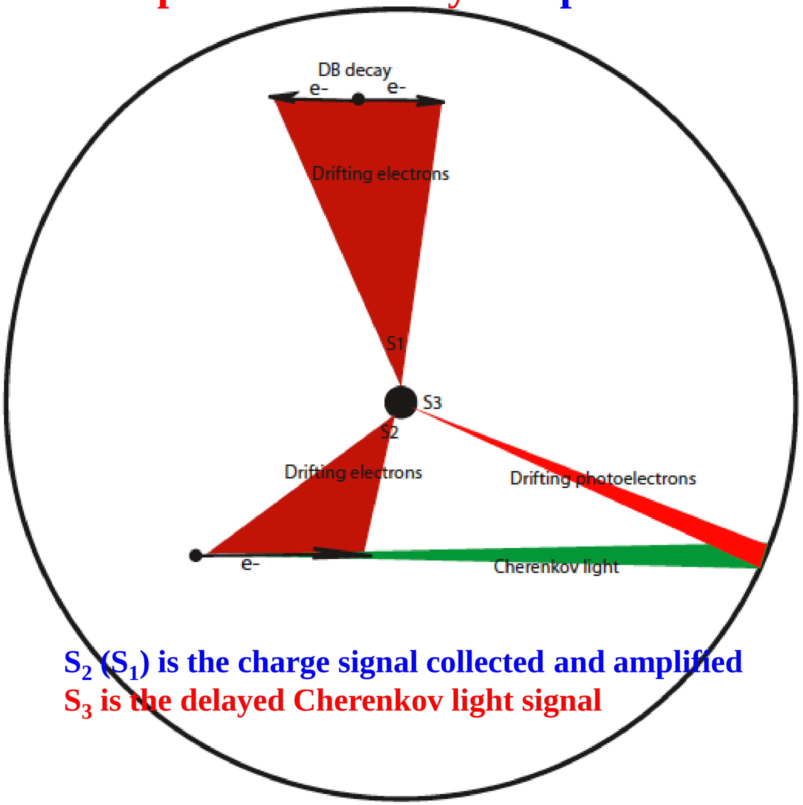
3200 Kg with a 3 m radius detector at p=20 bars

If additional rejection is required: new idea

Background free double beta decay experiment, *I. Giomataris, arXiv:1012.4289*

Spherical detector with Xenon-136 at high pressure

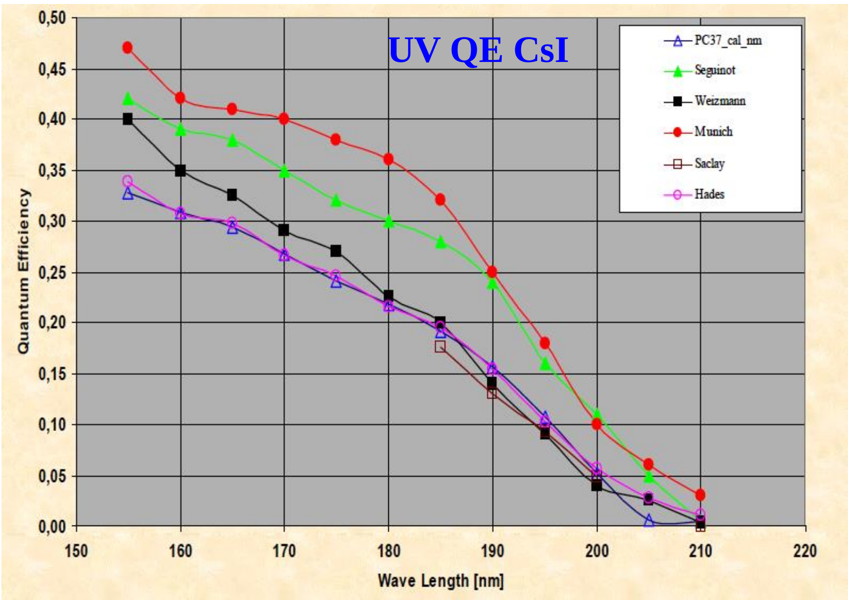
and CsI photocathode layer deposited at the internal vessel surface



S_2 (S_1) is the charge signal collected and amplified

S_3 is the delayed Cherenkov light signal

iomataris



CONCLUSIONS

- **A promising low background detector**
- **Ultra low energy threshold capability**
- **Light dark matter search down to 100 MeV**
- **Low energy neutrino physics projects**