# NEWS light-WIMP search

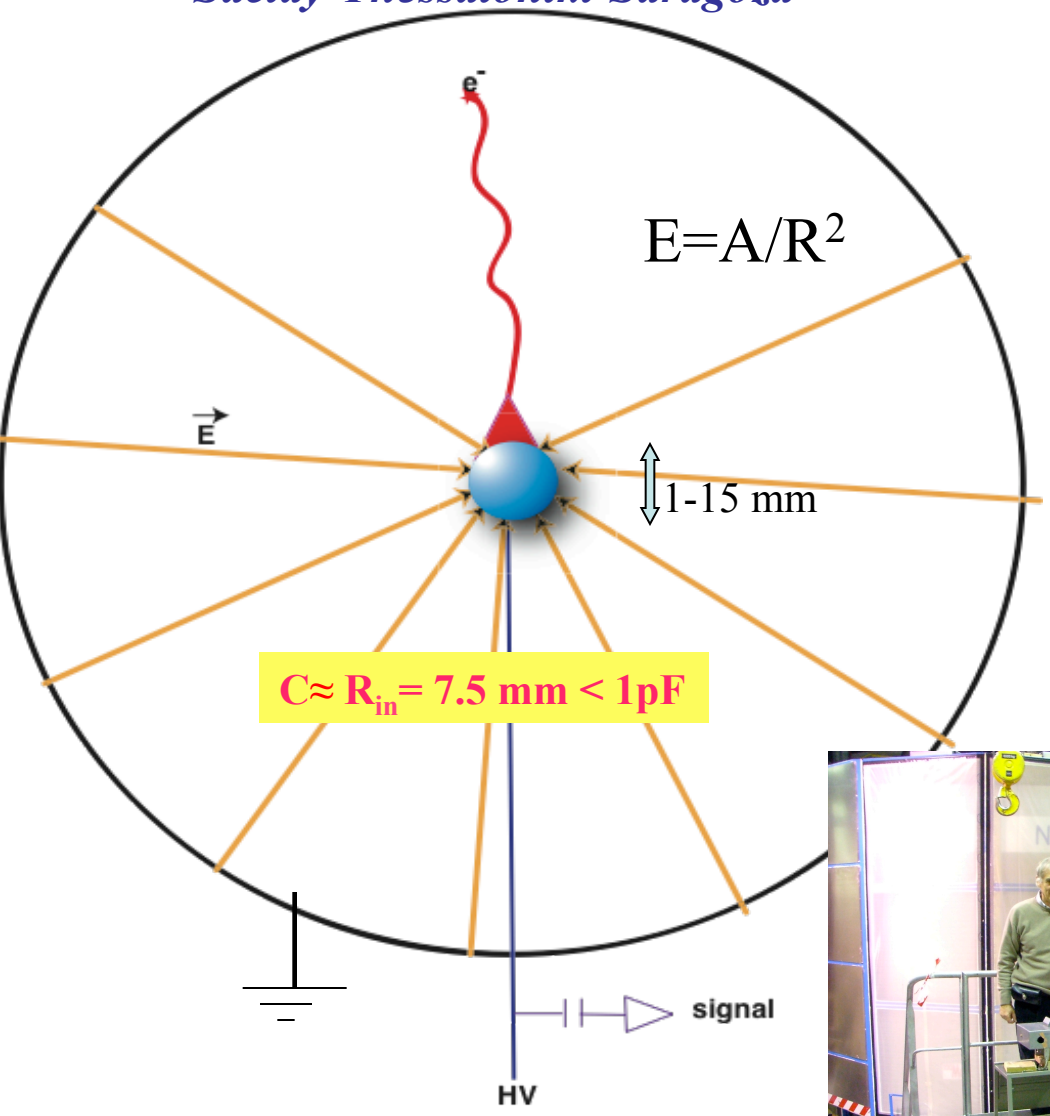
*I. Giomataris CEA-Saclay*

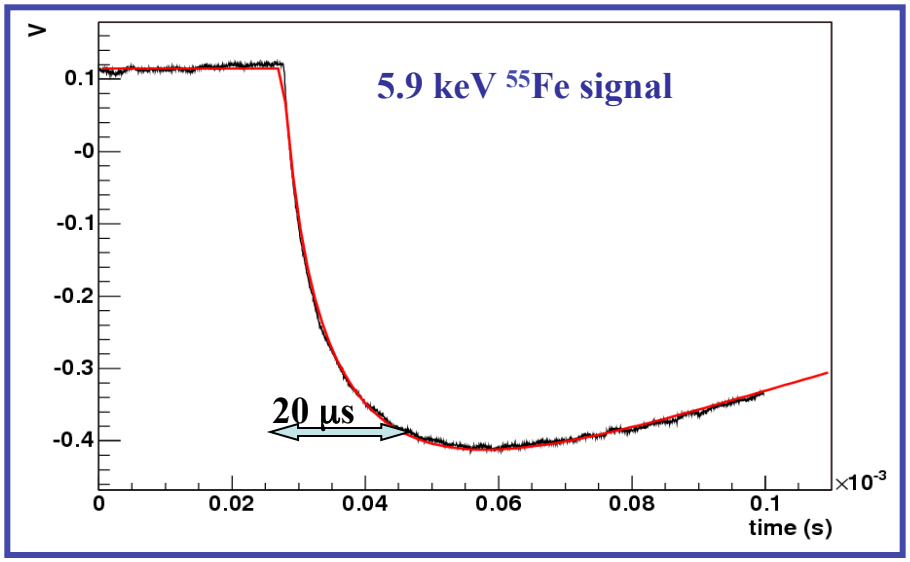
- NEWS-LSM, NEWS-SNO, NEWS-emulsions ??
- Principle of the Spherical detector
- NEWS collaboration and light dark matter search
- NEWS-LSM and results
- NEWS-SNOLAB future project
- New and future developments

# 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



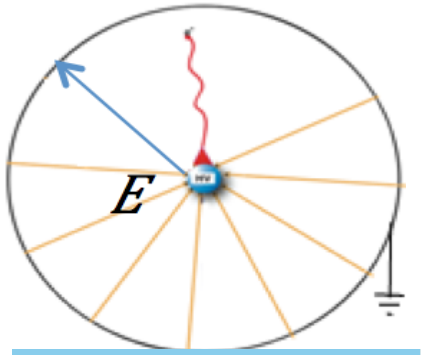



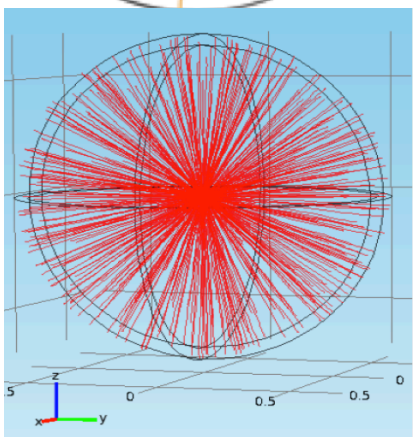


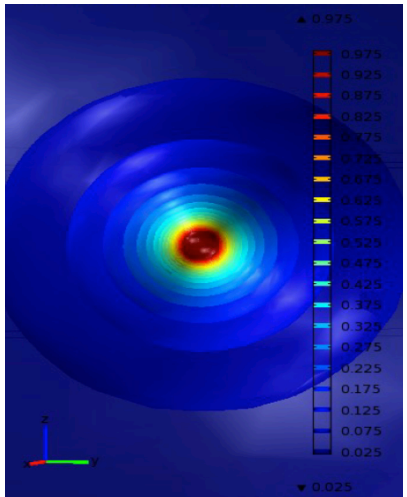
- Simple and cheap
- Large volume
- single read-out
- Robustness
- Good energy resolution
- Low energy threshold
- Efficient fiducial cut
- Low background capability

# Electrostatics deal - how to maintain a radial field

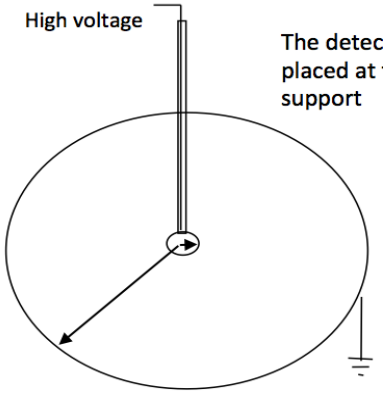
## Ideal case: ball non wire

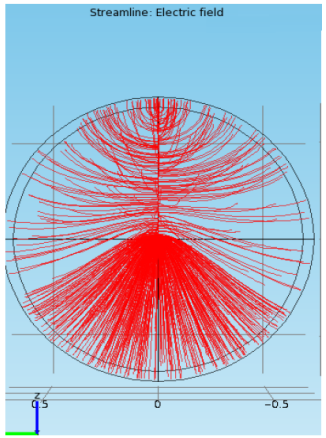


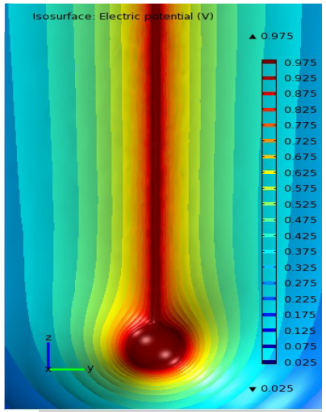





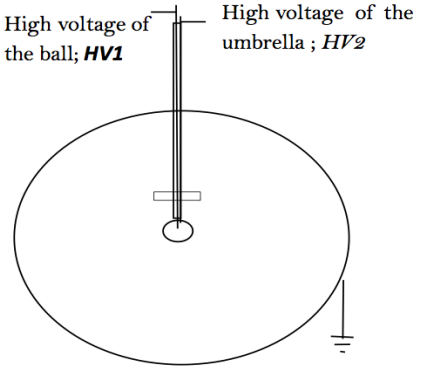
## Ball with wire

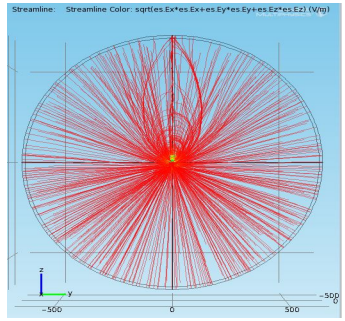


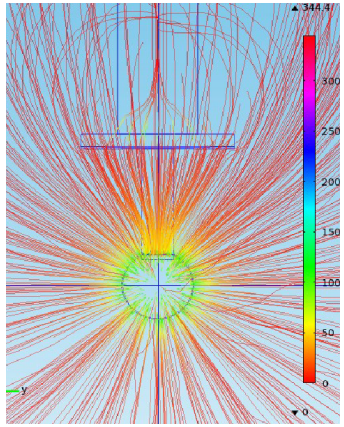



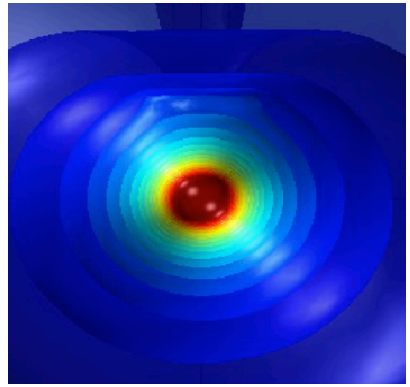




## The Ball with umbrella corrector



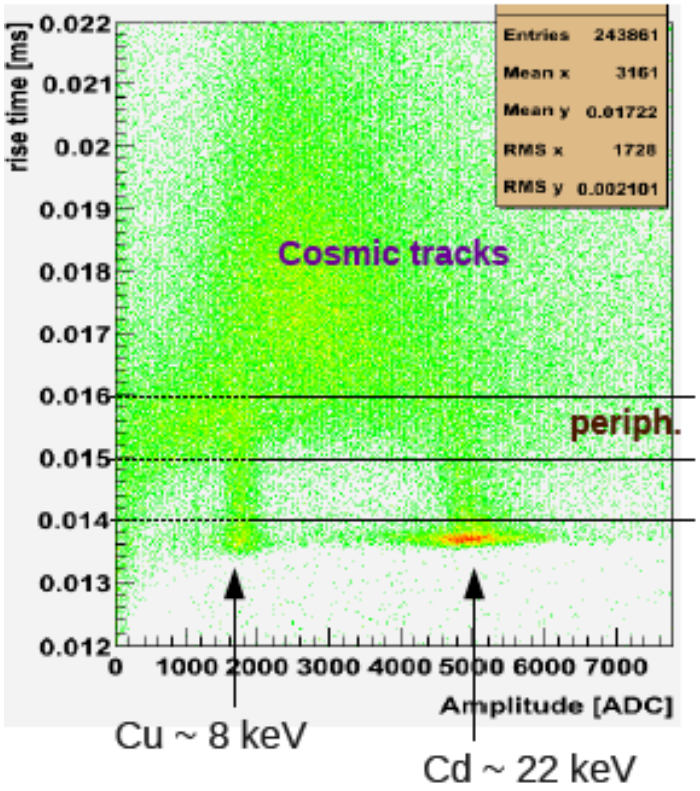


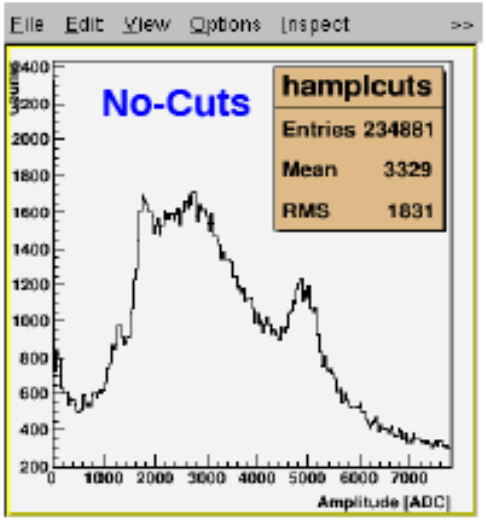


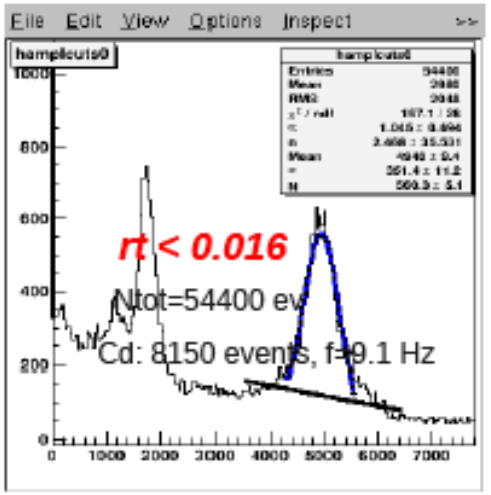
# Rejection power

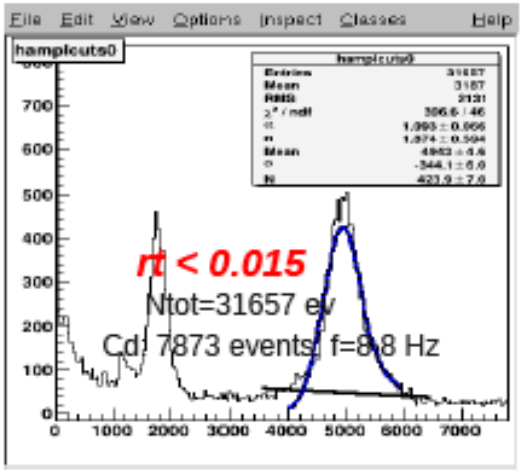
# Rise time cut

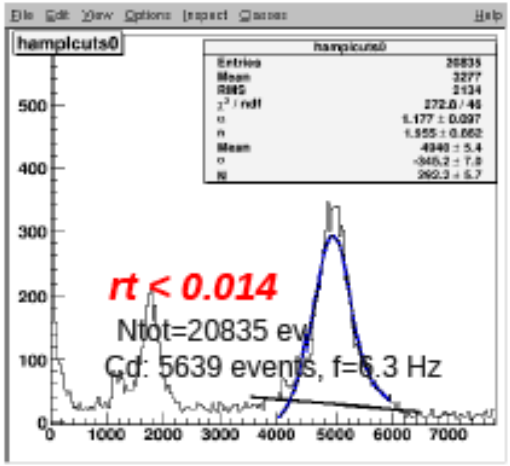
**Using Cd-109 source** – December 2009
Irradiate gas through 200μm Al window
P = 100 mb, Ar-$CH_4$ (2%)



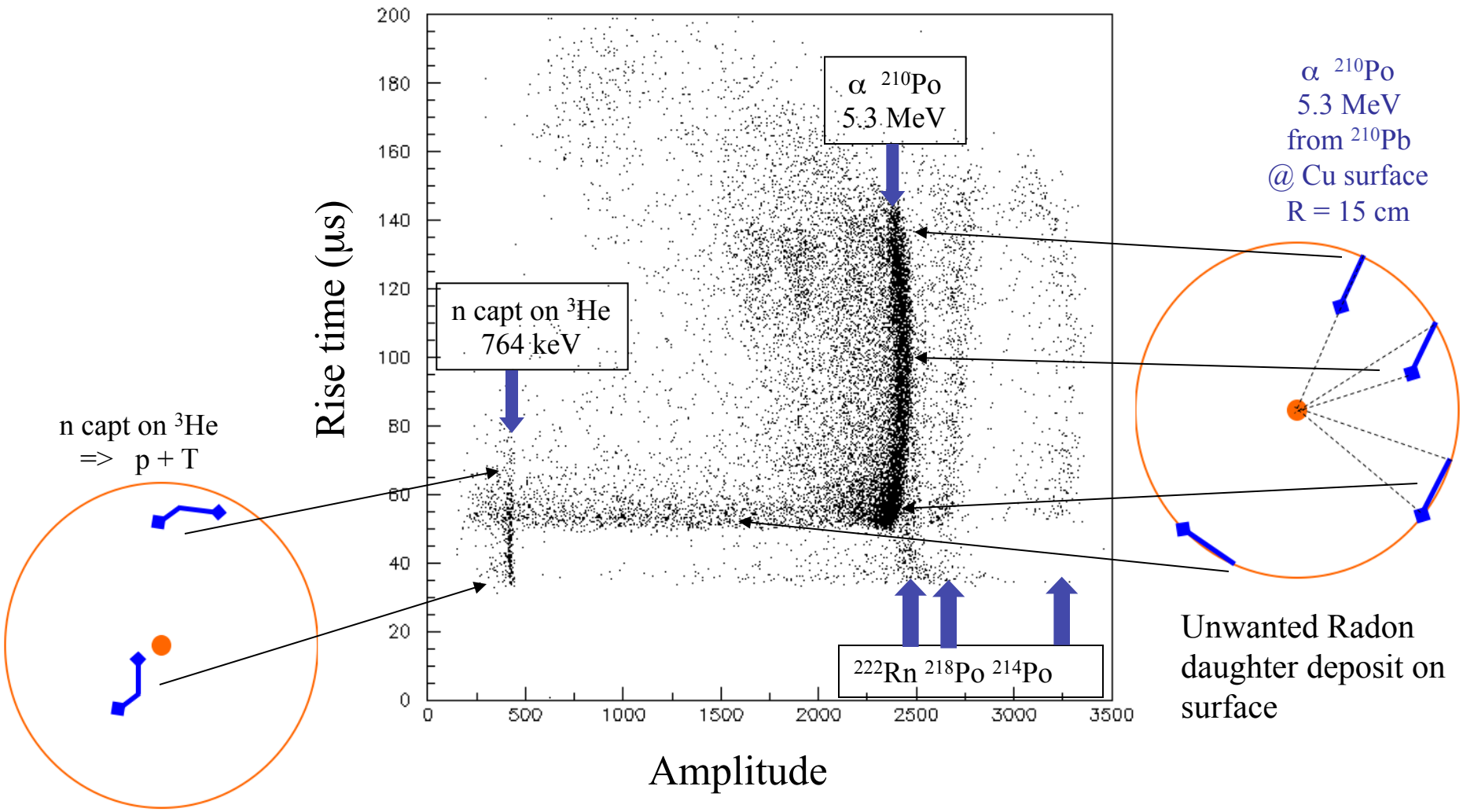

If rt ~ 0.0155 ms ==> R = 65 cm
0.014 ms ==> ~70% of signal

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

Severe background reduction

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

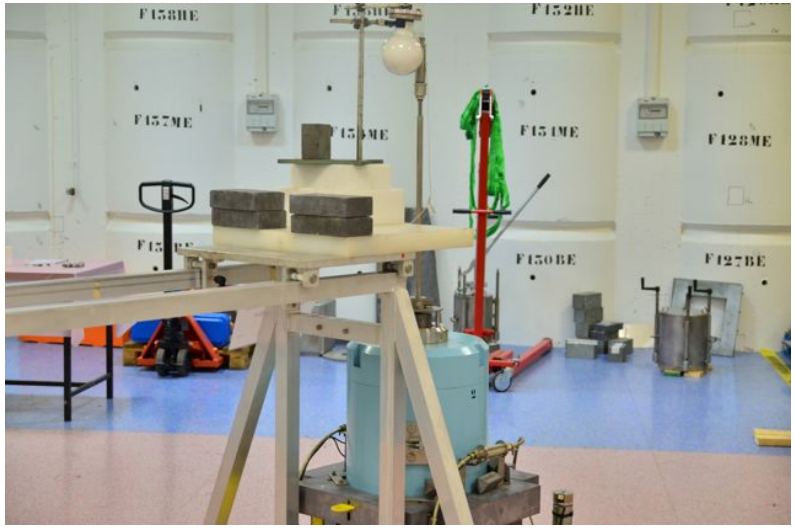
# Run at LSM - $Ar/CH_4$ + 4g $^3He$ 200 mb

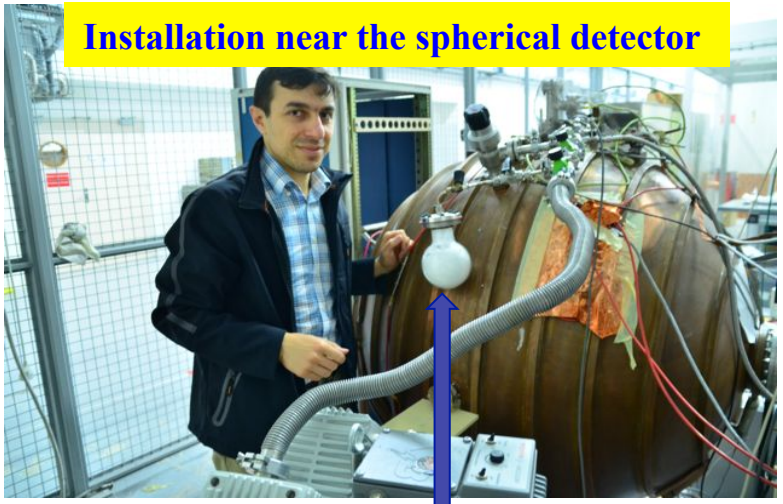



= > dependance of rise time on length of track and radius position

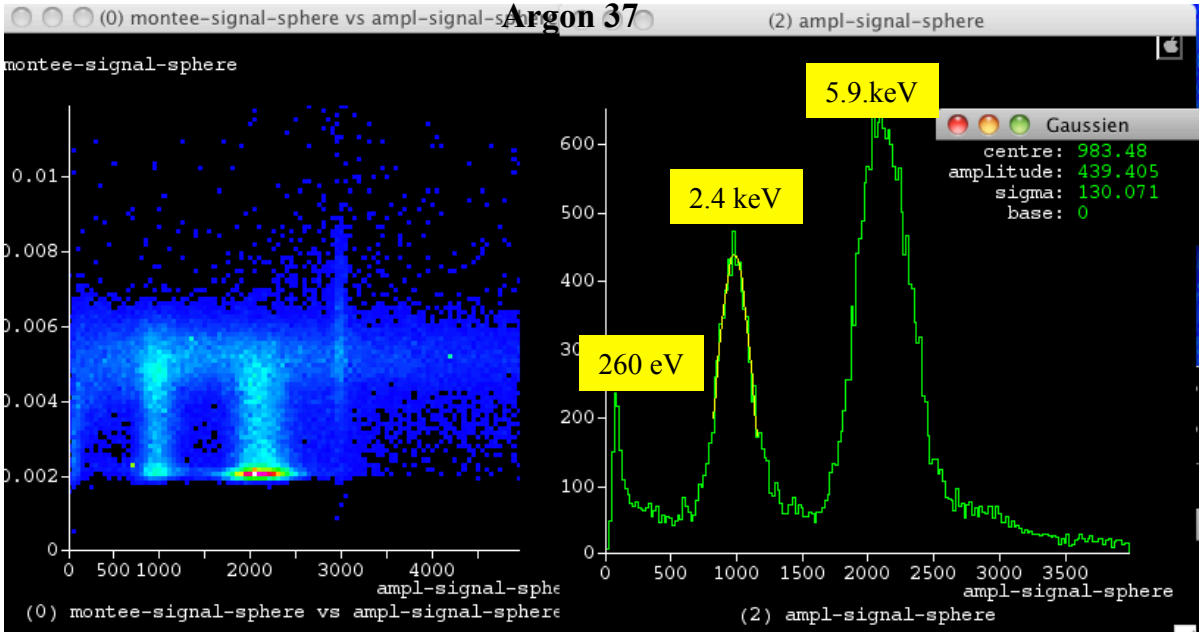
# Low-energy calibration source *Argon-37*

Home made Ar-37 source: irradiating Ca-40 powder with fast neutrons $7 \times 10^6$ neutrons/s
Irradiation time 14 days. Ar-37 emits K(2.6 keV) and L(260 eV) X-rays (35 d decay time)






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

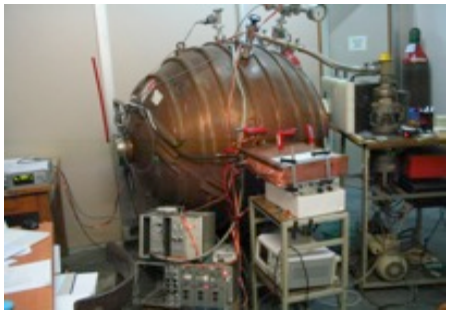


# Spherical Proportional Counter (SPC) word wide

60 cm low BG
SEDINE @ LSM

Détecteur du radon @ LSM

SPC @ Thessalonique

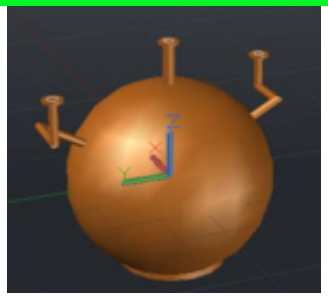


1st SPC @ Saclay

Queens University test sphere

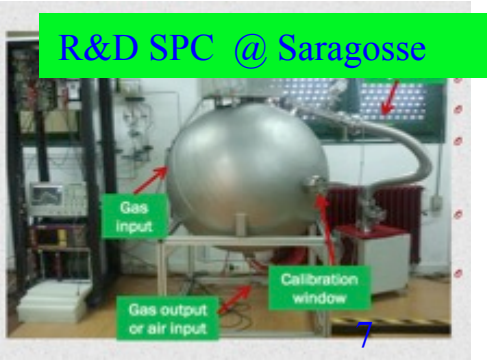
$^3$He SPC @ Pékin

Future 1.4 m NEWS SPC @ SNOLAB



Radon Monitoring (for SuprNEMO Experiment)@ CPPM

R&D SPC @ Saragosse



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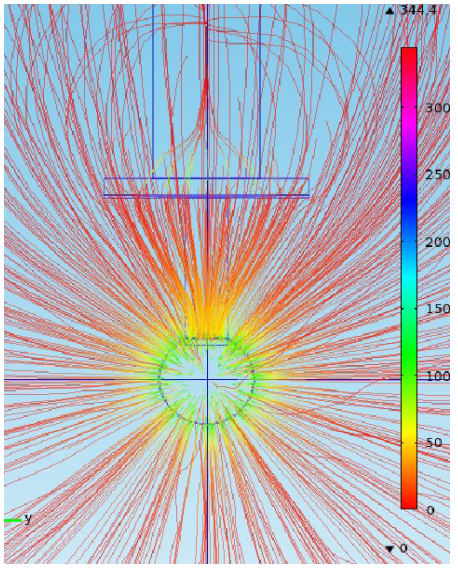
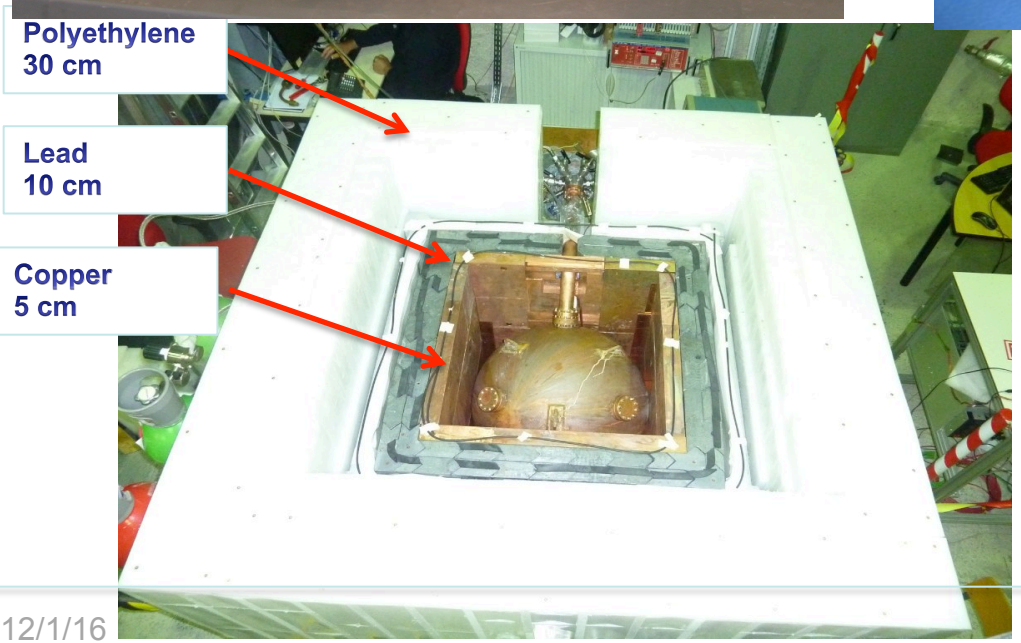
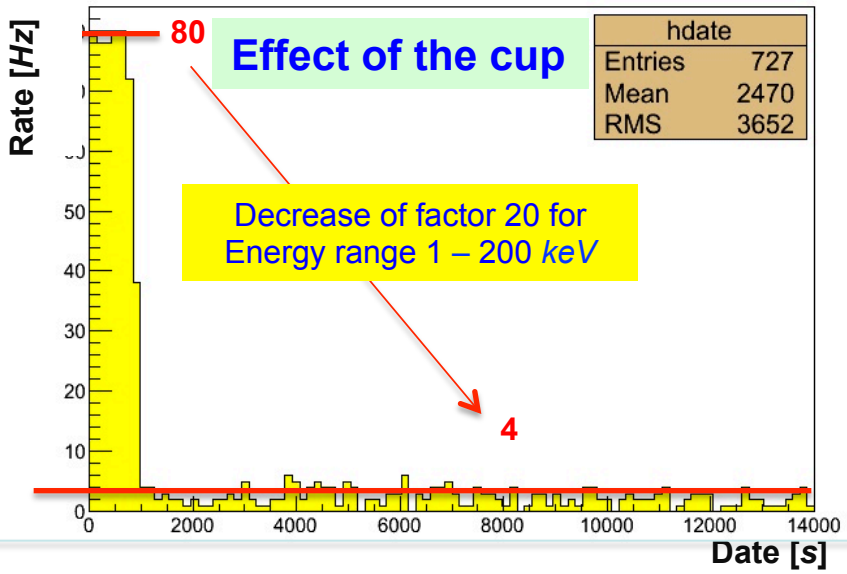
# NEWS-LSM: Exploration of light dark matter search at LSM

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

## Gas targets: Ne, He, CH4



# 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

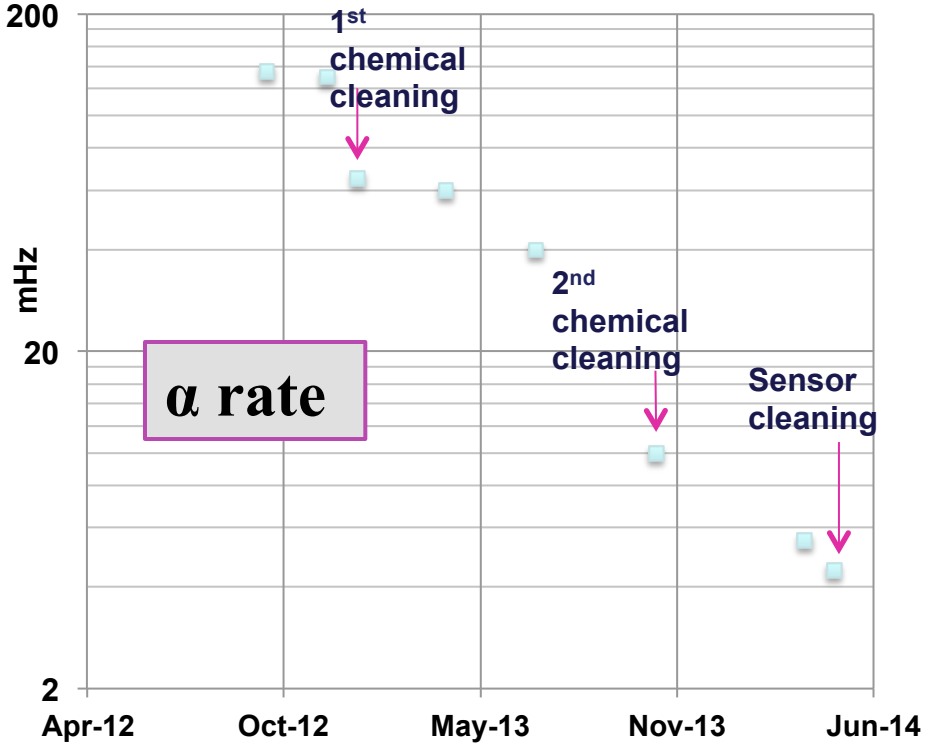
## 2nd chemical cleaning of sphere

**Conditions :**

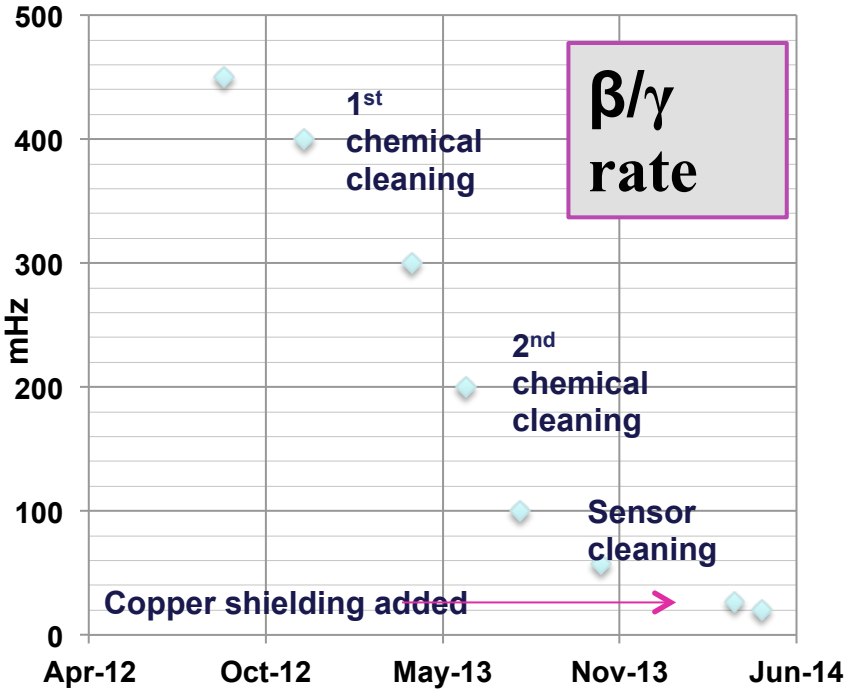
- Nitric acid (30 %)
- Temperature 30° *C*
- Cleaning by spray
- Washing by pure water
- Drying by hot nitrogen

# Background evolution of the detector

## Alpha rate evolution




## β/γ rate evolution




**NEWS detector: we will reduce the activation down to 2-3 weeks (14 months in SEDINE)**

**Novel way of cleaning, using high pressure jet, is under way to remove 10mm Cu layer and further improve surface contamination**

# Light WIMP search results

30.5 days run

Volume 122l, ball 6.3mm

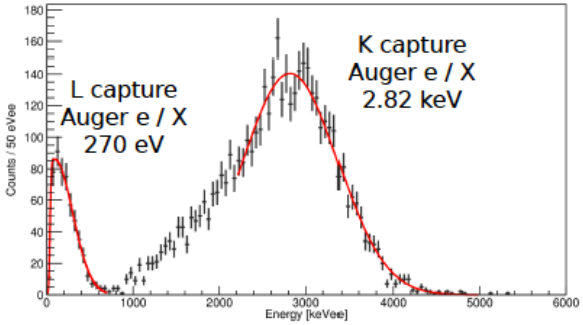
3 bars Ne + $CH_4$ (0.7%)

## Calibration

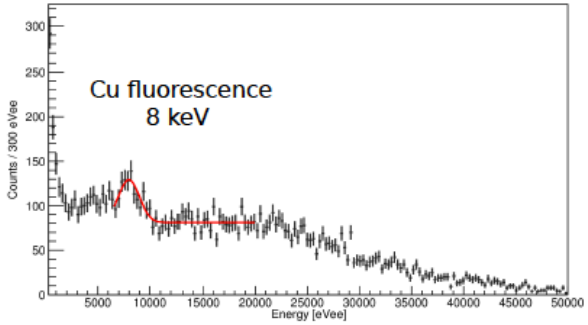
- Two methods
  - Volume calibration with **$^{37}$Ar source** (after end of run), obtained from **$^{40}$Ca(n,α)$^{37}$Ar**
  - Internal calibration with **8 keV peak** from **Cu fluorescence**

**Loss of gain of 4 % along 42 days monitored with $^{210}$Po line** + variation on days scale of +- 4%

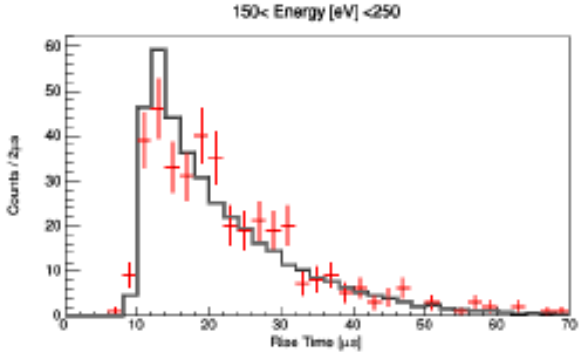
$^{37}$Ar X rays calibration

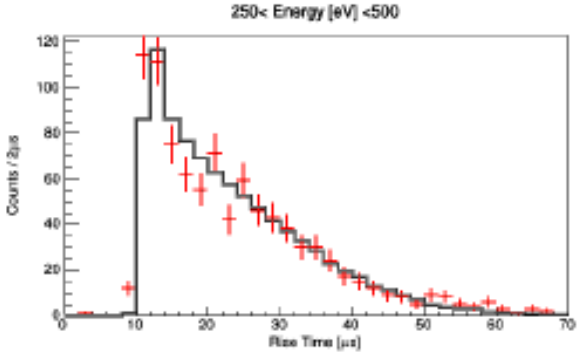


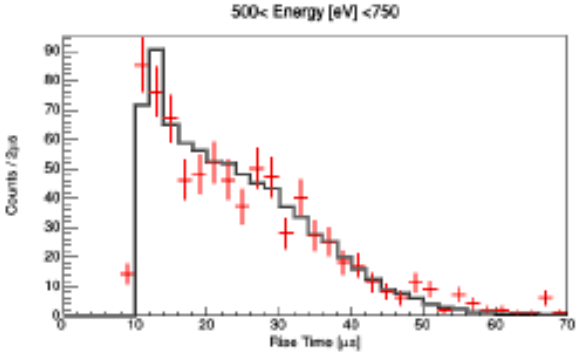

WIMP search data

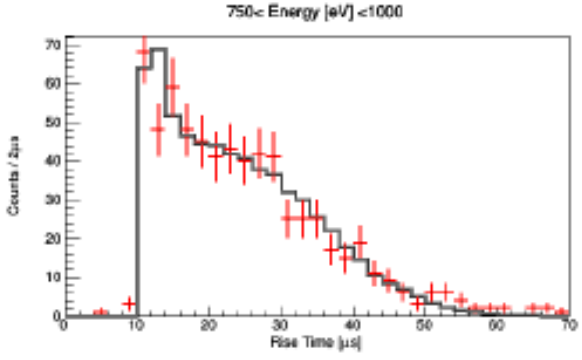


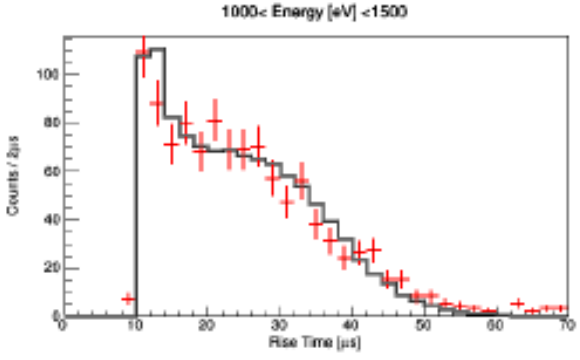
# Agreement between Neutron Calibration and simulations

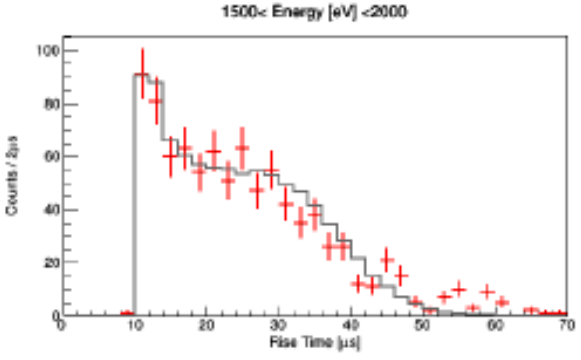


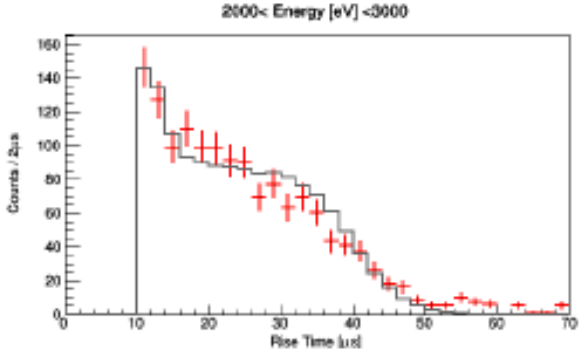



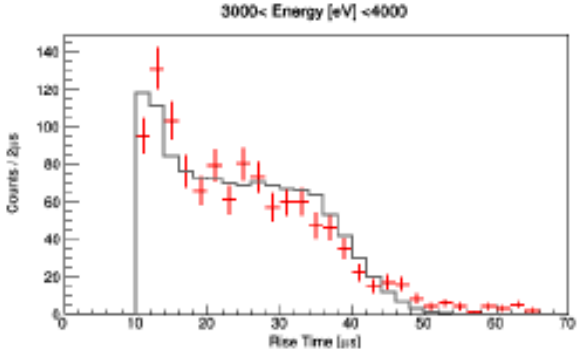



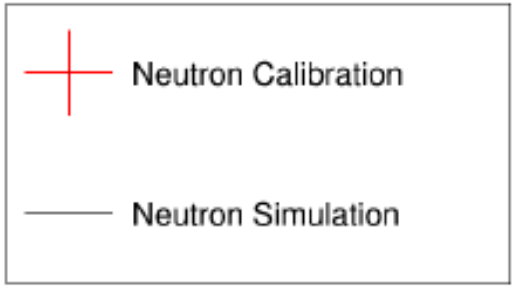



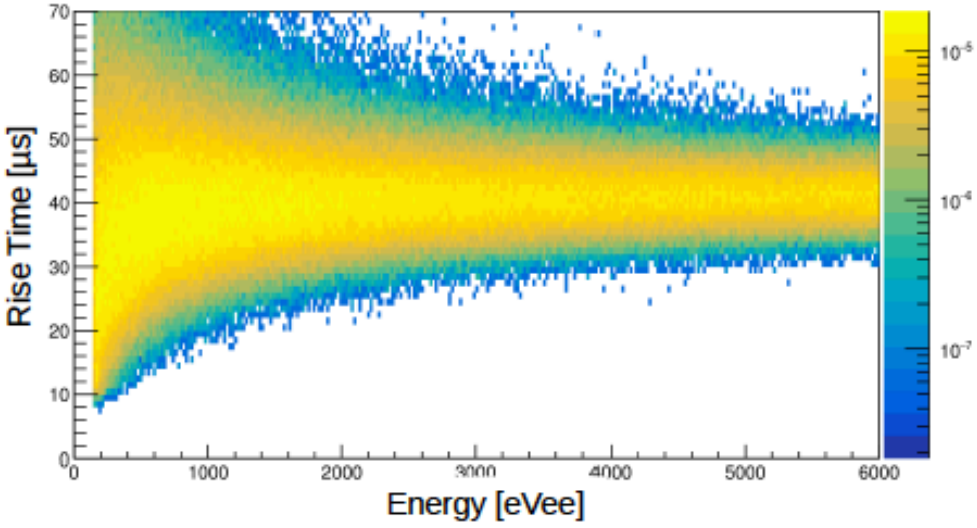



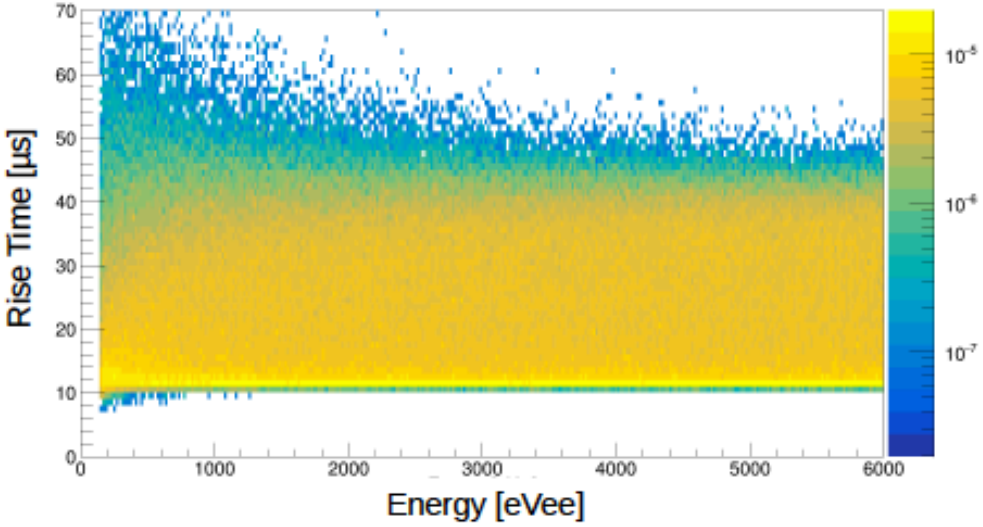
# Sedine Data and Simulations

## Background PDFs

### Surface events

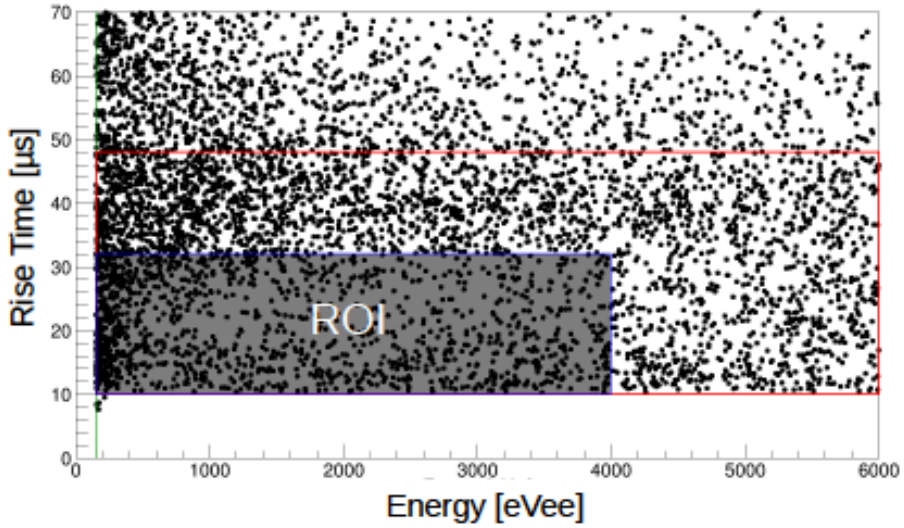



### Volume events




## Sedine data

### WIMP search run




**Analysis threshold** set at **150 eVee**
(100% trigger efficiency)

**Side Band region** used to determine
The number of background events
expected in the **ROI**

**~1619 events expected in the ROI ...**

**Need to determine a fine-tuned ROI optimized for signal/background**

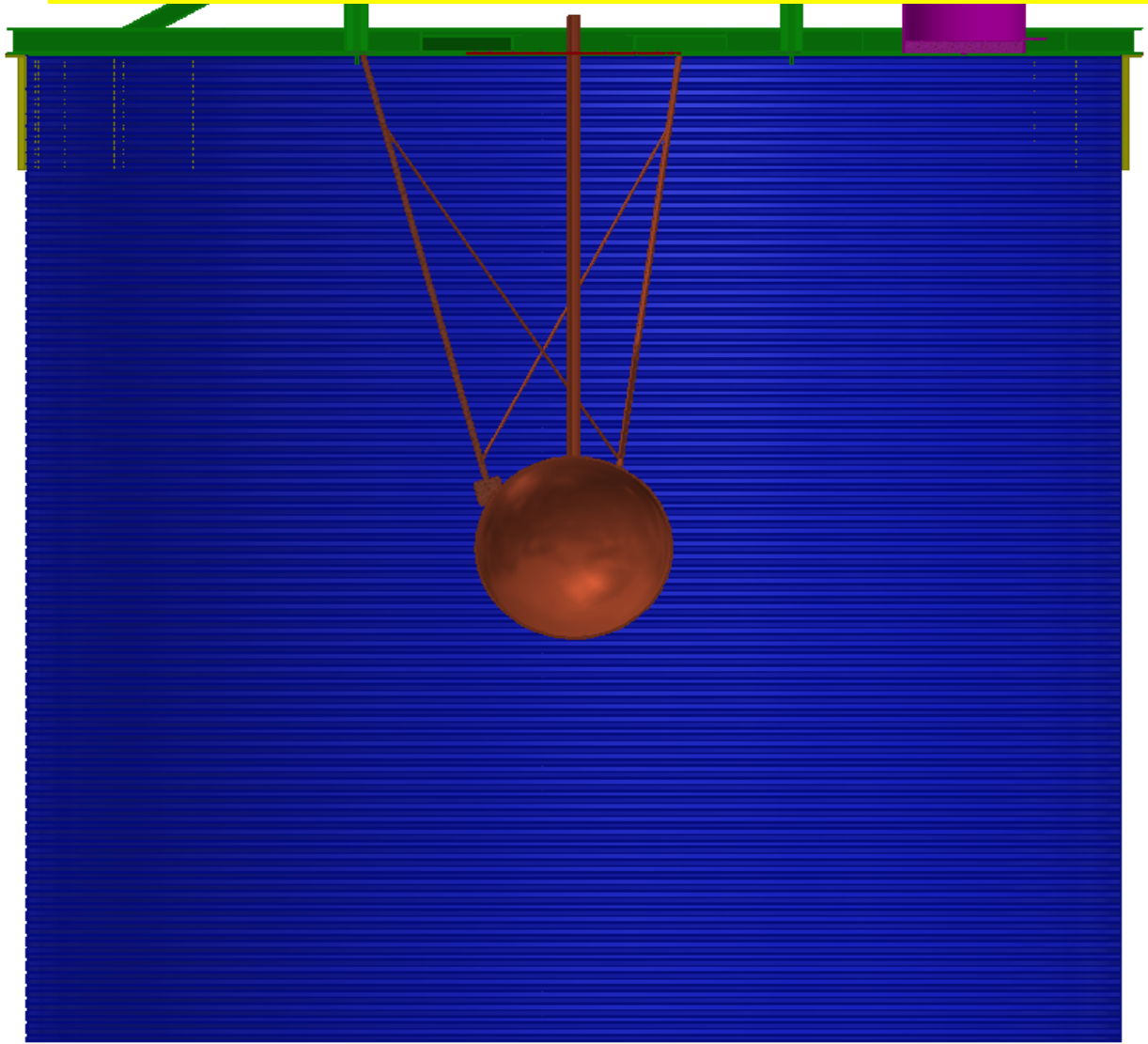
**Sensitivity of the experiment NEWS-LSM**
**Very competitive in the mass region < 3 GeV**
***Exclusion plot and other details will be presented next week in the PARIS-TPC conference***
***and in Dark Matter Workshop (Berkeley, CALIFORNIA)***

# NEWS-SNO project

## Funded by Canadian grant of excellence and ANR-France

LOI recently approved by SNOLAB committee

**Water Shield Tank Concept : initial idea**



Deck Design- Ian Fuller at Hallsal

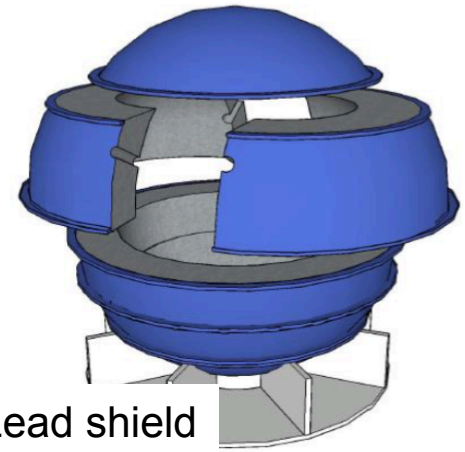
3D Model
Rodney Shnarr- Carleton
Stephen Stankiewicz- SNOLAB


NEWS in cryopit ?

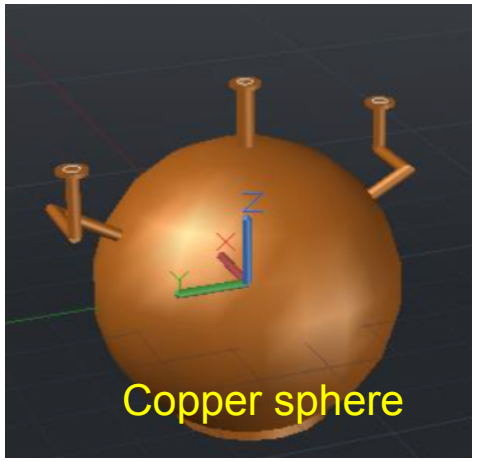
Not enough…

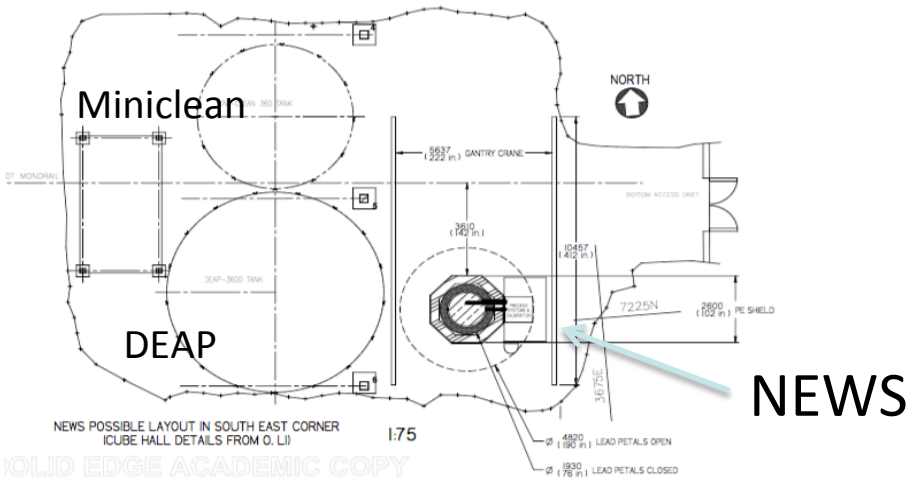
# NEWS-SNO with compact shield : implementation at SNOLAB by fall 2017

140 cm Ø detector, 10 bars, Ne, He, $CH_4$
Copper 1 mBq/kg
Compact lead –ancient- & PE shield solution

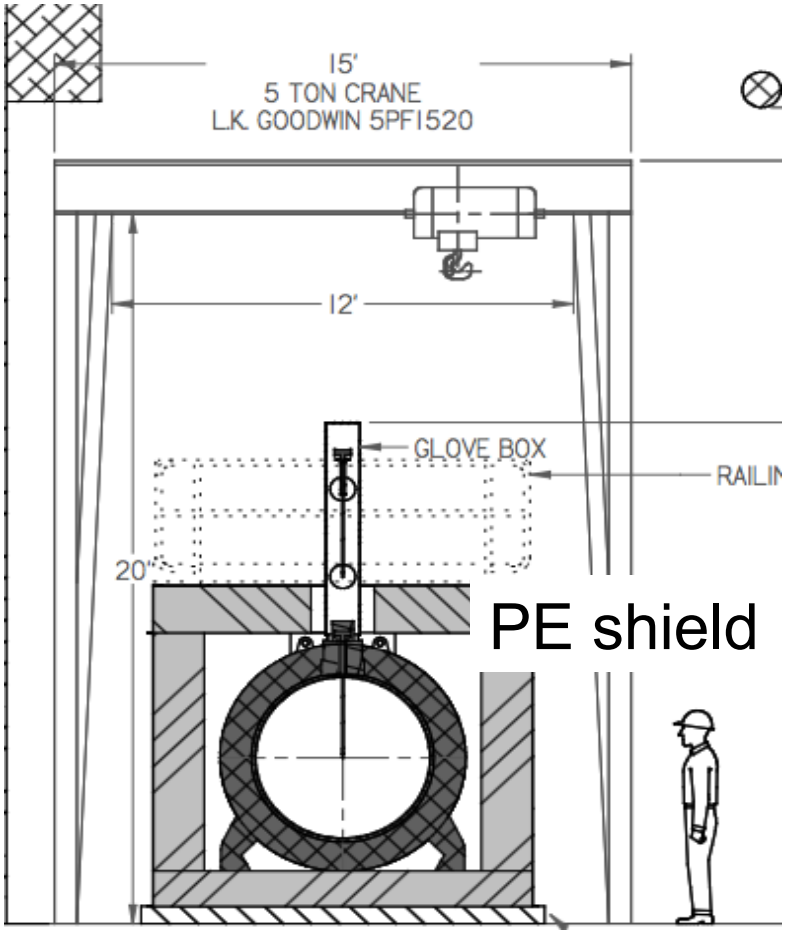


Lead shield



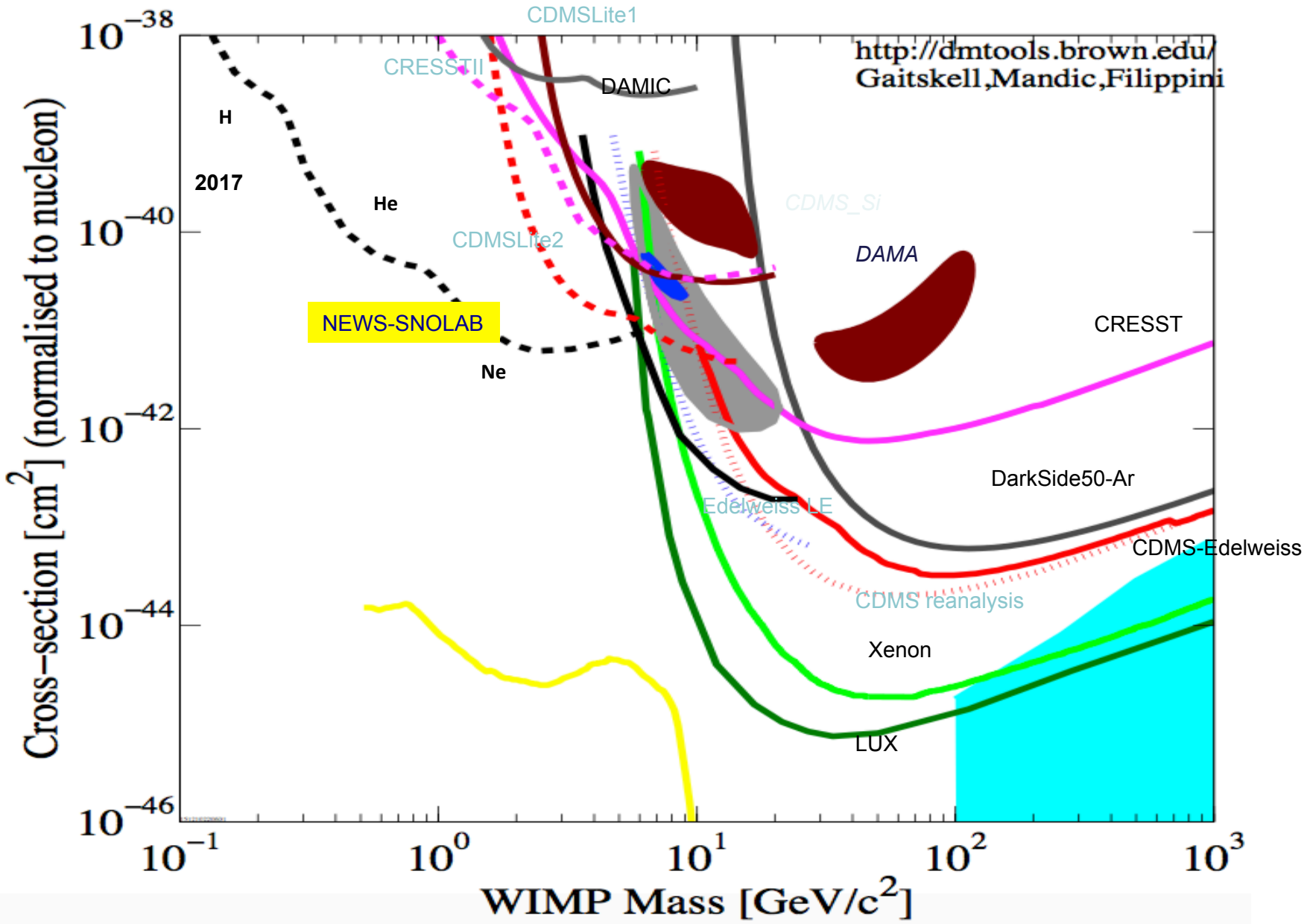




NEWS



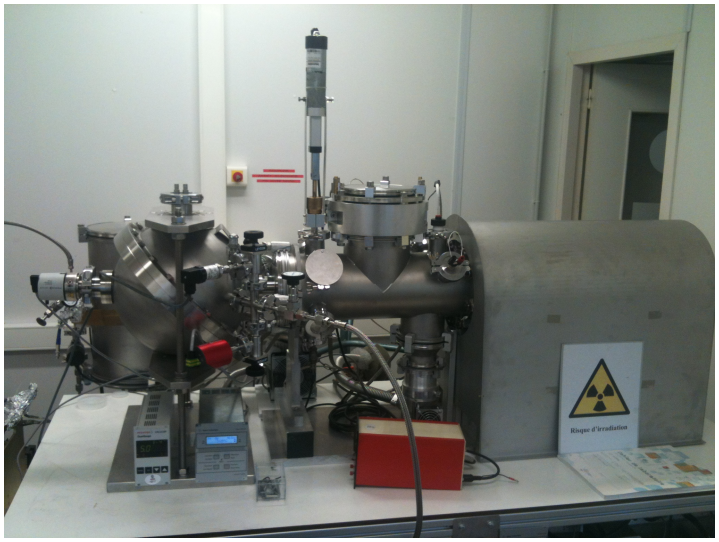

PE shield

# **NEWS-SNOLAB project** expected sensitivity



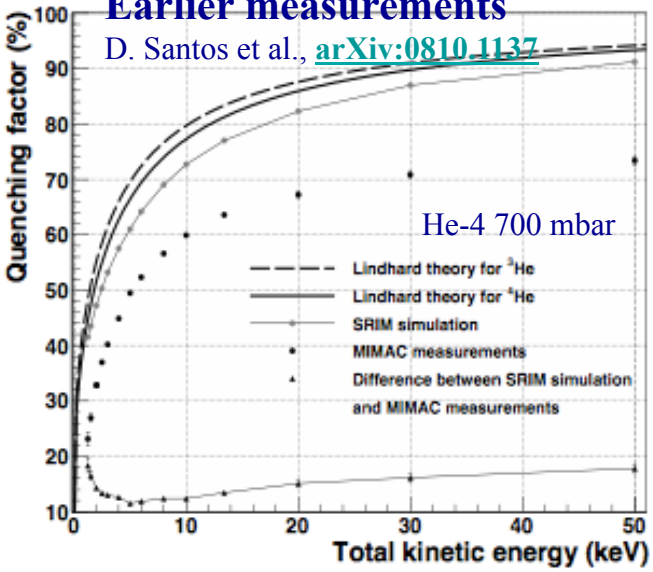
# Quenching factor measurements

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

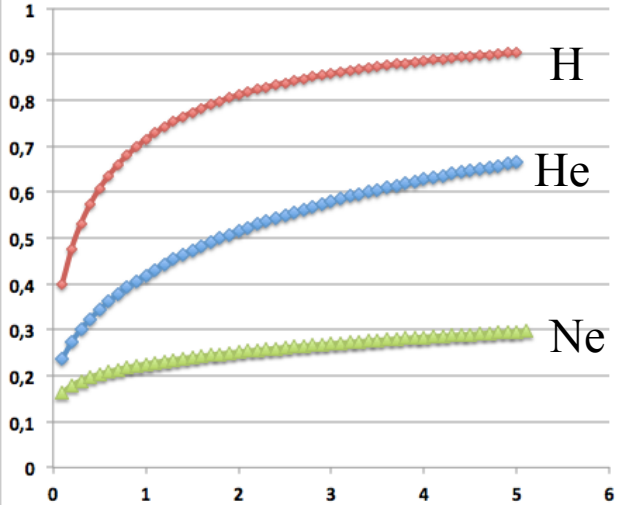


**Earlier measurements**

D. Santos et al., arXiv:0810.1137




**QF calculated**



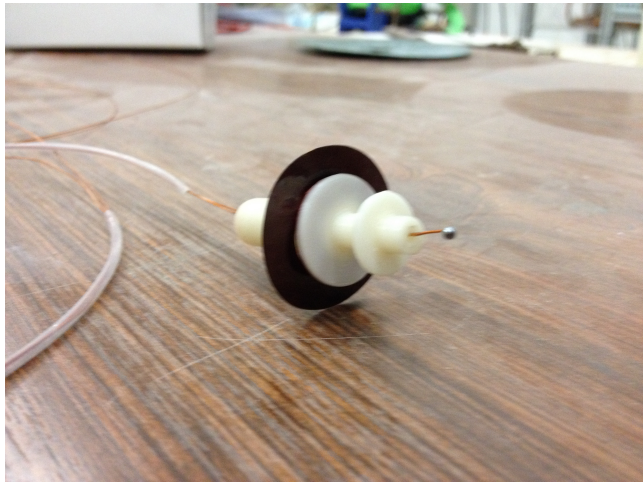

**Previous investigations with a 15 cm sphere show the capability to measure 500 eV He-4 ions with an estimated QF of about 25%**

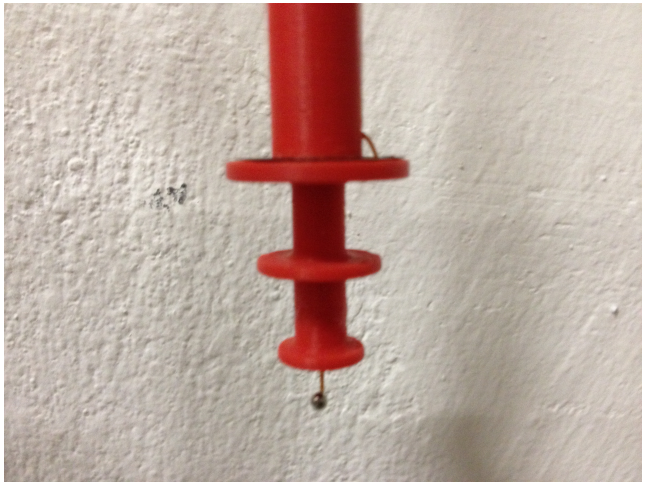
***Saclay, Grenoble, Thessaloniki, Queen's-Kingston***

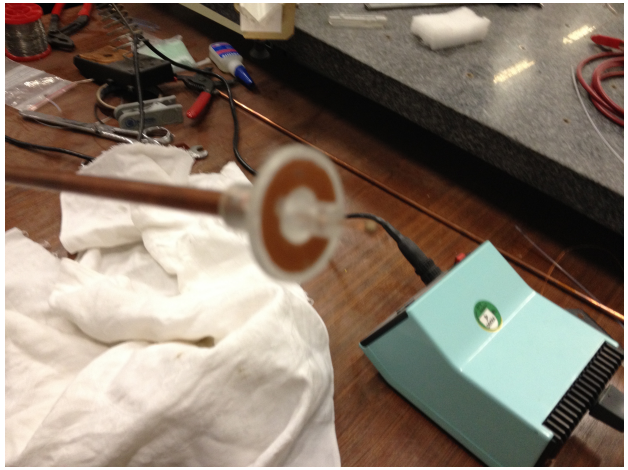
# Sensor optimization for high pressure operation

We use balls of 2 mm in diameter in order to reach stable conditions
With Neon or Helium mixtures up to 10 bar
(Work with Ilias, Ali and A. Giganon)

With Ilias, last January, we have started
these tests in a 30 cm sphere

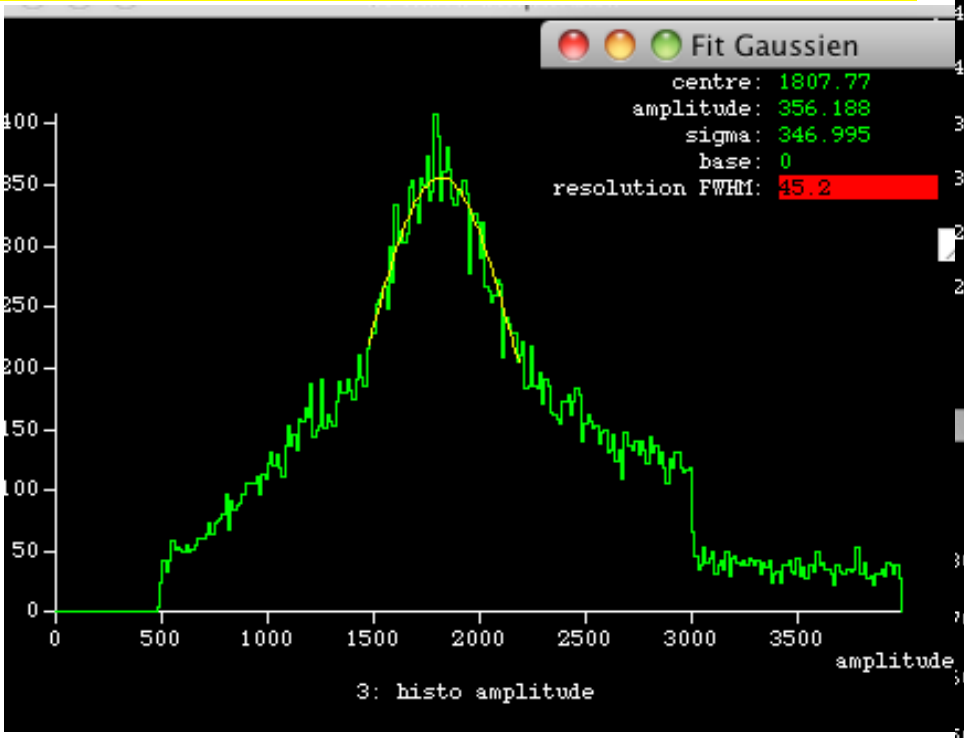


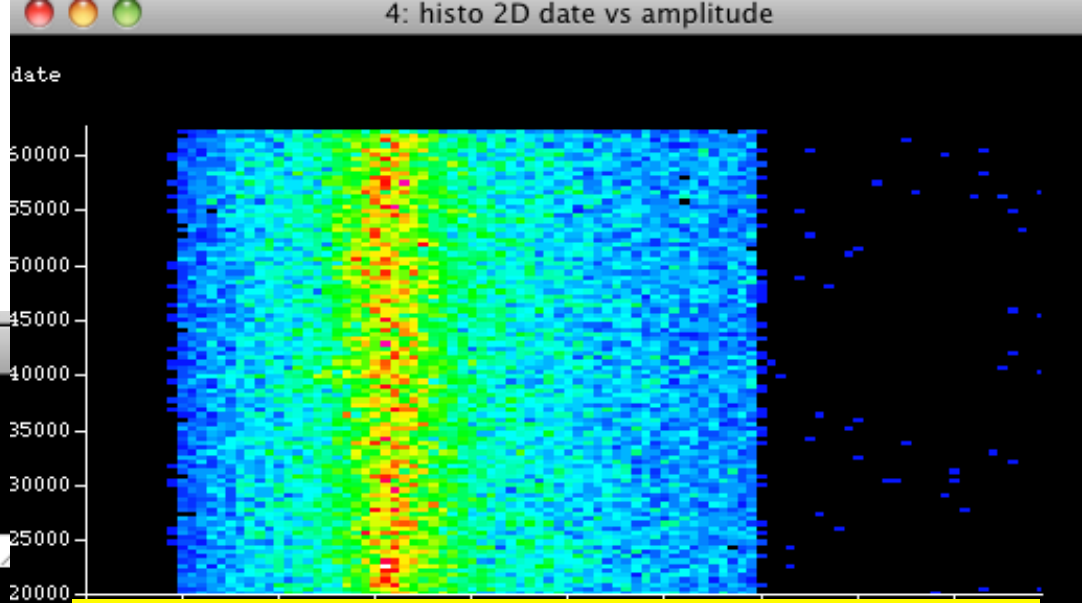




Ar+2% CH4, p=200mbar, 2mm ball,
130cm sphere, HV1=1420,
HV2=-200 Volts Plexiglass D=20mm, l=14mm

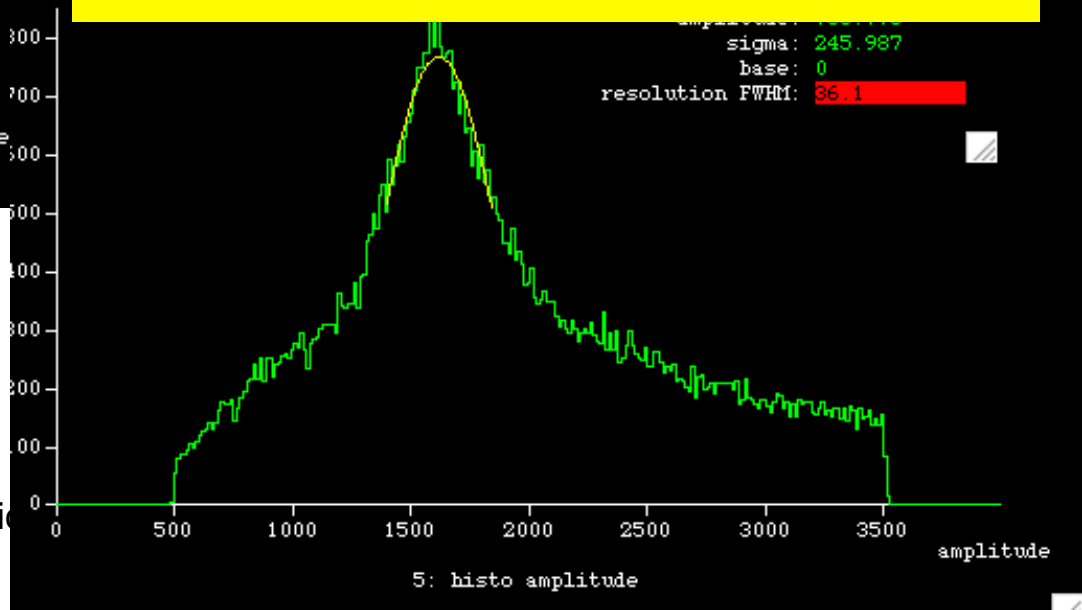
**8.1 keV rate: 1.48 Hz**



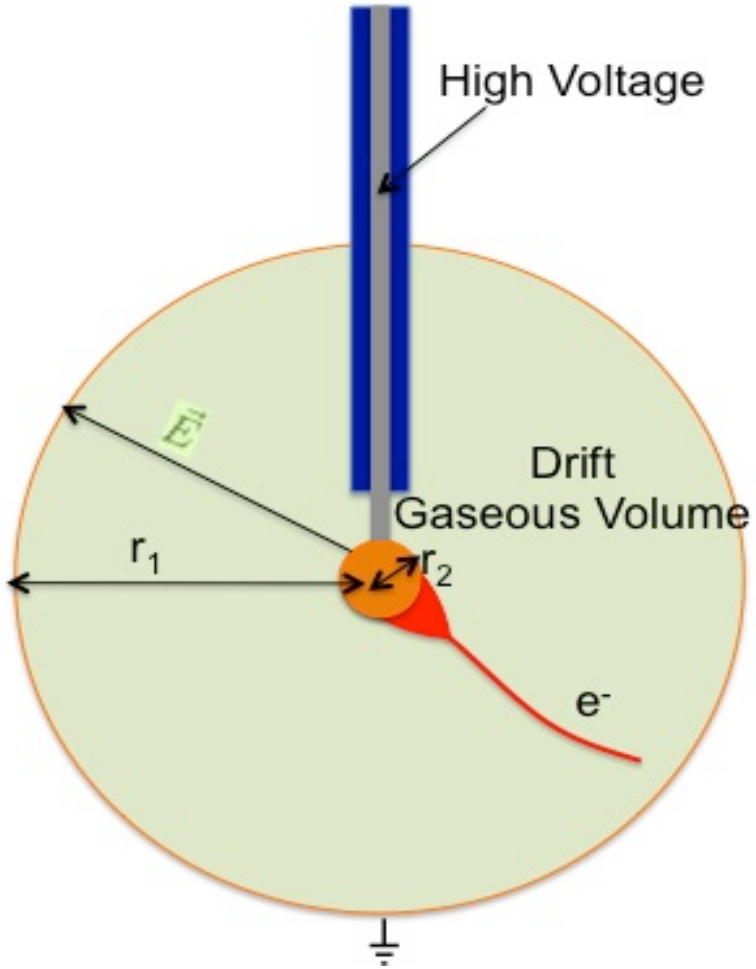

Ar+2% CH4, p=200mbar, 2mm ball,
130cm sphere, HV1=1370,
HV2=-600 Volts Plexiglass D=20mm, l=14mm

**8.1 keV rate: 1.47 Hz**




Conclusion:
There is not significant loss
With umbrella voltage from -200 to -600 Volts

# Problem of **very-weak** electric field at large distances could occur in large diameter spheres and at high pressure

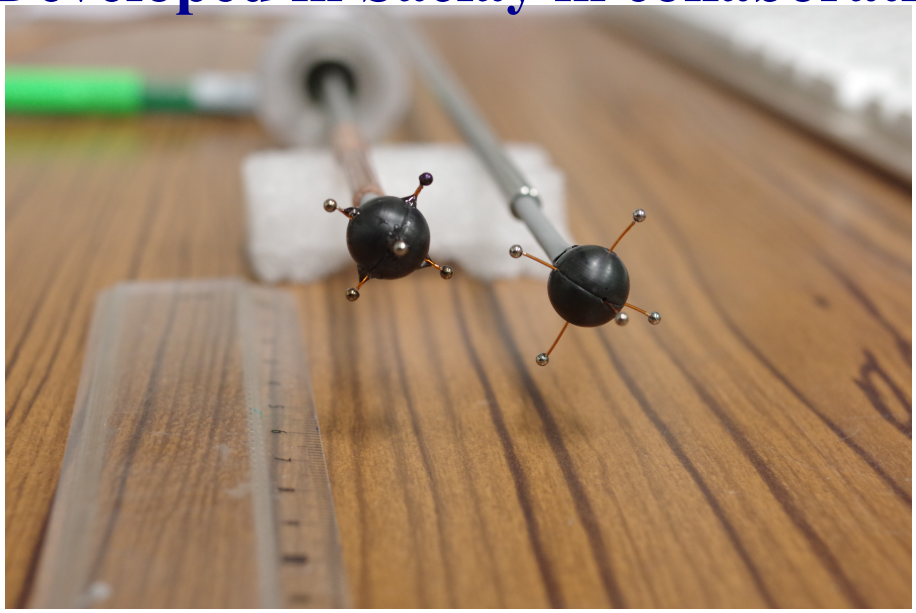


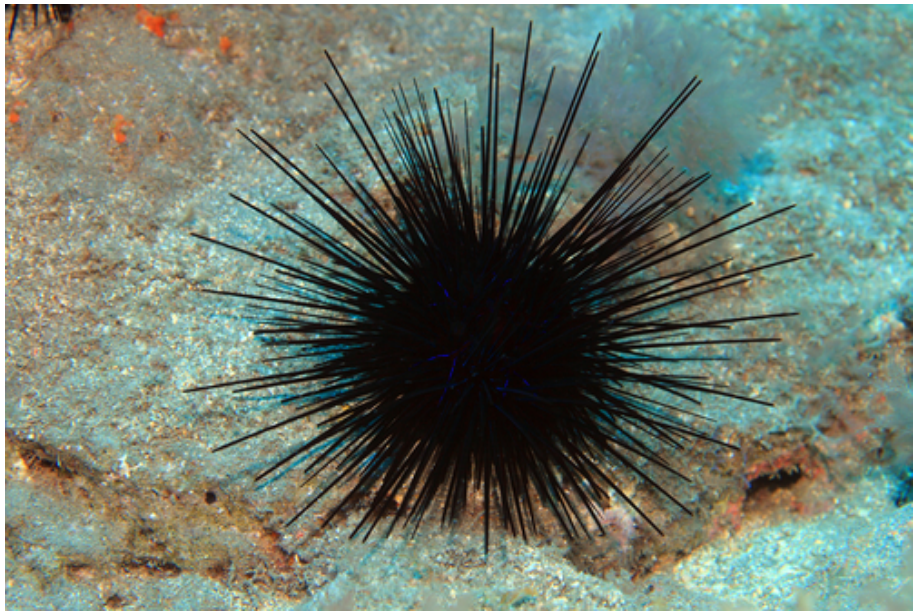

$$E(r) = \frac{V_0}{r^2}\frac{r_1 r_2}{r_1 - r_2} \propto \frac{r_2}{r^2}$$

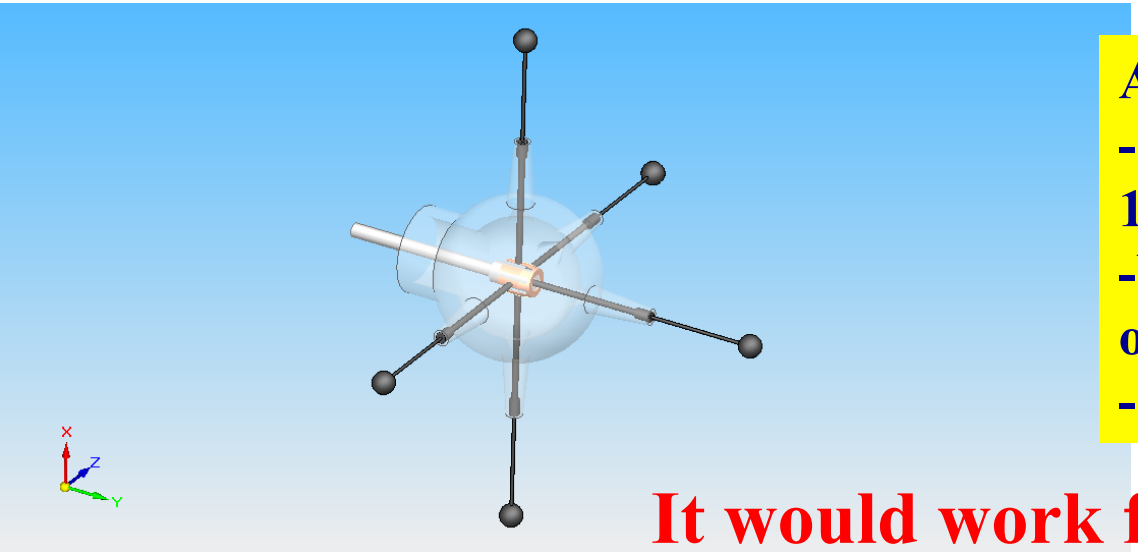
- At low pressures we can use large diameter ball ($r_2$>8mm)
- At high pressures we should use small diameter ball ($r_2$<5mm)

# An elegant solution: Multi-ball 'ACHINOS' structure

## Developed in Saclay in collaboration with University of Thessaloniki







**Advantages**

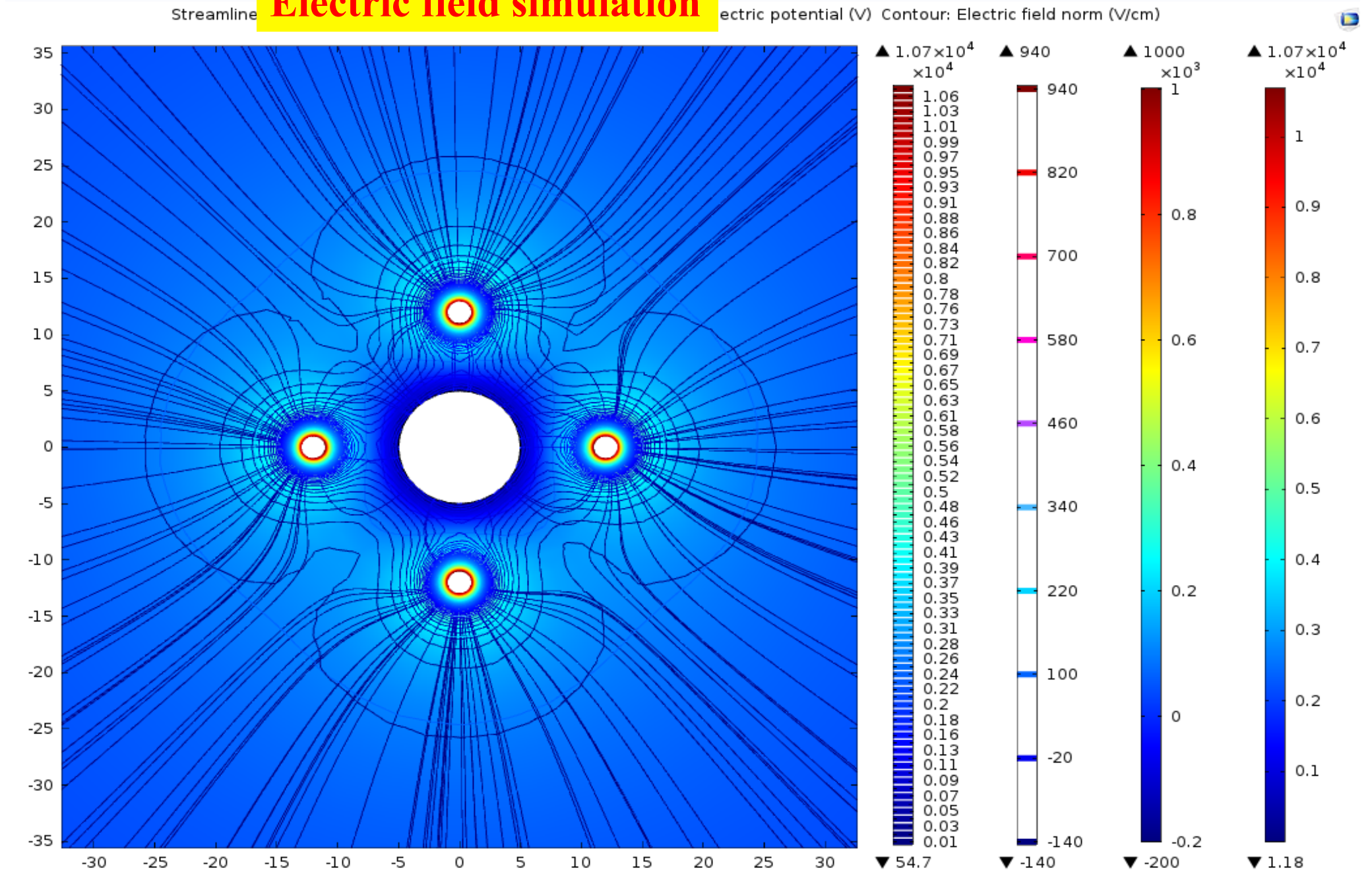
**- Amplification tuned by the ball size: 1mm diameter for high pressure**

**-Volume electric field tuned by the size of the ACHINOS structure**

**- Detector segmentation**

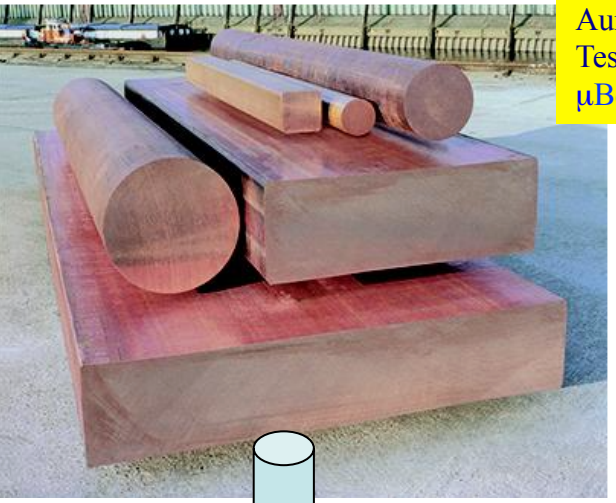
**It would work for any size of the sphere**

# Electric field simulation

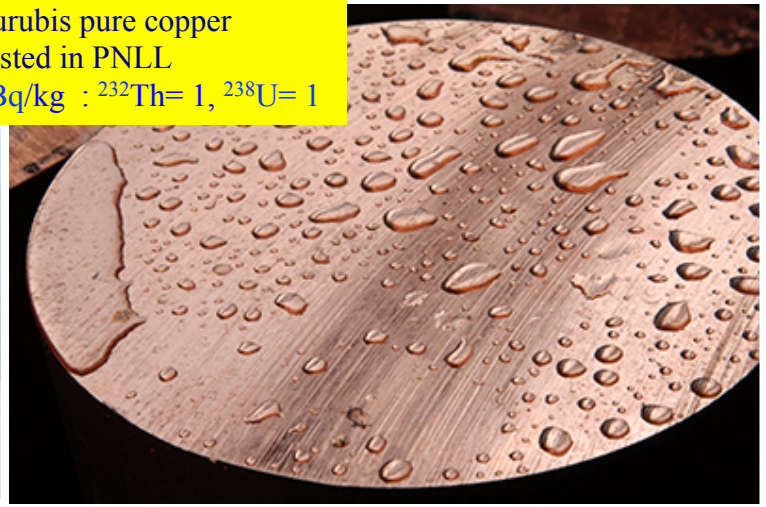


# CUBIC: a new way of fabricating an ultra low-background spherical detector – under study

*I. Giomataris, CEA-Irfu-France*



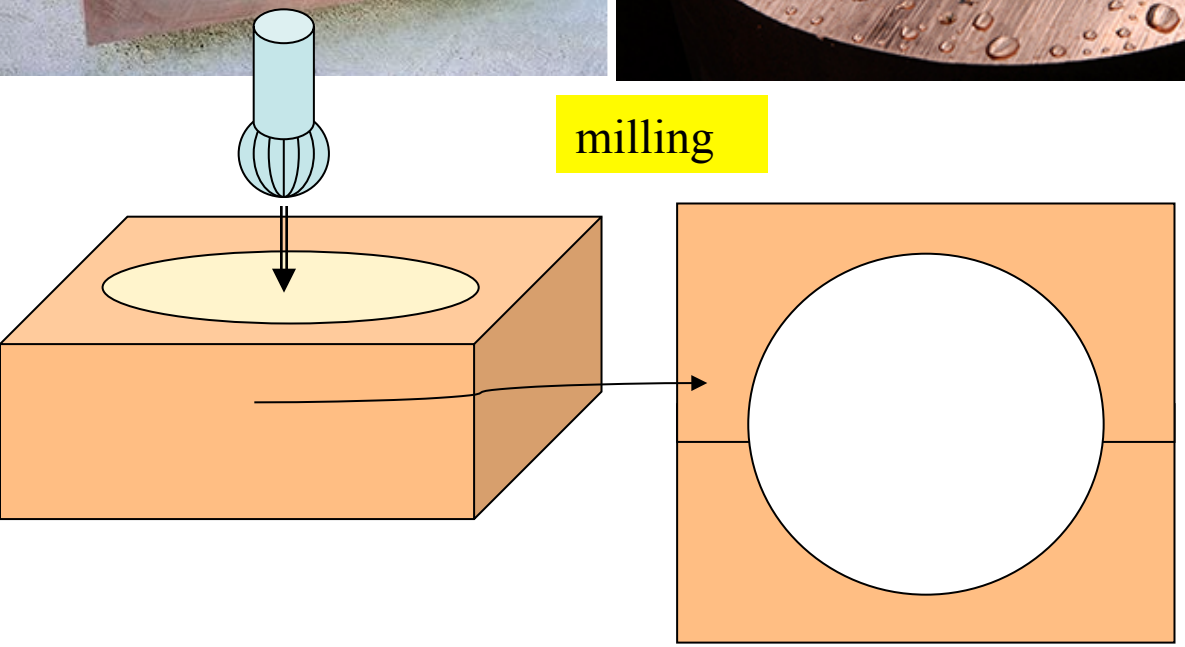
Aurubis pure copper
Tested in PNLL
μBq/kg : $^{232}$Th= 1, $^{238}$U= 1



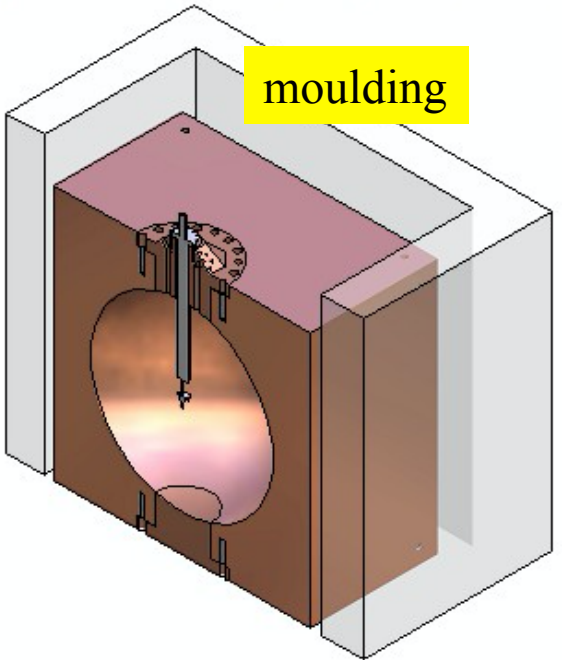
Advantages

- Auto-shield
- Pressure up to 50 bar
- Low cost
- Faster process

milling



moulding



# Collaboration


- **Queen's University Kingston – G.Gerbier,** P di Stefano, R. Martin, T. Noble, B. Cai, A. Brossard, A. Kamaha, P. Vasque, Q. Arnaud, K. Dering, J. Mc Donald, M. Clark and summer students
  - Copper vessel and gas set-up specifications, calibration, project management
  - Gas characterization, laser calibration, on smaller scale prototype
  - Simulations/Data analysis
- **IRFU/Saclay** -I. Giomataris, M. Gros, I. Katsioulas, T. Papaevangelou, A. Gigagnon, JP.Bard, JP. Mols, XF. Navick,
  - Sensor/rod (low activity, optimization with 2 electrodes)
  - Electronics (low noise preamps, digitization, stream mode)
  - DAQ/Software
- **LSM** (Laboratoire Souterrain de Modane) **-** F Piquemal, M Zampaolo, A DastgheibiFard
  - Low activity archeological lead for close electronics/valve shield
  - Coordination for lead/PE shielding and copper sphere
- **Thessaloniki University** – I Savvidis, S. Tzamarias, A. Leisos, C. Elefteriadis, A. Liolios
  - Simulations, neutron calibration
  - Studies on sensor
- **LPSC Grenoble** – D. Santos, JF. Muraz, O. Guillaudin
  - Quenching factor measurements < 1 KeV with ion beams
- **TU Munich** – A Ulrich
  - Gas properties and ionization process for Penning mixtures
- **Pacific National Northwest Lab**– E Hoppe
  - Low activity measurements, Copper electroforming
- **Associated lab : TRIUMF** - F. Retiere
  - light detection, sensor

*Oct 2016*

# NEWS collaboration

**Queen's University Kingston, IRFU/Saclay , LSM, Thessaloniki University, LPSC Grenoble, TU Munich,PNNLTRIUM**


# Related Event

**The eighth international symposium on "large TPCs for low-energy rare event detection" will be held in Paris on the 5th-7th of December 2016** : http://indico.cern.ch/event/473362/

The purpose of the meeting is an extensive discussion of currenly and future projects using a large TPC for low energy, low background detection of rare events (low-energy neutrinos, double beta decay, dark matter, solar axions).

# Thank you