SYMPOSIUM ON LARGE TPC FOR LOW ENERGY RARE EVENT DETECTION

2002-2021

Historical Review

- **Neutrino physics**

low energy neutrino properties, neutrino oscillations, magnetic moment, test of standard model at low-energy, coherent scattering, neutrino mass, neutrino-less double beta decay, neutrino cosmology, SuperNova neutrino detection

- **Dark matter**

dark matter experiments, WIMP search, directional Wimp search, light dark matter, other dark matter candidates etc..

- **Axion physics**

solar Axions, theoretical aspects, cosmology

- **Gamma, X- rays, polarization measurement, muon tomography, fast neutron detection at underground laboratories**

Experiments using gas or liquid TPCs

- **Neutrino experiments**

HELLAZ, MuNu, GOTARD Xenon TPC, EXO, NEMO, NOSTOS, T2K, ICARUS, NEXT, R2D2, DUNE

- **Dark matter experiments**

DRIFT, MIMAC, SEDINE, NEWS-G,
Solar Axion, experiments
CAST, IAXO, baby IAXO

- **Detectors**

Double phase XENON-ARGON detector, MPGDs, Micromegas, GEM, Thick GEM, Ionisation chambers, Positive ion TPC, Barium atom detection, Thermoluminence effect detectors, novel neutron detectors, PICOsecond, beta-imager, Gas amplification-CCD detectors, amplification in liquids, High pressure amplification devices

- **Theoretical aspects**

Reviews on neutrino physics, weak interactions, standard model, neutrino mass, cosmology, dark matter-candidates, low-mass models, Axions, ALPs, Physics with accelerators-effective theories…

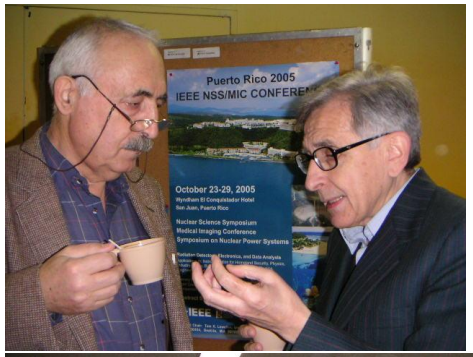
1st Workshop on December 2002

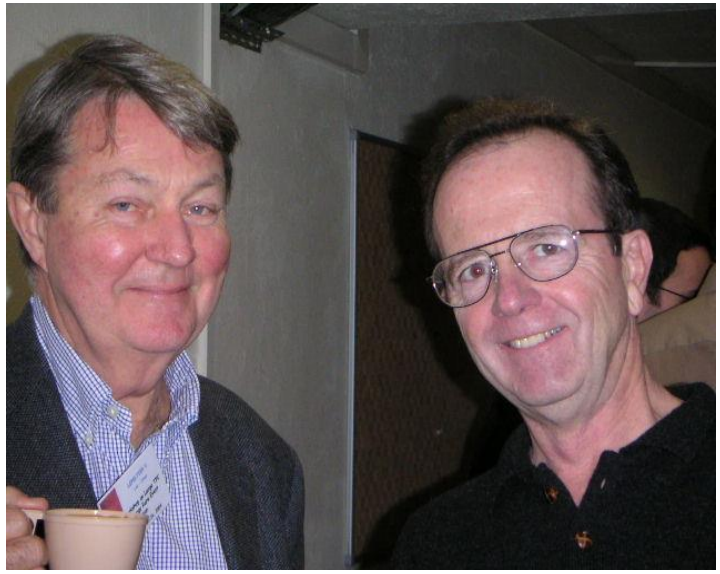
At the Collège de France, 5-6 December 2002

(45 participants)

2nd WORKSHOP ON LARGE TPC FOR LOW ENERGY RARE EVENT DETECTION

LPNHE - Paris VI and VII , 20 - 21 December 2004, (75 participants)

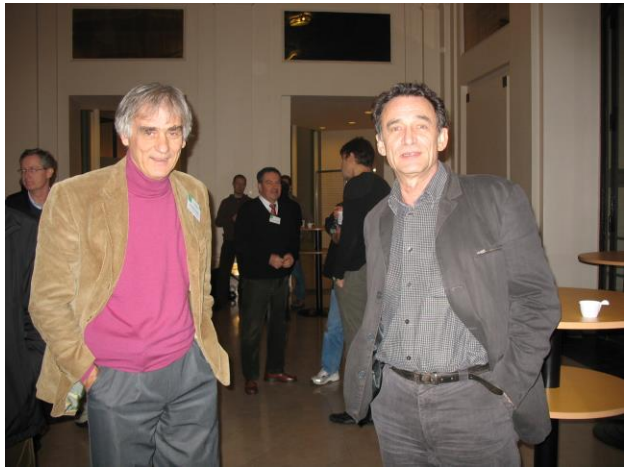




3rd SYMPOSIUM ON LARGE TPCsFOR LOW ENERGY RARE EVENT DETECTION

Carré des sciences, 11 - 12 December 2006 (90 participants)




Start of publishing Conference proceedings

4th SYMPOSIUM, 17–19 Dec 2008
Poincaret auditorium, (>*100 participants)*

- Physics and cosmology: the mili-eV scale (E. Masso)
- T2K experiment (C. Giganti)
- Spherical TPC development (I. Giomataris)
- Double beta decay in EXO (R. Gornea)
- The Next experiment (J. Diaz)
- Double beta decay in NEMO (R. Saakyan)
- Energy resolution with alphas in Micromegas (F. Iguaz)
- GridPix TPC (H. Van Der Graaf)
- The DMTPC (G. Sciola)
- Directional neutron detection TPC at LNLL (H. Hefner)

5th SYMPOSIUM, 14–17 Dec 2010
Diderot University, *(>100 participants)*

6th SYMPOSIUM, 17–19 Dec 2012
Diderot University, *(128 participants)*

7th SYMPOSIUM, 15–17 Dec 2014
Diderot University, *(90 participants)*

8th SYMPOSIUM, 5–7 Dec 2016
Diderot University, *(110 participants)*

- SuperNova with IceCube Observatory (L.Kopke)
- LArIAT TPC in Argon (F. de M. Blaszczyk)
- Beam test of HARPO polarimeter (Ph. Gros)
- Positive ion gaseous TPC (L.Arazi)
- Dark Mater directional detection with MIMAC (D. Santos)
- SPC review of recent developments (I. Katsioulas)
- **Joint WORKSHOP On SuperNova**
- **Large-Summary talk by Francis Halzen**

9th SYMPOSIUM, 12–14 Dec 2018
Diderot University, *(128 participants)*

10th SYMPOSIUM, 15–17 Dec 2021
Diderot University
Postponed due to COVID adjusted to safety regulations

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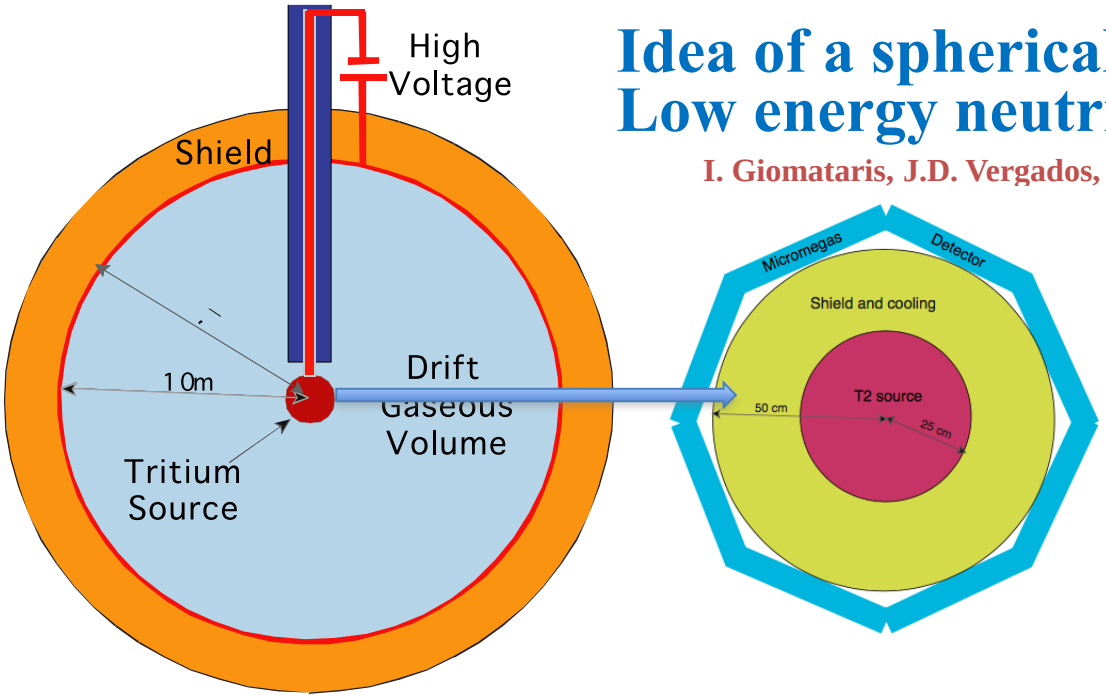
Highlights- New ideas

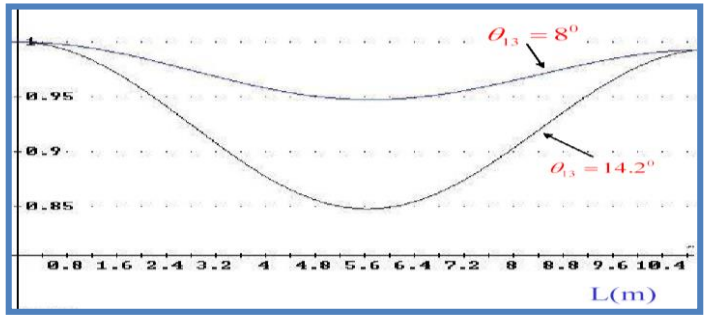
- Impressive results from the double phase Xenon or Argon TPCs
- EXO TPC neutrino-less double decay experiment with competitive results, first observation of double beta decay with two neutrinos in Xenon-135
- Barium tagging
  Hunting a barium atom produced in the double beta decay of Xenon-135 followed first by EXO (D. Sinclair) and later by D. Nygren group with remarquable results
- Low background level reached by the CAST gaseous detector (Microbulk-Micromegas): 10^{-6} /sec/cm^2 Saclay-Saragoza
- Fast fabrication and efficient TPC for T2K near detector system
- Progress on the directional TPC for dark mater search (DRIFT, MIMAC,..)
- Progress on muon tomography with a Micromegas tracker (cavity discovered in CHEOPS pyramid) developed in Saclay.
- PICOSEC gaseous detector with time resolution down to 20 ps !!
- NEXT experiment was developed at that time and widely discussed
- Spherical Detector (NOSTOS, NEWS-G, ECUME, DarkSphere, R2D2)

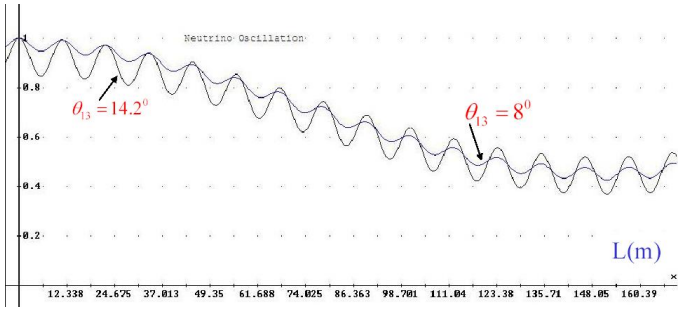
The spherical detector was invented and developed by I. Giomataris team on 2004



Idea of a spherical detector
Low energy neutrino oscilations-properties

I. Giomataris, J.D. Vergados, Nucl.Instrum.Meth.A530:330-358,2004

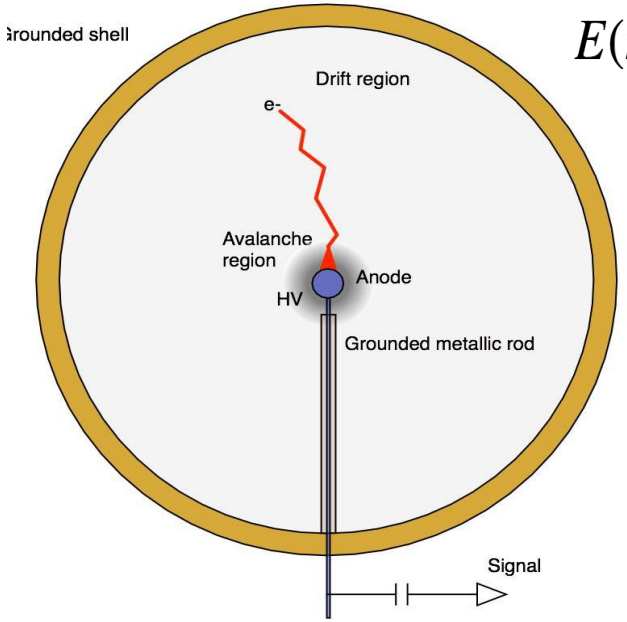




- Great contribution on sensor developments by I. Savvidis from 2005
- J. Derre simulations-analysis

The Spherical Proportional Detector

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



$$E(r) = \frac{V_0}{r^2}\frac{r_A r_C}{r_C - r_A} \approx \frac{V_0}{r^2} r_A$$

r_A = *anode ball radius*
r_C = *cathode radius*

C≈ r_a= 1 mm < 1pF

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

Built by radio-pure materials

- **Vessel made of Cu (~tens of kg)**
- **Rod made of Cu (~hundreds of gr)**
- **All the rest less than < 1 g**

G. Charpak visiting the spherical detector lab

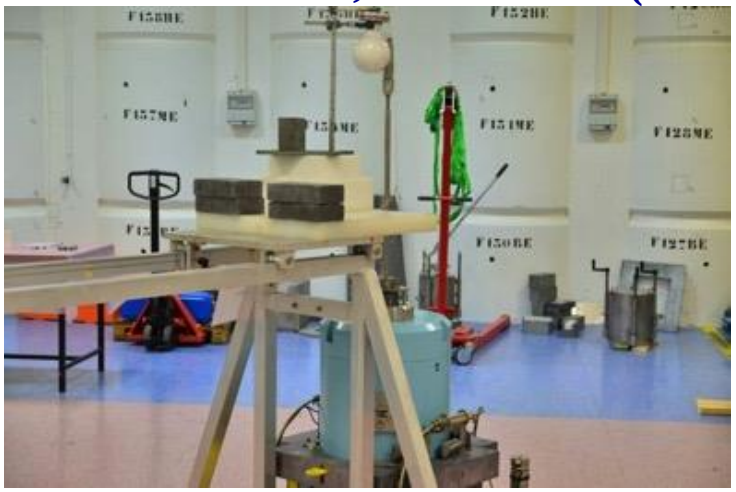
- Great contribution on sensor developments by I. Savvidis from 2005

- J. Derre simulations-analysis

I Giomataris and J.D. Vergados, NIMA530:330-358,2004,
S. Aune et al., AIP Conf.Proc.785:110-118,2005.
I. Giomataris et al. Nucl.Phys.Proc.Suppl.150:208-213,2006.
I. Giomataris and J.D. Vergados, Phys.Lett.B634:23-29,2006.
J. D. Vergados et al., Phys.Rev.D79:113001,2009.,
E Bougamont et al., J. Phys.: Conf. Ser. 309 012023, 2011

Low-energy calibration source *Argon-37*

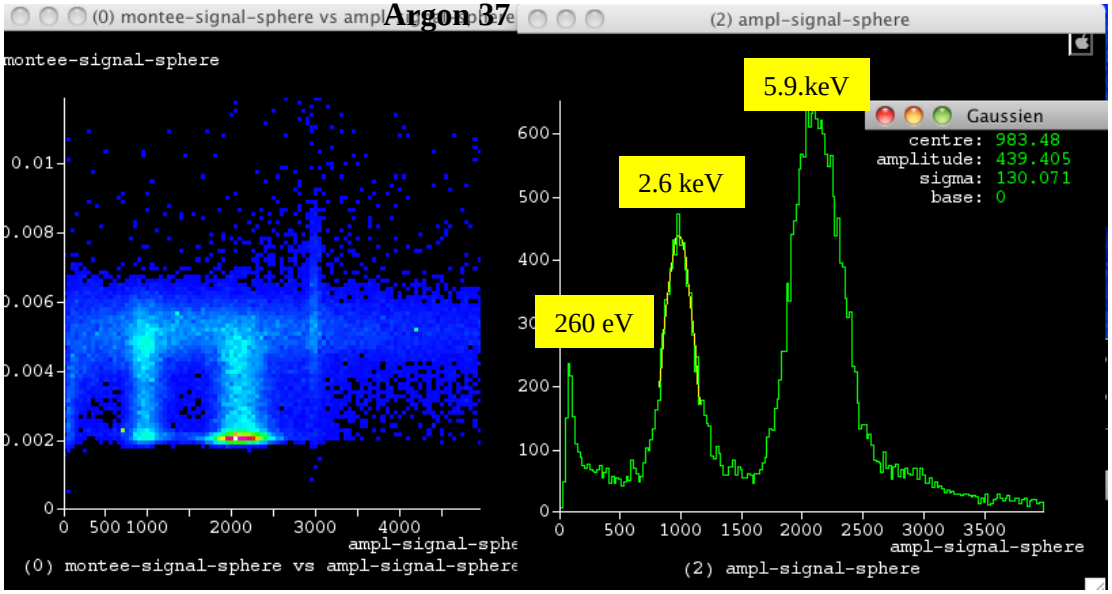
Developed in Saclay by our group by irradiating Ca-40 powder with fast neutrons
7×10^6 neutrons/s, Ar-37 emits K(2.6 keV) and L(260 eV) X-rays (35 d decay time)

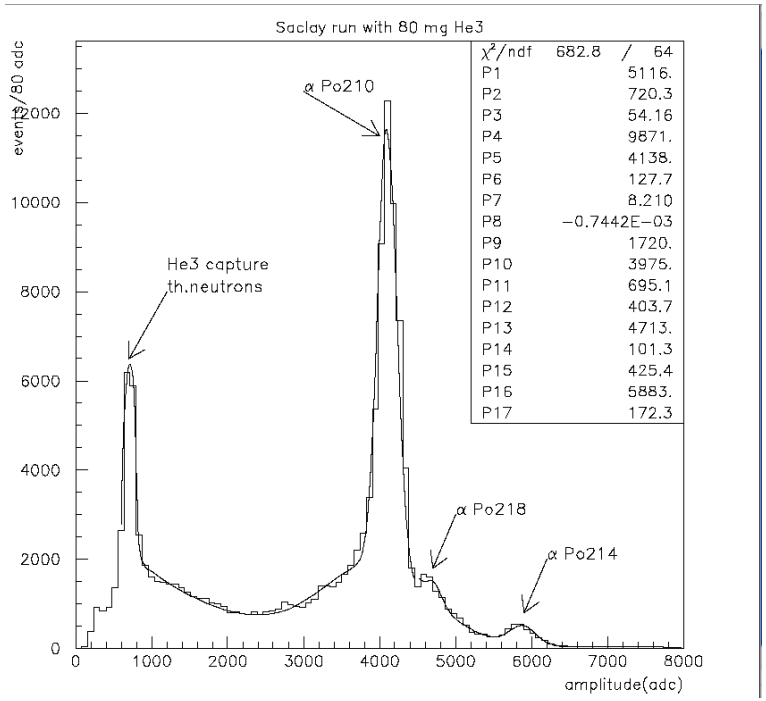


Installation near the spherical detector 2011

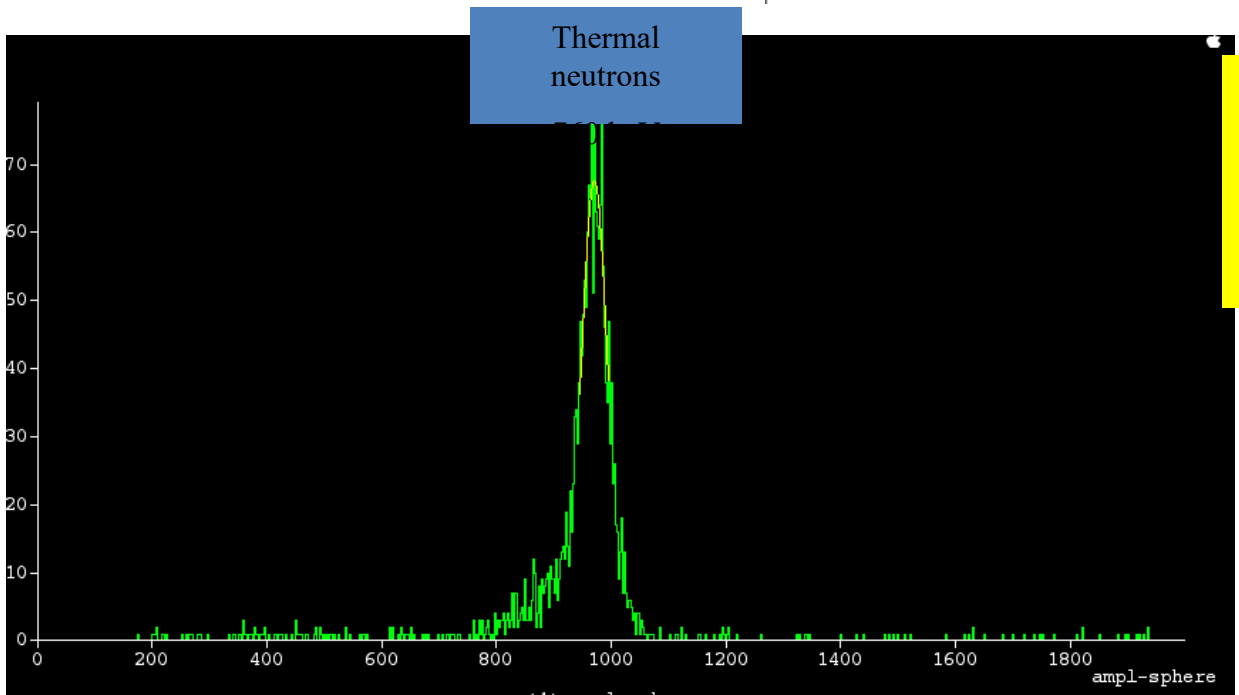
Argon 37

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





Neutron energy and flux measurement
Results at ground
Saclay Ar-CH4(98-2)+80mg He3



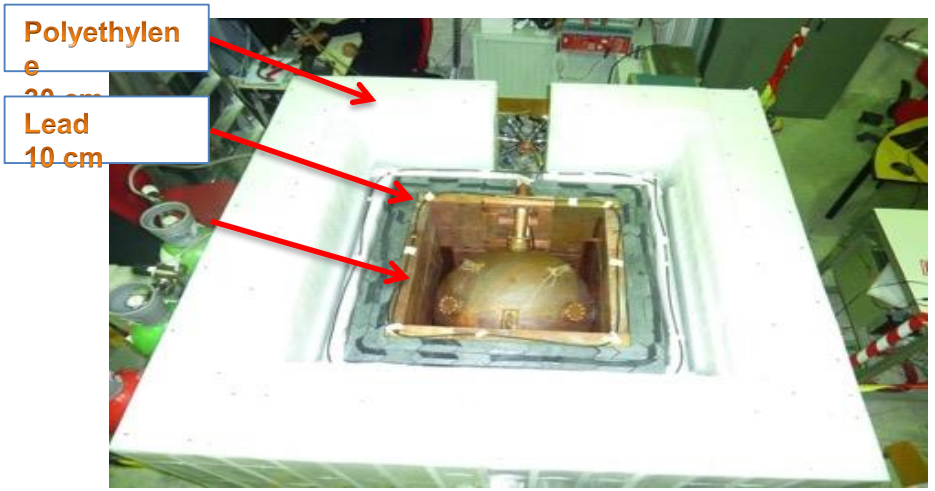
Results at LSM
Thermal neutron flux
$3{,}6 \times 10^{-6}/cm^2/s$

G. Gerbier has proposed NEWS experiment for WIMP search on 2011 at Thessaloniki

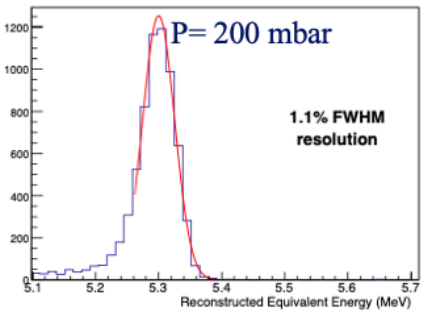
NEWS-LSM: Exploration of light dark matter search at LSM

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

Physics results with Neon gas published: Q. Arnaud and al, Astropart. Phys. 97 (2018) 54–62



Q. Arnaud and al, Astropart. Phys. 97 (2018) 54–62
I. Savvidis et al., Nucl. Instrum. Meth. A, vol. 877, 220–226, 2018.
I. Katsioulas et al., JINST, vol. 13, no. 11, P11006, 2018
A. Meregaglia et al., JINST, vol. 13, no. 01, P01009, 2018.
Q. Arnaud *et al.* Phys. Rev. D **99**, 102003, 2019
I. Giomataris et al., arXiv:2003.01068
R. Bouet et al., arXiv:2007.02570



Thank you