

6N/xN Spherical Proportional Counter

Cyprien BEAUFORT; Ali DASTGHEIBI FARD;
Olivier GUILLAUDIN; Jean-François MURAZ;
Daniel SANTOS; Michel ZAMPAOLO;

Prospective national IN2p3

[DéTECTEURS ET INSTRUMENTATION ASSOCIÉE](#)

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Outline

- I'll go to present the electroforming copper through the spherical proportional counter
- This technology is the solution for all rare events experiments such as DM or $\beta\beta$ decay
- Ultra radio pure copper: U/Th $< 0.1 \mu\text{Bq/kg}$

Principle of detection

Radial Electric field

Ball radius = 0.5-15 mm

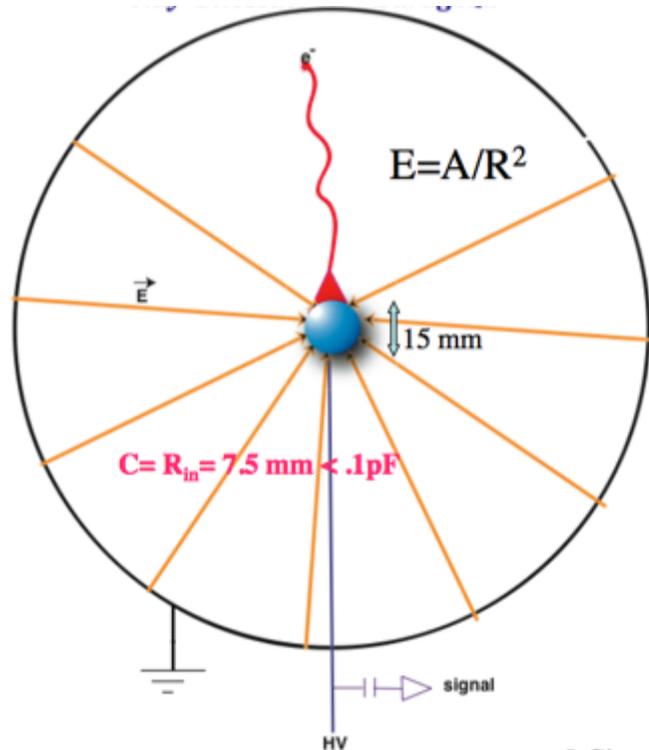
Spherical radius = 7.5-70 cm

$$C = 4\pi\epsilon\rho$$

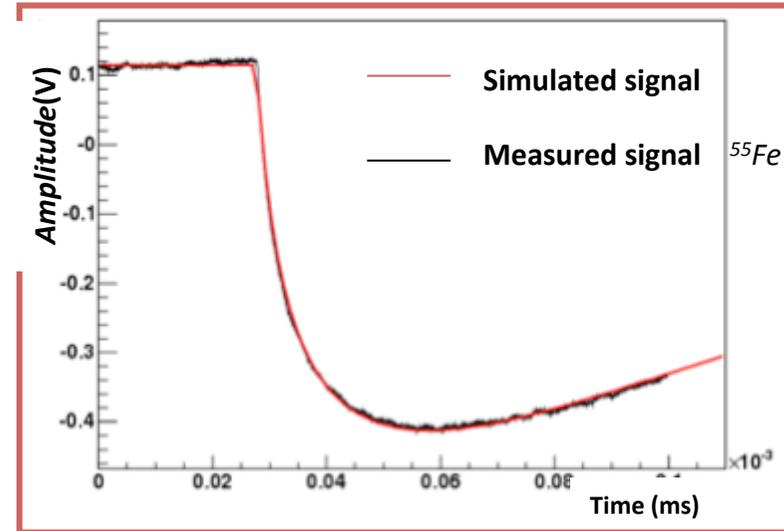
$$1/\rho = 1/r_2 - 1/r_1$$

$$\rho \approx r_2$$

$$E(r) = \frac{V_0}{r^2} \rho$$



I. Giomataris

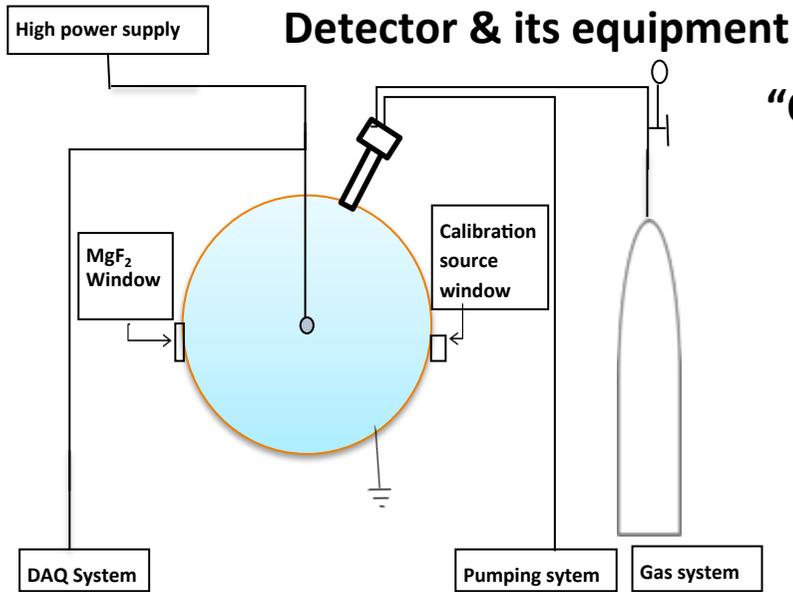


A Novel large-volume Spherical Detector with Proportional Amplification read-out,
I. Giomataris et al., JINST :P09007,2008

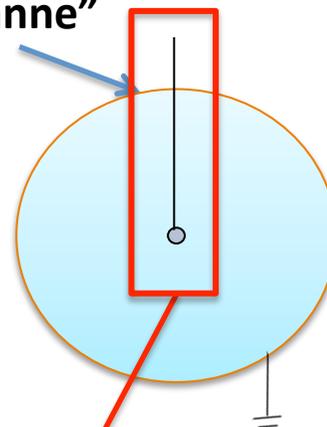
Main characteristics

- Low capacitance < 0.1 pF
- Low energy threshold ($\approx 0.5 e$)
- Good energy resolution
- A single measurement channel for a large volume
- Possibility of volume segmentation through multi-balls sensor
- Flexibility : gas, pressure
- Robust, simple and low material budget

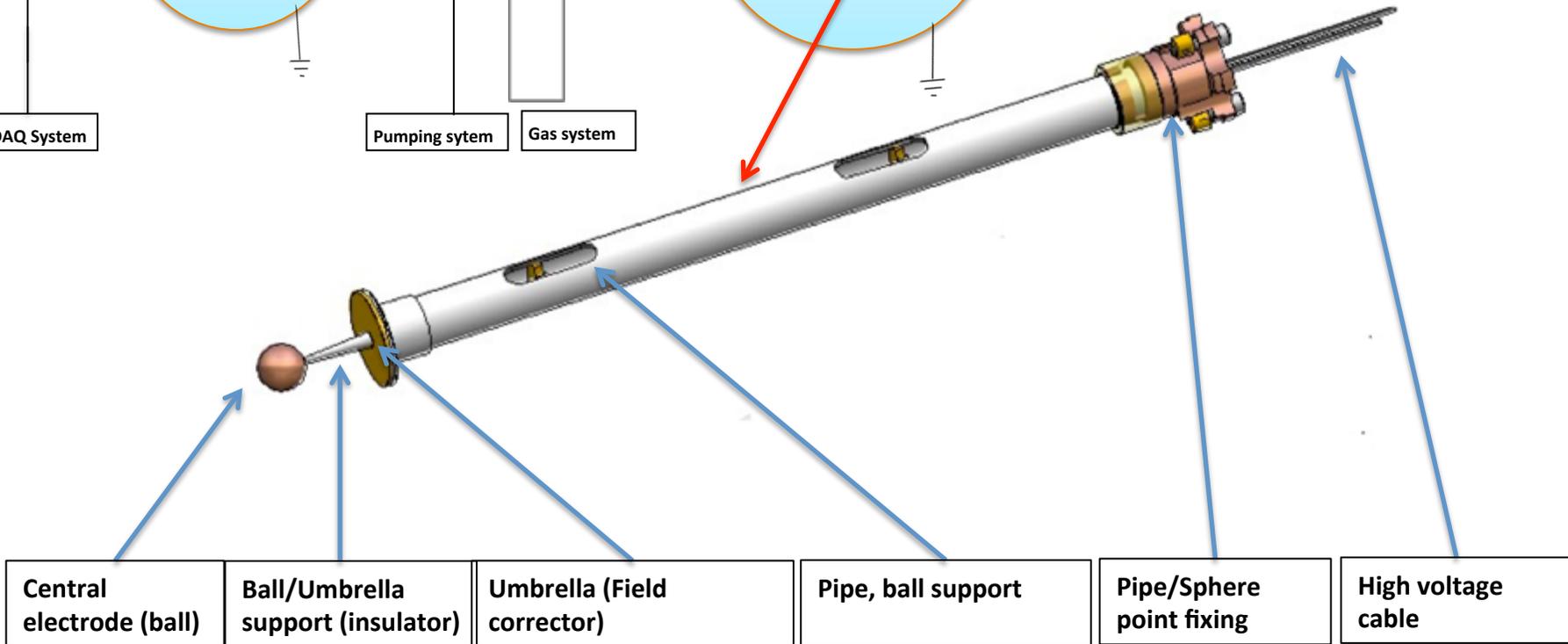
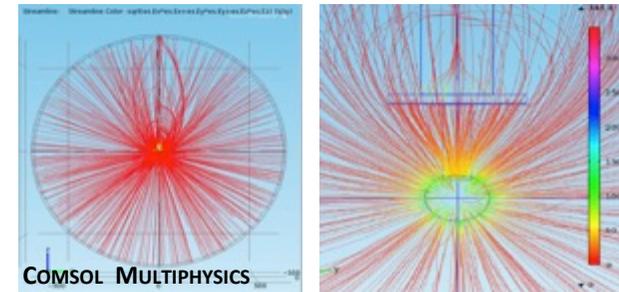
Detector design



“Canne”



Simulation of the electric field lines and the corresponding equipotential



SPC Evolution

2005 : 1st investigation SPC @ Saclay/CEA
LEP RF cavity



2008 : Neutron flux measurement @ LSM
LEP RF cavity



2012: SEDINE @ LSM

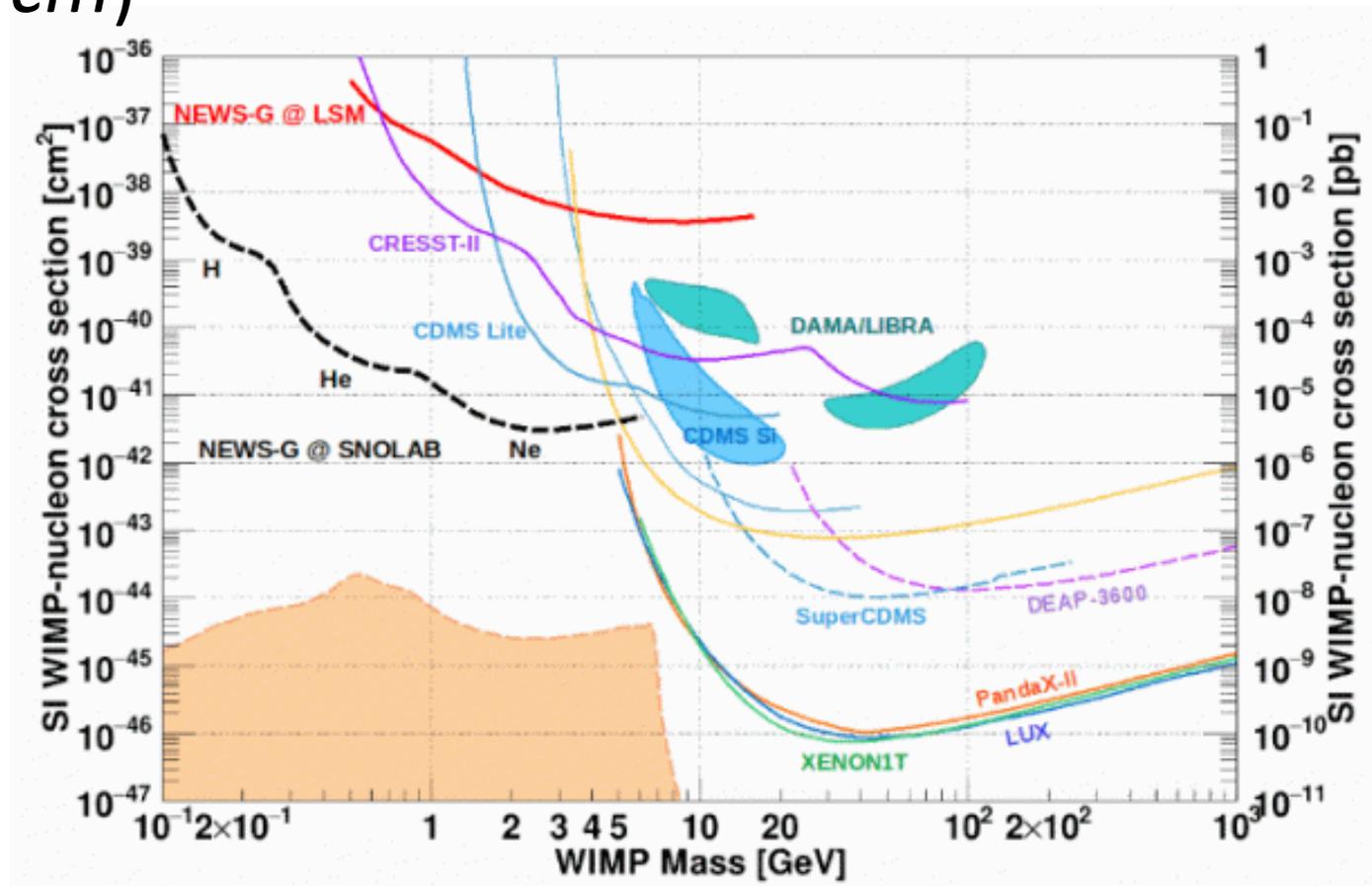


2018-2019: SNOGLOBE @ LSM



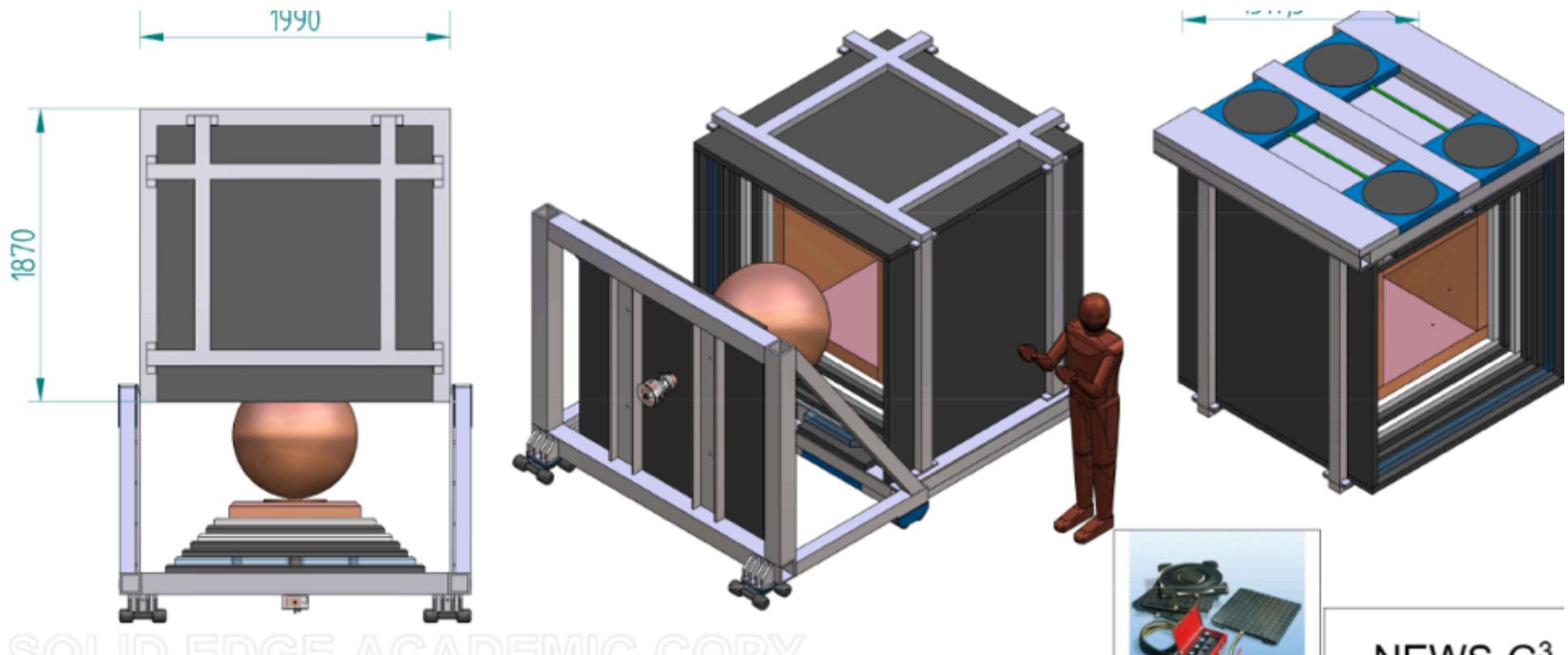
Results

- Light WIMPs search with NEWS-G_LSM (SEDINE $\Phi=60$ cm)



SPC Evolution and Next generation

- 6N SPC: Mitsubishi Copper (purity 99.9999)
 - Light DM search with He + 10% CH₄ and pure Methane (*realisable if shield improved*)



SPC Evolution and Next generation

- xN SPC: Electroformed copper “in underground lab”
 - Rare events experiment:
 - Light DM search
 - $\beta\beta$ decay
 - Other application:
 - Fundamental physic
 - Industry

Electroplating of copper (collaboration with PNNL)

Electroplating of copper @ LSM
(collaboration with PNNL)



Surface of electrolyte solution

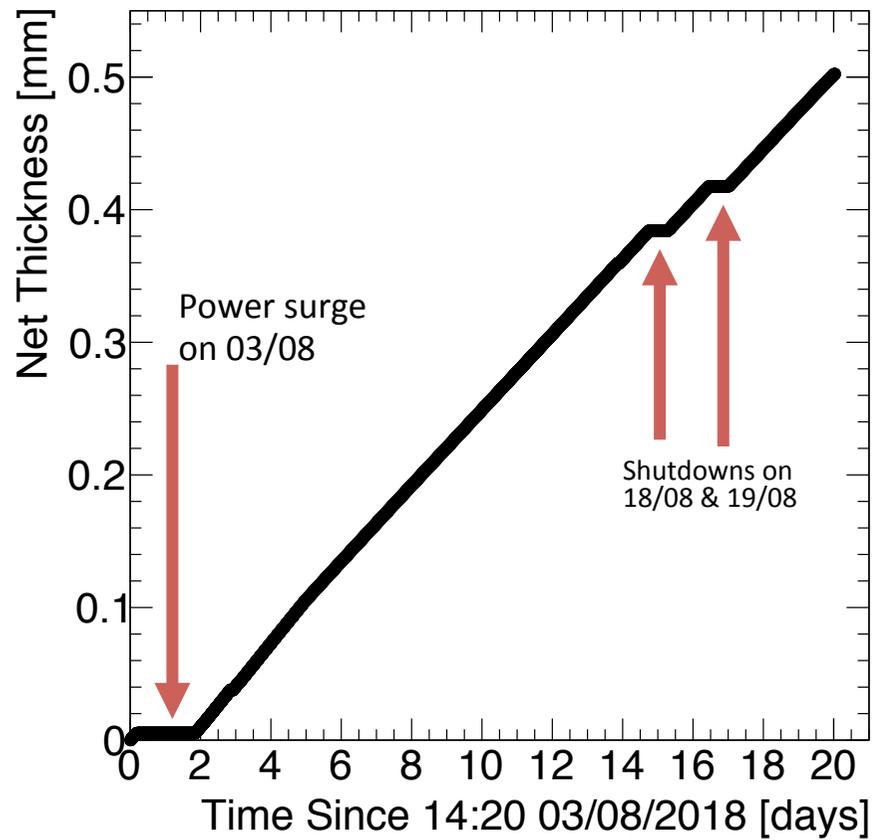


Upper few cm are smooth

Plating to steel ring

Electroplating of copper (collaboration with PNNL)

Operation for plating of 500 μm of copper



Surface Quality



Example of electroformed copper



Electroformed copper @ PNNL

Collaboration

NEWS-G



- **Queen's University Kingston** – G Gerbier, P di Stefano, R Martin, T Noble, A Brossard, A Kamaha, P Vasquez dS, Q Arnaud, K Dering, J Mc Donald, M Clark, M Chapellier
 - Copper vessel and gas set-up specifications, calibration, project management
 - Gas characterization, laser calibration, on smaller scale prototype
 - Simulations/Data analysis
- **IRFU (Institut de Recherches sur les Lois fondamentales de l'Univers)/CEA Saclay** - I Giomataris, M Gros, C Nones, I Katsioulas, T Papaevangelou, JP Bard, JP Mols, XF Navick,
 - Sensor/rod (low activity, optimization with 2 electrodes)
 - Electronics (low noise preamps, digitization, stream mode)
 - DAQ/soft
- **Thessaloniki University** – I Savvidis, A Leisos, S Tzamaris, C Elefteriadis, L Anastasios
 - Simulations, neutron calibration
 - Studies on sensor
- **LPSC/LSM Grenoble** - D Santos, JF Muraz, O Guillaudin, C Beaufort, MZampaolo, A DastgheibiFard
 - Low activity archeological lead
 - Coordination for lead/PE shielding and copper sphere
 - Quenching factor measurements at low energy with ion beams
- **Subatech P. Lautridou**
 - Signal processing
- **Pacific National Northwest Lab**– E Hoppe, D Asner
 - Low activity measurements, Copper electroforming
- **RMCC (Royal Military College Canada) Kingston** – D Kelly, E Corcoran
 - 37 Ar source production, sample analysis
- **SNOLAB –Sudbury** – P Gorel
 - P Gorel Calibration system/slow control
- **University of Birmingham** – Costas Nicolopoulos
 - Simulation, Analysis, R&D
- **University of Alberta** - M-C Piro
 - Data analysis, Simulation

Institutes



- **CEA/Thessaloniki**
 - I. Giomataris, M. Gros, J-P. Mols + I. Savvidis
- **LPSC_LSM**
 - D. Santos, M. Zampaolo, J-F. Muraz, O. Guillaudin, C. Beaufort , A. Dastgheibi Fard
- **CPPM**
 - J. Busto; H. Tedjiti
- **CENBG**
 - A. Meregaglia, C. Jollet, V. Cecchini
- **Subatech**
 - P. Lautridou



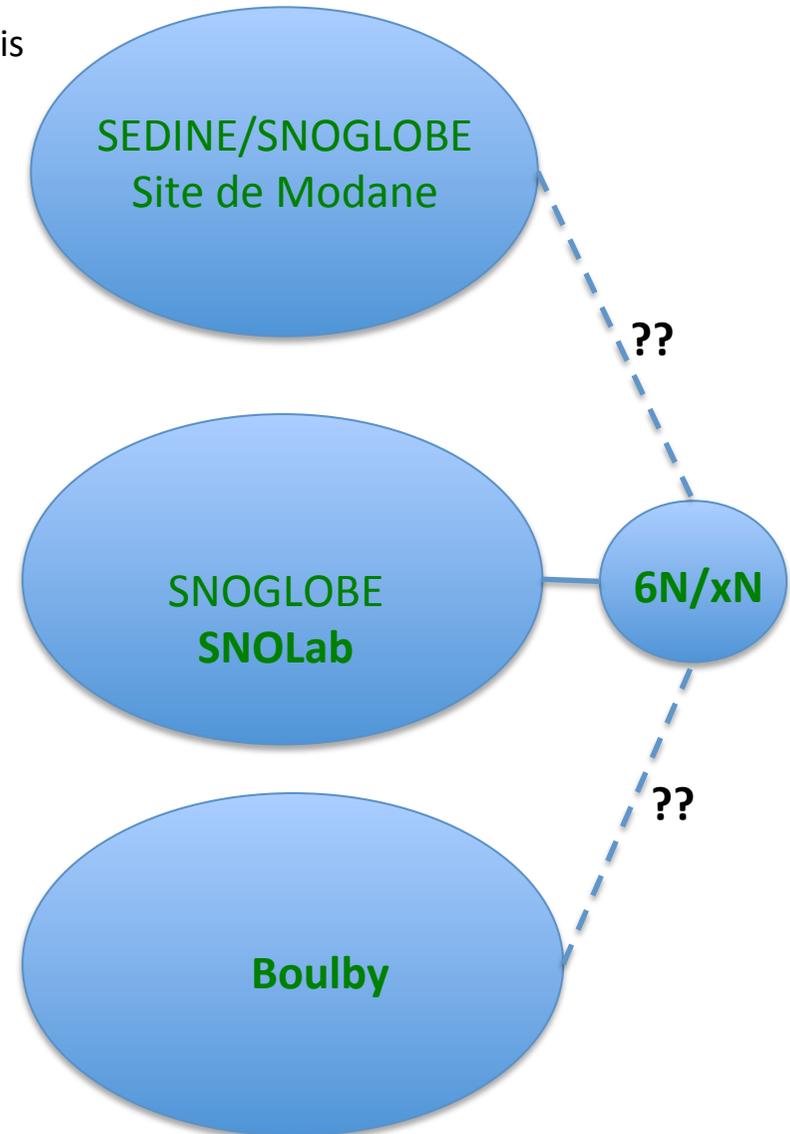
- **SNOLAB/Queen's University**
 - G. Gerbier, G. Giroux, 8 NP (PostDoc+PhD)



- **Boulby/Birmingham University**
 - Kostas, I. Katsioulas, P. Nights



- **PNNL**
 - E. Hoppe



تکیه بر تقوا و دانش در طریقت کافر است
راهرو گرسد هنر دارد توکل بایدهش



بعضی راهرو گرسد هنر دارد توکل بایدهش
Les autres peuvent vous indiquer la voie, mais vous devez la parcourir vous-même

Sur la voie de la recherche, le savoir-faire n'est pas suffisant;

Même si tu as beaucoup d'art, il te faut de l'assurance et du sentiment.

HAFEZ : Poète persan de XIII

MERCI POUR VOTRE ATTENTION