

Status of the NEWS-G dark matter experiment

Alexis Brossard, on behalf of the NEWS-G collaboration

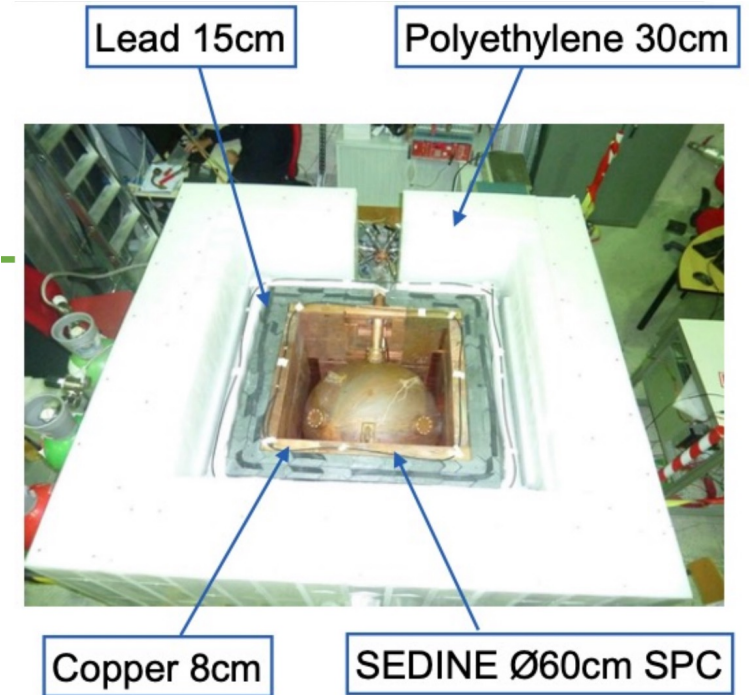
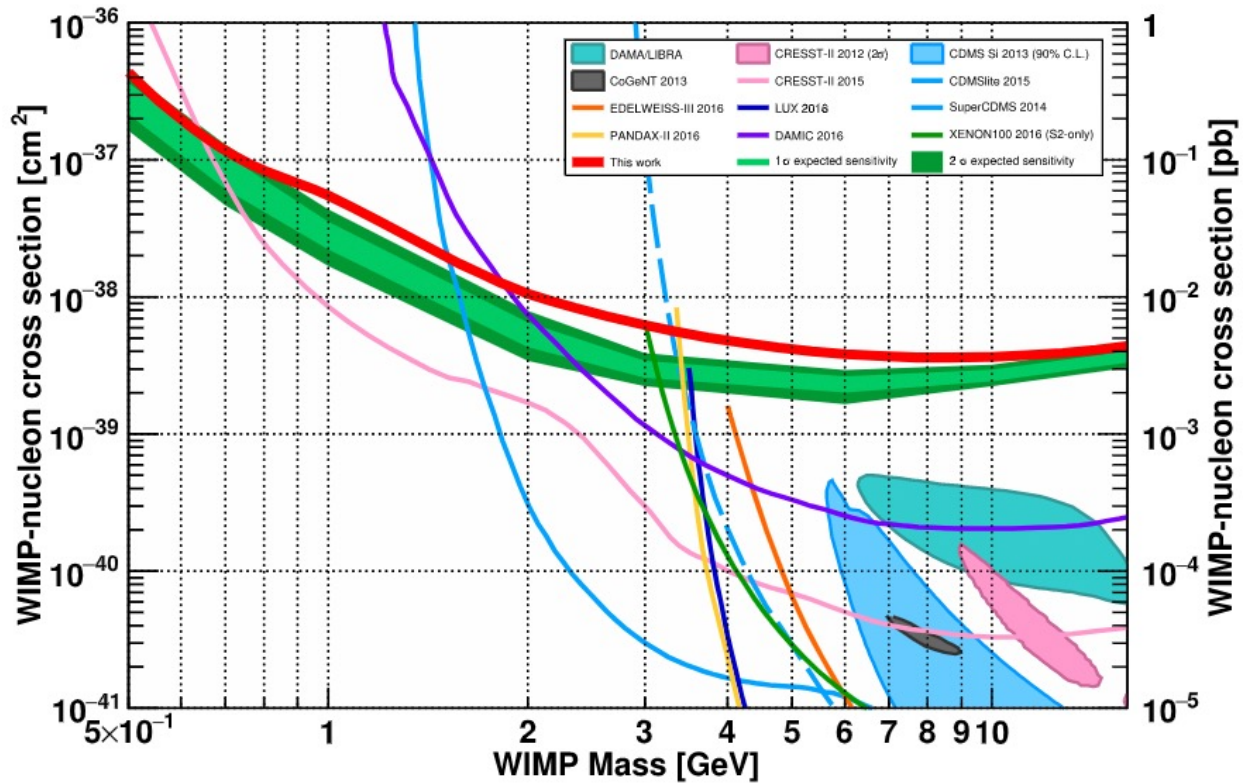
CAP conference

Monday June 7th, 2021



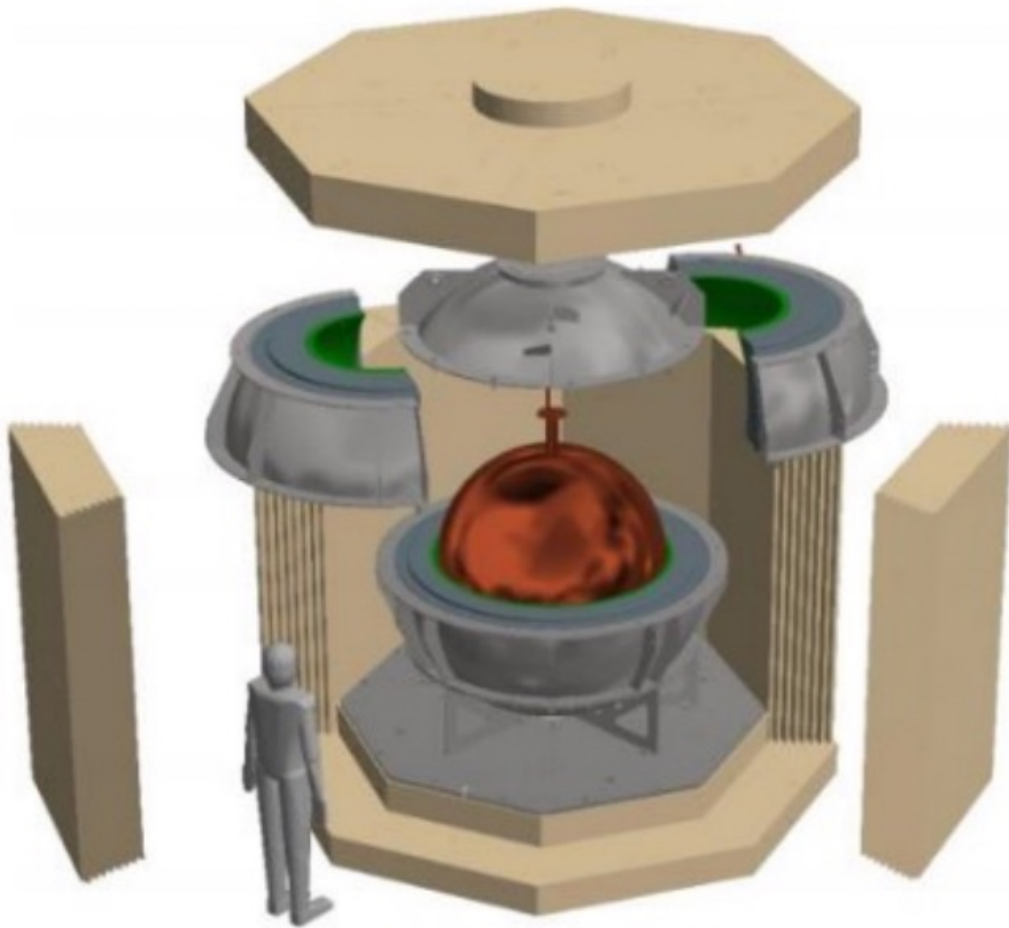
Result from the Sedine prototype

3.1 bars of Ne + 0.7% CH₄ 42 days of data



Q. Arnaud et al. (NEWS-G), *Astropart. Phys.* 97, 54 (2018).

140 cm detector

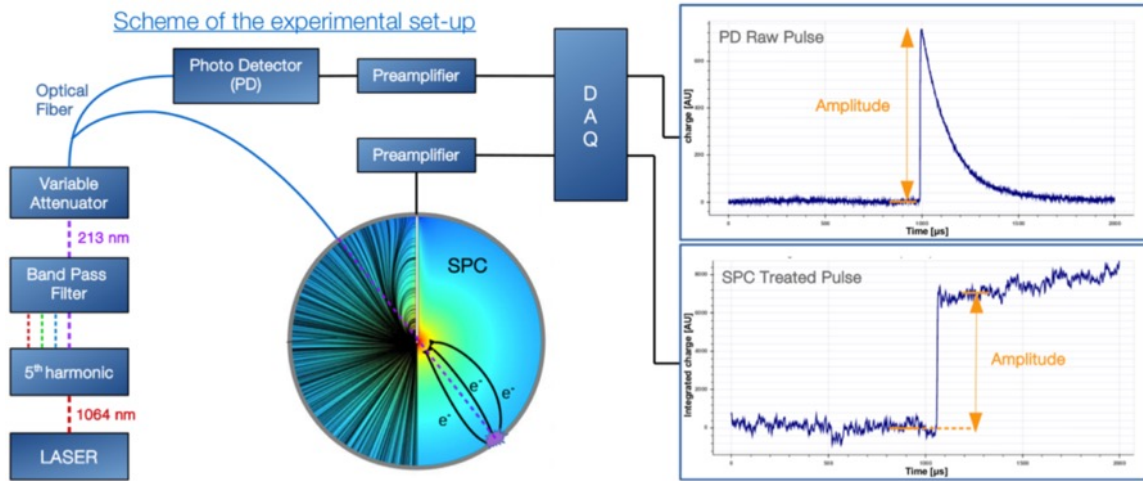


140 cm diameter low activity copper (C10100) SPC
7-25 $\mu\text{Bq/kg}$ ^{232}Th
1-5 $\mu\text{Bq/kg}$ ^{238}U

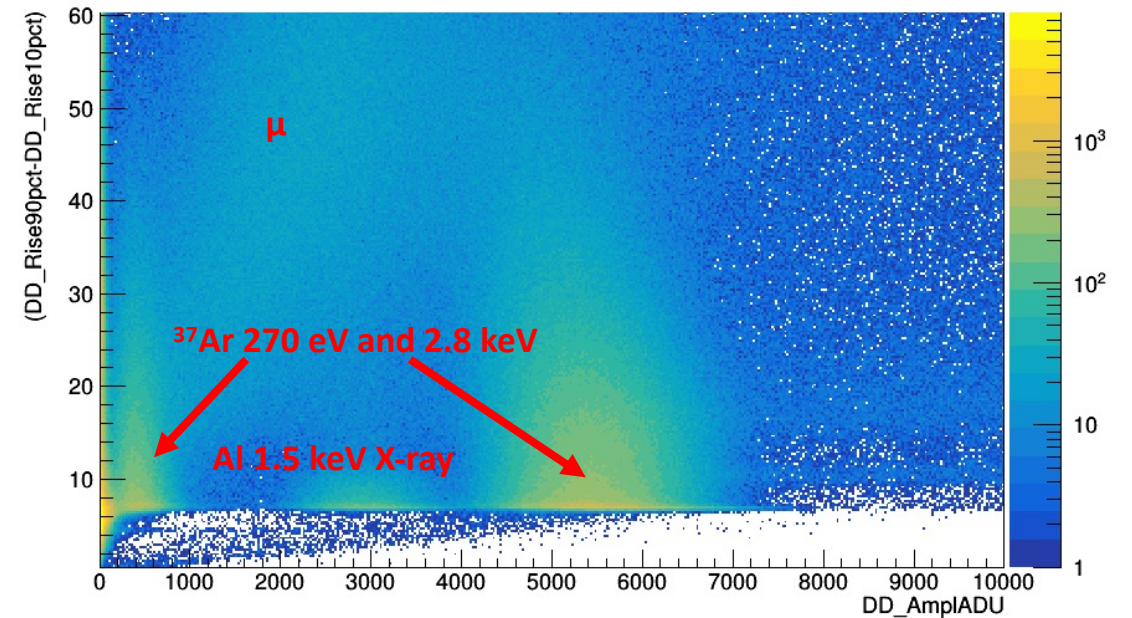
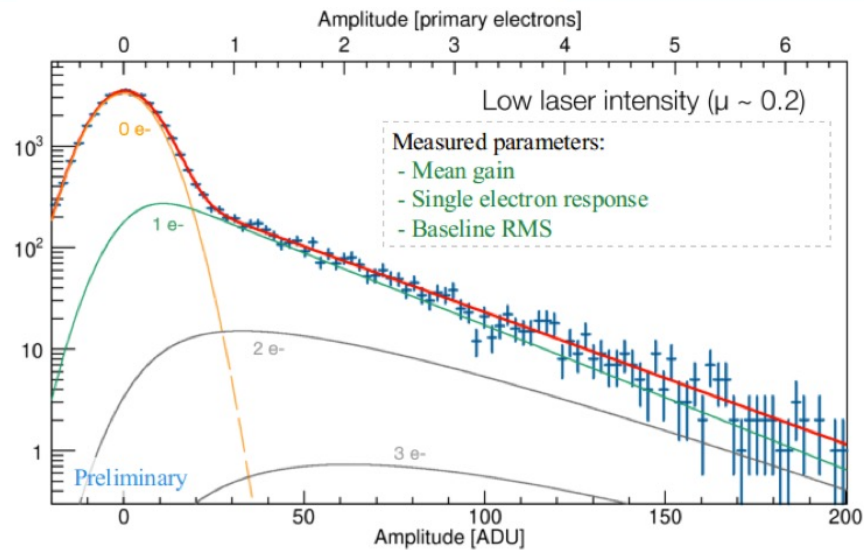
Compact shielding
40 cm polyethylene
22 cm very low activity lead
3 cm archeological lead
SS envelope flushed with nitrogen
Electroplating of the inner surface of the detector

Commissioning run at the LSM in 2019 with Ne & CH₄
Currently being installed at SNOLAB

Single electron calibration



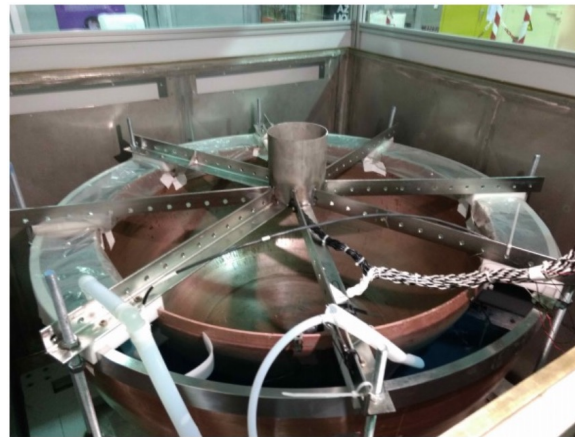
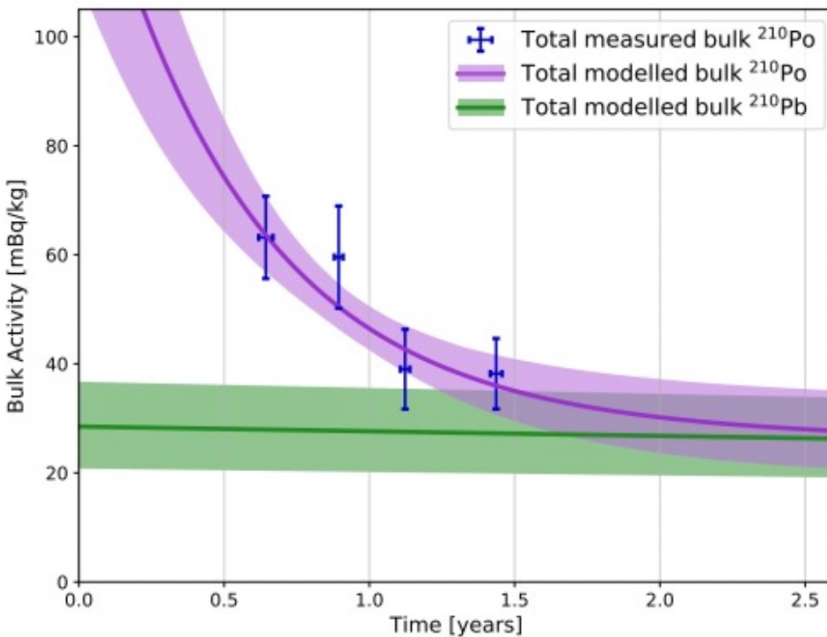
- Measure mean gain to 1% precision
- Measure drift and diffusion time
- Monitor stability of detector within 1%
- Measure trigger threshold efficiency
- Measure of W-value to 1% precision and constraint on the Fano factor



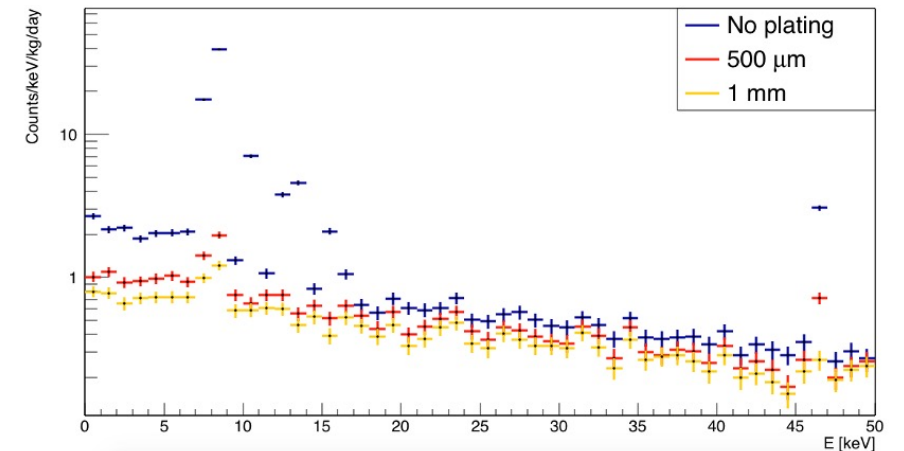
^{210}Pb contamination measurement and mitigation

The XMASS collaboration measures ^{210}Po activity with an XIA detector.
 The ^{210}Po activity can be used to calculate the ^{210}Pb concentration.
 ^{210}Pb activity is about 28.5 mBq/kg

X-rays from ^{210}Pb and ^{210}Bi is the dominant source of sub-keV background
 Electroplating of 500 μm of pure copper on the inner surface reduce this background by 62%.



Effect of the electroplating on gamma events

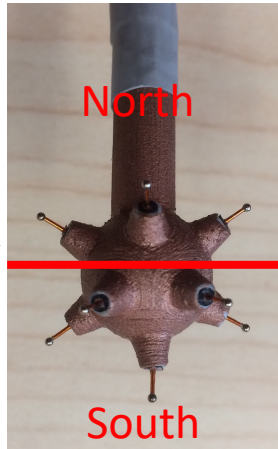
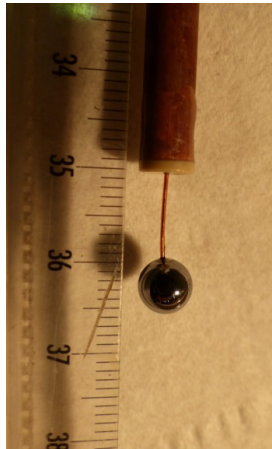


Achinos sensor development

$$E(r) = \frac{V_0}{r^2} \left(\frac{r_{sensor} r_{sphere}}{r_{sphere} - r_{sensor}} \right) \approx \frac{V_0}{r^2} r_{sensor}$$

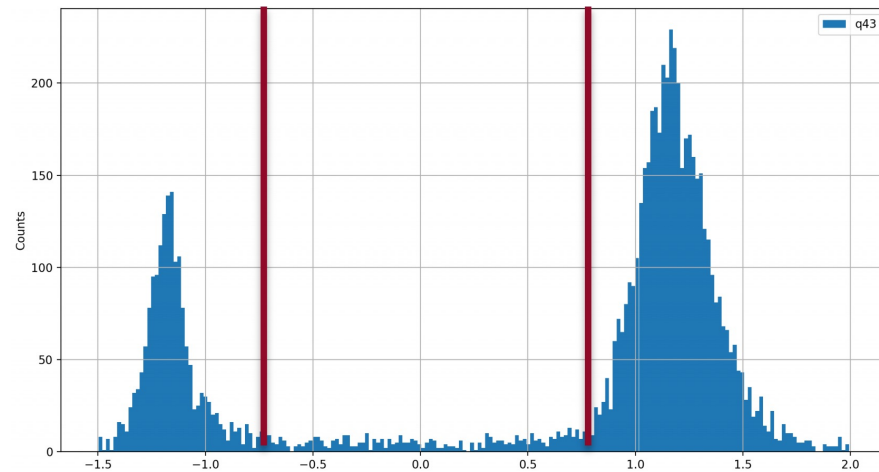
We need:

- Small anode for high amplification
- Large anode for high drift field in large detector



North events=24%
South events=69%
Shared events=7%

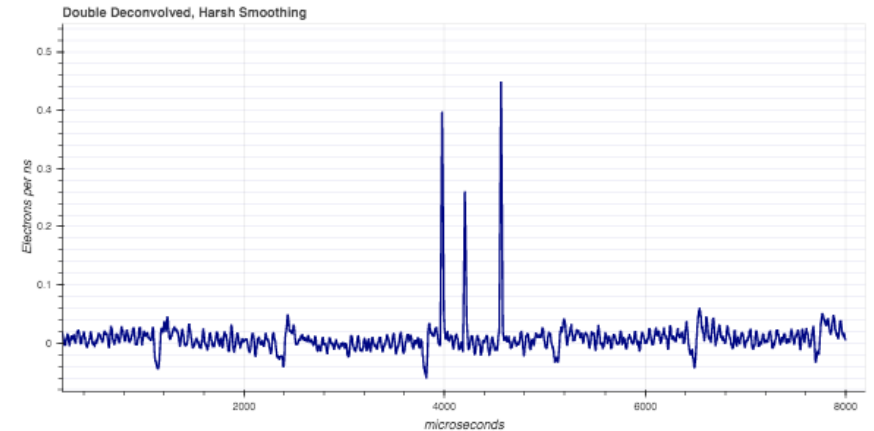
³⁷Ar volume fiducialisation



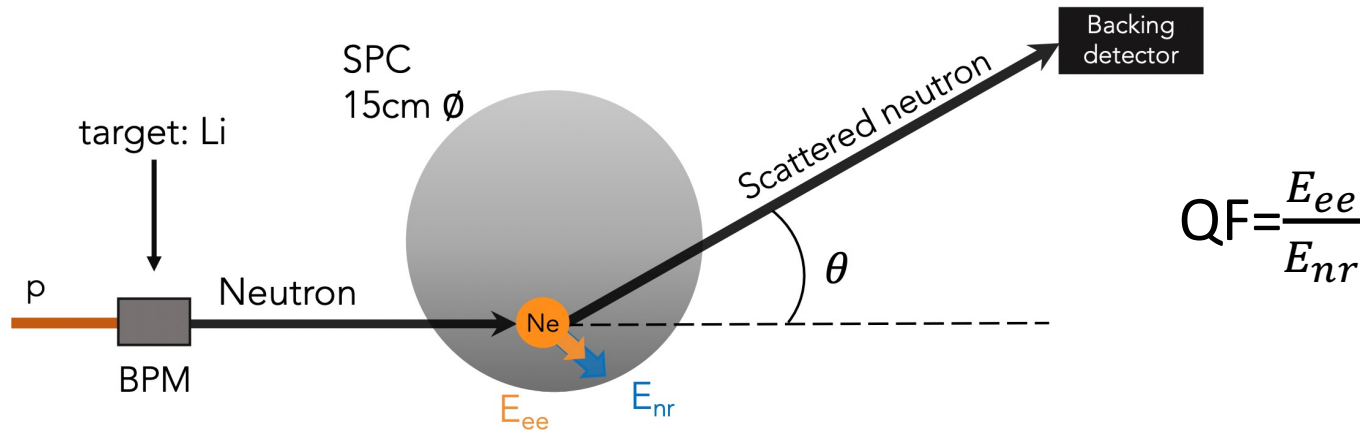
$\frac{North - South}{North + South}$

- Allows for increased target mass, larger volume, higher pressure.
- Individual readout TPC-like capabilities to the SPC depending on gas properties.

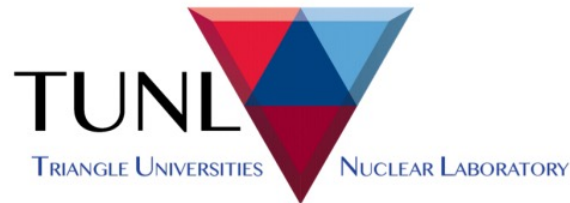
Single electrons detection in large detector from laser pulse



Nuclear ionization yield measurement

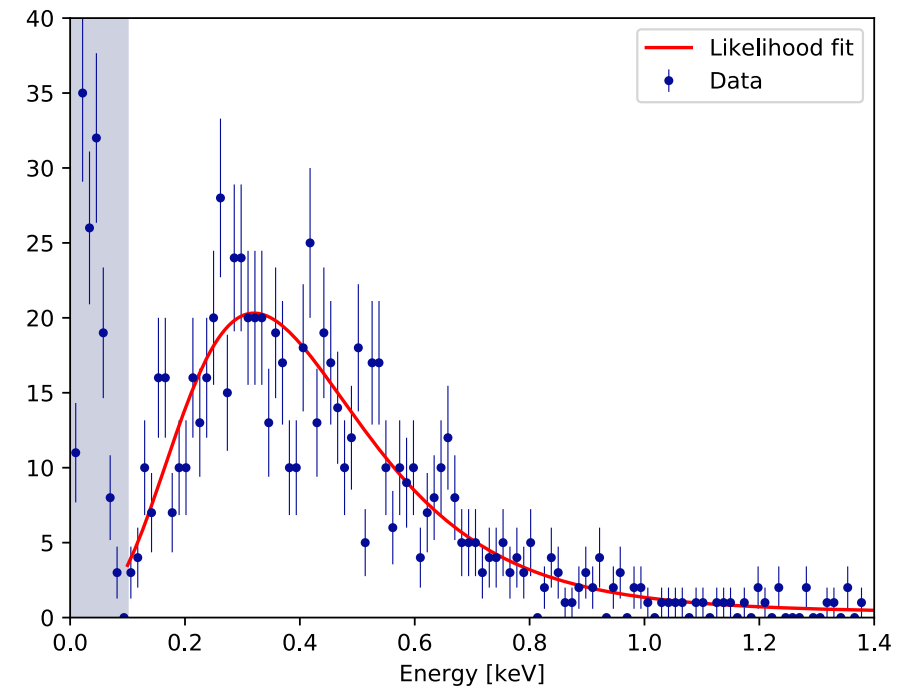


Measurement done at the TUNL facility
Neutron pulsed beam: $E_n = 545 \pm 20$ keV
8 energy points: 0.34 to 6.8 keV_{nr}
Publication under review



Same experiment is under development with the tandem accelerator of the Reactor Material Testing Laboratory at Queen's University.

1.3 keV nuclear recoil



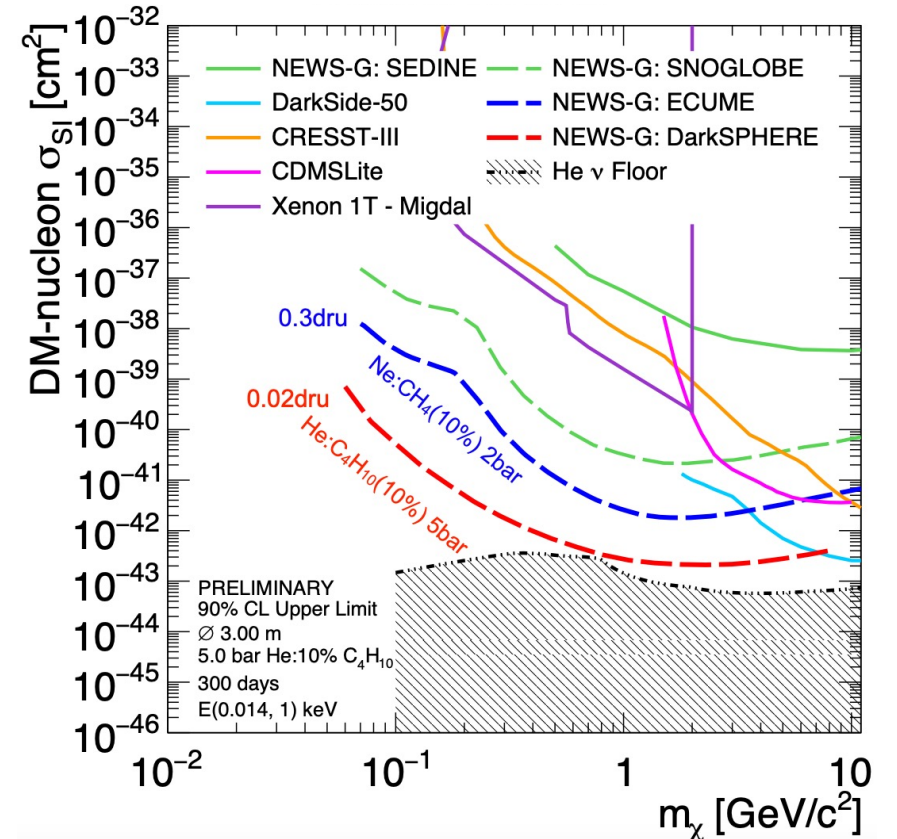
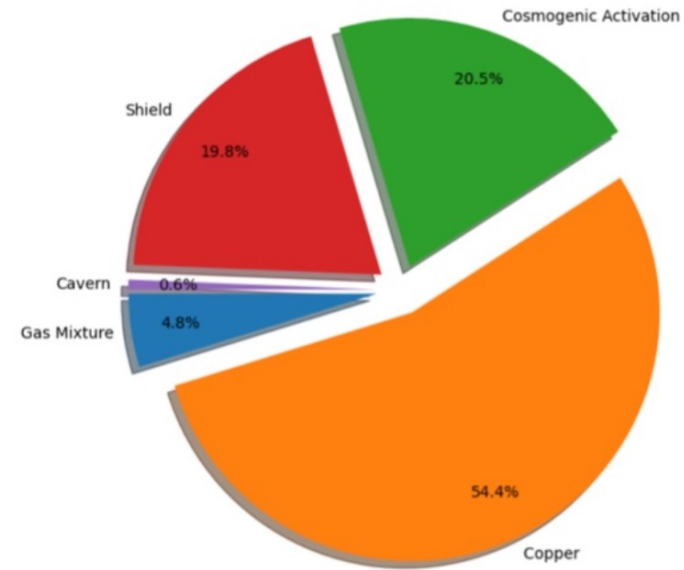
Marie Vidal
Ph.D. candidate,
Queen's University

Future detectors

Background of NEWS-G at Snolab
2.1 dru < 1keV

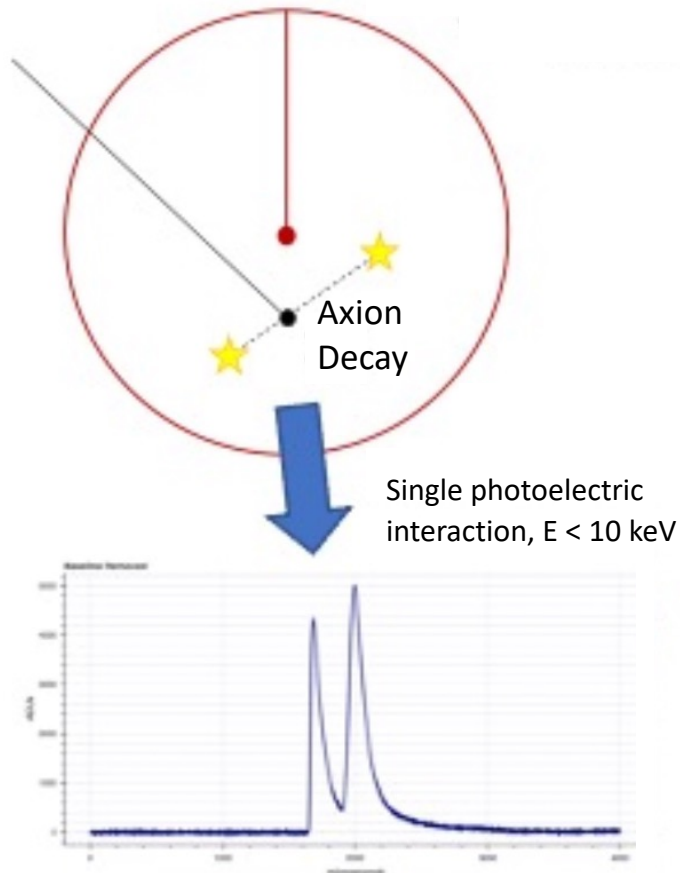
ECUME:
Electroforming a copper underground at
SNOLAB

DarkSPHERE:
3 m diameter sphere
Electroformed underground
Water shielding



Solar KK Axion

Axion decay rate depends on detector volume

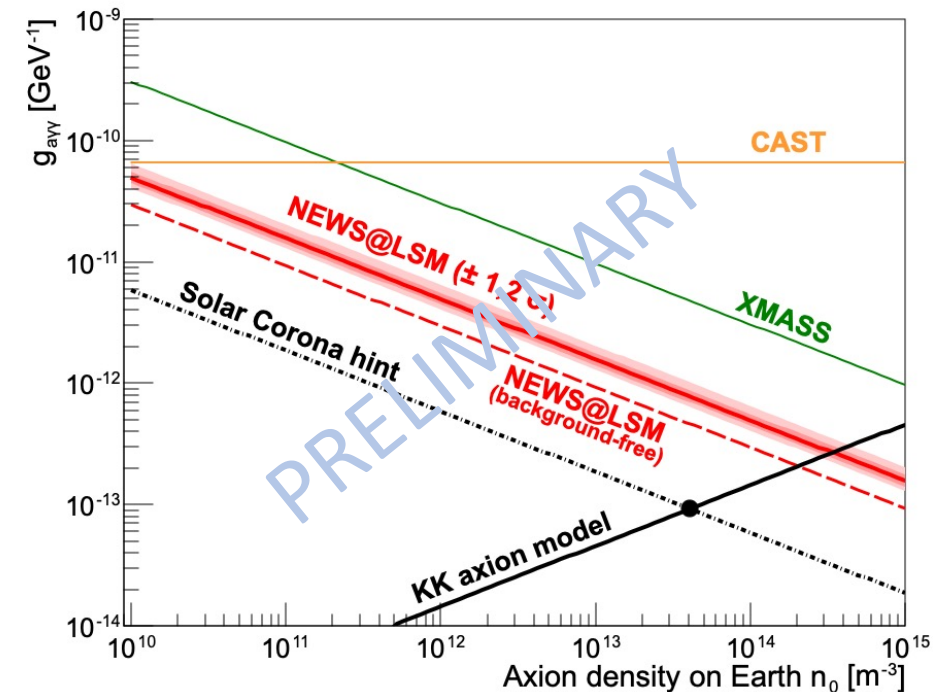


Francisco Vasquez: [Solar KK axion search with NEWS-G](#) today 12:45

Solar KK axion model predicts accumulation of heavy axions in the Solar System.

Can reject background by keeping only events with two pulses of similar amplitude.

Improvement of the XMASS limit by a factor 6 with a 60 cm prototype and 42 days run.



Francisco Vazquez Ph.D. thesis Queen's University
Publication under review

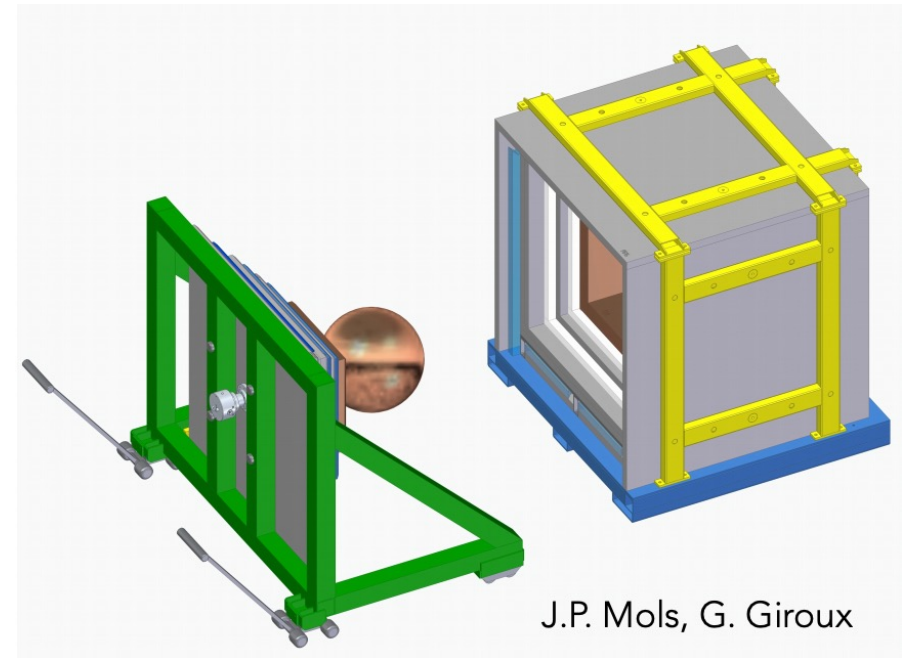
CE ν NS

- 60 cm sphere
- Compact shielding made of lead, copper and polyethylene
- Muon veto

- Commissioning run at Queen's University to assess background at surface by the end of the year.

Expected rate at 10 m from a 1 GWth reactor with 50 eV threshold considering 50 eV_{ee} energy threshold detector resolution and Lindhard ionization yield:

Xe: ~ 9 CE ν NS events/kg/day
Ar: ~ 15 CE ν NS events/kg/day
Ne: ~ 10 CE ν NS events/kg/day
He: ~ 2 CE ν NS events/kg/day



CONCLUSION

- Detector review and background summary paper to be published.
- Analysis of the commissioning run at the LSM is ongoing and the first WIMP scattering on proton limit will be published this summer.
- Publication about solar KK axions and ionization yield measurement are under review.
- NEWS-G at SNOLAB to be started by July.
- Commissioning of the 60 cm sphere and shielding for surface background assessment by the end of the year.



Queen's University Kingston - G Gerbier, G Giroux, R Martin, S Crawford, M Vidal, G Savvidis, A Brossard, F Vazquez de Sola, K Dering, V Millious, J McDonald, M Van Ness, M Chapellier, P Gros, JM Coquillat, JF Caron, L Balogh

- Copper vessel and gas set-up specifications, calibration, project management
- Gas characterization, laser calibration on smaller scale prototypes
- Simulations/Data analysis



IRFU (Institut de Recherches sur les Lois fondamentales de l'Univers)/CEA Saclay - I Giomataris, M Gros, JP Mols

- Sensor/rod (low activity, optimization with 2 electrodes)
- Electronics (low noise preamps, digitization, stream mode)
- DAQ/soft



Aristotle University of Thessaloniki - I Savvidis, A Leisos, S Tzamarias

- Simulations, neutron calibration
- Studies on sensor



LPSC/LSM Laboratoire de Physique Subatomique et Cosmologie, Laboratoire Souterrain de Modane) Grenoble - D Santos, M Zampaolo, A DastgheibiFard JF Muraz, O Guillaudin

- Quenching factor measurements at low energy with ion beams
- Low activity archaeological lead
- Coordination for lead/PE shielding and copper sphere



Pacific Northwest National Laboratory - E Hoppe, R Bunker

- Low activity measurements, copper electro-forming



RMCC Kingston - D Kelly, E Corcoran, L Kwon

- ^{37}Ar source production, sample analysis



SNOLAB Sudbury - P Gorel, S Langrock

- Calibration system/slow control



University of Birmingham - K Nikolopoulos, P Knights, I Katsioulas, R Ward

- Simulations, analysis, R&D



University of Alberta - MC Piro, D Durnford, Y Deng, P O'Brien, C Garrah

- Gas purification, data analysis, simulation



Associated labs: TRIUMF - F Retiere

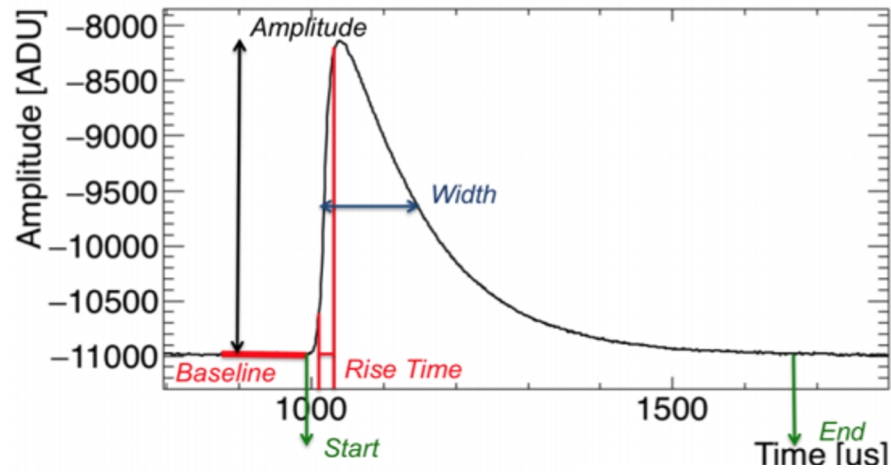


Subatech, Nantes – P. Lautridou, F. Vazquez de Sola



NEWS-G
Collaboration Meeting
14-18 December
2020

Pulse shape discrimination



Amplitude \propto Energy deposited

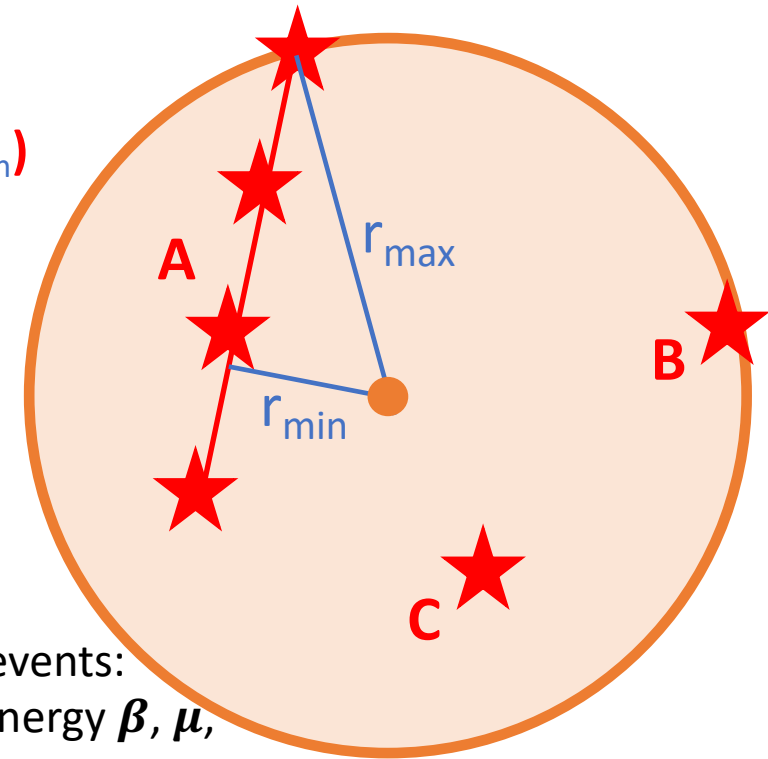
Rise time:

Track:

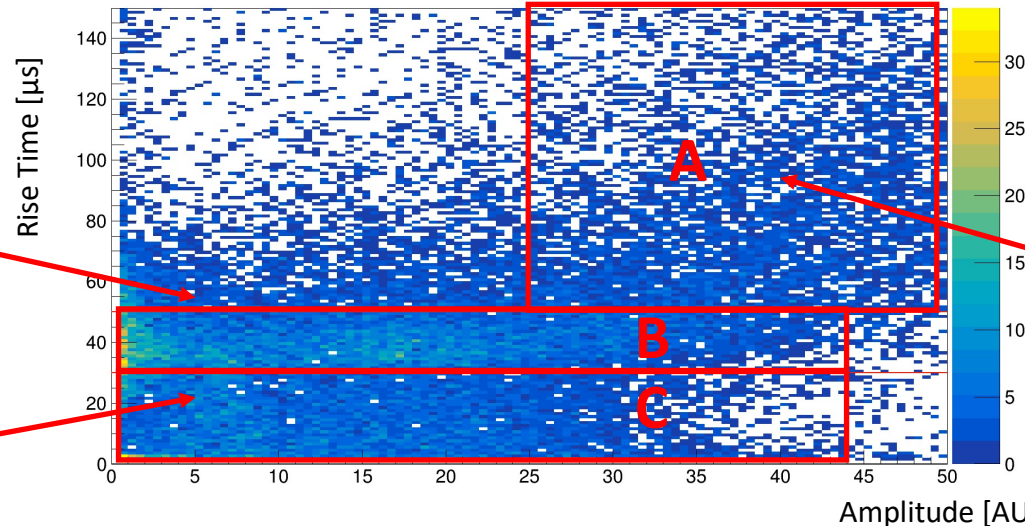
A: $RT \propto \text{DriftTime}(r_{\max}) - \text{DriftTime}(r_{\min})$

Point like:

B & C: $RT \propto \sigma(r)$



Rise time vs amplitude of background run



Surface events:
Low energy β , from the
Inner surface

Volume events:
Low energy Compton,
Photoelectric effect,
Nuclear recoil

Track events:
High energy β , μ ,
Compton...

Spherical Proportional Counter (SPC) functioning

- 1 Particle ionizes gas.
- 2 Primary electrons drift toward the sensor.
- 3 Close to the sensor, secondary ion/electron pairs are produced
- 4 Signal is induced by the motion of secondary ions.
- 5 The signal is processed by a pre-amplifier and digitized.

- Possibility to use large range of target mass.
- Sub-keV energy threshold, single electron.
- Identification of point like energy deposition by pulse shape.

