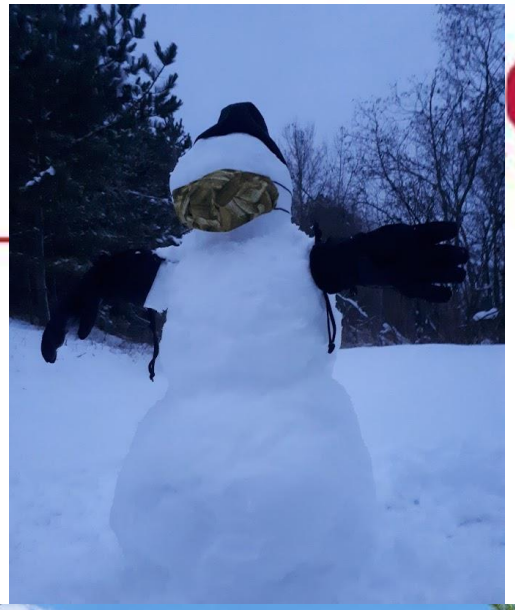
The NEWS-G Experiment

SNOLAB User Forum 2021-08-13

Philippe Gros (Queen's U)
for the NEWS-G collaboration

About me

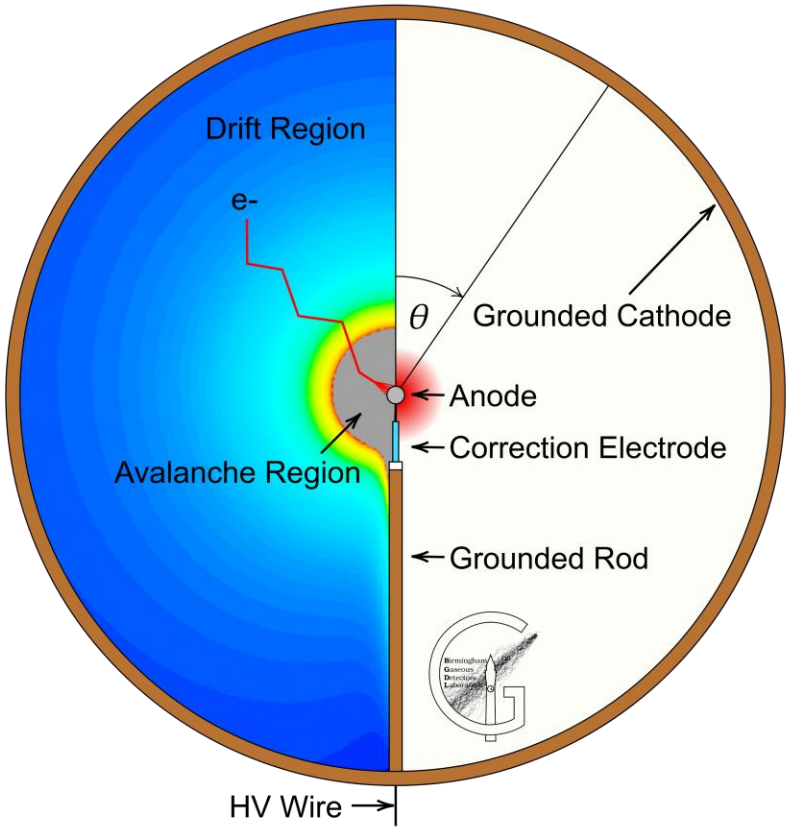
- Research scientist at Queen's
- Career on gaseous detectors
  - Hadron tracking in ALICE at LHC
  - Electron tracking detection for ILC
  - Gamma detection and polarimetry in HARPO
  - Dark matter detection in NEWS-G?
- Hobbies
  - Hiking, biking, traveling
  - Poor attempts at painting the landscapes out there
  - Snowman making



NEWS-G

- Gaseous detector:
  - light target nuclei (neon, helium, hydrogen)
  - Light WIMP sensitivity (<1GeV)
  - Capability to use multiple target gases, and different pressures for BG characterisation
- 140cm detector built
  - Full scale test at LSM (France) in 2019 with neon and methane
    - Copper sphere, lead shield, temporary neutron shield (water)
  - Installation complete at SNOLAB early August!

NEWS-G Spherical Proportional Counter (SPC)

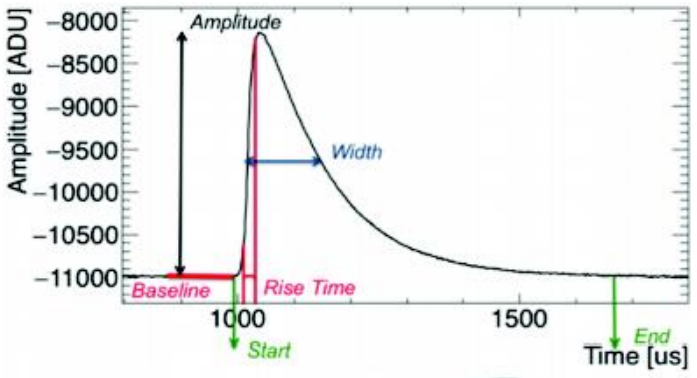


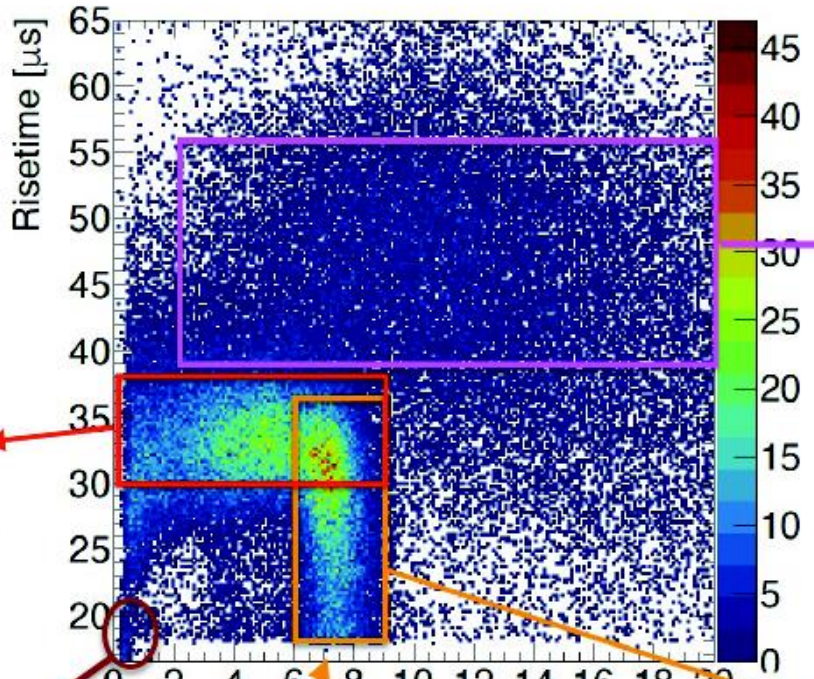
- Grounded sphere with sensor anode
- Low capacitance, high gain

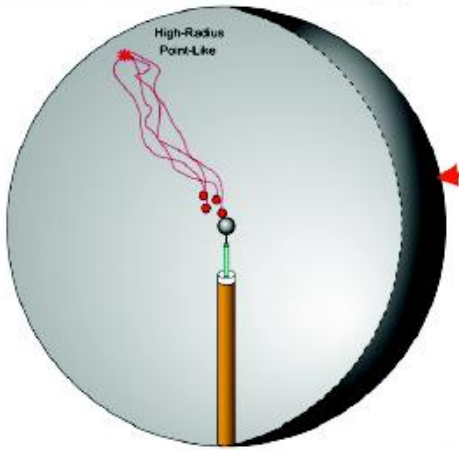
  -> low threshold
- Simple design

  -> pure materials, low background

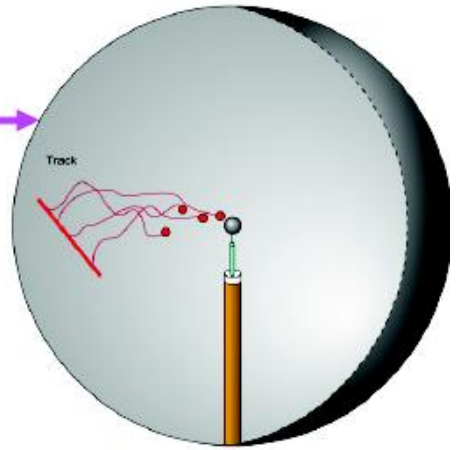
Pulse Shape Discrimination





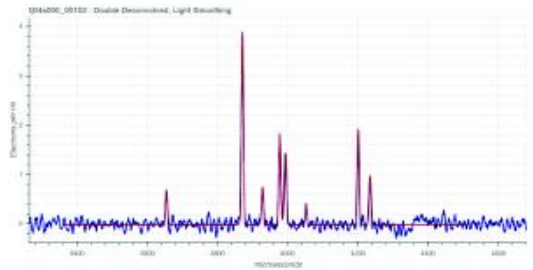


"Surface"-like events

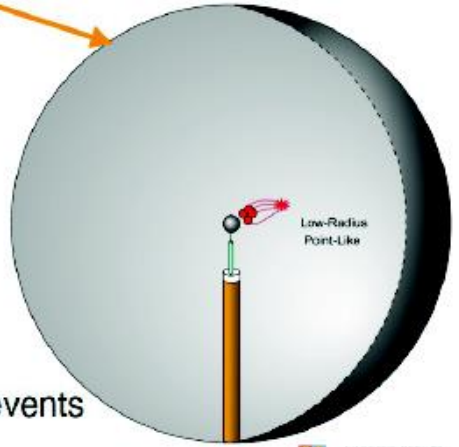


"Muon"-like events

Counting the electrons at very low energies



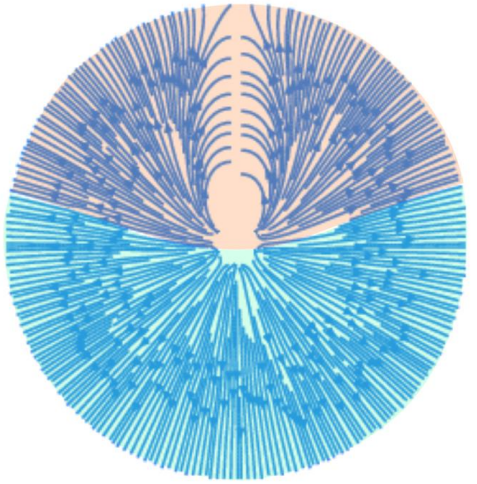
5.9 keV X-rays
from ^{55}Fe decays

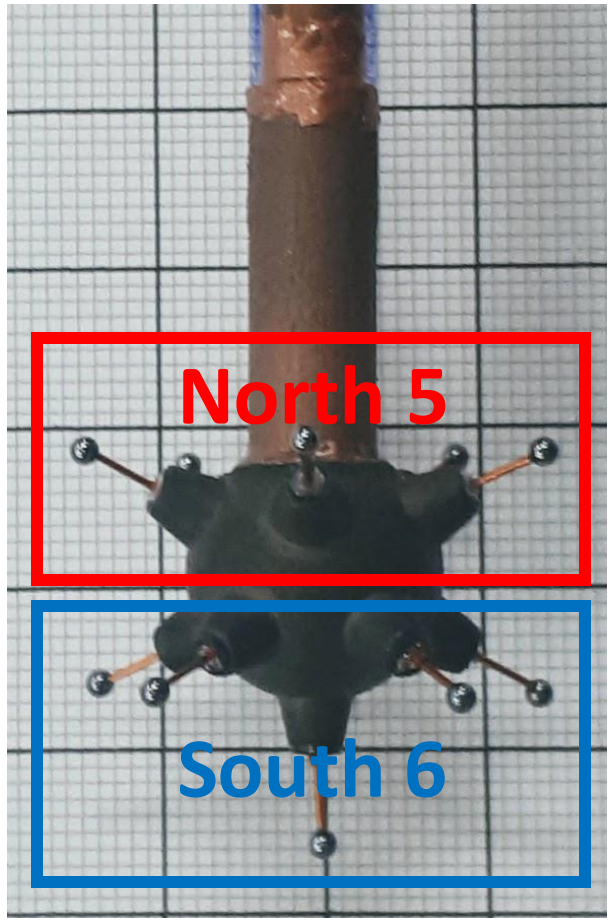


"Signal"-like events

2-channel Achinos sensor

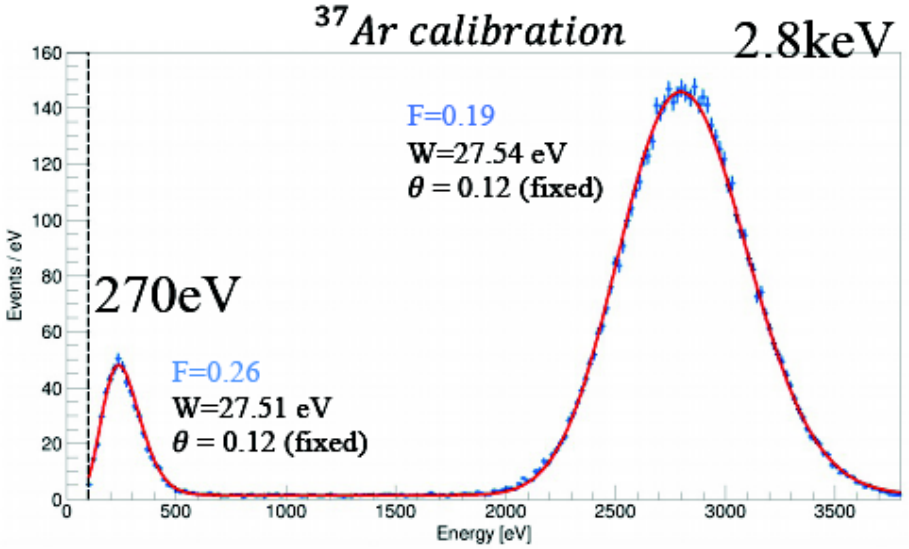
- Multiball sensor "Achinos"
  - Small balls -> high gain
  - Large structure -> high drift field
- 2 channels
  - "North" (5 balls), "South" (6 balls)
- Improved fiducialisation
  - N/S comparison
  - Possible rejection of localised background (bottom of sphere, equator)





Calibration tools

- 213nm UV laser
  - Single photon photoelectric from copper or steel surface
  - 10Hz repetition, 0.5mJ/pulse, adjustable: single electron to few keV equivalent (depends on gas and E field)
  - Pulse by pulse monitoring and tagging with photodetector
- Radio active sources
  - ^{37}Ar: 2.9keV, 0.27keV. Uniform volume distribution (gas). Not available during physics runs (would be strong background)
  - ^{22}Na (MeV gammas) external through copper sphere
  - AmBe (neutrons) external through copper sphere



Preliminary runs at LSM 2019

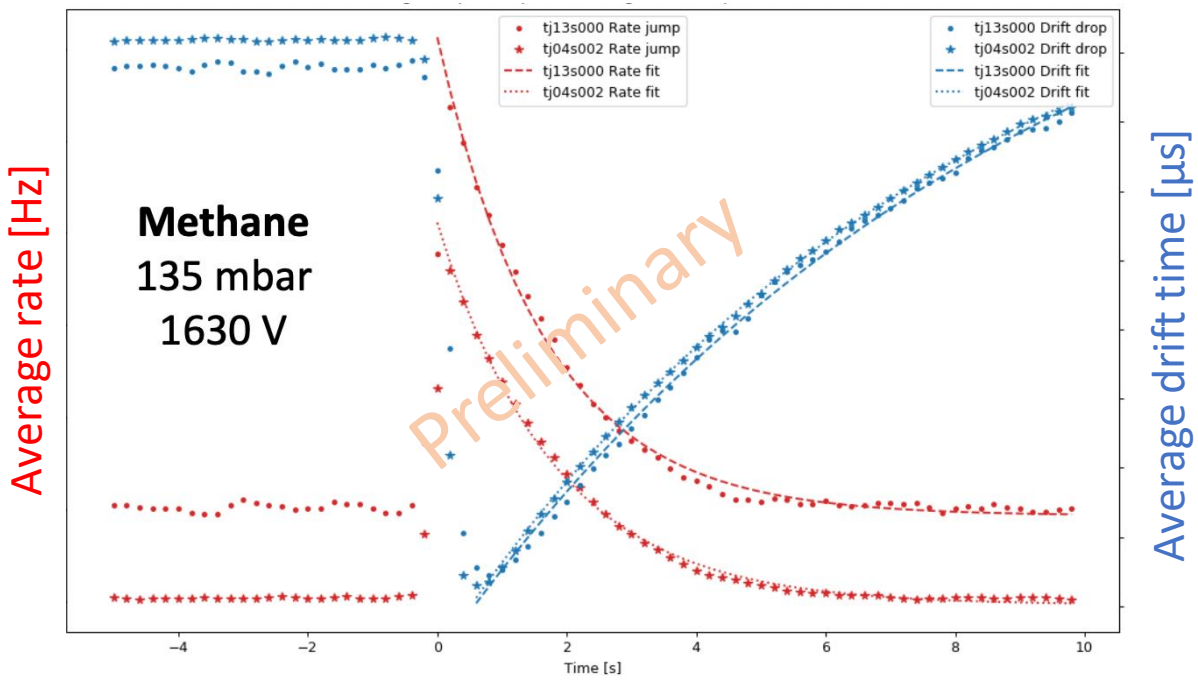
- Copper sphere and lead shield built in France
- Assembly test needed underground
- With small effort, possibility of quick physics
  - Final sphere and lead shield
  - Water tank for neutron shield
- 2 months data taking
  - Neon + 7% CH4 at 1bar
  - Pure CH4 and 135mbar

Information from 2019 runs

- Validation of sensor in low background
  - Sensitivity to "space charge" from secondary ionisation
- Validation of laser calibration system
  - Electrons extracted from copper surface through photoelectric effect at 213nm (UV)
- Development of analysis methods
  - 2 channel acquisition: crosstalk and shared signal
  - Electron counting
- Unexpected background
  - Excess surface background (possible contamination during surface etching)
  - Prompted second etching UG at SNOLAB

Space charge effect

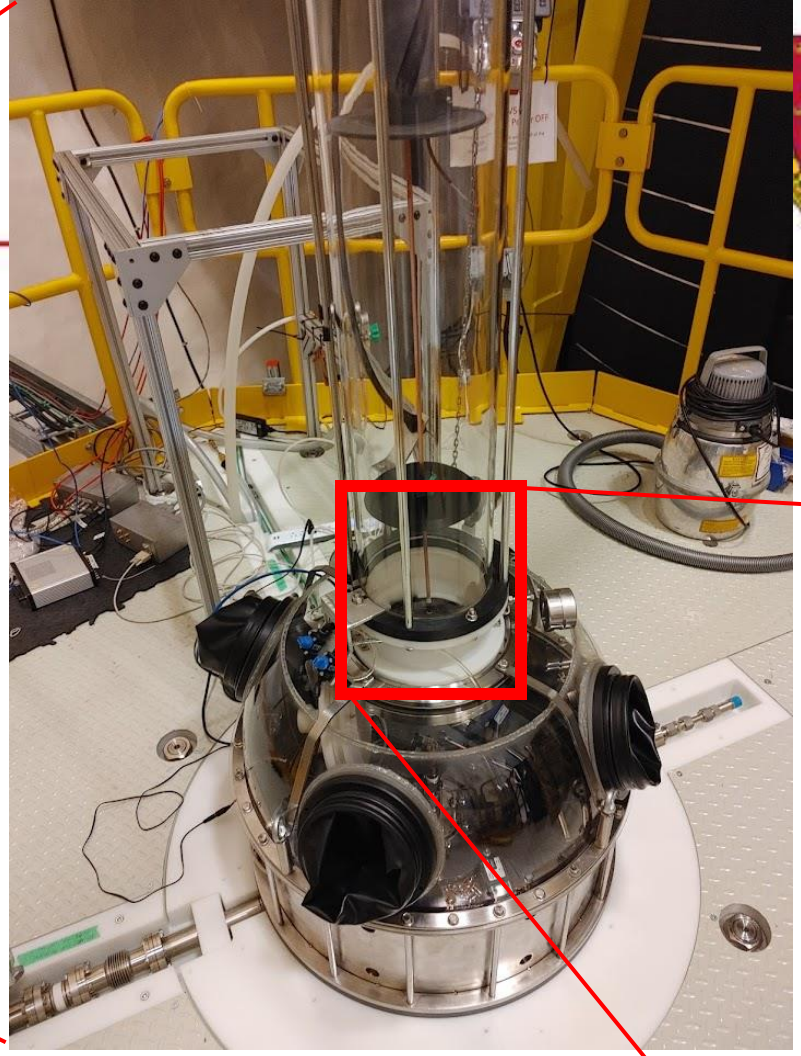
- Very low field at large radius
  - <1V/cm
  - Very sensitive to field created by drifting ions
- Charges created by alpha events
  - Ions drifts over several seconds
  - Drift velocity increased
- Laser measurement sensitive
  - Drift velocity
  - Electron extraction efficiency
- Background associated to alpha events
  - Increased rate for few seconds
  - Process unknown (recombination?)



Installation at SNOLAB 2020-2021

- Sphere and shield delivered in Sudbury Dec 2019
  - UG Jan-Feb 2020
- Stalled by Covid pandemic March 2020
- Sphere internal etching Oct 2020
- Sphere and shield installation in Cube Hall Nov 2020 – Jan 2021
- Stalled by 2nd lockdown
- Gas system installed May-July 2021
- Sensor installation August 4th 2021
- First Light in argon August 10th 2021 (!!!)
- Commissioning ongoing...

Sensor Installation



Conclusions

- NEWS-G has already proven performance in temporary shield at LSM 2019
- Installation completed at SNOLAB despite Covid restriction in 2020-2021

Many thanks to all at SNOLAB!

- Ready to take first data at SNOLAB now!

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

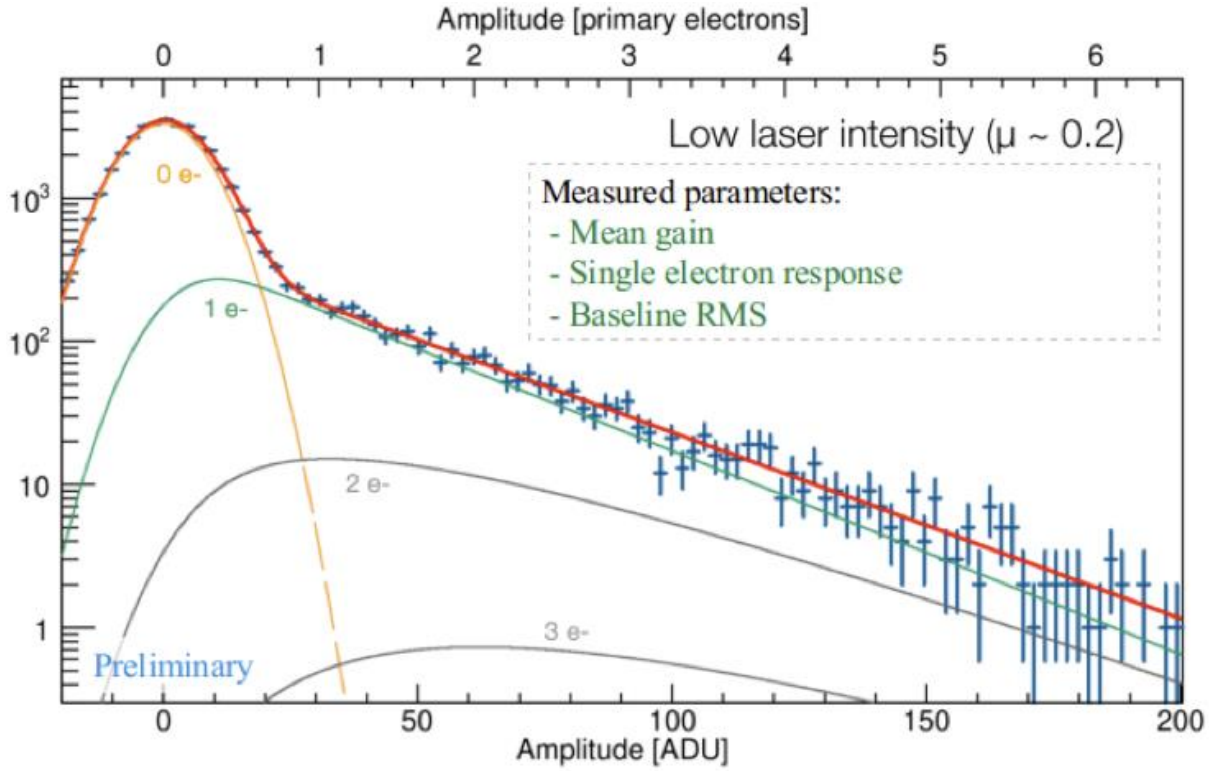
Associated labs: TRIUMF - F Retiere

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

Backup

Laser calibration: single electrons

- Low laser power:
  - mostly 0 or 1 primary electrons
- Trigger on photodetector
  - 0 electron background included
- Fitting Poisson distribution
  - Polya for gain fluctuation
  - Includes contribution of 2 or 3 electrons
  - mean number of electrons μ can be adjusted by with photodetector amplitude cuts

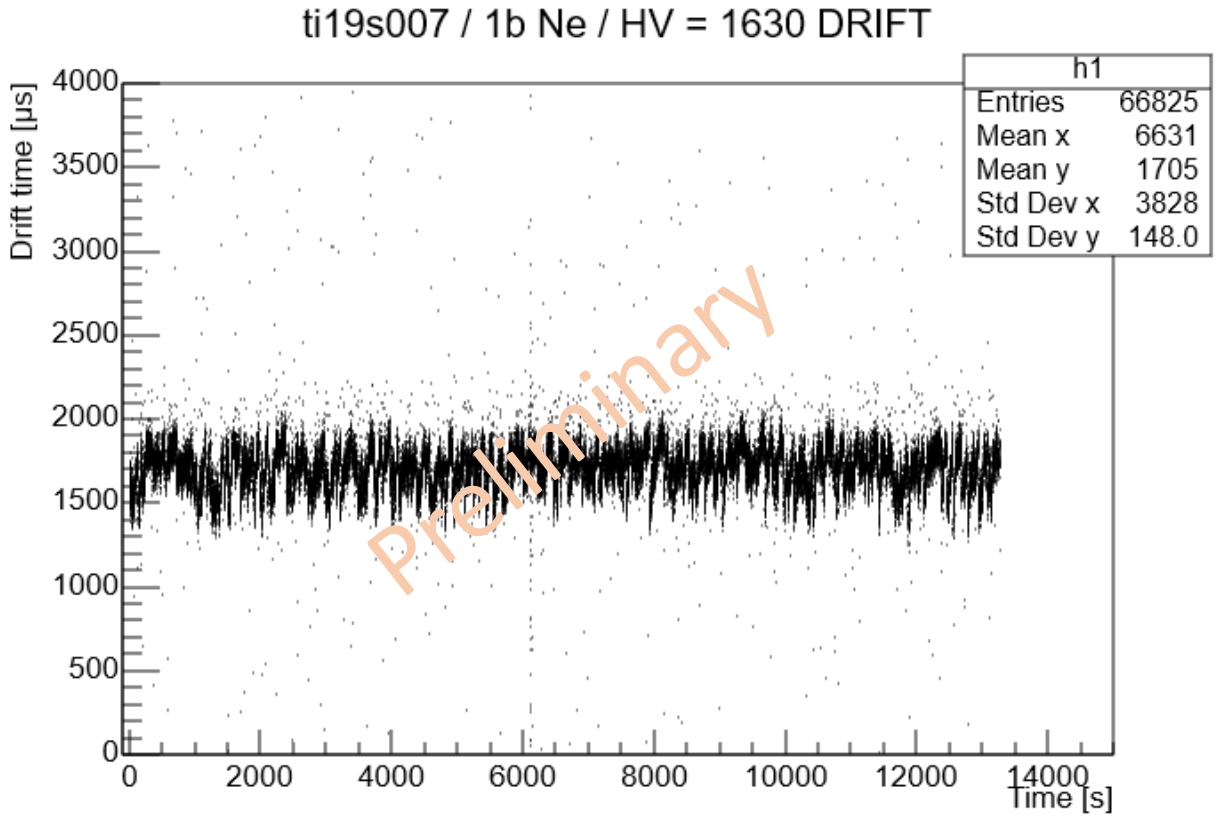


W value calibration

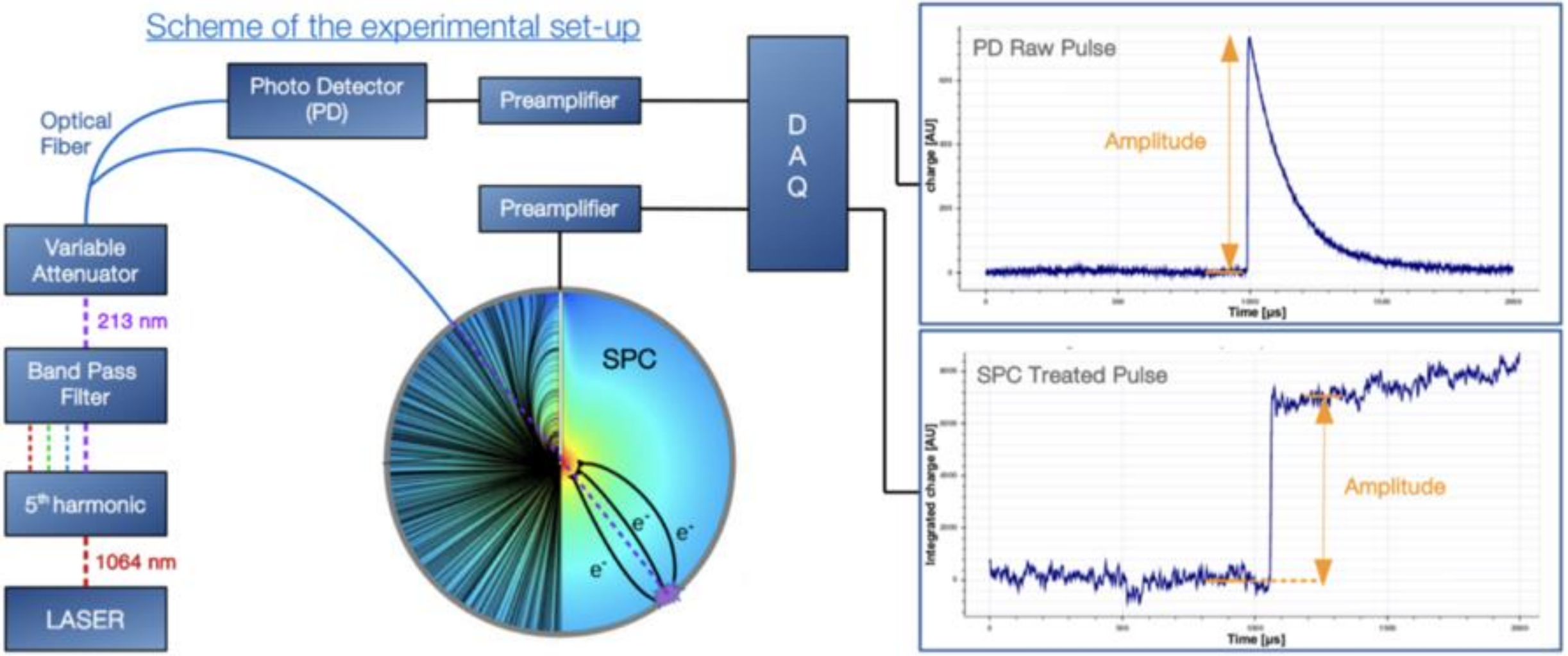
- Single electron response measurement
  - On underground detector
  - Regularly during physics measurement
- Electron recoil measurement from X-ray sources
  - ^{37}Ar (270eV, 2.9keV) on underground detector
  - Al (1.49keV) and ^{55}Fe (5.9keV) in smaller lab detectors
- Measurement of W-value in range 0.26 - 5.9keV
  - Measurement compatible with published values (within 10%) for CH4 gas
  - Extending to all gas mixtures used in NEWS-G

Detector monitoring

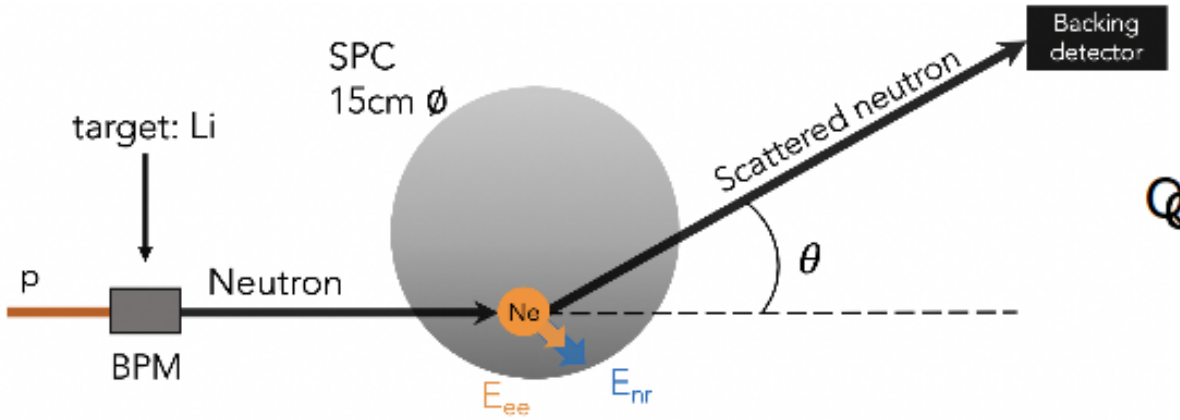
- High intensity laser (100s of electrons): low fluctuations
- Tagging from photodetector
- 10Hz during physics run
- Drift velocity measurement
  - t_{sphere}-$t_{photodetector}$



Calibration laser



Neutron scattering

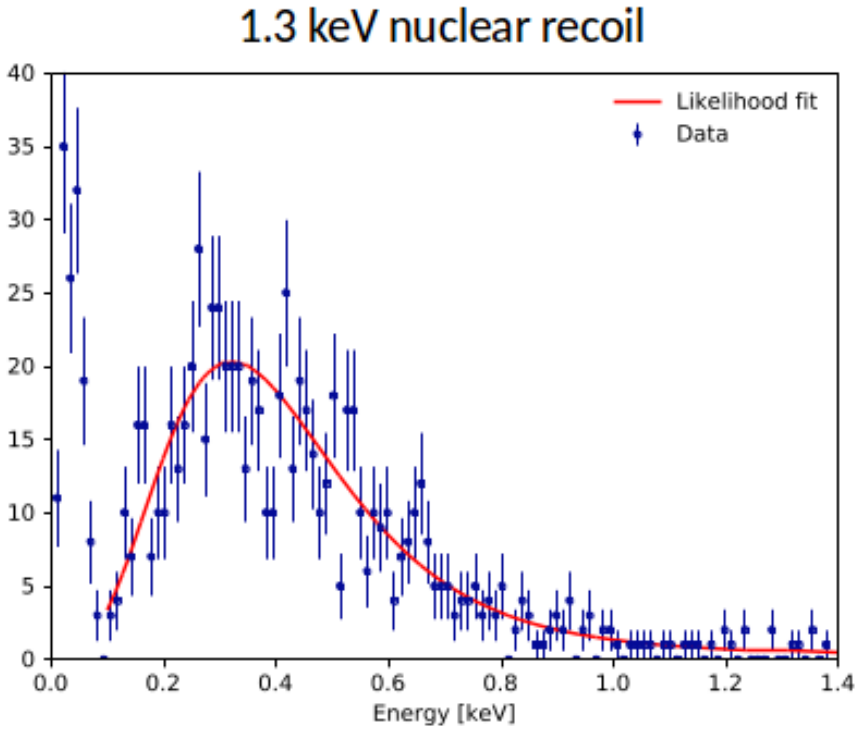


$$QF = \frac{E_{ee}}{E_{nr}}$$

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

TUNL
Triangle Universities Nuclear Laboratory

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



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Queen's University