New Experiments With Spheres - Gas

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Dark Matter search with SPCs

The NEWS-G dark matter direct-detection experiment uses Spherical Proportional Counters to search for low mass (0.1-3 GeV) WIMPs. The detector is made of a grounded copper vessel with an anode at its center.

- Single ionization electron sensitivity
- Low energy detection threshold + light targets (Ne, He, H) allow sensitivity to low-mass WIMPs
- Pulse shape discrimination, surface event rejection

Detection principle

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

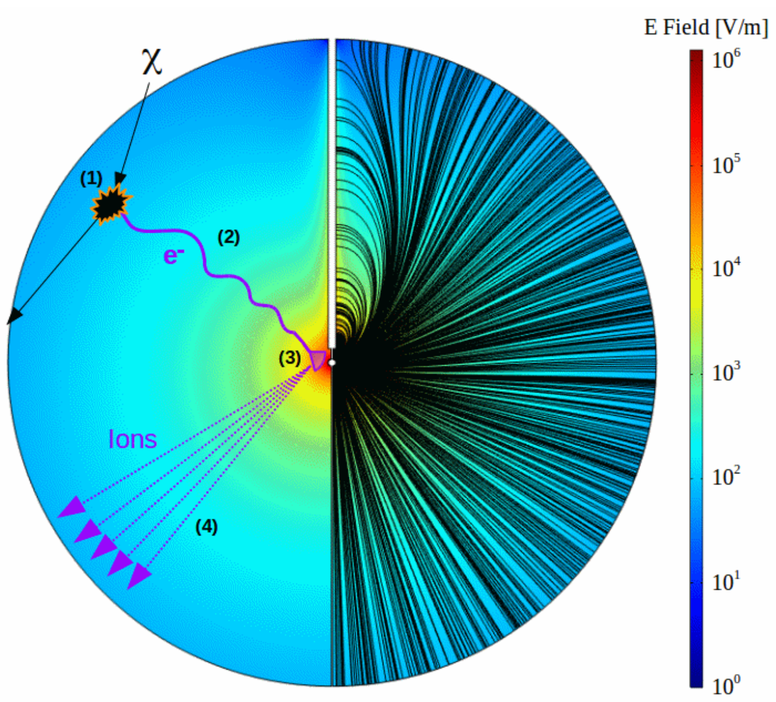

Fig. 1. Detection principle.

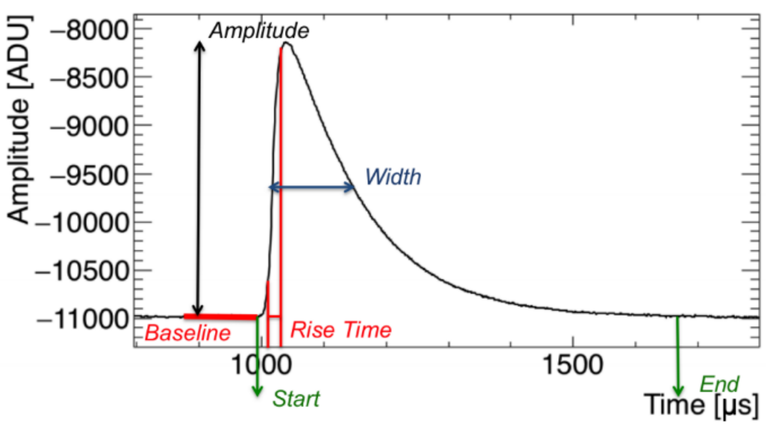

Fig. 2. Typical signal.

NEWS-G @ SNOLAB

140 cm diameter sphere capable of holding up to 10 bars, to be installed in SNOLAB by summer 2018. Several improvements, including radio-pure material selection, copper electro-polishing cleaning, and larger shielding, will improve the sensitivity.

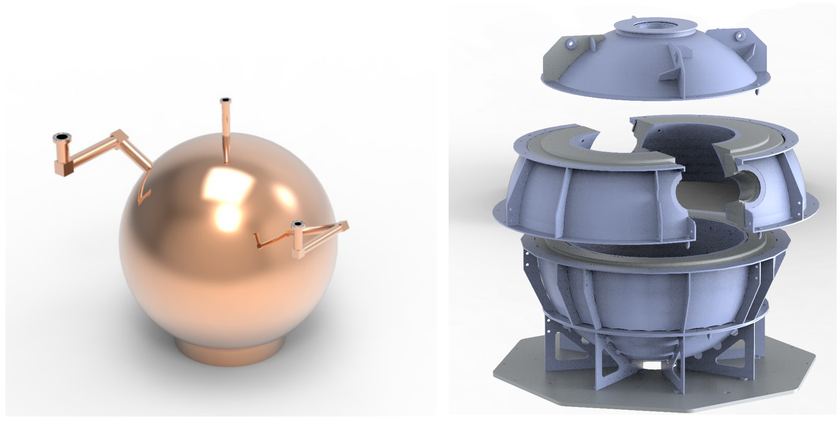

Fig. 3. Design of the copper sphere (left) and the 25 cm lead shielding (right) to be used in SNOLAB. The 40 cm high density polyethylene shielding is not shown.

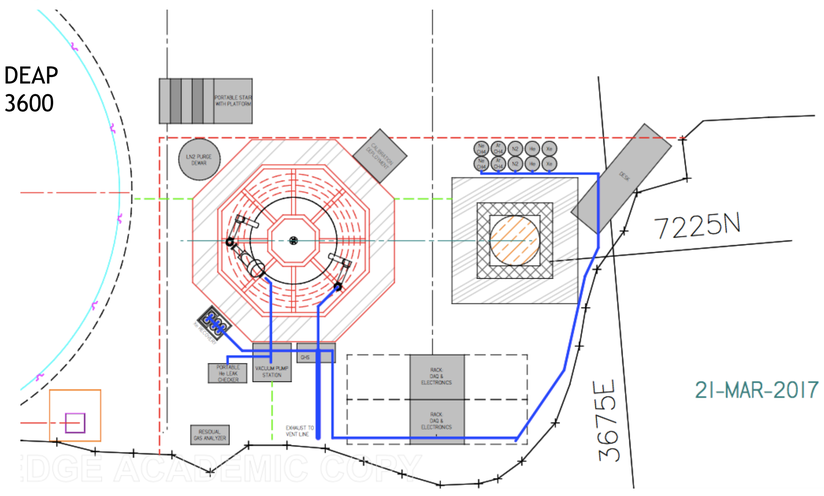

Fig. 4. Implementation of NEWS-G at SNOLAB.

Projected sensitivity

The NEWS-G detector at SNOLAB will set unprecedented constraints on the WIMP-nucleon cross section for sub-GeV WIMPs, improving by orders of magnitude the limit already set with the SEDINE 60 cm diameter SPC prototype at the Laboratoire Souterrain de Modane (LSM).

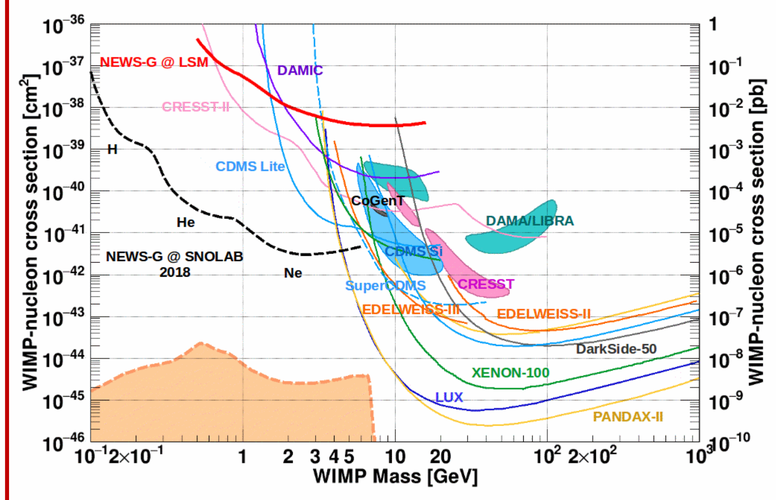

Fig. 5. Projected sensitivity of NEWS-G at SNOLAB (dotted black line), and limit set with SEDINE at the LSM (red line).

Other applications:

- Double Beta Decay
- Kaluza-Klein Axions
- Neutron Spectroscopy
- Low-Concentration Radon
- Coherent Neutrino Scattering

Sensor development

To correct for electric field anisotropy effects on the detector response, and improve the resolution, we apply a second voltage on the so-called "umbrella".

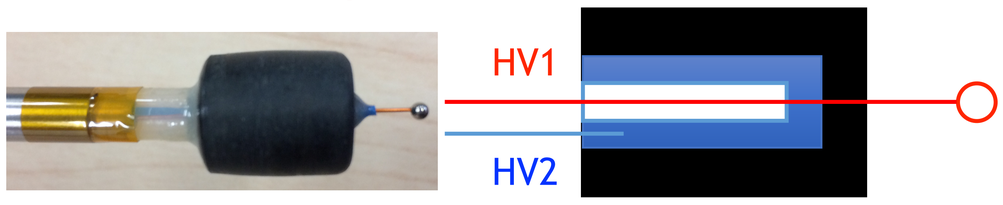

Fig. 6. Picture and schematic view of a bakelite sensor with a 2 mm ball. A first high voltage HV1 is applied on the sensor. A second voltage HV2 is applied on steel layer (blue) surrounded by a bakelite layer (black).

Low energy calibration with argon 37

Volume calibration is done with argon 37. Electron capture in the L and K shells release 270 eV and 2.82 keV X-rays respectively. The spectrum was obtained at Queen's University laboratory with a 30 cm sphere and a bakelite sensor. The gas mixture was 98% of argon and 2% of methane at 500 mbar. We applied 1990 V on the sensor and -100 V on the umbrella.

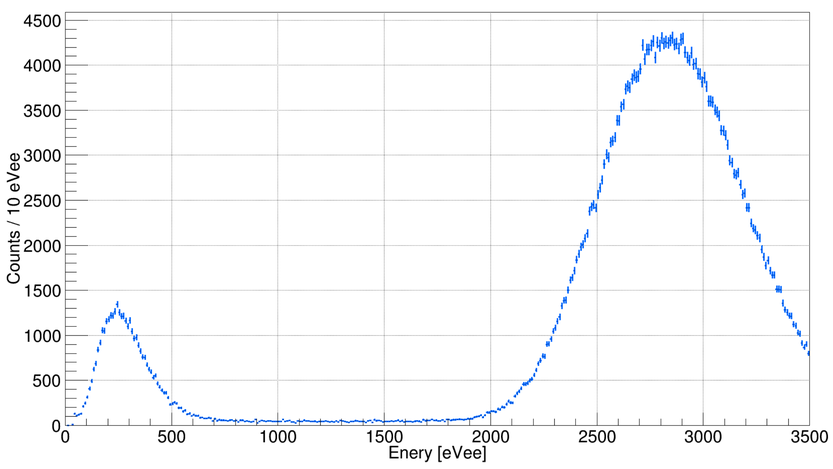

Fig. 7. Spectrum of argon 37.