New Experiments With Spheres - Gas

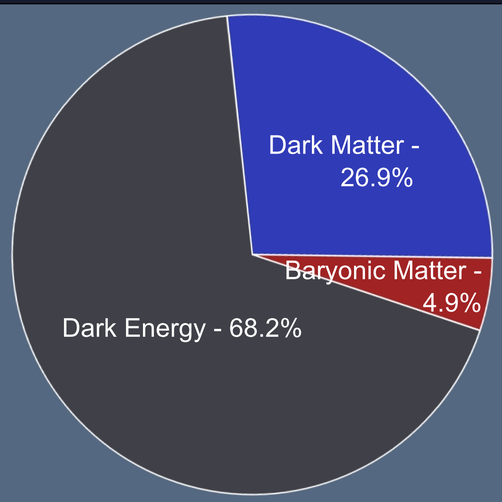
The Search for Dark Matter with NEWS-G at Queen's University

Collaboration Partners: Queen's University, Laboratoire Souterrain de Modane, Institut de Recherche sur les Lois Fondamentales de l'Univers/CEA Saclay, Aristotle University of Thessaloniki, Laboratoire de Physique Subatomique et de Cosmologie, Pacific Northwest National Laboratory, Royal Military College of Canada, SNOLAB, University of Birmingham

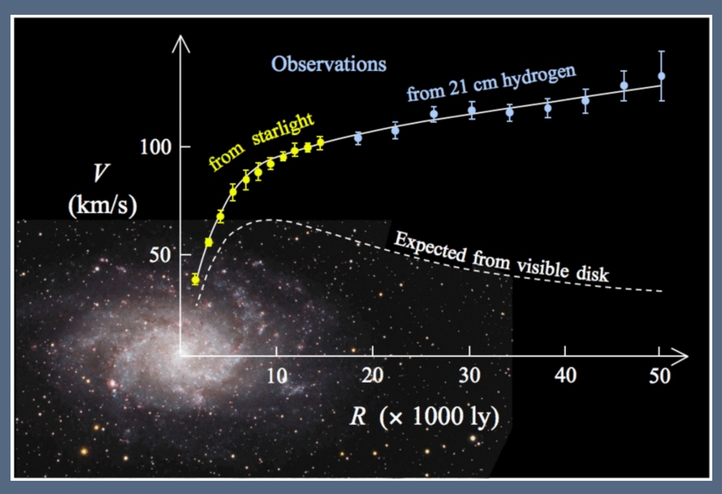
What is Dark Matter?

Many astronomical observations present evidence that most of the mass of the Universe is made of undetected dark matter.

Observations suggest that dark matter is likely a subatomic particle with properties including that it:

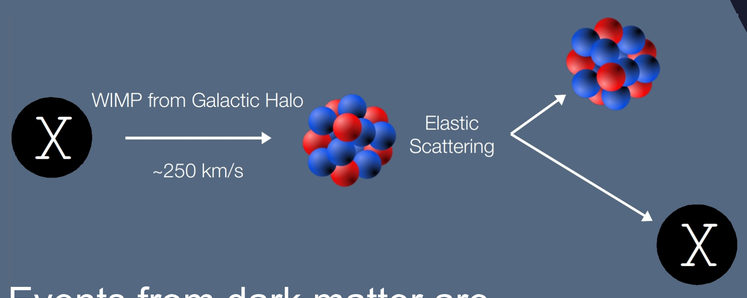


- Is relatively heavy (about the mass of a proton)
- Does not interact with the electromagnetic force (no chemical interactions, invisible)
- Rarely interacts with normal matter via the Weak Nuclear Force



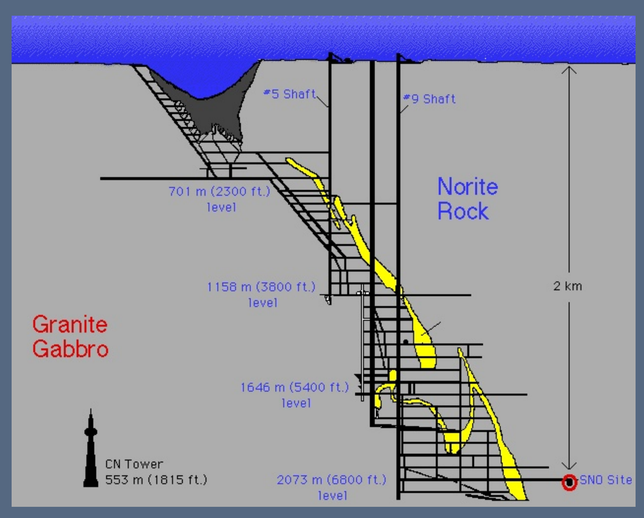
How do we detect it?

Dark matter interacts with normal matter very rarely by colliding with the nuclei of atoms. The amount of energy deposited is extremely small (about 10^{-16} Joules), so detectors need to be very sensitive.



Events from dark matter are far rarer than those from other sources of radiation, making it challenging to detect only dark matter and ignore the "background noise". Methods to overcome this include:

1. Placing experiments deep underground (like at SNOLAB in Sudbury) to protect them from radiation from the Sun, the atmosphere, and space.

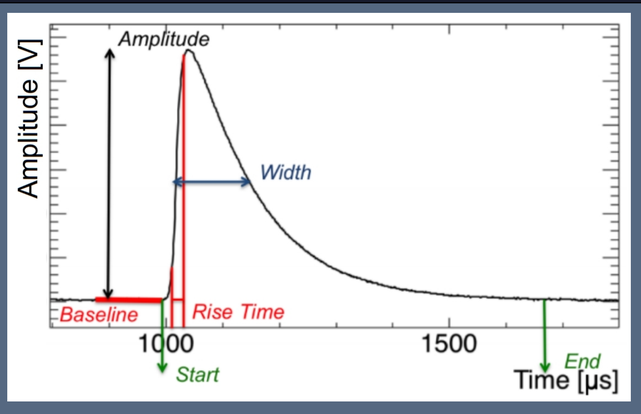


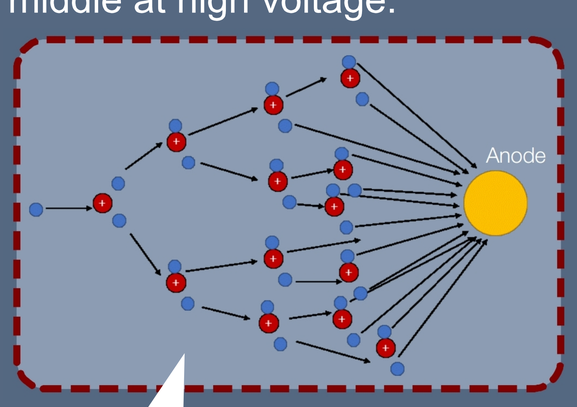
2. Making sure that detectors are as clean as possible, and fabricating them from very pure materials.

3. Shielding experiments from other sources of radiation. We use lead from ancient Roman shipwrecks to protect our experiments, since the radioactivity in the lead has been allowed to decay for thousands of years.

NEWS-G Detector

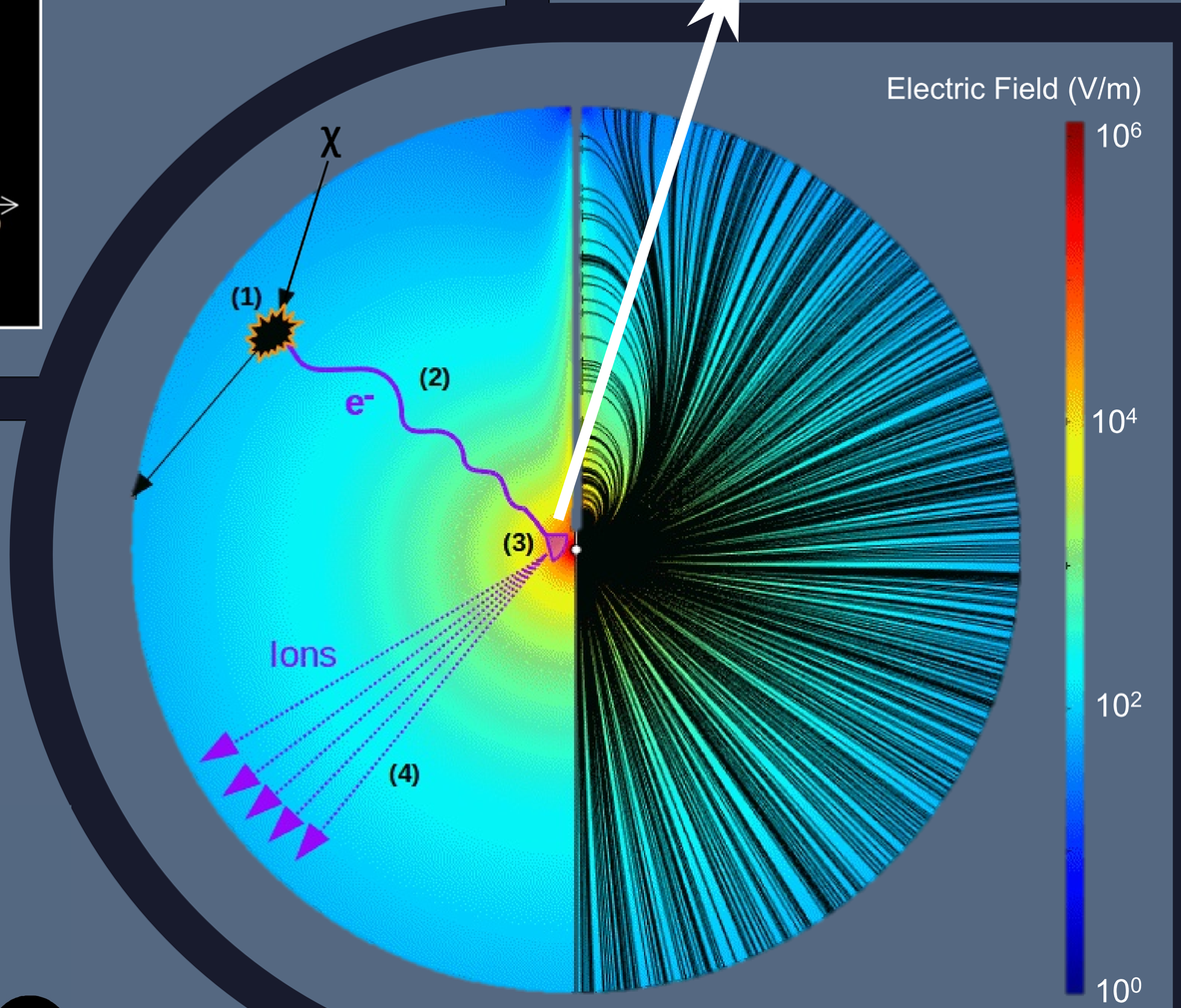
The NEWS-G experiment at Queen's studies particle detectors called Spherical Proportional Counters. They consist of spheres filled with noble gas mixtures (like neon or helium with methane), and a metal ball/sensor in the middle at high voltage.



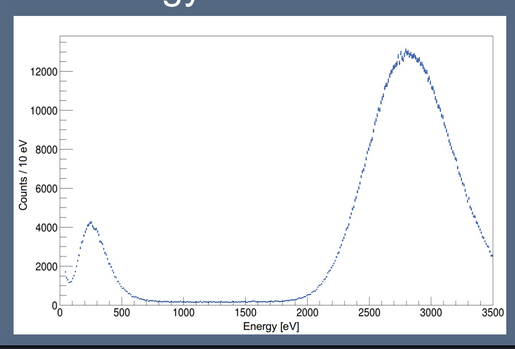


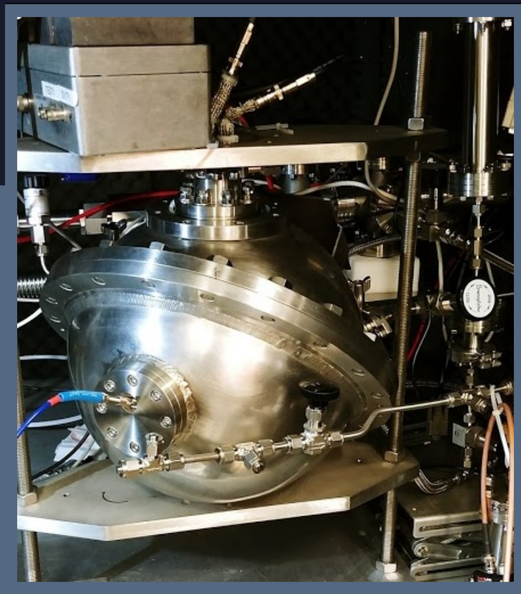
When particles such as dark matter interact in the detector:

1. Some electrons are freed from atoms of gas by the collision
2. Those electrons are then pulled towards the sensor by its electric field
3. When close to the sensor, the electrons accelerate so much that they start freeing other electrons in secondary collisions, creating an avalanche of electrons.
4. All the ions created drift away from the sensor, creating a current pulse that we collect as data



These detectors have been succesfully operated, and are very sensitive to low energy events.





Current Status

The NEWS-G collaboration has succesfully operated experiments with our partner institutions around the world, most notably at the LSM in Modane, France. Here at Queen's, our work is moslty focused on research and development for this novel technology.

So far, these detectors have demonstrated that they are exceptionally well suited to look for light dark matter.

In the coming years, we will be constructing a large new experiment in the world-class SNOLAB facility in Sudbury, Ontario. This new and improved detector will allow us to set world-leading constraints in the search for dark matter!