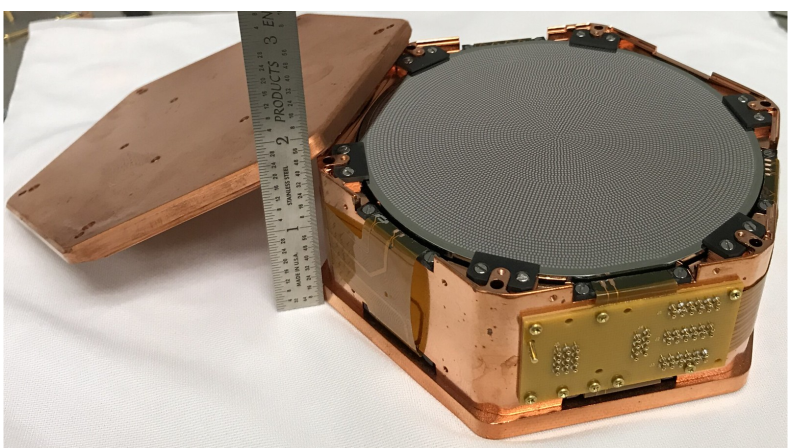
1. Description

Dark matter is a hypothetical form of matter that, if it exists, may account for more than a quarter of the energy density of our universe. Despite the variety of astrophysical evidence pointing to its existence, the direct interaction of dark matter in a terrestrial detector is yet to be observed. This does not stop us from searching, as the existence of dark matter is one of the biggest hints that our current physics theory is not complete. Unveiling the nature of dark matter can point us towards better understanding of the world we live in.

There are different strategies to tackle the dark matter detection task. Some take advantage of big machines like particle colliders. Others build giant telescopes, and sometimes put them into space. The experiment our group is involved in, The Super Cryogenic Dark matter Search (SuperCDMS) experiment, is (literally) one of the coolest.

The SuperCDMS experiment is able to observe a dark matter signal in silicon and germanium detectors operated below 50 miliKelvin. Our unparalleled advantage is the “Transition Edge Sensor” detector technology. We deploy small chunks of superconductors on pure silicon and germanium crystals. As superconductors cool down through their transition temperature, the resistances of the superconductors drop abruptly to zero, i.e. go through superconducting transition. We carefully control the temperature of the detector to be in the middle of the transition -- hence the name of “Transition Edge Sensor” -- so that a small energy deposited in the detector induces a big change in the detector resistance. Thus, our detectors are sensitive to tiny energy depositions down to electronVolts.



The SuperCDMS collaboration is building the next generation experiment in SNOLAB, Canada's world-leading astroparticle physics facility located 2 km below the surface in the Vale Creighton Mine near Sudbury. With the main experiment under construction, a few pilot “test facilities” have been commissioned and are supporting the main experiment by performing detector development, characterization and calibration. These test facilities include the Cryogenic Underground TEst (CUTE) facility at SNOLAB, and a portable test stand that is currently in our new cryogenic lab at UofT.

We have three summer projects available.

The first project will focus on the R&D and calibration effort of the SuperCDMS detectors. We operate a cryogenic detector test stand to calibrate a novel germanium gram-scale detector first in the lab with lasers and x-rays, then at a neutron beam facility. The student will be involved in the daily operation of the test stand and analyze the data from the detector. In the scenario where in-person lab work poses non-negligible risks, this project can be done fully remotely, with remote detector operations and data analyses.
Contact: Ziqing Hong

The other two projects will focus on simulations of the signal and backgrounds of the SuperCDMS experiment. The simulation package is based on GEANT4 and G4CMP packages, written in C++. The data analyses of the results will be in python. The students are expected to utilize the existing simulation tools on a computing cluster, and analyze results from the simulations.
Contact: Miriam Diamond and Pekka Sinervo

In the scenario of restricted lab access, all the tasks can be done remotely, although group members will be generally on campus permitted by the public health measures. The research group, as well as the wider collaboration, emphasizes principles of Equity, Diversity & Inclusion in the work environment.

For more information:

https://supercdms.slac.stanford.edu/

http://www.snolab.ca/

2. Requirements:

- 2nd year or above required, 3rd-year or above preferred
- Familiarity with C++, Python, and basic Linux command-line preferred
- Knowledge of particle physics and/or condensed matter physics preferred