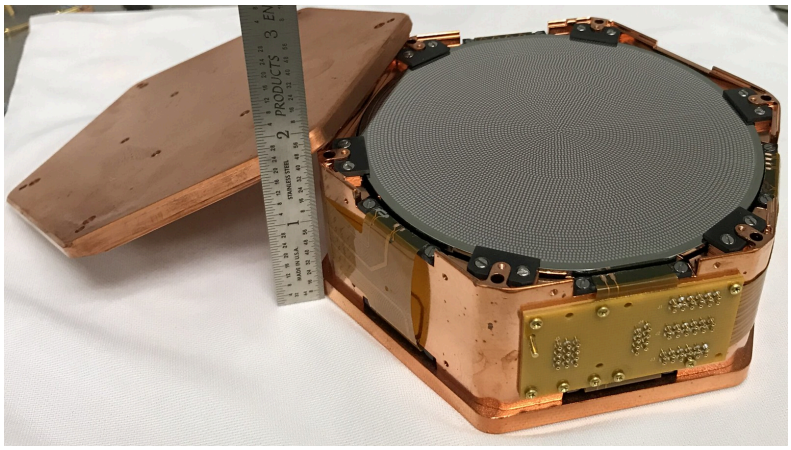
1. Description

Dark matter is a hypothetical form of matter that, if it exists, may account for over 85% of the matter in our universe. Notwithstanding a large body 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 theories are incomplete. Unveiling the nature of dark matter can point us towards better understanding of the fundamental building blocks of the universe.

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. Then there's the experiment our group is involved in, The Super Cryogenic Dark matter Search (SuperCDMS) experiment, which is (literally) one of the coolest.

The SuperCDMS experiment aims to observe a dark matter signal in cryogenic semiconductor detectors operated below 50 milliKelvin. 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. The UofT SuperCDMS group plays key roles in all aspects of the experiment, on and off-site. With the detector 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. In each project, you are expected to work with the graduate students and postdoctoral fellows in the group.

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. We are also in charge of operating the CUTE facility at SNOLAB. The student will be involved in the daily operation of the local test stand or the CUTE facility, and will analyze the data from the detector. Daily presence in the department or at SNOLAB or other laboratory facilities is required.
Contact: Ziqing Hong

The other two projects will focus on simulations of signal processes and background sources for the SuperCDMS experiment and the CUTE facility. The simulation software packages are based on GEANT4 and G4CMP packages (written in C++), and managed with a Git code versioning system. The students will be expected to run this software on a high-performance computing cluster, validate and analyze the simulation output (using Python), make changes to the input/run parameters as necessary, and document the results. The specific goals of these two projects (e.g. calibration, detailed detector modeling, or machine-learning techniques for data analysis) will be defined as we get closer to summer 2025. All work for these projects can be performed remotely, although in-person presence at weekly group meetings is preferred.
Contact: Miriam Diamond and Pekka Sinervo

The research group, as well as the wider collaboration, emphasizes principles of equity, diversity & inclusion in the work environment.

For more information:

https://www.physics.utoronto.ca/research/experimental-particle-physics/supercdms-at-toronto/

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

http://www.snolab.ca/

2. Requirements:

- 2nd year or above required in a physics program of study, 3rd-year or above preferred
- Familiarity with C++, Python, and basic Linux command-line (or a willingness to learn quickly!)
- Interest in particle physics and/or condensed matter physics