All photos by: Alex Dekker

Left to right: Dr. Tyler Reynolds, Elspeth Cudmore (PhD student), Dr. Miriam Diamond (PI) Lucas Perna (PhD student), Zehua Sun (Undergrad student), Dr. Ziqing Hong (PI)

SOLVING THE MYSTERY OF DARK MATTER

Evidence for dark matter was first discovered when astronomers observed unexpected gravitational forces acting on distant cosmic objects. These gravitational effects implied the existence of matter that could not be seen because it does not emit radiation in any form, including light. Several decades later, this “dark” matter is still proving difficult to understand.

“We think dark matter — which makes up 25% of the matter in the universe — is a new subatomic particle that is not in the Standard Model of physics,” says Dr. Miriam Diamond, an assistant professor at the University of Toronto. Dr. Diamond works on the Super Cryogenic Dark Matter Search (SuperCDMS) team, a collaborative international project that aims to find the dark matter particle. The Canadian SuperCDMS team and their partners in the U.S., India, France, Germany, Spain and the United Arab Emirates have banded together to undertake what Dr. Diamond calls “the greatest treasure hunt in human history.”

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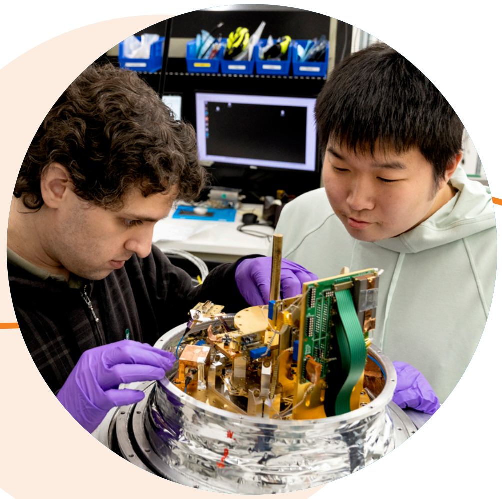
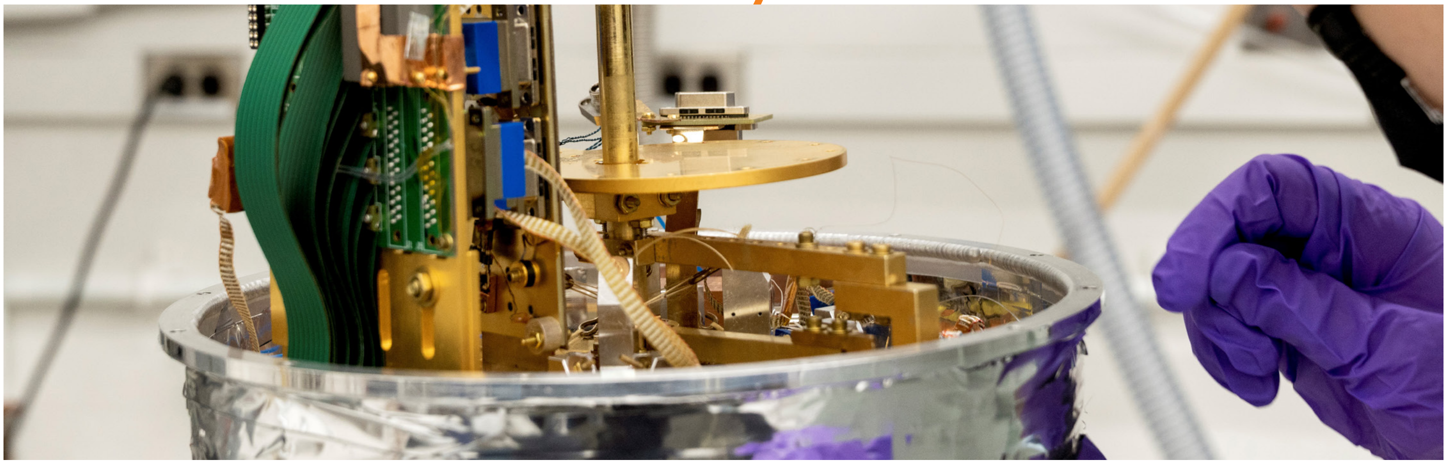


To find the dark matter particle, the project is building “the biggest and most sensitive detector we can afford,” says Dr. Ziqing Hong, assistant professor at the University of Toronto. The detector, made of pure silicon and germanium crystals, is housed in a cryogenic chamber at a temperature close to absolute zero. The cryogenic chamber is located 2 kilometres below the earth’s surface in the SNOLAB facility, which was built in a nickel mine near Sudbury for the purpose of neutrino detection.

In addition to operating the detection facility, Canada's role in SuperCDMS is focused on data acquisition. In this regard, a critical task for Dr. Diamond and her team is to filter out irrelevant signals ("noise") that could mask the signal produced by dark matter particles. Working deep underground acts to physically block background events such as cosmic rays or radioactive decay. But there are other kinds of noise, including noise caused by the experimental equipment, that must be identified and removed by precise, sophisticated computer algorithms. Creating, testing and refining these algorithms has been a major focus for Dr. Diamond and her team, which has quickly grown to comprise 7 graduate students, 4 postdoctoral fellows and 3 faculty members. In addition to filtering out noise, algorithms are used to convert raw signals into human-readable data that scientists can analyze.



Data storage and processing for this project requires hundreds of terabytes of disk space and hundreds of core-years of processing capacity. To avoid the risk that computer outages might disrupt the project schedule or result in data loss, storage and processing is being shared among Canada and three major centres in the U.S. About half the Canadian contribution to processing and storage has been supplied by SciNet, as part of a Digital Research Alliance of Canada allocation. SciNet is an Ontario DRI consortium led by the University of Toronto. We have been impressed with how stable the SciNet platform is and have really appreciated their flexibility when we have had to change our schedule because of things like COVID-19 outbreaks," Dr. Diamond says.

While SuperCDMS is about a year away from becoming fully operational, the work of building and testing the detectors and running simulations has already led to new learning about particle detection and other aspects of physics, Dr. Hong notes. The Canadian SuperCDMS team is supported by the McDonald Institute, NSERC and the Canadian Foundation for Innovation.