# Annual report

Exploring new frontiers in deep underground science

2020-2021

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# Our visionary partners







SNOLAB has established a bold vision: to be an internationally recognized laboratory and partner of choice in deep underground science, delivering world-class research, scientific discovery, and benefits to Canada and her global partners, by facilitating national and international access to its unique capabilities, facilities, and expertise.







## Contents

# Message from the Executive Director

I am proud to present the 2020-2021 annual report for SNOLAB which highlights how, despite a global pandemic, the SNOLAB community pulled toghther in a world-class way, to support people and progress the science. In the face of a challenging year, SNOLAB enacted the core values that our facility is built upon; you will see this reflected in the report that follows.

Through the continued focus of almost 150 staff and over 1000 users, we overcame obstacles to keep the lab running, the experiments advancing, and our community safe, by implementing robust COVID-19 mitigations and response actions. This annual report highlights advances made during the fiscal year 2020-2021, in which SNOLAB continued to operate with a focus on the health and safety of staff, users, and our community.

Significant progress was achieved on the construction, commissioning, and operation of several key detectors in the underground facility including NEWS-G, SENSEI, SuperCDMS, and SNO+. Aspects of the SNOLAB infrastructure saw advancements with upgrades to power and laboratory support systems. From the SNOLAB team's involvement in the creation of an emergency ventilator to face challenges created by COVID-19, to a complete reimagining of our outreach and professional engagement programming, SNOLAB continued to inspire and educate.

The successes outlined in this report were made possible by the unwavering support from a number of stakeholders including our Board of Directors and five Canadian University Joint Venture members, direct support from the Canada Foundation for Innovation and the Province of Ontario, and access to the 2km depths by Vale, our mining hosts.

**My sincere thanks to all!**

**Nigel J.T. Smith**
Executive Director, SNOLAB

# Foundational drivers

## SNOLAB vision

To be an internationally recognized laboratory and partner of choice for deep underground science, delivering world-class research, scientific discovery, and benefit to Canada and her global partners, by enabling national and international access to our unique capabilities, facilities, and expertise.

## SNOLAB mission

In support of its vision, SNOLAB will:

**Enable world-class science**

**Spearhead world-class science**

**Catalyze world-class science**

**Promote world-class science**

**Inspire and innovate**

# SNOLAB
# Board of Directors

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Chair
Professor of Physics,
McGill University

**Kimberly Strong**
Vice-Chair
Professor and Chair,
Department of Physics,
University of Toronto

**Sandra Crocker**
Associate Vice-President
(Research Planning and
Operations),
Carleton University

**Kim Devooght**
Director of Sales and
Advisory Services,
Pivotal Inc.

**Anthony Downs**
Digital Transformation
Global Leader, Vale

**Tammy Eger**
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**Aksel Hallin**
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**Mike Headley**
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Technology Authority, Laboratory
Director, Sanford Underground
Research Facility

**Julie Moskalyk**
Science Director,
Science North

**Robert Svoboda**
Professor of Physics,
UC Davis

**Kim Woodhouse**
Vice-Principal, Research,
Queen's University

# Core values

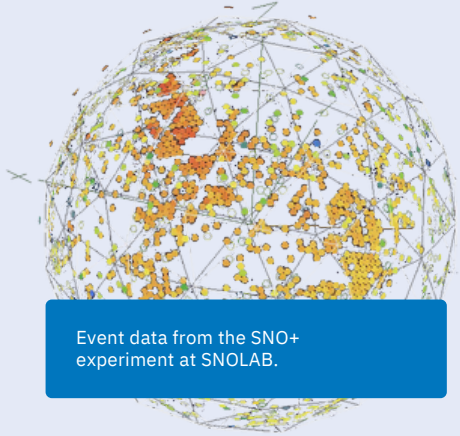
**Safety** - This is the foundation upon which we realize our mission: we are committed, both individually and as a team, to protecting the health and safety of our staff, users, and visitors.

**Excellence** - SNOLAB is committed to fostering a culture in which individuals make full use of their skills and knowledge, and provides opportunities to develop through continual improvement. Our focus is on delivering high-quality research, through driving, supporting, and enabling excellence in research and operations.

**Teamwork** - Our approach to teamwork is based on the belief that each member brings unique experience and important expertise to the workplace, allowing project challenges to be resolved and creating a work environment that supports cooperation and collaboration in all aspects of work.

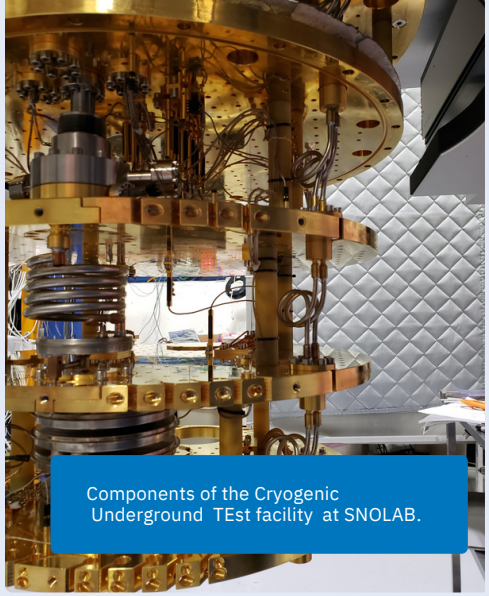
**Inspiration** - We strive to educate and inspire as a core component of our commitment to our public sponsors. To showcase the enthusiasm of our staff and users, and the excitement of the research undertaken, SNOLAB will continue to engage fully in professional and public outreach.

**Accountability** - SNOLAB is committed to upholding an environment of trust, responsibility, and accountability to our stakeholders. Accountability to our internal governance structures, external research communities, funding agencies, and public sponsors is an ongoing goal. Strong governance and effective management will guide our organizational development.



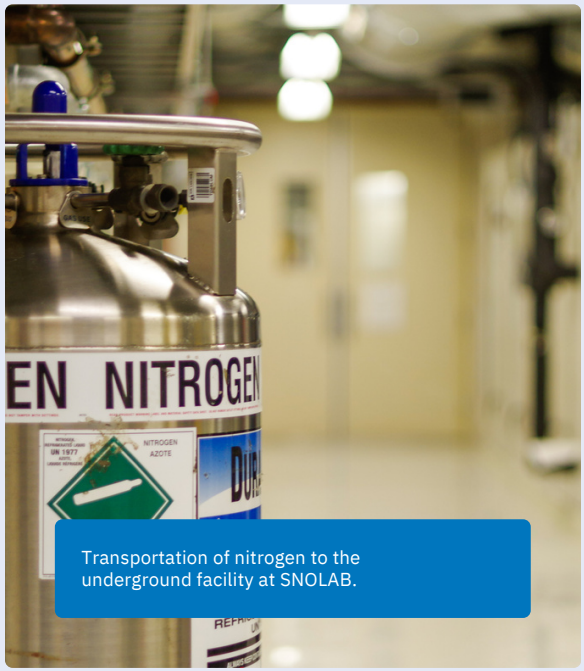
Event data from the SNO+ experiment at SNOLAB.

Construction of the seismic platform for the SuperCDMS experiment at SNOLAB.



Components of the Cryogenic Underground TEst facility at SNOLAB.

A member of the scientific support team in the chemistry and life science lab at SNOLAB.

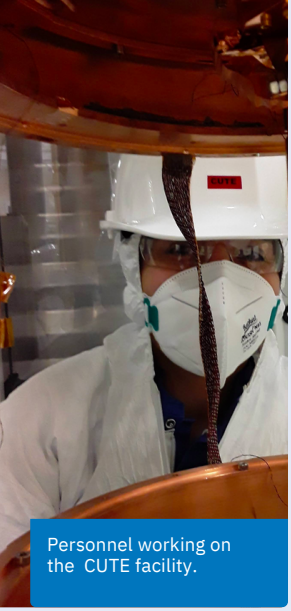



Transportation of nitrogen to the underground facility at SNOLAB.

Staff preparing supplies for COVID response initiatives.

Participants in the annual SNOLAB summer student talk competition, held virtually this year.

Construction of the NEWS-G experiment at SNOLAB.



Personnel working on the CUTE facility.

Cell cultures for the REPAIR experiment in the low radon glove box at SNOLAB.

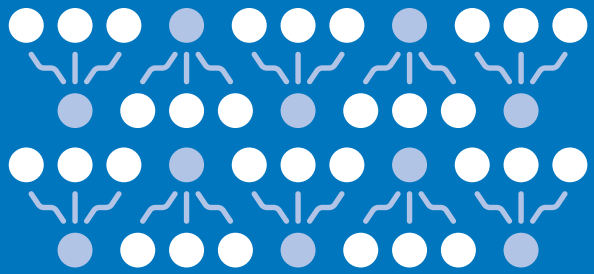
The FLAME experiment.


Launch of the *Drift: Art and dark matter* residency project online exhibit.

A research scientist working on the Cryogenic Underground TEst (CUTE) facility at SNOLAB.

The SENSEI detector under construction at SNOLAB via the remote guidance of collaboration members.

## Financial



**For every dollar of government investment, SNOLAB generates 3 dollars worth of economic impact**

## Showers

**5,000+**

## Underground shifts

**4,704**

## Visitors

**221**

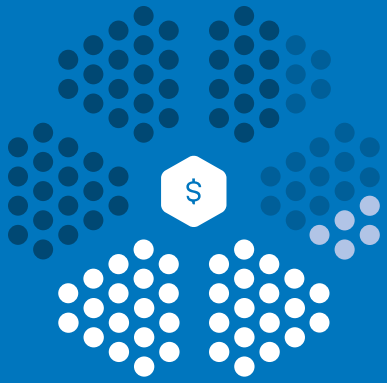
## EHS data

- Consecutive lost time injury-free days as of March 31: 74
- Injuries/illnesses reported requiring first aid: **5**
- Injuries/illnesses reported requiring medical attention: **3**
- Incident reports, including near misses: **12**

## Professional engagements

- **12** Presentations
- **27** High esteem engagements
- **9** Events hosted
- **16** Publications

## Funding & in-kind support



- CFI **$13,173,000**
- Ontario **$5.965,000**
- McDonld Institute **$283,000**
- Vale in-kind contributions **~12M**
- Federal COVID relief fund **$191,000**

**$31.17**

**+~12M In-kind**

## Users

**1015**

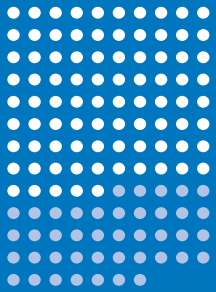
## Institutions

**130**

## Countries

**24**

## Employees



**154 Full-time employees**

**27 New employees** (including re-hires + students)

## Social

**3427** followers

**2032** followers

**3627** followers

# International community

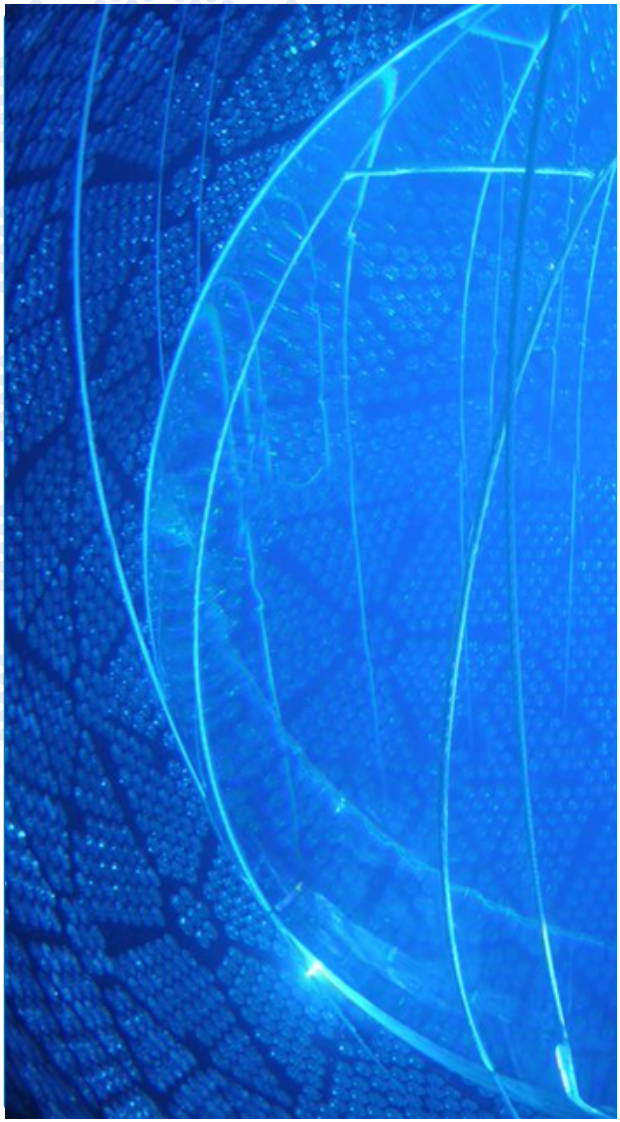
**SNOLAB hosts 1015 users representing 130 institutions across 24 countries**

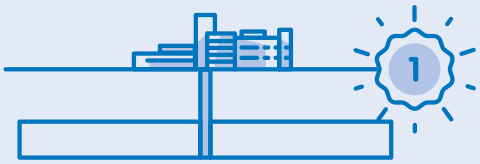
## Americas

Canada
Mexico
USA
Argentina
Brazil
Paraguay

## Europe & Asia

France
Germany
Greece
Israel
Italy
Poland
Portugal
Russia
Spain
Switzerland
Turkey
UK
China
India
Japan
South Korea




Strategic Goal 1

**Enable and spearhead world-class underground science**

## SNO+

The SNO+ collaboration reached a huge milestone in completing the linear alkyl benzene (LAB) liquid scintillator fill of the detector. To achieve the required purity levels, the LAB was refined and purified in a custom built scintillator plant that was constructed in the underground lab. The scintillator was continually monitored for quality during the fill and the backgrounds have been verified through assay and in-situ measurements to be better than the required specification. Filling the detector with LAB will make it more sensitive to neutrino interactions including low energy solar neutrinos, antineutrinos, and supernova neutrinos.

The SNO+ acrylic vessel now holds **787 tonnes** of liquid scintillator, all of which had to be shipped underground to SNOLAB in rail cars in the mine cage. Each of these purpose-built cars holds two tonnes, so in total it took about **144 rail car** trips to get the scintillator to the lab.

## NEWS-G

The NEWS-G detector was installed at SNOLAB. This success is the result of months and years of meticulous planning along with the combined efforts of collaboration members, SNOLAB staff, and technicians. Prior to installation, the copper sphere required a final cleaning, a chemical etching process, to remove any radioactive impurities. In March 2021 NEWS-G was ready for commissioning and is preparing for scientific data collection in 2022.

## SENSEI

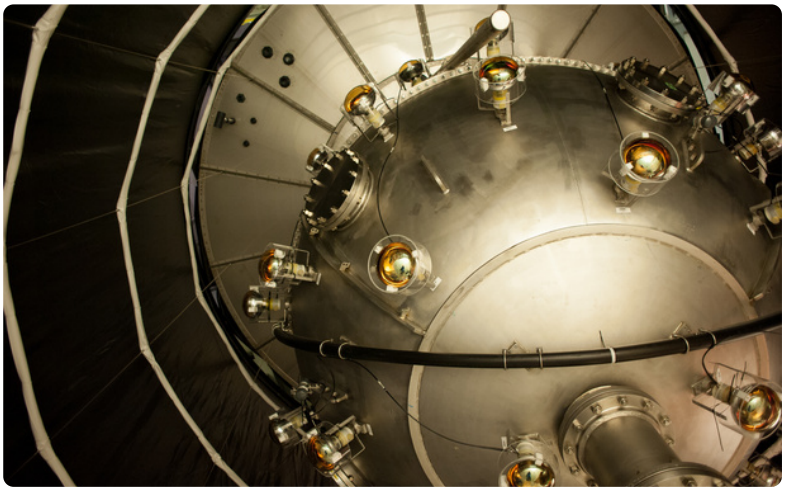
In the fall of 2020, members of the SENSEI Collaboration were awarded a Breakthrough New Horizons in Physics prize for advances in charged couple device (CCD) technology. The CCDs used in SENSEI are skipper CCDs made up of millions of pixels. This new technology allows for every electron within a pixel to be counted, leading to incredibly accurate measurements with no background noise. In the reporting year, all components of the SENSEI detector were received onsite. In response to the pandemic, SNOLAB staff completed the shielding and detector assembly under the remote assistance of collaboration members at Fermilab. SENSEI is a follow-on technology to DAMIC which continues to operate low threshold CCD detectors in SNOLAB and has published world leading results on low mass WIMP sensitivity. The next generation of this dark matter detection technology is OSCURA, which now in the conceptual design stage at SNOLAB.

## REPAIR

Now in the fifth year of operations at SNOLAB, REPAIR continues to research the effects of sub-natural background radiation and has expanded studies to include four types of organisms. Working with a team of SNOLAB scientists, engineers, and technicians, the REPAIR collaboration designed and commissioned a one-of-kind Specialized Tissue Culture Incubator (STCI), which proved to be one of the lowest radiation environments ever created for biological experiments. The first cell experiments began in winter of 2020 and new biological systems were introduced building on that success.

## DEAP-3600

DEAP-3600 analyzed data taken over four years and the collaboration published two papers: one on liquid-argon scintillation pulseshape and another where the collaboration worked with theorists to explore additional constraints on dark matter searches. DEAP-3600 completed its data run in 2020. The detector has been emptied and the team is completing hardware upgrades in advance of their third fill.



## Xenon Distillation Colum:

The xenon distillation column has been constructed and commissioned. A research and development project, this cryogenic distillation column is designed to investigate more economical isotopic separation of xenon isotopes to support the development of future experiments at SNOLAB.

Strategic Goal 2

**Develop and maintain world-class facilities and infrastructure**

## Liquid nitrogen plants

Two projects were resourced to improve the supply and production of high purity nitrogen in the underground lab. The first is a gas system coupled to the DEAP-3600 cryocoolers. The second is a larger system that will supply the needs for liquid nitrogen to experiments and infrastructure in the lab. This will remove the need to ship dewars underground, improving our operational efficiency.

## SNOLAB weekly brief

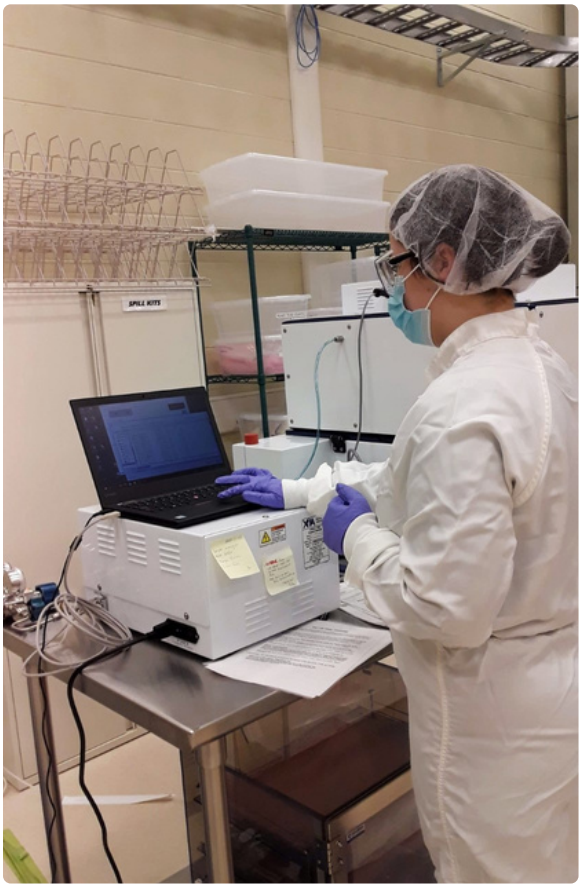
To provide timely and transparent information on site logistics along with updates on activities in the surface and underground facilities, the operations team circulated a briefing document each week. The SNOLAB Weekly Brief was created to communicate key information during our limited access mode of operation in response to the COVID-19 pandemic.

## Wireless access points

The SNOLAB IT team made upgrades to increase the distribution of wireless access points throughout the underground facility.  This initiative was an important improvement to our underground connectivity.

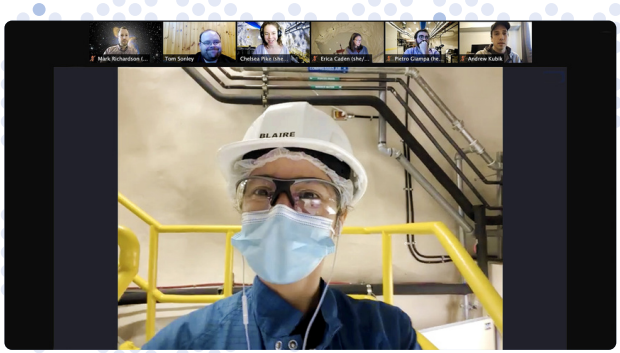
## Lab expansion study

The SNOLAB underground facility is approximately 5000m2  of clean room space that is comprises support infrastructure, experiment halls, and three large cavities. A study was initiated to obtain an understanding of the feasibility of an expansion to create new experiment cavities in addition to a resource plan. This positions SNOLAB to be ready to respond should the community demonstrate the need for additional space to host large-scale experiments in the SNOLAB underground facility.



## Power infrastructure

Advances on the diesel generator project were made to improve SNOLAB's electrical infrastructure and to meet the needs of large-scale experiments that have specific power requirements. As experiments hosted at SNOLAB become more sensitive and use more advanced technology, their operating conditions become more constrained. For example, SuperCDMS will operate at about 15 millikelvin. It takes time to achieve that low temperature, and a constant flow of electricity to the chillers to maintain it. When this power infrastructure project is complete, the three recently installed generators will provide reliable backup power to SNOLAB's underground facility in the event of a power outage. Each generator produces 1 megawatt and is capable of running for 3-4 days at full capacity using the built-in fuel tanks. The way the system is set up with at least two generators running at all times, they can power the lab for a week until refueling is needed.




### Taking E&O online

SNOLAB pivoted to accommodate a reduced access schedule by developing and delivering a virtual tour program that made use of newly upgraded wireless technology infrastructure in the underground lab. Live virtual tours were conducted for summer schools, conferences, and special events.

**"The SNOLAB tour was the best part of the summer school. It was exciting to see this incredible laboratory. It really opened up my eyes and made me more interested in the field."**

Strategic Goal 3

**Educate, inspire, and innovate**

## EDI Task Force

In 2020, SNOLAB initiated the formation of a task force to create an EDI Action Plan for the facility. This group conducted a survey of the staff and user groups to gain a baseline measurement, and to identify areas where SNOLAB can improve as an organization through the creation of a short-term EDI Action Plan. The action plan will guide SNOLAB from 2020 through to 2023 and is focused on creating meaningful and measurable progress and building a culture at SNOLAB that embraces equity, diversity, and inclusion.

## New public website

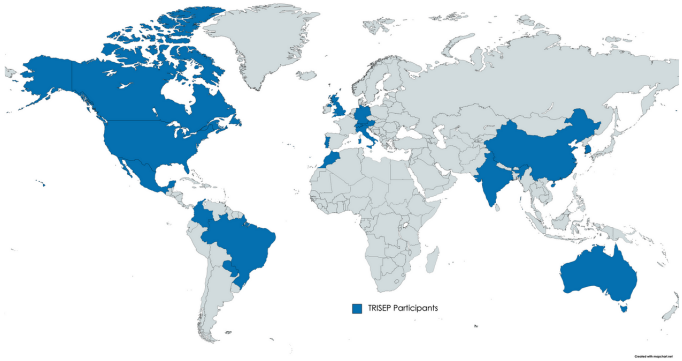
To communicate the science underway at the SNOLAB facility, and to improve the user experience, the SNOLAB Education and Outreach and Information Technology teams worked closely on the delivery of a new public website. This new site is optimized for mobile devices and the content communicates the science with stunning imagery. A new platform and features create a public site that is easy to navigate and beautifully designed.

## Bulletins

As a strategy to improve communications and connectivity among staff and users, a weekly bulletin was created to provide relevant information in an digestible format. Topics ranged from public health guidelines and time management to work from home resources and community engagement.

## TRISEP 2021 goes virtual

Due to the global pandemic, TRISEP 2021 was held fully online using the Zoom and Gather.Town platforms to host talks, group projects, and a colloquium, along with virtual dinner and games night. A significant increase from previous years, there were 104 applicants to the school and 80 participants from 18 countries.




## Drift artist residency and exhibit

The reporting year saw the launch of Drift: An Art and Dark Matter Residency that was developed in partnership with the Agnes Etherington Art Centre and the McDonald Institute. This trans-disciplinary residency explored the search for dark matter from an artistic perspective. The gallery exhibit was launched and began a national tour that will conclude in Sudbury in 2023. An online exhibit was also created to ensure this project was accessible to a broad audience.

## Dark Matter Day

SNOLAB took part in the organization of Dark Matter Day, an international outreach event hosted by the Interactions Collaboration that aims to shed some light on the cosmic riddle of dark matter. From Oct. 26-31 events around the globe highlight the search for dark matter. SNOLAB partnered with Science North to host a live chat and Q&A and created engaging campaigns for social media.

- **3 conferences supported**
- **31 SNOLAB-hosted seminars**
- **33 SNOLAB student presentations**
- **5 tech-transfer activities**
- **350 person days of training**

## Pro-Sapien

The SNOLAB EH&S team launched Pro-Sapien, a Microsoft SharePoint based EHSQ Management software. This paperless event reporting system replaced the use of the SNOLAB IIR and NCR form submissions is also used to report workplace violence and/or harassment.


Strategic Goal 4

**Develop delivery systems of internationally recognized standard**

### Microsoft 365 launch

With secure sign in features and user-friendly apps that are optimized for remote working, Microsoft 365 is allowing our teams to streamline tasks and processes to enhance our efficiently.

### Cyber security improvements

External consultants were retained to review and report on the security of SNOLAB's network infrastructure and Office 365 Email environment. During the reporting period, a security controls audit and report was completed on SNOLAB's IT operations and additional security controls were implemented on the email systems. A security awareness training program was sourced to improve awareness of staff and users.

### Creation of SNOLAB style guide

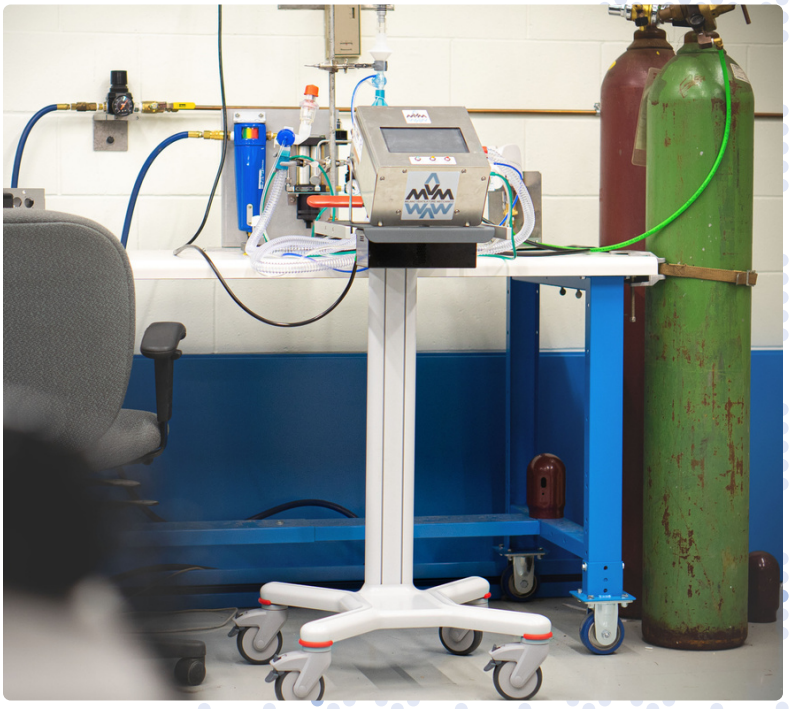
The SNOLAB style guide was launched to our share brand assets and to communicate critical communication guidelines including inclusive language recommendations and standards. This comprehensive document outlines SNOLAB's look and feel, writing style, and provides guidelines for the use of elements such as logo, tagline, etc. It helps make our organization more recognizable and keeps communications consistent as SNOLAB grows and becomes more recognized outside of the physics community.

## Local COVID-19 response

While COVID-19 mitigations impacted programming, our teams shifted their focus, took on new projects, and saw positive impacts. SNOLAB staff participated in local and national pandemic response initiatives such as the donation of personal protective equipment (PPE), including face shields 3D printed by staff, to local frontline healthcare workers. Members of our science team developed new technology utilizing UV light technology to sterilize N95 masks in the event of an absolute PPE shortage.

## MVM emergency ventilator

Early in the pandemic SNOLAB scientists, along with colleagues at Canadian Nuclear Laboratories, TRIUMF, and the McDonald Institute, joined the international MVM (Mechanical Ventilator Milano) collaboration. This group worked to quicky and safely develop a ventilator that could help ease the global shortage. Using gas handling expertise developed working on dark matter experiments and the collaborative nature of experimental physics, the scientists were able to design and prototype an emergency ventilator that used materials outside the typical supply chain and could be assembled quickly. In 2020 the MVM was approved for use by Health Canada. To date 6000 of the 10000 units ordered have been manufactured and delivered by VEXOS, a manufacturing facility in Markham, Ontario.




REFUGE

*Remember to look up at the stars and not down at your feet. Try to make sense of what you see and wonder about what makes the universe exist. Be curious.*

*- Stephen Hawking*

SNOLAB

Creighton Mine #9, 1039 Regional Road 24, Lively, ON, P3Y1N2 | 705.692.7000 | www.snolab.ca