

SNOLAB: A New International Facility for Underground Astroparticle Physics.

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Abstract. SNOLAB is a new international facility for Underground Physics currently nearing completion in Sudbury, Canada. In the following we present the status of both the construction project and the basic infrastructure available in support of the experiments. The status of the scientific programme, focused on dark matter searches, neutrinoless double beta decay, neutrinos and supernovae monitoring is also described.

1. Introduction

The past several years have been witness to great advances in the field of Astroparticle Physics. We now understand that neutrinos have a small, but finite mass, and flavour oscillations have been observed. Precision observational astronomy has also led to a new understanding of the Universe and its constituents. The Universe is now understood to be dominated by Dark Matter and Dark Energy, the nature of which remain complete mysteries today. A complete understanding of the neutrino sector, the origin of matter in the Universe and its integration into the standard model, is now a major industry world wide.

Experiments currently under design or operation aim to measure the mixing angles to high precision, determine the absolute masses or search for a CP violating phase that may give insight into the matter-antimatter asymmetry observed in the Universe today. Neutrinoless double beta decay experiments are searching for very rare nuclear decay processes which if observed may determine the absolute masses of neutrinos and will demonstrate that neutrinos are Majorana in nature. The Dark Matter is widely believed to be a new form of massive particle which will interact with normal material through weak interactions. These weakly interacting massive particles (WIMPs) may be observed through the detection of low energy nuclear recoils produced via the WIMP nucleon interactions. Numerous efforts are currently underway which attempt to observe Dark Matter particles through this direct detection.

These are very challenging experiments, as the experiments are looking for events which are difficult to observe, in a potentially large background, at a rate of order events per year per tonne of material. The next generation detectors currently under design aim to be able to probe these very low cross-sections using a variety of targets, and should challenge the theoretical predictions for the expected rates.

The experiments that will search for Dark Matter, Neutrinoless Double Beta Decay, as well as further solar neutrino experiments have in common the need for very large detector volumes with very low energy thresholds. The control of backgrounds in such experiments is paramount,

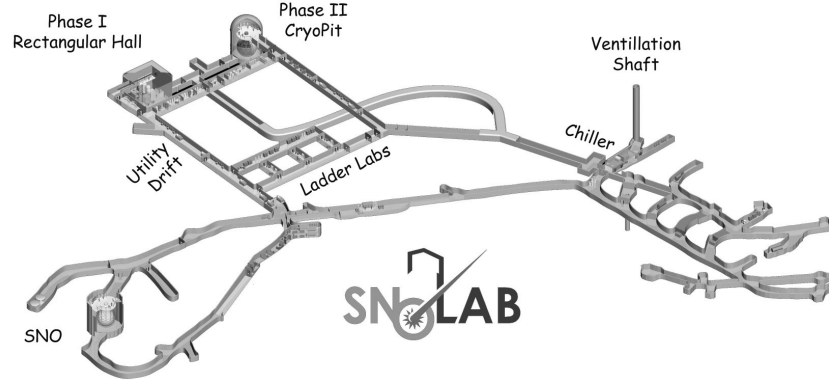


Figure 1. Schematic view of the SNOLAB facility. Only the cavern and utility room marked as SNO existed prior to the SNOLAB expansion.

Table 1. Underground Spaces in the new SNOLAB.

Phase	Clean Room Space		Experimental Area	
	Surface Area (m ²)	Volume (m ³)	Surface Area (m ²)	Volume (m ³)
SNO Original	1,133	13,321	752	11,679
SNO + Phase I	3,899	29,719	2,427	23,721
SNOLAB Total	4,942	37,241	3,055	29,555

and hence need to be performed in a deep underground laboratory in clean room conditions. SNOLAB was conceived in consideration of the need for such space in a deep clean underground laboratory. As an outgrowth of the very successful SNO programme, there was already one very large cavern, an established relationship with the mine owners (Vale-Inco), a highly skilled technical workforce and experienced physicists from SNO wanting to continue with an expanded astroparticle physics programme.

2. Description

SNOLAB was designed to be able to accommodate three to four large scale (order 1000 tonne) experiments, as well as a number of small to mid sized experiments. The large spaces are comprised of the existing SNO cavern, a new "Rectangular Hall" and a new "Cryopit". The latter has been designed to allow for high pressure bulkheads and a dedicated ventilation system that will allow the space to be operated safely with large volumes of cryogenic fluids or noxious gasses. Mid-sized experiments will be supported in the Ladder labs, and small experiments can be installed in a number of utility areas. Due to timing of capital funding, the Ladder labs and Rectangular Hall were excavated first in Phase I of SNOLAB, and the excavation of the Cryopit followed a few years later in Phase II of the project. The layout of the new facility is depicted in Figure 1.

Table 1 gives the total floor space and volume available in the existing SNO facility, as well as when combined with phases I and II. The main experimental halls have the dimensions as given in Table 2. In addition to this there are numerous utility areas.

Table 2. Sizes of main experimental halls and caverns in SNOLAB.

Phase	Length (m)	Width (m)	Height	
			to Shoulder (m)	to Back (m)
SNO Cavern		22 ϕ	24.2	30.0
Rectangular Hall	18.3	15.1	15.1	19.7
Cryopit		15.1 ϕ	15.1	19.7
Ladder Area 1	32.0	5.9	3.6	5.6
Ladder Area 2	22.9	7.5	5.1	7.6

SNOLAB also has a new building on surface, which has been occupied since 2005. This above ground facility supports experiments by providing research space including; four large clean laboratories, a clean assembly room, a low background counting facility, and a chemistry lab on the main floor. On the second floor, the facility has offices and meeting rooms, and on the third floor there are more offices, meeting rooms and experimental control rooms. In addition, there is a large auditorium suitable for collaboration meetings, a changing/showering area for personnel working underground, and an attached warehouse and machine shop.

To complement the physical lab spaces underground, SNOLAB also provides a significant amount of basic infrastructure. In addition to basic power, lighting, ventilation, water and fire protection, SNOLAB can provide a few specialty services including: ultra pure water, background counting facilities, chilled water and cooling, monitoring and slow controls for lab systems, liquid nitrogen, chemistry labs, and clean transportation of equipment and supplies. Finally, the facility will be operated by an experienced and highly skilled staff of about 40 personnel, including research scientists, engineers and technical staff.

3. Status of the Facility

The underground excavation of the two phases is 100% complete, finishing roughly two months ahead of schedule. The outfitting of Phase I and II (Installation of steel work, walls, painting, power, ventilation, lighting and plumbing) is progressing very well, and should be complete by October, 2008. Some aspects of the cryopit will not be outfitted until the experimental programme in that area is defined. With the excavation complete, the dirtiest work is finished and the experiments can now begin to install their experiment specific infrastructure.

4. Status of the Experimental Program

SNOLAB has held a series of workshops to help define the experimental program, and, conversely, to get input from prospective experiments to ensure that the lab design can cater to the needs of the experiments. Approximately 25 letters of intent have been received. These have been examined by an international experimental advisory committee, and an initial suite of experiments has been selected. The experiments presently being considered for installation or prototyping within the next two years are summarized in table 3. Roughly 50% of the space in the lab has been assigned for use by a number of these experiments.

Table 3. Initial Experimental Program.

Experiment	Physics	Status
PICASSO Ib	Dark Matter. Superheated Droplets with Spin-Dependent sensitivity	Prototype in Operation. Planning to scale up.
DEAP I	Dark Matter with Liquid Argon. 7Kg Mass Prototype. Scintillation and PSD	Installed in SNOLAB. Commissioning in progress.
MiniClean	Dark Matter with 360 Kg of Liquid Argon.	Installation of infrastructure foreseen for 2008.
DEAP/CLEAN	Large scale. Dark Matter with 3600 Kg Liquid Argon.	Installation of infrastructure in 2008.
SuperCDMS	Dark Matter with Germanium ZIP detectors.	Plan to upgrade and relocate from Sudan to SNOLAB.
SNO+	$0\nu\beta\beta$ Decay with Neodymium & Liquid Scintillator, Solar-, Geo- and Reactor-neutrinos	Reuses SNO detector. Currently working on design. Installation begins in 2008
EXO	Neutrinoless Double Beta Decay with Xenon Gas.	R&D in progress. Prototype envisioned for 2009.
HALO	Supernovae monitor. Hardware mostly pre-existing	Recently received funding for installation and operation.
PUPS	Seismicity , deep in the earth to avoid surface effects.	Installed and Operational.

5. Conclusions

SNOLAB, a new International Facility for Underground Astroparticle Physics, is essentially complete. The new space will be able to house several large next generation Dark Matter, Neutrinoless Double Beta Decay, Solar Neutrino, or Supernova Search experiments. SNOLAB also has space for several small or medium sized experiments. Finally, SNOLAB welcomes interests from other disciplines.

SNOLAB has approved a number of experiments for installation in 2008 and 2009, and several experiments are already running prototypes in the original SNO lab. The physics program looks rich and exciting. SNOLAB is well poised to act as host to a number of potentially world leading astroparticle physics experiments in the deepest and cleanest facility in the world. Discoveries made at SNOLAB have the potential to be of the greatest fundamental importance. The future for astroparticle physics at SNOLAB is very bright.