The **SNOLAB** Strategic Plan
2012-2017

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Dear Colleagues

I'm pleased to present to you, on behalf of the Board of Management, the SNOLAB Strategic Plan for the five-year period 2012-2017. This plan makes possible an exciting scientific opportunity, and one that the SNOLAB scientists, support staff and the four University member institutions, are strongly committed to.

This strategic plan arose from a process launched by the SNOLAB Institute Board of Management in November 2010, involving a consultation with the subatomic physics community in Canada and allied research areas. The Strategic Planning Committee then prepared a draft report, which the Board circulated for consultation with the stakeholder communities. The final report was approved by the Board of Management in August 2011.

SNOLAB has a clear vision and mission that will enable it to maximize the benefits SNOLAB brings to Canada, not just in leading-edge discovery and advancement of knowledge, but also in Canada's ability to develop and retain the very best scientists in Canada. I'm particularly excited with the inspiration in science and discovery that comes with a project such as SNOLAB.

My warmest wishes,

Pekka K. Sinervo

Pekka K. Sinervo, FRSC
Chair, SNOLAB Institute Board of Management

Executive Summary

SNOLAB is a world-class deep underground science facility based at the operational Vale Creighton nickel mine, near Sudbury, Ontario in Canada. The combination of great depth, at 2km SNOLAB is the deepest large-scale international facility in the world, and cleanliness that SNOLAB affords allows extremely rare interactions and weak processes to be studied. This strategic plan details the vision, mission and goals of the SNOLAB facility in developing the required infrastructure to undertake these science objectives, and to help SNOLAB foster, support and spearhead the science programmes. The plan covers the period between 2012 and 2017 when SNOLAB construction will be complete and the initial science programme is being realised.

The science programme at SNOLAB is currently focussed on sub-atomic physics. This follows the great success of the original SNO detector operated at the SNOLAB site, which resolved the 'solar neutrino' problem and provided categorical evidence that new physics existed beyond the standard model of particle physics. The current programme continues to study the elusive neutrino and also searches for the unidentified dark matter that constitutes some 23% of the Universe. Additional science strands are currently under development, linking into the wider underground physics community, including geology, mining and deep sub-surface life.

There are several intended audiences for this document. The strategic plan will guide SNOLAB management in the prioritisation of resource use, allowing a focus on projects that align with the strategic aims of the SNOLAB community. The plan is owned by the SNOLAB Institute Board and will provide a benchmarking document for oversight, to assess the effectiveness of the facility and the management team. Finally the entire SNOLAB community drives the strategic direction and so this document provides a vehicle for engagement and alignment with our community.

The vision of SNOLAB is to be the partner of choice for underground physics projects, providing world-class infrastructure and thereby delivering world-class science. To realise this vision our mission is to enable, spearhead, catalyze and promote underground science, whilst inspiring both the public and future professionals in the field.

To deliver the mission and place SNOLAB in a position to realise the long-term vision, four goals have been identified, with associated objectives and critical success factors. These goals focus on the four key areas and strengths of SNOLAB: the science programme, the facility infrastructure, the staff and community working to deliver the programme, and the development of the quality delivery systems required to do so. These four goals are:

- Enable and spearhead world-class underground science
- Develop and maintain world-class facilities and infrastructure
- Educate, inspire and innovate
- Develop quality delivery systems of internationally recognised standard

This strategic plan also enunciates the ambitions of the SNOLAB facility, through development of the opportunities that arise within the science community that SNOLAB supports, through development of the SNOLAB infrastructure, and through development of longer term strategic planning by our stake-holding partners. SNOLAB looks forward to an exciting future contributing to the underground science community.

Vision

The future vision for SNOLAB is:

To be the location and partner of choice for deep underground science, delivering world-class science and benefit to Canada, and her international partners, by providing and promoting national and international access to the unique facilities and expertise at SNOLAB.

Mission

The current mission of SNOLAB, in line with its vision, is to:

Enable world-class science to be performed at SNOLAB by national and international experimental collaborations, providing scientific underpin, technical skills and knowledge, generating and developing international connections, and through development of a strong reputation; SNOLAB will also provide risk mitigation, reacting quickly to challenges/crises to enable the efficient execution of the scientific programme

Spearhead world-class science at SNOLAB through its own research group as part of the international and national community, developing synergies with other groups worldwide;

Catalyze world-class science at SNOLAB by providing a sought after collaborator in its own right and through providing transformational opportunities for collaboration and knowledge exchange to other groups through workshops, external connections and local interactions;

Promote world-class science and societal benefits through a strong public and professional outreach programme, and through technical knowledge development and transfer;

Inspire the next generation of innovators through strong educational outreach, knowledge transfer and the training of highly qualified personnel;

Organisational Values

We commit to five core values as an organisation, in achieving the mission objectives of SNOLAB:

Safety

SNOLAB has an overarching emphasis on the safety of its programme. This is the foundation upon which we realise our mission. We are committed, both individually and as a team, to protecting the health and safety of our staff, users and visitors. We are aided in this process by the expertise and experience of our staff, safety teams, regulatory bodies and Vale, our hosts.

Excellence

Achieving the highest standards in research, operations, and management is paramount. SNOLAB is committed to fostering a culture in which individuals make full use of their skills and knowledge, and provides opportunities to develop through continuous improvement. Our focus is on delivering world-class research, through supporting and enabling excellence in research and operations.

Teamwork

The greatest resource SNOLAB has available is the expertise of diverse, competent people within its staff and community. Our approach to teamwork is based on the belief that each member brings a unique experience and important expertise to the workplace, allowing project challenges to be resolved. Together, we will exemplify a respectful 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 disseminate 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. To maximise the benefit from investment in people, we will continue to engage in educational and highly qualified personnel development programmes.

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 our goal. Strong governance and effective management will guide our organizational development. SNOLAB will facilitate the full lifecycle of research projects from conception to completion and aims to create a supportive research environment that ensures effectiveness and positive outcomes.

Situational Analysis — The SNOLAB Facility

Overview of SNOLAB

SNOLAB is a unique world-class international facility for deep underground science, located 2km underground in the Vale Creighton mine, near Sudbury, Ontario. The science programme at SNOLAB is primarily focussed on sub-atomic and astro-particle physics, specifically the search for the dark matter that makes up 23% of the matter in the Universe, and the study of neutrino properties and sources, such as the neutrino mass, mixing angles and terrestrial, solar and supernova production sites. This programme requires a variety of detector technologies but both fields ultimately require multi-tonne detectors that can operate in the ultra-low radioactivity background environment that SNOLAB provides. These particle detectors utilise a variety of target materials including liquid scintillator, liquid argon, solid and liquid gels, and are generally built through large, international, multi-institutional collaborations. The required support infrastructures for these experiments have, in many cases, projected lifespans of many years. Other research opportunities are occurring in areas such as rock characterisation, geotechnology, geochemistry and subsurface microbiology, which are being explored as potential future activities.

The great depth at which SNOLAB is located is required to shield these sensitive detection systems from the ubiquitous cosmic radiations that bombard the surface of the planet. By placing 2km of rock between the detectors and the surface these cosmic rays are sufficiently attenuated, by a factor of 50 million down to one cosmic ray muon every day per $4m^2$, that the rare and exquisite signals from the science of interest can be separated from the signatures from other backgrounds.

The facility includes a surface building which houses offices, conference rooms, IT systems, clean-rooms, electronics labs, warehousing and change rooms. The underground facility is located at a depth of 2070m and comprises $5000m^2$ of clean room facility, at better than Class2000, including three large detector cavities. In addition to the required health and safety systems and user support services, support infrastructure for experiments within the underground laboratory include HVAC, electrical power, ultra-pure water, compressed air, radiological source control, radio-assay capability, chemistry lab, I.T. and networking, and materials handling and transportation. The very specific requirements of developing and operating experiments in an underground laboratory are supported by a staff of ~50 covering business processes, engineering design, construction, installation, technical support and operations. The SNOLAB scientific research group connects to the experiments and provides expert and local support, as well as undertaking research in its own right as full members of the research collaborations.

The construction phase of SNOLAB was supported by capital funds totalling $70M, including an initial $38.9M capital award from the CFI through the International Joint Venture programme. These funds were managed by Carleton University on behalf of the SNOLAB Institute members. The Ontario Innovation Trust, the Northern Ontario Heritage Fund and FedNor provided the remaining funds for the construction. Operating costs have subsequently been supported by CFI, NSERC, Ontario ORF-RE and by the member institutions. The City of Greater Sudbury is supporting public education.

SNOLAB Core Competencies – the location of choice

At the heart of the SNOLAB philosophy is the ability to host experiments in an extremely quiet radiation environment, shielded from cosmic ray muons by extreme depth, and radiation from the environment by clean-room operation and high purity shielding systems. At a depth of 2070m, SNOLAB is one of the deepest underground laboratories in the world, with a flat-overburden providing a readily characterised and understood cosmic ray muon flux. Cleanliness of the entire laboratory is one of the unique design characteristics of the facility, with access to the laboratory controlled for both personnel and materials to remove dust contamination. HEPA filtering ensures no contamination from ventilation air, services are installed with easy access for cleaning, and infrastructure and the fabric of the facility are designed to minimise dust creation and simplify cleaning. All these steps are taken to ensure experiments do not need to construct clean-room structures themselves, minimising cost to the experiment, minimising deployment timescales, maximising utilisation of the laboratory space, but also capitalising on the expertise of the SNOLAB staff and ensuring no possible cross-contamination between projects. A less obvious, but substantial, benefit is the ability to rapidly deploy into a clean environment small, low cost, R&D and progenitor systems for experiment development, without incurring the additional cost for environmental control. In addition to the underground facilities, including unallocated space, the availability and access to surface clean laboratories and support services at both the Creighton site and Laurentian University provide the ability for radiochemical assay, experiment preparation, calibration and minor experiment machining and modifications.

Beyond the physical capabilities and characteristics of the facility itself, significant expertise is invested in the staff and user support at SNOLAB. Deployment of the complex systems required for current and future detectors requires multiple competencies be engaged to ensure health and safety, physical constraints, detector integrity and experiment services are all accommodated successfully. These competencies cover design engineering, service specification and installation, business processes, hazard and risk analysis and mitigation, health and safety assessment and regulatory compliance, science constraints, physical transportation and cleaning, installation and science delivery. All these competencies are available within the skilled staff at SNOLAB, drawn together through the strong scientific expertise of the local research group. SNOLAB also draws heavily on the extensive strengths of its University partners and the TRIUMF national laboratory for particle and nuclear physics.

The scientific community within Canada, the Institutes for Particle Physics and Nuclear Physics, federal and provincial funding agencies, continue to strongly support SNOLAB. This provides essential confidence in future operations and stability of the research environment. This tremendous stakeholder support includes the host mining company, Vale, which continues to provide extensive in-kind support to SNOLAB. This in-kind support allows SNOLAB to operate a highly efficient organisation, focussing on the delivery of science. SNOLAB also benefits greatly from strong connections to the local science outreach organisations, especially Science North, which provides a conduit by which we can undertake one of our key missions of inspiration.

The unique factors and core competencies detailed above, in physical characteristics and capabilities, staff and research competencies and expertise, community and stakeholder support and local networking make SNOLAB the location of choice for deep underground science.

The National Landscape

As a national facility, SNOLAB benefits greatly by extremely strong connections to institutions and other facilities within Canada. These national linkages are essential in providing a strong framework in which the unique capabilities available within Canada are enhanced and exploited. Strong coupling to Canadian University groups is crucial in providing SNOLAB with the required linkages to the academic and research communities for programme execution and development, providing significant leverage across the Canadian science and engineering base.

SNOLAB has strong connections to TRIUMF and Perimeter Institute at both a technical and management level. TRIUMF, as Canada's national laboratory for particle and nuclear physics, provides a national detector development and construction capability which augments the capabilities at SNOLAB. The Perimeter Institute, as a focus for national theoretical physics, provides a theoretical under-pinning which guides the experimental programmes and physics interpretation of results produced. The combination of SNOLAB, TRIUMF and Perimeter Institute provides complementary skills and capabilities, which afford Canada a truly global advantage in sub-atomic physics.

The International Landscape

SNOLAB is one of a growing family of underground facilities around the world. As the required space for underground science continues to increase, new facilities and expansions to existing sites have been developed, or are being planned. Underground facilities generally take two forms: cavities excavated within mines, either operational or not, and cavities excavated within mountains as part of tunnel complexes for transport or power generation. Commonly those facilities within mines, such as SNOLAB, require vertical access through shafts, those within mountains are usually reached by horizontal access by vehicle (although there are sites which break this generality). Facilities may also need to contend with differing constraints based on interference from nearby activities, such as mining, road and rail traffic, legislative issues, impact on the local environment and communities, etc. Access to facilities may vary depending on the national or international nature of the laboratory, the access protocols and experiment peer-review processes and, of course, funding and cost of operations. All of these factors come into play when determining the most appropriate location of an experiment, in addition to the various background constraints that may dictate depth, cleanliness and shielding for a detector.

Existing facilities continue to support experiments in France (LSM), Italy (Gran Sasso), U.K. (Boulby), U.S.A. (Soudan), Russia (Baksan) and Korea (Y2L). A new modest deep underground facility has been developed in China (CJPL), with completed expansion of facilities in Spain (LSC), Japan (Kamioka) and the U.S.A (SUSEL). Future development of underground laboratories is planned in Argentina (ANDES), France (Modane), Finland (CUPP), India (INO) and the U.S.A. (DUSEL). The planned DUSEL development is an extensive programme, providing space for both mega-tonne scale detector systems at shallower depths, with a potential for smaller expansion at SNOLAB equivalent depths should funding allow.

SNOLAB maintains linkages into the international underground physics facilities and associated communities by engaging in global networking, strategy and planning activities. SNOLAB maintains a discussion forum for the Directors of the deep underground facilities, and provides networking opportunities for dissemination of best practice throughout the facilities. The Experiment Advisory Committee, as an international peer review group, provides connections into the contemporary complementary activities around the world, ensuring that the SNOLAB science programme is both relevant and timely.

SNOLAB currently provides a unique capability, with strong core competencies detailed previously. The combination of depth, cleanliness, available space and expertise of the support staff and research team make SNOLAB a highly attractive location for the international research community. It is envisaged that SNOLAB will play a leading role in the underground community for many years as the natural host for kilotonne scale detectors systems that require great depth.

Governance of SNOLAB and accountability

Oversight and governance of the SNOLAB facility and the operational management is through the SNOLAB Institute Board of Management, whose member institutions are Carleton University, Laurentian University, Queen's University, University of Alberta and the Université de Montréal. Faculty at these institutes are fully active participants in the research programme at the SNOLAB facility. The SNOLAB Institute, on behalf of these member institutions and other stakeholders, provides direction in all affairs of the organization to ensure the organization has the means, quality, depth and continuity of management required to realize its major scientific and operational objectives. As one component of the accountability of SNOLAB to its stakeholders, the Board of Management also undertakes audit of the performance of SNOLAB and its Directorate, ensuring financial, health and safety, quality management, technical and scientific performance are exemplary.

The SNOLAB Institute is operated under a Trust agreement between the institutions, and includes external and international membership from both academic and industrial sectors. Vale has a seat on the Board of Management as the host organisation for SNOLAB, and as our industrial partner, with the chair of the Scientific Executive Committee also being a voting member. The SNOLAB Institute is formally an unincorporated Institute of Queen's University, providing overarching accountability, with each University partner acting as Trustee for SNOLABI assets.

Situational Analysis – The SNOLAB Science Programme

The measurements that can be performed in the unique underground environment at SNOLAB address some of the most fundamental questions in contemporary astro-particle and particle physics. The ability to address some of the most profound scientific issues of our era is a key driver in the development of the strategic scientific direction for SNOLAB. . These questions, and the research programmes required to address them, have been consistently endorsed in community research strategic plans within Canada, North America, Europe and Asia.

The ability to experimentally illuminate such questions as the development and fate of the Universe, the nature of the underlying physics of sub-atomic particles, and understanding the most extreme environments in the Galaxy, all ensure the scientific programme at SNOLAB remains inspiring and compelling for both public and professionals. Research in all of these areas is on the cusp of delivery; we are standing on the verge of major advances in our understanding of the Universe.

Astro-particle and Particle Physics – Dark matter studies

What are these Dark Matter particles left over from the Big Bang that make up a substantial fraction of the Universe and influence its evolution, and how do they fit into or modify the basic laws of elementary particle physics?

Over the last few decades, significant progress has been made in developing a concordant model for cosmology and understanding the prime components of the Universe, most of which are still unknown to us. This model is derived from a wide range of astronomical and cosmological observations, including cosmic microwave background studies, supernovae measurements at high redshifts, dynamical studies of structures on all scales and Big Bang modeling of nucleosynthesis. In this model, the Universe comprises 73% dark 'energy', 23% non-baryonic dark matter (weakly interacting massive particles - WIMPs), and 4% baryons. Currently favoured extensions to the standard model of particle physics would predict a whole new class of particles, which would be prime candidates for this dark matter. Within the standard cosmological model, the non-baryonic dark matter gravitationally seeds the creation of galaxies, with a current mass density within our own Galaxy of some 0.3 GeV/cc. Research programmes at SNOLAB aim to observe this Galactic dark matter, resolve what these particles are and how they are incorporated into the standard models of particle physics and cosmology.

The current programme at SNOLAB includes several Galactic dark matter searches using a variety of target materials and different techniques. The sensitivity of each experiment system is defined by many variables, such as target mass, energy threshold, background rejection and the constraints of the intrinsic detection technique, be it ionisation, scintillation or thermal. As the required sensitivity increases, or, in the event of dark matter observation, the physics exploitation occurs, larger detector systems will be required. Already in operation at SNOLAB are smaller scale detectors used for progenitors and R&D, but setting dark matter limits in their own right. PICASSO uses 2kg of superheated Freon liquid in a temperature and pressure controlled gel, such that a dark matter interaction in the Freon causes an audible transition. The fluorine in the Freon provides an ideal target to explore the spin-dependent coupling of dark matter particles in the nuclear recoil interactions. COUPP uses CF_3I as a target in a bubble chamber, with visual identification of the interaction points of a scattering dark matter particle. Both of these detectors are "gamma-blind" ensuring only nuclear recoils are detected, and are focussed on the reduction of backgrounds in the detector systems. Both have plans to increase the target mass of material within the experiments, COUPP planning to deploy a 60kg chamber during 2011.

Currently under construction, with planned start-up dates of 2012, are the DEAP-3600 and MiniCLEAN detectors. Both of these systems use liquid argon as a target medium, with an active volume of 3.6 tonnes and 500kg respectively. These detectors rely on scintillation light within the argon being detected by an array of photomultipliers tubes, and the high discrimination between incident particle species afforded by argon. The use of a large volume of liquid argon also provides significant self shielding and event location or fiducialisation of the detector volume, providing significant background rejection and suppression capability.

The near future also sees the anticipated deployment of SuperCDMS. CDMS has been a leading collaboration in the dark matter search community, and the SuperCDMS detector would see the deployment of up to 250kg of high purity cryogenic germanium detectors with exquisite energy threshold, particle identification and backgrounds. SNOLAB stands ready to host this exciting detector programme.

As the current and near-term programmes come to fruition, it is expected that the dark matter community will coalesce around two or three detection technologies in the drive to develop larger scale detectors to either improve sensitivity, or increase count rate. On a longer time frame, multi-tonne detectors will be required in dark matter studies. SNOLAB is well suited to deployment of such detectors.

Astro-particle and Particle Physics – Neutrino studies

What are the masses and transformation properties of neutrinos and how do they fit into the basic laws of physics? How do stars collapse into Supernovae, generating neutrinos and a substantial fraction of the elements in the Universe? What are the detailed properties of our Sun and its energy generation processes? Does nuclear fission contribute to heating the Earth?

Neutrinos, the most prolific particles in the Universe, have long been a source of surprise and discovery. The SNO detector, the antecedent for SNOLAB, provided conclusive proof that these particles were transmogrified from one flavour to another in transit, thereby confirming that these particles possess mass, and confirming the standard solar model for stellar burning. Incorporating these particles into the standard model of elementary particle physics now requires new physics to provide a mechanism for them to acquire mass. These new ideas range from the introduction of a new 'sterile' neutrino, through neutrinos with new natures, to additional fields in the standard model with significant coupling to neutrinos. These ideas are testable though a combination of accelerator-based and deep underground studies.

All of the massive fermions, of which the neutrino is one, have distinct anti-particles. Many of the theories developed to incorporate neutrino mass infer that the neutrino is its own antiparticle, similar to most force-mediating gauge bosons. A consequence of this nature would be the possibility for neutrino-less double beta decay, the observation of which would confirm the neutrino nature, and provide an extremely sensitive approach to directly measure the neutrino mass and mass hierarchy. A positive observation would open a window on fundamental physics at an energy scale totally inaccessible through other means.

The observation of oscillations in neutrinos by the SNO and Super-Kamiokande detectors used water Cerenkov emission techniques. This technique has an energy threshold which means that much of the spectrum of solar neutrinos is not observed in these detectors. There are important tests of neutrino properties that can be carried out by measuring the low energy neutrinos from other nuclear fusion reactions, such as the pep reaction, and one may be able to detect directly the rate of the sub-dominant CNO energy production cycle in the Sun.

In addition to these non-terrestrial sources of neutrinos, a low energy threshold would allow observation of neutrinos from Canadian nuclear reactors by SNOLAB based experiments. Such observation would provide additional information on neutrino oscillation parameters. Observing the antineutrinos from nuclear fission within the Earth would measure directly the total amount of uranium and thorium in the Earth. Understanding the radiogenic portion of the Earth's heat flow would provide fundamental information for geoscientists.

Supernovae are the explosive catastrophic release of energy that occur at the end of the life of a massive star, with almost 99% of the energy in a supernova given off as a burst of neutrinos. Detection of such a burst would provide unique information about the physics of the supernova process and the material through which the neutrinos propagate. The neutrino flash reaches the Earth several hours before any optical signal is produced, due to diffusion of the optical photons, and so may be used to alert the astronomical community of this very significant and rare event.

The current SNOLAB programme includes projects seeking to answer these questions about the intrinsic neutrino properties, and both terrestrial and cosmic sources of neutrinos. The SNO+ detector reuses much of the original infrastructure of the SNO experiment, replacing the kiloton of heavy water in SNO with 850 tonnes of LAB-based liquid scintillator, whilst maintaining and improving on the low backgrounds achieved in SNO. Transferring from Cerenkov to scintillation as the primary detection process allows the reduction in energy threshold needed to explore this new physics. The scintillator in SNO+ will also be loaded with neodymium for one operational phase, searching for the ^{150}Nd neutrino-less double beta decay signature expected if the neutrino is its own antiparticle. SNO+ also affords the opportunity to study terrestrial neutrino sources and maintains a capability for supernova detection. SNO+ is expected to turn on in 2012, with a decadal science programme. The HALO project reuses the SNO He-3 neutron detectors, within a matrix of 80 tonnes of lead from a decommissioned cosmic ray neutron counter at Chalk River. This efficient recycling of material allows the construction of a dedicated supernova detector, using the lead as a neutrino target from a supernova burst, and linking into the SNEWS early warning network. HALO will start operations in 2011.

In the near future, SNOLAB anticipates deployment of two additional neutrino detectors, both focussed on neutrino-less double beta decay, but using different technologies and source isotopes. EXO is a liquid/gaseous xenon detector, currently deployed in a 200kg liquid mode at the WIPP site in the U.S. Development of gas targets and larger scale xenon detectors has been underway at Carleton, with an expectation of deployment of both progenitor and larger scale systems in the near future, starting 2012. The COBRA detector is a room temperature CZT semiconductor detector, with an R&D phase currently underway at Gran Sasso. A statement of interest has been received from COBRA for a future deployment of a large scale experiment.

As these detector systems deliver greater sensitivity, they will directly address the questions posed within the neutrino sector of contemporary physics. On a longer time frame, larger detector systems at the multi-tonne scale will be required in double beta decay systems. SNOLAB is well suited to deployment of such detectors, as the collaborations coalesce around the favoured technology.

Mining – CEMI and the "Deep Mining Observatory" (DMO)

An initiative that has recently started at SNOLAB is the connection to the local mining innovation community. This is primarily undertaken with the Centre for Excellence for Mining Innovation (CEMI), located in Sudbury, a collaboration between academia and the mining industry, both local and international, including Vale the SNOLAB host organisation. CEMI has been highly effective in drawing together the required research teams to address the challenges faced by the mining industry as deep mining becomes ubiquitous. The CEMI vision is modelled on the successes of the particle physics community, with a distributed network of instrumentation and test sites across many mining environments, collectively forming a "Deep Mining Observatory". The driver for this collaboration is the scale and interconnectivity required within this research field, issues that have been successfully addressed within the SNOLAB physics communities.

Acting as a focal point for the research teams, a collaboration between CEMI and SNOLAB would also provide a mechanism to capitalise on the data management and interpretation skills and expertise available within the SNOLAB community. Supporting a central data management point for both local and remote mining-related CEMI research projects, SNOLAB can lever the significant experience gained in managing and supporting the academic-industrial connection, whilst developing the research base that it supports. This unique collaboration provides an exciting opportunity for SNOLAB aligning with the requirements of the local mining communities and provides significant federal and provincial relevance and political engagement.

BGE (Biology, Engineering, Geology)

SNOLAB has already hosted a distributed network of seismometers for the PUPS experiment; a project now completed which studied surface and underground effects in a seismic event. Further opportunities in this field are being developed cohesively across North America, with SNOLAB as a potential site for such studies. In addition to geological and geotechnical studies, access to deep underground sites also affords opportunities for studying deep subsurface, chemoautotrophic life, geo-chemistry and the evolution of gases within rock masses.

This area of research would benefit from the development of a similar distributed test-site model, as for the CEMI project. Neither BGE nor the DMO concept requires the clean, deep facilities SNOLAB provides, but benefits from the data management, accessibility, assay and chemistry support available in the surface facilities at SNOLAB.

Low background centre of excellence in Sudbury (SNOLAB, Laurentian, Cambrian)

Through the influence of the original SNO detector, and the pioneering work undertaken to develop low background detectors and assay materials to extremely low levels of radio-isotopic contamination, Sudbury has significant local expertise in this demanding field. A natural extension of this confluence is the development of a centre of excellence for low background studies, which incorporates and maximises the available expertise from SNOLAB, Laurentian University and Cambrian College. Such a centre would capitalise on the low background HPGe detectors at SNOLAB, the ICP-MS capabilities at Laurentian and Cambrian, and the significant assay and counting experience at Laurentian and SNOLAB. The intention is to explore and develop this exciting opportunity over the five years that this plan encompasses.

Strategic Goals, Objectives and Critical Success Factors

Strategic Goal: Enable and spearhead world-class underground science

The Goal

To ensure SNOLAB supports, maintains and executes a world-class research programme, and plays its own significant role in the shaping and delivery of the science.

Objective

The primary objective is to continue to develop, with the current SNOLAB user community and potential new partners, a programme of world-class research that utilises the key benefits and core competencies of the facility. This objective encompasses both the delivery of approved projects and the development of the research programme with new projects. To facilitate this objective SNOLAB will:

- Appoint a planning/QA officer during 2011 to act as an interface between the facility and experiments, ensuring regular and open information exchange to allow maximal use of resources from both the facility and the science teams;
- Engage closely with current experimental programme through project management processes to ensure we are moving as fast and efficiently as possible;
- Pro-actively engage with our community through our Experiment Advisory Committee and SNOLAB Experiments Forum, to ensure we deliver on community expectations;
- Hold scoping workshops, starting autumn 2011, to develop likely timescales for the third generation projects in dark matter, solar neutrino and double beta decay;
- Continue to engage SNOLAB research staff directly on our experimental programme, ensuring they take a leading role in shaping and delivering the scientific objectives.

A secondary objective for this strategic goal is to expand the science base from the current focus on astro-particle physics to a broader programme encompassing underground science in general, where we can capitalise on the competencies and expertise of the SNOLAB team. To facilitate this objective SNOLAB will:

- Engage with other science communities to develop plans that are relevant for our capabilities through direct contact and workshops;
- Directly engage with local groups at CEMI and the University of Toronto to assess the potential for a virtual Deep Mining Observatory and a Deep Carbon Observatory.

Critical Success Factors

To assess the performance of SNOLAB in achieving this goal we will use a combination of parameterised metrics and community feedback. Namely, we will:

- Engage with the SNOLAB Experiments Forum to determine the level of ‘user satisfaction’ with the science delivery at SNOLAB;
- Maintain metrics associated with facility planning and milestone delivery for experimental infrastructure – such as number, timescale and quality;
- Maintain metrics associated with the user base size, science programme delivery through programme size, cost and impact, space and resource utilisation and outreach engagement metrics.

Strategic Goal: Develop and maintain world-class facilities and infrastructure

The Goal

To ensure SNOLAB remains at the forefront of infrastructure provision for underground science.

Objective

The primary objective of this goal is to develop and realise the service requirement for underground science communities on a timescale that is relevant for the delivery of this science. This objective requires clear dialogue and engagement on the requirements for the near-term scientific programme. To facilitate this objective SNOLAB will:

- Engage with the experiment community and selected experiments to determine the service and infrastructure requirements for near-term programmes, through direct project management connections and the SNOLAB Experiments Forum;
- Internally develop the facility plan required to deliver these requirements, informed by the SNOLAB Strategic Plan for prioritisation of resources;
- Engage the community through the SNOLAB Experiments Forum and the Experiment Advisory Committee to ensure the plan meets the needs of the science community;
- Produce and maintain annually a facility Business Plan to provide a framework within with the facility developments may be planned and executed.
- Derive the optimal resource and infrastructure plan for the facility based on the input from the community, our advisory panels and the SNOLAB Institute Board.

The secondary objective is to develop, with the community, a long-term plan for potential experiments that may be expected to use the SNOLAB facility and spaces. To facilitate this objective SNOLAB will:

- Hold workshops, starting autumn 2011, to develop likely timescales for the third generation projects in dark matter, solar neutrino and double beta decay;
- Develop the low background counting and screening capability, and other supporting technologies, as community tools to advance the long term programme;
- Provide access for rapid deployment of R&D and prototyping systems to ensure effective development of the long-term science programme.

Critical Success Factors

To assess the performance of SNOLAB in achieving this goal we will use a combination of parameterised metrics and community feedback. Namely, we will:

- Determine, through the SNOLAB Experiments Forum, the level of 'user satisfaction' with the facilities at SNOLAB;
- Maintain metrics associated with facility planning and milestone delivery for experimental infrastructure, including rapid development R&D and prototyping projects – such as number, timescale and quality;
- Assess the usage of the SNOLAB facility infrastructures by maintaining metrics on the space utilisation at SNOLAB, the level of interest through letters of intent and approaches, and the scale of the user community.

Strategic Goal: Educate, inspire and innovate

The Goal

To develop broad economic impact to Canada and our surrounding region by educating and inspiring through both public and professional outreach, developing highly qualified personnel and delivering innovative solutions through the use of small and medium scale enterprises.

Objective

This goal has several objectives, namely the development of highly qualified personnel, public and professional inspiration through outreach, and economic impact to Canada and our locality.

To inspire both public and professional scientists using the highly accessible concepts prevalent in our research programme, SNOLAB will engage in a strong outreach programme including:

- Development of a new model and a variety of exhibits at Science North, our primary partner for local outreach;
- Hosting teachers workshops and student visits through Perimeter Institute and other research organisations such as TRIUMF and the Deep River Science Academy;
- Developing Masterclasses for student visits and developing summer school activities with other research laboratories, both Canadian and international;
- Engaging in media interactions as appropriate, reacting to community requests and directly engaging in SNOLAB events, such as the Grand Opening.

To develop highly qualified personnel we will continue to develop our own staff as ambassadors for SNOLAB, and directly develop HQP through the research programme. SNOLAB will:

Continue to engage strongly in student development internally and with local education institutes such as Laurentian and Cambrian;

- Continue to support visiting students, post-docs and research scientists at SNOLAB;
- Assess the possibility of joint appointments with Universities;
- Develop our staff through training, internal education and information dissemination.

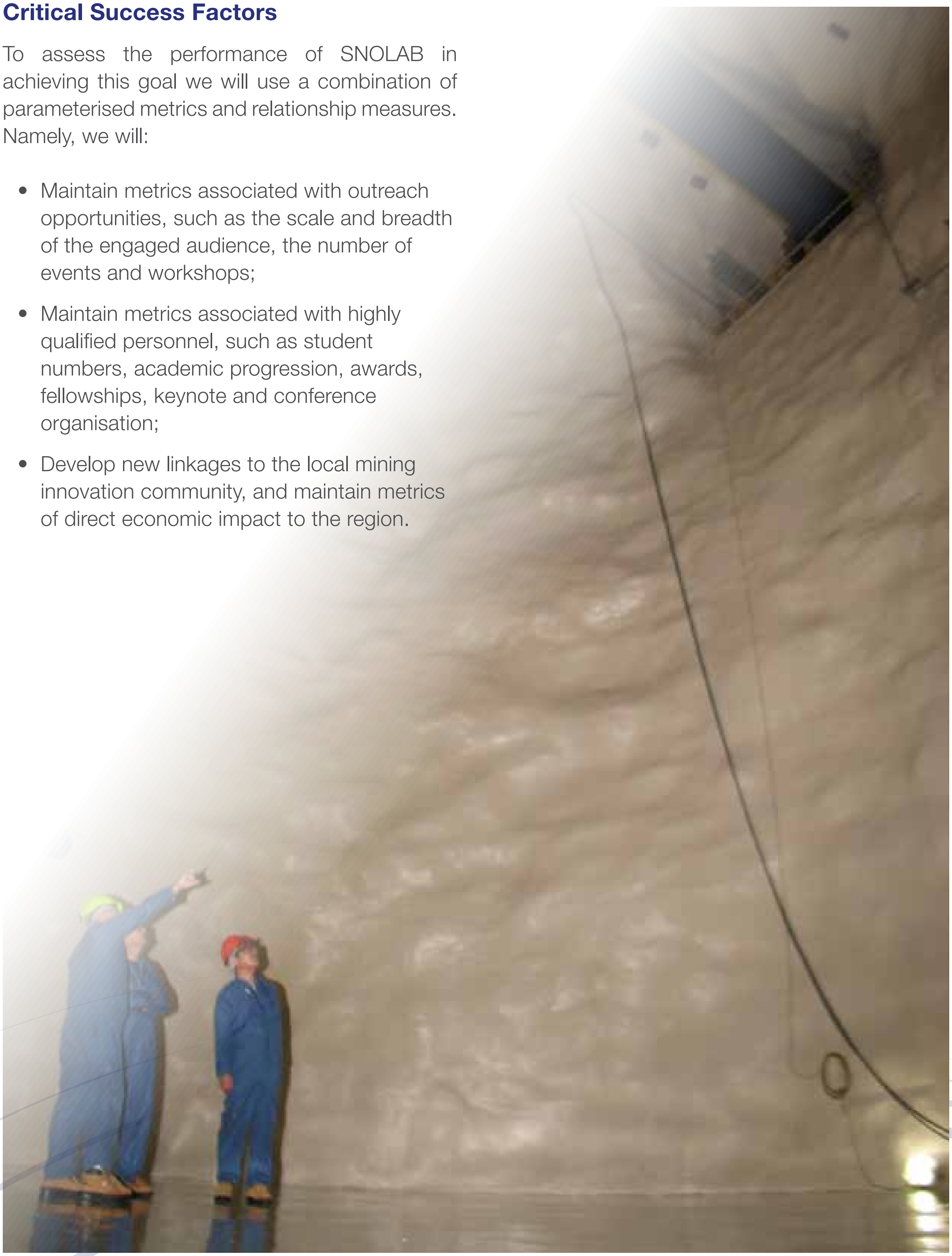
To develop economic impact through innovative solutions SNOLAB will:

- Continue to engage with local industrial, engineering and SME groups when delivering solutions for the research community at SNOLAB;
- Develop and exploit connections with the mining innovation community through CEMI;
- Assess the optimal route for exploitation of innovative solutions; ensuring the development of new connections remains a key focus for senior management.

Critical Success Factors

To assess the performance of SNOLAB in achieving this goal we will use a combination of parameterised metrics and relationship measures. Namely, we will:

- Maintain metrics associated with outreach opportunities, such as the scale and breadth of the engaged audience, the number of events and workshops;
- Maintain metrics associated with highly qualified personnel, such as student numbers, academic progression, awards, fellowships, keynote and conference organisation;
- Develop new linkages to the local mining innovation community, and maintain metrics of direct economic impact to the region.



Strategic Goal: Develop delivery systems of internationally recognised standard

The Goal

To develop SNOLAB internal quality management and delivery processes, and the connections to the experiments, through internationally recognised practices and processes to ensure efficient and effective management of resources and exemplary safety standards.

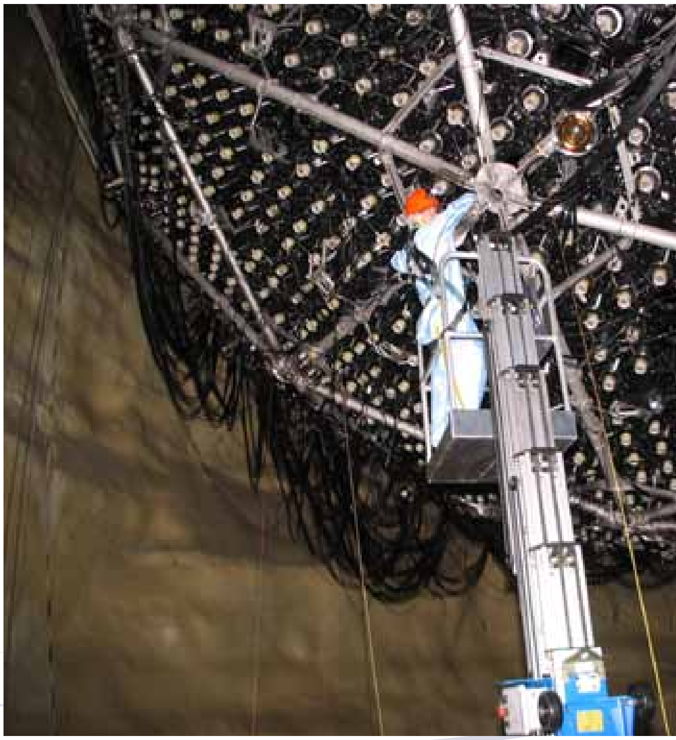
Objectives

The primary objective of this goal is to ensure SNOLAB continues to remain a safe and productive working environment, with clear facility operational and management processes, and clear interfaces to the programme. This objective requires us to develop internal health and safety, and management and Q.A., processes and our interface to the experiments to provide clear instruction and expectations, accessibility of policies/procedures, clarity of process and clarity of agreements between experiments and facility. To achieve this objective SNOLAB will re-engineer the internal processes to streamline and codify:

- SNOLAB document management and control systems;
- SNOLAB budgetary and financial definition, management, reporting and control;
- The interaction model with experiments, including a clear definition of responsibilities and liabilities;
- Restructure the experimental community forum to provide a fully inclusive framework for dialogue and interaction between experiments and the facility;
- Refine the Experiment Advisory Committee operations to provide full visibility throughout the experiment lifecycle;
- Generate and monitor clear definitions of agreed facility-experiment milestones, the facility plan, resource and infrastructure requirements.

Specific near-term objectives for the process re-engineering include:

- The development of a robust financial structure and clear delegated authority;
- The development of agreements and memoranda of understanding with experiments;
- To re-engineer the document management system to the ISO9001 international standard;
- To re-engineer the EH&S systems to the OSHA18001 international standard;
- Engage other international underground laboratories and equivalent organisations for dissemination of best practice through peer groups and organisations.



Critical Success Factors

To assess the performance of SNOLAB in achieving this goal we will use parameterised metrics and facility milestones. Namely, we will aim to achieve:

- Reconstruction of the financial and budgetary control by summer 2011;
- Complete all experiment MoU and agreements for the current programme and have them in place by the end of 2011;
- Ensure experiment Project Implementation Plans are completed on a timescale commensurate with deployment and, for the currently deployed projects, ensure required components are in place by the time of readiness reviews;
- Achieve ISO9001 and OSHA18001 accreditation by the end of 2013.

Long Term Opportunities and Aspirations

The experimental research programme at any facility continually evolves, reacting to the requirements of the fields supported. SNOLAB is no different, and the experimental programme will evolve as determined by the current generation of underground and astro-particle experiments. What is clear is that there will continue to be a need for a deep, clean, underground laboratory in which to conduct these future generation experiments to mitigate against potential background radiations.

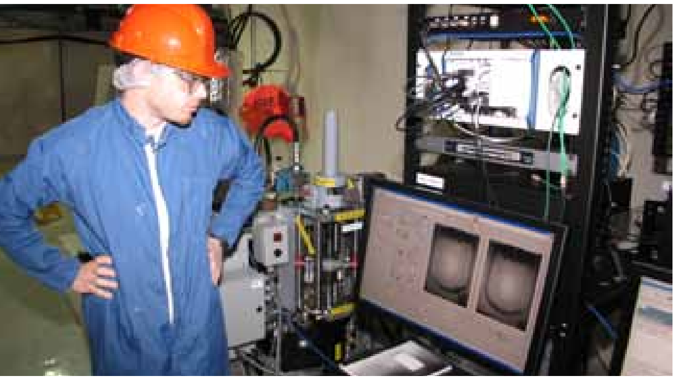
Utilisation of the current facilities

On a five year timescale the areas of neutrino studies and direct dark matter searches will continue to be a vibrant area of research with exciting potential for discovery and deeper understanding of our Universe. On this timescale it is anticipated that the direct dark matter experiments will be probing the parameter space currently favoured by theoretical models and current constraints. Larger mass targets, with different target materials, will be required to fully explore the physics of the dark matter particles, especially to constrain the particle physics models that may be used to predict such particles. The neutrino-less double beta decay projects will continue to require greater sensitivity to probe the mass range and nature of the neutrino, especially if the normal hierarchy of neutrino flavours is favoured. Accordingly the expectation is that more massive detector systems will be anticipated, potentially to kilo-tonnes of isotope, in the next generation system. SNOLAB will be ideally placed to support these kilo-tonne scale projects, through deployment in both the Cryopit and the Cube Hall, following completion of the DEAP and MiniCLEAN projects.

The operational planning for SNOLAB beyond the five year timescale of this strategic plan anticipates a continuation of the neutrino and dark-matter experimental programmes, with an expectation that detector systems at the kilo-tonne target scale will be developed in both fields and requiring deployment at SNOLAB. As an illustration of this planning, the Cryopit has been constructed with the ability to vent a large quantity of cryogenic fluid or high pressure gas, such as xenon or argon, without compromising health and safety, such that it could host a large-scale cryogenic noble liquid detector.

In addition to the astro-particle physics fields there is an anticipation that the additional science streams in underground science will continue to grow. Although not germane to the development of cleanroom underground space, the expansion of geo-technology, rock engineering and characterisation, and deep sub-surface life will all require augmented support from SNOLAB beyond the five year scope of this plan.

Although clearly a focus of the current strategic plan, there is an anticipation that beyond five years the support capabilities of SNOLAB will continue to be augmented through the provision of additional low background assay techniques. A longer term objective is the development of local high sensitivity ICP-MS and alpha-beta counting systems to allow radio-isotopic assay of materials used in detector construction.



Expansion of the current facilities

The extension of the SNOLAB facility infrastructure itself and provision of additional caverns will depend strongly on the development of the field, and on the availability of similar deep locations internationally. SNOLAB provides unique capability to our community with a combination of great depth and cleanliness. Should the community require greater capacity at depth, SNOLAB would certainly consider such expansion to provide additional cavities and infrastructure. At present there are no known geological conditions that would preclude the development of additional, and larger, cavities at SNOLAB. Additional underground capability would be developed in collaboration with our scientific research community, our host mining company Vale and the Canadian research agencies and community.

A significant influence on the timing of additional capability will be the fate of the U.S. DUSEL project, currently under review by the Department of Energy. SNOLAB has supported the development of the DUSEL and Sanford laboratories at the Homestake mine in South Dakota, as a strong underground programme in the U.S. would benefit the underground science community globally. Should the U.S. funding agencies conclude that the deep facility at Homestake, or expansion beyond the current Sanford facility, is not envisaged, and the U.S. community seek underground space at SNOLAB, then we would assess joint additional expansion options, as a dialogue between all interested stakeholders.

Development of a deeper laboratory – the ultimate limit

Is there benefit in developing a facility at an even greater depth than the existing campus at SNOLAB? From the perspective of reduction in muon flux, the ultimate limit is set by the balance point at which upward going muons created by neutrino interactions within the Earth provide an equivalent flux to the downward coming muons from cosmic rays. This balance point occurs at a depth of about 3500m and provides a reduction some three orders of magnitude greater than at our current facilities. The scientific justification for requiring this depth has not yet been reached. Only were such low backgrounds required, for example in relic neutrino detectors, and matched by improvements in intrinsic detector backgrounds, would such a development be motivated. Nonetheless, being sited on a working mining facility, where deeper workings are continually being developed as part of Vale's own strategic development plan, SNOLAB provides an ideal potential site for such a future aspirational facility.

The Development Process for the SNOLAB Strategic Plan

This Strategic Plan has evolved through initial facility specification, internal review and discussion, peer and science community consultation, and has been guided by an international executive steering group. Engagement with SNOLAB governance structures has been through the SNOLAB Institute Board of Management, with direct involvement of the host organisation, Vale.

The genesis of the Strategic Plan is encoded in the original funding applications to the Canadian Federal and Ontario Provincial governments for the evolution of the SNO experiment to the SNOLAB facility. These applications laid out the opportunity afforded to Canada in realising an international deep underground facility, and the science programmes that would be feasible. As part of the successful planning process, several workshops were held with the international community to develop a world-class science programme. The vision and mission of SNOLAB has, since inception, thus been focussed on the delivery of world-class deep underground science.

This Strategic Plan has evolved from this initial vision. Internal discussion led to the refinement of the vision, mission and clear statement of organisational values. Dialogue with stakeholders and the executive steering group developed the near-term goals and objectives, and articulated the key success factors. This Plan was disseminated for consultation with the SNOLAB stakeholder community through the SNOLAB Experiments Forum, the SNOLAB Experiment Advisory Committee and the SNOLAB Directorate. Following consultation, the final draft was presented to the SNOLAB Institute Board of Management for refinement and approval.

Membership of SNOLAB bodies

Members of the Strategic Plan Executive Steering Group:

- **Dr. Josh Klein,**
  University of Pennsylvania;
- **Dr. Barbara Sherwood Lollar,**
  University of Toronto;
- **Dr. Viktor Zacek,**
  Université de Montréal.

Supported by:

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  SNOLAB Associate Director, Operations;
- **Karen Galipeau,**
  SNOLAB Planning / Q.A. Officer;
- **Dr. Tony Noble,**
  SNOLAB Institute Director;
- **Dr. Nigel Smith,**
  SNOLAB Director.

The SNOLAB Directorate:

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- **Dr. Art McDonald,**
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- **Dr. Tony Noble,**
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- **Dr. David Sinclair,**
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- **Dr. Nigel Smith,**
  SNOLAB.

Members of the SNOLAB Institute Board of Management:

- **Caroline Davis,**
  V.P. Finance, Queen's University;
- **Dr. Steven Liss,**
  V.P. Research, Queen's University;
- **Sandra Crocker,**
  A.V.P. Research Planning and Operations,
  Carleton University;
- **Dr. Ken Peach,**
  Oxford University;
- **Dr. Patrice Sawyer,**
  Laurentian University;
- **Dr. Pekka Sinervo,**
  University of Toronto (Chair);
- **Dr. Francois Schiettekatte,**
  Université de Montréal;
- **Dr. Aksel Hallin,**
  University of Alberta (Chair of SEC);
- **Kelly Strong,**
  Director Production (North Atlantic),
  Vale Limited.

Members of the SNOLAB Experiment Advisory Committee:

- **Dr. Henrique Araujo,**
  Imperial College, London;
- **Dr. David Kaplan,**
  University of Washington;
- **Dr. Soo-Bong Kim,**
  Seoul University;
- **Dr. Reiner Krücker,**
  TRIUMF;
- **Dr. Alan Poon,**
  Lawrence Berkeley Laboratory;
- **Dr. Stew Smith,**
  Princeton University (Chair);
- **Dr. Hirohisa Tanaka,**
  University of British Columbia.

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