SNOLAB User Meeting 2024

Wednesday, June 26, 2024 - Thursday, June 27, 2024

SNOLAB

Book of Abstracts

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EDI at SNOLAB: The path ahead

Author: Samantha Kuula[1]

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A look back and forward at the EDI accomplishments at SNOLAB.

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The scintillating bubble chamber at SNOLAB

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The Scintillating Bubble Chamber (SBC) collaboration is developing liquid-noble bubble chambers sensitive to sub-keV nuclear recoils. These detectors combine the excellent electron-recoil insensitivity inherent in bubble chambers with the ability to reconstruct energy based on the scintillation signal for further background reduction. The targeted nuclear recoil threshold of 100 eV is made possible by the high level of superheat attainable in noble liquids while remaining electron-recoil insensitive. SBC-SNOLAB will probe the spin-independent dark matter-nucleon cross section down to 10^{-43} cm^2 at 1 GeV/c^2 with a 10-kg-year exposure. An overview of scintillating liquid-noble bubble chambers along with the status and physics potential of SBC-SNOLAB will be presented.

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Establishing Transition-Edge Sensor Technology for Advanced Nuclear Detection at CNL

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The establishment of advanced nuclear detection technology is critical for enhancing security and monitoring capabilities of nuclear materials. At CNL, we are focused on implementing transition-edge sensor (TES) technology to achieve superior detection performance over traditional techniques such as high-purity germanium detectors. TES sensors are renowned for their high resolution and sensitivity, making them highly effective for applications such as neutrino detection via CEvNS (for monitoring nuclear spent fuel or reactors and dark matter detection), and gamma and alpha spectroscopy (for special nuclear materials detection). Our project involves laying the foundational infrastructure, performing detailed simulations, and developing the initial designs for TES sensors for such applications. By integrating this technology, we aim to significantly improve the detection capabilities over current methods such as scintillating semiconductors. This poster will present our ongoing efforts in infrastructure setup, simulation results, and preliminary sensor development. The anticipated outcome is to establish TES technology to provide enhanced accuracy and reliability in nuclear detection at CNL.

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Thermal Modelling for the Scintillating Bubble Chamber Experiment at SNOLAB

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The Scintillating Bubble Chamber (SBC) dark matter experiment will operate a detector at SNOLAB, consisting of an active volume split into two distinct temperature regions, a cold region at the bottom and a superheated region at the top. This allows for any sediment or impurities to settle out into the cold regions at the bottom without nucleating bubbles while the superheated region can still maintain the high sensitivity needed for a dark matter search. Understanding fluid flow in the detector allows us to mitigate convection currents as needed to prevent the disruption of these distinct regions as well as better modelling the temperature distribution in the detector, which is important since the nucleation threshold for a bubble is dependent on temperature. The simulations were run in COMSOL multiphysics, modelling the time evolution of the velocity and temperature of the fluid components of the detector as it cools down. At this stage, several iterations of the simulation have been run, which can be compared to existing data from engineering runs at FermiLab. Convection currents do not appear to be a risk for the SBC detector at this stage, and further investigation is ongoing.

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Tales from the SNO+ Detector

Author: Matt Depatie[1]

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Overview of the SNO+ Detector systems (electronics, DAQ).
Stories of debugging challenges.

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Adapting Canada's National Radon Program to emerging technologies

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To address the risks Canadians face from radon, Health Canada leads the National Radon Program. Under this program, targeted research aims to close knowledge gaps and, in conjunction with outreach and stakeholder engagement, informs Canadians of these health risks and motivates action to reduce them. Integral to the program, Health Canada regularly reviews and updates the national radon risk guidance and resources to address these gaps and reflect the most current evidence and situation in Canada.

One key strategy, aiming to increase radon testing and mitigation among Canadians, involves adapting Health Canada's testing guidance to include the emerging market of electronic radon monitors now available to consumers. The recently-launched electronic radon monitor testing program, in partnership with SNOLAB, is working to ensure their accuracy, develop guidance on their use, and ultimately protect Canadians from the health hazards associated with measurements from devices that are found to be inaccurate.

Following an overview of the various approaches used by the National Radon Program, this presentation will provide an update on the findings and impact of testing performed to date along with the prospective guidance on how these devices will be incorporated into how Canadians test for radon in their homes. While many questions have been answered on the use of these devices, many more have been raised, providing opportunities for future exploration into the various environmental factors that may affect their performance and limitations of their use.

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Rare nuclear decays for standard and exotic physics

Author: Phillipe Di Stefano[1]

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We discuss some small-scale searches for rare events that may benefit from the low-radioactivity environment of SNOLAB. The mechanisms include standard nuclear decays which will inform nuclear models and matrix elements, and which are of interest to other fields such as neutrinoless double beta decay. A related example is revisiting the decays of uranium of importance in geochronology. Exotic processes can also be involved, like nuclear axion decays.

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Anti-neutrino Measurements and Prospects in SNO+

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SNO+, the successor experiment to the Sudbury Neutrino Observatory (SNO), is now filled with an optimized scintillator mixture after an initial water fill and a sustained period of being partially filled with scintillator. The SNO+ experiment has demonstrated good neutron detection through all phases of the experiment to date, allowing for the detection of anti-neutrinos by the inverse beta decay (iBD) interaction. A recent publication has demonstrated the first detection of anti-neutrinos in a water Cherenkov detector. Ontario based nuclear reactors at the Bruce, Pickering and Darlington installations produce 60\% of the anti-neutrinos detected by SNO+, all of which are at distances greater than 300 km with the remainder coming from reactors at much larger distances. An analysis of data collected through the pause in scintillator fill has yielded a measurement of anti-neutrinos oscillations over the distances between SNOLAB and reactors across North America. The results and consequences of these measurements will be described in this presentation. Future prospects for the IDB detection channel in SNO+ will also be presented.

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XeStill Project: Isotopic Dependence of Vapor Pressure in Xenon

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Future searches for neutrinoless double beta decay may require over 50 tonnes of enriched ^{136}Xe, driving needs for increased xenon production as well as efficient enrichment methods. Centrifuge separation, currently available from a limited number of manufacturers, is the primary technique used for enrichment. Cryogenic distillation is a proposed alternative that depends on the relative vapour pressure differences of the xenon isotopes. Our group has provided the first credible measurement of these parameters for xenon using a 1.8-meter tall still, and has operated an eightfold scaled-up version in the Cryopit at SNOLAB since 2020, the Xe-Still Project. We have already gathered calibration data using argon and krypton. This talk will discuss these updates, the current status of the project, and outline our plans for the future.

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The Search for Dark Matter with Liquid Argon: DEAP-3600, DarkSide-20k, and ARGO

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The Global Argon Dark Matter Collaboration is carrying out a phased program of direct search for dark matter using liquid argon. First, we will briefly summarize the results from DarkSide-50 and DEAP-3600 followed by an overview of the DEAP-3600 hardware upgrades, goals and run plan for the third fill. Second, we will discuss the work for DarkSide-20k, currently under construction at LNGS. Finally, we turn to ARGO, a multi-hundred tonne detector proposed for deployment with SNOLAB as the preferred site. We will present the long-term science scope and detector design. To test and select the optimal detector technology, we plan to build a pair of one-tonne scale R&D test detectors –one dual phase and one single phase –proposed for deployment once DEAP-3600 is decommissioned. The R&D program required for ARGO includes the development of SiPM-based Photon to Digital Converters, design of an AI-based real-time data acquisition system to handle the large data rates, development of advanced coatings to suppress backgrounds, and in-depth study of the background budget.

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TeA-TeDiol-DDA system for SNO+

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SNO+ is a liquid scintillator-based neutrino detector that aims to detect neutrino-less double beta decay (NDBD) which can confirm whether the neutrino is its own antiparticle or not. The detection process demands a very low radiogenic background level, good energy resolution, and at the same time large mass of isotopes in the detector. 130Te is chosen due to its high isotopic abundances for detecting NDBD events. Telluric acid purification is necessary before loading it into the main detector. Tellurium with butane diol forms a complex compound that is soluble in liquid scintillator. In addition to this, DDA will be added as a stabilizer. In this talk, I'll cover the tellurium purification process, and distillation process of butane diol and DDA.

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nEXO: Searching for 0vBB

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The nEXO experiment is a proposed next-generation liquid xenon detector to search for neutrinoless double beta decay (0νββ) of ^{136}Xe. The experiment will use a 5-tonne liquid xenon monolithic single-phase time projection chamber enriched to 90% in ^{136}Xe. Ionization electrons and scintillation photons from energy deposits in the Xe will be recorded by a segmented anode place and a large SiPM array. This talk will present recent progress in the detector design, an improved modelling of signal readout and the development of a deep neural network based data analysis architecture to improve signal/background separation. These developments result in a 90% CL 0νββ halflife sensitivity of 1.35×1028 yrs in 10 years of data taking.

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Investigating the Biological Impact of Sub-Natural Background Radiation: Insights from the REPAIR project

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Natural background ionizing radiation is ubiquitous, yet its biological significance remains elusive. The REPAIR (Researching the Effects of the Presence and Absence of Ionizing Radiation) project investigates the consequences of sub-natural background radiation exposure, 2 km underground at SNOLAB. With experimental radiation dose rate reductions of between 7x and 550x compared to normal levels, we aim to understand the role of natural background radiation in maintaining normal function in biological systems. REPAIR has conducted three experiments to date. First, continuous cultivation of human hybrid CGL1 cells in a 30x reduced radiation environment at SNOLAB for 16 weeks compared to a surface control. We found increased alkaline phosphatase (ALP) activity in SNOLAB-cultured cells, suggesting elevated transformation rates. Second, desiccation and storage of yeast (S. cerevisiae) in a 7x reduced radiation environment at SNOLAB for up to 48 weeks. Reduced survival and metabolic activity in the sub-background environment indicate a negative response to the absence of background radiation. Third, further reduction in desiccated yeast background dose rate using lead shielding and a tailored yeast broth with a low concentration of the radioactive isotope 40K. This experiment achieved a 550x reduction in background dose rate, and its impact on yeast metabolic rates was significant. Our findings suggest that sub-background radiation exposure may increase neoplastic transformation rates in human cells and consistently affect yeast metabolism,

underscoring the potential importance of natural background radiation in maintaining normal biological function. Further experiments are underway, probing deeper into the observed increase in neoplastic transformation resulting from sub-natural background radiation exposure.

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Event by Event classification of alpha-n and IBD Interactions at SNO+

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In the study of reactor and geo antineutrinos, tagging of the inverse beta decay (IBD) positron-neutron coincidence signature allows for the elimination of most backgrounds. In many detectors, the primary remaining background is caused by captures on 13C —so called (α, n) events —which release a neutron and closely mimic the IBD's signature. The most common (α, n) prompt event is produced by protons recoiling from the neutron, which gives rise to a distinct pulse shape compared to that of the positron from an IBD. A powerful classifier is thus presented, able to purify the IBD signal from most of its (α, n) background, by discriminating between these pulse shapes. Particular attention is paid to the construction of appropriate training data from Monte-Carlo simulations. The tuning of the β and proton scintillation timing models in these simulations for SNO+ is also discussed. Tuning of the former is achieved via the selection of a high purity sample of in-situ 214Bi to 214Po decays. The latter makes use of the deployment of a radioactive Americium-Beryllium source. Finally, results of this classification on expected reactor and geo-neutrino signals are shown, and the question of over-tuning is tackled.

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Characterizing superconducting qubits in a deep underground environment

Author: Jeter Hall[1]

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Similar to semiconductor electronics, ionizing radiation upsets superconducting electronics. However the research on mitigating the impact of ionizing radiation on superconducting electronics is not well developed. We describe an experiment to operate an array of superconducting qubits underground at the CUTE facility in SNOLAB.

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Automated Shifting in SNO+

Author: Mark Ward[1]

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Control of the SNO+ detector has evolved since commissioning was completed and shifting started in 2017. SNO+ used control rooms with a minimum of 2 computers to perform monitoring and control of the detector. Through the years of successful data taking by hundreds of shifters, the obvious question is, can this task be done by fewer people? Freeing up students, postdocs and faculty to do other tasks. During this talk I will discuss the approach taken by the Detector working group to bring the burden on the shifter to a very manageable level, and then safely remove human control entirely during known quiet periods.

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Radon Mitigation for SNO+

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Radon is an unwanted background in current rare-event search experiments taking place at SNOLAB. The radon is ever-present and naturally occurring due to the uranium and thorium in the surrounding rock in the mine, and as such poses challenges when creating a system for radon mitigation. SNO+ is a multi-purpose neutrino detector and radon is one of the backgrounds that needs to be well understood and reduced as much as possible. This includes in-situ analysis as well as ex-situ measurement through assays. The assays are performed to monitor and quantify the radon content in the water shield or the nitrogen covergas system. The assay programme is extensive and originates from the SNO experiment. One method of radon mitigation that is currently being explored is a radon trap that can be attached to the covergas system of the Universal Interface (UI) that will use charcoal to remove some radon, thereby lowering the radon content. Ongoing efforts that use charcoal as a medium to trap radon are quite extensive and include some dark matter experiments as well as assay efforts currently taking place at SNOLAB.

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SNOLAB Safety Training Management System (STMS)

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The SNOLAB Safety Training Management System (STMS) is a comprehensive SharePoint-based platform. This system features a user-friendly dashboard and a suite of applications that enable users to enroll in the system, schedule training sessions, and manage their profiles among other functionalities.

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SNOLAB Site Access Changes and Processes

Author: Samantha Kuula[1]

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A discussion of recent changes in site access policies from Vale, along with implications for SNOLAB processes and procedures and recommended best practices.

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Welcome and Opening Remarks

Welcome from SNOLAB leadership

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Goals of the Meeting

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Anti-Neutrino Measurements and Prospects in SNO+

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Investigating the Biological Impact of Sub-Natural Background Radiation: Insights from the REPAIR project

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The Scintillating Bubble Chamber at SNOLAB

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Characterizing superconducting qubits in a deep underground environment

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The Search for 0nbb with nEXO

Author: Soud Al Kharusi[1]

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The nEXO neutrinoless double beta decay experiment aims to detect a hypothetical decay mode in the isotope xenon-136.
A positive observation of this decay mode would serve as direct evidence for lepton number violation and confirm the Majorana nature of neutrinos, representing a breakthrough in physics beyond the Standard Model. Such an observation could also offer new pathways for understanding the mass generation mechanism of fermions, and potentially provide insights into the matter-antimatter asymmetry problem.

To increase the likelihood of observing neutrinoless double beta decay, nEXO requires stringent measures for background mitigation such as placing the experiment deep underground to shield it from cosmic rays. Despite these measures, the residual cosmic muon flux remains a concern.This talk will present an evaluation of the cosmogenic background rate in nEXO as well as the impact of these backgrounds on the experiment's sensitivity to neutrinoless double beta decay.

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Harmonizing muon flux modelling for SNOLAB

Author: Soud Al Kharusi[1]

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The accurate modelling of underground muon fluxes is critical for the success of underground experiments in particle astrophysics, providing essential background understanding for rare event searches such as neutrinoless double beta decay and dark matter interactions. This proposal seeks to unify the muon flux modelling efforts across various experiments hosted at SNOLAB, leveraging the rich data legacy of the SNO and subsequent experiments.

We recognize ongoing efforts in the Canadian community addressing this issue (e.g., the MUTE software) and would like to provide a platform for discussion on how to best integrate these efforts into modern Monte Carlo software suites (Geant4, FLUKA) more seamlessly, reducing the reducing the activation barrier to those who would like to propose searches at SNOLAB without having to rebuild the same muon flux model in standardized software packages.

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Special Lecture: The Search for Neutrinoless Double Beta Decay with nEXO (CAP PPD Thesis Prize)

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Rare nuclear decays for standard and exotic physics

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Water Assays for SNO+

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Presentation by and discussion with NSERC

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nEXO: Searching for $0\nu\beta\beta$

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TeA-TeDiol-DDA system for SNO+

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Tales from the SNO+ Detector

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Single photon detection at SNOLAB and beyond

Author: Fabrice Retiere[1]

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Single photon detectors are used in a wide range of experiments at SNOLAB, from SNO, to DEAP-3600, and experiments on the horizon, nEXO and ARGO. The technology continues to evolve from vacuum Photo-multiplier tube to Silicon photo-multiplers, to the future "photon to bit" converter. I will review the evolution of the technology and highlights its relevance to ongoing and future experiments at SNOLAB and show how the technology can be used beyond asto-particle physics.

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Single photon detection at SNOLAB and beyond

Author: Fabrice Retiere[1]

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Single photon detectors are used in a wide range of experiments at SNOLAB, from SNO, to DEAP-3600, and experiments on the horizon, nEXO and ARGO. The technology continues to evolve from vacuum Photo-multiplier tube to Silicon photo-multiplers, to the future "photon to bit" converter. I will review the evolution of the technology and highlights its relevance to ongoing and future experiments at SNOLAB and show how the technology can be used beyond asto-particle physics.

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The Cryogenic Underground TEst (CUTE) facility at SNOLAB

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The Cryogenic Underground TEst (CUTE) facility at SNOLAB, provides an opportunity for its users to test and operate their devices in a low-background environment at cryogenic temperatures. CUTE uses a dilution refrigerator to reach a base temperature of ~12mK, and can hold a payload of up to 20 kg. The facility has been used to test detectors for SuperCDMS and is transitioning to become a SNOLAB user facility. The main design features of CUTE will be discussed in this talk along with a brief overview of the past, current and future projects at this facility.

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The Cryogenic Underground TEst (CUTE) facility at SNOLAB

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The Cryogenic Underground TEst (CUTE) facility at SNOLAB, provides an opportunity for its users to test and operate their devices in a low-background environment at cryogenic temperatures. CUTE uses a dilution refrigerator to reach a base temperature of ~12mK, and can hold a payload of up to 20 kg. The facility has been used to test detectors for SuperCDMS and is transitioning to become a SNOLAB user facility. The main design features of CUTE will be discussed in this talk along with a brief overview of the past, current and future projects at this facility.

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Current Status and Plans for the SNOLAB Radon Assay Board

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Radon is a limiting background in many leading dark matter and low energy neutrino experiments. One way to mitigate radon background is to fill external experimental components with a clean cover gas such as N2. At SNOLAB, the radon concentration in the experiments cover gas system are monitored using a radon assay board. To improve the sensitivity of gas assays a new trapping mechanism is developed. This talk will present the current status of this mechanism and the sensitivity of the radon board after its installation

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Health Canada Environmental Monitoring Network: Laboratories and Gamma Detectors

Author: Jean-Francois Mercier[1]

Co-authors: Jessica Vanderveen [1]; Pawel Mekarski [1]

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Health Canada operates three distinct environmental networks and two radionuclide laboratories, which include an array of gamma spectroscopy systems. This presentation will provide an overview of the networks and systems. It will also present a performance comparison between several germanium-based gamma spectroscopy systems using the same set of environmental samples. The comparison includes the SNOLAB deep underground laboratory system. The presentation will demonstrate how the SNOLAB deep underground laboratory could be invaluable as a reach-back partner for sample beneficiation for ultra-low background analysis.

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Current Status and Plans for the SNOLAB Radon Assay Board

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Health Canada Environmental Monitoring Network: Laboratories and Gamma Detectors

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FLUKA/GEANT4 Comparisons: Progress and Differences

Author: Regan Ross[1]

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A short talk on the differences between FLUKA/Geant4 and current status. He can maybe highlight some results from nEXO to initiate a discussion with the DM folks on what their comparisons may look like / what the harmonization process for SNOLAB experiments might look like.

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FLUKA/GEANT4 Comparisons: Progress and Differences

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Owing to its depth underground, SNOLAB is an excellent site for hosting rare event searches such as searches for WIMP-like dark matter or neutrinoless double beta decay. The overburden of rock at SNOLAB provides a reduction in the cosmic muon flux of over 7 orders of magnitude as compared to the flux at sea level. Still, even the residual fluxes of cosmic muons can contribute to backgrounds; either themselves or by producing secondaries locally.

Adequate background models for such rare event experiments include calculations—typically via Monte Carlo simulations—of these would-be steady-state backgrounds. Common simulation toolkits like GEANT4 and FLUKA are deployed to transport the virtual particles through detector configurations wherein they randomly interact according to various material cross sections (to the extent which they are known). Often, those tasked with performing virtual measurements with simulations will compare results between the canonized FLUKA and GEANT4 as a test for convergence. Without delving into the underlying mechanics of the simulations with any profundity, I will discuss the effort within one such rare event search, nEXO to quantify cosmogenic activation using both GEANT4 and FLUKA

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SEF Survey Questions: Discussion of Additional Question(s)

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CLOSEOUT