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Alignment with the McDonald Institute Research Strategy

This document provides guidelines to help interpret the vision and scientific goals for the McDonald Institute (MI) research program. Historically a focus for MI has been on research capacity building such that the Canadian researcher community has the capacity to lead on major international projects destined for the SNOLAB facility, and where this community are leading efforts in the development of the theories underpinning the experimental pursuits. With new funding received in 2024, the MI continues to support the programs in partnership with SNOLAB but also supports new programs in astroparticle physics that build on the community's expertise in neutrino and dark matter physics, detector development, and rare search technologies. This document was created to assist in the appointment considerations for any McDonald Institute-funded researchers (faculty, postdoctoral fellows, graduate and undergraduate students), engineering and technical staff, and as well will be used to check the alignment of new proposals for research support.

General Guiding Principles:

The overall scientific objectives of the McDonald Institute are as follows:

- Expand on the scientific culture at Queen's University and its partner institutions by building a powerful and integrated team working on all aspects of astroparticle physics including the SNOLAB experimental program, astroparticle and astrophysics theory, related observational astrophysics, cosmology, detector development and low background techniques.
- Equip the Canadian research community with engineering and technical resources, such that the community may undertake major responsibilities on new projects and lead the next generation of increasingly challenging experiments. This will attract international scientists and technology along with the capital and operational funding necessary to allow one or more global-scale next-generation detectors to be hosted at SNOLAB. It will also enable the community to be leaders on emerging new programs, at other facilities within Canada, and internationally
- Maximize the scientific output from the suite of experiments that are currently operational or under development at SNOLAB or other Canadian facilities by hiring key additional highly qualified personnel, strengthening international collaborations, and engaging the broader scientific community in the undertaking.

Hence, when considering alignment, it is important to keep in mind that we want to build the community in such a way that this will contribute to making the SNOLAB and Canadian astroparticle physics program a success. This does not imply that only experiments currently planned for Canadian facilities are relevant. However, research taking place on other projects should be developing the technology or expertise with a clear long-term goal of preparing for potential future benefit to the Canadian program.

In the case of research taking place in cross-disciplinary research areas, such as radio-analytic chemistry, these activities need to add value to both parties and provide identifiable benefit to the Canadian astroparticle physics programs.

These physics topics will be primarily aligned with the physics program at SNOLAB, and include working on experiments in dark matter, supernovae monitoring, neutrinoless double beta decay, solar/geo-neutrino physics experiments, and other physics pursuits that benefit from the advantages of a deep underground laboratory or the Ocean Networks Canada underwater infrastructure. It also includes research programs which are developing the technologies that are required for an identified or potential future experimental program. Some examples of these include:

- Working on the technology for or contributing directly to any of the current or planned astroparticle physics programs currently at SNOLAB or other Canadian facilities,

  and/or,

- Working on experiments or technology developments currently outside of Canadian facilities but where the overarching goal is to gain expertise and develop the technology for a future program for which there is the potential for a future generation version to take place within Canadian facilities. Examples of this could be the xenon neutrinoless double beta decay program, or DarkSide-20k with the goal of bringing the next generation detectors to SNOLAB. Other examples could include the development of SiPM's for a variety of applications relevant to the astroparticle physics programs with future LXe and LAr detectors, or the development of low background techniques,

  and/or,

- Detector development, which could include the development of semiconductor devices at cryogenic temperatures, the development of SiPM and other novel light detection technologies, and their applications in commercial opportunities, medical physics or astroparticle physics. This area of alignment could include technology development programs advantageous to both non-McDonald Institute related offshore programs (e.g. accelerator based, short/long baseline, or underwater/under-ice detectors) and identifiable components of the McDonald Institute program.

In general, support for theorical research is somewhat broader in scope as the research interests are not necessarily tied to a particular experimental program. However, the clear intent is support for research personnel where these individuals would work closely with the broader Canadian astroparticle physics community to help guide the development of the experimental research programs, the interpretation of model dependent results, and to bring theoretical insight into topics of interest to the astroparticle physics community in areas such as neutrino physics, dark matter, neutrinoless double beta decay, and similar, and potentially, how these relate to the field of astronomy/cosmology. Similarly, multi-messenger astroparticle physics research can be broader in scope, but the clear intent for these research areas is that the researchers would work closely with the community to engage with data that supports theoretical or experimental work relevant to the Canadian astroparticle physics program.

There may also be positions in cross-disciplinary areas where for example, the focus may be to develop new analytical tools and chemical procedures required by the next generation of astroparticle physics experiments to measure radioactivity at extremely low levels, and to purify complex materials of radio-impurities and other sources of backgrounds. It may also include the development of means to produce or purify detector materials such that they meet a variety of other experimental requirements, such as optical transparency, light output, or isotopic content. Other contribution areas could be the development of instrumentation for low-background studies, or detector development and characterization. This includes the development of quasi mono-energetic neutron beams ideal for the calibration of dark matter detectors, the measurement of detector thresholds, the production of special short-lived radioactive calibration sources peculiar to the needs of astroparticle physics experiments, the development and testing of sensitive neutron spectrometers, and the training of students with hands on experience in accelerator and nuclear physics.