Proposal for TRIUMF Commitment (5YP 2015-2020)

Date:
September 17, 2012

PROJECT/COMMITMENT TITLE: Infrastructure facility for LIght Detector Development (ILIDD)

PROPONENT: F. Retiere **TRIUMF CONTACT:** F. Retiere

PRINCIPAL COLLABORATORS: H. Tanaka (UBC), A. Goertzen (U. Manitoba), P-A. Amaudruz, A. Konaka, S. Kreitzman, C. Lim (TRIUMF)

PROJECT DESCRIPTION:

A variety of experiments relying on photon detection are expected to be developed in the Canadian community between 2015 and 2020. They can be classified in two categories: 1) large area detectors for neutrino physics and dark matter searches that require good performance at low cost per unit area and 2) applications that transition from using vacuum tube photo-multipliers (PMTs) to using so called silicon photo-multipliers (SiPMs) in order to achieve optimum performance. The latter applications include spectrometers for μSR and βNMR, new detectors at ISAC and detectors for Positron Emission Tomography. The cost of detectors for muon tomography would also likely be significantly lower using SiPMs rather than PMTs. It is nevertheless important to stress that some applications such as water Cerenkov detectors will continue using some form of vacuum tube (or plane) technology because the dark noise rate in silicon photo-detectors at room temperature remains order of magnitudes larger than the signal. The purpose of ILIDD is to help users develop new compelling solutions using state of the art technologies. ILIDD will provide equipment, laboratory space and expertise to users. As far as providing equipment and laboratory space, ILIDD mode of operation will be similar to the existing detector facility in which it may be integrated. The detector facility currently offers equipment and laboratory space that is well suited for developing gas detectors but not photo-detectors. The detector facility is expected to remain responsible for design and construction of complete solutions, with ILIDD supporting only design and construction of prototypes. ILIDD will provide the following resources:

- Concept development and prototype design. Continued support of the photon transport software within GEANT4. Provide support for finite element calculations and design using Solidworks. ILIDD scientists are expected to keep abreast with technological developments in the fields of photon transport and detection, which are rapidly evolving.
- Prototype fabrication facility through the scintillator shop (which should be maintained). The part-time highly skilled technician, C. Lim, will assist in the development of prototypes and ancillary apparatus. A vacuum evaporation system for making thin films and mirrors would be very useful.
- Test facility. A temperature controlled dark room is required to properly interlock lasers and to avoid having to design and build a variety of dark boxes, which also simplifies cabling and cooling. The dark room must be temperature controlled because SiPMs in particular are very sensitive to temperature variations. The large area PMT test setup initiated by Hirohisa Tanaka is expected to be part of the overall facility but it is not large enough to accommodate more users. A new dark room is hence required. In order to maximize its use, it should be large enough to accommodate multiple users at the same time using appropriate partitioning solutions. Most of the equipment is expected to be obtained from grants.
- Associated electronics and Data Acquisition (DAQ). The development of photo-detectors goes hand in hand with electronics and DAQ. Indeed being smaller and faster than PMTs, SiPMs tend to require higher density of electronics channels with more stringent speed requirement. The SiPM control electronics developed for T2K is very versatile and should be further expanded.

SCIENTIFIC JUSTIFICATION:

ILIDD is meant to help physicists in Canada characterize and develop new technologies for photon detection. The list of applications relying on photo-detectors that are expected to move forward on the 2020 time scale includes Hyper-Kamiokande, EXO, Ultra cold Neutron, detector upgrade at ISAC, μSR and βNMR, and detectors for Positron Emission Tomography (PET). See the individual project proposal for details. The large number of projects on the horizon ensures that the ILIDD's capabilities will be fully used. Hence, ILIDD's first and foremost motivation is to enhance the performance of photo-detector applications being developed by TRIUMF.

In addition, ILIDD scientists are expected to be involved in developing new photo-detectors solutions by taking full advantage of recent technological advances. In particular, we expect to be involved in the development of next generation SiPMs that are expected to achieve >50% efficiency with very fast response. We are also considering investigating optimizing light transport using interference filters and photonic crystals. On the longer term, emerging technologies such as carbon nanotubes may worth investigating.

RELATIONSHIP TO BROADER CANADIAN RESEARCH COMMUNITY:

Being an infrastructure facility, ILIDD will provide manpower, lab space and equipment to users within the Canadian research community. The resources, especially manpower, included in this request would be allocated to projects, according to need and availability. A fraction of ILIDD resources is expected to be used for investigating emerging technologies and hence may not be directly motivated by any specific project.

While ILIDD's scope is clear, the mechanisms for allocating resources to projects, defining which equipment should be acquired and choosing which emerging technology to investigate are not fully defined yet. The collaborators listed in this proposal are expected to be involved in defining ILIDD's detailed capabilities and mode of operation. The collaborators are meant to represent the community (particle physics, nuclear physics, condensed matter, medical imaging) and the key scientists, engineers and technicians that are expected to contribute to ILIDD.

BROADER IMPACTS:

Working on detector R&D is a unique opportunity for students, especially undergraduate and master students interested in subatomic physics research. It exposes them to nuts and bolt issues that they may not encounter later on during their PhD. Furthermore, because developing detectors require using a wide variety of applied tools (e.g. finite element calculation, electronics testing, CAD design software, etc...), it is a very valuable experience for students choosing to work in the private sectors.

The facility is expected to provide users with tools and expertise to develop their applications. The success of the facility will rely not only on efficiently pooling resources but also on retaining and disseminating knowledge within the community. Students are expected to be an important medium to disseminate such knowledge outside the subatomic physics community. It is our hope that the knowledge base generated by ILIDD will lead to the development of commercial applications directly driven by users or commercial partners. Possible partners with facility in Canada include Excelitas and Zecotec.

MAJOR MILESTONES:

Description	Date
Setup dark room	Dec 2015
Evaporation system	Dec 2016
Hyper-K detector solution decision	Mid 2017

RESOURCE REQUIRMENTS:

CASH FLOW REQUIREMENTS						
\YEAR SOURCE \	ONE	TWO	THREE	FOUR	FIVE	TOTAL
TRIUMF	50,000	25,000	25,000	25,000	25,000	150,000
EXTERNAL	100,000	70,000	70,000	100,000	70,000	410,000
TOTAL	150,000	95,000	95,000	125,000	95,000	560,000
TRIUMF NON-CASH RESOURCES						
\YEAR RESOURCE\	ONE	TWO	THREE	FOUR	FIVE	TOTAL
Technician	20	20	20	20	20	100
DAQ	5	5	5	5	5	25
Electronics dev.	5	5	5	5	5	25
GEANT physicist	10	10	10	10	10	50

EXTERNAL FUNDING INFORMATION:

CFI is expected to be the primary source of funding. As discuss earlier the source of funding may be multiple grants pooling equipment together.

ONGOING OPERATIONAL REQUIREMENTS:

C. Lim is currently expected to work on detector development at 20%. This contribution would be included in ILIDD.

DECOMMISSIONING REQUIREMENT:

Expected to remain active after 2020. Minimum decommissioning cost.

Accepted: Date: