Proposal for TRIUMF Commitment (5YP 2015-2020)

Date:
September 17th, 2012

PROJECT/COMMITMENT TITLE: Detector development for Positron Emission Tomography

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PROJECT DESCRIPTION:

We are proposing to develop detectors for Positron Emission Tomography (PET) focusing on niche applications that are expected to enhance the capabilities of Canadian research centers. The detector development project is a collaboration between UBC, University Manitoba, McGill University and TRIUMF. We are expecting to develop instruments that will be used at UBC brain research center and at BC Cancer Agency. Between 2015 and 2020, we foresee constructing a Magnetic Resonance Imaging (MRI) compatible PET detector for brain imaging. We also foresee constructing a low cost planar solution for organ dedicated PET imaging and especially Positron Emission Mammography. The low cost planar detector could be combined with endoscopic probes for in-situ imaging.

Our collaboration is currently working on a novel high resolution pre-clinical MR compatible PET insert that can be coupled with open low field and traditional high field MRI systems. The system is based on modules prototyped at McGill and Manitoba with two offset pixilated LYSO crystals stacked on top each other readout by one matrix of SensL SPMArrays. An electrical multiplexer reduces the number of electronics channels per module from 4 to 16 which minimizes the system complexity. The spatial and energy resolutions are comparable to Sherbrooke's LabPET2 system that requires a factor of 4 more channels. A 2 ring demonstrators is expected to be built in 2013 and commissioned in 2014.

The planar PET detector technology is well suited for low cost and organ dedicated applications. Two solutions are expected to be relied upon: digital SiPM (made by Philips) and wavelength shifting light guides coupled to analog SiPMs. Both solutions are currently being investigated with the digital SiPM solution expected to offer optimum performance and the wavelength shifter option being for low cost applications.

The basic Research and Development for PET detectors will be performed within the Infrastructure for Light Detector Development (ILIDD). The scope of this proposal is the construction of complete detectors that can be readily used in pre-clinical and clinical applications. Funds for detector construction will be obtained from grant. The following TRIUMF resources are expected to be needed:

- Detector design and mechanical integration. TRIUMF detector facility expertise is well suited because the design of PET detectors is similar to subatomic physics detectors, especially medium resolution gamma ray detectors.
- Electronics design. We foresee requiring a combination of passive, analog and digital electronics board that are customized for each solution. Due to space, power and performance requirement, it is essentially impossible to build a PET detector using commercial electronics.
- Data acquisition. A PET detector produces very high raw data rate, which must be rapidly processed to deliver images to users. TRIUMF DAQ group has a strong expertise in high speed data transfer and online data reduction (from working on projects such as DEAP). Support from TRIUMF DAQ group will be essential to achieve the desired data rate (> 1MHz).

SCIENTIFIC JUSTIFICATION:

The development of detectors for Positron Emission Tomography (PET) has attracted renewed interests in the research community with the advent of pixelated Geiger-mode avalanche photodiodes commonly called Silicon Photo-Multipliers (SiPMs). Indeed, SiPMs offer several benefits over Photo-Multiplier Tubes (PMTs): 1) they can be operated in Magnetic Resonance Imaging (MRI) systems because they are insensitive to magnetic field, 2) they achieve better performance than PMTs, especially better timing resolution and photo-detection efficiency, and 3) they are more compact than PMTs, potentially providing smaller granularity and minimizing dead spaces. Major companies, General Electric, Philips and Siemens are developing MRI compatible, Time of Flight capable, full body PET detectors based on SiPMs.

Users at UBC and BCCA have strong needs for new application specific PET systems, either MRI compatible or for organ dedicated scans. A brain scanner combining PET and MRI would enable cutting edge research at UBC. The BC Cancer Agency is interested in investigating PET for breast cancer diagnostic. Taking advantage of SiPM technology, we can develop a cheaper and better solution at a fraction of the cost of the only currently available scanner made by Naviscan Inc.

RELATIONSHIP TO BROADER CANADIAN RESEARCH COMMUNITY:

The development of SiPM based PET detectors is a collaboration between UBC, the University of Manitoba, McGill University and TRIUMF. The systems developed by the collaboration are expected to be used at UBC, U. Manitoba and BCCA.

BROADER IMPACTS:

The R&D, design and construction of the PET systems will involve undergraduate and graduate students and postdocs. HQPs will be exposed to multi-modality imaging from inter-disciplinary perspectives: physics/engineering and medicine, with the addition of industry. HQPs will be required to spend time in the existing imaging laboratories of the PIs and familiarize themselves with imaging techniques to better understand the system design requirements. For-credit interdisciplinary directed study courses will be offered by the PIs when needed.

The system that we are developing could be commercialised eventually. We are collaborating with a commercial partner, MRI tech, on the development of the PET insert for small combined PET-MRI imaging. MRI-Tech is a spin-off company from the NRC, producing open, low field MRI systems based on technology developed by NRC, allowing reduction of the production costs while maintaining high image quality. MRI tech currently specialised in MRI magnet and coils, but it is interested in expanding its scope. Our primary aim is to build prototypes that provide sufficient functionalities to the end users to demonstrate their capabilities. Then, we intend to collaborate with our commercial partner for the construction of full scale complete systems that can be commercialized. End users have indeed shown strong interests in the solutions that we are developing especially for research on brain diseases, as there is currently only one manufacturer that offers dedicated brain scanners.

MAJOR MILESTONES:

Description	Date
MRI compatible Micro-PET detector used for research	2015
Completion of planar PET detector	2017
Completion of MRI compatible brain scanner	2018
Completion of endoscopic probe	2019

RESOURCE REQUIRMENTS:

CASH FLOW REQUIREMENTS						
\YEAR SOURCE \	ONE	TWO	THREE	FOUR	FIVE	TOTAL
TRIUMF						
EXTERNAL	180,000	180,000	180,000	180,000	180,000	900,000
TOTAL						
TRIUMF NON-CASH RESOURCES						
\YEAR RESOURCE\	ONE	TWO	THREE	FOUR	FIVE	TOTAL
Det. Fac. design	10	10	10	10	10	50
Det. Fac. Tech	15	15	15	15	15	75
Electronics dev.	10	10	10	10	10	50
DAQ	10	10	10	10	10	50

EXTERNAL FUNDING INFORMATION:
The external funds are expected to be obtained from NSERC, CHRP, CIHR and CFI. The 180,000$ per year assumes that only the CHRP application will be successful.

ONGOING OPERATIONAL REQUIREMENTS:
None

DECOMMISSIONING REQUIREMENT:
None.

Accepted: Date: