Proposal for TRIUMF Commitment (5YP 2015-2020)

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PROJECT/COMMITMENT TITLE: Building in-house solid state physics and chemistry research groups at TRIUMF

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PROJECT DESCRIPTION:

Since the mid 1980's TRIUMF has become a world's leading facility for muon spin rotation and relaxation (MuSR) studies on solid state physics and chemistry. Although TRIUMF's proton beam current is lower than that of PSI, quality and quantity of scientific product from MuSR researches at TRIUMF have been at least comparable to or possibly even better than those from PSI if integrated over recent 25 years. Especially, in the study of high-Tc cuprate and other unconventional superconductors, several results from TRIUMF, such as the system and temperature dependences of the superfluid density, became well-known landmarks frequently quoted by other solid state researchers working on correlated electron systems. More than 10 papers have been published in Nature, Science, and Nature group journals based on MuSR results from TRIUMF. Both in the usage of delivered beam and in quality and quantity of scientific output, MuSR activity has now become a very prominent part of the entire research effort at TRIUMF. Development of beta-NMR activities at ISAC has provided additional new capabilities in surface / thin film studies and further strengthened the solid state physics and chemistry researches at TRIUMF.

Despite these remarkable achievements, thanks to strong University-based visiting groups and excellent support staff at the CMMS led by Syd Kreitzman, there is a major element missing in TRIUMF's MuSR program. In every successful accelerator or reactor facilities, there exist strong in-house research teams which guarantee high-quality research accomplishments of the relevant scientific subjects. This is true for both particle / nuclear physics and solid state physics / chemistry. For example, TRIUMF has a strong particle physics research team led by Doug Bryman and other eminent particle physicists. ILL has many excellent solid state physicists among their staff, and the success of neutron program at BNL was directly related to existence of a strong in-house group led by Shirane and Tranquada. PSI's MuSR program also has several superb scientists among their permanent staff, including Luetkens, Khasanov, Amato, Morenzoni, in addition to many post-doc researchers. The strong in-house group guarantees: 1) steady production of high-quality and elaborate researches; 2) accessibility of less-experienced outside users to experiments; and 3) possibility of developing novel facilities such as Low Energy Muon beamline and spectrometers.

In view of these, we would like to urge TRIUMF to employ at least three permanent research scientists to build up strong in-house condensed-matter physics and chemistry research groups. Thanks to 25 years of successful operation of MuSR program at TRIUMF, many excellent and well-experienced young scientists have been trained both as technical experts of MuSR and as leading researcher of their given scientific subject.
Many of them have accumulated further experiences in neutron scattering, NMR or materials productions, and now are ready to lead strong research groups at leading national laboratories or universities. With employment of a few of them, TRIUMF will certainly keep the leading role in MuSR researches for next 10 years. This feature is really crucial for TRIUMF to be competitive against PSI, ISIS and JPARC MuSR facilities which have much stronger infrastructures in researches compared to current situation at TRIUMF.

SCIENTIFIC JUSTIFICATION:

Modern Condensed Matter Physics studies have made a phenomenal progress in recent 30 years due to (a) discoveries of novel materials, such as, high-Tc cuprates and other unconventional superconductors, graphene, carbon nano-tube, and doped magnetic semiconductors; and (b) progress of state-of-art experimental techniques using accelerator-based particle probes (neutron, x-ray, ARPES and muon) and scanning imaging probes (STM, TEM). In studies of magnetism, MuSR has been established as a strong probe sensitive to magnetic order and dynamics of uniform or random spin systems even with a very small moment size, which provides information about volume of magnetically ordered regions complementary to neutron scattering. In studies of superconductivity, MuSR is the most reliable method in determination of the absolute value of the superfluid density. These features have led MuSR to make decisive and unique contributions in studies of superconducting properties and magnetic phase diagrams of many unconventional superconductors.

With recent discoveries of Fe-based superconductors, topological insulators and superconductors, novel doped ferromagnetic semiconductors, geometrically frustrated magnets and Skyrmion spin systems, MuSR is expected to provide crucial information on these system and will be in the forefront of condensed matter physics studies in the next decade. Low energy MuSR and beta NMR will enable additional capabilities in depth-sensitive studies of thin films, low dimensional systems and surfaces, which cannot be done by neutron scattering or NMR due to the limitation in sample volumes. Advances in molecular designs in modern chemistry will enrich subjects of chemistry studies by MuSR. Thus, availability of strong MuSR facilities would benefit not only immediate users and MuSR practitioners but also much wider community of general solid state physicists and chemists.

RELATIONSHIP TO BROADER CANADIAN RESEARCH COMMUNITY:

Thanks largely to successful operation of TRIUMF, Canada has a unique strength in MuSR studies with strong research groups existing in UBC, Simon Fraser, Alberta, McMaster and Mount Allison. These groups also have close collaborators in other

Canadian universities and institutions, such as Toronto, Sherbrooke, McGill, Chalk River and Saskachewan/Manitoba. This is a very unique situation by far exceeding strength in any other countries. MuSR can be called as “Canada’s national research tool”. Strengthening TRIUMF will allow Canadian researchers to make further dominant and decisive contributions in condensed matter physics and chemistry.

BROADER IMPACTS:

For recent 30 years, TRIUMF has also supported involvements of research teams from the US (Columbia, Reverside, Texas Tech, LANL) and Japan (Tokyo, Osaka, KEK, JAEA, JPARC). Finishing PhD studies with TRIUMF results, several young researchers recently obtained faculty and research positions in UC Urbana Champaign, SUNY, Villanova and ORNL. Based on collaborations of researchers from Columbia, McMaster and TRIUMF, the US NSF has funded several major grants on international collaborations in Materials World Network (MWN) and Partnership for International Research and Education (PIRE) programs, which have supported visits of scientists and students from the US, UK, Japan, China, Brazil, and Argentina to TRIUMF. These foreign researchers will be hugely benefitted by further development of MuSR infrastructures at TRIUMF.

FACILITIES AND SCIENCE:

Support on the CMMS facilities is an important element for maintaining and strengthening infrastructures for MuSR at TRIUMF. The present document can be viewed also as providing arguments for supporting a separately-filed CMMS 5 yr proposal. We are filing this document separately to request investment on scientific activities by creating TRIUMF in-house research group. Proper combination of supports on facilities, technical staff and leading scientists will make optimal results in building up strong MuSR activites at TRIUMF in the future.

BUDGET AND PERSPECTIVES

Since this document is written for advocating a concept of having in-house MuSR research activities, we will not specify detailed budget scheme or plans on how to fund the positions. Currently, a very limited research of Iain Mackenzie on Chemistry, allowed by a partial SFU funding, is the only existing in-house research activity at TRIUMF. We believe that it is imperative to start at least one condensed matter physics research group in 2014 or 2015. Then, ideally the group may be expanded by hiring of two additional permanent researchers in following years.

Accepted:	Date: