Proposal for TRIUMF Commitment (5YP 2015-2020)

Date:
September 17, 2012

PROJECT/COMMITMENT TITLE: CMMS Technical and base support Infrastructure

PROPONENT: Syd Kreitzman **TRIUMF CONTACT:** Syd Kreitzman

PRINCIPAL COLLABORATORS: Jess Brewer, Kim Chow, Kashayar Ghandi, Rob Kiefl, Graeme Luke, Andrew McFarlane, Paul Percival, CMMS Group Scientists, Jeff Sonier, Tomo Uemura (alphabetical)

PROJECT DESCRIPTION:

The overall project consists of three related initiatives which are required to develop, maintain and support the long term viability of the CMMS program at TRIUMF.

i) Deploying new MuSR spectrometers to provide the state of the art experimental capabilities.
ii) Insuring that the deteriorated critical aspects of target station/secondary channel infrastructure, without which muon production and transport cannot exist, is addressed/replaced in a timely fashion to sustain the long term viability of this program.
iii) Supporting the manpower requirements for the increase usage of b-N/QMR and the evolution toward a facility which can support a broad range of non-expert users on its new beamlines. Planning for the potential attenuation of current CMMS facility staff salary funding from the promised, but as yet unknown, MRS replacement program. Ameliorating the debilitating facility user fee is also a priority.

i) Spectrometers:
   a. 9T, 10ppm Magnet & Spectrometer -$275K;
   b. Axial Dilution Refrigerator for above - $750K;
   c. 3T Magnet for M20 + Spectrometers for M9A & M20 - $550K;
   d. Ultra LT High Pressure Cell Spectrometer for VSU Dilution Refrigerator on M9B. -$75K.

ii) Long Term Sustainability of beam delivery to the CMMS-MuSR beamlines:
   a. T2 Environment;
      i. Addressing T2's misalignment and the connectivity in its secondary channels
      ii. Replacement Q1s for M20 and M9, while enabling more clearance for i.- $175K;
   b. The M9B Solenoid; Persistent mode replacement - $1,350K;
   c. Selected Power Supply Replacement for M15 and M9B - $350K;
   d. Replacement of M15 permanent Q1/Q2 - $50K.

iii) Enhanced Experimental Support Manpower and Operational funding:
   a. b-NM/QR support with the advent of an eLinac driven ^{8}Li source; ½ FTE Scientist, ½ FTE Tech.
   b. Scientific support for non-expert and casual users on new beam lines; ½ FTE Scientist, and M20 IOF support; ½ FTE Technician.
   c. Contingency plans and funding is required if the NSERC replacement funds for the defunct MRS program (which supports 3+3 scientists+ CMMS technicians) does not fully materialize.
   d. CFI IOF + TRIUMF funding to eliminate common fund assessment (i.e. user) fees. $100K/yr

Capital Cost: $3,575,000; CMMS Manpower Increment: 1 FTE scientist + 1FTE tech.;
Operational Costs: $100,00/yr; TRIUMF DO, MS, Engineer, Technical: 5½ man years.

SCIENTIFIC JUSTIFICATION:

The areas of research supported by the CMMS facility are broad and diverse. The listing below is indicative of the scope of research typically carried out in the TRIUMF CMMS facility.

i) Superconductivity, with specific emphasis on HTC. MuSR is a major research tool due to its sensitivity to the correlation length, penetration depth and symmetry of the superconducting electrons.
ii) Automotive batteries; Hydrogen storage and thermal stability for fuel cells, Li kinetics (b-NMR)
iii) Interfaces and probes of Nanomaterials (b-NM/QR); Variable penetration depth of polarized low energy ^{8}Li provides sensitive nuclear magnetic resonance studies of near surface interfacial phenomena.
iv) Materials (Polymer) Design; Muons probe bonding of metal-organic complexes.
v) Semiconductors and Spintronics; Muons acts as a heavy isotope of H and is a sensitive probe and instigator of hydrogen-like induced localized charge and magnetic states, which MuSR can easily detect.
vi) Muoniated Free Radicals: Green Chemistry, GenIV Reactor Research; Muons can be injected into very hostile/reactive environments, where its presence as Muonium allows detailed reaction rate studies.
vii) Fundamental Chemical Reactions; Reaction rates of simple $Mu^{x}H$ or $\mu^{-}He$ molecules or atoms leads to the capability to sensitively test the detailed aspects of chemical kinetics wrt current theories.
viii) Magnetism; The muon is an exquisite probe of local **B**(t) due to its large moment and 100% polarization.
ix) Quantum Phase Transitions; Sensitive probe of local magnetic fluctuations as $T \rightarrow 0$ in degenerate systems.

JUSTIFICATION FOR THE PROPOSED TECHNICAL INFRASTRUCTURE:

The primary justification of this proposal is to promote the necessary actions that will allow TRIUMF's CMMS facility the means to continue to deliver world class experimental capabilities to its user community. The three broad categories of requirements (not necessarily in priority sequence) all cooperate in the evolution of the overall process. To wit, the muon beam lines must be consistently available, the experimental capabilities must be competitive, and finally, the user support must be adequate.

The T2 environment: Over the past several years TRIUMF and CFI/BCKDS have invested close to $10,000,000 in capital and human resources into the new M20 and M9A MuSR beamlines. To utilize these beamlines effectively, the T2 environment must be made reliable. Instability problems have plagued the T2 monument/secondary channel connections for over a decade, and TRIUMF has literally "stuck its head in the concrete block sand box" for that time. A long term solution needs to be implemented. Given that M20 and M9 are now solely dedicated to MuSR, the redesign & replacement of the somewhat impaired Q1/Q2 pairs (M20Q1 leaks, requiring repair and an M9Q1 ground fault) in both beamlines should enable more space to allow for robust "flexible" joints to be installed, even if the ideal solution of stabilizing/replacing the crumbling blocks is not fully possible.

Beam time on M9B (which remains a unique MuSR beamline in the world due its capability to spin rotate a high momentum muon beam) will continue to be significantly lost due to the frequent and fatal (for the current solenoid) power failures that plague TRIUMF. Its replacement with a persistent coil device will fully alleviate this problem. The new solenoid can be charged via the CMMS/UCN liquefier and will obviate the need for the current "monster" compressor and its associated energy costs.

Selected M5 and M9B power supplies (20 and >30 years old respectively) are now significantly unreliable, irreparable and should be replaced. Also, the deterioration in the M15 rate over the last decade, due to radiation damage and subsequent field degradation in its permanent Q1, calls for its replacement.

The spectrometer "phase space" advantages (7T @ 1.5K or 5T @ 15mK) which the TRIUMF CMMS has uniquely enjoyed will be surpassed in 2013 by new beamline/spectrometer developments at the PSI muon facility. However, the new M20 and M9 beamlines are both kicked (for "Muons on Request") and fully spin

rotated. Since no PSI beamline has both, TRIUMF can regain "MuSR experimental spectrometer supremacy" simply by matching the 9T magnet and low temperature (axial DR) capabilities that will come online at PSI. The remaining spectrometer upgrades (i.e. VSU DR pressure cells) will give the T2 sourced beamlines an arsenal of flexible MuSr experimental capabilities that will unique solely to the TRIUMF.

RELATIONSHIP TO BROADER CANADIAN RESEARCH COMMUNITY:

The CMMS is, unlike the more common dedicated facilities at TRIUMF, a user facility and as such provides spectrometers and facilitates beam (muons and ^{8}Li) utilization to a broad variety of worldwide condensed matter and physical chemistry research groups. Approximately 40% of these groups are Canadian based. The enumeration below lists the Canadian groups which are active users of the facility. The groups flagged with a * have historically had research programs critically dependent on the TRIUMF CMMS facilities.

A. Bianchi	Physics, U. Montreal	R.F. Kiefl*	Physics, UBC
J.H. Brewer *	Physics, UBC	D. Leznoff	Physics, SFU
K.H. Chow*	Physics, Alberta	G.M. Luke*	Physics, McMaster
J.A. Clyburne	Chemistry, St. Mary's	W.A. MacFarlane*	Chemistry, UBC
D.G. Fleming*	Chemistry, UBC	A. Mar	Chemistry, Alberta
J.A. Forrest	Physics, Waterloo	Y. Mozharivskyj	Physics, McMaster
K. Ghandi*	Chemistry, Mount Allison	P.W. Percival*	Chemistry, SFU
J.E. Greedan	Chemistry, McMaster	J.E. Sonier*	Physics, SFU
M. Greven	Physics, Manitoba	C.R. Wiebe	Chemistry, U. Winnipeg
T. Imai	Physics, McMaster		

BROADER IMPACTS: The broad impact may be gauged by the spokespersons of approved and/or active experiments from 2006 – 2012:

A. Aczel	USA	S.R. Julian	USA	G. Morris	TRIUMF
J. Akimitsu	Japan	R. Kadono	Japan	Y. Mozharivskyj	Canada
J. Arai	Japan	H. Kageyama	Japan	K. Ninomiya	Japan
A. Bianchi	Canada	R.F. Kiefl	Canada	H. Ohato	Japan
L. Bouchard	USA	P.J.C. King	UK	K. Ohishi	Japan
J.H. Brewer	Canada	H-H. Klauss	Germany	O.Ofer	Israel
J. Chakhalian	USA	A. Koda	Japan	P.W. Percival	Canada
K.H. Chow	Canada	K.M. Kojima	Japan	A. Romanenko	USA
J. Clyburne	Canada	R. Laxdal	TRIUMF	H. Saadaoui	Switzerland
S. Dunsiger	Germany	D.B. Leznoff	Canada	Z. Salman	Switzerland
J.A. Forrest	Canada	R.L. Lichti	USA	K. Satoh	Japan
D.G. Fleming	Canada	G. Luke	Canada	A.T. Savici	USA
M. Fluss	USA	W.A. MacFarlane	Canada	J.E. Sonier	Canada
K. Ghandi	Canada	D.E. MacLaughlin	USA	K. Shimomura	Japan
J.M. Gil	Portugal	A. Maniv	Israel	L. Shu	China
T. Goko	Columbia	T. Maniv	Israel	V.G. Storchak	Russia
A. Grasselino	TRIUMF	J.L. Manson	USA	J. Sugiyama	Japan/Toyota
J.E. Greedan	Canada	A. Mar	Canada	Y.J. Uemura	USA
R.H. Heffner	USA	I. McKenzie	Canada	R.C. Vilao	Portugal
W. Higemoto	Japan	T. Mibe	Japan	R. West	USA
T. Imai	Canada	M. Mihara	Japan	C.R. Wiebe	Canada
K. Ishida	Japan	E. Morenzoni	Switzerland	S. Zhao	USA
T. Ito	Japan			X.G. Zheng	Japan

16% local (B.C.), 20% Canada (AB,ON,NB,NS), 18% U.S.A., 32% Japan, 14% Europe

MAJOR MILESTONES:

Description	Date
Investigate T2 stability issues	Long shutdown 2013
Design of new T2 Q1s, T2 stability enhancements, and flexible connections to Q1s	Prior to 2014
CFI application for all capital upgrades, including Spectrometers, Q1/Q2s, M9B solenoid and manpower requirements.	Fall of 2014
Assuming successful funding: Review designs and order major spectrometer components, M9B solenoid and Q1s. Submit T2 connectivity flanges/beam to shop.	Spring 2015
Take delivery of Spectrometer Magnet, DR and begin assembling Spectrometers	Early 2016
Take delivery of Q1s and assemble Q1/Q2 skids	Summer 2016
Install major T2 upgrades and new M9B solenoid , complete the project	Jan-Jun 2017

RESOURCE REQUIRMENTS:

CASH FLOW REQUIREMENTS						
\YEAR SOURCE \	ONE 2015	TWO 2016	THREE 2017	FOUR 2018	FIVE 2019	TOTAL
TRIUMF	50,000	50,000	50,000	50,000	50,000	250,000
EXTERNAL	1,000,000	1,275,000	1,350,000	50,000	50,000	3,725.000
TOTAL	1,050,00	1,325,00	1,400,000	100,000	100,000	3,975,000

TRIUMF NON-CASH RESOURCES						
\YEAR RESOURCE\	ONE	TWO	THREE	FOUR	FIVE	TOTAL
(in man months)						
Design Office	5	3				
Engineer	4	4	3			
Machine Shop	6	5				
Contract Manage^{mt}	3	3	3			
Scintillator Shop	4					
Remote Handling			9			
Technicians			4			
Riggers			3			
	22	15	22			59

EXTERNAL FUNDING INFORMATION:
CFI 40% , BCKDF 40%

ONGOING OPERATIONAL REQUIREMENTS:
$100K/yr CMMS Operating funds and MRO : 50% TRIUMF, 50% CFI IOF

DECOMMISSIONING REQUIREMENT:
Current M20 and M9 Q1/Q2 will have to be stored in bunker. Current M9B solenoid sold?

Accepted: Date: