Proposal for TRIUMF Commitment (5YP 2015-2020)

Date: September 17, 2012

PROJECT/COMMITMENT TITLE: Gamma-Ray Spectroscopy at ISAC

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PROJECT DESCRIPTION:

This submission identifies the TRIUMF resources required for the ongoing operation of the Gamma-Ray Spectroscopy programs at ISAC-I and ISAC-II throughout the 2015-2020 5-Year Plan. This program involves the operation and maintenance of more than $20M of capital equipment funded by NSERC and CFI, including:

1) The $8.1M TIGRESS gamma-ray spectrometer at ISAC-II for which capital funding was received from NSERC from 2003-09. Our projections include TRIUMF technical resources required for the movement of the TIGRESS spectrometer between its current stand-alone location and its alternate location in front of the EMMA recoil mass analyzer at ISAC-II.

2) The $8.9M GRIFFIN gamma-ray spectrometer at ISAC-I, for which capital funding was received from CFI, TRIUMF, and the University of Guelph in 2011, and which will be completed and fully operational in the first months (May 2015) of this 5-Year Plan.

3) The $2.0M DESCANT neutron detector array, funded by CFI and the Ontario MRI in 2007, which will be completed in 2012 and will move between ISAC-II and ISAC-I during this 5-Year period for use in conjunction with both TIGRESS and GRIFFIN.

4) The $312k SPICE internal conversion electron spectrometer, funded by CFI and Ontario MRI in 2011, which will be completed and operational with TIGRESS in 2013.

5) The TIGRESS Integrated Plunger (TIP) and CsI charged-particle detector array, with combined NSERC funding of $144k, which will be used in conjunction with TIGRESS at ISAC-II.

6) The GPS 4π gas-proportional β counter and its associated fast tape transport system and two large-volume HPGe γ-ray detectors for high-precision β-decay half-life measurements which, following a change of beamline location in the ISAC-I hall, will be recommissioned in early 2013.

7) A suite of auxiliary detectors systems, including the 4π SCEPTAR β detector array, the PACES Si(Li) conversion electron detector array, the DANTE BaF_2 and $LaBr_3$ fast-timing γ-ray detectors, and an in-vacuum moving tape system, with combined NSERC funding in excess of $300k, that are currently used with the 8π Spectrometer at ISAC-I and will continue to be used with GRIFFIN.

8) The operation of the large-volume TIGRESS and GRIFFIN detectors at other locations in ISAC-I and ISAC-II, including, but not limited to, the Doppler-Shift Lifetime facility at ISAC-II and the focal plane of the EMMA recoil mass analyzer.

In developing the TRIUMF resource requirements contained herein we note that:

1) The technical resource requirements in year 1 (2015) are moderately higher than in the subsequent "steady-state" operation throughout the remainder of the 5-year period due to the scheduled installation and commissioning of a new Bragg detector (funded in the U.K.) for use with TIGRESS, as well as the first movement of DESCANT from ISAC-II to ISAC-I for use with GRIFFIN, in 2015.

2) The resources identified here are related only to the ongoing operation of infrastructure that either already exists or is fully funded and currently under construction. The completion of GRIFFIN Phase II, which will see the addition of Compton Suppression Shields to GRIFFIN and will require new capital funding, is presented in a separate submission.
3) The gamma-ray spectroscopy programs at ISAC are also obviously dependent on TRIUMF resources for the development and delivery of beams (primarily radioactive, but also stable beams from OLIS) to the spectrometers. It is assumed that these general resources for ISAC beam development and delivery are presented elsewhere, and this submission focuses only on the TRIUMF resources required for the ongoing operation of the spectrometers themselves.

SCIENTIFIC JUSTIFICATION:

Gamma-ray spectroscopy, in combination with the coincident detection of particles such as internal conversion electrons, β particles, neutron, protons, α particle, and heavy ions, provides one of the most powerful and versatile techniques to study nuclear structure, nuclear states of astrophysical importance, and to perform precision measurements to test fundamental symmetries of the Standard Model and its extensions. The gamma-ray spectroscopy programs with low-energy radioactive beams at ISAC-I and accelerated beams at ISAC-II thus form a core component of the ISAC research program. This program is currently supported by the state-of-the-art TIGRESS spectrometer and its auxiliary detection systems at ISAC-II, as well as the unique low-energy decay spectroscopy facility at ISAC-I that has been developed around the 8π Spectrometer and its auxiliary detectors. At the present time, a new high-efficiency gamma-ray spectrometer for ISAC-I, GRIFFIN, which will replace the 8π Spectrometer in 2014 and will be fully operational in May 2015, is under construction. GRIFFIN will provide 300 times the γ–γ coincidence detection efficiency of the 8π Spectrometer and will revolutionize decay spectroscopy research with the most exotic, and lowest intensity, radioactive beams produced at ISAC, ARIEL, and their future target and driver upgrades at TRIUMF. The gamma-ray spectroscopy programs centered around the state-of-the-art TIGRESS and GRIFFIN spectrometers, together with their auxiliary detection systems, are thus envisioned to play a central role in the scientific exploitation of ISAC and ARIEL throughout the lifetime of these facilities. This will include a broad range of research into the evolution of nuclear structure at the limits of stability, experiments targeted at specific states of interest for understanding the pathways, time scales, and energy releases in the explosive astrophysical environments responsible for the synthesis of the heavy elements, and precision measurements such as the superallowed Fermi β decay studies that currently provide the most precise determination of the V_{ud} element of the CKM quark-mixing matrix and limits on scalar currents in the weak interaction, as well as a potential search for new CP-violating interactions through precision electric-dipole moment measurements on radon isotopes produced at ISAC.

RELATIONSHIP TO BROADER CANADIAN RESEARCH COMMUNITY:

The gamma-ray spectroscopy facilities, and their associated auxiliary detectors, at ISAC support the research programs of faculty from across Canada, as well as many international users of the TRIUMF-ISAC facility. The Principal Collaborators of this submission include 12 faculty/staff scientists from 7 institutions across Canada.

BROADER IMPACTS:

The research programs supported by the gamma-ray spectroscopy infrastructure at ISAC provide an outstanding training environment for highly qualified personnel at all levels. A very wide range of advanced technology, from highly-segmented semiconductor detectors, scintillation detectors, and gas detectors, to vacuum technology and state-of-the-art digital electronics, is involved in this research. The scale of the individual projects, however, remains such that young researchers can contribute to, and gain hands-on experience with the operation of all these components, placing them in high demand for permanent positions in academia, national research laboratories, and industry.

MAJOR MILESTONES:

Description	Date
GRIFFIN (Phase I) completed and operational at ISAC-I	May 31, 2015
TIGRESS, GRIFFIN, DESCANT, SPICE, TIP and associated auxiliary detectors	
operating at ISAC-I and ISAC-II throughout the 2015-2020 period.	

RESOURCE REQUIRMENTS:

CASH FLOW REQUIREMENTS						
\YEAR SOURCE \	ONE (2015)	TWO (2016)	THREE (2017)	FOUR (2018)	FIVE (2019)	TOTAL
TRIUMF						
EXTERNAL	$230,000	$230,000	$230,000	$230,000	$230,000	$1,150,000
TOTAL	$230,000	$230,000	$230,000	$230,000	$230,000	$1,150,000
TRIUMF NON-CASH RESOURCES (FTE-weeks)						
\YEAR RESOURCE\	ONE (2015)	TWO (2016)	THREE (2017)	FOUR (2018)	FIVE (2019)	TOTAL
Admin (Office)	5	5	5	5	5	25
Admin (Procurement)	5	5	5	5	5	25
Design Office	40	20	20	20	20	160
Engineer (Electronics)	2	2	2	2	2	10
Engineer (Mechanical)	15	1	1	1	1	19
IT (Applications)	30	10	10	10	10	70
IT (DAQ Professional)	60	60	60	60	60	300
IT (Systems Admin)	2	2	2	2	2	10
Physics (Beam Dynam)	1	1	1	1	1	5
Physics (Detectors)	15	5	5	5	5	35
Physics (Nuclear BAE)	150	150	150	150	150	750
Technical (Electronics)	20	10	10	10	10	60
Technical (Machinist)	15	10	10	10	10	55
Technical (Mechanical)	70	70	70	70	70	350

EXTERNAL FUNDING INFORMATION:

The $230,000/year of external cash flow indicated above represents the expected CFI IOF funds associated with the GRIFFIN project. These funds will be used to directly support a significant fraction (~50%) of the TRIUMF technical personnel (non-BAE) identified in the above table, thereby reducing the effective cost to TRIUMF of providing these personnel resources. It should be noted that the γ-ray spectroscopy at ISAC program is also strongly supported by an NSERC Team Discovery Grant held by a number of the Principal Collaborators. This NSERC Discovery Grant is funded at a level of $1.390M in 2015-16 and $1.412M in 2016-17, and is expected to be renewed at similar levels throughout the period covered by this 5-Year Plan. This NSERC grant provides the cash resources required to maintain the detectors and electronics of the gamma-ray spectroscopy facilities at ISAC and also supports a significant number of postdoctoral Research Associates who are stationed full-time at TRIUMF and who play a major role in the day-to-day operation and maintenance of the spectrometers, significantly reducing the overall requirements for TRIUMF-funded technical resources associated with the operation of the gamma-ray spectroscopy at ISAC program.

ONGOING OPERATIONAL REQUIREMENTS:

Ongoing operational requirements for the gamma-ray spectroscopy program at ISAC, at levels approximately equal to those given above, are expected for the lifetime of the ISAC and ARIEL facilities.

DECOMMISSIONING REQUIREMENT:

No extraordinary requirements. Detectors and electronics are modular and transportable.

Accepted:	Date: