The Context and Environment of Subatomic Physics Research at Canadian Universities

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In June 2014, Samir Boughaba, NSERC's Research Grants Team Leader for Physics, Astronomy and Computer Science, requested that the CINP and IPP jointly prepare a short document on "the context of Canadian subatomic physics research" for distribution to SAPES shortly before the fall policy meeting, with the opportunity for the committee to ask questions on it. This was in response to our request (echoed annually also in the SAPES Chair's report) to reinstate the discontinued SAPES fall site visits, given their value to both international and domestic members of the committee in understanding the Canadian research context and environment. We do not believe that this brief can even begin to provide the depth of knowledge that university site visits could provide to SAPES, but it is our hope that this document can at least provide an overview of some of the most important information. In order to understand the overall research environment and the context in which the research is conducted, including the quality of the research space, the age and status of equipment and other infrastructure, technical support personnel, the level of engagement and interactions of the students and postdocs, interactions between researchers within an institution or institutions within geographical proximity, as well as the level of support of the institution's administration, a site-visit is required.

Roles of Canadian research funding agencies in support of subatomic physics

The decisions that you make as SAPES member are of crucial importance to the Canadian subatomic physics research enterprise, as the NSERC Subatomic Physics Envelope is the only major means of operating funds support for Canadian subatomic experiment and theory research. The additional operating research funds provided through Canadian universities, or other federal or provincial agencies, are limited in scope and are often not accessible to researchers in non-applied areas. Subatomic physicists also rely on the SAP-RTI program to provide funding for equipment, and historically, the RTI funds were used to build experiments and provide the Canadian hardware contributions to the experiments of large international collaborations. For most subatomic physicists in Canada, the NSERC SAPES awards are their sole source of research operating funding.

The NSERC Subatomic Physics Envelope also supports several resource facilities through the Major Resources Support (MRS) program. The resources at these facilities are available to the entire subatomic physics community normally allocated via resource allocation boards. At the University of Alberta, the CPP+ MRS Centre is available to provide help with NSERC-funded projects. The MRS facilities at Carleton, Queen's and Victoria are available to support subatomic physics related detector development work. The resources include engineering design, hardware fabrication and installation, and data acquisition/simulation expertise. The Université de Montréal MRS facility provides electronics design and support for subatomic physics projects.

Two NSERC scholarship programs that are commonly used by subatomic physics researchers are the Undergraduate Summer Research Assistantship (USRA) and Postgraduate Scholarship (PGS) competitions. These are awarded directly to the student and in the case of the USRA require an additional funding commitment from the supervisor's NSERC grant. It is important to note that these scholarships are only available to Canadian citizens and permanent residents, so international students studying in Canada are excluded from this means of support. NSERC also runs a series of smaller, more competitive graduate scholarship programs (e.g. Vanier Scholarships) as well as a small PDF fellowship program.

The Canada Foundation for Innovation (CFI) is a major federal source of research infrastructure funding. CFI will fund up to 40% of the costs for a major piece of experimental equipment, with the requirement that 60% of the funds come from elsewhere, including provincial matching funds, industrial or international contributions. In principle the CFI funds, when matched, can be used to make large capital contributions to the experiments of

large international collaborations. However, the CFI grant cycle is uncertain and the process for decision-making on a grant is independent of NSERC SAPES. CFI also contributes funds to the ongoing operations and maintenance needs of national research facilities on a cost-shared basis through the Major Science Initiatives (MSI) program, including SNOLAB. CFI also provides funding to Compute Canada, which operates a variety of national high performance computing centers discussed further below.

The Canada Research Chairs (CRC) program provides direct funding for 2000 research professorships in a wide array of disciplines in Canadian universities. Holders of these chairs often have reduced teaching loads and preferential access to certain types of federal research funding. There are CRC chairs in subatomic physics at the universities of McGill, Carleton (search underway), Laurentian, Queen's, York, Guelph, Winnipeg, Alberta, and UBC.

Also noteworthy is that within the Canadian research environment there are various resources, such as subsidized technical shops, that can be accessed through the leveraging of institutional and grantee resources. Moreover, the cost sharing of resources from grantees on different research projects within an institution, or even from different institutions, is common and the use of the MRS centres facilitate and encourage these efficiencies.

Canadian subatomic physics research institutes

TRIUMF, Canada's national laboratory for particle and nuclear physics in Vancouver, is funded via a separate mechanism. The main source of TRIUMF's ongoing operations funding is $222M over five years (2015-20) from the Government of Canada through the National Research Council of Canada (NRC). Additional funds come indirectly from CFI (through the consortium of Canadian universities operating TRIUMF), and capital funds come from the province of British Columbia. In addition to its extensive on-site research programs, TRIUMF is a vital national support centre for all types of subatomic physics research, including detector construction and testing facilities, and the ATLAS Tier-1 computing centre. The individual CFI awards are now being used to build unique research infrastructure that TRIUMF is unable to support through its NRC funding. TRIUMF research scientists have academic appointments at partnering universities, some of which are jointly funded, and supervise graduate students from the universities with which they are affiliated.

SNOLAB, Canada's underground physics laboratory, is located two kilometers below the earth's surface in the Vale Creighton nickel mine near Sudbury Ontario. SNOLAB has its operations currently funded 40% through the CFI Major Sciences Initiatives (MSI) program, with 40% from the Ontario MRI program and 20% from an in-kind contribution by Vale Inc. The construction of the surface facilities and underground laboratories of SNOLAB have been funded by the International Joint Venture program of the CFI, the Ontario Innovation Trust, the Northern Ontario Heritage Fund Corporation and FedNor. SNOLAB research scientists can have academic appointments at partnering universities and supervise graduate students from the universities with which they are affiliated.

Perimeter Institute (PI) is an independent, resident-based research institute devoted to foundational issues in theoretical physics located in facilities in Waterloo, Ontario. PI receives public funding from both the Ontario Government and Government of Canada, as well as from CFI. Private funds come from a variety of individuals, corporations, and foundations – including BMO Financial Group, Templeton Foundation, SunLife Financial and others. Researchers are also supported by grants and awards from NSERC and Templeton. In addition to its full-time faculty members, PI has Associate Faculty members who are regular faculty members at a partnering Canadian universities and are also employed part-time at PI. PI offers a course-based Master's program through which students receive an M.Sc. from the University of Waterloo. PI faculty supervise Ph.D. students who receive their degree from the partnering university where their supervisor has an affiliation.

The Canadian nuclear and particle physics communities are self-organized into two institutes, the CINP and IPP, which are federally-incorporated non-profit corporations. Both institutes are supported by a combination of NSERC MRS funds and internal funds provided by their institutional members. The IPP and CINP provide

representation of their respective research communities to various bodies, such as the NSERC Subatomic Physics Long Range Planning Committee, ICFA and NuPECC, and enhance university-based theoretical and experimental subatomic physics research in Canada. The IPP has the additional role of coordinating the participation of Canadians in international particle physics collaborations, and employs Research Scientists who hold academic appointments at IPP Institutional Member universities and who can be located at an IPP university or at a laboratory, in Canada or abroad. IPP Research Scientists hold NSERC grants and supervise both M.Sc. and Ph.D. students who receive their degrees through their affiliated university. The CINP does not presently employ any Research Scientists, although this matter has been discussed from time-to-time within the institute.

Compute Canada is an organization formed by the research community across Canada and is funded by CFI (and the corresponding provincial funding organizations) via the MSI program. The subatomic physics community uses computing resources for the analysis and reconstruction of data, production of simulated data samples, and theoretical calculations. The majority of the resources are owned and operated by Compute Canada. In addition, there are the ATLAS Tier 1 computing centre at TRIUMF, and small local clusters at many institutions. Compute Canada operates computing centres at most major universities and access to substantial resources is allocated, based on merit, by a resource allocation committee. The ATLAS Tier 2 centres in Victoria, SFU, Toronto and McGill use Compute Canada resources. The ATLAS Tier 1 centre at TRIUMF is managed independently of Compute Canada and is funded by CFI through a special award. The computing centres are linked with a high-speed research network provided by CANARIE (funded by Industry Canada to provide a national research network and connections to the international community). CANARIE provides the subatomic physics community with a dedicated link from TRIUMF to CERN, as well as high-speed connections from the Compute Canada centres. Apart from desk-top computers, which are purchased with NSERC Subatomic Physics Project, Team or Individual Discovery grants, small local clusters at several institutions and the ATLAS Tier 1 as mentioned above, essentially all computing in Canada is now provided via Compute Canada.

Canadian M.Sc. and Ph.D. programs

One of the unique aspects of the training of physics graduate students in Canada is the structure of the Master of Science (M.Sc.) degree program. In Canada, the completion of the M.Sc. degree in physics in most institutions requires the production of a substantial (~100 pages) thesis on original research as well as the completion of a required number of graduate level physics classes. In many institutions an oral defense of the M.Sc. thesis is required. It typically takes 2-3 years to complete a M.Sc. degree, with this time divided about 1/3 on coursework and 2/3 on research under the close supervision of the supervisor. Subatomic physics M.Sc. students are exposed to a large number of research techniques, but not to the depth or level of research independence expected of a Ph.D. student. Many M.Sc. students have a desire to enter industry in the early stages of their career, and may have little interest in an academic career, and therefore begin their M.Sc. with no intention of continuing towards a Ph.D.

The successful completion of the Ph.D. degree requires a significantly greater level of research depth and independence. Ph.D. students are required to take additional graduate classes, complete a comprehensive exam, and orally defend a 100-200 page thesis. Students performing particularly well in their M.Sc. studies may have the opportunity to transfer directly to the Ph.D. program after their first year of Master's studies. Other students may elect to complete the M.Sc. first and then apply to the Ph.D. program. In some universities, it is possible for an exceptionally strong student to directly enter the Ph.D. program without having an M.Sc. In most Canadian universities, if a student enters a Ph.D. program without an M.Sc., either via direct entry or transfer, it is not possible for the student to later receive an M.Sc. degree should problems arise in the course of their Ph.D. studies. The typical graduate student spends 3-5 years in the Ph.D. program, in addition to the time spent in the M.Sc. Program.

As alluded to above, subatomic physics graduate students at Canadian universities typically take graduate classes and do research work in a concurrent manner from an early stage of their graduate studies. Typically, both M.Sc. and Ph.D. students also have Teaching Assistantship (TA) duties for eight months of the year. This differs from

some other countries, where the physics graduate student spends several years exclusively working on graduate classes and passes a qualifying exam before transitioning 100% to research. During the full duration of the M.Sc. and Ph.D. degrees, subatomic physics students are typically supported by a combination of teaching assistantship funds, research assistantship funds from their supervisor's NSERC grants, and scholarships. Subatomic physics students performing research at offshore labs typically try to complete their courses in a manner that enables them to move to the labs for extended periods of time. When they move to the labs, they no longer receive TA funds and the funding difference is made up from the supervisor's NSERC research grant. When students are posted at a lab such as CERN, there can be a significant difference in the cost-of-living as compared to their home city and a Cost Of Living Adjustment (COLA) must be provided from the grant. More information on these support levels are given in the table in the appendix to this document.

Regional differences in the training of Highly Qualified Personnel (HQP)

Canada is a sparsely populated country of vast geographic extent. As a result of this geography, and the fact that education is a provincial jurisdiction, it is not surprising that a number of regional variations in physics HQP training have developed. The university system is primarily publicly funded through the provinces, with tuition fees varying considerably from province to province. Some provincial governments, e.g. Ontario, operate graduate scholarship programs, but others do not. Tuition fees and other academic costs cannot be paid directly from the NSERC grant of the supervisor, but rather is paid by the students from the support they receive from research grants, teaching and any scholarships that they might hold. The universities in Quebec, Ontario, Saskatchewan, Alberta and B.C. follow a fairly traditional model, with most of the research performed at the larger, research-intensive Ph.D. granting universities. Quebec is distinguished with a significantly lower tuition rate than the rest of the country. Tuition fees in the other provinces are more similar, with Alberta being the lowest and Ontario the highest. In all provinces, the cost of supporting a student from the supervisor’s grant is two to three times less expensive than the cost of hiring a postdoc.

HQP training in subatomic physics also involves undergraduates extensively, especially at primarily undergraduate institutions. Universities in Atlantic Canada are a prime example of the role of undergraduates in NSERC-funded research. Relative to its population, the Atlantic region has a very large number of small, primarily undergraduate universities and a much smaller number of Ph.D. granting institutions. These primarily undergraduate universities attract students from across Canada, many of them being very good students. As part of their B.Sc. Honours project requirements, they take part in the research of physics faculty members. In addition to their contributions to NSERC-funded research, the students graduating from these undergraduate research programs often go on to become subatomic graduate students across the country and therefore have a broad impact on HQP training in Canada.

To further illustrate the regional differences in HQP-training, we also profile the universities in the province of Manitoba. The University of Manitoba (UofM) is the only Ph.D.-granting institution, and the other universities in that province are all primarily undergraduate. Active researchers at the universities of Winnipeg and Brandon hold adjunct faculty status at the UofM and as such can directly supervise M.Sc. and Ph.D. students. Their graduate students register and take their classes through the UofM, but spend significant time at the campuses of their supervisors.

A sense of the institutional and regional differences and similarities can be obtained from the table in the appendix.

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Appendix:
Table of information provided by various
Canadian universities in geographic order of east to west

Institution	**No. funded SAP Faculty**	**Local facilities**	**SAP Research Programs**	**Typical Grad Student Support from Supervisor/yr** **assuming students are at the university (when at the labs, the supervisor pays the TA rate plus COLA)**
Memorial – Grenfell campus (Corner Brook, NL)	1 Theory	Atlantic Computational Excellence Network (ACEnet)	Low energy QCD, precision PV tests of Standard Model, Searches of physics beyond SM. Collaborative projects with JLab, Mainz, Dubna. (1 M.Sc.)	Ph.D. program available through St. John's campus of Memorial. Supervisor contributes $8k-19k (NSERC) grant.
Saint Mary's (Halifax, NS)	3 Exp	Subatomic physics has been listed in SMU's strategic research plan. 2 rooms lab space, Linux servers, Atlantic Computational Excellence Network (ACEnet)	Leads CFI-funded IRIS and CANREB facilities at TRIUMF. Offshore research at GSI, Mainz (Germany); JLab, MSU (USA), RIKEN (Japan) (3 PDF, 5 PhD at Dalhousie, 4 MSc)	Typical supervisor support $21-25k
Acadia (Wolfville, NS)	1 Theory	Designated room for undergraduate students working in subatomic theory	Hadron structure in ChPT, NLO and NNLO contributions to electroweak scattering, search for new physics, theory support for experiments at JLab and Mainz	M.Sc. and Ph.D. programs available through Memorial. Typical supervisor support $8k.
Mount Allison (Sackville, NB)	1 Exp, 1 Theory, 1 adjunct Theory (Moncton)	1 detector lab, computers	Experimental research at Mainz (Germany). Theory: non-perturbative computation of rare B decay observables for LHCb.	Undergraduate institution
McGill Montréal, QC)	Particle Physics: 6 Exp, 7 Theory Nuclear Physics: 3 Exp 3 Theory	Lab space for ATLAS muon upgrade; desktops and access to CLUMEQ/GRID; technicians and machine shop	Particle Physics Experimental Program: ATLAS, Belle II, VERITAS, ILC, BaBar: (3 PDF, 10 PhD, 5 MSc); Theory (1 PDF, 12 PhD, 7 MSc)	$17.7k from NSERC grant, $4.7k TA, $3.7k scholarship; Total=$26.1k
Concordia (Montréal, QC)	1 Theory	Unix server	Theory: part-time RA, 3PhD, 1 MSc	$8-10K from NSERC grant; $7.5k TA; $5k scholarship, International Fee Remission, additional performance-based scholarships ($3K-$10.8K); Total = $22.5k

Institution	**No. funded SAP Faculty**	**Local facilities**	**SAP Research Programs**	**Typical Grad Student Support from Supervisor/yr** **assuming students are at the university (when at the labs, the supervisor pays the TA rate plus COLA)**
Université de Montréal (Montréal, QC)	5 Exp, 3 Theory	500m^2; class 10 000 clean room with class 1000 section;300m^2 detector construction space; local computing. In house Tandem Van de Graaff facility, proton and heavy ion test beams for detector calibrations; irradiation facility to study radiation hardness of materials and detector components; low energy (keV) mono-energetic neutron facility for detector calibrations; machine shops with 3 NC lathe/milling machines, 2 technicians; MRS Supported Groupe technologique - High energy physics instrumentation R&D, prototyping and development of detector read-out modules, support of SAP projects	Experimental Particle Physics Program: ATLAS, Pico/PICASSO, Belle II (3 PDF, 7 PhD, 4 MSc); Theory (1 PDF, 1 PhD, 1 MSc)	$18k from NSERC grant, $5k TA per term depending on no. of credits; for two terms/year of TA support; Total=$23k
Carleton University (Ottawa, ON)	5 Exp, 5 Theory	Half of large research wing devoted to P.P. Research; Large high bay assembly area for detector assembly and testing; Large clean room in detector assembly; Computer farm with ~400 cores + > 150TB storage for HEP with dedicated computer room with stand alone HVAC system; Access to precision machine shop; MRS personnel and detector facilities available to community.	Particle Physics Experimental Program: ATLAS, EXO, DEAP, ILC (6 PDF, 7 PhD, 4 MSc); Theory (4 PDF, 4 PhD, 4 MSc)	$15k from NSERC grant, $10.5k TA, $5k scholarship; Total=$30.5k
Queen's University (Kingston, ON)	8 Exp	Two clean rooms, Four general laboratories; optical cryostat, CDMS test cryostat, bubble chamber, optical spectrometers for scintillation studies, dark rooms for PMT testing, low background counting facilities (radon emanation); local computing - HPVCL on campus; three admin assistants, an engineer, and 4 technical staff members supporting the SNOLAB effort.	Current Particle Physics Program: SNO+, Deap-3600, SuperCDMS, PICO/PICASSO(6 PDF, 9 PhD, 13 MSc)	$12k from NSERC grant, $8k TA, $6k scholarship; Total=$26k

Institution	**No. funded SAP Faculty**	**Local facilities**	**SAP Research Programs**	**Typical Grad Student Support from Supervisor/yr** **assuming students are at the university (when at the labs, the supervisor pays the TA rate plus COLA)**
Laurentian (Sudbury, ON)	5 Exp	SNOLAB Lab on campus shared among the experiments, 4 rooms for computer, electronics and test work, 1 room for detector testing and storage, 1 chemistry lab, 2 half rooms for storage; also uses SNOLAB cleanroom space; 2 technical personnel	Experimental Program: SNO+, EXO, PICO, HALO (4RA/Postdoc, 2 PhD, 5 MSc students)	Average $17.7k from NSERC grant, $6.4k TA, $1k university stipend (one-time); Total = $25k
SNOLAB (Sudbury, ON)	6 Exp research scientists (adjunct professors at Laurentian University)	4,900 m^2 underground clean room research laboratory with associated services and infrastructure including lay down areas, personnel facilities and material handling. 3,300 m^2 surface facility including clean room laboratories, meeting rooms, control rooms, office space, warehouse, laydown areas and material handling. Low background counting facilities. IT support including Gb/s networking and guested experiments. Technical and logistics support for experiments.	SNO+, DEAP-3600, PICO/PICASSO/COUPP-60, HALO, DAMIC, MiniCLEAN, SuperCDMS	
Toronto (ON)	7 Exp, 4 Theory	1 prototyping lab (50m2); 1 clean room (40m2) + 1 Construction Lab (100m2) + 1 dirty/storage room (20m2); Access to computing via SciNet(www.scinet.utoronto.ca.) Departmental Physics Computing Services does not provide CPUs, but is an excellent resource for software and hardware advice.	Particle Physics Experimental Program: ATLAS, T2K, SRF/ARIEL (4 PDF; 13 PhD; 2 MSc); Theory (1-2 PDF, 12 PhD, 4 MSc)	$16k from NSERC grant, $5k TA, $9k scholarship; Total=$30k Note: HEP students at the University of Toronto do not do Thesis M.Sc. but instead do 1 year M.Sc. which require courses and a research report.
York (Toronto, ON)	3 Exp, 4 Theory	Two labs for small construction projects; 320 compute ores, machine shop	Experiment (3 PDF, 5 PhD) Theory (2 PDF, 1 PhD, 1 MSc)	$9k-$15k from NSERC grant, $11k TA, $4k scholarship; Total=$24-$30k
McMaster (Hamilton, ON)	1 Exp	CFI-funded detector lab, local computing and lab space available.	radioactive beam experiments at TRIUMF and Argonne (1 PDF, 2 MSc)	Supervisor contributes $11.5k, univ TA and scholarship brings total to $25k

Institution	**No. funded SAP Faculty**	**Local facilities**	**SAP Research Programs**	**Typical Grad Student Support from Supervisor/yr** **assuming students are at the university (when at the labs, the supervisor pays the TA rate plus COLA)**
Guelph (ON)	2 Exp 1 Theory	Local facilities Lab for small projects, machine shop	Led the NSERC funded TIGRESS gamma-ray spectrometer, the CFI-funded DESCANT neutron detector array and GRIFFIN gamma-ray spectrometer. TRIUMF-ISAC and ISAC-II, offshore at Munich, Lexington (KY), Jyvaskyla (3 PDF, 8 PhD, 4 MSc). Theory: Contributed 700-core CFI-funded cluster to SHARCNET (2 MSc)	$13k from NSERC grant, $13k TA, $4k scholarship; Total=$30k
Perimeter Institute (Waterloo, ON)	13 Theory (8 full-time PI; 4Associates; 1 Emeritus)	Office and seminar space; local computing resources	Particle theory, quantum fields and strings; 15 PDF, 12 PhD, 10 MSc; Note that 2 faculty and 2 PDF's also engaged in the APEX and HPS experiments at JLAB;	$21k from NSERC grant, no TA as there is no undergraduate program at PI, $5k scholarship; Total=$26k
Western Ontario (London, ON)	2 Exp, 2 Theory (1 cross-appoi nted with PI)	Computing resources: SHARCNET	Experiment (1 PDF, 4 PhD) Theory (1 PDF, 4 PhD)	$18k from NSERC grant, $5k TA, $4k scholarship; Total=$27k
Manitoba (Winnipeg, MB)	5 Exp, 1 Theory, 4 additional research-act ive Emeriti (3 exp, 1 theory) and 4 Adjunct (3 exp, 1 theory)	2 CFI-funded detector labs on campus. Facilities include VME DAQ setups, extensive lasers and optics setup, local workstations and core server.	Canadian Penning Trap at Argonne; cold neutrons at SNS; ultra-cold neutrons at TRIUMF; Qweak/Moller at JLab; Atomic Parity Violation at TRIUMF, Heidelberg Exp (5 PDF, 7 PhD, 5 PhD(by adjuncts), 6 MSc) Theory (1 PhD, 1 PhD(by adjuncts), 1 MSc)	Supervisor typically contributes $14.4k, univ TA and scholarship brings total to $22.2k. Students working at national labs receive cost-of-living top-ups.
Winnipeg (MB)	3 Exp 1 Theory	Four labs, including clean room, gas systems, detectors, , DAQ electronics, lasers, NMR equipment, SQUIDS, Xe polarizer, magnetometers, magnetic shielding	Neutron EDM search with Ultra-cold neutrons at TRIUMF, neutrinos, neutrons and electron scattering, particle physics theory, string theory (4 PhD at Manitoba)	Supervisor contributes $7-18k, TA and scholarships bring total to ~$25k.

Institution	**No. funded SAP Faculty**	**Local facilities**	**SAP Research Programs**	**Typical Grad Student Support from Supervisor/yr** **assuming students are at the university (when at the labs, the supervisor pays the TA rate plus COLA)**
Regina (SK)	Nuclear Physics: 3 Exp Particle Physics: 2 Exp	Three labs including detector construction and testing space, two CPU clusters; access to electronic and machine shops at a fee	GlueX and Pion Form Factor at JLab (USA), Proton Polarizabilities at Mainz (Germany), T2K. (2 PDF, 3 PhD, 2 MSc) Particle Physics Experimental Program: T2K (1 PDF, 1 PhD, 1 MSc) One Research Scientist also supported via mix of NSERC and local funds.	In nuclear physics: Supervisor contributes $20k, TA brings total to $25k. In particle physics: $16.4k NSERC, $4.4k from TA; Total: $20.4k
Saskatchewan (Saskatoon, SK)	1 Exp, 2 Theory	Faculty are members Subatomic Physics Institute (SPIN). 2 detector testing rooms. Collaboration with Canadian Light Source on campus has been helpful on many occasions.	Experiments at Triangle Universities Nuclear Lab (USA). Particle physics theory and phenomenology. (Exp: 2 MSc. Theory: 1PDF, 2 PhD, 3 MSc)	Supervisor contributes: $5.5-11k, Scholarship: $6.4-$15k. Total: $17.5-20.5k
Alberta (Edmonton, AB)	7 Exp, 2 Theory	8 labs (Radon free shop, Low background counting, IceCube Lab, Radioactive work lab, X-Ray lab, Assembly Lab, Detector lab, Clean Assembly Lab); Electronics shop, Machine shop, CPP+ personnel available to the community(engineer, detector technician, electronics technician; Westgrid as part of Compute Canada, Thor cluster for ATLAS, Theory cluster	Particle Physics Experimental Program: ATLAS, DEAP, IceCube, PICO/PICASSO, SNO+, MoEDEL, ALTA: (7 PDF, 12 PhD, 3 MSc); Theory (2 PDF, 1 PhD)	$10.3k from NSERC grant, $20.7 TA, $3.3k scholarship
Simon Fraser (Burnaby, BC)	Particle Physics: 3 Exp Nuclear Physics & Chemistry: 2 Exp	Primarily use TRIUMF lab space; a machine Shop is used to compliment TRIUMF-based resources; use Compute Canada and local ATLAS Tier-3 cluster built slowly over many years, maintained by physicists and SFU staff. Nuclear facilities: D/T neutron generator, 8pi HpGe/BGO spectrometer, segmented HpGe counting station, radiochemistry lab, alpha spectrometer, XRFIN system.	Particle Physics Experimental Program: ATLAS (2 PDF, 9 graduate students) Nuclear: In-trap decay spectroscopy using TITAN, gamma-ray and decay spectroscopy using ISAC-1, ISAC-11 at TRIUMF, integrated plunger program using neutron activation & spectroscopy	Particle Physics: $17k from NSERC grant, $6k TA, $3.5k scholarship; Total=$26.5k Nuclear: $13-15k from NSERC, $6k TA, $0-2k scholarship. Total=$21-23k.

Institution	No. funded SAP Faculty	Local facilities	SAP Research Programs	Typical Grad Student Support from Supervisor/yr assuming students are at the university (when at the labs, the supervisor pays the TA rate plus COLA)
British Columbia (Vancouver, BC)	Particle: 9 Exp, 6 Theory; Nuclear: 1 Exp	Use of TRIUMF facilities; Shared BELLE II, BaBar, T2K lab space, Shared High Bay assembly facility (shared with entire Phys/Astro Dept), ATLAS lab space; Large projects: people use detector lab and scintillator shop at TRIUMF. Detectors apparatus with gas system and DAQ may be done at TRIUMF instead at UBC.	Particle Physics Experimental Program: ATLAS, T2K, PIENU, TREK at JPARC, SuperCDMS, Belle II, BaBar (6 PDF, 21 PhD, 10 MSc); Theory (2 PDF, 16 PhD, 1 MSc) Nuclear Physics Experimental Program: ISAC/ARIEL (3PhD)	$13-15k from NSERC grant, $9k TA, $4.5k tuition scholarship for PhD students; Total=$26.5k
TRIUMF-Accelerator Physics (Vancouver, BC)	11 staff	TRIUMF accelerator complex, SRF testing facilities, beta-NMR and MuSR materials characterization facilities	Research Program: SRF and cyclotron development, target and ion-source development, wake field acceleration (12 PDF, 11 PhD, 4MSc, 6 Engineers in Training (EIT))	Support varies for different home universities.
TRIUMF – Nuclear Physics (Vancouver, BC)	9 Exp, 3 Theory on staff, many off-site users	Full TRIUMF facilities	Nuclear Physics Programs: Exp (20 PDF, 2 PhD, 4 MSc) Theory (4 PDF, 11 PhD) ,see discussion on p.2 re. grad student supervision	Support varies for different home universities.
TRIUMF – Particle Physics (Vancouver, BC)	11 Exp, 2 Theory	Full TRIUMF facilities: detector facilities, ATLAS upgrade facilities;ATLAS Tier-1, Tier-3, T2K Tier-1, M11 test beam	Particle Physics Experimental Program: ATLAS, T2K, ARIEL (14 PDF, 7 PhD, 2 MSc); Theory (3 PDF, 1 MSc) see discussion on p.2	Support varies for different home universities.
Victoria (BC)	7 Exp, 3 Theory	Large shared lab space; clean room; machine shop; electronics shop; local cluster plus access to WestGrid; MRS detector development expert available to the community	Particle Physics Experimental Program: ATLAS, T2K, Belle II, BaBar, ALTAIR Accelerator/ARIEL/ILC (4 PDF, 10 PhD, 8 MSc); Theory (2 PDF, 3 PhD, 2 MSc)	Department policy Minimum: $17.7k from NSERC grant, $4.9k TA, $2k;Total $24.6k