The Prairie Particle Physics Institute at the University of Regina

1. Preamble

Subatomic physics is the main research area of the Department of Physics. This appears to be a single research area, but in reality the research conducted by its members is fairly diverse, spanning the range between low energy/nuclear and high energy/particle physics.

Among the latter practitioners, the largest sub-group consists of four experimentalists with Jefferson Lab (JLab) as their research base. Recently, a new hire in particle physics has strengthened the existing experimental particle physics research program (GlueX) of the Department and may add new directions of research such as the Next Linear Collider (NLC) and/or CLEO-c at Cornell.

The theory component, in particle physics, is also diverse. One theorist conducts his research in Lattice Gauge Theory (LGT) in the non-perturbative QCD regime, and another investigates topics in the perturbative, high-energy region in connection to super-symmetry and dark matter. LGT is closely related to the JLab-based experimental effort and requires significant computing resources, a technical requirement that parallels the GlueX experimental infrastructure requirements. Super-symmetry, on the other hand, is closer to NLC physics and such a connection may develop with the new hire in Physics.

2. Objectives

Given the common objectives of the particle physics researchers in the Department and their common funding agencies, infrastructure and research culture, the formation of an institute parallel to the Department and drawing on some common resources, will strengthen the cohesiveness of its researchers, provide an organizational basis for planning and will enhance the image of the practitioners. For example, a computational physicist associated with the institute can oversee, maintain, update and develop software in support of GlueX, LGT and NLC research while coordinating the software installations and updates, and overseeing hardware maintenance for all sub-groups. The institute could also be employed as a conduit towards the organization of seminars and workshops, and the invitation of speakers. The ultimate goal is for the institute to become associated with other institutes in the Prairie Provinces and eventually to become the nucleus of a regional particle physics institute.

The objectives then of the proposed institute are to focus and organize, to enhance and expand the research activities and reputation of the particle physics research of the Department while maintaining a certain autonomy of action and planning and assume a separate resource management structure from that of the Department to better allow it to respond to new opportunities and changing demands. A key goal is to provide education and training for highly qualified personnel: students and postdoctoral fellows (PDF's).

Institute Name, its Resources and Manpower

Note: This application is made within the context of a university-wide institute (Schedule B). Therefore, this document addresses the resource and manpower issues within the context of a local institute. However, the fundamentals should be organized in such a way as to facilitate the future expansion – from a local to a regional institute – without major restructuring, in collaboration with other prairie-based Institutes and particle physics groups. Such an institute does yet not exist, however, several local institutes are in place already and they can combine into such a regional institute.

At this stage, we propose a name that would be also appropriate for a regional center in the future: "Prairie Particle Physics Institute at Regina", or "P^3I" for short. The natural, initial nucleus of P^3I will be the five SPARRO members (Barbi, Brash, Huber, Lolos and Papandreou) and the two theorists (Dutta and Lewis). Presently, the SPARRO group supports three PDF's while Dutta and Lewis also support three. In addition, Lewis and the SPARRO group have considerable computing infrastructure and both parties plan on major upgrades and new acquisitions. SPARRO has considerable detector design and testing infrastructure as well.

It is clear that P^3I will assemble a team that is already well established and well funded and with considerable computational infrastructure. Until now, faculty members have maintained the latter with the expenditure of time and effort and this is no longer feasible. As computers age and new ones are added, the level of effort needed to maintain them, install software upgrades and generally manage them exceeds the capacity of the present faculty members. The Institute will need a full-time software physicist/systems manager to support the researchers and ideally the same person will also be a researcher in his/her own merit, in order to install and run particle physics applications such as Monte Carlo simulations.

The GlueX project will be – by sheer size, project duration and budget envelope – a major component of P^3I**.** In fact, it can be argued that GlueX more than any other aspect defines the need for an institute. Given the complexity of the project and the leading role that SPARRO plays, a research scientist with a long term (project tenure) position is necessary to provide continuity, interaction with counterparts in other GlueX groups and the overseeing of the day-to-day needs of the project within the mandate of the SPARRO group. Such a (hardware) research scientist – coupled with the software research scientist above – will provide much needed support to the institute.

When P^3I combines with other groups in Alberta, Saskatchewan and Manitoba to form a regional center, the two research scientists will also assume further responsibilities to meet the new demands. Since GlueX alone will be the focus of the experimental part of P^3I up to at least 2015 and further upgrades are already planned, both research funding and project tenure have reasonable life terms to justify research scientist positions with project tenure.

3. Training of Highly Qualified Personnel

Our research tasks involve, but are not limited to, theoretical and analytical calculations, analysis of data, computational simulations to model physical processes or to understand detector behavior, technical research and development leading to new instrumentation, and the planning and execution of experiments.

Our groups have a number of PDF's, graduate and undergraduate students assigned to these research efforts. Each such HQP is expected to become familiar with the theoretical aspects of our research, understand the functionality and learn to operate our electronics equipment and data acquisition systems, and apply this knowledge in experiments under lab and beam (accelerator) conditions.

Significant resources in manpower and time are expended to achieve this level of training. Whereas much of it is accomplished by direct contact between our HQP's and the faculty members, additional experience results from participating in international collaborations and field trips, as well as attending conferences and workshops. Typically, PDF's are hired with some experience. However, this may not be directly in our areas of research, and thus even these individuals require considerable training, but once this is complete they become trainers for students.

In the past six years, over 50 undergraduates and around 10 graduate students and 10 PDF's have been employed, trained and some have received degrees. Most of these HQP's worked on the calorimeter detector of the GlueX Project, an endeavor that has required a lot of personnel in its R&D phase and that will require dozens of HQP's when it reaches its production phase. Among the undergraduates, a significant number were Physics Co-Op students that carried out work terms on our projects. We expect to continue to train similar numbers of HQP's under the Institute's umbrella.

All HQP's have received quality education and training, experience in a wide-ranging set of experimental detectors, hands-on expertise in computer programming and physical modeling, as well as exposure to international collaborative research. As a result, these they are well poised to pursue successful careers, in academia or the private sector, and this is evidenced, in part, by their present positions.

4. Projects and Partnerships

The nature of particle physics demands a spectrum of skills of its researchers.

On the experimental side, each HQP must be equipped with strong software and hardware skills. The project assigned to each HQP is – to some level – tailored to their expertise. Those in hardware often require experience with electronics, high voltage equipment, solid-state devices, etc. For many aspects of our R&D, interaction with Engineers is desired and in the future we anticipate hiring Engineering students on Co-Op work terms. The intensive computation of our projects requires intimate knowledge of cutting edge software packages from CERN or the commercial sector, as well as with emerging technologies such as portals, grid and web services. For this reason, students and faculty from the Department of Computer Science are expected to play a role.

Our projects are large, international and collaborative in scope. Our researchers have proven to be very successful in being awarded substantial grants, which, in turn allow an increasing level of involvement in the collaborations. Physics students and staff alone cannot meet the personnel needs of GlueX project the future; rather, collaborations will need to be struck with individuals from other departments in Science and Engineering.

On the theoretical side, students and PDF's must possess advanced mathematical skills. This has lead to the appointment of several faculty members from the Department of Mathematics to our theoretical M.Sc. and Ph.D. committees, and to the recent investigation of graduate courses in Mathematics as approved courses for our students. Amendments are planned for the physics section of the Graduate Calendar to reflect this need.

5. Space

Current research space in particle physics includes computer rooms, equipment laboratories and offices of PDF's.

Our main computer facilities are located in AH106, and represent an investment approaching \$3 million. These include four large computational clusters consisting of rack-mounted CPU's, RAID storage arrays, controllers and Ethernet switches, and combine to produce a heat load of almost 2/3 of the capacity of AH106, a space that includes other research clusters and the majority of the University's administration and Banner systems. The AH106 provisions are adequate for our present and near-term needs but will most likely be inadequate five years from now. A committee has been struck by Computing Services that includes all stakeholders to address this issue.

Our key equipment assembly and testing areas are LY002, LB117 and LB127. These contain sophisticated electronics, data acquisition systems, detectors and computer servers. Whereas these facilities are well equipped for the R&D phases of projects, they are inadequate for the production (construction) phases, when large floor space (in excess of 2000 ft^2) and 2-ton overhead cranes are required. For this reason, we have entered into partnership with the Centre for Subatomic Research at the University of Alberta, where we successfully completed the assembly of a 1-ton prototype module last summer.

Our PDF's occupy offices in the first and second floor of the Laboratory Building. This is just adequate for our present needs, although the CRC Tier II Chair's (R. Lewis) PDF space is rather limited. In order to meet the needs of P^3I, the Dean of Science and the Registrar have assigned a classroom (LB205) as temporary office space for its Research Scientists, pending a periodic (each semester) move of courses scheduled for this classroom. If this arrangement is not made permanent, alternate space will be have to be found.