Canadian Spallation Ultracold Neutron Source

J.W. Martin (Spokesperson)[1], P. Carlson[2], S. Kondratchuk[2], C. Saunders[2], J. Birchall[3], M. Gericke[3], S.A. Page[3], and W.T.H. van Oers[3]

[1] *University of Winnipeg, Winnipeg, MB*
[2] *Acsion Industries, Pinawa, MB*
[3] *University of Manitoba, Winnipeg, MB*

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1 Project Overview and Scientific Motivation

The University of Winnipeg is leading an international collaboration of physicists in the construction of the world's highest density source of ultracold neutrons (UCN), the Canadian Spallation Ultracold Neutron Source (CSUNS). This is a collaboration between Canadian, Japanese, and U.S. groups, and the collaboration is expected to grow in size. The ultracold neutron source will be constructed in Vancouver, because the appropriate facility (a high-energy proton accelerator) is available. It will be used primarily for fundamental physics research on the interactions of neutrons with fundamental fields. The source would eventually also be used for a branch of nanotechnology known as surface nanoscience.

The source will be located in Canada at TRIUMF, Vancouver, BC. This location is ideal because of the high-intensity high-energy proton beam available from the TRIUMF cyclotron, which is used to drive the UCN source. The truly high density that could be obtained at TRIUMF would allow a class of precision measurements of the fundamental properties of the neutron to be conducted with significantly higher precision than any other UCN source. The source would therefore make a major impact on studies of fundamental physics with UCN. Funding for physics experiments would be requested in the future from a combination of NSERC, Japanese, and other international sources.

Funding for the source is being sought for from the Canada Foundation for Innovation (CFI) through the University of Winnipeg. Matching funds for the CFI grant would be provided by a combination of Japanese sources and by TRIUMF (Canada's National Laboratory for Particle and Nuclear Physics, which is the eventual location for the neutron source). The overall project cost is \$10M, with \$4M supplied by CFI, \$4M supplied by Japan, and \$2M supplied by TRIUMF.

The University of Winnipeg has been the lead institution in the project since the very beginning. In the past year, J.W. Martin, the spokesperson for the project, has gone through the process of building an impressive international collaboration. Numerous Canadian and international collaborators are involved in the project. Prof. Martin organized an international workshop "UCN sources and experiments", which was held at TRIUMF on September 13-14, 2007. Fifty experts in neutron physics from around the world attended the workshop. The workshop concluded decisively that Canada would be an ideal location for a next-generation UCN source.

As a part of the planning process, J.W. Martin has presented the project to review committees four times over the past year, and has organized two collaboration meetings. The UCN source project was most recently reviewed by the TRIUMF Special Experimental Evaluation Committee (March 2008). The committee concluded that "a high density UCN source will support a fundamental physics program at TRIUMF well into the future, thus maintaining the strong tradition at the laboratory of a broad program of measurement of nuclear interactions, nuclear structure, nuclear astrophysics, and fundamental symmetry tests. Like the latter it will furthermore bridge the gap between particle and nuclear physics." Such a strong endorsement has resulted partially from the excellent support and interest from the TRIUMF laboratory. The project will be presented again by J.W. Martin to the Advisory Committee on TRIUMF (ACOT) on May 9, 2008. The membership of both committees includes some of the most well-known nuclear and particle physicists in the world. The membership of ACOT additionally includes representatives from the National Research Council Canada (NRC) and from NSERC.

2 The Advantage of Manitoba: Acsion Industries

Acsion Industries (Pinawa, MB) was approached by the collaboration to assist in R&D for the neutron source. The company's core competencies with nuclear techniques, in particular in the design of nuclear reactor sources, has already proven invaluable to the collaboration. It is this activity for which we are also seeking funding at this time.

The services that would be provided by Acsion to the collaboration would be as follows:

1. R&D consulting and services provided by ANCs scientists, engineers and technicians, as required by U of W. ANCs initial research will focus on:
   - Developing and documenting MCNPX computer models of UCNS.
   - Performing modeling and validation studies with the prototype Japanese facility.
   - Optimizing equipment designs.
   - Perform parametric studies of tank and geometry dimensions and effect on UCN density to optimize the new TRIUMF facility.
   - Collaborate with TRIUMF and Japanese groups re materials design.
   - Investigate the effects of various guide reflective materials.
2. Operational Health Physics Support: Provide operational health physics support to U of W locations and to other program participants UW customers. Duties may include:
   - Providing Radiation Protection (RP) Program management and oversight, including preparing radiation protection procedures, implementing and maintaining radiation protection performance metrics, monitoring non-conformances and corrective actions, performing compliance inspections and reviews.
   - Operational health physics services for assigned projects, including developing RP controls, radiological safety assessments, preparing work plans, and investigating unplanned events.
   - Providing facility design support.
3. Government relations, business development and regulatory compliance support.
4. Training for selected graduate students and post-doctoral candidates, jointly selected by U of W and ANC, in MCNPX computer modeling.

In completing the work, Acsion and the University of Winnipeg and Manitoba will gain exposure far beyond the borders of Manitoba. Initially the work will focus on computer simulations of a neutron source in Japan which our Japanese collaborators operate. Acsion scientists have already contributed to the project by beginning to study neutron transport in a computer model of that source.

3 Training of Highly Qualified Personnel (HQP)

The project would contribute to the training of a large number of undergraduate students, graduate students, and postdoctoral fellows from across Canada. The project has attracted a world-class group of scientists, and will therefore attract HQP from around the world to Canada. In fact, postdoc applications to the U. Winnipeg group have already been received citing interest in the UCN project (from ILL Grenoble and from Indiana U.).

Performing research on neutron physics experiments is excellent training for problem-solving in real-world situations. Students and postdocs in nuclear physics must use a variety of resources in order to achieve highly complex tasks. In the course of an experiment, personnel can be trained on design of future experiments, computer simulation, design and construction of custom hardware, installation and commissioning of hardware, acquisition and analysis of data, and effective communication of progress at meetings and of results through authorship of publications. Unique technologies used in this proposal are cryogenics, vacuum technologies, nuclear instrumentation, RF technology, and superconducting technology. Many of these technologies are common to the medical field as well, and there is typically a large cross-over in personnel.

In addition to traditional research positions in nuclear physics, students trained in experimental nuclear physics have gone on to leadership and technical positions in a variety of industries. Known to me personally are those with positions in: medical physics research, materials research, quantitative analysis of the stock market, management consulting, internet start-up companies, and aerospace engineering. This incredible diversity in possibilities, in such a large variety of highly technical fields, represent the possibilities available to one who possesses the training obtained as an experimental nuclear physicist.

U. Winnipeg students trained in J.W. Martin's CFI-funded subatomic physics detector lab have received offers of employment advancing their positions in physics, and have presented at meetings of physics societies of Canada, Japan, and the U.S. This group of students includes a Rhodes Scholar, two Stevenson awardees, and an NSERC PGS-D awardee.

4 Requested Funding

Funds are requested based on an estimated workload of 1000 hours per year total for Acsion staff, over the four-year course of the project. Also included are software licensing fees and travel expenses for Acsion staff. The total project is therefore expected to cost $225,000 per year or $900,000 total. Of this total, fully one-half of the funds will be supplied by Acsion Industries themselves. For the remaining funds ($112,500 per year) we are seeking equal funding support from each of: CFI (as a part of the aforementioned $10M total cost of the neutron source itself), and the Government of Manitoba (this request). A memorandum of understanding between the University of Winnipeg and Acsion Industries is complete which describes the budget in detail.

The total requested from the Government of Manitoba is therefore $56,250 per year over four years, thus totalling $225,000.