Building on Success in Canadian Subatomic Physics

We welcome the opportunity to make this presentation to the House of Commons Standing Committee on Industry, Science, and Technology on behalf of the Canadian subatomic physics community. Our comments will focus on two topics: federally funded research performed in academia, and Canada's approach to "big science" projects. In what follows we will give a brief overview of the field, the community, the importance to Canada of the research, the facilities we build and use, and the challenges we face.

<u>What is subatomic physics and who does subatomic physics research in Canada?</u>

Subatomic physics is the study of the most fundamental constituents of matter – of everything we see around us – encompassing the areas of nuclear, particle, and astro-particle physics. The curiosity that drives this field of research is the same as that felt by any schoolchild with a magnifying glass: What are things made from? How are they held together? How do they work? Where do they come from?

Subatomic physics is a global scientific endeavor, and Canada is a world-class player. The 1000-strong Canadian subatomic physics community includes students, post-doctoral fellows, technical staff, lab scientists and university faculty members. We develop and manage forefront facilities that attract the best foreign scientists to Canada, and, in turn, we are sought-after contributors to leading international projects. Canada's national laboratory for subatomic physics, TRIUMF, also hosts a broad base of research in materials science, nuclear chemistry, and the life sciences.

Canada's subatomic physics community has a record of excellence embodied by projects such as SNO, the world-famous underground experiment near Sudbury which unequivocally showed that neutrinos emitted by the Sun mutate on their passage to Earth. The SNO result is one of the most important and internationally recognised of the last decade in subatomic physics.

The University-based researchers in subatomic physics in Canada are supported by competitive grants from the Natural Sciences and Engineering Research Council (NSERC). The Canada Foundation for Innovation (CFI) has been instrumental in the last decade in providing capital funds. The community periodically conducts, under the aegis of NSERC, long-range planning exercises to establish research priorities and to gauge the health of subatomic physics in Canada. The last such exercise, in 2006, found that the Canadian subatomic physics community was strong and thriving, and established a prioritised scientific road-map with explicit budget recommendations. Most notably, it recognised that without additional operational support, Canada would be unable to fully exploit its recent capital investments – they would be, in a word, wasted.

<u>Why is subatomic physics important for Canada?</u>

Subatomic physics is important for Canada because it pushes the frontiers of human knowledge; in doing so it lays the foundations for new technologies in the physical and life sciences. Subatomic physics captures the imagination of the best and brightest students to attack the most fundamental questions mankind has been able to pose. Making progress on these questions requires the most elaborate scientific instruments ever devised. These instruments, in turn, challenge physicists, engineers and computer scientists to apply the tools of their respective trades in novel and undreamed of ways to make advances. The research is “curiosity-driven” but there are very real and substantial economic benefits. The economic impacts include not only the technological benefits of the research, but also the highly qualified personnel who transfer knowledge and skills to Canadian industry. These people, many of them students, are exposed through subatomic physics to international collaboration and world-class research and development. This interdisciplinary effort brings out innovation in all fields and regularly produces new instruments and capabilities that are of immediate benefit to society (medical imaging, radioactive tracers, the world-wide web, etc.). An investment in subatomic physics training is an investment in a technologically innovative economy, competitive on the international stage.

Given the nature of the knowledge produced, the timescales involved and the degree of international inter-dependency necessary to produce forefront facilities in subatomic physics (particle accelerator complexes, deep underground laboratories, distributed computing networks), it is unreasonable to expect that this work would be undertaken on a commercial basis. And yet, it is crucial that Canada play an active role in this research if we are to reap the intellectual and economic benefits – initially from the researchers trained in the use of cutting edge technologies, but ultimately from direct industrial involvement in the production of the building blocks. Thus, governments in general – and the federal government in particular – have a major role to play.

<u>Canada’s facilities in subatomic physics</u>

Canada has an excellent record of leadership in subatomic physics projects. This record stretches back to the founding of the Chalk River laboratories after the Second World War, through the establishment of TRIUMF in the late 1960s, to Canada's involvement in accelerator projects based in Germany and at CERN through the 1980s and 90s. Recently, Canadians have constructed and operated the SNO experiment in Sudbury and we are now commissioning its CFI-funded expansion to SNOLAB, the world's premier site for deep underground science. Canada has an envied position in subatomic physics and, over the last decade, an exemplary track record in the construction of major science infrastructure.

The TRIUMF laboratory in Vancouver, which started operation in 1974, is Canada’s national laboratory for particle and nuclear physics. It remains, today, the site of the world's largest cyclotron. TRIUMF’s flagship program is the ISAC facility, the world’s leading facility for the production of exotic short-lived isotopes. ISAC’s unique capabilities allow critical and challenging measurements which have already made important contributions to our understanding of the nuclear processes driving stars and the mechanism which produces the heavy elements in the Universe. TRIUMF is currently designed a high-power electron accelerator to complement the isotopes produced by the cyclotron. The technological heart of this accelerator is being developed in conjunction with Canadian industry and an eye to potential medical and industrial applications.

One quarter of the Canadian subatomic physics community is working at the European Laboratory for Nuclear and Particle physics (CERN) near Geneva, Switzerland. CERN is the preeminent international particle physics laboratory today, and hosts the Large Hadron Collider (LHC), the largest scientific instrument ever assembled by mankind. Canadians have made significant contributions to both the LHC accelerator complex and to the ATLAS experiment. CERN's LHC will provide the ATLAS experiment with the highest energy proton-proton collisions on Earth, where we expect to see the resolution of the origin of mass and may see even stranger phenomena emerge: dark matter, extra dimensions of space and time and possibly ties between particle physics and gravity.

Canada's second domestic subatomic physics facility, SNOLAB nearing completion at the Inco Creighton mine in Sudbury, provides the tools for a further quarter of the Canadian subatomic physics community. An extension of the successful Sudbury Neutrino Observatory (SNO) experiment, SNOLAB is the deepest underground experimental facility in the world, offering unique sensitivity to rare processes. SNOLAB is the ideal location to host experiments that search for cosmic dark matter and others that will make contributions to our understanding of neutrino physics that may be even more important than those already made by the Sudbury Neutrino Observatory. While CFI has been instrumental in funding the capital costs of the facility, ongoing operations funding and funds for construction of major experiments at the lab are still not definitively in place.

In the coming decade Canadian researchers also aspire to be full partners in the realisation of the next large subatomic physics project, the International Linear Collider (ILC), currently undergoing an extensive design review after several years of technical R&D. The ILC will collide electrons and positrons at energies that will allow precision measurements of new phenomena discovered at the LHC, and has been identified as the highest priority future particle physics facility by the international scientific community.

Major new projects like the ILC will require new international commitments for both the construction of the accelerator and the construction and operation of detectors. Canadian participation in an ILC experiment will necessitate capital contributions to a detector and, most probably, to the accelerator itself sometime in the next decade. International partners – including the US, the UK, the EU, and Japan – have established a committee of Funding Agencies for the Linear Collider (FALC) that has met periodically (the most recent of these meetings was in Canada in January 2008) over the last six years. NSERC and the National Research Council (NRC) have been approached to champion Canada's interests at FALC but have been reluctant to take on this role, we suspect, because they are unable to identify a funding mechanism that would allow Canada to contribute to such a project. Sadly, Canada is missing important scientific and industrial opportunities while other countries move forward.

It is vital that Canada develop the mechanisms to provide stable, long-term funding for these – and other – internationally-recognised scientific endeavours. This includes not only major Canadian facilities such as SNOLAB, but also participation in globally-organised projects such as the ILC, and a suite of smaller international projects from which the next scientific opportunities may arise. Ongoing research in these efforts is valued in and beyond Canada, and contributes very positively to Canada's scientific reputation and technological progress.

<u>What does Canada need to succeed in subatomic physics?</u>

The ILC example is indicative of the size and timescale of projects in subatomic physics and demonstrates that other nations are developing a comprehensive approach to the funding of large new facilities. We encourage the Canadian government to develop a robust mechanism for building and managing leading-edge research facilities. Canadian science in general – and subatomic physics in particular – needs a mechanism that ensures that all large science initiatives have, from the outset, identifiable resources for both capital funding and operations.

Our community has struggled with the variety of funding mechanisms available in Canada. Recent experience with CFI projects has made it apparent that it is not just the initial capital investment that must be considered, but also operating, exploitation and decommissioning costs, when undertaking any such adventure. Subatomic physicists have long been aware that continued support for facility exploitation can be a much tougher sell than initial construction. Construction often implies direct benefits to Canadian industry and benefits other governmental jurisdictions while the exploitation "only" benefits scientists and students, sometimes at off-shore facilities. This has been a continuous struggle for us for the last several decades. Funding volatility forced our community to make scientific compromises that limited our involvement in projects that had seen significant initial Canadian capital investments. While the researchers usually recognise the full cost associated with these endeavours, the current Canadian system encourages us to compartmentalise funding requests in order to move forward. A scheme that took into account the full costs – but also appreciated the full benefits (scientific, economic and educational) – would have a significant, positive, impact.

The 2006 Subatomic Physics Long-range Plan "Perspectives on Subatomic Physics in Canada 2006-2010" (LRP) identified three key requirements in order for the community to build on its recent successes, fully exploit the opportunities in the near future, and deliver scientific, technological, and educational benefits to Canadians.

- A reinforcement of NSERC's Discovery Grants programme. The Discovery Grants program is the heart of funding for fundamental research in Canada, providing funds through internationally peer-reviewed competitions. The current Discovery Grants budget (2006-2007) is $390M/yr. In order to capitalise on the infrastructure investments that have been made over the last decade, our LRP concluded that a doubling of the subatomic physics base funding (currently ~$23M/yr) over 10 years is necessary, costing approximately $100M and resulting in an annual growth rate of 8.25%.
- A robust mechanism, and long-term support, through programs such as the Canada Foundation for Innovation (CFI), for the construction and operation of world-class research facilities such as SNOLAB. CFI's mandate currently does not extend beyond 2010.
- Increased operational support for the internationally recognised TRIUMF lab, which is currently preparing a new 5-year plan for the period 2010-2015.

Subatomic physics is entering an exciting era; truly revolutionary discoveries – new dimensions, dark matter, unified theories – may be exhilaratingly close. The Canadian subatomic physics community is well-positioned to play a leadership role in that era. We believe that implementation of these recommendations will allow us, a decade hence, to be positioned at the very forefront of that revolution – recognised as leaders at home and actively sought out as scientific partners abroad – as we seek to continue the millenia-old quest to understand the very fundaments of the world around us

We thank the Standing Committee for this chance to present our views. For more information, including the full text of the 2006 Long-range Plan, please see www.subatomicphysics.ca

Ken Ragan, Professor of Physics, McGill University, and chair of Canadian Subatomic Physics Long-range Planning Committee.

William Trischuk, Professor of Physics, University of Toronto, and Director of the Institute of Particle Physics.

April 18, 2008