A Productive Collaboration: TRIUMF & The University of Victoria

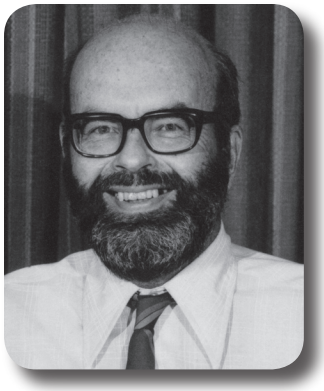
by Richard Keeler

TRIUMF and the Department of Physics and Astronomy at the University of Victoria (UVic) share a common history and a long and productive collaboration. Shortly after the founding of UVic in 1963, the Department began hiring nuclear physicists. Two years later, they began writing a proposal for an accelerator laboratory, and in 1968, UVic became a founding member of the TRIUMF joint venture.

The team at UVic took responsibility for the design of TRIUMF's beam line optics. The original meson production target as well as the first temporary beam dump were both designed and constructed in Victoria and then transported to Vancouver. At TRIUMF, the M9 muon beam line, which initiated the molecular and materials science studies that are now an important research component of TRIUMF, was developed with significant input from UVic. The design of the M8 medical channel and the first design of the M11 septum magnet were also done at Victoria.

As the initial construction work at TRIUMF proceeded, scientists in the UVic group began planning and building physics experiments of international scope to exploit TRIUMF's unique features, including the latest in its instrumentation technologies and high-performance computing. The BASQUE experiment, the first experiment in the then new TRIUMF Proton Hall, was a collaboration among the University of Victoria, the University of British Columbia (UBC) and AERE Harwell, the University of Surrey, Queen Mary College and Bedford College in the UK. This collaboration used TRIUMF's cyclotron to accelerate polarized protons to produce record intensity polarized proton beams. The UVic group contributed a liquid deuterium target capable of producing polarized neutrons and intense unpolarized intermediate energy neutron beams while surviving the high-radiation environment and a large deposited heat load. Nucleon-nucleon cross sections and spin dependent measurements published by the BASQUE collaboration in 1983 established unambiguous phase shifts for kinetic energies up to 500 MeV. (see Fig.1)

The second focus of the UVic group was on the "other side" of the cyclotron, using low energy pions. Dr. Michael Pearce started and led a productive program of mesic and muonic X-ray physics. His untimely death was a severe blow to this work and a sad personal loss to those who knew him. The University created a named professorship in his memory and, in 1983, Dr. Alan Astbury became the first holder of the Pearce Chair of Physics. His appointment changed the main focus of the UVic group towards particle physics.



Dr. Michael Pearce

In the early 1980s, TRIUMF, with the UVic group, built one of the world's first operating time projection chambers (TPC) to make precision measurements of pion decay modes to establish stringent limits on lepton universality, a key component of modern particle theory. The collaboration was also actively involved in calculating the correction needed to understand the new high-precision data. In 1983, an important review article was published in *The Review of Modern Physics* (50:11-21) on double beta decay as well as calculations of branching ratios, radiative corrections and strong interaction effects. A second group unraveled the subtle and complex atomic and molecular interactions involved in muon catalyzed fusion.

Two years later, in 1985, TRIUMF proposed building a Kaon Factory. Alan Astbury was the Kaon Factory

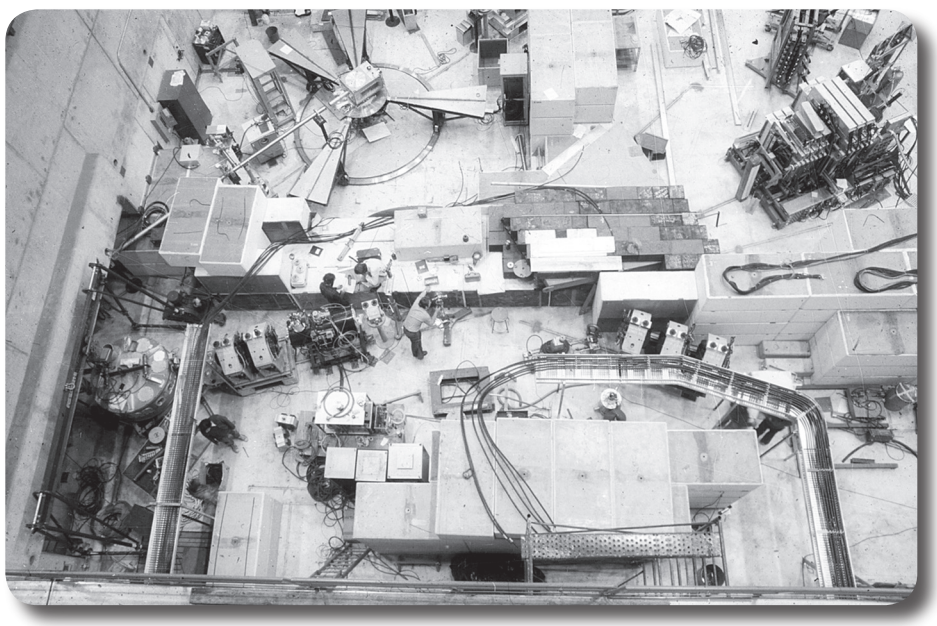


Fig. 1: Aligning the Basque experiment beam line.

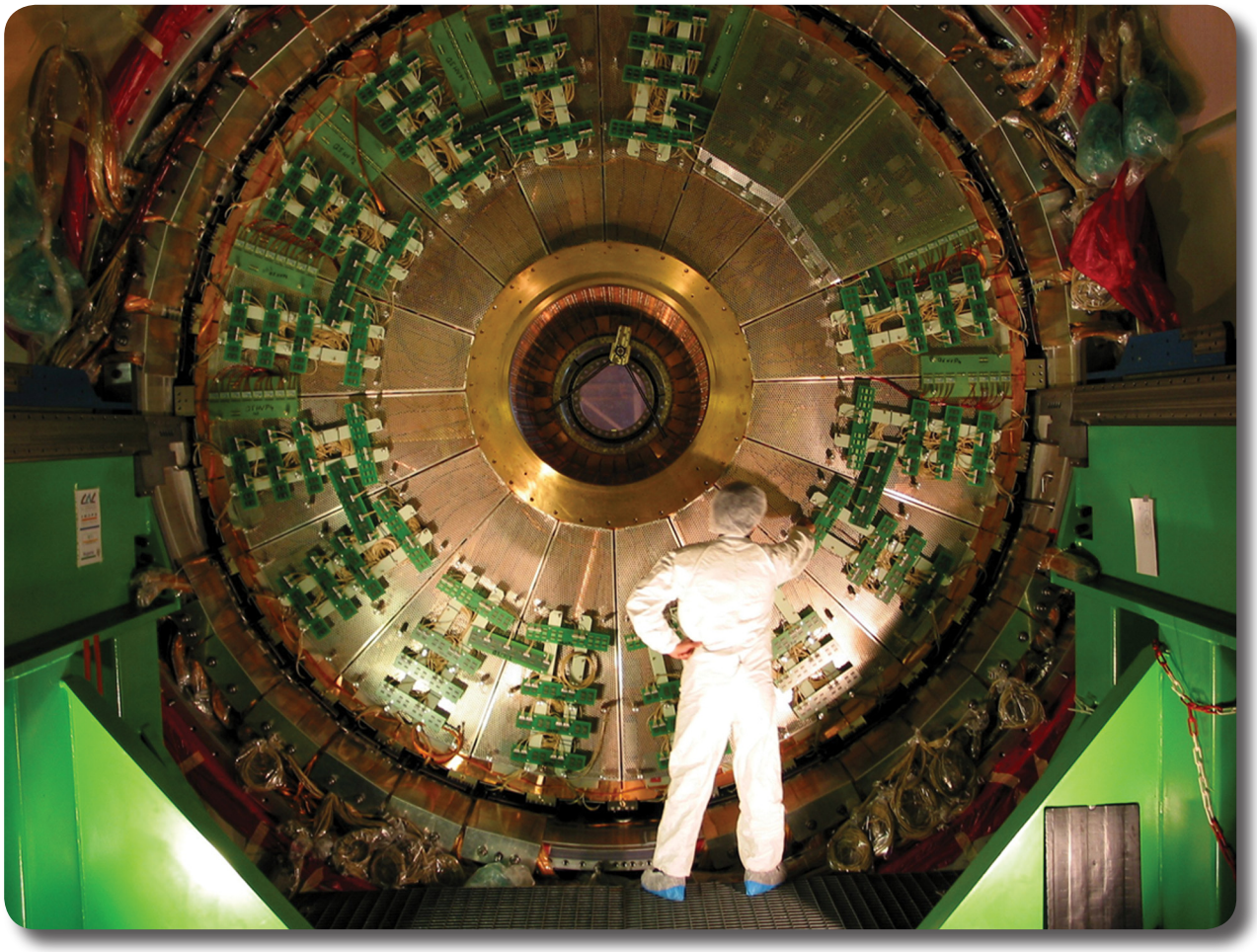


Fig. 2: Rear view of ATLAS Hadronic End Cap.

Definition Study Director, and the UVic group became involved in several critical design components. The Kaon Factory was not to be, but the innovative work done by TRIUMF and UVic as one of the partners was not completely lost. University of Victoria and TRIUMF scientists began work on rare kaon physics at the Brookhaven National Laboratory in the USA, and the Victoria targets group designed a new target for the Alternating Gradient Synchrotron (AGS) that enhanced the kaon beam used in the observation of the ultra rare decay of a charged kaon into a charged pion and two neutrinos. Ultimately, a project with many of the same goals as the TRIUMF Kaon Factory was proposed and is being built in Tokai Japan. It is an interesting coincidence that the present Pearce Professor of Physics, Dr. Dean Karlen, is playing a leading role with the Tokai to Kamioka (T2K) neutrino experiment.

In the late 1980s, the University of Victoria joined the SLD experiment at the Stanford Linear Accelerator (SLAC). TRIUMF and Victoria were responsible for the mechanical design of the liquid argon calorimeter and half of the modules of the electromagnetic section were built at TRIUMF. A very nice engineering project involved designing and testing earthquake protection, called snubbers. In operation, the hydraulic liquid changed phase and was supersonic; not a textbook problem by any means. It is a credit to the advanced engineering skills of the TRIUMF-UVic group that the snubbers actually worked as predicted and prevented any significant damage from occurring to the SLD detector as a result of the hugely destructive 1989 San Francisco earthquake.

In 1991, TRIUMF and UVic scientists joined the OPAL collaboration at CERN, where they played a leading role in designing and building an advanced silicon micro-vertex detector that led to the world's best measurements of B meson and tau lepton lifetimes. TRIUMF-UVic's detector expertise was on the international stage again in 1997 when the large drift chamber at the heart of the BaBar experiment was assembled at TRIUMF. The detector was instrumental in the discovery of CP violation in B mesons.

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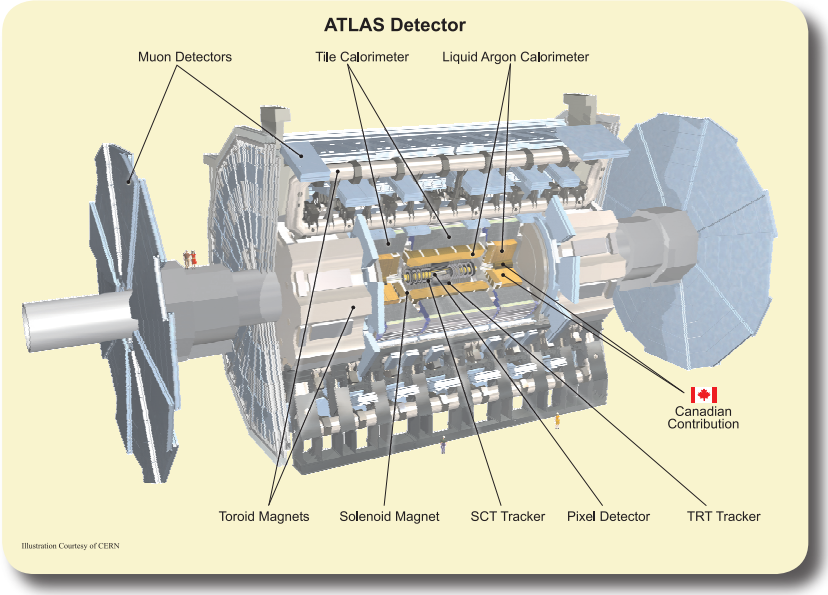
Virtually every particle physics laboratory in the world has been called upon to make contributions to the Large Hadron Collider and the associated detectors soon to be complete at CERN in Geneva. The University of Victoria founded ATLAS Canada, the Canadian collaboration that now has approximately 40 leading scientists from across Canada. UVic and TRIUMF worked with the University of Alberta, UBC, Carleton University and collaborators in Europe to design, construct and install the liquid argon hadronic calorimeters in the end cap region of the detector. (see Fig. 2) A member of the TRIUMF-UVic group was the chief mechanical engineer for this project and played a critical role as a member of the ATLAS cryogenics steering committee. In collaboration with the Brookhaven National Laboratory, the TRIUMF-UVic engineering group also designed, built, tested and installed advanced high-density cryogenic feedthroughs. TRIUMF personnel were responsible for managing the installation of the calorimeters and feedthroughs at CERN.

In 1994, Alan Astbury temporarily left Victoria to become the Director of TRIUMF. Under his direction, the laboratory redirected its efforts to design and build the world's most powerful isotope separator and accelerator (ISAC). The initial thermal calculations for the ISAC target were done in Victoria, and the beam dump module was designed by the Victoria target group.



The ATLAS detector at CERN.

ISAC-I Opening: Dr. Alan Astbury and The Honorable John Manley.

Dr. Alan Shotter replaced Dr. Alan Astbury as TRIUMF's Director in 2001, and the relationship and collaboration between TRIUMF and UVIC continued to be strong. The ATLAS Tier 1 Data Centre (see page 4) was secured for the Canadian ATLAS collaboration in 2006, and the TRIUMF-UVic collaboration on T2K expanded as UVic and Canada's interest in the proposed experiment grew. Advanced engineering by UVic for targets at ISAC and for the TRIUMF beam lines is continuing as well. More recent efforts include studies and measurements to help develop targets capable of taking higher beam power, effusion oven designs and prototypes, heat shield analysis and forced electron beam induced arc discharge (FEBIAD) ion source development.

The 37 years that the University of Victoria and TRIUMF have collaborated have been wonderful years of discovery and invention. At the present time, significant engineering and detector development is in progress for the T2K neutrino oscillation experiment. Thermal analysis of electronic crates and research and development in advanced TPC detectors is also ongoing with design and manufacture of prototypes moving into full-scale production. And the future looks just as bright: for ISAC-II experiments, ATLAS and the LHC, as well as TRIUMF-UVic research and development on gas detector systems for a future International Linear Collider.

Richard Keeler is a Professor of Physics at the University of Victoria and member of the TRIUMF Board of Management.