# VISPA 2022 NEWSLETTER

VICTORIA SUBATOMIC PHYSICS AND ACCELERATOR RESEARCH CENTRE

UVIC AND VISPA POSTDOC DR. ELLIS KAY ATTACHES OPTICAL FIBRE DATA PATHWAYS FOR AN UPGRADE TO THE ATLAS EXPERIMENT AT THE CERN LARGE HADRON COLLIDER (LHC).

**IN THIS ISSUE**



University of Victoria

# ATLAS EXPERIMENT

*Geneva, Switzerland*

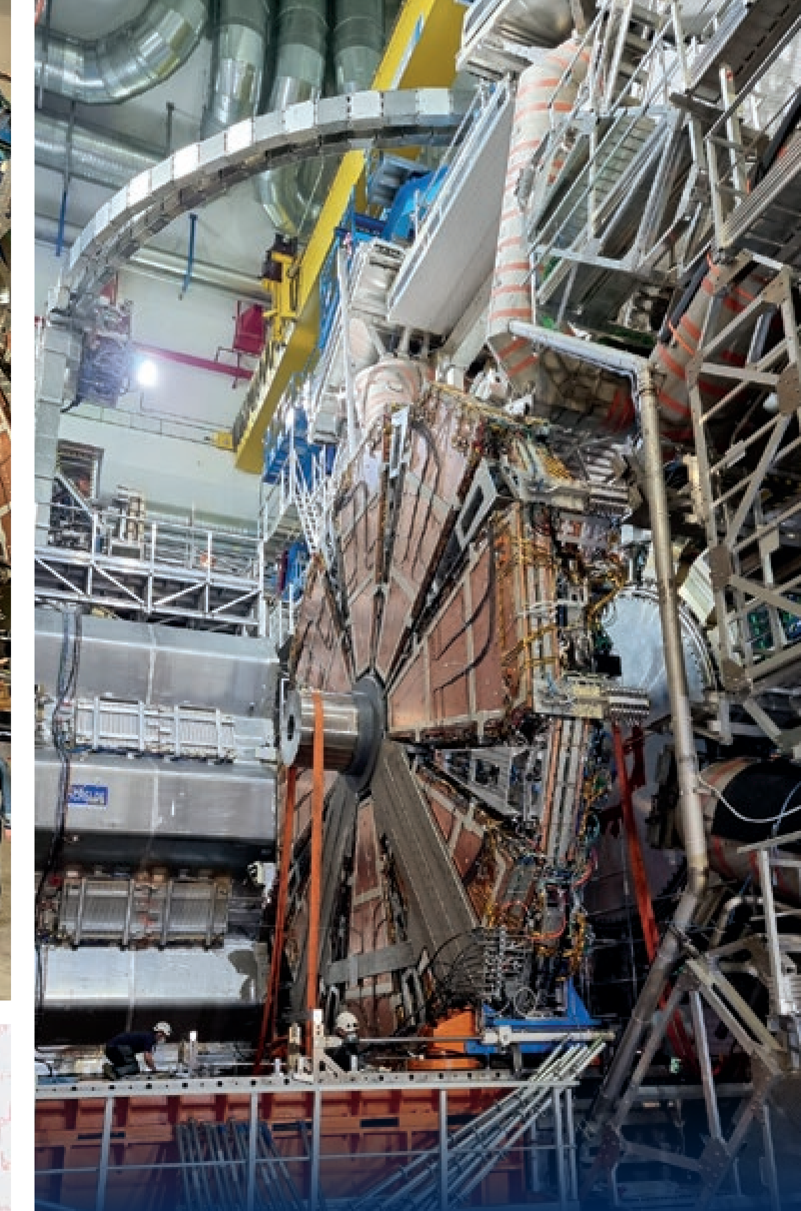
The Large Hadron Collider (LHC) at the CERN laboratory is the highest energy particle collider in operation. The ATLAS detector is one of two multipurpose detectors designed to record high energy collisions at the LHC, and the UVic ATLAS group has been a member of the ATLAS Collaboration since its foundation in 1992. Michel Lefebvre acted as founding spokesperson of the ATLAS Canada collaboration, and Rob McPherson recently served as Deputy Spokesperson of the worldwide ATLAS collaboration. VISPA members involved in ATLAS also include Justin Albert, Richard Keeler, Bob Kowalewski, Leonid Kurchaninov, Heather Russell, Randall Sobie and Isabel Trigger. UVic was instrumental in the initial design and construction of ATLAS Liquid Argon Endcap calorimeters, and is now playing key roles in the upgrades of the readout electronics of the calorimeters needed for the higher rates of LHC data taking planned for the coming two decades. UVic has also led the construction, installation and commissioning of the massive small-strip thin gap chamber (sTGC) detector, half of the ATLAS Muon New Small Wheel upgrade project which has recently been completed and installed and will be commissioned with proton collisions in 2022 and operate for the duration of ATLAS to about 2040. UVic also plays critical roles in ATLAS computing, with the Kubernetes cloud on the UVic Arbutus cluster contributing the most computing cores of any comparable site in Canada.

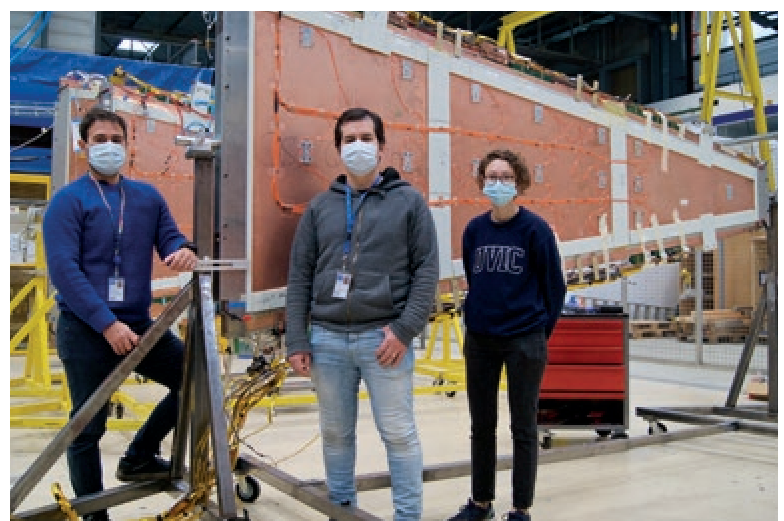
Bottom row of photos (left to right)

- Two completed sTGC wedges at CERN ready for installation into ATLAS for use in the higher-rate upgraded LHC. Pictures from left to right are UVic postdocs Gerardo Vasquez and Rimsky Rojas, and UVic MSc student Leesa Brown.
- UVic postdoc Ellis Kay installing and testing readout electronics for the first phase of the ATLAS endcap calorimeter upgrade for higher-rate operation in the upgraded LHC. UVic postdoc Clément Camincher also worked on the LAr system.

**ATLAS Muon New Small Wheel (NSW) in CERN Building 191:**

This photo is from July 2021 showing the first NSW (NSW-A) finished and commissioned, and the second wheel (NSW-C) just starting assembly. UVic postdoc (Gerardo Vasquez) coordinated the massive commissioning effort of the sTGC (one of the two technologies used in the NSW) in CERN Building 191 (on the surface), with three UVic students (Evan Carlson, Juan Cristóbal Rivera and Leesa Brown) active in the effort, and another UVic postdoc Rimsky Rojas leading installation and testing of the NSW trigger readout system. Rob McPherson was the ATLAS sTGC Coordinator, and Isabel Trigger and Heather Russell also worked on this project.






**ATLAS Muon New Small Wheel (NSW) being installed underground in ATLAS:**

Photo is from July 2021 when the first NSW, NSW-A , was installed in ATLAS. This wheel is now essentially fully commissioned, and we're actively working on NSW-C in the ATLAS pit during early 2022. Again, UVic postdoc Gerardo Vasquez is coordinating the sTGC commissioning in the ATLAS pit (both wheels), and UVic ATLAS PhD student Juan Cristóbal Rivera and postdoc Rimsky Rojas are also active in the effort.

## MEMBER LIST

### FACULTY

| NAME | RESEARCH AREA |
|---|---|
| Justin Albert | Experimental particle and astroparticle physics |
| Kristan Jensen* | Theoretical physics |
| Tobias Junginger* | Accelerator physics |
| Dean Karlen | Experimental particle physics |
| Pavel Kovtun | Theoretical physics |
| Bob Kowalewski | Experimental particle physics |
| Michel Lefebvre | Experimental particle physics |
| Robert McPherson | Experimental particle physics |
| Adam Ritz | Theoretical physics |
| J. Michael Roney | Experimental particle physics |
| Heather Russell* | Experimental particle physics |
| Randall Sobie | Experimental particle physics |

* = new member

### EMERITUS FACULTY

| NAME | RESEARCH AREA |
|---|---|
| George Beer | Experimental particle physics |
| Richard Keeler | Experimental particle physics |
| Charles Picciotto | Theoretical physics |
| Lyle Robertson | Experimental particle physics |

### ADJUNCT FACULTY

| NAME | RESEARCH AREA |
|---|---|
| Rick Baartman | Accelerator physics |
| Alexander Gottberg | Accelerator physics |
| Mark Hartz | Experimental particle physics |
| Cornelia Hoehr | Accelerator physics |
| Oliver Kester | Accelerator physics |
| Akira Konaka | Experimental particle physics |
| Shane Koscielniak | Accelerator physics |
| Leonid Kurchaninov | Experimental particle physics |
| Bob Laxdal | Accelerator physics |
| David McKeen* | Theoretical physics |
| David Morrissey | Theoretical physics |
| Petr Navratil | Theoretical physics |
| Art Olin | Experimental particle physics |
| Thomas Planche | Accelerator physics |
| Maxim Pospelov | Theoretical physics |
| Isabel Trigger | Experimental particle physics |

### STAFF

| NAME | NAME |
|---|---|
| Sam de Jong | Mark Lenckowski |
| Colson Driemel | Catherine Meng |
| Marcus Ebert | Rolf Seuster |
| Kenji Hamano | Tristan Sullivan |
| Colin Leavett-Brown | Peggy White |

### POSTDOCTORAL RESEARCHERS

| NAME | RESEARCH GROUP |
|---|---|
| Nikita Blinov | Theory |
| Clément Camincher | ATLAS |
| Ellis Kay | ATLAS |
| Eric Mefford | Theory |
| Rimsky Rojas | ATLAS |
| Aleksey Sibidanov | Belle-II |
| Gerardo Vasquez | ATLAS |

### GRADUATE STUDENTS

| NAME | RESEARCH GROUP |
|---|---|
| Mina Abbaslou | Accelerator |
| Joseph Adegun | Accelerator |
| Asad Asaduzzaman | Accelerator |
| Alexandre Beaubien | B-Physics |
| Ferran Boix Pamies | Accelerator |
| Nick Booth | Neutrino |
| Leesa Brown | ATLAS |
| Evan Carlson | ATLAS |
| Charlie Chen | ATLAS |
| John Coffey | Theory |
| Saeid Foroughi Abari | Theory |
| Michael Gennari | Theory |
| Sahar Gholipourverki | B-Physics |
| Ruth Gregory | Accelerator |
| Vincent Gousy-Leblanc | Neutrino |
| William Harvey | Theory |
| Raphael Hoult | Theory |
| Paul Jung | Accelerator |
| Spencer Kiy | Accelerator |
| Rouchuan Liu | Theory |
| Danika MacDonell | ATLAS |
| Aveen Mahon | Accelerator |
| Fernando Maldonado Millan | Accelerator |
| Fatemah Maroufkhani | Neutrino |
| McMullin | Accelerator |
| Caleb Miller | B-Physics |
| Afif Omar | Theory |
| Andrew Paul | Accelerator |
| Yuhao Peng | B-Physics |
| Jakob Rimmer | Neutrino |
| Juan Christóbal Rivera | ATLAS |
| Maheyer Schroff | ATLAS |
| Olivier Shelbaya | Accelerator |
| Marla Cervantes Smith | Accelerator |
| Marina Stefanyk | Theory and ATLAS |
| Sahar Taghayor | Neutrino |
| Kate Taylor | Theory |
| Noah Tessema | B-Physics |
| Benjamin Wright | ATLAS |

Two VISPA students (Vincent Gousy-Leblanc and Nick Booth) stand beside a prototype multi-PMT detector for the Hyper-Kamiokande project currently in development. More than 200 of these detectors are to be constructed for the Hyper-Kamiokande near detector, IWCD.

# HYPER-KAMIOKANDE EXPERIMENT *(Japan)*

**Members of VISPA are currently working with others in Canada and around the world towards the realization of Hyper-Kamiokande, a 250kton water Cherenkov detector in Japan. When completed later this decade, it will be the world's largest detector for neutrinos in the range of a few MeV to tens of GeV, covering the solar, supernova, atmospheric, and accelerator neutrino energy range.**

The goal of the project is wide ranging, from precise neutrino oscillation measurement in accelerator and atmospheric neutrinos, neutrino astronomy of solar and supernova neutrinos, and searches for new physics phenomena such as proton decay and dark matter. An schematic drawing of the detector is shown below.

One of the main goals of Hyper-Kamiokande is to discover CP violation in neutrino oscillations. This is done by observing a difference in the muon neutrino to electron neutrino transition probability between neutrinos and anti-neutrinos. Hyper-Kamiokande can be sensitive to even a small amount of CP violation, provided the systematic uncertainties are significantly less than the statistical error on the event rate of 3%.

VISPA and the Canadian Hyper-K group are engaged in the challenging program to reduce systematic uncertainty in neutrino oscillation measurements. The major sources of systematic uncertainty are related to the initial neutrino flux, neutrino interaction cross section, and the detection efficiency of the water Cherenkov detector. We are leading several projects to address each of these components:

- We lead the EMPHATIC experiment to measure hadron interaction cross sections to better understand the neutrino flux.
- We lead the crucial near detector project for Hyper-Kamiokande. The Intermediate Water Cherenkov Detector (IWCD) will span a range of off-axis beam angles to better understand neutrino cross sections by using multi-PMT detectors. The University of Victoria is the lead institution for the projected funded by the Canada Foundation for Innovation to construct multi-PMT detectors for the IWCD.
- We lead the Water Cherenkov Test Experiment (to be undertaken at CERN in the coming years) to test multi-PMT detectors in a smaller version of the IWCD with a controlled test beam.



UVic PhD student, Alexandre Beaulieu (far right), provided a tour of the Belle II experiment for Canadian Minister of Science the Honourable Kirsty Duncan (left) when she visited the KEK laboratory in Japan. Also present were Belle II Project Manager Yutaka Ushiroda (2nd from left), Head of Accelerator Div.IV Haruyo Koiso (3rd from left), Belle II Spokesperson Thomas Browder (3rd from right), and VISPA member Michael Roney (2nd from right).

# BELLE II EXPERIMENT *(KEK, Japan)*

The Belle II experiment is looking for evidence of new physics at the precision frontier in the collisions of electrons and positrons (i.e. the antimatter equivalent of electrons) at a centre-of-mass energy of around 10 GeV. Belle II measures properties of particles produced in the SuperKEKB e+e- collider—the highest luminosity particle collider in operation. Luminosity is a measure of the number of particles in the colliding beams squeezed through a given space in a given time and SuperKEKB achieved the world record of $3.9\text{x}10^{34}$ per square centimetre per second in December 2021, roughly double that of the proton-proton collisions at the LHC. In the coming years, SuperKEKB is set to further increase its luminosity and will deliver to Belle II more than 30 times more electron-positron collision data than all previous generation experiments at 10GeV combined.

The Belle II Collaboration consists of 980 members from 117 institutions in 26 countries—McGill, UBC and UVic are the Canadian institutions involved with three VISPA members on Belle II (R. Kowalewski, M. Roney and R. Sobie). UVic has been involved in measuring neutron and photon backgrounds from the accelerator since its commissioning phase and has developed a new instrumentation technique to identify particle types with the Belle II electromagnetic calorimeter. Since collisions began in 2018, UVic through the work of R. Sobie, has also played a critical role in Belle II computing and has provided Canada's contribution to the computing needs of the experiment. R. Kowalewksi is involved in precision studies with B meson particles. R. Sobie and M. Roney search for new physics signatures with tau leptons and in searches for dark sector particles. Roney also serves as the Chair of the Belle II Executive Board and is spearheading the effort to upgrade the SuperKEKB collider with polarized electron beams, which further broadens the scientific reach of the experiment to areas of precision electroweak physics with unique sensitivities to the dark sector and other new physics.

# RESEARCH COMPUTING

**Computing is an integral part of particle physics research and it is a key element of our Research Centre. Our international projects, ATLAS, T2K and Belle II, store large samples of collision data that require significant computing resources for the analysis of the data.**

Researchers in VISPA are leaders in developing the computing infrastructure in Canada for particle physics research projects. We are spearheading cloud computing projects in the ATLAS and Belle II experiments. We have developed a distributed cloud computing system that utilizes cloud centres in Europe, Australia and North America, and exploits commercial clouds such as Amazon EC2 and Microsoft Azure (https://www.youtube.com/watch?v=5Kixh66AJNM).

The University of Victoria will host the Canadian Belle II Raw Data Centre, a CFI-funded project led by VISPA, that will store a fraction of the raw data generated by the Belle II experiment at the KEK Laboratory in Tsukuba, Japan (https://www.uvic.ca/news/topics/2021+cfi-innovation-fund+news).

Canada is establishing a new organization, called the Digital Research Alliance of Canada, that will oversee computing, data management and research software in Canada. One of our members, R. Sobie, is Chair of the Alliance Researcher Council (https://engagedri.ca/latest/ndrios-researcher-council-elects-new-chair-dr-randall-sobie) and a member of the Alliance Board of Directors.

VISPA is also home to HEPNET/Canada, which is responsible for national and international network connectivity for the entire Canadian particle physics community. HEPNET works with CANARIE, provider of Canada's research network, to link our centres to the laboratories and universities around the world. HEPNET is actively engaged in network R&D that has had significant involvement from network and computing industry partners.

Computing in particle physics has been an excellent training ground for students. VISPA has employed many undergraduate science and engineering students in this area. The students return to complete their education and use their experience to find employment in wide variety of areas. In addition, many of our staff have transitioned to careers in industry in Canada and abroad.



# THEORETICAL PHYSICS

The UVic theoretical physics group (with faculty Kristan Jensen, Pavel Kovtun and Adam Ritz, and adjunct faculty David McKeen and David Morrissey at TRIUMF) is active in exploring several overlapping research directions. Recent work within the formal theory group explores fundamental questions about the nature of gravity, including the quantum properties of black holes, and properties of the hydrodynamic regime for quantum and classical systems relevant at finite temperature. The particle phenomenology group seeks to resolve puzzles within the Standard Model of particle physics, such as the nature of dark matter in the universe, and physics beyond the TeV energy scale.

UVic Adjunct faculty member and TRIUMF Research Scientist David Morrissey. Photo Credit: TRIUMF

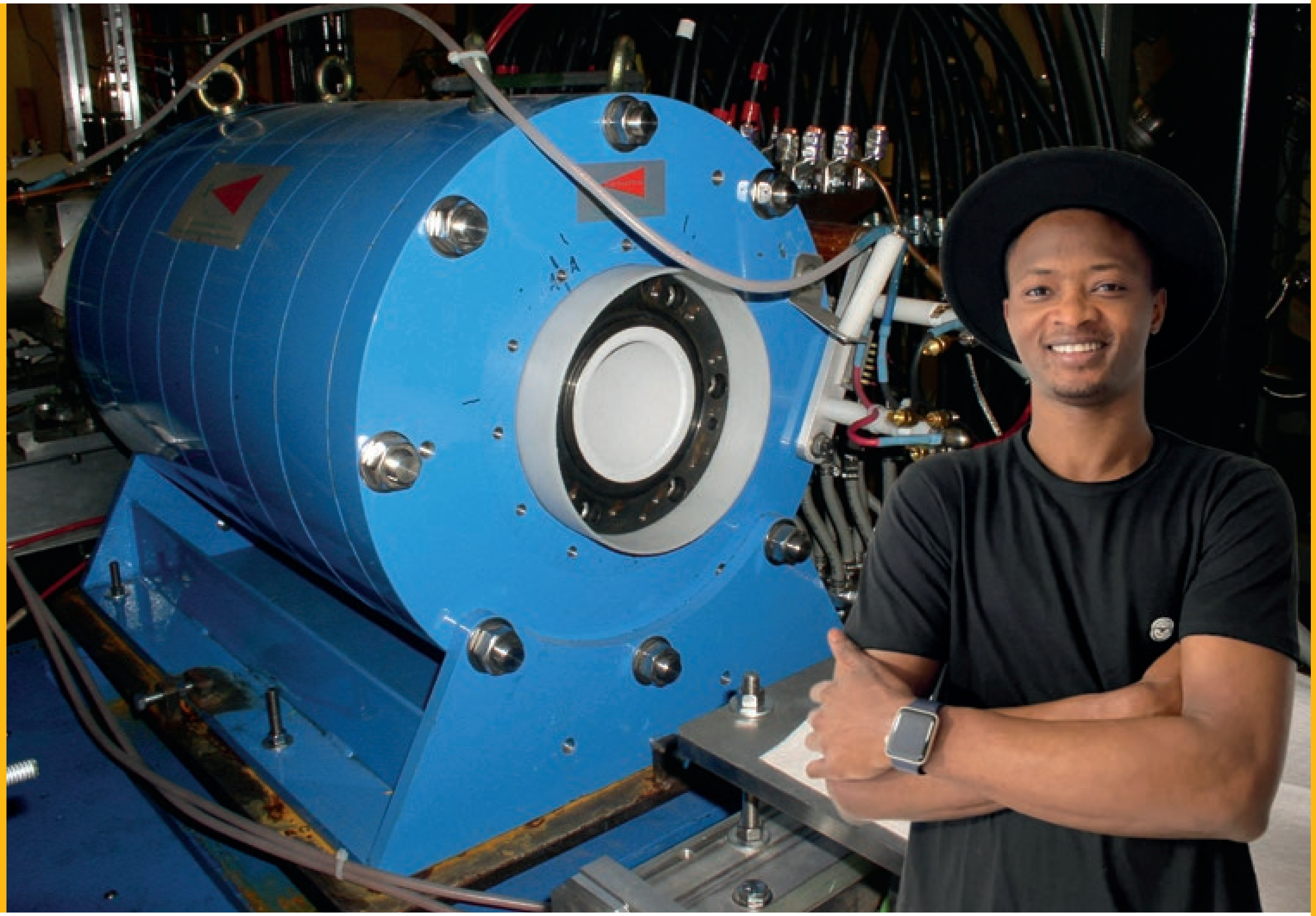
# ACCELERATOR PHYSICS

*(UVic and TRIUMF)*

The University of Victoria is a founding member of TRIUMF and has a long standing tradition in accelerator physics. TRIUMF accelerators are the heart of the Canadian accelerator-based experimental subatomic physics program, both because they enable on-site world-class research in nuclear physics and material sciences (CMMS), and because TRIUMF's expertise allows Canada to make significant in-kind contributions to off-site international accelerator projects thus enabling participation in experiments at those facilities.

Currently five TRIUMF accelerator physicists are members of the UVic adjunct faculty. All of them have active research programs and together with faculty members Dean Karlen and Tobias Junginger we are currently supporting 13 graduate students in accelerator physics based at TRIUMF. Several students have already graduated from this program and have won several awards at international conferences. Most recently, Joseph Adegun received the student poster price at the 2021 International Conference on ion sources (ICIS) for his contribution Improvement of the Efficiency and Beam Quality of the TRIUMF Charge State Booster (CSB). The image below shows Joseph in front of his experiment, the charge state booster.

The research program based at UVic focuses on material aspects for superconducting radiofrequency accelerators in collaborations with the CamTec research center and the condensed matter group. We take advantage of the local infrastructure at the Advanced Microscopy Facility and the condensed matter theory expertise. Projects are geared towards undergraduate involvement and include building cryocooler based low temperature experiments, surface analysis of witness samples from TRIUMF cavities treated by novel procedures and to study the applicability of accelerator technology to quantum computing.

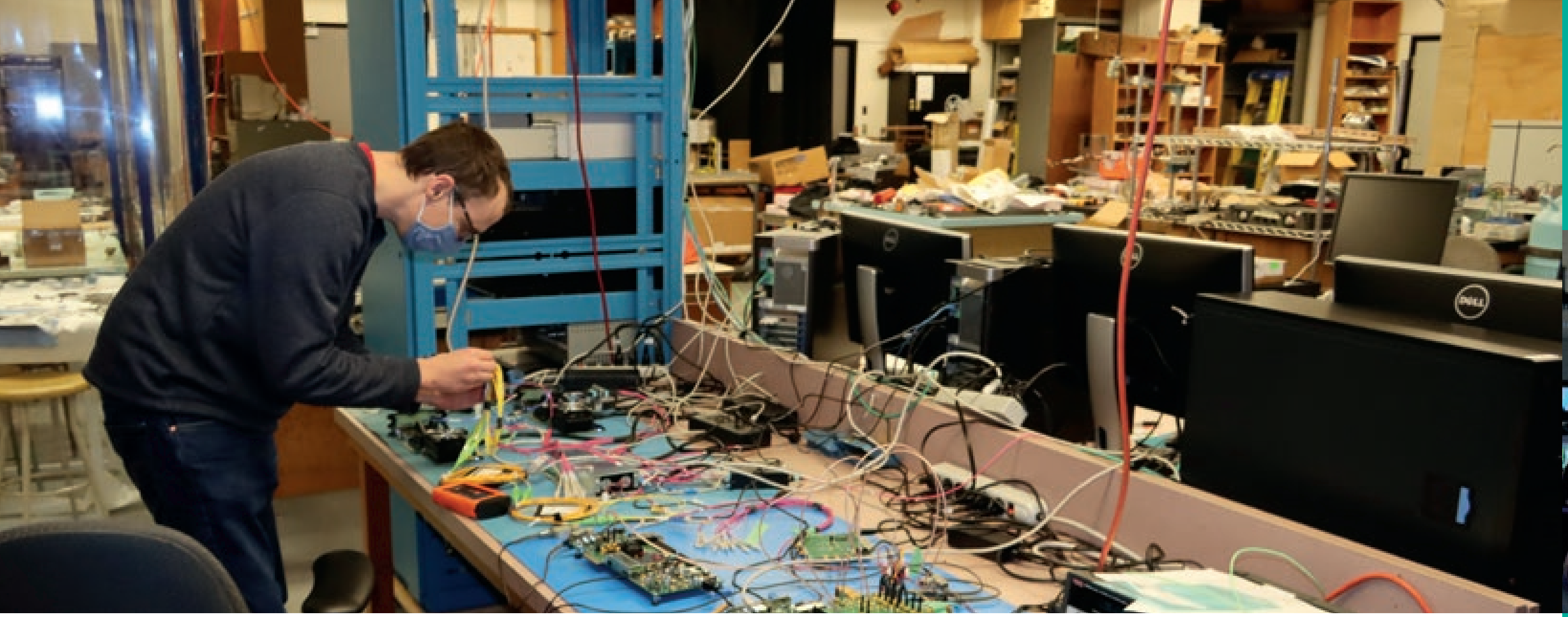


# ALTAIR & ORCASat CALIBRATION PROJECTS

The ALTAIR project founded by Justin Albert provides a precision [0(0.1%) uncertainty] photometric reference calibration using in-situ-calibrated light sources above the atmosphere, in the optical and microwave spectra. ALTAIR will provide the means to eliminate the largest uncertainty in measurements of dark energy using supernovae, and (via an onboard precisely-polarized microwave source) a major uncertainty in the search for gravitational waves in the CMB, and additionally provides key information on atmospheric science. Our partner project, ORCASat, led by UVic students, will be launching a CubeSat version of the optical source of ALTAIR into low Earth orbit in 2022!

**A cutaway view of the 3D CAD model for the ORCASat CubeSat satellite (https://orcasat.ca), presently under construction right here on campus. ORCASat will be launched into low-Earth orbit later this year (2022), via first being ferried to the International Space Station (ISS), and then ejected from the ISS into its own orbit, via the NanoRacks ISS CubeSat launch system.** ***(right)***

**The ORCASat student team** ***(below)***

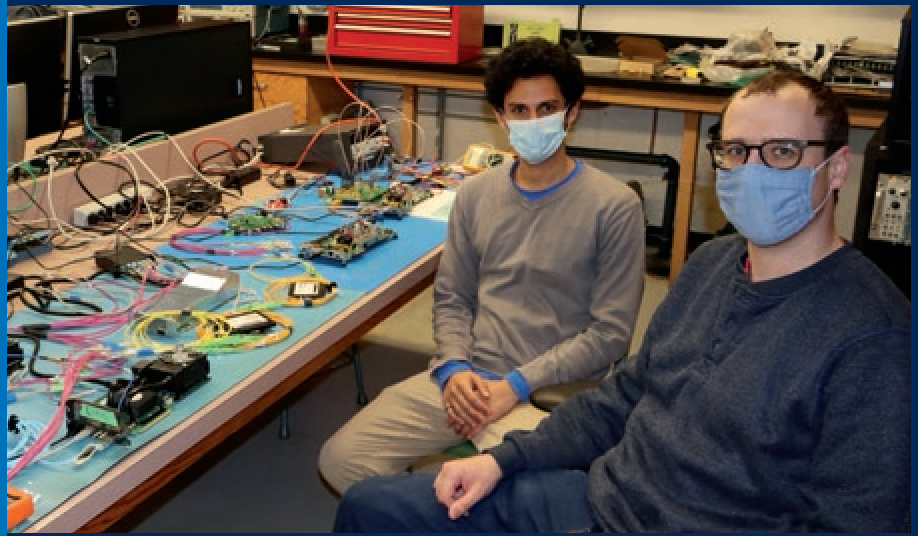


# VISPA DETECTOR LAB

The VISPA Laboratory provides state of the art equipment for the development and construction of detectors and electronics for particle and accelerator physics projects. The laboratory has been used to build components for the ATLAS, T2K and Belle II experiments. A full-time detector-physicist with a background in particle physics detectors and programmable electronics, Sam DeJong provides support for these projects. The laboratory also has a small machine shop and clean room, and has access to the local machine and electronics shops of the Faculty of Science and Department of Physics and Astronomy.

Among its facilities, the VISPA Lab houses state-of-the-art digital electronics and analogue equipment for characterizing circuits. A critical application of this equipment is the research and development of a new electronic read-out for the liquid argon calorimeter of the ATLAS experiment at CERN. ATLAS is one of the two experiments at the Large Hadronic Collider (LHC) that discovered the higgs particle. The LHC is being upgraded to provide higher data rates and the ATLAS experiments is being upgraded to take advantage of the improvements. The electronics and firmware being created by the ATLAS scientists and VISPA detector scientist will handle 28 Terabytes per second. This extraordinarily huge amount of data will be selected and then studied in order to understand, for example, the self-interaction of higgs particles and to search for hitherto unknown physical phenomena.

The VISPA Laboratory is part of a national infrastructure and is used by other Canadian projects who can benefit from the local expertise. We also collaborate closely with the TRIUMF detector group.



Dr. Sam de Jong and graduate student Maheyer Shroff are working on the electronics for the future high luminosity Large Hadron Collider. They are doing cutting edge work on high data transmission and data processing techniques.

Lorraine and Eric can be seen working on the right hand side of this panorama of the ATLAS Control at CERN. They were part of the expert team running the detector.

# CAREERS OF FORMER STUDENTS

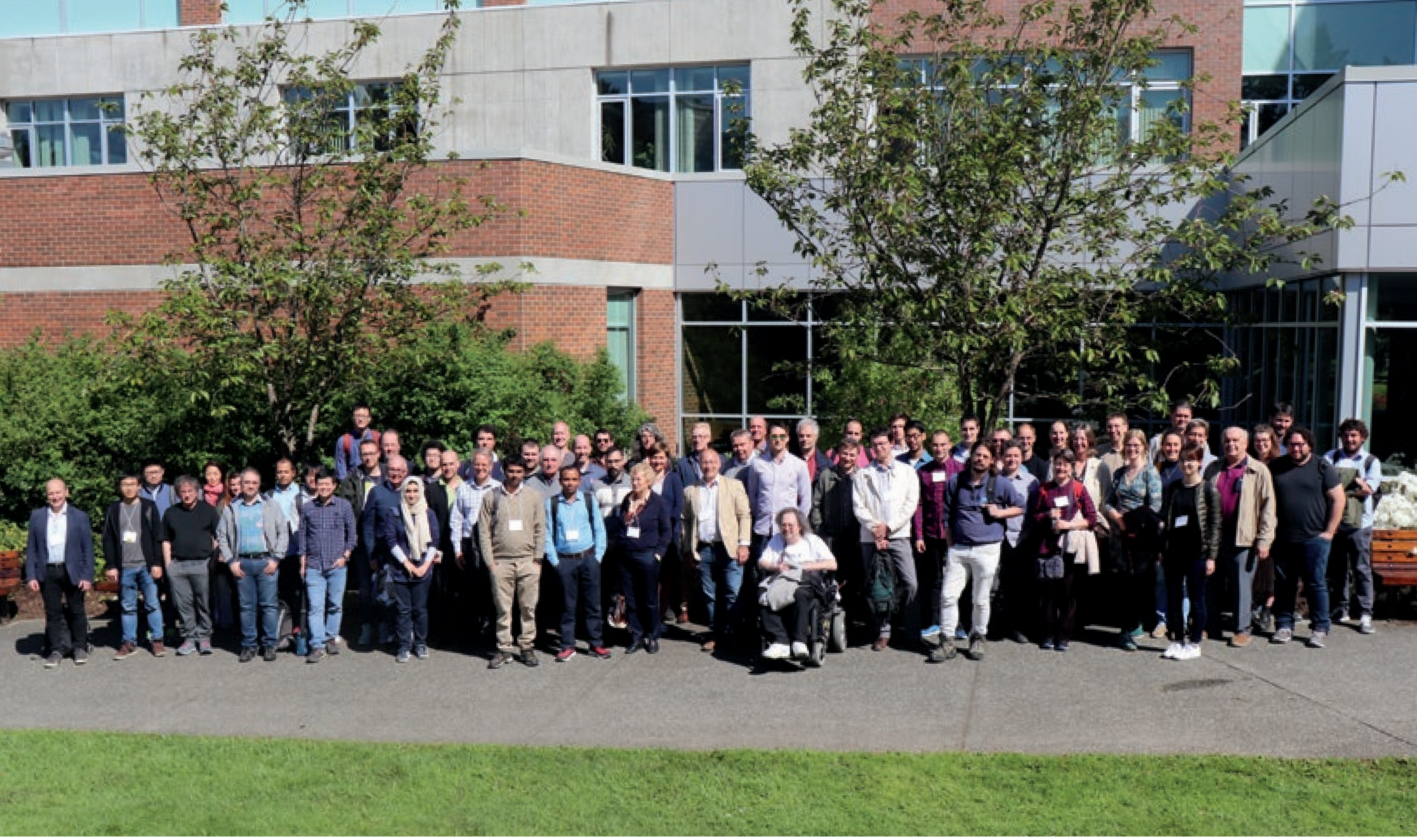
What do physics graduates do? Lorraine Courneyea and Eric Ouellette worked on the ATLAS experiment for their PhDs.

Lorraine went on to study at the Mayo Clinic and is now a clinical professor in medical physics at the University of Toronto. Her PhD experience with VISPA gave her an international perspective, skill in working in and leading teams of people from many different countries and cultures and practice speaking to international experts about her work on a weekly basis.

Eric moved into actuarial science following his PhD, and now works as an actuary for LifeWorks (formerly Morneau Shepell) in Halifax, NS. His skills analyzing complex data, and working within a large team, have translated well into this quantitative career.

Lorraine Courneyea

Eric Ouellette



# CONFERENCES: FPCP 2019 IN VICTORIA

The Flavor Physics and CP Violation conference (FPCP2019 – https://fpcp2019.triumf.ca/) was held on campus May 6-10, 2019. It was organized through the VISPA research centre (Bob Kowalewski was the head of the local organizing committee and Ms. Peggy White and the TRIUMF laboratory provided logistical support). It has been held annually since 2002, with the venue moving between the Americas, Asia and Europe on a 3-year rotation.

- The conference program focused on leading science questions such as the nature of ordinary matter, the properties of established and hypothesized interactions, the puzzling imbalance between matter and antimatter in the universe and the nature of the Dark Matter implied by astronomical observations, to name a few.
- The conference talks reported on recent research findings in experimental and theoretical particle physics from leading laboratories and institutes around the world (in Switzerland, Italy, France, Germany, UK, Japan, South Korea, China, Australia, USA, Canada)
- There were 82 delegates from 19 different countries, from graduate students and post-doctoral researchers through eminent professors, including winners of prestigious prizes (Helmholtz Award, J.J. Sakurai Prize, J.E. Lillienfeld Prize, Panofsky Prize, USSR Academy of Sciences Medal, Breakthrough Prize in Fundamental Physics).

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