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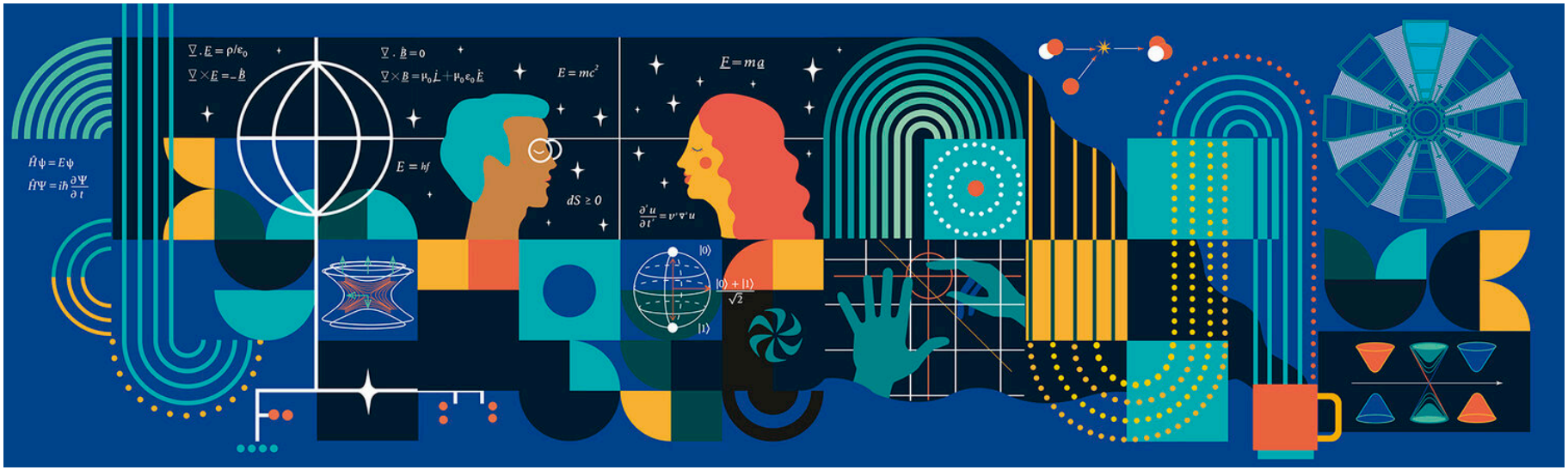

Particle Physics, Science and Technology and Scientific Computing

Nigel Hessey, Oliver Stelzer-Chilton, Reda Tafirout

ACOT Meeting, November 2021

2021-11-10

Discovery, accelerated

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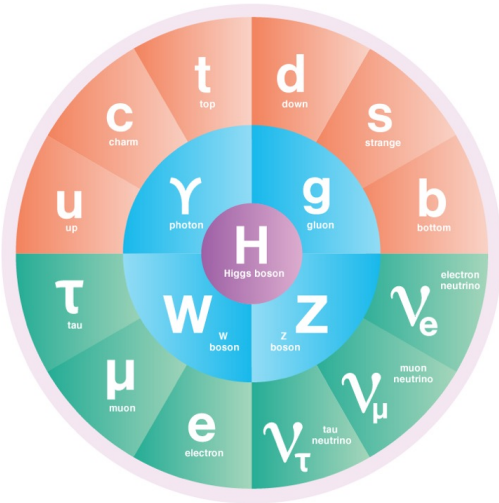
Particle Physics within the Physical Sciences Division

The Departments for **Particle Physics**, **Science & Technology, Scientific Computing** as well as **Theory,** address the following Research topics:

- High Energy Frontier
- Neutrinos and Dark Matter
- Precision Tests of Fundamental Interactions



Monthly meetings inclusive to Particle Physics Theory, Science and Technology and Scientific Computing Department members

Dark Matter Forum Meetings
Science and Technology Seminars
Quantum Forum Meetings (planned)

Discovery, accelerated

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Personnel

- New BAE **Kate Pachal** started in October this year
  - Research on DarkLight
  - PIONEER (former PienuXe)
  - Longer term interest in future collider experiment (FCC or ILC)

- Recruited Journey person CNC Machinist **Clayton Handley**
  - Deep CNC knowledge
  - Will train in specialist techniques of scintillators
  - Starting with NuTime detector (CMMS)

- UCN Project Engineer hire in progress
- Still require cryogenics expertise for UCN, HAICU, CMMS in future hire

- **Steve Chan**
  - Retired after 39 years of dedicated and highly valuable service in the scintillator shop

- **Patrick de Perio** (BAE on HyperK) starting new position at IPMU/ University of Tokyo in Sep 2022
  - Will be greatly missed
  - Seamless replacement hire on same timescale to keep HyperK on critical mass

- Request for new ALPHA BAE hire approved
- Search will move ahead imminently

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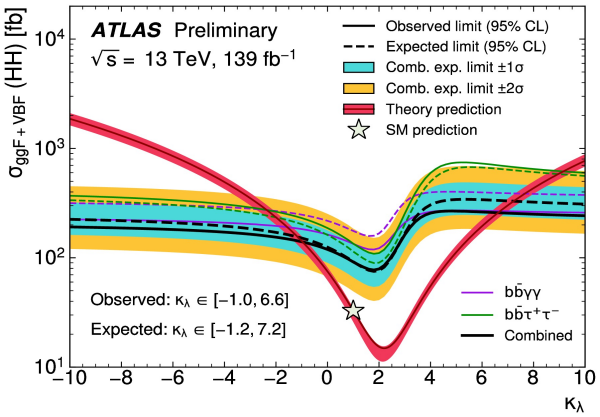
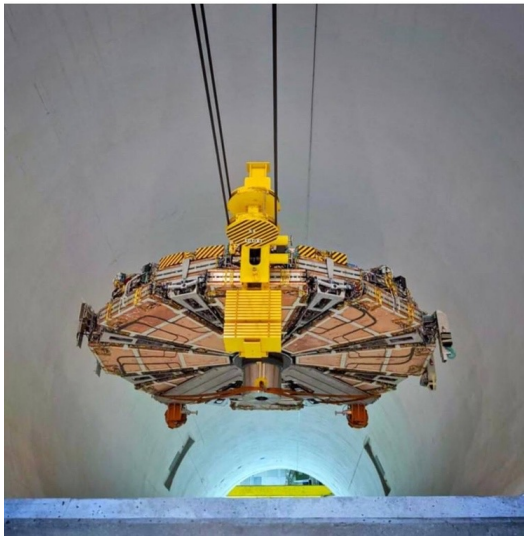
Particle Physics Highlights



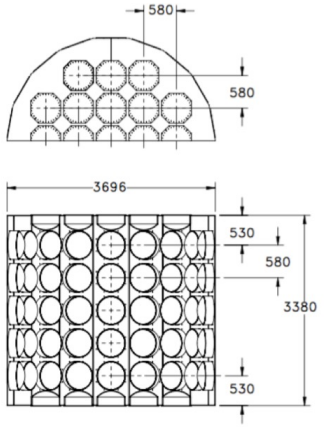
ATLAS

World-leading di-Higgs cross-section & self-coupling limits



Both New Small Wheels completed & installed

HyperK



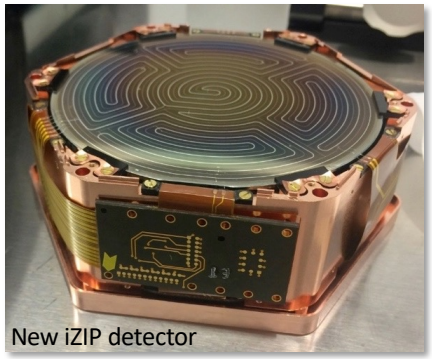
Received official recommendation for Water Cherenkov Test Experiment (WCTE) beamtime at June SPSC meeting

ALPHA-g

First trapped antiprotons from ELENA

SuperCDMS

Successful DOE/NSF review for additional $6.4M to complete the construction of the experiment. Good technical progress.


New iZIP detector

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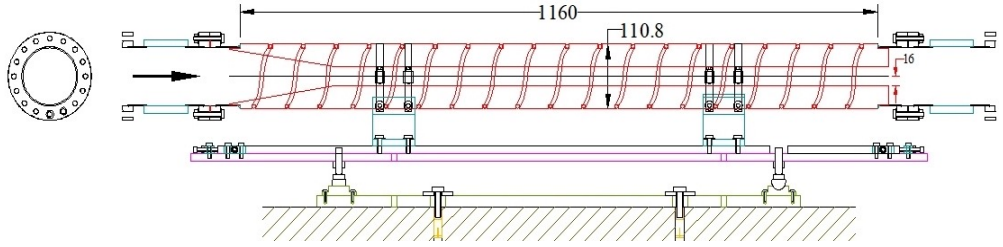
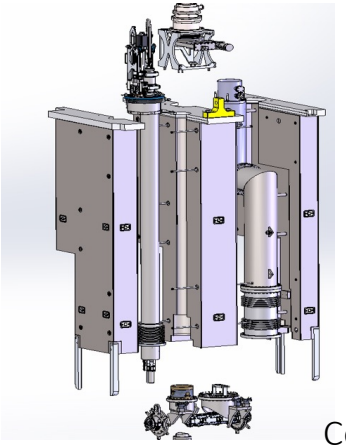
Science and Technology Highlights

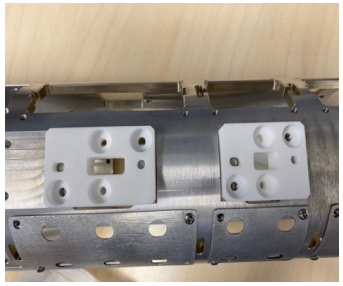
ARIEL



BL4N collimator design

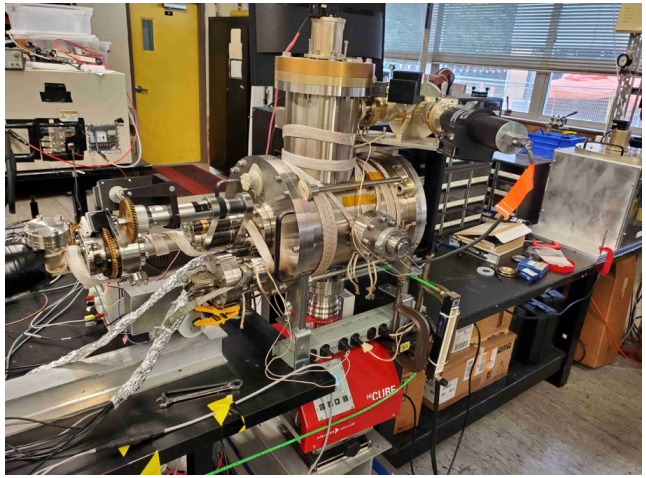


RIB module design



Specialist parts:
Ceramics for HV insulation

PHAAR



Silicon photomultiplier (SiPM) characterization up & running

ALPHA-g

Radial TPC rotated upright and inserted into Barrel Cosmic Veto which in turn is dressed with services, inserted into solenoid

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Science and Technology in High Demand

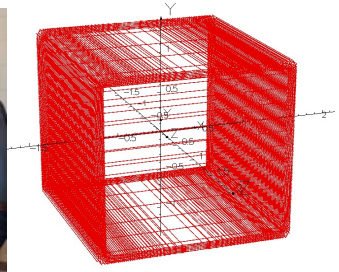
- **Ongoing large commitments**
  - ARIEL
  - TUCAN
- **Ongoing medium commitments**
  - ALPHA-g (antihydrogen @ CERN)
  - GRIFFIN/TIGRESS DAQ (ISAC experiments)
  - HyperK: IWCD & multiPMT
  - ATLAS liquid Argon upgrade
  - MOLLER DAQ (lep-lep electroweak interaction @ Jefferson Lab)
  - Darkside 20k (UV infrastructure for liquid Argon experiment @ Gran Sasso)

- **Major upcoming projects**
  - nEXO (CFI $16M, conditional approval – next slide)
  - DarkLight (requesting NSERC project funding)
  - PIONEER @ PSI (former PieNuXe, requesting NSERC)
  - P-One (requesting CFI funding)
- **In addition:**
  T3 spectrometer, NuTime scintillators, TiSTAR

Hoping to benefit from Workday's time entry system to keep track of hours worked on each project; check we are following our plans and agreements

Critical for SciTech to manage work on numerous projects

Challenging UCN source tail section wall welding completed, no leak test successful



High precision coil design for TUCAN

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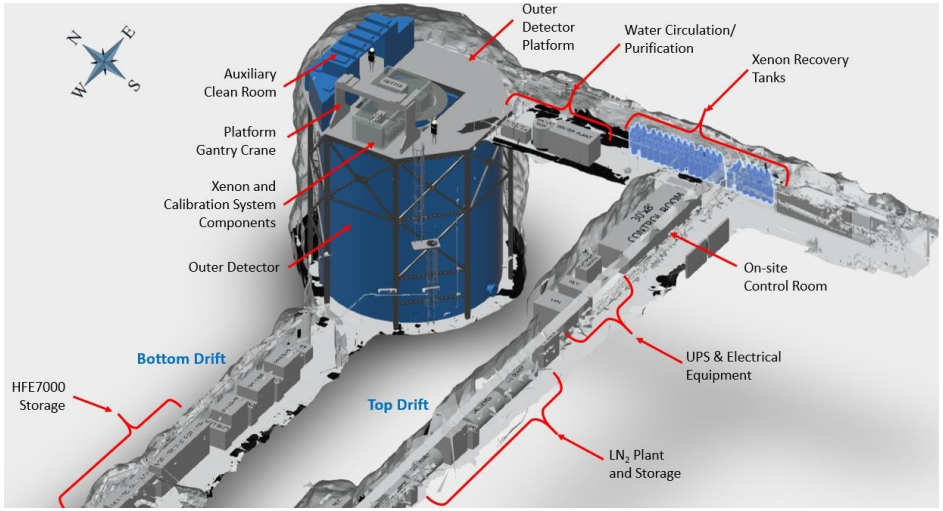
Major Upcoming Project

- **Neutrino-less double beta decay summit Sep 2021**

The international stakeholders … do agree in principle that the best chance for success is an international campaign with more than one large ton-scale experiment implemented in the next decade, with one …in Europe and the other in North America.

- **nEXO at SNOLAB**
  - Next big experiment in Canada and TRIUMF will be heavily involved in the project
  - $6M of the last round CFI award would flow through TRIUMF
  - Major involvements foreseen
    - Photodetector development and assembly



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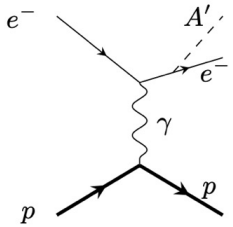
Particle Physics - EEC

- Interest in carrying out more Particle Physics experiments onsite lead to the creation of the Particle Physics – Experiment Evaluation Committee earlier this year
- First meeting took place April 22nd with a subsequent report by the committee
- Four experimental submissions
  - Search for New Physics in e^+e^- with an Invariant Mass of 13-17 MeV using ARIEL (Darklight)
    - **High priority**
  - Rare Pion Decays: PIENUXE (PIONEER), 10 x precision on $R_{e/\mu}$ and Pion Beta decay
    - **High priority**
  - Search for a cosmologically-relevant boson in mu^+ decay
    - **Medium priority**
  - Progress Report TUCAN EDM Experiment



$$\mu^+ \to e^+ X^0$$

$$R_{e/\mu} = \frac{\Gamma\left(\pi^+ \to e^+ \nu(\gamma)\right)}{\Gamma(\pi^+ \to \mu^+ \nu(\gamma))}$$

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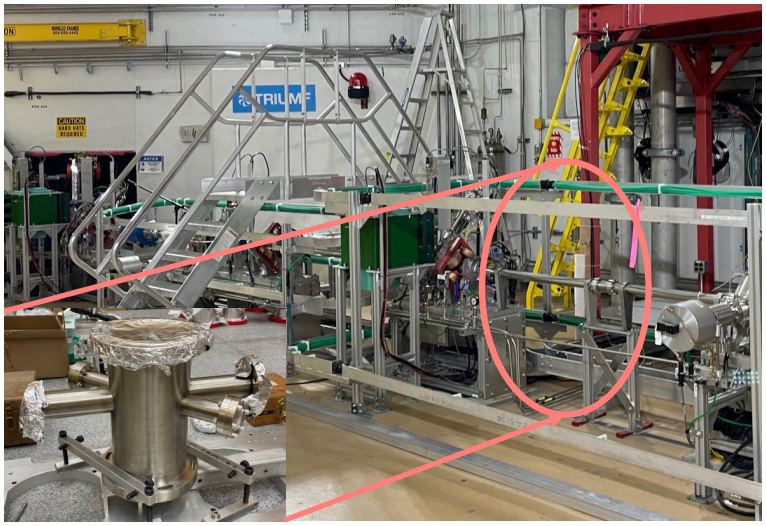
New Particle Physics Experiments

- **DarkLight @ ARIEL**
  - Use ARIEL e-linac to search for new (dark) bosons around 10-20 MeV, multi-stage plan (next 4-5 years)
  - Initial proof-of-principle experiment (@ 31 MeV)
  - Installation of 2nd cryo-module will enable parasitic running alongside ARIEL at 50 MeV
  - Allows DarkLight to confirm or exclude "5th force" represented by X17 excess

- **Search for a cosmologically relevant boson**
  - Muon decay search $\mu^+ \rightarrow e^+ X_0$ near kinematic limit
  - 1.16×10^8 μ^+ stops collected over 5 days in October
  - Proof-of-principle demonstrated
  - Data was taken mostly with 75 µm, which reduces implantation depth → backgrounds x50 higher
  - Plan to request additional exposure with thin 25 µm window, to reach design sensitivity



Preparing for installation and first tests of e-beam on tantalum foils in a prototype target chamber

Scientific Computing Status and Plans

- **CFI Funding Opportunities (Innovation Fund 2023 competition)**
  - Canadian ATLAS Tier-1 center: internal NOI submitted to SFU in August
    - Budget reworked using WLCG costing model, recent Tier-1 purchases and HL-HLC Computing Design Report projections. Capital costs to covers 2025-2030. Total $21.6M
  - Pan-Canadian Ion Trap QC: SFU & Waterloo not going ahead with internal NOIs
    - The new initiative will have to go through a strategy review process to assess further TRIUMF's role & long-term commitments
- **Canada-wide efforts & TRIUMF involvement:**
  - Close collaboration with Compute Canada since its inception
    - WLCG Regional Operation Centre (ROC_Canada)
    - Subatomic Physics National Team
    - National Networking team which includes HEPNET/Canada, CANARIE and BCNET
  - **Pan-Canadian Quantum Computing effort (recently formed)**
    - Four affiliated scientists from SFU, Waterloo and Manitoba have joined the department
    - Strategy discussed as part of the 20-year vision process (WG report & Science Week)

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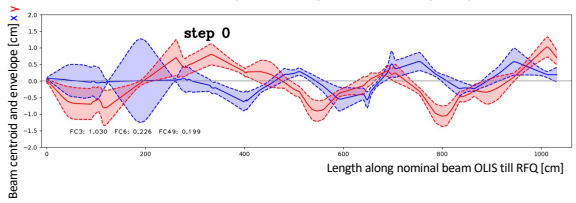
Data Science and Quantum Computing Highlights

- Supporting projects and enhancing science output across Physical Sciences and Accelerator Division (Hyper-K, ATLAS, NA62, PIONEER, Belle 2, ISAC)
  - Cutting edge (Quantum ML, real-time FPGA for ATLAS)
- Leadership in international efforts in ML applications (Hyper-K, ATLAS)
- Public results, invited talks, several publications, additional ones in the pipeline and recent success with major ML conference (NeurIPS 2021)
- Instrumental in securing additional research funds (NFREF)
- Fostering international collaboration
  - MITACS GRAs: ISAC AI control (Nov 15th); Hyper-K (Jan 1st 2022)
  - Each four months from Juelich
- Training HQP (postdocs, MDS, grads, coops)
  - SFU/TRIUMF Postdoc now at 1-Qubit
  - Former coops now at General Fusion, LinkedIn

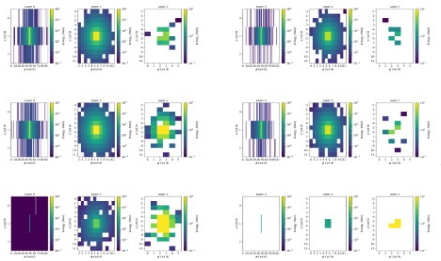
Accelerator Tuning with Deep Reinforcement Learning

Automated (simulated) tune of OLIS (ISAC)



CaloDVAE : Discrete Variational Autoencoders for Fast Calorimeter Shower Simulation

Showers generated by the classical analog of a QML model



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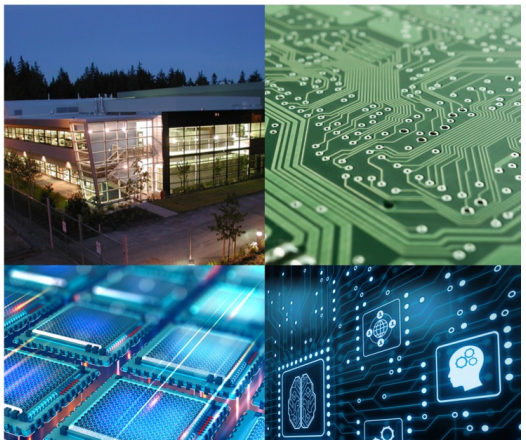
TRIUMF Summer Institute (TSI) on Quantum Computing

- Cornerstone Models of Quantum Computing
- Collaboration with UBC SBQMI, QAI, UVic, SFU, Sherbrooke, Helmholtz/DESY, D-Wave, Xanadu
- Core program:
  - Gate Model QC
  - Quantum Annealing
  - Measurement Based QC
  - Continuous Variable QC
- Applications and technologies:
  - Ion trapping
  - Superconducting qubits
  - Nuclear theory
  - Quantum Chemistry
  - Quantum Machine Learning
- Program well received
  - Hands-on challenges
  - Office hours
  - Tutorials and solutions sessions



Quantum Algorithms INSTITUTE

HELMHOLTZ ASSOCIATION

DESY.

UNIVERSITÉ DE SHERBROOKE

D-Wave The Quantum Computing Company™

Stewart Blusson Quantum Matter Institute THE UNIVERSITY OF BRITISH COLUMBIA

UBC

QUANTUM BC research · training · innovation

XANADU

SFU

University of Victoria

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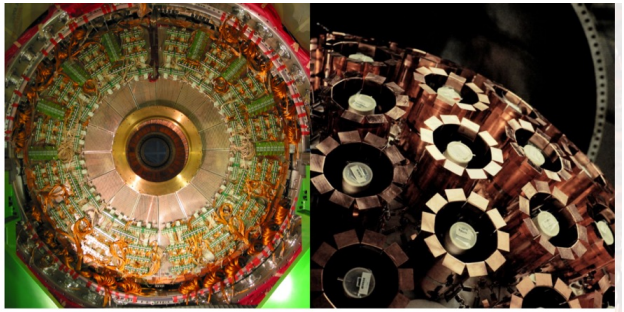
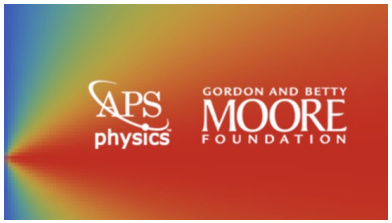
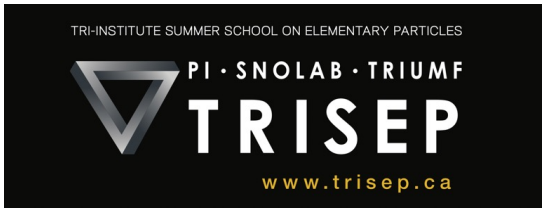
Connecting to the Community

- **TIPP – successful online format**
- May 24-28, 2021
- ~500 participants





- **Next Developing New Directions Workshop**
- Moore Foundation Award has been extended until May 2022
  - Co-organized with Center for Experimental Nuclear Physics and Astrophysics (CENPA) at UW



- **TRISEP and GRIDS Summer Schools**
- Planning for in-person schools during summer of 2022
- Backup with online format similar to this year at SNOLAB
- **WNPPC**
- February 2022, going ahead online

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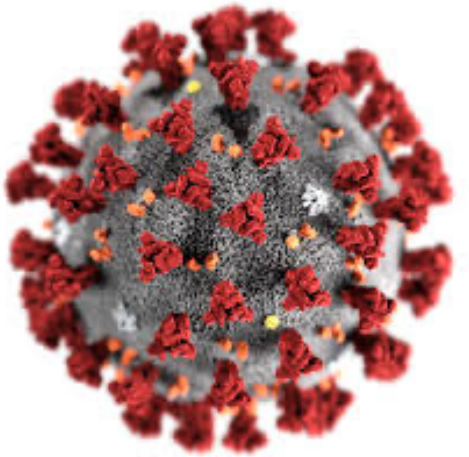
The Pandemic at TRIUMF



- On-site activities remain focused on prioritizing technical work, however given that most areas on site are no longer subject to COVID related occupancy limits, more people choose to be on-site following safety and mandatory mask wearing rules
- Overall research experience and efficiency clearly impacted
- Many networking opportunities lost, especially for HQP
- Social gathering to increasing team spirit, keep in touch and welcome new people
  - Particle Physics meeting at Jericho in June
  - Farewell party for Jens Dilling in July
  - Science and Technology open meeting in November

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Impact from the Pandemic on research groups

- **ATLAS**: **Delays in detector upgrade** construction. **Delays in postdoc hires**, e.g. a postdoc coming to TRIUMF to work on ITK upgrade from India suffered ~1.5 years delays before she could get her PhD and travel. **Some grad student stays at CERN cancelled or postponed**. Students and postdocs based at CERN could not benefit from what is usually an intense and vigorous environment.
- **HyperK/T2K:** The EMPHATIC Phase-1 run originally scheduled for April 2020 was finally rescheduled for January 2022. T2K and SuperK **operations shifts** became **remote**. Work on the PTF and photogrammetry was delayed but is now proceeding. **Global supply chain issues are delaying the sourcing of some components**, which is impacting the mPMT project in particular.
- **ALPHA**: There have been some delays in projects, but good progress has been made in the past few months. **Visas for international students** to enter Canada have been **delayed** significantly.
- **TUCAN:** HQP missing out on networking opportunities. **Difficulty finding postdoc candidates**. Postdoc had forced stay in Japan while on EPECR at KEK during lockdown (extended stay in guesthouse).
- **SuperCDMS:** Access restrictions to CUTE facility at SNOLAB meant that local staff had to be **trained remotely** causing delays. Planned **student tasks** on CUTE could not be carried out and the students have been **redirected to software tasks** (analysis and slow-control systems).

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Summary

- Particle Physics together with Science and Technology and Scientific Computing is fully engaged in shaping the present and future of TRIUMF
- We will ensure the continued relevance and success of Canadian and TRIUMF's Particle Physics Engagement by exploiting previous and forthcoming investments in projects in Canada and abroad and by planning for future initiatives as part of the TRIUMF's 20-year vision
- Excellent track record on designing, enabling and extracting science from Particle Physics experiments (see Research Highlights in parallel session and Poster Session)
- The newly created Particle Physics – Experiment Evaluation Committee allows for a peer-reviewed evaluation for new on-site experiments and projects
- The Pandemic continues to pose a challenge, but we are dealing with it the best we can
- Moving forward with BAE hires for ALPHA (highest priority in PSD divisional hiring plan) and the replacement hire for HyperK (search will start imminently)

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Thank you
Merci

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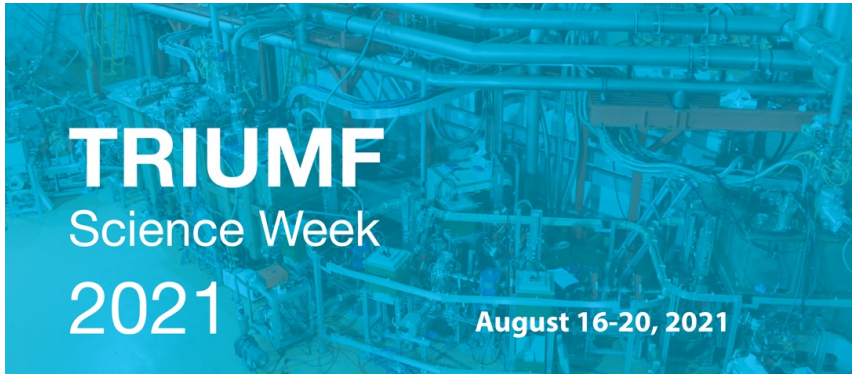
20-year Vision

- Topical Groups summarized their visions in a 5-page brief and slides providing answers to the Guiding Questions
- Broad consultations via surveys, ThoughtExchanges and direct consultations with stakeholders in Canada and abroad

- Particle Physics
  - covers and builds on the scope of the IPP brief to SAP-LRP process and the community consultation associated with the development of this brief
- Fundamental Physics with AMO techniques
  - covers AMO techniques and how they can be used to address Fundamental Physics questions from Dark Matter to Gravitational Waves
- Quantum Technologies
  - covers application of quantum technologies from radiation detectors, photon sensors, and AMO techniques from the fundamental to the applied
- Scientific Computing
  - covers big data, advanced research computing infrastructure, machine learning and artificial intelligence as well as quantum computing

20-year Vision



- Science Week in August was focused on 20 year vision
- Summaries from the Topical Groups were presented
- Round Table discussions allowed for discussion
- Inputs towards overall convergence on vision framework – presented at Science Week

- Subatomic Physics Round Table centered around the following questions
  - **What challenges will TRIUMF confront over the next 20 years?**
  - **What are the opportunities for 2040 and beyond?**
  - **Should TRIUMF diversify into new areas, maintain, or strengthen its traditional focus areas?**
- Panel members: Eckhard Elsen, Ritu Kanungo, Stephan Malbrunot Ettenauer, Brigitte Vachon

- In parallel:
- Canadian Subatomic Physics Long Range Plan was discussed during the CINP/IPP session at the CAP Congress in June
- Final text released end of September