TRIUMF

Beam Physics and the five-year plan

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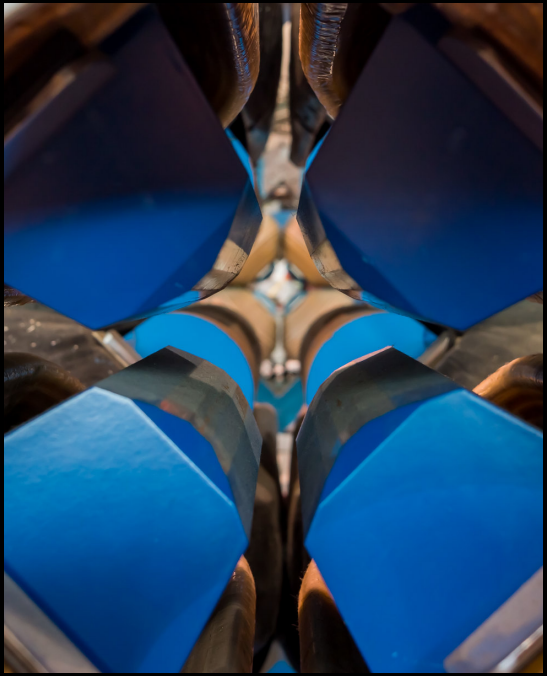
July 2022



Outline

- Beam Physics team
- Department goals for the next 5-8 years

TRIUMF's Beam Physics Team

Beam Physics department:
4 staff, 4 PhD students, 2 post-docs

Beam Physics experts at TRIUMF:
12 people in the core team (left),
16 reporting weekly at our departmental meeting.

Overlap: Accelerator Systems and Beam Delivery

Expertise ranges from cyclotrons to linear accelerators, high-energy (LHC) to beams decelerated to a stop (β-NMR, CSB, etc), high-power beams to rare-isotope beams.

Goals

Department goals for the next 5-8 years:

1. Develop the newly built infrastructure to its full potential, and bring the entire accelerator complex to a high level of performance and availability.
2. Leverage infrastructure and know-how to pursue new capabilities, train HQP, and transfer to the industry.
3. Lead and shine in a few domestic and international collaborations.

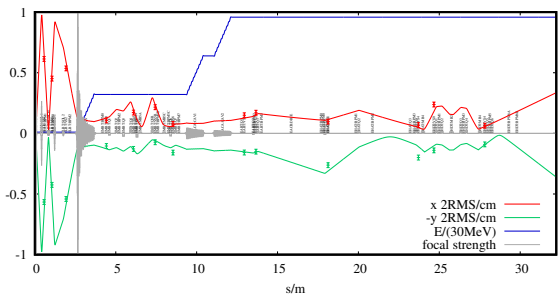
Goal #1: Develop ARIEL/CANREB/IAMI to their full potential

What does it take?

Thorough Beam Commissioning

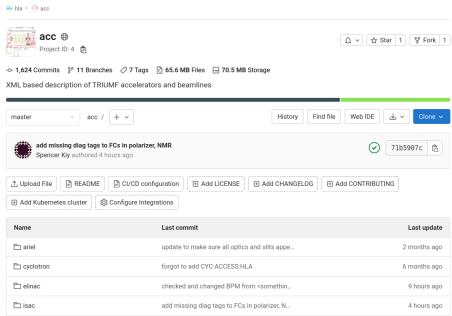
Strategy:

- Develop a quantitative understanding of the beam optics.
- Achieve reliability before the handover to Operations (Gate-4B).



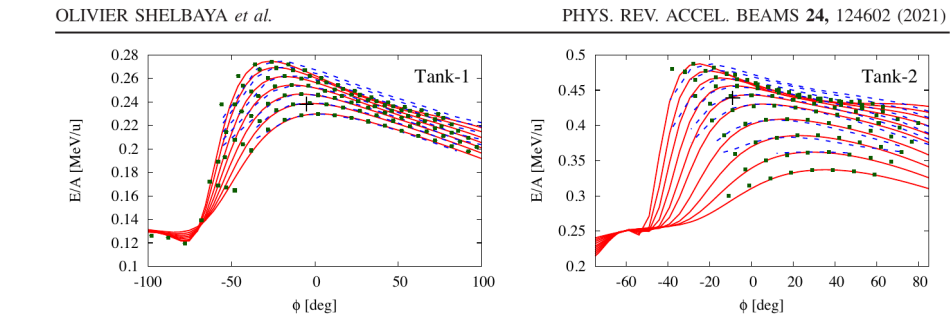
Comparison between calculated (solid lines) and measured (points) 2 RMS beam sizes. This particular example is the 28 MeV tune that served as intermediate step in our ramp up from 25 MeV to 30 MeV.

Post Gate-4B: Configuration Control



- Work closely with facility coordinators to ensure tight configuration control of all accelerators and beamlines (see acc data base).
- Periodically test the models during dedicated beam development time.
- Develop our continuous improvement strategy in consultation with the international accelerator community: e-Linac Reliability Workshop.

Model Coupled Accelerator Tuning

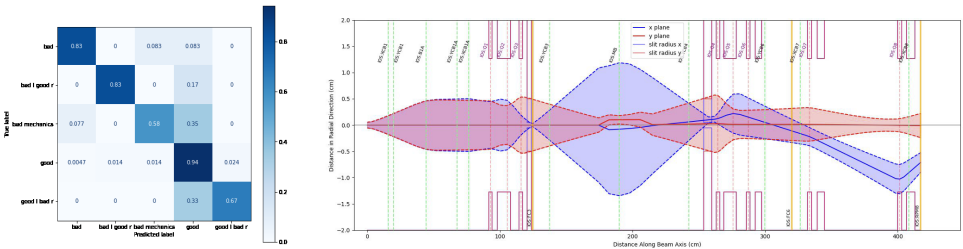


ISAC-DTL, green squares: measurements ($^{16}O^{4+}$), red lines: TRANSOPTR model [Shelbaya et al., 2021]

Strategy:

- Generalize the usage of model-based tunning across TRIUMF.
- Develop reliable standardized user interface (HLA task force).

Machine Learning to Assist Operators



Left: profile monitor signal classification using **Random Forest Classifier** [Wu, 2021]. Right: **Neural Network** trained to steer the beam out of OLIS (Achim Andres, Wojtek Fedorko, et al.).

Strategy: apply Machine Learning to solve targeted problem which affect accelerator reliability and tunability.

Areas to Grow

- Provide more support to train Operators.
- Establish a strong collaboration between Beam Physics/Beam Delivery and IAMI on the operation and development of their cyclotron.

Goal #2: Pursue New Capabilities

Evolve the facility to track the ever-evolving needs of our user's community:

- Science opportunities within the e-hall: DarkLight, FLASH, THz, see: S.D. Rädel's talk at CAP 2022
- Development of ISAC-I/II acceleration path: second accelerator path? Energy upgrade of ISAC-II?
- Development in ISAC experimental hall: isotope storage ring, see recent workshop? Low energy electron scattering [Ohnishi et al., 2015]?

We need to collect feedback from the users, and the funding agencies (several CFI proposals in the pipes) to finalized our 5-year plan and remove these question marks.

Goal #2: Invent the next Generation of Cyclotrons

Why cyclotrons?

Table 1: The Energy Efficiency

	PSI cyclotron	**SNS linac**	**J-PARC linac and RCS**
Beam energy	0.59 GeV	1 GeV	3 GeV
Beam Power	1.4 MW	1.4 MW	1 MW
Power consumption	4.5 (RF) in total 10 MW	16.3 MW	32.6 MW
Fraction of grid power converted to beam power	~18-19%	~9%	~3%

Table: outcome of the Proton Driver Efficiency Workshop [Yakovlev et al., 2017].

Tangible Societal Impact

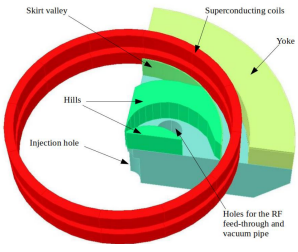
What is the business of medical isotopes?

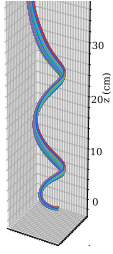
Medical imaging technology using medical isotopes plays an important role in the diagnosis and treatment of everything from neurological diseases to cancer. It drives a multi-billion dollar worldwide business with a predicted growth of 1-4% per year for at least a decade.

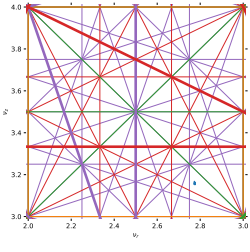
from www.triumf.ca/faq-medical-isotopes

Implement our Radical Cyclotron Designs

Strategy: implement some of our bold ideas into real-life cyclotrons, with two objectives: HQP training and commercialization.







Figures: TR-100 [Rao et al., 2019], magnetic inflector [Zhang, 2022], and constant-tune high-energy cyclotrons [Planche, 2022]

Goal #3: Domestic Collaboration

Canadian initiatives that we support:

- Plasma and ion-sources modelling with D-PACE, leveraging our expertise in space-charge simulations [Jung, 2020]
- Dielectric Wall Accelerator, in collaboration with McGill University (C.M. Lund AAPM'22 talk)
- PC-CANS (see [Laxdal et al., 2021] and D.D. Maharaj's talk)

Goal #3: International Collaborations

Flagship collaboration: with CERN on the LHC.

PHYSICAL REVIEW ACCELERATORS AND BEAMS **25,** 041001 (2022)

Editors' Suggestion

Dust-induced beam losses in the cryogenic arcs of the CERN Large Hadron Collider

A. Lechner,[1,*] P. Bélanger,[1,2] I. Efthymiopoulos,[1] L. Grob,[1,4,†] B. Lindstrom,[1,5] R. Schmidt,[1,4] and D. Wollmann[1]

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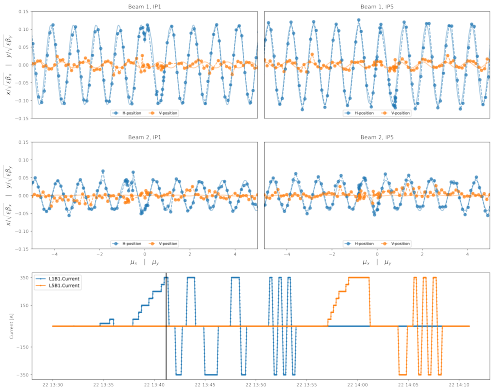
See: [Lechner et al., 2022].

Beam-Beam Modelling and Compensation for the LHC



Effect on the closed orbit of the LHC coming from a misalignment of wire compensators. Dotes: measurements from the Beam Position Monitors around the LHC. Lines: analytical model.

Summary

- Beam Physics at TRIUMF: a team with a strong overlap is Beam Delivery and Accelerator Systems.
- Down-to-earth department goals with a strong sense of service to the community and a touch of boldness.
- Beam Physics collaboration with CERN is strong. We will develop new collaborations using this one as a model (Rutherford Appleton Lab, SCK-CEN)

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Thank You

Thank you for your attention