



Overview of TRIUMF

HL-LHC
collaboration
meeting

Oliver Kester
Director, Accelerator Division
TRIUMF

Monday, September 25, 2023



Welcome to B.C.!

Home of TRIUMF

TRIUMF is Canada's particle accelerator centre. We are a world-class hub of research, education, and innovation that is home to ~600 staff and students

Founded in 1968 by the University of British Columbia, Simon Fraser University, and the University of Victoria, TRIUMF is a cornerstone of BC's innovation ecosystem, driving impact locally, nationally, and around the world



TRIUMF is located on the traditional, ancestral, and unceded territory of the Musqueam people, who for millennia have passed on their culture, history, and traditions from one generation to the next on this site.

TRIUMF's home has always been a seat of learning.



 **TRIUMF**

Discovery, accelerated.

Our multidisciplinary community uses TRIUMF's world-class accelerator infrastructure to drive leading-edge research that delivers impact in **science, medicine, and industry, helping position Canada as a global leader**

Member Universities:

University of Alberta
University of British Columbia
University of Calgary
Carleton University
University of Guelph
University of Manitoba
McGill University
McMaster University
Université de Montréal
University of Northern
British Columbia

Queen's University
University of Regina
Saint Mary's University
Université de Sherbrooke
Simon Fraser University
University of Toronto
University of Victoria
University of Waterloo
Western University
University of Winnipeg
York University



TRIUMF accelerator complex

Primary beam driver (1974):
 500 MeV Cyclotron, 300 μ A, H⁻
 Produces rare isotopes, neutrons and muons

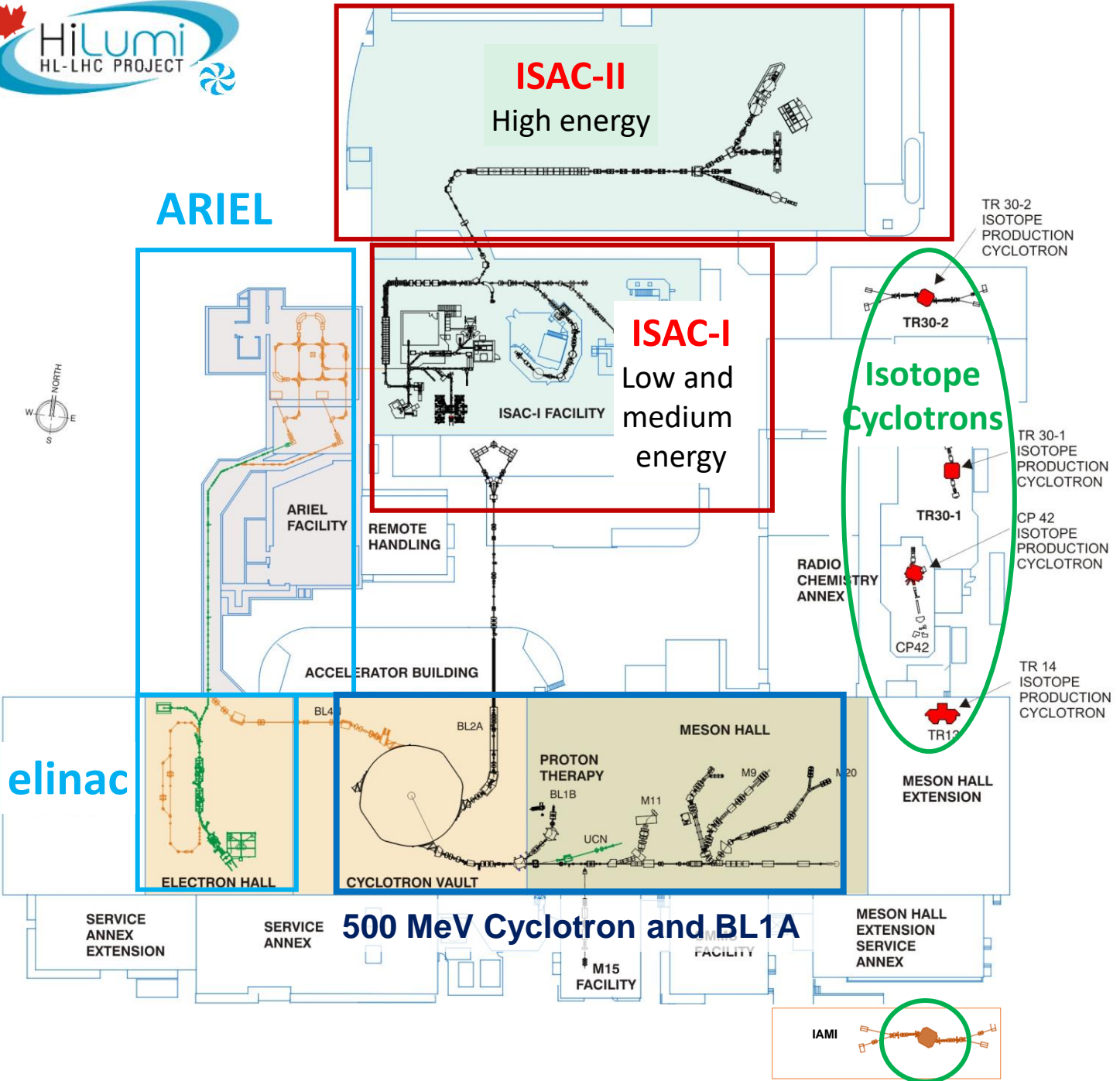
Isotope Separator and Accelerator facility – ISAC (1996)

- ISAC-I: Normal conducting-linac
 - 0.15-1.8 MeV/u (2000)
- ISAC-II: Superconducting-linac
 - 1.5-16.5 MeV/u (2006)

Advanced Rare Isotope Laboratory – ARIEL (in progress)

- Superconducting electron linac
 30 MeV, 10 mA, cw (2019)

4 (+1) Cyclotrons for medical isotope production – TR30 and TR13 designed by TRIUMF



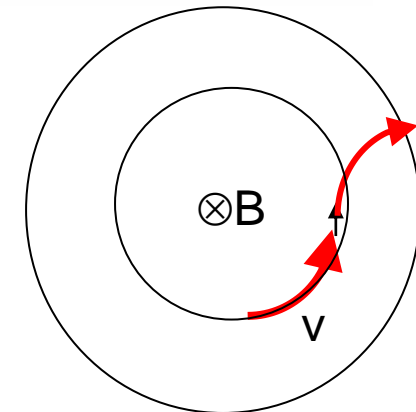
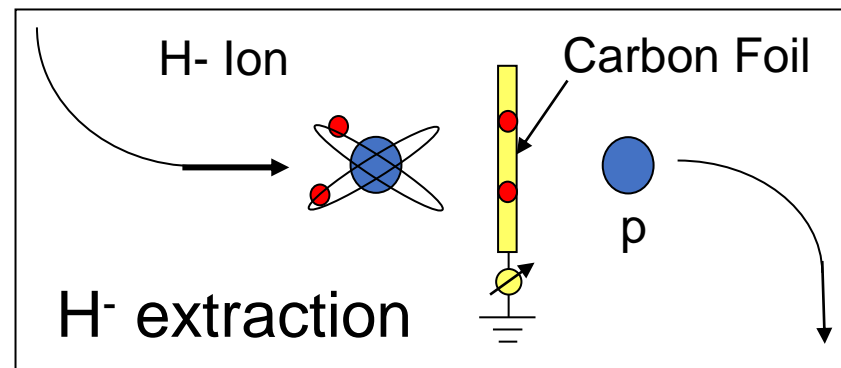
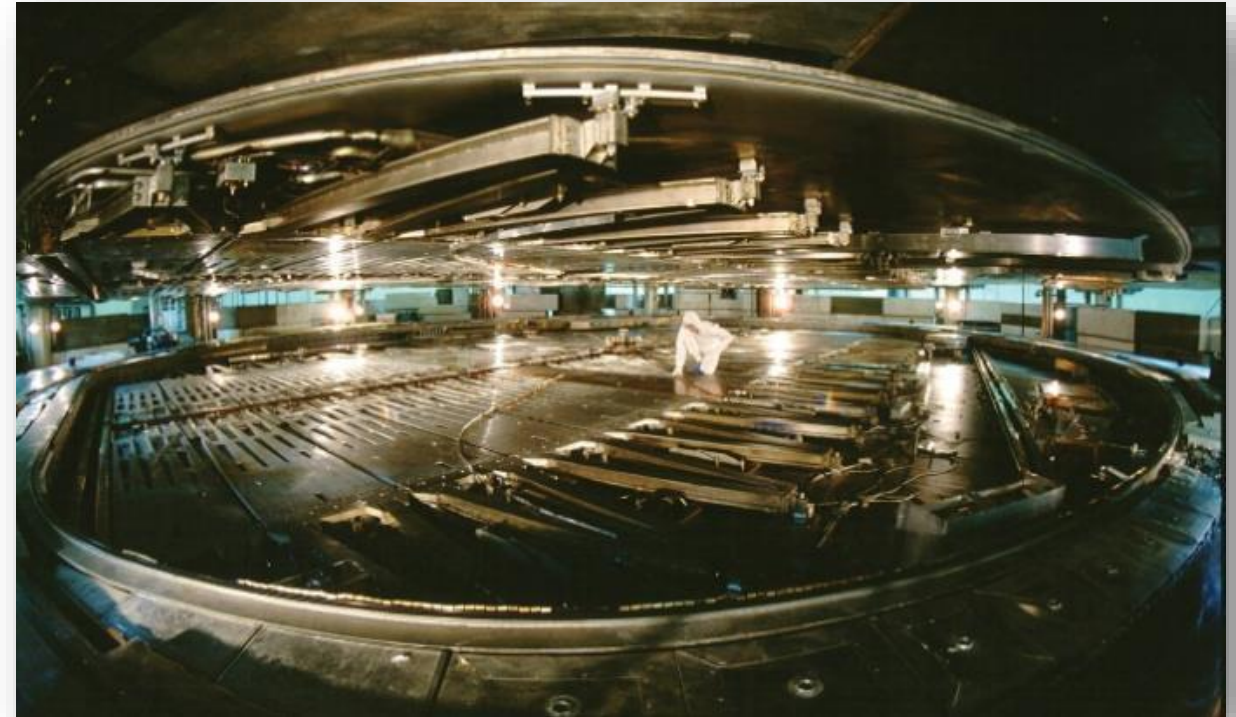
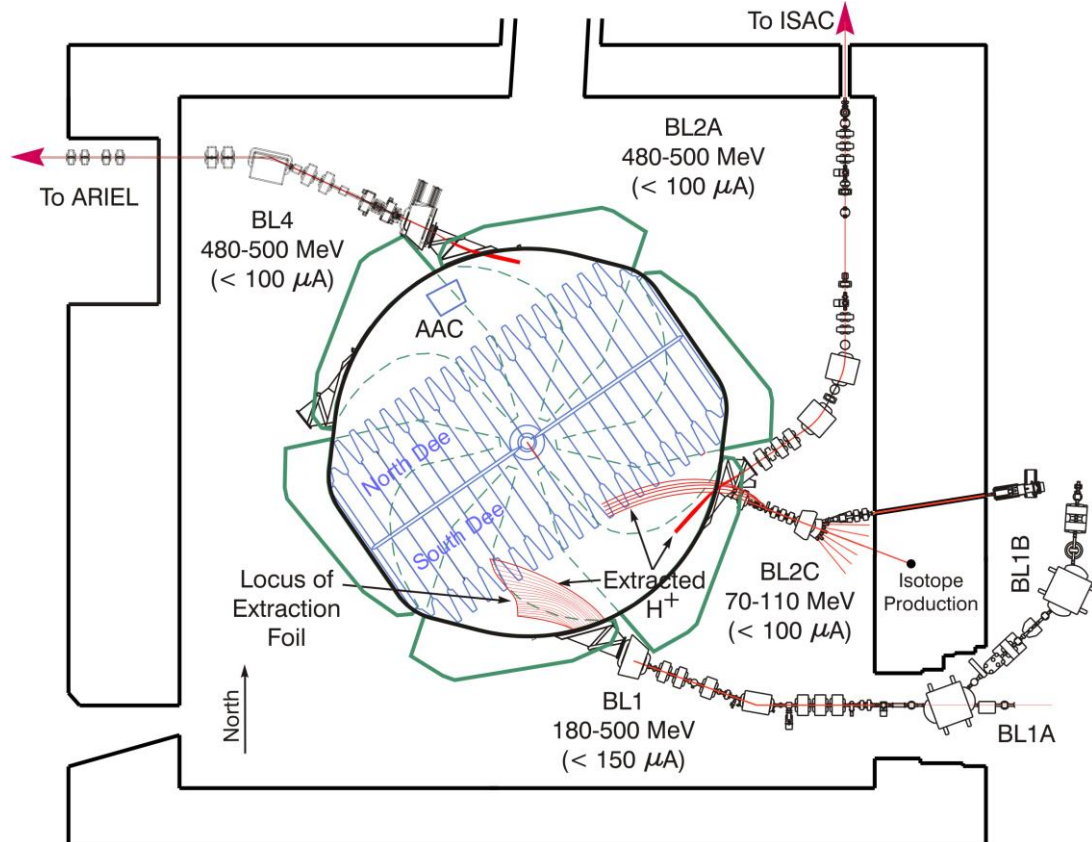


- Constructed in the early 70th of last century
- Largest normal conducting Cyclotron in the world: $D = 18\text{ m}$
- Magnet weight: 4000 t, Coil current: 18500 A
- H- cyclotron (multiple extraction at different energies)
- 5500 hours of beam delivery per year

The TRIUMF 500MeV Cyclotron

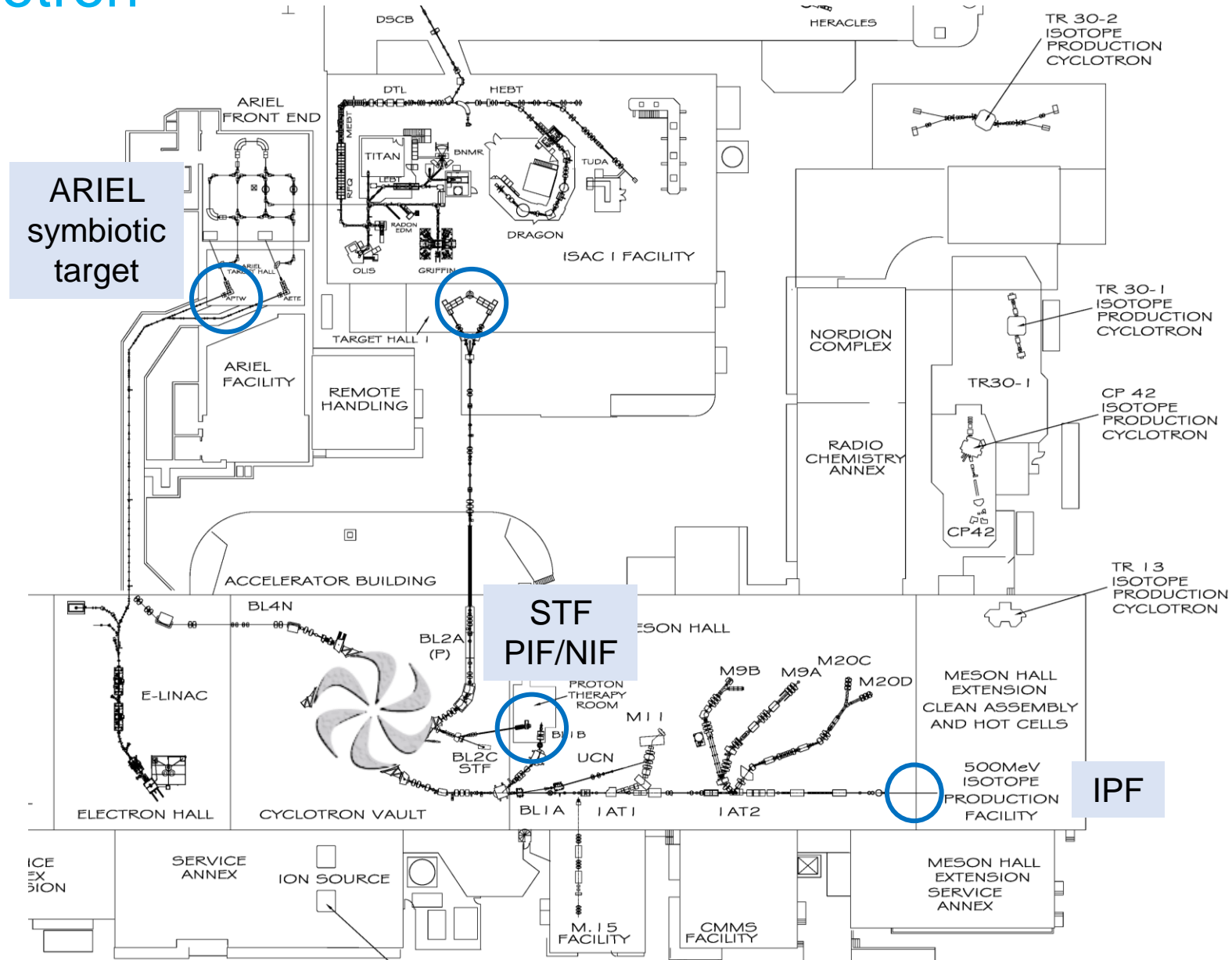
■ H^- extraction

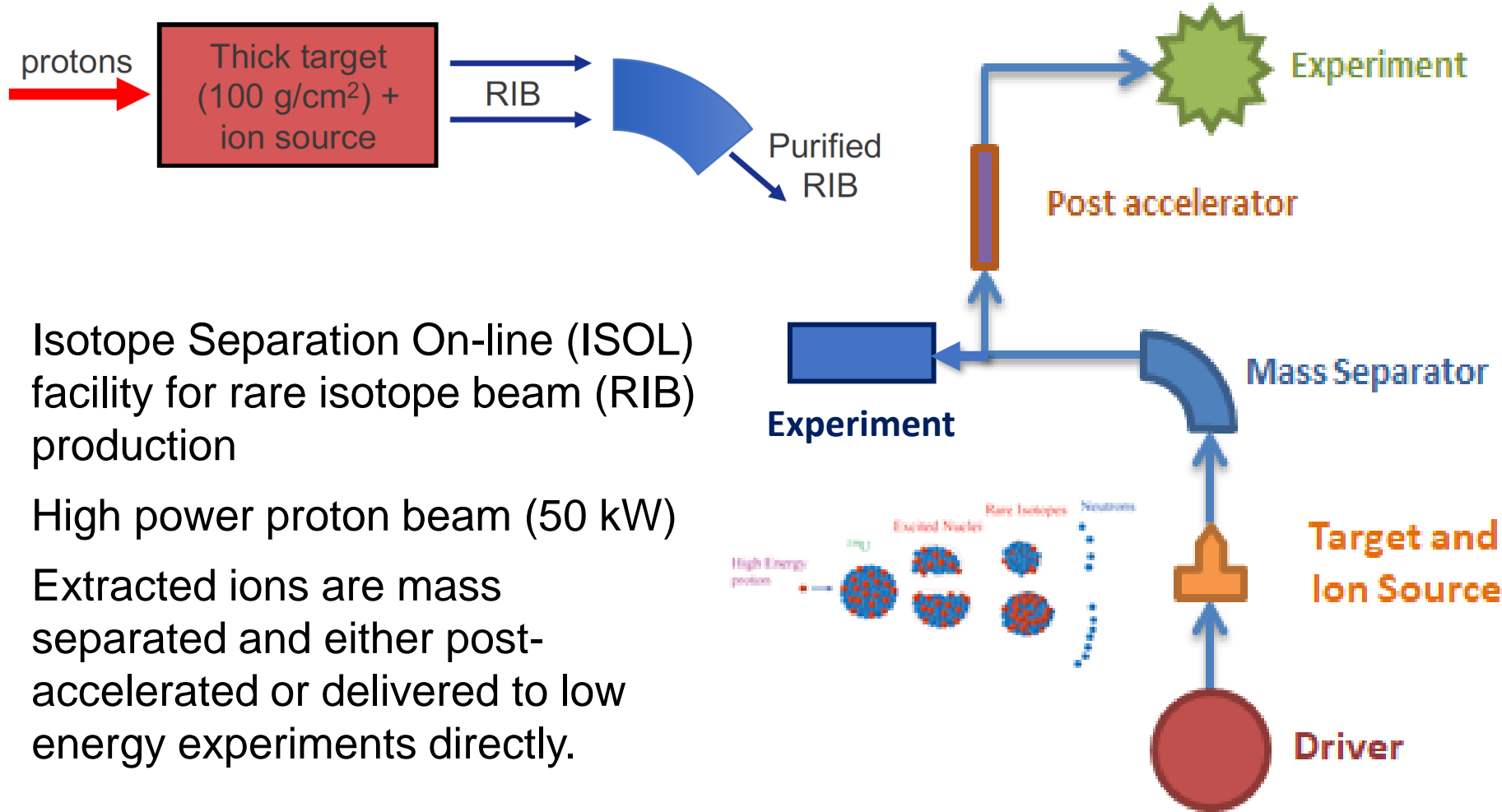
- Multiple high-power beams by stripping extraction
 - Variable energy – simultaneous beam delivery – presently 3 beams extracted



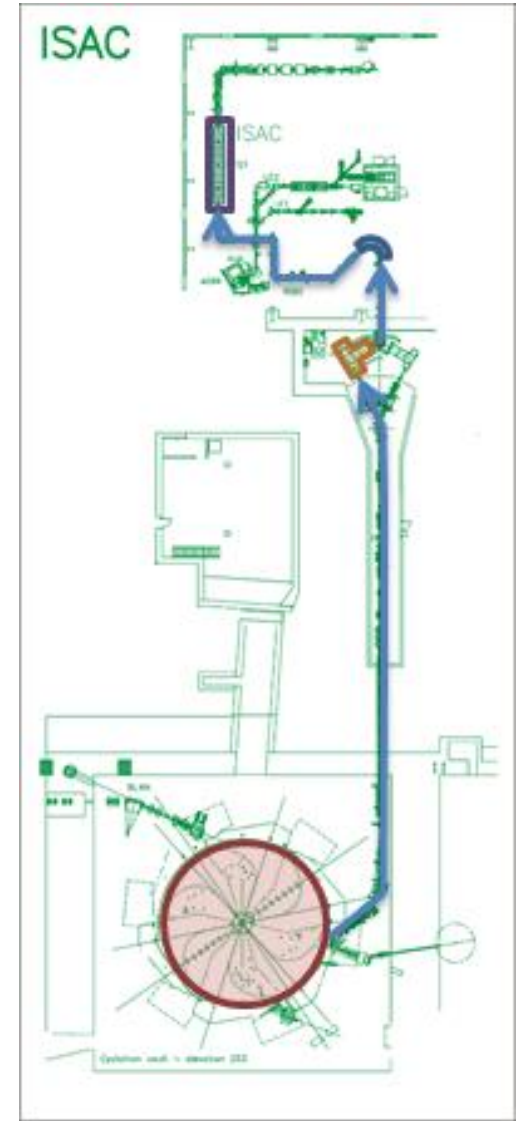
TRIUMF Overview of applications driven by the 520 MeV Cyclotron

- The 520 MeV cyclotron provides beam for medical isotope production (Nuclear Imaging & research on particle radiation therapy).
- Irradiation capabilities with protons and neutrons.
- Proton beams are delivered to
 - the Solid Targetstation Facility (STF) for Sr production [$^{85}\text{Rb}(p,4n)^{82}\text{Sr}$]
 - Isotope Production Facility (IPF)
 - Proton Irradiation Facility (PIF)
 - Neutron Irradiation Facility (NIF)
 - And in the future to the ARIEL Proton Target Station West (APTW) with the symbiotic medical target in the beam dump.

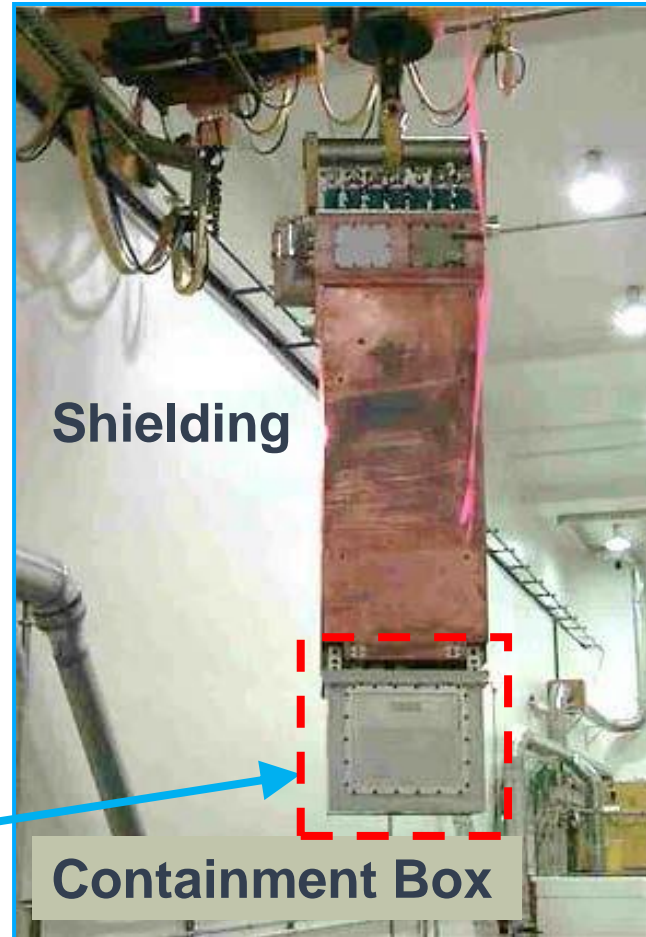
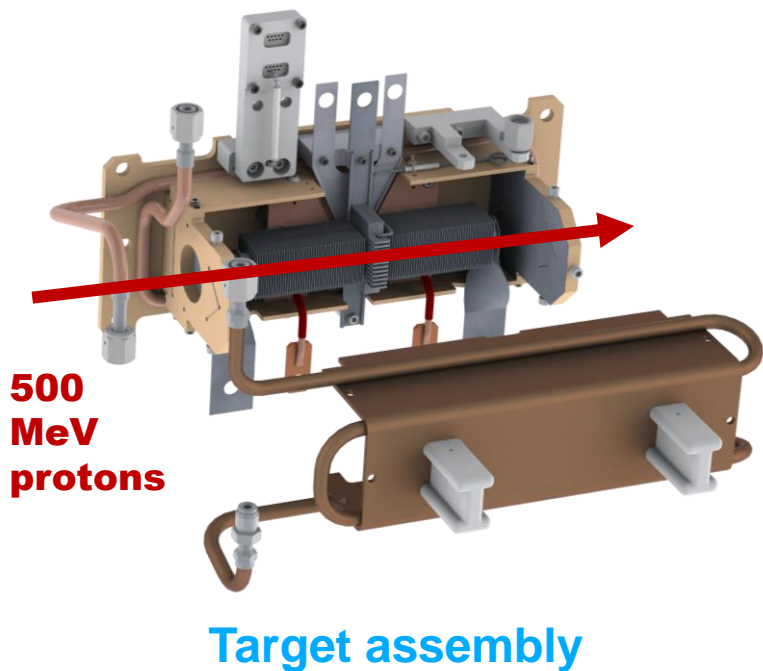
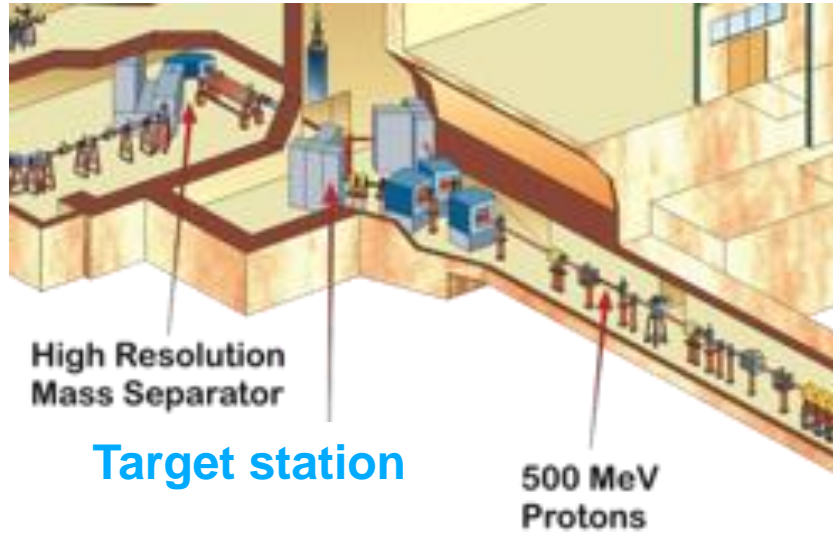




- Isotope Separation On-line (ISOL) facility for rare isotope beam (RIB) production
- High power proton beam (50 kW)
- Extracted ions are mass separated and either post-accelerated or delivered to low energy experiments directly.



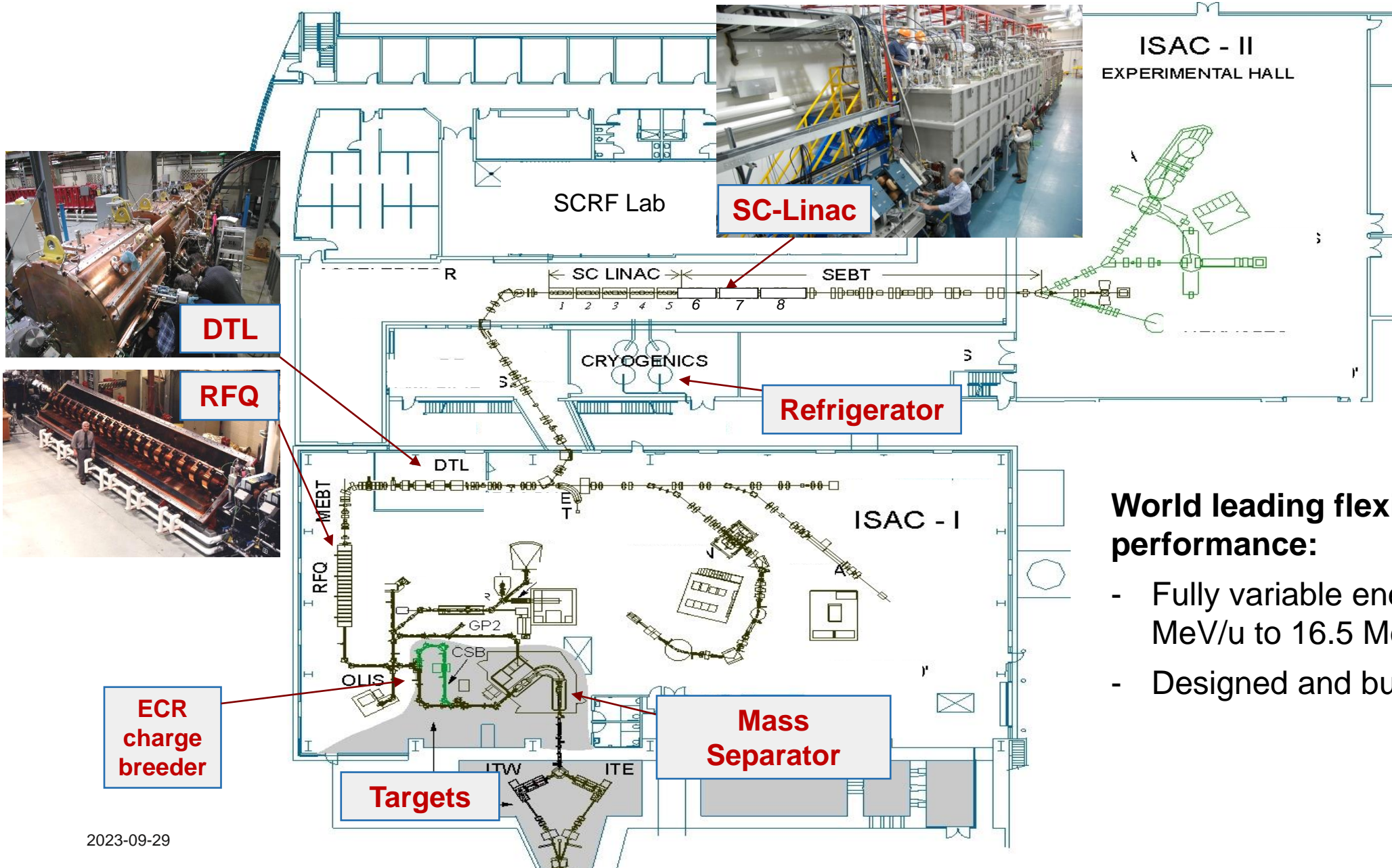
ISAC – World's Highest Power ISOL Target Systems



Target module

- **Target assembly** mounted in the Target Module containment box
- The target containment box is mounted on the bottom end of the **target module**.
- The target module is moved to/from **target stations** via remote handling crane – target exchange is done in a hot cell



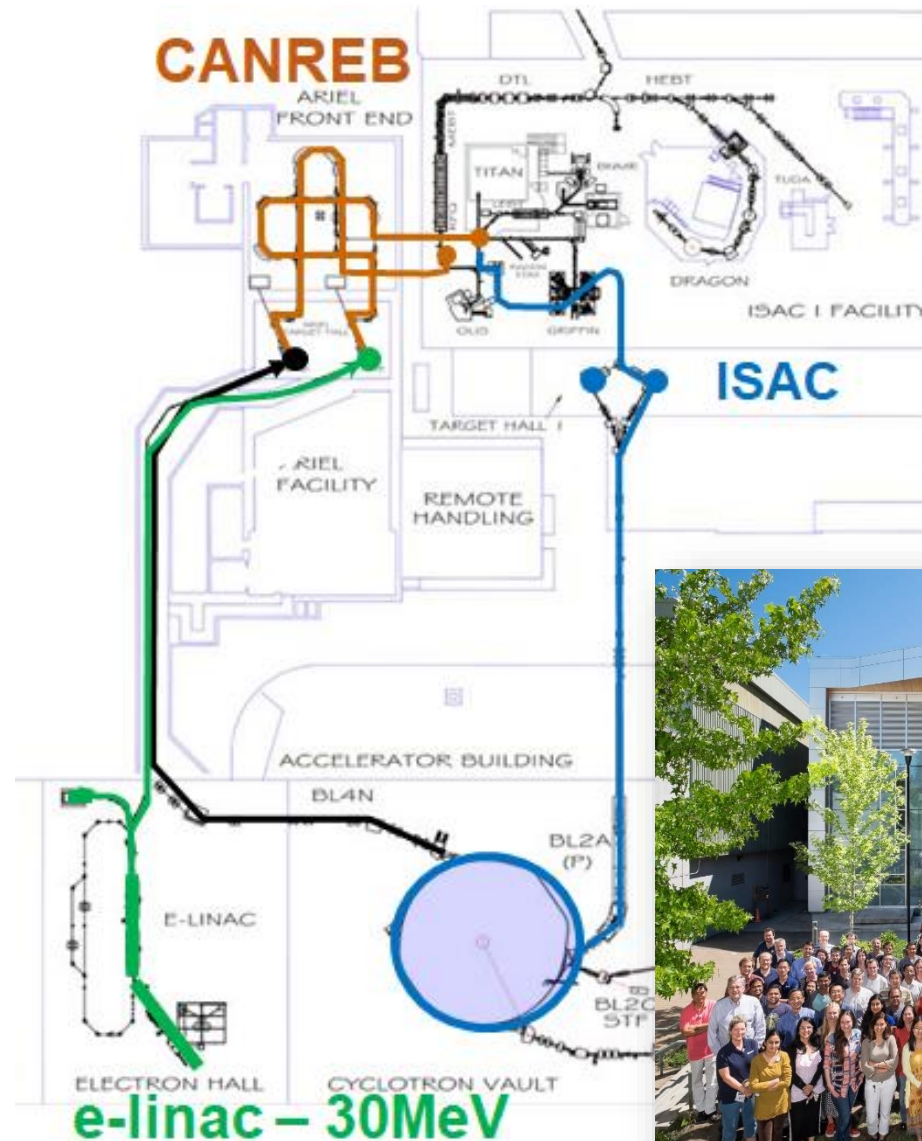


World leading flexibility and performance:

- Fully variable energy from 0.15 MeV/u to 16.5 MeV/u
- Designed and built in house

ARIEL: ISACx3

- ARIEL is the world's most powerful isotope separation online complex.
- It will triple ISAC's present rare isotope capabilities by adding
 - a 50kW proton target station
 - a 100kW electron target station
 - Unique beam preparation and transport system (CANadian Rare isotope facility with Electron Beam ion source - CANREB)
- ARIEL is the only rare isotope facility that will provide three RIB beams simultaneously to experiments.
- ARIEL completion is planned for 2027



ARIEL – superconducting electron-Linac

10 kW beam dump

cryo-module 2

cryo-module 1

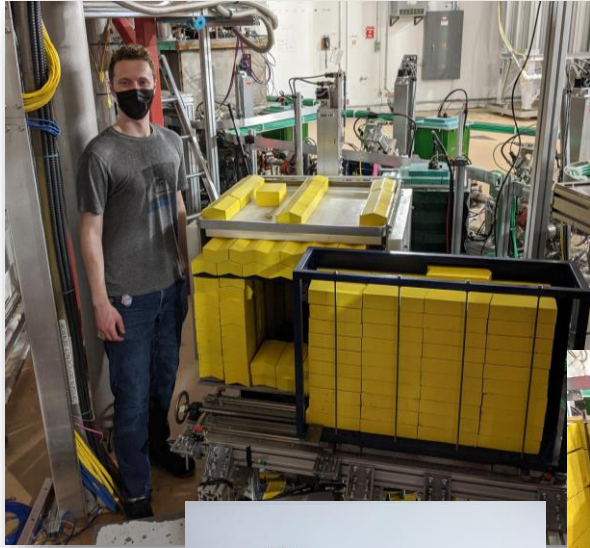
e-gun

- Elliptical cavities, 1.3 GHz
- 9 cell, TESLA type
- 11 MV/m demonstrated



- E-gun delivers max. 10 mA at 300 keV beam
- The injector cryomodule (1) accelerates to 5-10 MeV
- The accelerator cryomodule (2) is equipped with two cavities and reaches max. 30 MeV.

Early science supported by the ARIEL e-linac (active)

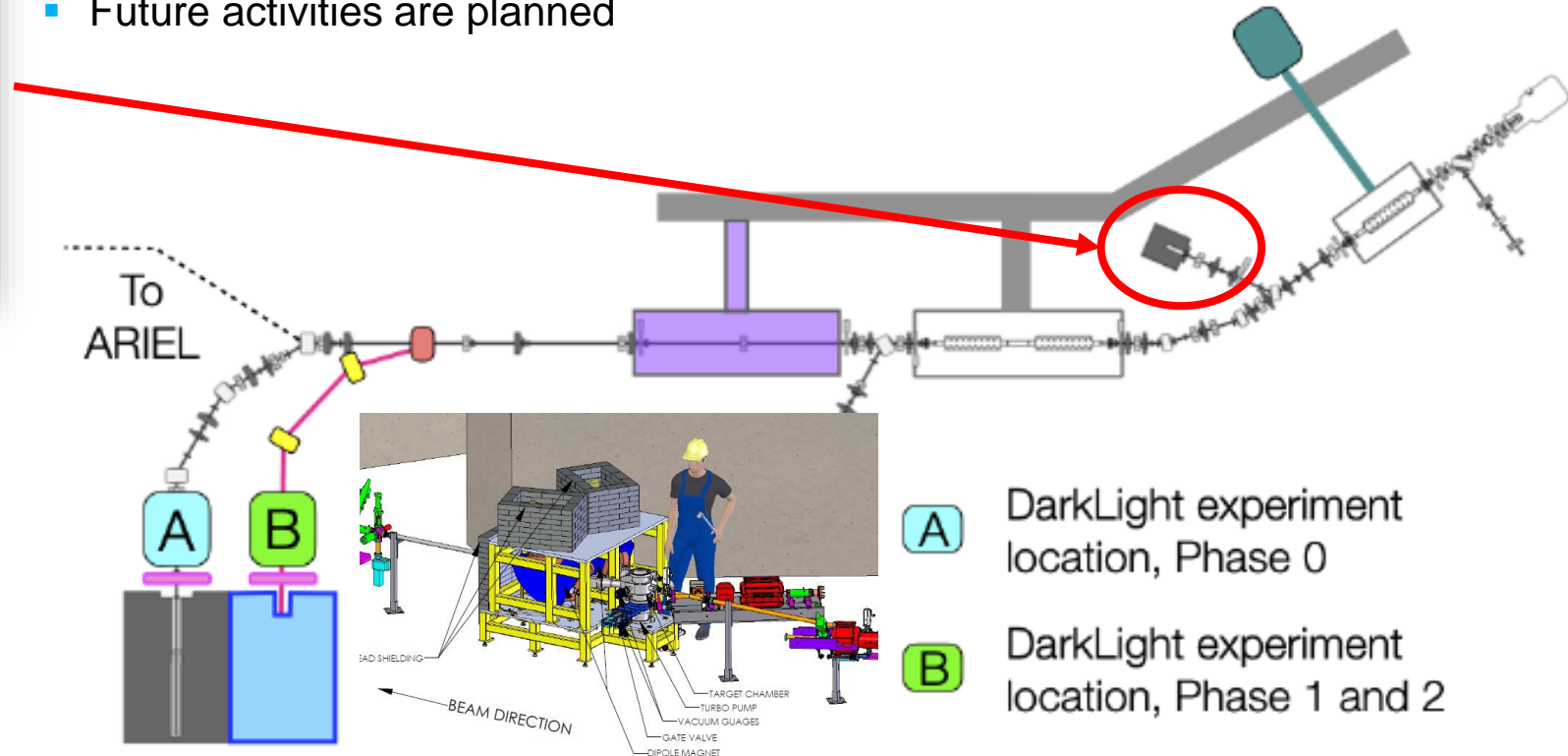


FLASH radiotherapy

involves the ultra-fast delivery of radiation treatment at dose rates several orders of magnitude greater than those currently in routine clinical practice. It is enabled by the new ARIEL convertor technology:

- Studies comparing response to identical dose deposited at FLASH and conventional rates in mouse, fruit fly and DNA completed
- FLASH does rates about 100 Gy/s, conventional 0.1 Gy/s
- Future activities are planned

Dark matter search – DARK LIGHT experiment looking for a 5th force (dark photons) in electron scattering at the ARIEL e-linac
Experiment gets additional motivation from recent results from the muon g-2 experiment at Fermilab.



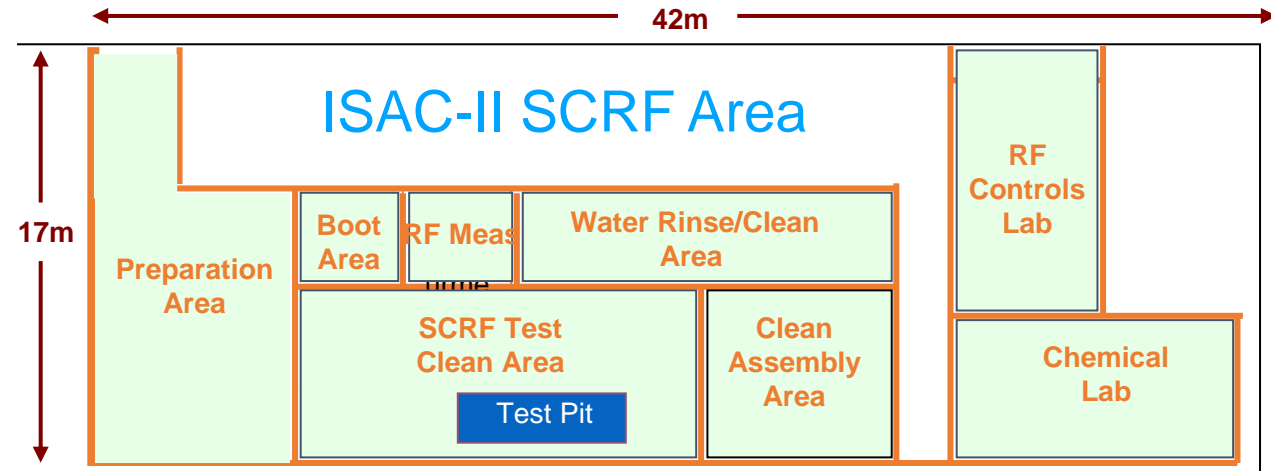
TRIUMF SRF Infrastructure (I)

- TRIUMF hosts two SRF linacs (ISAC-II heavy ion linac and the ARIEL electron linac) and SRF supporting infrastructure.
- Activities range from student R&D on test resonators to work for others (prototyping cavities and components) and to full cryomodule assemblies
- For student training and R&D we have added
 - UHV RF induction oven
 - Coaxial test resonators for fundamental studies
 - New high parallel field spectrometer for beta-NMR



TRIUMF SRF test and assembly areas

- 500m² of floor space, overhead crane comprising:
 - US cleaning tanks, HPWR area, cryogenics on tap, cryomodule assembly area (clean room for hermetic string assembly), chemical etching lab (BCP), rf testing
- Minor upgrades of clean room performed to meet the HL-LHC requirements.
- Cryomodule test capability in ISAC-II
 - LHe – 100ltr/h in falling level, 200W at 4K, 40W at 2K
 - LN2 at 1.5 Bar
 - Shielded pit, LLRF, controls
- Issues with space for the HL-LHC project (larger CM assembly space in adjacent hall)
 - New clean room for ISAC-II ordered!





A global leader in discovery science, delivering breakthroughs that unlock the deepest mysteries of the universe

Strengthening Canada's leadership in groundbreaking particle and nuclear physics



A world-class accelerator centre driving use-inspired research – from the life sciences to quantum and green technologies

Leveraging our unique infrastructure to pursue research in Canada that will change the world



An inclusive multidisciplinary talent incubator, attracting and developing the best people from around the world

Producing Canada's future science leaders and innovators



A leader in a flourishing national Big Science ecosystem

Catalyzing the success and growth of Canada's network of major research facilities



A national innovation hub translating discovery science into health and sustainability solutions

Responding nimbly to complex societal challenges for the benefit of Canadians

- TRIUMF released the [20-year vision](#) September 2022 as a response to an international peer review.
- The product of an 18 months process engaging a broad research and stakeholder community leading to five core themes.
- The Visions lays out a long-term direction for the laboratory built around five pillars defining how the community sees the laboratory's future.



Discovery and Innovation for a Better World

Our 20-Year Vision
2022–2042

Thank you
Merci

www.triumf.ca

Follow us @TRIUMFLab

