

New TRIUMF facility: ARIEL

Oliver Kester

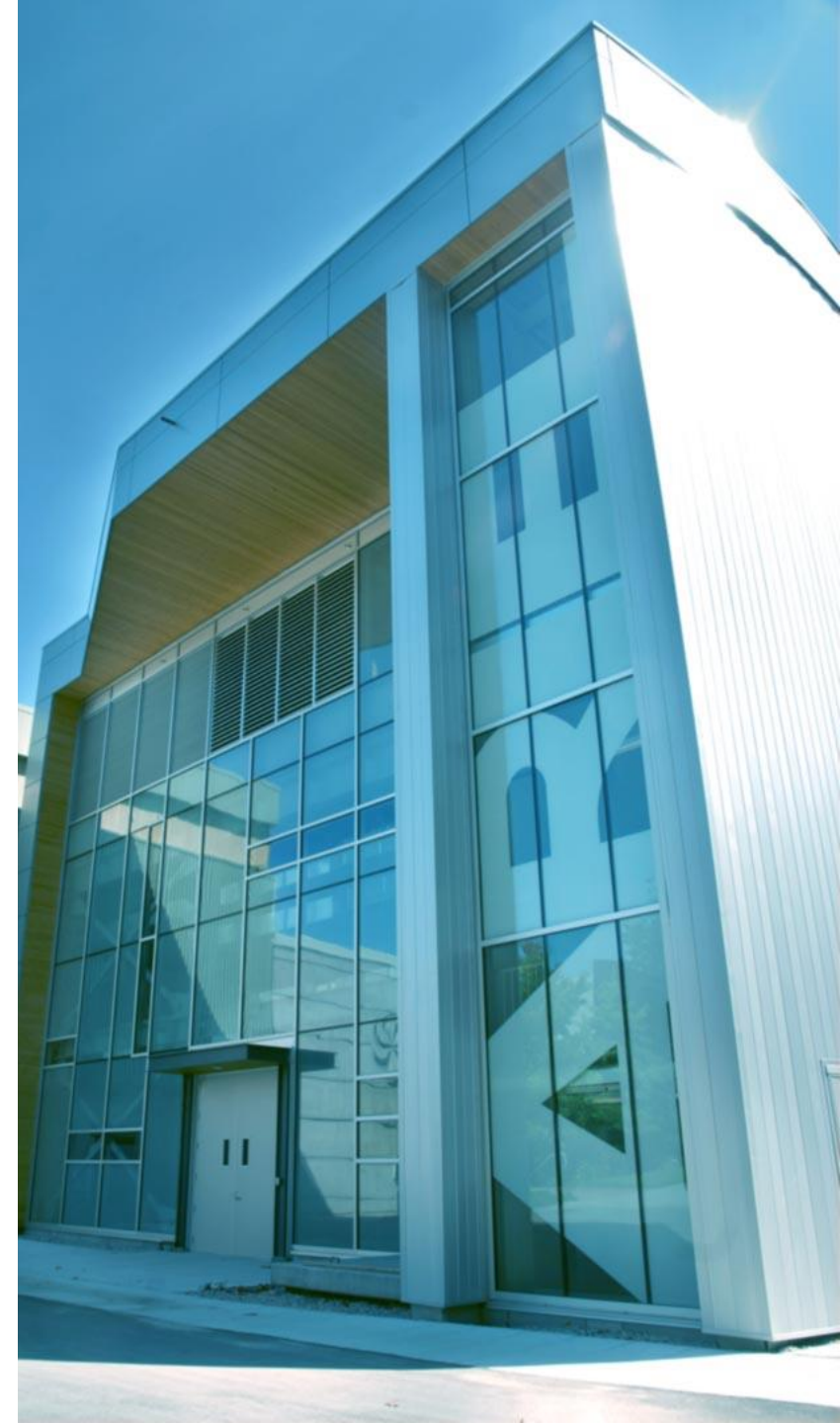
Director, Accelerator Division
for the ARIEL team

KEK / TRIUMF Symposium
September 28, 2025



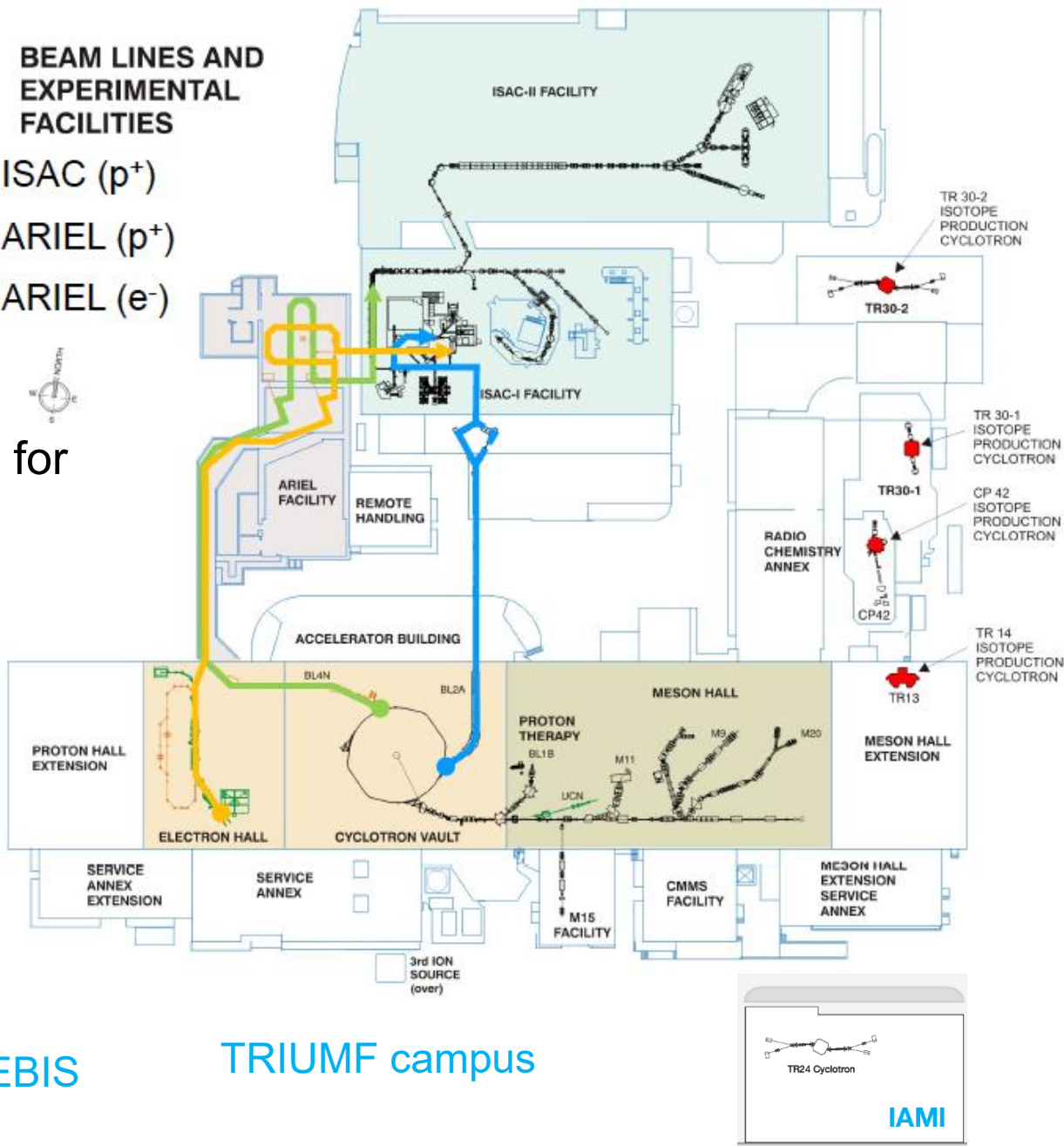
ARIEL: ISAC×3

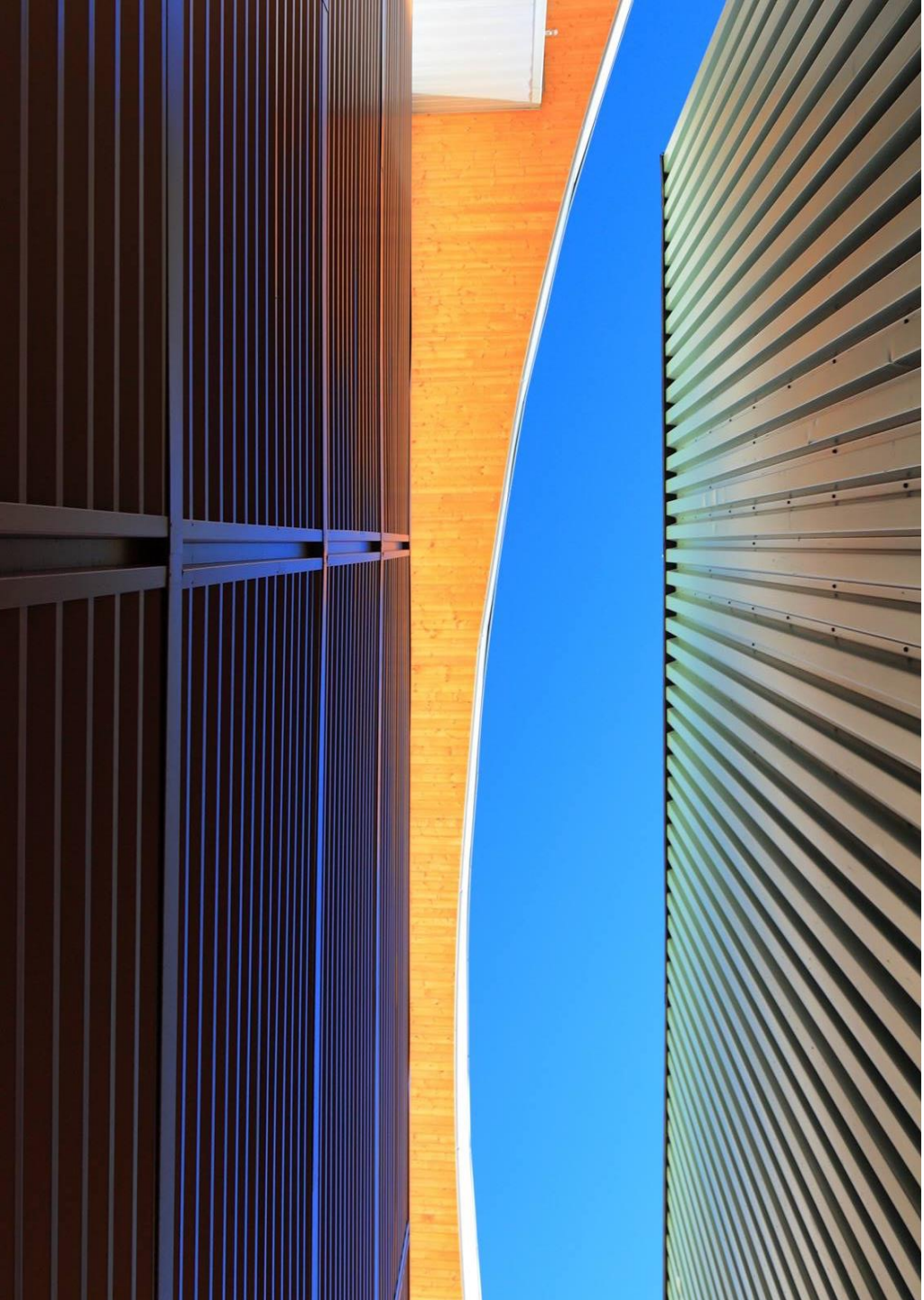
- The Advanced Rare IsotopE Laboratory (ARIEL) is the world's most powerful Isotope Separation OnLine (ISOL) complex.
- It will triple the present rare isotope capabilities of the Isotope and ACcelerator facility (ISAC).
- ARIEL is the only rare isotope facility that will provide three RIB beams simultaneously to experiments.



ARIEL - TRIUMF's flagship project

- Simultaneous RIB production from 3 targets
 - 50 kW existing ISAC proton target
 - 50kW new ARIEL proton target
 - 100kW new ARIEL electron target
- Multi-user capability with more and new isotopes for
 - Nuclear Structure and Dynamics
 - Nuclear Astrophysics
 - Fundamental Symmetries
 - Materials Science
 - Life Sciences
- Unique beam preparation and transport system (CANadian Rare isotope facility with Electron Beam ion source - CANREB)
 - High resolution separator
 - Beam preparation with RFQ cooler buncher and EBIS



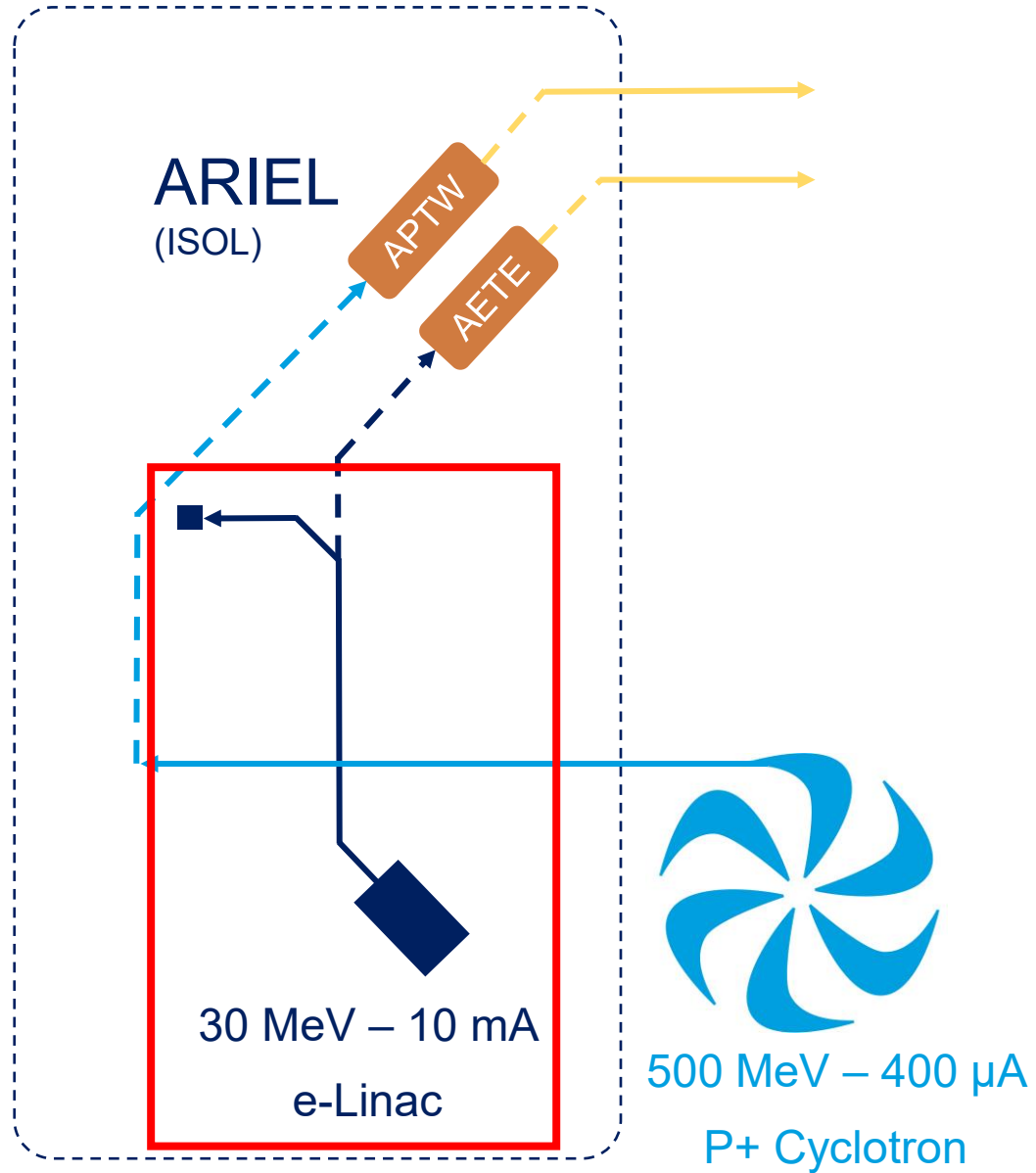


Development of ARIEL – the ARIEL project

- ARIEL-I (2012 - 2014)
e-Linac, beam tunnel, target building
- ARIEL-II (2017 - 2028)
target stations, shielding, hot cells, RIB distribution
- CANREB (2014 - 2019)
charge state breeding and purification for post-acceleration in ISAC II
- Therapeutic Isotopes (2020 - 2028)
production and processing of medical isotopes at ARIEL proton target station

\$200 million investment by federal and provincial governments; supported by 21 universities across Canada, about 700 FTE years total effort

ARIEL

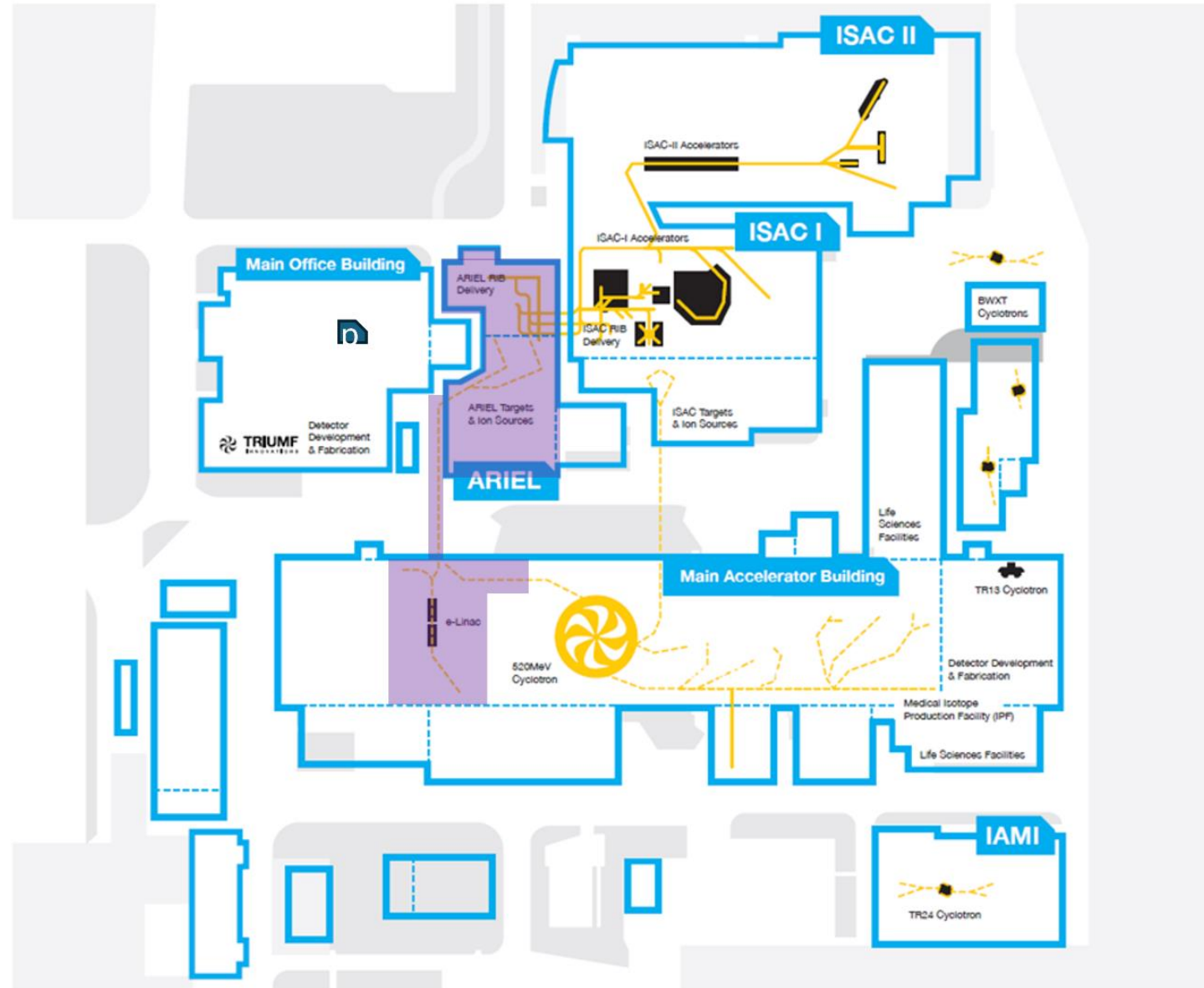


ARIEL ISOL targets (from 2027)

Cyclotron & beamlines (since ~1975)

RIB lines

E-linac and beamline (since ~2013)



ARIEL – superconducting electron-Linac

10 kW beam dump

cryo-module 2

cryo-module 1

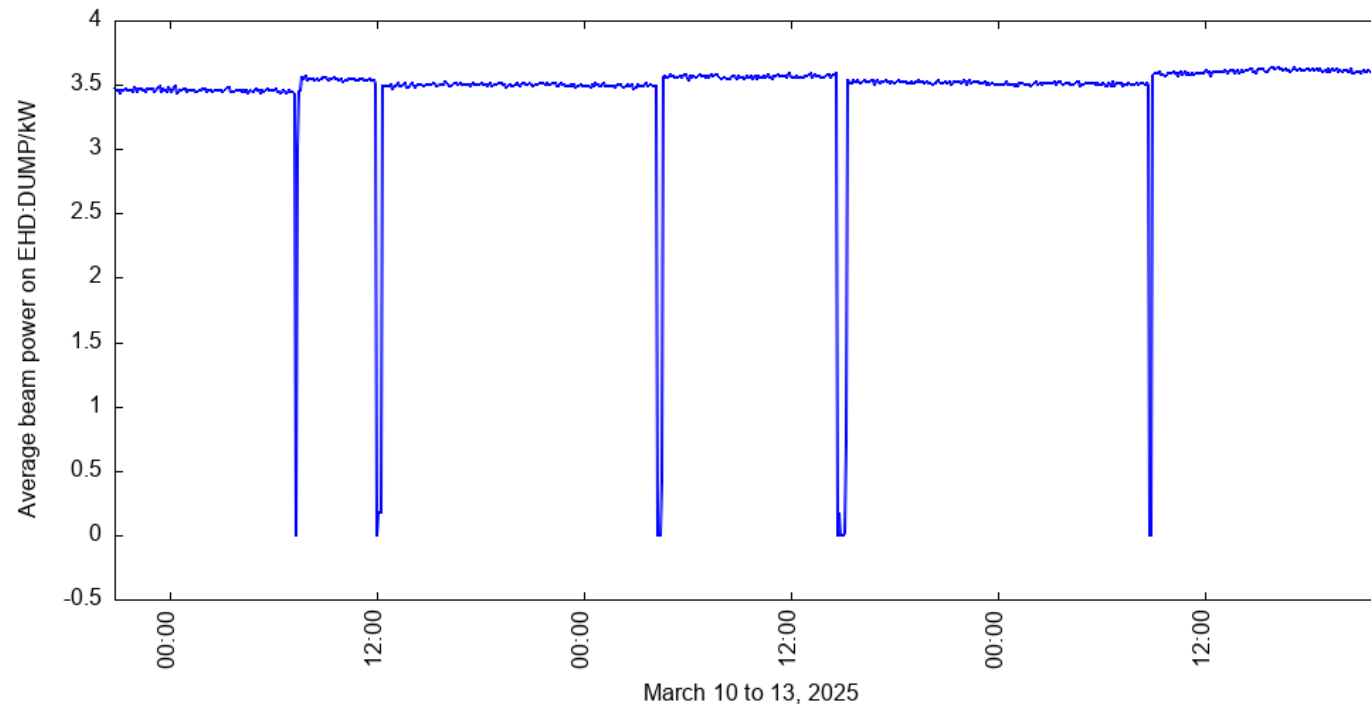
e-gun



- 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.

- 10 kW demonstration @ 30 MeV : September 2021
- Reliability efforts
 - 3-days of continuous beam delivery in March 2025
- Currently e-Linac shutdown
 - Next step, in 2027: commissioning the beamline in the ARIEL tunnel

E-LINAC	
BEAM	ON
PATH	EHD:DUMP
PEAK CUR.	498 μ A
ENERGY	30.2 MeV
POWER	10.0 kW

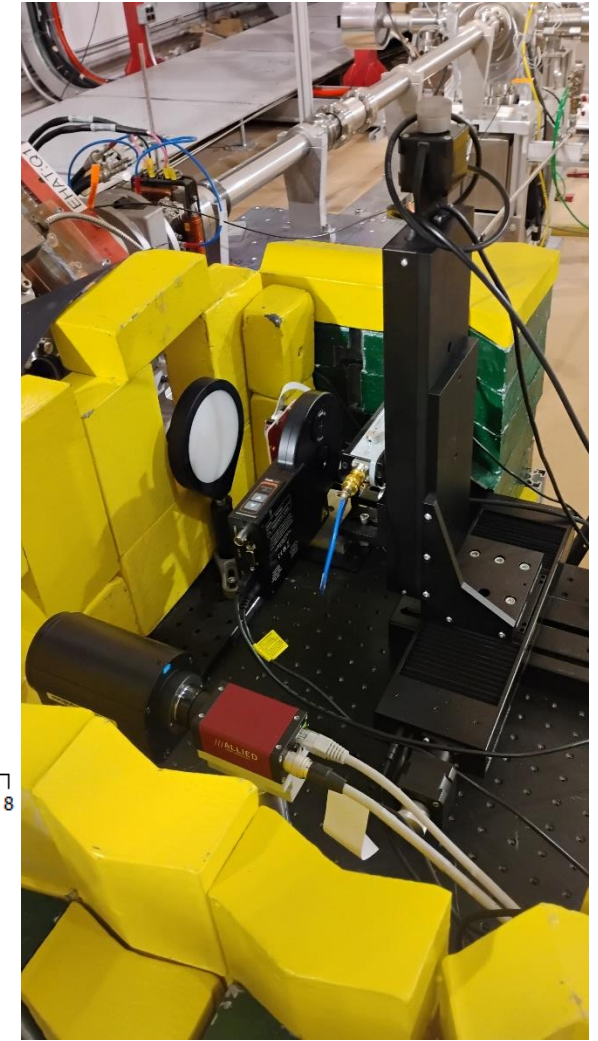
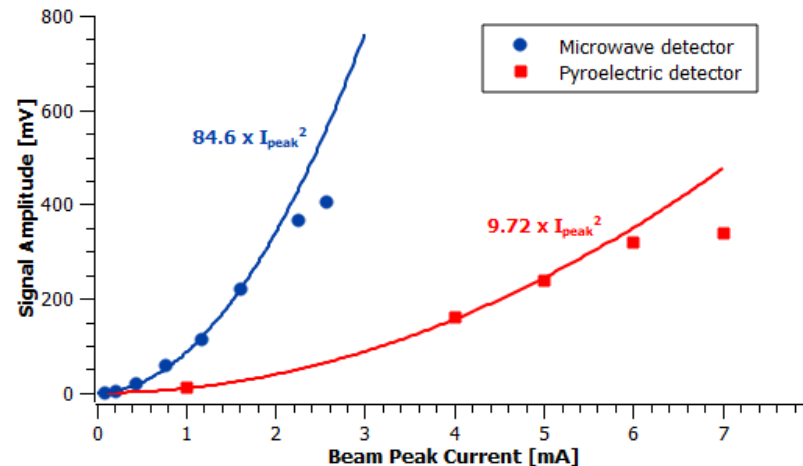


Milestones:

- Succeeded to secure a CFI grant in 2023.
- A series of demonstration experiments were conducted since 2024 to learn the THz-oriented e-Linac operation and to develop the THz instrumentation.
- First e-Linac-THz paper published 2026 in Canadian Journal of Physics [1].

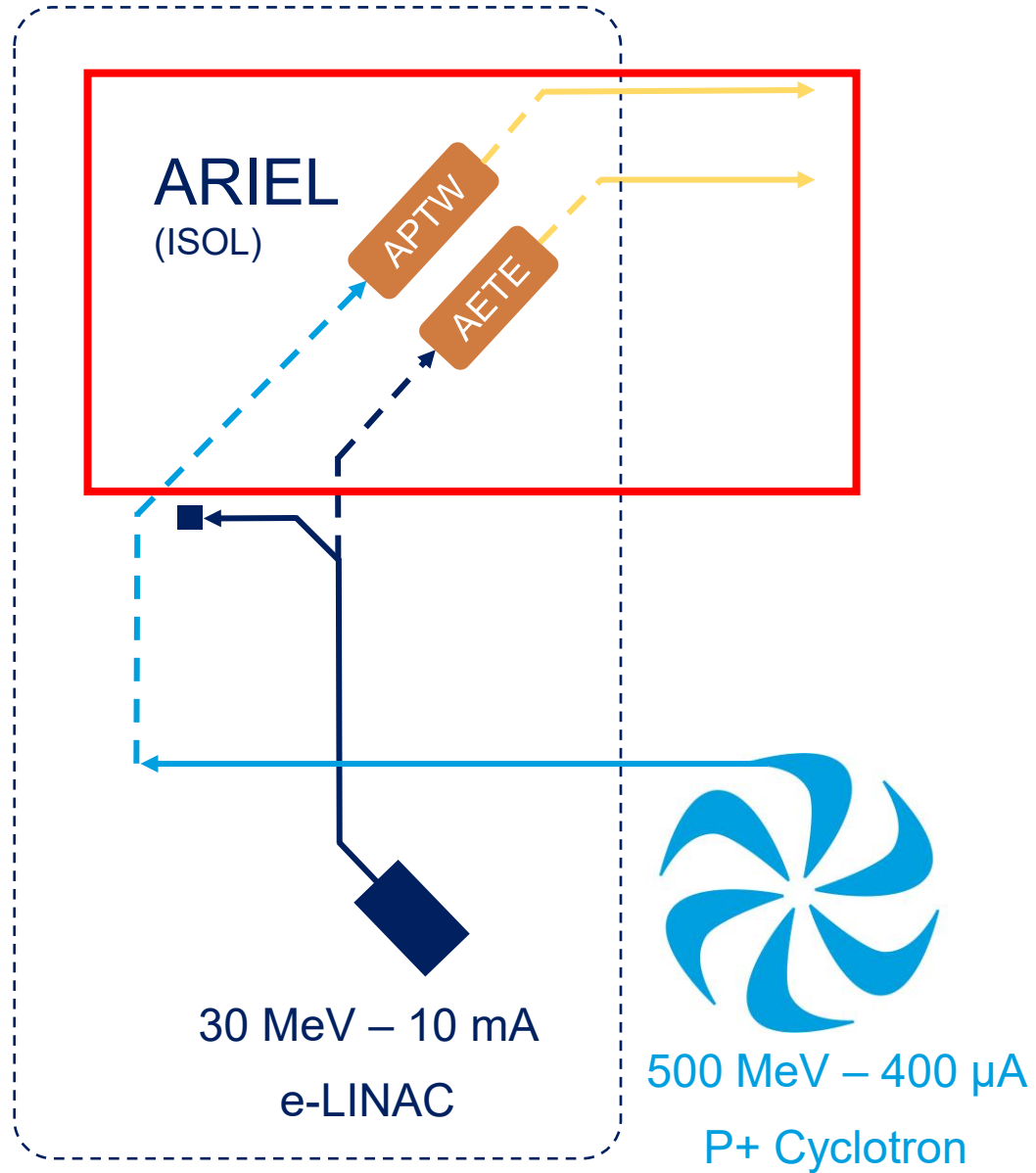
Upcoming:

- Build and install a new photo-gun capable of producing high-charge electron bunches.
- Construct a laser lab to host the laser system.
- Design, build and install a magnetic compressor to shorten the electron bunches (wavelength $\gg$ bunch length)

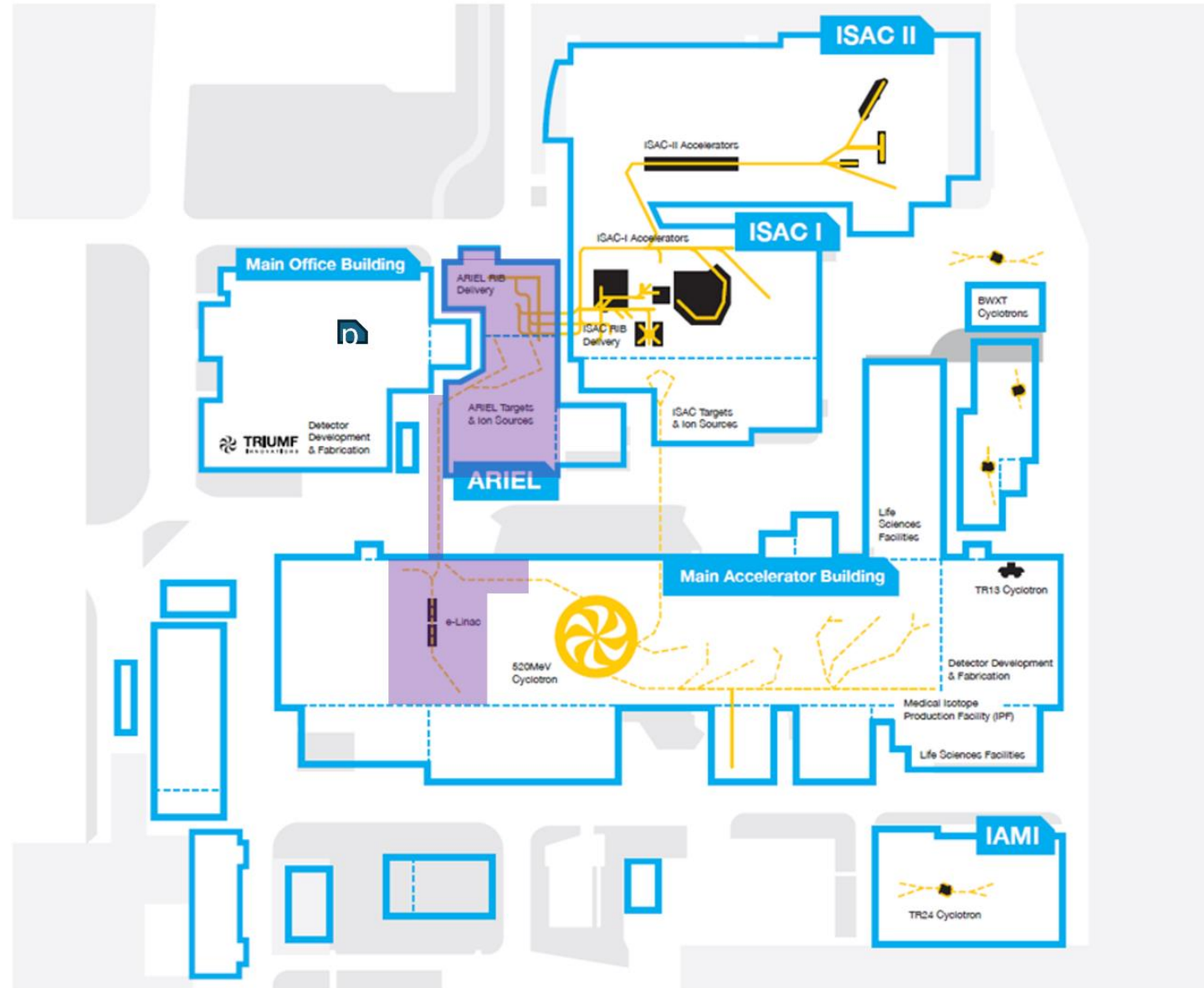


Will increase the availability of beam from the e-linac for ARIEL operation!

ARIEL



- Cyclotron & beamlines (since ~1975)
- RIB lines
- ARIEL ISOL targets (from 2027)
- E-linac and beamline (since ~2013)

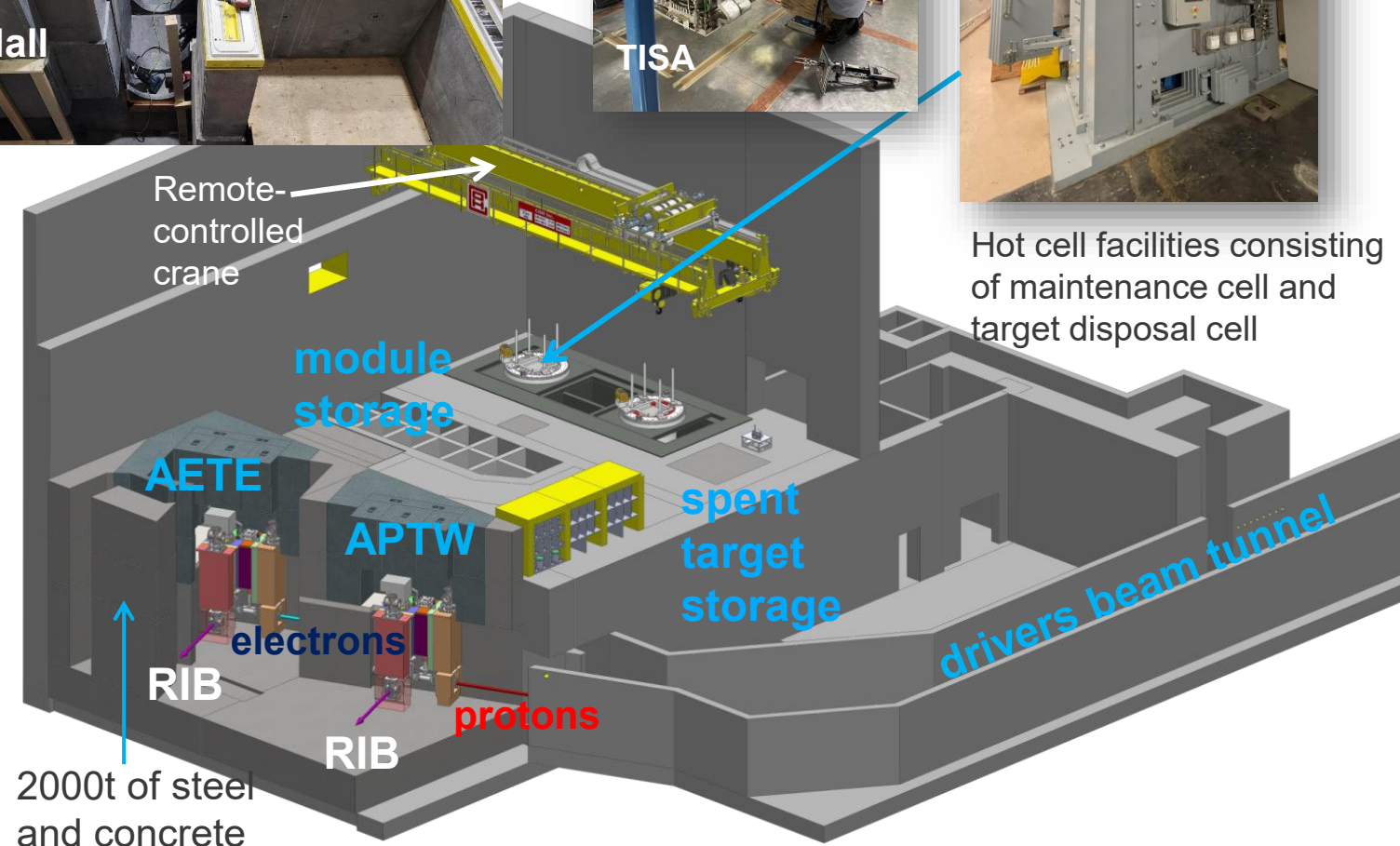


Completion of the ARIEL project

- Requires the target hall infrastructure for both stations (shielding, target building infrastructure, gas handling, HV infrastructure, vacuum systems)
- Target and RIB modules and beam dumps including the medical target and transfer system
- Beam line 4 North (BL4N) and the electron beam line and the integration, testing and commissioning of all systems
- Required for the ramp up in operation :
 - Spent target decay storage vault
 - Target production infrastructure (laboratories)
 - Offline target acceptance stand – TISA
 - HV infrastructure for APTW
 - e-Linac upgrade to full performance
 - CANREB operation (EBIS, RFCB and HRS)



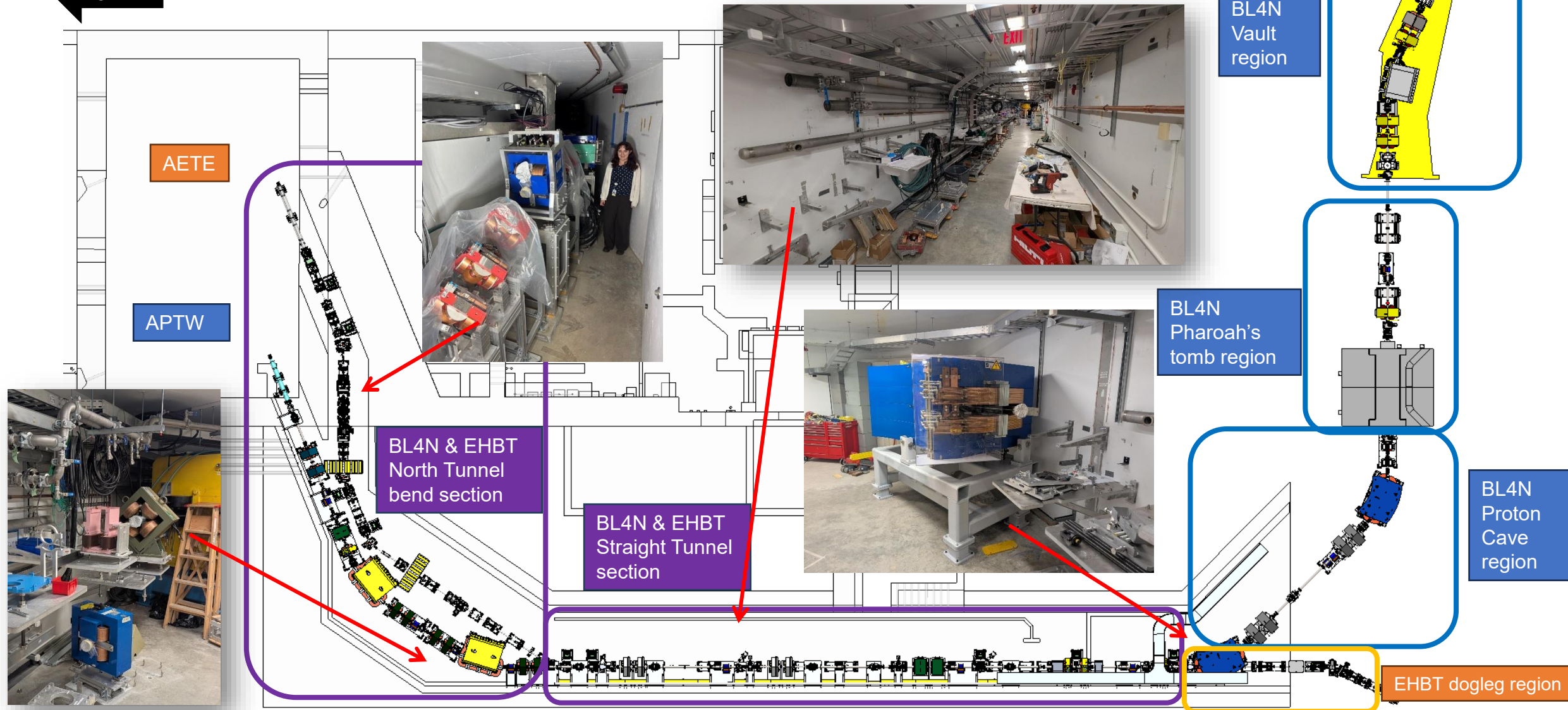
Hot cell facilities consisting of maintenance cell and target disposal cell



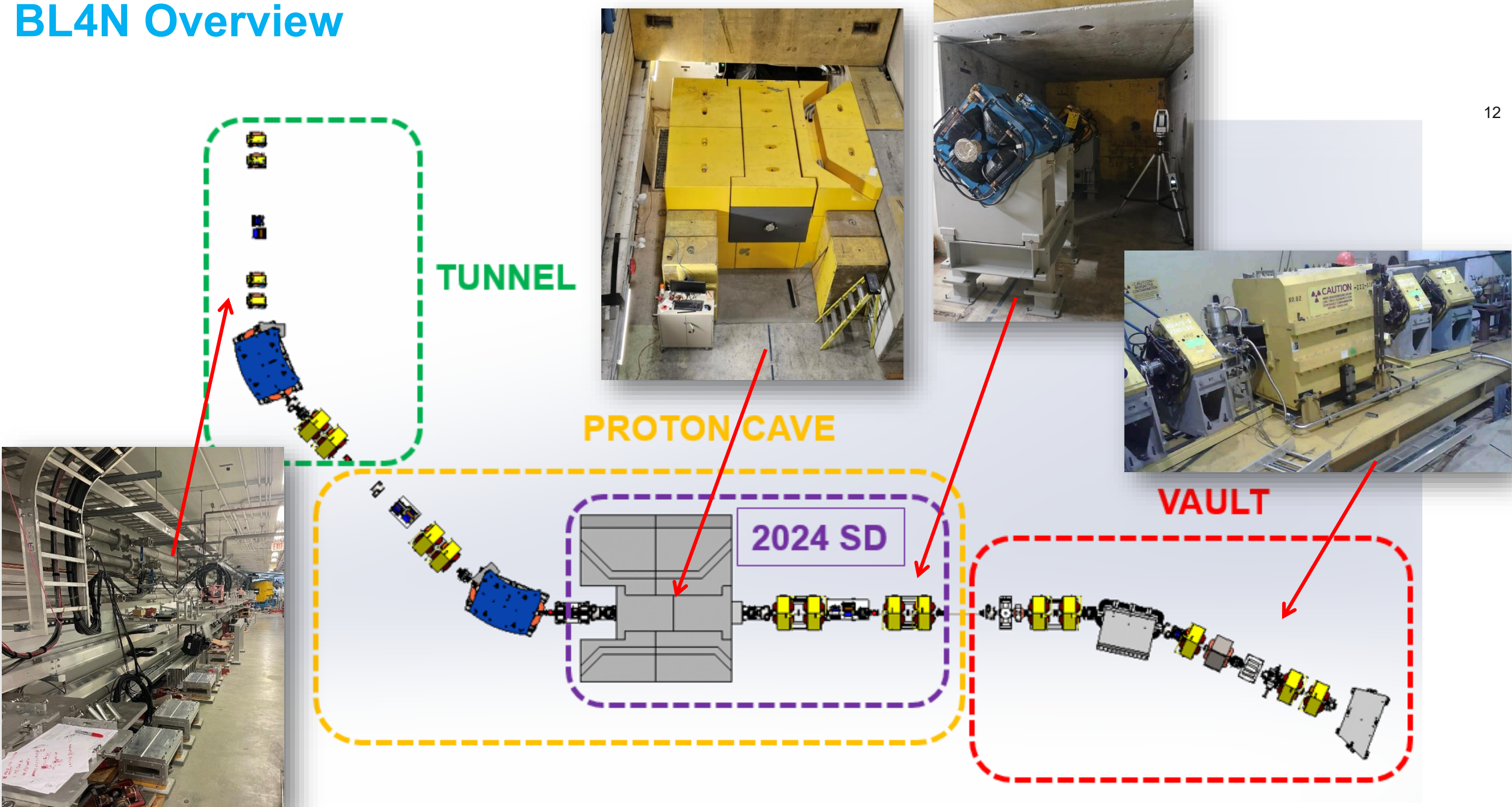
Tunnel Overview

NORTH

- EHBT (Electron Beam Transport) delivers an electron beam from the e-Linac to the AETE Target Station
- BL4N (Beam Line 4 North) delivers a proton beam from the Cyclotron to the APTW Target Station



BL4N Overview



Shielding Design Structure

- The Target Pit Shielding → ensure the access to the hall while beam operation, provide all services (cooling water, ventilation, compressed air etc.)
- It consists of 9 layers of fixed shielding and removable cap shielding.

Level 4b: Removable Cap Shielding

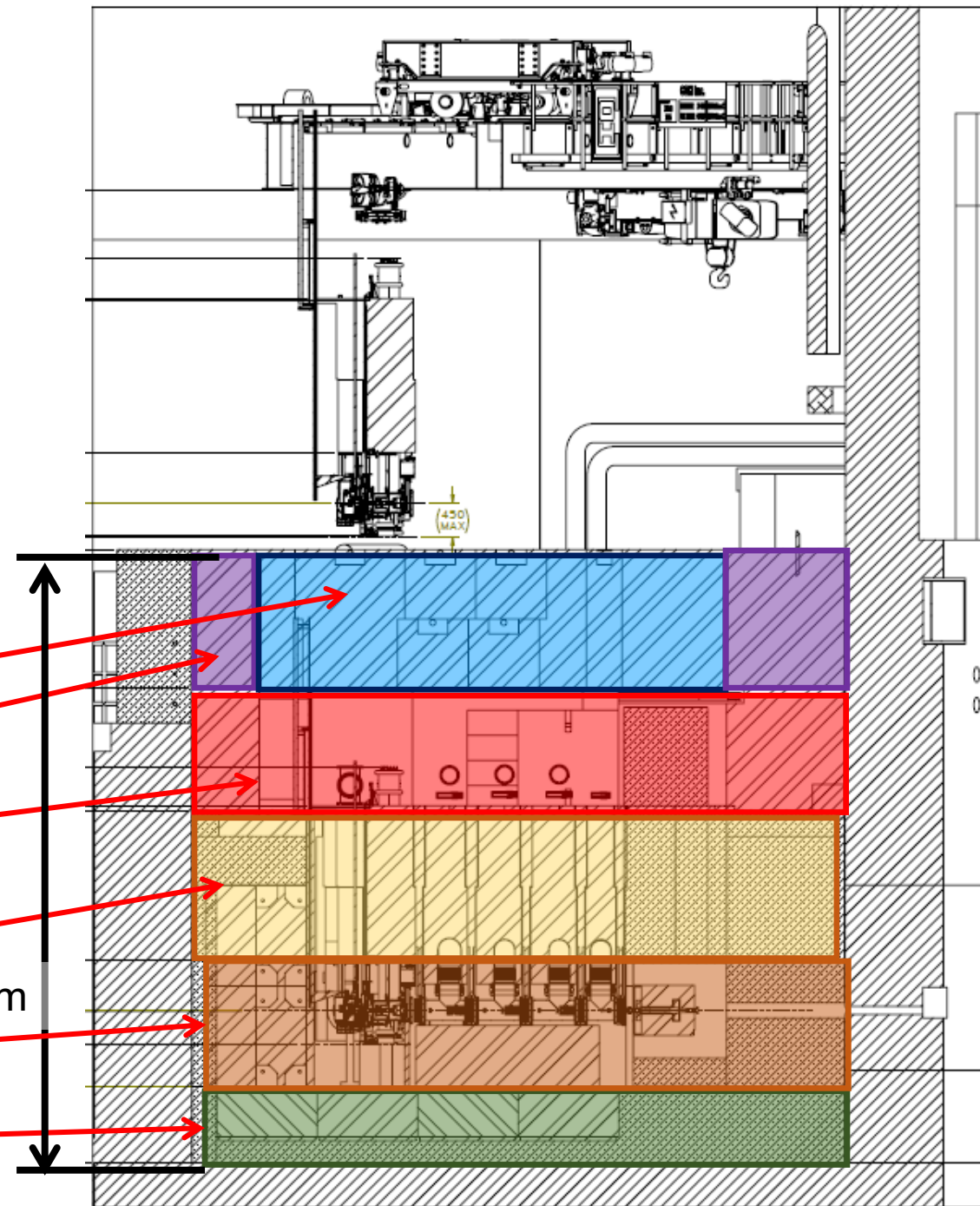
Level 4a: Fixed Cap Shielding

Level 3: Service Space

Level 2-4, 2-5, 2-6: Upper Canyon

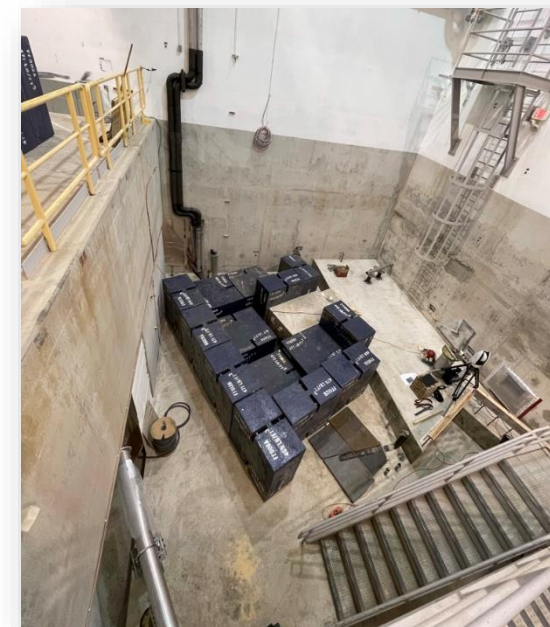
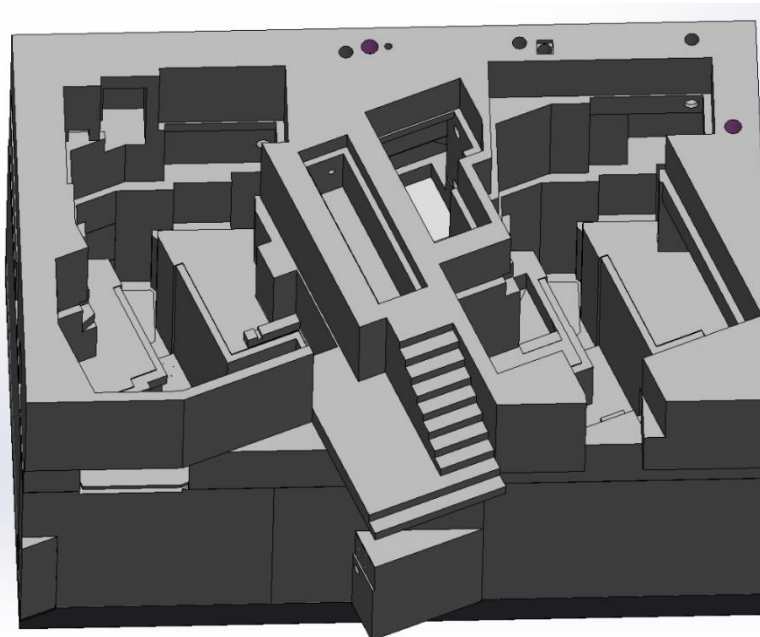
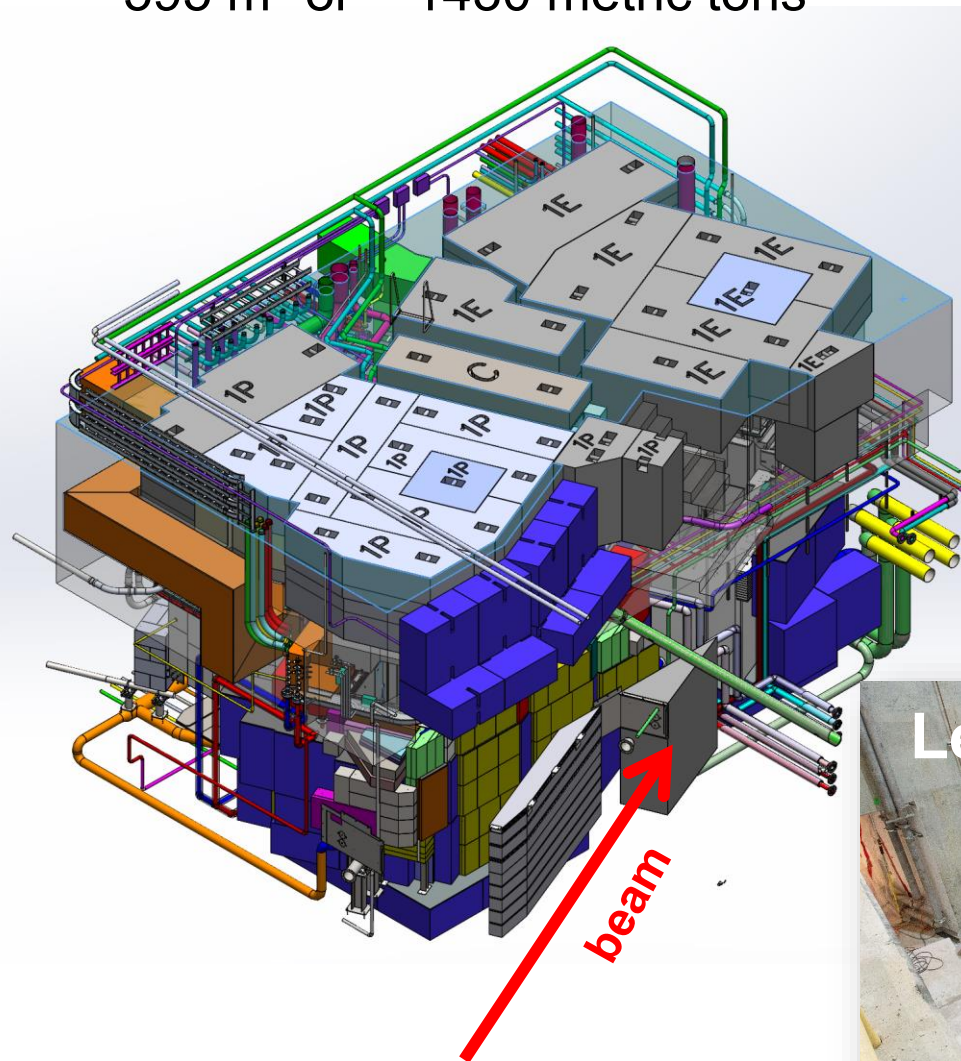
Level 2-1, 2-2, 2-3: Lower Canyon

Level 1: Below Station

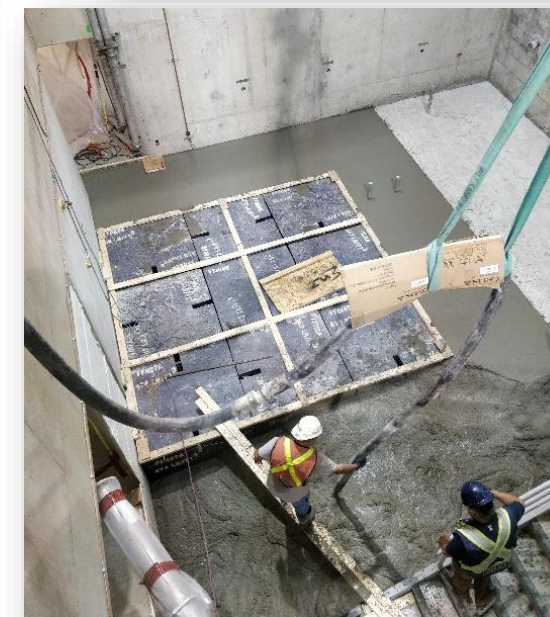


- Concrete poured for all levels combined:
~ 595 m³ or ~ 1430 metric tons

Target Hall Shielding Progress



Level 1 Complete 2020



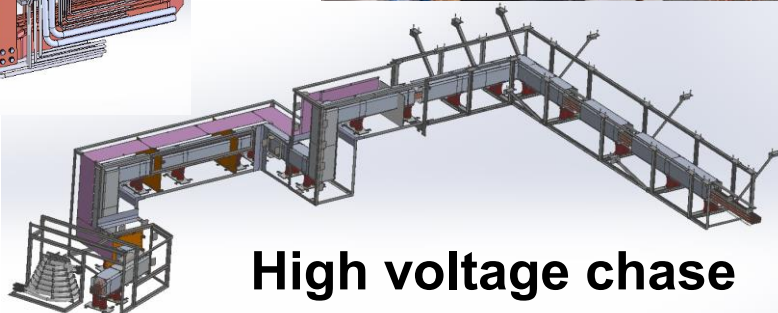
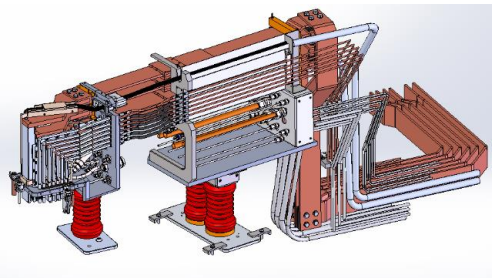
Target Hall Shielding Progress

Finally, Summer 2025 level 9 completed!
Installation work in the target hall started.



Target Hall installations

- With module mounting system installation complete, ARIEL is now ready* to receive modules!
- Module mounting system is the module interface with the ARIEL canyon and provide a smooth, level landing surface → Allows for repeatable positioning of modules and seals the secondary gas volume
- HV chase provides supply lines for high voltage, high current (target heating) and cooling water.



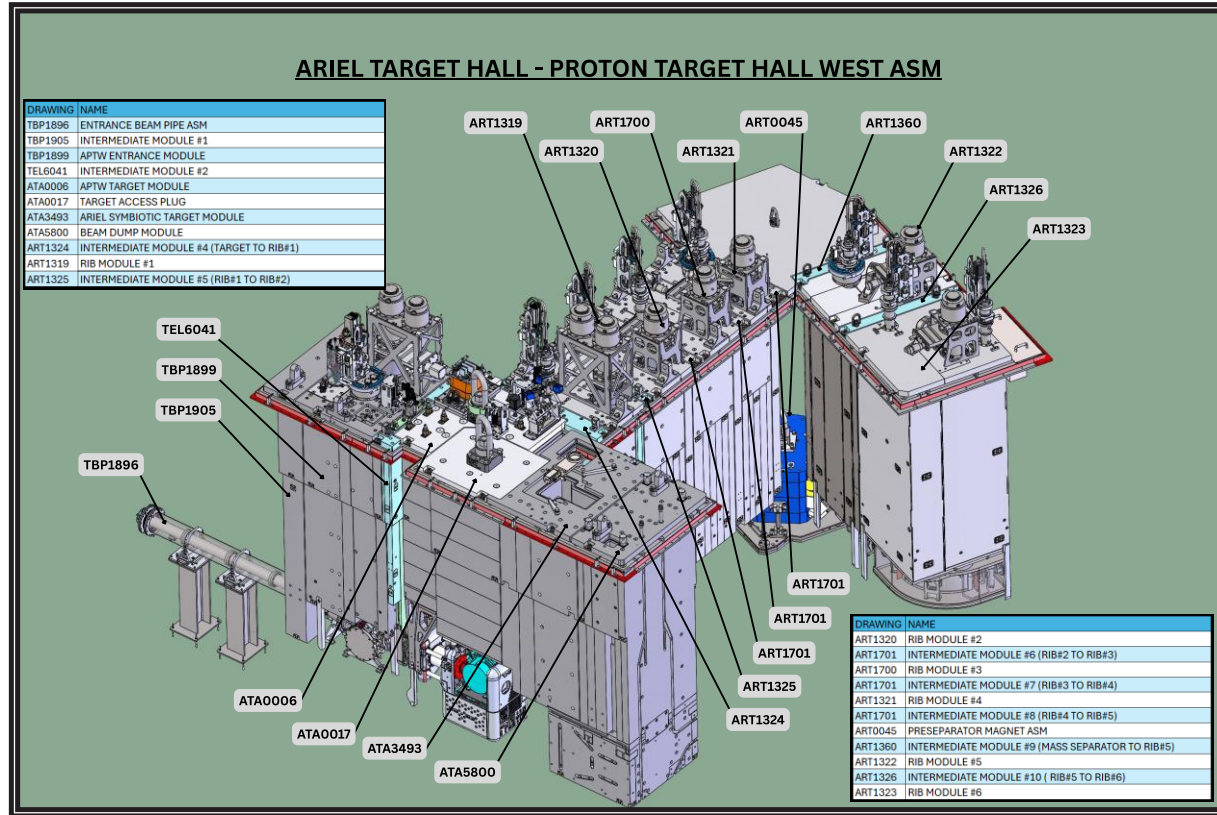
High voltage chase



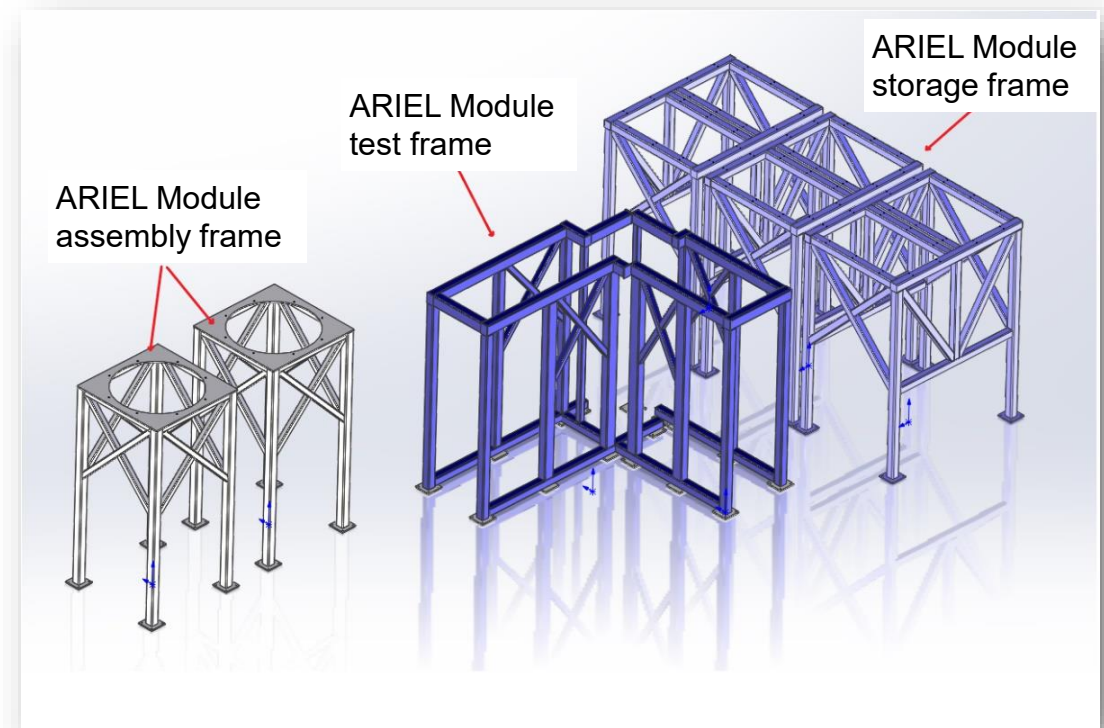
ARIEL Module Mounting System



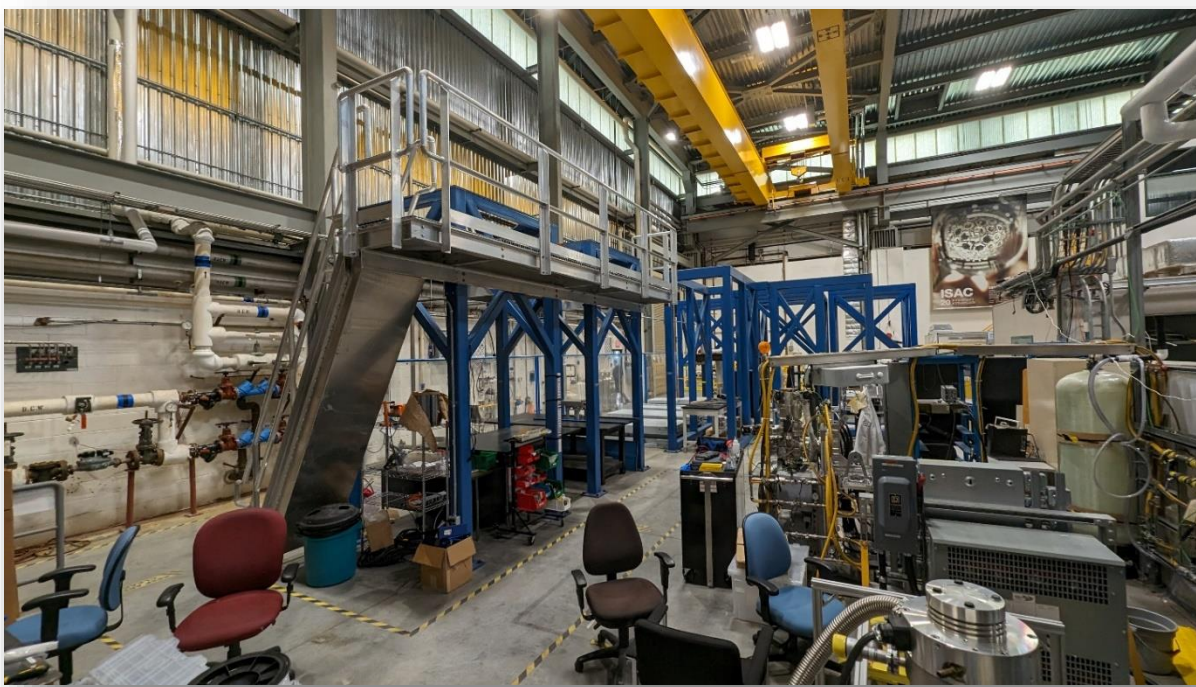
ARIEL module assembly in ISAC-I



- Assembly of the modules requires assembly of the shielding and of the related beam line element
- Target module, RIB modules → support structure



Module assembly jungle



ARIEL target modules

HV Services
(HVFT)

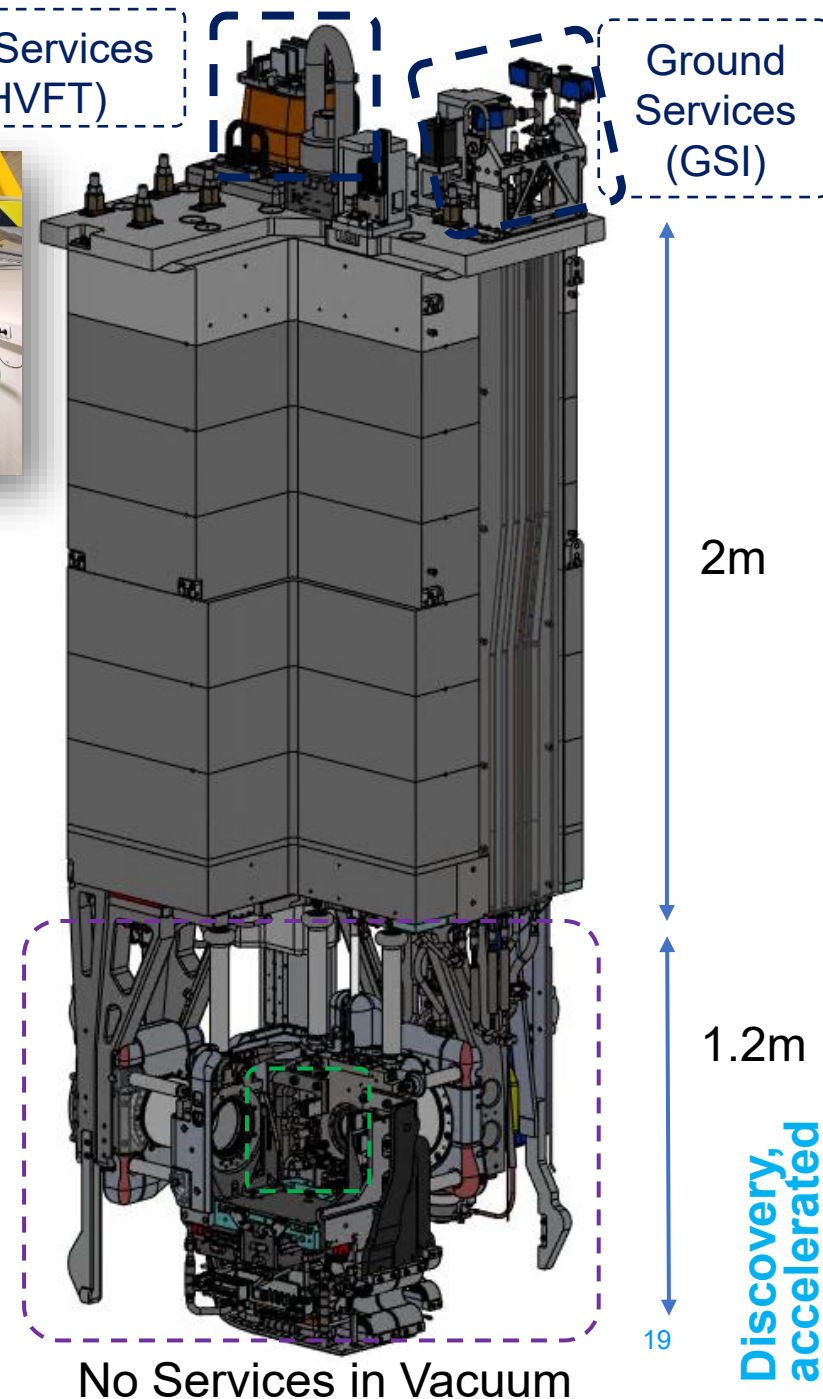
Ground
Services
(GSI)

2m

1.2m

Discovery,
accelerated

19



Alignment Shim Plates

RIB Side
assembly

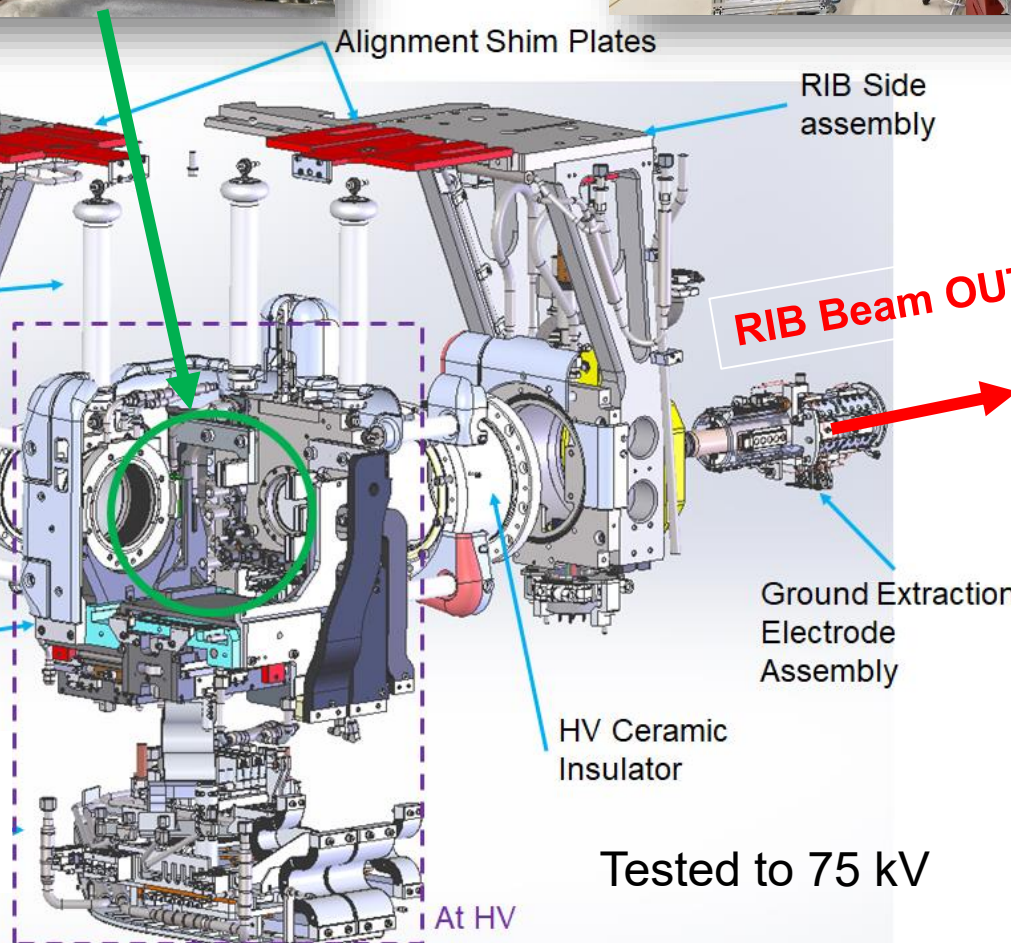
RIB Beam OUT

Ground Extraction
Electrode
Assembly

HV Ceramic
Insulator

Tested to 75 kV

At HV



Presentation last saved: Just now

Driver
Side
Assembly

HV
Ceramic
Rods
Polished Plate

HV
Ceramic
Insulator

HV Chair

Driver Beams IN

- Proton on APTW
- Electron on AETE

TRIUMF ARIEL target module front end (FE) Remote Handling (RH) tests

The ARIEL FE has around 120 RH maintenance operation possible, 6 times more than the ISAC FE → ARIEL hot cell

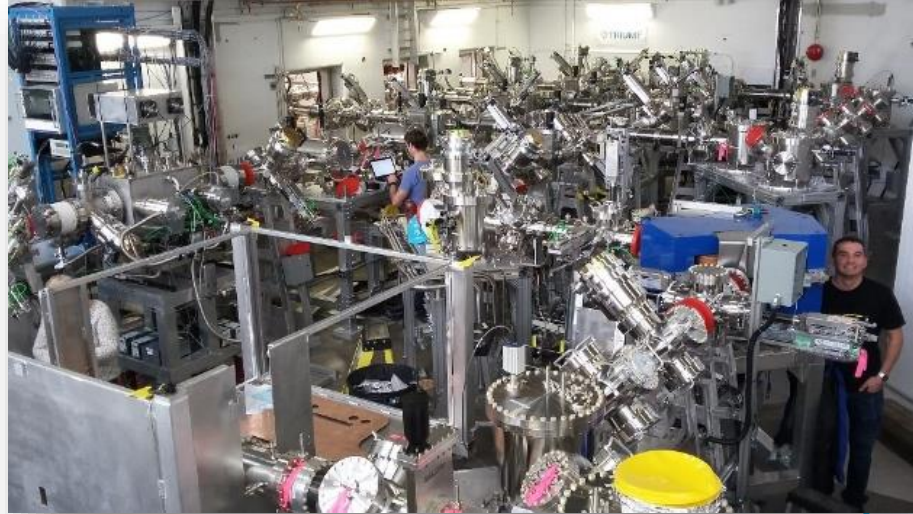
- Exchange of every services possible (hoses, connectors, pistons, limit switches)
- Exchange of the Extraction electrode, swap from an AETE configuration to an APTW configuration



Status of Beam Delivery Systems - CANREB

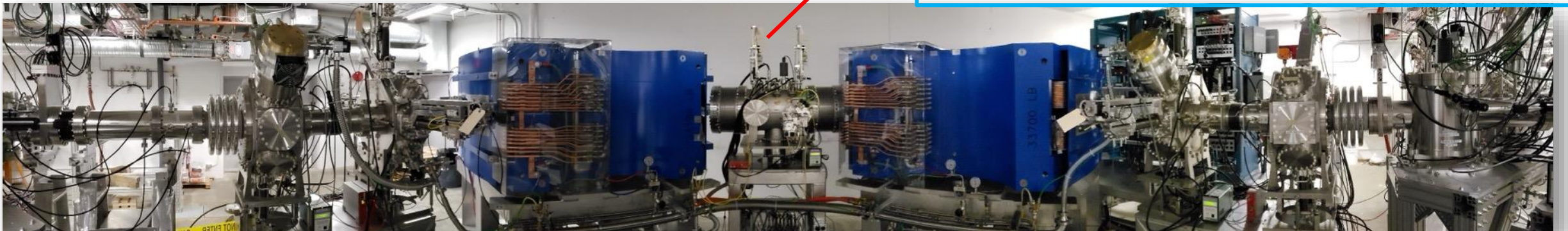
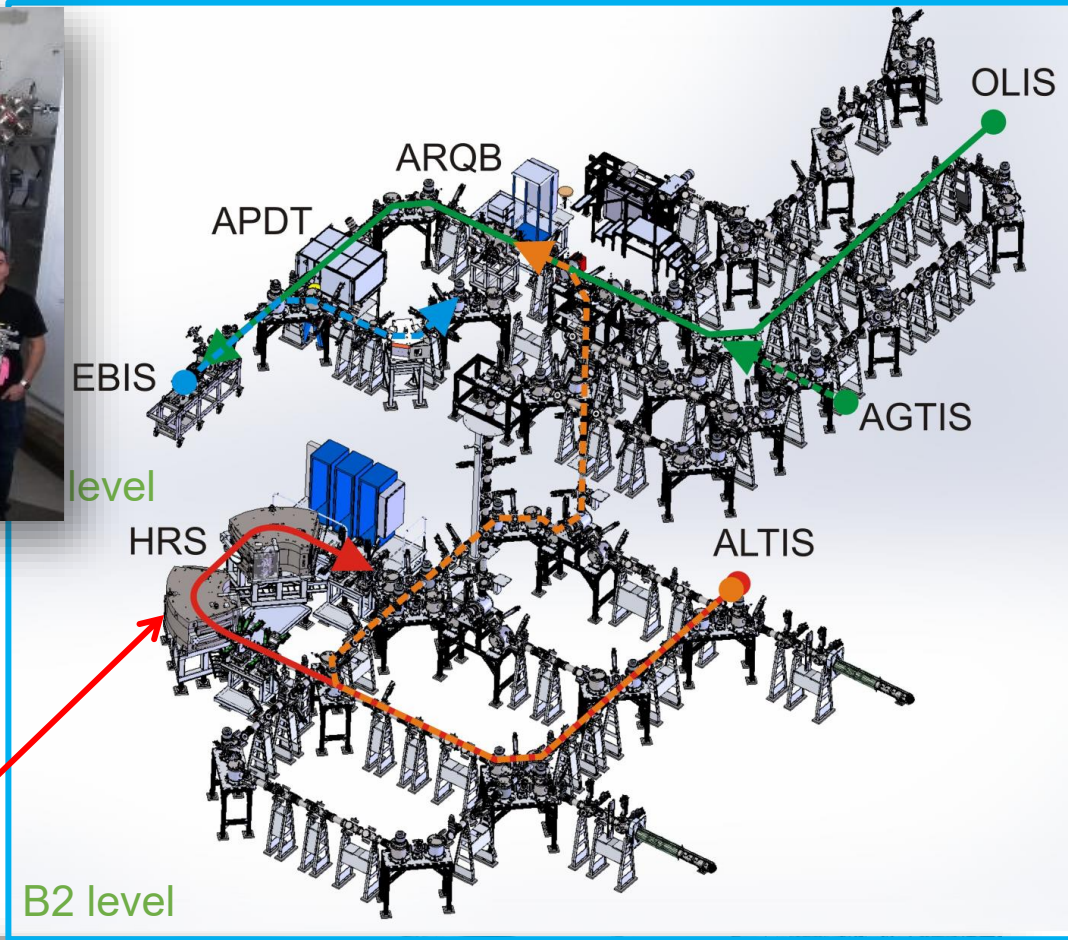
Completed:

- 250 m of RIB beam distribution lines
- CANREB HRS with world-record mass resolving power
- ARIEL yield station



Ongoing:

- Address remaining issues with CANREB EBIS (e-gun test stand) and CANREB RFQ
- HRS HV enclosure to be assembled
- RIB modules → module assembly



ARIEL Science Workshop, 20-23 April 2026

Nuclear Physics - Nuclear Astrophysics - Fundamental Interactions

- Around 135 international participants.
- Nuclear-physics focused workshop was the first in a series of ARIEL Science Workshops.
- Series of invited presentations, panel discussions on ten nuclear physics research topics.
- Strong endorsement of the existing research programs at ISAC and the plans to strengthen and expand these with ARIEL beams.
- A clear message that post-accelerated RIBs are needed and have been a problem in the past.
- There is a large demand for a ramp up to the 9000 RIB hours RIB operation ARIEL will be able to provide in the future.
- A consensus on new ideas emerged for nuclear structure and astrophysics to perform dedicated campaigns of study around the peaks of photo-fission production (Ga, Sn and Ba etc).
- Radioactive molecules at ARIEL show significant promise and excitement for impactful science.
- Suggestions for TRIUMF to host an active time-projection chamber and a solenoid-based transfer reaction detector were put forward.





ARIEL Progress in Long
Shutdown 2026 is significant



towards the completion of ARIEL



Thank you

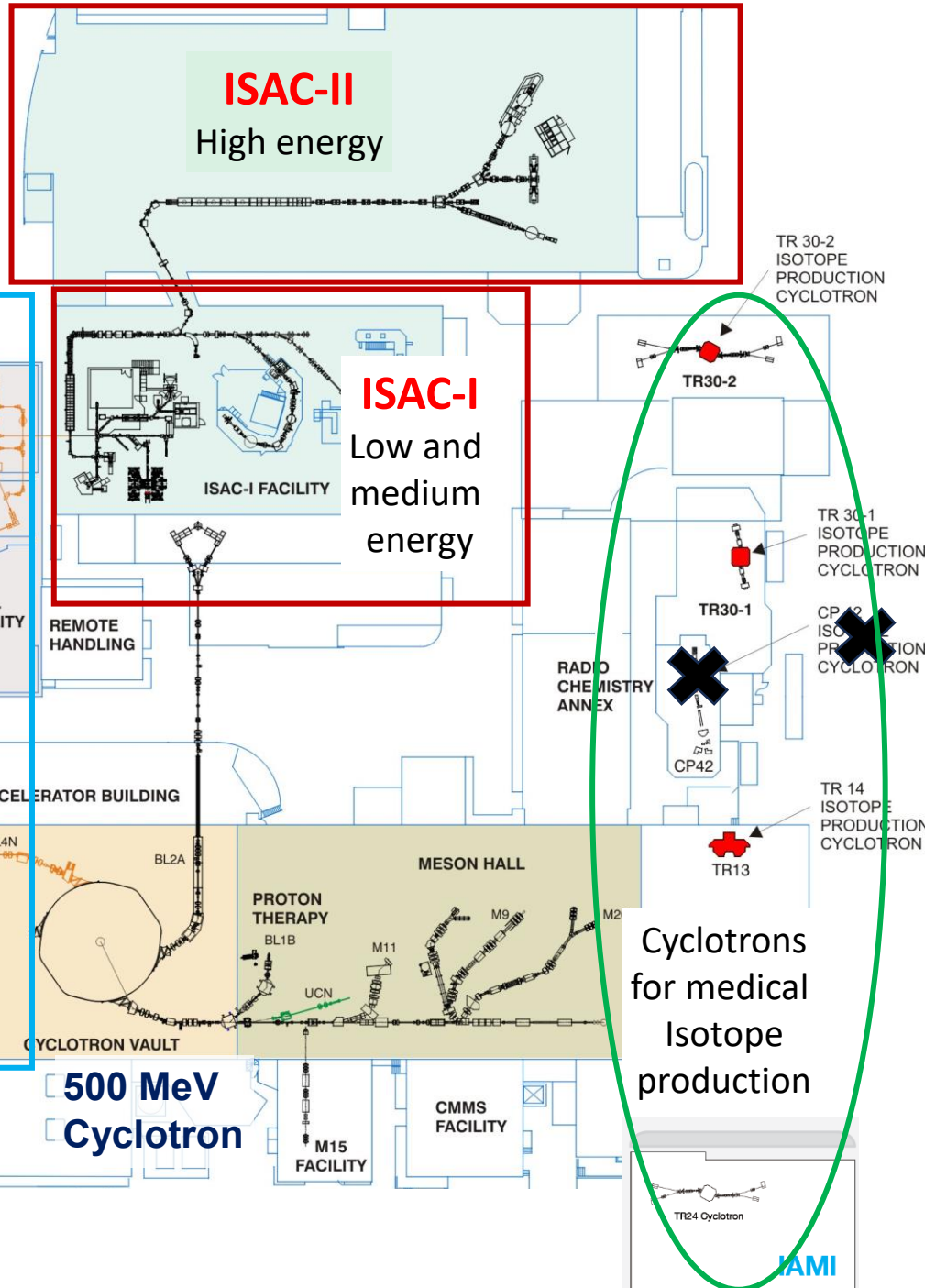
Merci



Additional slides

TRIUMF accelerator complex

ARIEL



Primary beam driver:
Cyclotron, 500 MeV, H⁻
Produces rare isotopes, neutrons and muons!

Providing beam for:

Isotope Separator and Accelerator facility – ISAC (ISOL facility)

ISAC-I: Normal conducting-linac, 0.15-1.5 MeV/u

ISAC-II: Superconducting-linac, 5-15 MeV/u

And the

Advanced Rare Isotope Laboratory - ARIEL

4 Cyclotrons for medical isotope production
(with a TR24 to be commissioned in the Institute
for advanced Medical Isotope – IAMI)

ARIEL ORG CHART

ARIEL Program Leader

Alexander Gottberg

(Deputy: Peter Bayliss)

ARIEL Project Manager

Cherishma Sadasivuni

P353

Target Stations

Trian Groumoutis

Luca Egoriti

P424

Target Hall Infrastructure

Asita Perera

Mike Vogel

P487

Hot Cell

Adam Newsome

Chad Fisher

P354

Separator & RIB Transport

Marco Marchetto

David Wager

P179/P363 BL4N/HEBT

Yuri Bylinskii /
Thomas Planche

Jason Chak

P358

Technical Infrastructure

Bill Richert
Adrian Watt (Mech.)
Mel Almario (Elec.)
Julie Cho (Controls)

P355

Laboratories

Peter Kunz

Keyur Chauhan

P374

e-linac

Thomas Planche

Stephanie Radel

P310

CANREB

Brad Schultz

P359/P360 VECC - closed

Bob Laxdal

Medical
Module
and Target

Medical
Transfer
System

Medical
Target
Handling

P405

Therapeutic Isotopes

Alexander Gottberg

Cherishma Sadasivuni

P342 PMO

Program Leader	Alexander Gottberg
Deputy Program Leader	Peter Bayliss
Project Manager	Cherishma Sadasivuni
Project Sponsor	Oliver Kester
Project Physicist	Bob Laxdal
Principal Scientist	Adam Garnsworthy
Project Accountant	Francis Pau
Project Coordinator	Tamás Revoczi
Manufacturing Coordinator	Camille Belanger-Champagne
Commissioning Coordinator	Fernando Maldonado Millan

Assembly and Installation Coordination

Target Hall and Adjacent Areas

Michael Vogel/Asita Perera

Driver Beam Tunnel

Claire Pearce/Jason Chak

Module Assembly

Tony Hessels

Cable Management

Dharmesh Patel/ Jon Aoki

B1-08 Integration

Jens Lassen

Stakeholders

ARIEL-II

PI: Dean Karlen (University of Victoria)
TRIUMF Sponsor: Oliver Kester

CANREB

PI: Rituparna Kanungo (Saint Mary's
University)
TRIUMF Sponsor: Oliver Kester

Rare Isotopes for Cancer

Therapy

PI: François Bénard (The University of
British Columbia)
TRIUMF Sponsor: Paul Schaffer

e-linac

TRIUMF Sponsor: Bob Laxdal

Legend

Project Leader

Project Integrator