TRIUMF

Status of the CANREB high resolution separator at TRIUMF

Marco Marchetto

ARIEL-II RIB front-end & separator project leader

September 21, 2018 - EMIS2018 Conference

Discovery, accelerated

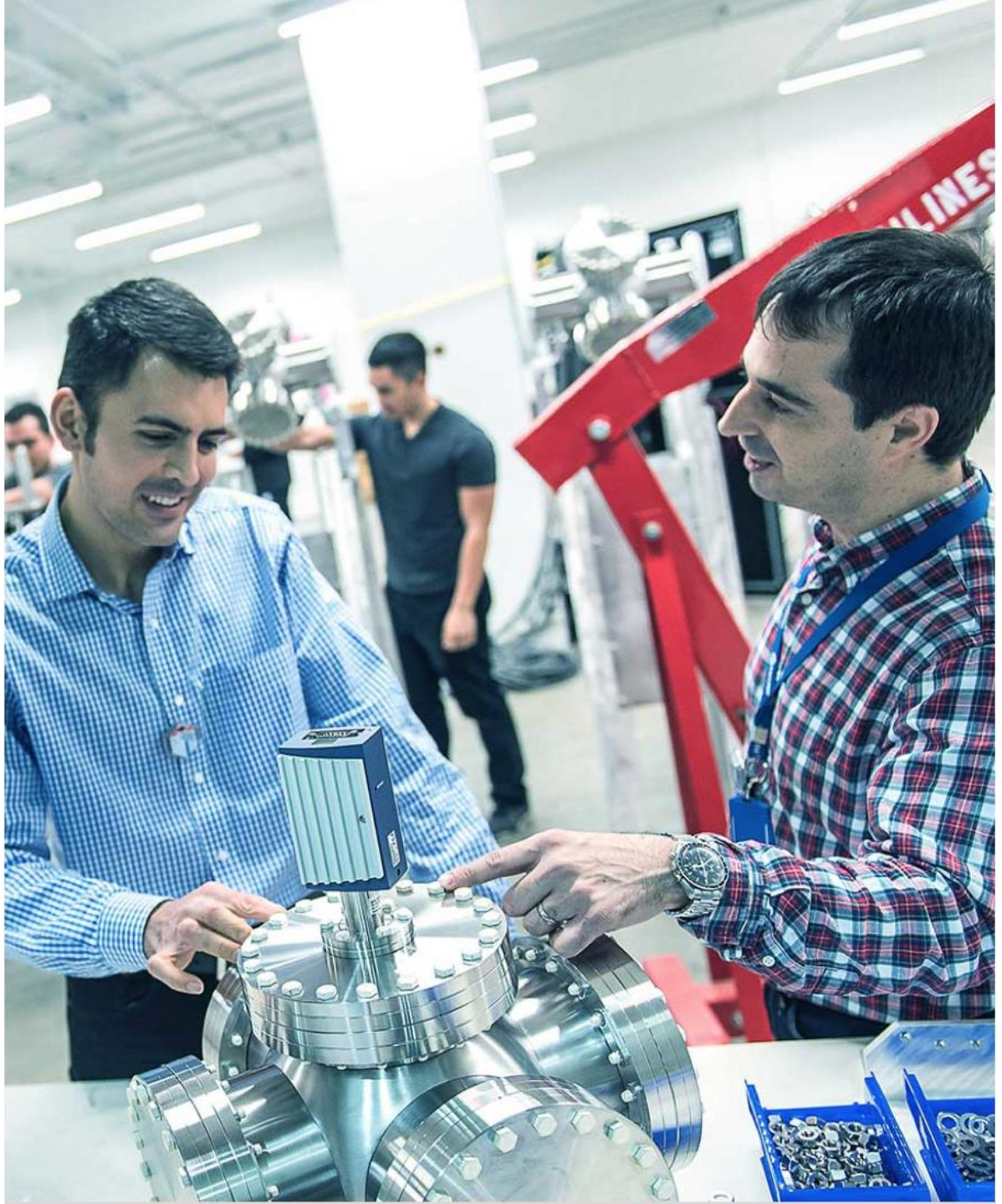
TRIUMF

Status of the CANREB high resolution separator at TRIUMF

Marco Marchetto

ARIEL-II RIB front-end & separator project leader

September 21, 2018 - EMIS2018 Conference



Discovery, accelerated

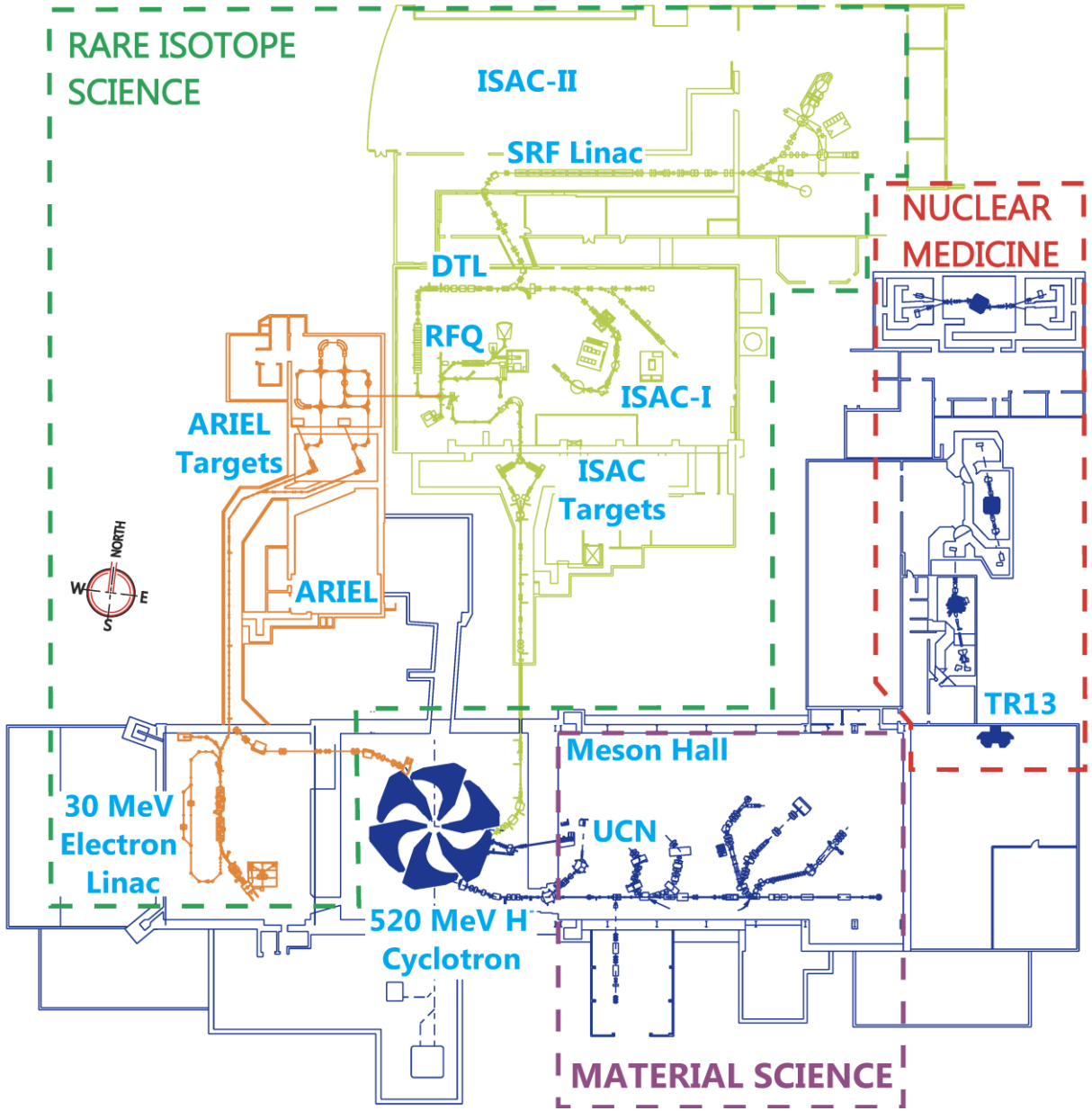
RIB front-end & separator layout

- ISOL facilities at TRIUMF
- High resolution separator overview
- Hardware Status
- Summary

RIB front-end & separator layout

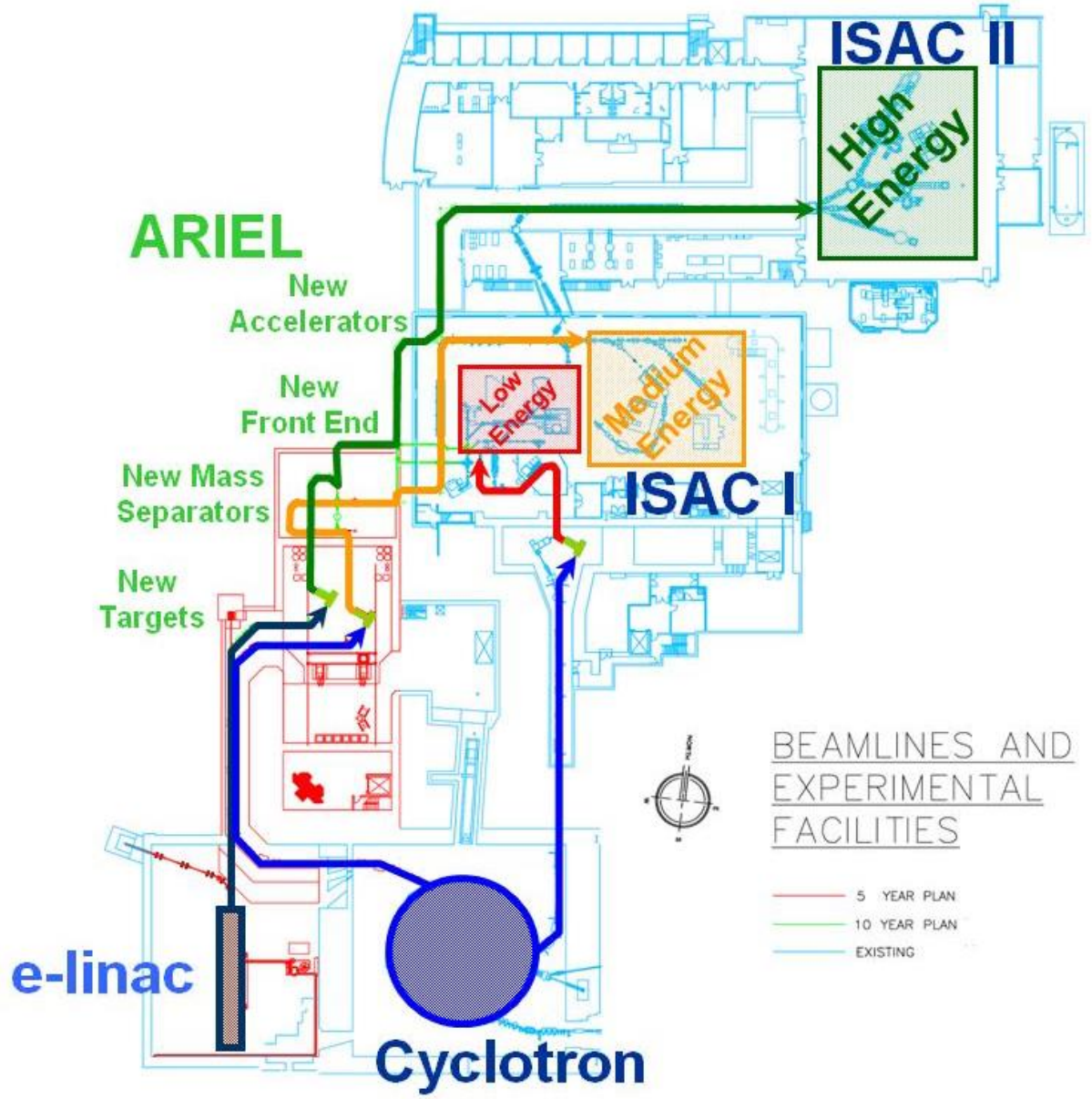
- ISOL facilities at TRIUMF
- High resolution separator overview
- Hardware Status
- Summary

HRS layout


RARE ISOTOPE SCIENCE
ISAC-II
SRF Linac
NUCLEAR MEDICINE
DTL
RFQ
ISAC-I
ARIEL Targets
ISAC Targets
ARIEL
NORTH
W
E
S
TR13
Meson Hall
30 MeV Electron Linac
UCN
520 MeV H⁻ Cyclotron
MATERIAL SCIENCE

ISOL facilities: ISAC and ARIEL

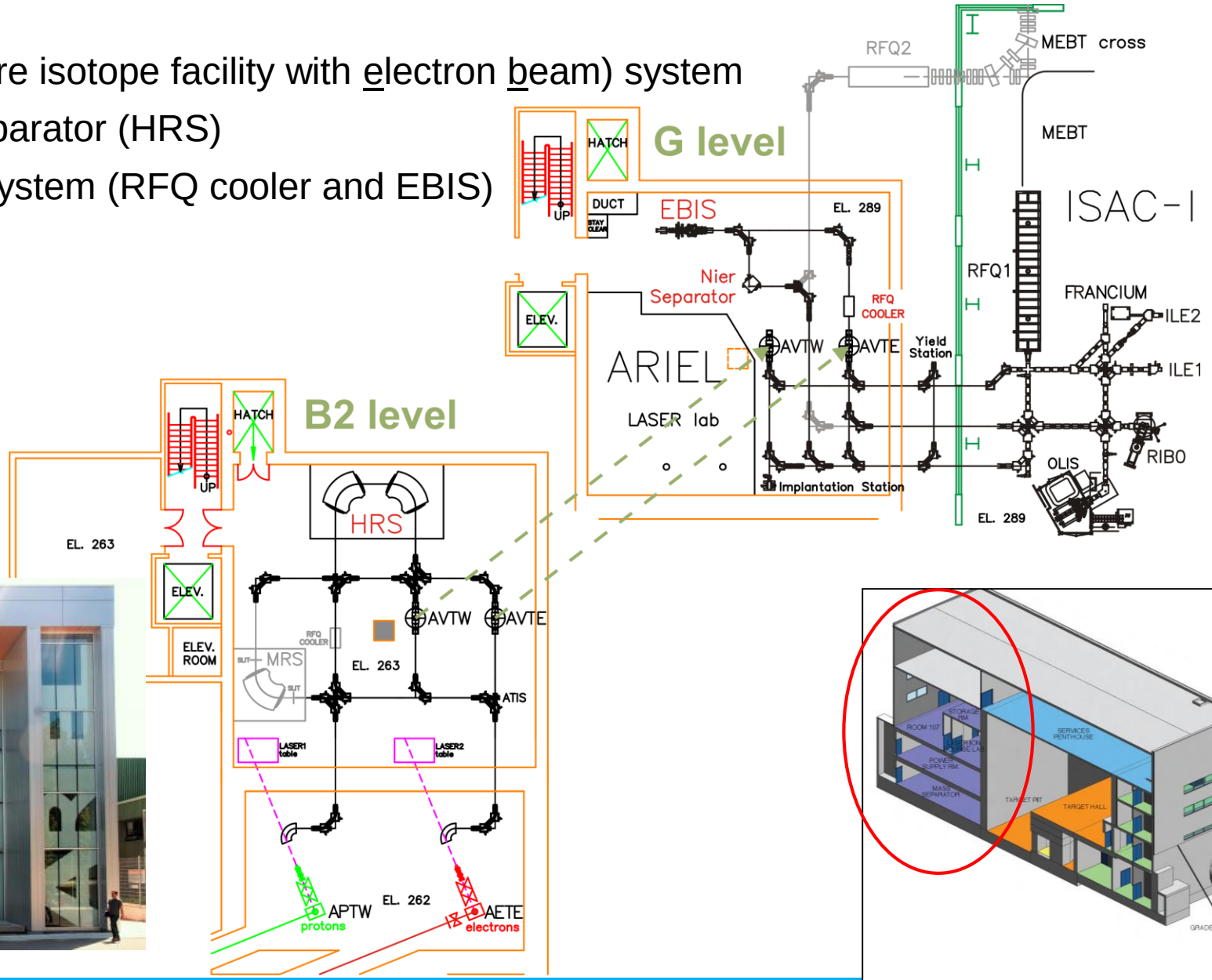
- ISAC (isotope separation and acceleration)
  - 50 kW proton driver (cyclotron)
  - 2 target stations but single operation
  - 3 experimental area: Low (60 keV) medium (1.8 MeV/u) and high (15 MeV/u)
- ARIEL (advance rare isotope facility laboratory)
  - electron linac (500 kW) in addition to the 50 kW proton driver
  - Two additional target stations with simultaneous operation
  - RIB front-end that allows three (2 ARIEL + 1 ISAC) simultaneous RIB's to be delivered to the ISAC experimental stations

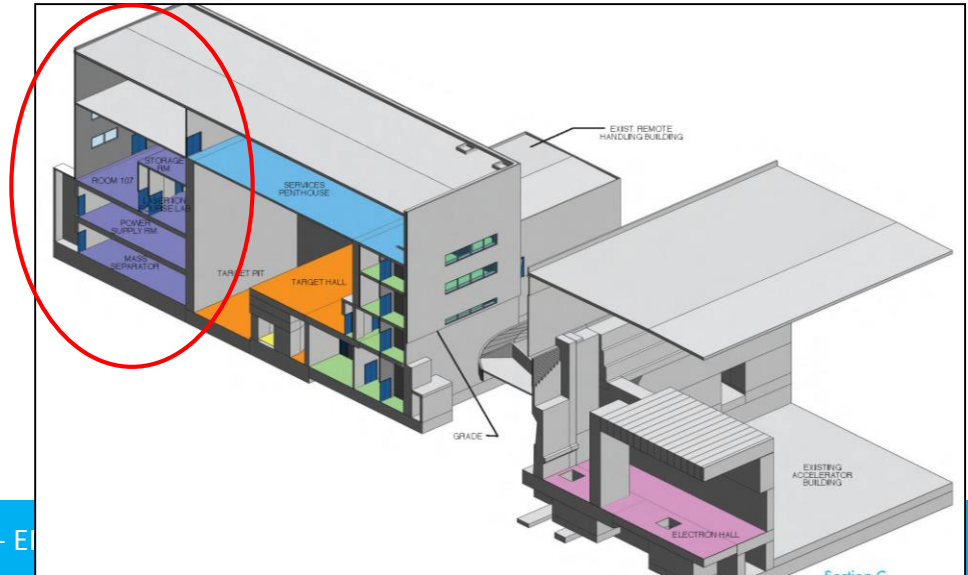


CANREB in the RIB front-end layout

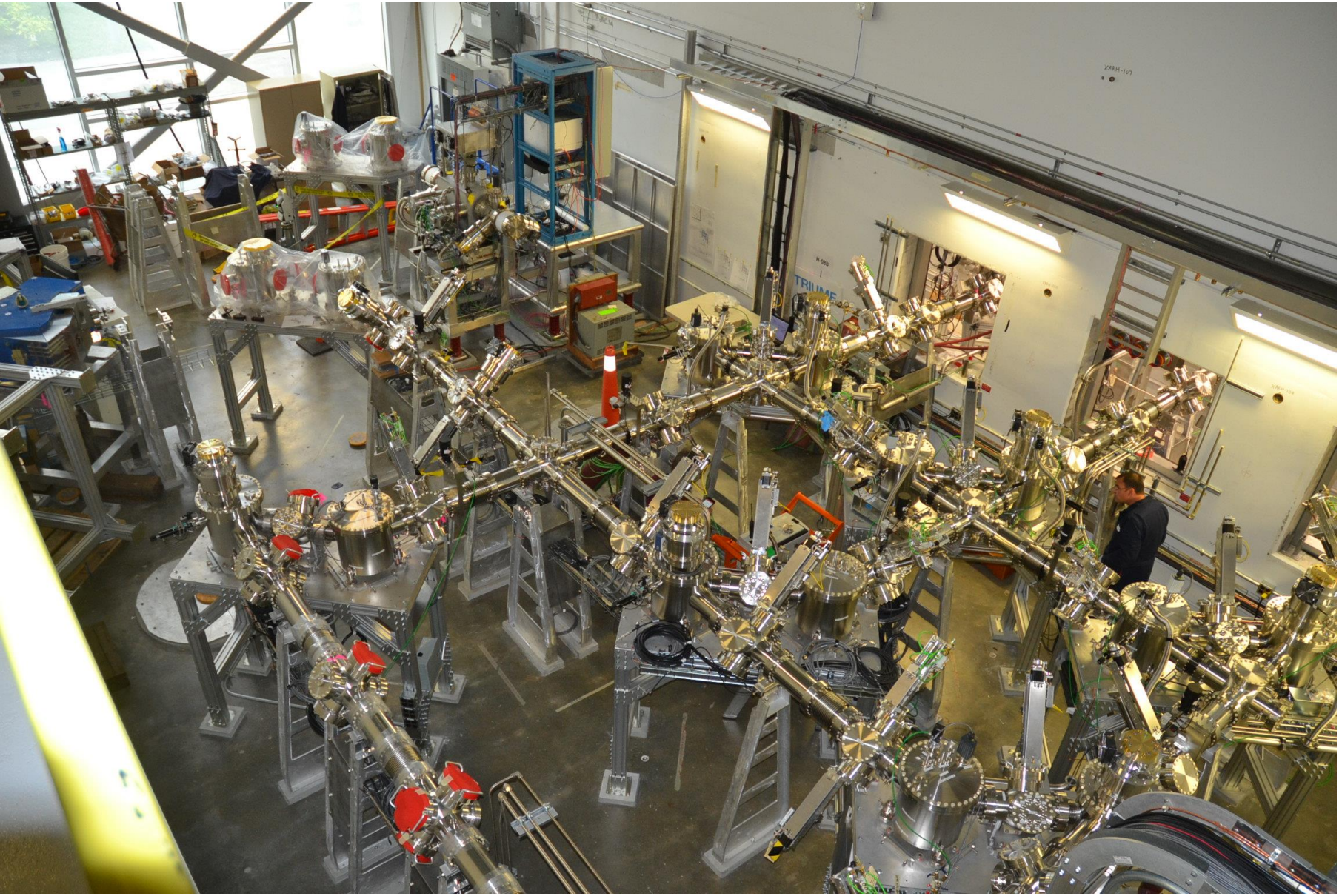
CANREB (Canada rare isotope facility with electron beam) system

- High resolution separator (HRS)
- Charge breeding system (RFQ cooler and EBIS)
- Nier separator

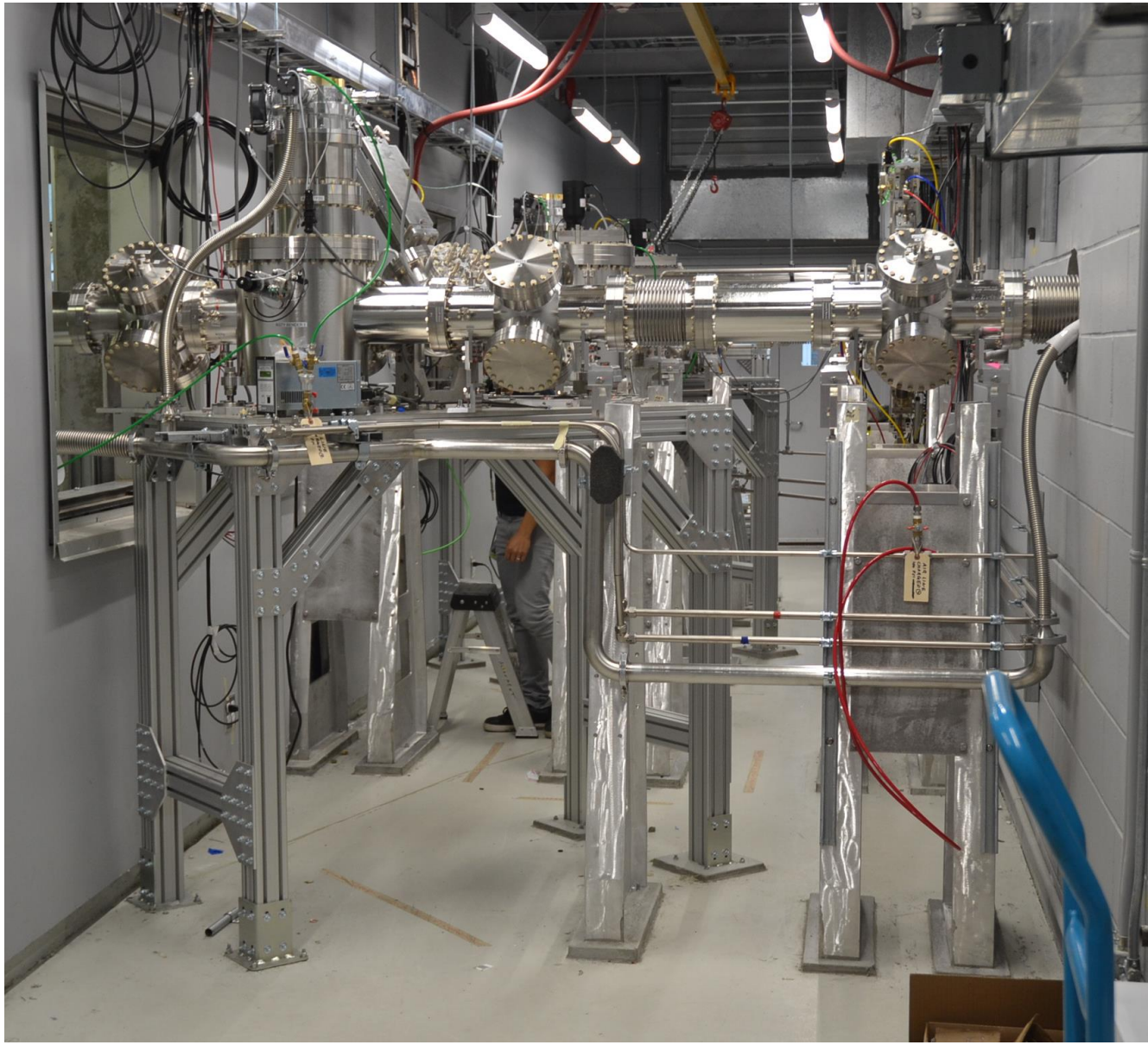




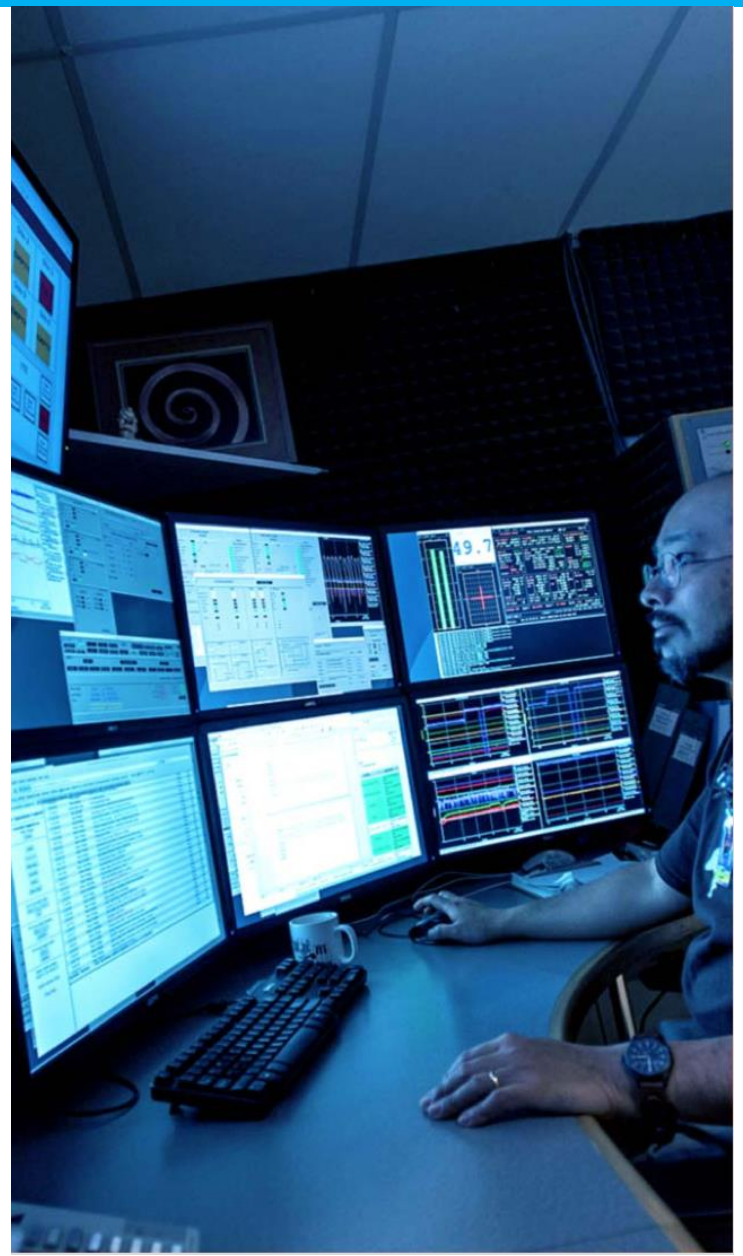
CANREB in the RIB front-end layout



CANREB in the RIB front-end layout



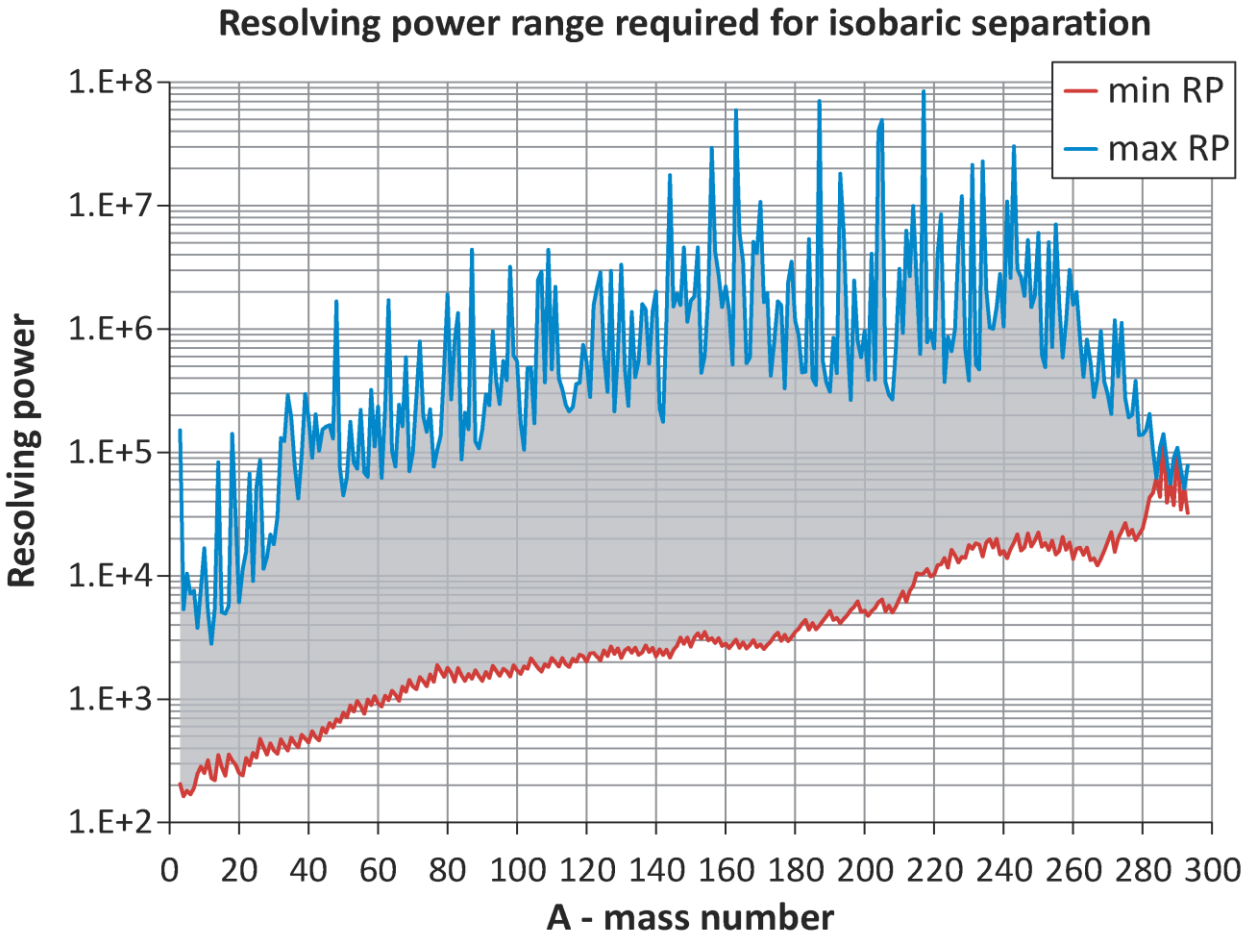
RIB front-end & separator layout

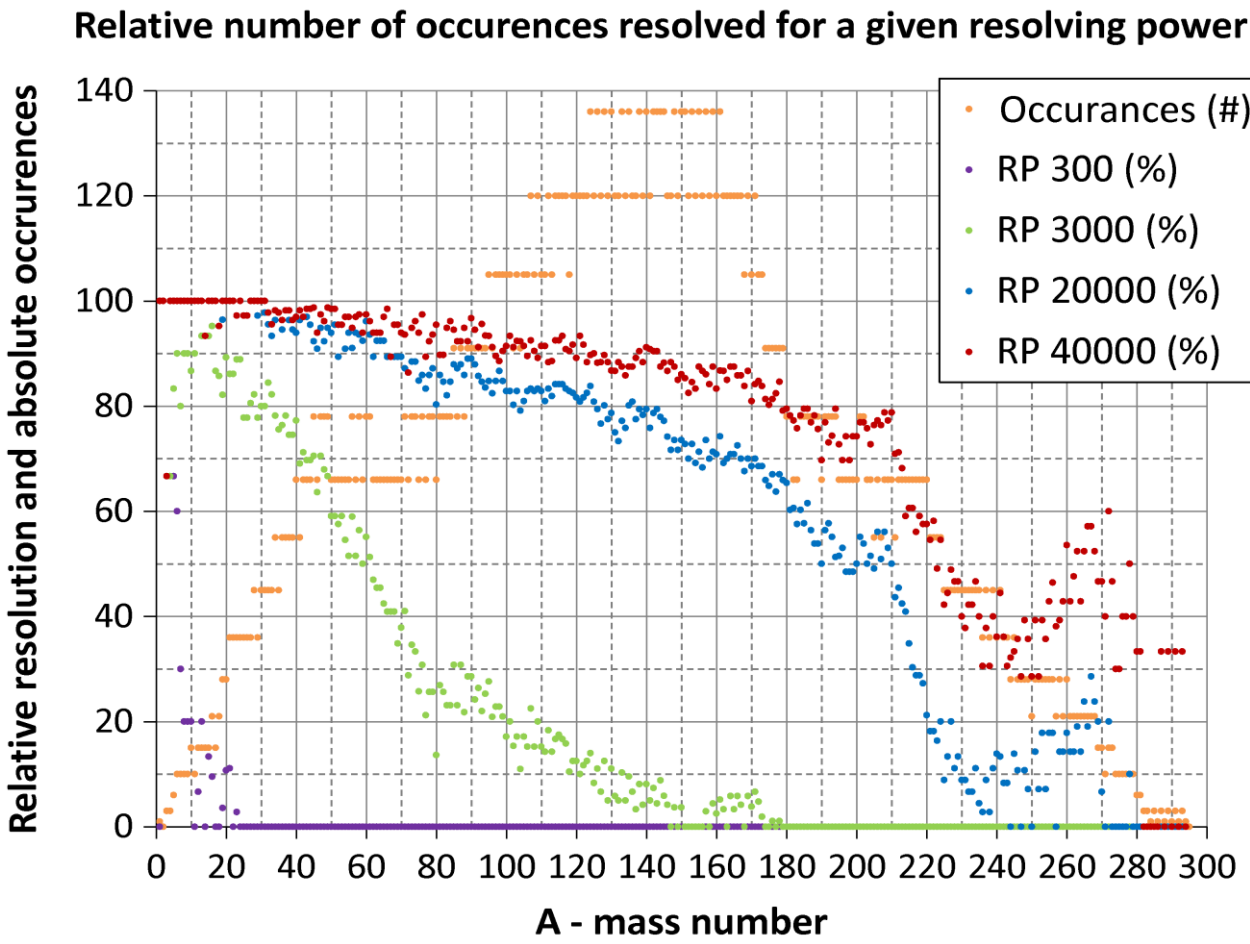


- ISOL facilities at TRIUMF
- high resolution separator overview
- Hardware Status
- Summary

HRS parameters

- R=20,000 for 3 pi*mm*mrad transmitted emittance
- design for a **magnetic rigidity** of up to **^{238}U at 60 keV** (**Bρ=0.544 Tm**)

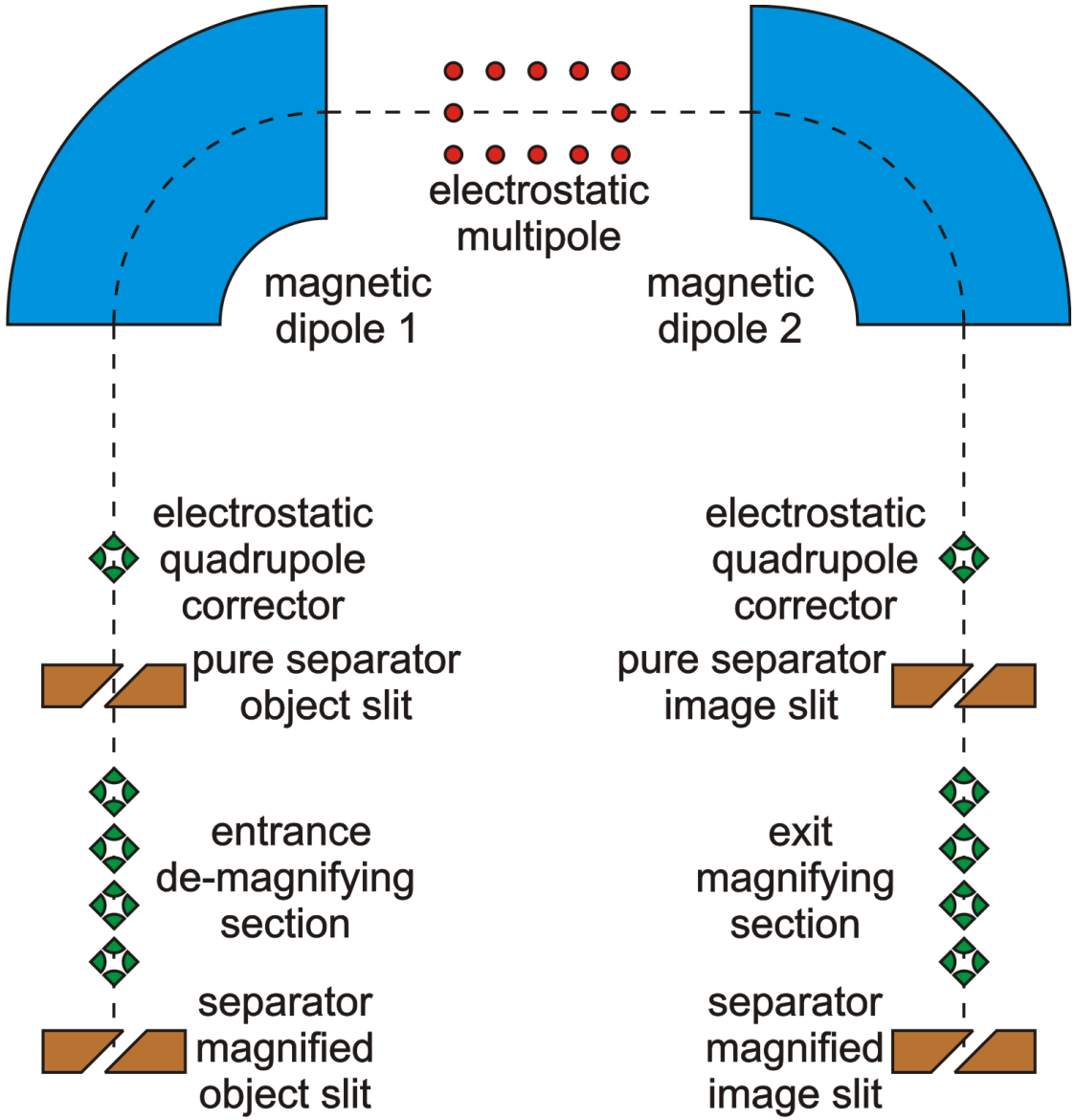




HRS layout

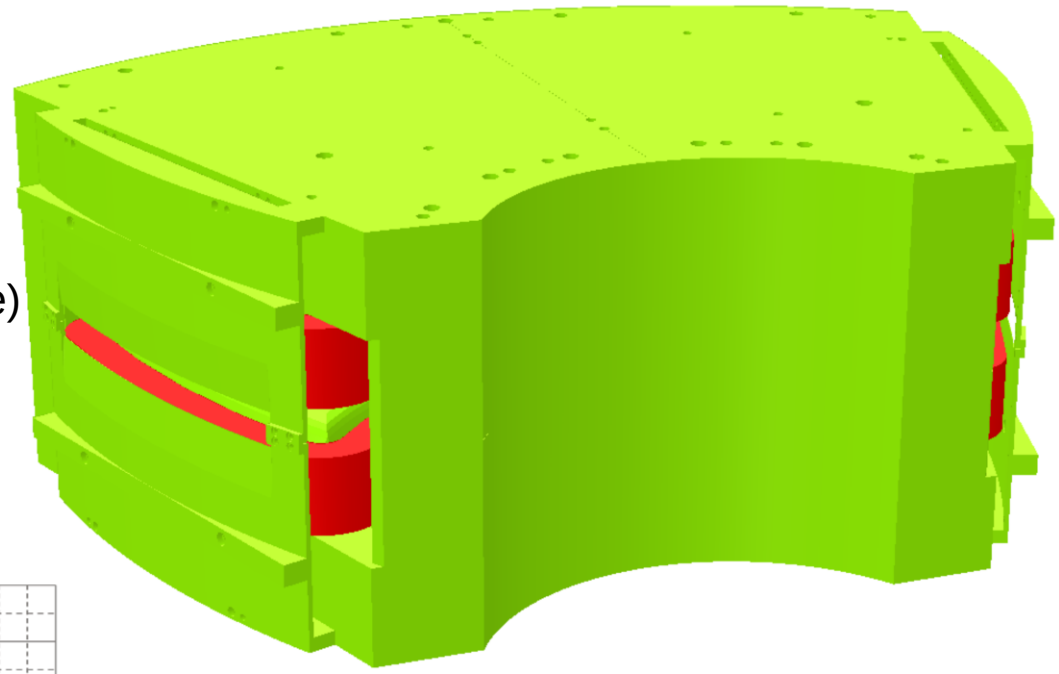
- design is based on the “pure separator”
- symmetrical optical design to minimize aberration†: horizontal imaging slit to slit (unit magnification)
- 2x 90 degree identical magnetic dipoles that provide vertical focusing and 2nd order correction
- multipole in between dipoles for high order correction
- Magnification section added upstream and downstream of pure separator in order to ease mechanical tolerances during operation

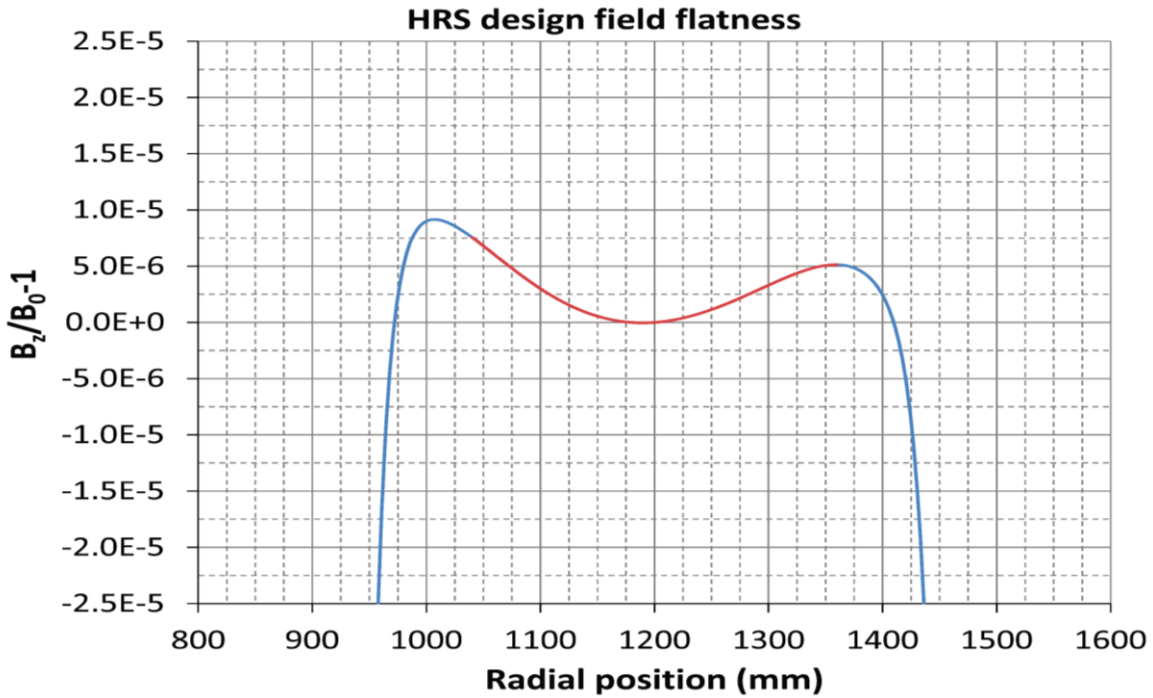
† “New design studies for TRIUMF’s ARIEL High Resolution Separator” J. Maloney et al. Nuclear Instruments and Methods in Physics Research B376 (2016) 135–139



HRS magnetic dipole

- Magnetic§ and engineering design produced at TRIUMF
- Reference radius of curvature of 1200 mm
- Maximum magnetic field 0.453 T
- Steel far from saturation allows for linear behavior over full range
- Vertical focusing (edge angle) and second order correction (edge curvature) built in
- **Field flatness** requirements $2.5 \cdot 10^{-5}$ or better **within ±160mm** around the refence trajectory (1200 mm)

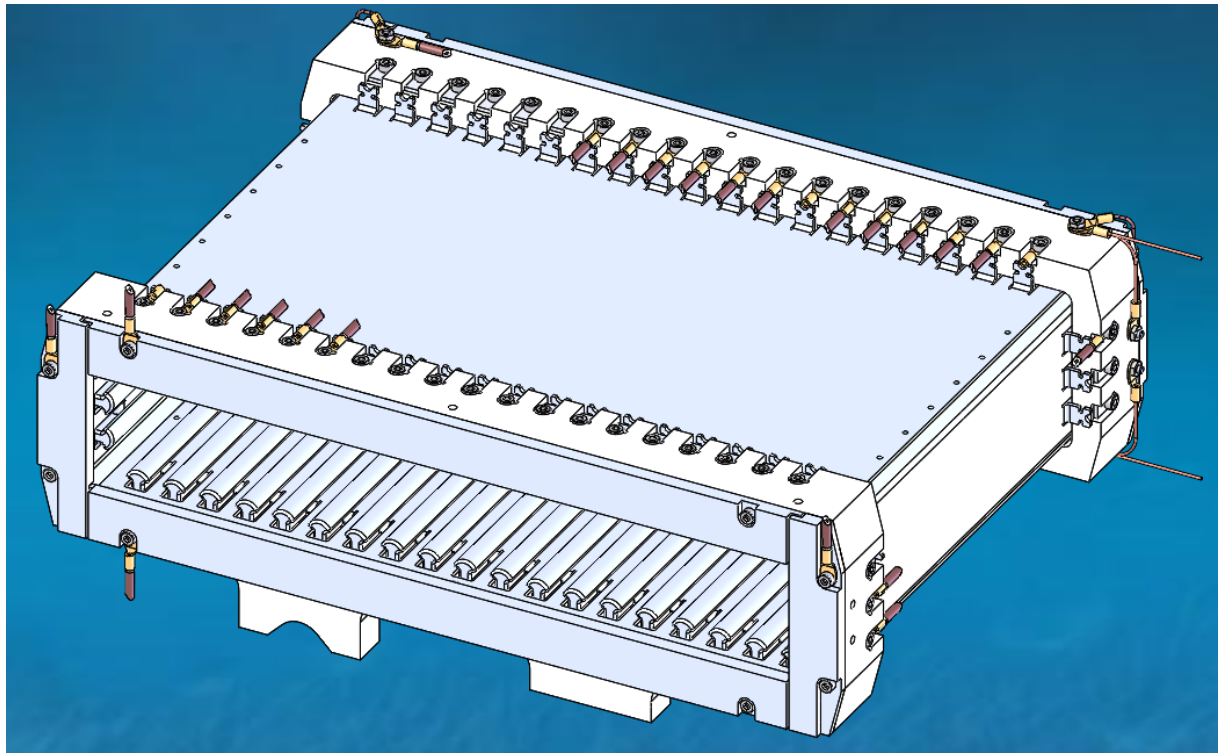


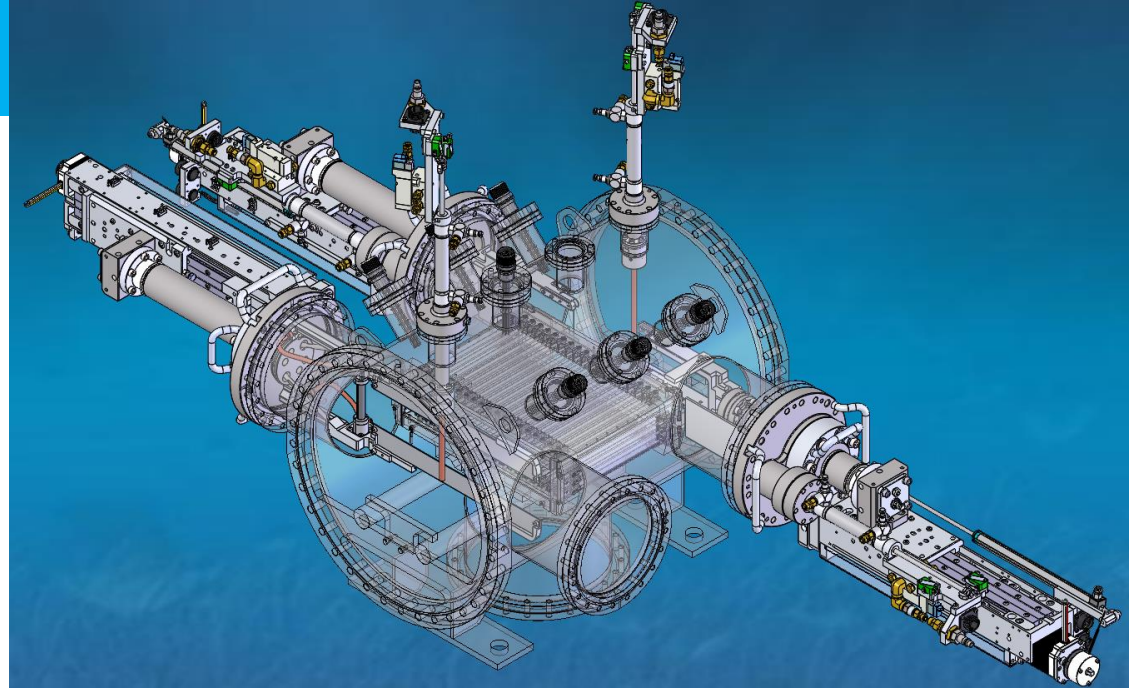


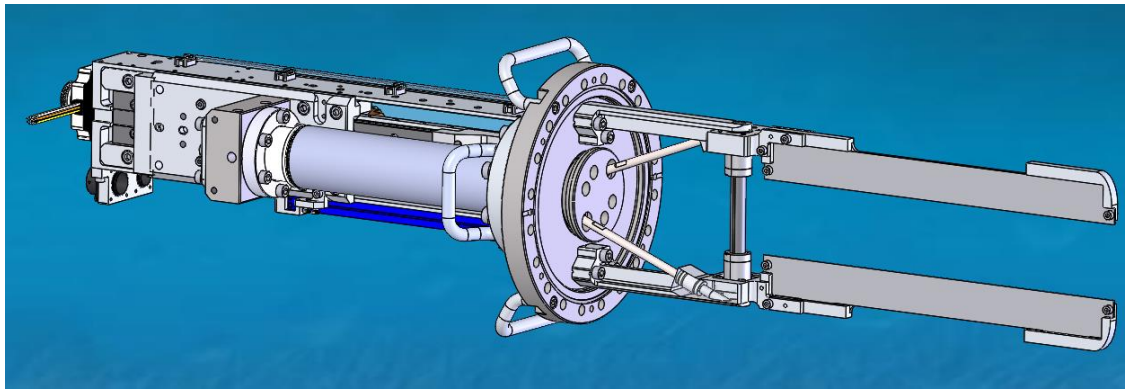
§ http://hdl.handle.net/2429/64129

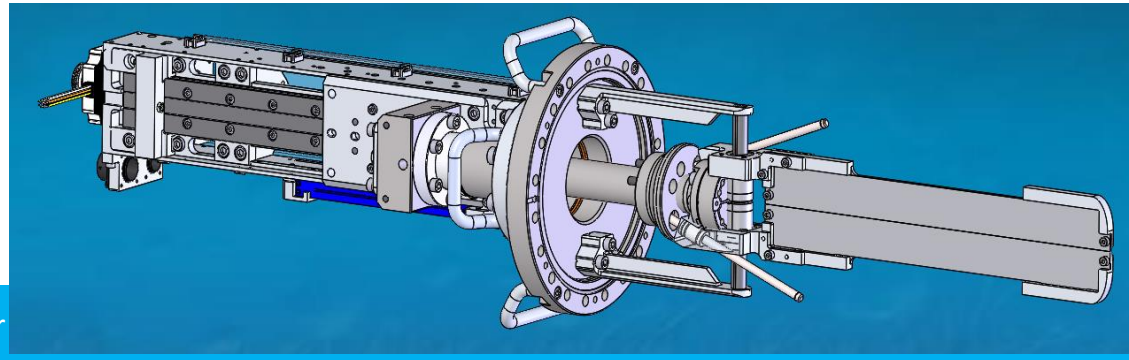
HRS multipole

- Multipole corrects high order aberrations by generating multipole field in the region between the dipoles that has a 90 degree phase advance with respect to the slit location (positions *x* transfer to angles *x′* in the phase space)
- Square geometry to match the beam envelope (ribbon like) with 44 individually powered electrostatic poles
- Set of dedicated diagnostic to characterize/trim the beam





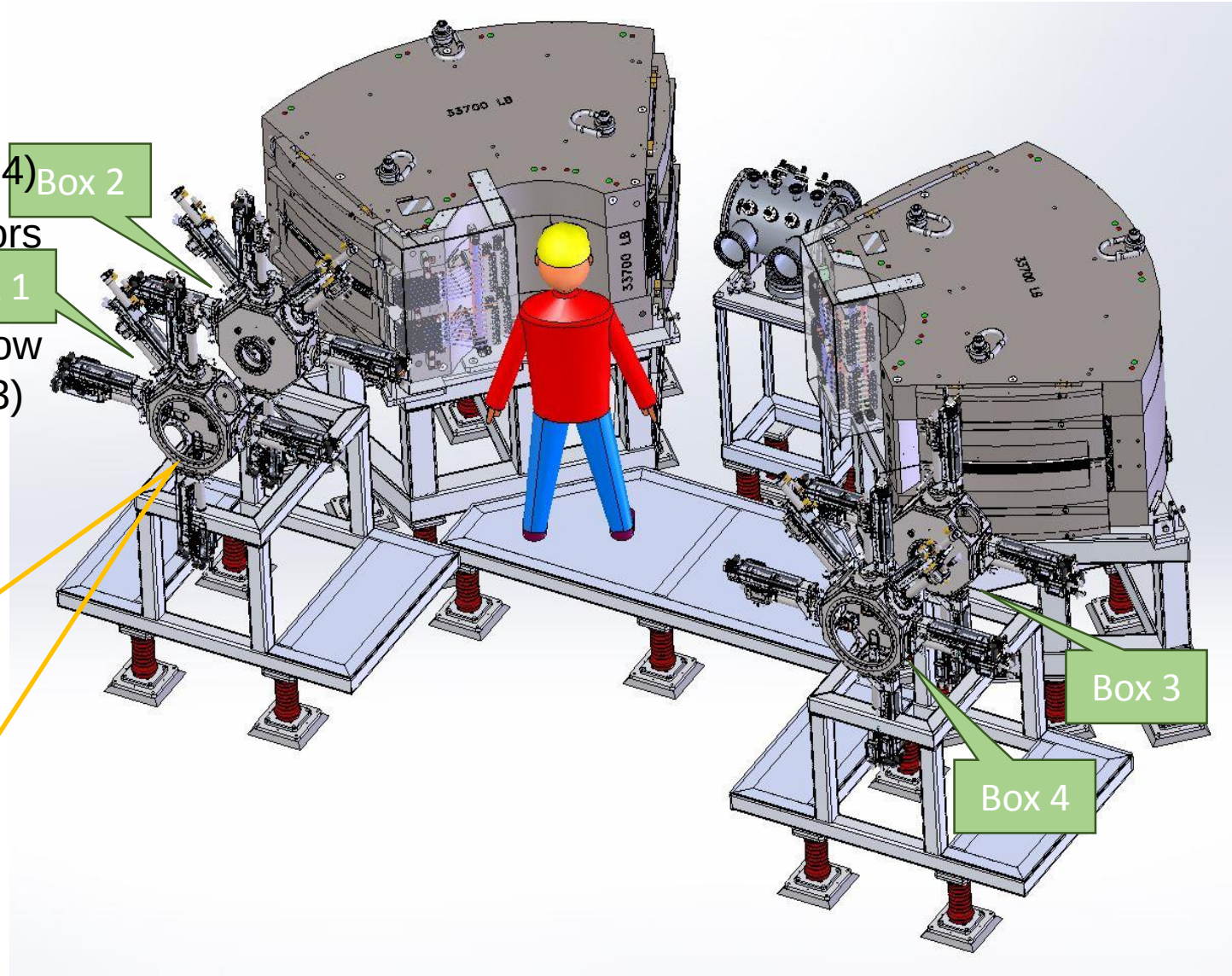


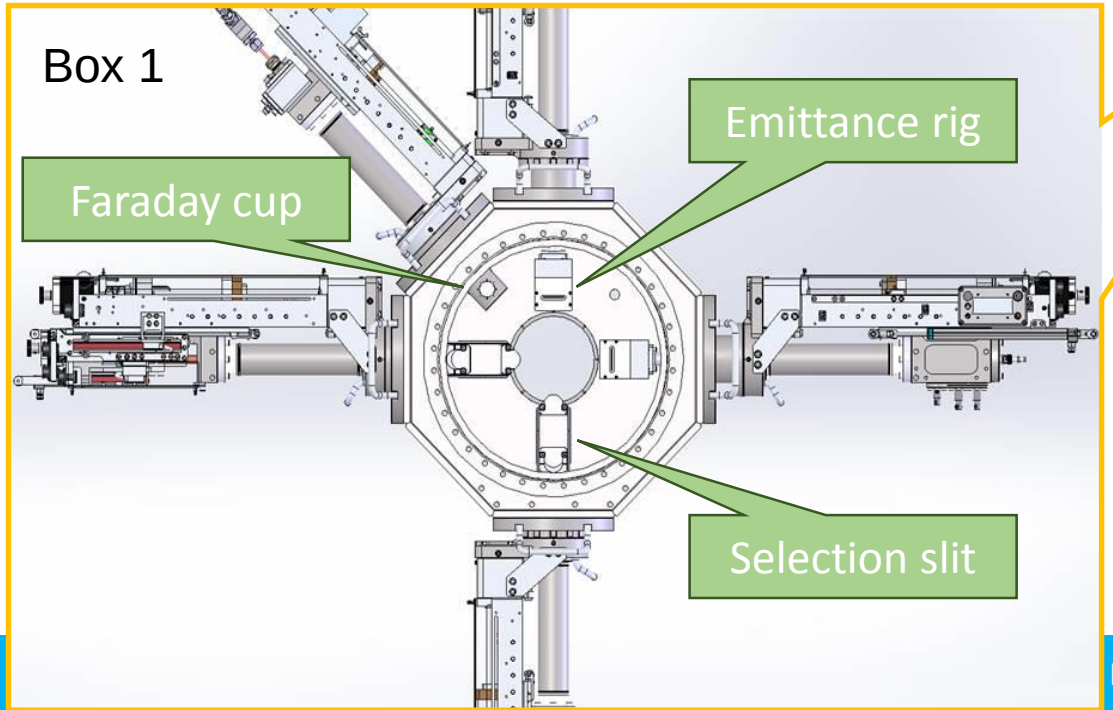


HRS diagnostics

4 diagnostic boxes: pure separator (boxes 2,3) and magnified sections (boxes 1,4)

- beam **current monitors**: high intensity (FC in boxes 1,2,4) and low intensity (CEM in boxes 2,4)
- **selection slits** to be used also as profile monitors (in boxes 1,2,3,4)
- **emittance meters** (Allison scanner): high and low intensity combined, high resolution (in boxes 2,3) and low resolution (1,4)

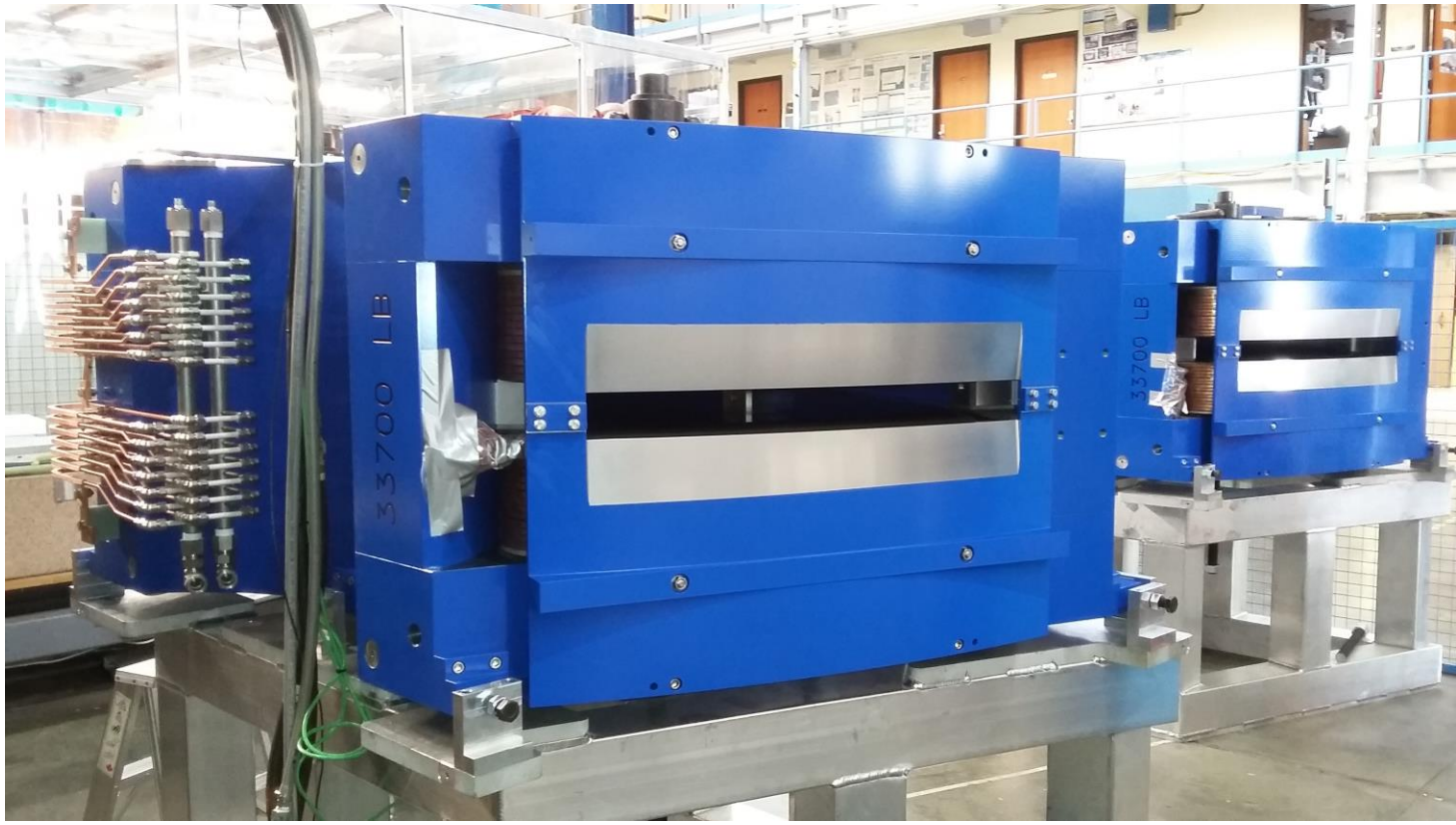




- ISOL facilities at TRIUMF
- High resolution separator overview
- Hardware Status
- Summary

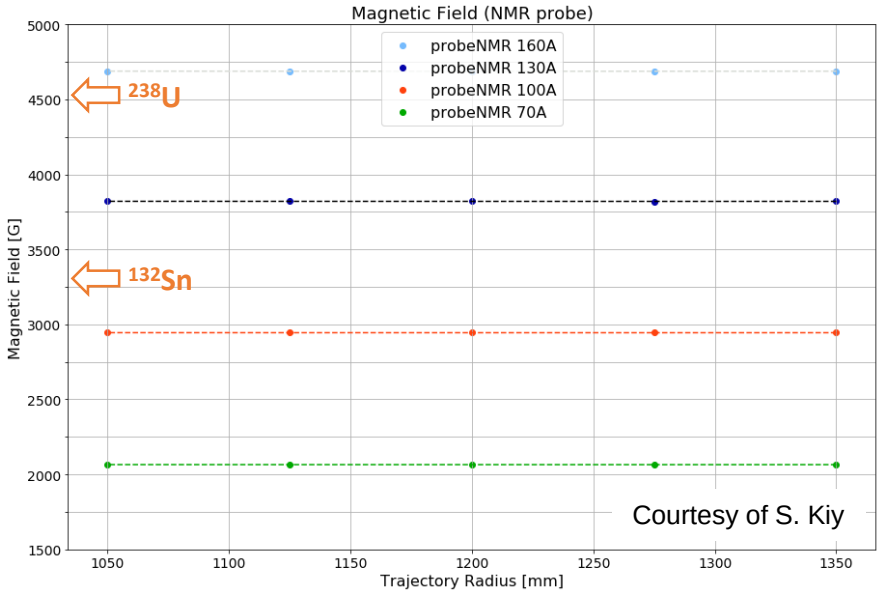
HRS dipoles status

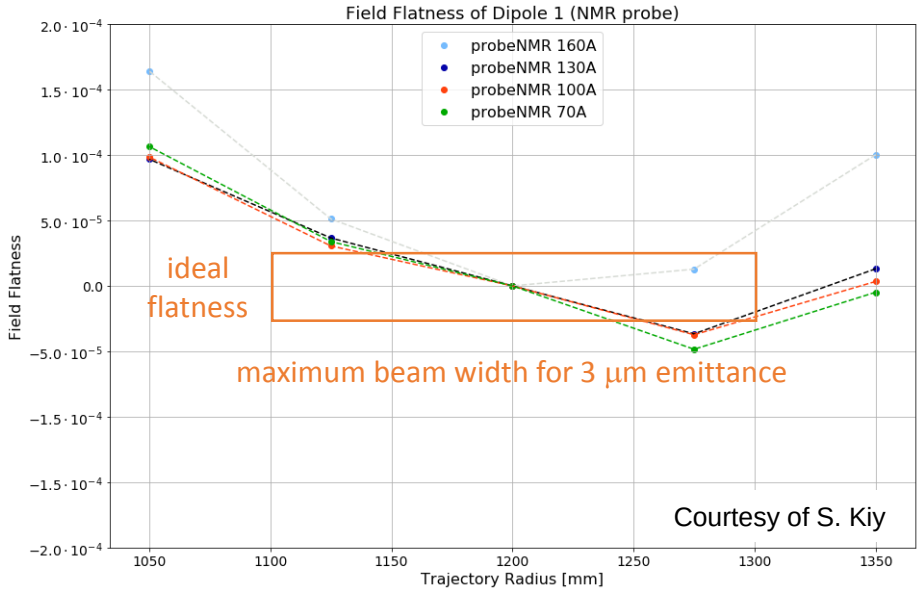
- HRS dipole manufactures Buckley System Ltd. (BSL) in New Zeeland
- Manufacture dipoles were measured by TRIUMF technician at BSL: all manufacturing within tolerances
- dipole were **fully mapped** at Buckley; mapping shows magnetic field profile dependency from ramping rate
- TRIUMF characterization completed
- Vacuum chamber to be installed before lowering the dipoles in the B2 level for final installation
- HRS **installation** to be completed by **Feb. 2019**

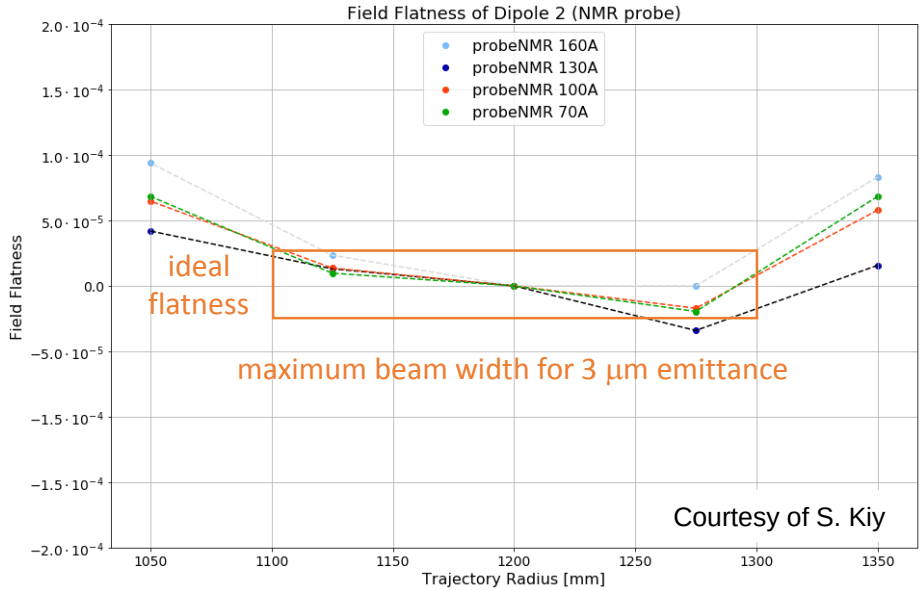


HRS characterization

- HRS dipoles being characterized at TRIUMF to establish the ramping procedure for best field flatness (in the middle of the magnet)
- Ramping procedure: overshoot the final current in a slow ramping mode followed by a fast drop to the final current
- Overall we are approaching the ideal flatness of $2.5 \cdot 10^{-5}$ (dipole 2 yields better result than dipole1)
- Beam testing of Ramping procedure is part of commissioning

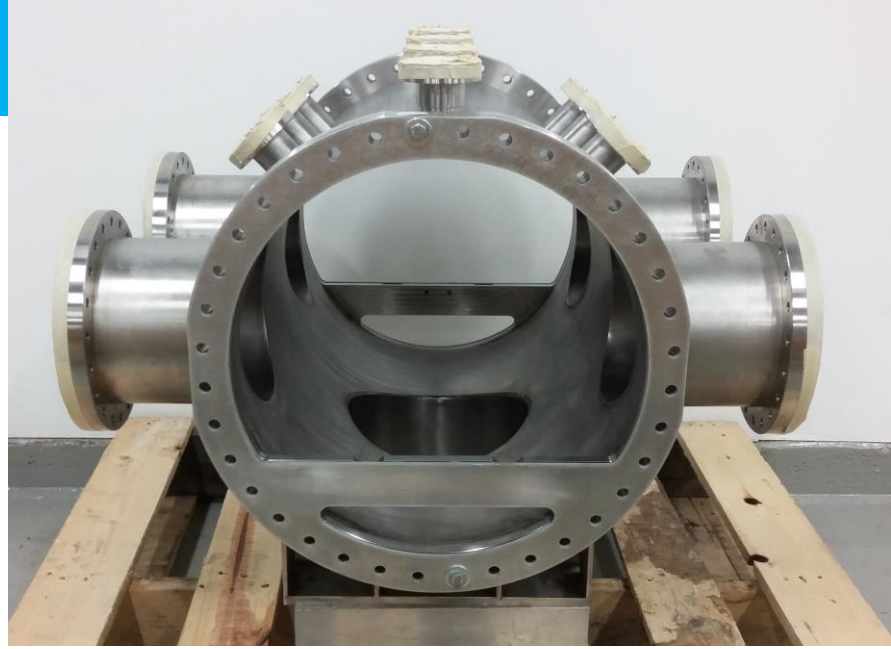


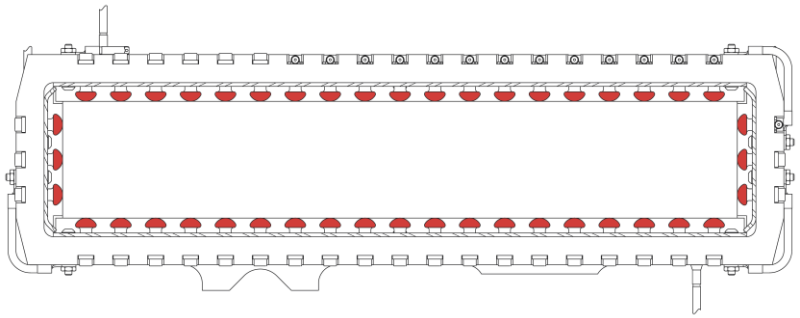


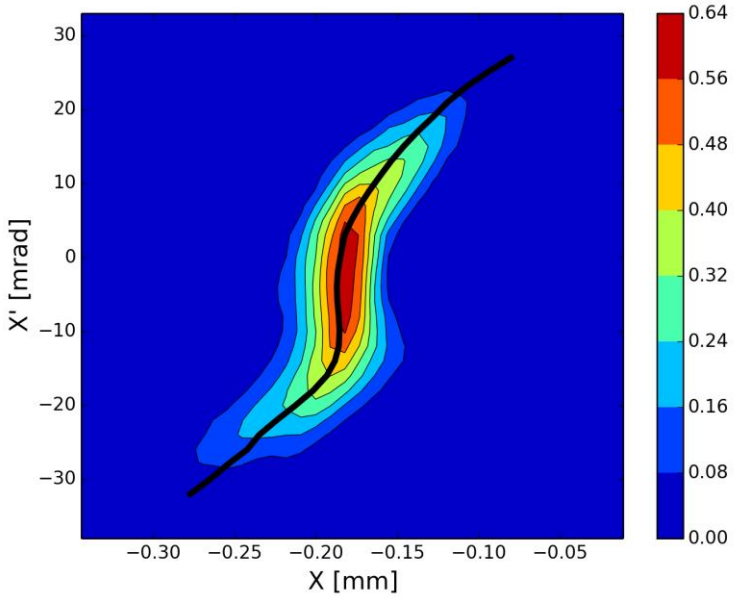


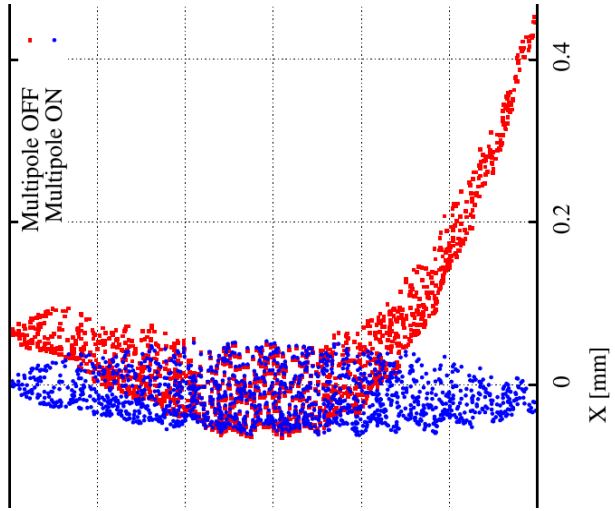
HRS multipole status

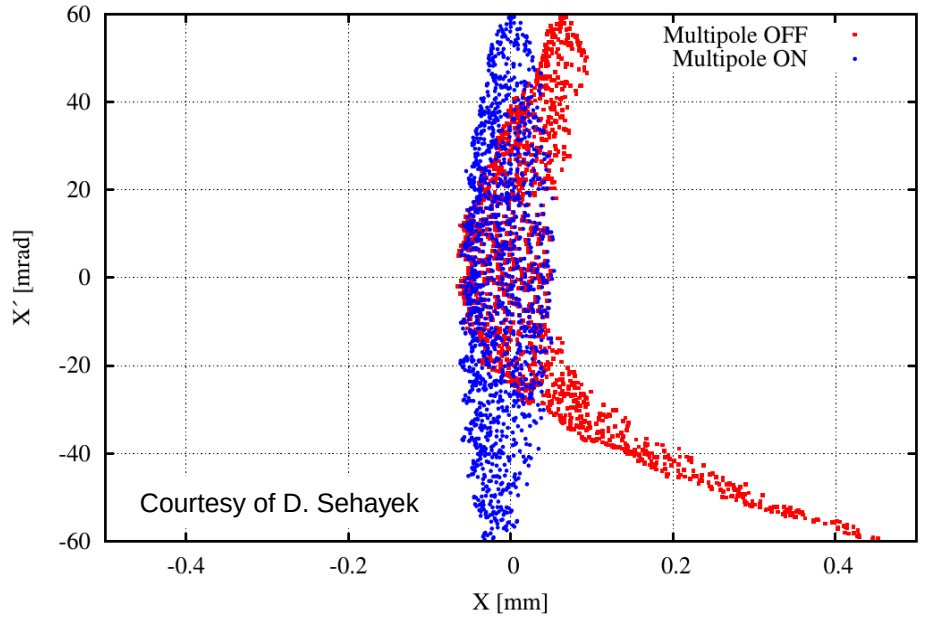
- multipole vacuum chamber fabricated
- multipole components in final stage of fabrication
- established a multipole tuning algorithm‡ where the setting of each electrode is directly determined from the shape of the emittance at the pure separator slit location
- Web-based application available that reads as input the emittance scan and set the voltage of the electrodes in EPICS







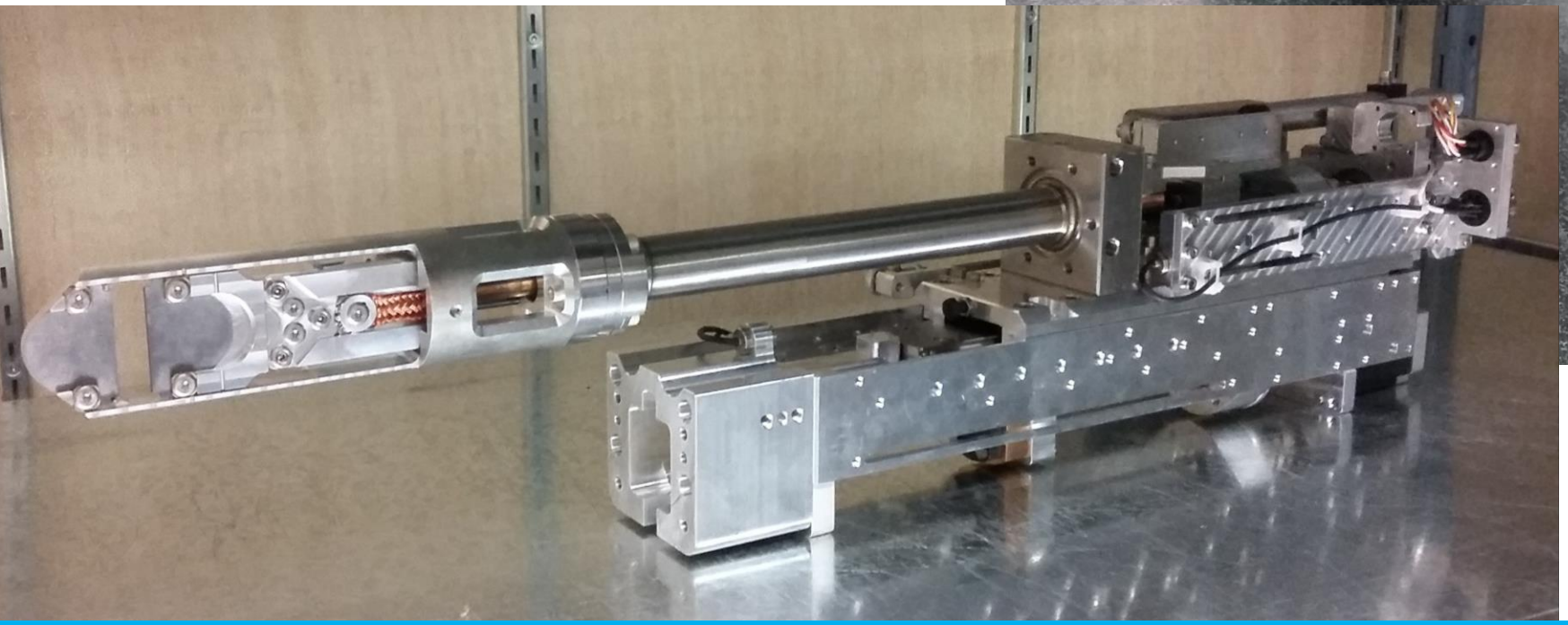




‡ "Multipole tuning algorithm for the CANREB HRS at TRIUMF" D. Sehayek et al. International Particle Accelerator Conference 2018 (IPAC2018), Vancouver, Canada

HRS diagnostic status

- **selection slits** fabricated and operational aspects (open/close and centroid location movement) currently being tested by the EPICS controls group
- **Faraday cup** are assembled and ready installation
- **emittance meter** fabrication in progress



- ISOL facilities at TRIUMF
- High resolution separator overview
- Hardware Status
- Summary

TRIUMF

Summary

- HRS dipole manufactured based on TRIUMF manufacturing drawings (Buckley system limited (BSL) in New Zeeland)
- established the proper ramping procedure

  to be tested during beam commissioning
- novel, intuitive approach for higher order correction

- HRS installation to be completed by Feb. 2019

questions ?

comments

Magnetic Field Study for a New Generation High Resolution Mass Separator
Dissertation by Marco Marchetto (University of British Columbia Feb.2018)

Thanks to
EMIS2018 organizers, TRIUMF, TRIUMF Beam Dynamics group