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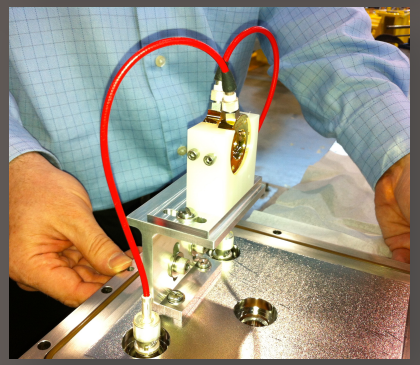
Canada's national laboratory for particle and nuclear physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

High-mass beam delivery at TRIUMF's ISAC facility

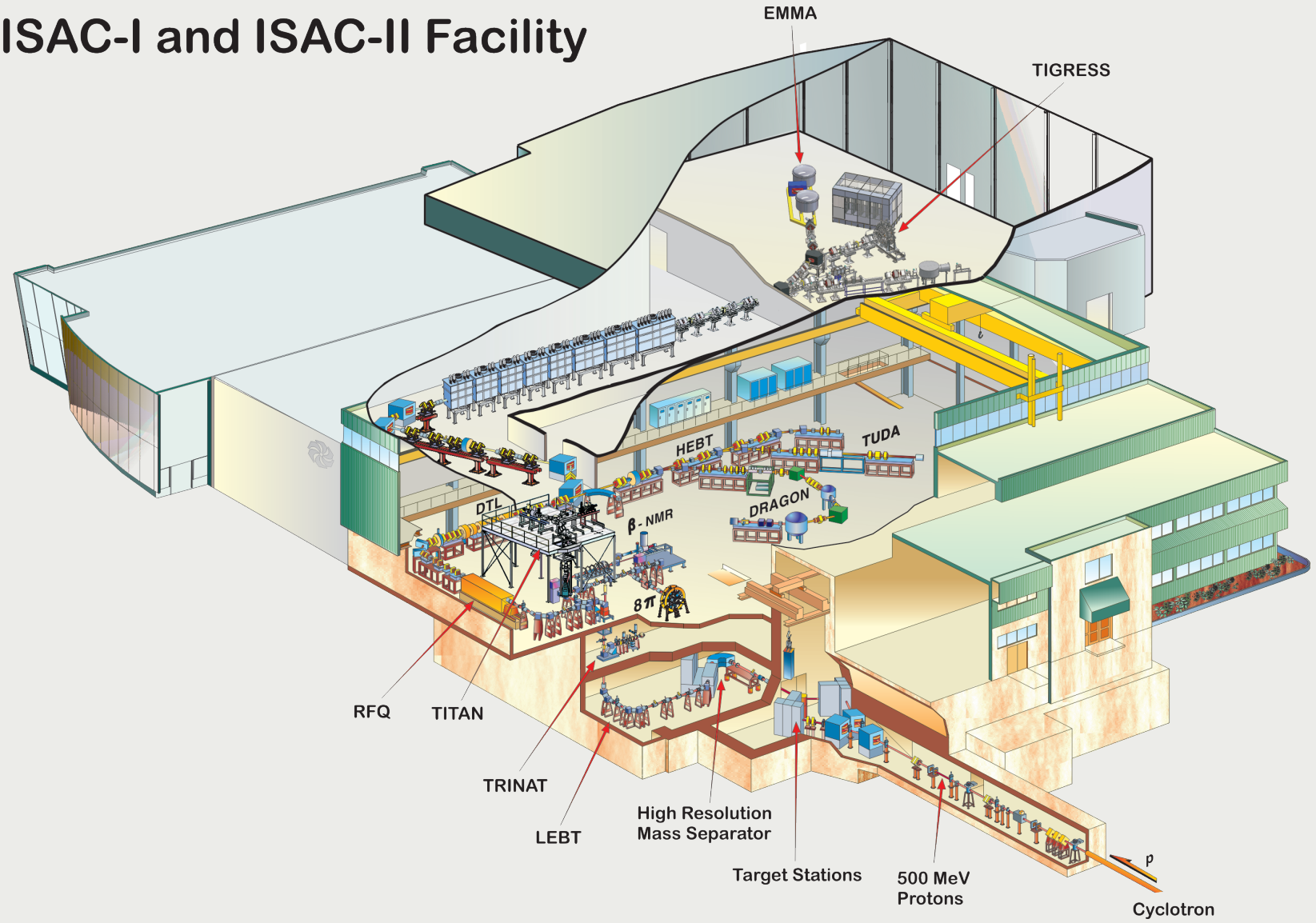
Recent activities of the High Mass Task Force

High-mass RIB workshop, ANL, June 22, 2012

Colin Morton | Beam Delivery Group Coordinator | TRIUMF



ISAC-I and ISAC-II Facility



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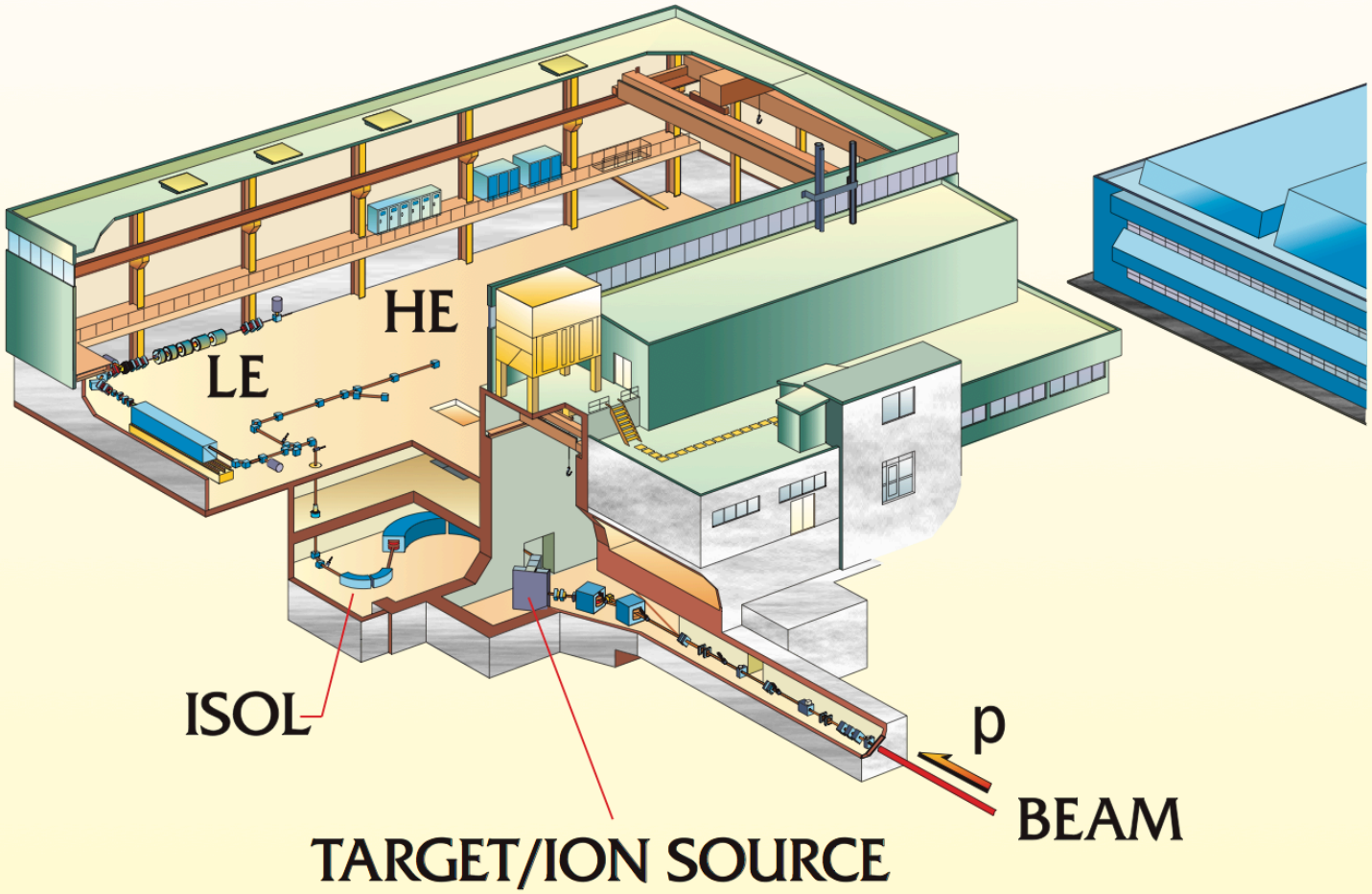
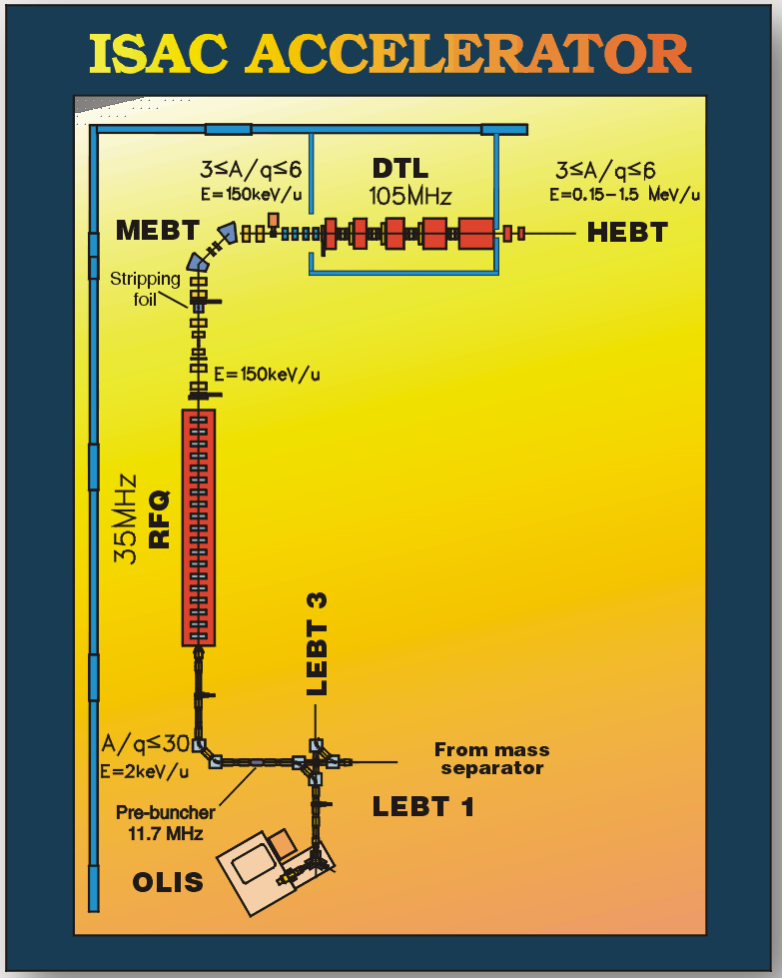
ISAC AT TRIUMF



History

ISAC-I:

- A ≤ 30, up to 1.5 MeV/u
- Constraints:
  - Ion source
    - Up to 60 kV target bias
    - Singly-charged ions
  - RFQ
    - Input energy 2 keV/u
    - **Input A/q ≤ 30**
  - MEBT
    - A/q ≤ 6 through dipoles



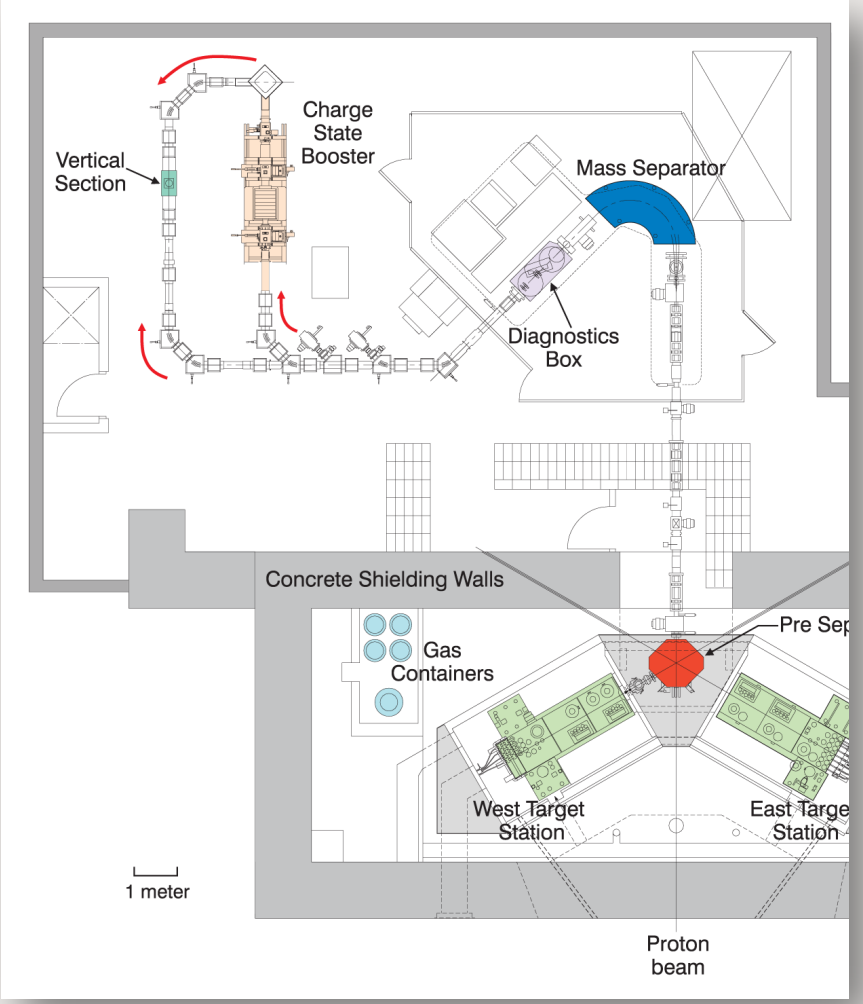
History

ISAC-II:

- A ≤ 150, up to ~6.5 MeV/u
  - RIB above the Coulomb barrier for all masses
- Need to overcome A/q ≤ 30 limit
  - Can't change A
  - Can change q – higher q means lower A/q
  - **Charge-state booster at low energy**

ISAC Charge State Booster

- (Modified) Pantechnik Phoenix ECRIS
  - Located at target level in mass separator room
- **Goal: A/q ≤ 6 before acceleration**
- Issues? Efficiency, **beam purity**



Towards high-mass delivery

- August 2010: High Mass Task Force struck
  - Response to an attempt to deliver $^{78}Br^{14+}$ to TIGRESS
  - Mandate to “develop hardware and techniques”
  - Program of infrastructure improvements and development started
- November 2011: High Mass RIB Workshop
  - Working groups on charge breeding, accelerators, and diagnostics
  - Actions recommended, many of which had already been identified

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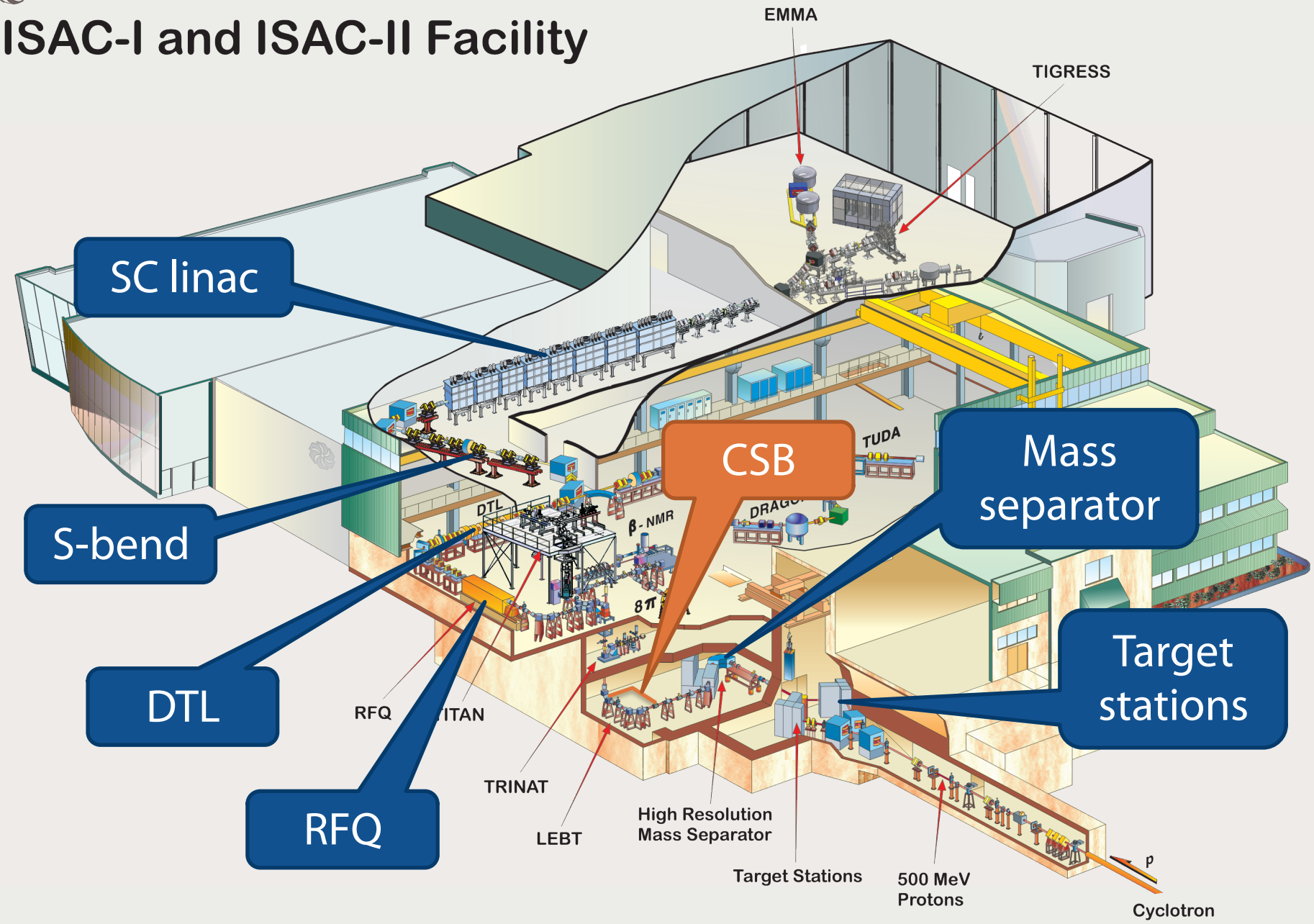
ISAC-I and ISAC-II Facility

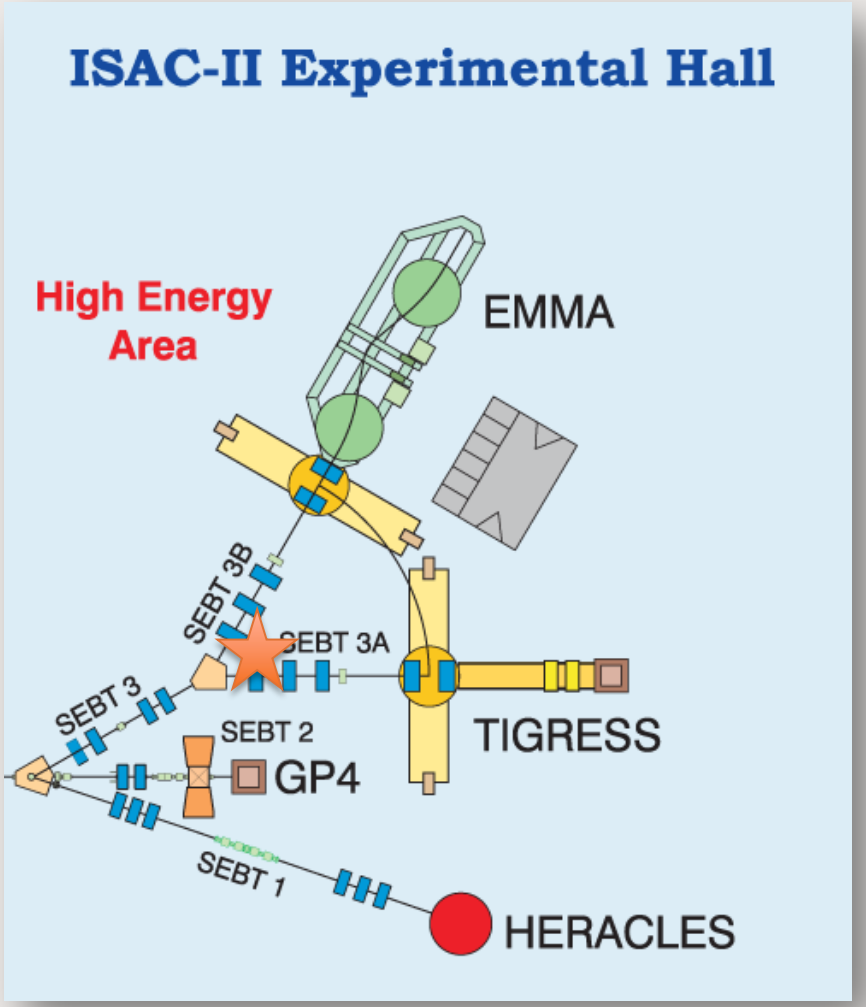


Diagnostics

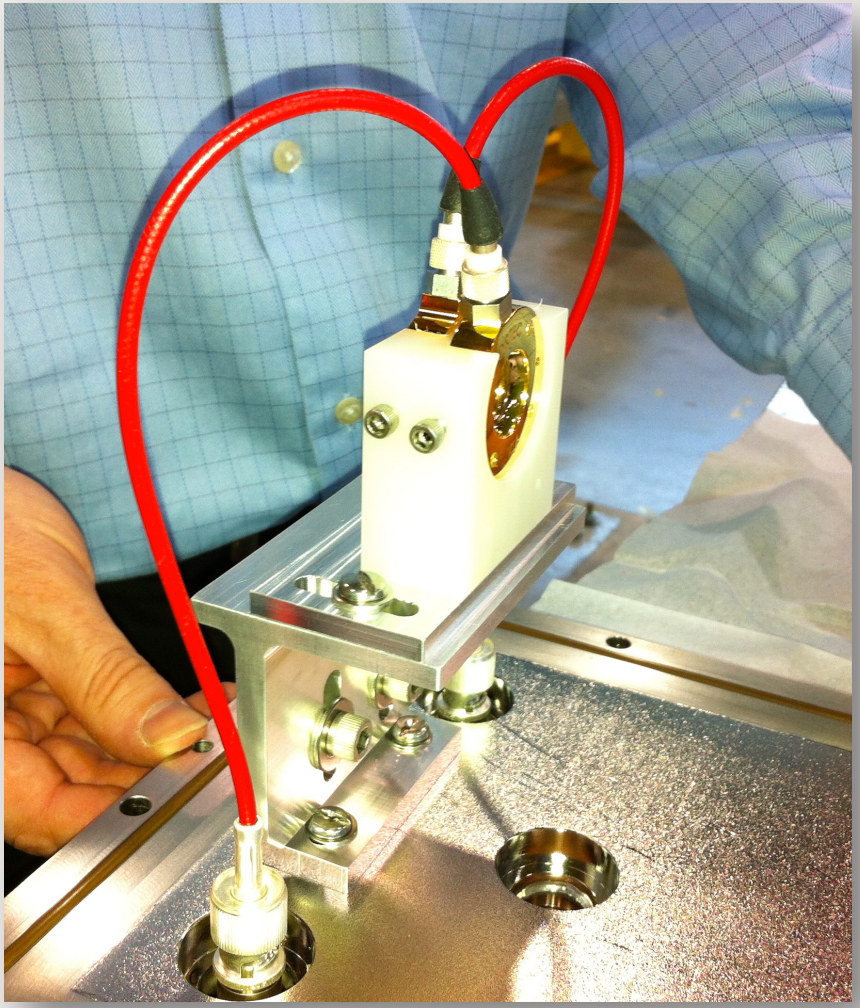
- Key recommendation: More diagnostics
  - High-intensity, low-intensity, RIB detection, particle ID
- Recent focus: Particle ID
  - Si telescope for initial use
  - Bragg detector to be installed this summer
  - Effort led by Science Division

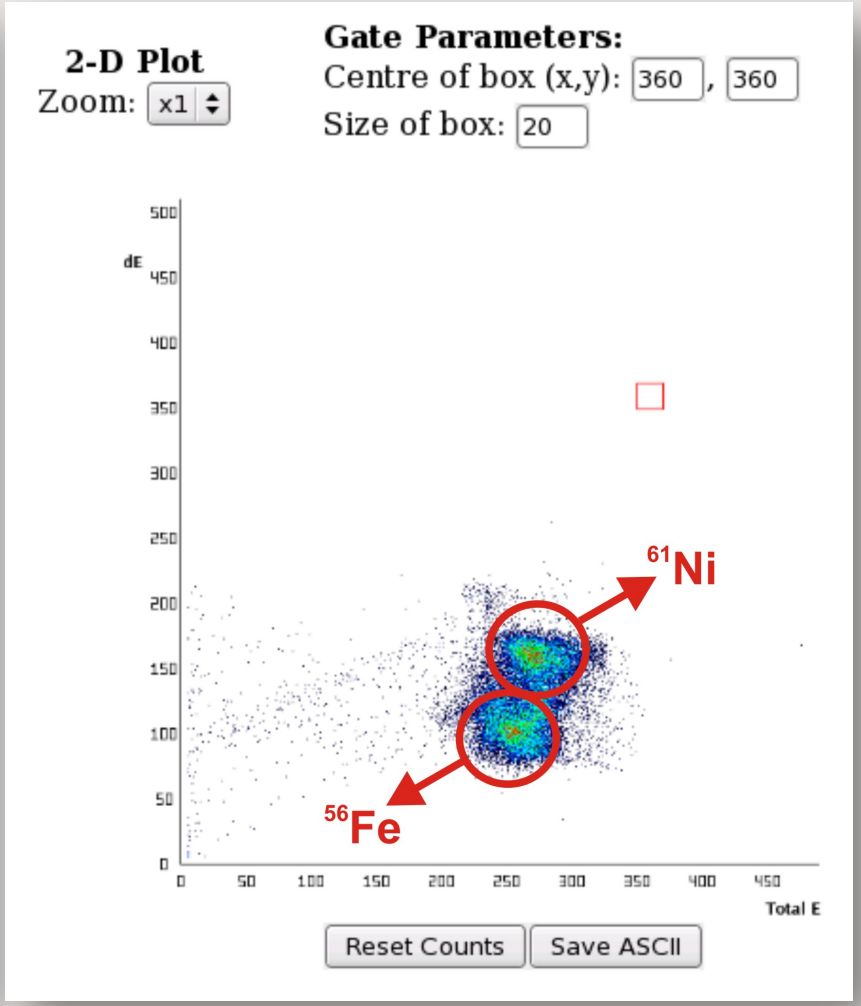
Si telescope

- Standard ΔE/E arrangement
  - 18.5 μm ΔE detector, 300 μm E detector
- Located in ISAC-II experimental hall, between TIGRESS and EMMA (SEBT3)



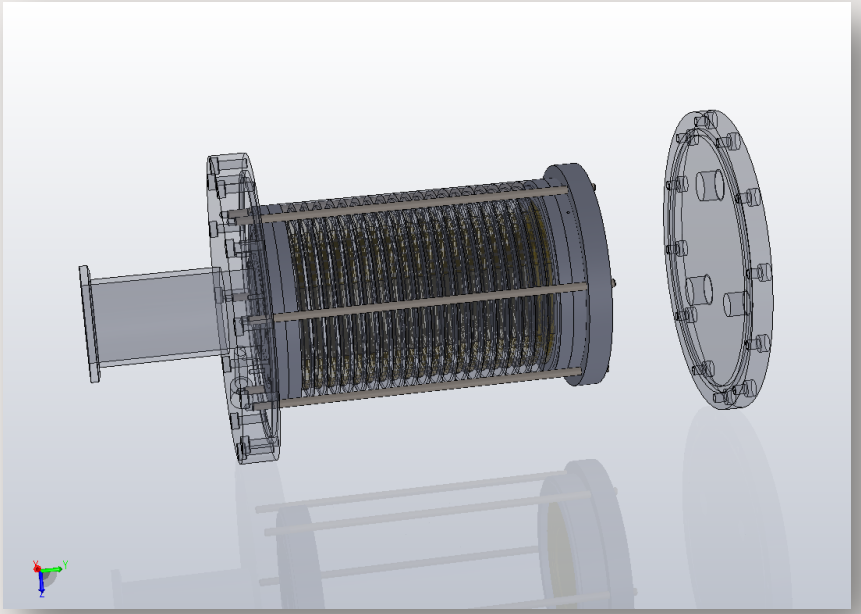
Si telescope



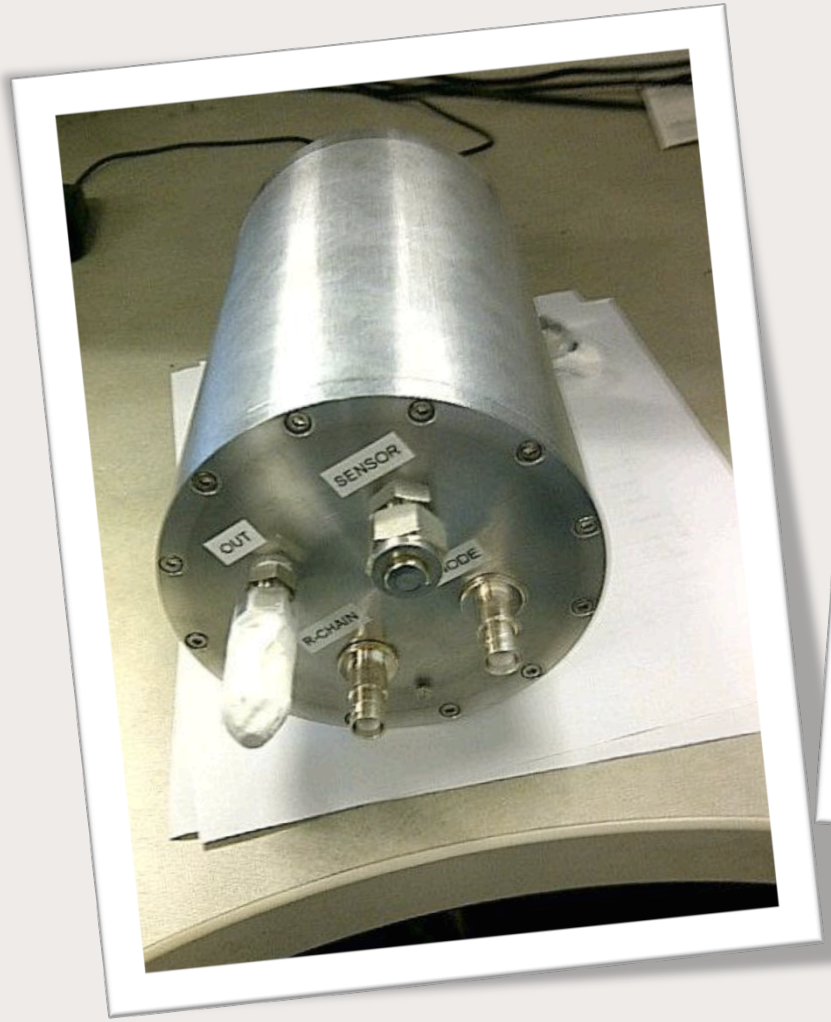


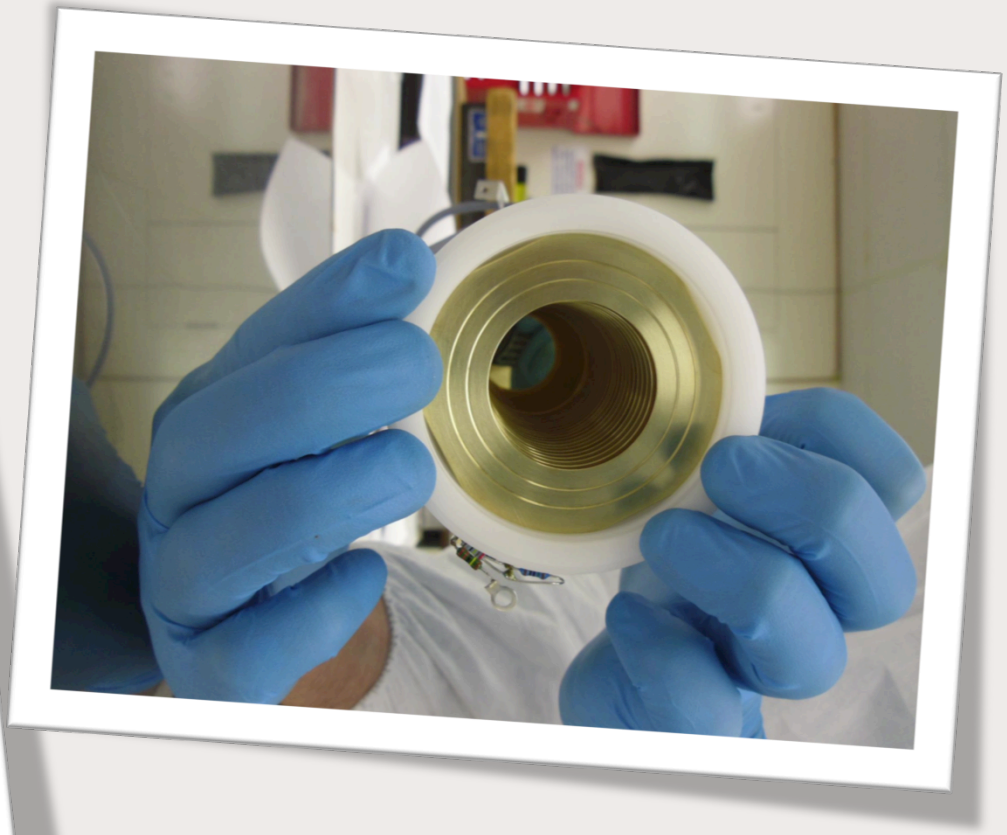
Bragg detector

- Stopping gas detector
- Fabricated in Munich for use at ISAC
- On-site, assembled, undergoing bench testing



Bragg detector





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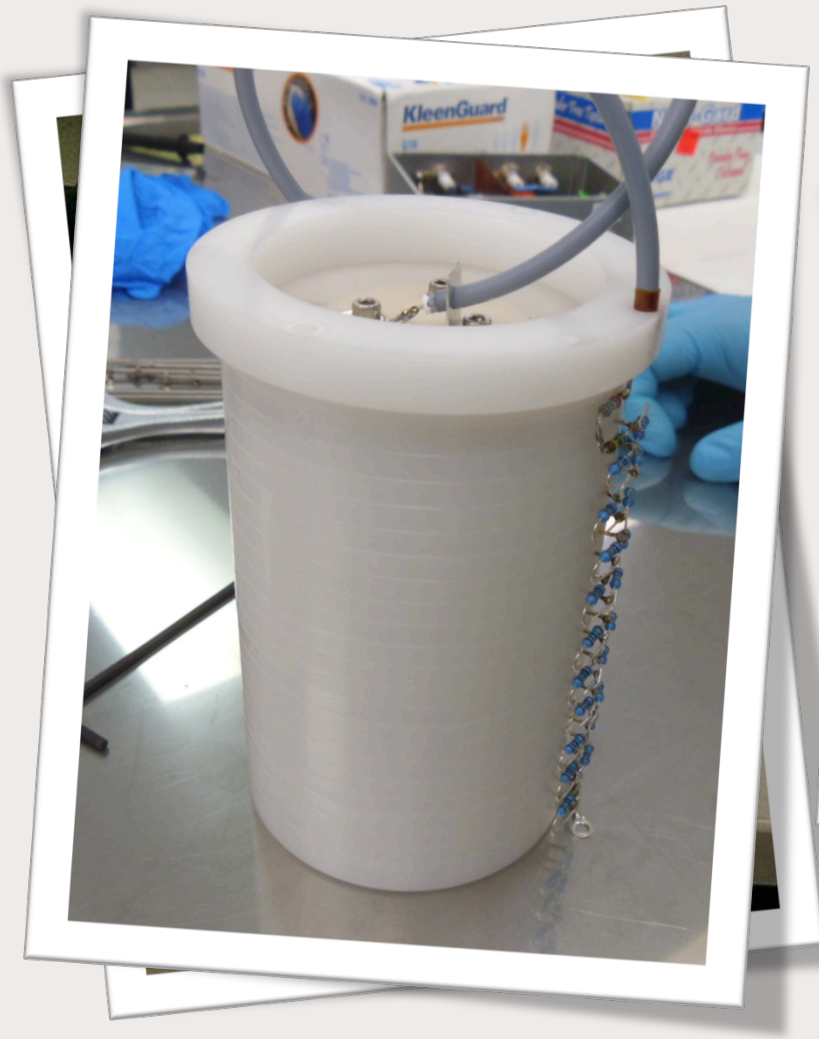
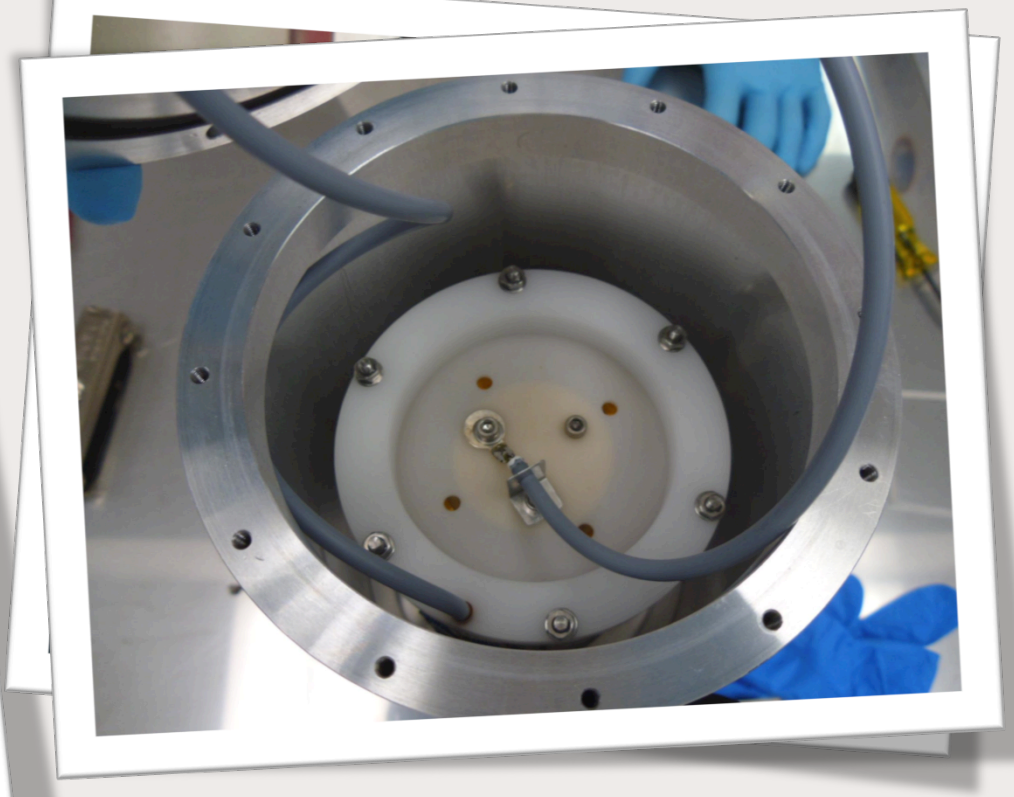




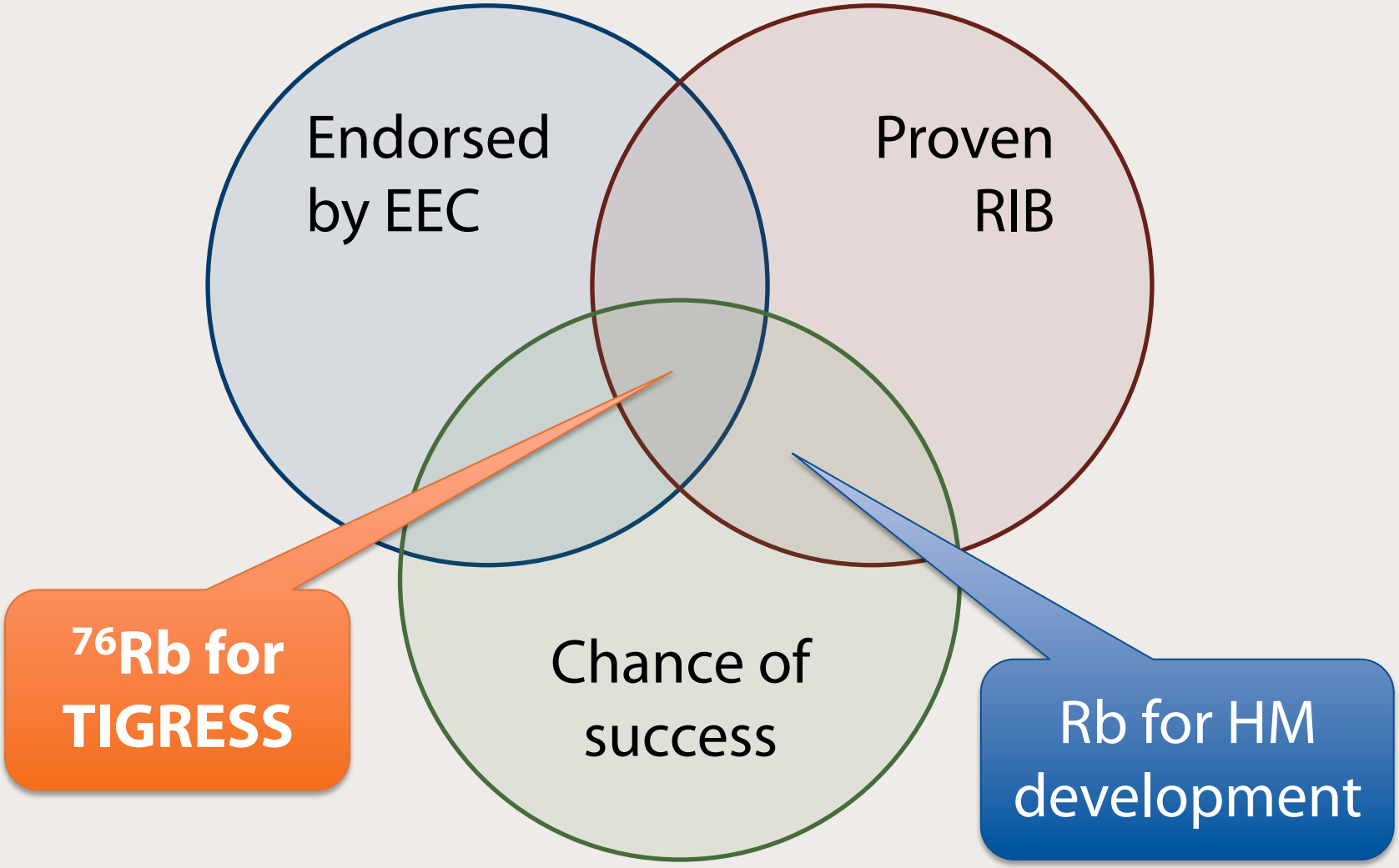
PID detector strategy

- Si telescope has been used on-line with RIB
  - Web-based interface to MIDAS DAQ
- Bragg detector is being tested
  - In-beam testing planned for late July (ISAC-I)
- By fall, the Bragg detector will replace the Si telescope in SEBT3
  - Si telescope is sufficiently compact to move to another location

Accelerators

- Several diverse recommendations:
  - Identify candidates for first delivery to exp't
  - Improved tune scaling and beam modeling
  - More diagnostics and development time
  - Develop in-flight filtration techniques
  - Modifications to the CSB separator, etc.
  - Management support

RIB candidates



Tune scaling

- New EPICS-based scaling routine implemented
  - Electrostatic element voltages
  - Magnet currents
  - Dipole scaling based on magnetic field
  - RF amplitudes
- Future improvements:
  - “Jog” feature – step-by-step scaling of the entire accelerator chain
  - Extend system to LEBT – one-step scaling from RIB source to experiment

"CSB Assistant"

- Web application to support high-mass beam development
  - Identifies expected and potential contaminants at each A/q for a given isotope
  - Calculates charge state distributions and energy loss with stripping in different sections (i.e. at different energies)
  - Includes known CSB background
- Under development within Science Division (Adam Garnsworthy)

MEBT dipole power supply upgrade

- New, higher-current power supplies
  - Increased fields
  - Increased A/q limit
  - Improved reliability
- Supplies installed and commissioned
- A/q = 7 transport has been demonstrated
  - Greater flexibility in choosing charge states to avoid contamination

Charge breeding

- Key recommendations:
  - Take efforts to reduce contamination at the source
  - Begin planning now for ARIEL – use an EBIS, not an ECR, and establish whatever collaborations are needed

CSB upgrades

- Initial improvements:
  - Aluminum plasma chamber and injection electrode
  - First attempt to remove stainless steel from source
- Shutdown 2012:
  - Pure aluminum coating of interior of plasma chamber and magnet steel
  - Einzel lens removed – not needed for beam optics

CSB upgrades

- Shutdown 2012 (cont'd):
  - Second injection electrode changed to aluminum
  - Extraction electrode changed from copper to aluminum
  - Extraction quadrupole configured as steering quad
  - New gas inlet system; improved regulation
  - Reorganized HV rack
  - Lead shielding to allow 24/7 operation

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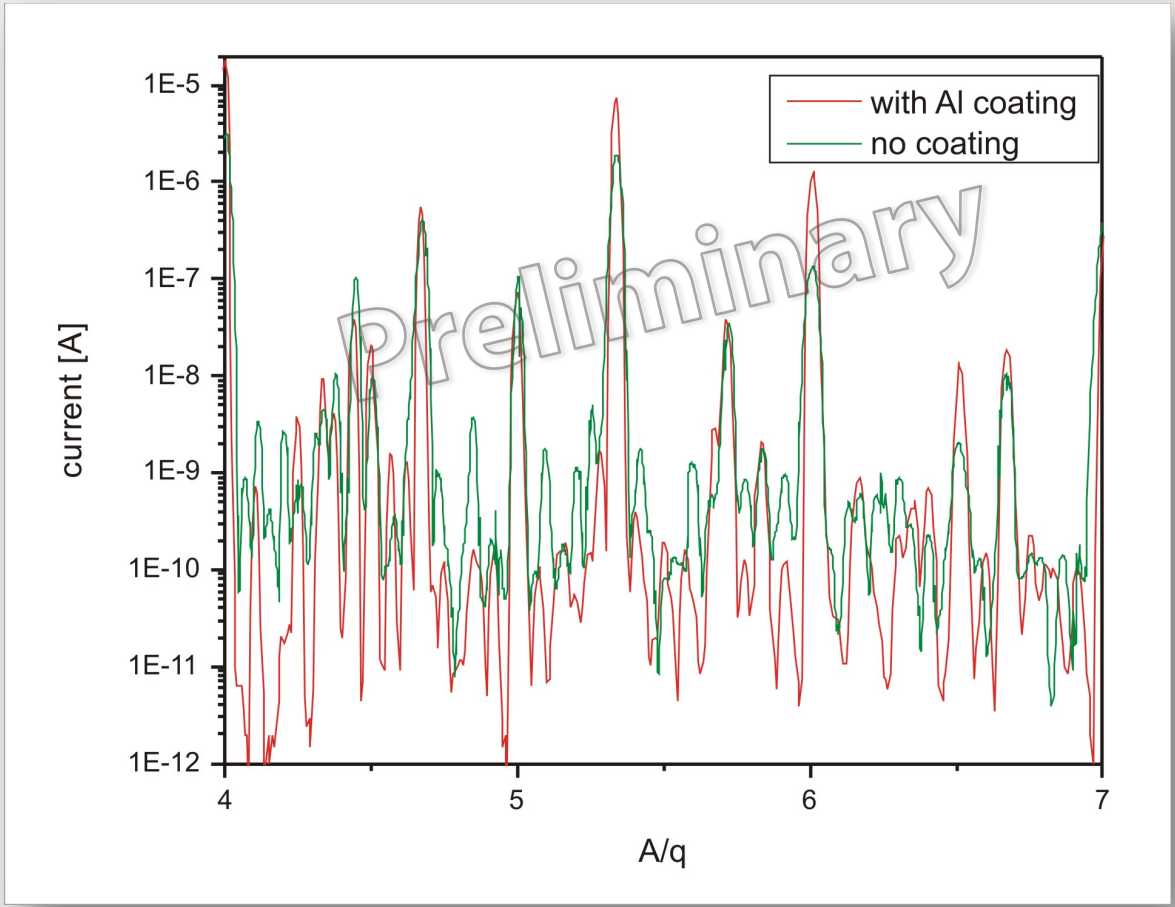
CSB upgrades



Results?

- Significant reduction in background
- Still 10s of pA across a broad range of A/q

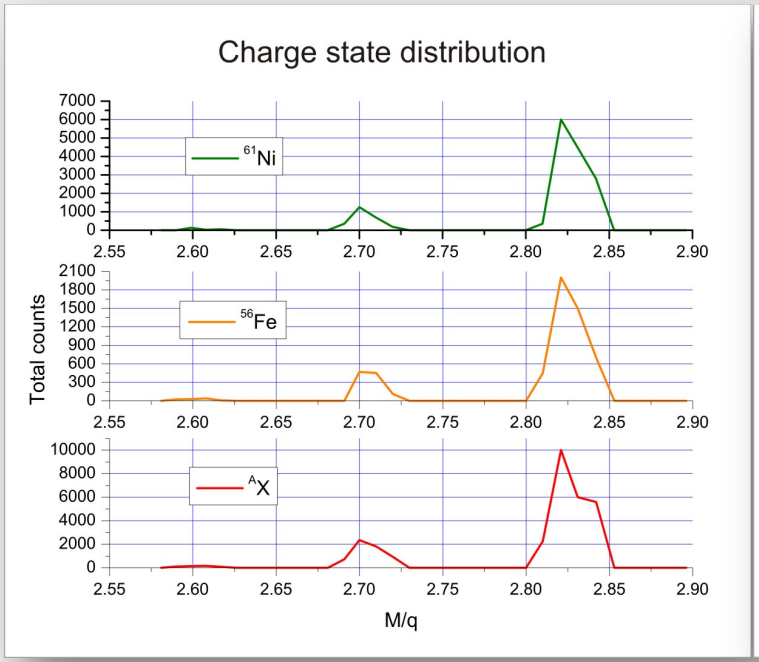
Recent RIB development

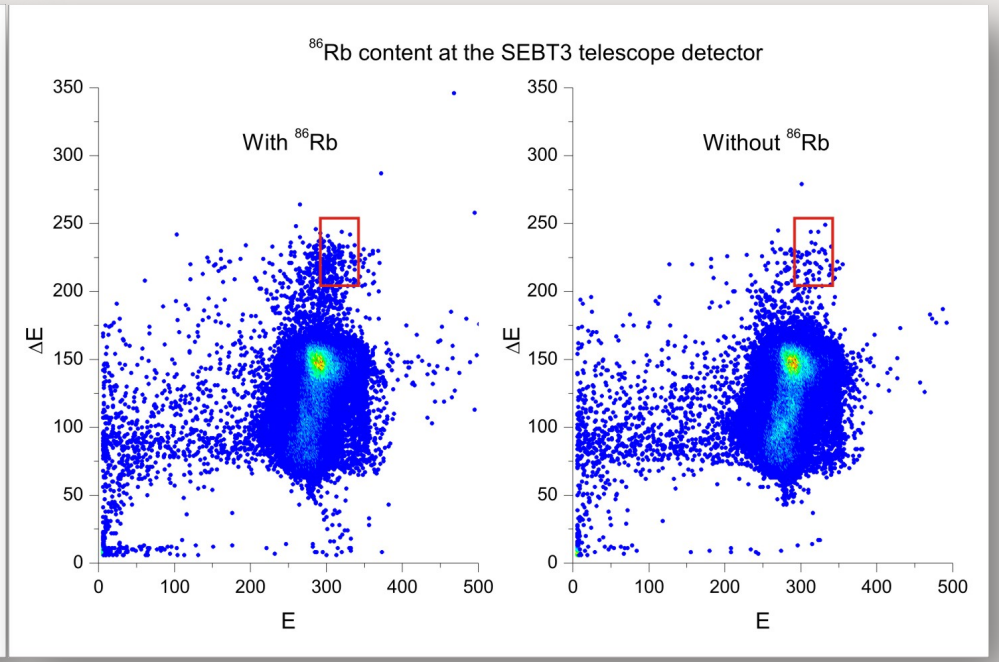
- Nine-day run in late May – low-power Nb target
  - CSB characterization at low energy, followed by combined CSB and accelerator development
  - Acceleration to 5 MeV/u, transportation to SEBT3 for Si telescope use
- Plan? Use all of the tools available to try (to figure out how?) to get a beam of ^{76}Rb to SEBT3

Recent RIB development

- $^{76}Rb^{15+}$ charge state from CSB chosen based on accelerator acceptance and expected contaminants
- Accelerator tune established with $^{12}C^{2+}$, stripped to 5+ at 1.5 MeV/u
- Tune scaled reliably across A/q between 2 and 3
- Charge-state distributions of ^{61}Ni, ^{56}Fe, etc. were measured; $^{61}Ni^{21+}$ used as the starting point for scaling to $^{76}Rb^{26+}$ (post-stripper)
- $\Delta E/E$ spectra were taken with/without ^{76}Rb from the source

Recent RIB development





- Excess of counts near ^{76}Rb seen with RIB in beam – offline analysis is continuing
- **A good starting point**

Upcoming development

- July: Offline development (Bragg detector test)
  - Stable beam from OLIS Supernanogan
- August: CSB development with RIB
  - Low-power UO_2 target with FEBIAD
- September: Stable Sn beam development
  - Not technically HMTF, but the same challenges
- October: ^{76}Rb development, delivery to TIGRESS
- Continuing: Facility upgrades, etc.
  - New diagnostics station at the Prague (energy-measuring) magnet post-DTL

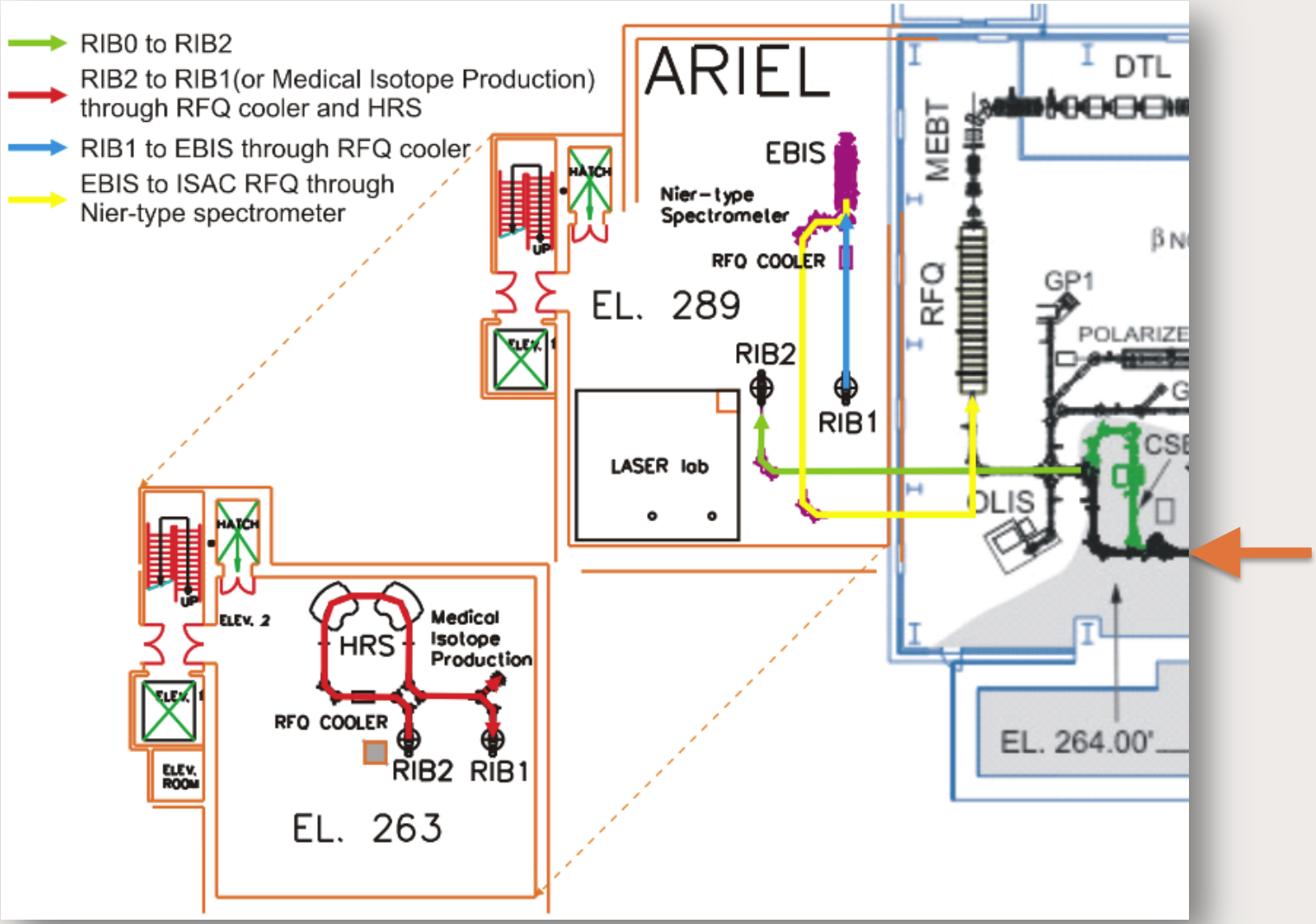
One other thing…

- A question was raised at the first High-Mass RIB Workshop:
  - "When you're staging out ARIEL construction, why not build the EBIS first so you can use it with beams from ISAC while waiting for an ARIEL target station?"

CANREB

- "CANadian Rare isotope facility with Electron Beam ion source"
- CFI-NIF proposal led by St. Mary's University (Halifax) with U. Manitoba, TRIUMF
- Includes ARIEL EBIS charge-state booster, high-resolution separator, RFQ coolers, Nier spectrometer, and low-energy transport
- Major commitment: ~$4.5M total
- Decision expected in November

CANREB implementation with ISAC RIB



In conclusion…

- TRIUMF's High Mass Task Force is still pushing to get high-mass beams to experiments at ISAC
- There has been a significant amount of progress since the first High-Mass RIB Workshop
- In addition to mechanical upgrades, we're developing the tools we need to deliver beams
- We're already looking towards a future EBIS/T charge breeder for ARIEL

High Mass Task Force

- Accelerator Division:
  - Colin Morton, Friedhelm Ames, Marco Marchetto, Bob Laxdal, Victor Verzilov, Rick Baartman
- Science Division:
  - Greg Hackman, Adam Garnsworthy, Barry Davids, Peter Bender (PDF)

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et en physique des particules

Thank you!
Merci!

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