THC3H102

Practical Considerations in the Design of a High Current Commercial H-minus Cyclotron

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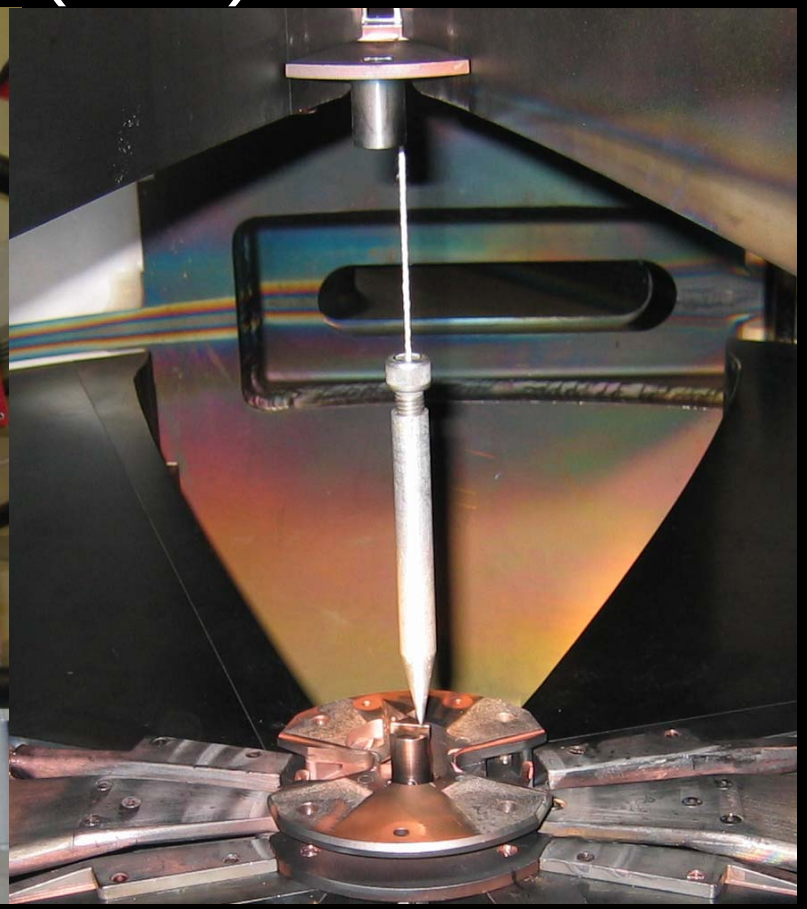
Abstract:

High current H-minus cyclotrons are being developed and implemented for radioisotope production, radioactive therapeutic implants and other applications. The beam dynamics and general physics design of these cyclotron systems must be well done. However, to not compromise an elegant and effective physics design, engineering practicalities must be carefully considered.

Introduction

- Over thirty Cyclone30 Cyclotrons installed
- Half-Dozen TR30 Cyclotrons installed
- Given the large number of Cyclone30 cyclotrons installed, and our consulting experience, this paper uses the Cyclone30 circa 1990s as a baseline reference.

Ion Source & Injection (ISIS)

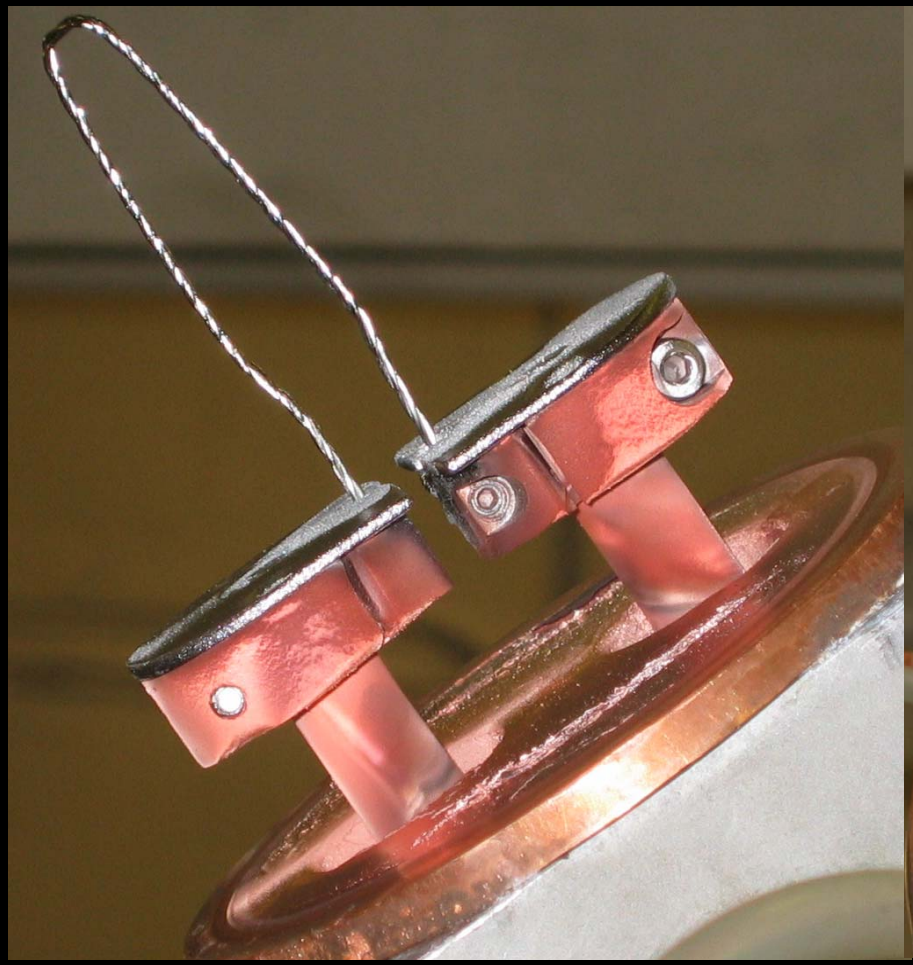


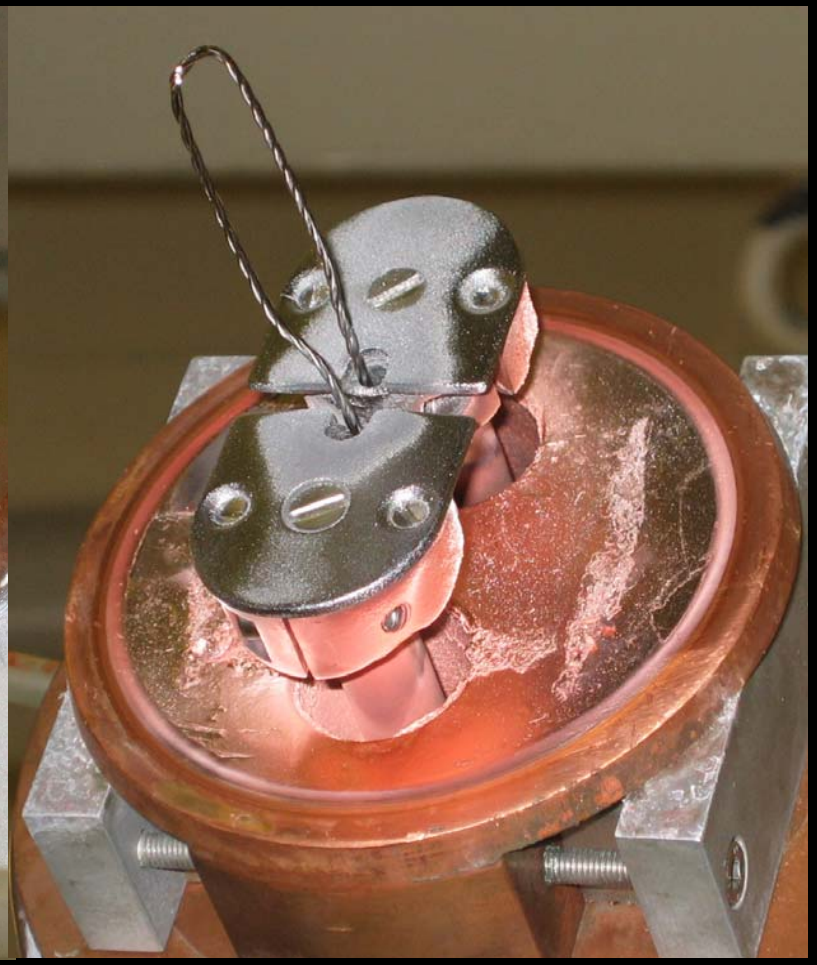
ISIS mounted on the moveable upper half of Cyclone30 with a cantilevered support. ISIS is moved each “lid-up” maintenance, and with a springy cantilevered support ISIS can become misaligned and requires correction as shown in RHS.

Diffusion Pumped ISIS

Cyclone30 ISIS is diffusion pumped. This introduces hydro-carbons into the ion source vacuum environment. Filament life-time decreases to ~80 hours, and H^- production drops. Thick deposits (2mm to 3 mm) form on the source chamber walls. Debris drops onto the plasma electrode, and can fall through aperture to next lenses, buncher or inflector.

IS Filament & Backplate

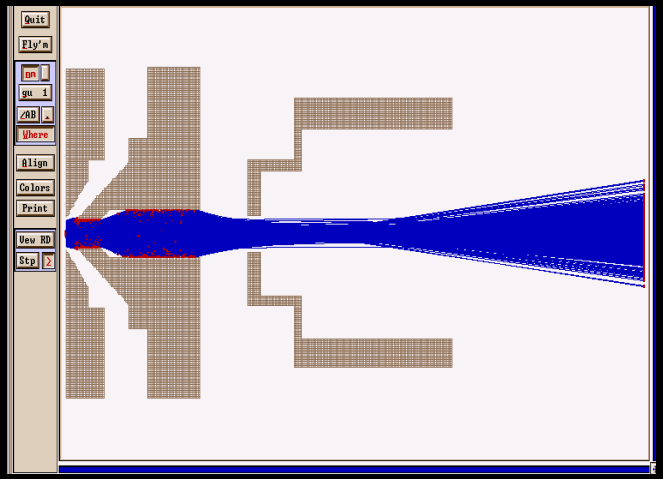


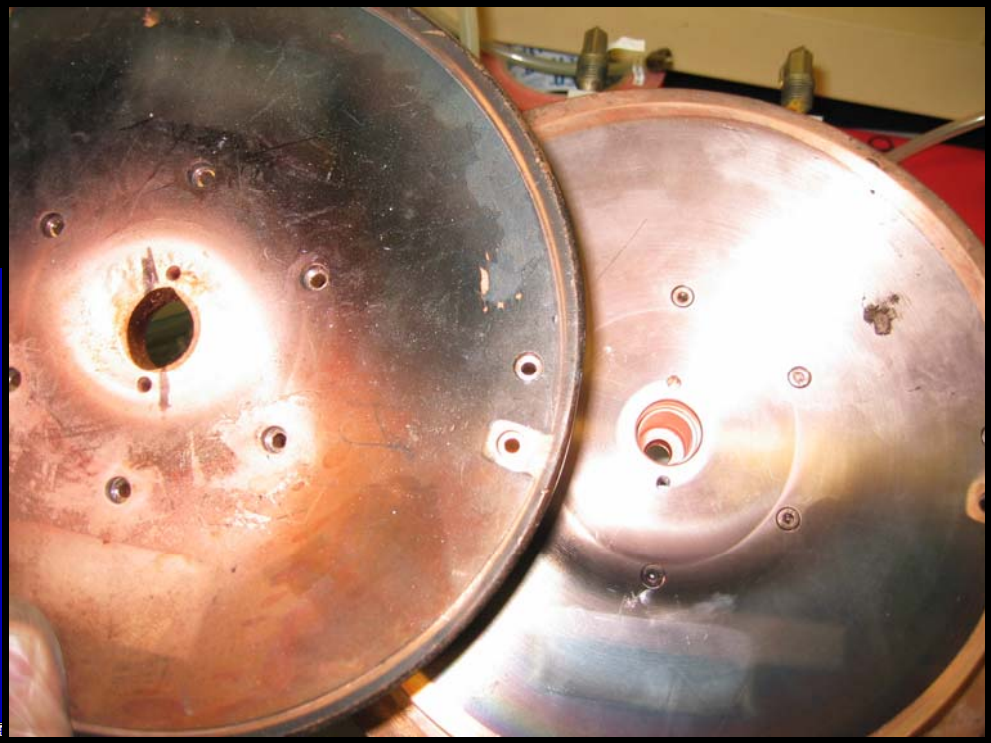


Hairpin tungsten filament and exposed support posts. The backplate has two cusp magnet rows

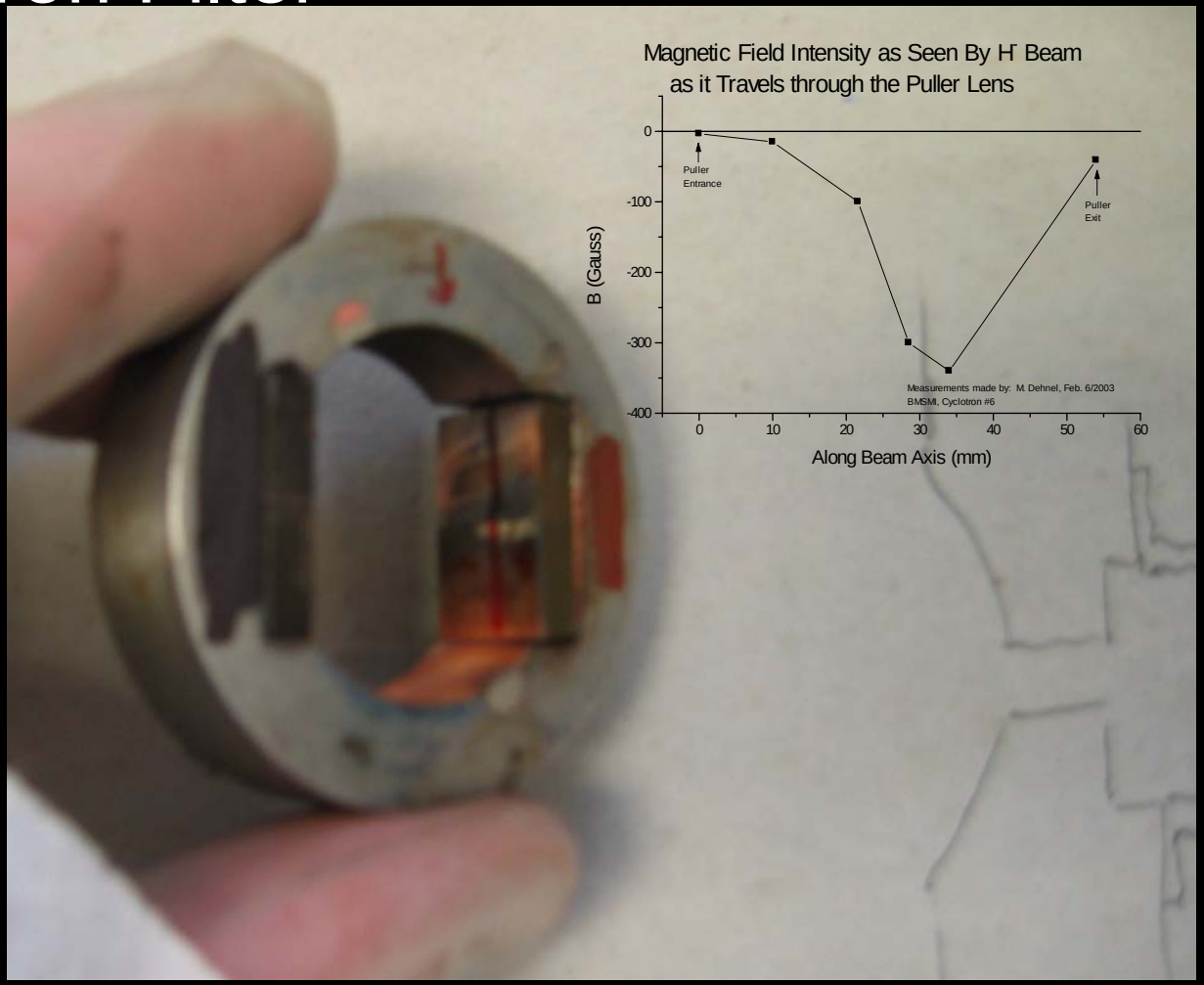
Ion Source lenses

Lens spacing optimization is required.





Electron Filter

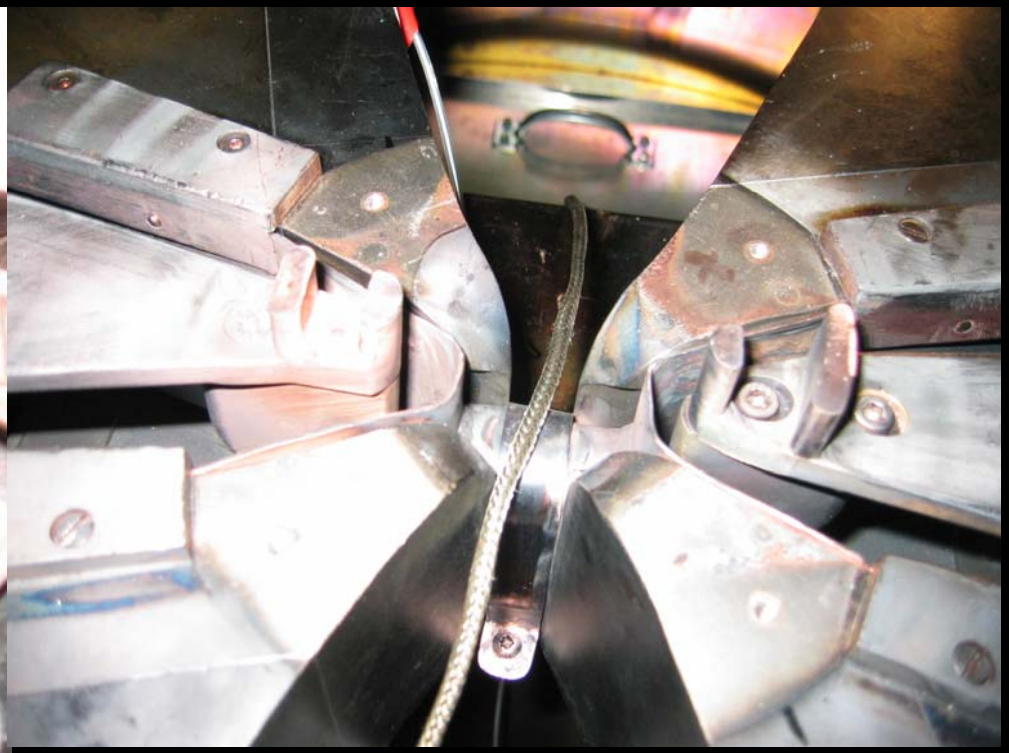


Beamline Simulator Software, Ion-Optics

Electron Filter – Steering Issues

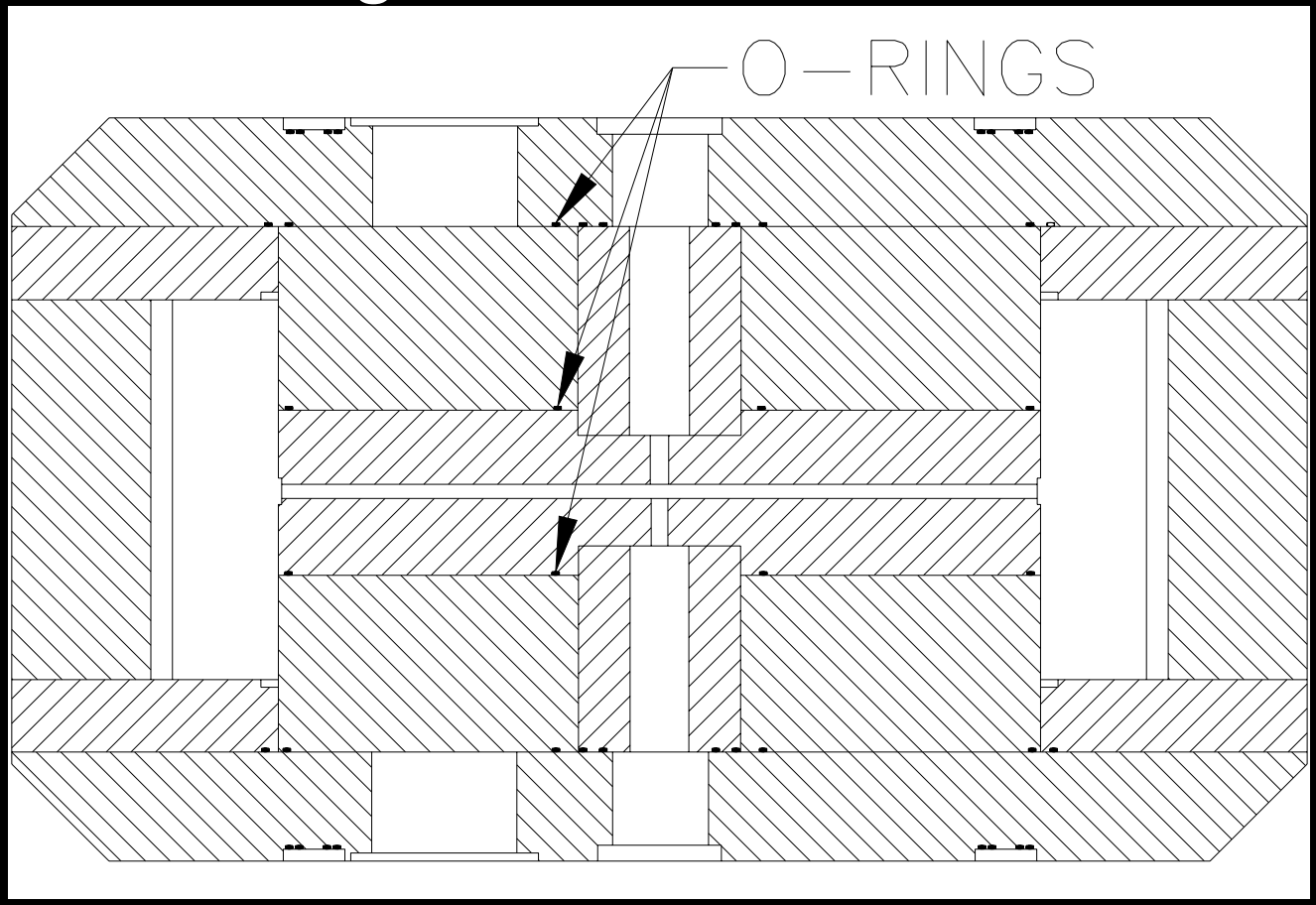
IS ground lens wear due to single dipole electron filter. A permanent steering magnet is used to correct beam steering introduced by the filter.

Central Region



Cyclone30 inflector entrance with open ground enclosure, and no entrance collimator for beam diagnostic information. Right hand image shows dee bottoms in centre region, and hand connected high voltage cables for the inflector electrodes.

Cyclotron Magnet



Cyclone30 magnet steel & o-ring arrangement. O-ring replacement requires disassembly of the cyclotron magnet steel. This is particularly onerous for replacement of a lower-half o-ring. Special care must be taken to ensure that the relatively soft magnet steel does not bind. Fasteners and dowels are not shown.

Extracted Beam

Cyclone30 switching magnet with shared return yoke with cyclotron. This design makes simultaneous dual extraction difficult.

Conclusion

- Aspects of a good physics design can be compromised by the manner in which the engineering is implemented.
- The good news is there are straight forward ways for the manufacturer to correct the issues brought forward here.