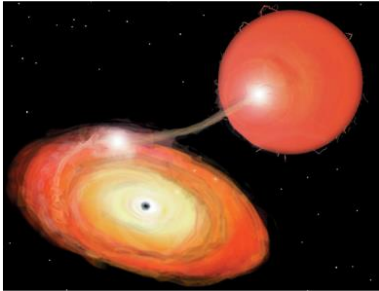


Manoel Couder
University of Notre Dame

SECAR Science

- Focus on p/α induced reactions on neutron-deficient unstable nuclei
- Specifically direct measurement of astrophysical reaction rates of (p,γ) and (α,γ) reactions



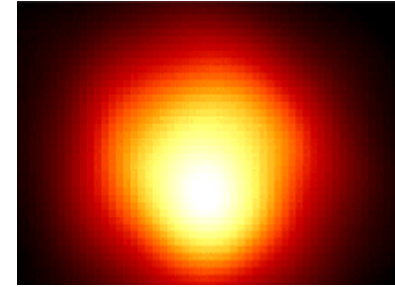
Accreting compact objects

- X-ray bursts
- Novae



Supernovae

- νp -process
- p -process
- Explosive burn



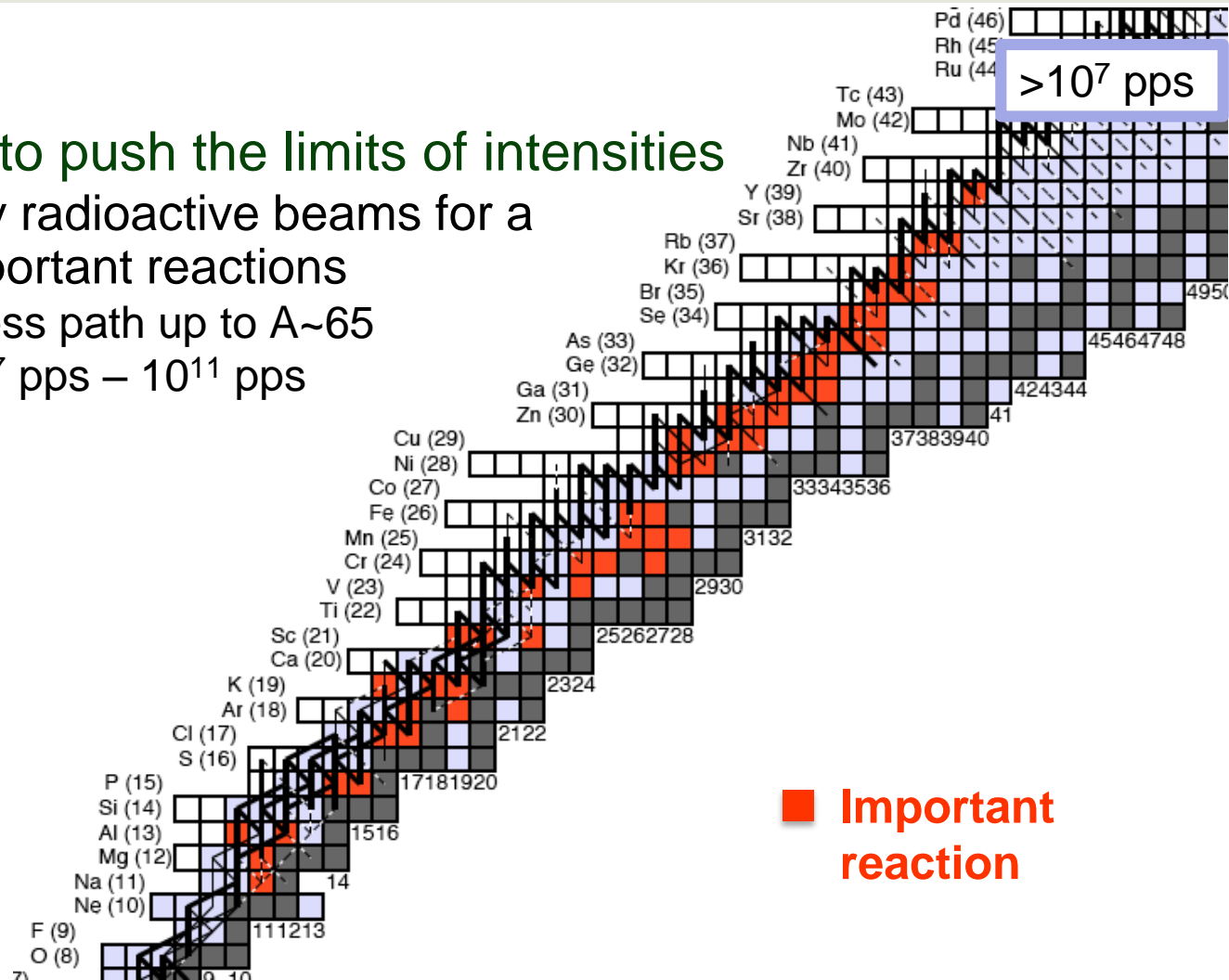
Extreme Stars

- Thorne Zytkov objects?
- Massive first stars

SECAR Beams Intensities

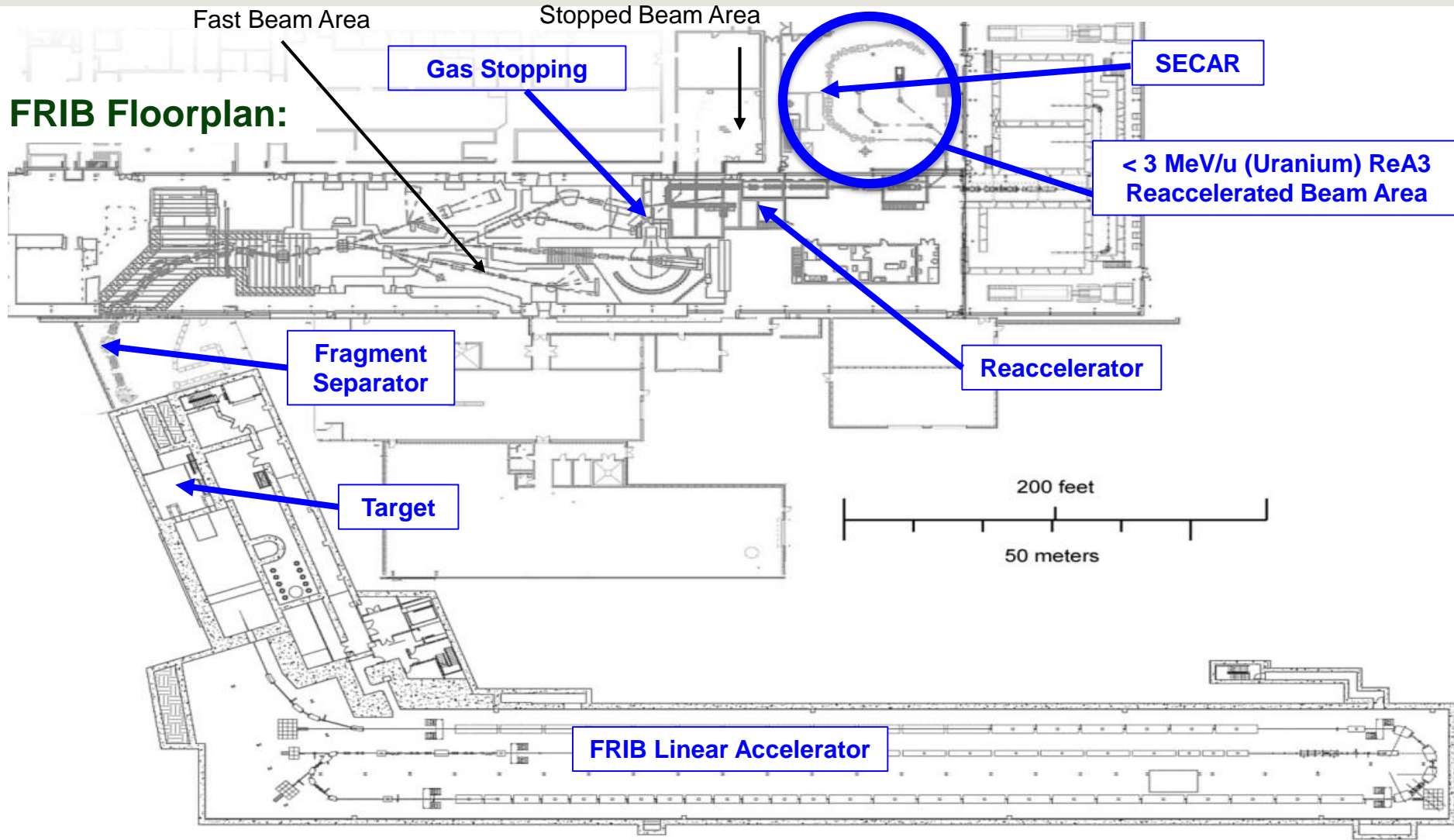
SECAR will require to push the limits of intensities

- Intense low energy radioactive beams for a broad range of important reactions
 - » Along the rp-process path up to $A \sim 65$
 - » Intensity range 10^7 pps – 10^{11} pps

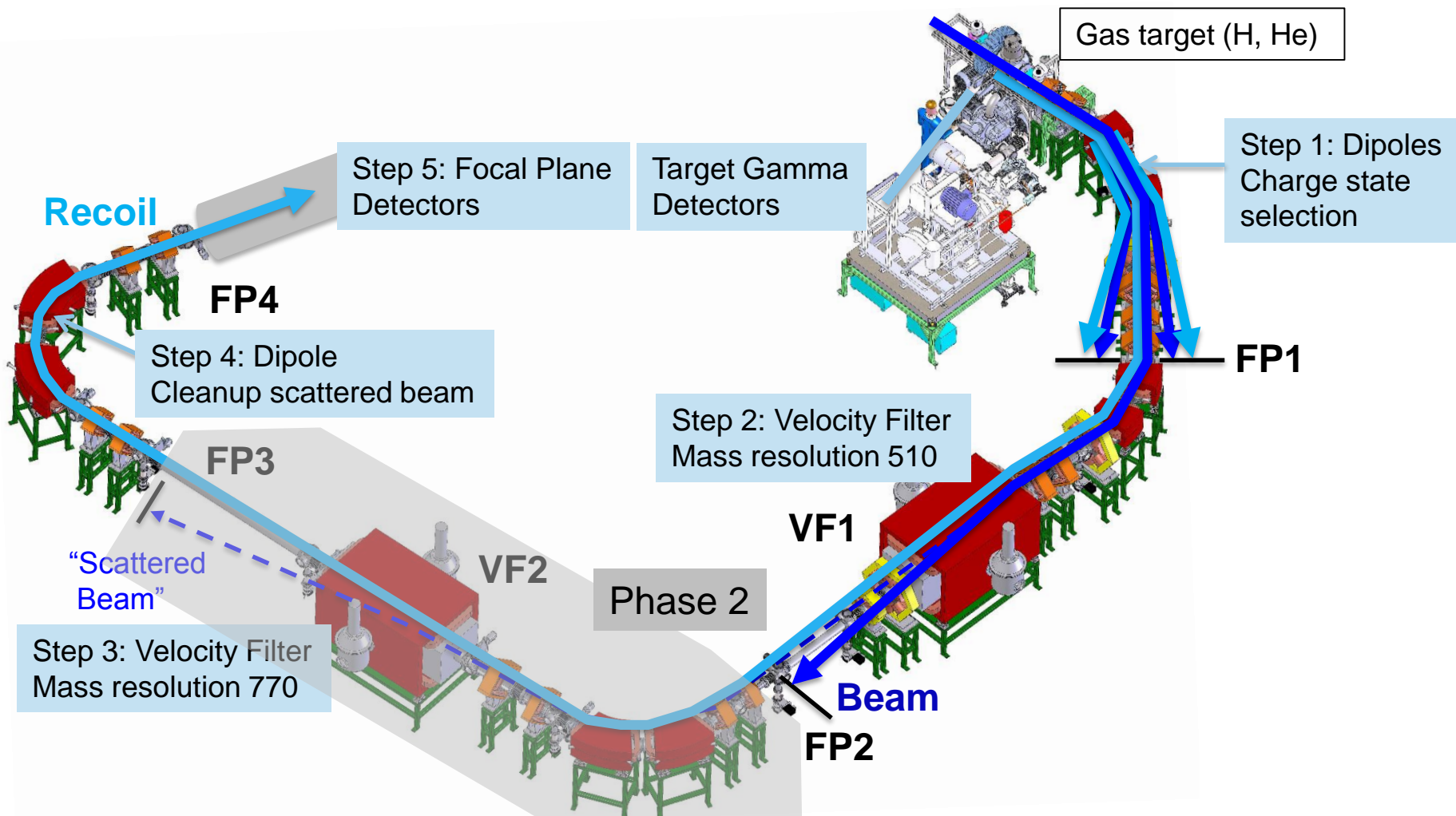


■ Important reaction

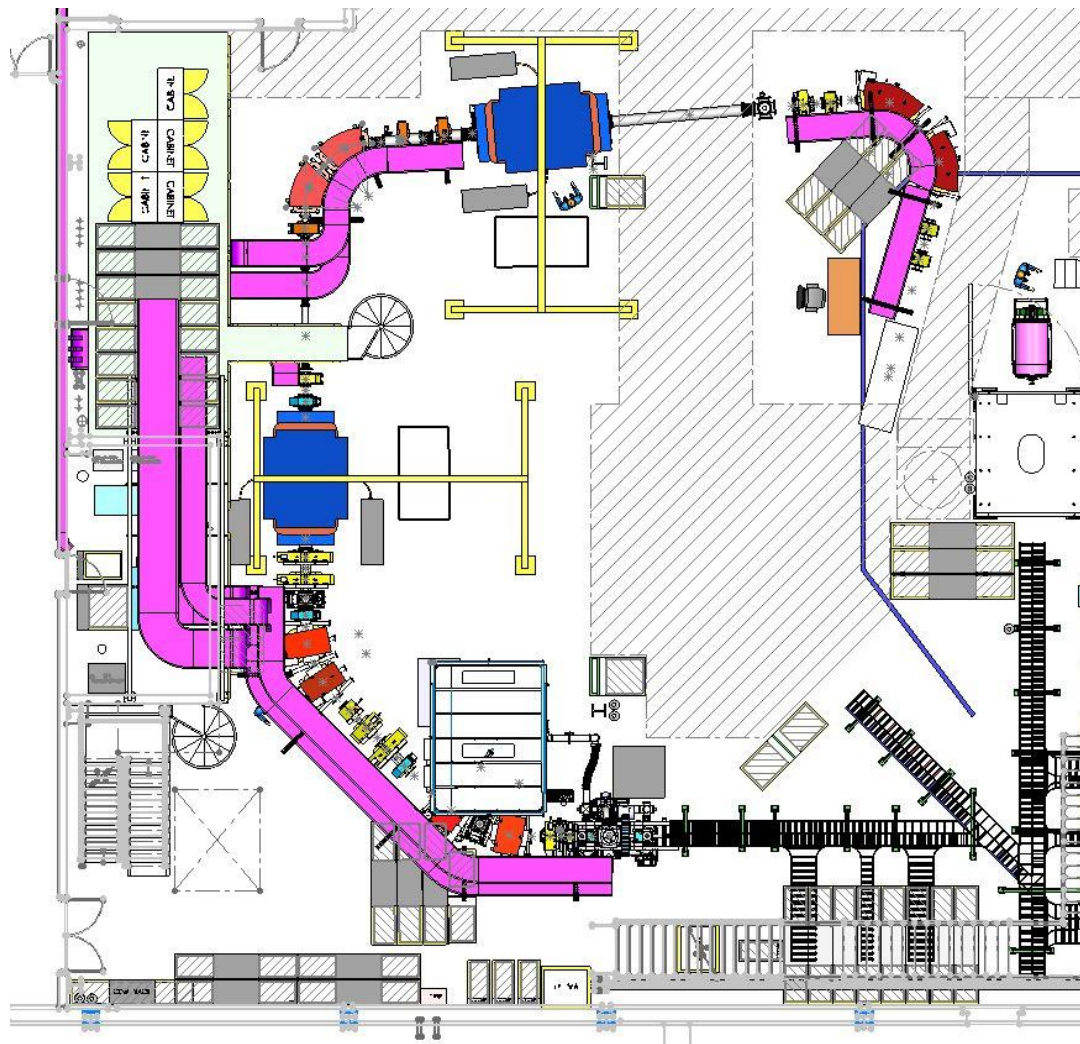
Integration in the Laboratory



Conceptual Approach



SECAR Integrated in ReA3 Hall



Procurement Approach

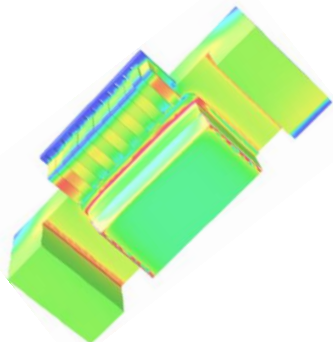
- SECAR team is in charge of
 - » Installation – Vacuum – Diagnostics -- Focal plane detectors
- Single vendor for magnets, Wien filter and power supplies
 - » Vendor build to specs
 - Magnetic and electric field
 - » Defined by ion optics requirements
 - » Tolerances provided
 - Detailed Factory acceptance process
 - » Field mapping on/out plane
 - » Rotating wire for quads and multipoles
 - Stands and magnets vacuum chambers part of contract
 - Interface with vacuum and diagnostic equipment

Procurement Approach (2)

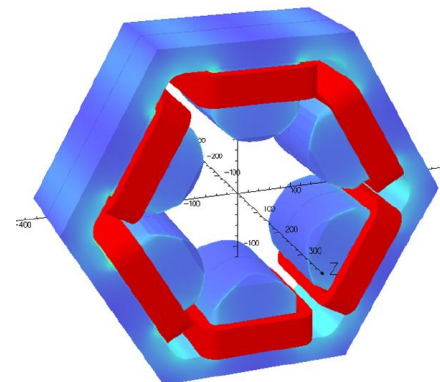
- Process:
 - » Vendor provide results of magnetic field design calculation
 - » Element and mechanical design reviewed
 - Risk: As slightly out of specs magnet are accepted we raise the importance of the specification to be met for the rests of the magnets
- Pros and Cons
 - » Vendor is accountable to deliver the field and other specifications
 - » Vendor not responsible for facility integration, does not see the big picture
 - » Risk of requesting tasks outside of the scope with cost and schedule consequences
 - It actually happens
 - » Typo in specs
 - » Underestimated spacing between magnets...
 - » Design of vacuum station for Wien filter could be added to the scope of contract

Scope of Procurement

Magnets, Velocity Filters, Power Supplies



- 2 (1) velocity filters
- 8 (6) dipole magnets
- 15 (11) quadrupole magnets
- 4 (4) multipole magnets
- Power supplies

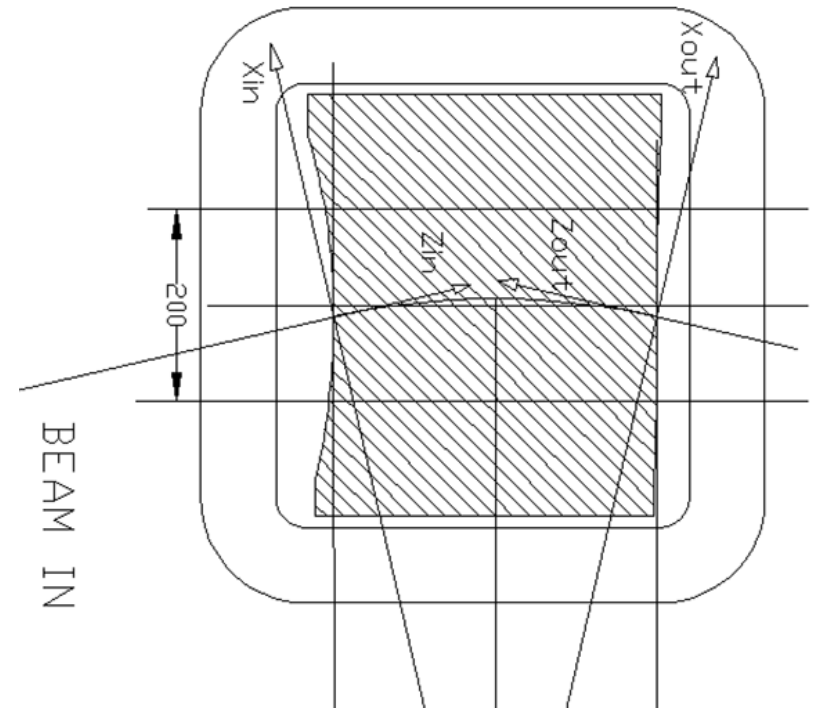


▪ Includes:

- Materials and labor to **specify, design and procure** the magnets/velocity filter including
 - » Chambers, stands, safety guards
- Magnets and velocity filters **manufacturer oversight**
- High voltage power supplies **provider oversight**
- **Perform** factory acceptance tests

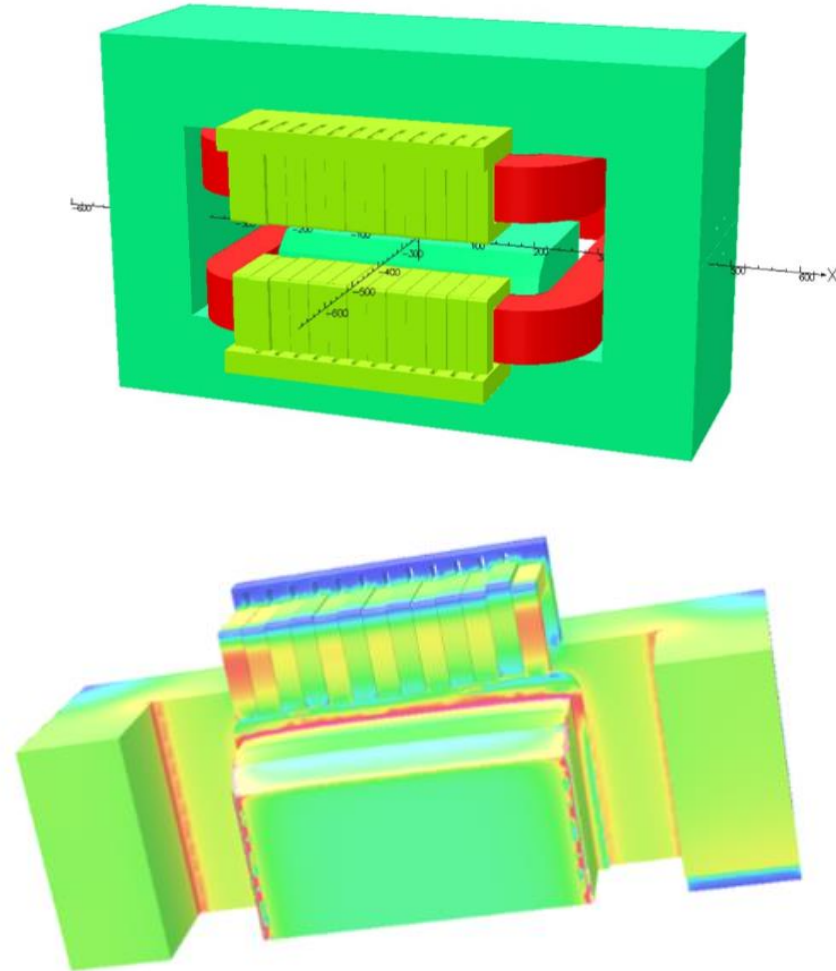
Dipole Magnets Higher Order Content

- Specified according to COSY expression
- Pole end shaped to partially correct for higher order contributions
- $B\rho : 0.14 - 0.80 \text{ Tm}$
- $\rho=0.75\text{m}$
- Tolerance on dipoles
 - » homogeneity in GFR 0.02%
 - » 0.1mm on EFL and edges shapes



Dipole Magnets Higher Order Content

- Individually moving fingers, field clamps, to shape field according to specs
- Position of field clamps adjusted in OPERA script
- Goal: Minimize post manufacturing retrofitting



Higher Risk Items: Wien Filters

- Specified

- » EFL for B and E

2365 mm

- » Electrode gap

220mm

- » Electric field

+/-300 kV (operate at +/-250 kV) $E_p = 1-16\text{MV}$

- » Volume of field homogeneity

220mm wide x70 mm height

- » Integrated field homogeneity

2×10^{-4}

- » Moveable field clamp

- » Surface polishing

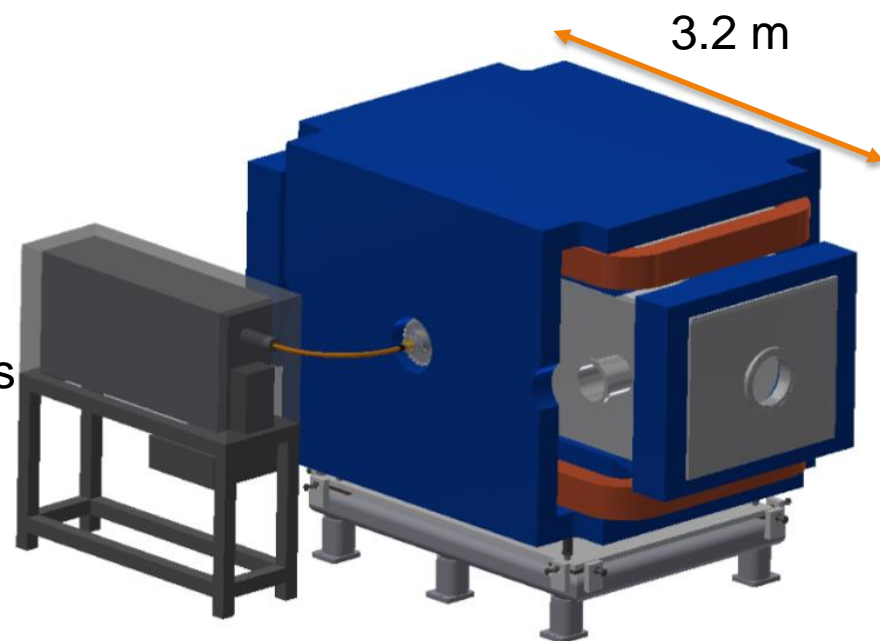
- Vendor provides

- » Magnetic and electric design

- Deviate from 2D preliminary design

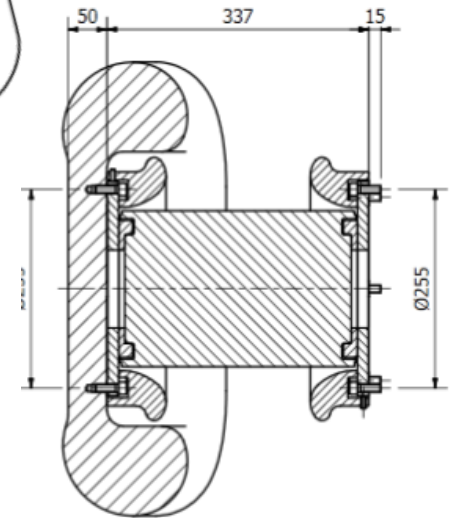
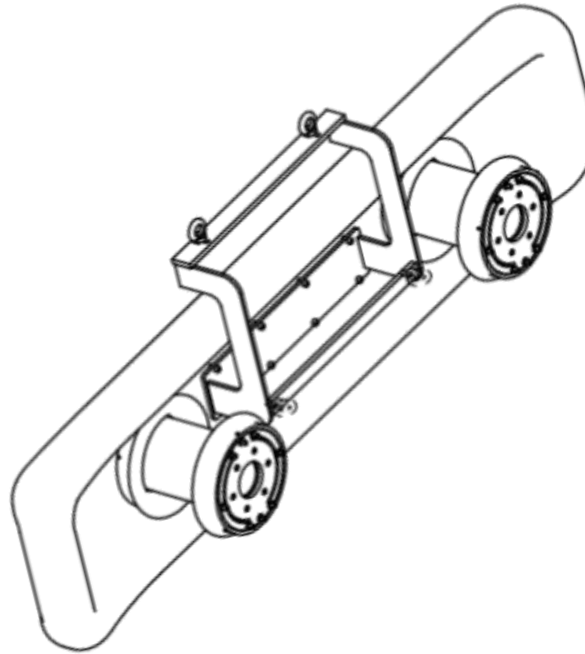
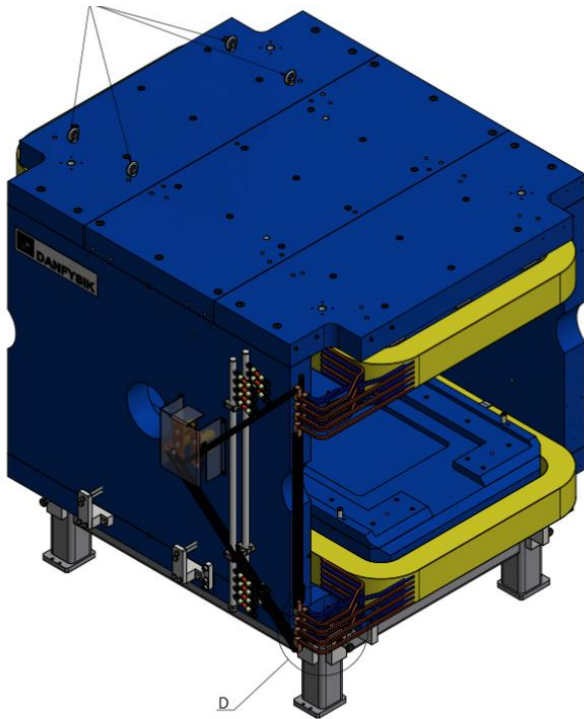
- » commercial off-the self HV power supplies

- Vendor evaluate request of resistor in feedthrough to minimize energy deposition during sparks



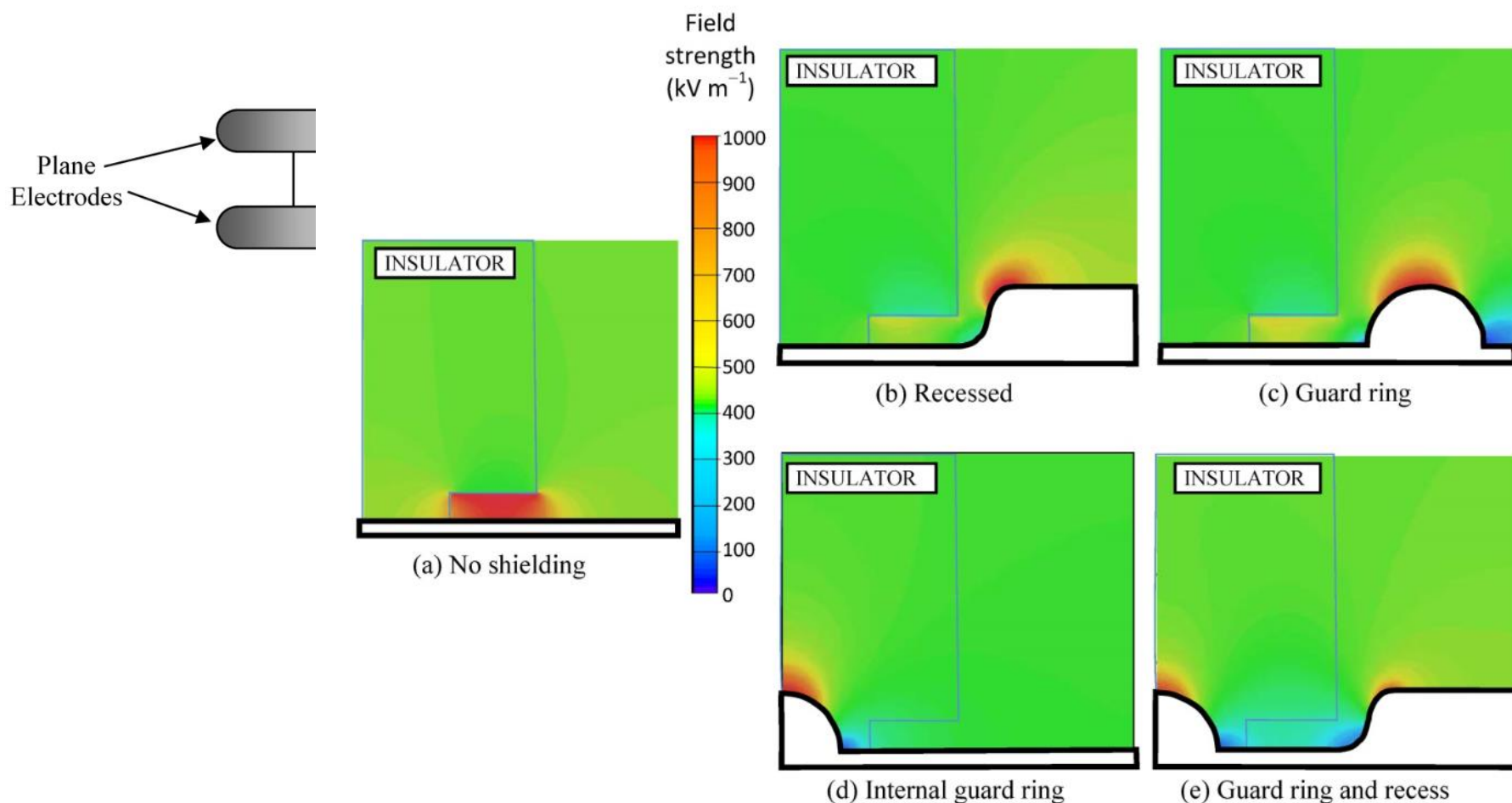
Higher Risk Items: Wien Filters

- Magnetic pole and electrodes shaped to deliver fields
- Ti electrodes polished to $Ra_{0.05\mu m}$
- Mockup to be built to evaluate the manufacturing procedure and to make sure not scratch would result



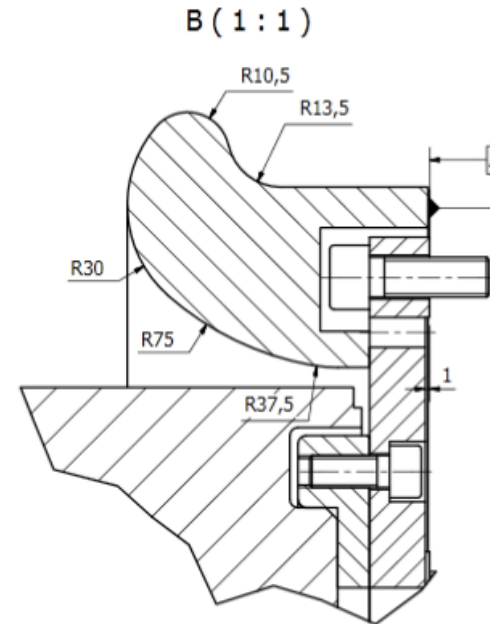
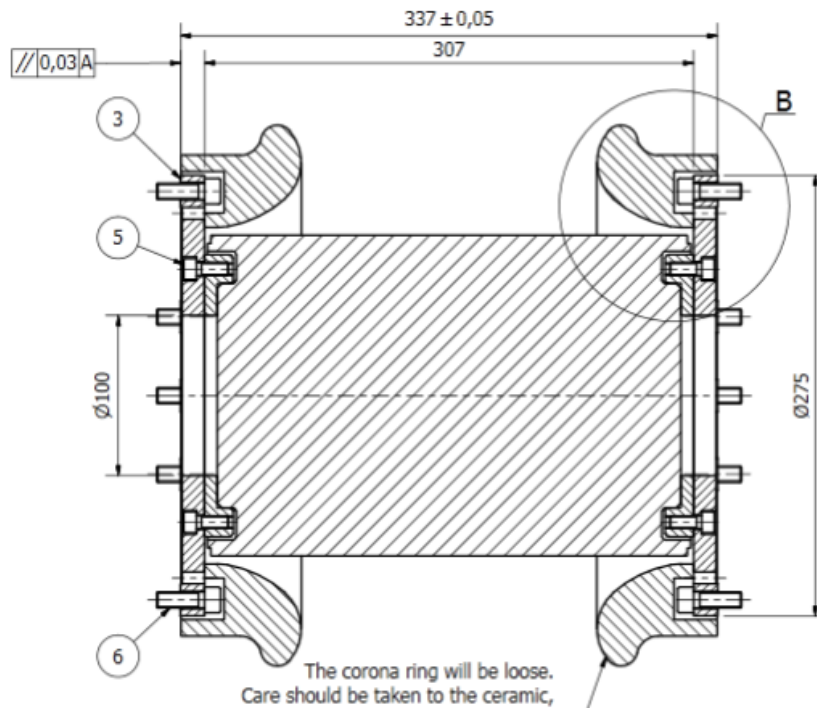
Higher Risk Items: Wien Filters

- Triple point: Intersection of ceramic, vacuum and metal= DANGER



Higher Risk Items: Wien Filters

- Triple point: Intersection of ceramic, vacuum and metal
 - Corona ring build around them



Conclusions

- SECAR will be an important tool of the low energy nuclear astrophysics community at FRIB
- The magnets, Wien filter, power supplies designed and manufactured according to specification (instead of build to print) as multiple advantages but requires permanent oversight and vigilance on cost and schedule deviation
- The SECAR elements are being developed with a collaborative vendor and that, based on the current status, will deliver quality equipment on time and on budget.