Considerations of HI Beam and Vacuum System Arrangement

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Why Revisit Prometheus's Heavy Ion Beam Design Decisions?

- The overall design concept is very similar, although details of multiple beam vs. stored, single beam are different
- Shielding, beam layout, and isolation of chamber environment and debris may suggest ideas
- The Prometheus did a complete 3-D CAD layout of entire power core, beam lines, and power plant that helped assure a high degree of integration fidelity

Prometheus-H Site Plan

- **Excluding the single beam accelerator and the storage ring, the layout will be similar to the envisioned multiple beam approach**

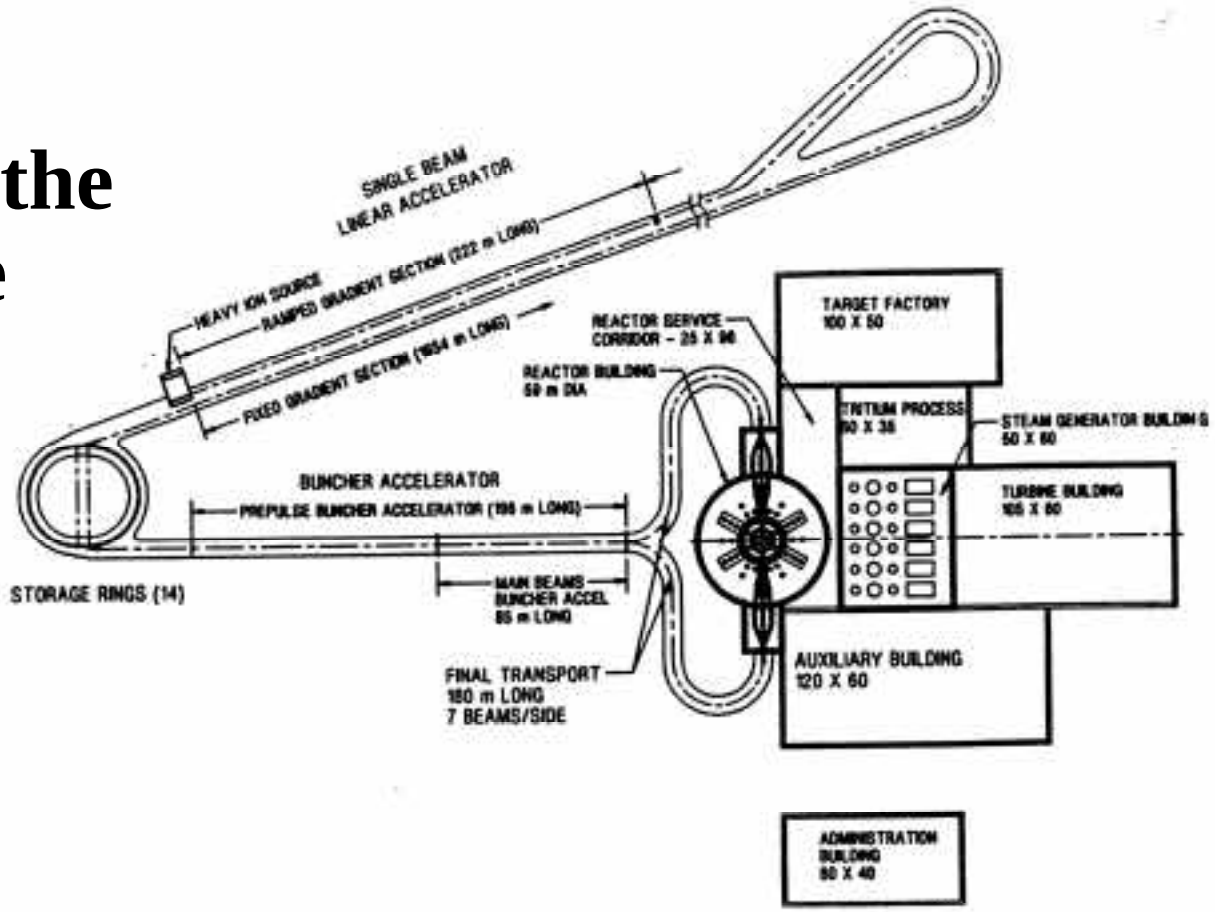

Figure 2.5-1. Heavy Ion Reactor Plant Site Plan

Final Focus Design Approach

- 2-sided ID drive
- 6 main beams + 1 central prepulse (each side)
- Triplet quadrupoles focus beams on rear surface of blanket
- Lead vapor cell neutralizes beams
- Port shield plug has openings just larger than beams
- Additional shielding in vacuum enclosure and in the final focus inner radius
- Vacuum pump enclosure provided behind shield and ahead of final focus magnets
- Target injection is on an oblique line, but intersects at core center

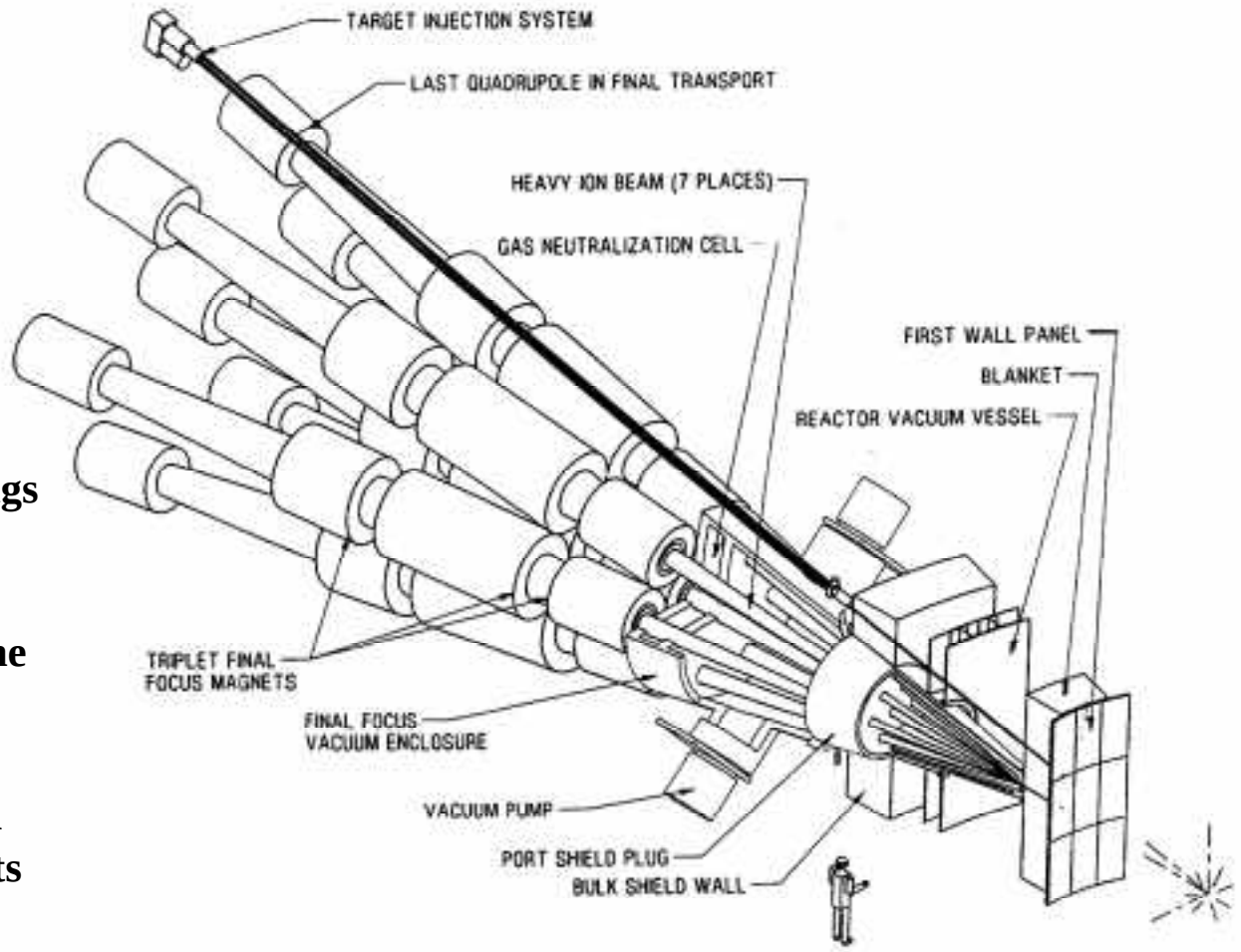

Figure 2.5-4. Physical Arrangement of Final Focus Coils, Plenum, and Shielding Penetrations

Beam and Power Core Arrangement

- Cross-sectional view shows beam and target injector arrangement
- Beams converge at back of blanket
- Beam Vacuum Enclosure is between blanket and magnets
  - 100 mTorr in chamber
  - 0.01 mTorr in enclosure
  - 10^{-6} mTorr in beamline

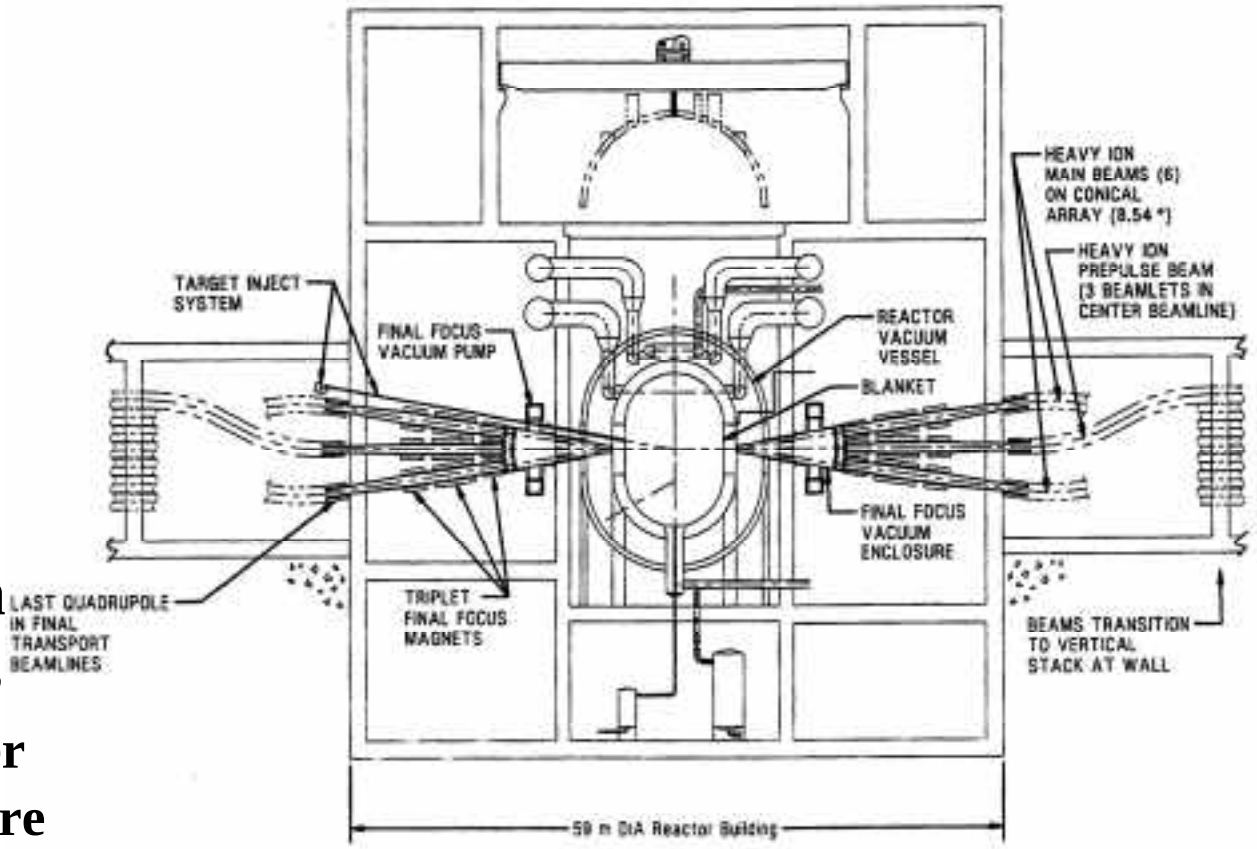

Figure 2.5-5. Prometheus-H Reactor Cavity Arrangement

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Space Charge Neutralization in a Gas Cell

- Beyond the final lens, space charge is a major problem as it dominates the final spot size (6 mm in Prometheus)
- To reach a 6-mm spot 10 m from the last lens, the minimum convergence angle must be 0.6 mR
- In order for the beam to reach its desired diameter, the effects of space charge must be eliminated soon after it leaves the final lens
- Prometheus chose to use a passive, collisional ionization of a fairly high density lead gas with the beams to generate co-moving electrons

Stripping Beams for Channel Formation

- At the point where the beams focus on the back of the blanket a lead vapor strips the beams to a charge state of 2+ to 82+ and vastly increased the beam current to help self-focus the beams

- Beam diameter will be 6 mm and opening in blanket is 2 cm

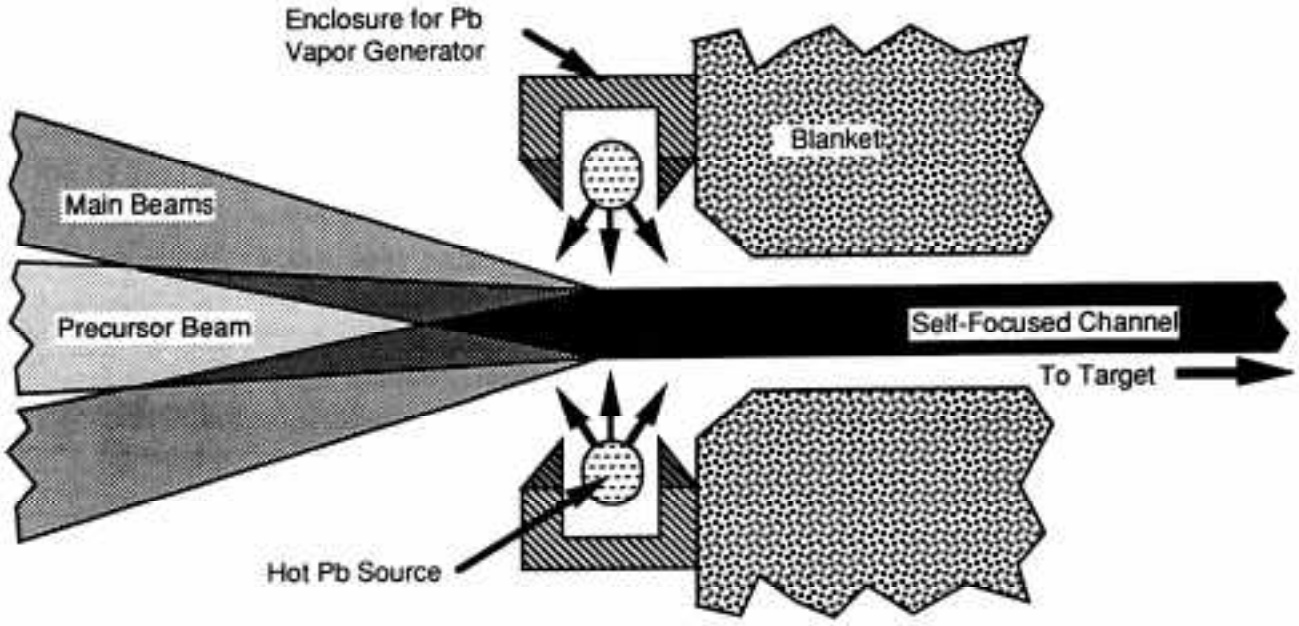


Figure 6.5.2-42. Schematic of Lead Jet System for Stripping Pb Heavy Ions

Details of Channel Transport Configuration

- Square window houses the lead vapor gas jet to strip beams
- High temperature helium gas tube (enclosure) keeps lead in vapor state
- Cone shaped vacuum plenum extends from magnets forward to blanket (0.01 mTorr)
- Vacuum plenum keeps all gases behind blanket and shield isolated from beam system

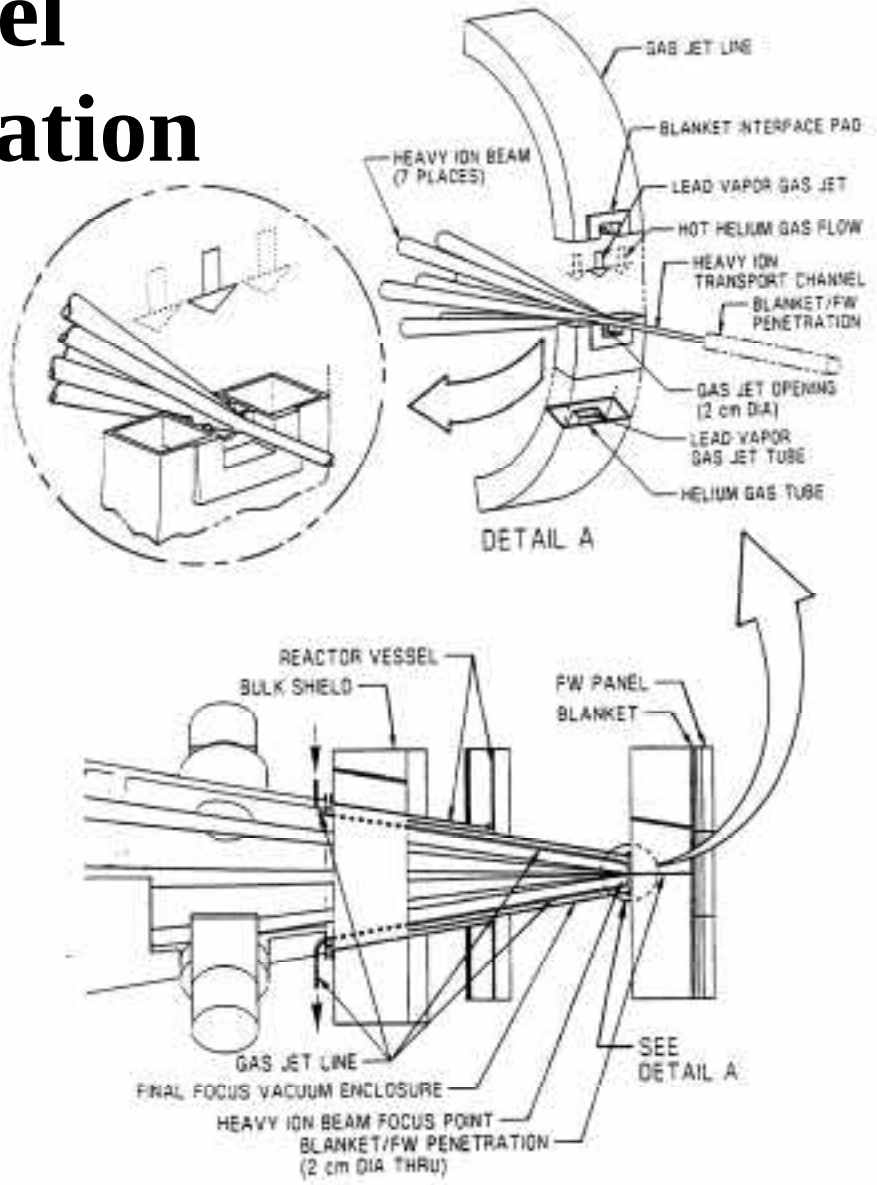


Figure 6.3.1-31. HI Beam Channel Transport Configuration

Vacuum System Design

- Three vacuum pumps (roots blowers) installed on four ports
- Eight active blowers are required for the chamber pressure of 100 m Torr
- A lead vapor trap is at the entrance to the vacuum ports to reduce the pumped gas to < 800K.

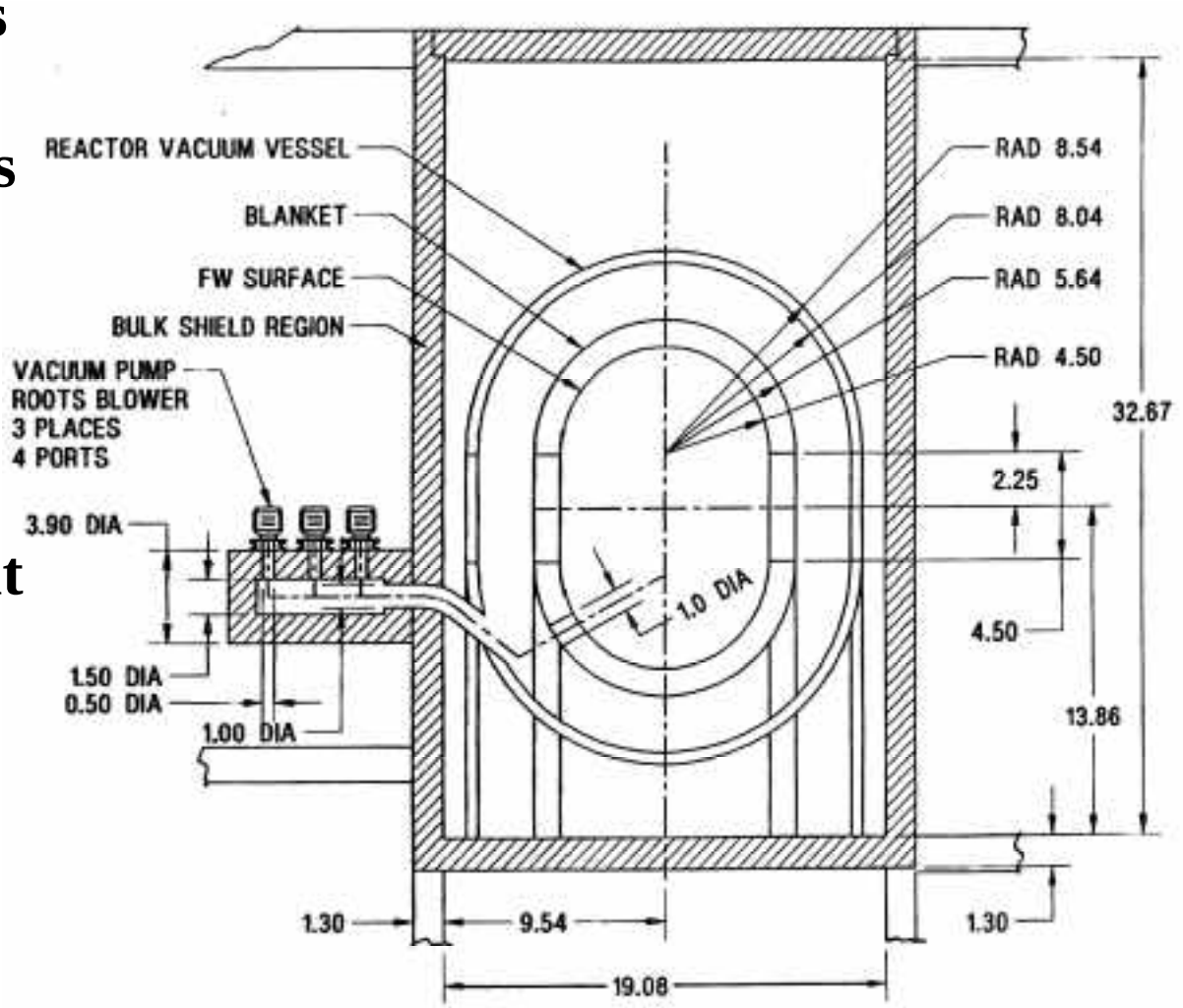


Figure 6.3.1-33. Prometheus-H Elevation of Central Reactor Cavity Region

Power Core and Heat Transport Systems

- Shield closely fits around Vacuum Vessel
- The hemi-spherical top of the power core containing most of the plumbing is removable.
- The cylindrical first wall and blanket panels are in five separate sectors
- Life of FW was 5 y and the blanket was 10 y as determined by neutronics

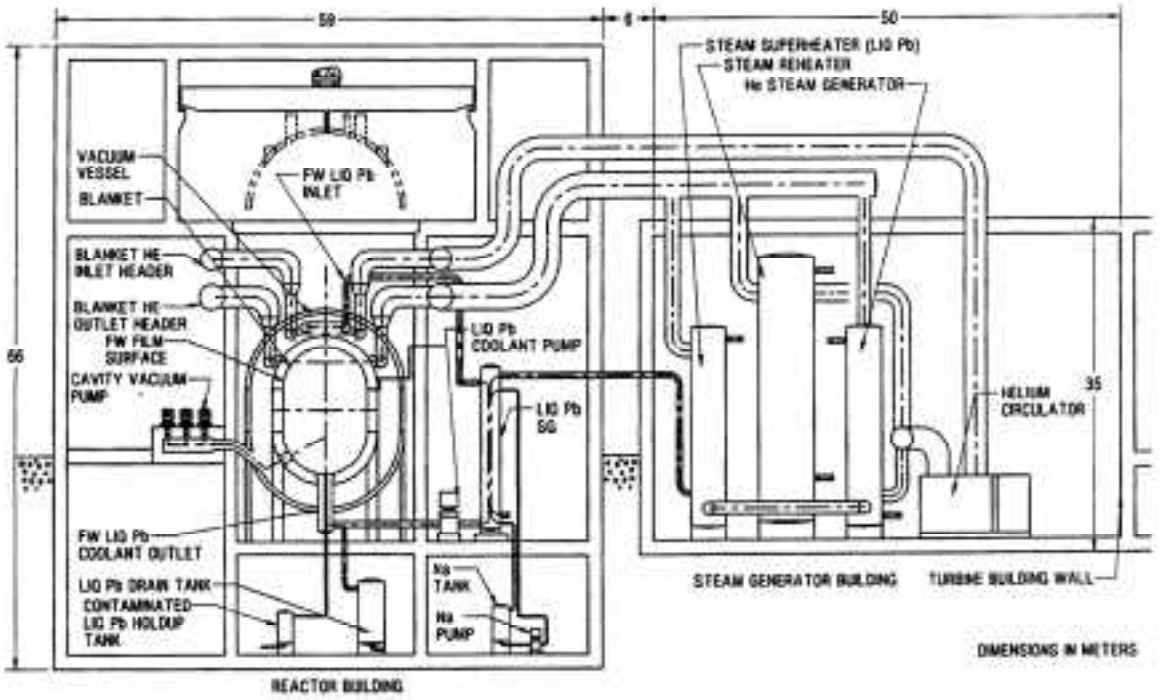


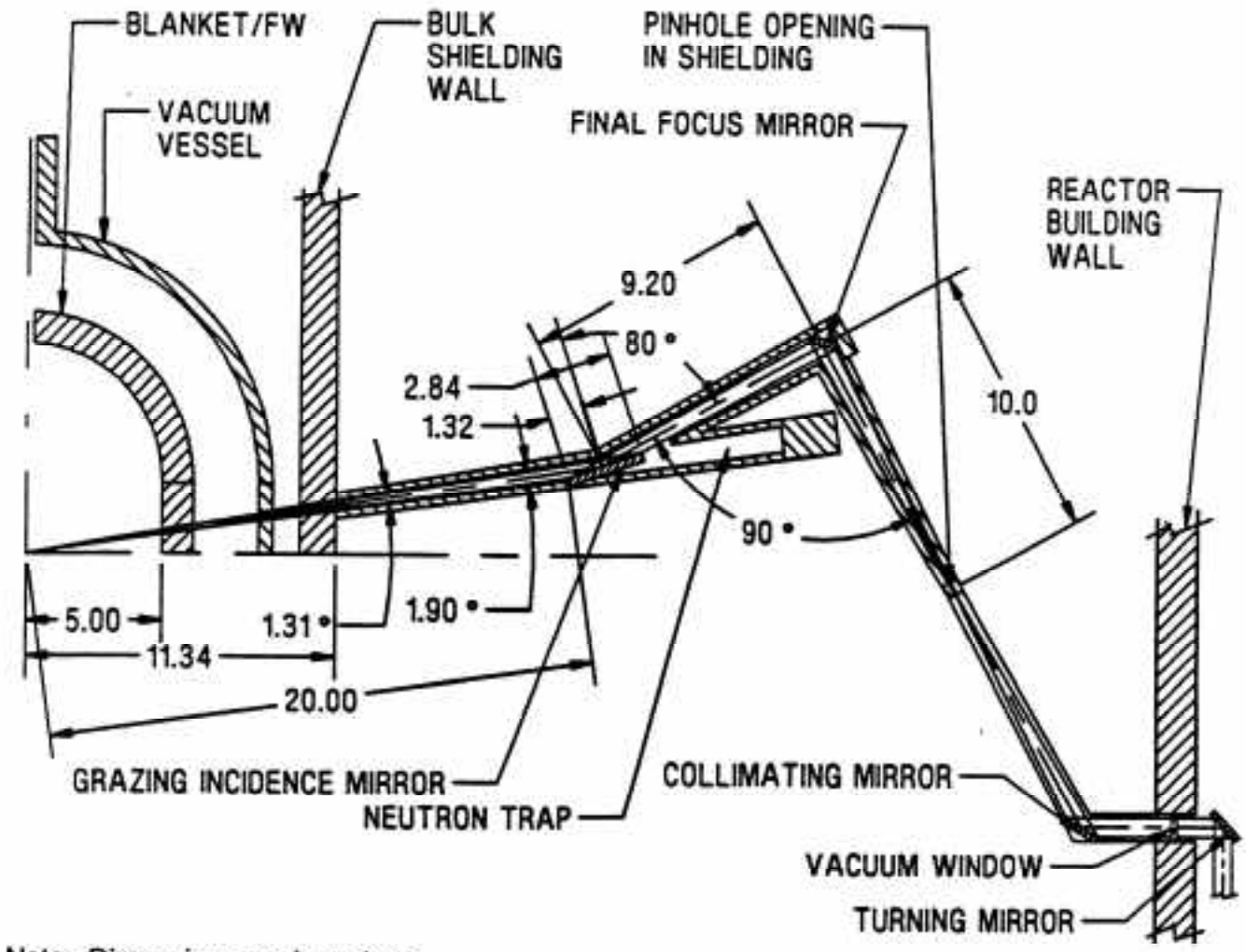
Figure 6.3.1-32. Elevation View – Reactor Systems/Heat Transport Interface

Summary

I hope this review contains some ideas that may useful in the development of the ARIES HI approach.

Reference Material to Support Laila's Presentation

Prometheus-L Laser Layout



Note: Dimensions are in meters.

Figure 2.4-7. Final Optics Configuration-Reactor Building

SOMBRERO Laser Layout