Review of NFMCC Studies 1 and 2: Target Support Facilities

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Meeting on High Power Targets

University of Oxford

May 1-2, 2008

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

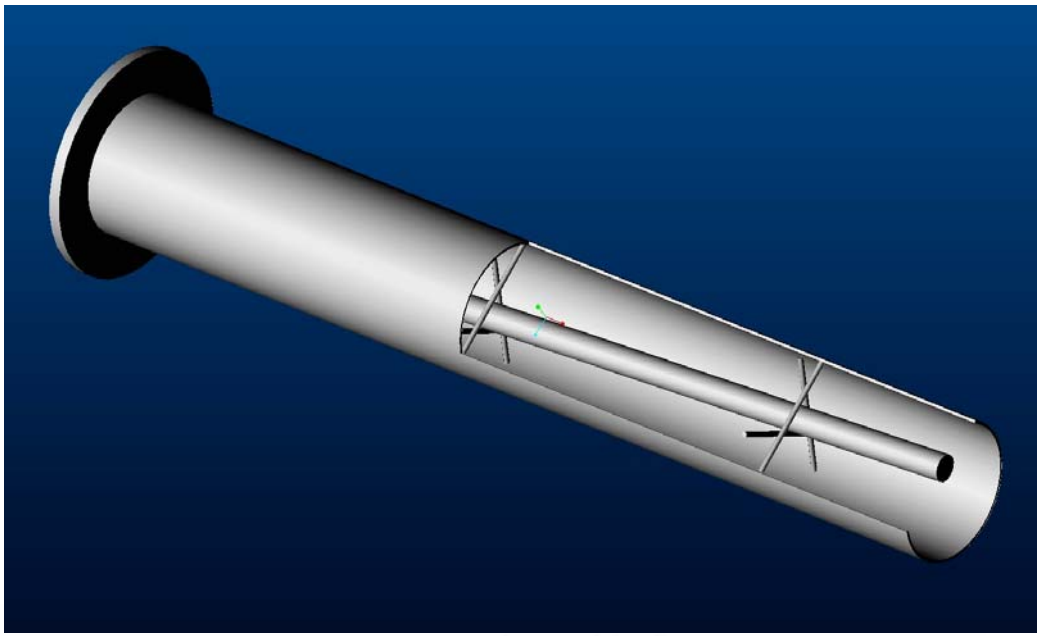
UT-BATTELLE

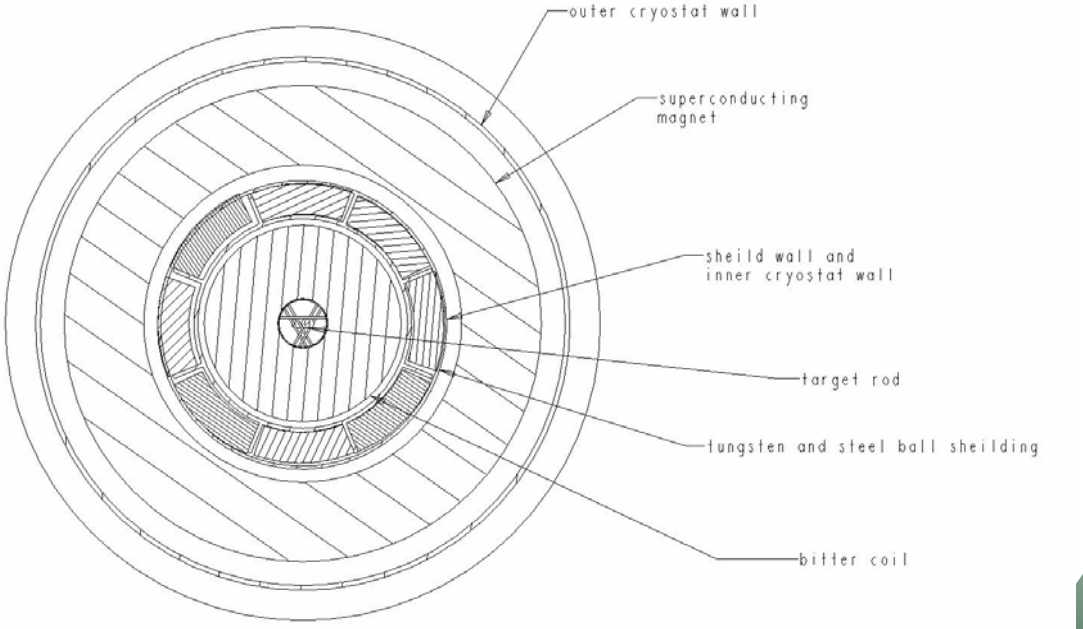
Neutrino Factory Studies

- **ORNL completed two studies describing support facilities for neutrino factories**
  - **2000, Graphite Target**
  - **2001, Mercury Jet Target**
  - **Included descriptions of targets, expected radiation, required shielding, remote handling systems, and rough cost estimates**
- **ORNL documents used as contributions to broader scope NFMCC documents**

Study 1 - Carbon Target

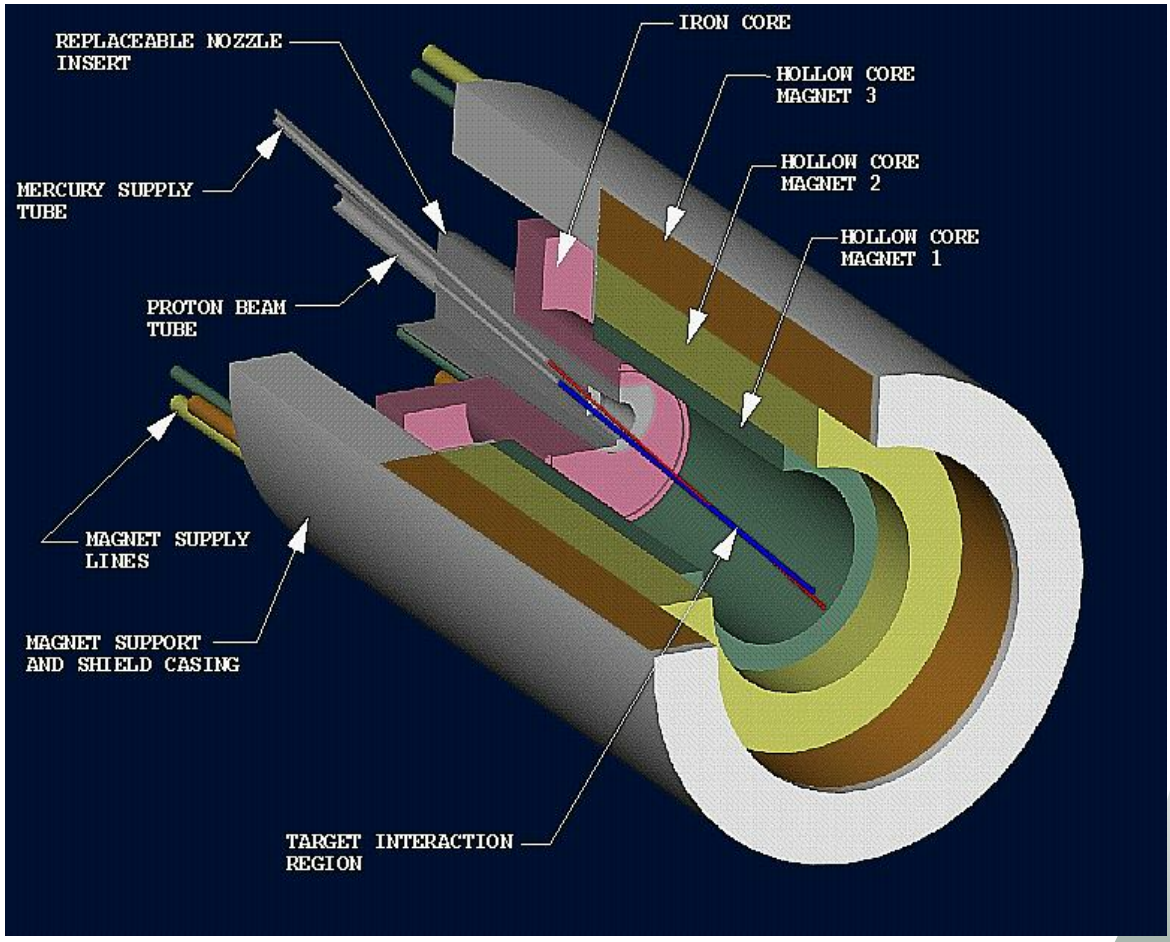
- **16 GeV, 1.5 MW proton beam**
- **1.5 cm diameter, 80 cm long graphite rod inside a helium environment**
- **Target held by two spoke-like graphite supports**
- **15 cm diameter containment tube**
- **20 T magnetic field**





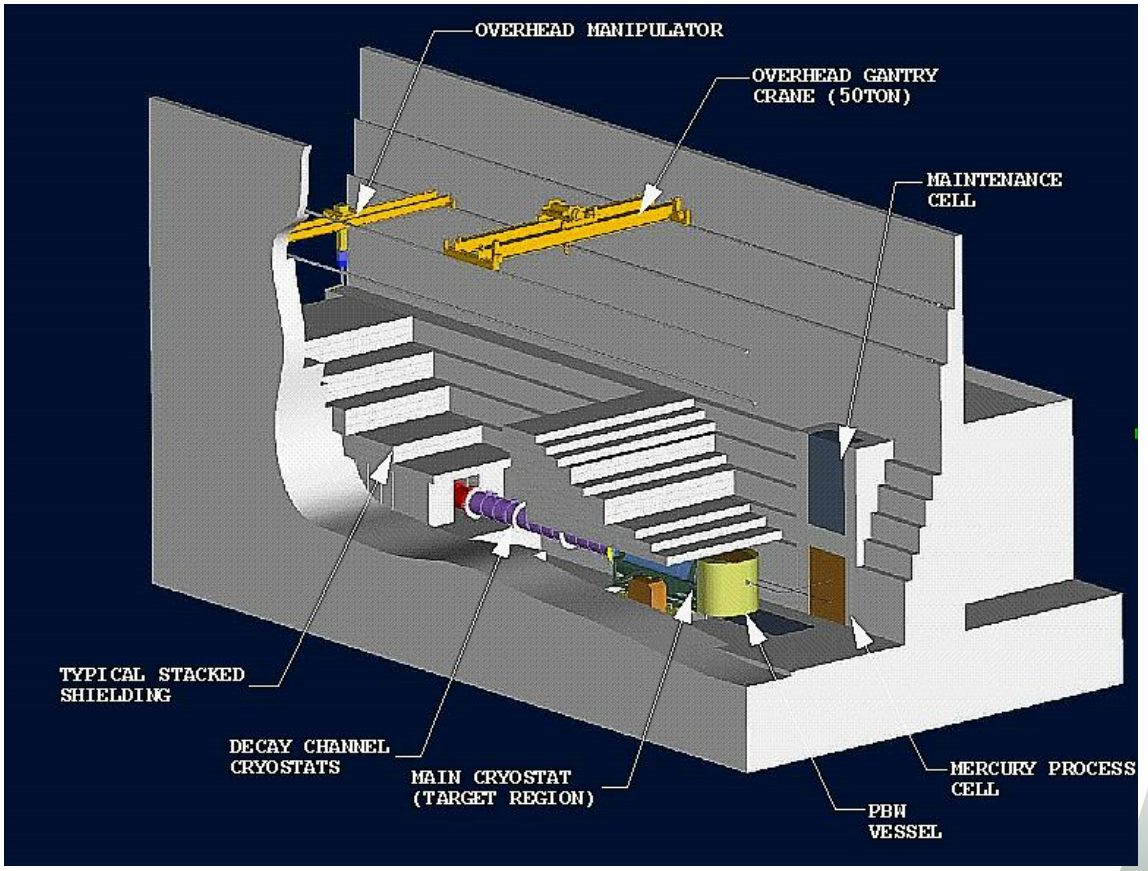
Study 2 – Mercury Jet Target

- **24 GeV, 1 MW proton beam**
- **1 cm diameter, 30 m/s jet**
- **20 T magnetic field**
- **Removable nozzle assembly inside an iron core**



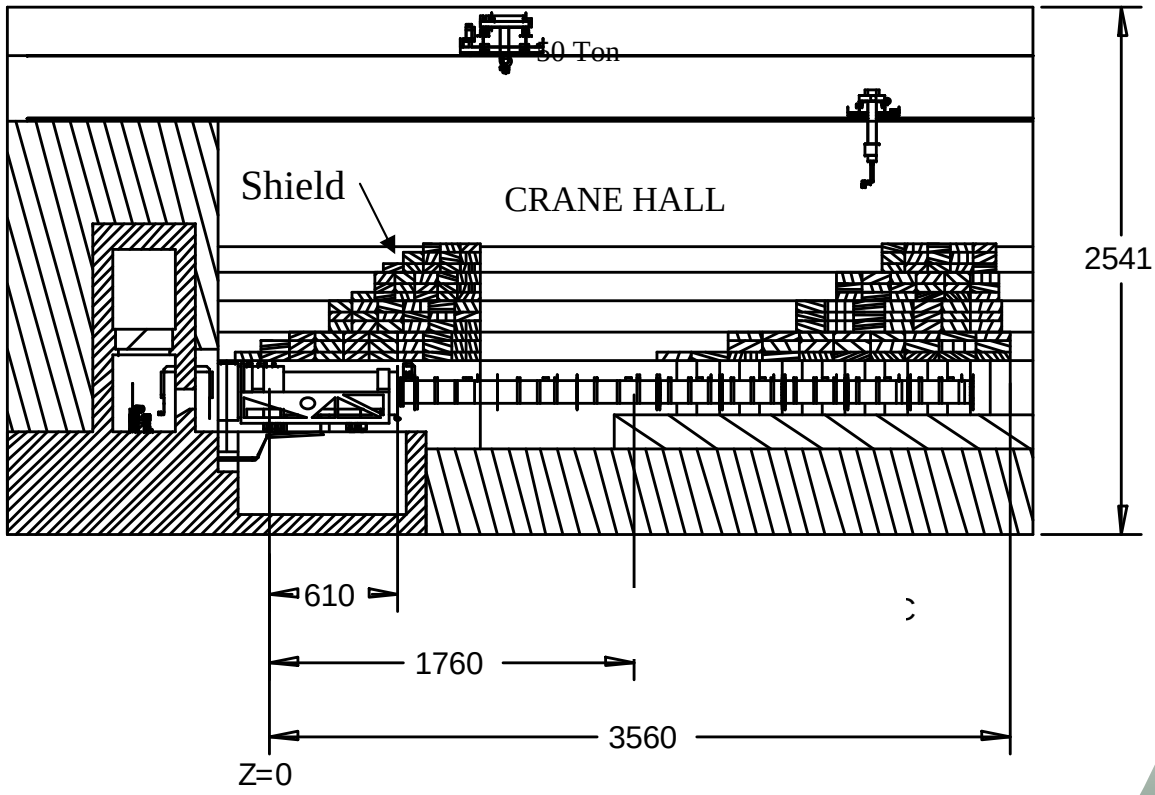
Study 2 Target-Capture Facility

- 24 GeV, 1 MW proton beam on Hg target
- Upgradeable to 4 MW
- 20 T target solenoids
- 1.25 T capture solenoids
- 5-m steel shield for unlimited personnel access
- Facility concept development
  - Beam, target parameters
  - Neutronic analysis
  - Shielding requirements
  - Equipment definition
  - RH requirements, crane sizing
  - Cost estimate



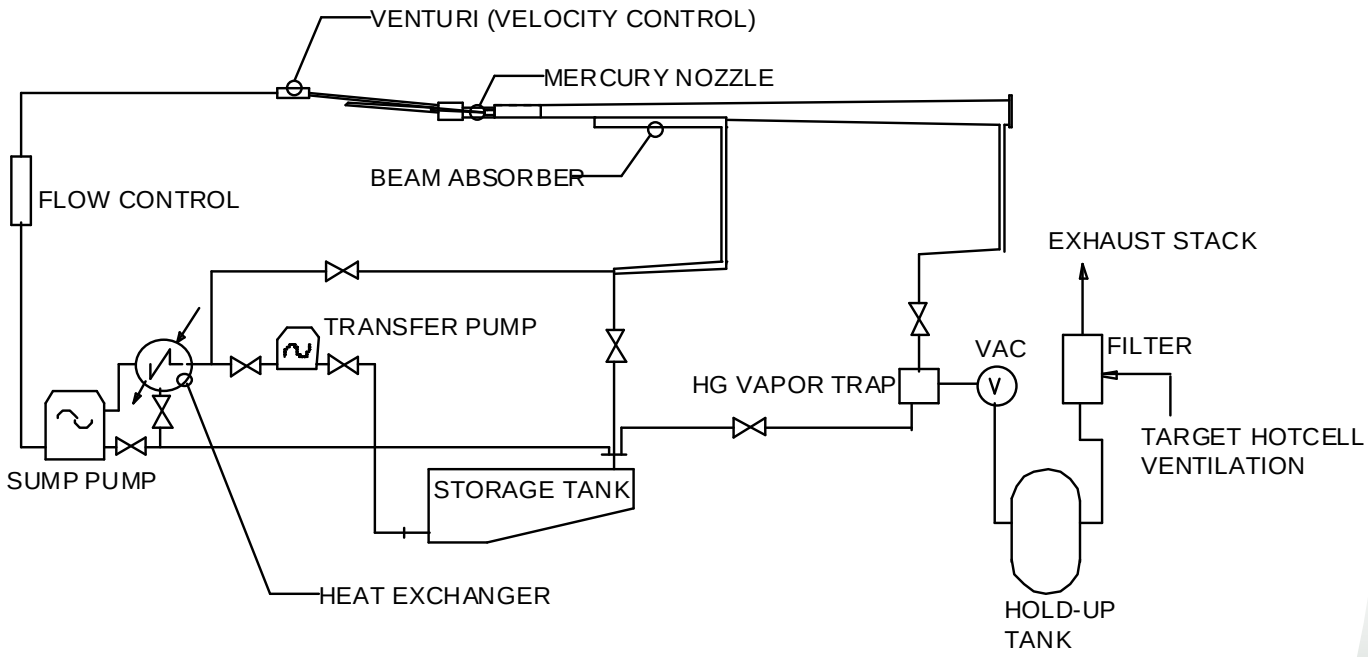
The Target/Capture Facility is 40-m Long

- **Removable, stacked shielding allows personnel in the crane hall**
- **50-ton crane and bridge manipulator are the primary remote handling tools**



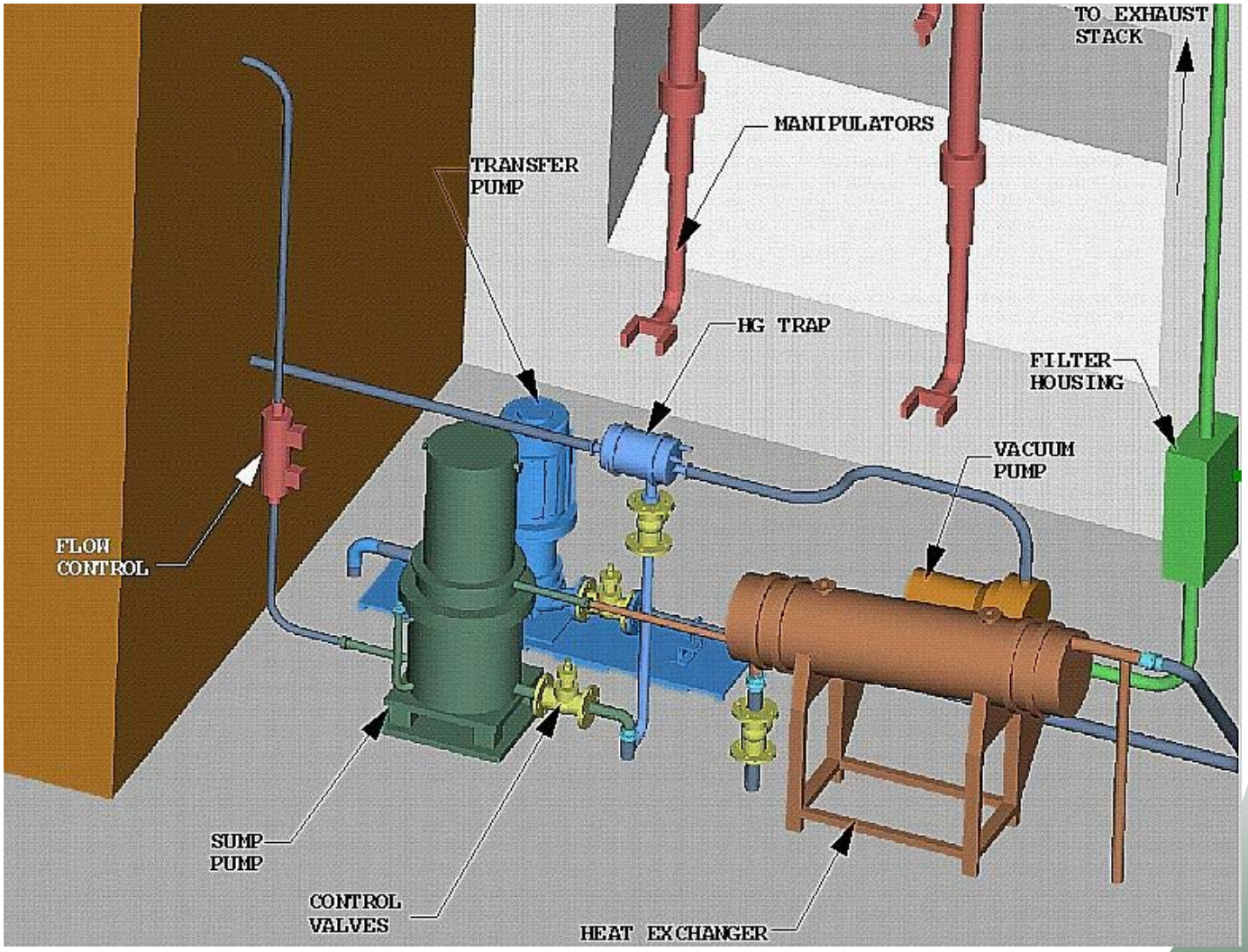
Hg-Jet Target/Beam Absorber is a Closed Loop System

- **Hg jet interaction region: r = 5 mm x 30 cm long**
- **110 liters of Hg total volume**
- **V = 30 meters/s**
- **Q = 2.4 liters/s**



Hg-Target Hot Cell

- **All components can be remotely replaced**



Maintenance requirements for the target system components

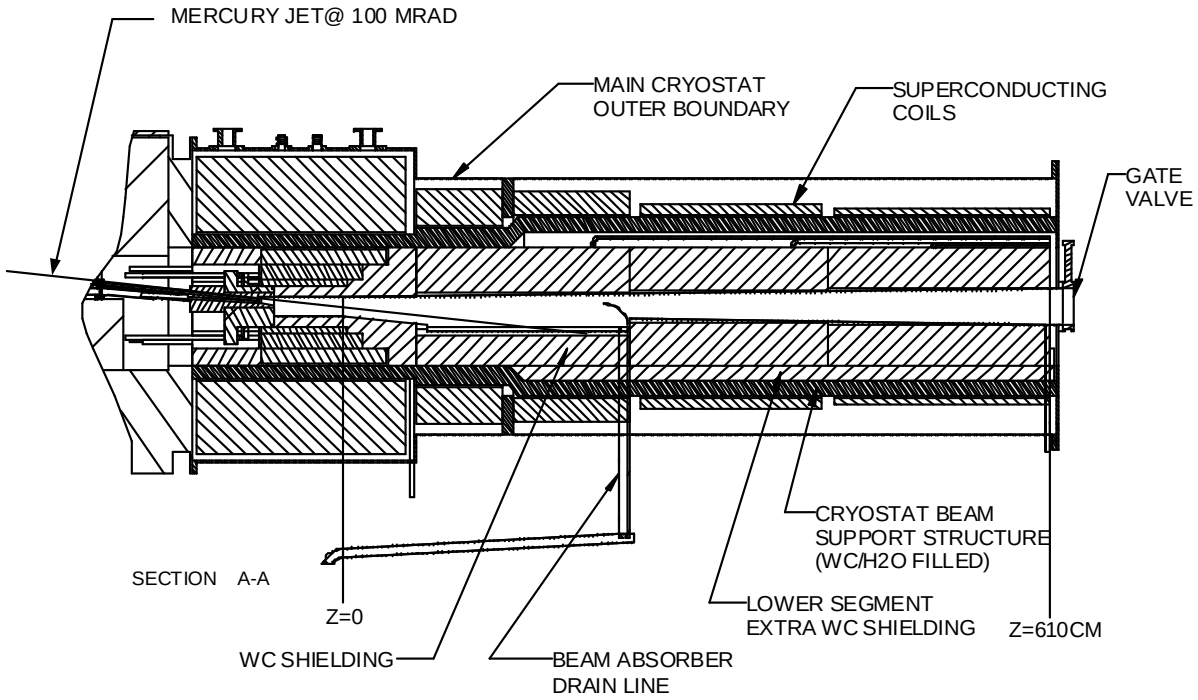
- **Most of the target system components are life-of-the-facility**
- **Key components are replaced every 2-3 yrs**

Component (Class)	Failure Mode	Dose Rate (Rad/h)	Expected Life (yrs)	Replacement Time (days)
Nozzle Insert	erosion, embrittled beam window	$>10^6$	2-3	11-16
Beryllium Window	embrittlement	$10^4 – 10^5$	2	7-11
Isolation Valve	mechanical	$10^4 – 10^5$	5-7	1-2 (plus time for beryllium window repl.)
Filters	saturated	Contamination	2	2-3
Pumps, Valves	mechanical	Contamination	5-7	2-3
Heat Exchanger, Piping, Tanks	mechanical	Contamination	> 40	5-8

* Based on assuming either 12-hour or 8-hour maintenance shifts.

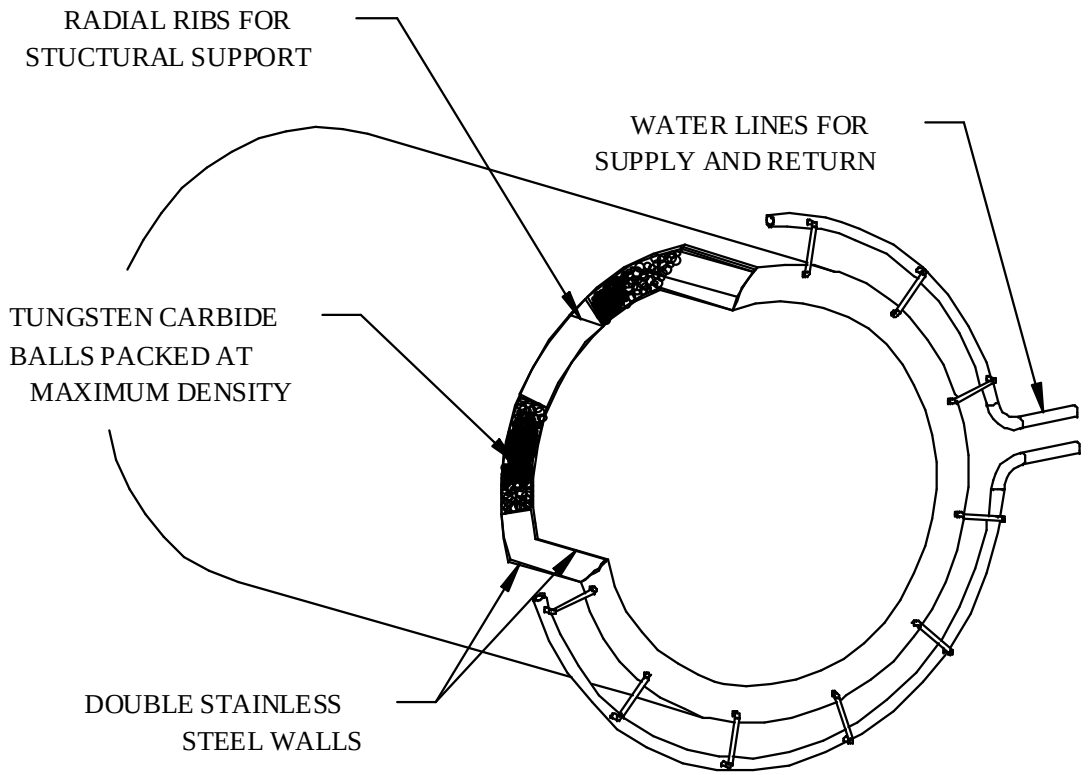
The Target and High Field Solenoids Are Contained in a Common Cryostat

- **The cryostat is a trunnion-mounted beam that simplifies initial installation of coil modules**
- **The resistive coils and target nozzle are mounted coaxially in the large SC solenoid**



Tungsten-Carbide Radiation Shielding Protects the Superconducting Coils

- **Solenoids are lifetime components**
- **W-C balls are 2-6 mm diam.**
- **Water-cooled flow channels**
- **Stainless steel shell and rib design**



TYPICAL SHIELD MODULE CONSTRUCTION

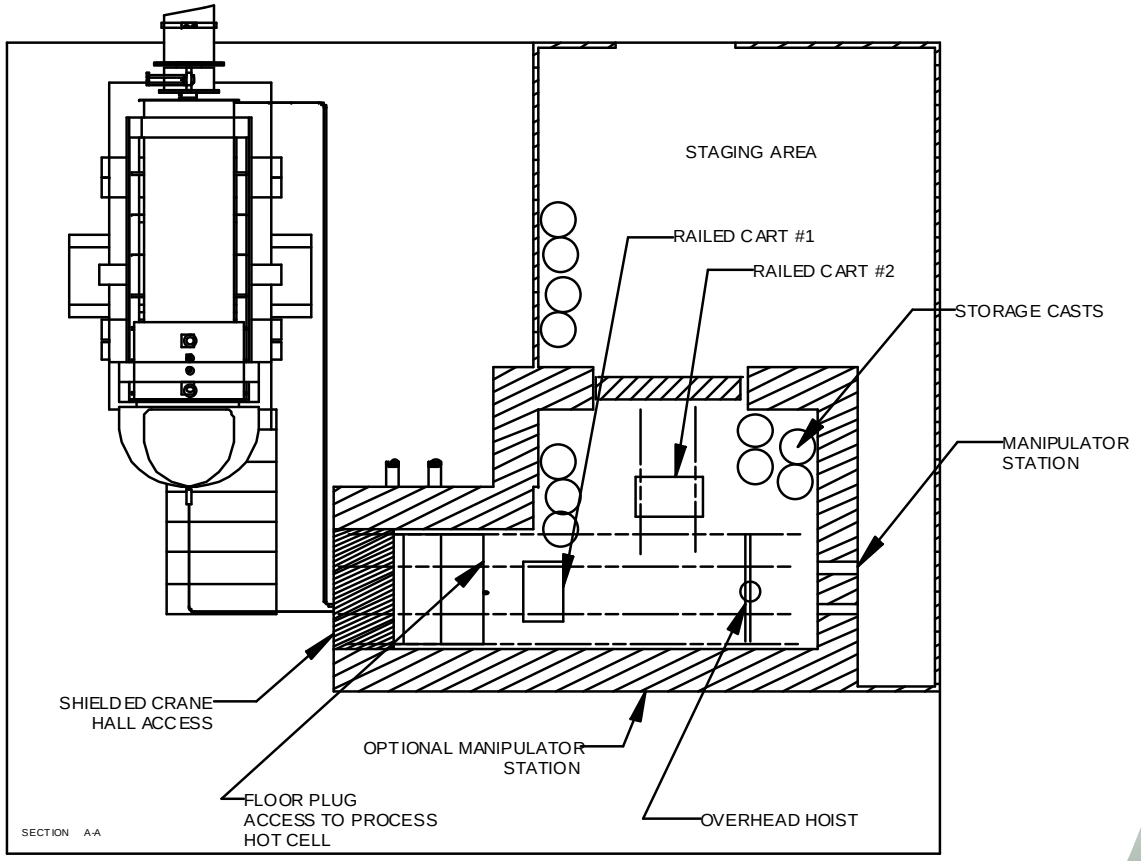
Component Weights and Sizes

- **Weight and size of major components established the facility dimensions and lifting requirements**

Component	Outer Diam. (cm)	Length (cm)	Module Wt. (lb)
Resistive Module	110	180	47,500
Iron Plug	-	-	-
HC1	-	-	-
HC2	-	-	-
HC3	-	-	-
W-C Shield	-	-	-
Main Cryostat + Shield Beam	270	740	73,600
SC1	256	178	61,000
SC2-3	202	183	21,700
2-3 Shield	128	183	59,600
SC4-5	176	351	17,900
4-5 Shield	148	351	86,400
SC6 + Shield	104	50	<4,000
SC7 + Shield	104	185	11,800
SC8 + Shield	104	185	10,800
SC9 + Shield	104	185	9,600
SC10 + Shield	104	185	8,400
SC11 + Shield	104	185	7,700
SC12 + Shield	104	185	6,600
Decay Coils + Shield (6)	87	296	12,600

The Maintenance Cell is Located on the Crane Hall Level

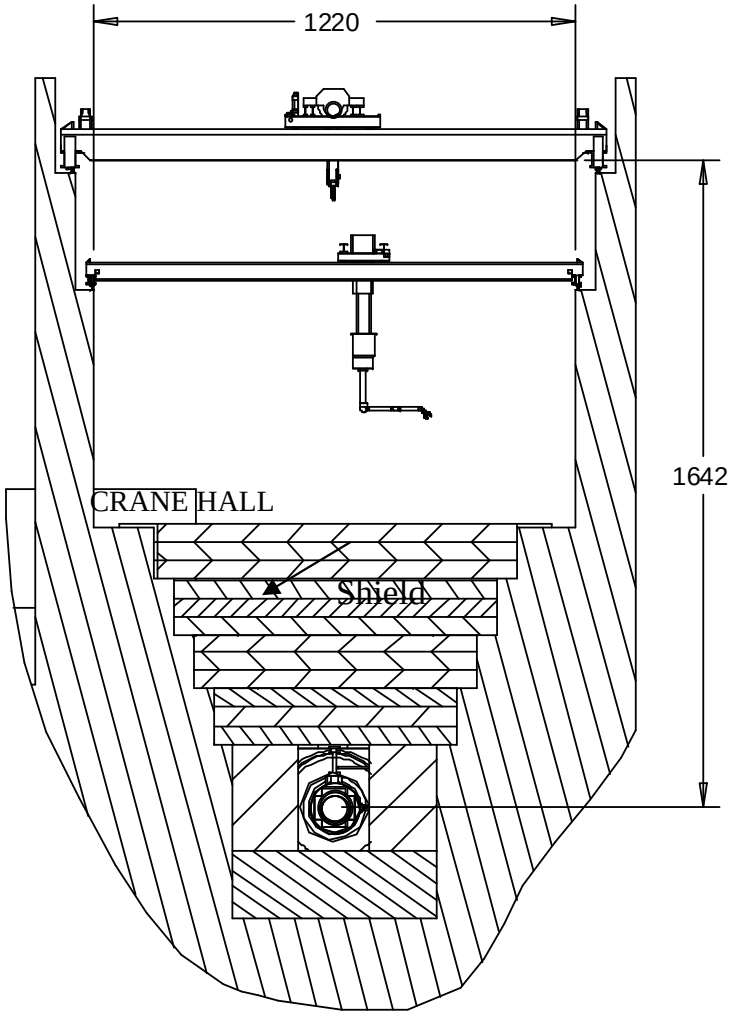
- **Sized for handling cryostat modules**
- **Located above the target hot cell with a hatch access**
- **Staging area for bringing new components into the crane hall**
- **Waste handling area**



Maintenance Cell Plan View

Unlimited Personnel Access is Permitted in the Crane Hall

- **5.2 meters of steel + 30 cm of concrete to limit worker dose to 0.0025 mSv (0.25 mrem/h)**
- **2 meters of steel in the tunnel to meet ground water protection requirements**



SECTION B-B
DECAY CHANNEL SHIELDING

R&D Issues Identified

- **Graphite target**
  - **Detailed target design**
  - **Beam dump design, incl. coolant connections/piping**
  - **Utility connections in target region**
  - **Details for helium environment, purge air**
- **Mercury jet target**
  - **Thermal mixing of pool by jet**
  - **Nozzle erosion**
- **Shielding for high-field solenoids (W-C spheres)**
  - **Ball distribution**
  - **Pressure drop**
  - **Heat transfer coefficient**

Summary

- **Previous studies provided concepts for Target Support Facilities based on graphite and mercury jet targets**
- **A logical method was used to determine facility size**
  - **The facilities were based on size and weight of the solenoids and the radiation shielding that protects the superconducting coils**
  - **Rad shielding was sized to permit unlimited worker access in the crane hall**
  - **The decay channel (tunnel) is shielded to meet ground water protection requirements**
- **Remote handling systems were incorporated into the facility design even at the early conceptual stage**