UT-BATTELLE

MERIT Hg System Final Design Review

Hg Target System Operations

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MERIT Collaboration Meeting

MIT Plasma Science & Fusion Center

Oct 5, 2005

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

Outline

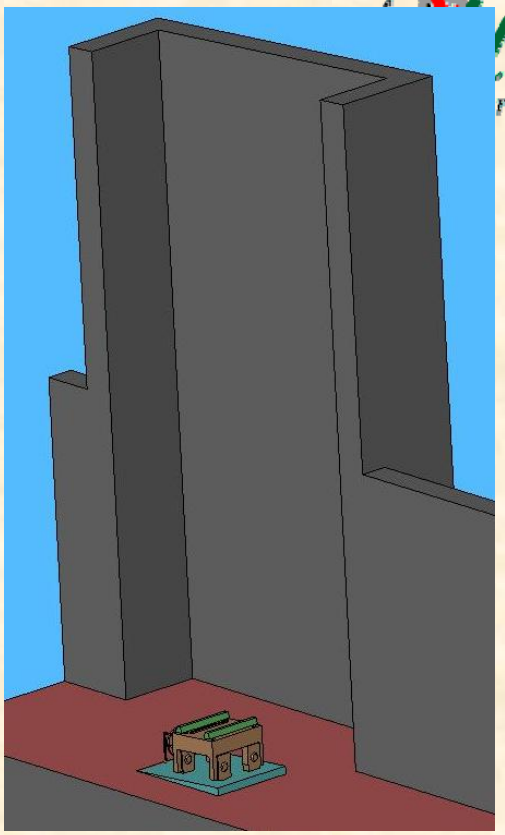
- **Facility constraints**
- **System installation**
  - **Components in TT2A**
  - **System assembly & alignment**
- **Hg handling & filling**
- **Off-normal conditions**
- **System removal and decommissioning**
  - **System disassembly**
  - **Hg drain**
  - **Prepare for shipment**

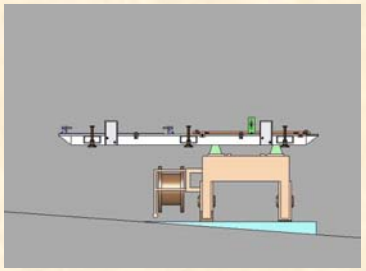
Facility Constraints

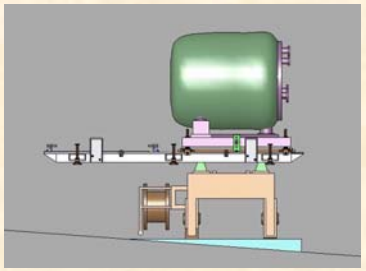
- **No overhead lifting capability within tunnel**
- **Modularity required**
  - **Component footprint size limitation is 1.3m x 4.4m**
- **40cm step traversal required to enter TT2A**

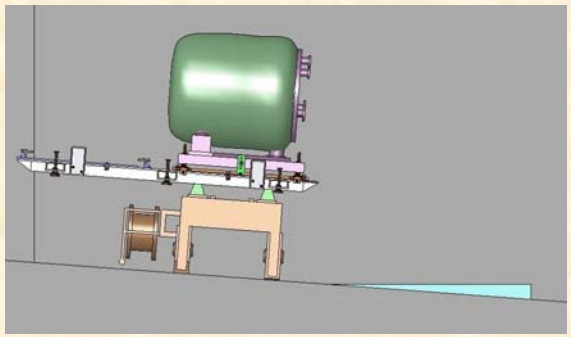
Components into TT2A

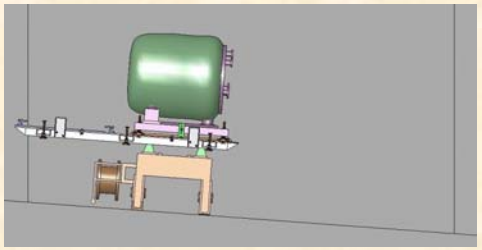
- **Mobile crane used to lower equipment from ground level to pit floor**
- **Hilman rollers or on-board casters allow component transport**
- **CERN "turtle" available as needed**
- **Prefer to use cable ratchet to control travel down slope**





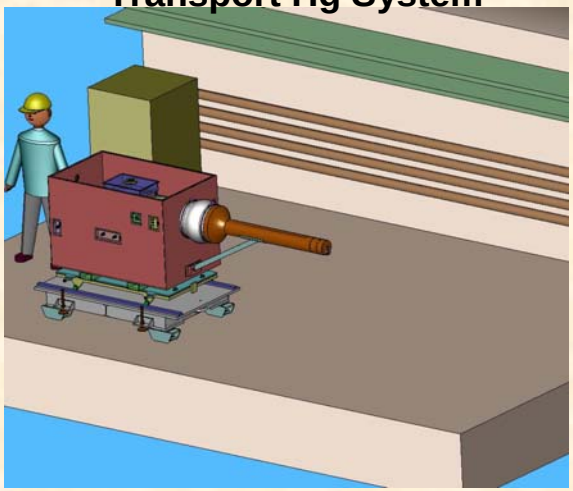




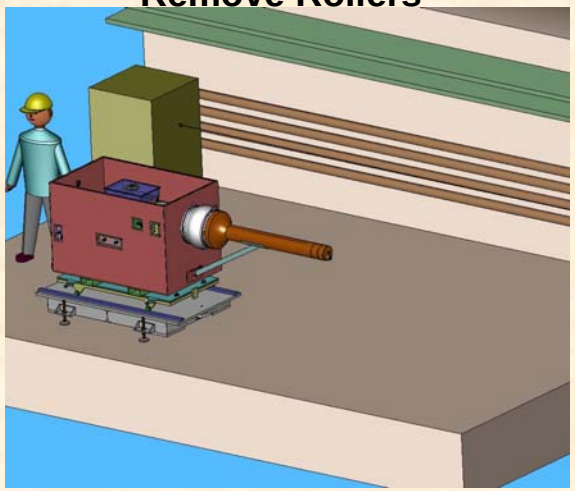


Installation Sequence Part 1 (Out-of-beam)

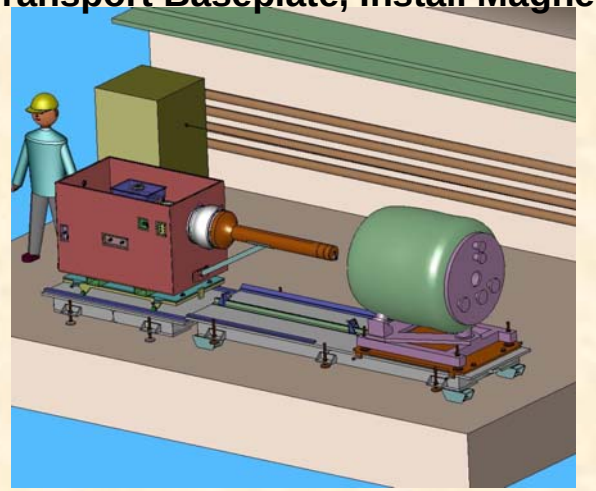
Transport Hg System

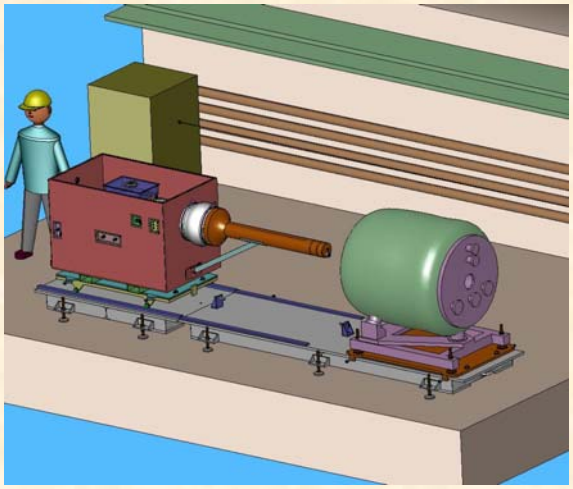


Remove Rollers

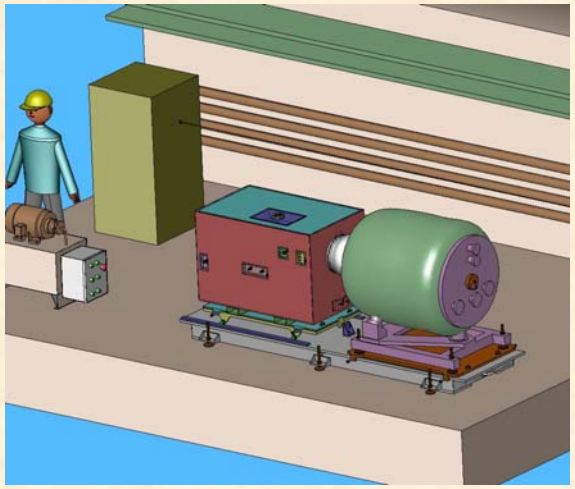


Transport Baseplate, Install Magnet

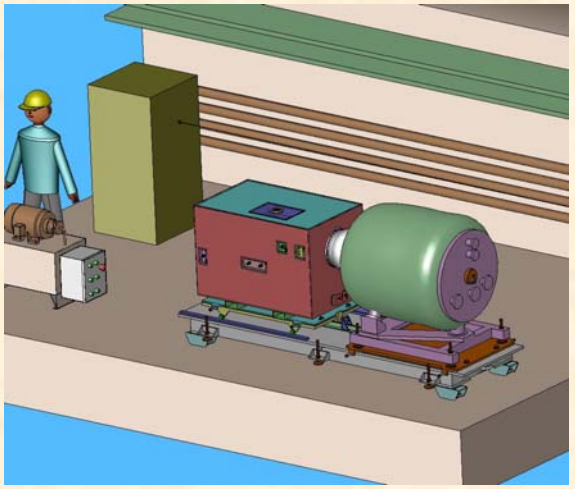




Remove Rollers, Level Magnet



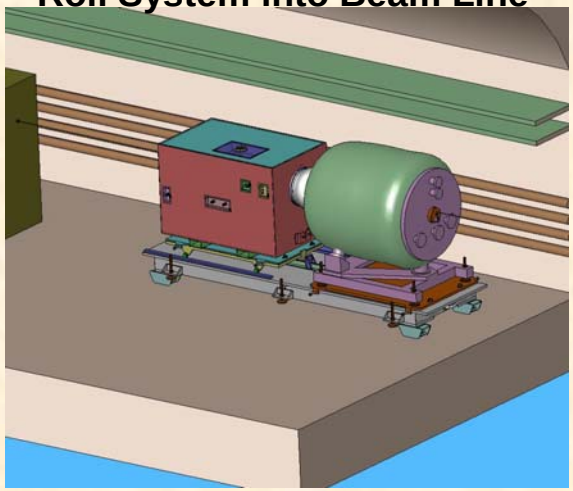
Roll Hg System into Magnet



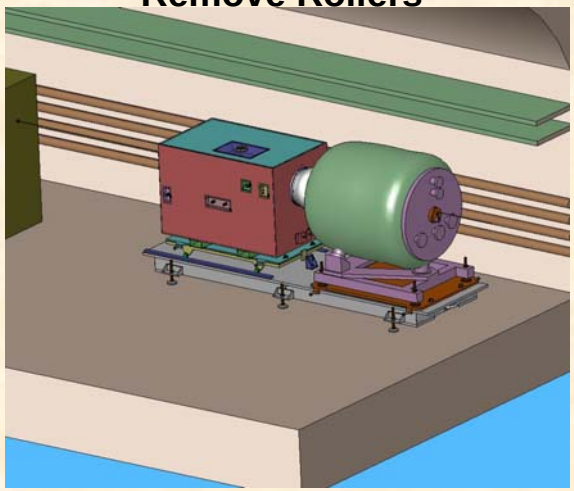
Add Rollers

Installation Sequence Part 2 (In-beam)

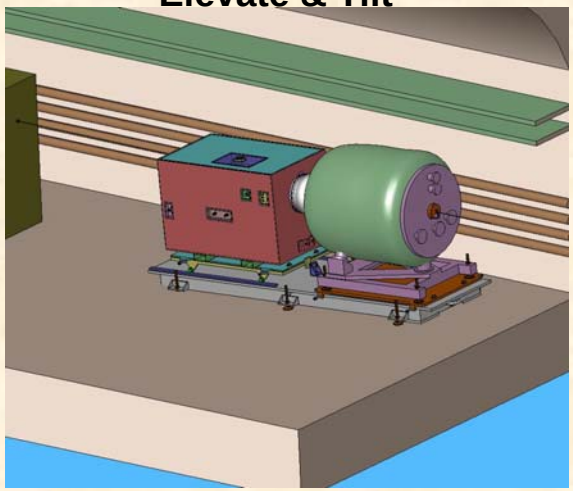
Roll System into Beam Line



Remove Rollers



Elevate & Tilt



- **Baseplate & magnet will go in beam line prior to Hg system**
- **Blocks under magnet end to provide adequate tilt**

Alignment to Beam

- **Fiducials assumed to be on magnet baseplate and Hg system secondary containment sleeve**
- **Gross alignment with Hilman rollers**
- **Fine alignment with baseplate alignment mechanisms for magnet & Hg cart**
- **Precision alignment using CERN beam locators**
  - **May still require fine tuning after first few beam pulses**
- **May need secondary/magnet interface bracket to prevent nozzle movement**

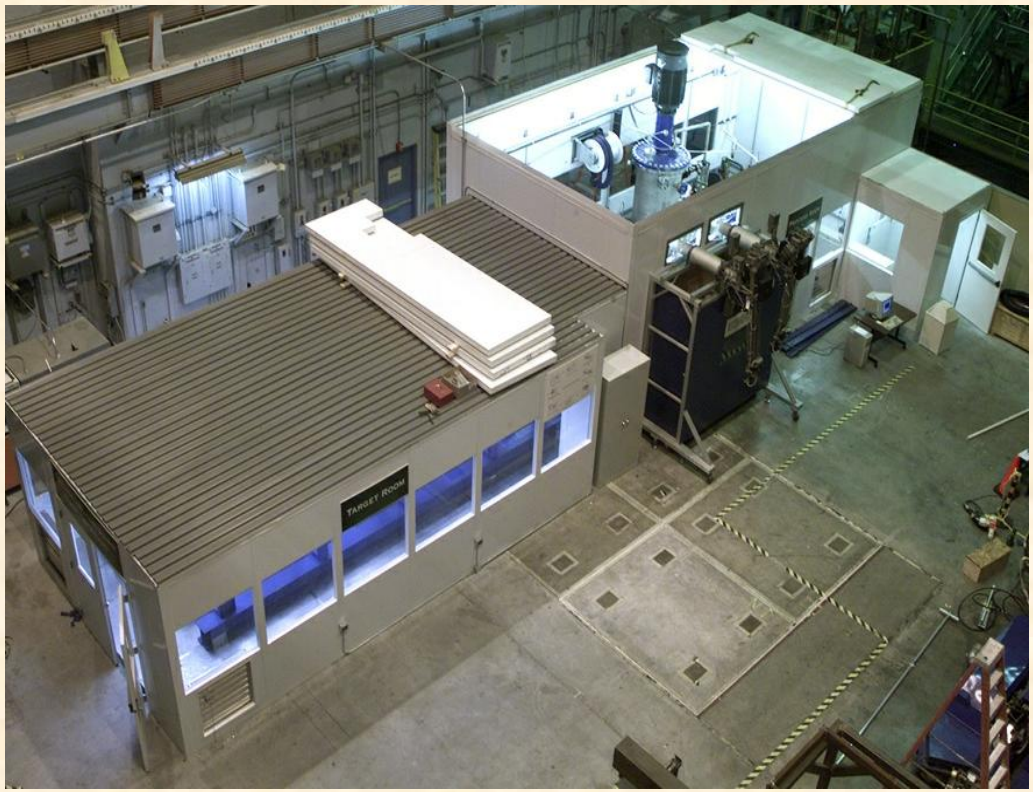
Hg Handling Issues

Properties, Safety Limits, Standards

- **Atomic Weight: 200.59**
- **Boiling Point: 357 degree C**
- **Specific Gravity: 13.6**
- **Vapor Pressure: 0.0012 mm Hg**
- **Vapors: colorless, odorless**
- **Solubility: insoluble in water**
- **NIOSH/OSHA limits: 0.05 mg/m^3, 10 h/day; 40 h/wk**
  - ***ORNL: 0.025 mg/m^3, respirators at 0.012 mg/m^3***

The Target Test Facility (TTF) - Basis For ORNL's Hg Handling Experience

- **Full scale, prototype of SNS Hg flow loop**
- **1400 liters of Hg**
- **Used to determine flow characteristics**
- **Develop hands on operating experience**
- **Assess key remote handling design issues**



TTF Pump Room and Target Room

- **75 Hp centrifugal pump**
- **Nominal flow at 1450 liters/min (380 gpm)**
- **Completed several major equipment upgrades for piping and target configuration**

TTF Hg Loading

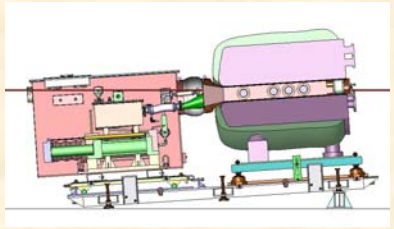
- **TTF vacuum pump was used to transfer Hg directly into the storage tank from 540+ flasks**
  - **Peristaltic pump available as backup**

Proper PPE Is Mandatory

- **Overalls, gloves, and overshoes are the minimum requirement for TTF loop maintenance**

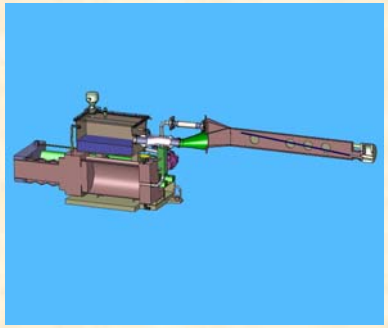
Operational Issues

- **Is special notification required at MIT for Hg operations for integrated systems testing**
  - **The schedule shows a safety review and target test plan to be presented to MIT staff in Feb. 2006**



- **Will CERN provide the third vapor monitor for sampling the tunnel environment?**
  - **Who is responsible for monitoring the tunnel?**

- **Will MIT and CERN provide support for repackaging the target equipment and Hg for delivery back to ORNL?**

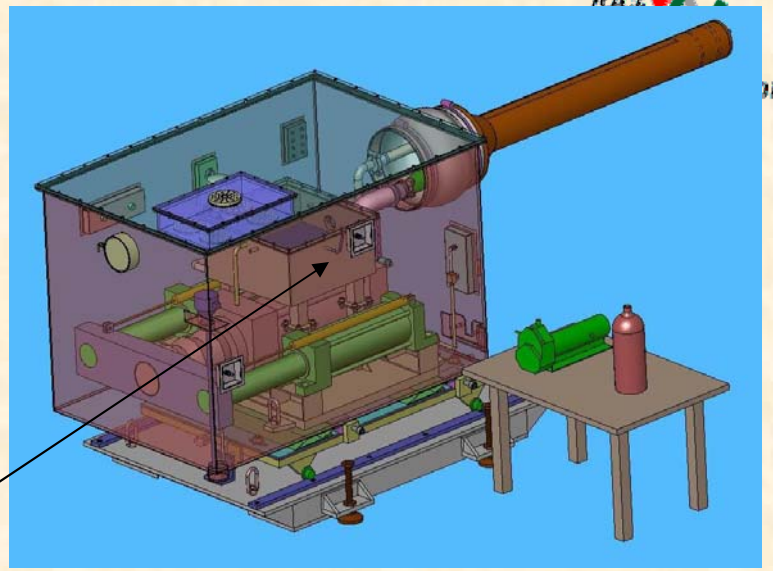


Hg Loading

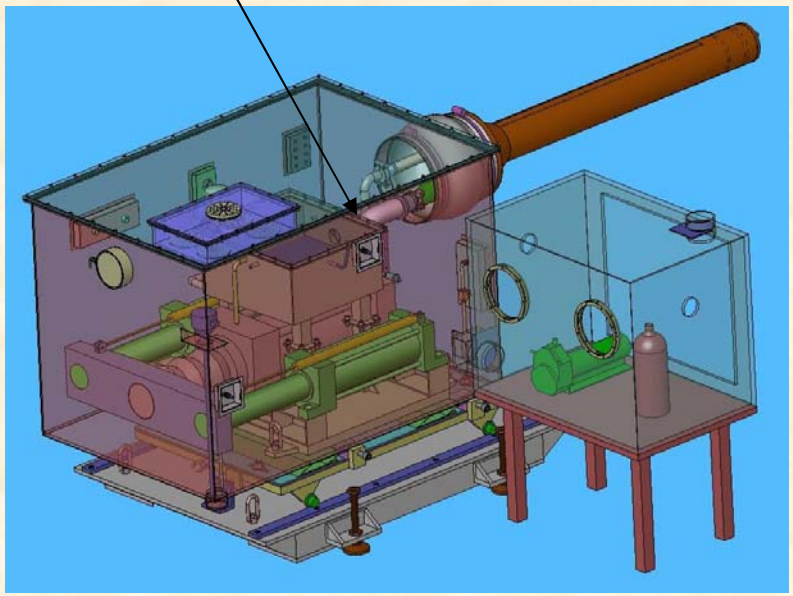
- **A glove box could be required for unloading Hg at the completion of testing if refilling flasks is not permitted outside of the secondary containment**
  - **Consider use of snorkel near flasks in lieu of glove box**

Hg Loading Operation

- **Secondary containment cover remains installed**
- **Pump into sump tank**
  - **Air displaced from sump tank vented through secondary passive filtration**
- **Hg vapor control with snorkel**
- **Glovebox used if required**

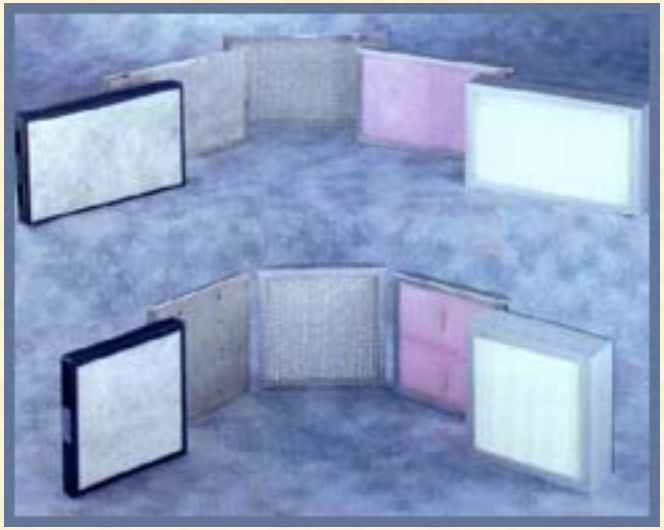


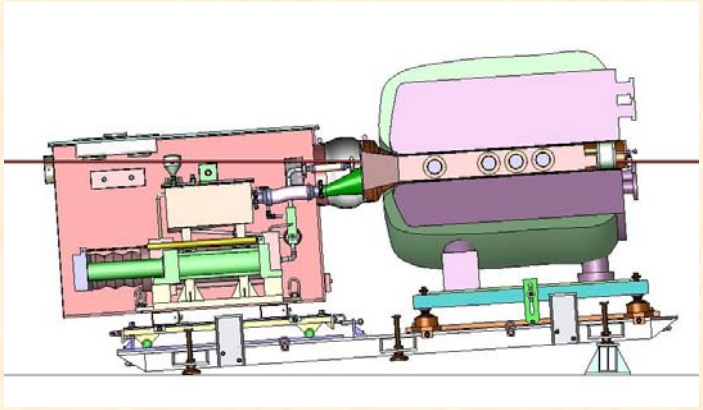
Inlet port



Filter Replacement

- **Effectively requires breaching the secondary containment**
- **Filter pack will be covered by a plastic bag taped in place**
- **Snorkel will be placed adjacent to the filter**
- **Monitor # 3 will be used to sample air in the filter region**





Estimate For Filter Lifetime

Saturation Pressure

$$\log P_{sat} = -3105.5 / T_{0\,K} + 4.9294 \quad \text{(bar)}$$

Saturation Concentration

$$C_{sat} = 2.445 P_{sat} / T_{0\,K} \ (\mathrm{Kg_{Hg}/m^3}) \qquad (P_{sat}\,mbar)$$

Ref. Quechsilber und seine Gefahren, Swiss government worker safety report, SBA No. 145, Luzern

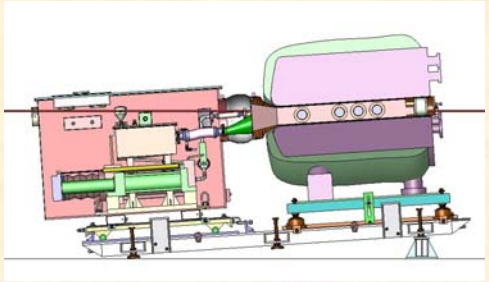
- **Flow Rate 110 cfm**
- **Temp. 25 ^{0}C**
- **Filter Effic. 99.0%**
- **Filter Weight 6 lbs**
- **Filter Satur. 12%**
- **Filter Life 185 hrs**
  - **Does not incl. reduction for humidity**

Selected Off-Normal Events and Recovery

- **We need to address credible off-normal occurrences and recovery**

1. **Small spill (1 ml) or vapor leak into the secondary containment verified by vapor monitors # 1 and # 2**
   - **Continue to operate to the expected limit of the filter lifetime based on the measured vapor concentration-analysis**
     - **Monitor for changes to vapor readings in the secondary enclosure**
     - **Monitor air in the tunnel for indications of vapor**
       - **if none, continue testing**

Note: If only one monitor registers vapors – could be a false-positive; continue to operate if #3 reads <0.0125 mg/m³



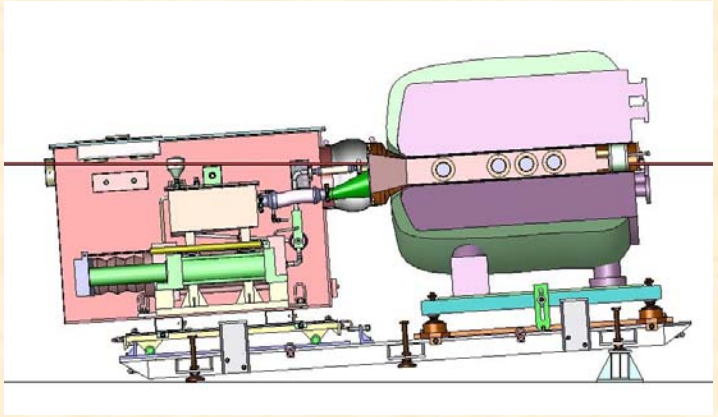
Off-Normal Events (cont.)

2. **Medium spill (100 ml) into secondary containment verified by vapor monitors # 1 and # 2**
   - **Continue to operate to the expected limit of the filter lifetime based on measured vapor concentration-analysis**
     - **Monitor for any changes to vapor readings in the secondary enclosure**
     - **Monitor air in the tunnel for indications of vapor; if none, continue testing**
     - **If approaching limit of filter life consider connecting the snorkel to extend the time of operation, if that allows completion of the test program.**

(Note: Connecting the snorkel may require a waiting period of one or more days for a safe activation level; therefore the snorkel may be already connected but not turned on.)

Off-Normal Events (cont.)

3. **Full inventory spill into the secondary containment**
   - **Monitor target instruments for clues to the source of leakage**
     - **Verify by checking sump tank level sensor, conductivity sensor, and nozzle pressure sensor**
   - **Cease operations, wait for cool down to visually inspect**
   - **Monitor air in the tunnel for indications of vapor**
   - **Seal inlet and outlet vents on secondary enclosure**
   - **Wait for additional cool down to permit hands on recovery and storage of Hg.**



Off-Normal Events (cont.)

4. **Vapors detected outside of secondary containment by monitor # 3 - assume the secondary containment is breached or that the filter is saturated**
   - Confirm with readings from #1 and #2 vapor monitors
     - If confirmed … cease operations
     - If not confirmed … continue operations
   - Monitor target instruments for clues to the source of leakage
     - verify by checking sump tank level sensor, conductivity sensor, and nozzle pressure sensor
   - Wait for cool down, visually inspect and sample local air
     - If levels are above safe limit (0.025 mg/m^3 ??), inspect with full face mask-Hg respirator cartridges
   - Repair breach in enclosure if possible, pressure check, continue test operations

CERN limit ?? mg/m^3

OSHA limit 0.050 mg/m^3

ORNL limit 0.025 mg/m^3

TTF limit 0.0125 mg/m^3

Miscellaneous Equipment For The Target System

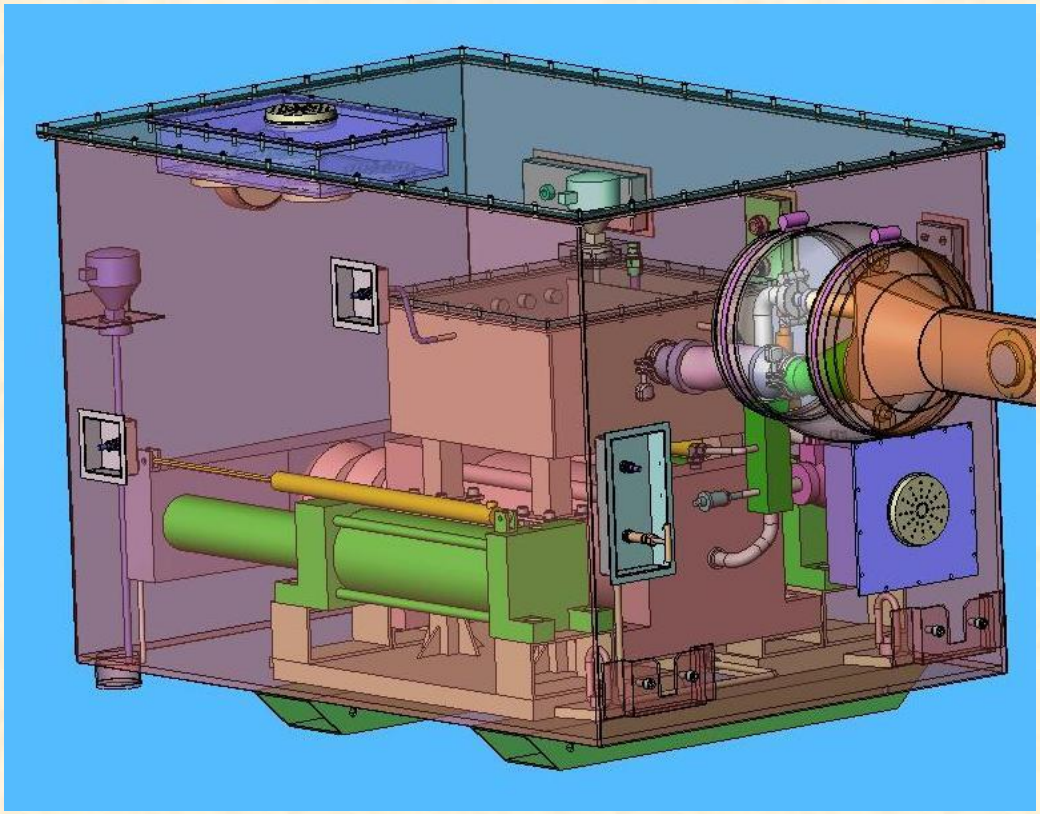
Large Items	Small Items
Vacuum Cleaner – Dry	Merc-X Cleaning Solution
Snorkel	Sponges
2 Vapor Monitors	Plastic Buckets
Spare Filters (qty. TBD)	Plastic Pans
Glove Box	Gauze – roll
Vacuum Pump ?	Small Tools
	Vinyl Tape
	Herculite
	Plastic Bags – asst'd (1 gal. – 20 gal.)
	1-liter plastic bottles
	Lab Coats
	Tyvek Hooded Suits
	Nitrile Gloves
	Full Face Mask/Respirator Cartridges

Post-Experiment Operations

- **The target equipment (and the solenoid) will have neutron-induced activation**
- **Based on (H. Kirk 9/01/04)**
  - **200 pulses**
  - **16 x 10^{12} protons/pulse (avg.)**
  - **30 days of operation**
  - **Contact dose rate on the iron exterior will be:**
    - **after 1 hr 40 mrad/hr**
    - **after 1 day 21 mrad/hr**
    - **after 1 week 13 mrad/hr**
    - **after 1 mo. 5 mrad/hr**
    - **after 1 year 1 mrad/hr**
  - **Sergei Striganov (FNAL) performing separate analysis**
- **Move experiment out of beam line several days after conclusion, minimizing operator time near equipment**

Hg Draining

- **Extract Hg & prepare for shipment after several month cool-down**
- **CERN requirement that secondary containment not be opened during draining**
- **Will be trapped Hg in extraction tube, flex hoses, Hg cylinder, plenum**



Disassembly Operations

- **ORNL will take back the Hg target system and the activated Hg and components**
  - **Is hydraulic system and fluid activated, or can we adequately shield?**
- **Hopefully other uses for system will emerge**