Mercury Intense Target (MERIT) Update

Status of the Target System Design

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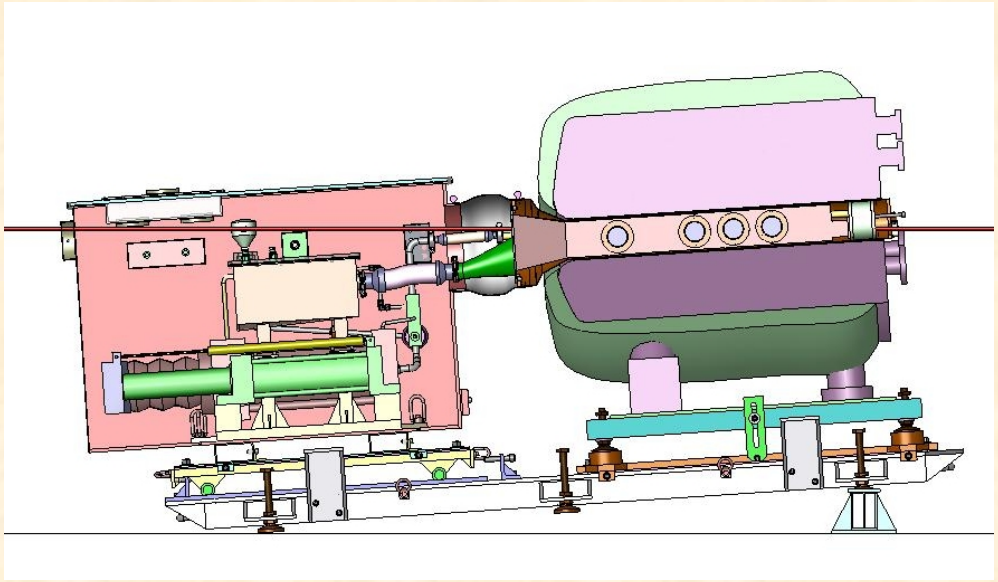
Muon Collaboration Friday Meeting

October 28, 2005

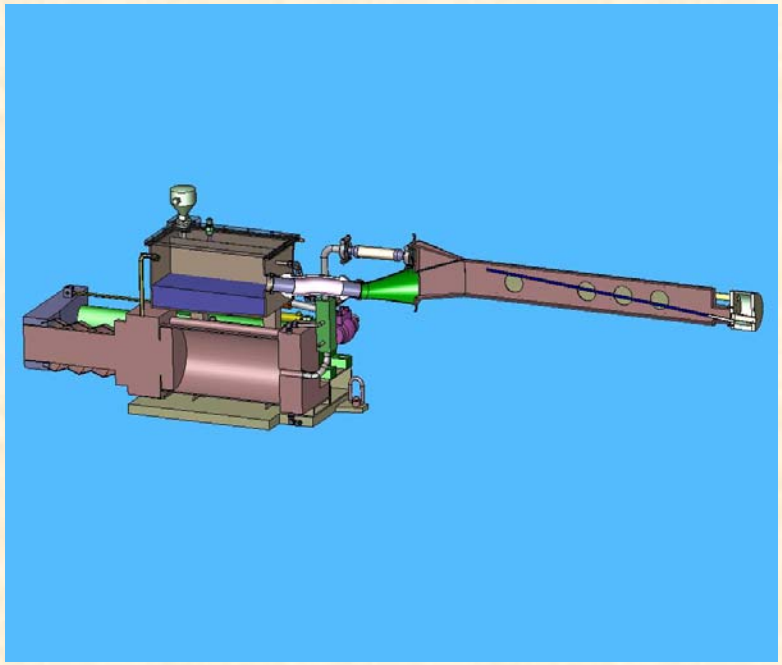
OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

Design Review in July for Syringe; Design Review in Oct. for Remainder of Equipment



Cutaway view of the target and solenoid

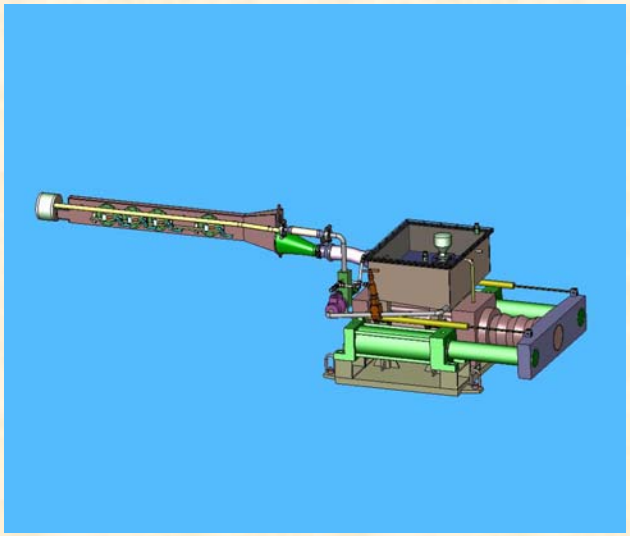
Cutaway view of the target system



Design Approach – Two Design Packages to Expedite Procurement

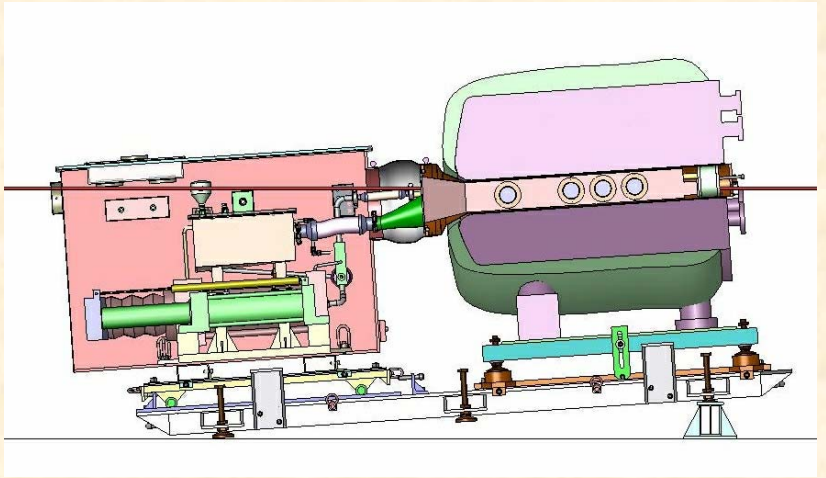
(1) Syringe Pump

- Syringe pump design replaced the original centrifugal pump due to the high pressure requirement for the system to deliver a 20 m/s jet
- Two hydraulic cylinders drive a Hg cylinder
- Stainless vs carbon steel cylinders
- Procurement underway thru BNL and the vendor chosen *(kickoff meeting with Airline Hydraulics Co. today!)*



(2) Target Delivery System

- Consists of primary and secondary containments, supports, sump tank, instruments, filtered vent, supply line, laser optic windows, and beam windows
- Procurement in November using BNL procurement process

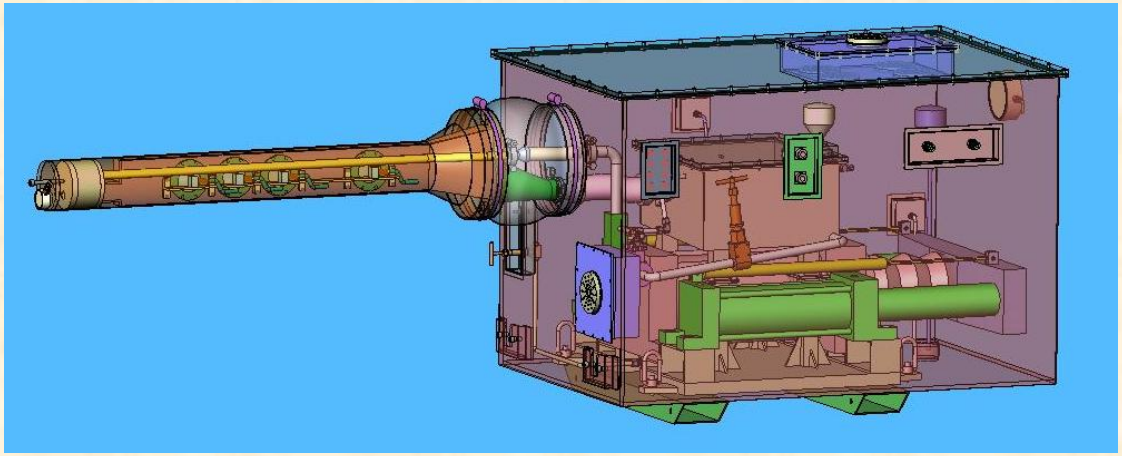


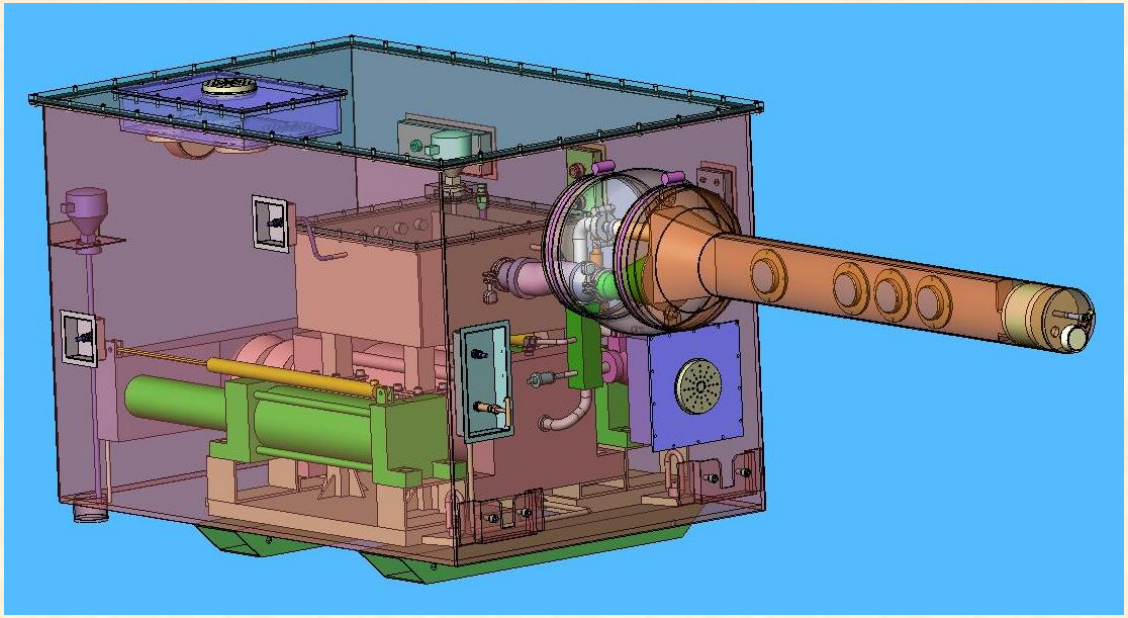
Overall Plan

- **Pump equipment and target delivery system are designed at ORNL**
  - **Funding is provided for design, assembly, and testing**
- **Procure all hardware thru BNL (except for misc. items)**
- **Assemble equipment and test the system at ORNL/TTF**
  - **Characterize operating parameters of the target equipment and the laser diagnostic (pictures of Hg jet)**
  - **Ship the target to MIT along with auxiliary equipment, and support base structure**
- **Integrated system tests at MIT (w/solenoid)**
  - **Characterize operating parameters in the magnetic field environment (pictures of Hg jet in high field)**
  - **Fit up test of solenoid/target equipment on base support structure**
  - **Ship back to ORNL *(NEW - assess sending solenoid to ORNL for subsequent shipping to CERN)***
  - **Ship system to CERN along with all support equipment**
- **Beam-on-target tests at CERN**
  - **Proof-of-principal tests in TT2A tunnel, store, decon., pack, and**
  - **Ship mildly activated equipment plus Hg back to ORNL**

Hg Delivery System

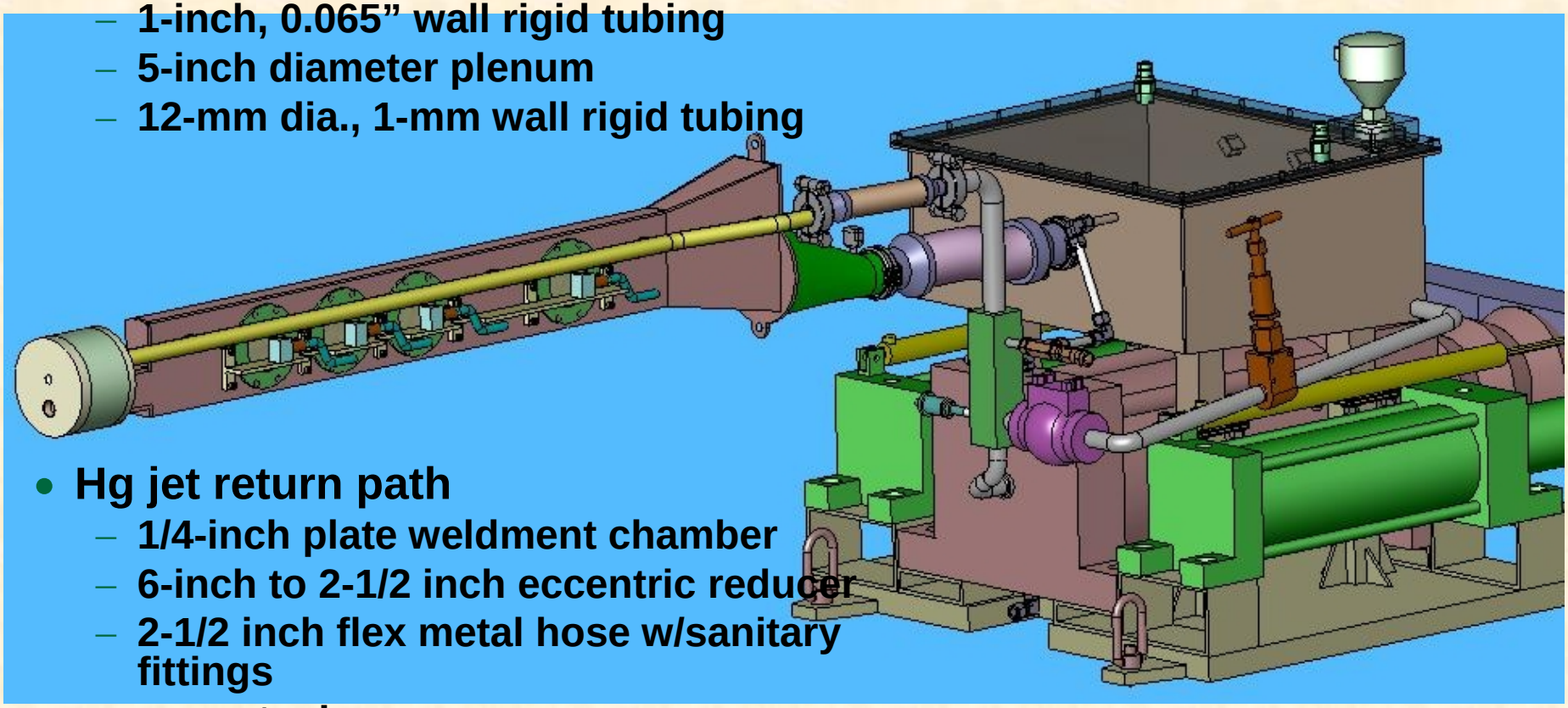
- **Capacity 23 liters Hg (~760 lbs)**
- **Provide 1-cm dia., 20 m/s jet for up to 12 sec**
- **Secondary containment size 960mm x 1475mm x 960mm**
- **Estimated weight 2 tons incl. Hg**





Primary Containment

- **Hg supply flow path**
  - **1-inch Sch.-40 pipe**
  - **1-inch flex metal hose w/sanitary fittings**
  - **1-inch, 0.065” wall rigid tubing**
  - **5-inch diameter plenum**
  - **12-mm dia., 1-mm wall rigid tubing**



- **Hg jet return path**
  - **1/4-inch plate weldment chamber**
  - **6-inch to 2-1/2 inch eccentric reducer**
  - **2-1/2 inch flex metal hose w/sanitary fittings**
  - **sump tank**

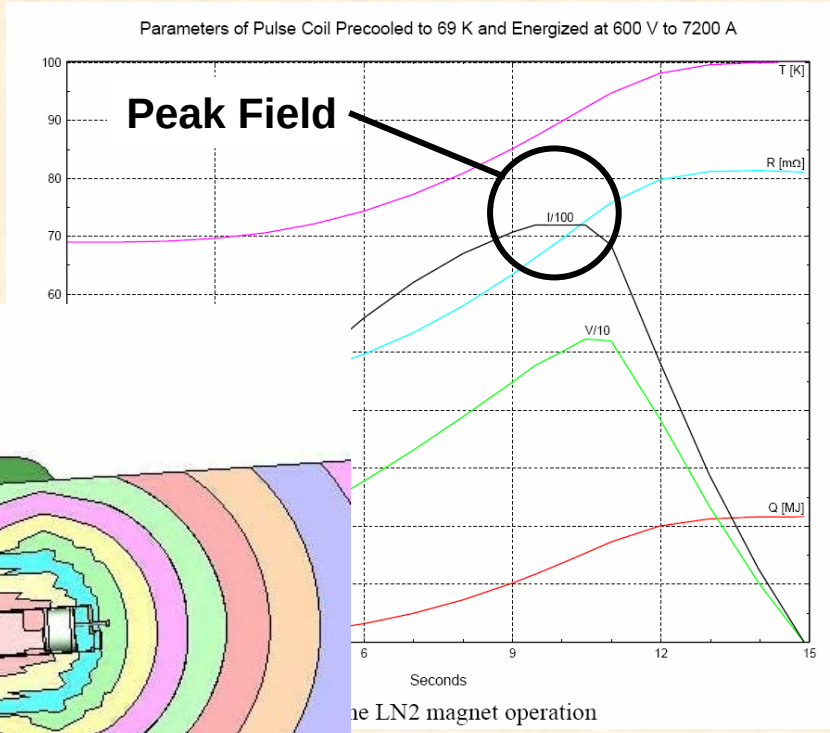
Reqmts and Operating Conditions:

Target system must deliver a stable, unconstrained jet of Hg in 1-atmosphere of air, into 15 Tesla field (Vacuum Is Under Review)

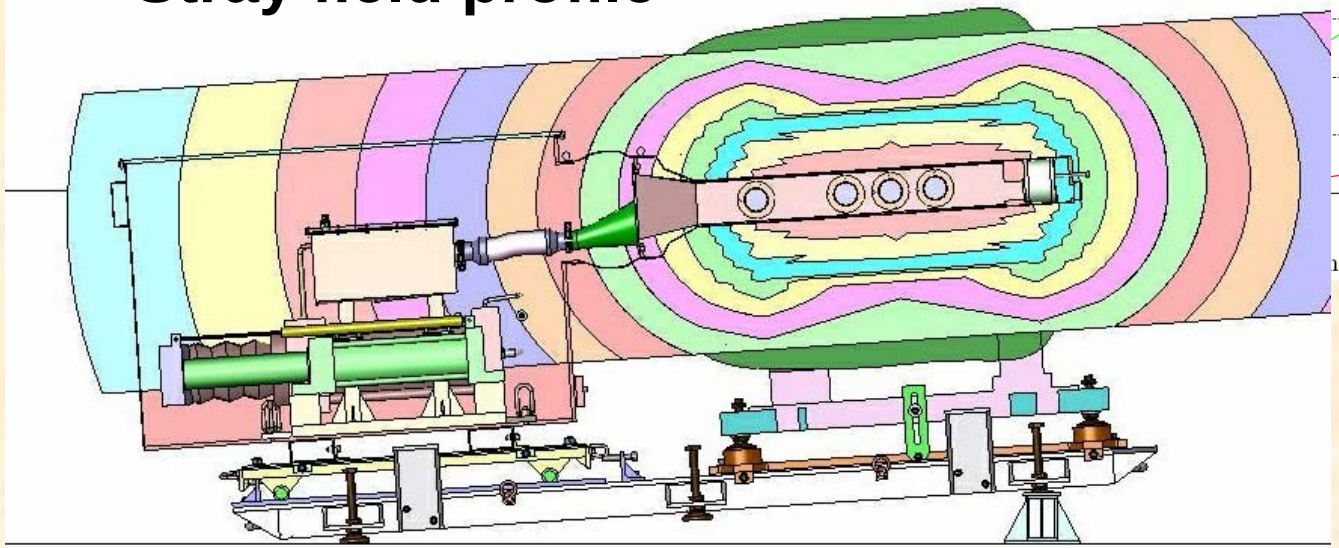
- **1-cm diameter jet at 20 m/s delivered every 30 minutes**
- **>1-sec steady state jet during the magnet peak field**
- **Full-beam interaction length is 30-cm**
- **24 GeV, 1 MW proton beam, <20x10^{12} ppp**
- **Beam line is 120-cm (47.2”) above the tunnel floor**
- **Up to 100 pulses for the CERN test, >500 operating cycles for system testing**
- **The pump equipment operates in a range of 6000 Gauss to 300 Gauss (*1 Tesla = 10^4 Gauss*)**

Magnetic Field Profile

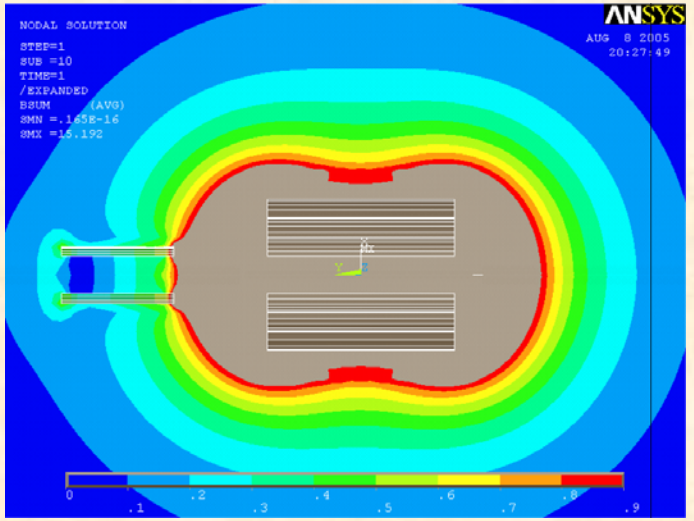
- **15 Tesla peak field has a 1-sec flat top at t = 9.5 s**



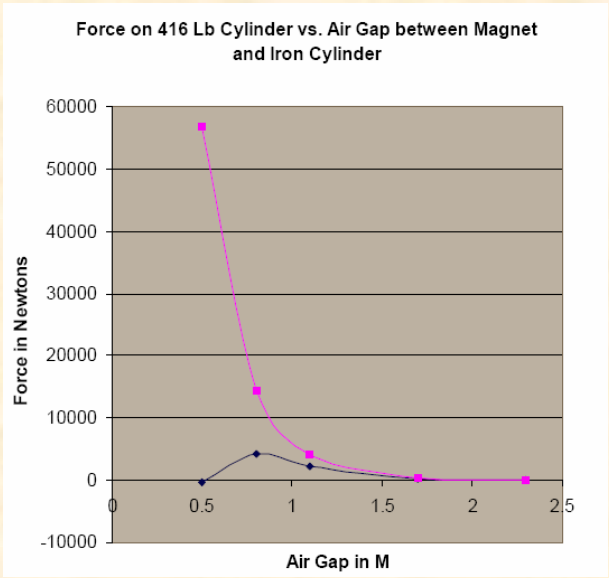
Stray field profile



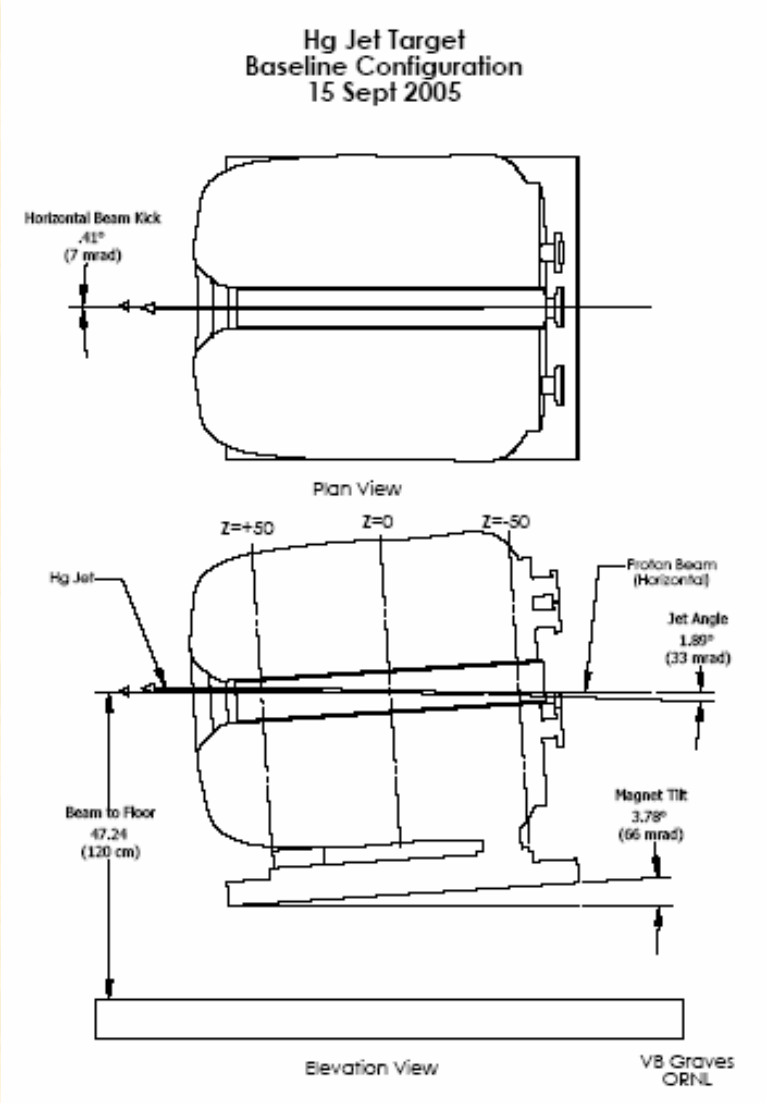
Magnetic Force Analysis



- **Peter Titus performed ANSYS analysis of attractive forces between magnet and single iron cylinder**
- **Force nearly 13000lb**
- **Further analysis showed force decreases significantly with separation distance > 1m**
- ***Outcome: Syringe system is stainless steel!***

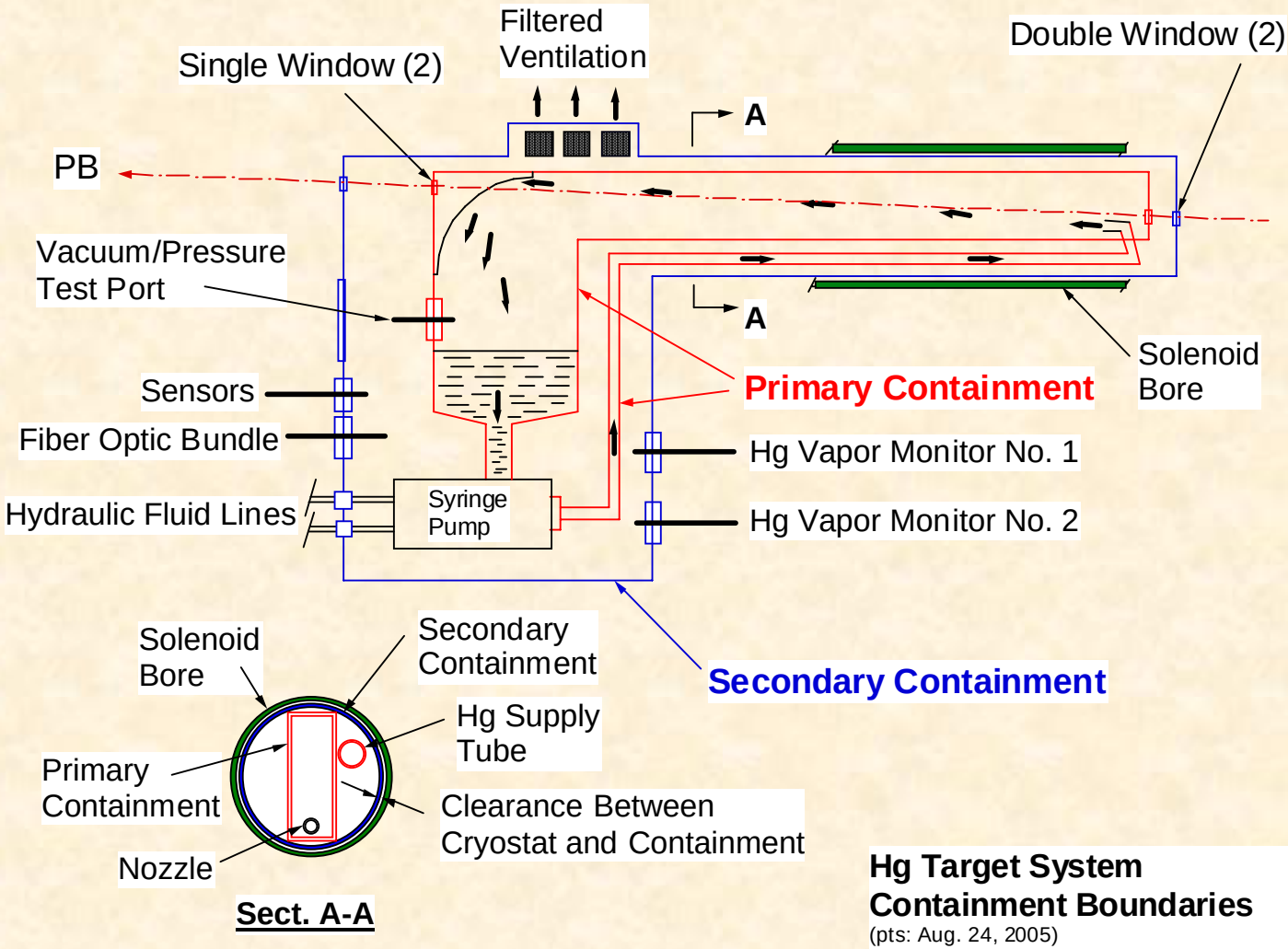


Geometry of the Interaction Region



- **0.4° horizontal kick**
- **Jet to beam is 33 millirad (1.89°); *jet to magnetic axis is 100 millirad (5.73°)***
- **The PB crosses the jet centerline at Z=0, which is also at 15 T in the center of the solenoid**

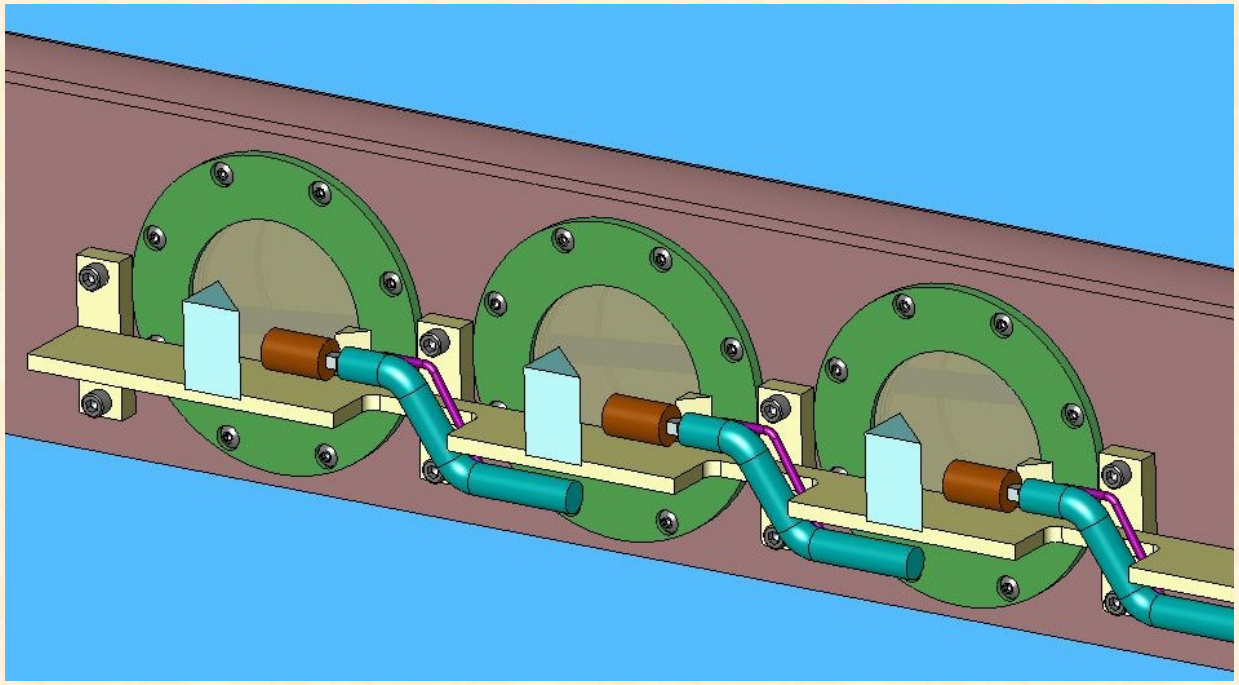
Containment Schematic



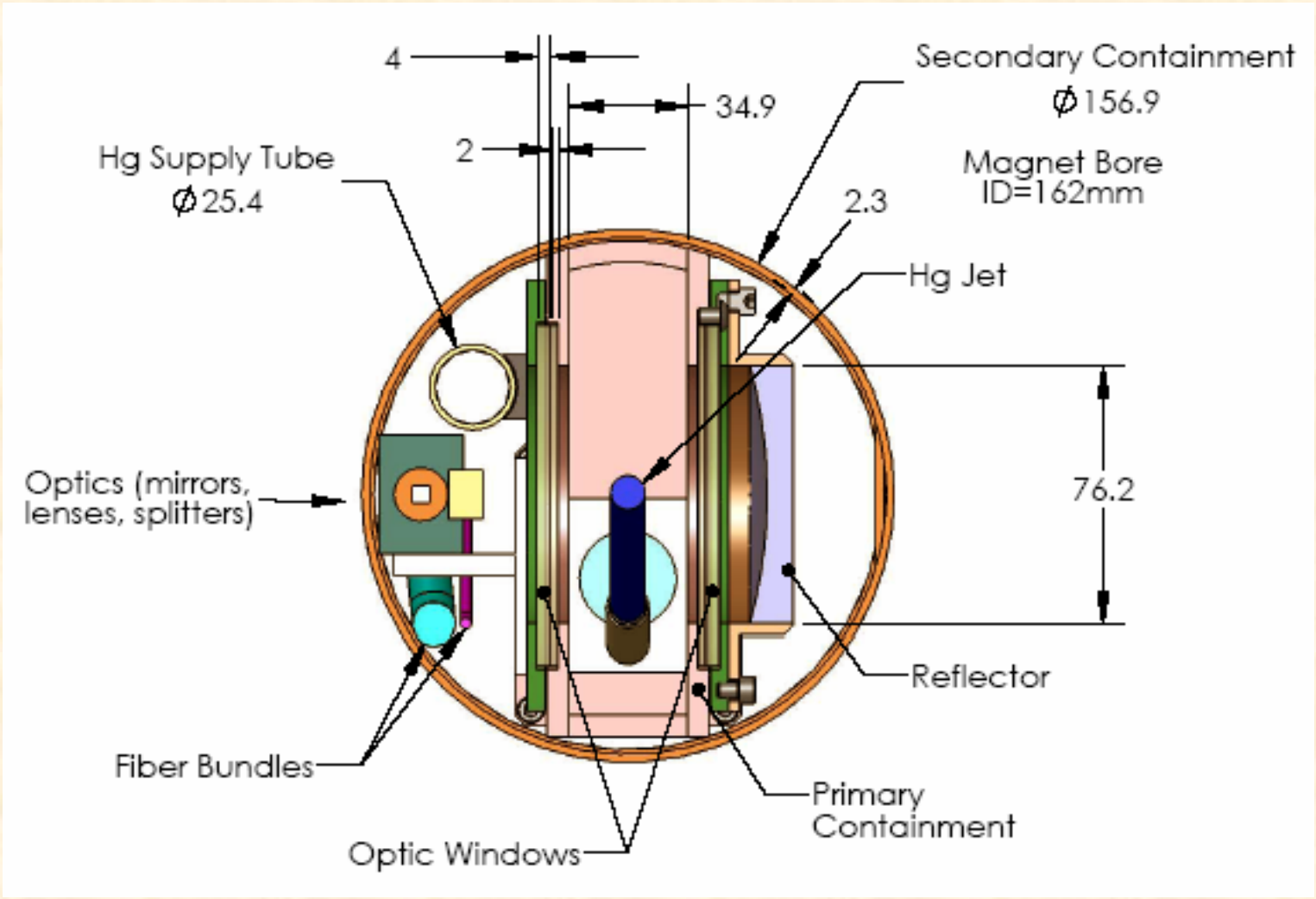
Hg Target System Containment Boundaries
(pts: Aug. 24, 2005)

Optical Components – Target Interfaces Are Defined

- **BNL provides splitters, prisms, lenses, bracket, mounting hardware & adjustment mechanisms**
- **Rad tolerant fused silica cable is being tested at CERN**



Z=0 Section Cut



Hg Loading/Unloading Under Study

- **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**
  - **Develop list of activated Hg byproducts and determine effectiveness of filtration**

Preliminary Estimate For Filter Lifetime is Calculated

Saturation Pressure

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

Saturation Concentration

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

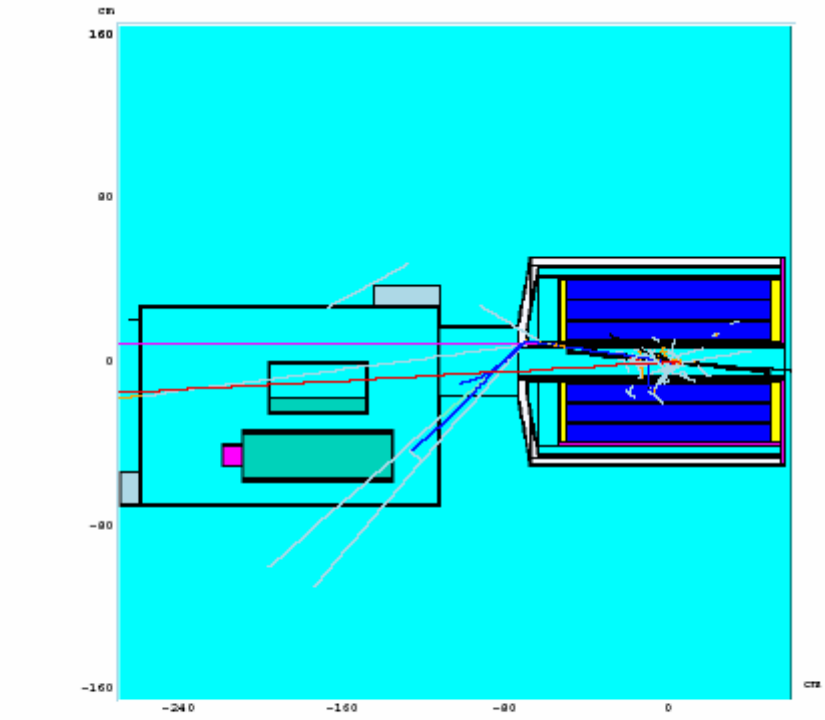
Ref. Quechsilber und seine Gefahren, Swiss government worker safety report, SBA No. 145, Luzern

Filter effectiveness tests could be done at ORNL

- **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***

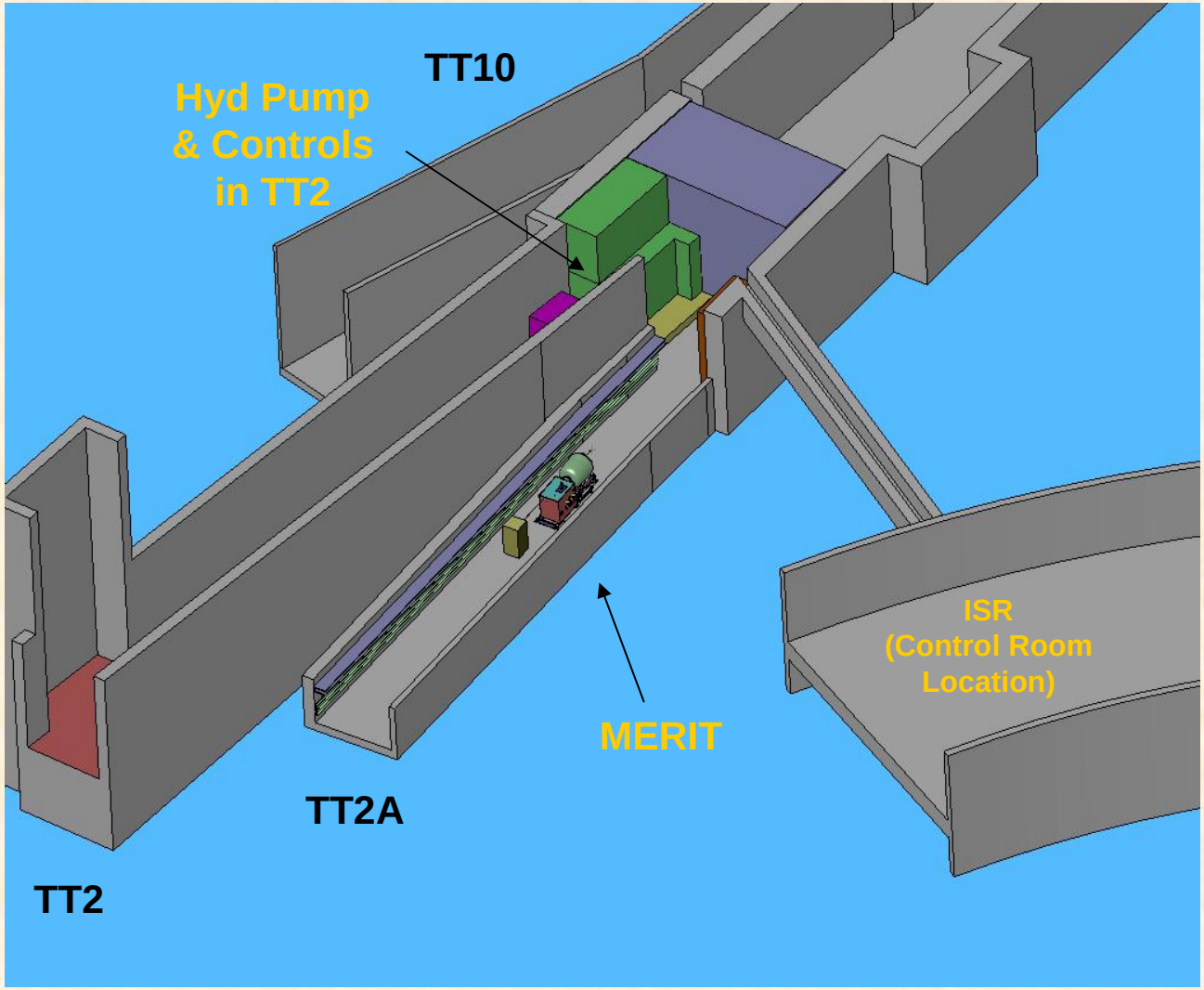
MARS15 Simulations at FNAL are Underway to Assess Activation of the Target System

- **Preliminary results indicate that activation levels are not a problem for electronics, instruments, or materials**



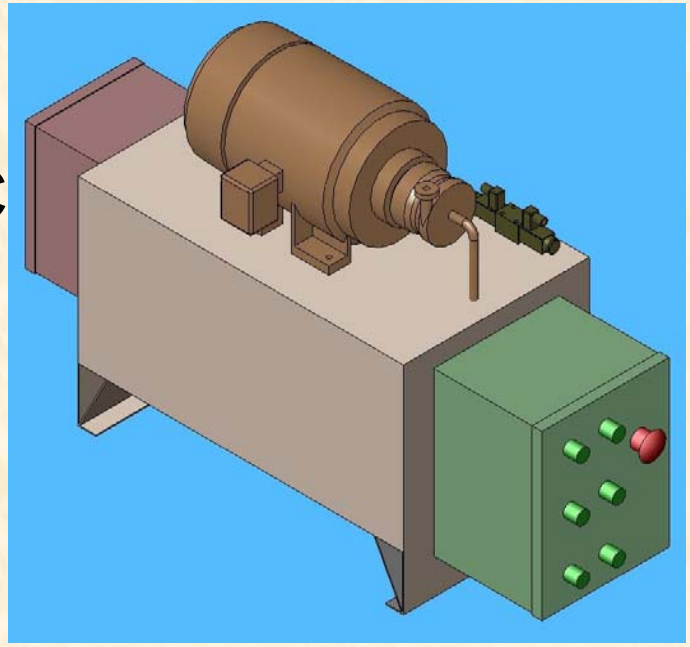
per Sergei Striganov

CERN Tunnel Layout



Power Requirements

- **Hydraulic pump – 380/460VAC, 50-60Hz, 60A *(power connection at CERN)***
- **Proportional control valve – 24VDC**
- **Heater foil – 120VAC**
- **Hg vapor monitors – 120VAC**
- **Instruments – 24VDC**



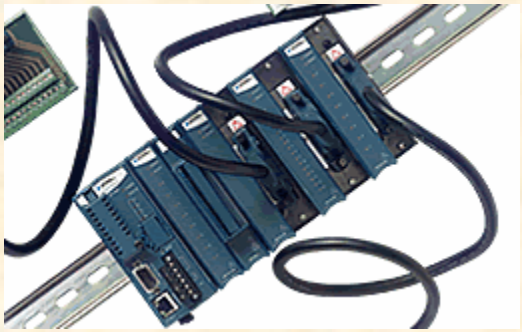
Instrumentation & Sensors

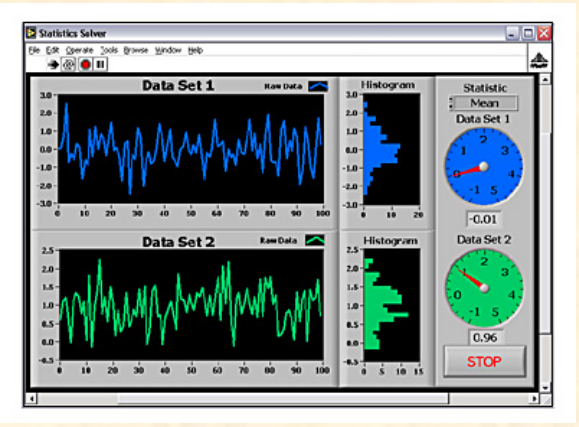
Controlled Components			
Hydraulic pump	Proportional control valve*	Heater foil	
Analog Sensor Inputs			
Hg discharge pressure	Hg level	Hg sump thermocouple	Secondary containment thermocouple
Cylinder 1 position*	Cylinder 2 position	Hg vapor 1	Hg vapor 2
Hydraulic fluid high pressure	Hydraulic fluid low pressure	Beam window 1 pressure*	Beam window 2 pressure*
Digital Sensor Inputs			
Hydraulic filter dirty switch	Hydraulic low level switch	Conductivity probe	

** Critical for system operation or safety*

LabView®-Based Control System

- **Remote control over long distance limited choices**
  - **Analog I/O modules need to be close to equipment and power supplies**
- **LabView controller on laptop computer was chosen**
  - **National Instruments recommends Compact PCI I/O modules**
  - **Communicates to laptop via EtherNet cable**
  - **Allows custom operator interface, data logging if required during development**
  - **Should allow straightforward integration with other control systems**
- **Control system development to begin late October**



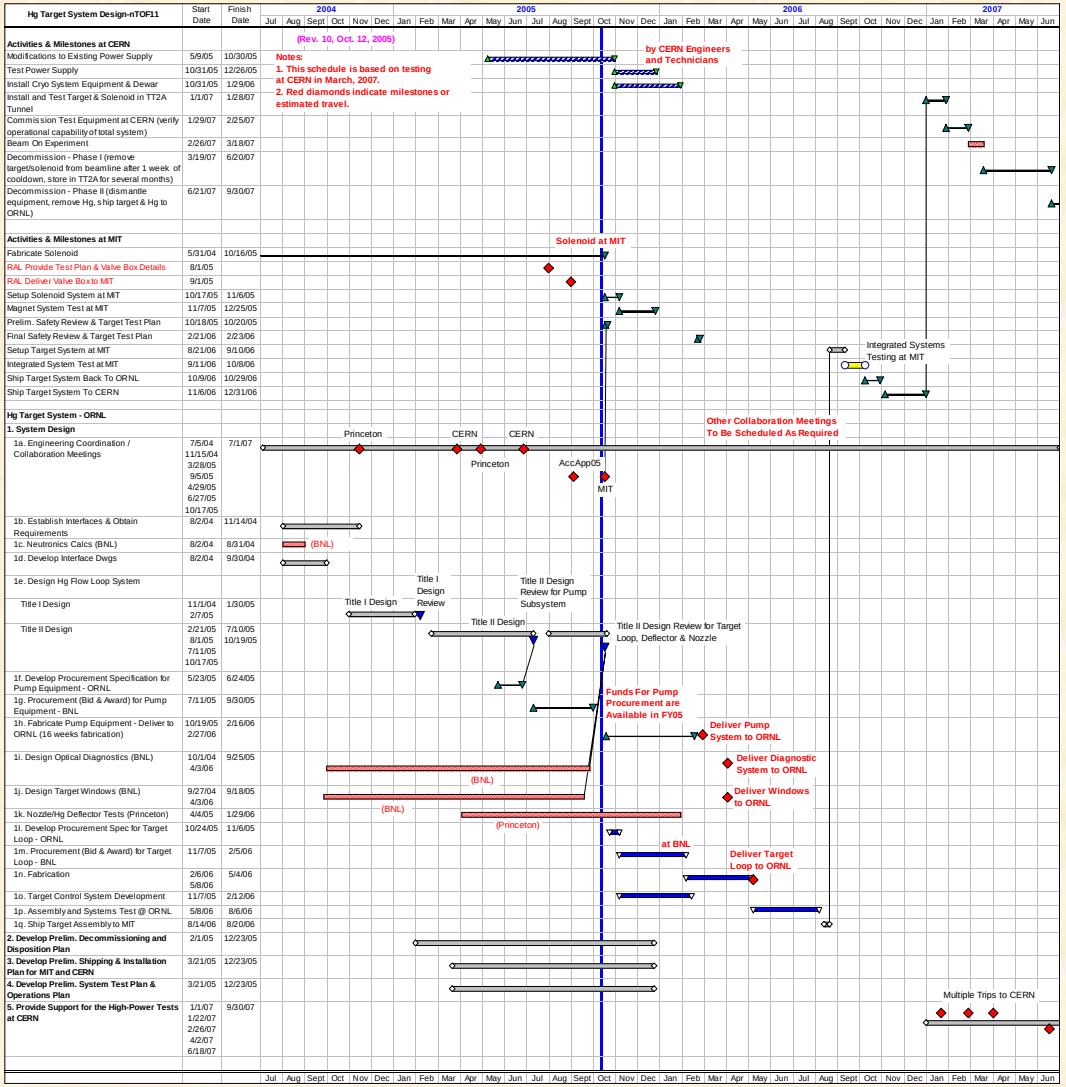


Miscellaneous Equipment For The Target System

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
VacuumPump ?	Small Tools
	Vinyl Tape
	Herculite
	Plastic Bags– asst'd (1 gal.– 20 gal.)
	1-liter plastic bottles
	Lab Coats/Shoe Covers
	Tyvek Hooded Suits
	Nitrile Gloves
	Full Face Mask/Respirator Cartridges

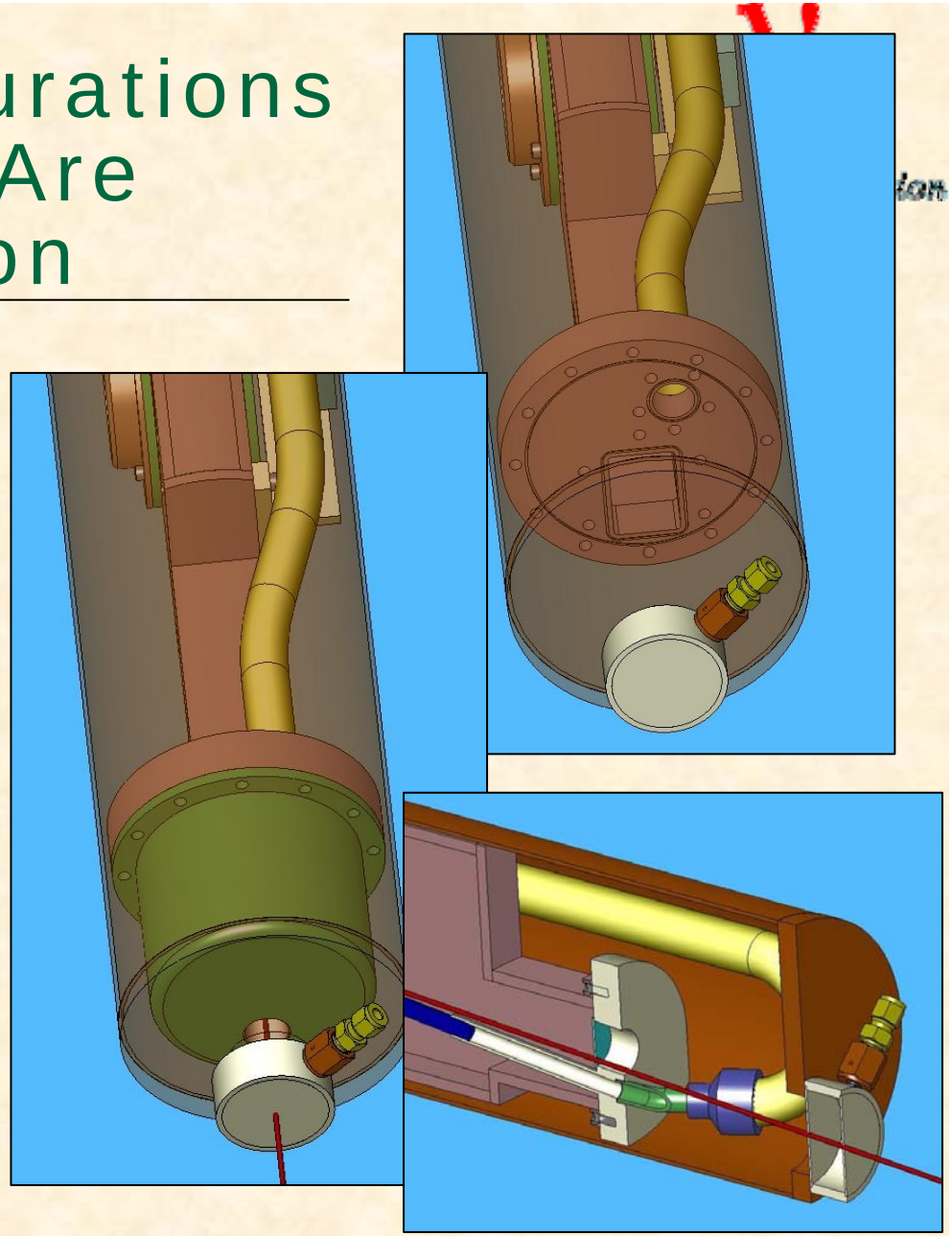
Project Schedule

- **Assemble syringe pump and target hardware May-Jun 2006**
- **Target system tests at ORNL Jul-Aug 2006**
- **Integrated system tests at MIT Sep-Oct 2006**
- **Beam-on-target experiment at CERN Mar-Apr 2007**



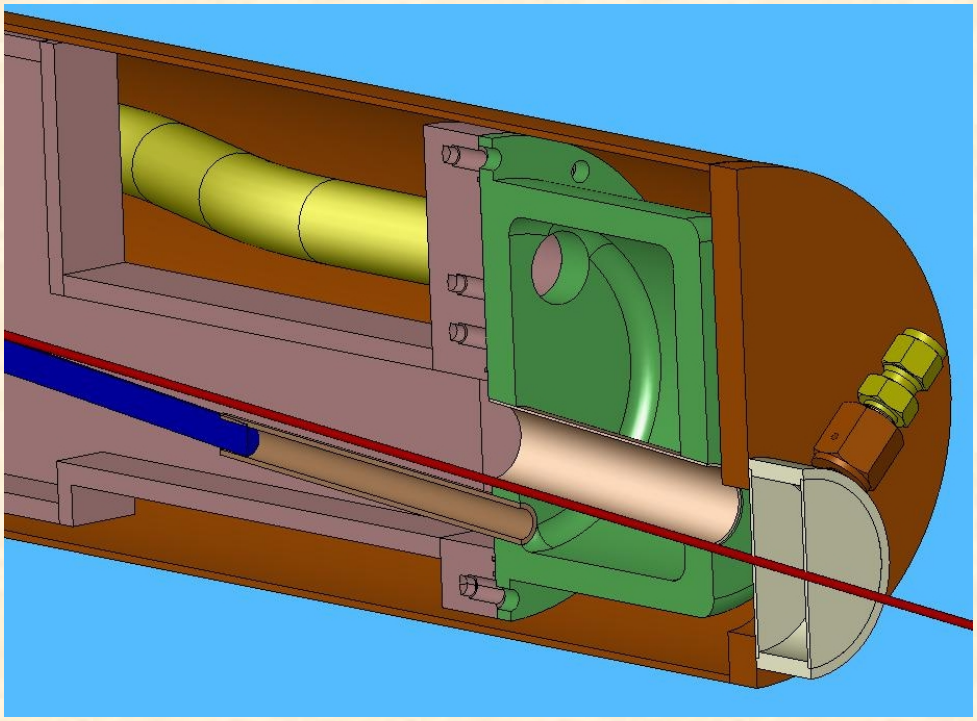
Alternative Configurations for Nozzle/Plenum Are Under Consideration

- **Attaching plenum from up-beam end requires smaller diameter plenum**
- **Rigid supply tubing must bend towards center to accommodate flange bolt circle**
- **Non-plenum tubing requires Hg flow to bend away from center (adds 4 bends before 180-deg turn)**



Removable Plenum Concept

- **Adding exterior bolts reduces plenum ID**
- **Beam tube positioning will be a problem**
- **Plenum wall thicknesses may not be representative**



Conclusions

- **Procurement for the Hg delivery system has slipped approx. 1 month**
  - **Not a problem; sufficient slack in schedule**
- **Syringe pump system contract was awarded thru BNL – vendor design review in 30 days**
- **Hg Delivery system procurement package will be sent to BNL before end of November**
- **Target system is on schedule to meet April 2007 testing at CERN**