Mercury Intense Target (MERIT) Update

Status of the Target System Design

P.T. Spampinato
V.B. Graves
T.A. Gabriel

Muon Collaboration Friday Meeting
October 28, 2005
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

Primary Containment

Secondary Containment

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
\[ \log P_{sat} = -3105.5 / T_0^K + 4.9294 \text{ (bar)} \]

Saturation Concentration
\[ C_{sat} = 2.445P_{sat} / T_0 \text{ (Kg}_Hg / m^3) \quad (P_{sat mbar}) \]

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

- Flow Rate 110 cfm
- Temp. 25 °C
- Filter Effic. 99.0%

- Filter Weight 6 lbs
- Filter Satur. 12%
- Filter Life 185 hrs
  - **Does not incl. reduction for humidity**

Filter effectiveness tests could be done at ORNL
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

Hyd Pump & Controls in TT2

TT10

TT2A

MERIT

ISR (Control Room Location)
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

<table>
<thead>
<tr>
<th><strong>Controlled Components</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic pump</td>
<td>Proportional control valve*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Analog Sensor Inputs</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hg discharge pressure</td>
<td>Hg level</td>
</tr>
<tr>
<td>Cylinder 1 position*</td>
<td>Cylinder 2 position</td>
</tr>
<tr>
<td>Hydraulic fluid high pressure</td>
<td>Hydraulic fluid low pressure</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Digital Sensor Inputs</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic filter dirty switch</td>
<td>Hydraulic low level switch</td>
</tr>
</tbody>
</table>

* 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

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