MERIT Hg System Design Update

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MERIT Collaboration Meeting
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Outline – Design Issues

- Design changes since last meeting
  - Syringe piping
  - Sump tank
- In-situ nozzle replacement
- Beam window fabrication
- Optic window materials
- Hg jet distortion
Hg Syringe System at Design Review

- Baseplate
- Discharge manifold
- Relief valve
- Rectangular sump tank
- Multiple Hg cylinder ports
Latest Syringe System

- No baseplate
- No manifold
- No relief valve
- Vent & Hg discharge are same pipe
- Drain & Hg inlet are same pipe
- Lugs on cylinders not representative
More of the Latest System

- Circular sump tank
  - Drain at back
  - Ports for Hg fill, Hg extraction, cylinder vent, overpressure, Hg level sensor
  - Will support vacuum operations

- Sump tank supported by Hg cylinder

- Hg pressure transducer on supply pipe
Effects of Syringe Changes

- Real cylinder models not available yet
  - Overall syringe height decreased
  - Length will increase
Magnet Model Changes
In-situ Nozzle Replacement

- Extend secondary sleeve past end of magnet to expose screws
- Plenum *might* be accessible from end, non-plenum more difficult
- Risk of spilling Hg into secondary sleeve much greater
- Details of design not initiated
Replaceable Nozzle Recommendations

- Magnet end not readily accessible with all utility lines connected

- Proposed MIT testing
  - Conduct integrated tests with level baseplate until nozzle finalized
    - Changeouts better controlled, less risk of Hg spill if Hg system extracted from magnet
  - Tilt baseplate for final tests
Beam Windows

- Currently have a simple, flexible beam window concept
- Welded attachments provide more usable space for beam (greater tilt capacity)
- Discussions with ORNL welding expert did not lead to proven welding process
  - Welding may be feasible but require development (and $$)
- Mechanical attachment possible but at expense of reducing tilt accommodation
- Resolution needed now to finish design
Optic Windows

- **Current**: fused silica backed by lexan
- **Alternative**: Sapphire instead of silica
Silica vs. Sapphire

- Mechanical properties of sapphire generally exceed those of silica

- Design tensile strength
  - Silica: 48 MPa
  - Sapphire: 400 MPa

- Use sapphire without lexan???

Sapphire Table of General Properties

<table>
<thead>
<tr>
<th>Physical Properties</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Formula</td>
<td>Al₂O₃</td>
</tr>
<tr>
<td>Structure</td>
<td>hexagonal-rhombohedral</td>
</tr>
<tr>
<td>Molecular weight</td>
<td>101.96</td>
</tr>
<tr>
<td>Lattice Constants</td>
<td>A = 4.785, c = 13,000</td>
</tr>
<tr>
<td>Density (g/cm³)</td>
<td>3.98</td>
</tr>
</tbody>
</table>

| Hardness            | 9 Mohs |
|                     | 1800 knoop parallel to C-axis |
|                     | 2200 knoop perpendicular to C-axis |

| Water Absorption    | Nil |
| Young Modulus (Gpa) | 379 at 30° to C-axis |
|                     | 352 at 45° to C-axis |
|                     | 345 at 60° to C-axis |
|                     | 386 at 75° to C-axis |
| Shear Modulus (Gpa) | 145    |
| Bulk Modulus (Gpa)  | 240    |
| Bending Modulus /   | 350 to 690 |
| Modulus of Rupture (MPa) |
| Tensile strength (MPa) | 400 at 25°C |
|                     | 275 at 500°C |
|                     | 345 at 1000°C |

Fused Silica Properties

Fused Silica GE
Hg Jet Distortion

- Discussions indicating that jet distortion in field is real and potentially serious effect

- Alternatives
  - Move nozzle closer to high field (changes angle)
  - Decrease nozzle/solenoid angle & put nozzle above beam
    - Would simplify Hg supply & lend itself to non-plenum approach
    - Would not be able to decrease magnet tilt angle without changing nozzle because nozzle would intercept beam
Hg System Costs

• Syringe ~$80K

• Remaining items
  – Common baseplate
  – Target transporter
  – Target cart
  – Primary / secondary containment
  – Controls hardware ~$5K
  – Integration & testing

• More accurate fabrication cost estimate to be initiated next week
Conclusions

- Final design details of Hg system must be decided
  - Tilt angle
  - Nozzle position
  - Beam window fabrication & attachment

- Fabrication drawings must be completed soon so procurement process can begin
  - Go-forward design approach must be decided now