MERIT Hg System Design Update

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MERIT Collaboration Meeting

Princeton University

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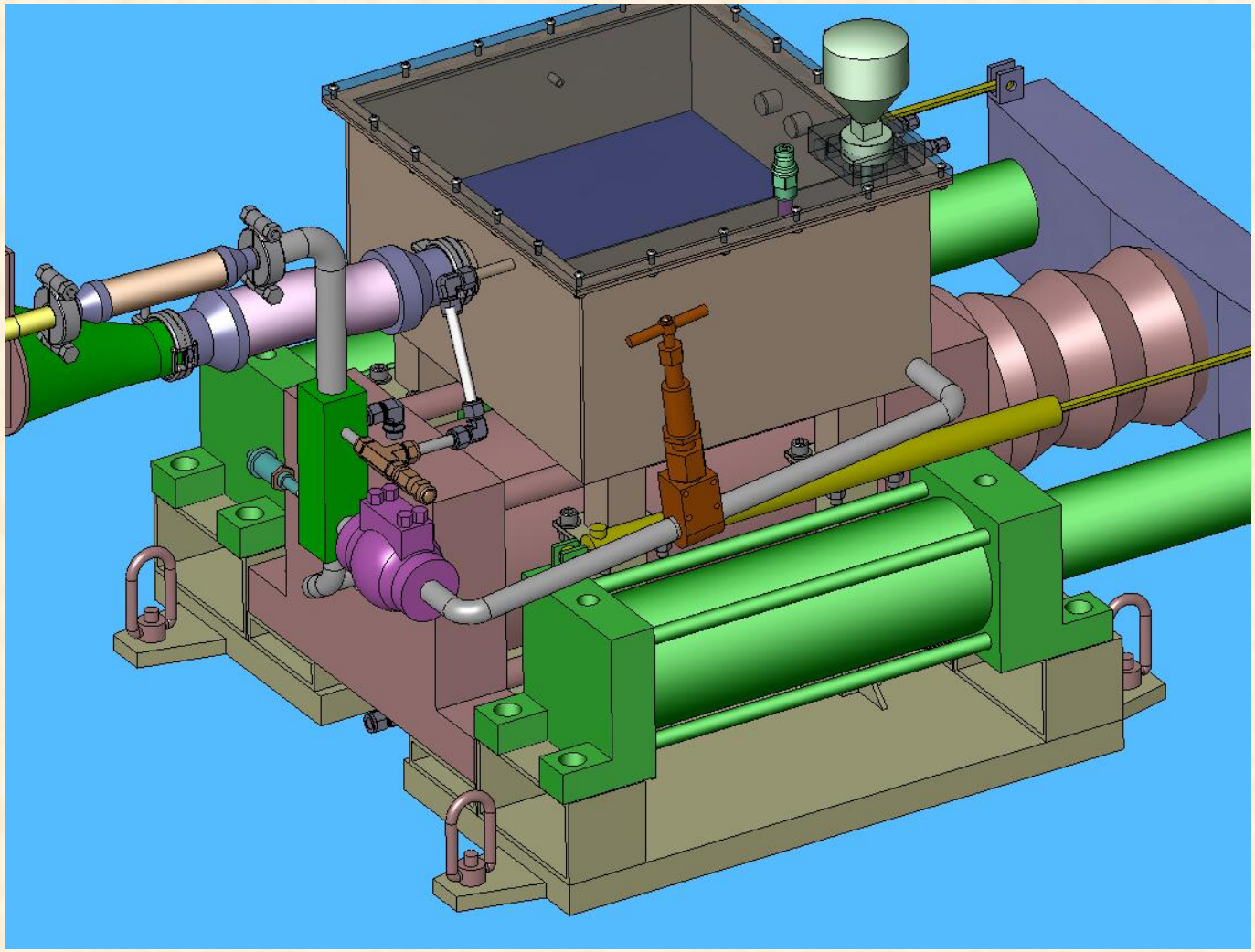
OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

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**

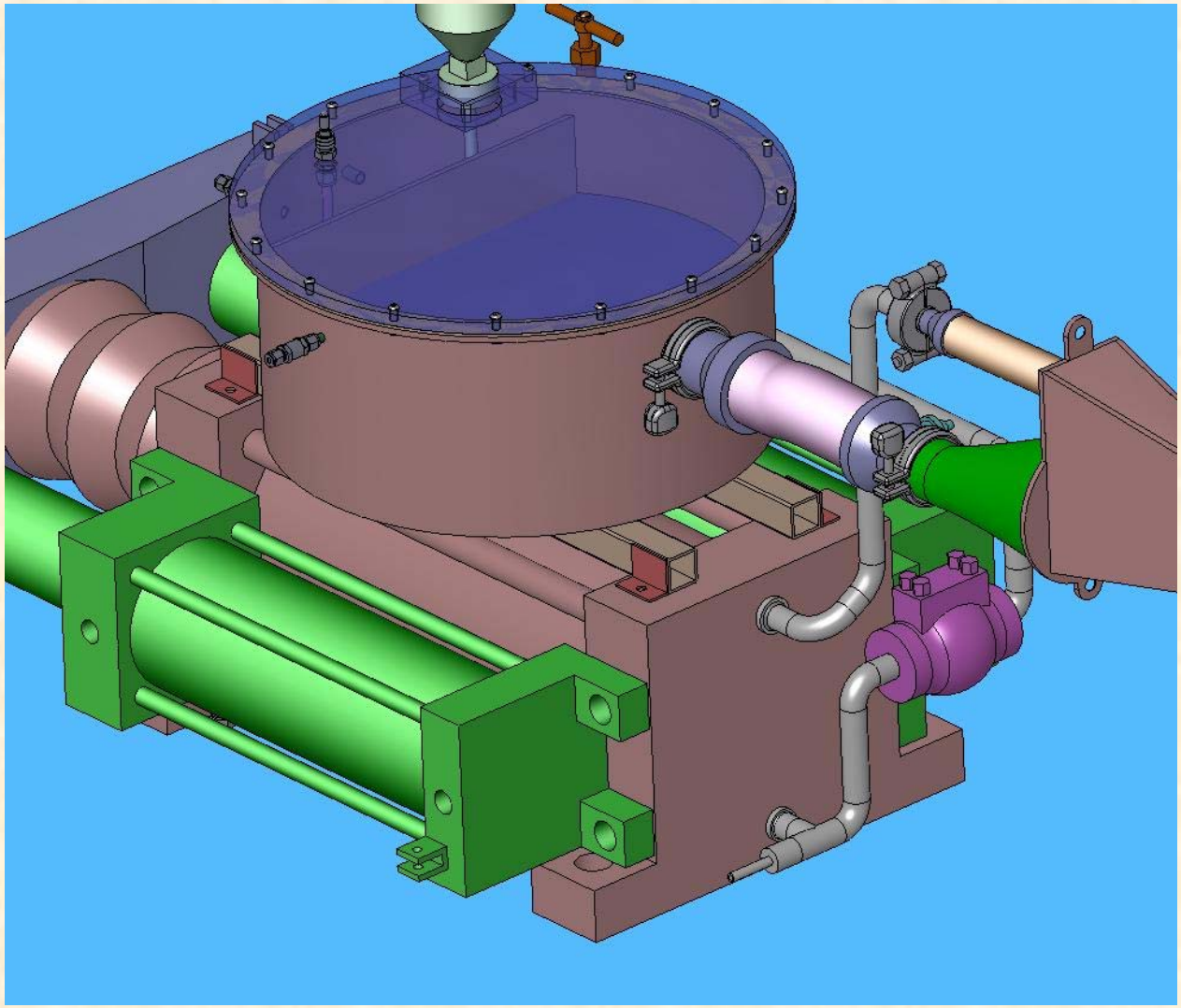
Hg Syringe System at Design Review

- **Baseplate**
- **Discharge manifold**
- **Relief valve**
- **Rectangular sump tank**
- **Multiple Hg cylinder ports**



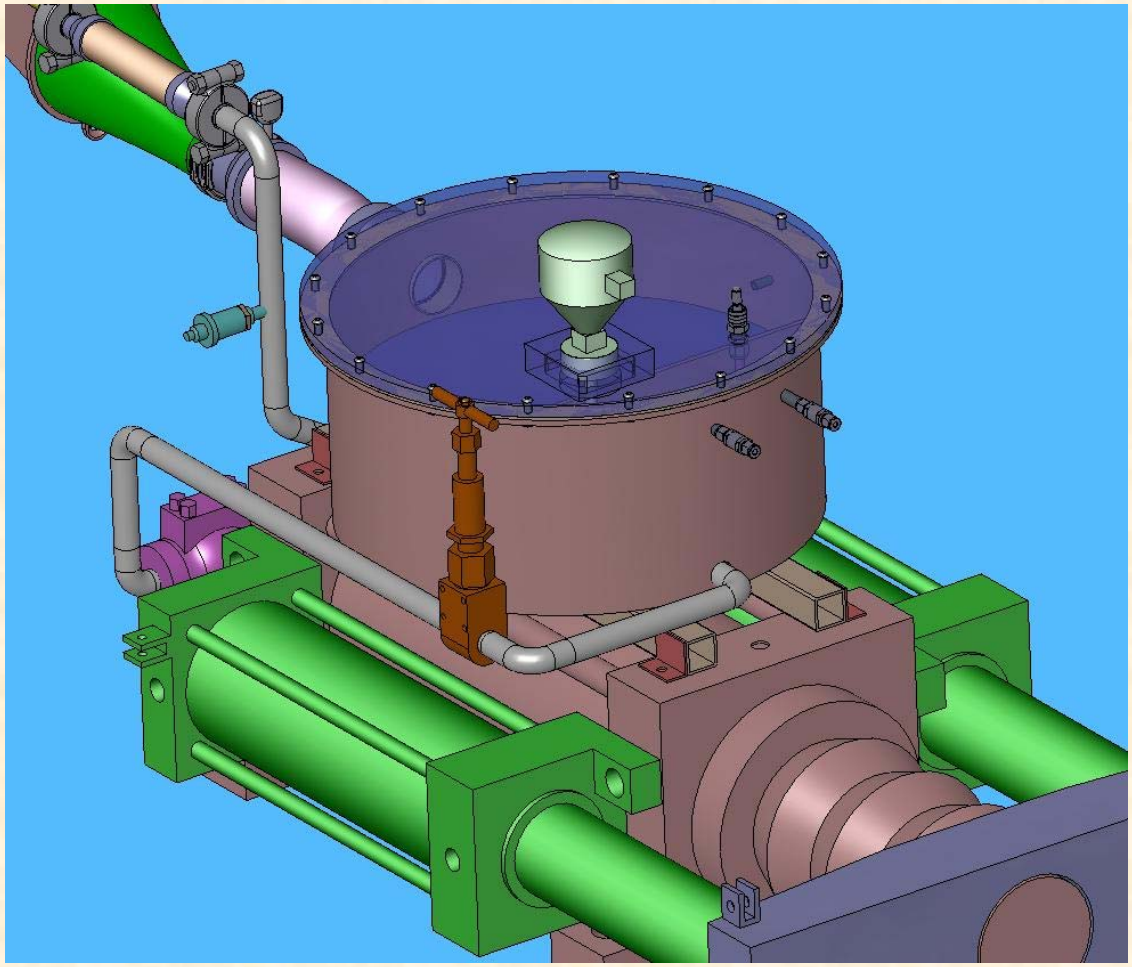
Latest Syringe System

- **No baseplate**
- **No manifold**
- **No relief valve**
- **Vent & Hg discharge are same pipe**
- **Drain & Hg inlet are same pipe**
- **Lugs on cylinders not representative**



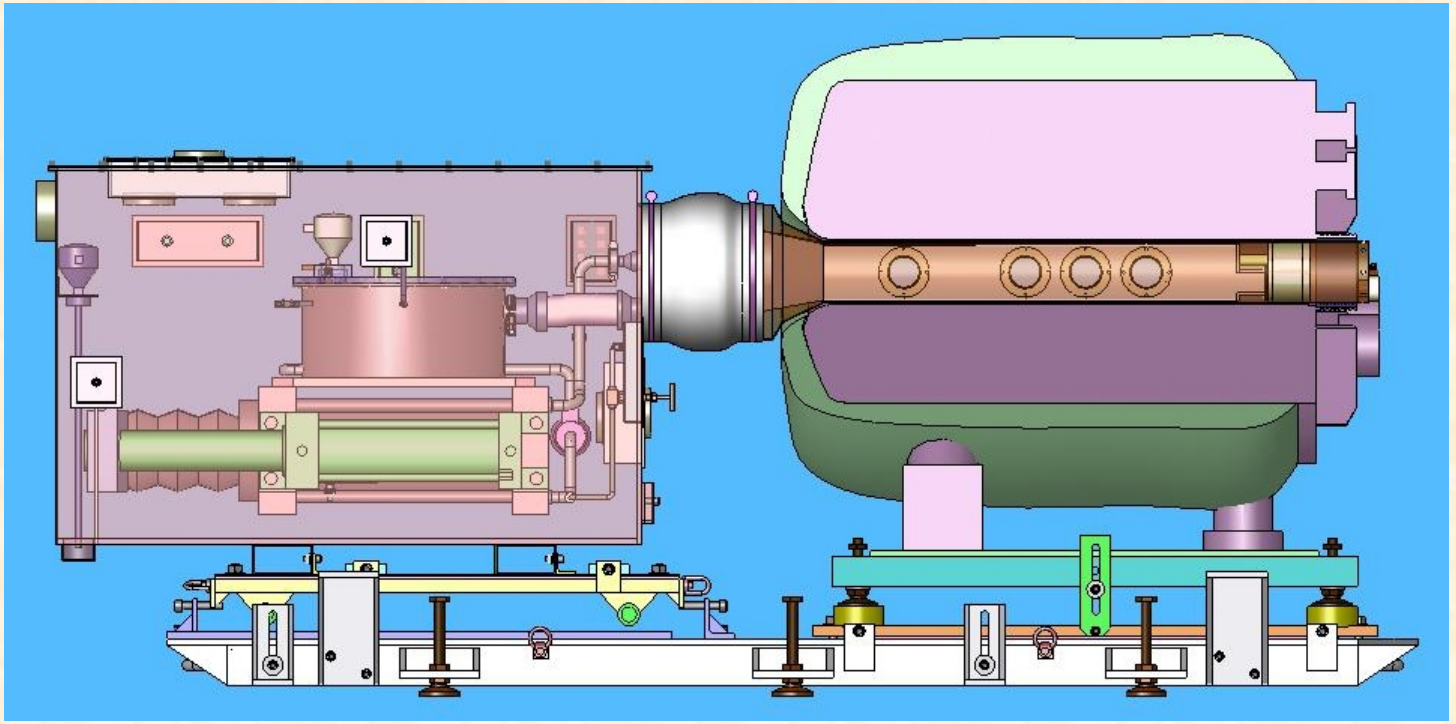
More of the Latest System

- **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**

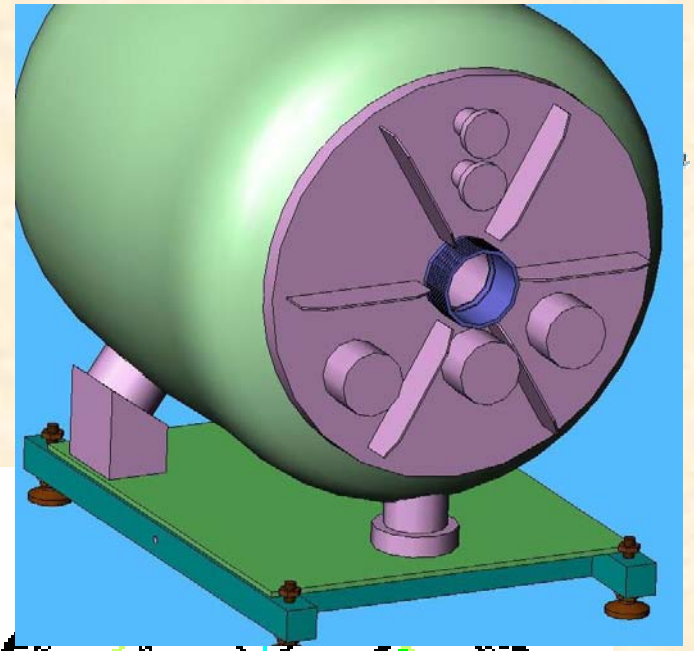


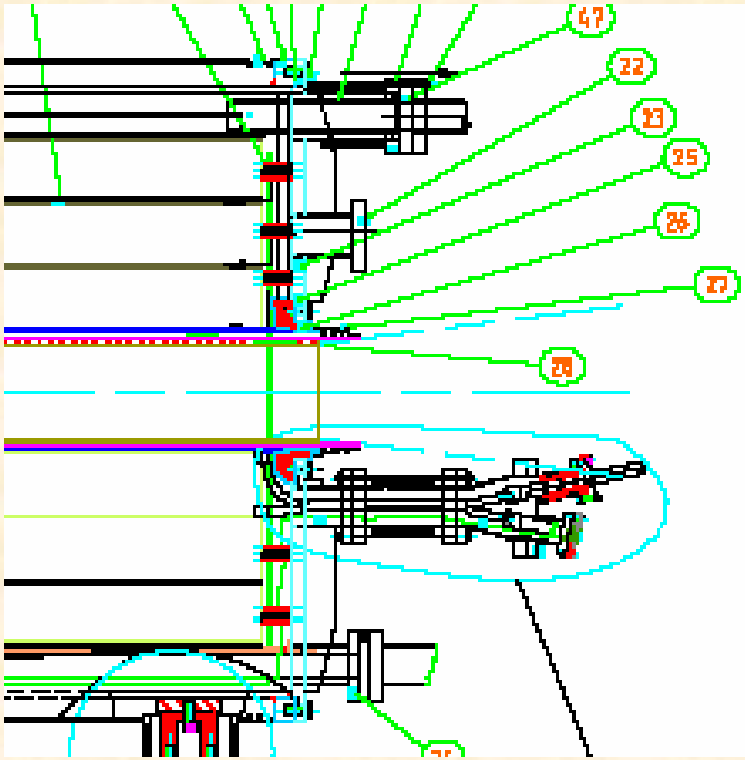
Effects of Syringe Changes

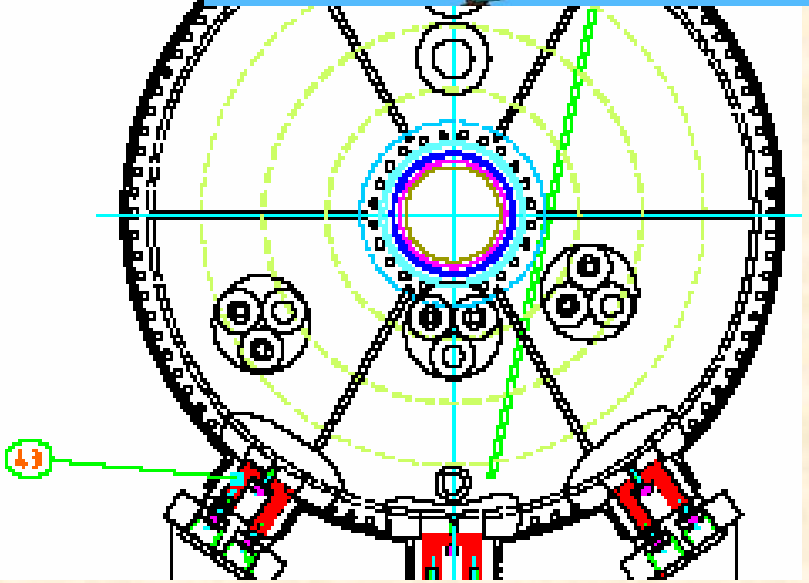
- **Real cylinder models not available yet**
  - **Overall syringe height decreased**
  - **Length will increase**



Magnet Model Changes

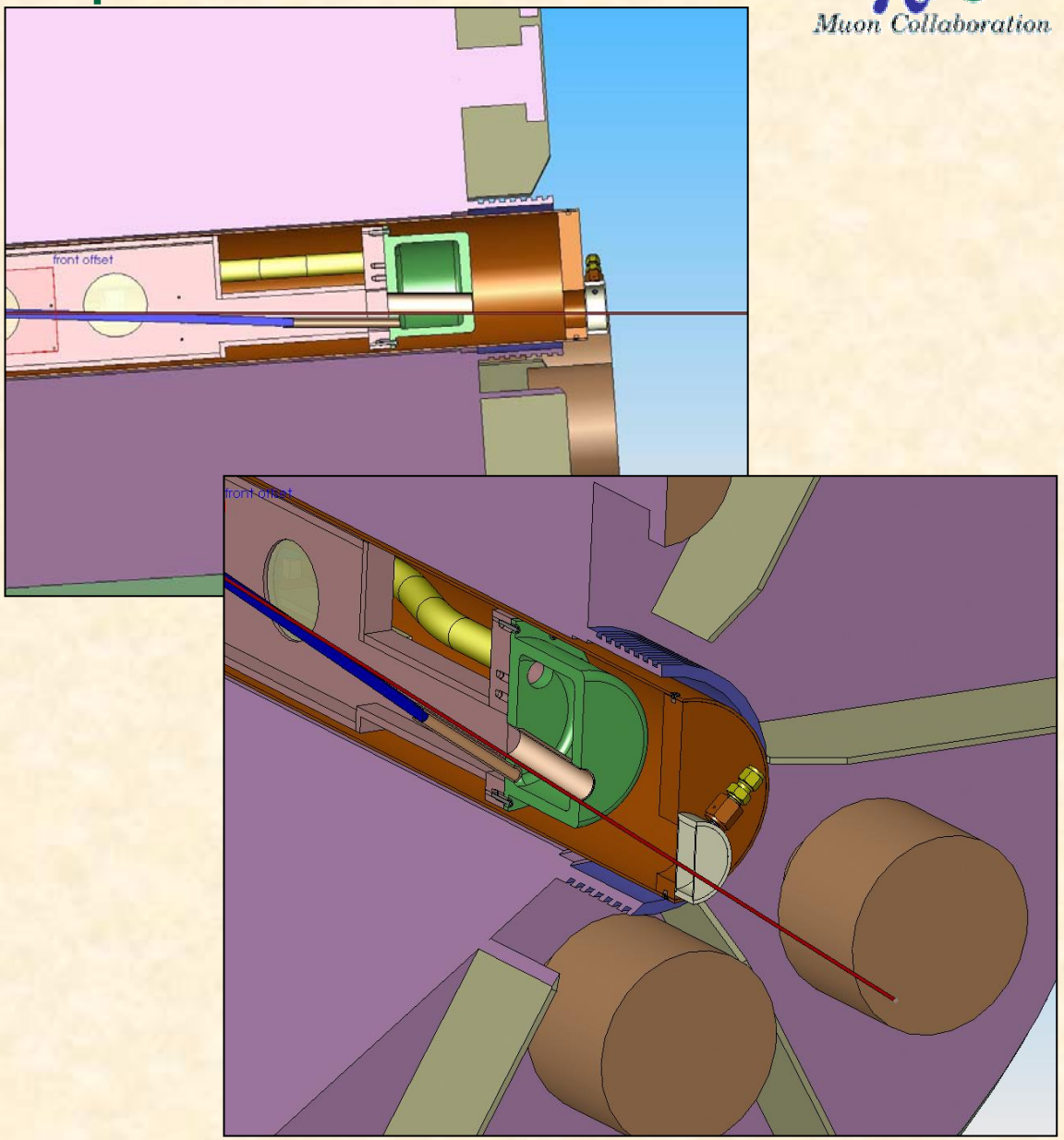






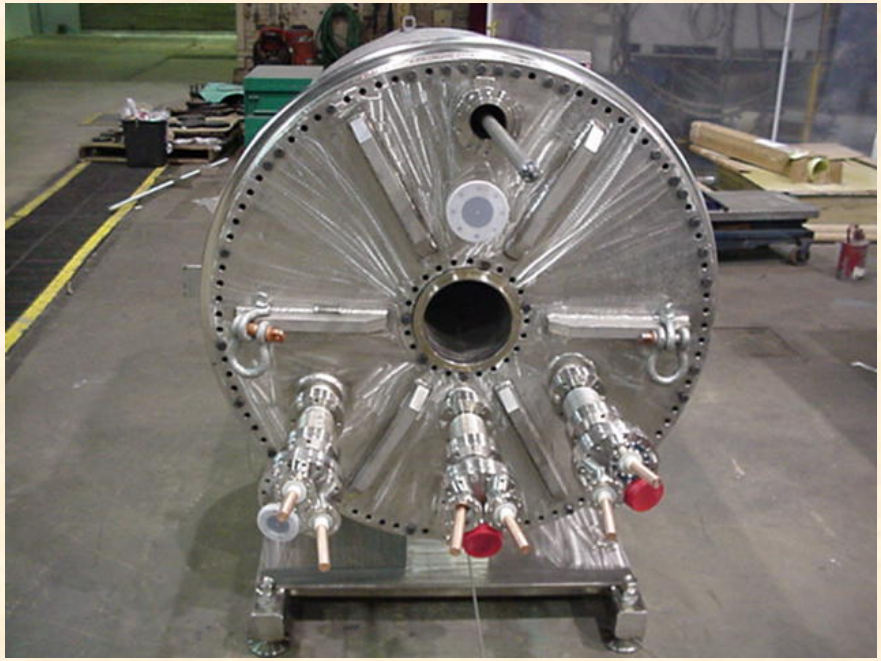
In-situ Nozzle Replacement

- **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**



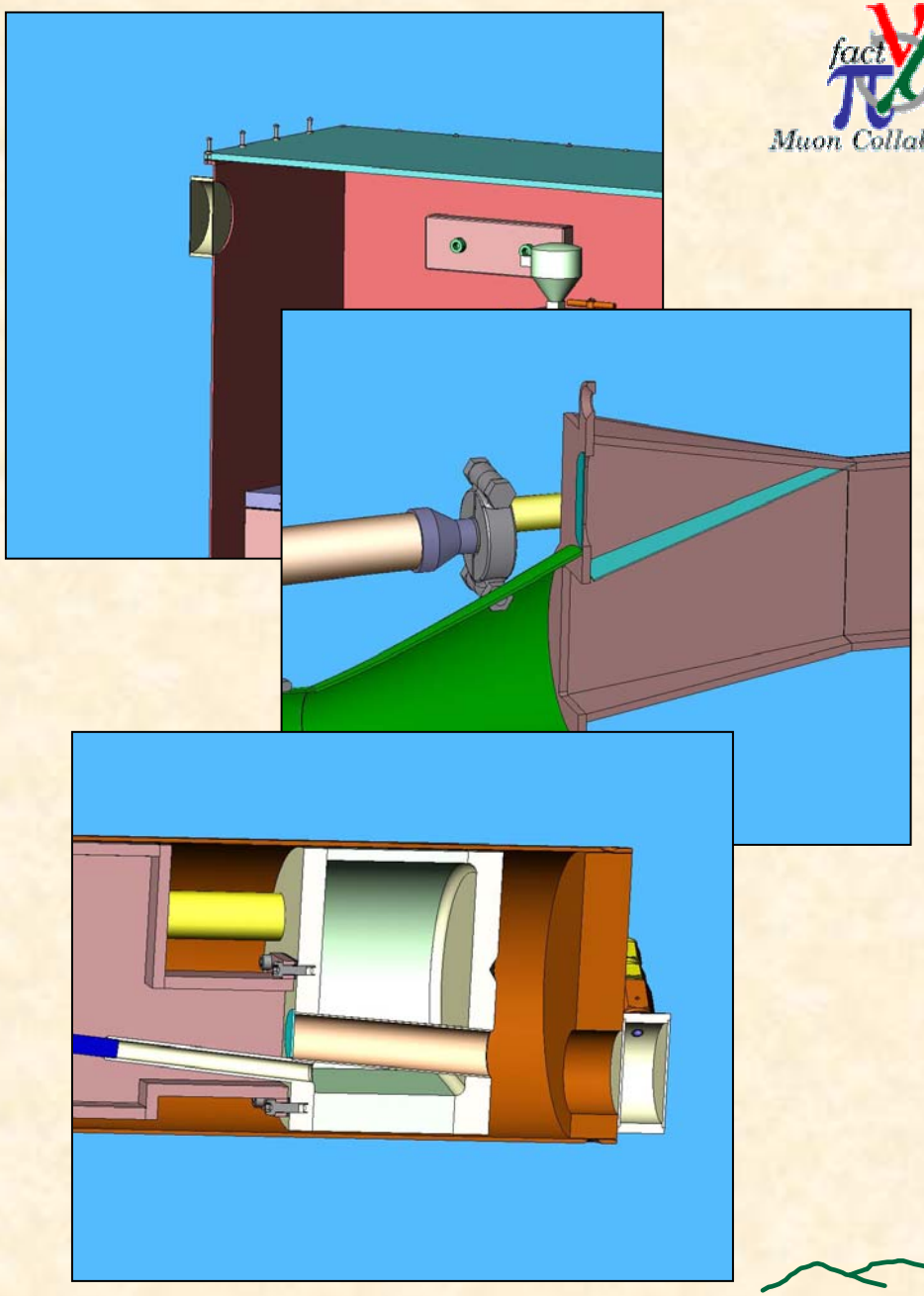
Replaceable Nozzle Recommendations

- **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**



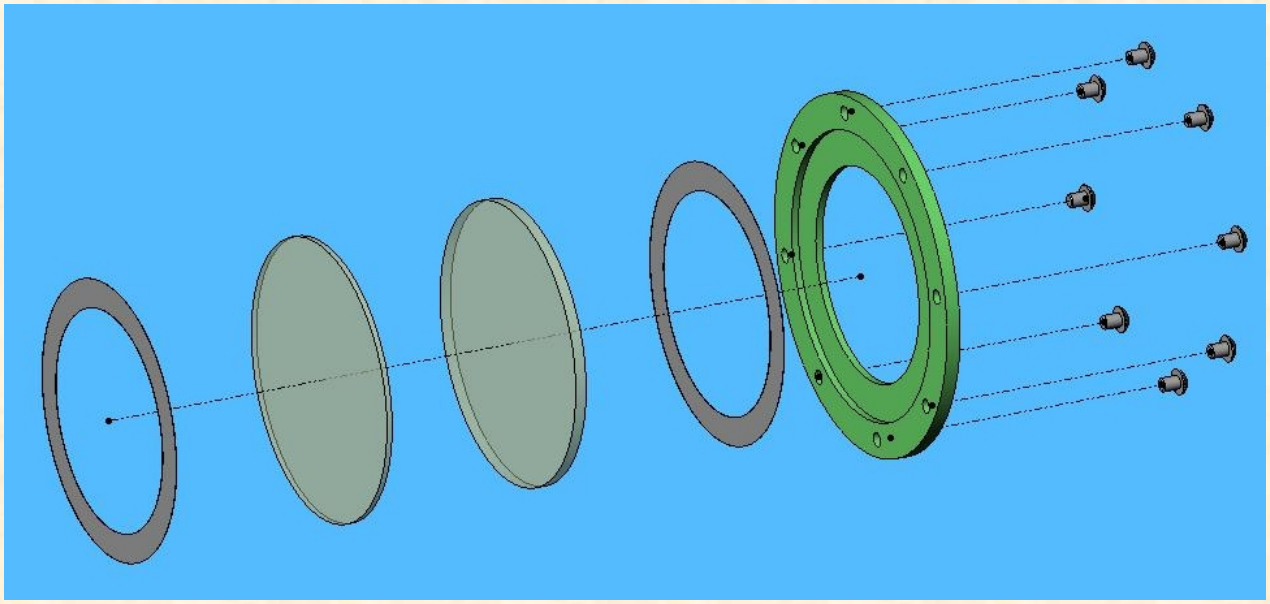
Beam Windows

- **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???**

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Sapphire Table of General Properties

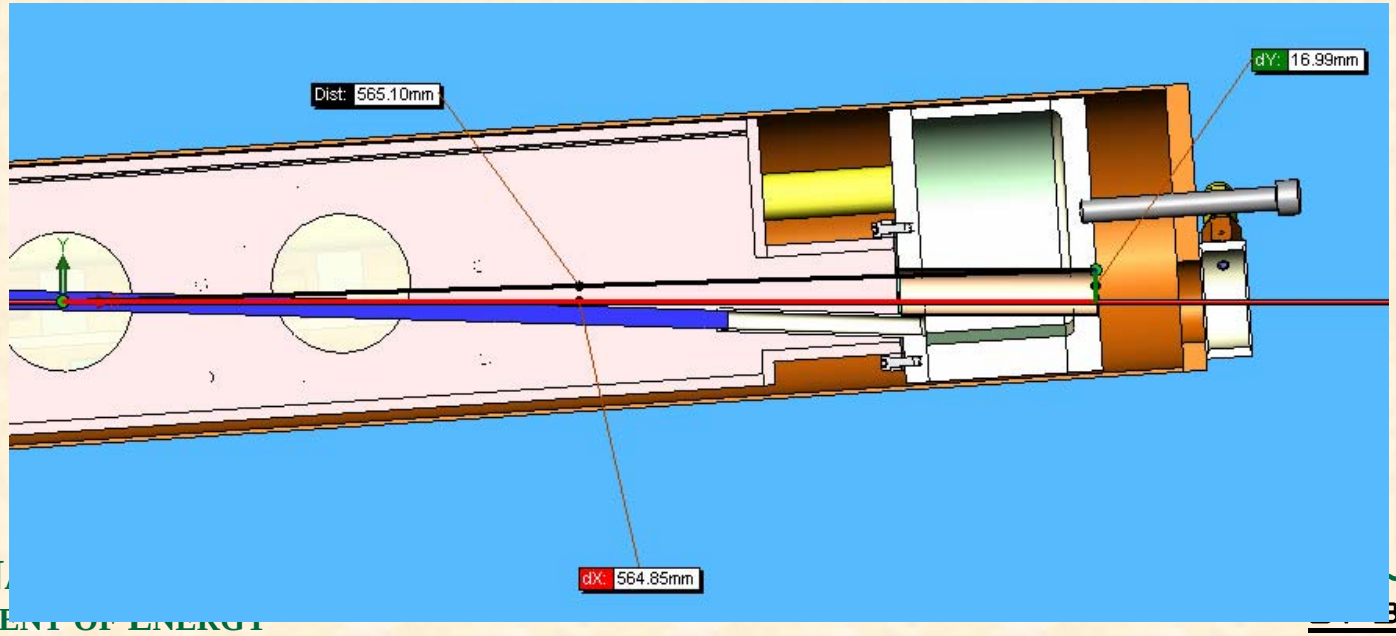
Physical Properties	
Chemical Formula	Al_2O_3
Structure	hexagonal-rhombohedral
Molecular weight	101.96
Lattice Constants	Å a=4.765, c=13,000
Density (g/cm^3)	3.98
Hardness	9 Mohs 1800 knoop parallel to C-axis 2200 knoop perpendicular to C-axis
Water Absorption	Nil
Young Modulus (Gpa)	379 at 30° to C-axis 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 / Modulus of Rupture (MPa)	350 to 690
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**