UT-BATTELLE

Hg System Operation Review

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MERIT Pre-Installation Review

CERN

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OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

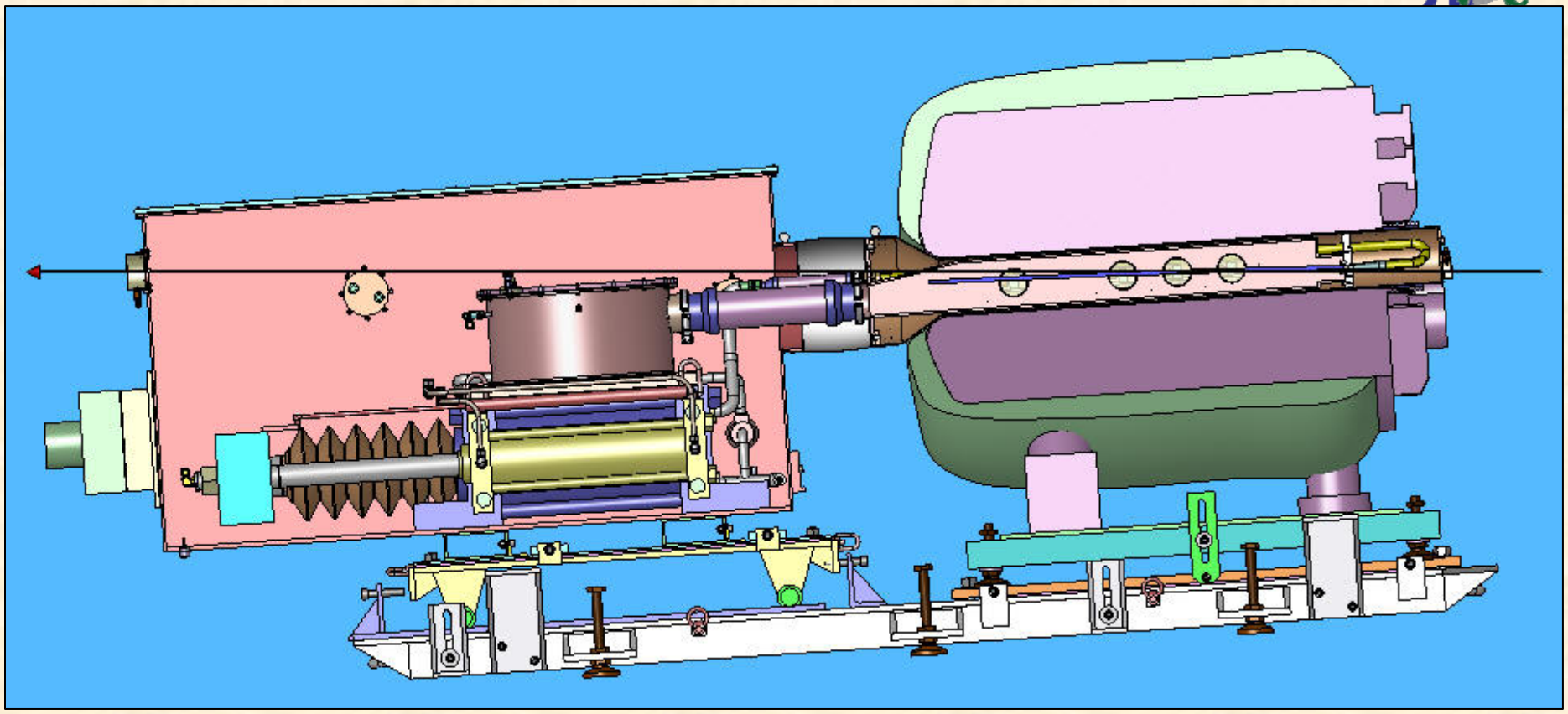
Outline

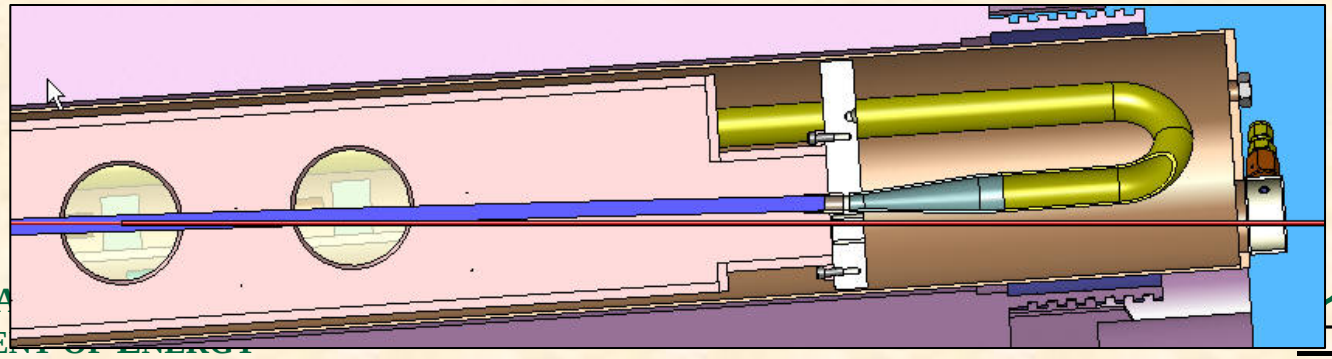
- **Hg system description**
- **Integrated testing results**
- **Operational experience**
- **Plans at CERN**

Hg System Description

- **Syringe pump**
- **Hydraulic power unit w/control system**
- **Optical diagnostic system**
- **Baseplate support structures**

MERIT Side View





Syringe Pump System

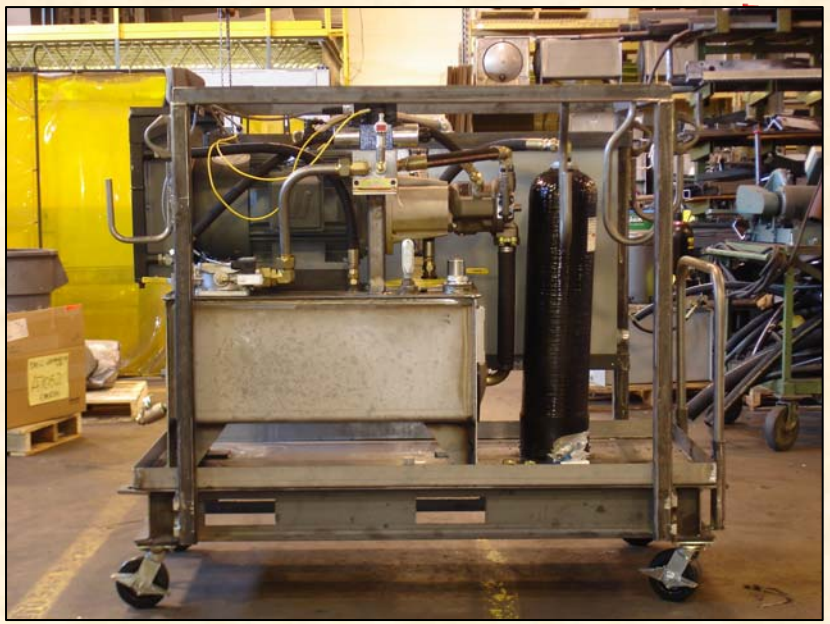
- **Primary containment**
  - **Hg-wetted components**
  - **Capacity 23liters Hg (~760 lbs)**
  - **Jet duration up to 12 sec**
- **Secondary containment**
  - **Hg leak/vapor containment**
  - **Ports for instruments, Hg fill/drain, hydraulics**
- **Optical diagnostic components**
  - **Passive optics**
  - **Shadow photography**
- **Beam Windows**
  - **Ti alloy components that directly interact with beam**
  - **Single windows on primary, double windows on secondary**

Syringe Statistics

- **30hp / 4000psi / 12.9gpm hydraulic pump**
- **40 gal vegetable-oil based hydraulic fluid**
- **Hg flow rate 1.6liter/s (24.9gpm)**
- **Piston velocity 3.0cm/s (1.2in/sec)**
- **Up to 100 bar (1500 psi) Hg pressure in cylinder**
- **Hg cylinder force 525kN (118kip)**

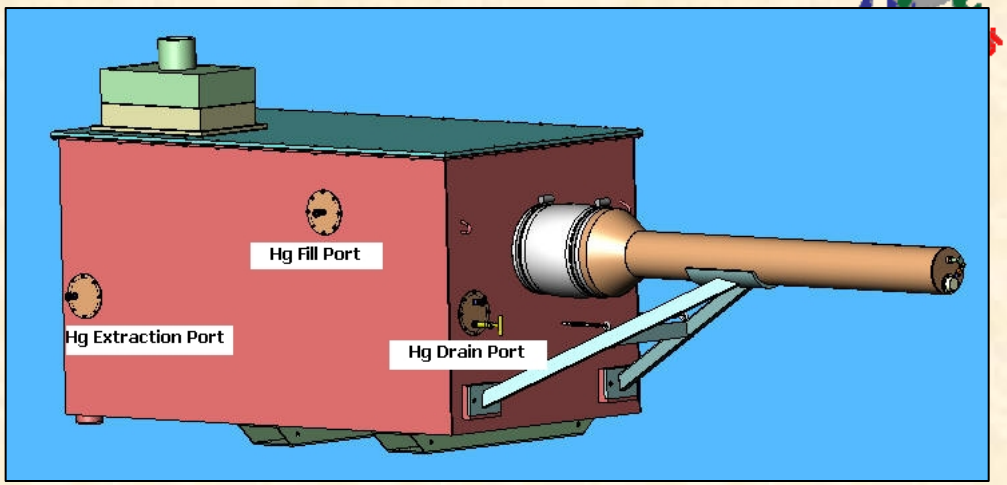
Hydraulic Power Unit

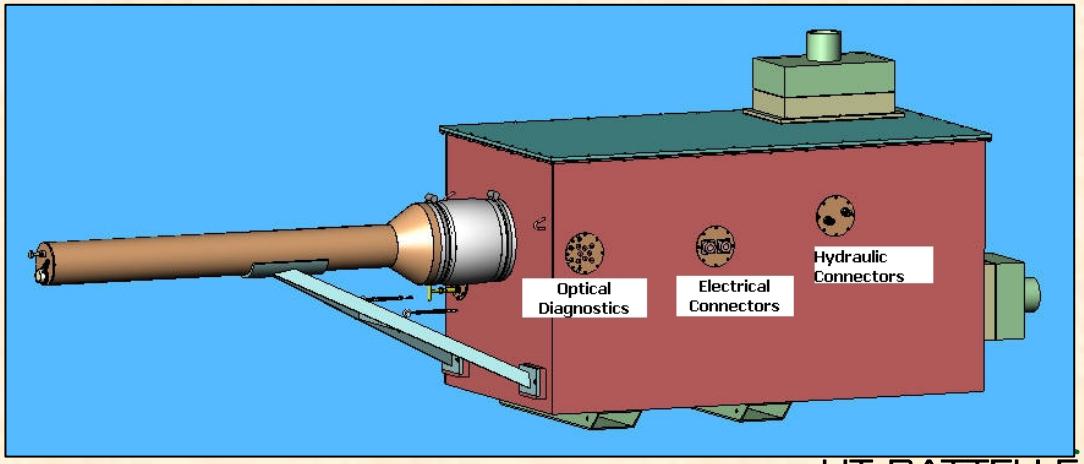
- **Actuates syringe drive cylinders**
- **Connected to secondary containment through non-magnetic hoses**
- **Proportional control valve provides precise hydraulic flow based on command signal from control system**
- **200 bar (3000 psi) nominal operating pressure**
- **Incorporates relief valve to prevent over-pressure condition**
- **Breather-vent filter isolates reservoir air from tunnel**
- **Drip pan for small fluid leaks**



Ports

- **Hydraulics**
- **Instrumentation**
- **Optical diagnostics**
- **Hg drain & fill (without opening secondary)**
- **Hg extraction (in event of major leak in primary containment)**
- **Passive filtration**





Load Testing of Common Baseplate & Target Cart

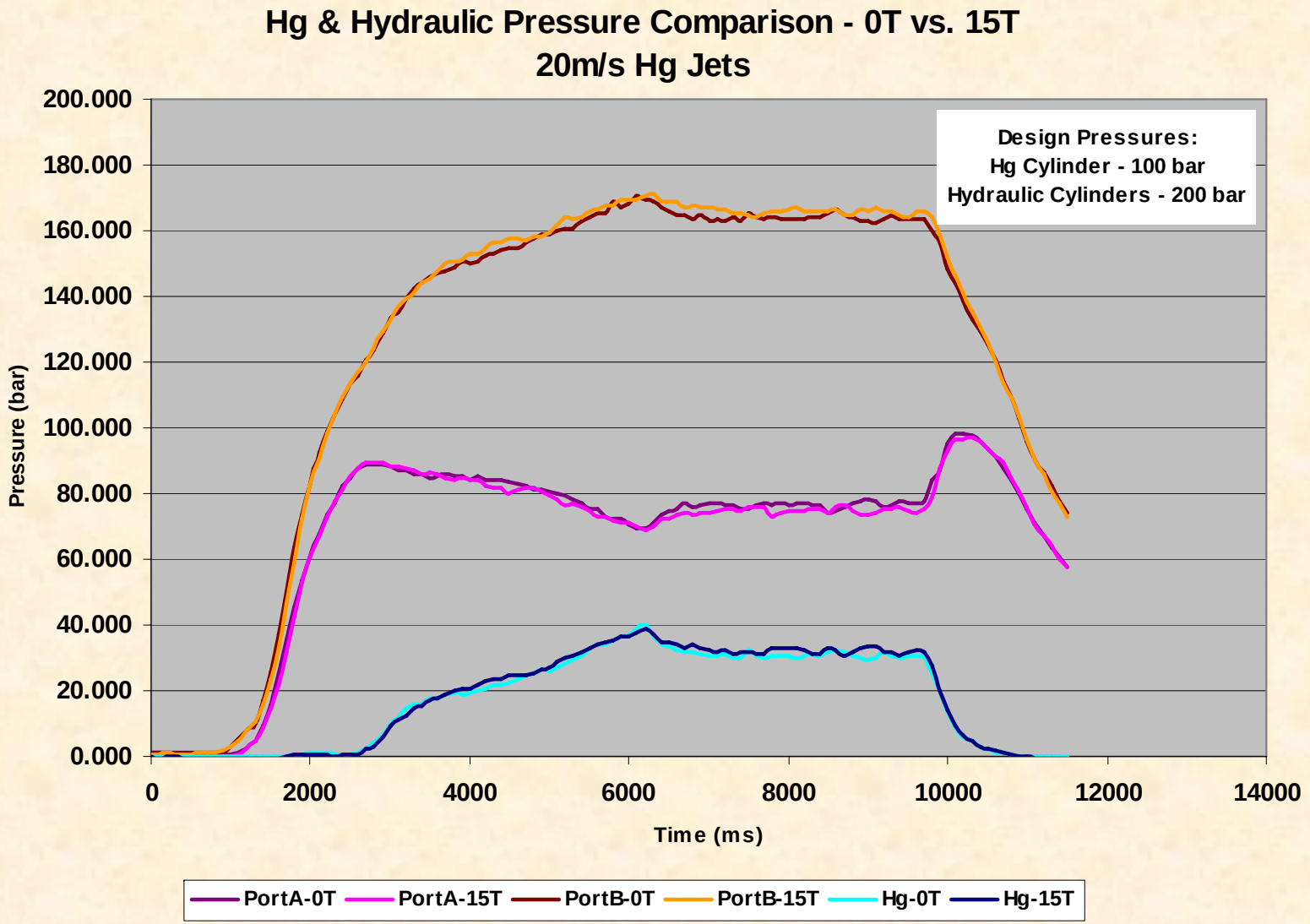
- **CERN Safety Commission voiced concerns regarding analysis performed on common baseplate design**
- **Load test performed on structures to verify strength and test adjusting mechanisms**
- **Estimated component weights**
  - **Magnet: 12000 lbs (5440 kg)**
  - **Hg system (with 23liters Hg): 4000 lbs (1810 kg)**
- **Test weights**
  - **Magnet: 13600 lbs (6170 kg) = 113% estimated weight**
  - **Hg system: 4500 lbs (2040 kg) = 113% estimated weight**

In Nominal Test Position

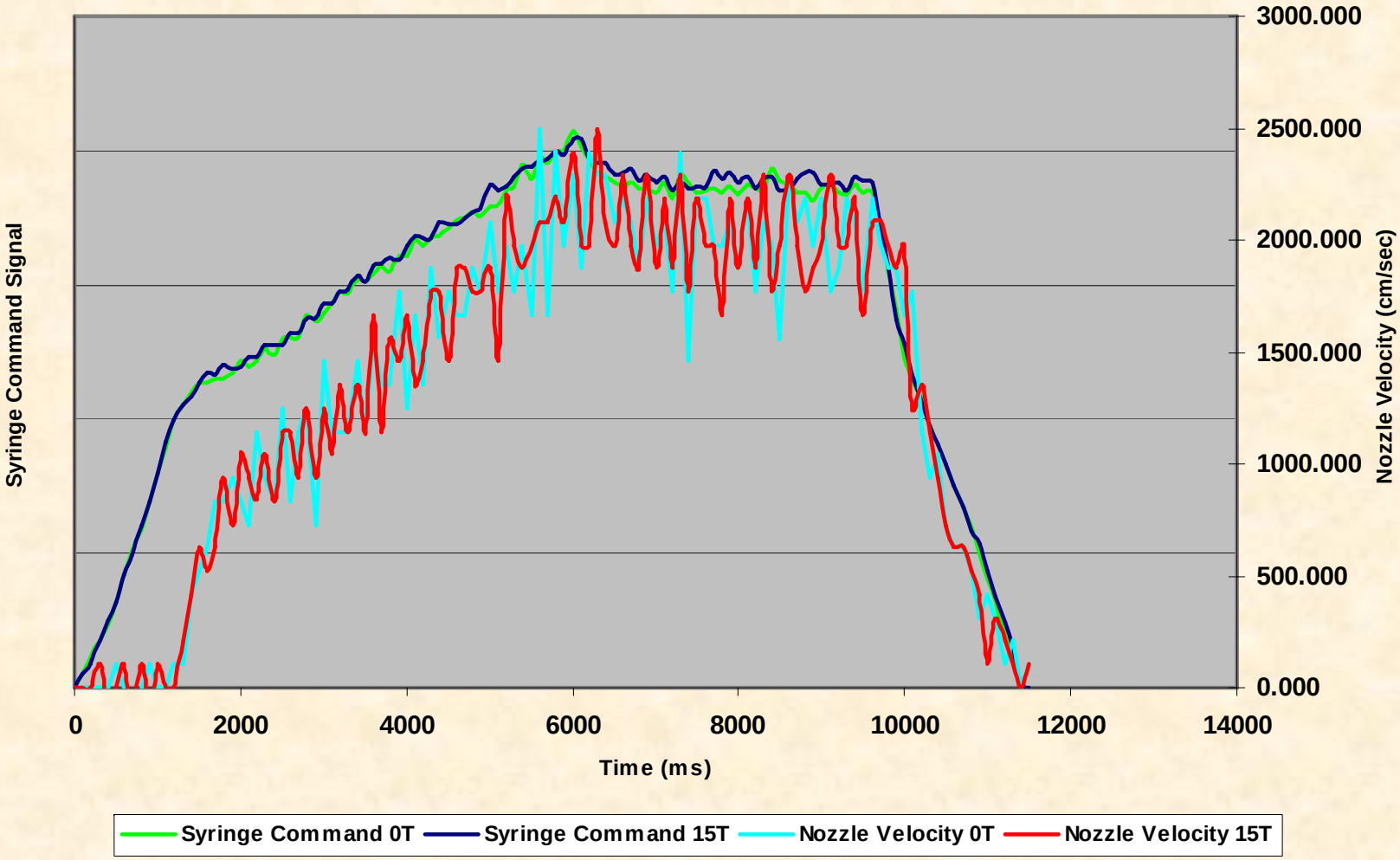
- **Baseplate tilt ~ 66mrad**
- **Elevation matches CAD models**

MIT Testing Result Summary

- **Completed 14 runs with field (10-15-20 m/s jets, 5-10-15 Tesla fields)**
- **Syringe pump performed as expected**
  - **No fluid leaks during testing**
- **Expected increased Hg pressure due to field, but no effects observed**
- **Water vapor issues inside jet chamber resulted in addition of strip heater on exterior of chamber**
- **External bore heater had to be reconfigured due to clearance issues**

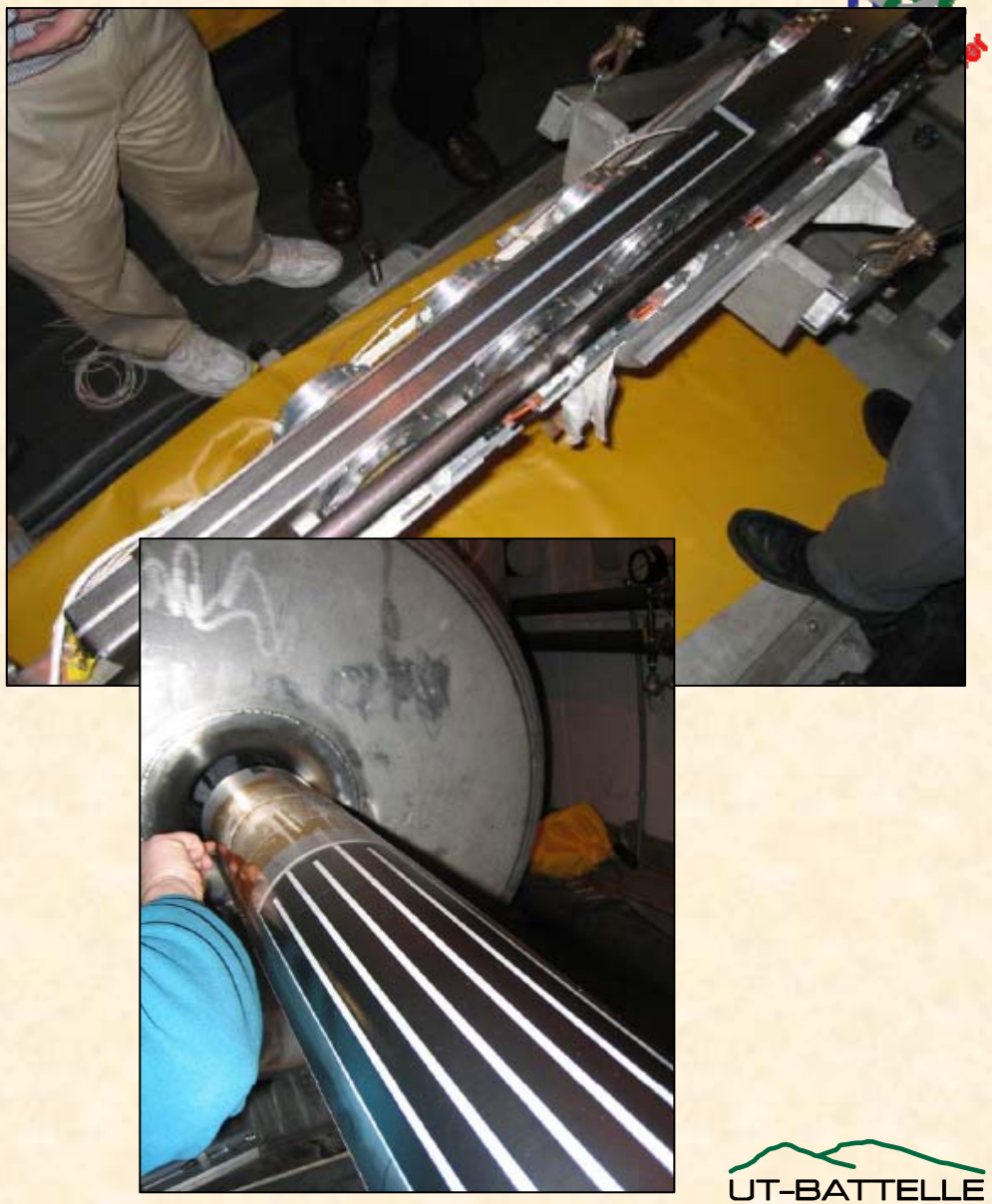

Hg & Hydraulic Pressure Comparison - 0T vs. 15T
20m/s Hg Jets
Design Pressures:
Hg Cylinder - 100 bar
Hydraulic Cylinders - 200 bar
Pressure (bar)
200.000
180.000
160.000
140.000
120.000
100.000
80.000
60.000
40.000
20.000
0.000
0
2000
4000
6000
8000
10000
12000
14000
Time (ms)
PortA-0T
PortA-15T
PortB-0T
PortB-15T
Hg-0T
Hg-15T

Nozzle Velocity Comparison - 0T vs. 15T



Addition of Strip Heaters

- **Approx 0.5L water not removed from system prior to Hg operations at ORNL**
- **Insertion into magnet caused condensation on viewports**
- **Modified existing flexible heaters to prevent condensation**
- **New heaters and controllers procured for CERN operation**



Operational Experience

- **Hg fill/drain process performed twice without incident**
- **Small Hg leak occurred at ORNL**
  - **Contained within secondary, no problems in cleanup**
- **Control system functions as expected**
  - **Tested emergency stop conditions**
- **Hg vapor detection and capture**
  - **Vapor monitors work as expected**
  - **Local ventilation system (Scavenger) quickly removes any vapors within secondary, zero emissions detected at exhaust**

Hg Fill & Drain Procedures Tested

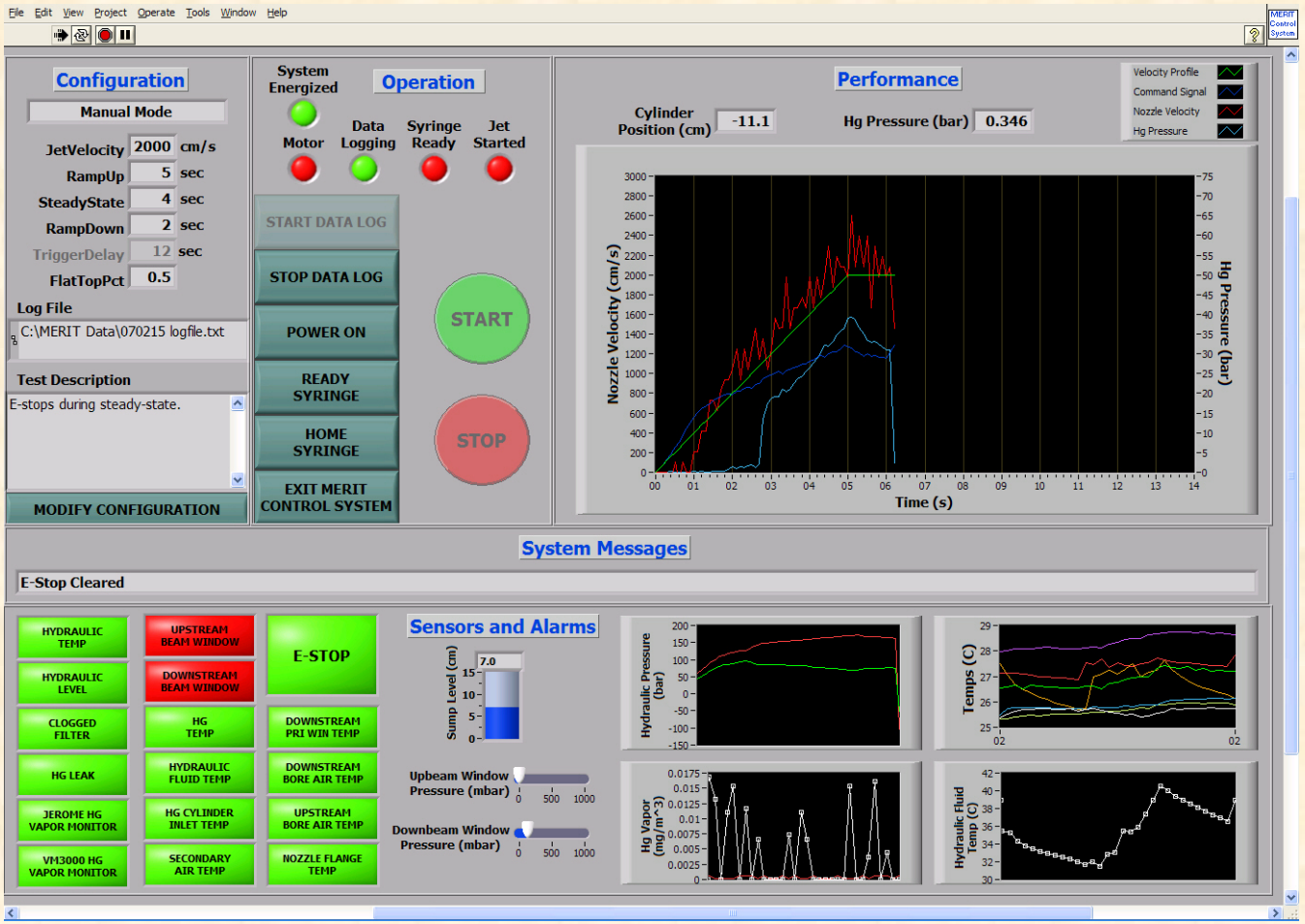
- **Two fill and drain cycles completed**
  - **MIT cycles observed by CERN personnel**
- **Peristaltic pump method works well, minimizes spill risk & vapor generation**
- **Drain into intermediate container reduces chance of overfilling flask**
- **Flasks weighed empty & full to track inventory**
- **No spills or operational problems**

Hg Leak Experienced

- **Very high vapor levels inside secondary detected at ORNL**
  - **No vapors detected outside secondary**
  - **Scavenger snorkel successfully removed vapors**
- **Suspected Hg cylinder bellows & made effort to seal seams**
  - **Upon disassembly, no vapors detected inside bellows**
- **Small Hg leak discovered in nozzle supply threaded joint**
- **Successfully removed liquid and tightened joint**

Emergency Stops Tested

- **Syringe pump stopped during 20m/s jet creation**
- **No detrimental effects on equipment**
- **No noticeable vibration or shudder**



Plans at CERN for Hg System

- **Transport all equipment into TT2/TT2A**
- **Open secondary containment prior to Hg loading**
  - **Procedures in place for this operation**
  - **Leak check primary containment (pressure decay test without opening primary)**
  - **Connect optical diagnostics system & adjust viewport optics**
  - **Install new heater strips**
  - **Install umbilicals and operate optical diagnostic system**
- **Close secondary**
  - **Install other umbilicals (hydraulics, sensors, vapor monitors)**
  - **Load Hg**
- **Perform Hg system commissioning tests**
  - **System can be operated and tested independently of solenoid**

Conclusions

- **System operating characteristics have been quantified during ORNL and MIT testing**
- **15T field induced no additional pressure on Hg piping, system well within design pressures**
- **Secondary containment has prevented vapor escape**
- **Valuable operational experience gained**
  - **Hg leak experienced**
    - **Detected with instrumentation, contained within secondary, successfully mitigated**
  - **Control system functionality proven**

Backup Slides

Operational Testing

- **Lifting jacks and lateral position adjustment mechanisms tested**

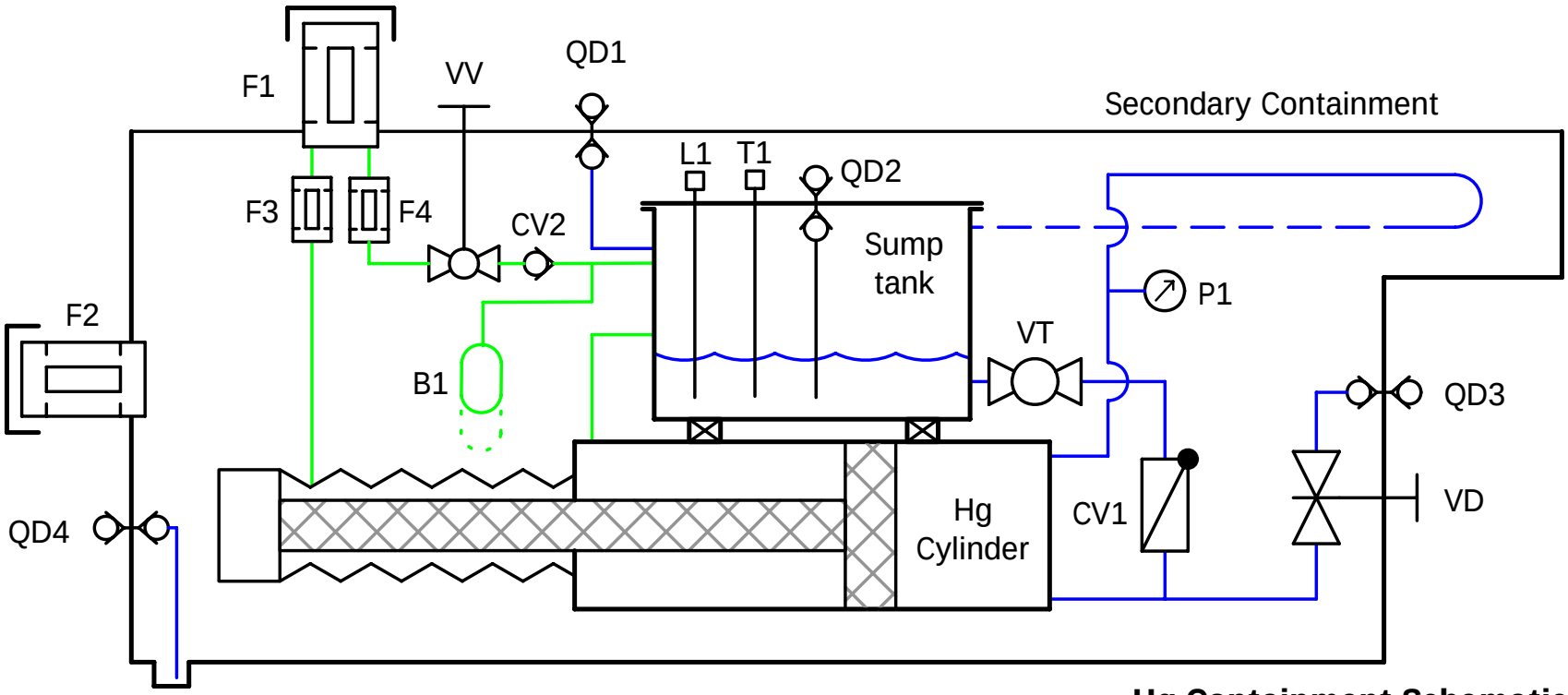
Roller Testing

- **Loaded baseplate pushed with pallet jack while on three Hilman rollers**

Leveling Jack Testing

- **Baseplate adequately supported by four leveling jacks**

Hg System Schematic



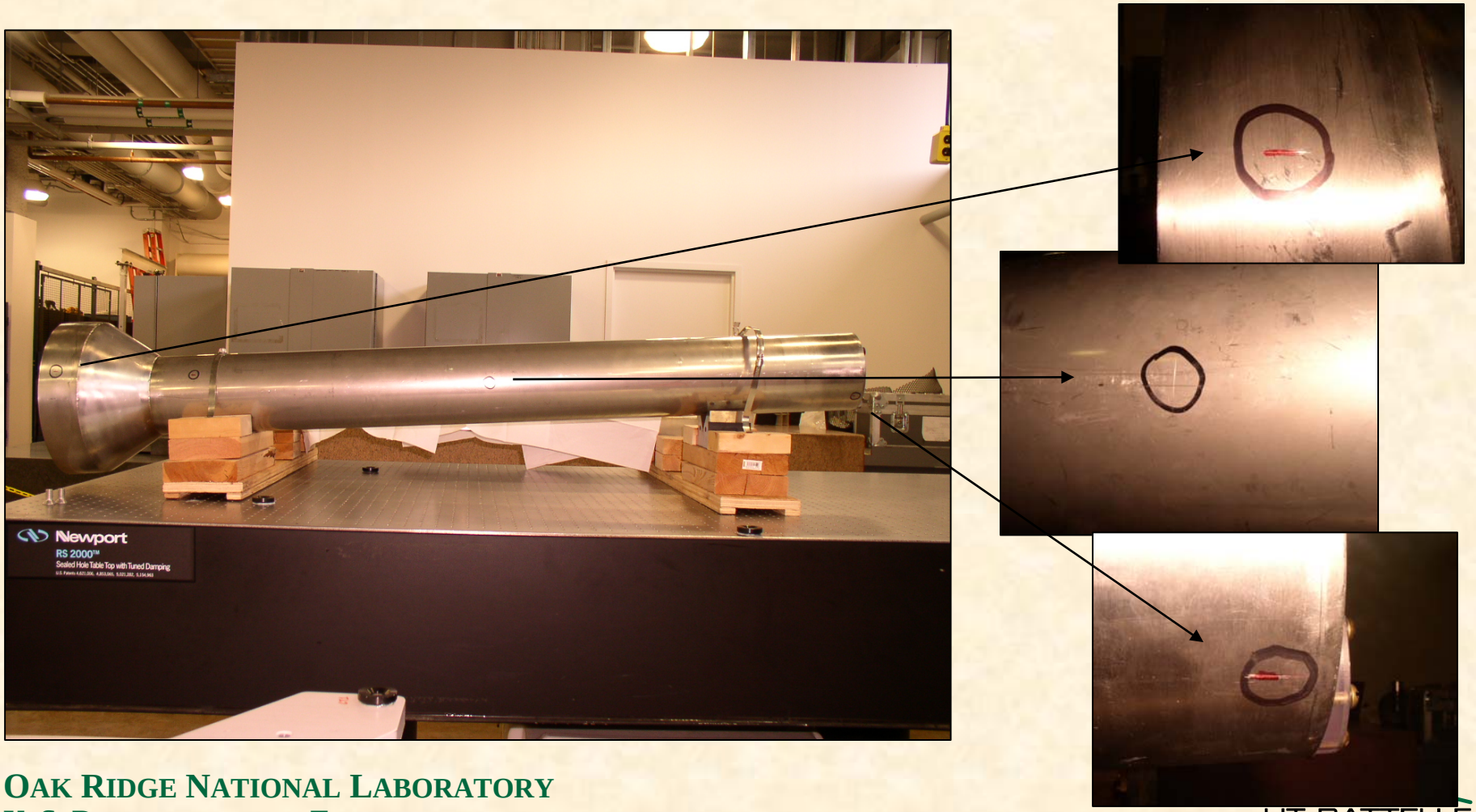
Hg Containment Schematic
8Feb2007

Secondary Snout Fiducialized

- **Marks on exterior of target snout will aid in alignment (tilt and elevation only)**
- **Service provided by SNS Survey & Alignment Group**

Installation Marks

- **Optical survey equipment required to see scribe marks**

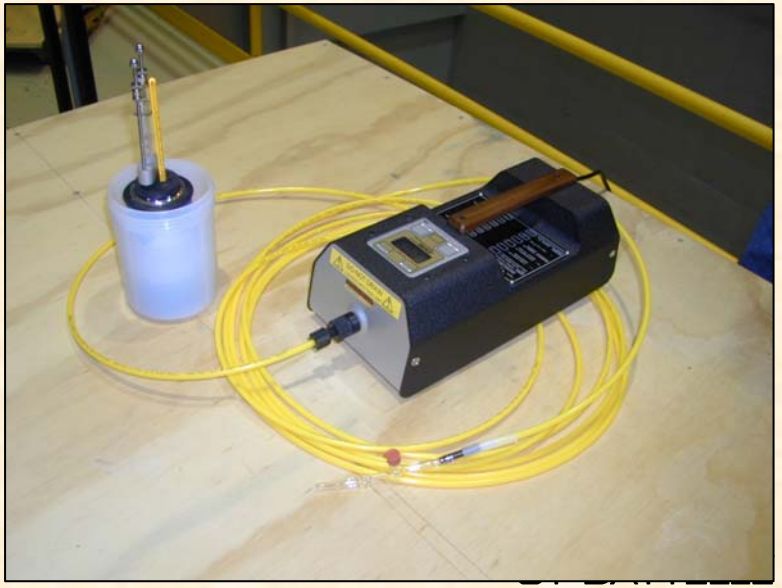


Sumptank Standpipes Added

- **Testing revealed potential Hg surge under splash plate could allow Hg to exit sump tank through vents**
- **Additional height added to eliminate condition**

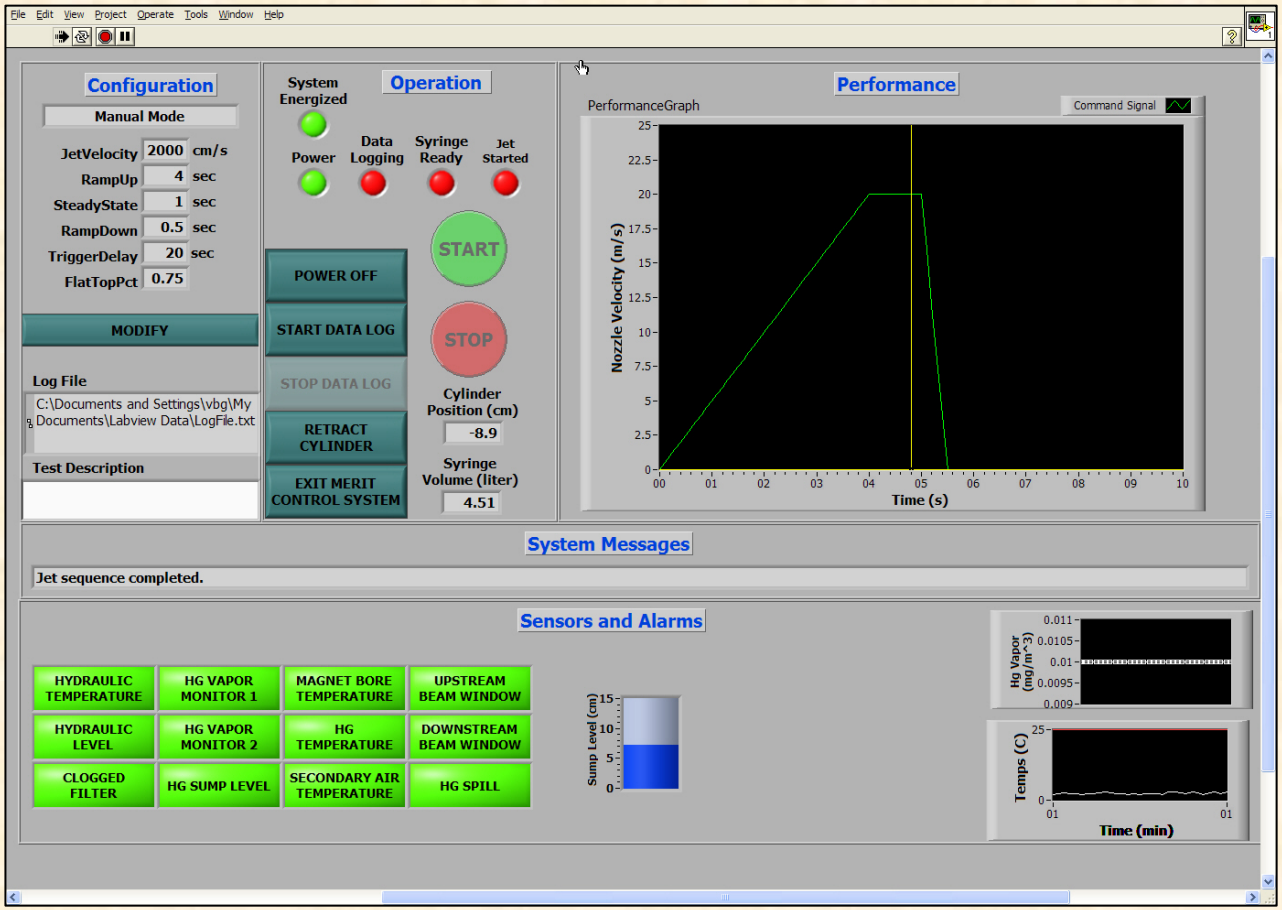
Vapor Monitor Tests

- **Both vapor monitors (Jerome 431-X and Mercury Instruments VM3000) tested to verify ability to read vapors through 10m, small-dia tubing**
  - **Jerome samples every 5 minutes, VM3000 continuously samples**
  - **Both units detected elevated vapor levels**
    - **VM3000 within a few seconds**
    - **Jerome within 2 samples**
- **Signals integrated into Labview control system**
  - **VM3000 output correctly read by Labview**
  - **Having some difficulties with the Jerome unit, discussing with vendor tech support**



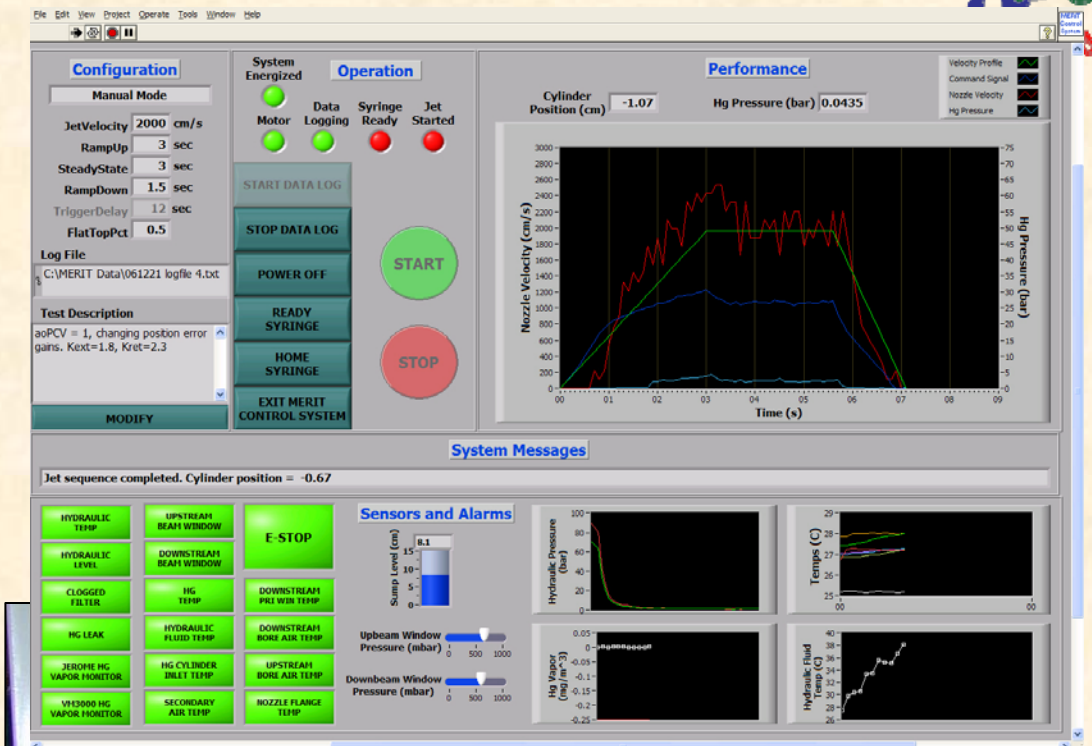
Hg Syringe Control Operator Interface

- **Jet velocity profile**
- **Syringe control**
- **Performance feedback**
- **Data logging**
- **Operator messages**
- **Status & alarm indicators**



LabView-Based Control System

- **LabView on laptop computer was chosen as system controller**
  - **CompactFieldPoint sensor modules housed in HPU control cabinet**
- **Hydraulic system controlled via Labview over ethernet**



Instrumentation & Sensors

Controlled Components			
Hydraulic pump	Proportional control valve		
Analog Sensor Inputs			
Hg discharge pressure	Hg level	Hg vapor 1	Hg vapor 2
Cylinder 1 position	Cylinder 2 position	Beam window 1 pressure	Beam window 2 pressure
Hydraulic fluid port pressures	Eight RTDs		
Digital Sensor Inputs			
Hydraulic filter dirty switch	Hydraulic low level switch	Hydraulic fluid high temperature	Conductivity probe leak detector
Beam trigger			