MERIT Hg System Testing Status

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Neutrino Factory Muon Collider Collaboration Meeting

UCLA

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Outline

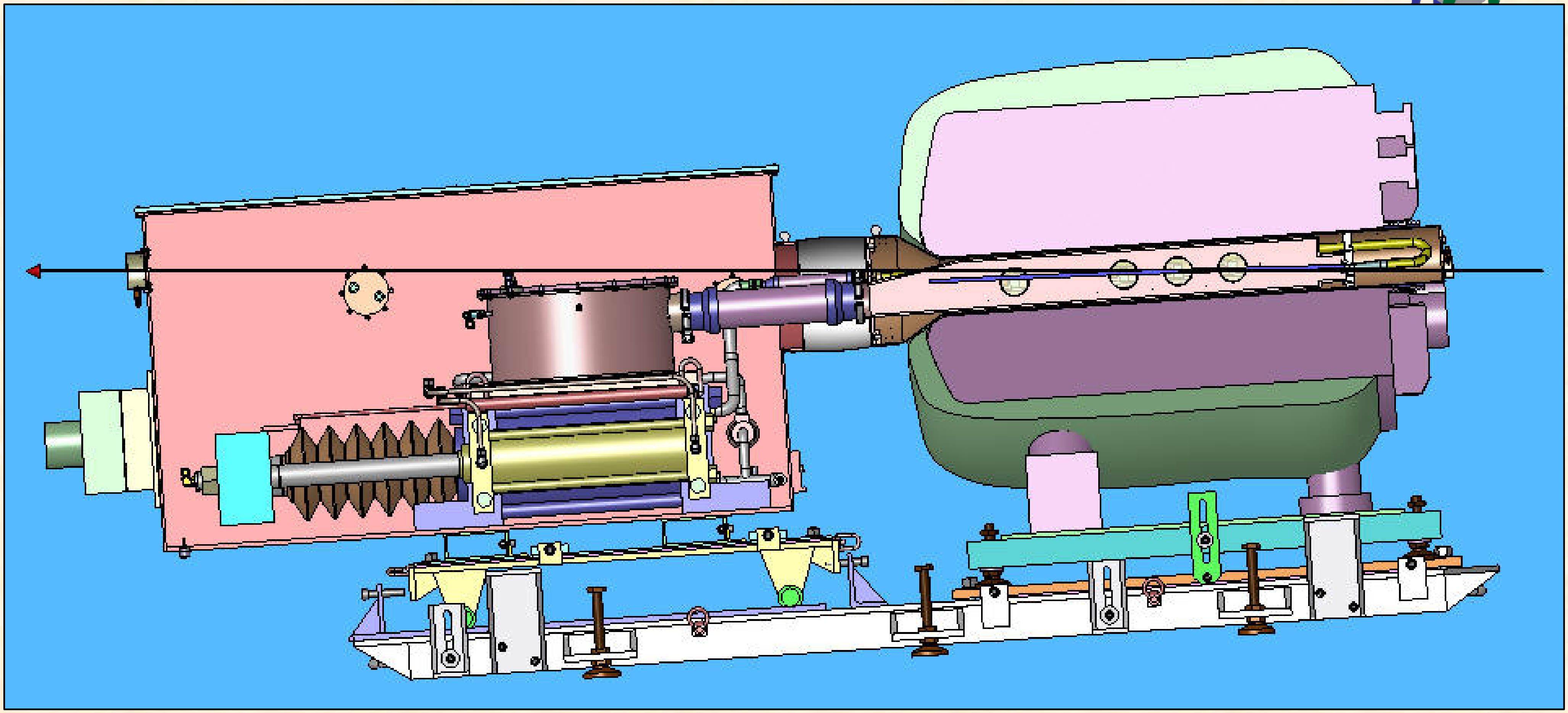
- **Requirements review**
- **System description**
- **Testing to date**
- **Preparations for CERN**
- **Next steps**

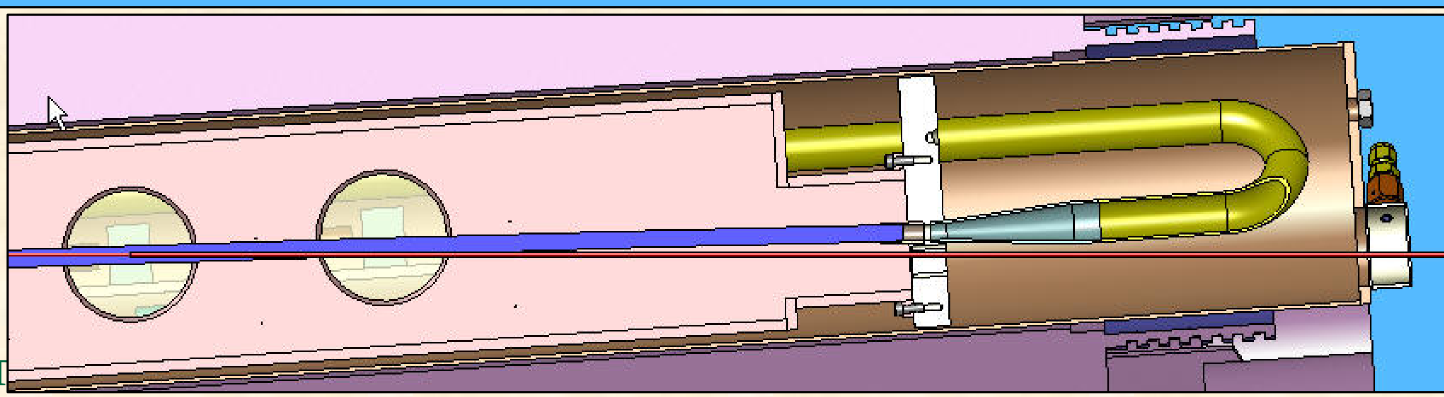
Requirements and Operating Conditions

Target system must deliver a stable, unconstrained jet of Hg into a 15 Tesla field

- **1-cm diameter jet at 20 m/s delivered every 30 minutes**
  - **Q=1.6liter/s**
- **Steady state jet must exceed magnet peak field duration**
- **Hg environment is 1-atm air**
- **Two barriers between Hg and tunnel environment**
- **Small angles between magnet axis, jet, and beam**
- **Up to 100 pulses for the CERN test**

MERIT Side View



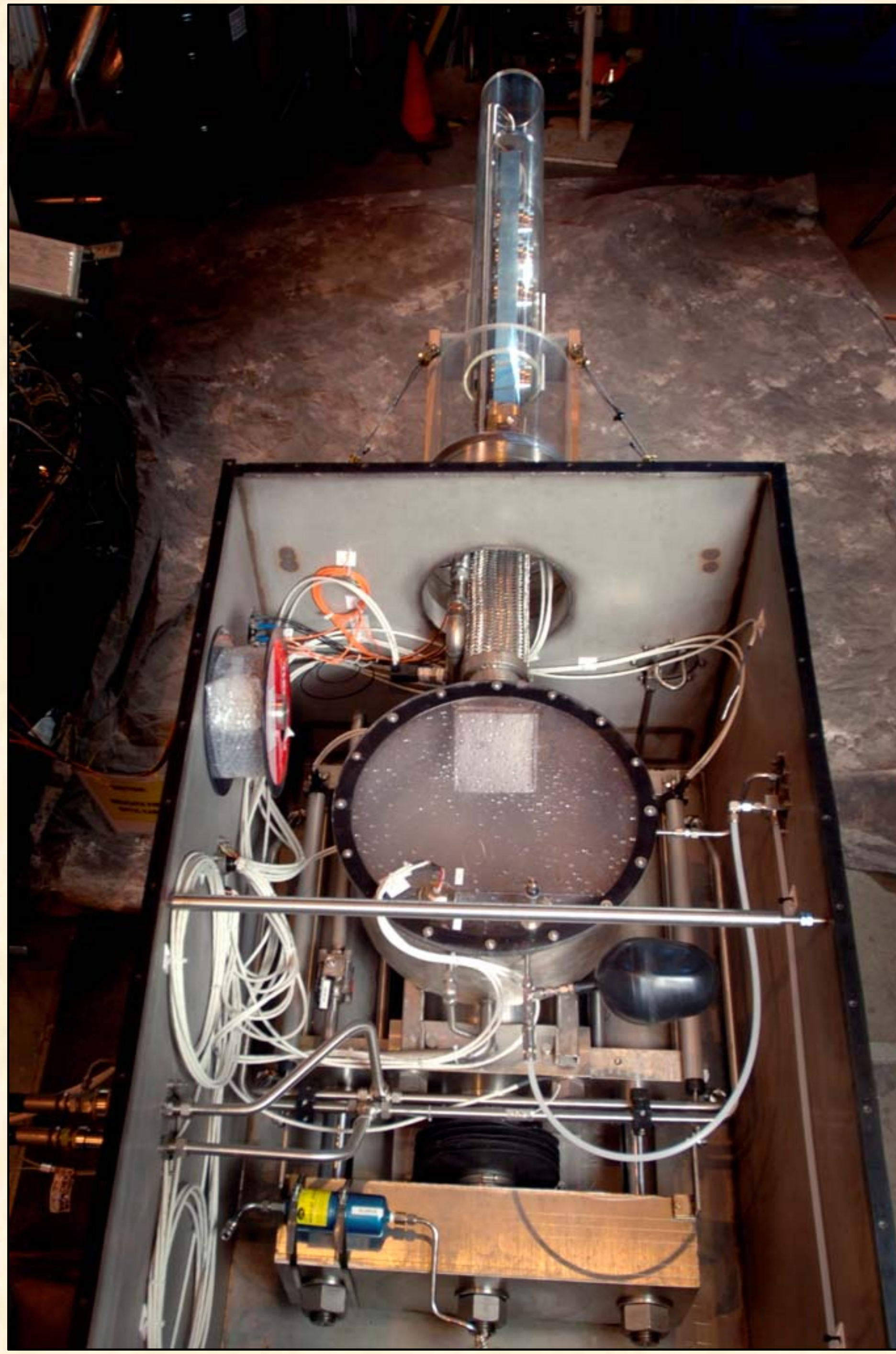


Hg Delivery System

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

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)**

LabView-Based Control System

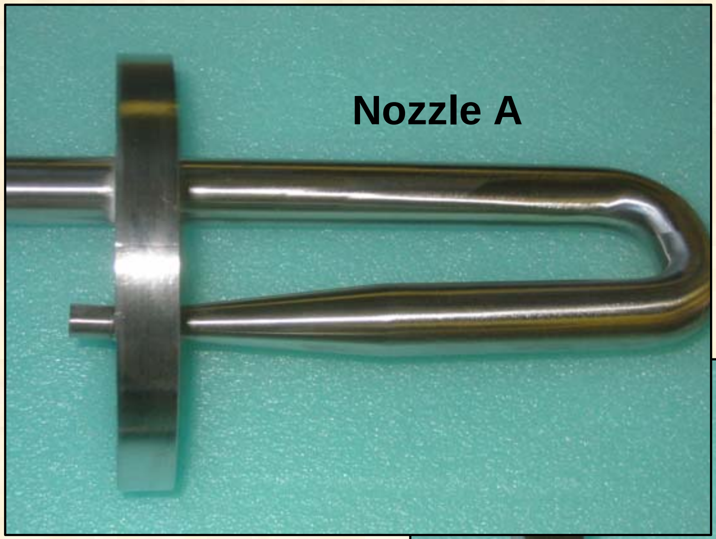
- **Control room will be housed in remote location from experiment, requiring network control of equipment**
- **LabView on laptop computer was chosen as system controller**
  - **CompactFieldPoint sensor modules housed in HPU control cabinet**

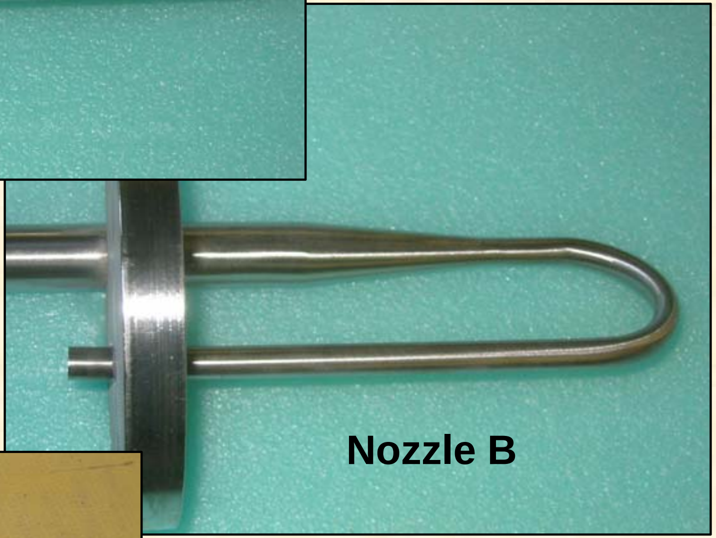
Instrumentation & Sensors

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			

SS Water Test Nozzles

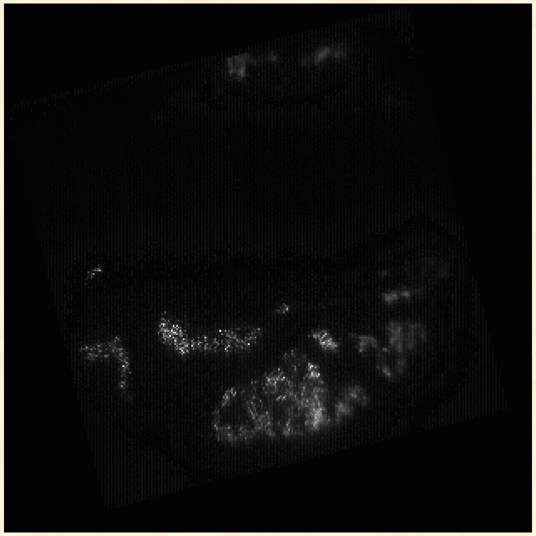
- **Nozzle A – diameter reduction after bend, 2.5° nozzle angle**
- **Nozzle B – reduction before bend, 2.5° nozzle angle**
- **Nozzle C – test nozzle with reduction after bend, straight nozzle tip, internally similar to nozzle A**
- **Nozzle D – nozzle A after reaming out the tip**



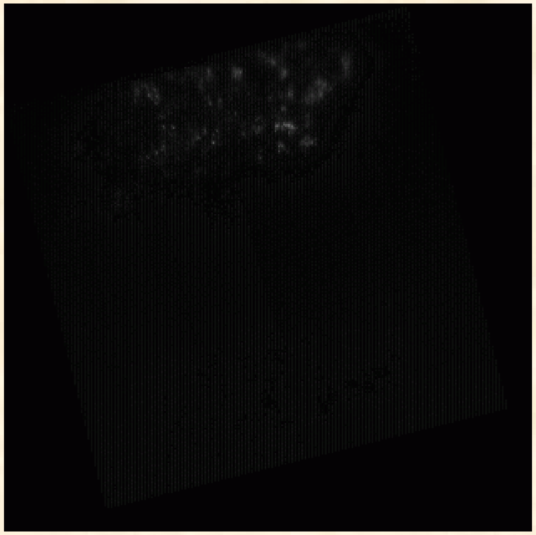


Results

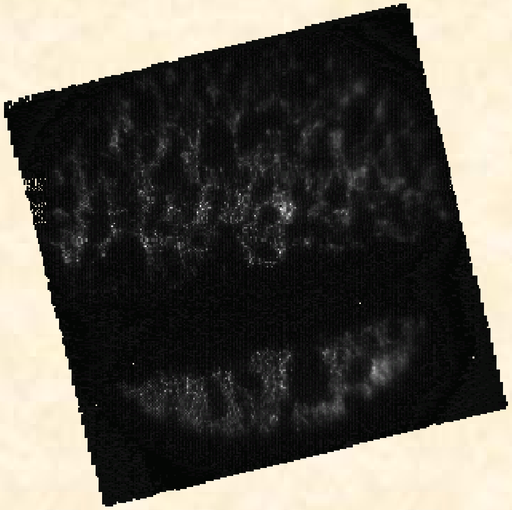
- **Nozzle B spray worse than Nozzle A**
  - **Neither jet was acceptable**
- **Definite increase in jet diameter at higher velocities**
- **Nozzle C gave best results**
- **Water droplets on windows was a problem**



Nozzle A, 20m/s



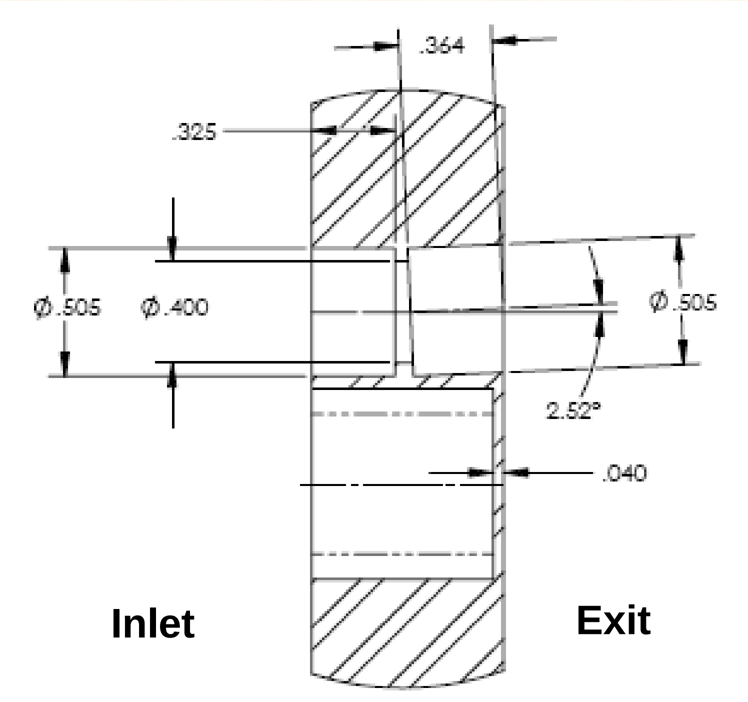
Nozzle B, 20m/s



Nozzle C, 20m/s

Nozzle Issues

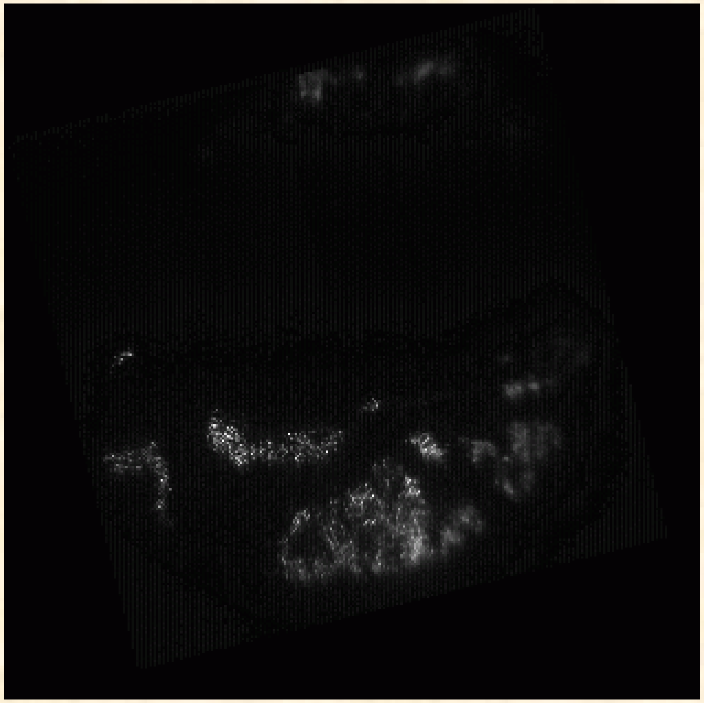
- **Flow path is a three-piece weldment**
  - **Inlet tube**
  - **Nozzle flange**
  - **Short angled nozzle tip**
- **Change in direction required for beam to miss piping geometry**
- **Smooth path requires constant ID**
- **Investigation revealed SS nozzles had step in flow path (flange thru hole smaller than tube IDs)**



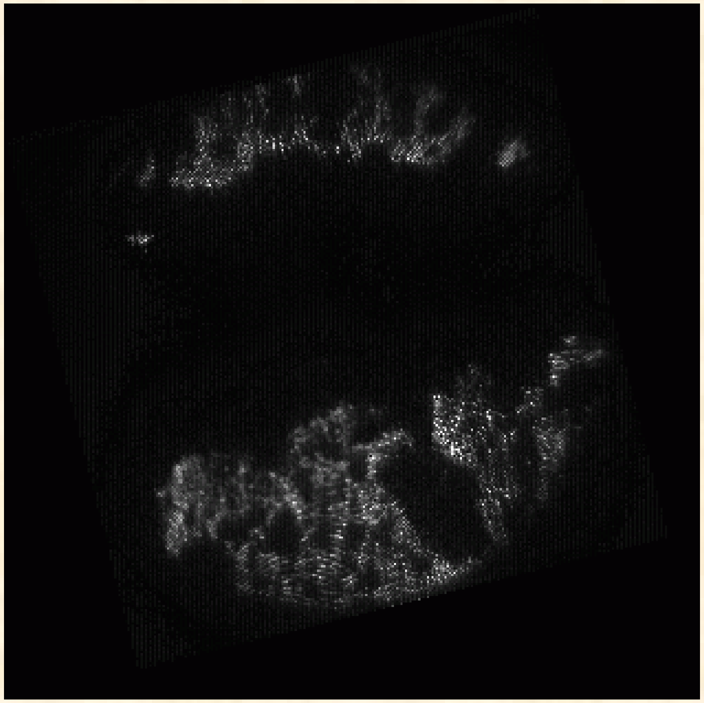
Dimensions in inches

Nozzle D Tested

- **Nozzle A was manually modified using drill bits to provide nearly constant ID from flange to tip**
- **Tests showed definite improvement, but still not satisfactory**
  - **Field of view 5.5cm, so Nozzle D generates ~2cm jet**



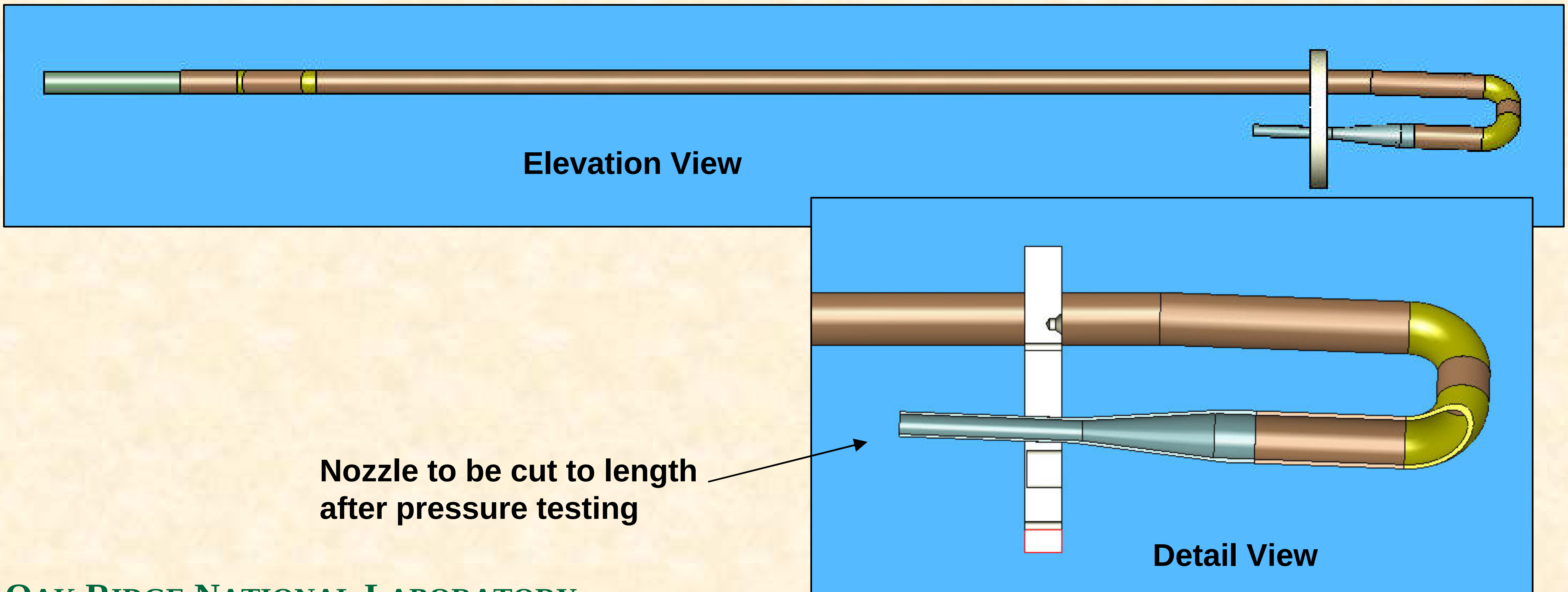
Nozzle A, 20m/s



Nozzle D, 20m/s

Nozzle E configuration

- **Straight flow path after 180deg bend**
- **"Kink" made prior to bend**
- **Fabricated from final Ti materials**

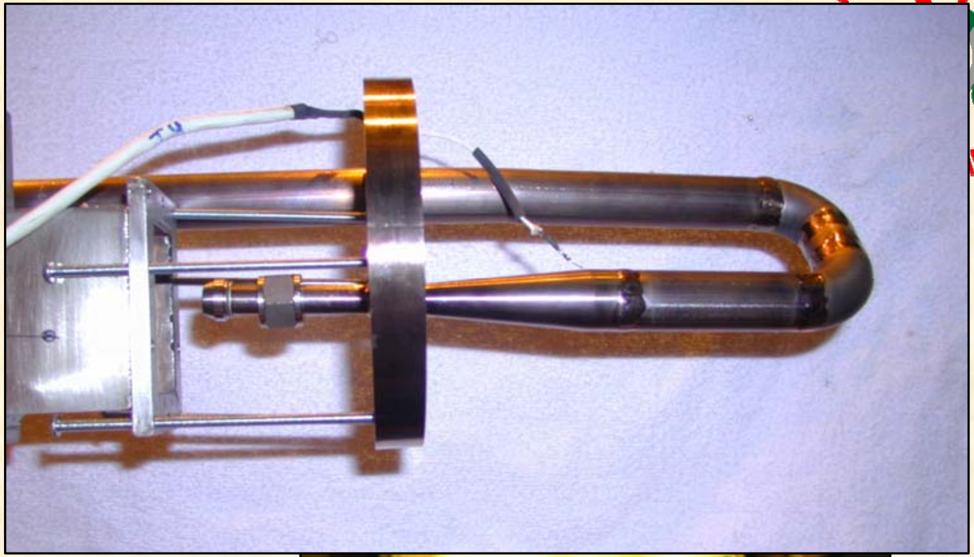


Ti Nozzle Fabrication

- **Final nozzle configuration fabricated from grade 2 and grade 5 Ti**
- **Assembly anodized after welding**
- **Fabrication error in assembly length**
  - **Requires removal of 1" piping**

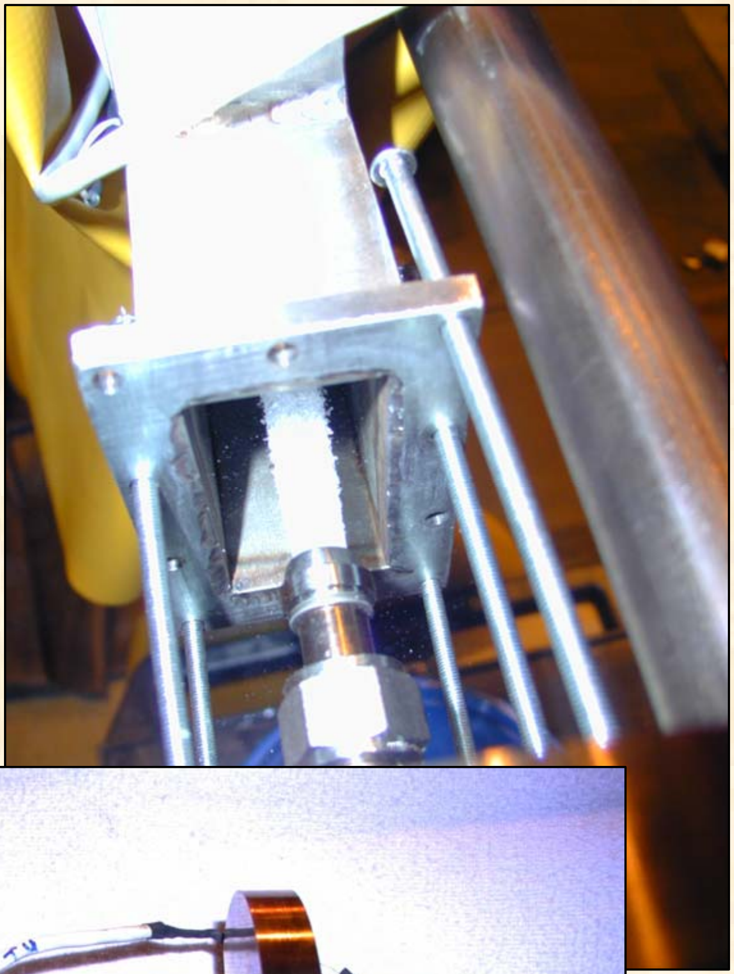
Ti Nozzle Testing

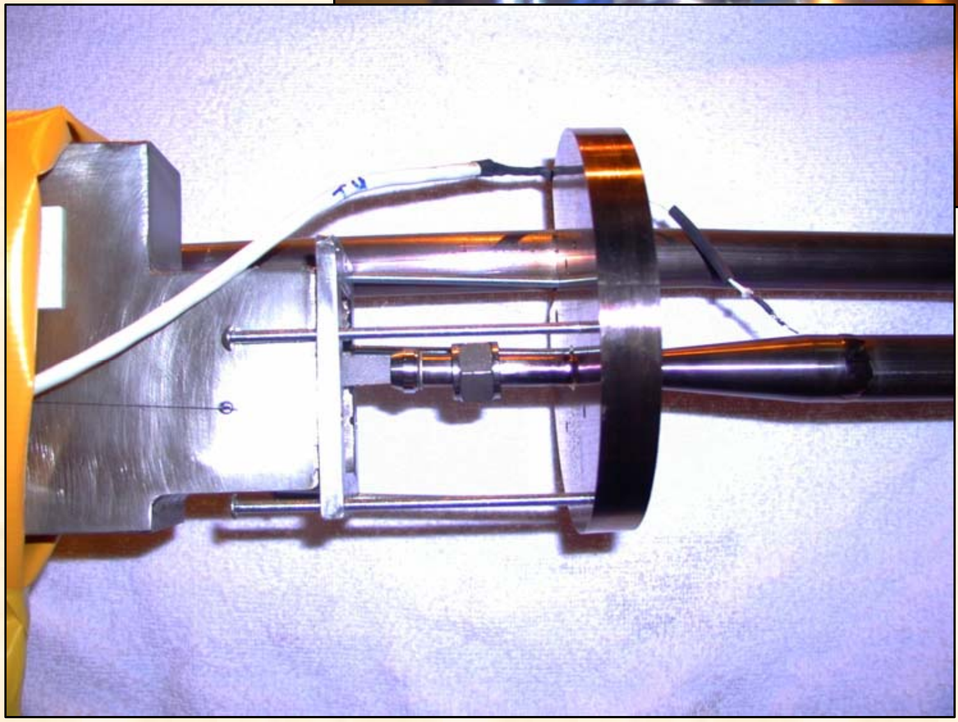
- **Nozzle testing compromised due to installation issues**
  - **Most interested in jet shape in these tests**
  - **Could not install nozzle in final position, so jet direction and angle measurements not meaningful**



Visual Results

- **Visual observation noted jet shape much improved over previous nozzle configurations**
  - **Observations verified by optical diagnostics system**
- **Any directional issues will be resolved once final assembly takes place**



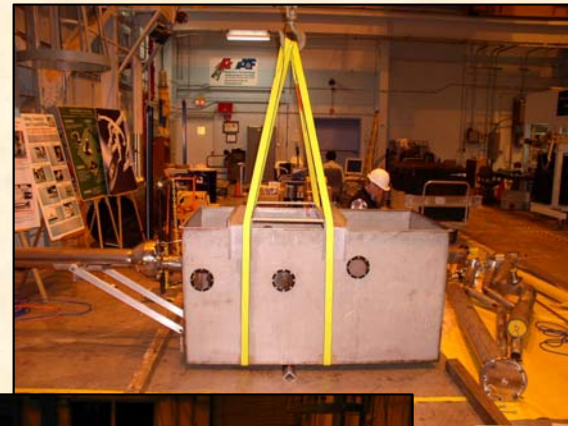


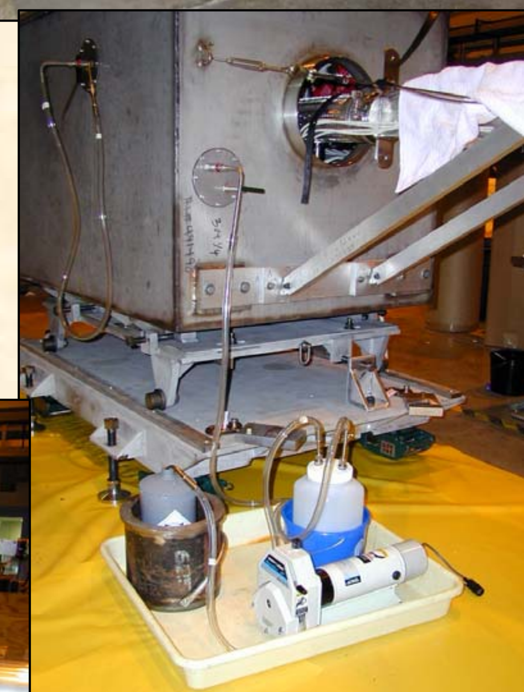
Nozzle Modification Status

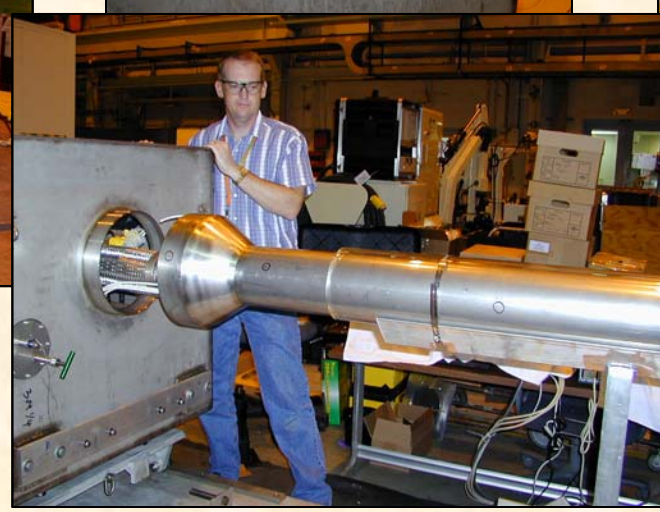
- **Initial water testing of Ti nozzle completed Jan 25**
- **Nozzle assembly taken to local Oak Ridge fabricator for modification**
  - **Cutting, re-welding, x-ray weld inspection, assembly pressure testing**
- **Modified assembly due back Jan 30**
- **Installation and additional testing will start Jan 31**
- **If no further problems encountered, Hg testing will commence a few days later**

Other Activities

- **Handling/lifting tests**
- **Hg vapor monitor testing at 10m tubing lengths**
- **Baseplate tests**
- **Assembly tests**



Shipping

- **Shipping issues have required more resources & attention than expected**
- **Custom crates for Hg system, HPU, & magnet procured**
  - **Certified for international shipment (ISPM-15)**
- **12 flasks Hg on their way to CERN**
  - **Separate Hg supply will be used at MIT**

Next Steps

- **Install modified Ti nozzle**
- **Conclude water tests**
- **Drain system, clean viewports, load Hg**
- **Conduct Hg tests and drain system**
- **Pack and transport to MIT for integrated testing in February**
- **Air-ship entire system to CERN in March**

Final Comments

- **Syringe pump system functions as designed (at least with water!)**
- **Optical diagnostics integrated with Hg system & is operational**
- **Safety & monitoring equipment tested**
- **Transportation plan developed and in place**