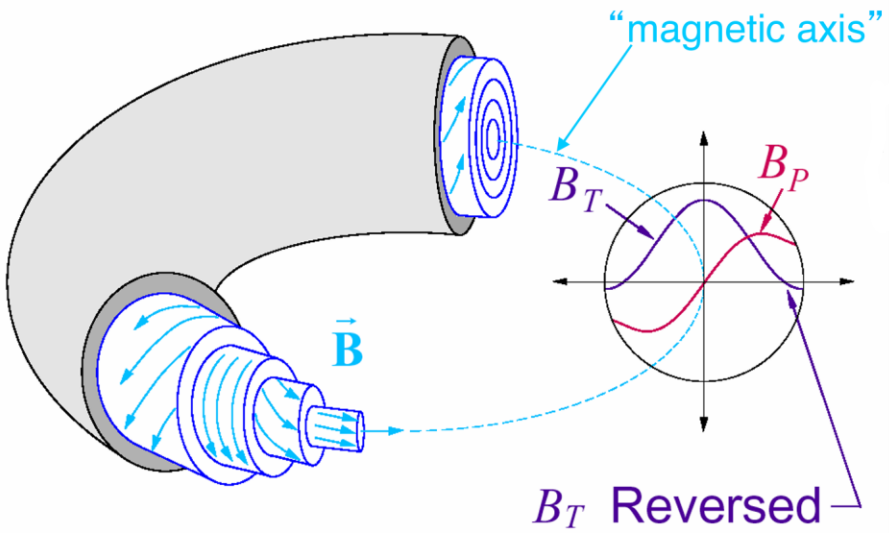
“A leak is a leak”: Vacuum Integrity in the Madison Symmetric Torus

Patrick Tracy

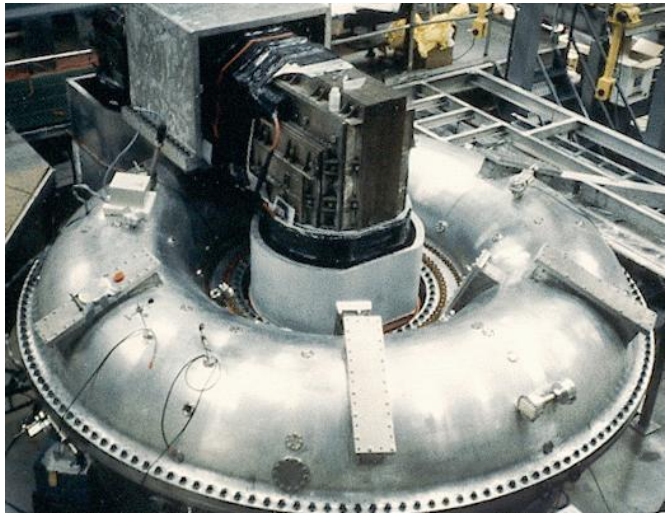
5/28/2025

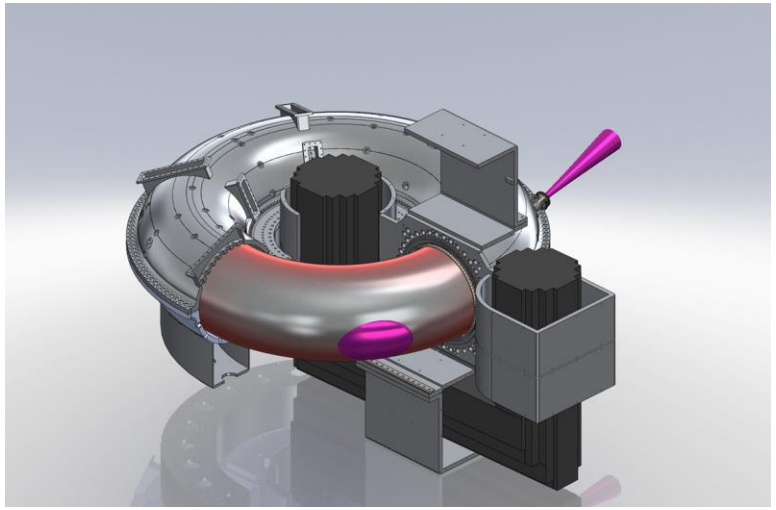
Madison symmetric torus overview

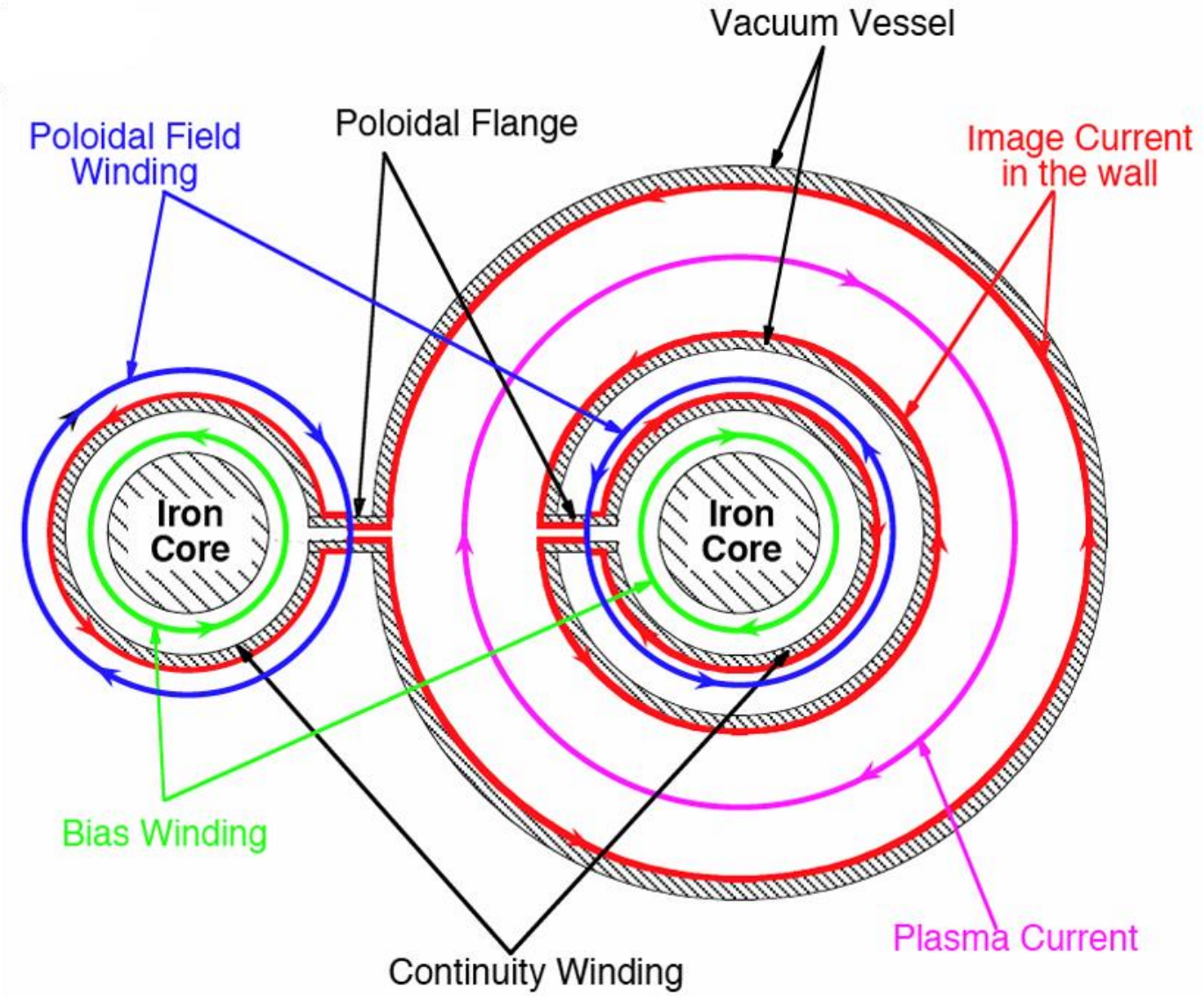


- Major radius 1.5m, minor radius .52m
- RFP: confinement achieved primarily by current in the plasma: Toroidal plasma current generates the poloidal magnetic field. Plasma dynamo and poloidal current generate the toroidal magnetic field after a relatively small initial field is applied externally. The applied field is then reversed at the wall.

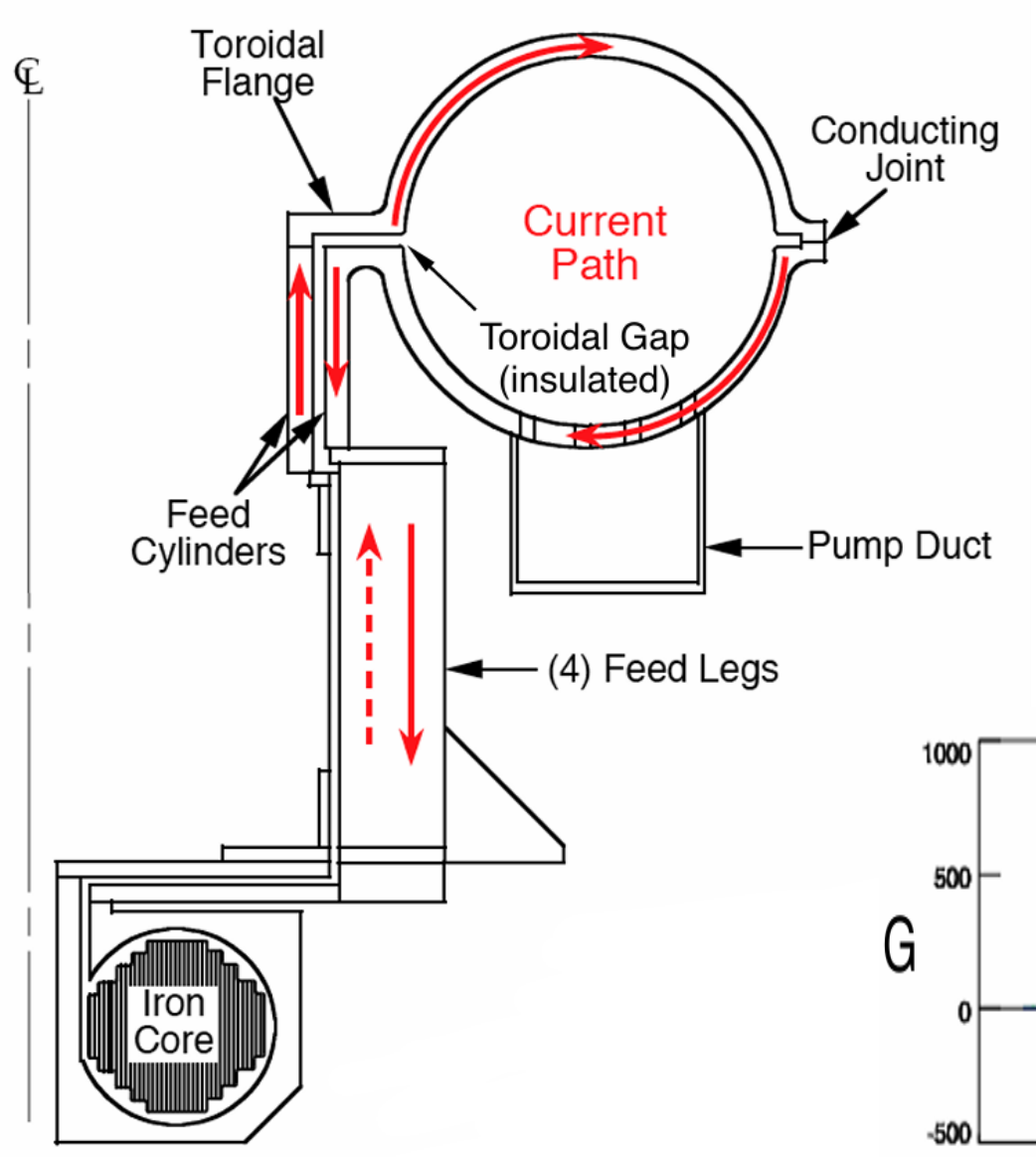
Poloidal field

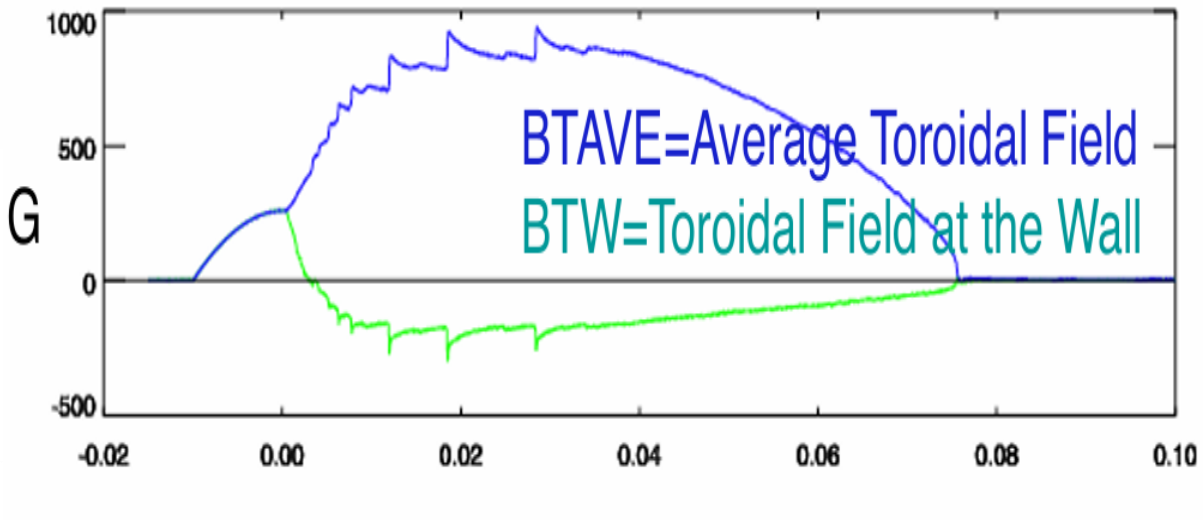




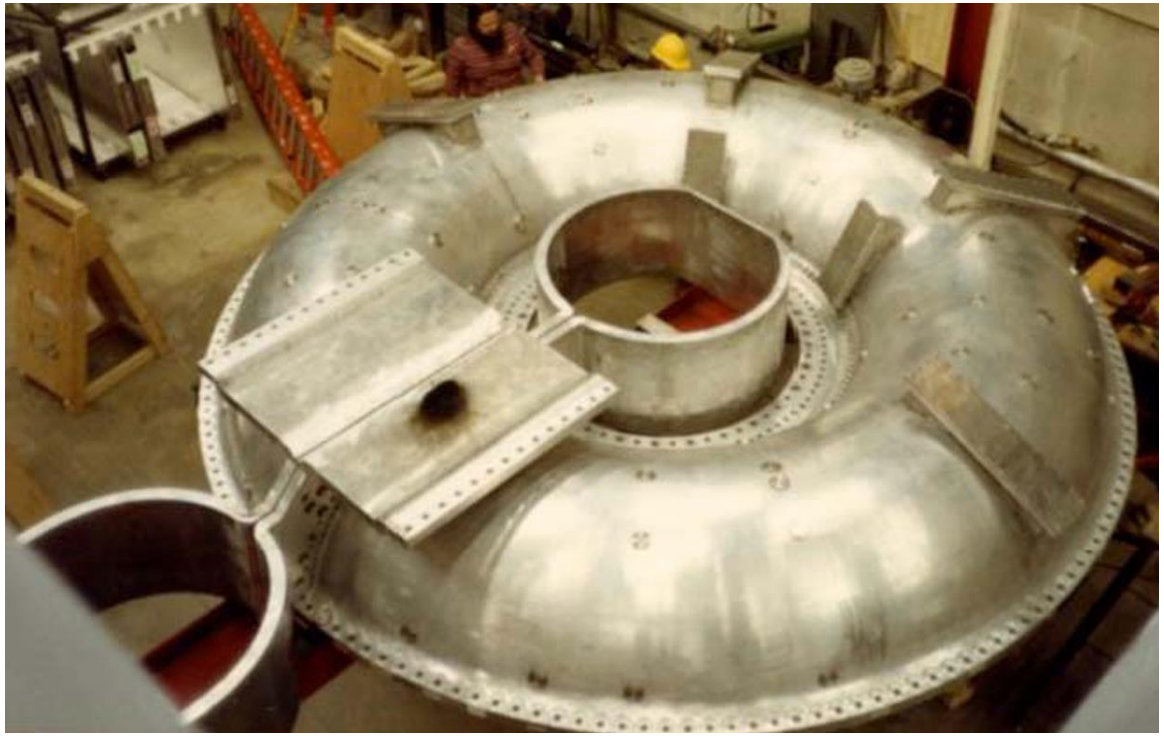


Toroidal field

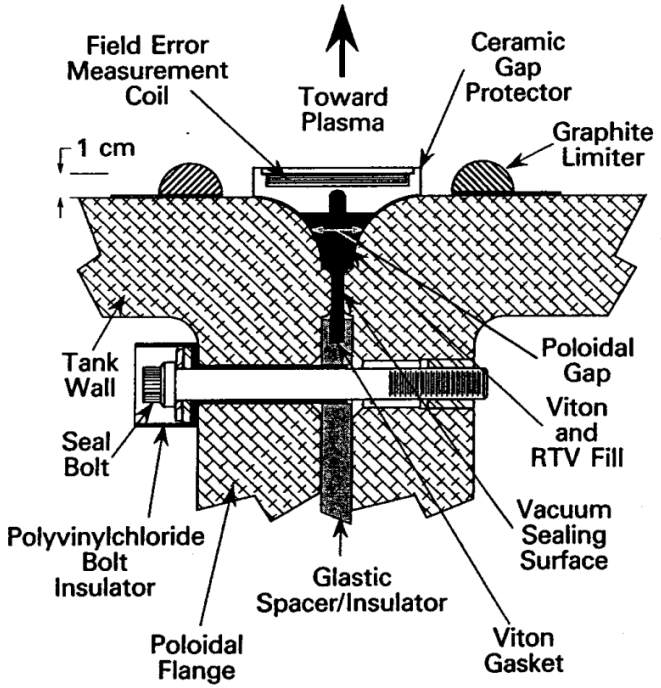


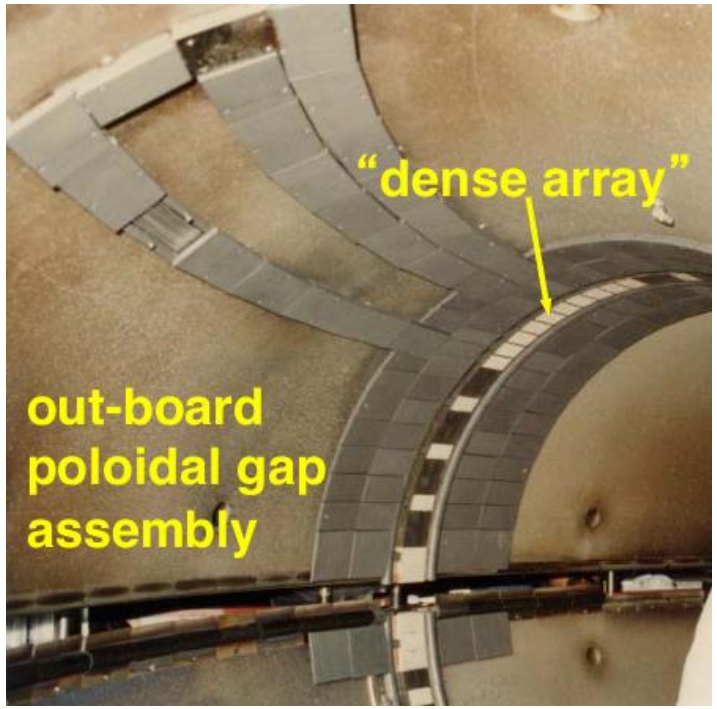


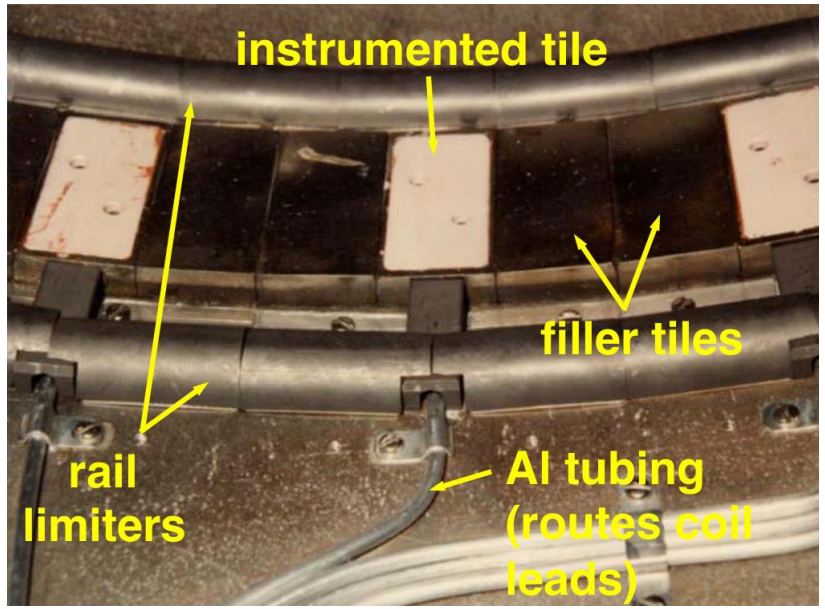
Toroidal and poloidal gap need seals

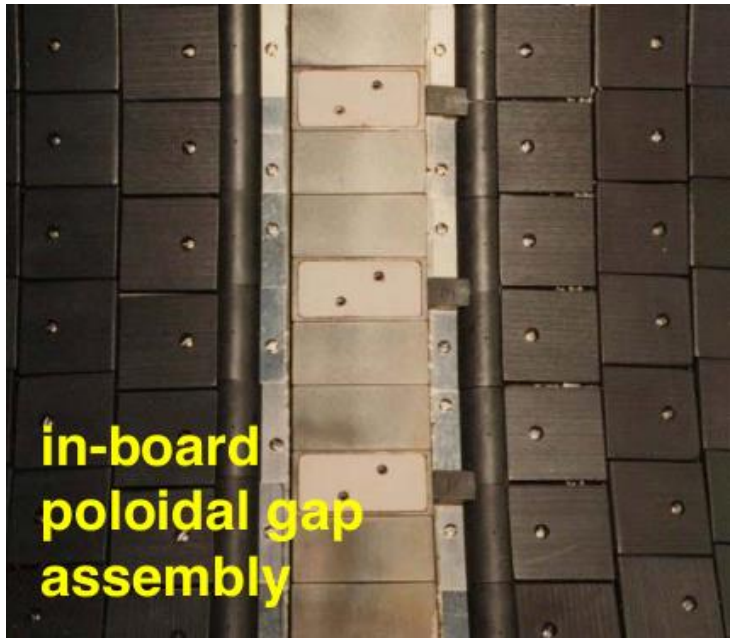


Poloidal gap seals



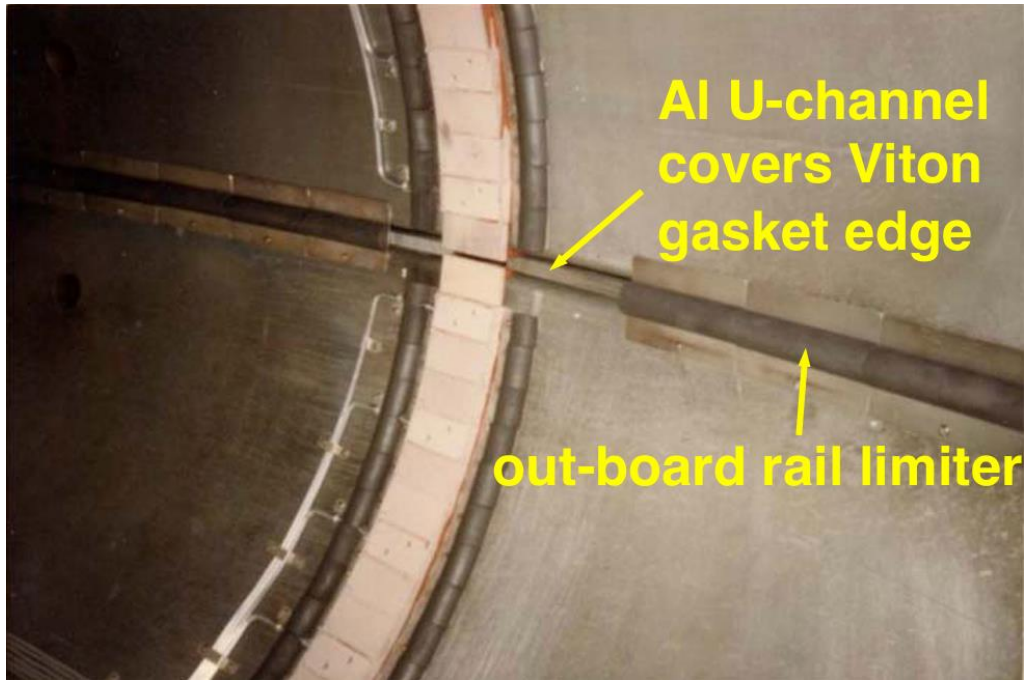




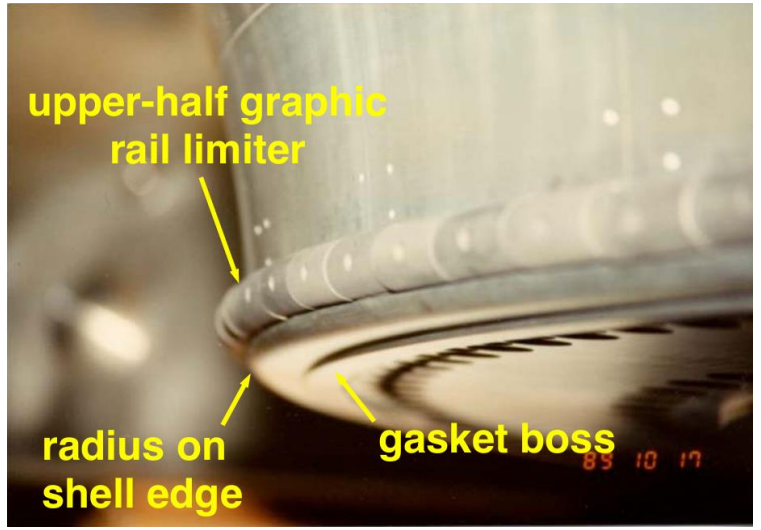


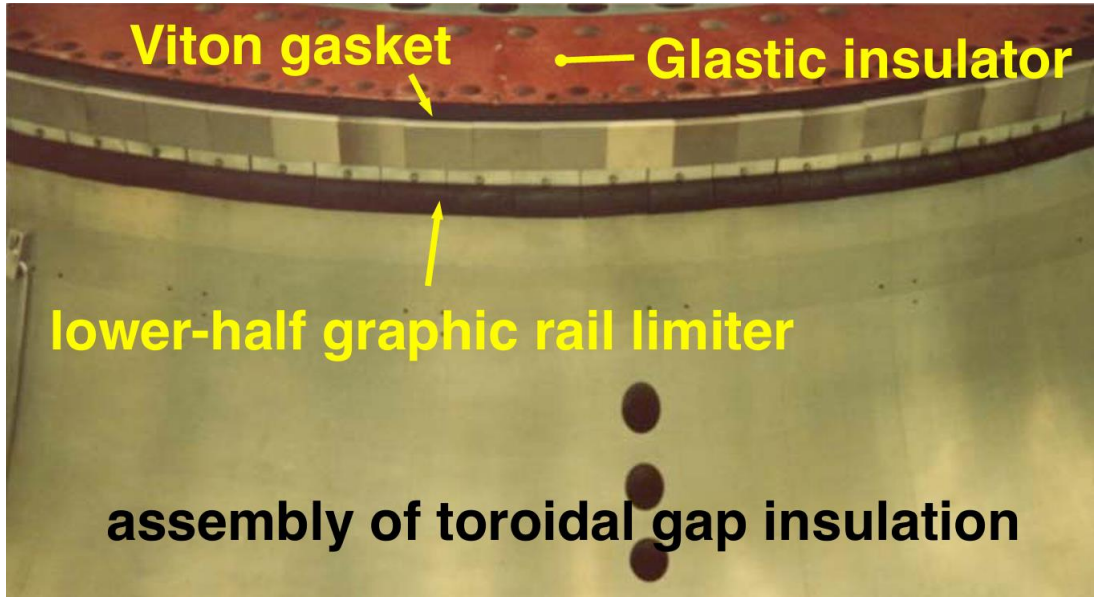
Toroidal gap seals

- outboard

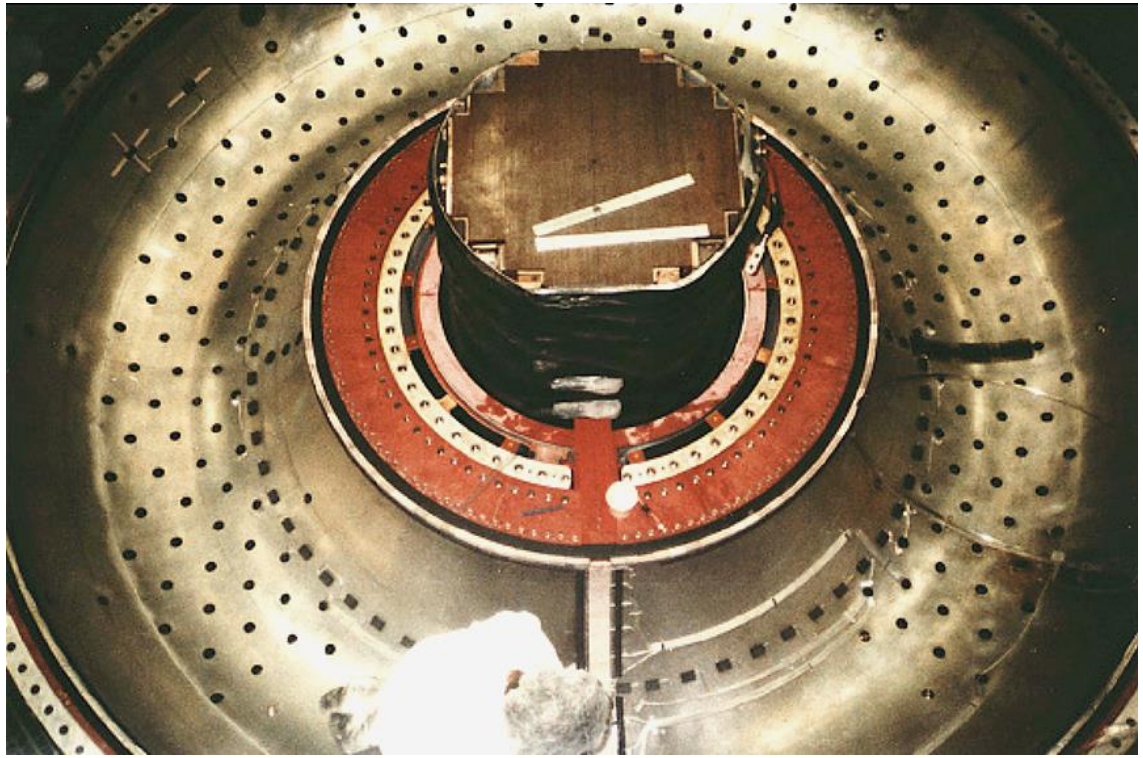


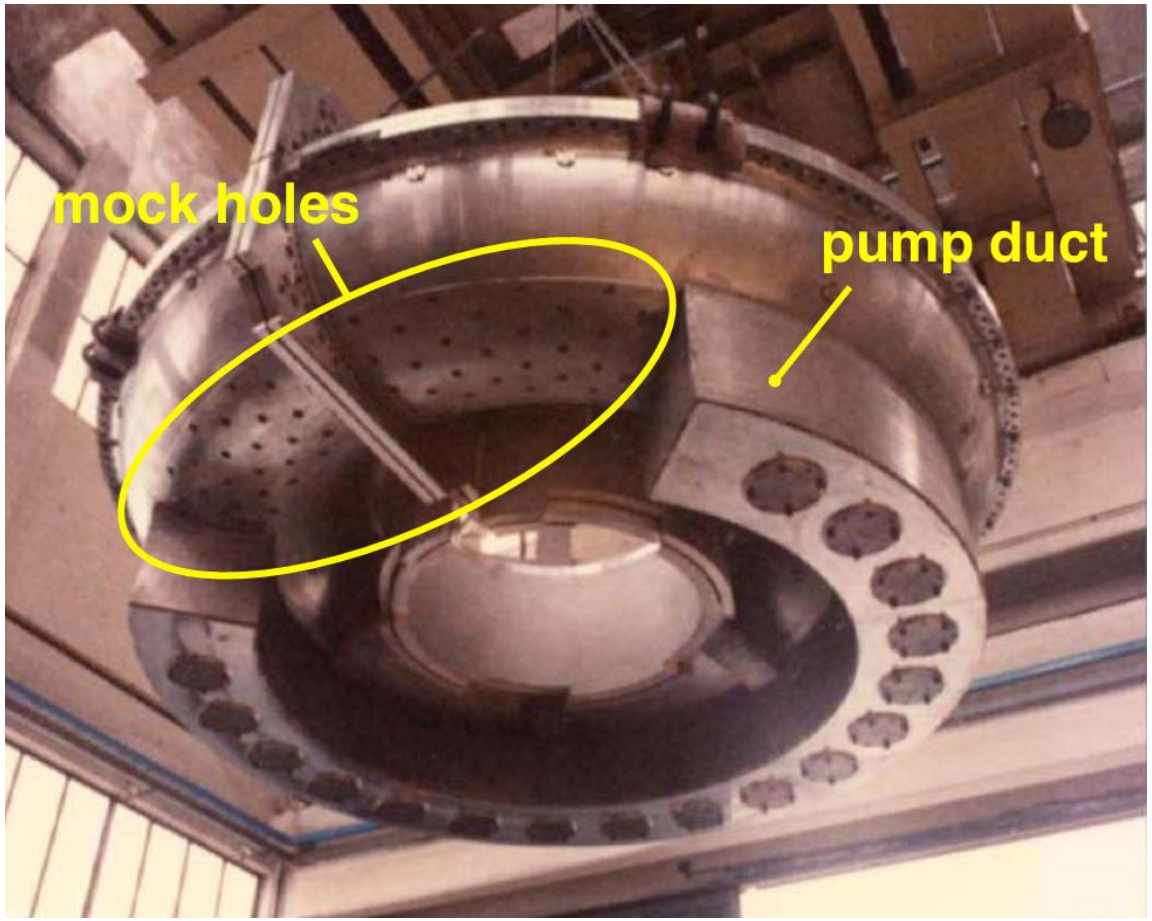
- inboard





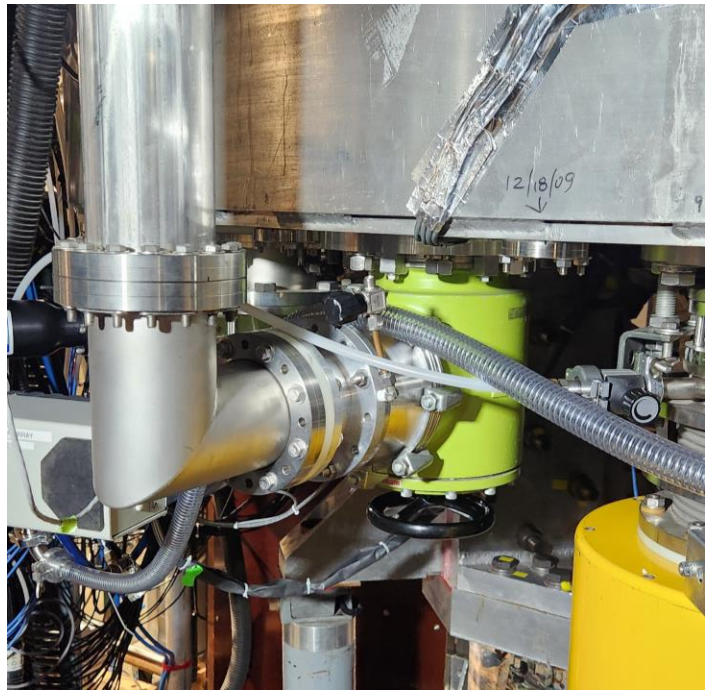
Pumping duct





Rough vacuum

- Leybold D65B: 12.7L/s
- Edwards E2M80: 26.7 L/s
- Only used after venting, until Cryos and turbos can be turned on



High vacuum

Cryo pumps: Qty(3) CTI 8F, 1500 L/s. Two in operation

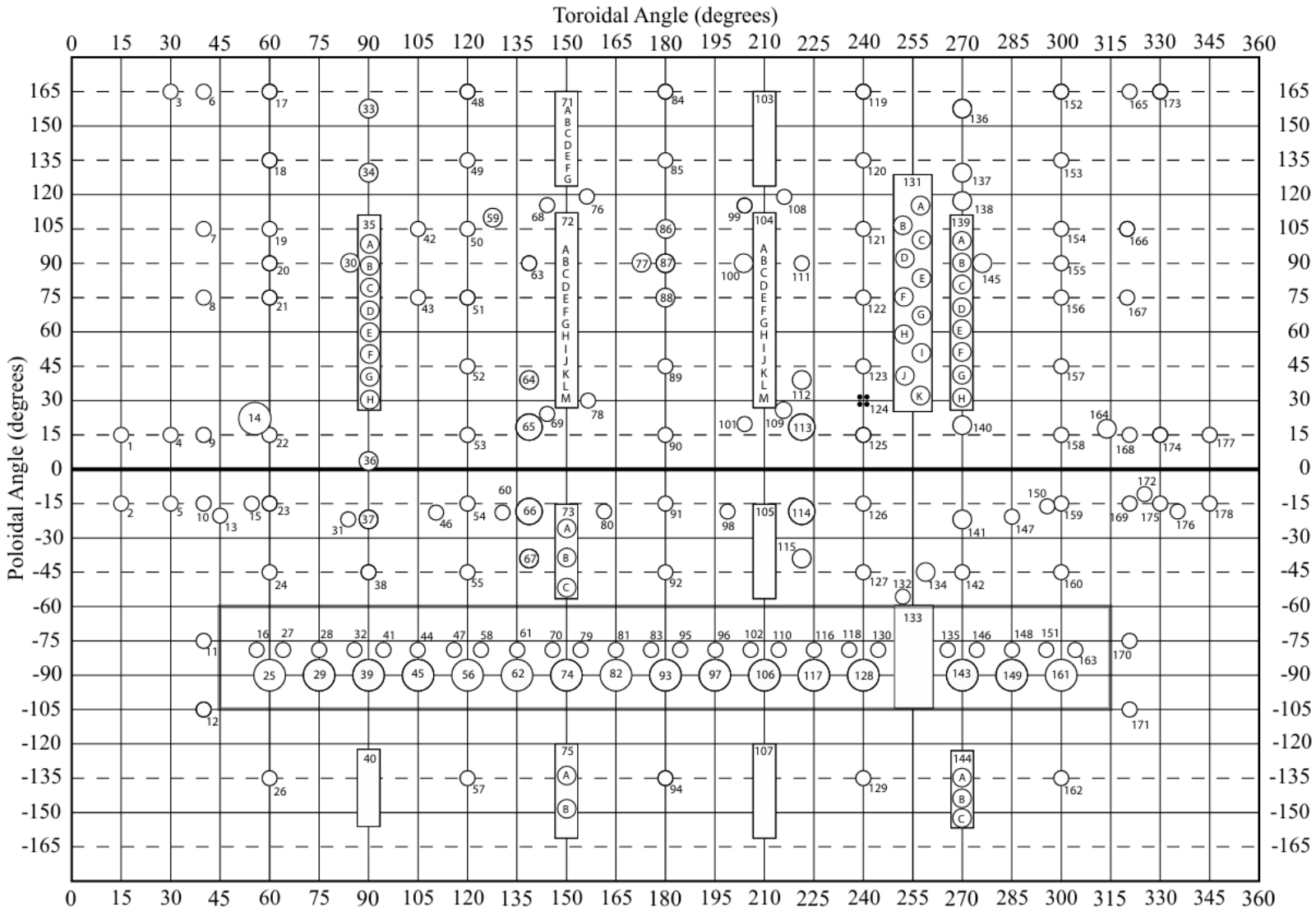
Turbomolecular pumps: Qty(3) Varian V1000-HT, 1000 L/S. two in operation

Foreline pumps

Turbos:

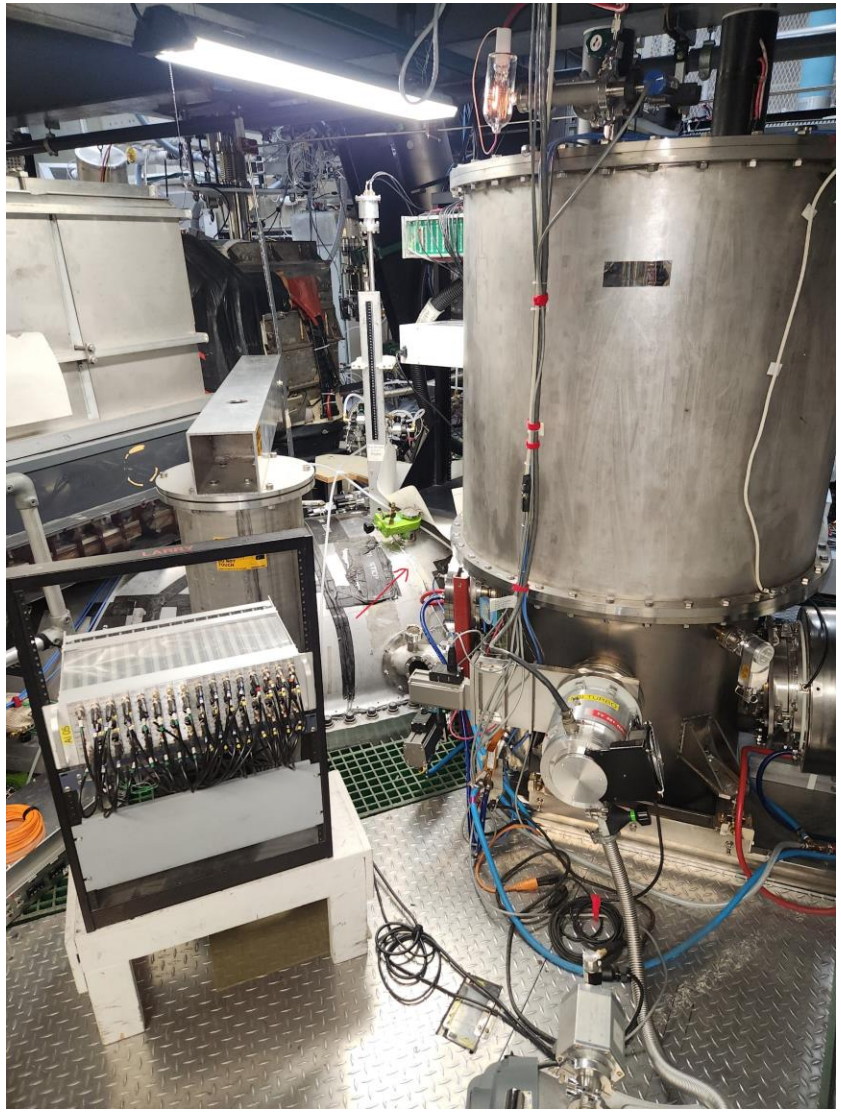
- Leybold D16B
- 5.25 L/s
- Foreline trap
- Oil mist eliminator
- Fume extraction
- Similar setup on other oil filled roughing pumps around MST

Diagnostics

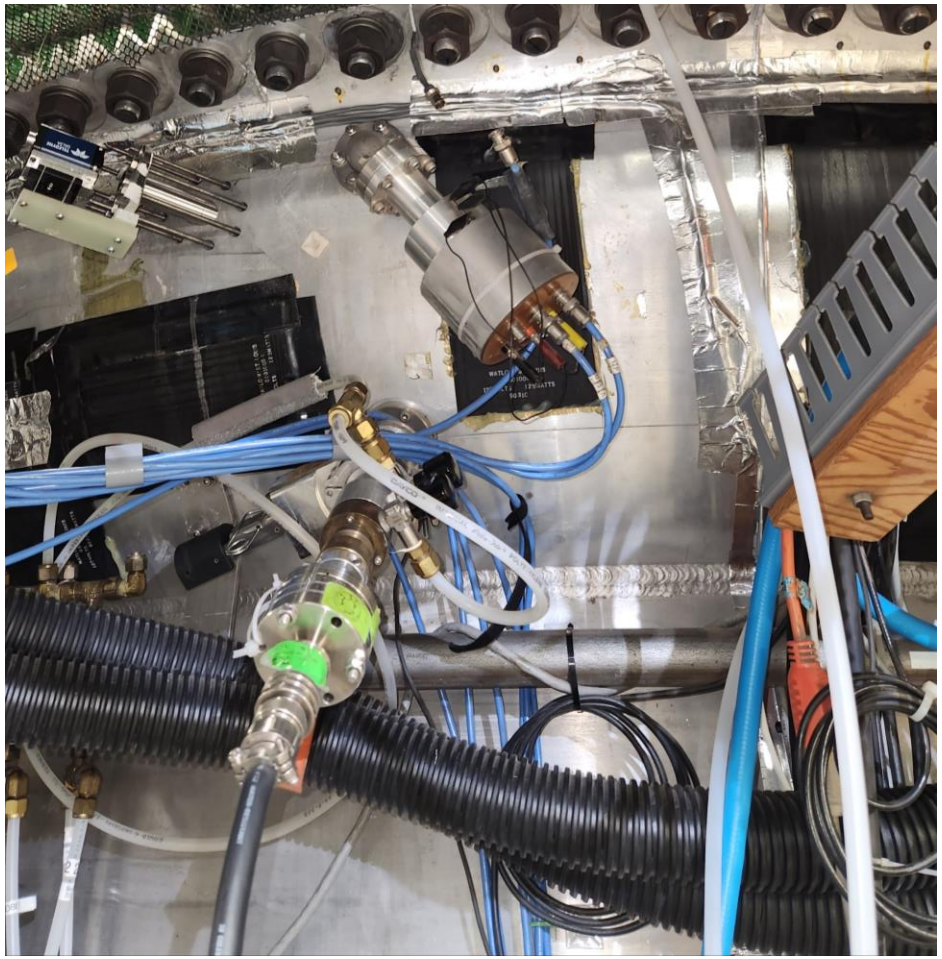


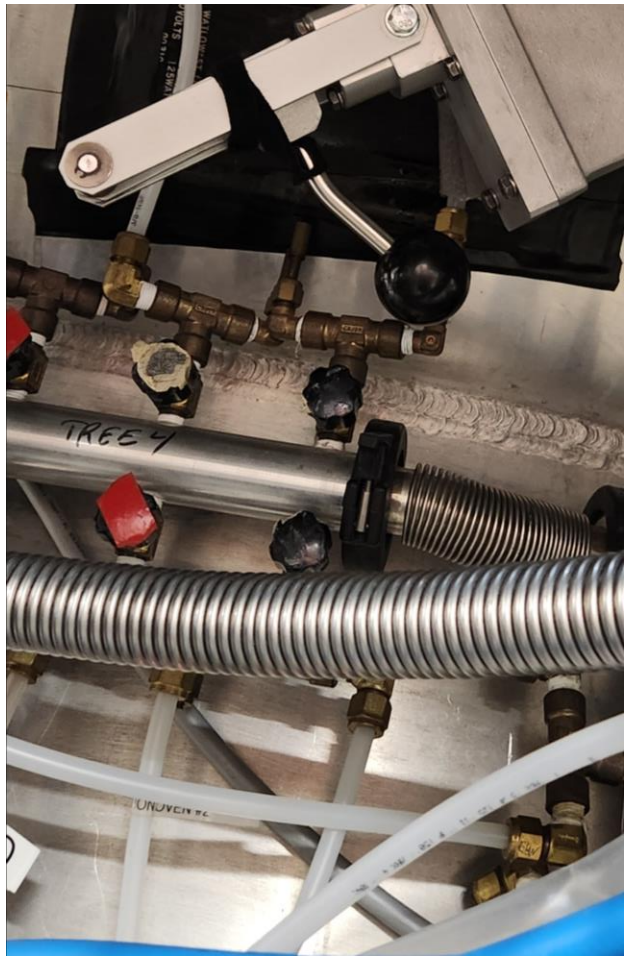
Dedicated turbos

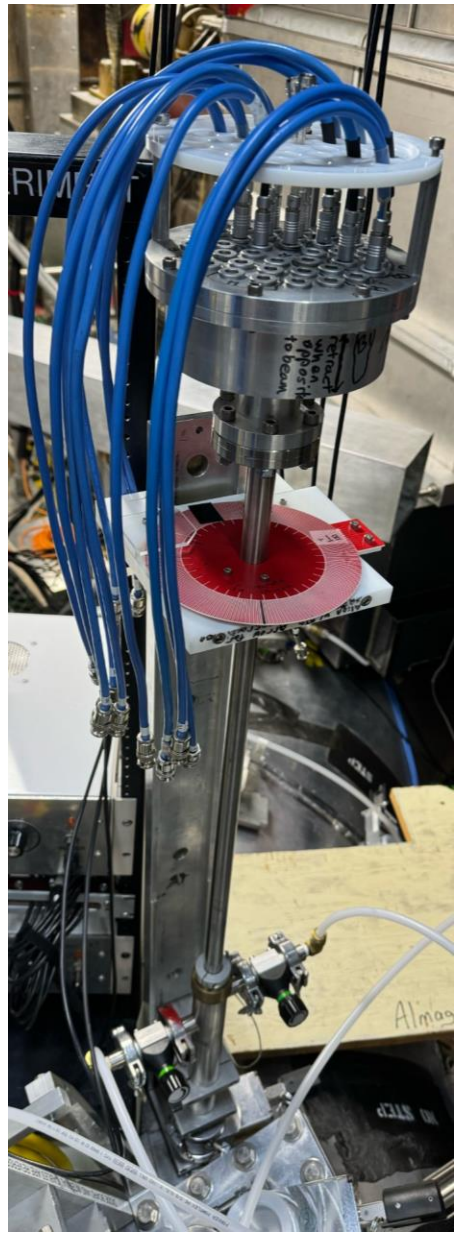
- For large volumes; high vacuum must be achieved before opening to MST
- Separate turbo, gate valve, and roughing pump
- Interlocks and remote controls for gate valves
- Neutral beam injector, Thomson beamline, Heavy Ion Beam Probe, Diagnostic Neutral Beam, others



Roughing line

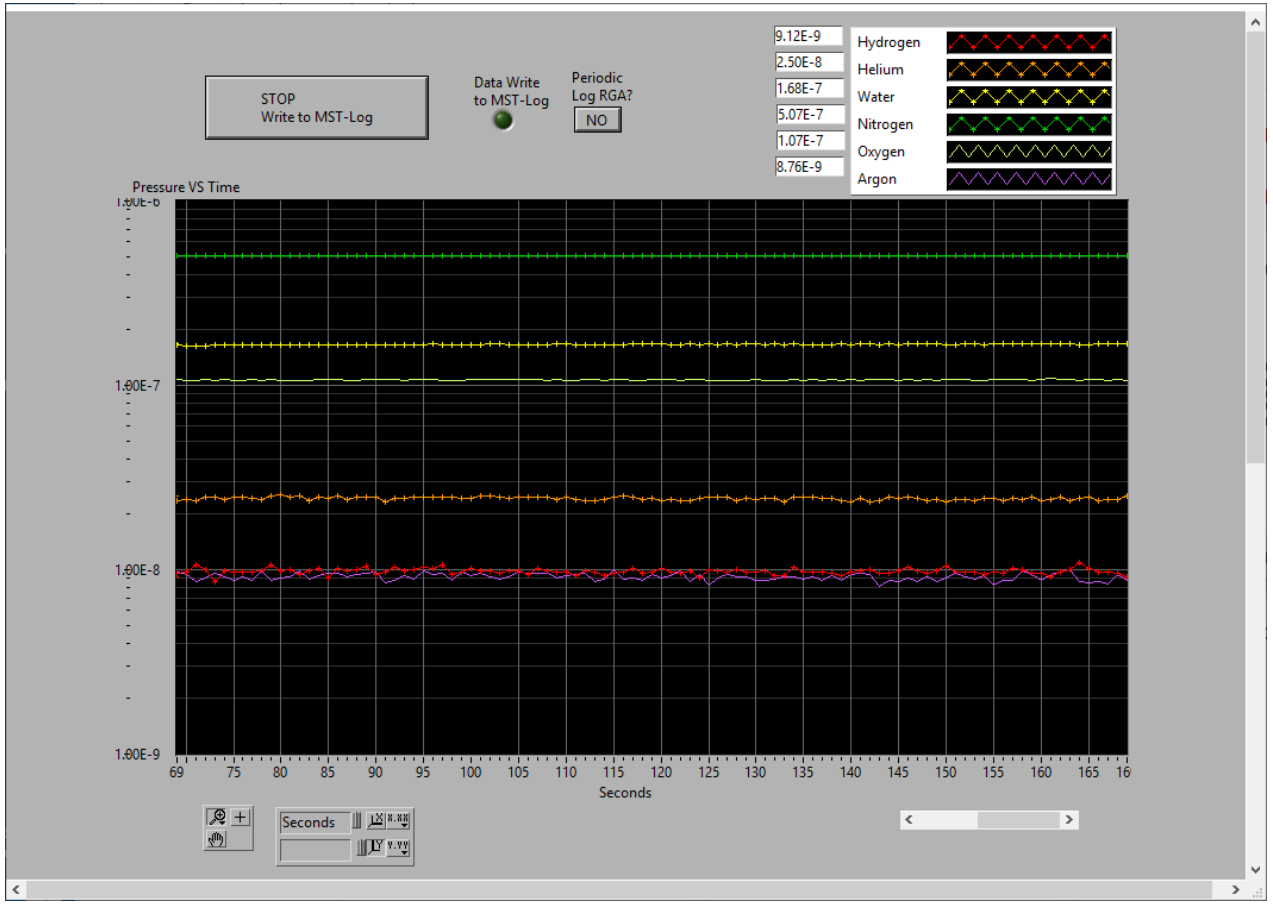


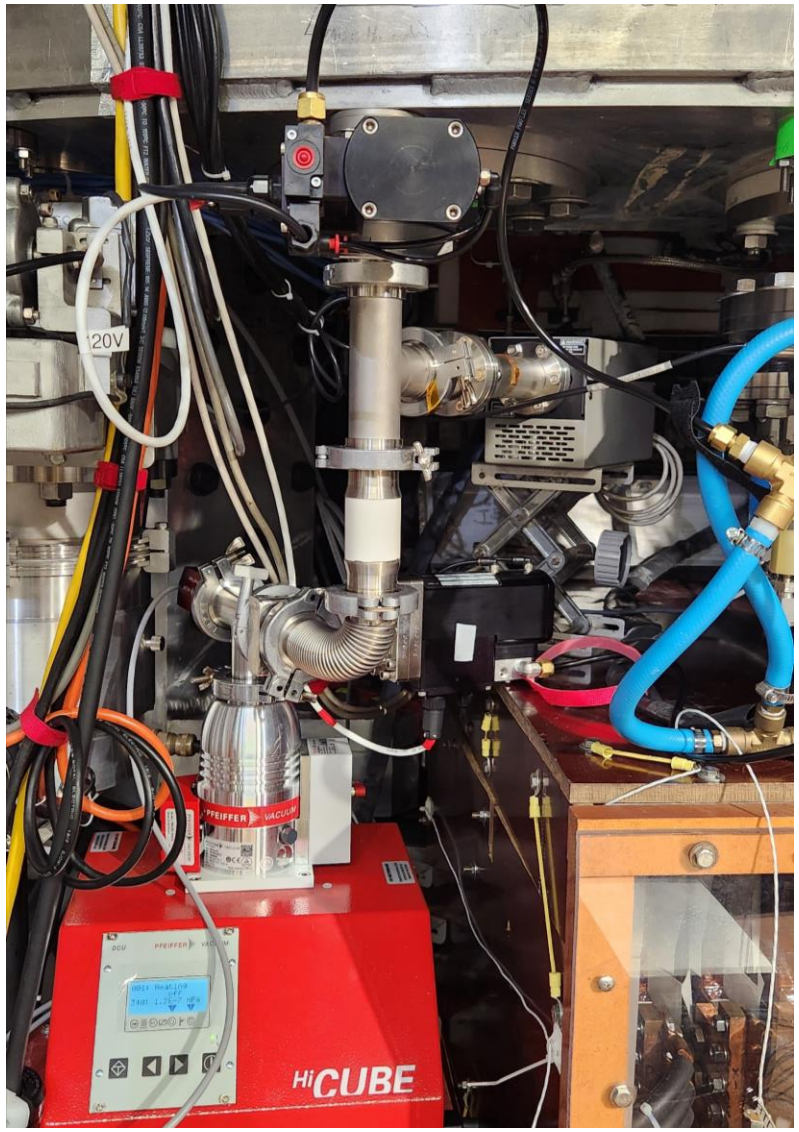




Residual Gas Analyzer,

and dedicated turbo station





RGA for probe removal

Close valve to probe housing

Close valve on roughing line tree

Place cross in roughing line

Connect Helium line

Rough up to cross (open roughing tree)

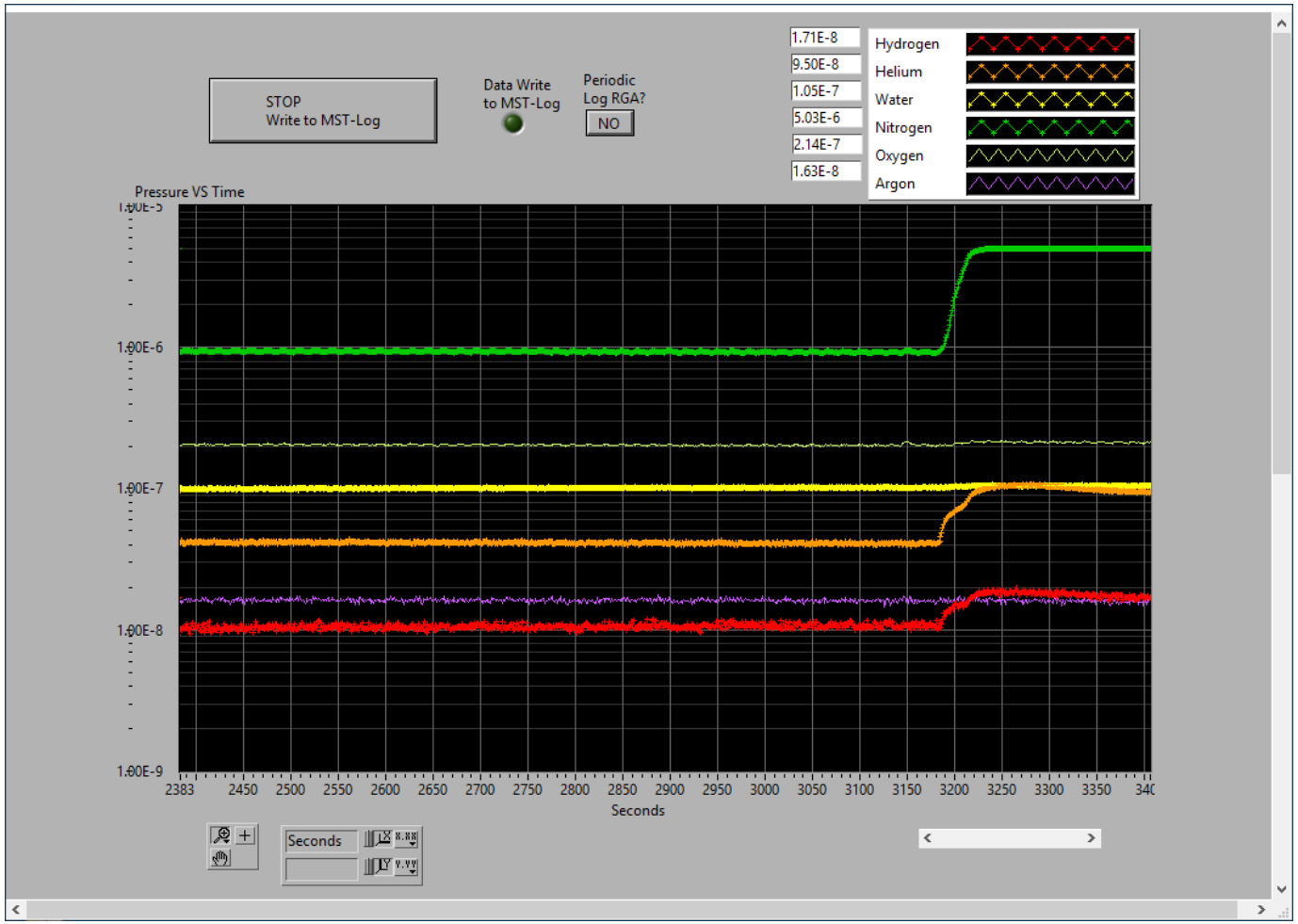
Rough up to probe (open cross to rough)

Close roughing tree

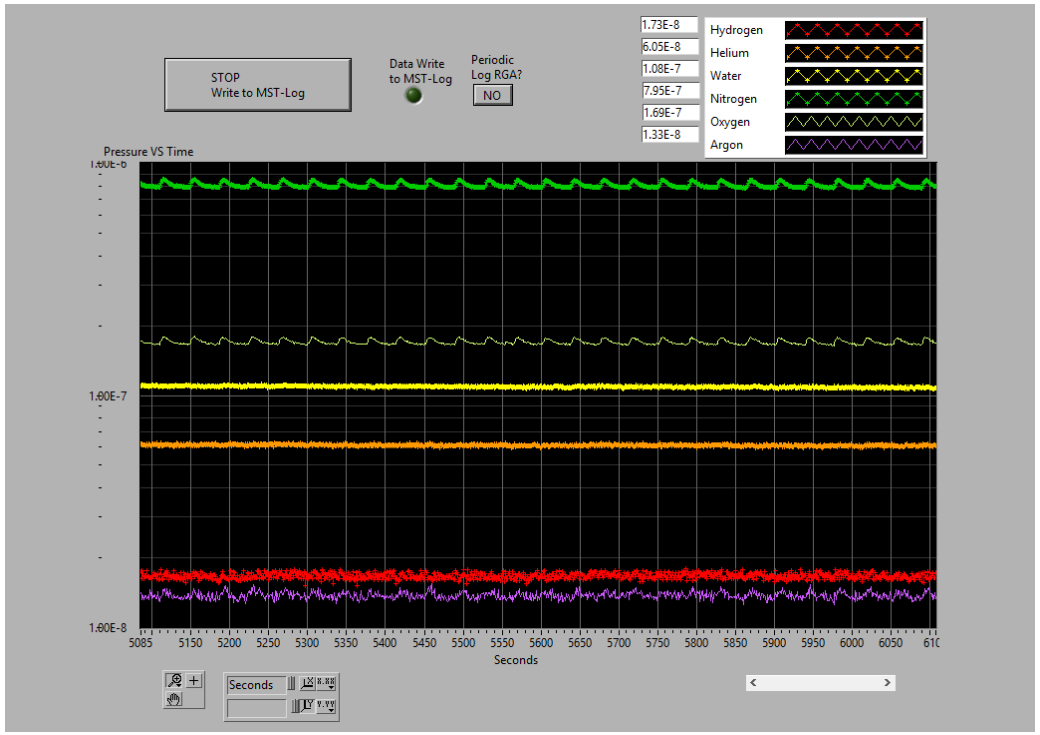
Close roughing to cross

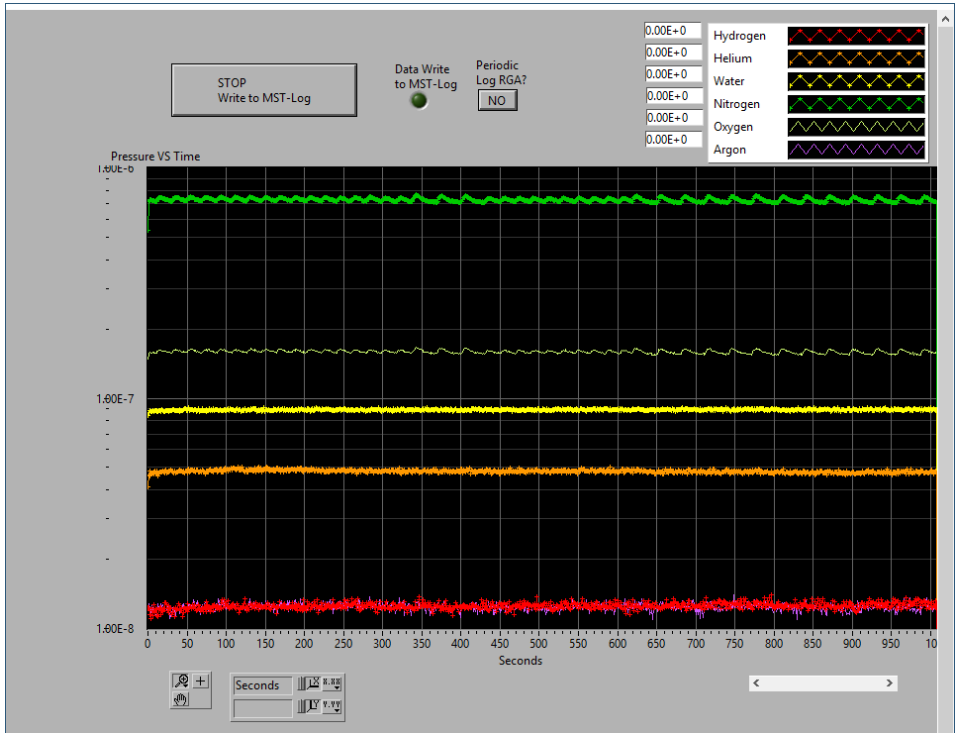
Fill with helium

Slowly allow some into probe housing and observe RGA signal



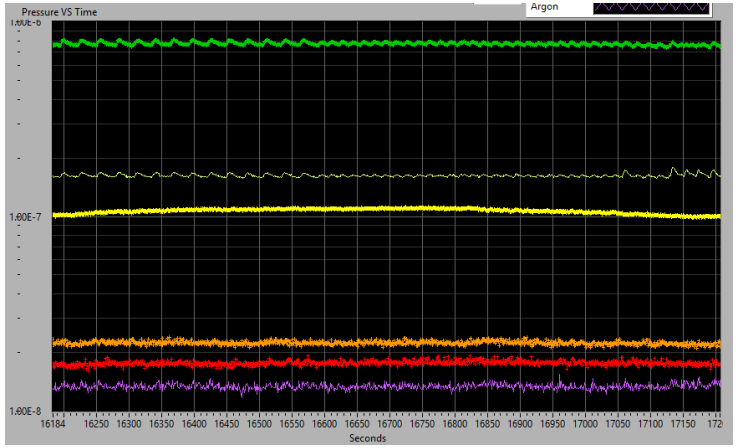
Fluctuating RGA signal – the Ides of March



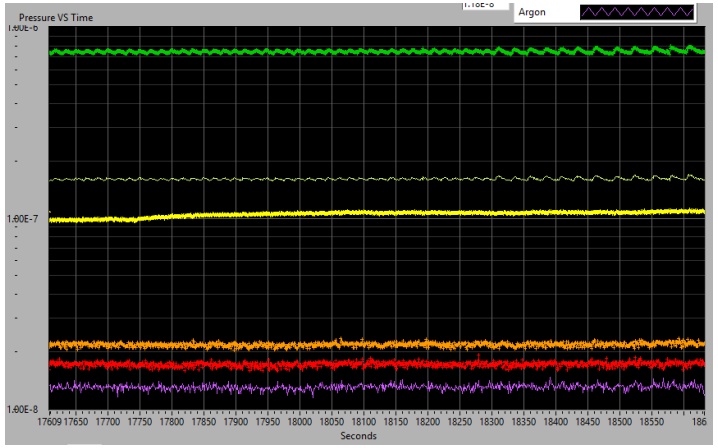


Wrong suspect – SXR Tomography

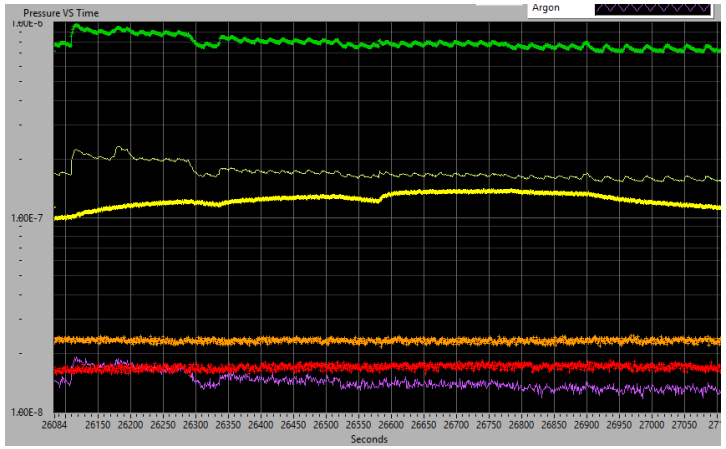
Opening one valve



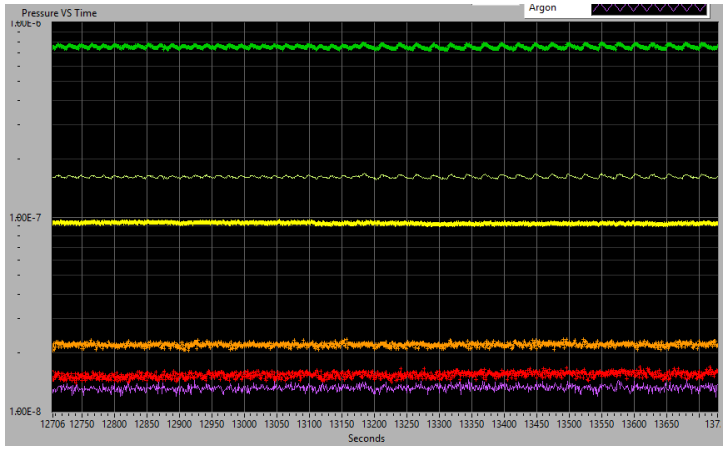
Opening another valve



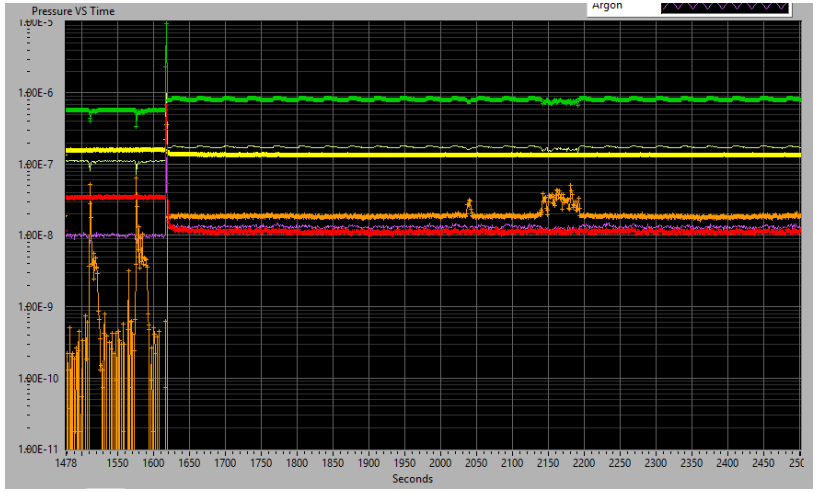
Open and close all valves

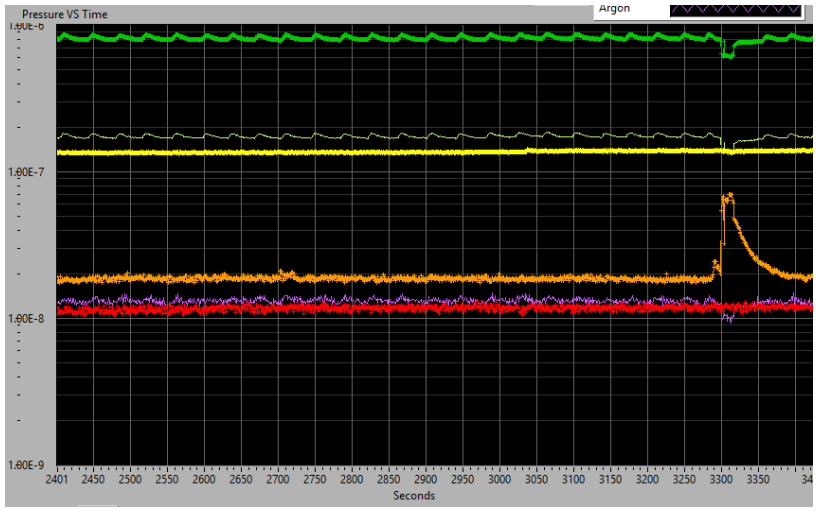


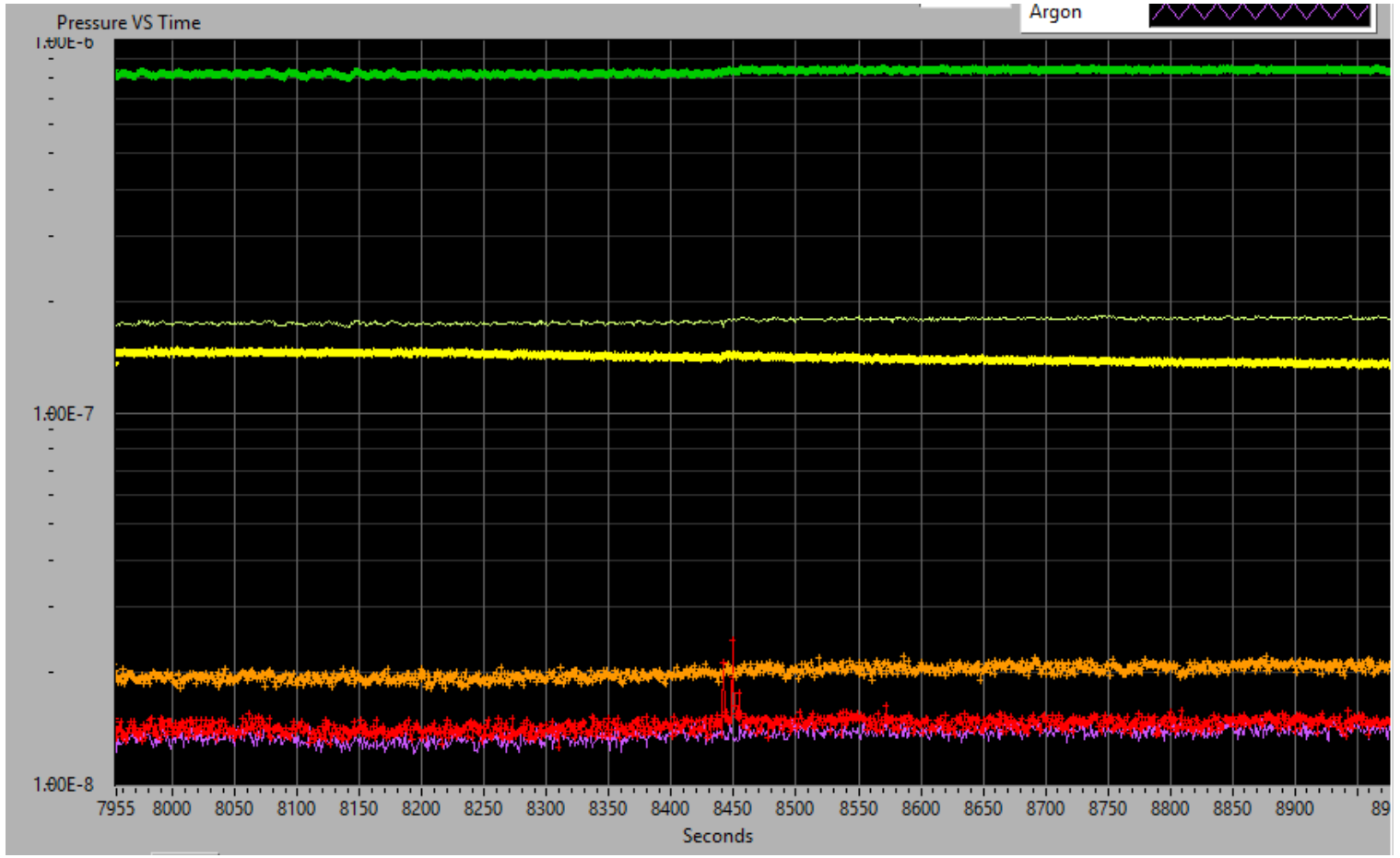
Doing nothing



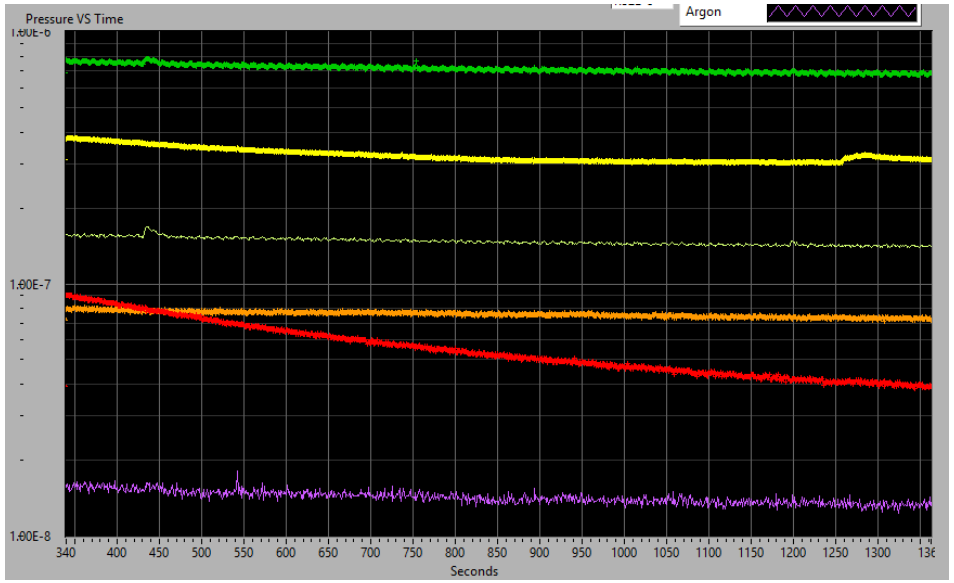
What worked – Helium on RGA apparatus

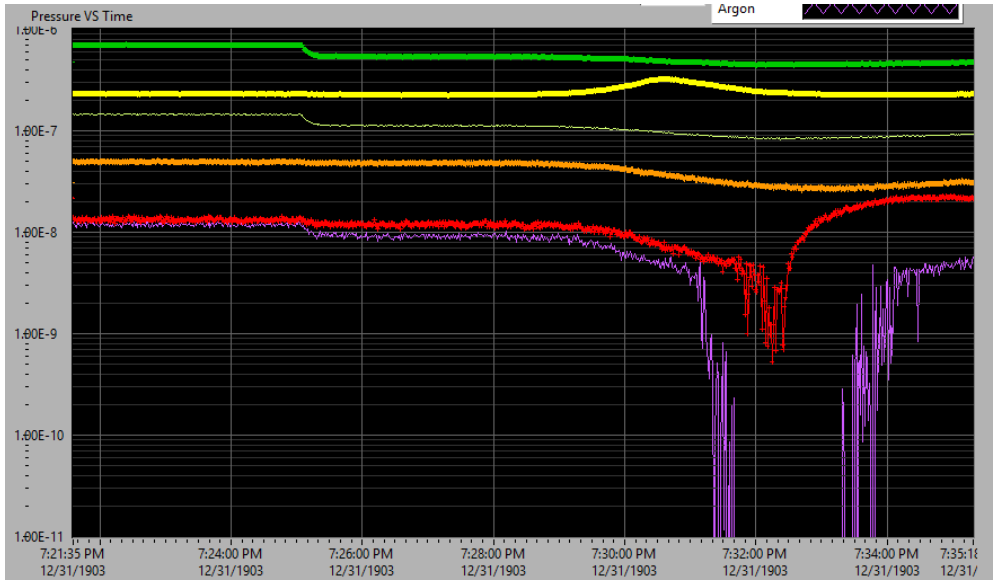


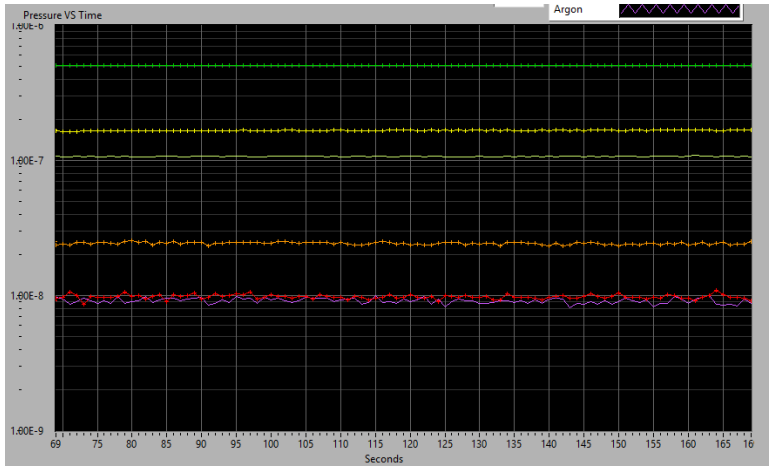


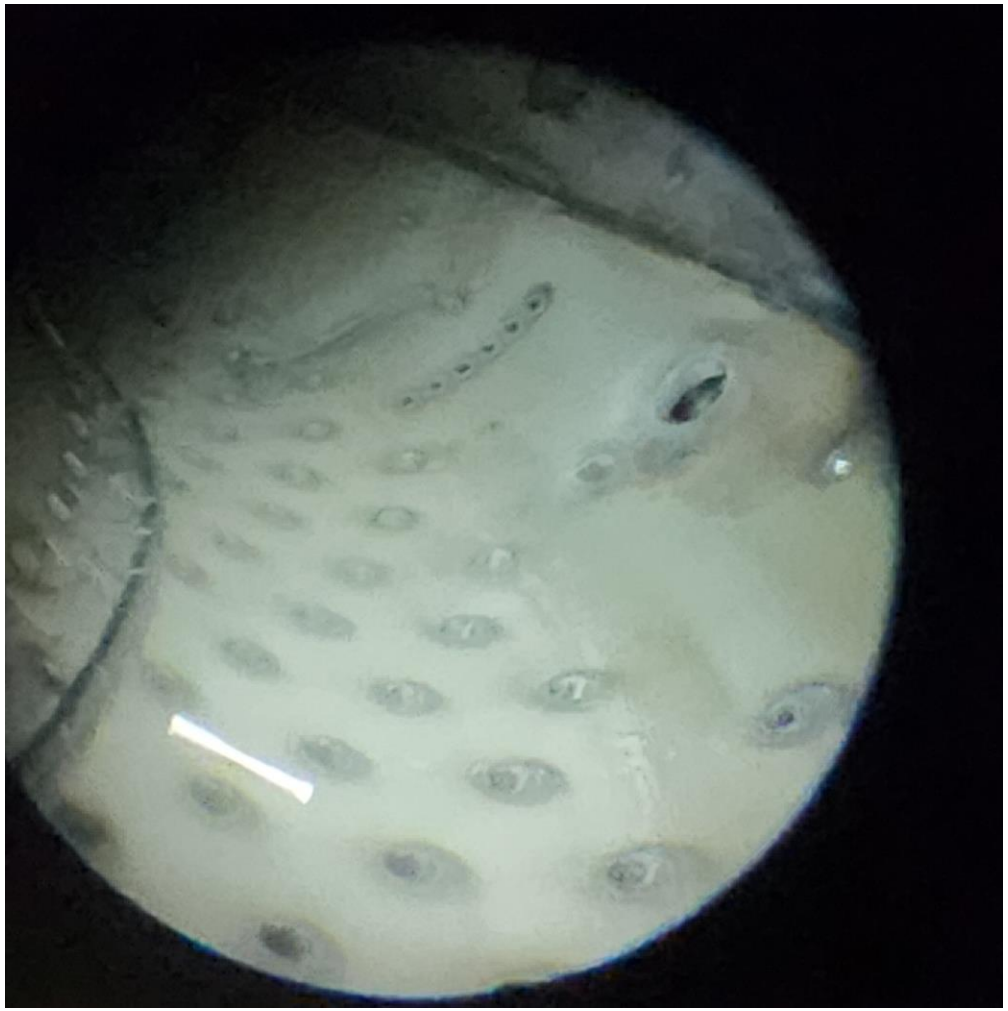


The next week – bakeout, retry









Vent

Gate valve maintenance

Venting valve

Safety overpressure valve

Vent

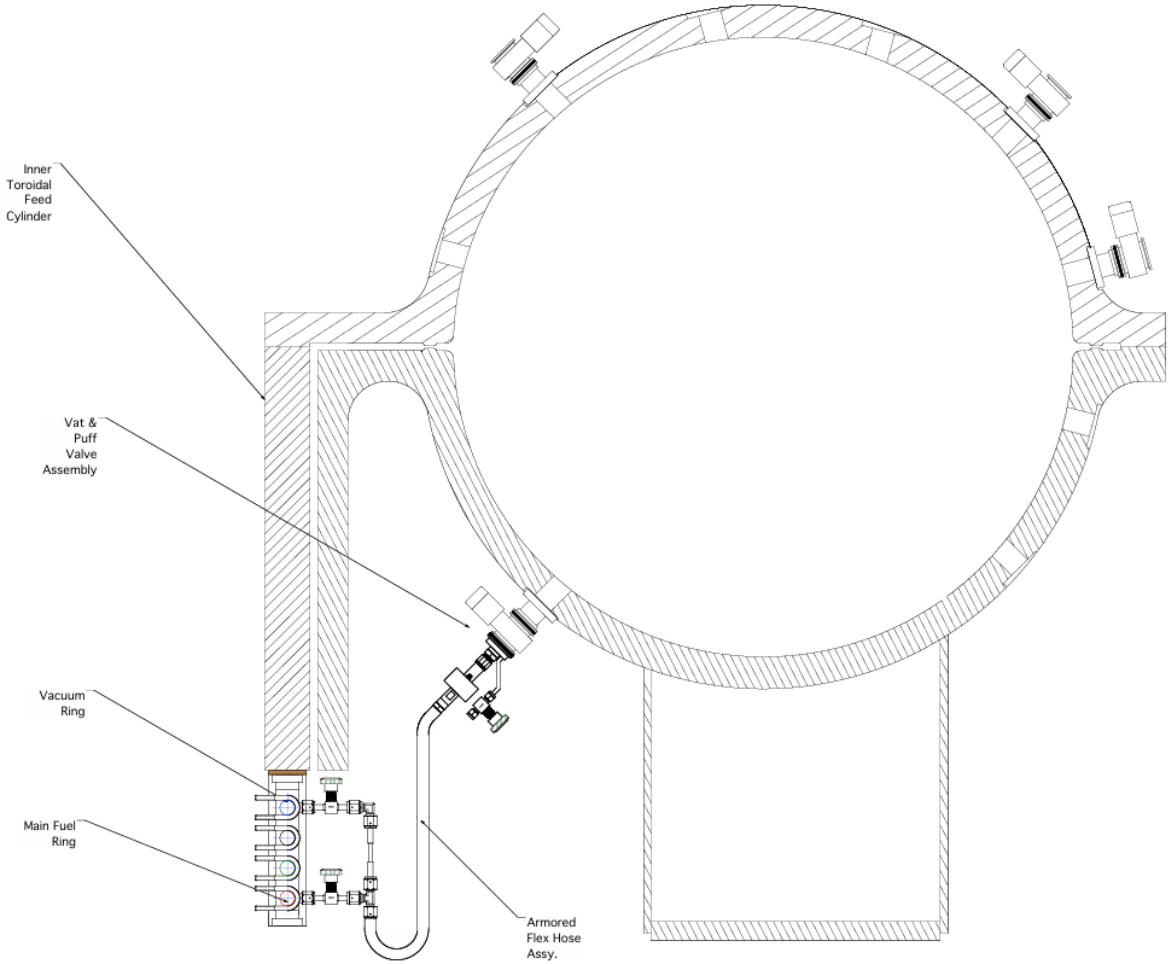
Dry air

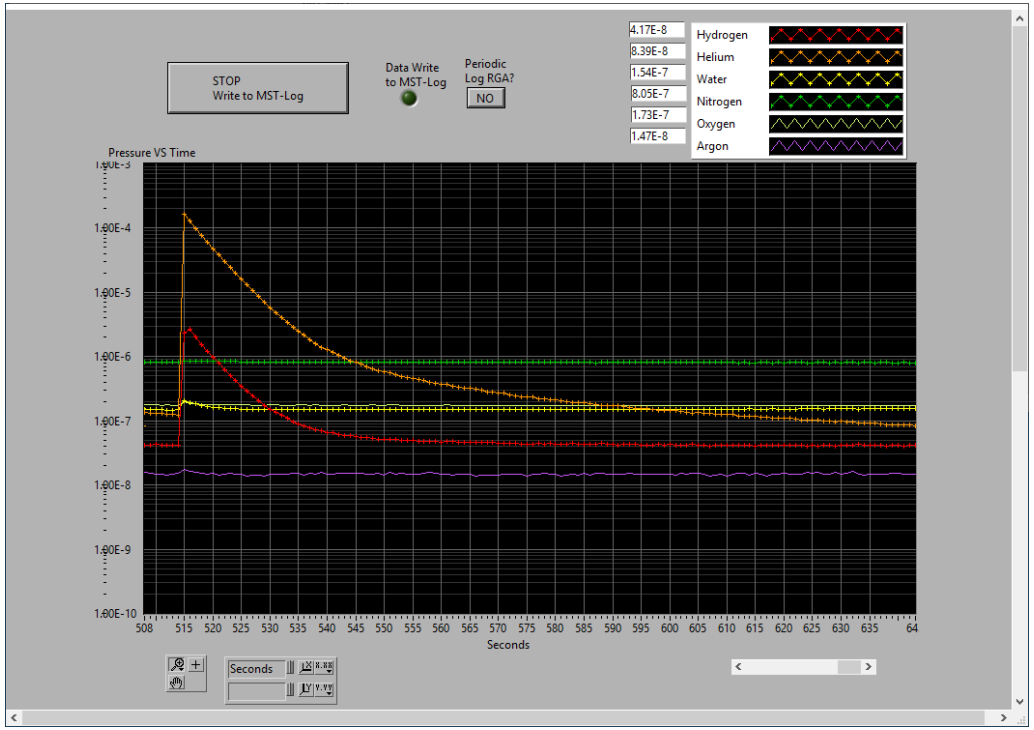
- For hardware changes
- Can be multiple days

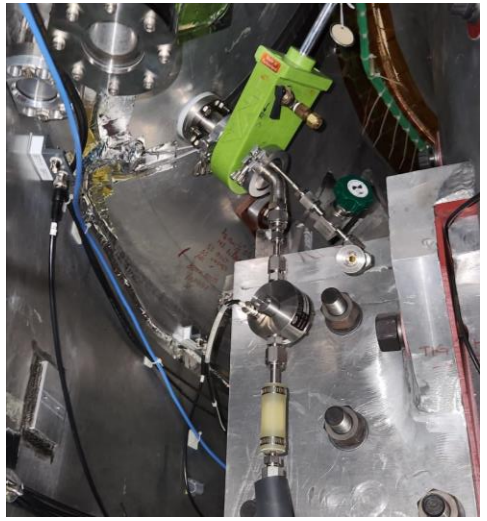
Nitrogen

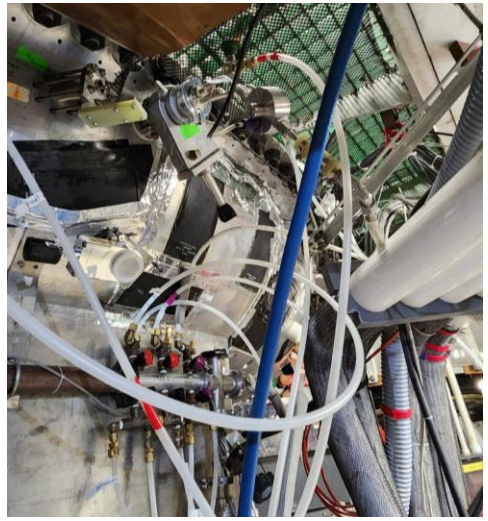
- Impromptu
- As brief as possible

Puff valves


Inner Toroidal Feed Cylinder
Vat & Puff Valve Assembly
Vacuum Ring
Main Fuel Ring
Armored Flex Hose Assy.

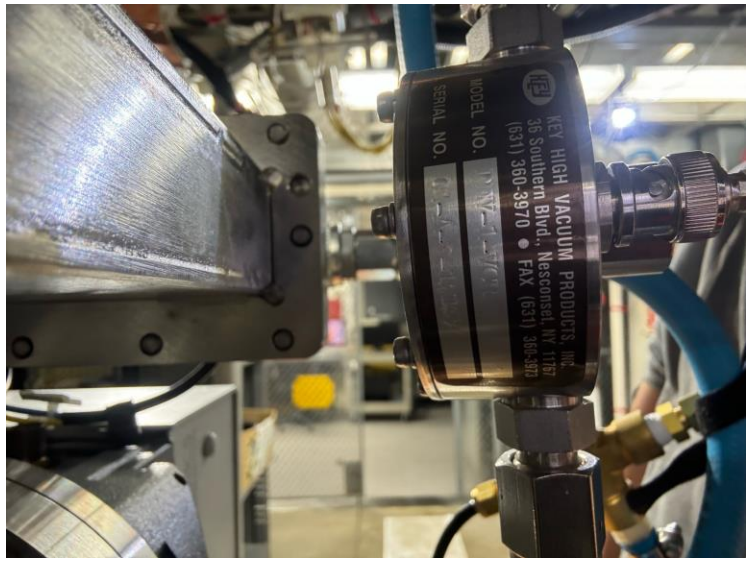

STOP
Write to MST-Log
Data Write to MST-Log
Periodic Log RGA?
NO
4.17E-8
8.39E-8
1.54E-7
8.05E-7
1.73E-7
1.47E-8
Hydrogen
Helium
Water
Nitrogen
Oxygen
Argon
Pressure VS Time
1.00E-4
1.00E-5
1.00E-6
1.00E-7
1.00E-8
1.00E-9
1.00E-10
508 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 64
Seconds
Seconds

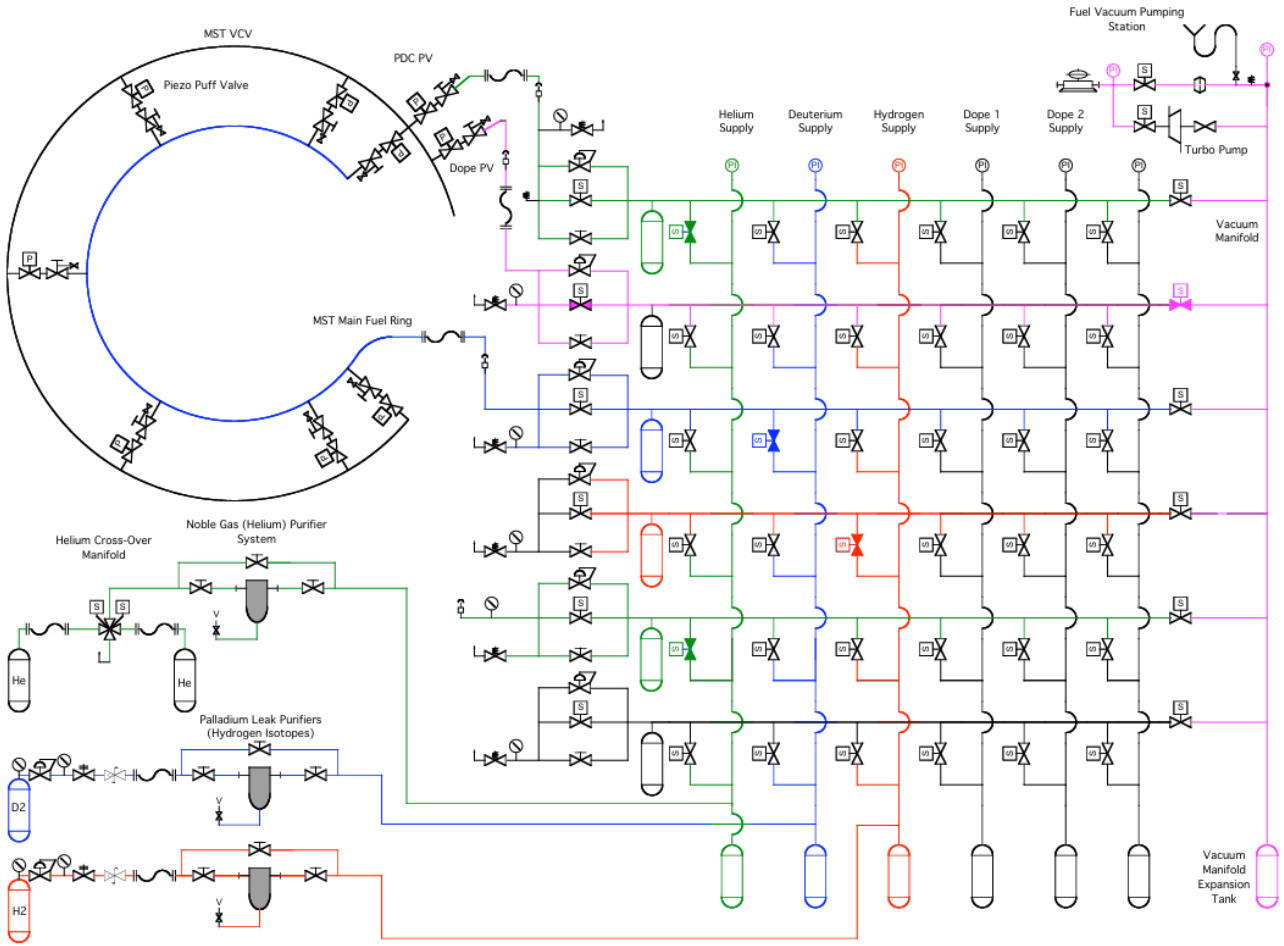




Puff valves

- Key High Vacuum Products: PEV-1-VCR
- Piezoelectric
- 0-525 sccm





Fuel