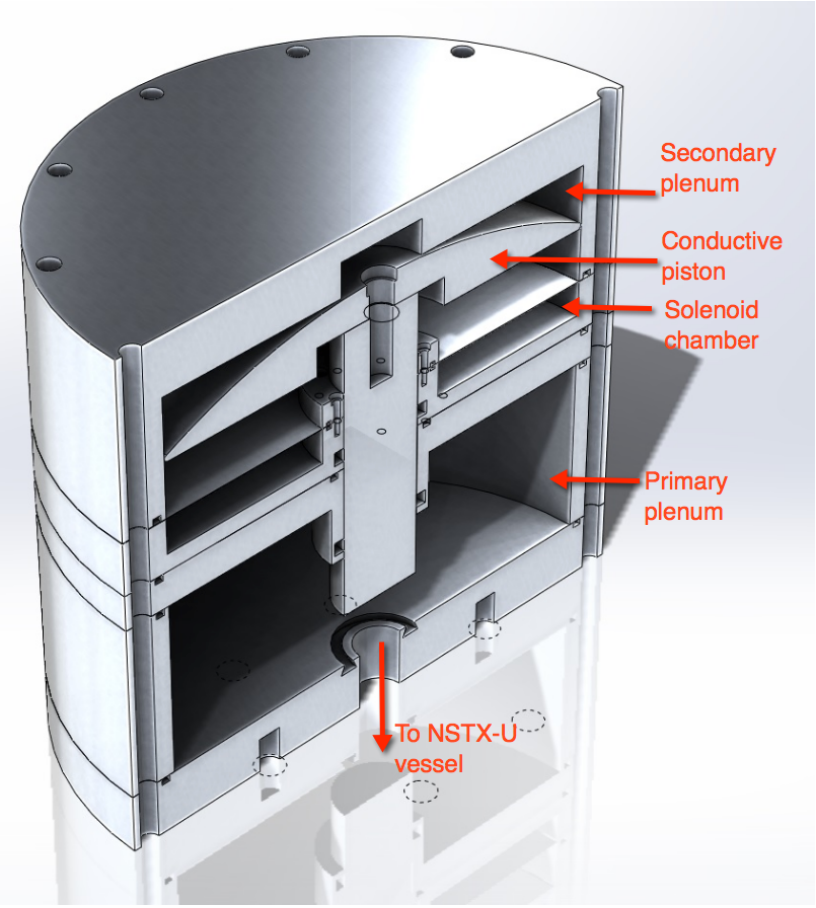
Third Peer Review for New MGI Valves for NSTX-U (Update on Valve Testing and Installation Configurations on NSTX-U)

R. Raman, et al.

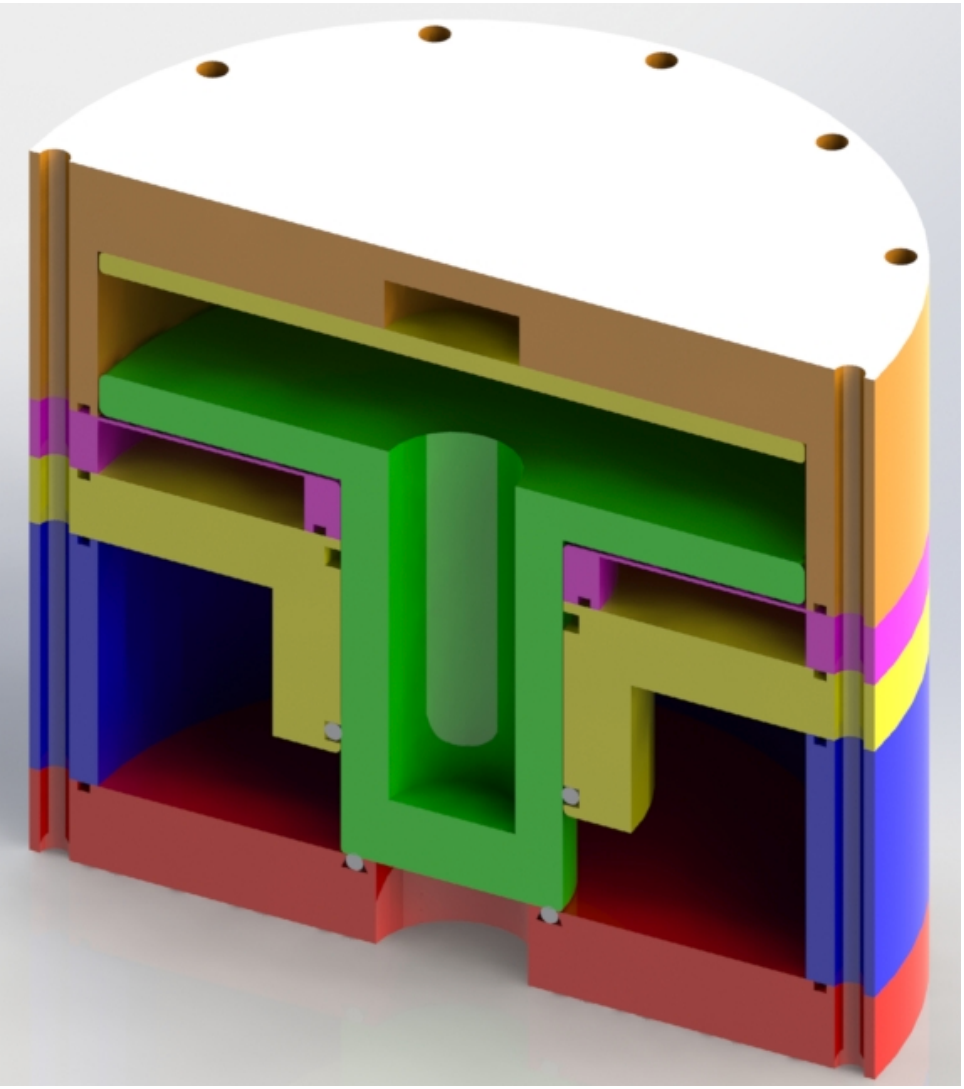
March 14, 2014

Version 1 Valve



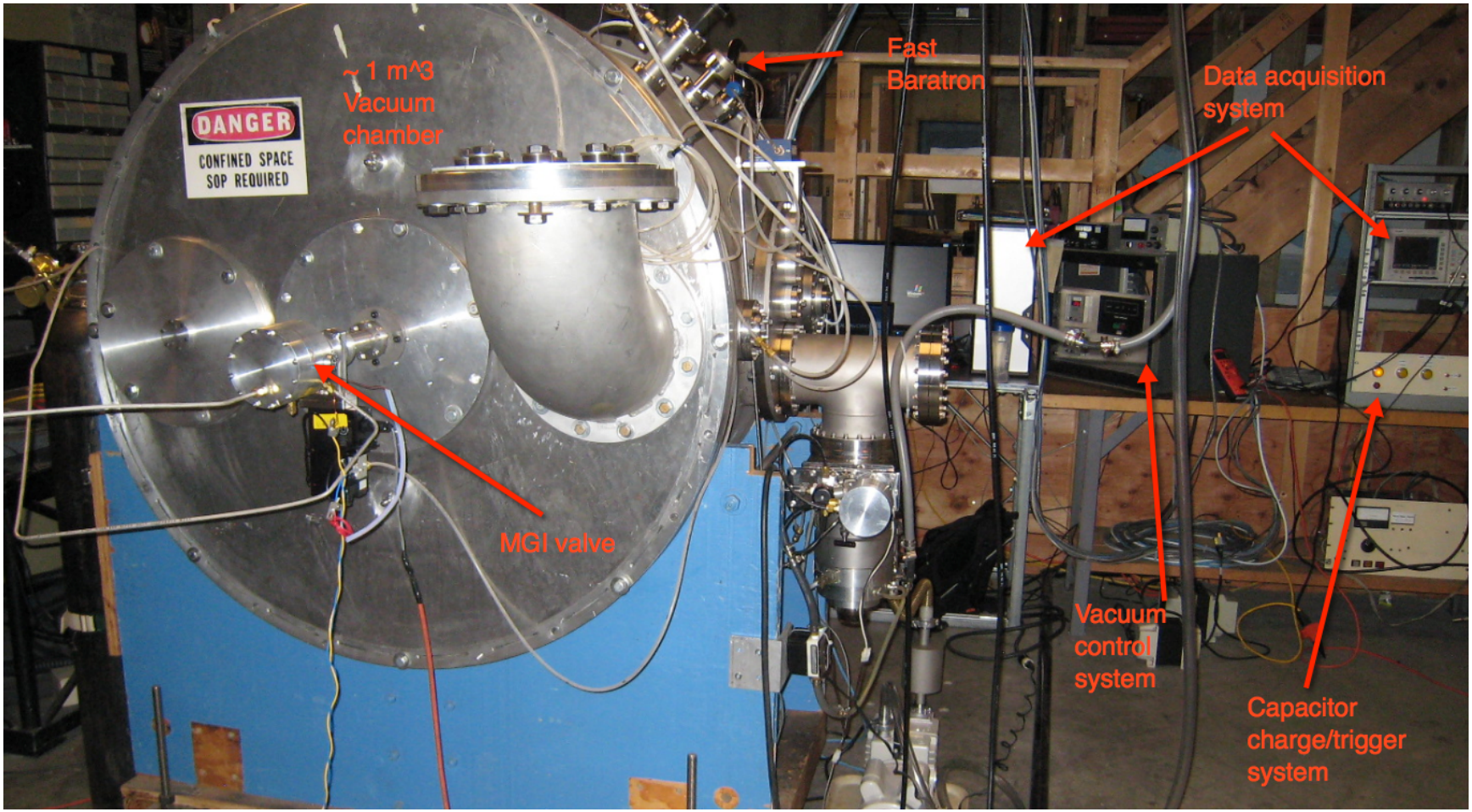
- Primary plenum volume ~ 1000cc
- Primary exhaust orifice diameter is 1.08 cm
- Solenoid chamber composed of several components

Version 2 Valve

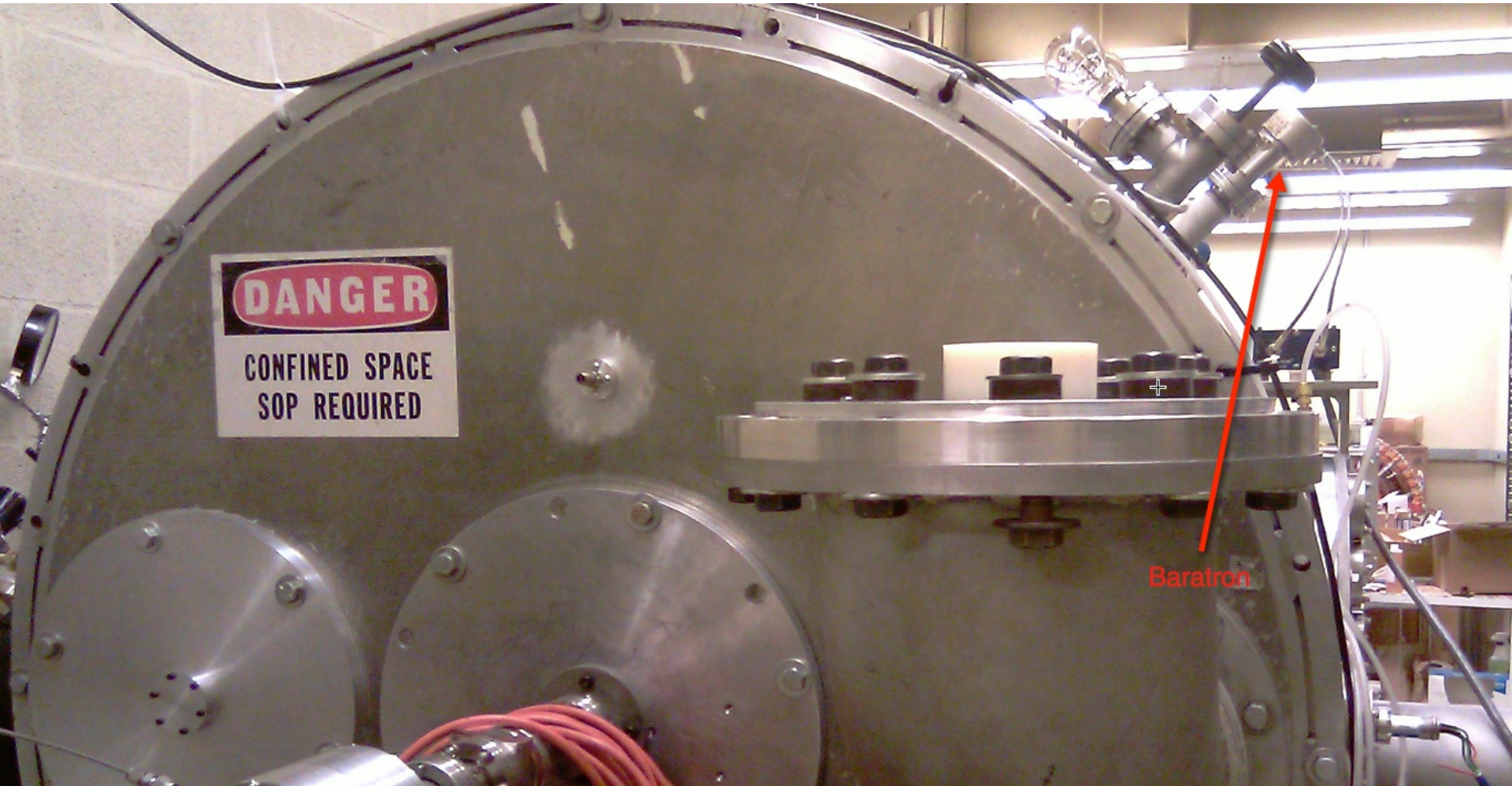


- Primary plenum volume ~700cc
- Primary exhaust orifice diameter doubled to 2.3 cm
- Solenoid chamber simplified and fabricated out of a single block
- Internal components made thicker and strengthened

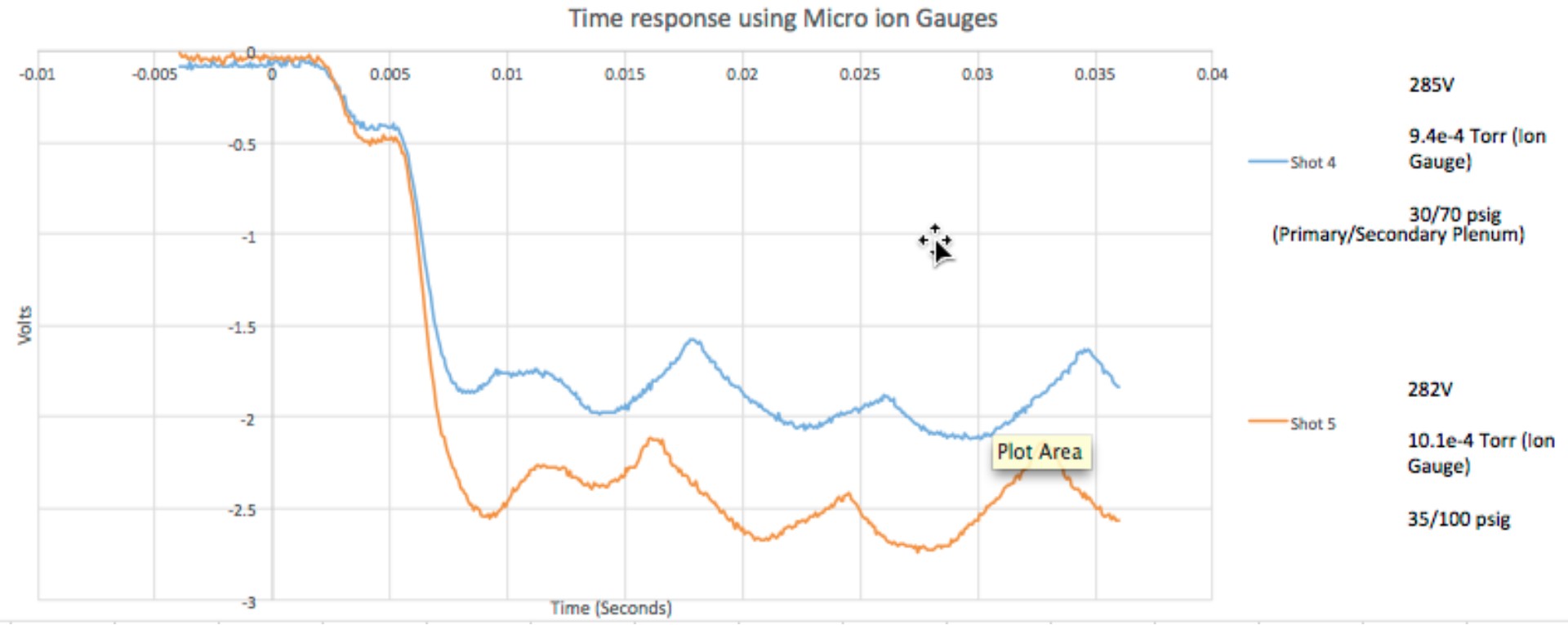
Valve and Baratron Locations on 1.3 m^3 Test Chamber



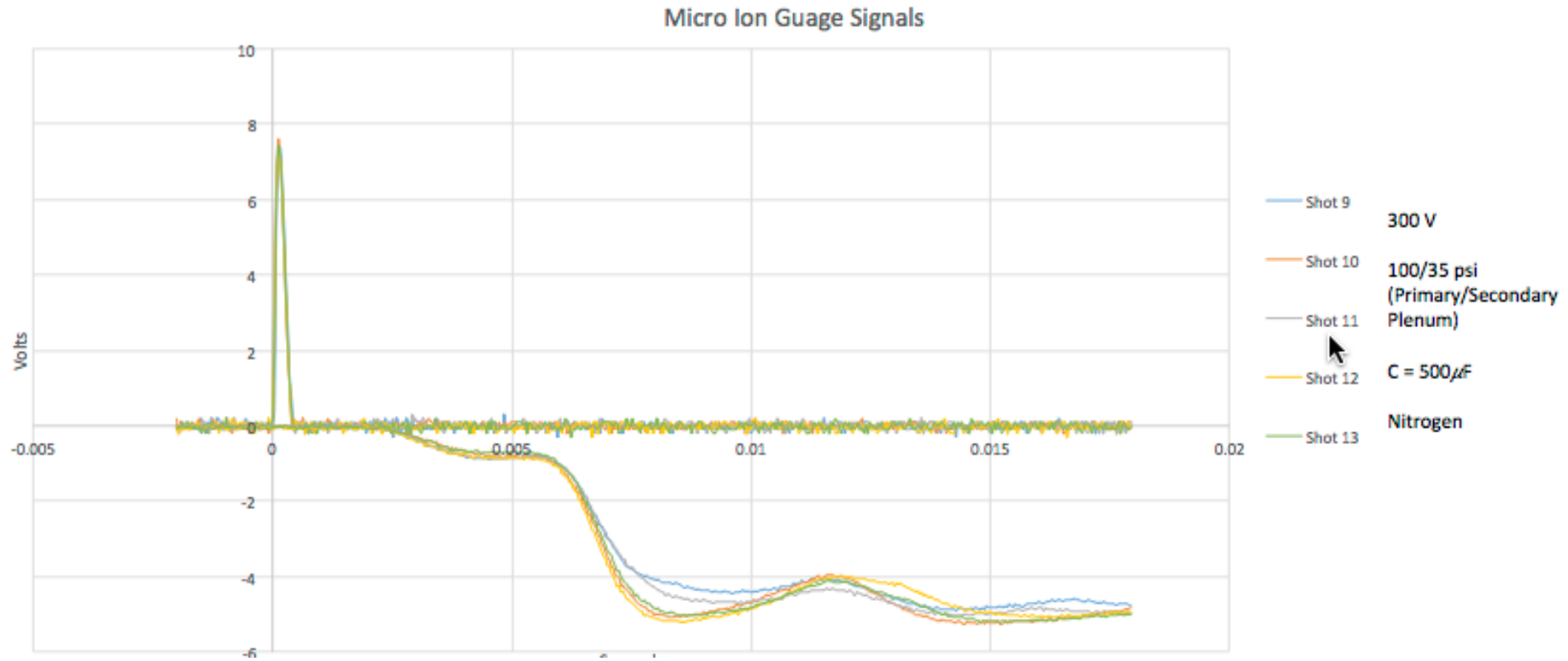
Test Chamber Relocated to New Isolated Lab (for safety)



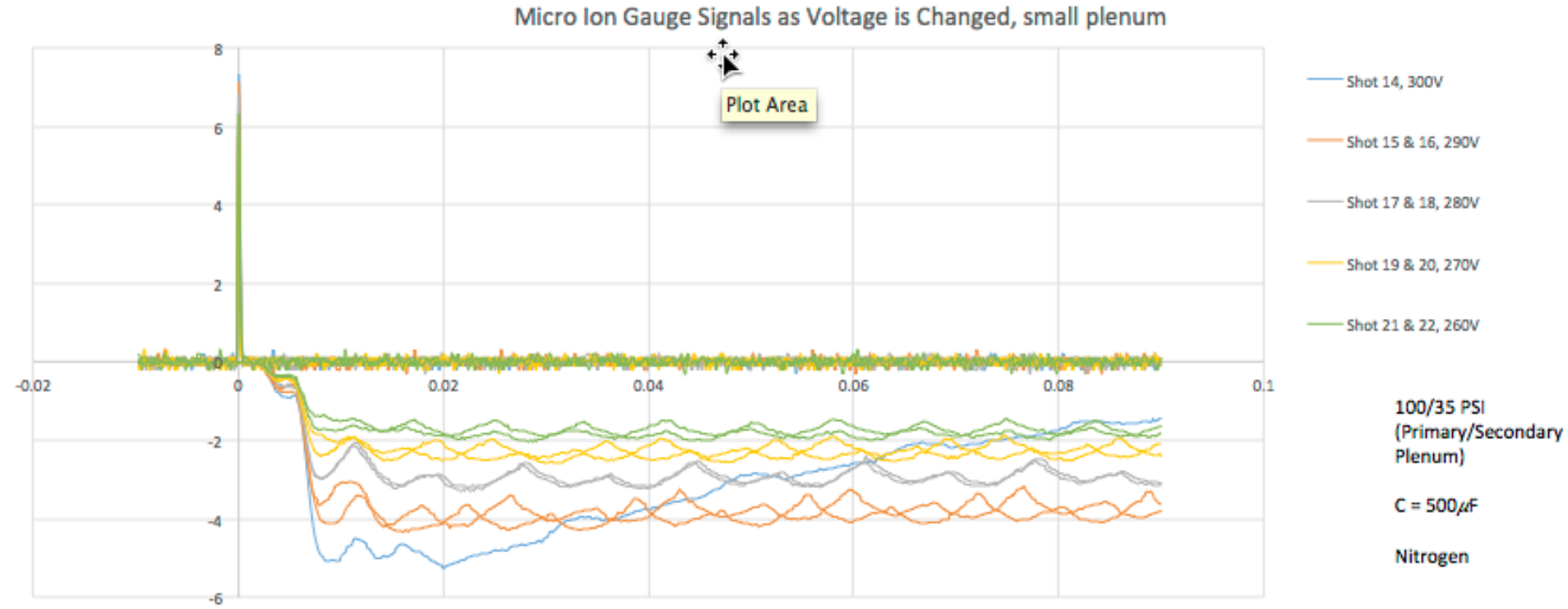
Valve -1 Response is about 4ms (Micro Ion Gauge – 3-5 Torr.L N2)



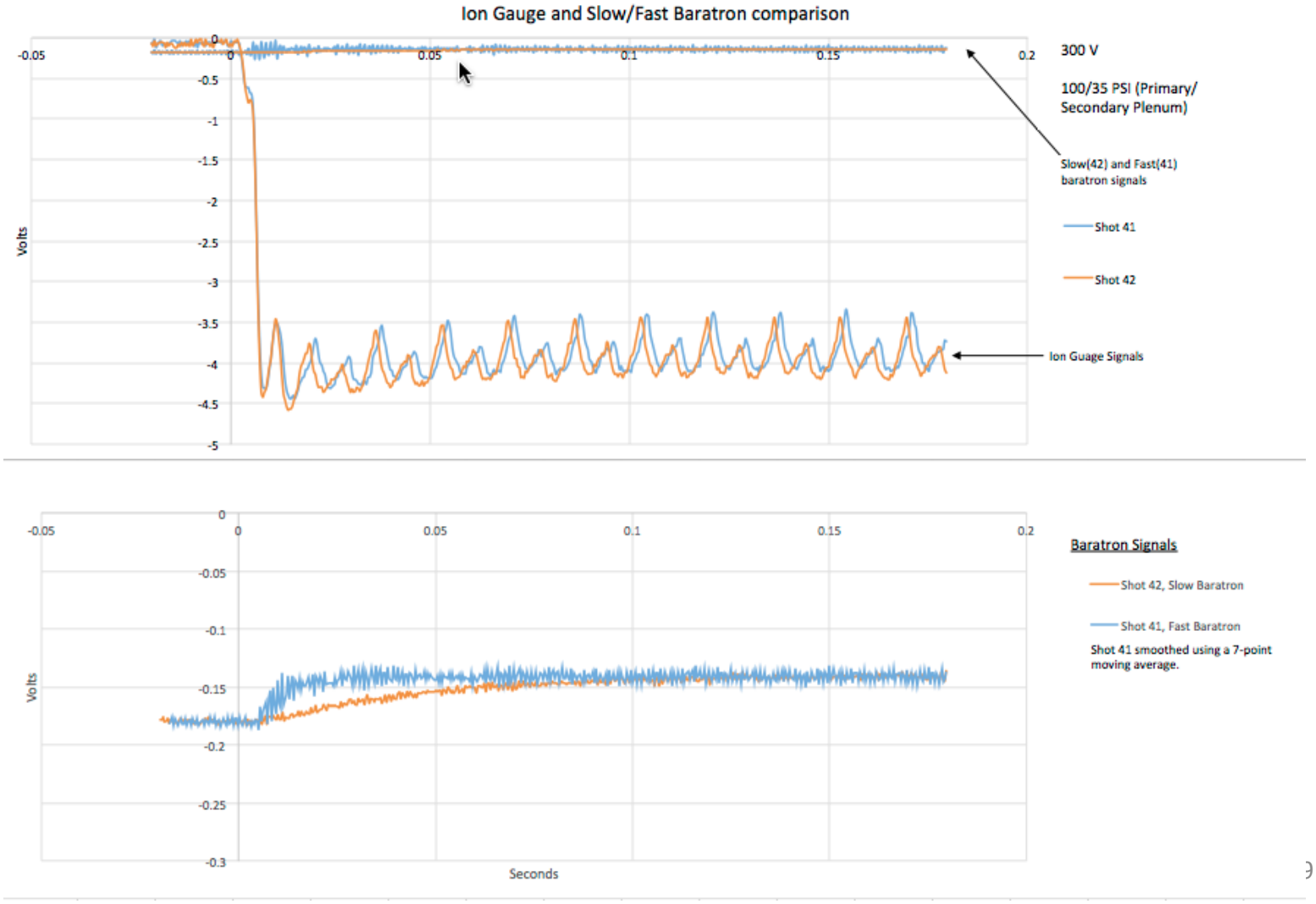
Valve -1 Reproducibility
5 Sequential shots (4-5 Torr.L)
Micro Ion Gauge



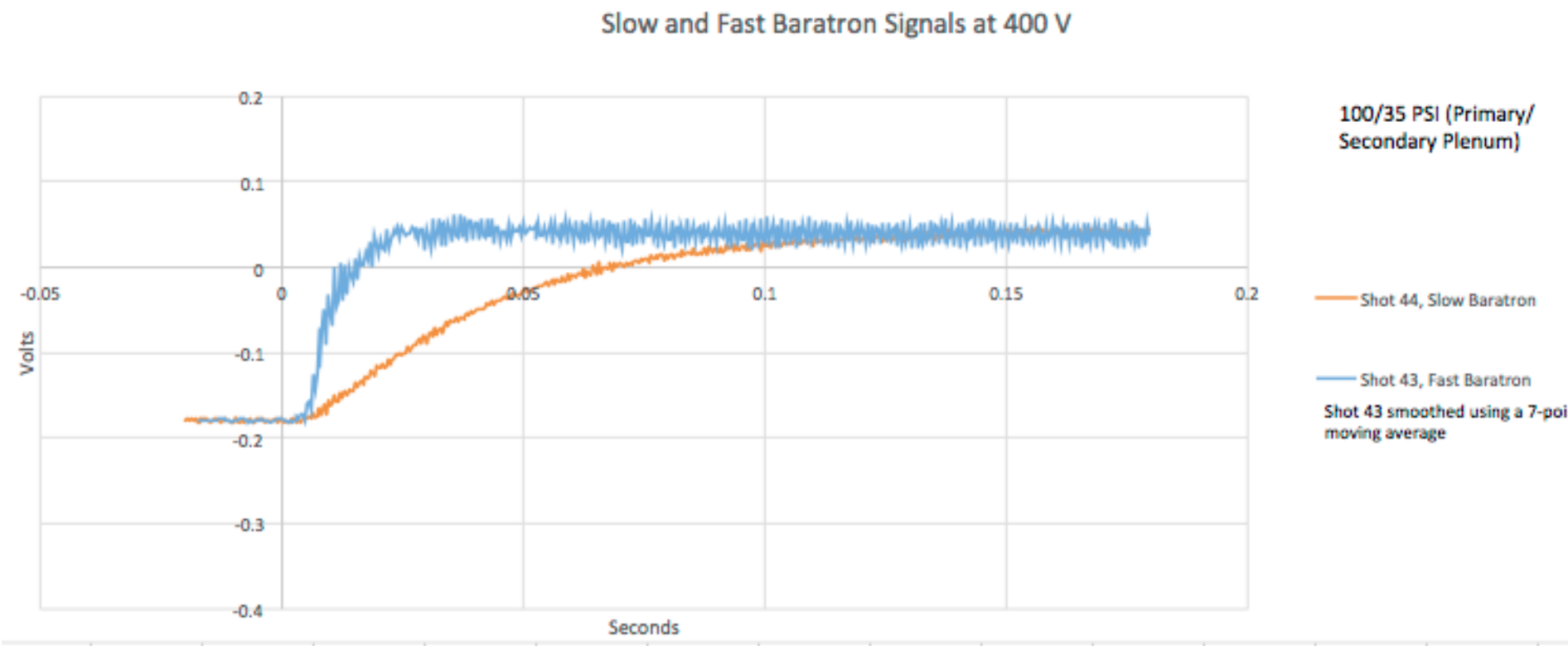
Valve -1 Increasing Valve Voltage
5 Sequential shots (4-5 Torr.L)
Micro Ion Gauge



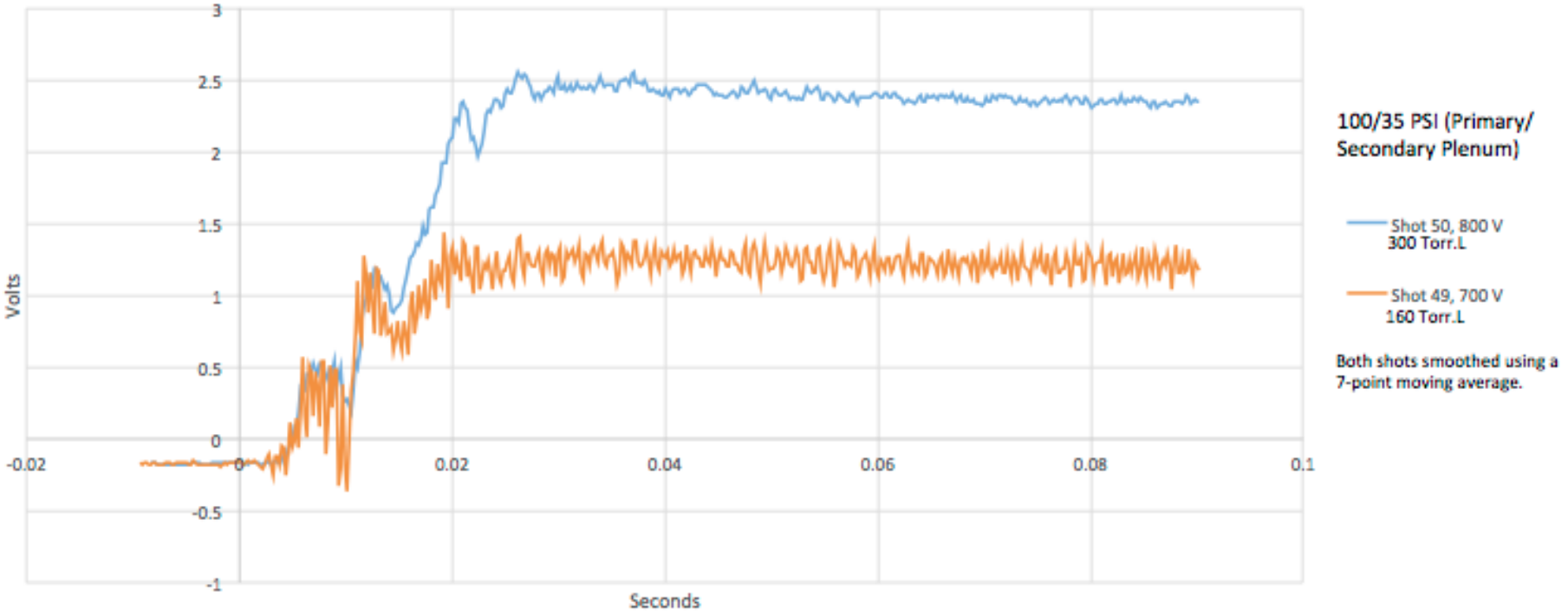
Valve -1 Comparison of MIG, and Slow and Fast Baratron Signals



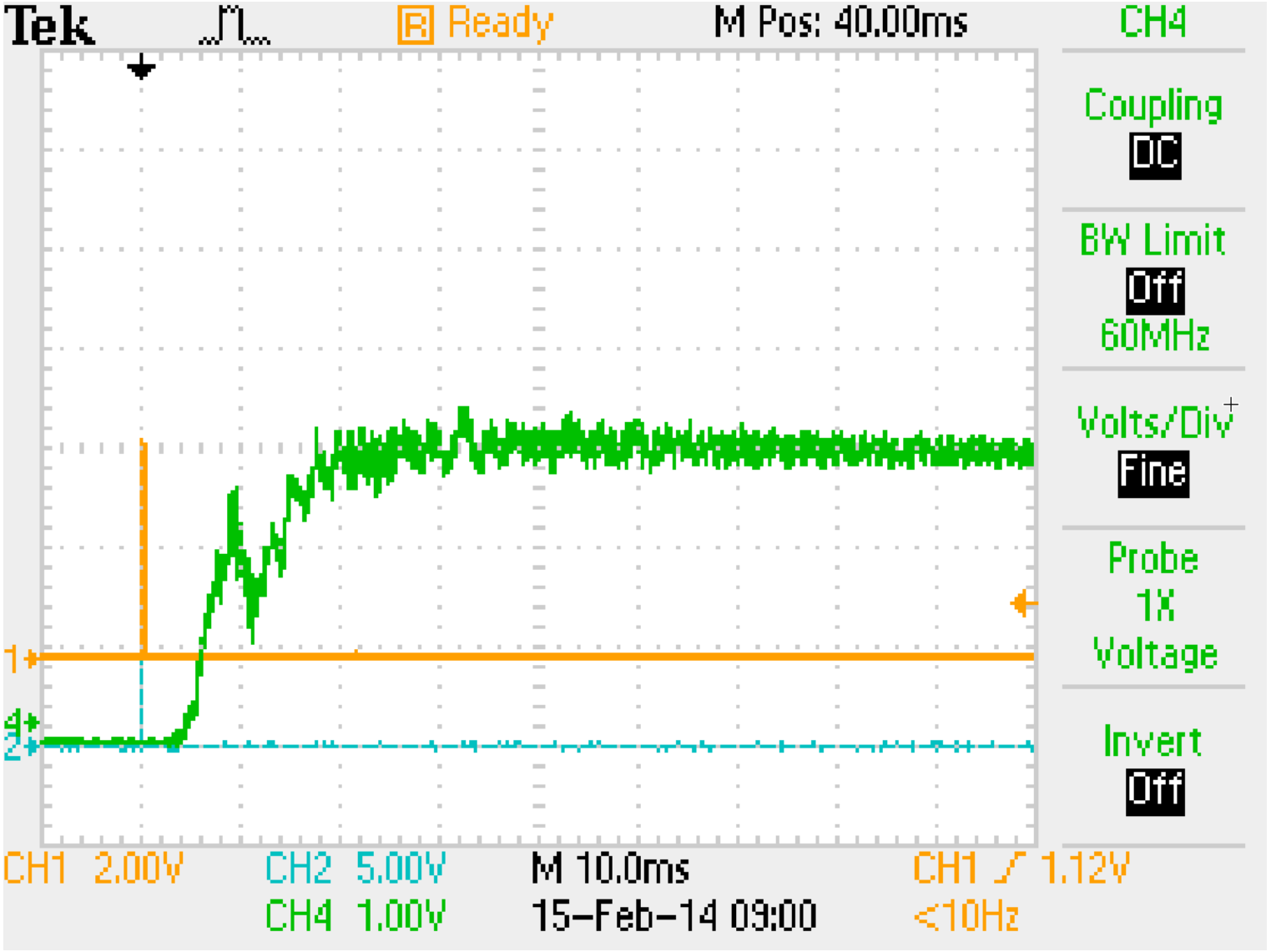
Valve -1 Comparison of Slow and Fast Baratron Signals



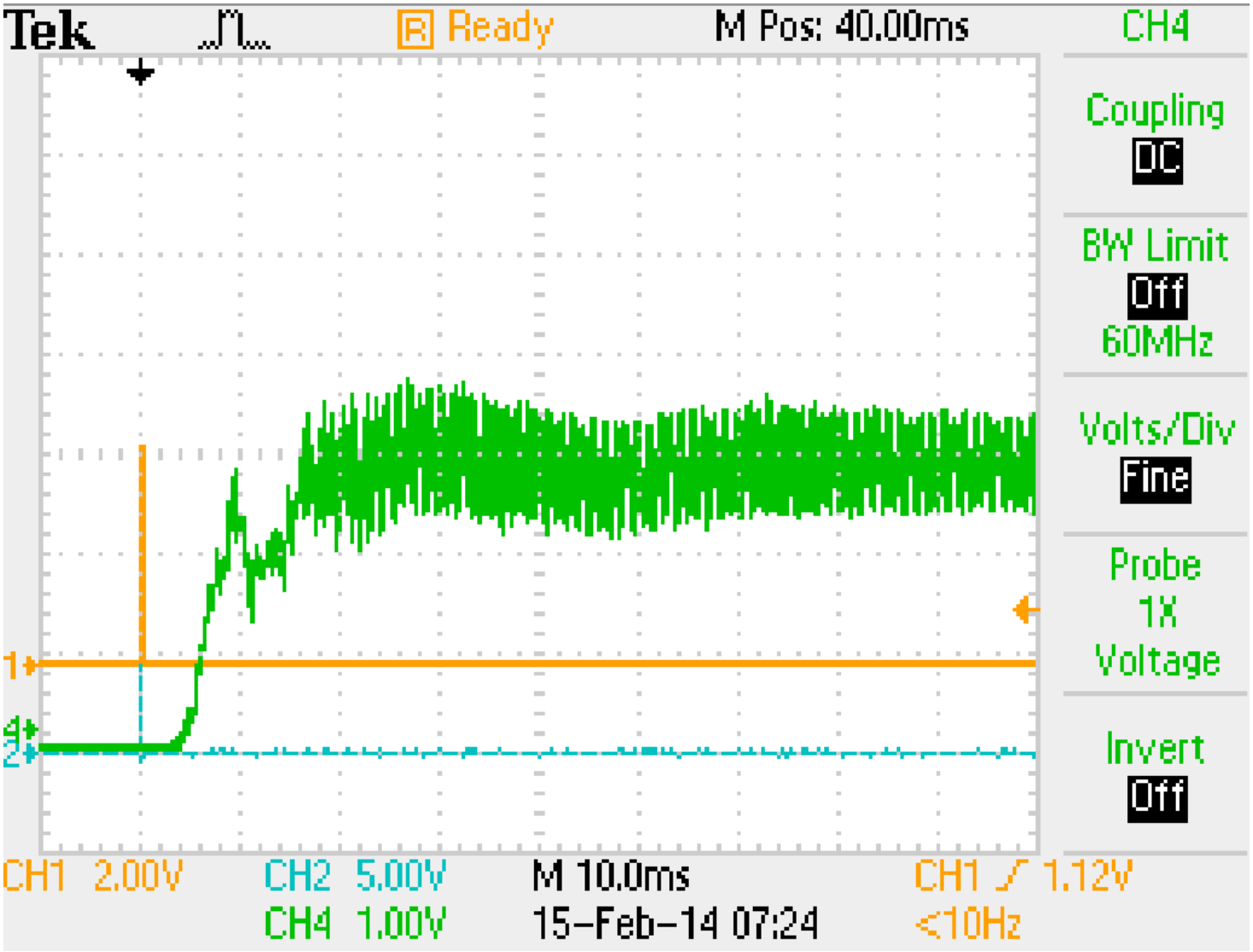
Valve -1 @ 160 and 300 Torr.L (Fy 2015 gas injection rates) Fast Baratron



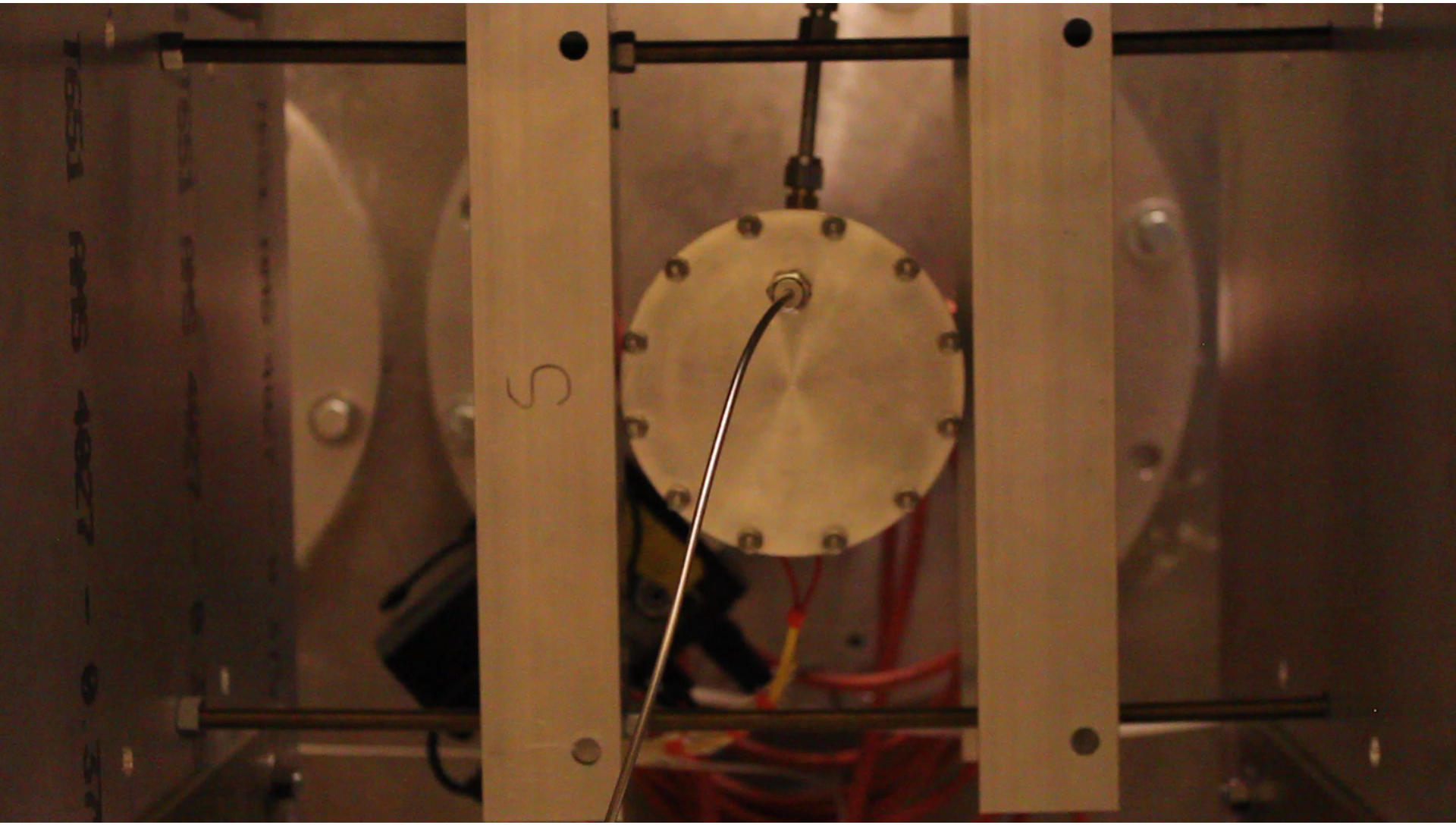
Valve -2 @ 222 Torr.L, Br = 0
(About 5ms rise time vs 20ms for Valve 1)



Valve -2 @ 254 Torr.L, with 0.1-0.2T Br (About 5ms rise time vs 20ms for Valve 1)



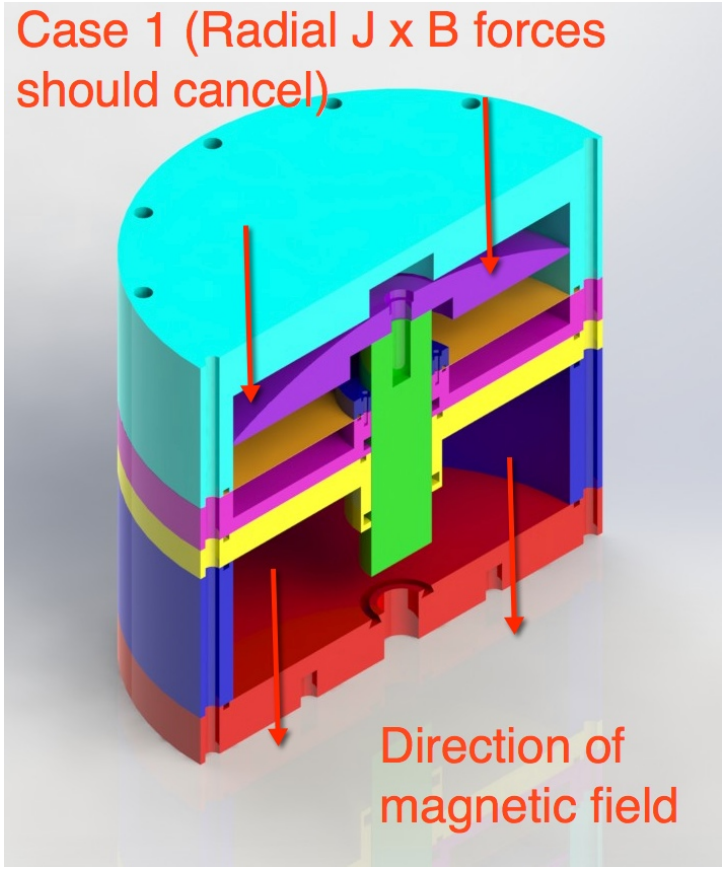
Movie of Valve Operation

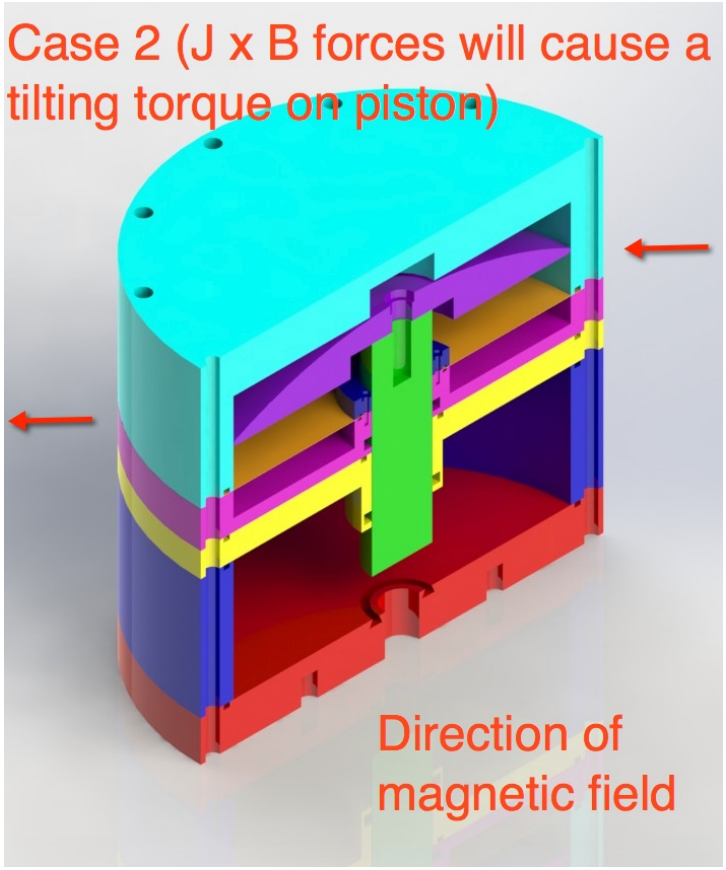


Installation Configurations (Action items shown in Red)

- Electromagnetic Forces on Valve
- Valve accessibility is important
  - Clean valve if seals contaminated by Li
  - Install upgrades to valves
- Would also like to test valve in NSTX-U magnetic fields to provide data to ITER
  - Valve is similar in design to ITER MGI valve

Forces on the Valve



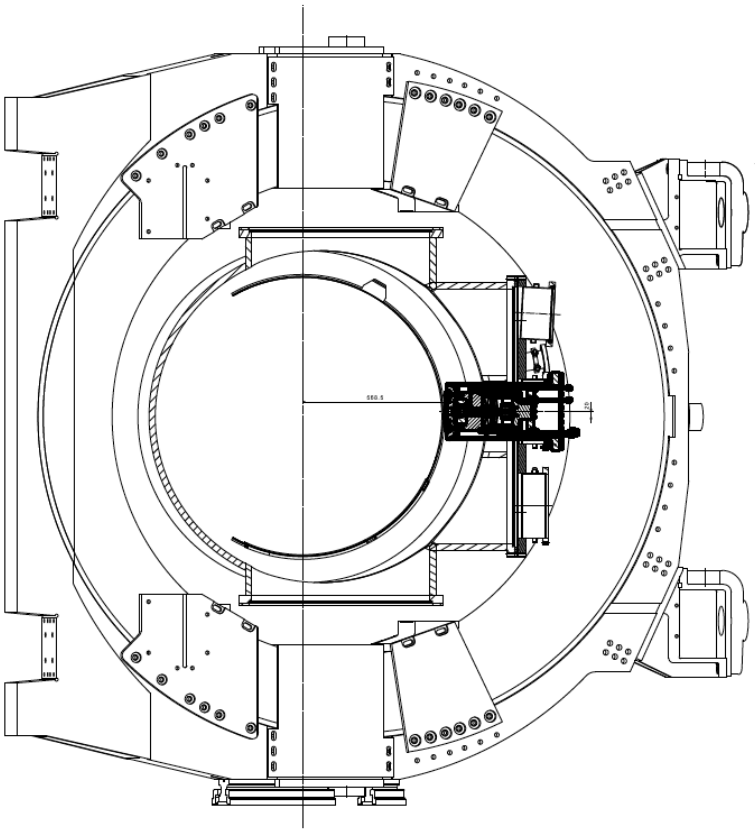


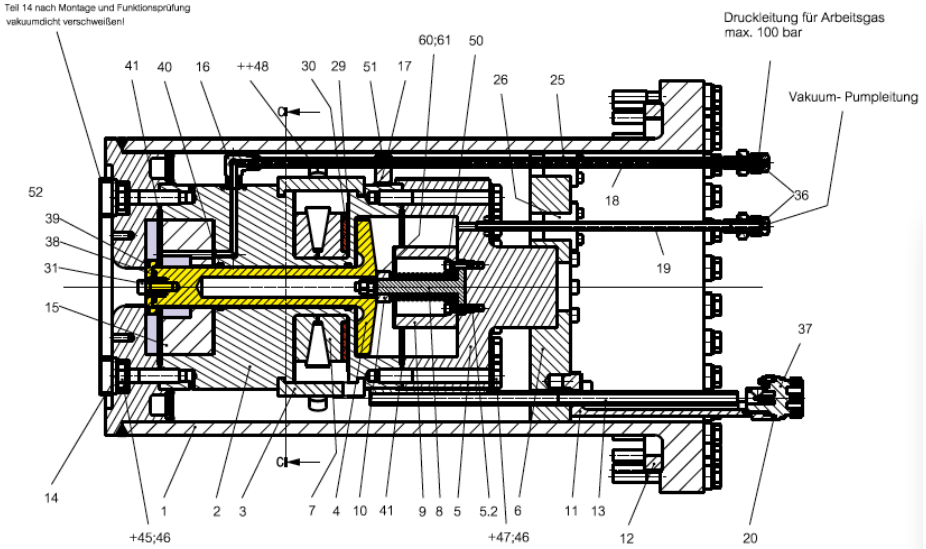
TEXTOR Valve Operated at 2T Radial Fields

Set-up of the new valve (installed March 2011)

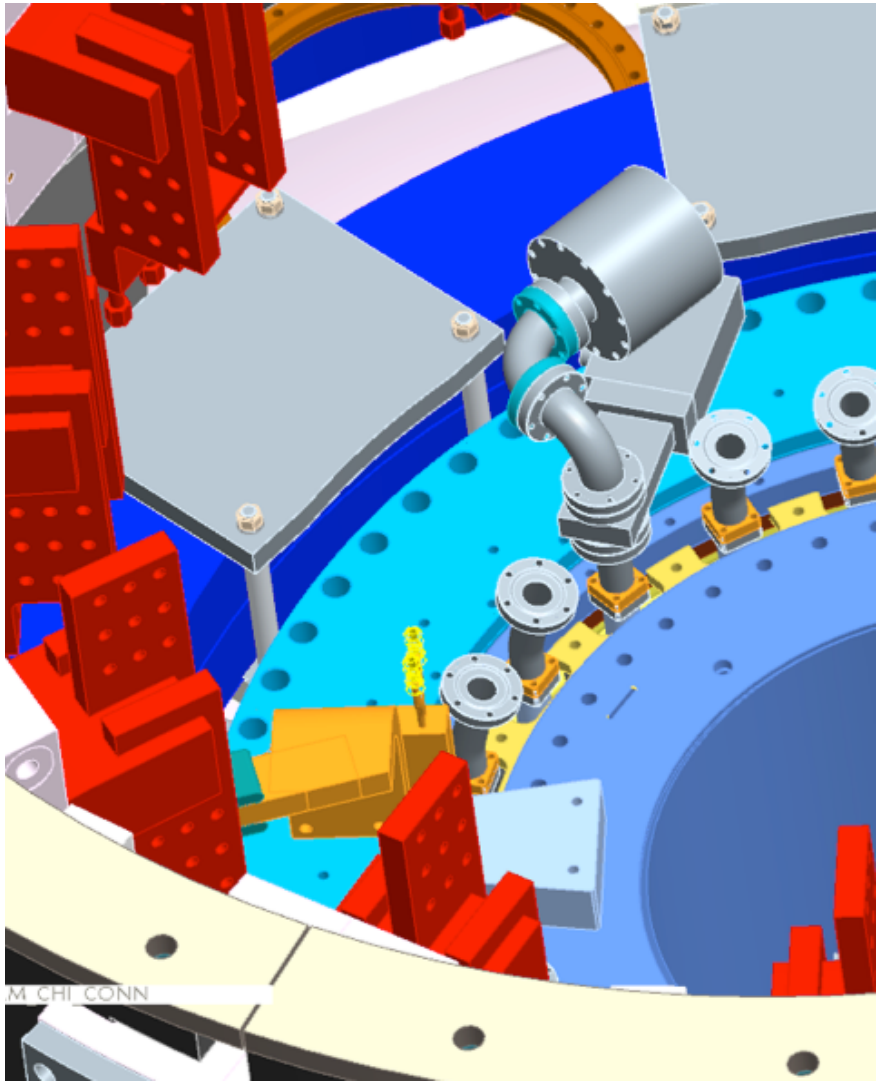
main features

- short distance to plasma ~ 0.1m
- high pressure up to 100 bar **(15 X NSTX-U valve)**
- operation inside toroidal field (~2T)
- large orifice (d=30mm)



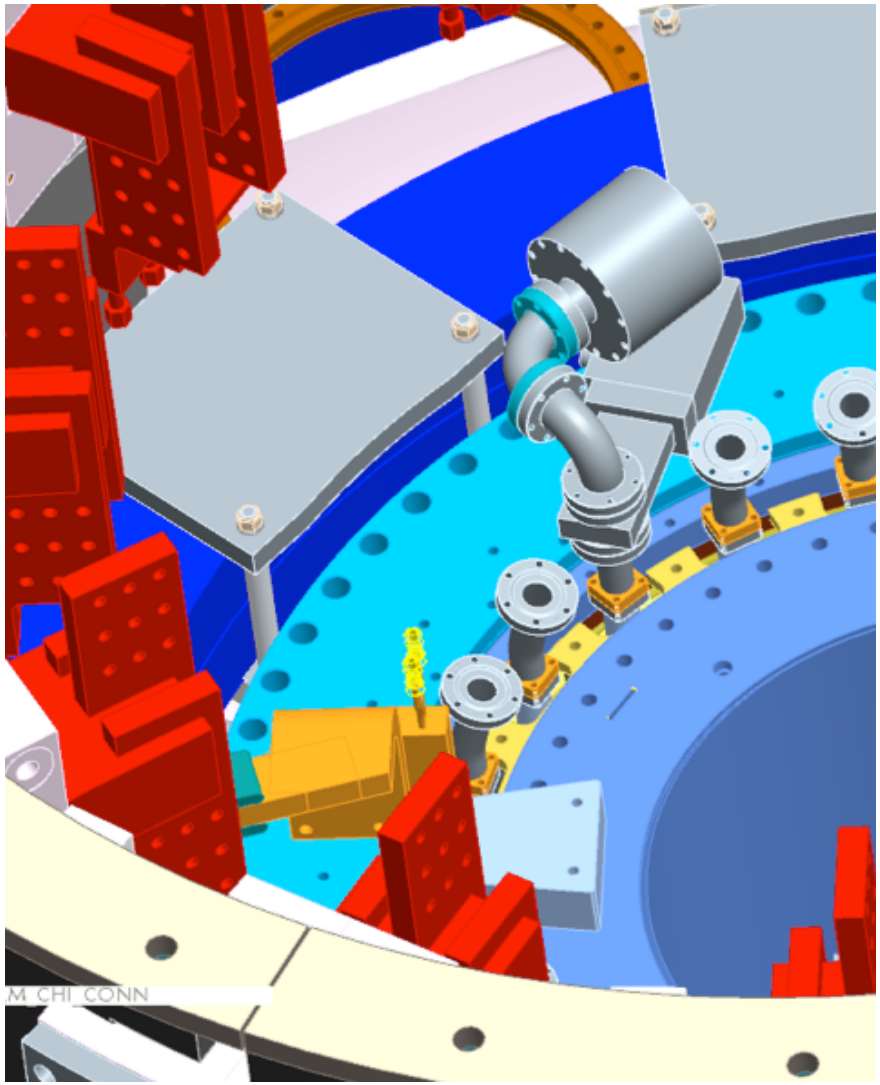


Installation Concept - 1



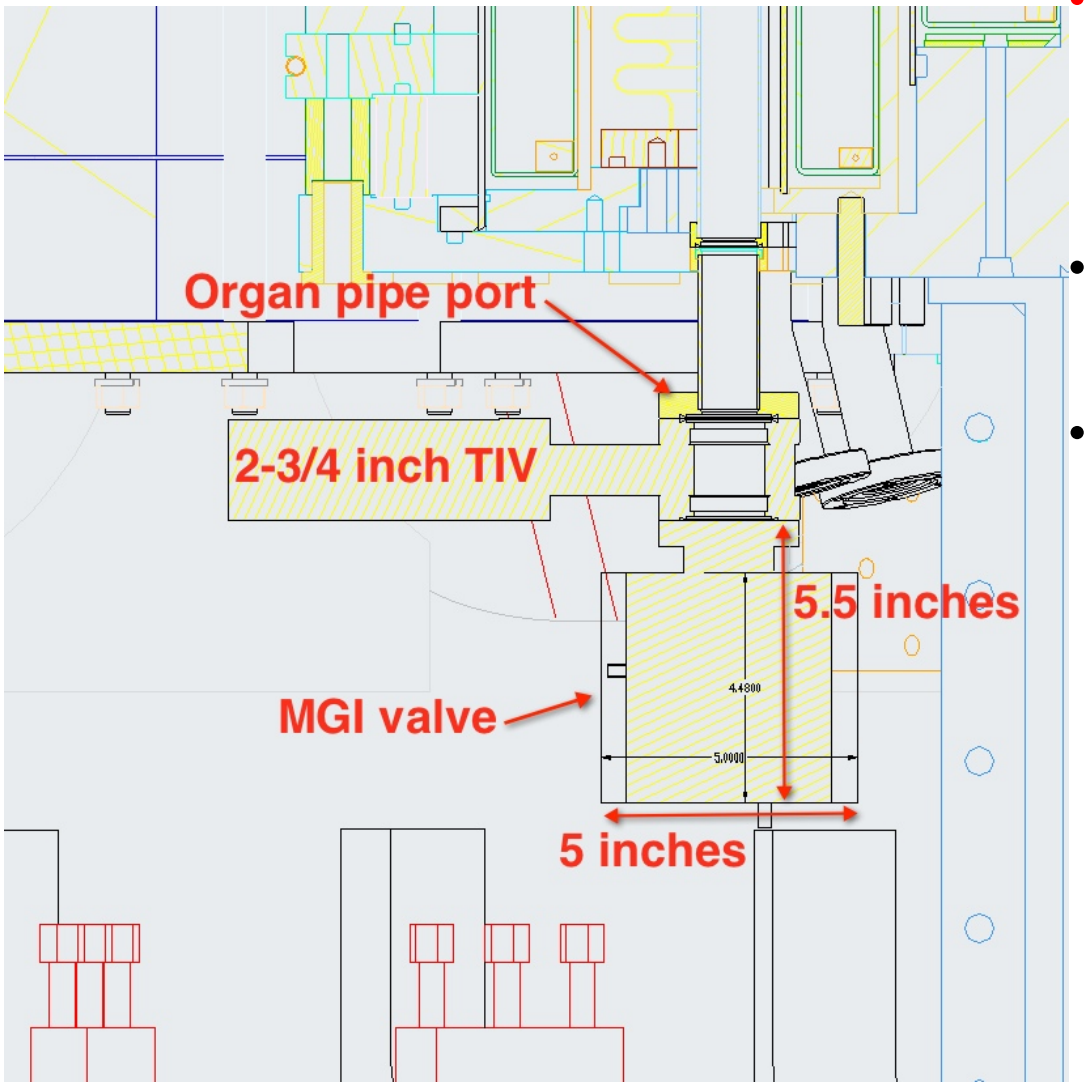
- Align the Valve so that the magnetic field is nearly perpendicular to the flat face of the piston
- This installation arrangement also avoids issue of lithium getting trapped near O-ring seals
  - Need to consider how to support current leads from the valve (2-5kA current, twisted pair)
  - Additional support for external valve body
  - Valve will be electrically isolated from vessel by a suitable insulating (non-ceramic) spacer (0.5 inch thick), and insulated bolt sleeves

Installation Concept – 1b

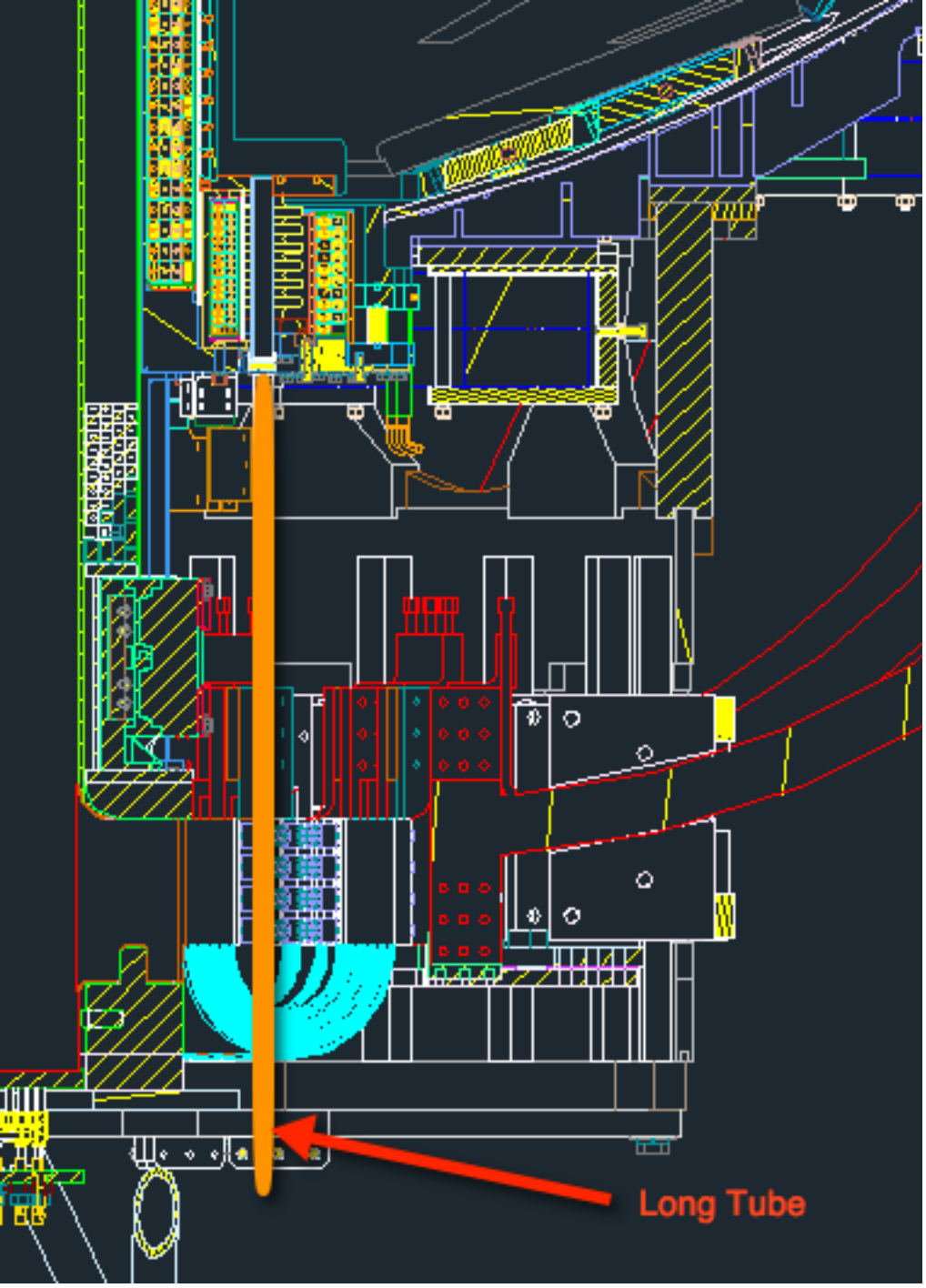


- In this case the tube bends will be extended to put the valve outside the TF coils to allow accessibility to valve
  - This is desired bot to ensure that the valve can me maintained
  - Need to identify suitable path of tube through TF coil legs, and specify total tube length and the number of tube bends

Installation concept -2
(High Conductance – Valve is 35 cm below Divertor Plate)

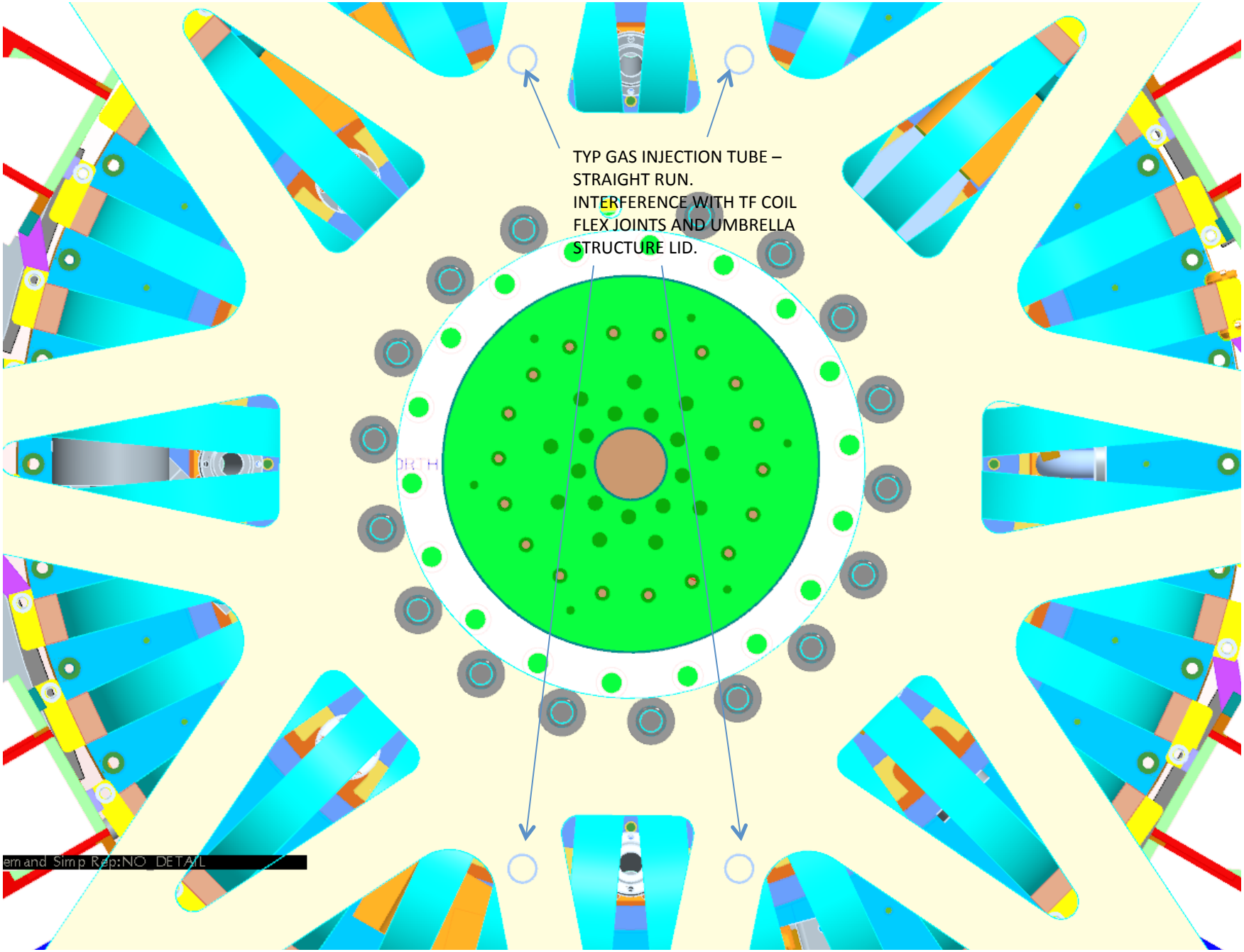


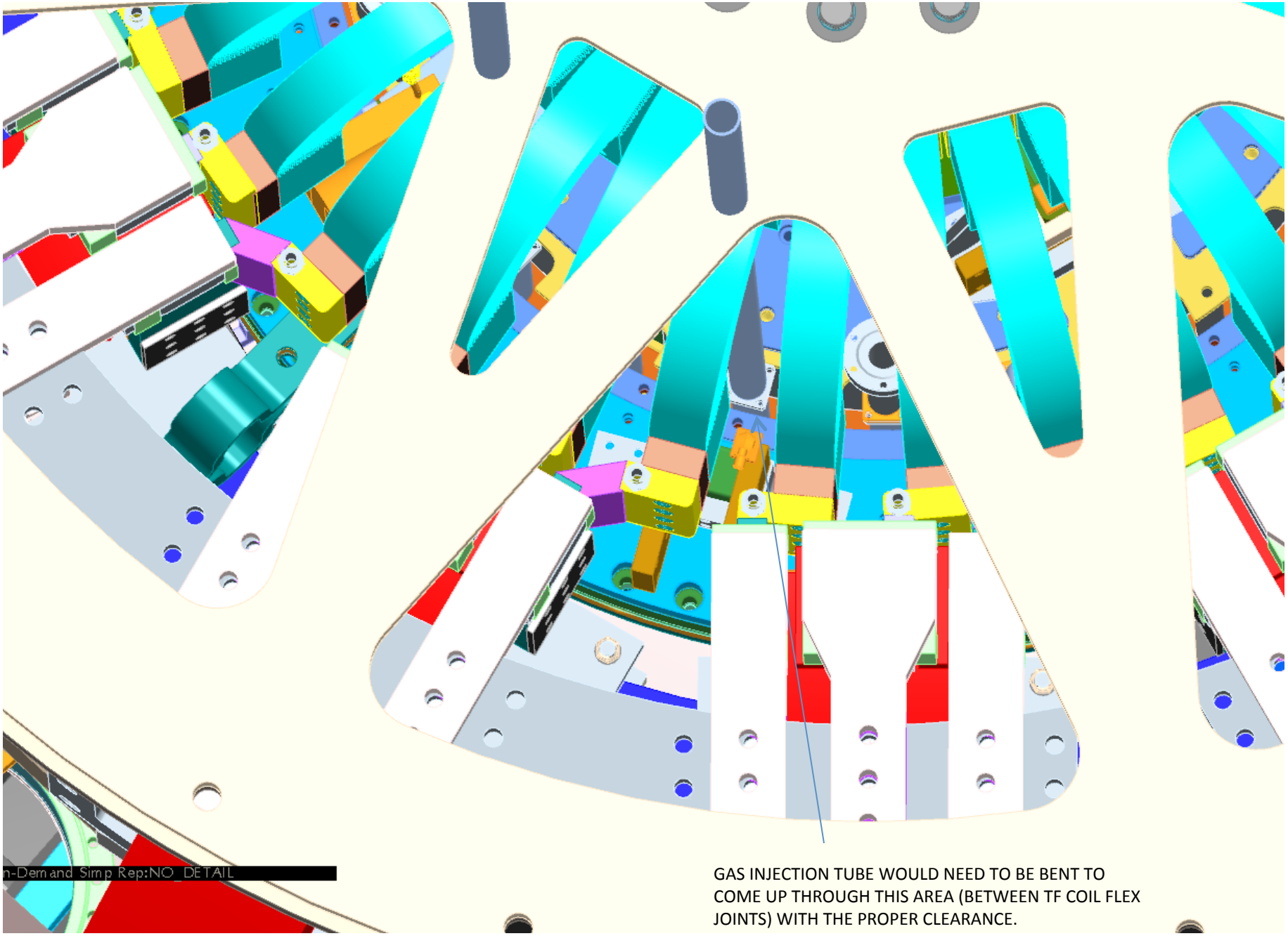
- Preferable to install one valve in this high-conductance configuration in upper divertor
  - Need TF/PF interlocks, similar to interlock to be used for CHI
- Will allow us to study the importance of valve proximity to plasma
- Will initially operate this valve in low B_T plasma with nearby PF coil de-energized
  - Will gradually increase magnetic fields to higher levels
  - Off-line tests in magnetic fields will provide supporting data
  - Mid-plane valve arrangement can be changed before experiments to assume either a low conductance of a high conductance configuration.



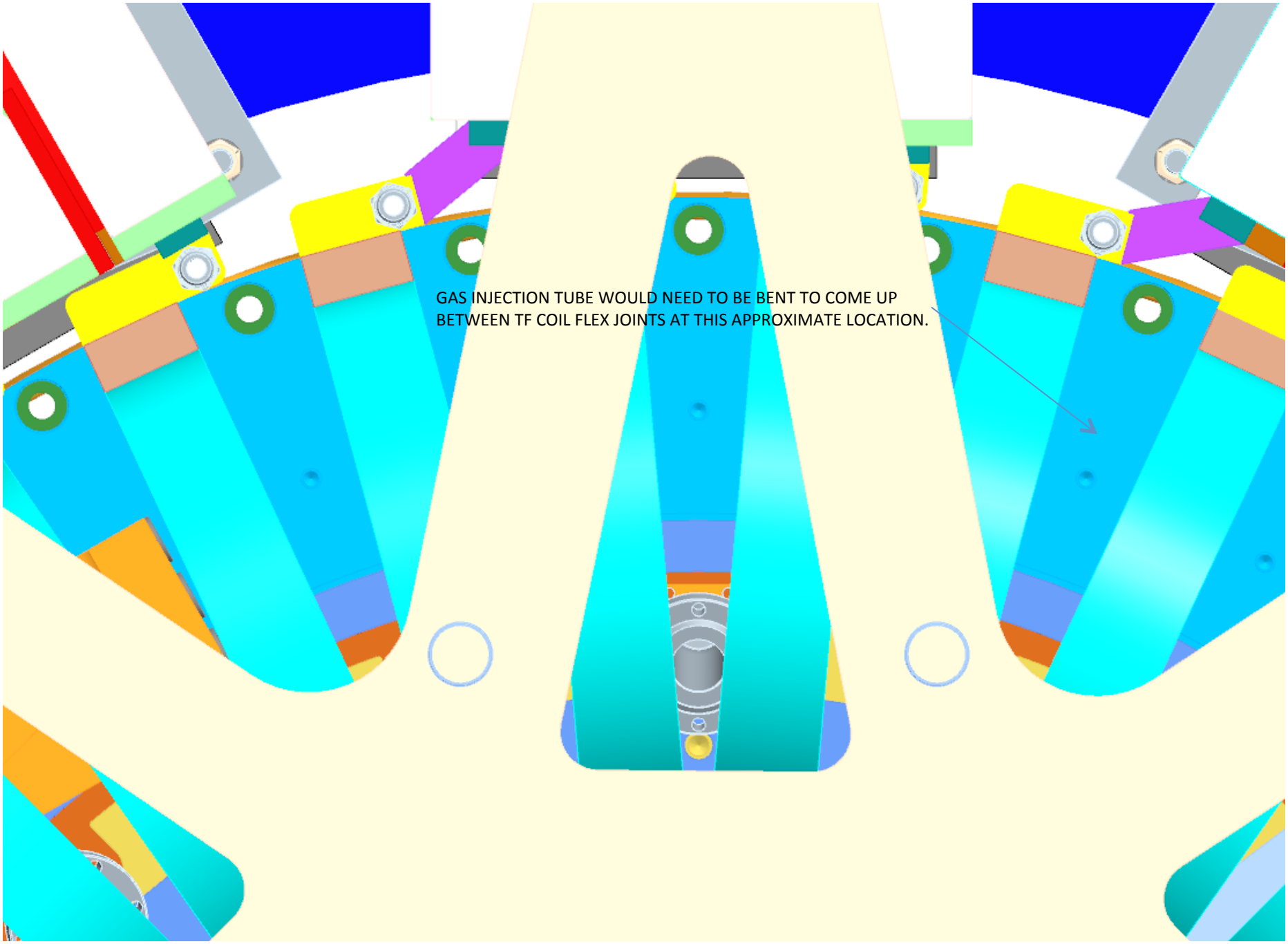
Installation concept -3 (Reduced Conductance – Valve is 135 cm below Divertor Plate)

- Almost straight through tube preferable to tube with bends to increase conduction (see next three slides from Lew Morris)
- Need to keep tube ID close to valve orifice ID of ~1 inches throughout length
  - Preferable to add lower diameter (2.5cm) adapter tube inside the organ pipe (based on DIII-D results)
  - Needs to identify extent of tube bends and total tube length to compare to case 1b


TYP GAS INJECTION TUBE –
STRAIGHT RUN.
INTERFERENCE WITH TF COIL
FLEX JOINTS AND UMBRELLA
STRUCTURE LID.
em and Simp Rep:NO_DETAIL



GAS INJECTION TUBE WOULD NEED TO BE BENT TO COME UP THROUGH THIS AREA (BETWEEN TF COIL FLEX JOINTS) WITH THE PROPER CLEARANCE.


GAS INJECTION TUBE WOULD NEED TO BE BENT TO COME UP
BETWEEN TF COIL FLEX JOINTS AT THIS APPROXIMATE LOCATION.

Off-Line Supporting Test Plans

- Off-line tests to use solenoid from HIT-II experiment to initially increase Br to up to 0.75T
  - Br will continue to be increased over time (some upgrades to coil and power supplies may be needed)
  - Increase pressure to 10,000-15,000 Torr in primary chamber
- V2 valve diameter will increase to about 5.5 inches to accommodate ¼-28 bolts for holding valve components together
- Need information on additional threaded holes on top of valve to support it on NSTX-U

NSTX-U Supporting Activities

- Would like to install 1 valve on upper divertor in the high-conductance configuration #2
  - The valve end away from the vessel should be supported
  - Current leads from the valves also need to be supported
- Determine tube lengths for configurations 1b and 3, and also the extent and the number of tube bends
  - This would determine which configuration will be used. However, configuration 3 may the preferred as it avoids severe tube bends, and the the additional straight extension of about 1m may provide adequate conductance to keep the system close to a high-conductance configuration
  - Are there any organ pipe ports on the lower divertor that allow a straight tube to be installed, with no bends?
  - Are other organ pipe locations more suitable (to minimize tube bends)?
- Need to calculate magnetic fields for a suitable discharge at all three valve locations
- The mid-plane valve installation should be such that it can be adapted to configuration 2, 3 or 1b as needed for the comparison experiments
  - The tube lengths and bends for the midplane valve should be identical to the configuration that is being used on the divertor and we would like the flexibility to replace the connecting tube with a different tube to ensure identical gas injection systems (this is the unique feature of the NSTX-U experiment)