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Vacuum Vessel Modifications

Erik Voirin

March 31, 2016

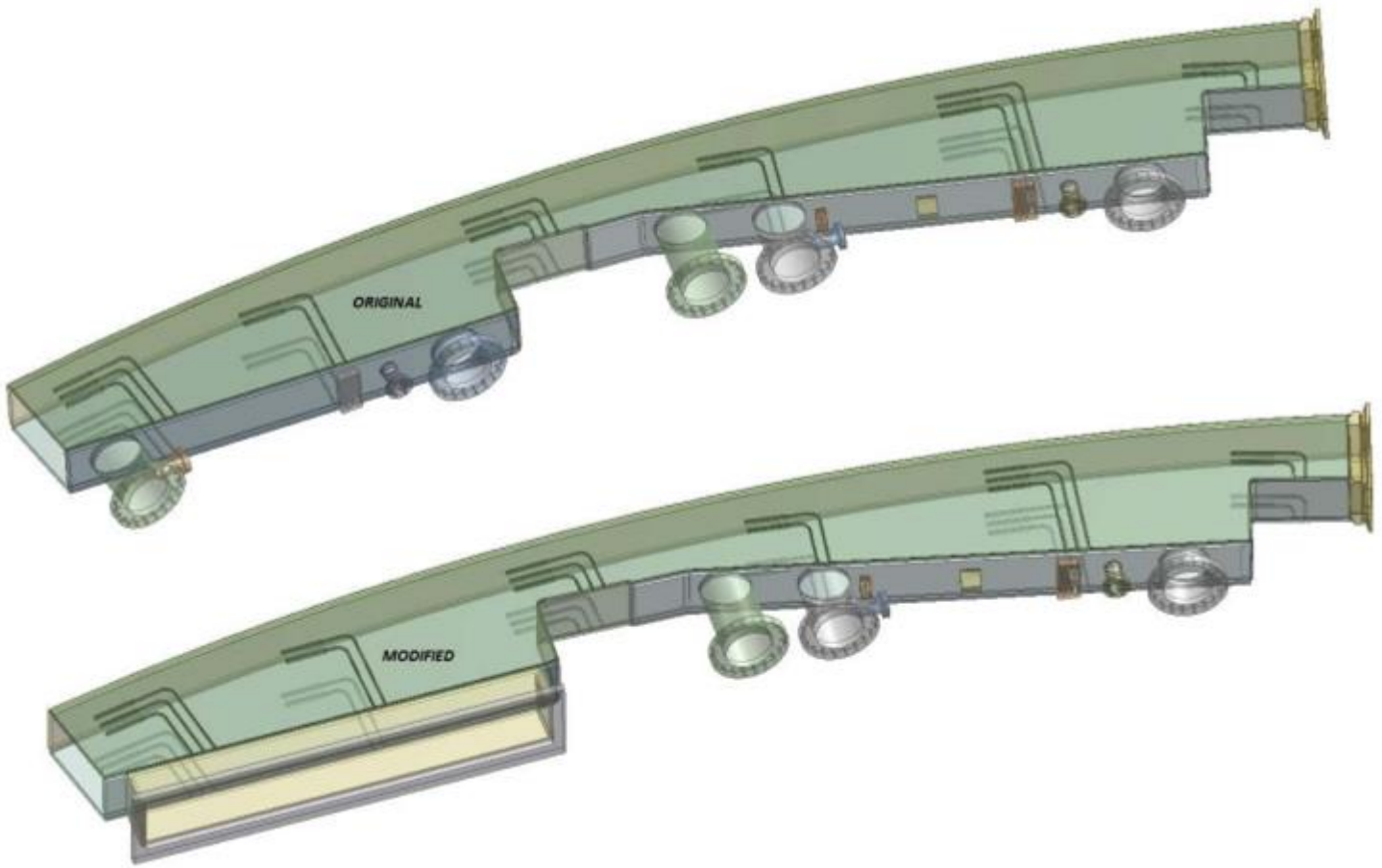
Acknowledgment to Glenn Thayer, Heitor Mourato, Lee Roberts, Cary Kendziora, Del Allspach, Joe Grange, Fermilab Welders, and others

Contents of Presentation:

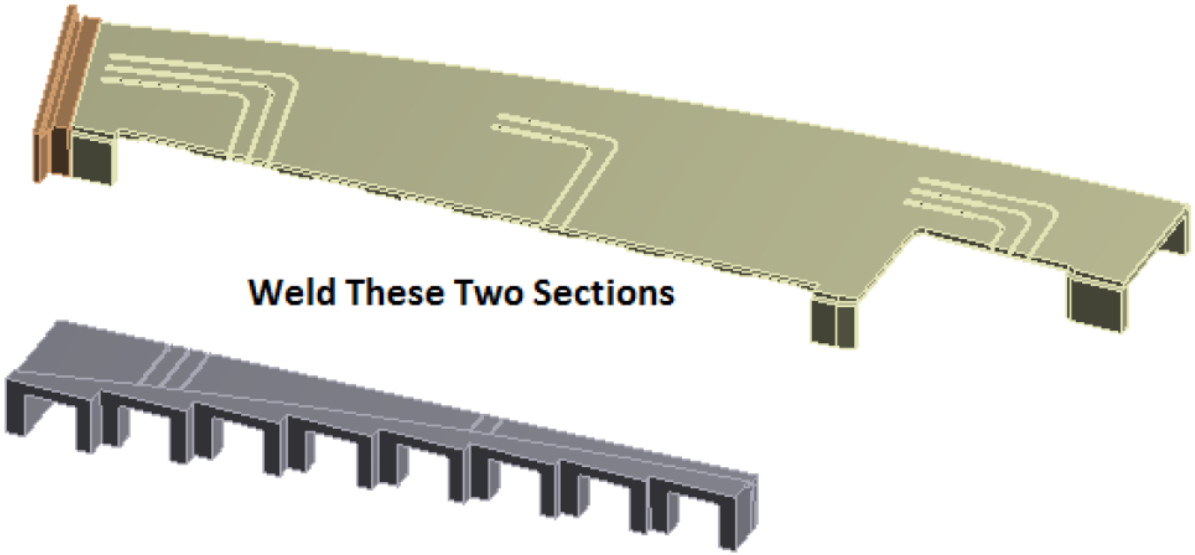
- **Straw Tracker Vacuum Chamber**
  - Need to build three of these chambers
  - Modify standard vacuum chambers, Cut and weld additional flange.
  - One built and at Fermilab now (at D-Zero)
  - Second and Third ones are being machined

- **Plunging Probe Vacuum Chamber**
  - Need to build / modify a single chamber
  - Modify right side of Trolley Garage Vacuum chamber
  - Design / Dimensions Complete
    - Discussing whether to build out of plates, or machine out of 3D blocks.
      - Aluminum Deforms when welding.
        - Welding Procedures can help control this
        - Small welds
        - Weld on both sides of the neutral axis to “balance” the deformation

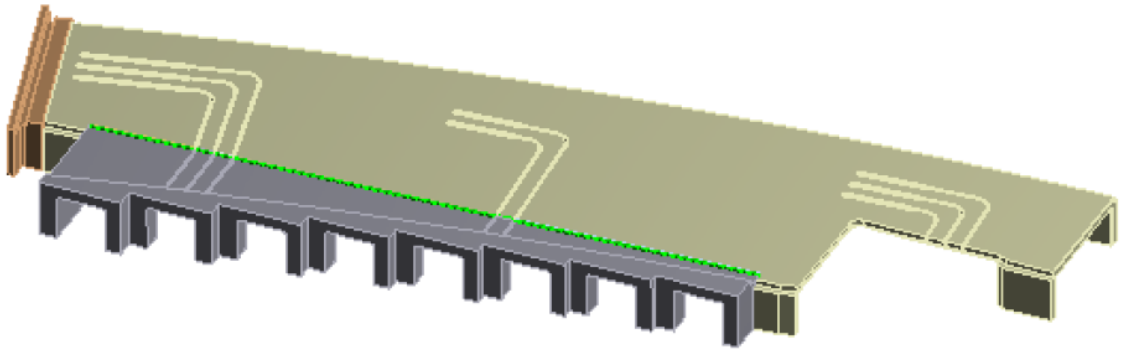
First Concept for Straw Tracker Chamber Modification



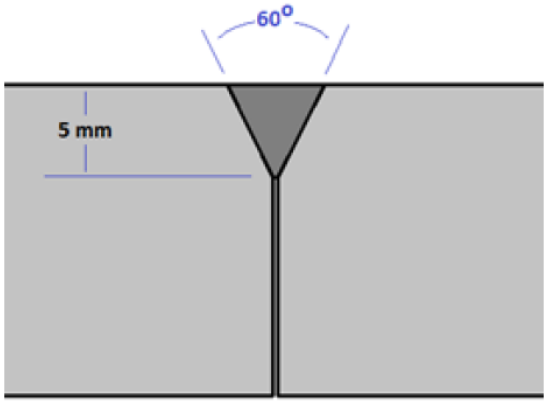
Straw Tracker Chamber Modifications
Final Design: Stair Step Flange



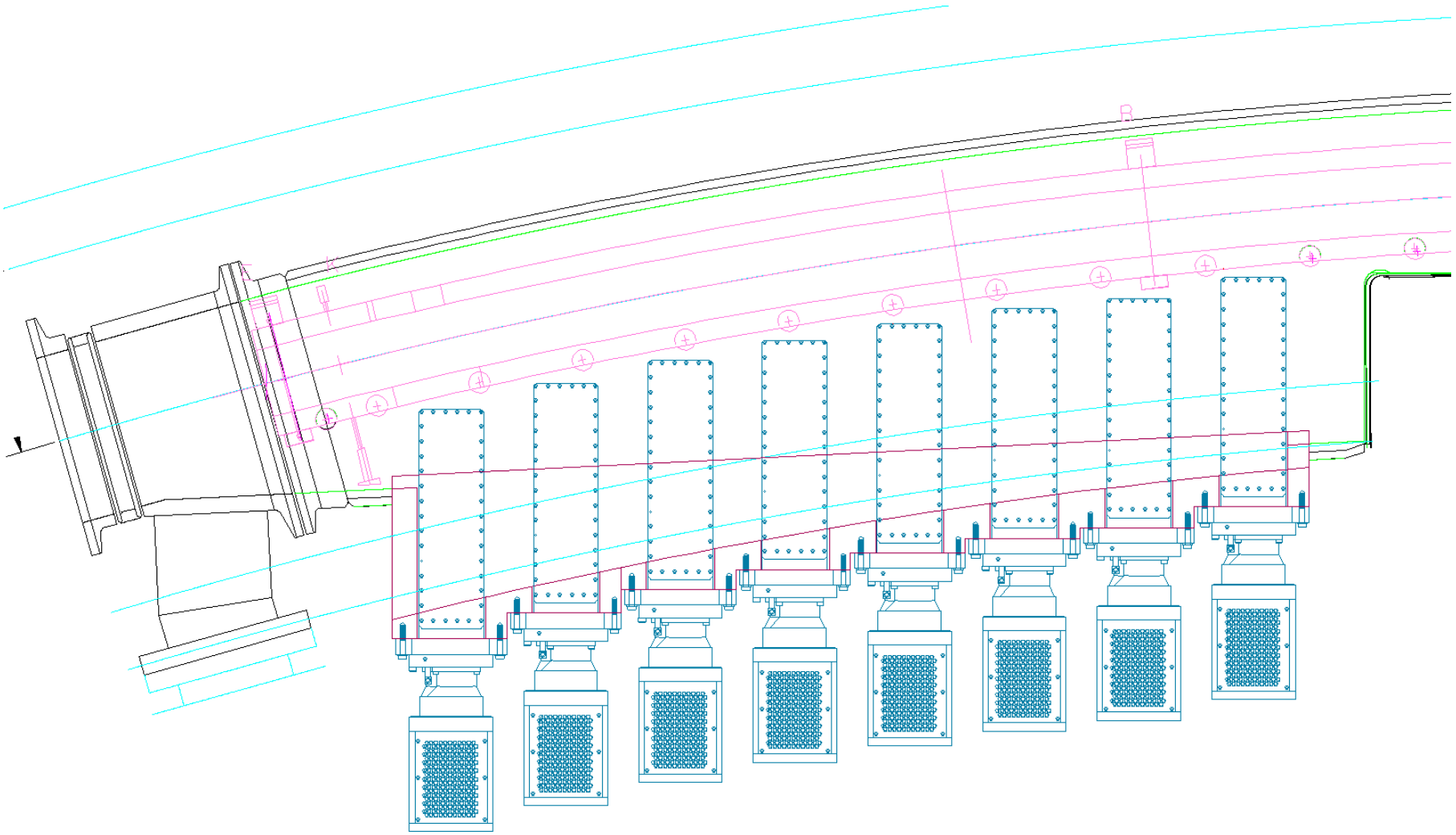
Butt weld location shown in green below, as well as weld cross section dimension (Note only half of the chamber is shown due to symmetry across the XY plane)



Prototyped welding procedure with plates to determine best welding procedure



Plan View with Straw Tracker modules installed



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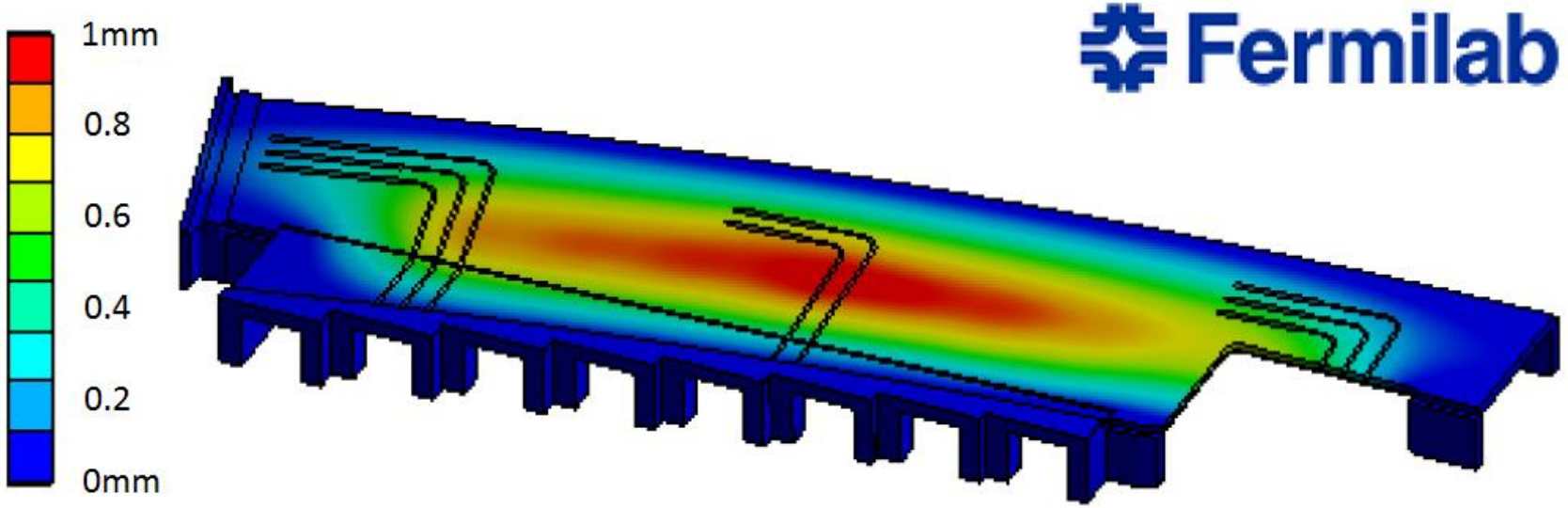
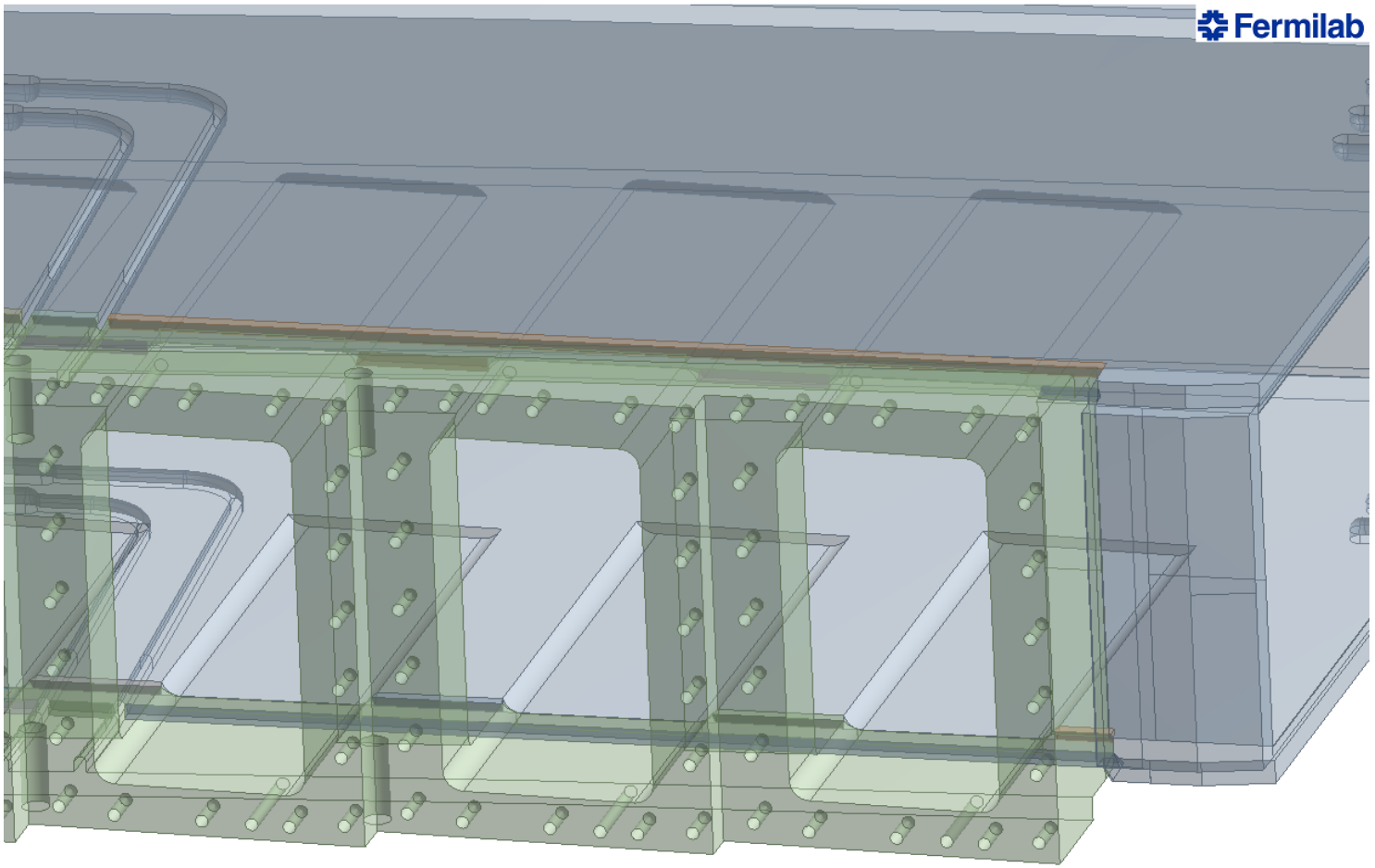
Deformation under vacuum: ~1mm per side

- Deformation is 1mm
  - Which is more than the 0.5mm clearance to tracker modules

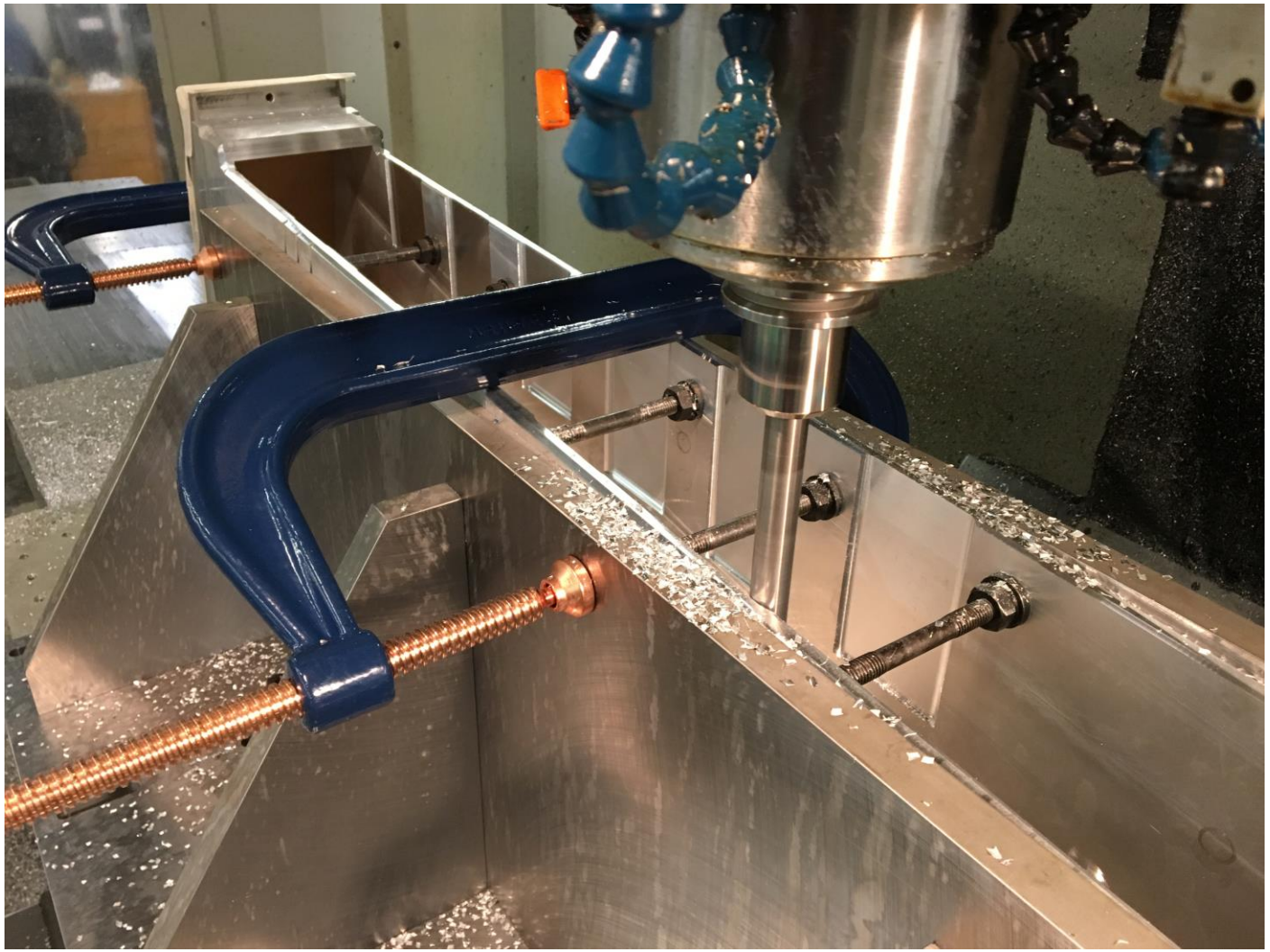


Cut Pockets into top and bottom surfaces of vacuum vessel

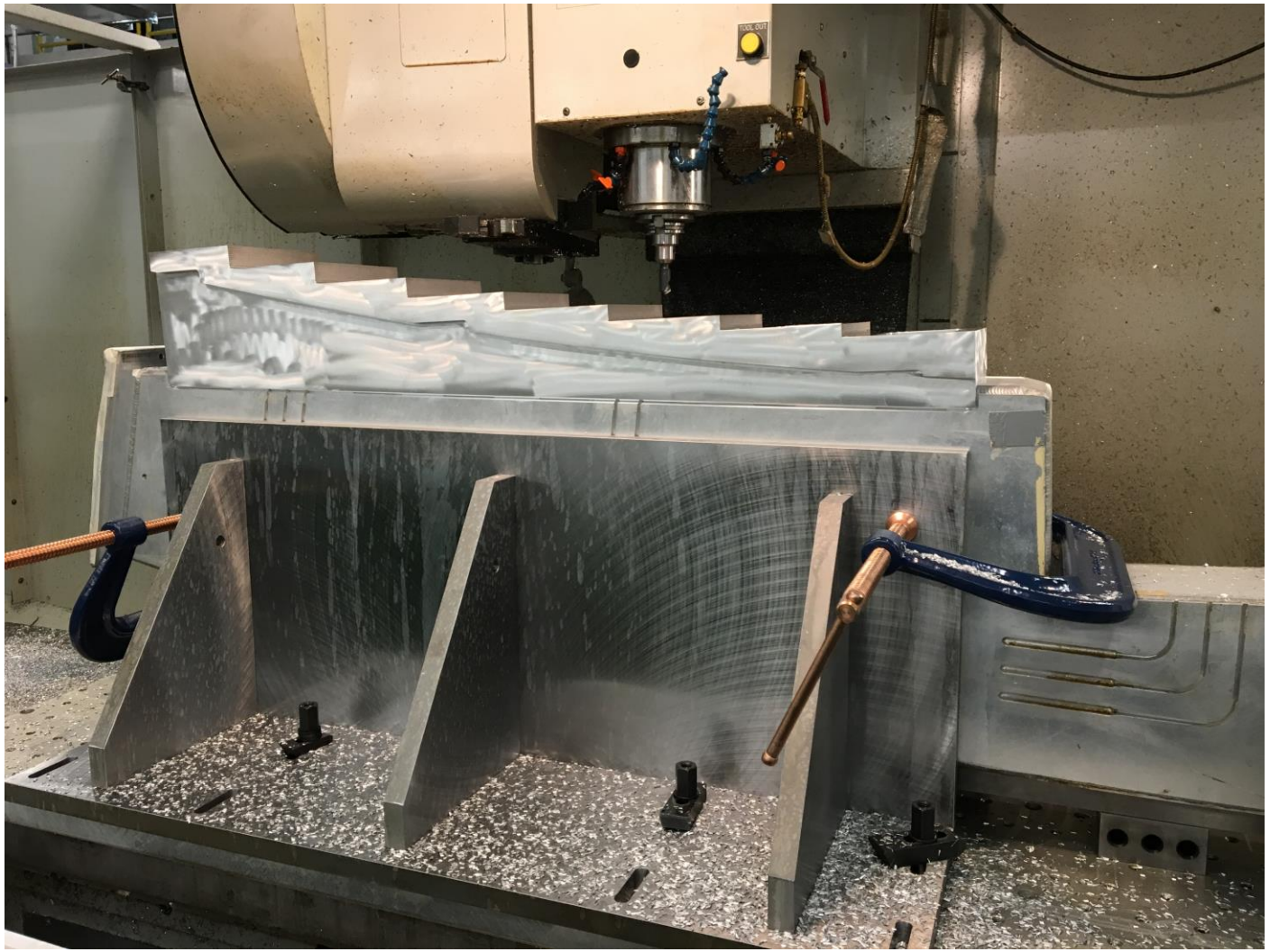
Pockets give 5mm clearance (10x original value of 0.5mm)



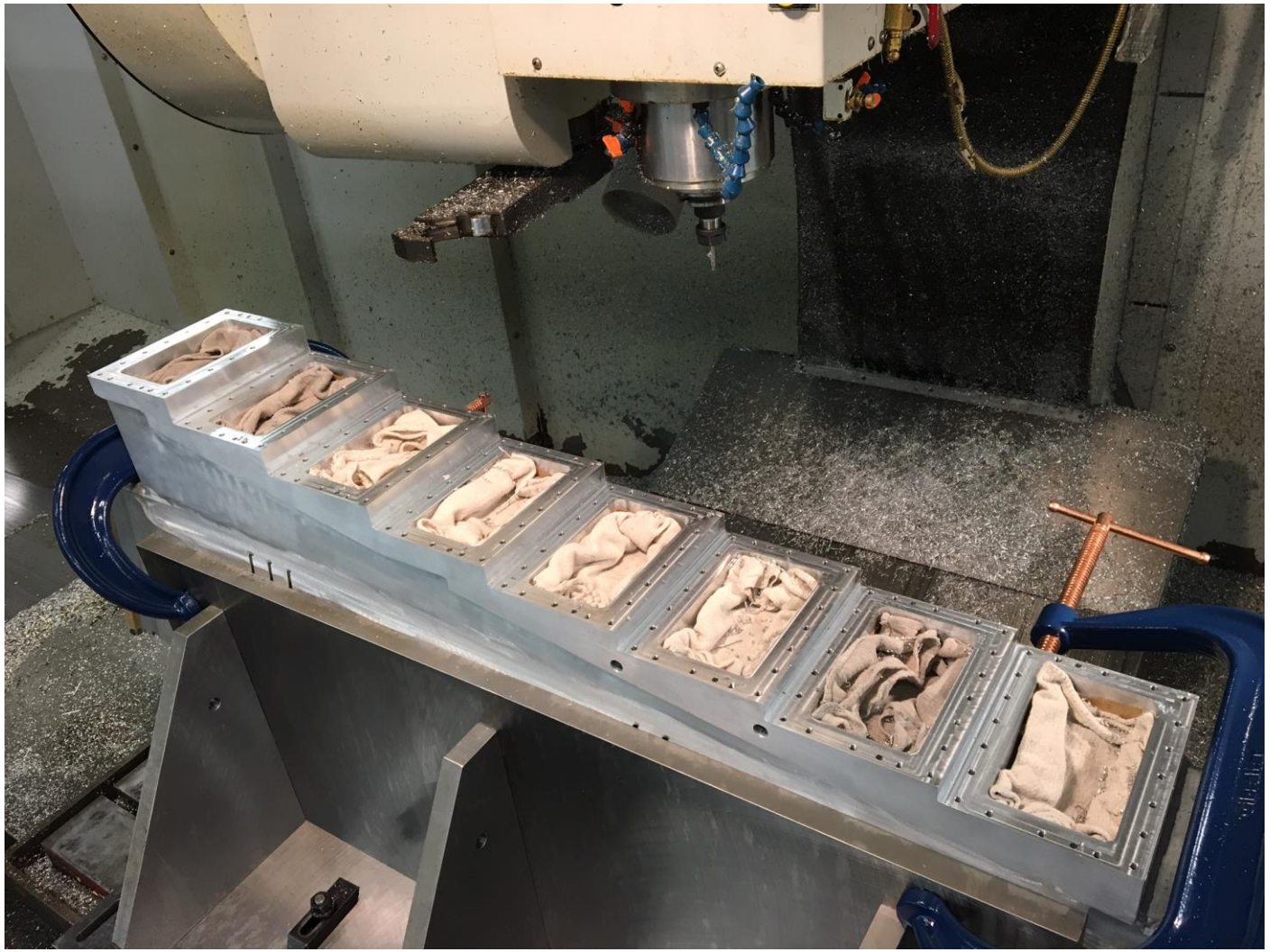
Machining Pockets in Original Vessel: Boston University



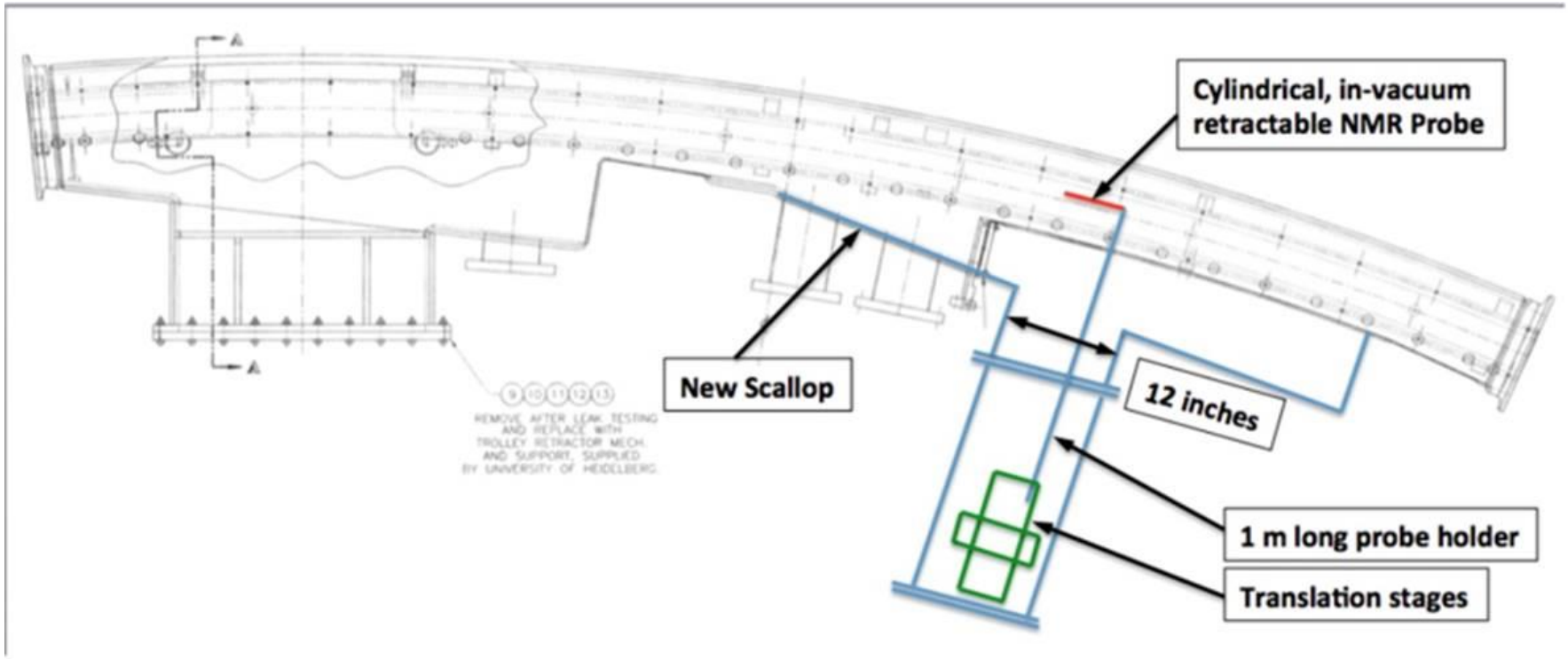
Stair Step Flange Placed on Vessel Cut out before welding



Final Machining of Flange Face / Bolt Holes after Welding.

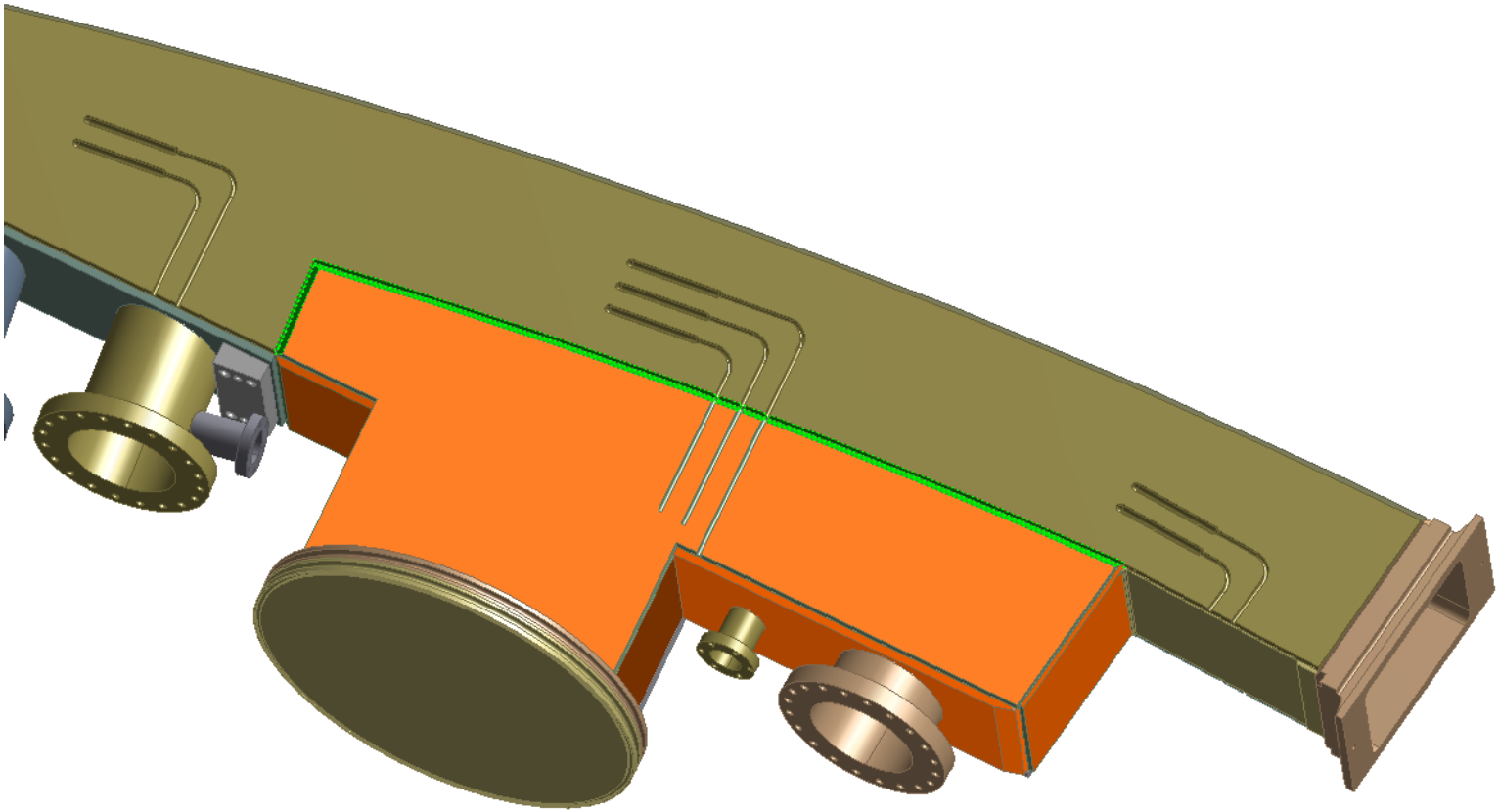


Plunging Probe Addition / Modification

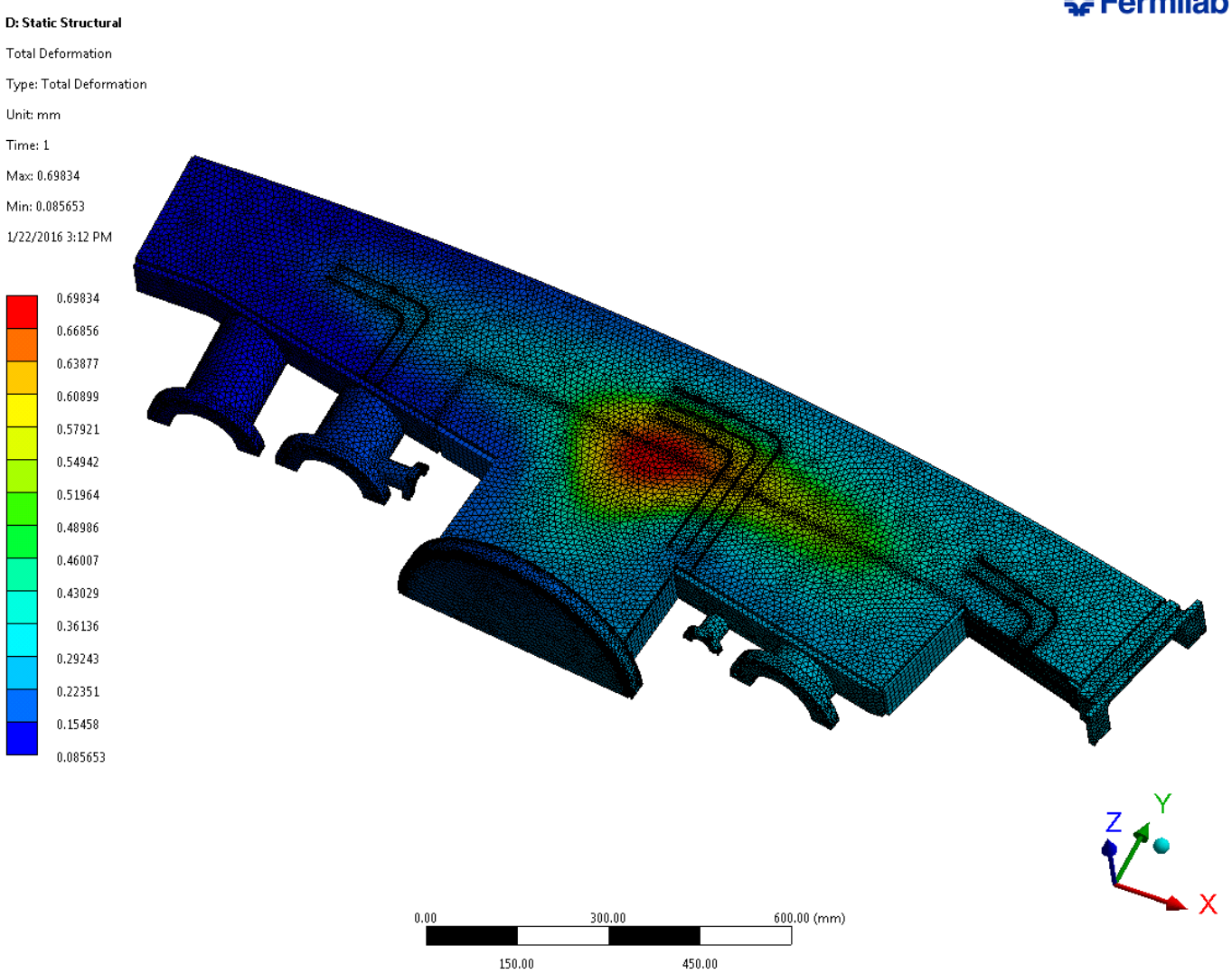


Scallop / Plunging Probe Addition

- Orange: Scallop addition
- Green: Weld to existing Vessel
- ISO flange at for attaching plunging probe vessel



Deformation under Vacuum is 0.7mm



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Ring Leveling / Yoke Alignment

Erik Voirin

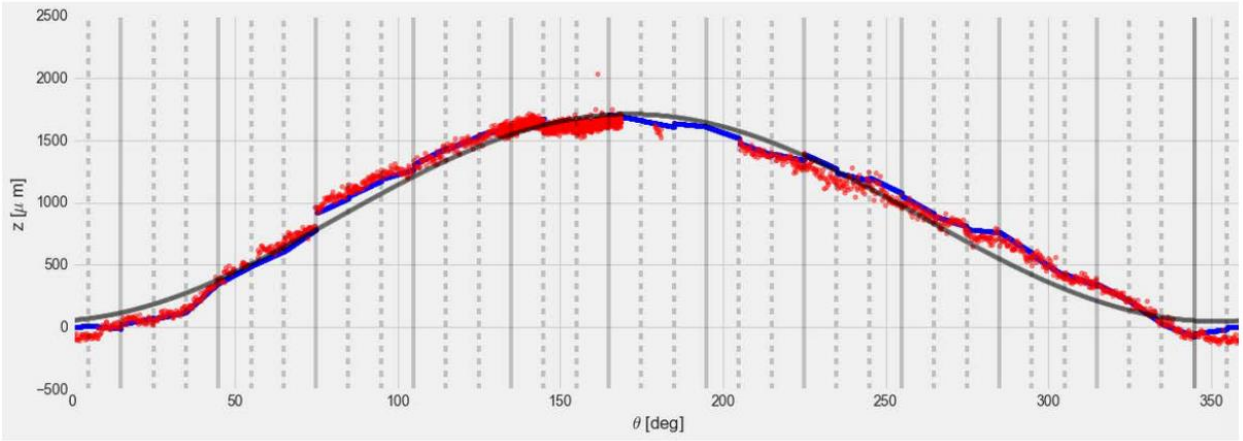
March 31, 2015

Acknowledgement to Alignment group, Brenden Kiburg, Matthias Smith, Del Allspach, Mechanical Installation Group, and others.

Ring height data from Erik Swanson

Z-height data is fit to tilt plane
z0*cos(phi – p0)

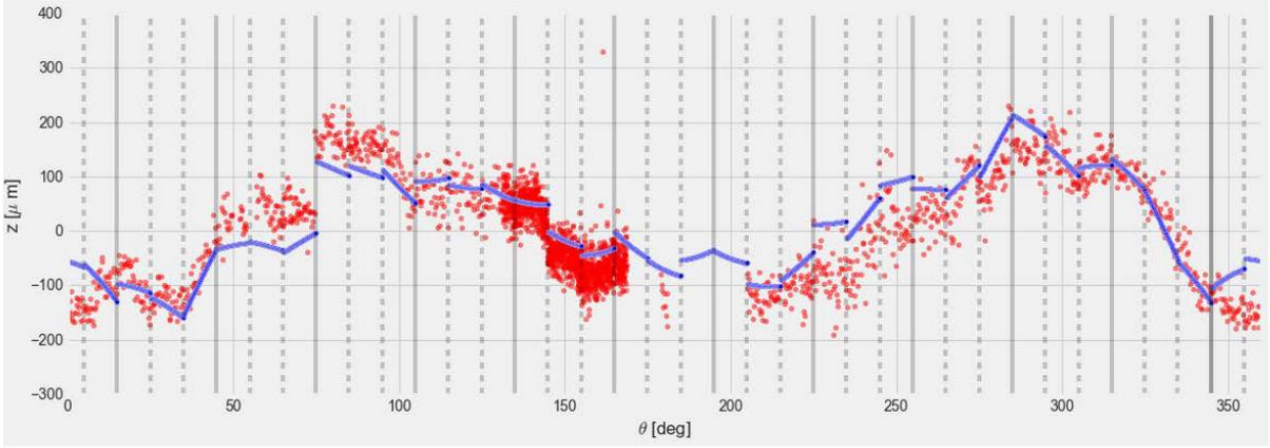
- Z0 = 832 microns, p0 = 171 degrees
- Tilt plane -> highest at 189 degrees and lowest at 351 degrees towards the inflector
- 1.7 mm difference across ring



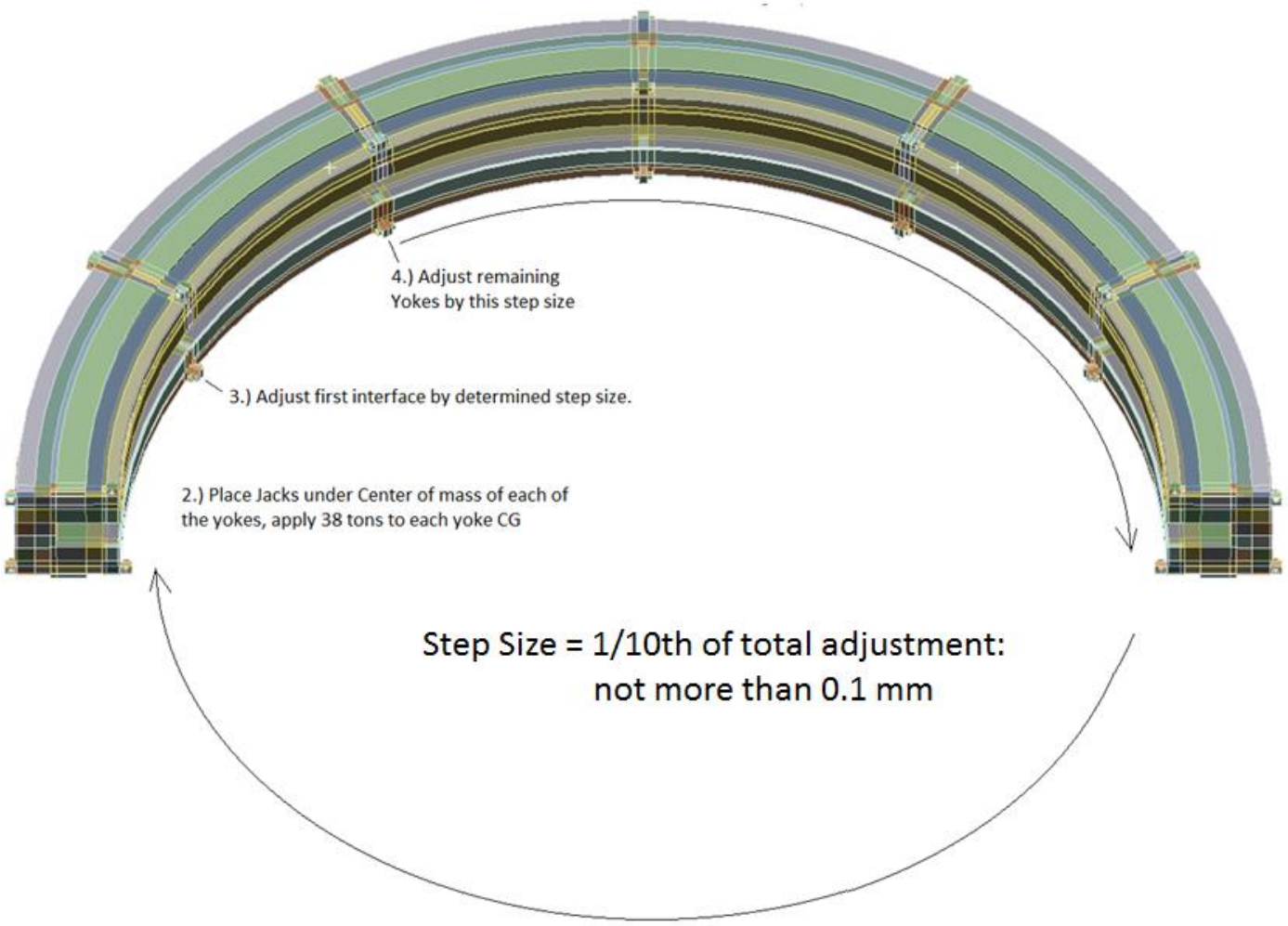
Ring height data from Erik Swanson

Pole height variations about the tilt plane

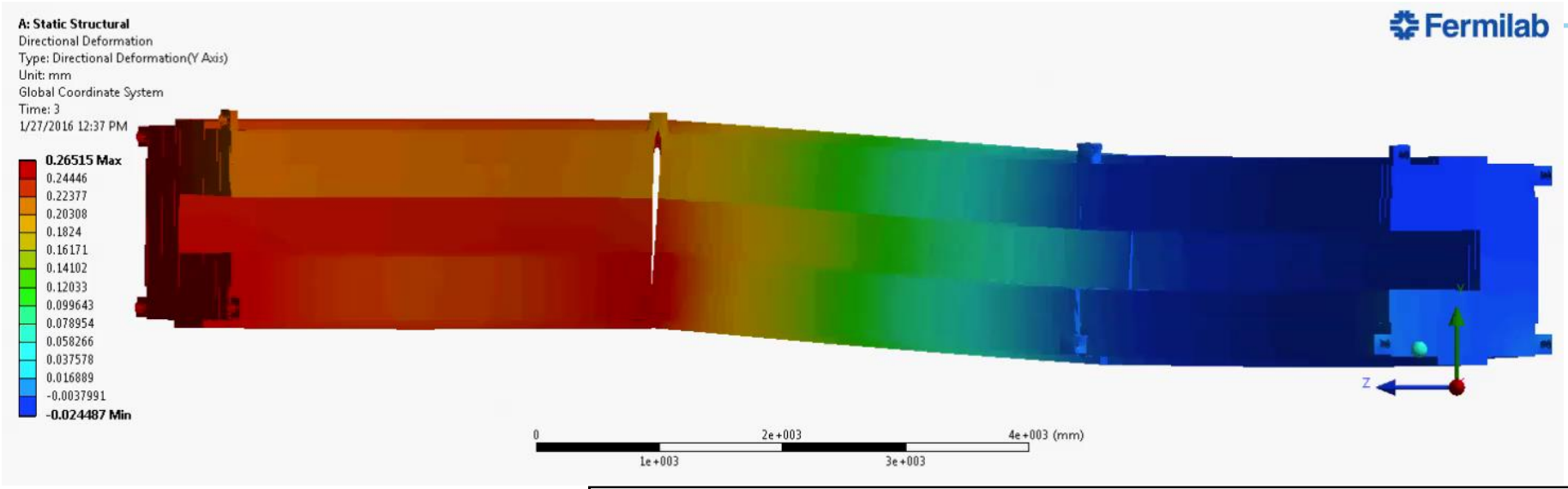
- Subtracting off the tilt plane shows the +/- 100 micron “potato chip” variation around the ring
- Is the ring sufficiently elastic to undo this?



Procedures: Adjust one interface at a time (4 jack stands)

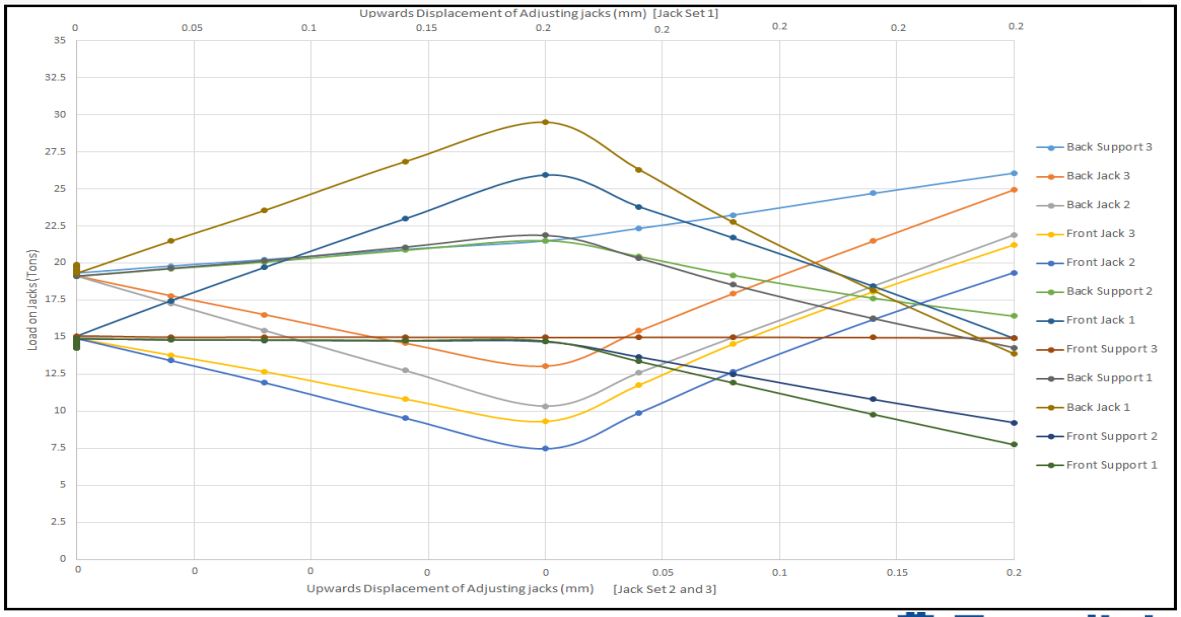


Without Unbolting Ears: Move one entire interface at a time.



Force on Jacks:

Start out higher than dynamic load rating of jacks on back jacks. Secondary jacks needed for any movement of yokes.



Jack Stands: 25 Ton static Limit – 20 Ton Dynamic Limit.

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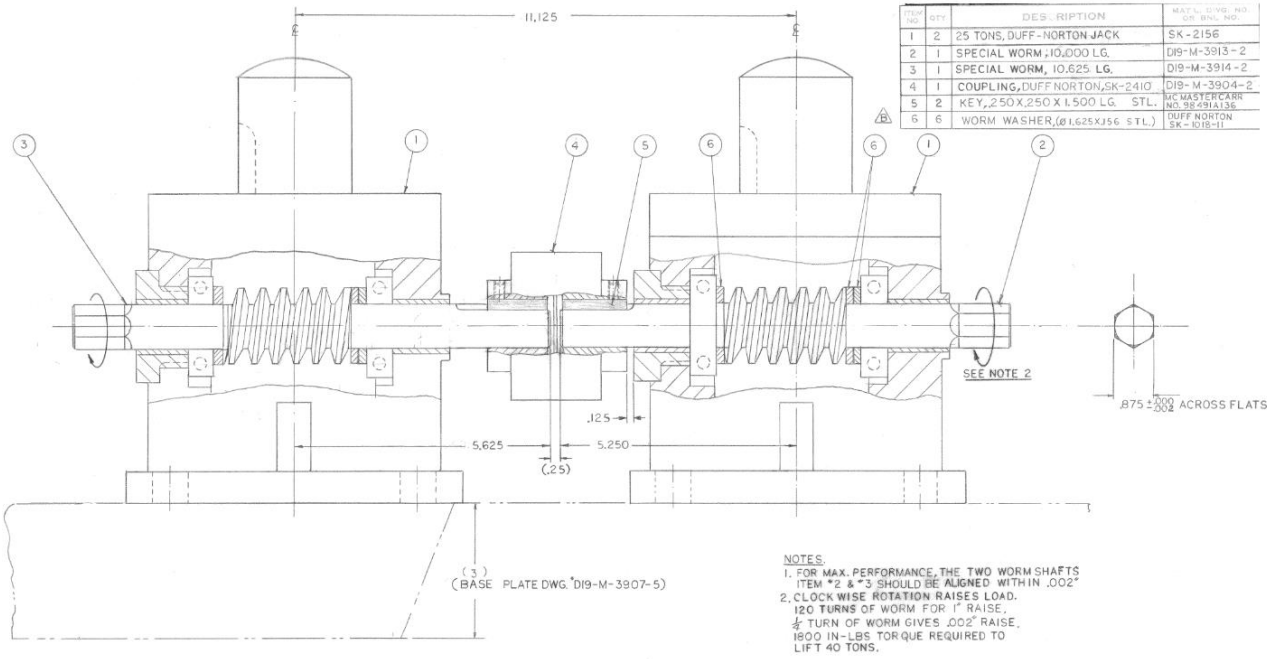


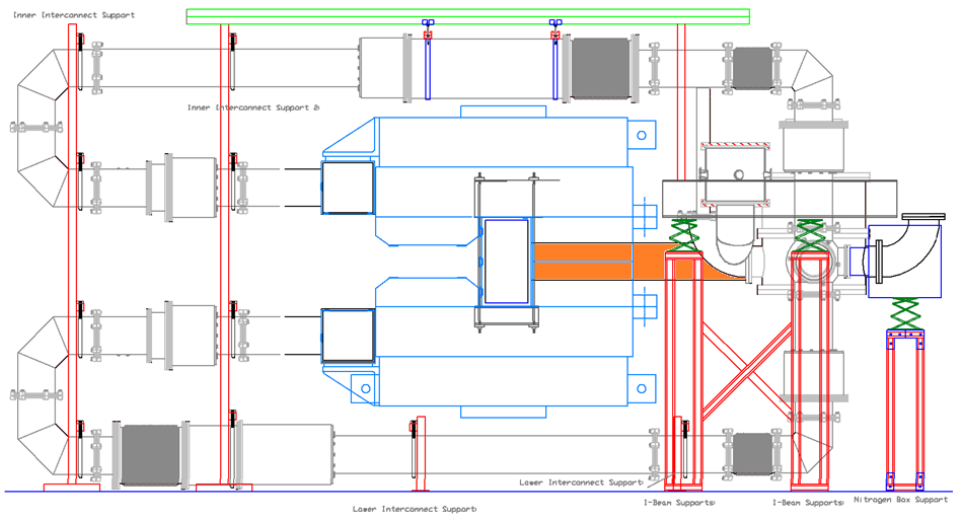
ITEM NO.	QTY.	DESCRIPTION	MATL. DWG. NO. OR STD. NO.
1	2	25 TONS, DUFF-NORTON JACK	SK-2156
2	1	SPECIAL WORM; 10.000 LG.	DI9-M-3913-2
3	1	SPECIAL WORM, 10.625 LG.	DI9-M-3914-2
4	1	COUPLING, DUFF NORTON, SK-2410	DI9-M-3904-2
5	2	KEY, .250 X .250 X 1.500 LG. STL.	UC MASTERCARR NO. 98491A136
6	6	WORM WASHER, (Ø 1.625 X .156 STL.)	DUFF NORTON SK-1018-11

NOTES.
1. FOR MAX. PERFORMANCE, THE TWO WORM SHAFTS ITEM "2 & "3 SHOULD BE ALIGNED WITHIN .002"
2. CLOCK WISE ROTATION RAISES LOAD. 120 TURNS OF WORM FOR 1" RAISE, ¼ TURN OF WORM GIVES .002" RAISE, 1800 IN-LBS TORQUE REQUIRED TO LIFT 40 TONS.

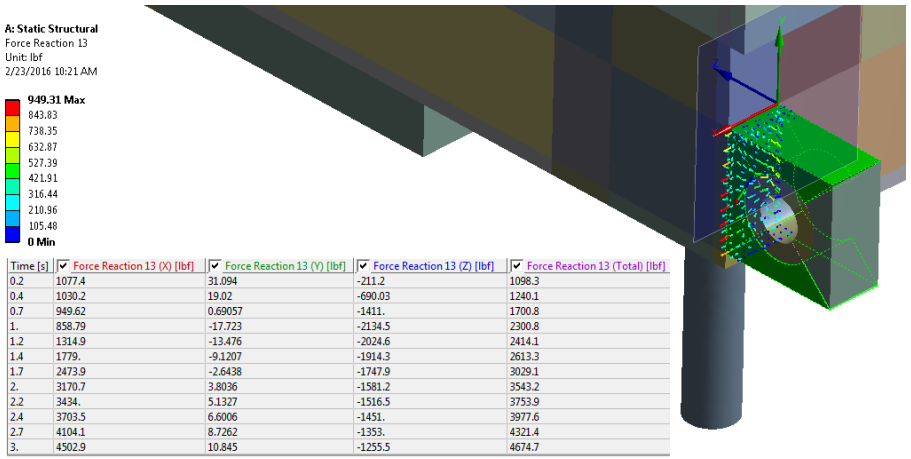
Secondary Jacks:
100 Ton

Cylinder Capacity (tons) [max.]	Stroke (in)	Model Number	Cyl. Effect. Area (in^2)	Oil Cap. (in^3)
100 [98.1]	2.25	**RCS-1002****	19.63	44.18

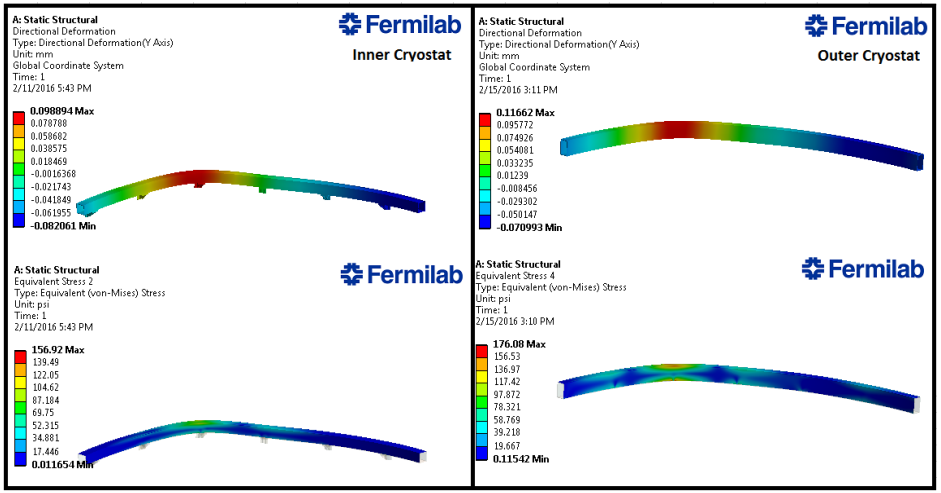
Calculate / Monitor Stresses During Adjustments



- Strain gauges used to monitor Dongle Pipe stresses.
- Calculations performed for Dongle Pipe, Cryostats, Yoke Ears, Jack Stands.
- Torque Wrenches used during adjustments to record jack stand forces.
- Calculations done for 200 micron step size, 100 microns used in procedure.



Time [s]	Force Reaction 13 (X) [lbf]	Force Reaction 13 (Y) [lbf]	Force Reaction 13 (Z) [lbf]	Force Reaction 13 (Total) [lbf]
0.2	1077.4	31.094	-211.2	1098.3
0.4	1030.2	19.02	-690.03	1240.1
0.7	949.62	0.69057	-1411.	1700.8
1.	858.79	-17.723	-2134.5	2300.8
1.2	1314.9	-13.476	-2024.6	2414.1
1.4	1779.	-9.1207	-1914.3	2613.3
1.7	2473.9	-2.6438	-1747.9	3029.1
2.	3170.7	3.8036	-1581.2	3543.2
2.2	3434.	5.1327	-1516.5	3753.9
2.4	3703.5	6.6006	-1451.	3977.6
2.7	4104.1	8.7262	-1353.	4321.4
3.	4502.9	10.845	-1255.5	4674.7



Initial vs Final Elevation: Tilt Removed

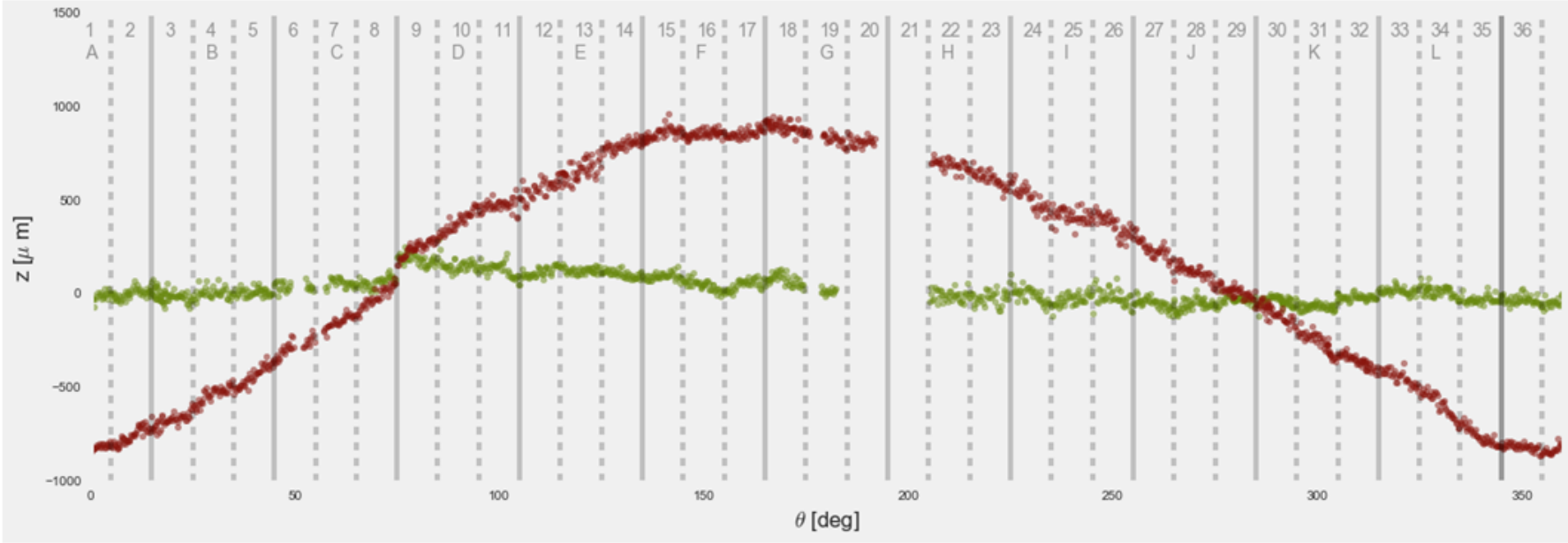


Figure 1: The initial laser tracker (red) and the final laser tracker (green)

Initial vs Final Elevation: Pringle Shape Removed

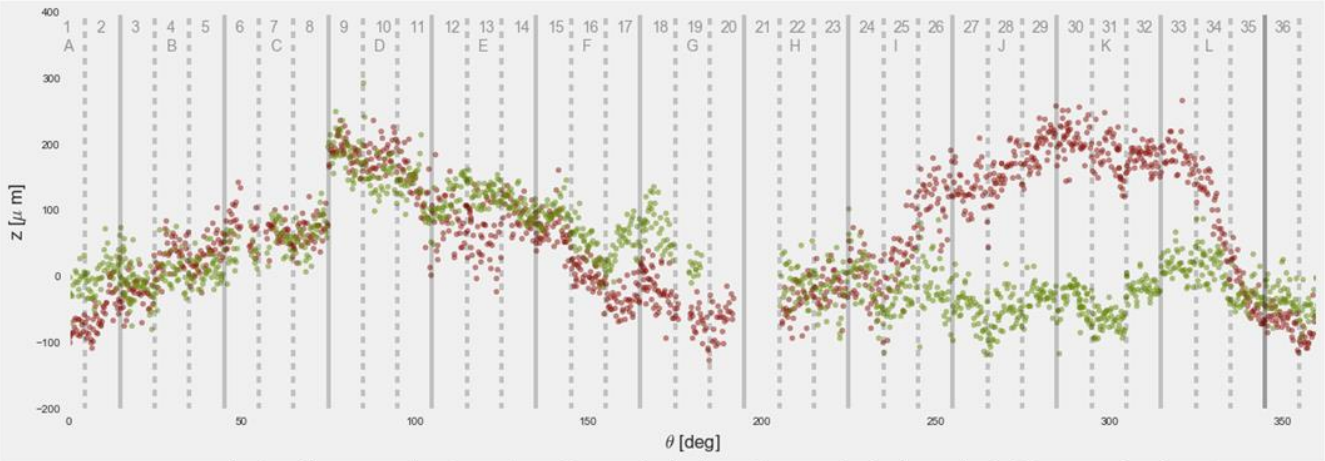


Figure 2: the final laser tracker (green) vs the residuals from the initial tilt plane (red) (the 'Pringle' shape)

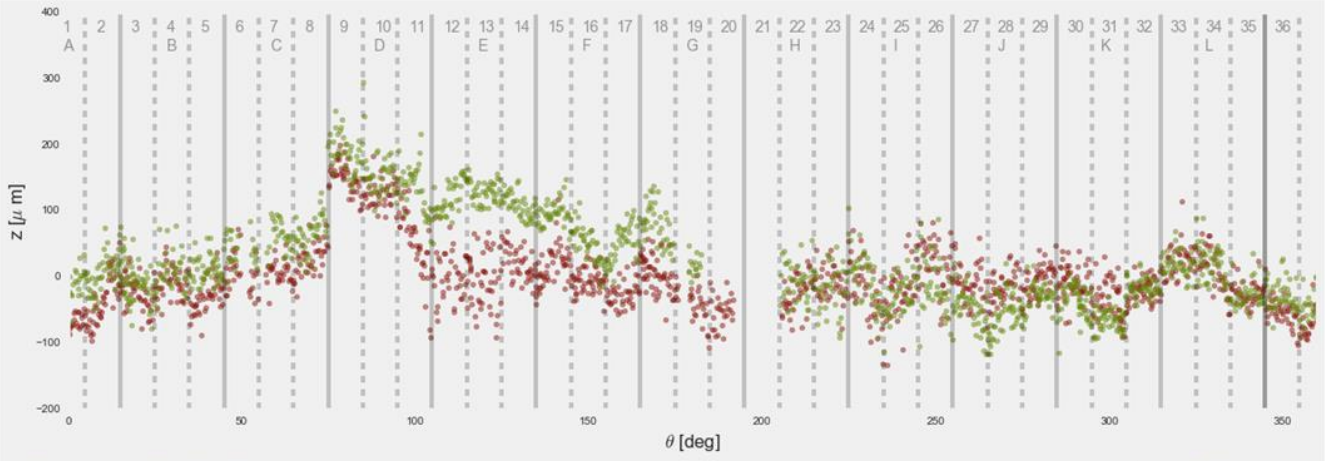
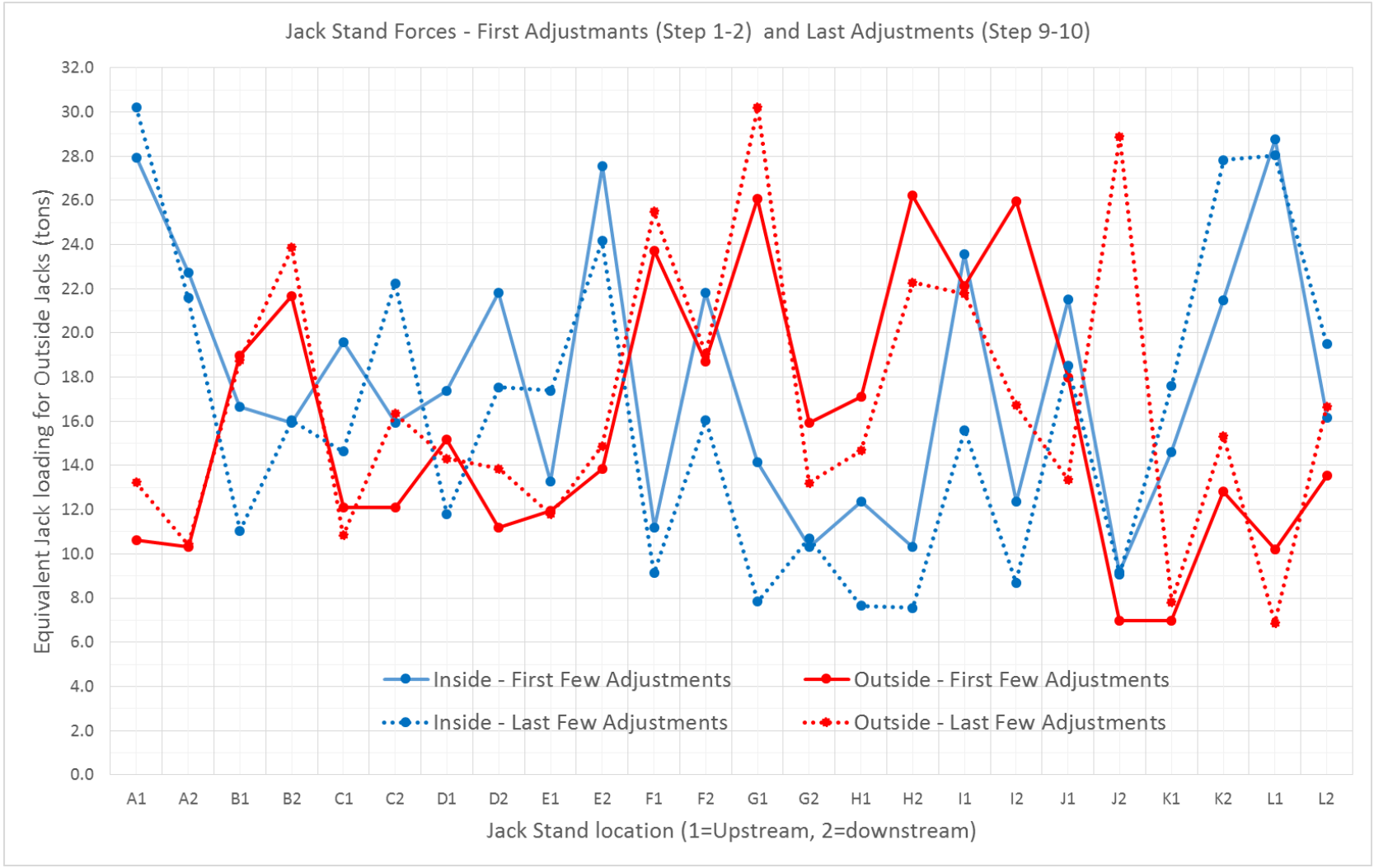


Figure 3: The final laser tracker measurement along with the projected heights if everything had gone perfectly. We ended pretty close to perfect here.

Jack Stand Forces at Beginning and End of Adjustments



A few Jacks stands were / still are over the 25 Ton rating
Calculations show they are still well within the elastic range
These Jack stands have a 3.56x safety factor for the 25 ton rating
The jack with the highest load has a 2.84x safety factor to failure