650 MHz Cryomodule Design Activity In CMEL

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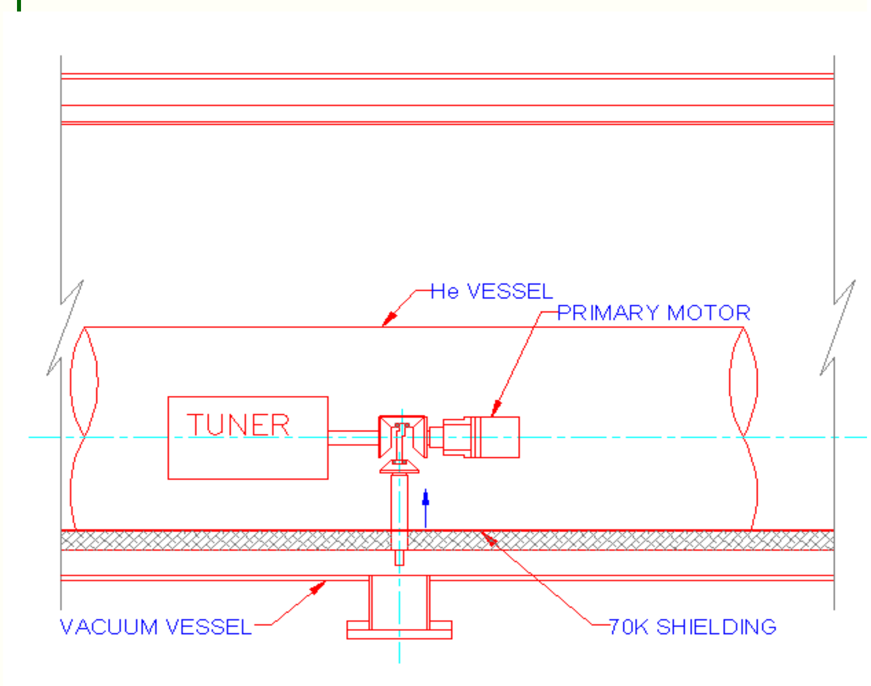
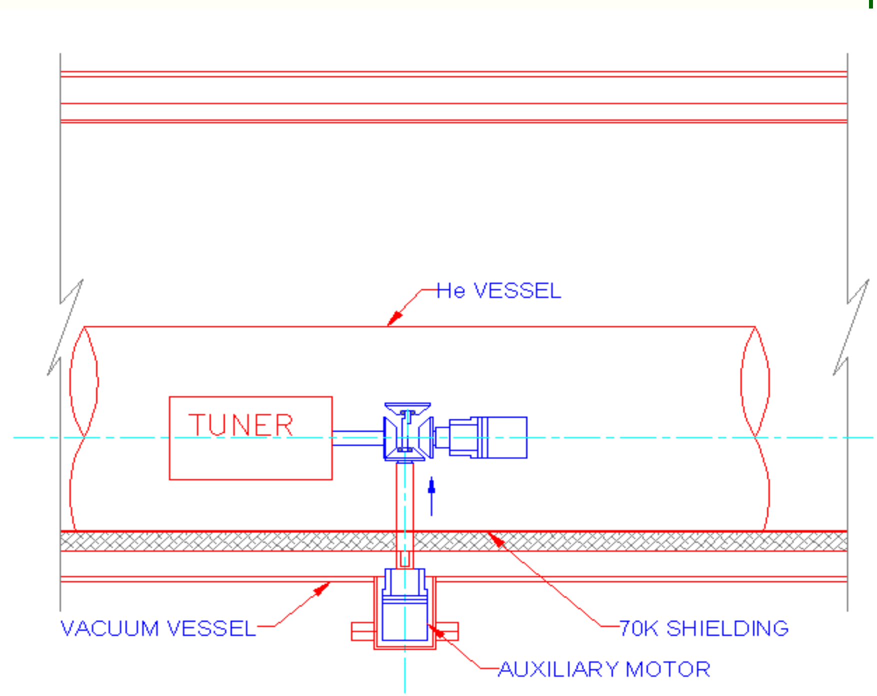
Part A
Rapid removal and Coupling of Auxiliary system for Cavity Tuning

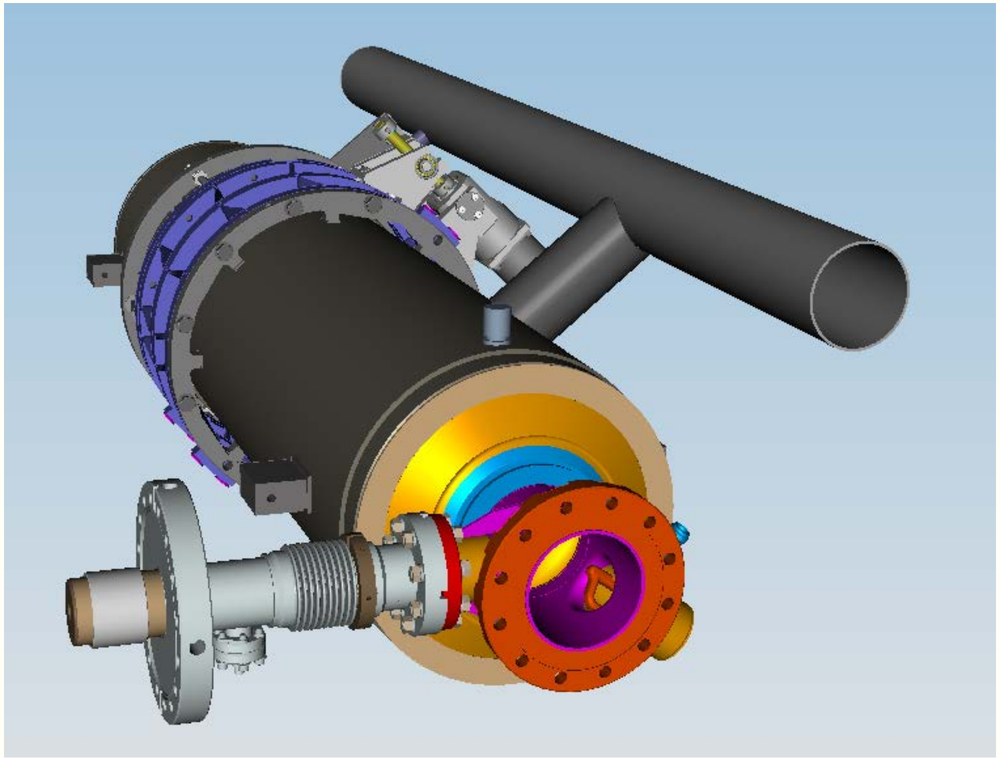
Concept -1 presented in last Web-X

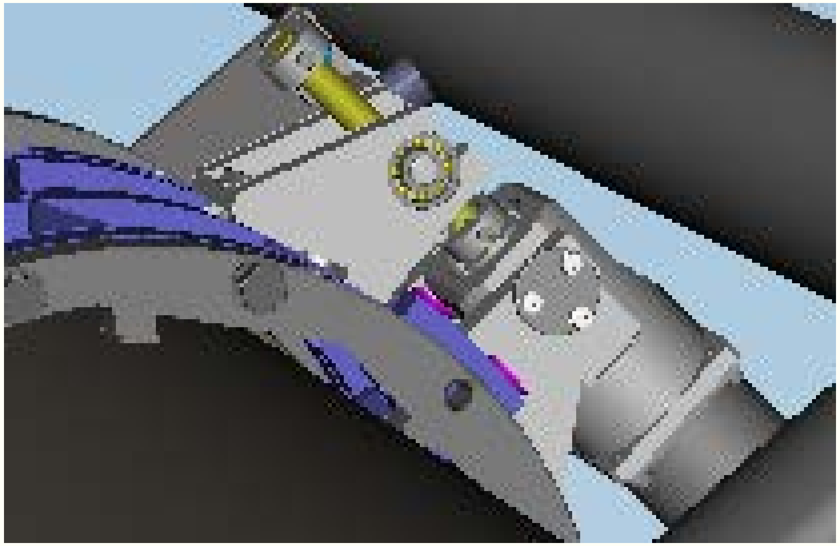
- Presented the Tuner modification Based on Original blade Tuner configuration (where the motor is parallel to cavity axis
- In this concept, the problem is faced in changing the direction of motion by 90°
- This would require a complex gearbox mechanism with possibility of increased backlash





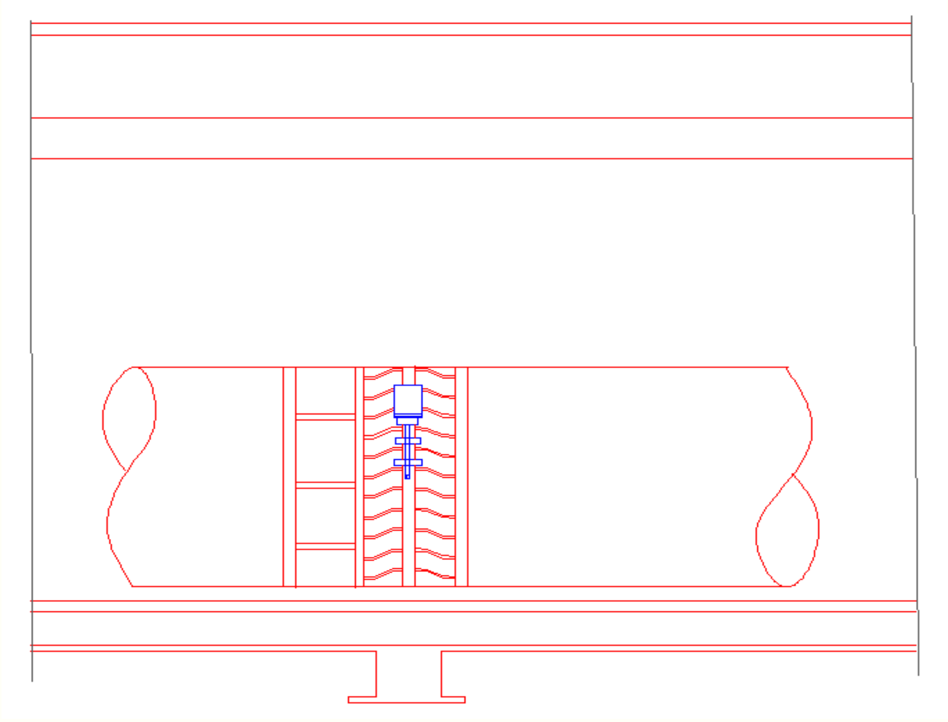
Tuner Arrangement as discussed probably is now perpendicular to the axis of cavity and Tangential to helium vessel

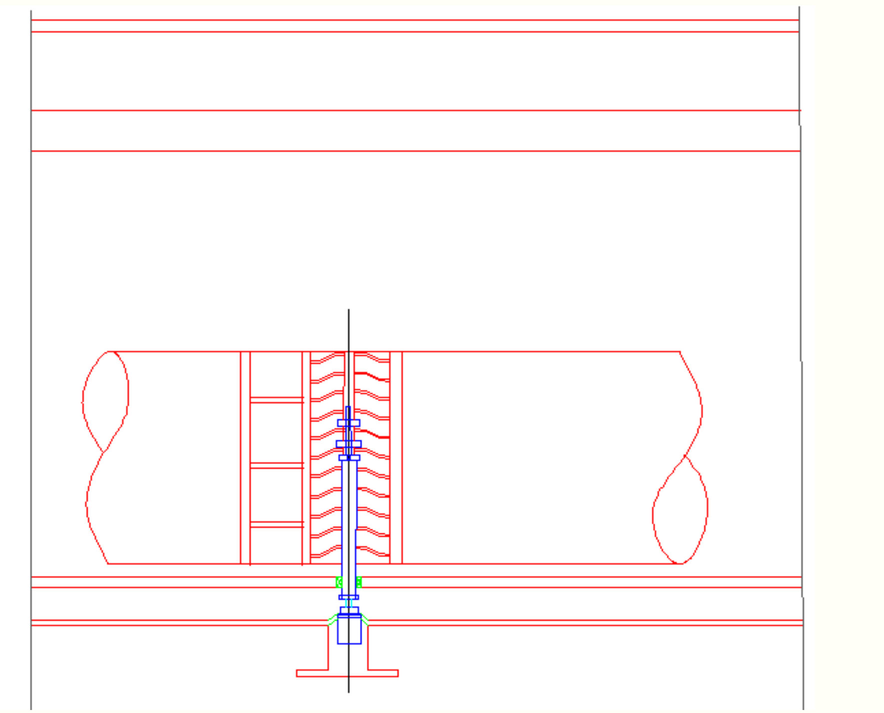




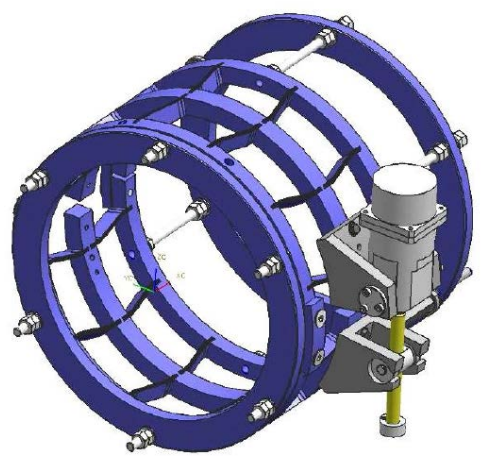
Concept - 2

- **Concept – 2A : Primary motor located inside thermal shields and mounted on tuner rings**
- **Concept – 2B : Primary motor located outside thermal shield and supported on vacuum vessel**

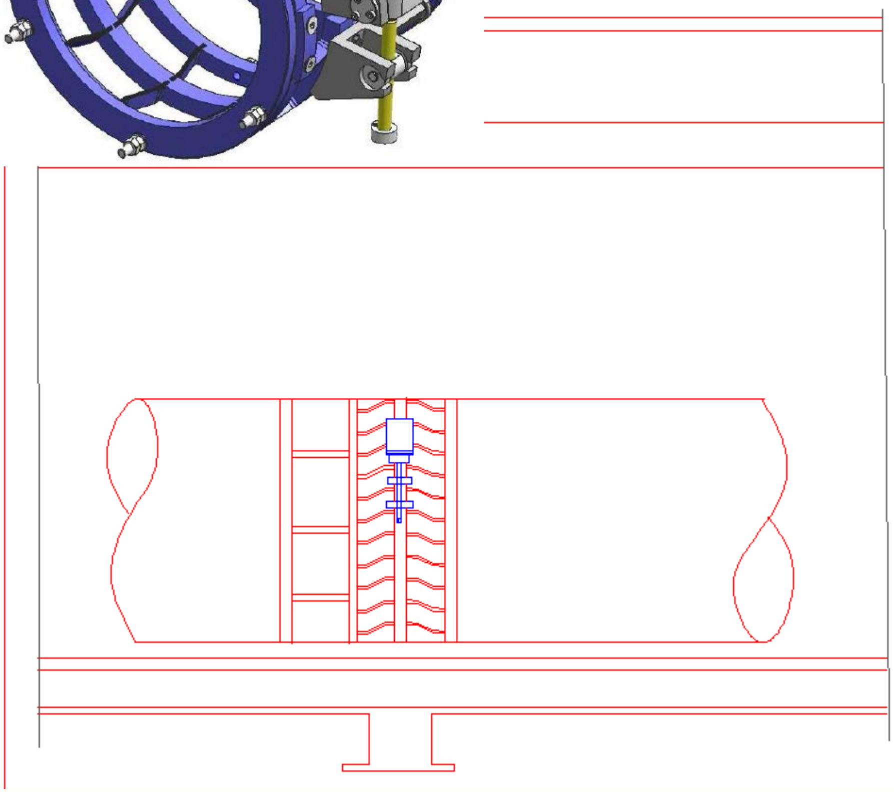




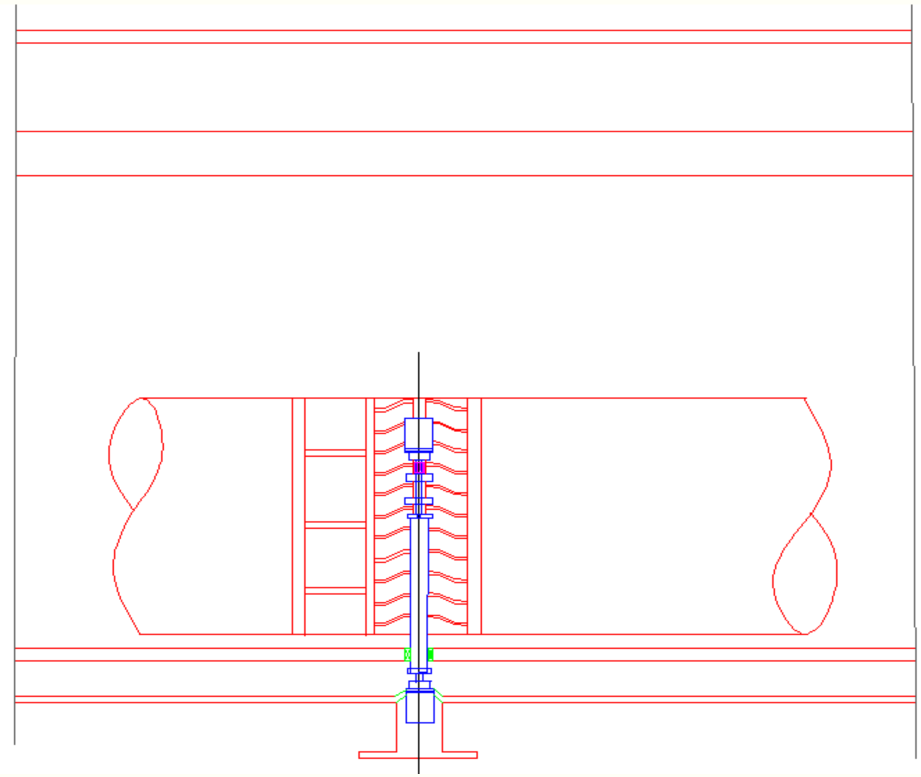
Concept – 2A Arrangement proposed for Auxiliary System (concept under development)



Mounting of motor on tuner outer ring will restrict there movement so presently searching for suitable place



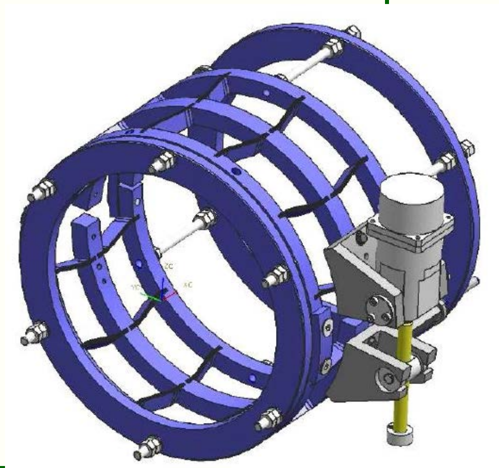
Reverse direction of Tuner Motor



Coupling of auxiliary tuner motor in case of primary motor failure

Modification needed for Arrangement proposed for Modified Tuner

- Need to clock the motor by 180° on the other side of cavity
- Primary motor mounting support need to be shifted to side rings or more appropriate place where it does not restrict tuner motion
- Double sided threads on tuner screw
- Inverted cup type support from Vacuum Vessel
- Thermal intercept with bearing support at 80 K shield
- G-11 shaft for connecting auxiliary motor
- A decoupling mechanism to disconnect the primary motor (still looking for Ideas)

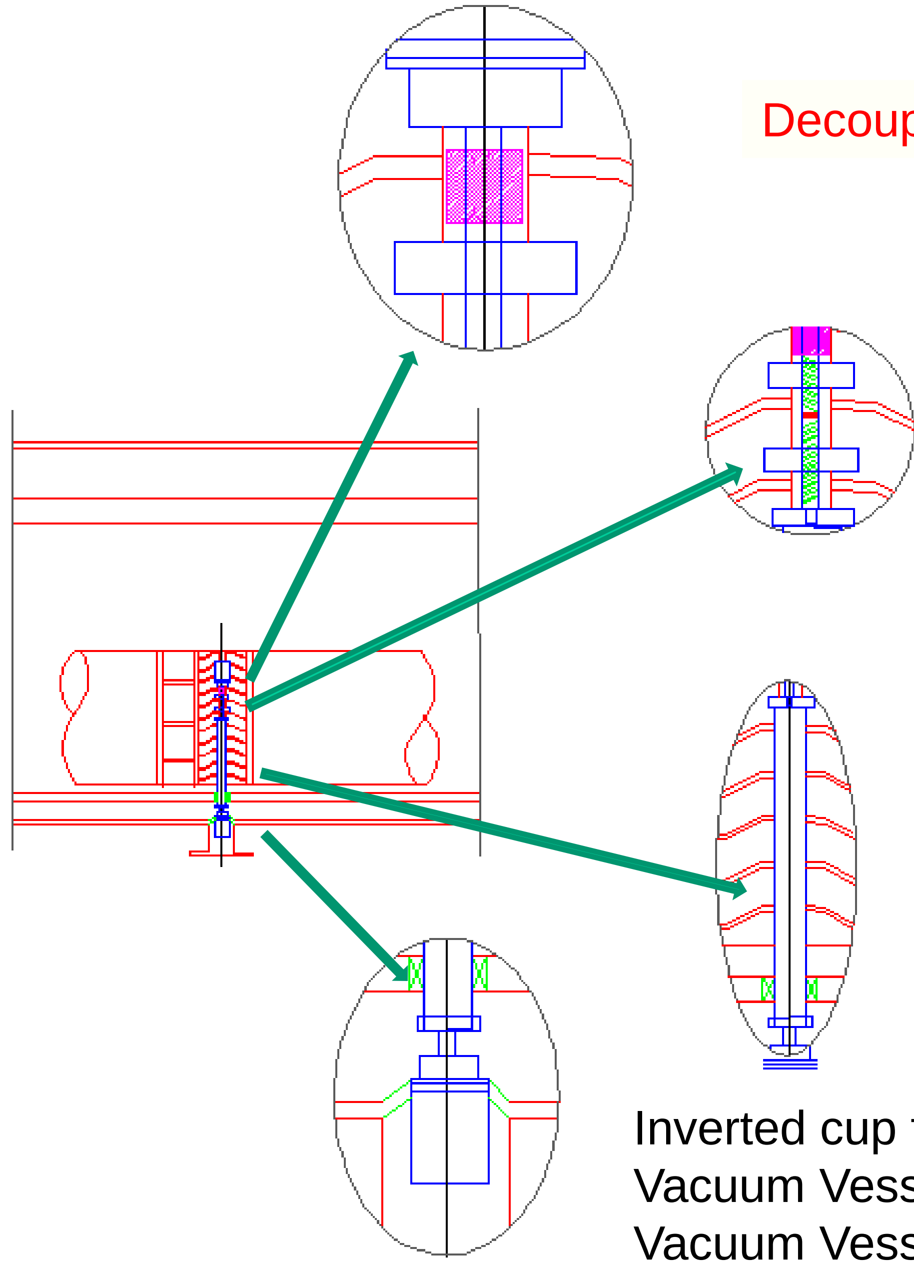


G-11 shaft detailing

- Allowable shear strength of G-11 = 250 MPa
- Dia 70mm & wall thk 6mm
- With FOS = 4, Max torque it can take is 2100 Nm
- Limitation is from Shrink fit joint
- Shrink fit joint can take max torque of 630 Nm
- Torque required is 150 Nm (well within range)
- Heat load from Vacuum vessel to 80 K shield = 0.5 W

Calculation done by: Rupul Ghose

Decoupling Mechanism = ?

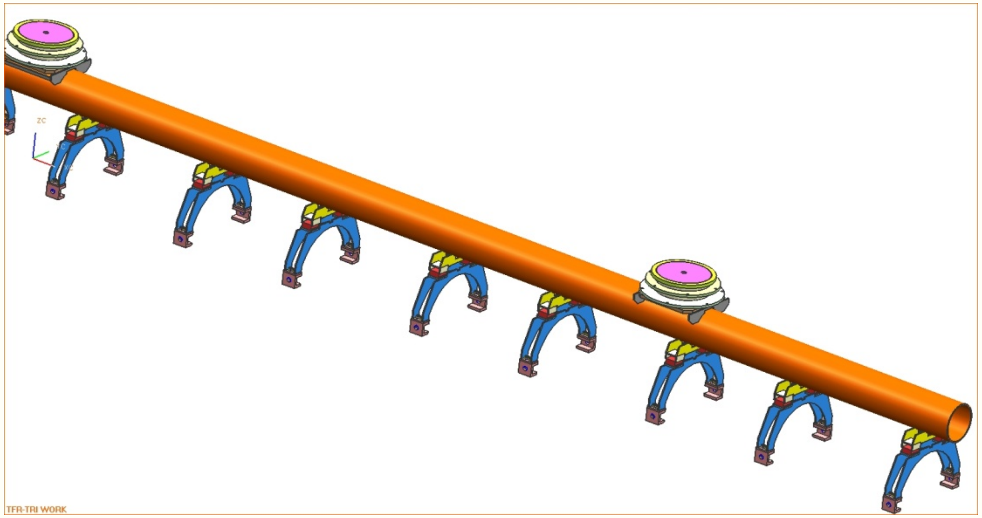


Double sided threads on tuner screw = effect on tuner resolution

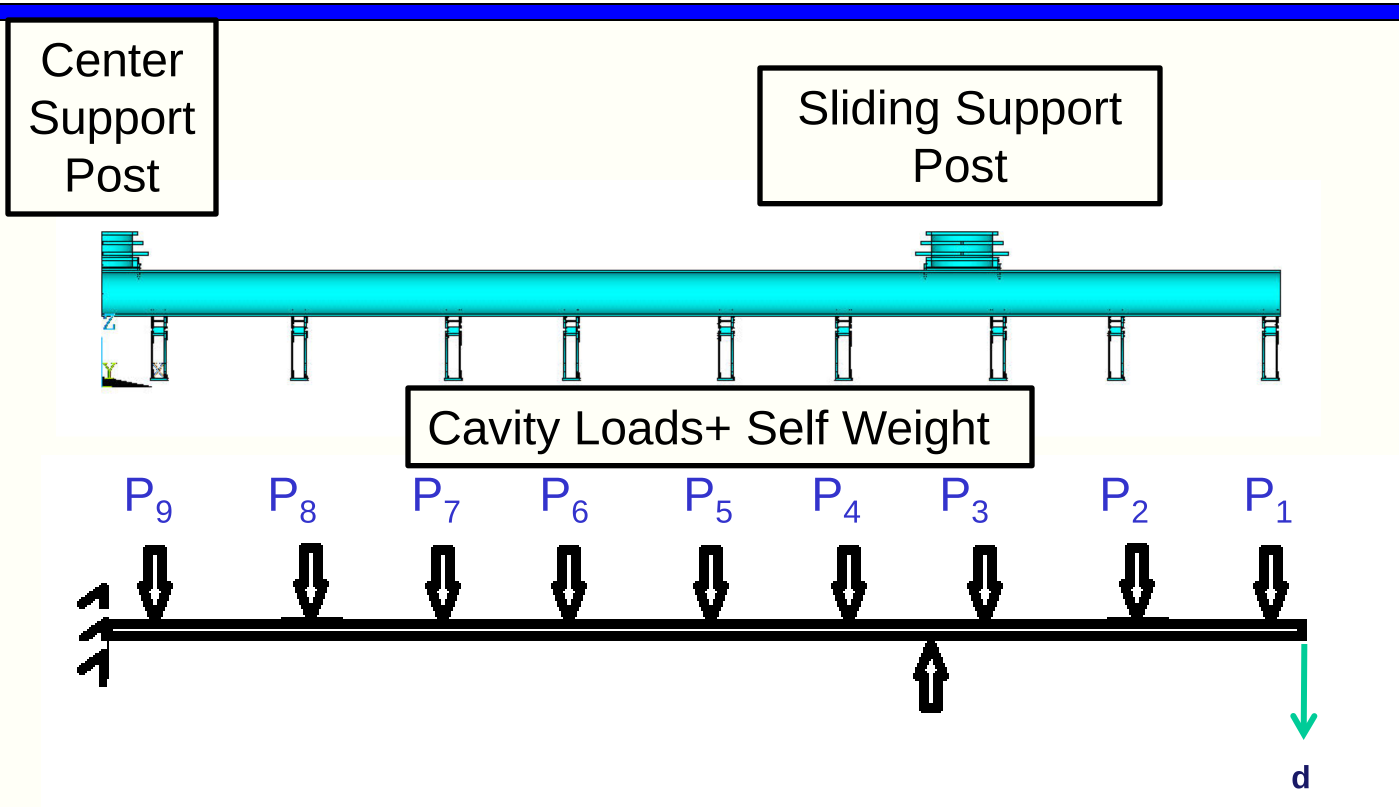
G-11 shaft for connecting auxiliary motor = heat in-leak minimal (≈ 0.5 W)

Inverted cup type support from Vacuum Vessel = load transfer to Vacuum Vessel

Part B
Cavity Support Structure
(For new cavity support pipe of dia 200 mm)



Simplified Model for Analytical Calculation



Deflection by Superposition method:

$$\delta_{freeend} = y_1 + y_2 + y_3 + y_4 + y_5 + y_6 + y_7 + y_8 + y_9 + y_{selfweight}$$

Maximum deflection at free end = 0.275 mm

Spread Sheet for Analytical Solution

HGR Pipe OD	219	mm				
HGR Pipe Thickness	8.17	mm				
HGR Pipe ID	202.66	mm				
HGR Pipe Cross Secn. Area	5411.33397	mm2	0.005411334	m2		
HGR Pipe Moment of Inertia,I	30111393.44	mm4	3.01114E-05	m4		
HGR Pipe Material Density	7800	kg/m3				
UDL, w	414.0644527	N/m				
Material Elastic Modulus,E	200	GPa	2E+11	Pa		
Flexural Rigidity,EI	6022278.689	Nm2				

Total length of HGR Pipe	12	m			
Distance between consequtive post	4.175	m	P1	750	N
Length of propped Cantilever Beam,L	5.72	m	P2	750	N
Distance of redundant support , a	4.175	m	P3	750	N
Distance of Force P1 , l1	5.7212	m	P4	750	N
Distance of Force P2 , l2	4.9712	m	P5	750	N
Distance of Force P3, l3	4.3945	m	P6	750	N
Distance of Force P4, l4	3.64445	m	P7	750	N
Distance of Force P5, l5	3.06775	m	P8	750	N
Distance of Force P6, l6	2.31775	m	P9	750	N
Distance of Force P7, l7	1.74105	m			
Distance of Force P8, l8	0.99105	m			
Distance of Force P9, l9	0.275	m			

$$K0 = \frac{wa^2}{24}(a^2 + 6l^2 - 4la) \quad K1 = \frac{P_1a^2}{6}(3l_1 - a) \quad K2 = \frac{P_2a^2}{6}(3l_2 - a) \quad K3 = \frac{P_3a^2}{6}(3l_3 - a) \quad K4 = \frac{P_4 l_4{}^2}{6}(3a - l_4) \quad K5 = \frac{P_5 l_5{}^2}{6}(3a - l_5) \quad K6 = \frac{P_6 l_6{}^2}{6}(3a - l_6) \quad K7 = \frac{P_7 l_7{}^2}{6}(3a - l_7)$$

$$K8 = \frac{P_8 l_8{}^2}{6}(3a - l_8) \quad K9 = \frac{P_9 l_9{}^2}{6}(3a - l_9) \quad R = (K_0 + K_1 + K_2 + K_3 + K_4 + K_5 + K_6 + K_7 + K_8 + K_9)\frac{3}{a^3}$$

K0	35550.82568	K1	28299.92698	K2	23397.5637	K3	19627.97316	K4	14743.95068
K5	11125.37894	K6	6854.123798	K7	4086.112933	K8	1416.052024	K9	115.8007813

Sum of all constants K0 to K9	145217.7087	
Reaction Force at Support, R	5986.478061	N

$$y0 = \frac{wl^4}{8EI} \quad yR = \frac{Ra^2}{6EI}(3l - a) \quad y1 = \frac{P_1l_1^2}{6EI}(3l - l_1) \quad y2 = \frac{P_2l_2^2}{6EI}(3l - l_2) \quad y3 = \frac{P_3l_3^2}{6EI}(3l - l_3) \quad y4 = \frac{P_4l_4^2}{6EI}(3l - l_4) \quad y5 = \frac{P_5l_5^2}{6EI}(3l - l_5) \quad y6 = \frac{P_6l_6^2}{6EI}(3l - l_6) \quad y7 = \frac{P_7l_7^2}{6EI}(3l - l_7) \quad y8 = \frac{P_8l_8^2}{6EI}(3l - l_8) \quad y9 = \frac{P_9l_9^2}{6EI}(3l - l_9)$$

y0 to y9 are deflection at free end due to respective forces

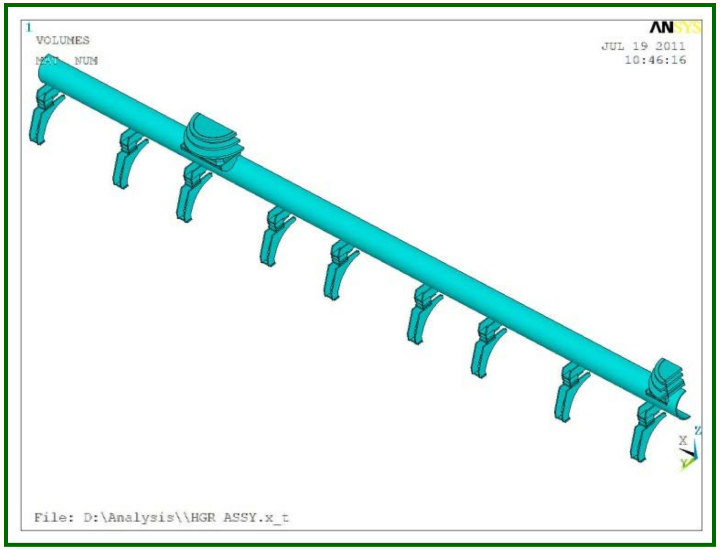
y0	0.009200284	m	yR	-0.03749853	m	y1	0.007771483	m	y2	0.006252196	m	y3	0.005116888	m	y4	0.003726	m
y5	0.002752767	m	y6	0.001654939	m	y7	0.000970122	m	y8	0.000329626	m						

Deflection at Free End	0.000275813	m	0.27581337	mm downward

Sheet1 Sheet2 Sheet3

: Calculation by Rupul Ghosh

FEM Formulation

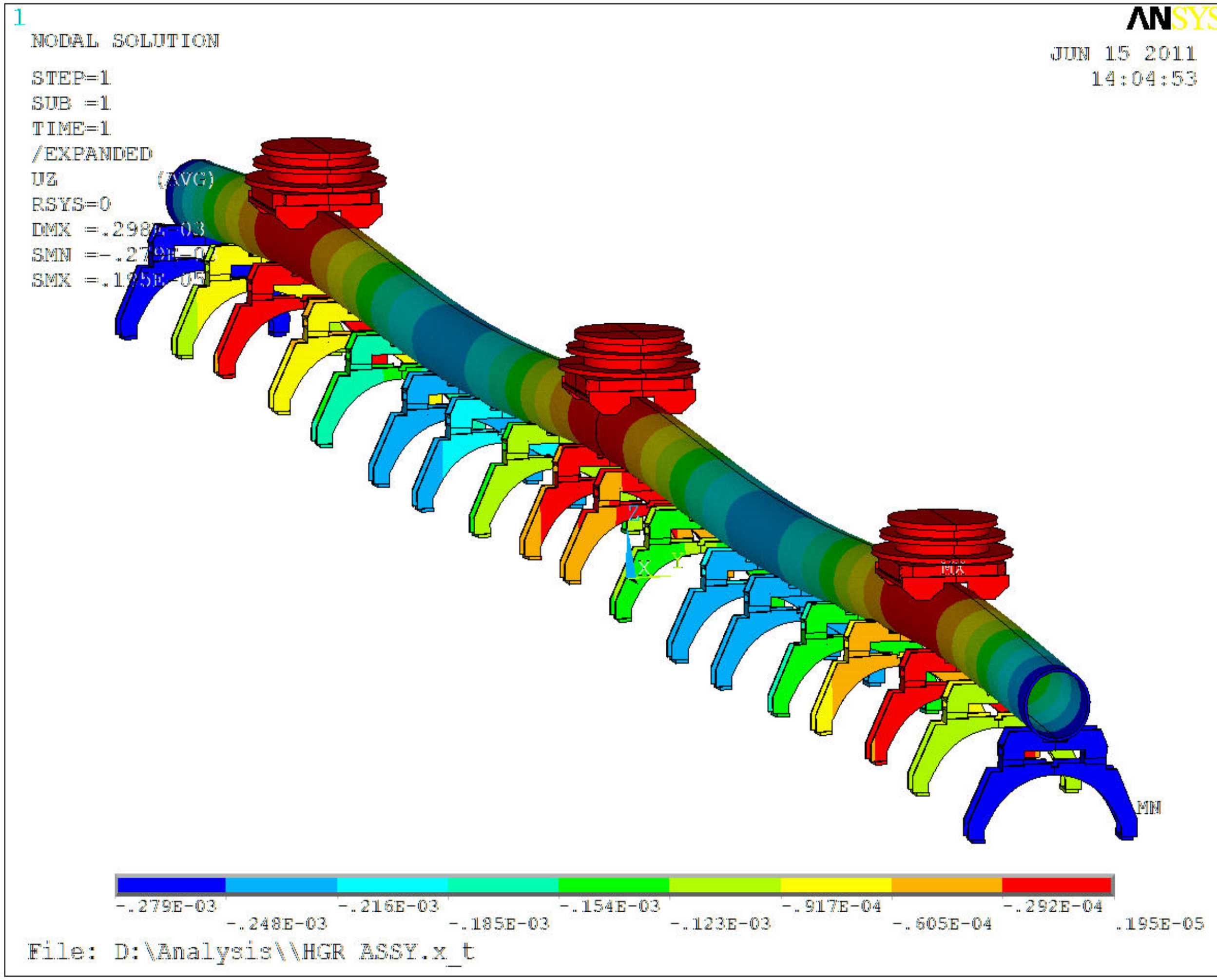


¼ th Geometrical Model

Meshed Model

- Material : SS 304
- A 20 nodes solid element is taken for FEM formulation
- Boundary Conditions:
  - Cavity Weight 0f 150 kg is taken –(Is weight of 150 Kg adequate??)
  - Center support post – Fixed post
  - End support post- Sliding post

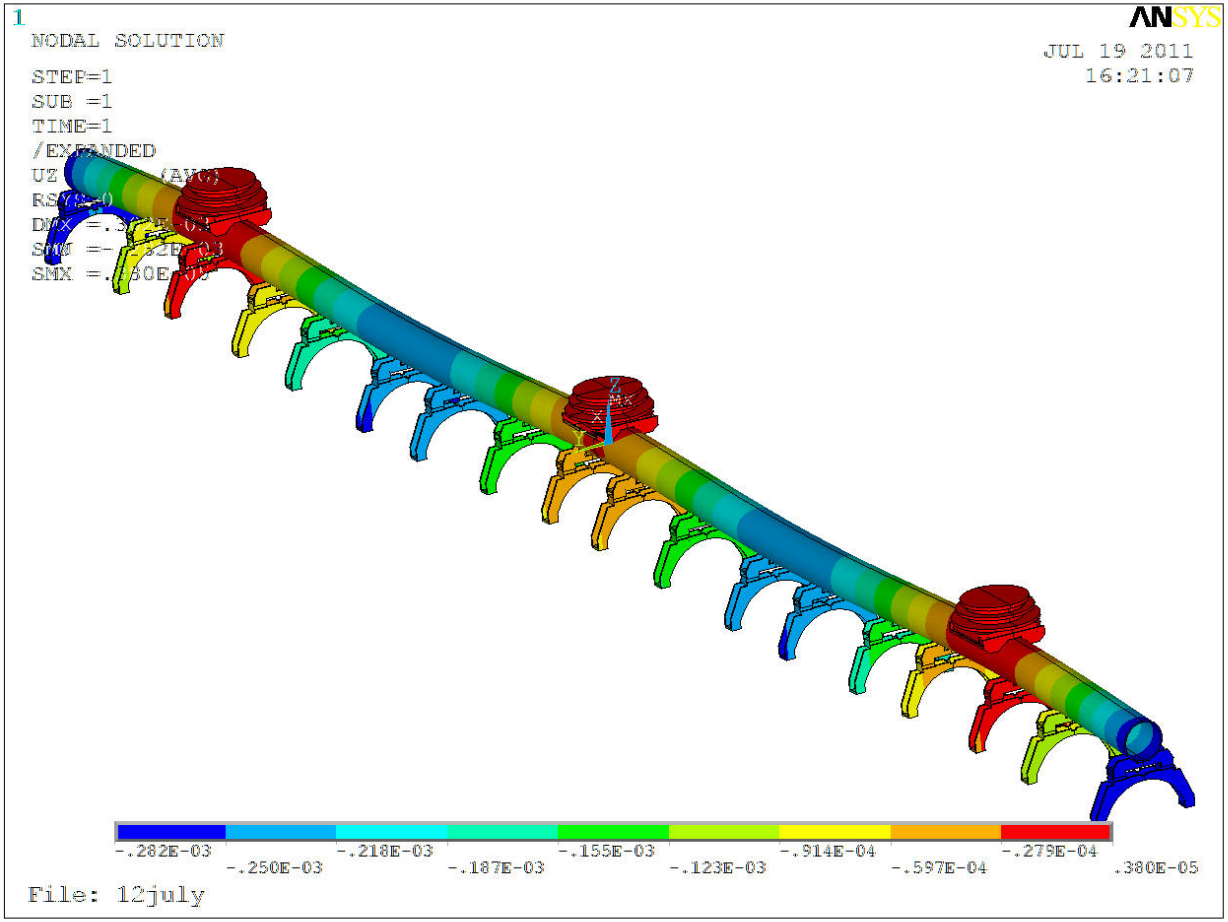
Results



Results:

- Maximum deflection at free end is found to be 0.279 mm which is close matching with analytical value of 0.275 mm.

Cambered pipe Analysis



A pipe with 20 mm vertical camber is taken for analysis:

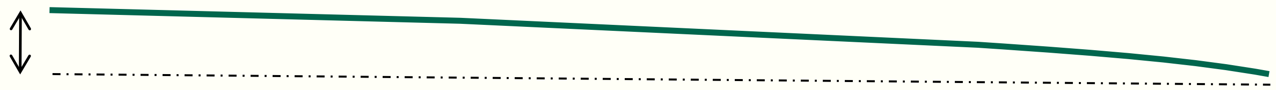
Boundary Conditions:

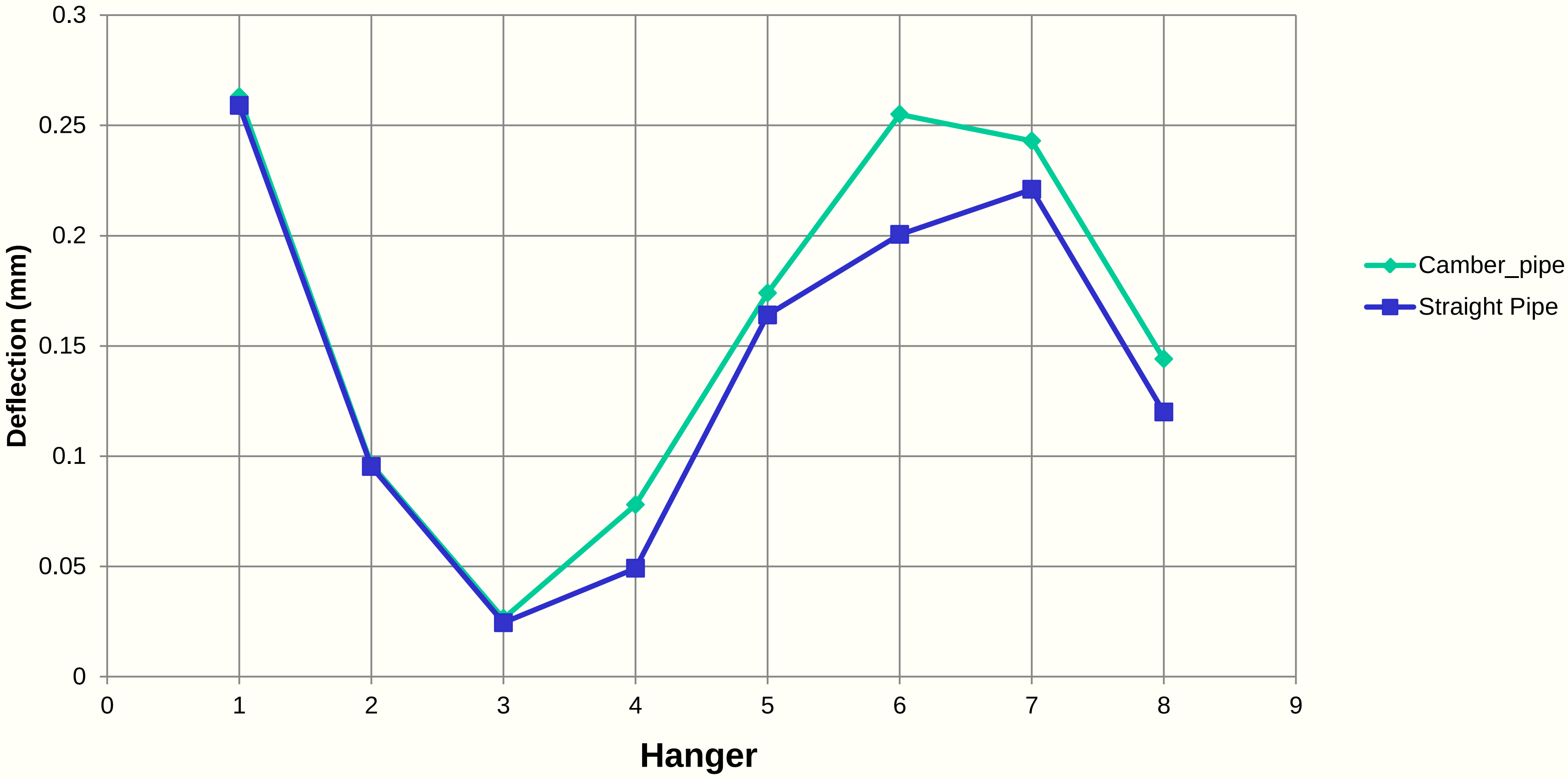
- Cavity Weight 0f 150 kg is taken
- Center support post – Fixed post
- End support post- Sliding post

Results:

- Maximum deflection at free end is found to be 0.282 mm

Camber pipe Vs Straight pipe





Proposed Work

- We want to study how much will the titanium pads move when-
  - Cool down take place

    (thereby causing shift for the cavity as in straight pipe some shift is there)
  - How is it different from straight pipe and 300 mm dia support pipe

Thank you