Crab cavity: Cryostat

KEKB Crab Cavity R&D Group
(presented by NAKAI Hirotaka)

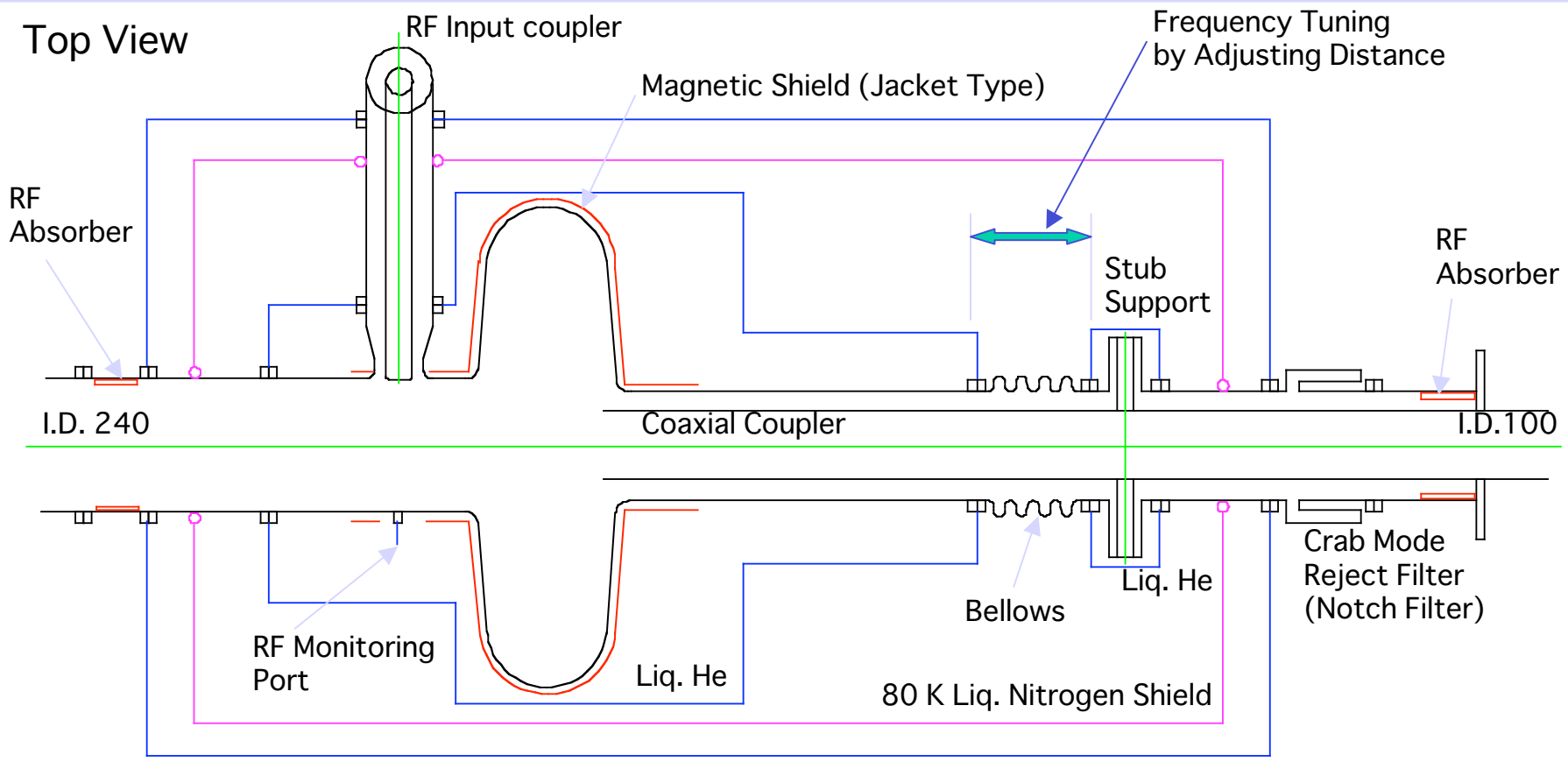
Overview

- Design of cryostat
- Results of Numerical Analyses
  - Buckling
  - Stress etc.
- Status of cryostat manufacturing
  - Magnetic shield
  - Frequency tuner
  - Vacuum vessel etc.

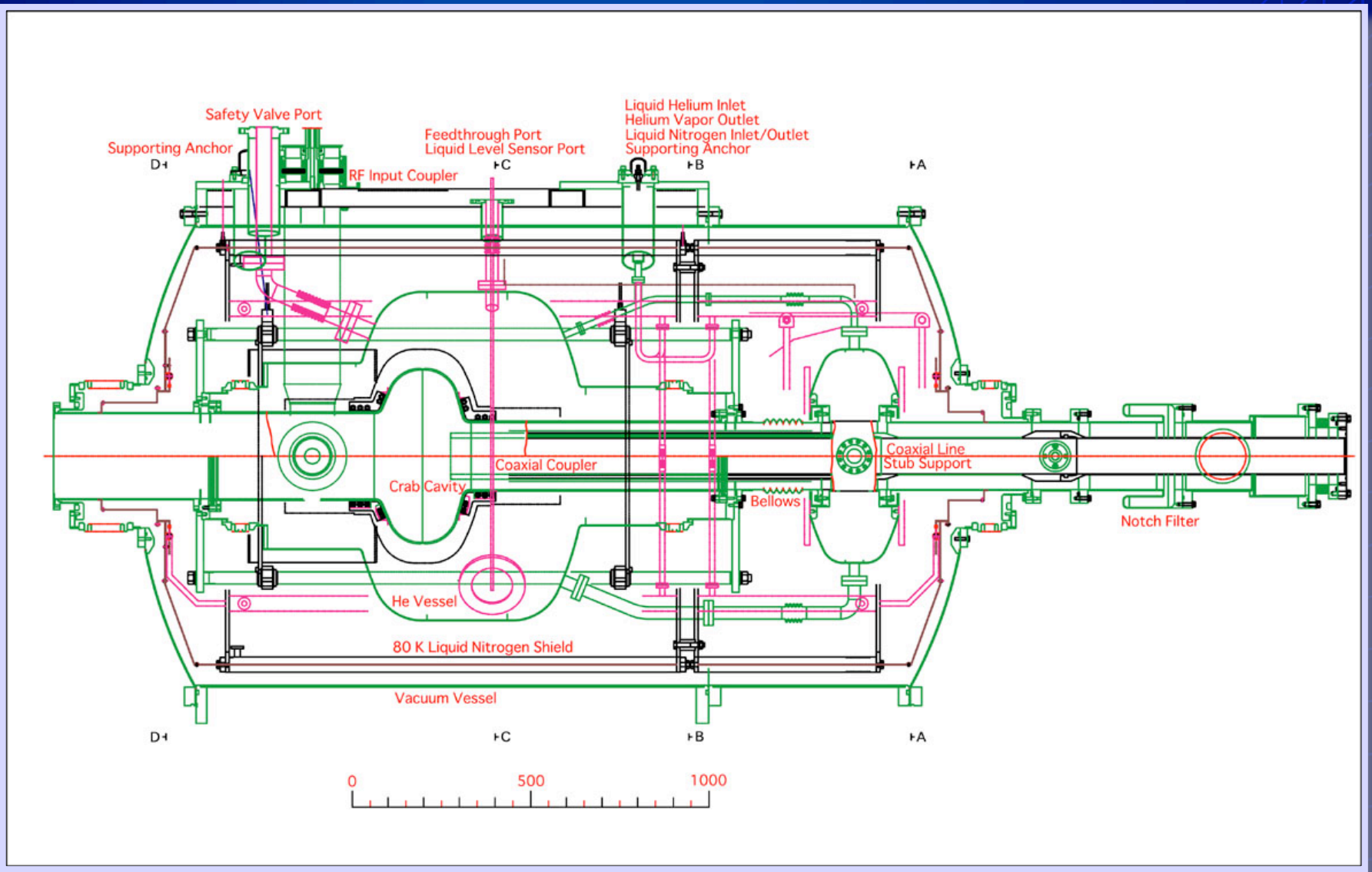
Cryostat Design Concept

- Jacket-type liquid helium vessel
- Coaxial coupler with bellows for frequency tuning: 28.3 kHz/mm
- Stub support for long coaxial coupler for mechanical support and cooling of coaxial coupler tip
- Jacket-type magnetic shield around cavity

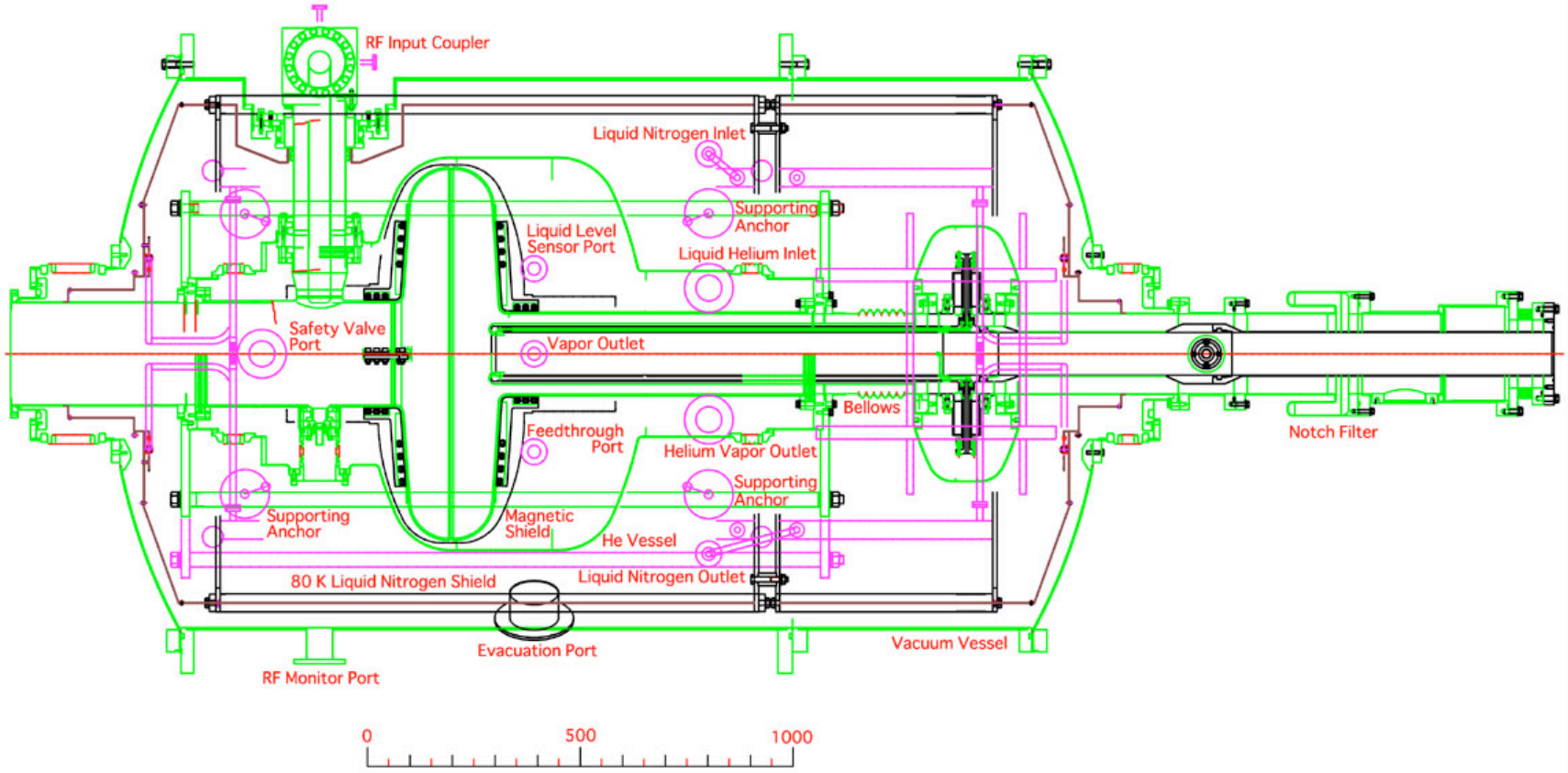
Cryostat Conceptual Design



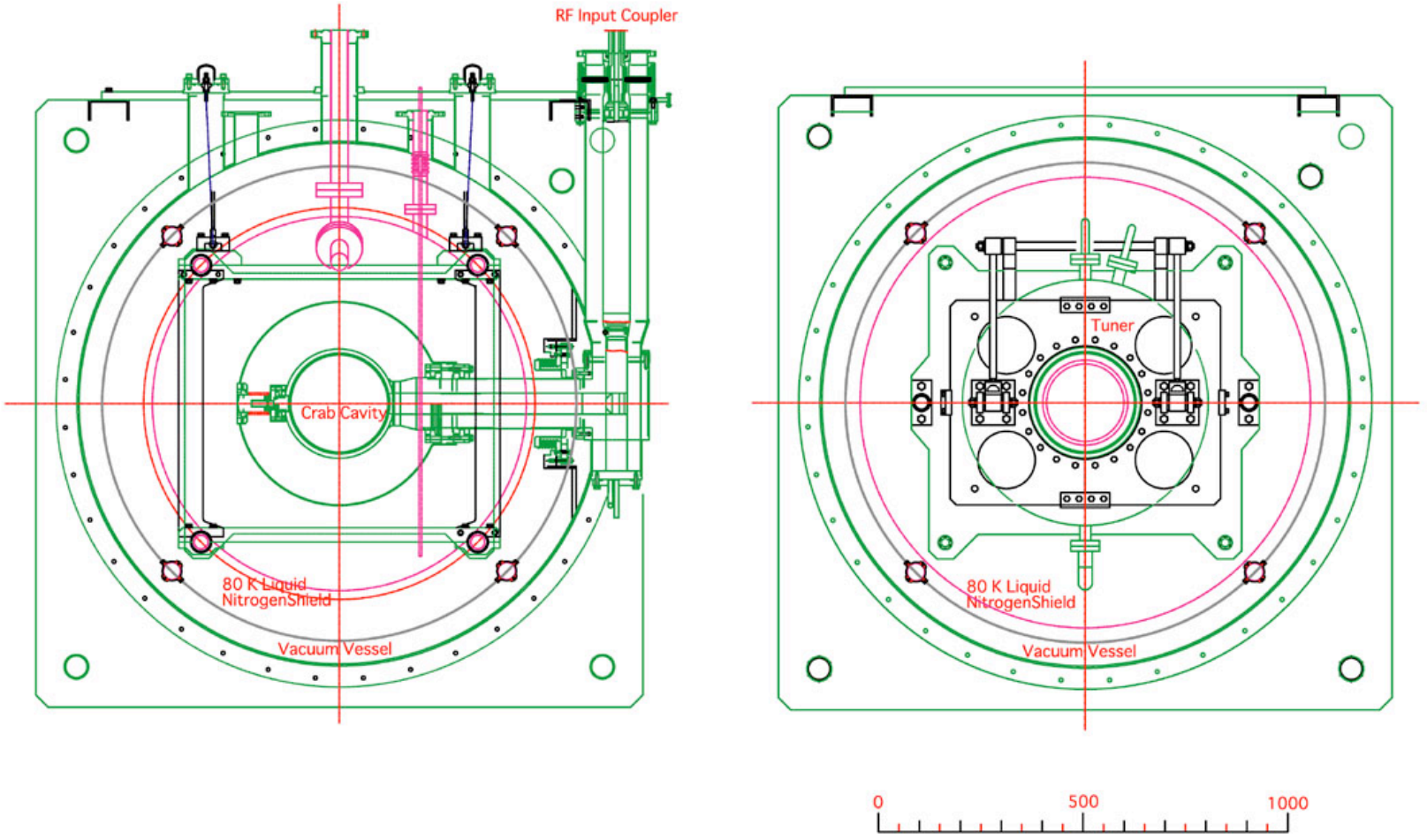
Cryostat Design (Side View)



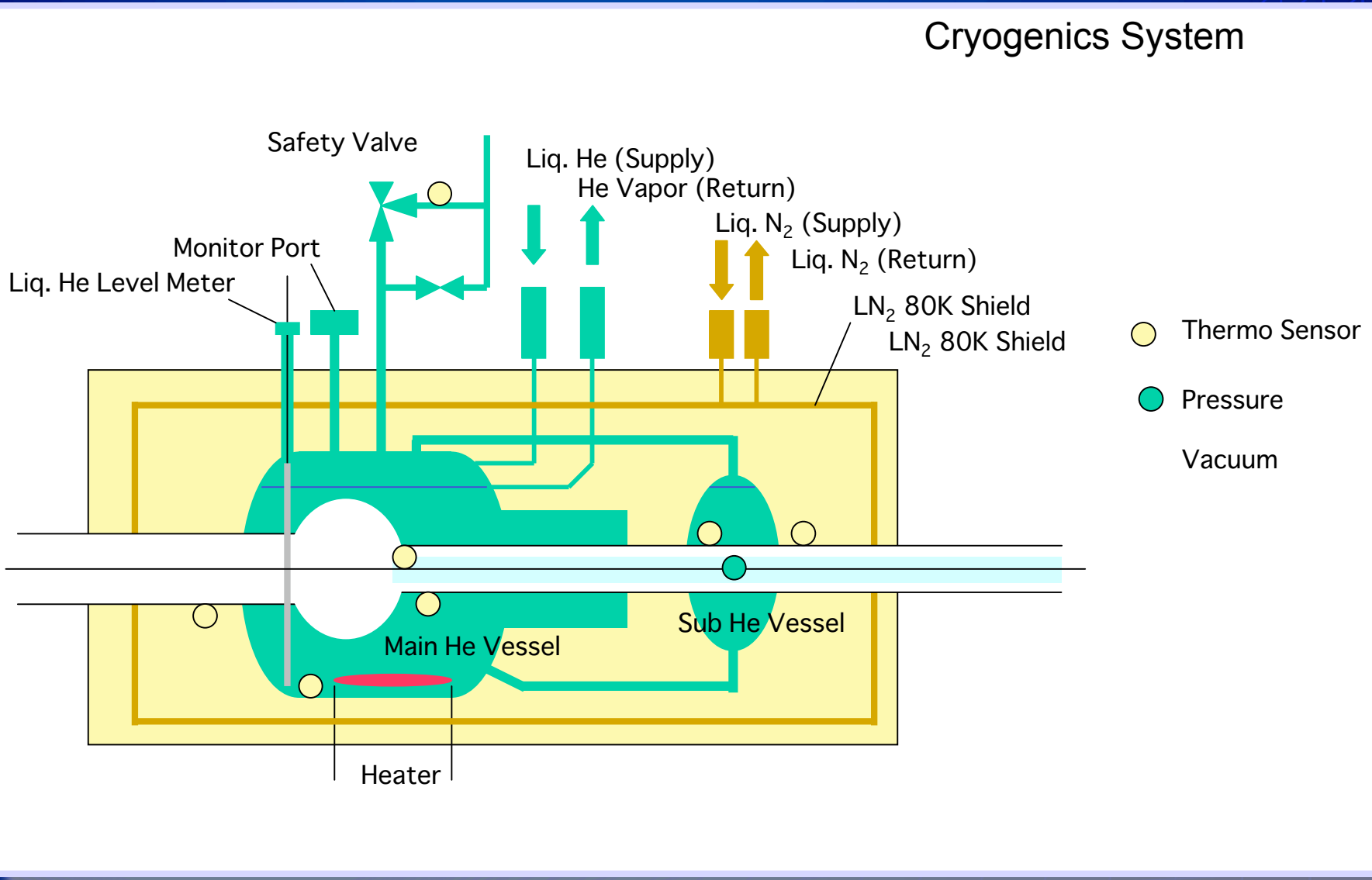
Cryostat Design (Top View)



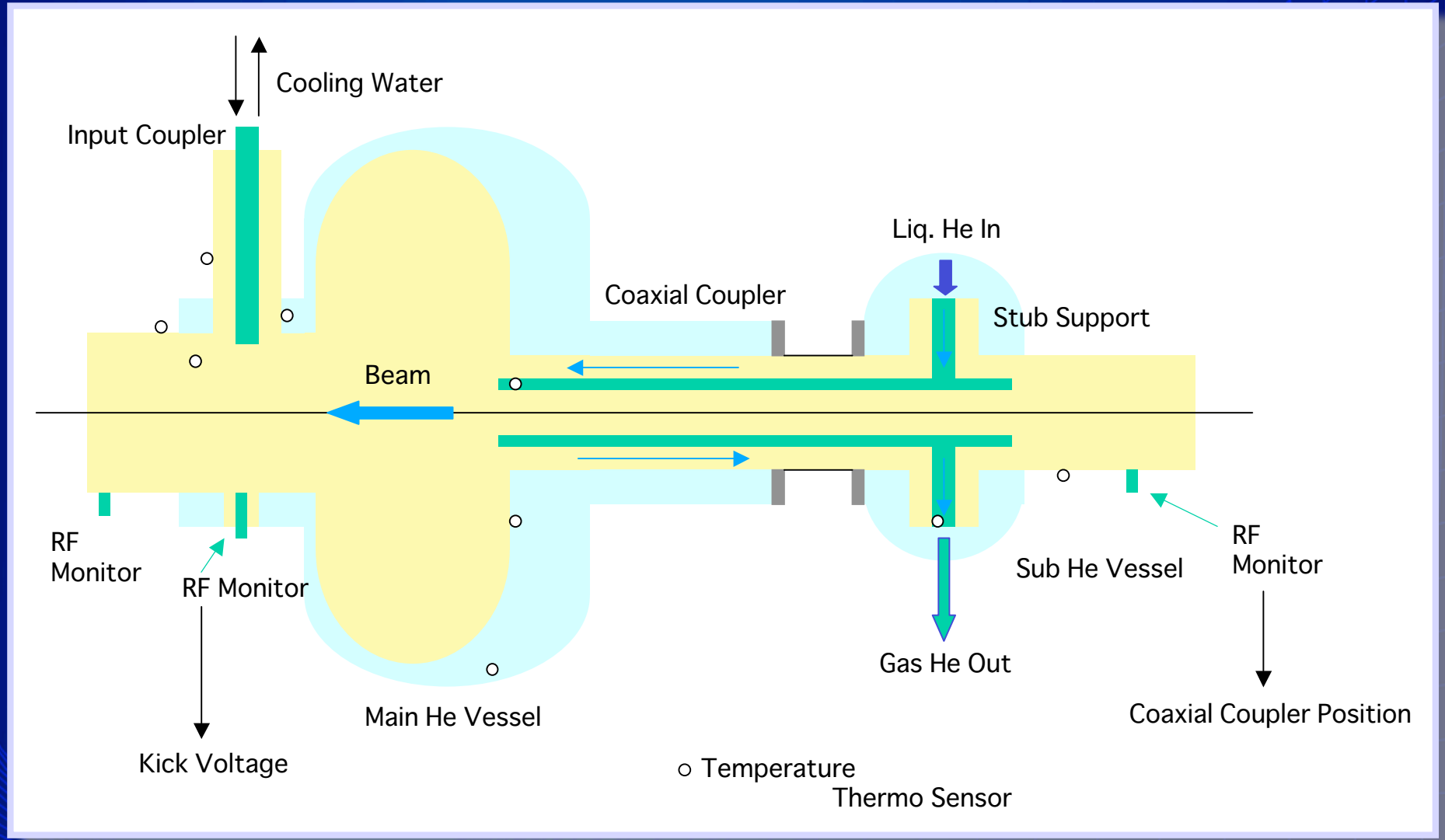
Cryostat Design (Front View)



Cooling Scheme



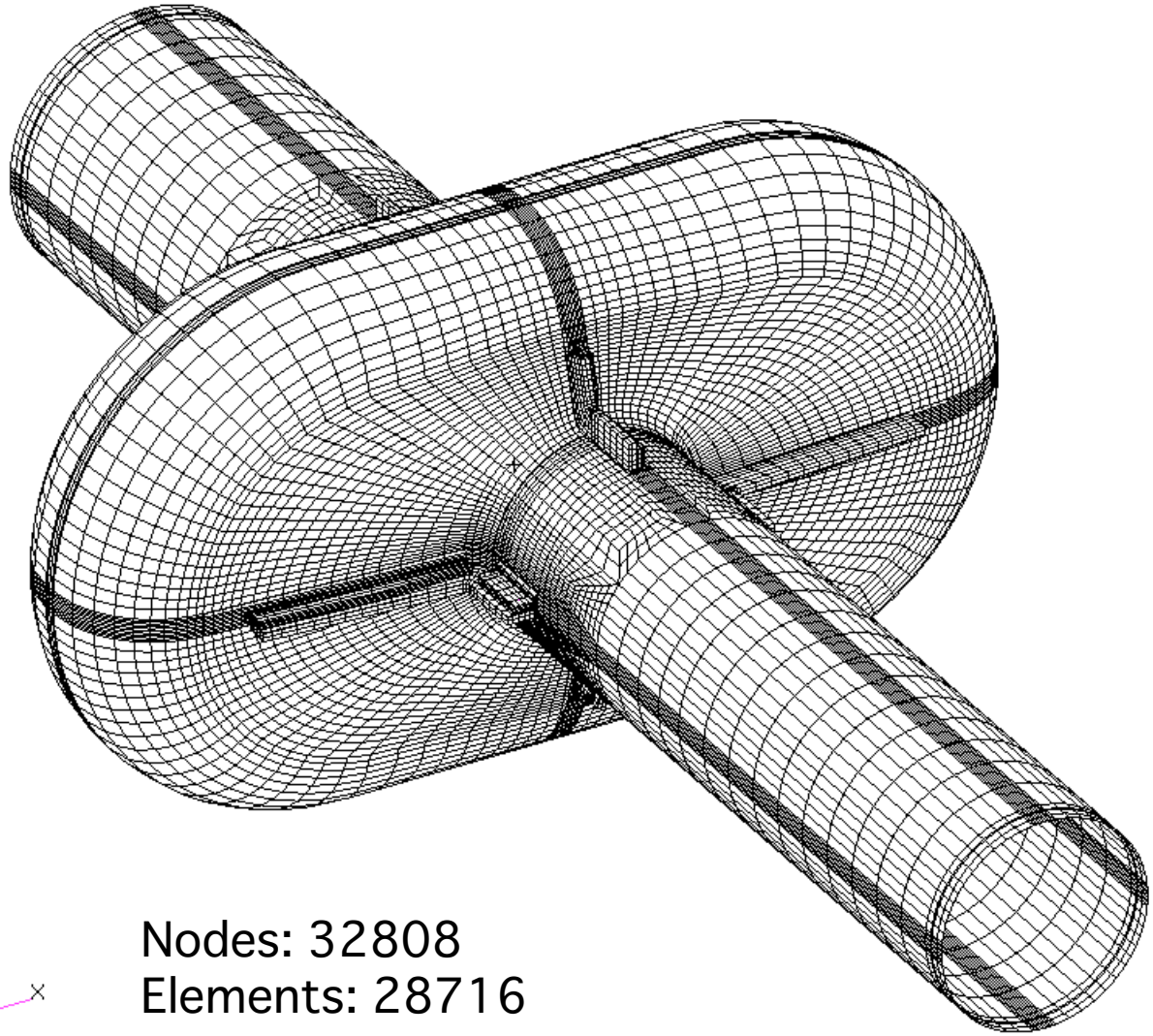
Cooling Water System



Heat Leak to Cryostat

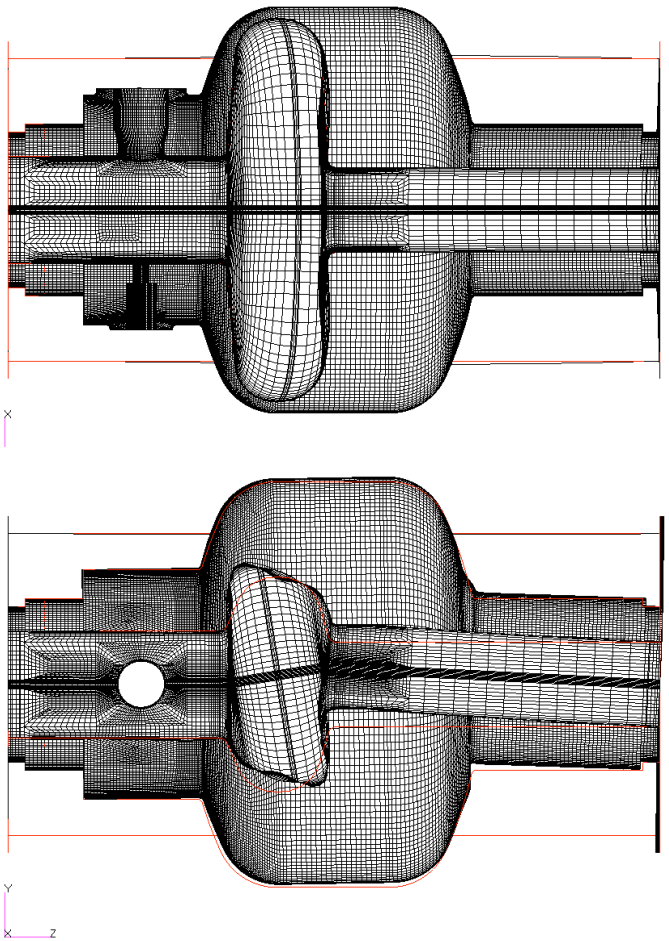
Heat Transfer Mode	Heat Leak Path			Heat Leak [W]	
				To 80 K Region	To 4 K Region
Conduction	Coaxial Coupler	Inner Conductor	Stainless Steel Tube	–	1.8
			Copper Plating	–	0.8
		Outer Conductor	Stainless Steel Tube	24.2	1.1
			Copper Plating	5.4	1.5
	Input Coupler	Outer Conductor	Stainless Steel Tube	13.0	1.0
			Copper Plating	3.2	1.9
	Beam Pipes	Beam Pipes	Stainless Steel Tube	41.2	1.9
			Copper Plating	6.9	1.9
	Tuner	Inner Rods (2 Rods)		1.4	0.1
		Outer Sleeves (2 Sleeves)		3.4	0.3
	Supports	Cavity Supports (4 Wires)		–	0.6
		80 K Shield Supports			–
	Plumbing	LHe Transfer Tubes (2 Tubes)		–	0.7
		Liquid Level Sensor Support		–	0.6
		Safety Valve Plumbing			
	Wiring	Thermocouples, Cables, etc.			
Radiation	Vacuum Vessel to 80 K Shield			10.6	–
	80 K Shield to LHe Vessel			–	0.4
Total Amount of Heat Leak				**109.3**	**14.6**

Cavity Model for Analysis

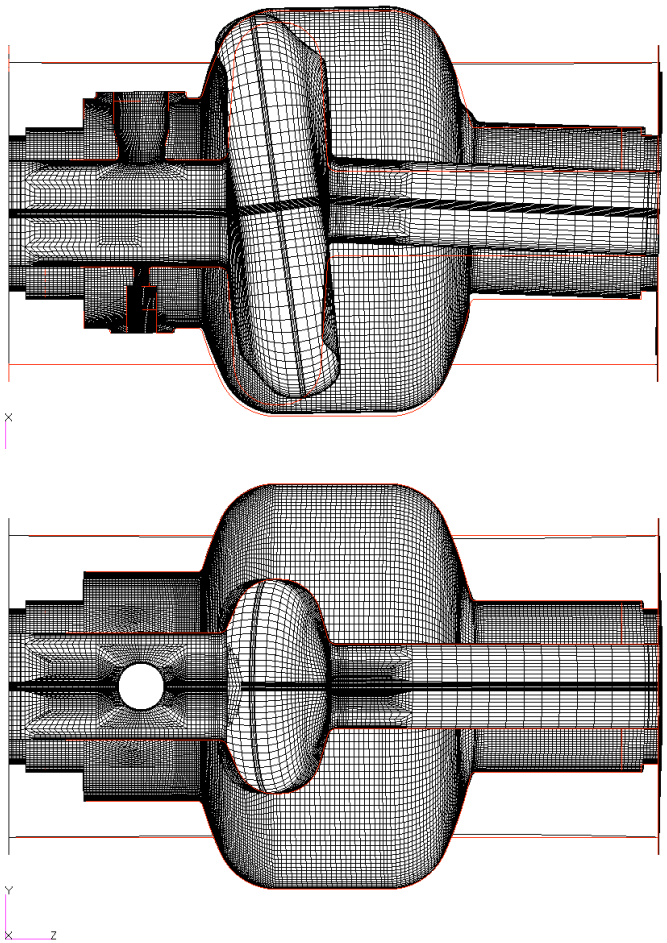


Nodes: 32808
Elements: 28716

Buckling Analysis of Cavity

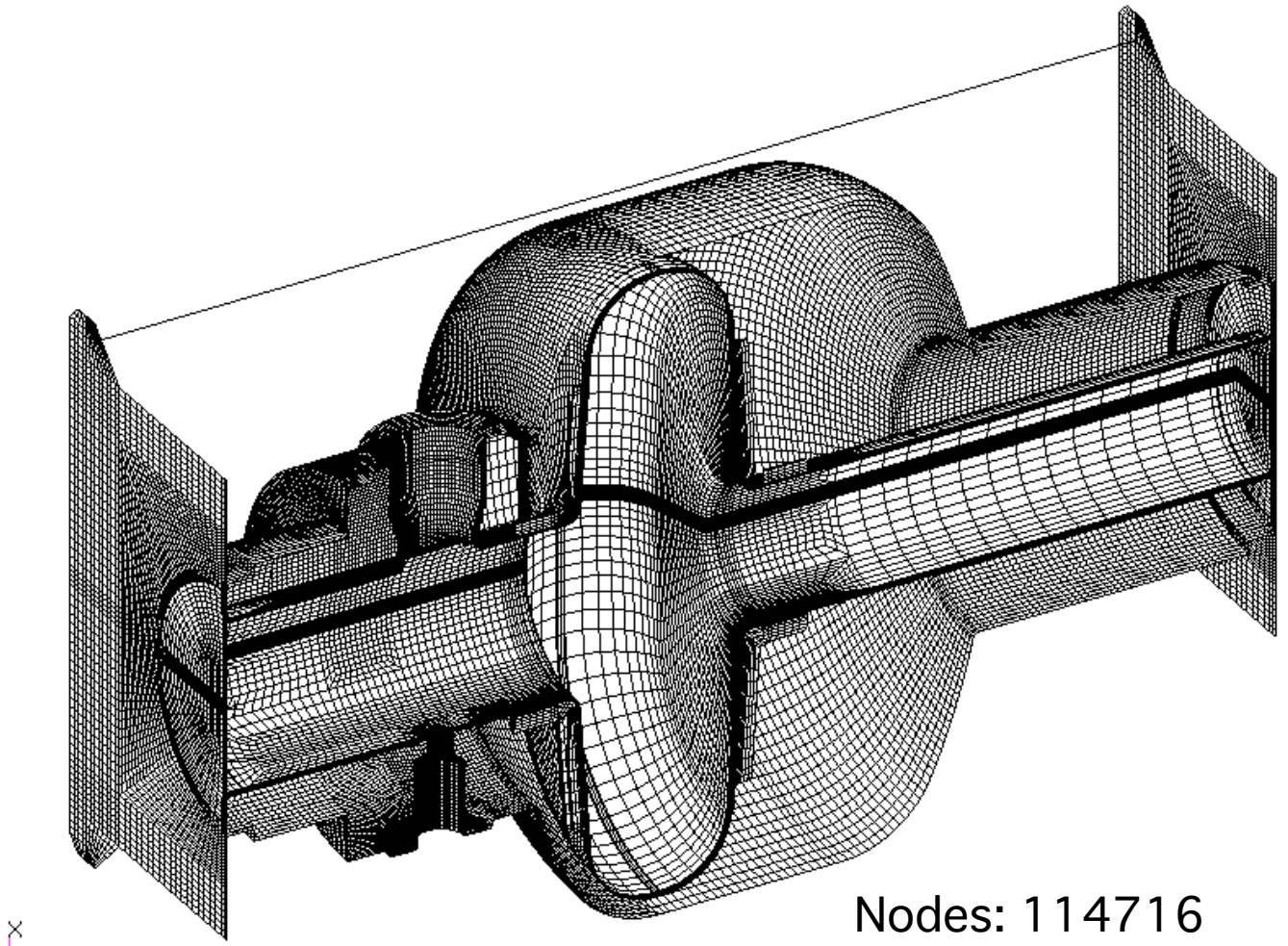


1st Order Mode
Buckling Load: 0.7772 MPa



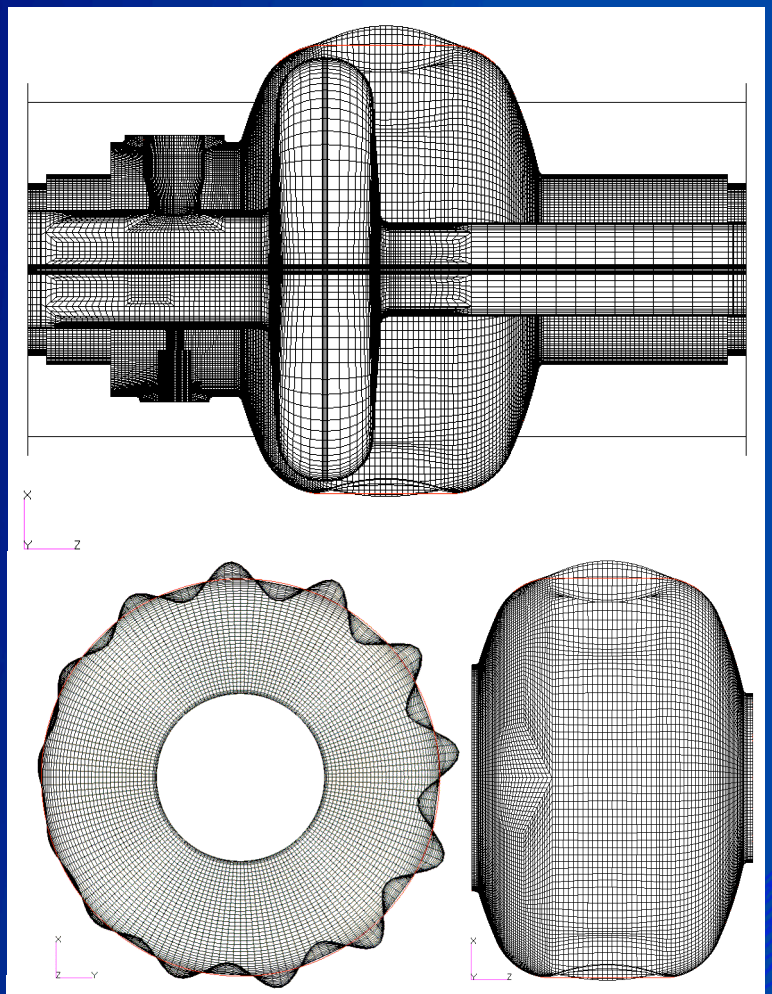
2nd Order Mode
Buckling Load: 0.8500 MPa

Helium Jacket Model for Analysis

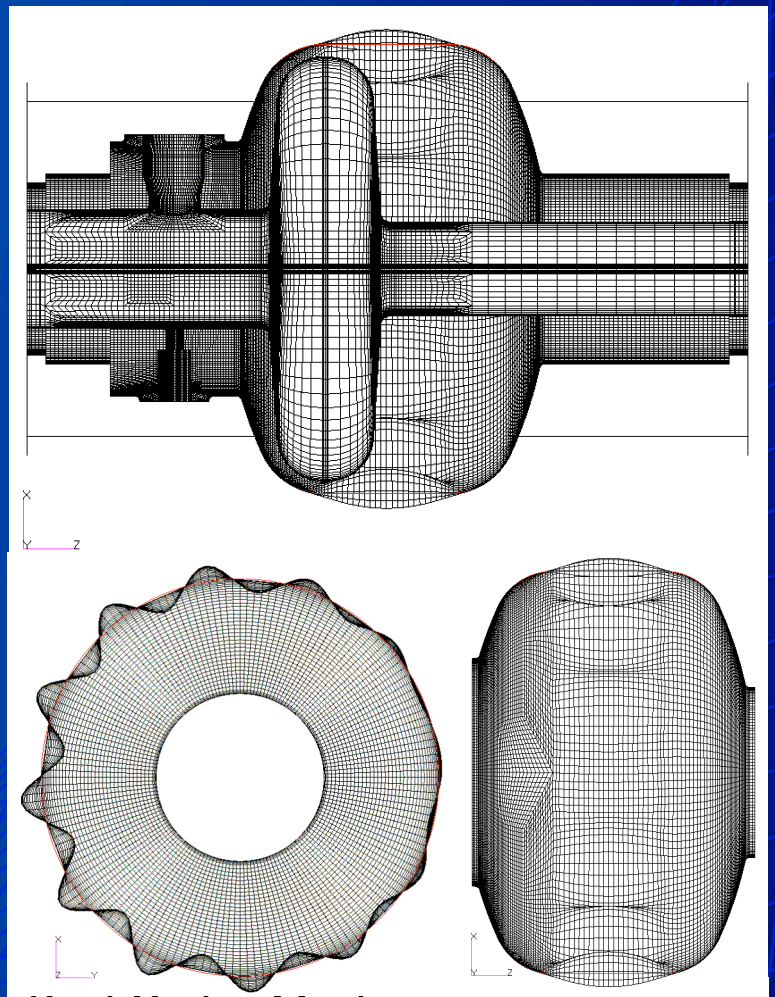


Nodes: 114716
Elements: 109426

Buckling Analysis of Helium Jacket

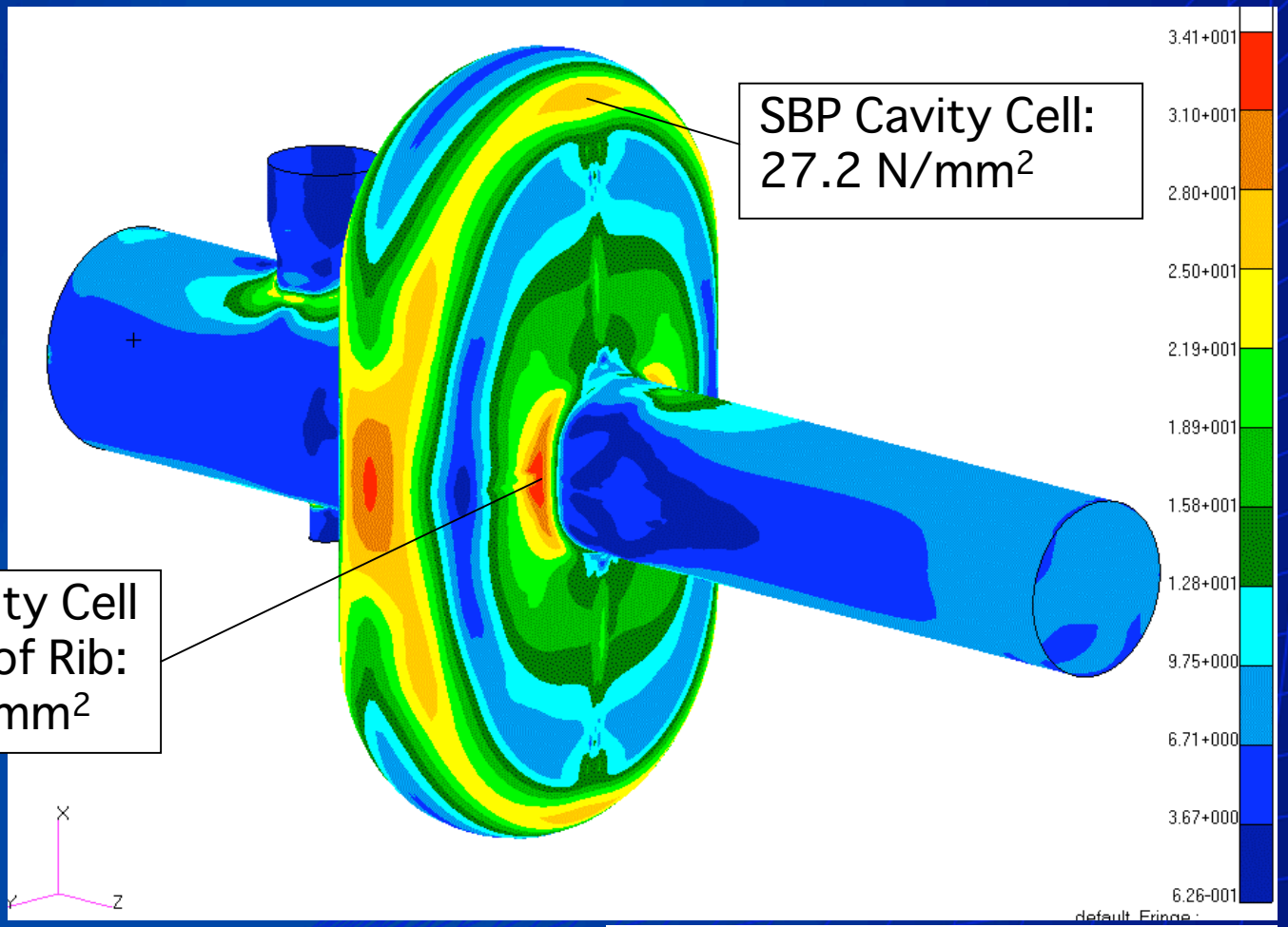


1st Order Mode
Buckling Load: 0.3218 MPa



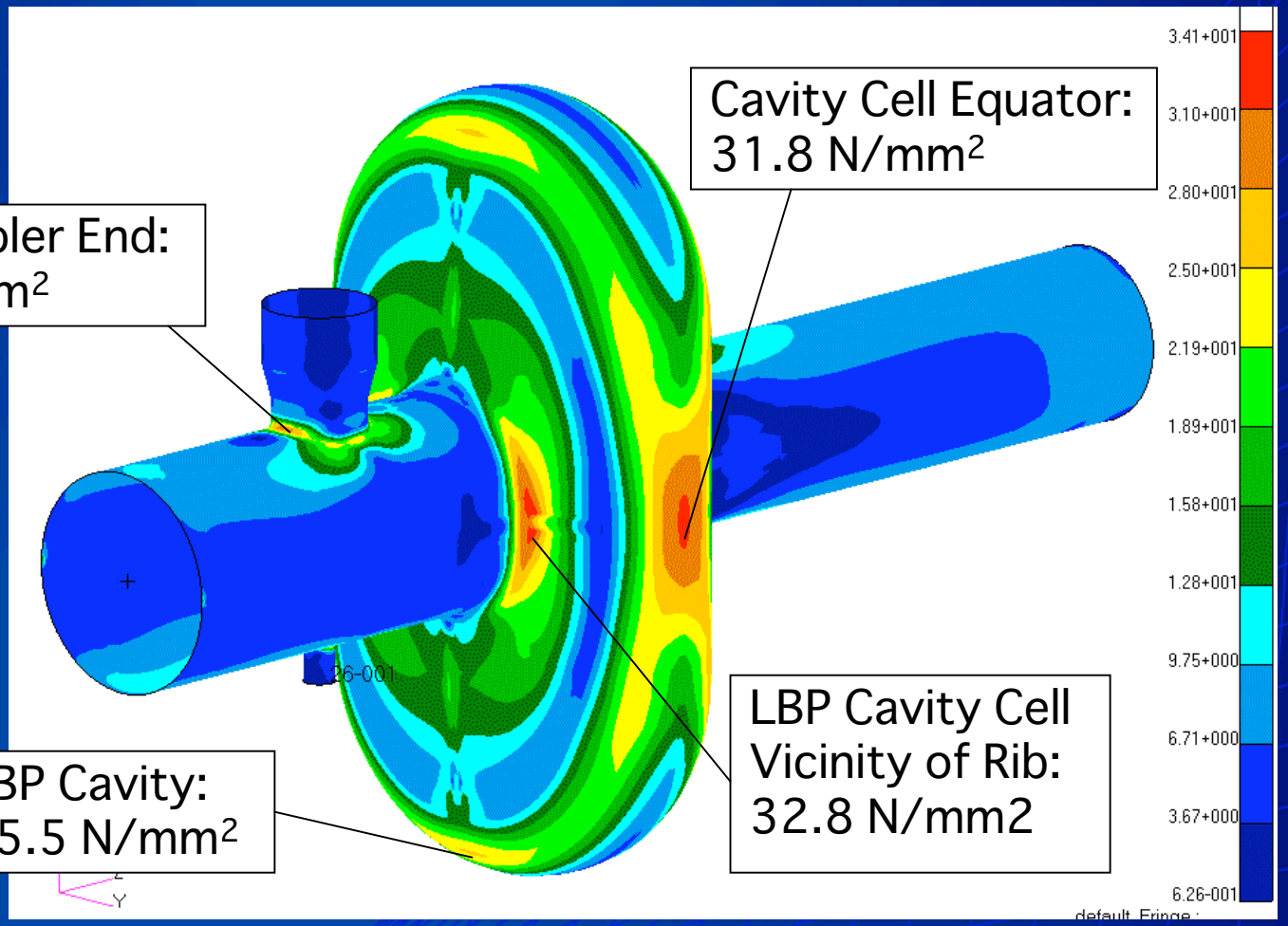
2nd Order Mode
Buckling Load: 0.3219 MPa

Stress Contour of Cavity (1)



Tresca stress contour in middle plane

Stress Contour of Cavity (2)

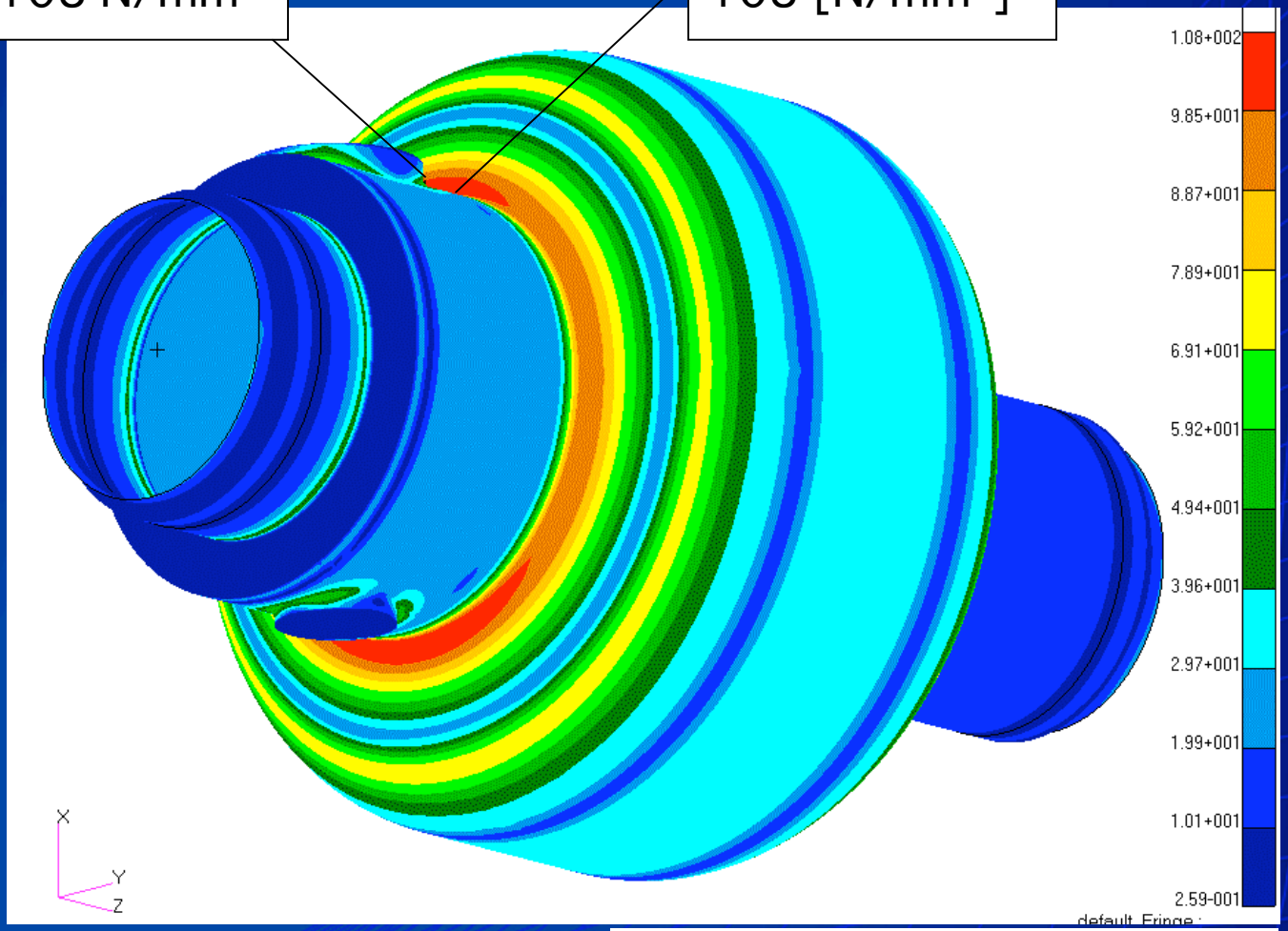


Tresca stress contour in middle plane

Stress Contour of Helium Jacket (1)

LBP End:
108 N/mm^2

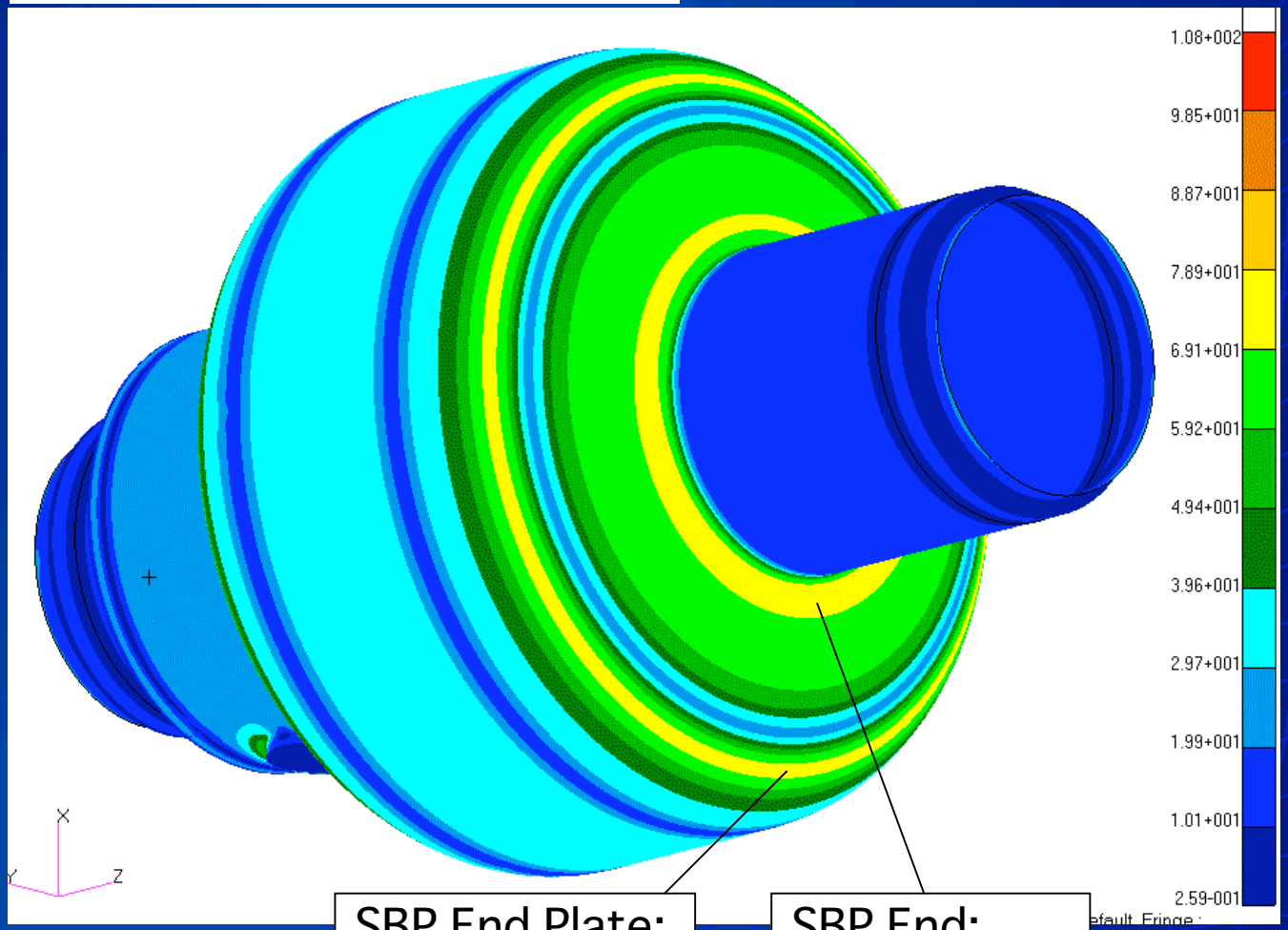
LBP End Plate:
108 [N/mm^2]



Tresca stress contour in middle plane

Stress Contour of Helium Jacket (2)

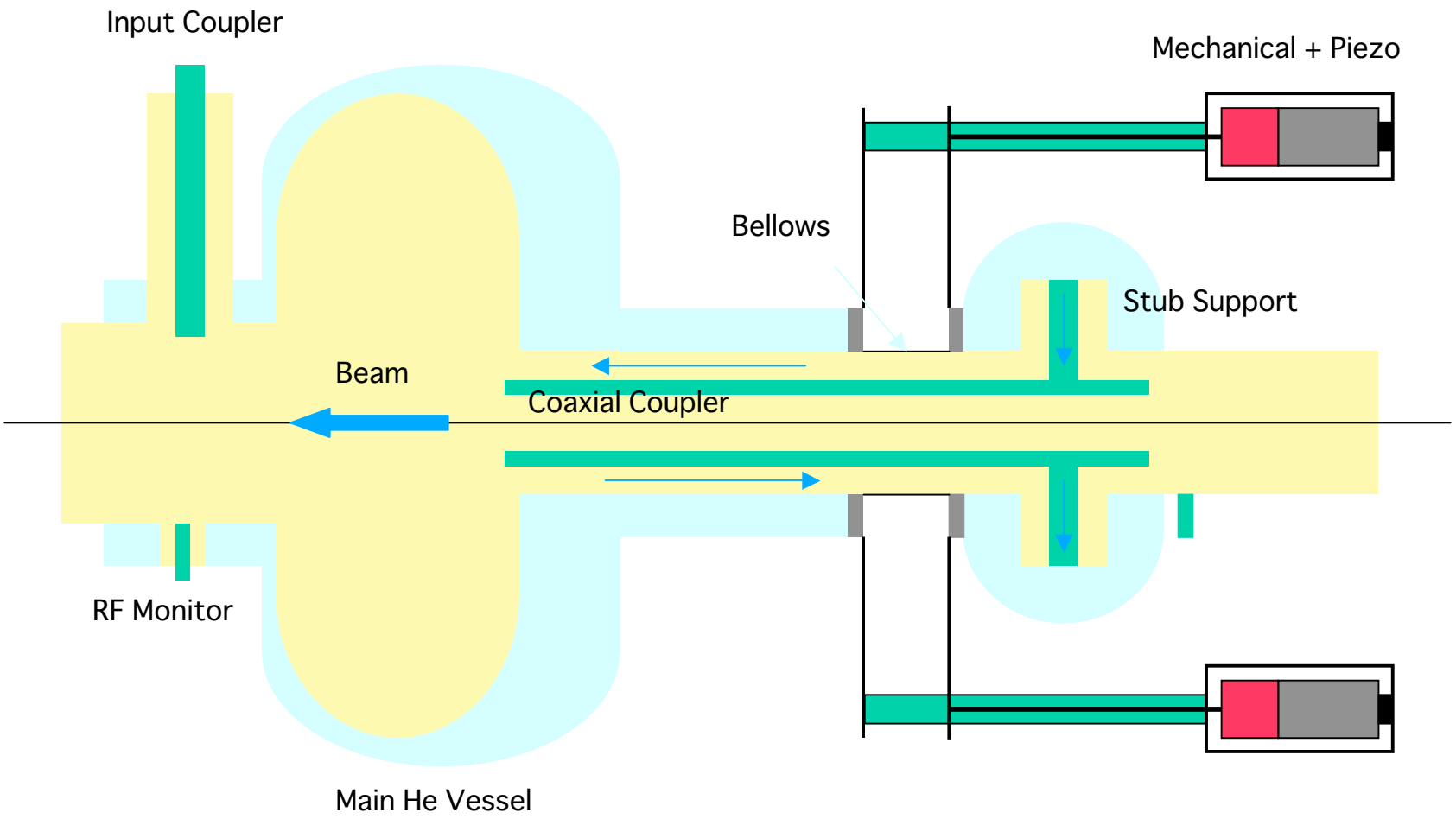
Tresca stress contour in middle plane



SBP End Plate:
71.9 N/mm^2

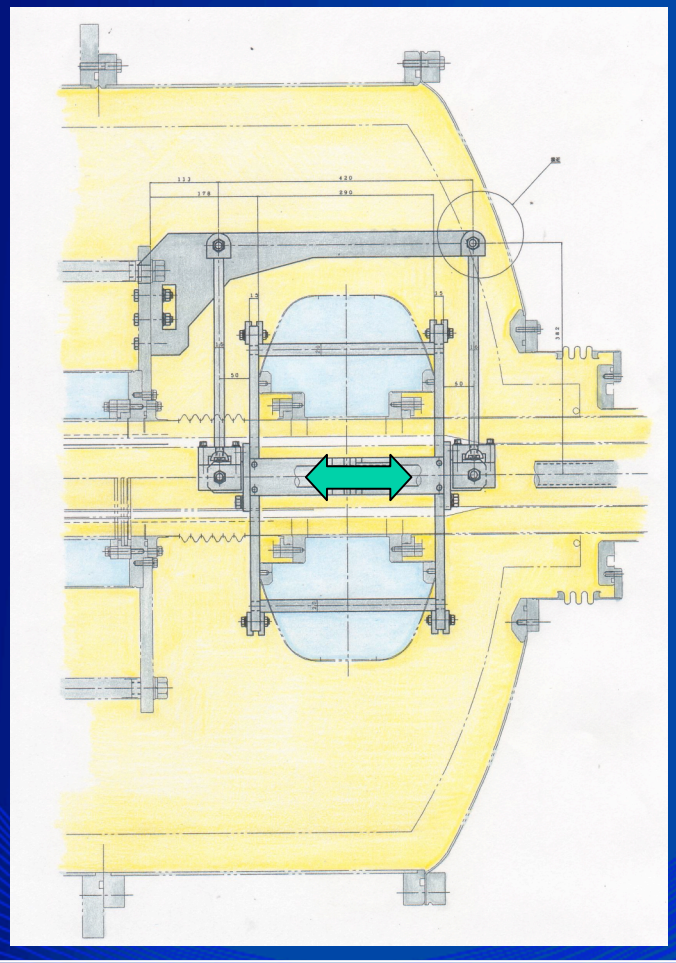
SBP End:
70.2 N/mm^2

Frequency Tuner Schematic



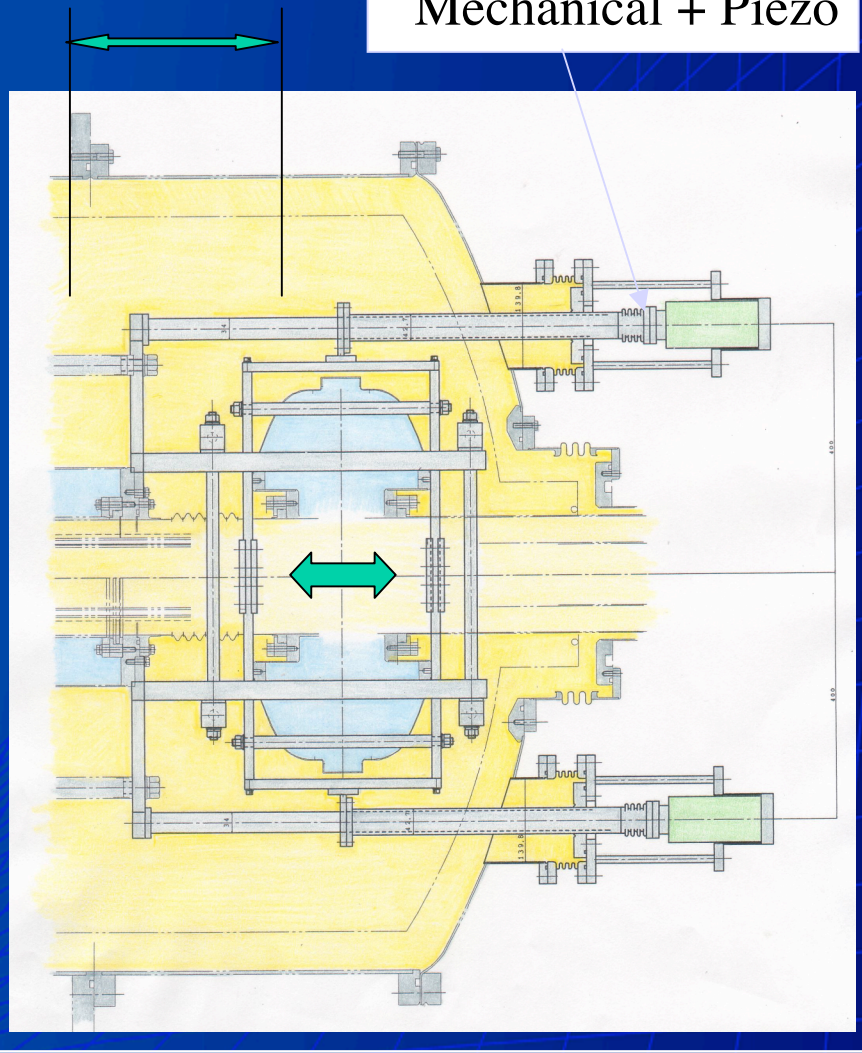
Frequency Tuner (1)

Side View



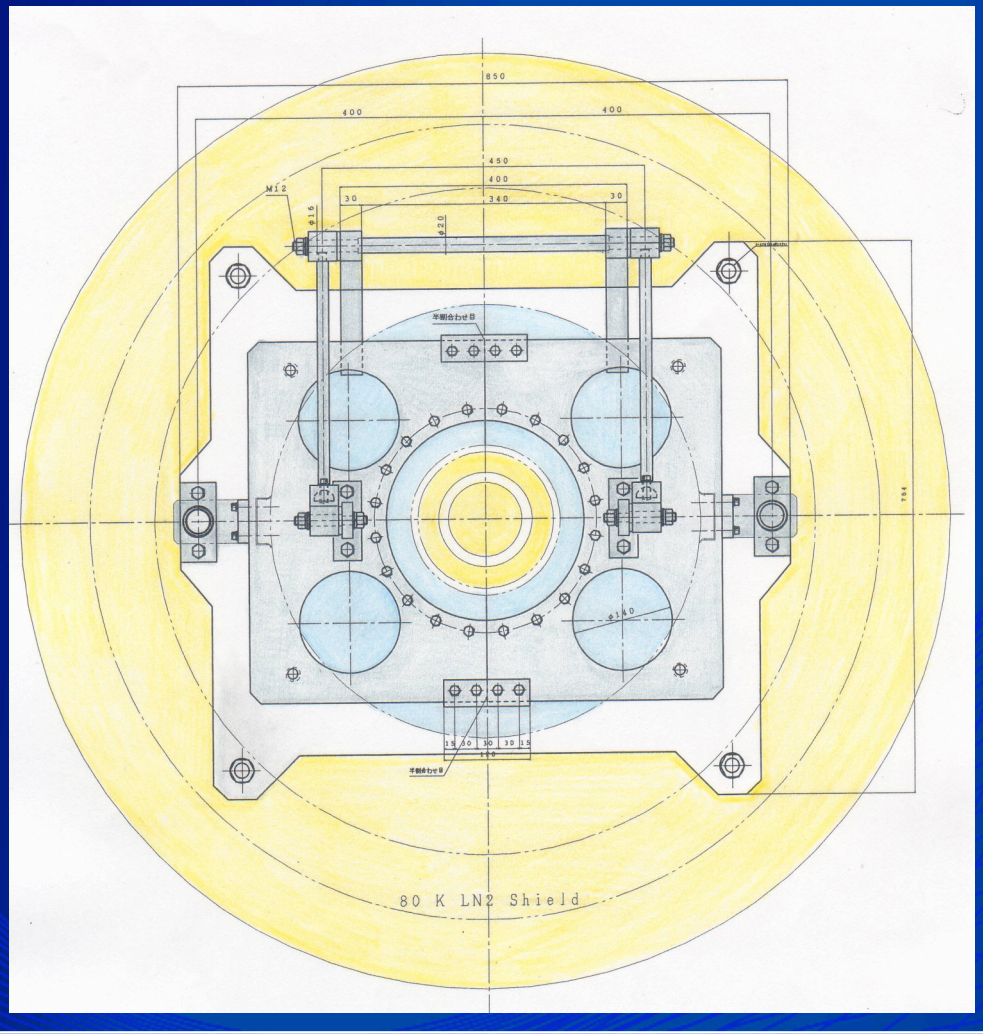
Top View

Driver
Mechanical + Piezo

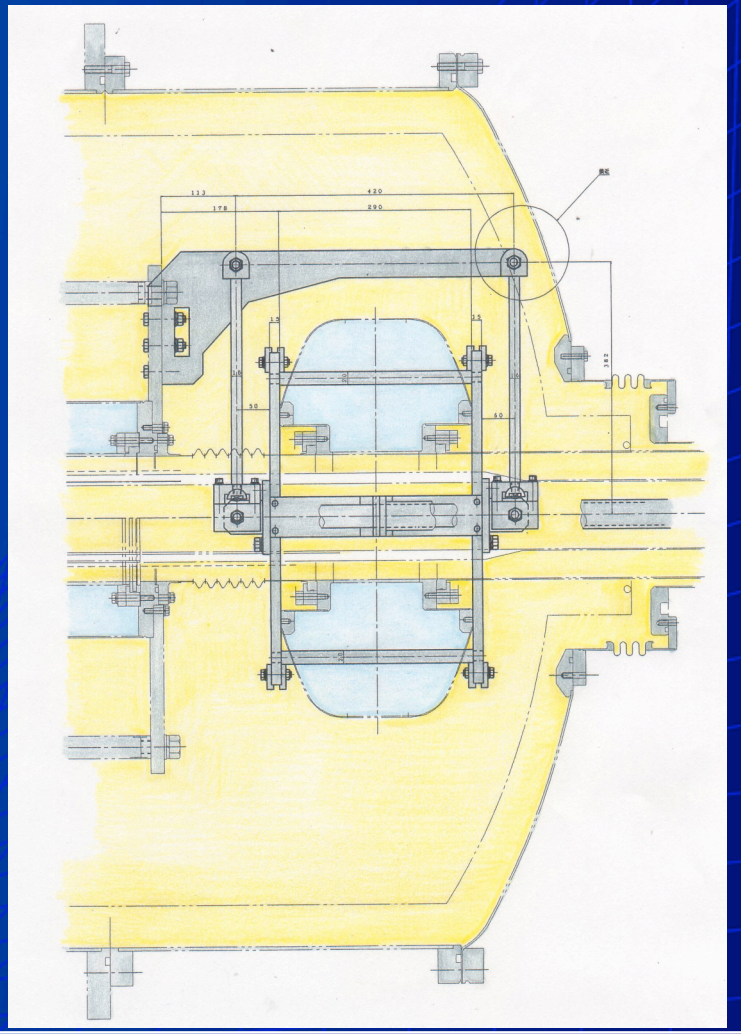


Frequency Tuner (2)

Front View

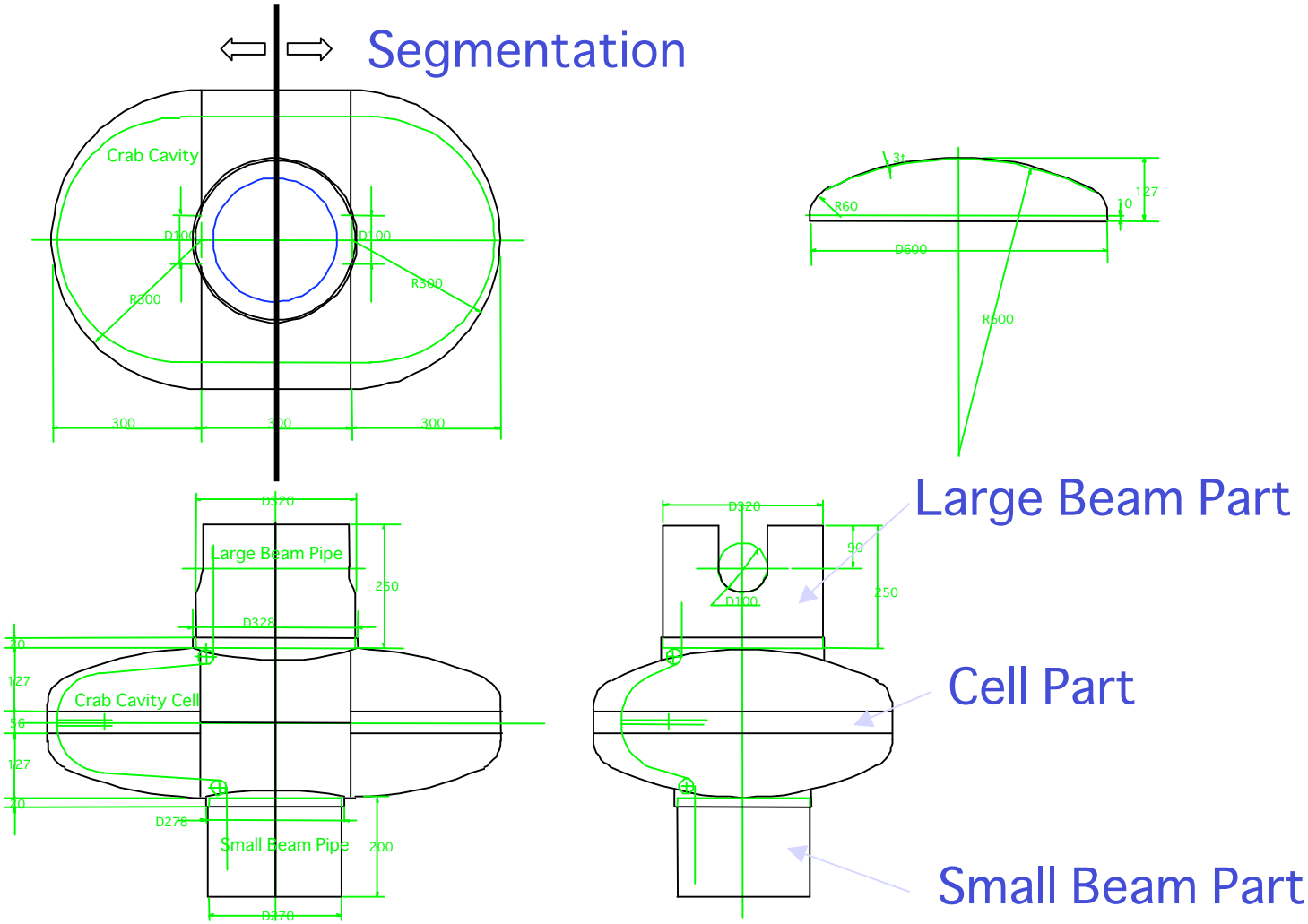


Side View



Test Stand for Frequency Tuner

Magnetic Shield (Jacket Type)

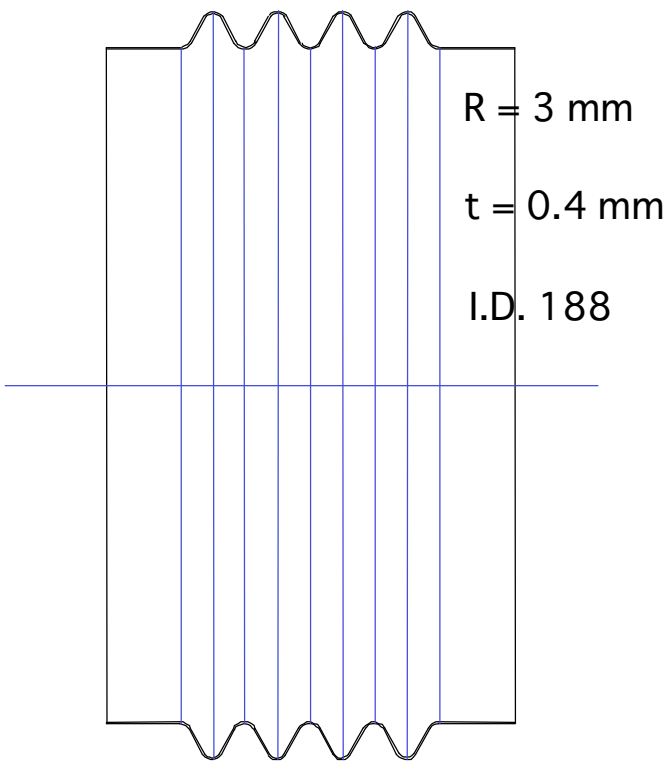


Magnetic Shield (Jacket type)

Material: Permalloy, 3 mm thick

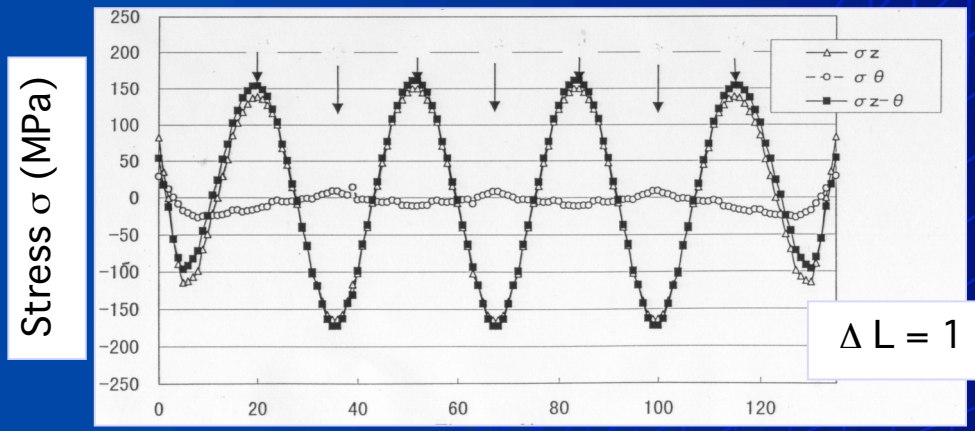
Copper Bellows

Copper Bellows



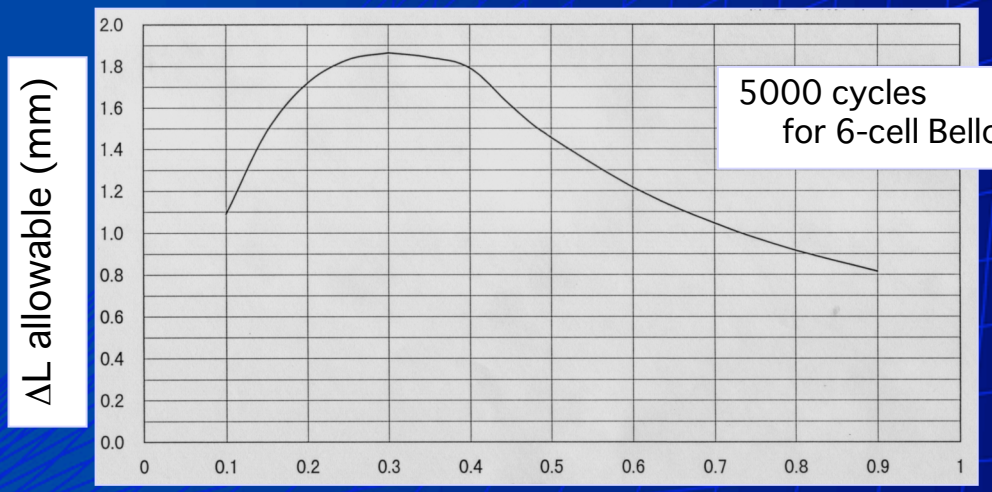
Young's Modulus: E = 127,000 MPa
Poisson's Ratio: ν = 0.34

Stress Analysis by ABAQUS

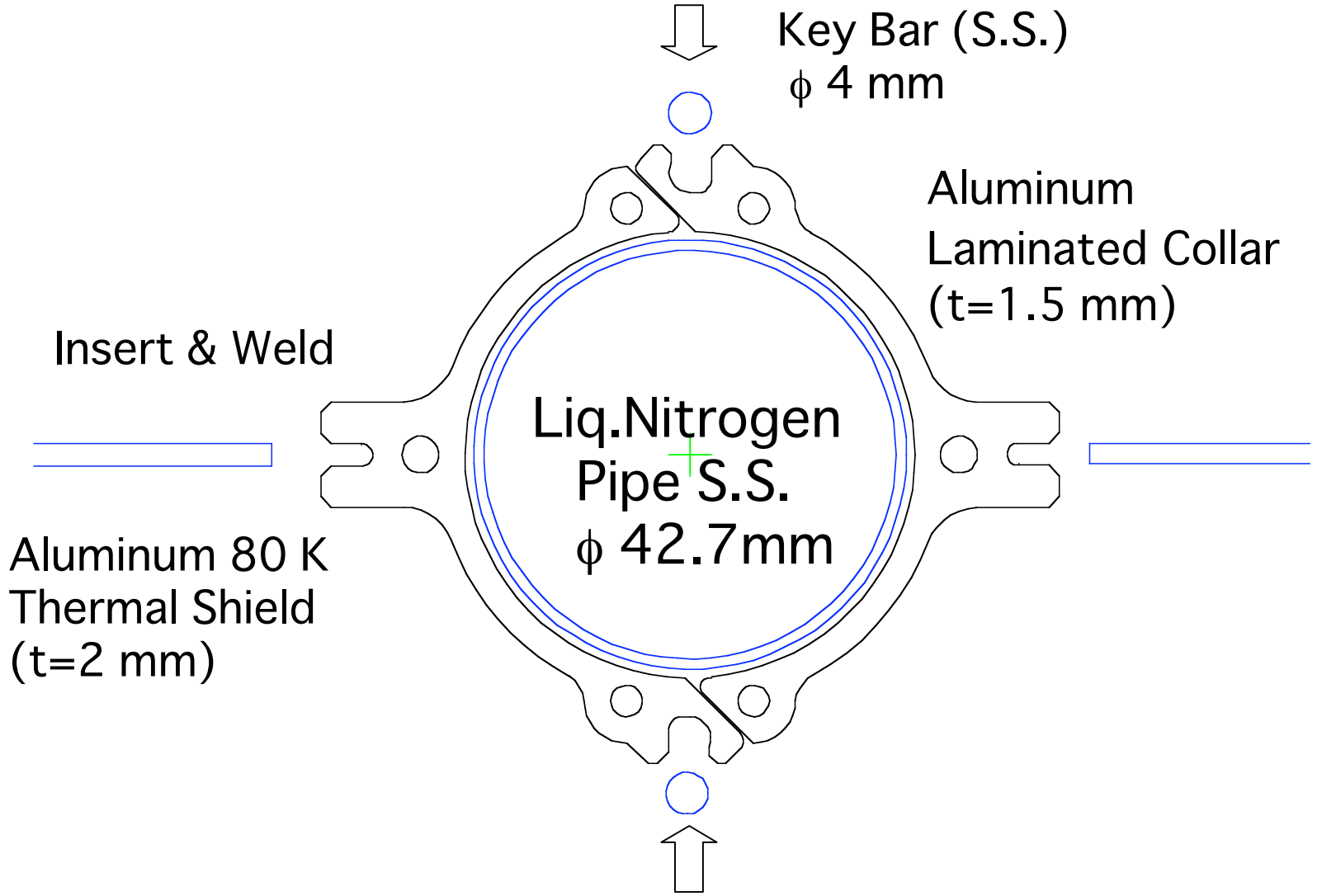


Δ L = 1 mm

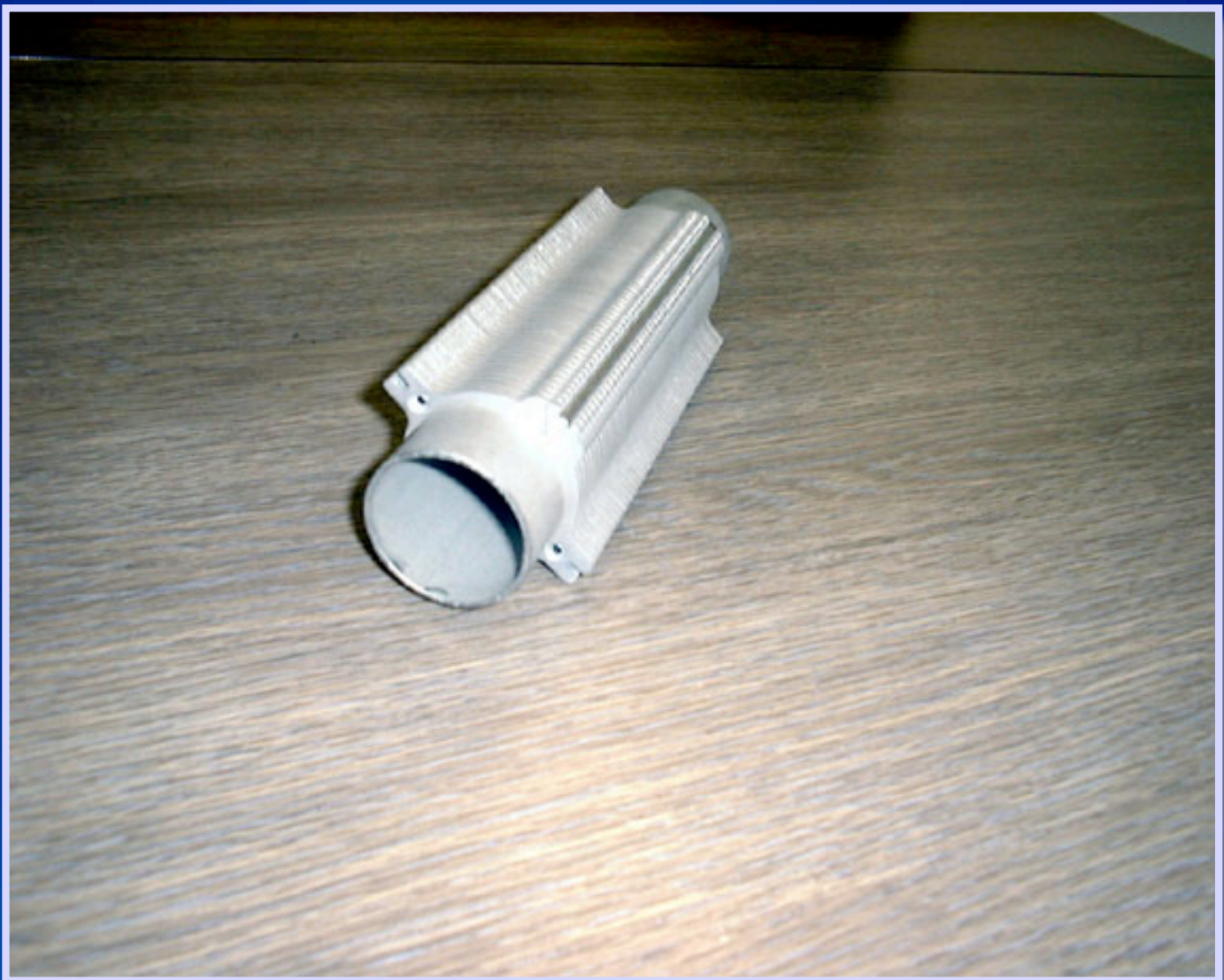
Allowable Deformation ΔL of Bellows



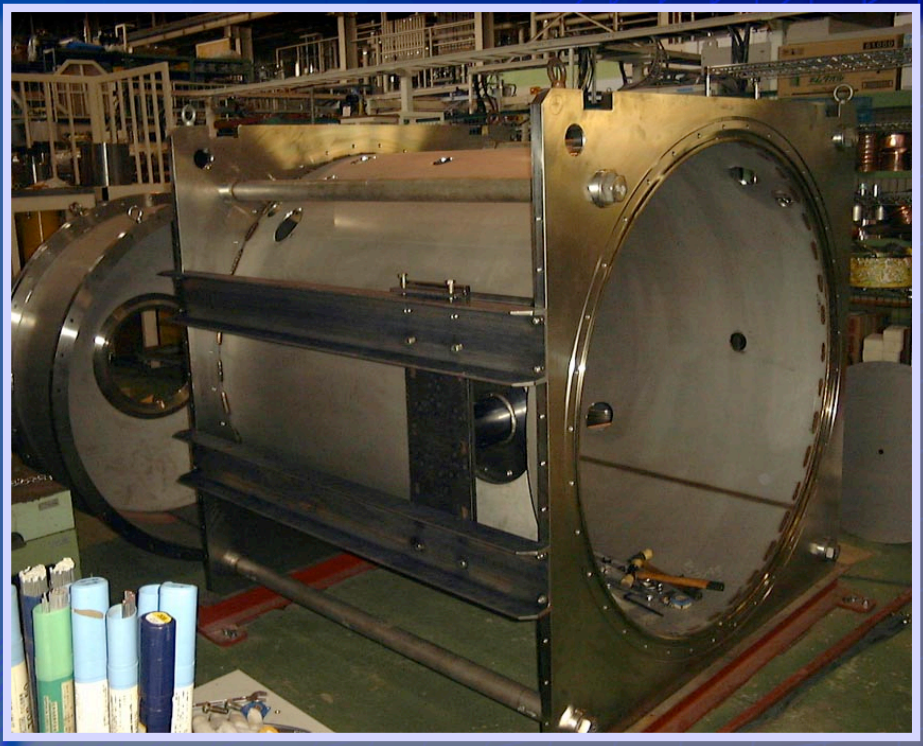
80 K Thermal Shield Structure



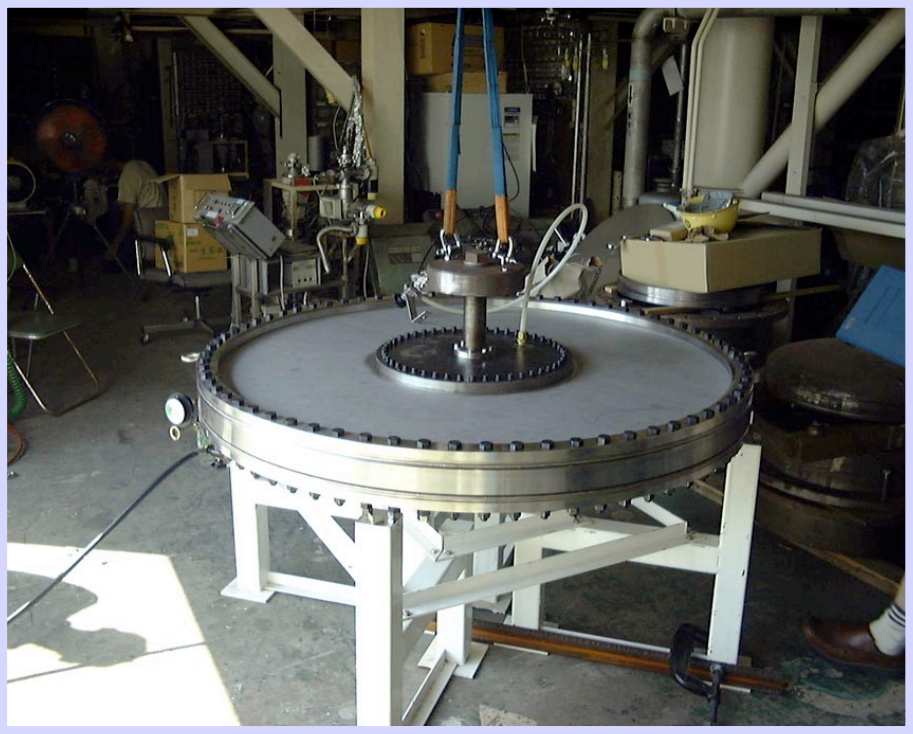
80 K Thermal Shield



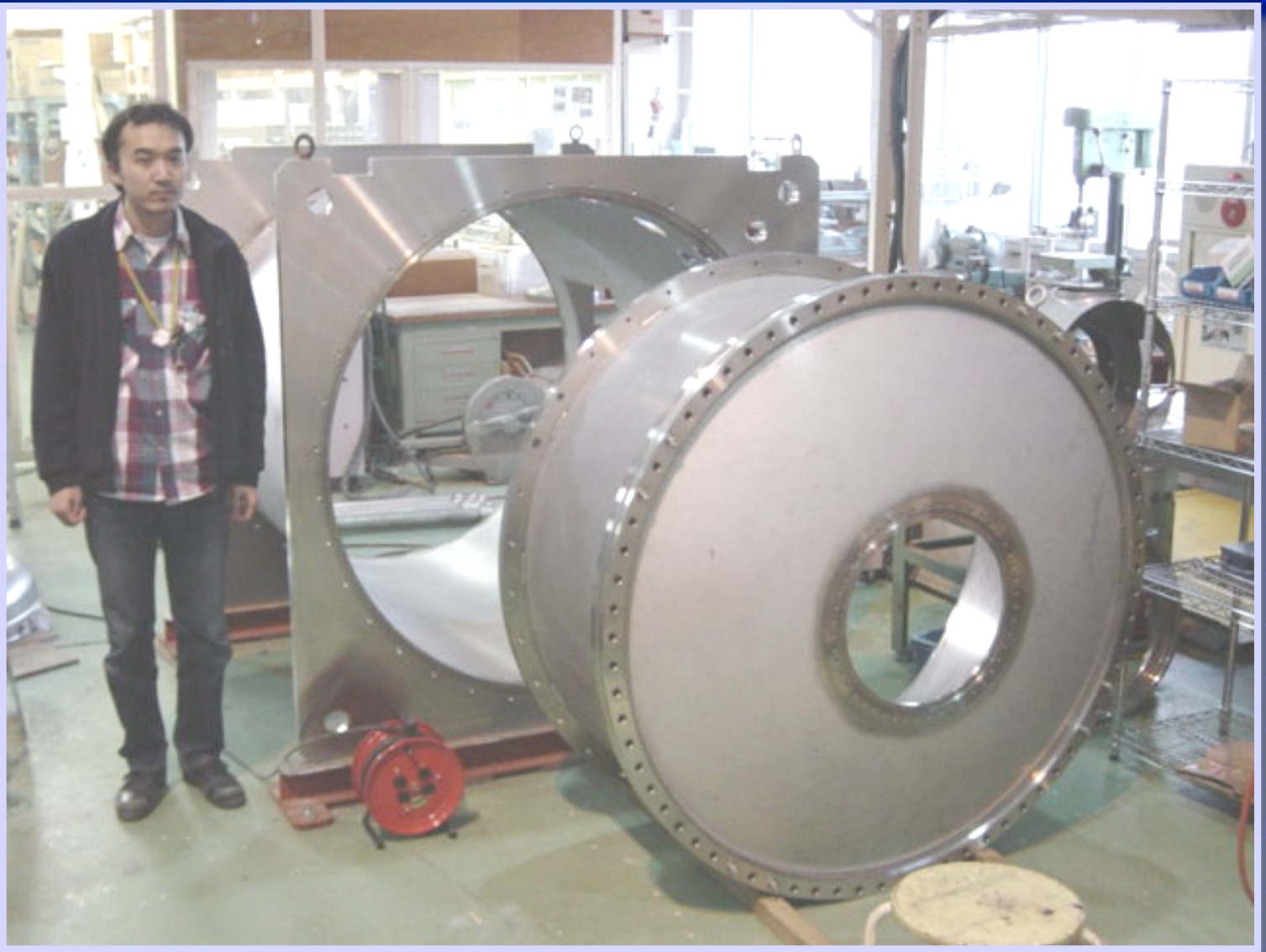
Vacuum Vessel



End Shell Hydroforming



Assembled End Shell



Summary

- Cryostat design almost completed and numerically analyzed
- Prototype cryostat for assembly check and cooling test under construction
- Parts Fabrication in Progress