COUPLED ELECTROMAGNETIC AND MECHANICAL SIMULATIONS FOR HALF-WAVE RESONATORS

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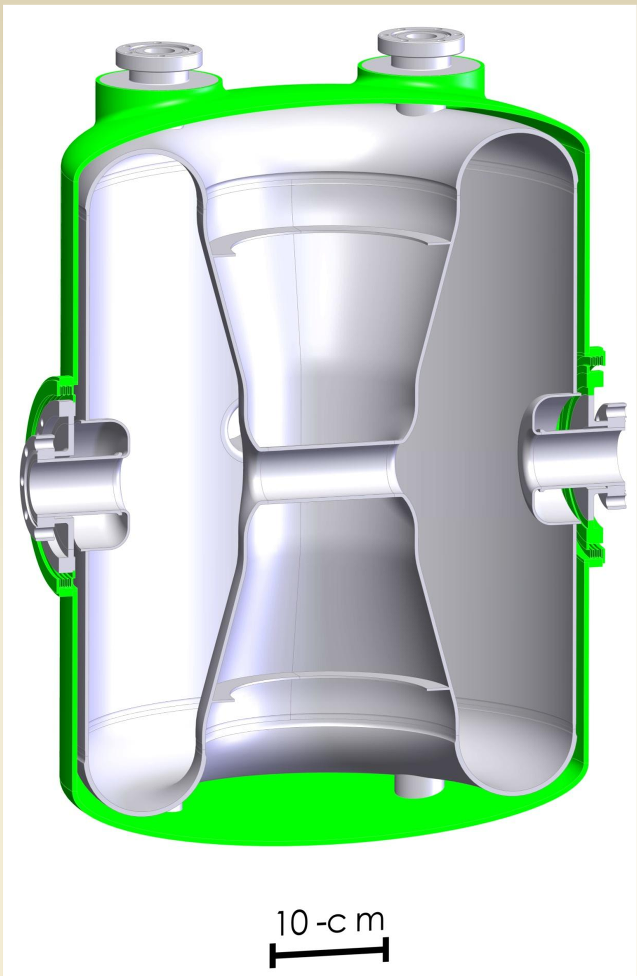
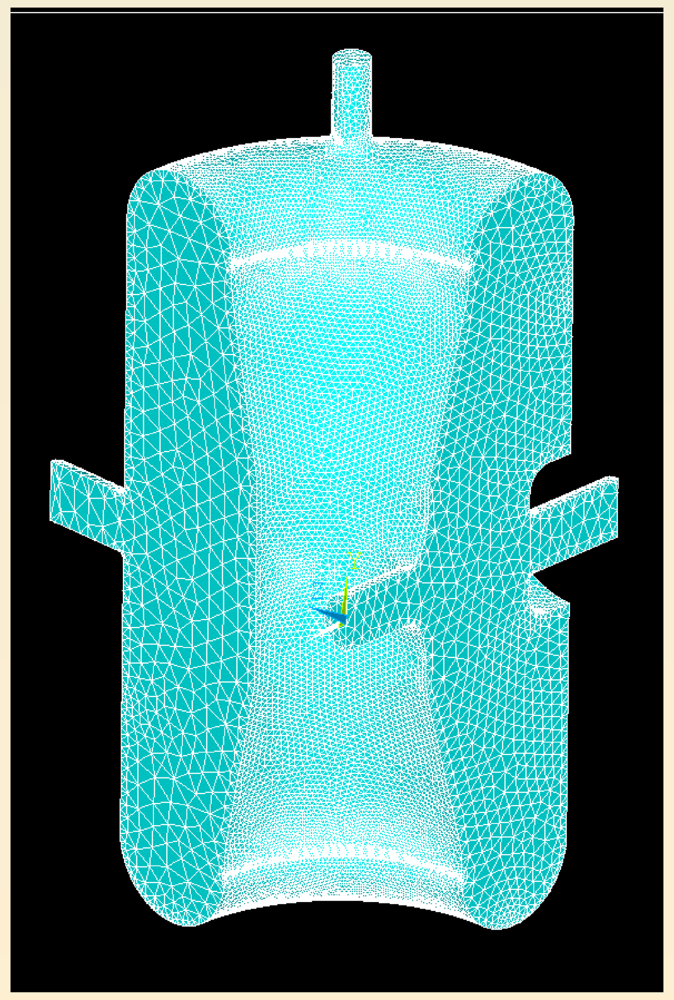
Coupled Simulation Procedure

Cavity Mechanical Design



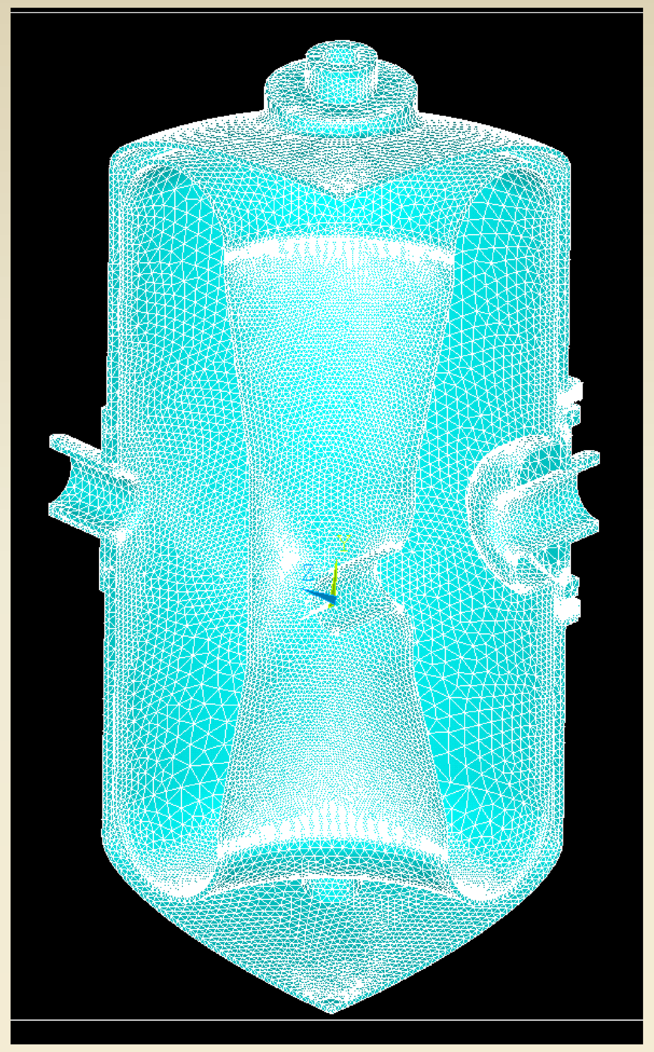
Meshed Cavity Vacuum



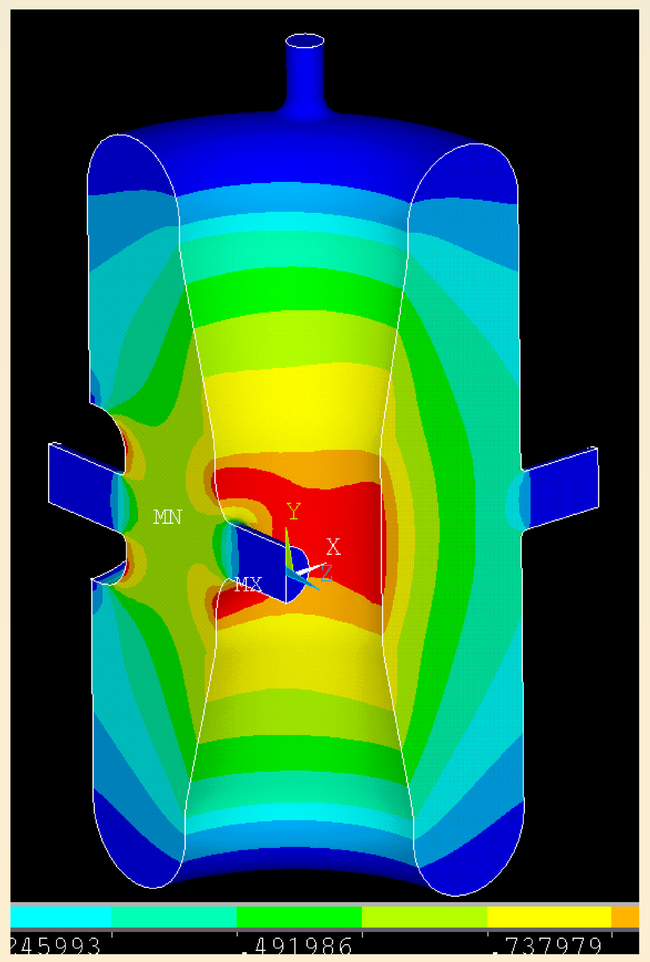
1. Import mechanical model into ANSYS
2. Create Vacuum Space from mechanical model
3. Attach mechanical properties to parts
4. Mesh all components
5. Solve for cavity figures of merit
6. Redefine Vacuum Space as a solid with extremely weak mechanical properties
7. Apply desired pressure
8. Simulate the resulting deformation of the cavity walls
9. Resolve for cavity figures of merit with perturbed mesh

-Preserving the Vacuum Space mesh allows extremely accurate frequency shift calculations

Meshed Niobium Space



Example Cavity Electric Field



Lorentz Force Detuning

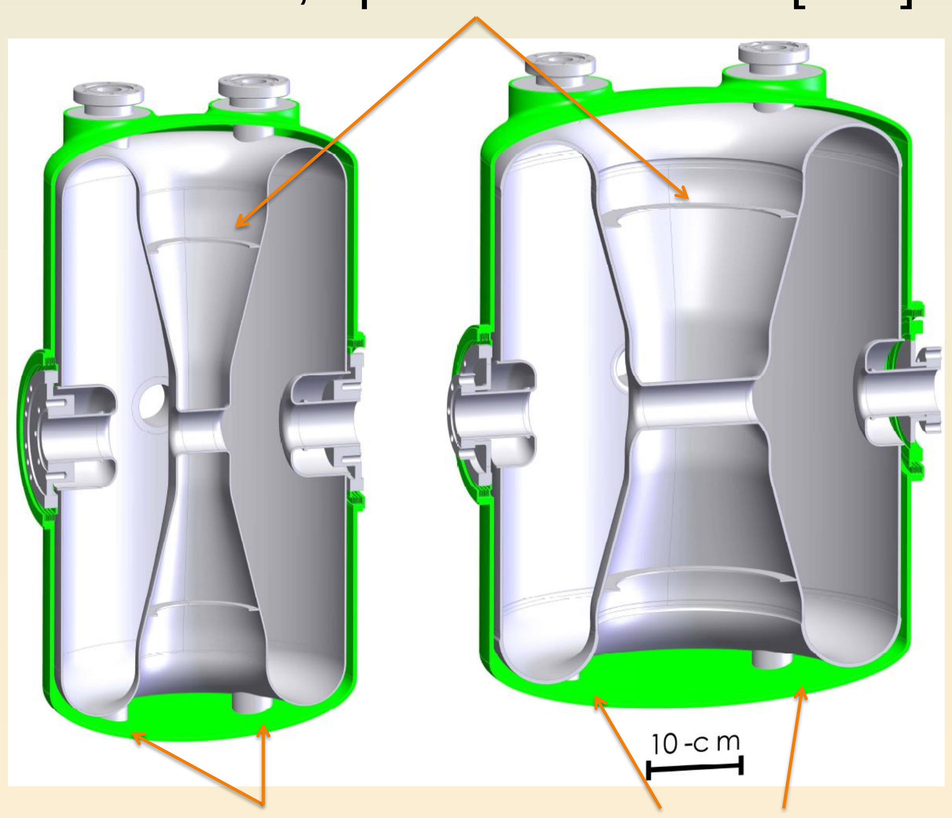
- The cavity fields interact with the induced charges and currents in the cavity surface
- This Lorentz Force deforms the cavity, shifting the resonant frequency
- Experience determines the requirement that $|K_L| \leq 3$ [Hz/(MV/m)^2]
- With Beam Ports Free: $|K_L| = 4.1$ [Hz/(MV/m)^2]
- With Beam Ports Fixed: $|K_L| = 2.1$ [Hz/(MV/m)^2]
- In operations with tuner is expected to closer to the beam ports fixed condition

$$\frac{\Delta f}{f_0} = \frac{1}{4U}\int_{\Delta V}(\varepsilon_0 E^2 - \mu_0 H^2)dV = -\frac{1}{U}\int_{\Delta V}(P)dV \qquad K_L = \frac{\Delta f}{(\Delta E_{acc})^2}; E_{acc} = \frac{V_{acc,\beta_{opt}}}{\beta_{opt}\lambda}$$

Pressure Sensitivity

$$\left|\frac{df}{dP}\right| \leq 2\left[\frac{Hz}{torr}\right]$$

Stiffening Rings on the Inner Conductor, optimized to ±180 [mm]

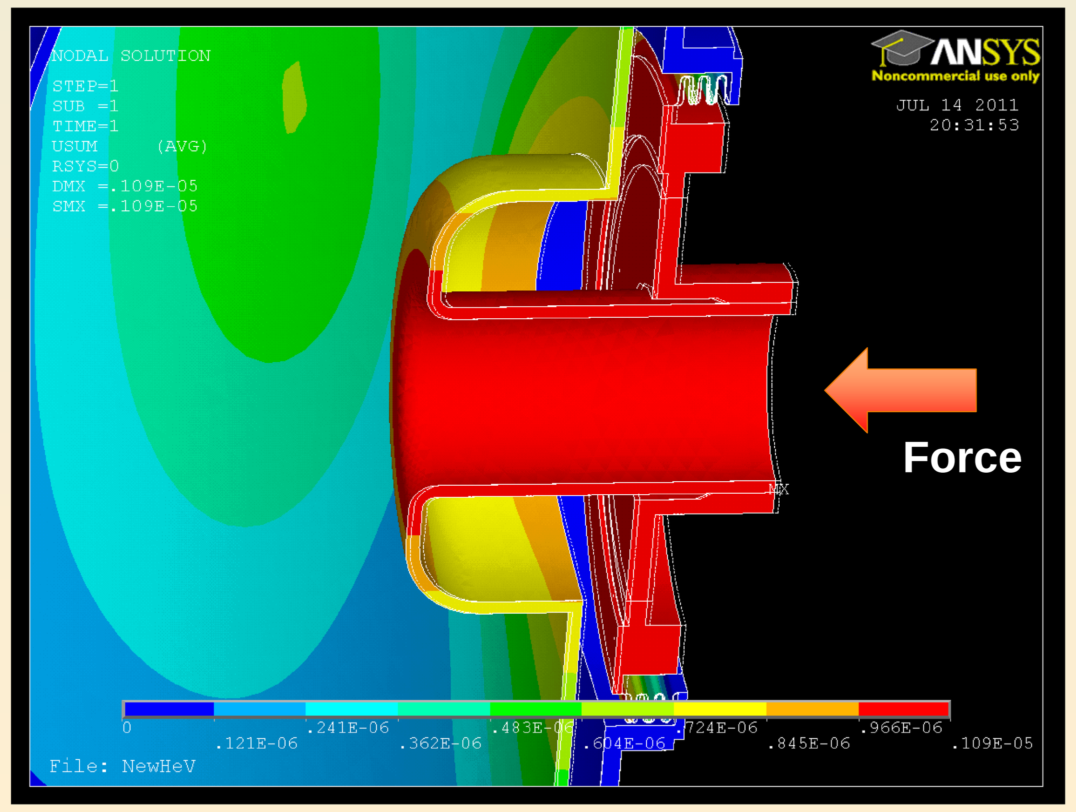


Symmetric Helium Vessel Attachments

Cavity Tuning

- Mechanical Tuner has been designed and tested for the 0.53 HWR
- Mechanical Advantage of 8:1

$$\frac{df}{dF} = 70.6\left[\frac{kHz}{kN}\right] \qquad \frac{df}{dx} = 121\left[\frac{kHz}{mm}\right]$$



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U.S. Department of Energy Office of Science
Michigan State University

This material is based upon work supported by the U.S. Department of Energy Office of Science under Cooperative Agreement DE-SC0000661.
Michigan State University designs and establishes FRIB as a DOE Office of Science National User Facility in support of the mission of the Office of Nuclear Physics.