Lorentz force detuning for the SNS cavities

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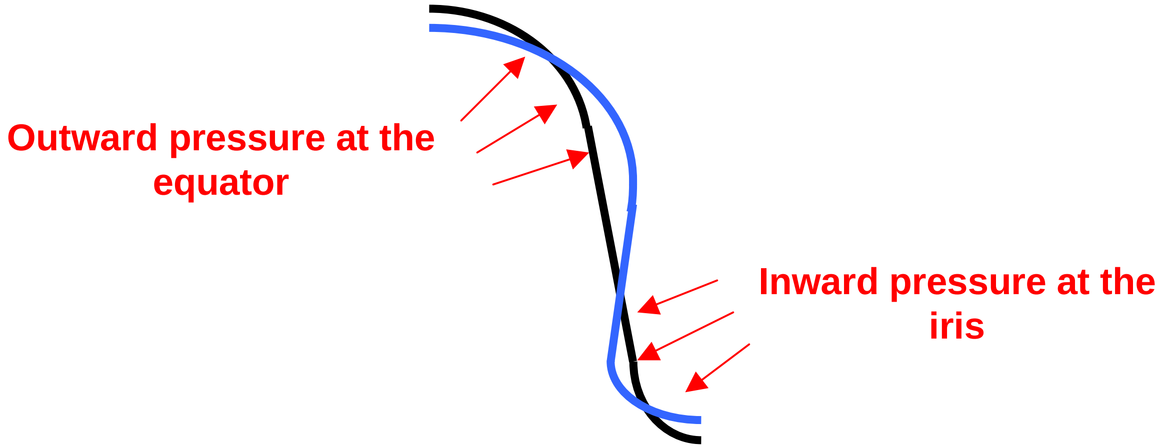
Problem definition

- Radiation pressure : $P = (\mu_0 H^2 - \varepsilon_0 E^2)/4$

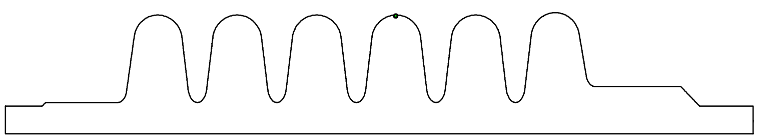
- Deformation of the cavity shape:



- Frequency shift : $\Delta f = KL^*E^2_{acc}$

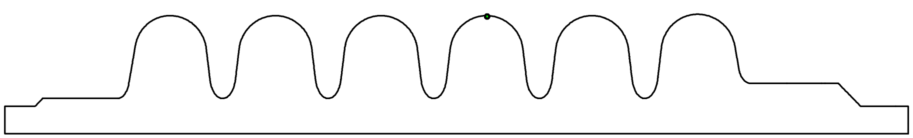
Computation tools

- SUPERFISH computes the radiation pressure on each mesh element
- ABAQUS computes the displacement of each mesh element
- SUPERFISH computes the frequency of the deformed shape



SNS β=0.61

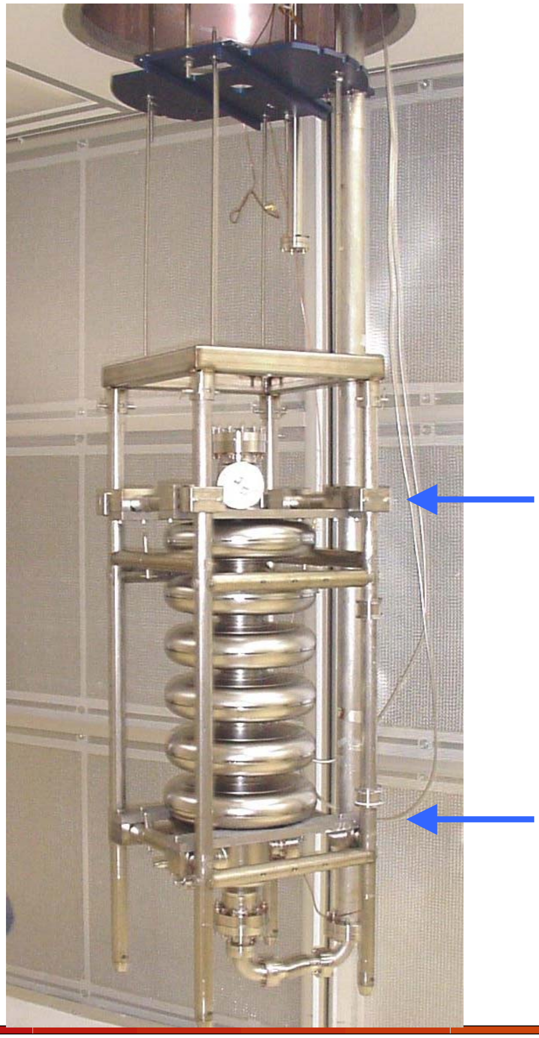
$P_{max}(E_{acc}$=10MV/m) = 1.63 kPa

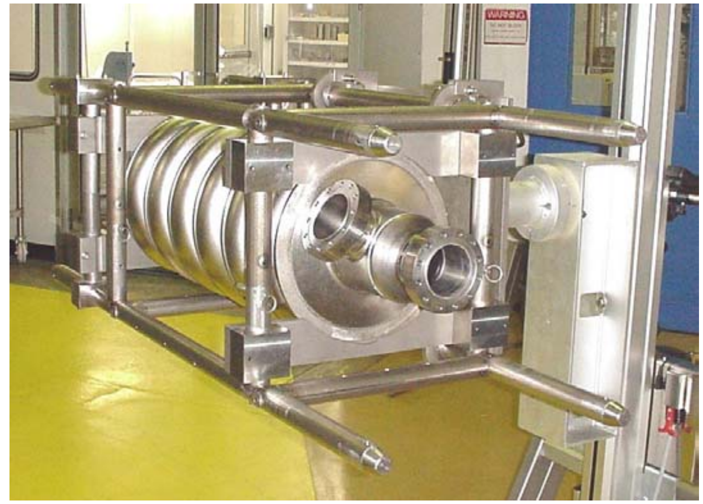


SNS β=0.81

$P_{max}(E_{acc}$=10MV/m) = 1.02 kPa

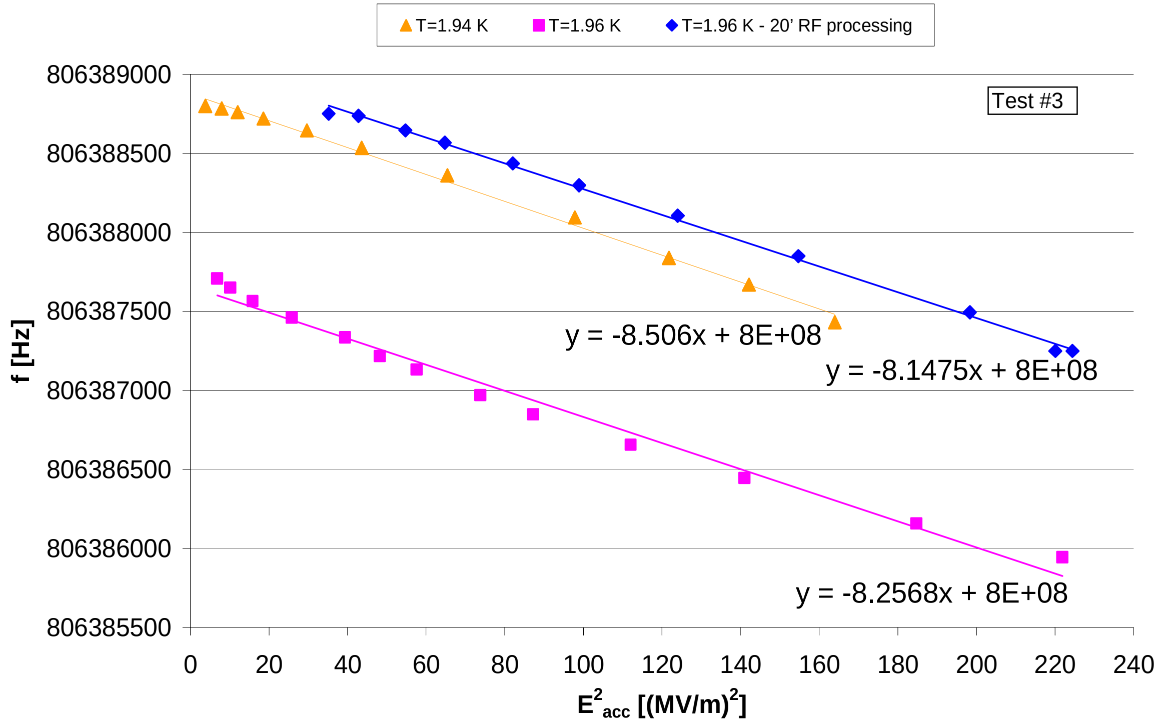
SNS cavities' fixture





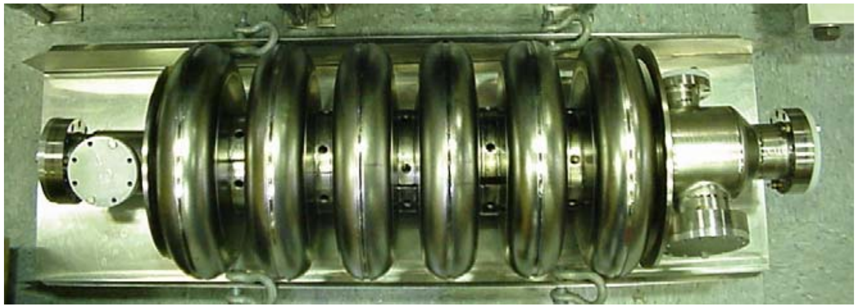
The cavities tested in the VTA are supported in a titanium fixture with calculated spring constant of $5.43*10^5$ kg/m

β=0.61 cavity: experimental results



- Stiffening ring welded at 70mm from cavity axis
- Lorentz force coefficient: KL = -8.25 Hz/(MV/m)^2
- The test done on the π/6 mode, which has negligible field in the end cells, shows that there's no appreciable contribution from the unstiffened half end cells

β=0.61 cavity: calculation results



	No stiff	70mm stiff	80mm stiff	80mm+probe end cell stiff	127mm stiff
Fixed end	-2.89	-1.65	-2.07	-1.98	-2.63
Fixture	-7.85	-7.0	-7.45	-7.45	-4.73
Free end	-31.1	-27.0	-24.4	-24.1	-6.85

- Good agreement with the experimental value
- Stiffening the end half cells does not improve significantly the value of KL
- Prototype configuration: iris's thickness = 1/16"

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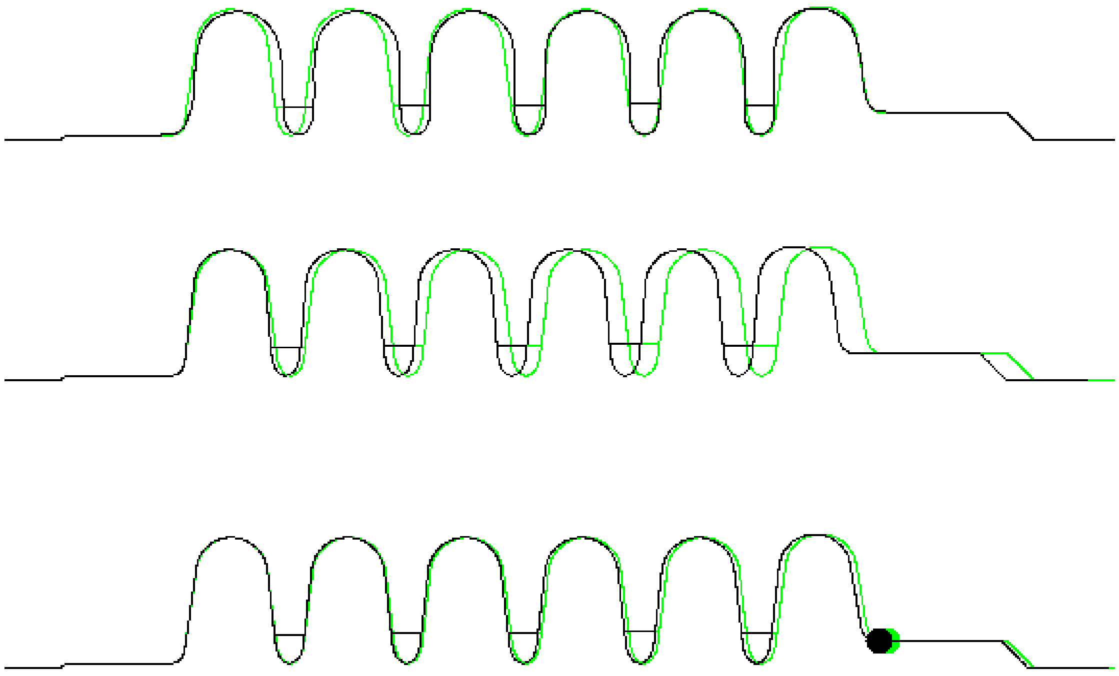

Fixed end

Free end

Simulated fixture

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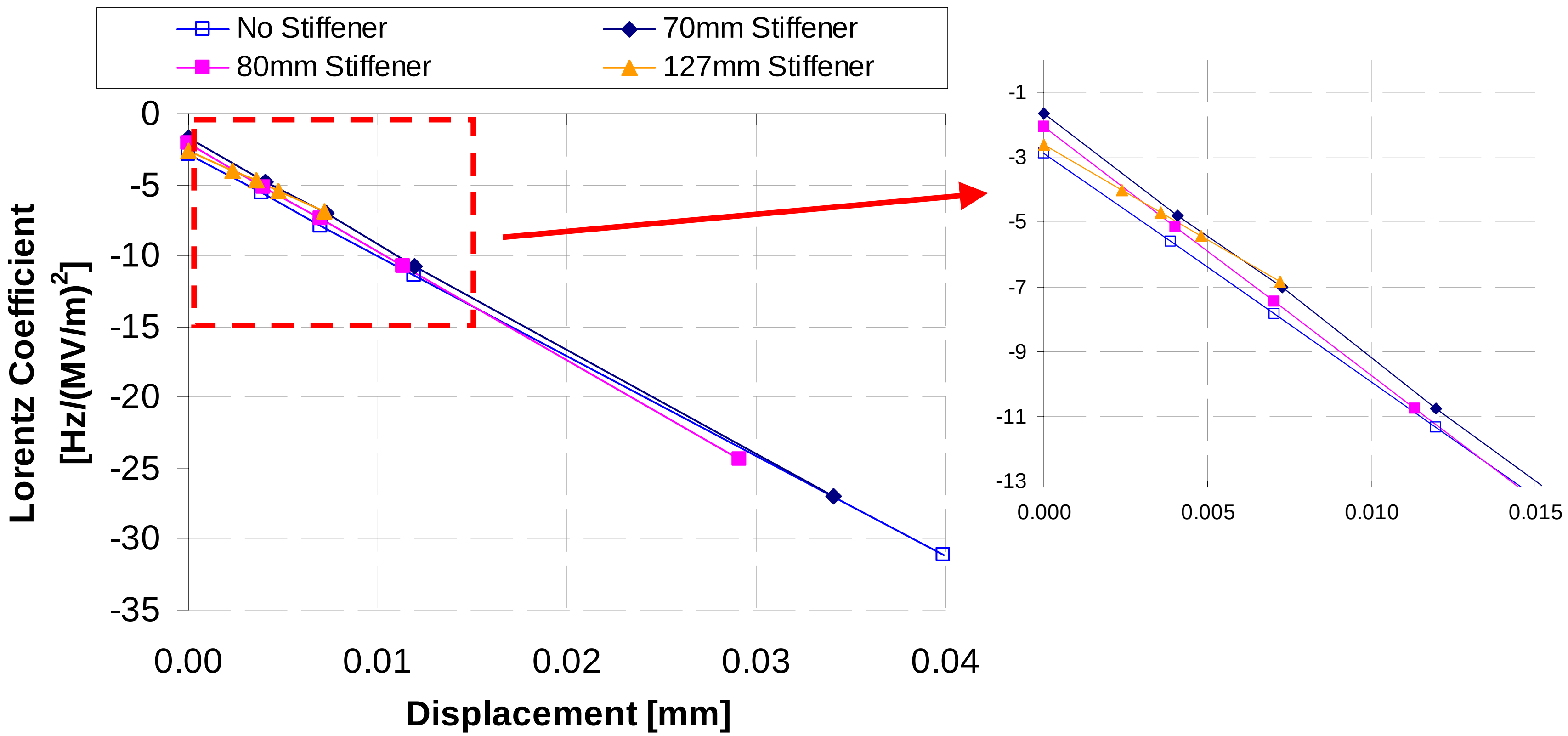
Lorentz force coefficient vs. overall cavity displacement (different boundary conditions)



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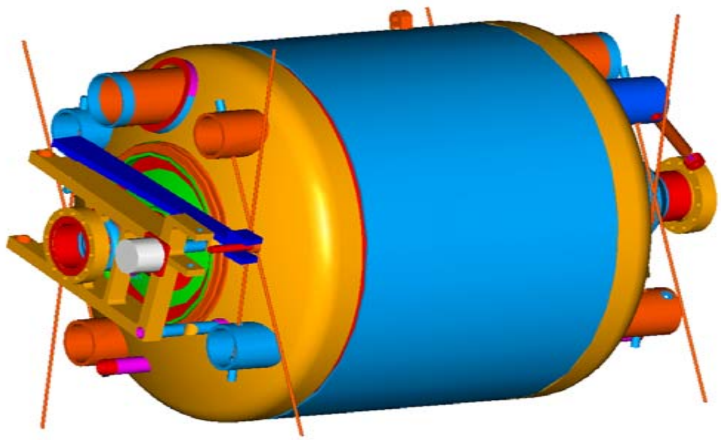
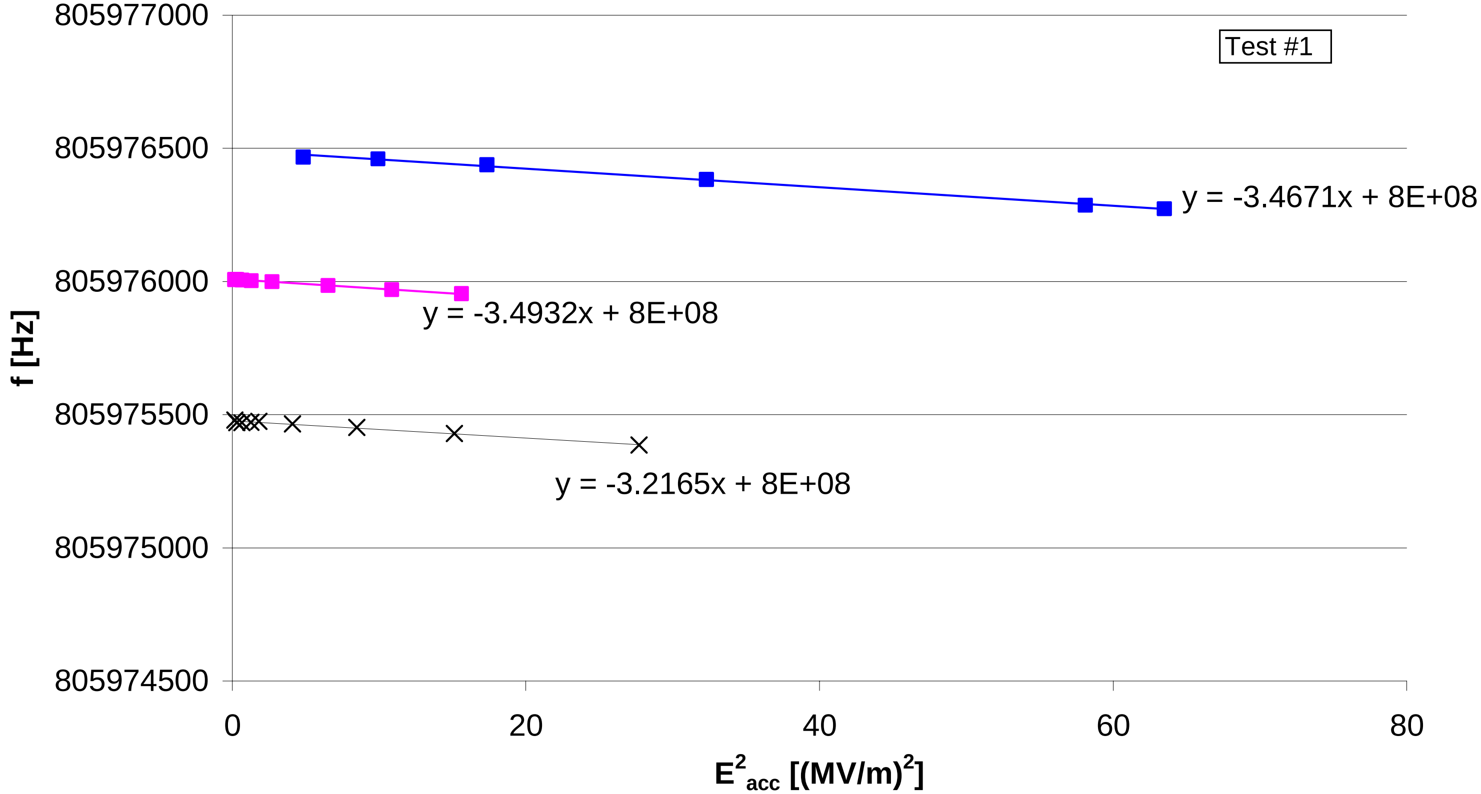


- The stiffness of the He vessel + Tuner has been evaluated and is 1.895×10^6 kg/m
- The Lorentz force coefficient computed with this configuration is $-3.55\ Hz/(MV/m)^2$
- The He vessel will be added to the cavity and KL will be measured. This work is in progress

Production cavity: 1/8" iris thickness

- Stiffening ring at 80mm: $KL = -3.68\ Hz/(MV/m)^2$
- No stiffening ring: $KL = -4.03\ Hz/(MV/m)^2$

β=0.81 cavity: experimental results



- Stiffening ring welded at 80mm from cavity axis
- Lorentz force coefficient: KL = -3.5 Hz/(MV/m)^2

β=0.81 cavity: calculation results

	No stiff	*80mm stiff*	*127mm stiff*
Fixed end	-0.775	-0.43	-0.765
Fixture	-3.62	-3.5	-2.02
Free end	-12.15	-10.1	-2.68

- **Good agreement with the experimental value**
- **Prototype configuration: iris's thickness = 1/16"**
- **The calculations for the configuration with He vessel + Tuner gives a Lorentz force coefficient of –1.58 Hz/(MV/m)^2 while the unstiffened case yields –1.76 Hz/(MV/m)^2**

Production cavity: 1/8" iris thickness

- Stiffening ring at 80mm: KL = -1.54 Hz/(MV/m)2
- No stiffening ring: KL = -1.69 Hz/(MV/m)^2

Conclusions

- The model gives good agreement with the experimental results
- The results from the tests of the high beta cavity with stiffening ring at 127mm and the medium beta cavity in the helium vessel will give further confirmation of the calculation results
- The “boundary conditions” are strongly influencing in the value for the Lorentz coefficient
- For the high beta cavity, the need for stiffening rings has to be re-evaluated