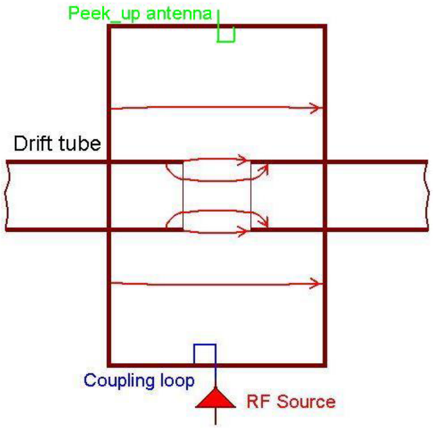
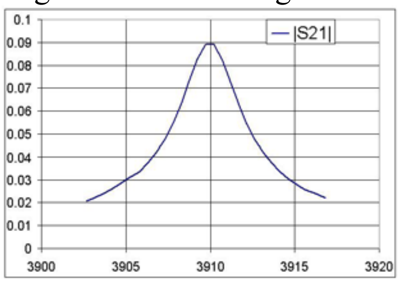
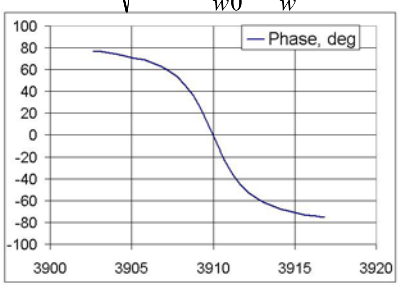
Resonance cavities



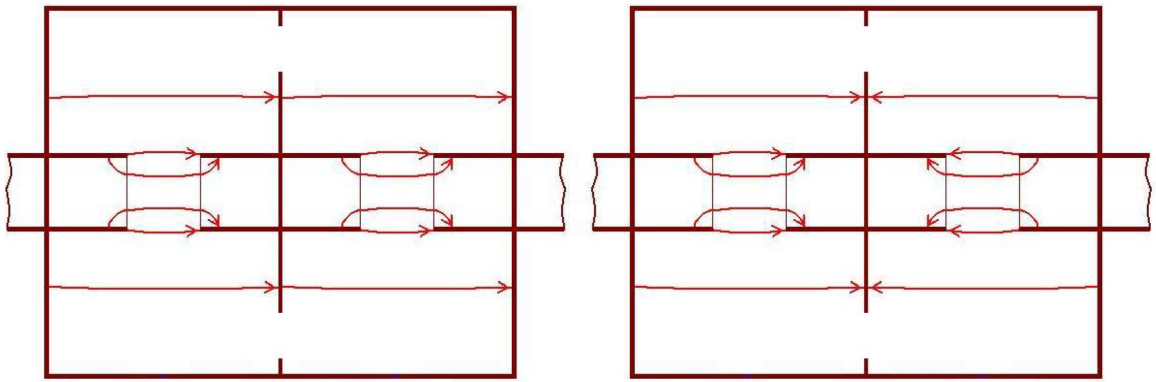
Single cell accelerating structure



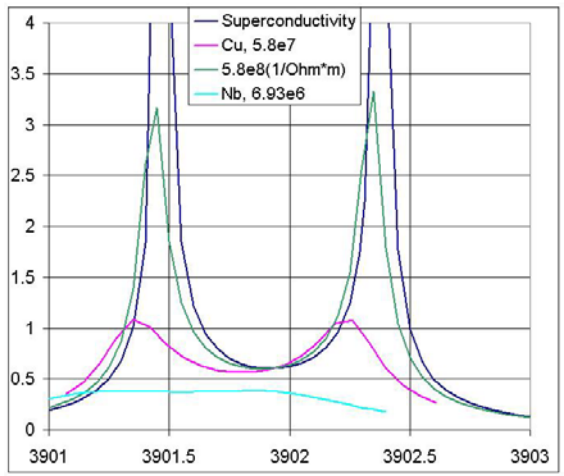
$$A = \frac{A0}{\sqrt{1 + Q^2\left(\frac{w}{w0} - \frac{w0}{w}\right)^2}}$$

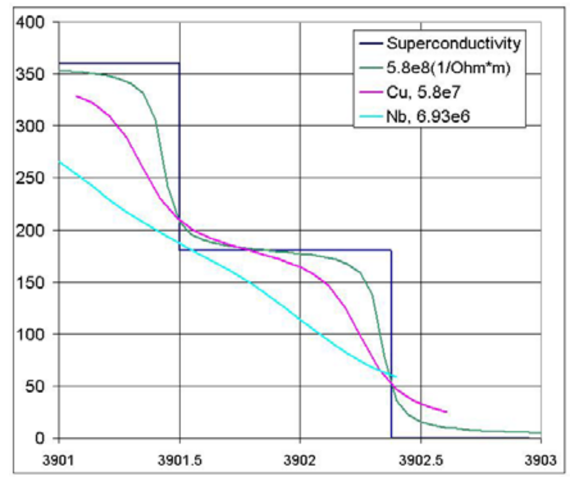


$$\varphi = arctg\,[Q(\frac{w0}{w} - \frac{w}{w0})]$$



0 mode Double cell accelerating structure π mode



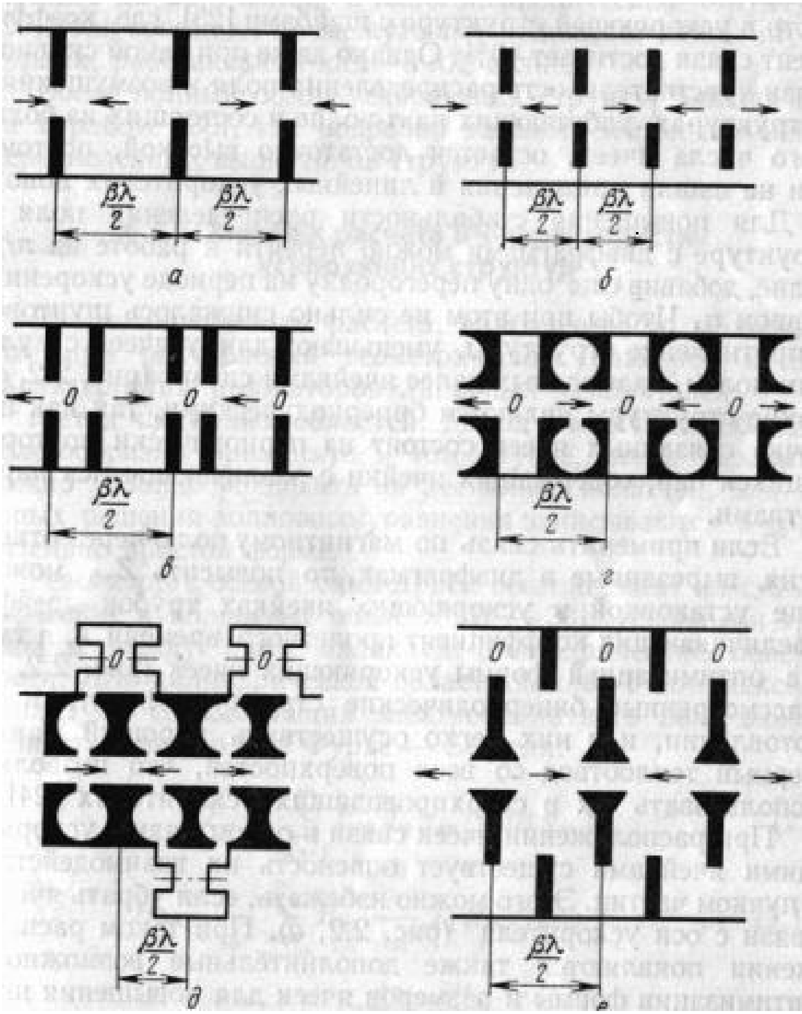


Resonance cavity accumulates electromagnetic energy supplied by RF Source. Banch spacing usually several times more than period of field oscillations.

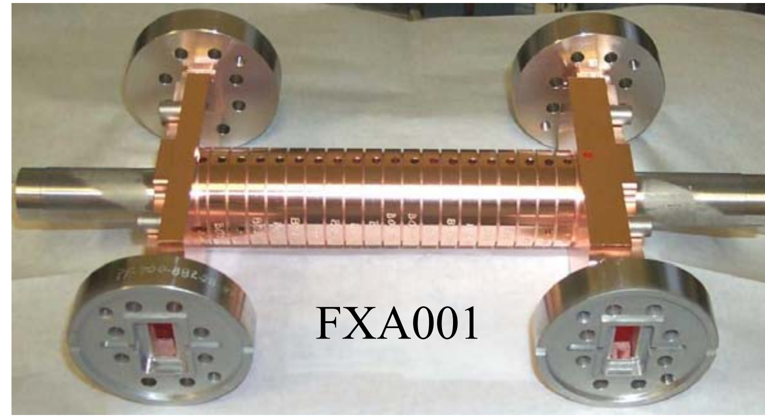
Resonance frequency shifted due to power loss in the cavity wall.

$$\frac{\Delta w}{w} = -\frac{1}{2Q}$$

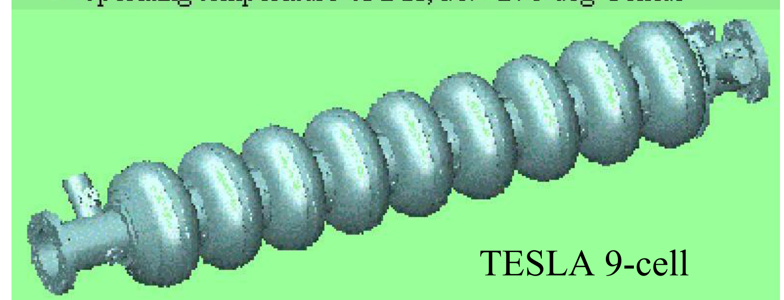
Standing wave and traveling wave accelerator structures.

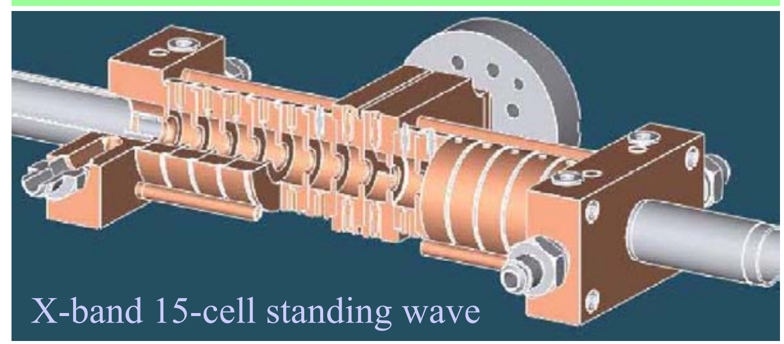


Different types of accelerating structures.

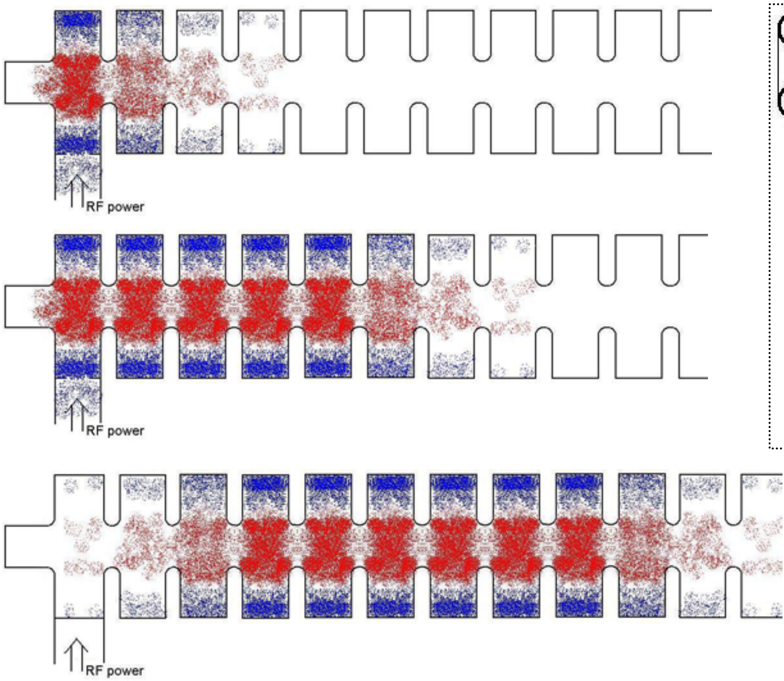


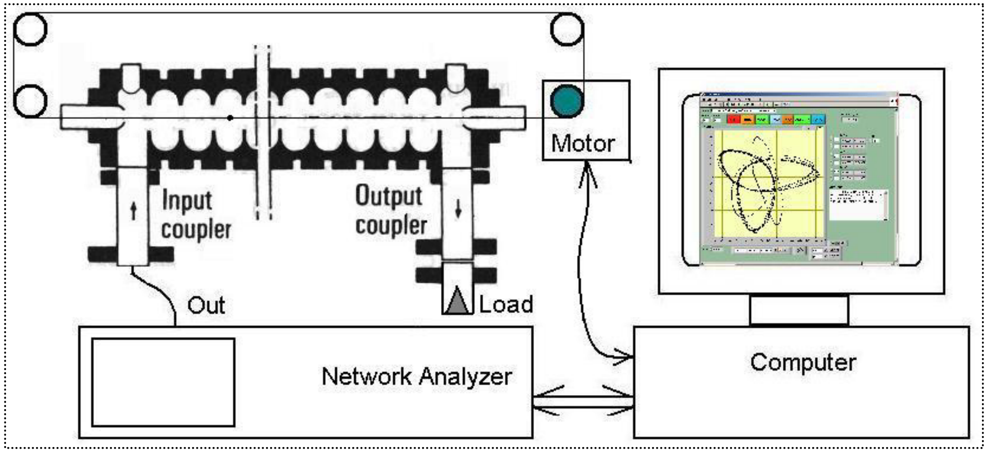
- superconducting accelerating structures
- operating temperature of 2 K, i.e. -271 deg Celsius





RF tuning of traveling wave accelerating structures.





Energy propagation in periodical structure.

Phase velocity **v** of RF field is equal to velocity of beam. In case of electrons **v** ≈ **c** – velocity of light.

Group velocity – energy propagation velocity depends on coupling between cells and mode type.

In traveling wave structure should be adjusted phase of the electric field in the axes and minimized reflected wave.

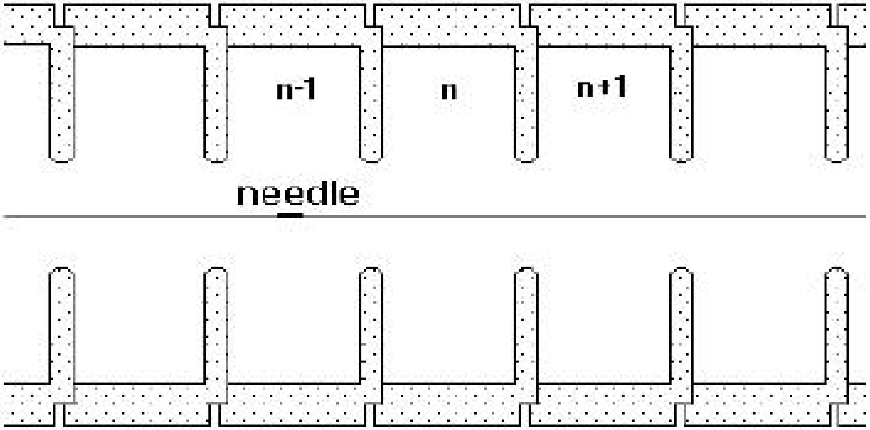
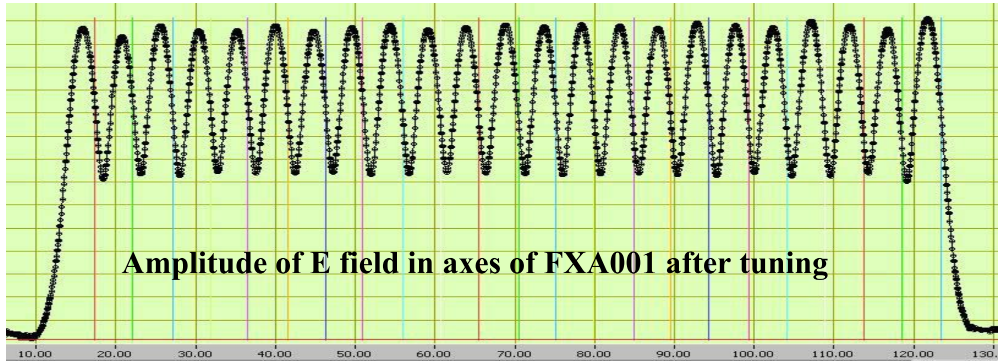
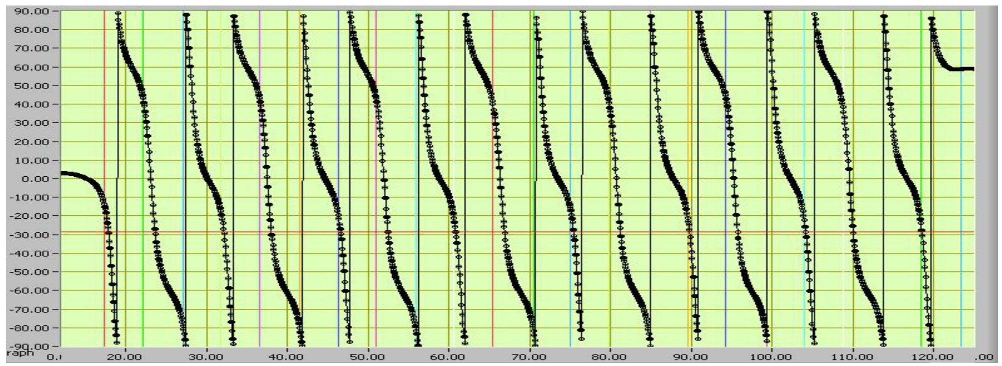


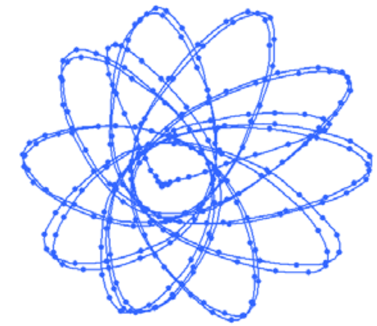
Figure 2.1. Bead-pull measurement.

$$2P(\vec{\Gamma} - \vec{\Gamma}_0) = -jw[\alpha_E \varepsilon \vec{E}^2 - \alpha_H \mu \vec{H}^2]$$

RF tuning of traveling wave accelerating structures FXA001.

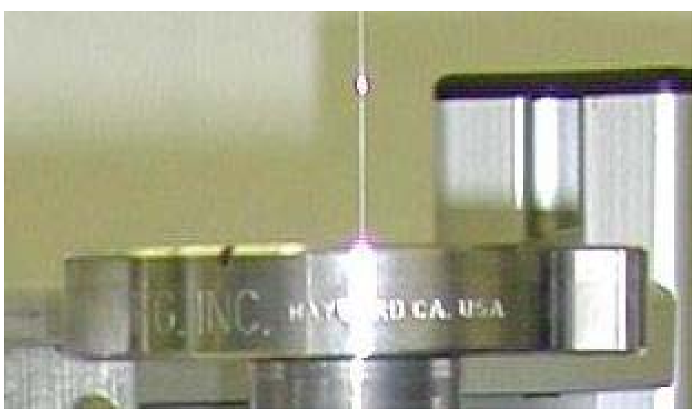


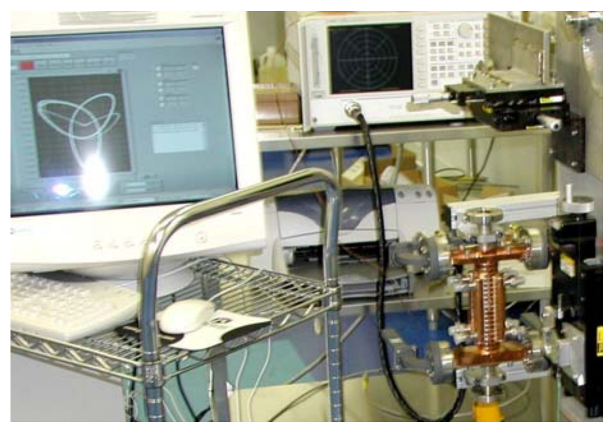


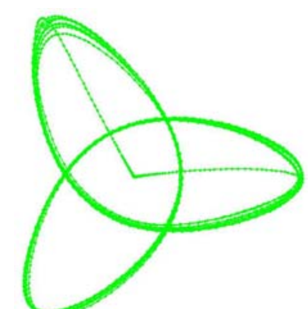


Before tuning

After 2 steps of tuning

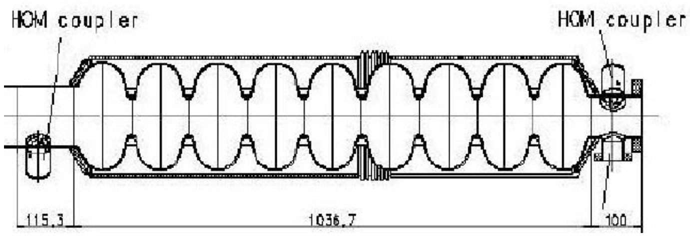




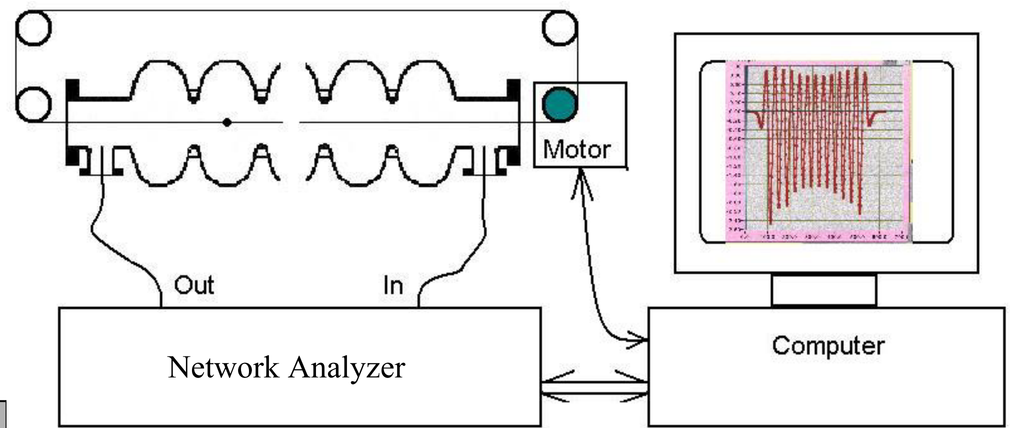


After tuning

RF tuning of standing wave accelerating structures.



TESLA 9cell superconducting Nb cavity



Small perturbation theory, Slater formula:

$$\frac{\Delta w}{w} = -a\frac{E^2}{\Xi} + b\frac{H^2}{\Xi}$$

Coefficients a and b depends on shape, material and orientation of perturbation body. For spherical body:

$$\frac{\Delta w}{w} = -\alpha\frac{V}{\Xi}[\varepsilon_0\frac{\varepsilon-1}{\varepsilon+2}E^2 - \mu_0\frac{\mu-1}{\mu+2}H^2]$$

For metallic sphere, $\varepsilon=\infty$, $\mu=0$:

$$\frac{\Delta w}{w} = -\alpha\frac{V}{\Xi}[\varepsilon_0 E^2 - \mu_0\frac{H^2}{2}]$$

Some different technique for bead pull in standing wave case:

- for each position of bead calculation of the frequency corresponding to max|**S21**|.

- tracking of phase, calculation of the frequency corresponding to phase(**S21**)=const.

- frequency F=const, measurement of phase for each position of bead.

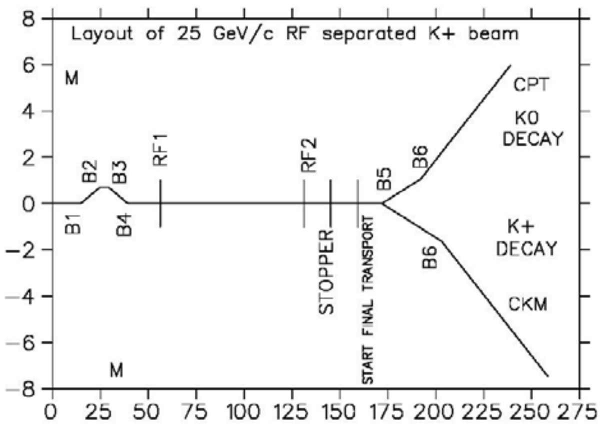
Tuning procedure includes:

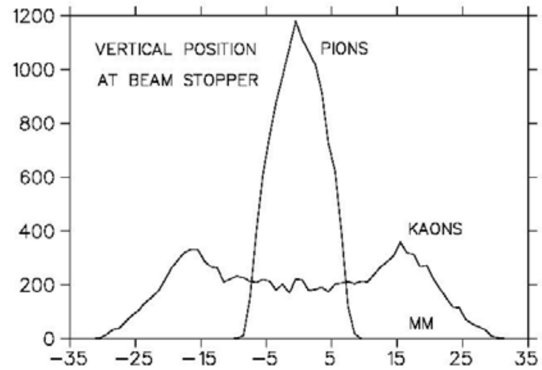
1) bead-pull measurements and calculation of field distribution

2) tuning of each cell frequency by deforming of the cell

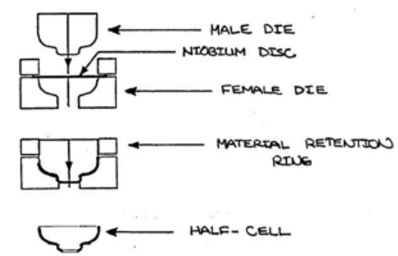
3) go to step 1) if necessary

CKM cavity

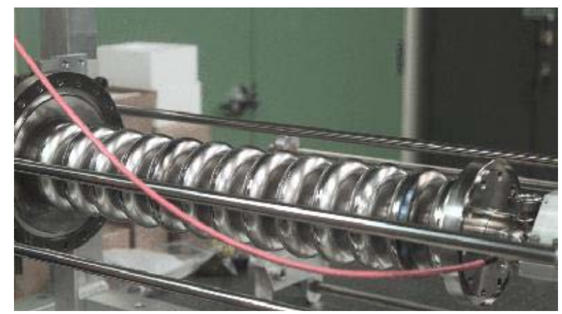




y Coordinate of Pions and Kaons at the Stopper



Die for deep drawing.



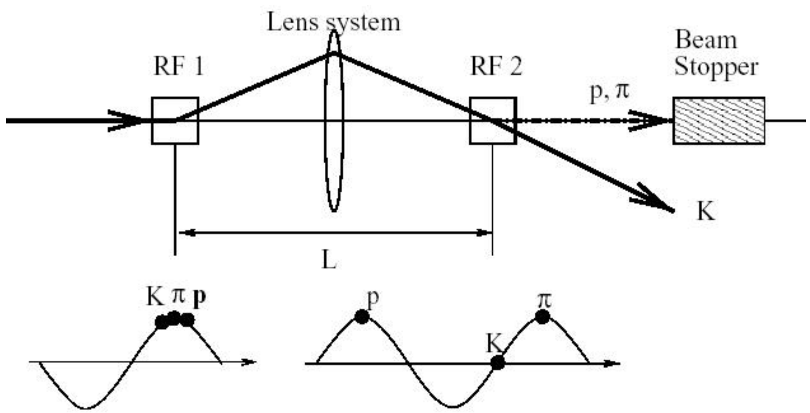
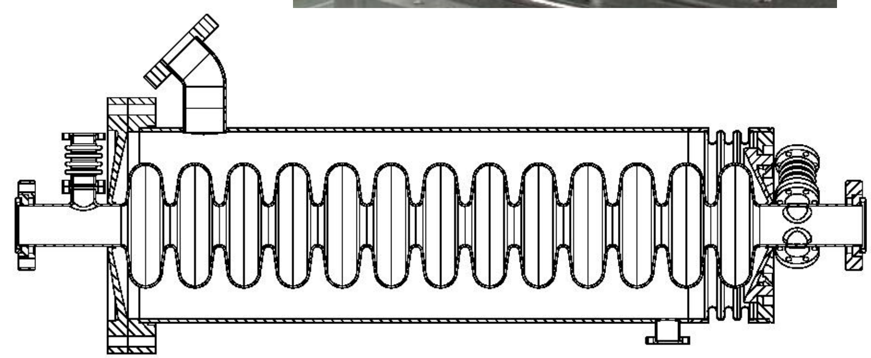


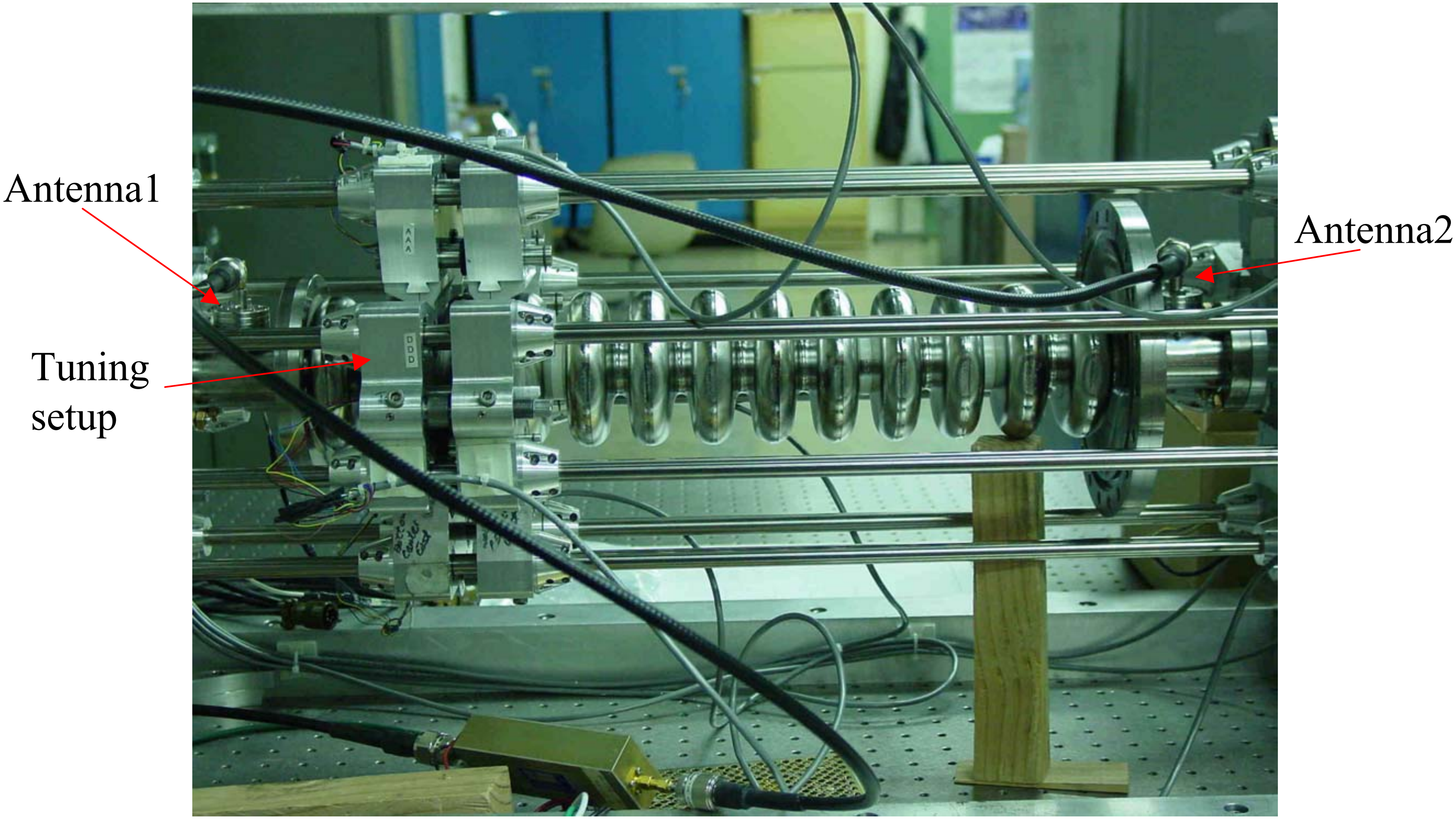
Figure 1: Kaon beam separation.

The phase slip between pions and kaons is given by:

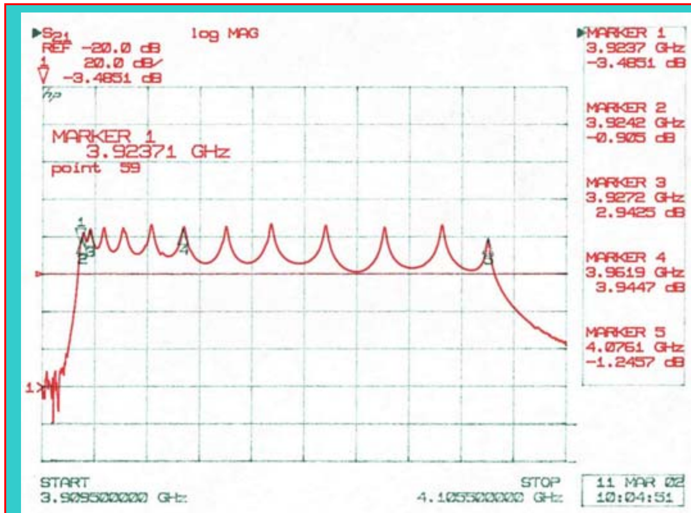
$$\Delta\phi = 2\pi\ f\ L\,\frac{1}{c}\left(\frac{1}{\beta_K} - \frac{1}{\beta_\pi}\right),$$



RF tuning setup for CKM cavity.



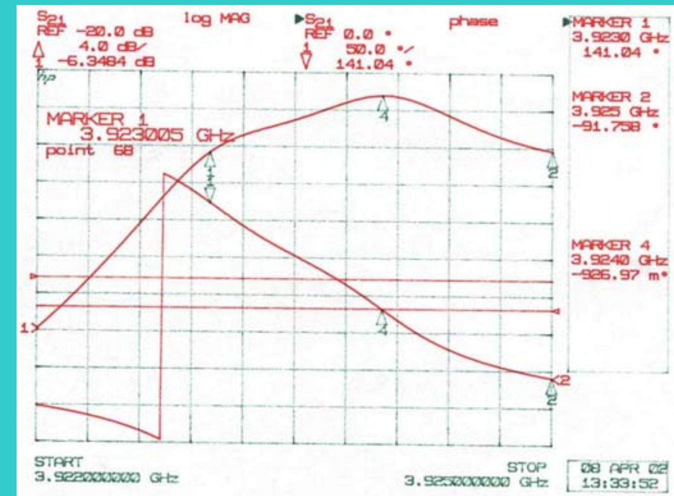
RF properties of CKM cavity.



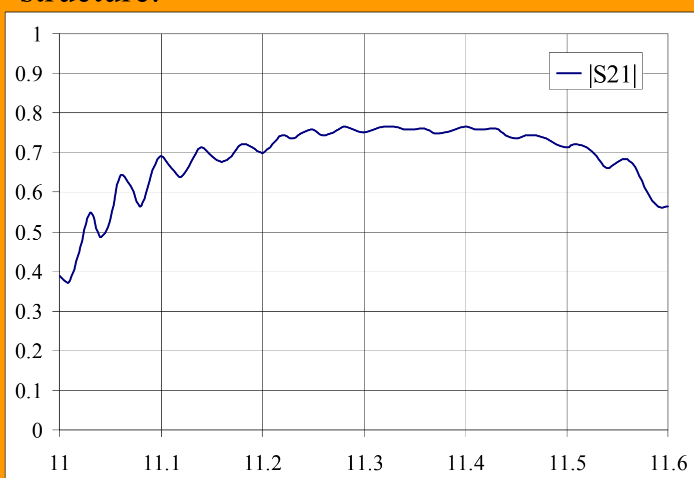
Transition coefficient S21 measurement for CKM cavity.

Operating mode is π mode. For π mode group velocity is very small.

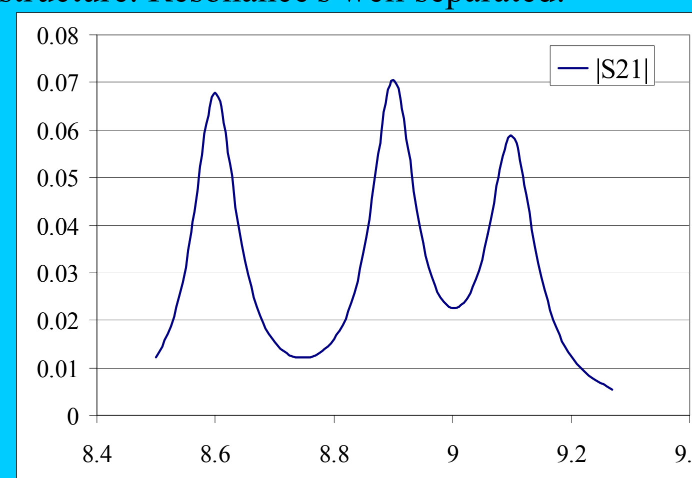
Spacing between π and π -1 is very small: dF=1.1MHz.



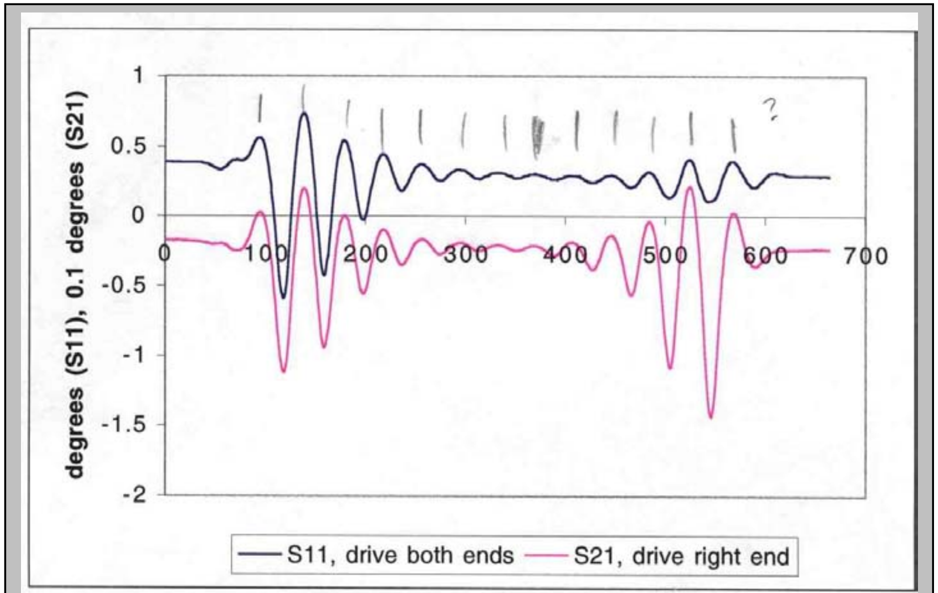
Transition coefficient S21 for traveling wave structure:



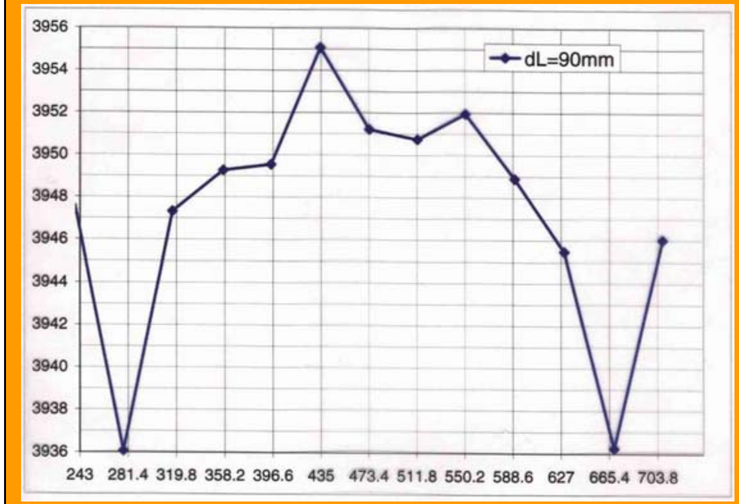
Transition coefficient S21 for standing wave structure. Resonance's well separated:



RF tuning by plunger method of CKM cavity.

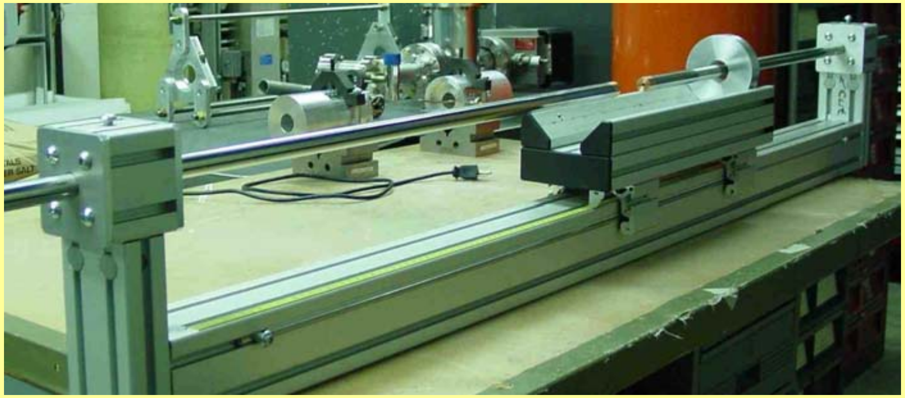


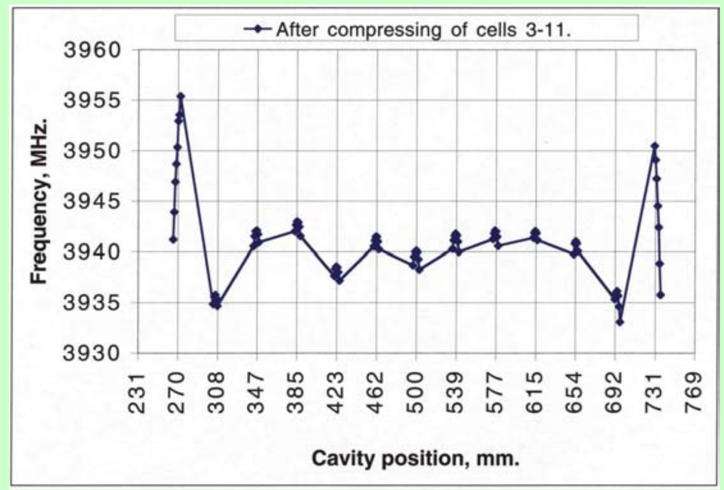
Field distribution was far away from design shape.



Plunger measurement data before tuning.

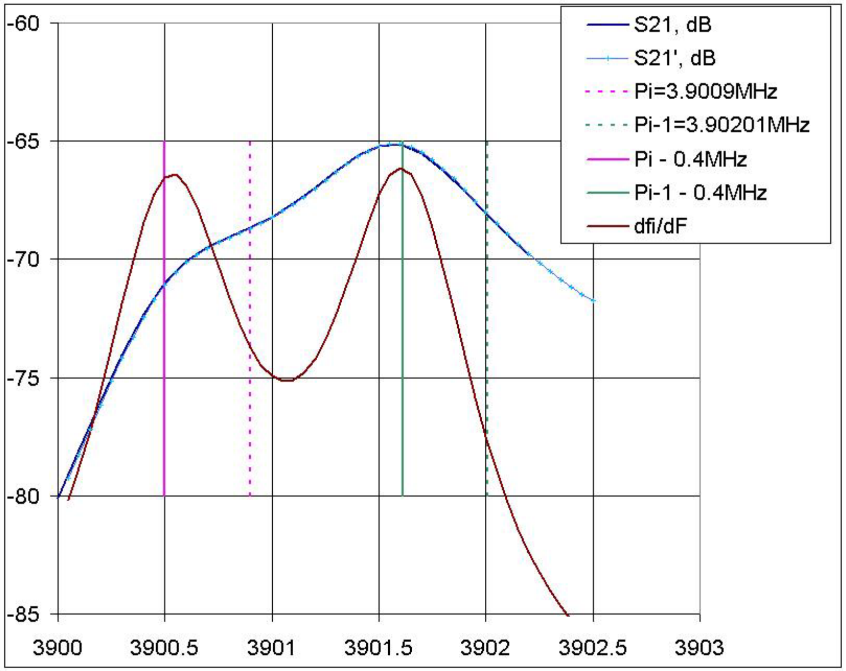
Plunger measurements used for single cell frequency estimations.





Plunger measurement data after tuning cells 3-13.

HFSS simulations of CKM cavity.



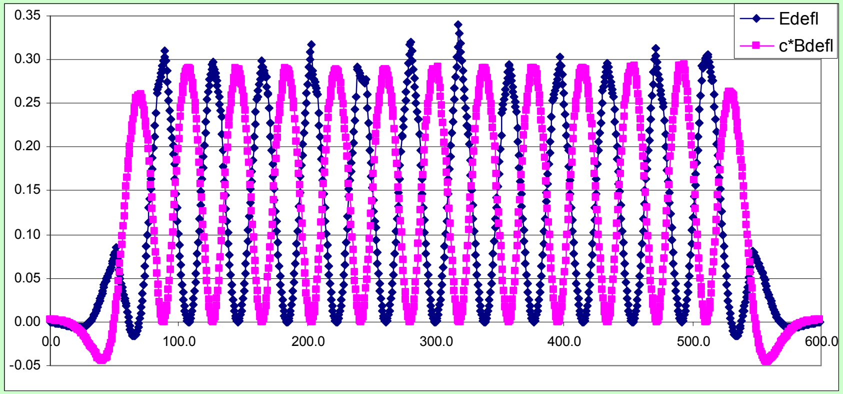
HFSS simulations of CKM cavity.

Dotted lines correspond to infinite conductivity.

Frequency shift due to finite conductivity 0.4MHz and in good agreement with formula: $\frac{\Delta w}{w} = -\frac{1}{2Q}$

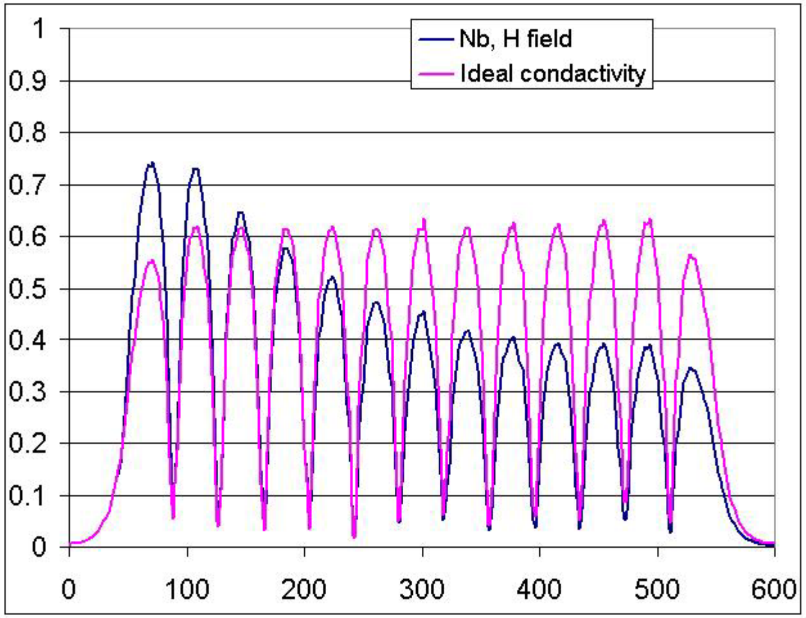
Tuning frequency can be calculated by two method:

- F = F_{max} - 1MHz
- calculation of derivative transition coefficient phase



Deflecting field calculations. Electrical and magnetical parts of deflection approximately same.

HFSS simulations of bead-pull.

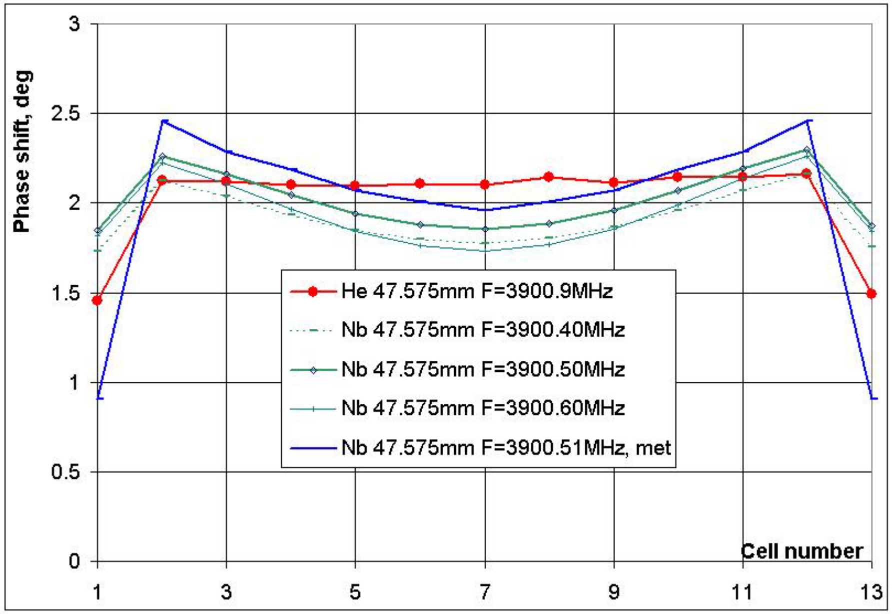


HFSS simulations of magnetic field in CKM cavity for the same geometry

For finite conductivity some slope in field distribution. The reasons is:

- Operating mode is π mode. For π mode group velocity is very small.

- Spacing between π and π -1 is very small: ΔF=1.1MHz about the value F/Q=0.8MHz. As a result mode mixing.



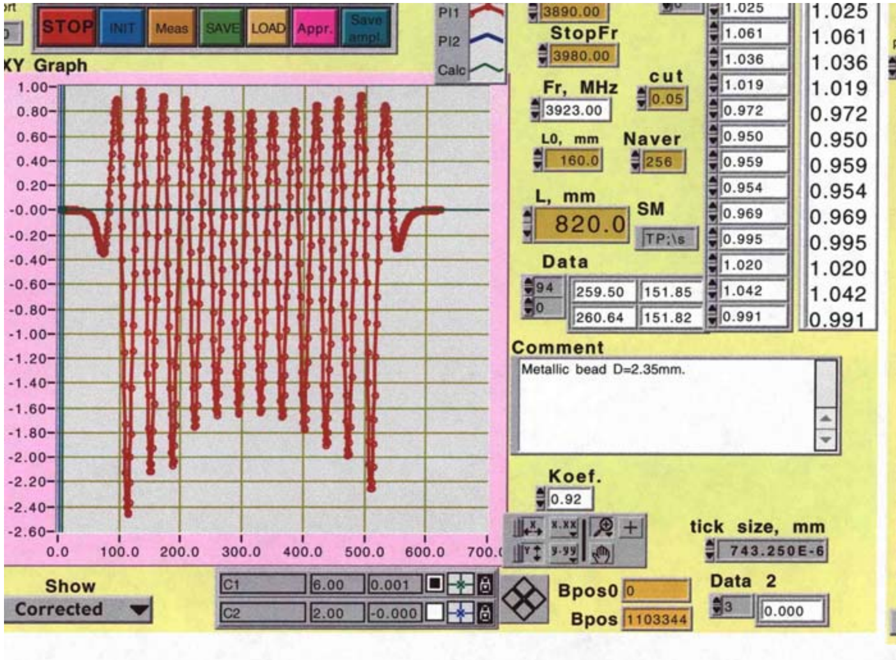
HFSS simulations of bead-pull in CKM cavity.

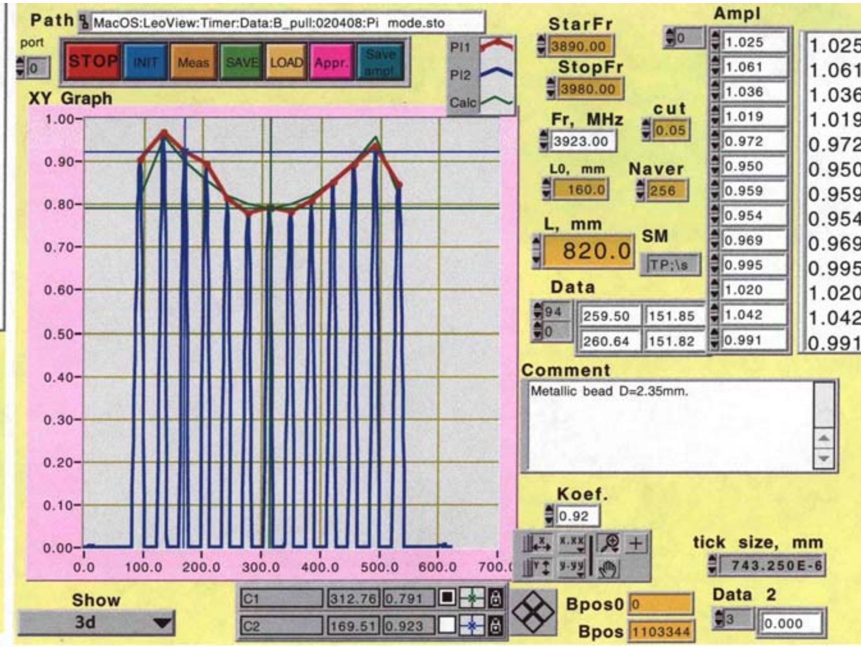
Transient coefficient S21 phase shift due to bead are symmetrical. The same picture we see for real measurements. Does not depend on exitation position.

1-st line (red) for infinite conductivity.

Green lines for paramagnetic bead.

Last line for metallic bead. Low field in end cells due to electric field in centers of these cells.





Last bead-pull measurement data.

Fields in the end cells should be decreased by ~15%.

Mechanical properties: the cavity is very soft. For π mode field distribution is very sensitive to geometry of the cavity.

Etching can change field distribution in the cavity.

Therefore it's reasonable to check field after transportation and etching.