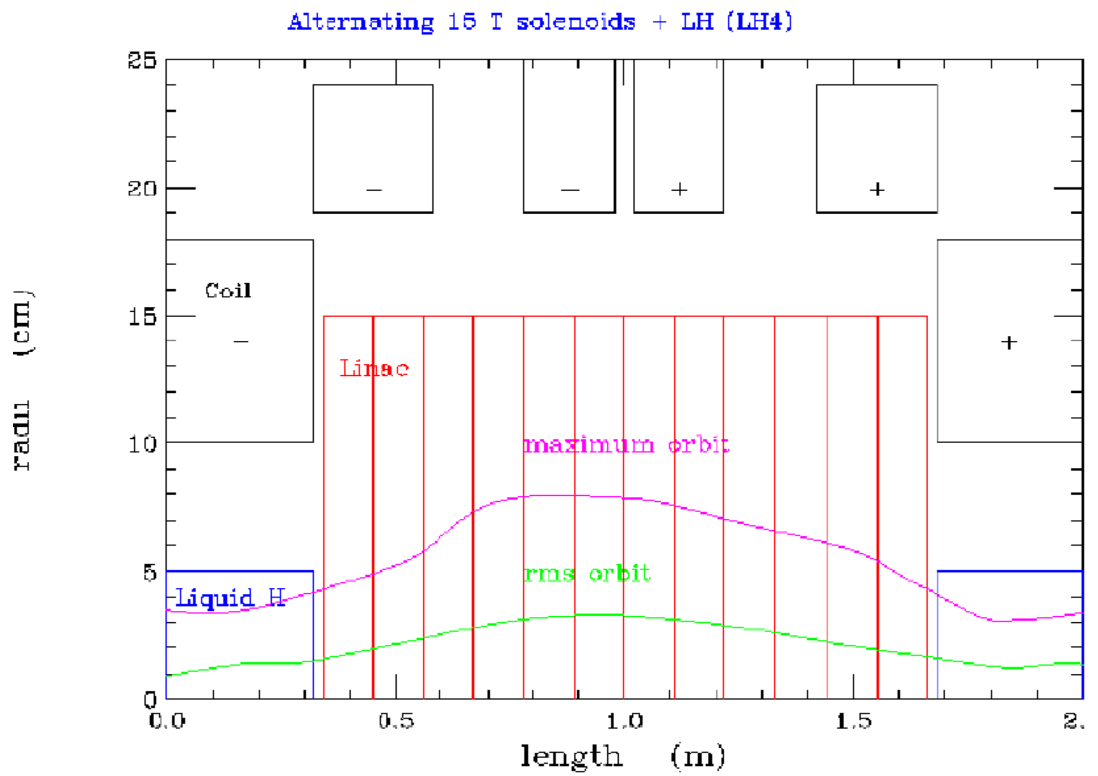
Longitudinal Cross Section of a Muon Cooling Module

Transverse ionization cooling: $$\frac{d\varepsilon_N}{ds} = -\frac{\varepsilon_N}{\beta^2 E}\frac{dE}{ds} + \frac{\beta\,\gamma\,\beta_f}{2}\frac{d\langle\theta_{rms}^2\rangle}{ds}$$

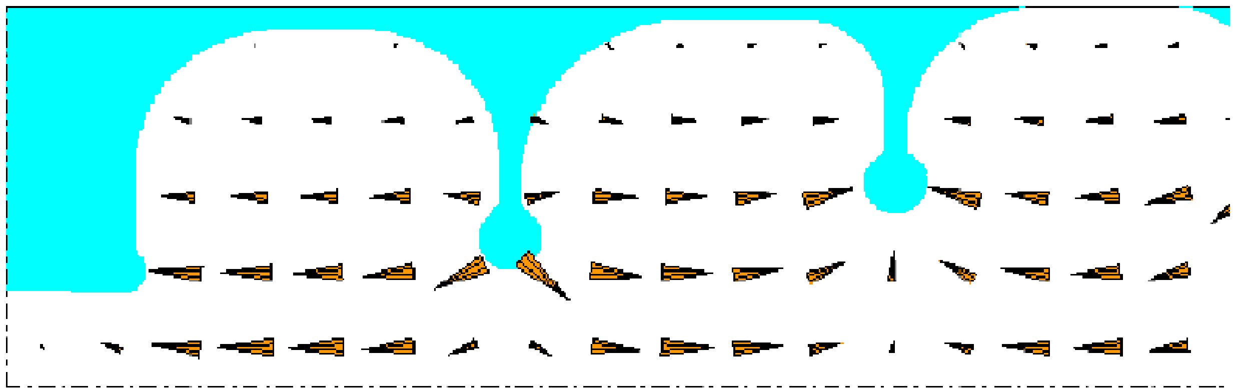


RF Specifications of the Cavity System

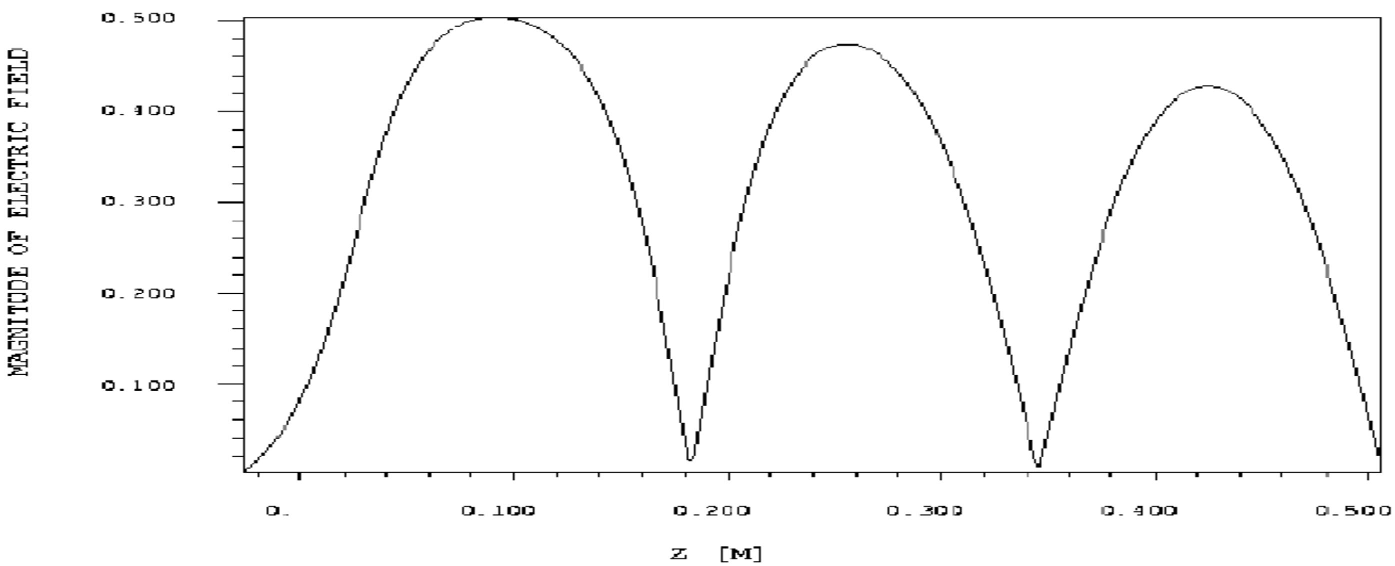
- **Cavity**
  - frequency (MHz) = 805
  - shunt impedance Zt^2 (MΩ/m) = 17.2
  - quality factor Q_o = 32800
  - filling time (μs) = 6.5
  - transit time factor = 0.76
  - power (MW/m) for 30 MV/m = 30
- **High power coupler**
  - critical coupling β = 1
- **Transition waveguide**
  - reflected power < 1 % of incident power
  - bandwidth > 1 % of 805 MHz

MUCOOL Cavity: Open Iris Standing Wave Structure (one half of the structure is shown)

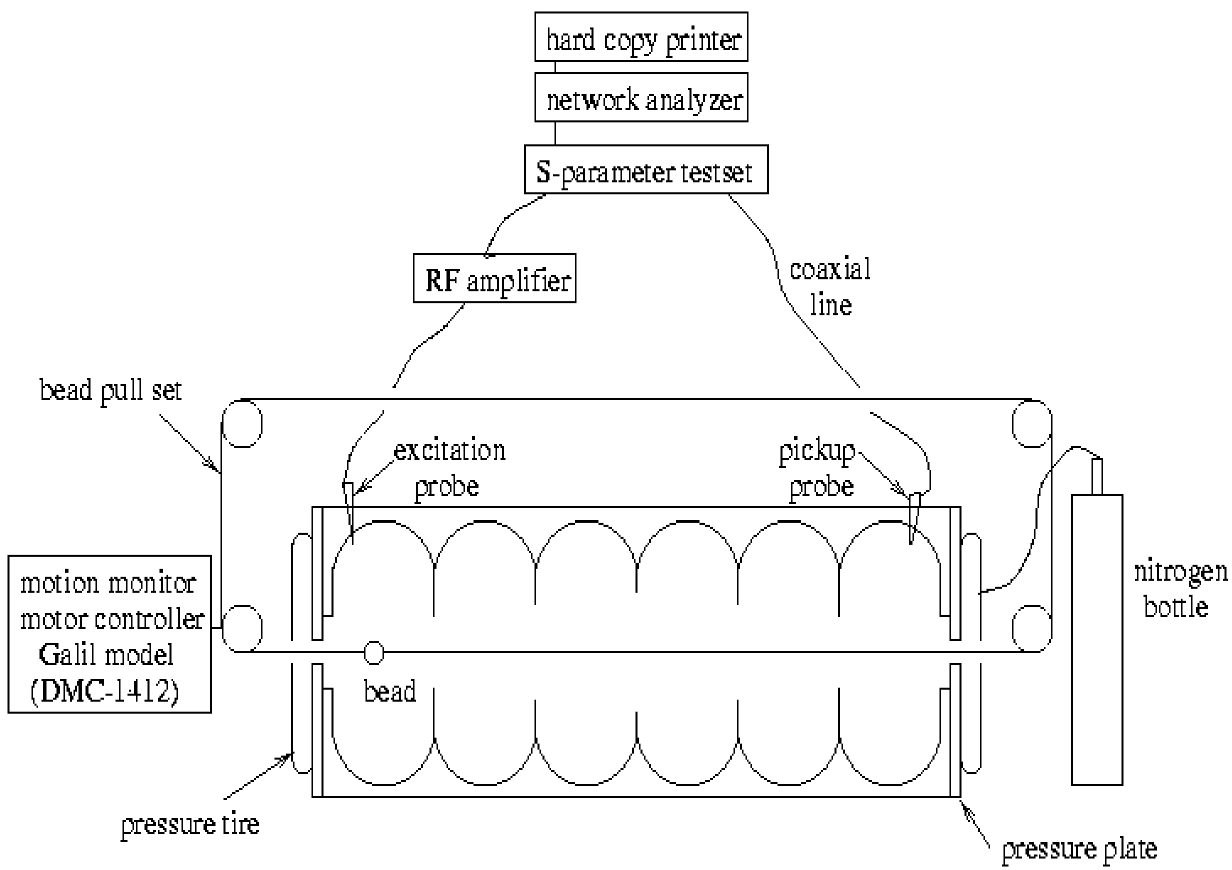
Acceleration π Mode



On Axis Electric Field

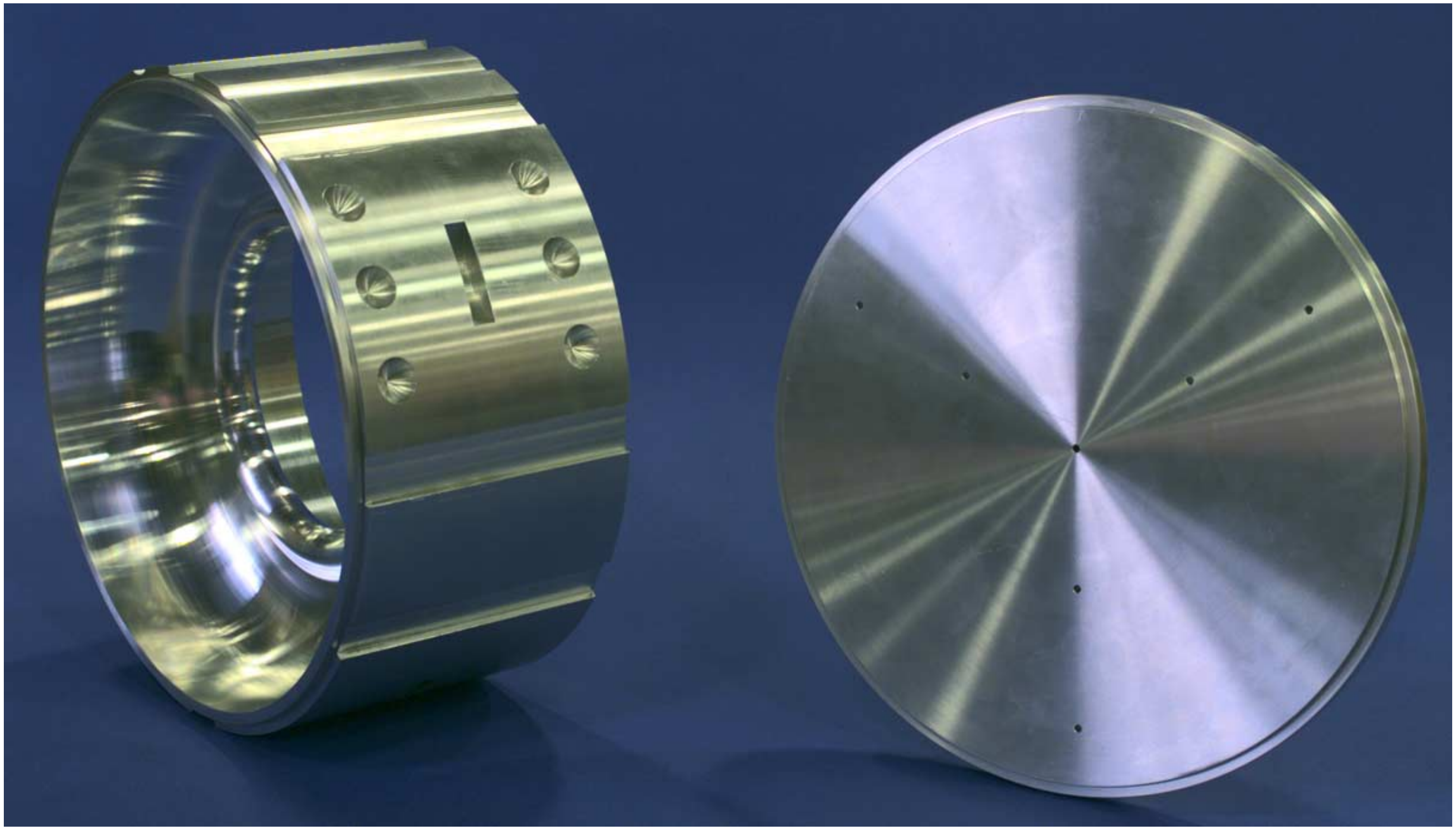


Schematics of Low Power Test Setup



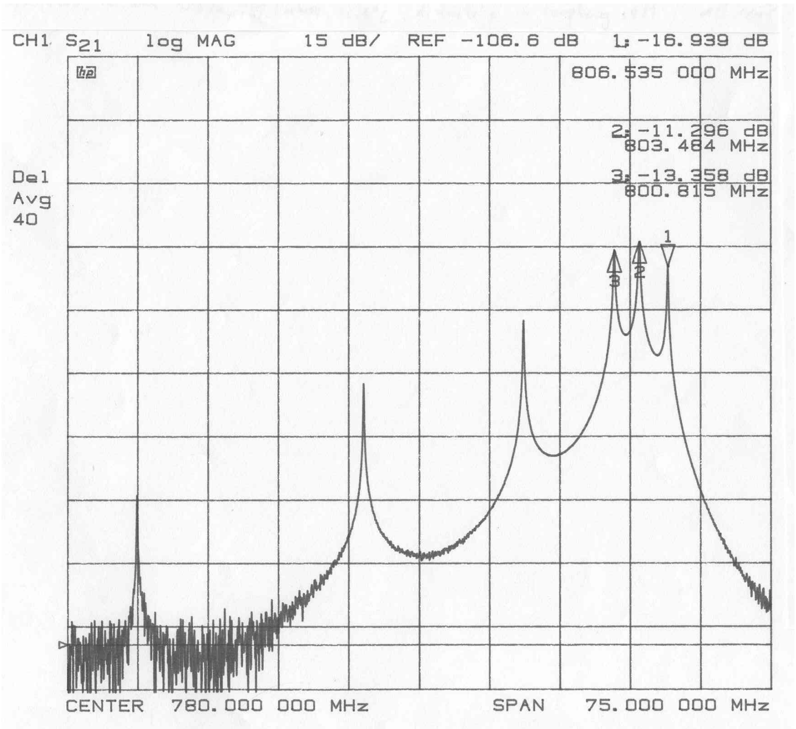
RF Cavity System (Aluminum Model)

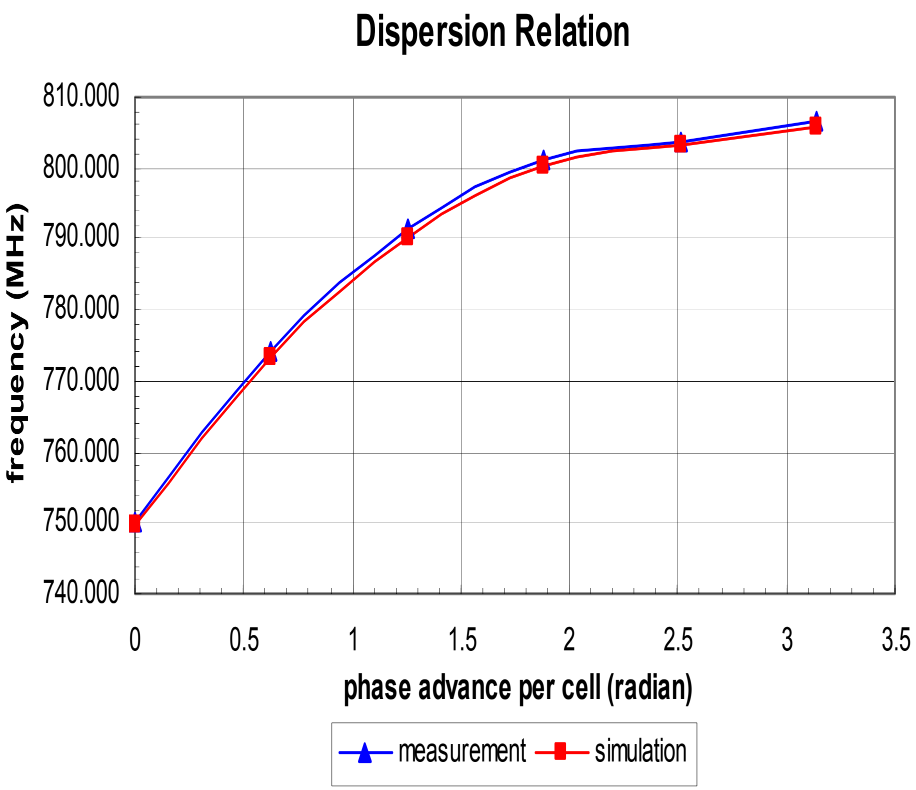
Two-Half Cell Aluminum Cavity



First Passband of TM Modes (Acceleration Modes) Spectrum

Transmission Amplitude vs. Frequency

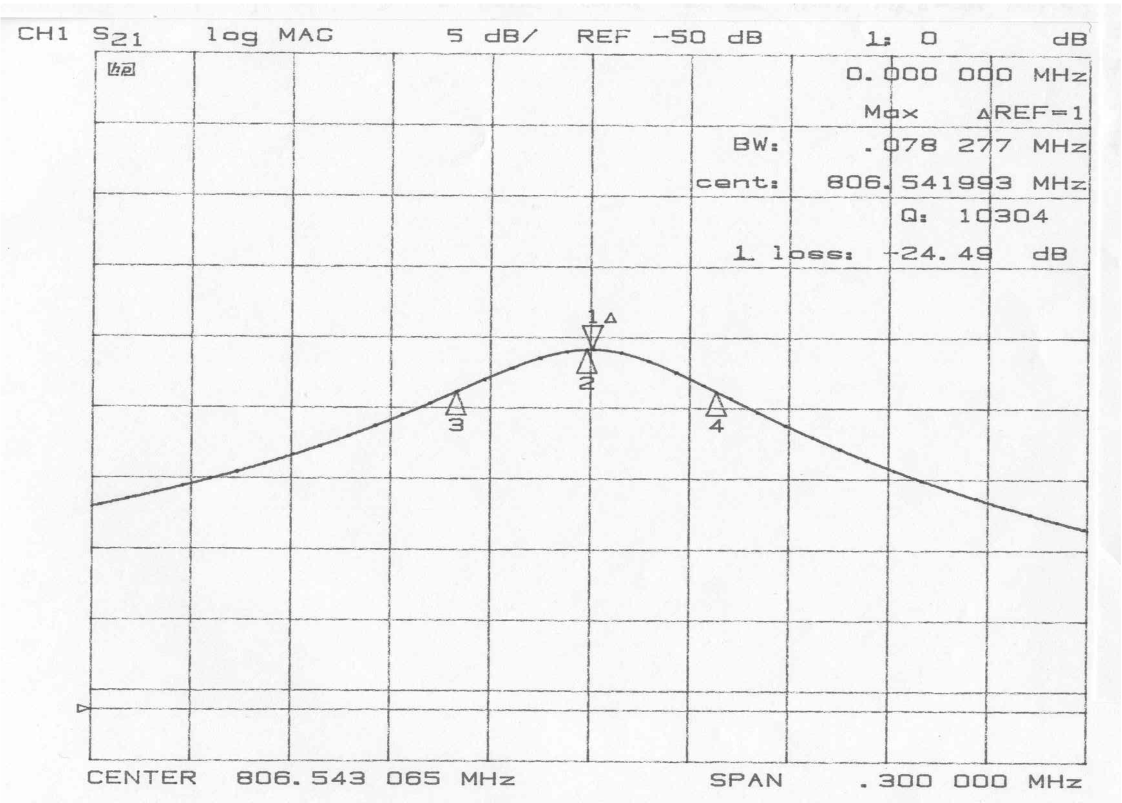




Disagreement: ~ 0.1% or 0.8 MHz

Q Measurement of the Acceleration π Mode

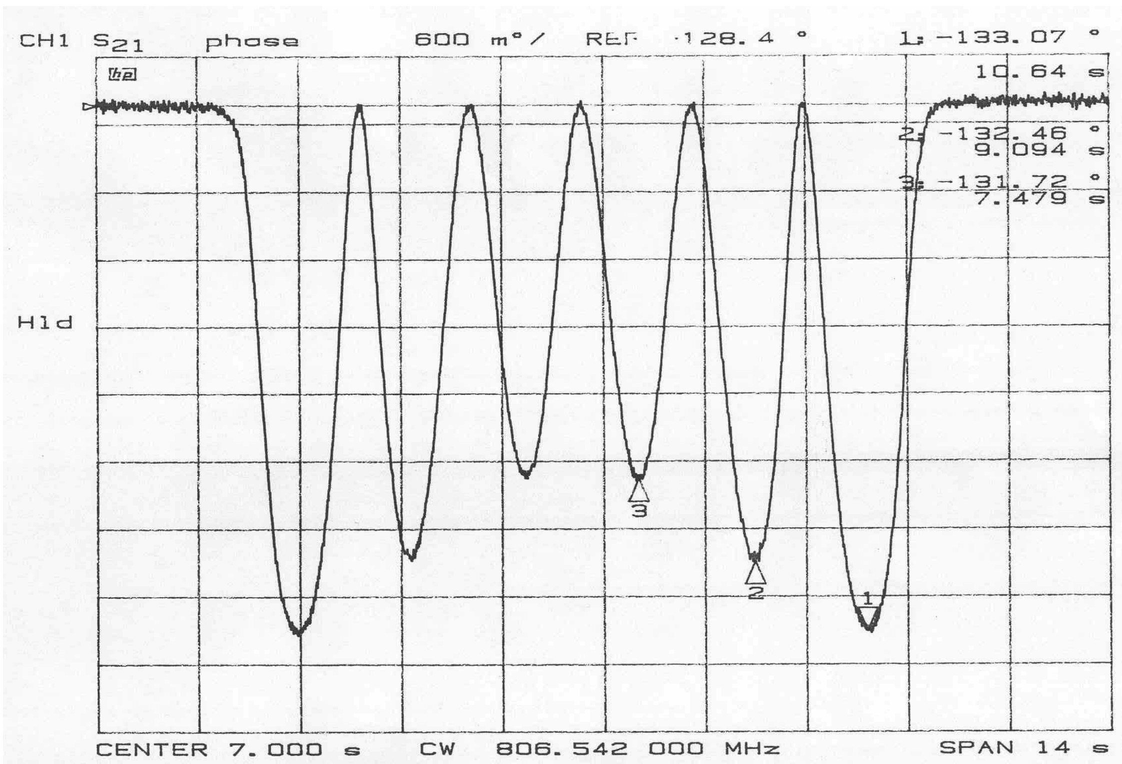
Transmission Amplitude vs. Frequency



Bead Pull Measurement of the Electric Field of the π Mode

Bead pull: $$\frac{\delta\omega}{\omega_o} = -\frac{3v}{4U_T}\left(\frac{\varepsilon_r - 1}{\varepsilon_r + 2}\varepsilon_o E^2 + \frac{\mu_r - 1}{\mu_r + 2}\mu_o H^2\right) \qquad \frac{\delta\omega}{\omega_o} \propto \delta\phi \propto E^2$$

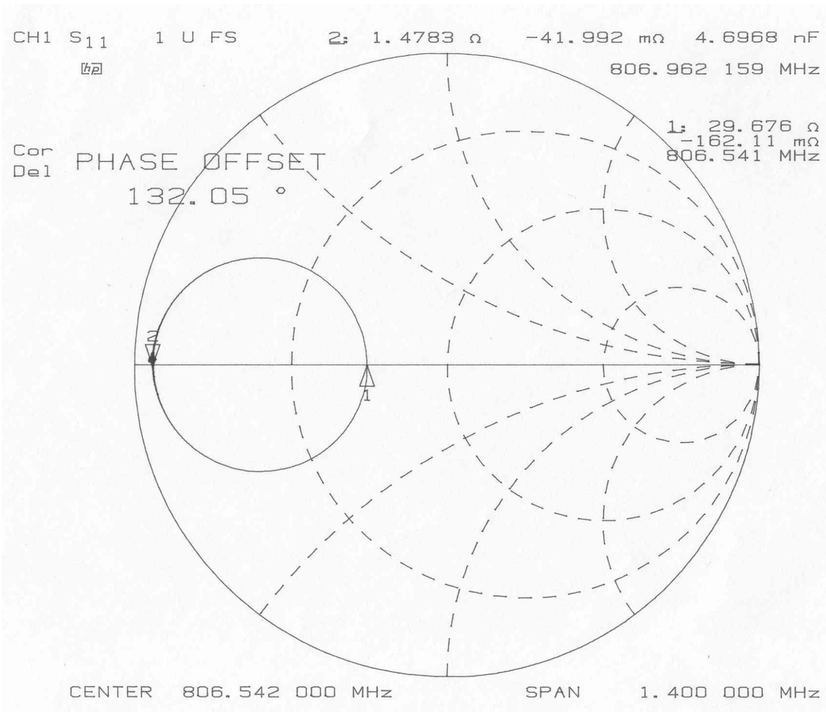
Transmission Phase vs. Time



Coupling Coefficient β Measurements

Smith chart: an example of external coupling measurement

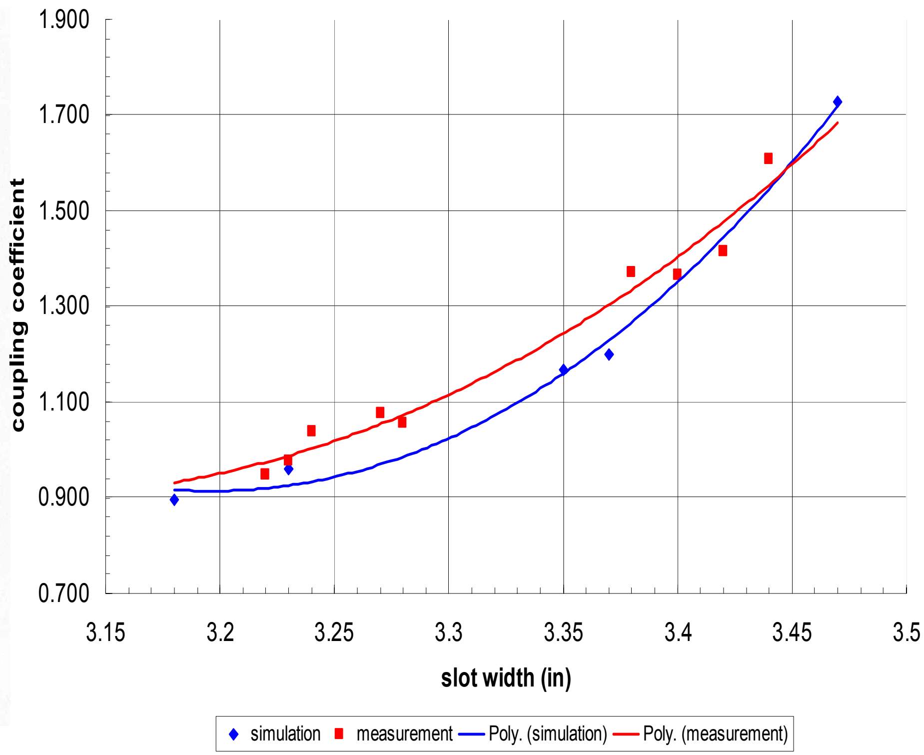
Reflection Coefficient



Measurement: $\beta = \dfrac{r}{50\Omega} = 0.594$

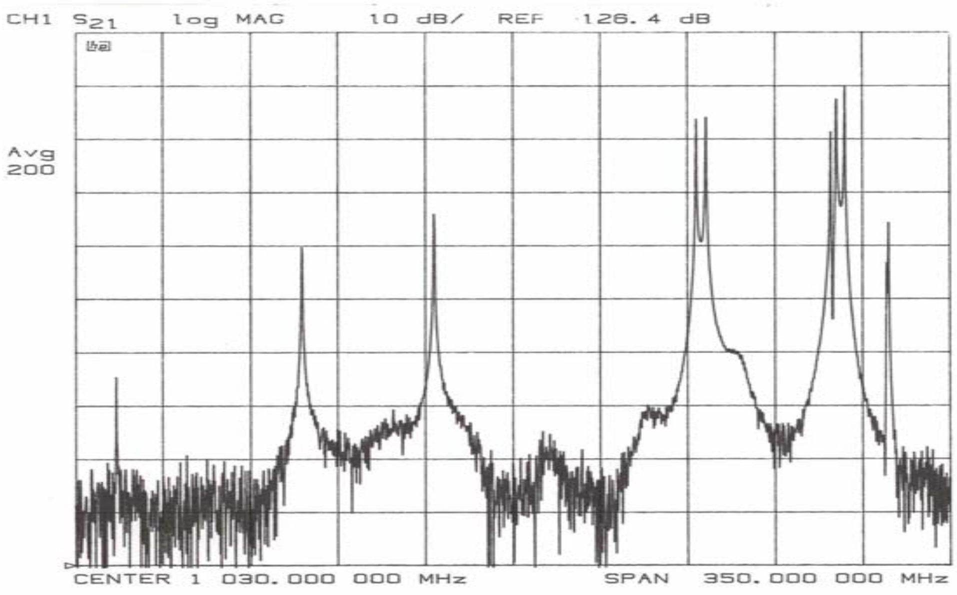
Simulation: $\beta = 0.584$

Simulation: $\beta = \dfrac{P_{ext}}{P_w} = \dfrac{(1/2)\int_s (\vec{E}x\vec{H})_l\, ds}{(R_s/2)\oint_s \vec{H}^2 ds}$

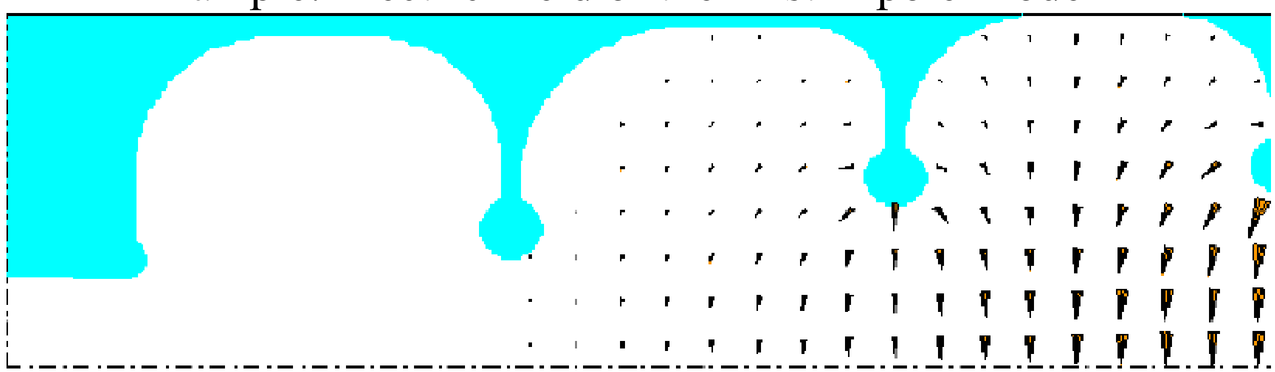


Disagreement: <10 %

Higher Order Cavity Modes: First Ten Dipole Modes



Example: Electric Field of the First Dipole Mode



Simulated frequency = 874.676 MHz   Measured frequency = 871.608 MHz

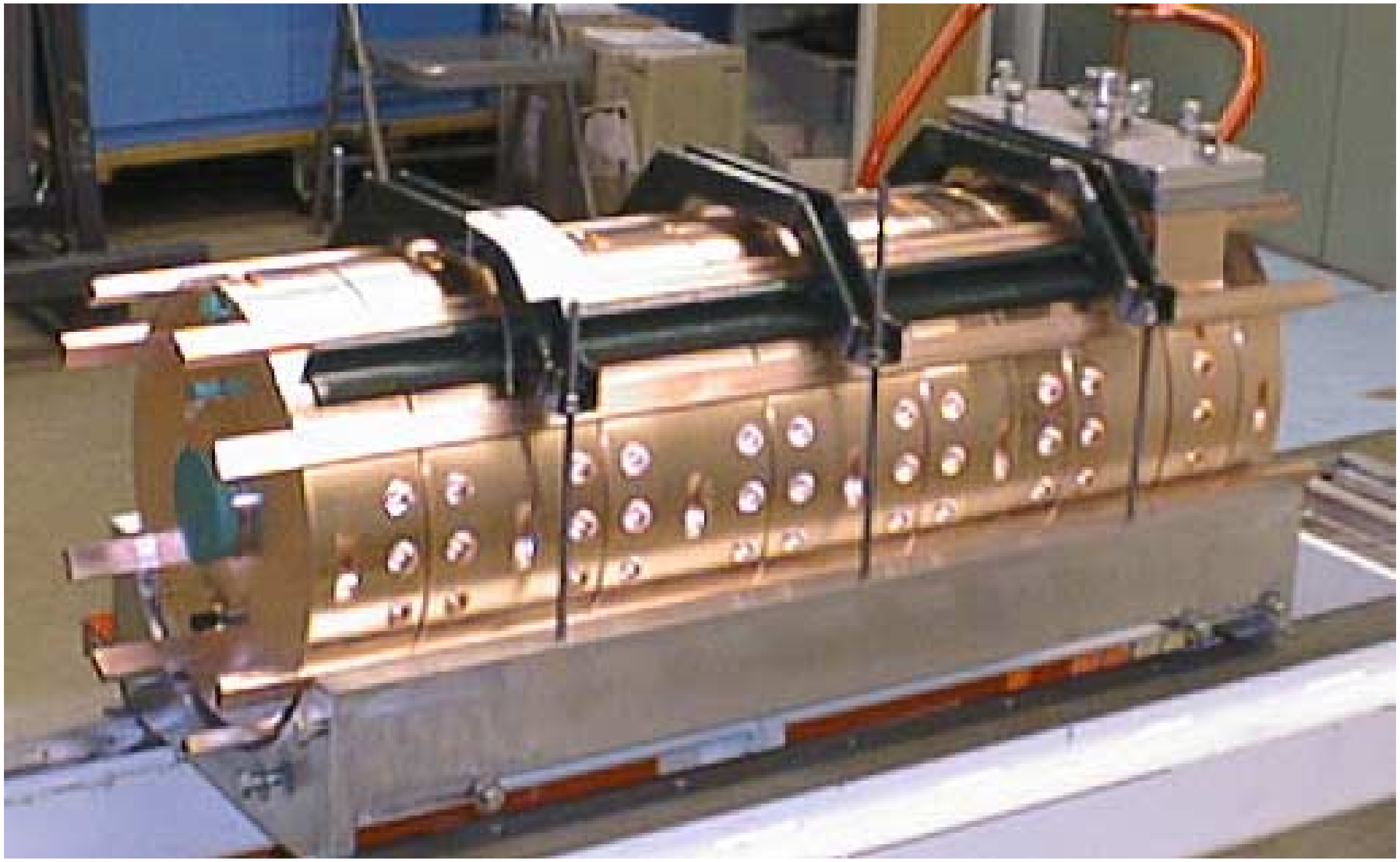
Comparison Between Simulations and Measurements

	measurement	simulation	disagreement
frequency (MHz)	806.542	805.687	0.1%
Q	10304	10650	3%
coupling coefficient	0.594	0.584	2%

On Axis Electric Field

cell	1	2	3	4	5	coupling
measurement	1.186	1.106	1.000	1.000	1.103	1.191
simulation	1.176	1.108	1.000	1.000	1.108	1.176
disagreement	2 % or less					

Copper Cavity After Brazing



Copper Cavity Measurements Before Tuning

frequency (MHz)	804.996
Q	16774
coupling coefficient	1.053

cell	1	2	3	4	5	coupling
field strength	1.156	1.093	1.000	1.000	1.086	1.102

-- Field level in coupling cell is off by ~ 6%.

-- Fine tuning corrects the discrepancy to 1% level.

Future Plans for High Power Test at Lab G

- First, condition cavity with superconducting solenoid turned off.
- Study high voltage breakdown in the cavity.
  - Measure incident and reflected klystron powers as a function of time.
  - Measure charges from the cavity.
  - Monitor vacuum behavior.
- Measure field gradients.
- Study the behaviors of the cavity and the superconducting solenoid when both are on.

Lab G: superconducting solenoid

805 MHz klystron

Low Power Test Of The MUCOOL High Gradient RF Cavity

Vincent Wu