56 MHz SRF Upgrade

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on behalf of Superconducting Accelerator and Electron Cooling Group

Collider-Accelerator Department

DOE RHIC S&T Review Meeting

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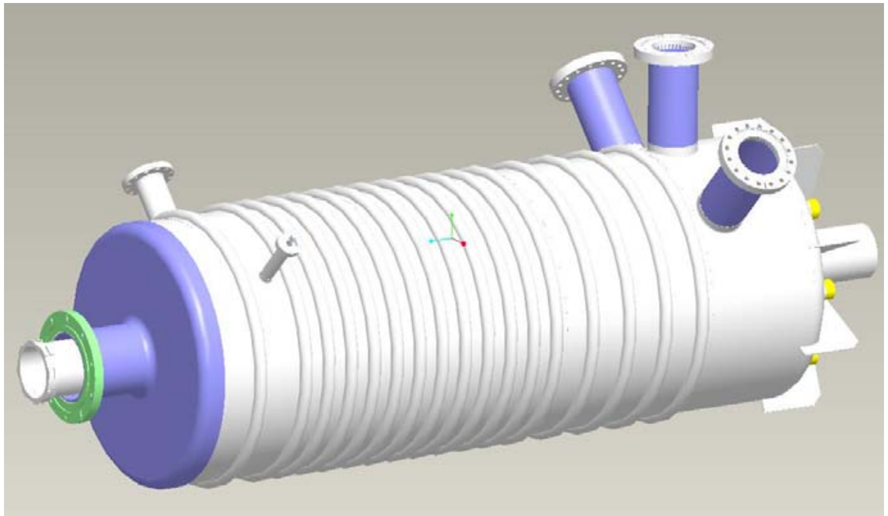
Outline

- Advantages of 56 MHz SRF cavity
- Status
- Summary

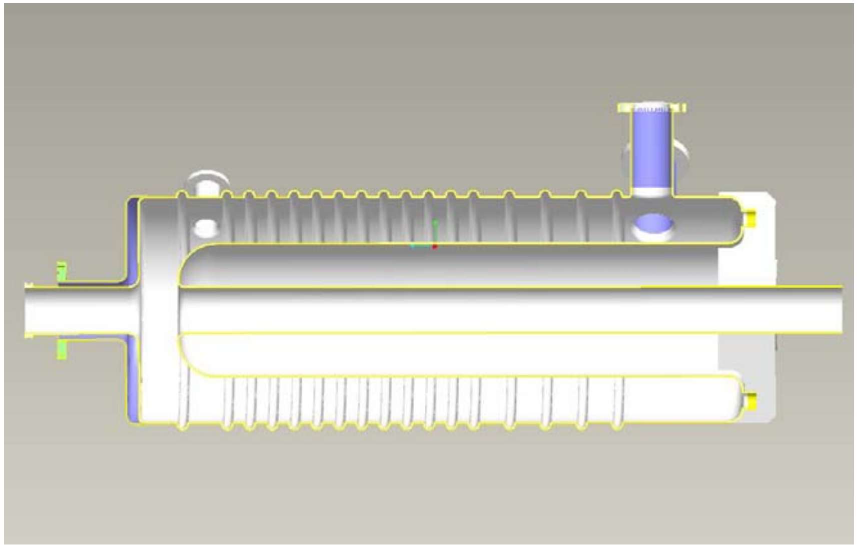
56 MHz SRF Storage Cavity for RHIC



- Beam driven SRF cavity
- Up to 2.5 MV on gap with one cavity.
- Cavity placed in common section, serve both RHIC rings.

- Prevent beam loss from bucket
- Allow adiabatic capture – improve longitudinal emittance.

Result: Double luminosity in vertex.



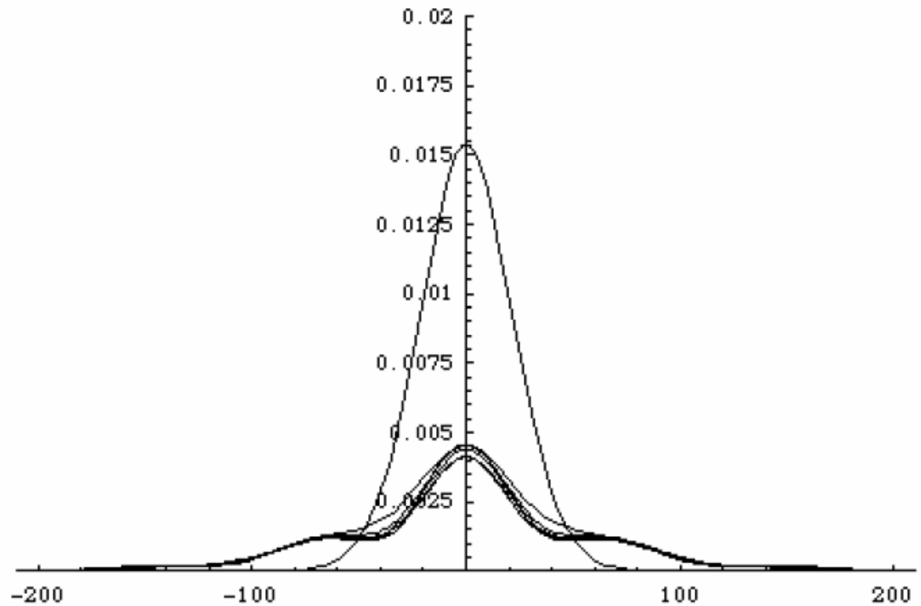
Advantages of 56 MHz SRF cavity for high luminosity

- A superconducting cavity provides a large voltage (2.5 MV) at a low frequency.
- Large bucket: 5 times larger than 197 MHz cavities
  - No lost beam (const. luminosity, less background)
  - Adiabatic re-capturing into 56 MHz
    - Does not increase longitudinal emittance in contrast to RF gymnastics with re-bucketing into the 197 MHz system
- Increase luminosity with and without cooling
- For low energy operation (critRHIC), 56 MHz SRF cavity can offer potential luminosity increase.

Average store luminosity per store

β*=0.8 m, without vertex cut, Alexei Fedotov, BETACOOL simulation

<L> @:	2h	3h	4h	5h
IBS (1e9)	2.9e27	2.7e27	2.5e27	2.3e27
IBS (1.5e9)	6e27	5.4e27	4.9e27	4.5e27
IBS (2e9)	1e28	8.9e27	8e27	7.4e27
With Stochastic Cooling (1.5e9, beta* = 0.5m, 2PUs, 6-12 GHz) M. Blaskiewicz, MAC08			~8e27	~7e27
Run-7 (1.1e9, achieved)				1.2e27



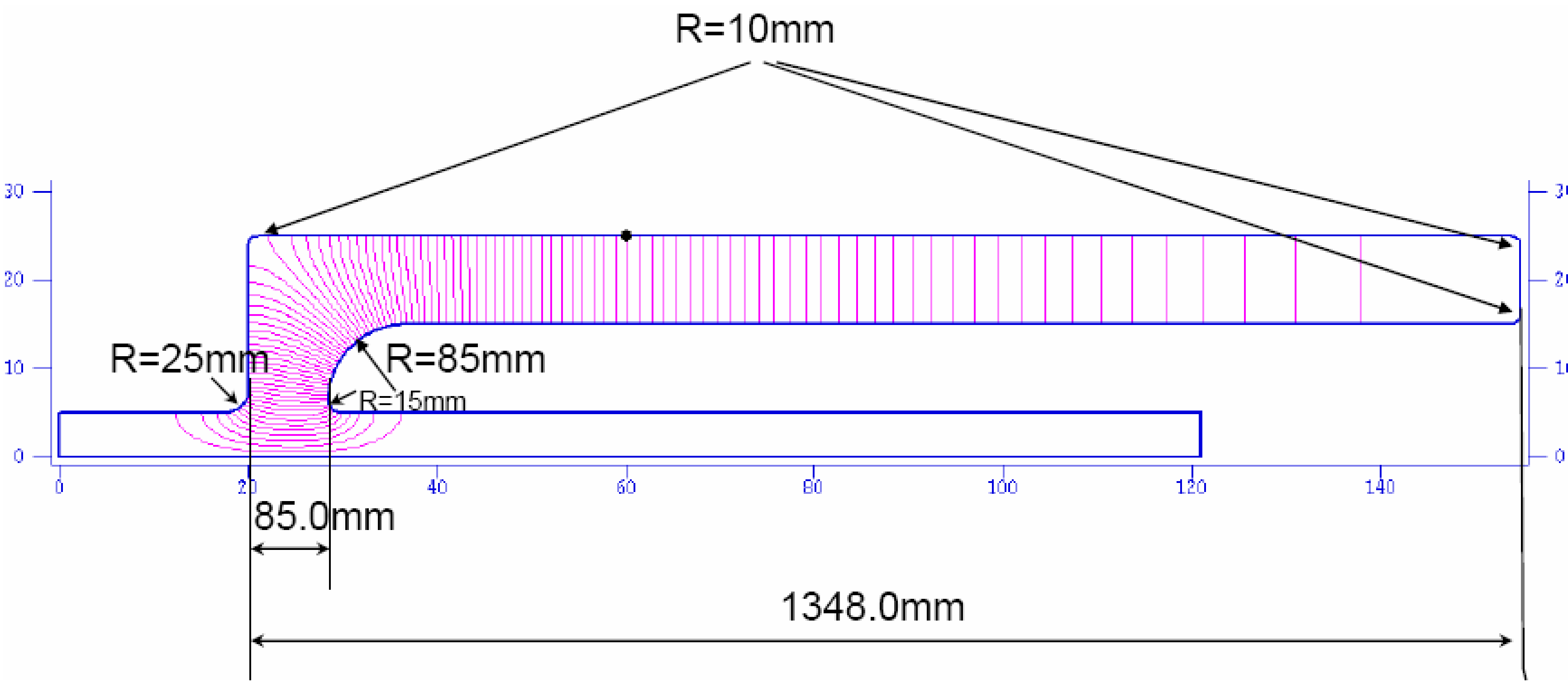
Luminosity distribution in the IR (horizontal scale is in cm): top curve is for 56 MHz case, six the curves show evo lution in the 197 MHz case.

Status

- Cavity shape is optimized
- The first prototype are being tested
- Stability analysis mostly done
- Dampers designed and being tested
- Power coupler for fast tuner and PUs specified
- Slow tuner design done
- Multipactoring 2-D advanced stage, 3-D will start soon
- Mechanical design underway
- Cryogenic design underway
- Chemistry and Vertical Testing moving forward

Status: Cavity shape

Optimized by SUPERFISH (by Xiangyun Chang)

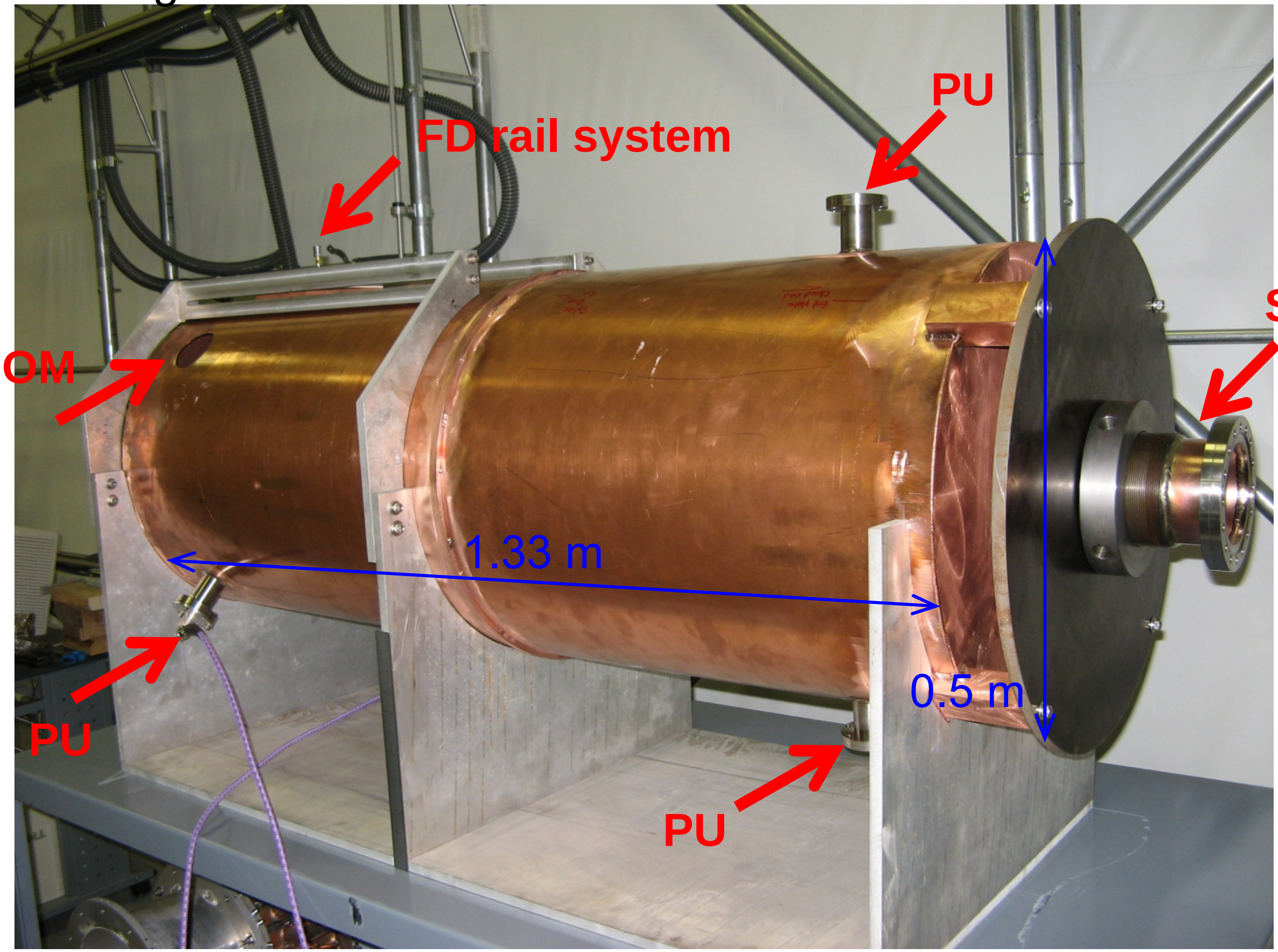


Cavity parameters

Frequency	56.25 MHz	R/Q (accelerator definition)	79.9
Voltage	2.5 MV	Maximum H	85 kA/m
Stored energy	221 J	Maximum E	42.5 MV/m
Power dissipation (4.2 K)	42 W	Tuning sensitivity	15.8 kHz/mm
Q (assuming 11 nOhm residual)	1.9E9		

Status: 1st prototype

Located in Bldg. 905



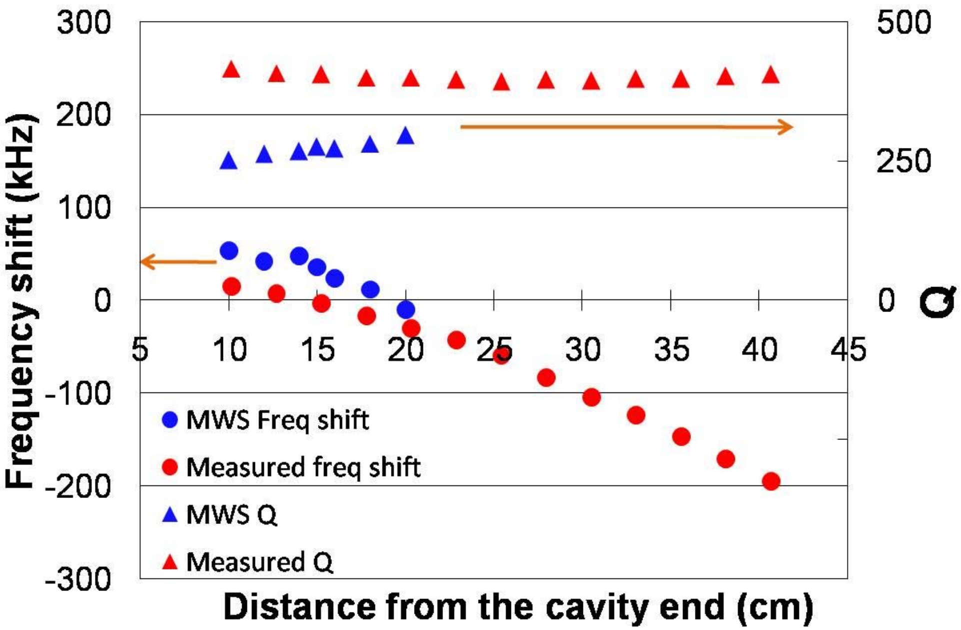
Features:

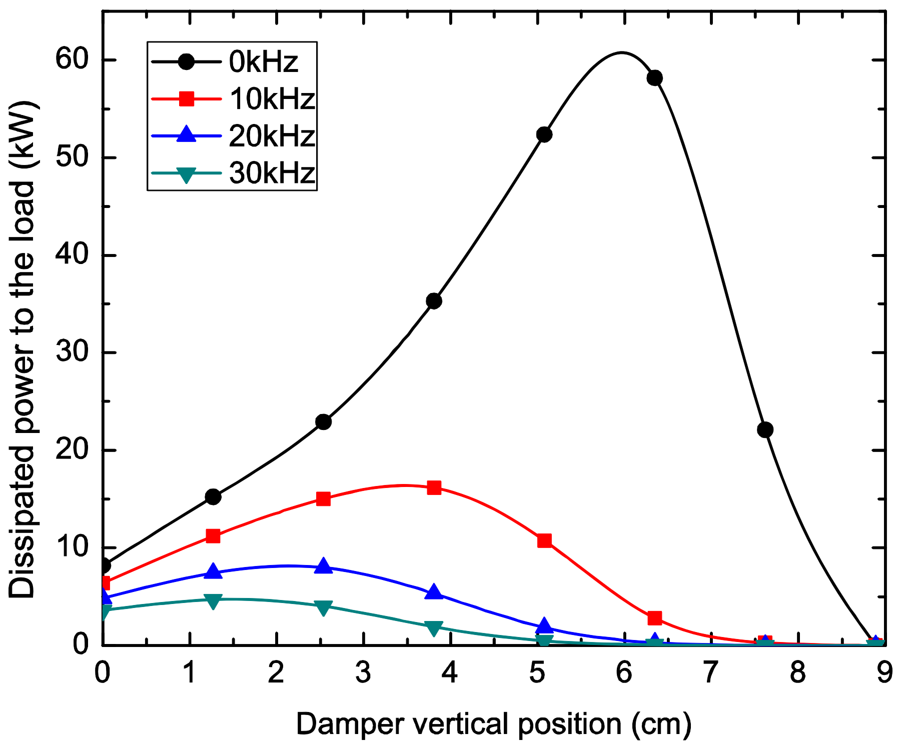
- The rail system for the fundamental damper
- 2 HOM damper opening, 90 degree each other
- Slow tuner

Status: Dampers

Fundamental mode damper

- Inductively coupled loop
- Size and location determined
- Power dissipated to the load is calculated based on Q measurements

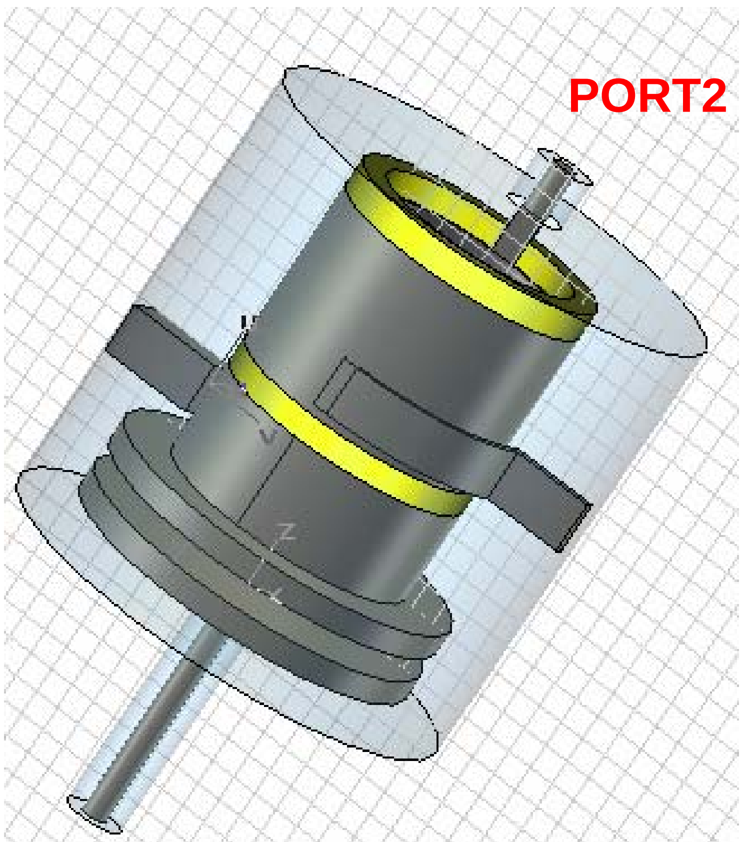




Status: Dampers

HOM damper

- Inductively coupled loop
- Size and location determined
- High pass band filter tested
- Q of HOMs measured



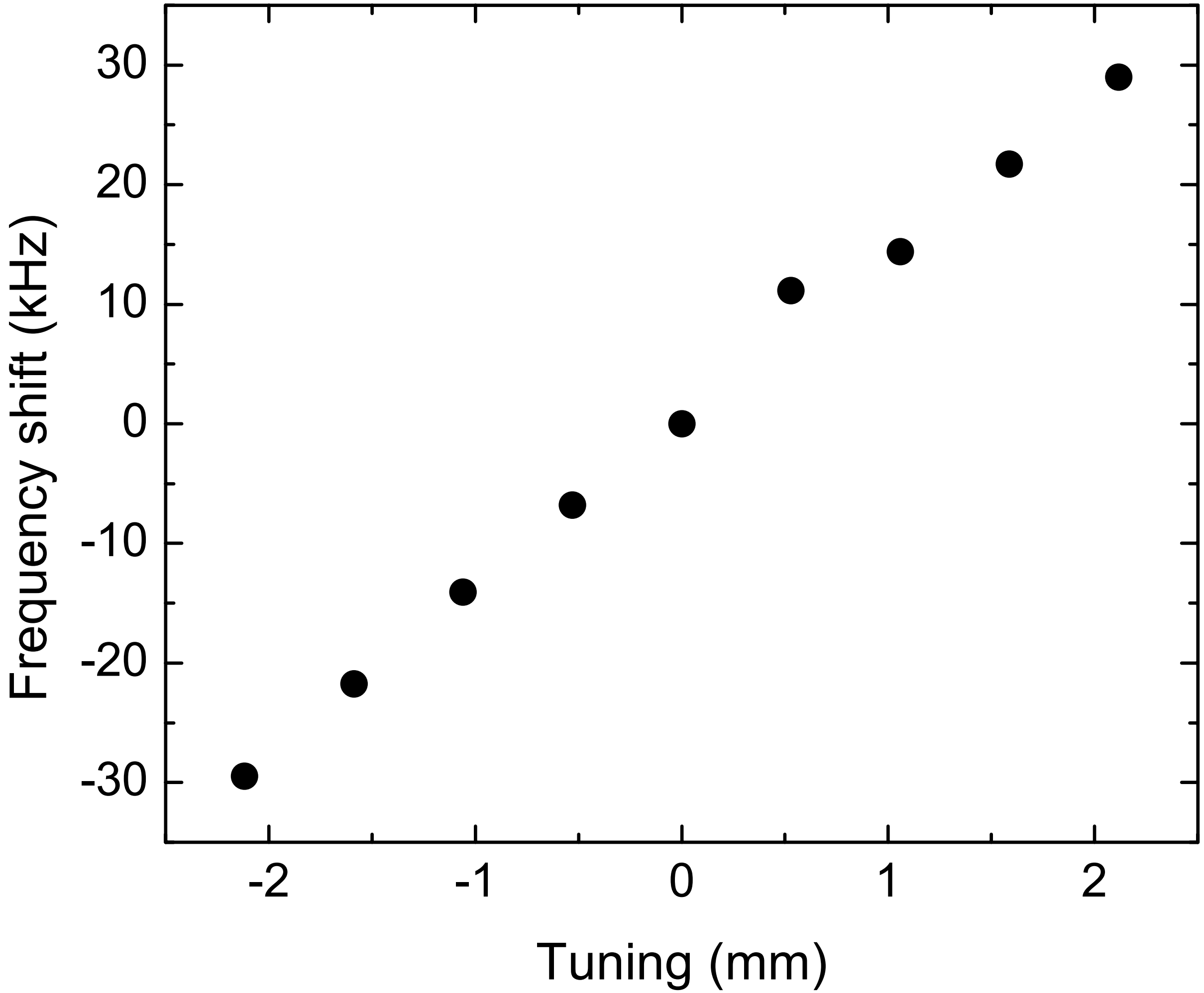
PORT1 **HOM filter**

f (MHz)	Q0	Qload	Q(tolerance)
168.042	13830	1600	2000
278.012	17670	1520	Not specified
384.053	18060	1000	25000
485.285	18080	10680	7000
584.947	18340	220	5000
688.105	15390	200	25000
795.691	16220	1520	100000
1104.98	14860	3400	10000

The measured Q values with the HOM damper meet the tolerances from stability analysis.

Status: Slow tuner

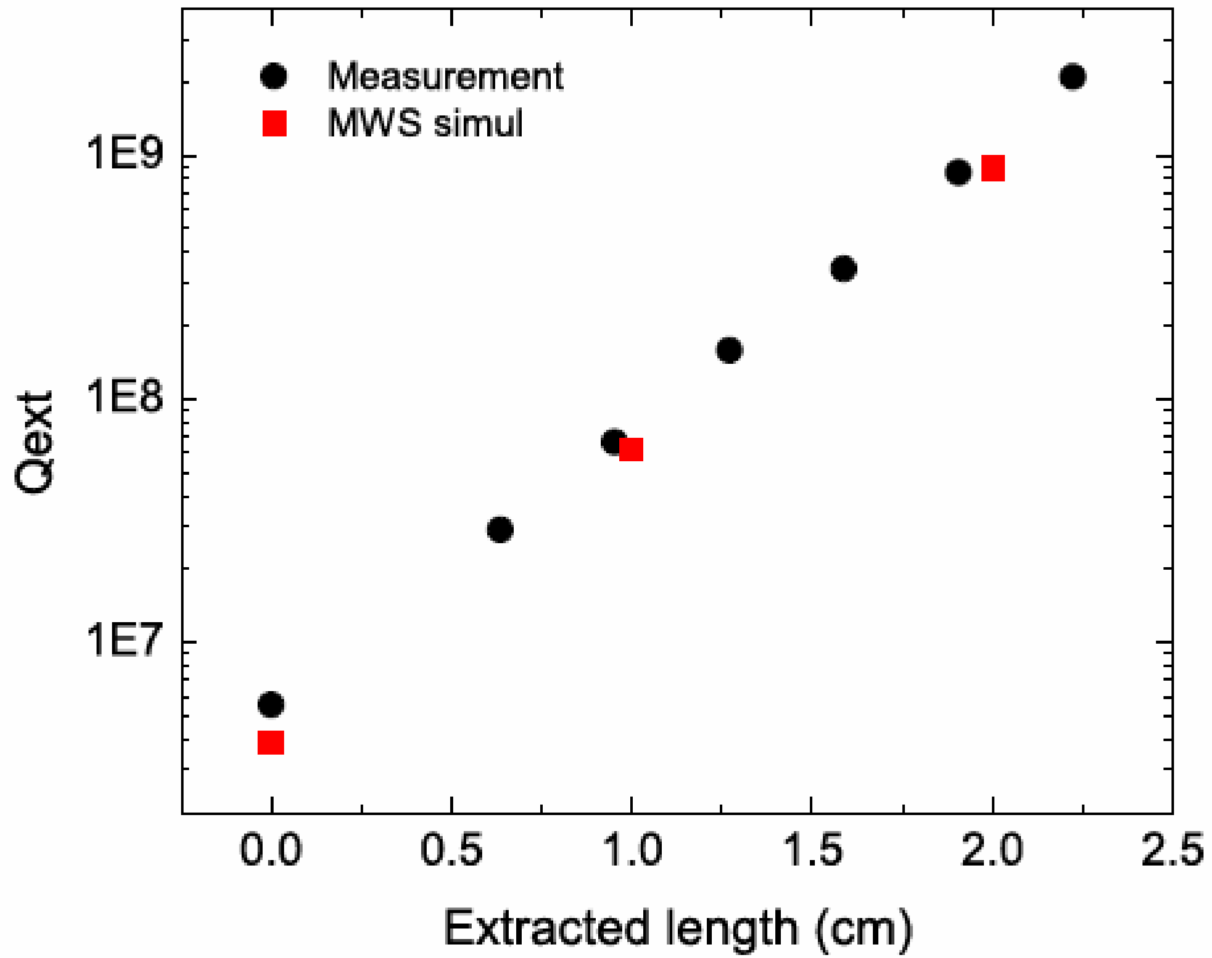
Slow tuner scheme tested on the prototype cavity



Measured tuning range (~15 kHz/mm) agrees well with simulation

Status: FPC and PU

Comparison between measurement and simulation for FPC port

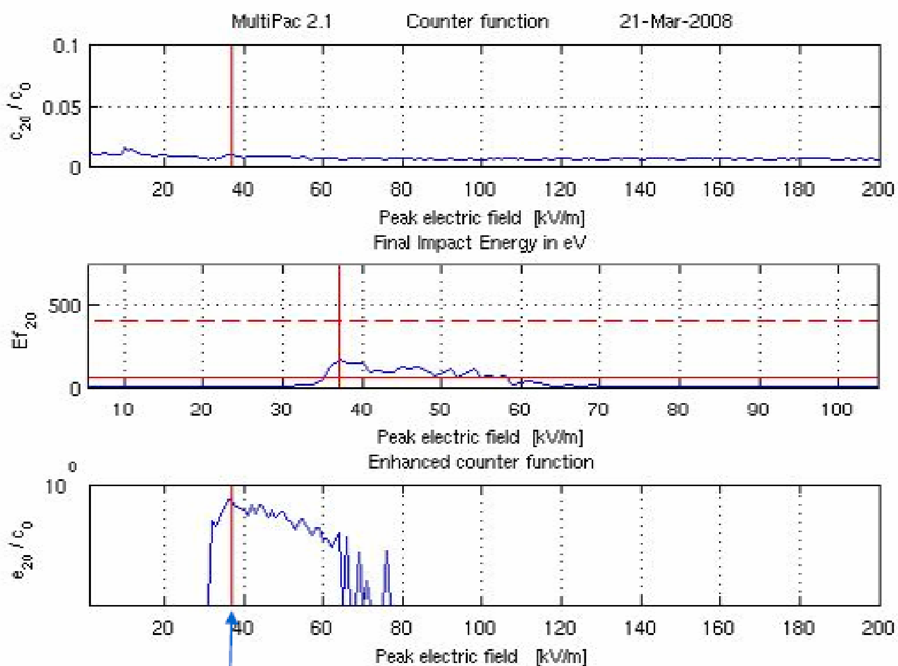


- The location and the size of the FPC are decided based on the measurements and simulations. (Q_{ext} ~ 4×10^7)
- The location and the size of the PU are decided from simulations.

Status: Multipacting

- Cavity corrugation prevents multipacting: Verified by 2D multipacting simulation
- 3D multipacting simulation will be carried on soon.

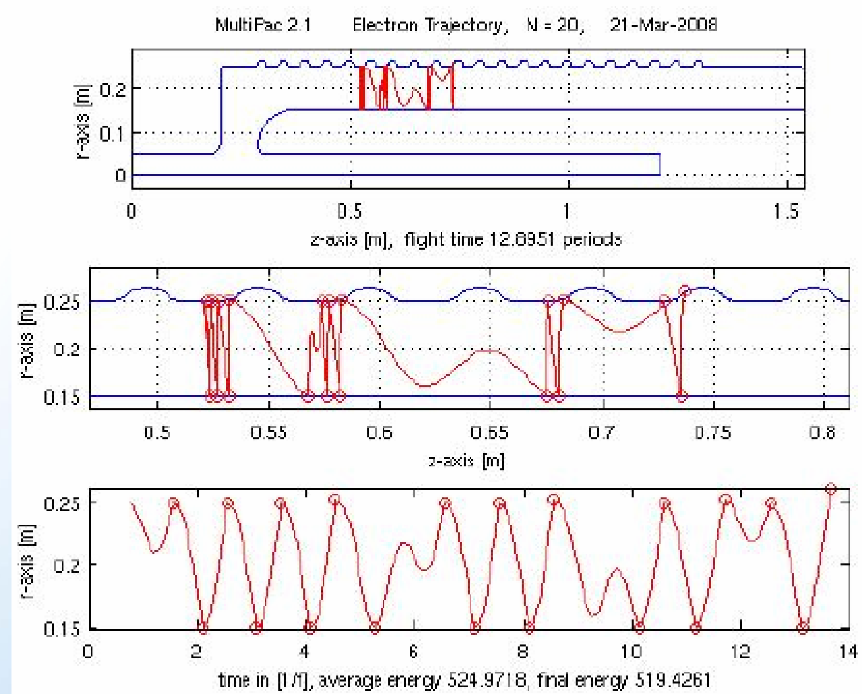
Triplot: 1-200 kV/m(28-100 cm)



37 kV/m

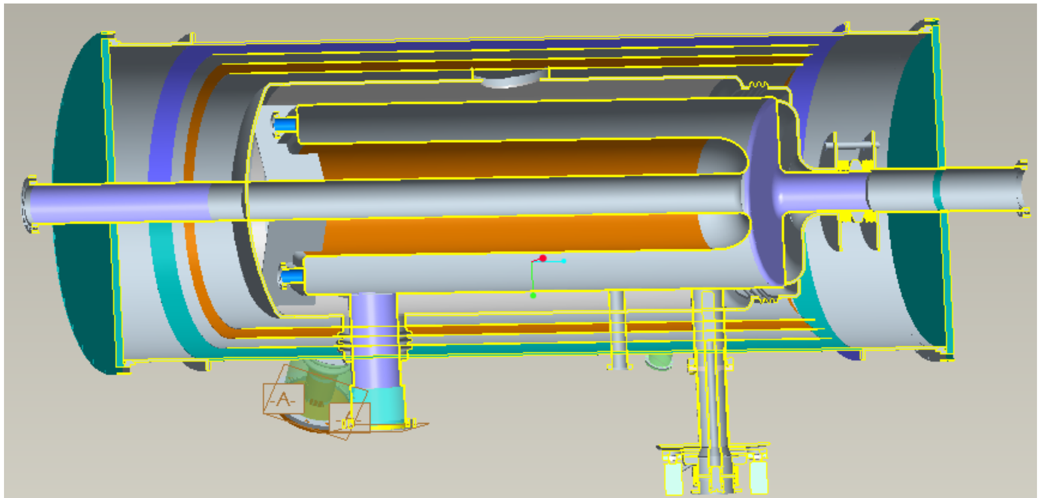
Electron-impact number: 20

Electron trajectory: 37 kV/m



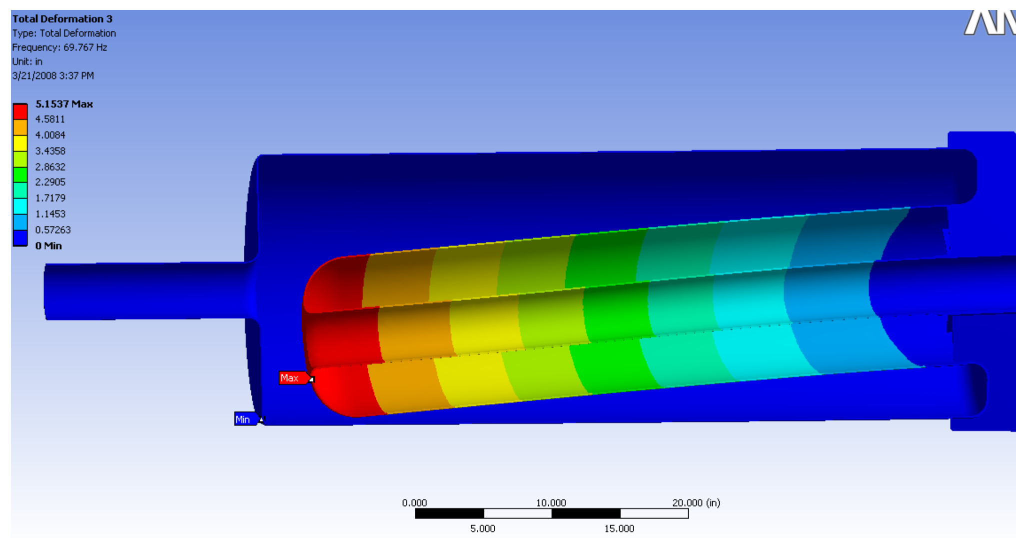
Simulation by Damayanti Naik

Status: Mechanical design



Mechanical design done:
- Cavity stiffened to satisfy pressure vessel code requirements
- Tuning interface designed to satisfy code requirements and provide desired tuning range

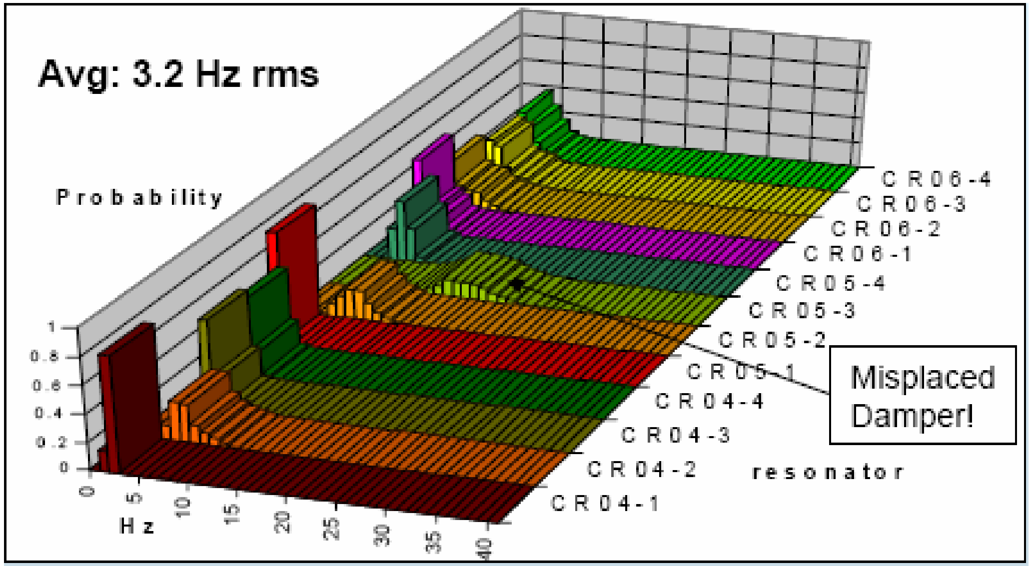
Mechanical design underway:
- Sensitivity to pressure fluctuations
- Thermal analysis of trapped vapor on inner conductor surface



By Daniel Chenet

Status: Frequency stability

Legnaro80 MHz QWR



Distributions of the frequency oscillation amplitudes in a 24 hour record for all low beta cavities in ALPI.

The 1 kW RF amplifier can provide fast amplitude control equivalent to ±0.75 Hz tuning by introducing reactive power to satisfy the stability requirements.

Summary

- AIP Project for 56 MHz SRF storage cavity for RHIC has been launched.

- The cavity will be in service for run11.

- The cavity will
  - provide a luminosity increase to ~$5x10^{27}$ with achieved RHIC parameters,
  - increase the luminosity of stochastic cooled RHIC by 50 %,
  - offer potential luminosity increase in low energy operation