ERL Cavity for High Currents

Rama Calaga

Brookhaven National Lab

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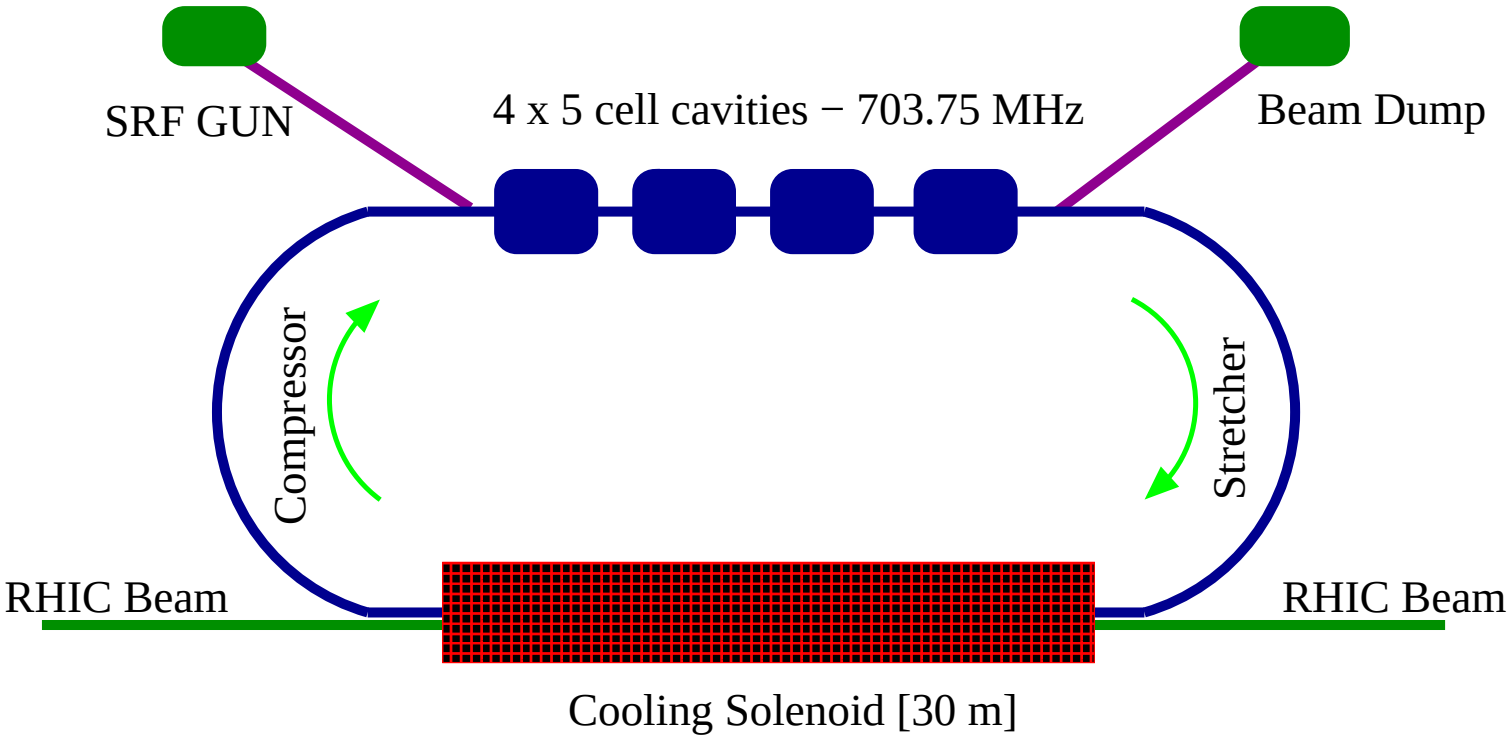
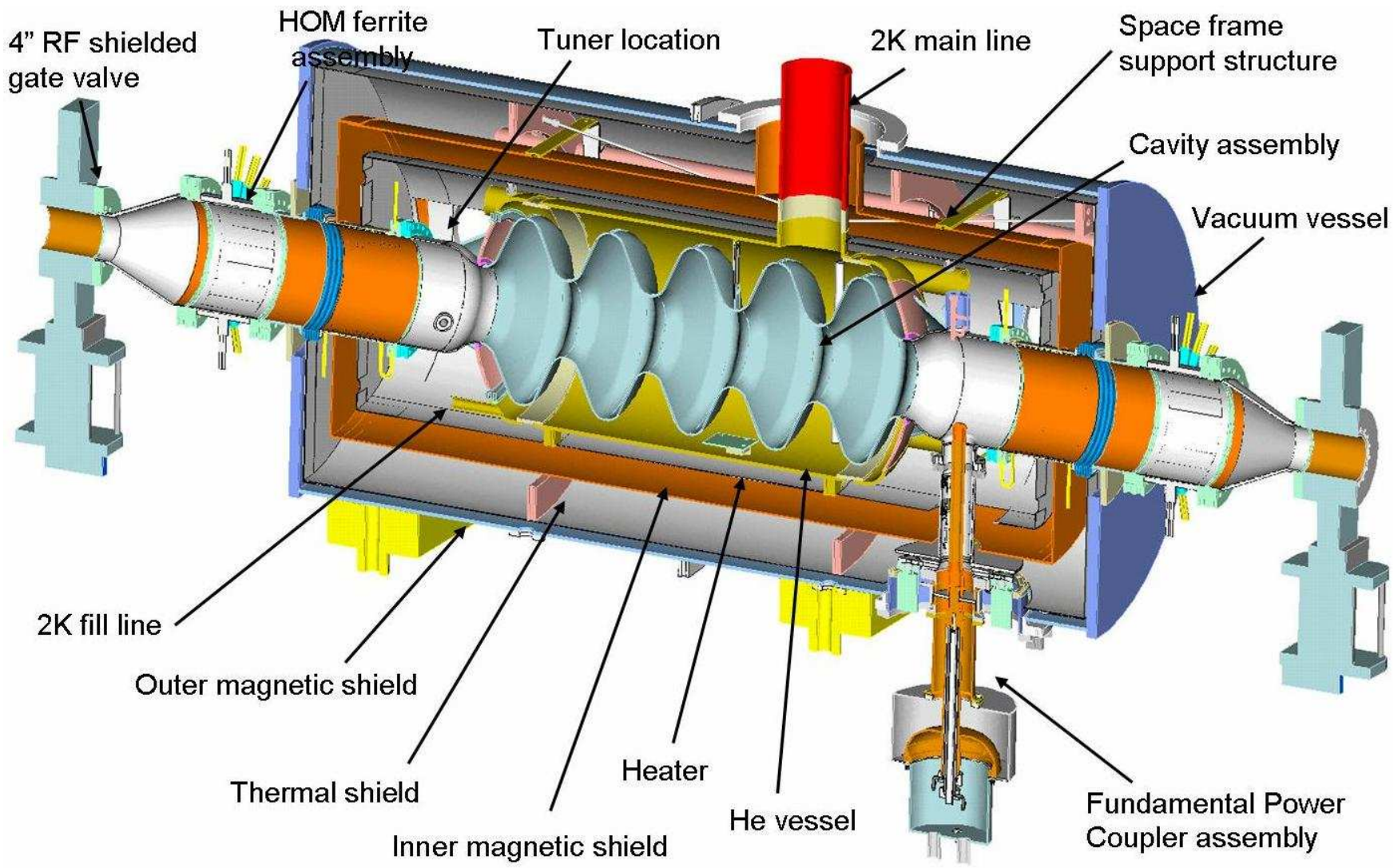
Motivation: ecooling@RHIC

- Cooling Au beams at 100 GeV requires - $\sim$ 54 MeV e^-
- High current ($> 200mA$) and high bunch charge (10-20 nC)
- Replenish e^- every cycle - energy recovery



BNL 5-Cell ERL Cavity



Criteria for Cavity Design

- **Fundamental Mode**:

$$\frac{E_{peak}}{E_{acc}} \ (\downarrow), \ \frac{H_{peak}}{E_{acc}} \ (\downarrow), \ \frac{R_s}{(R/Q)G} \ (\downarrow)$$

- **Higher Order Modes**:
  - HOM Power & Kick ($k_{||}$, $k_{\perp}$)

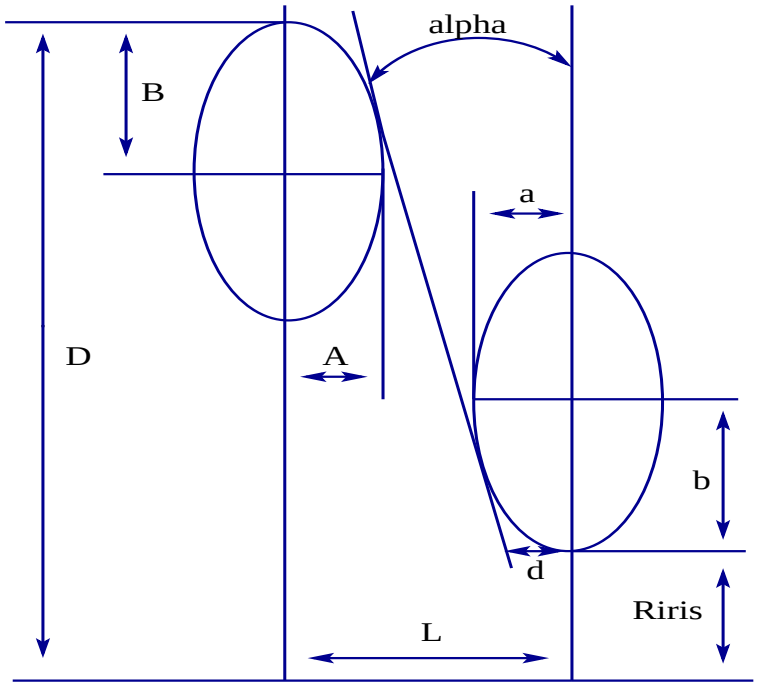
$$P_{avg} = 2k_{||}IQ$$

  - BBU - Trapped Modes ($k_{cell-cell}$, N_{cells}, Q_{ext})

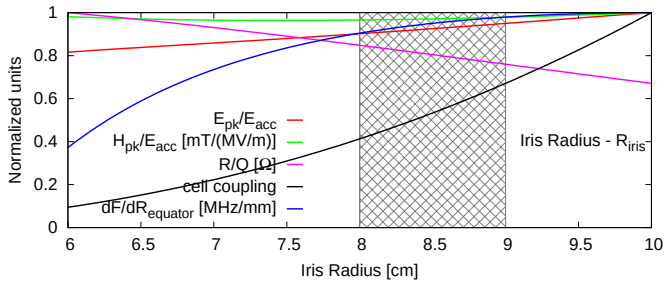
$$I_{thr} = \frac{-2p_r c^2}{\left[e\left(\frac{R}{Q}\right)Q_e\omega_m\right]\left[M_{12}sin(\omega_m t_r)\right]}$$

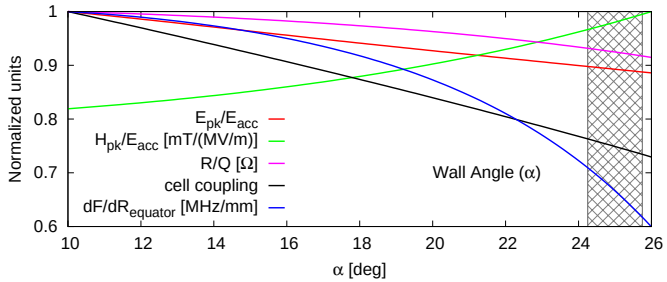
  - Efficient extraction of HOMs

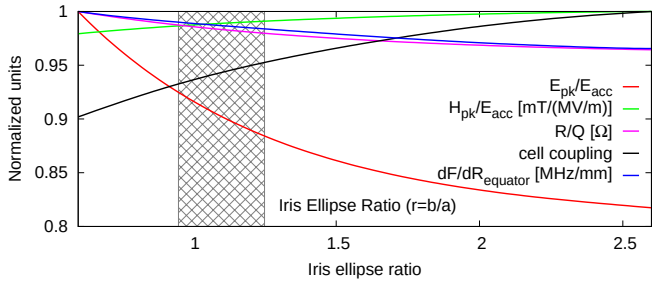
Cavity Shape Optimization

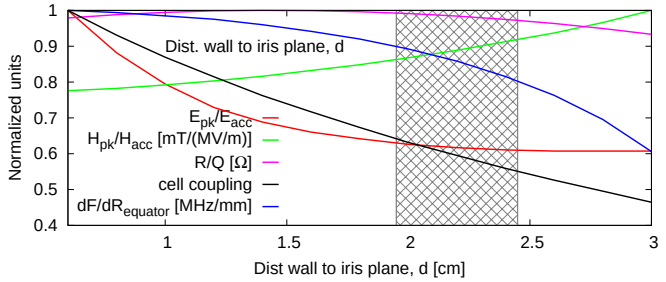


Iris Radius, R_{iris}	8.5 [cm]
Wall Angle, α	25 [deg]
Equatorial Ellipse, $R = \frac{B}{A}$	1.0
Iris Ellipse, $r = \frac{b}{a}$	1.1
Cav. wall to iris plane, d	2.5 [cm]
Half Cell Length, $L = \frac{\lambda\beta}{4}$	10.65 [cm]
$H = D - (R_{iris} + b + B)$	4.195 [cm]
Cavity Beta, $\beta = \frac{v}{c}$	1.0



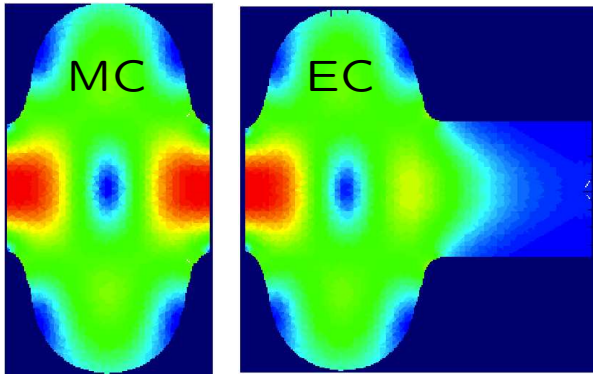




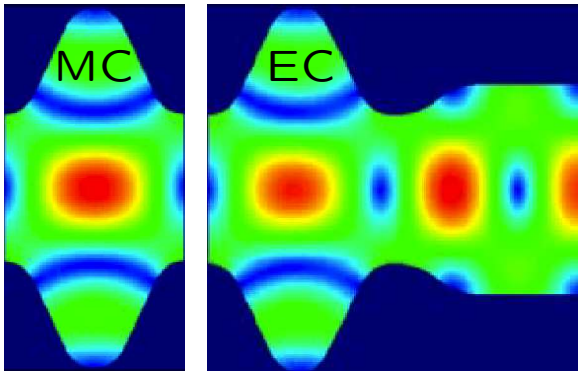


Trapped Modes

Frequency Difference

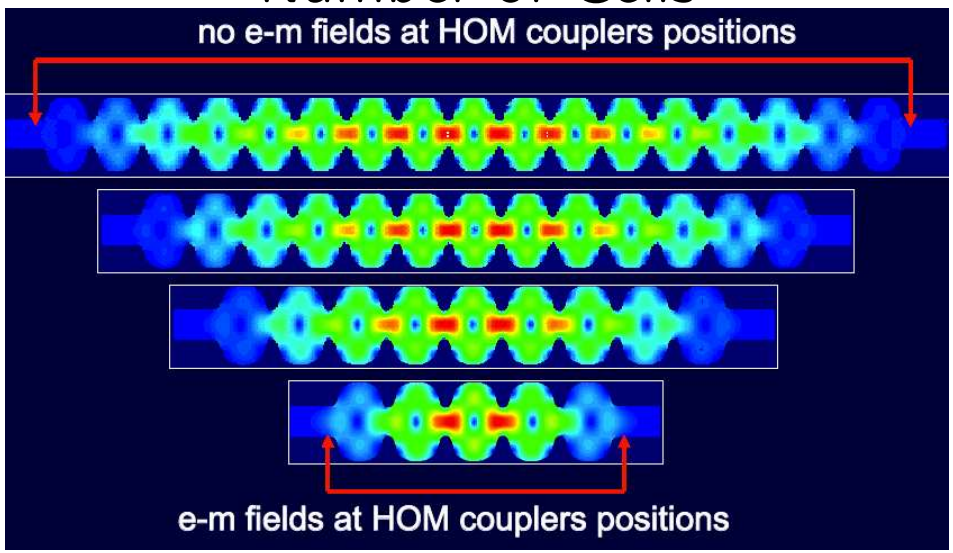


$\Delta f = 30 MHz$ (2.4 GHz)



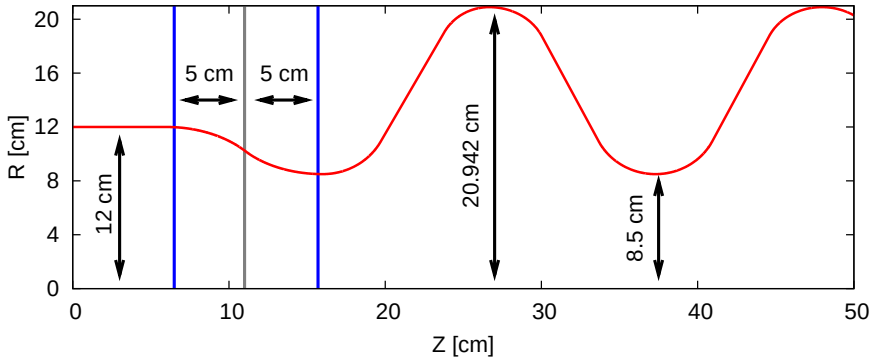
$\Delta f = 13 MHz$ (1.4 GHz)

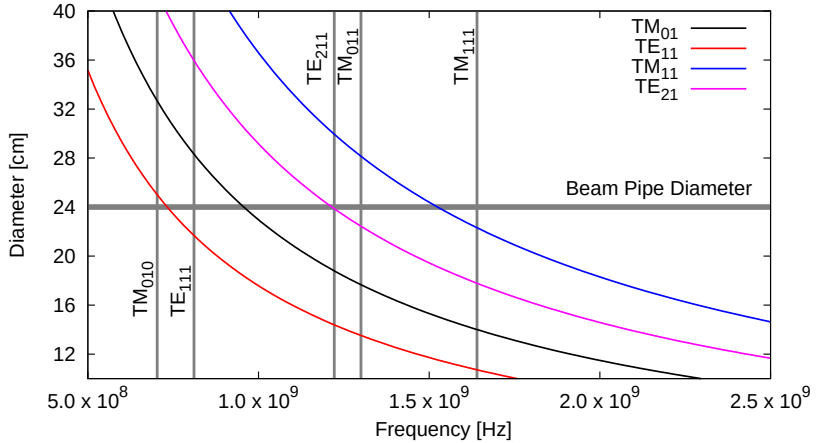
Number of Cells

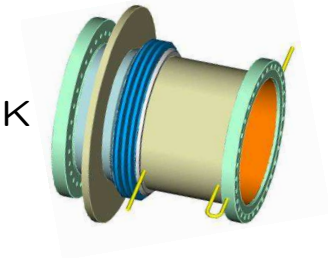


Beam Pipe Transition

- Damping HOMs
  - Enlarged BP (KEK, BNL)
  - Loop couplers (TESLA, CEBAF)
- Minimize fundamental leakage ($> 10\ W$).
- Minimize FPC kick
  - Enlarged BP (KEK, BNL)
  - Symm. couplers
- Cold to warm transition (Counter Flow of He)

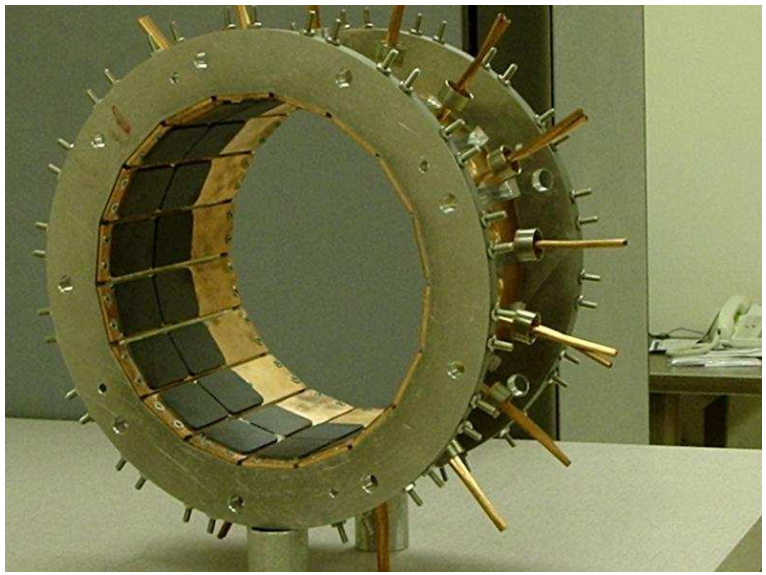






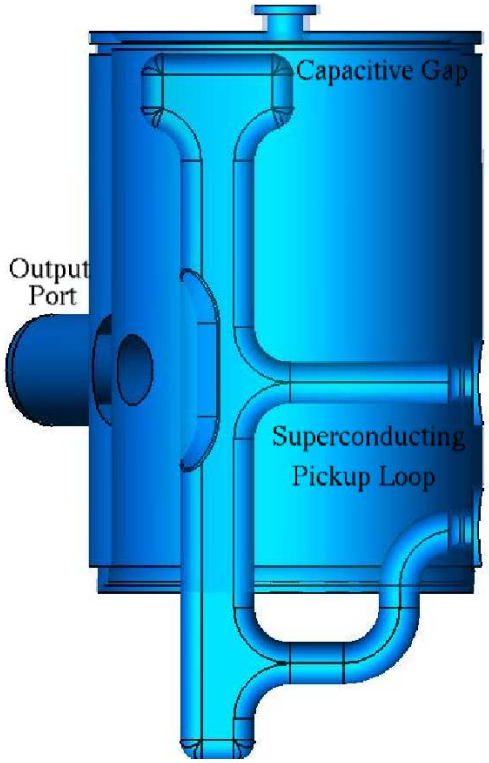
HOM Extraction & Damping

Ferrite Absorbers
Broadband (300 K)



(Cornell Type)

Loop Couplers
Resonant Ciruit (2 K)

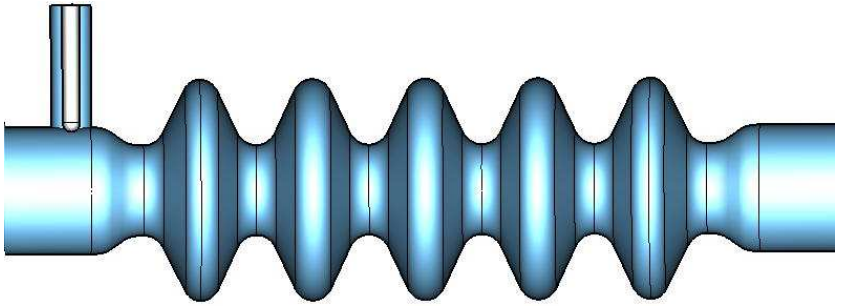


(TESLA Type)

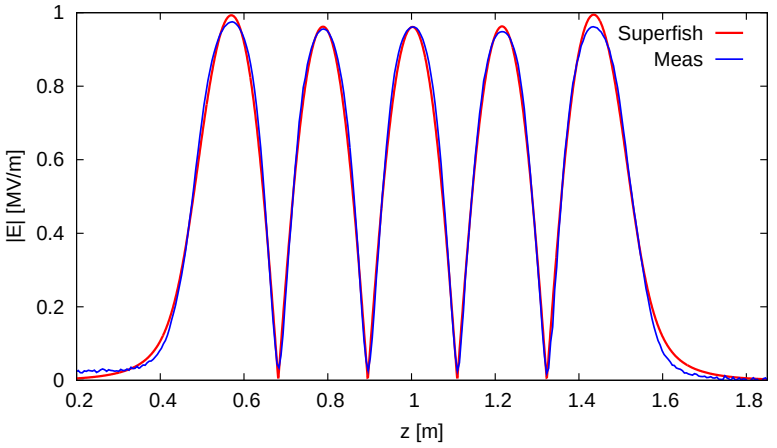
BNL High Current Cavity

Main Parameters:

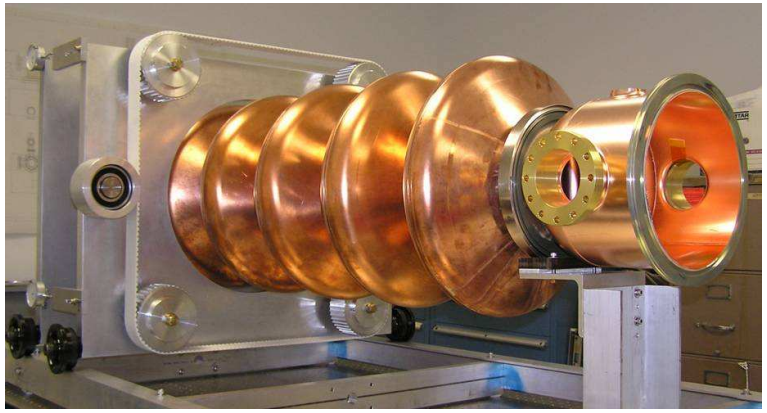
Frequency	703.75 [MHz]
RHIC Harmonic	25
Number of cells	5
Active cavity length	1.52 [m]
Iris Diameter	17 [cm]
Beam Pipe Diameter	24 [cm]
G (Ω)	225
R/Q	403.5 [Ω]
Q BCS @ 2K	4.5×10^{10}
Q_{ext}	3×10^6
E_p/E_a	1.97
H_p/E_a	5.78 $[mT/MV/m]$
cell to cell coupling	3%
Sensitivity Factor ($\frac{N^2}{\beta}$)	833
Field Flatness	96.5 %
Lorentz Detuning Coeff	1.2 [Hz/MV/m]
Lowest Mech. Resonance	96 [MHz]
$k_{\|\|}$ ($\sigma_z - 1cm$)	1.1 [V/pC]
$k_\perp$ ($\sigma_z - 1cm$)	3.1 [V/pC/m]
HOM Power (10-20 nC)	0.5-2.3 [kW]

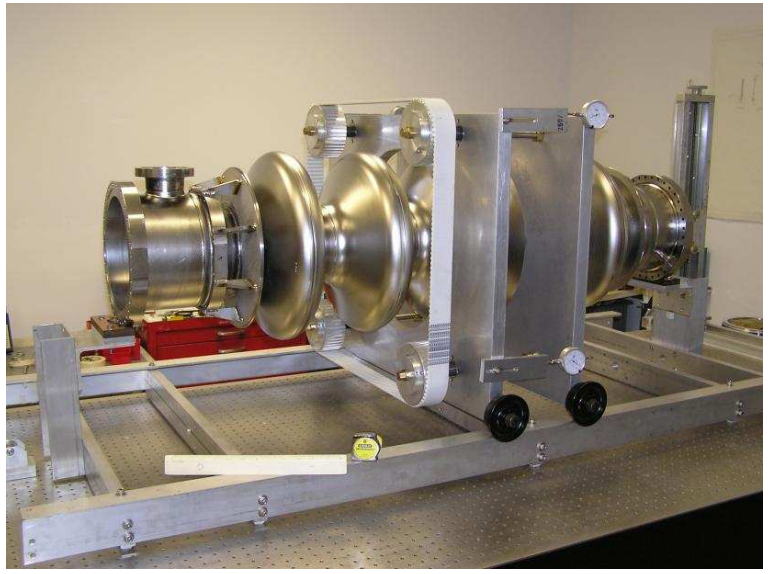


Field Flatness



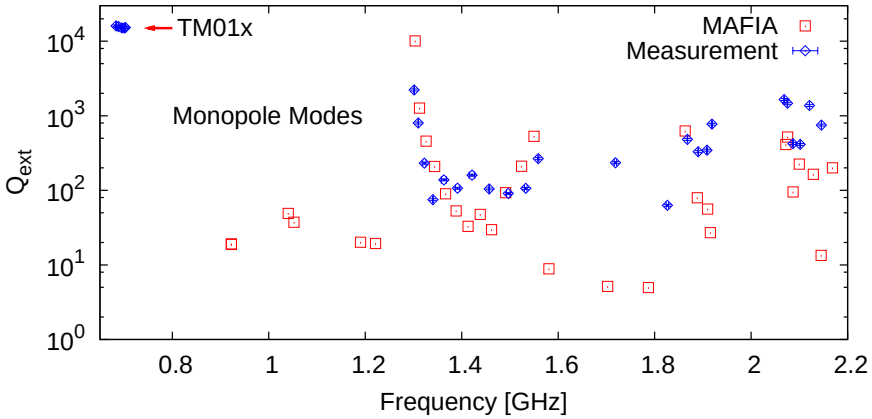
Fabrication, Tuning & Testing

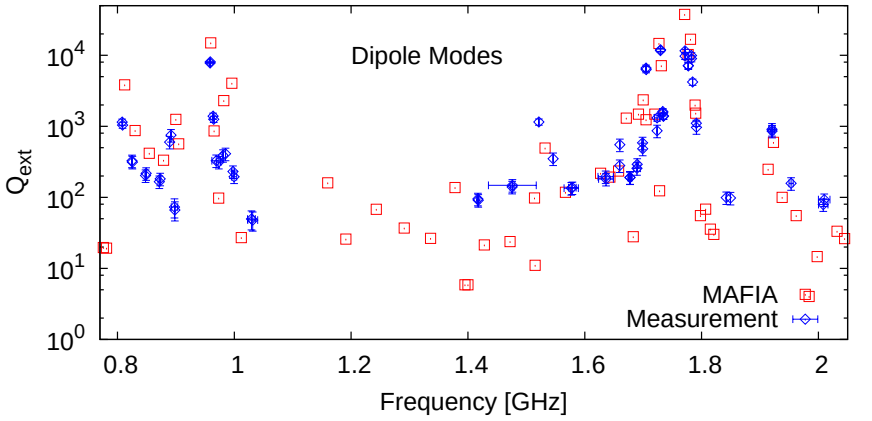




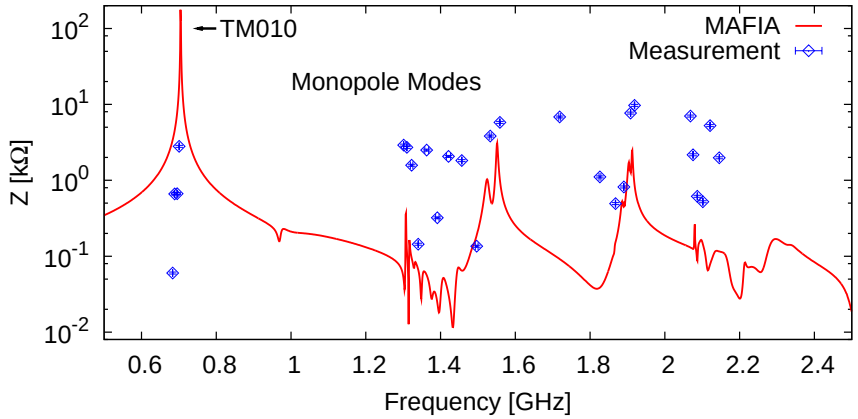
HOMs: Simulation & Measurements

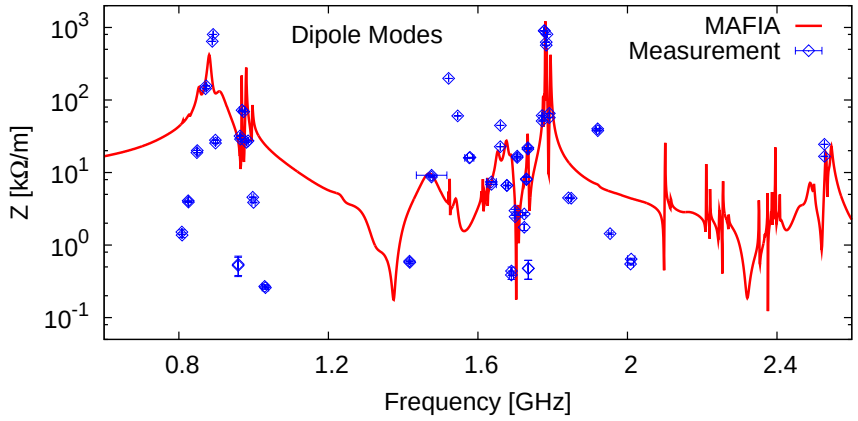
Frequency Domain





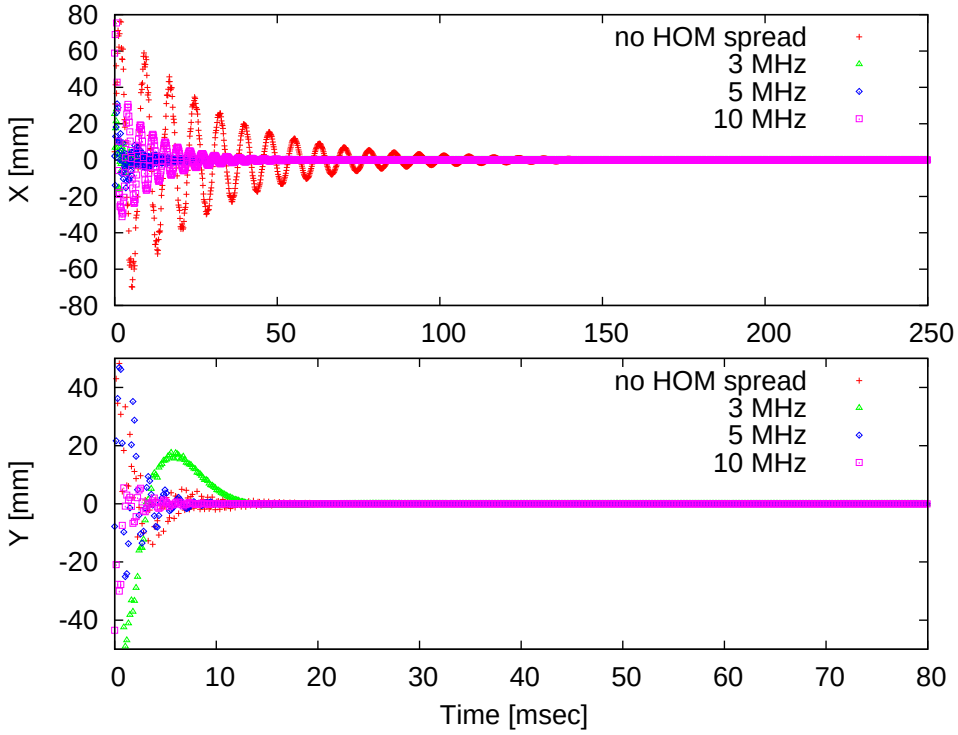
Time Domain



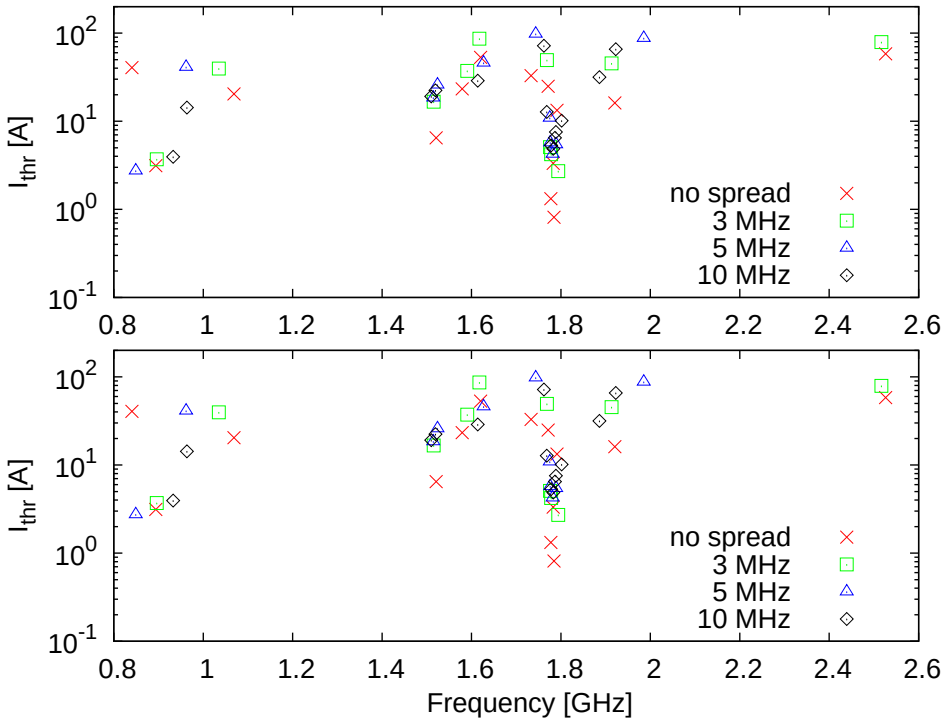


Multibunch BBU

TDBBU



MATBBU



Threshold Current > 2 Amps

BNL eCooling Configuration - 4 Cavities - 54 MeV

(Numerical Codes from JLAB)

Summary

- Design, fabrication and prototype testing is complete.
- Nb cavity is being prepared for surface chemical treatment.
- Cryomodule assembly at BNL (Dec. 2005) and horizontal testing to take place early next year.

Thanks: I. Ben-Zvi & Ecooling team, J. Sekutowicz, JLAB, & AES