High current SRF cavity at BNL

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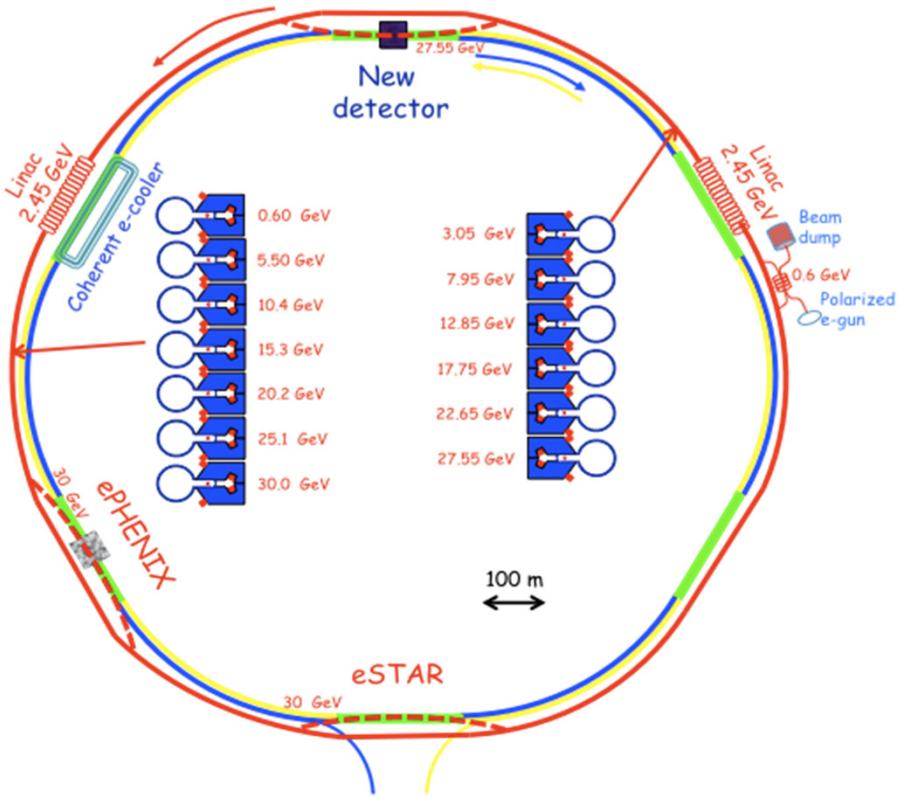
Outline

- SRF Requirements of eRHIC
- BNL1 cavity in ERL prototype
- High current BNL3 cavity design
- HOM coupler design for BNL3cavity
- Mechanical design
- Summary

eRHIC: requirements



Electron beam Parameters	eRHIC
Bunch charge [nC]	3.5
Beam current [mA]	50
RMS Bunch Length[mm]*	2
Beam energy [GeV]	5-30
Number of Passes	**6**
Operation mode	CW

*bunch length maybe changed to 4mm.

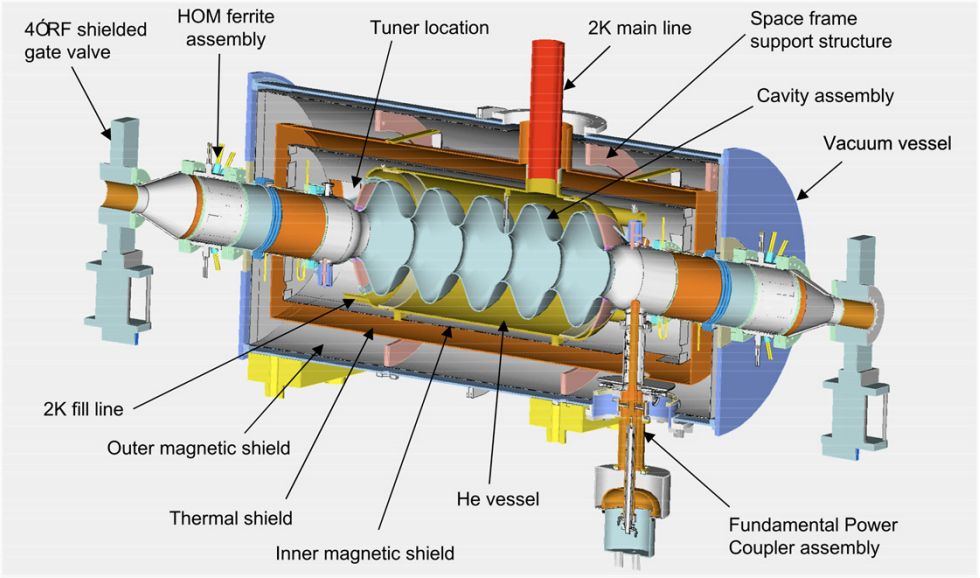
HOM damping requirement

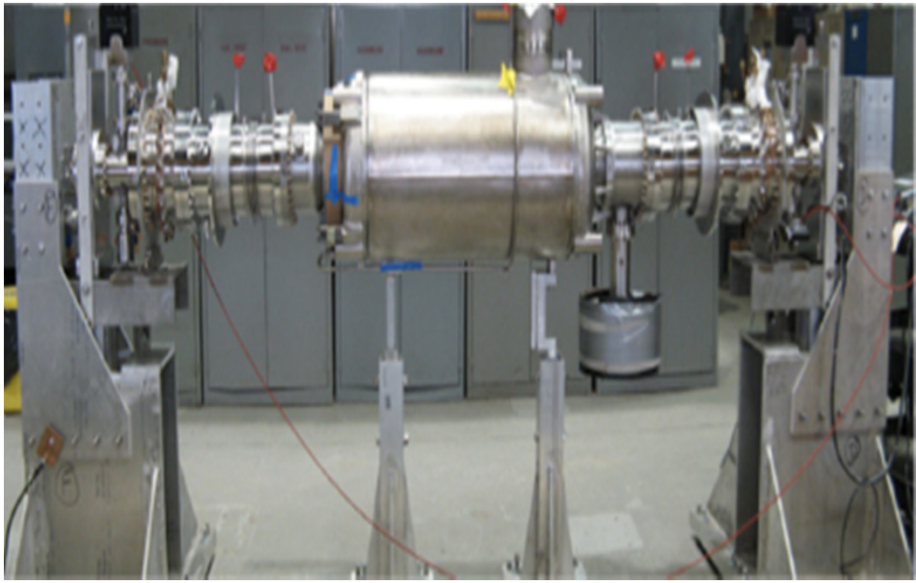
- Monopole:7.3kW/cavity
- Dipole: Qext~40,000
- Quadrupole: Qext ~10^7

- High current multipass ERL: HOM damping
- All in the existing RHIC tunnel : High “real estate gradient”: 12.3MV/m for eRHIC.

See: TUOAN4 in detail

BNL1: HOM damping

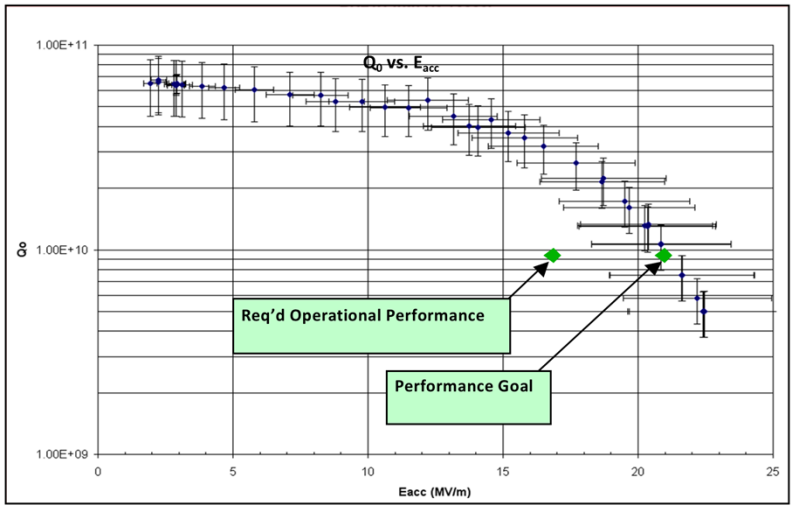


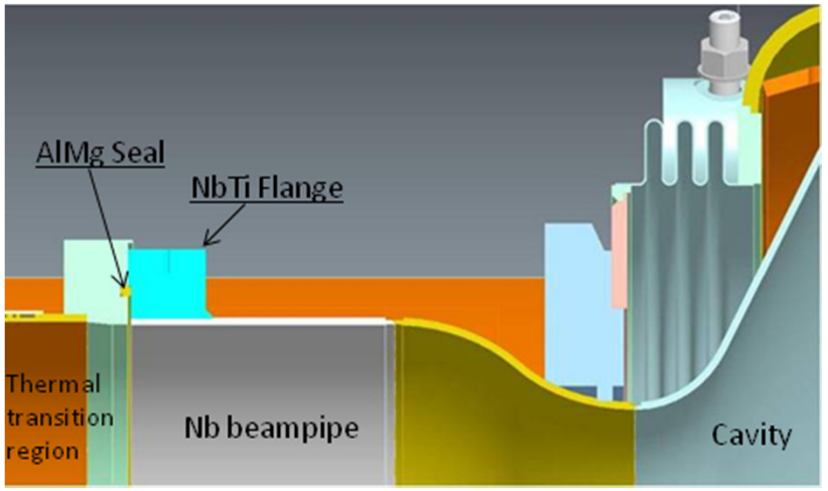


- ❖ Enlarged beam pipe
- Fundamental mode: attenuated in the beam pipe;
- HOMs: Propagate out of the cavity and are damped at room temperature with ferrite;

- ❖ Ferrite provides extremely good HOM damping, however, it also dramatically decreases the “real estate gradient”.
- ❖ However, very strong cavity-to -cavity coupling was found in the prototype model.

BNL1: CW operation



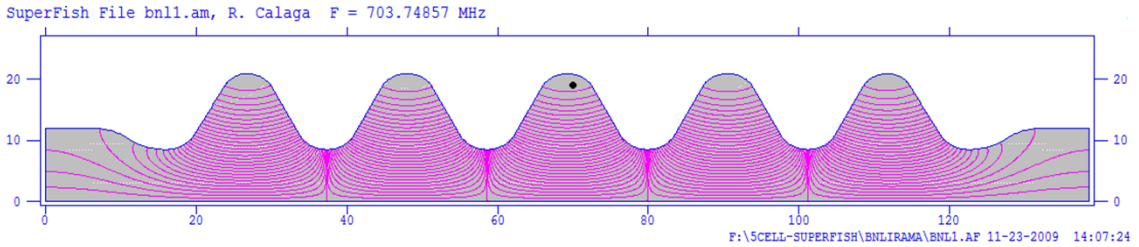


- The BNL1 cavity performed well during the vertical test(Q_0~10^{10} at 20MV/m)
- However, 12 MV/m was observed to be the threshold at CW mode, due to the $AlMg_3$ seal located between the NbTi and stainless steel flanges on the beam pipe.
- Quasi-CW operation mode: Test showed that the cavity can safely(thermal stability) run 18MV/m with a 6.25% duty factor.

See: TUP272,TUP56 in detail

Comparison of BNL1 and BNL3

BNL1 design:



BNL3 design:

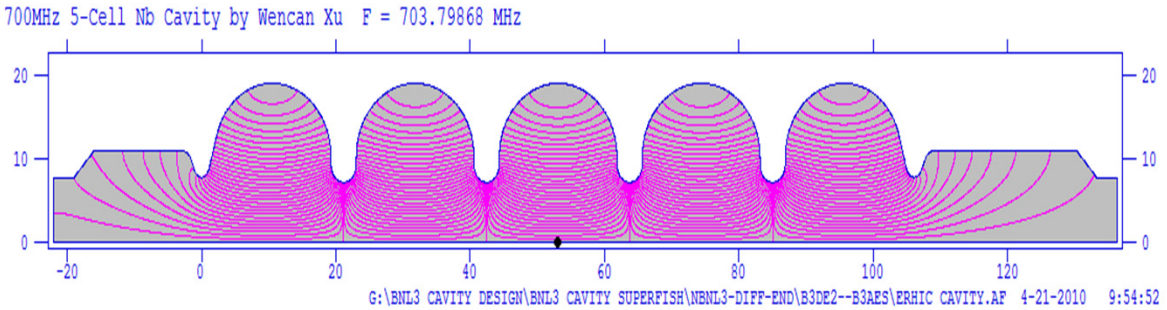
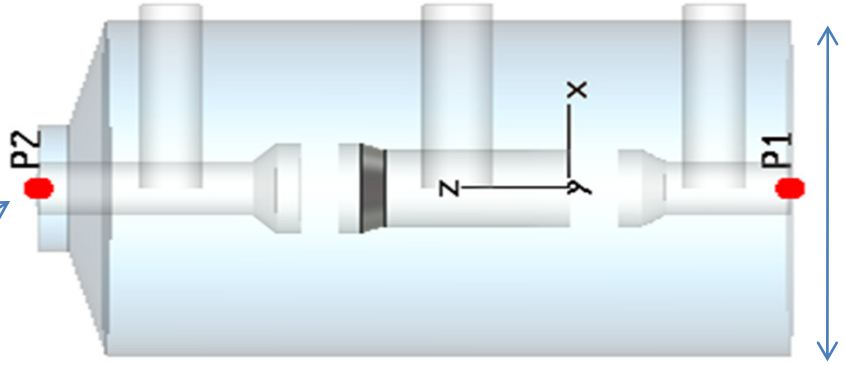


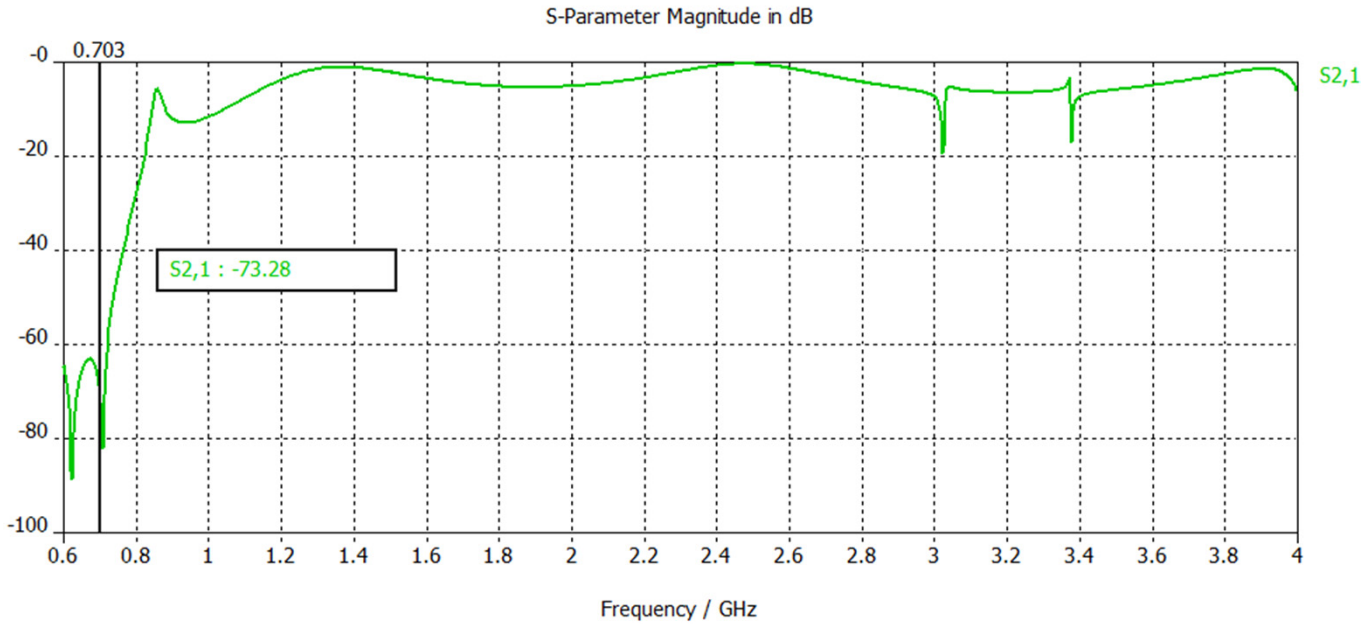
Table I: 704 MHz 5-cell cavities at BNL

Parameters	BNL I	BNL III
Geometry Factor	225	283
(R/Q)/cell [Ω/cell]	80.8	101.26
Epeak/Eacc	1.97	2.46
Bpeak/Eacc [mT/MV/m]	5.78	4.26
Length (cm)	152 + Two ferrite dampers	160
Beam pipe radius (mm)	120	110
Coupling factor [%]	3.00	3.02

2-stage HOM coupler design for eRHIC

50 Ω transmission line
to room temperature

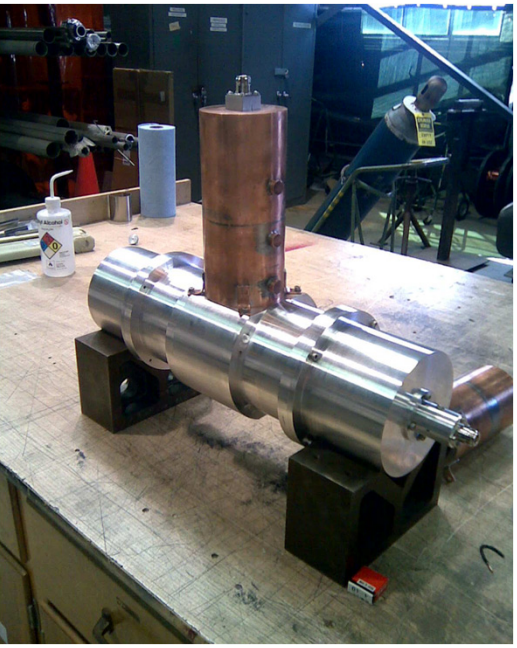


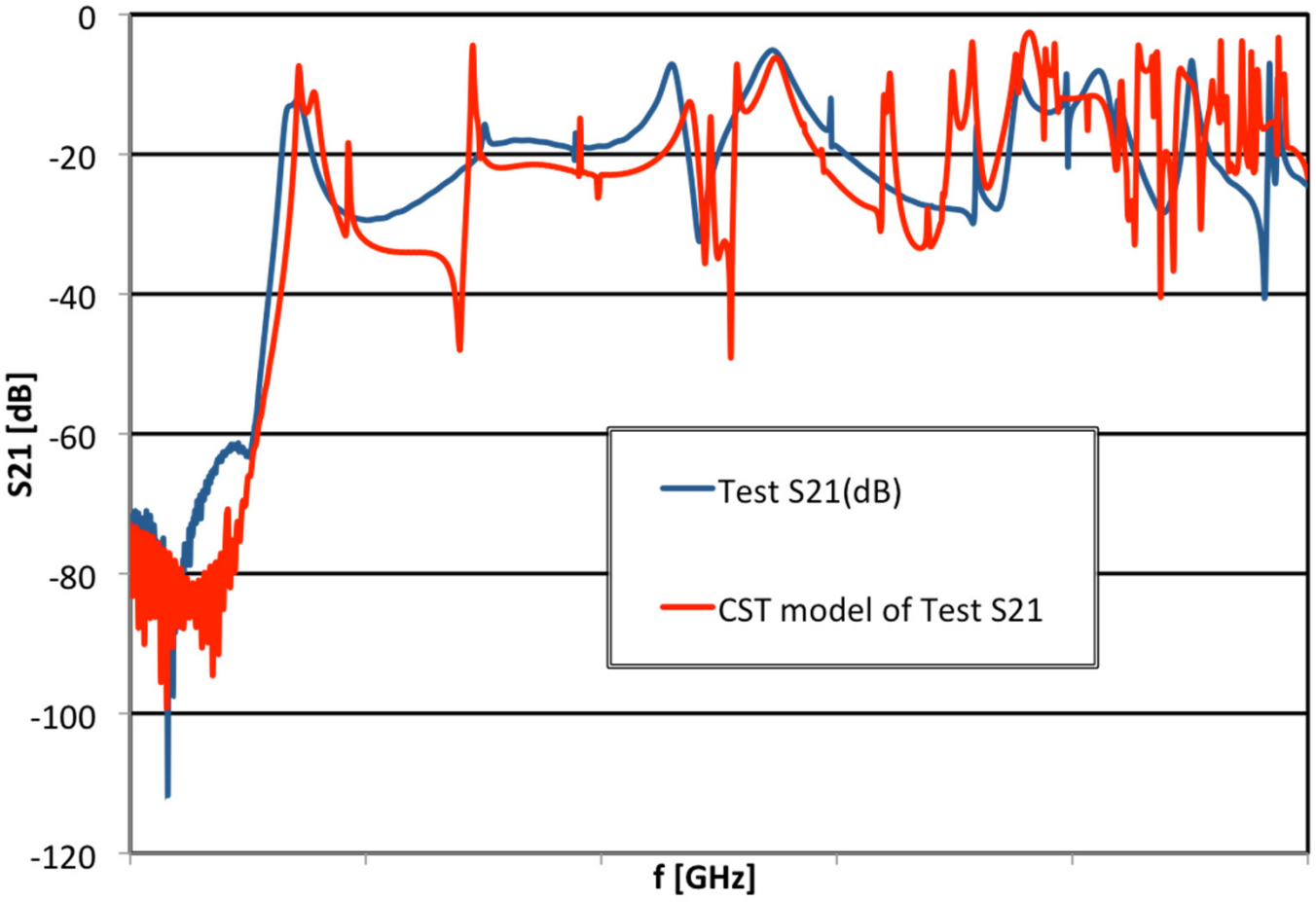


- Between the two notches, s21<-65 dB, 1st HOM is 0.82GHz, S21=-23dB,
- It still has good damping at high frequency
- Capacitors can be add to the transmission line to reduce the thermal conduction

See: TUP60 in detail

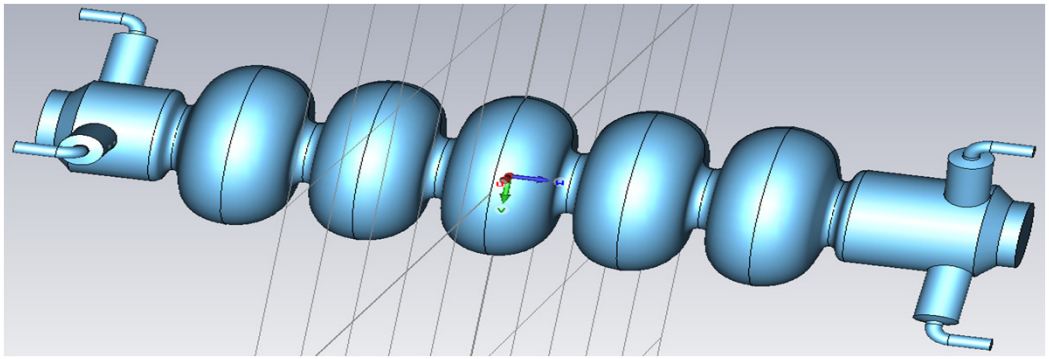
2-stage HOM coupler-model test

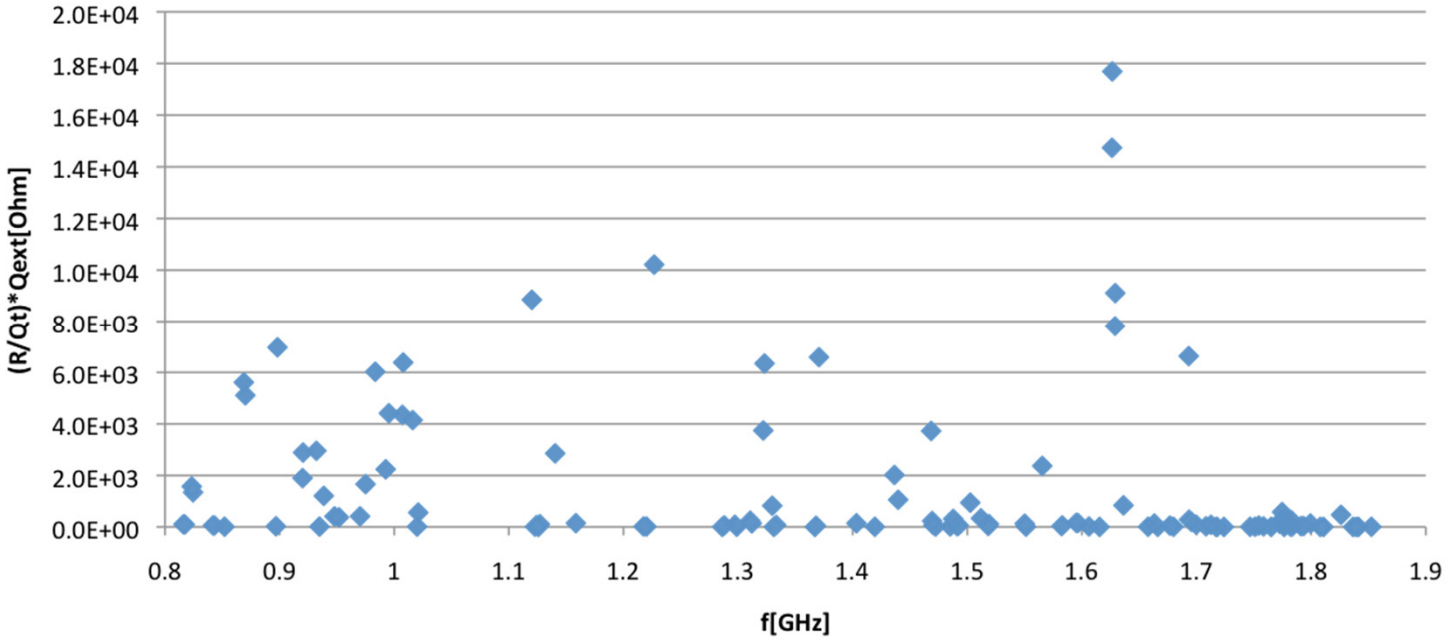




- The test by transmission line verified the design.
- Because of the big diameter(D=72mm) of the HOM couplers, the transmission line's diameter is so big that some HOM appears.

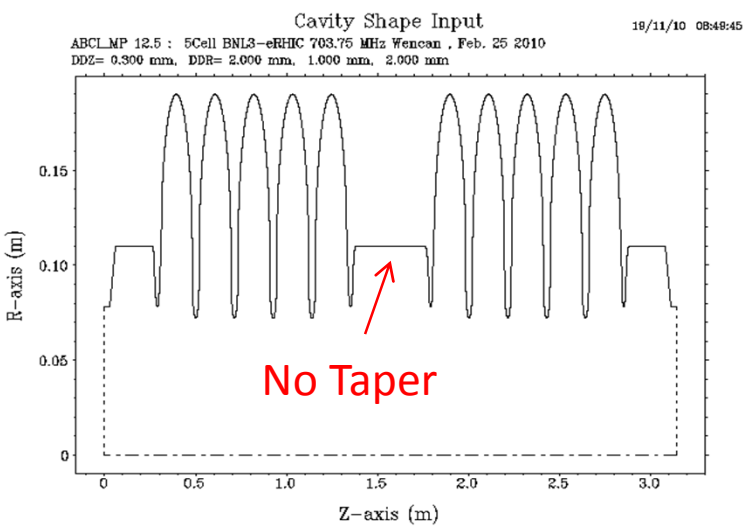
2-stage HOM couplers – on cavity

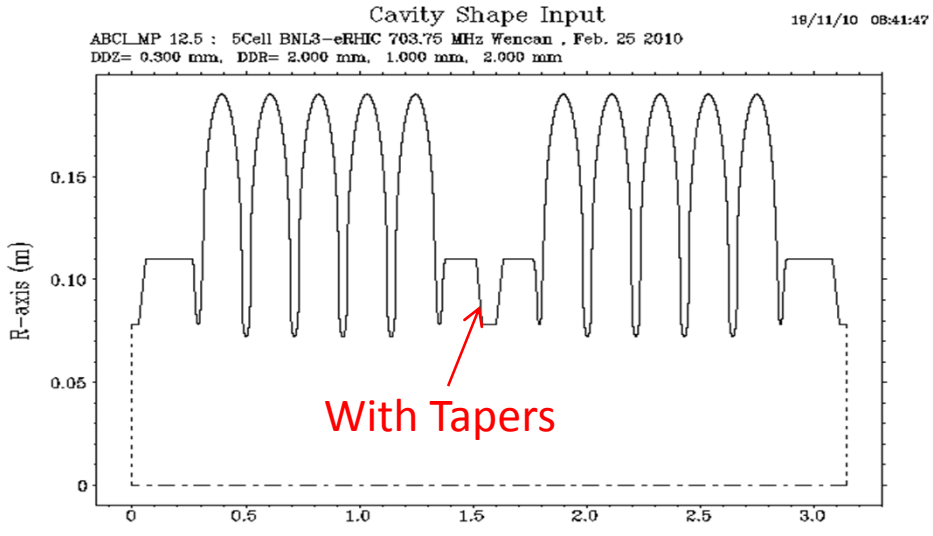


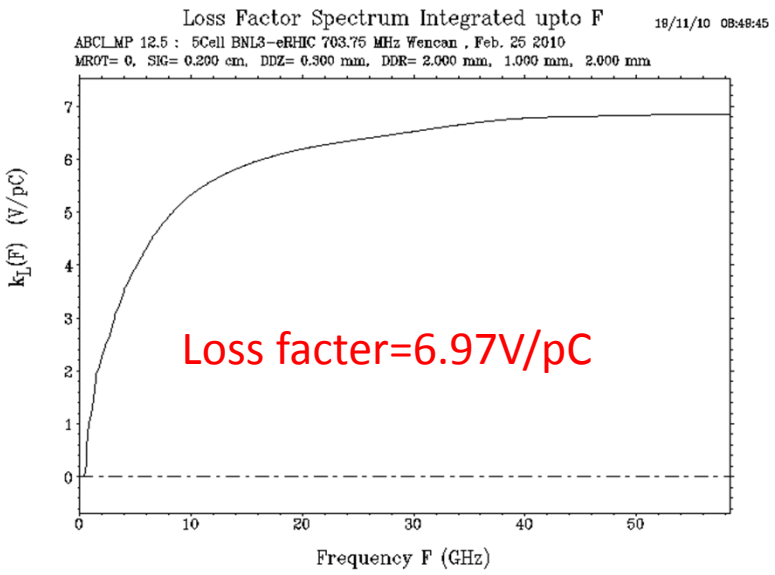


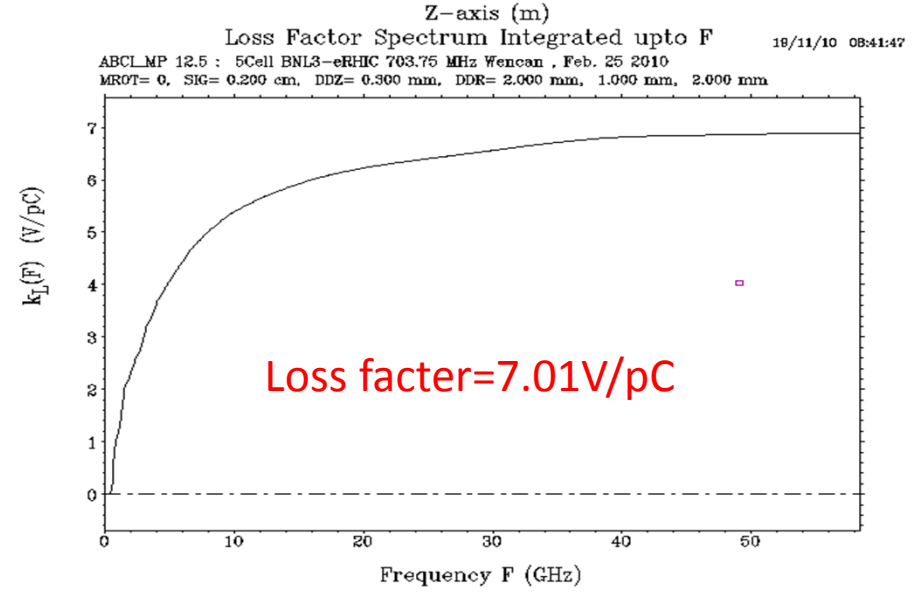
•We decided to have three HOM couplers at each end: to reduce power propagating through each HOM coupler, and also damping the HOMs better.

Impact of tapering into a waist



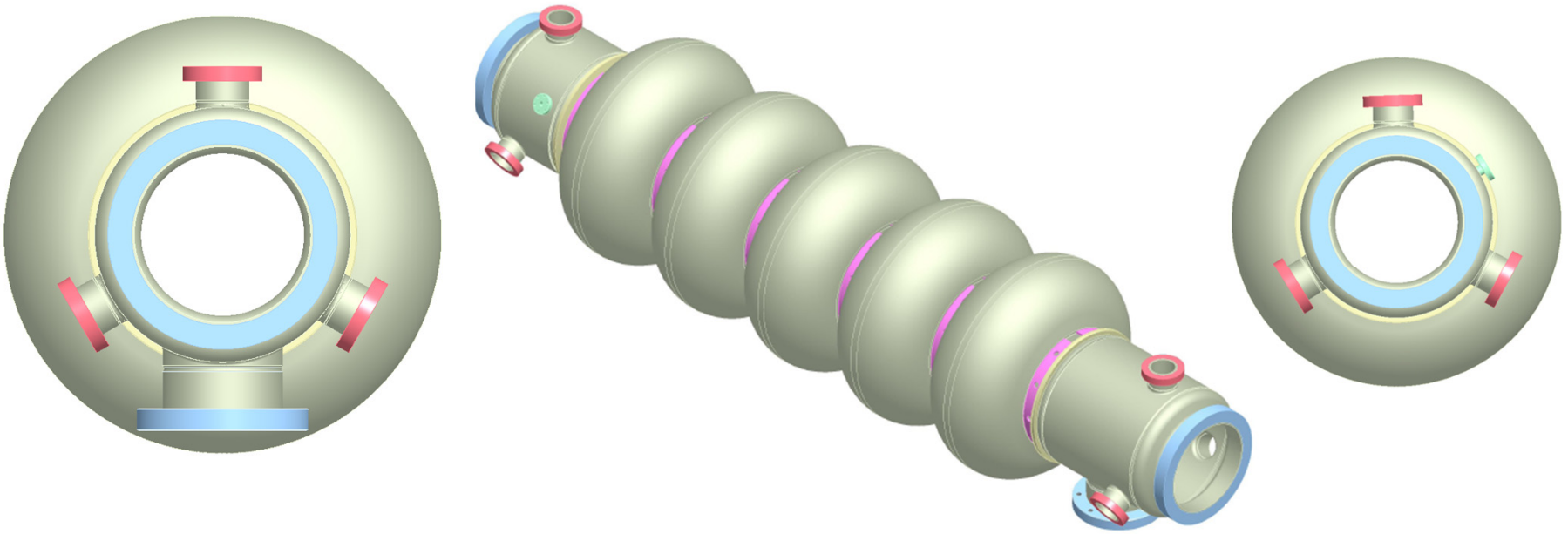






* The waist's impact on loss factor is negligible with quasi-symmetric structure.
* Cross-talk is also avoided by the waist.

Mechanical Design



- Three HOM couplers at each side of cavity;
- Cavity flange to flange length: 1.6 m;
- Radius of Stiffeners: 10.45 cm (Riris= 7.5 cm)

See: Tup269

Mechanical Characteristics

Parameters (2 K)	**Results**
Tuner[kHz/mm]	157.5
Tuning range[kHz]	+/-700
Frequency tuning sensitivity[kHz/lbf]	0.160
Lorentz detuning coefficient k[Hz/(MV/m)^2]	1.36
Helium Pressure sensitivity[Hz/mbar]	26
First mechanical mode with LHe vessel[Hz]	162.2

Summary

- We got lots of experience during the operation of the BNL I cavity in ERL prototype.
- BNL3 cavity has been designed for the high current SPL and ERL-based machine- eRHIC.
- A new prototype HOM coupler for high current SRF cavity has been designed and tested.
- Mechanical analysis of BNL3 cavity has been done and copper prototype will be completed next month.

Thank you