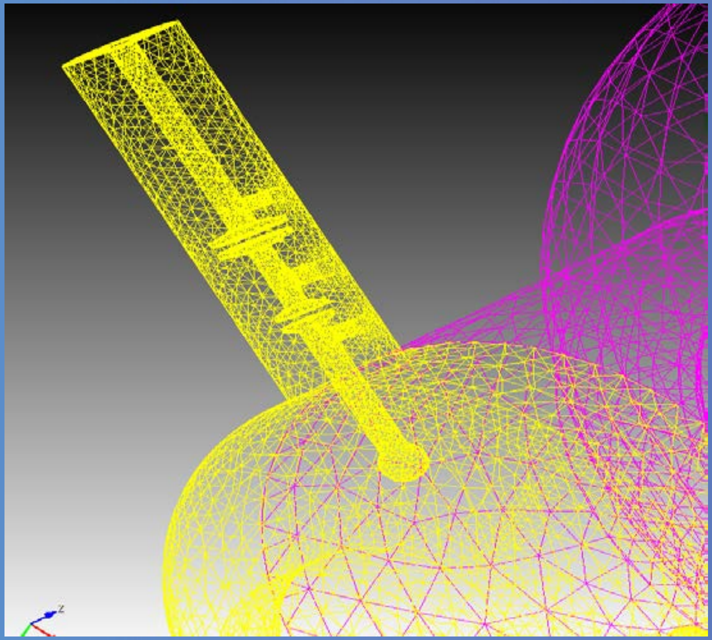
Development of antenna-type HOM couplers at BNL



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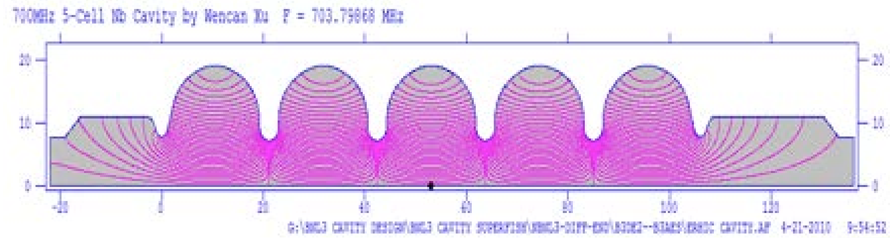
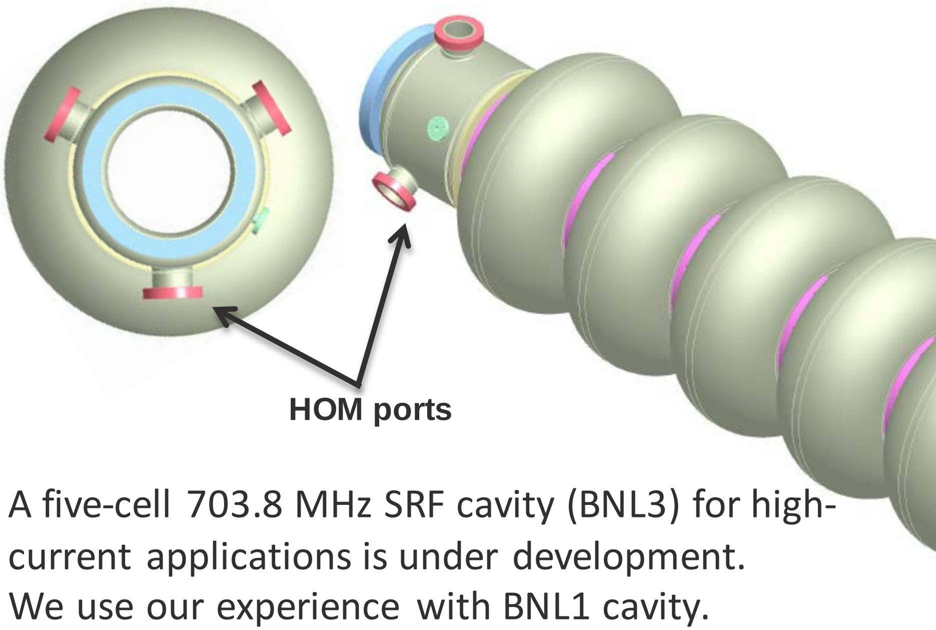
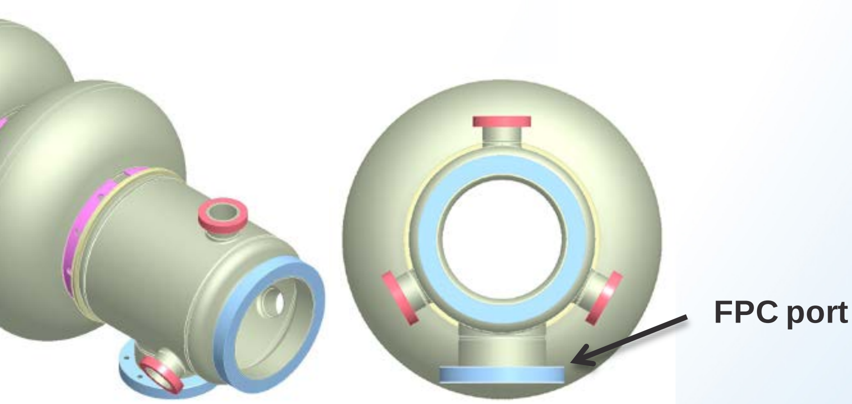
Five-cell SRF cavity with strong HOM damping







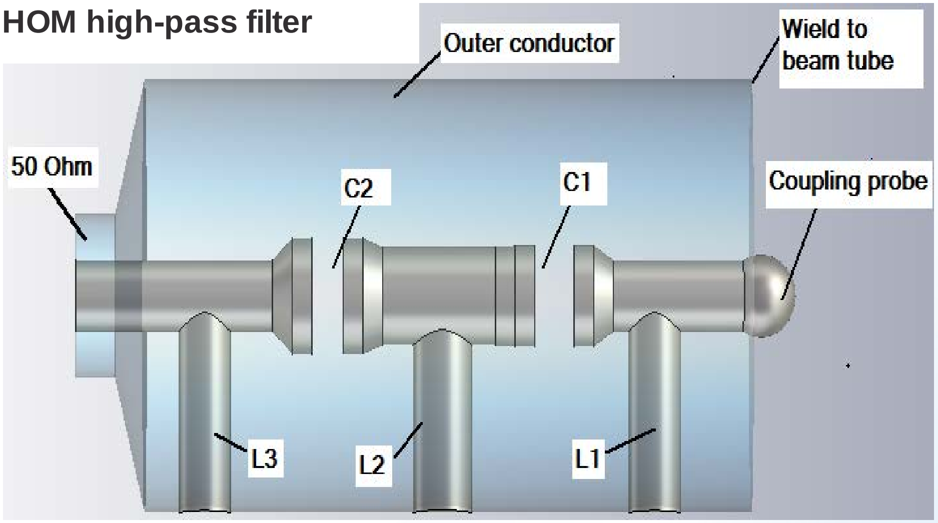
- A five-cell 703.8 MHz SRF cavity (BNL3) for high-current applications is under development.
- We use our experience with BNL1 cavity.
- The cavity is optimized and designed for applications such as eRHIC and SPL.
- Reduced peak surface magnetic field -> reduced cryogenic load.
- Three antenna-type couplers will be attached to a large diameter beam pipes at each end of the cavity and will provide strong HOM damping while maintaining good fill factor for the linac.
- HOM tolerances from BBU simulations.
- The cavities will operate at 19.2 MV/m.

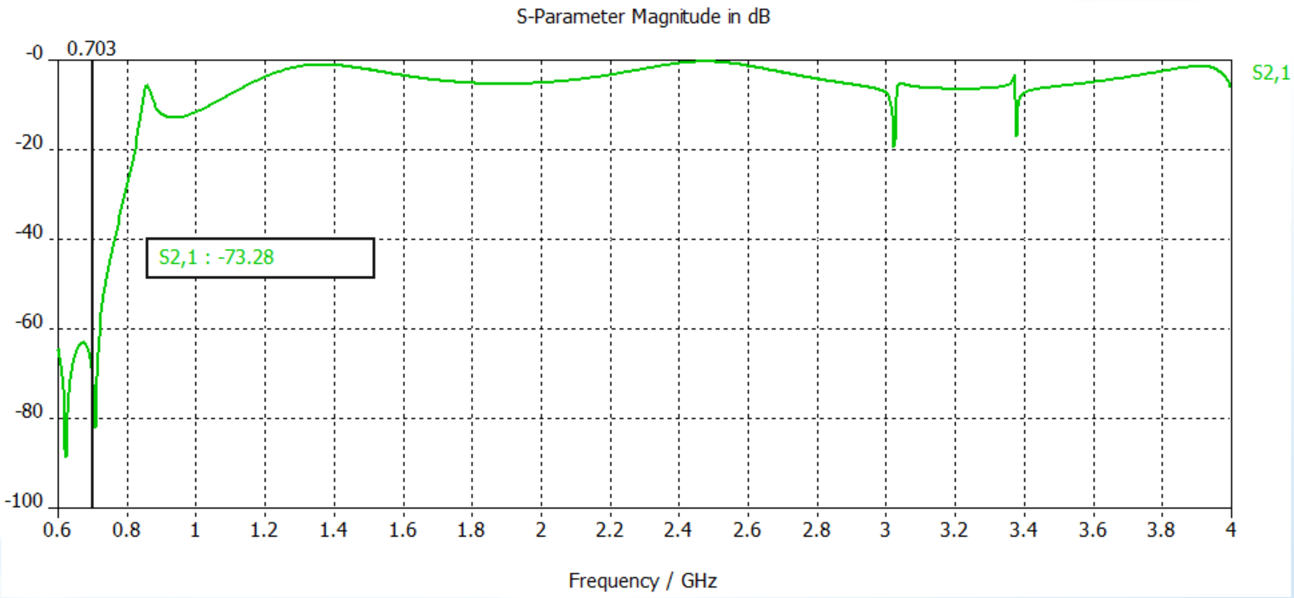
Parameters	BNL1	BNL3
Frequency [MHz]	703.5	703.8
No. of cells	5	5
Geometry Factor	225	283
R/Q [Ohm]	404.0	506.3
E_{pk}/E_{acc}	1.97	2.46
B_{pk}/E_{acc} [mT/MV/m]	5.78	4.26
Length [cm]	152	158
Beam pipe radius [mm]	120	110

HOM damping with antenna-type couplers

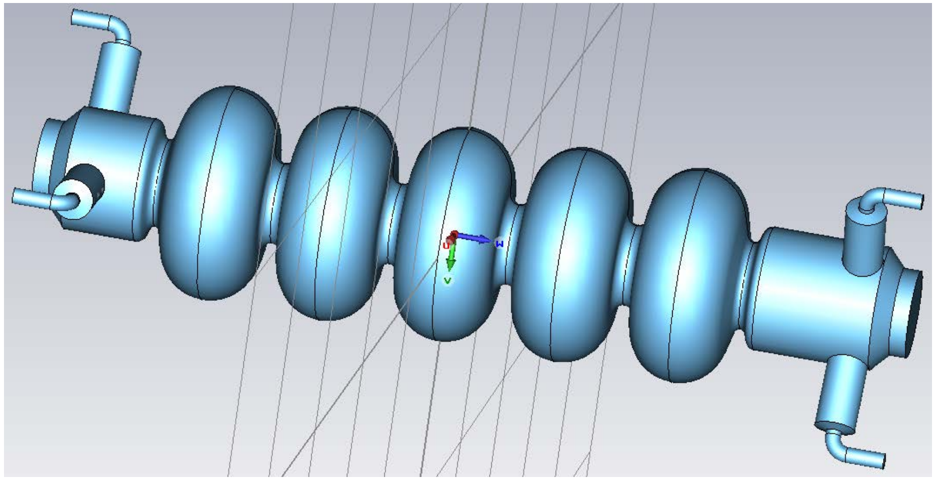
- A two-stage high-pass filter rejects fundamental frequency, but allows propagation of HOMs toward an RF load.
- 1st HOM is at 0.82 GHz.

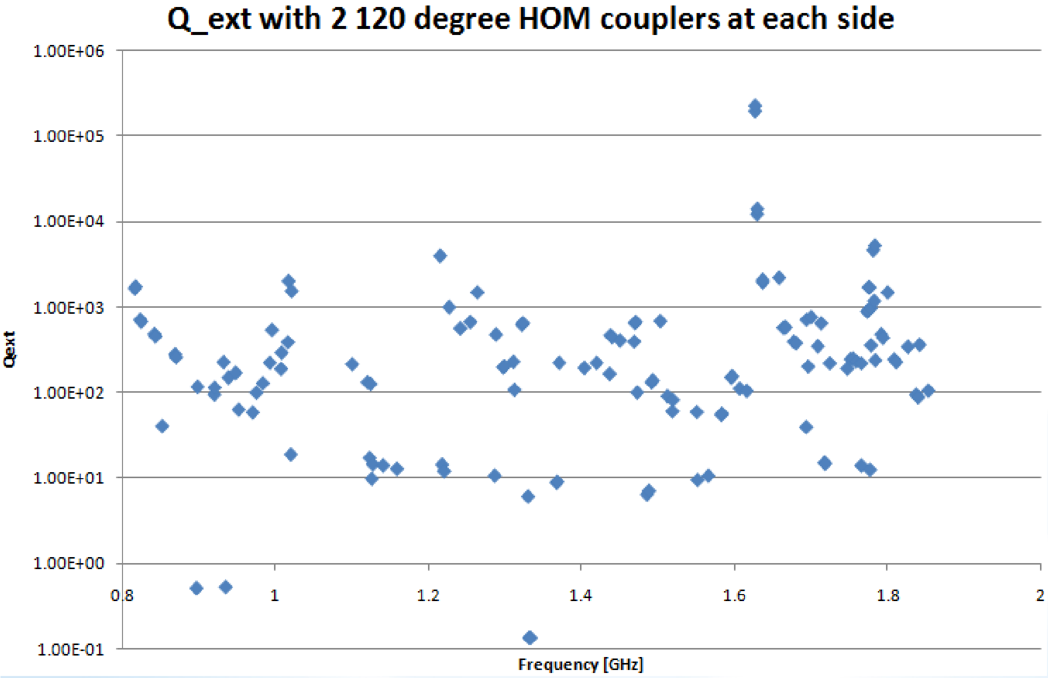
HOM high-pass filter





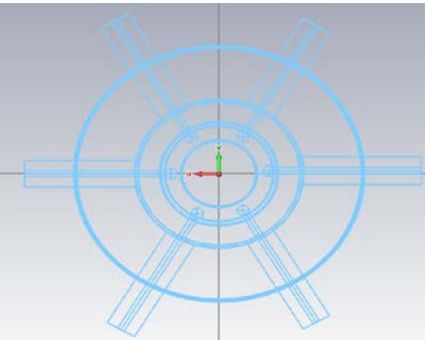
HOM damping

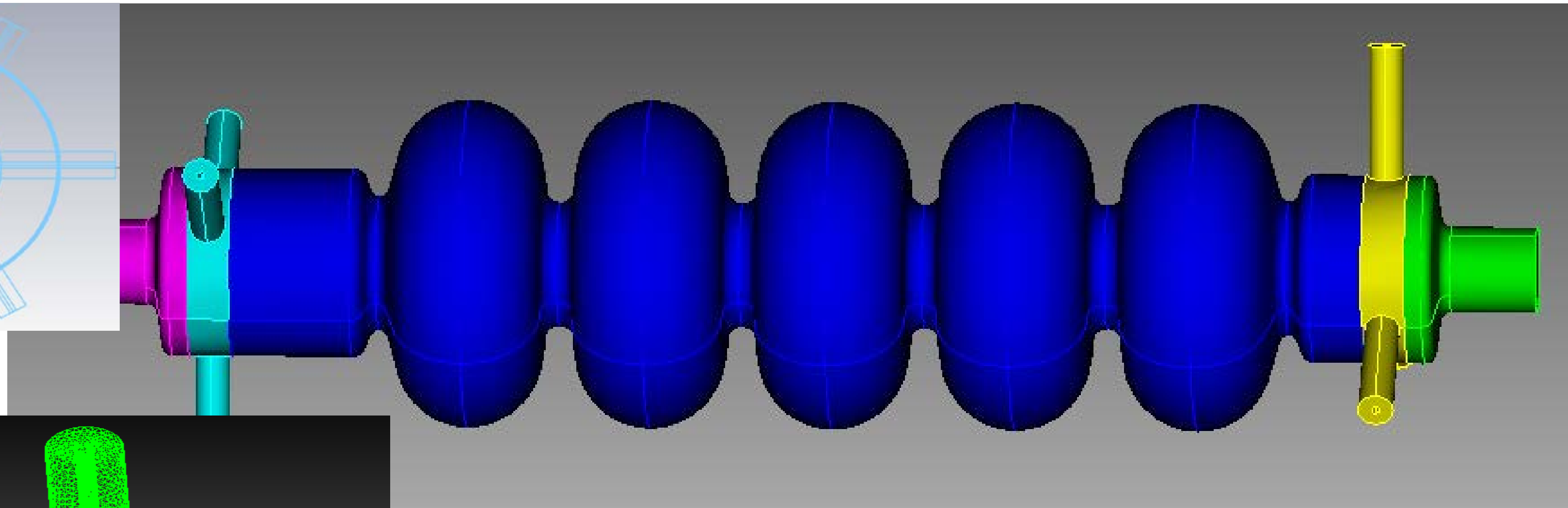


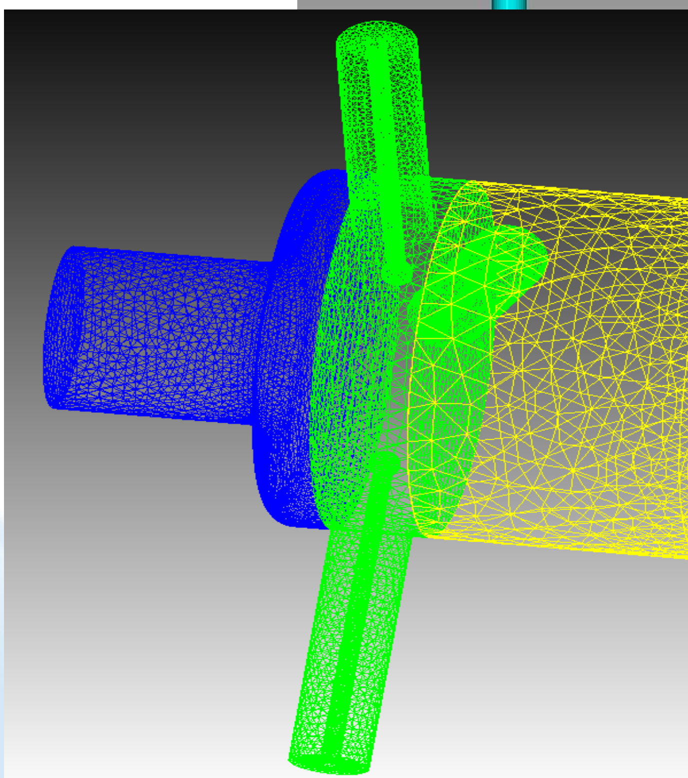


- Total HOM power to extract is 7.3 kW per cavity (loss factor 3.5 V/pC).
- Simulated a model with two HOM couplers per side using CST MWS.
- Modes at 1.62 GHz have R/Q of ~0.1 Ohm.
- Q_{ext} required from BBU simulations for dipole modes is ~40,000.

Optimization of the cavity with 3 couplers







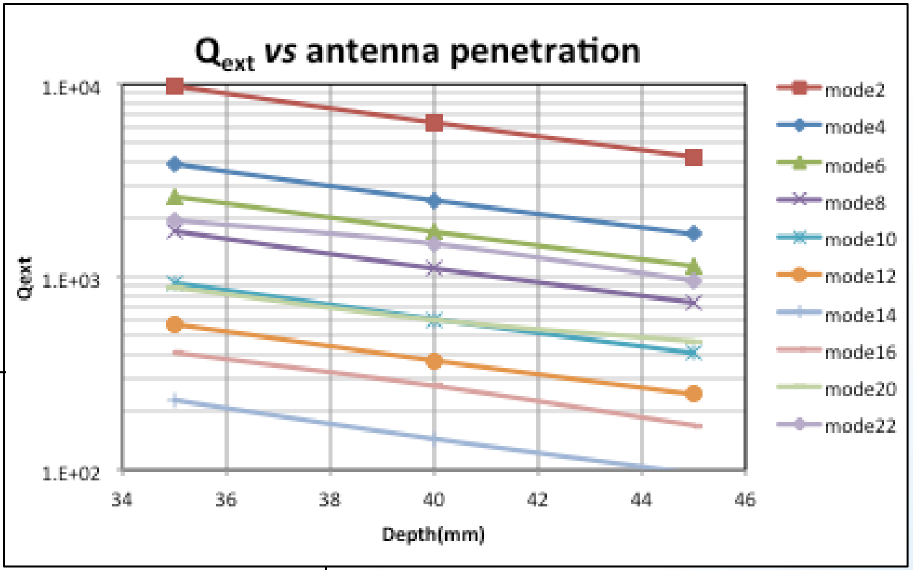
Optimization using Omega3P:

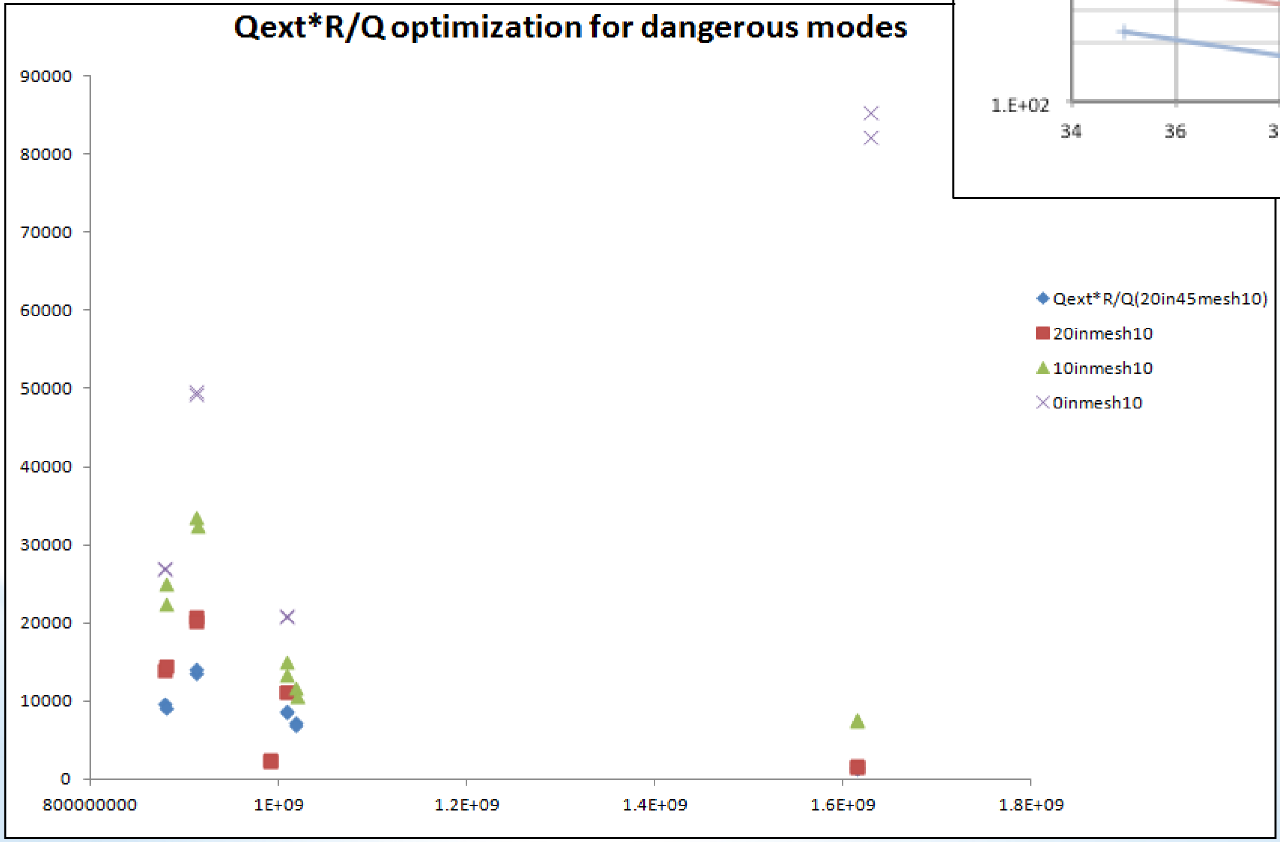
- Longitudinal position of the HOM coupler.
- Length of the antenna.
- Ball radius at the end of antenna.

First step: no filter.

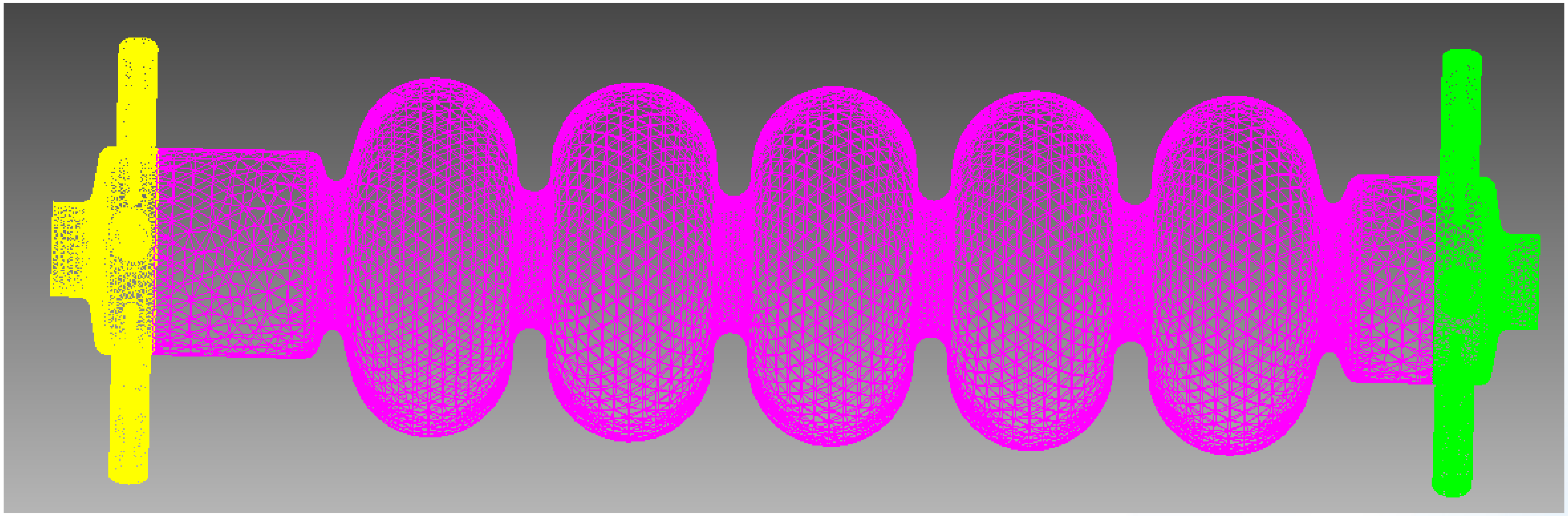
Preliminary simulation results

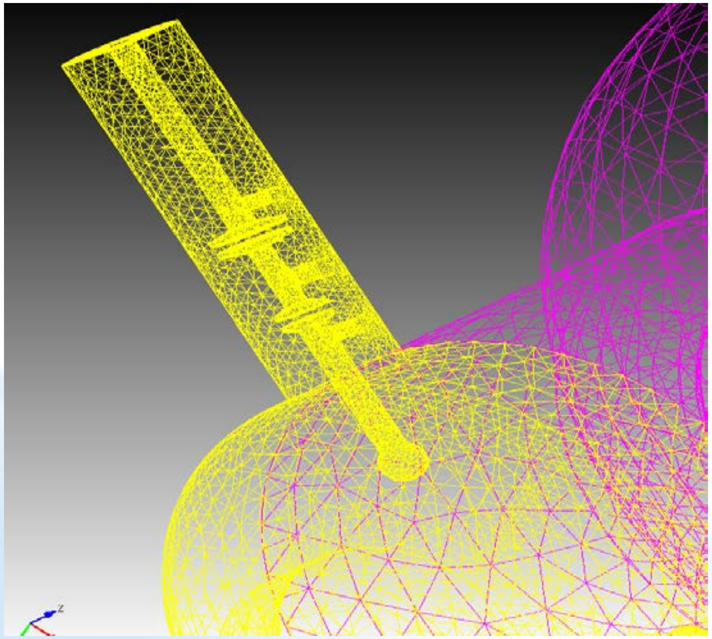
- For 5 GeV eRHIC ERL with 48 cavities the BBU threshold is 156 mA for 0.1% rms HOM frequency spread.
- The threshold increases to 206 mA for 0.5% frequency spread.
- This is still work in progress, the linac optics is not optimal yet.





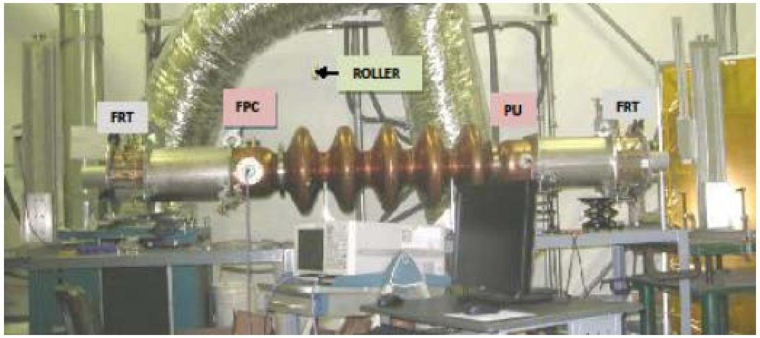
Next steps



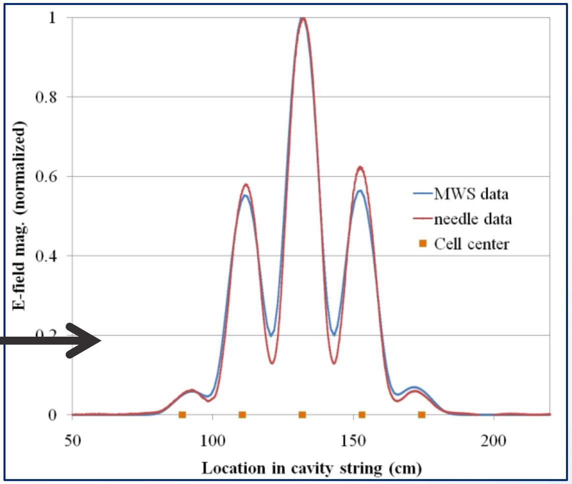


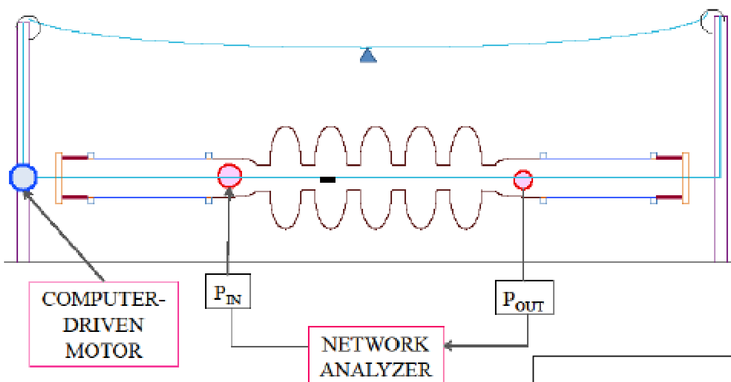
- Add FPC – should fix mode polarization.
- Finalize antenna length/position.
- Add high-pass filter.
- Simulate a string of cavities.
- Compare results with measurements on the BNL3 copper model.

HOM identification with bead pulling

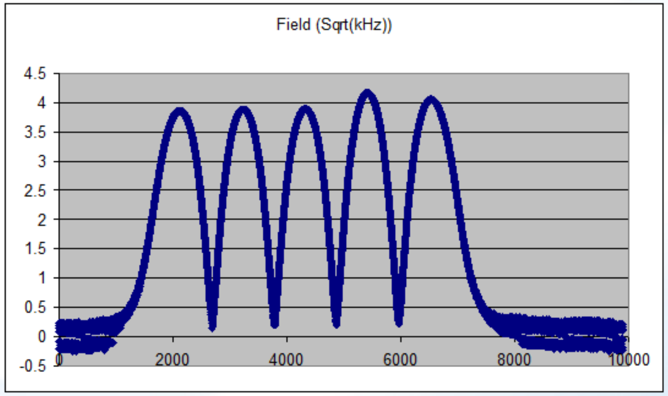


- A method of HOM identification using a bead pull system was developed.
- BNL1 cavity copper model was used for initial measurements.
- Both a metallic needle and a dielectric sphere were calibrated.
- 959 MHz dipole HOM



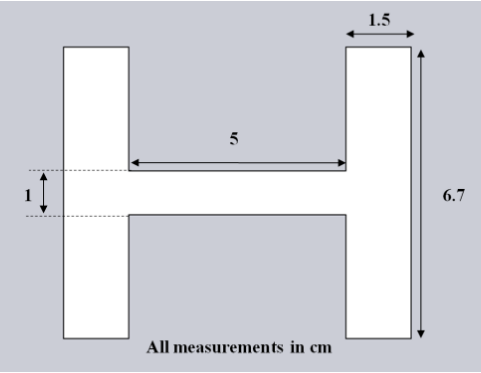


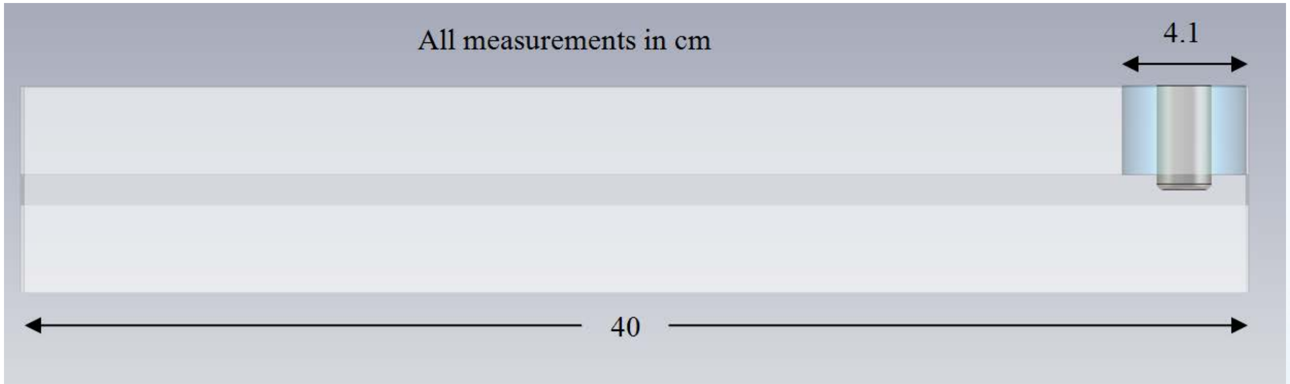
- BNL3 copper model field flatness right after fabrication: the fields are 93%,93%,93%,100%,97%



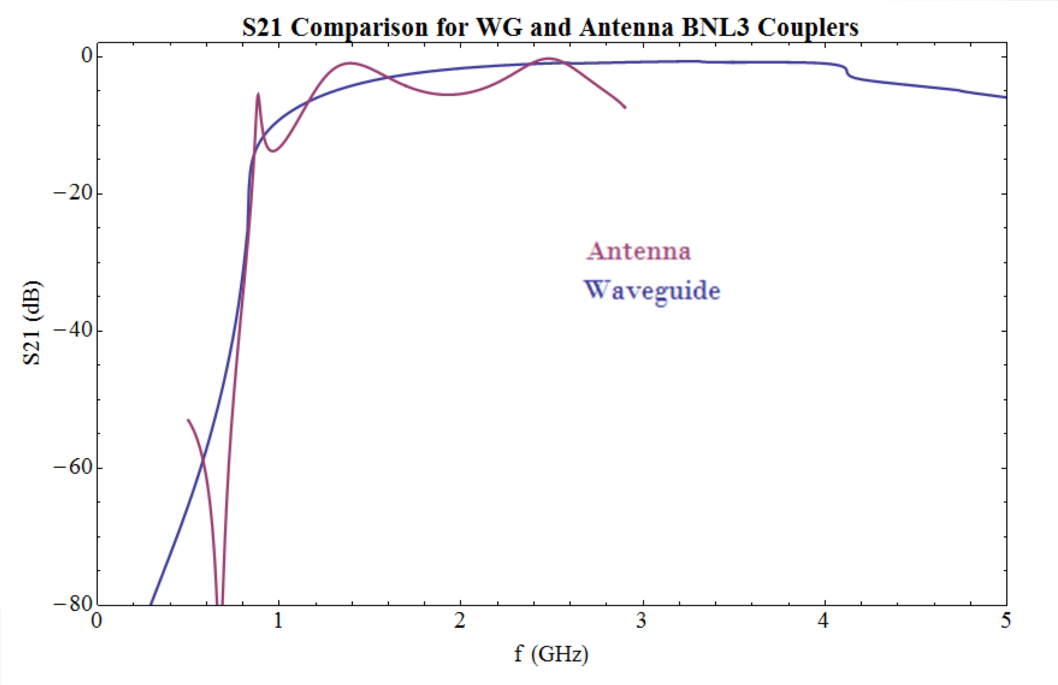
BNL3 cavity ready to be tuned at AES

Alternative coupler scheme





- Waveguide as a high-pass filter.
- Ridge WG for compactness.



Summary

- Antenna-type HOM coupler are being developed at BNL for future ERLs of eRHIC.
- The couplers use high pass filters to prevent unwanted loading of the fundamental mode.
- Two designs are under considerations: one employing coaxial-line-based filter and one employing a waveguide filter.
- Computer simulations with CST MWS and Omega3P are in progress.
- They will be compared with measurements of a BNL3 copper model.