HOM Damping of the Fundamental Power Couplers of the BNL ERL Electron Gun

L. Hammons / H. Hahn

Brookhaven National Laboratory

Collider-Accelerator Department

State University of New York at Stony Brook

11 October 2010

International Workshop on Higher-Order-Mode Damping in Superconducting RF Cavities

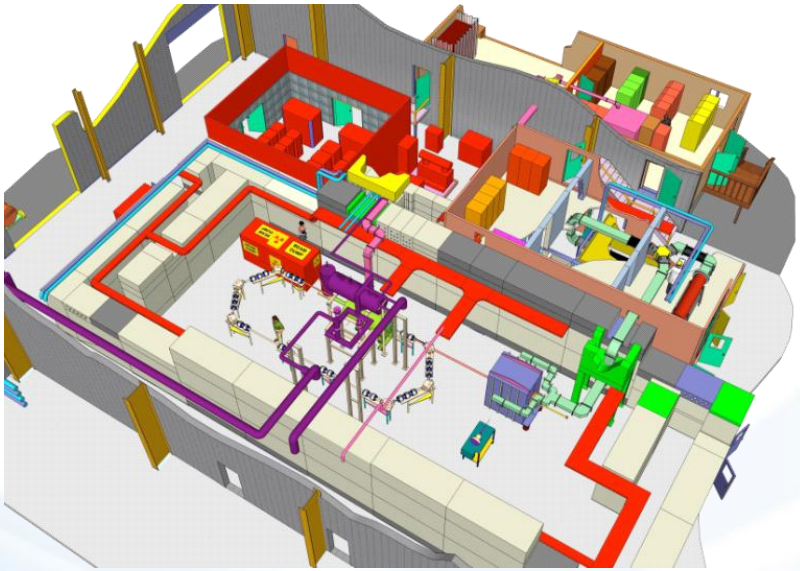
BROOKHAVEN NATIONAL LABORATORY

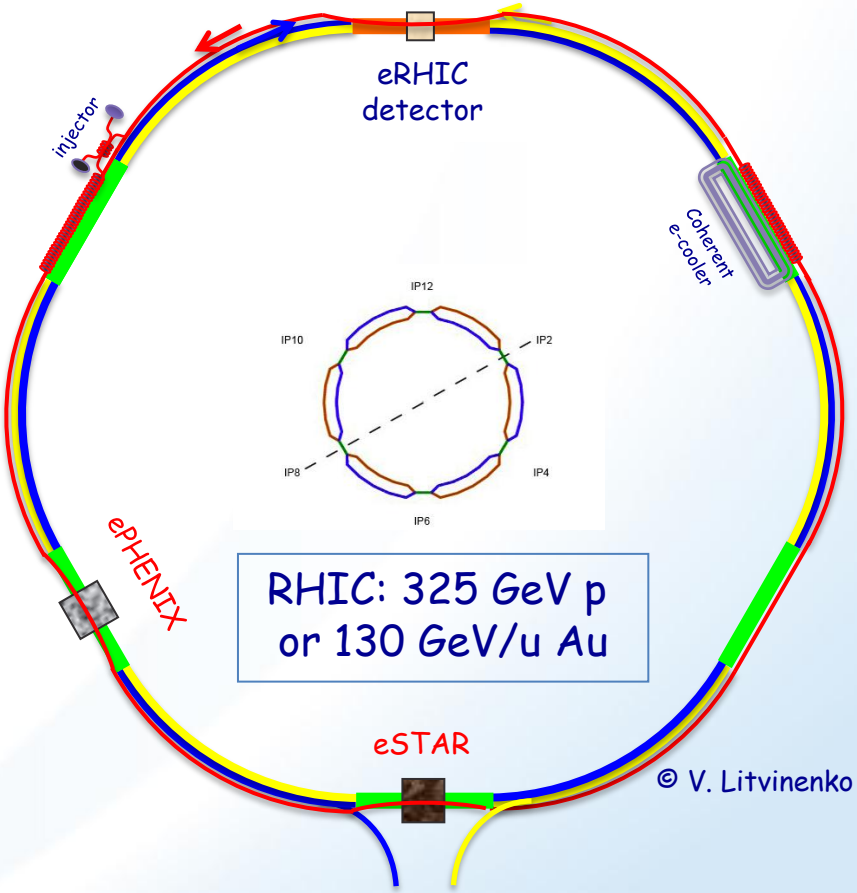
a passion for discovery

Office of Science U.S. DEPARTMENT OF ENERGY

Effective HOM Absorber Development is Crucial to ERL and eRHIC

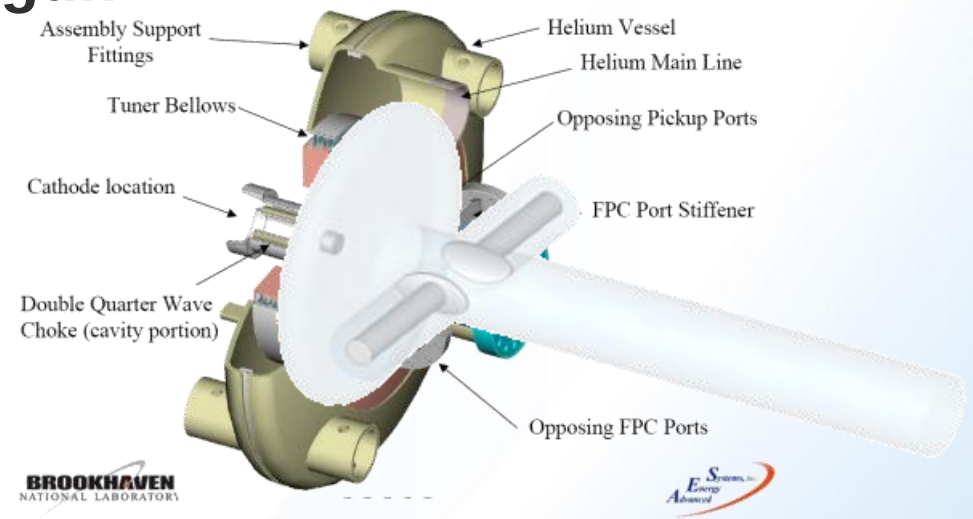
- ERL R & D facility with superconducting 5-cell cavity and ½-cell electron gun
- eRHIC

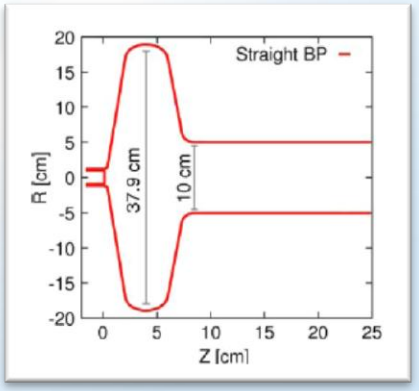




Electron Gun for the Energy Recovery LINAC

- **½-cell superconducting gun**
  - 703.75 MHz
  - 2.5 MeV injection energy
  - 1 MW power from klystron
  - 500 mA average current
  - Dual coupler ports





Cathode →

← Coaxial Coupler

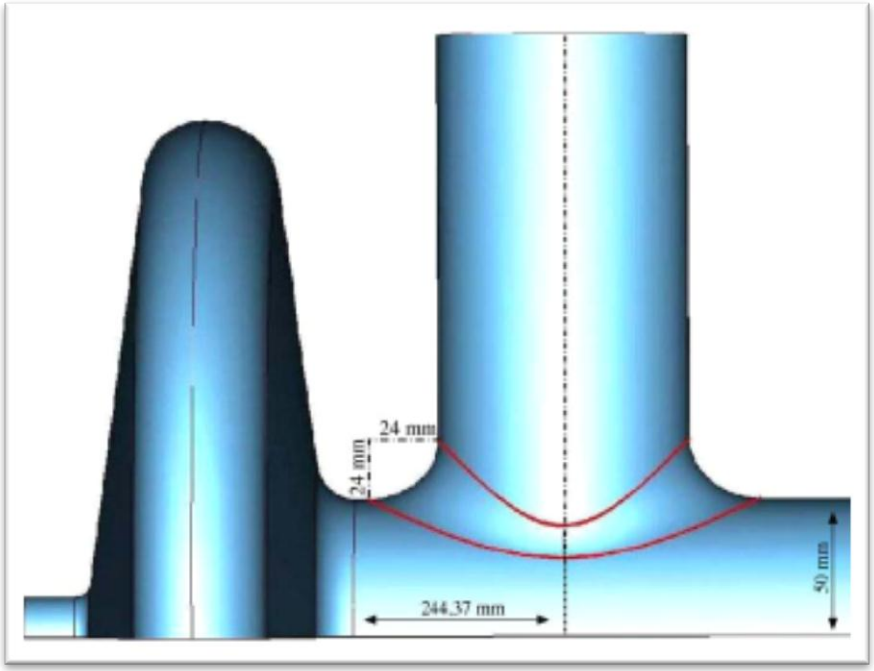
← Beam Pipe

“Pringle” Tip ↖

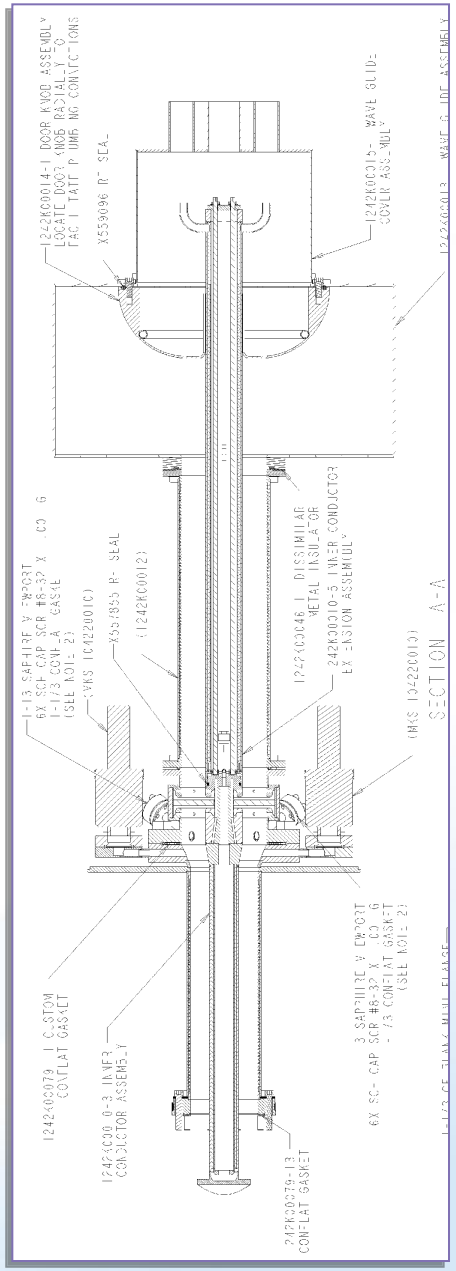
Fundamental Power Couplers

- **Gun requires strong coupling of FPCs**
  - $Q_{ext} \sim 4 - 5 \times 10^4$
  - Coaxial coupler with curved tip was found to be effective choice
    - Radius of curvature conformal with beam pipe radius
    - Dual coupler design minimizes destabilizing effect of non-zero fields on axis at relatively low energy
    - Also halves average power through each coupler

Coupler Design



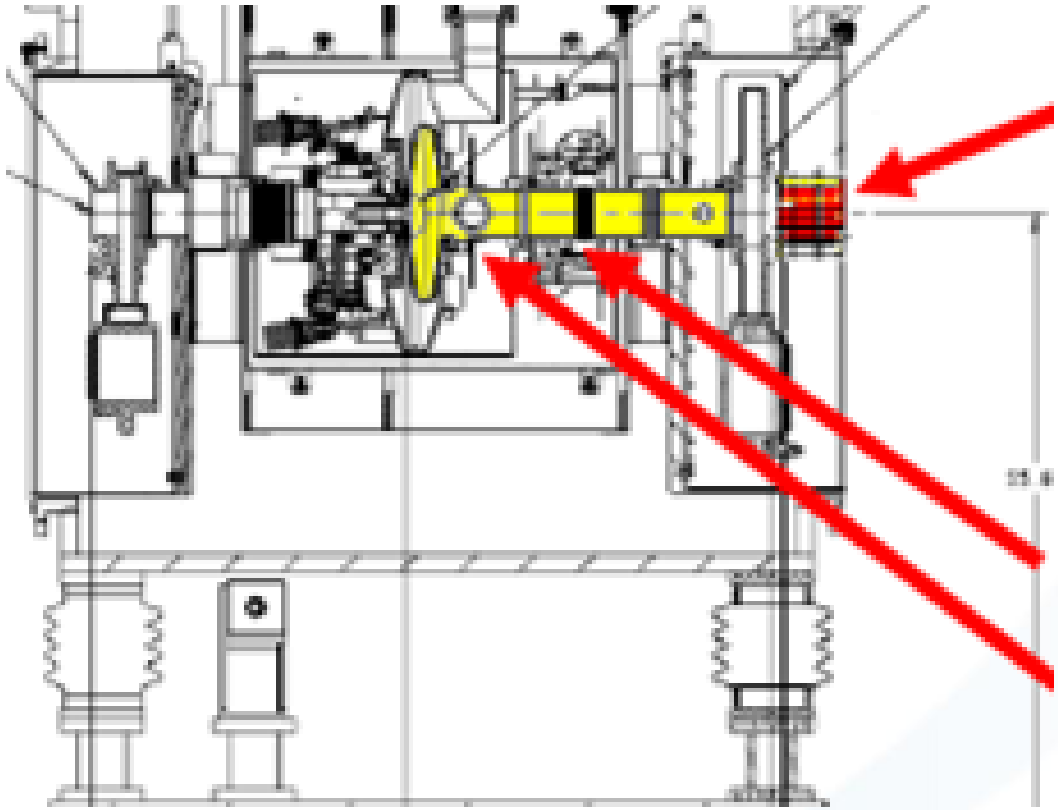
Calaga, R., et al., Physica C, 2006



HOM Considerations

- **High current beams dissipate large power in HOMs**
  - Approximately 0.5 KW for 500 mA beam current and 1.4 nC bunch charge
  - Must be extracted outside cryogenic environment
- **Beampipe ferrite absorber placed in warm section to absorb HOM power**
  - Only effective for modes beyond cutoff of beampipe
    - Cutoff: ~2.2 GHz

Can FPCs Play Effective Role in Damping?



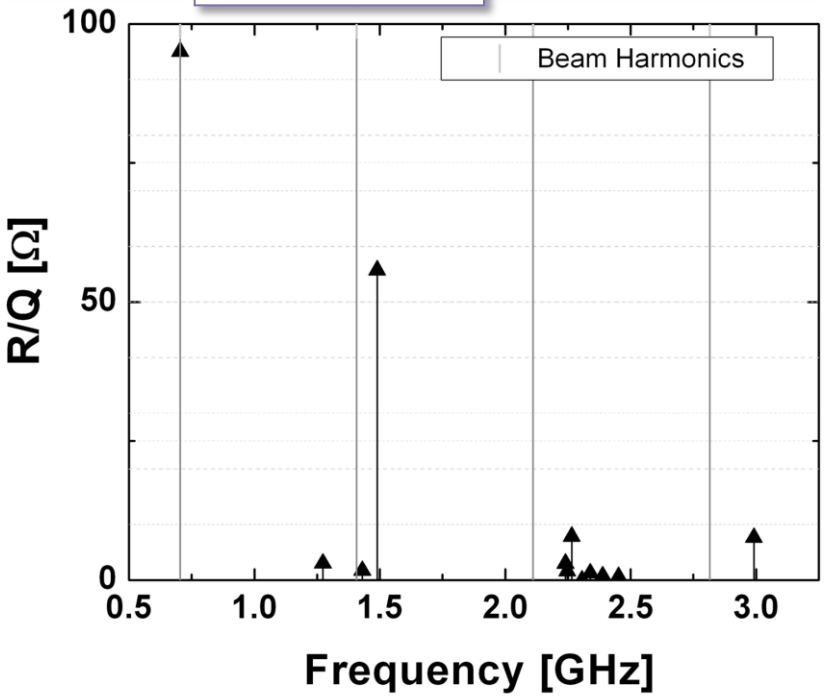
Ferrite Absorber

Beampipe

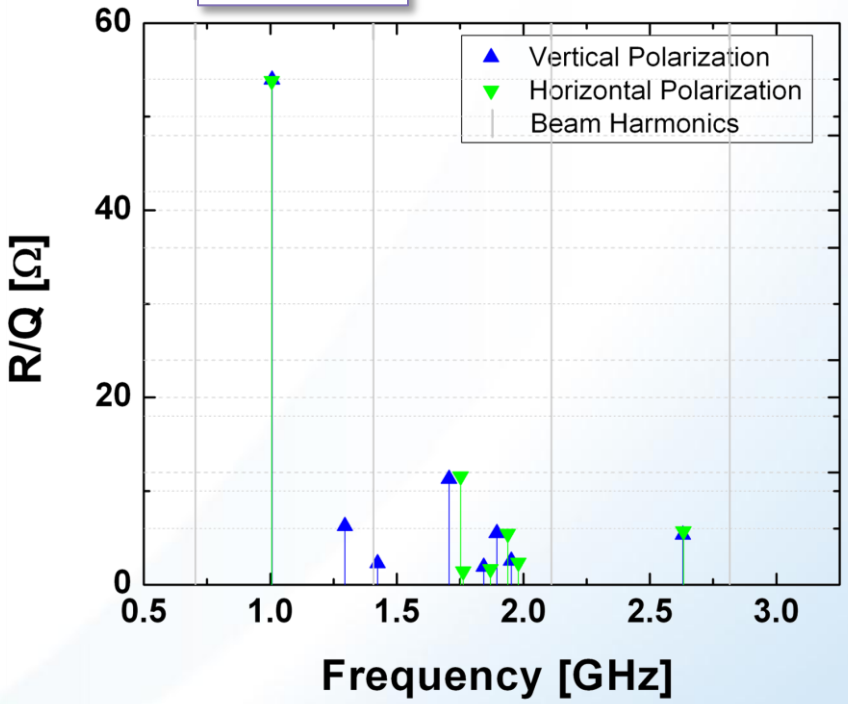
Gun Cavity

HOM Modes in Gun

Monopoles

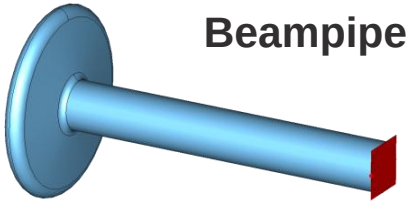


Dipoles

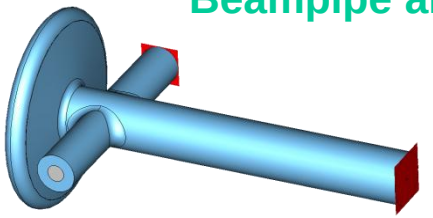


Simulation Studies Using Microwave Studio Indicated Strong Coupling of FPCs to HOMs

Beampipe termination



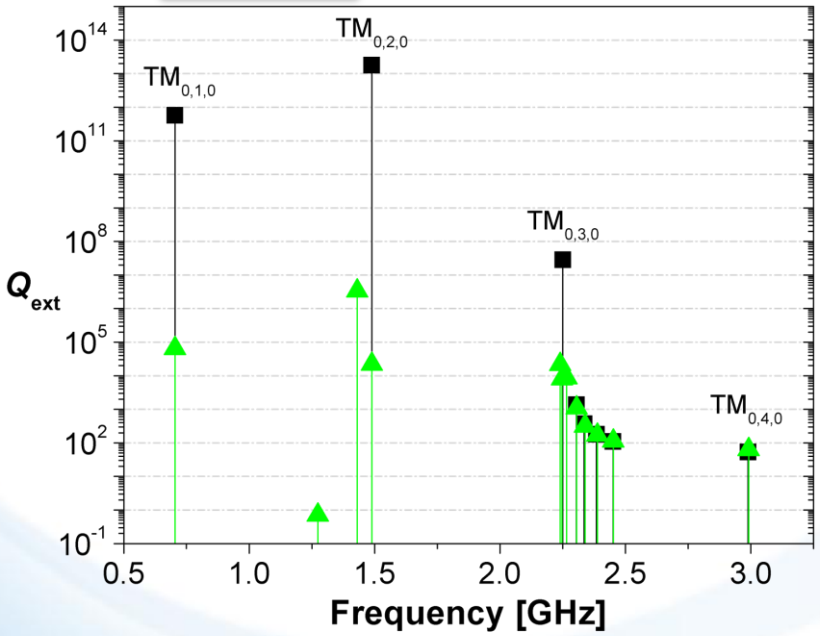
Beampipe and coupler termination



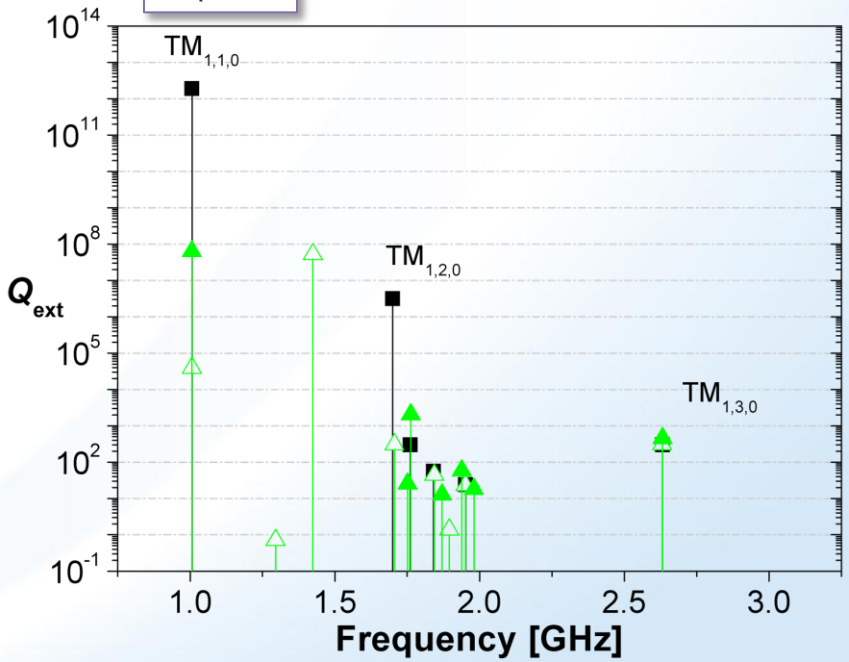
Horiz. Polarization

Vert. Polarization

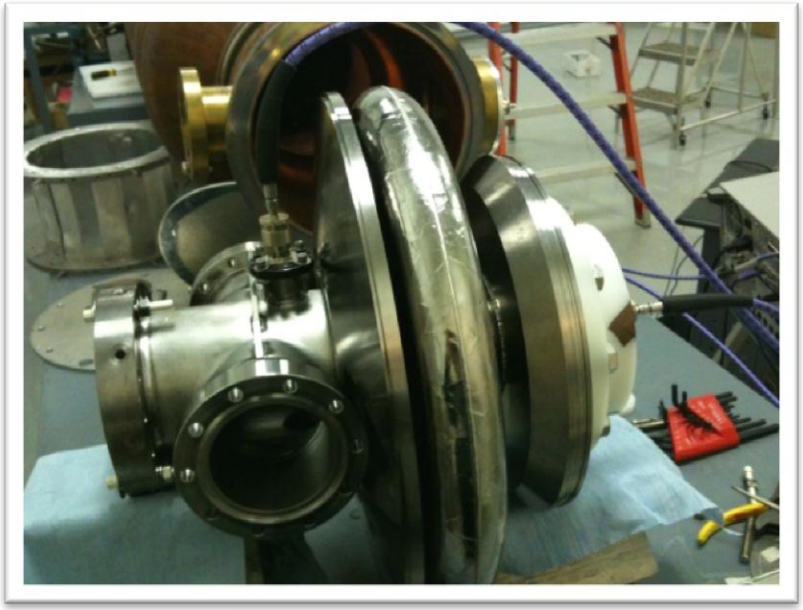
Monopoles

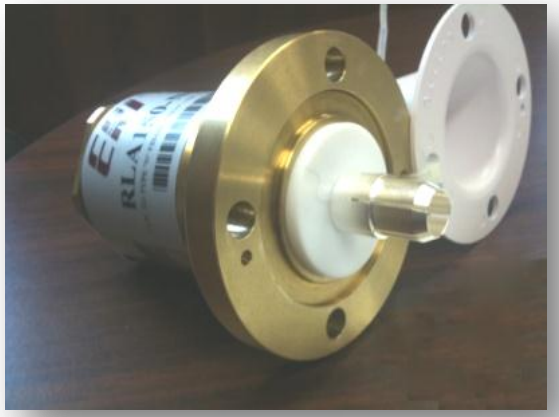


Dipoles



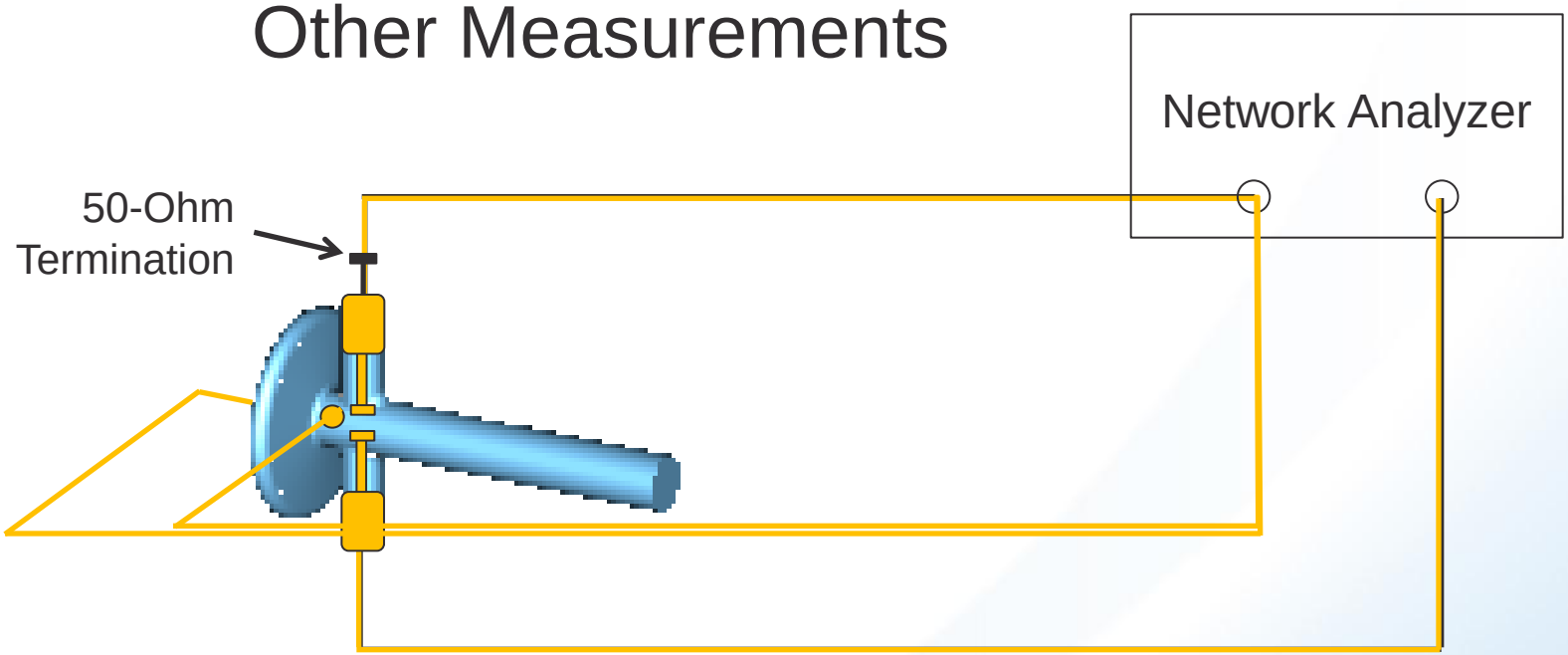
Measurement of HOMs



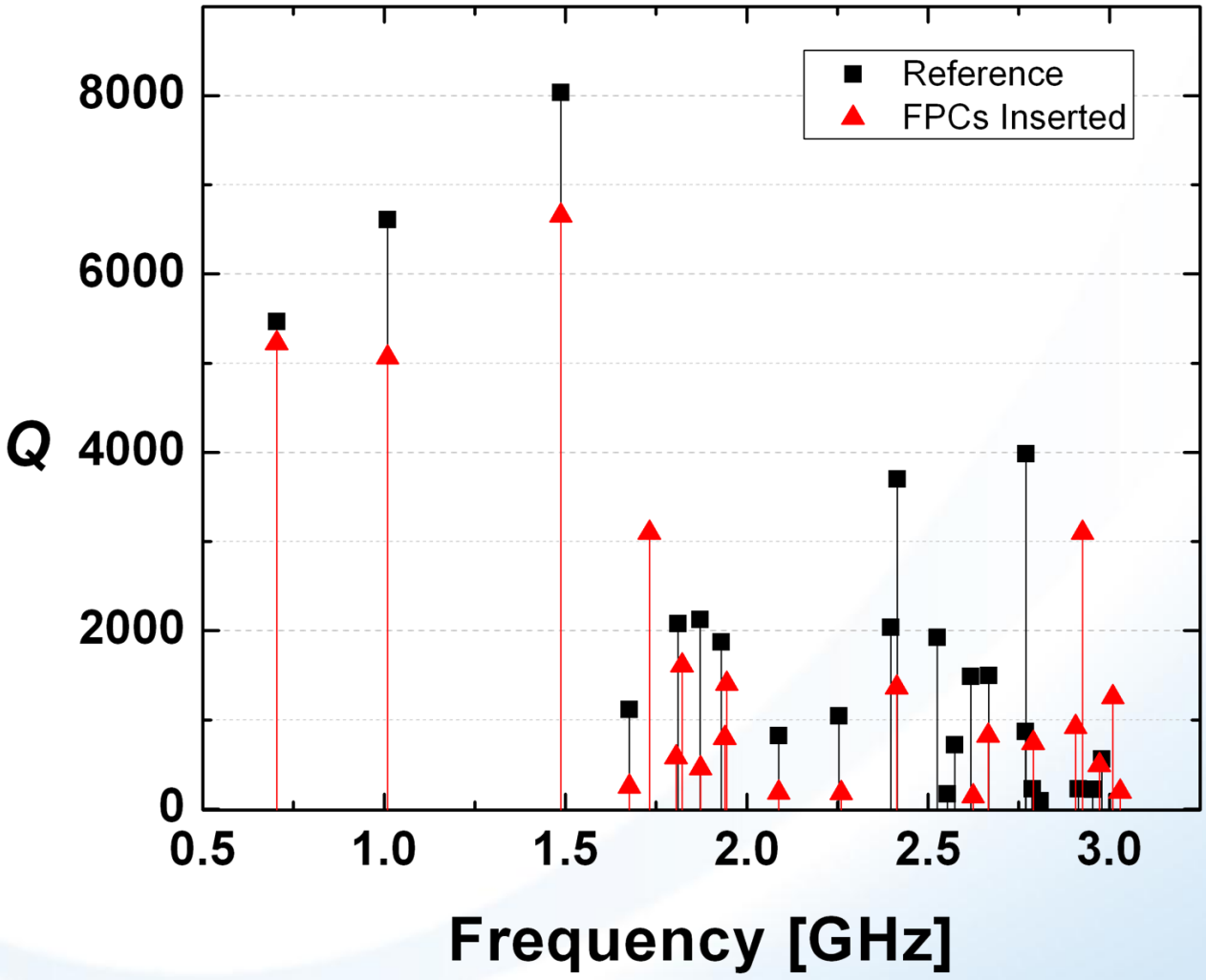


Measure FPC Coupling

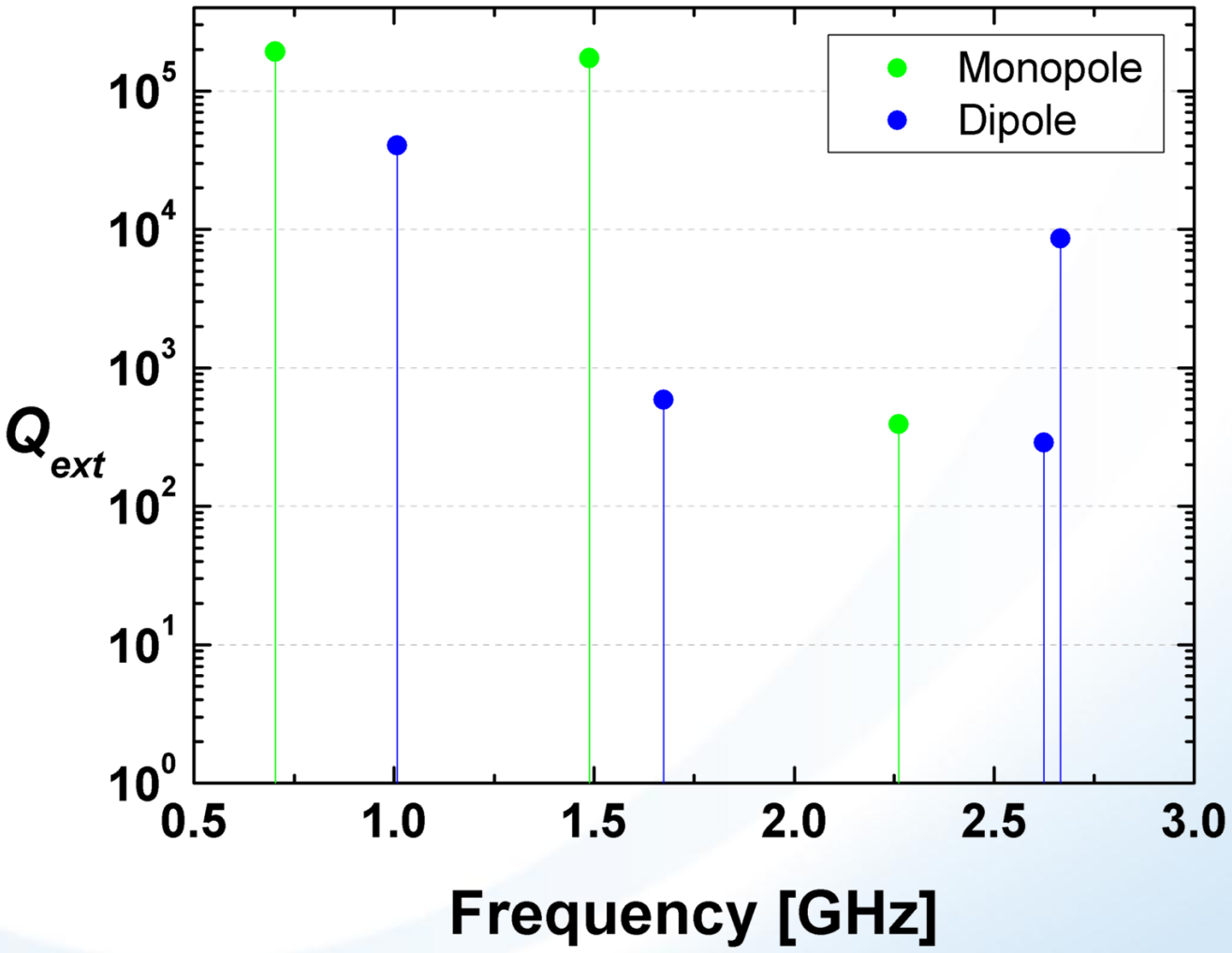
Baseline Measurement (No FPCs)
Measurement with FPCs
Other Measurements



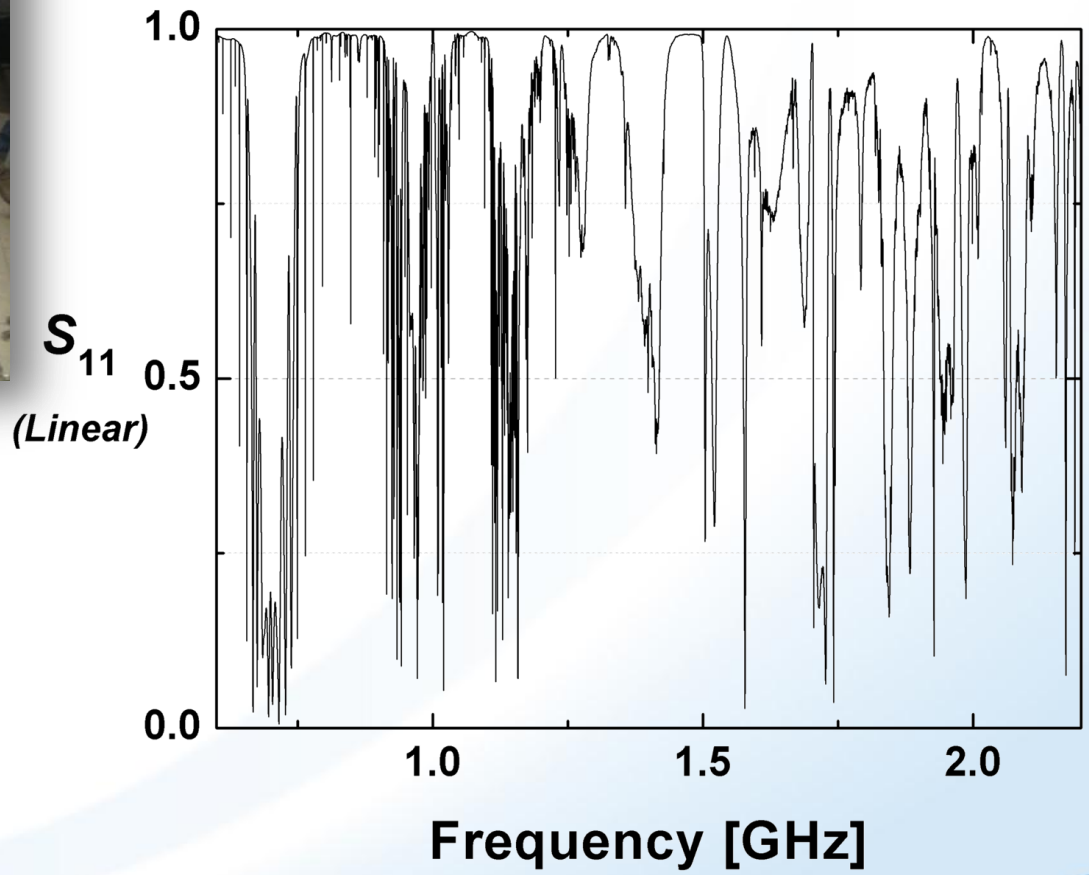
Measurement of FPC Coupling



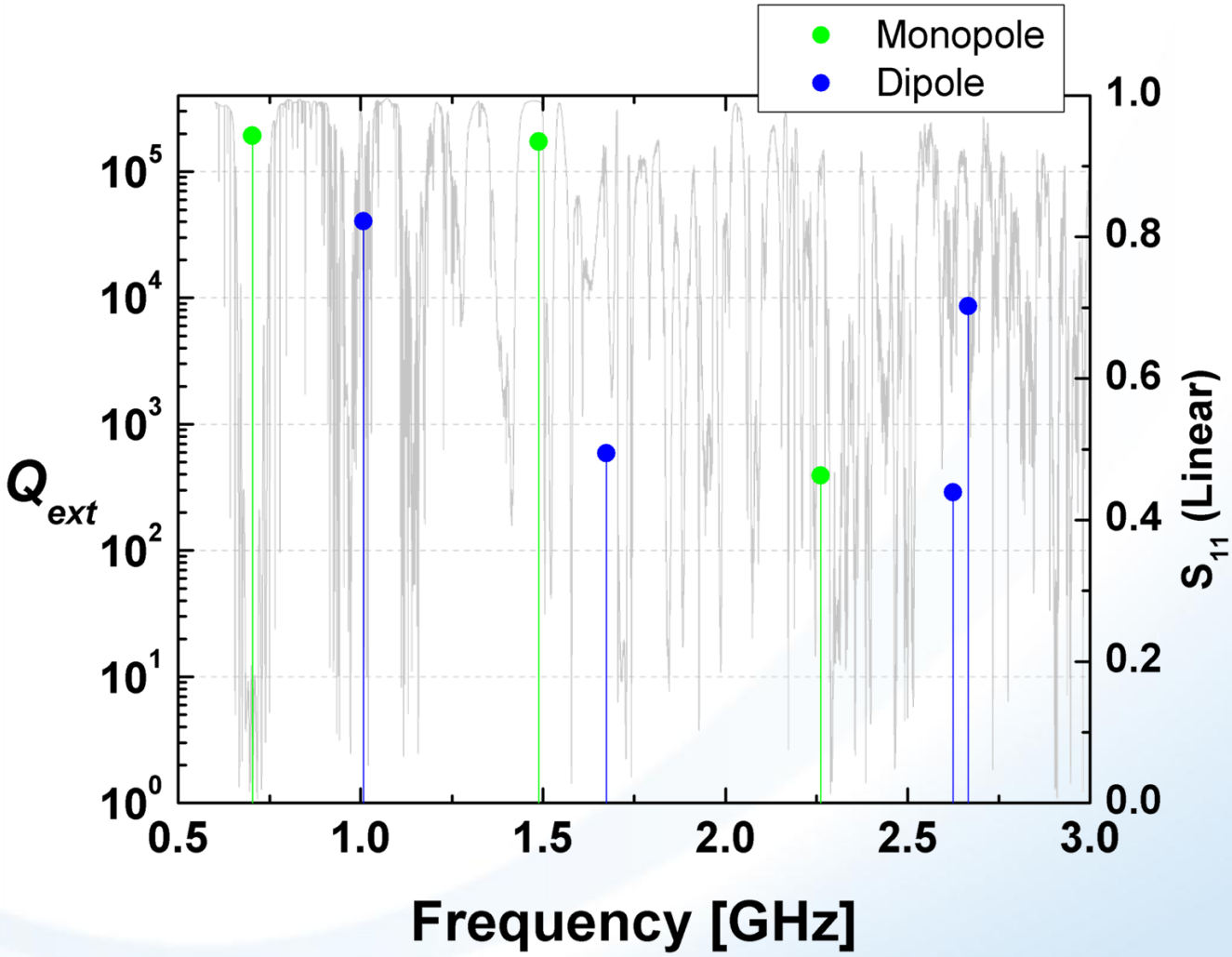
Q-external Calculation



Disposal of Energy



HOM Mode Frequencies Compared to Circulator Response



Conclusions

- HOMs are strongly coupled to the FPCs
  - Potential for HOM damping exists
- Potential damping is significant
- However, full damping may not be achieved due to reflections at circulator
- Mock FPCs do not fully characterize FPC response
  - Require study of real FPCs with transition from coaxial to waveguide to fully characterize the HOM damping.