LHC Crab Cavity Conceptual Design at SLAC

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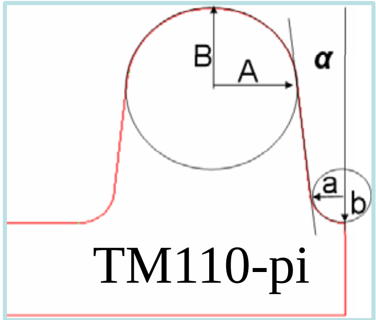
Outline

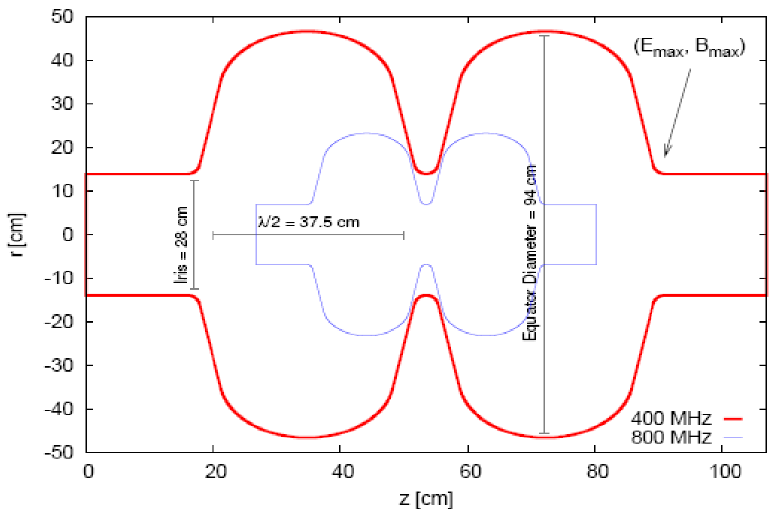
- **Cell Shape Optimization**
- **Optimum Squash Ratio**
- **LOM/SOM Coupler Design**
- **HOM Coupler Design**
- **Cavity Configuration Considerations**
- **Summary**

Cell Shape Optimization

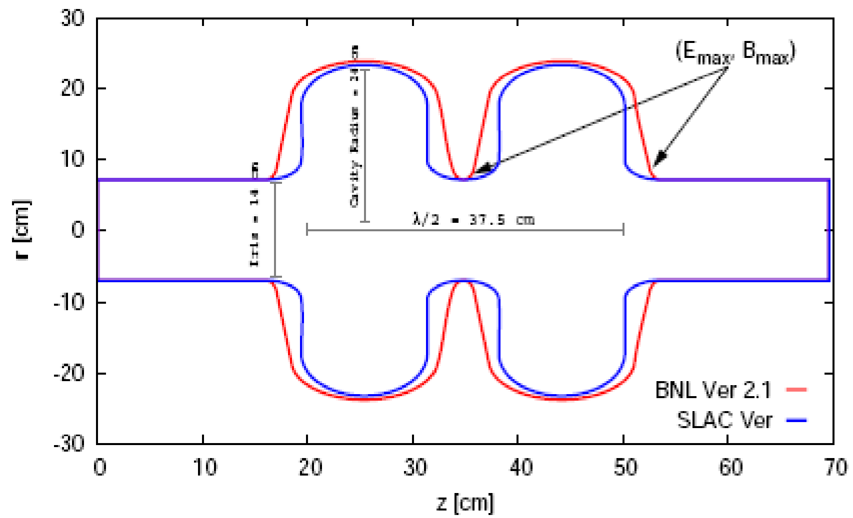
800MHz crab cavity design

- Maximum kick gradient limited by B_{peak}
- Optimize disk parameters for optimal E_{peak} and B_{peak}
- Cell_l=187.5mm, R_disk=70mm



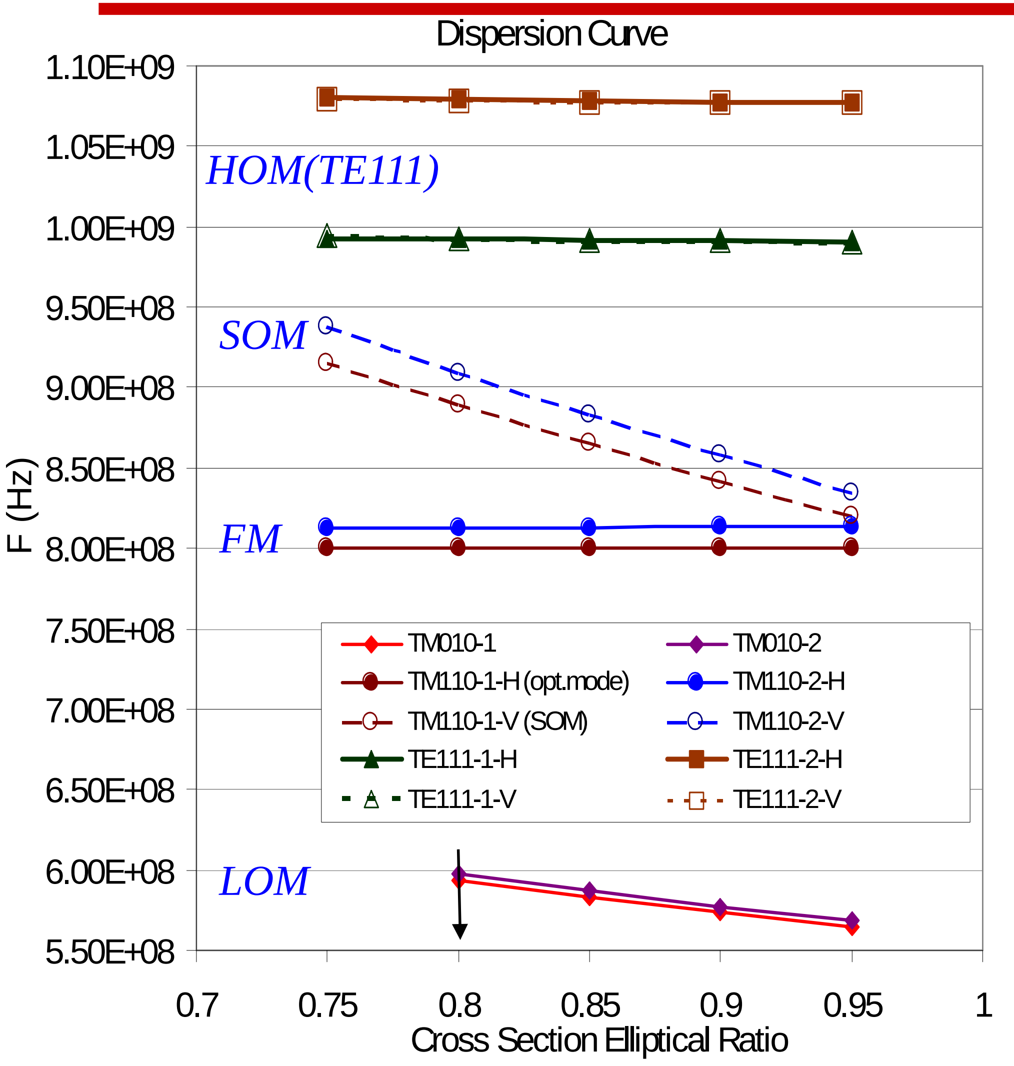


400MHz Cavity Design, Courtesy Rama Calaga's



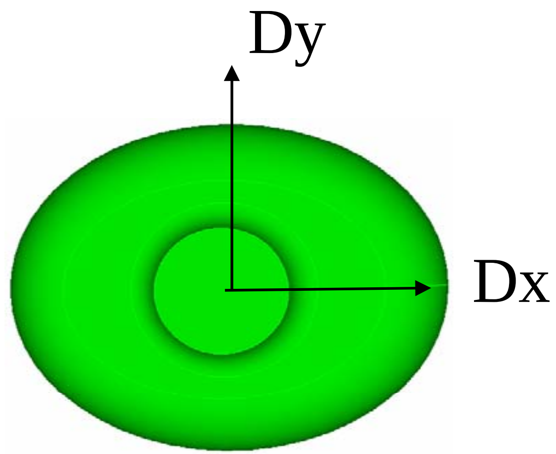
Without Squashed, Courtesy Rama Calaga

Optimum Squash Ratio



Squash ratio is chosen to optimize mode separation.

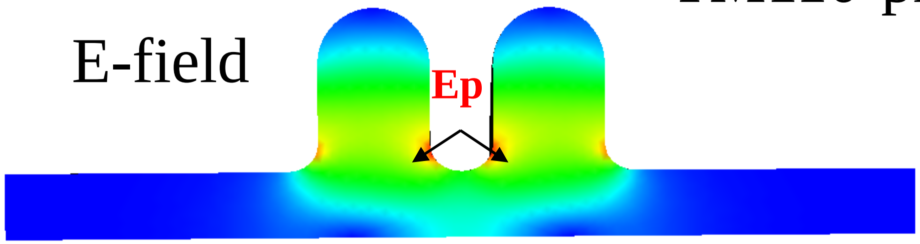
Max Dx is limited by available horizontal space

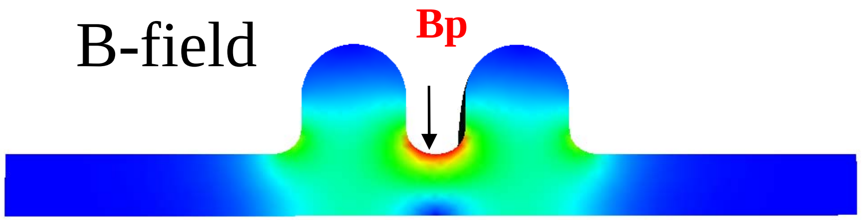


Fc=1.2GHz@R_beampipe=70mm

800MHz Crab Cavity RF Parameters

TM110-pi mode

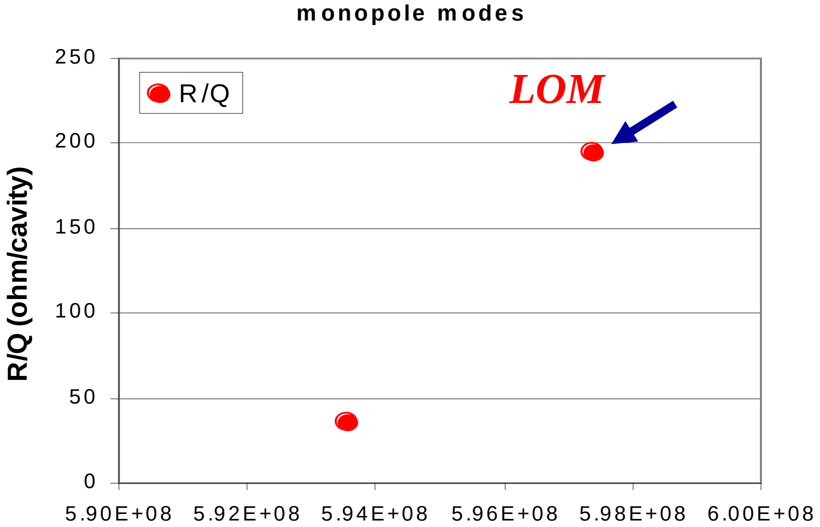


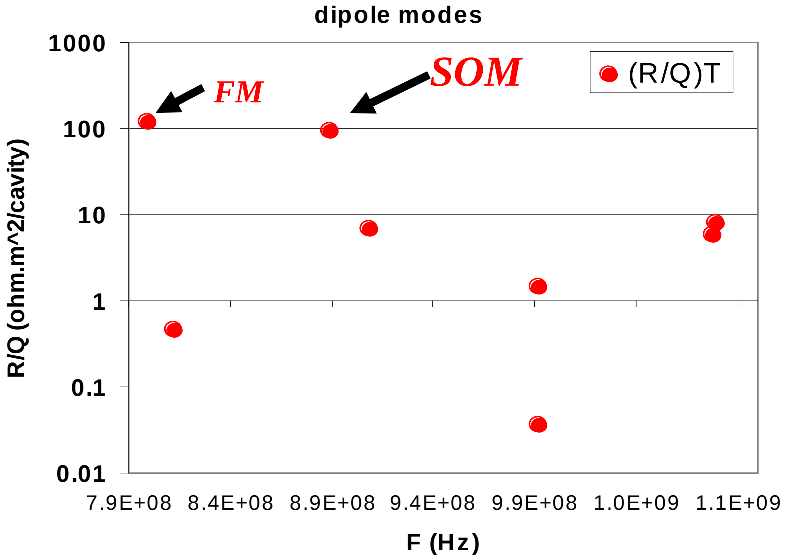


Frequency	800MHz
(R/Q)_T	117ohm/cavity
Deflecting Voltage V_T	2.5MV
Deflecting Gradient Ekick	6.67MV/m
Epeak	24.72MV/m
Bpeak	82.75mT
Mode separation (Opt.-SOM)	89MHz

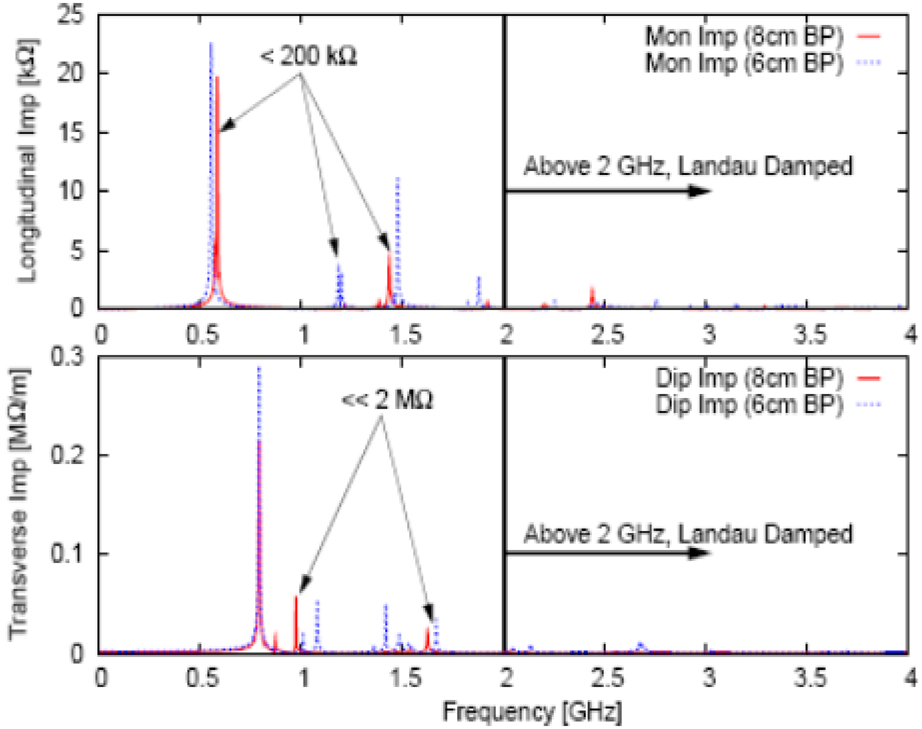
TESLA TDR cavity peak fields for comparison
(Eacc: 37-47MV/m)
Epeak: 70-90MV/m
Bpeak: 150-190mT

Damping Requirements





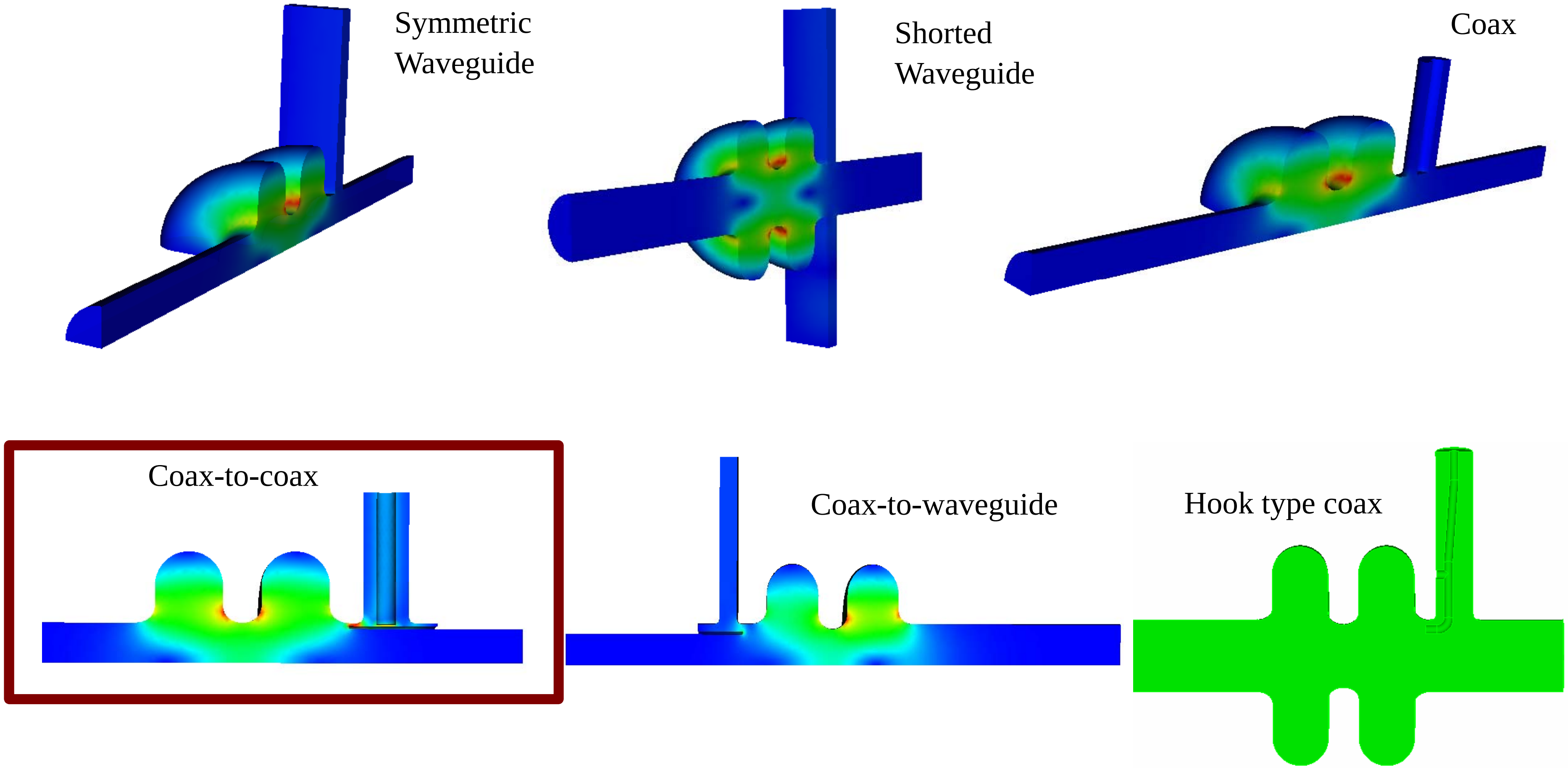
Qext for LOM<200



Courtesy F. Zimmermann, R. Calaga

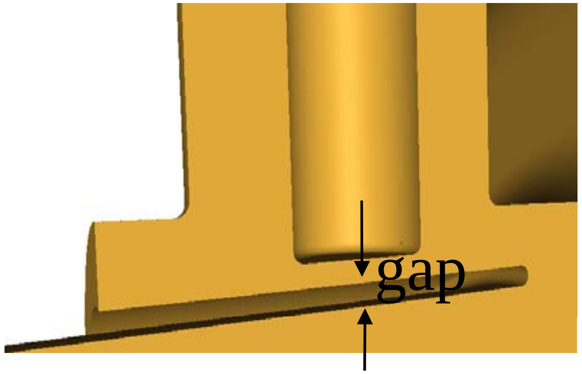
High R/Q LOM and SOM modes need to be strongly damped.

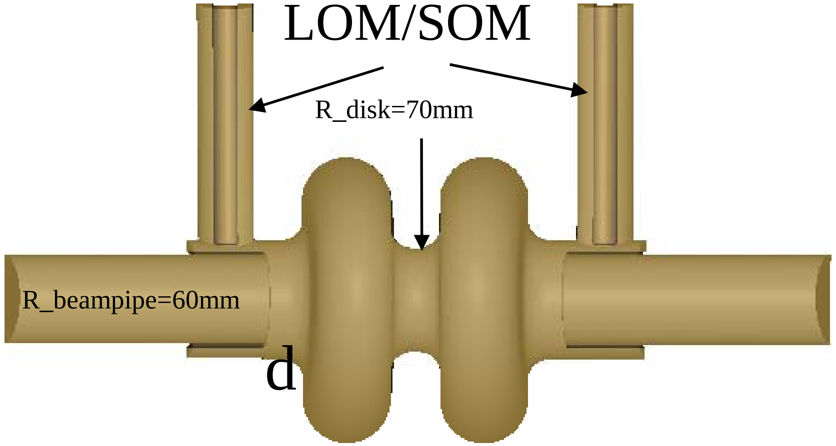
LOM/SOM Damping Schemes

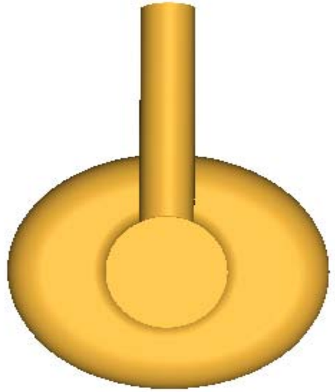


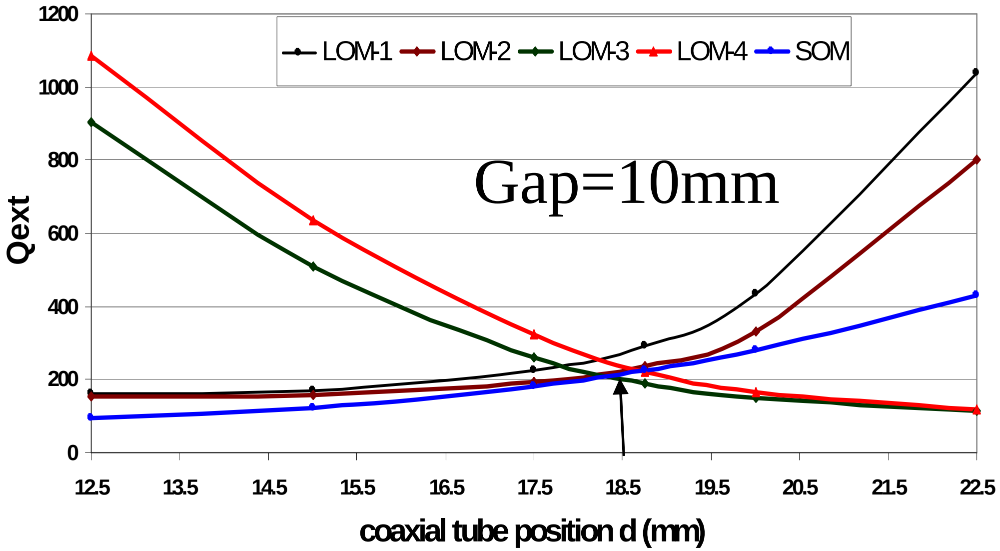
Other coupler ideas (BNL, JLAB, LBNL, FNAL, ANL, UK …)

LOM/SOM Coax-to-Coax Coupler Design



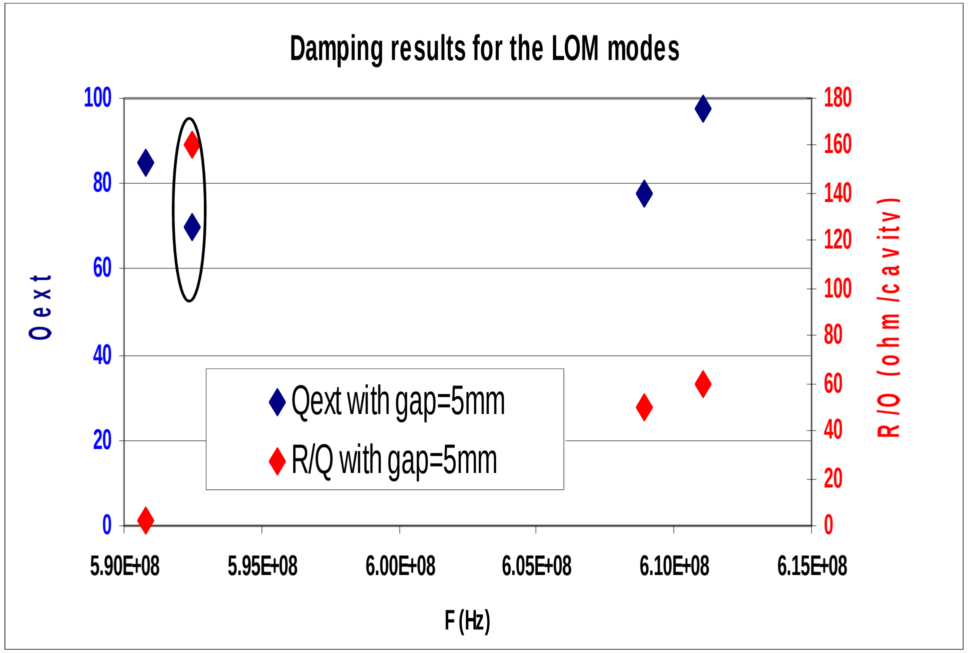


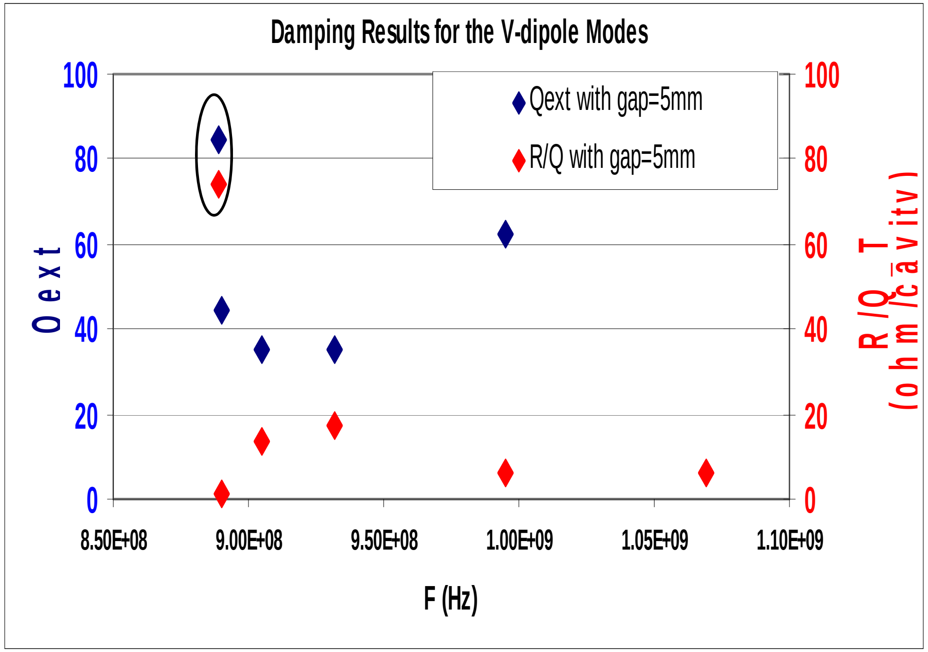




- **Give strong damping on unwanted modes in a compact structure because no cutoff for TEM mode in the coax**
- **Is more flexible to achieve the required damping by adjusting the location of the beampipe tube and the intrusion of the coupler probe**

There are two additional LOM modes due to the coupling of the cavity modes to the shorted coaxial beampipe TEM modes.





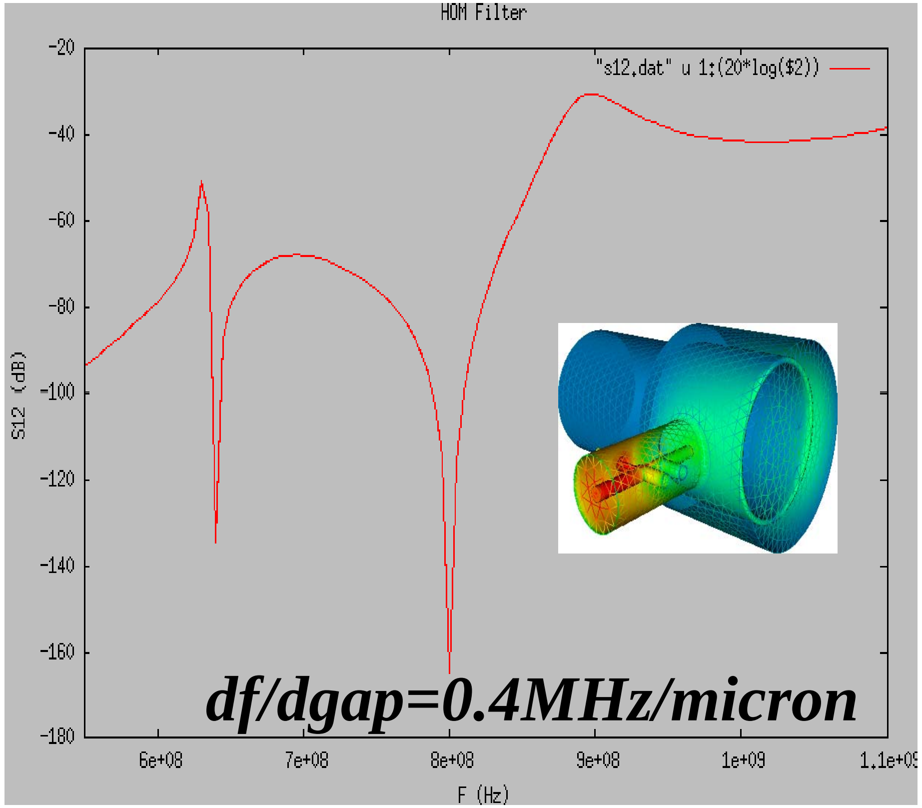
LOM/SOM damping results meet the requirements! Qext<100

HOM Coupler Design

HOM coupler: damp the dipole modes in the horizontal plane

reject the operating TM110 mode at 800MHz.

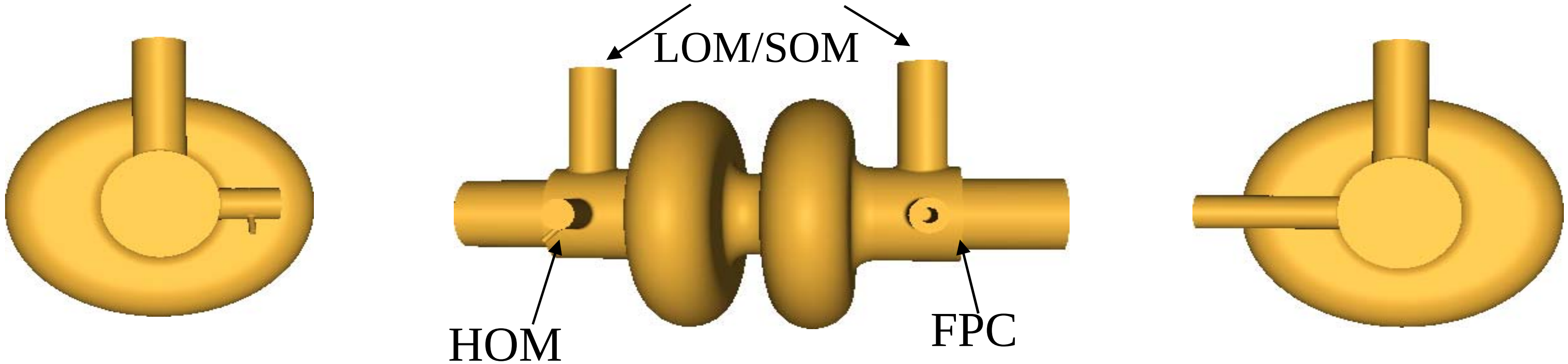
HOM notch filter transmission curve



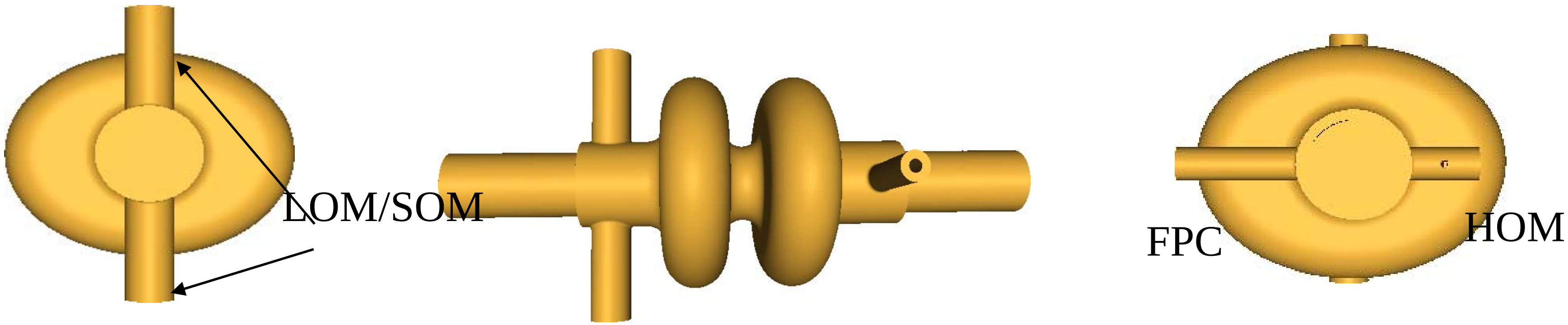
- A two-stub antenna instead of the coupling loop is proposed.
- This can simplify the model and remove the narrow gap between the loop and the outer cylinder which is prone to multipacting.

Cavity Configuration Considerations

LOM/SOM couplers use the electric node to reject operating mode, and symmetry is very important in cavity-coupler integration.



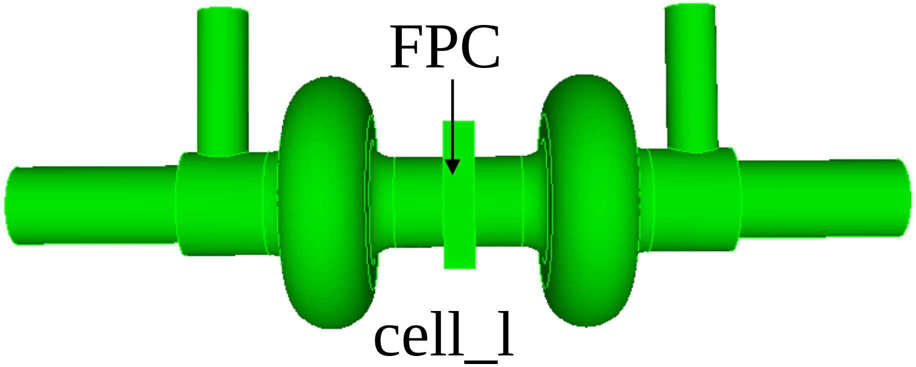
Option 1: Significant coupling of input power to LOM/SOM couplers

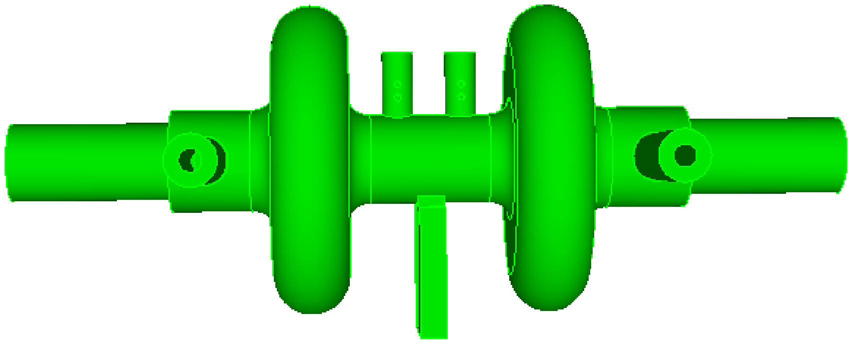


Option 2: LOM mode may shift to one side due to asymmetry, may result in ineffective damping

Option 3: Power coupler and HOM couplers in between of the two cells

- Maintain field symmetry in LOM/SOM coupler regions
- Avoid cross coupling between power coupler and LOM/SOM couplers





Modes	R/Q& (R/Q)T (ohm/cavity)	Qext
LOM: TM010-pi (~600MHz)	94	80
LOM: TM010-0 (~600MHz)	130	80
Operating Mode TM110-0 (800MHz)	110	10^6 @ FPC
SOM: TM110-0 (890MHz)	80	50

Further HOM coupler optimization is needed. Waveguide coupler can also be considered as HOM coupler.

Summary

•Significant progresses have been made for the 800MHz crab cavity design for LHC

–Strong damping achieved using coaxial-beampipe to coax LOM/SOM couplers, Qext of high R/Q modes below 100

–HOM coupler optimization is underway

•Multipacting simulations in cavity/couplers are in progress

•Further simulations planed to analyze RF/thermal/mechanical effects

Thanks all the members of LHC Crab Cavity Collaboration for valuable discussions.