DH Cavity Design Summary

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General Comments:

- Higher harmonic cavity → manipulate bunch profile
- $V_2 \leq ½ V_1$ (8 MV maximum)
- Sync. freq. spread with DH system → increased stability threshold

First Attempt:

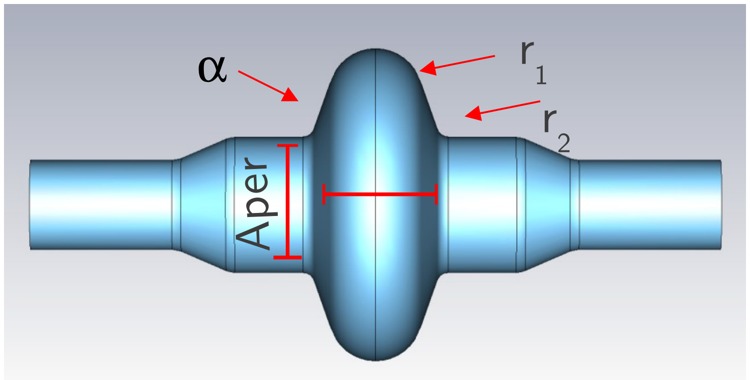
- Scaled model of 400 MHz cavities
- Cavity design somewhat straight forward, ensure tunability
- Bulk Nb or Nb-Coated is still for discussion

Challenges:

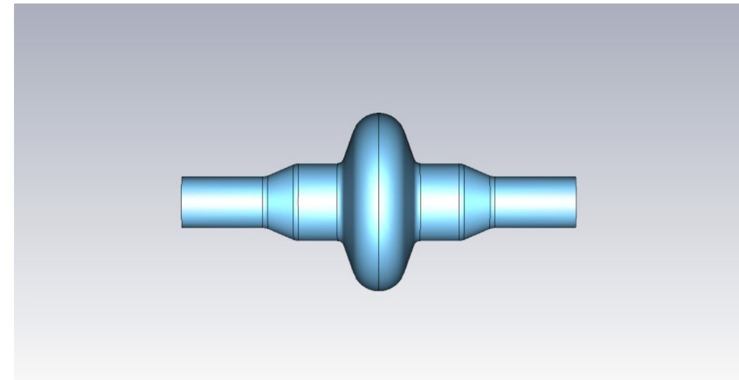
- Main limitation may come from Power Coupler (? MV/cavity)
- May require variable coupler to passively damp during Inj/Ramp
- Similar 4-cavity configuration w/o cold-warm transitions assumed

Cavity Design

LHC 400 MHz



Scaled 800 MHz



Freq [MHz]	400.79	801.4
L_{cell} [mm]	320	140
Aper [mm]	300	150
α [deg]	20^0	10^0
r_1/r_2 [mm]	104/25	52/12.5

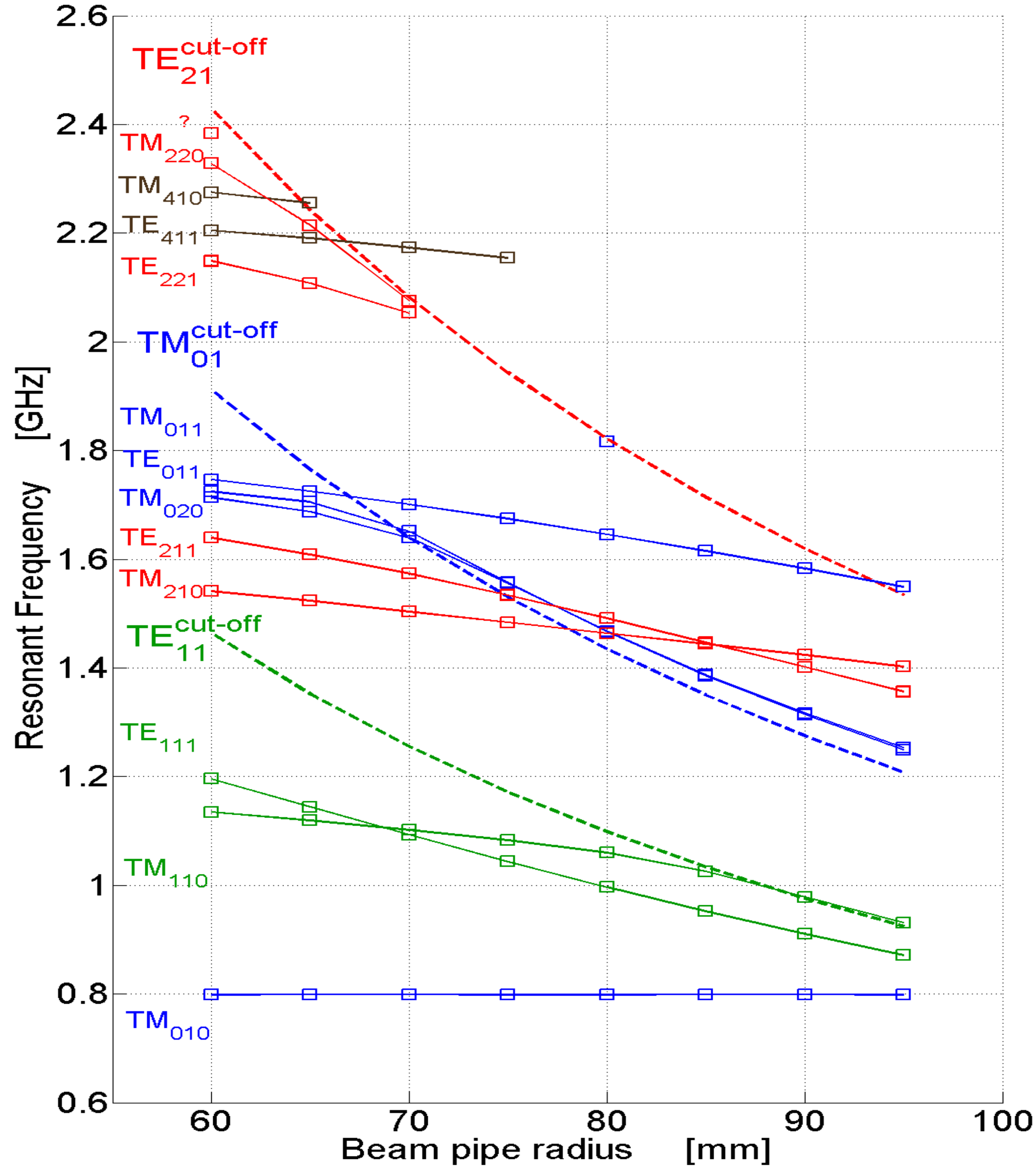
Freq [MHz]	400.79	801.4
V [MV]	2.0	1.0
R/Q [Ω]	44	45.5
E_{pk} [MV/m]	11.8	14.6
B_{pk} [mT]	27.3	28.2

Cavity Optimization

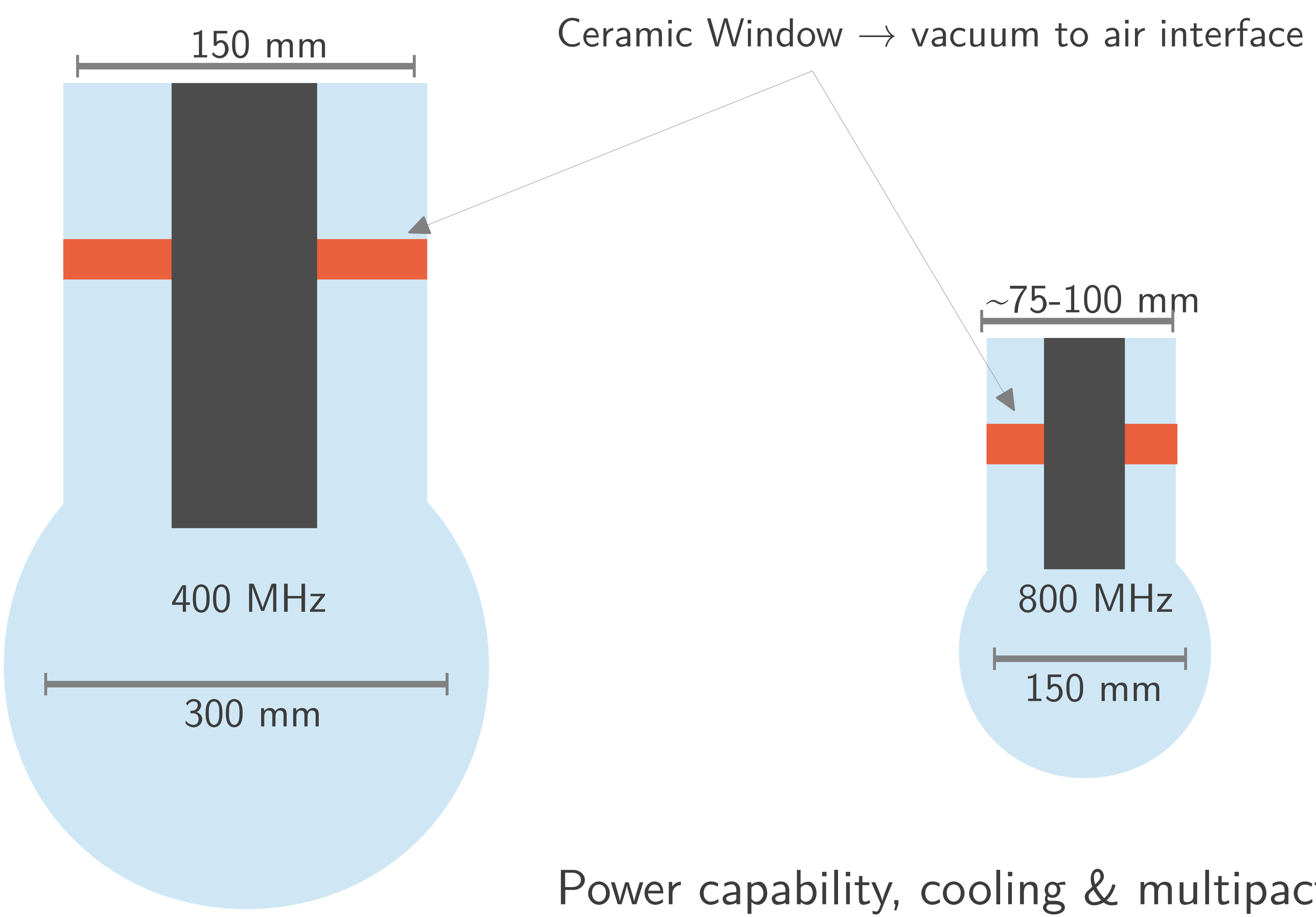
Move HOMs farther away from fundamental mode and close to their cutoff.

Performance of fundamental mode is far from limits, so some compromise can be accepted to aid HOM damping

Other techniques exist fluted/enlarged pipes, but come with drawbacks as well.



Power Coupler, ~ Factor 2 Scaling

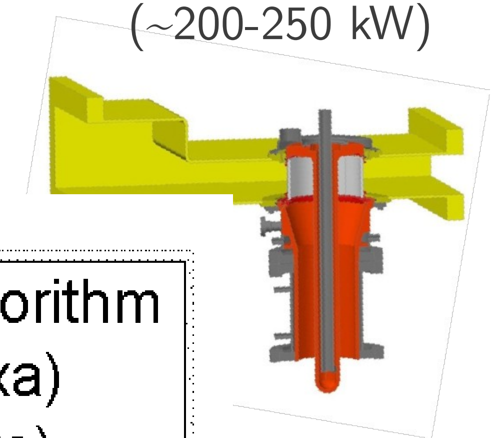


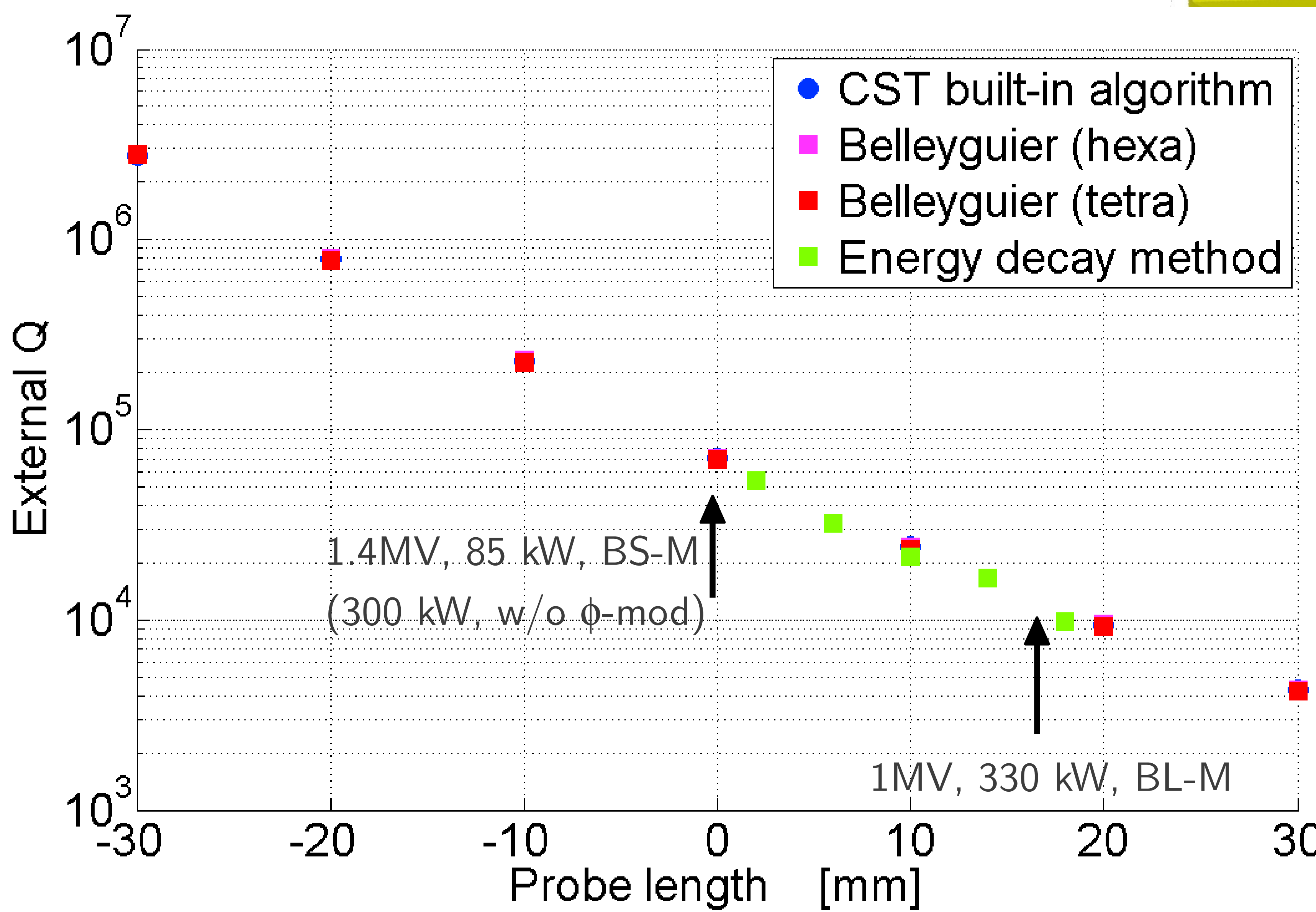
Power capability, cooling & multipacting

Cavity Power & Coupling

SPL like coupler

(~200-250 kW)





The HOM Saga

For high current machines

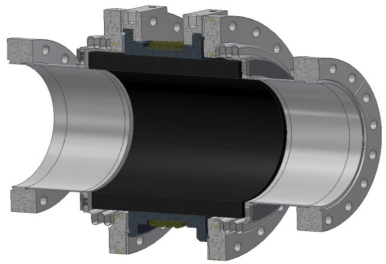
- HOM damping (below instability thresholds)
- Power extraction (resonant or broadband)

Ferrite Absorbers (Broadband but "dirty" for SRF + cold-warm transition)

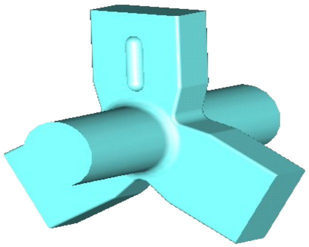
Notch Filters (Narrow-band and sensitive)

Waveguides (Bulky @800MHz & thermal losses)

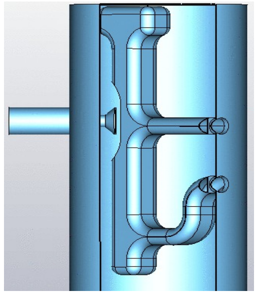
Ferrites



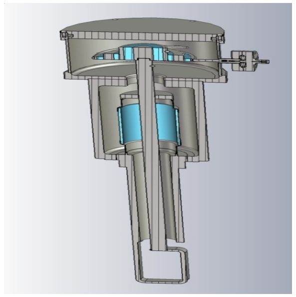
Waveguides



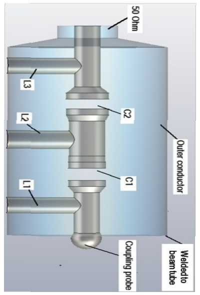
Notch filters



Band-Pass

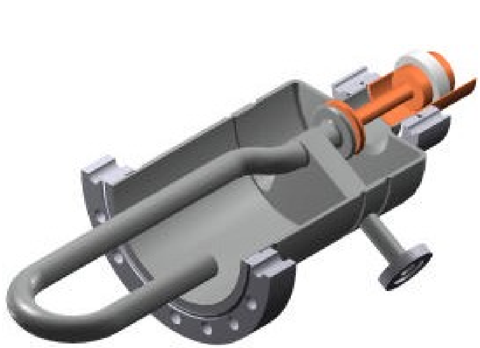


Double-Notch

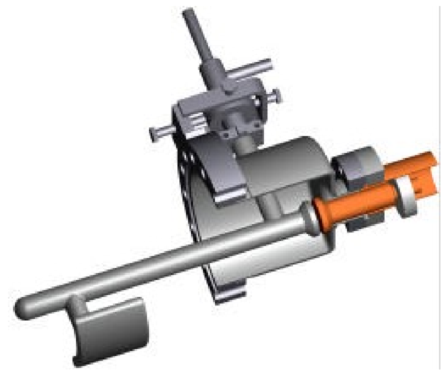


LHC Type HOM Couplers

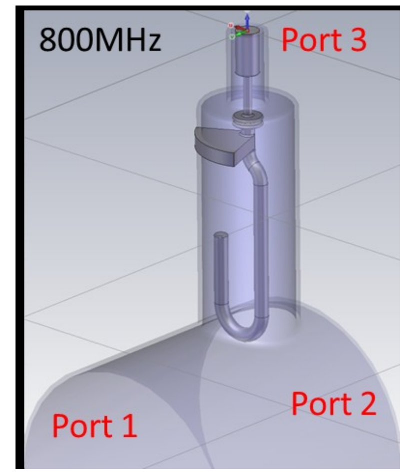
Narrow-band



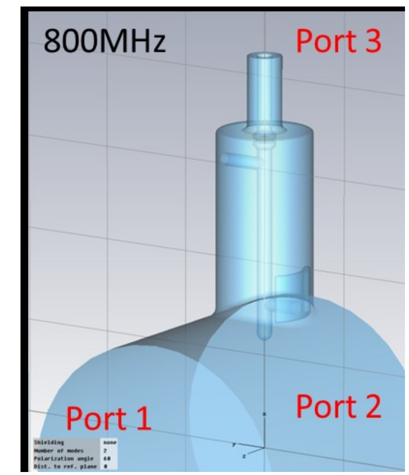
Broadband



Narrow-band



Broadband



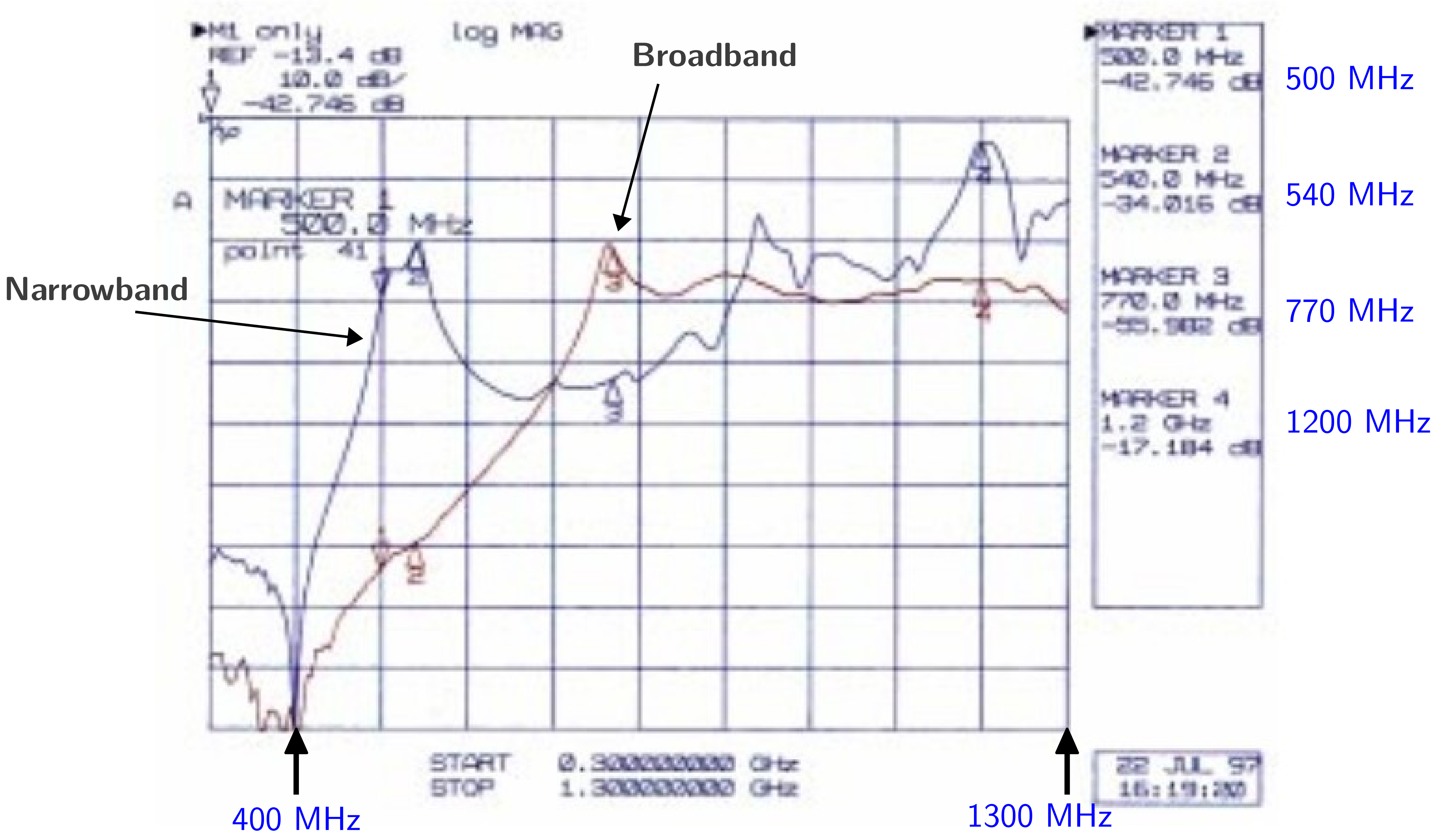
400 MHz

Freq	Mode	Qext
500 MHz	TE_{111}	137
534 MHz	TM_{110}	93
779 MHz	TM_{011}	270

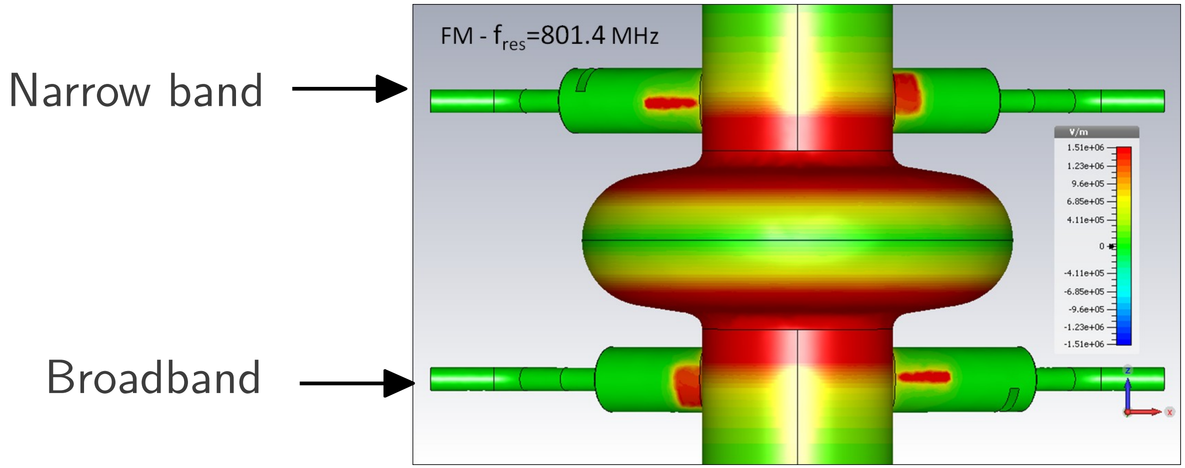
800 MHz

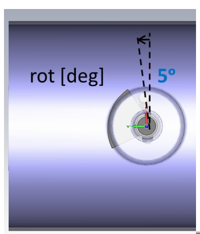
Freq	Mode	R/Q [Ω]	Qext
1.03 GHz	TE_{111}	2	137
1.09 GHz	TM_{110}	12	93
1.7 GHz	TM_{011}	11	Above cutoff

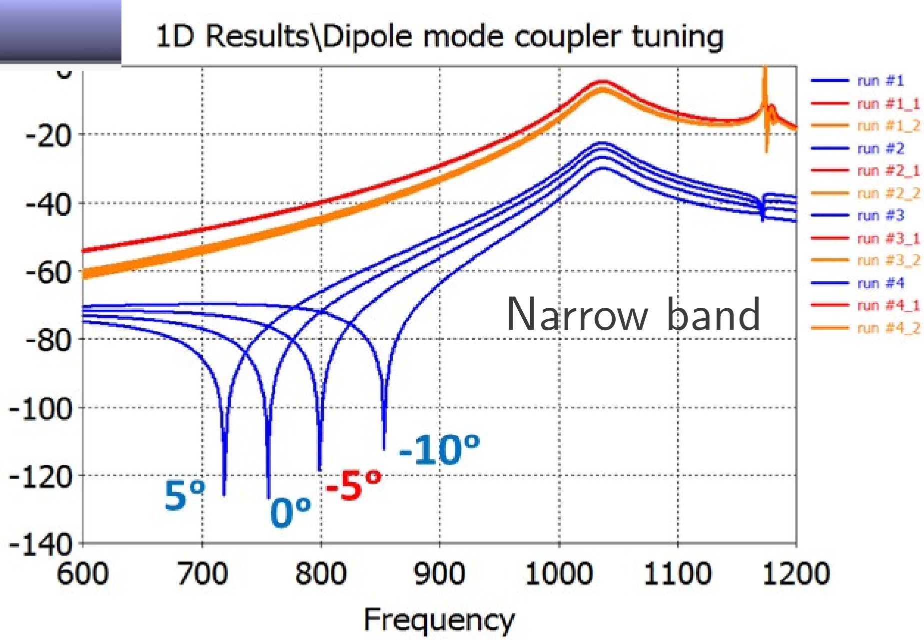
General Principle → Use two couplers

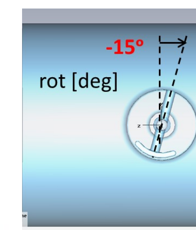


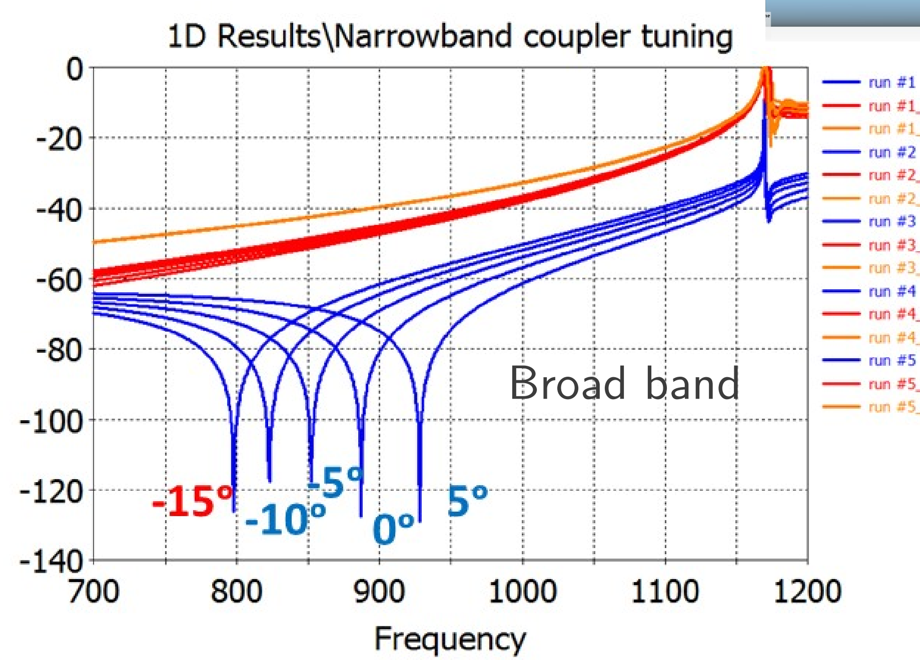
Fundamental Mode Leakage into HOMs





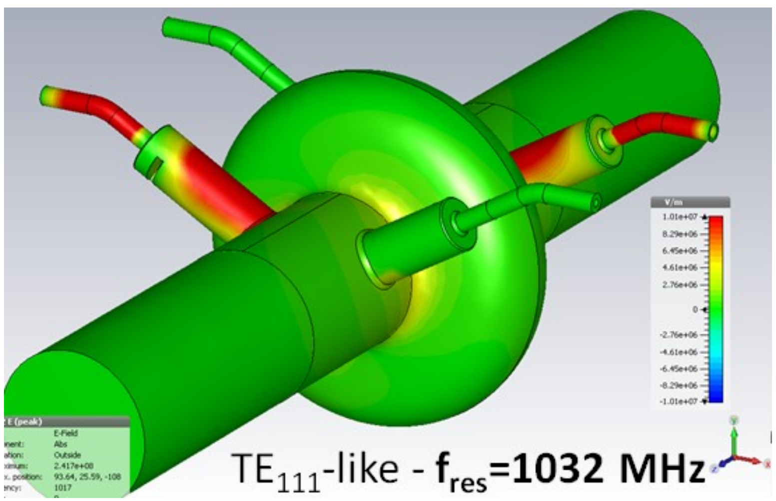




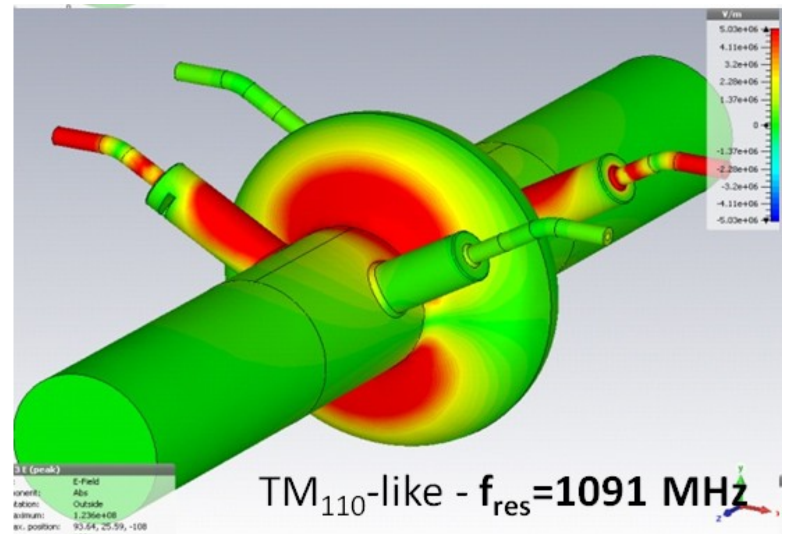


HOM Damping, Example

TE_{111} like

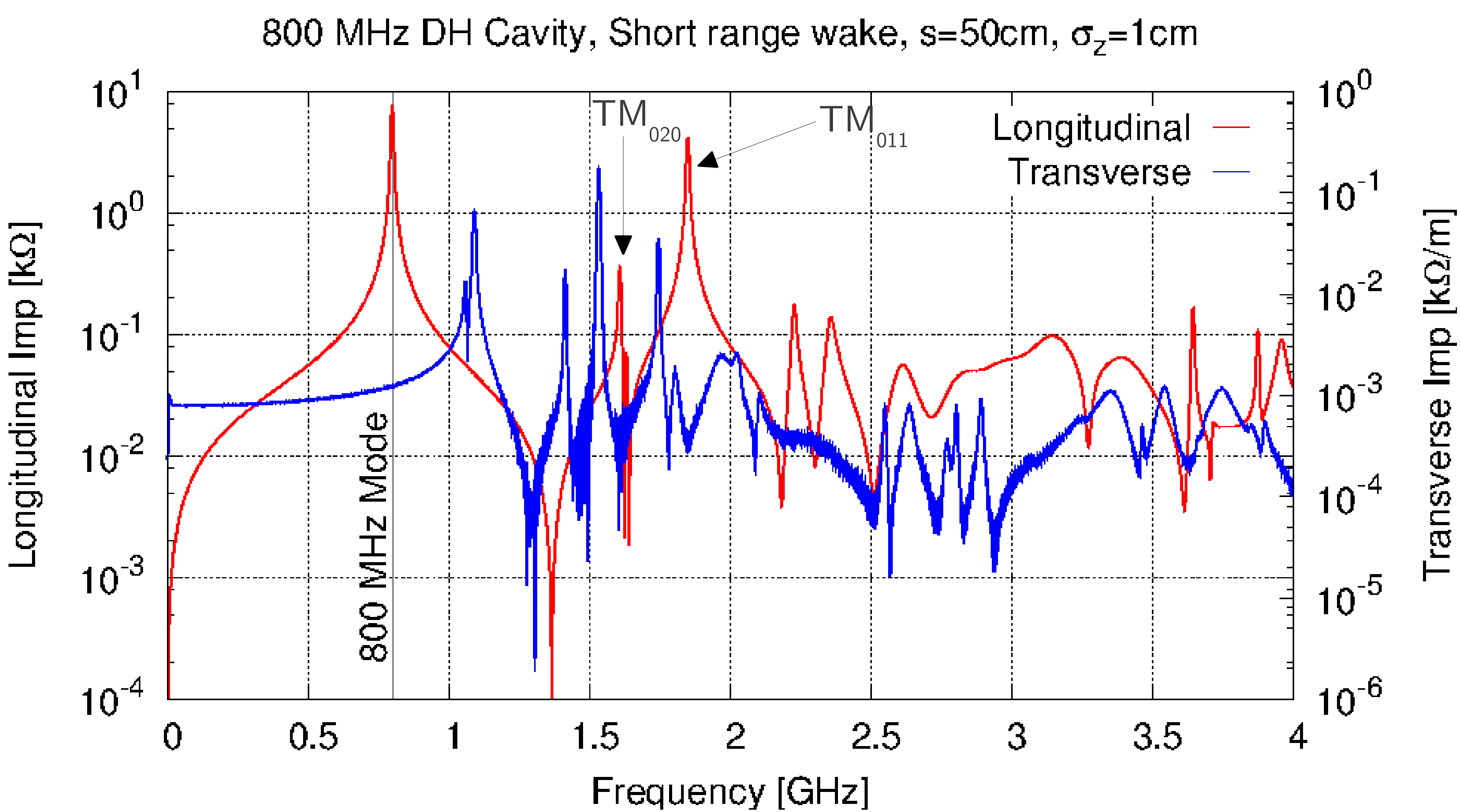


TM_{110} like

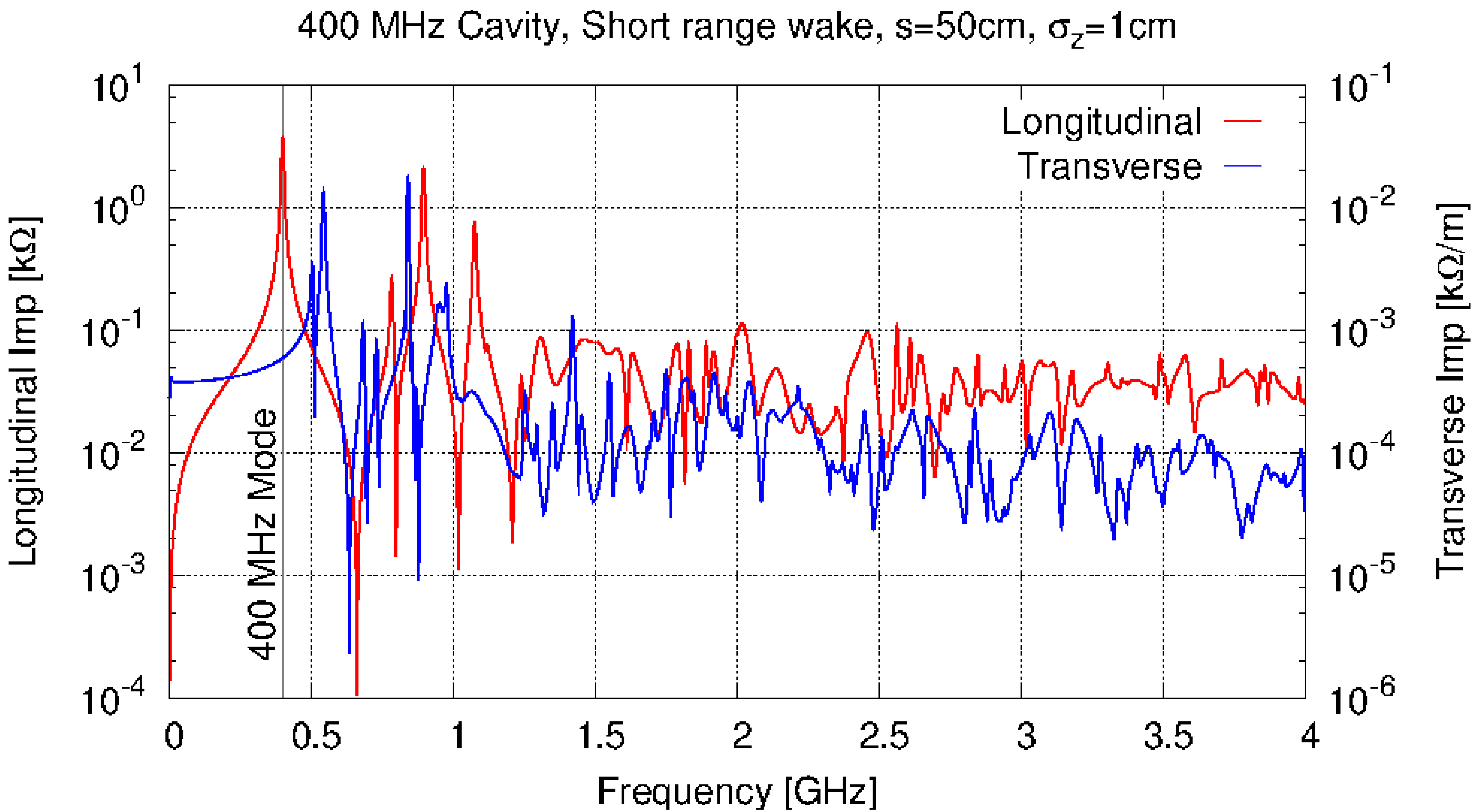


Damping quite effective with 2 sets of narrow-band and broadband couplers (Qext ~ 100-200)

Imp Spectrum, 800 MHz

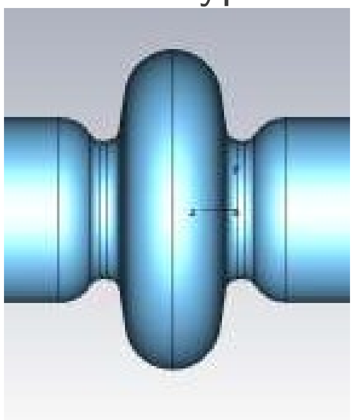


Ref: Imp. Spectrum, 400 MHz

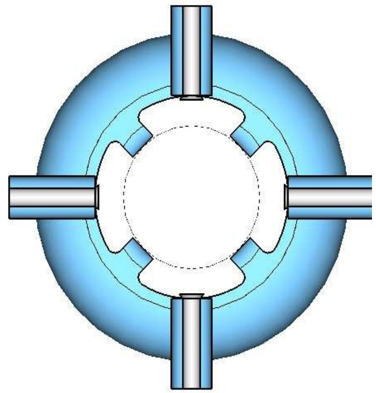


Alternative HOM Damping Schemes

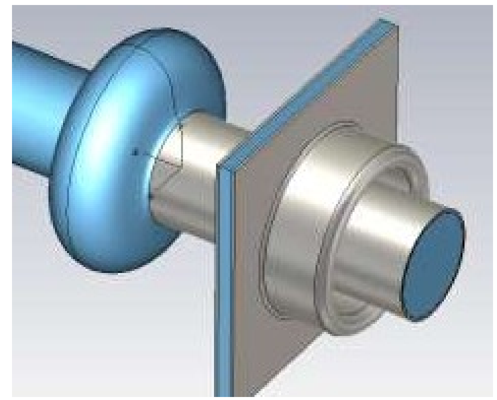
KEK-type



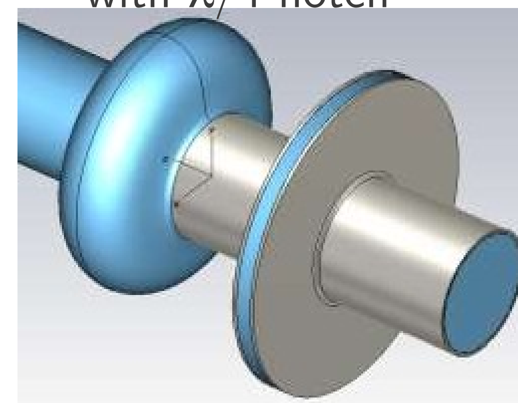
"Cornell like"



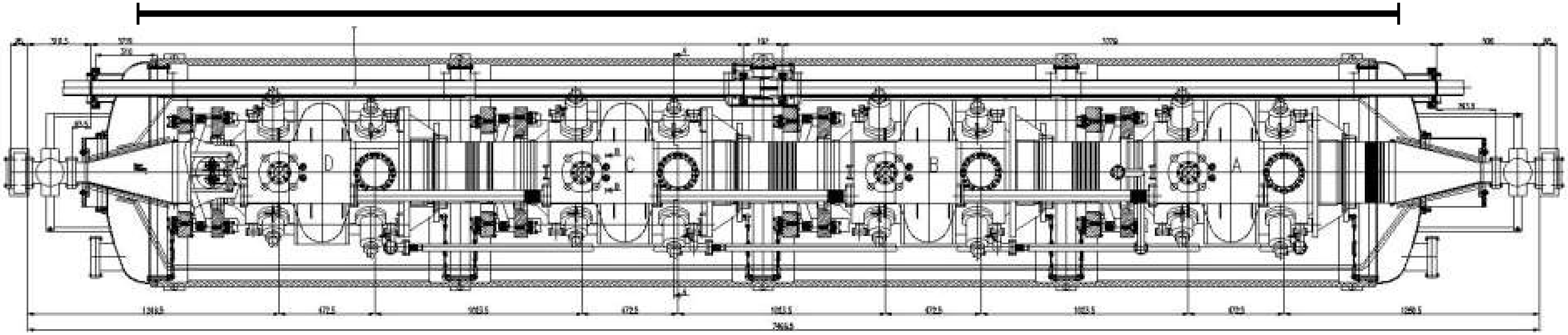
$\lambda/4$ notch



Radial or photonic-band with $\lambda/4$ notch



Standard LHC Module: No cold-warm transitions

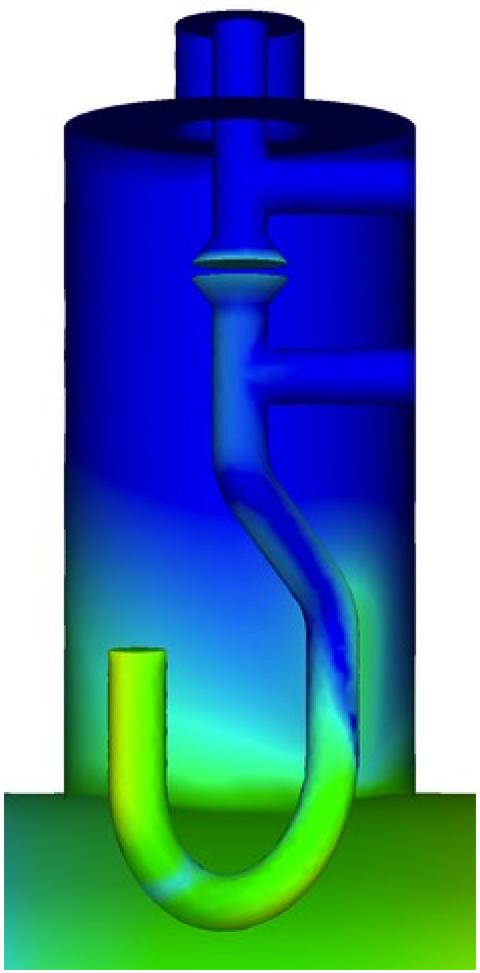


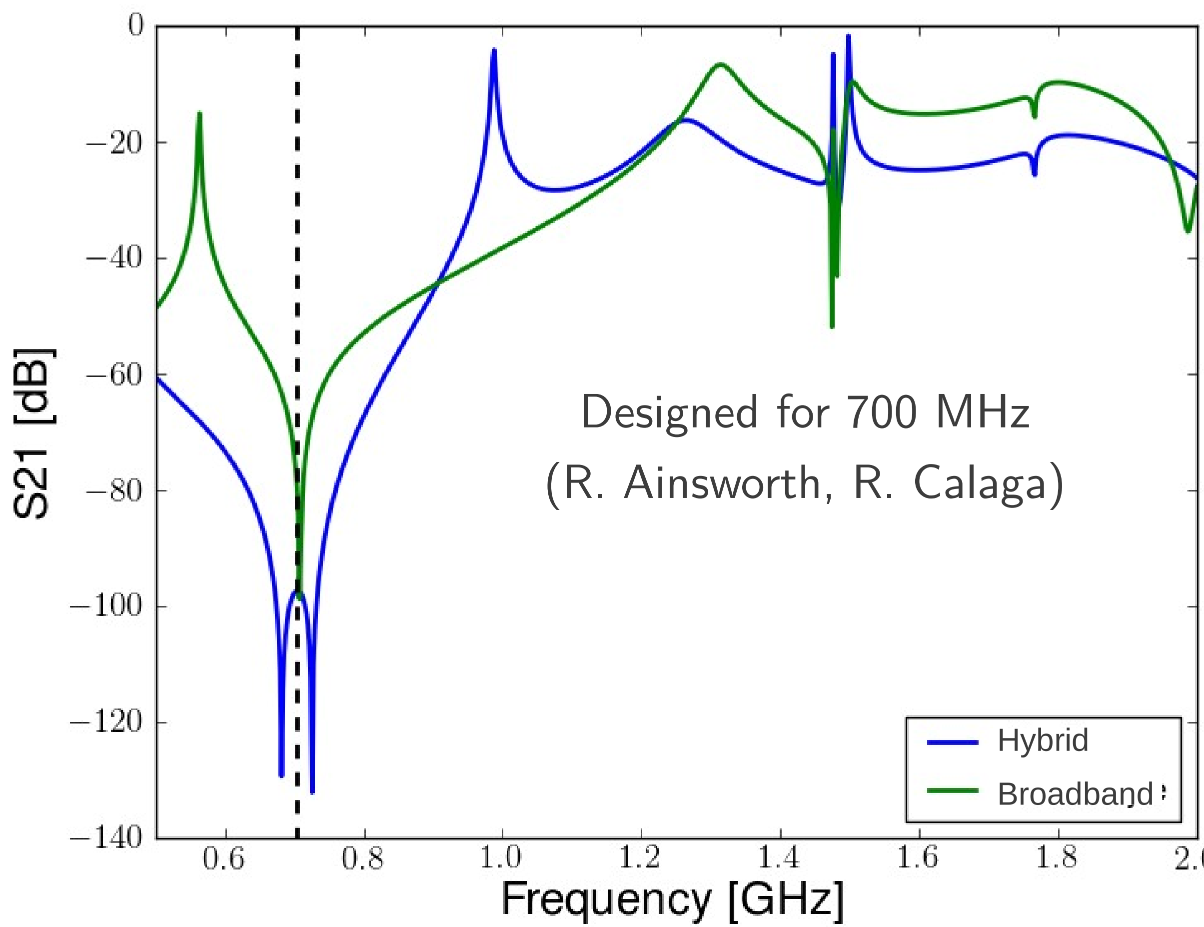
Academically interesting but practically difficult in multi-cavity CM

Hybrid HOM Coupler

An attempt to combine the narrow/broadband coupler

(Advantage to reduce # of HOM couplers)





Next Steps

- Where to put them
  - Obvious choice is P4, check space requirements

- Impedance evaluation (8 cavities) & budget
  - Resonant excitation & power handling (P μ R/Q . $I^2 \rightarrow$ 100's watts)
  - Check compatibility with crab crossing

- Mechanical design of the cavity
  - Cavity tuning, LF etc.. to define the final geometry (EN-MME)
  - Power coupler, variable or not ?
  - Prototyping (?) of cavity and HOM couplers

- Nb coating on Cu-substrate always a possibility
  - Will need some R&D time to establish the