Slim elliptical cavity at 800 MHz for local crab crossing

Luca Ficcadenti, Joachim Tuckmantel

CERN – Geneva

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A slim highly eccentric elliptical cavity with vertical deflection at 800 MHz, compatible to beam line distances everywhere in the LHC ring, was designed; it is a good fall-back solution in case of problems with new compact 400 MHz designs. RF characteristics of the deflecting mode, HOM spectra and damping, tuning and multipacting are presented.

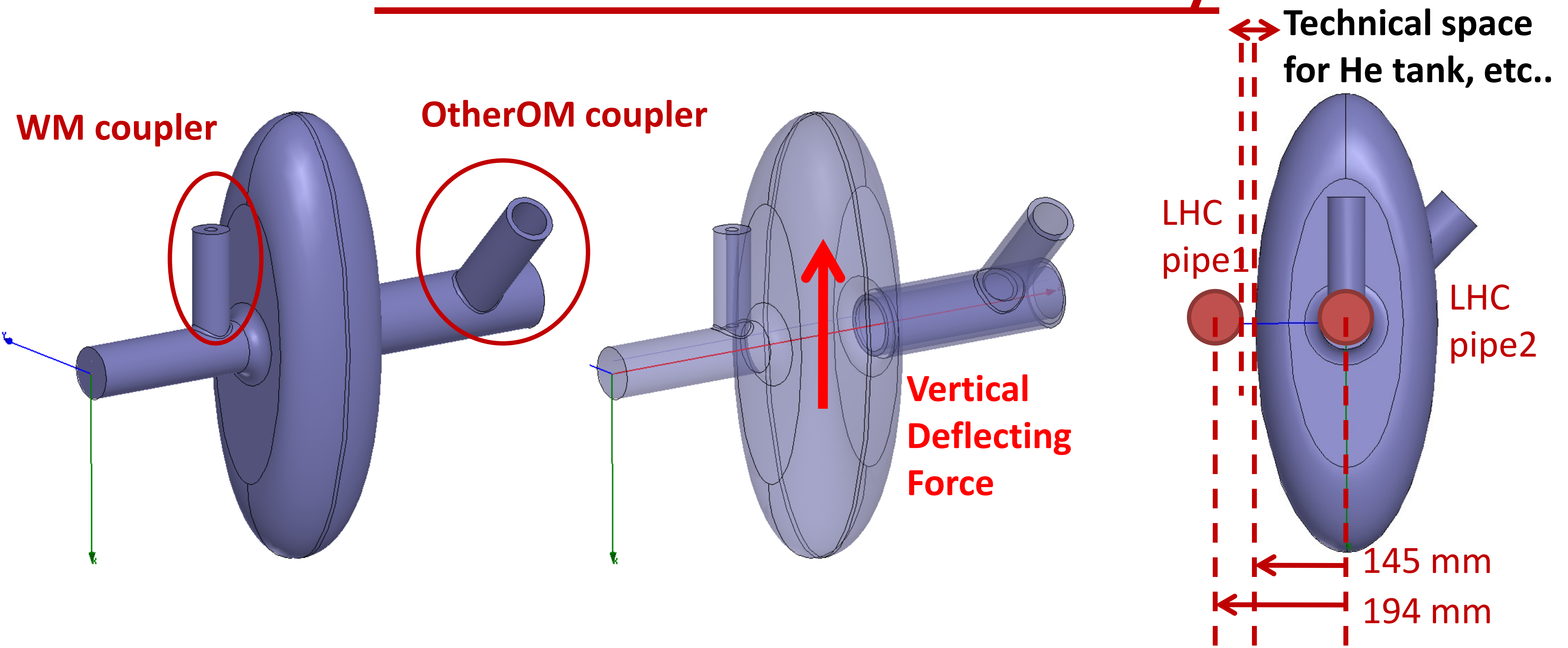
Outline

- Design considerations
- CRAB cavity parameters
- Tuning
- Other Order Modes damping coupler
- Working Mode Feed Power coupler
- Damping LO and HO modes
- Preliminary Multipacting studies
- Summary

Design Considerations

- Compact horizontal size to fit anywhere in the LHC ring
- A single cell design for both local and global schemes
- Cavity dimensions determined by local scheme(≈145mm)
- Deflecting Working Mode at 800MHz
- Effective dumping of unwanted LO and HO modes

800-MHz CRAB Cavity

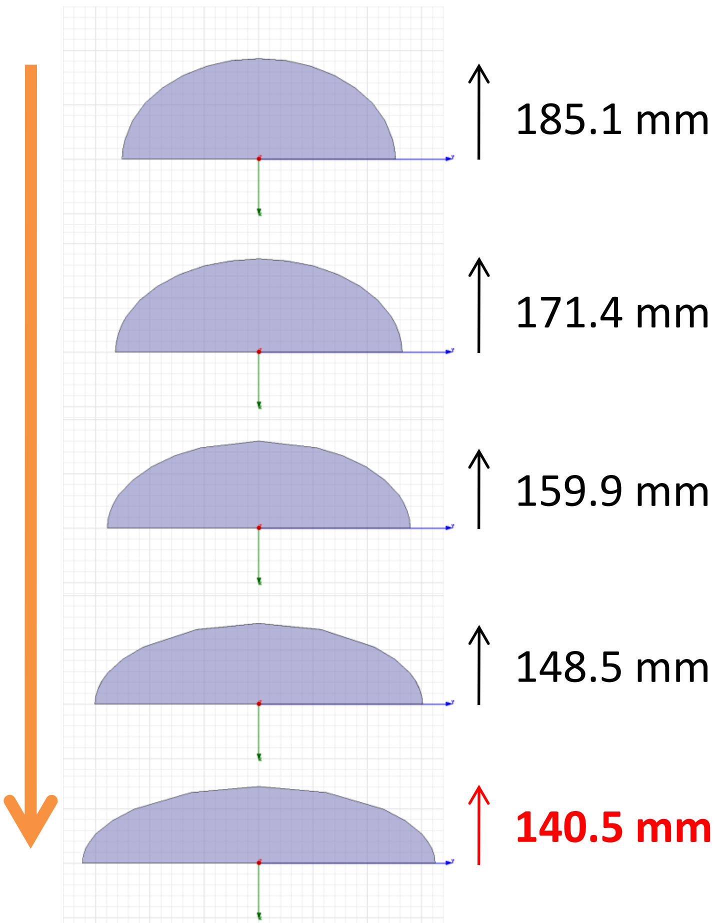


- Cavity design fits both GLOBAL and LOCAL schemes
- Surface field and RF parameters optimized
- Other Order Mode Coupler to be optimized
- Working Mode Coupler optimized
- Preliminary Multipacting analysis performed

Squashed pillbox @800MHz

Deflecting Voltage: $$V_{\perp} = \int_0^h \frac{F_{\perp}}{q} e^{-j\omega \frac{z}{c}} dz = \int_0^h \left(E_{\perp} + c\mu H_{\perp}\right) e^{-j\omega \frac{z}{c}} dz \,[V]$$

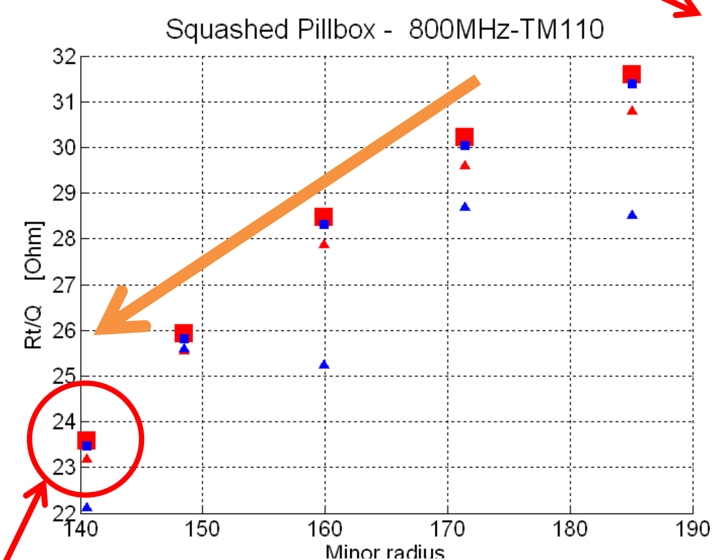
Rt/Q in circuit ohm: $$\frac{\hat{R}_{\perp}}{Q} = \frac{\left|V_{\perp}\right|^2}{2\omega_r W_t}[\Omega]$$

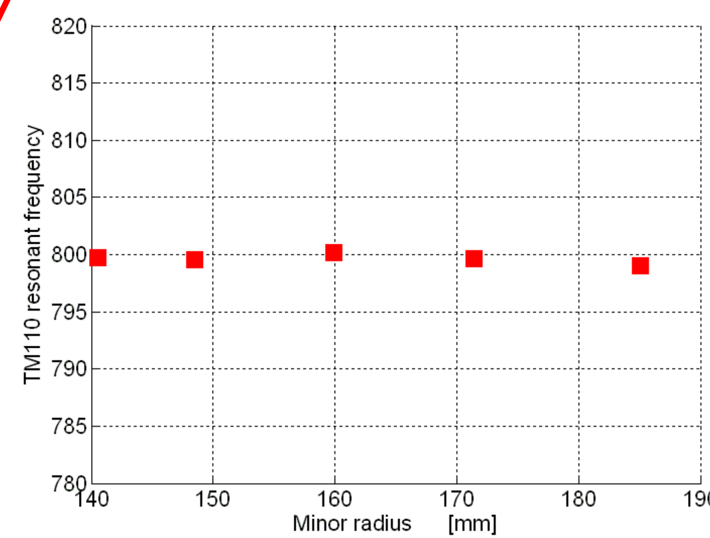


Low Rt/Q equals higher helium consumption , this is the price to pay to fit a single cell in the local scheme

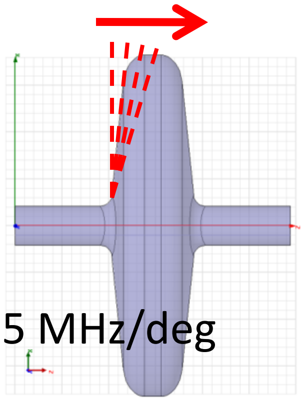
Possibility of 800MHz with Rt/Q≈23 Ohm

Pillbox pure Rt/Q=34Ohm

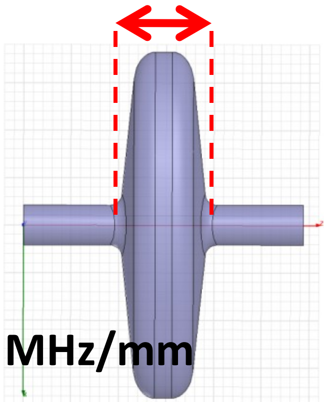




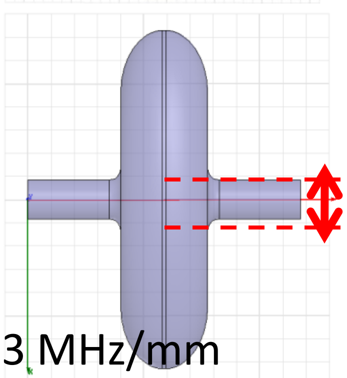
Sensitivitiy Studies and Tuning



Wall degrees [deg]	Transverse dim[m]	Fres [MHz]	Rt/Q [Ω]	Ep@2.5MV [MV/m]	Bp@2.5MV [mT]	Q
5.8	0.729*0.290	792.1	18.2	36.4	105	35960
7.3	"	807.6	17.0	38.8	114	34182
8.9	"	827.7	15.6	41.2	151	32047



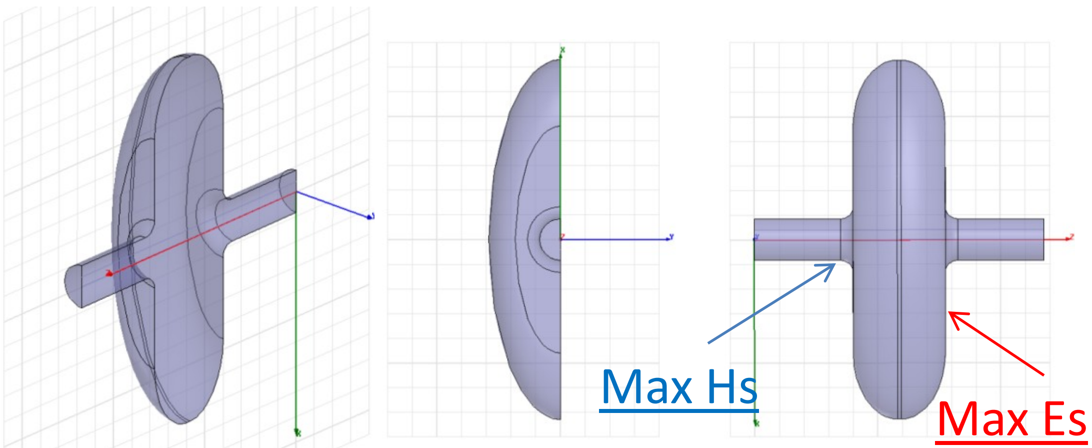
Cell length [mm]	Transverse dim[m]	Fres [MHz]	Rt/Q [Ω]	Ep@2.5MV [MV/m]	Bp@2.5MV [mT]	Q
225	0.729*0.290	792.2	18.0	36.6	128	36848
215	"	789.5	19.2	36.0	175	36747
205	"	786.6	20.1	35.8	199	36571



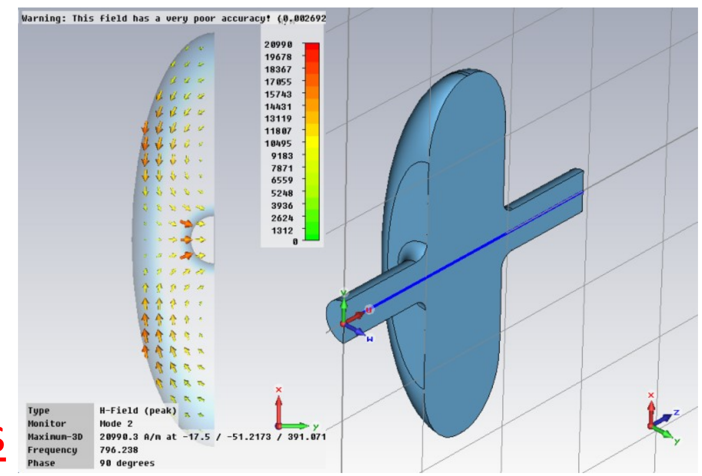
Pipe radius [mm]	Transverse dim[m]	Fres [MHz]	Rt/Q [Ω]	Ep@2.5MV [MV/m]	Bp@2.5MV [mT]	Q
42	0.729*0.290	799.9	19.1	32.3	116	41871
52	"	797.0	18.1	35.6	113	41281
62	"	793.4	16.8	41.4	117	40590

800MHz slim CRAB Cavity Parameters

HFSS 3D geometry & transverse shape

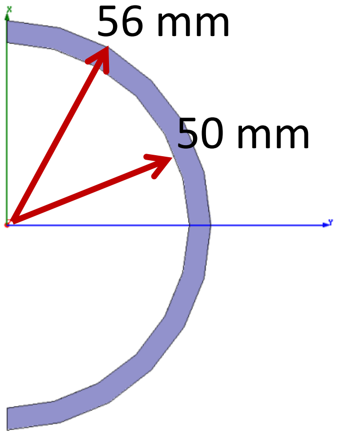


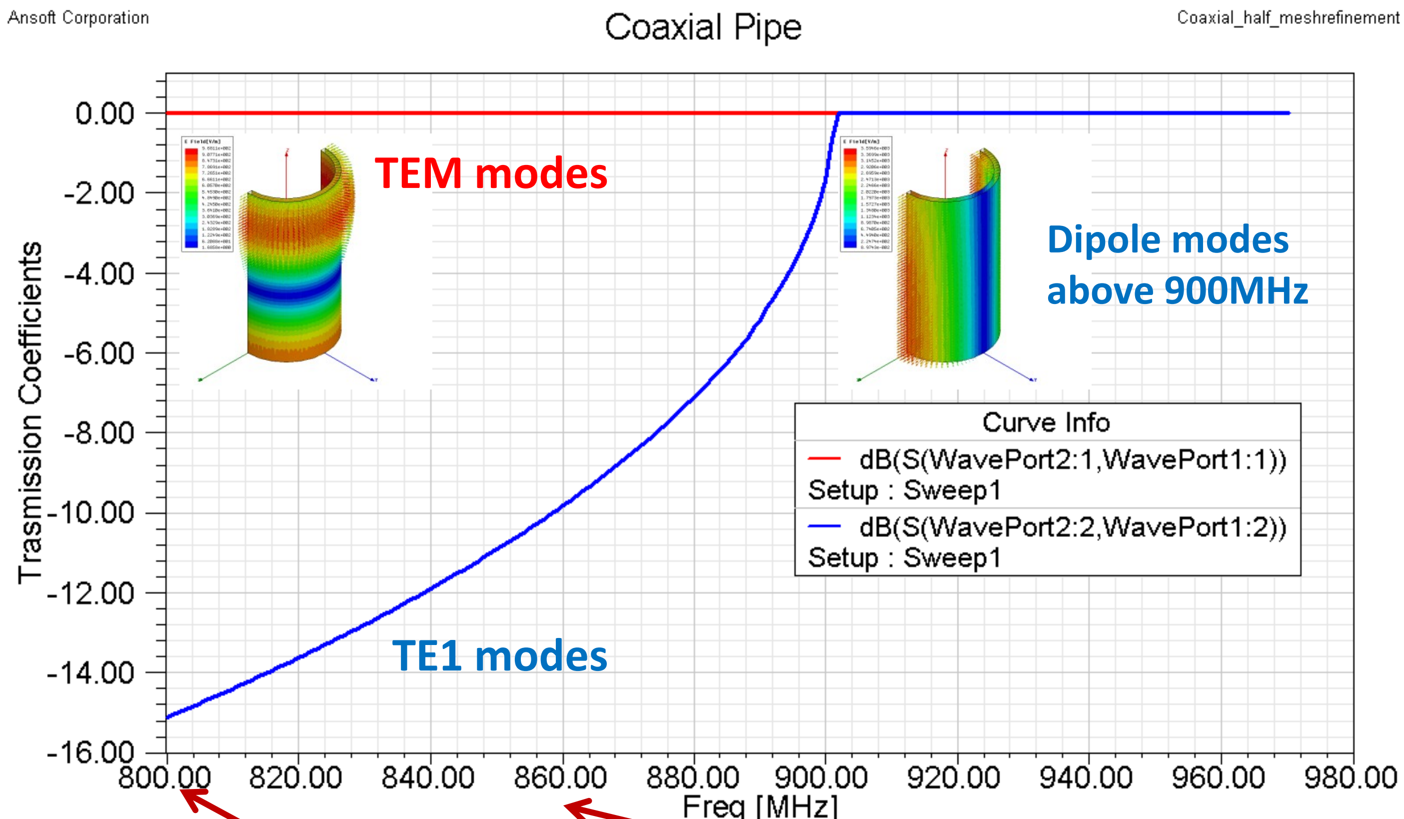
CST Microwave Studio



Parameter	Unit	HFSS	CST-MWS
Operating mode frequency	MHz	799.9	796
Cell transverse dimensions	mm	**0.290*0.729**	**0.290*0.729**
Cavity length	mm	**187.5**	**187.5**
Beam pipe radius	mm	**42**	**42**
Iris curvature radius	mm	25	25
Rt/Q	Ohm	19	19
Epeak @ 2.5MV	MV/m	32	33
Bpeak @ 2.5MV	mT	115	107

How to avoid notch filter to reject WM

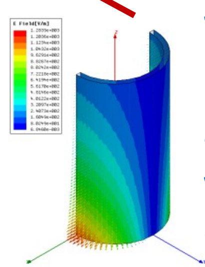




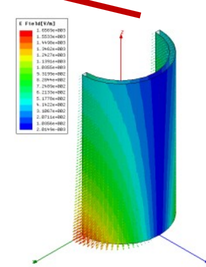
All Monopole modes can propagate in the coaxial pipe

The Dipole modes above 900 MHz can propagate through TE coaxial mode in both polarizations

$$f_c^{TE_1} \cong \frac{c}{\pi(a+b)} = 900.8[MHz]$$



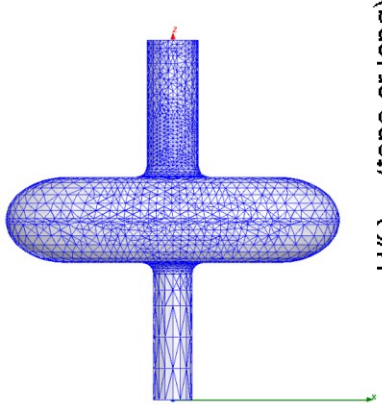
Working mode is under cut-off to avoid coupling with HOM Coax-Coax Coupler



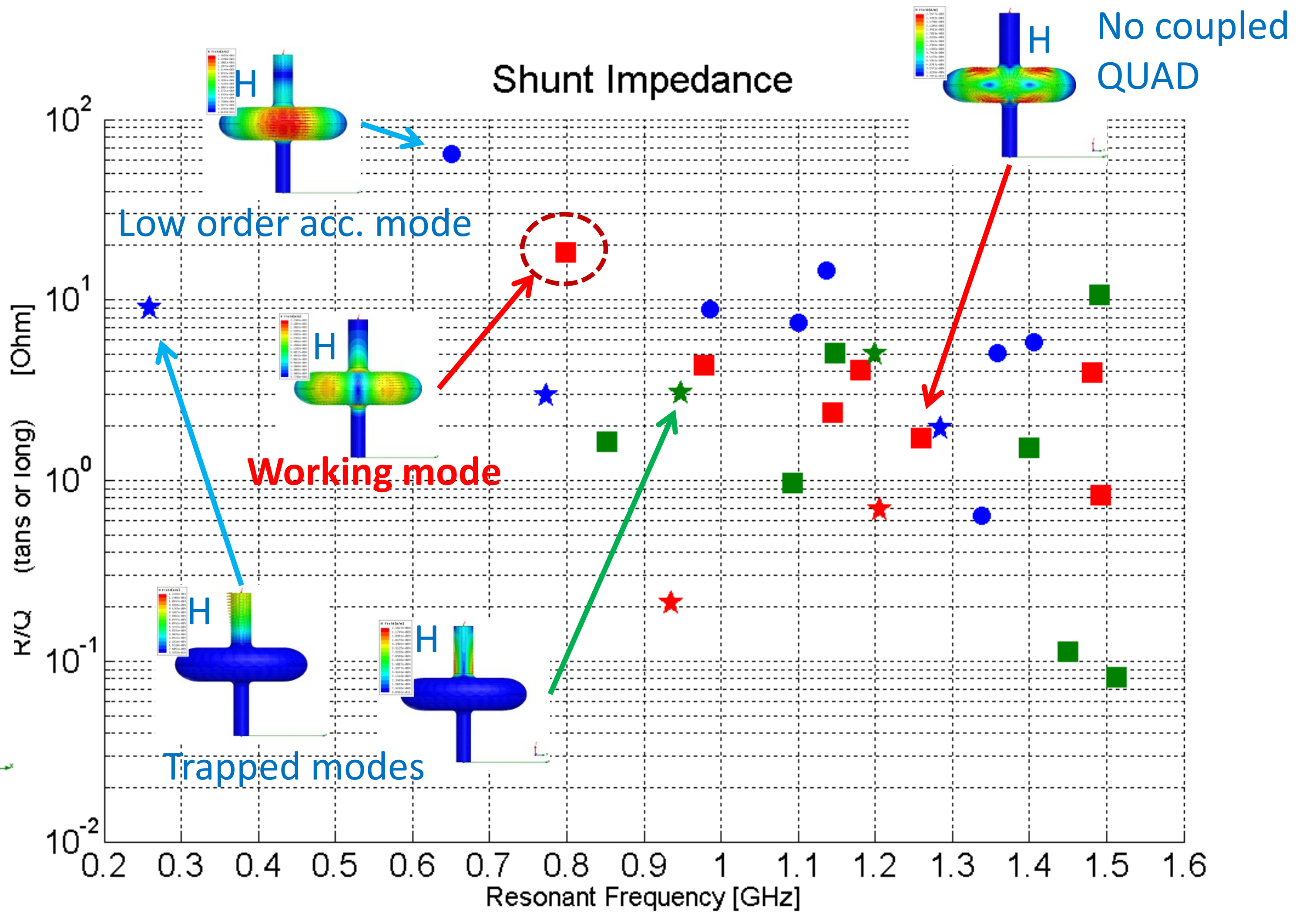
The first dipole mode immediately after the WM, is the most critical to damp

Other modes studies with Eigenmode solver

- Ez
- Ex, Hy
- Ey, Hx
- Hz
- 0, 0
- All types
- ★ Trapped



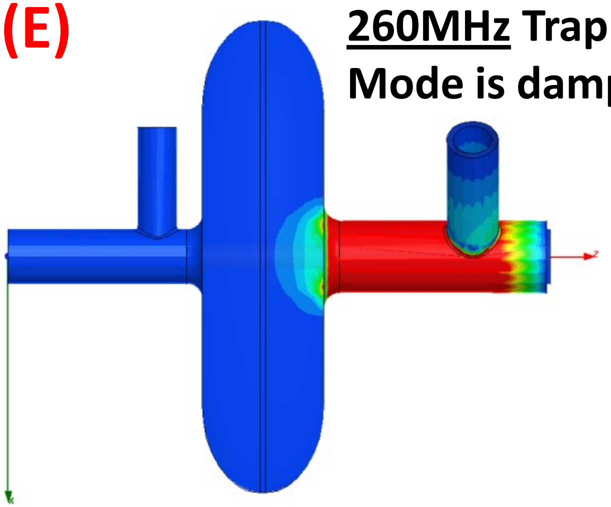
N. tetrahedra=52k



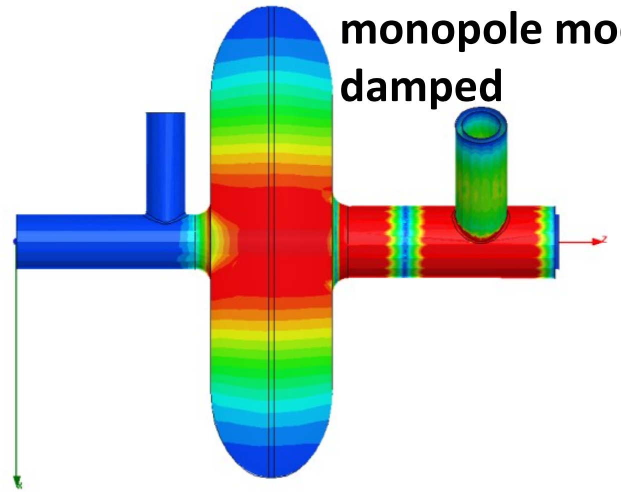
LOM/HOM-v/HOM-o Coupler

Mag(E)

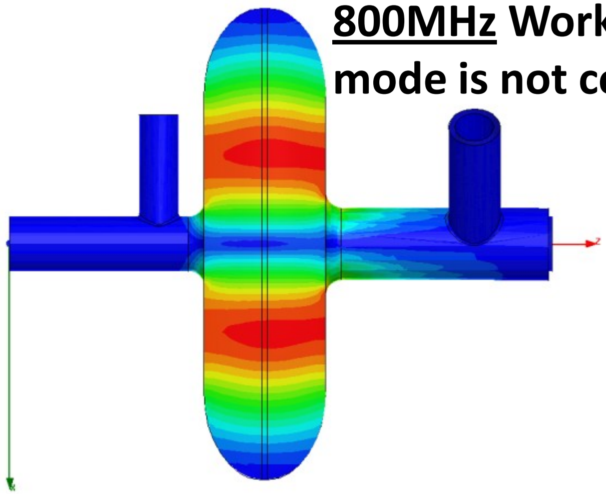
260MHz Trapped-monopole Mode is damped



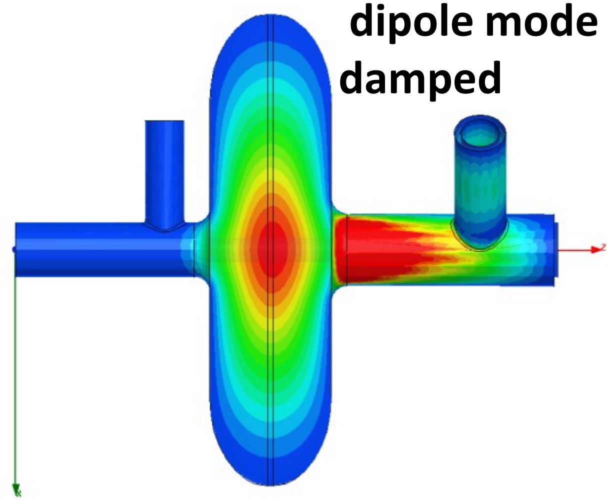
650MHz Accelerating monopole mode is damped



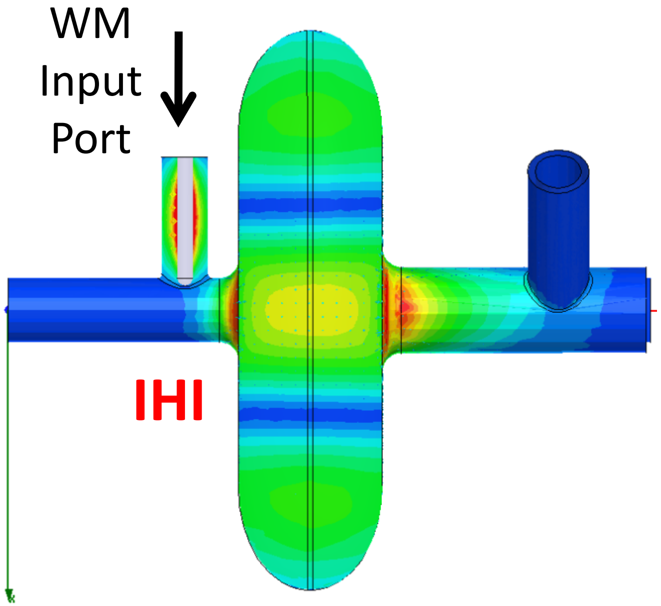
800MHz Working dipole mode is not coupled

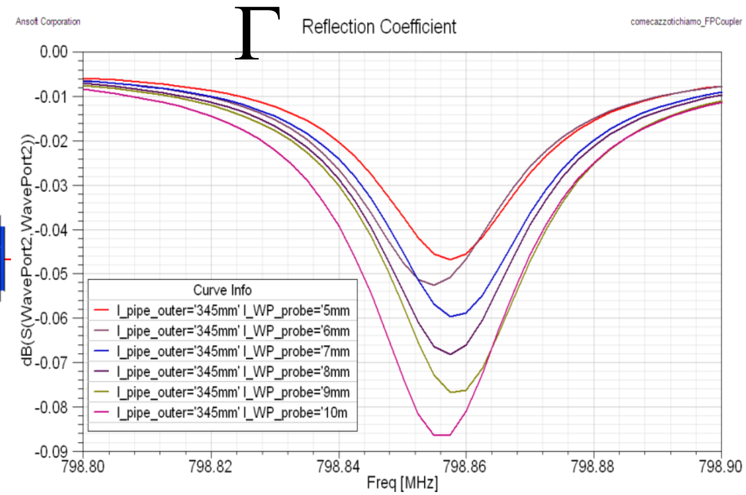


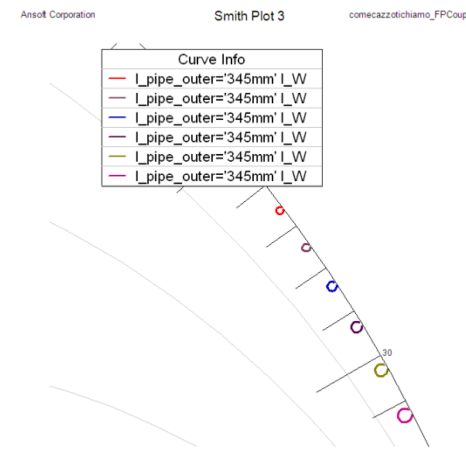
860MHz Most critical dipole mode is enough damped

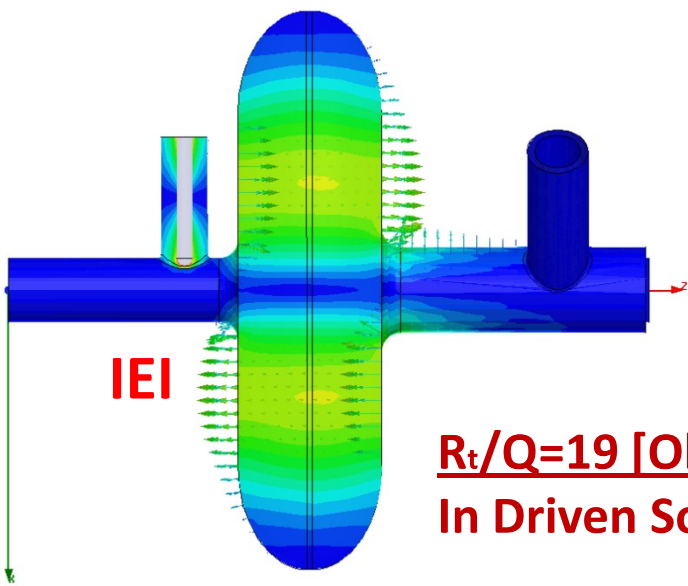


Feed Power Coupler



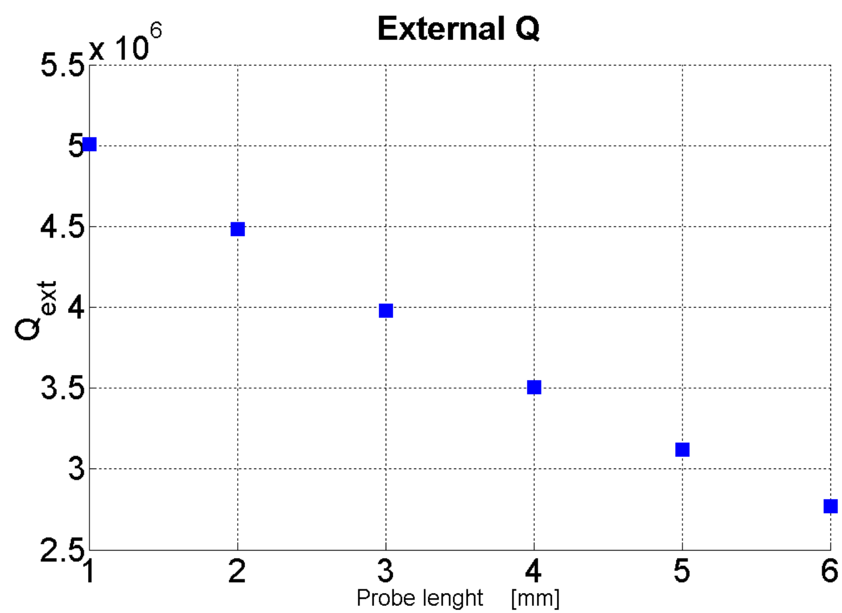




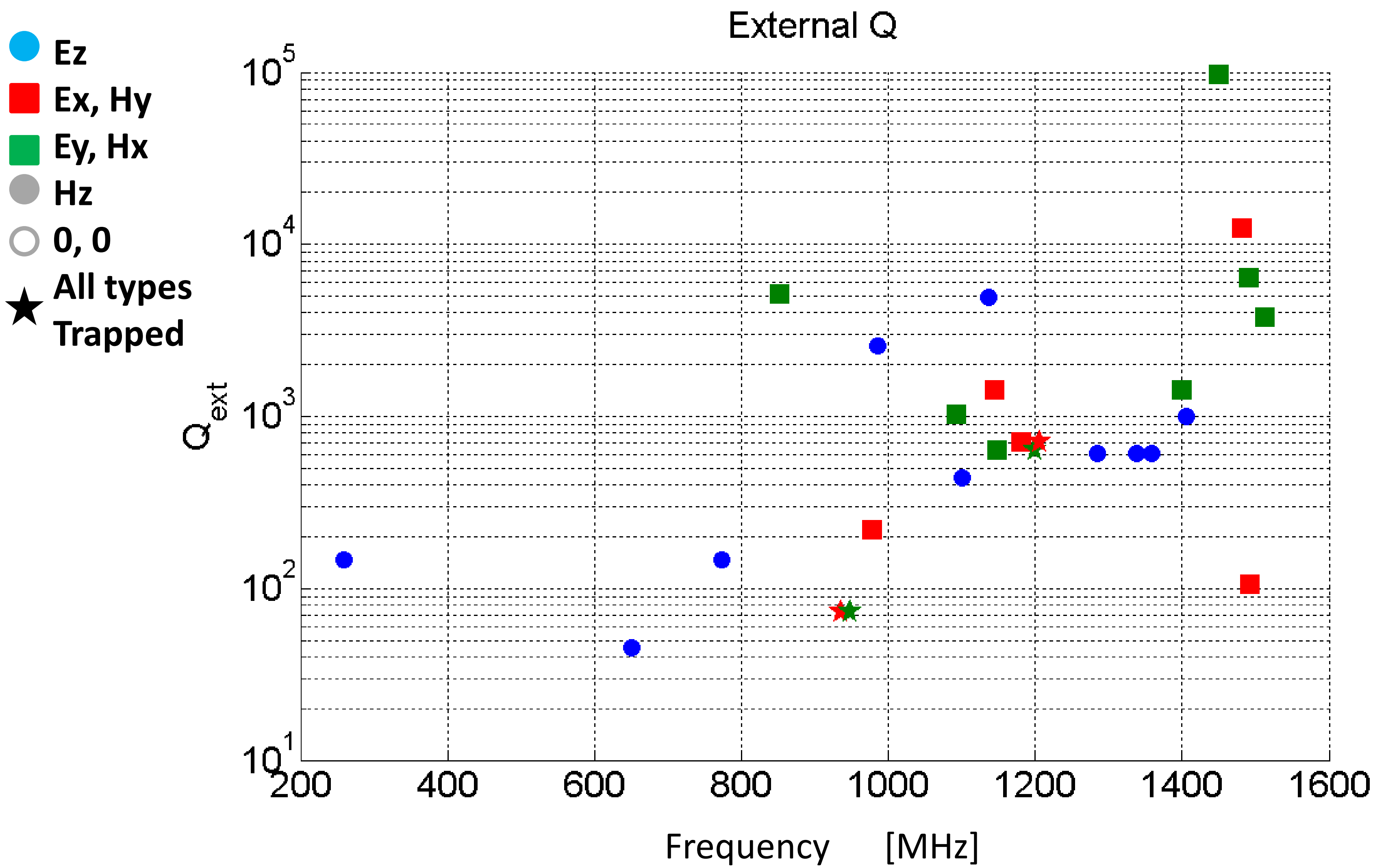


R_t/Q=19 [Ohm]

In Driven Solution

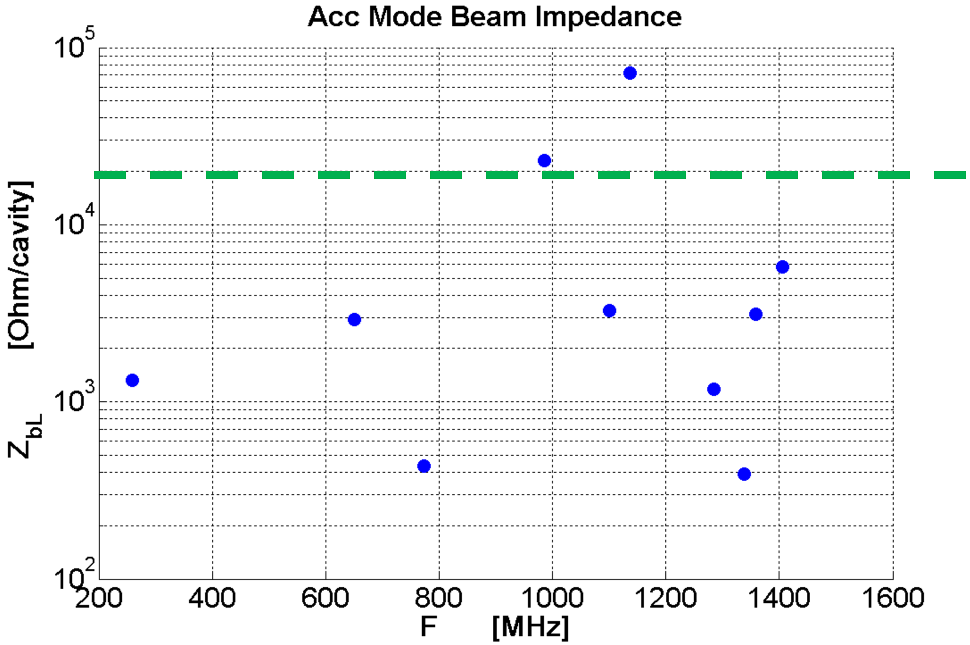


Damping Qext



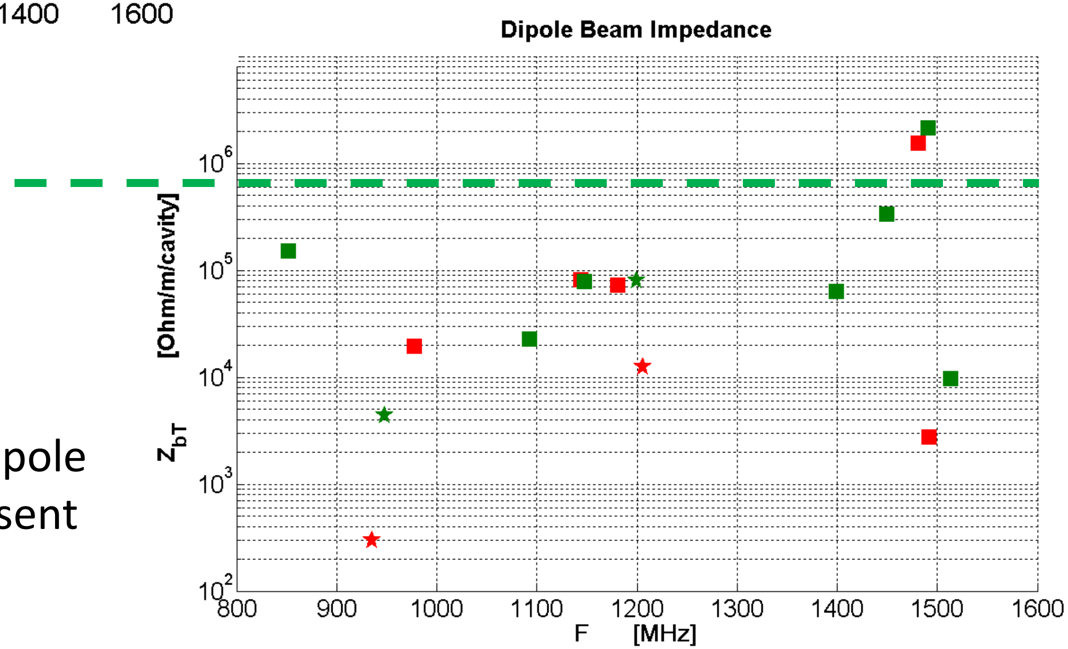
In this chart, we have omitted the dipole working mode@800MHz and the quadrupole mode@1.2GHz, because it has a greatly reduced field inside the coaxial pipe.

All Modes Beam Impedance



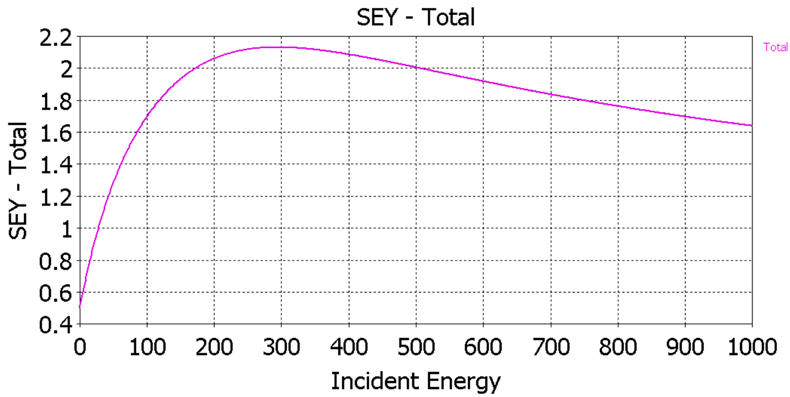
Beam instability requirement
for accelerating modes
20 [kOhm/cavity]

Beam instability requirement
for dipole modes
750 [kOhm/m/cavity]



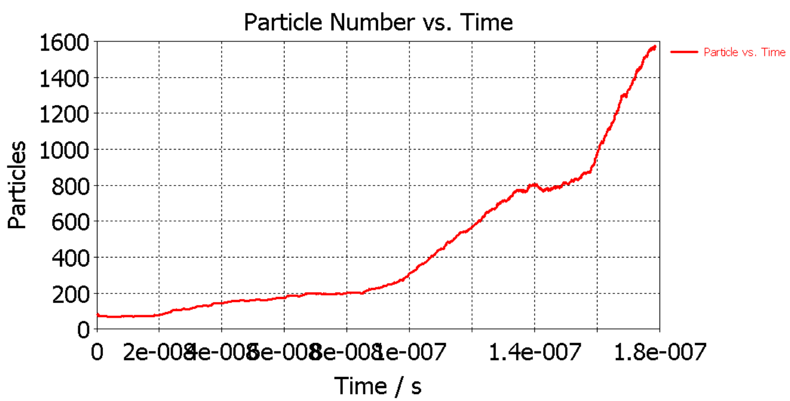
We must optimize the position of the OOM coupler to damp the two monopole and two dipole modes, which still present high beam impedance.

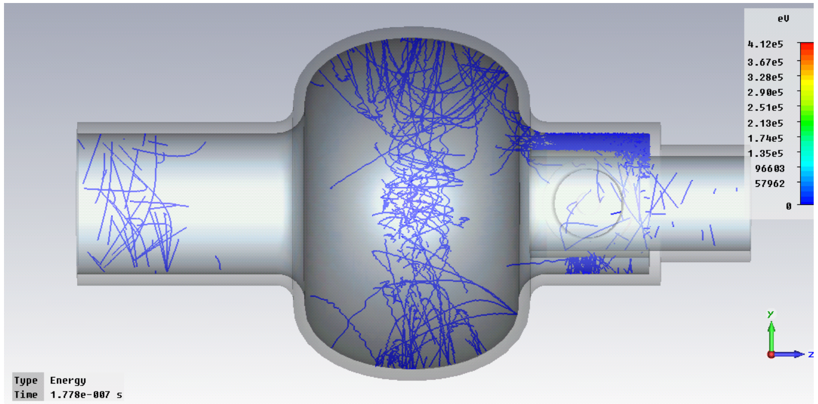
Multipacting preliminary studies

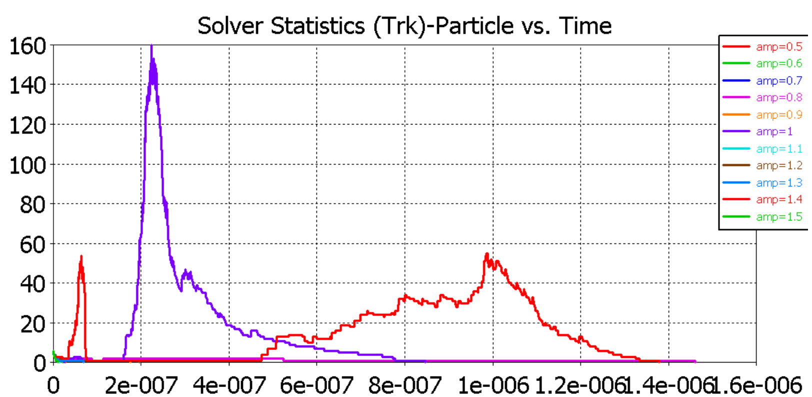


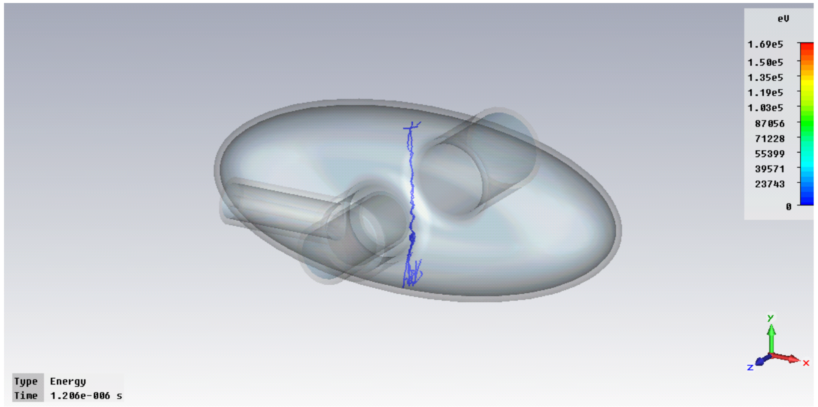
Secondary Emission Yield used

Electron avalanche has been calculated in a preliminary geometry with a not optimized OOM coupler









Summary

- As an alternative to a 400MHz CC design, a very slim cavity at 800MHz with very low Peak Fields has been developed

- 800MHz single cell cavity for a local CC scheme has been analyzed and optimized

- Feed Power Coupler has been optimized

- LOM and HOM Coupler is to optimize

- Surface Peak Fields in presence of coupling system is to optimize

- MP Amplitude and Phase scan is to be analyzed inside a final geometry