Slim crab cavity development

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Brief Introduction

- Our goals: Classical cavity body (elliptical - squashed) HOMs damping system as simple as possible.
- HOM scheme I: Single damping coupler for the monopole and both polarizations of dipole modes, as compact as possible. Working Mode rejection system based on a coaxial beam pipe cut-off of the TE_{11}.
- HOM scheme II: Single damping coupler with more relaxed mechanical constrictions respect the KEK crab cavity. Working Mode rejected by a TE_{11} $\lambda_g/4$ Stub Resonator between Cavity body and damper.

Slim crab HOMs scheme I (1/5)

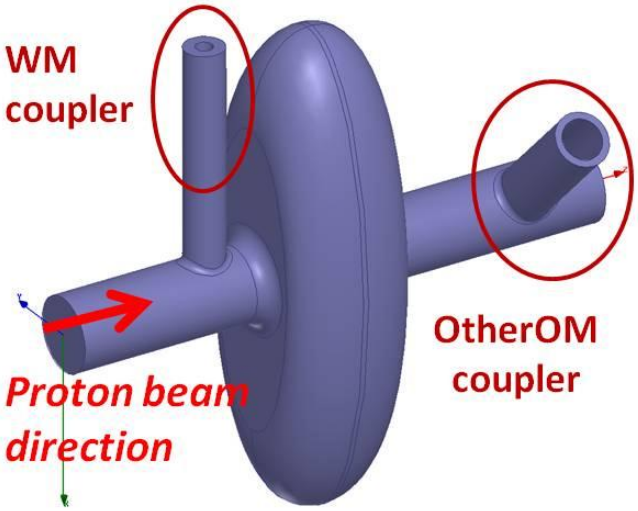
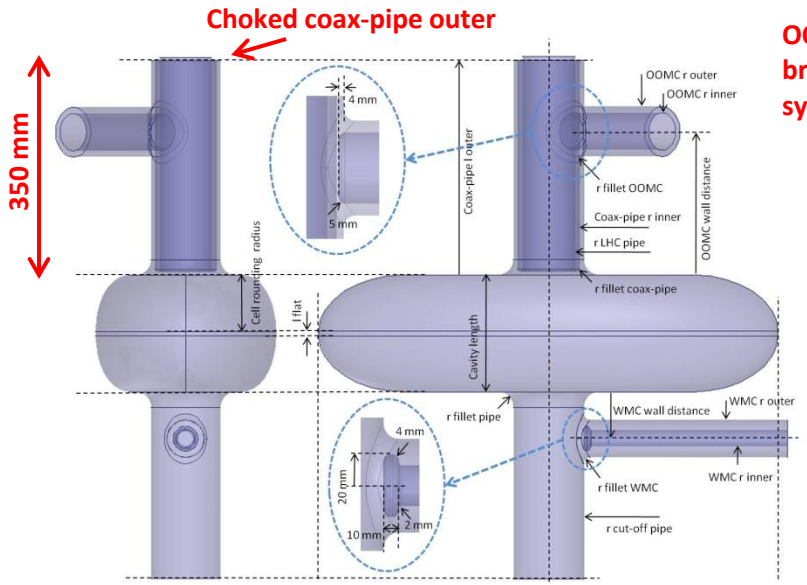
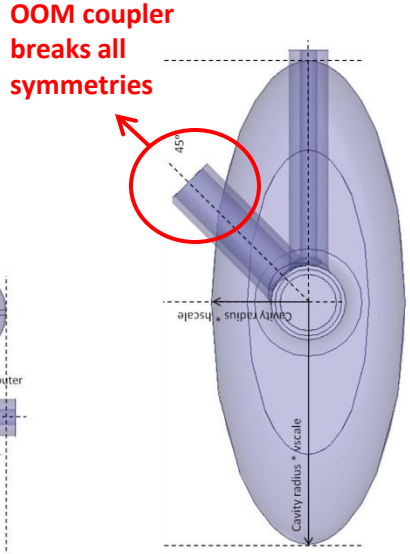


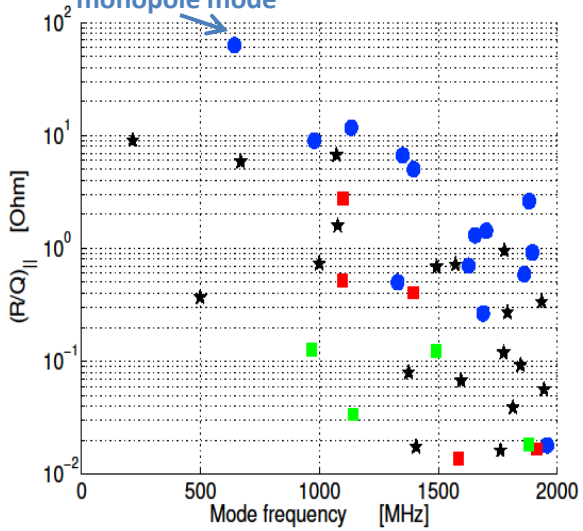
Table 3: Mode Types

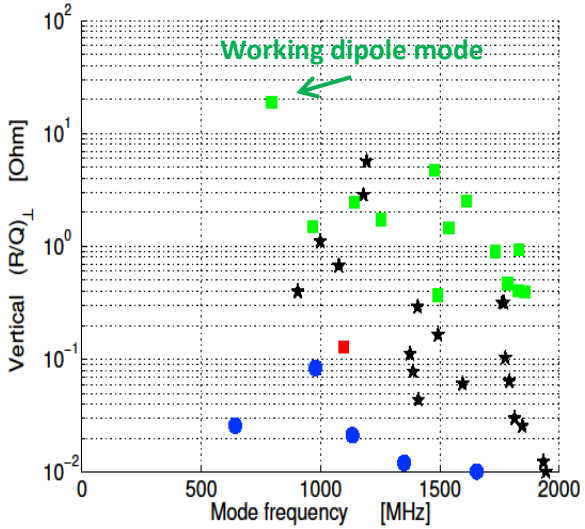
Essential field on beam axis	Type of mode	Chosen marker
E_z	Accelerating	●
E_x, H_y	H-Deflecting	■
E_y, H_x	V-Deflecting	■
H_z	Not excited	●
Negligible	Coupler trapped	★

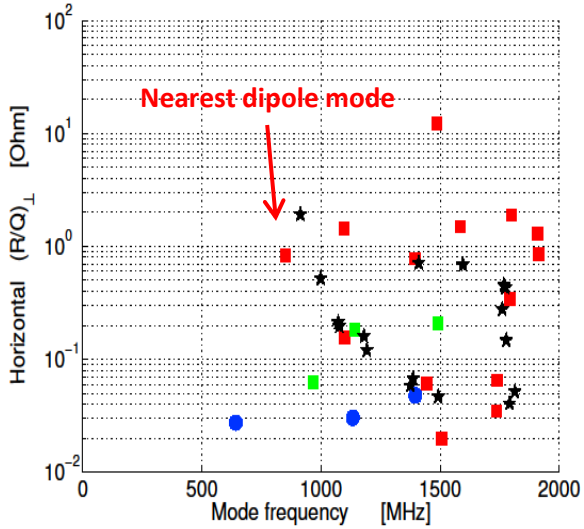




Calculated R/Qs in asymmetric structure – up to 2 GHz

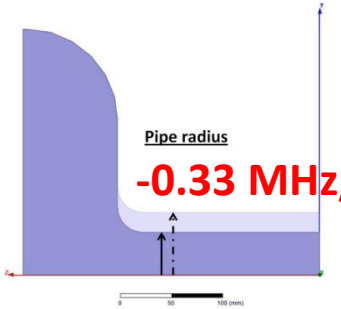




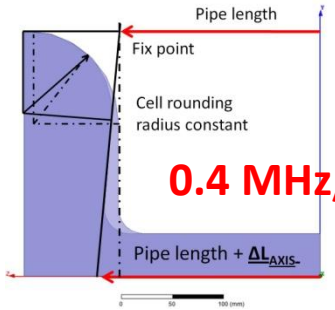


Slim crab HOMs scheme I (2/5)

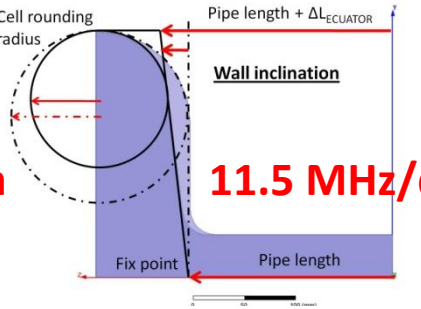
Sensitivity at the geometric variations & Frequency Tuning



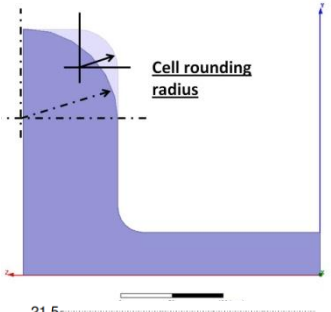
-0.33 MHz/mm

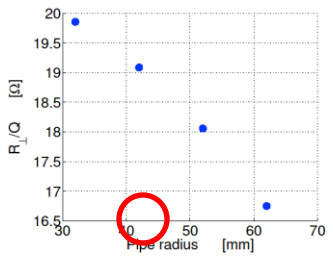


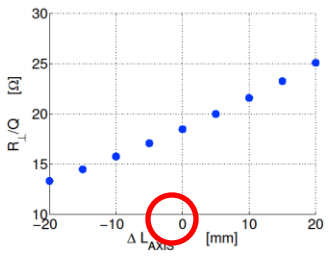
0.4 MHz/mm

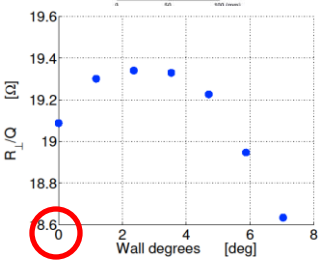


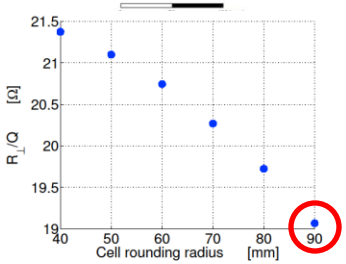
11.5 MHz/deg

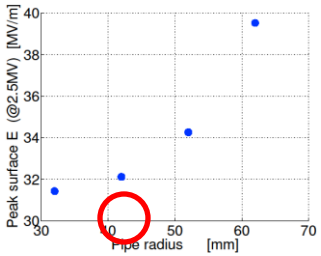


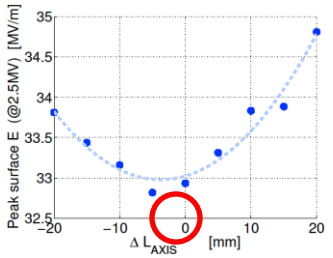


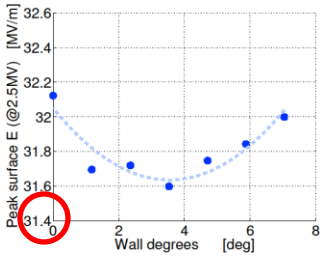


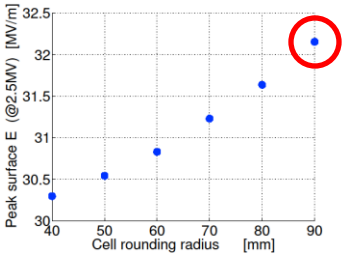


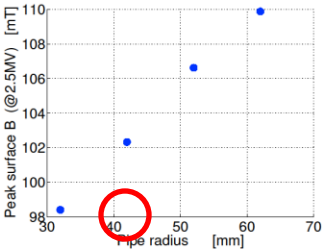


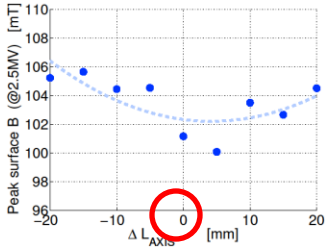


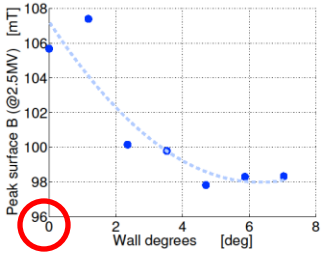


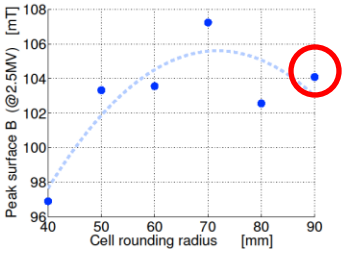








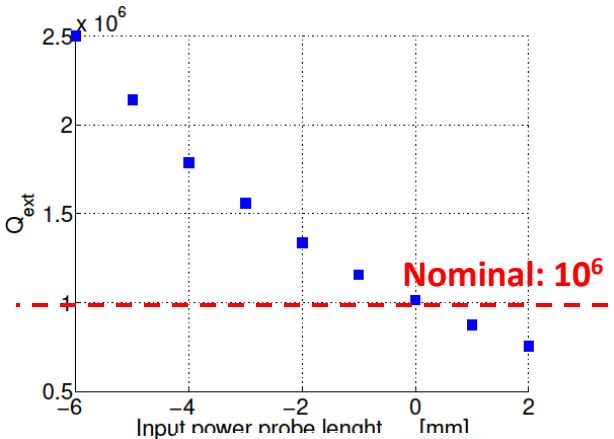




For more details refer to "Slim elliptical cavity at 800 MHz for local crab crossing", **4th LHC Crab Cavity Workshop**

Slim crab HOMs scheme I (3/5)

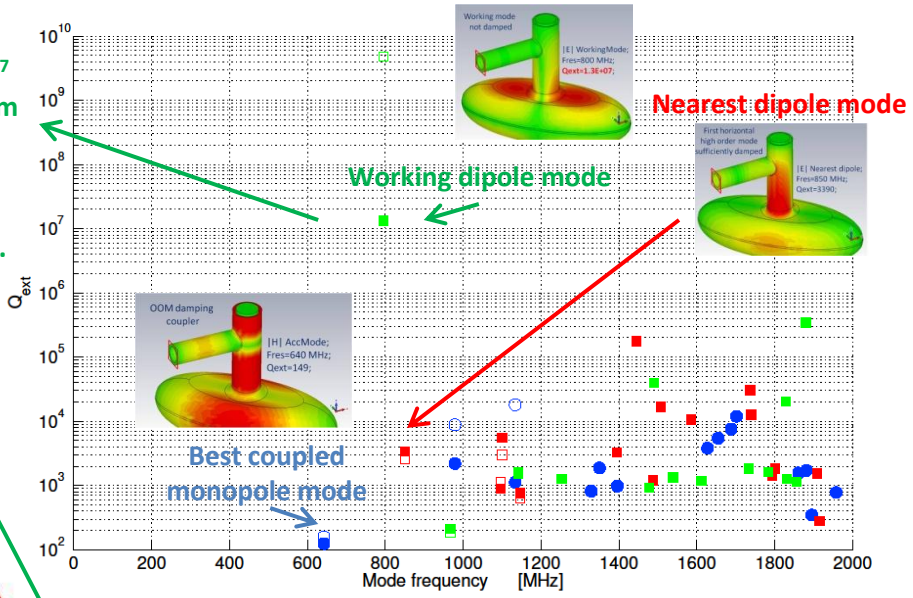
WM coupler & OOM coupler performance & limitations

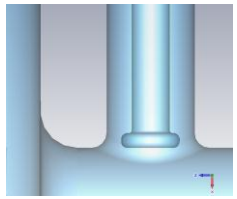


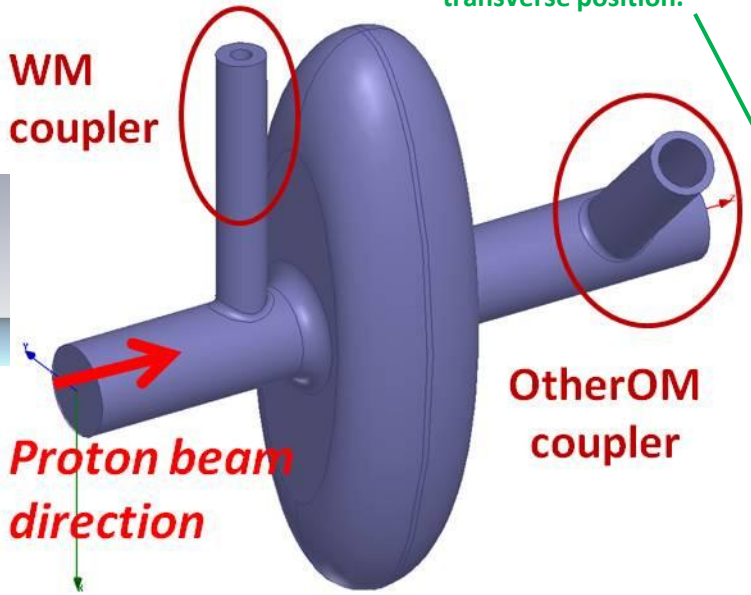
With a Q_{ext} equal to 10^7 The leakage power from the WM is 18 kW.

We need at least two magnitude order more.

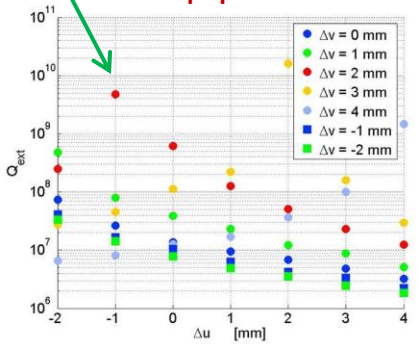
With this geometry we can increase WM Q_{ext} acting on the inner coax-pipe transverse position.

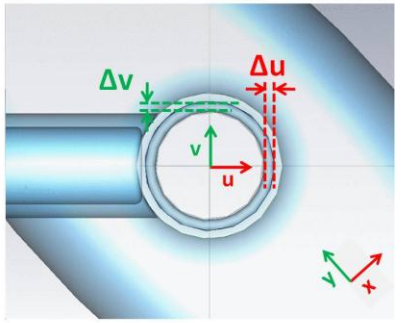






Coax-pipe inner transverse displacement

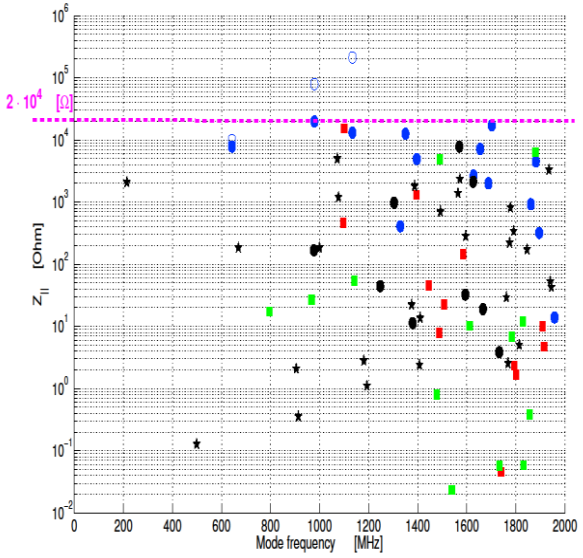


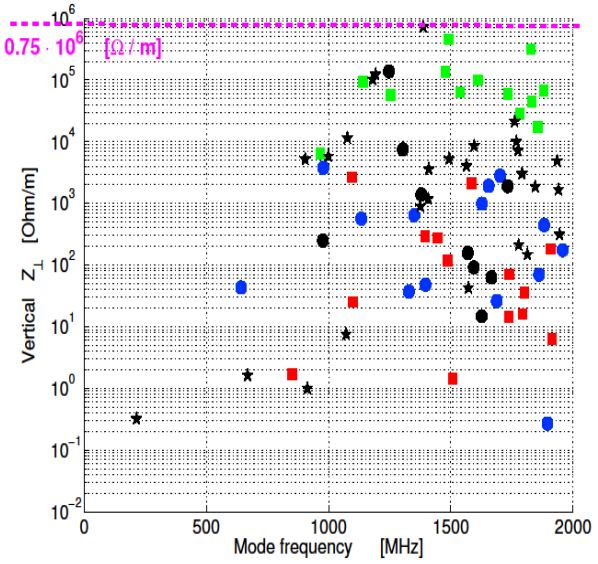


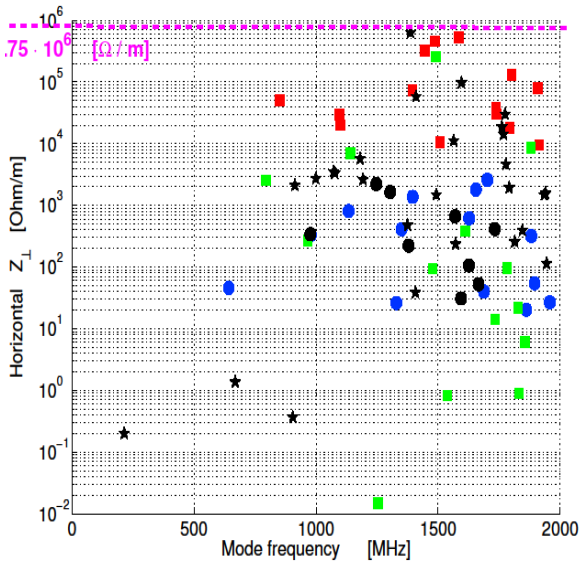
Slim crab HOMs scheme I (4/5)

Beam impedances achieved

- Impedance limit for the LHC crab cavity are in dashed lines
- With the proposed damping scheme all parasitic modes are damped below limit values
- Un luckily, if the inner coax-pipe geometric modification produces good results with regard to the rejection of the WM the inevitable decoupling with some HOMs leads to an non-acceptable increase of the beam impedances

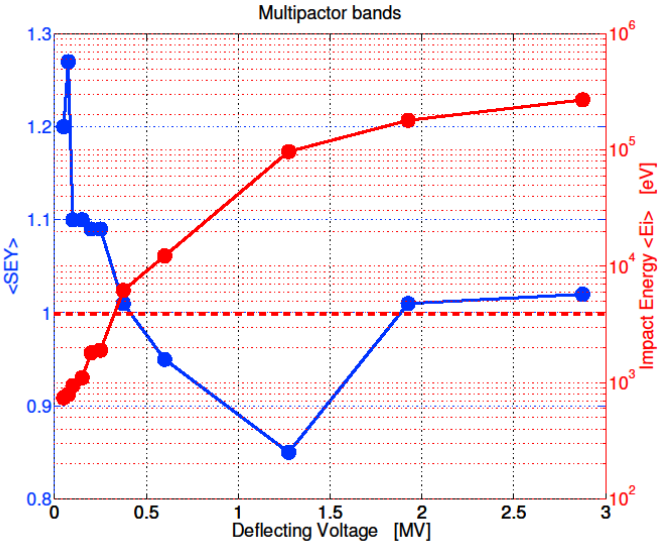






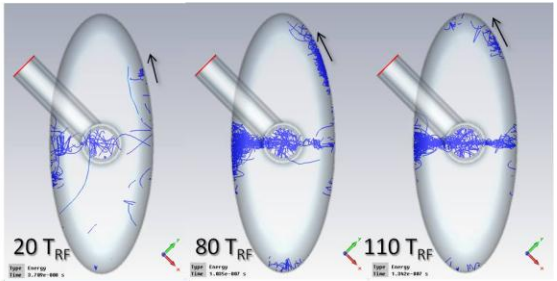
Slim crab HOMs scheme I (5/5)

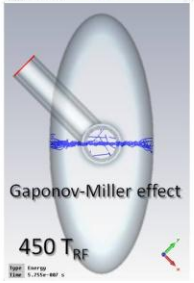
Multipacting studies results

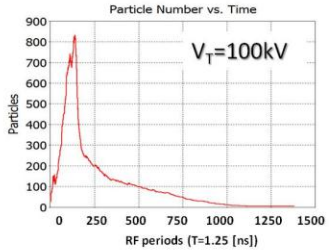


1) Particle source all around the OOM side iris;
2) MP simulations at 800MHz WM;
3) Symmetries reasons leads to scan field phase up to 180deg;
4) From tens ok kV up to 3MV was scanned;
5) At least 50RF T were simulated.

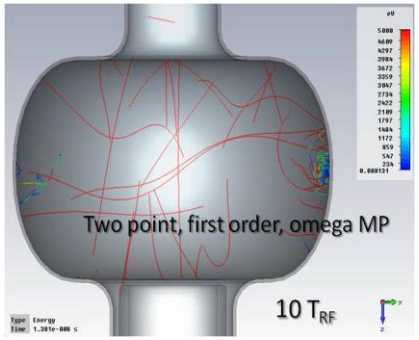
Run-away resonant trajectories:
- In the direction of the small radius equatorial area;
- More stable trajectories in the equatorial area;
- Gaponov-Miller effect, particles pushed towards low field amplitude regions.

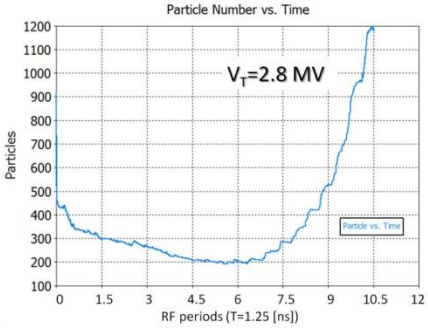




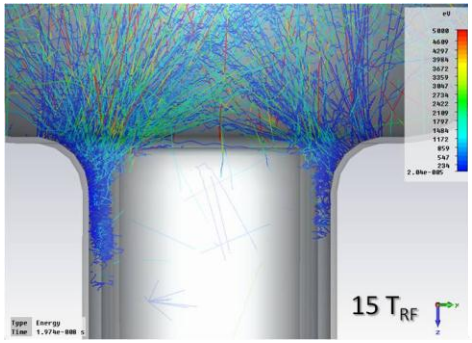


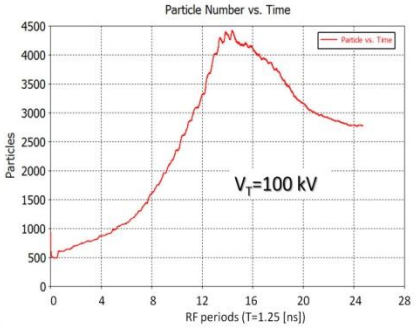
Stable resonant trajectories within the high field band:
- Above the nominal deflecting voltage using a worse SEY than Nb
- Mostly Omega MP were found, surmounted by RF processing in many cases.





Stable resonant trajectories in the OOM coupler at low field:
- Located at the end of the inner coaxial line near the ires;
- Such MP has been observed in RF processing and can normally be processed through .



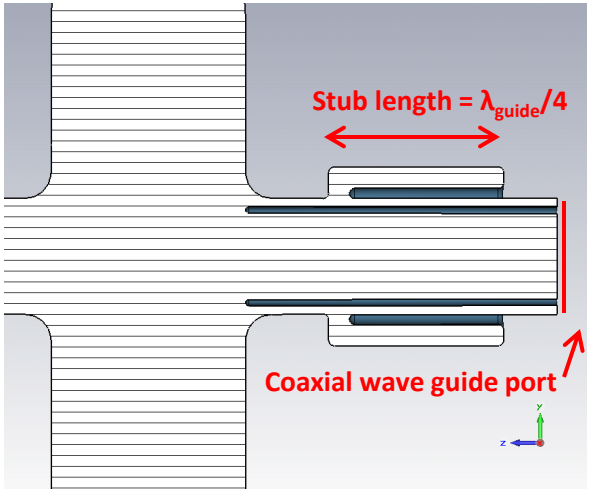


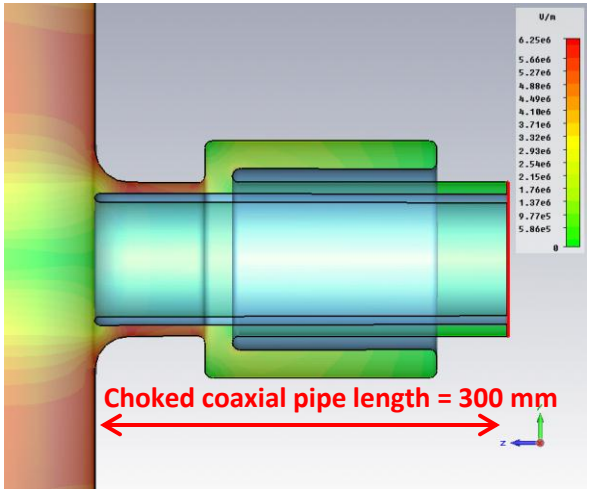
How reject so much power from WM?

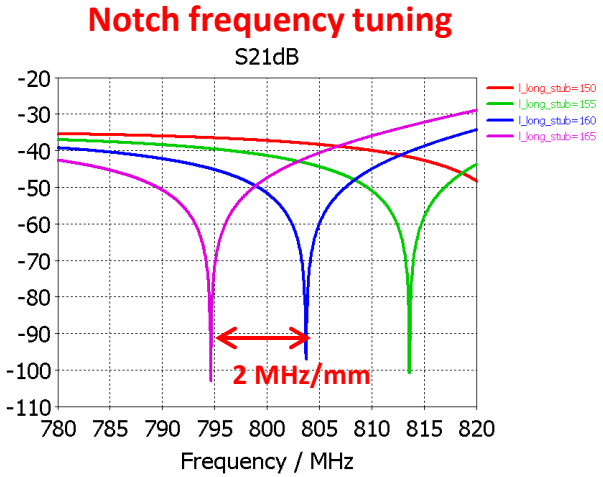
1) Resonant Notch filter
   - Filter inside the cryostat
   - The OOM coupler geometry could remain the same
2) KEK-type Notch filter
   - Power absorber (outside cryostat)
   - Long coaxial pipe, mechanical issues
   - Geometry changes
3) SLAC-type damping system
   - 3 OOMs damping coupler
   - Resonant narrow band notch filter
   - Geometry changes
3) New/Others idea and suggestions are welcome…

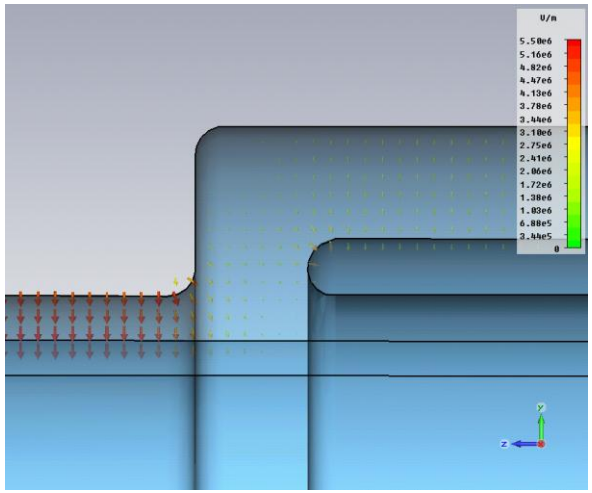
Slim crab HOMs scheme II (1/2)

Lambda quarter notch filter – TM_{11} dipole coax-pipe mode rejection

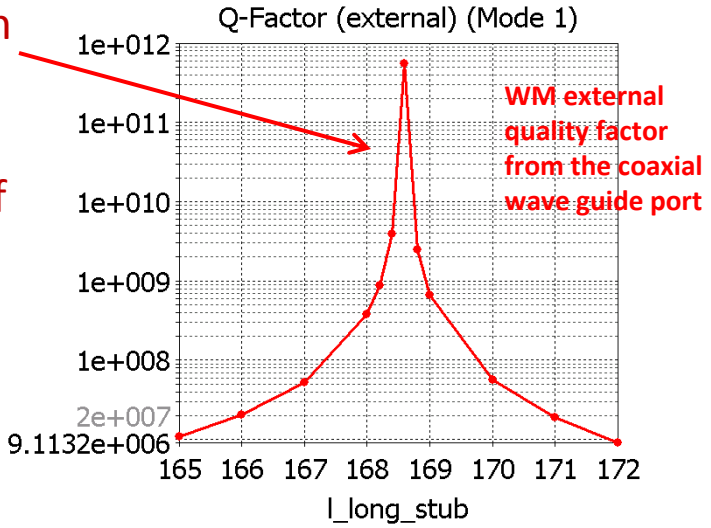






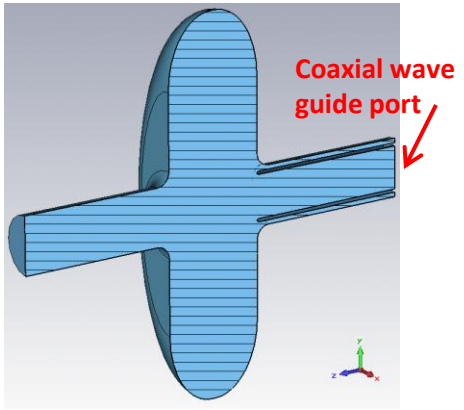


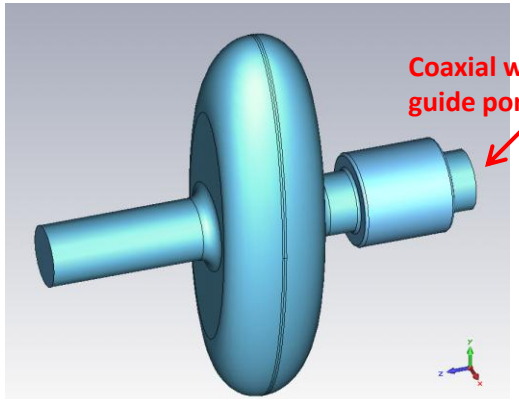
-The stub notch act on the first dipole mode of the coaxial pipe
- TM_{11} is under cut-off
- The WM rejection is very high
-The coax-pipe length is still 30 cm

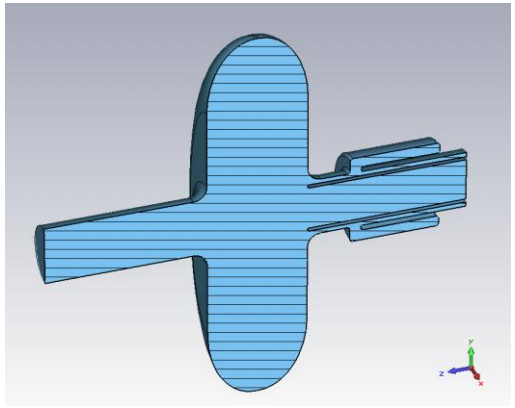


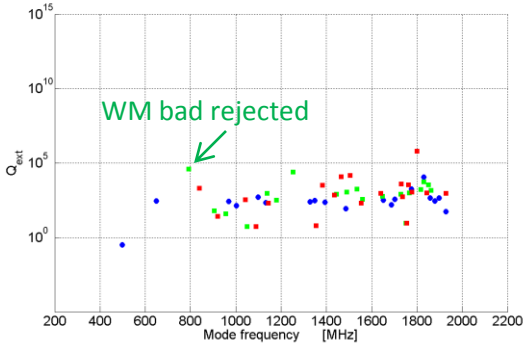
Slim crab HOMs scheme II (2/2)

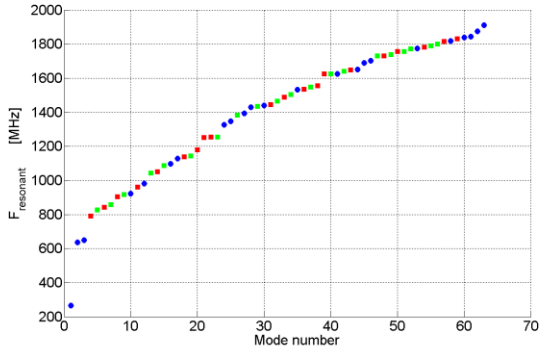
Beam impedances achieved

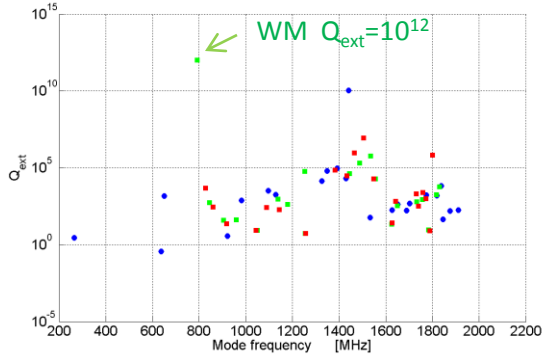


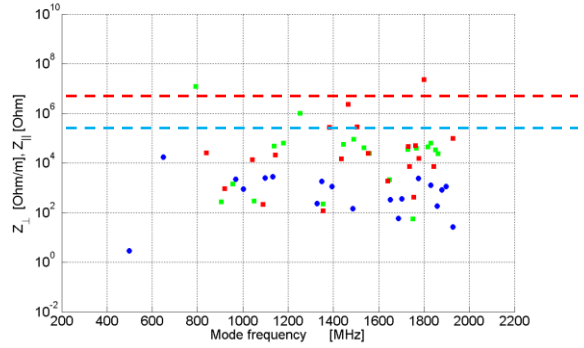


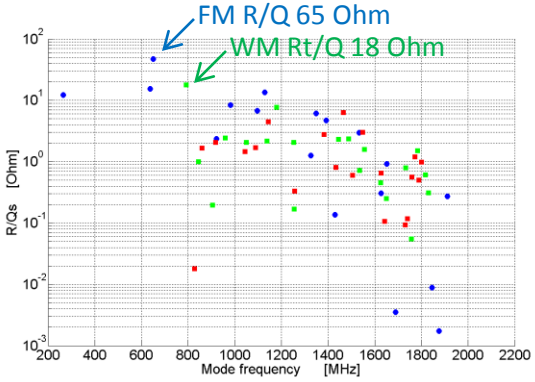


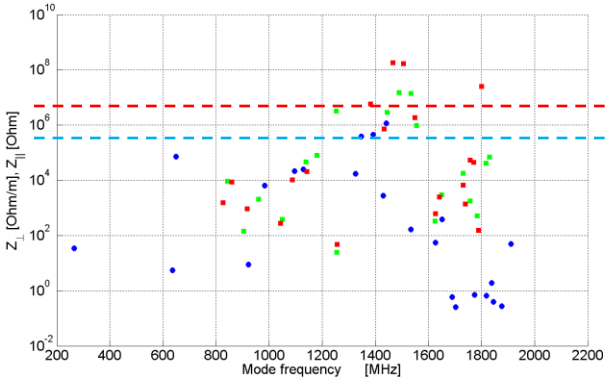












Conclusions

1) The most simple design, using a coaxial choked (SLAC type) beam pipe and a 45deg coax-to-coax transition to well damp both the LOM and the HOMs needs a more challenge WM rejection system.

2) Keeping a simple and compact design, a notch filter based on the λ/4 resonator coaxial stub (KEK idea) was designed. The filter assure a strong WM rejection while maintaining an acceptable length of coax-pipe (30 cm).

3) Further MP studies are needed inside the notch filter.

4) Further damping system upgrades will be considered.