Lancaster University

Science and Technology Facilities Council

# ILC Racetrack Crab Design

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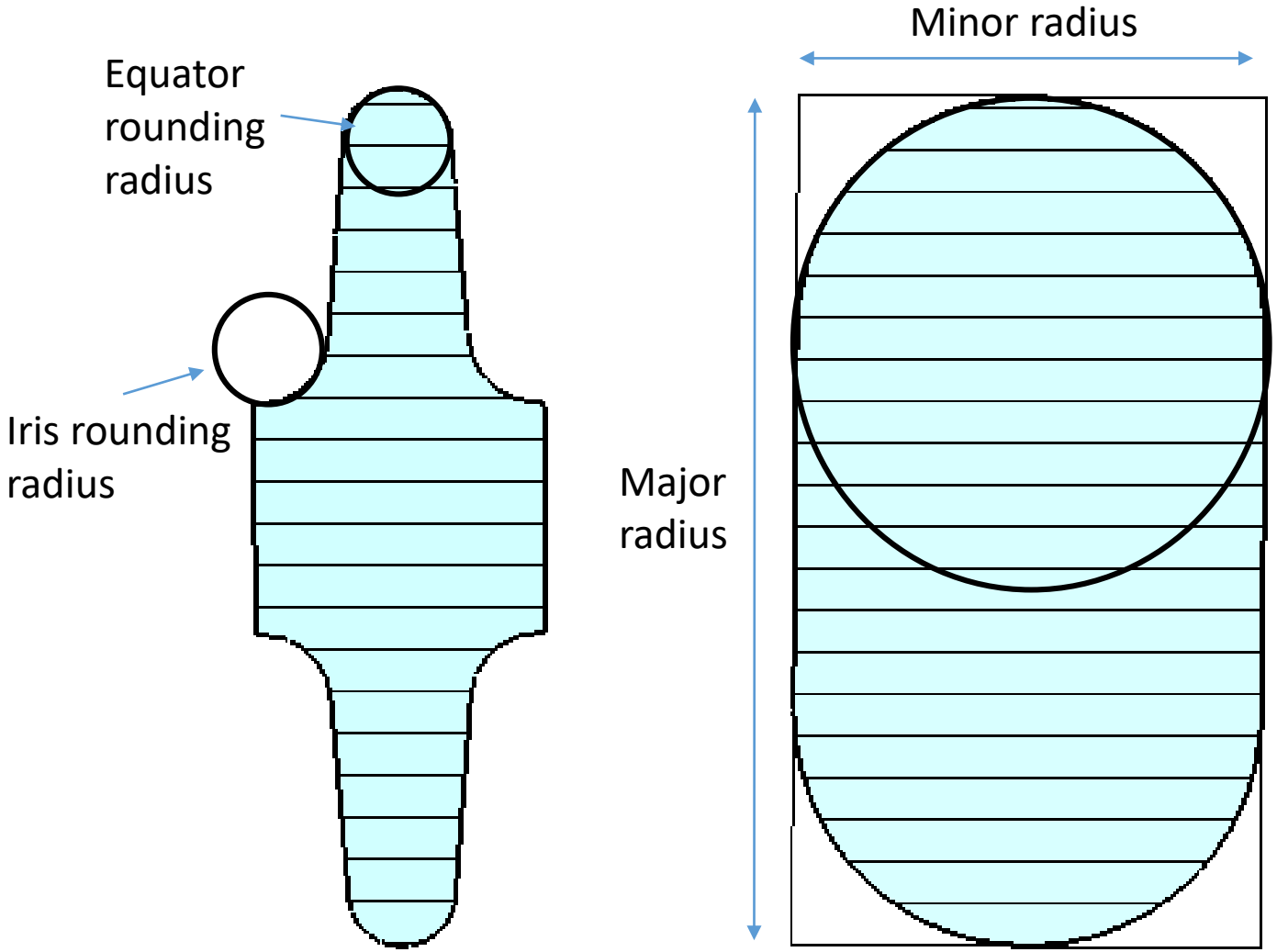
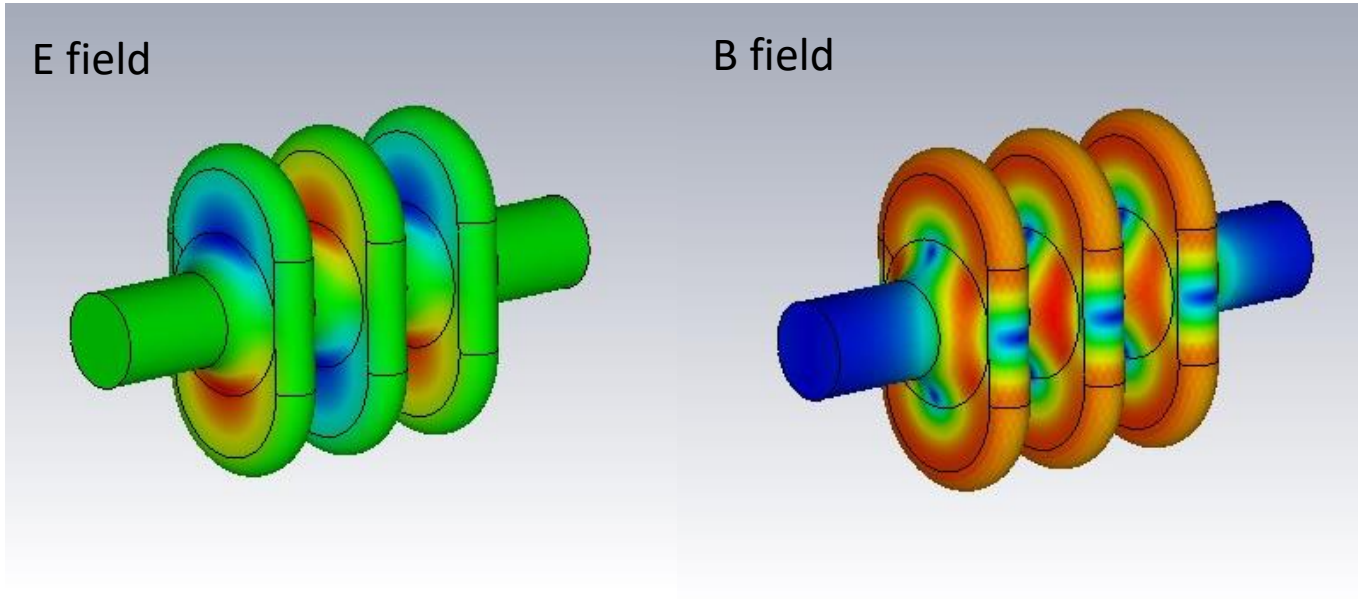
# Re-optimizing the ILC crab

- 250 GeV ILC requires a 3-cell cavity @ 5 MV/m, or 2x2-cells at @4.2 MV/m
- 4 x 3 cells @5.5 MV/m or a 5x2 cells @6.5 MV/m at 1 TeV

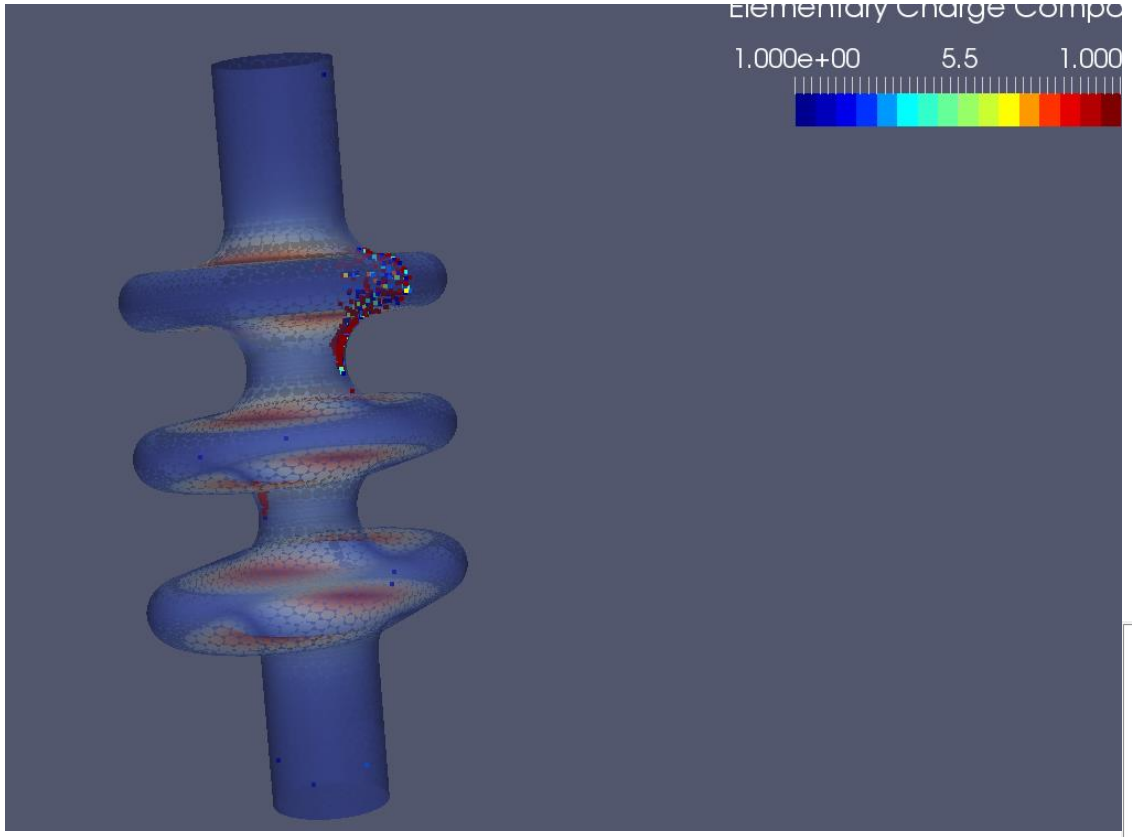


# 3 cell cavity

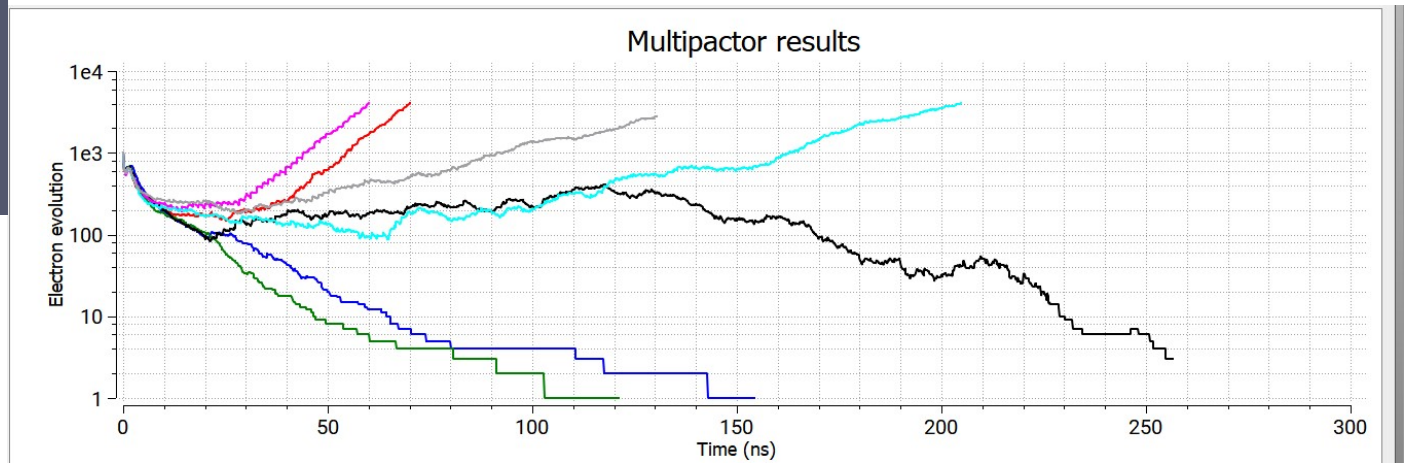
- End cells initially had lower peak magnetic field
- Larger beampipes were used on the end cells to aid damping (30 mm)
- Slightly higher B field means that gradient is limited to 9.7 MV/m at 80 mT
- $R_t/Q$=132 Ohms



# Multipactor

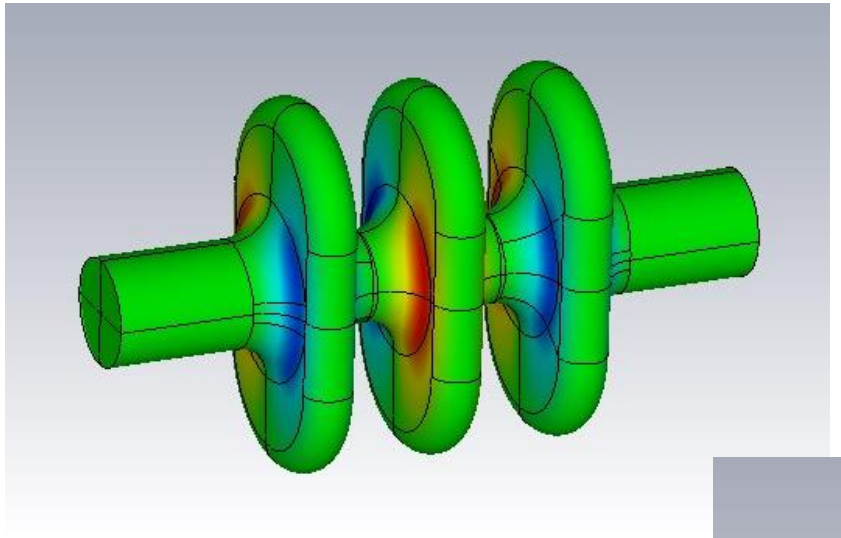


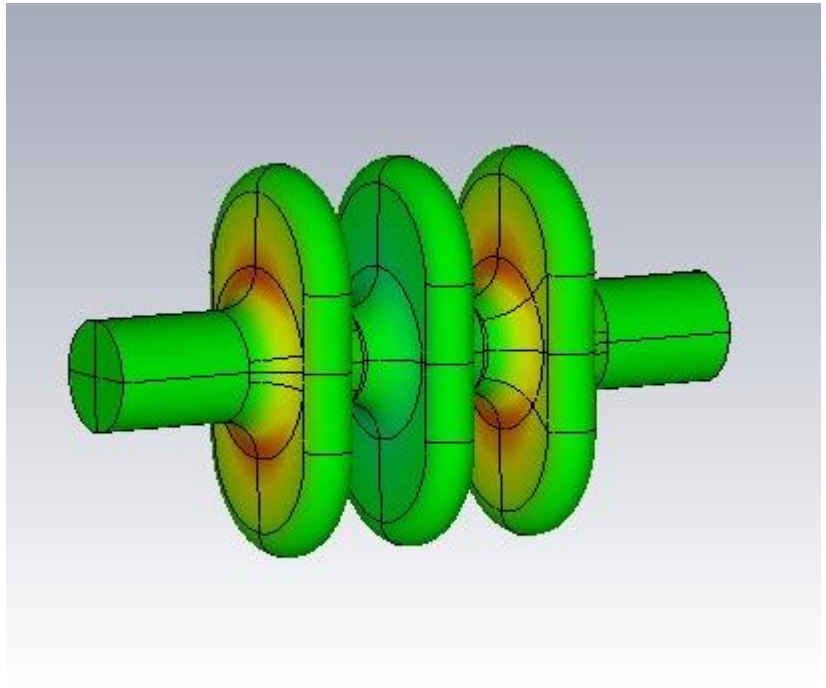

- Multipactor band found at 7.15 MV/m on minor axis iris.
- Required gradient is only 6.5 MV/m so this is acceptable
- Appears very narrow band (not at 7 or 7.3 MV/m)



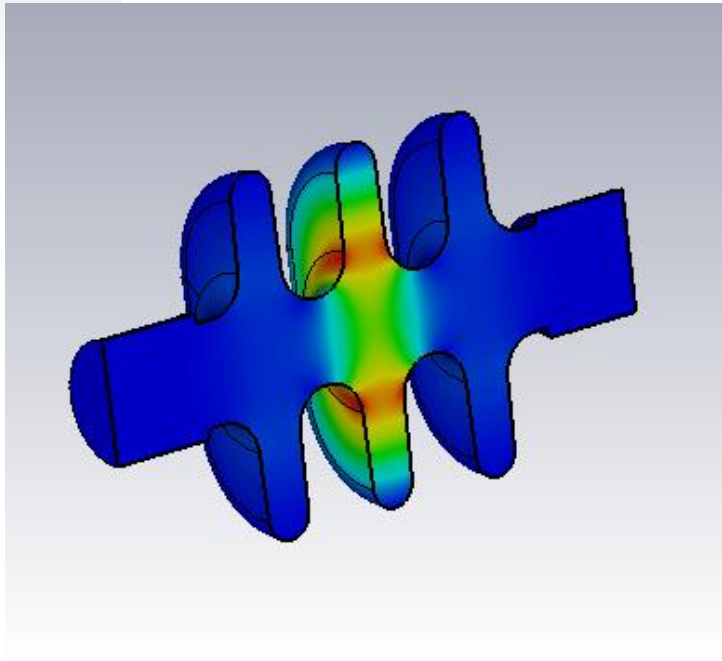
# Same order and lower order modes

- Highest impedance SOM is the pi mode at 5.07 GHz, Rt/Q is only 50 Ohms/m due to frequency not being synchronous.

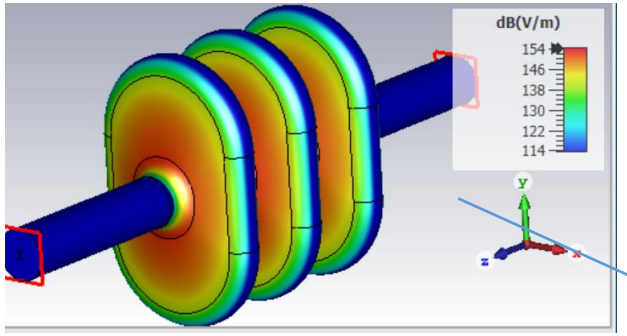


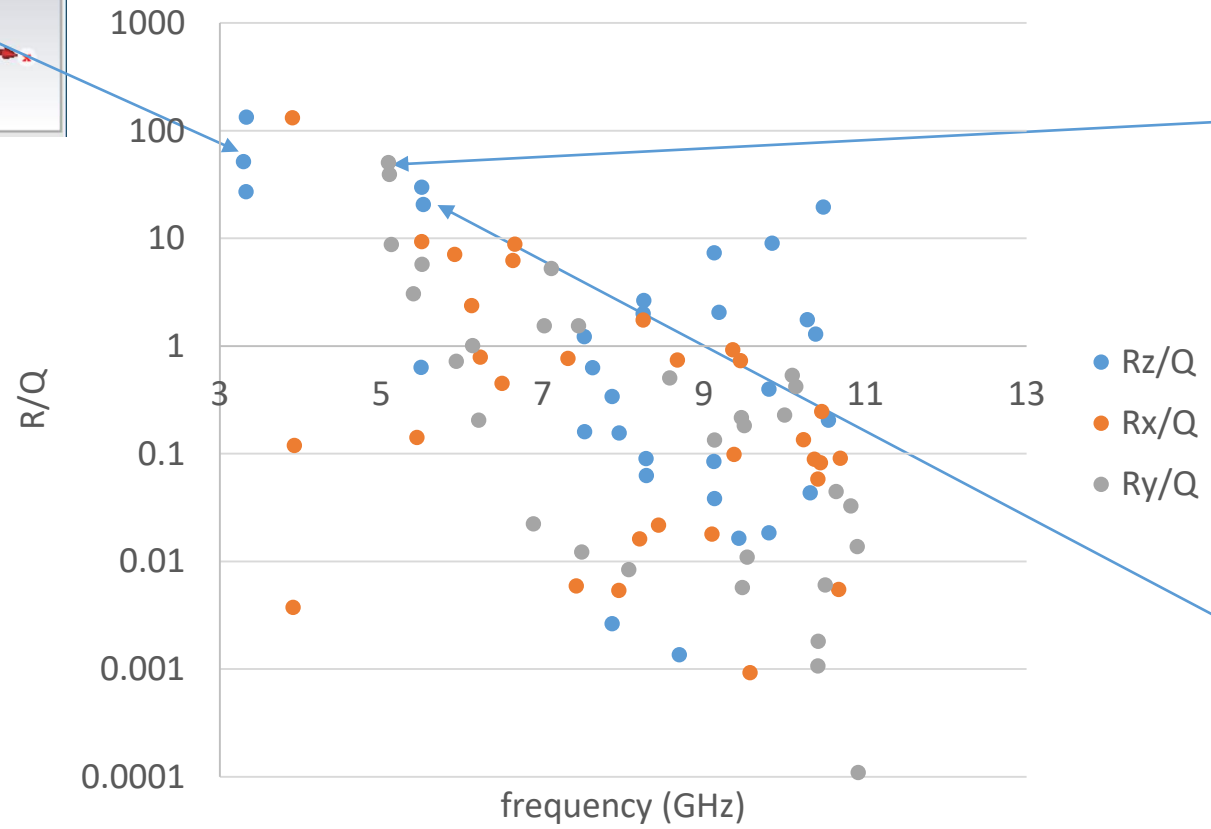


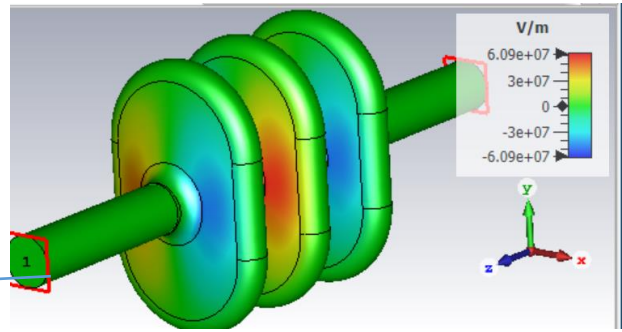
- Highest impedance LOM is the pi/2 mode at 3.32 GHz, R/Q is only 134 Ohms
- Trapped mode in the centre cell may be difficult to damp so may be a larger issue

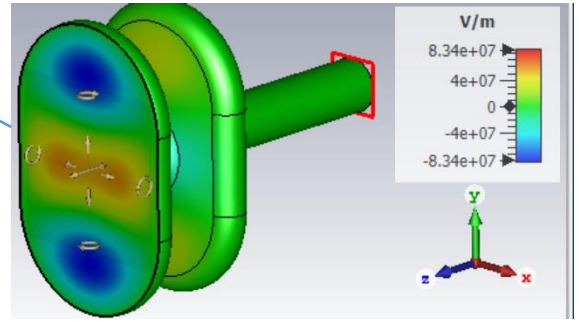


# Mode spectrum

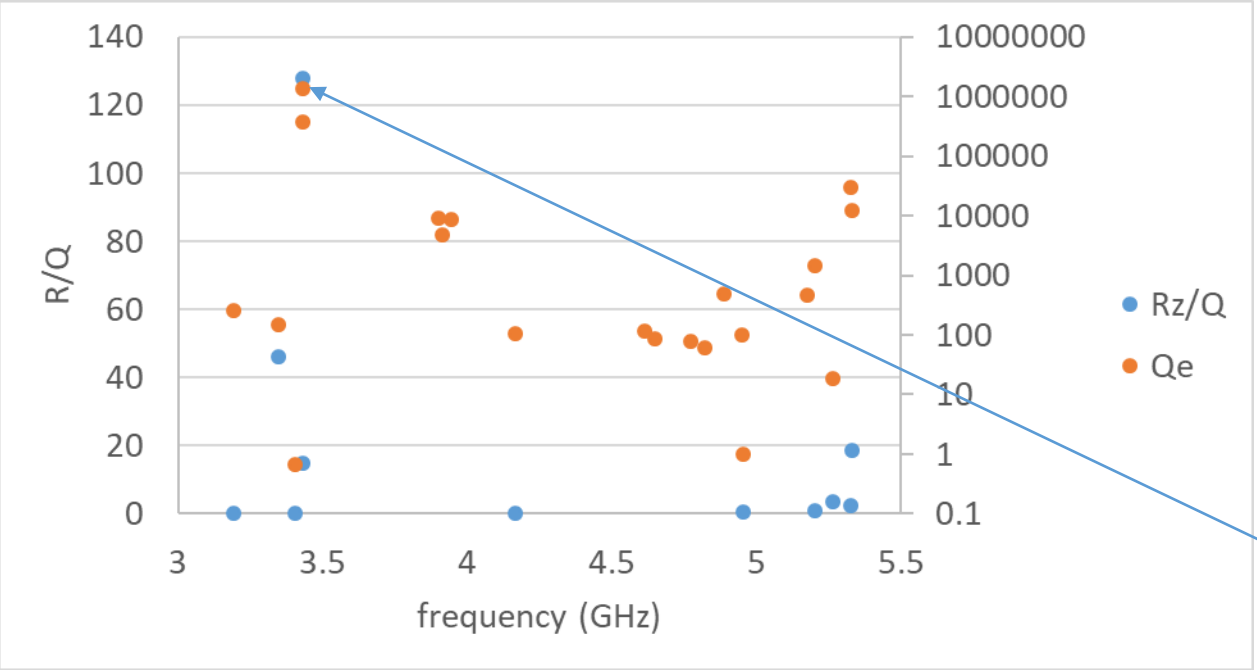


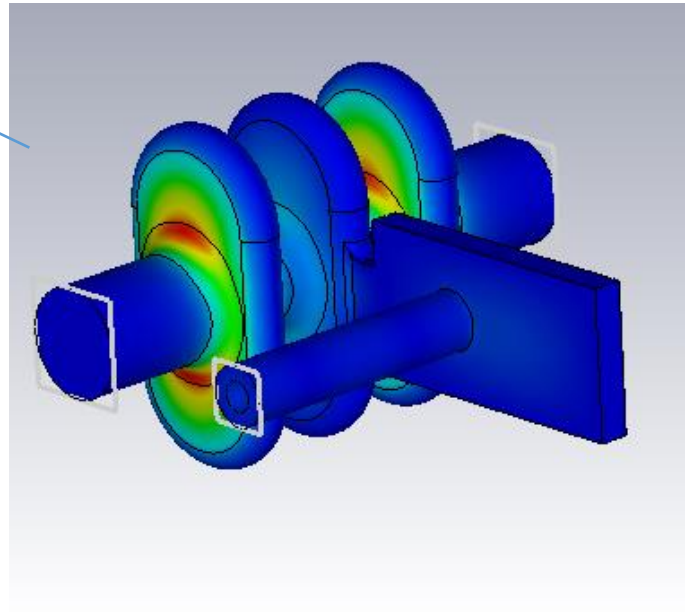



# Waveguide damping



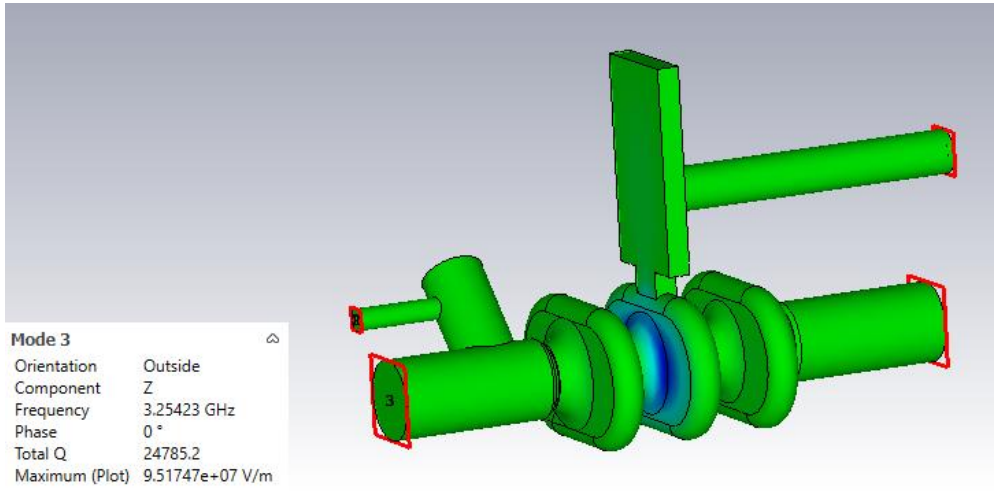

Considering a waveguide section with a coax coupled to it to minimize size and heat leak. Coax can be positioned to prevent coupling to the crabbing mode.

Good damping overall except one mode, unfortunately the highest impedance mode.

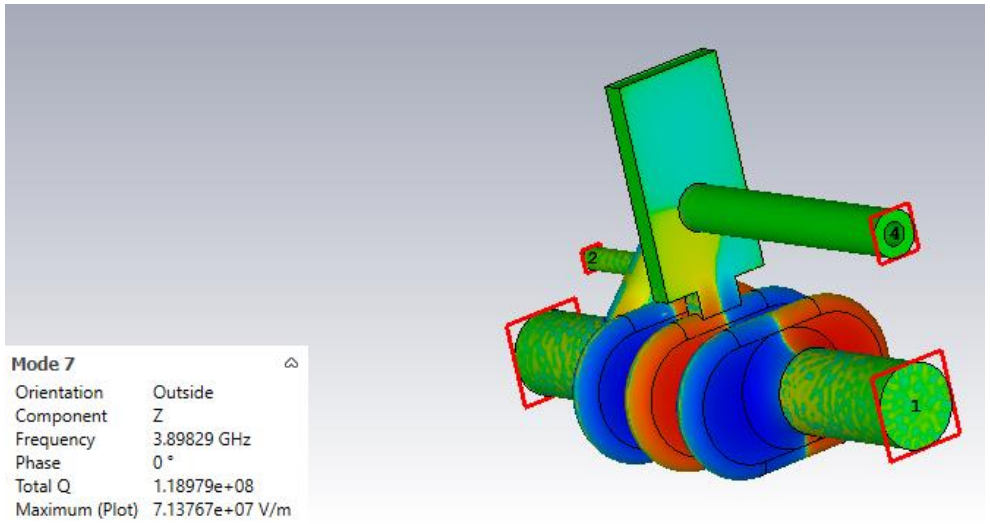


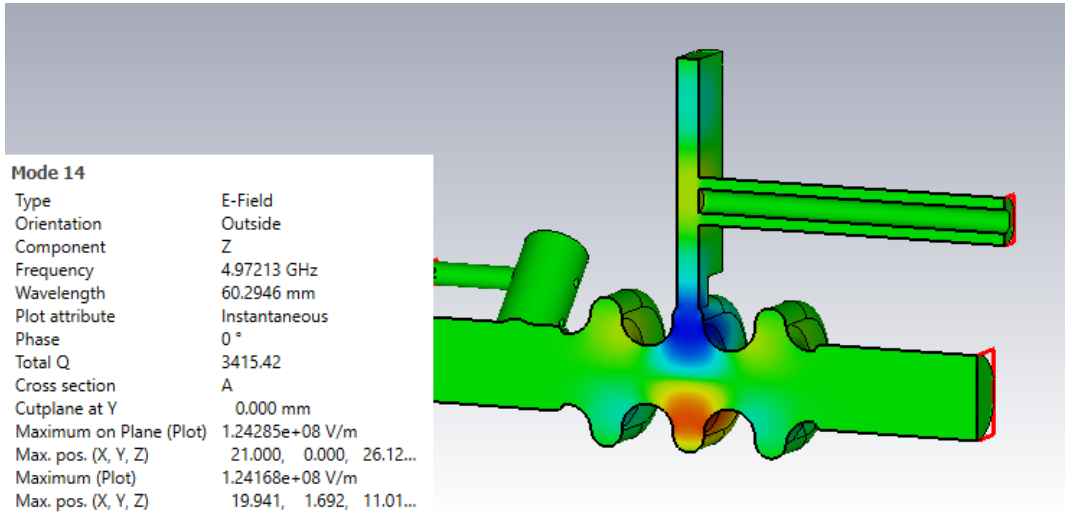
- Waveguide damper does damp the pi and 0 modes well but doesn't damp the pi/2 modes but these will be damped strongly by a coax damper in the beampipes.

# Waveguide damper with coax antenna

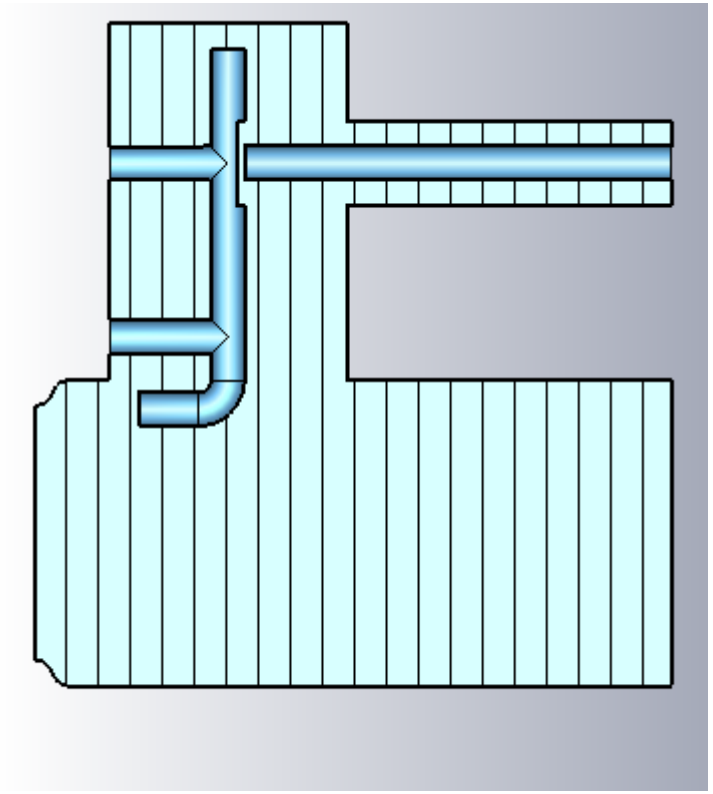



- Waveguide has a coax antenna positioned at the field null in the waveguide at 3.9 GHz but field maxima at 3 and 5 GHz to damp LOM and SOM
- LOM Q is 25,000 and SOM Q is 3,500

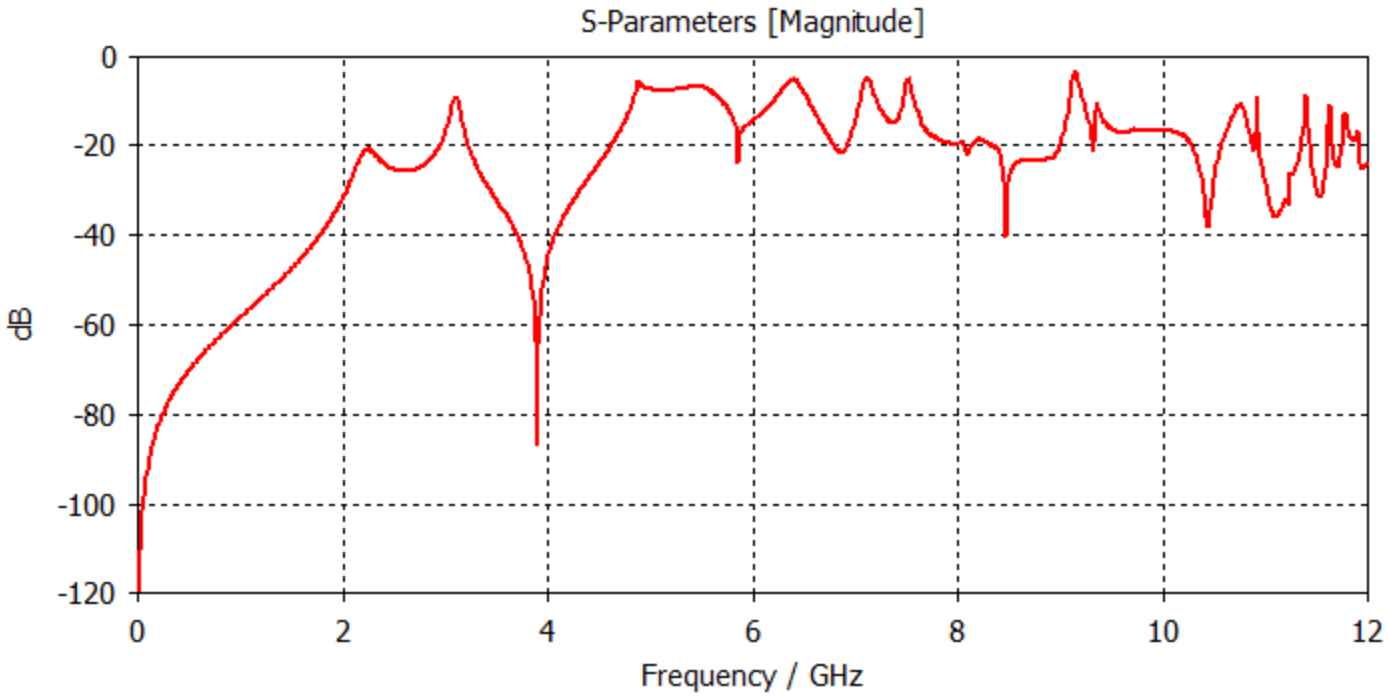


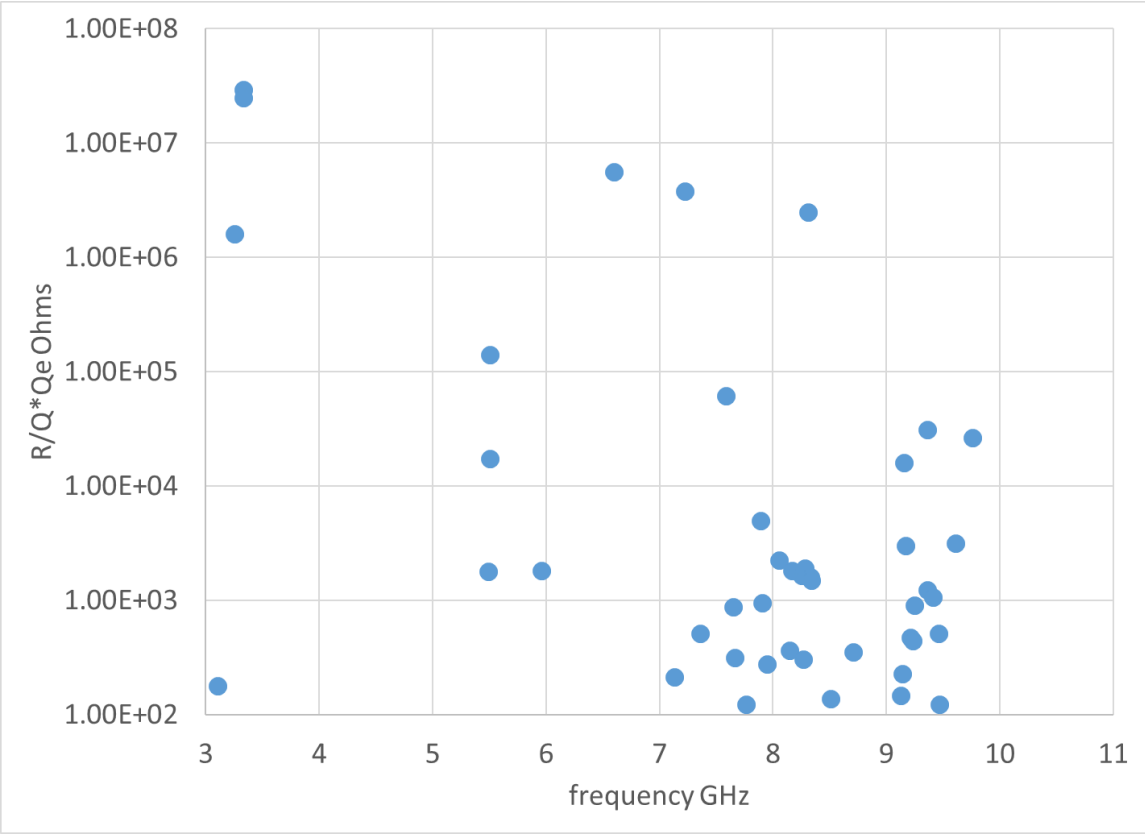
# HOM coupler design

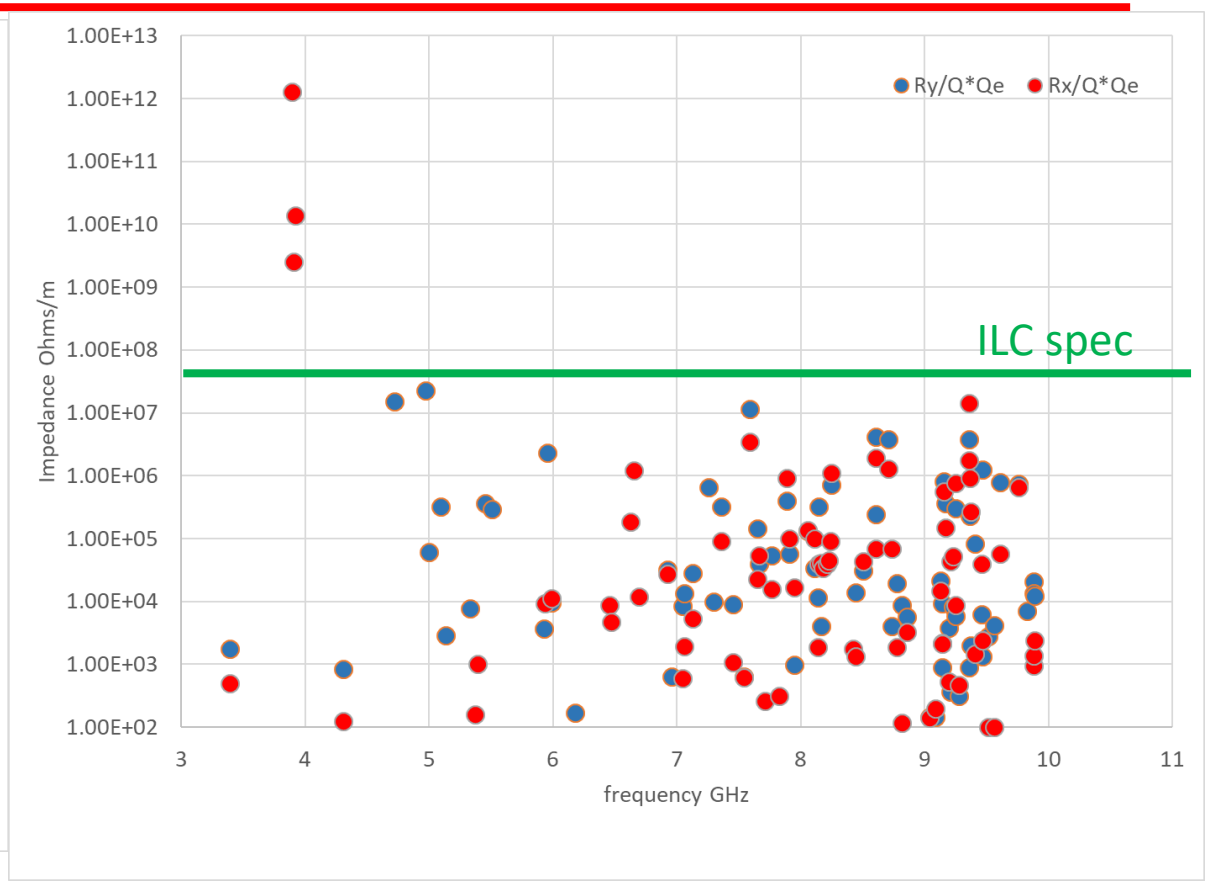


- Modified version of old ILC HOM coupler, similar to ILC main linac coupler
- Designed to have larger transmission at the LOM and SOM frequencies while filtering 3.9 GHz



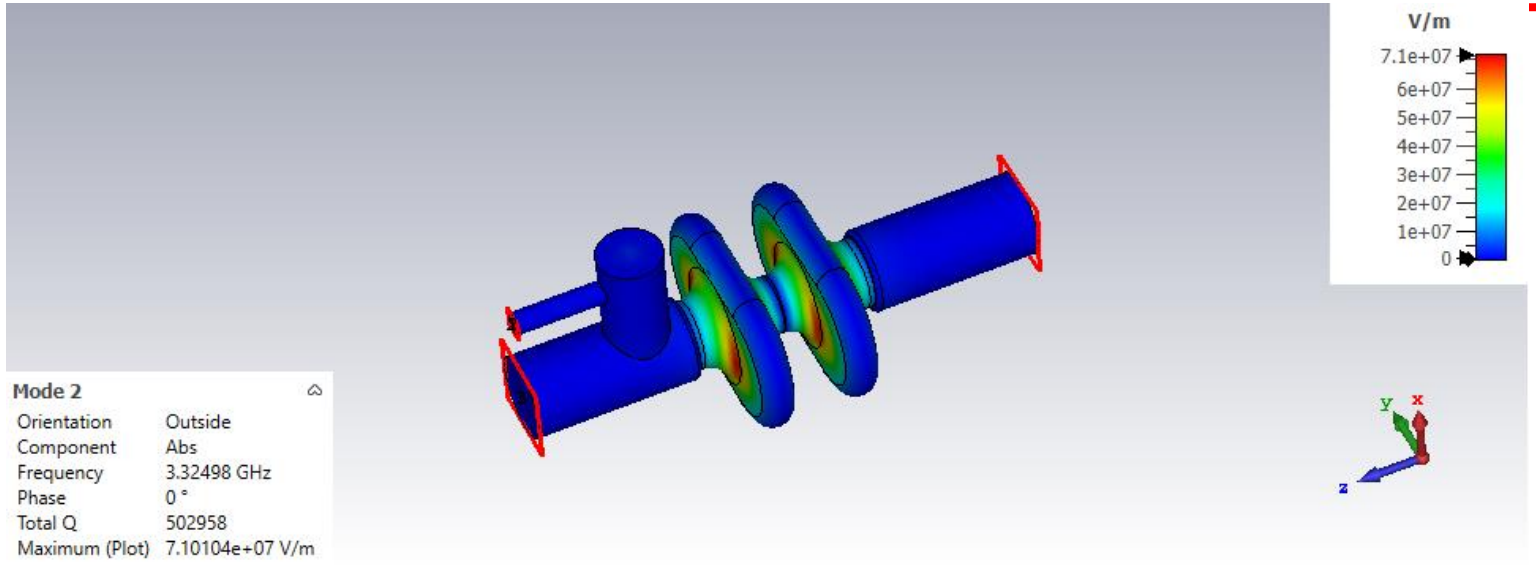
# Impedance for waveguide damped 3 cell



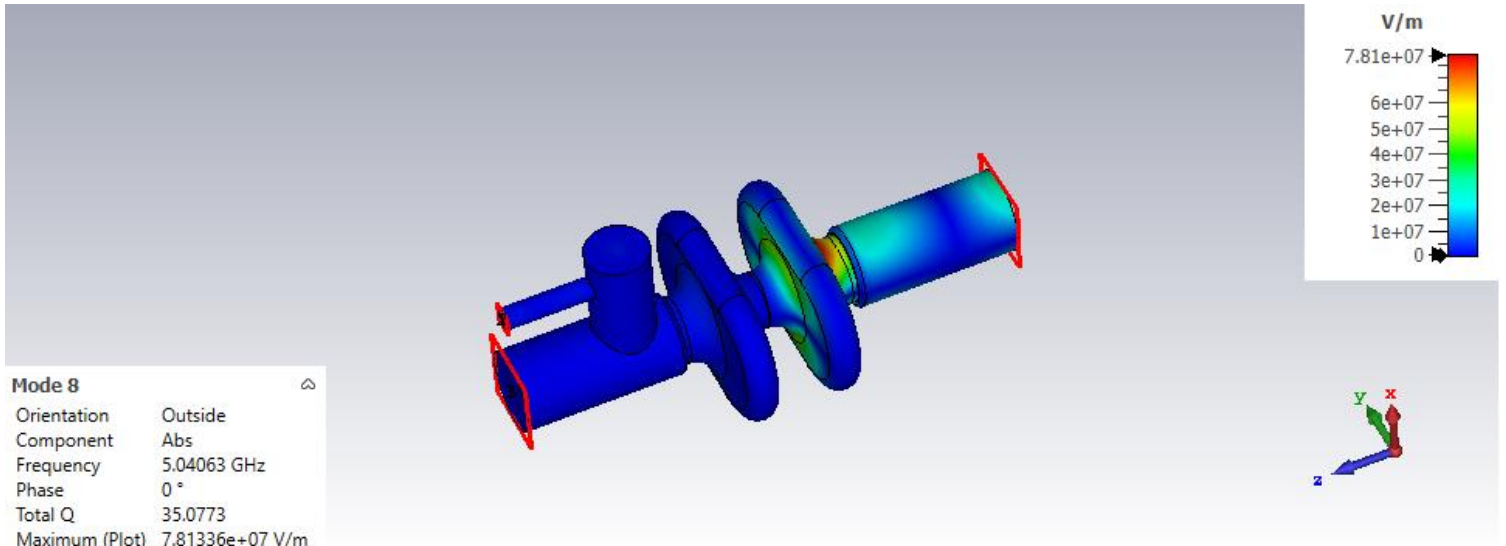

- The long. Impedance has no spec, the transverse impedance meets the spec except the other modes in the crabbing passband
- The FPC may well damp these

# 2 cell cavity



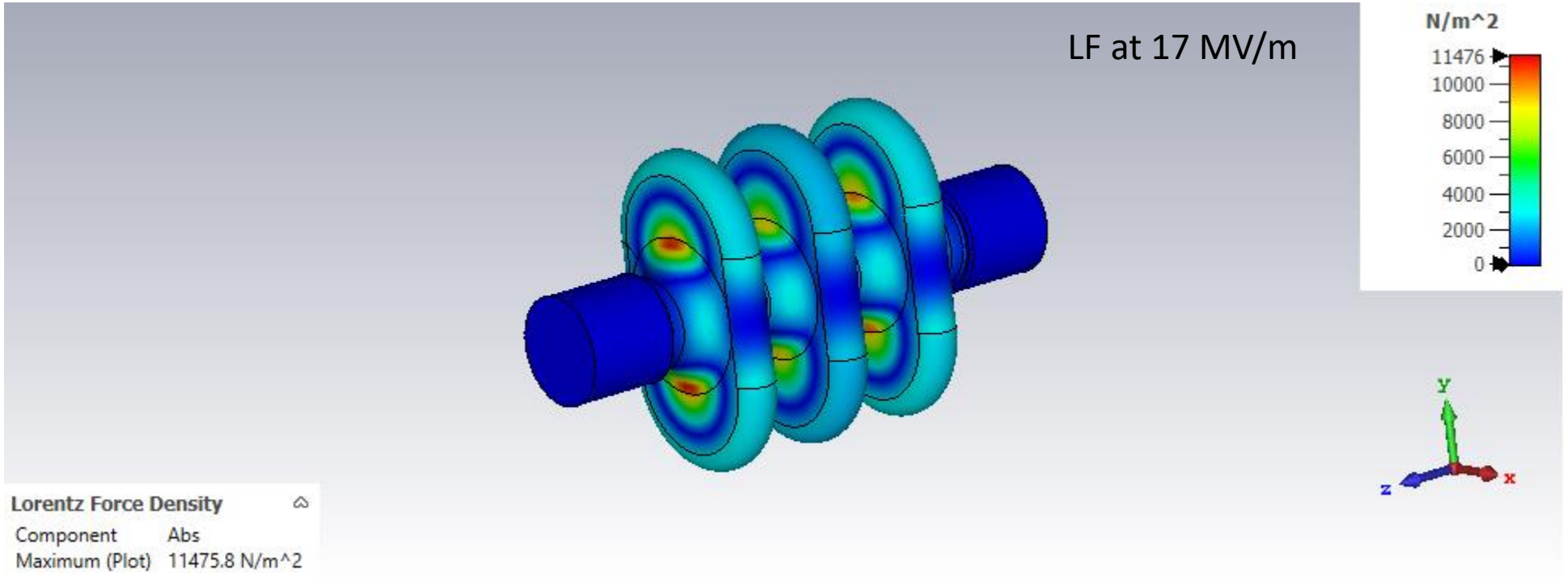

- A 2 cell cavity has no trapped mode so the on-cell waveguide damper is no longer required

- LOM Q factor increases to 500,000 so depends what the spec is
- SOM Q is 35-100 so not an issue.



# Lorentz force

- Lorentz force is 4.6 kN/m^2 at 7 MV/m gradient which is fairly small
- Equivalent to a 50 nm displacement



# Conclusions

- Multipactor limit is 7 MV/m so we have set the cavity gradient at <6.5 MV/m
- Trapped LOM in the middle cell could be an issue with a 3 cell cavity, requiring on-cell damping. A waveguide with a coax antenna provides sufficient damping while rejecting the crabbing mode
- To avoid an on-cell damper a 2 cell cavity can be used
- Both designs meet the ILC specification except the 0 and pi/2 crabbing modes
- The modes in the crabbing passband could be damped by the FPC which needs investigation.