NEW CAVITY SHAPE DEVELOPMENTS FOR CRABBING APPLICATIONS

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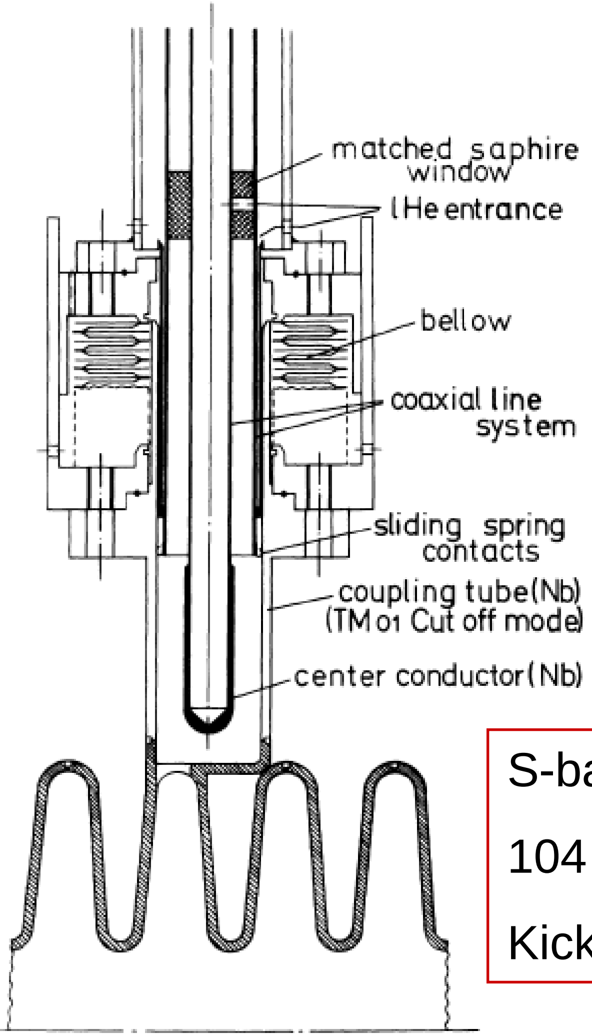
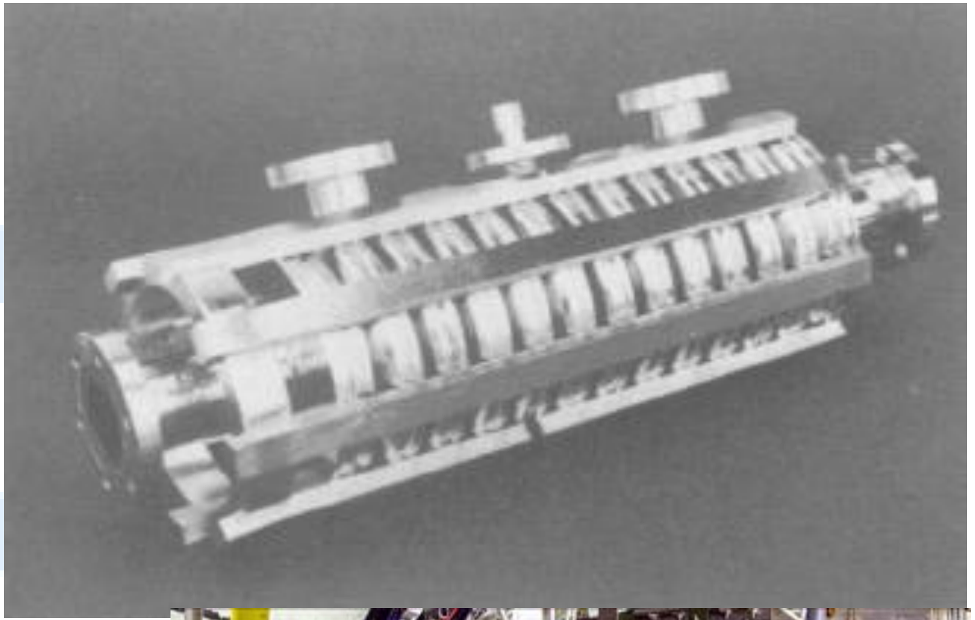
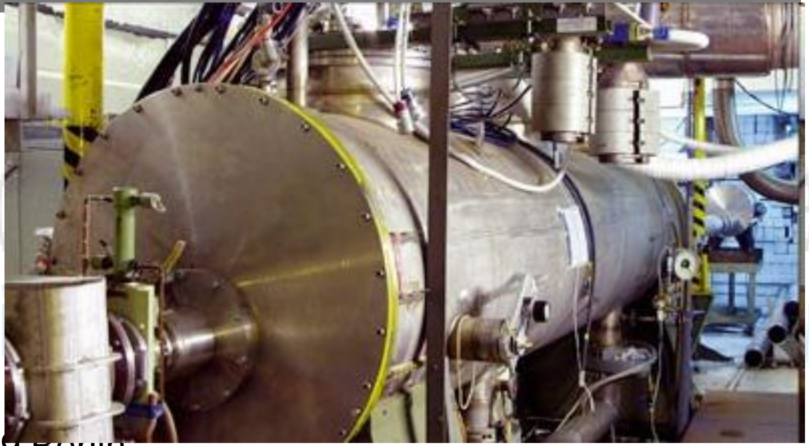
CERN-Karlsruhe cavity





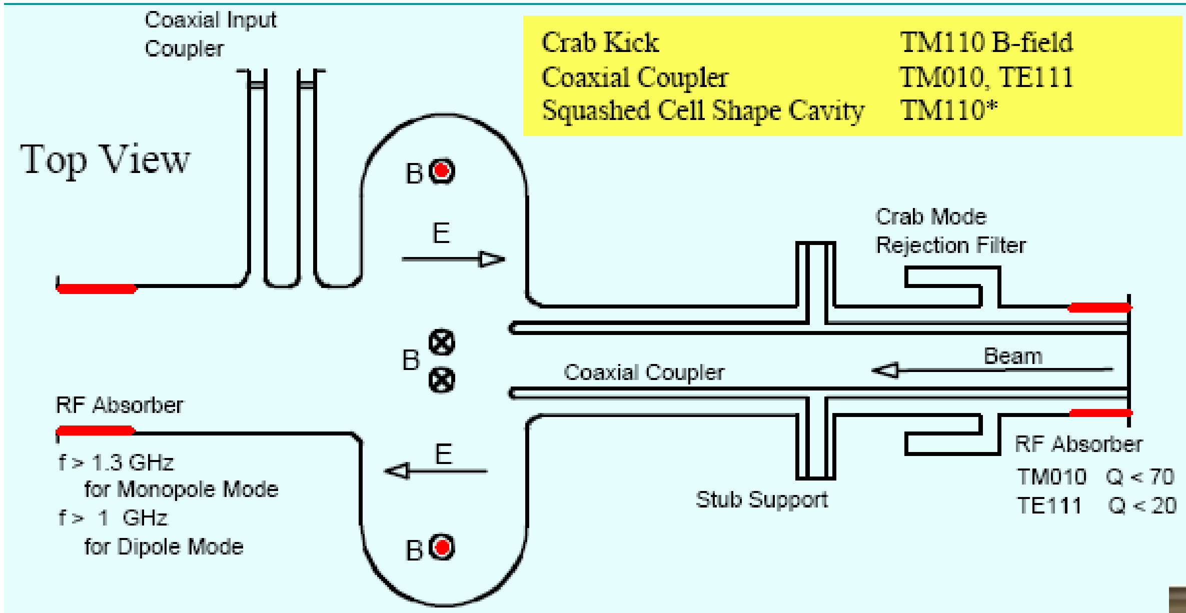


S-band

104 $\pi/2$ cells

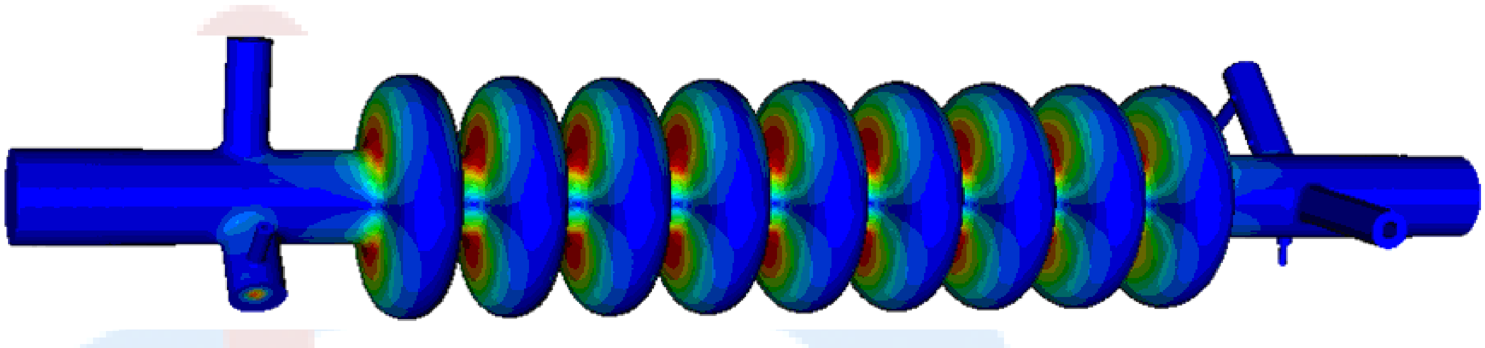
Kick= 2 MV/m

KEK-B Crab cavity



- More recently there has been a lot of attention paid to the KEKB crab cavities.
- These 508.9 MHz single cell Nb cavities operate at 1.44 MV and have special hollow coaxial dampers to deal with the monopole mode (LOM) of the cavity.

CKM / ILC Crab Cavity

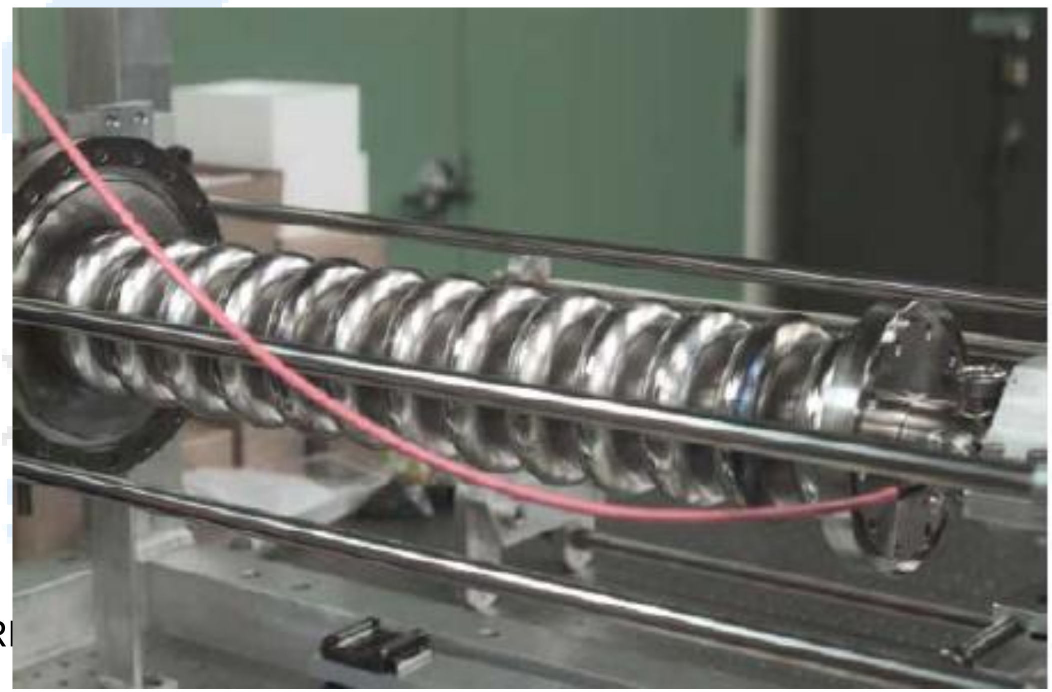


There is also interest in a 9 cell S-band cavity for the ILC.

This cavity is based on the FNAL 13-cell S-band CKM cavity.

A novel hook-type coupler is utilised for strong coupling to the lower order accelerating mode (LOM).

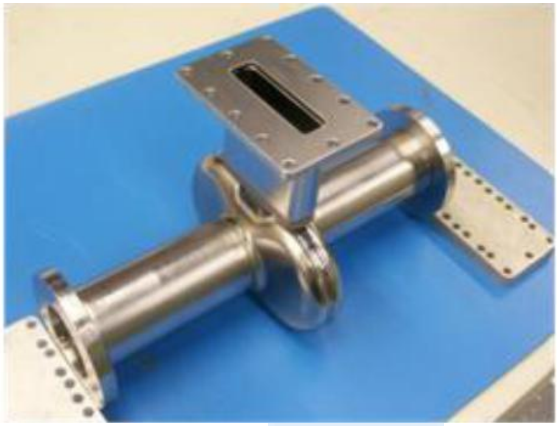
Designed to operate at 5 MV/m deflecting voltage and 73 mT B_{peak}.



New Shapes - Damping

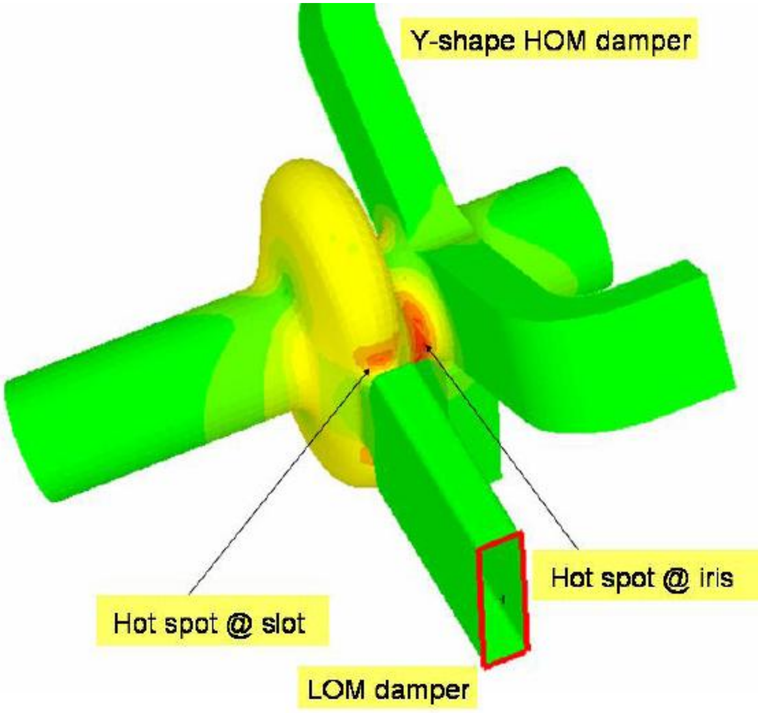
- The lower order and same order modes of the crab cavities often couple strongly to the beam.
- In addition they are difficult to damp as they are low frequency modes and the SOM is close to the operating mode.
- This requires novel coupling schemes to damp these modes.

On-Cell damping



On-cell damping involves coupling directly into the cavity cell as opposed to the beam-pipe as is common in most elliptical cavities.

- This is not possible for accelerating modes due to the high surface currents but in crab cavities the fields and currents are zero perpendicular to the mode polarisation.
- Jlab have constructed a single cell Nb prototype of the ANL crab cavity with an on-cell waveguide damper.



LANCASTER UNIVERSITY
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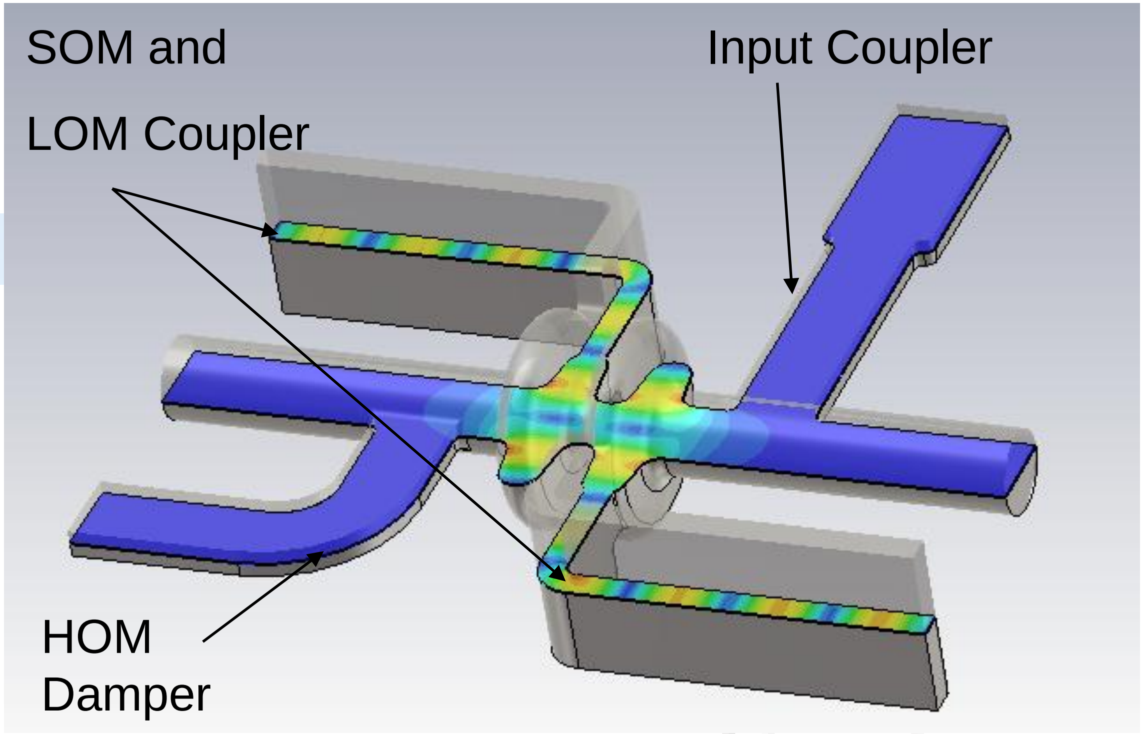
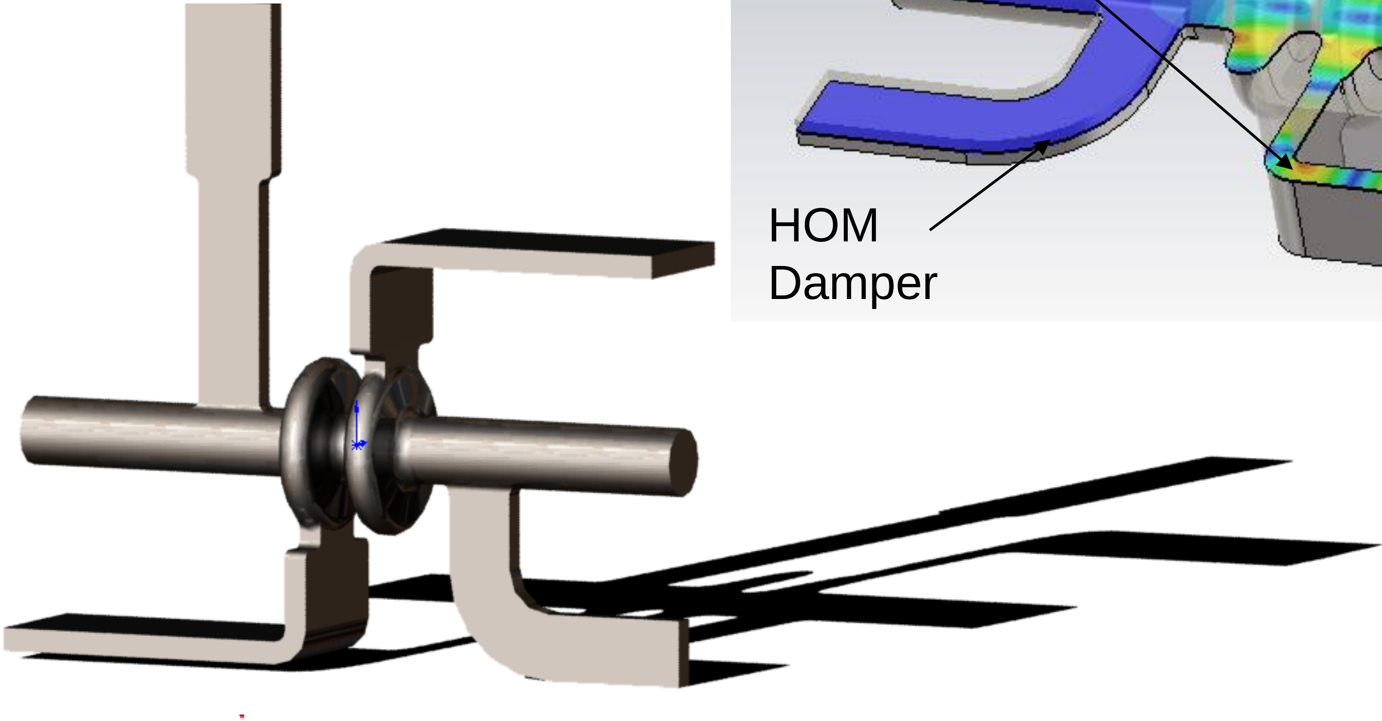
On-Cell Damping LHC

A 2-cell on-cell damped cavity is proposed by Cockcroft, Jlab and Tech-X for the LHC global scheme. Each cell as an on-cell waveguide which damps the SOM and the LOM to Q's below 100.



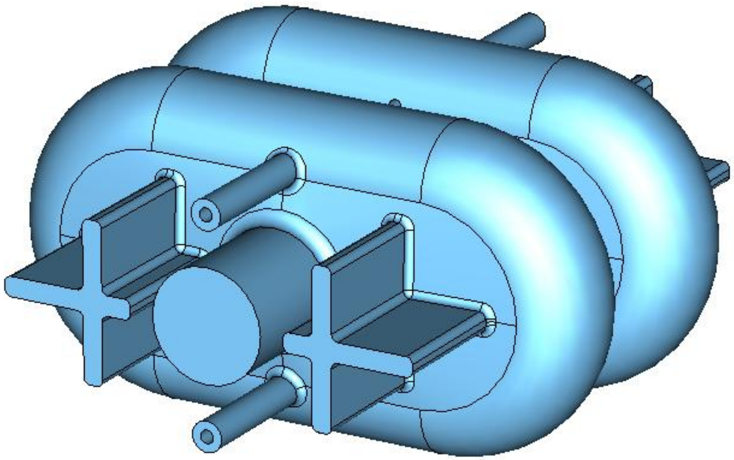


At 6.6 MV/m

B_{peak}=69 mT

E_{peak}=28 MV/m

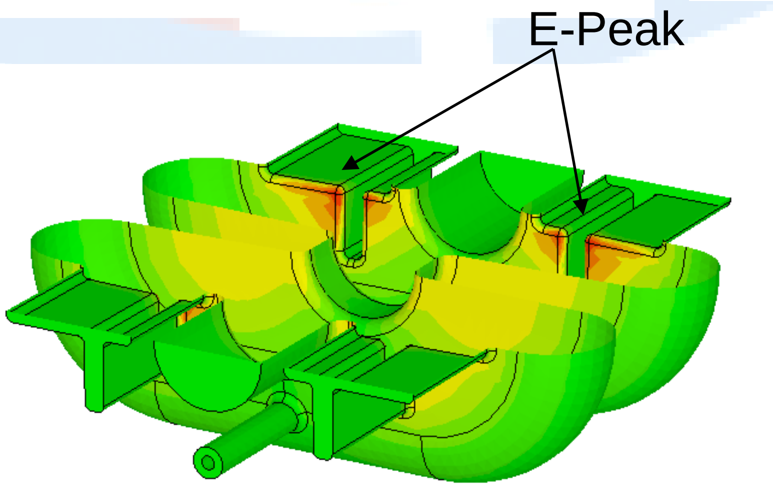
On-Cell Damping SKEK-B (LHC)



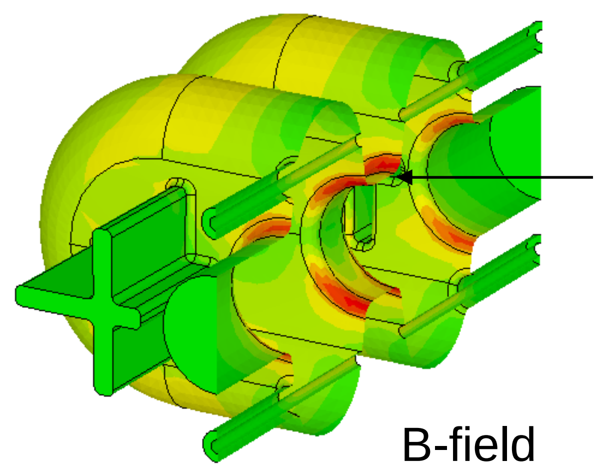
KEK have proposed a coaxial on-cell LOM damper for SuperKEKB and also for the LHC.

The inner conductor of the coax stretches across the cavity for maximum LOM damping.

This design also has on-cell waveguide damping for the SOM and HOMs.



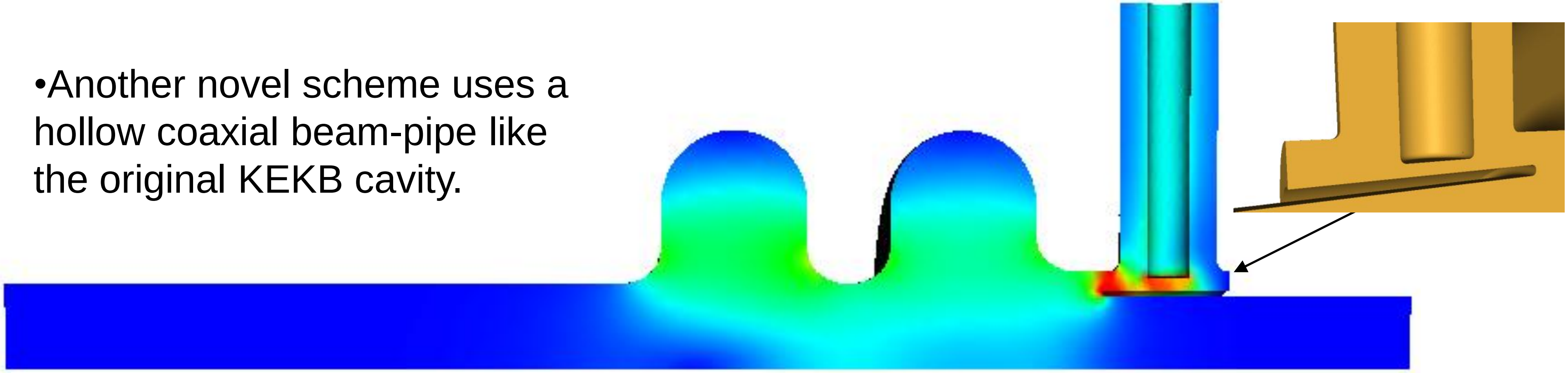
E-field



B-field

SLAC Coax-Coax damping

•Another novel scheme uses a hollow coaxial beam-pipe like the original KEKB cavity.

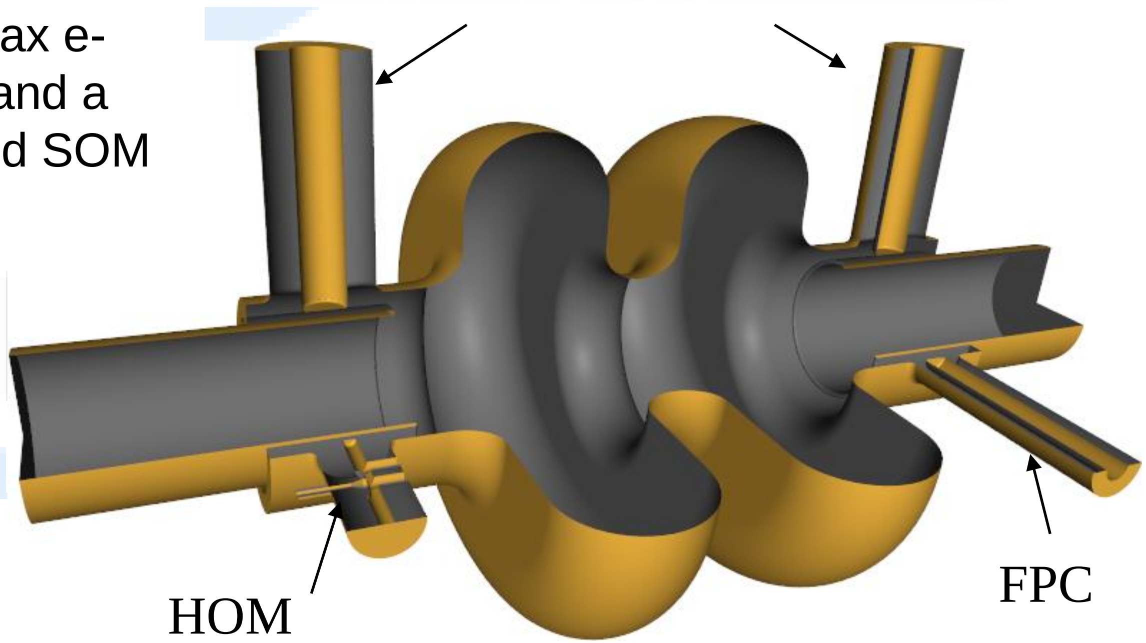


•However this design has the coax e-beam welded to the beam-pipe and a 2nd coax to remove the LOM and SOM to achieve Q's of around 250.

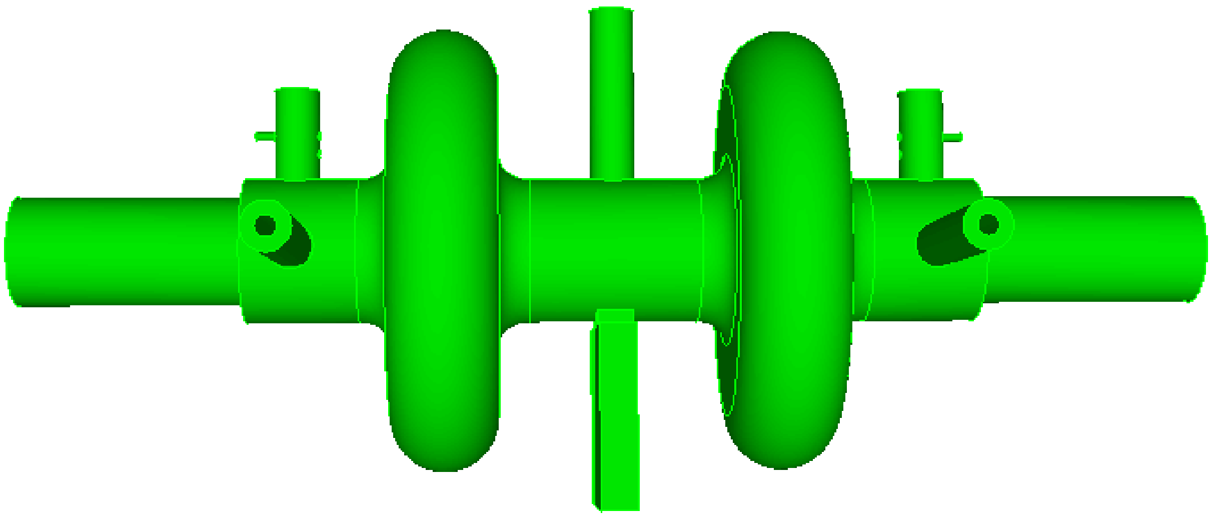
At 6.7 MV/m

B_{peak}=83 mT

E_{peak}=25 MV/m

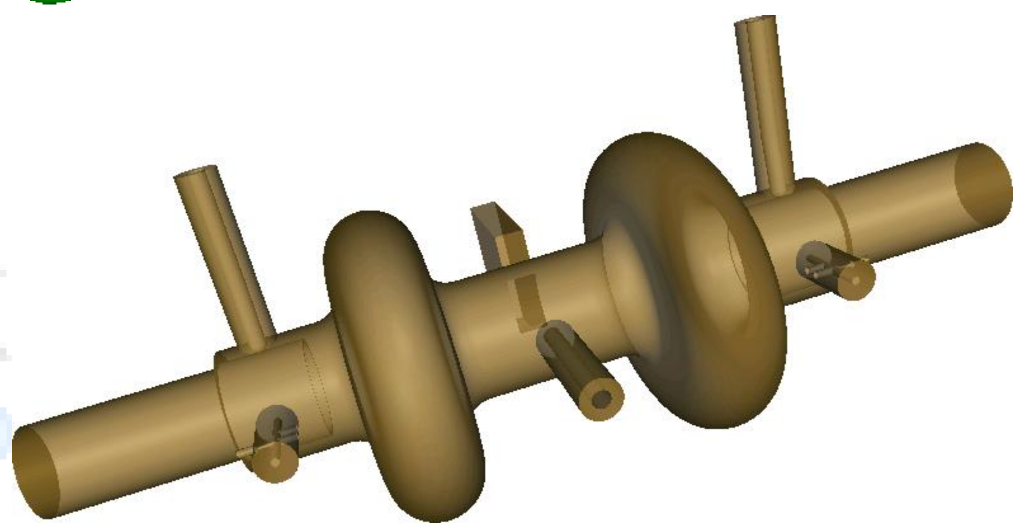


Alternative Coax-Coax Design

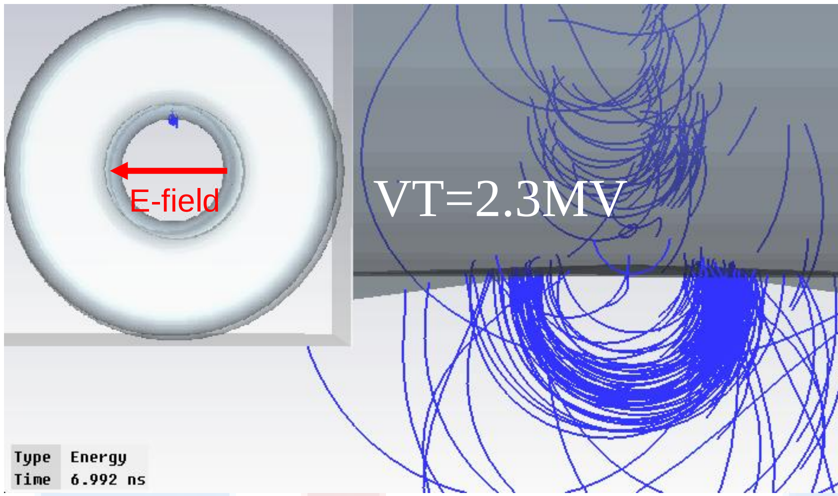


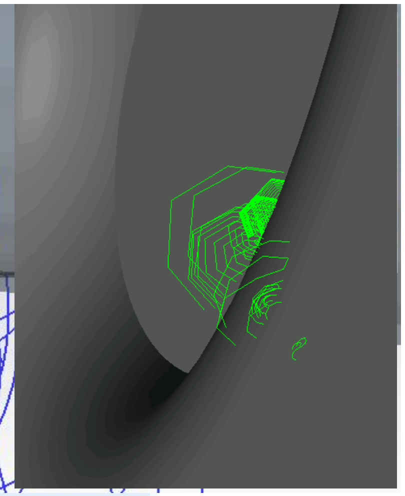
An alternative of this design also from SLAC uses a half wave separation between the cells.

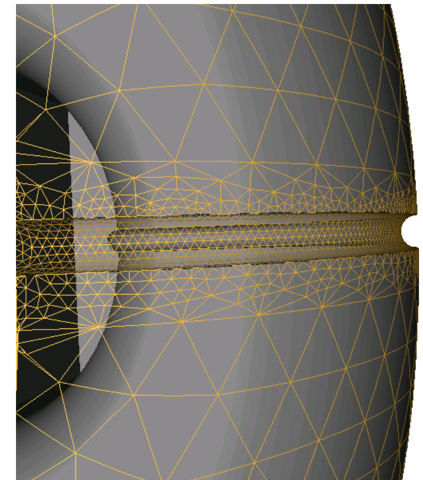
This allows the addition of a damper to couple to the pi crabbing mode without coupling to the 0 crabbing mode (operating).



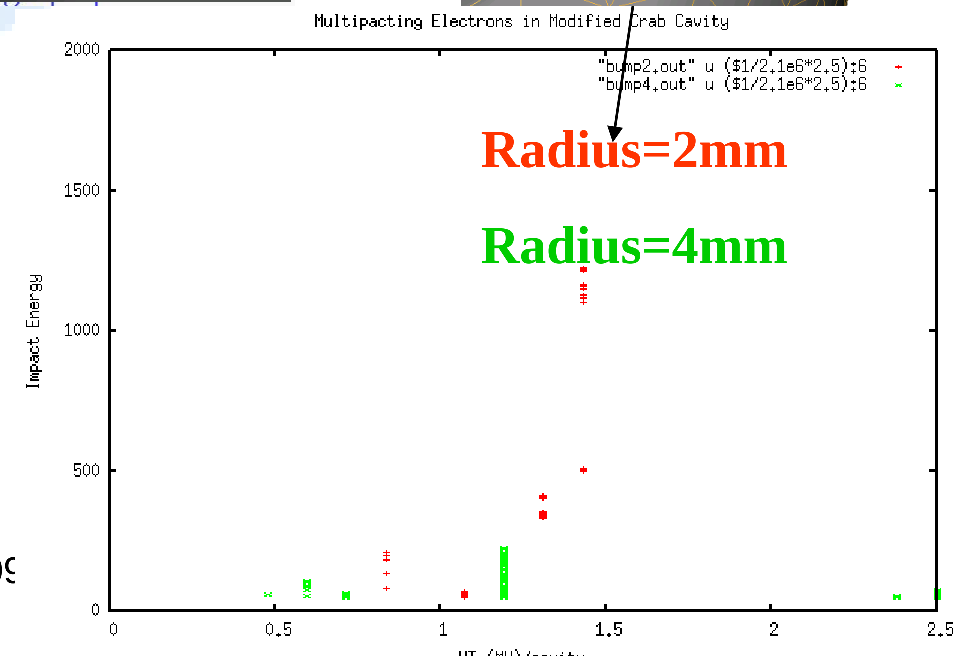
Multipacting







- CST simulations show the cavities always multipact when the B field on the iris is 57 mT for 800 MHz cavities.
- This is exactly half the cyclotron frequency.
- SLAC have also proposed putting a groove in the iris to suppress multipactor.

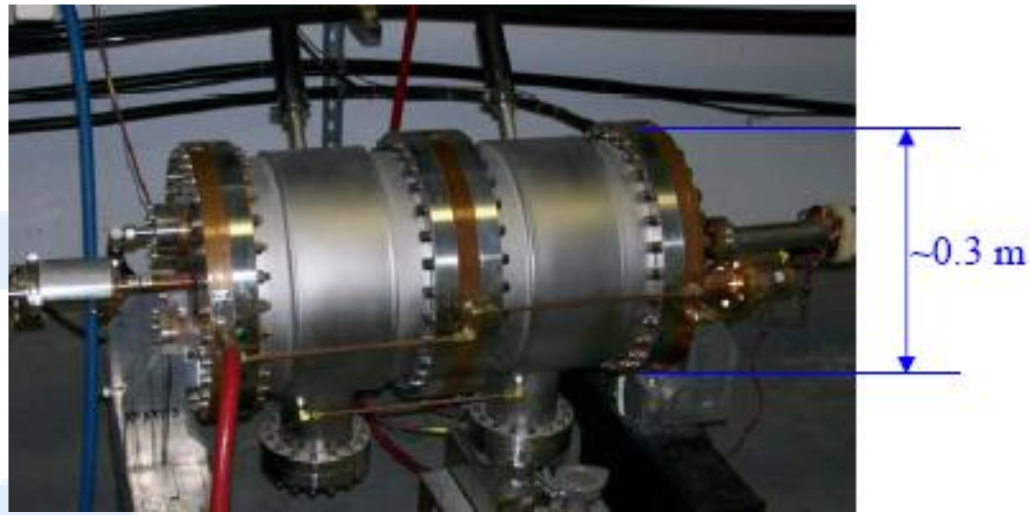


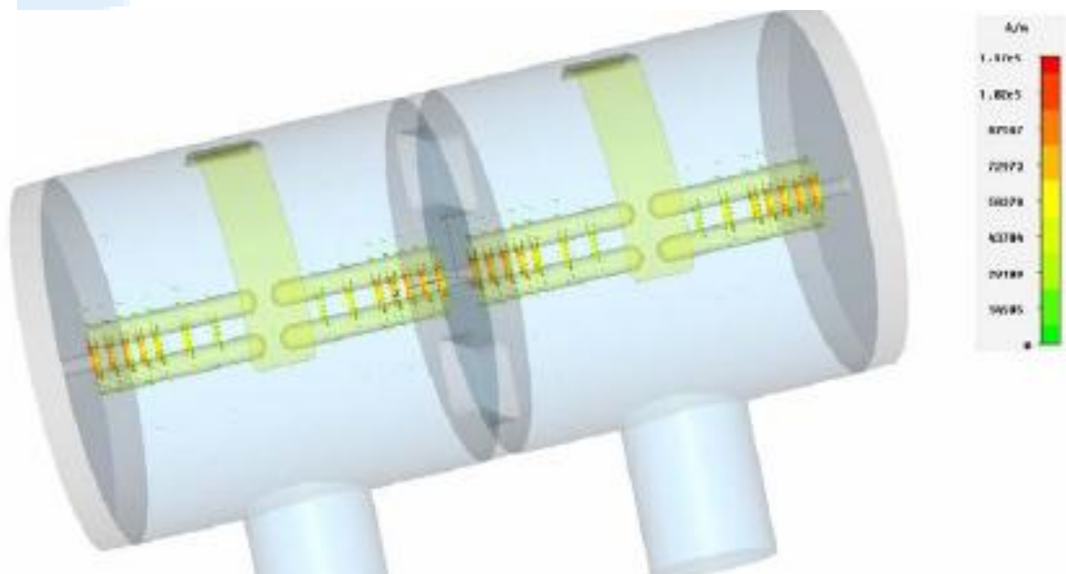
New Shapes - Compact Cavities

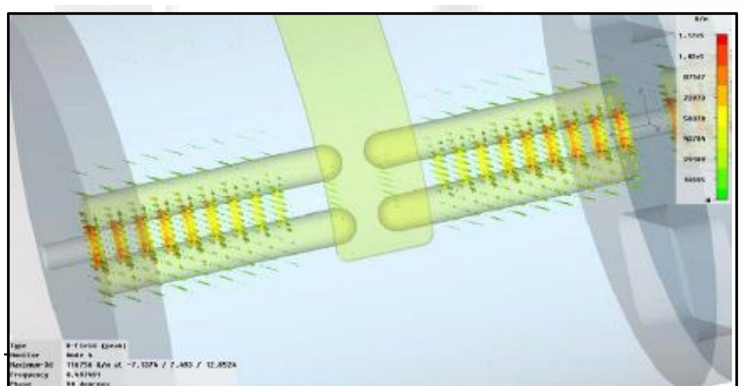
- Many crab cavities operate in areas where space is limited such as the IP of a collider.
- As crab cavities or often larger than accelerating cavities this poses a problem.

CEBAF Cavity

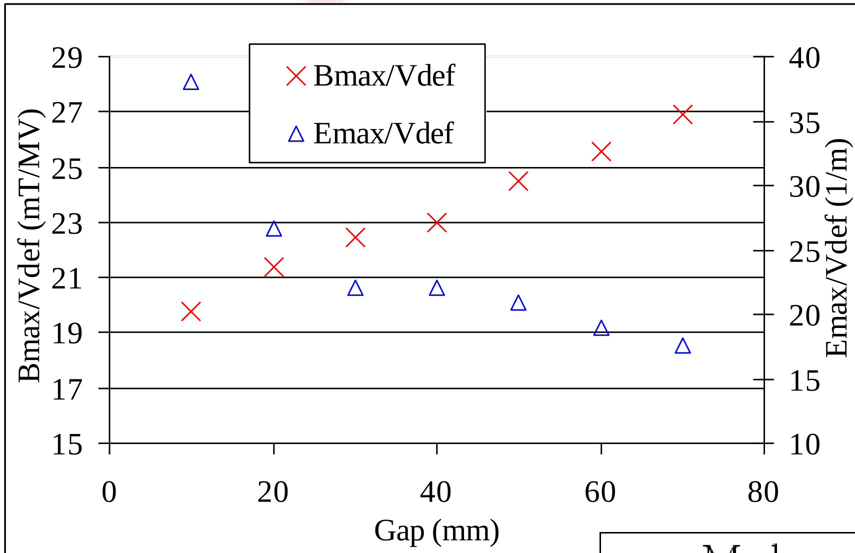
- CEBAF currently uses a compact normal conducting separator.
- It operates using the TEM mode of four parallel rods (two sets of two co-linear rods).
- To provide the transverse deflection a capacitive gap is placed between the two co-linear rods

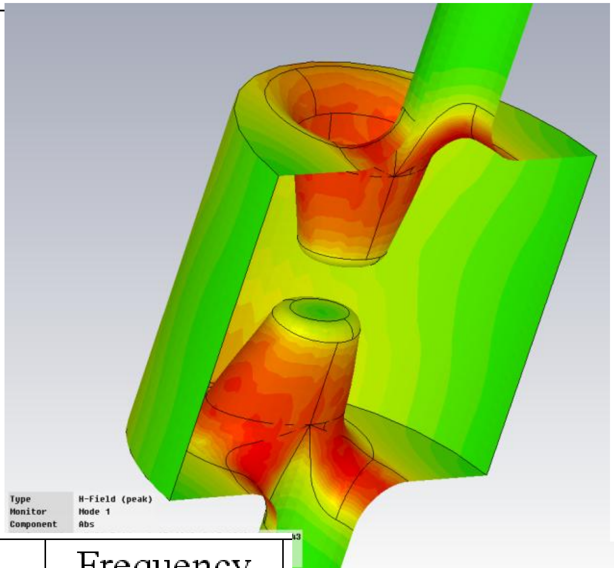




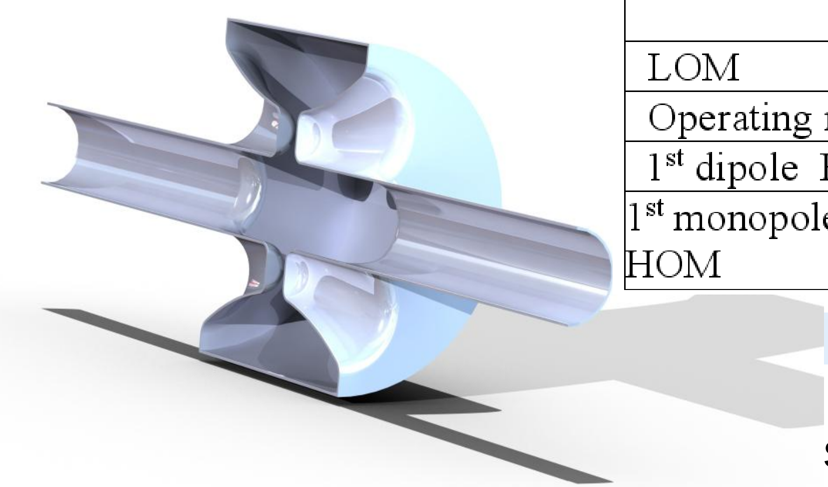


Four Rod Parallel Bar Cavity





A SRF version of the CEBAF cavity is being pursued. This design will require significantly thicker con-cal rods to reduce microphonics.



Mode	Frequency (GHz)
LOM	0.3356
Operating mode	0.4000
1st dipole HOM	0.4866
1st monopole HOM	0.5178

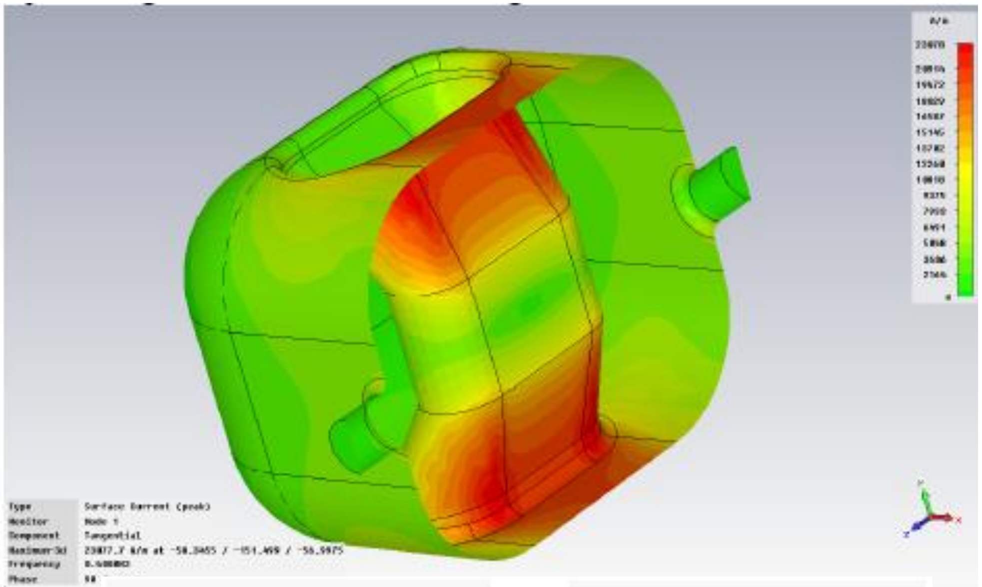
The low fields on the outer can allows couplers to be added easily and a low RRR Nb can be used for the outer can with high RRR for the rods.

At 3 MV we achieve

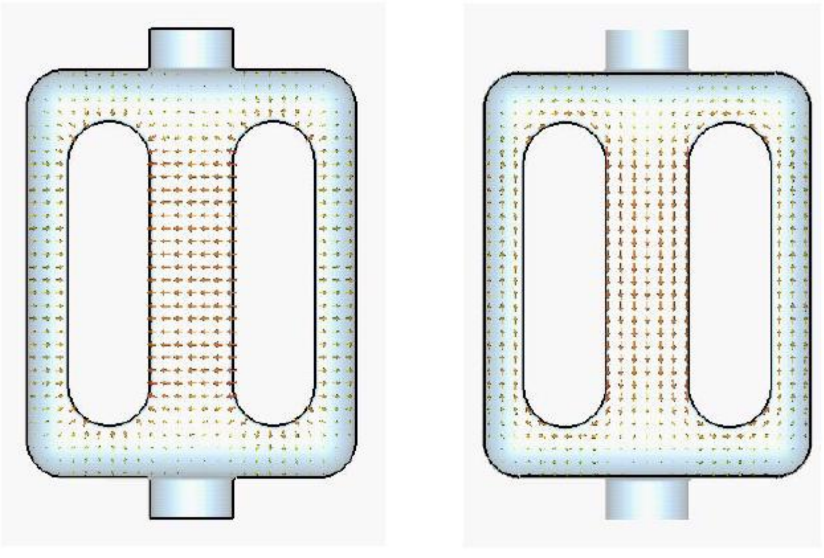
E_{peak}=40 MV/m

B_{peak}=53 mT

Parallel bar cavity (THPPO023)

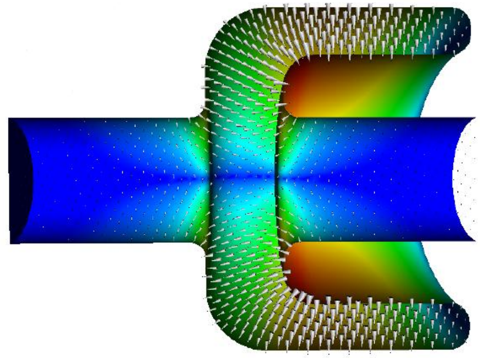


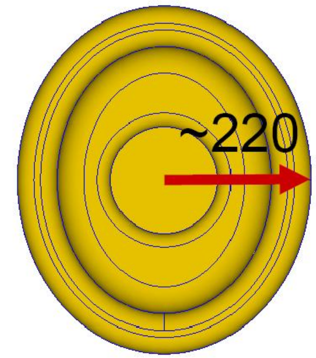
- Another variant of the CEBAF cavity is the Parallel bar cavity.
- This design doesn't need the capacitive gap as the beam travels perpendicular to the rods.
- This means that the peak surface currents is not near the beam-pipes significantly reducing surface fields (22.8 MV/m and 59.4 mT at 10 MV/m kick).



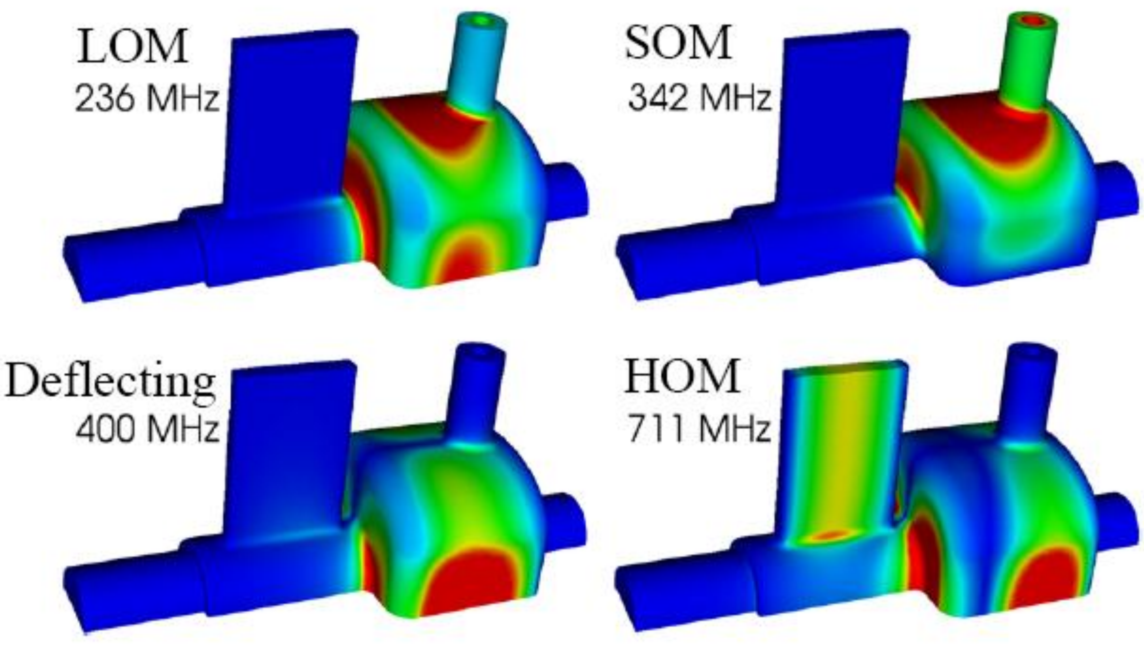
SLAC/BNL Half Wave Resonator

- Coaxial lines have a much lower cut-off for dipole modes.
- This means a coaxial crab cavities can be much smaller than pillbox crab cavities.





Deflecting voltage per cavity	1.5 MV
Peak surface magnetic field	89 mT
Peak surface electric field	42 MV/m

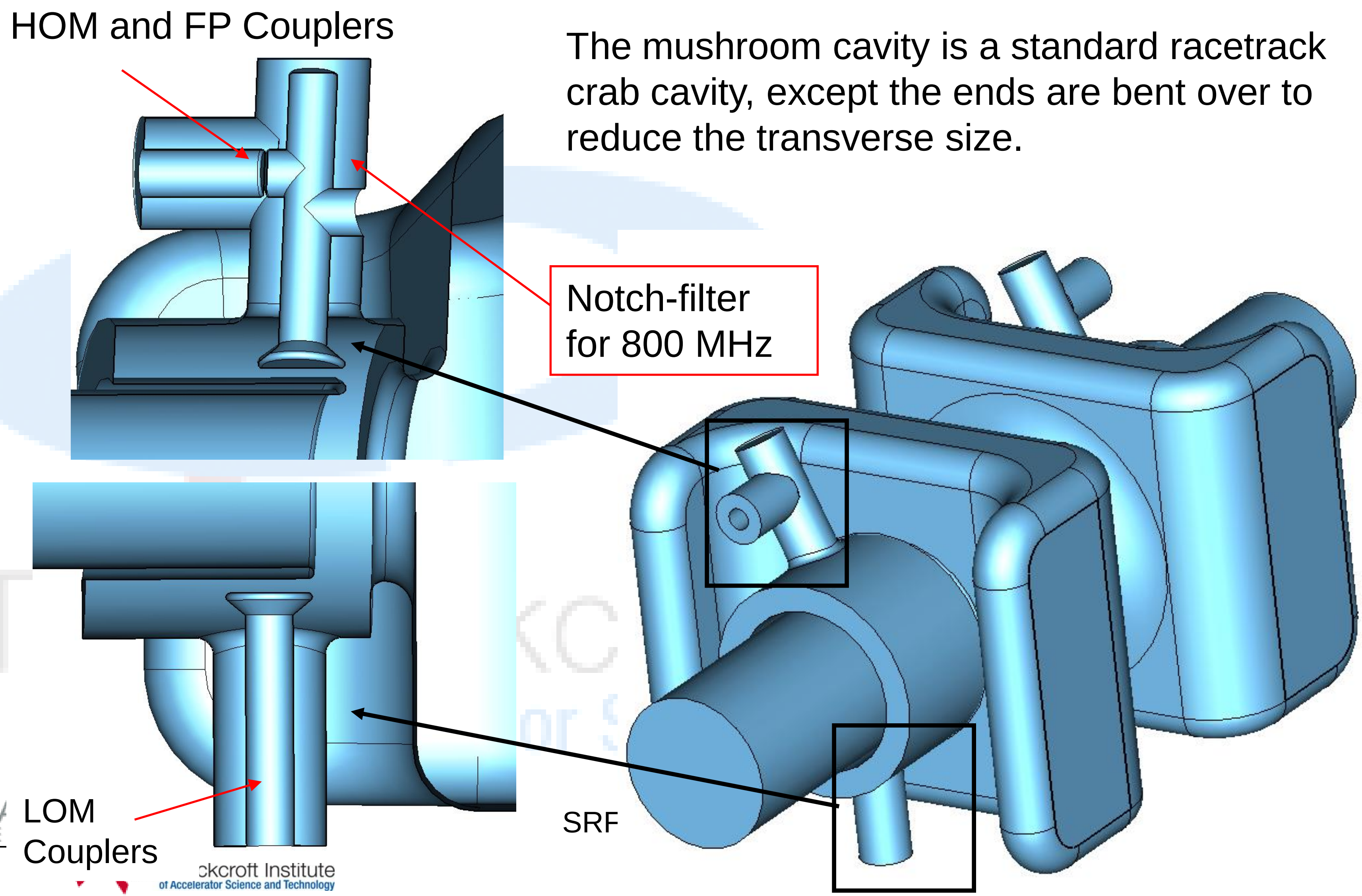


The small gap and single cell design means 3-4 cavities are required per beam for the LHC.

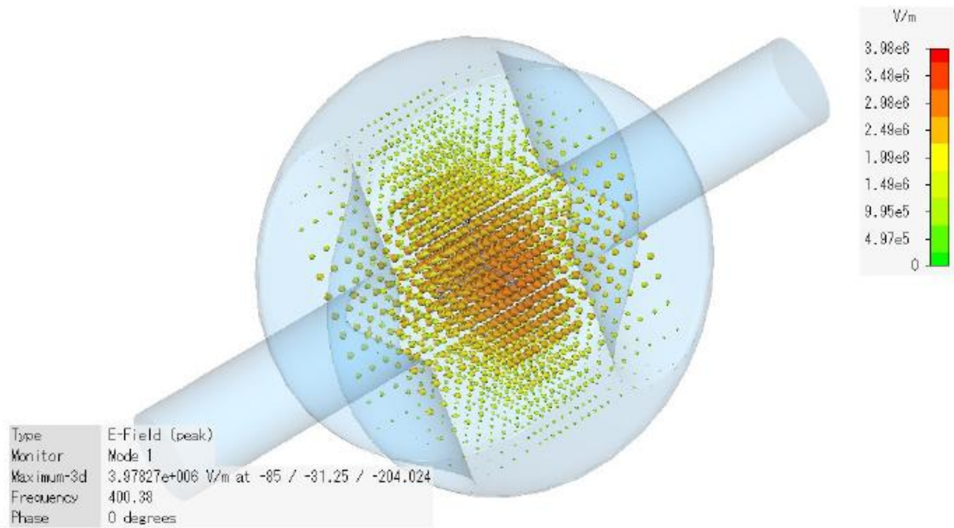
A beam-pipe coax-to-waveguide damper is used for HOM damping, and an on-cell coax for the LOM and SOM.

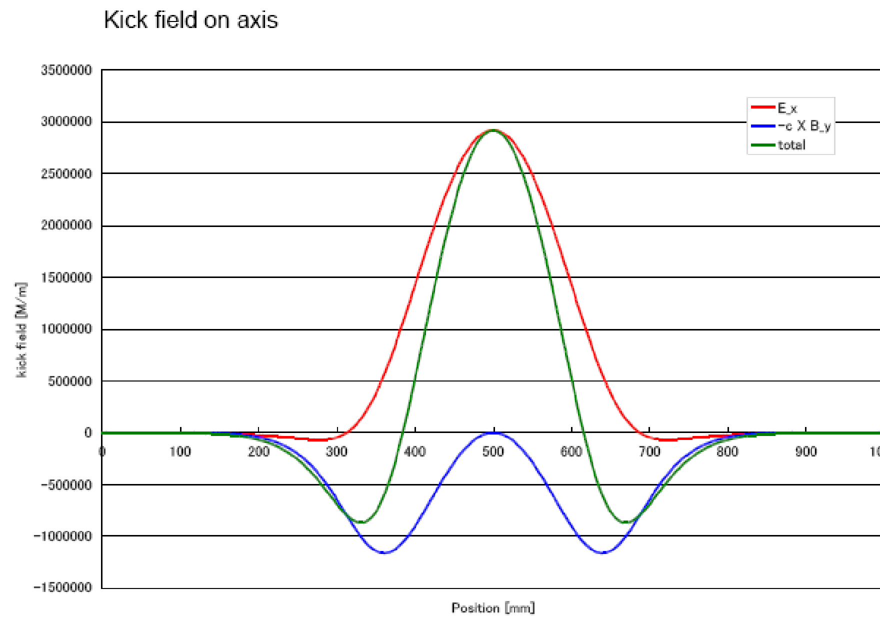
FNAL Mushroom Cavity

The mushroom cavity is a standard racetrack crab cavity, except the ends are bent over to reduce the transverse size.

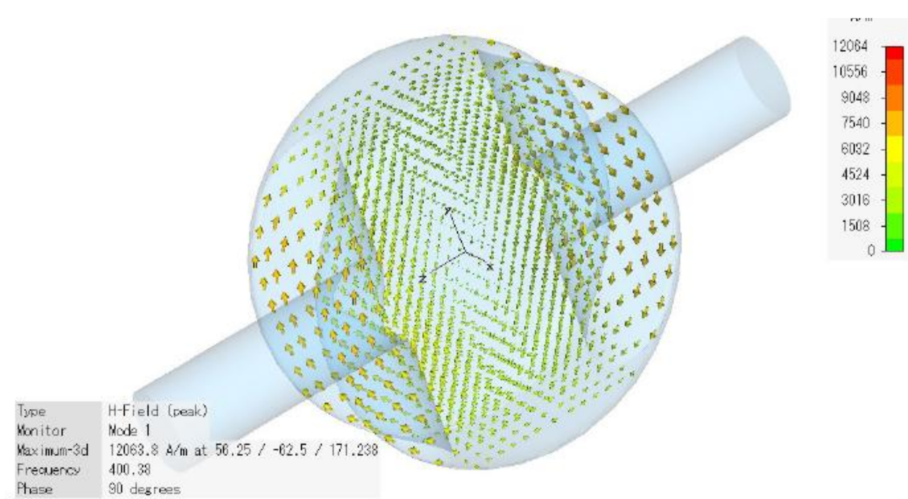


KEK Kota Cavity

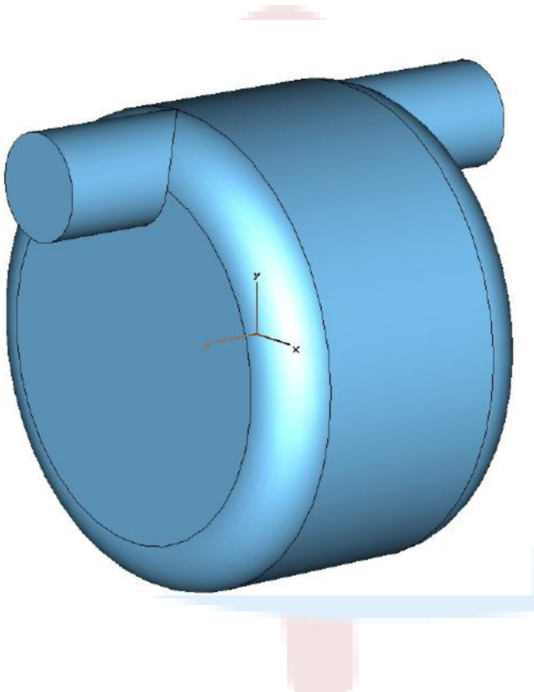


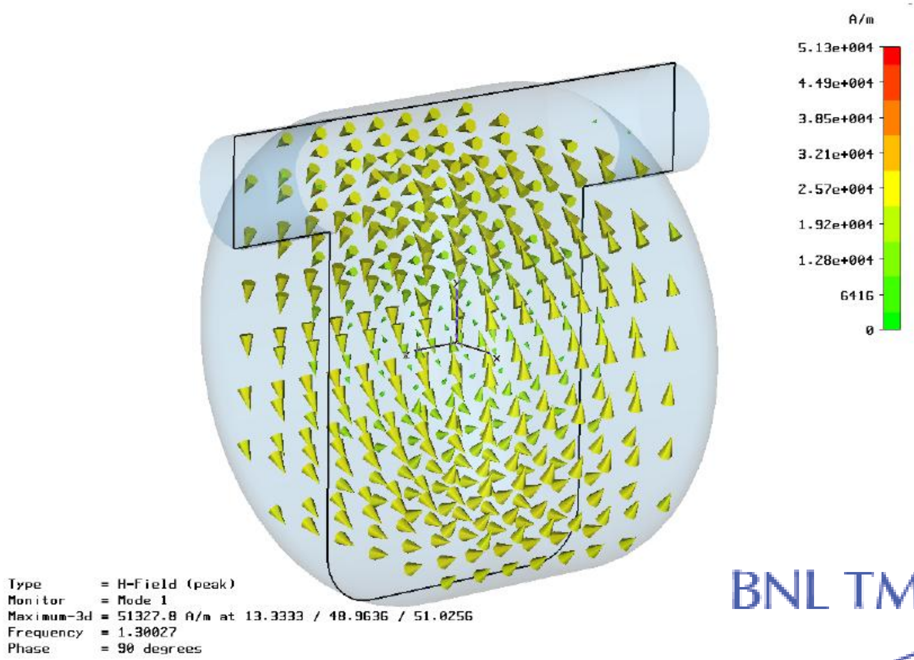


- The KEK Kota cavity is a novel twist on this concept by having the beam travel transversely.
- Normally the E and B field cancel each other out but by using special nose-cones the B field can be shielded.
- For 1.13 MV kick the surface magnetic field is 84.3 mT.

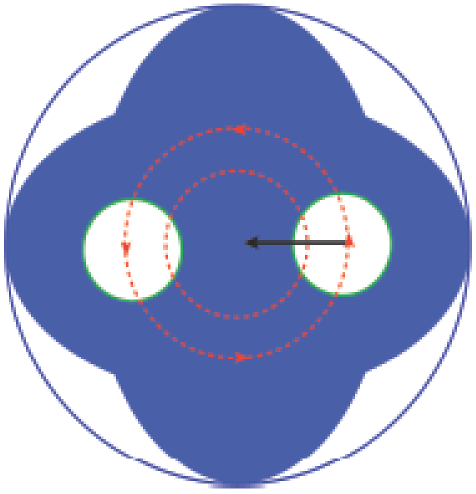


Monopole Cavity





BNL TM010, BP Offset



- Originally proposed in 2005 by CI for ILC, this design uses a conventionally accelerating cavity for crabbing.
- These cavities are much smaller than deflecting cavities.
- BNL proposed that a similar scheme could be used for LHC with both beams sharing a cavity.

Conclusions

- There are a number of novel cavity concepts for utilisation as crab cavities in accelerators. The designs primarily address the concerns of LOM and SOM damping or cavity transverse size.
- The new damping shapes all use either couplers attached directly to the cavity or the use of hollow coaxial beam-pipes. Both of these design concepts bring with them problems in cavity manufacturing and processing which will require further investigation. ANL have constructed a single cell prototype of the on-cell damper which may address some of these issues.
- The compact designs are based on TEM mode cavities, folded waveguide or monopole type cavities. These designs are all novel but much can be adapted from the construction of low-beta cavities.
- The fact that each accelerator requires a very small numbers of these cavities, and that they are not completely essential components (a collider will still collide albeit at a lower luminosity) allows the designers to attempt brave new concepts that would not be considered for accelerating cavities.

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