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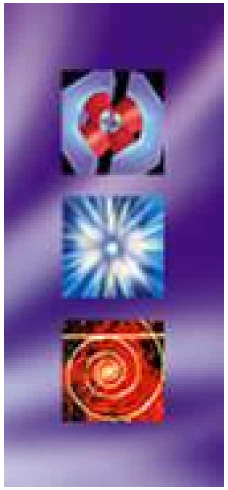
ASTeC

Design of a Crab cavity for the ILC

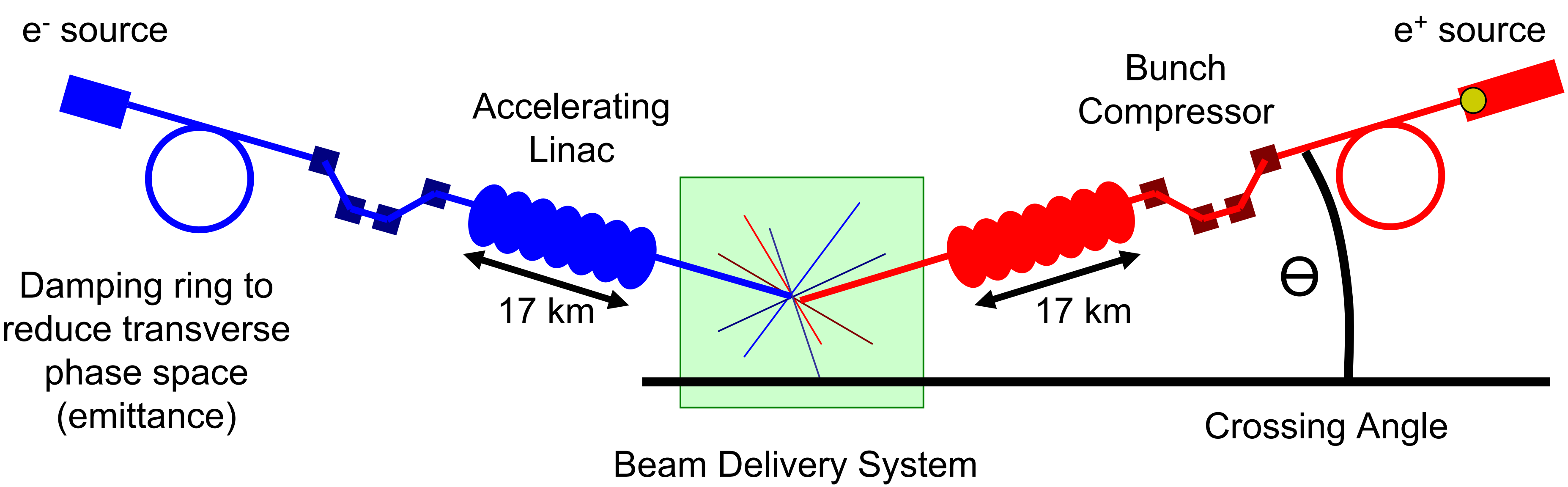
ILC-BDIR

21/06/2005



Graeme Burt – Lancaster University
Philippe Goudket – ASTeC
Carl Beard – ASTeC
Alexander Kalinin – ASTeC
Amos Dexter – Lancaster University

What is a crab cavity?

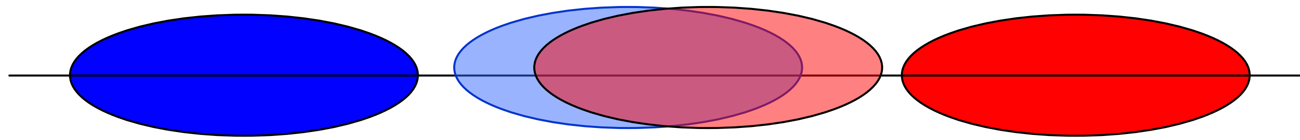


Crossing angle is introduced to aid beam extraction

What is a crab cavity?

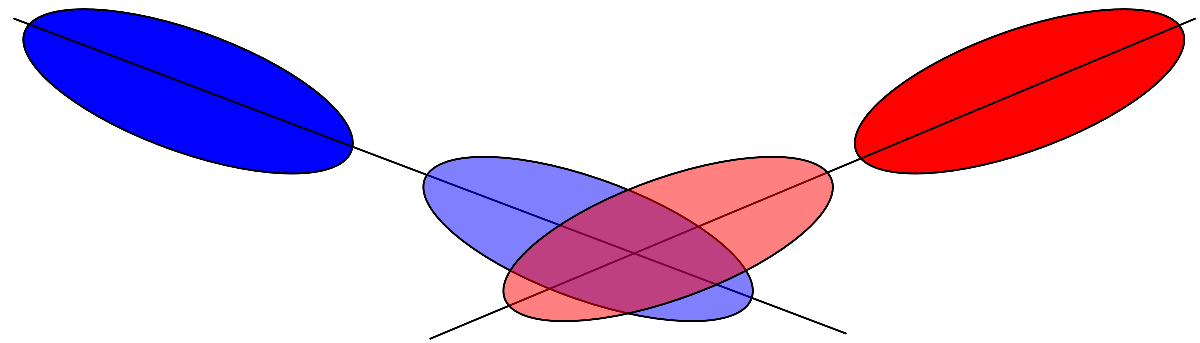
Head-on collision

Maximum luminosity



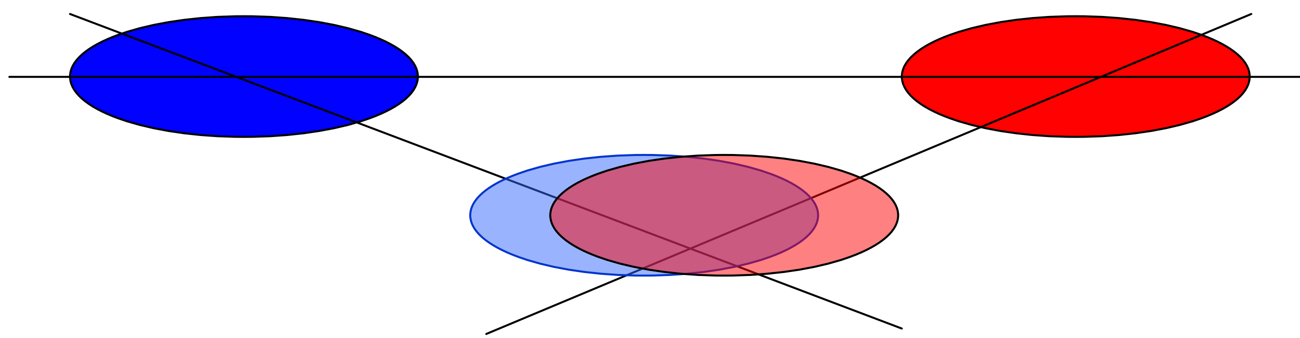
Crossing angle introduced

Reduced luminosity due to crossing angle



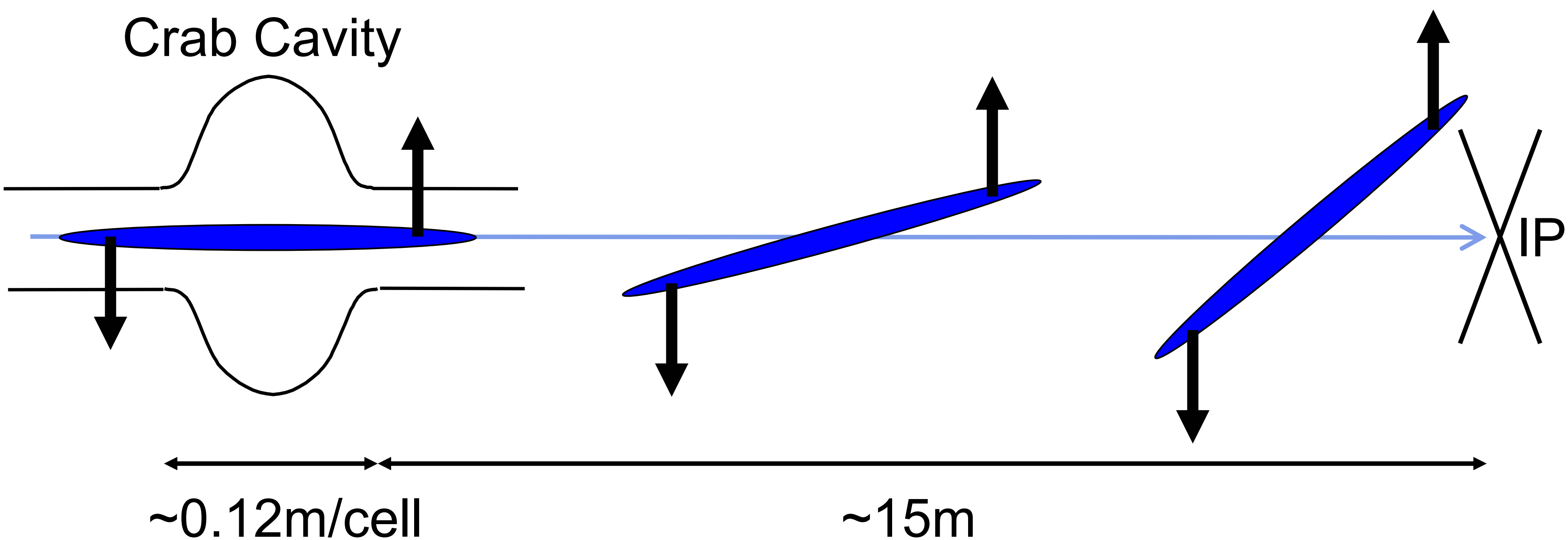
Crossing angle with crab rotation

Effective head-on collision

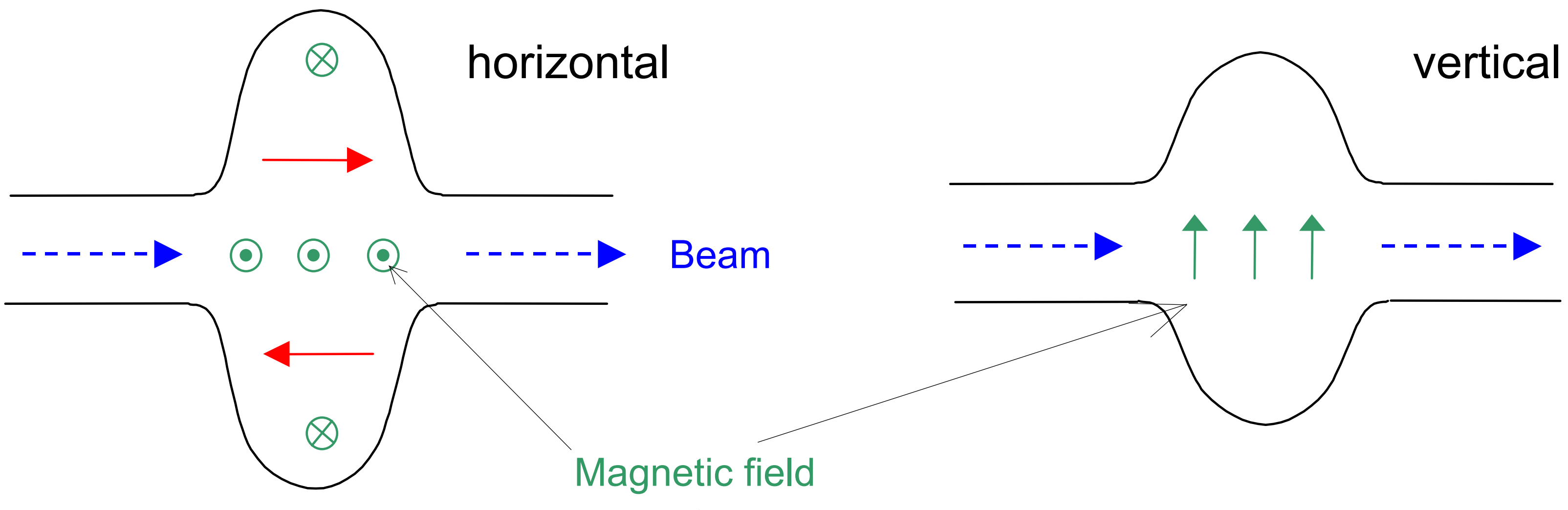


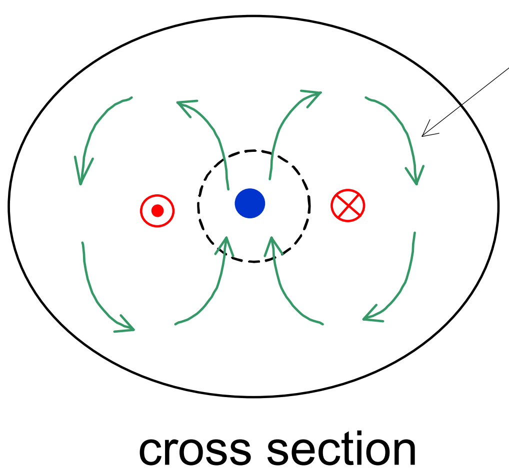
What is a crab cavity?

- The crab cavity imparts a transverse momentum to the bunch.
- The bunch continues to rotate outside the cavity.



Why is a crab cavity different from an accelerating cavity?





- Use of the magnetic field of a TM_{110} horizontal dipole mode
- The field gives a phase-dependant transverse momentum kick to the beam

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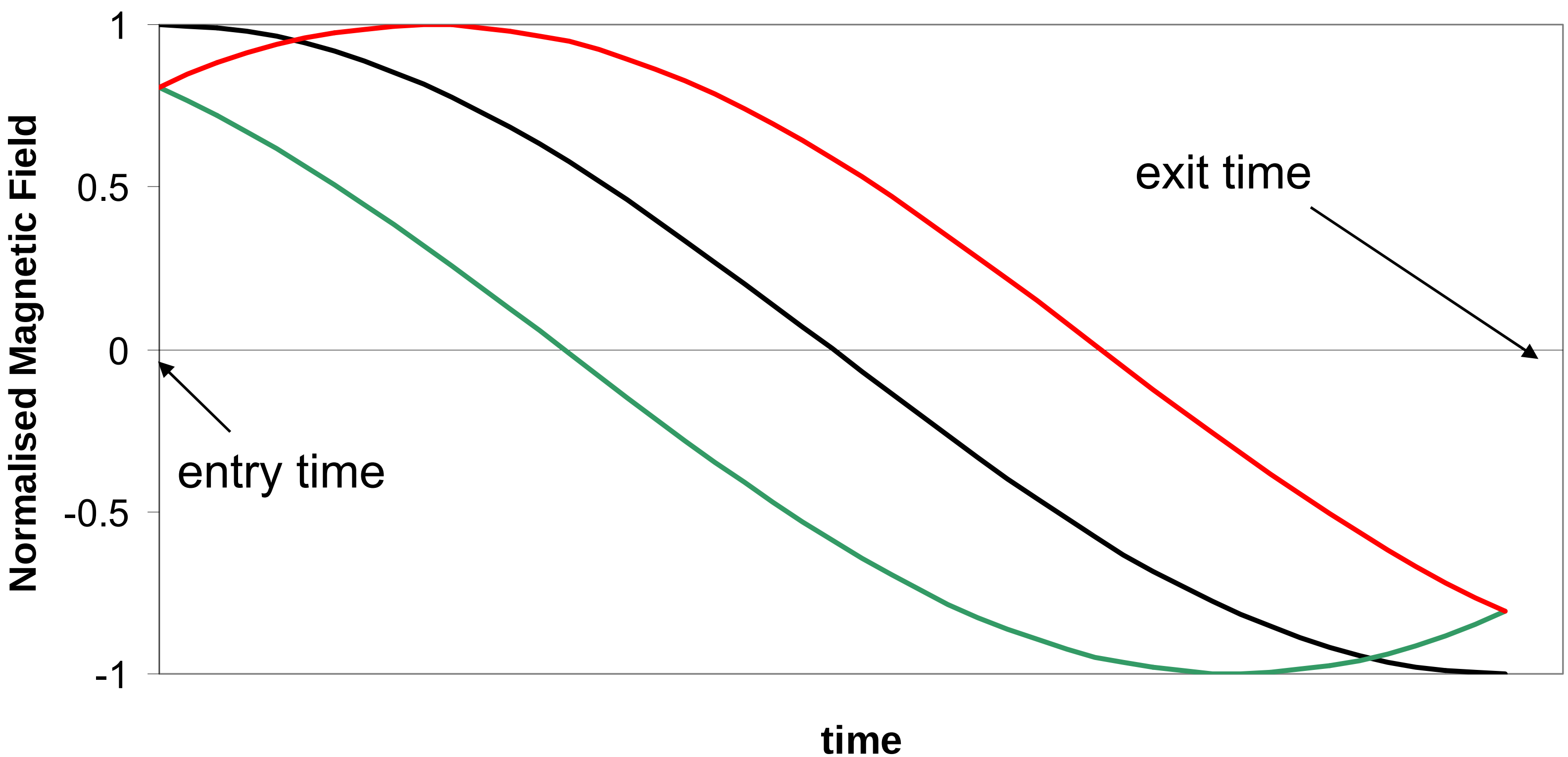
Why is a crab cavity different from an accelerating cavity?

- Magnetic Field as seen by front, middle, and back of the bunch as a function of position across the cavity.
- *(At any instant the magnetic field is uniform across the cavity)*



SC Deflecting cavity development worldwide

- CERN/Karlsruhe SC deflecting cavity for separating the kaon beam 1970's, 2.86 GHz
- Cornell 1500 MHz crab cavity 1/3 scale models 1991
- KEK 500 MHz crab cavity with extreme polarization 1993 - Present
- Fermilab CKM deflecting cavity - 2000 - present
- CERN is again interested in crab cavities or LHC upgrades

What are the main problems?

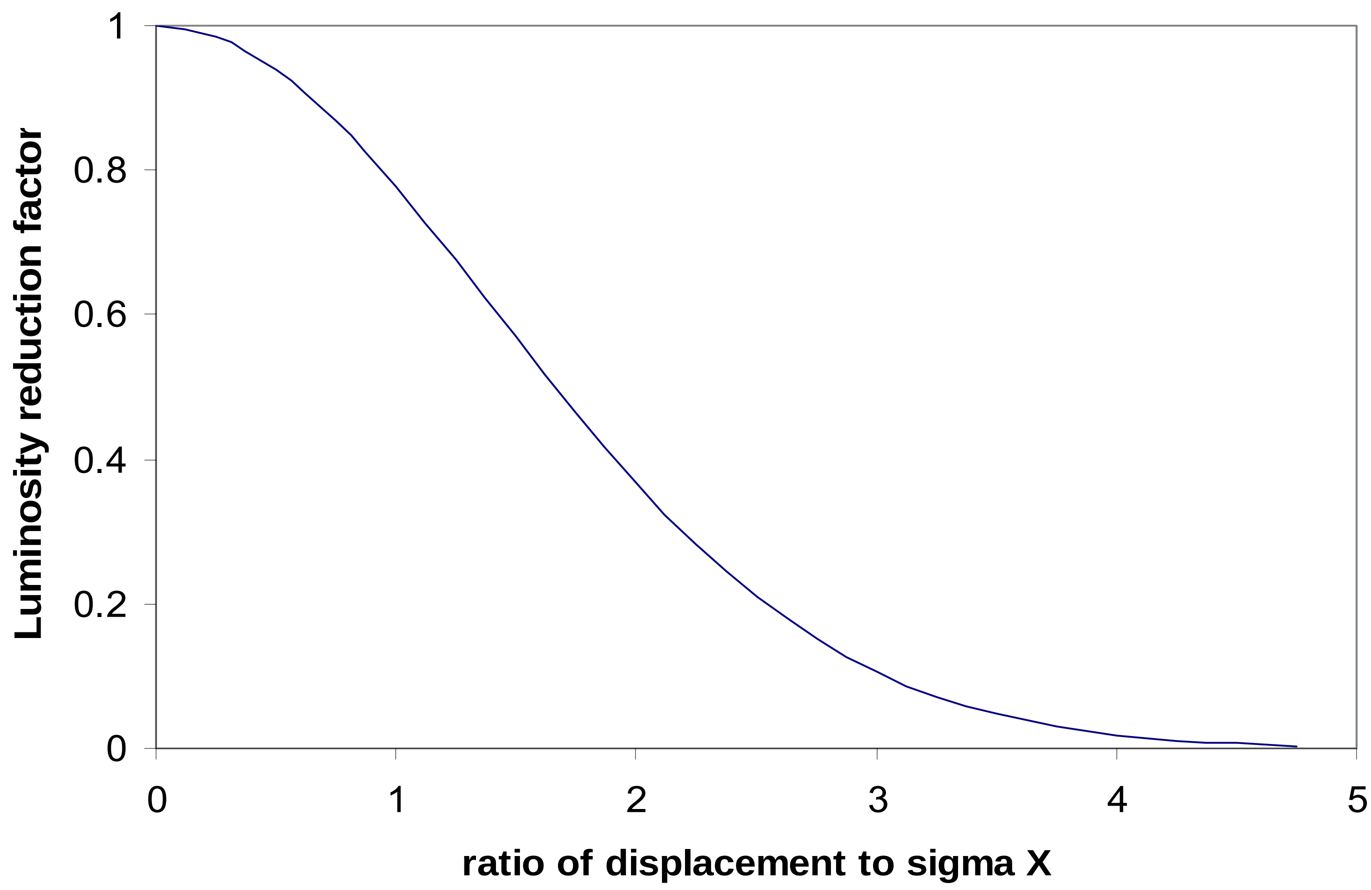
Transverse deflection is caused by :-

- Field asymmetry due to Microphonics
- Phase stability of dipole mode
- Deflection by other modes,
  - Higher order modes (HOM)
  - Lower order modes (LOM)
  - Same order modes (SOM)

See P. Goudket, Crab cavity considerations for the ILC, Wednesday 10:30

Tolerances to transverse deflection

Loss in luminosity due to transverse deflection



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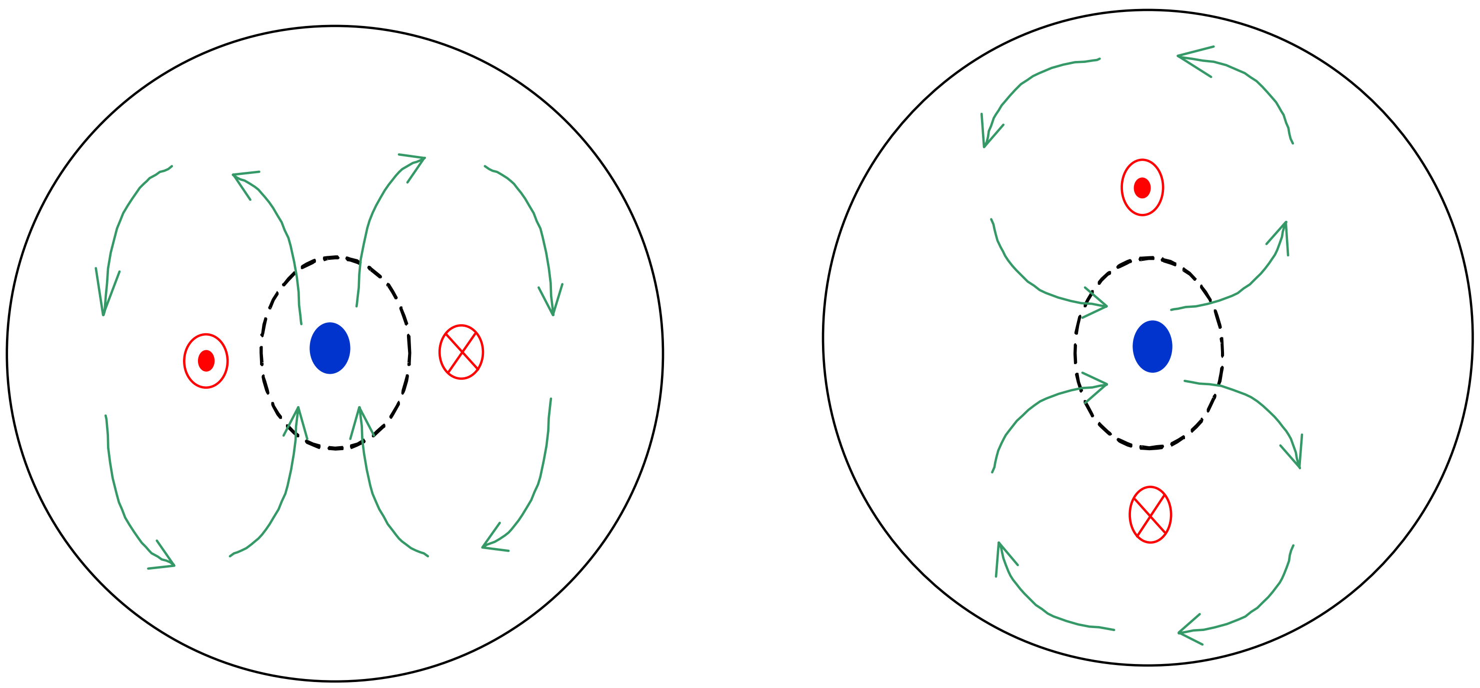
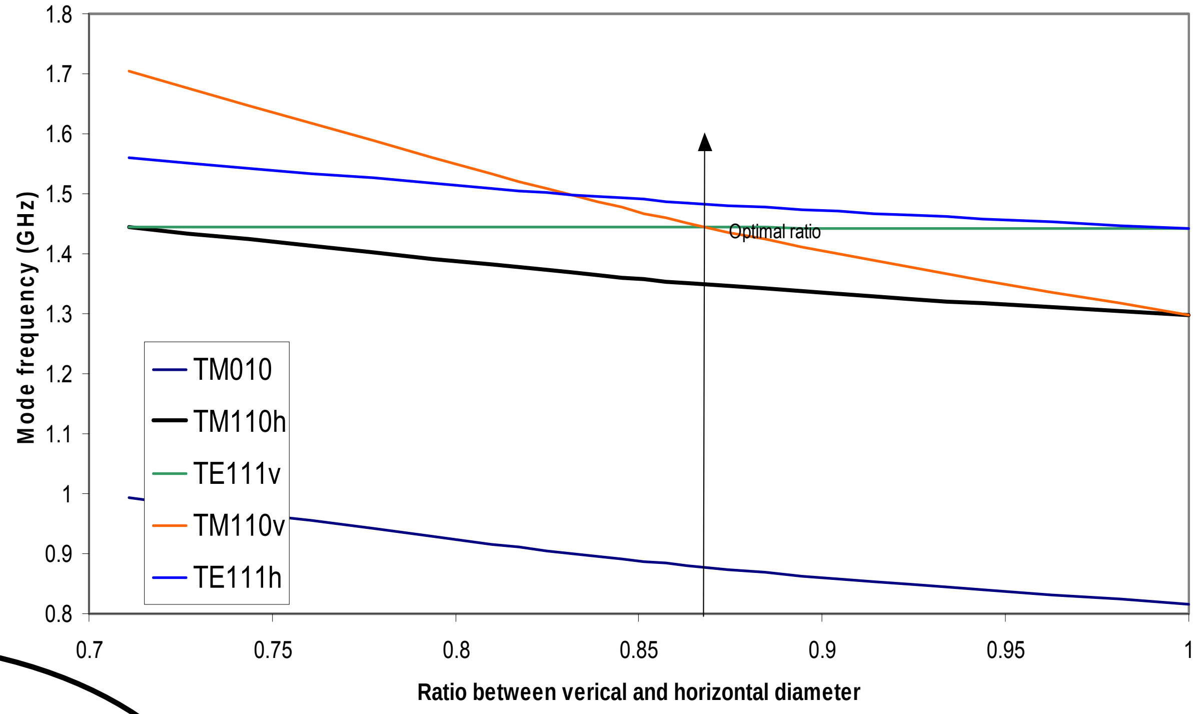
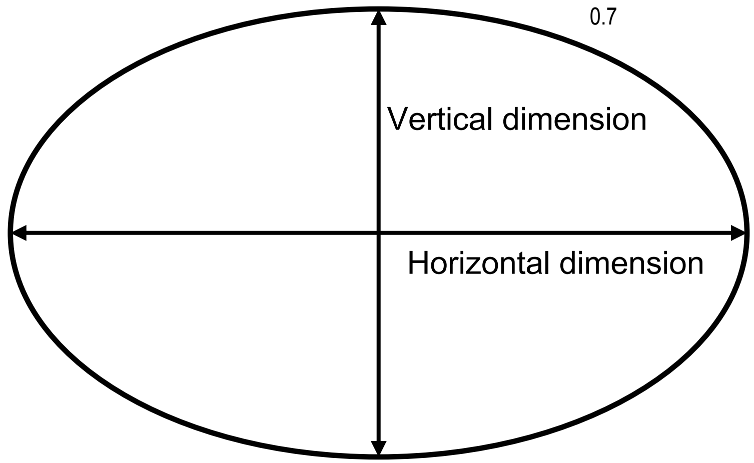
Same order modes



- Dipole mode has more than one polarisation
- These polarisations must be separated

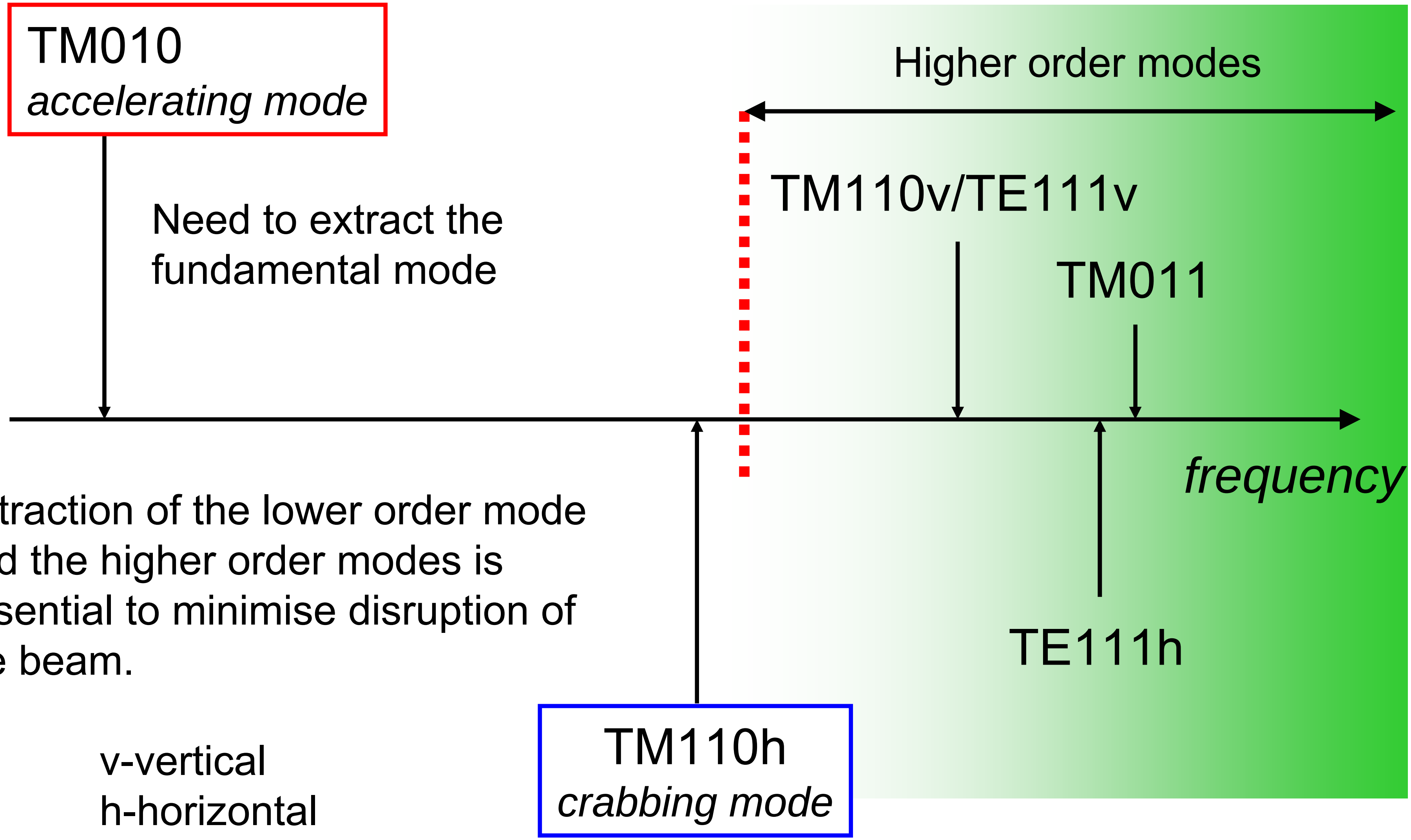
Elliptical cross section.





Each geometry has an optimal ratio between horizontal and vertical dimensions giving maximal separation between the TM_{110} mode and HOMs.

Order of modes in an elliptical cavity

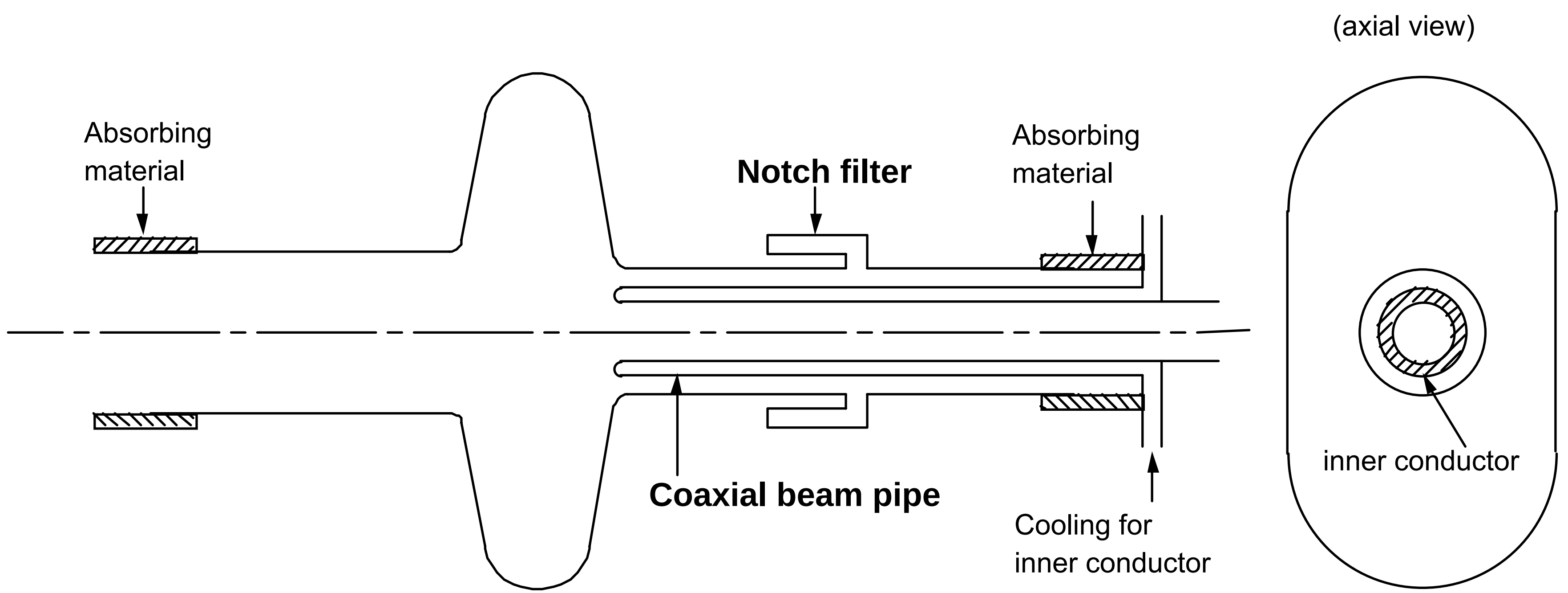


Need to extract the fundamental mode

Extraction of the lower order mode and the higher order modes is essential to minimise disruption of the beam.

v-vertical
h-horizontal

KEKB Coaxial beampipe coupler



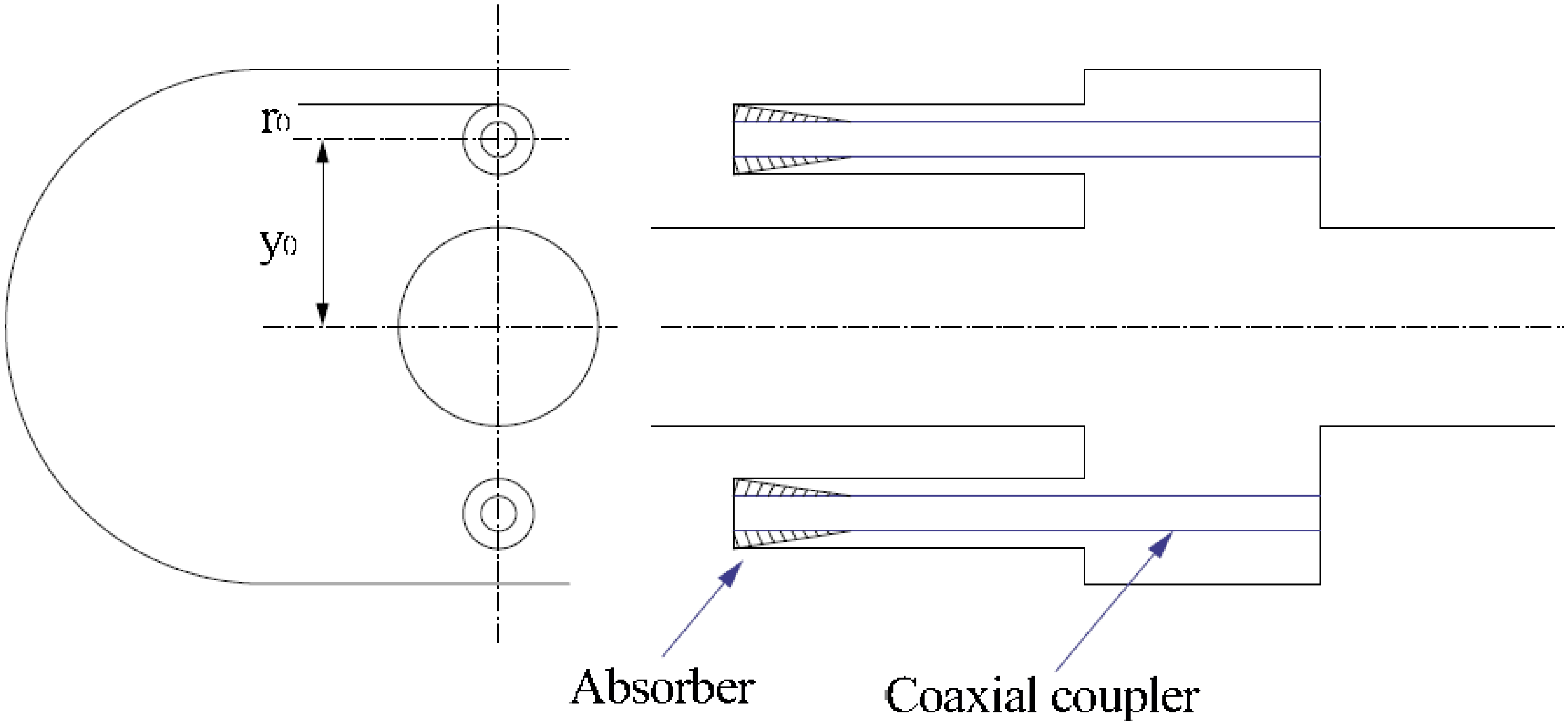
"Squashed cell"

Co-axial waveguide couples to monopole modes

Squashed Crab cavity for B-factories

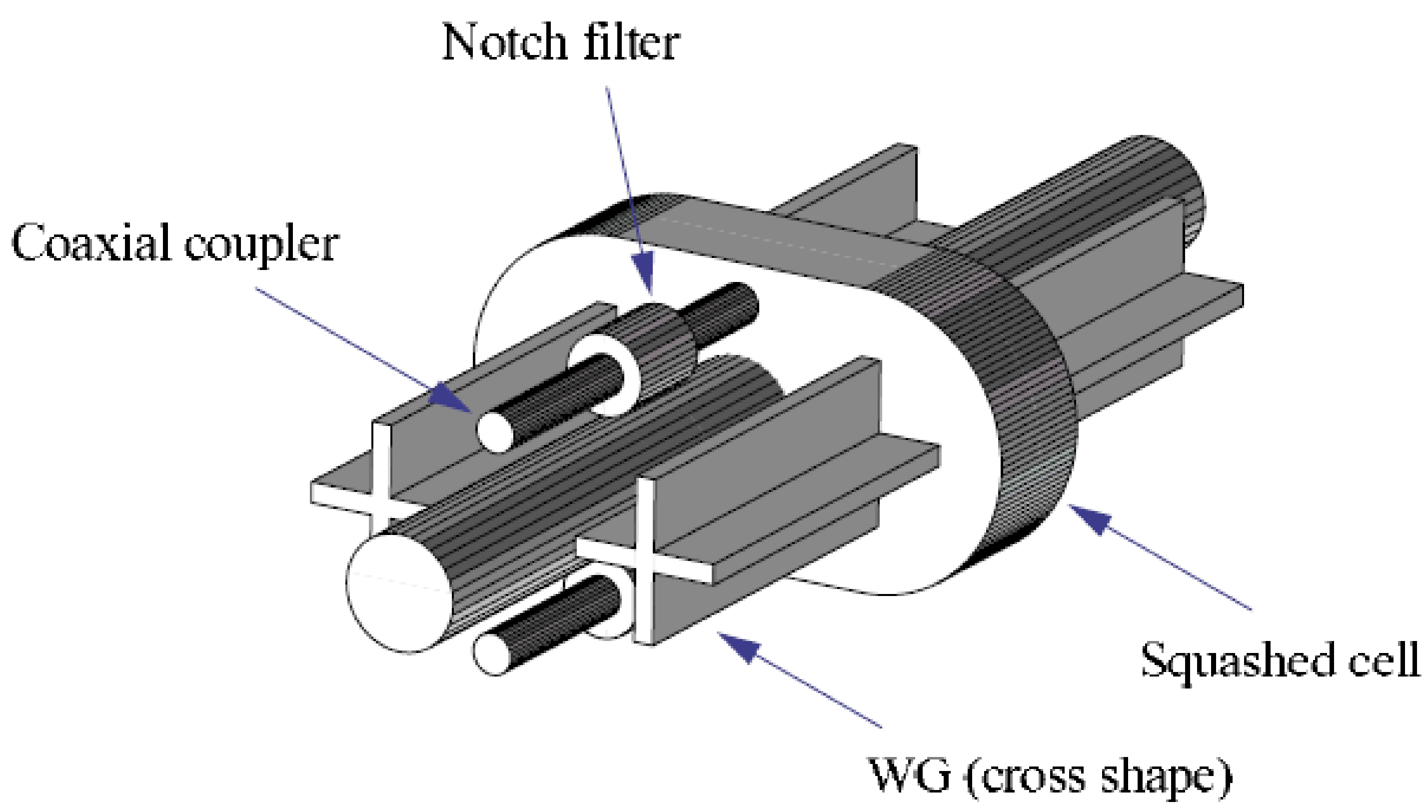
(K. Akai et al., Proc. B-factories, SLAC-400 p.181 (1992).)

Co-axial coupler for LOM (Super KEKB)



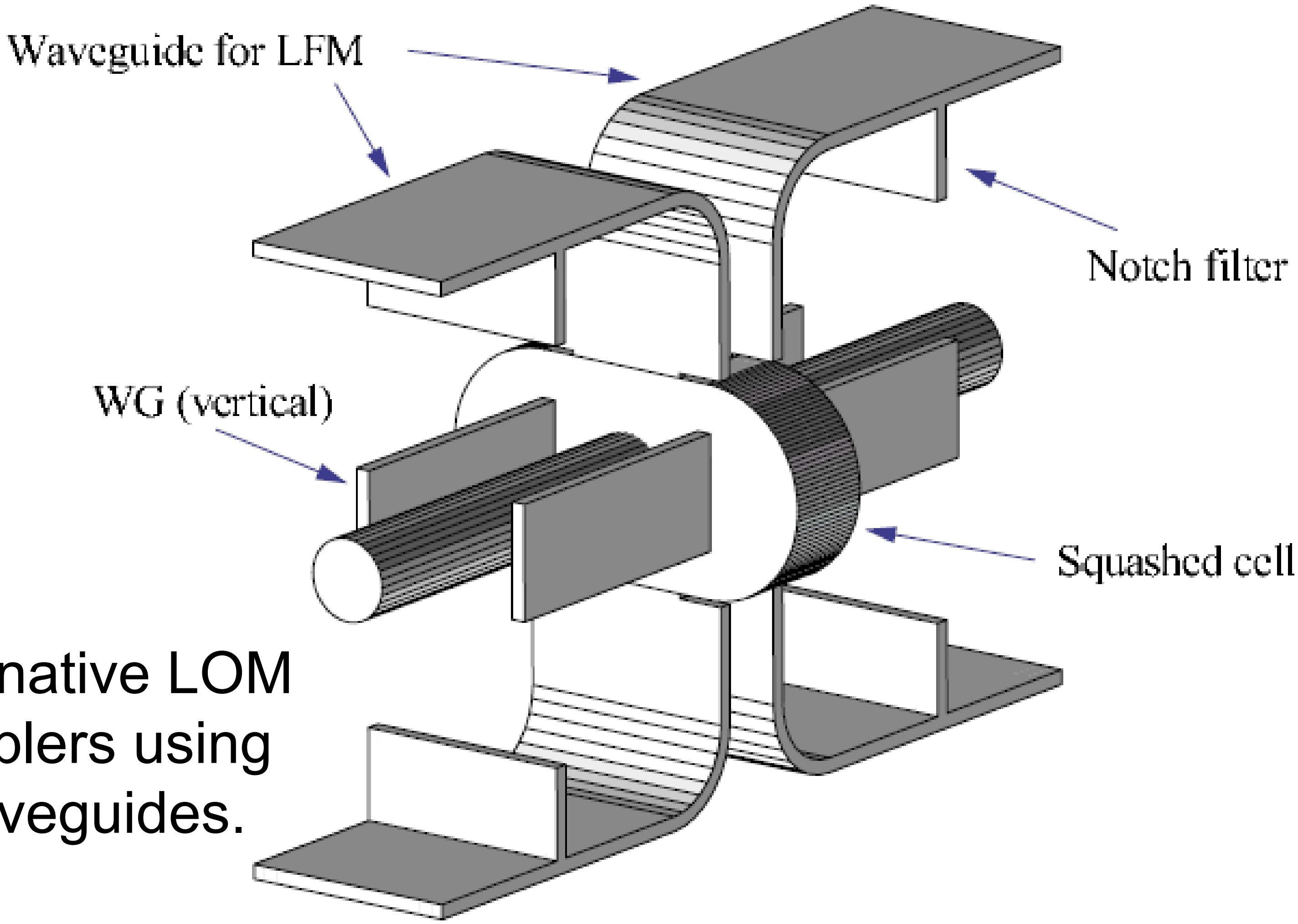
Using co-axial waveguide off axis is a better design as it is removed from the beampipe.

Co-axial coupler for LOM (Super KEKB)



Additional waveguide couplers are required for the TE111 mode.

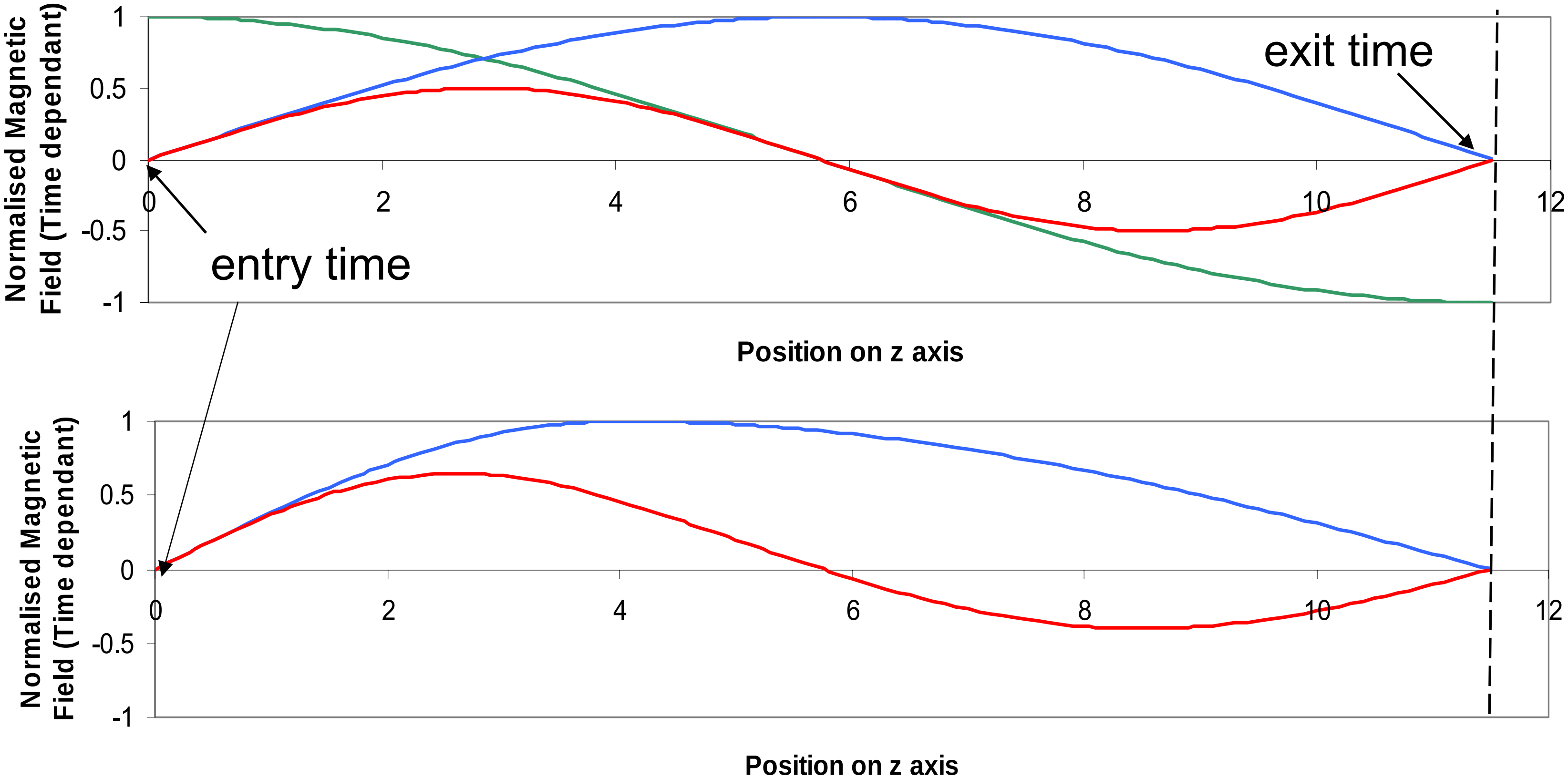
Co-axial coupler for LOM (Super KEKB)



Alternative LOM couplers using waveguides.

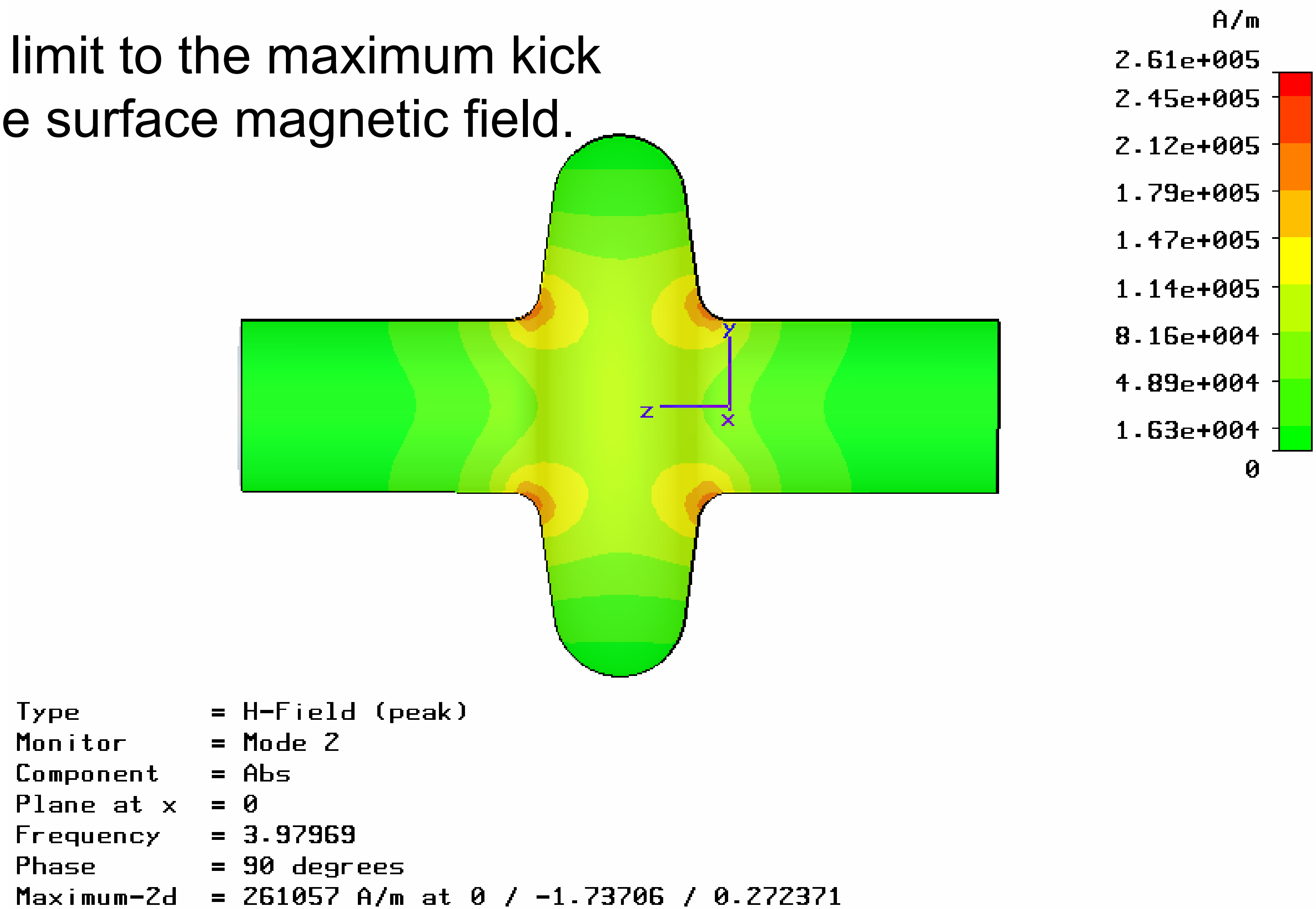
Cavity asymmetry / microphonics

- Magnetic field as seen by the middle of the bunch as a function of position across a cavity cell.

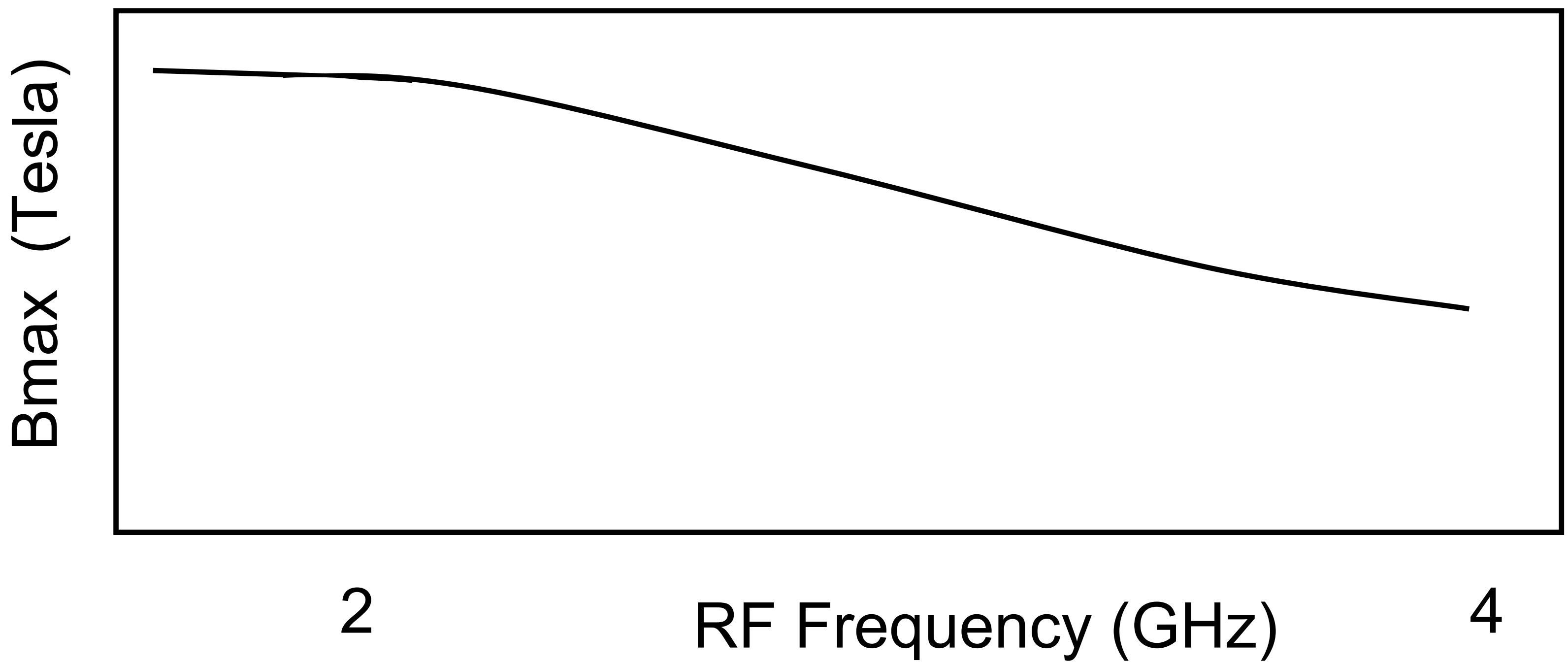


Maximum Magnetic field.

The limit to the maximum kick is the surface magnetic field.

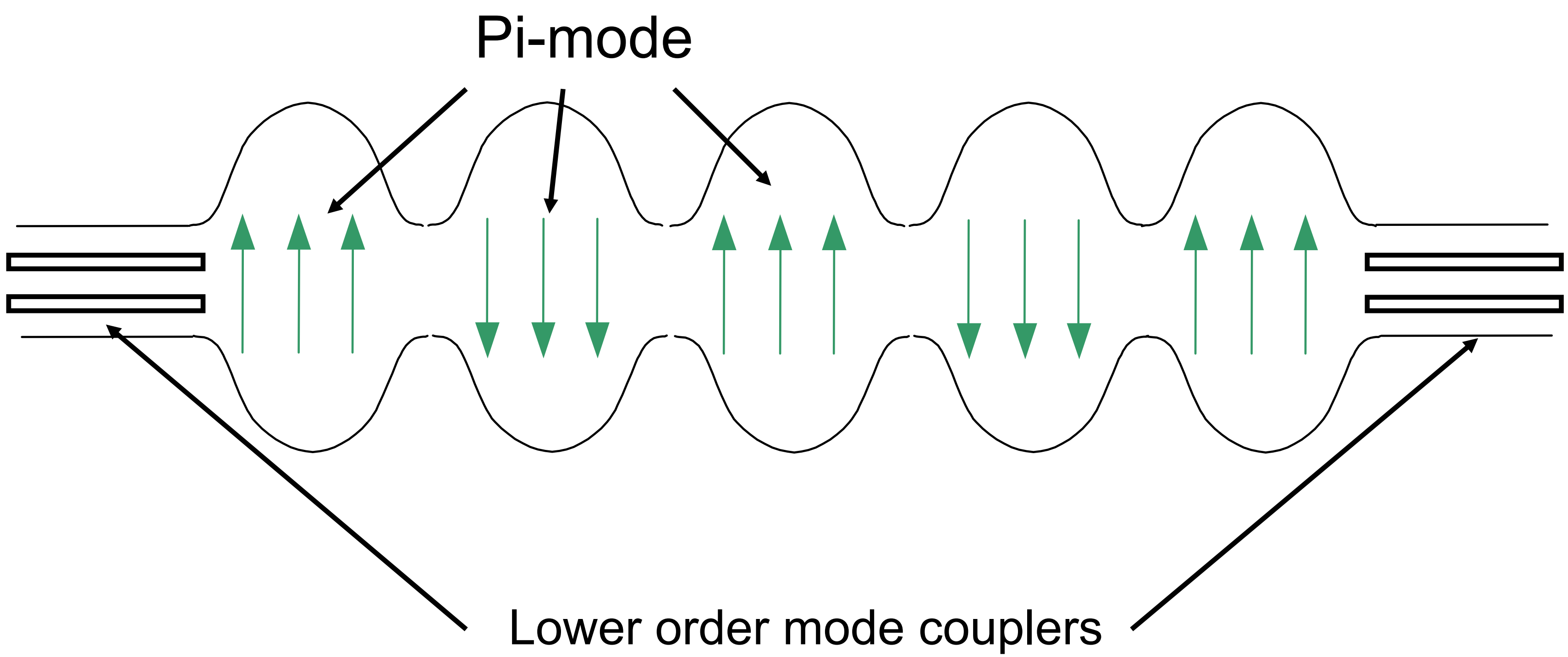


Frequency Choice, 3.9GHz vs. 1.3GHz



- B_{max} drops with increasing frequency in SC cavities
- Size of cavity is inversely proportional to frequency
- The phase tolerance is relaxed for higher frequencies.

Multicell cavity



Difficult to damp LOMs in the middle cells.

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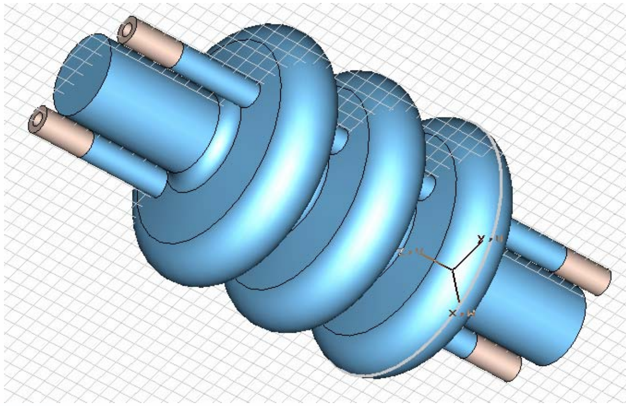
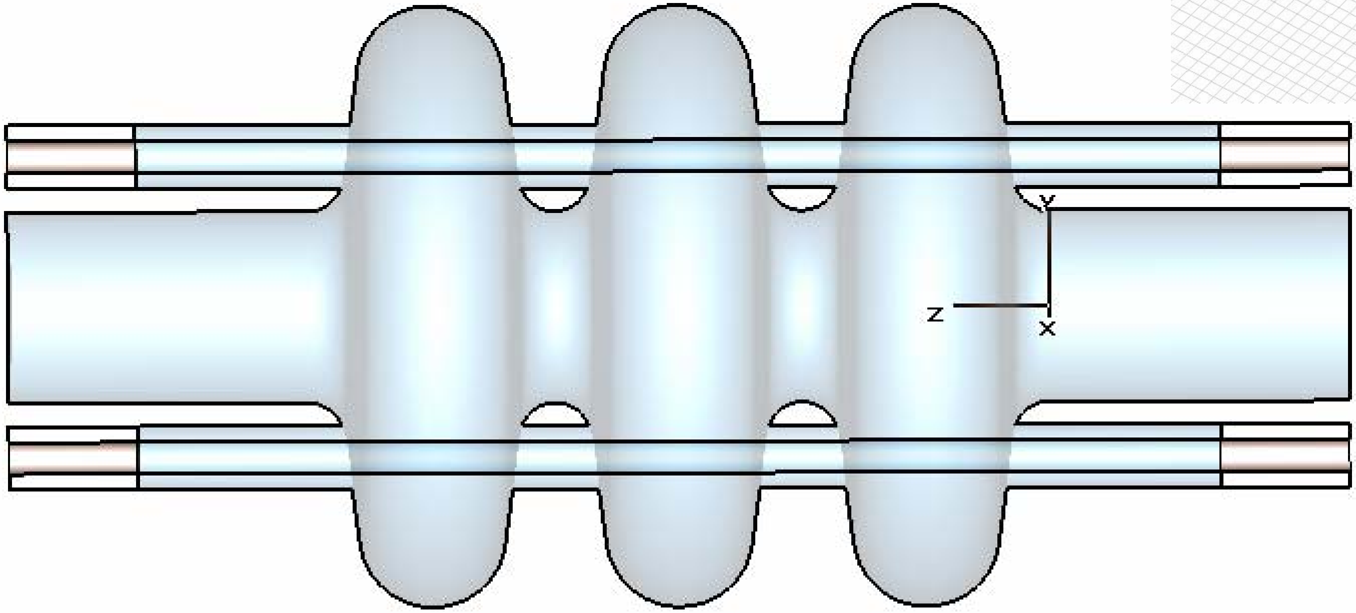
Co-axial coupler for LOM

Design of multicell LOM couplers.





Conclusion

- Cavity should be very stable.
- Crab cavity should be superconducting.
- Cavity should have an elliptical cross section.
- LOM damping in multicell cavities will be a major consideration in the design.
- The optimum design should have as small a ratio as possible between the surface magnetic field and the magnetic field on axis.