Cavity studies and prototype tests for the ILC crab system.

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On behalf of the Cockcroft Institute crab cavity team

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The ILC Crab Cavity Team

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  - Alex Kalinin (ASTeC)
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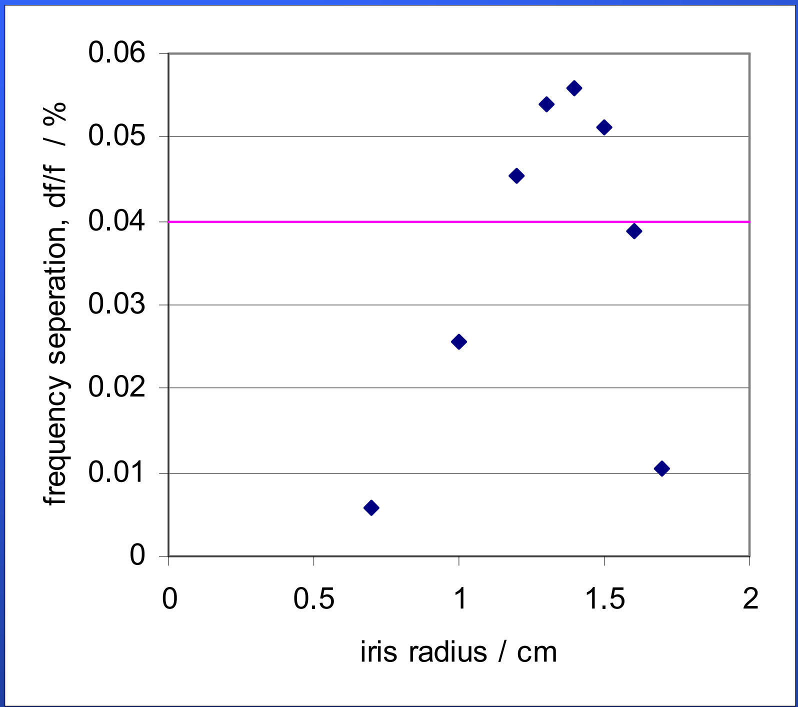
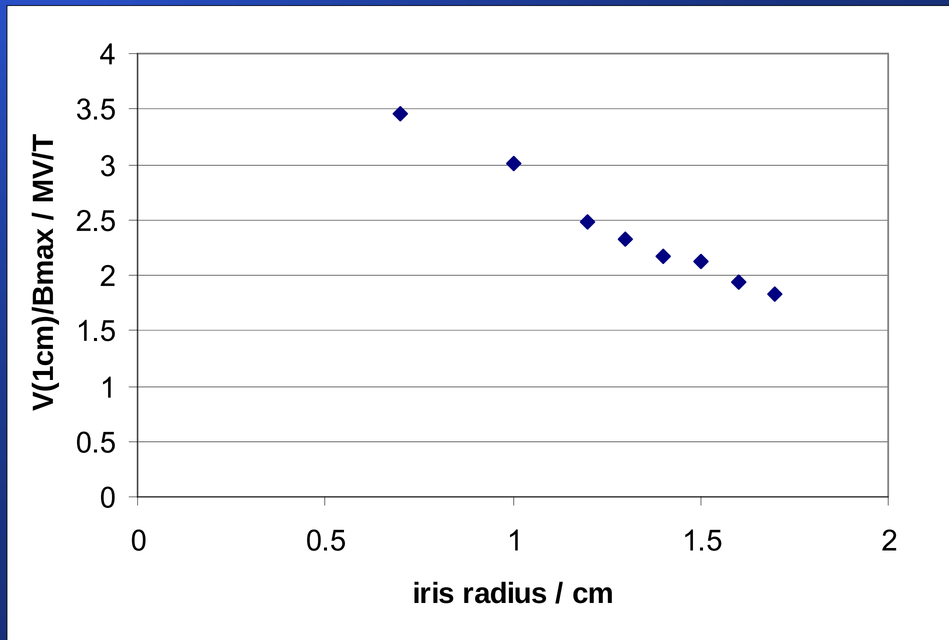
- **SLAC**
  - Chris Adolphson
  - Kwok Ko
  - Zenghai Li
  - Cho Ng
- **LBNL**
  - Derun Li

Cavity optimisation

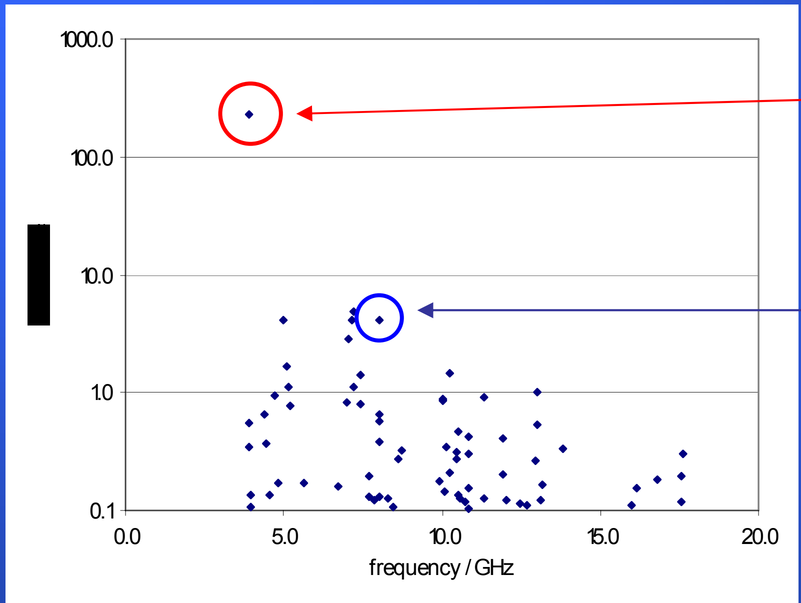


The FNAL CKM cavity was chosen as a starting point for the ILC crab cavity design

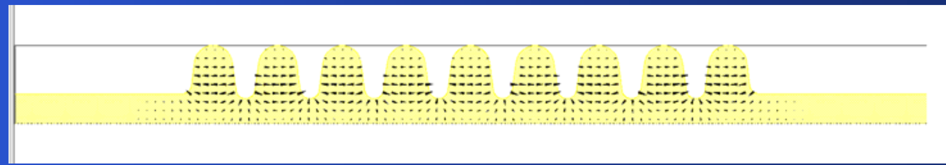
A parameter space exploration was undertaken to make sure the CKM cavity shape was optimum for the ILC.



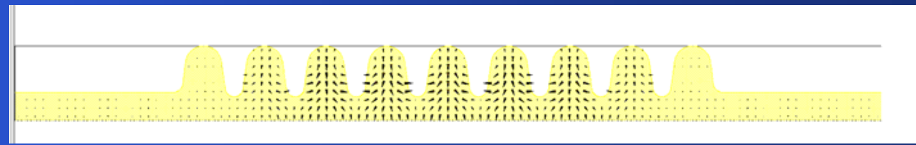
Calculation of Higher and Lower Order Modes



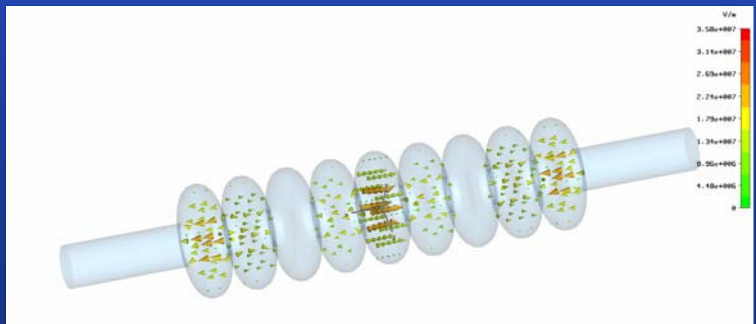
R/Qs for 1st 250 dipole modes



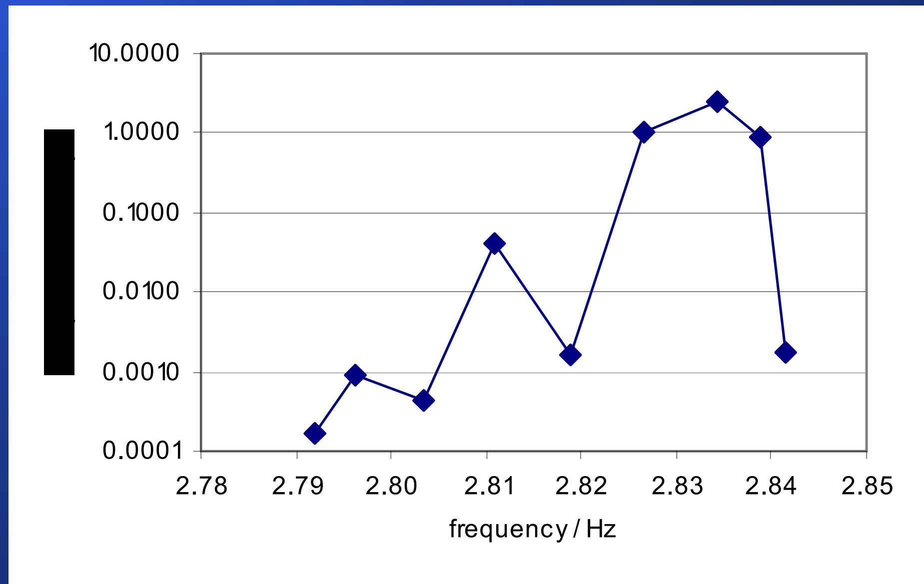
Fundamental dipole π mode



Trapped mode in the 5th dipole passband.



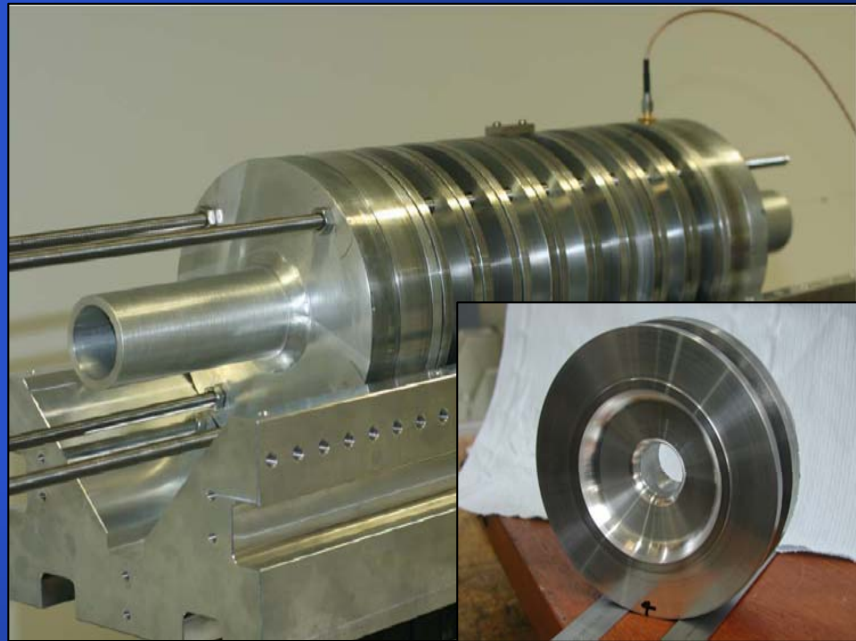
Fundamental Monopole 7π/9 mode

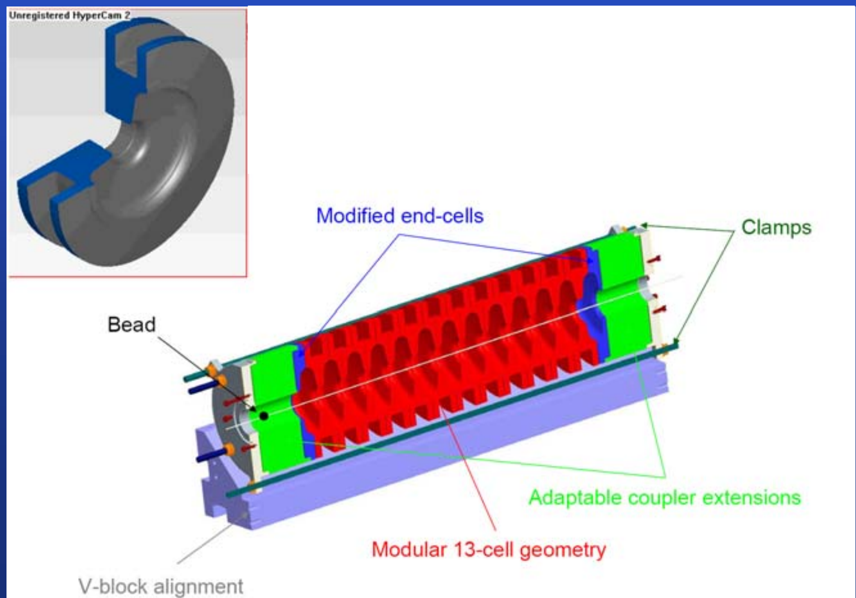


Loss parameter of the 1st monopole passband

Crab Cavity Prototype

- Model fabricated at DL and used to evaluate:
  - Mode frequencies
  - Cavity coupling
  - HOM, LOM and SOM Qe and R/Q

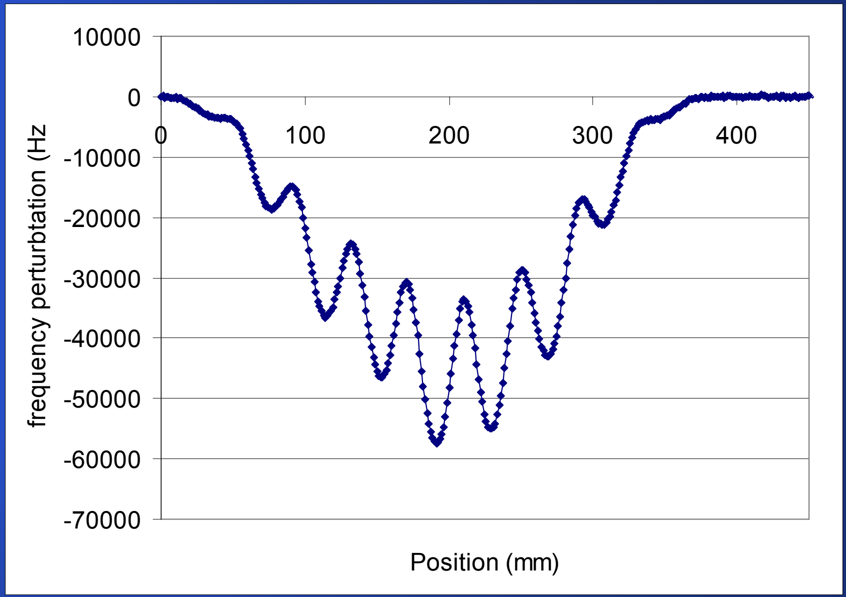


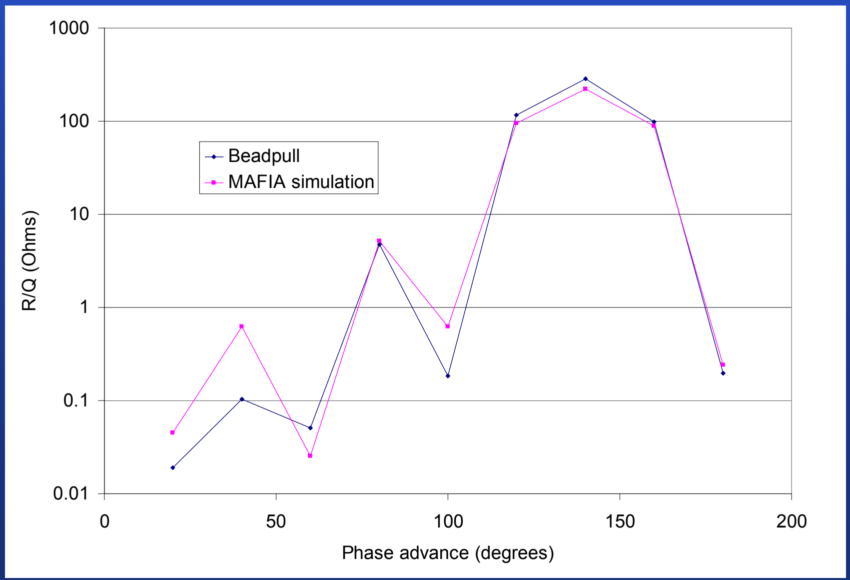


- Modular design allows evaluation of:
  - Up to 13 cells.
  - Including all mode couplers.

Crab Cavity Prototype

A beadpull measurement was used to find the cavity field profiles.

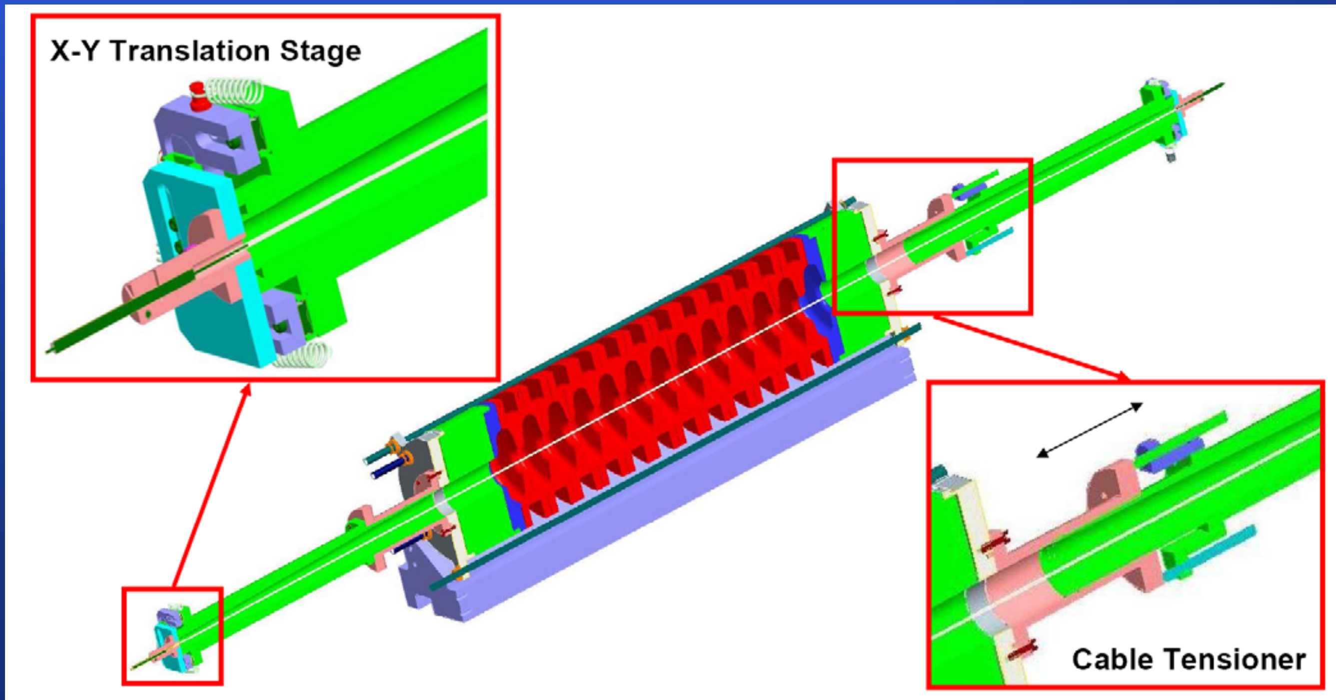




- The R/Qs for the LOM gives excellent agreement with the MAFIA simulations for a 9 cell cavity.

Wire Measurements Technique

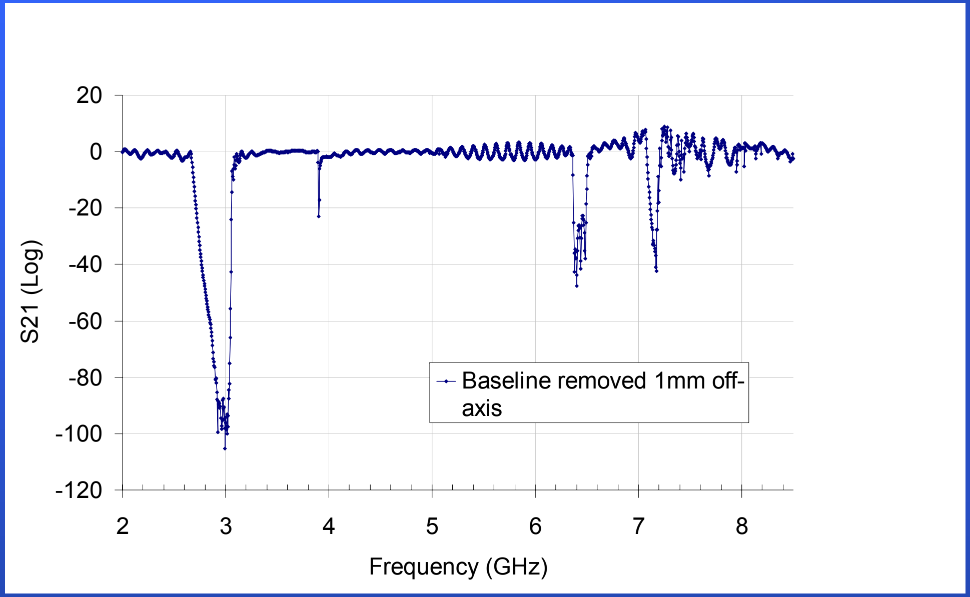
- **Technique employed extensively on X-band structures at SLAC.**
- **Bench measurement provides characterisation of:**
  - **mode frequencies**
  - **kick factors**
  - **loss factors**



A pulse travelling along a wire has a similar field profile to a relativistic bunch.

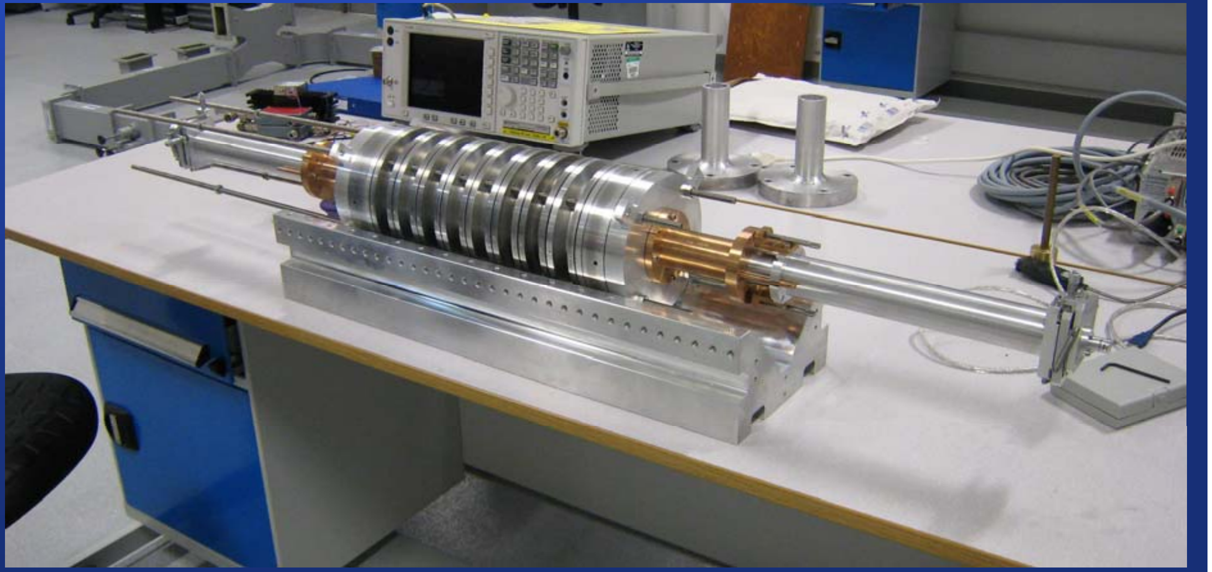
The wire can move off axis to induce dipole modes.

Wire Measurements Technique

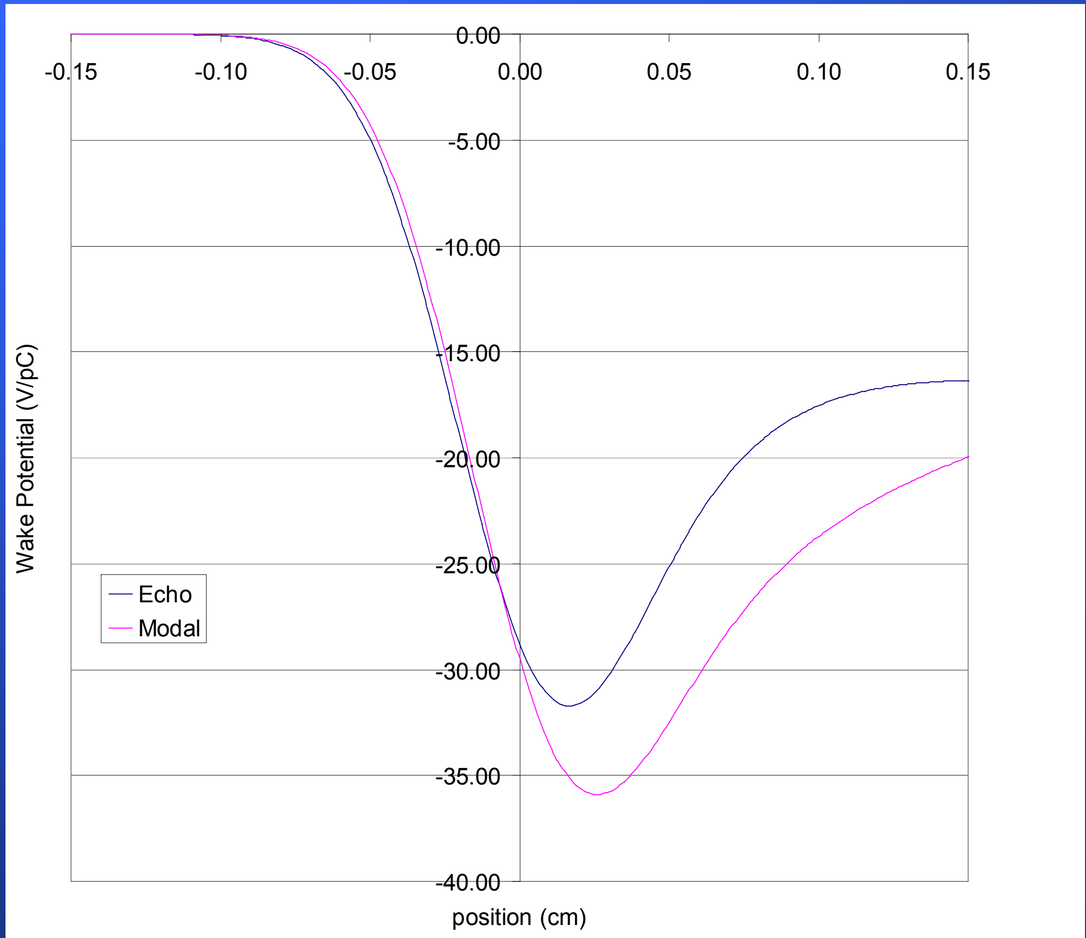


By using a frequency domain signal we can measure the impedance as a function of frequency.

This technique is a fast method of measuring the impedance over a large bandwidth.



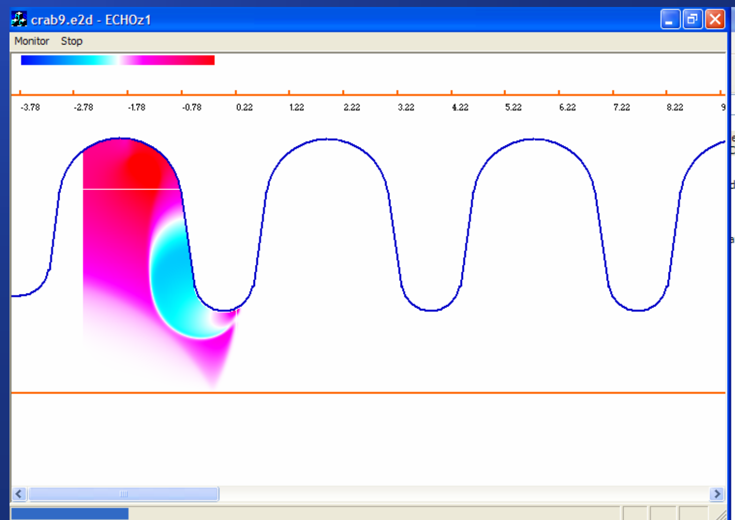
Short range wakes



A comparison of the monopole wake functions between ECHO 2D and the analytical theory for a 1ps bunch in a 9 cell Crab Cavity.

Loss factor (ECHO)=23.5 V/pC

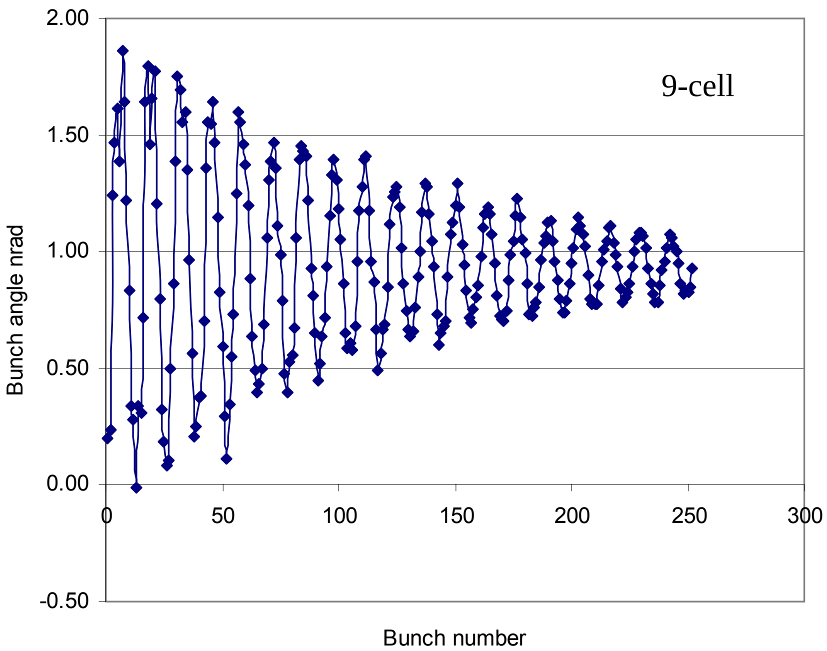
Loss factor (modal)=24.9 V/pC



Short range wakes have been shown to be negligible.

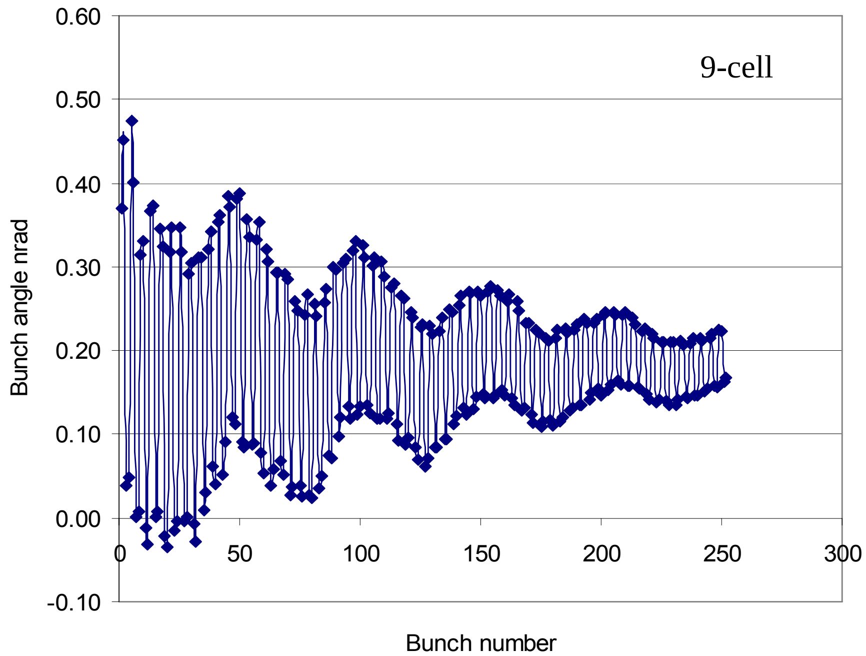
Long Range Transverse Wakes (without frequency errors)

Horizontal kick for 4σ offset.



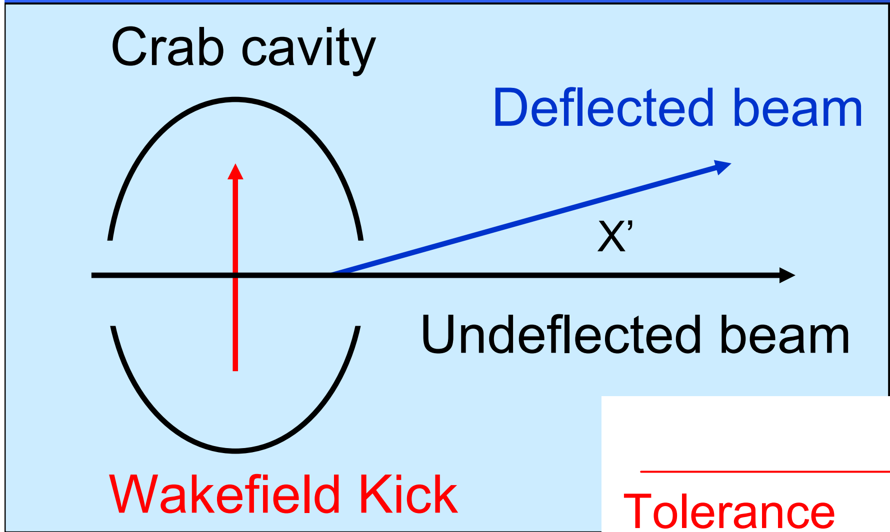
- Horz. wakes lower than ILC threshold (10 nrad).
- Deflecting mode not included.
- External Q's are estimated.

Vertical kick for 4σ offset.



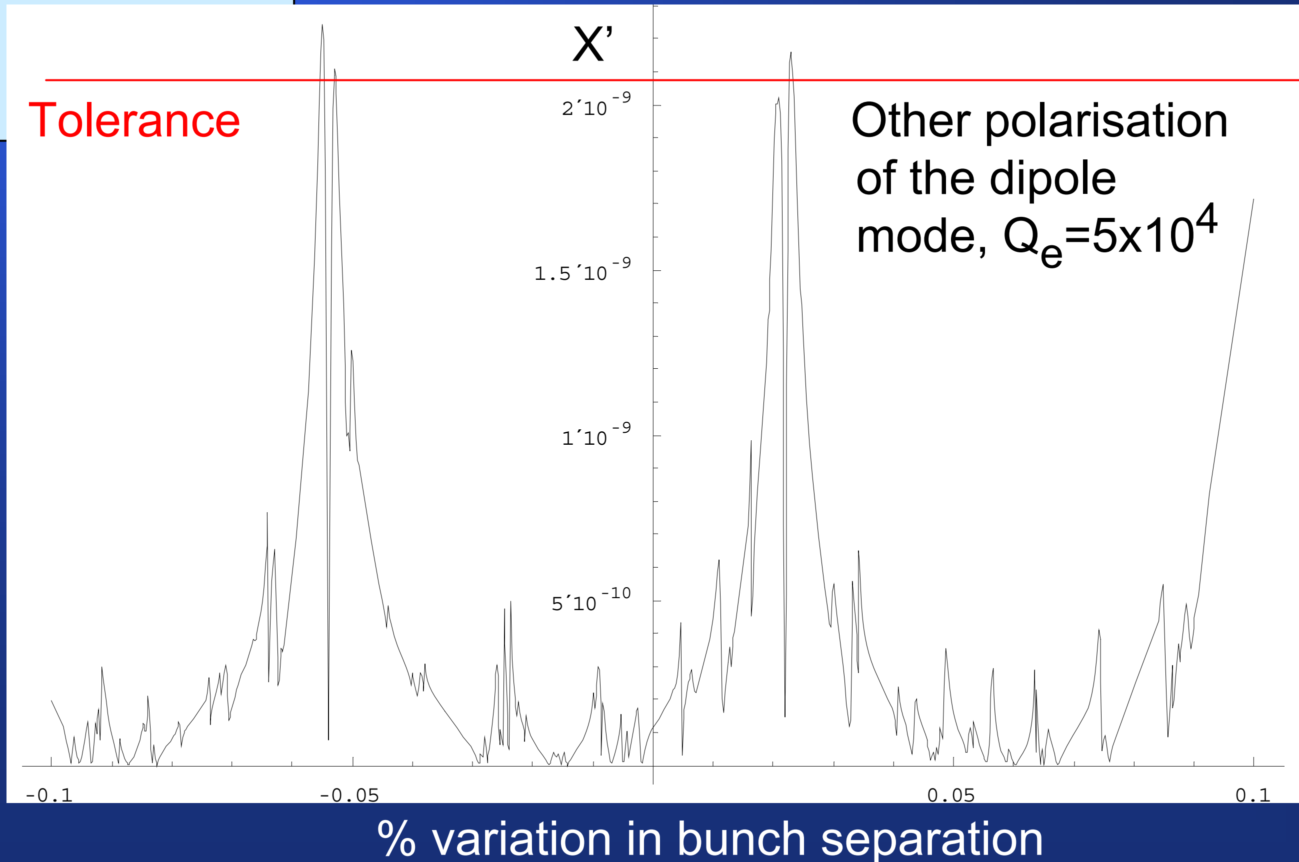
- Vert. wake limited by unwanted polarisation of dipole mode, ILC threshold 0.7 nrad.
- Highly dependent on frequency separation.

Sum Wakefield Kicks



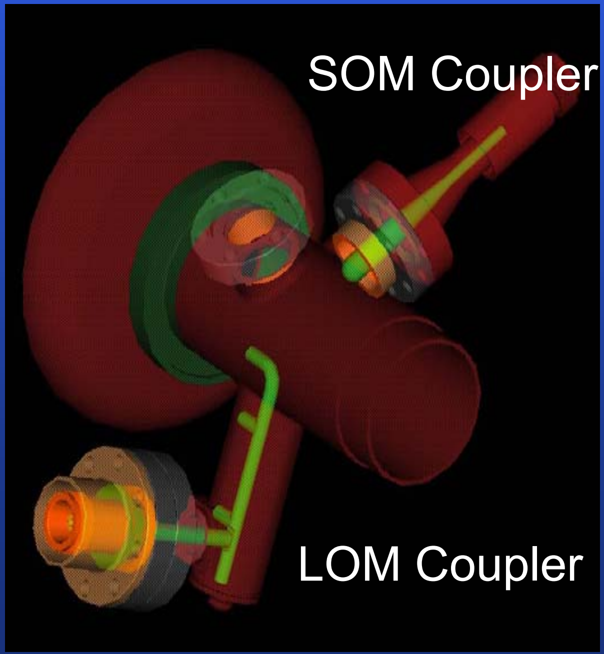
The modal information was used to calculate the effect of the wakefields in the Crab cavity.

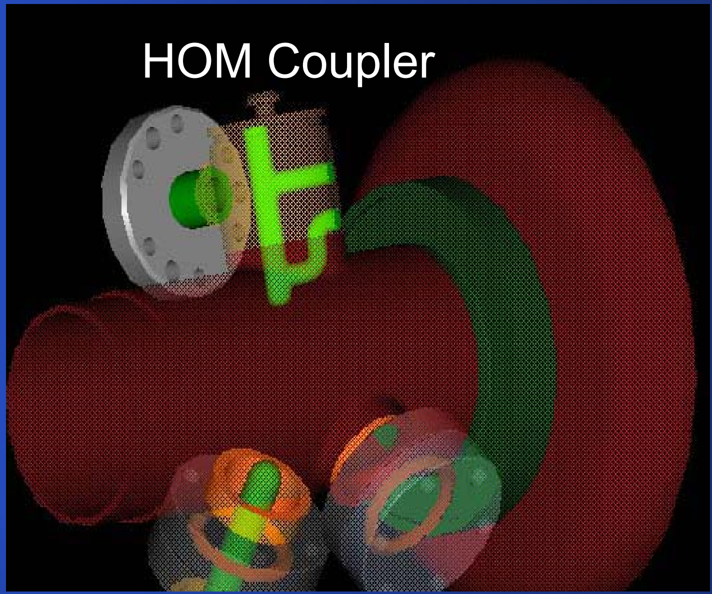
As can be seen if the beam hits a resonance with the Same-order-mode the wakefields increase significantly.



Crab Cavity Mode Couplers

- 3 different couplers for mode extraction required:
  - Higher Order Mode (HOM)
  - Lower Order Mode (LOM)
  - Same Order Mode (SOM)

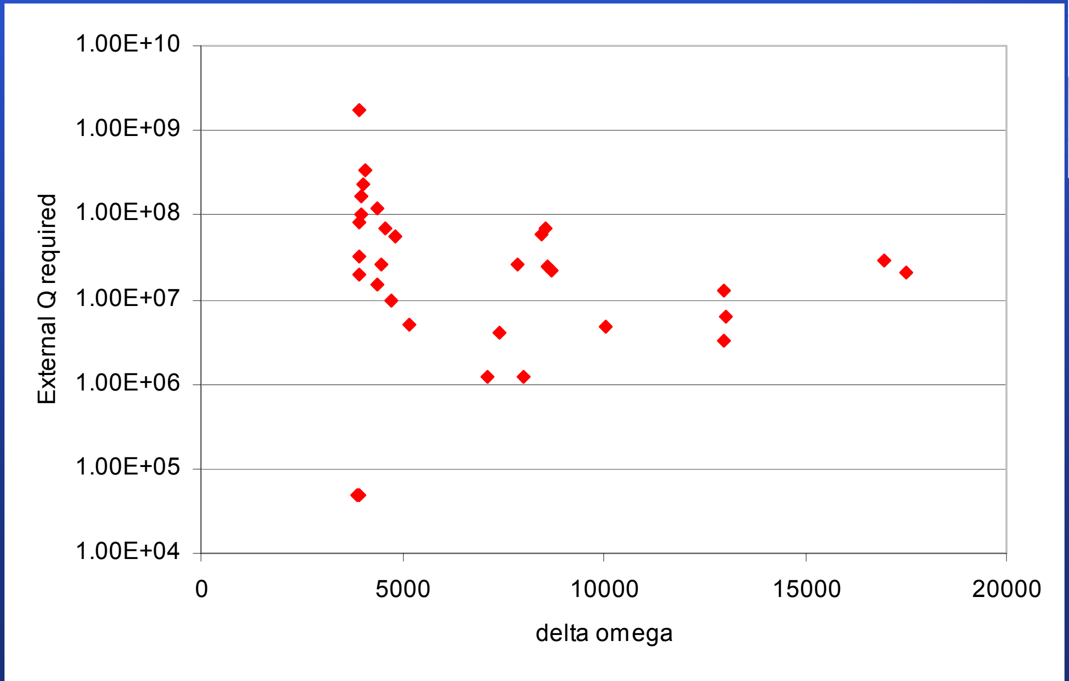


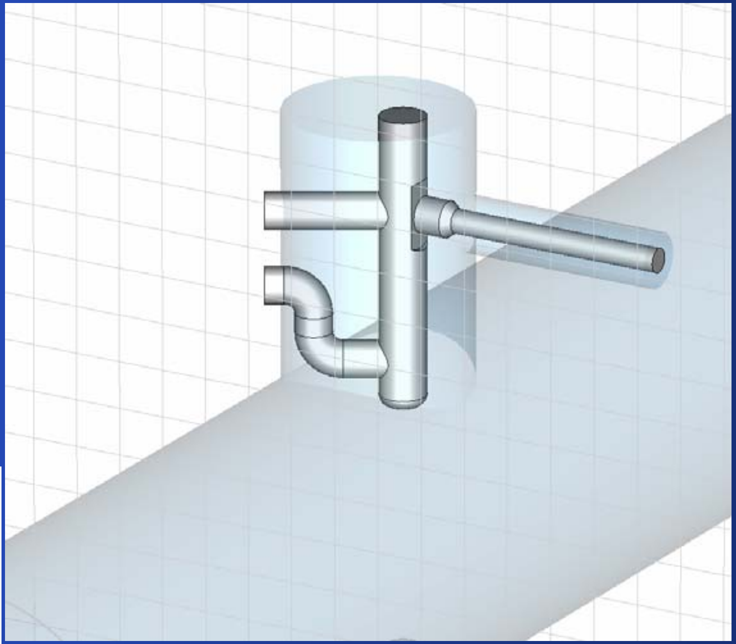


- These couplers are difficult to fabricate at 3.9GHz.
- CKM cavity HOM couplers have shown problems in tests:
  - high tuning sensitivity (~ 1.6 MHz/μm)
  - multipacting.
- New HOM coupler needed for ILC!

HOM damping requirements

- The required damping of the most significant HOMs were calculated using the wakefield information.

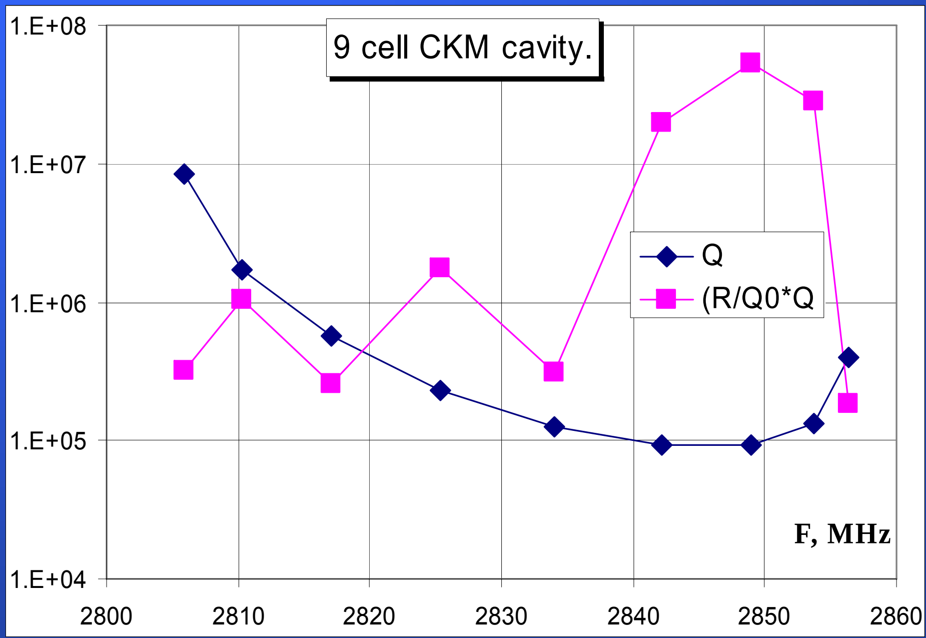


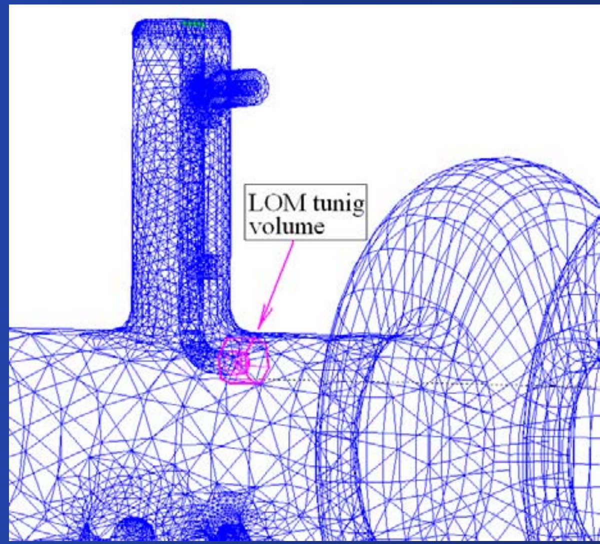


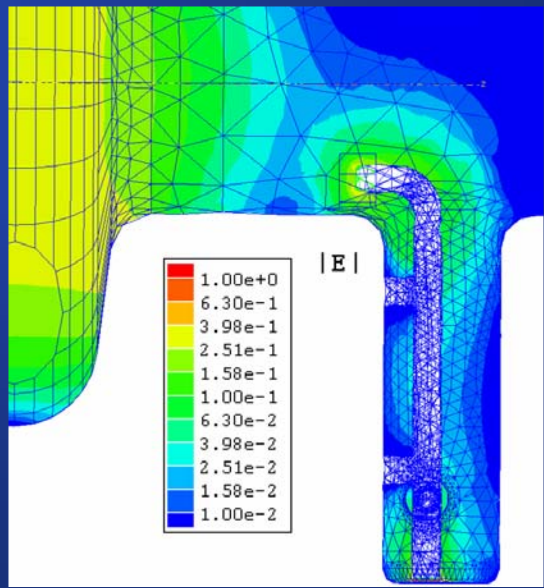
HOM coupler

Novel analytical techniques were developed in order to calculate these tolerances.

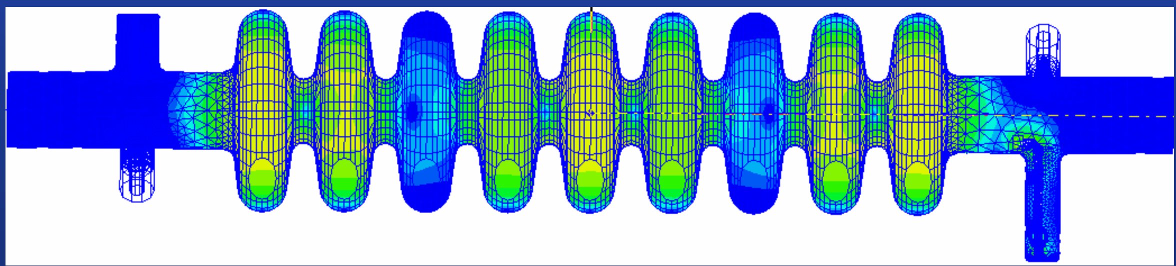
Coupler modelling



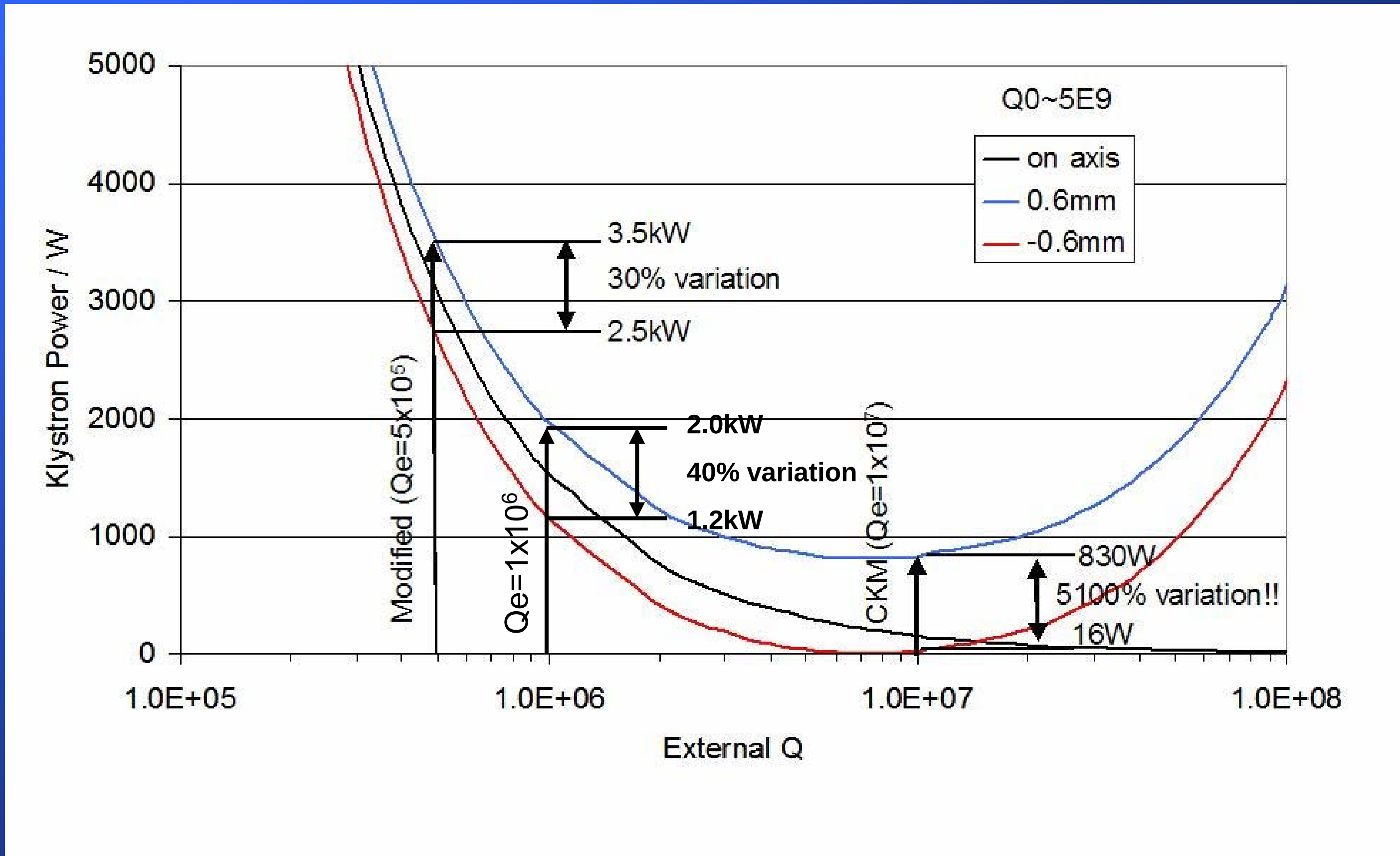




|E|, 7π/9 mode, F=2848.95MHz, ε=1.15 tip_LOM.



Input Coupler

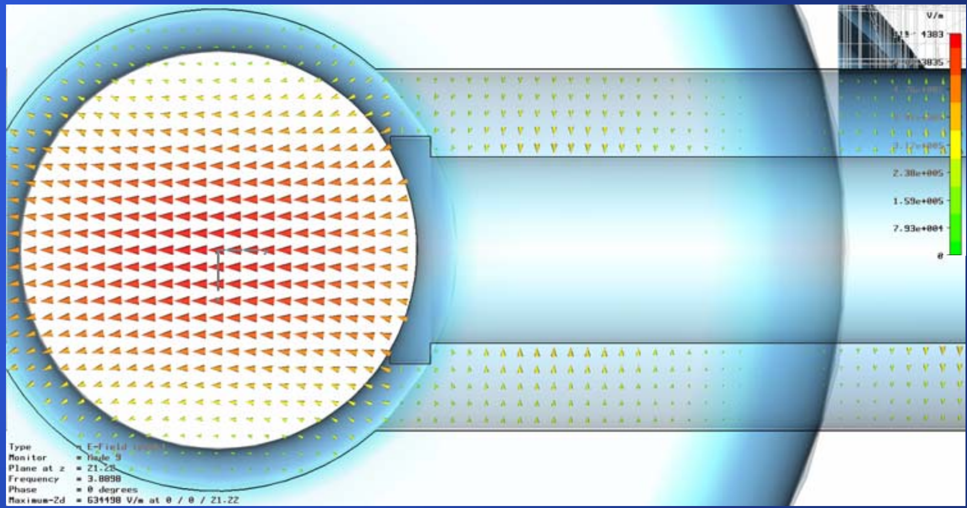


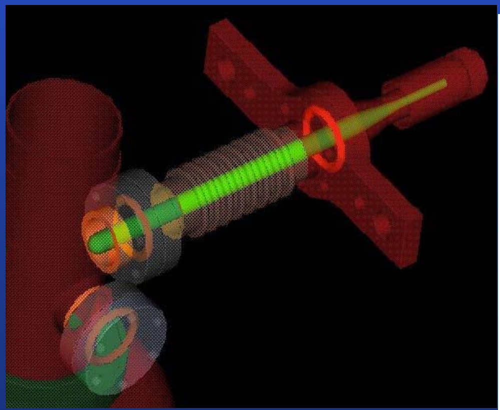
- For 0.6 mm offset, up to 3.5 kW input power needed.
- A lower external Q is required
- New input coupler needed for ILC crab cavity. Possibly by altering the 3rd harmonic coupler.

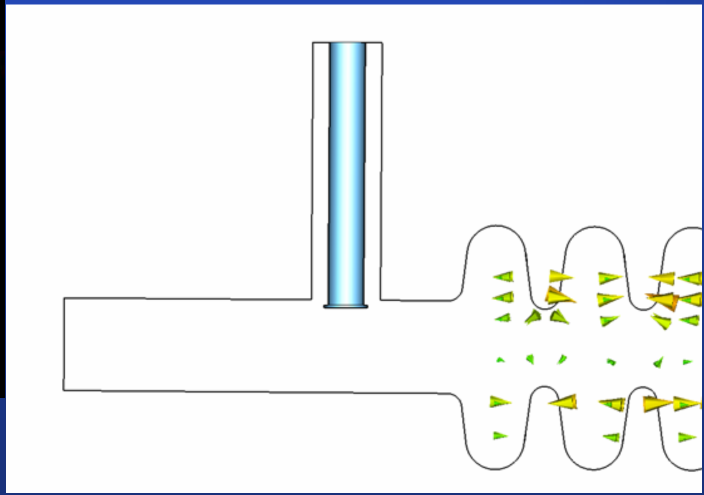
Crab Cavity Input Coupler and SOM coupler

1st iteration of improved coupler:

- 50 Ohm coaxial line
- Shaped tip for higher coupling
- Centre line is 40mm from cavity.
- 3mm beampipe penetration
- Simulation Qe=5x10^5

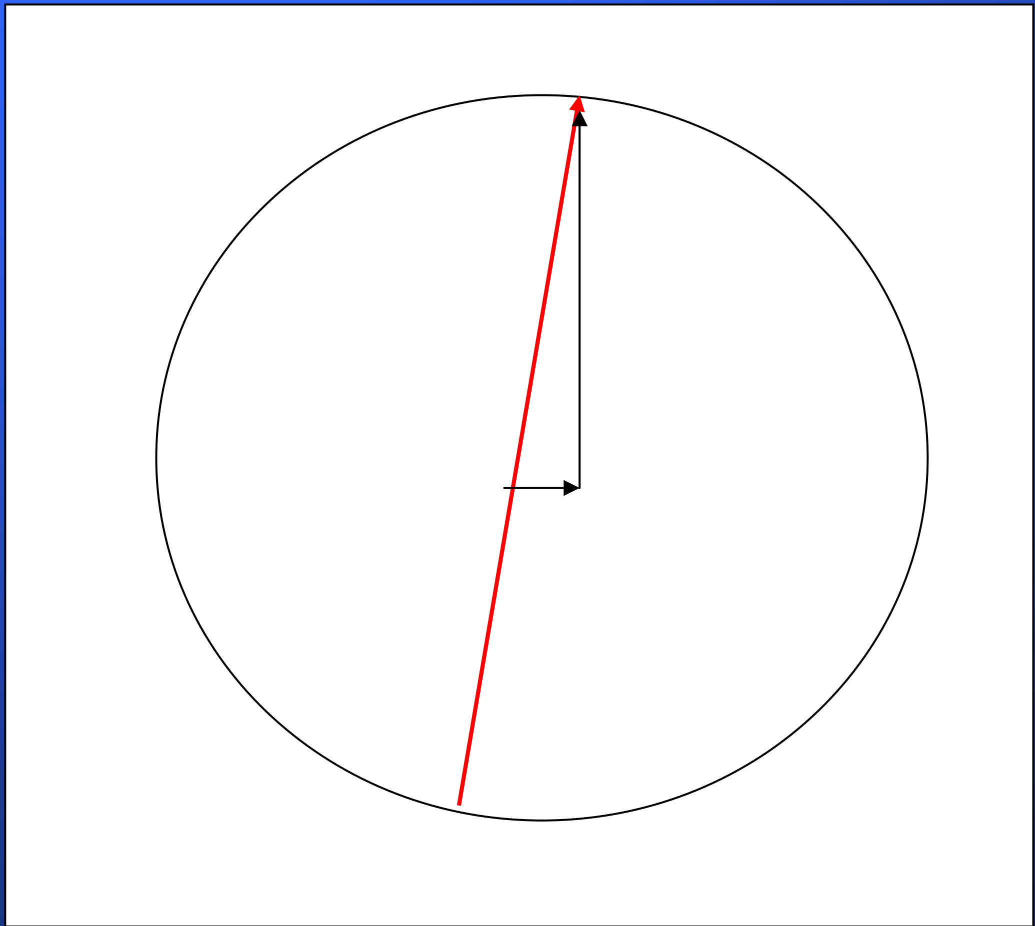






Tests are planned on various tip shapes using normal conducting prototypes with a removable tip.

Cavity orientation



- If the cavity is not orientated correctly it will produce a spurious vertical crabbing effect, which could reduce luminosity.

A method to measure and correct the cavity orientation is required.