Crab Cavity Design for the ILC BDS (III)

- **Baseline Design (FNAL)**
- **Damping Requirements (Cockcroft Institute)**
- **Damping Results (SLAC)**

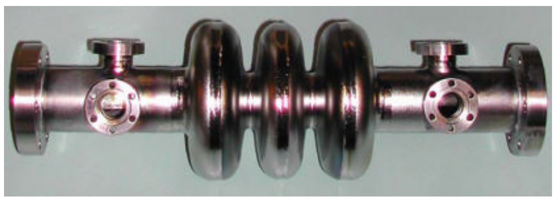
  a) FNAL Baseline design
  b) SLAC New design

- **MP Analysis**
- **Summary**

Collaboration with FNAL and UK lab on this project.

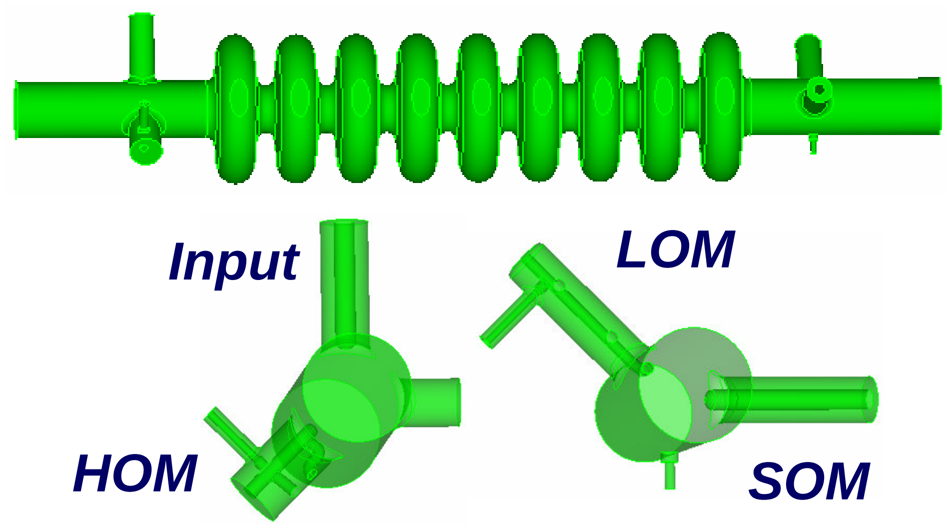
1. Crab Cavity Base Line Design (FNAL)

9-cell without couplers



3-cell with couplers

Prototype of FNAL



Computational Model of SLAC

Input Coupler: $TM_{110\text{-}\pi}$ mode (3.9GHz)

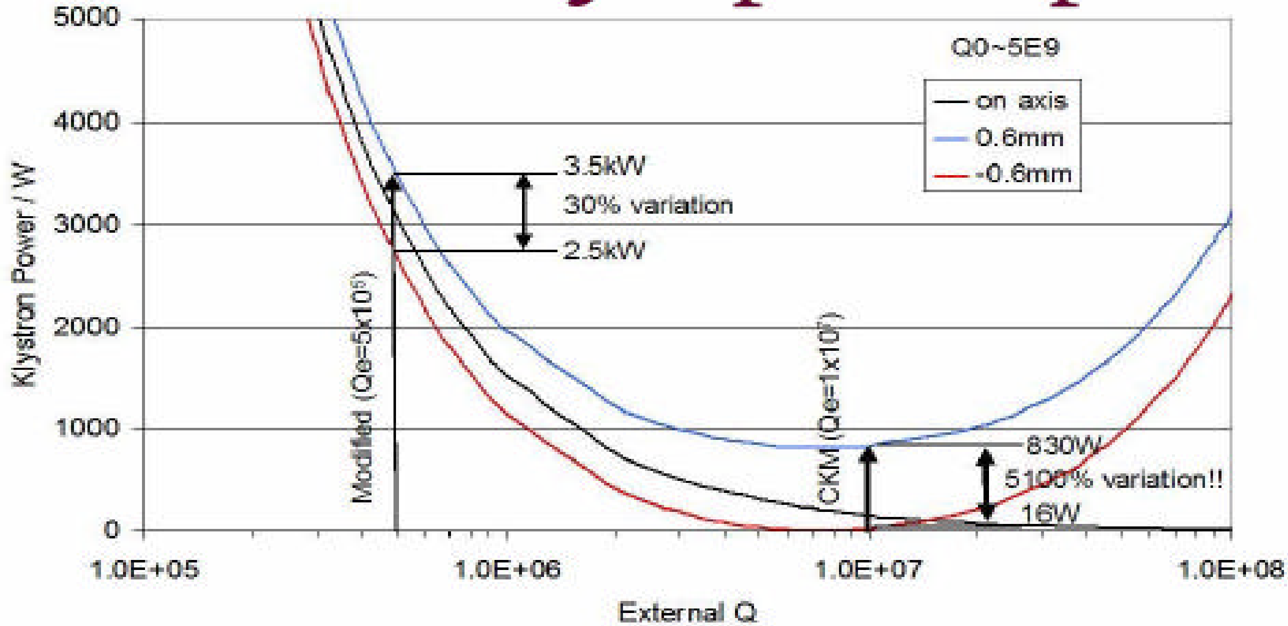
LOM Coupler: TM_{010} mode (< 3.9GHz)

SOM Coupler: Unwanted polarization of $TM_{110\text{-}\pi}$ mode (~3.9GHz)

HOM Coupler: higher order modes (>3.9GHz)

2. Damping Requirements (Cockcroft Institute)

Crab Cavity Input Coupler

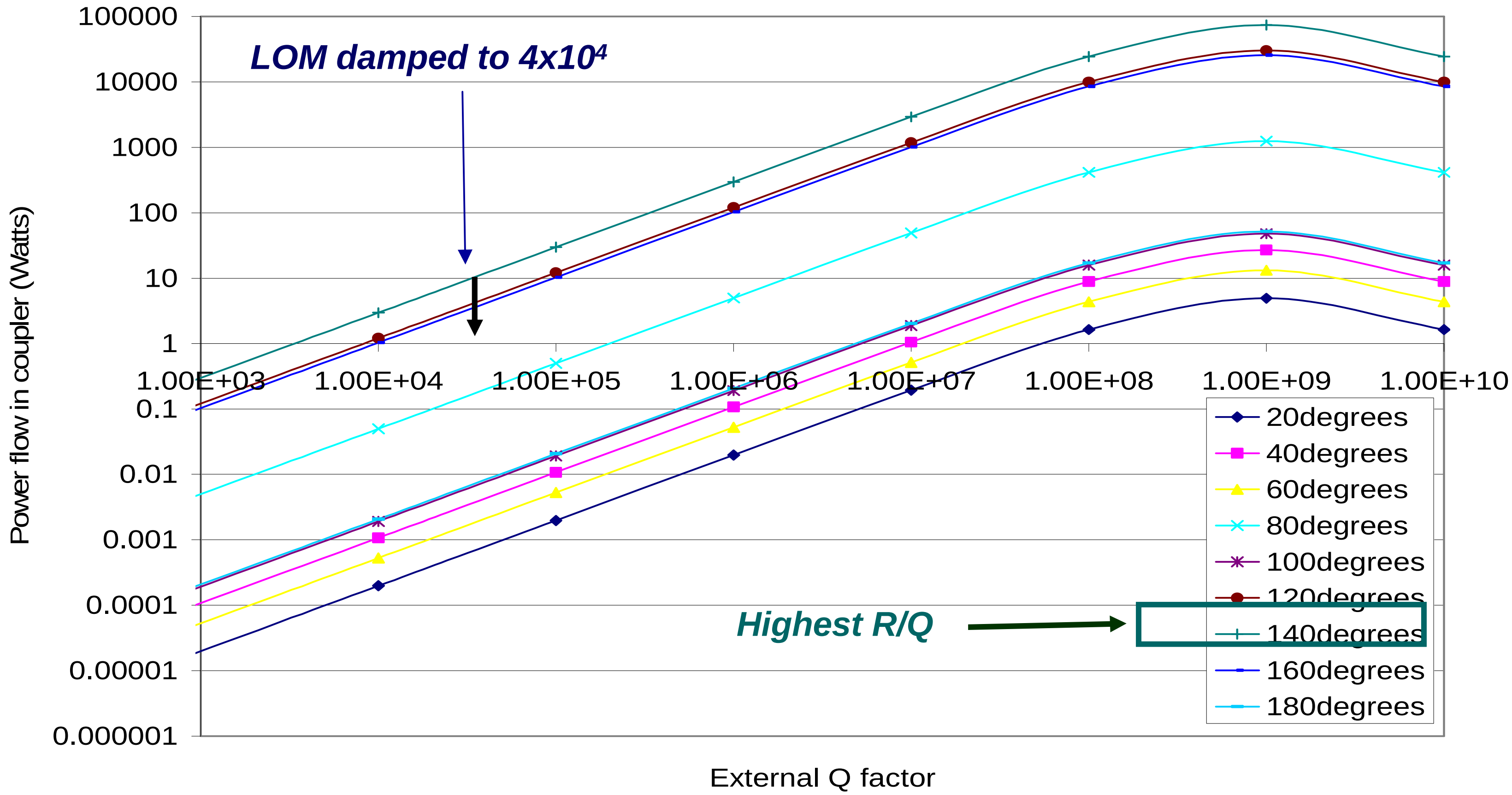


- For high Qe (1×10^7), expected beam loading $\Rightarrow$ large power fluctuations:
  - Consequently large phase variations!
- Choosing a lower Qe (5×10^5) $\Rightarrow$ significantly reduce o/p phase variability.
- For 0.6 mm offset, up to 3.5 kW input power needed.
- FNAL input coupler only designed for <500 W CW.
- Developing a control model to determine the LLRF phase control capability.
- New input coupler needed for ILC crab cavity.

Cockcroft SAC Meeting *Peter McIntosh*

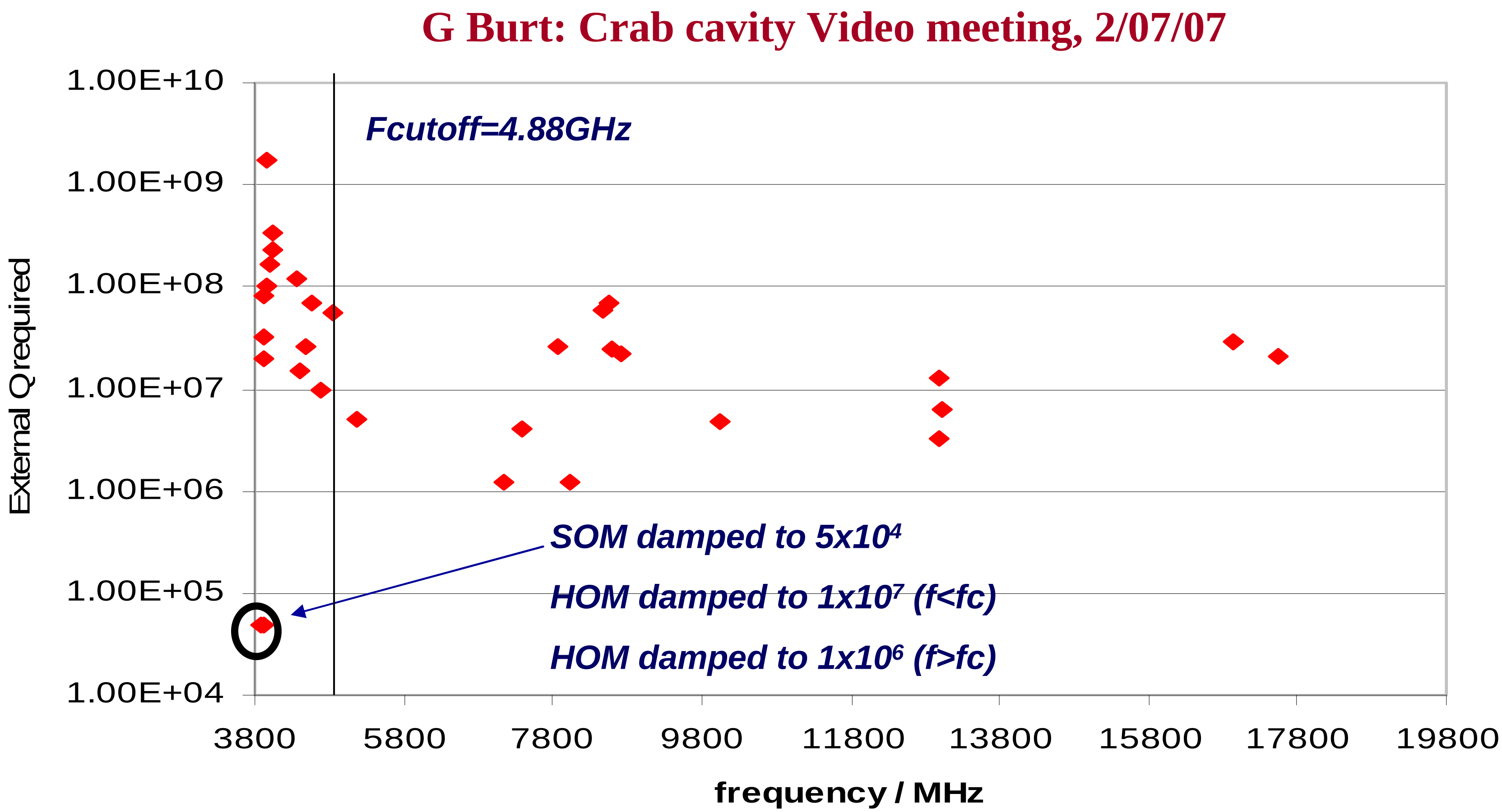
2. Damping Requirements (Cockcroft Institute)

G Burt: Crab cavity Video meeting, 2/07/07



Assuming the modes are resonance with beam

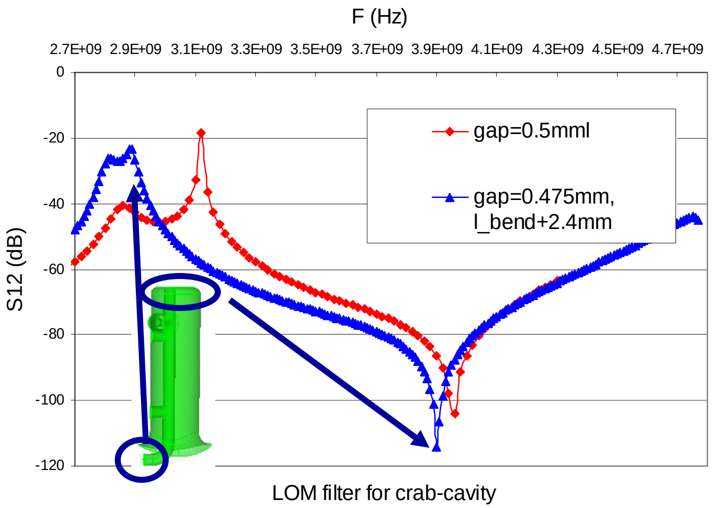
2. Damping Requirements (Cockcroft Institute)



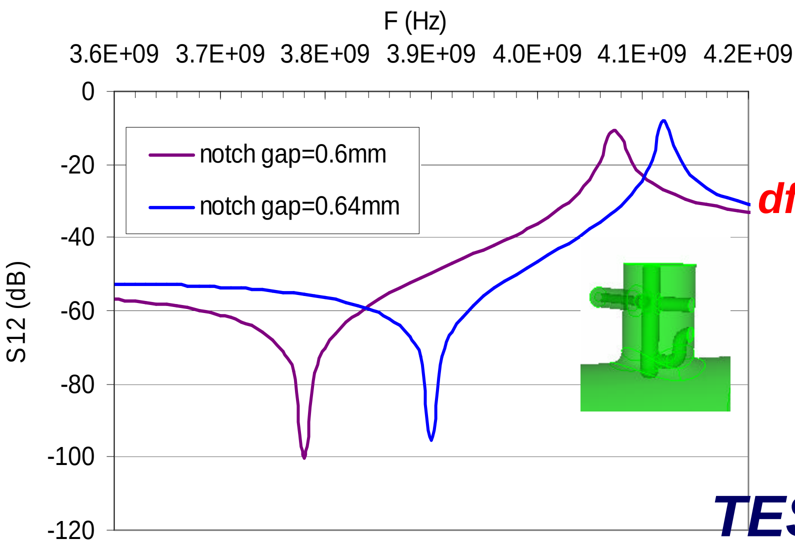
Analytical techniques were used to calculate the required damping for the worst case for each of the dipole modes individually

3. Damping Results (SLAC-Omega3P/S3P)

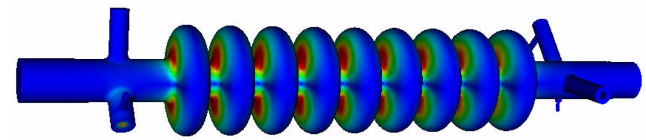
a) Baseline Design:



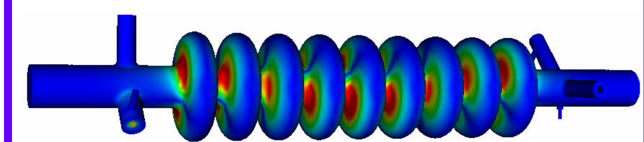
df/dgap=2.2MHz/um



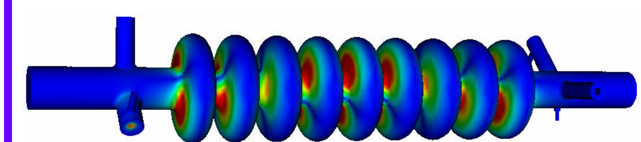
df/dgap=1.6MHz/um



F=3.90303GHz, operating mode
Qext=7x10^6 (Require: 5x10^5)



F=3.91209GHz, 7π/9 mode



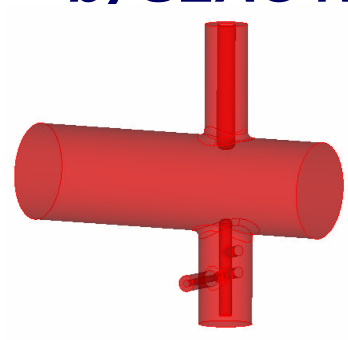
F=3.91212GHz, SOM mode
Qext=2.6x10^6 (Require: 4x10^4)

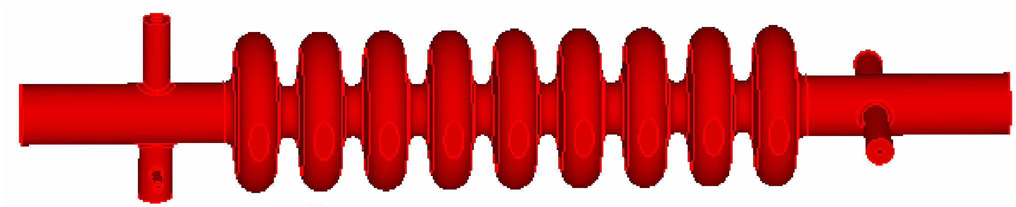
X-Y coupling

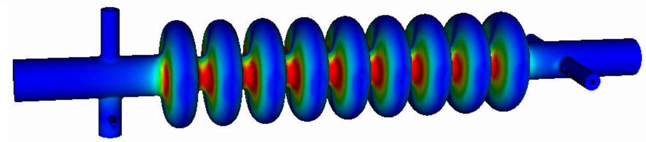
TESLA: ~0.1MHz/um

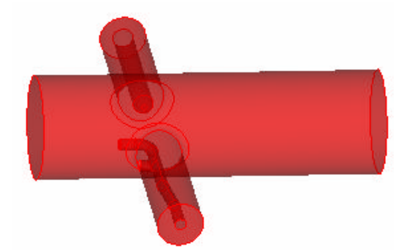
3. Damping Results (SLAC-Omega3P/S3P)

b) SLAC New Design





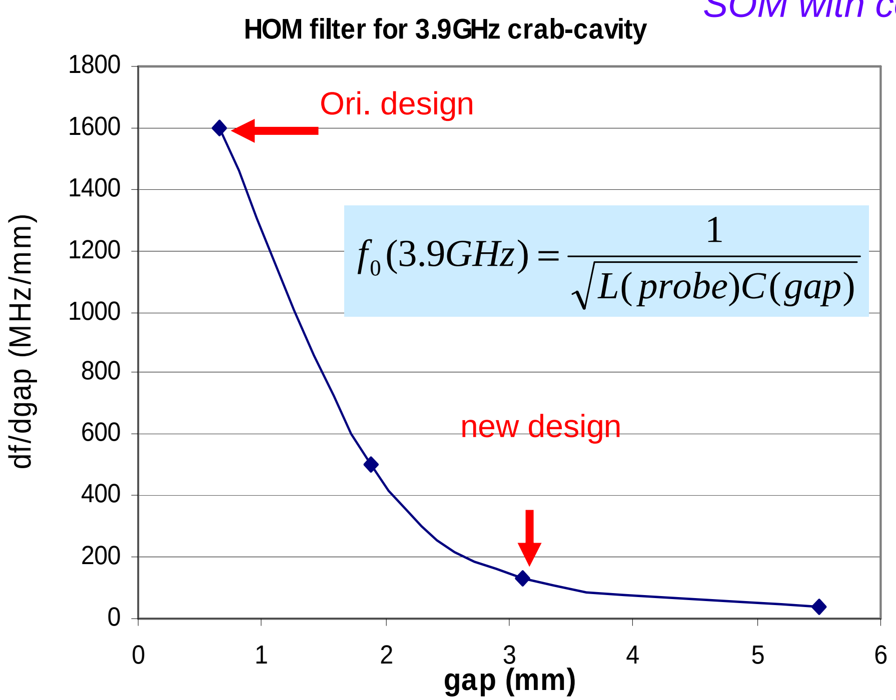


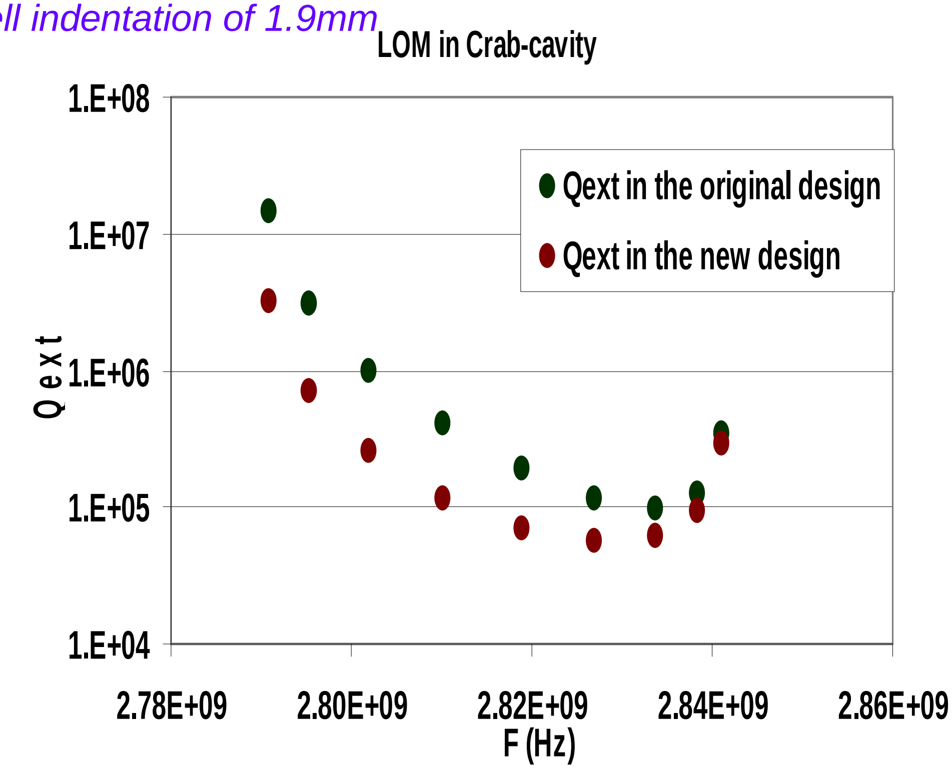


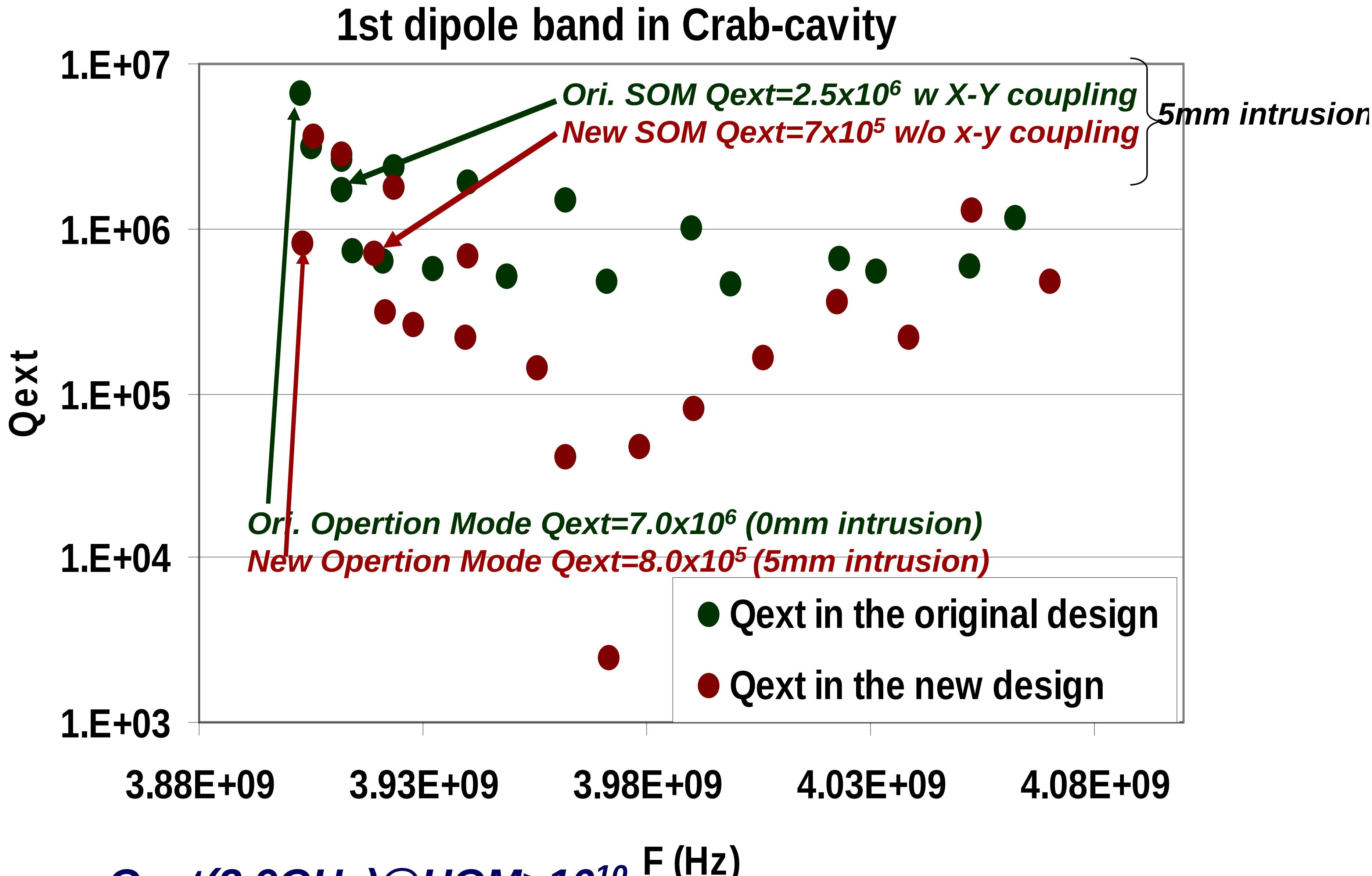
Reduce sensitivity

SOM with cell indentation of 1.9mm

Eliminate notch filter







Qext(3.9GHz)@HOM>10^{10}

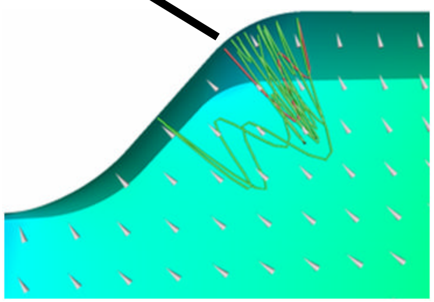
	Input Coupler	LOM $-7\pi/9$	HOM ($f<fc$)	SOM
Base Line Design	**$7x10^6$**	$1x10^5$	$<1x10^7$	**$2.5x10^6$**
New design	**$8x10^5$**	$6x10^4$	$<1x10^7$	**$7x10^5$**
Requirement (CI)	**$<5x10^5$**	$<4x10^4$ (Pflow<10W)	$<1x10^7$	**$<5x10^4$** **(worse case)**

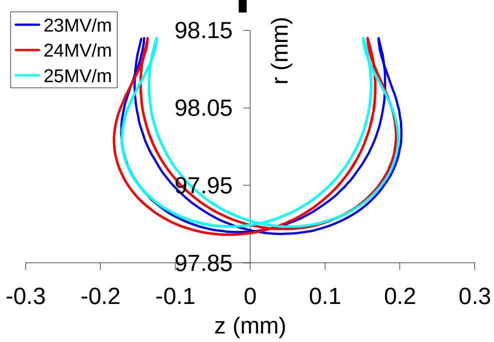
Need to estimate the realistic requirement on SOM damping!

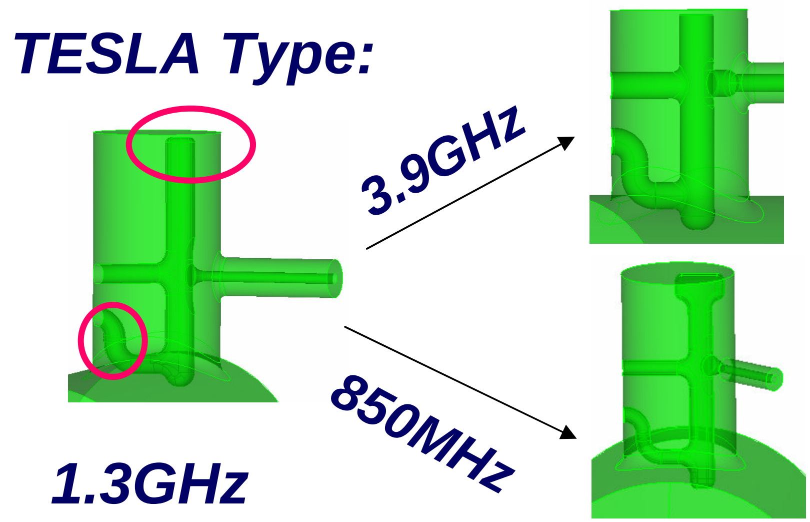
Need to study new input and SOM couplers.

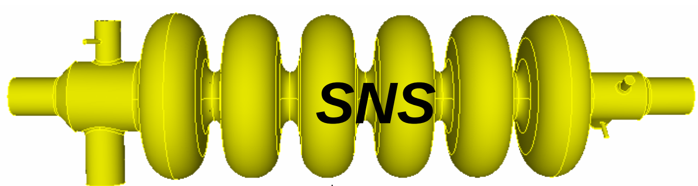
4. MP Analysis (SLAC-Track3P)

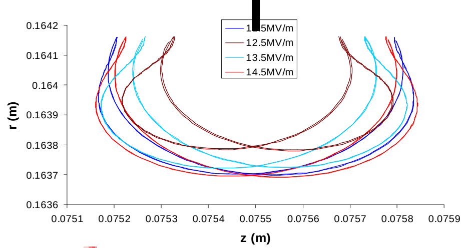
MP in SC Cavity and HOM couplers.

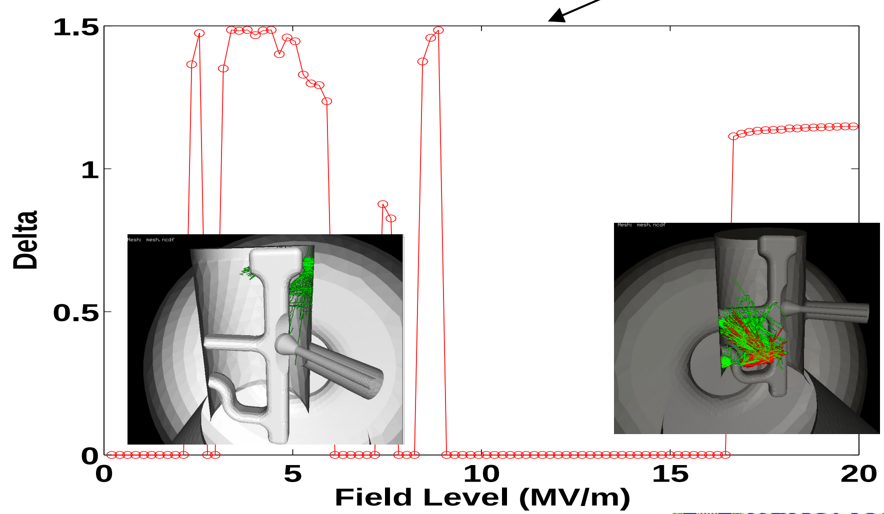






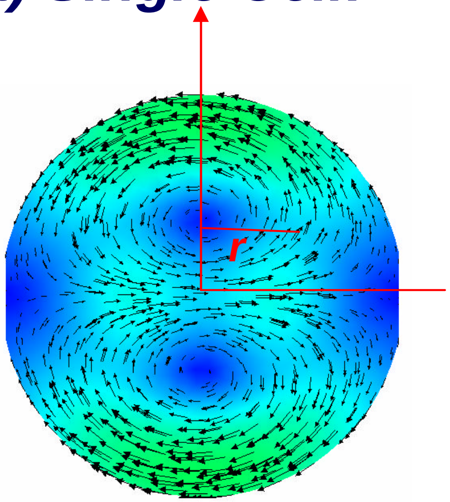






4. MP Analysis (SLAC-Track3P)

a) Single Cell:

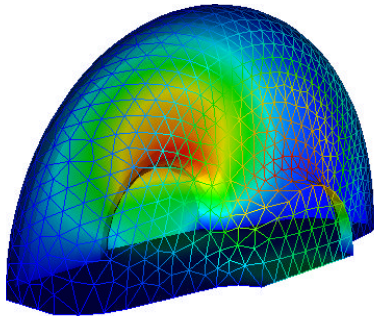


$V_T$max=5MV/m

$$V_T = \frac{V_z(r)}{r\frac{\omega}{c}},$$

$$V_z(r) = r\frac{\omega}{c}V_T$$

$$Vz(5mm) = 2.04e+6(V/m)$$



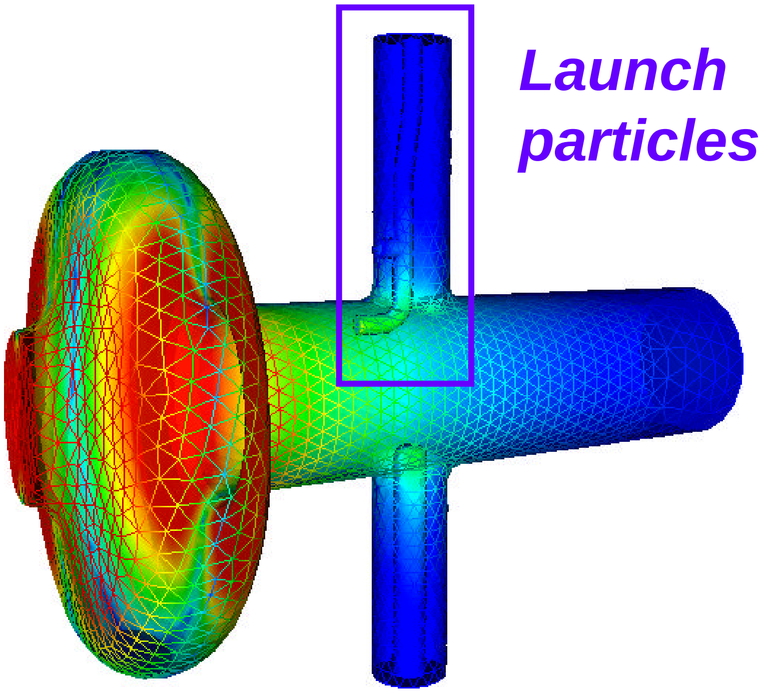
Computational Model

1. Field level scan: Ez:0.1MV/m ~ 2.2 MV/m @r=5mm with dEz=0.1MV/m
2. Launching location scan: space and phase (360^o)
3. Launching energy: 2ev-5ev
4. Track out trajectory: field level, location, impact energy.
5. Postprocess to find out the MP with SEY curve

No MP found

4. MP Analysis (SLAC-Track3P)

b) New LOM Coupler:



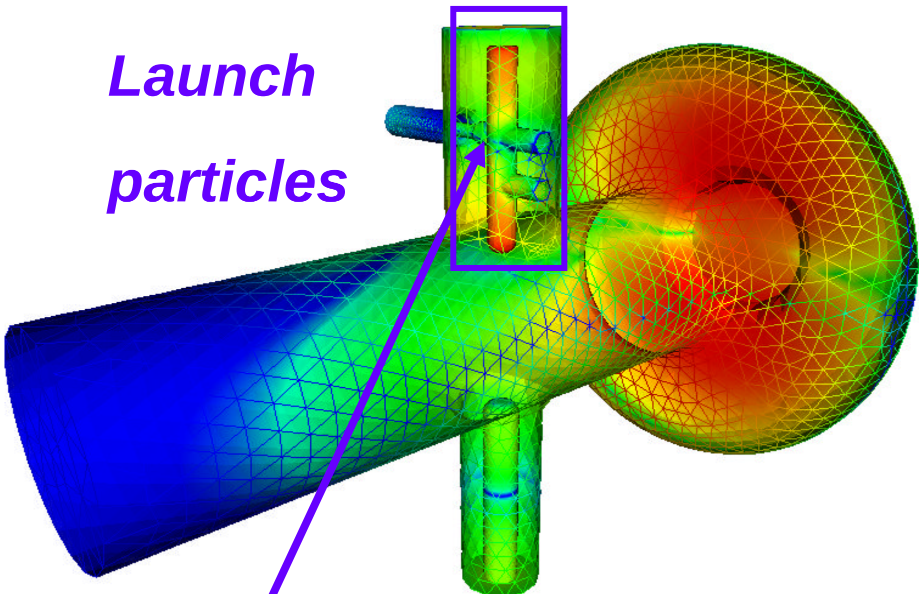
At dr=5mm,
Ez=0.1MV/m ~ 2.2MV/m
with dEz=0.1MV/m
No resonant trajectories found

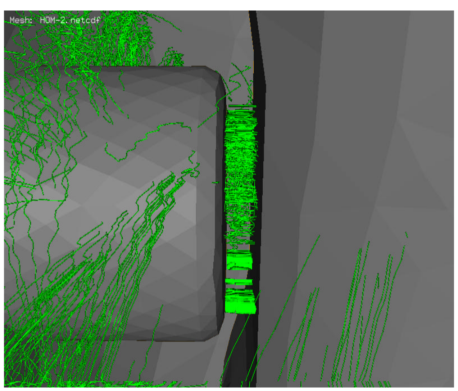
Computational Model

4. MP Analysis (SLAC-Track3P)

c) New HOM Coupler:

Launch particles

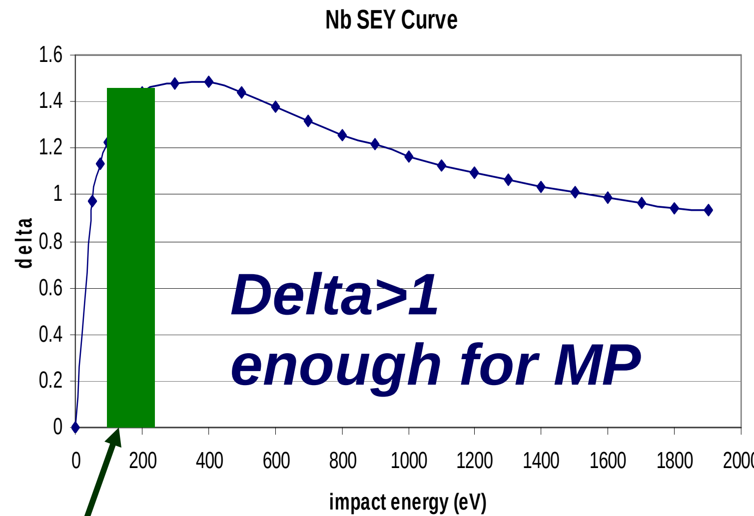


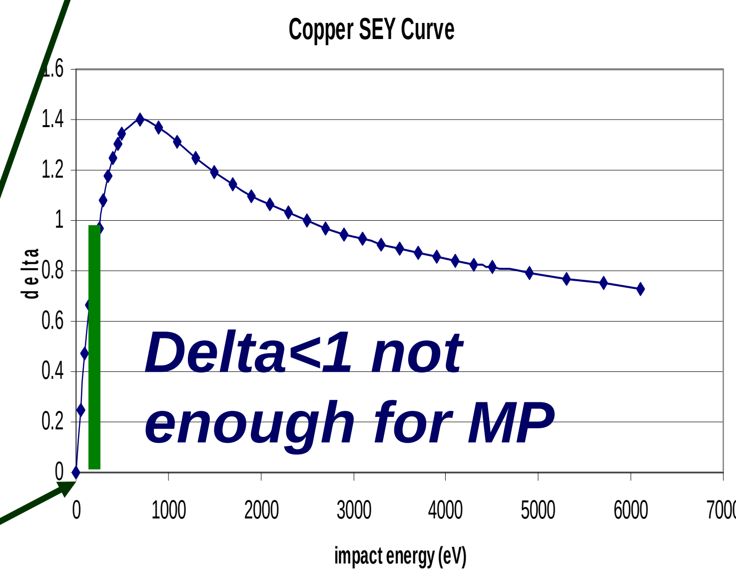


Resonant particle trajectories found when Vt=3MV/m~5MV/m

Impact Energy:

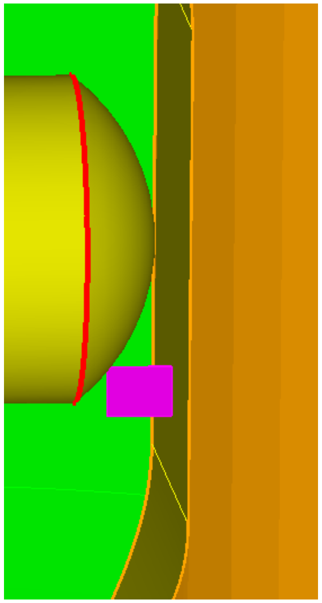
E=85eV ~ 240eV





4. MP Analysis (SLAC-Track3P)

Modified the pick up probe to reduce the occurrences of resonant trajectories (in progress)



Impact energy: 43eV/68eV

When Et=1MV/m~1.8MV/m

Summary

UK lab will build a copper model based on SLAC new design

Next to do:

1. ***Determine the damping requirements for the ILC crab cavity***
2. ***Optimize the FM/LOM/HOM/SOM couplers to meet them***
3. ***3D coupler kicks***
4. ***Compute the trapped modes between cavities***
5. ***Wakefield study with cavity imperfections***