WakeFest Summary 2

ILC Wakefest Workshop, Dec 11-13, 2007

Subject Areas

- Wakefield with cavity imperfection
- Beamline HOM absorber
- Large system simulation
- Multipacting simulation

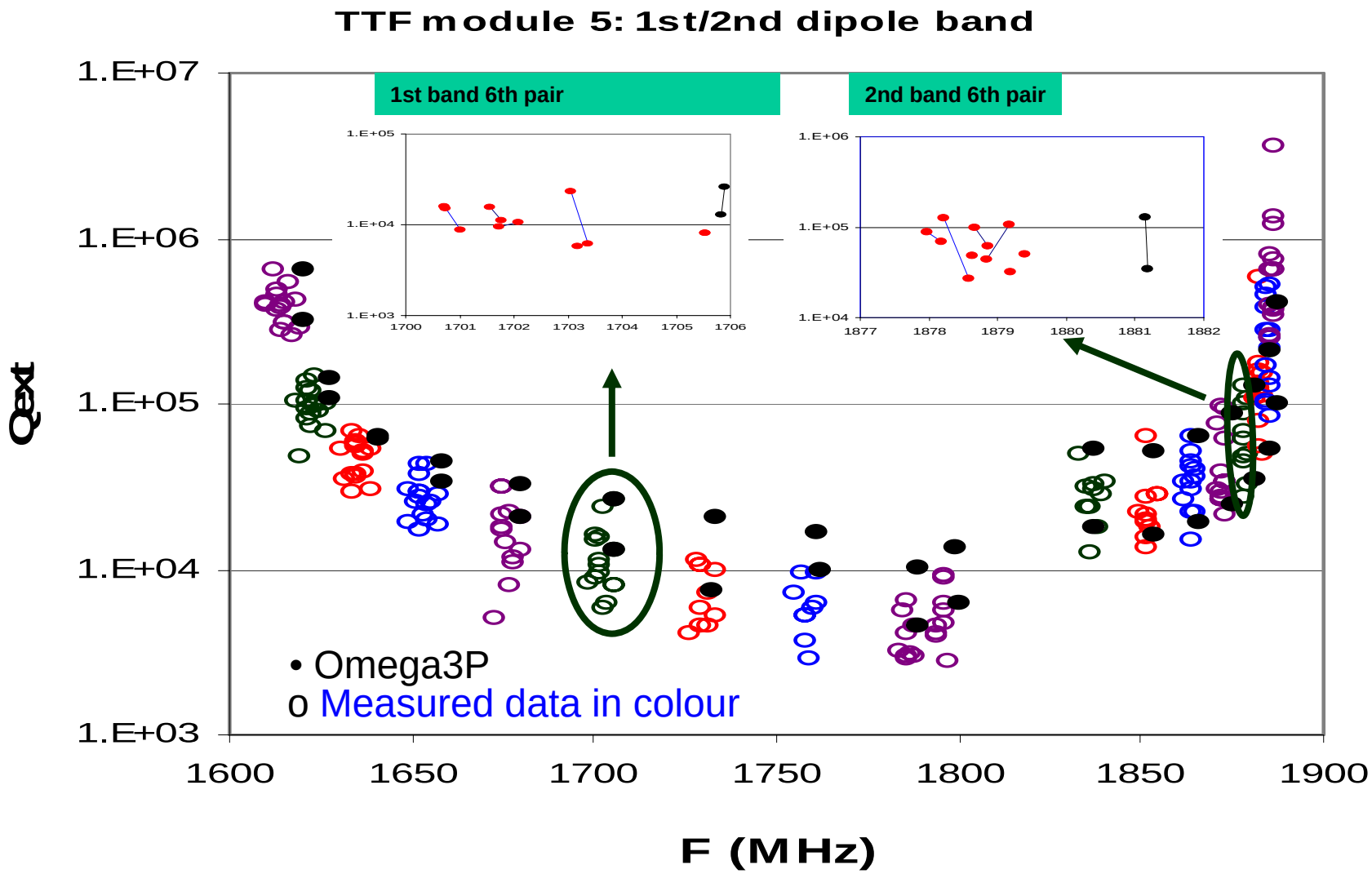
<u>A total of 9 talks</u>

Modeling Imperfection Effects on Dipole Modes in TESLA Cavity

Liling Xiao

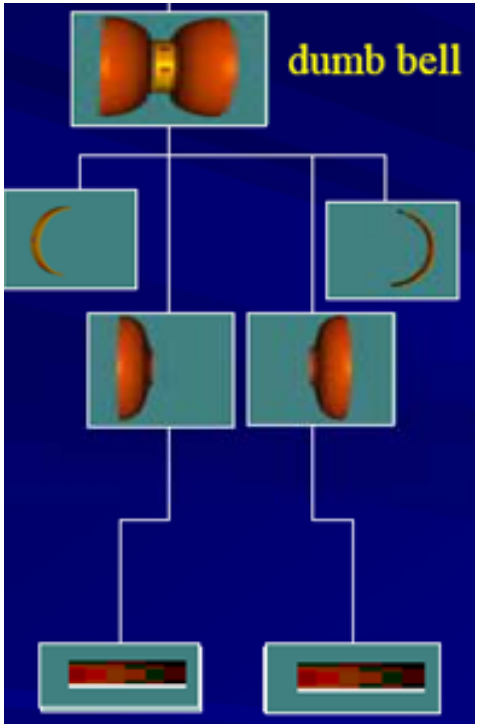
Advanced Computations Department, SLAC

1. TESLA Cavity Dipole Mode Measurement Data

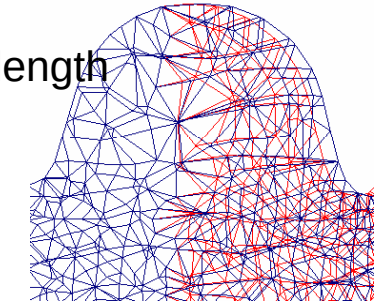


Dipole mode frequencies shift and Qext scatter

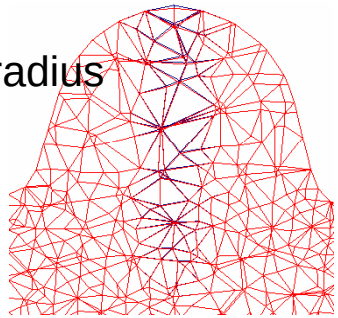
2. TESLA Cavity Imperfection Model



a) Cell length error

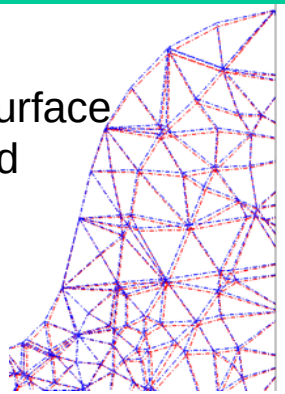


b) Cell radius error

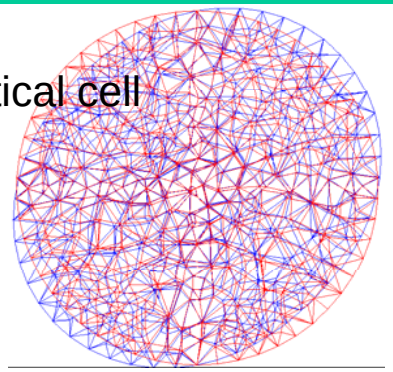


Red: ideal cavity, Blue: deformed cavity

c) Cell surface deformed



d) Elliptical cell shape

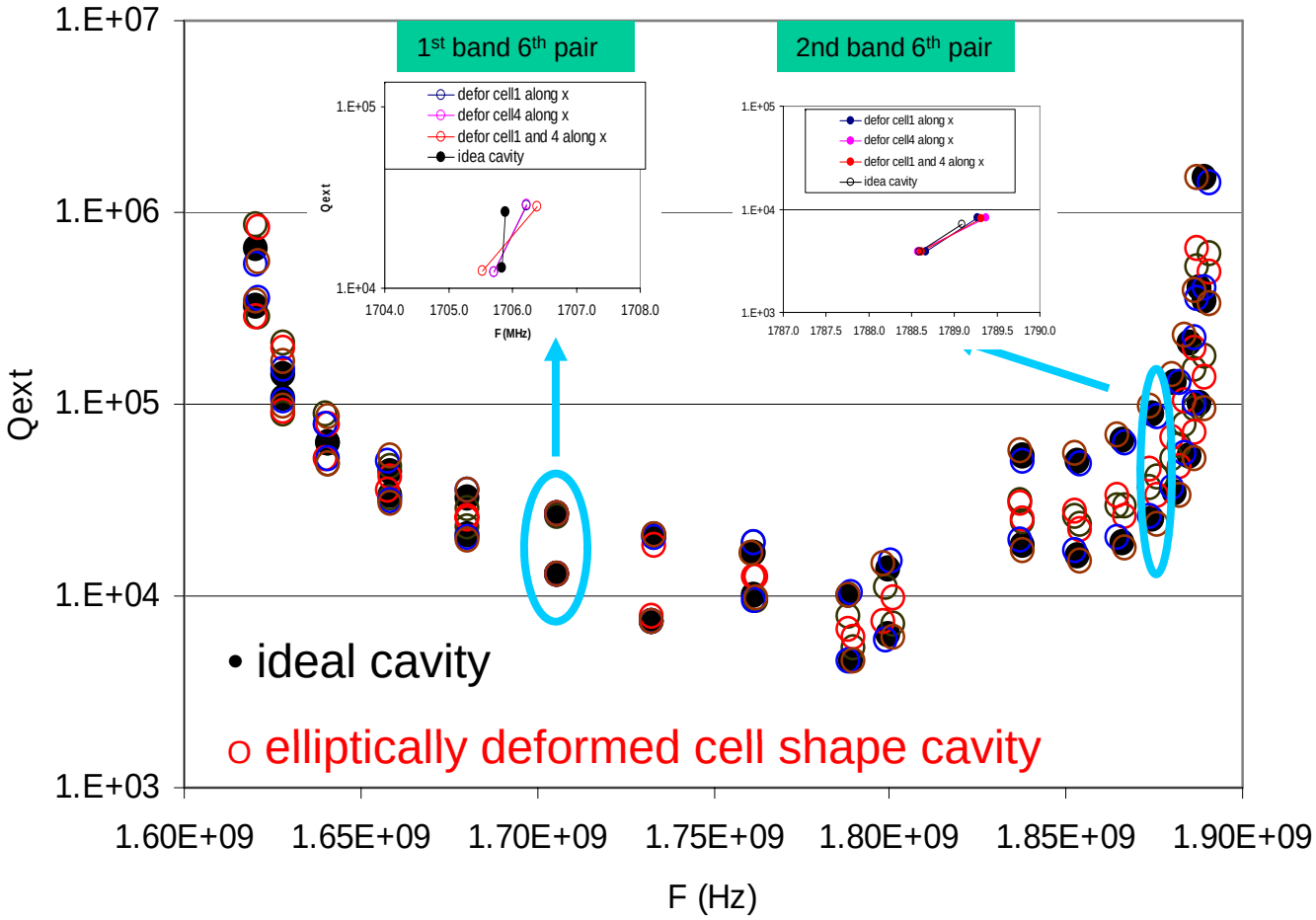


Distorted mesh for the cavity imperfection model

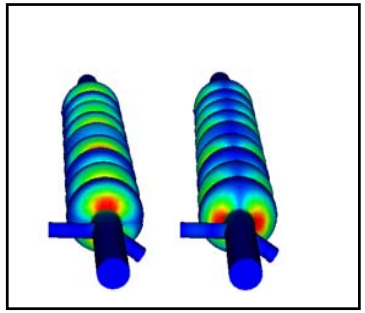
Example 2: Cell shape elliptical deformed (dr=0.25mm)

- cause mode polarization change and mode splitting

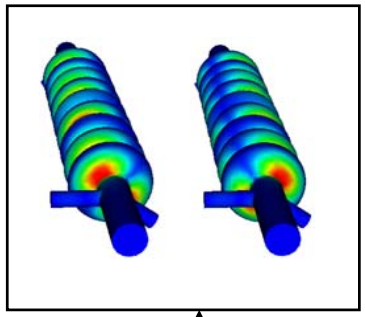
TDR cavity with elliptical cell shape

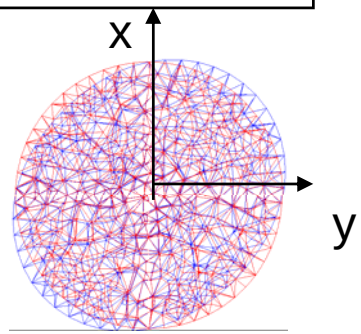


ideal cavity



Elli. deformed cavity

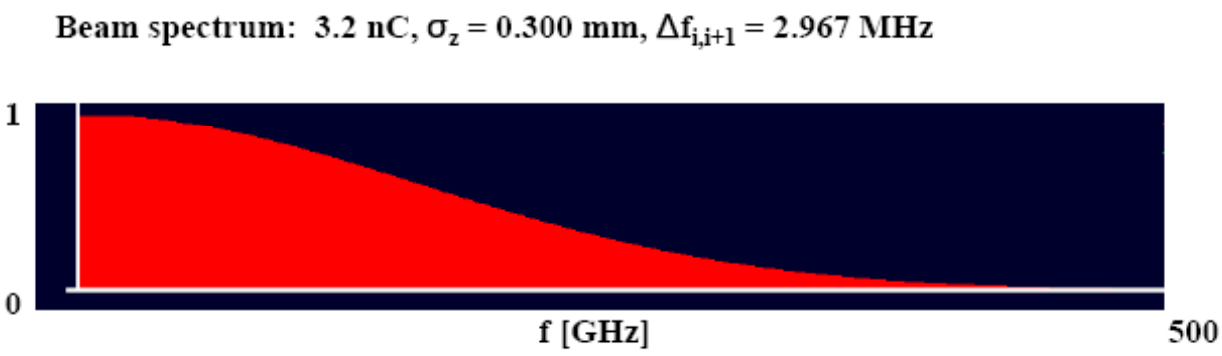


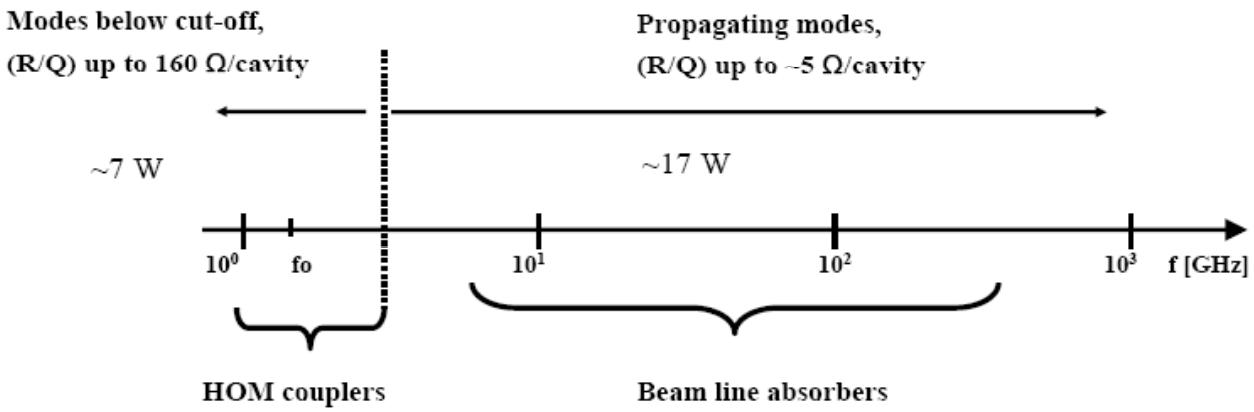


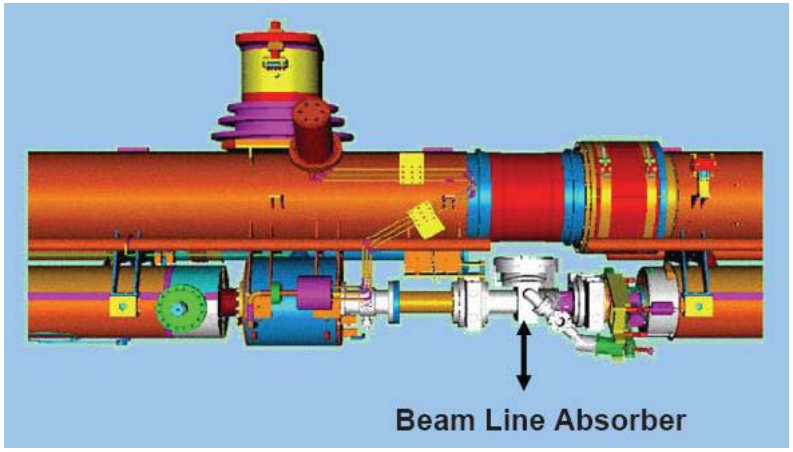
Beamline HOM Absorber

Talks:

- Beamline HOM Absorber – Oleg Nezhevenko, FNAL
- Beamline HOM absorber simulation using T3P – Liling Xiao, SLAC

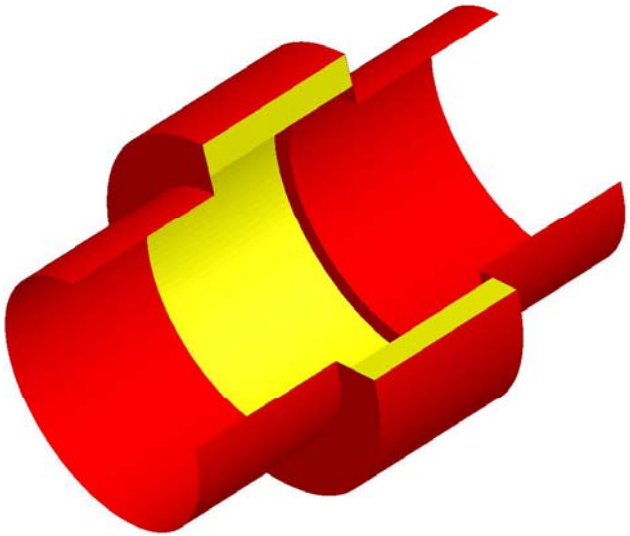




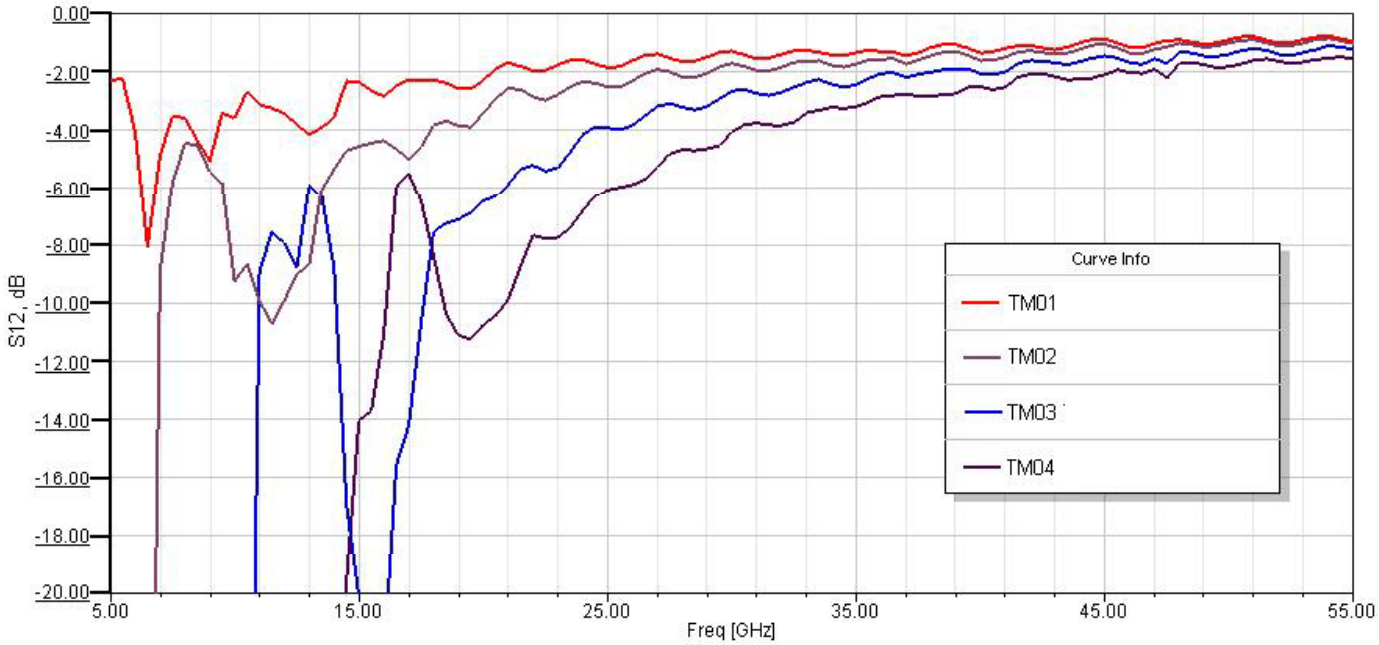


T.Higo, et al, IId ILC Workshop

Absorption efficiency estimations.

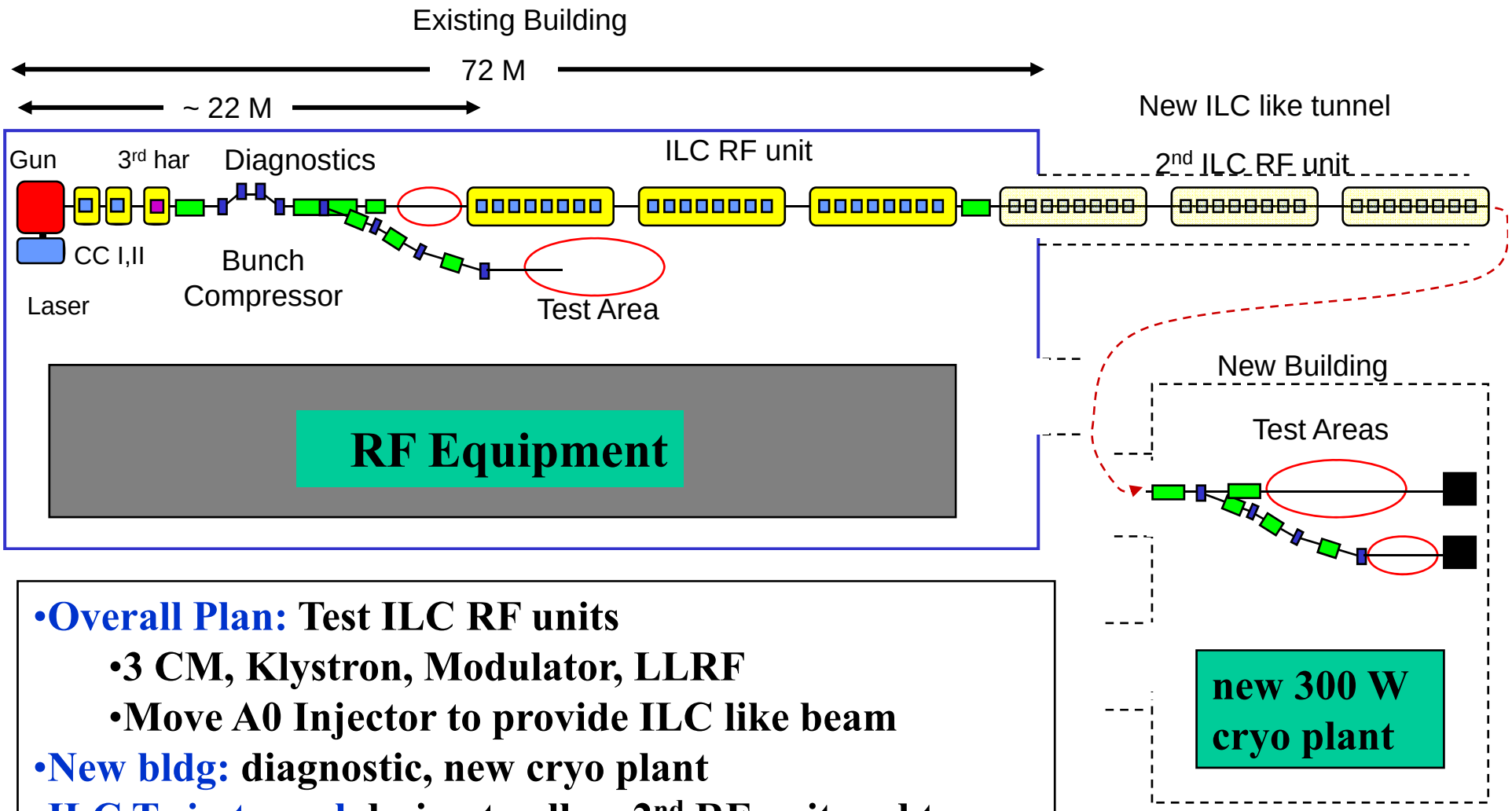


Simple model of HOM absorber: the ring has the length of 50mm, internal diameter of 90 mm, and the thickness of 10mm (DESY style).



RF Unit Test Facility

O.N.

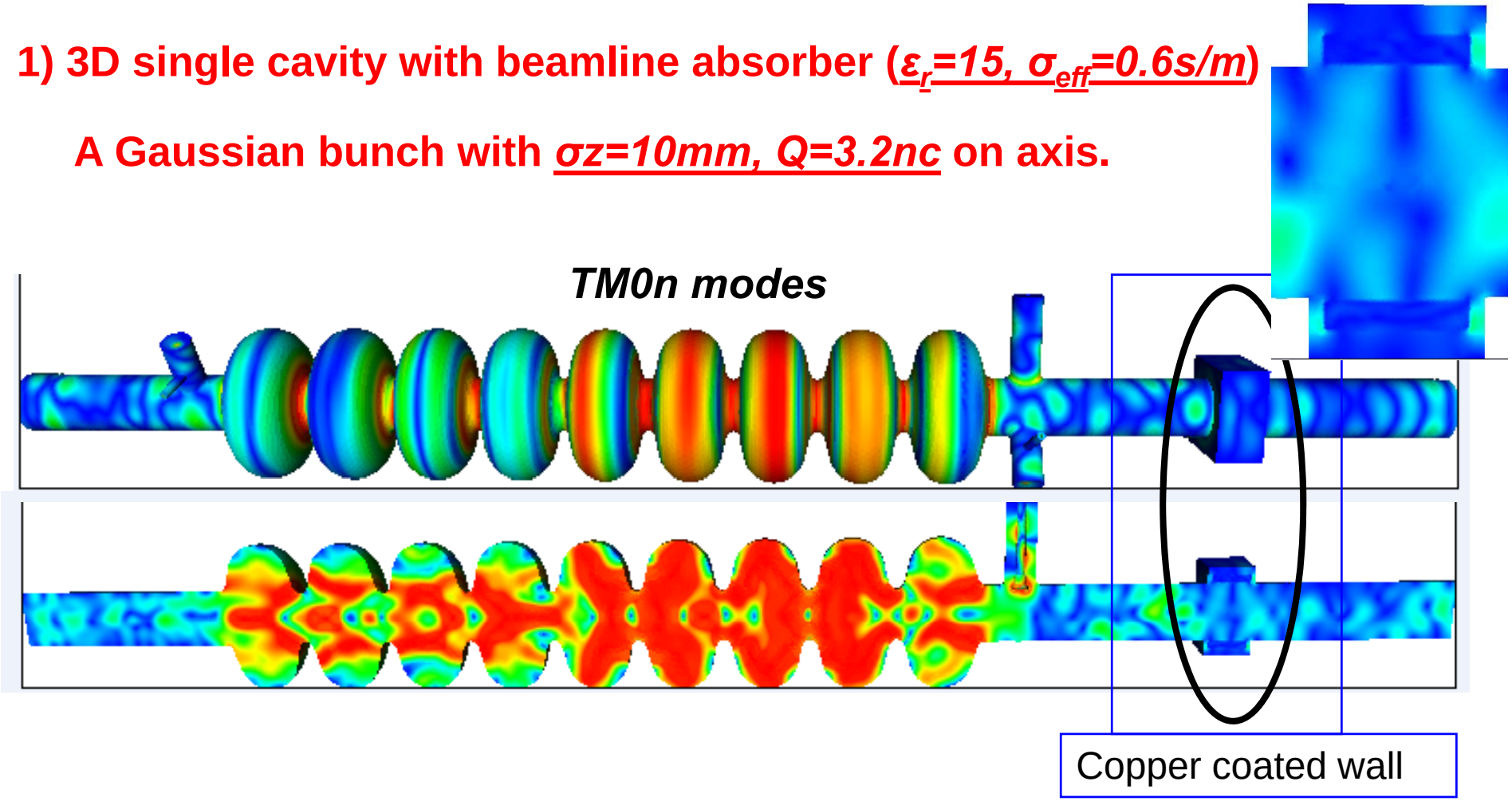


- **Overall Plan: Test ILC RF units**
  - **3 CM, Klystron, Modulator, LLRF**
  - **Move A0 Injector to provide ILC like beam**
- **New bldg: diagnostic, new cryo plant**
- **ILC Twin tunnel design to allow 2nd RF unit and to study tunnel layout and maintenance issues**

• Simulation Results

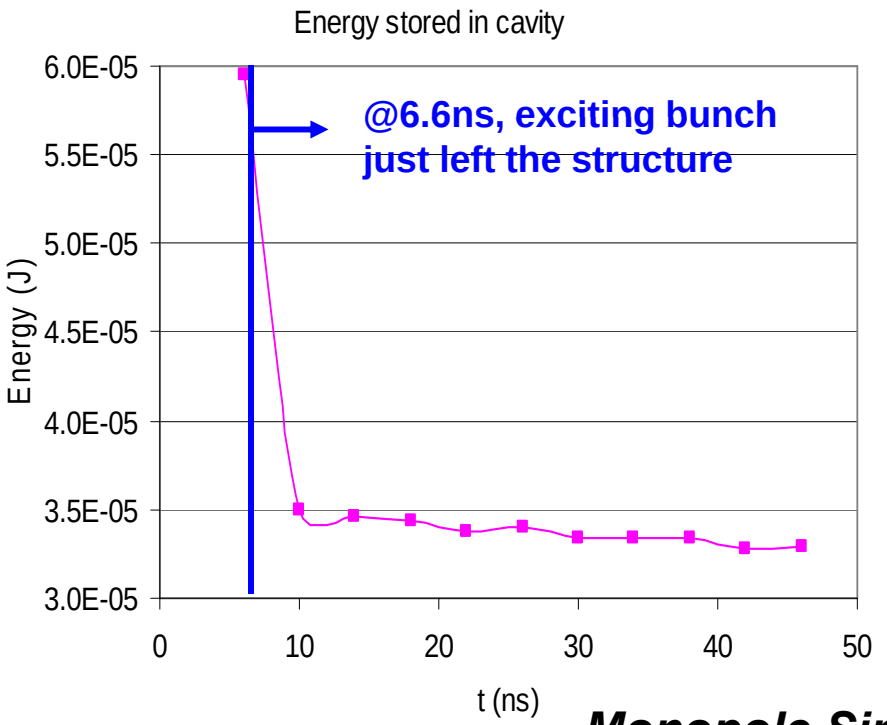
1) 3D single cavity with beamline absorber (*ε_r=15, σ_{eff}=0.6s/m*)

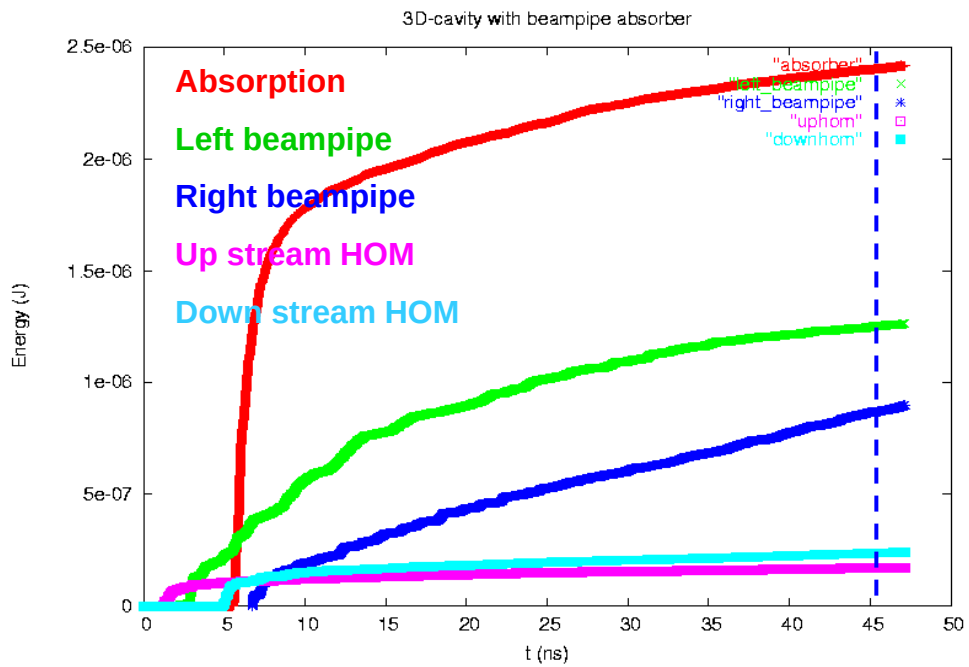
A Gaussian bunch with *σz=10mm, Q=3.2nc* on axis.



3.5million mesh elements, 2nd basis function run on Franklin at Nersc.

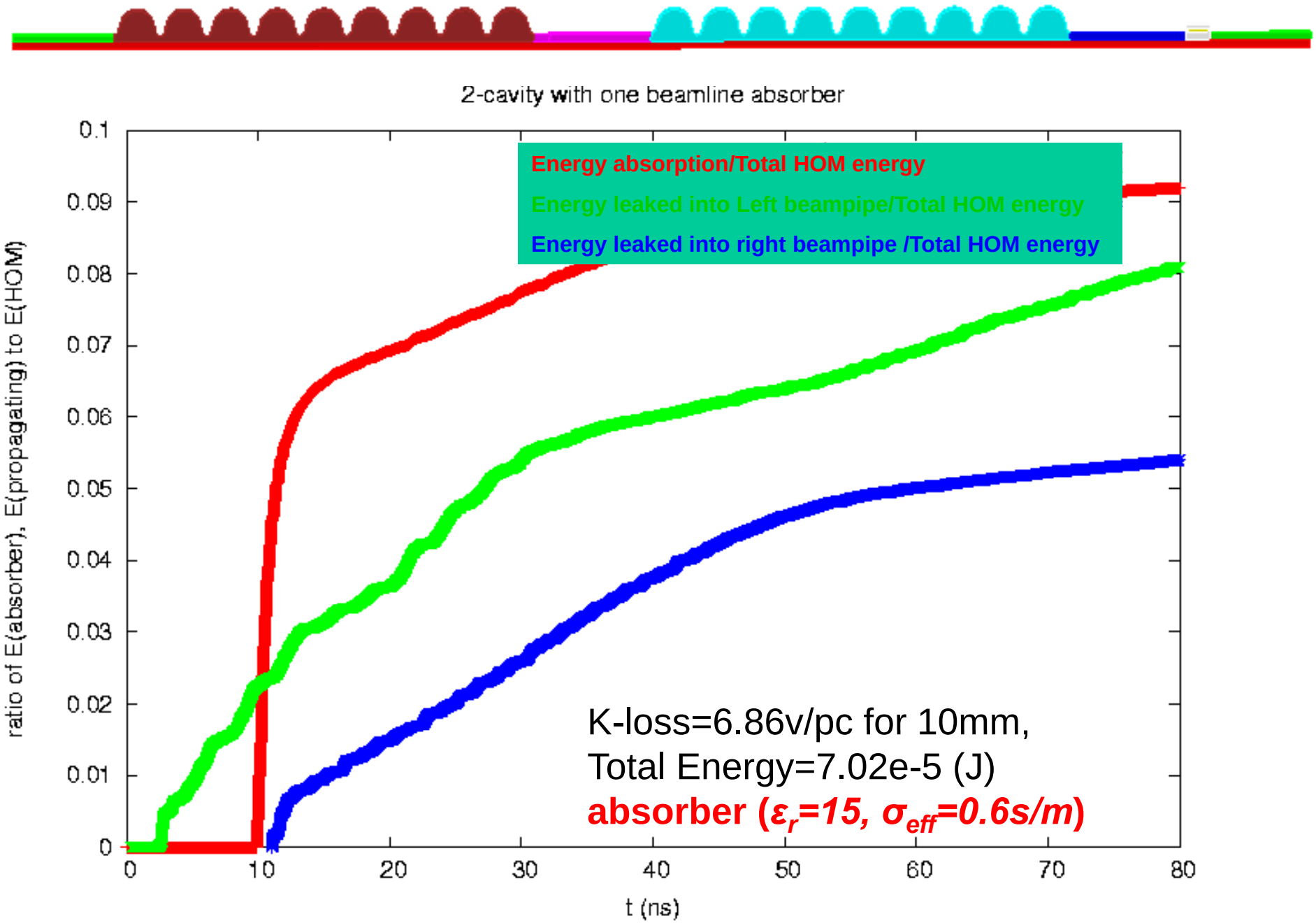
512 processors 24000 time steps within 12 hours





Monopole Single Passage Losses

One bunch Q=3.2nc, bunch length=10mm Loss factor (V/pc)=3.566V/pc	**Lossy dielectric conductivity σ_{eff}=0.6(s/m)** **Dielectric constant ε_r=15, Within 45ns**
Total Energy Generated by Beam (J)	**3.65e-5**
Energy stored in cavity (J)	*3.25e-5* *(FM mode energy=2.06e-5J)*
Energy leaked out HOM coupler ports (J)	*4.05e-7*
Energy propagated into beam pipe (J)	*2.11e-6*
Energy dissipated in the absorber (J)	*2.4e-6*
Energy loss on the copper absorber beampipe wall (J)	6.6e-10 (cold copper conductivity=350ms/m)

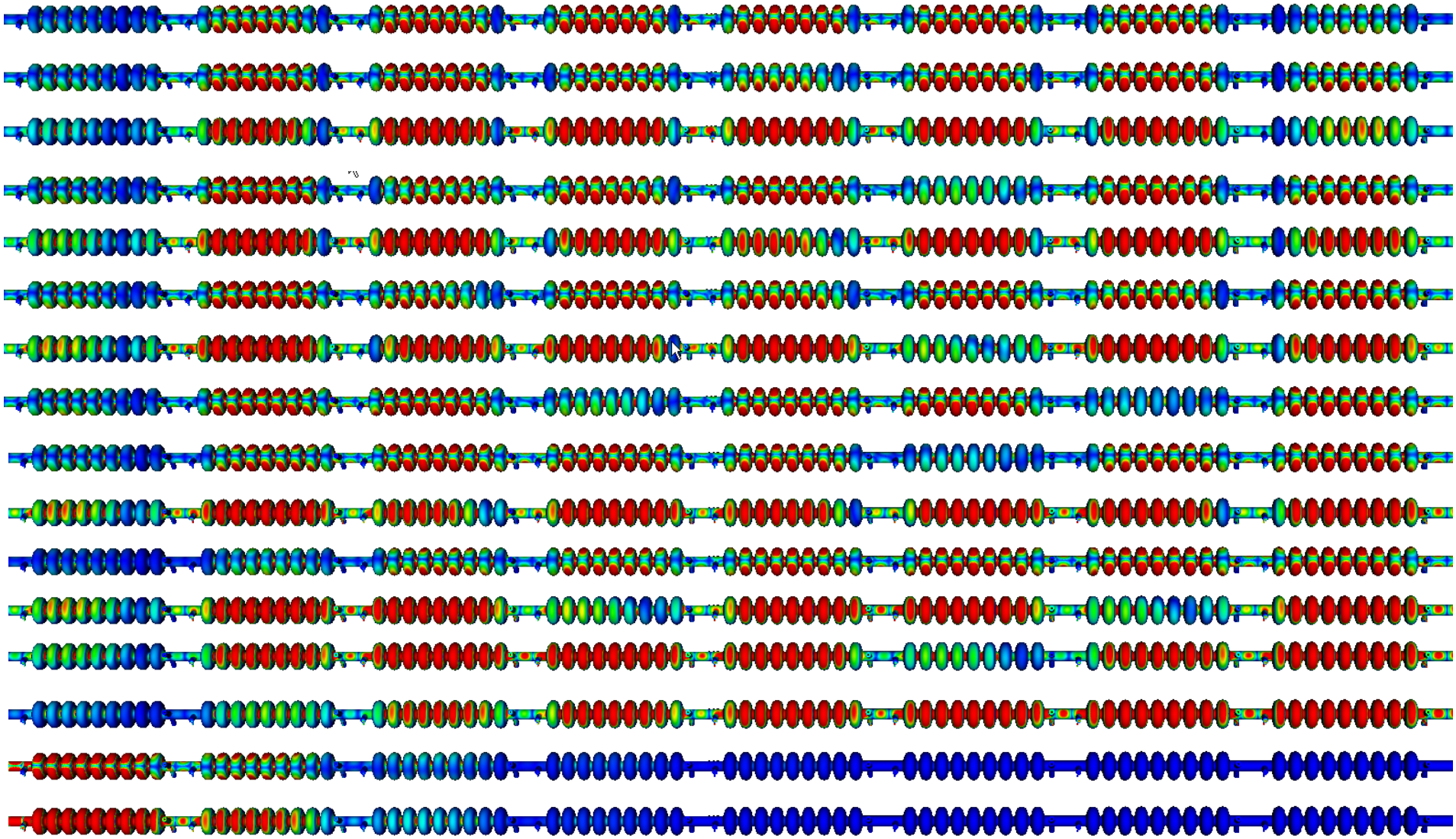

2-cavity with one beamline absorber
Energy absorption/Total HOM energy
Energy leaked into Left beampipe/Total HOM energy
Energy leaked into right beampipe /Total HOM energy
ratio of E(absorber), E(propagating) to E(HOM)
t (ns)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0
10
20
30
40
50
60
70
80
K-loss=6.86v/pc for 10mm,
Total Energy=7.02e-5 (J)
absorber (ε_r=15, σ_{eff}=0.6s/m)

Large System Simulation

Talks:

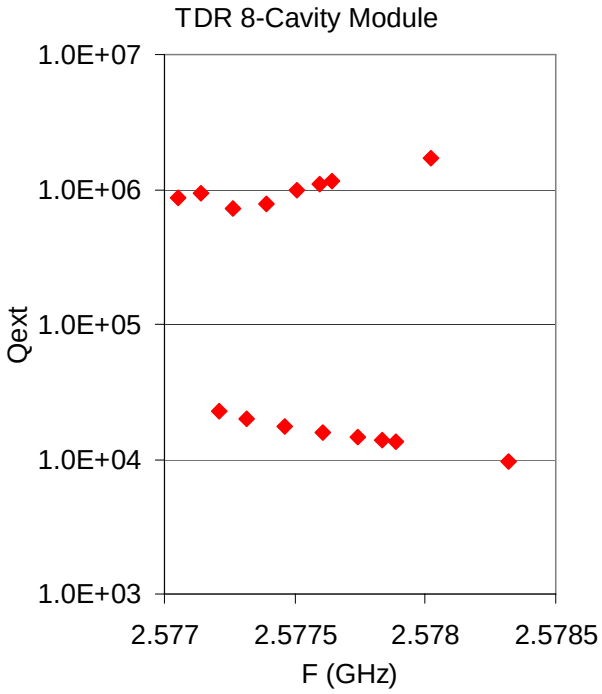
- Multi-cavity trapped mode simulation – Cho Ng, SLAC
- Globalised scattering matrix simulation in ILC cavities and modules – Ian Shinton, Manchester University
- Large scale 3D wakefield simulations with PBCI – Sascha Schnepp, T.U. Darmstadt

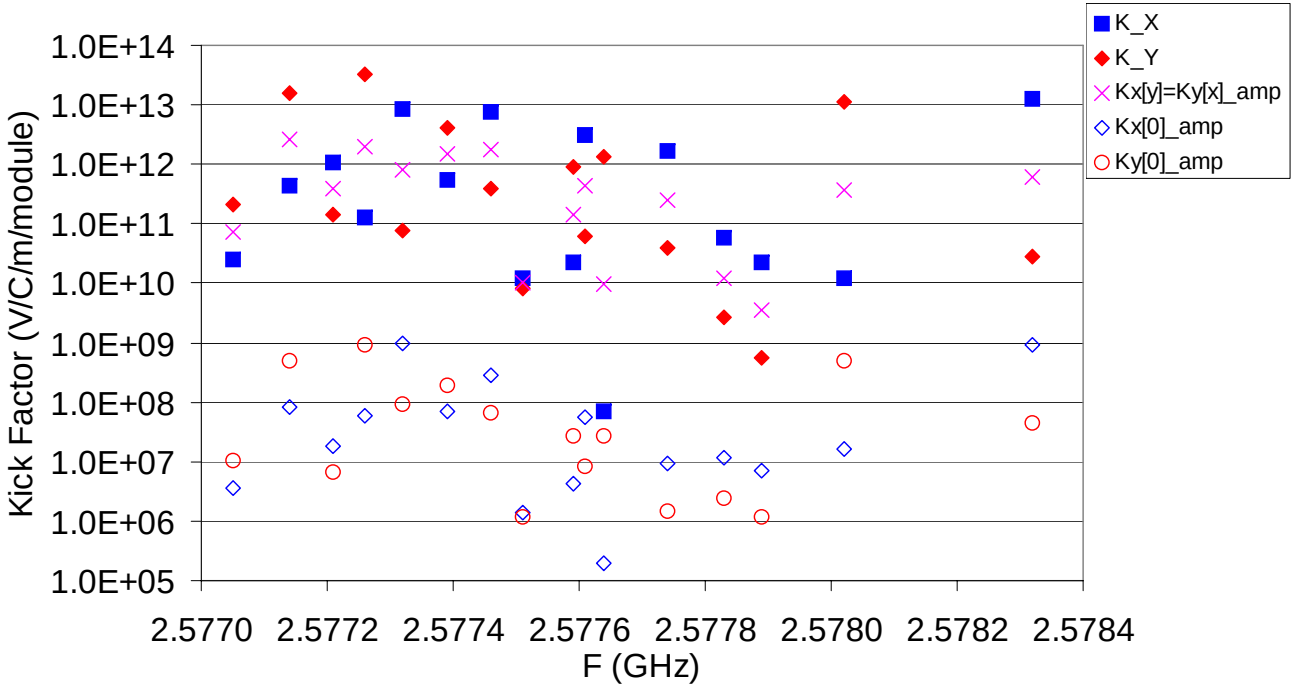
3rd Dipole-Band Trapped Modes in Cryomodule



C.N.

Cryomodule 3rd Dipole-Band Mode - Q_{ext} and Kick



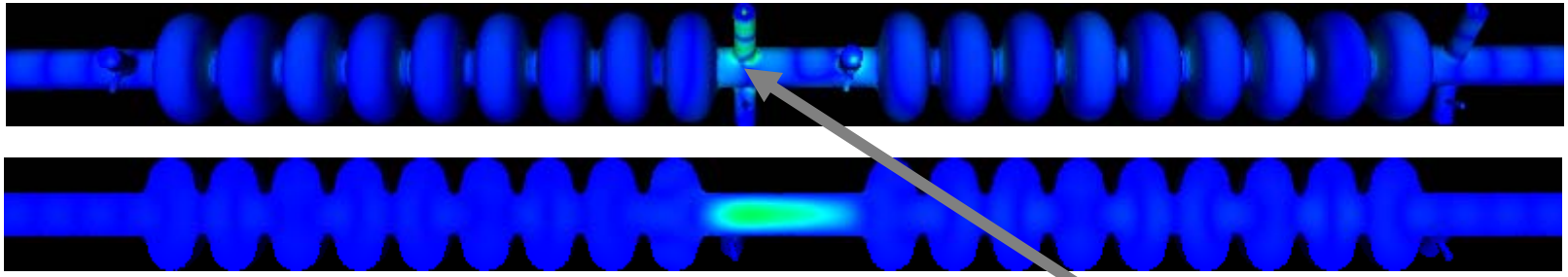


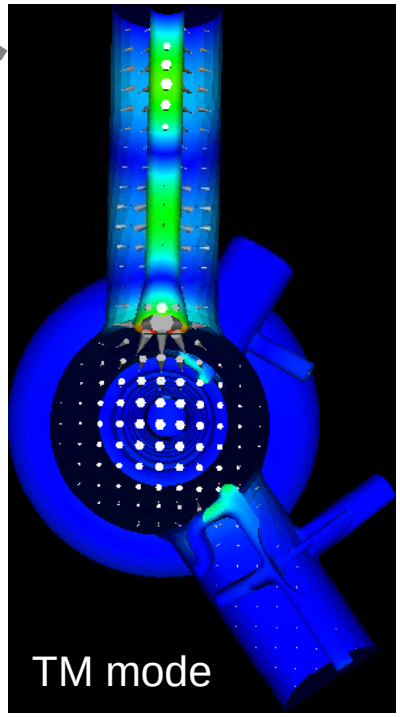
- Modes above cutoff frequency are coupled throughout 8 cavities
- Modes are generally x/y-tilted & twisted due to 3D end-group geometry
- Both tilted and twisted modes cause x-y coupling

C.N.

Trapped Mode using Omega3P

Electric field



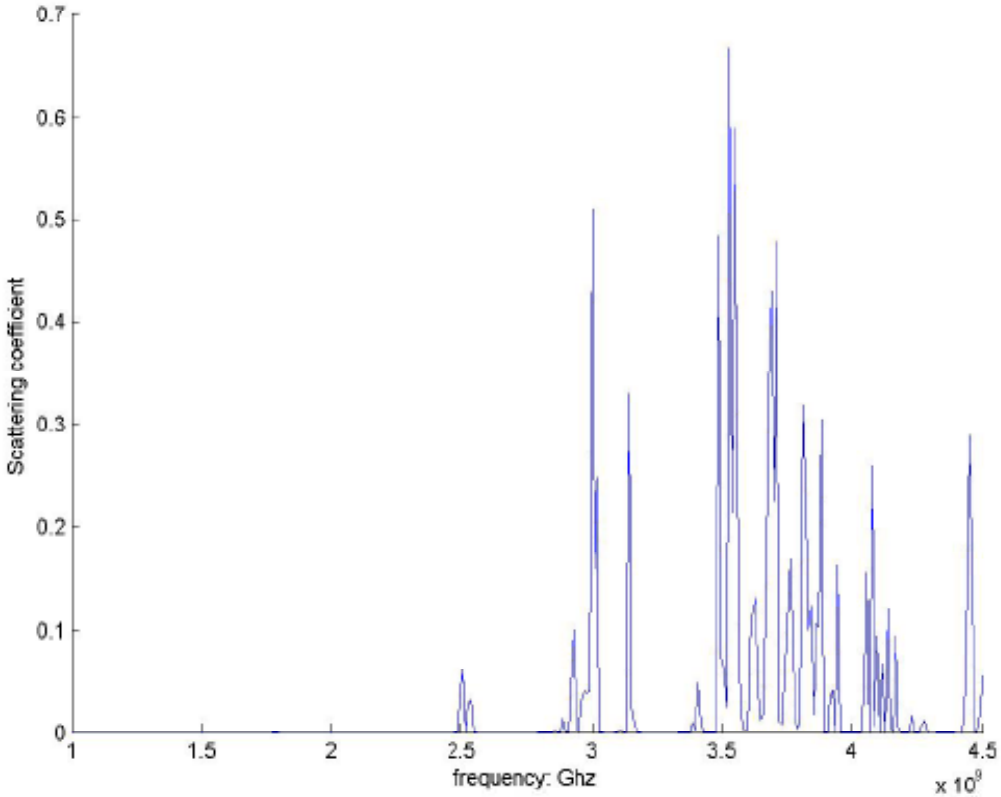


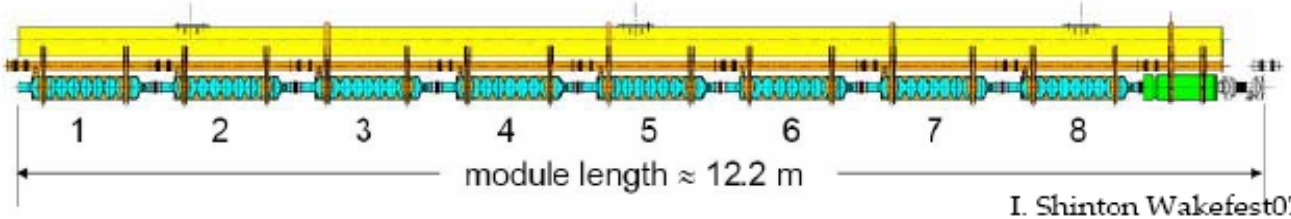
Trapped mode

- TM-like mode localized in beampipe between 2 cavities
- Frequency = 2.948 GHz, slightly higher than TM cutoff at 2.943 GHz
- R/Q = 0.392 Ω; Q = 6320
- Mode power = 0.6 mW (averaged)

C.N.

Cascaded scattering matrix S21 of mode 1 as a function of mode 1 (TE11) in a complete Tesla Module



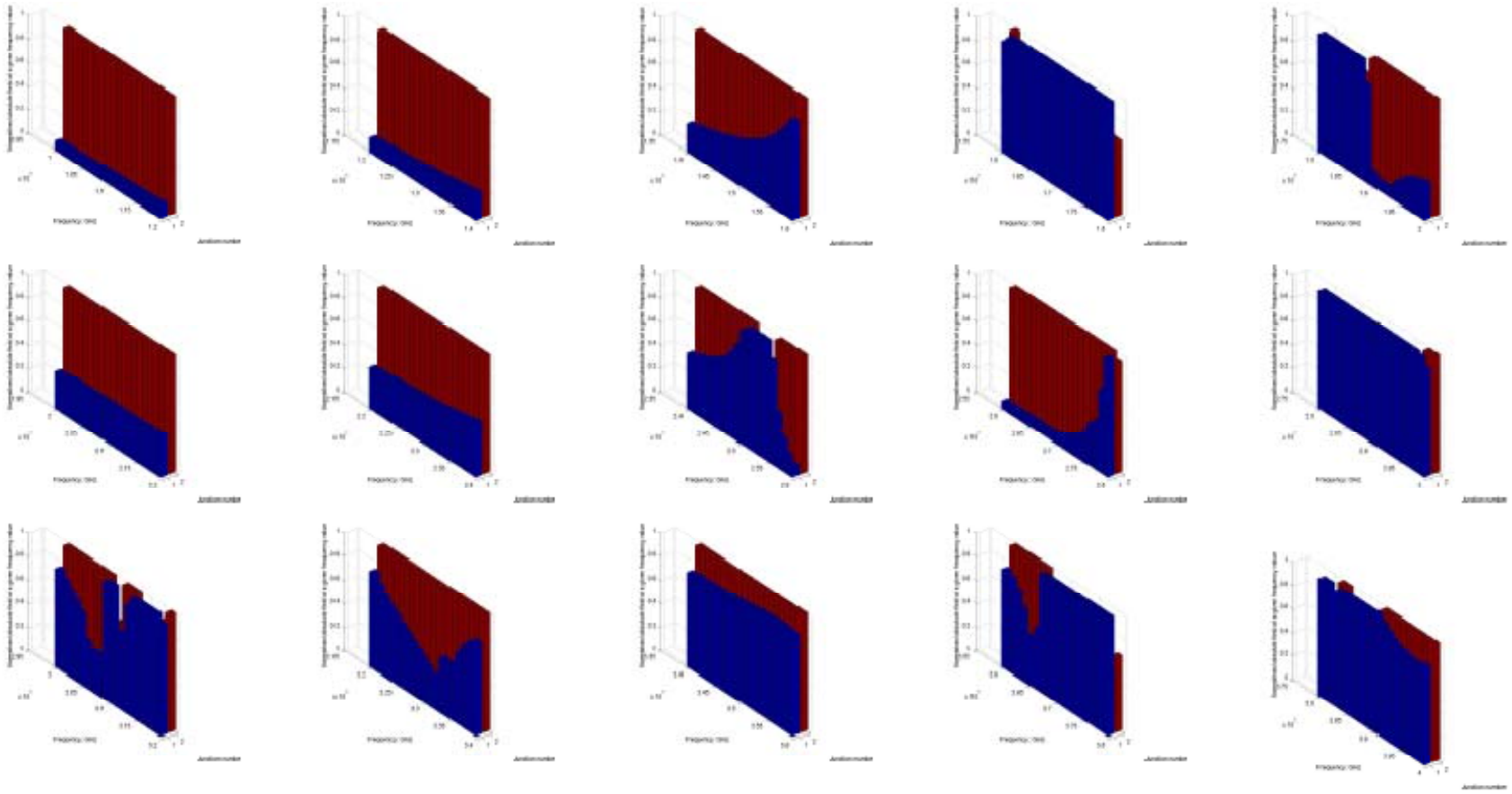


Obtaining useful electromagnetic fields, kicks, R/Q's and wakefields from a cascading simulation

- By itself the GSM does not tell us a great deal
- The derivation of the electromagnetic fields from the GSM is what is required for useful design information: kicks, R/Q's, Wakefields etc.....
- There are a number of possibilities that could be used to calculate the electromagnetic field from the GSM:

1) Mode matching – computationally inexpensive; however care with the physics must be used.
2) Use the GSM as boundary conditions in a reworked driven modal solution – note this method would be computationally very expensive and time consuming.

A quick look at the normalised fields at the junctions across all frequencies



Introduction

There is an actual demand for:

1. Wake field simulations in arbitrary 3D-geometry

   3D-codes

2. Accurate numerical solutions for high frequency fields

   (quasi-) dispersionless codes

3. Utilizing large computational resources for ultra-short bunches

   parallelized codes

4. Specialized algorithms for long accelerator structures

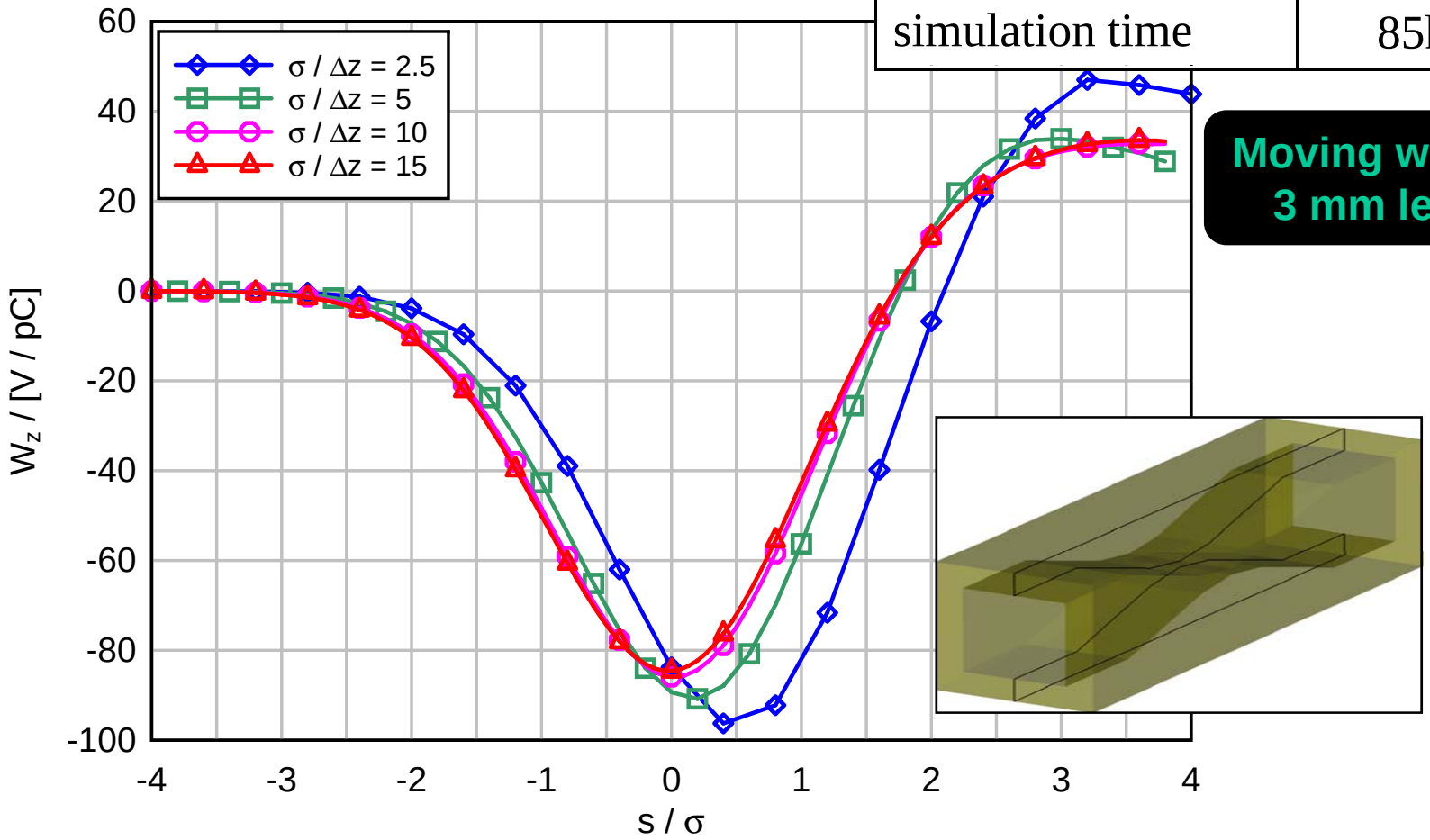
   moving window codes

ILC-ESA collimator

ILC-ESA collimator #8

bunch size	*300μm*
no. of grid points	~450M
no. of processors	24
simulation time	85hrs

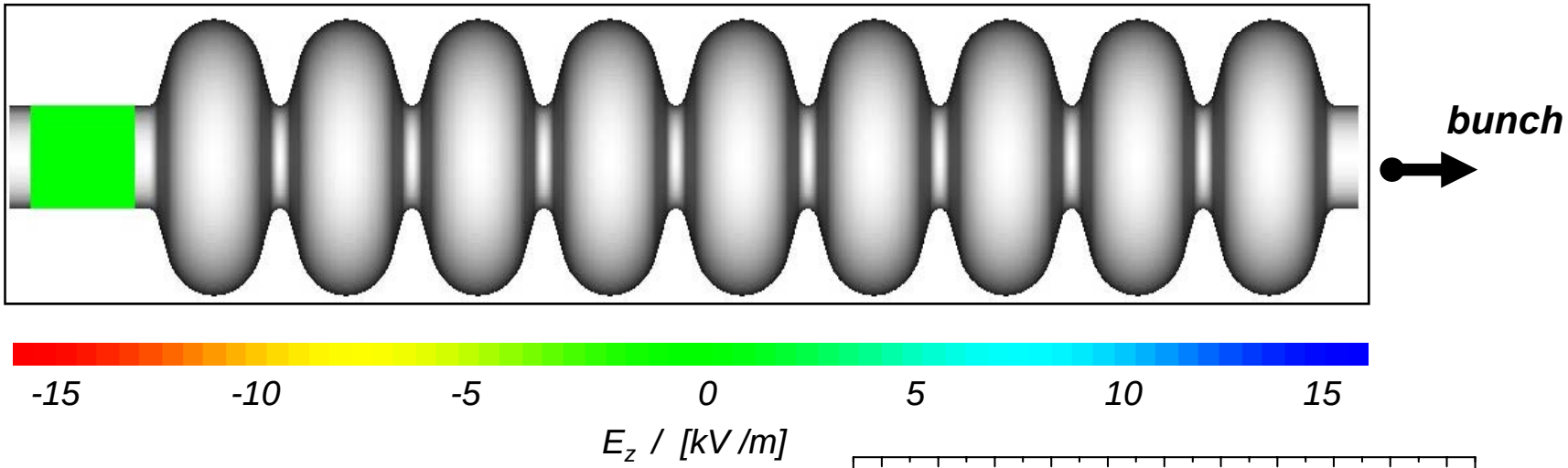
Convergence vs. grid step



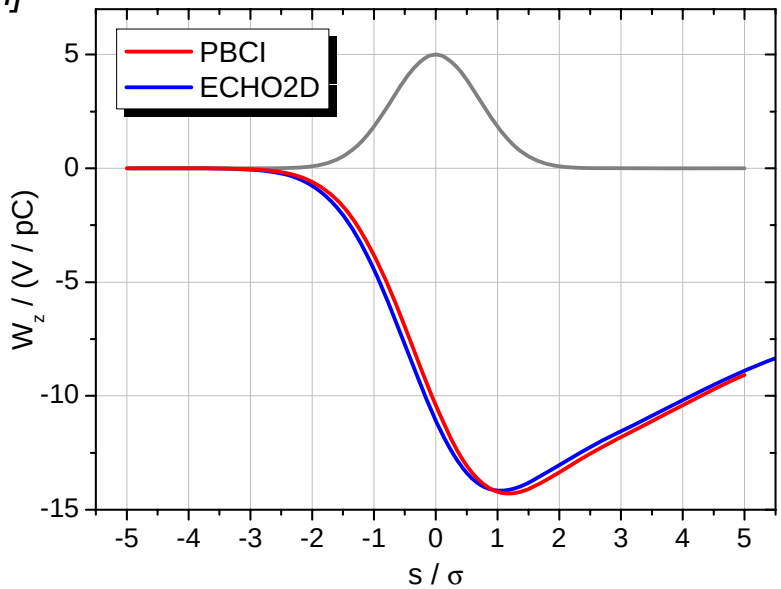
Moving window: 3 mm length

TESLA / HOM coupler

TESLA 9-cell cavity



bunch length	1mm
bunch charge	1nC
cavity length	1.5m
no. of grid points	~760M
no. of processor cores	408
simulation time	~40hrs



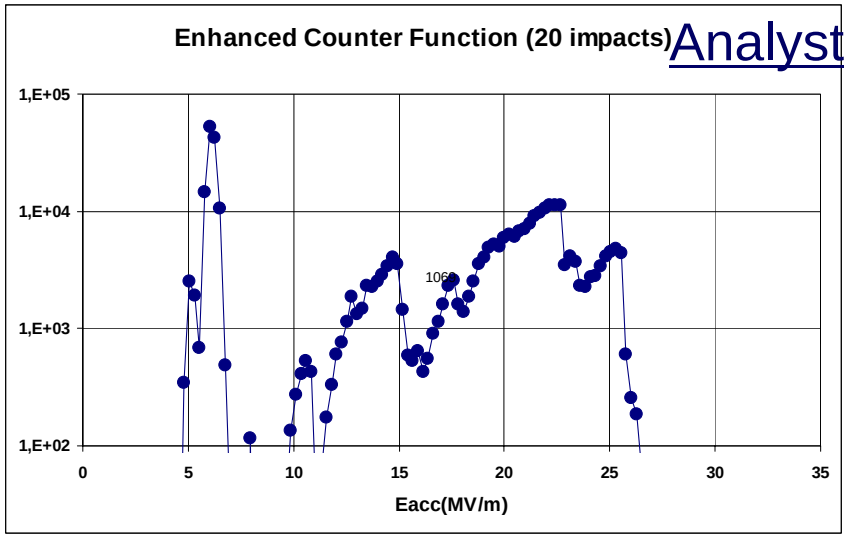
Multipacting Simulation

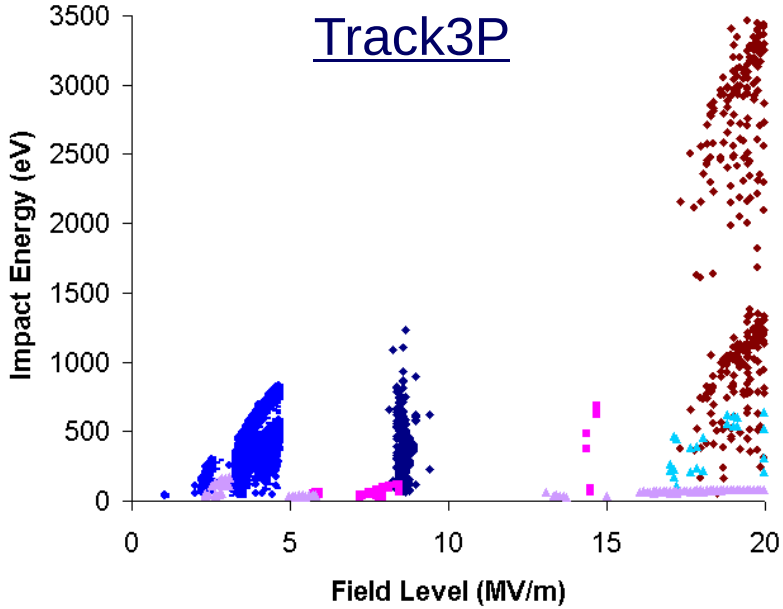
Talks:

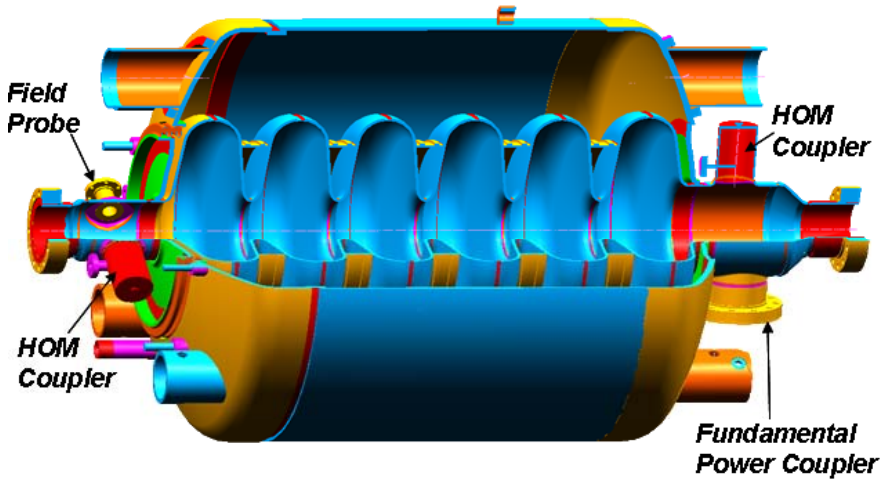
- Multipacting simulation for the SNS cavity using Analyst – I. Gonin, FNAL
- Multipacting simulation using parallel code Track3P – Lixin Ge, SLAC
- TTF-III coupler processing and multipacting simulation using MAGIC – Faya Wang, SLAC

MP IN SNS CAVITY

I.G & L.G.



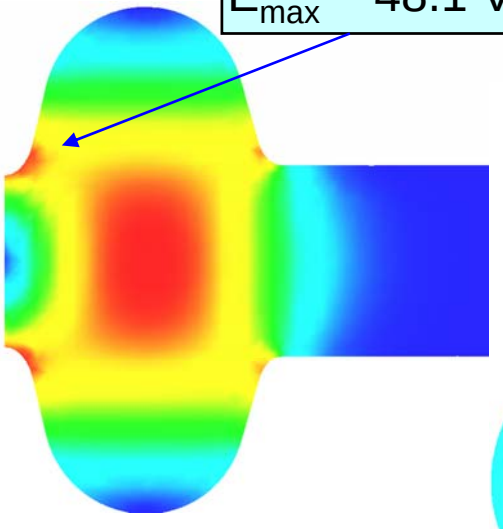


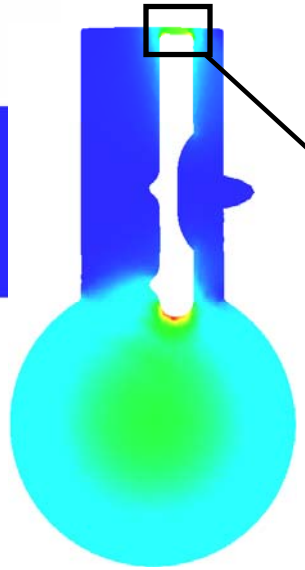


Models simulated using Analyst and Track3P are different!

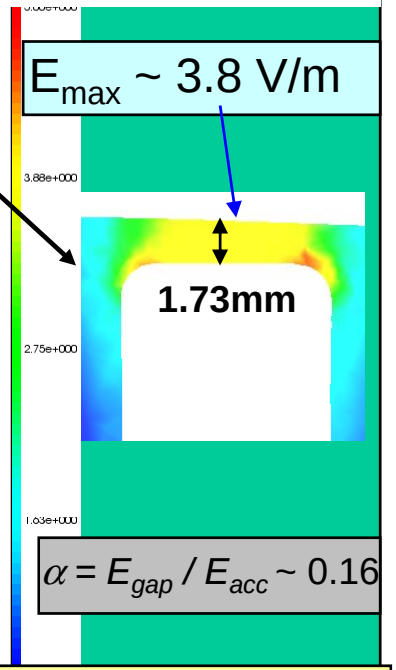
MP in ILC HOM coupler: notch gap

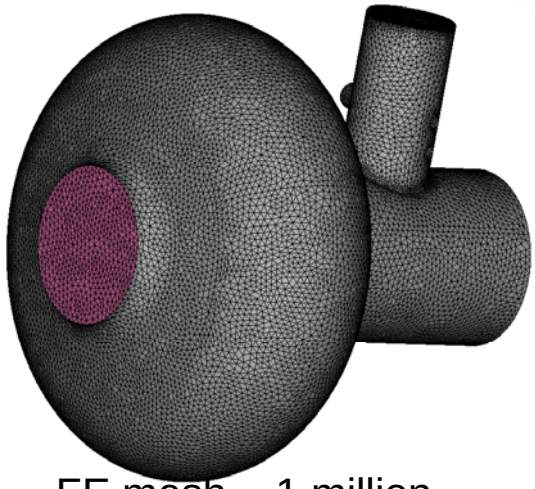
I.G.



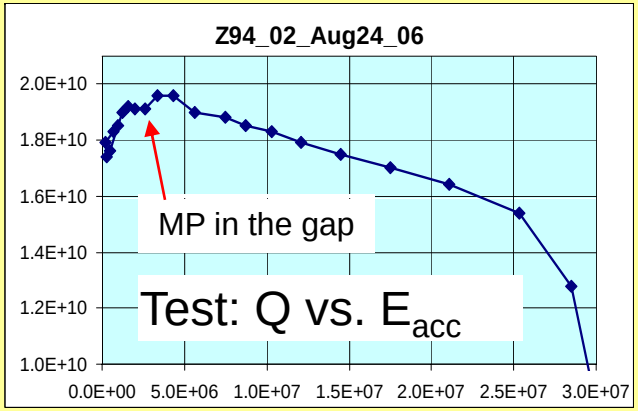


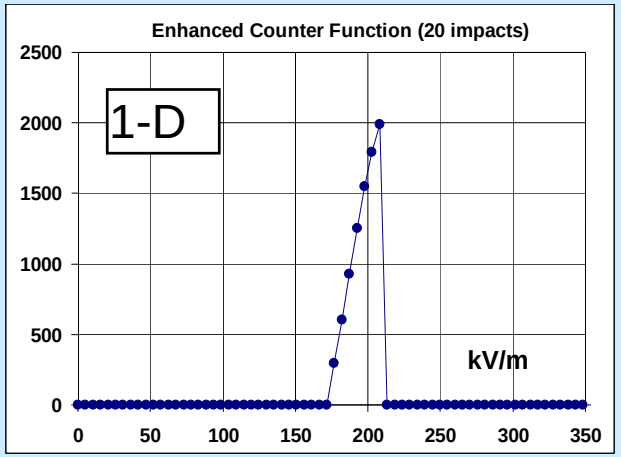
HOM coupler





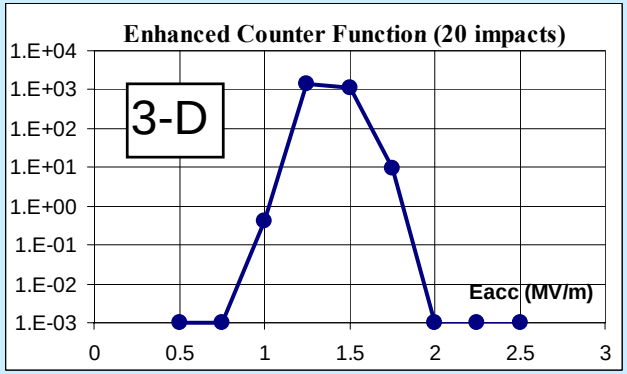
FE mesh, ~1 million second order elements





Enhanced Counter Function for gap 1.73mm and 1.3GHz

$E_{MP\_analytical}$ ~ 200 kV/m
$E_{acc} = E_{MP} / \alpha$ ~ 1.25 MV/m

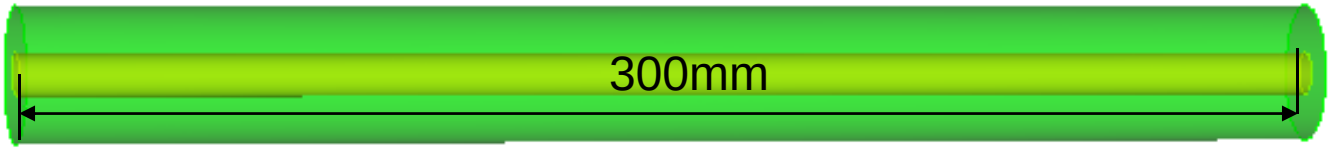


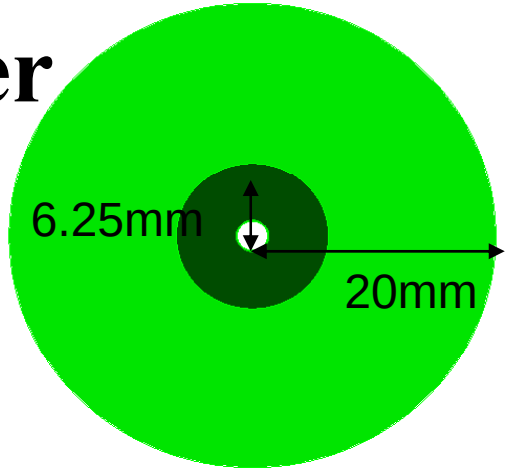
Analyst results

Good correlation between 1D, 3D&measurements

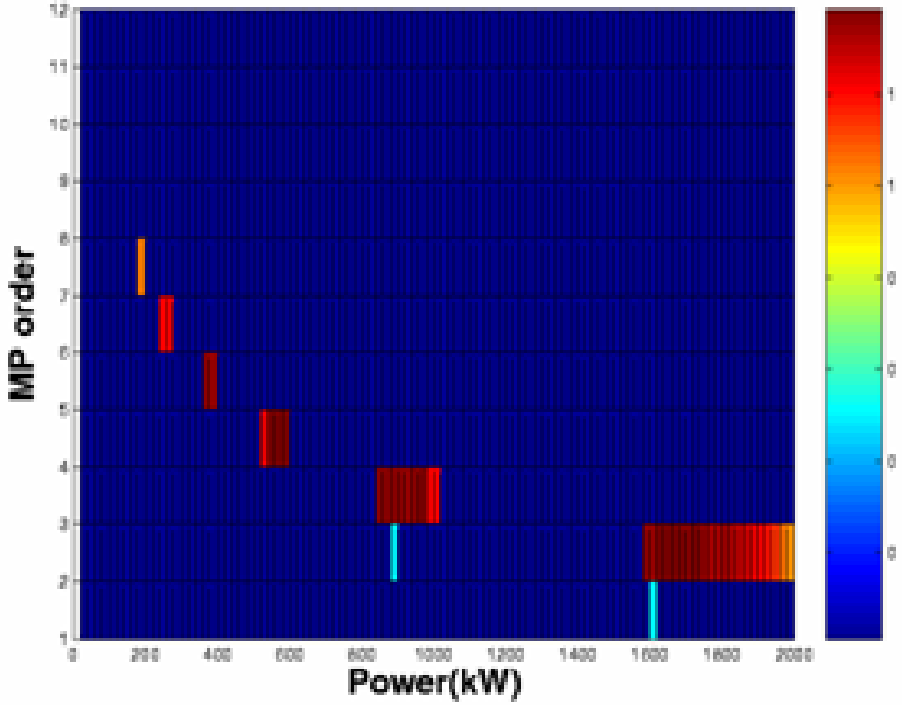
L.G.

Cold Coax in TTF-III Coupler

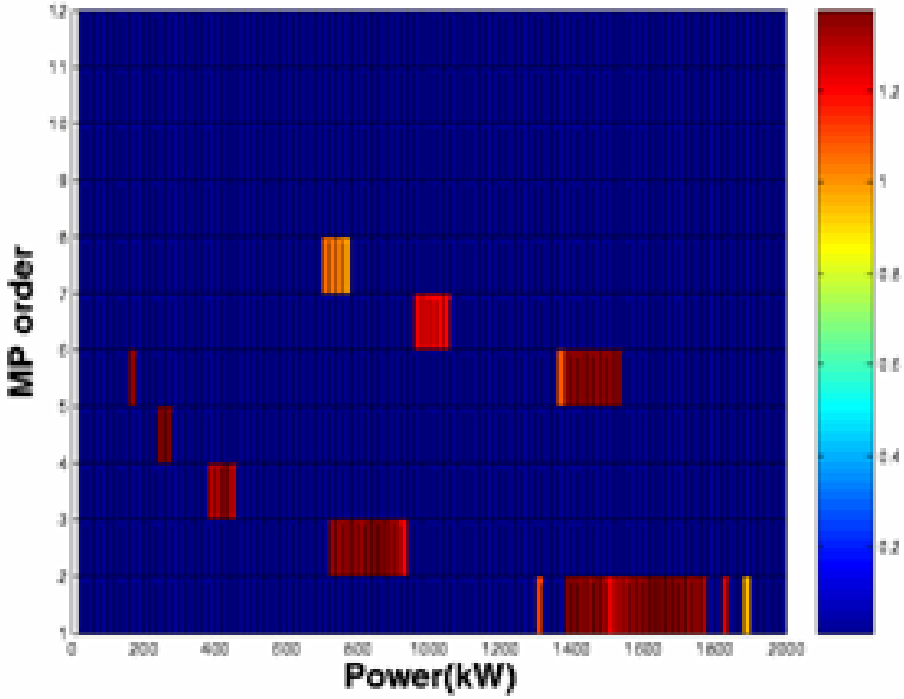




Reflection: 0.0

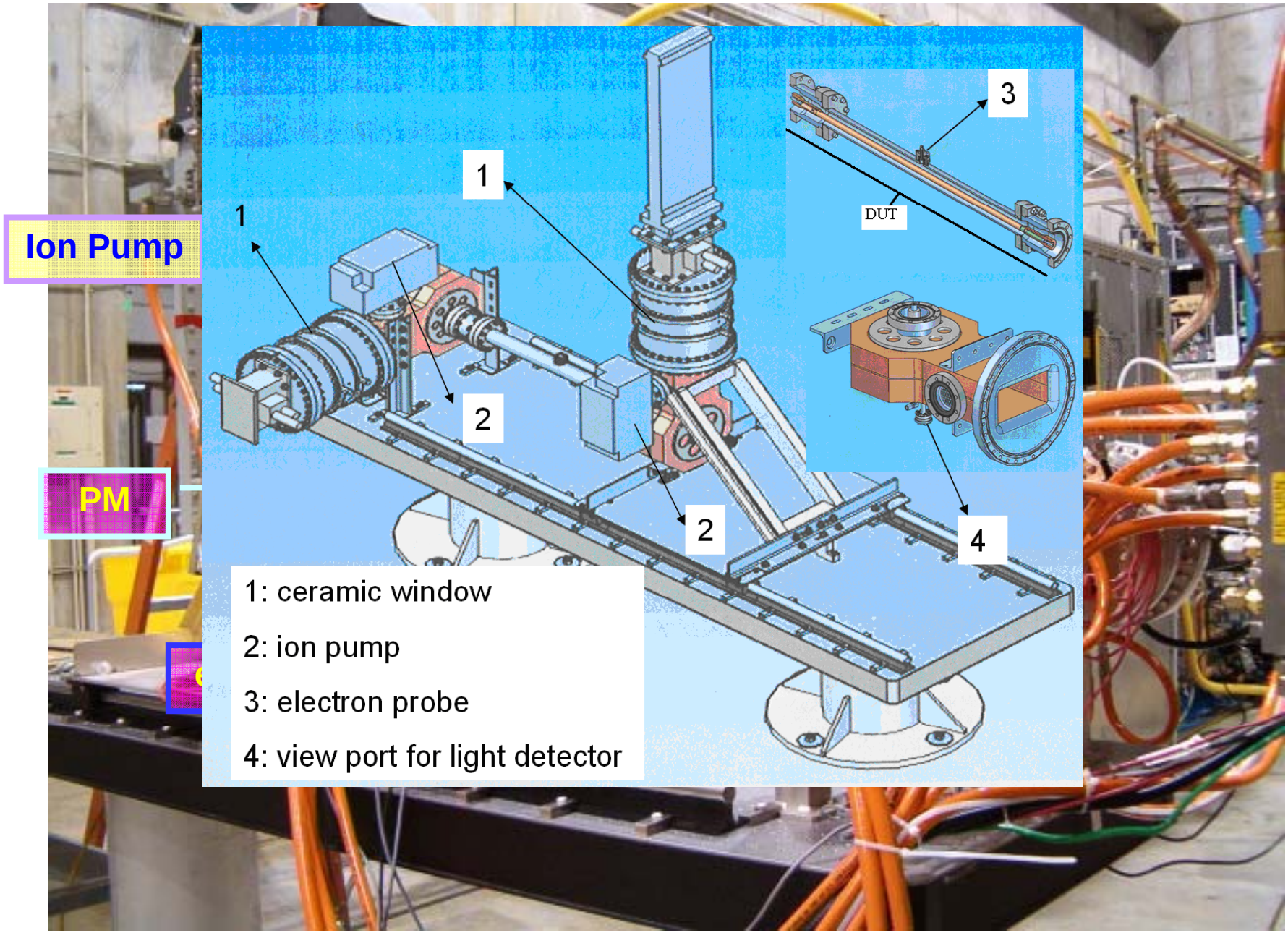


Reflection: 0.5



Delta as a function of RF input power and Multipacting order

F.W.

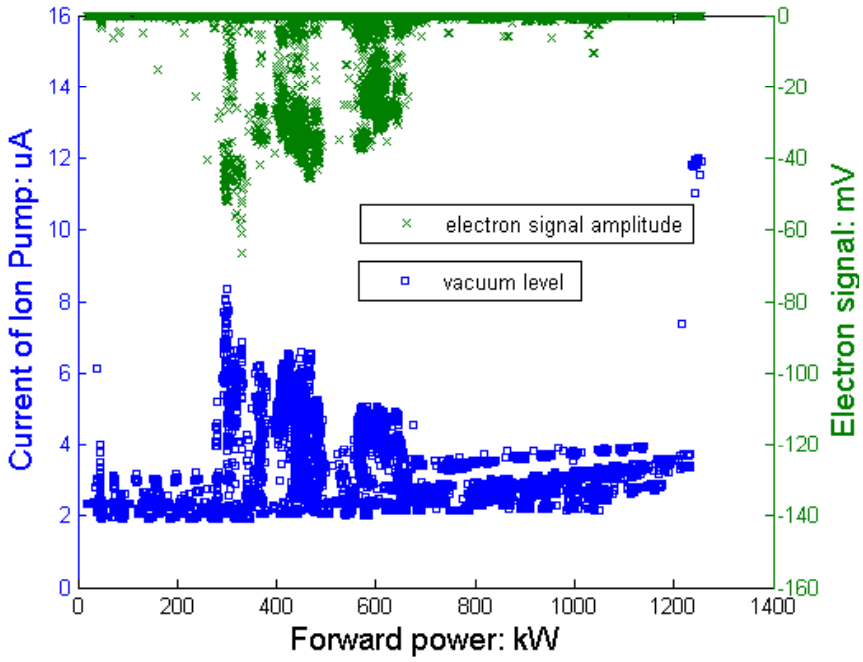

Ion Pump
PM
1
1
2
2
3
4
DUT
1: ceramic window
2: ion pump
3: electron probe
4: view port for light detector

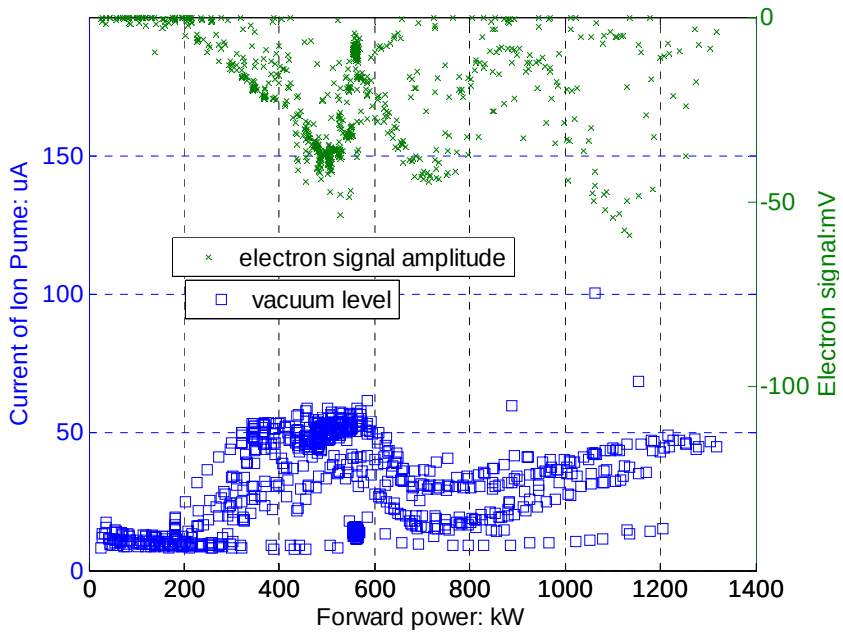
TTF-III coupler processing

F.W.

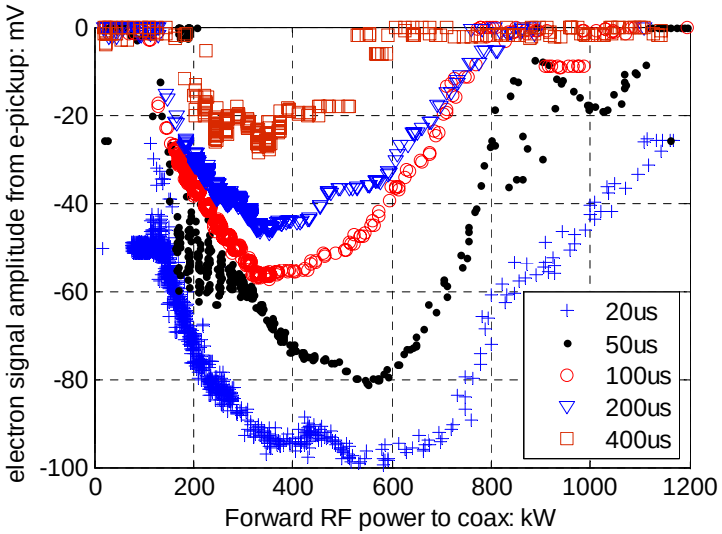
600mm long straight SS coax section test results

600mm long straight Copper plated SS coax section test results

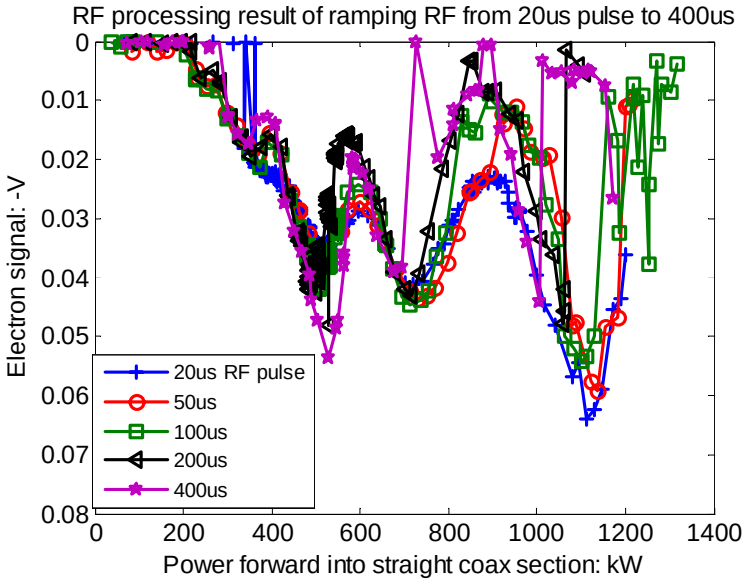




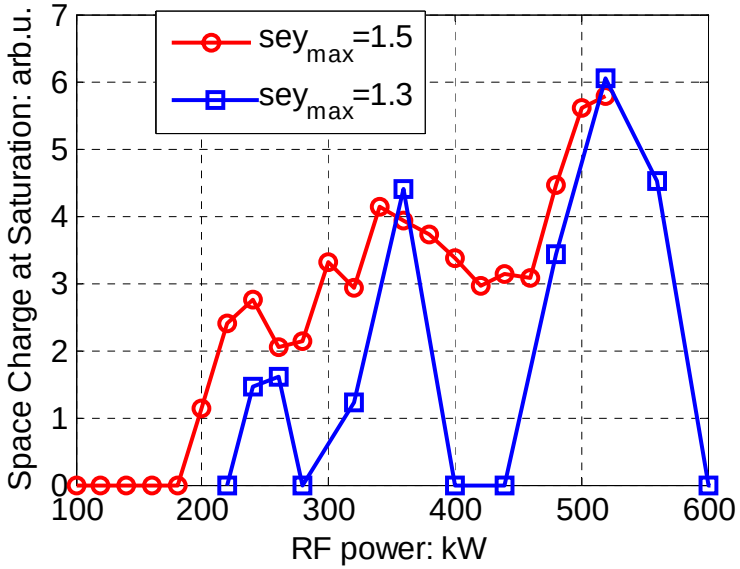
Strong MP around 300kW!



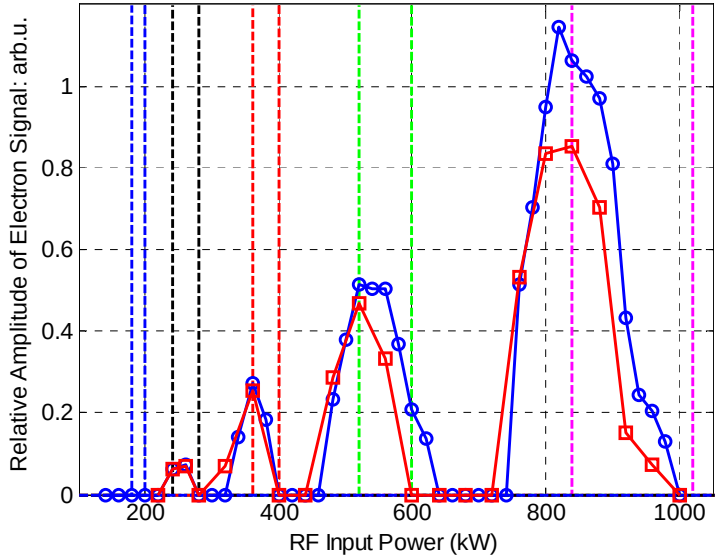
Stainless Steel Coax Tube



Copper plated S/S Coax Tube



Magic Simulation



Track3P simulation (indicated by dashed lines) is independent of SEY.