Beamline Absorber Study Using T3P

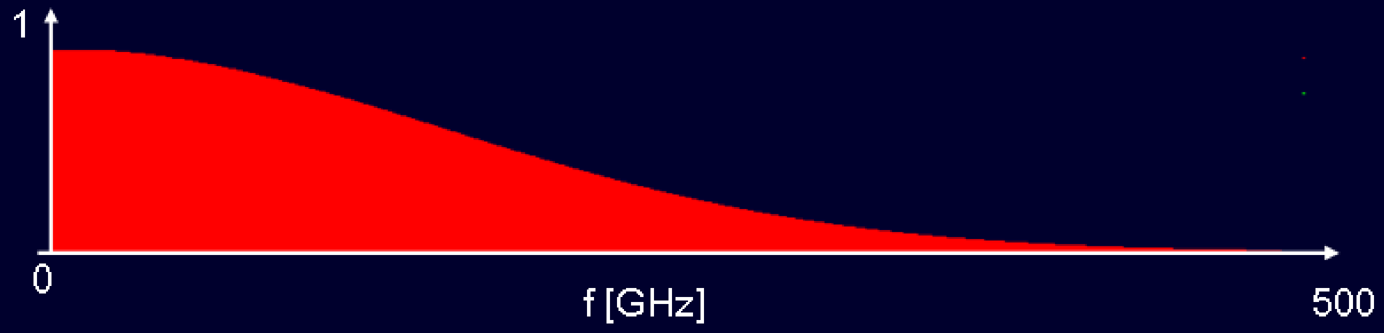
Liling Xiao

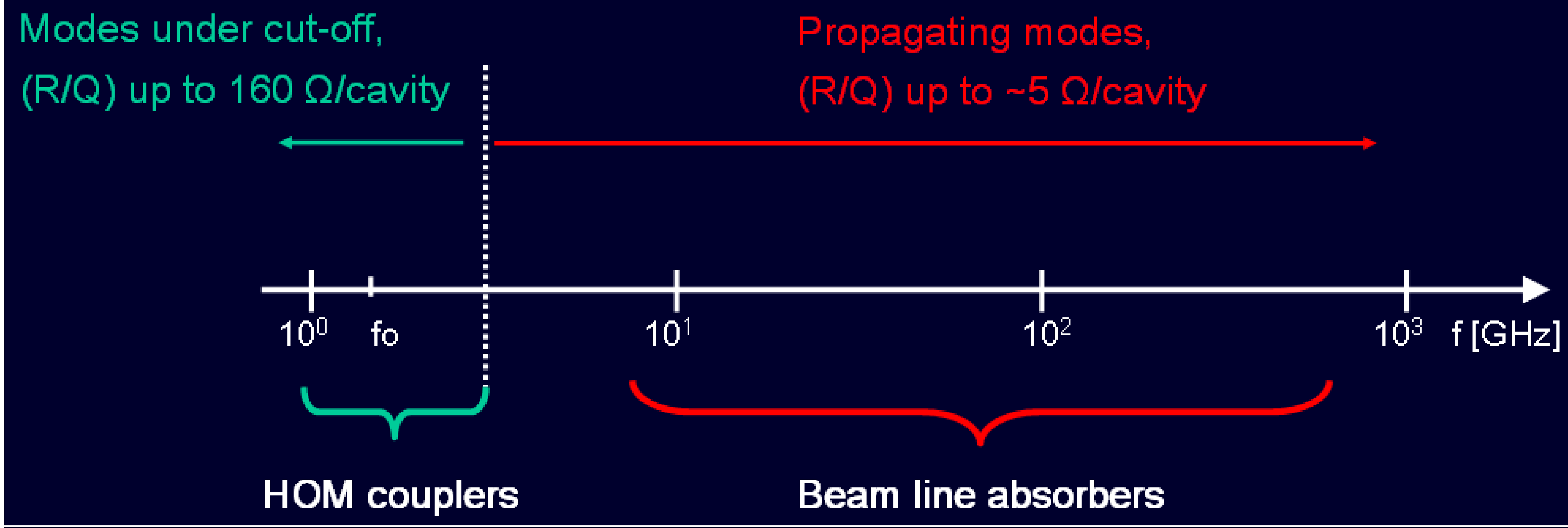
Advanced Computations Department, SLAC

Wake Fest 07, Dec.11, 2007

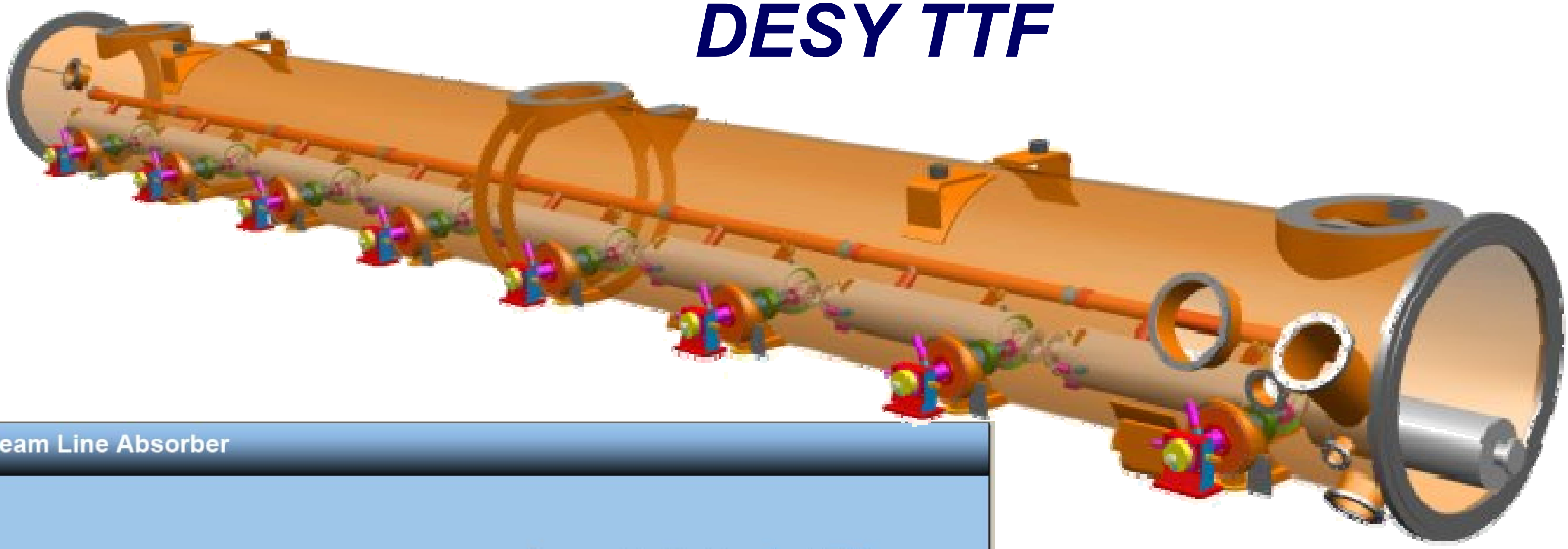
1.1 Introduction; Beam spectrum

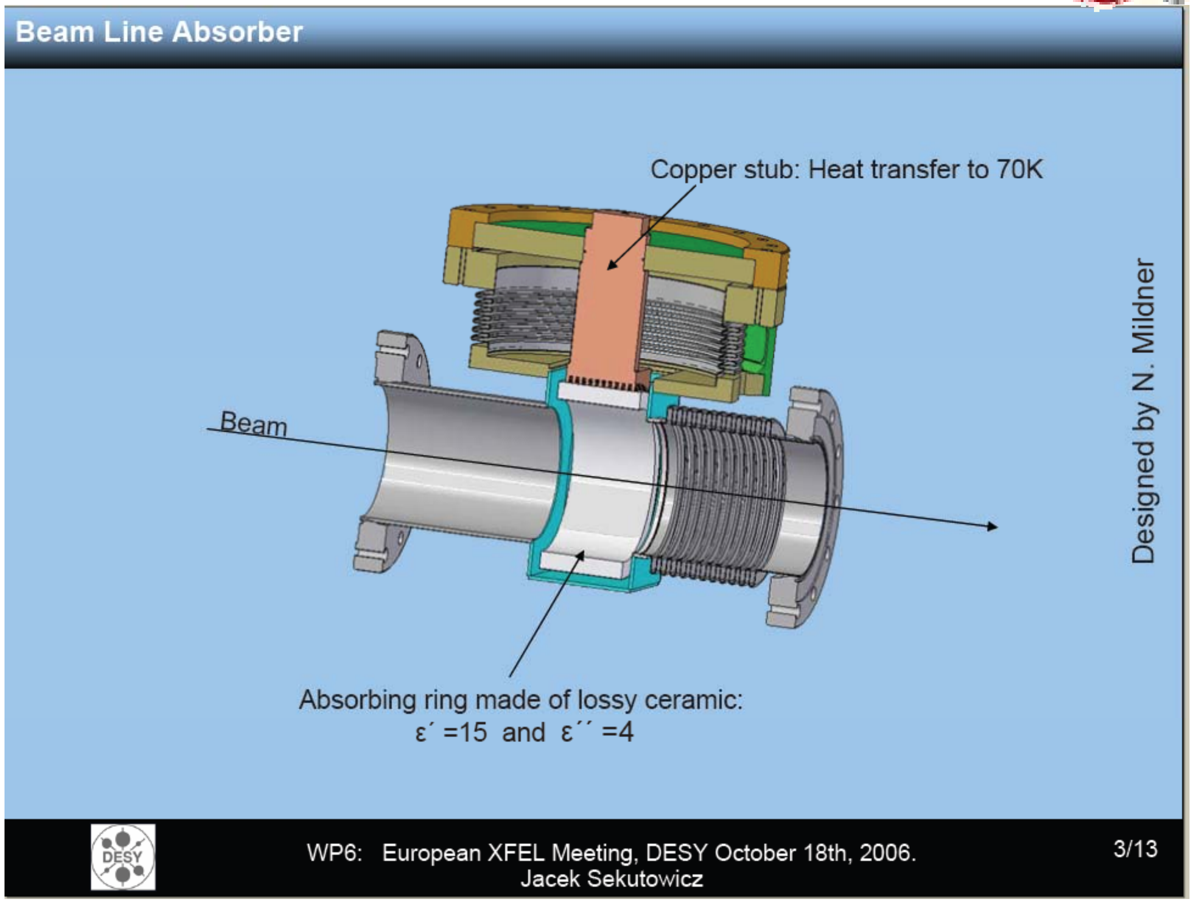
Beam spectrum: σ_z = 0.300 mm, $\Delta f_{i,i+1}$ = 2.967 MHz





DESY TTF





Beam Line Absorber
Copper stub: Heat transfer to 70K
Beam
Designed by N. Mildner
Absorbing ring made of lossy ceramic:
ε´ =15 and ε´´ =4
WP6: European XFEL Meeting, DESY October 18th, 2006.
Jacek Sekutowicz
3/13

- **T3P – Parallel finite element time domain code**
  - Wakefields with lossy materials

$$\nabla \times \nabla \times \vec{E} + \mu\varepsilon \frac{\partial^2 \vec{E}}{\partial t^2} + \mu\sigma_{eff} \frac{\partial \vec{E}}{\partial t} = -\mu \frac{\partial \vec{J}}{\partial t}$$

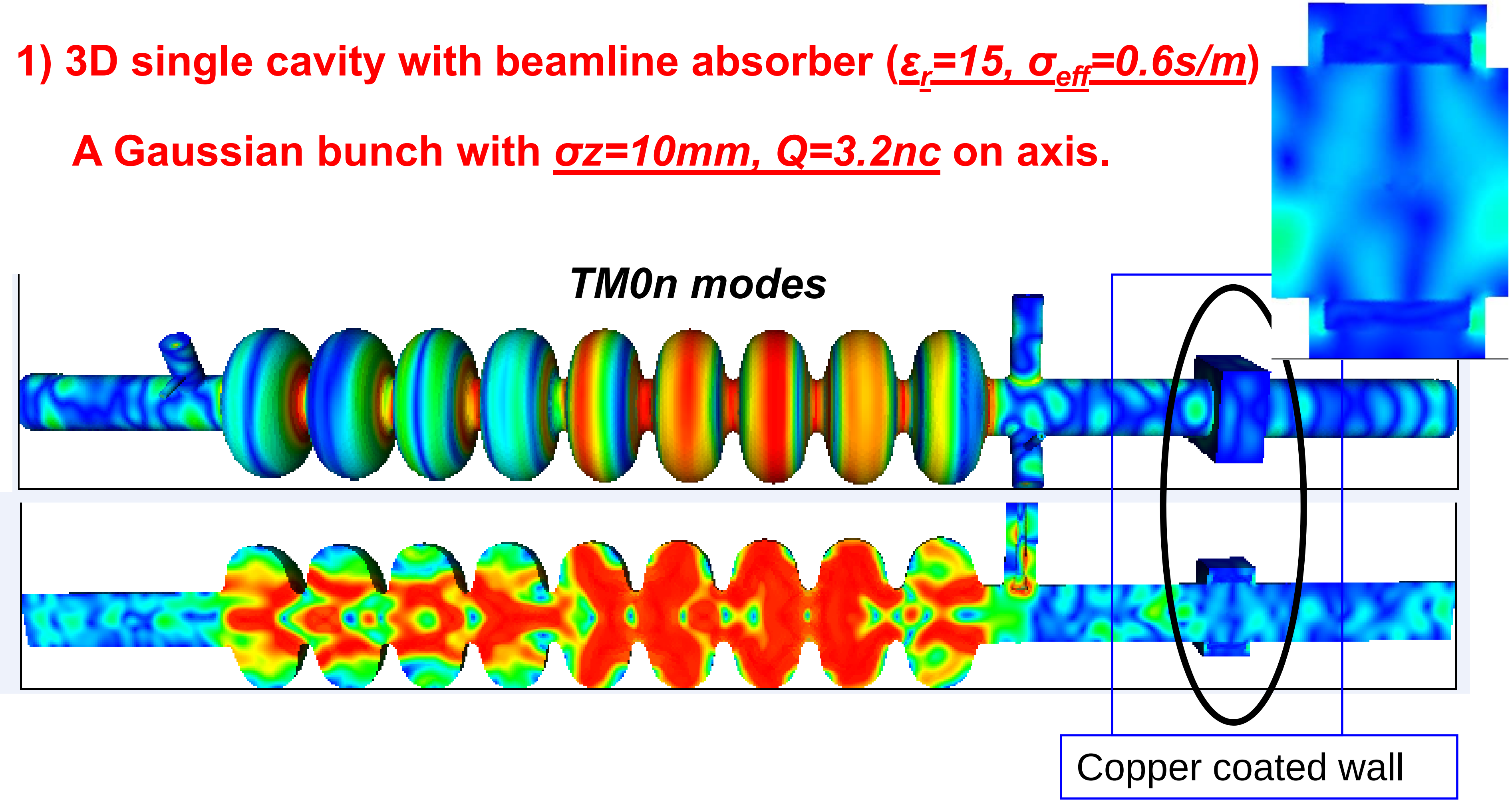
$$\sigma_{eff} = \omega\varepsilon_0\varepsilon_i$$

- **HOM Absorber study**
  - Drive a beam with a certain bunch length through the cavity
  - Calculate the total power generated by the beam
  - Calculate the power dissipated in the HOM absorber
  - Calculate the power heating on the copper coated beampipe wall
  - Calculate the power propagation in the beampipe

- **Simulation Results**

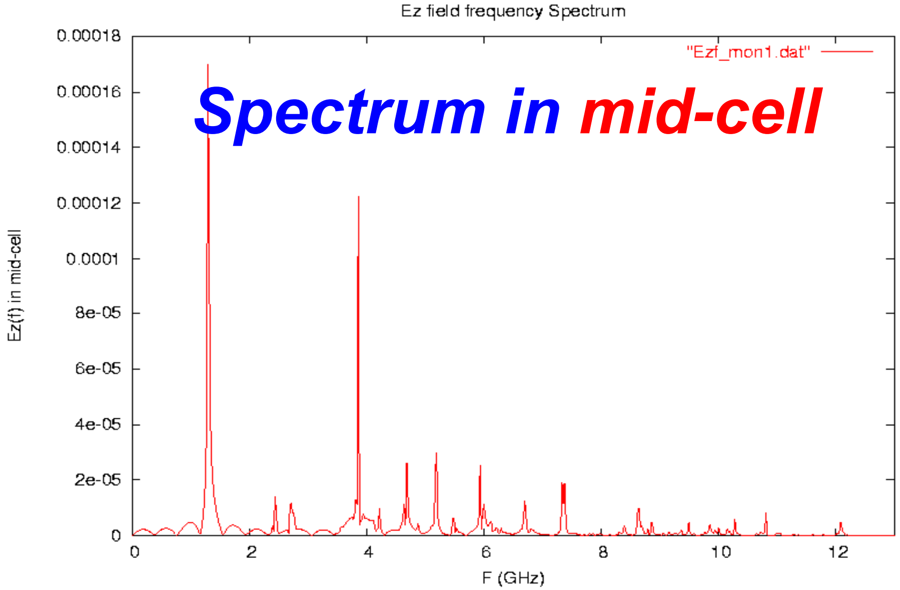
1) 3D single cavity with beamline absorber (*ε_r=15, σ_{eff}=0.6s/m*)

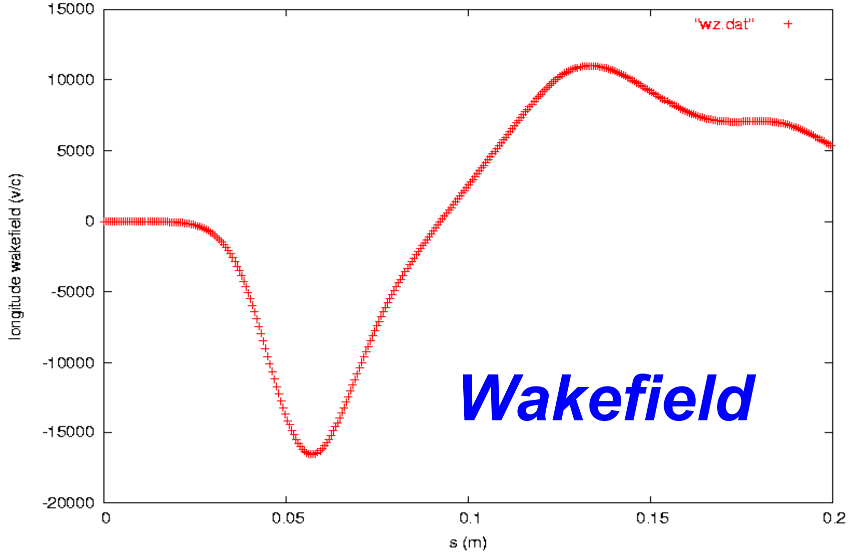
A Gaussian bunch with *σz=10mm, Q=3.2nc* on axis.

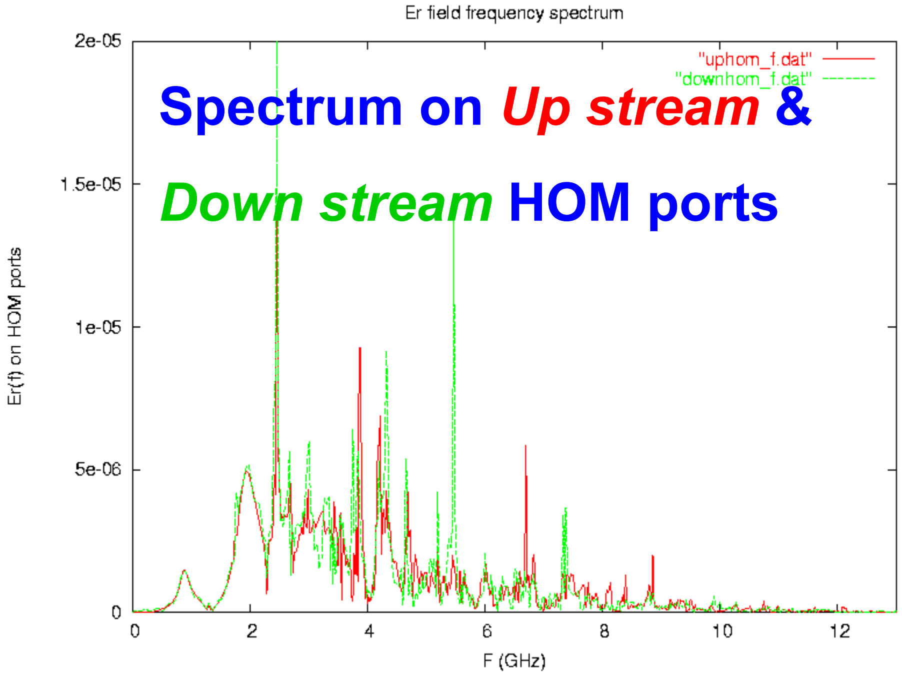


3.5million mesh elements, 2nd basis function run on Franklin at Nersc.

512 processors 24000 time steps within 12 hours

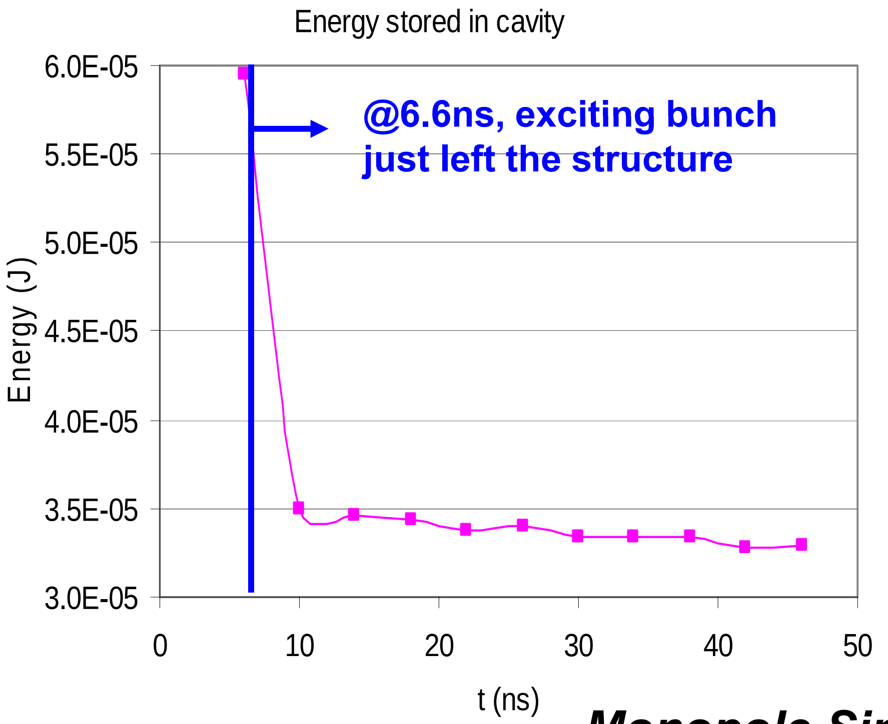


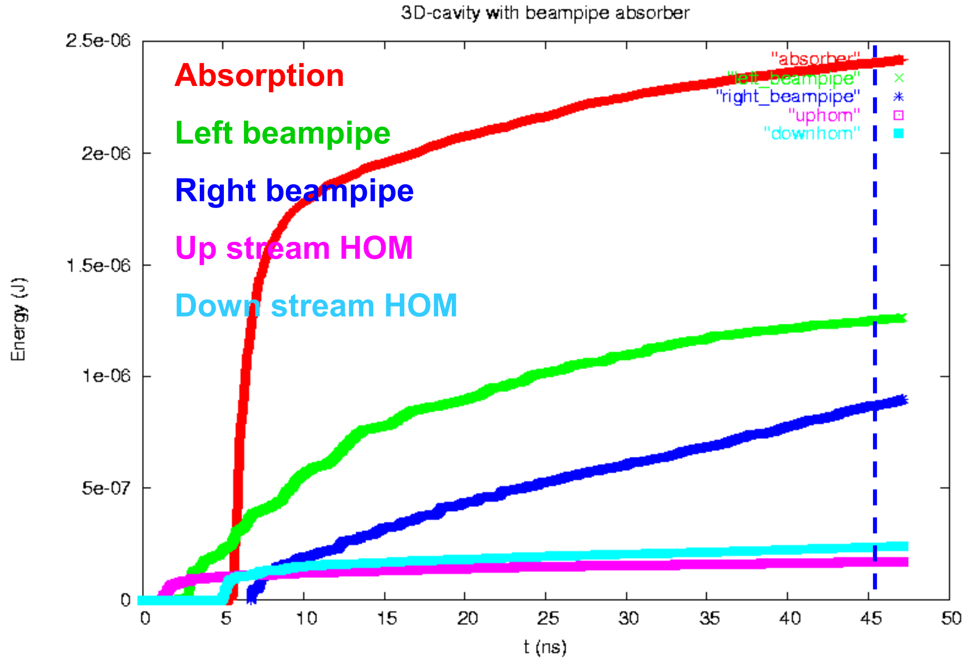




$$Kloss = \frac{1}{Q}\int_{0}^{+\infty} W_z(s)q(s)ds \qquad (V/C),$$

$$Energy = Q^2 * Kloss \qquad (J)$$





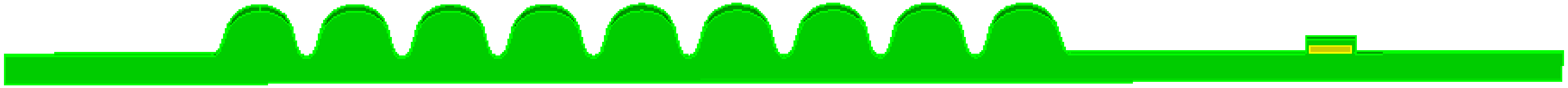
Monopole Single Passage Losses

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) 2D single cavity with beamline absorber (ε_r=15, σ_{eff}=0.6s/m)

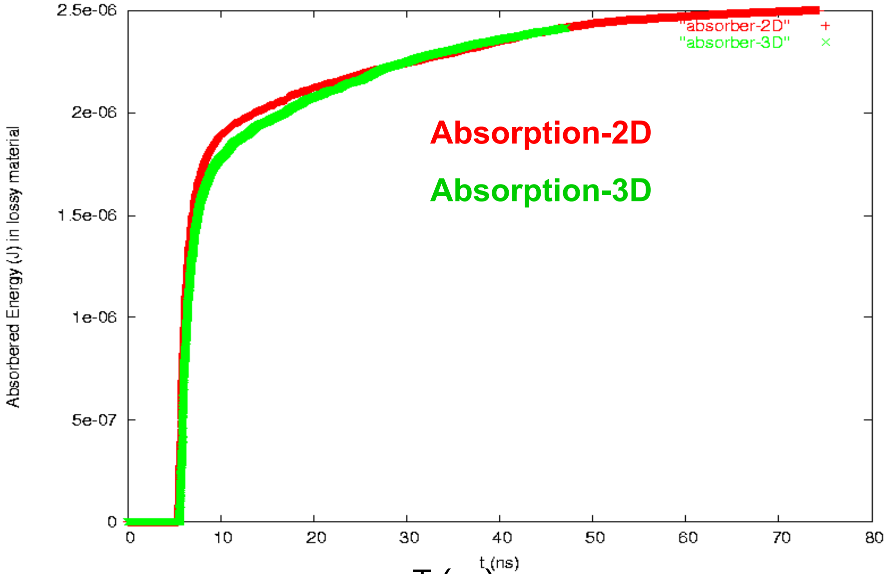
A Gaussian bunch with *σz=10mm, Q=3.2nc* on axis.

TM0n modes

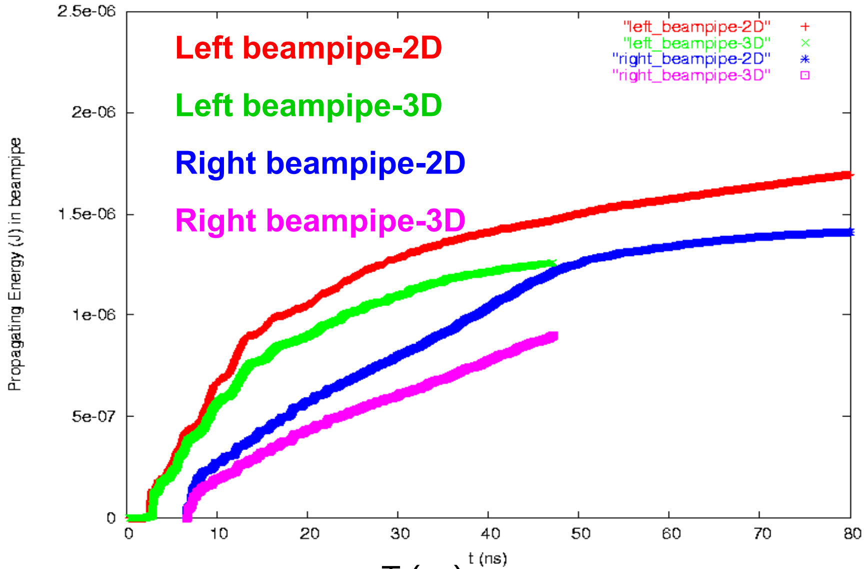


10 degree slice with HH-BC on symmetric plane

Energy Absorption



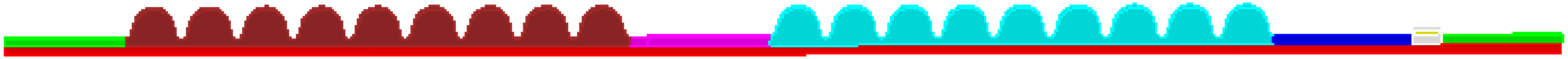
Energy Propagation



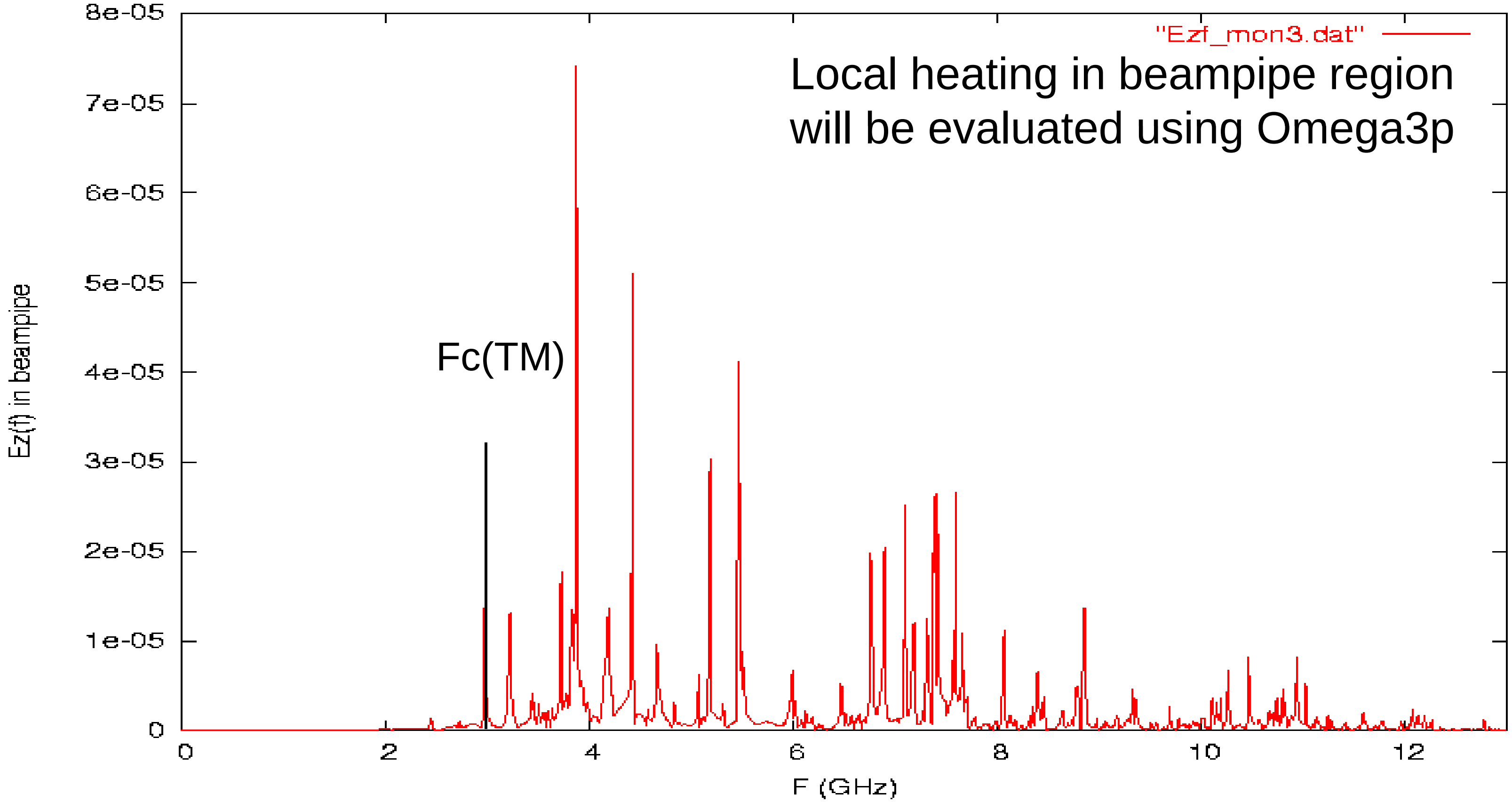
2D structure is a good approximation to study the efficiency of beamline absorber.

3) Multi-cavity with beamline absorber (ε_r=15, σ_{eff}=0.6s/m)

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

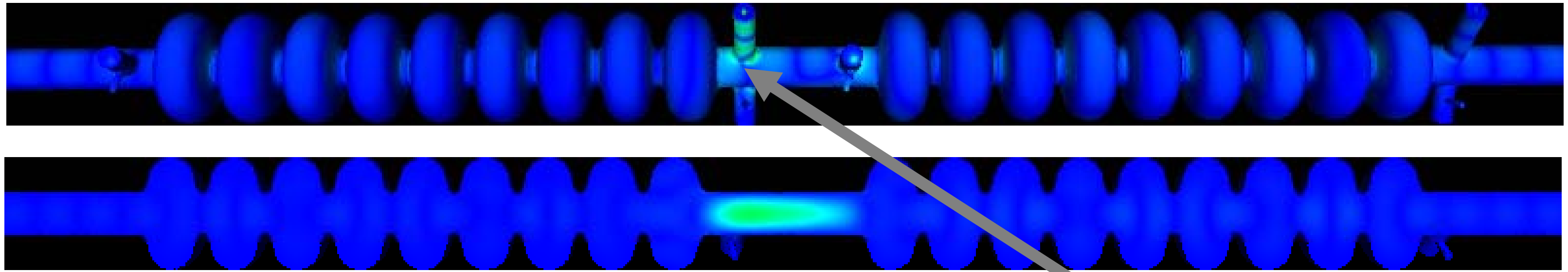


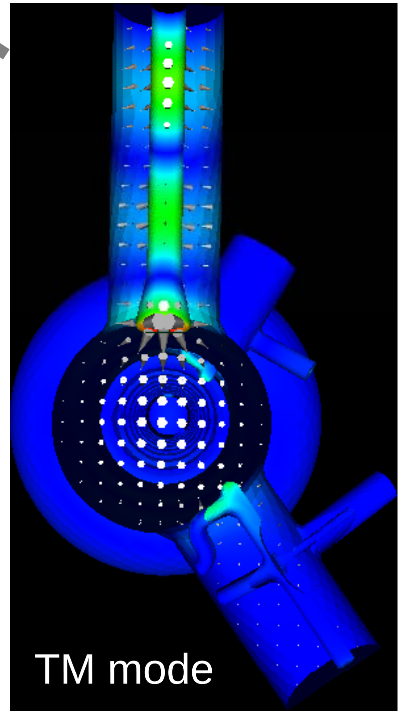
Trapped modes in interconnection



Trapped Mode at beampipe

Electric field



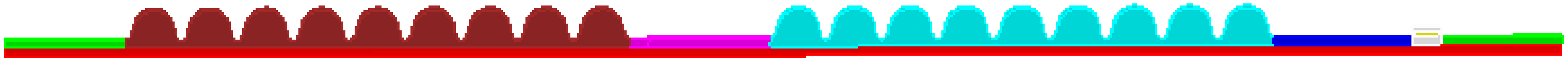


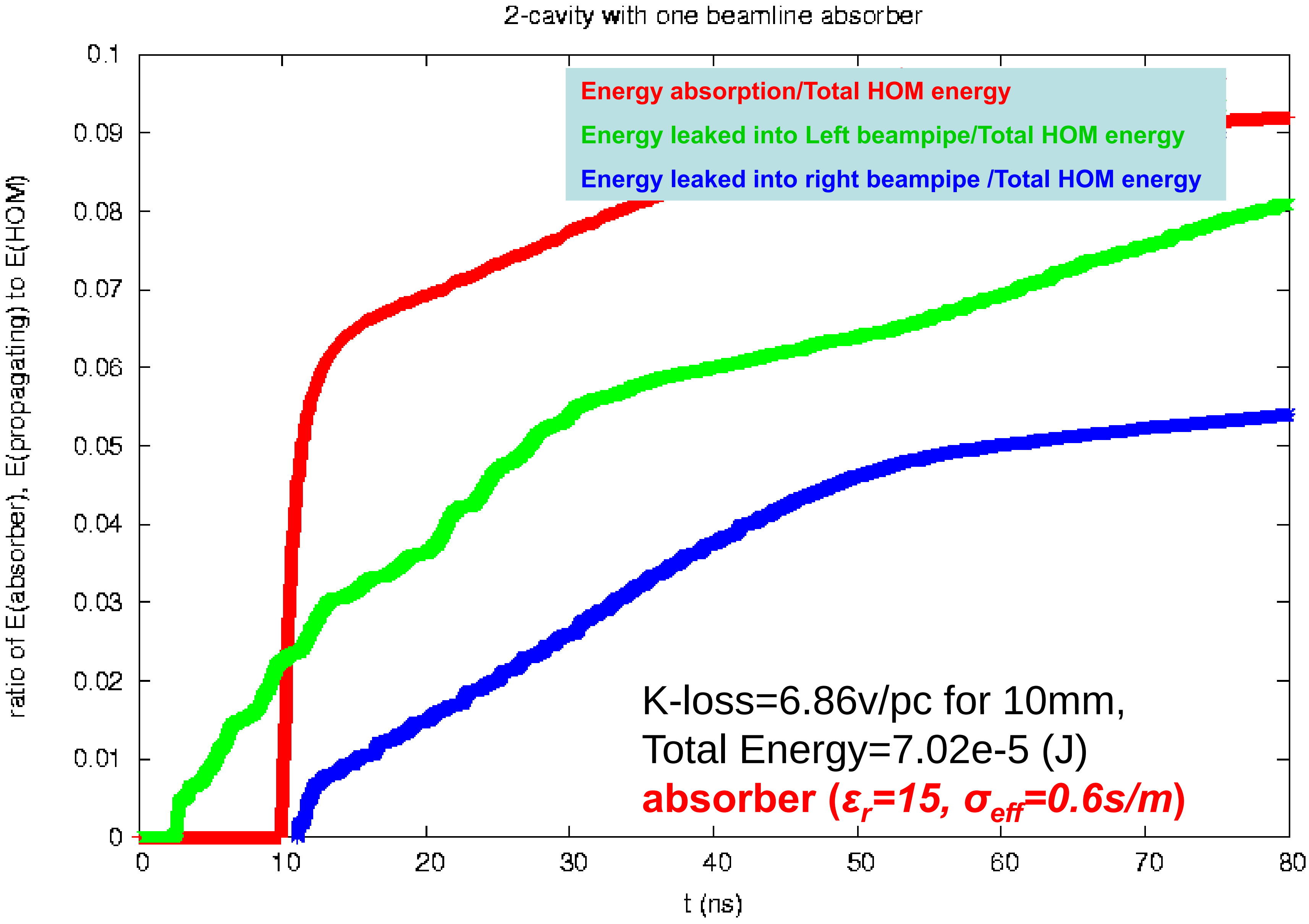
Trapped mode

- 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 = 0.11 W (single bunch)

Cho Ng, “Multi-cavity trapped mode simulation”,

Wakefest Meeting, 2007



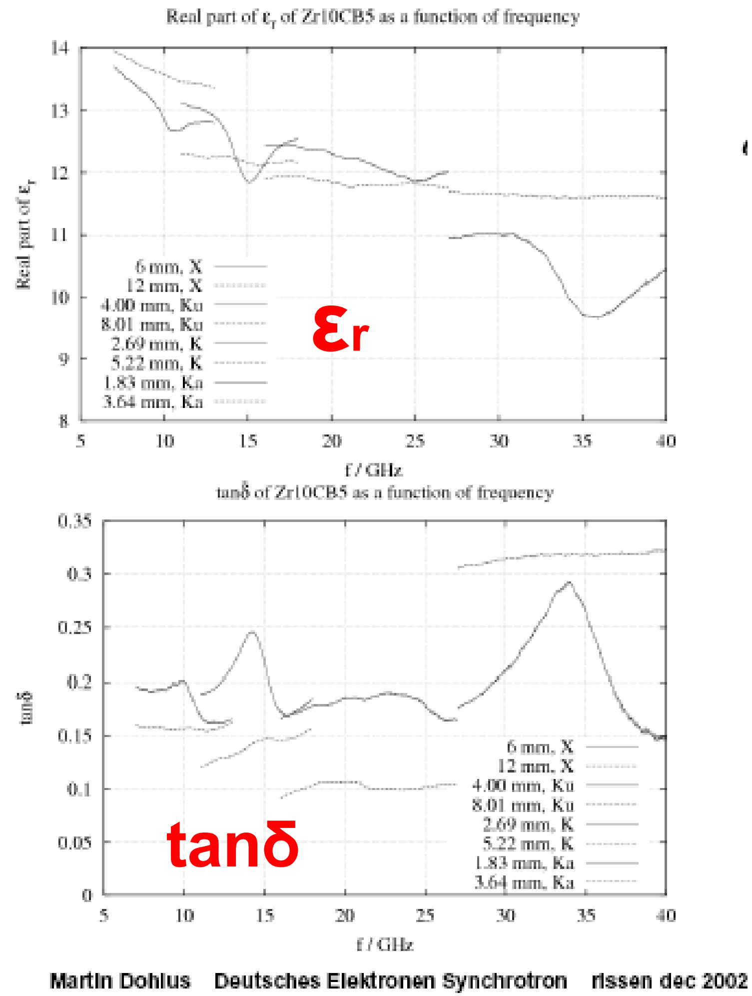


2-cavity with one beamline absorber
Energy absorption/Total HOM energy
Energy leaked into Left beampipe/Total HOM energy
Energy leaked into right beampipe /Total HOM energy
ratio of E(absorber), E(propagating) to E(HOM)
t (ns)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
70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

Preliminary results show that

✓ ***2D structure can be as a good approximation to study the efficiency of the beamline absorber. Later 3D structure could be used to check the results.***

✓ ***All results are based on certain bunch length (10mm) and certain constant dielectric conductivity (0.6s/m).***



Next Step:

- Implement the dispersion and lossy dielectric in T3P (in progress).

$$\varepsilon_r(\omega) = \varepsilon_{r\infty} + \frac{\varepsilon_{r0} - \varepsilon_{r\infty}}{1 + j\omega\tau_0},$$

- Simulate cryomodule with beamline

  absorber for shorter bunch length.