T3P - Time Domain

Advanced Computations

SLAC National Accelerator Laboratory

CW10, Stanford, September 20, 2010

SLAC
NATIONAL ACCELERATOR LABORATORY

T3P - EM Time-Domain Solver

Combine Ampere's and Faraday's laws

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

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

*Unconditionally stable time integration**

***Navsariwala & Gedney**, *An unconditionally stable parallel finite element time domain algorithm*, Antennas and Propagation, **1996**

Solve linear system at every time step:

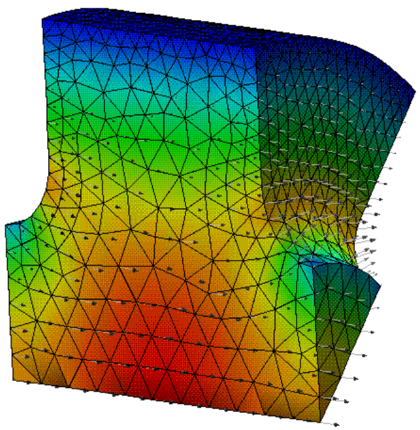
Ax=b

T3P Capabilities

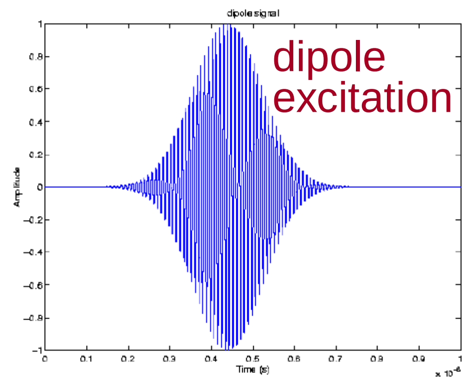
- **Beam excitation**
  - Short-range wakefield of beamline components
  - Wakefield driven HOMs/trapped modes
  - Moving windows for short bunches
- **Dipole excitation**
  - Mode identification in cavities
- **Port excitation**
  - Monochromatic pulse at waveguide ports
  - Broadband pulse

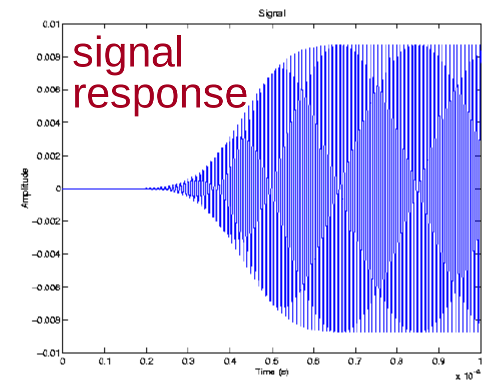
T3P – Dipole and Wakefield Benchmarks

Dipole Excitation Benchmark



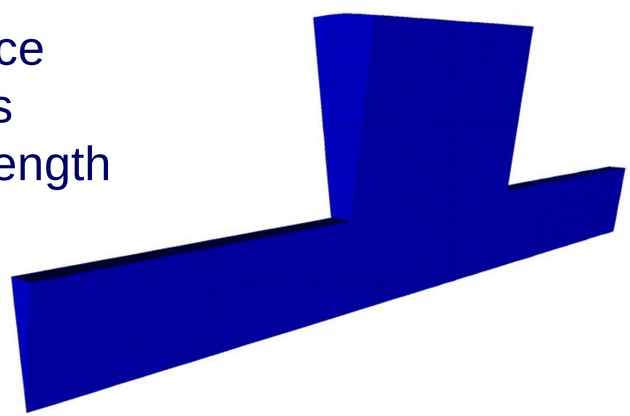
Frequency (GHz)	p=1	p=2
Omega3P (frequency domain)	11.024	11.037
T3P (time domain)	11.024	11.037

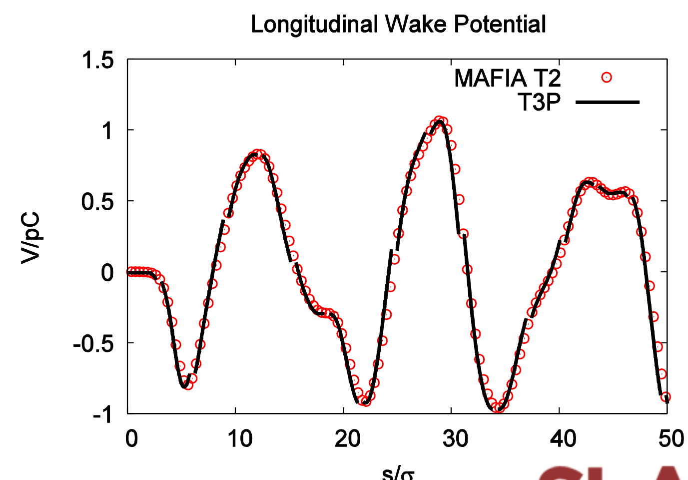




Wakefield Benchmark

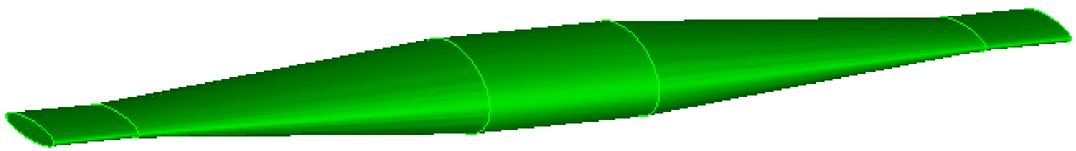
- 10 degree slice
- 25K elements
- 1 cm bunch length
- dt = 1 ps

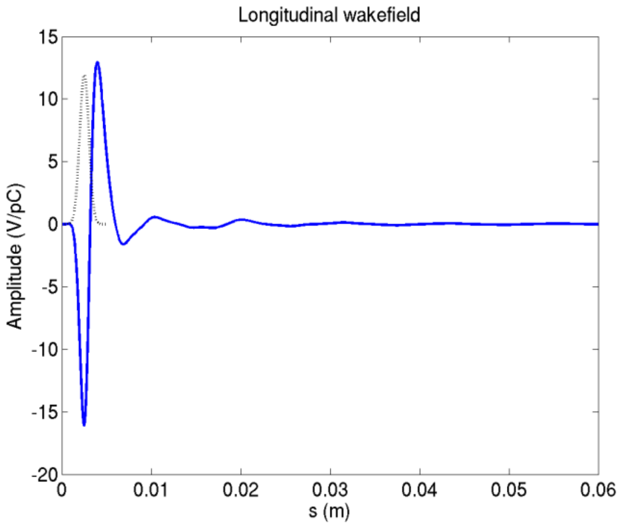




T3P - Short bunch Wakefields in Long Taper

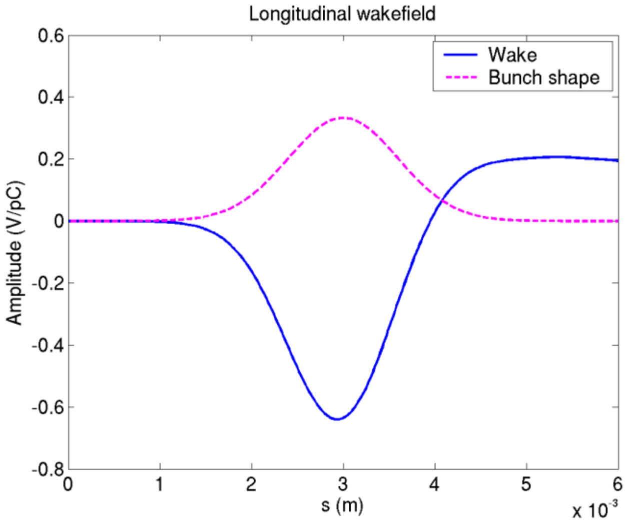
PEP-X Undulator Vacuum Chamber





ERL Vacuum Chamber Transition

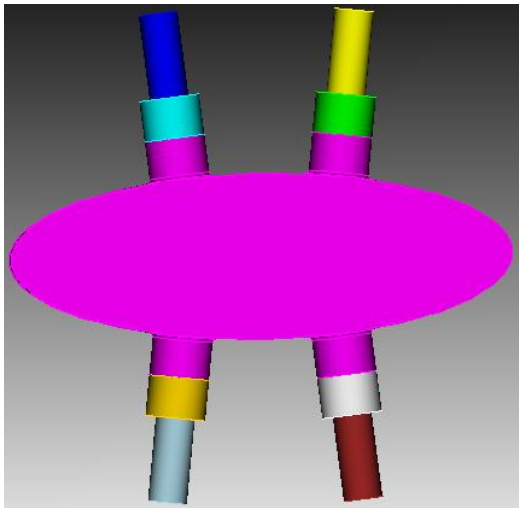
Loss factor = 0.413 V/pC
for 0.6 mm bunch length

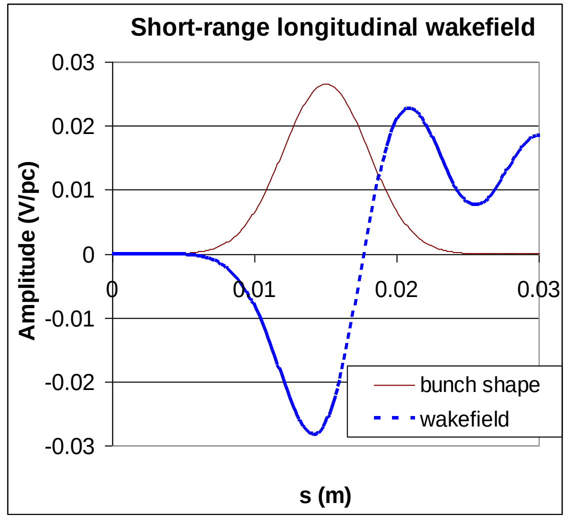


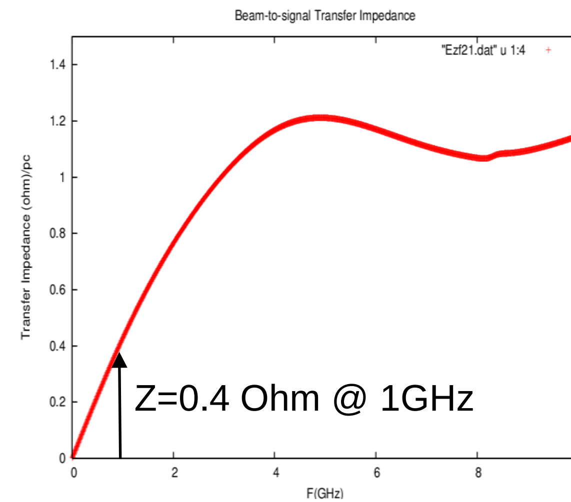
SLAC
NATIONAL ACCELERATOR LABORATORY

T3P - PEP-X Beam Position Monitor

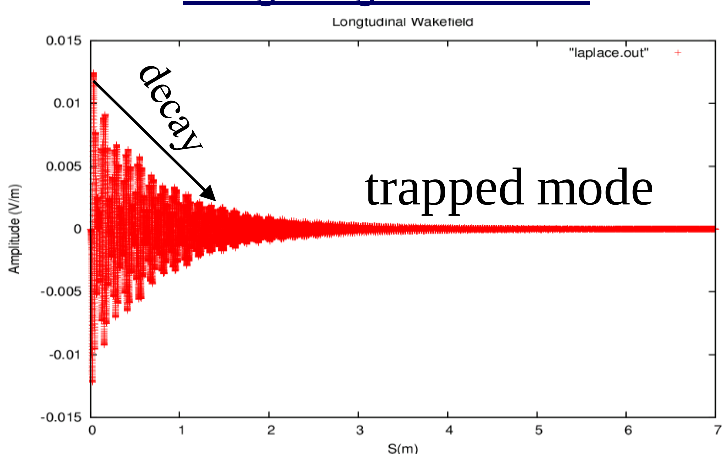
Short-range Wakefield, Trapped Mode, Impedance Spectrum



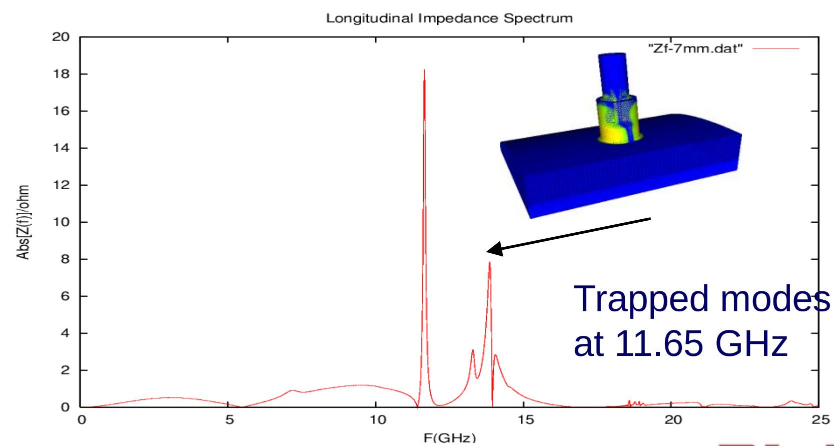




Long-range wakefield



Impedance spectrum

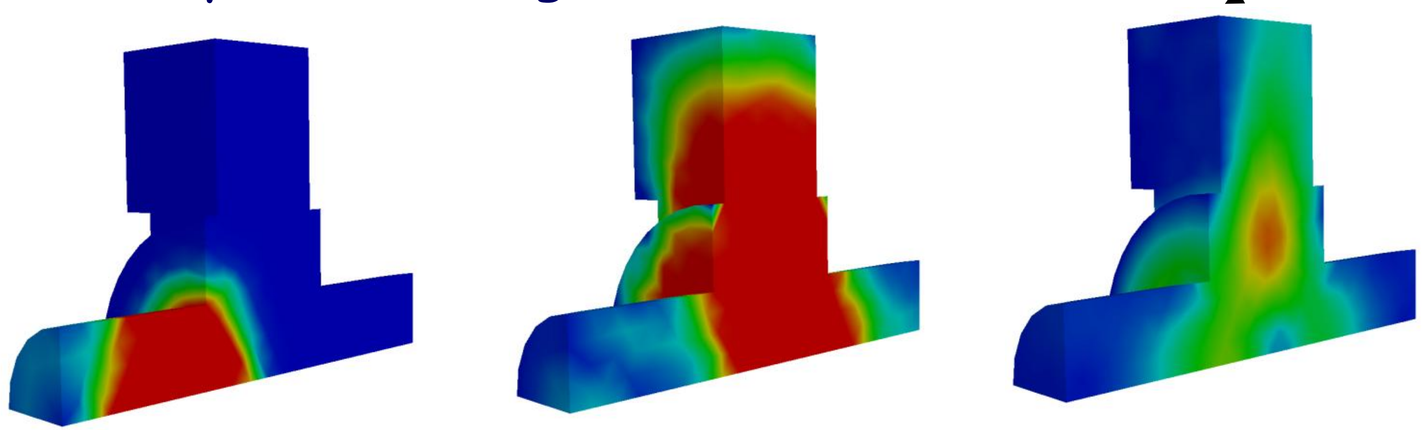


NATIONAL ACCELERATOR LABORATORY

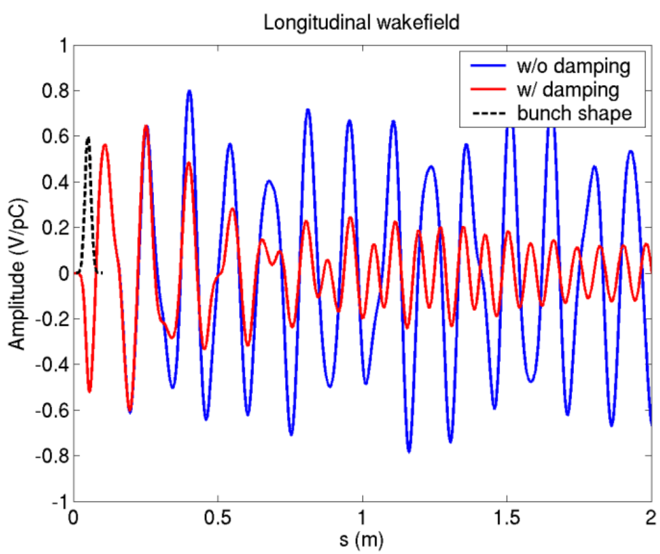
T3P - Trapped Mode & Damping

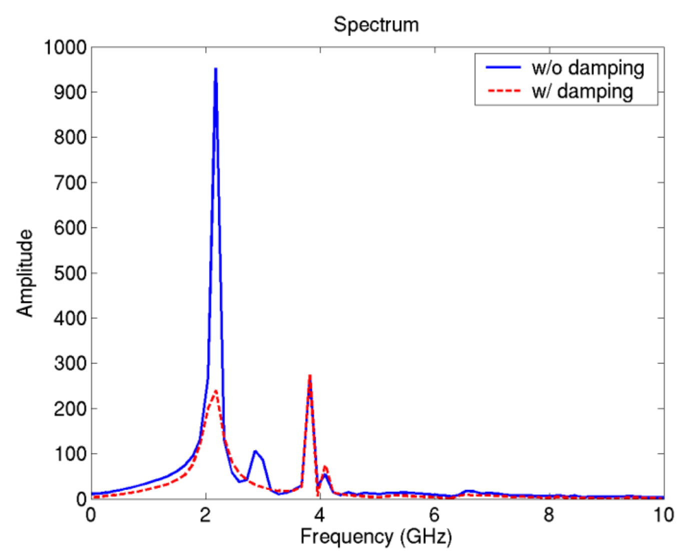
Pillbox Cavity with Waveguide

Broadband port



Field Snapshots from beam transit



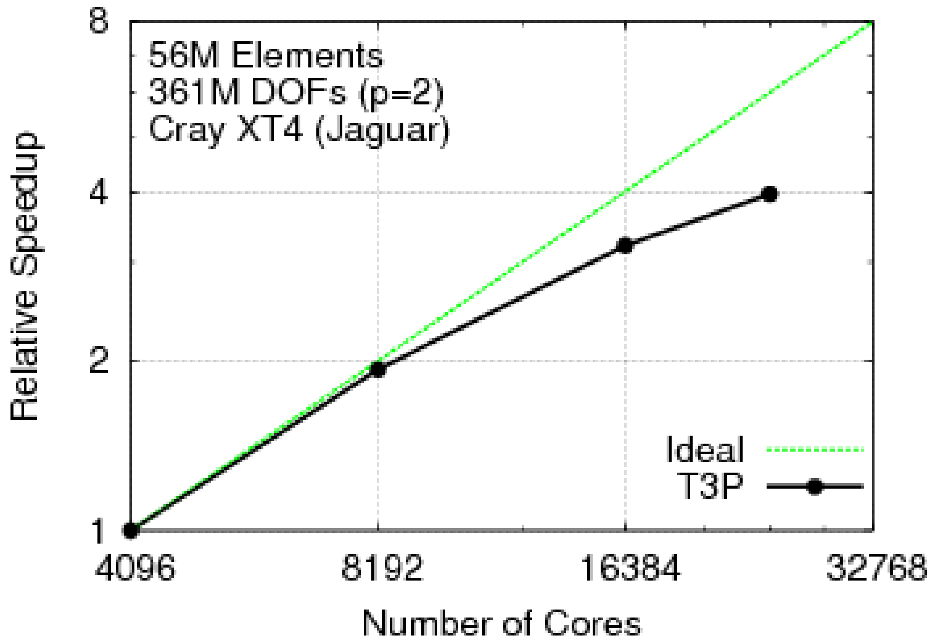


T3P - Parallel Performance

Runtime parameters for T3P PETS simulations:

Basis Order	Degrees of Freedom	CPUs	Walltime/step
p=1	10M	1152	0.30 secs
p=2	54M	1152	1.63 secs
p=3	159M	4096	10.6 secs

Strong scaling for 7x larger mesh:



SLAC NATIONAL ACCELERATOR LABORATORY