Status report IST

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Plasma based accelerators @ IST

Self modulation of long beam drivers (e-,e+,p) [J.Vieira]

   Hosing (mitigation) & Ion motion

Polarized radiation sources from plasma accelerators [J.Vieira]

Plasma accelerators with exotic drivers [J.Vieira]

   OAMs and hollow e- beams

Positron acceleration [J.Vieira]

Plasma accelerator beams for radiation reaction/QED studies [T. Grismayer]

OSIRIS and reduced models [R. Fonseca] (T.Mehring now @ IST)
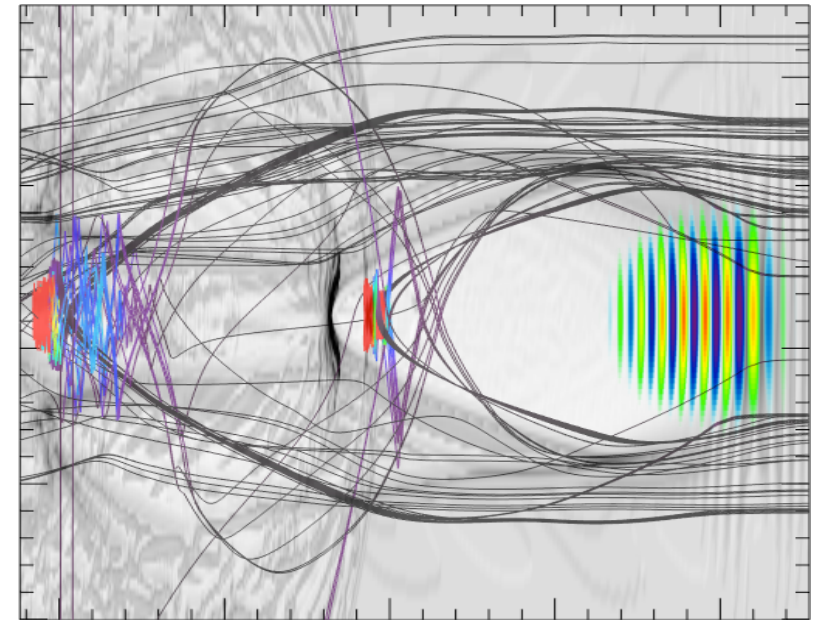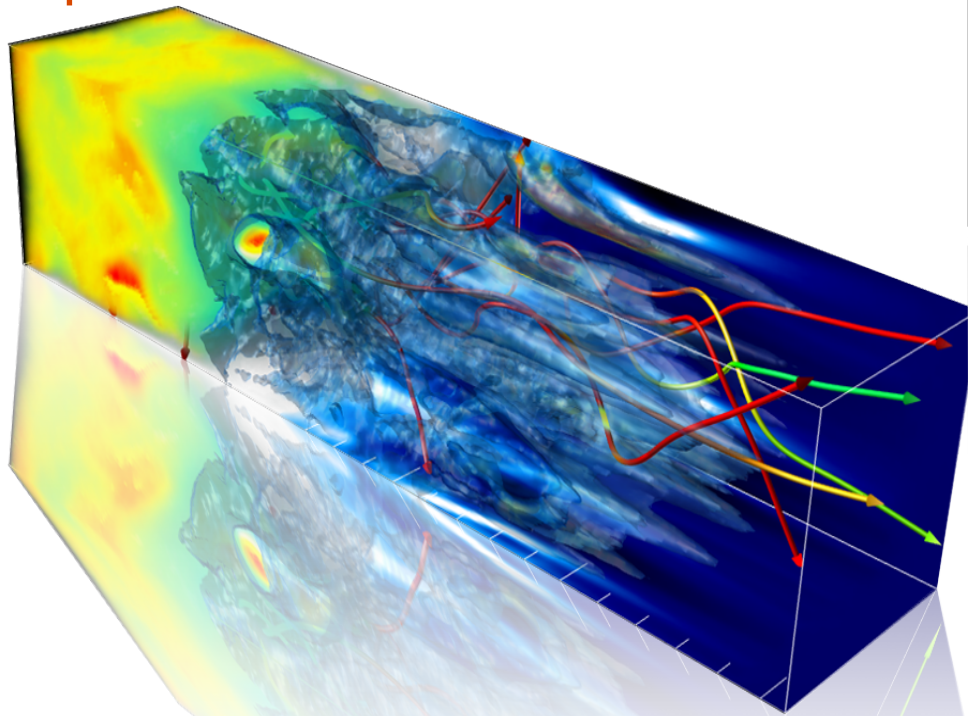
OSIRIS 2.0 - 3.0 - ...

osiris v2.0

osiris framework

- Massivelly Parallel, Fully Relativistic Particle-in-Cell (PIC) Code
- Visualization and Data Analysis Infrastructure
- Developed by the osiris.consortium
  ⇒ UCLA + IST

New Features in v2.0

- Bessel Beams
- Binary Collision Module
- Tunnel (ADK) and Impact Ionization
- Dynamic Load Balancing
- PML absorbing BC
- Optimized higher order splines
- Parallel I/O (HDF5)
- Boosted frame in 1/2/3D

Ricardo Fonseca: ricardo.fonseca@ist.utl.pt
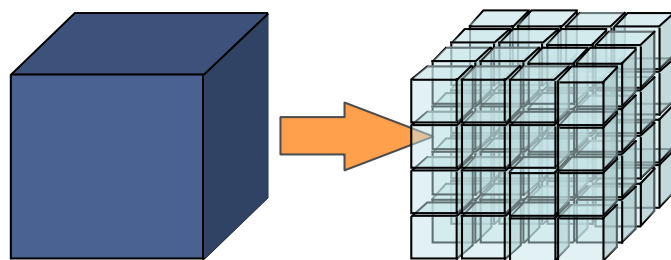**Frank Tsung:** tsung@physics.ucla.edu

http://cfp.ist.utl.pt/golp/epp/
http://exodus.physics.ucla.edu/

Scaling to 1.6 million cores

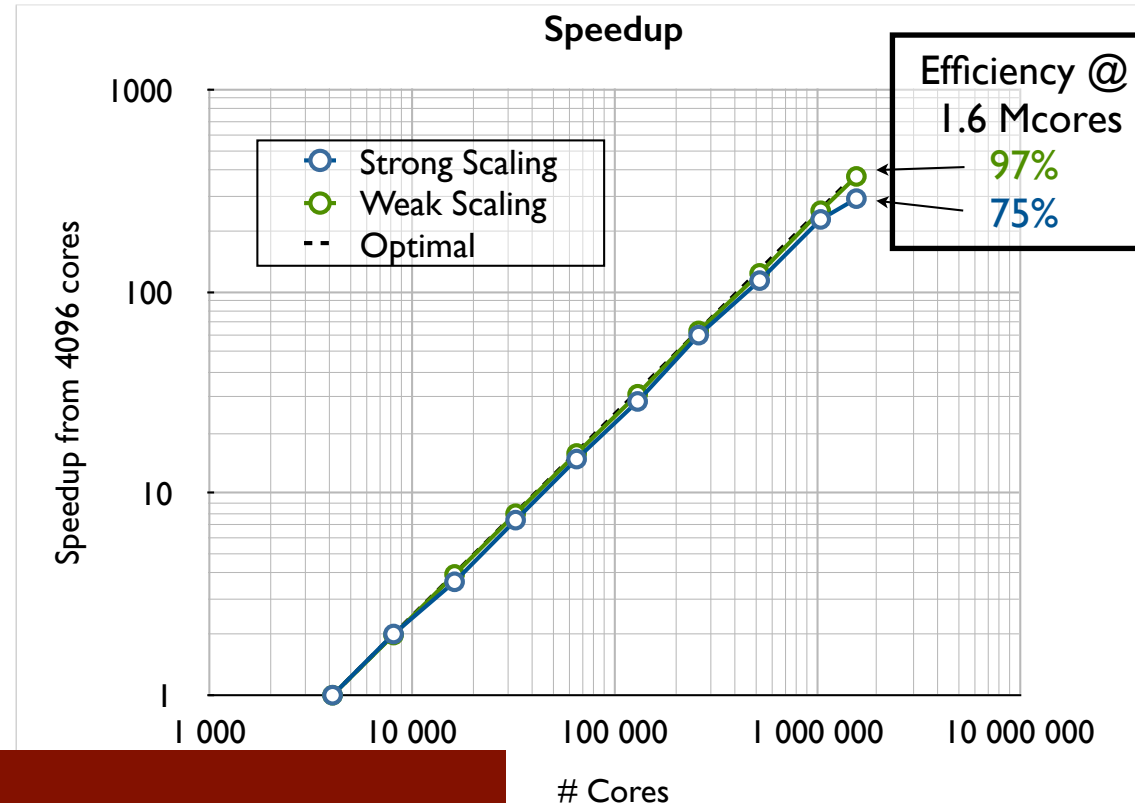## Scaling Tests

Sim. Volume → *Parallel*

- Scaling tests on LLNL Sequoia
  $4096 \rightarrow 1572864$ cores (full system)
- Warm plasma tests
  Quadratic interpolation
  $u_{th} = 0.1$ c
- Weak scaling
  Grow problem size
  cells = $256^3 \times (N_{cores} / 4096)$
  2^3 particles/cell
- Strong scaling
  Fixed problem size
  cells = 2048^3
  16 particles / cell

Speedup

Efficiency @ 1.6 Mcores
97%
75%

Strong Scaling
Weak Scaling
Optimal

Speedup from 4096 cores

\# Cores

Also on GPU & Intel MIC Xeon Phi

LLNL Sequoia
IBM BlueGene/Q
\#2 - TOP500 Nov/12
1572864 cores
R_{max} 16.3 PFlop/s

F. Fiúza *et al.* (2013)

Reducing numerical Cerenkov radiation

▸ **We developed NCI theory, and elimination strategies to simulate relativistic plasma drift in PIC code.**
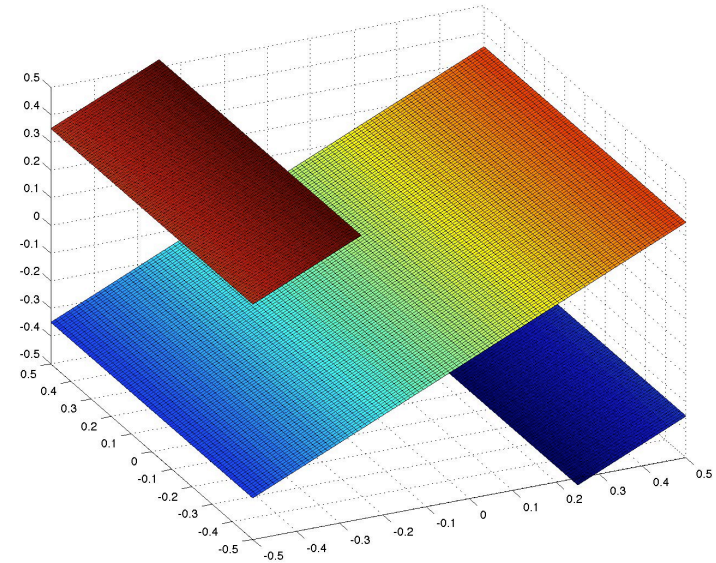
Langmuir mode **EM mode**

$$\left((\omega' - k_1' v_0)^2 - \frac{\omega_p^2}{\gamma^3} (-1)^\mu \frac{S_{j1} S_{E1} \omega'}{[\omega]} \right) \times$$
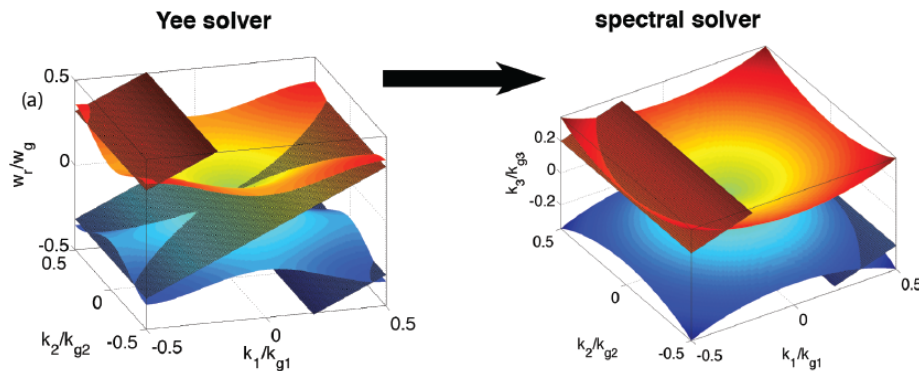$$\left([\omega]^2 - [k]_{E1}[k]_{B1} - [k]_{E2}[k]_{B2} - \frac{\omega_p^2}{\gamma} (-1)^\mu \frac{S_{j2}(S_{E2}[\omega] - S_{B3}[k]_{E1} v_0)}{\omega' - k_1' v_0} \right)$$
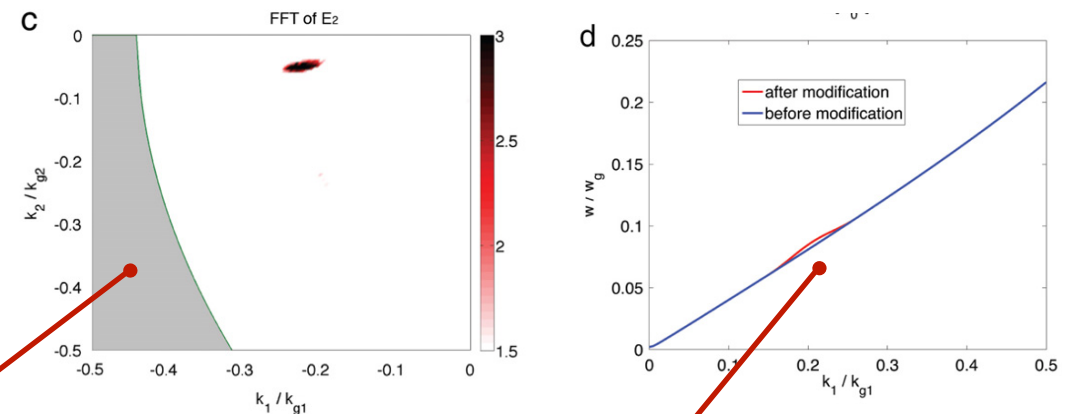$$+ \mathcal{C} = 0$$

Intersection

FDTD to FFT-based solver

Yee solver → spectral solver

low-pass filter

FDTD to FFT-based solver
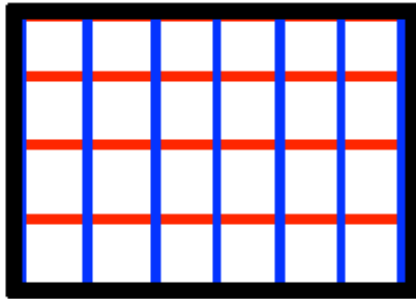

c   FFT of E2

d

after modification
before modification

modify EM dispersion

Xinlu Xu, Peicheng Yu et al.

Development of reduced models

Hybrid Yee-FFT solver

$$[k_1] = k_1$$

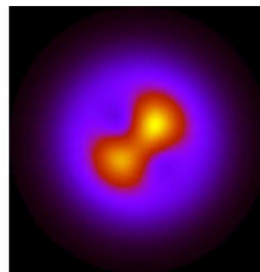$$[k_2] = \frac{\sin(k_2 \Delta x_2 / 2)}{\Delta x_2 / 2}$$
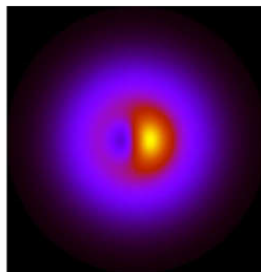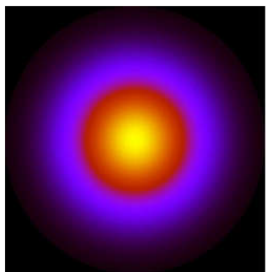
x2

Xinlu Xu, Peicheng Yu et al.

Quasi-3D + Lorentz boosted frame
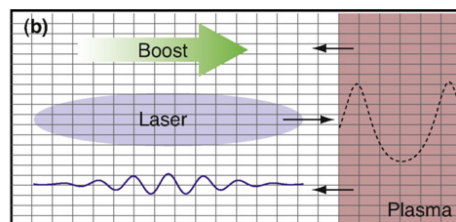
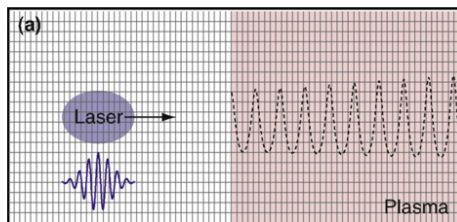A. Lifshitz *et al.*

one mode   two modes   three modes
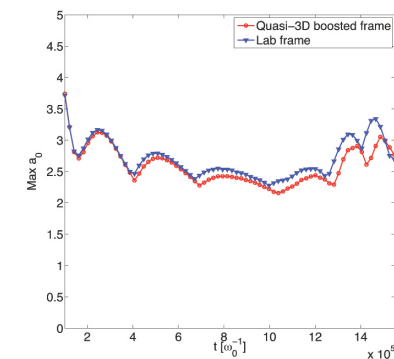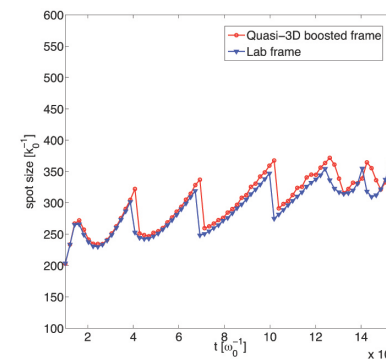

A. Davidson et al.
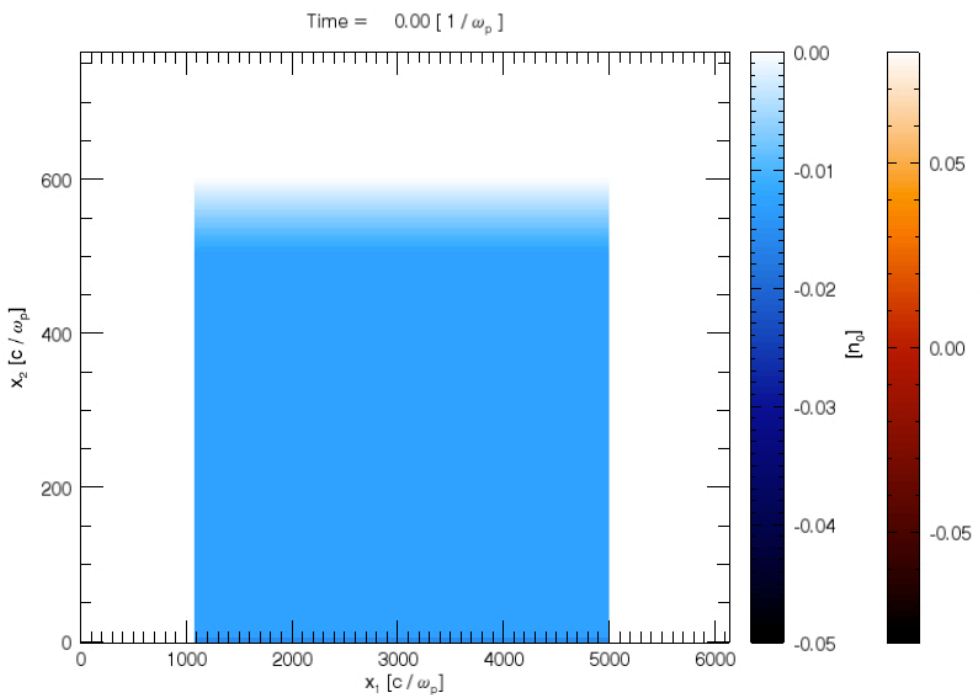
+

J. L. Vay; S. F. Martins *et al.*

H3O

Time = 3296.33 [1 / ω_p]
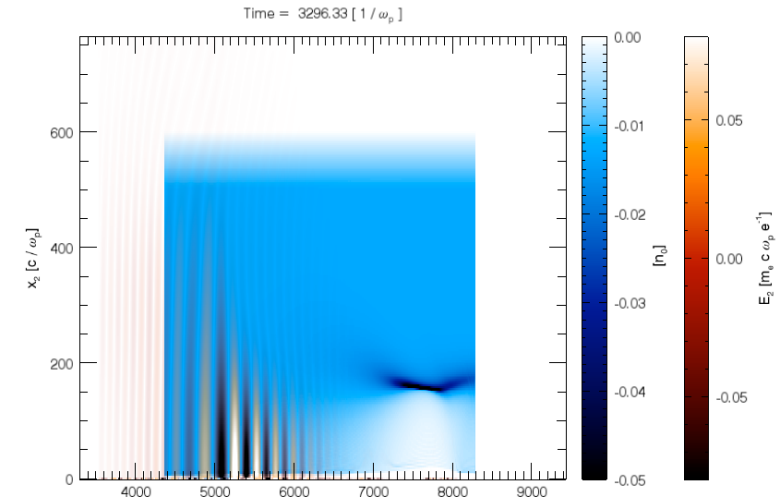
Reproducing lab frame data with
100k ~ 1M
speed up

H₃O   H   H   H   Osiris

Hybrid Yee-FFT solver

Hybrid geometry (quasi-3D)

Hybrid MPI/OPENMP/GPU/MIC architecture

Time = 0.00 [1 / ω_p]

Lorentz boosted frame
γ^2

quasi-3D algorithm (200-500)

hybrid Yee-FFT solver

Potential speed up = (100~10,000) x 100 = 1 million