Session S0069:
GPU Computing Advances in 3D Electromagnetic Simulation

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CST (Computer Simulation Technology)

Abstract

Computer Simulation Technology (CST) has been providing GPU acceleration for its 3D Full Wave electromagnetic field simulation tools for several years. The latest version of CST Studio Suite supports the full range of Tesla products on both Windows and Linux operating systems.
Using GPU, multi-GPU and MPI-GPU Computing drastically reduces the simulation times for CST customers. We will provide a status of current and future GPU developments at CST and share detailed simulation results.

CST Milestones

1992

Foundation of CST

Commercialization of MAFIA (FIT)

1998

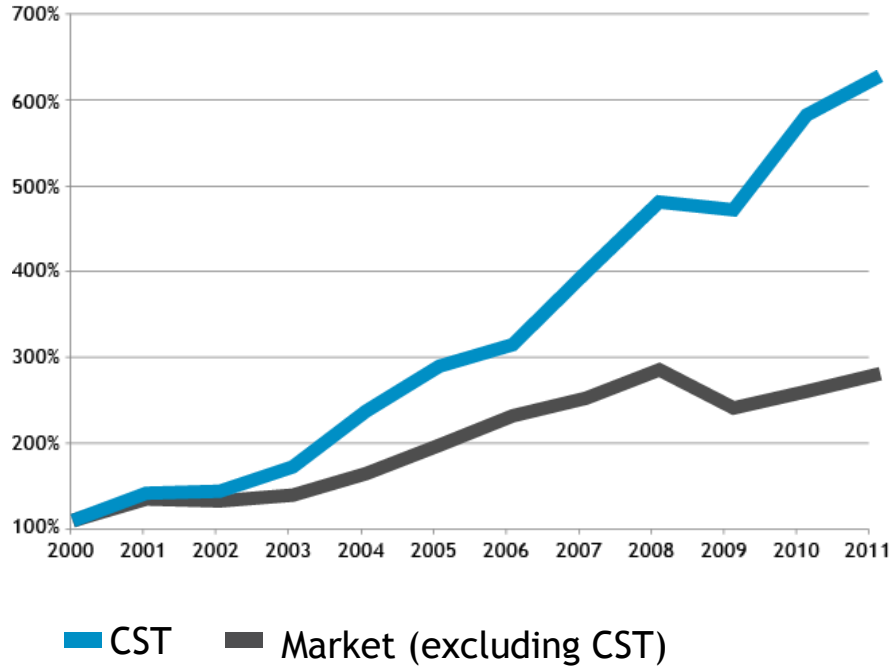
CST MICROWAVE STUDIO® — PERFECT BOUNDARY APPROXIMATION (PBA)®

2005

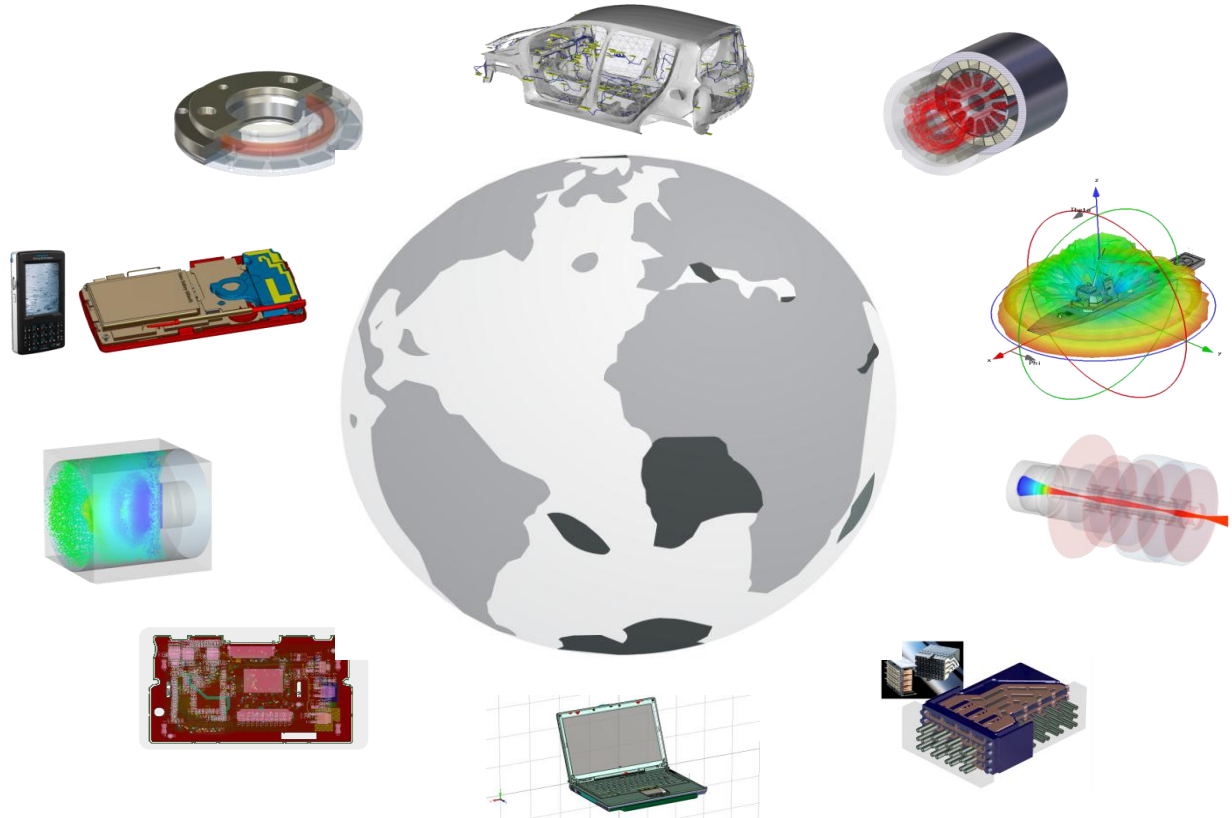
Complete Technology for 3D EM

2011

System Assembly and Modeling (SAM)



CST Worldwide



CST Customers

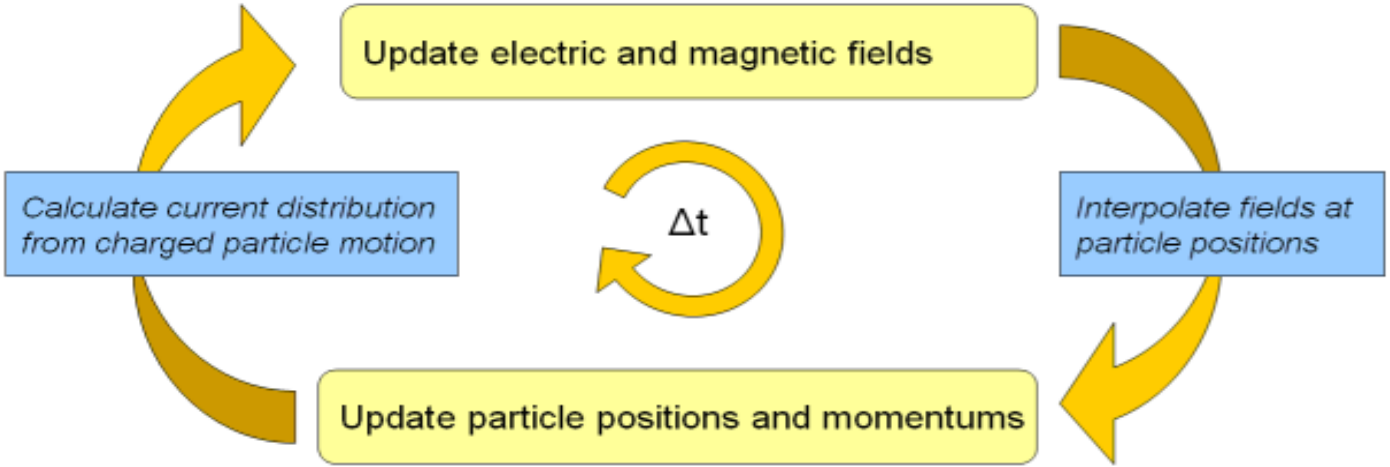
CST GPU Computing Update

- In 2007 began support of nVidia GPU acceleration in our main product, the MWS Time Domain Solver (FIT)
- Between 2008-2010 added multiple GPU and MPI+GPU support for the FIT solver

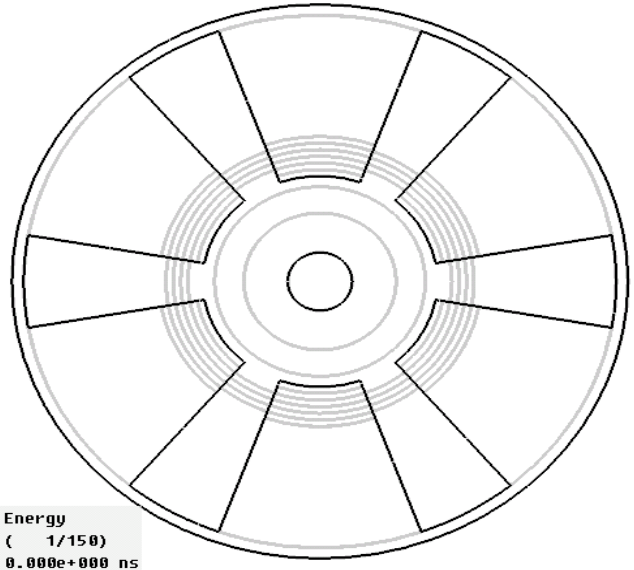
- In 2012, we added GPU acceleration support for three other solvers:
  - Particle in Cell Solver
  - Integral Equation Direct Solver
  - TLM Solver

Particle in Cell Solver: Introduction

- The PIC solver calculates the electromagnetic field by integrating Maxwell's equations
- At the same time, it calculates trajectories of particles through the calculated field.

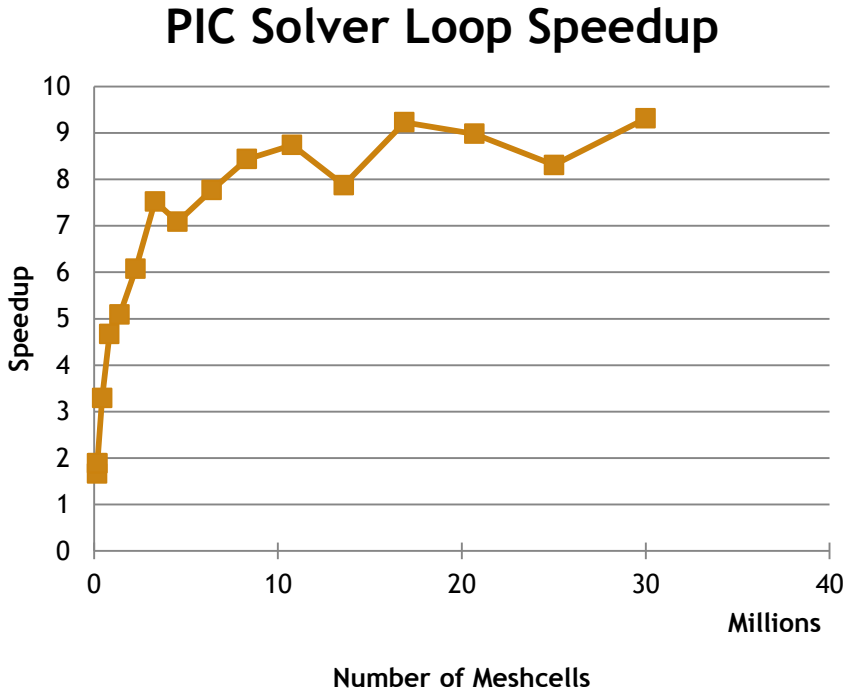


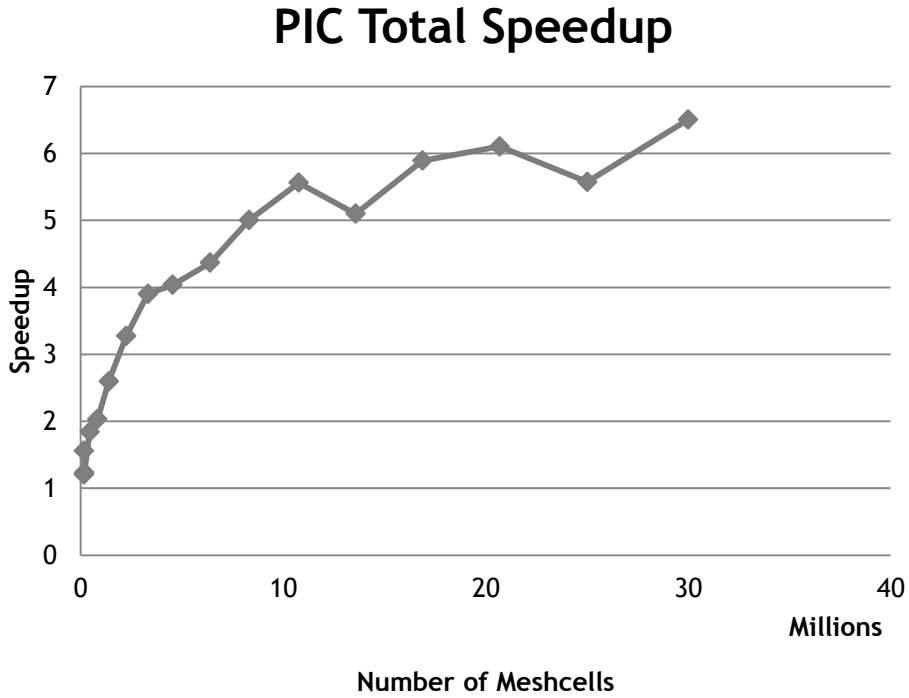
Magnetron Benchmark



Number of Meshcells	1,610,280
Av. Particle Number	1.39e4
Time CPU	36h 40m 07s
Time GPU	9h 05m 48s
Total Speed Up	4.03

Particle in Cell: Core Benchmarks

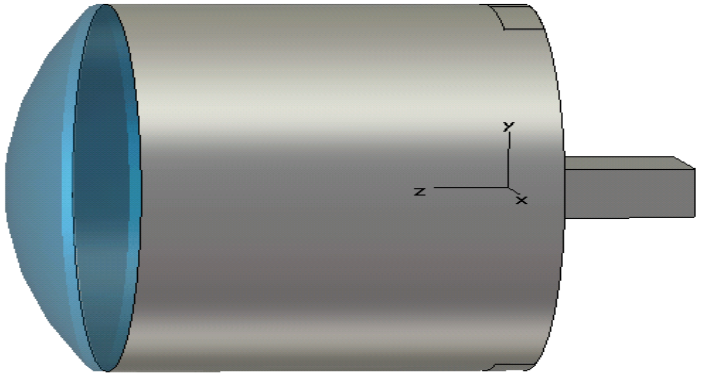


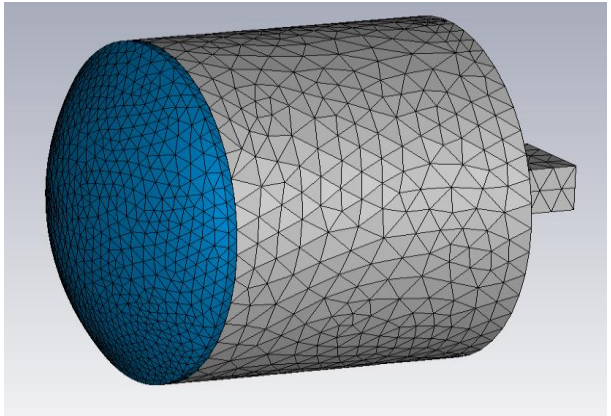


Comparison: nVidia Tesla C2050 vs. 2x Intel XEON E5620 @ 2.4 GHz (8 cores total)

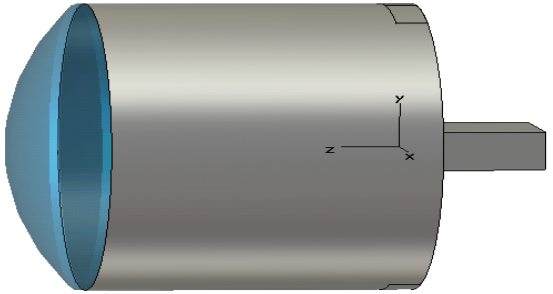
Integral Equation Solver: Introduction

- Boundary Element Solver
  -> works on surface mesh
- Frequency Domain
- Targeted at electrically large & mid-size structures (≥ 10 λ)
- Generates a complex dense matrix to be factorized



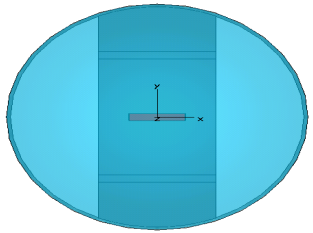


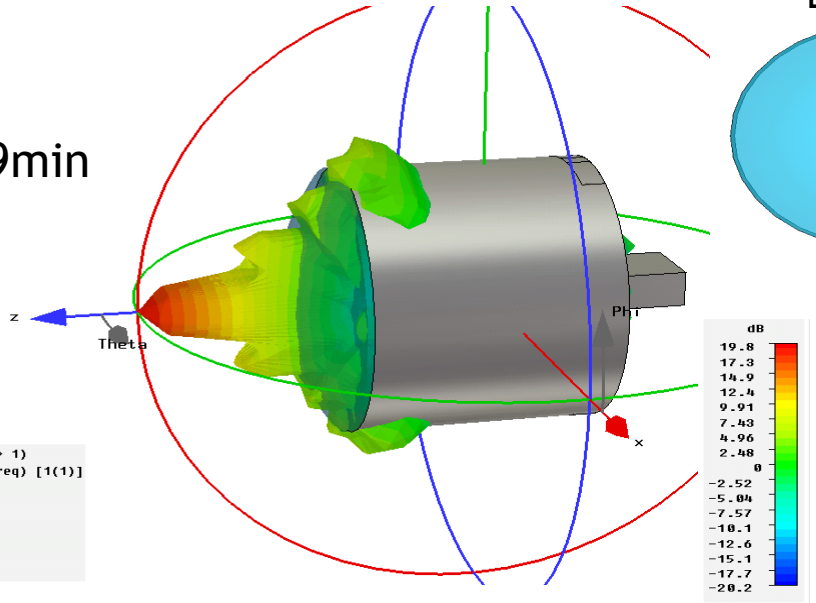
Dielectric Lens in K_u/K-Band



- 14 - 28 GHz, Lens diameter=60mm
- Lens: eps=3, thickness=12.2mm
- Surface cells: 16k
- SAsw 500
- Simulation time w/ Tesla C2075: 69min
- Memory used : 11 GB

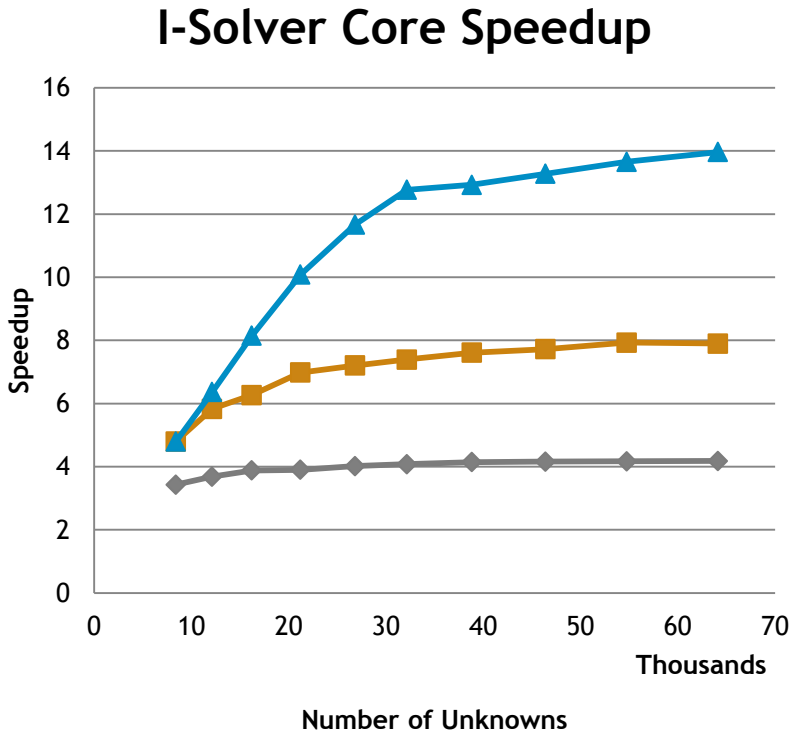
Diam. 60mm

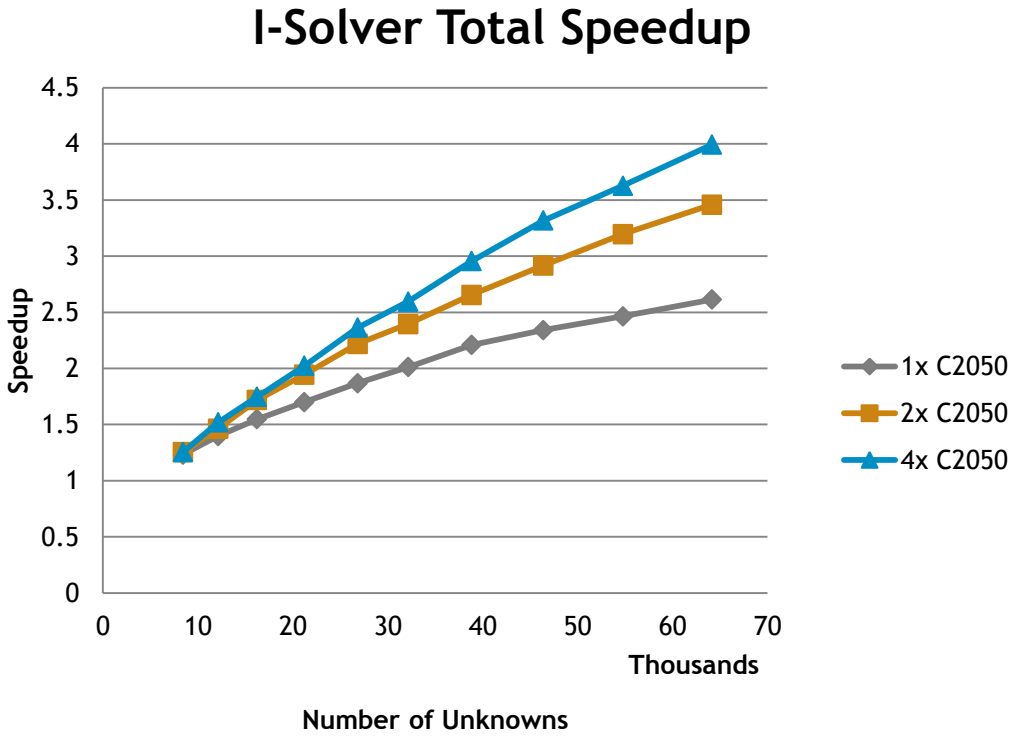




Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=freq) [1(1)]
Component	Abs
Output	Gain
Frequency	30
Rad. effic.	0.2238 dB
Tot. effic.	-0.3367 dB
Gain	19.82 dB

Integral Equation Solver: Core Benchmarks

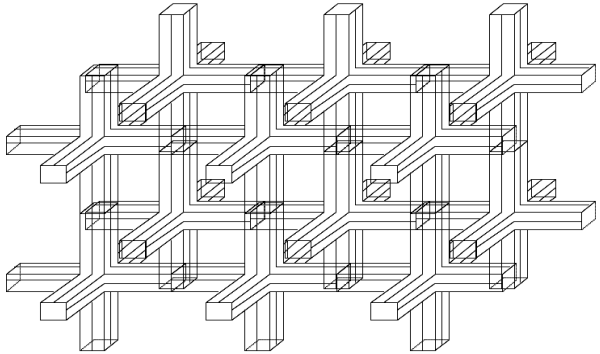




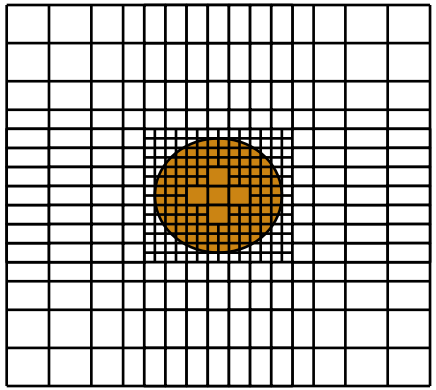
Comparison: nVidia Tesla C2050 vs. 2x Intel XEON E5620 @ 2.4 GHz (8 cores total)

TLM Solver: Introduction

- Broadband Transient Solver
- Special aperture and wire modeling (EMC/EMI)
- Octree localized mesh
- Compact models: vents, seams, slots, shielded cables



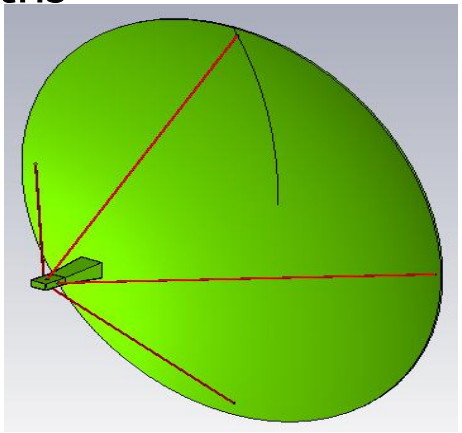
SCN

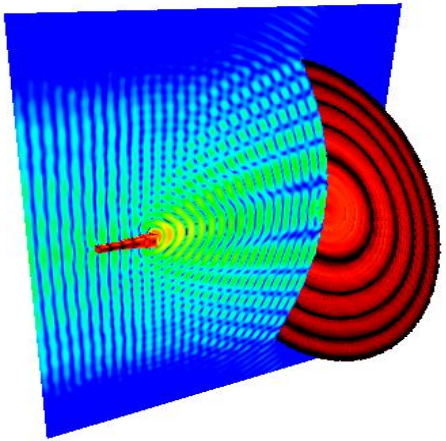


Octree mesh

TLM GPU Speedup

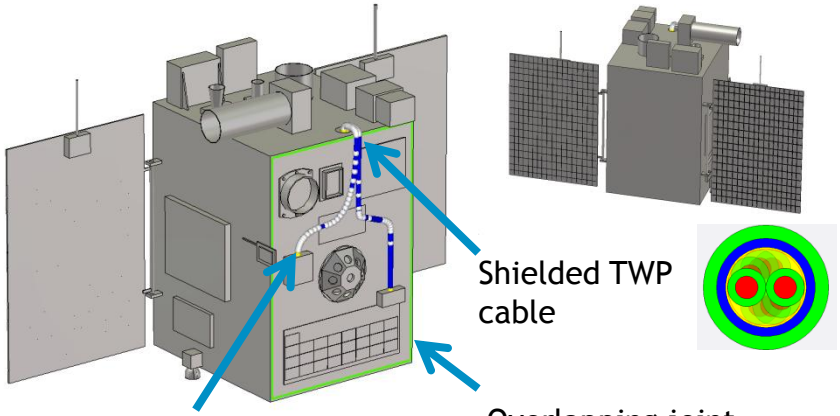
- Rectangular waveguide horn antenna with parabolic reflector
- 2m diameter dish @ 3.5GHz
- Approximately 23 wavelengths

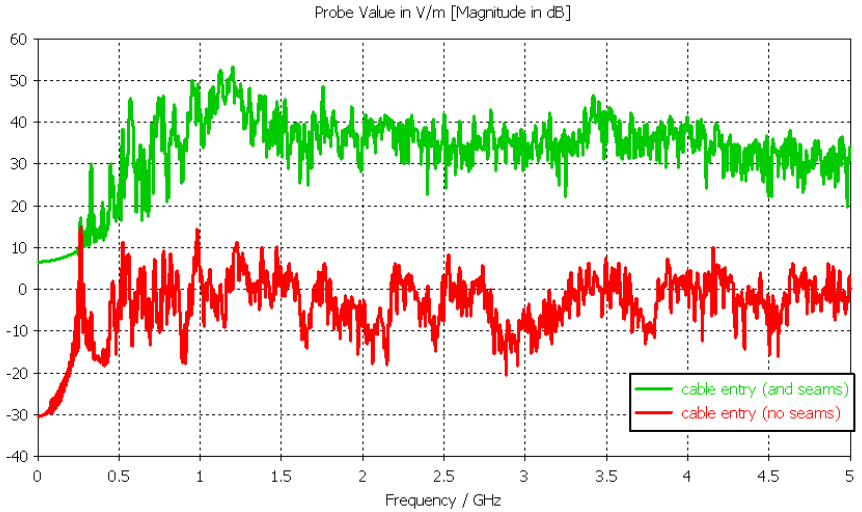




	2012	2012 GPU
Time	20:09	4:35
Speedup		4.4

Satellite system benchmark

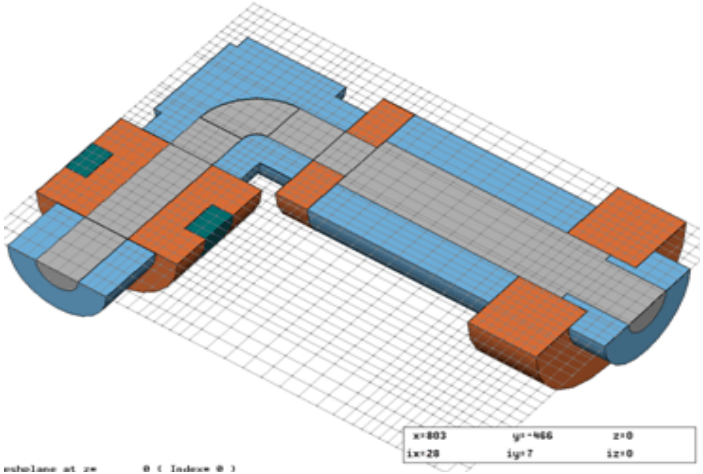


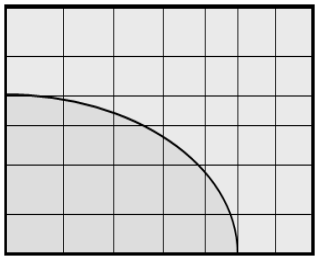


GPU Tesla 2050 solve time 45min
8-core Westmere-EX CPU 180min: 4X speedup

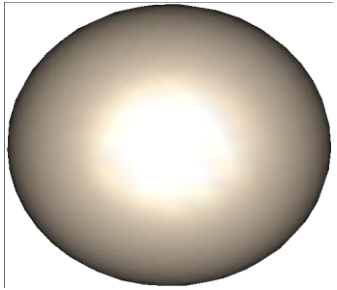
Time Domain (FIT) Solver

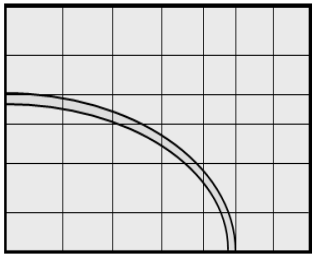
- Transient, low memory, broadband solution
- Conformal meshing (PBA, TST)
- Support for multi-GPU, MPI+GPU





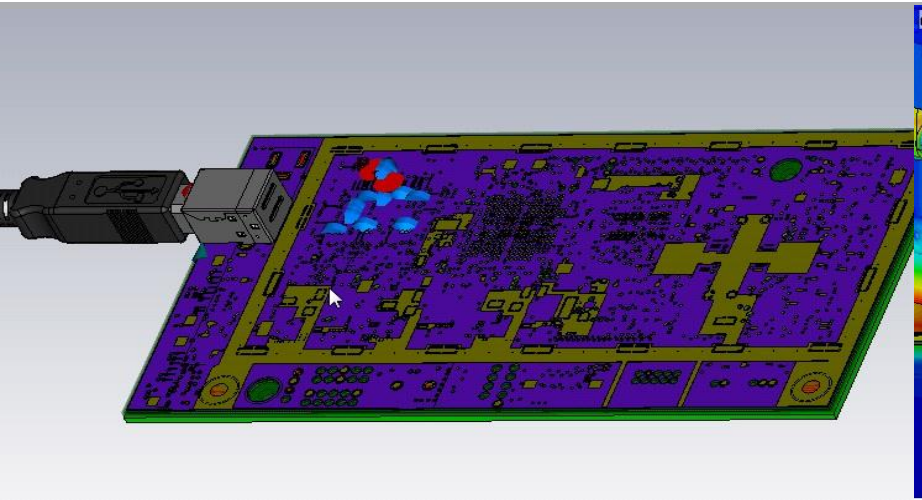
PBA

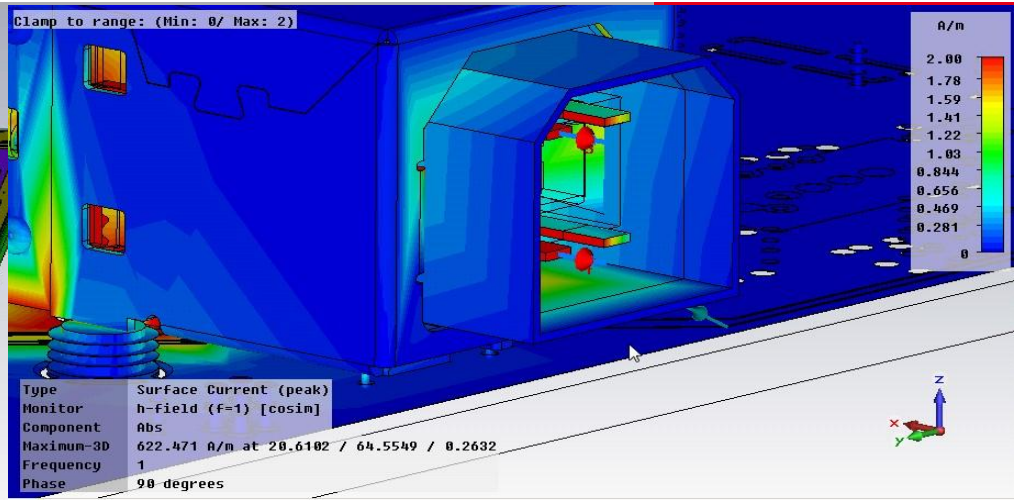




TST

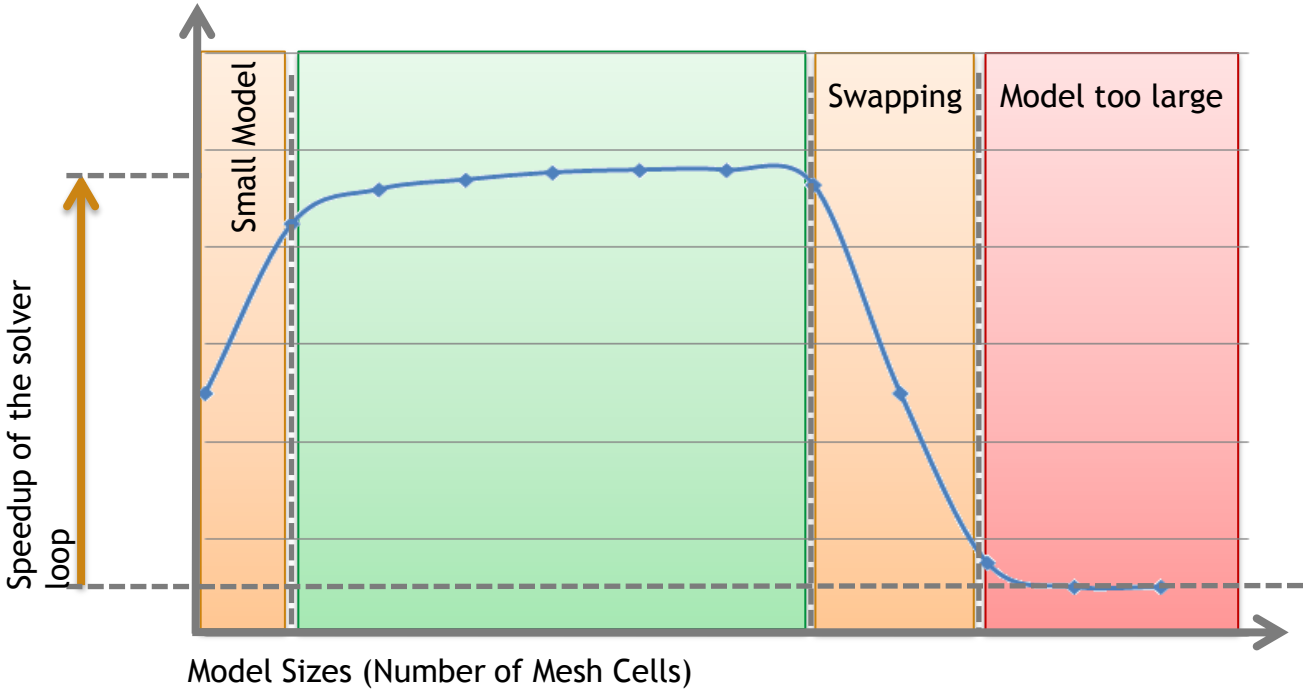
PCB with USB connector/cable





20M mesh cells
12 Westmere-EX core Solver Loop=7840s
2xM2070 Solver Loop=1596s
Solver Loop Speedup = 5x

GPU Computing - Typical Performance

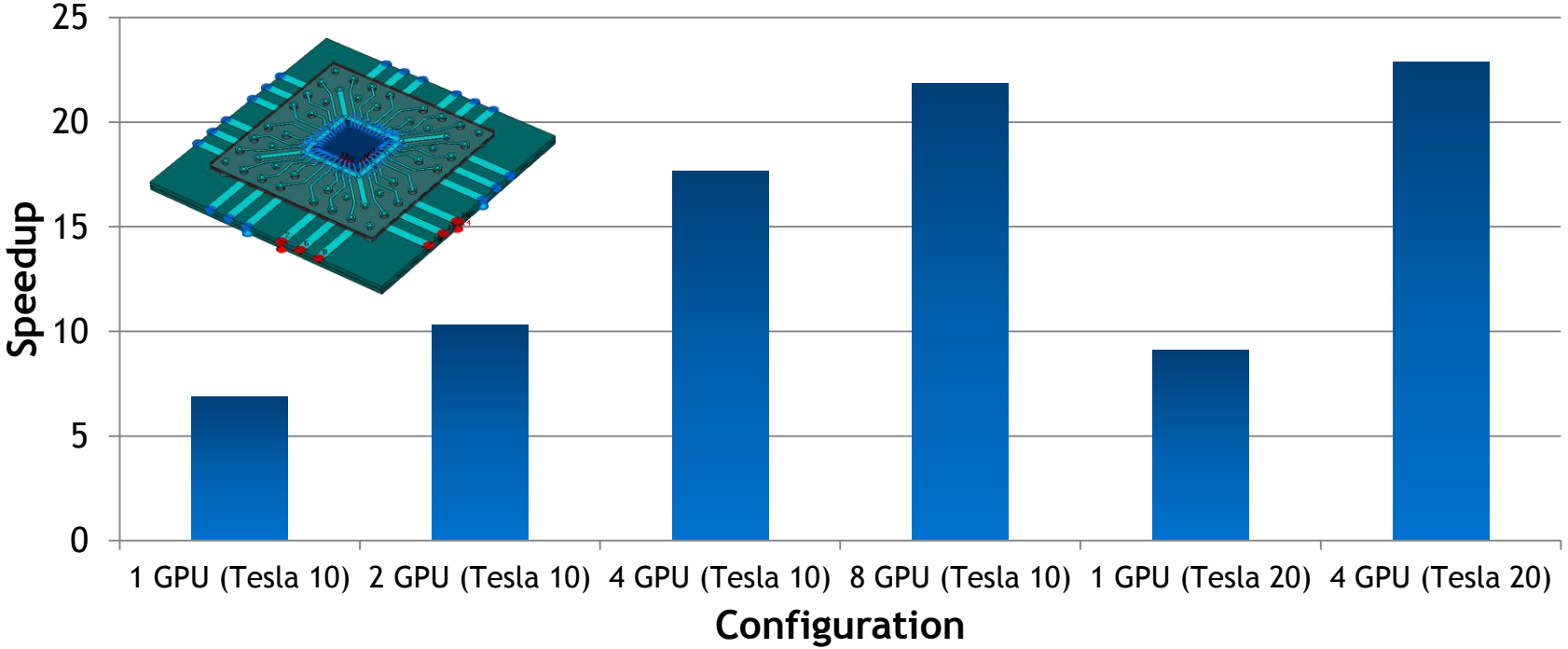


The features which need the largest amount of memory on the GPU are:

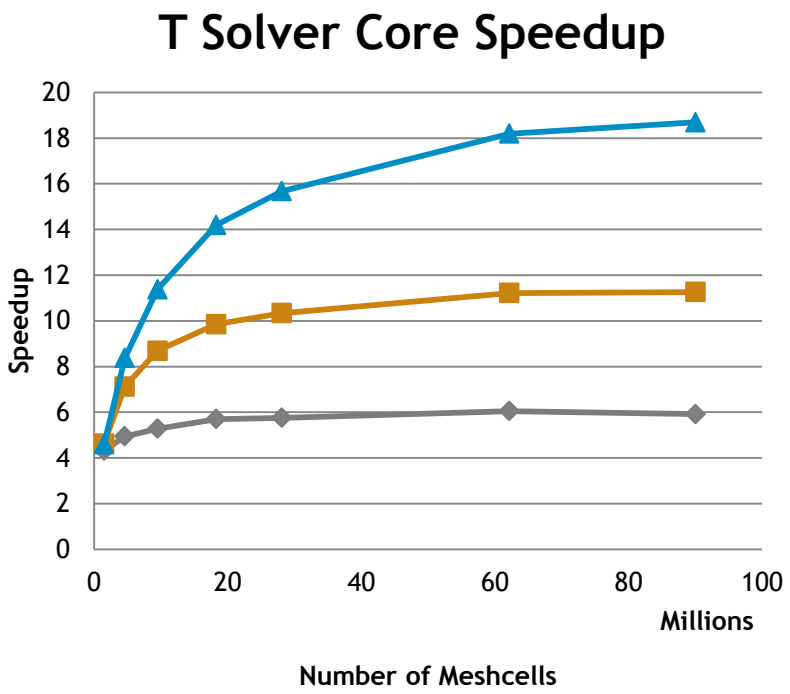
- dispersive materials
- lossy metal
- open boundaries

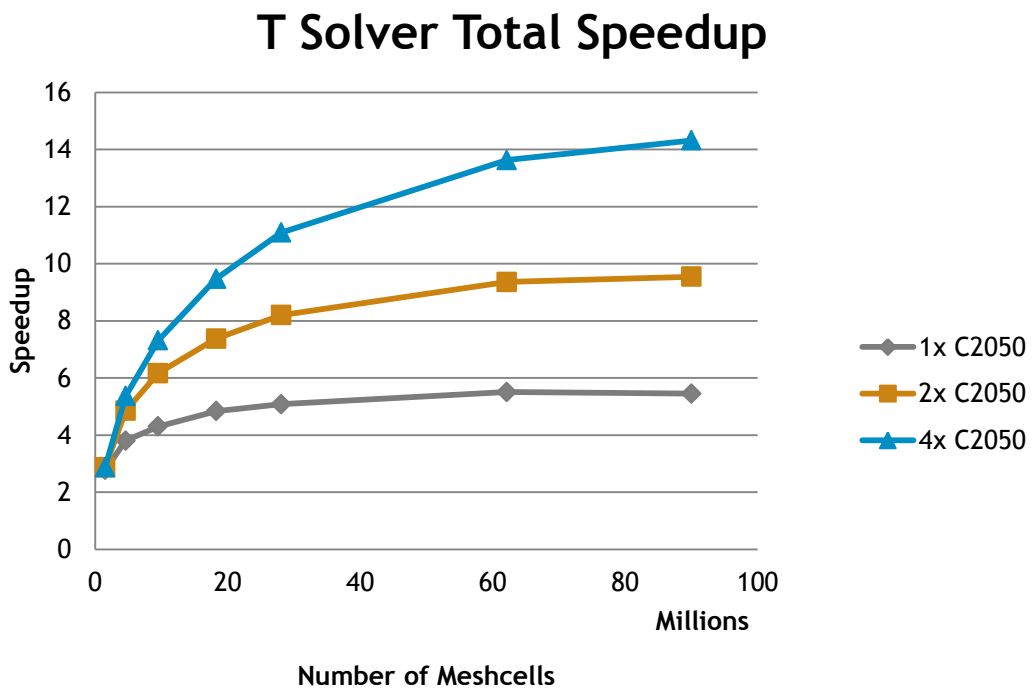
GPU Computing – Typical Performance

Mean Speedup of Solver Loop
(compared to dual Intel Xeon X5550, fastest memory configuration)



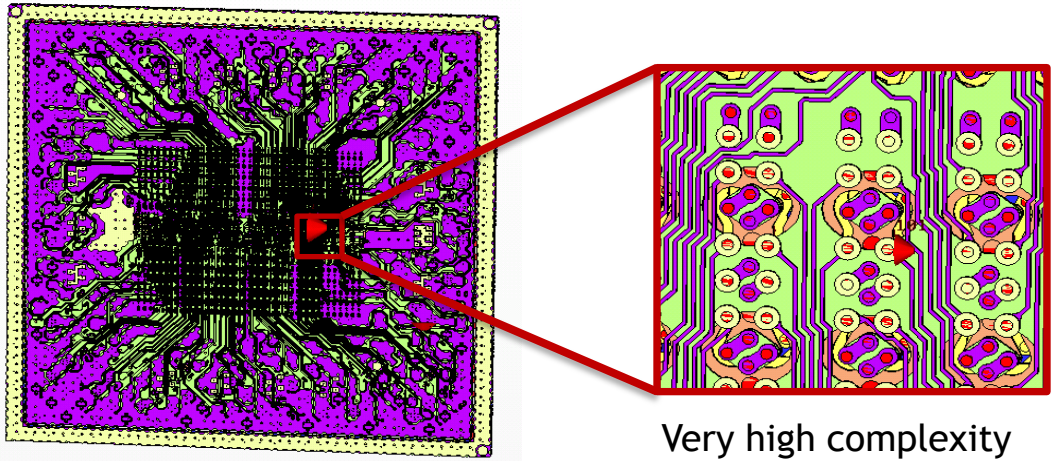
Time Domain Core Benchmarks





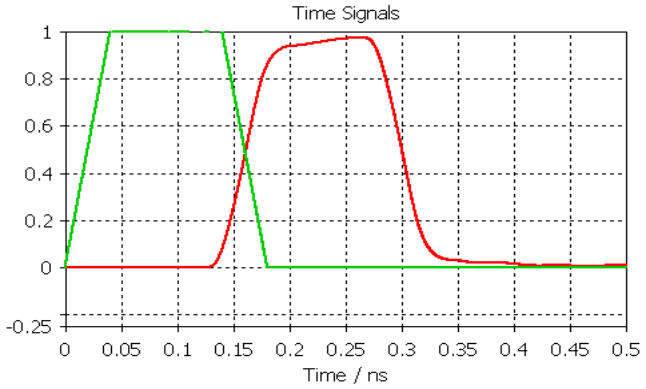
Comparison: nVidia Tesla C2050 vs. 2x Intel XEON E5620 @ 2.4 GHz (8 cores total)

Complex Package Benchmark (SI)



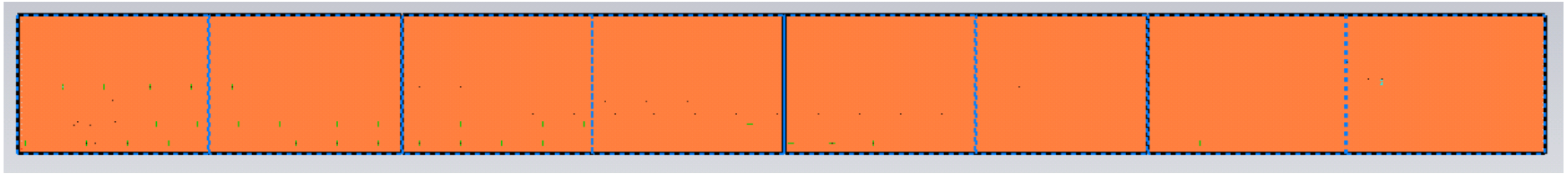
50 million mesh cells

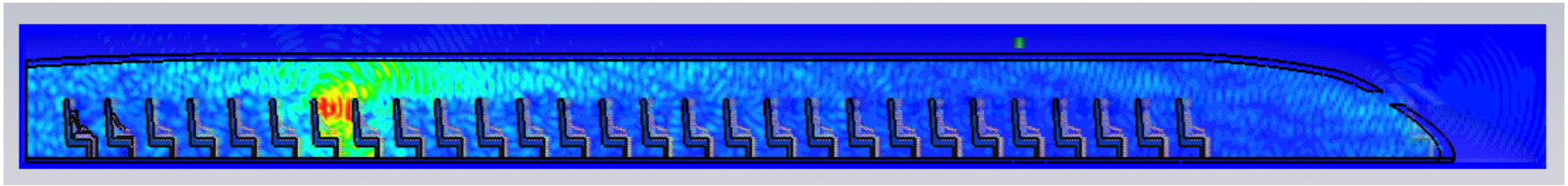
Very high complexity



	CPU (2x Quad Core Intel Xeon E5530, 2.4 GHz)	4x Tesla 10 GPUs	4x Tesla 20 GPUs
Solver Loop Time/s	39467	1662	990
Solver Loop Speedup	1	23.7	39.8

Passenger Aircraft Benchmark: MPI+GPU





146M mesh cells, (4) MPI+GPU nodes, (2) Tesla C1060 per node
Total simulation time = 8 hours

Conclusion

- Significant performance improvement using GPU Computing
- CST GPU solvers (PIC, TLM, IE, TD) available for various applications
- Support of up to 8 GPUs/host for TD, IE Solvers; Cluster MPI+GPU for TD Solver