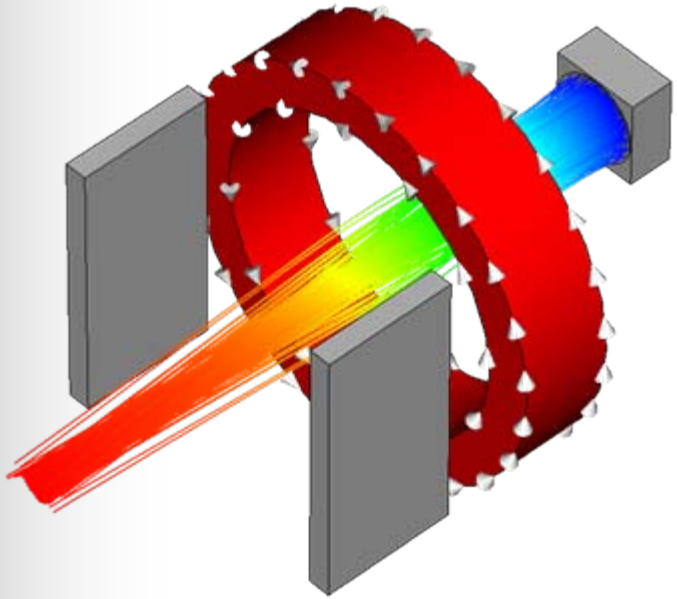
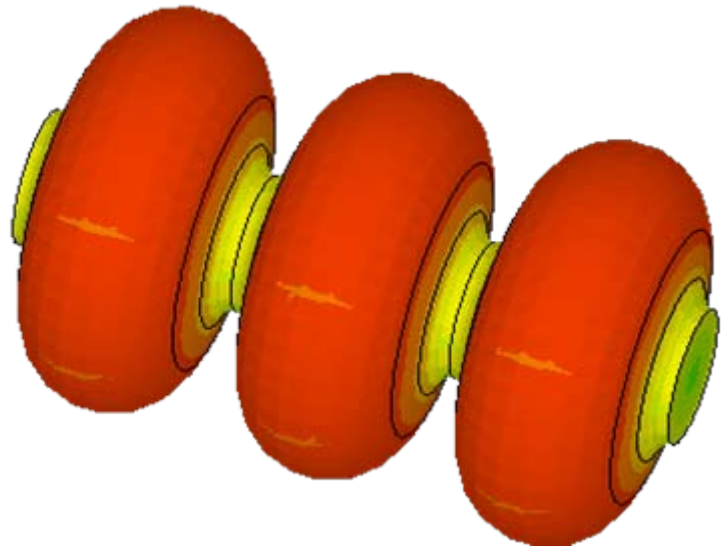
CST‘s commercial Beam-Physics Codes

Ulrich Becker
CST
(Computer Simulation Technique)



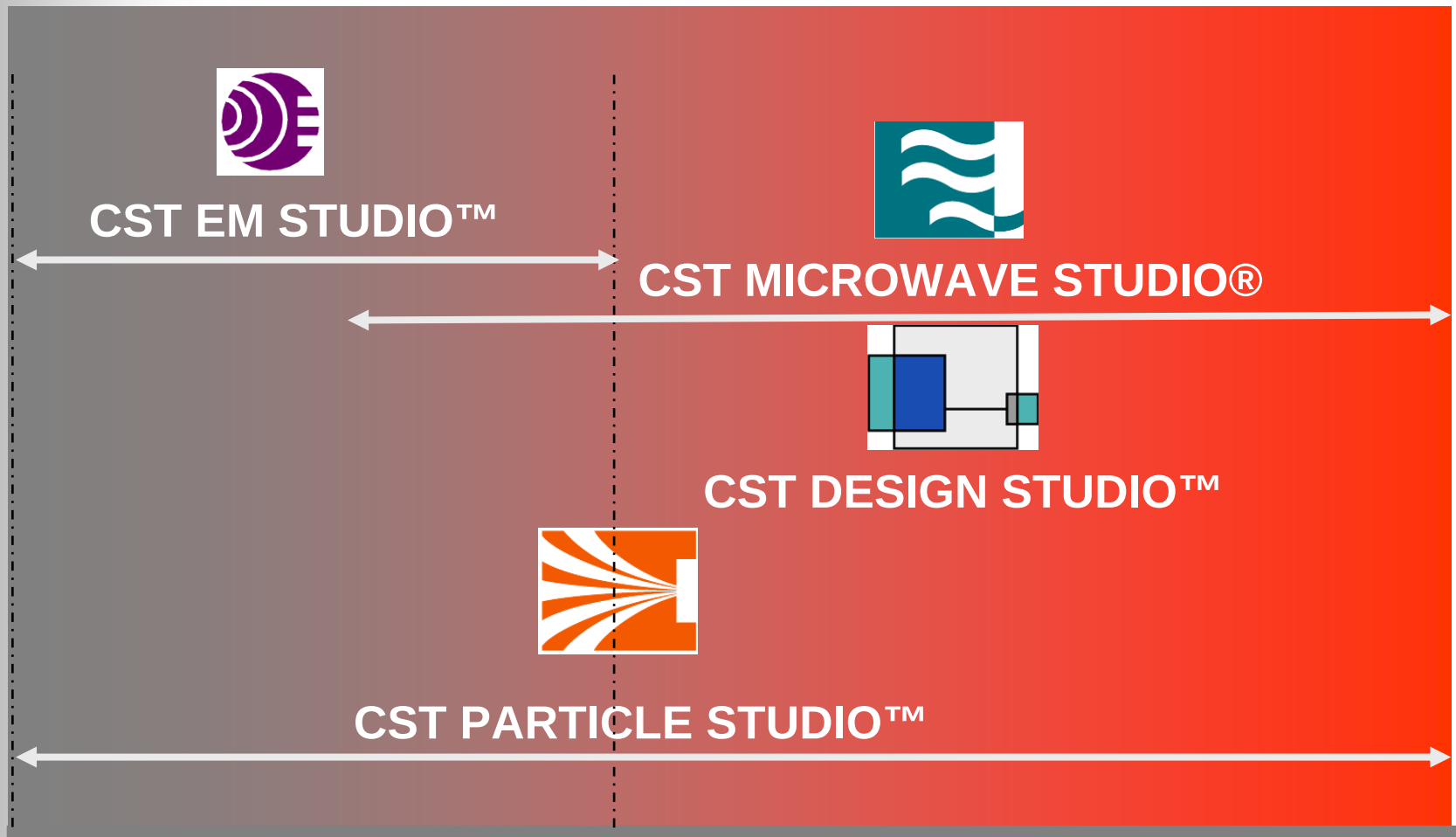


Outline

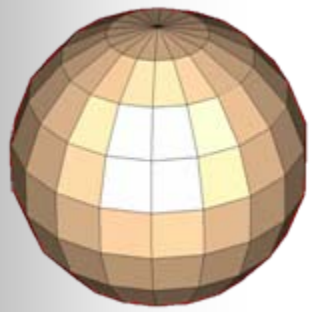
- Overview CST STUDIO SUITE
- Accelerator related examples with
  - CST MICROWAVE STUDIO
  - CST EM STUDIO
  - CST PARTICLE STUDIO
- New key features in version 2006B
- Summary

CST STUDIO SUITE™

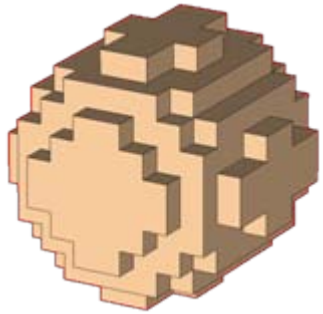
Products Inside



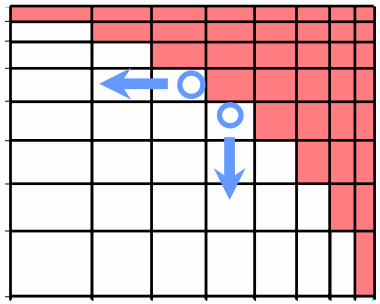
Used discretization technique

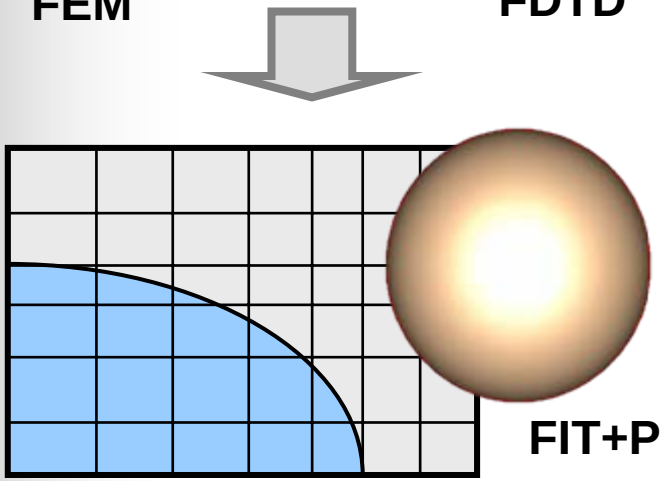


FEM

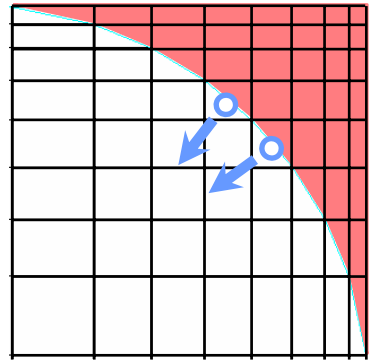


FDTD





FIT+PBA

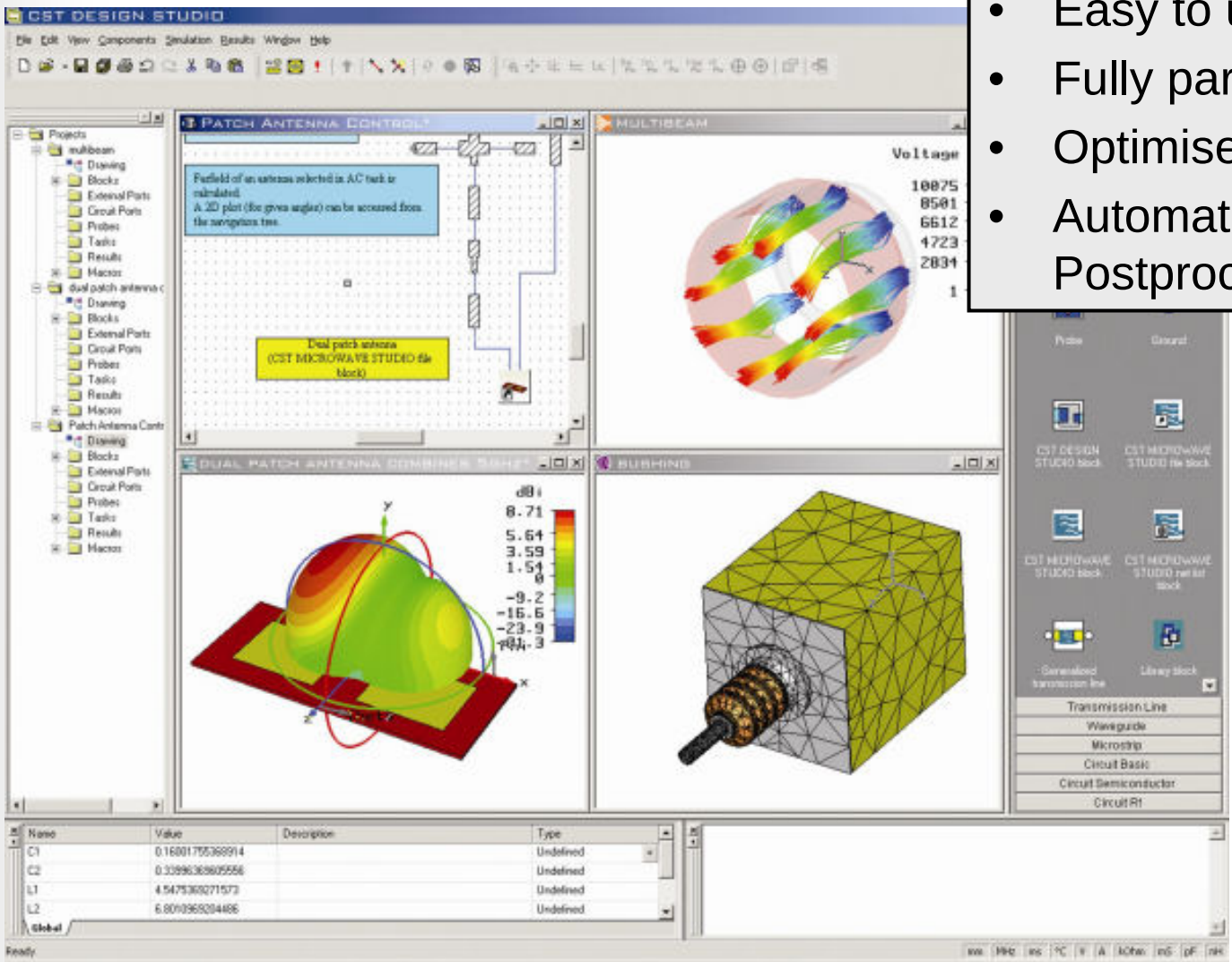


FIT = Finite Integration Technique
PBA = Perfect Boundary Approximation

☺ Representation of rounded objects
☺ Simple explicit Time Algorithm
(like FDTD, but no staircase meshing, no matrix inversion)

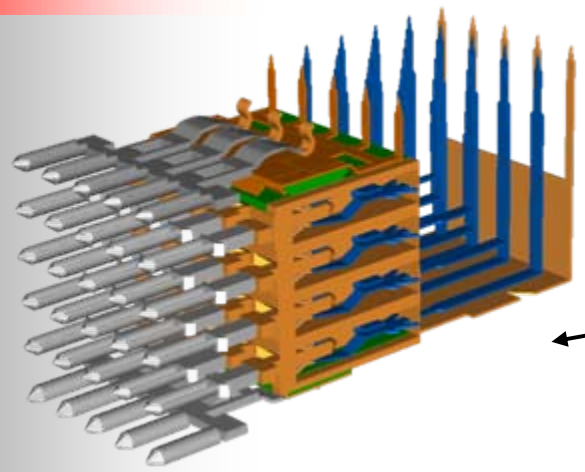
CST STUDIO SUITE

Interface



- Easy to use 3D
- Fully parametric
- Optimiser
- Automated Postprocessing

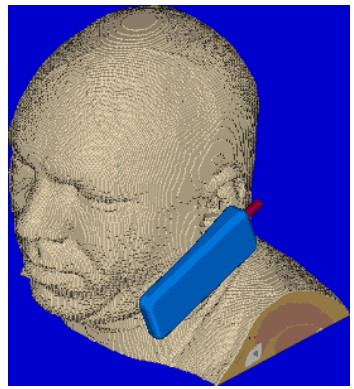
Mechanical CAD Systems



Step

CATIA 5

SAT...
STL...
IGES (up to 5.3)...
VDA-FS (up to 2.0)...
STEP (AP203, AP214)...
Autodesk Inventor (up to 7)...
Pro/E Release 16 to 2001...
CATIA Release 4...
CATIA Release 5...
ADS Model...
CoventorWare...
Sonnet Model...
DXF...
GDSII...
GERBER...
Voxel Data...



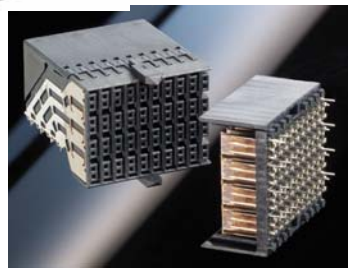
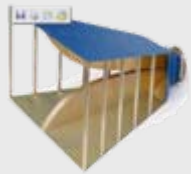
Arbitrary Voxel Data

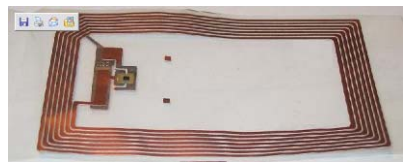
CST MICROWAVE STUDIO®

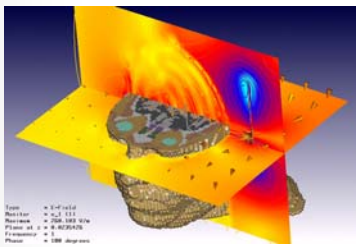
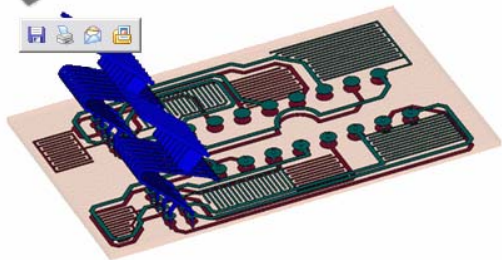
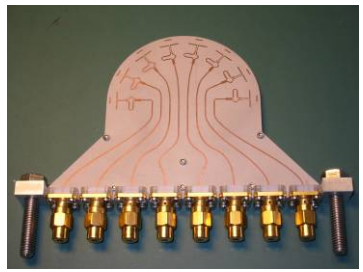
Some selected Application Areas

- Classical MW
  - Waveguide, Antenna, Filter, Coupler, Balun, Splitter, Cavity, Connector
- EMC/EMI
- SI
- RFID
- Medical
  - Mobile Phones & SAR
  - CT/NMR



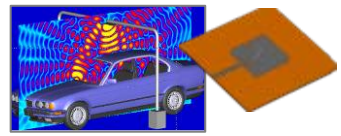
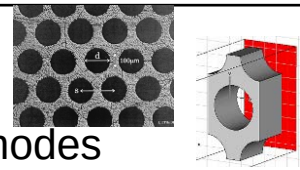






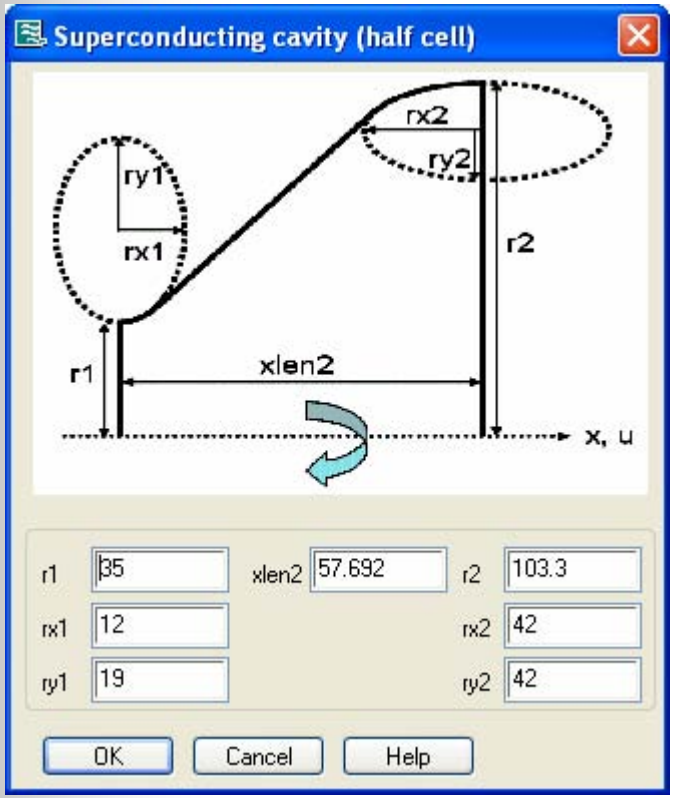
CST MICROWAVE STUDIO®

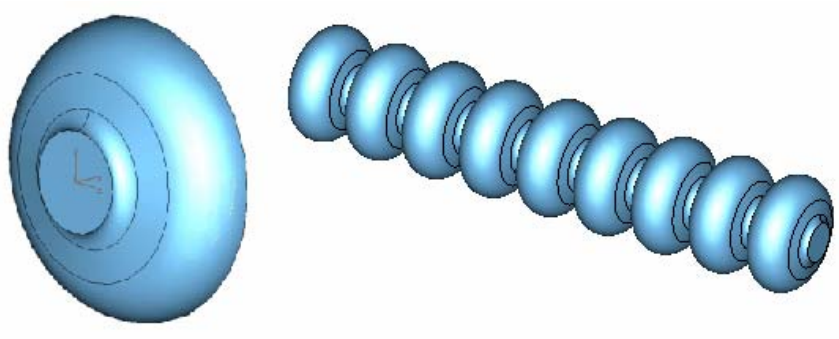
Solver

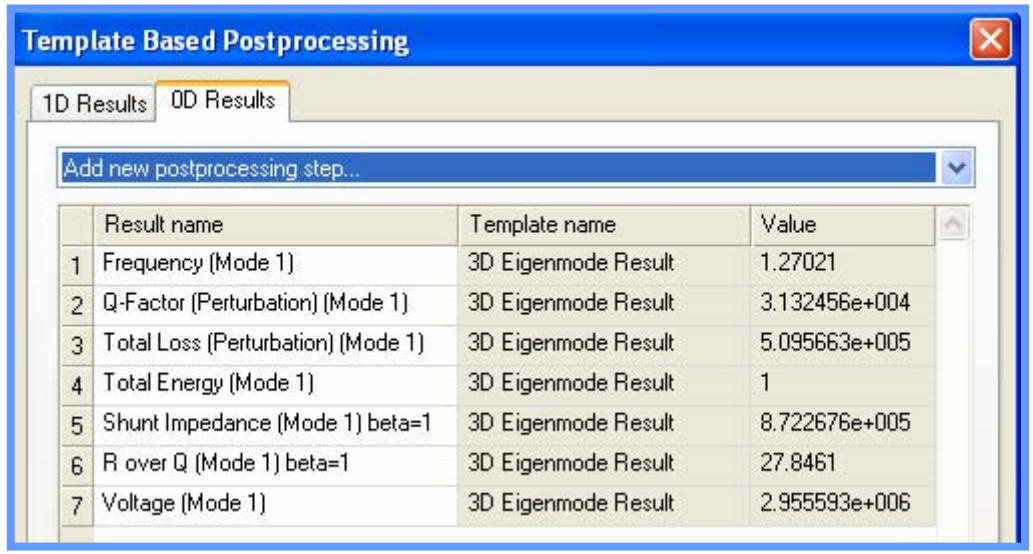
General Purpose Solver 3D-Volume		
!T	**Transient**	• Large problems • Broadband • Arbitrary time signals 
!F	**Frequency Domain**	• Narrow band / single frequency • Small problems • Periodic structures with Floquet port modes 
Special Solver 3D-Volume: Closed Resonant Structures		
!E	**Eigenmode**	• Strongly resonant structures, narrow band • Cavities 
!F Resonant	**FD Resonant**	• Strongly resonant, closed structures 
Special Solver 3D-Surface: Large open metalic structures		
!I	**M**ulti-**L**evel **F**ast **M**ethod of **M**oments	• Large Structures • Dominated by metal  

Example Superconducting Cavity

easy construction via Macros -> Construct -> Superconducting Cavity

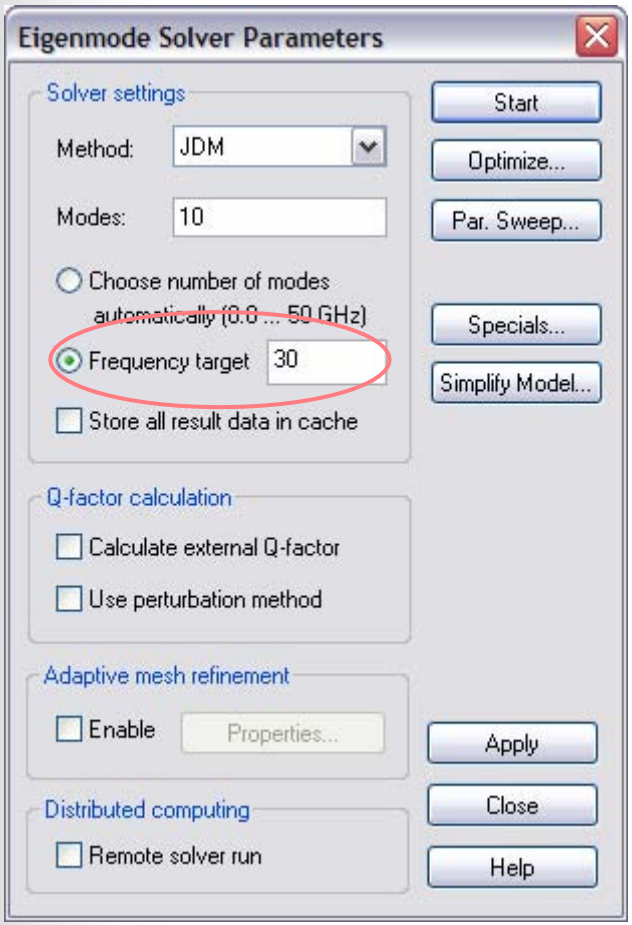


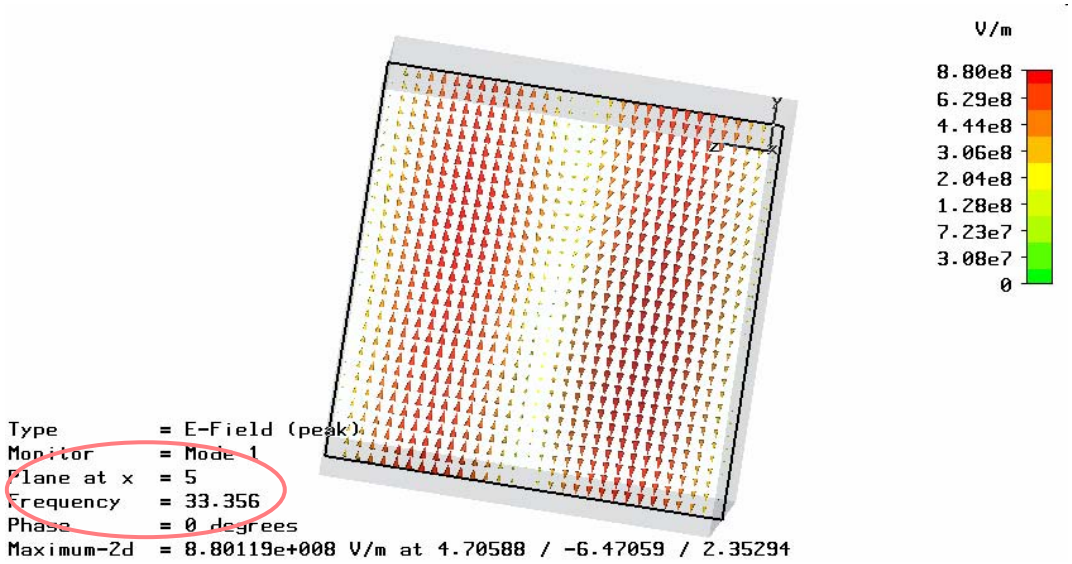




	Result name	Template name	Value
1	Frequency (Mode 1)	3D Eigenmode Result	1.27021
2	Q-Factor (Perturbation) (Mode 1)	3D Eigenmode Result	3.132456e+004
3	Total Loss (Perturbation) (Mode 1)	3D Eigenmode Result	5.095663e+005
4	Total Energy (Mode 1)	3D Eigenmode Result	1
5	Shunt Impedance (Mode 1) beta=1	3D Eigenmode Result	8.722676e+005
6	R over Q (Mode 1) beta=1	3D Eigenmode Result	27.8461
7	Voltage (Mode 1)	3D Eigenmode Result	2.955593e+006

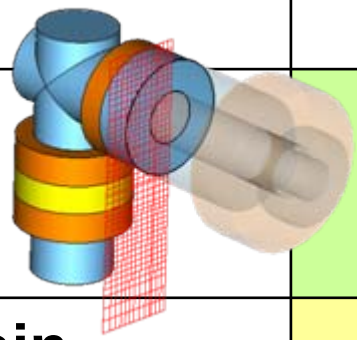
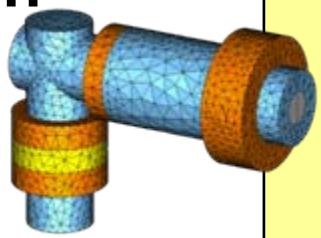
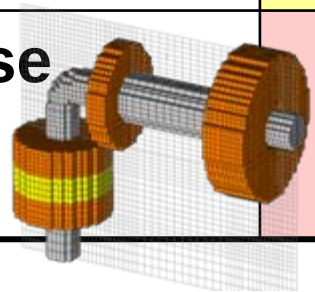
Efficient simulation of high order Eigenmodes by choosing a frequency target





Comparison and Cross Verification

Transient-PBA, Transient-Staircase, Frequency Domain

Solution Technique	CPU - Time
Transient PBA 	2 minutes, 30s
Frequency Domain 	3 minutes, 36s Slower than PBA: 1.44
Transient Staircase 	24 minutes, 26s Slower than PBA: ~10

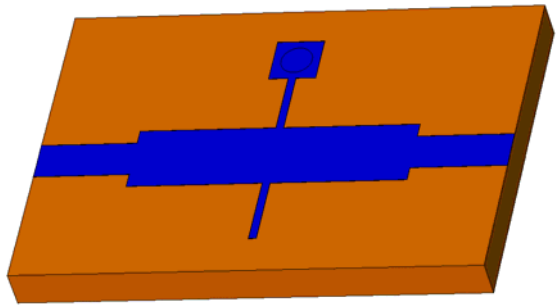
CST DESIGN STUDIO™

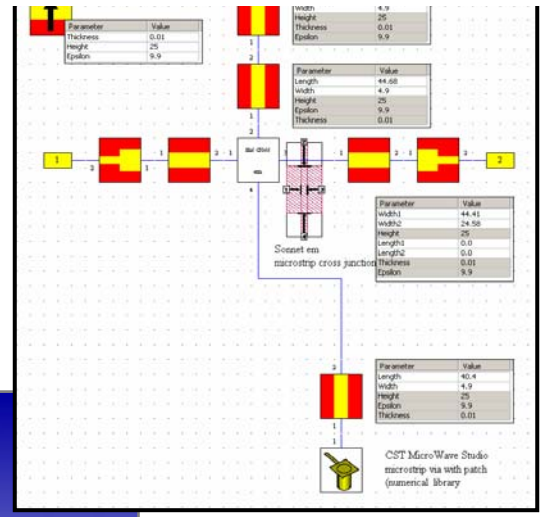
Coupling of Circuit and EM Simulation:

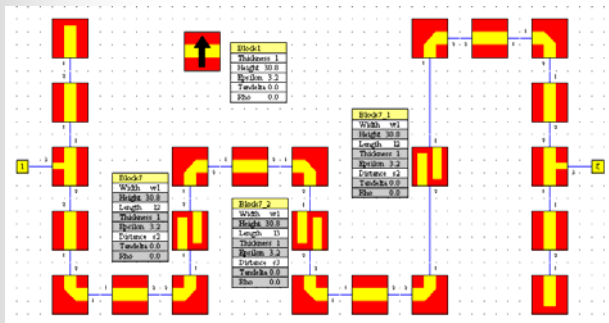
- CST MWS Blocks
- Analytical Blocks: Microstrip, Stipline, WG, ...
- Transistors, Diodes
- Planar EM Coupling: Sonnet
- Coupling to mode matching: Mician

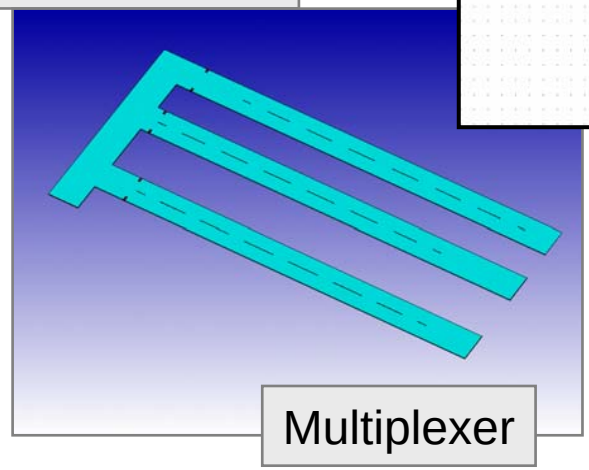
Main Applications:

- Antenna Feeding networks
- Splitting of complex EM Models









Multiplexer

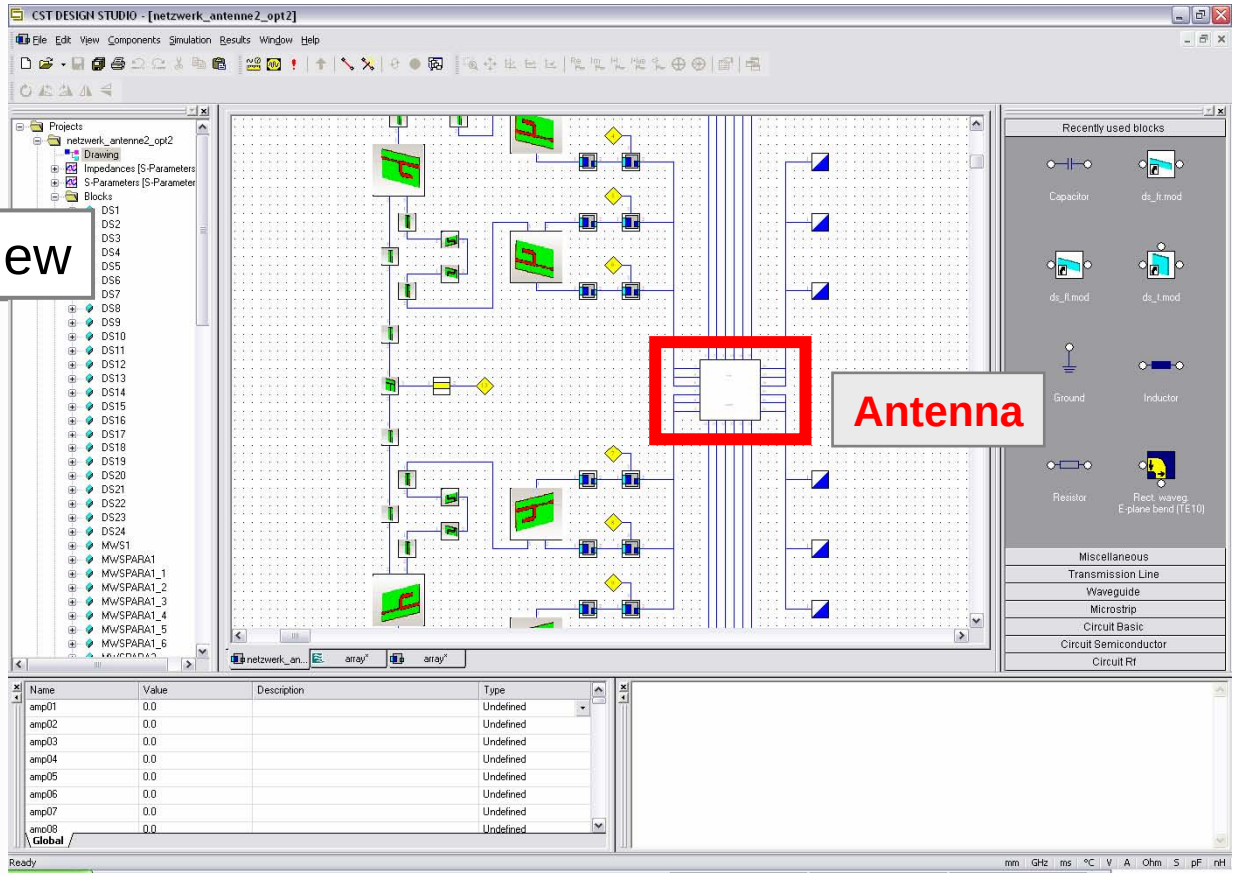
Co-Simulation

CST DS – CST MWS

Toggle between Circuit-Block View and 3D Model View

Easy optimisation and parameter sweeps for complete circuit model

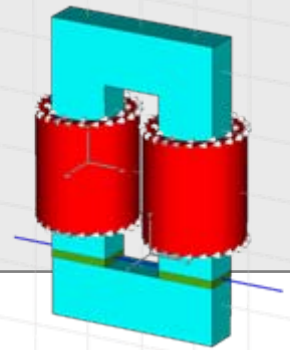
Circuit View

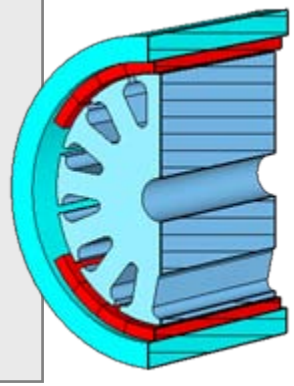


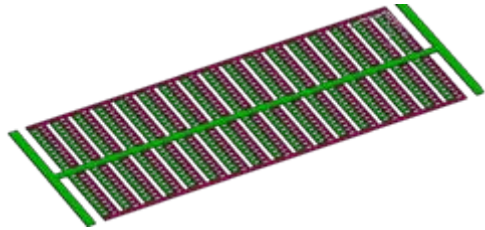
CST EM STUDIO™

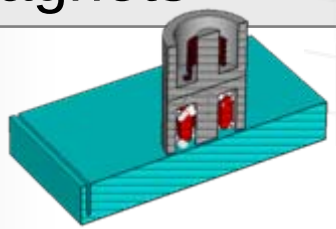
Some selected Applications

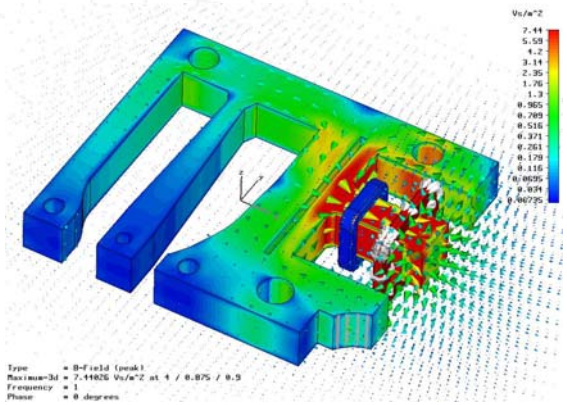
- Sensors: Inductive, Capacitive
- Actuators
- NDT
- Transformers
- Motors
- Magnets

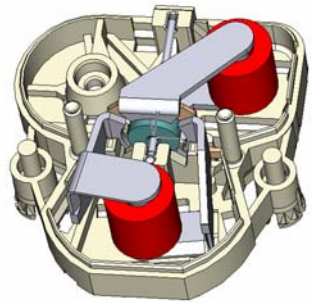








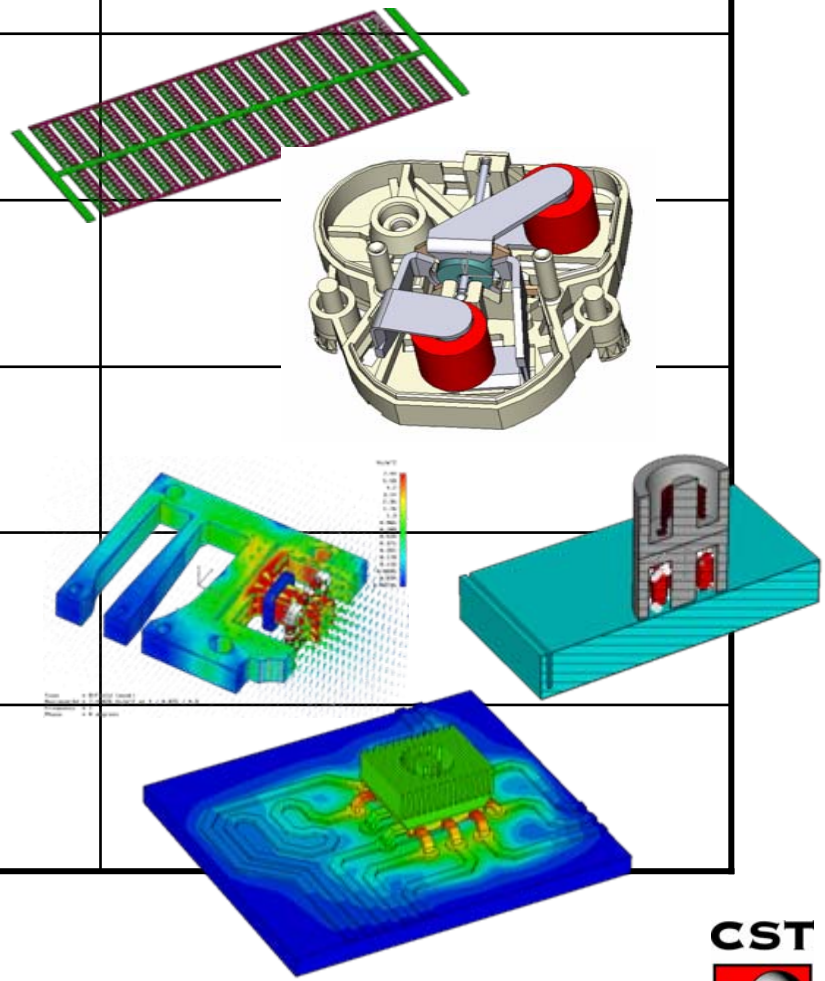




CST EM STUDIO™

Solver Overview

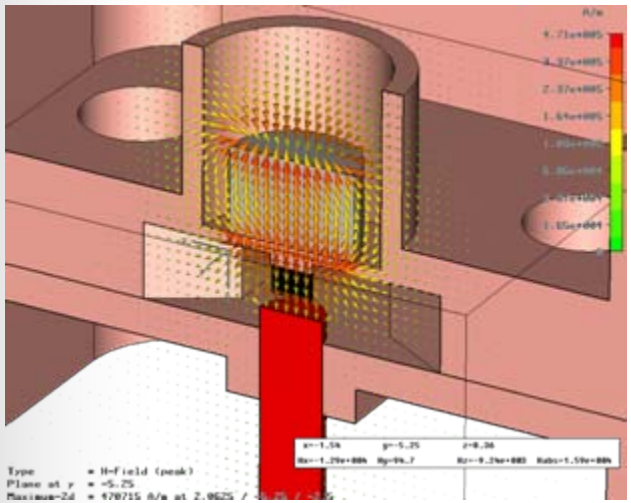
Solver	
Electrostatic	
Magnetostatic	
Stationary Current	
Low-Frequency (new: EQS-Solver)	
Temperature	



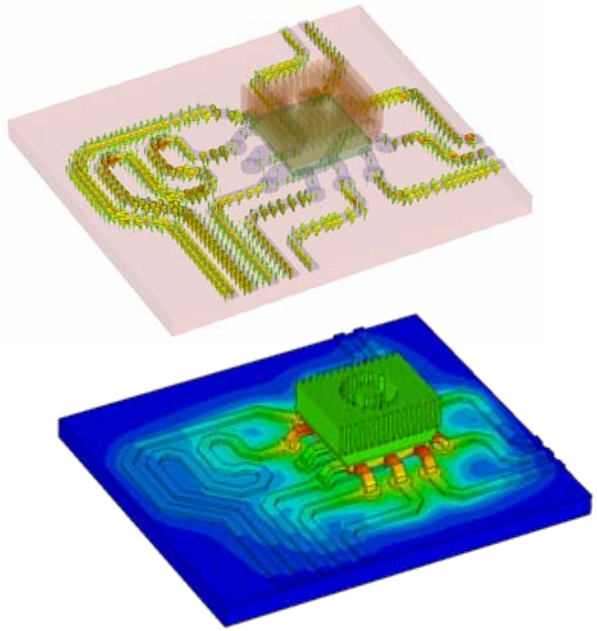
Co-Simulations

CST MWS – CST EMS

Ferrite magnetisation



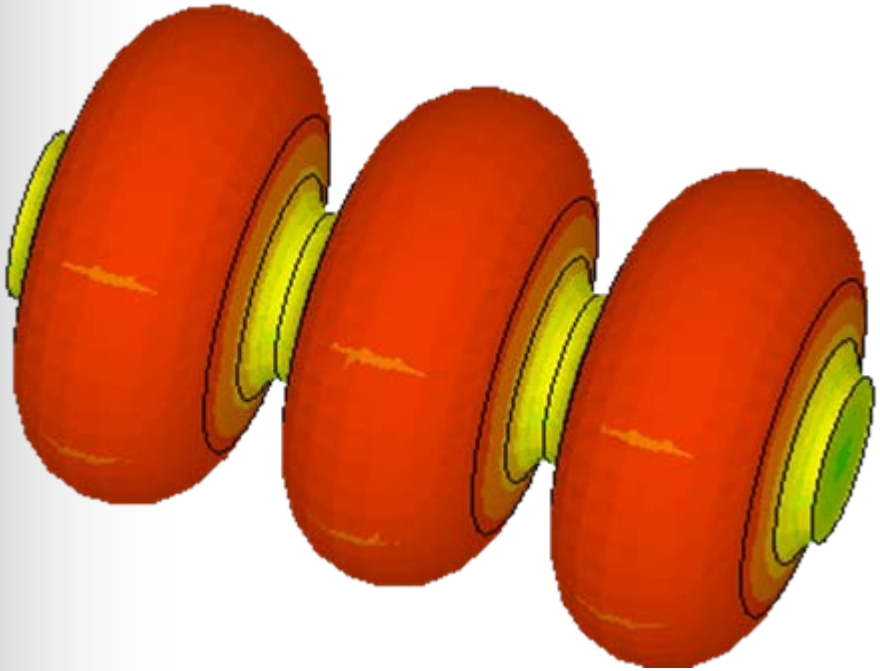
Thermal Analysis of electric losses

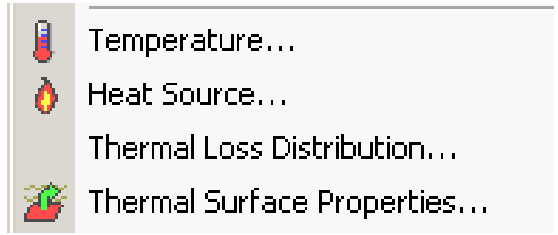


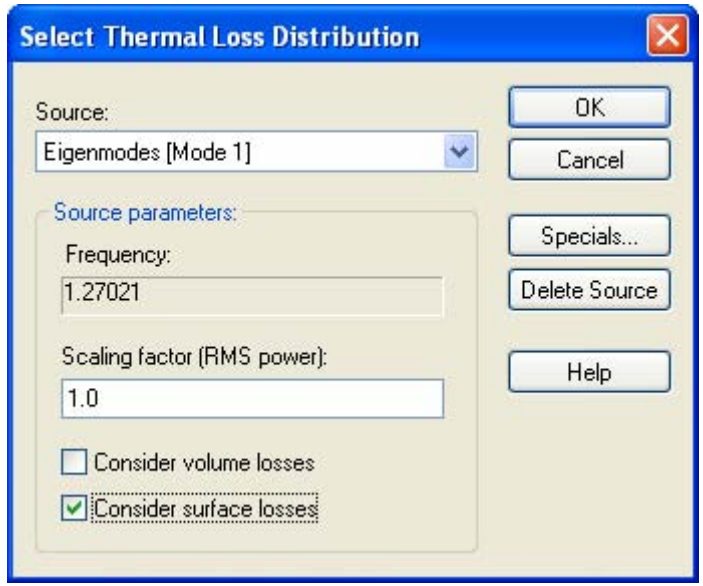
1. Static Magnetisation – CST EMS
2. HF Analysis – CST MWS

1. Currents: CST MWS
2. Temperature Analysis: CST EMS

Thermal Calculation



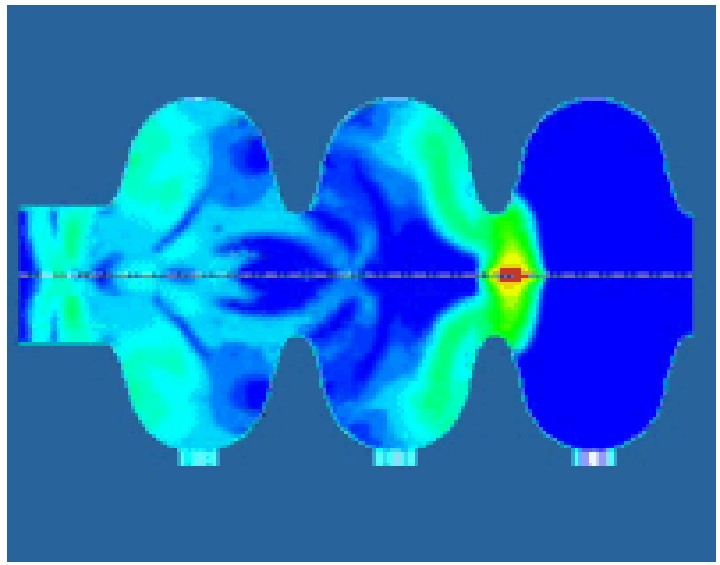


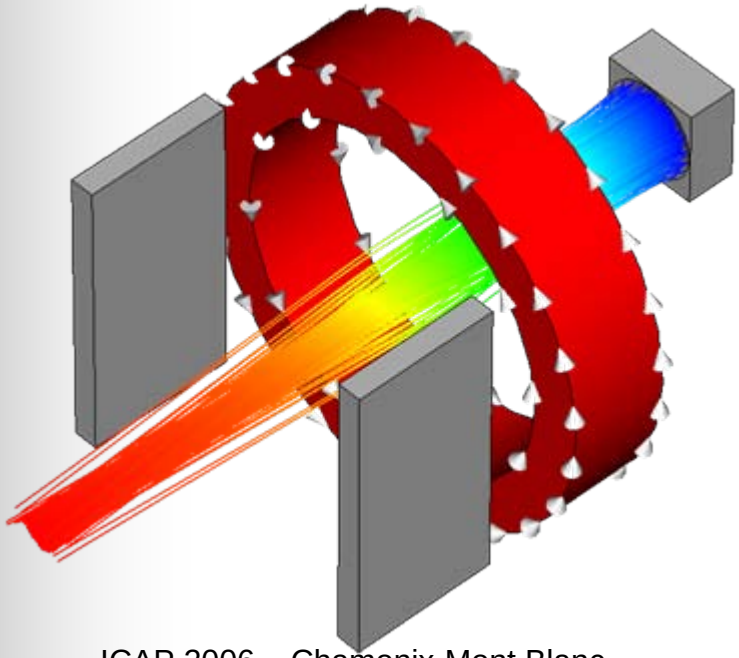


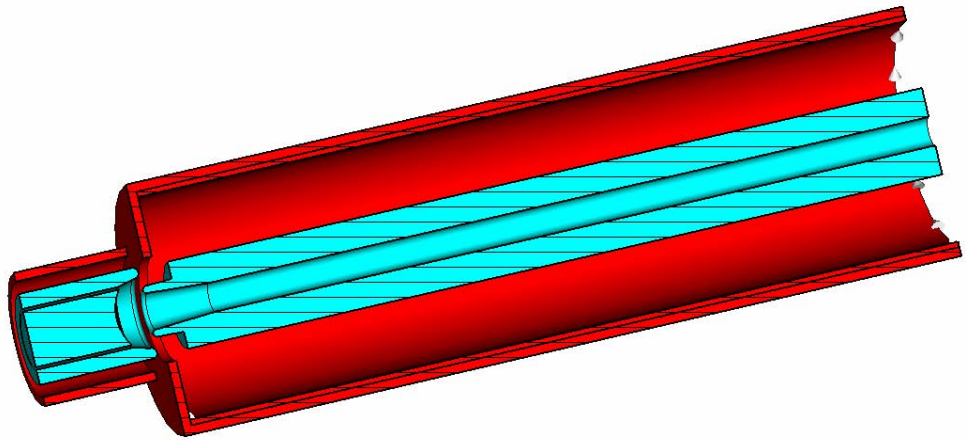
CST EM STUDIO **2006B** is able to perform a thermal simulation inlcuding surface and volume losses from a previous eigenmode simulation

CST PARTICLE STUDIO™

- Gun and Collector Analysis
- Wakefield Analysis
- Link to MAFIA PIC codes

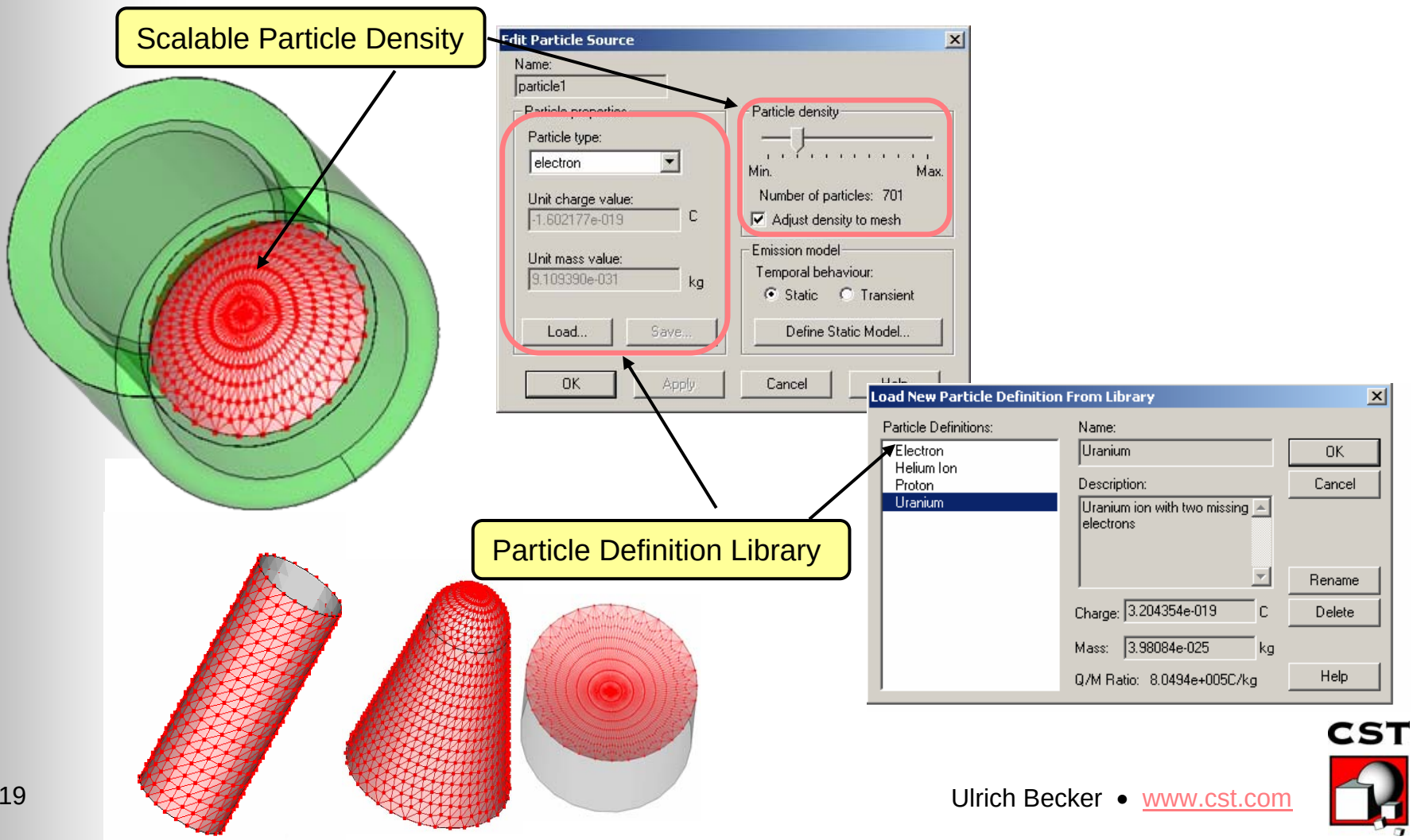






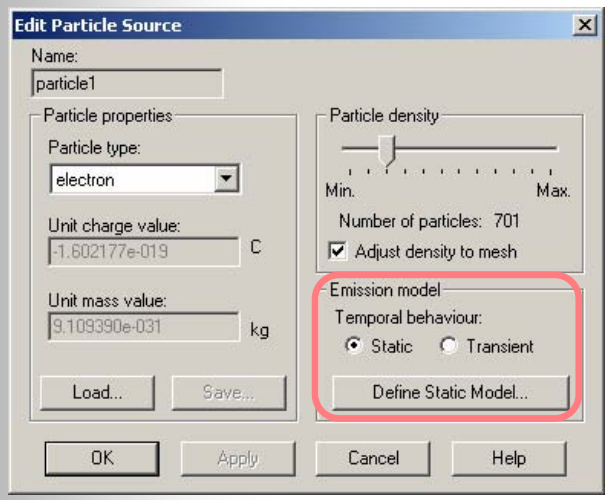
Particle Emission

Particle Source Definition:

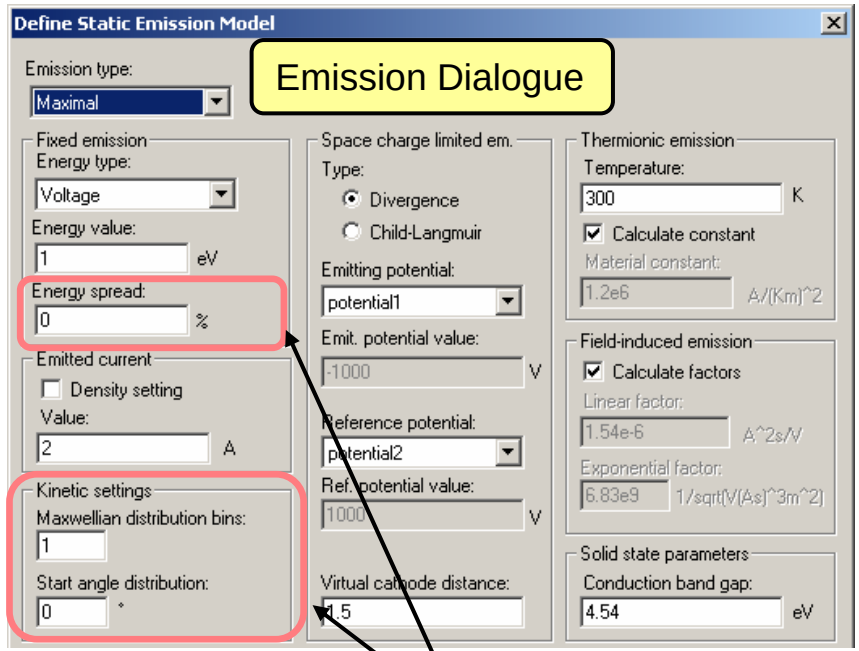


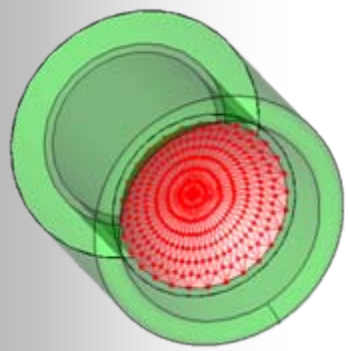
Particle Emission

Static Emission Models:



Static Emission Model



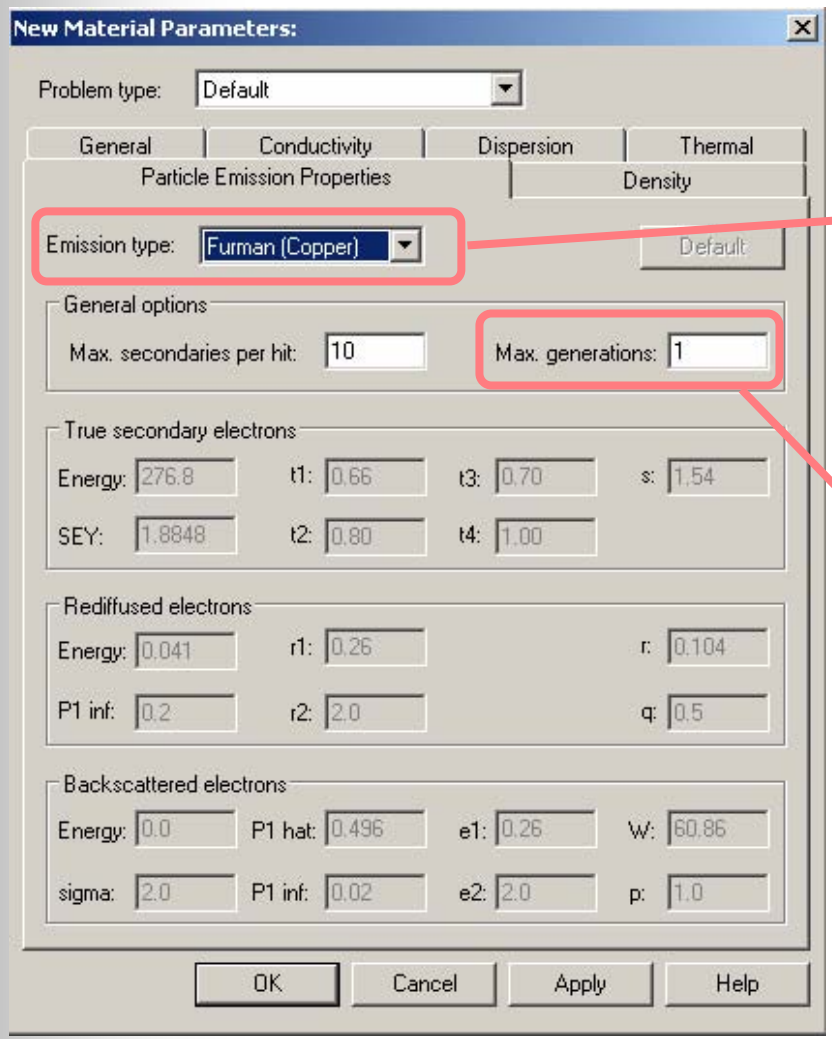


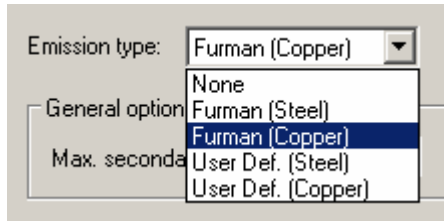
1. Fixed emission (predefined current and energy)
2. Space charge limited emission (Child‘s law)
3. Thermionic emission (Richardson-Dushman)
4. Field induced emission (Fowler-Nordheim)
5. Automatic maximal selection

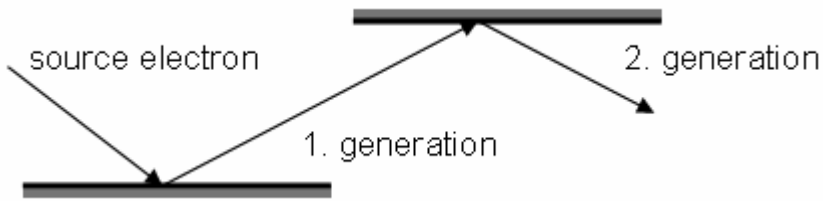
Additional features:

- Random energy spread
- Maxwell-Boltzmann velocity distribution

Secondary Electron Emission



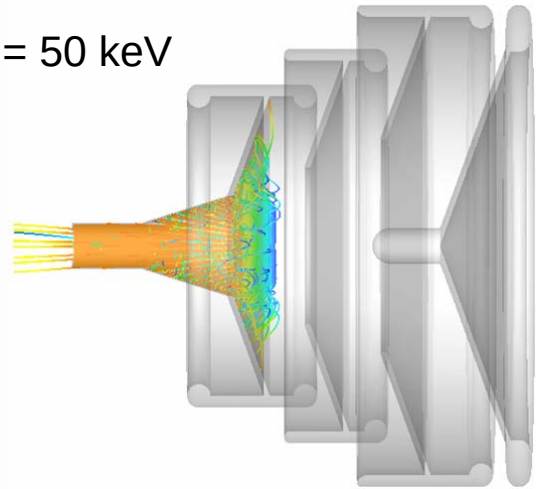




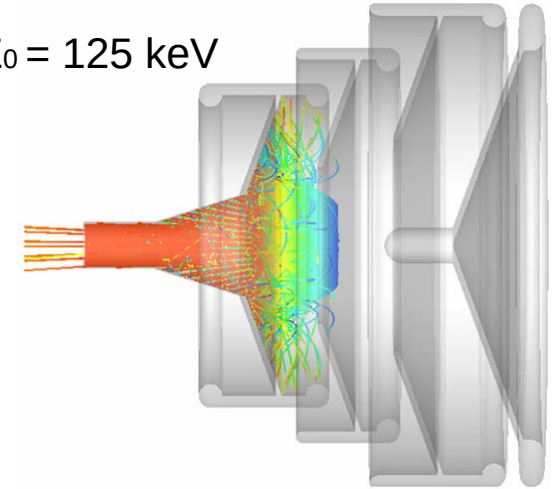
Secondary Electron Emission

Example: Collector

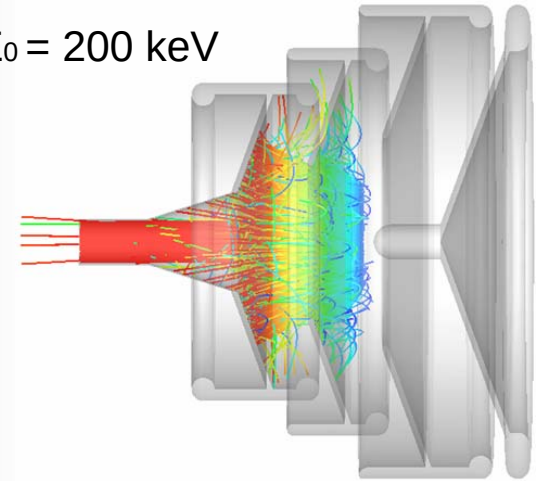
E_0 = 50 keV



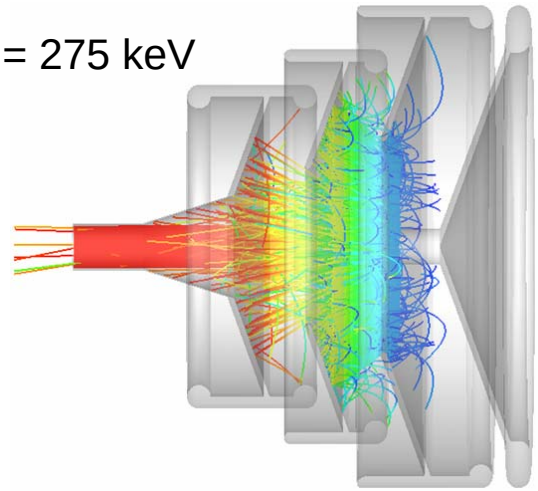
E_0 = 125 keV



E_0 = 200 keV

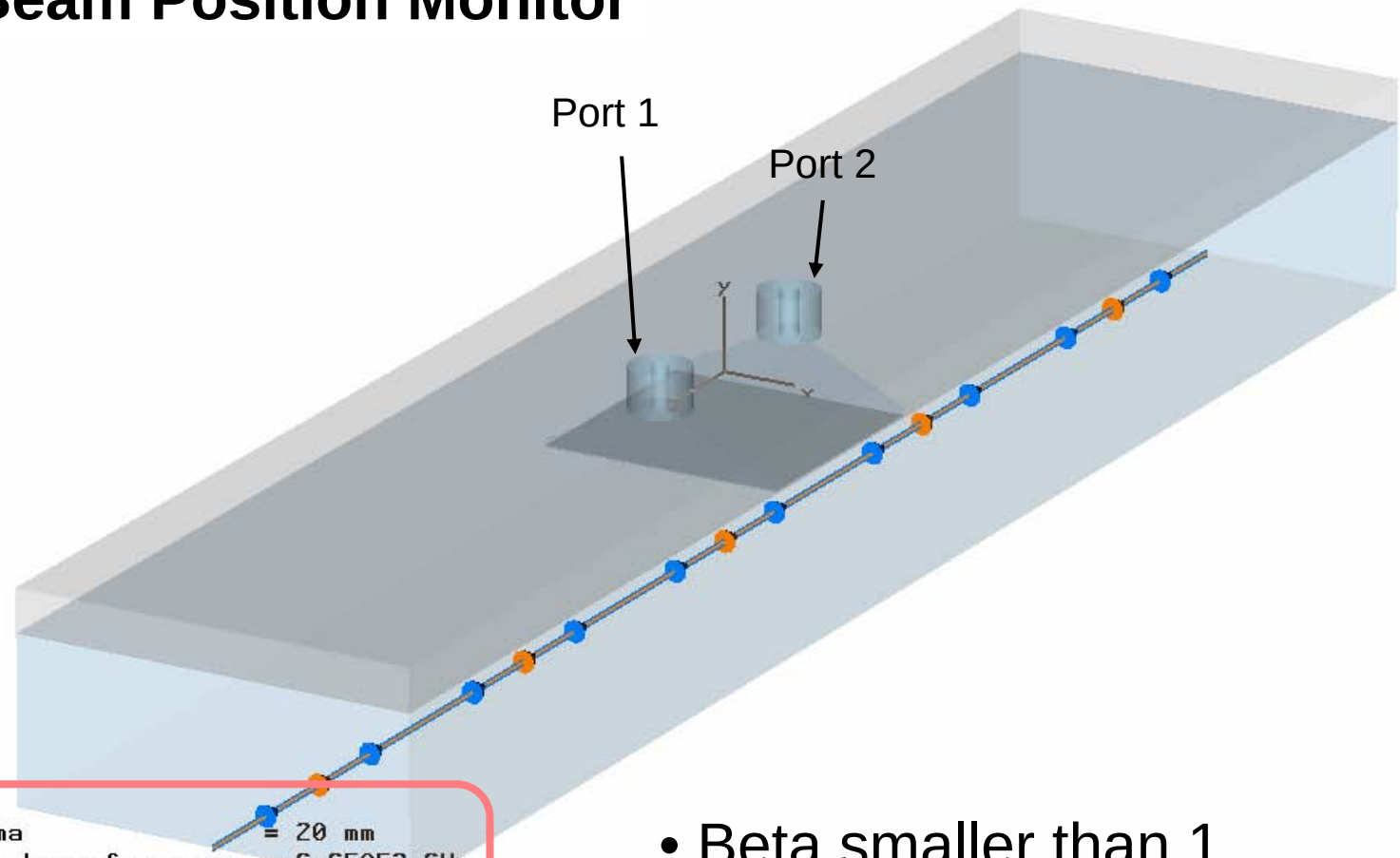


E_0 = 275 keV



Wakefields

Beam Position Monitor

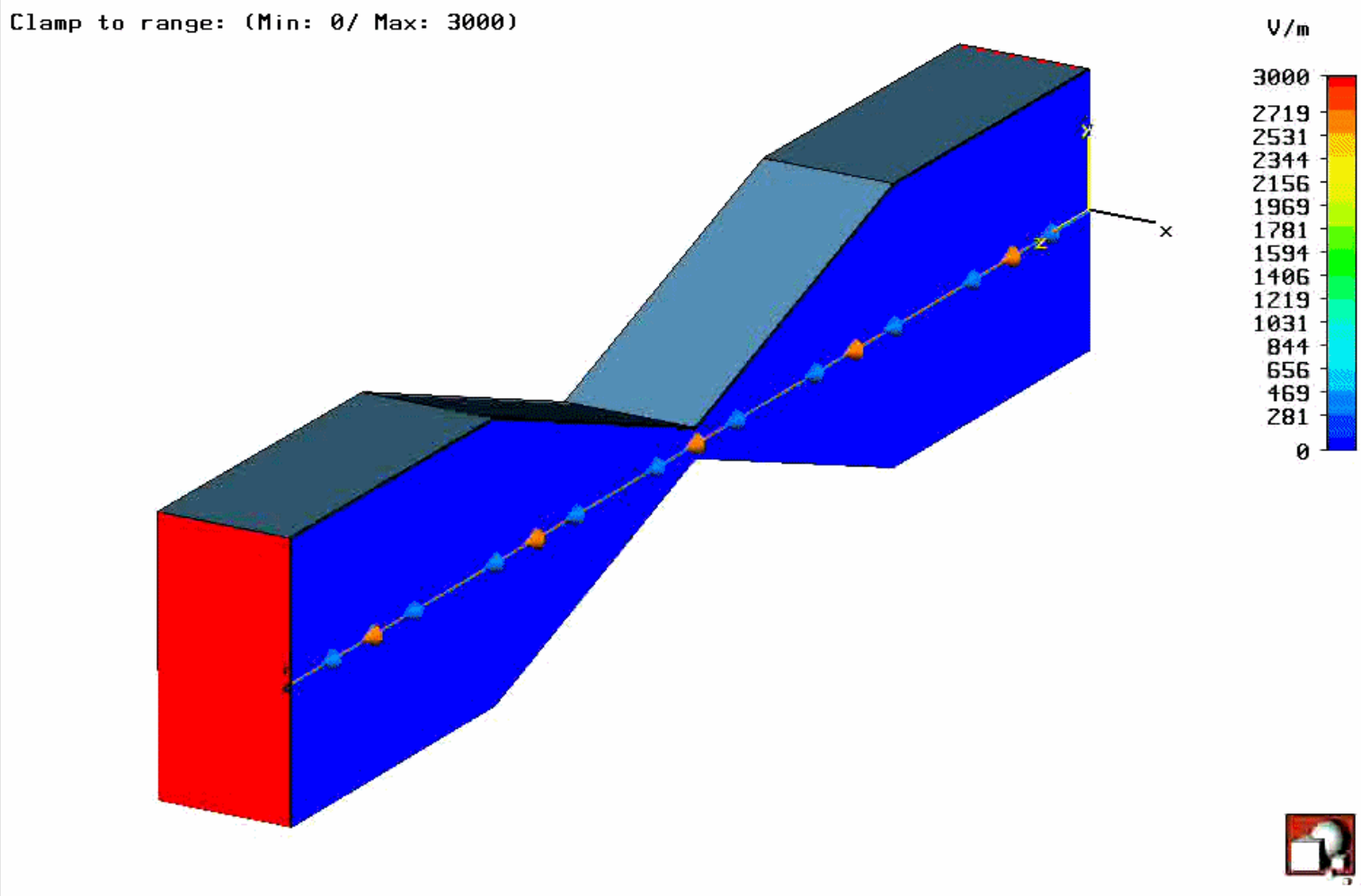


- Beta smaller than 1
- Resistive wakes

  (simulating skin effect losses)

Wakefields

Collimator



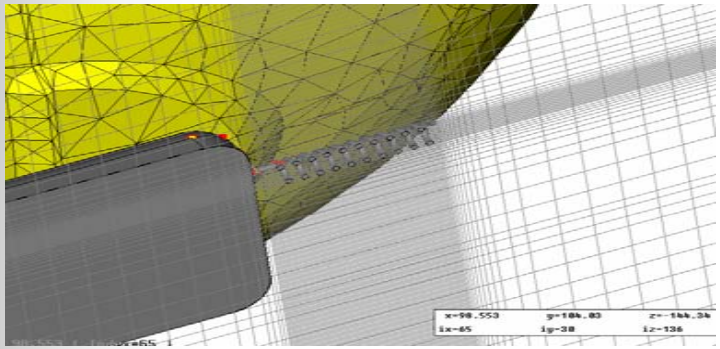
CST STUDIO SUITE™ 2006B

**(currently in beta-phase,
released in couple of weeks)**

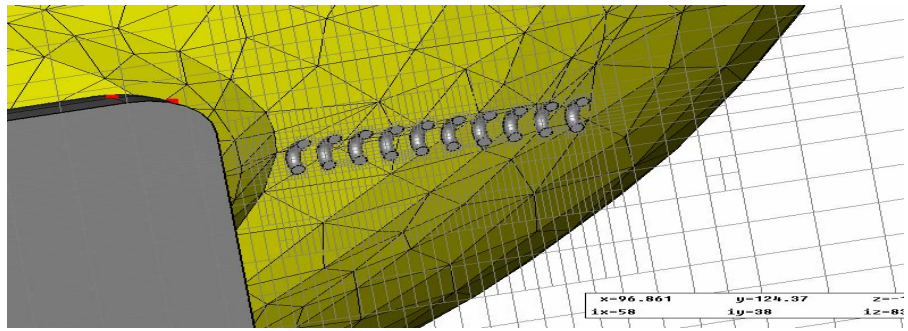
New Key Features

Time Domain Solver - Subgrids

1.9 Million cells

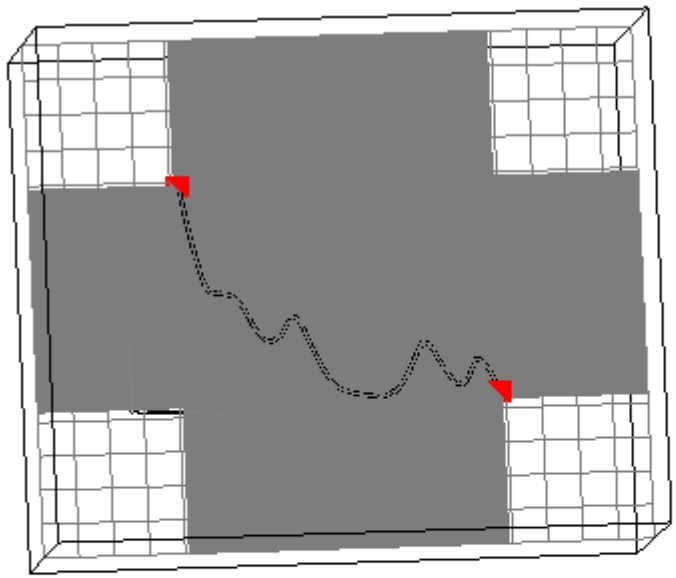


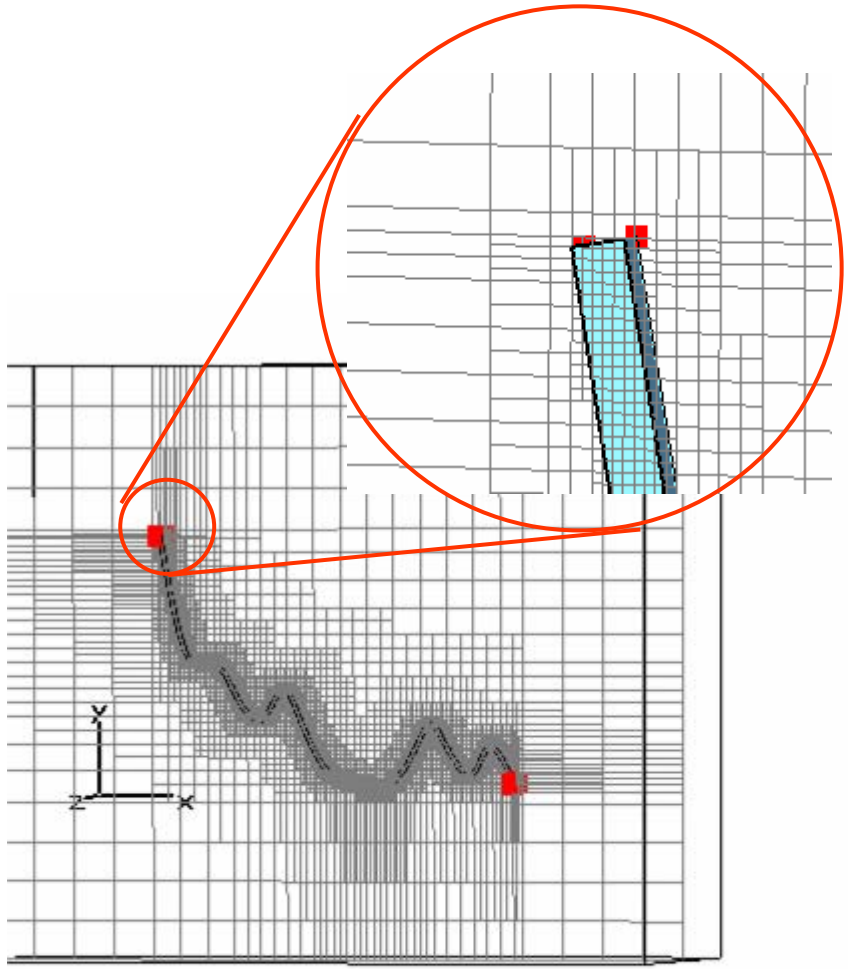
260.000 cells



Here: Subgridding reduces number of cells by factor > 7

Subgridding





x=6.0511 y=3.0576 z=0
ix=236 iy=152 iz=4

z= 0 (Index= 4)

ntitled_0*

Raster=1.000 Meshcells=1,246,752 Norr

x=2.02 y=-2.4721 z=0
ix=35 iy=1 iz=4

Raster=1.000 Meshcells=62,311

Some More New Features...

- Linux version of MWS-T + F solver modules
- 64 Bit version of all solvers
- Solver Speedup for most hardware platforms
- Slanted WG-ports for HF TET solver
- SPICE-like Time Domain Solver integrated in CST DESIGN STUDIO
- ...

Summary

- 3D Solution of Maxwell‘s equations using Finite Integration Technique
- Different Mesh Types + different solvers
  ➔ Easy Cross Verification increases reliabilty
- Accelerator related examples with
  - CST MICROWAVE STUDIO
  - CST EM STUDIO
  - CST PARTICLE STUDIO