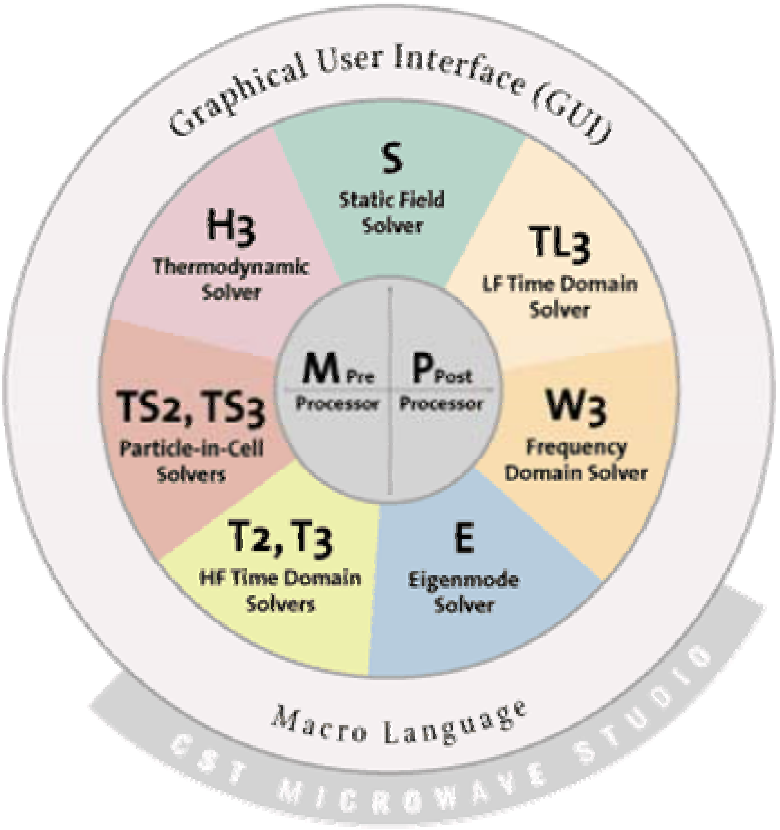
Lecture 12

RF Modeling and Simulations

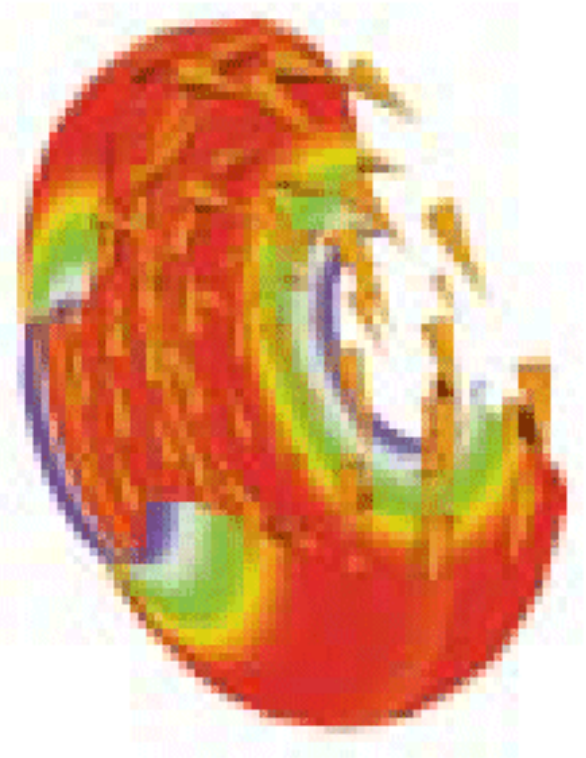
JUNE 20, 2003

MAFIA 4 - Solvers



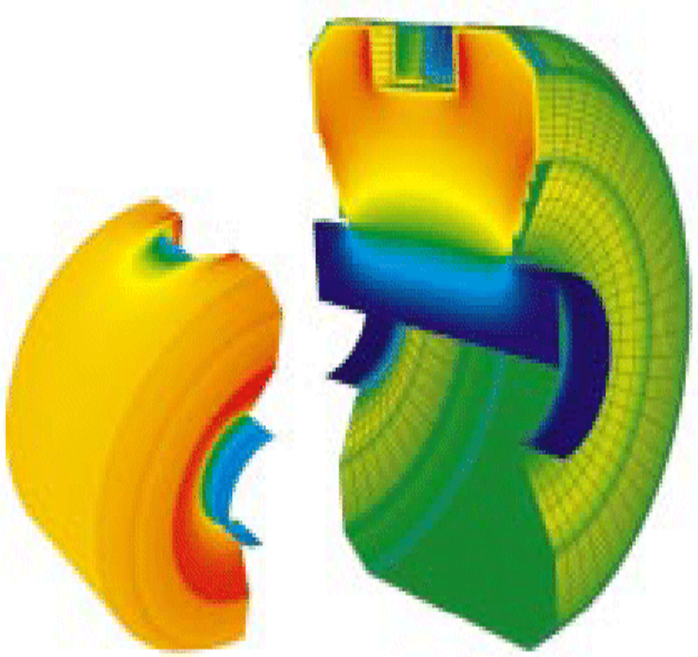
- Mafia consists of many modules defined to perform various calculations.
- Each module may run either individually or inside the Graphical User Interface
- The M3 module is the pre-processor where the simulation geometry is constructed.
- The P3 module is the post-processor which permits plotting and calculation of field and derived quantities.
- The T2, T3, TS2, TS3, S, E, and W3 modules each calculate the electromagnetic fields within the defined geometry.

Eigenmode Solver I



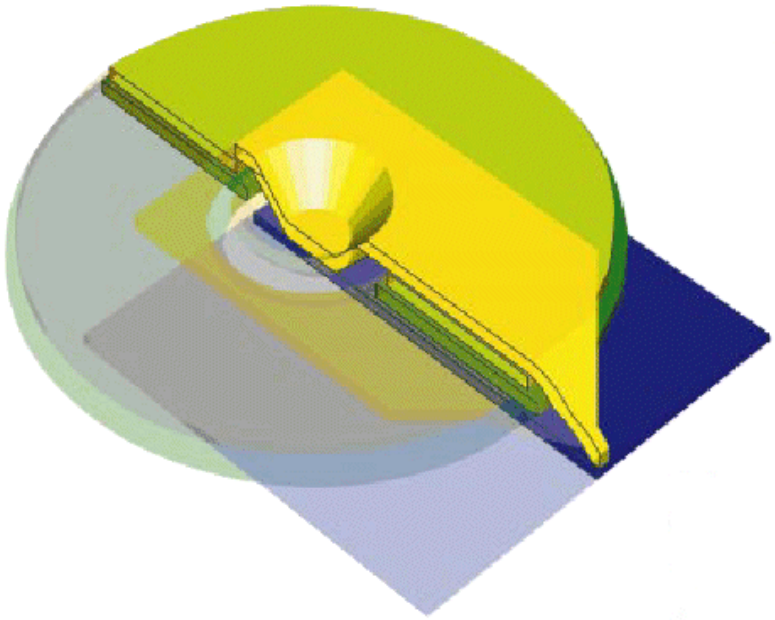
- The eigenmode solver E is used to calculate the resonant fields in 2D and 3D structures.
- Useful for the simulation and optimization of resonators, filters, and waveguides
- Anisotropic materials and lossy materials are available

Eigenmode Solver II



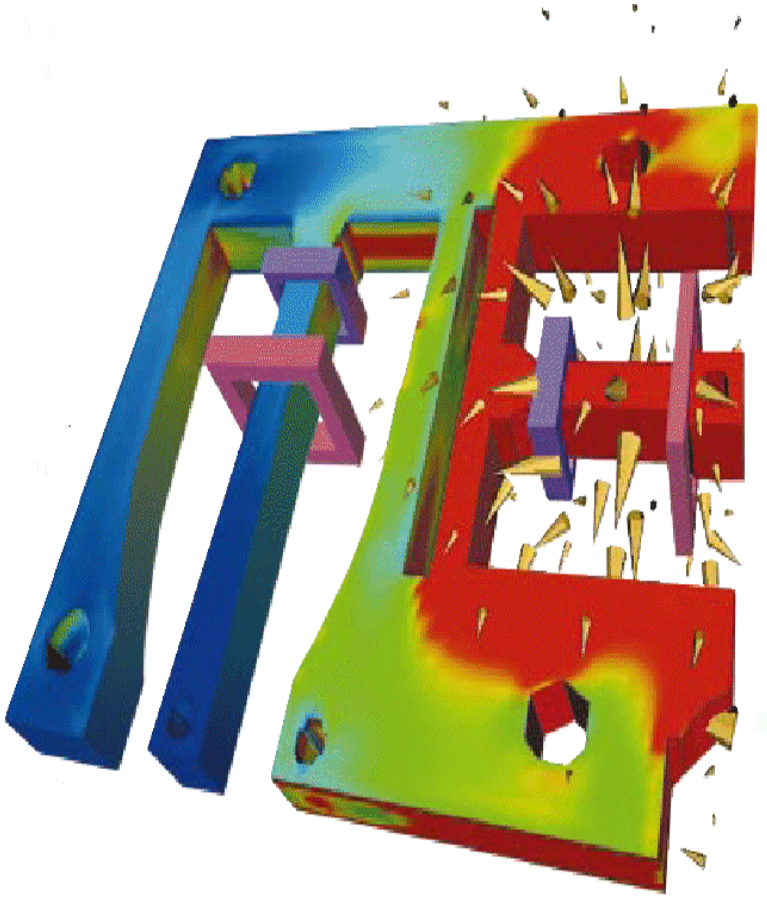
- Calculates the eigenmodes without spurious solutions. Does an excellent job avoiding false multiple resonances at nearly identical frequencies
- Selective computation of all modes within a specified frequency range
- Automatic quality check and accuracy determination
- Boundary conditions for symmetric and periodic structures

Static Solver I



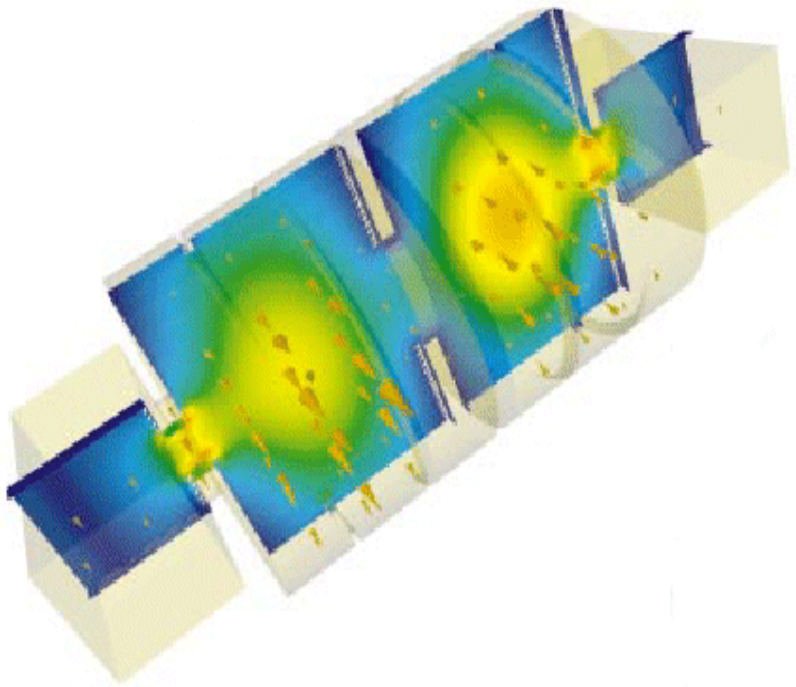
- The Static Solver S calculates electrostatic and electro-quasistatic fields as well as magnetostatic fields
- Determines the electric currents and temperature distributions within the geometry
- Supports non-linear, anisotropic material properties

Static Solver II



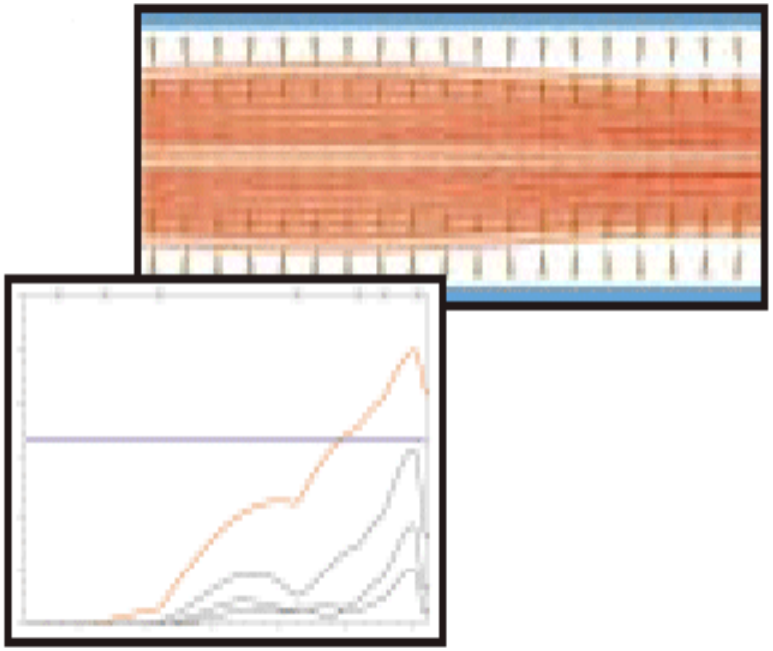
- Electrostatic fields are crucial to the acceleration and the deflection of electron beams as well as to high voltage technology.
- Typical applications for magnetostatics can be found in the design of sensors, electromechanical devices, electromagnetic instrument shielding, and accelerators.
- Non-linear materials, permanent magnets and coil systems, can be taken into account by Mafia

Time-Domain Solvers I



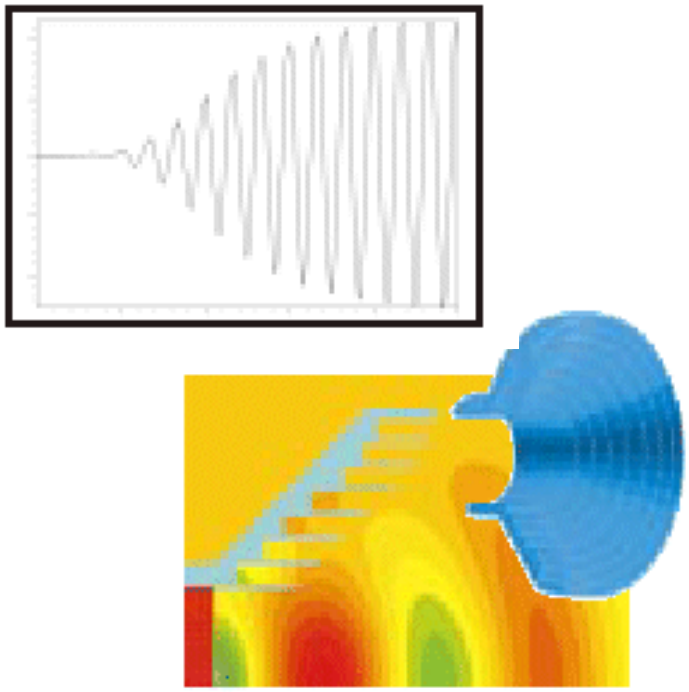
- Time domain solvers T2 and T3 are used for the calculation of radiation and scattering problems
  - Power splitters, Directional couplers, Antennas
  - Connectors, filters, optical waveguides, switches, EMC and EMI
- Time domain simulations calculate steady-state parameters such as s-parameters, impedances, etc
- Also calculate the transient signals such as time domain reflectometry
- Broadband simulation of frequency dependent materials

Particle in Cell Solvers I



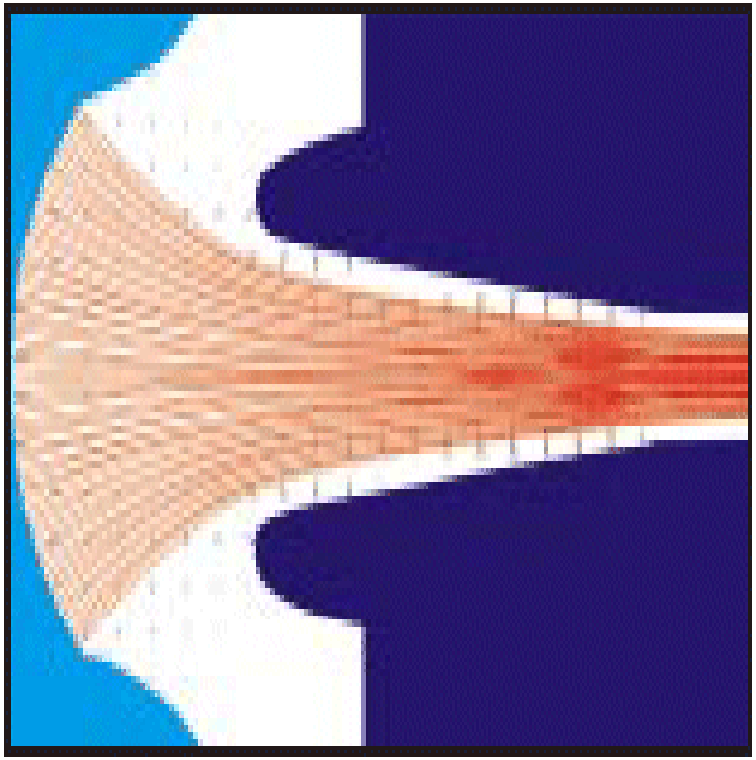
- The TS2 and TS3 modules calculate the relativistic effects of particle motion
- Static and dynamic fields can be assumed as initial conditions
- Electron / ion gun and tube simulation (2D and 3D)
  - Space charge limited emission
  - Temperature limited emission
  - Examination of high frequency properties

Time-Domain Solvers II



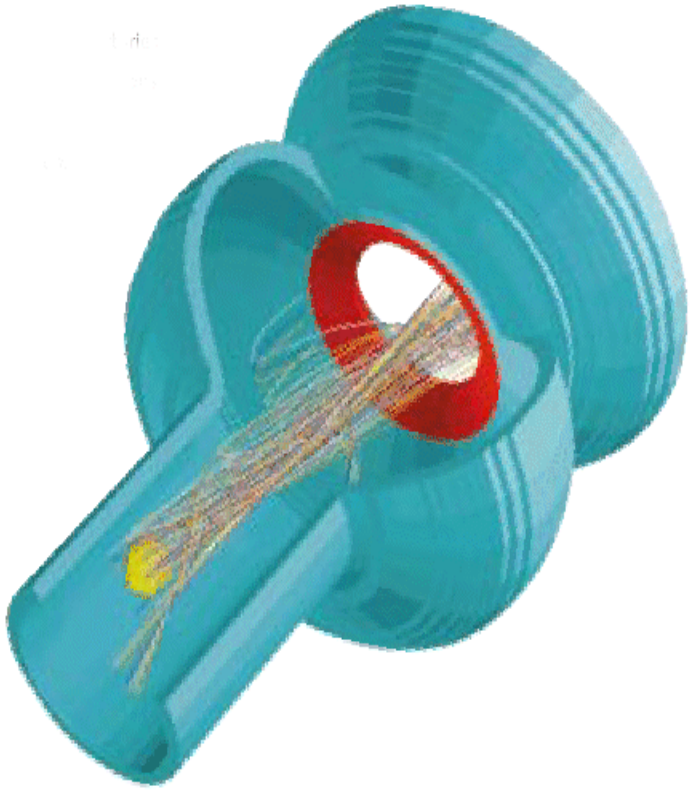
- Excitation by incident plane waves, waveguide modes or superposed electric currents or voltages
- Specialized model for skin effect simulations of highly conductive materials
- Specialized models for thin wires or sharp edges of electric conducting materials
- Gyrotropic materials such as ferrites, and plasmas can be simulated
- Calculation of particle beam wake fields

Particle in Cell Solvers II



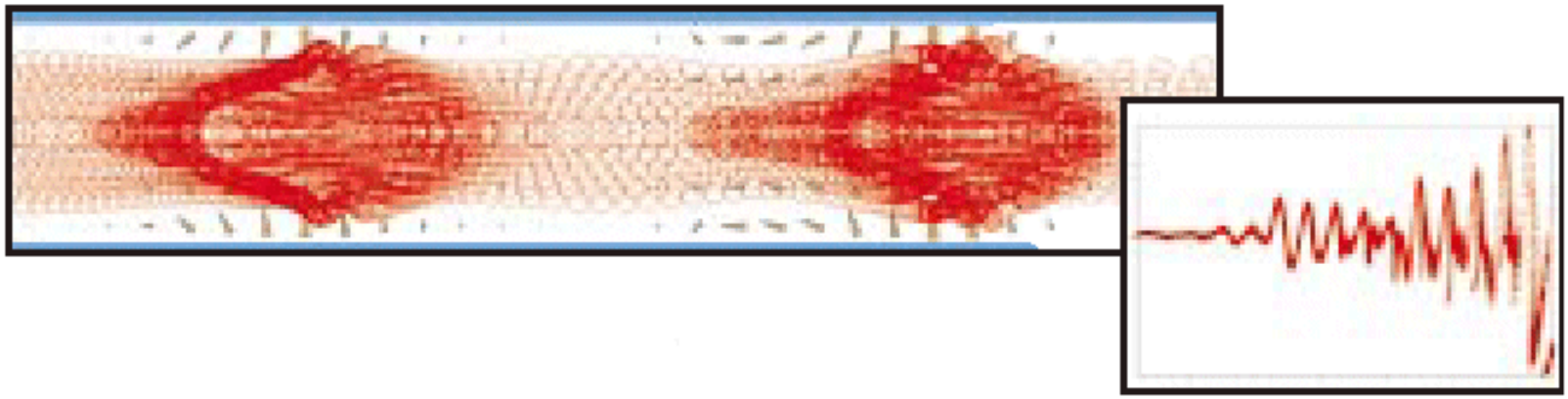
- Boundary conditions
  - Electric, magnetic, open
  - Broadband waveguide boundary condition
  - Interface to previous TS2 simulation
- Particle definition
  - Flexible definition of cathodes
  - Separation of particles into different bunches
  - Various charge to mass ratio permitted for each bunch
  - Particle emission from curved surfaces

Particle interaction: TS2 and TS3 I



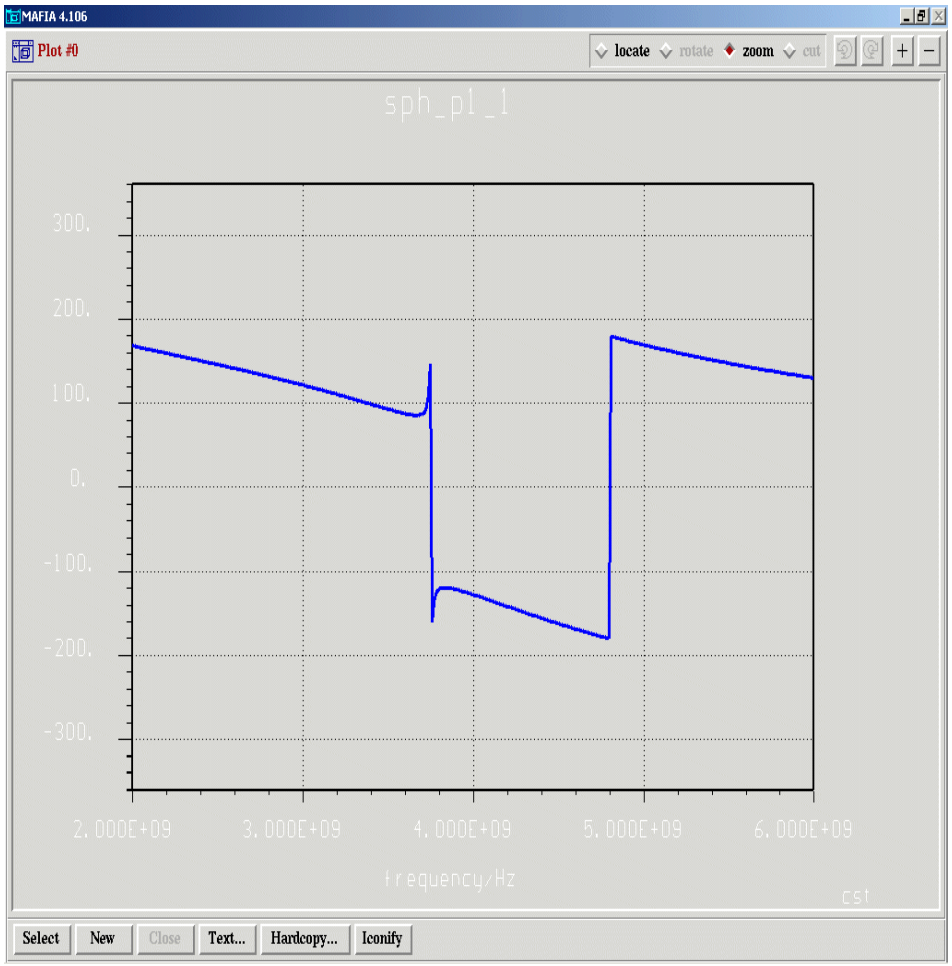
- The interaction of the relativistic motion of charged particles in the presence of electromagnetic fields can be simulated
- Many studies on the behavior of charged particles are possible.
- Effects of static and high frequency fields on particles can be evaluated
- Range of applications include
  - electron guns, cathodes
  - devices for beam focusing and beam deflection
  - high-power tubes for radar, broadcasting, and accelerators.

Particle interaction: TS2 and TS3 II



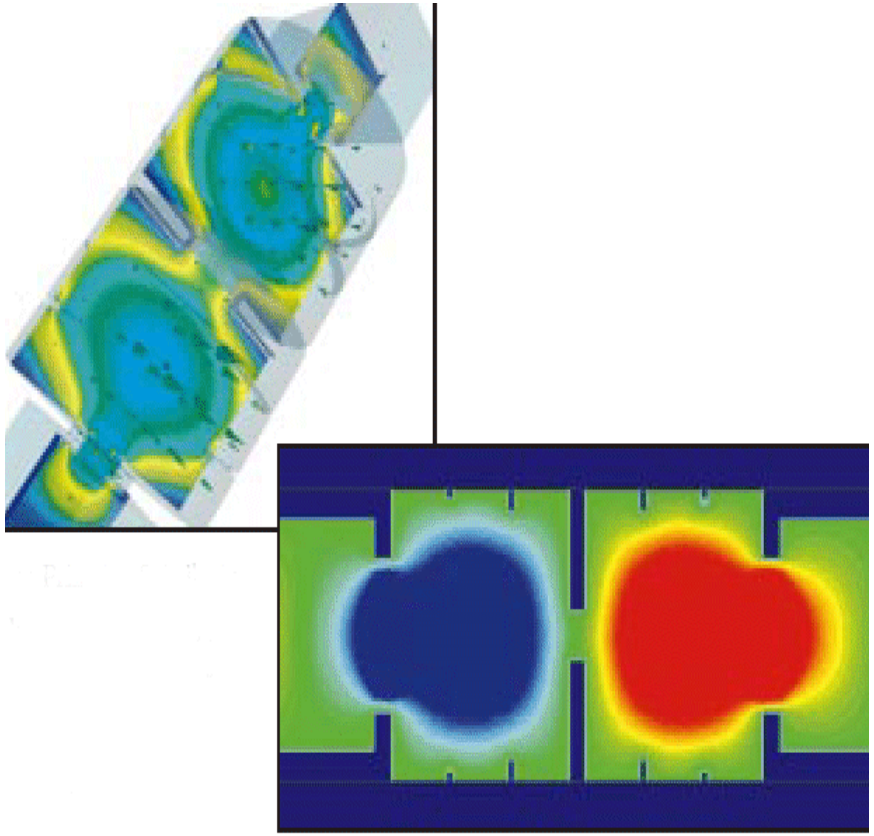
- Study of 3D electron / ion guns and tubes can use various emission schemes such as space charge limited and temperature limited
- Consistent coupling between particles and fields are accurately realized with FIT algorithm for these emission schemes

Post Processing



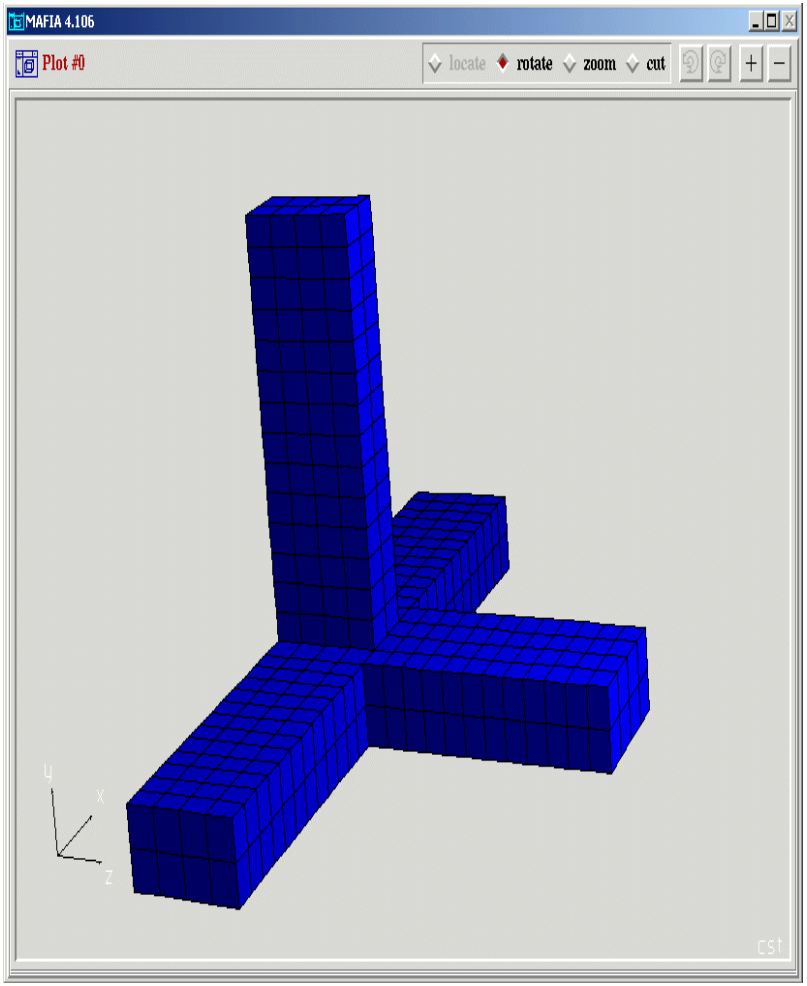
- The P3 module permits the display of S-Parameters and impedances
- Calculates energies, losses, integrals, forces, etc
- Calculate Discrete Fourier Transform, Fast Fourier Transform, Auto Regressive Filter
- VRML export capability
- Force computation

Post-Processing: Field Visualization



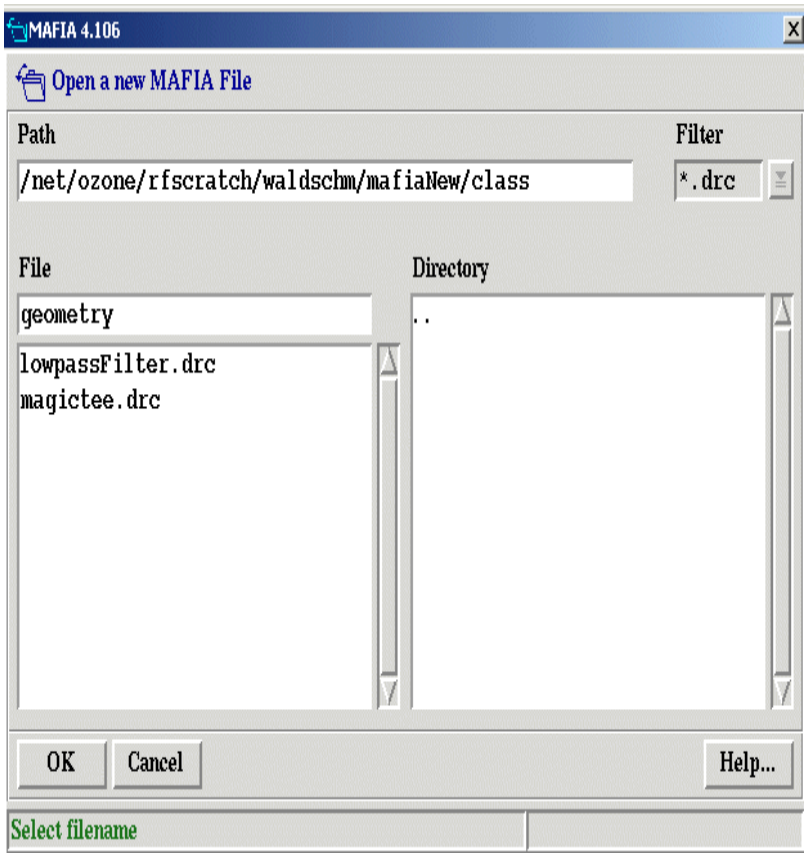
- Field Quantities may be viewed in isometric and contour plots
- 1-d plots of field quantities
- 2-d and 3-d visualization capability
- Calculations and manipulations of field quantities can be performed
- Far-Field data (radiation, RCS patterns) can be generated and plotted

Exercise: Waveguide Hybrid



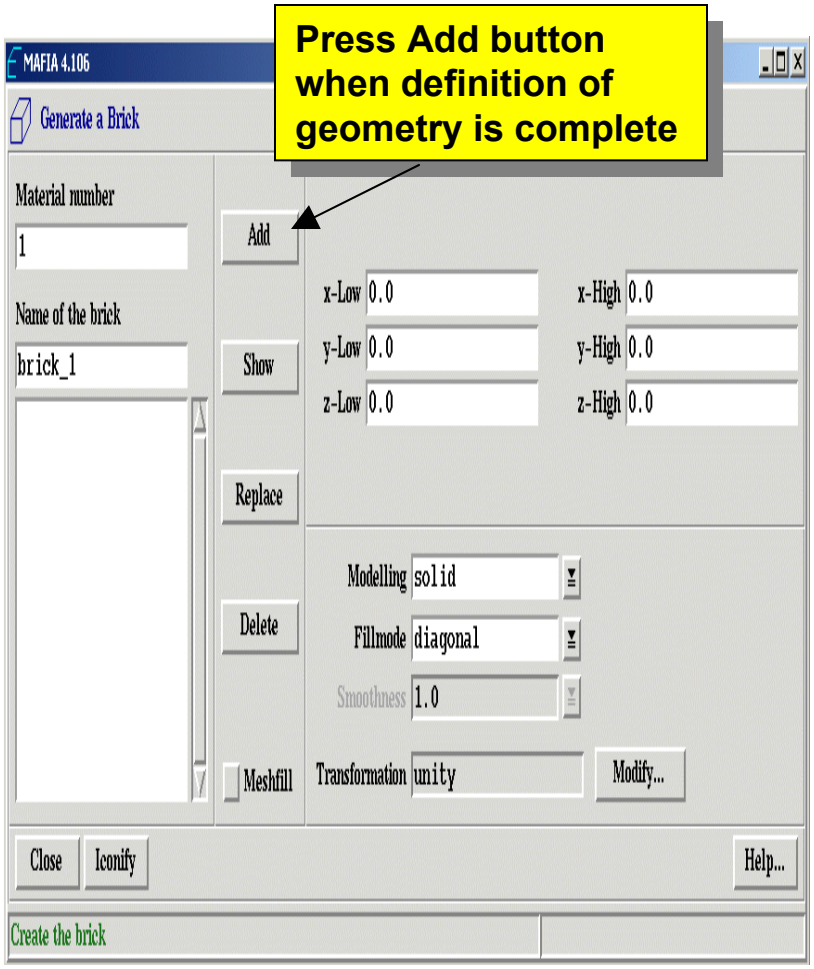
- We will explore the complete geometry construction of a waveguide tee problem using the MAFIA M3 module.
- We will build the geometry for this problem but not solve it.
- The tee is constructed from WR 2300 waveguide with dimensions 23 in x 11.5 in.
- Its operating frequency will be 352 MHz.

Create Mafia file



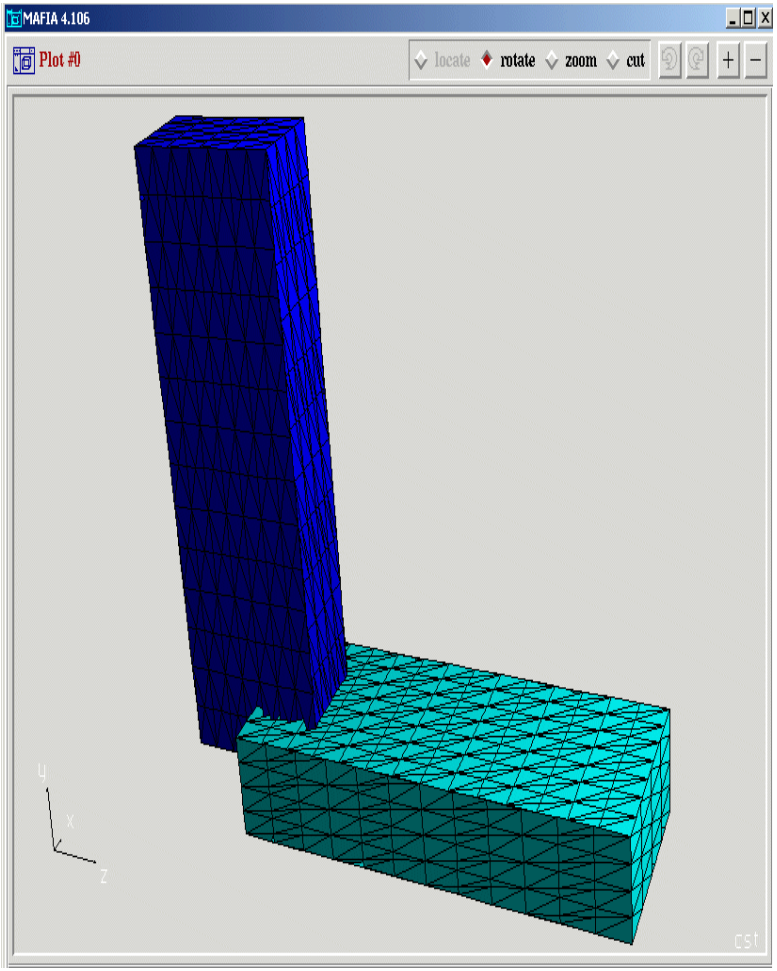
- Go to File > New. Enter the filename ‘magictee’ when prompted. Press ‘OK’. Do not save previous project by pressing ‘No’
- Open the M3 module. Go to Module > M - The Mesh Generator.
- We will begin constructing the magic tee

Create Brick



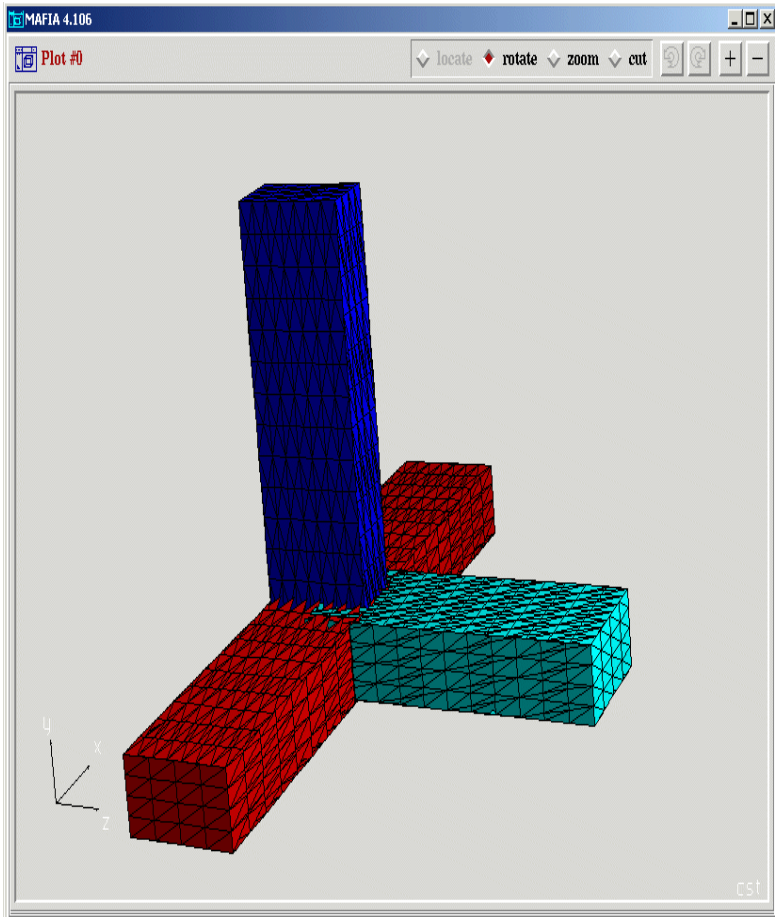
- The magic tee consists of simple waveguide arms. Therefore we will use the 'brick' primitive.
- Go to Shapes > Brick. Enter the following input:
  - Material number: 1
  - Name: 'arm_1'
  - Xlow: -0.2921
  - Xhigh: 0.2921
  - Ylow: -0.14605
  - Yhigh: 0.14605
  - Zlow: 0
  - Zhigh: 1.651

Create Second Brick



- Click on the ‘Add’ button located in the second column on the left side of the dialogue window.
- Add another brick. Go to Shapes > Brick. Enter the following input:
  - Material number: 2
  - Name: ‘arm_2’
  - Xlow: -0.14605
  - Xhigh: 0.14605
  - Ylow: 0
  - Yhigh: 1.651
  - Zlow: -0.2921
  - Zhigh: 0.2921

Create Third Brick



- Press the ‘Add’ button
- Go to Shapes > Brick. Enter the following input:
  - Material number: 3
  - Name: ‘arm_3’
  - Xlow: -1.651
  - Xhigh: 1.651
  - Ylow: -0.14605
  - Yhigh: 0.14605
  - Zlow: -0.2921
  - Zhigh: 0.2921
- Press the ‘Add’ button. Then press ‘Close’