

#### Remcom, Inc.

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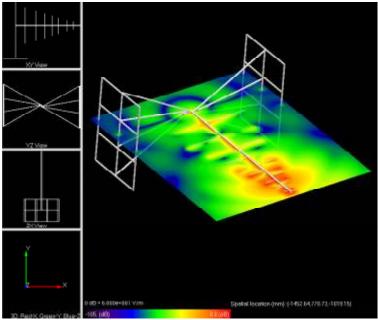


#### A Full-Wave Three-Dimensional EM Solver based on the Finite Difference Time Domain Method

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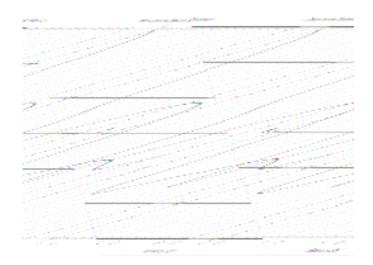
## **R**A-General Capabilities (1)

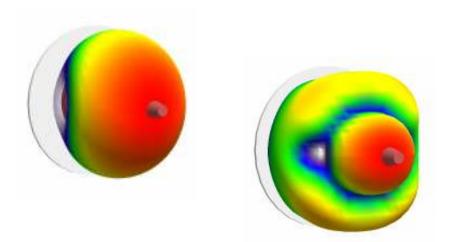
- Full-Wave Three-Dimensional EM Solver based on the popular Finite Difference Time Domain method
- \* Antennas, Microwave Circuits, Bio-EM, EMC, Scattering, Photonics, more



## **R**A-General Capabilities (2)

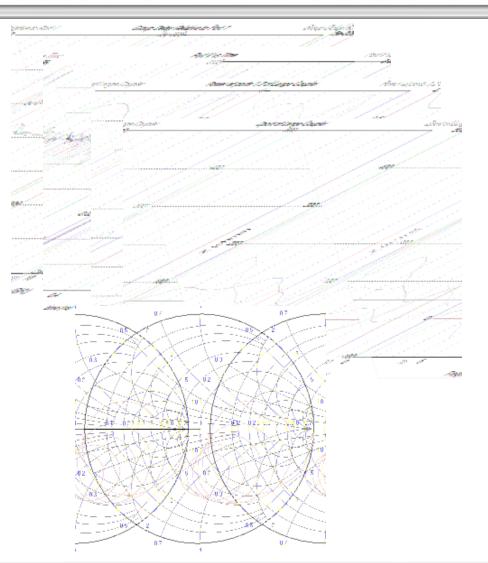
- Time-domain analysis provides results for a wide band of frequencies in a single computation
- Data available in frequencyand time-domain
- Automatic multiple-frequency calculations from transient calculation including efficiency, SAR, fields and patterns





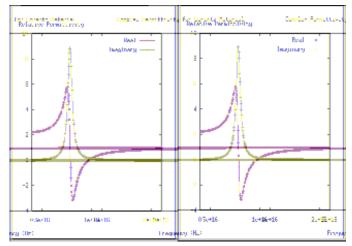
## **R**A-General Capabilities (3)

- Impedance
- \* Antenna Patterns
- System and Radiation
   Efficiency
- и SWR
- \* S-Parameters
- ✤ SAR
- Radar Cross Section
- Antenna Gain, Coupling, and Diversity



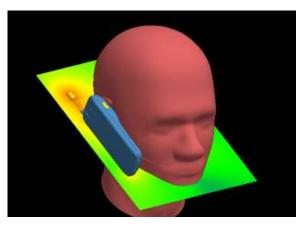
## RA-Material Capabilities

- Lossy Dielectric Materials including Frequency-Dependence and Tensor Dielectrics
- \* Specify Bulk Conductivity or Loss Tangent
- \* Material Parameters can be specified for multiple frequencies
- Surface Conductivity available for more accurate loss/efficiency calculations
- Lossy Magnetic Materials including Frequency-Dependence and Magnetized Ferrites with Permeability Tensor
- Double Negative Meta-Materials
- \* Non-linear Capacitors
- \* Non-Linear Anisotropic Dielectrics
- \* Non-Linear Magnetic Materials
- ✤ Thin wires
- \* Material Library



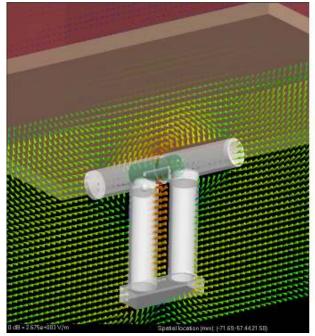
## **R**A-**Bio-EM Capabilities**

- Male and Female Human Body Meshes/Male Head Mesh with automatic adjustment of tissue parameters for single frequency calculations
- Male and Female Human Body Meshes /Male Head Mesh with frequency-dependent tissue parameters for transient wide bandwidth calculations
- Specific Absorption Rate with 1 and 10 gram averages, whole body average, locate peak SARs, follows protocol of latest C95.3 standard
- \* Temperature Rise in Human Body
- \* SAM Head for SAR for FCC acceptance
- Import voxel objects and mesh conformally
- Manual/Automatic Partial Volume SAR
- \* Rotating B (B+/B-) fields for MRI



### **R**A-**Port/Excitation Capabilities**

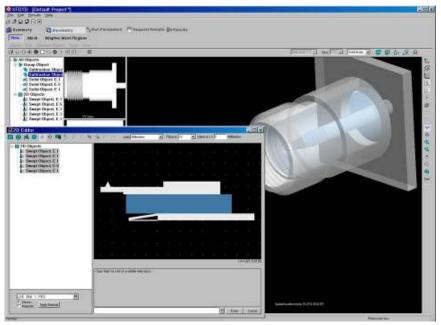
- \* Voltage and Current Sources with Source Resistance
- \* Static solver to set initial conditions for Static Discharge calculations
- \* Passive/Active Ports with Graphical editing include drag/drop/cut/paste
- \* Total Field or Scattered Field Incident Plane Wave
- Incident Gaussian Beam
- \* Lumped RLC Series-Parallel
- \* Non-Linear Capacitors
- \* Non-Linear Diodes w/variable parameters
- Programmable on-off switches
- Multi-Port S Parameters
- **\*** TEM/TE ports for microstrip/waveguide
- Independently specify time delay for multiple sources
- \* Automatic Convergence



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### **R**A-Geometry Modeling Capabilities (1)

- Import Three-Dimensional Geometries from AutoCAD-DXF/SAT/STEP/ProE/IGES/STL/Inventor/CATIA V4 and V5 files
- Import STEP files with ProE part names
- \* Remember part names when modified CAD files imported
- ✤ Geometry export to SAT, STEP and IGES
- Fast meshing algorithm (FMA)
- Preserves Object Hierarchy
- Export object names
- \* Export Material Assignments
- Powerful Interactive Graphics
- Fast 3D Mesh Viewing
- Automatically determine if meshed geometry objects are in contact



## **R**A-Geometry Modeling Capabilities (2)

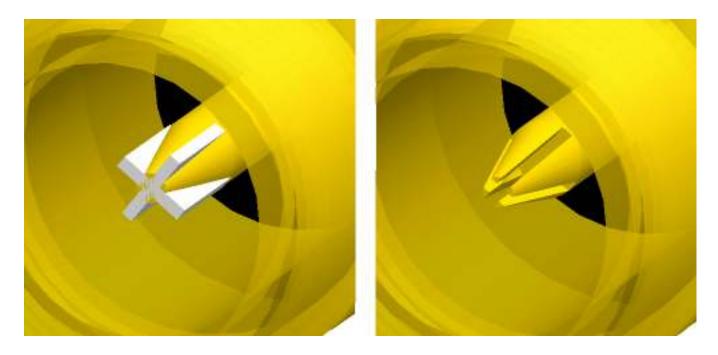
- Import Planar CAD files from AutoCAD/DXF with extrusion
- Built-in Object Primitives
   with Dimension-Based
   Editing and Automatic
   Adaptive Meshing
- \* 2D Editor with scripting
- Object Edit, Copy, Move, Repeat
- \* Cartesian and Polar Arrays
- \* Lofting between faces
- Join Faces function moves groups of objects

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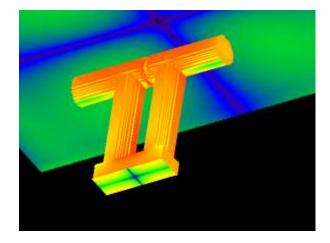
### **R**A-Geometry Modeling Capabilities (3)

- \* Sweeping and Shelling
- \* Face Selection/Alignment
- Graphical Scale/Rotate/Move
- ✤ Boolean



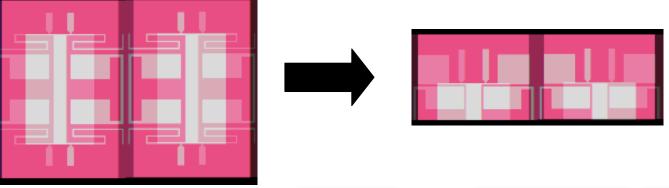
## **R**A-Output Capabilities

- \* Line Plotting, Polar plots, and Smith Chart plots
- Color 2D Field Displays including both Transient and Steady State Fields, SAR, and Temperature Rise in Human Body
- \* Display multiple 2D field slices on 3D geometry view
- MPEG movies of transient fields or mesh slices
- Display 3D surface currents
- Display 3D Antenna Patterns
- \* Far Zone over infinite PEC Plane
- \* Antenna Pattern Rotation
- \* Axial Ratio
- \* Ludwig Polarization
- Partial Pattern Efficiency
- \* Antenna Diversity
- \* Citi File Output



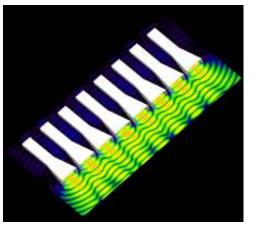
## RA- Special Capabilities

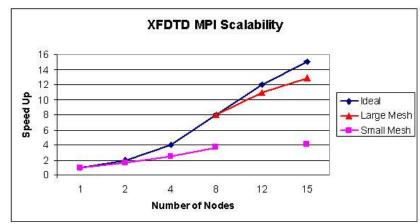
- \* Transient and sinusoidal periodic boundary conditions with phase shift
- \* Power flow over a plane for reflection/transmission from semi-infinite structures
- \* PML outer boundaries with adjustable thickness
- Sinusoidal results at multiple frequencies from transient calculation via DFT
- \* Liao, PMC, and PEC outer boundaries



## **R**A-Calculation Capabilities

- Geometric Modeler available for Windows 2000/XP and 64-bit
   GUI for Windows Vista
- \* Analysis Modules for both Windows and Unix/Linux including 64 bit processors
- Multi-Processor Analysis Module for shared memory computers, Windows and Linux/Unix
- Message Passing Interface (MPI) Analysis Module for distributed memory computer clusters, Windows and Linux/Unix



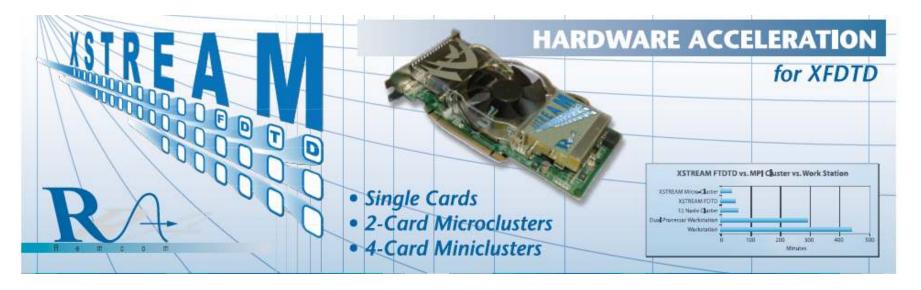


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## **R**A **XSTREAM Hardware FDTD**

- XSTREAM Hardware FDTD cards available in both single and dual configurations
- \* Single cards with either up to 1.5 GByte RAM
- Micro-Cluster configuration with up to 6.0 GBytes Ram
- \* Faster than 16 Node Cluster Computer



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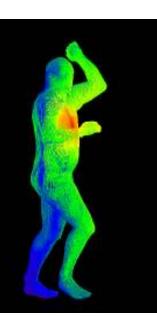
### **R**A-New Features in XFDTD 6.5

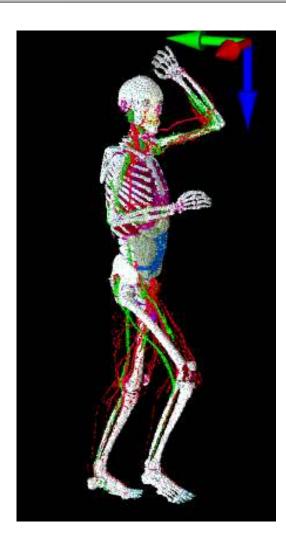
- Multi-frequency Sinusoidal Results such as Efficiency, SAR, Fields and Currents, and Antenna Patterns from one transient calculation
- **Full 64 bit GUI including CAD import and support for Vista**
- \* Periodic Boundary Conditions with Phase Shift
- Power flow over a plane for reflection/transmission from semi-infinite structures
- \* Total Field AND Scattered Field plane wave for accurate results for both scattering and shielding calculations
- \* Nonlinear Diodes with variable parameters
- \* Rotating B field display for MRI calculations
- \* Axial Ratio and Ludwig Polarization
- Independently specify time delay for multiple sources
- \* Automatically determine if meshed geometry objects are in contact
- Import Voxel objects and mesh conformally
- \* Programmable Switches
- \* XSTREAM 3.0 with up to 6.0 GB of GPU memory

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## **R**A-Special Bio-EM Capabilities

- Adaptive Meshing applicable to Body Meshes
- Calculate Temperature Rise in Human Body due to EM Fields
- Varipose software to reposition human body meshes

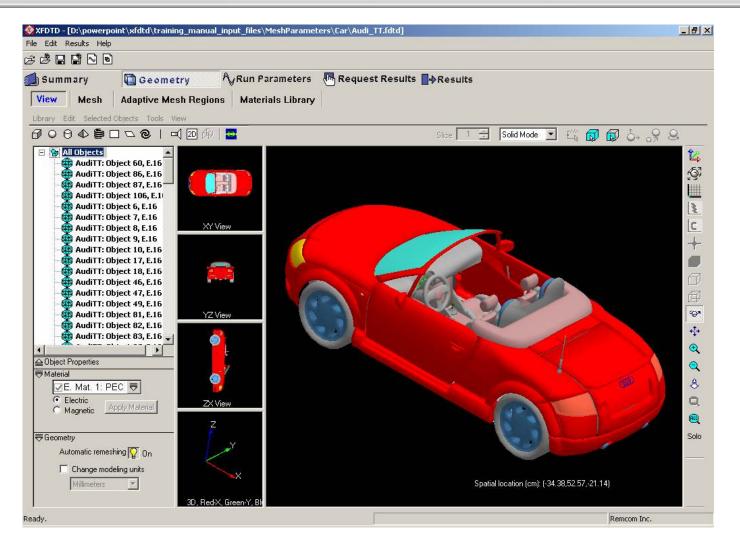




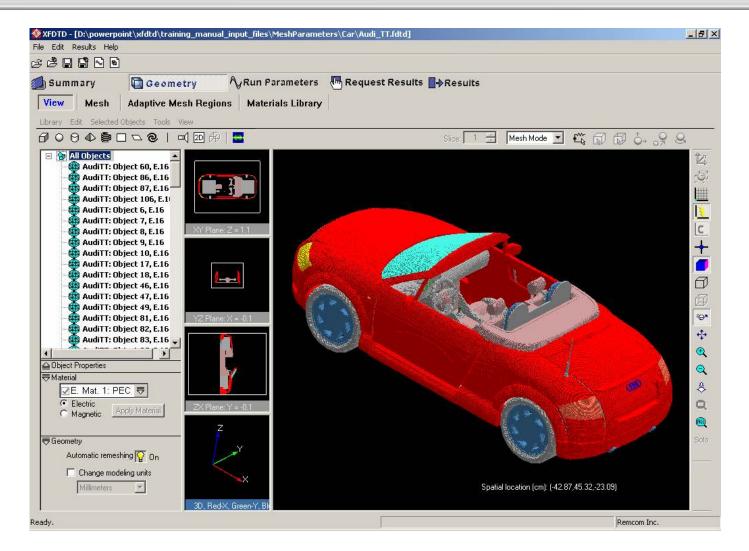
### **R**A-Geometry Generation in XFDTD

- \* Extremely Fast and Accurate CAD Import
- Importation of Object Names
- \* Object Names/Hierarchy retained even for modified CAD files
- \* Automatic assignment of materials based on color
- \* Extensive set of Built-in Object Primitives
- \* 2D Editor with scripting
- Combine CAD import object, 3D and 2D Primitives all in dimension-based editor
- Fully Automatic Mesh Generation
- \* Adaptive Meshing automatically refines mesh
- ✤ View Mesh in 2D and 3D
- \* Complete Mesh Editing Capability if needed
- \* Visualize (and edit) the mesh before making calculations

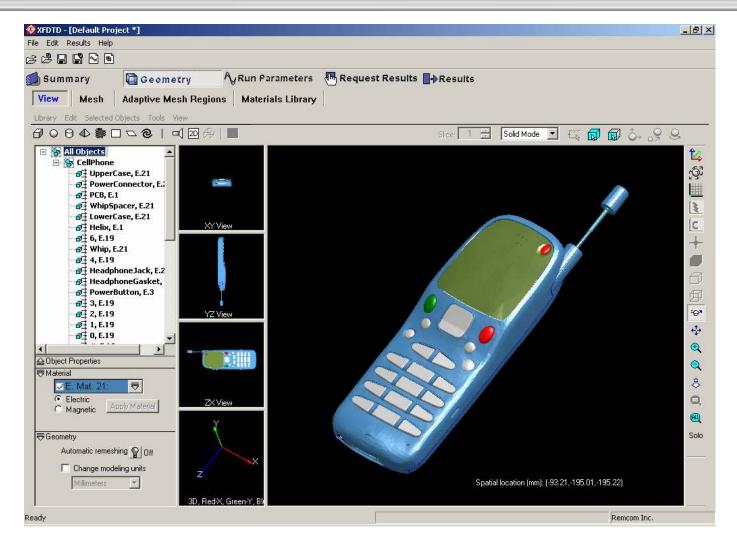
### **R**A *Solid Mode CAD View*



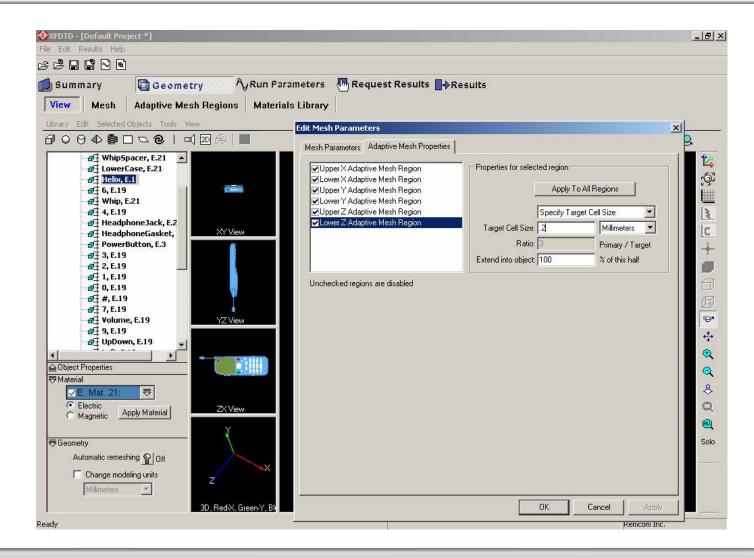
# RA XFDTD Graphical Interface 3D Mesh View



# XFDTD Assigns Materialsbased on CAD File Color Attributes



#### **R**A *Assign Adaptive Mesh Region to Helix*

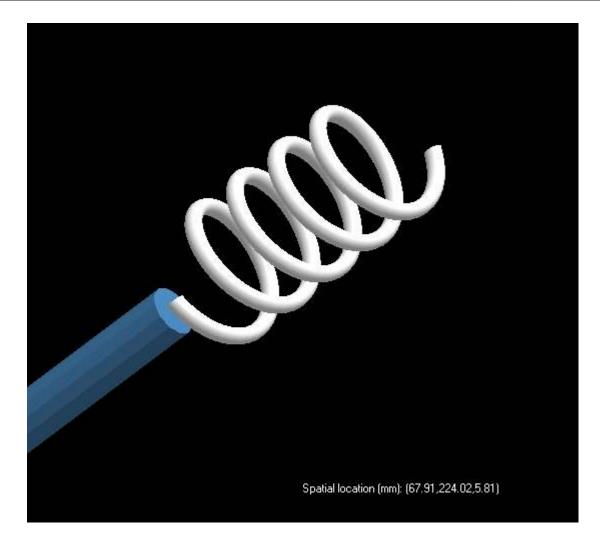




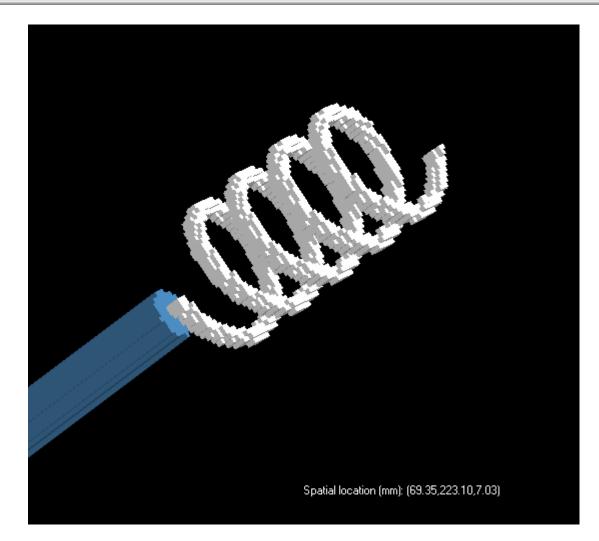


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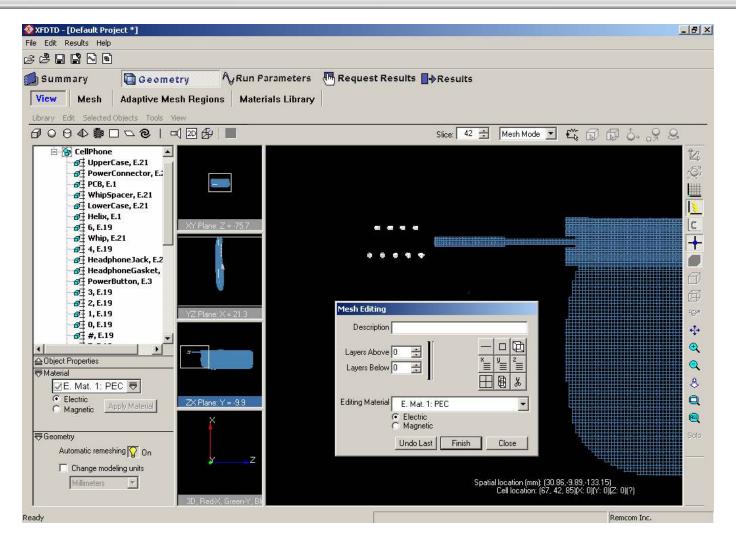


# RADetail-Mesh ViewShowing Adaptively Meshed Helix



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### **R**A-**Examine and Edit Mesh BEFORE Calculation**



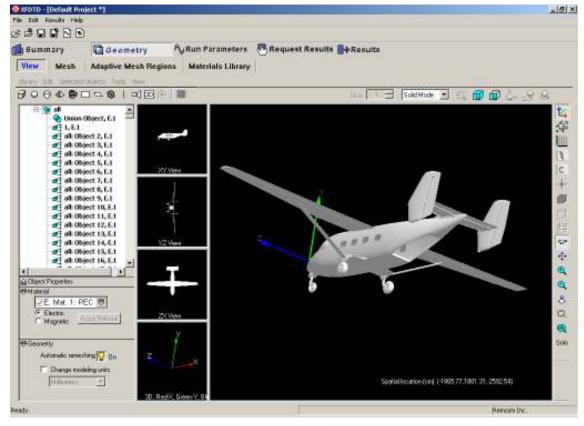
### **R**A Antenna on Aircraft Example

- Challenge: Locate Flight Inspection Antennas on M-28 Aircraft for reliable coverage for both approach and orbit measurements
- Dual Vertical Stabilizers produce antenna blockage for typical antenna location on vertical stabilizer
- \* XFDTD used to generate aircraft geometry, antenna geometries, and investigate radiation for different antenna locations



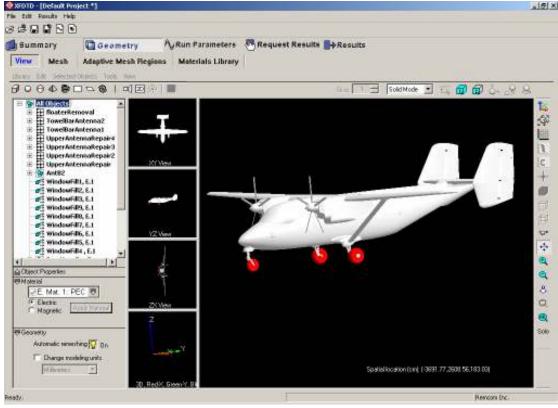
## RA- Antenna on Aircraft (2)

- \* Analysis starts with CAD file of M-28
- \* CAD File is 150 Mbytes with 10,827 objects
- Imports in 3 minutes



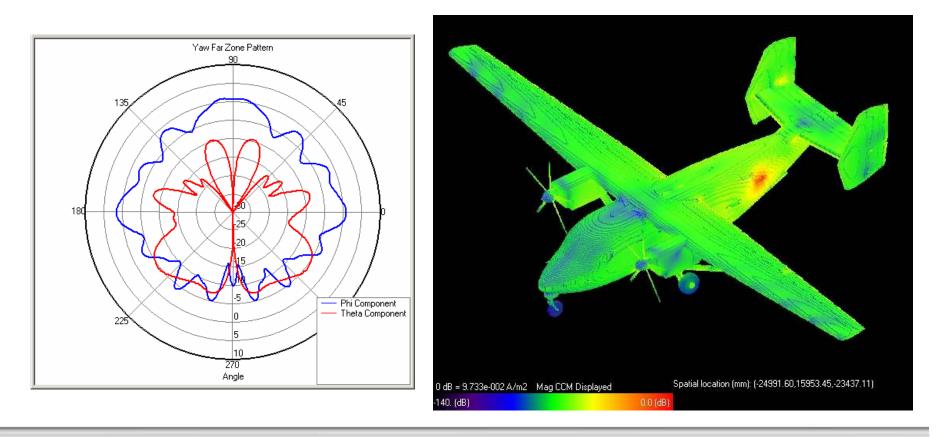
## RA-Antenna on Aircraft (3)

- \* Geometric Modeler first used to add parts missing from CAD file
- Geometric Modeler then used to model antennas and locate them on the aircraft



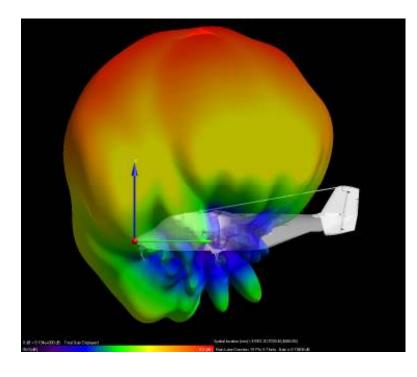
## RA- Antenna on Aircraft (4)

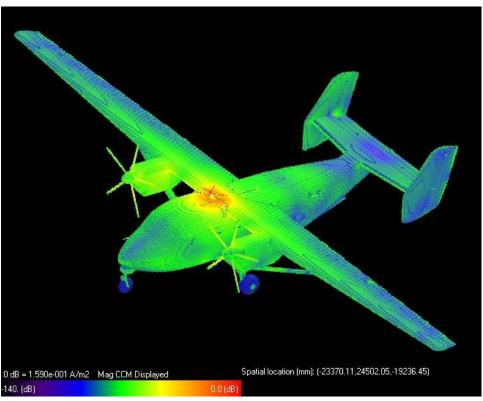
- \* Balanced Loop "towel bar" considered first
- \* Location shown provides good coverage to sides, forward null



## RA- Antenna on Aircraft (5)

- Bent Dipole above cockpit has good forward coverage, poor coverage to sides
- Solution: switch between bent dipole and towel bars for orbit vs approach measurements





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## RA-Vivaldi Antenna Example

- \* Vivaldi Antenna drawn as 3D solid in AutoCad
- \* Imported into XFDTD using 3D CAD Mesher
- \* Transient Source excitation added in XFDTD
- Calculated results include S parameters, antenna gain patterns, and near zone fields
- \* Excellent agreement with published results

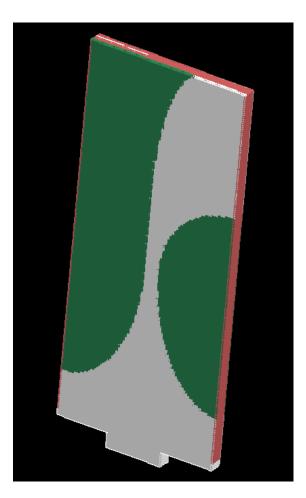
## **R**A-Vivaldi Antenna Before Meshing



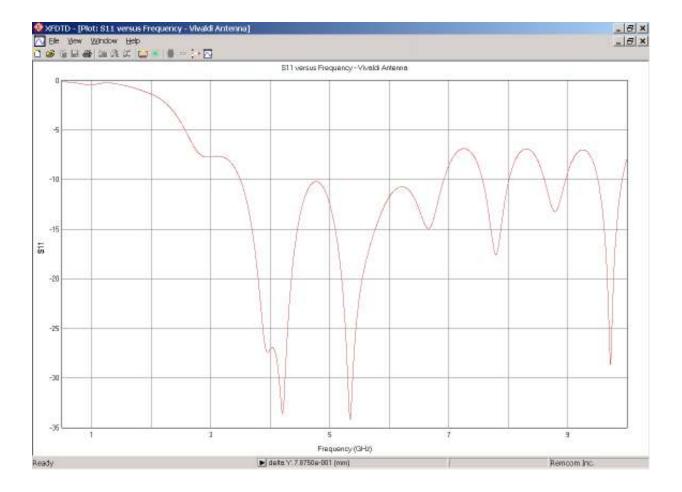
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### RA-Vivaldi Antenna Meshed in XFDTD







### Smith Chart Plot of S<sub>11</sub>

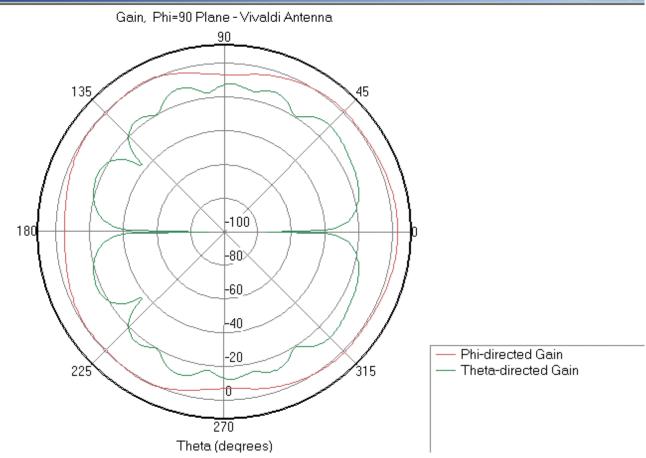
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lot: S11 - Vivaldi Antenna S11 - Vivaldi Antenna 1 0.7 0.5 2 3 0.3 0.2 5 0.1 10 0.1 0.2 0.3 0.5 0.7 187 0.1 10 0.2 5 0.3 3 0.5 2 0.7 1

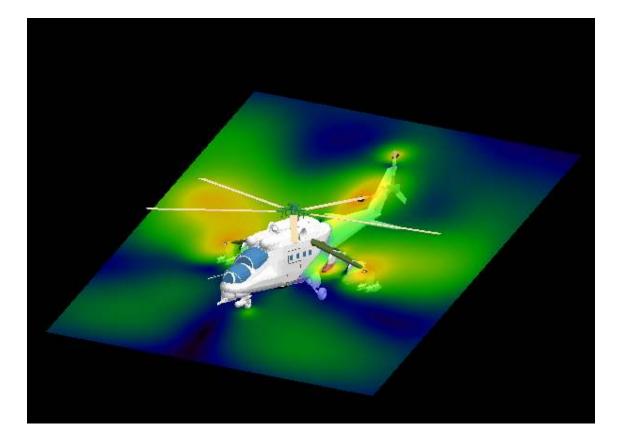
### **R**A-Vivaldi Antenna Gain Pattern

🔽 Plot: Gain, Phi=90 Plane - Vivaldi Antenna

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#### **R**A Fields Scattered by CAD import Hind Helicopter

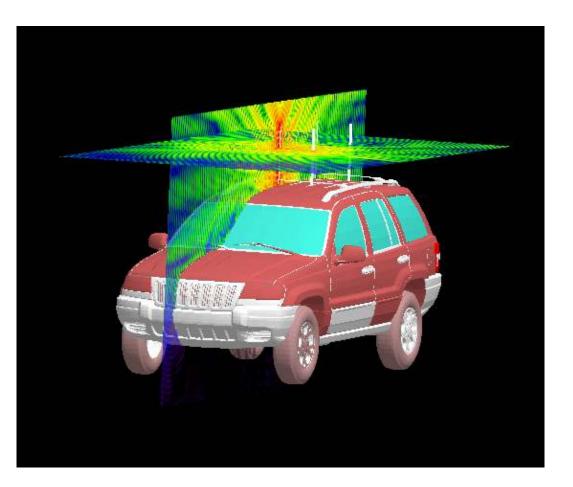


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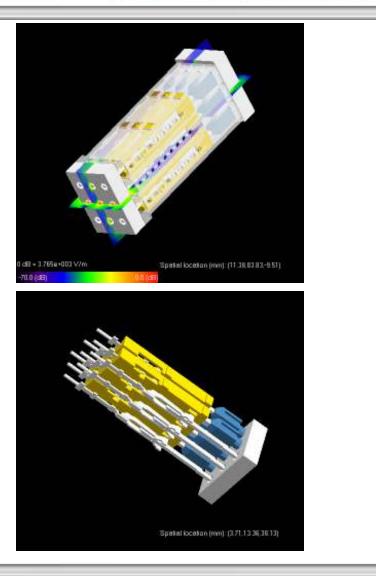
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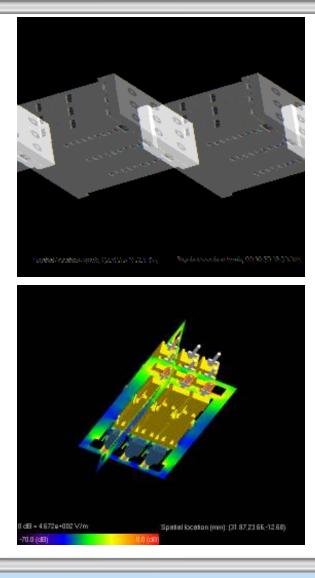
#### **R**A *Space-Diversity Antenna System on CAD import vehicle*

- Displays antenna patterns for diversity antenna system and calculates antenna correlation/diversity performance
- Calculates partial pattern efficiency for both Open Sky and Upper Hemisphere with Pattern Rotation



#### **R**A-CAD-Import of Connector





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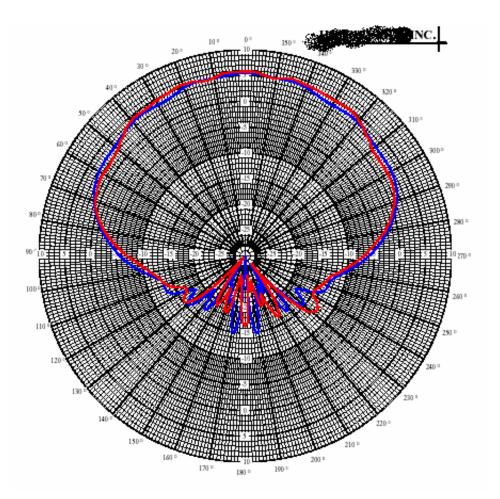
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\* Text of e-mail from XFDTD user:

"Here is a plot that shows a comparison between one of our GPS antennas measured in the range and modeled in XFDTD. For both the tests were performed using a 48" x 48" ground plane. Plots in Red are Measured Plots in Blue are Calculated"

#### **R**A *Customer Graph of XFDTD vs Measurements*



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### **R**A-**XFDTD** Calculation of SAR

- \* XFDTD was first commercial FDTD EM solver with SAR capability
- Raymond Luebbers, President of Remcom, and Dr. Christopher Penney, Remcom VP, are active on Standards Committees
- XFDTD meets Requirements in ANSI/IEEE C95.3: 2002: "IEEE Recommended Practice for Measurements and Computations of Radio Frequency Electromagnetic Fields With Respect to Human Exposure to Such Fields, 100 kHz–300 GHz"
- \* XFDTD complies with SAR averaging as described in IEEE/ICES Draft Standard 1528.1:

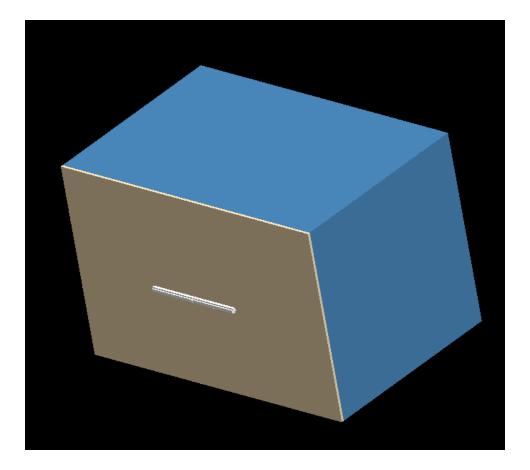
Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body from Wireless Communications Devices, 30 MHz - 6 GHz: General Requirements for using the Finite Difference Time Domain (FDTD) Method for SAR Calculations

\* XFDTD has been validated using results in IEEE Standard 1528-2003: IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques

# **R**A-**XFDTD SAR Validation**

- IEEE 1528 Flat Phantom calibration geometry composed of plastic shell filled with tissue-equivalent liquid
- \* Phantom exposed by dipole antenna
- Liquid parameters and dipole size adjusted for frequency from 300 MHz to 3000 MHz
- Calibration values given for peak local SAR and 1 and 10 gram averages
- Excellent agreement was obtained between XFDTD and the calibration results at all frequencies

#### **R**A *Flat Phantom and Dipole in XFDTD*



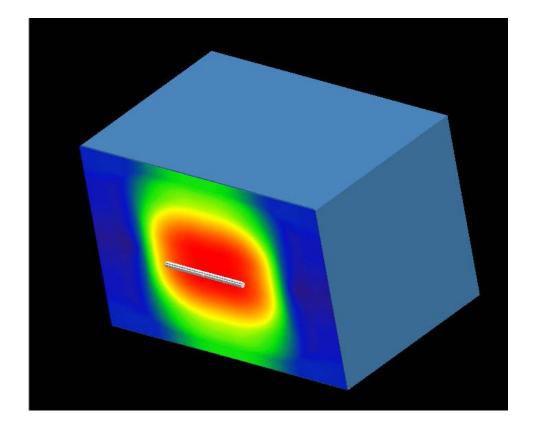
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# RA XFDTD SAR Calibration Results for Flat Phantom

	Reference		Reference			
Frequency	Peak 1g	<b>XFDTD Peak</b>	Peak 10g	<b>XFDTD Peak</b>	Reference	XFDTD
(MHz)	SAR	1g SAR	SAR	10g SAR	Local SAR	Local SAR
300	3	3.1	2	2.1	4.4	4.5
450	4.9	4.9	3.3	3.2	7.2	7.4
835	9.5	9.2	6.2	5.9	14.1	14.1
900	10.8	10.5	6.9	6.6	16.4	16.3
1450	29	28	16	15.2	50.2	50.5
1800	38.1	36	19.8	18.4	69.5	68.3
1900	39.7	37.8	20.5	19.1	72.1	71.4
2000	41.1	39.7	21.1	19.9	74.6	75.1
2450	52.4	52.4	24	23.3	104.2	109.9
3000	63.8	61.6	25.7	23.8	140.2	150

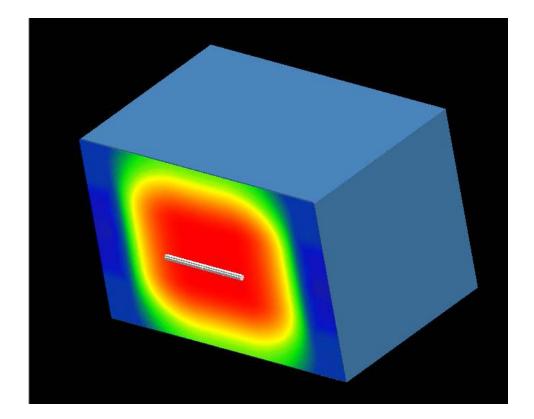
#### **R**A *One Gram Average SAR Display in XFDTD*



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# Restart Ten Gram Average SAR Display in XFDTD



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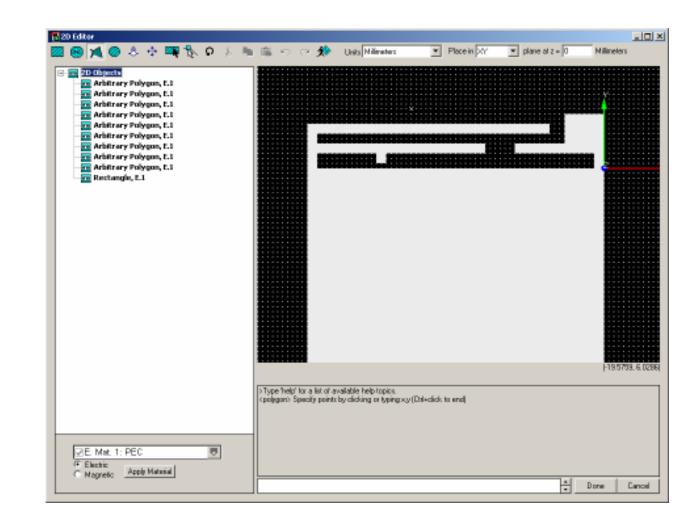
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# RA-Planar FL Antenna (1)

- While XFDTD is fully three-dimensional it can be applied easily to planar geometries
- \* These can be combined with 3D geometries and exported to CAD files
- Results for a planar antenna are compared with measurements from "An Inverted FL Antenna for Dual-Frequency Operation" by Nakano, Sato, Mimaki, and Yamauchi, August 2005 IEEE AP-S Transactions

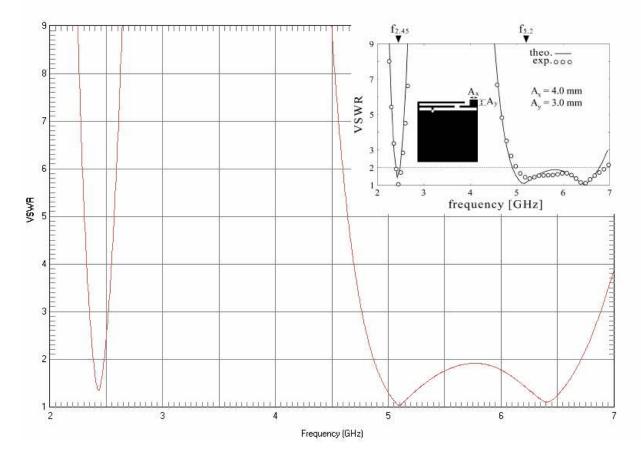
# RA Planar FL Antenna (2)

The XFDTD
 2D editor
 quickly
 draws the
 antenna
 geometry
 using mouse
 and grid
 snap



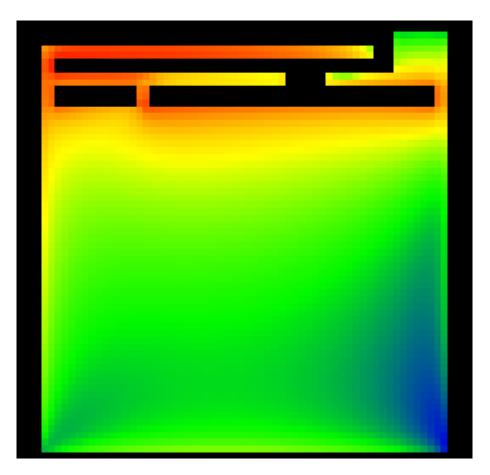


#### \* One transient calculation provides VSWR vs Frequency



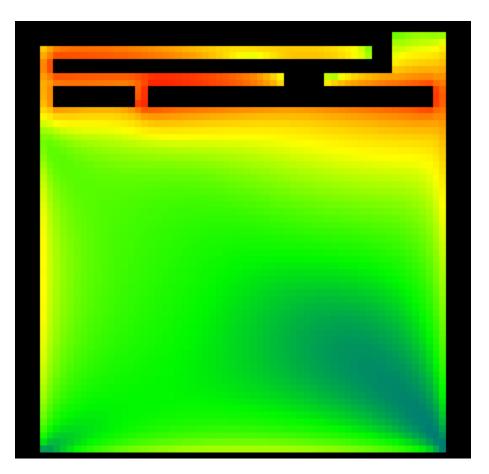
#### **R**A-Current on FL Antenna (2.45 GHz)

 Current Distribution for Low Frequency (2.45 GHz) resonance for dual frequency inverted FL antenna shows strong current on long "L" portion of antenna



### **R**A-Current on FL Antenna (5.2 GHz)

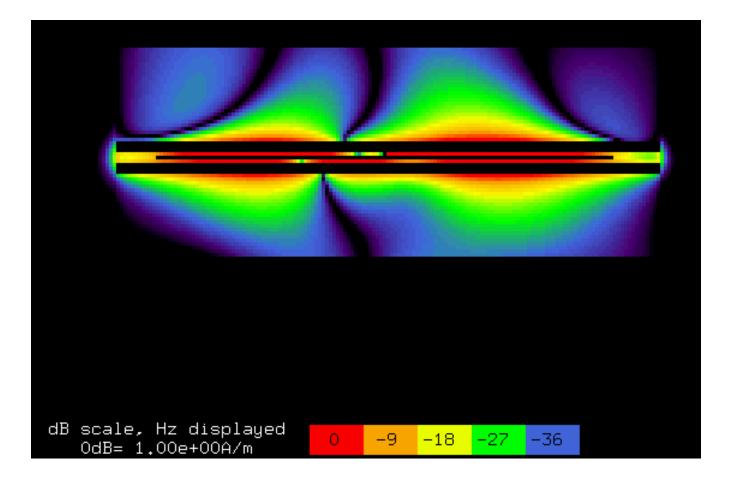
 Current Distribution for High Frequency (5.2 GHz) resonance for dual frequency inverted FL antenna shows strong currents on shorter "F" portion of antenna





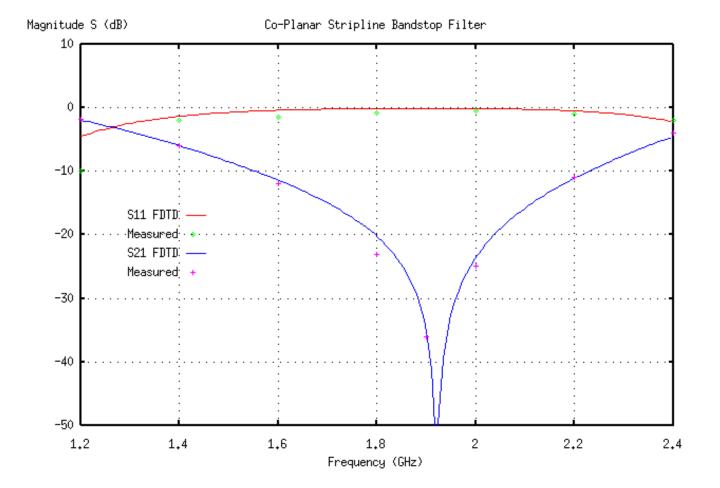
- \* XFDTD is easily applied to a coplanar stripline bandstop filter
- Results are compared with measurements from "Coplanar Stripline Component for high Frequency Applications" by Goverdhanam, Simons, and Katehi, IEEE MTT Transactions, October 1997
- \* This simple geometry can be drawn using XFDTD 2D editor

### **R**A Coplanar Stripline Bandstop Filter



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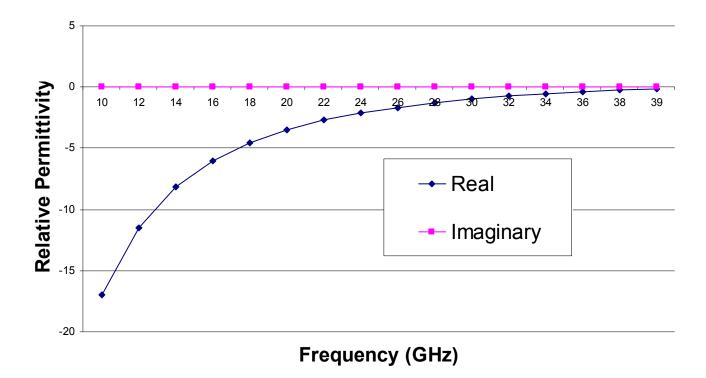


## **R**A-**Frequency-Dependent Dielectrics**

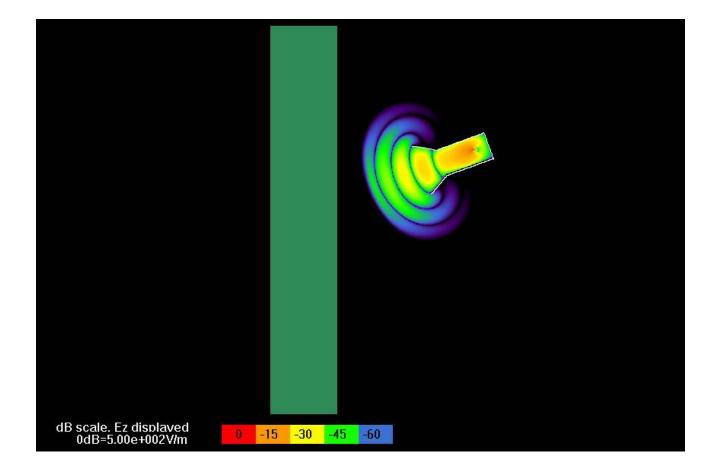
- XFDTD allows for wide frequency band transient calculations for frequency-dependent materials
- Debye useful for materials with condensed polar molecules such as water
- Drude similar to the Debye model but with an added electrical conductivity term
- \* Lorentz used to describe absorption bands, often in the optical frequency range
- \* The latter two are useful in making calculations for Double Negative (DNG) materials, also called Negative Index Materials (NIM), which have negative real part of both permittivity and permeability



**Complex Permittivity** 

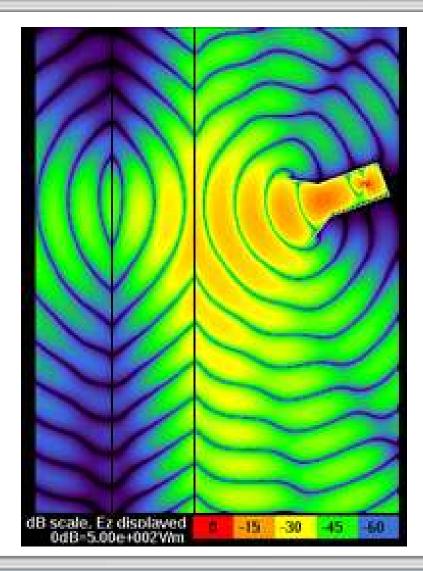






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#### **XFDTD Results showing Reversed Phase Fronts in DNG Material**

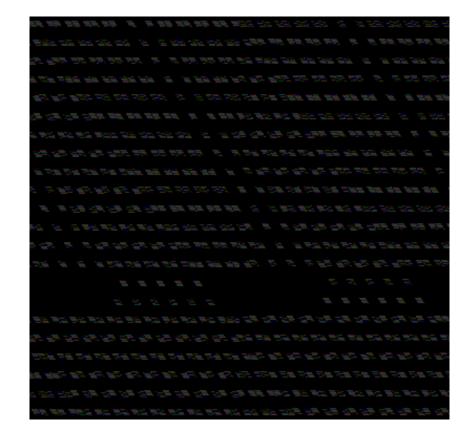


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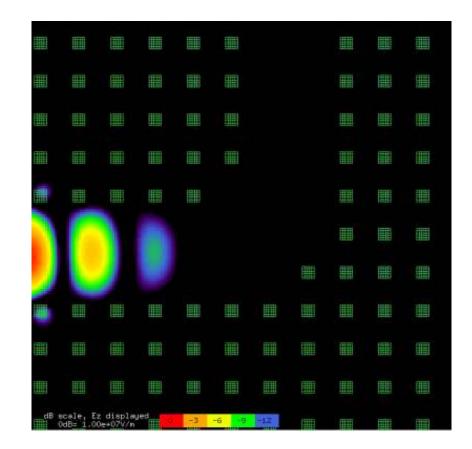
# **R**A-Photonic Band Gap Structure

- \* A two-dimensional array of photonic crystals with a curved line defect are simulated in XFDTD
- The crystal geometry is a two-dimensional array of rods, each 0.18125 microns on a side and spaced at a period of 0.58 microns
- \* A curved waveguide line defect is introduced by removing several rows of rods
- Properties of gallium arsenide (n=3.4) are assigned to the rods in the XFDTD mesh
- \* A ramped sinusoidal input source centered at 1.55 microns is applied to the crystal at a cell edge in the center of the waveguide.

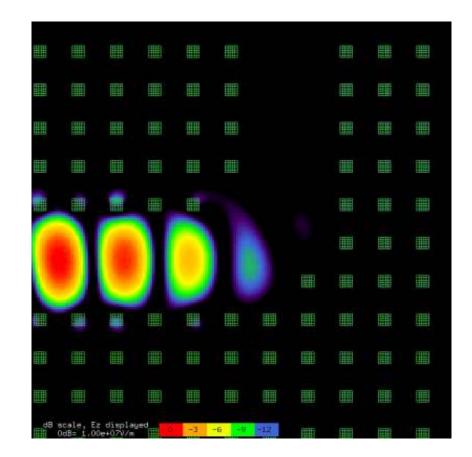
#### **R**A *XFDTD Mesh of Photonic Crystal with Curved Waveguide Defect*



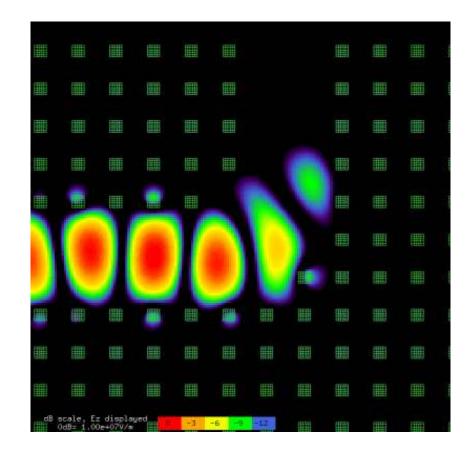
## **R**A-**Transient Propagation (1)**



## **R**A-**Transient Propagation (2)**



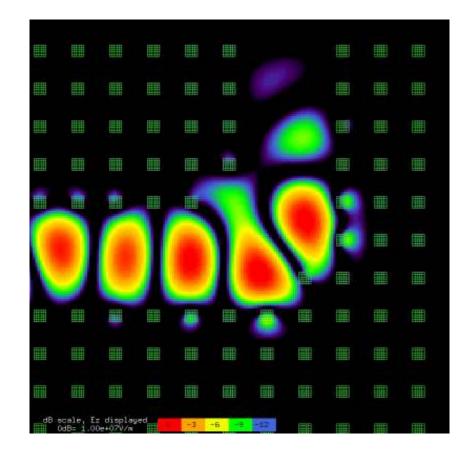
## **R**A-**Transient Propagation (3)**



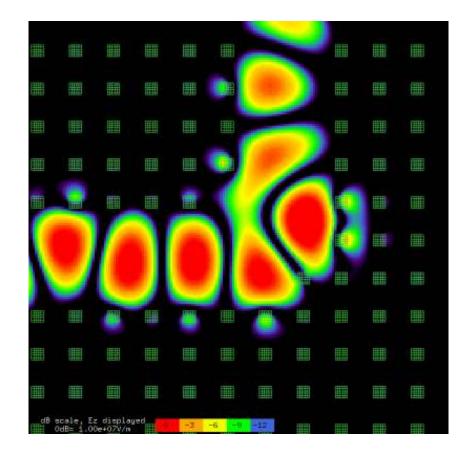
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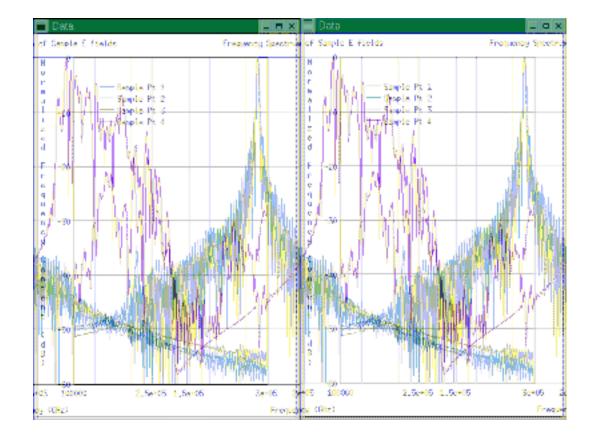
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#### **R**A *Photonic Band Gap Structure Results*

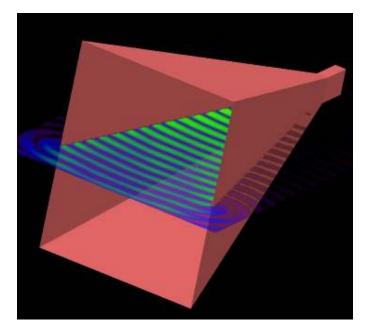
- \* The propagation of the applied signal is shown in the sequence of fields in the previous figures
- \* The containment of the fields within the waveguide is clearly visible as the signal turns the corner and continues
- \* The line plot in the next figure shows the frequency content for four sample points where points 1-3 are within the waveguide region and contain the input signal while point 4 is within the crystal and only contains frequencies outside the band gap.

#### **R**A-Field Samples Indicating Band Gap Regions



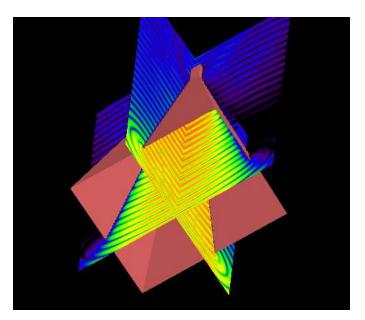
# **R**A-**Example Calculation**

- \* To illustrate some of the capabilities of XFDTD a pyramidal horn will be considered
- \* The horn geometry could be generated using CAD import, or using by XFDTD capabilities for sweeping and/or shelling
- For this example the built-in horn primitive of XFDTD will be used



## **R**A-Horn Antenna Parameters

- Optimum gain pyramidal horn antenna
- Horn aperture dimensions are 18.46 cm by 14.55 cm with a horn length of 33.98 cm
- Fed by a WR-90 waveguide with an input signal of 9.3 GHz
- First step is to use the Horn library object in XFDTD

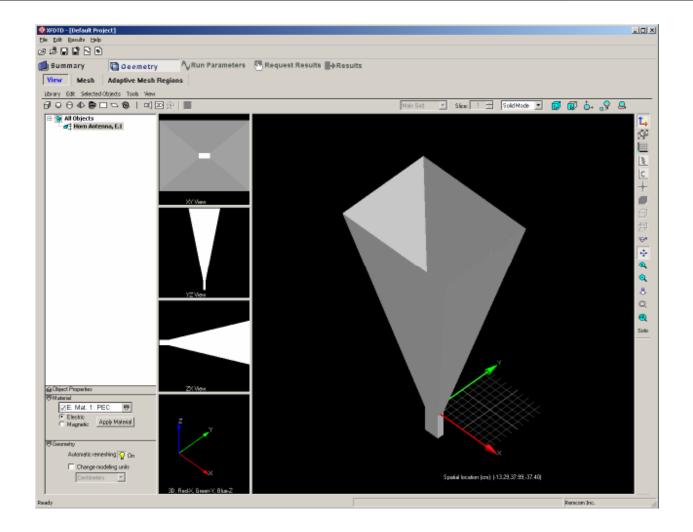


### **R**A-Horn Antenna Library Object

- Start XFDTD and in the Geometry window select the horn button
- Enter the Horn Parameters for the Horn and Waveguide Feed as shown in the menu

Name: Horn Antenna Units: Centimeters Units: Centimeters Waveguide Width: 2.286 Horn Length Re/Rh 33.98 Uaveguide Height: 1.016 Lh 39.8659 Le 37.2482 Aperture Width: 18.46 Aperture Width: 18.46 Aperture Height: 14.55 Thickness: 0.00t Ridge Width (in X): 0 Minimum Separation Distance: 0 Center Point Rotation in degrees
Waveguide Width: 2.286 Waveguide Height: 1.016 Waveguide Length: 4 Aperture Width: 18.46 Aperture Height: 14.55 Thickness: 0.00th Ridge Width (in X): 0 Minimum Separation Distance: 0
Waveguide Width: 2.286 Waveguide Height: 1.016 Waveguide Length: 4 Aperture Width: 18.46 Aperture Height: 14.55 Thickness: 0.001 Ridge Width (in X): 0 Minimum Separation Distance: 0
Waveguide Length: 4 Aperture Width: 18.46 Aperture Height: 14.55 Thickness: 0.001 Ridge Width (in X): 0 Minimum Separation Distance: 0
Aperture Width: 18.46 Aperture Height: 14.55 Thickness: 0.001 Ridge Width (in X): 0 Minimum Separation Distance: 0
Aperture Height: 14.55 Thickness: 0.001 Ridge Width (in X): 0 Minimum Separation Distance: 0
Thickness: 0.001 Ridge Width (in X): 0 Minimum Separation Distance: 0
Ridge       Width (in X):       0       Minimum Separation Distance:
Width (in X): 0 Minimum Separation Distance: 0
Minimum Separation Distance: 0
,
Center Point Rotation in degrees
X Position: 0 X Axis: 0
Y Position: 0 Y Axis: 0
Z Position: 0 Z Axis: 0
E. Mat. 1: PEC C Electric Magnetic
<u>A</u> dd <u>C</u> lose

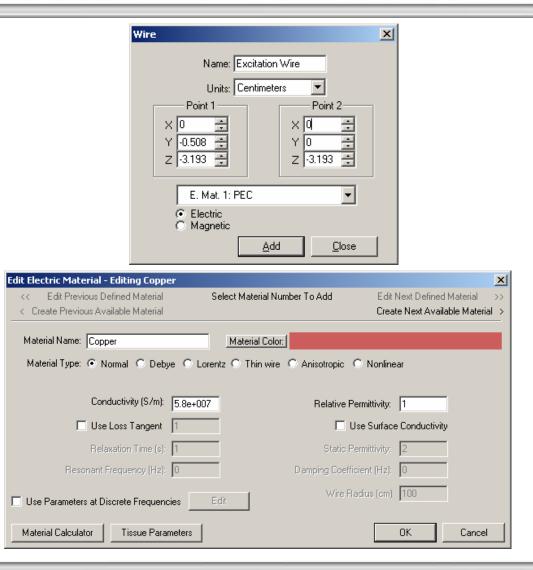
## **R**A The Horn Antenna in Solid View



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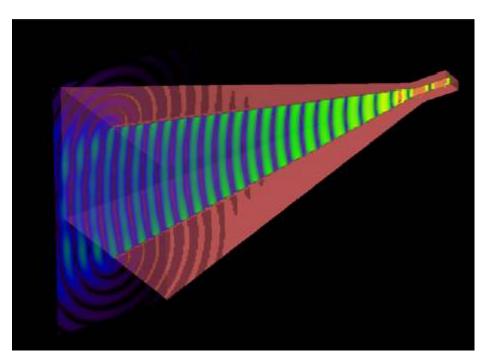
### **R**A-Add Coaxial Conductor

- Use Wire primitive to add a coaxial center conductor near (~1/4 wavelength) the end of the waveguide feed
- Change Material to Copper

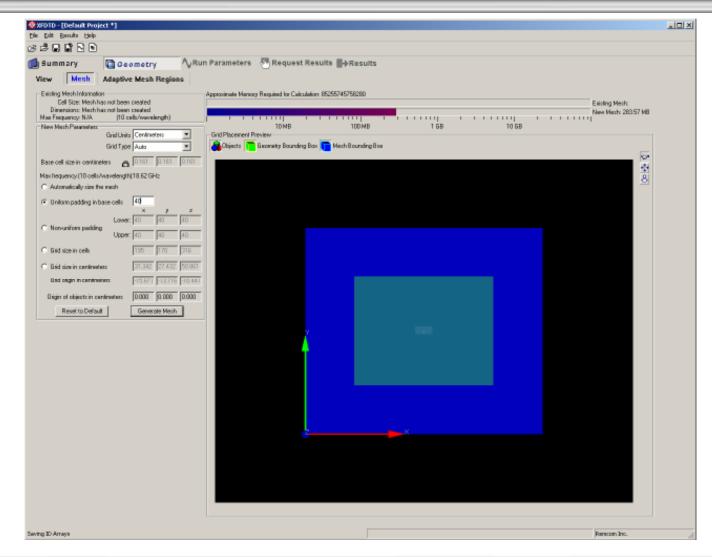


# **R**A-Mesh Parameters

- Now ready to create the calculation mesh
- Open Mesh Tab (next slide) to create the mesh
- Set cell size to 0.161 cm for 20 cells per wavelength at desired frequency of 9.3 GHz, set outer boundary padding, and Generate Mesh in seconds.



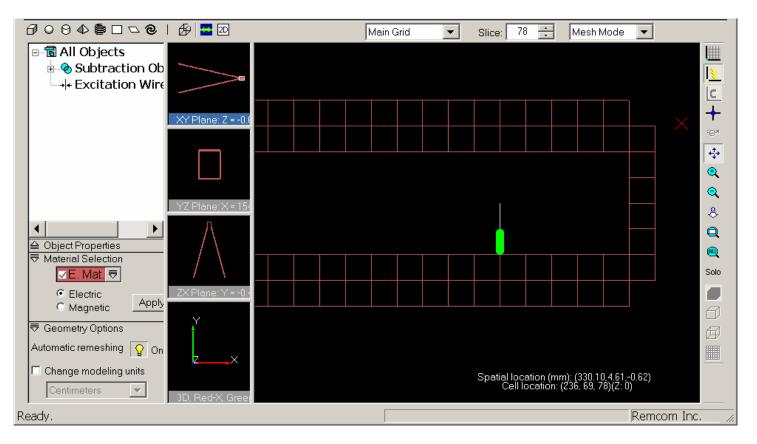
# **R**A-Meshing the Horn Geometry



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### **R**A-**Specify Port Location**

In Mesh View locate excitation (green) port at base of coaxial center conductor using mouse pointer



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## **R**A-Specify Port Configuration

um	nmary		Geometry	A Run Param	neters 🖶	Request Results 📕 🕂	Results	
vet	form s	Source Ty	pe Compon	ents/Ports Outer	Boundary			
	Fee	d Specificatio	ns					
				Series Voltage	•	Amplitude: 1	(Volts)	
		Y-Directed	i 💌	+ Polarity	•	Phase: 0	(Degrees)	
		x 239 📑	9	Parallel Load	Ψ.	Resistance: 50	000000 (obms)	
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		'arameter∕VSV	<b>I</b>	Specify Active Feed:	1	Switch at 60 Transition Duration 60 Static Voltages	timesteps	
	Port	arameter/VSV On odate: Compon	ient [ (Amp/Phase)	Add Component	T D Load/Swi	Switch at 60 Transition Duration 60 Static Voltages Enable Solver elete Component tch Type (R,L,C) or Switch 1	timesteps timesteps Voltage Points	
	Up	arameter/VSV On odate:Compon	ient [	Add Component	- 1	Switch at 60 Transition Duration 60 Static Voltages Enable Solver elete Component	timesteps timesteps Voltage Points Delete All Components	
	Port	arameter/VSV On odate: Compon	ient [ (Amp/Phase)	Add Component	T D Load/Swi	Switch at 60 Transition Duration 60 Static Voltages Enable Solver elete Component tch Type (R,L,C) or Switch 1	timesteps timesteps Voltage Points Delete All Components	
	Port	arameter/VSV On odate: Compon	ient [ (Amp/Phase)	Add Component	T D Load/Swi	Switch at 60 Transition Duration 60 Static Voltages Enable Solver elete Component tch Type (R,L,C) or Switch 1	timesteps timesteps Voltage Points Delete All Components	
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	Port	arameter/VSV On odate: Compon	ient [ (Amp/Phase)	Add Component	T D Load/Swi	Switch at 60 Transition Duration 60 Static Voltages Enable Solver elete Component tch Type (R,L,C) or Switch 1	timesteps timesteps Voltage Points Delete All Components	

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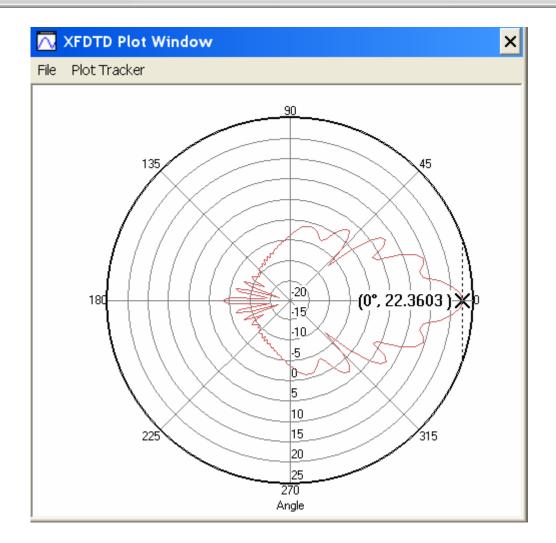
#### Set 9.3 GHz Sine Wave Excitation

경 교 값 진 한 Summary Decometry AyRun Pa	rameters 🖑 Request Results 📑 Results	
Components/Pe     Geussian     Geussian      Geussian	Outer Boundary           Pulse Width (bese cell time steps):           Far-Zone Transformation:           Steady-State           Amplitude (Volts):           1           Waveform Frequency (GHb):           Material Paremeter           Using Waveform Frequency           Calculations Frequency (GHb):	Simulation termination oritaria Number of Timesteps 2000 Number of Seconds 6.2011 Be-009 Number of Periods 57.671 Automatic Convergence Advenced Convergence Threshold 40 I de
	Time Dombin	
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951 27.1 1/41 9112 9112 9112	Frequency Domain 22.1 211 211 121 121 131 313 513	
1.12 N 12 2 14 4 16	6 18 8 21 10 U 12	
384)	frequency (GFIz)	tre



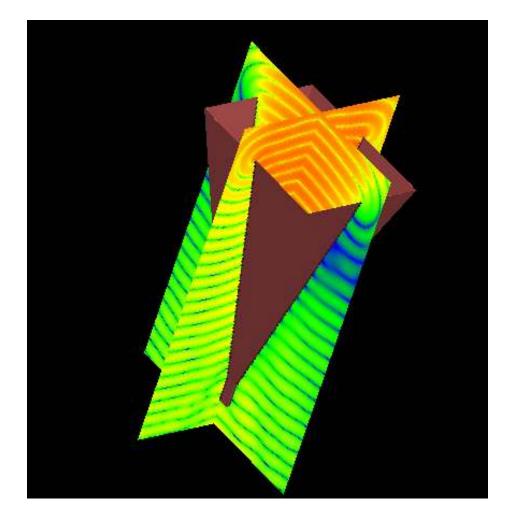
- \* Theoretical gain is 22.1 dB with half-power beam widths of 12 degrees in the E-plane and 13.6 degrees in the H-plane
- \* XFDTD computed gain matches the theoretical to onetenth of a dB, beamwidths within a few tenths of a degree
- Display Far Zone Antenna Patterns, Impedance, S Parameter, Efficiency
- Display Near Zone Fields Numerical Plots and Color Display

#### **R**A-Horn Antenna E-Plane Gain Pattern



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# RANear Zone Field Display Illustrating<br/>Polarization-Dependent Diffraction



# **R**A *XFDTD Summary*

- \* XFDTD is a highly accurate full wave EM solver
- \* These charts illustrate only a few applications and a small sampling of available output
- More information available at www.remcom.com
- \* Arrange for a test drive with xfdtd@remcom.com

