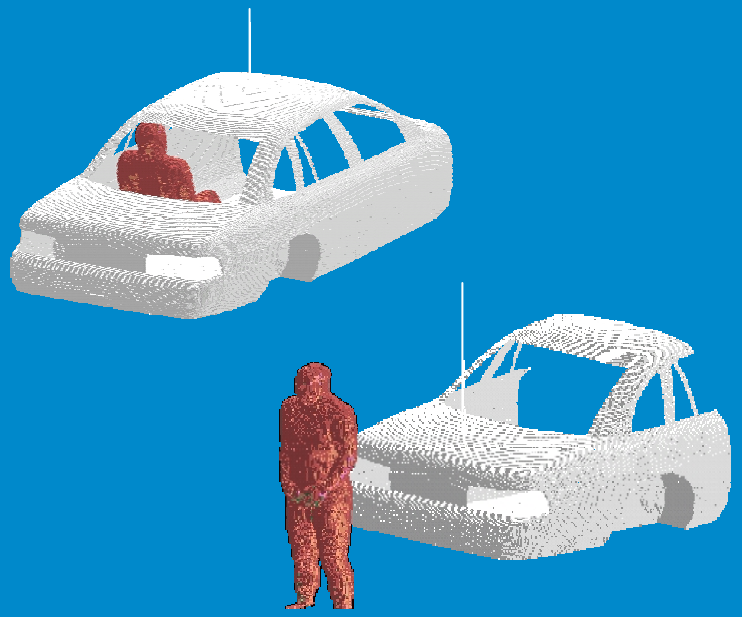
Validation of Mobile Antenna Modeling by Comparison with Near-field Measurements

Simulation & numerical assessment of RF exposure from vehicle-mount antennas

IEEE/ICES TC34 SC2 meeting:

Cancun, June 9, 2006



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Objectives

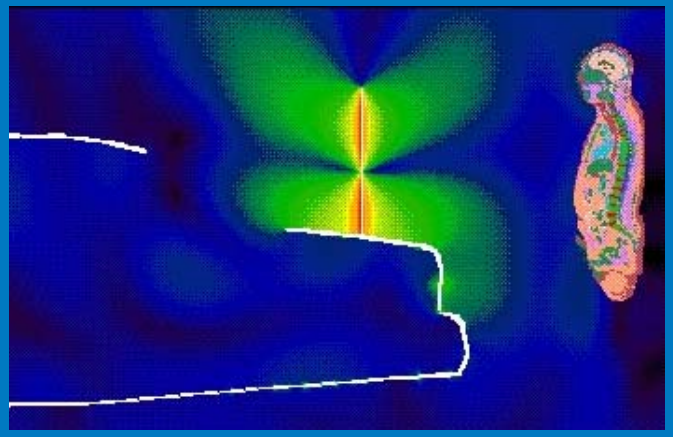
Demonstrate validity of different vehicle mount antennas (monopoles) modeling using FDTD method for exposure assessment

- **Validity of simplified antenna models with helical loads represented by lumped inductor elements in limited resolution FDTD models**
- **Validity of ideal feed point impedance matching assumption in simulations without detailed consideration of the matching circuit located at the base of some real antennas**

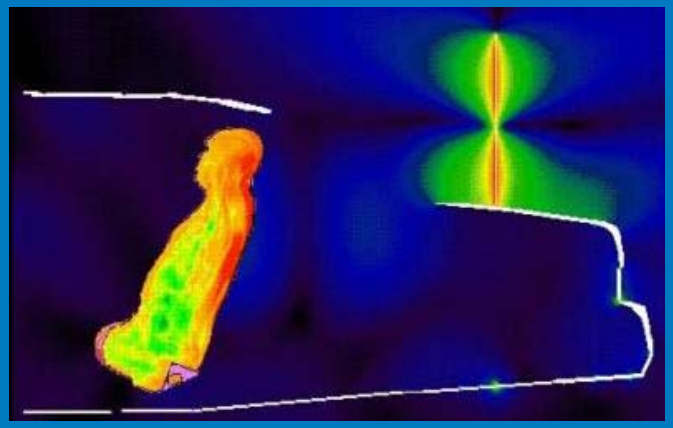
Overview of exposure simulations using FDTD

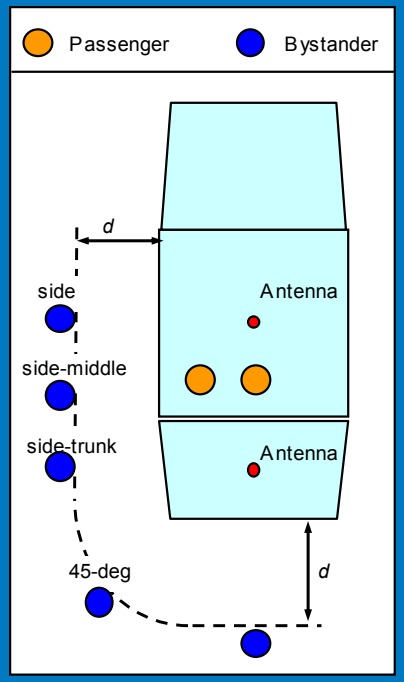
- Car model imported from CAD database of actual sedan car
- Heterogeneous Human model with frequency-dependent tissues

Bystander Exposure

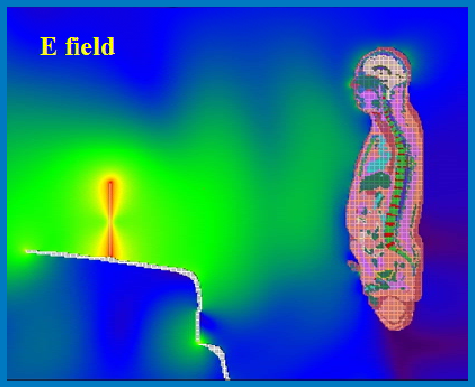


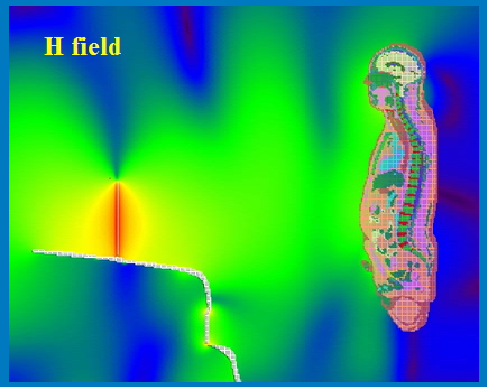
Passenger Exposure

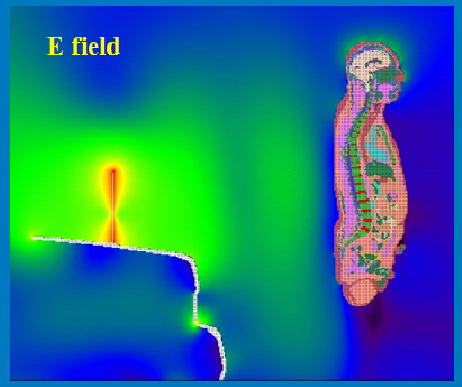


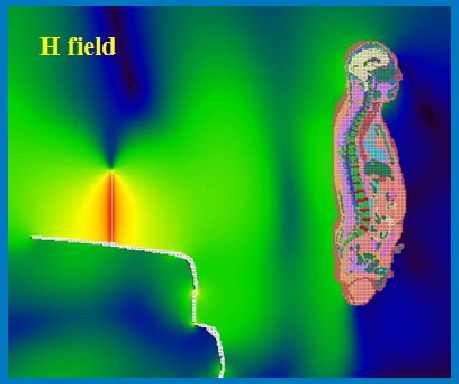


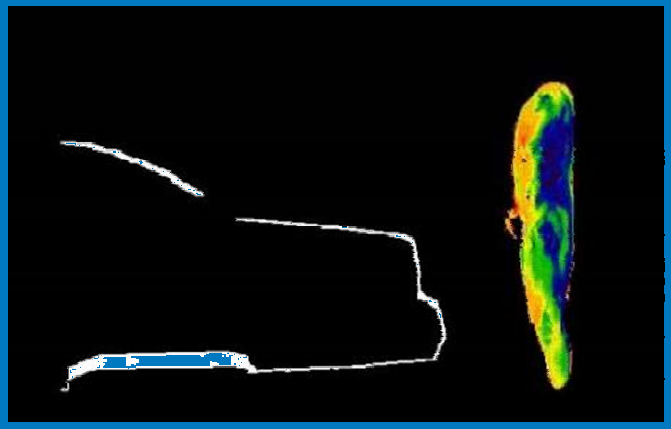
Bystander Exposure











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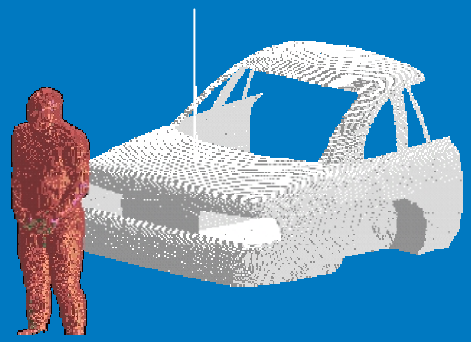

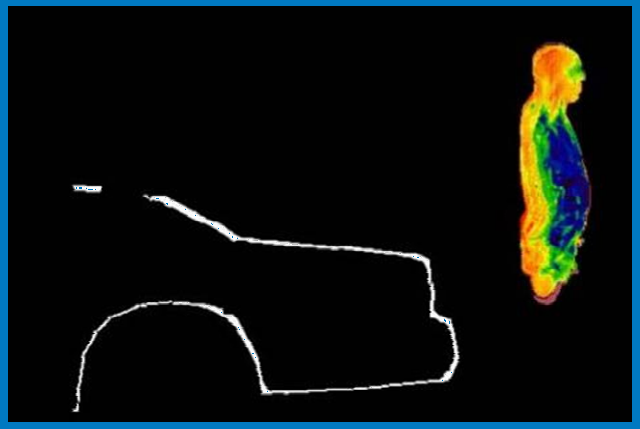

BACK

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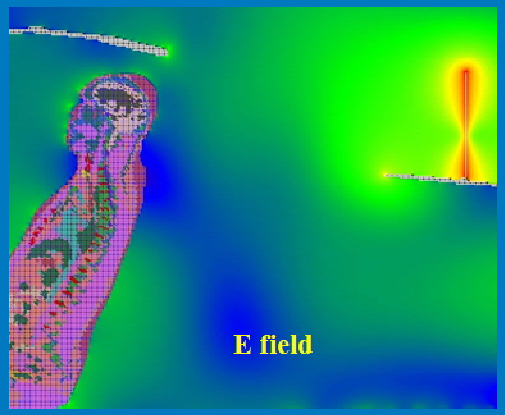
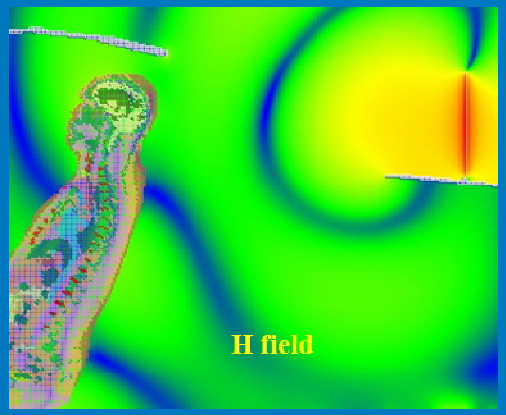
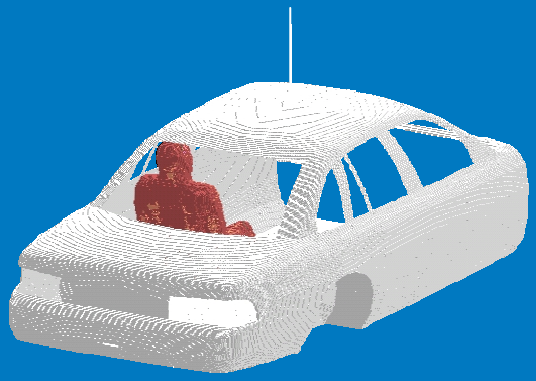
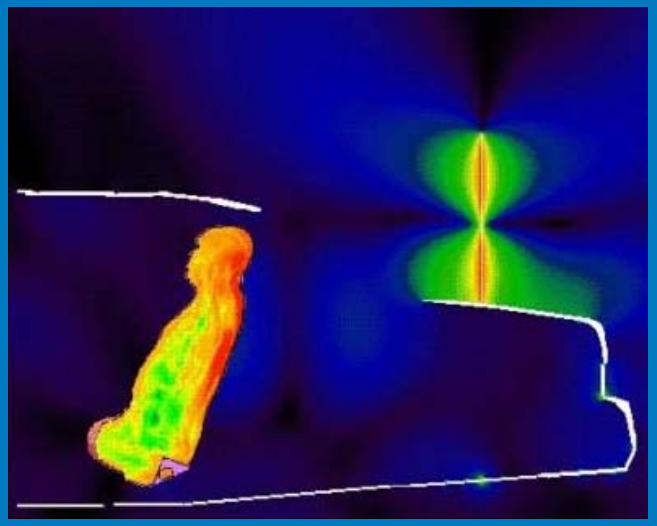
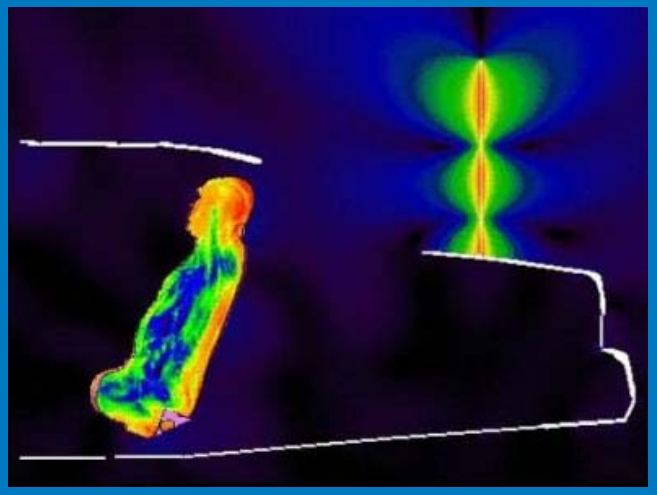
Passenger Exposure











Validation of XFDTD antenna models vs. near-field measurements

Antennas

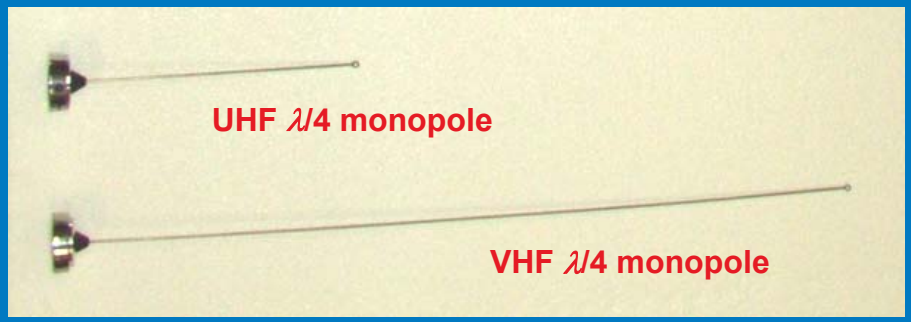
- **VHF** quarter-wave monopole
- **UHF** quarter-wave monopole
- HAE6010A (**UHF** gain antenna)
- HAE6011A (**UHF** gain antenna)
- HAE6013A (**UHF** gain antenna)

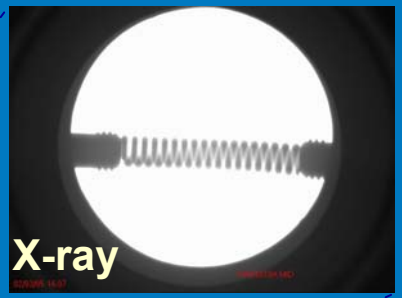
Mounted on the center of a circular (53 cm radius) ground plane

XFDTD™ modeling

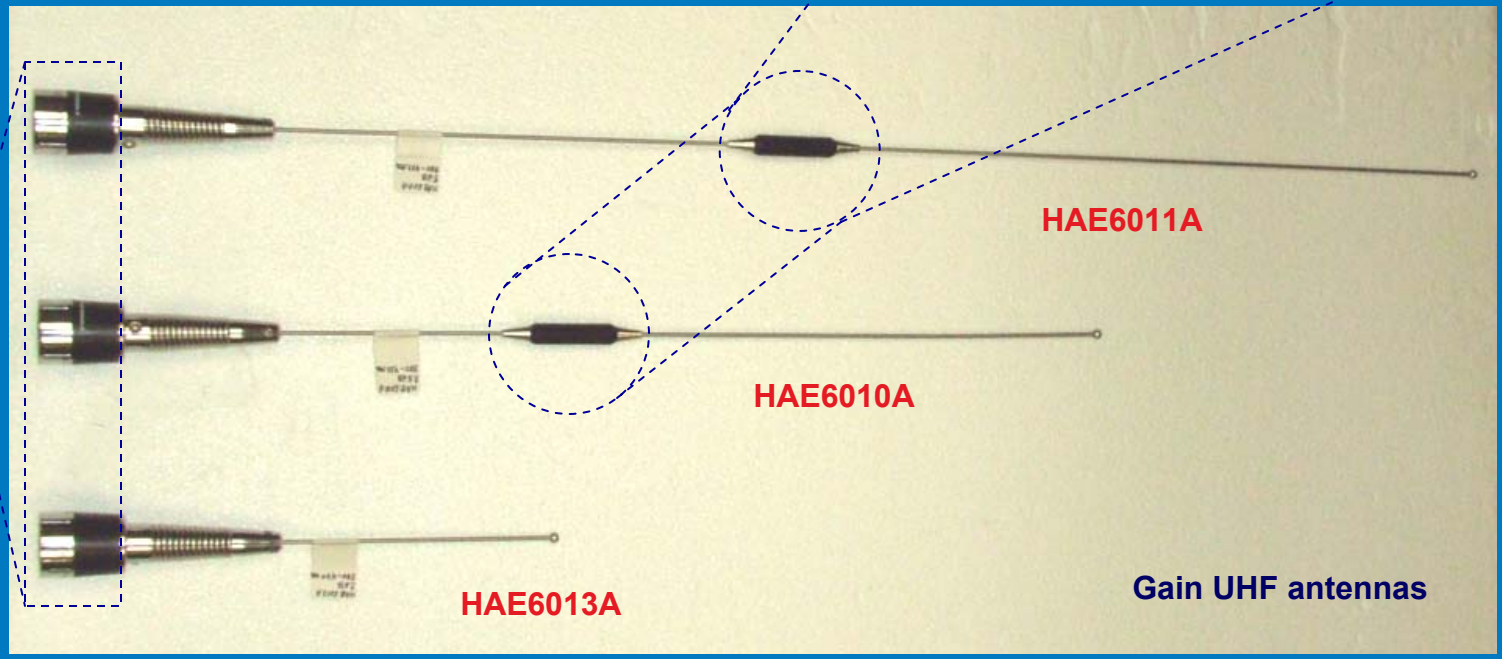
- 50 Ω resistive voltage source, no matching network
- PML BC at all domain bounds
- 5 mm discretization

Typical Vehicle Mount Antennas





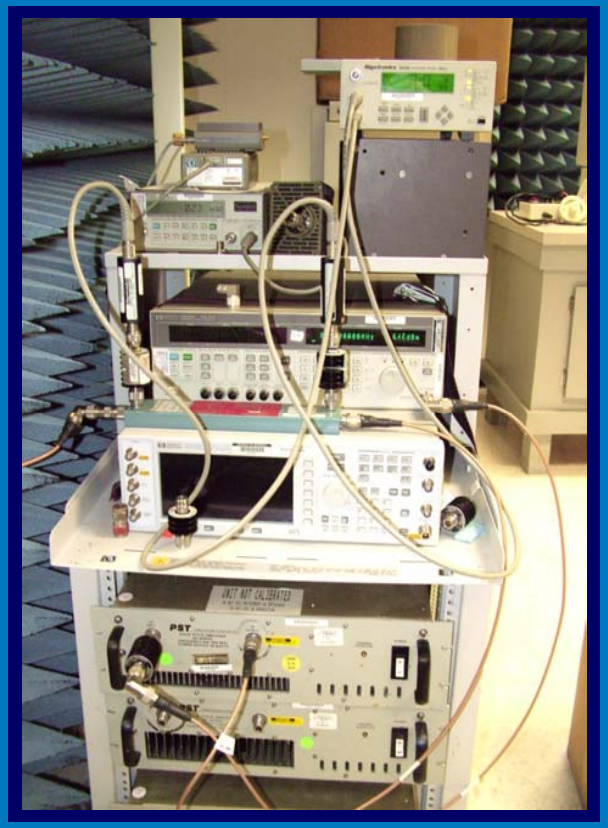
Embedded matching network



Description of measurements

Equipment Used:

DASY4
E and H field probes: *ER3DV5R & H3DV6*
Signal generator: *HP83732A*
Power amplifiers: *PST* 50 W, 1-500 MHz
Power meters: *HP437B & Giga-tronics 8542B*
Network Analyzer: *Wiltron 3721B*



Measurement Procedure:

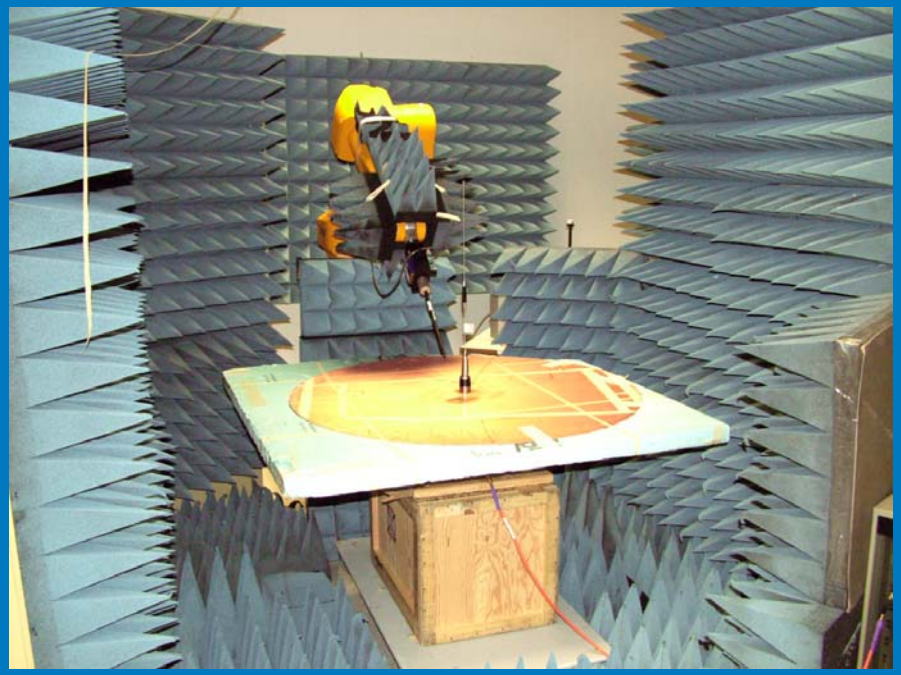
The near field of each antenna mounted on the center of circular ground plane was measured in the rectangular area covering the full height of the antenna and within the reach of the robot arm

Radius of the ground plane: 53 cm

Antenna return loss was measured and taken into account in normalization of the results to 1.0 W radiated power

Description of measurements

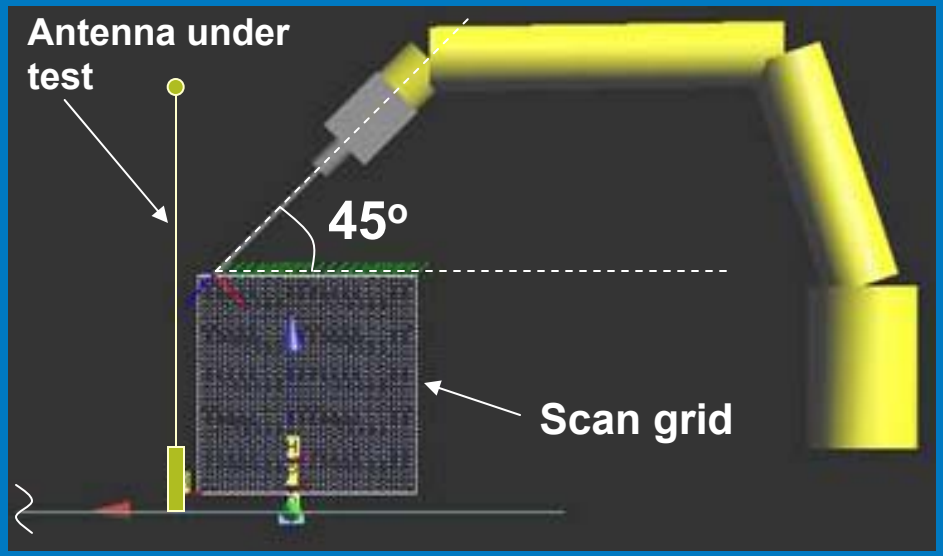
- Quasi-anechoic environment
- The DASY4 robot arm closest to the probe was covered with absorbing material
- Both E- and H- were measured within 43 cm distance from the antenna and with 1 cm grid step

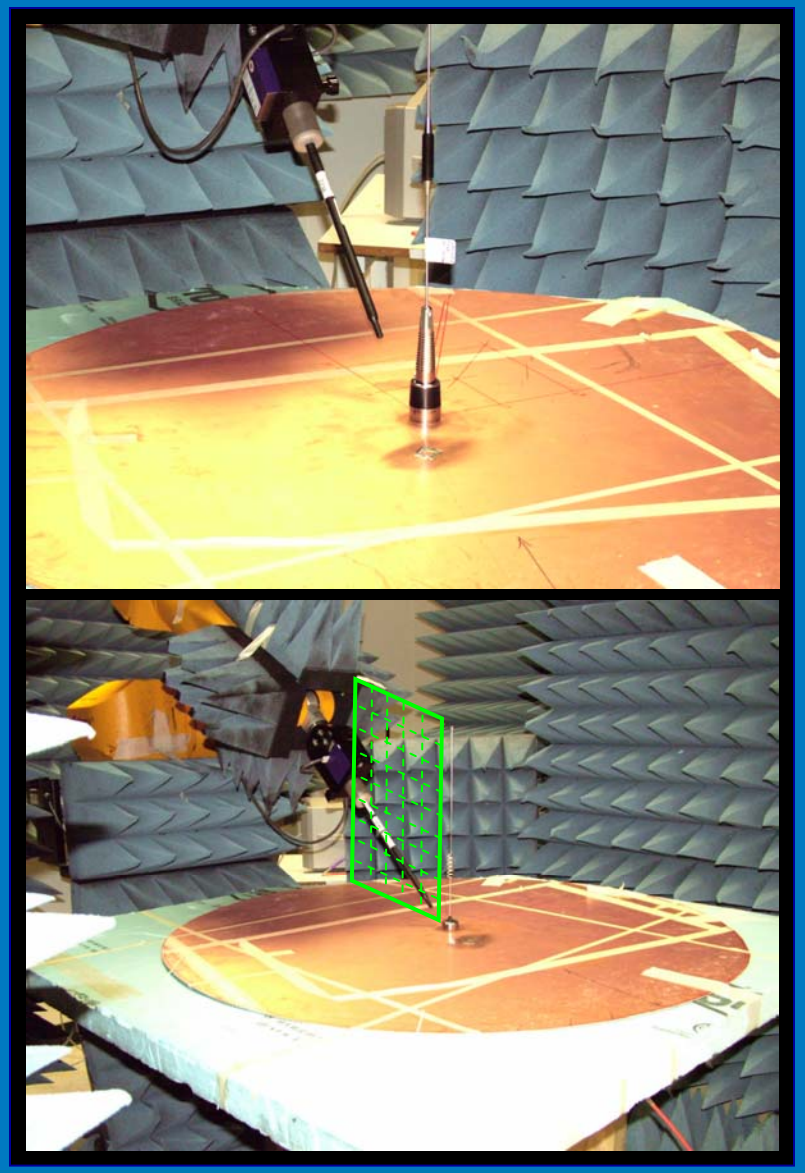


Description of measurements

DASY4 system

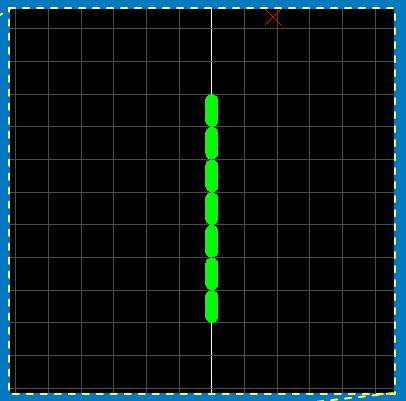
Probe at all time tilted at 45 degree from vertical position to minimize interaction with antenna and ground plane

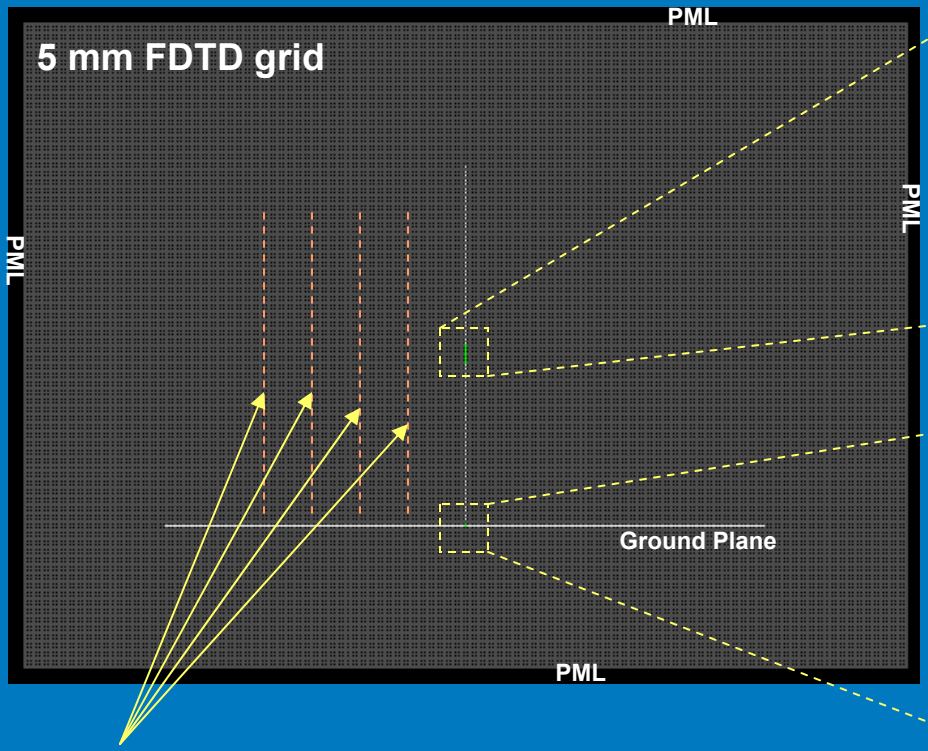




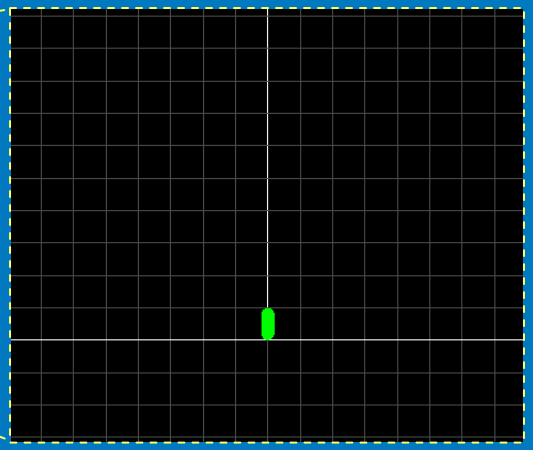
Details of the numerical model – FDTD

Coil along the antenna - Lumped inductors connected in series





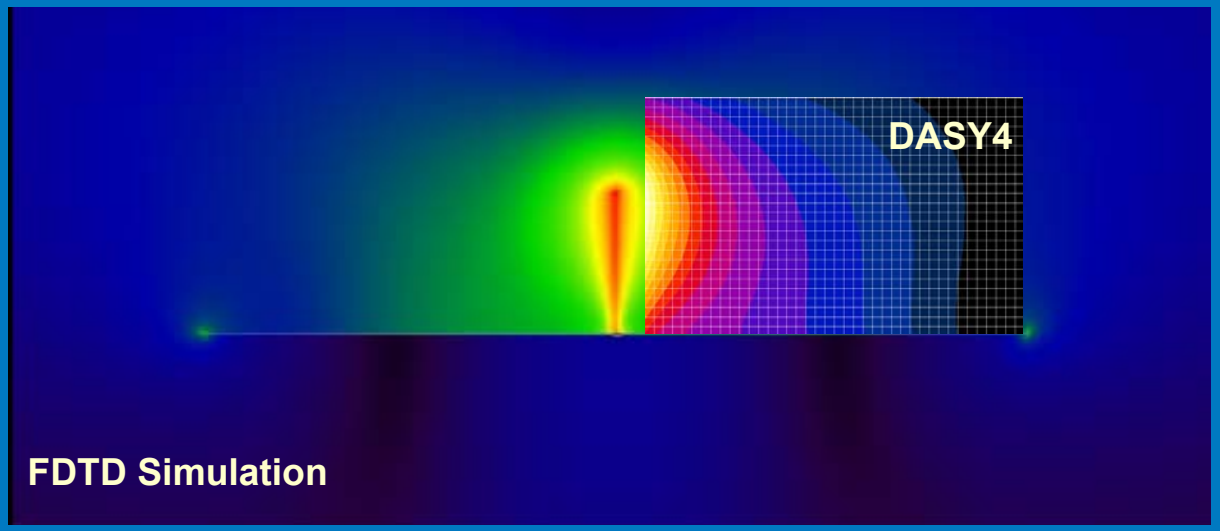
Lines at 10, 20, 30, and 40 cm from antenna along which the simulated and measured field values were compared



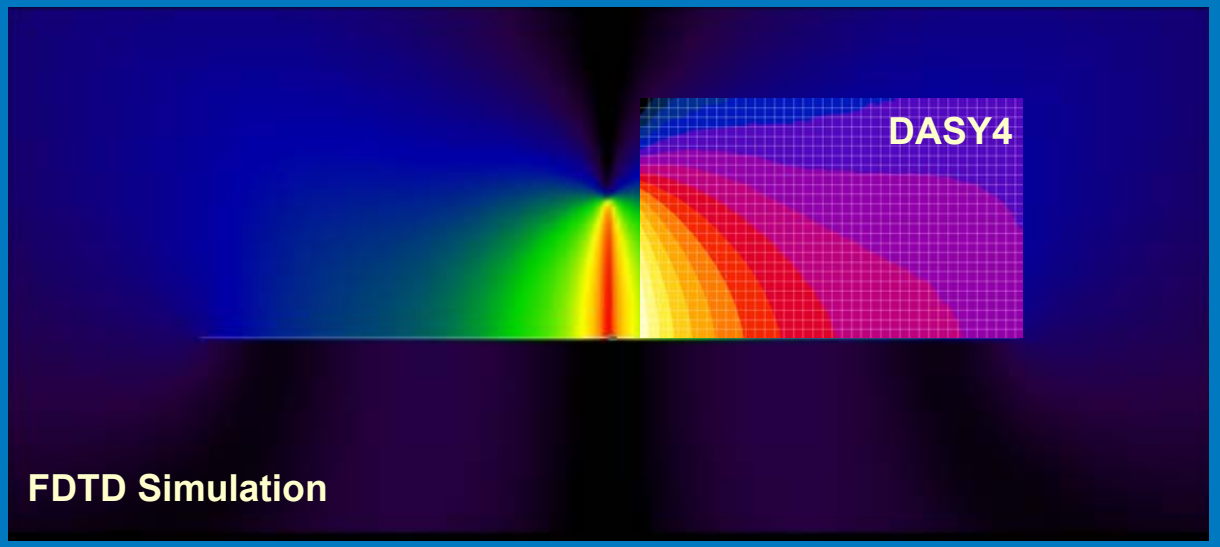
Feeding - Lumped Resistive Voltage Source

UHF $\lambda/4$ monopole – 400 MHz

E-field

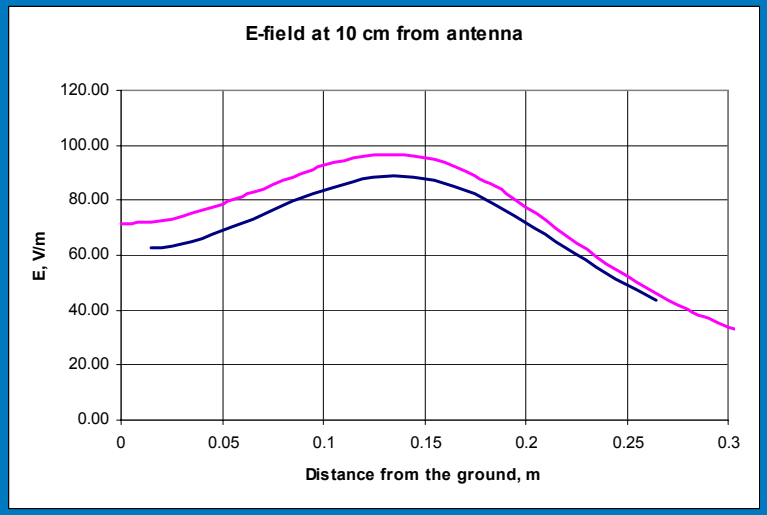


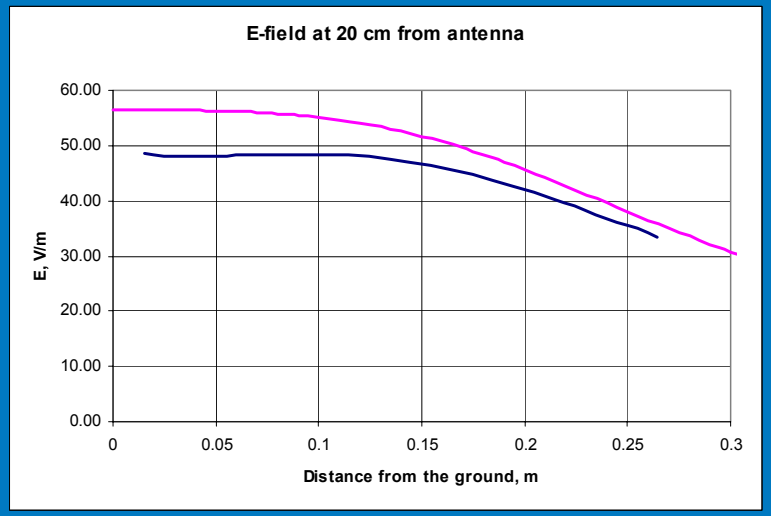
H-field

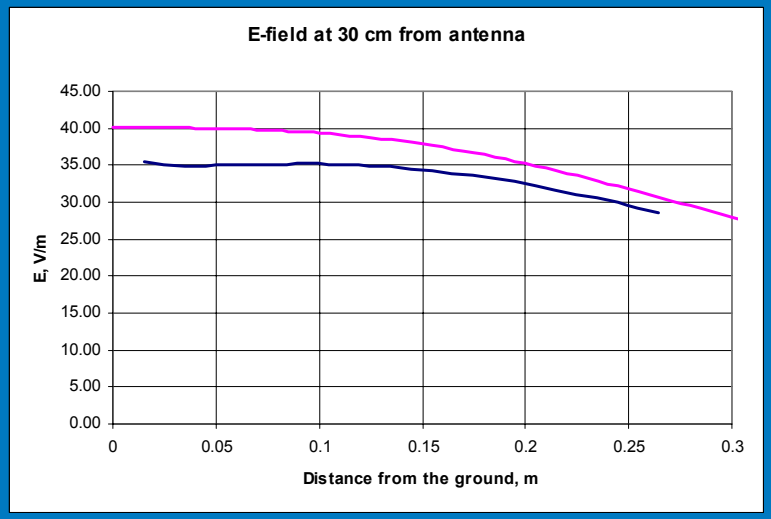


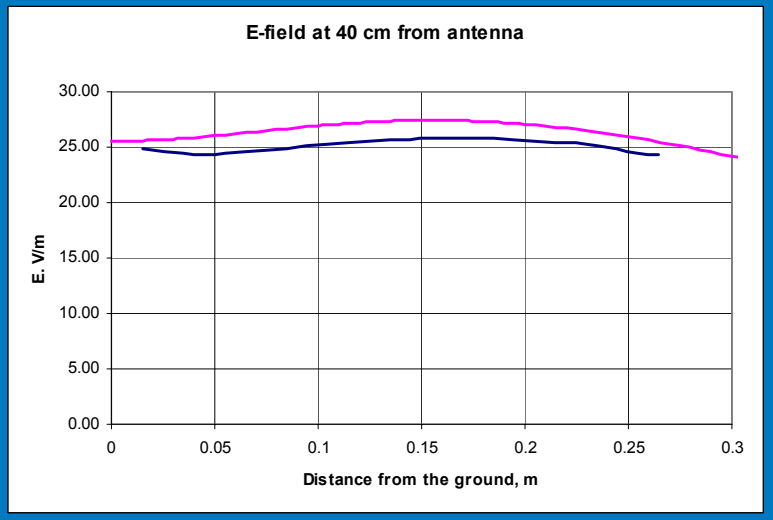
UHF $\lambda/4$ monopole – 400 MHz

Simulated and measured E-field



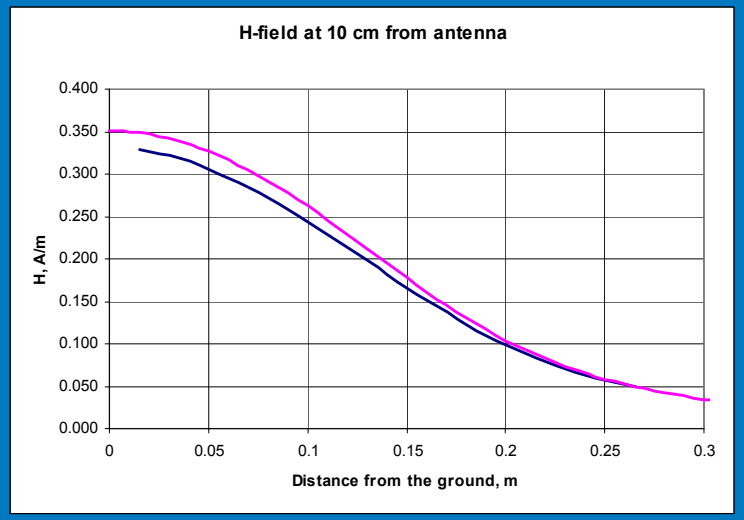


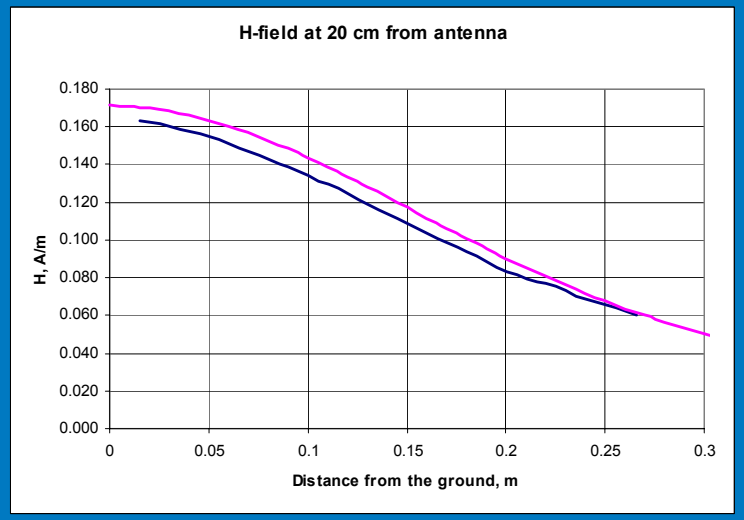


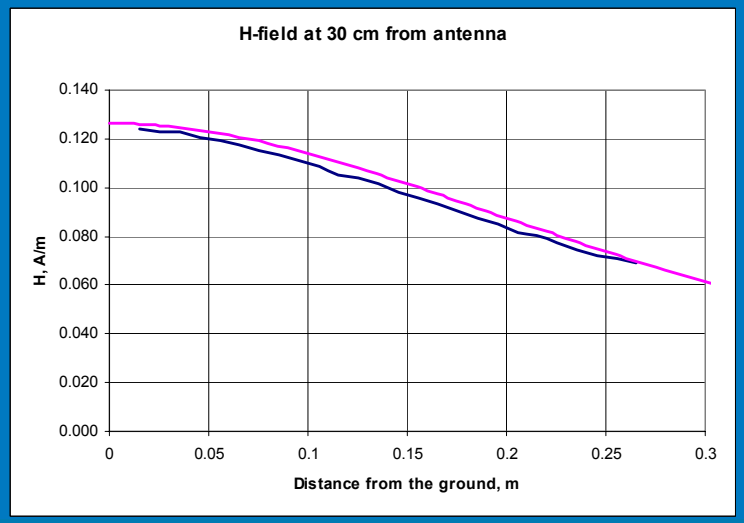


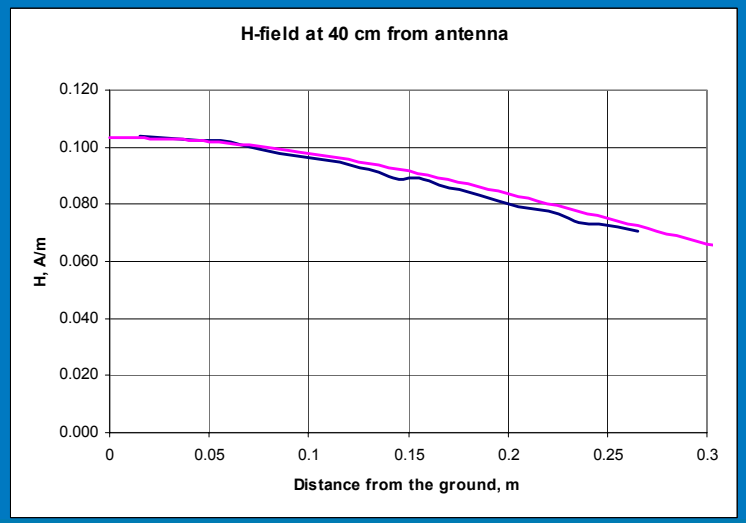
UHF $\lambda/4$ monopole – 400 MHz

Simulated and measured H-field



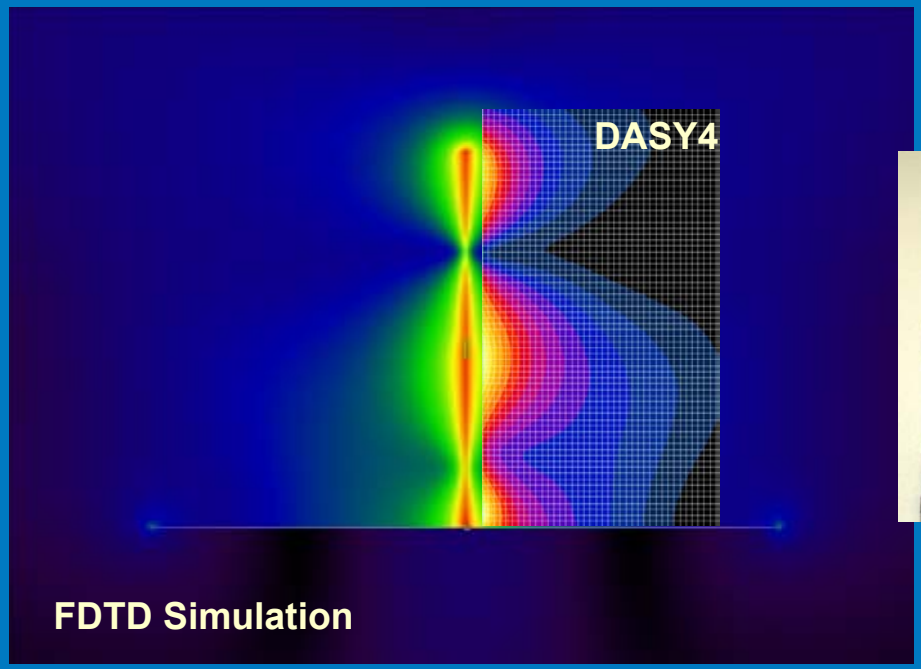




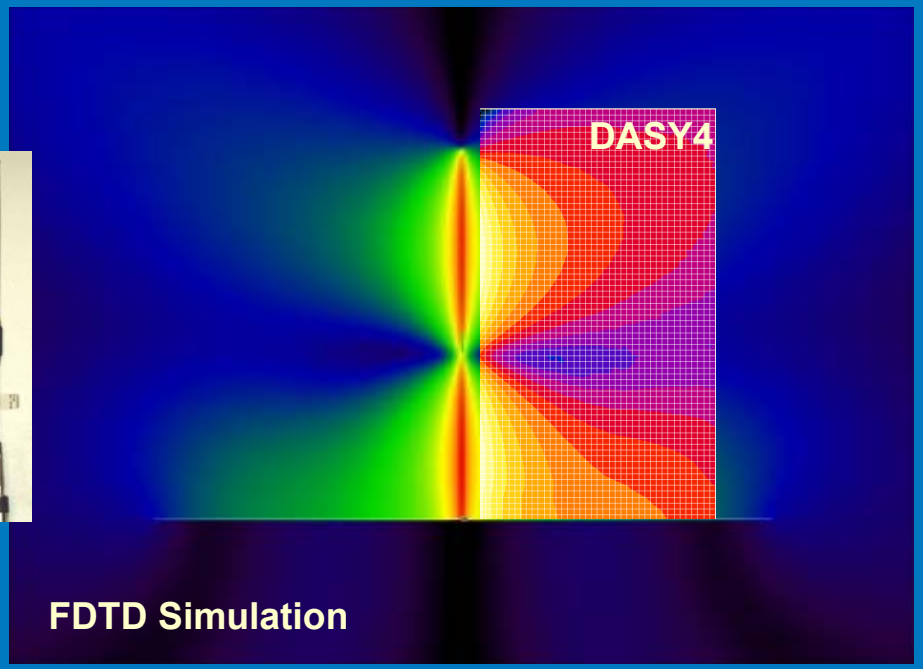


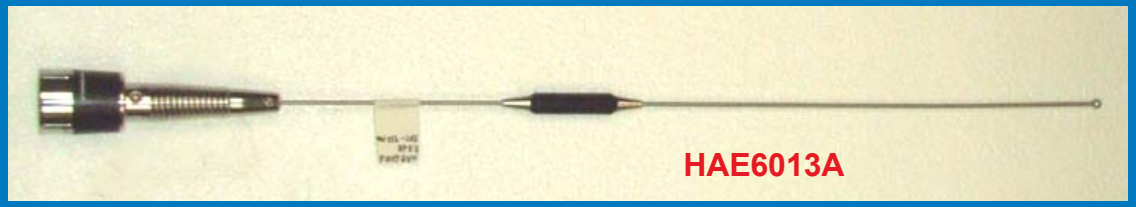
UHF Gain Antenna HAE6010A – 400 MHz

E-field



H-field





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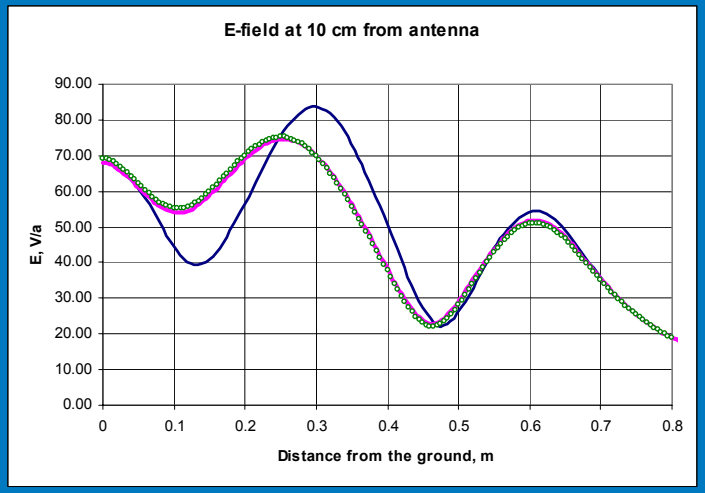
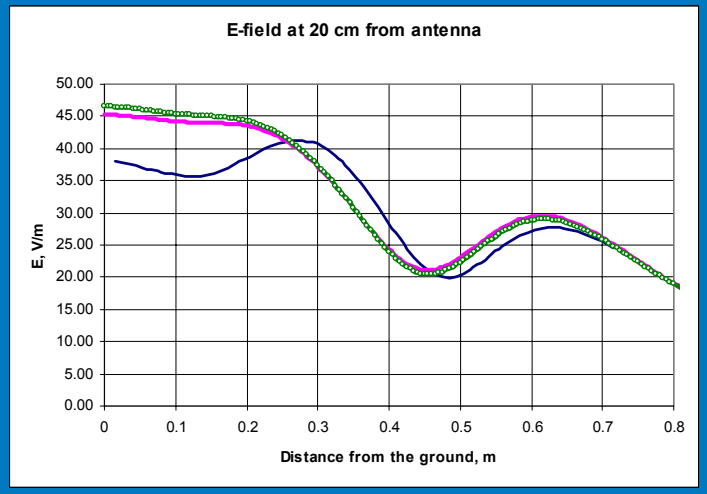
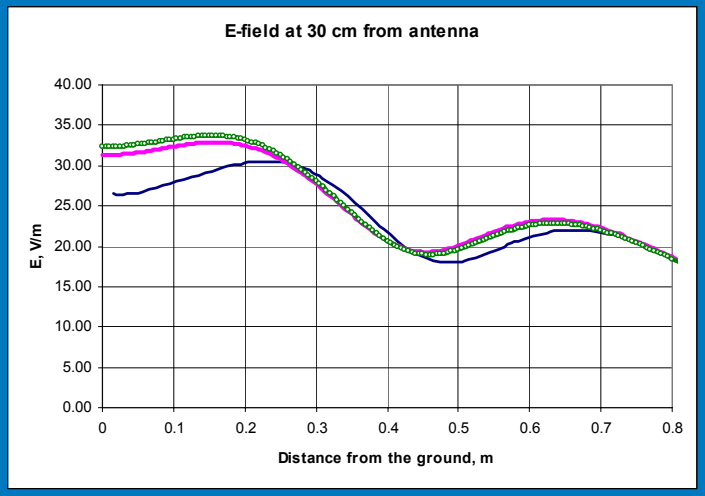
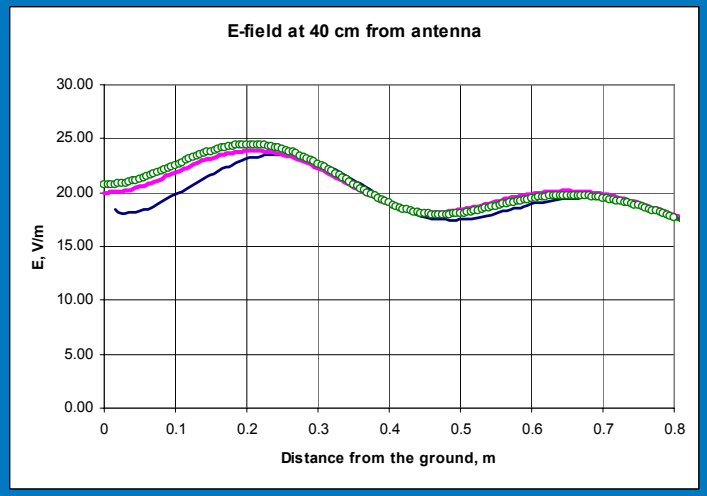
UHF Gain Antenna HAE6010A – 400 MHz

Simulated and measured E-field





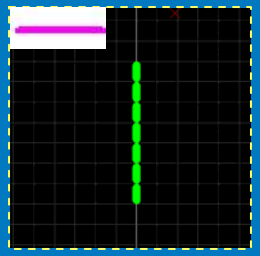


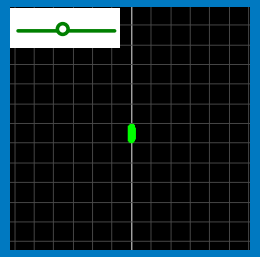


DASY4

FDTD

FDTD - single inductor element





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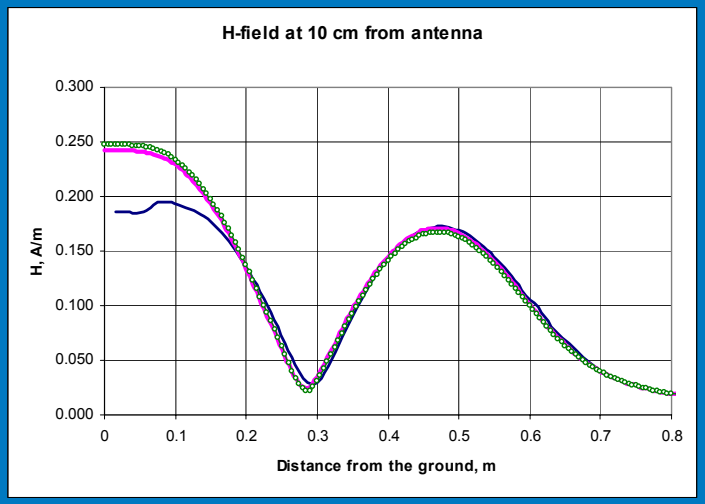
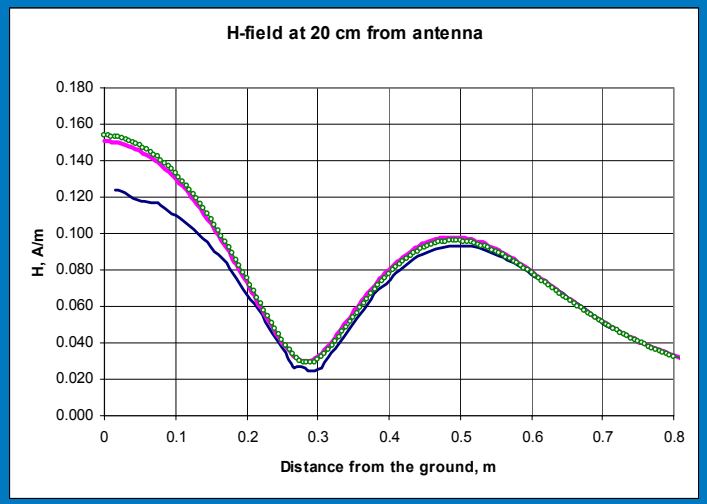
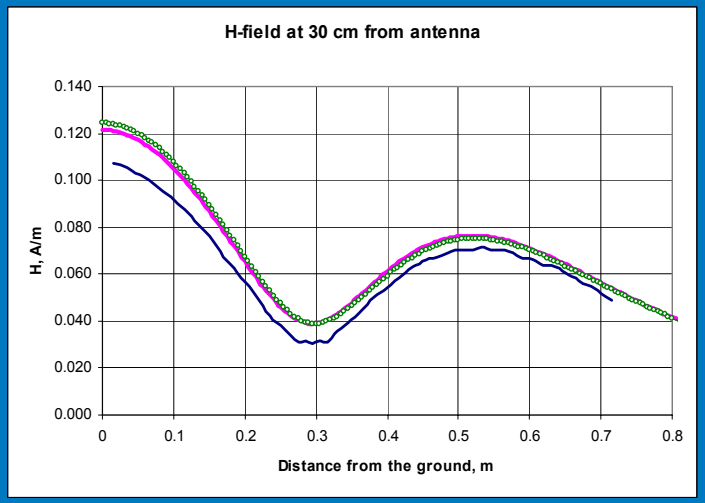
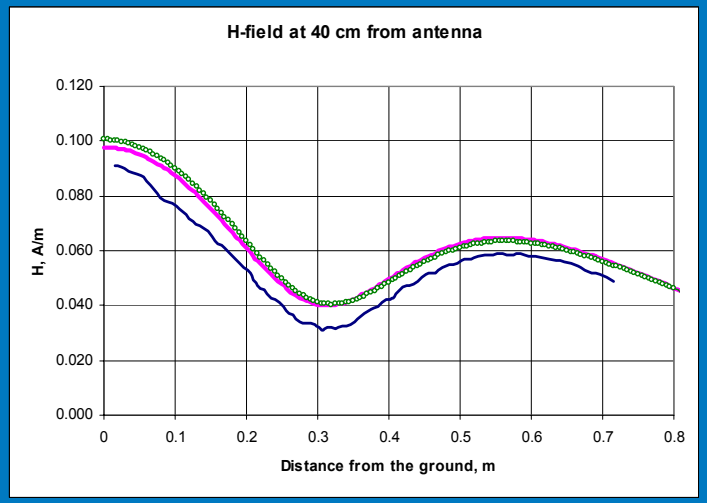
UHF Gain Antenna HAE6010A – 400 MHz

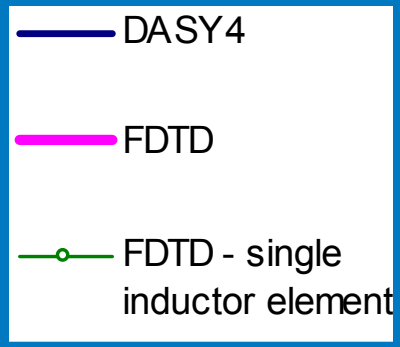
Simulated and measured H-field

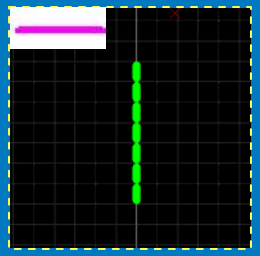


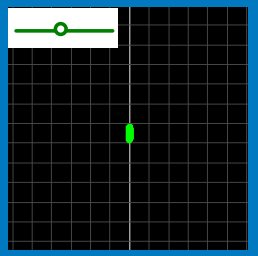






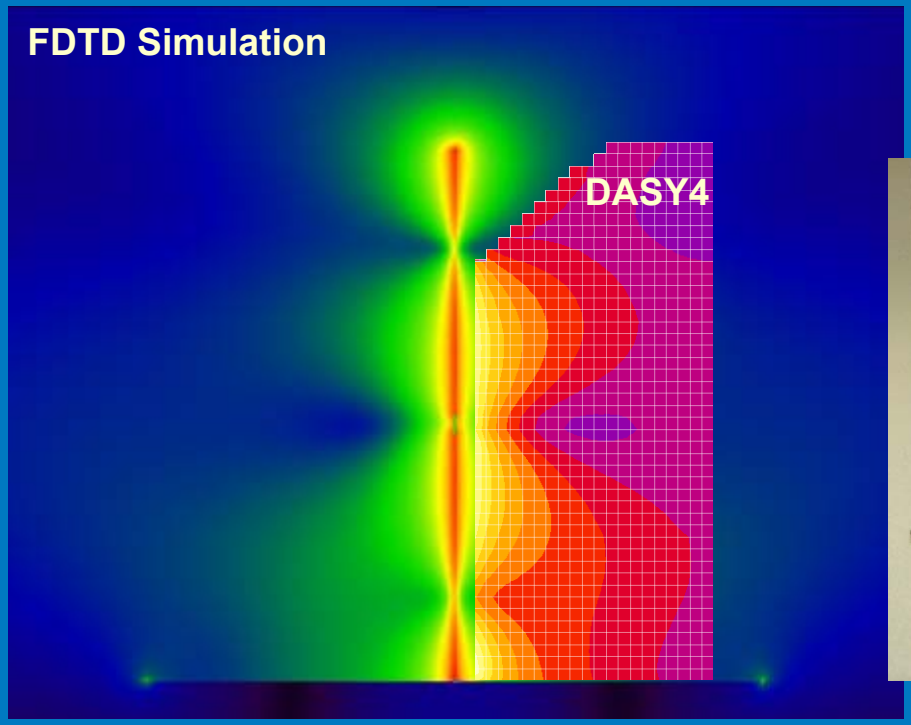




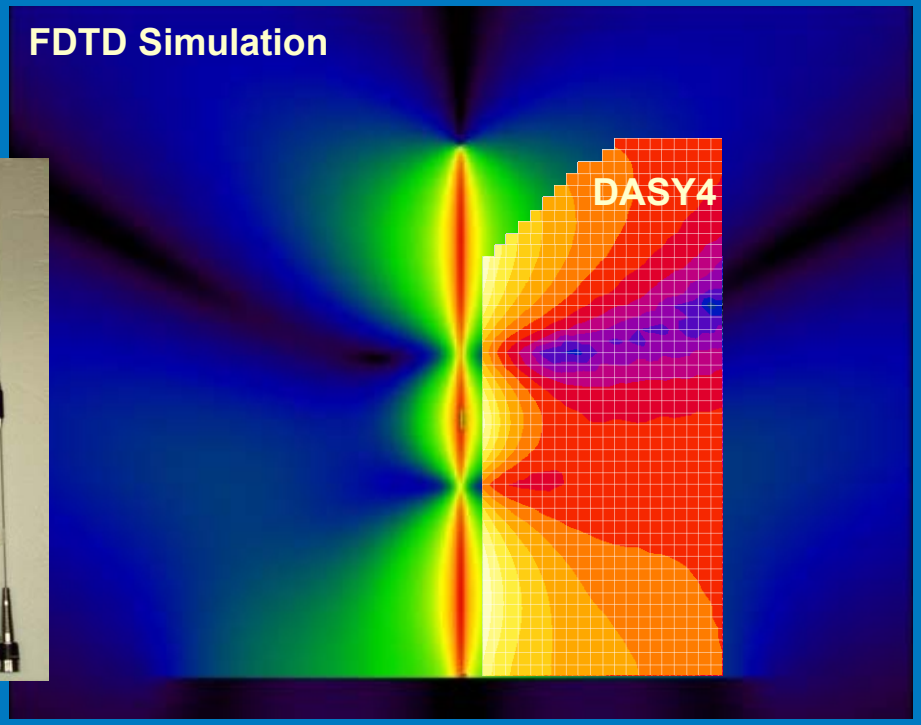


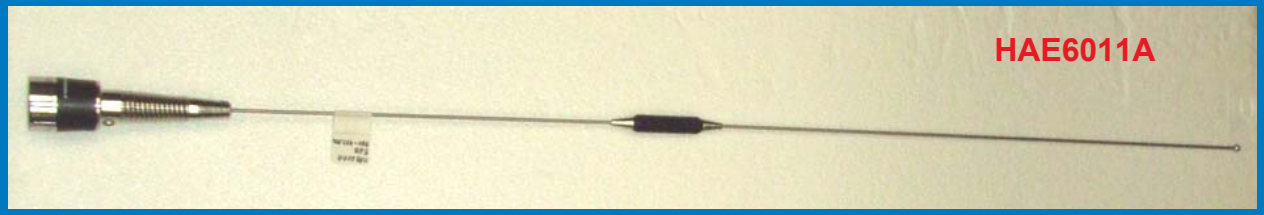
UHF Gain Antenna HAE6011A – 400 MHz

E-field



H-field





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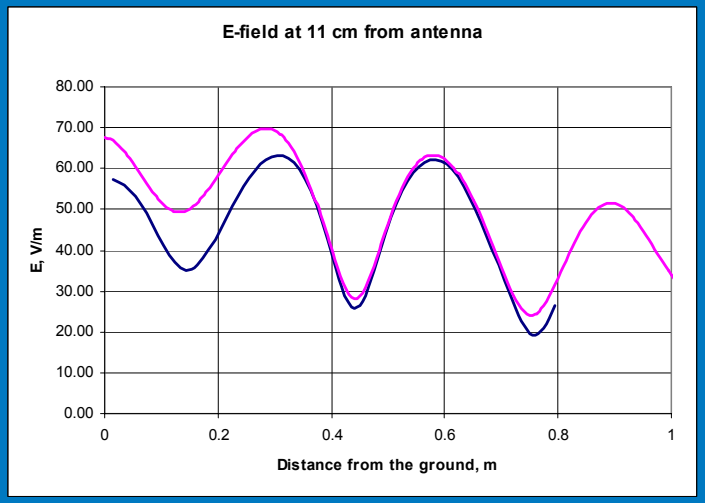
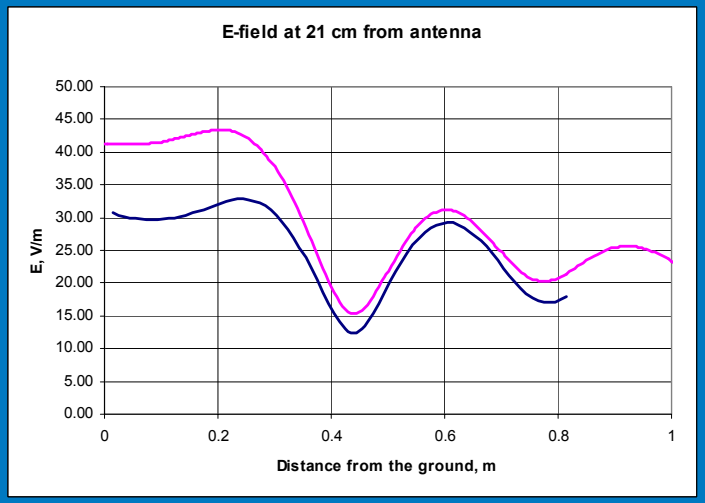
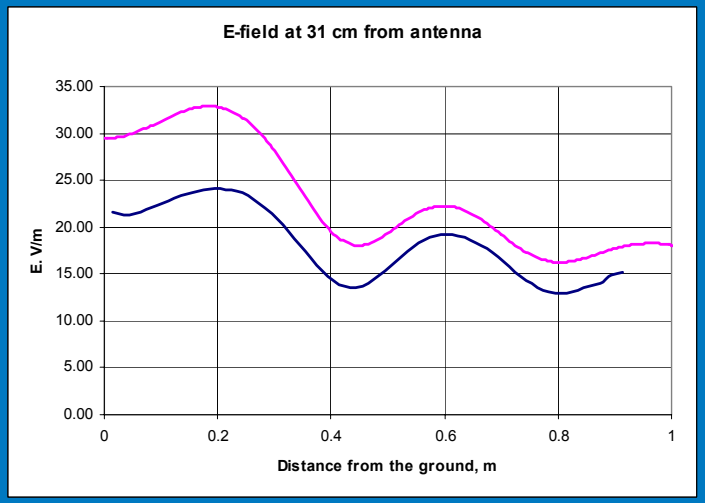
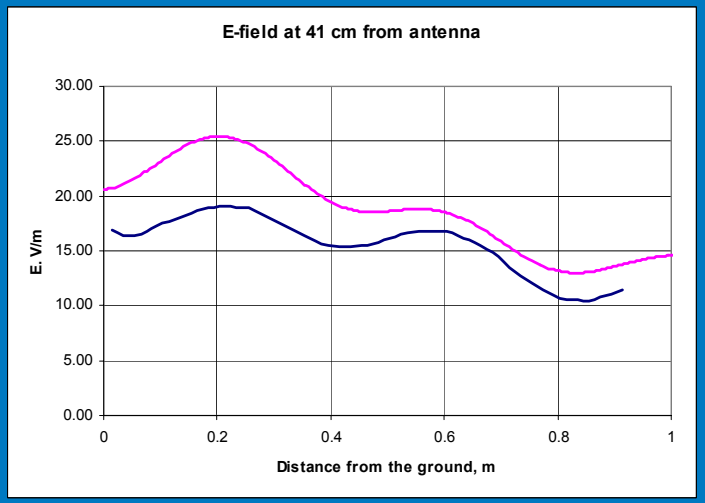
UHF Gain Antenna HAE6011A – 400 MHz

Simulated and measured E-field



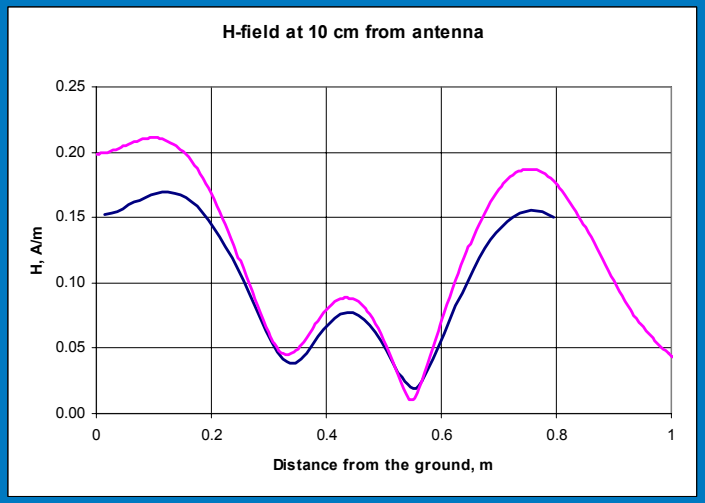


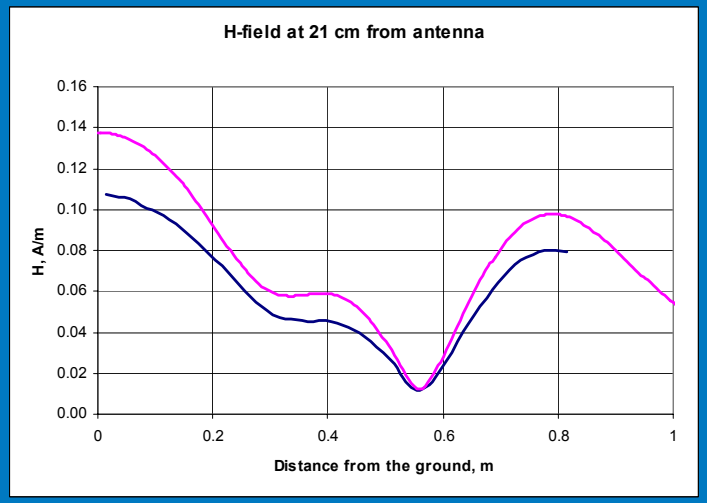


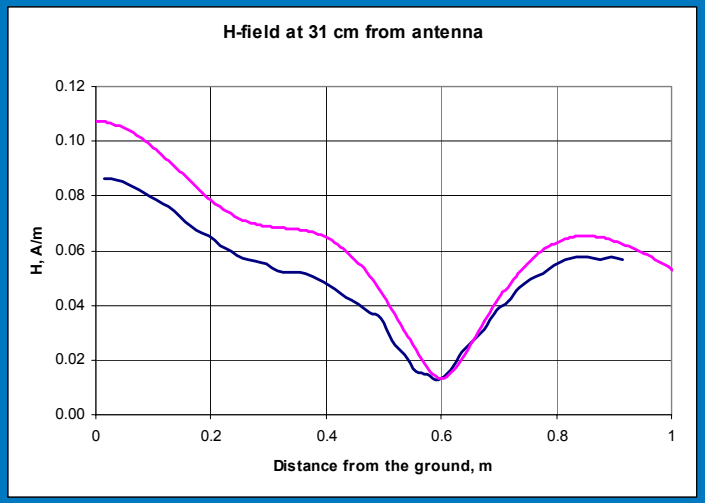


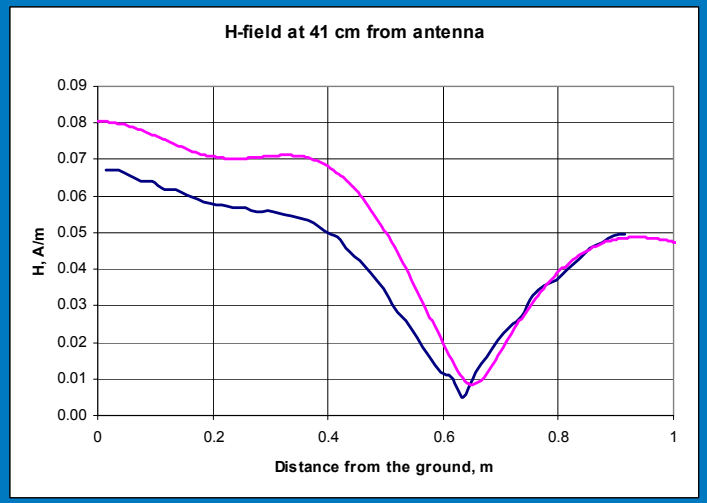
UHF Gain Antenna HAE6011A – 400 MHz

Simulated and measured H-field









DASY4

FDTD

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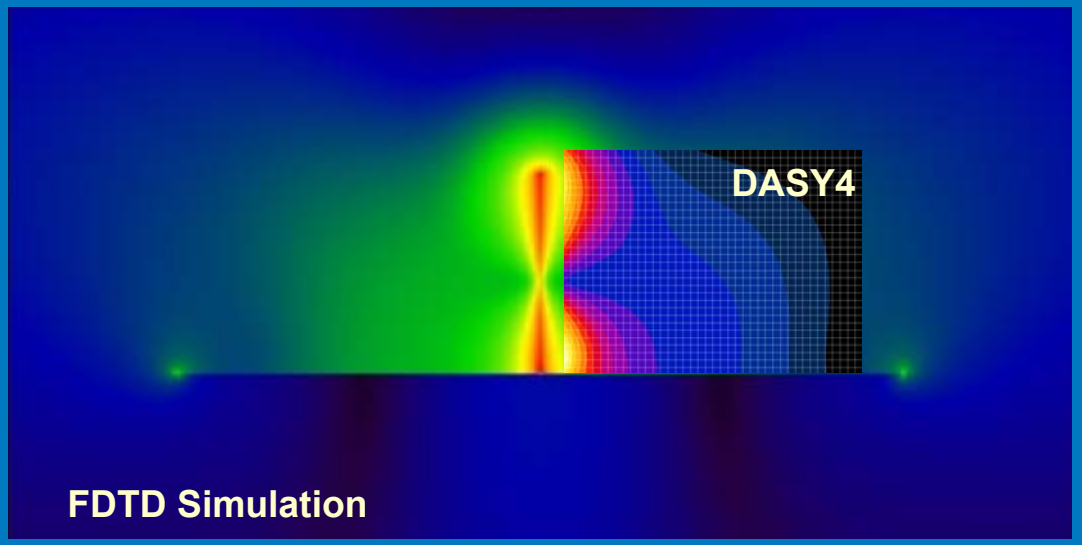
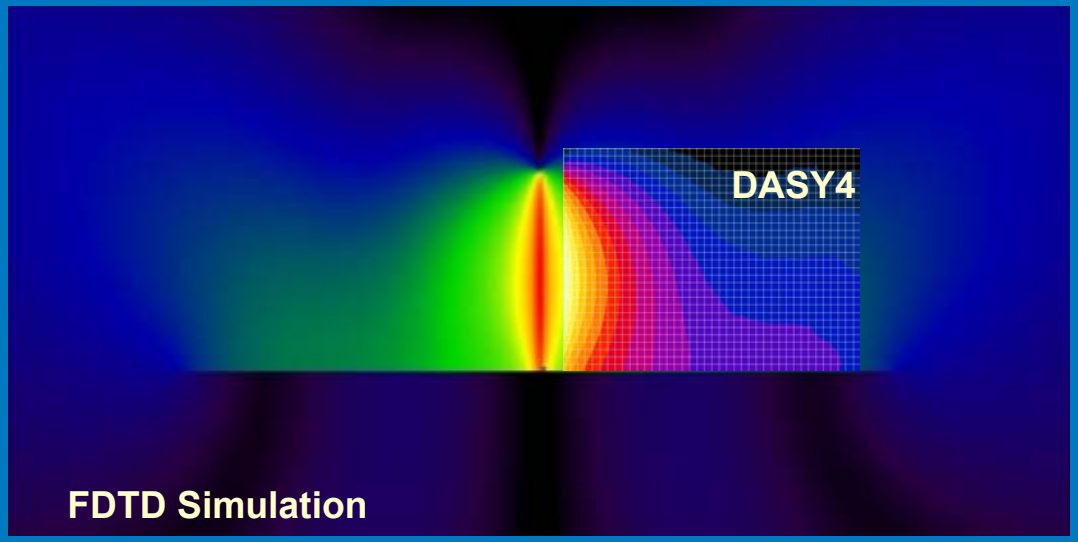
UHF Gain Antenna HAE6013A – 435 MHz

E-field



H-field



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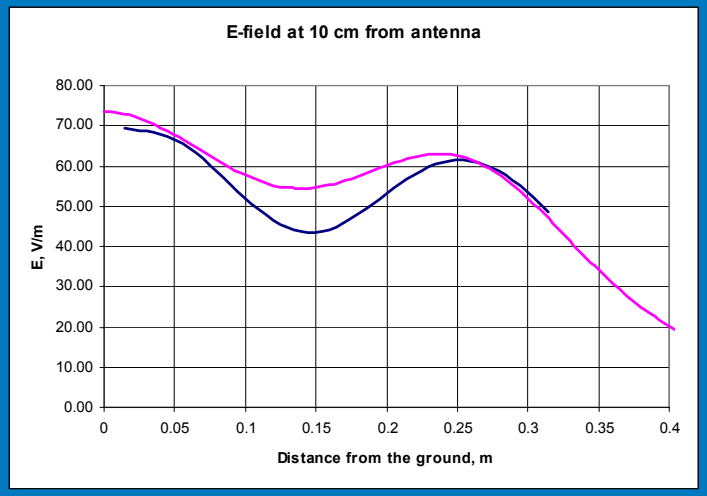
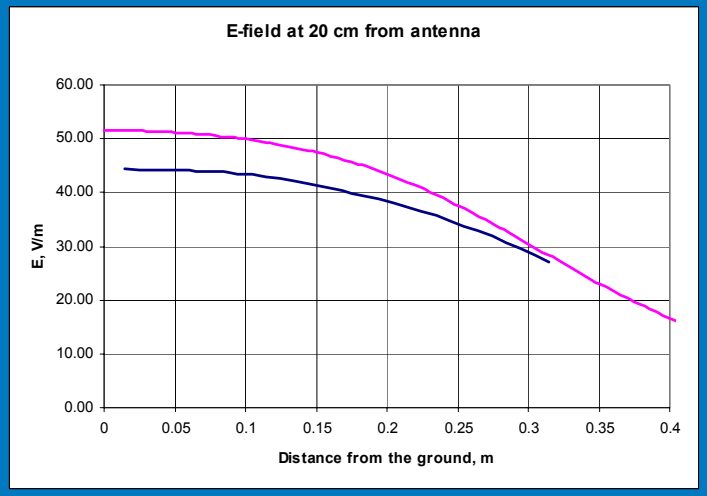
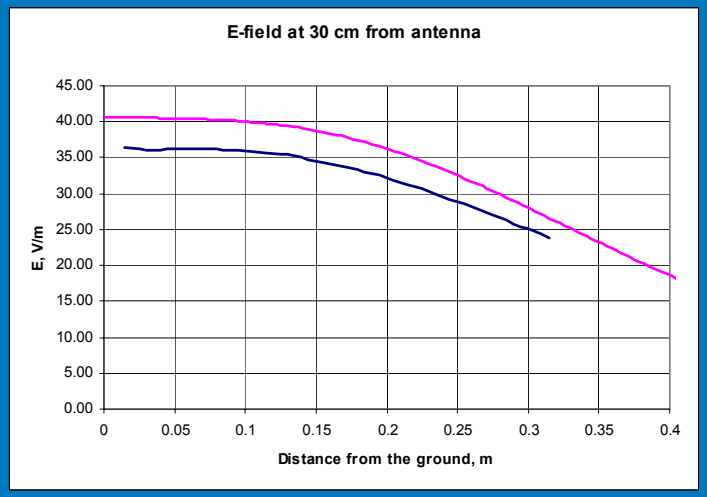
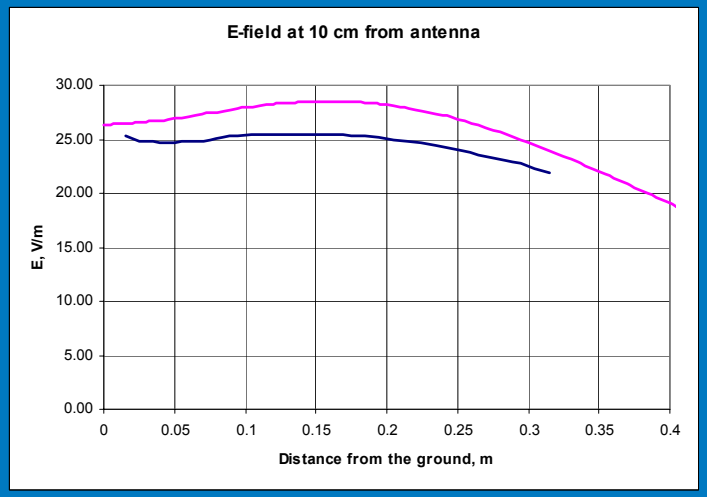
UHF Gain Antenna HAE6013A – 435 MHz

Simulated and measured E-field



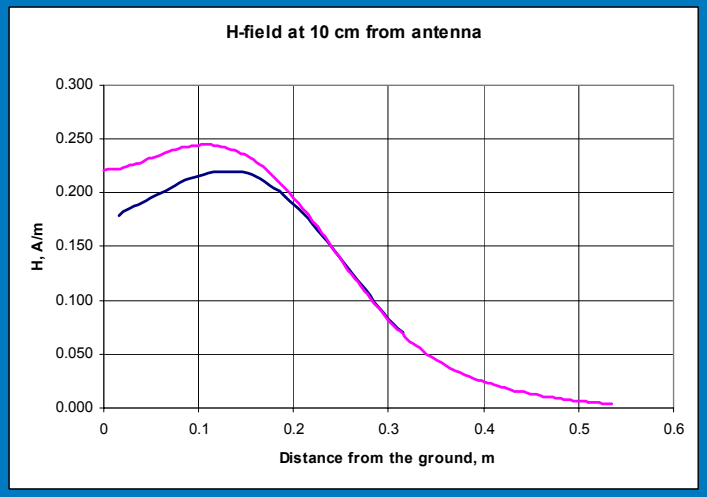


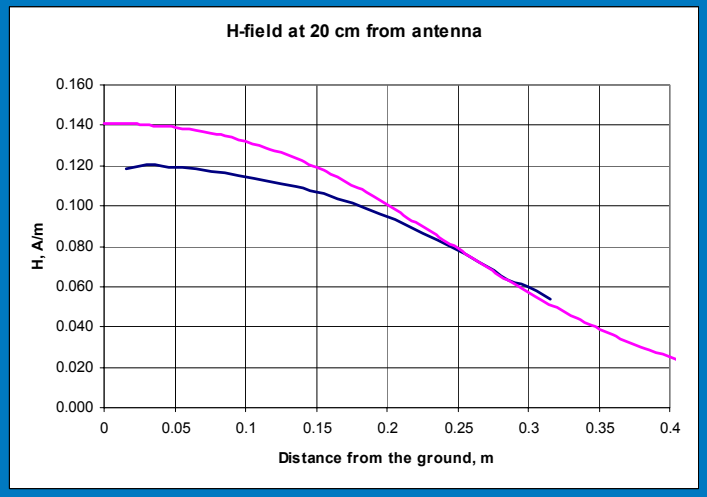


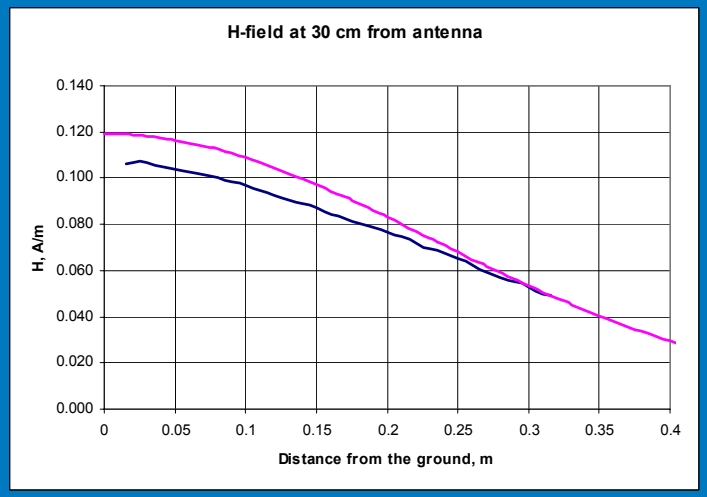


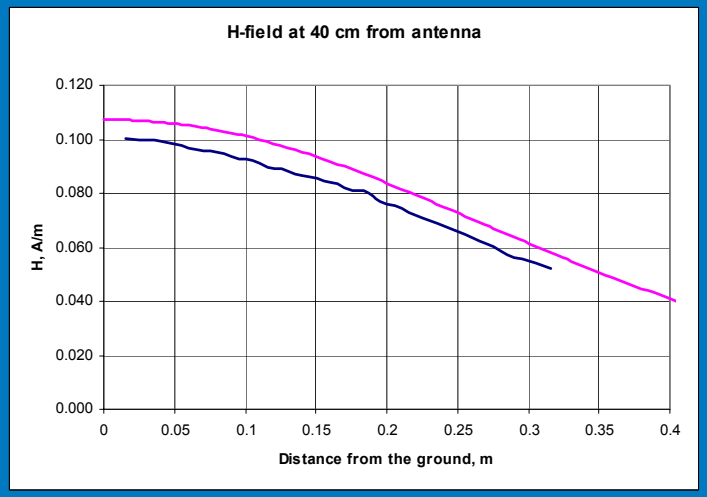
UHF Gain Antenna HAE6013A – 435 MHz

Simulated and measured H-field



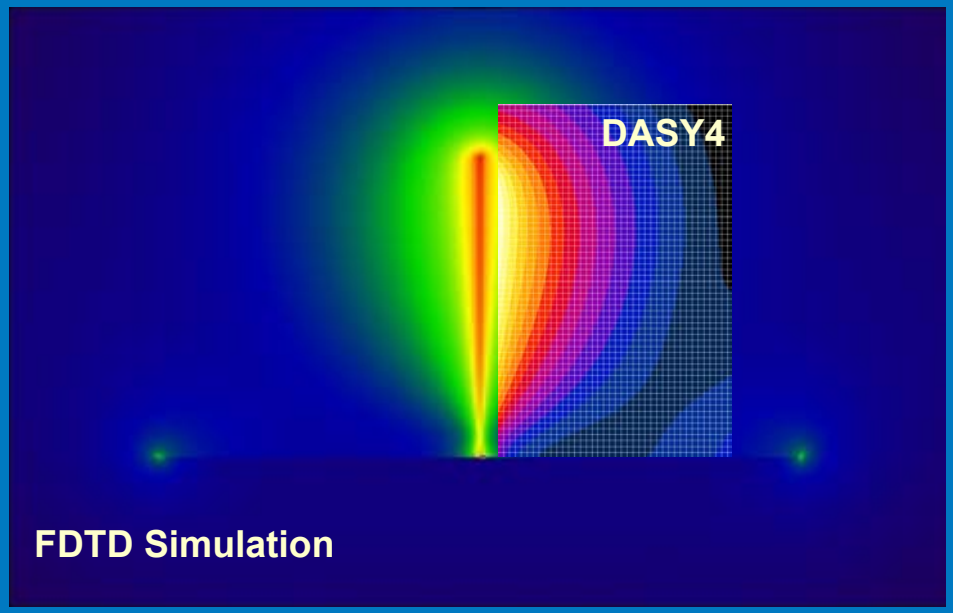




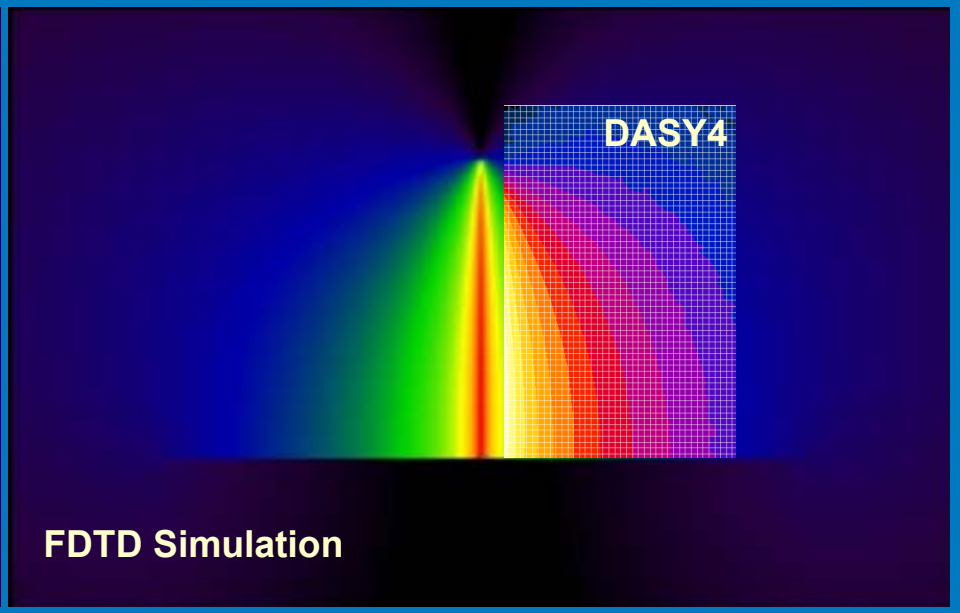


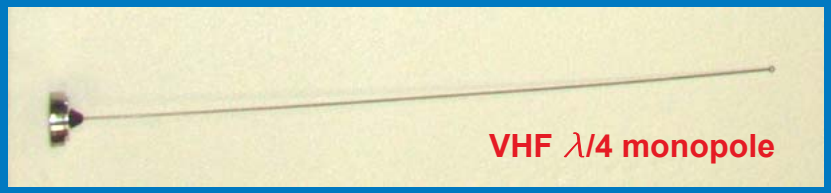
VHF λ/4 monopole – 150 MHz

E-field



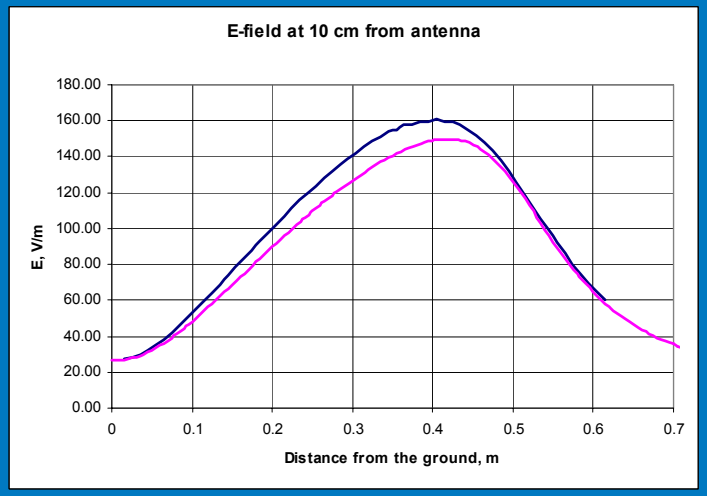
H-field

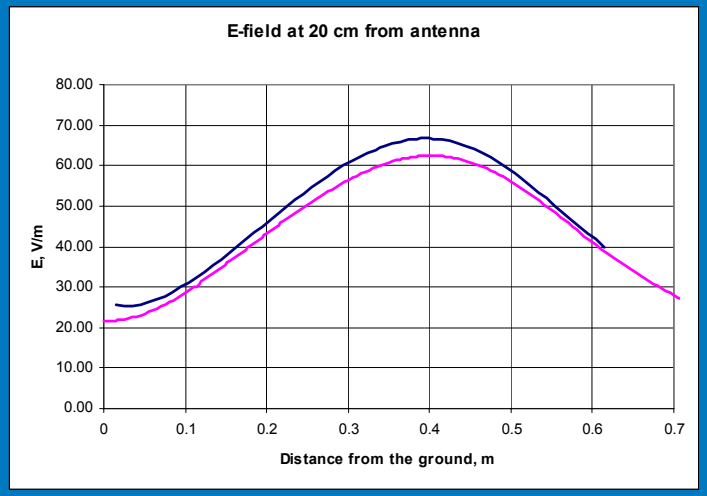


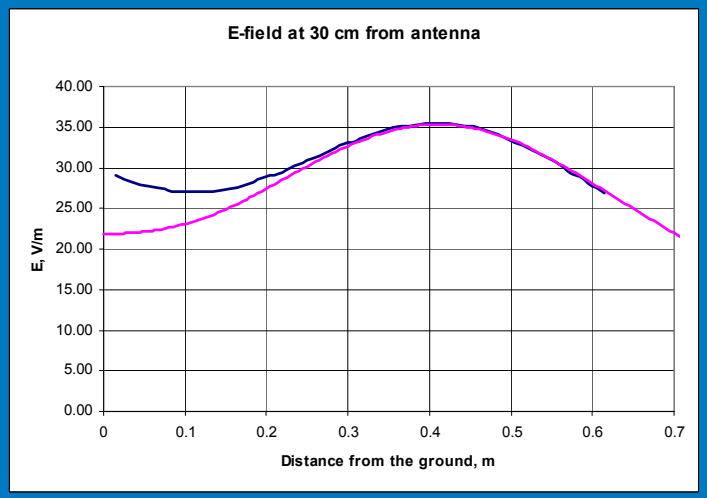


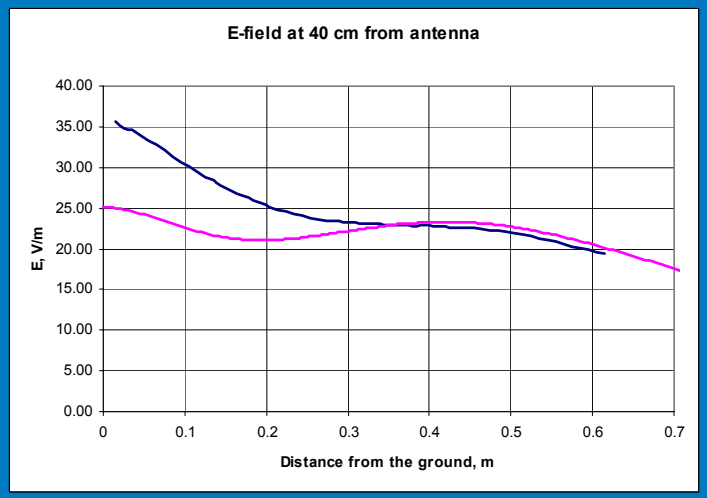
VHF $\lambda/4$ monopole – 150 MHz

Simulated and measured E-field



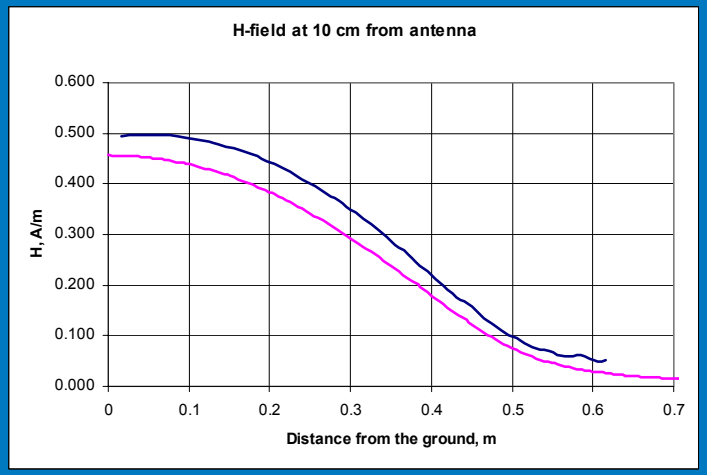


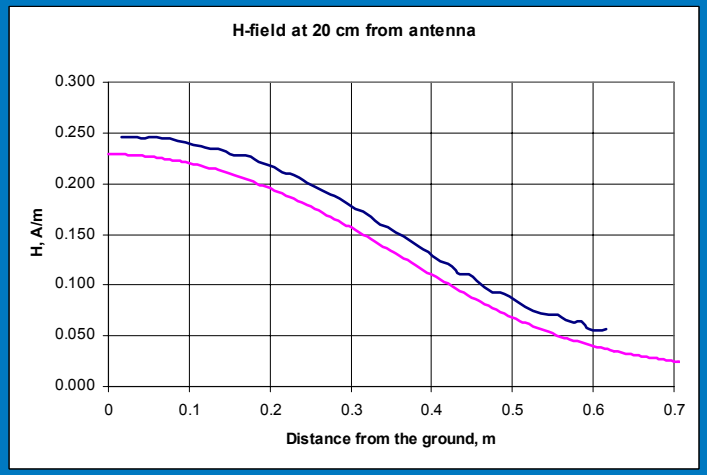


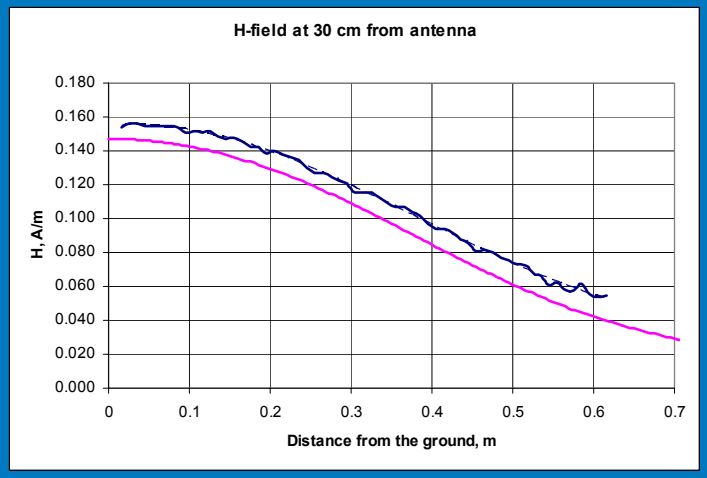


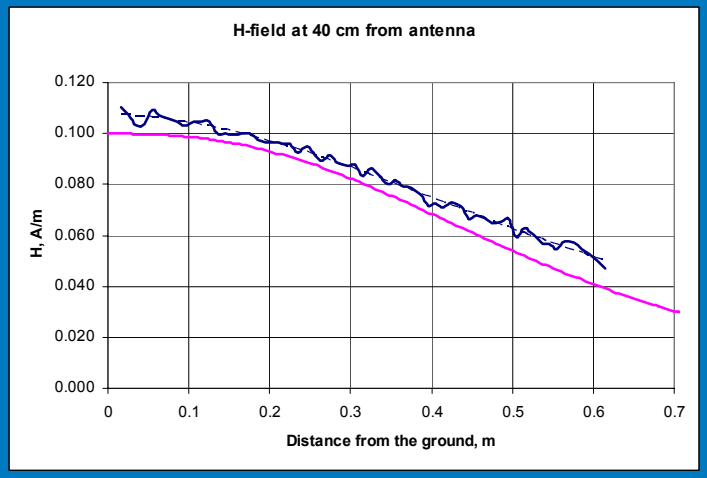
VHF $\lambda/4$ monopole – 150 MHz

Simulated and measured H-field









Observations

The comparison of measured and simulated near-field for a number of mobile radio antennas appears to be satisfactory.

Spatial electric and magnetic field distributions in the vicinity of the antenna are well reproduced using FDTD models of the antennas mounted on a circular ground plane

The “traps” employed on gain antennas to re-phase currents on different antenna sections can be represented by means of individual or multiple lumped inductances in the FDTD model of the antenna.

The absolute values of the fields are well reproduced by assuming perfect match of antenna feed point impedance with the source that eliminates the need of modeling the matching circuit

Thank You

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