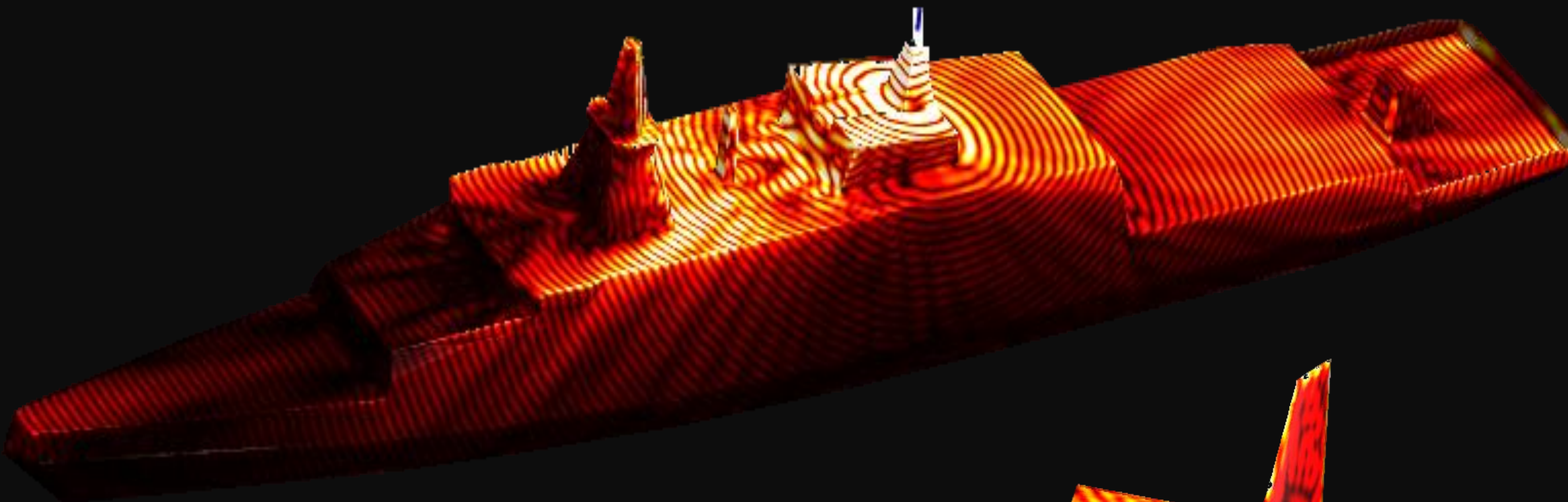
CONCEPT-II

Advanced Electromagnetic Field Simulation



Institute of EM Theory
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CONCEPT-II in a Nutshell

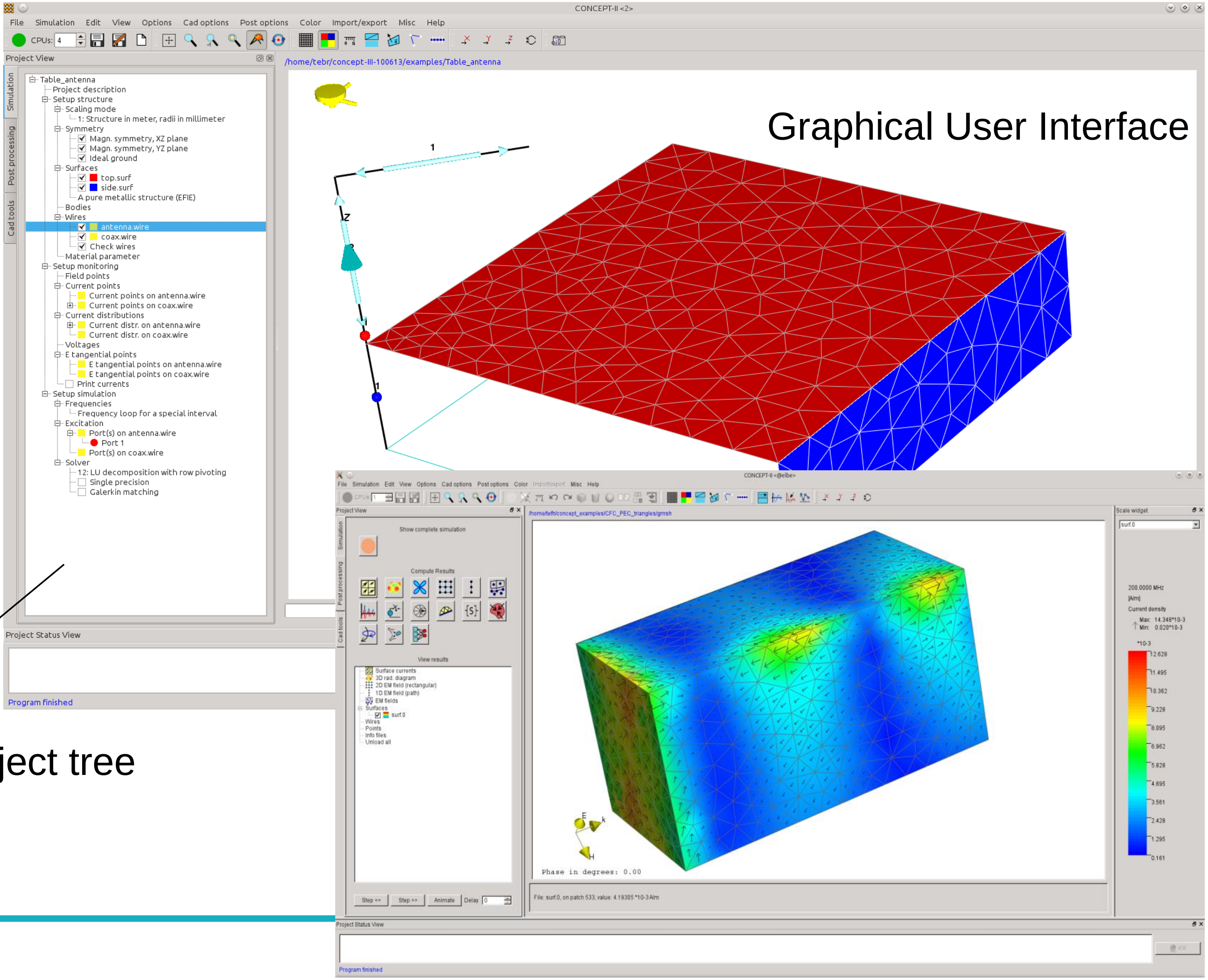
- Code based on the method of moment (MoM)
- Frequency domain formulation for metallic and dielectric objects
- Parallel direct solver, parallel fast solver based on the Multilevel Fast Multipole Algorithm (MLFMA)
- Wires, wire-grid structures
- Metallic objects and (lossy) dielectric bodies by surface patch modeling
- Currently supported platforms: Windows and Linux (only 64 bit)
- Computation of electromagnetic quantities as a result of the excitation by various impressed sources
- Under development at the 'Institut für Theoretische Elektrotechnik' at the Technische Universität Hamburg-Harburg (TUHH)

CONCEPT-II GUI

Simulation

Post processing

CAD tools



Simulation project tree

CONCEPT-II Features

Main features:

- Structures in free space or over ideal ground
- Exploitation of magnetic symmetry
- Electromagnetic fields at arbitrary locations in space
  - Near fields, radiation patterns, radar cross section (RCS)
- S-parameters, antenna input impedances
- Wires loaded by lumped circuit elements
  - Voltages over lumped loads
- Wire and surface currents
- Surface impedance, lossy layers on metal (thin sheet approximation, TSA)
- Thin homogeneous lossy dielectric and magnetic layers
- Multilayered anisotropic material
- Transient system responses based on an IFT
  -Modeling of lightning impact including the stroke channel (direct/indirect stroke)

CONCEPT-II Features

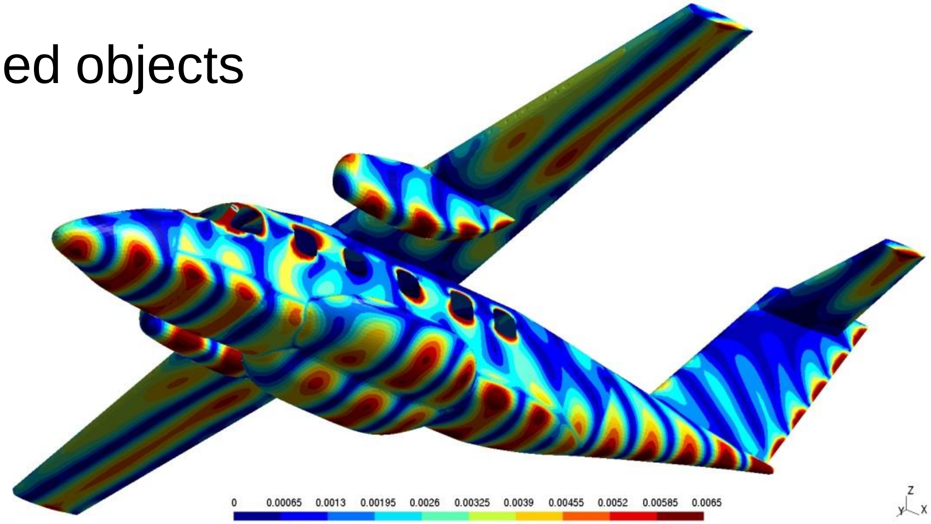
Types of excitation:
- Lumped voltage or power generators
- Impressed line currents, current generator
- Plane wave field (linear or elliptical polarization)
- Edge generators

CAD tools:
- Import of STL data
- Interface to *gmsh* ((http://geuz.org/gmsh)
- Meshing of basic geometries
- Easy local grid refinement
- Error detection and grid healing capabilities

Post processing:
- Field distributions on 2D or arbitrary surfaces
- System responses as a function of frequency
- Current and charge distributions on 3D structures
- Movies of 2D field distributions
- Wire current distributions
- Monostatic RCS (1D or 2D)
- Radiation patterns (2D and 3D)

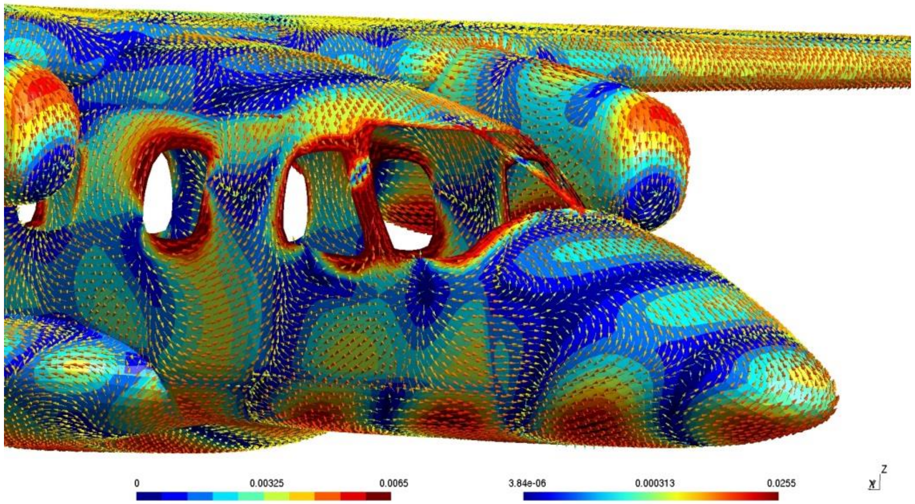
Scalar Fast Solution

- Solution of electrically medium-sized objects using the scalar MLFMA



Example: Aircraft at 225 MHz.
(125.000 unknown currents)

- Computation time: 1.3 h on 2.6 GHz AMD Opteron CPU
- Memory: 5.44 GB

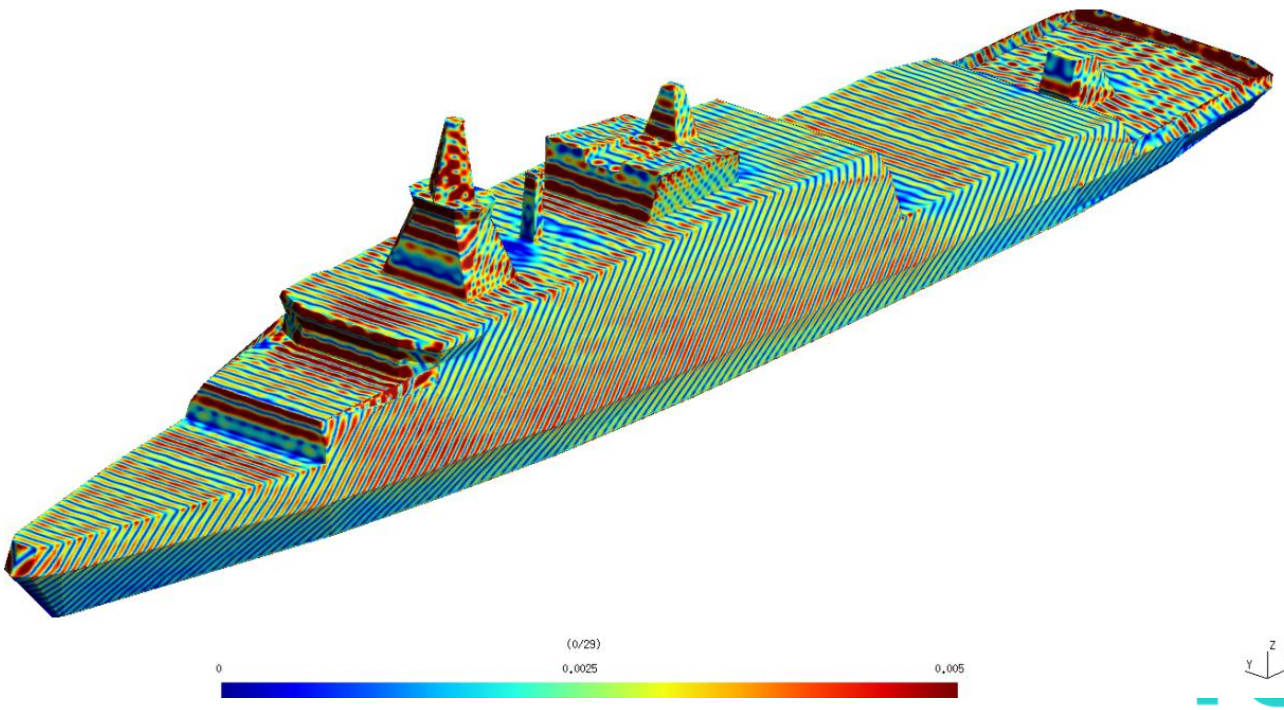


Parallel Fast Solution

- Solution of electrically large objects using the parallel MLFMA-FFT

Example: Ship superstructure at 200 MHz. (> 1 million unknown currents)

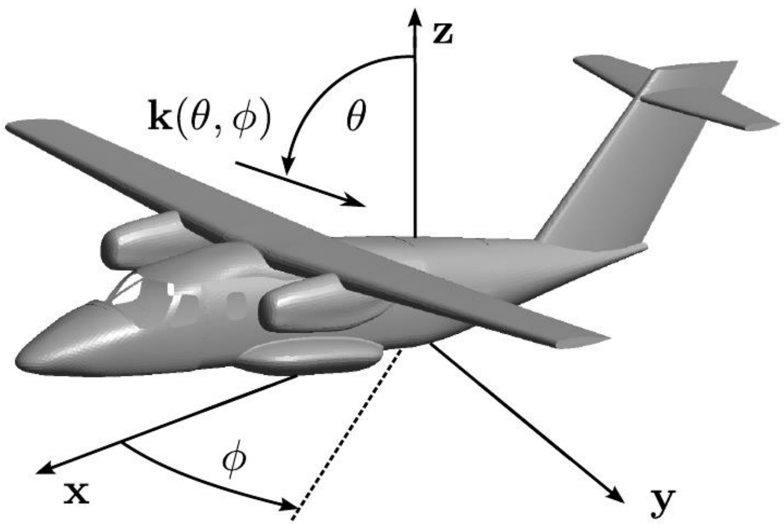
- Computation time: 0.26 h on 24 AMD Opteron CPU 2.6 GHz
- Memory: 16.7 GB (conventional: 18 TB)

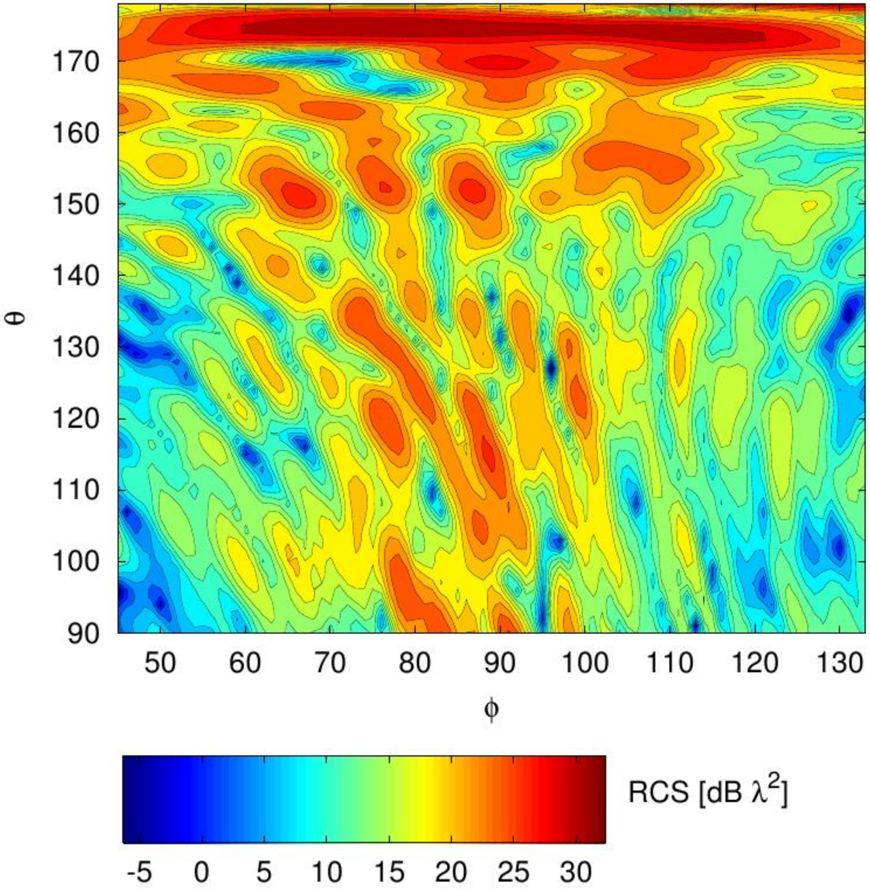


Fast Computation of Multiple Excitation Problems

Monostatic radar cross section for $45° \le \phi \le 135°,\ 90° \le \theta \le 180°$

Setup Time*:	4 h
Solution Time* (Conventional):	303 d
Solution Time* (Prop. Method):	1.5 d
Speed-Up:	202





* On a single 3 GHz Intel Core 2 Duo CPU

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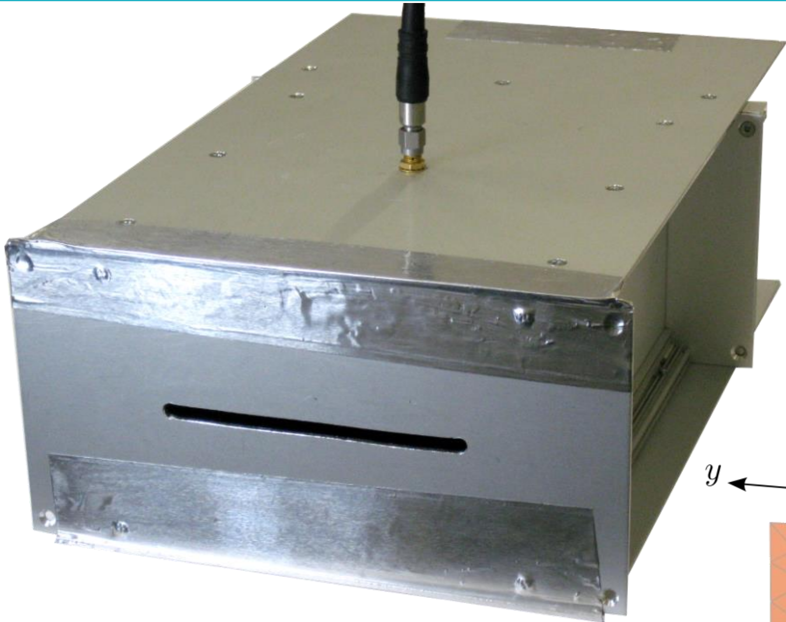
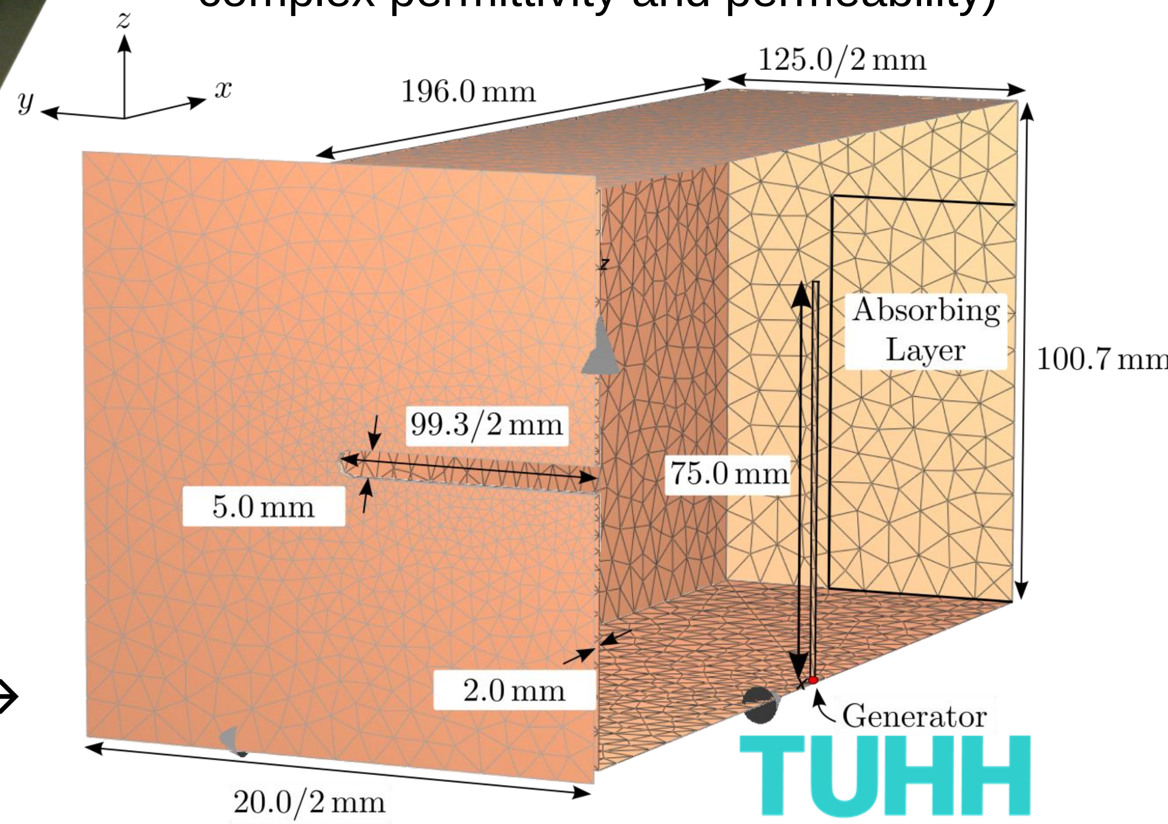
Thin Dielectric/Magnetic Layers



← Measurement setup:

- Slotted box, excited by monopole antenna
- SMA-connector with copper rod soldered onto pin
- Damping sheets at the rear (8x8cm, complex permittivity and permeability)



Simulation setup →
6500 unknowns

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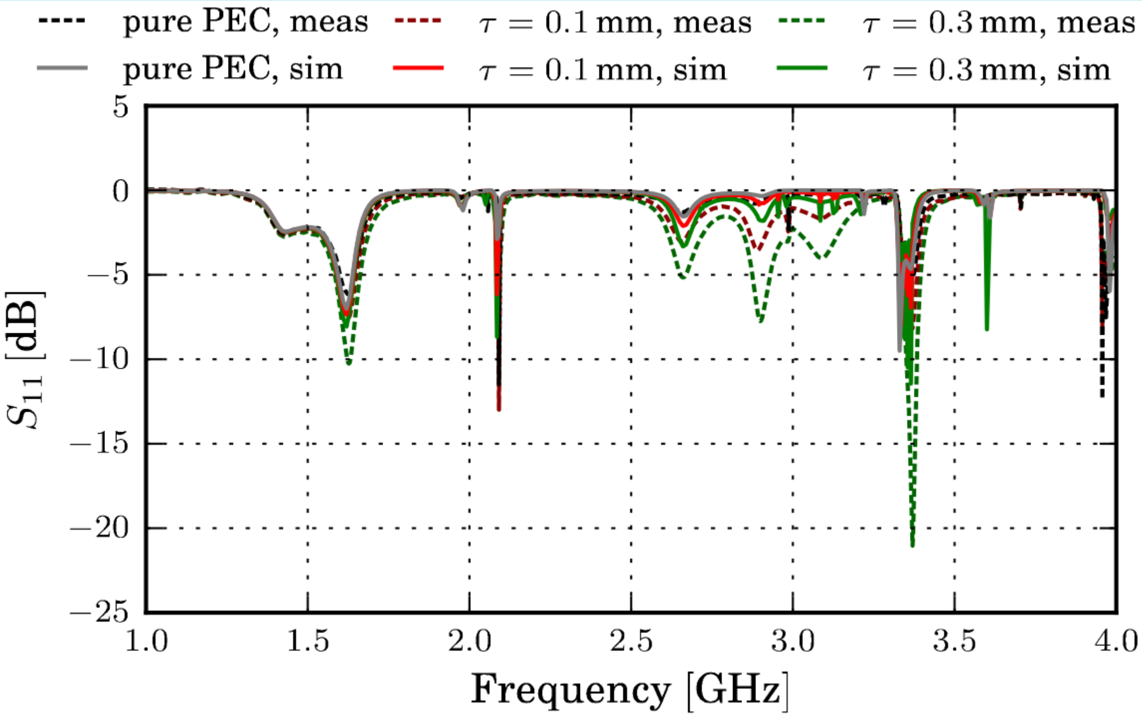
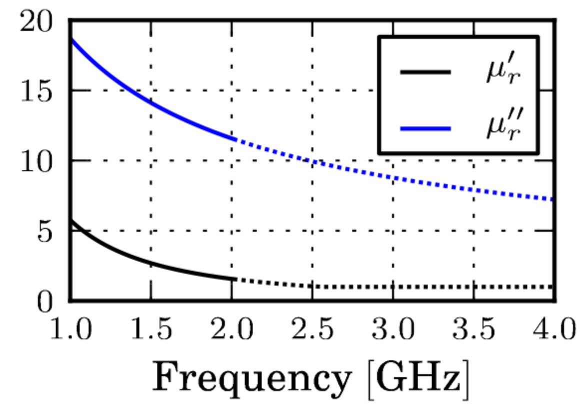
Comparison of Measurement & Simulation



Material parameters of the absorbing sheets extrapolated above 2GHz:



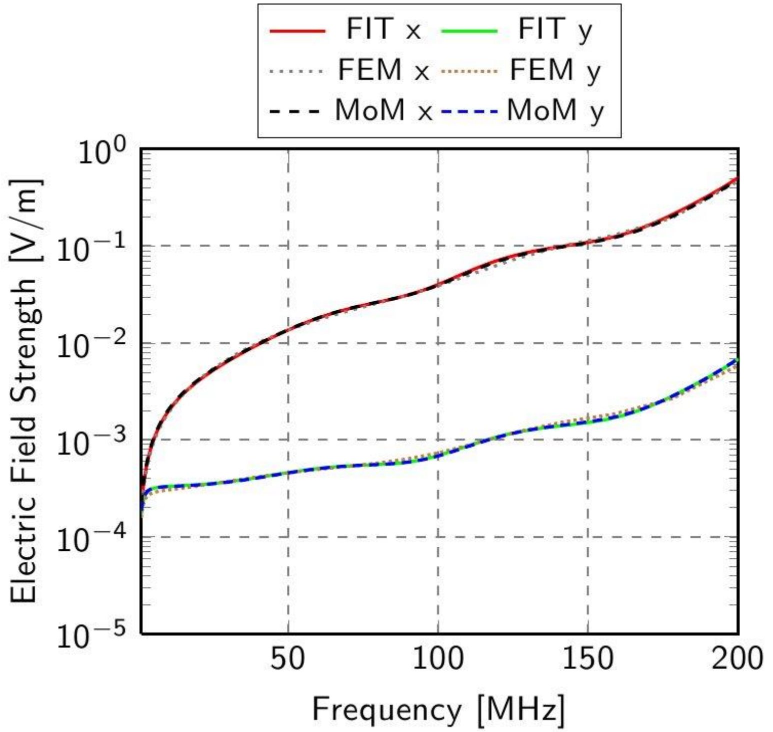
- Good correlation between measurement and simulation!

Great reduction in simulation effort (single core):

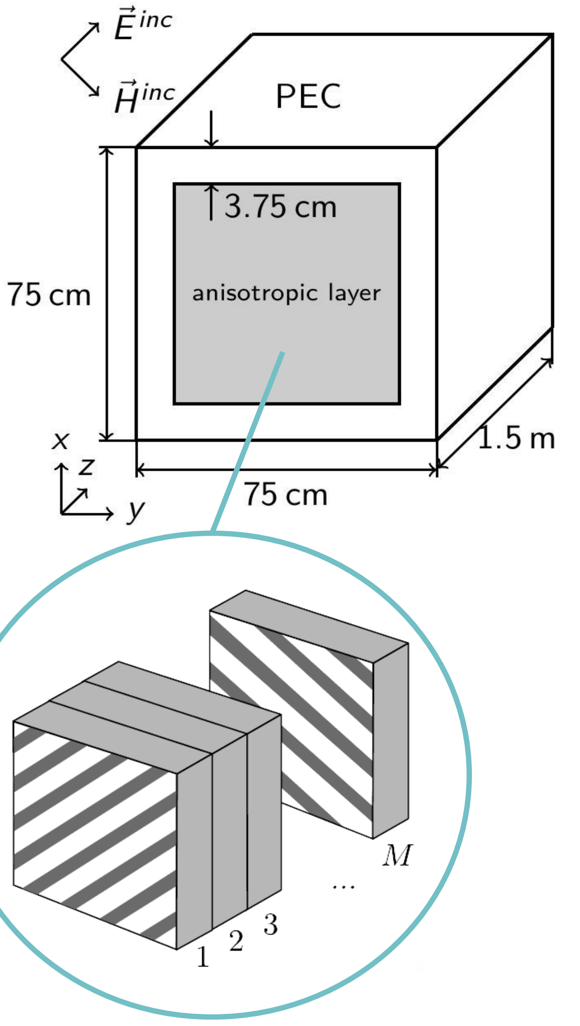
- 201 Frequencies: 7.5 Hours for TSA
- 201 Frequencies: 13.5 Hours for full-model MoM

Investigation of Multiple Anisotropic Sheets

- Quick analysis of field coupling through anisotropic and inhomogeneous advanced shielding materials such as carbon fiber composite



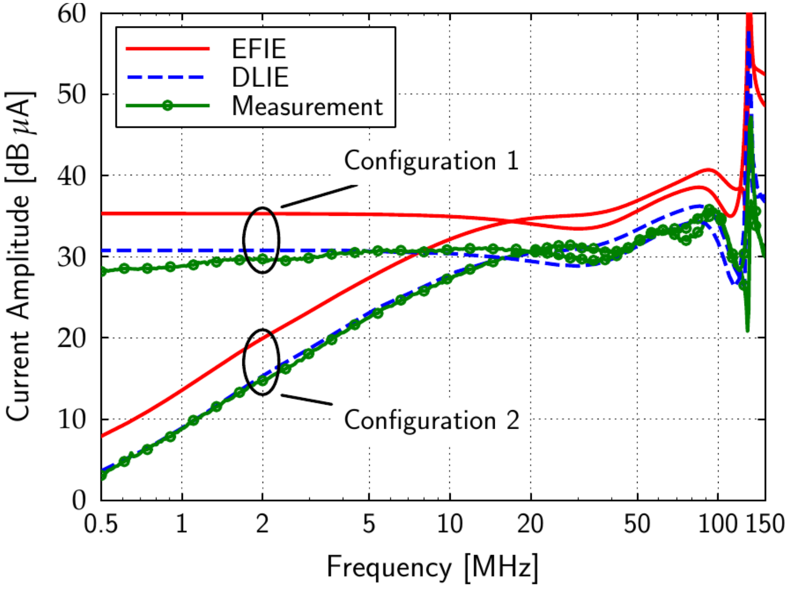
Internal E field (one anisotropic layer)

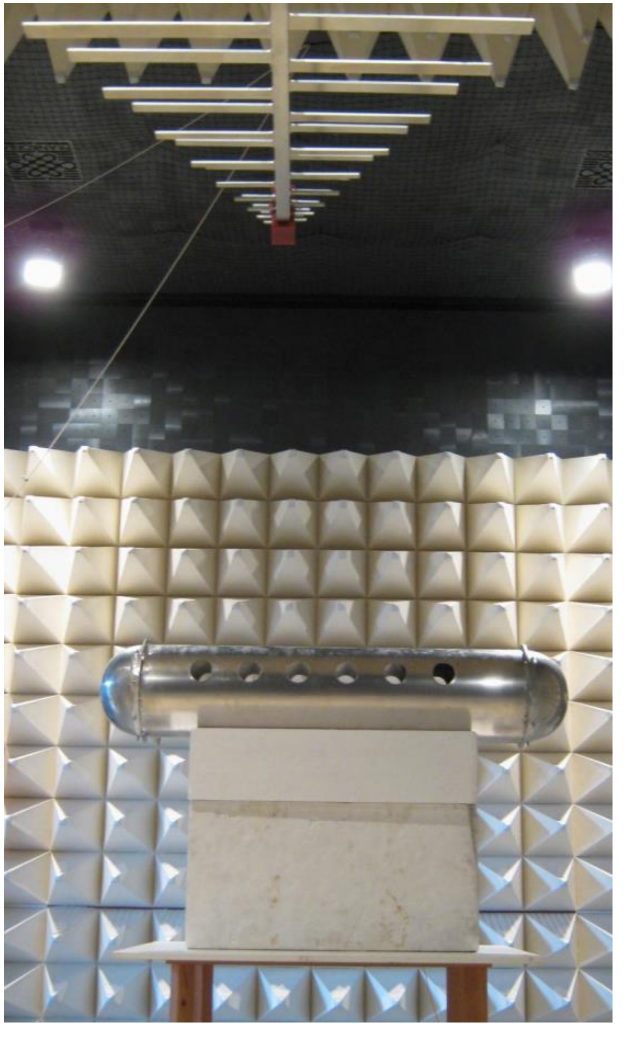


Investigation of Aperture Coupling

- Accurate internal field prediction using coupled integral equations (DLIE)

Example: Generic aircraft structure
(courtesey of EMCC Dr. Rašek)

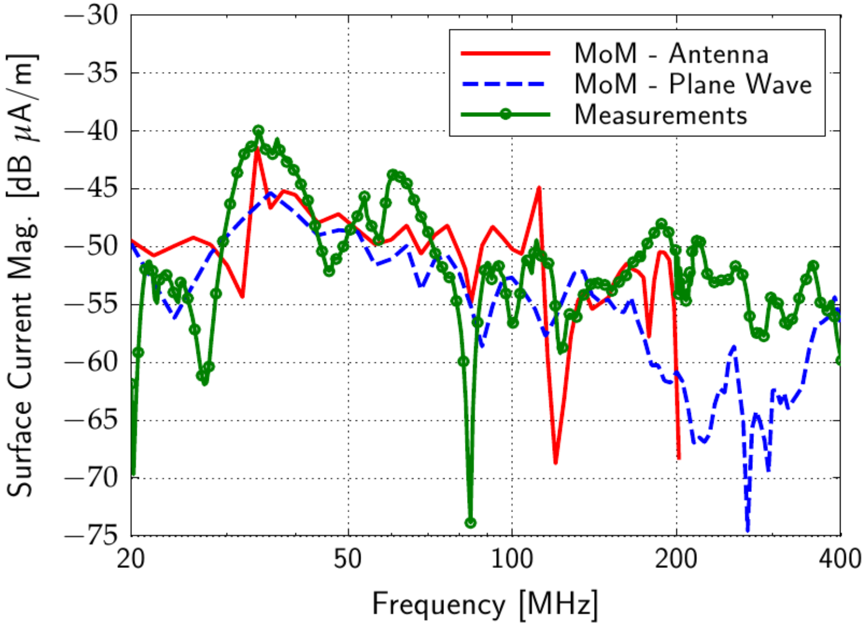




Analysis of Real World Aircrafts

- Investigation of complex real world systems, such as aircraft, ships …

Example: EVEKTOR VUT-100
(courtesey of Evektor, spol. s r.o., and EMCC Dr. Rašek)



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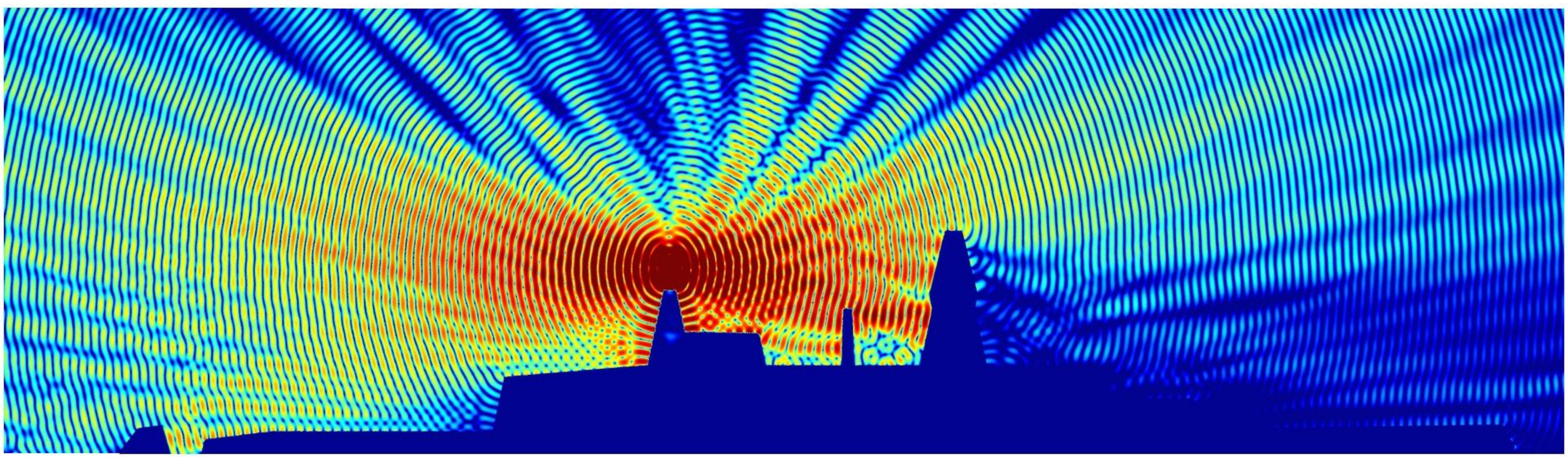
Fast Evaluation of EM Fields

- Rapid visualization of scattered, coupled and radiated fields
- Based on hierarchical adaptive cross approximation
- Parallelization using master-worker scheme

Example: Radiated field of dipole antenna on ship superstructure

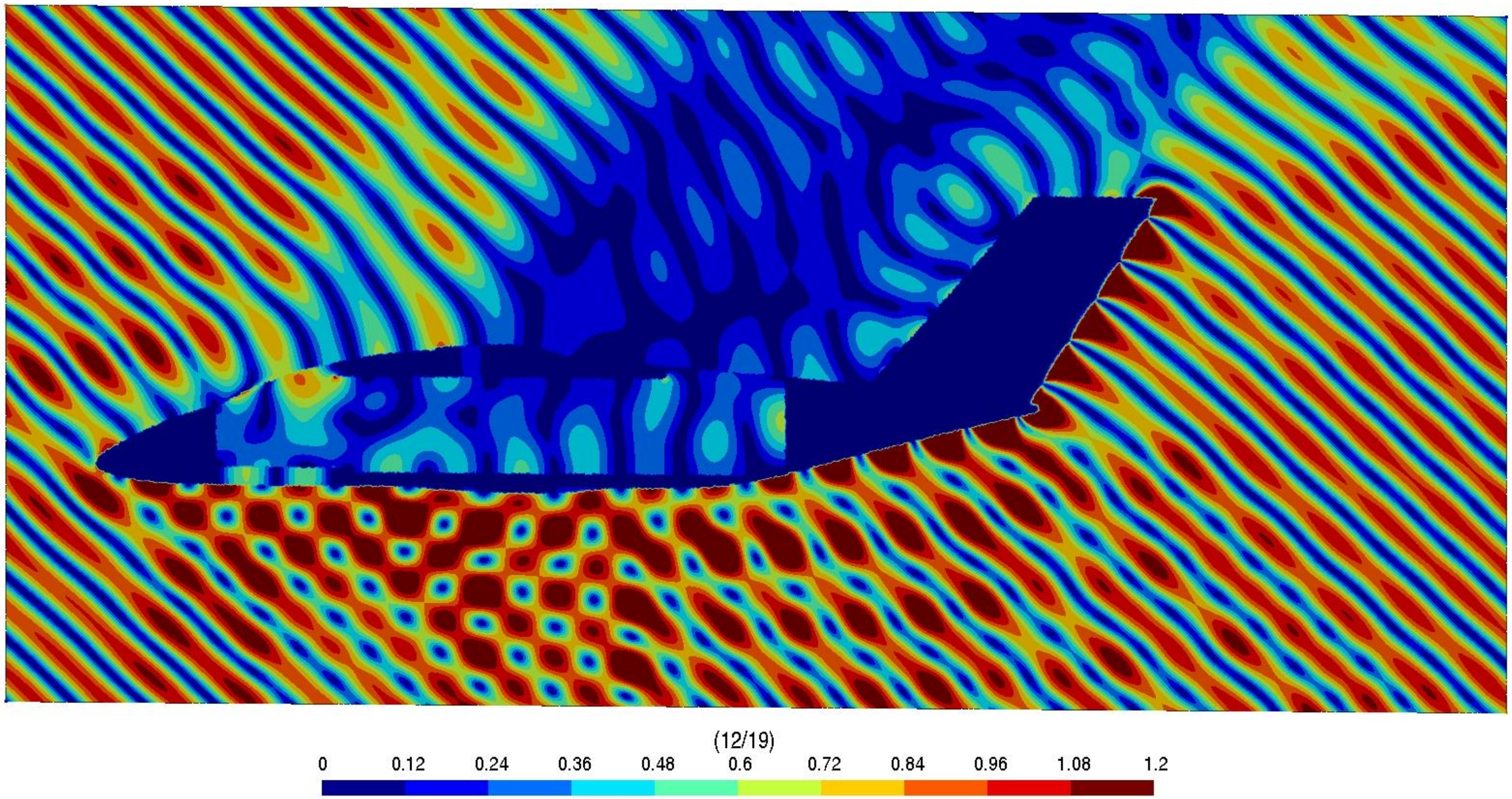
- Field of 1 Mio current amplitudes at 2 Mio observation points
- Computation Time: 8.1 min (conventional: 2.12 d)
  on 32 AMD Opteron 2.6 GHz CPUs



Fast Evaluation of EM Fields

Example: Aircraft in a plane wave field at 225 MHz.
(125.000 current amplitude, 300.000 observation points)

- Computation time: 1 min on 24 AMD Opteron 2.6 GHz CPUs



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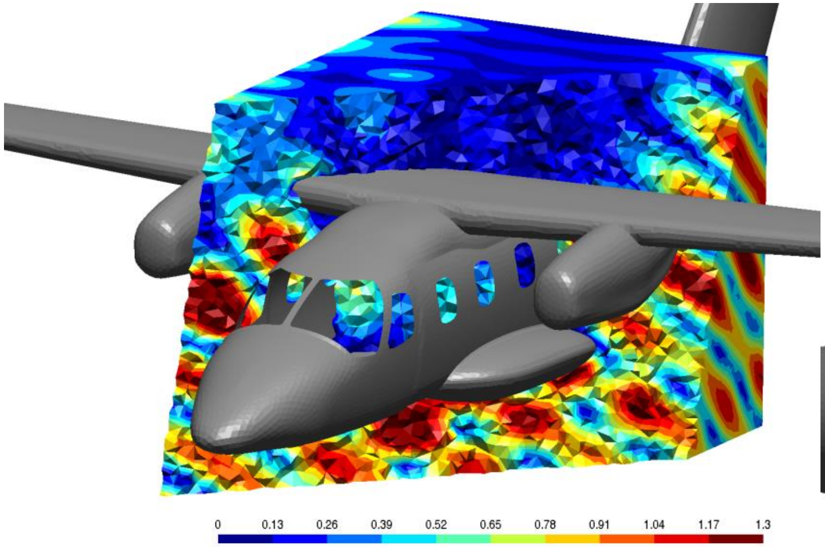
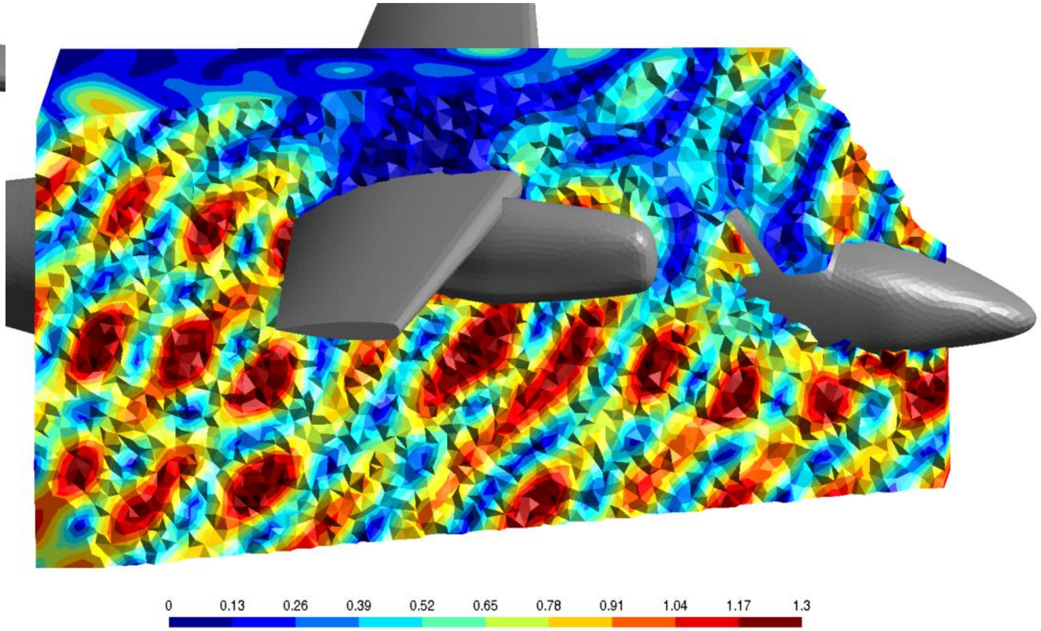
Fast Evaluation of EM Fields

Example: Aircraft in a plane wave field at 225 MHz.

- Computation of fields in volumes





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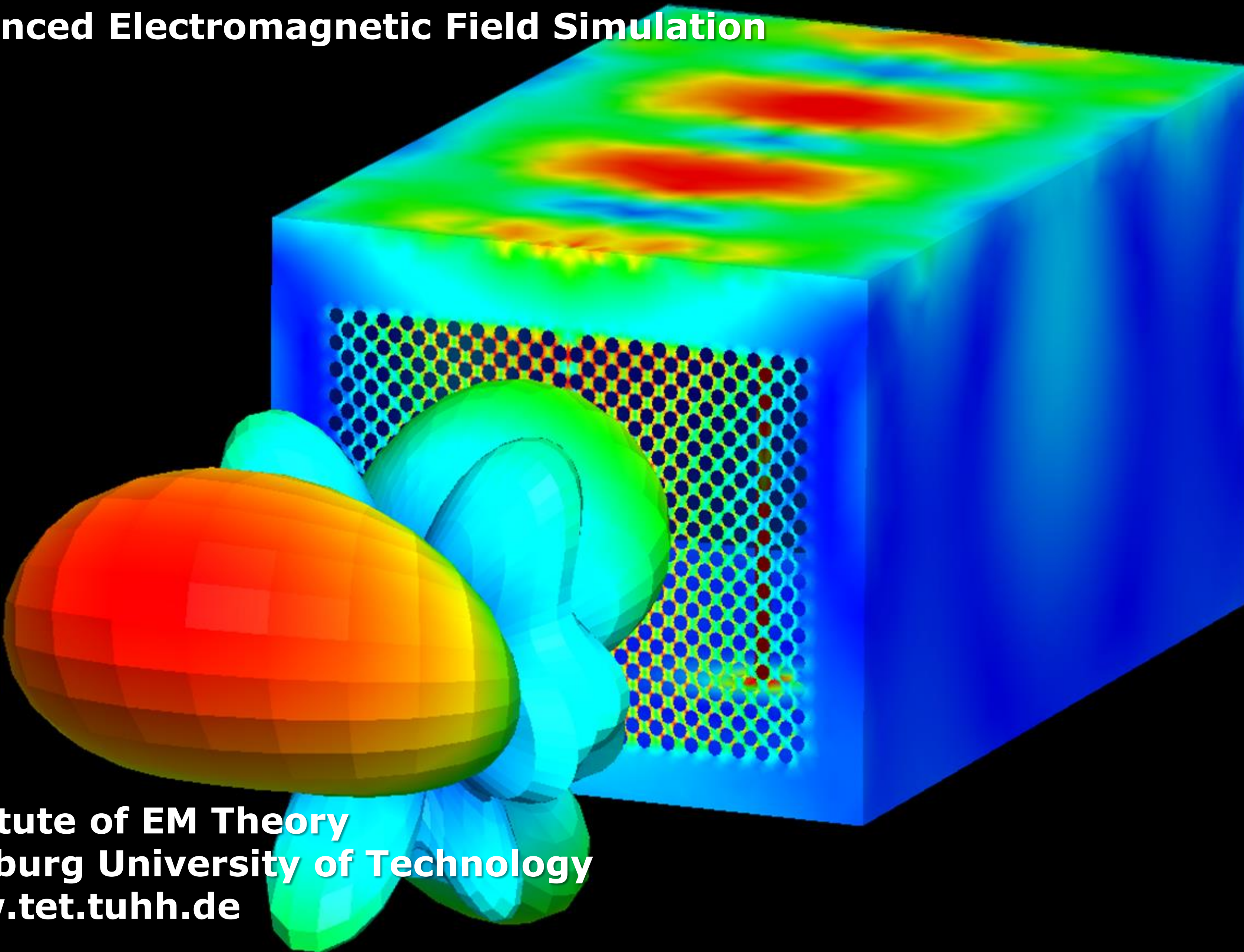

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