How Near-Field Scanning can support EMC Simulations

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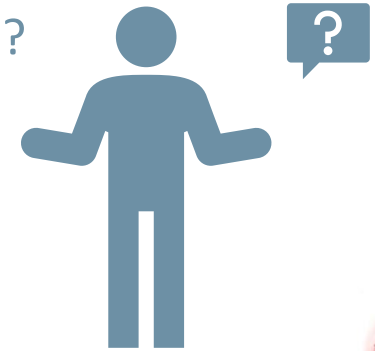
Agenda

- Motivation
- Fundamentals of Equivalent Near-Field Sources
- Near-Field Scans and Combination with Field Simulations
- Conclusion

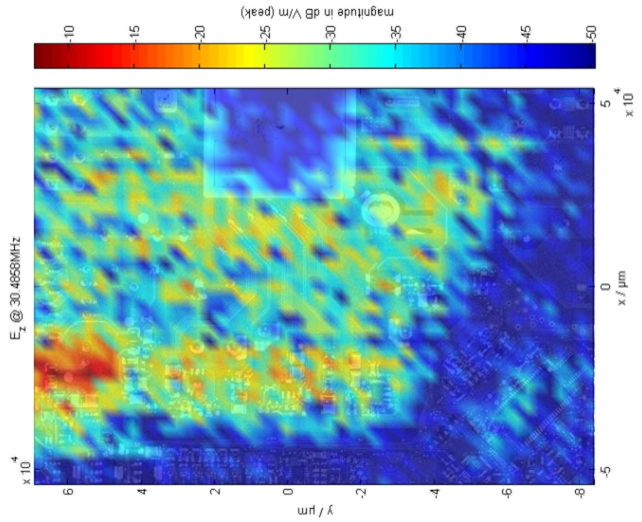
Motivation

EMC issue??



Why Automated Near-Field Measurements?

- An effective method for systematic (EMC) debugging
- In contrast to far-field measurements
  - High local resolution, close to the test object
  - No anechoic chamber required
- In contrast to field simulations
  - Simulation of the entire system is usually not possible at all
  - Realistic representation of the (complex) switching and radiation behavior
- Additional advantages
  - Fast, reproducible analysis method
  - Comparative measurements possible
  - Investigation of subcomponents
  - **Post-processing of data for further use**



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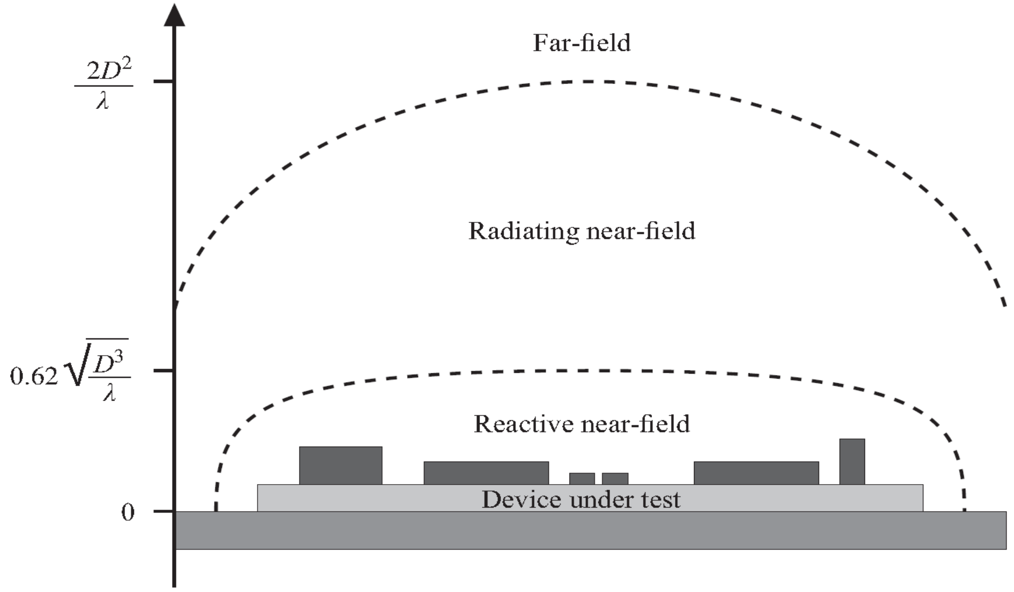
Near-Field Definition and NFS-System

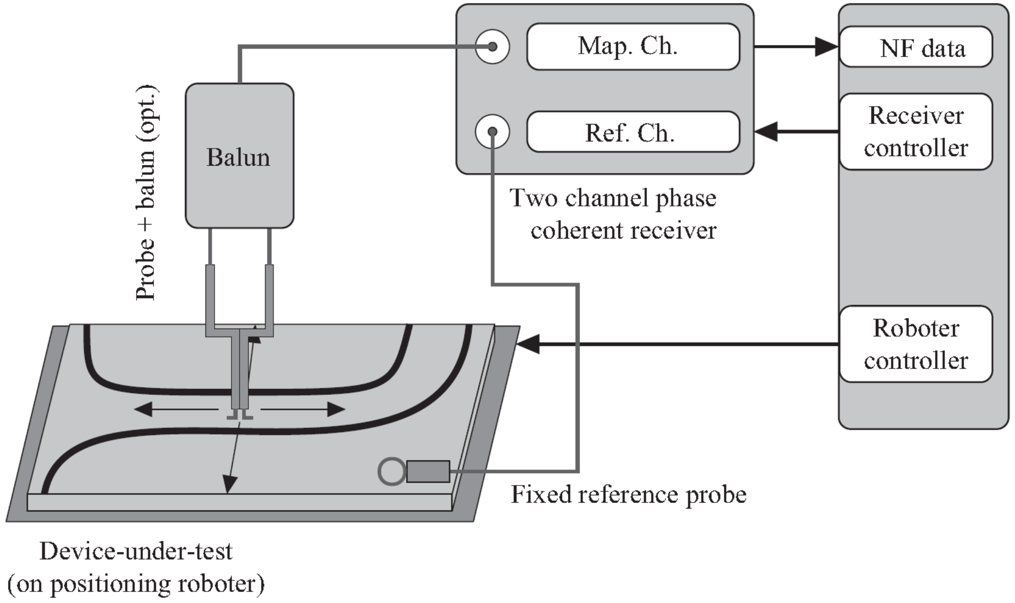
How close is Near-Field?

- *D* is the size of radiating object
  - Antenna, ground loop, micro strip, ...
- λ: Wavelength

- E.g. at 1 GHz and λ-sized element
  - Far-field beyond 60 cm
  - Reactive near-field below 19 cm

- Basic concept of a near-field scanner for two-channel measurement
  - Amplitude and phase measurement
  - Phase is necessary for near-field sources





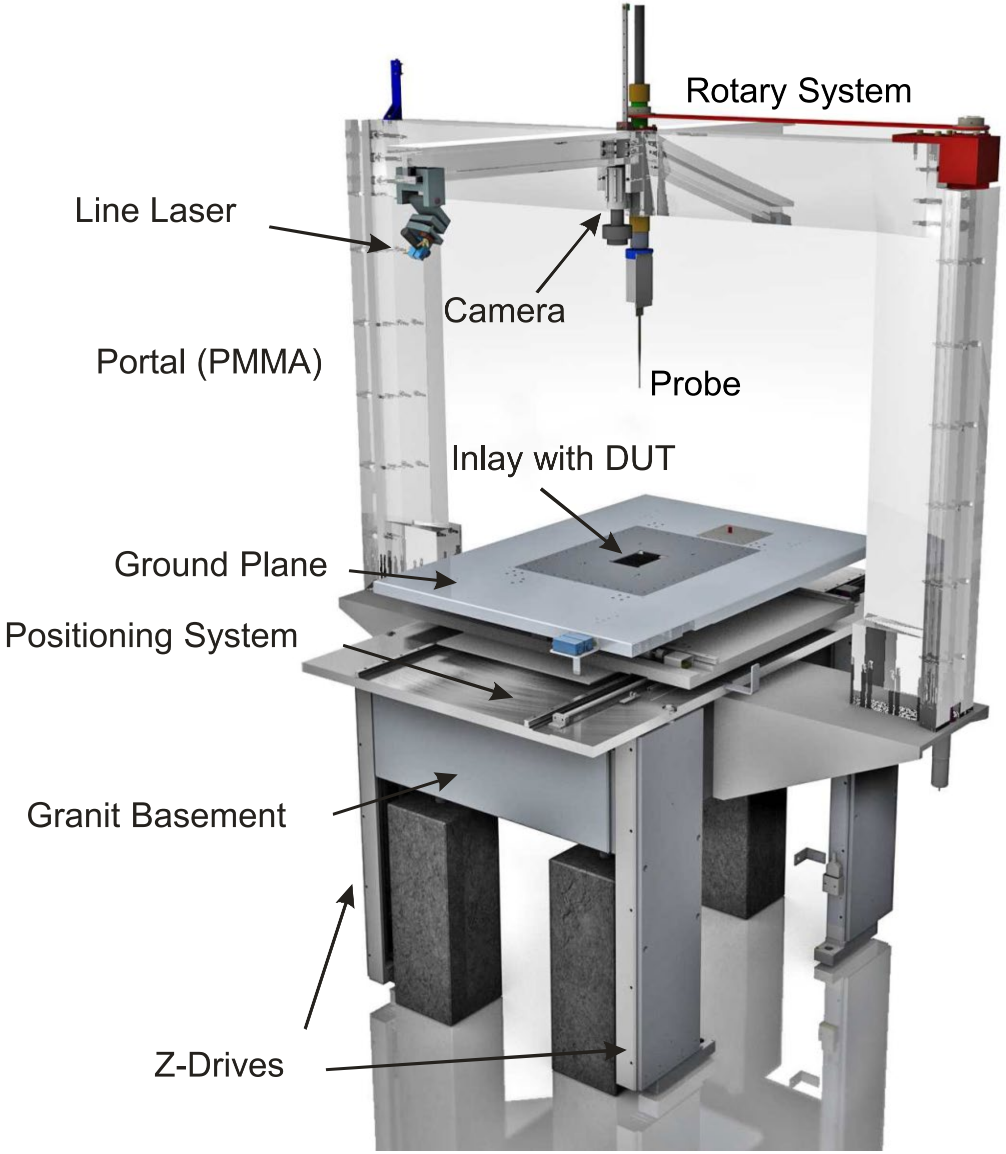
Near-Field Scanner NFS3000

Main Specifications

- Near-field scanner with a portal robot to move the DUT
- Two-channel measurement of amplitude and phase

- Measurement frequenies: up to 90 GHz
- Positioning volume: 50 cm x 80 cm x 50 cm
- Positioning accuracy: 1 µm
- Rotatable field probe (360° in 0,01° steps)
- Measurement of cartesian or cylindrical coordinates

- Metal free (almost) upper hemisphere
- 500 kg granit-bed for mechanical stability
- 3D scanning unit for heightmap capturing
- Automated measurement procedure



Measurement of an Equivalent Near-Field Source

Principle behind the Scenes

- Only tangential near-fields on *S* are measured

$\longrightarrow$ Surface equivalence principle

- Near-fields on *S* built near-field source
- Equivalent source has same EM properties

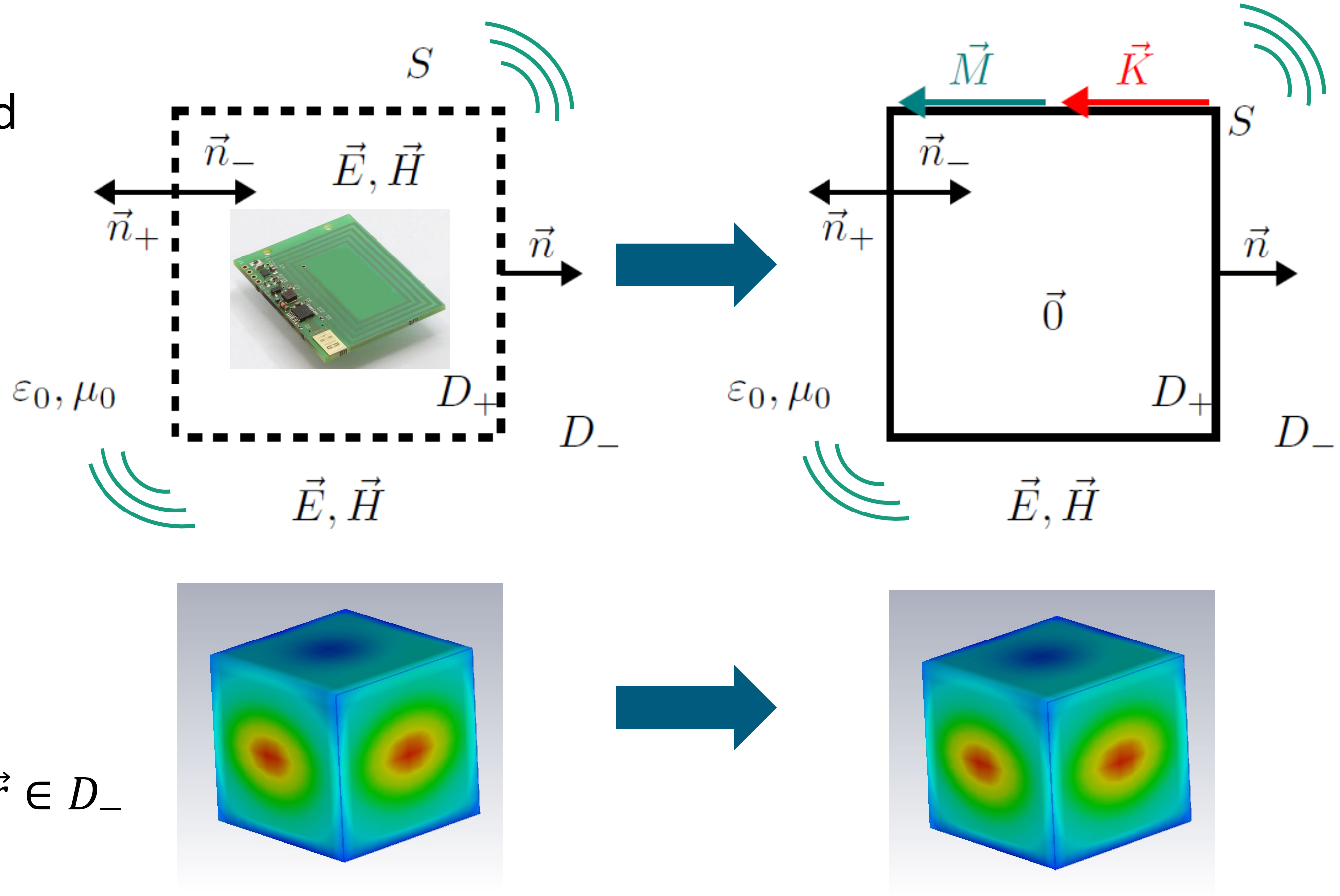
- Equivalent surface current density

$$\vec{K} = \vec{n} \times \vec{H}\big|_{\vec{r}\in S}, \vec{M} = -\vec{n} \times \vec{E}\big|_{\vec{r}\in S}$$

- Formula for the electric field

$$\vec{E}(\vec{r}) = -\mathrm{j}k_0 Z_0 \vec{A}_e(\vec{r}) - \nabla\Phi_e(\vec{r}) + \nabla \times \vec{A}_m(\vec{r}), \vec{r} \in D_-$$

Same fields outside the surface



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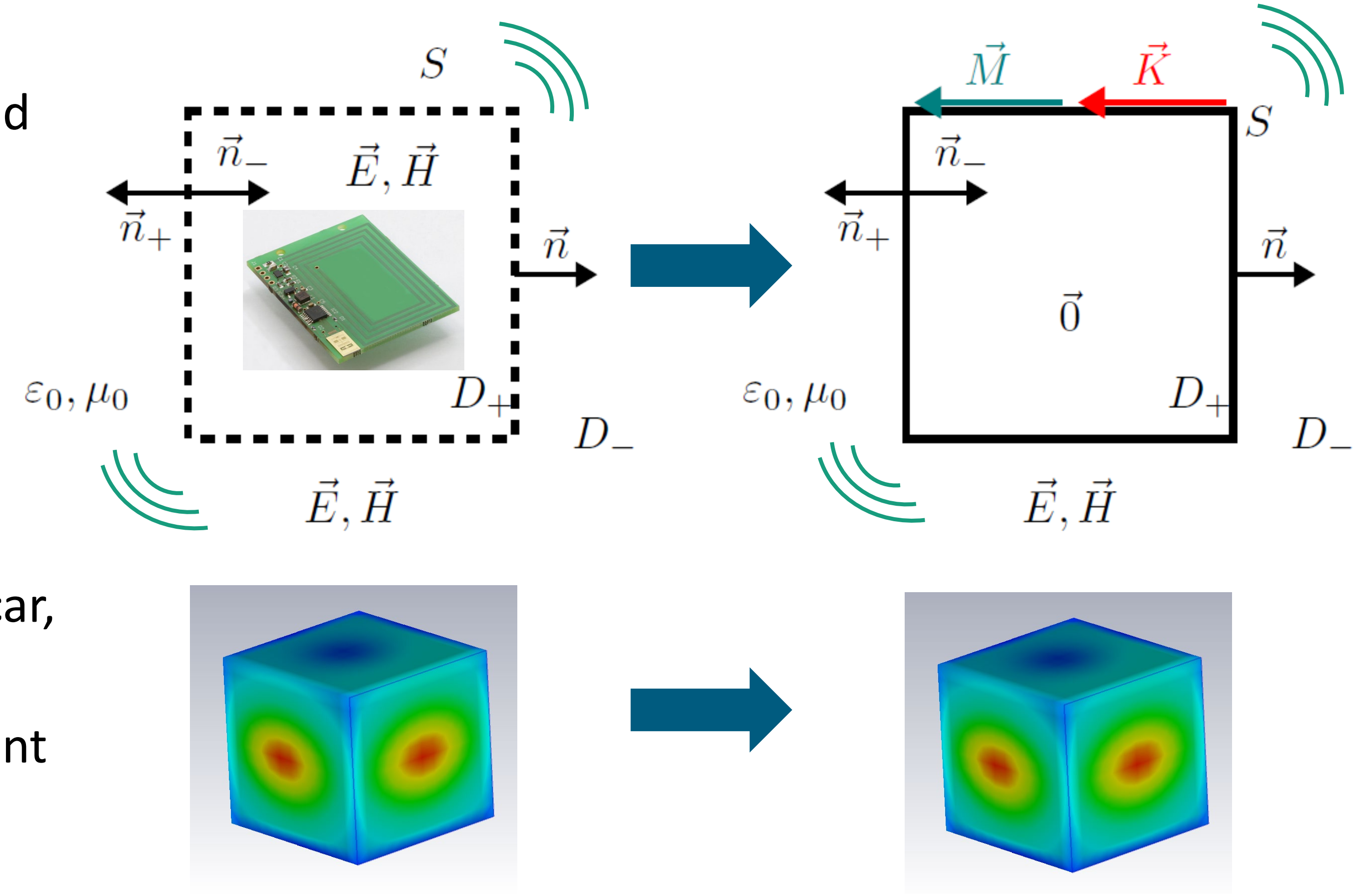
- Different purposes, for example
  - Near-field to far-field
  - Simulation of near-field interactions with car, housing, human and so on
  - Simulation of radiation into the environment

Same fields outside the surface



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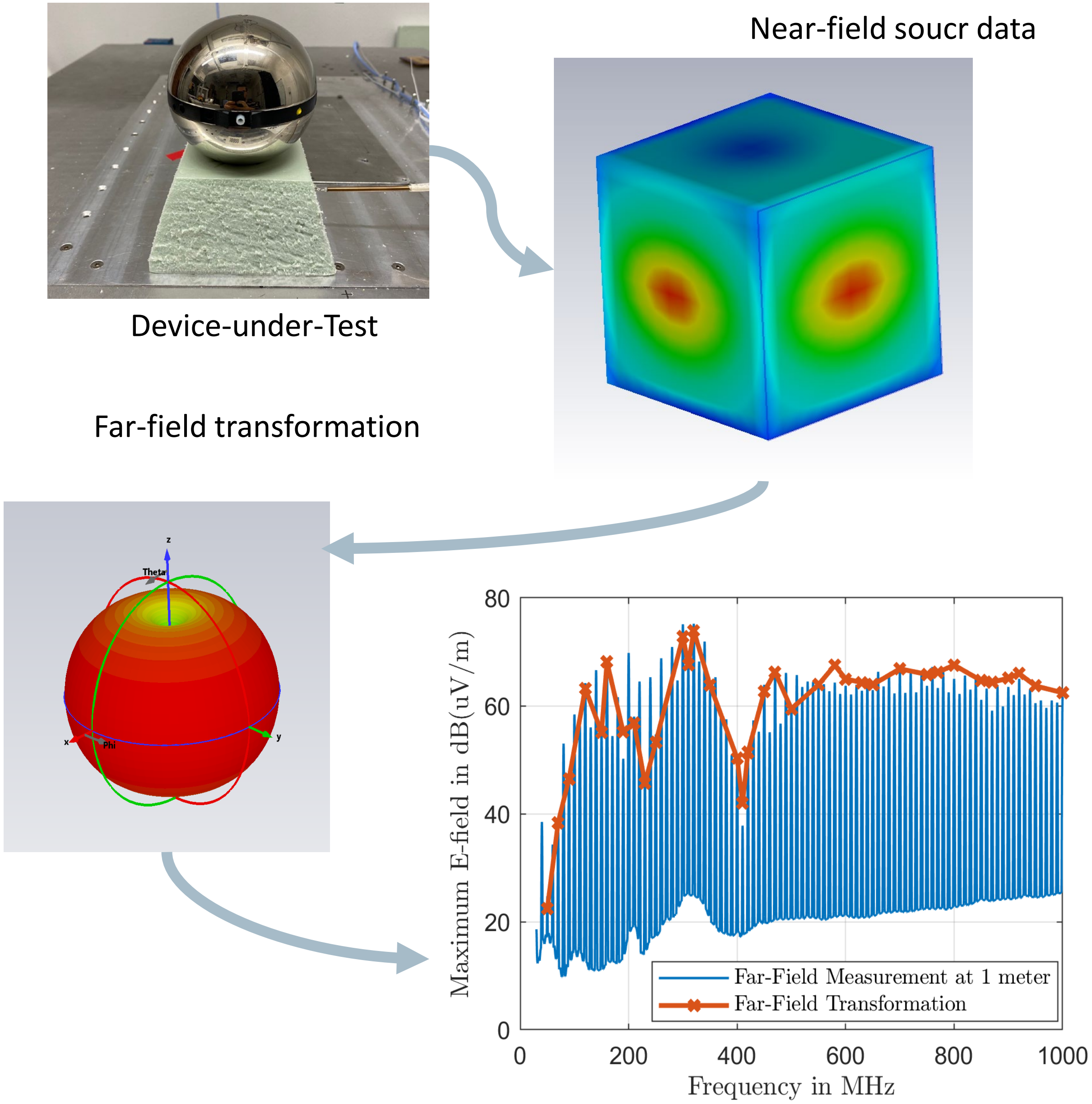
Device-under-Test – Spherical Dipole

Reference DUT

- A representative reference object is needed
- Spherical dipole antenna with diameter of 10 cm
- Battery driven comb generator (10 MHz comb frequency)
- Broadband, dipole shaped radiation pattern

Near-Field to Far-Field vs. Measurement

- Near-field measurement from 30 MHz to 1 GHz
- Far-Field measurement in the same range
  - Measurement at 1 meter distance
- Results are quite similar



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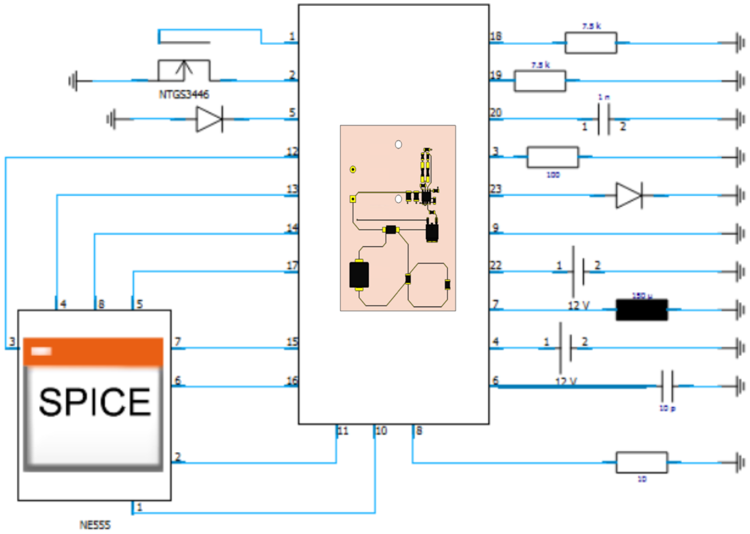
Device-under-Test – Buck Converter

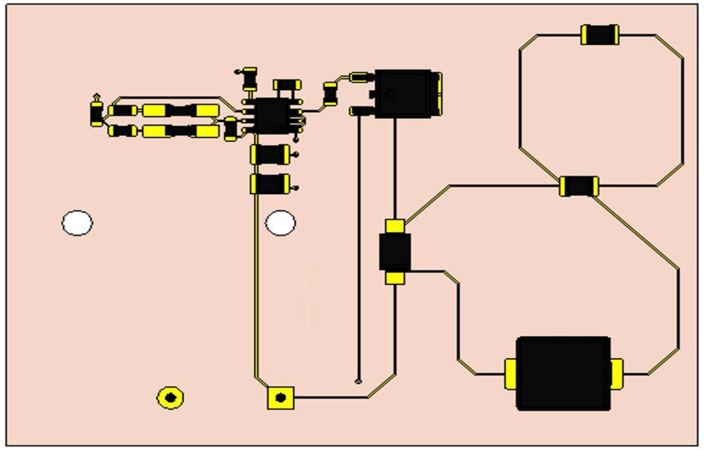
Setup of a Simple Buck-Converter for Verification Purposes

- Step-down regulator with low-side MOSFET
- Controlled by a NE555 timer circuit
- Fundamental frequency 100 kHz, 50% duty cycle
- 12 V to 6 V with a 10-ohm load
- Footprint 80 mm x 60 mm
- Battery operation possible
- Implementation in circuit simulation, CST,
  and as a physical test setup

Now:

- Co-simulation in CST and Near-field measurement





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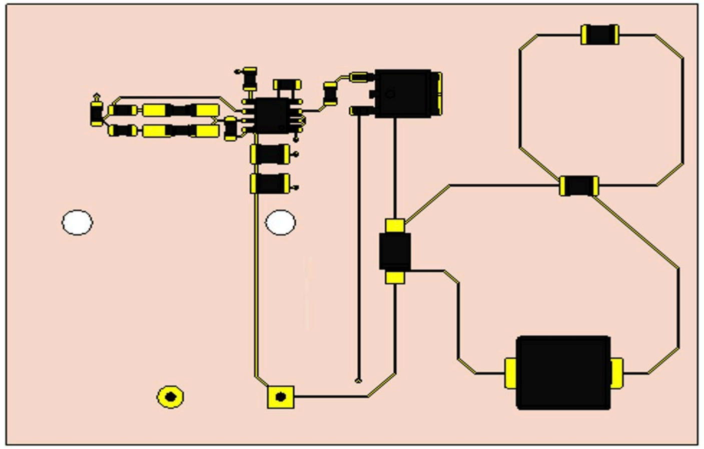
Buck Converter – Co-Simulation and Results

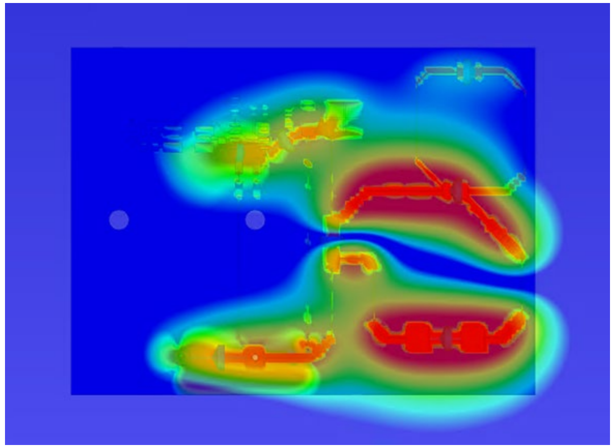
Results from the Co-Simulation

- Setting up the board with components in CST Co-Simulation
- Circuit and field simulations

Here: Validation by near-field scan

- Tangential H-field component
- At 100 MHz
- Within reactive near-field at z = 3 cm





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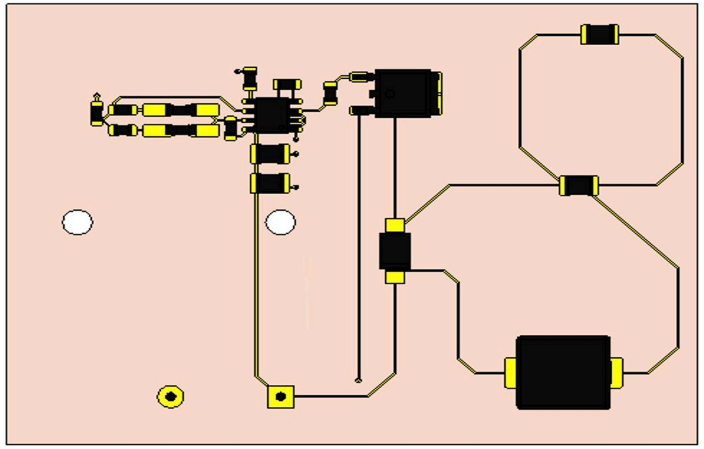
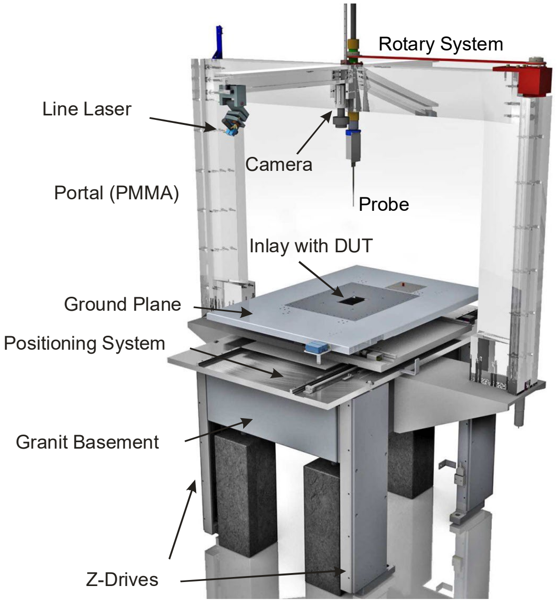
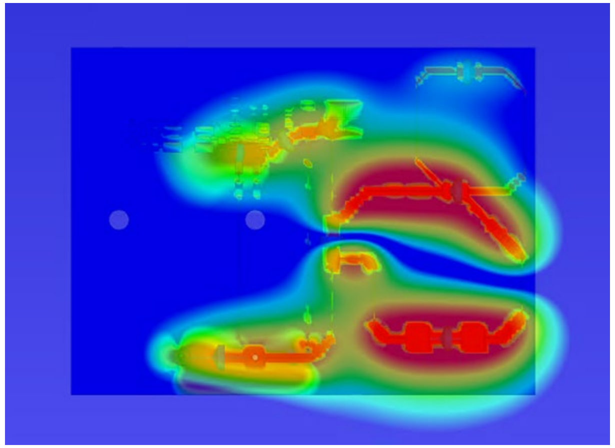


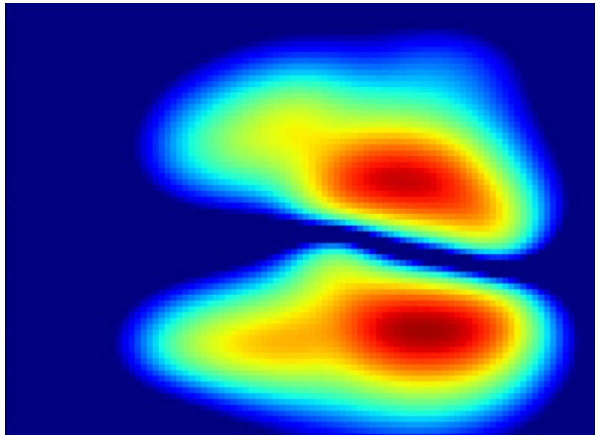


Here: Validation by near-field scan

- Tangential H-field component
- At 100 MHz
- Within reactive near-field at z = 3 cm

- Near-field scan at same conditions

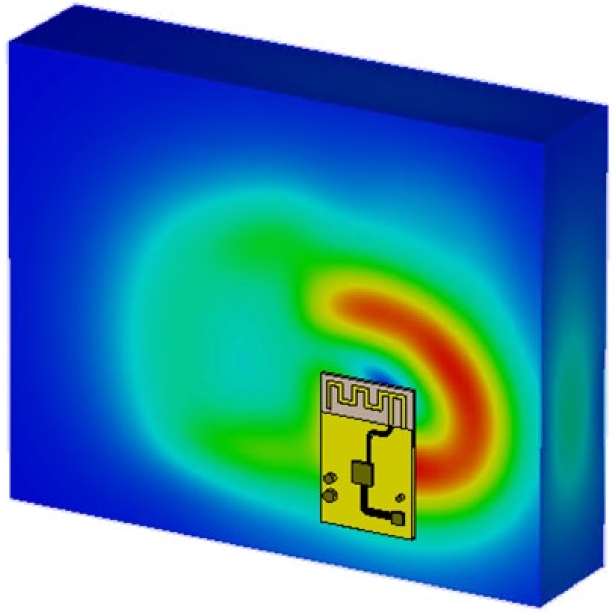




Near-Field Source and Near-Field Interaction

Near-Field Source in the Vicinity of a Target Device

- Next, the near-field interaction is examined
- Near-field source measured from buck-converter
  - Operating at 120 MHz as an example
  - 6-sided with rotation of the device upside-down
- A target device is imported/designed
  - ESP32-like module
  - 50-ohm resistor as a dummy load for the antenna
- ESP32 module placed 2 cm above the “hotspot”



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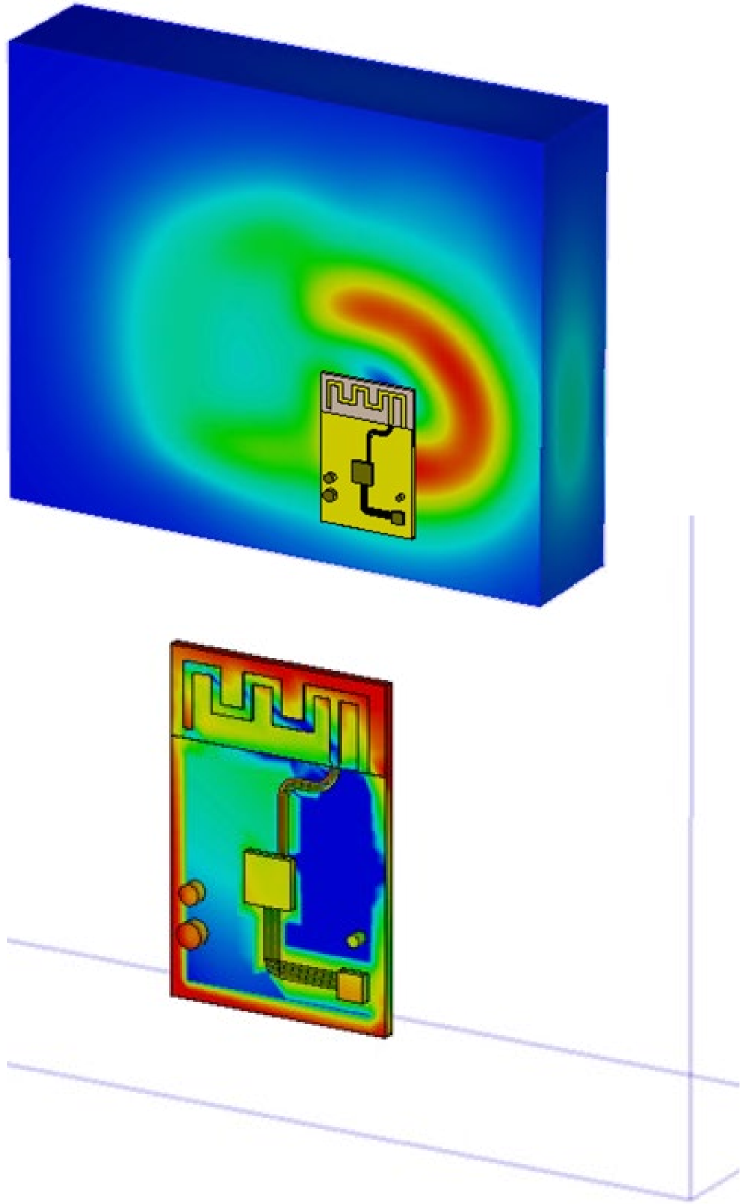
- Results
  - At the 50 Ohm resistor an induced voltage of 5 mV can be seen
  - Fields spread across the whole board



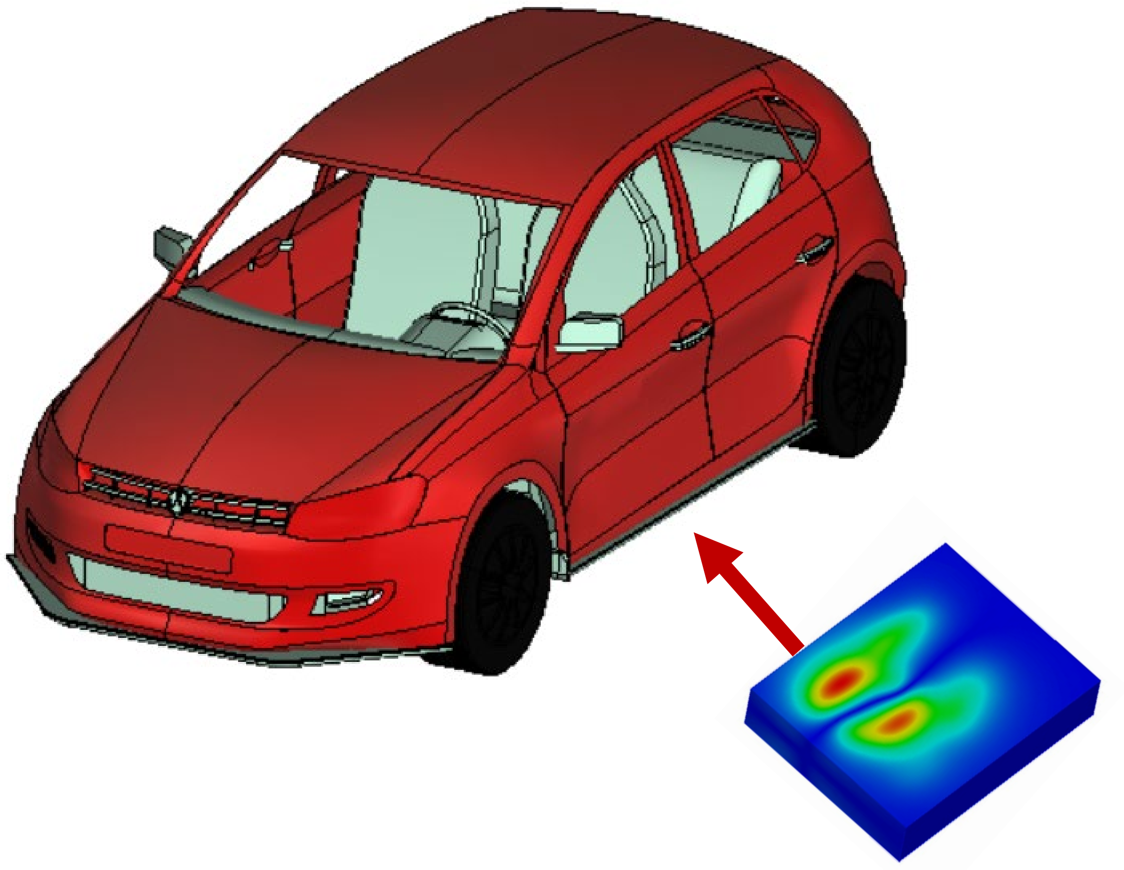
Near-Field Source and Interaction with Intended Environment

Simplified Model of a Car

- Scaled car model with three different materials
  - Chassis: PEC
  - Interieur: Plastics
  - Wheels: Rubber

Simulation-Setup

- Near-field source of buck converter at 120 MHz
- Placed at the bottom of a car model
  - E.g. battery, charger
- Simulation of the electric field in the car



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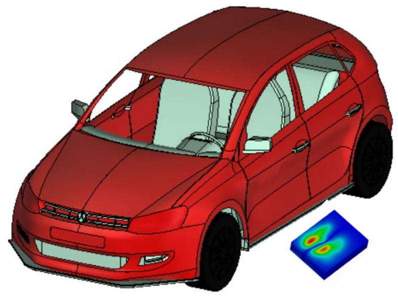

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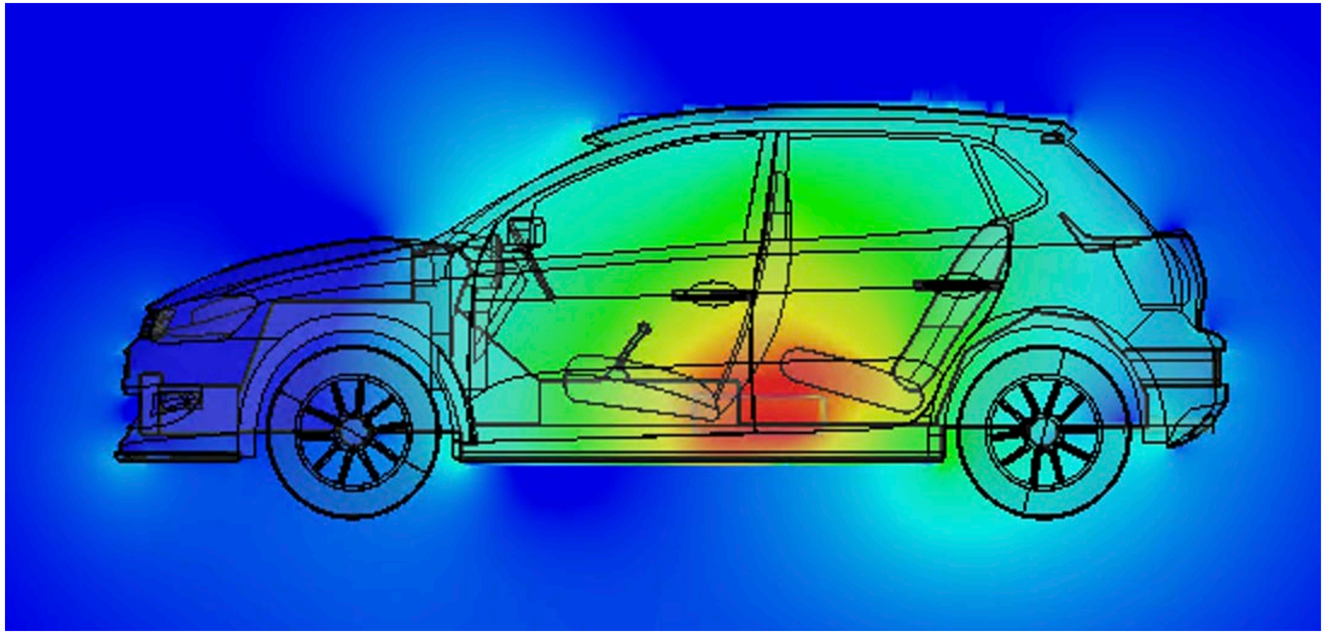

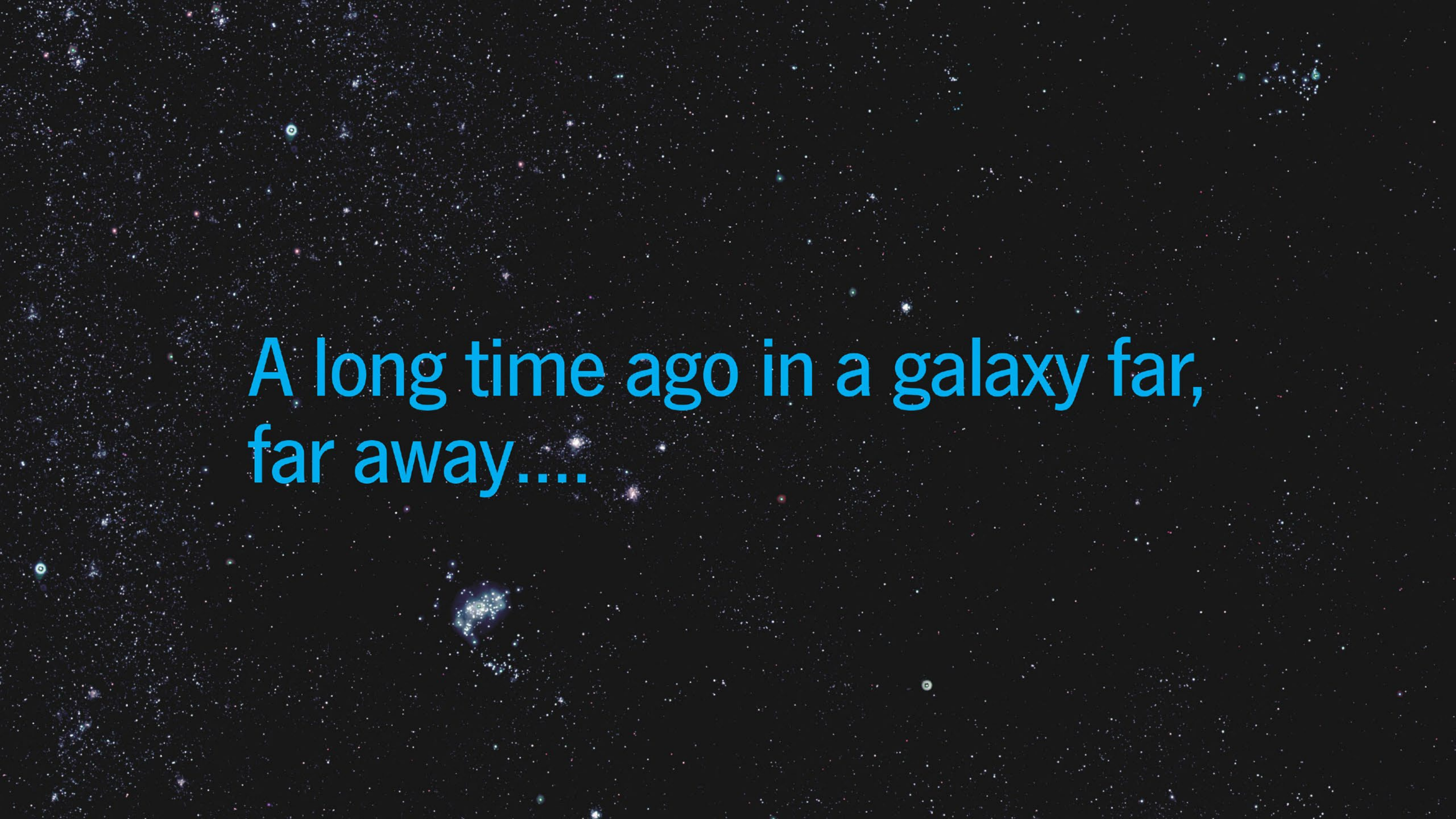
A long time ago in a galaxy far,
far away....

EMC Examination of an X-Wing with an Equivalent Near-Field Source

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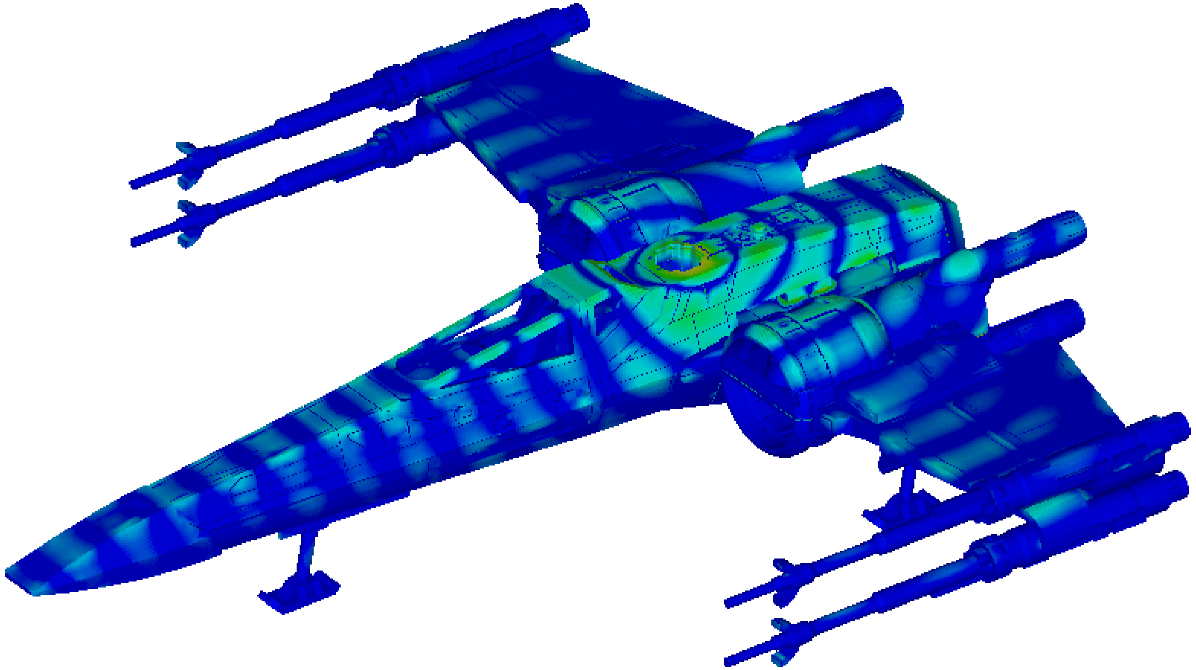
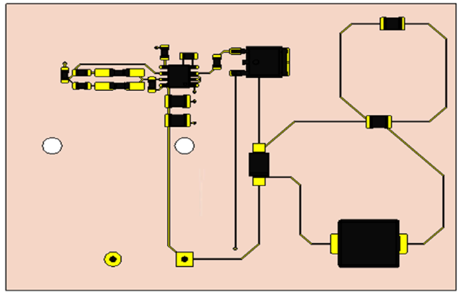
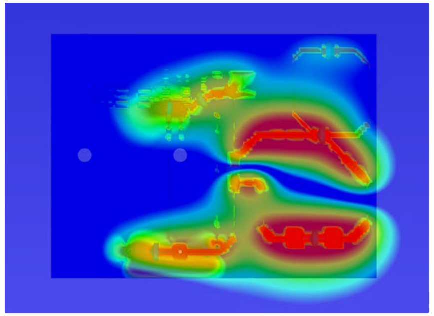


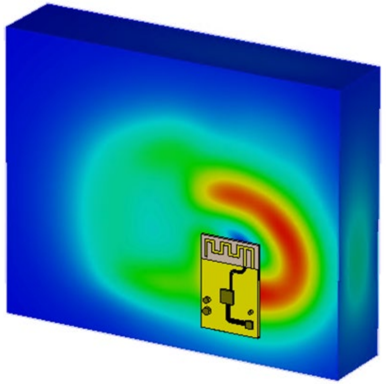
Conclusion

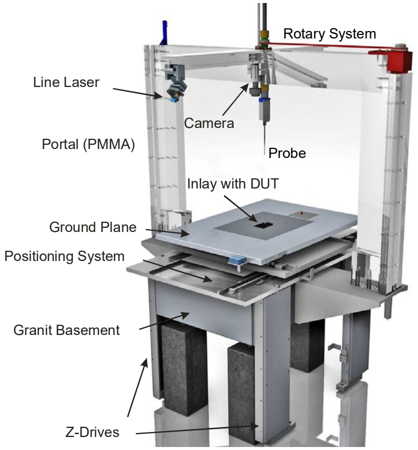
Automated near-field measurements
… are useful for systematic EMC debugging
… can resolve fields by amplitude and phase
… can be used as equivalent near-field sources

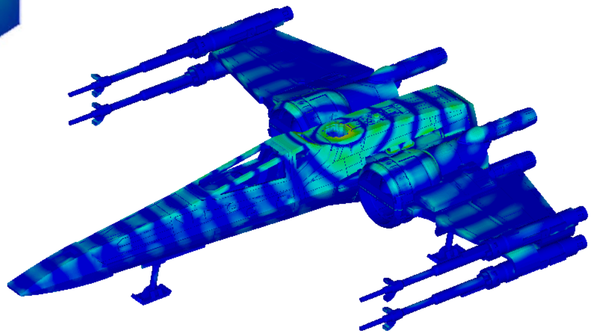
With equivalent near-field sources, it is possible to
… transform the near field into the far field
… investigate coupling into target devices
… simulate intra-system EMC











Many Thanks for Your Attention!