Emission Measurements of an Artificial EUT in an Anechoic Chamber up to 40 GHz

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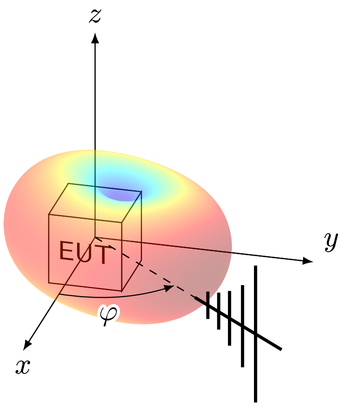
September 30, 2024

Introduction

- classic focus of EMC - protection of radio communication services
- garantueed by compliance with emission limits
- verification in fully or semi-anechoic chambers
- spatial sampling of the radiated electric field in the azimuth plane



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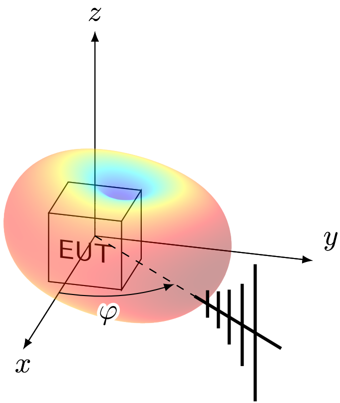
- existing normative procedures were adopted for frequencies up to $40\,\mathrm{GHz}$
- more complex radiation patterns at higher frequencies
- detecting the maximum becomes less likely



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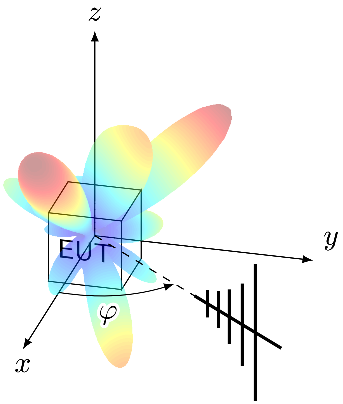

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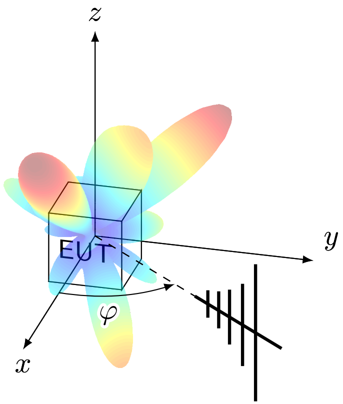
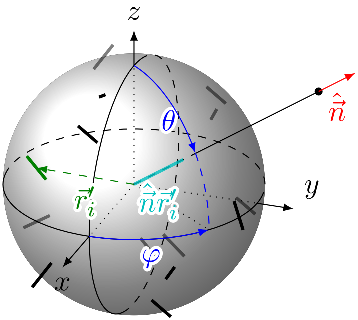


Are the normative methods still suitable?

Stochastic model of a physical unintentional radiator



- small, randomly, oriented and distributed dipole sources
- sphere enclosing EUT
- superposition of far fields
- polarisation effects represented

J. Petzold, et. al. "Monte Carlo Simulation of a Physical Random Unintentional Radiator as a Basis for Statistics in Fully Anechoic Room Measurements," 2023 International Symposium on Electromagnetic Compatibility – EMC Europe, Krakow, Poland, 2023, pp. 1-6

Outline

Artificial EUT

Artificial EUT (Front View)

- $310 \times 290 \times 230\,\text{mm}$ (W × H × D)
- arbitrarily distributed and oriented slots
- longest slot $75\,\text{mm}$, $f_r = 2\,\text{GHz}$
- shortest slot $6\,\text{mm}$, $f_r = 25\,\text{GHz}$

Artificial EUT (Back View)

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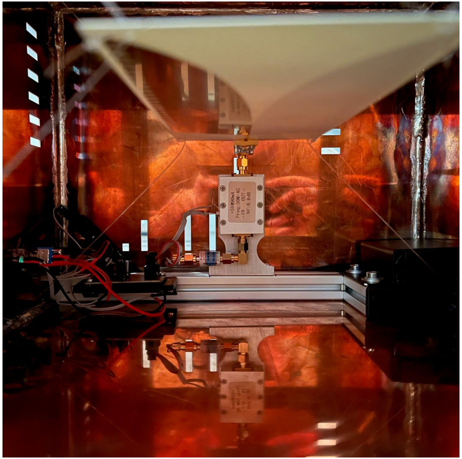
Artificial EUT (Interior View)

- 1 GHz sine wave oscillator
- amplifier
- comb generator
- broadband planar vivaldi antenna
- battery powered



Setup & Procedure

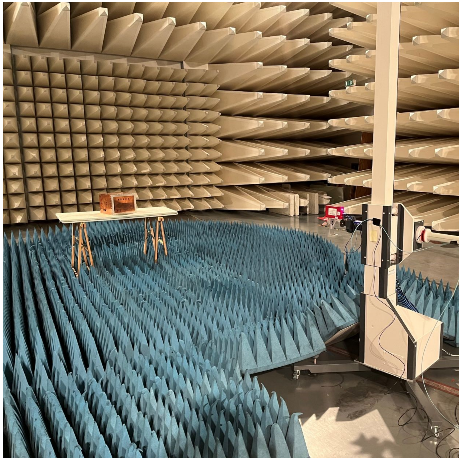
Normative Procedure for Emissions Measurements

Standards

- CISPR-16-2-3 (up to $18\,\text{GHz}$)
- ANSI C63.4-2014 (up to $40\,\text{GHz}$)

General Procedure:

- spatial sampling of the EUT
- horizontal and vertical polarisation
- ANSI: manually position antenna over surface of EUT



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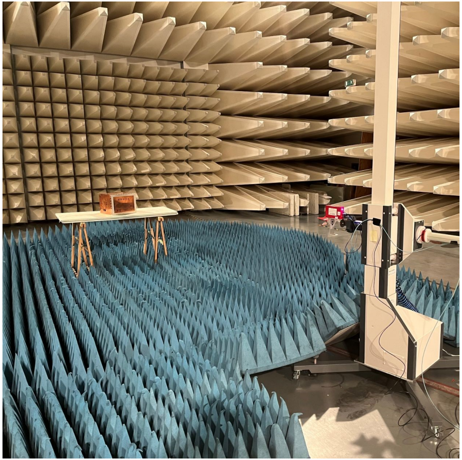
Setup:

- absorber-lined semi-anechoic chamber
- non-conductive table
- turntable and antenna mast



Normative Procedure: Measurement Distance

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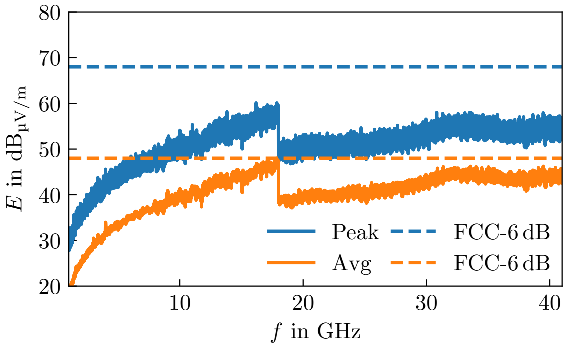

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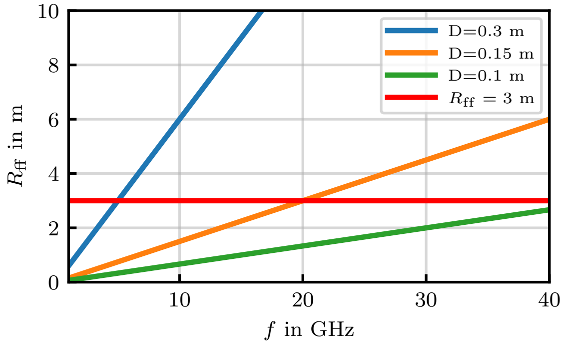
- far field distance $R_{\mathrm{ff}} \approx \frac{2D^2}{\lambda}$

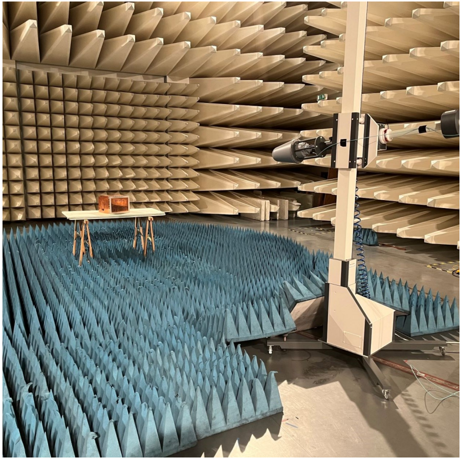


Normative Procedure: Spatial Sampling

- full rotation in azimuth $0°$ to $360°$
- CISPR: $\Delta\phi_{\min} = 15°$
- ANSI: $\Delta\phi_{\min} = 22.5°$
- step size used: $\Delta\phi = 1°$

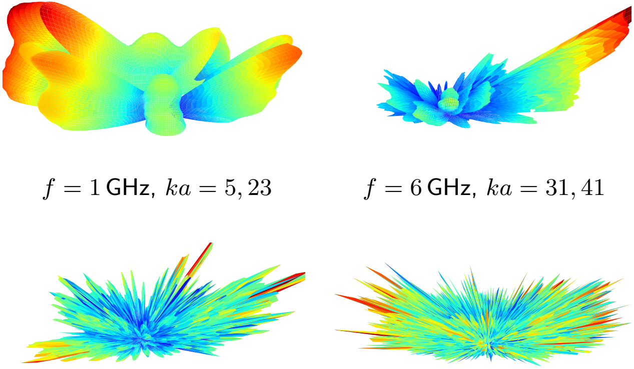
Normative Procedure: Height Scan

- if beamwidth of antenna smaller than vertical dimension
- $1\,\mathrm{m}$ to $4\,\mathrm{m}$ (no antenna alignment)
- step size used: $\Delta\phi = 1^\circ$



Results & Validation

Radiation Patterns

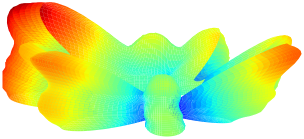


$f = 1\,\text{GHz},\ ka = 5,23$ $f = 6\,\text{GHz},\ ka = 31,41$

$f = 18\,\text{GHz},\ ka = 94,24$ $f = 40\,\text{GHz},\ ka = 209,43$

- lower frequencies, few wide beams
- higher frequencies, many narrow beams
- maximum not in azimuth
- insufficient to determine direction of maximum at one frequency
- despite complexity, many local maxima of same magnitude

Maximum electric field strength



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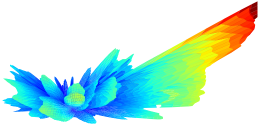

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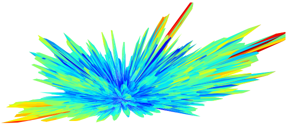

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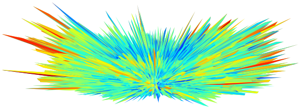

$f = 40\,\text{GHz},\ ka = 209,43$

Real detected maximum:

$$E_{\mathrm{real}} = \max_{\varphi,\vartheta}\{E_{\mathrm{h}}(\varphi,\vartheta), E_{\mathrm{v}}(\varphi,\vartheta)\}$$

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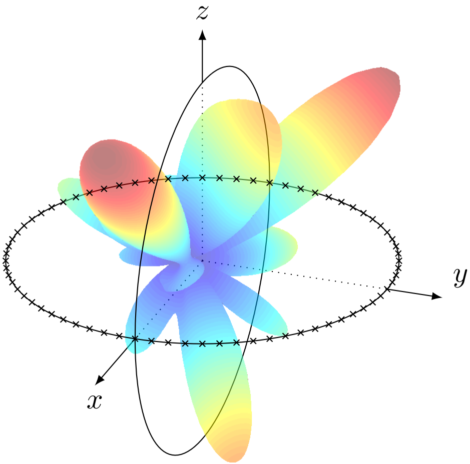

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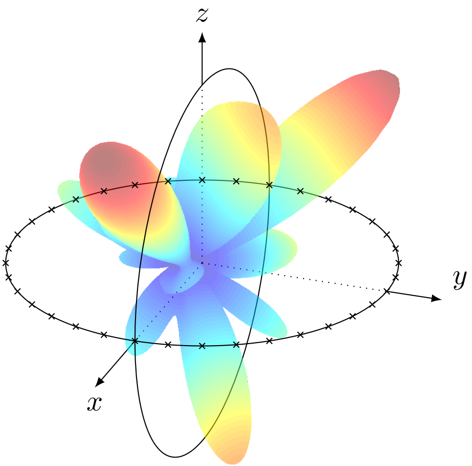

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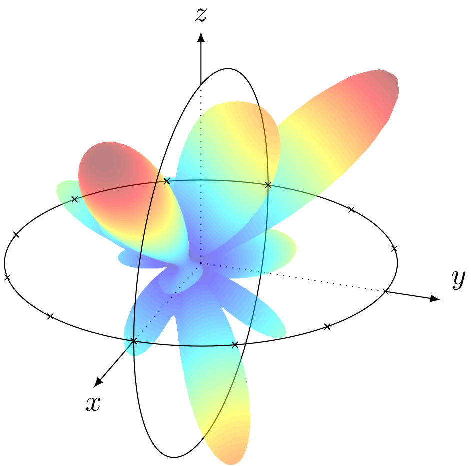

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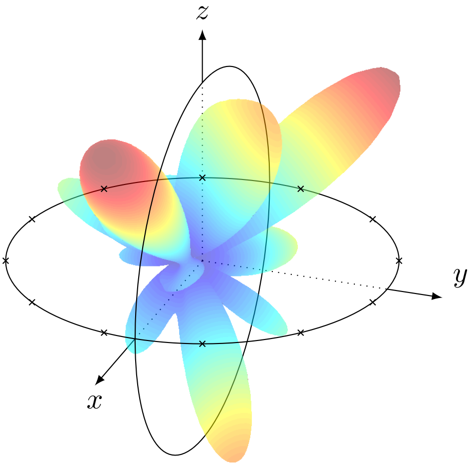

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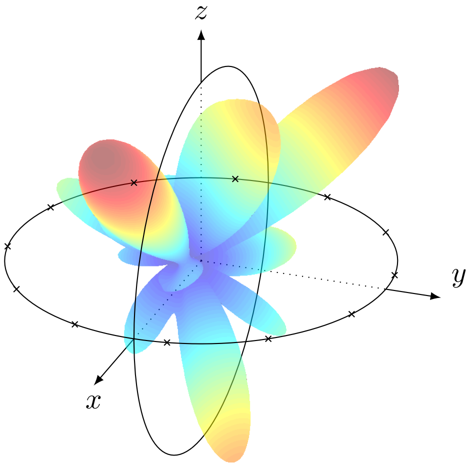

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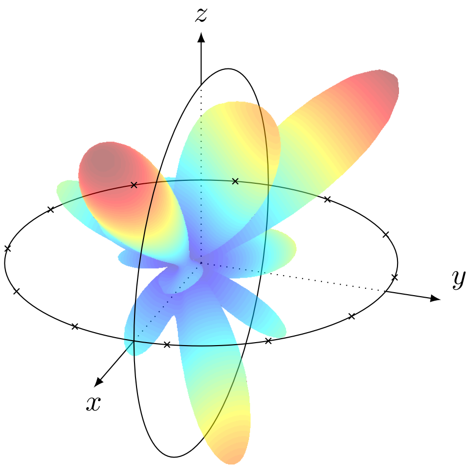

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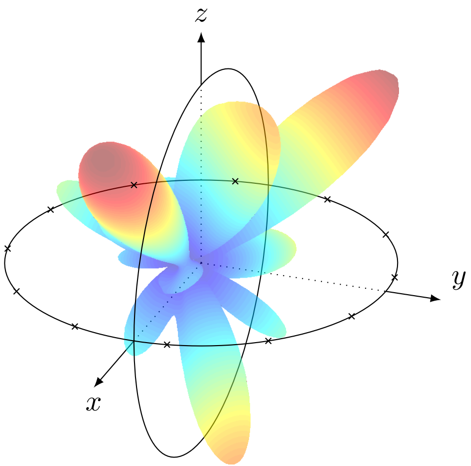

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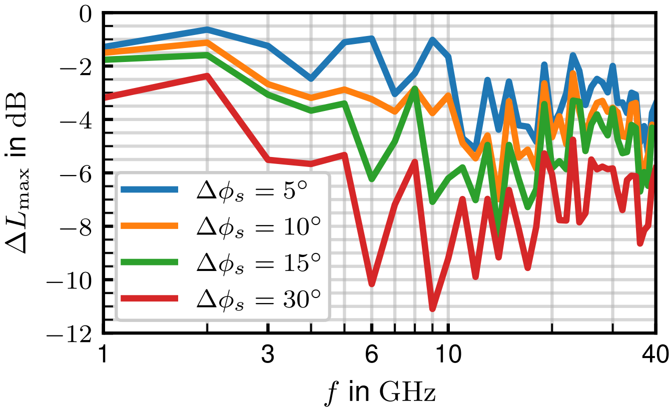
Relative level difference:

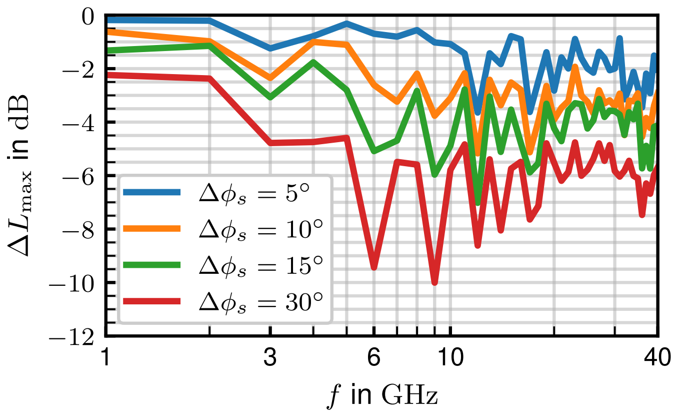
$$\Delta L = 20\log_{10}\left(\frac{E_{\text{sta}}}{E_{\text{real}}}\right)$$

Influence of the spatial sampling (without height scan)



- $\Delta\phi_s \uparrow$, $\Delta L_{\max} \uparrow$
- $f \uparrow$, $\Delta L_{\max} \uparrow$
- high f, $\Delta L_{\max} = const.$

Influence of the spatial sampling (with aligned height scan)



- improvement $2\,$dB to $4\,$dB

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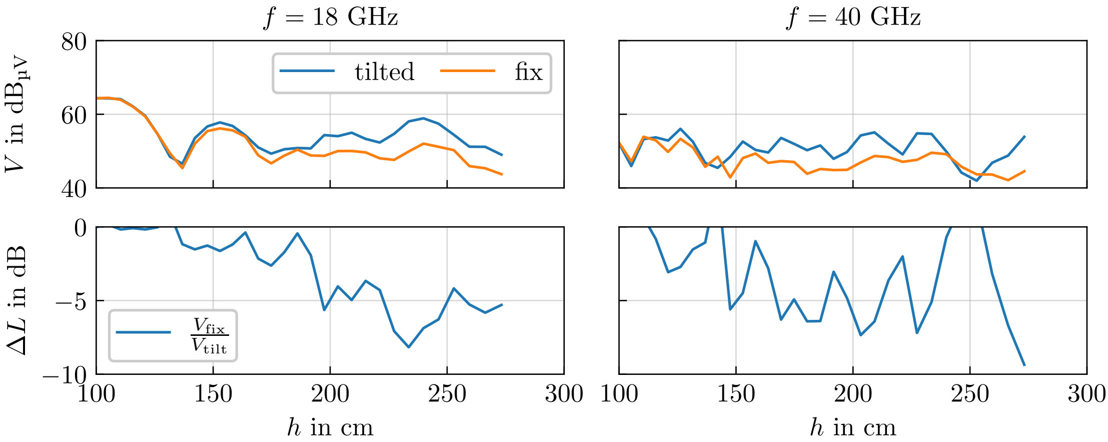
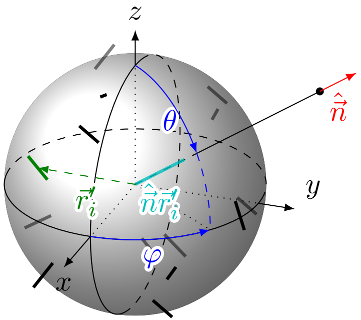


Stochastic model of a physical unintentional radiator



- 50 dipole souces
- radius $a = 24\,\mathrm{cm}$
- replicate measurements by Monte Carlo simulation
- 1000 realisations

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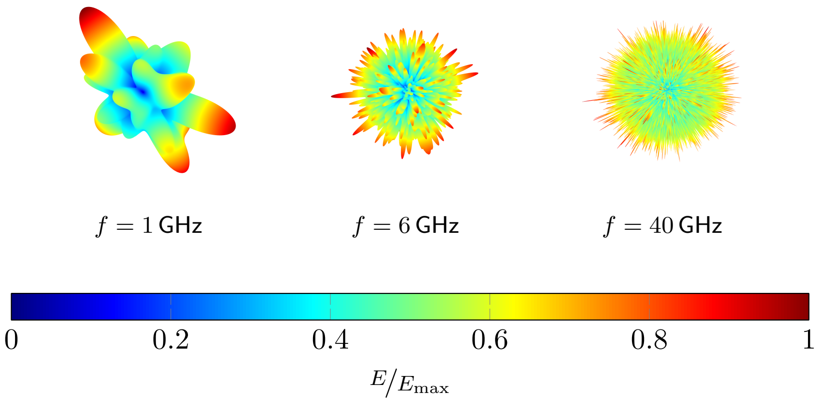
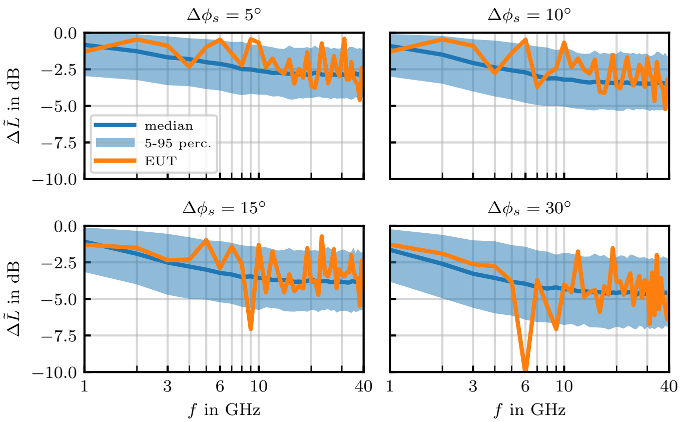
Radiation Pattern EUT $a = 24\,\text{cm}$



Validation of the theoretical Model



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Conclusion & Outlook

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- For higher frequencies height scan without antenna alignment insufficient
- Stochastic radiator model represents the deviations very well

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Discussion

- Normative procedure not suitable in terms of accuracy and reproducibility
- Definition of a frequency-dependent angular resolution
- Definition of a frequency and angular dependent uncertainty
- Alternative procedure in the mode-stirred chamber according to IEC-61000-4-21

Thank you for your attention!