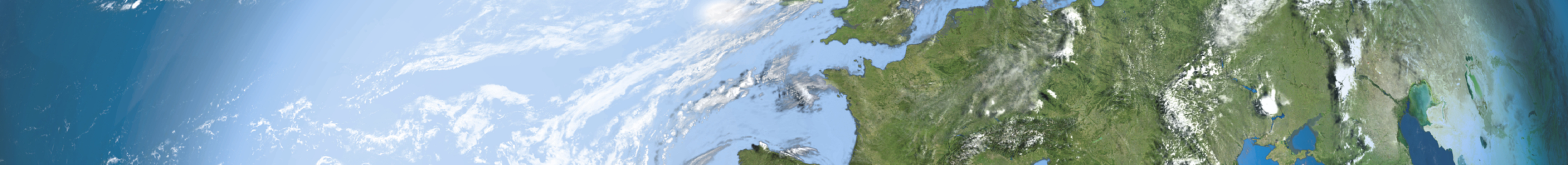

A Wave Propagation Model for a Terahertz Single Pixel Camera

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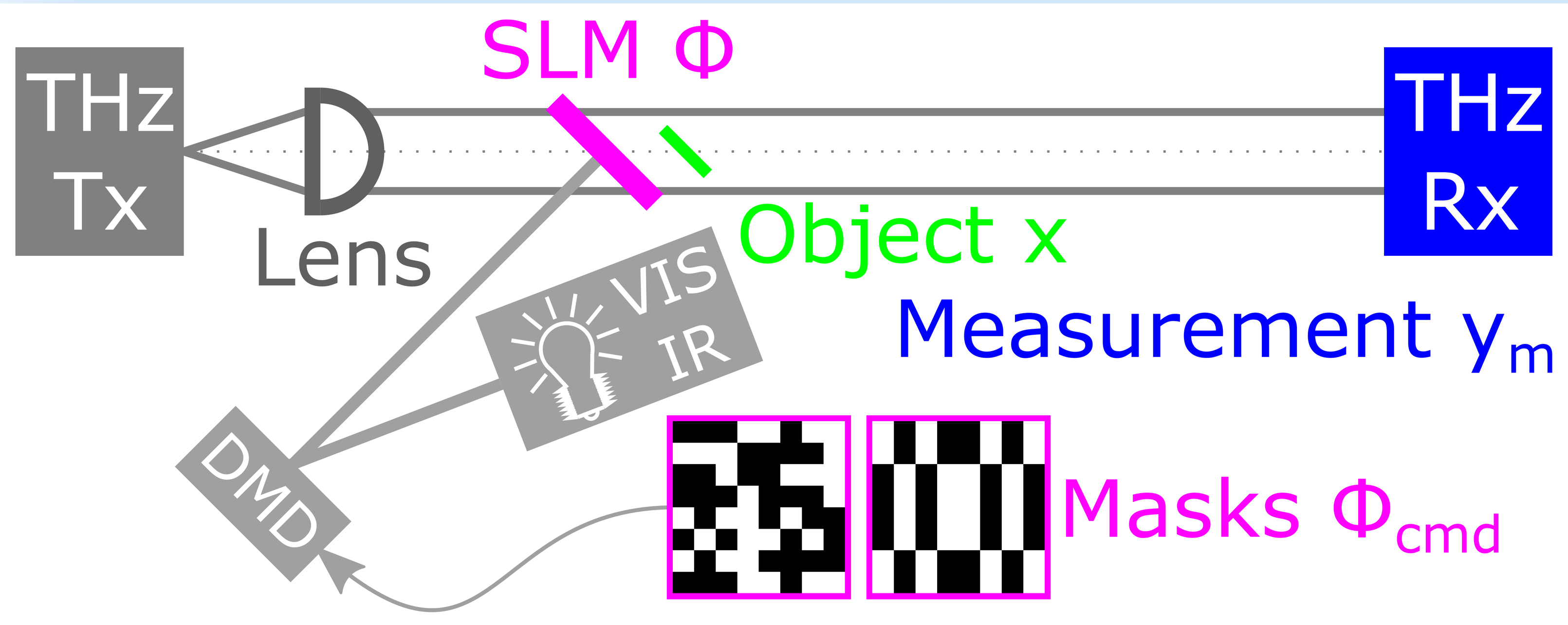
Introduction

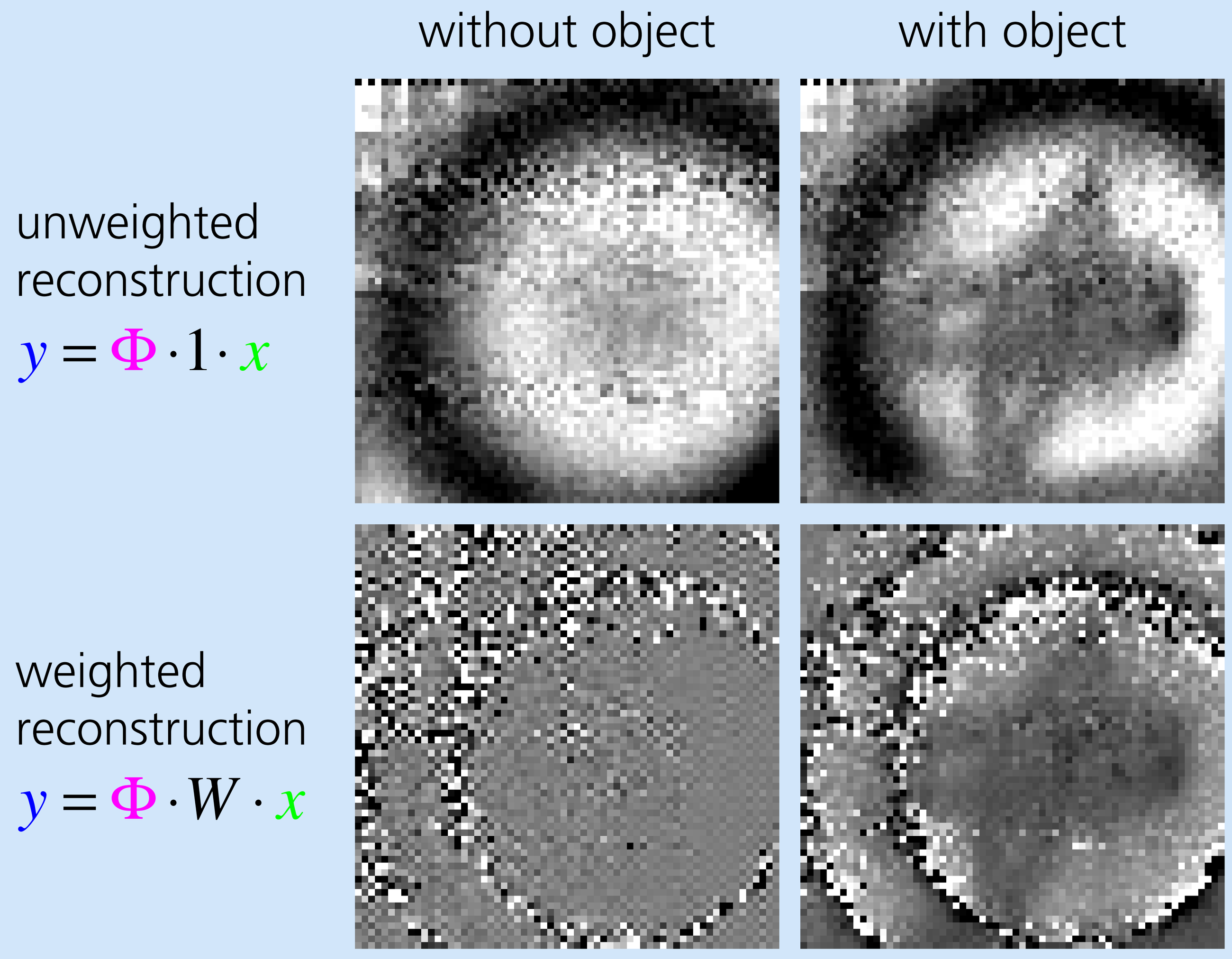
Spatially resolved terahertz measurements usually require either mechanical scanning, large and expensive detector arrays, or a combination thereof. So called Single Pixel Cameras (SPCs), consisting mainly of a Spatial Light Modulator (SLM) and a single pixel detector, provide an alternative approach, which has already been demonstrated [1, 2]. For a successful image acquisition, the setup, and especially the behaviour of the SLM, needs to be physically well-understood. A wave propagation model was developed that takes into account the nature of coherent radiation emitted by the THz source. It is capable of predicting signal values at the single pixel detector for a given wavelength, spatial filter configuration, flat object and detector position. The developed model is presented here and verified using a 0.345 THz SPC setup.

Single Pixel Camera Imaging Setup



- 0.345 THz electronic source
- Heterodyne receiver or bolometer
- Spatial Light Modulator (SLM), illuminated Germanium
- Digital Micromirror Device (DMD)
- Image acquisition without mechanical scanning
- Image reconstruction by inverting masks
  - Intended in future: Compressed Sensing

Circular Imaging Artefacts

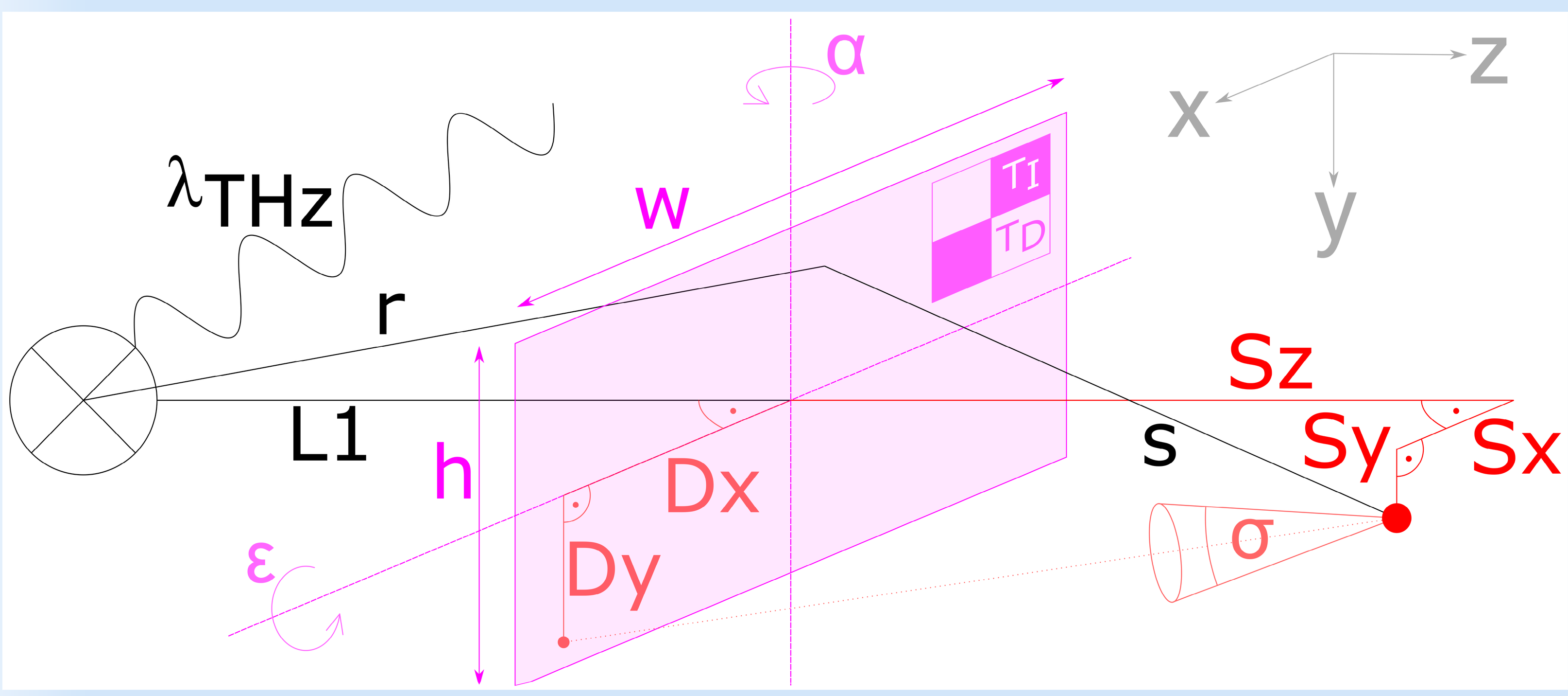


- Periodic ring structure around the imaged scene, limiting the field of view of the THz single pixel camera

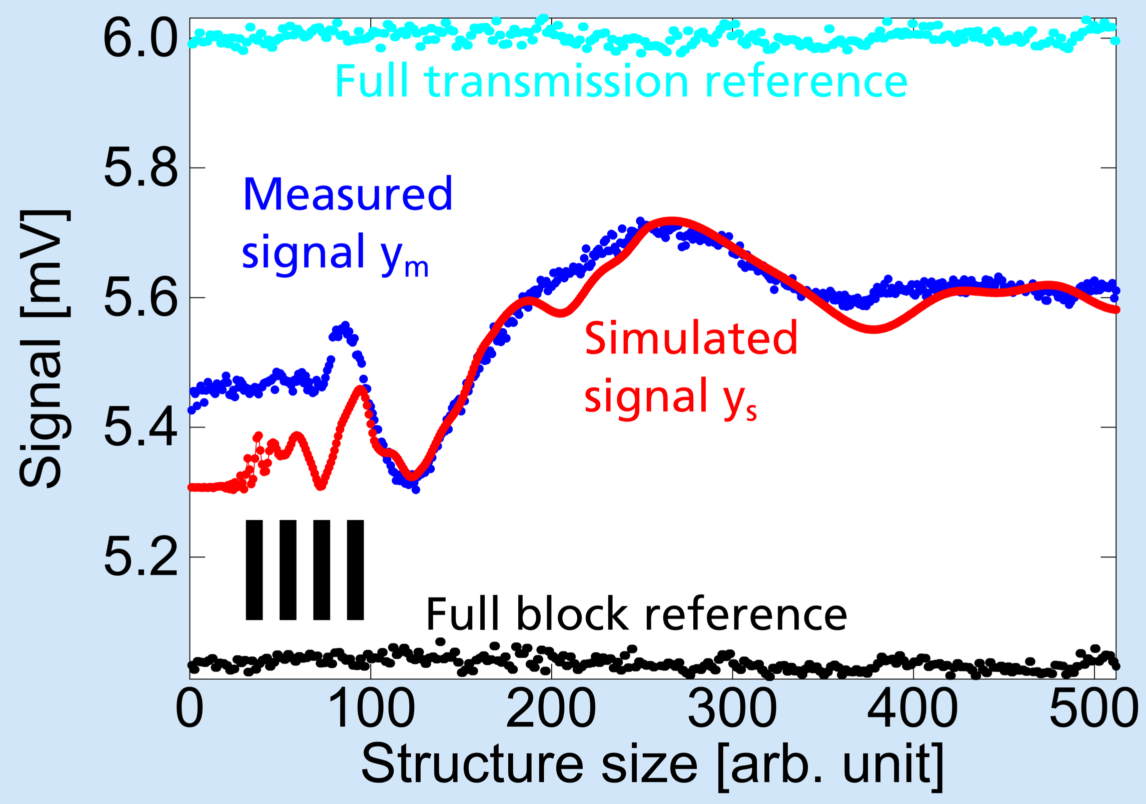
Wave Propagation Model of the SPC

- Model is based on Fresnel-Kirchhoff's diffraction formula
  - Wave length of the source (λ_{THz})
  - Distance to source (L1), dimension (w, h) and transmittance (TI, TD) of the aperture / mask / SLM
  - Position (Sx, Sy, Sz) of the detector
- Extended by parameters to consider
  - Tilt of the aperture (α, ε)
  - Viewing direction (Dx, Dy) and antenna profile (σ) of the detector

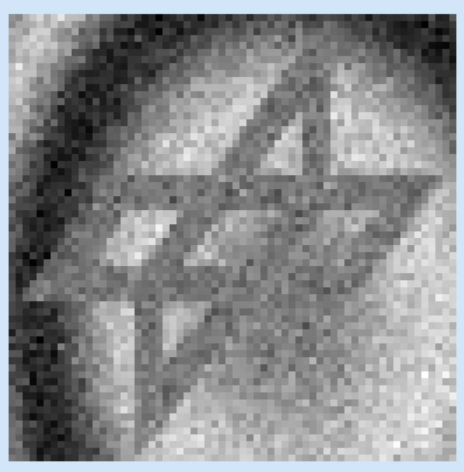
$$\frac{a}{i\lambda}\int_{SLM} dS\,\Phi_S\,\frac{e^{i\frac{2\pi}{\lambda}(r+s)}}{r\cdot s}\left(\frac{\cos(\vartheta)+\cos(\vartheta_1)}{2}\right) = y_s$$



Simulation Results



- Simulated signal agrees on most dominant features
- Model yields a good description of the setup



- Image reconstruction of simulated signal exhibits ring artefact
- Ring frequency depends on distance of detector to SLM
- Ring position depends on detector position wrt. optical axis
- Reconstruction with artefact suppression should be possible

References and Acknowledgements

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[2] Augustin, S.; Hieronymus, J.; Jung, P. & Hübers H.-W.: "Compressed sensing in a fully non-mechanical 350 GHz imaging setting" Journal of Infrared, Millimeter, and Terahertz Waves, 36(5), pp. 496–512, 2015.

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