[dstl] The Science Inside

# The Difficulties of Seeing Through Walls

## Why Stand-off Structure Reconnaissance with Radar is Hard

Joshua Hellier



Ministry of Defence

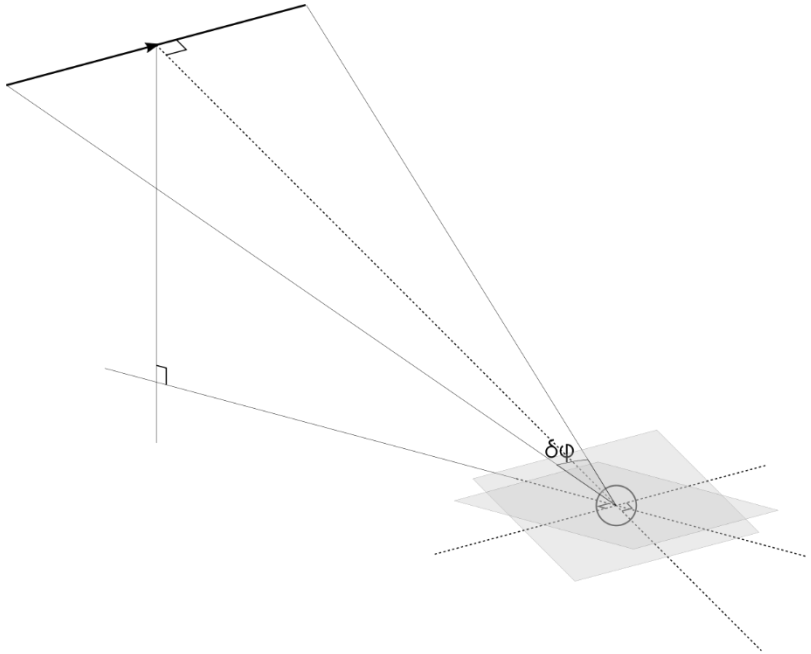
# Conventional Spotlight-Mode Synthetic Aperture Radar

[dstl] The Science Inside

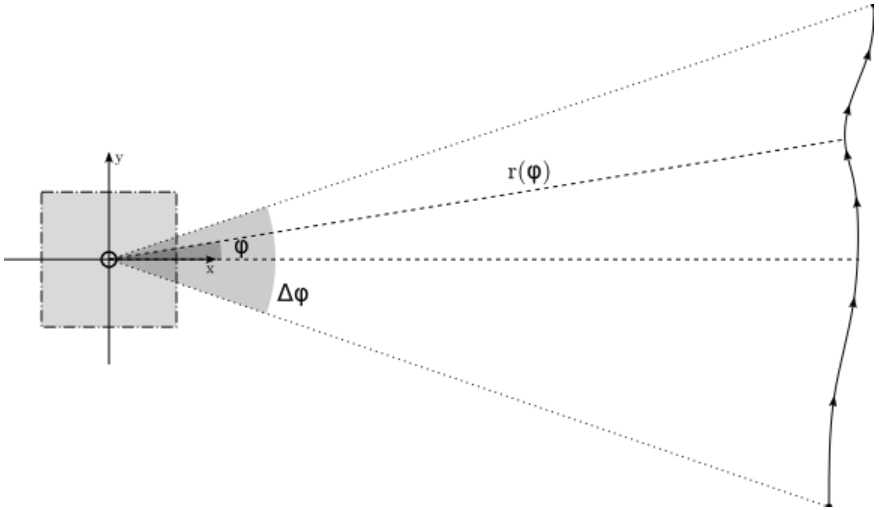
- Aperture (mostly) confined to single slant plane.
- Trivial propagation model.
- Long range.
- Linearization of target scattering model gives image suitable for further interpretation.
- Fourier modes of slant-plane scattering profile measured; restricted angle, frequency

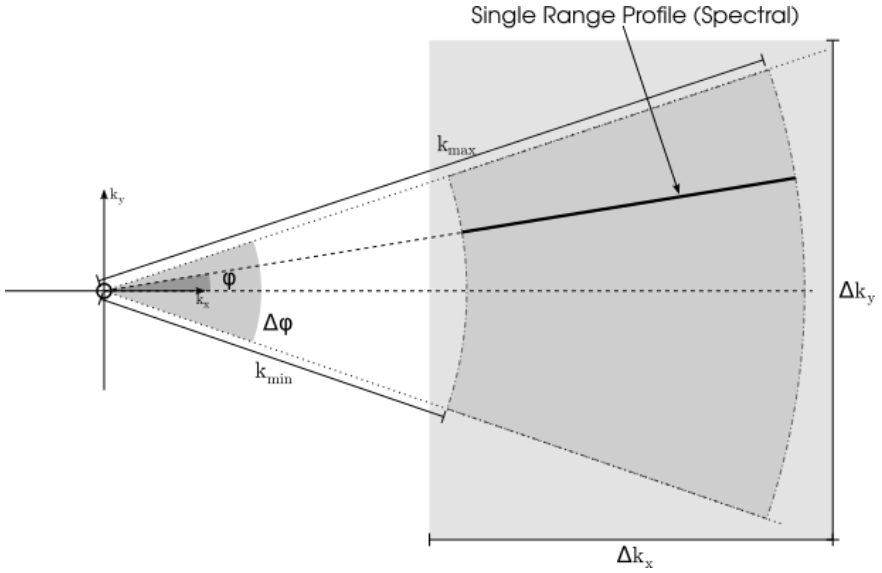
*ESA's Sentinel-1 sensor. S1A-IW-GRD-VV-20221007T151909-20221007T151934-045338-056bb1-001*

# Conventional Spotlight-Mode Synthetic Aperture Radar



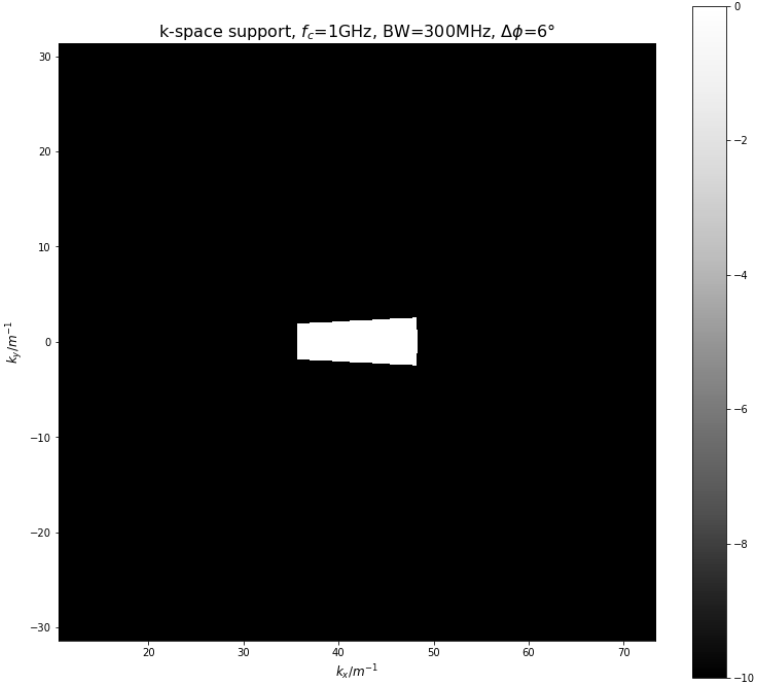
# Conventional Spotlight-Mode Synthetic Aperture Radar

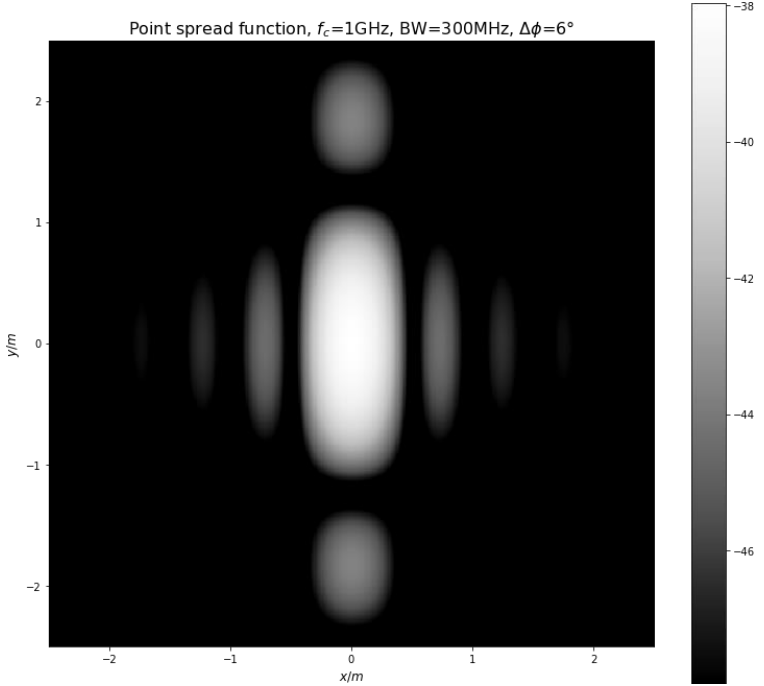


# Conventional Spotlight-Mode Synthetic Aperture Radar

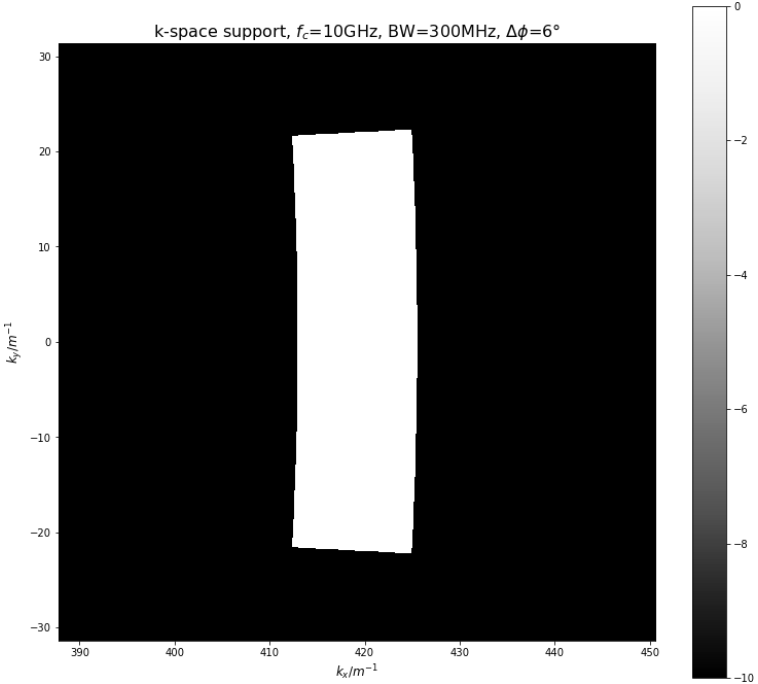
1GHz

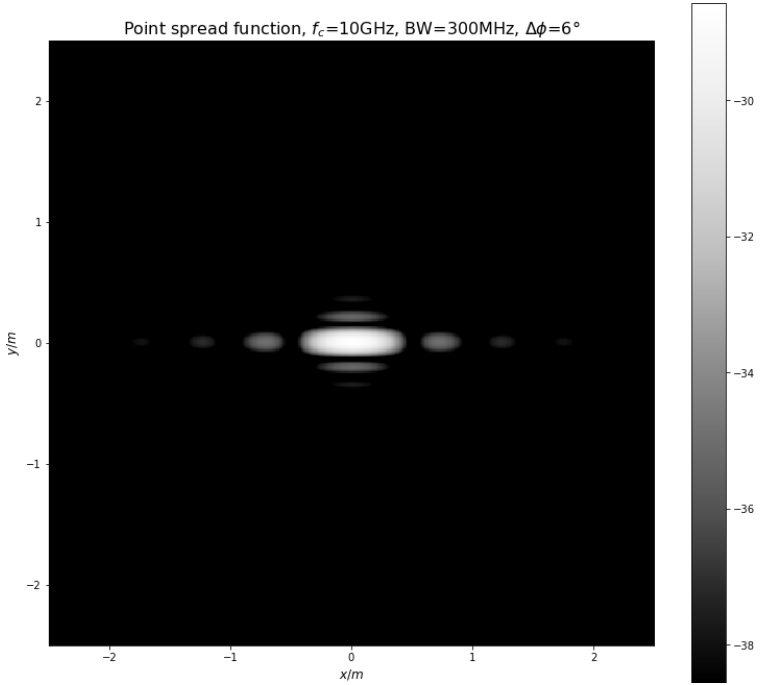


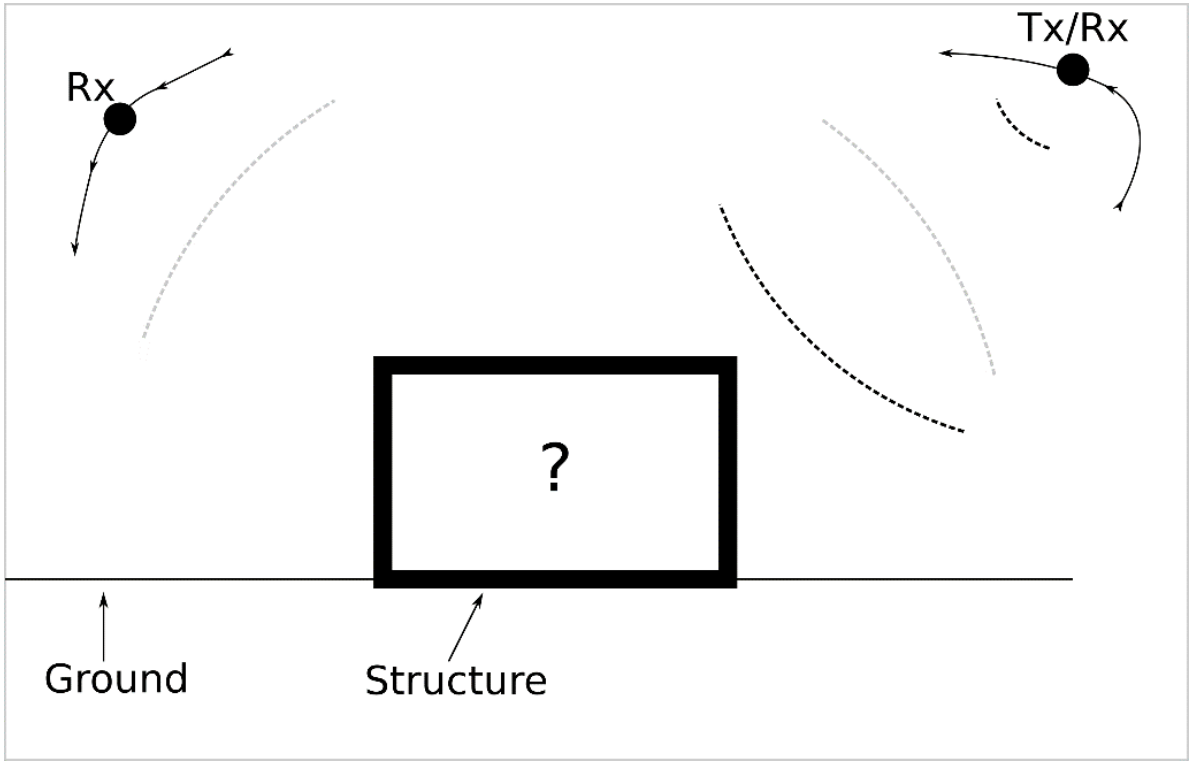
# Conventional Spotlight-Mode Synthetic Aperture Radar

10GHz

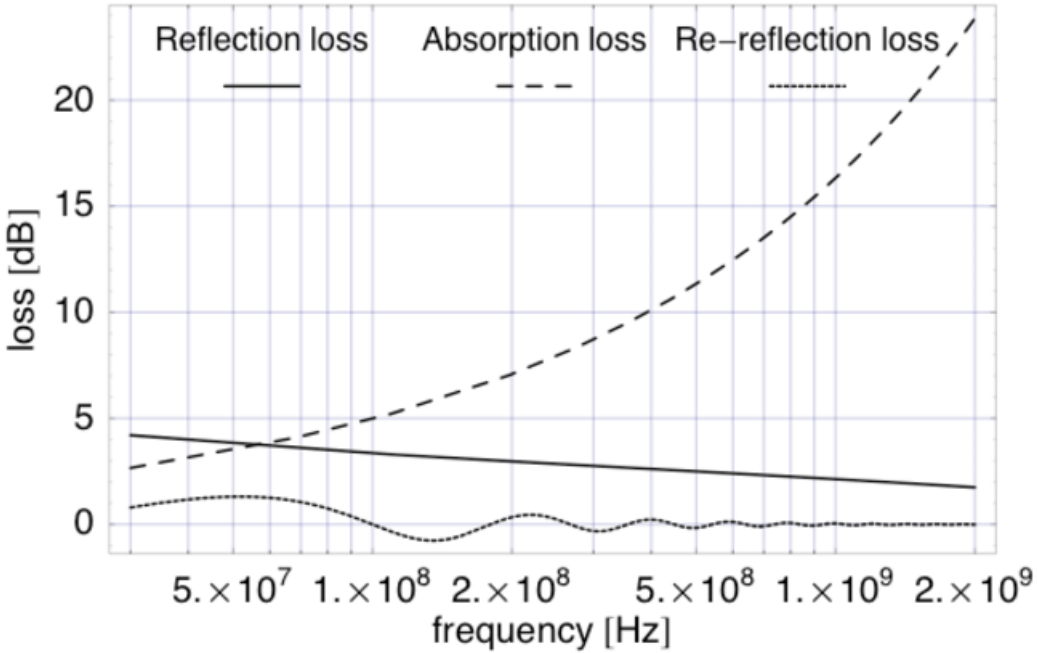


# Through-Wall Imaging Concept

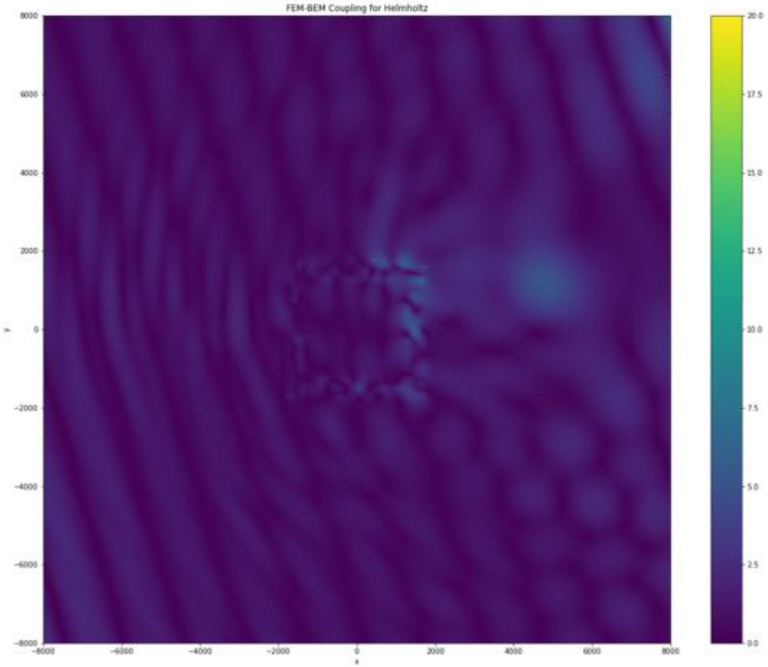


# Building Materials Absorb EM Waves




*Shielding Effectiveness of Concrete Buildings*
*Ogunsola, Reggiani, Sandrolini*
*DOI: 10.1109/EMCECO.2005.1513064*

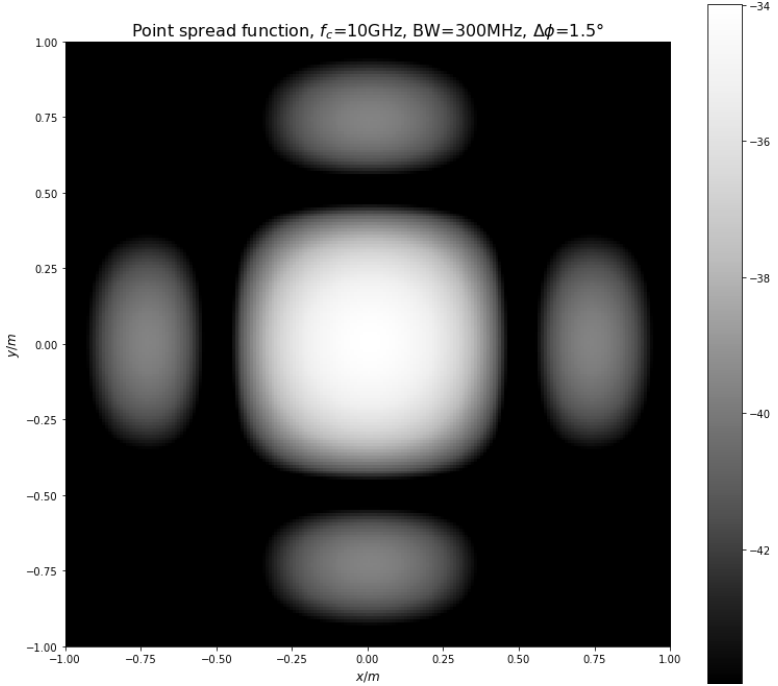
# Building Materials Refract EM Waves



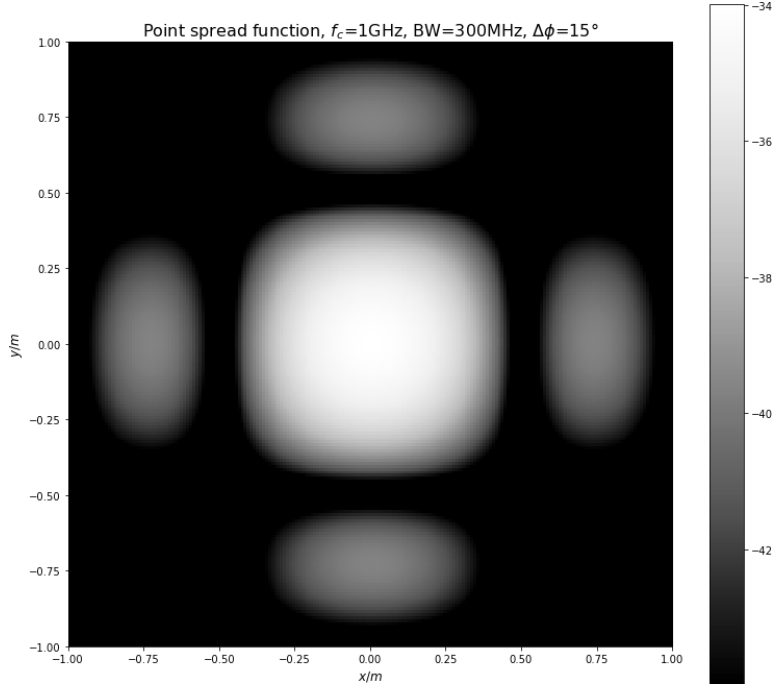
# Building Materials Block and Reflect EM Waves

*Leg of Talbrücke Brünn during construction*
*CC BY-SA 3.0, Florian.Arnd and Störfix*

# Low Frequencies and High Resolution?

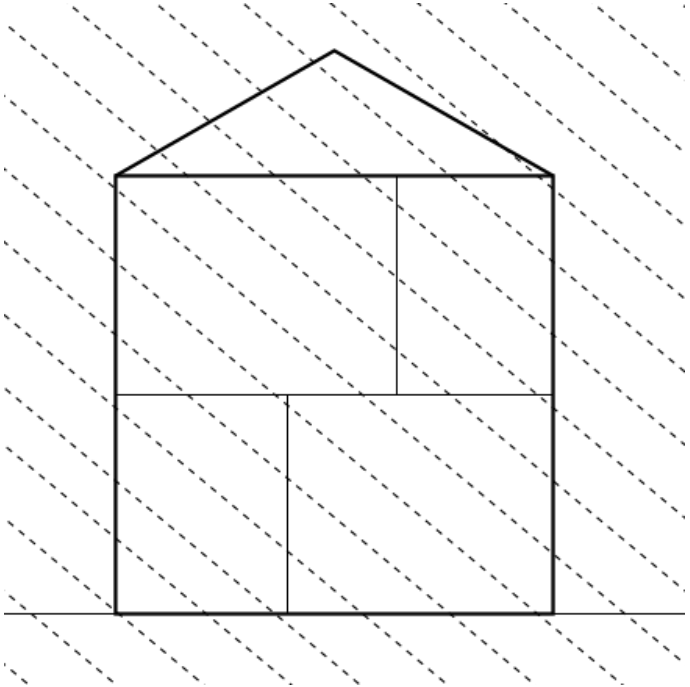



*10GHz, 1.5°*




*1GHz, 15°*

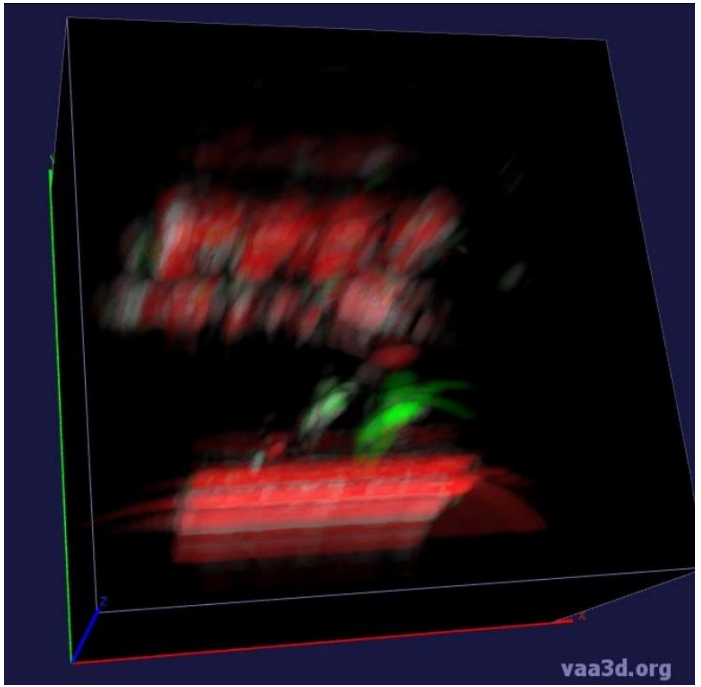
# Buildings are Three Dimensional Objects



# Is Through-Wall Imaging Hopeless?

- **Maybe.**
- As discussed, a lot of obstacles to overcome.

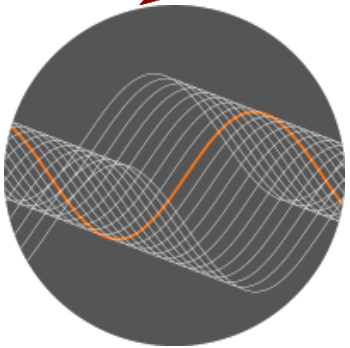
# Experimental Data Collection


*Through-Wall Multistatic Polarimetric 3D SAR*
*Andre, Sabiers, Finnis*
*EuSAR 2022*

# Forward Modelling

*https://fenicsproject.org*



*https://bempp.com*

*https://www.firedrakeproject.org/*


*https://www.gprmax.com/*

$$p(h|m) = \frac{p(m|h)p(h)}{p(m)}$$

# Conclusions

- Horrible problem
- Incremental progress
- A matter of **when**, not **if**, through-wall remote sensing will become commonplace.

[dstl] The Science Inside

Discover more