Towards Determining Wall Properties with Bistatic Radar
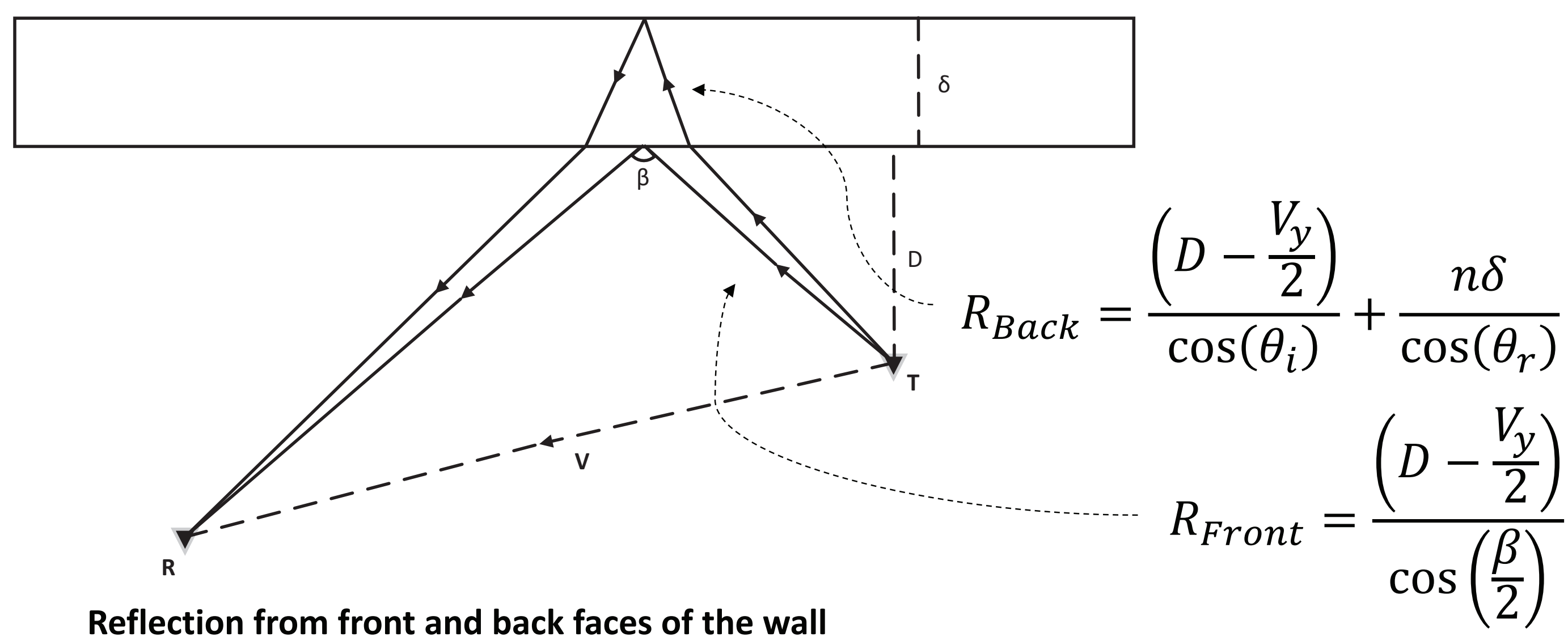
Key Objective
- There is a strong need for **high resolution through-wall remote sensing** imagery of urban environments, for both military and civilian applications.
- A critical aim is to better understand how electromagnetic waves interact with both buildings and building materials, and to: **obtain information about walls remotely, with a novel and practical technique.**

Methodology
Understand the problem through development of better propagation models validated through rigorous experiments and radar imagery development.

Theoretical Basis
To calculate the theoretical range from the radar to the wall, a form of ray-tracing is used; given wave refraction, the minimum distance from the transmitter (T) to the wall and back to the receiver (R) is calculated.

$$R_{Back} = \frac{\left(D - \frac{V_y}{2}\right)}{\cos(\theta_i)} + \frac{n\delta}{\cos(\theta_r)}$$

$$R_{Front} = \frac{\left(D - \frac{V_y}{2}\right)}{\cos\left(\frac{\beta}{2}\right)}$$

Reflection from front and back faces of the wall

Using the theory, a parameter estimation algorithm was developed to evaluate the refractive index (n) and the thickness (δ) of the measured wall.
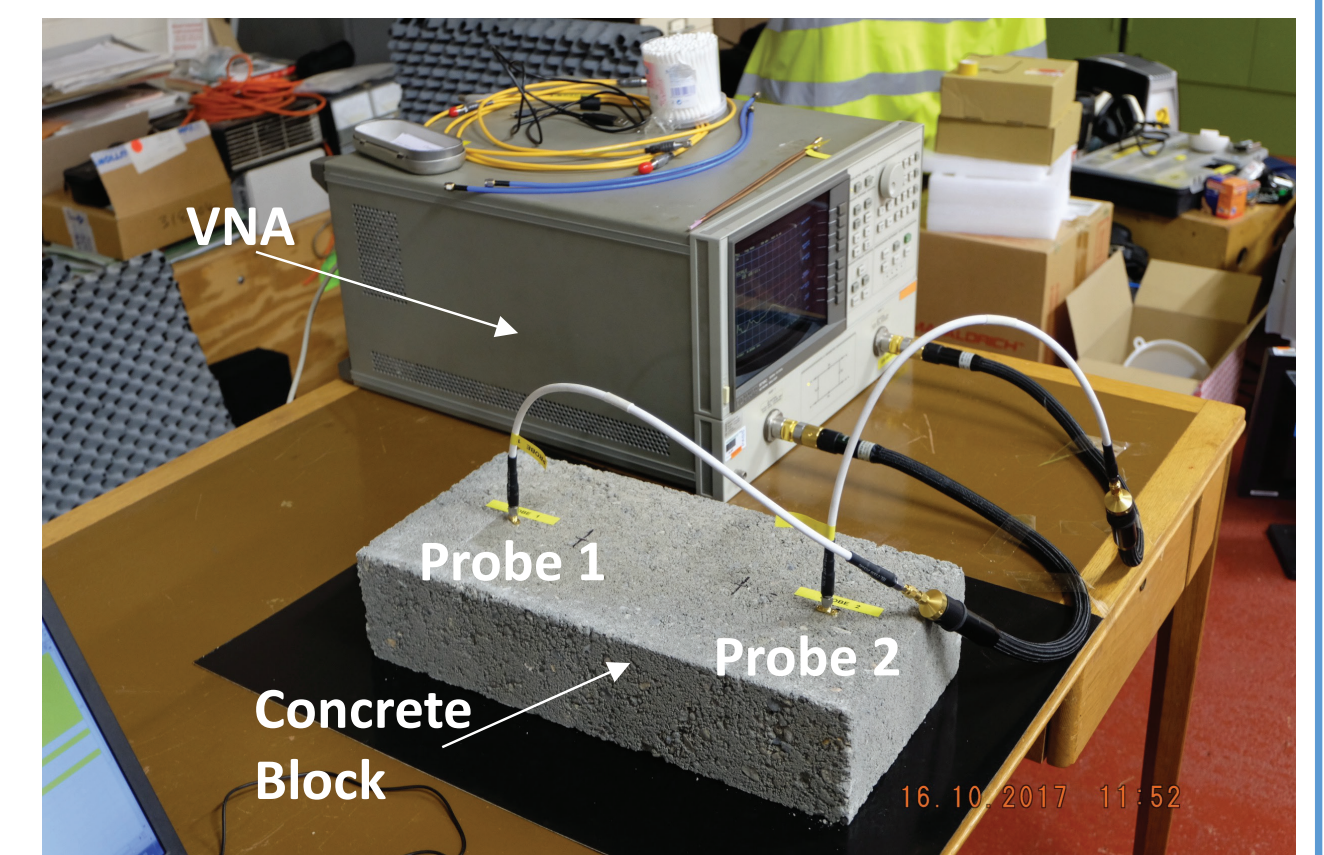
Laboratory Measurements
Bistatic SAR and probe measurements were conducted in Cranfield's Antennas and Ground Based SAR Laboratory (AGBSAR), with frequency range of 1-6GHz.


Bistatic radar measurement
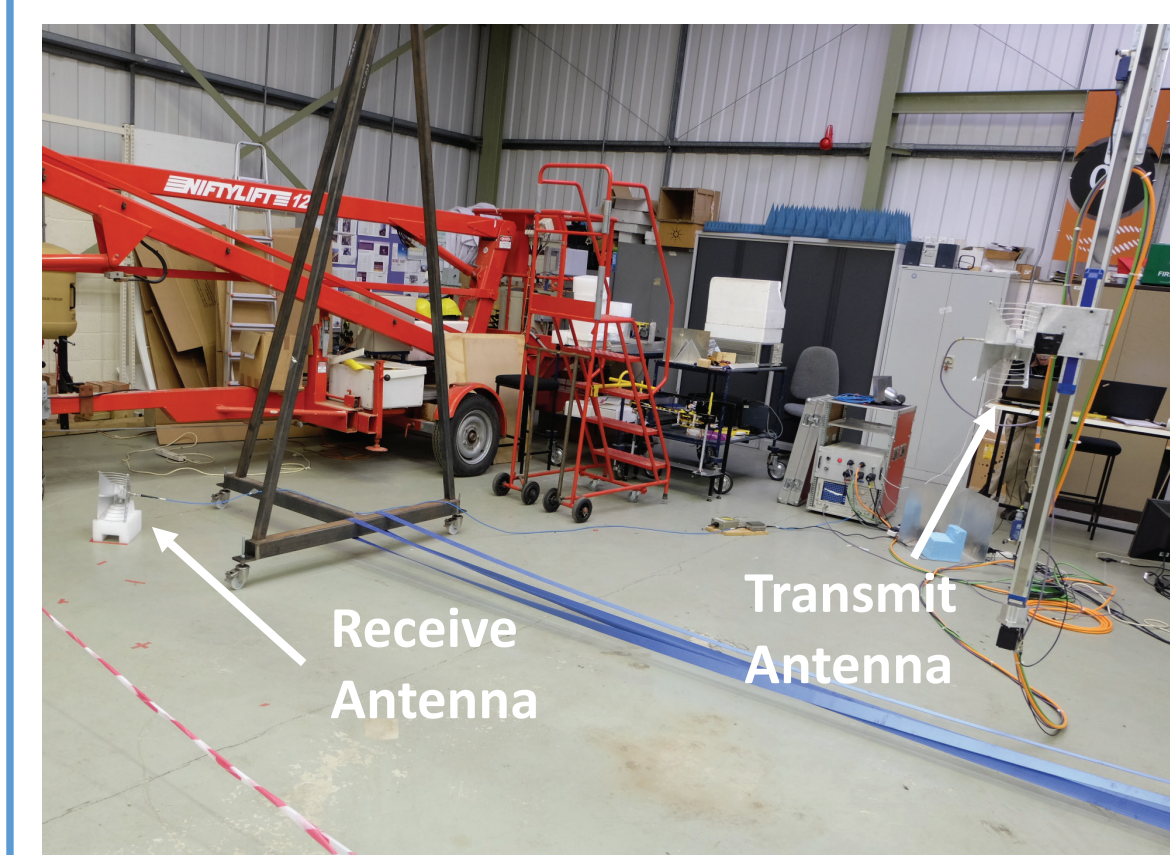
Bistatic radar antennas

Concrete block undergoing microwave measurement as a grounded dielectric slab waveguide
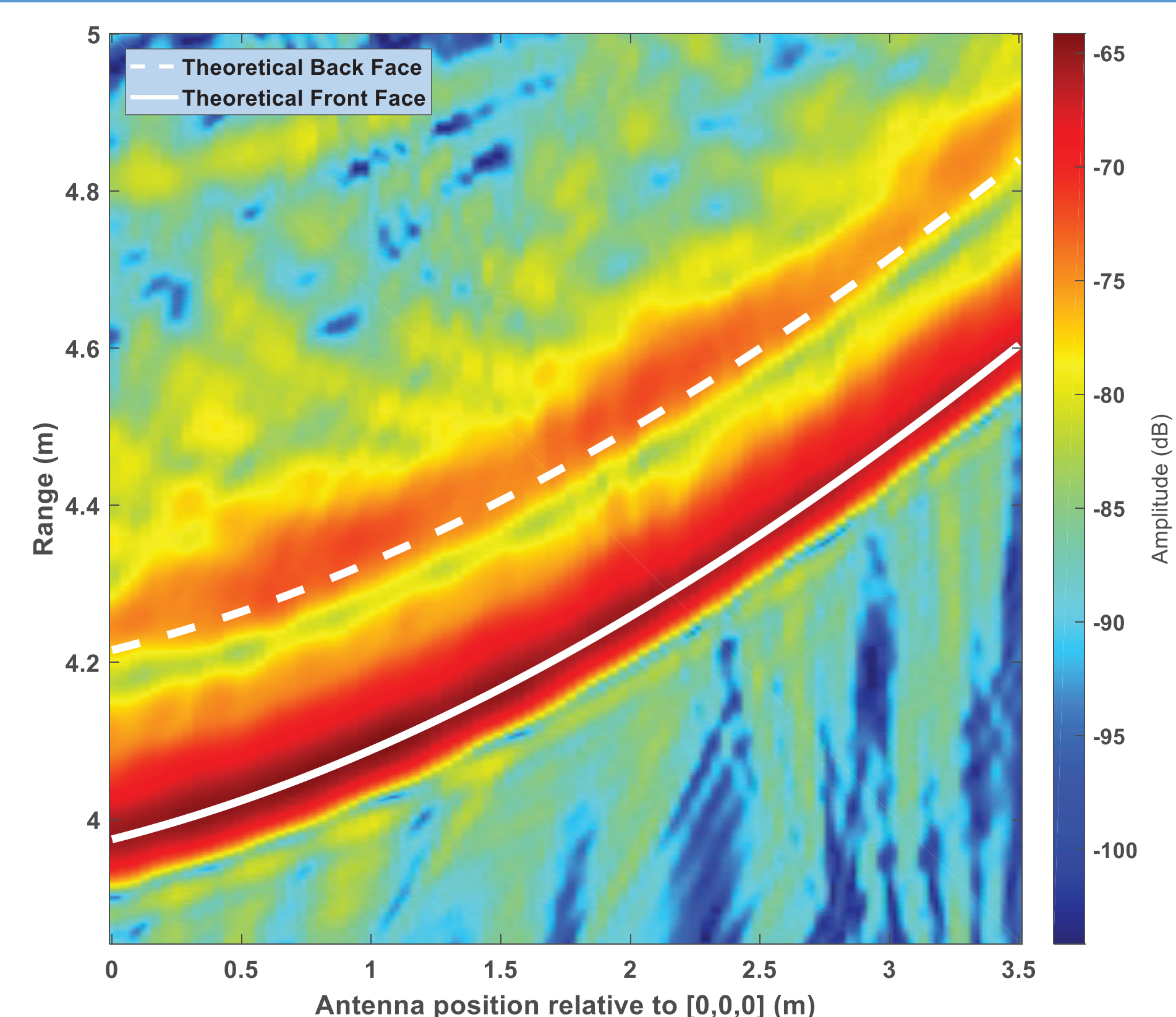
Results
- **A novel bistatic geometry** suppresses the unwanted signatures, such as strong ground-wall bounce scattering.
- This symmetry breaking allows for an analysis of front-back wall signatures which **cannot** be done with monostatic geometries.
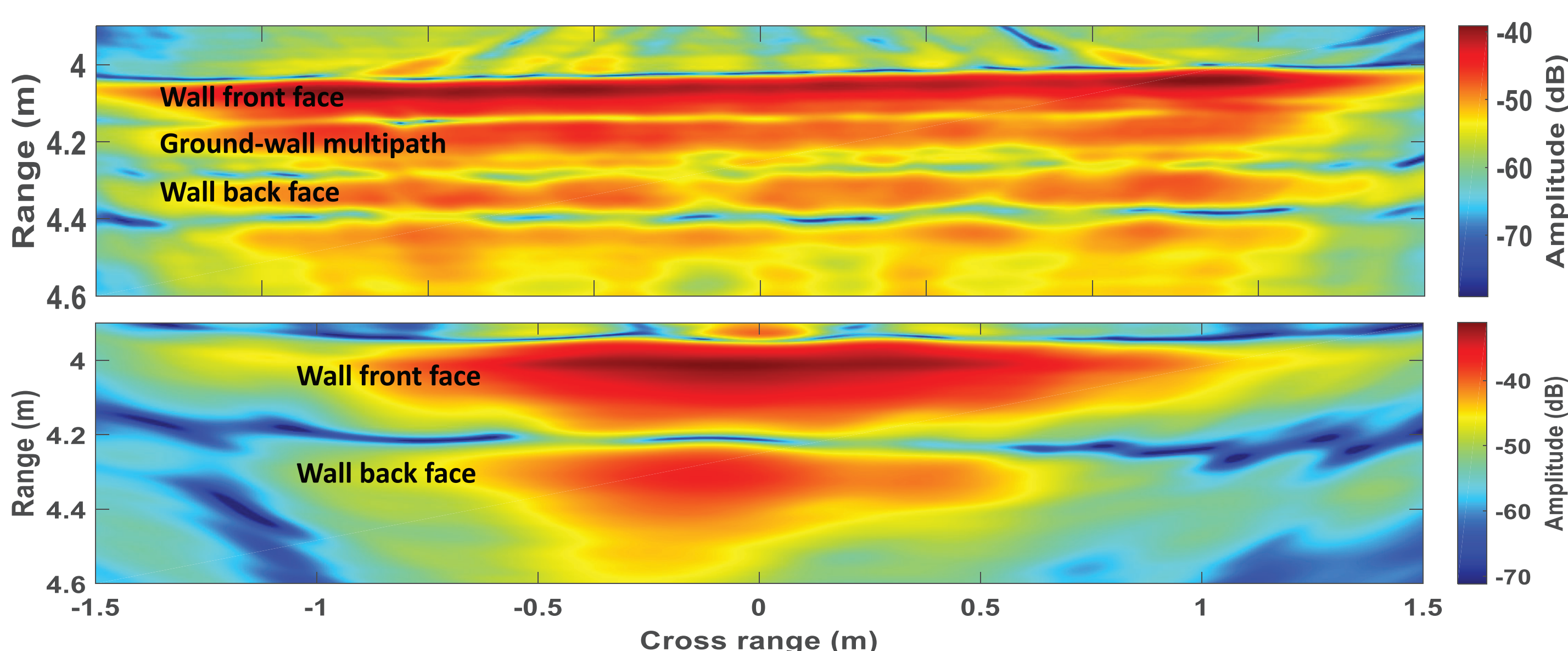
Monostatic (top) and Bistatic (bottom) SAR images of same wall

Bistatic range profiles showing front and back face wall reflection

- Varying bistatic range profiles are used to estimate properties of the wall.
- These properties were compared to an established invasive method.
- Sources of error, such as moisture content, are being investigated.

This work will help to identify building walls material and thickness, remotely

	Transmission Line Approach	Bistatic Radar Approach
Refractive Index	2.4	2.8
Thickness (m)	0.10 (ruler measurement)	0.1

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