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Microwave Characterisation of Materials using a Quasi-Optical Free-Space Focussed Beam System

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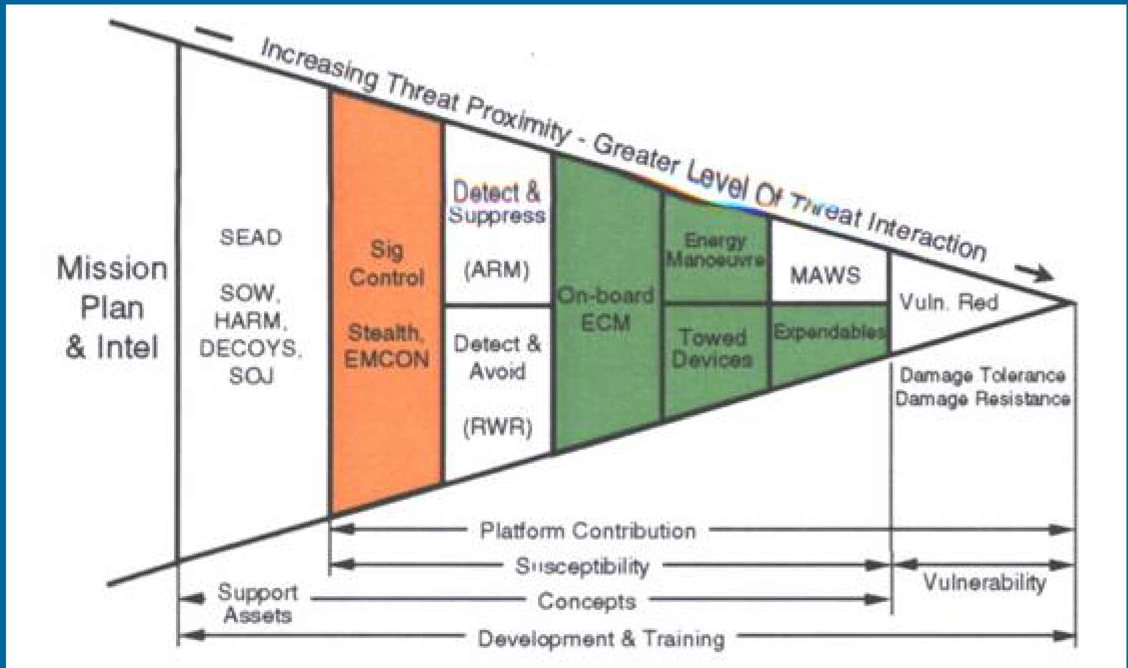
Introduction

- Rationale for microwave measurements, why make EM measurements?
- What we measure and why
- Current microwave measurement techniques
- Need for free-space technique
- Apparatus and Method
- Benefits
- Overview of results carried out using the system
- Summary and Conclusions

EM Measurements - Why? Radar Signature Management

- Used to improve platform survivability with other methods:
  - Shaping
  - Passive Cancellation
  - Active Cancellation
- Influences, detectability, only one factor in overall survivability however
- Survivability is one of the top level properties (ALFAS) of a platform



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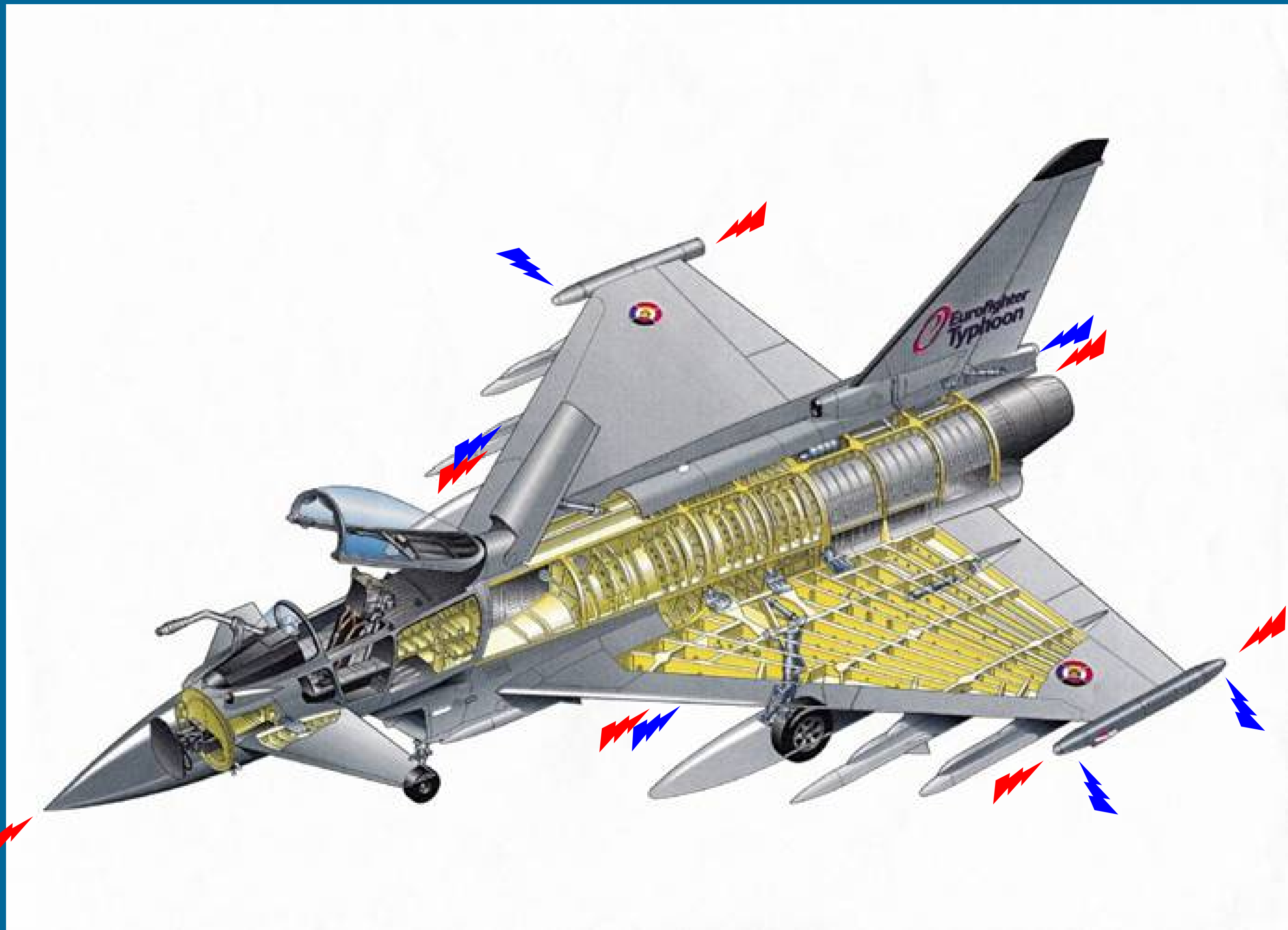
EM Measurements - Why? EMI Reduction - Example EFA



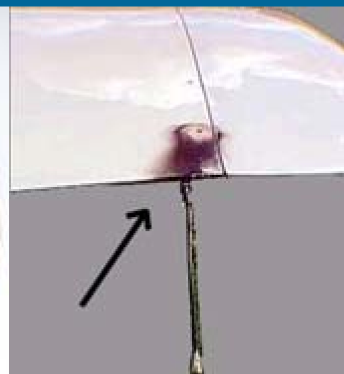
•Also important for airport search radars

EM Measurements - Why? EMC and Screening

- Military Aircraft - NEMP specification compliance
- Military Aircraft - HPM DEW
- Military Aircraft - TEMPEST regulations
- Civilian Aircraft - EMC spec. and mobile phone use

Other Needs for EM Characterisation

- Radome Design and Manufacture - Low loss materials
- Lightning Protection
- LO Antenna design and manufacture
- Device manufacture, e.g. delay lines, resonators etc



AMSAR or **A**irborne **M**ulti-mode **S**olid-state **A**ctive-array **R**adar

Material Parameters

- Reflection and Transmission Loss
- Complex Permittivity and Permeability (refractive index)
- Sheet resistivity of thin layers
- Normalized lumped admittance of thin layers
- Radar Cross Section (of objects)

Methods




- Slotted line - homogeneous materials
- Conventional Waveguide - homogeneous, non-low-loss materials
- Dielectric Waveguide - for homogeneous materials or thin sheets
- Open/Cavity Resonator - very low loss (radome) materials
- Co-axial Probe - broadband dielectrics, intermediate loss
- Free space techniques - lossy in-homogeneous materials

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Quasi Optical Free Space Focussed Gaussian Beam Systems

•Use pair of corrugated horn feeds to generate a beam with Gaussian amplitude

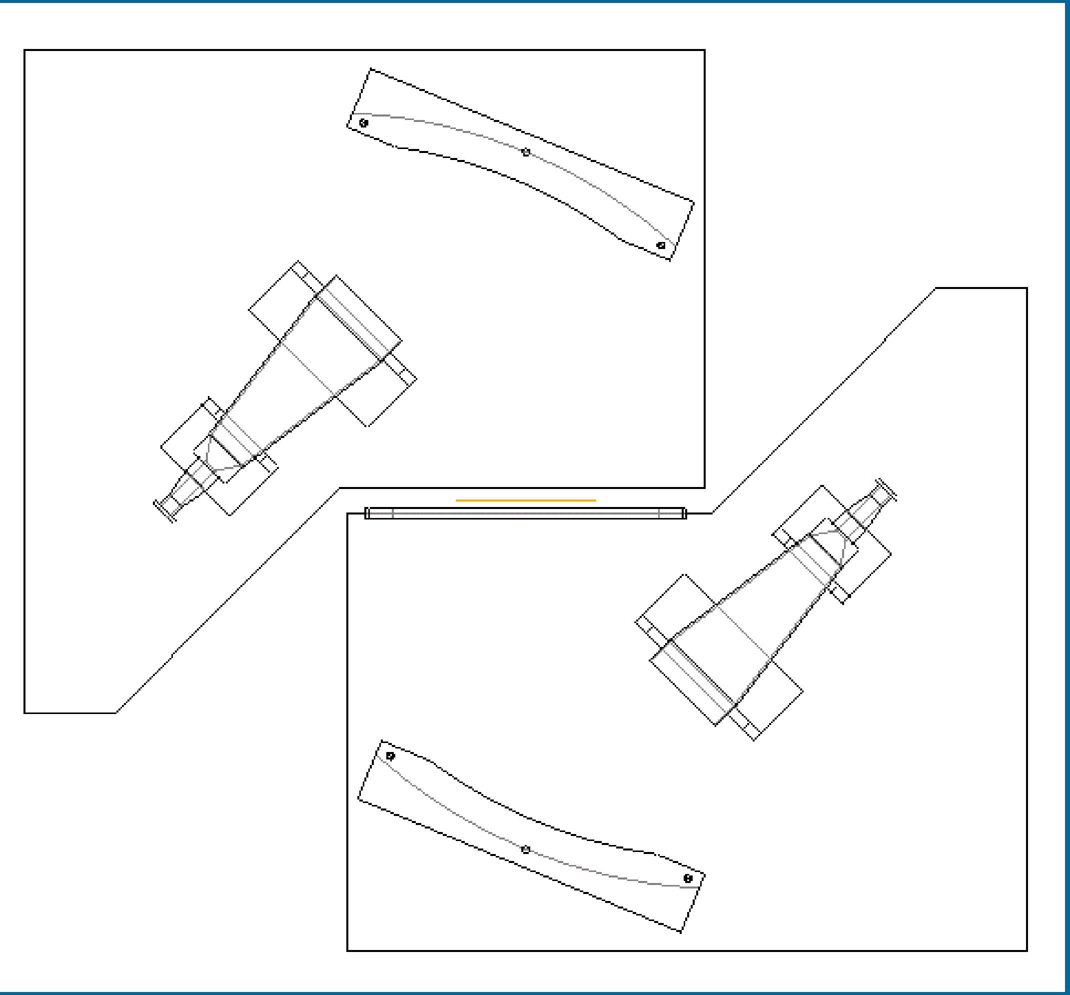
•Reflect beam off spherical/elliptical reflectors

•Pass beam through sample in forward and reverse directions

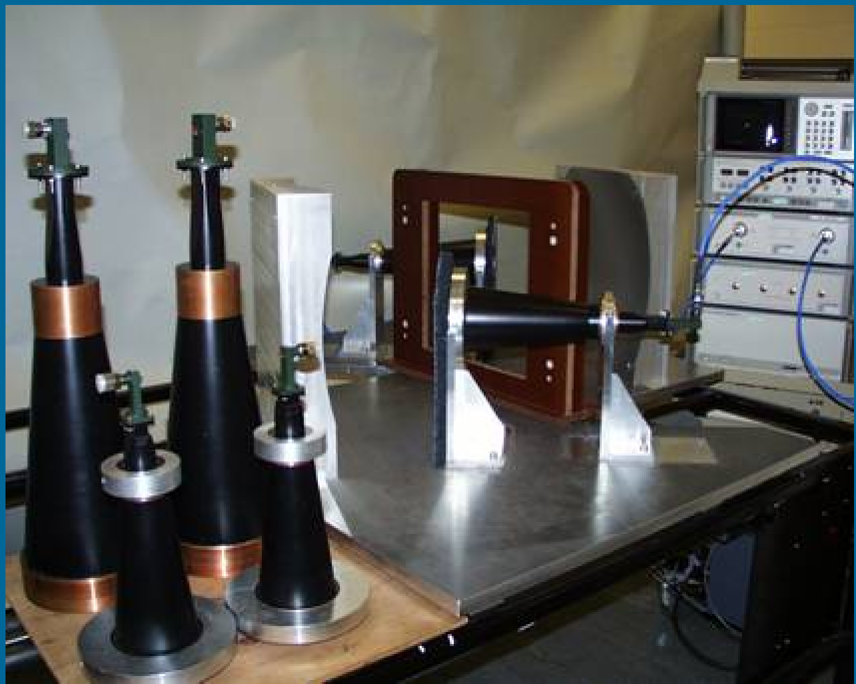
•Half of system is movable

•Permits TRL calibration

Plan View of a Focussed Beam System



The High Frequency Focussed Beam System In Use



The Low Frequency Focussed Beam System in Use

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WG8 and WG12 Feed Horns

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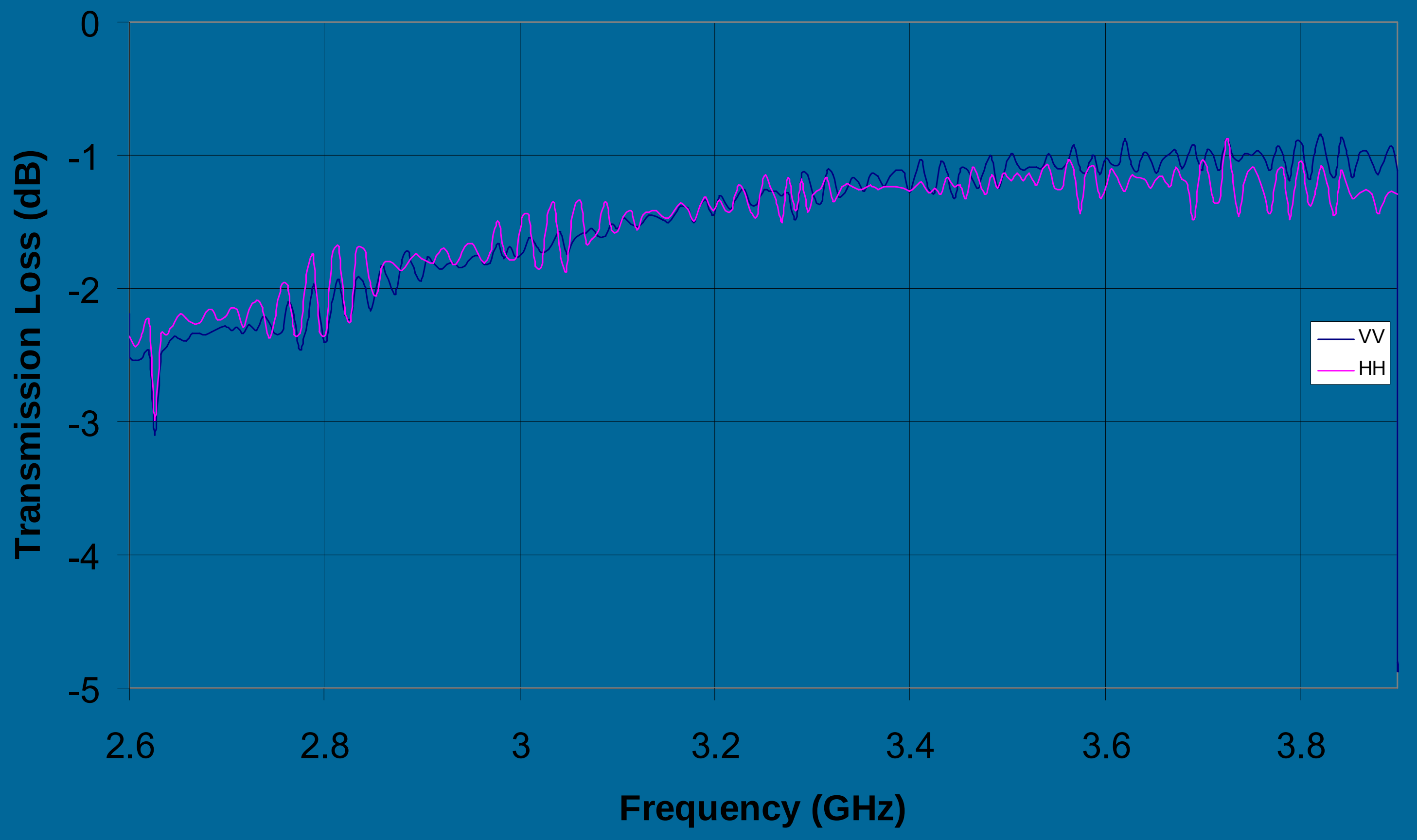
Benefits of This Equipment

- Can obtain permittivity/permeability for inhomogeneous materials.
- Permits characterisation of dispersives.
- Can be used to determine thin layer properties.
- Products supplied to customers are measured directly, no need for WG.
- Can measure S-parameters of FSSs or CARAM

Measured S21 Through System



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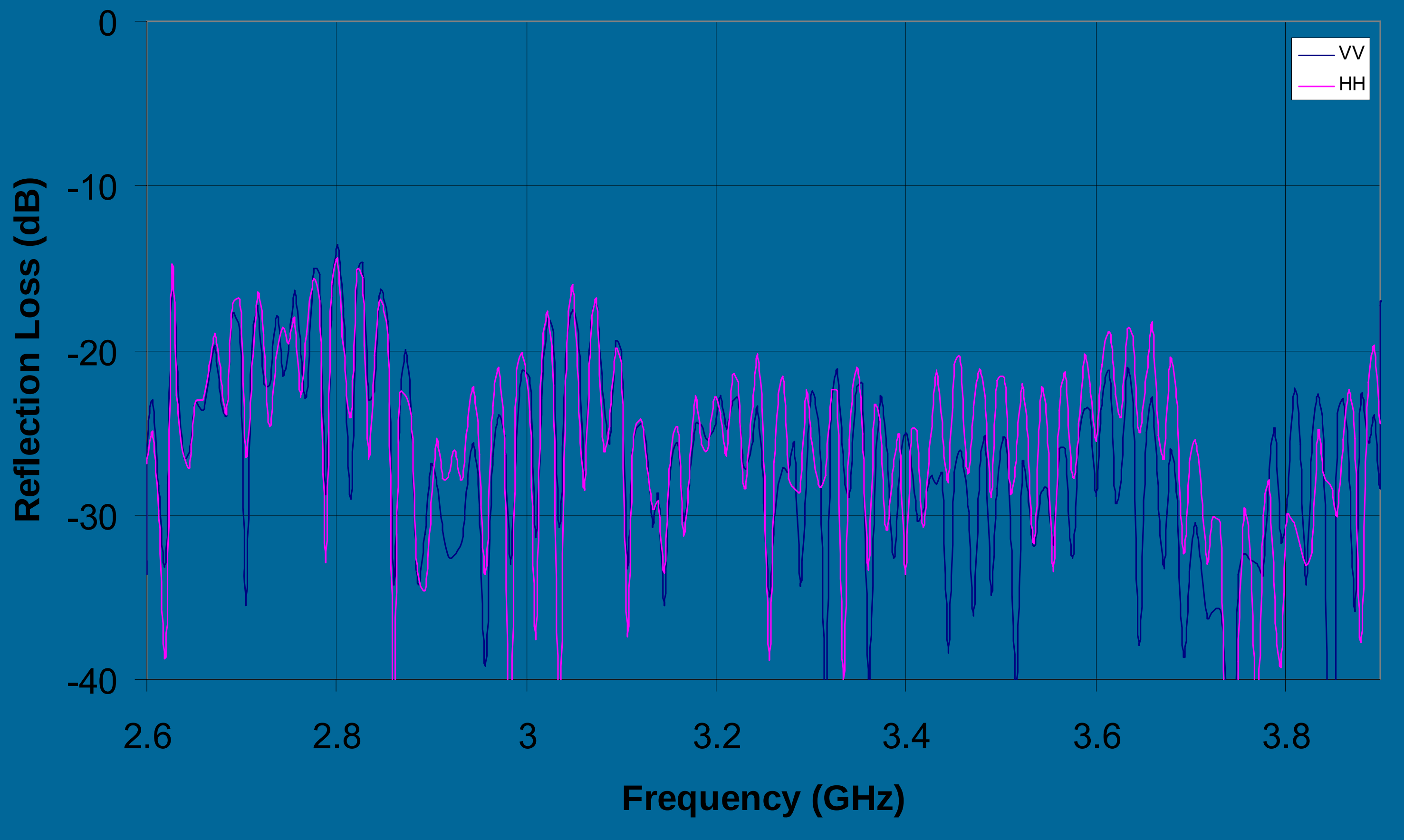
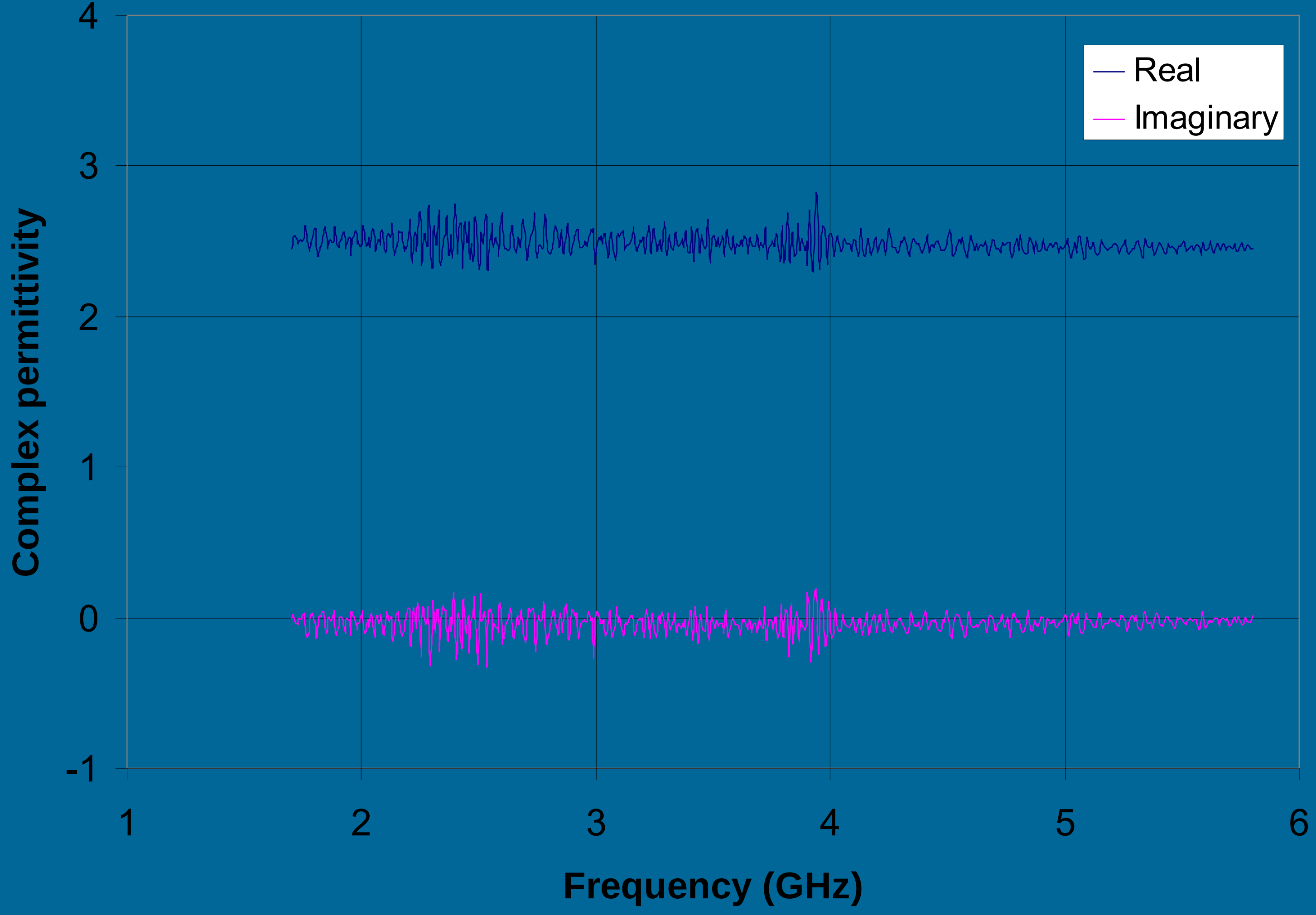
Measured S11 of the System



Measured Complex Permittivity of Perspex



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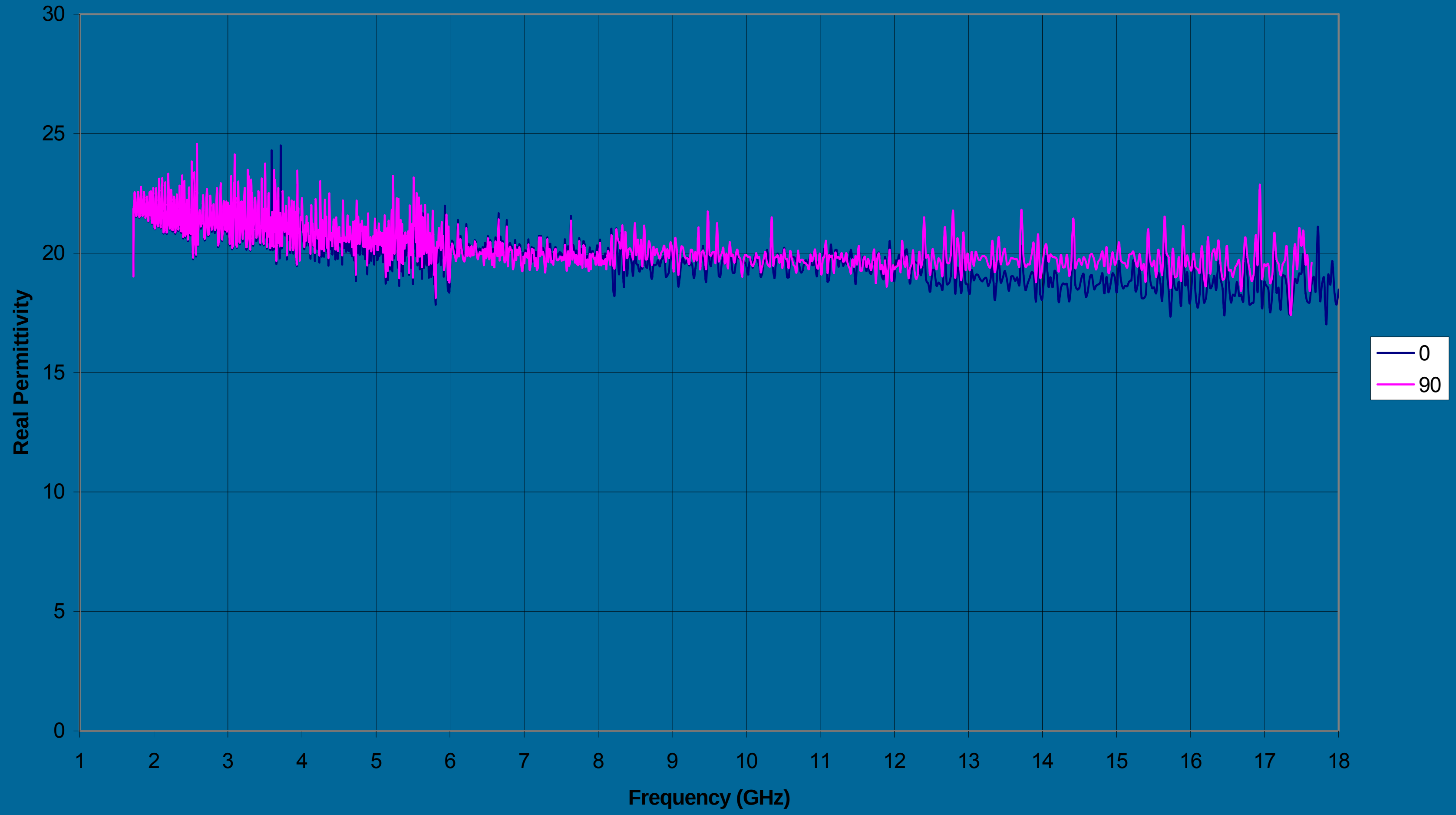
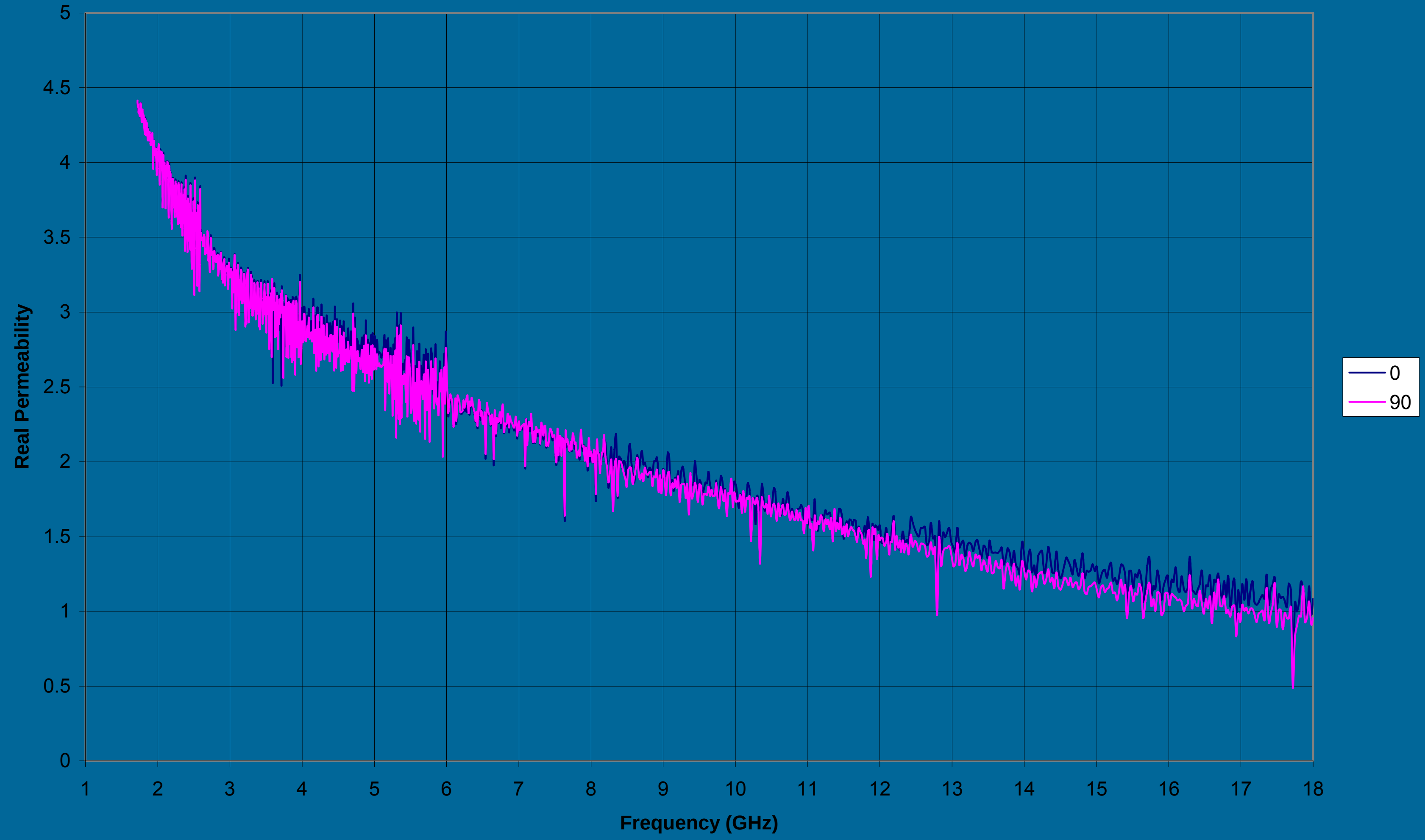
Broadband free-space measurement of 50% iron loaded elastomer



Broadband free-space measurement of 50% iron loaded elastomer



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Conclusions

- Proven to be an accurate and effective technique
- System losses can be an issue, so can stray fields
- Technique provides large area illumination removing effects of in-homogeneities
- Permits products supplied to customers to be measured directly - no need for WG samples
- Can function at significantly higher frequencies than WG (W-band)