Free Space and Absorber Box Methods of Planar Shielding Measurement

Dawson, J. & Pissoort, D. , "Overview of the P2715 WG - IEEE Guide for the Characterization of the shielding effectiveness of planar material: Double Horn Set-up/Absorber Box" , Electromagnetic Compatibility (EMC), 2019 IEEE International Symposium on , 2019

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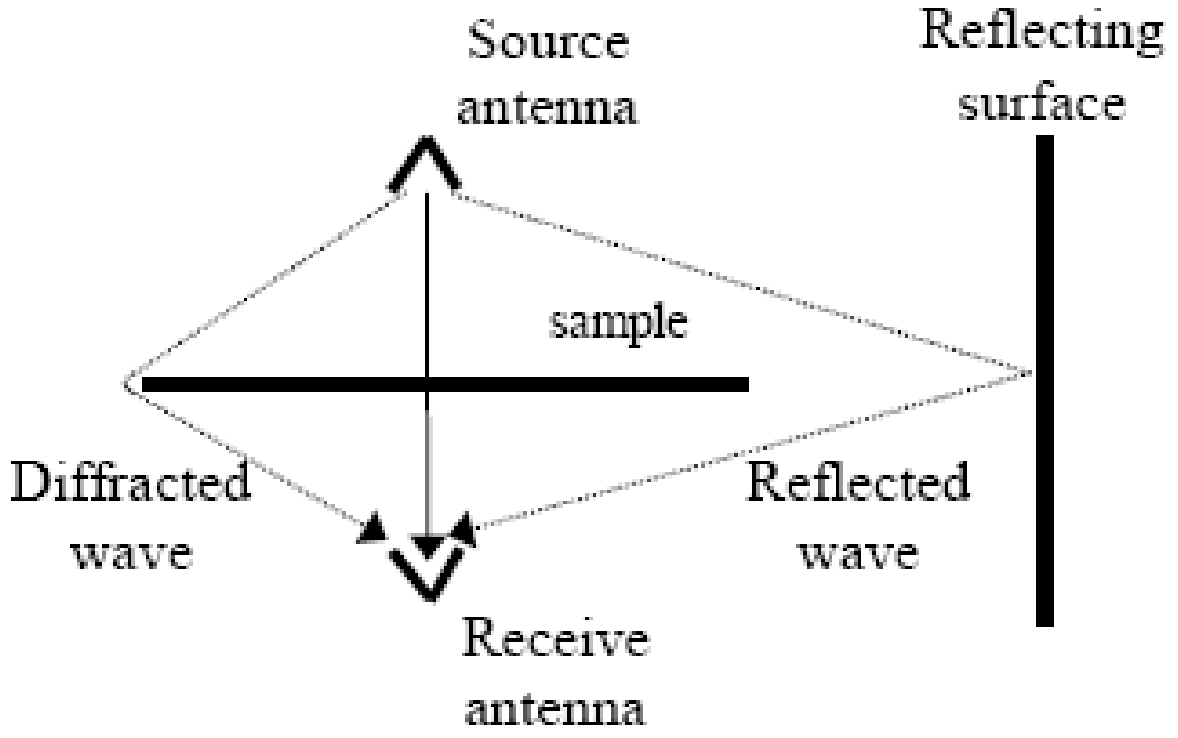
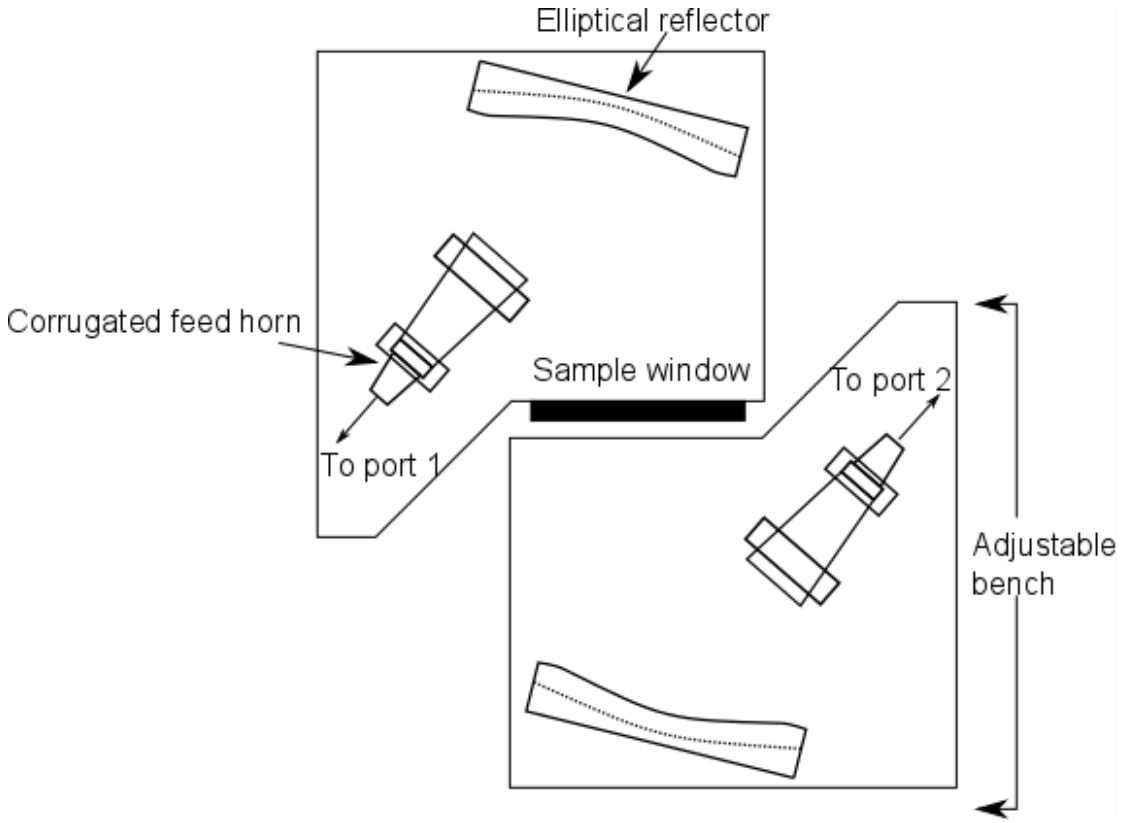
The free space method - concept

- Why not just shine a beam at the sample ?
- Edge diffraction and reflections make this difficult
- Need a focussed (Gaussian Beam)
- Sample must be large in wavelengths



The free space method - reality

- Need to focus beam (Gaussian beam)
- Minimise edge diffraction
- Sample must be large in wavelengths
  - 600mm x 600mm sample for 8.2GHz to 12.4GHz.
- May need absorber on and around jig to minimise reflections
- May be able to time gate reflections



Images Courtesy of BAE Systems

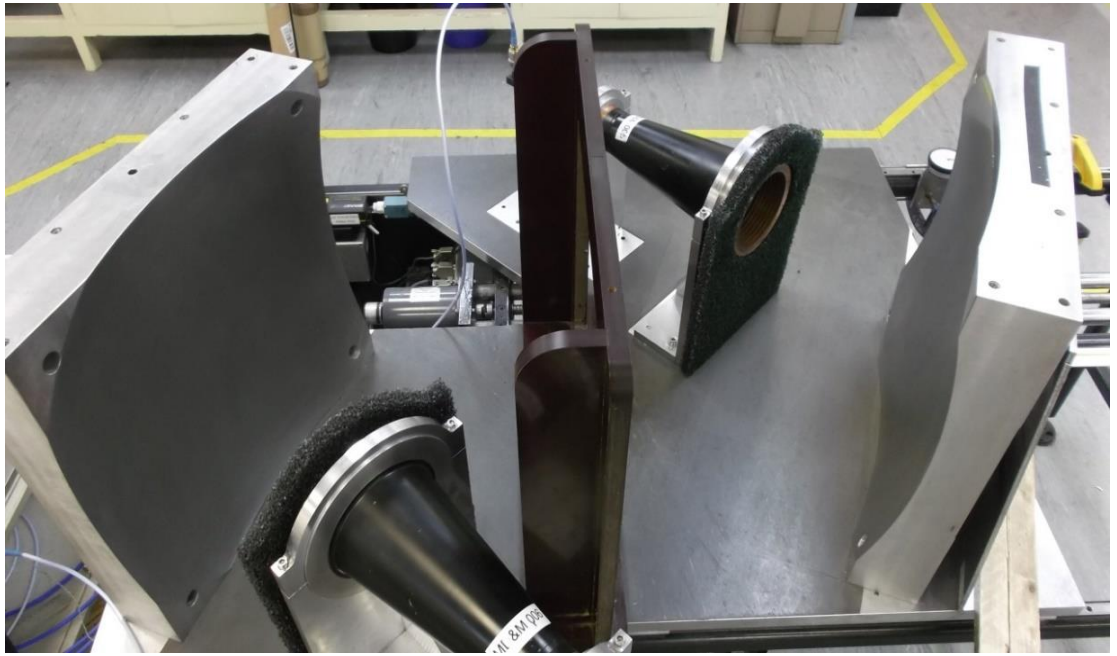
See also: Clarke, B., Gregory, A., Cannel, D., Patrick, M., Wylie, S., Youngs, I., & Hill, H. (2003). *A guide to characterisation of dielectric materials at RF and microwave frequencies.* London: NPL

The free space method - SE

- Thru, Reflect, Line calibration ofA Simple calculation of SE used here:

$$SE = -20 \log_{10} S_{12,\text{sample}} \text{ dB}$$

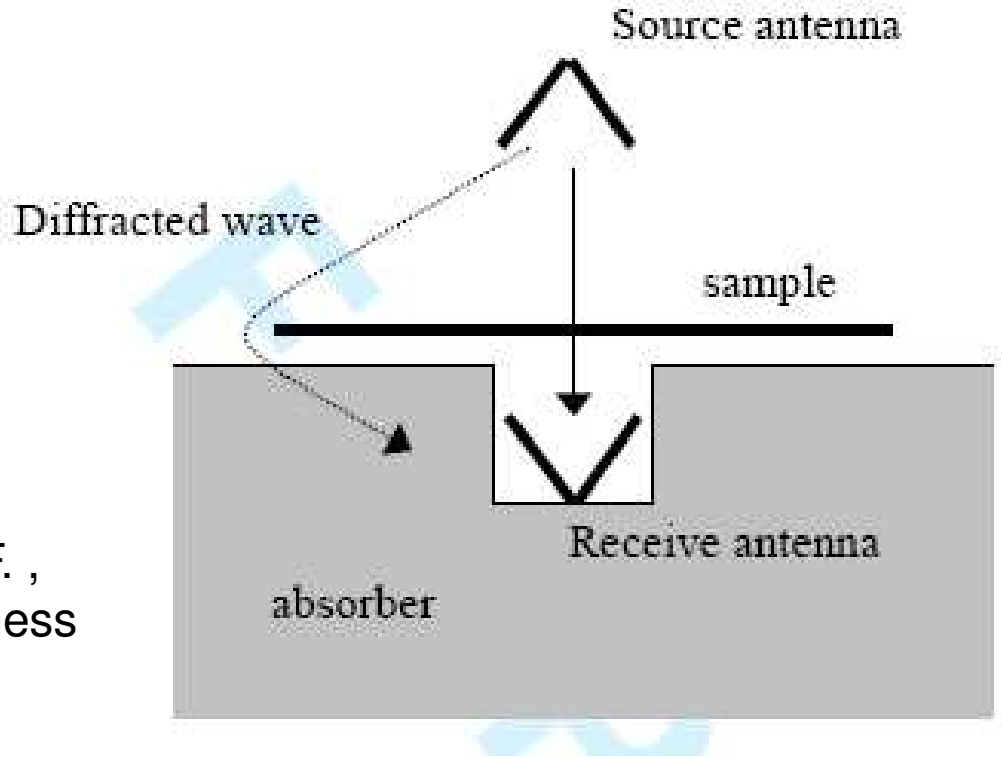
- $S_{12,\text{sample}}$ is the transmission between antennas for the jig with sample in place
- Can measure two polarisations by rotating sample and cross polar also if antenna is rotated.



Images Courtesy of BAE Systems

Absorber box method – concept

- Surround one (or both) Antenna(s) with radio absorptive material
- Prevent diffraction and reflections
- No sample edge preparation – just overlap
- Works 1-10GHz (current system)



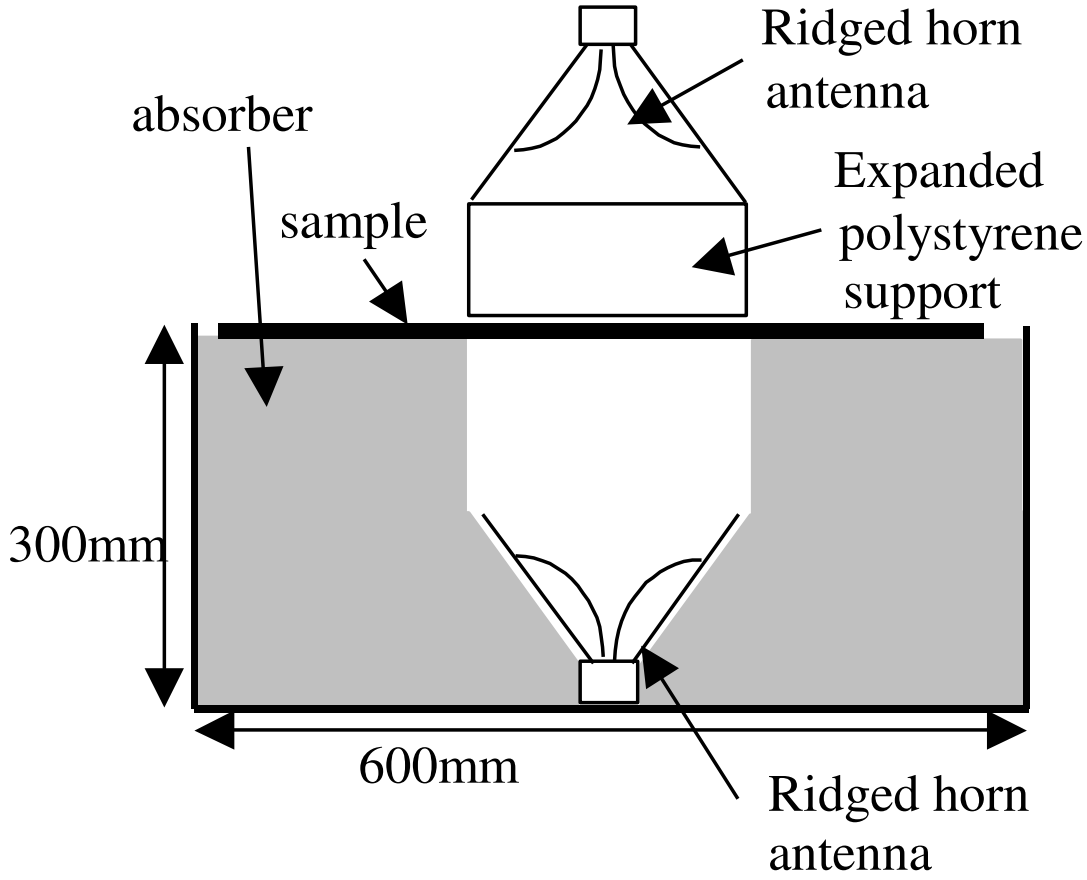
Marvin, A. C.; Dawson, L.; Flintoft, I. D. & Dawson, J. F. , "A Method for the Measurement of Shielding Effectiveness of Planar Samples Requiring No Sample Edge Preparation or Contact" , *IEEE Transactions on Electromagnetic Compatibility* , *vol. 51, no. 2* , 255-262 , May, 2009

Absorber box method - SE

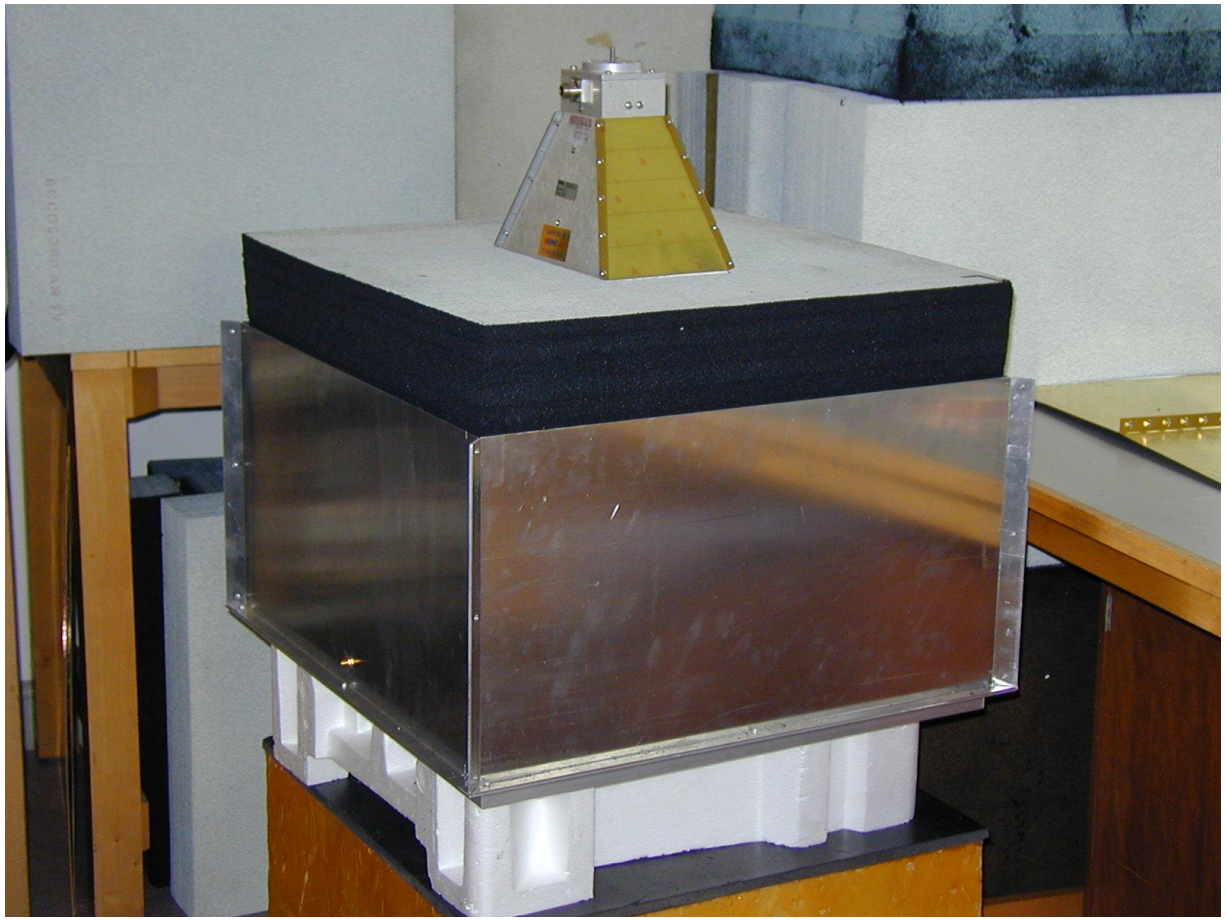
- SE using known reference:

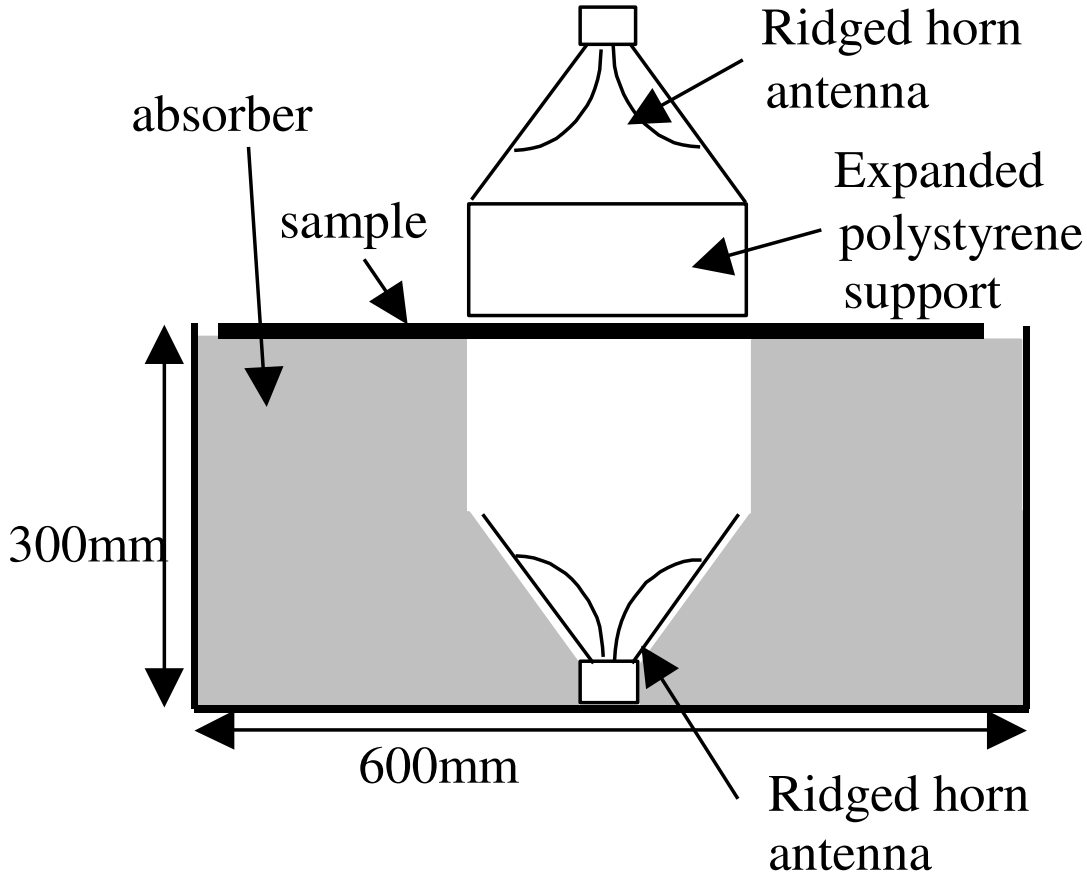
$$SE = SE_{\text{ref}} + 20\log_{10}\frac{S_{21,\text{ref}}}{S_{21,\text{sample}}}\ \text{dB}$$

- $S_{21,\text{ref}}$ is the transmission between antennas with known sample having SE_{ref} (in dB)
- $S_{21,\text{sample}}$ is the between antennas with unknown sample in place
- Can measure two polarisations by rotating sample



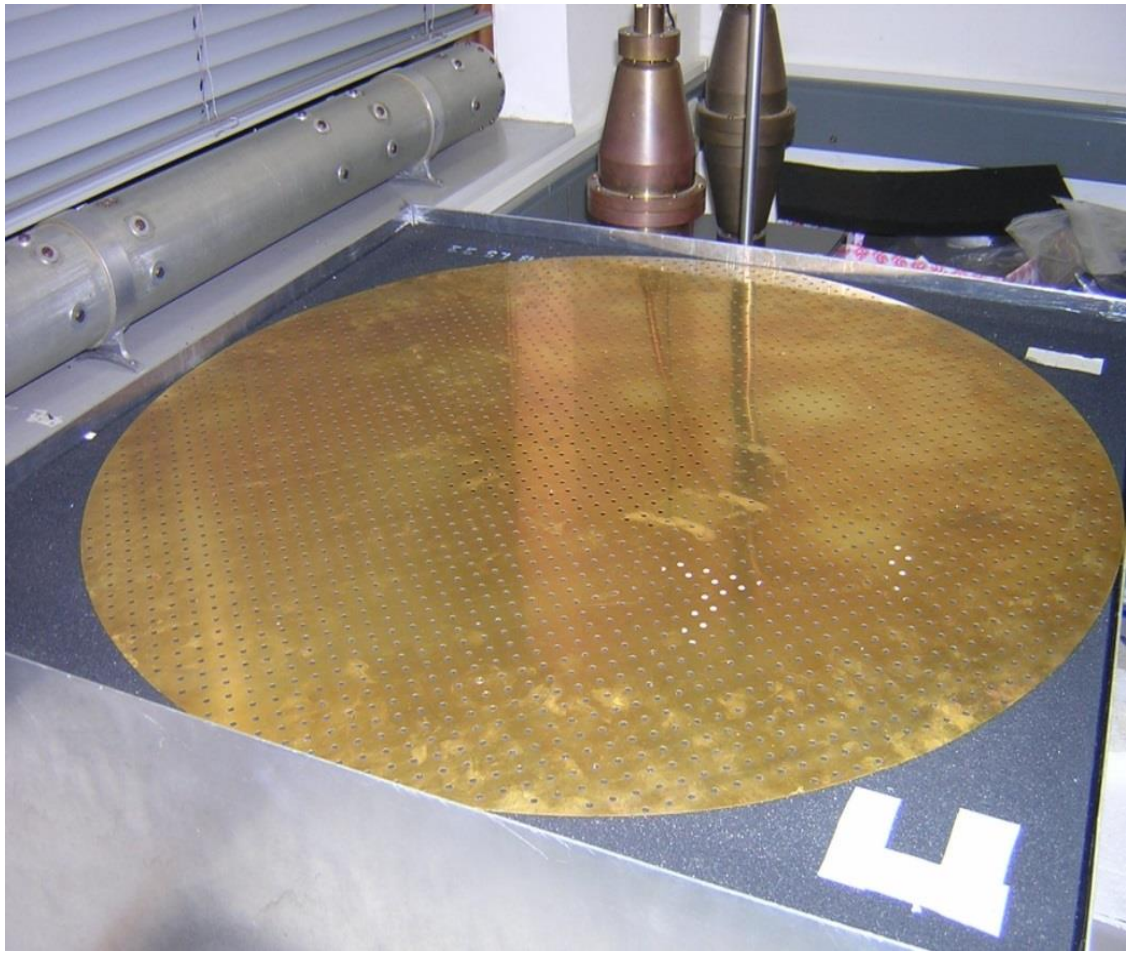
Absorber box method - reality





Absorber box method - reality

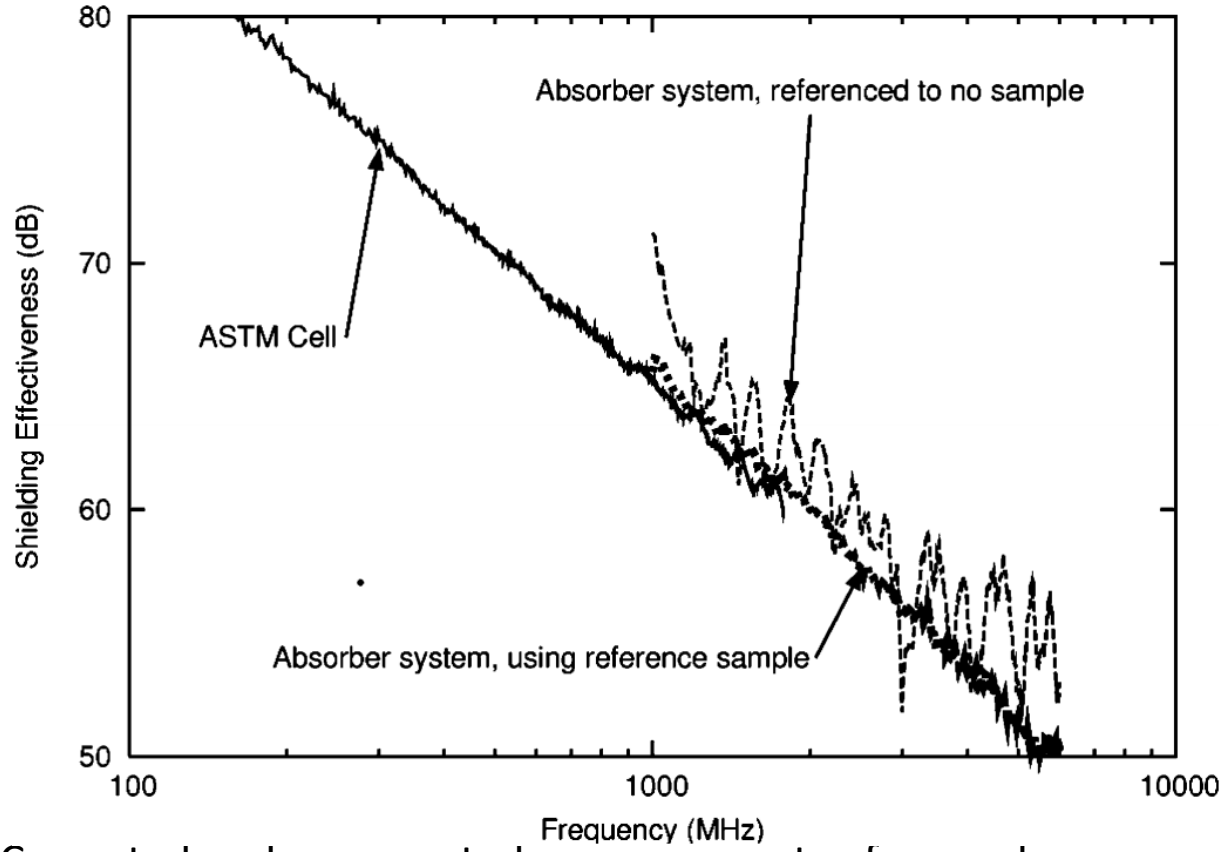
- In practice we use a known reference sample for calibration
- Proximity of the absorber to RAM means simple free-space assumptions no longer apply
- As sample just sits on absorber no special preparation is required
- Anisotropic materials can be measured easily



Measurement video

Video showing measurement of reference sheet and sample takes about 90s. The sample edge is prepared with plastic tape to avoid fraying and to protect hands from fibres

Some results compared to other methods



Corrected and uncorrected measurements of second-perforated brass plate (in absorber system) and ASTM cell measurement.

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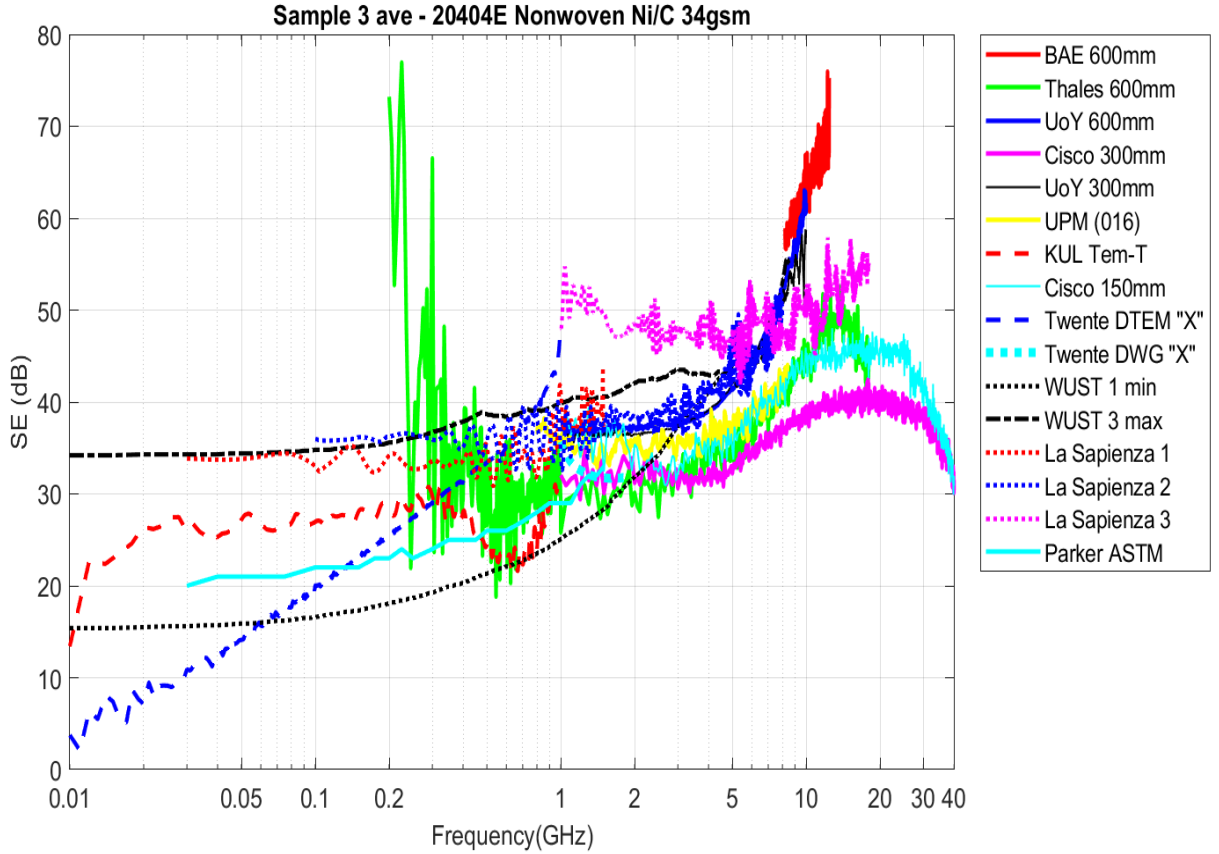
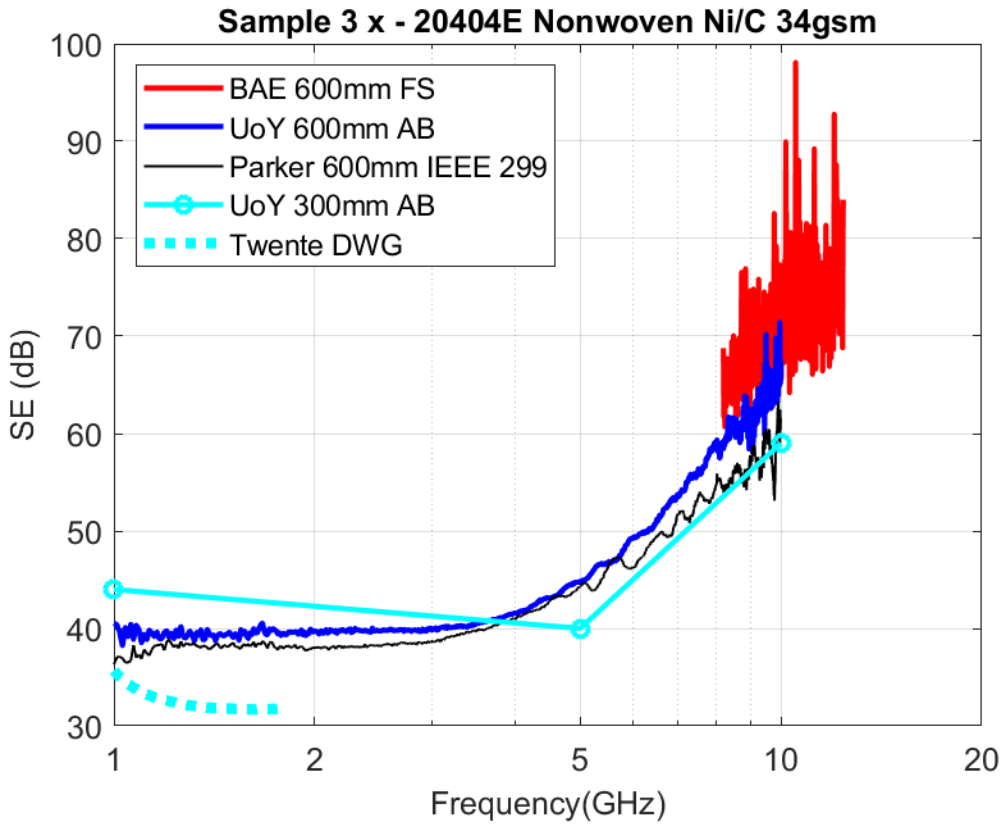
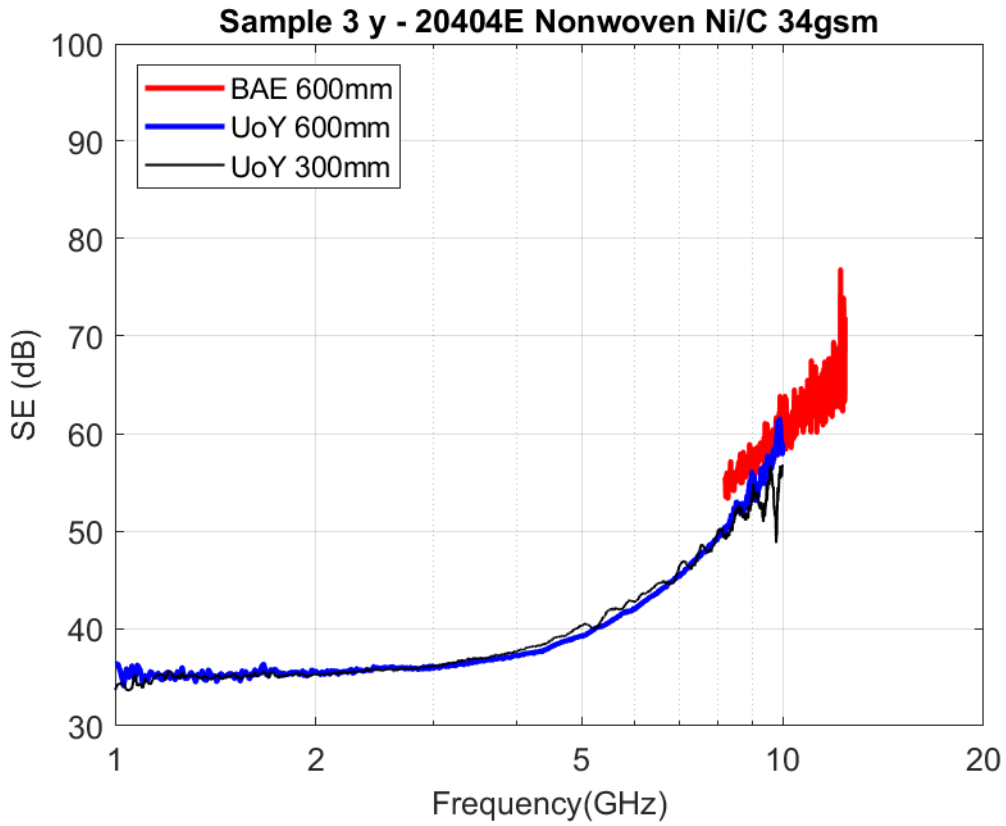


Comparing the free space (BAE), and Absorber box (UoY) average SE with Coaxial (WUST/La Sapienza) and Reverberation chamber measurements for anisotropic material.

Anisotropic materials – sample #3

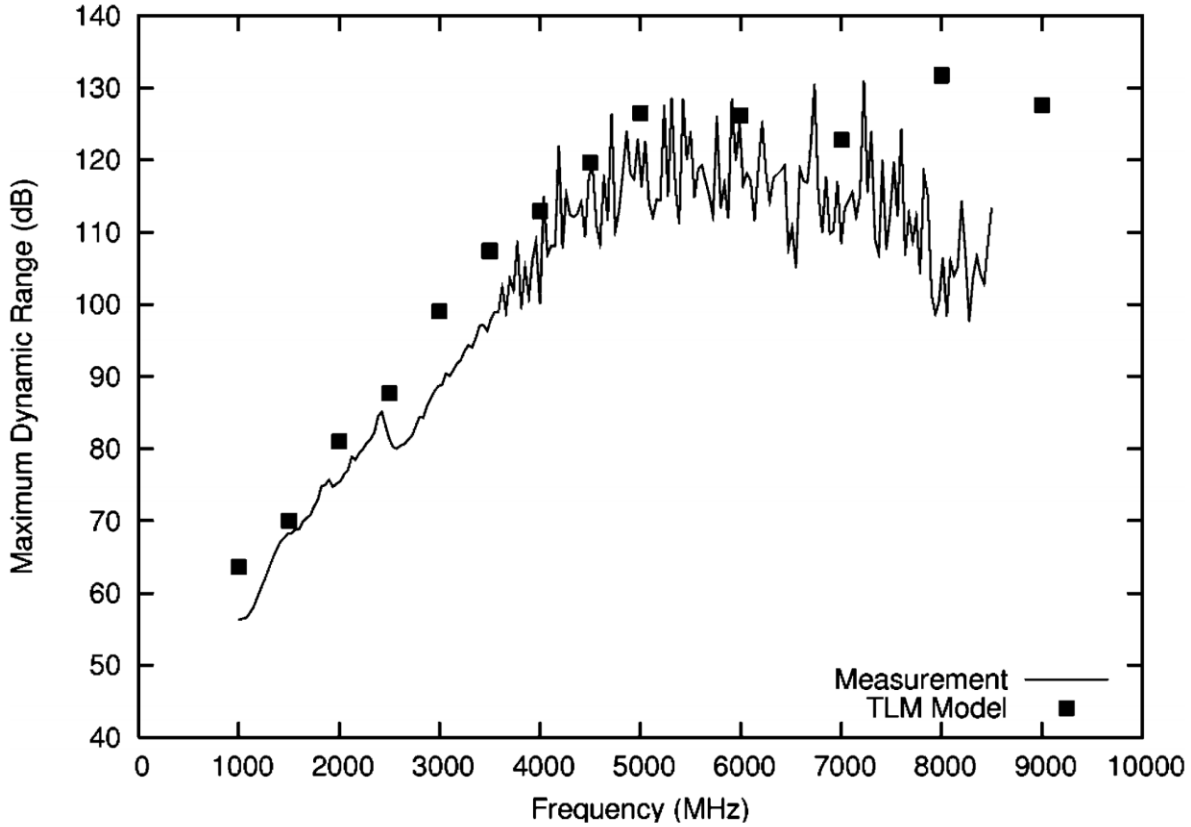




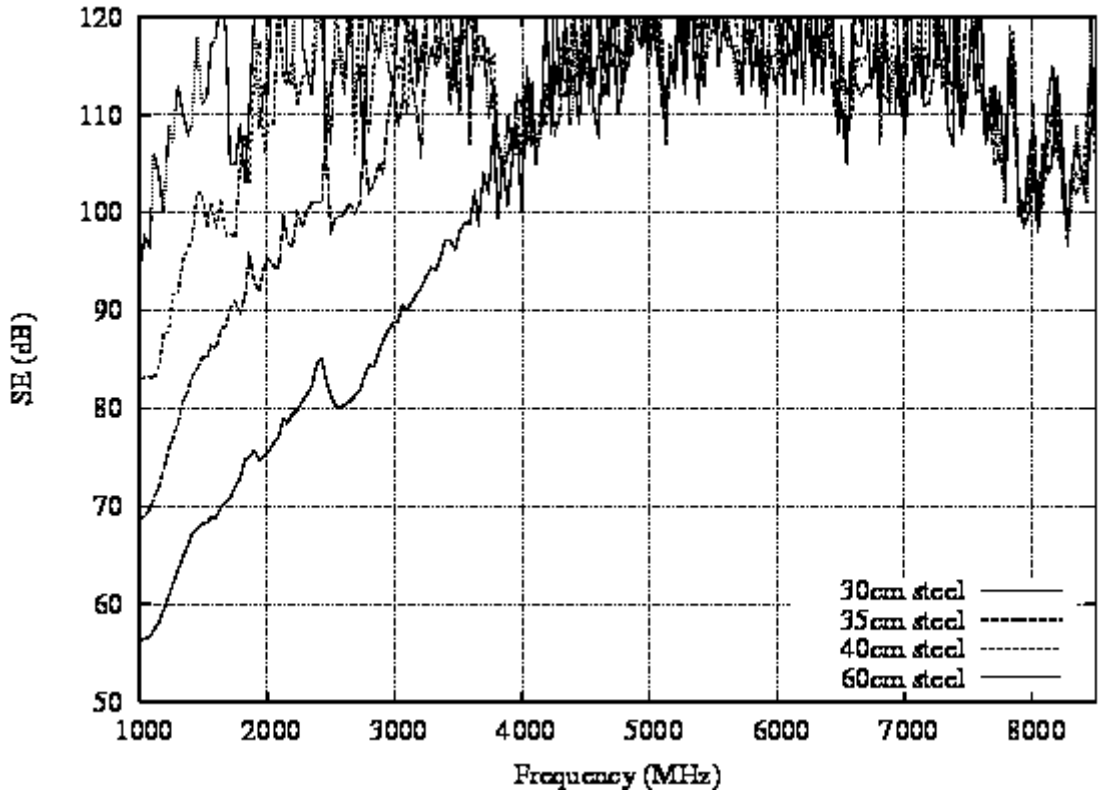
Comparing two orientations for a anisotropic non woven material

See also: Dawson, J. F.; Austin, A. N.; Flintoft, I. D. & Marvin, A. C. , "Shielding Effectiveness and Sheet Conductance of Nonwoven Carbon-fibre Sheets" , *Electromagnetic Compatibility, IEEE Transactions on , vol. 59, no. 1* , 84-92 , Feb, 2017 , DOI: 10.1109/TEMC.2016.2601658 , Available: http://eprints.whiterose.ac.uk/104001/

Dynamic range



Modeled and measured dynamic range of the absorber system with a 300-mm square sample.



Ultimate Shielding Effectiveness (SE) dynamic range for sample sizes (300mm, 350mm,400mm and 600mm square).

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Conclusions: Free-space and Absorber box

- Pro
  - Simple method with no surface preparation of sample required
  - Extended low frequency range compared with Free space for given sample size (AB)
    - Low frequency limit is that of antenna
  - Good dynamic range
  - No need to machine sample to fit jig, a range of shapes an sizes possible
  - Fast measurement
  - Can measure anisotropic materials
  - Can measure features such as joints and seams
- Con
  - Needs relatively large sample compared to some methods
    - Sample size must be a number of wavelengths in size (FS only)
    - Sample must overlap absorber sufficiently to achieve isolation (AB only)
  - Needs reference sample (AB only)
  - Upper frequency limit due to higher order modes in absorber waveguide cavity (AB only)