Above 1GHz Issues

Andy Griffin, Cisco Systems, Rev 1.2, Nov 8 2015

Issues

Problems	Issue relating to performing radiated emission measurements in the range above 1GHz.

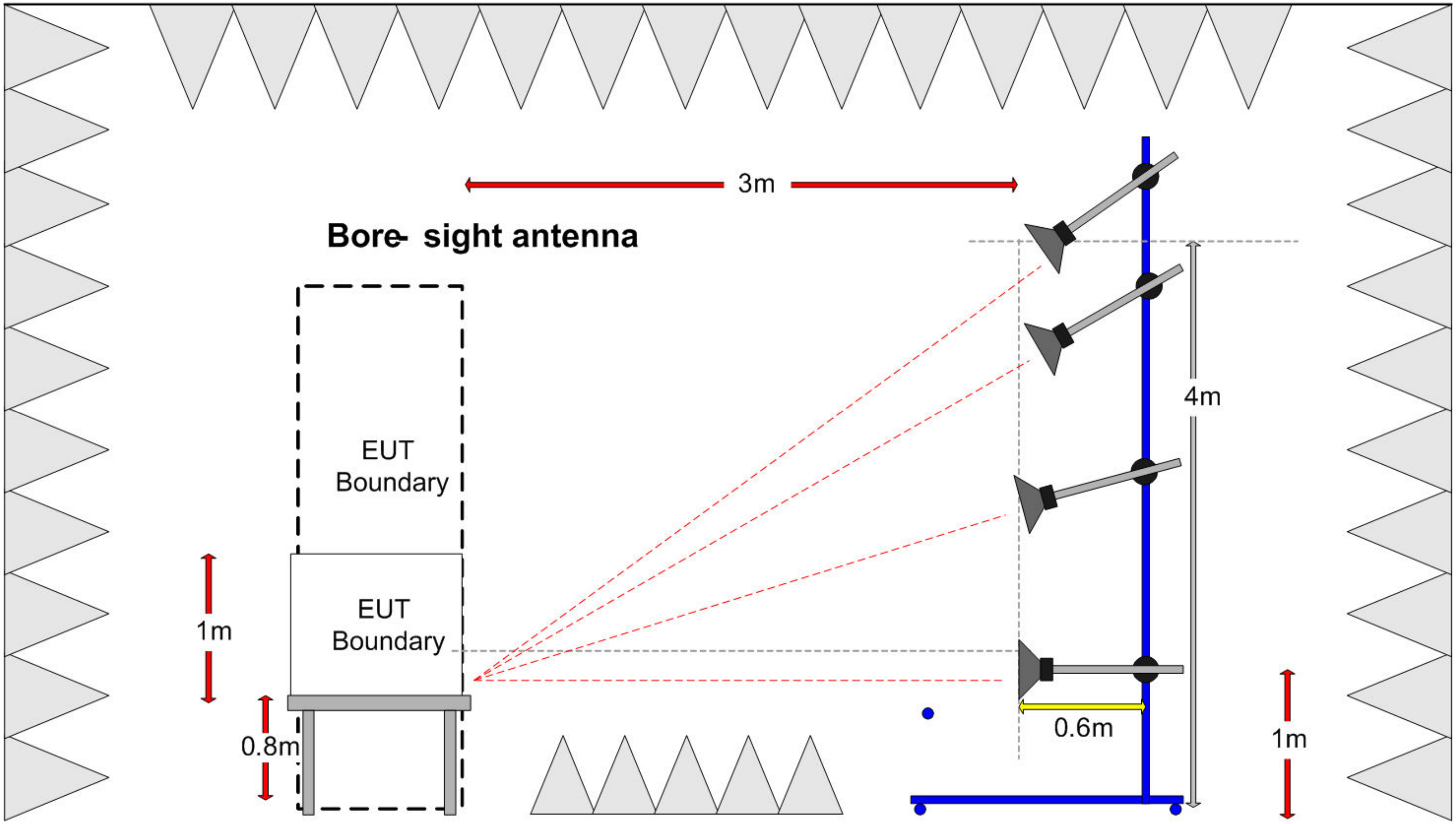
The short (test process)….

- We would prefer a full 360 rotation for all emissions formally measured (15 degree stepped prescan allowed) *CISPR requires just a 15 degree scan (around the worst case).*
- We would prefer a full 100-400 antenna scan for all emissions formally measured (50 cm pre scan allowed, must start at 1m). Range 1m to 4m.
- Divide into separate bands. Guidance and <u>different</u> requirements needed for each band. In the upper band pre-scanning is manual.
- Prescan/Bore-sighting etc to be discussed..

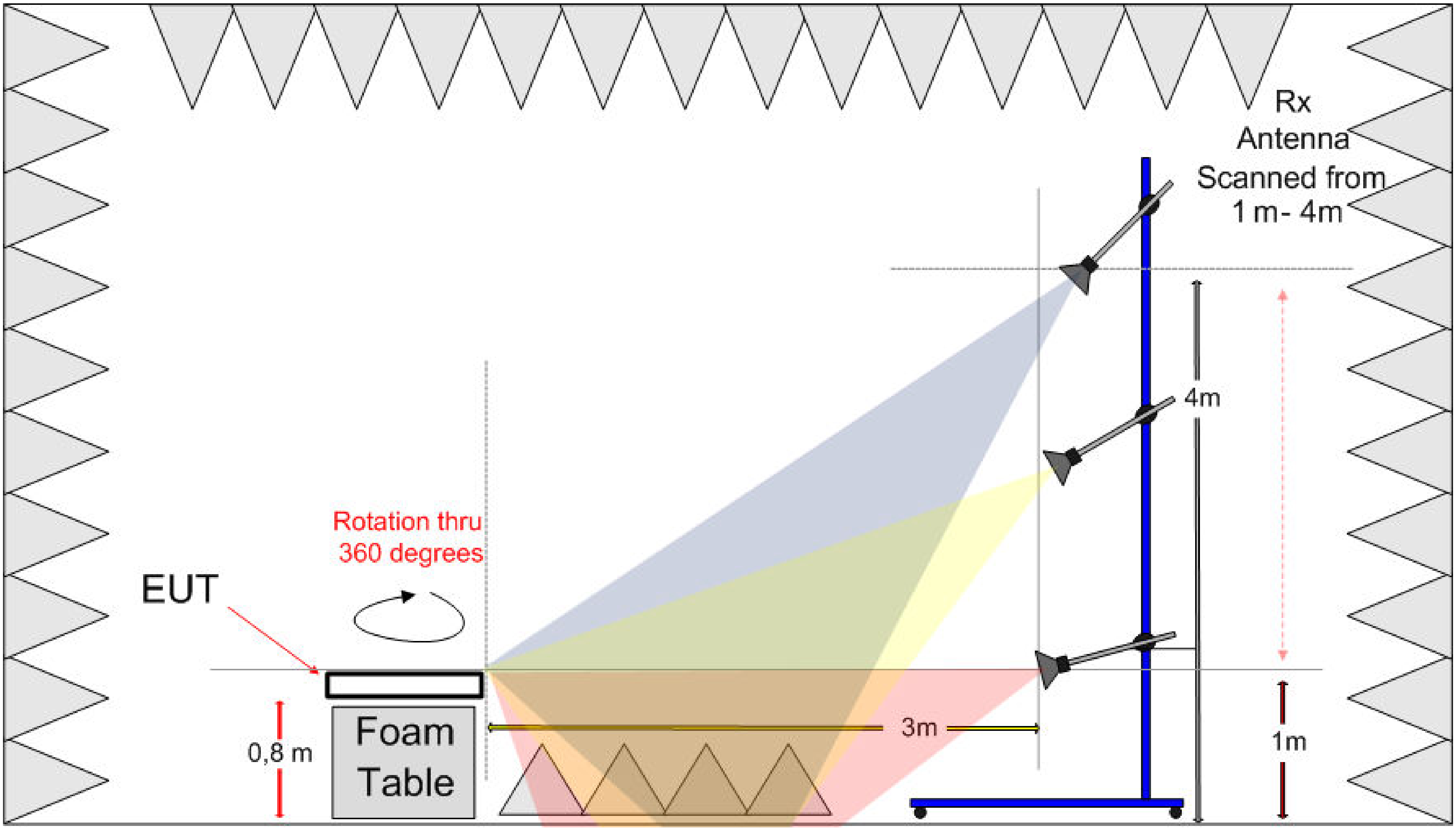
Bore-sighting, the shorts ….

- Compare bore-sight and other scanning methods
  - – Perfect pointing, gave worst case, ie ok small EUTs, but the limits within the bore-sight cause problems… !
  - – Bore-sighting at the limits, gave lowest responses.
  - – Planar gives a reasonable and a simple process.
  - – No results for bore-sight an the lower limits but expect some where in between.
- CISPR method does not work, but at the Stresa CISPR A WG2 decided to possibly change the method. Several proposals in CISPR H to modify the limit based upon the change in test method.
- This is our chance to influence CISPR !
- Once we go to different distances all bets are off !

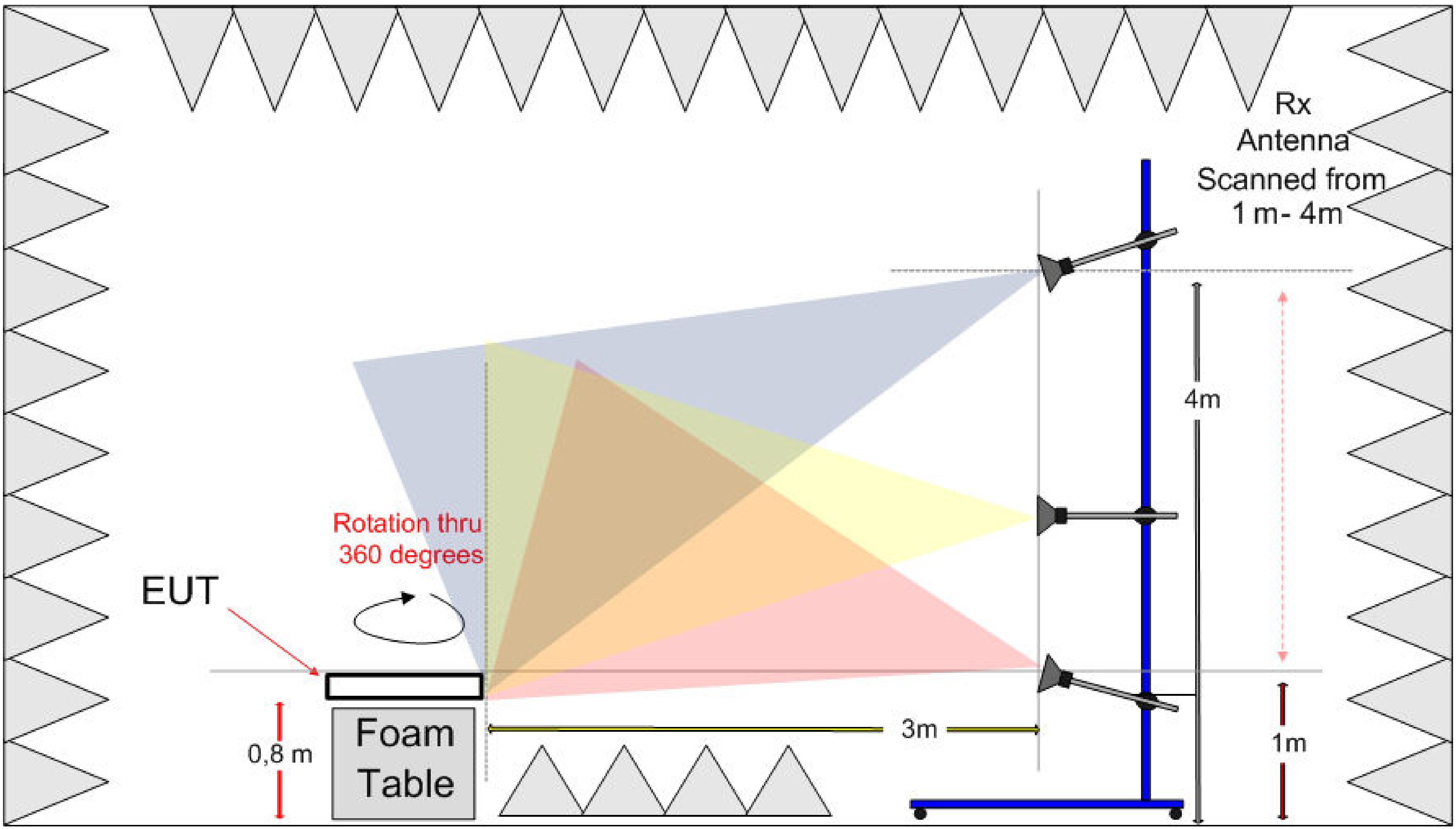
Possible Setups…(6) Bore-site at 0.8m height.



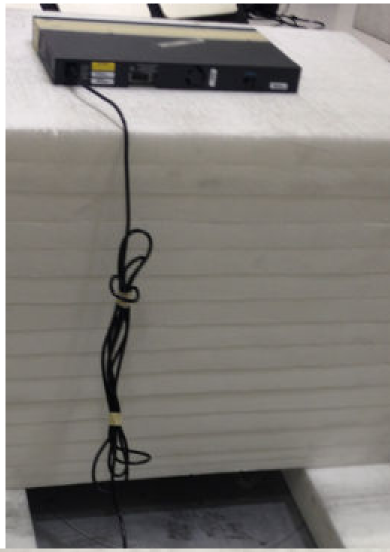
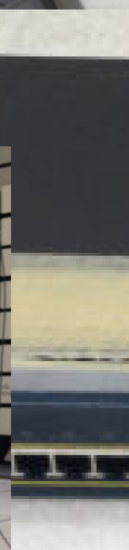
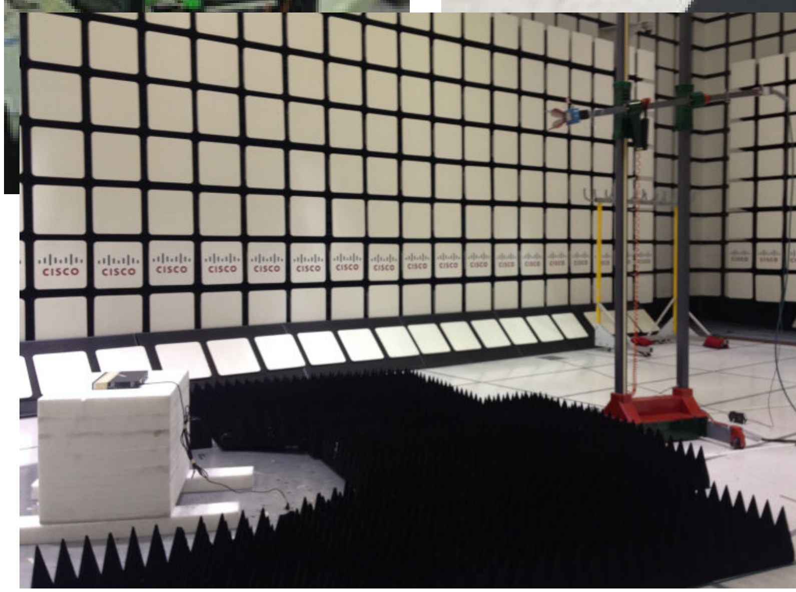
Possible Setups…(8) Bore-site at lower limit of the 3dB points



Possible Setups…(9) Bore-site at lower limit of the 3dB points

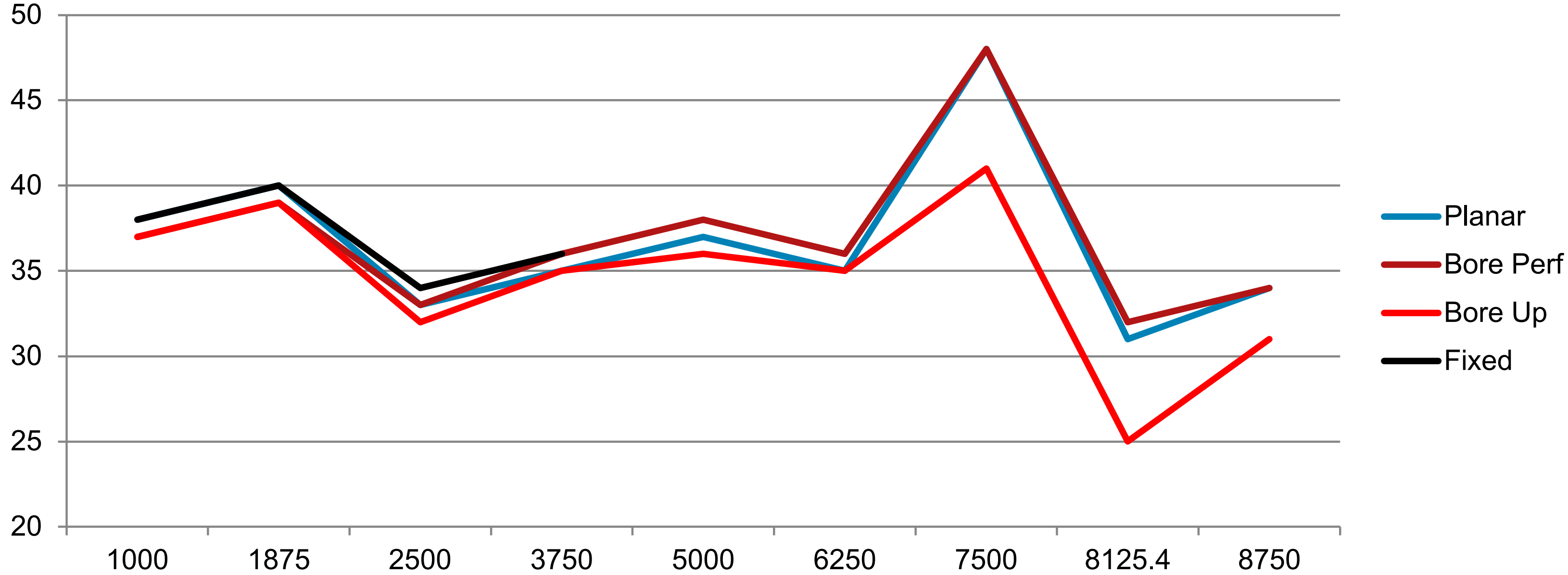


EUT

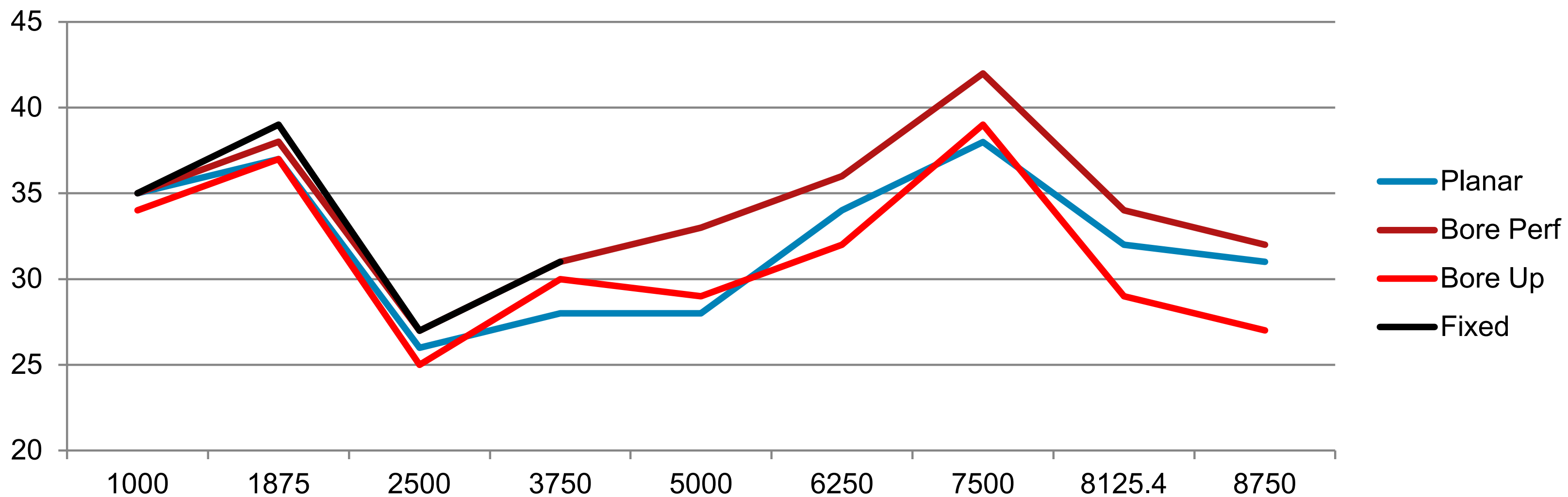






EUT 1, Results Summary

H-pol EUT 1

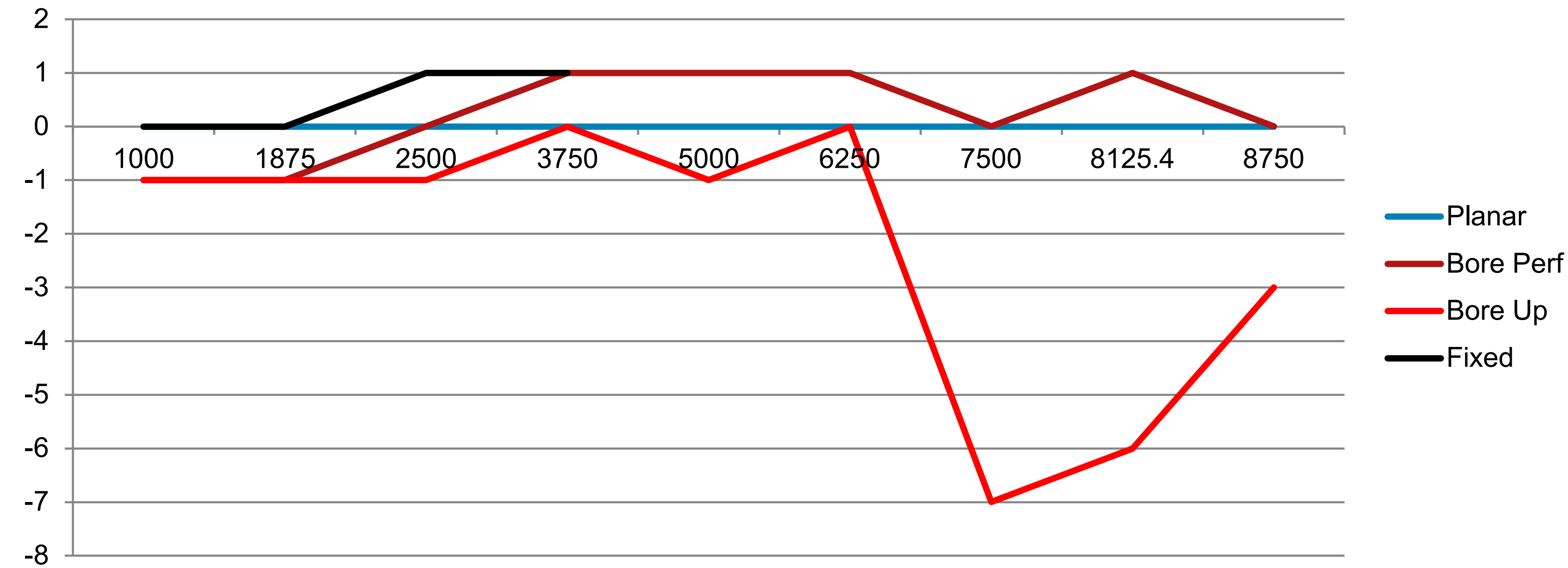


V-pol EUT 1



EUT 1, Normalize planar scan

H-pol EUT 1



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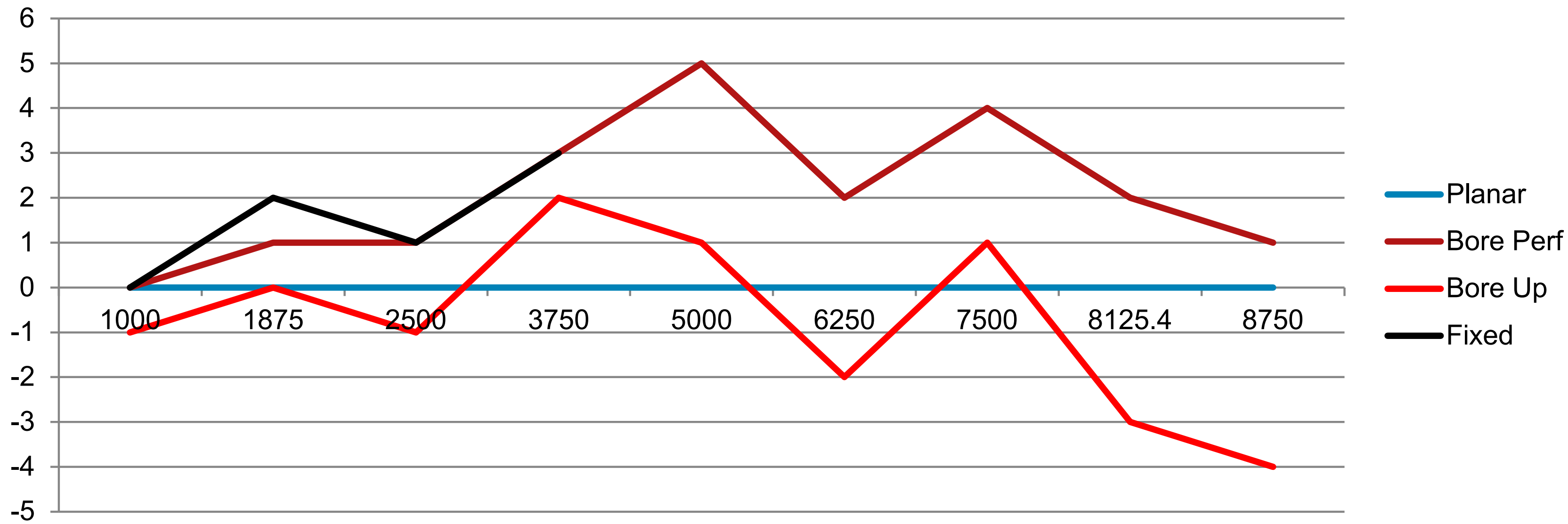
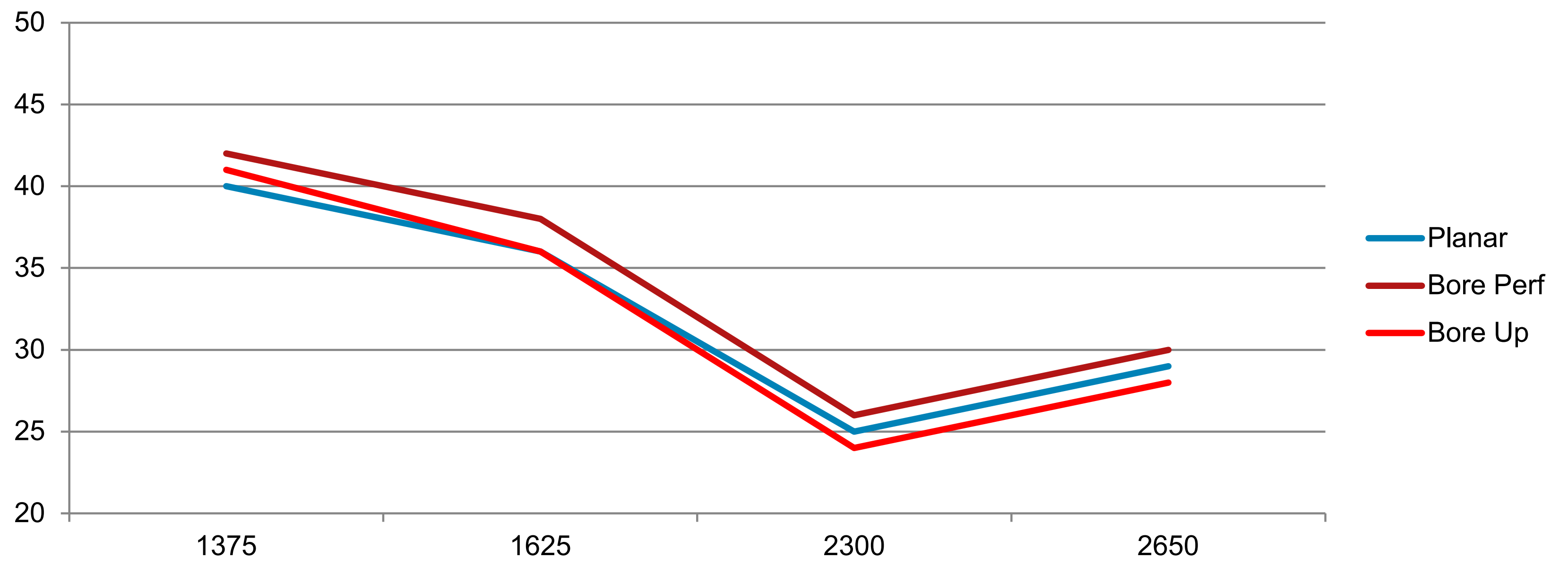
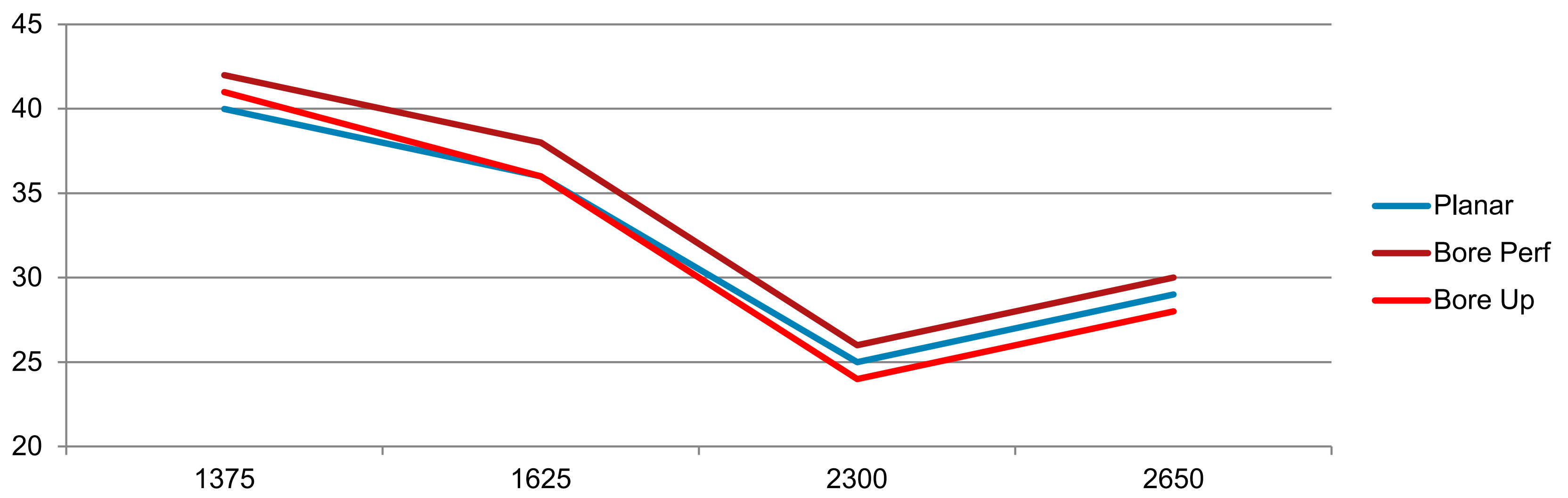


EUT 2, Results Summary

H-pol EUT 2

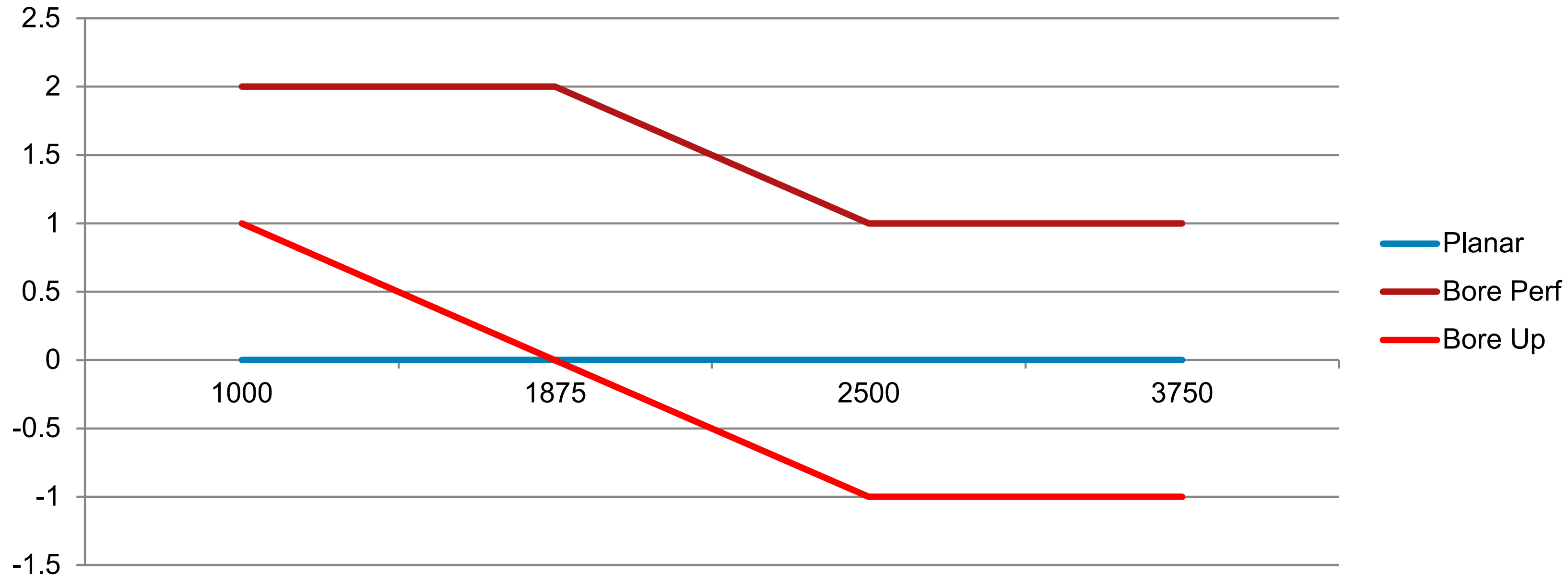


V-pol EUT 2

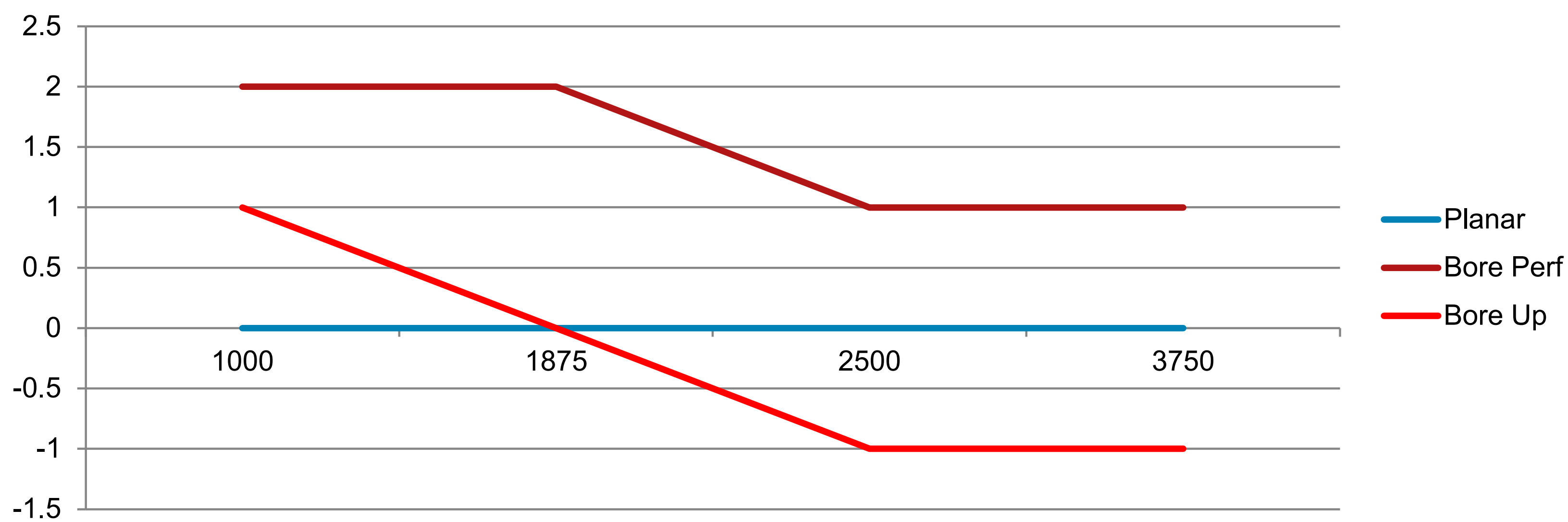


EUT 2, Normalize planar scan

H-pol
EUT 2



V-pol
EUT 2



The long ….

Measurement Distance / Noise Floor

Measurement Distance	Must allow different measurement distances. Preference is still for a 3m distance? Extrapolation … 20 dB Log (Meas Dist/Spec Dist) is not as effective if the EUT is large and the frequency high.
Amplifiers	Need high gain amplifiers, mounted at the back of the antennas (if possible !) Do they have any influence on the measurement? These amplifiers come in bands. One amplifier will not cover the entire band (1-40 (or 50) GHz), hence logic is to divide the testing into bands.

Different Bands / Configurations

Band 1 & 2	Measure equipment can be easily outside the screened room / Chamber
Band 3	Measure equipment may be setup outside the screened room / Chamber
Band 4	Measure equipment needs to be inside the screened room / Chamber. Minimize cable loss (4m or less), but most of the measurement system has to be in the room.

Possibilities

Band 1 **1GHz–6GHz**	Noise floor not a real problem This is the current CISPR 22/32 requirements Would be good to have one method covering both CISPR 22 and 47CFR. *CISPR A has finally agreed to work on the method. This will be in collaboration with CISPR H (CISPR I threatened to do it)*
Band 2 **6GHz–10GHz**	Still have the measurement instrumentation outside lab. GR1089 stops at 10GHz. Typically antennas stops at 10GHz (or 18GHz)
Band 3 **10GHz–18GHz**	Still have the measurement instrumentation outside lab. Closer to 18GHz, the noise floor gets too close to the limit. There are solutions of reducing the measurement distance, reducing the video bandwidth, reducing the resolution bandwidth.

Possibilities

Band 4 **18GHz–40GHz**	Sub divide at 26.5GHz (STD gain horn split) Prescan close to the EUT, hunting for the signals. Absorber gets in the way. Repeatability is a problem, but close in just hunting for signals.
Band 4+ **40GHz–+GHz**	Radio measurements, up to 200GHz?

Intentional

Highest frequency generated or used in the device or on which the device operates or tunes (MHz)	Upper frequency of measurement range (MHz)
Below 1.705	30.
1.705-108	1000.
108-500	2000.
500-1000	5000.
Above 1000	5th harmonic of the highest frequency or 40 GHz, whichever is lower.

Unintentional

§15.33 Frequency range of radiated mea

(a) For an intentional radiator, the spectru
the device, without going below 9 kHz, up to a

(1) If the intentional radiator operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

(2) If the intentional radiator operates at or above 10 GHz and below 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 100 GHz, whichever is lower.

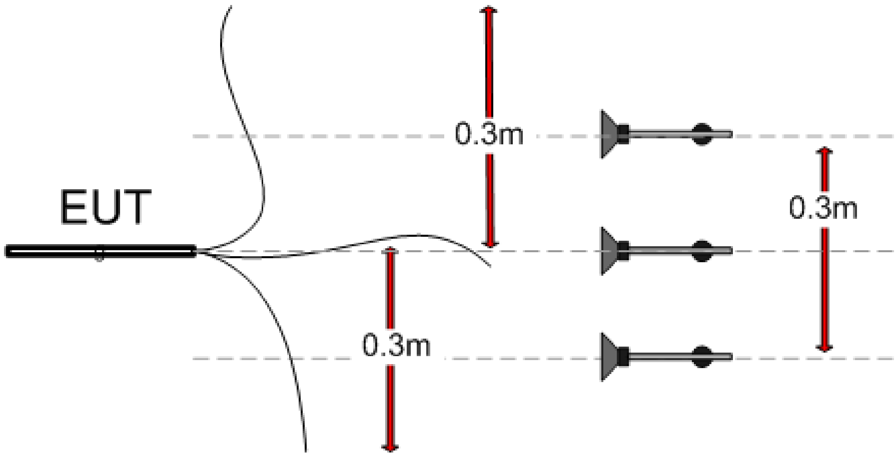
(3) If the intentional radiator operates at or above 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 200 GHz, whichever is lower, unless specified otherwise elsewhere in the rules.

(4) If the intentional radiator contains a digital device, regardless of whether this digital device controls the functions of the intentional radiator or the digital device is used for additional control or function purposes other than to enable the operation of the intentional radiator, the frequency range shall be investigated up to the range specified in paragraphs (a)(1) through (a)(3) of this section or the range applicable to the digital device, as shown in paragraph (b)(1) of this section, whichever is the higher frequency range of investigation.

EUT

EUT Set up	One basic test arrangement for different EUTs, rack, floor and table top. No argument about transitions, what to do with combination setups. The source within the EUT is at different heights, and may have emissions pointing at different angles. Up (or down or flat). Large rack mounted equipment are very heavy, hence the idea that these can be simply ‘raised’ or ‘tilted’ is not workable. Safety is a problem. Even the suggestion of raising the EUT 30cm is problem. The sources of the Emission is not from cables, hence how much cable exposure should we include with the EUT? If cables were good radiators above 1GHz then ultra fast communication would not use fiber.

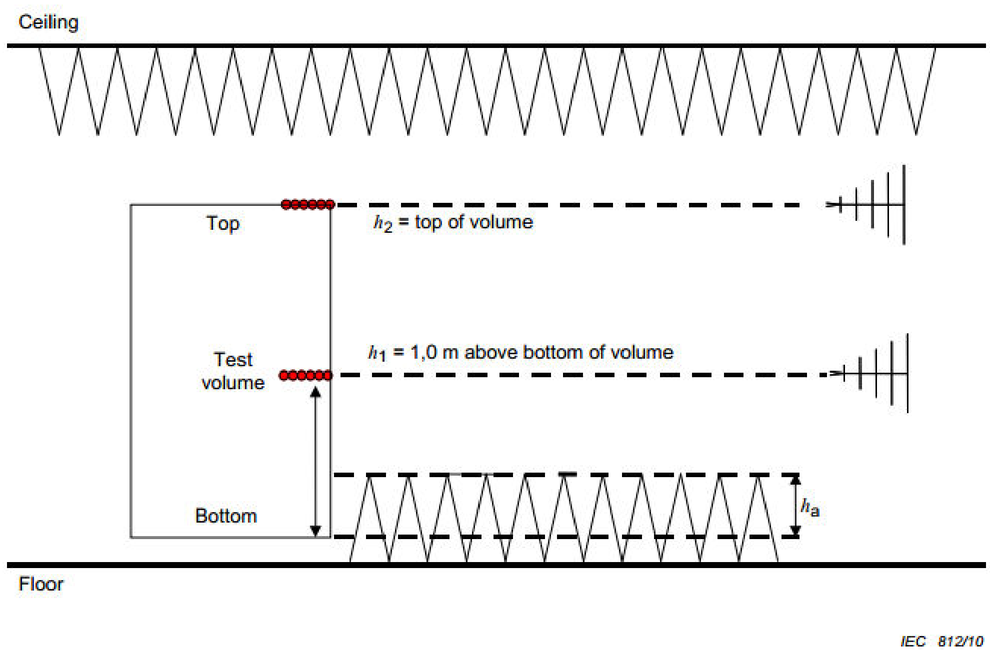
EUT

EUT Set up	The source of the emission are typically from slots or from local areas, hence the rest of the system tends to be not relevant to the setup.
CISPR 16	In CISPR 16, you are suppose to use 30cm or cabling (at 1GHz). This causes confusion of where to place the receiving antenna. 

Limit considerations

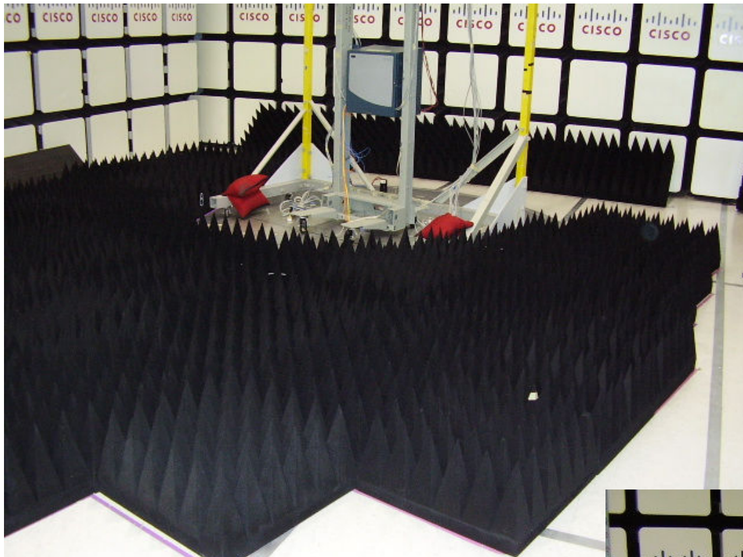
Limits	The TEST method can not be decoupled from the limits. They should some technical basis, they were mostly from just saying, we have to protect the spectrum so we will just extended the line from 1GHz-XGHz. NOTE: CISPR H develop limits that were slopping 10dB from 1GHz-18GHz. These were developed using probability factors. The CISPR limits are tighter from 1G-3G, compared with those in 47CFR, but the set method is at a fixed height (effectively). The interference potential is not the same at 1GHz, compared with 40GHz. *Why do we need a 50dB pre-amp to get good noise margin above 26GHz. (30dB from 18-26GHz).. And use very short cables.*

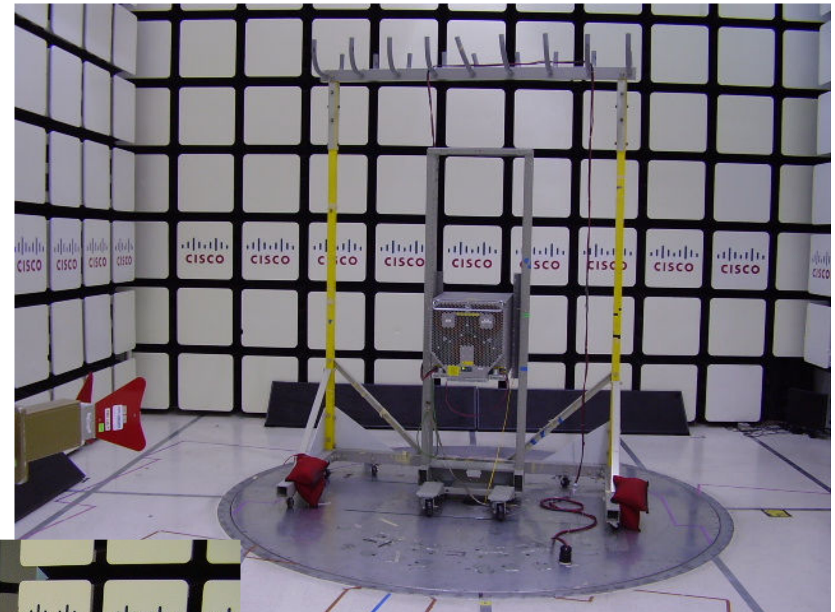
Calibration Method

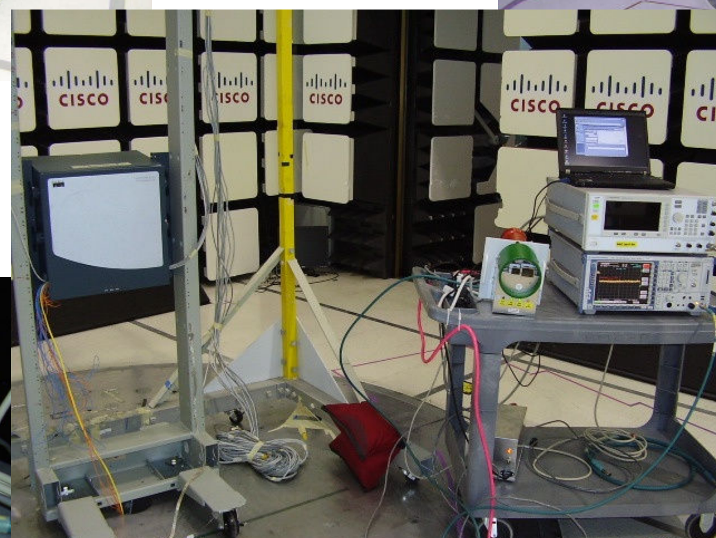
Calibration method	Should reflect the test set up and the antenna calibration should reflect use. Below 1GHz, NSA and antenna calibration ‘mimic’ the test set up. These principles should be applied to above 1GHz.
Calibration method CISPR16-2-3 Section 8.3	The Svswr method uses planar antennas 

General Objective for Tests Methods

Test Methods	The more complicated the set up, the less likely everybody will do it the same way. Simplicity wins ! Repeatability is the key element. Different is different bands. The Physics are different Pre-scan measurements may be at a different distance than the formal distance. Emissions are extremely directional. Minimize the use of the manual methods. *Whilst achieving a maximum response is necessary, we are not going to find the maximum response unless we do a RVC measurement? A full circular scan?*







Test Equipment

Possible bands with methods

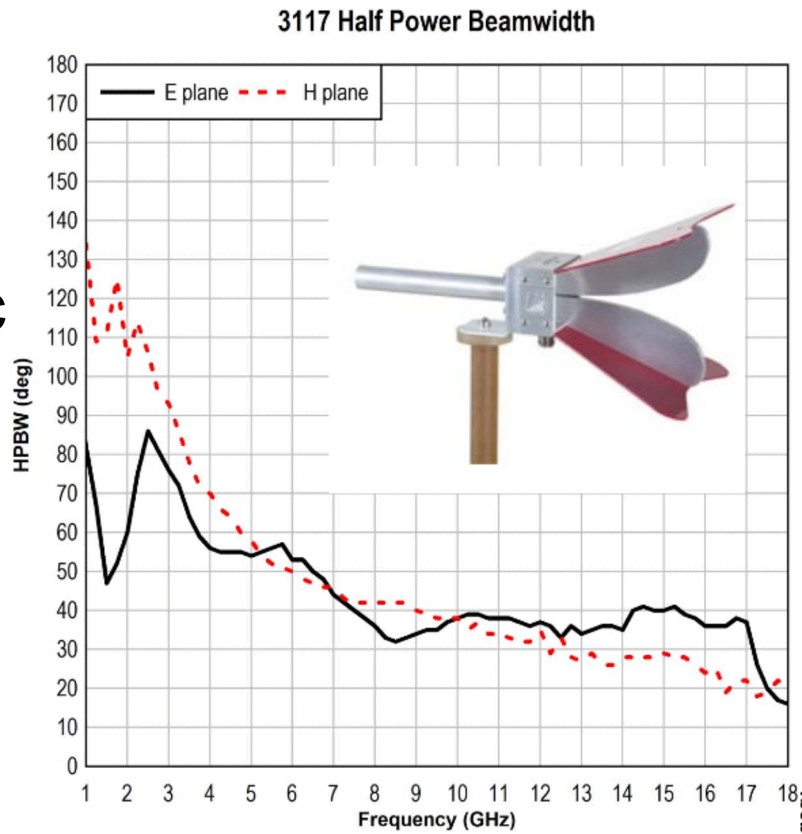
Band	Freq Range	Test Equipment Location	Prescan	Formal Measurement
1	1-6GHz	Outside lab	Standard CISPR Modified	Standard CISPR Modified
2	6-10GHz	Outside lab	Standard	Standard
3	10-18GHz	Outside lab	Lower Noise floor Solution	Lower Noise floor Solution
4	18-40GHz	Inside lab	Manual Solution	Standard

Key Issues

Noise floor	What to at different measurement distances What to do if the resolution / video bandwidth different
Preview method	Need to define automate and manual methods Minimize step size for turntable / tower.
Final method	Need to define automate and manual methods Minimize step size for turntable / tower.

3 dB Points

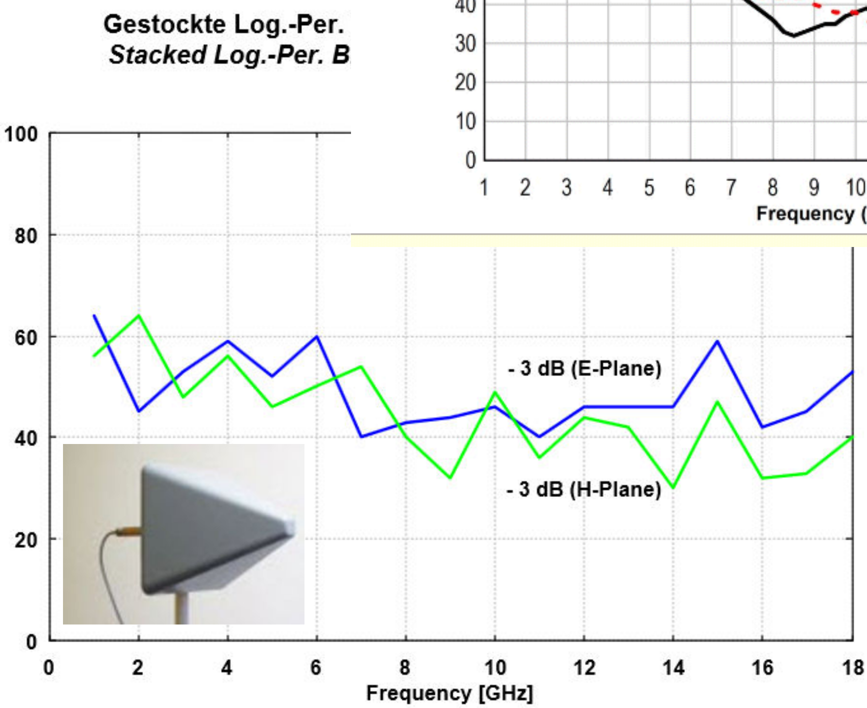
Horn 3117

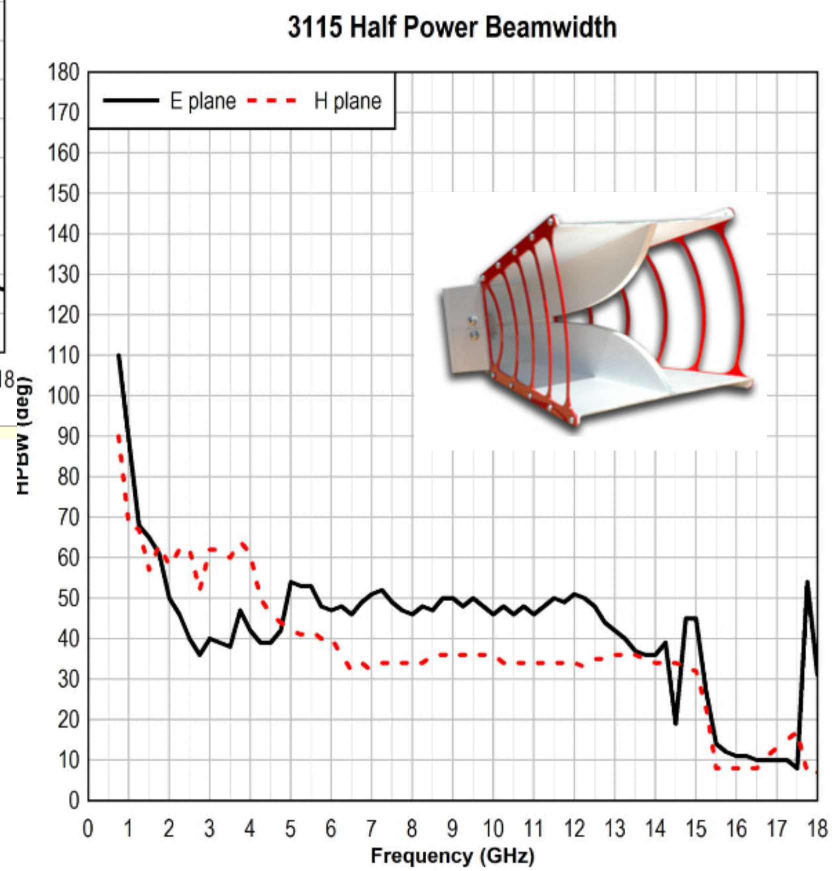


Horn 3115

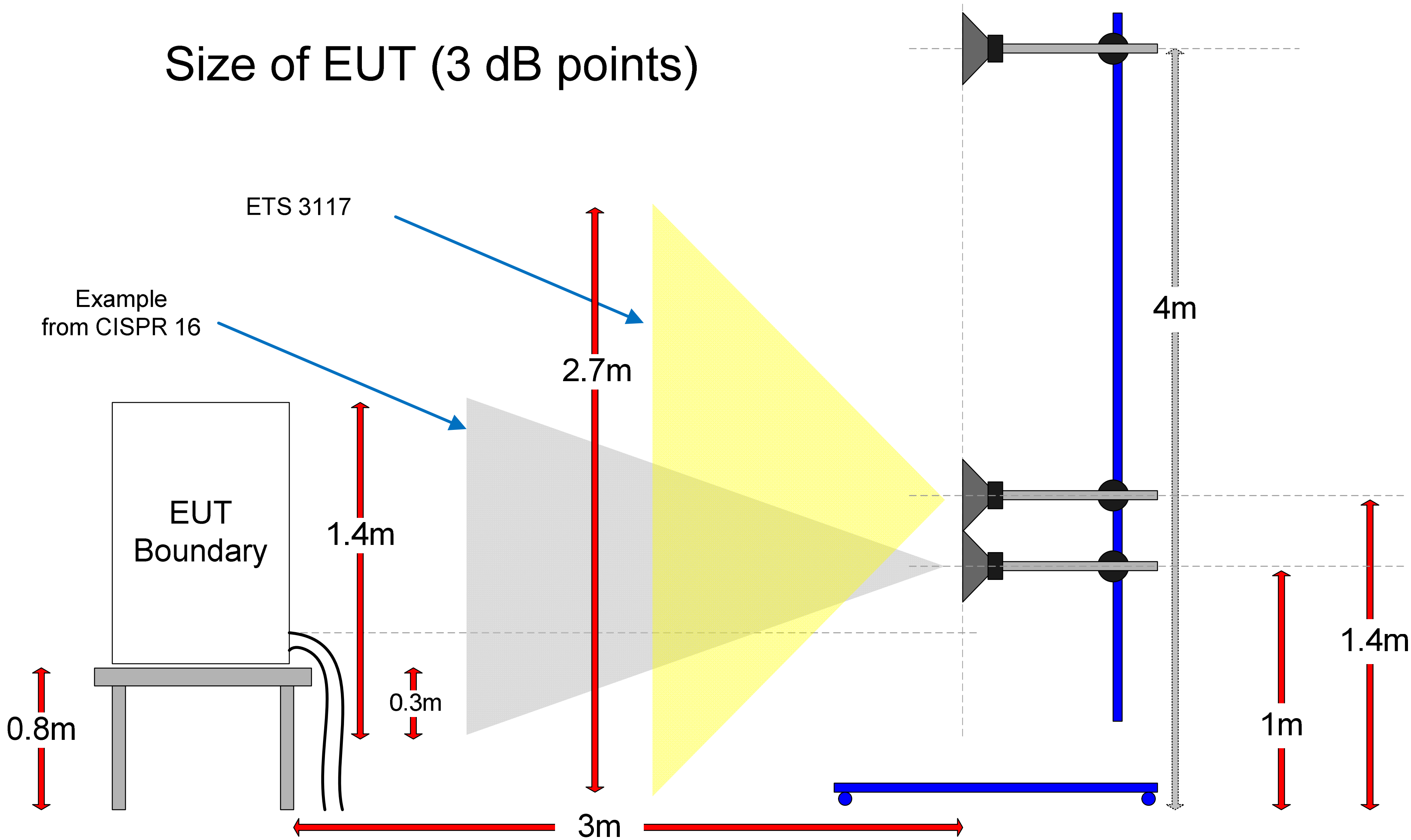
Log Periodic

STLP 9148

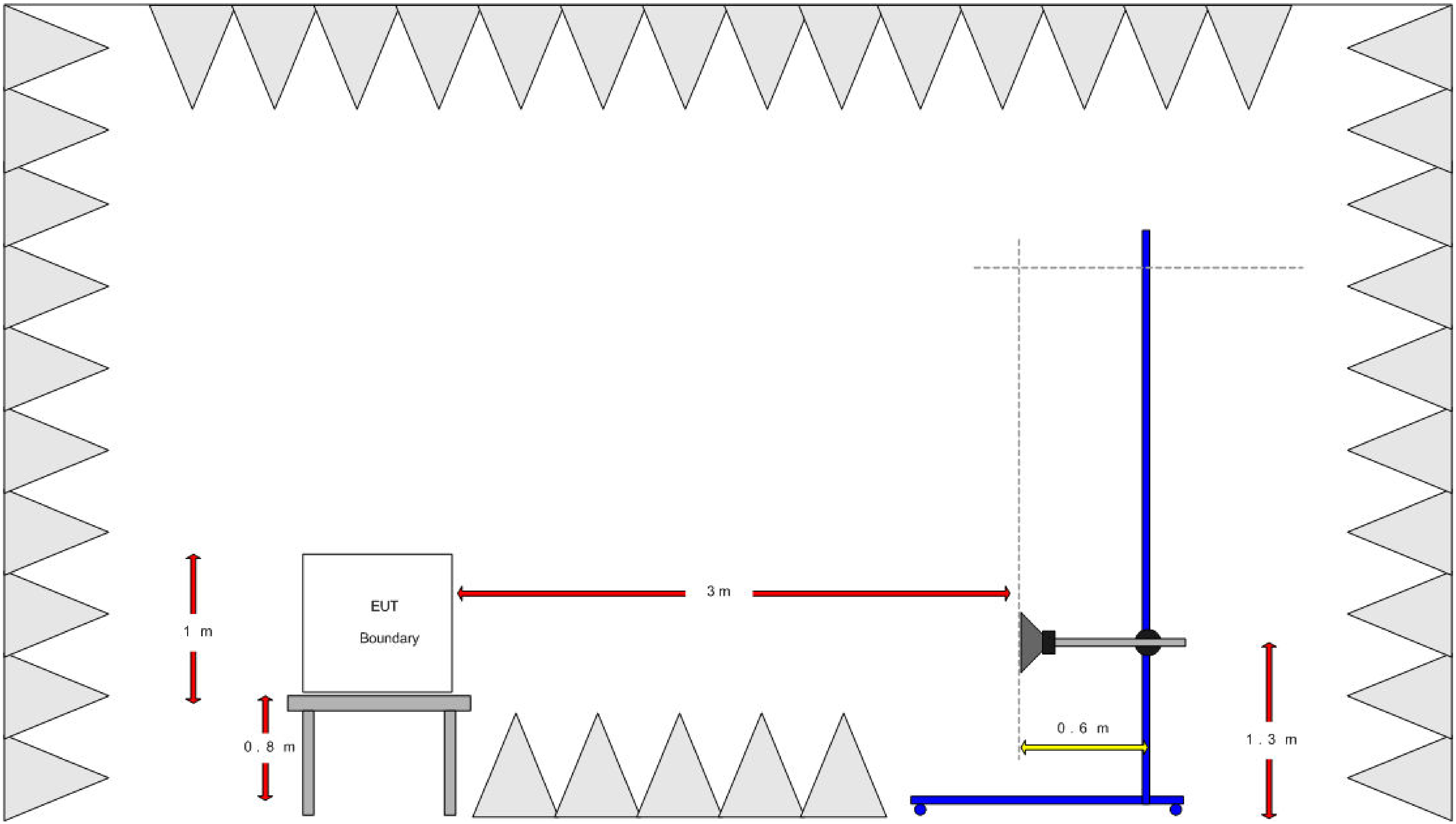




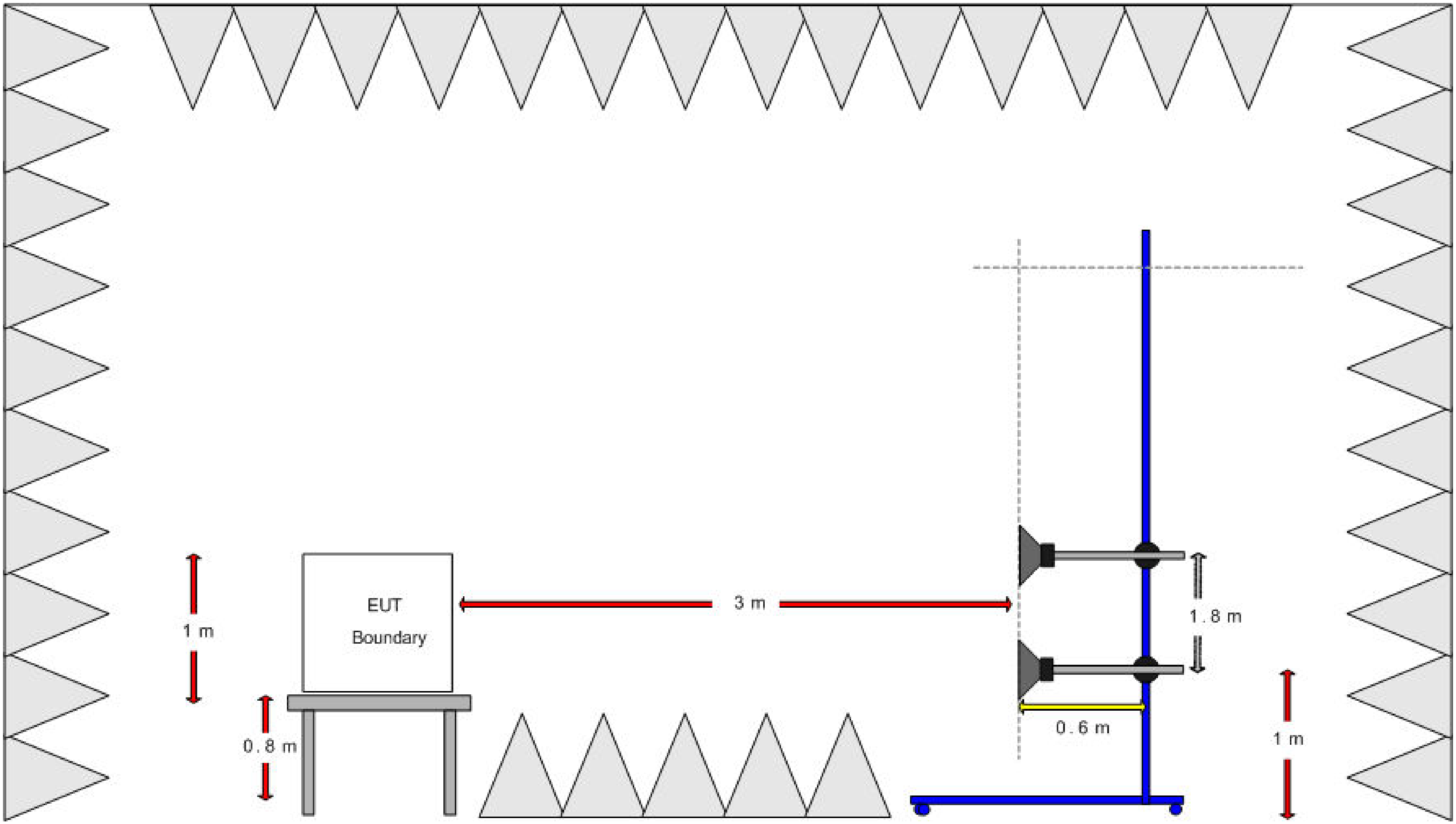
3dB Points


Size of EUT (3 dB points)
ETS 3117
Example
from CISPR 16
EUT
Boundary
1.4m
2.7m
0.3m
0.8m
3m
4m
1.4m
1m

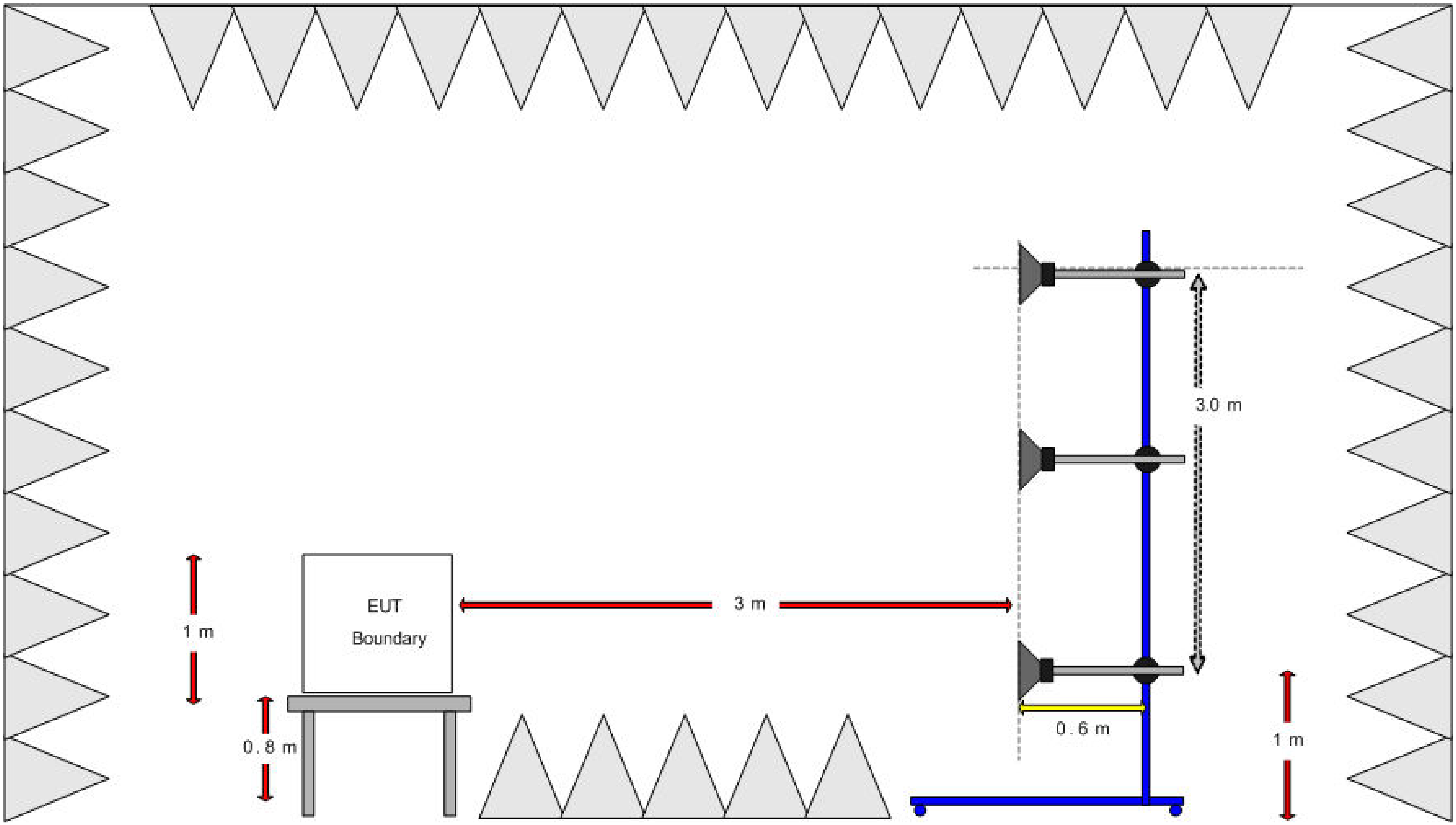
Possible Setups (1)… (CISPR 16)
Fixed height at the center of the EUT



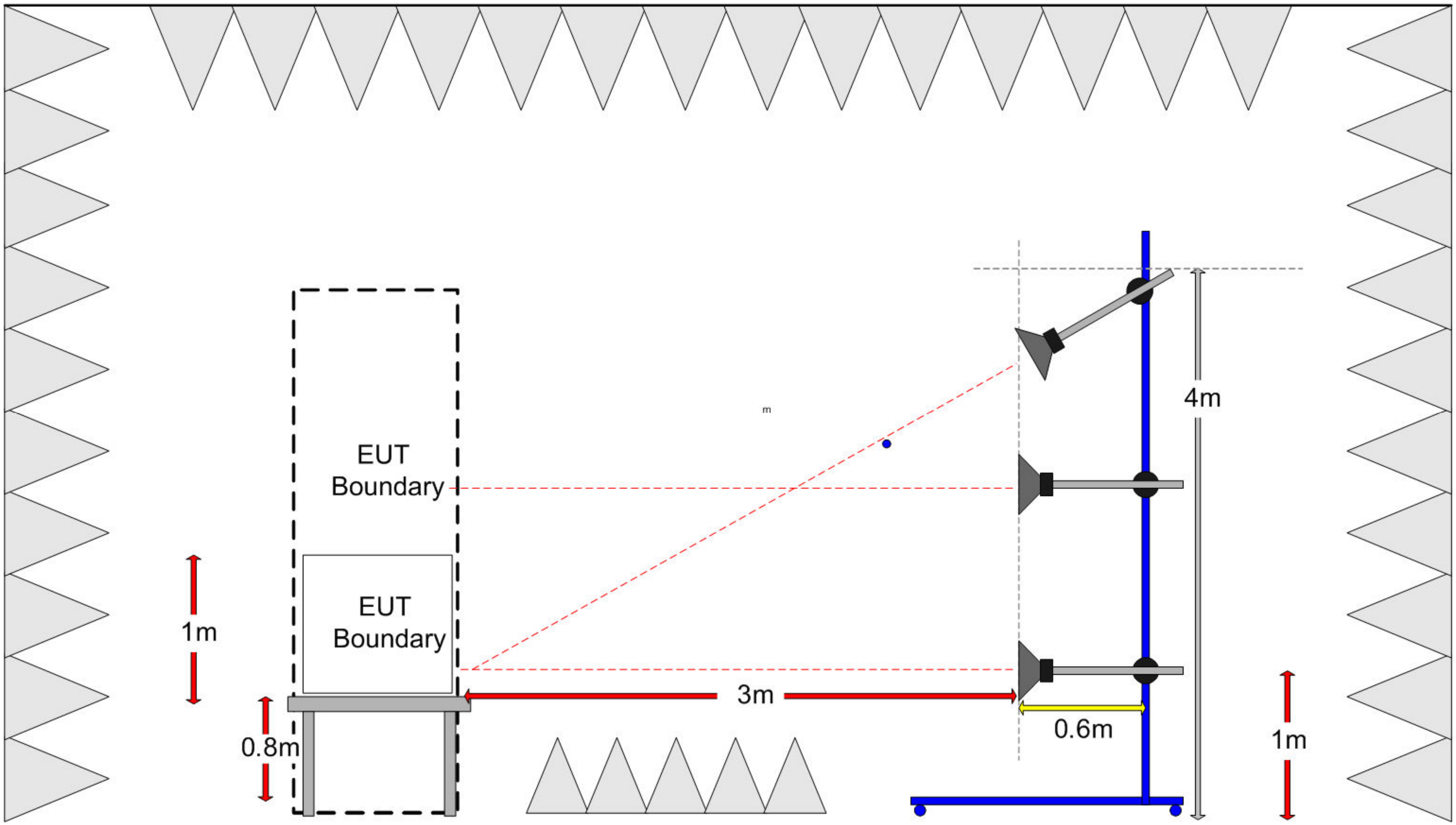
Possible Setups (2)… (CISPR16+)
Scan 1m – Height of the EUT



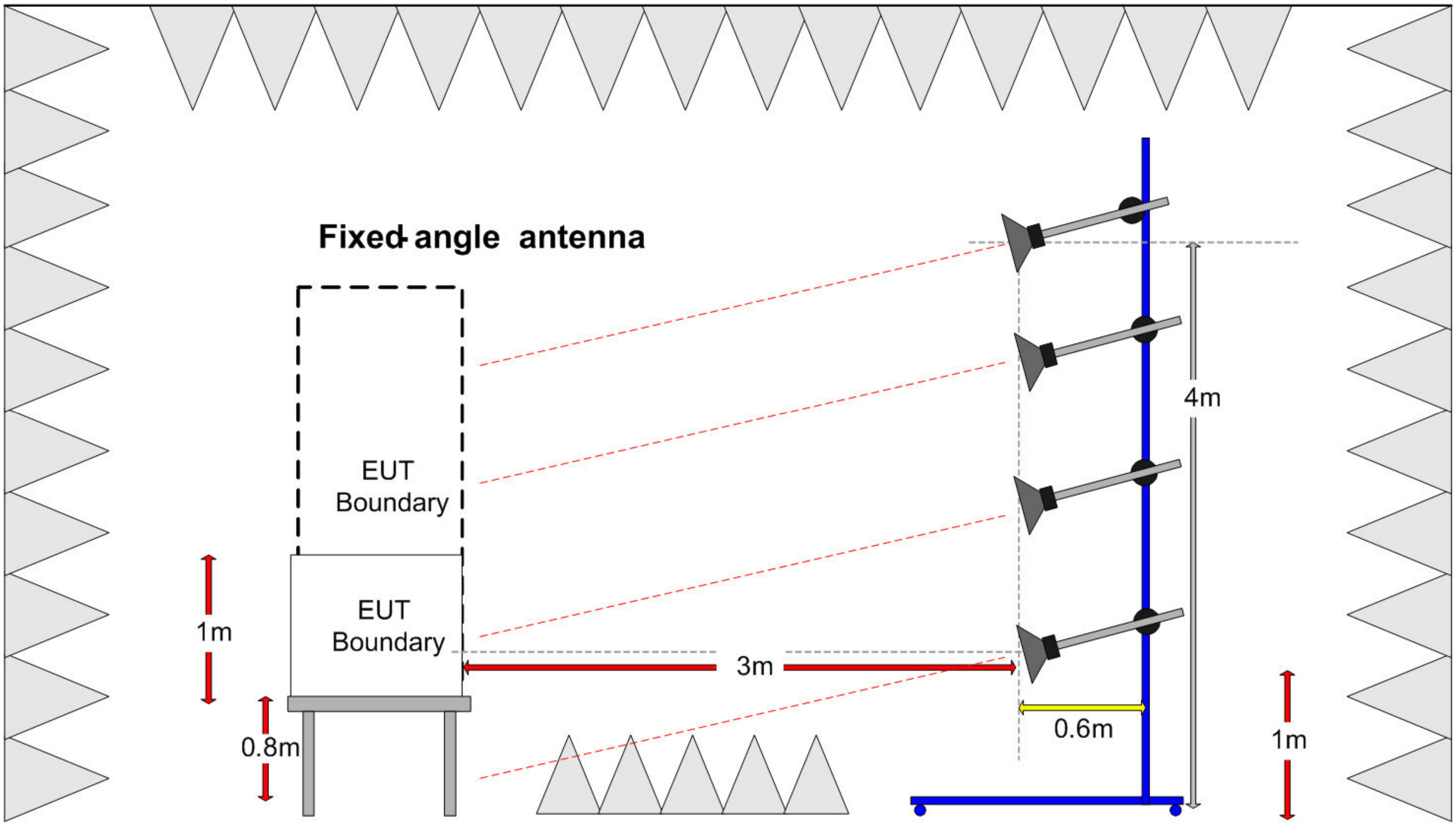
Possible Setups (3)…
Scan 1m to 4m (independent of EUT height)



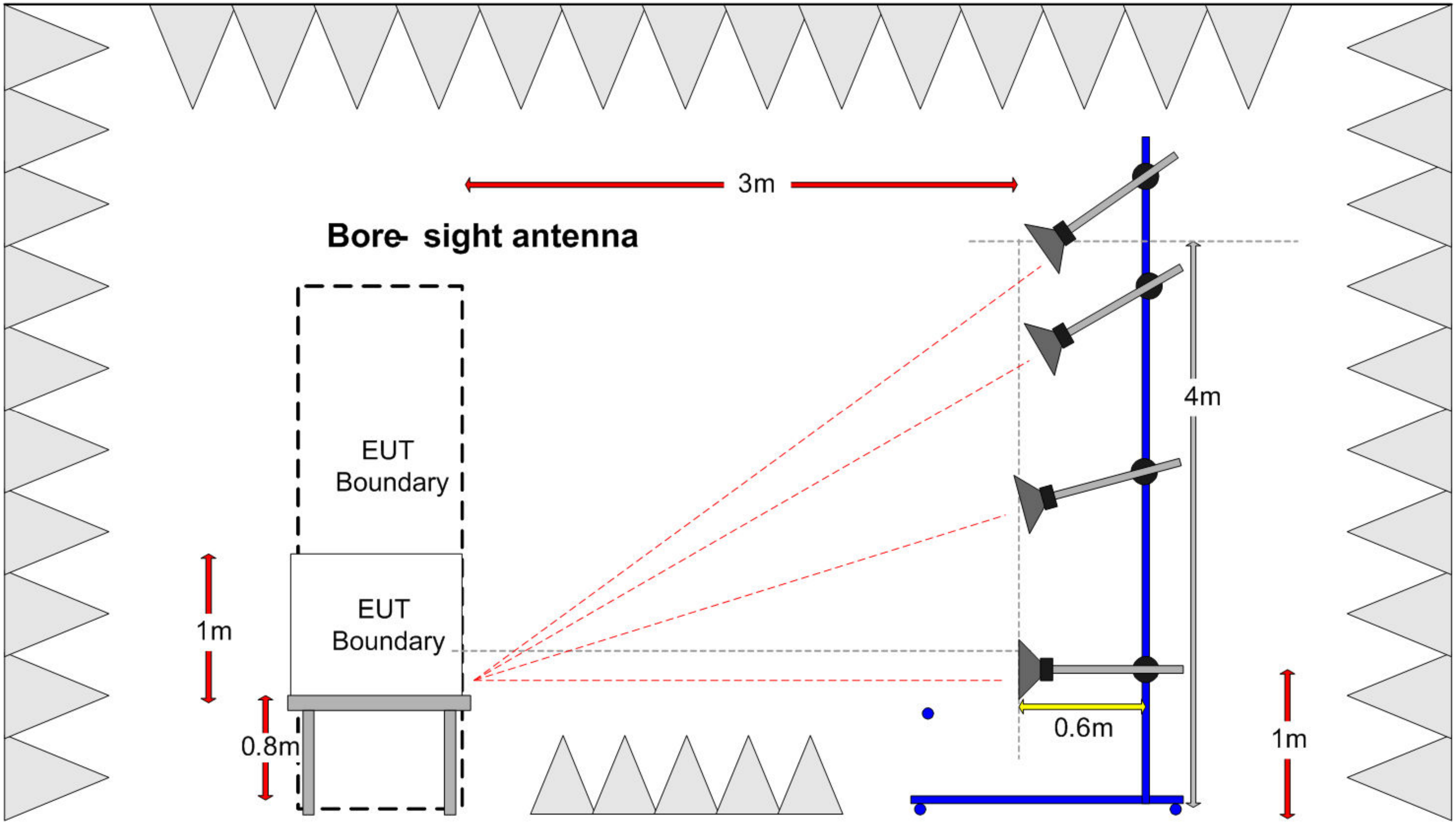
Possible Setups…(4) as set up 3 but point the antenna down at 4m.



Possible Setups…(5) always point antenna at a specific angle.



Possible Setups…(6) Bore-site at 0.8m height.



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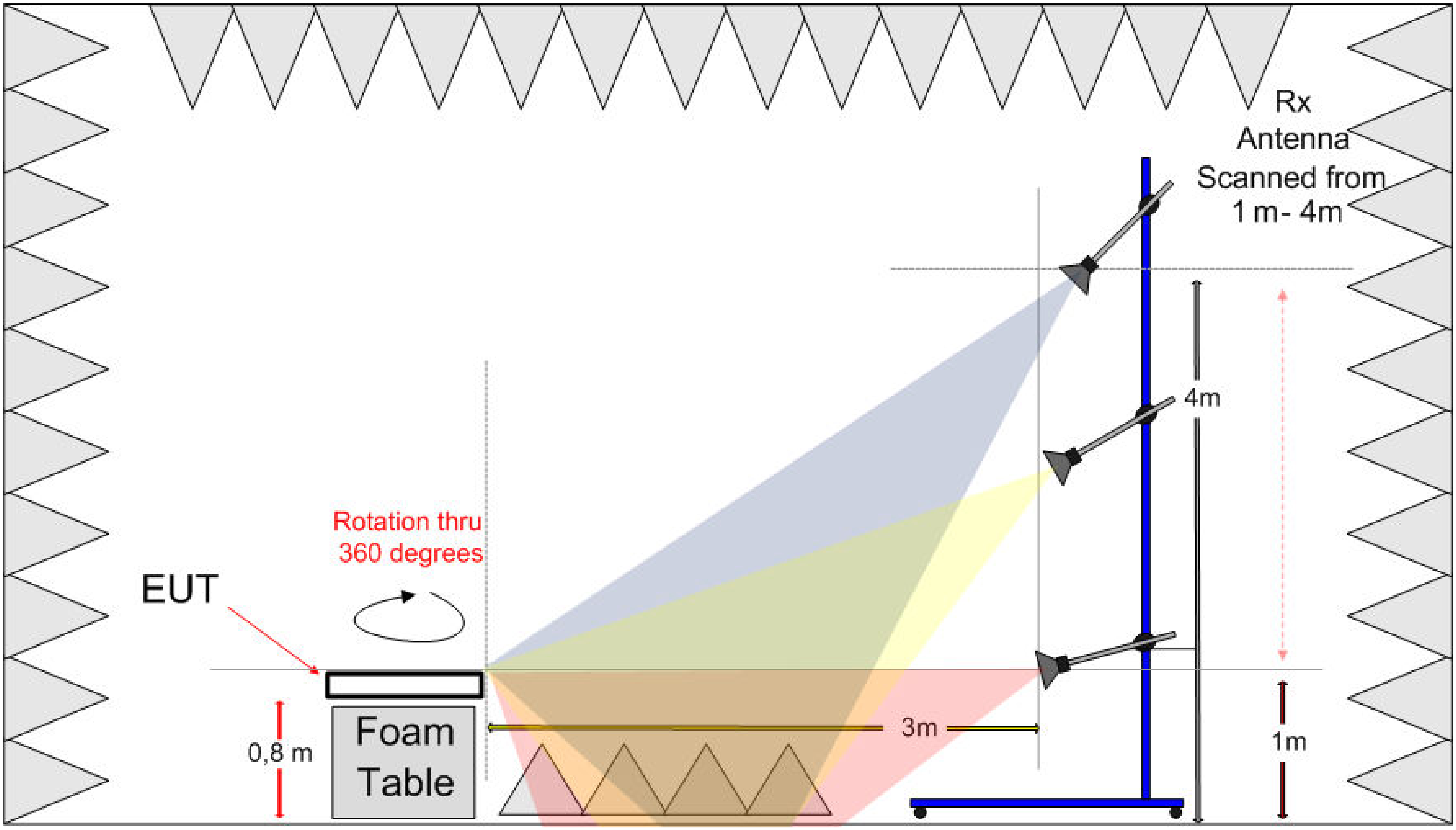

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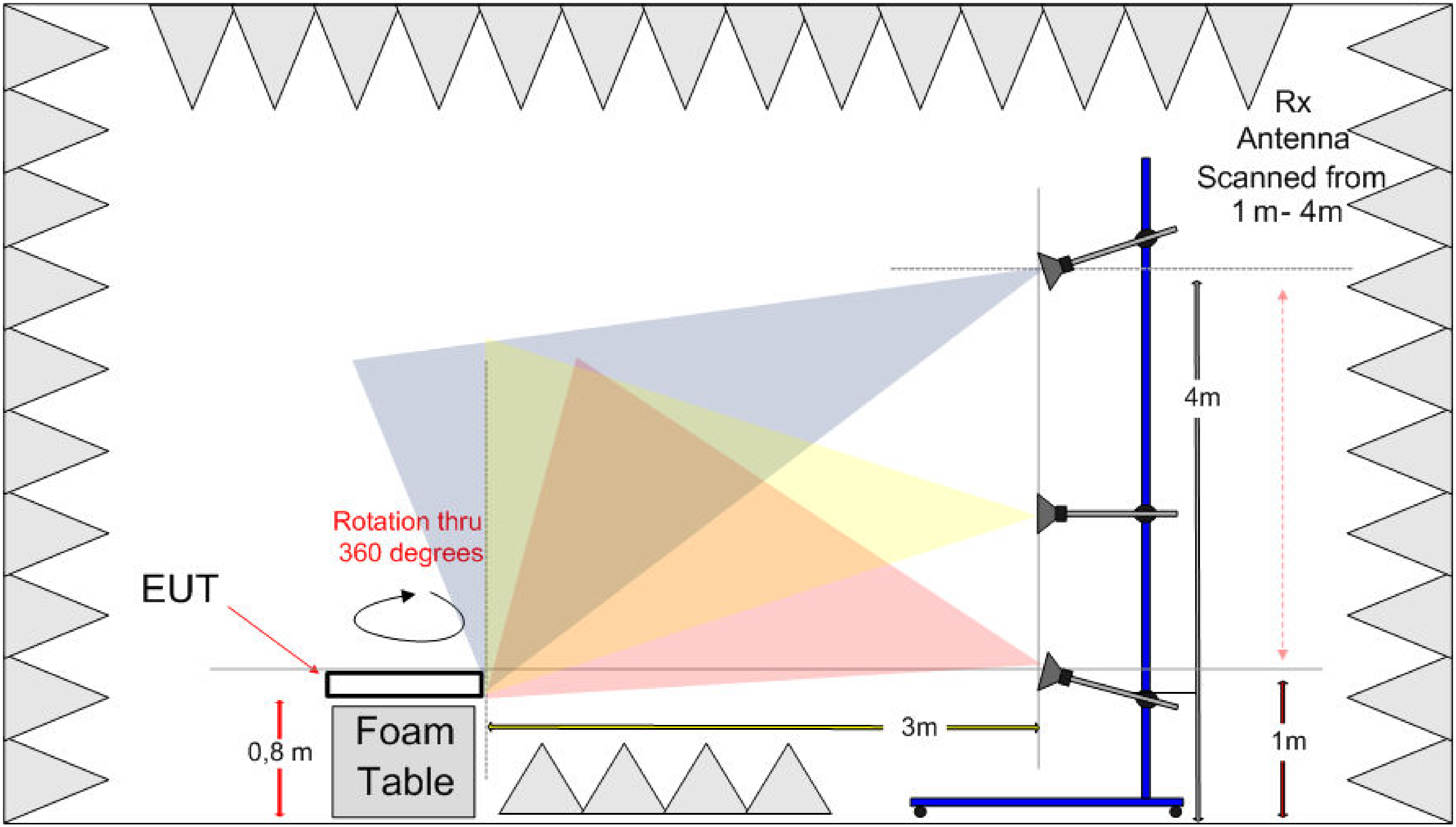
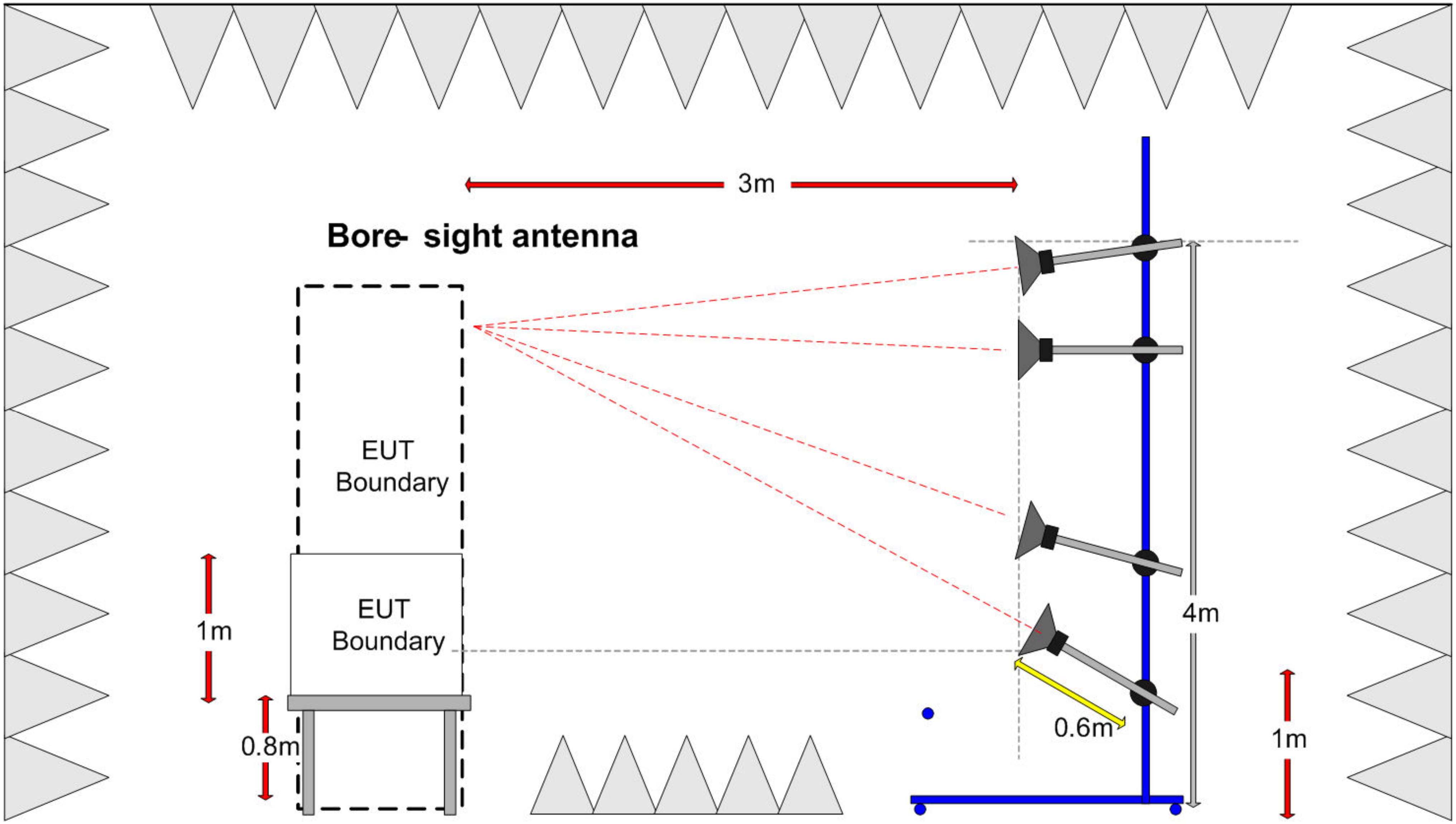


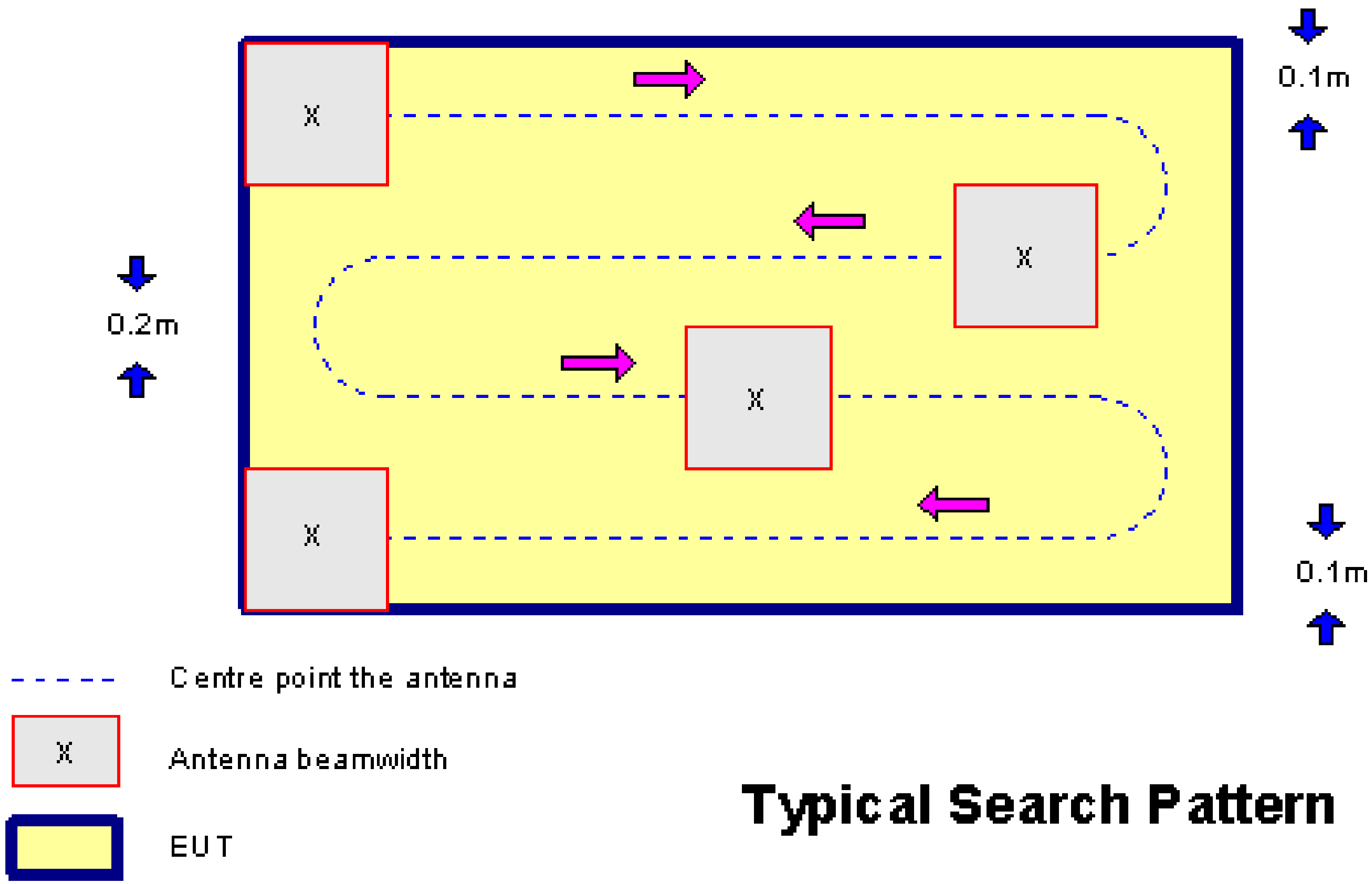
Possible Setups…(7) Bore-site at limit of the 3dB points



Preview tests Methods, Above 18GHz…

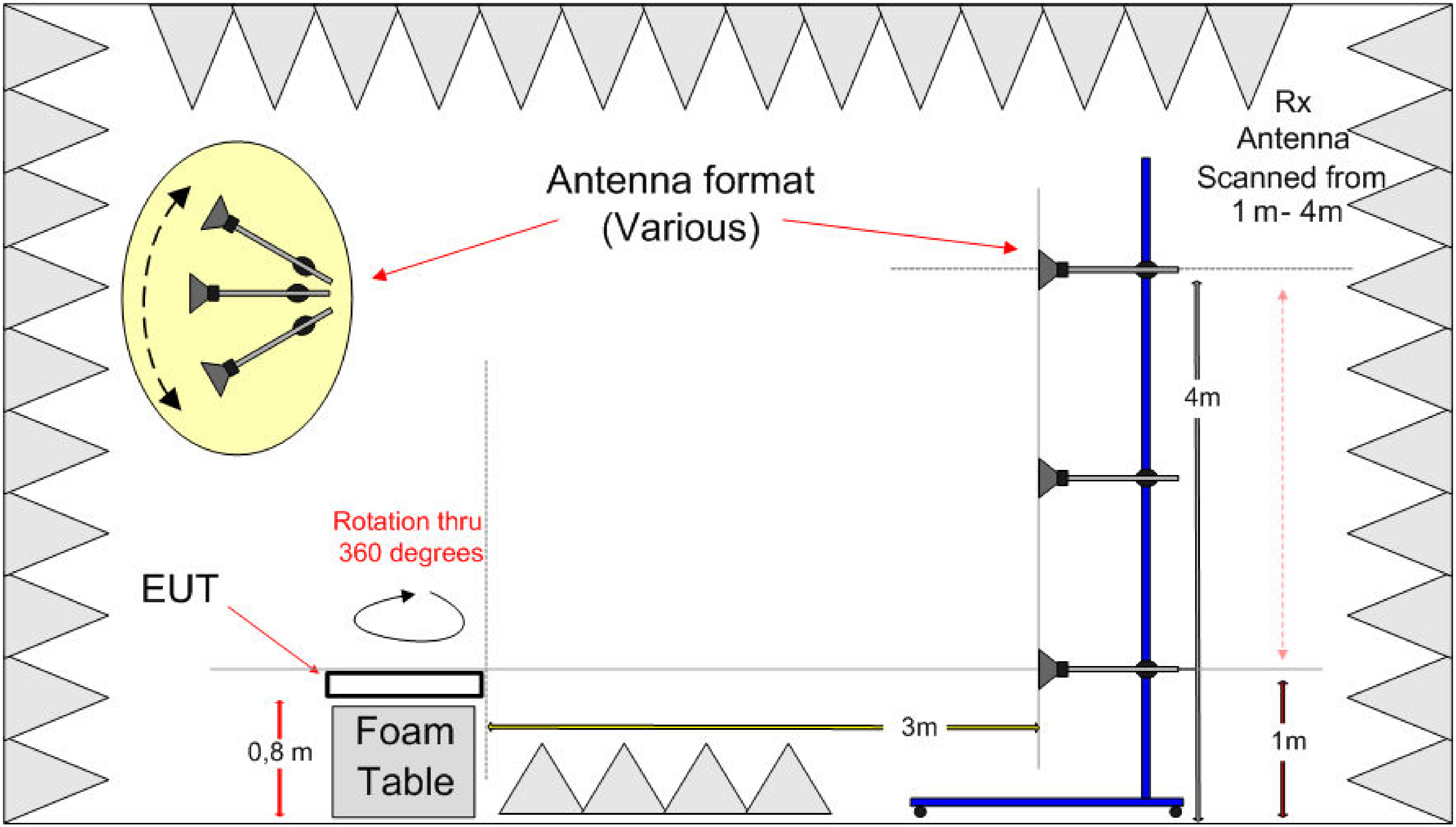
Possible search pattern above 18GHz.

At 0.5m



EUT

EUT Test Results



Process

EUT1 Standard Router configuration.

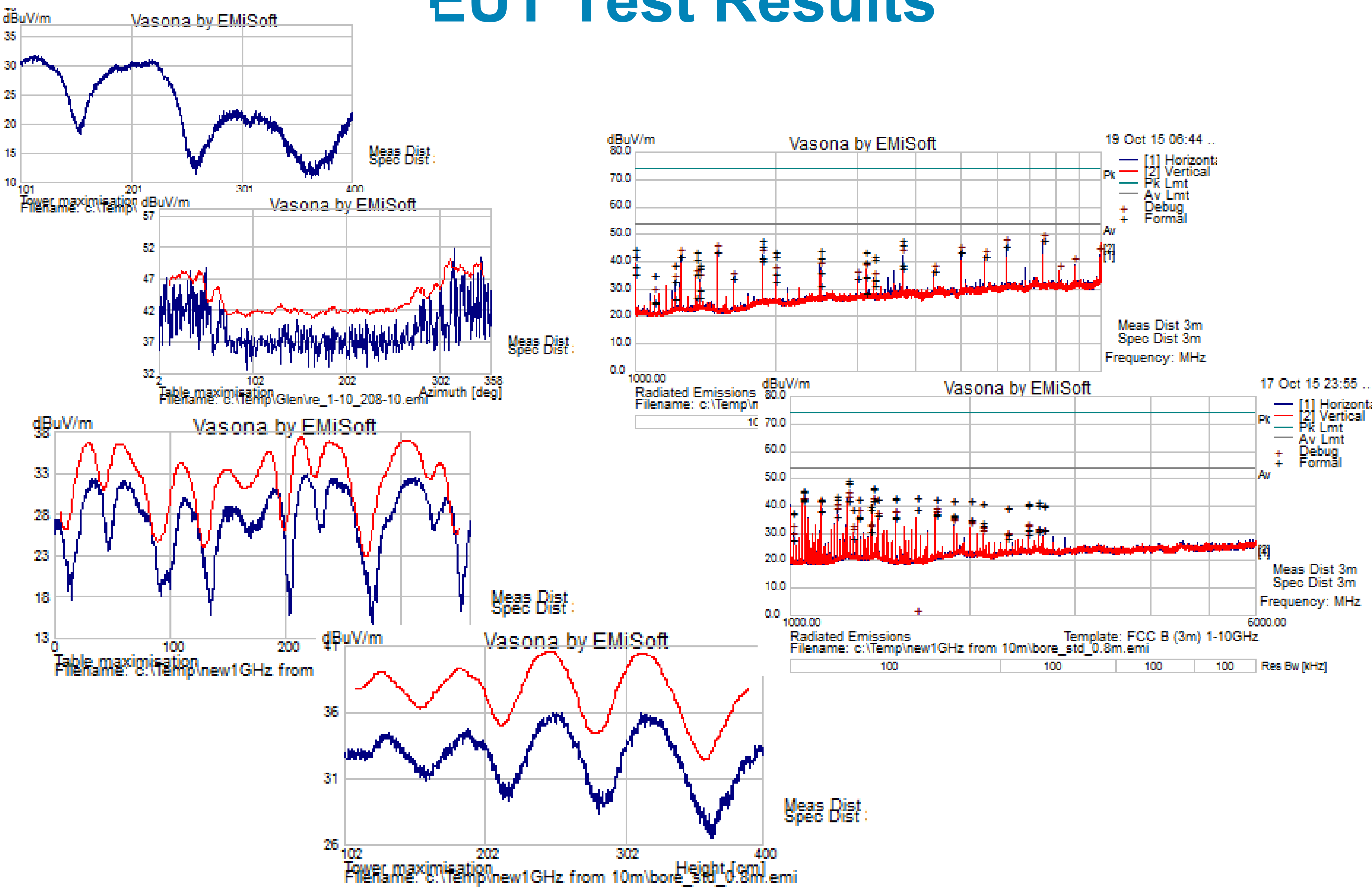
EUT2 (router-1U) top panel slightly opened, emissions easily recorded.

Set resolution and video bandwidth lower than typical to get improvements in noise floor. During formal test set video bandwidth to 500 Hz, to remove impacts of modulation.

After highlighting the major emissions (from a prescan)

1. Select frequency, set to zero span.
2. EUT Rotate thru 360, go back to worst case.
3. Changing antenna height (scanned) from 1 m to 4 m.

EUT Test Results



EUT 1 Freq :1000MHz

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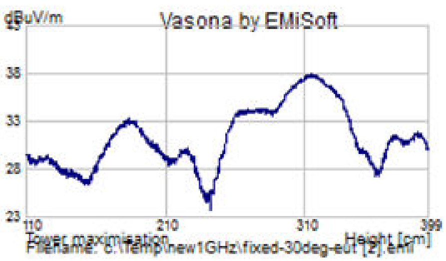
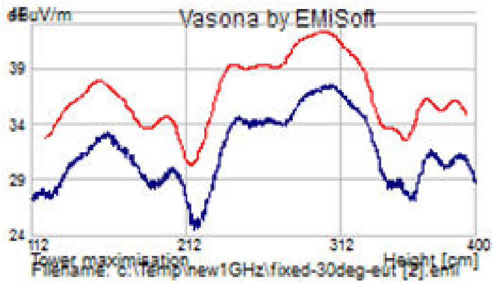
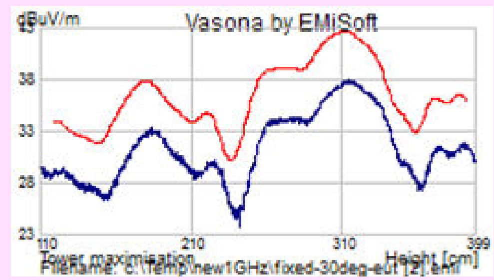
Scan: Planar (3)</td><td>Pol: H, Result: 37
Scan: Bore Dwn (6)</td><td>Pol: H, Result : 37
Scan: Bore Up 3dB (7)</td><td>Pol: H, Result : 38
Scan: Fix Angle (5)</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>Pol: V, Result : 35
Scan: Planar (3)</td><td>Pol: V, Result: 35
Scan: Bore Dwn (6)</td><td>Pol: V, Result : 34
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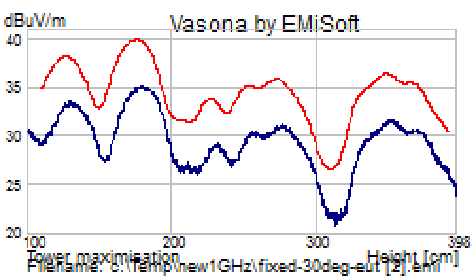
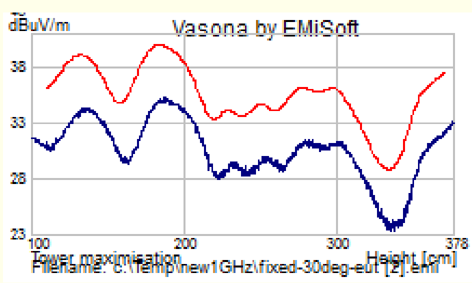
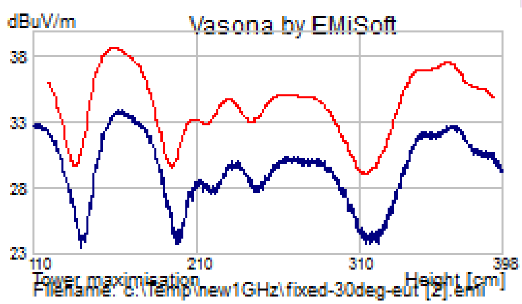
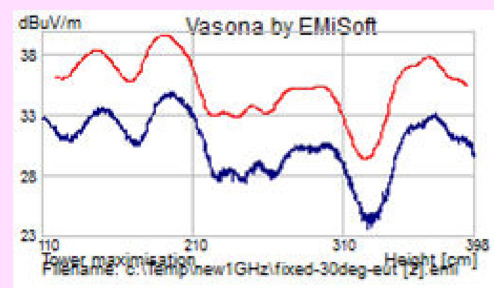
Scan: Fix Angle (5)</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
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EUT 1 Freq : 1875MHz

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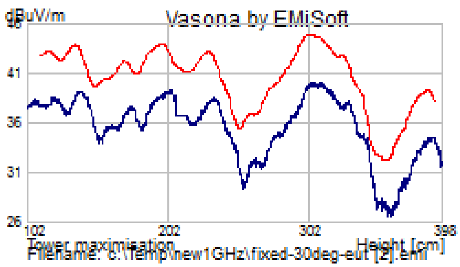
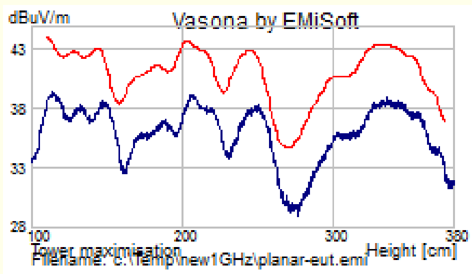
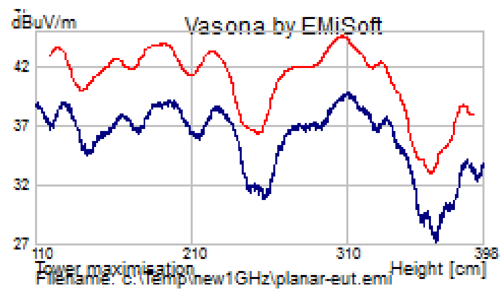
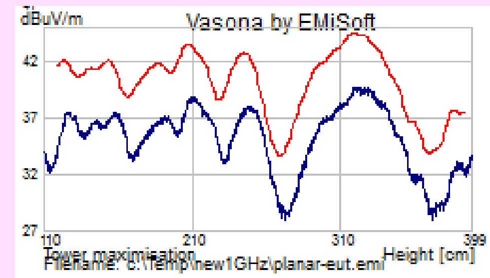
Scan: Planar (3)</td><td>Pol: H, Result: 39
Scan: Bore Dwn (6)</td><td>Pol: H, Result : 39
Scan: Bore Up 3dB (7)</td><td>Pol: H, Result : 40
Scan: Fix Angle (5)</td></tr>
<tr><td>
</td><td>
</td><td>
</td><td>
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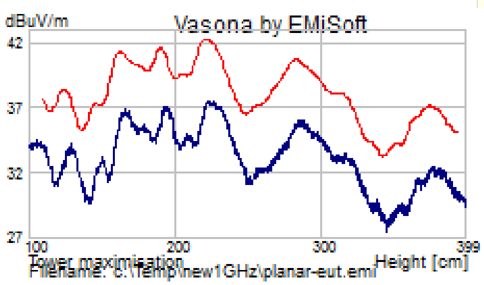
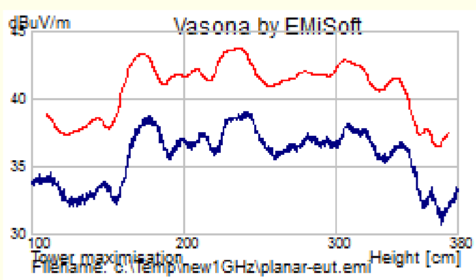
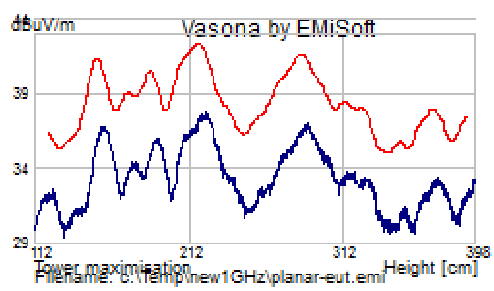
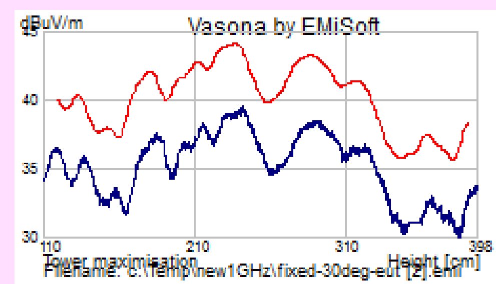
<tr><td>
</td><td>
</td><td>
</td><td>
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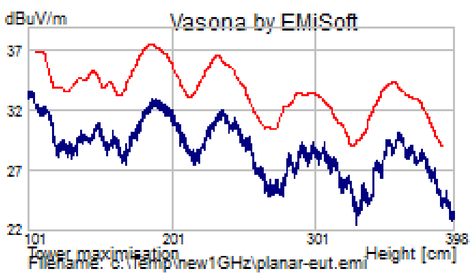
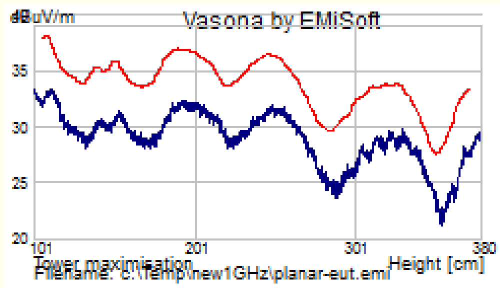
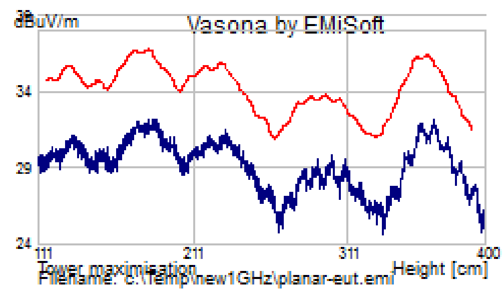
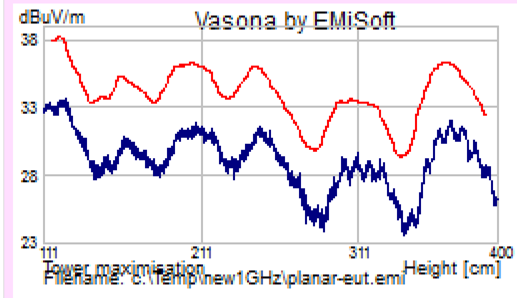
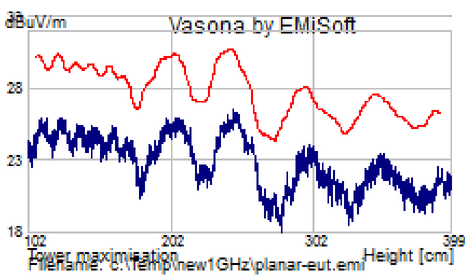
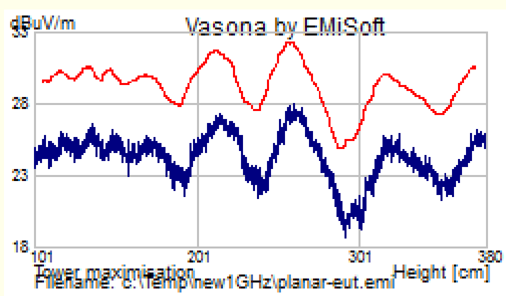
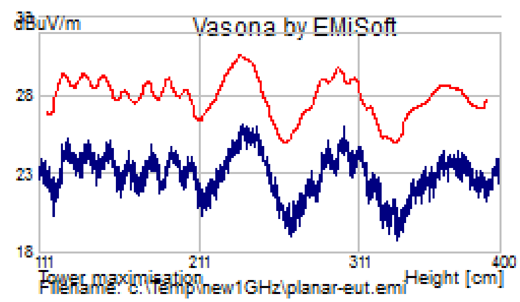
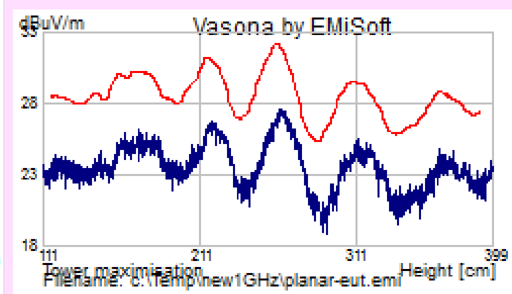
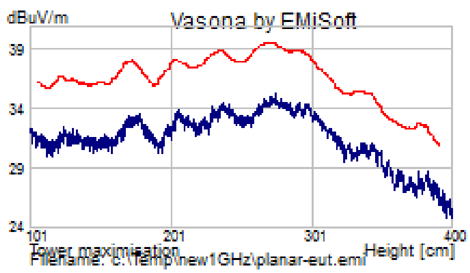
EUT 1 Freq : 2500MHz

Frequency **2500**			
Pol: H, Result : 33 Scan: Planar (3)	Pol: H, Result: 33 Scan: Bore Dwn (6)	Pol: H, Result : 32 Scan: Bore Up 3dB (7)	Pol: H, Result : 34 Scan: Fix Angle (5)
			
Pol: V, Result : 26 Scan: Planar (3)	Pol: V, Result: 27 Scan: Bore Dwn (6)	Pol: V, Result : 25 Scan: Bore Up 3dB (7)	Pol: V, Result : 27 Scan: Fix Angle (5)
			

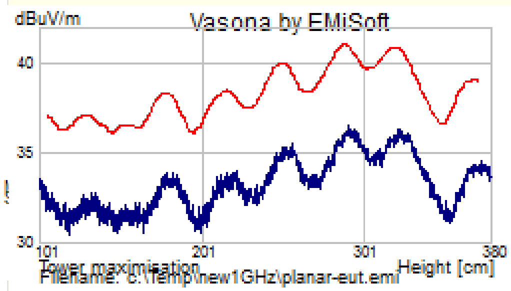
EUT 1 Freq : 3750MHz

Frequency **3750**

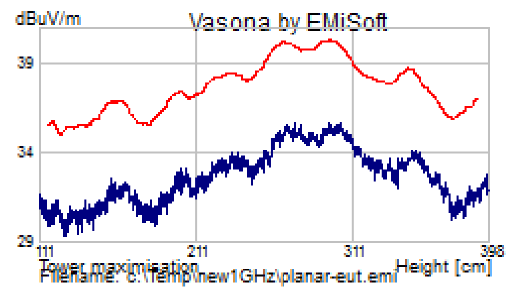
Pol: H, Result : 35
Scan: Planar (3)



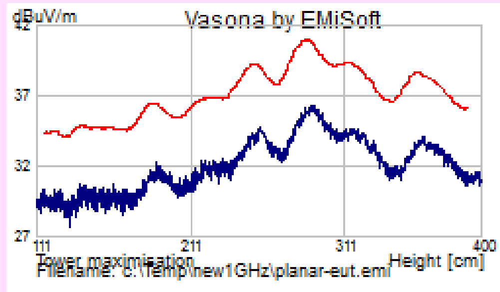
Pol: H, Result: 36
Scan: Bore Dwn (6)



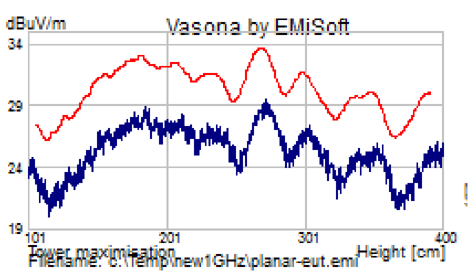
Pol: H, Result : 35
Scan: Bore Up 3dB (7)



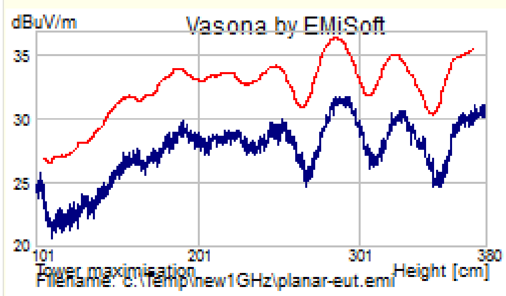
Pol: H, Result : 36
Scan: Fix Angle (5)



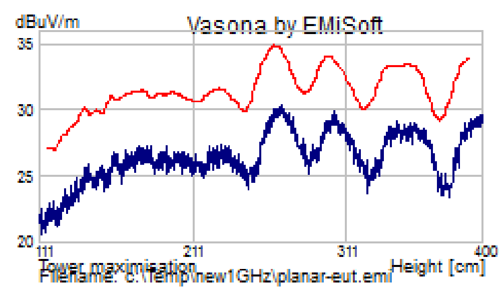
Pol: V, Result : 28
Scan: Planar (3)



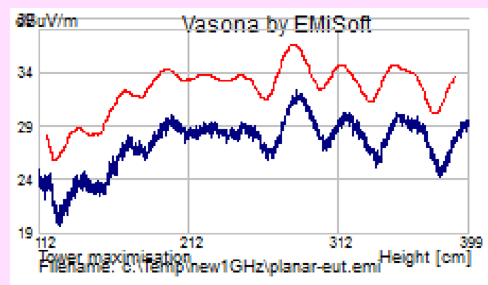
Pol: V, Result: 31
Scan: Bore Dwn (6)



Pol: V, Result : 30
Scan: Bore Up 3dB (7)



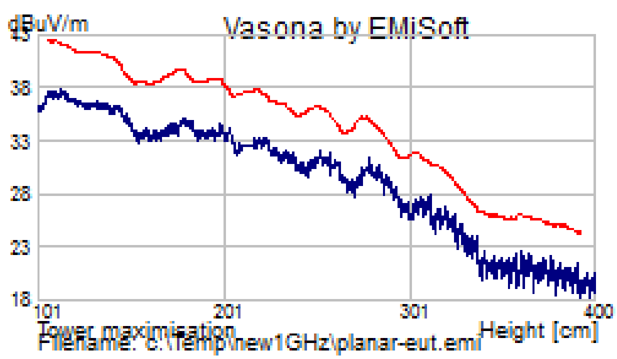
Pol: V, Result : 31
Scan: Fix Angle (5)



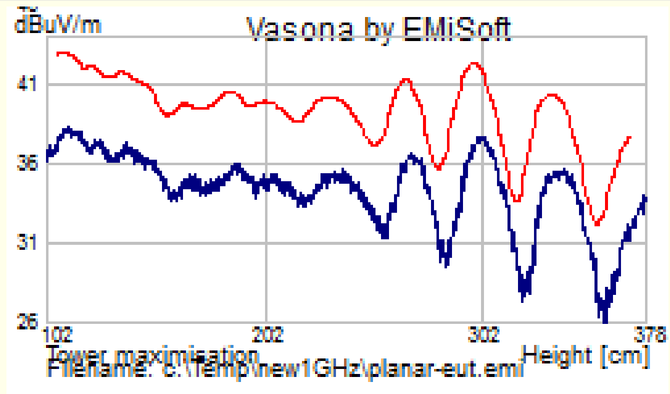
EUT 1 Freq : 5000MHz

Frequency **5000**

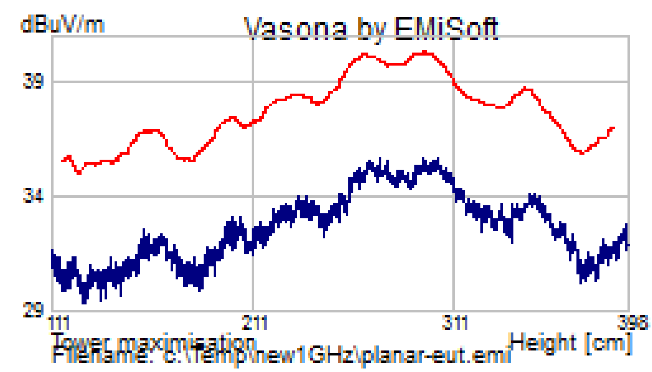
Pol: H, Result : 37
Scan: Planar (3)



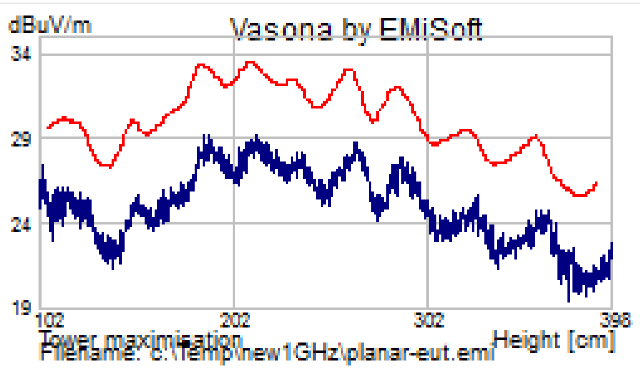
Pol: H, Result: 38
Scan: Bore Dwn (6)



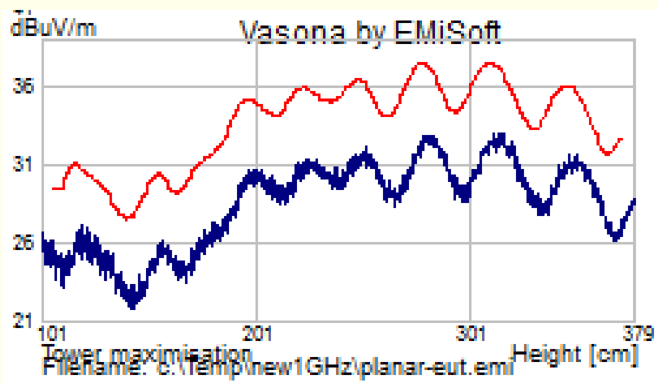
Pol: H, Result : 36
Scan: Bore Up 3dB (7)



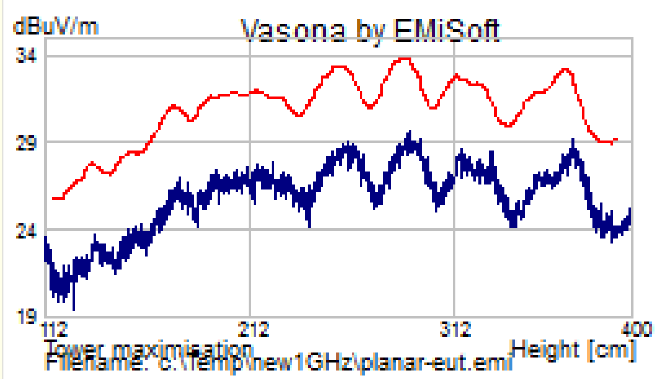
Pol: V, Result : 28
Scan: Planar (3)



Pol: V, Result: 33
Scan: Bore Dwn (6)



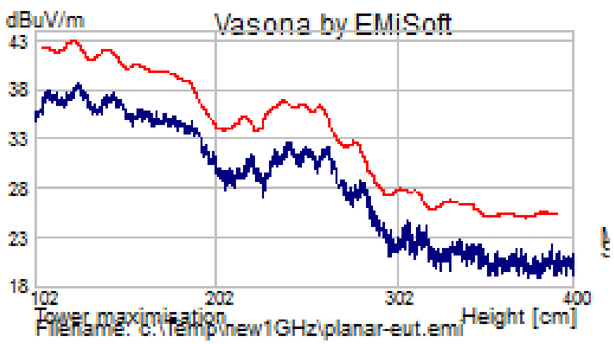
Pol: V, Result : 29
Scan: Bore Up 3dB (7)



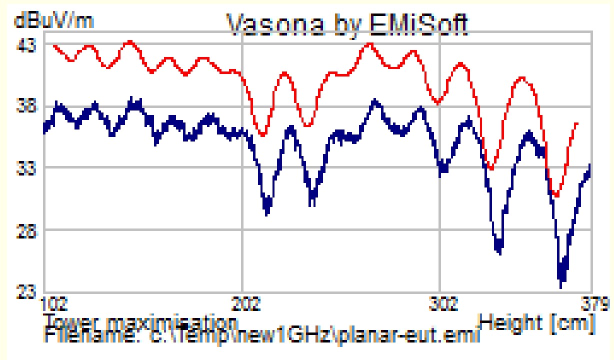
EUT 1 Freq : 6250MHz

Frequency **6250**

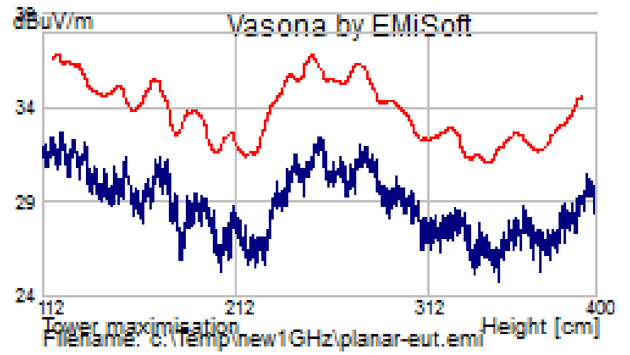
Pol: H, Result : 35
Scan: Planar (3)



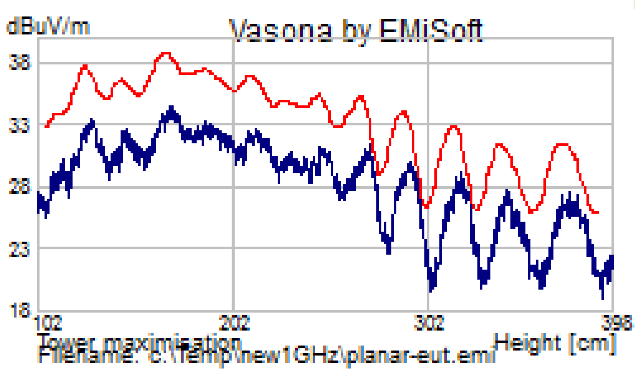
Pol: H, Result: 36
Scan: Bore Dwn (6)



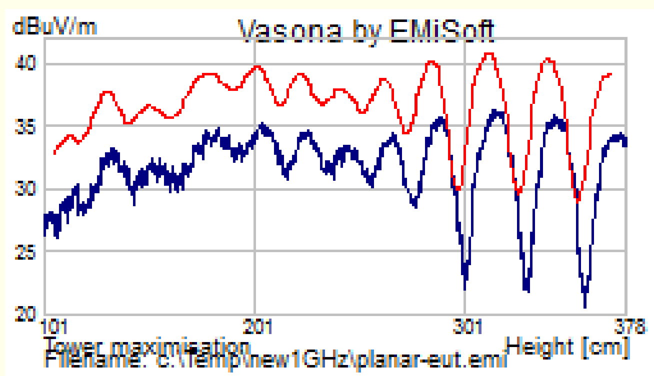
Pol: H, Result : 35
Scan: Bore Up 3dB (7)



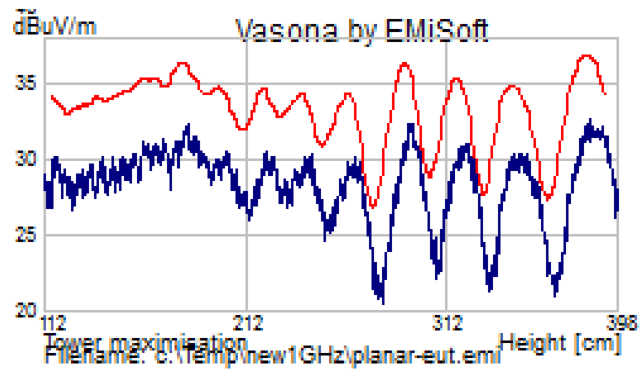
Pol: V, Result : 34
Scan: Planar (3)



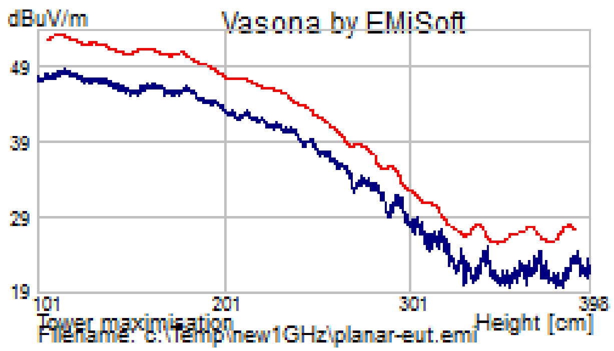
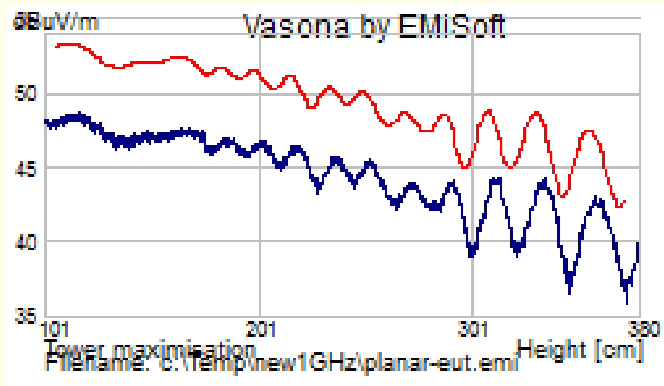
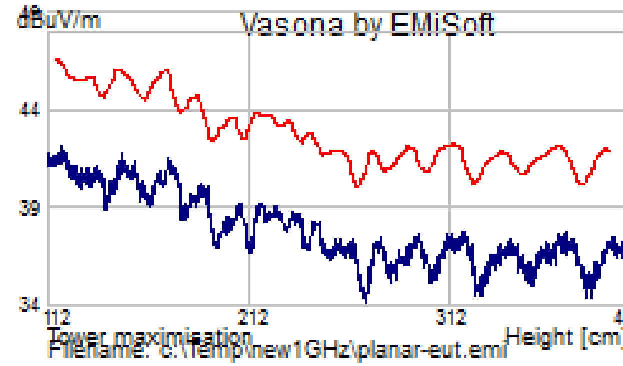
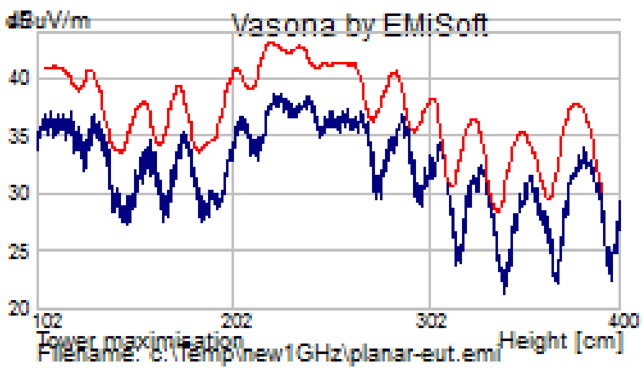
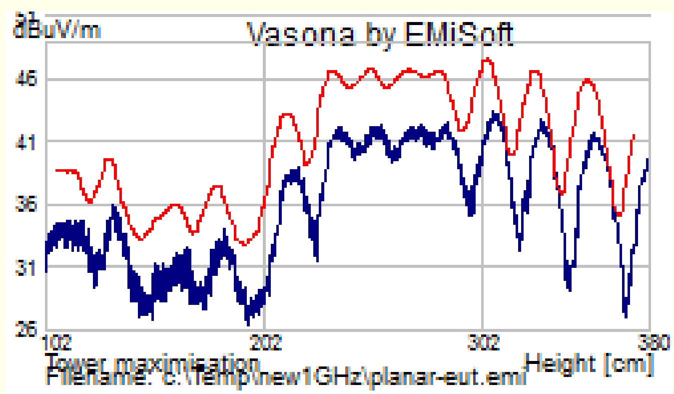
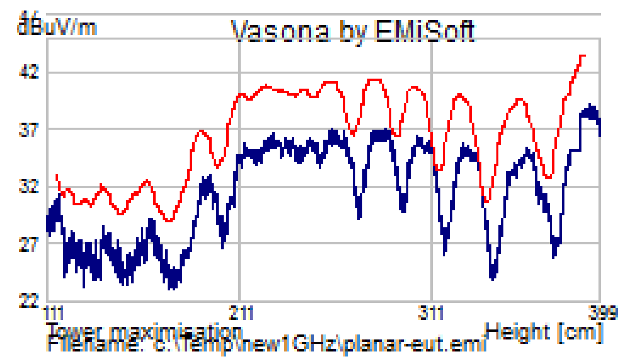
Pol: V, Result: 36
Scan: Bore Dwn (6)



Pol: V, Result : 32
Scan: Bore Up 3dB (7)



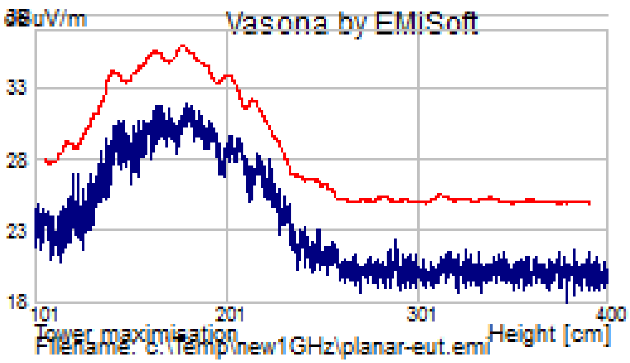
EUT 1 Freq : 7500MHz

Frequency **7500**		
Pol: H, Result : 48 Scan: Planar (3)	Pol: H, Result: 48 Scan: Bore Dwn (6)	Pol: H, Result : 41 Scan: Bore Up 3dB (7)
		
Pol: V, Result : 39 Scan: Planar (3)	Pol: V, Result: 42 Scan: Bore Dwn (6)	Pol: V, Result : 39 Scan: Bore Up 3dB (7)
		

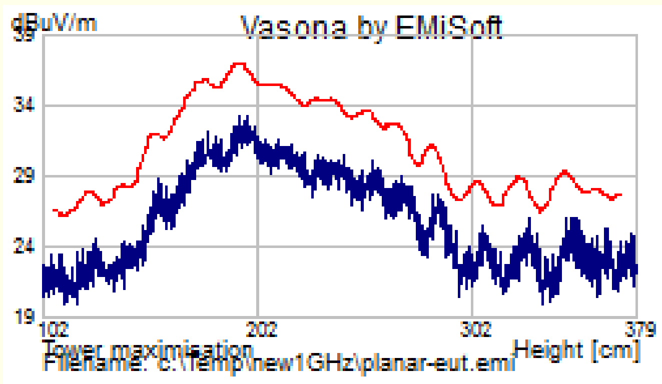
EUT 1 Freq : 8125.4MHz

Frequency **8125.4**

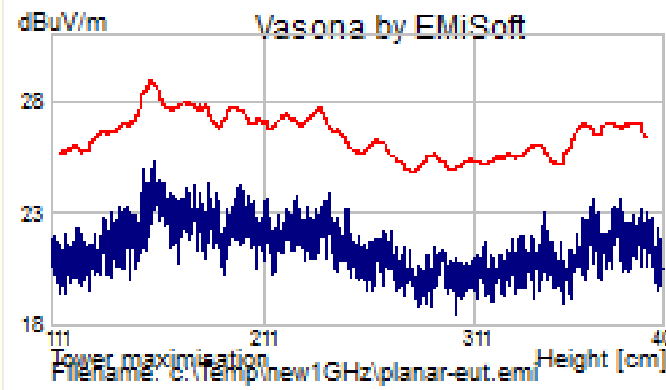
Pol: H, Result : 31
Scan: Planar (3)



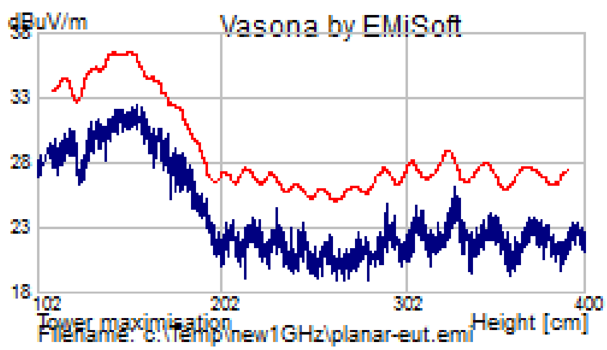
Pol: H, Result: 32
Scan: Bore Dwn (6)



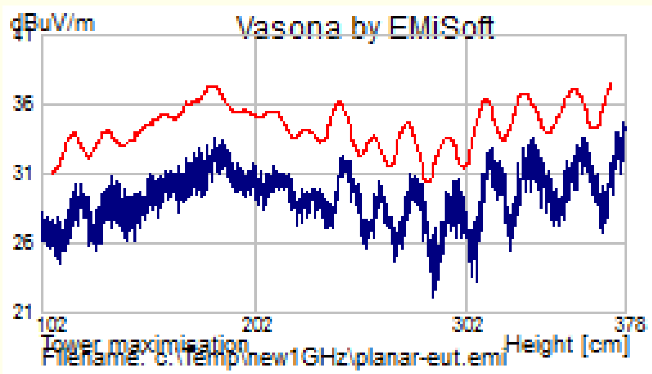
Pol: H, Result : 25
Scan: Bore Up 3dB (7)



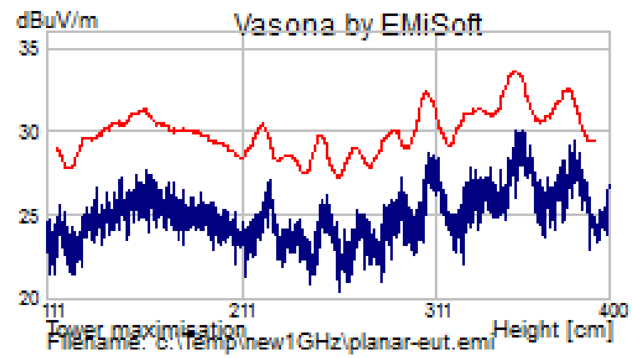
Pol: V, Result : 32
Scan: Planar (3)



Pol: V, Result: 34
Scan: Bore Dwn (6)



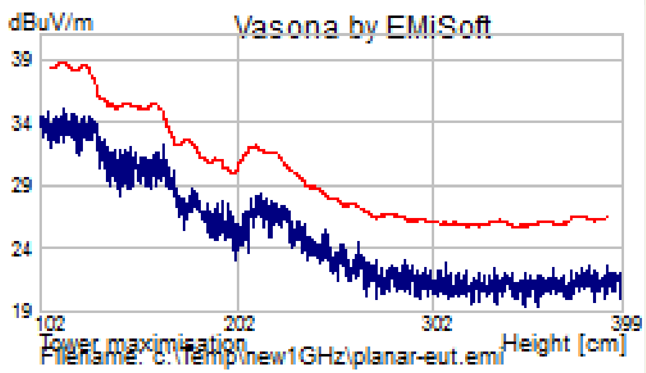
Pol: V, Result : 29
Scan: Bore Up 3dB (7)



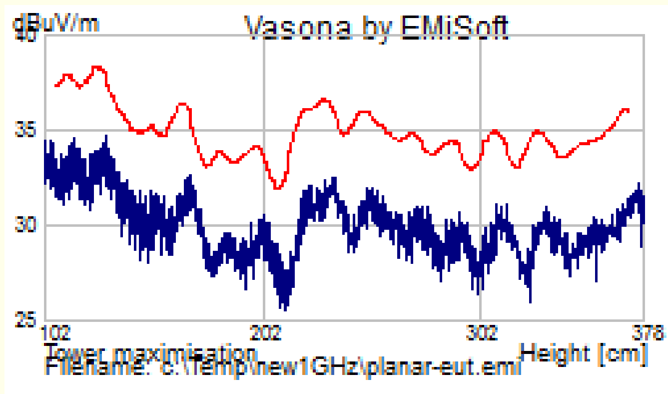
EUT 1 Freq : 8750MHz

Frequency **8750**

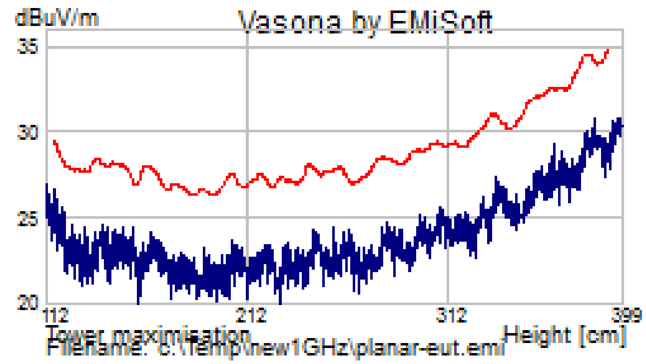
Pol: H, Result : 34
Scan: Planar (3)



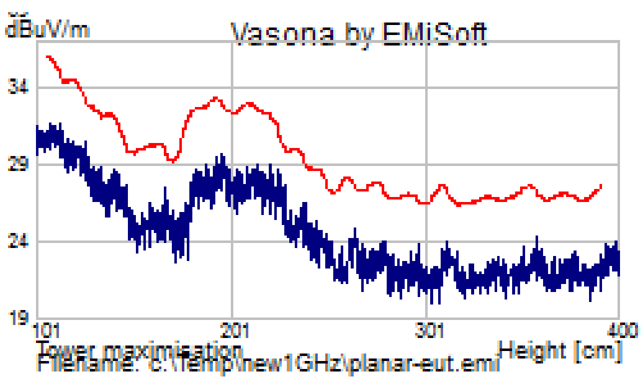
Pol: H, Result: 34
Scan: Bore Dwn (6)



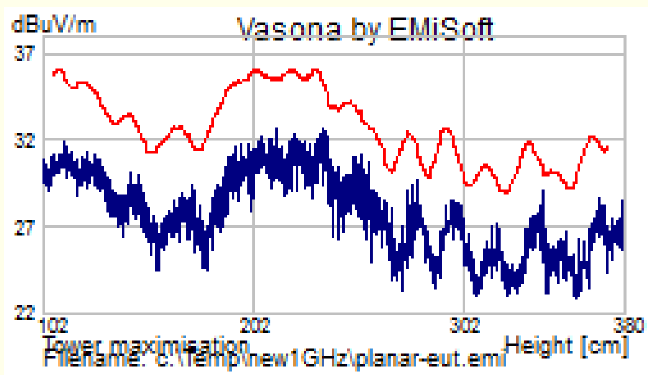
Pol: H, Result : 31
Scan: Bore Up 3dB (7)



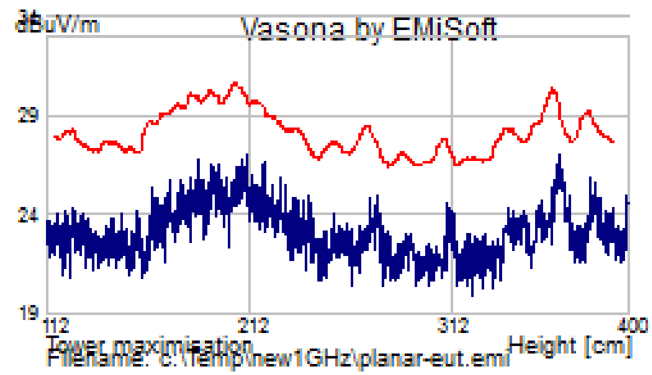
Pol: V, Result : 31
Scan: Planar (3)



Pol: V, Result: 32
Scan: Bore Dwn (6)



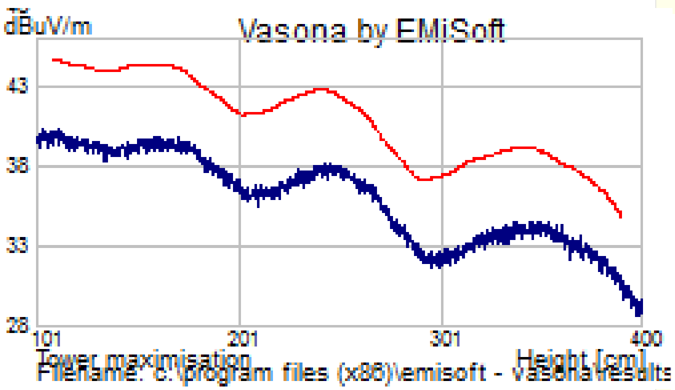
Pol: V, Result : 27
Scan: Bore Up 3dB (7)



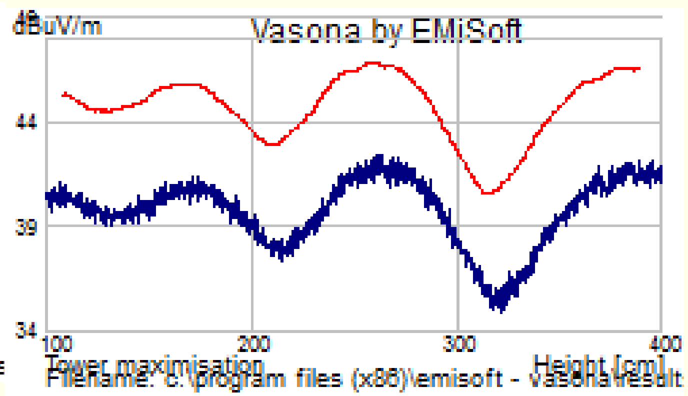
EUT 2 Freq : 1375 MHz

Frequency **1375**

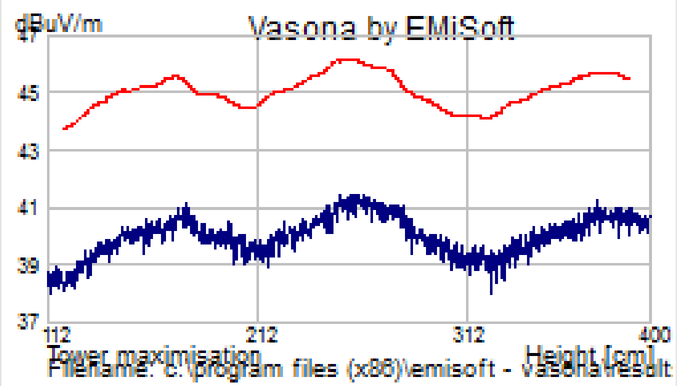
Pol: H, Result : 40
Scan: Planar (3)



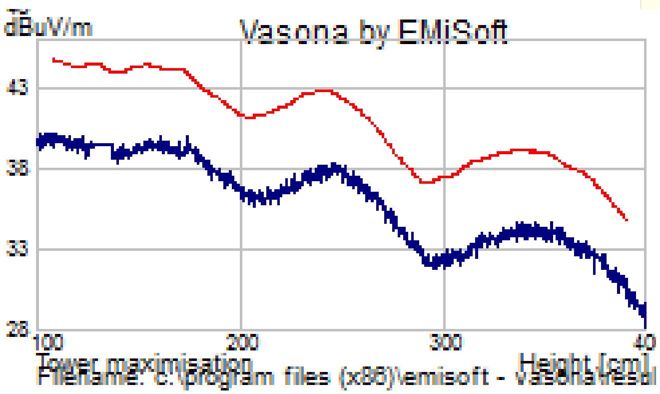
Pol: H, Result: 42
Scan: Bore Dwn (6)



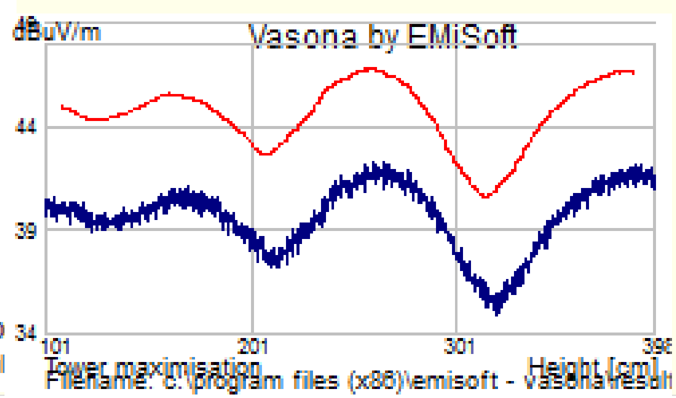
Pol: H, Result : 41
Scan: Bore Up 3dB (7)



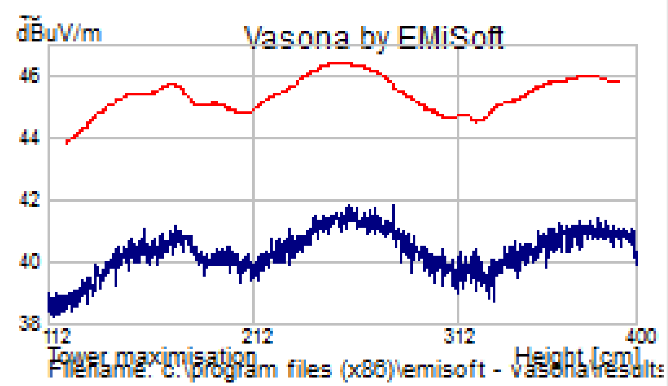
Pol: V, Result : 40
Scan: Planar (3)



Pol: V, Result: 42
Scan: Bore Dwn (6)



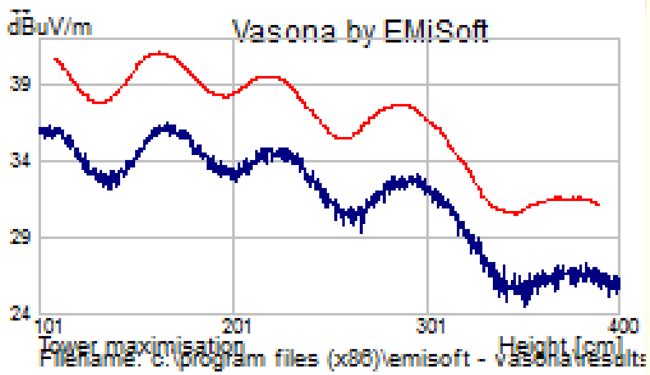
Pol: V, Result : 41
Scan: Bore Up 3dB (7)



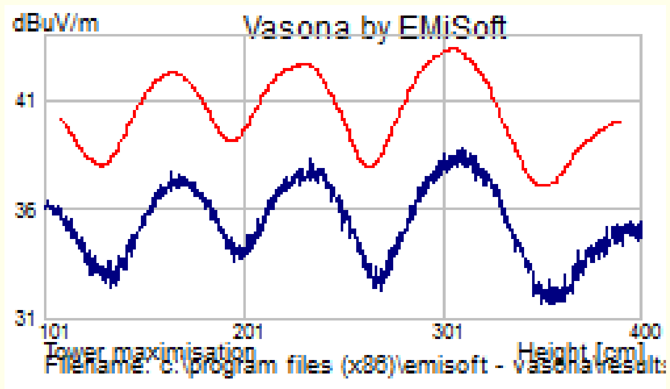
EUT 2 Freq : 1625 MHz

Frequency **1625**

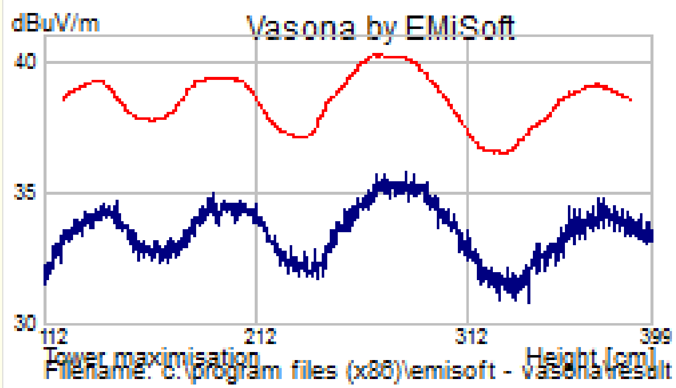
Pol: H, Result : 36
Scan: Planar (3)



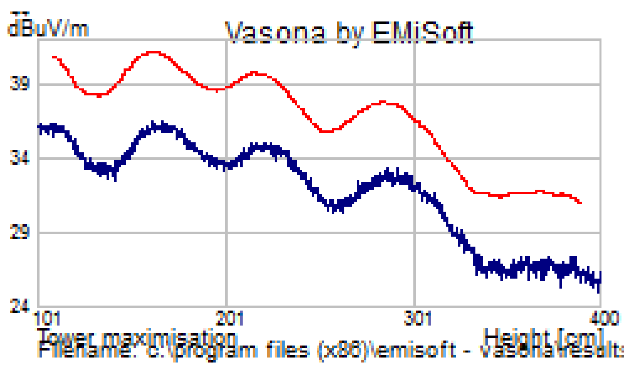
Pol: H, Result: 38
Scan: Bore Dwn (6)



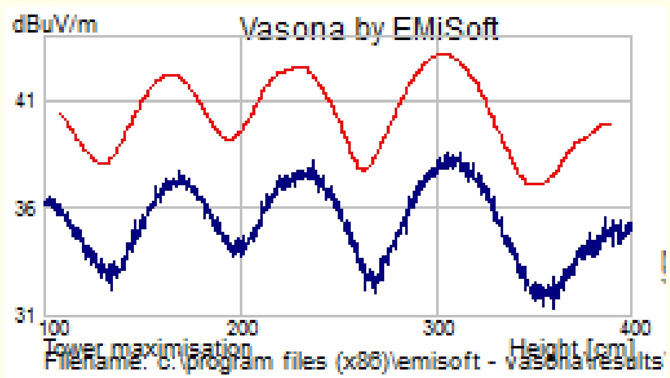
Pol: H, Result : 36
Scan: Bore Up 3dB (7)



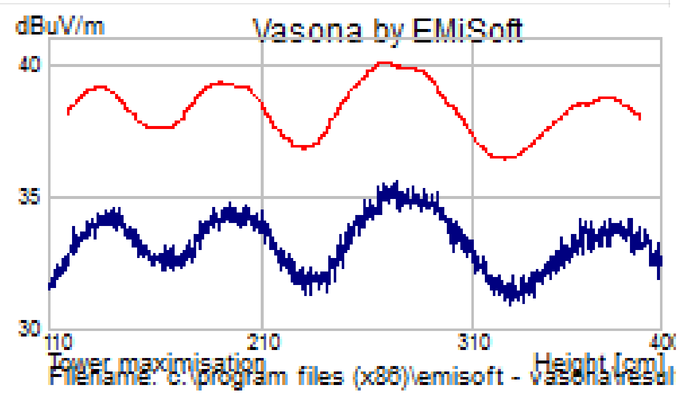
Pol: V, Result : 36
Scan: Planar (3)



Pol: V, Result: 38
Scan: Bore Dwn (6)



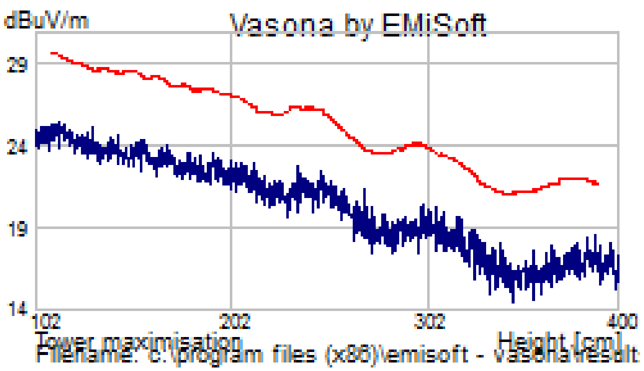
Pol: V, Result : 36
Scan: Bore Up 3dB (7)



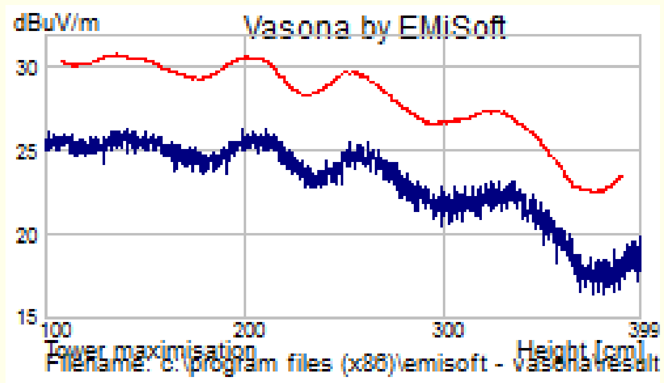
EUT 2 Freq : 2300 MHz

Frequency **2300**

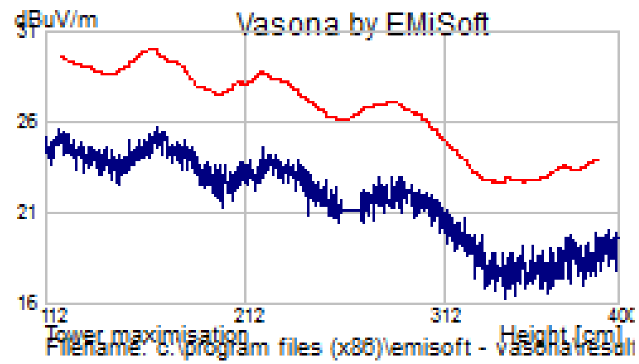
Pol: H, Result : 25
Scan: Planar (3)



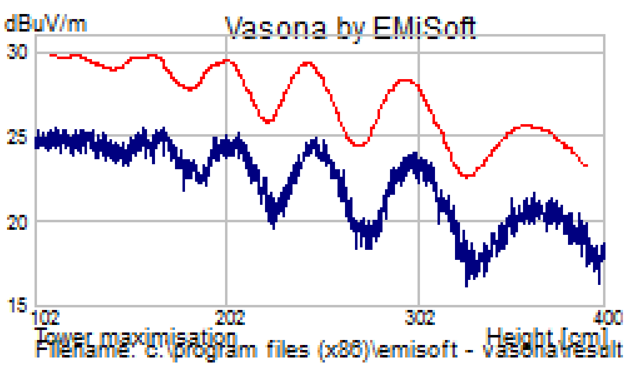
Pol: H, Result: 26
Scan: Bore Dwn (6)



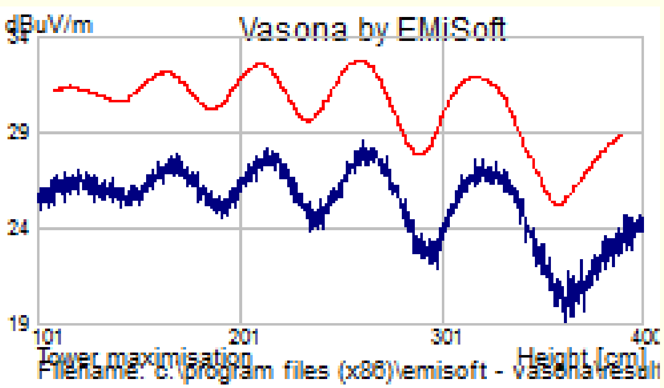
Pol: H, Result : 24
Scan: Bore Up 3dB (7)



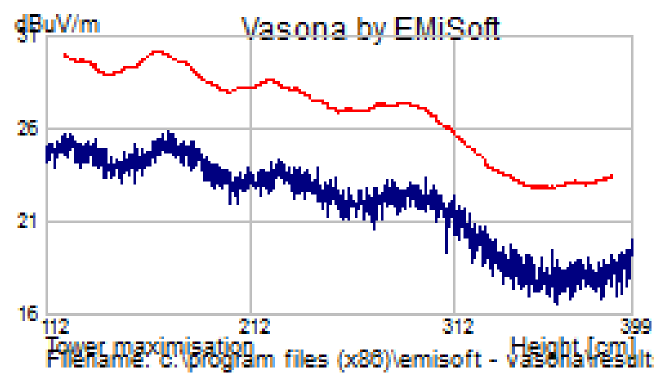
Pol: V, Result : 26
Scan: Planar (3)



Pol: V, Result: 28
Scan: Bore Dwn (6)

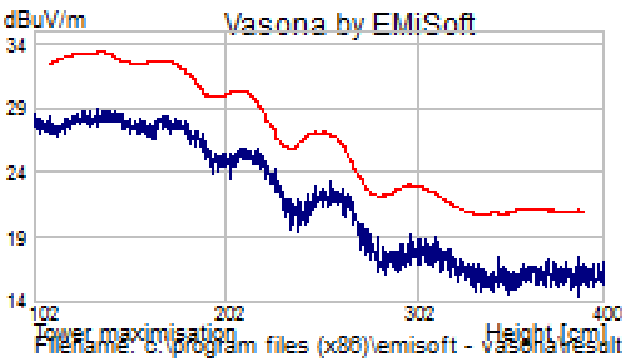
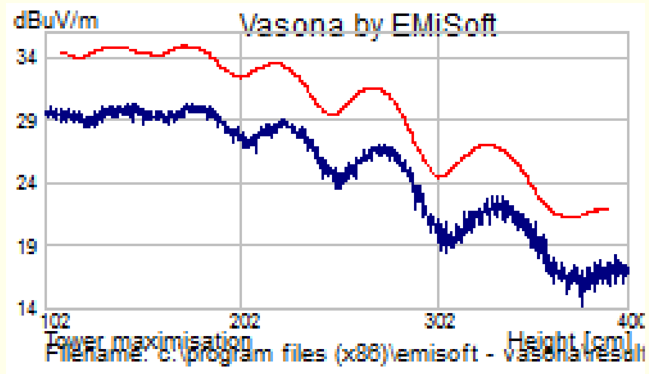
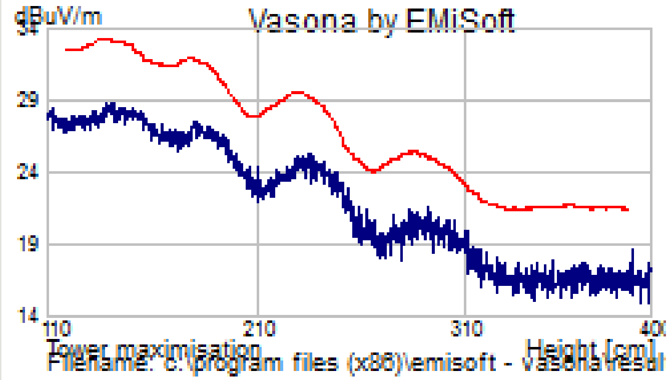


Pol: V, Result : 25
Scan: Bore Up 3dB (7)



EUT 2 Freq : 2650 MHz

Frequency **2650**

Pol: H, Result : 29 Scan: Planar (3)	Pol: H, Result: 30 Scan: Bore Dwn (6)	Pol: H, Result : 28 Scan: Bore Up 3dB (7)
		
Pol: V, Result : 28 Scan: Planar (3)	Pol: V, Result: 30 Scan: Bore Dwn (6)	Pol: V, Result : 28 Scan: Bore Up 3dB (7)