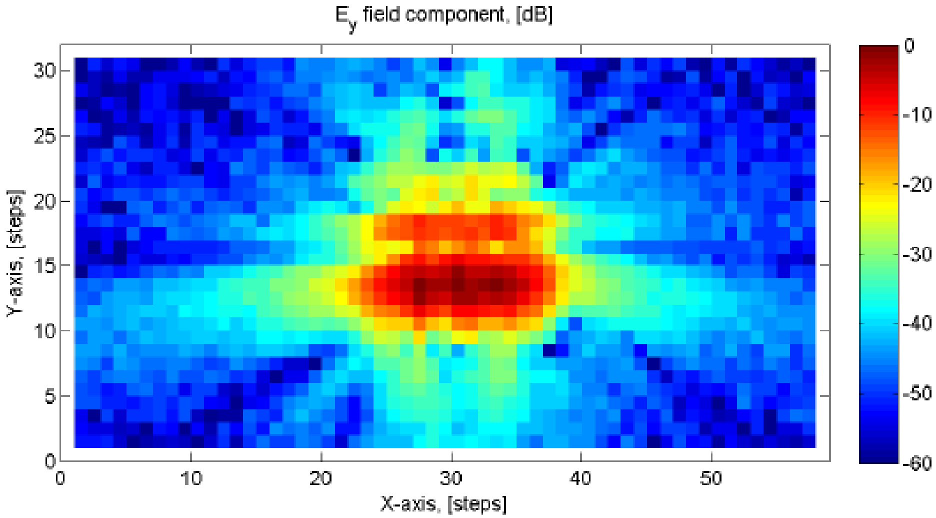
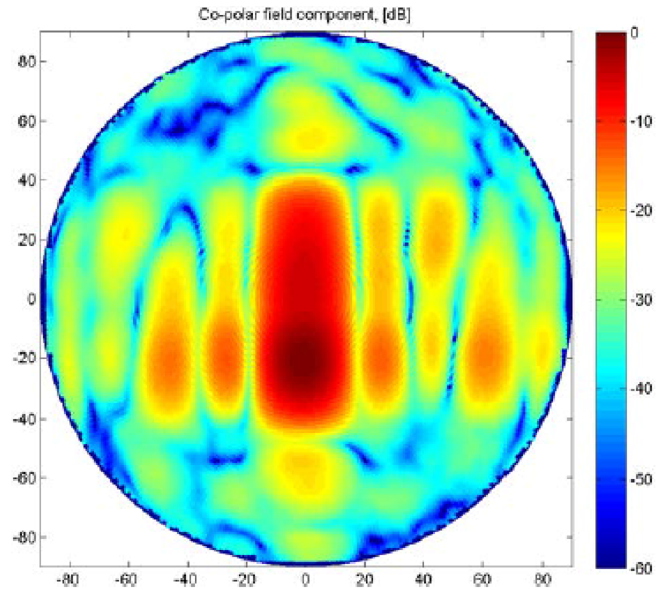
Near-Field Measurement Techniques



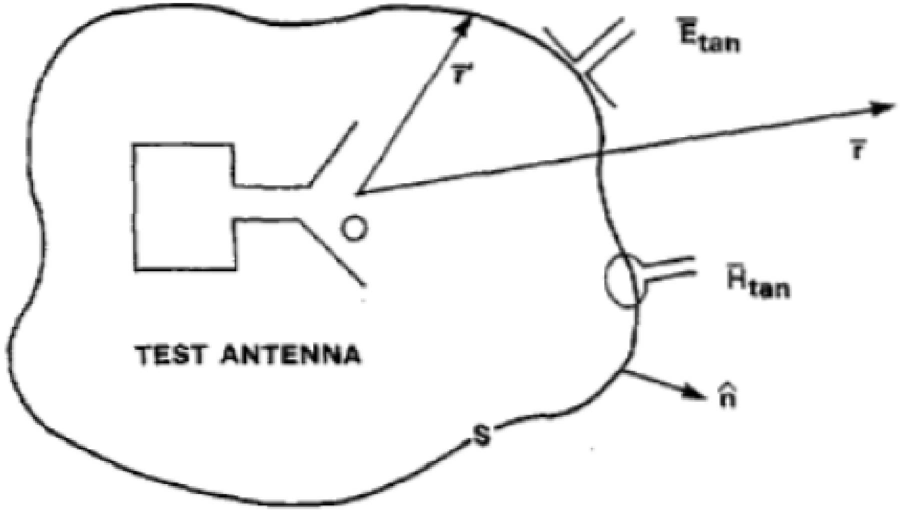
Measured near field

Near-field to far-field transformation algorithm ?



Calculated far field

NF techniques: general problem



$$\bar{E}(\bar{r}) \underset{r\to\infty}{=} \frac{-ike^{ikr}}{4\pi r}\,\hat{r}\times\oint_S(\bar{K}_m + Z_0\,\hat{r}\times\bar{K}_e)\,e^{-ik\hat{r}\cdot\bar{r}'}\,dS'$$

$$\bar{K}_e = \hat{n}\times\bar{H} \qquad \bar{K}_m = -\hat{n}\times\bar{E}$$

$$\bar{E}(\bar{r}) = \oint_S [\hat{n}'\times\bar{E}(\bar{r}')]\cdot\bar{\bar{G}}(\bar{r}',\bar{r})\,dS'$$

Assume we have ideal probes that measure the electric and magnetic field tangential to an arbitrary surface S enclosing the test antenna

The far field is then given by vector Kirckhoff integral of the equivalent electric and magnetic currents

It can be derived in terms of tangential electric or magnetic field alone: expression with dyadic Green's function $\bar{\bar{G}}$

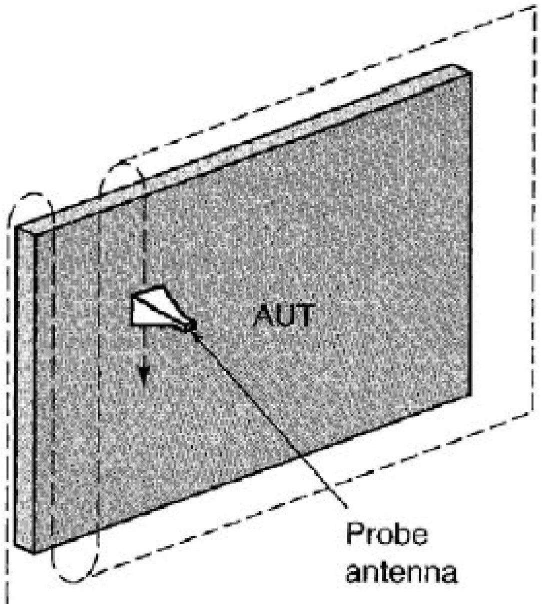
However, $\bar{\bar{G}}$ is impractical to find, unless the surface S supports orthogonal vector wave functions

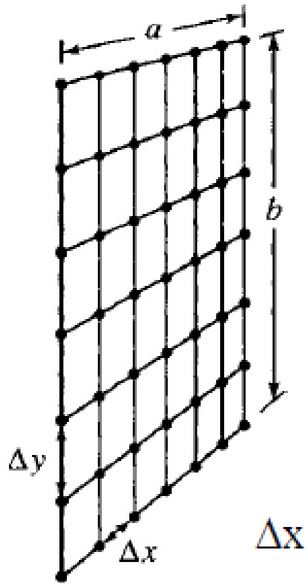
Three coordinate systems offer mechanically convenient scanning possibilities:
planar, cylindrical, and spherical

A.D. Yaghjian, "An overview of near-field antenna measurements", *IEEE Trans. Antennas Propagat.*, vol. 34, no. 1, 1986, pp. 30-45.

Scanning Geometries I

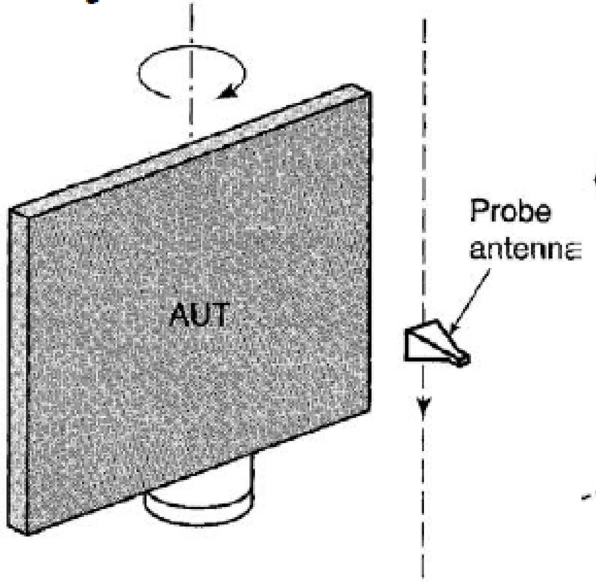
planar

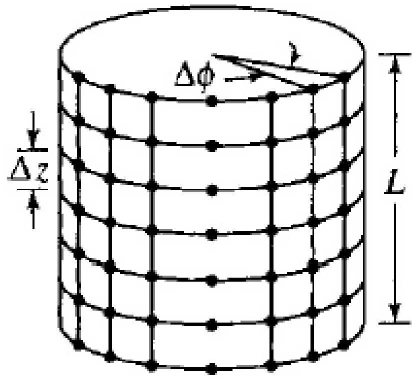




$\Delta x = \Delta y \leq \lambda/2$

cylindrical

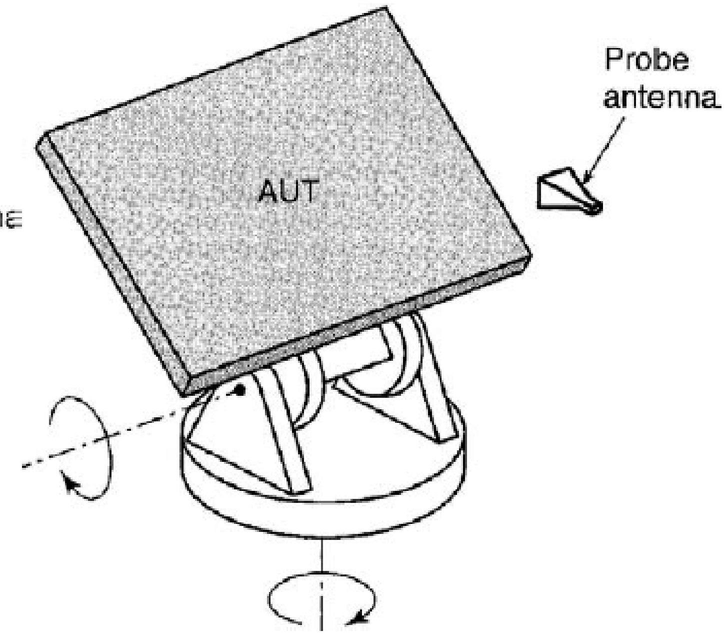


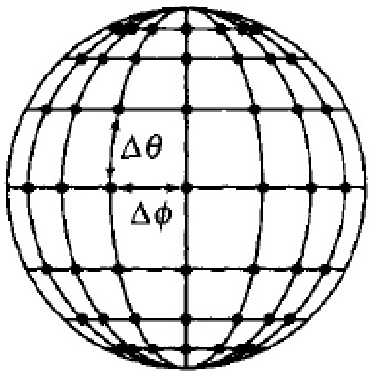


$\Delta z \leq \lambda/2$

$\Delta \phi = \lambda/2(a+\lambda)$

spherical

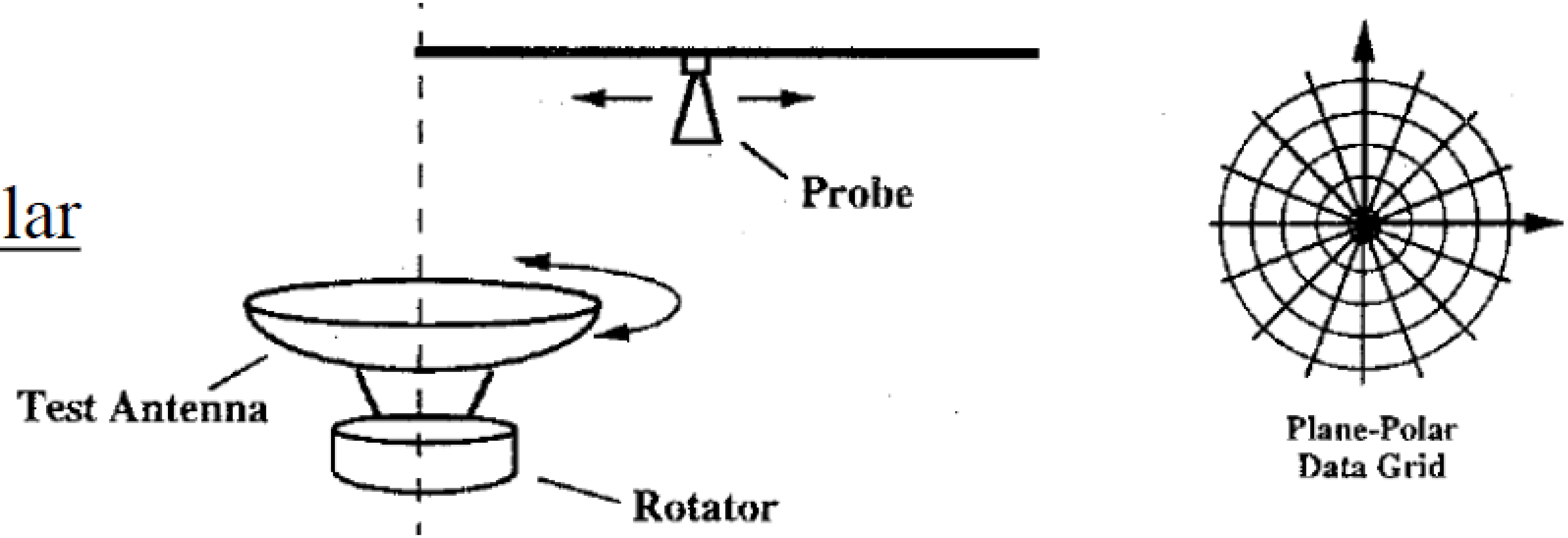




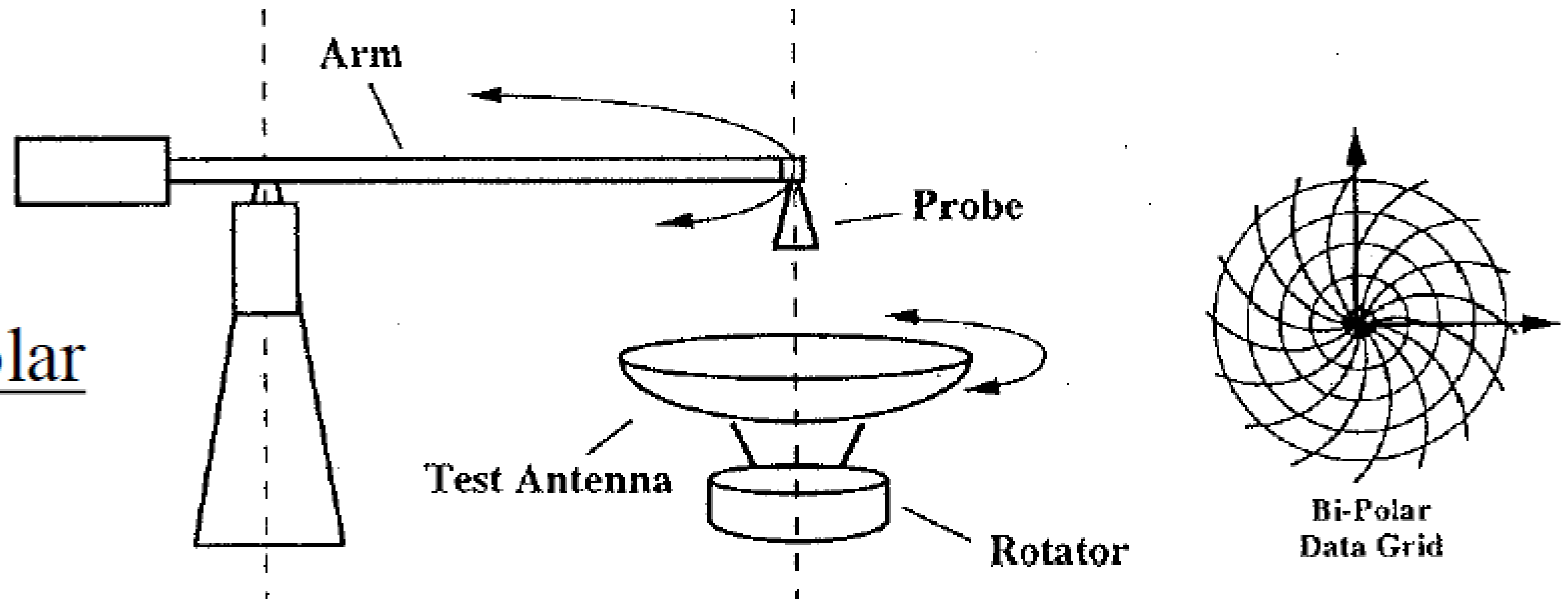
$\Delta \phi = \Delta \theta = \lambda/2(a+\lambda)$

Scanning Geometries II

plane-polar

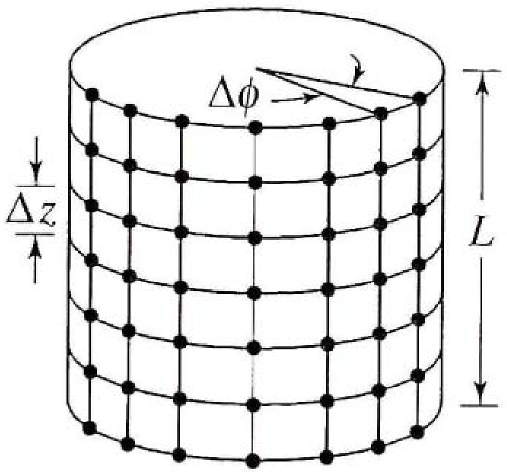


plane-bi-polar



Cylindrical Scanning

Spherical Scanning



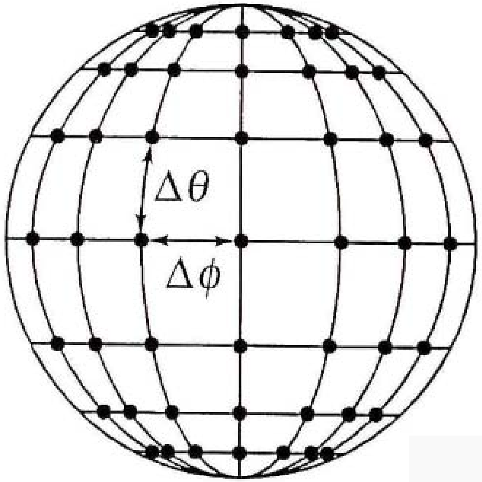


Fig. 17.12(b,c)

Maximum Sampling

Cylindrical (a = radius of cylinder)

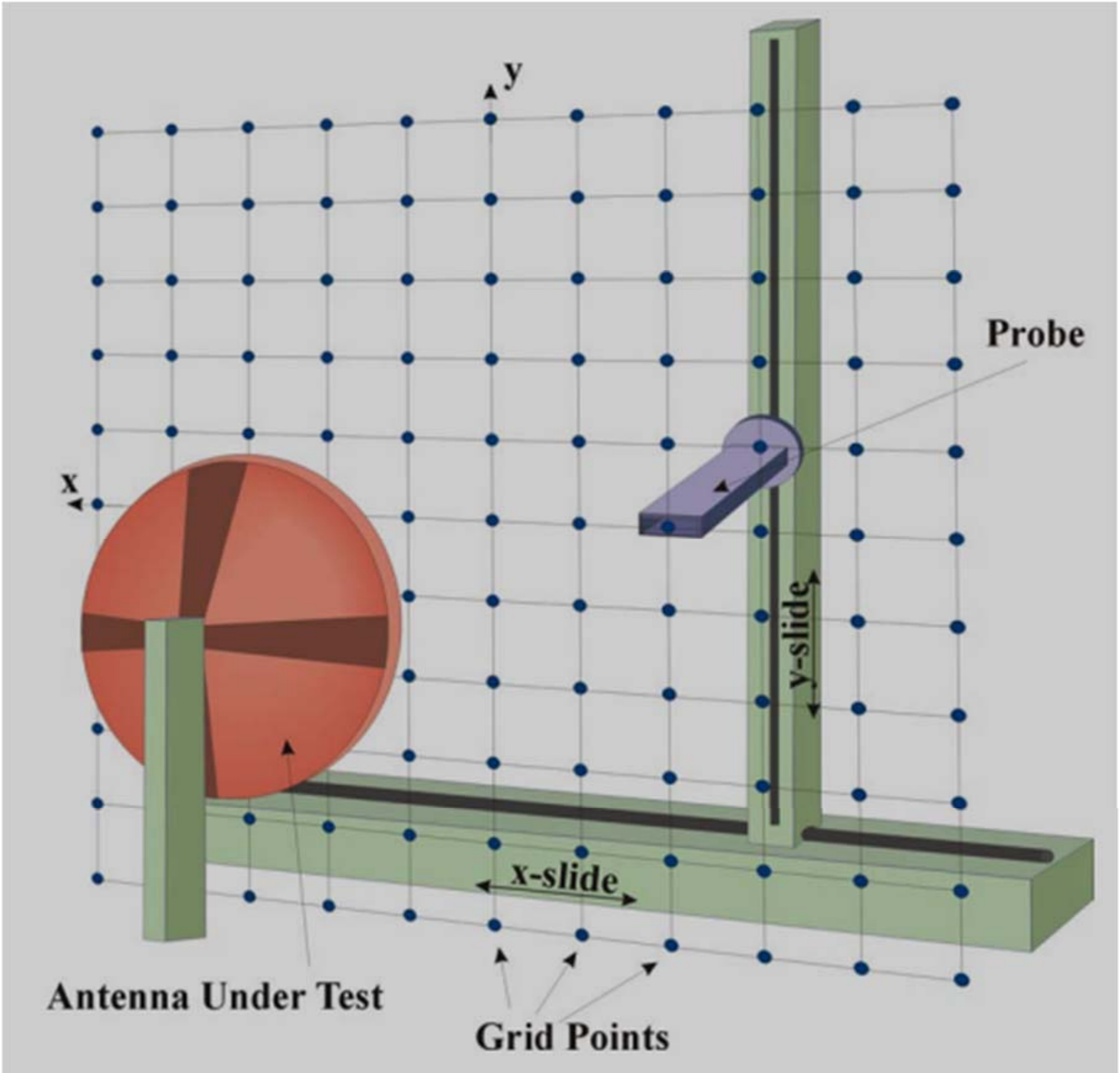
$$\Delta\phi = \frac{\lambda}{2(\alpha+\lambda)} \tag{17-1}$$

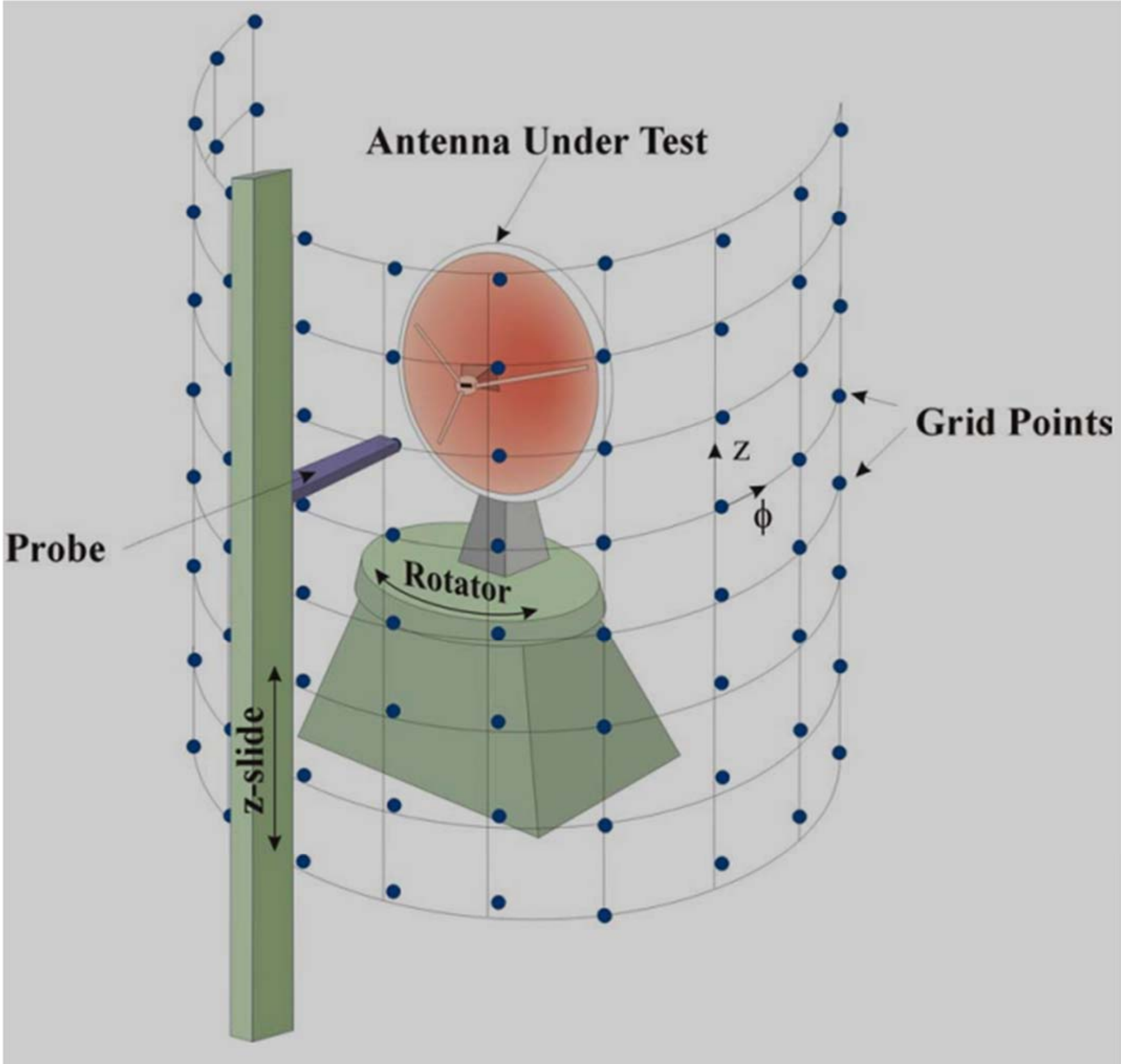
$$\Delta z = \lambda/2 \tag{17-2}$$

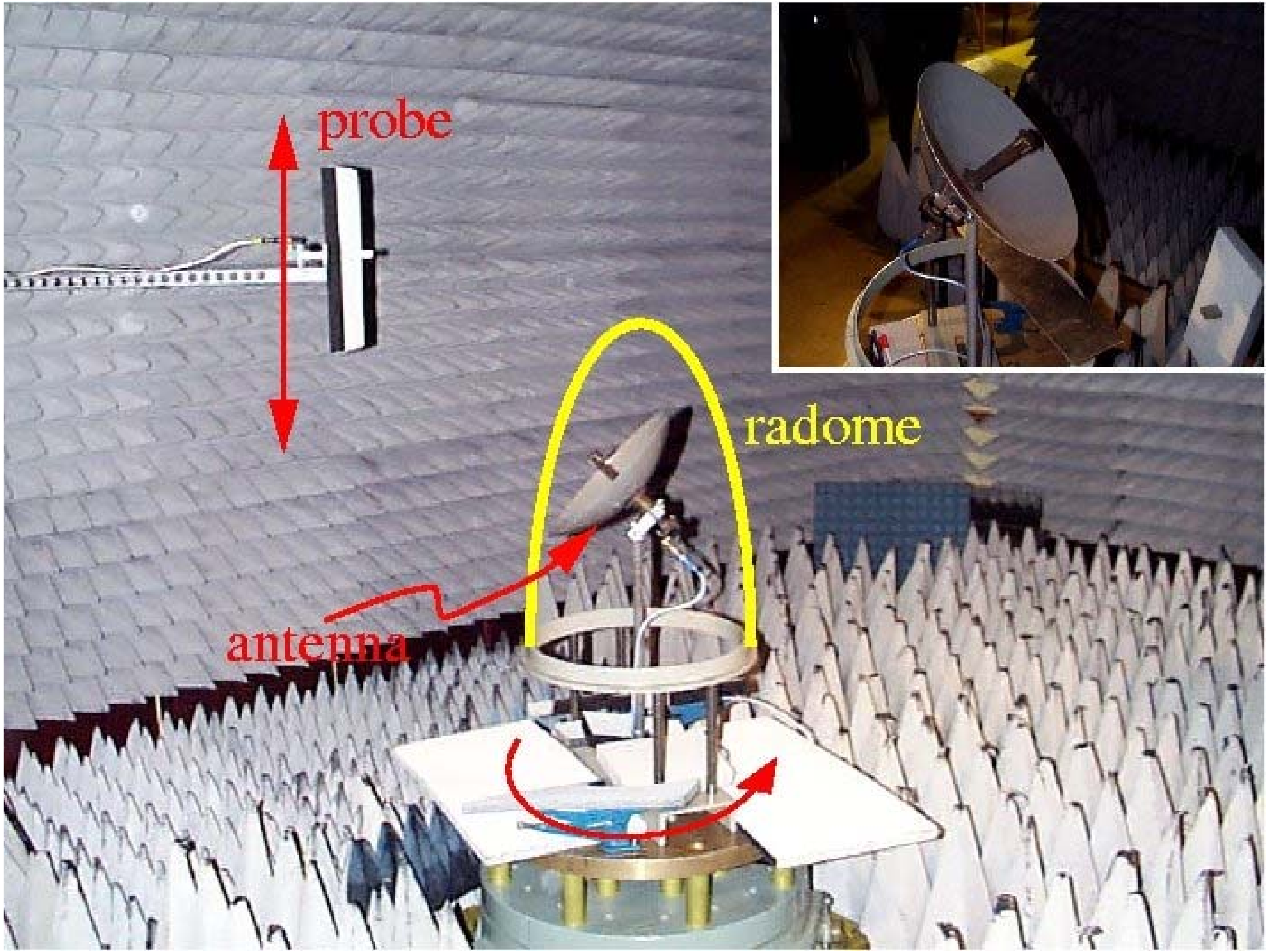
Spherical (a = radius of sphere)

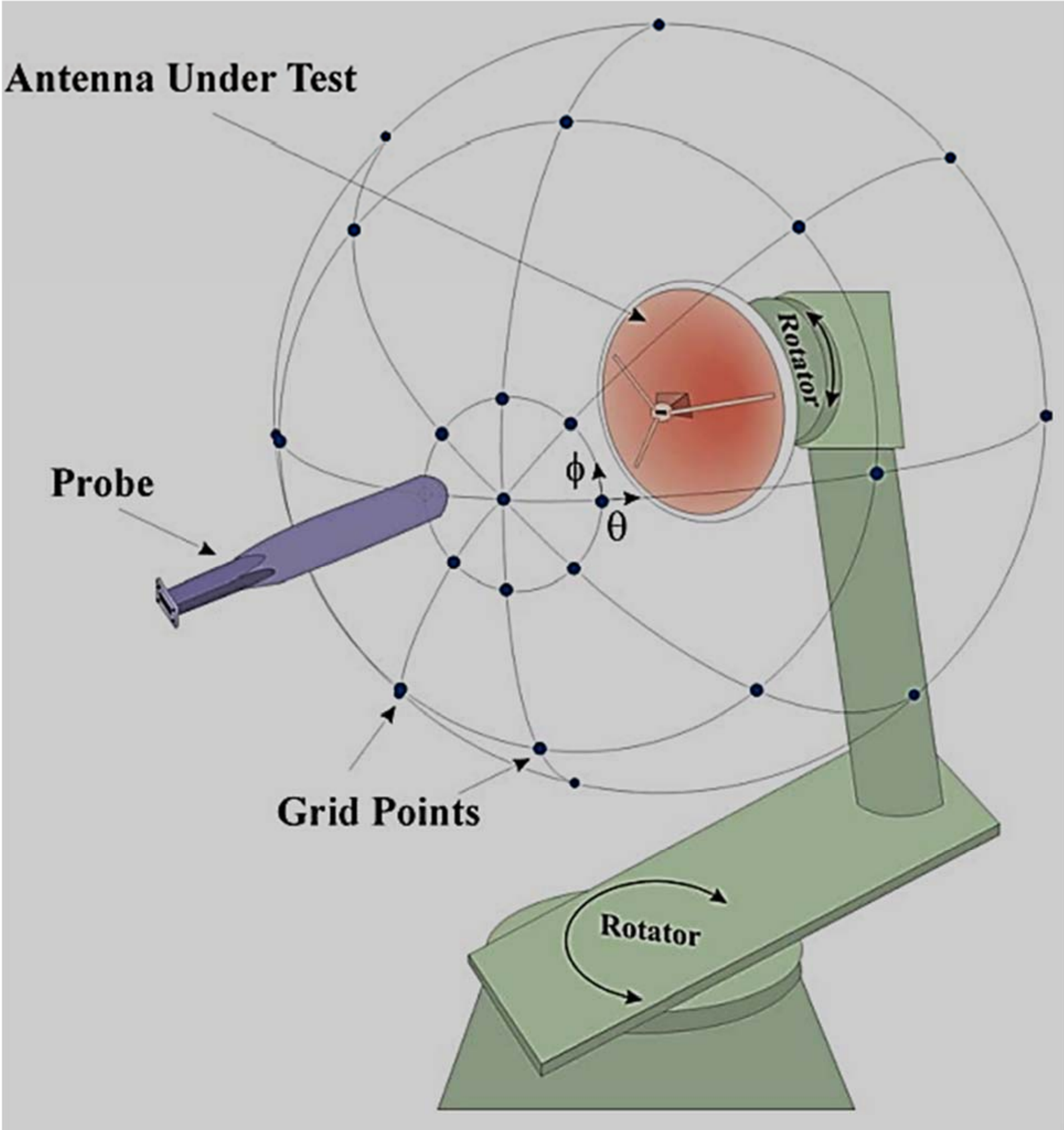
$$\Delta\theta = \frac{\lambda}{2(\alpha+\lambda)} \tag{17-3}$$

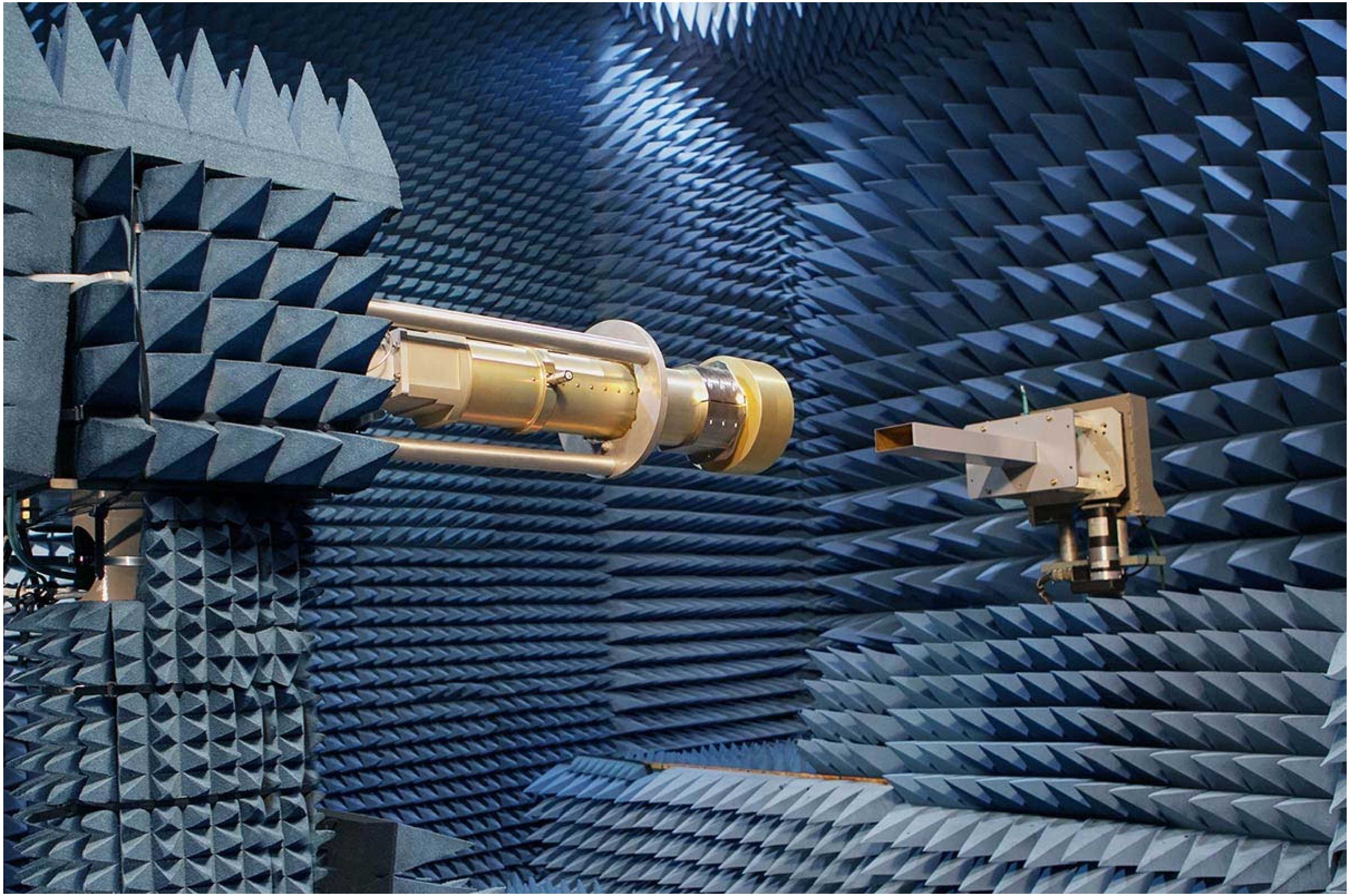
$$\Delta\phi = \frac{\lambda}{2(\alpha+\lambda)} \tag{17-4}$$

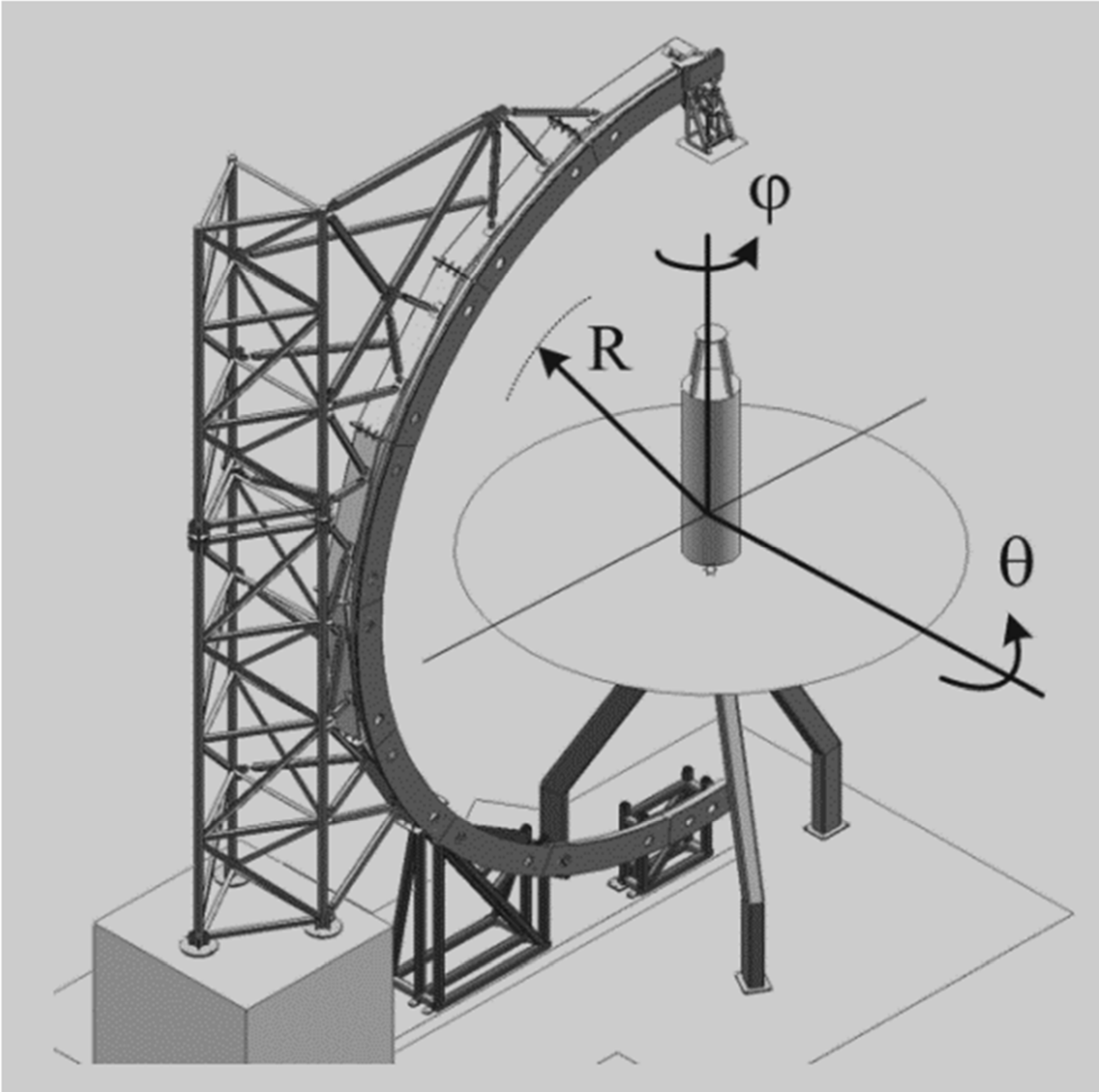

y
x
Probe
y-slide
x-slide
Antenna Under Test
Grid Points


Antenna Under Test
Grid Points
z
ϕ
Probe
Rotator
z-slide


probe
radome
antenna

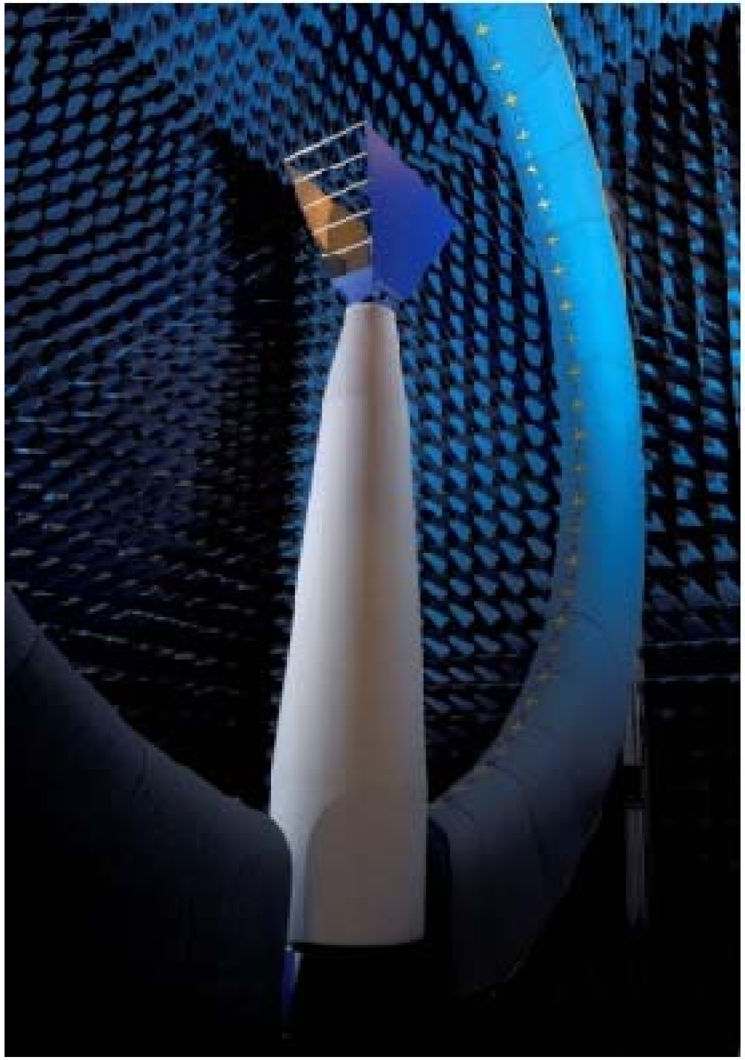

Antenna Under Test
Rotator
Probe
ϕ
θ
Grid Points
Rotator

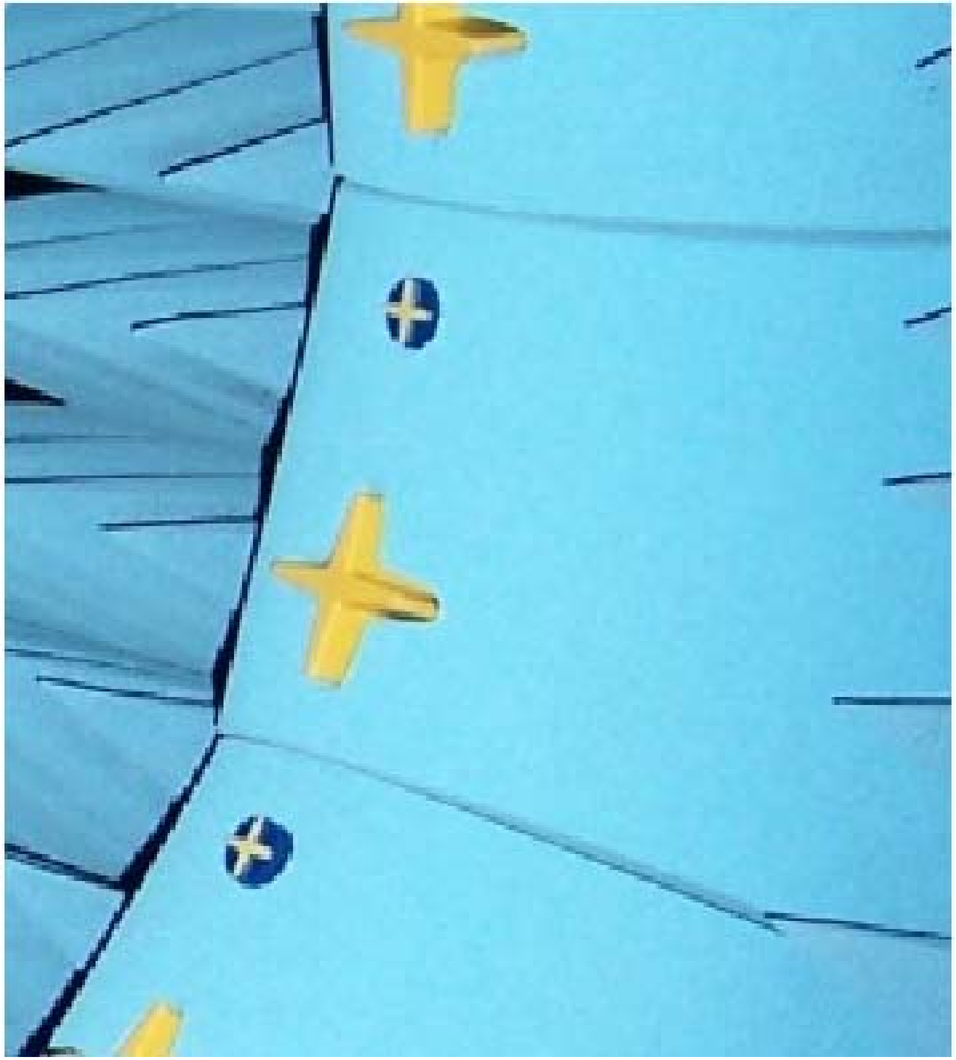


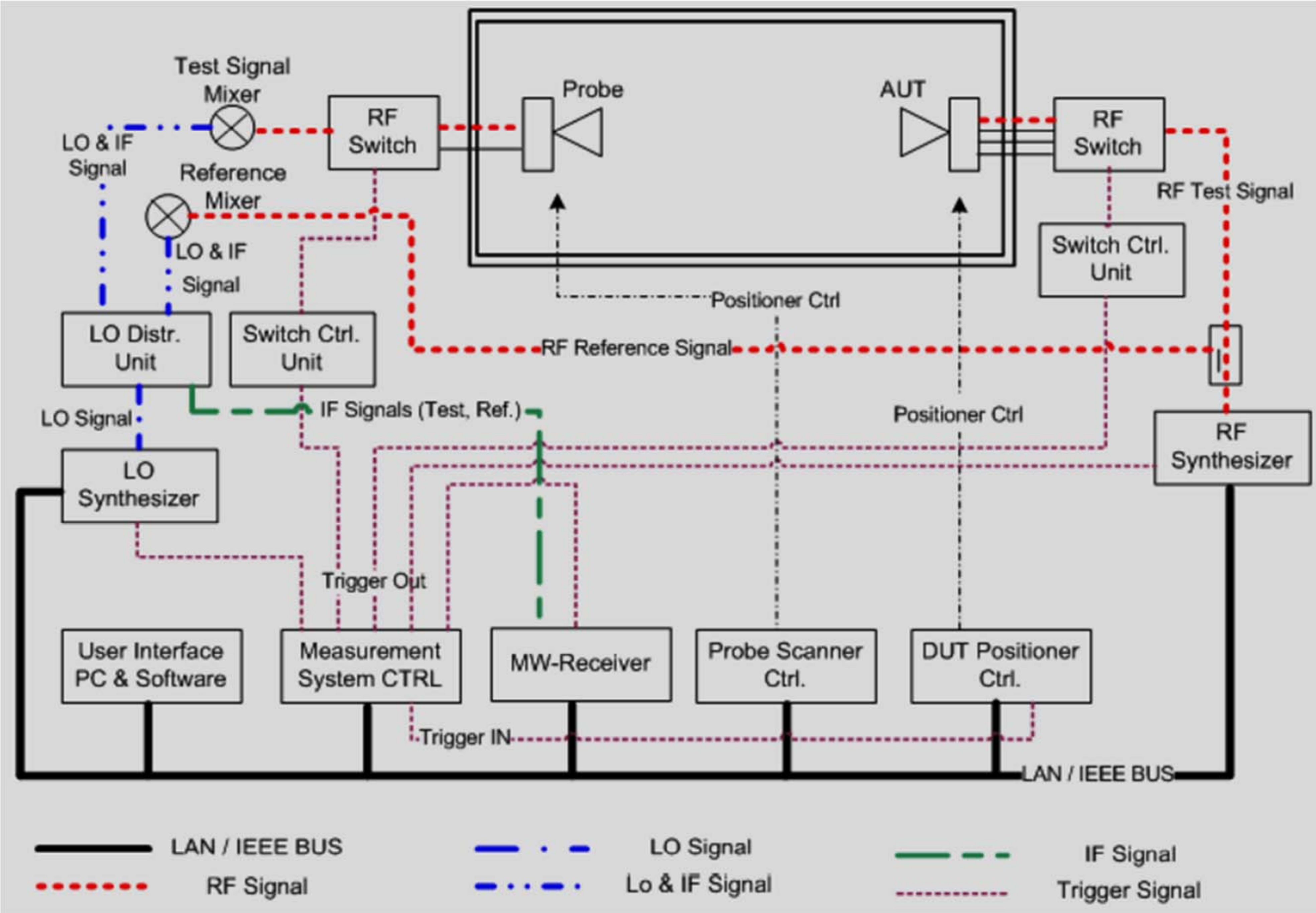


φ
R
θ


NSI MI



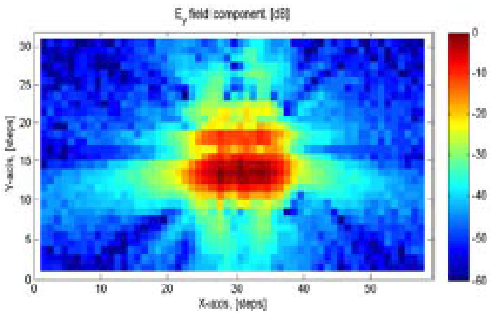



Test Signal Mixer
LO & IF Signal
Reference Mixer
LO & IF Signal
RF Switch
Probe
AUT
RF Switch
RF Test Signal
Switch Ctrl. Unit
Positioner Ctrl
LO Distr. Unit
Switch Ctrl. Unit
RF Reference Signal
LO Signal
IF Signals (Test, Ref.)
Positioner Ctrl
RF Synthesizer
LO Synthesizer
Trigger Out
User Interface PC & Software
Measurement System CTRL
MW-Receiver
Probe Scanner Ctrl.
DUT Positioner Ctrl.
Trigger IN
LAN / IEEE BUS
LAN / IEEE BUS
RF Signal
LO Signal
Lo & IF Signal
IF Signal
Trigger Signal

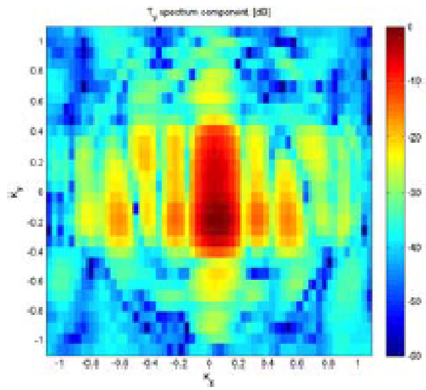
Domain Transformation II

The Plane Wave Expansion: ***E*** is a divergence-free electromagnetic field

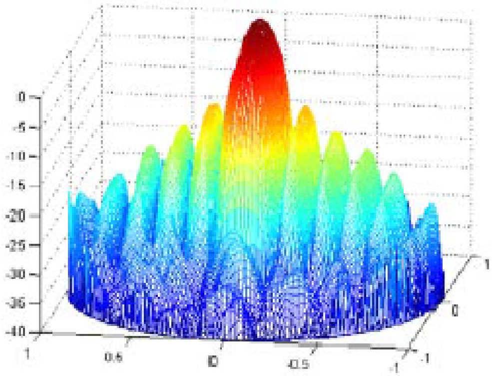
$$\mathbf{T}_s(k_x,k_y)=\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\mathbf{E}_a(x,y,0)e^{-i(k_x x+k_y y)}dxdy \qquad \boldsymbol{E}(\boldsymbol{r})=\frac{1}{4\pi^2}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\boldsymbol{T}(k_x,k_y)e^{i(k_x x+k_y y+\sqrt{k^2-k_x^2-k_y^2}z)}dk_x dk_y$$



Spectral domain



Field domain

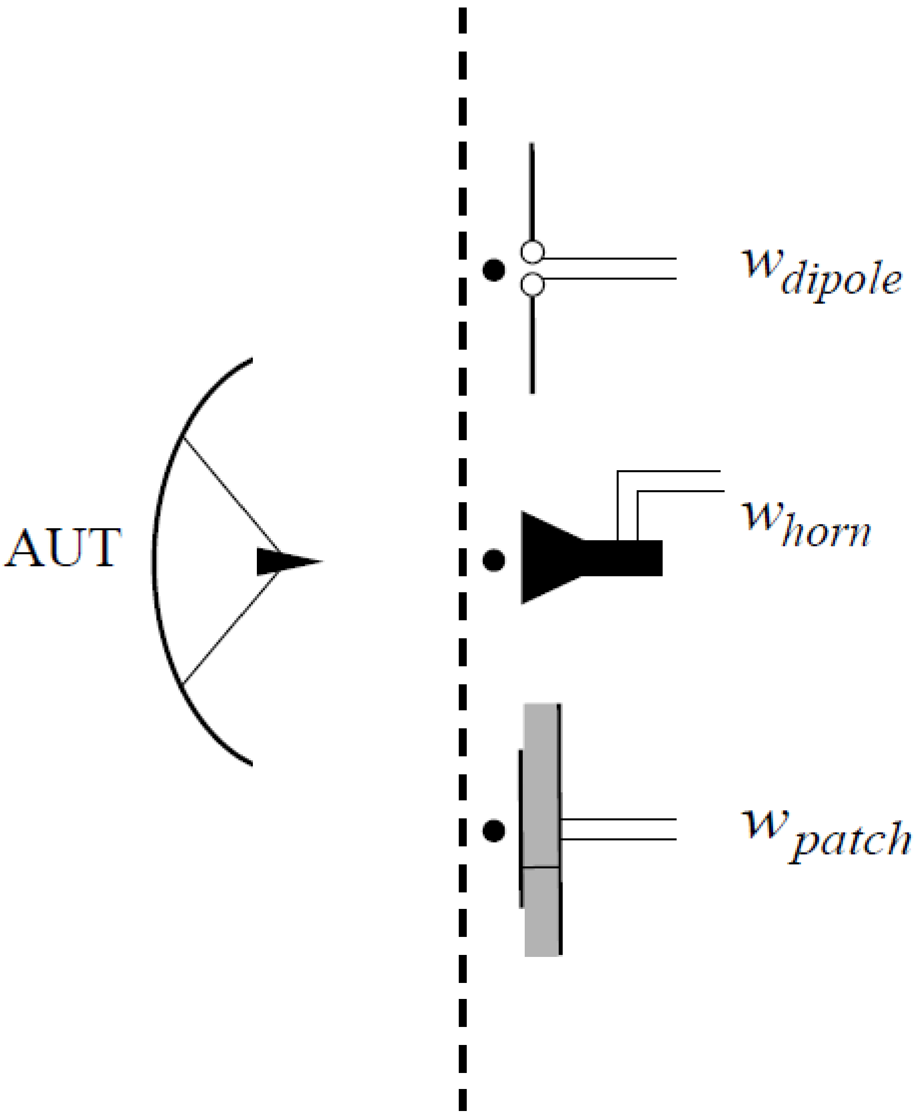


We choose the known **expansion functions**

We determine the unknown **expansion coefficients** from measurements/samples of the signal or field according to some **sampling criterion**

We determine the **far field** from the found expansion coefficients

Probe Correction



The signal measured by the probe w_{probe} is not equal to the electric field $\boldsymbol{E}$

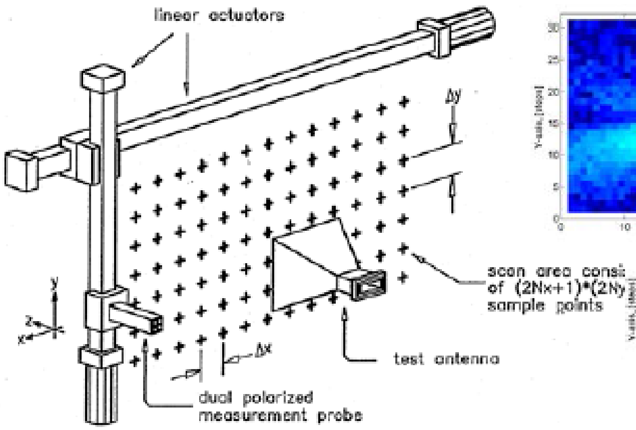
Different probes give different measured signals

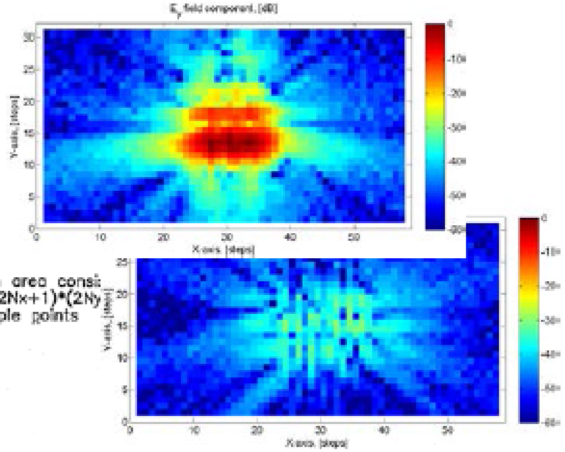
$$w_{dipole} \neq w_{horn} \neq w_{patch}$$

To determine the electric field we need to compensate for the influence of the probe – hence we need to know the characteristics of the probe

Planar Near-Field Antenna Measurement

Step 1: Measurement of near field

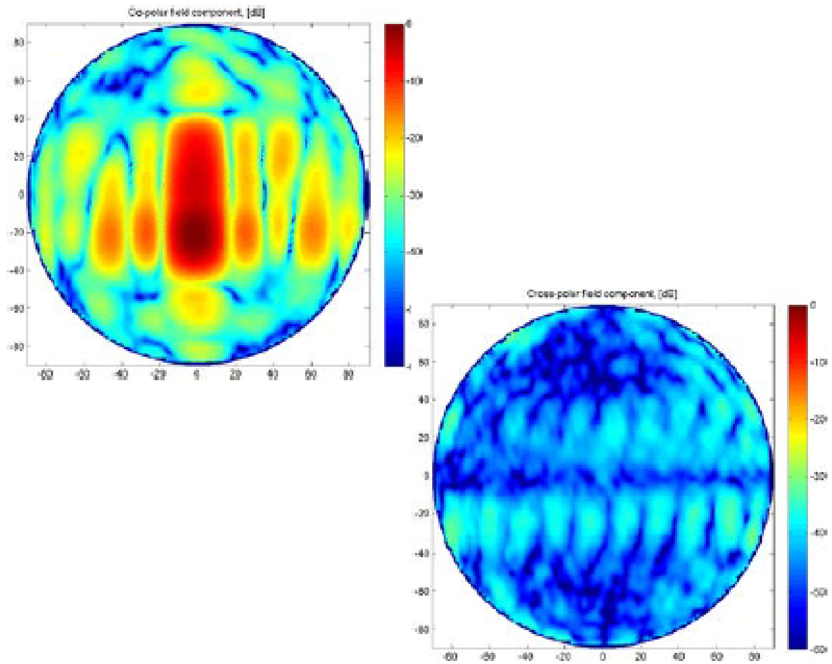




Step 3: Applying probe correction, calculation of the far field

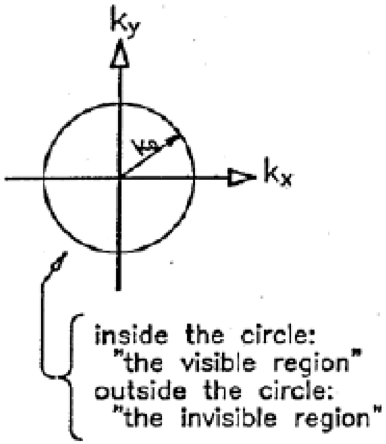
$$\mathbf{T}_x \approx \sum_{x,y} \mathbf{T}_s \mathbf{P}_{s,1} \Big/ \mathbf{P}_{x,1} \qquad \mathbf{T}_y \approx \sum_{x,y} \mathbf{T}_s \mathbf{P}_{s,2} \Big/ \mathbf{P}_{y,2} - \sum_{x,y} \mathbf{T}_s \mathbf{P}_{s,1} \Big/ \mathbf{P}_{x,1}\, \rho_2$$

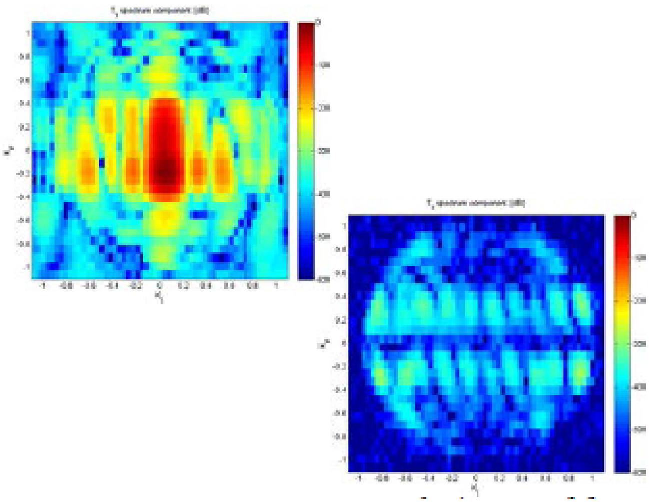
$$\mathbf{E}(r,\theta,\phi) \approx \frac{-ik}{2\pi} \cos\theta \frac{e^{ikr}}{r} \mathbf{T}_s(k_{x0}, k_{y0})$$



Step 2: Calculation of the spectrum

$$\sum_{x,y} \mathbf{T}_s \mathbf{P}_s = e^{-ik_z z_0} \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \mathbf{E}_a(x,y,z_0)\, e^{-i(k_x x + k_y y)}\, dx dy$$





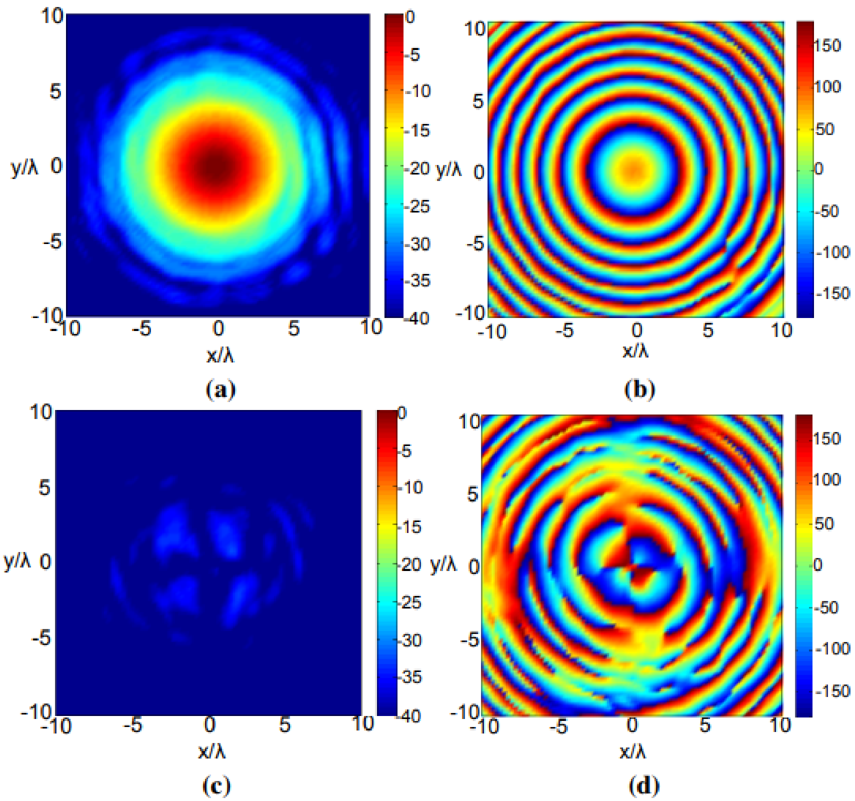


Figure 7. Measured near field aperture distributions after OSI interpolation at 35.75 GHz (a) Copol amplitude distribution, (b) Copol phase distribution. (c) Xpol amplitude distribution. (d) Xpol phase distribution.

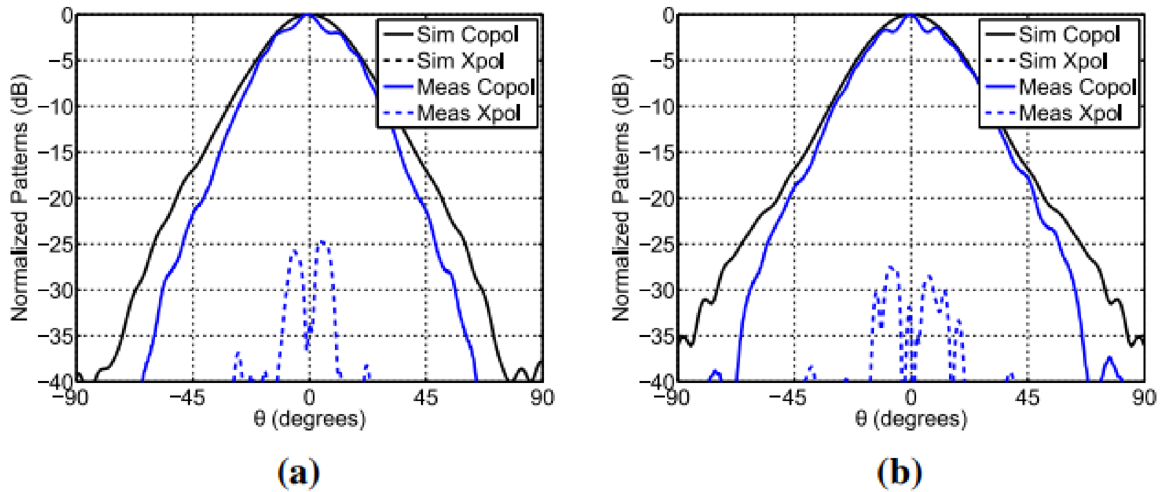


Figure 8. Resulting far field pattern for the AUT at 35.75 GHz. These patterns were generated using the FFT operation. (a) E-plane pattern. (b) H-plane pattern.

Table 1 Comparison of NFM and FFM

	NFM	FFM
Measurement Location	Simple Anechoic Chamber	Anechoic Chamber
Measurement Distance	Near Field Approx 3λ (ex. 32 mm to 54 mm@28 GHz)	Far Field (ex. 3 m or 10 m)
Directivity Measurement	3D Directivity	2D Directivity (3D Directivity measurement requires equipment and time)
Antenna Diagnostics and Analysis	Supported	Difficult

Fin

(End)