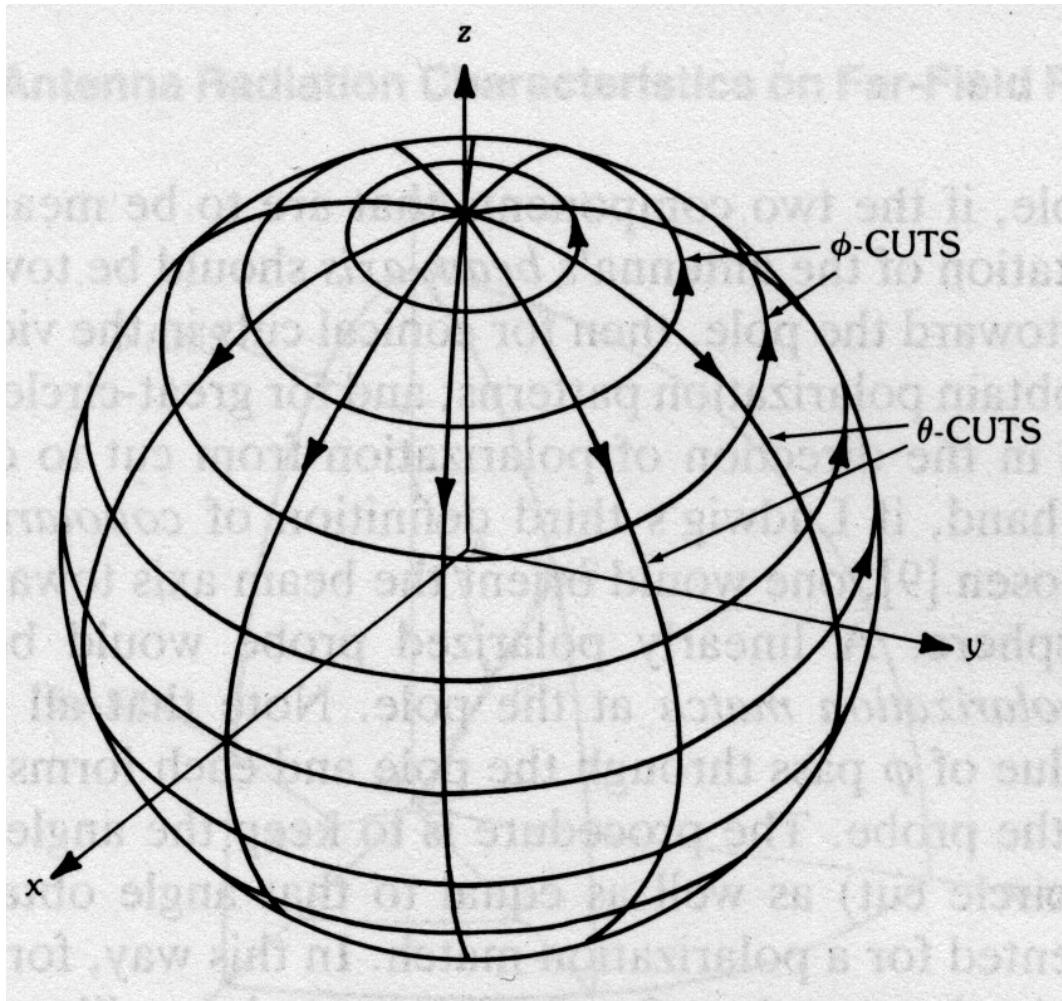


# Communication Systems

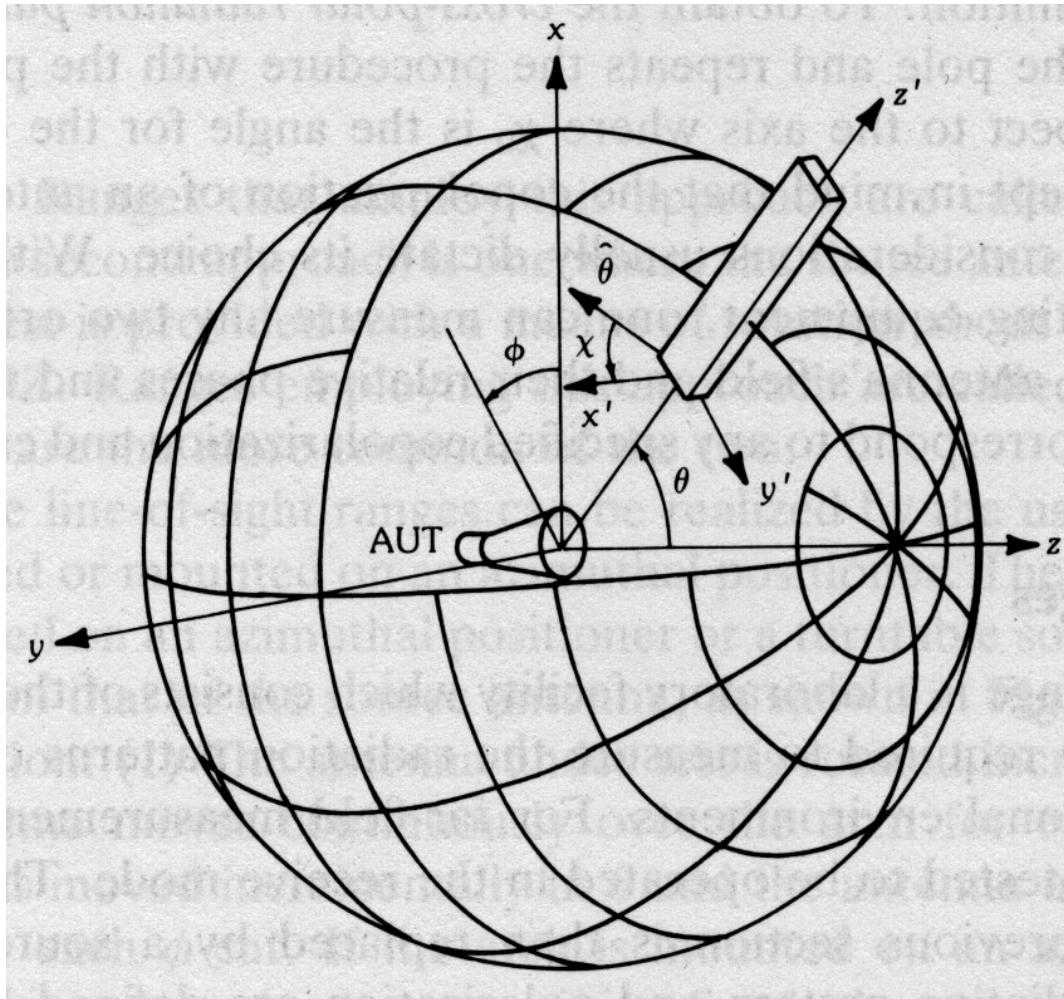
( Lecture 4, part I, Antenna Measurements)

Gert Frølund Pedersen  
Aalborg University

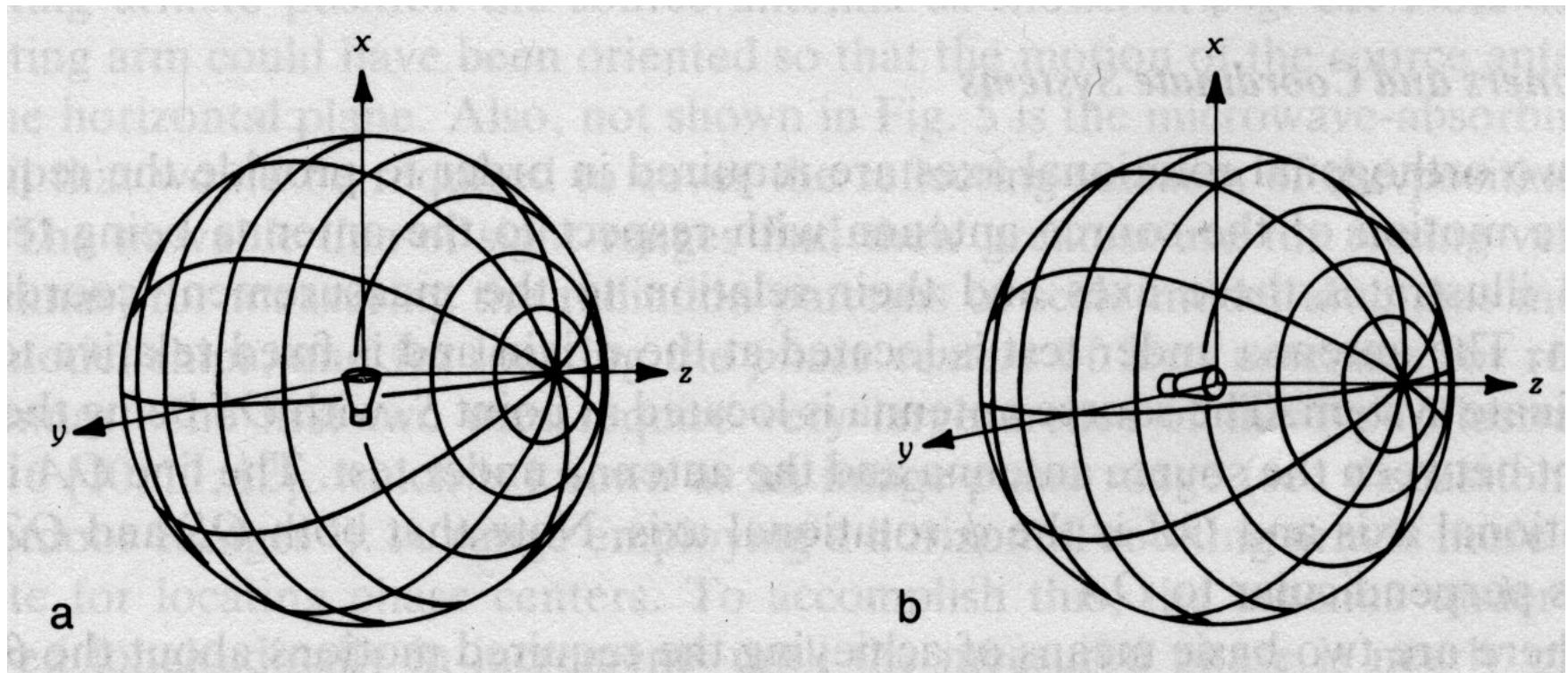
# Measurements coordinate system



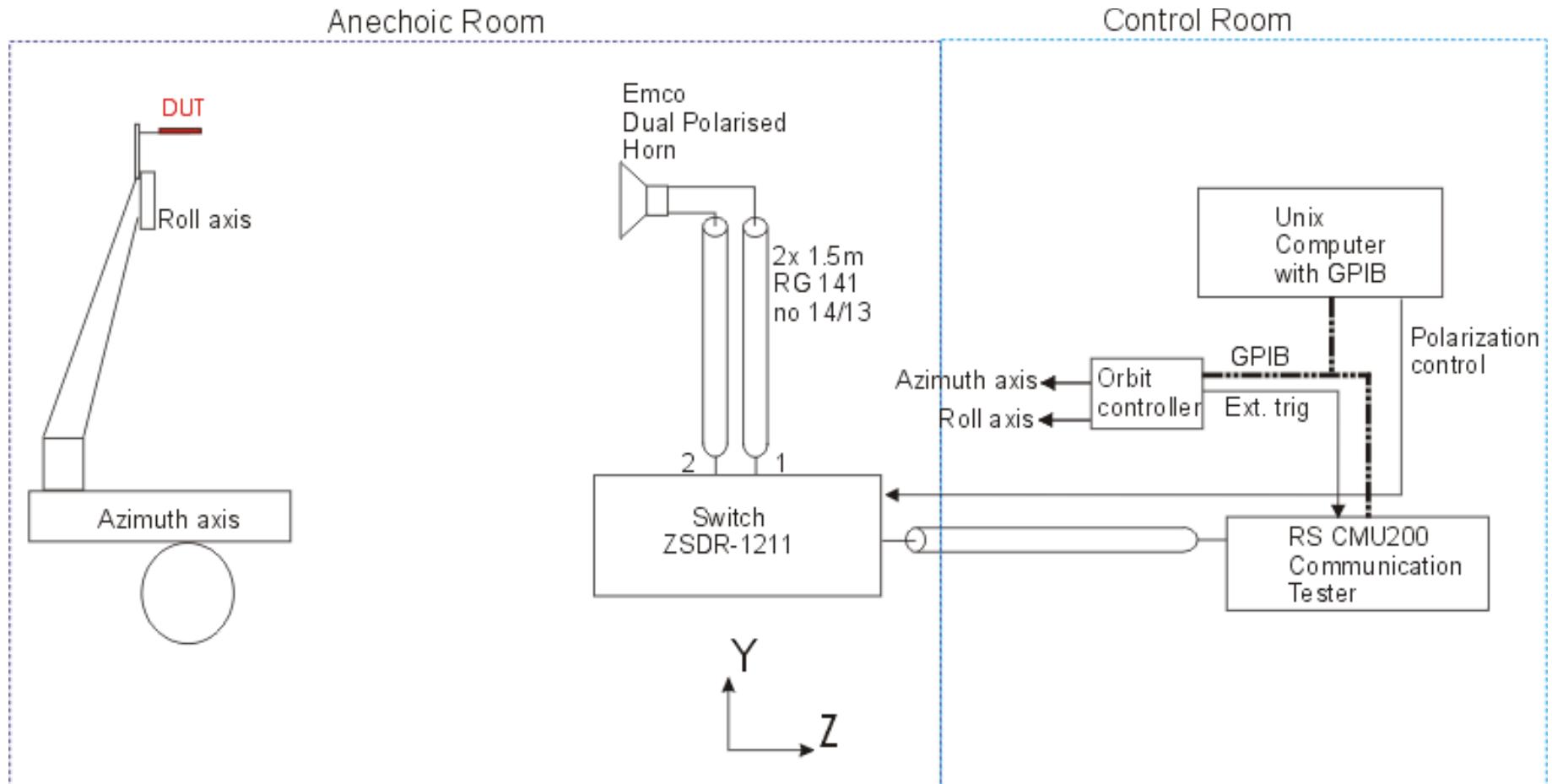
# Measurements coordinate system



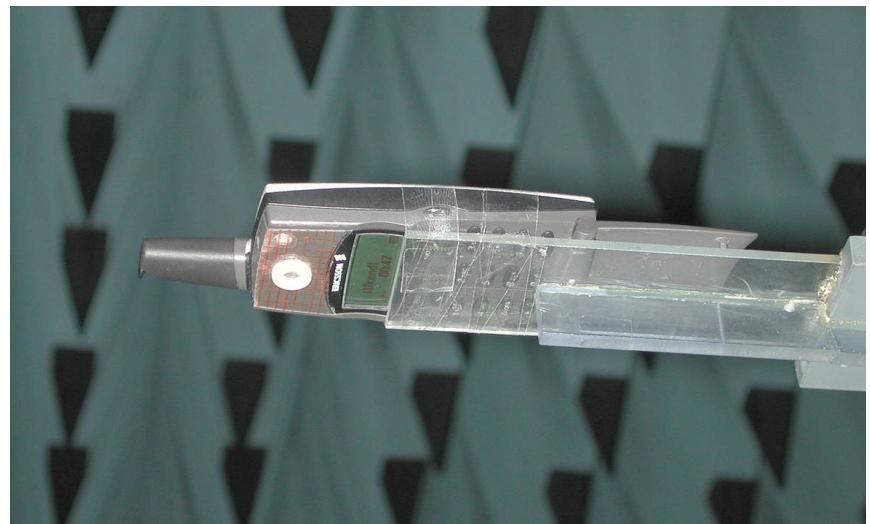
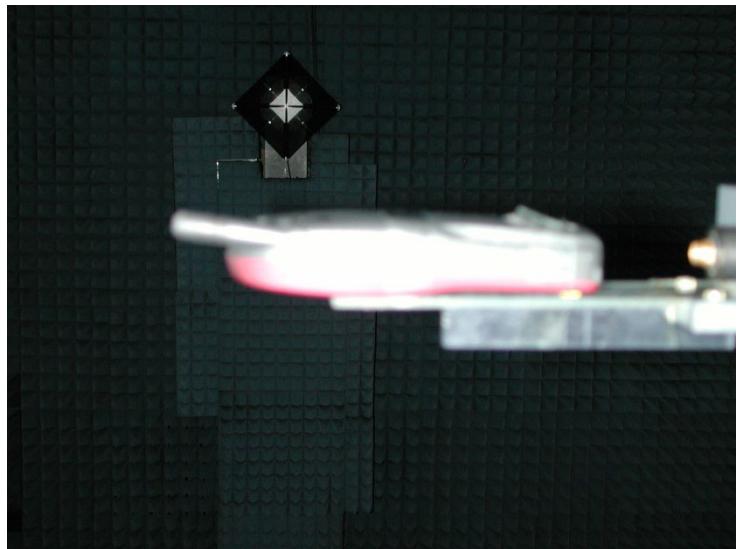
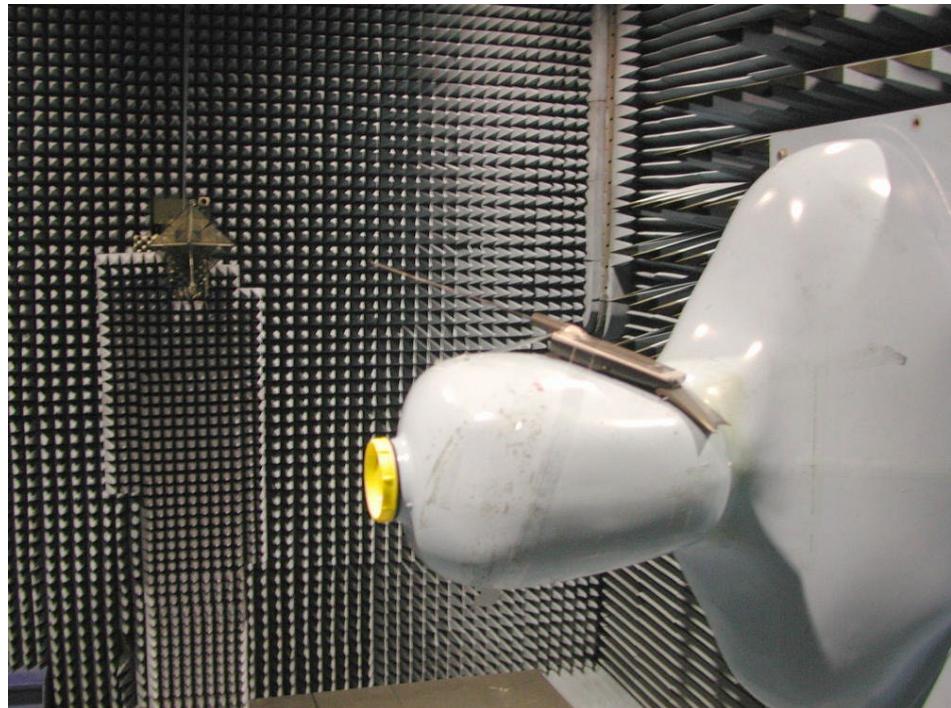
# Measurements coordinate system - sampling



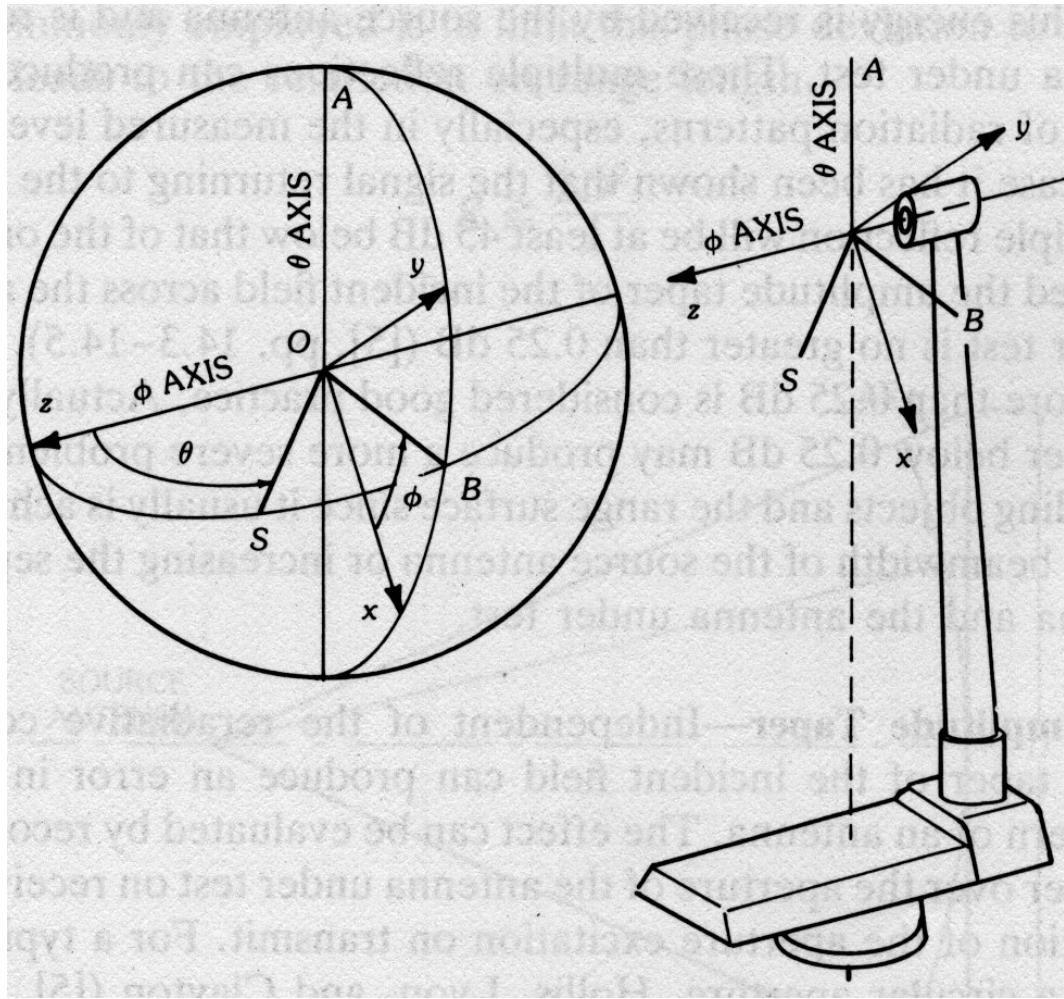
# Active measurements



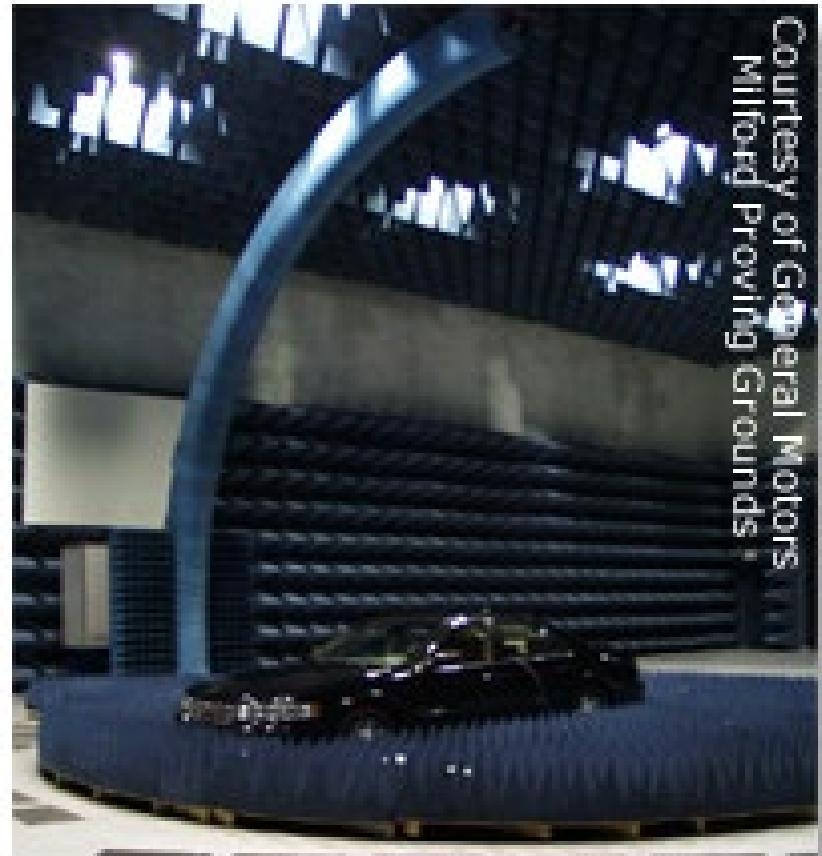
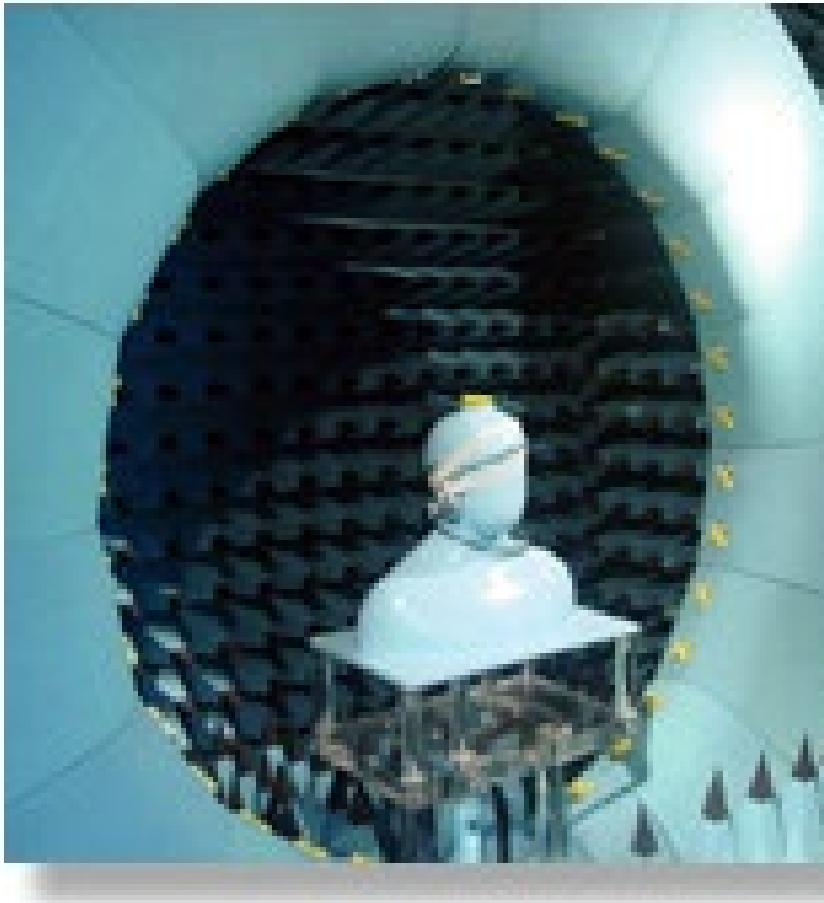
# Active measurements of small mobile terminals



# Measurements Setup



# Measurements Setup

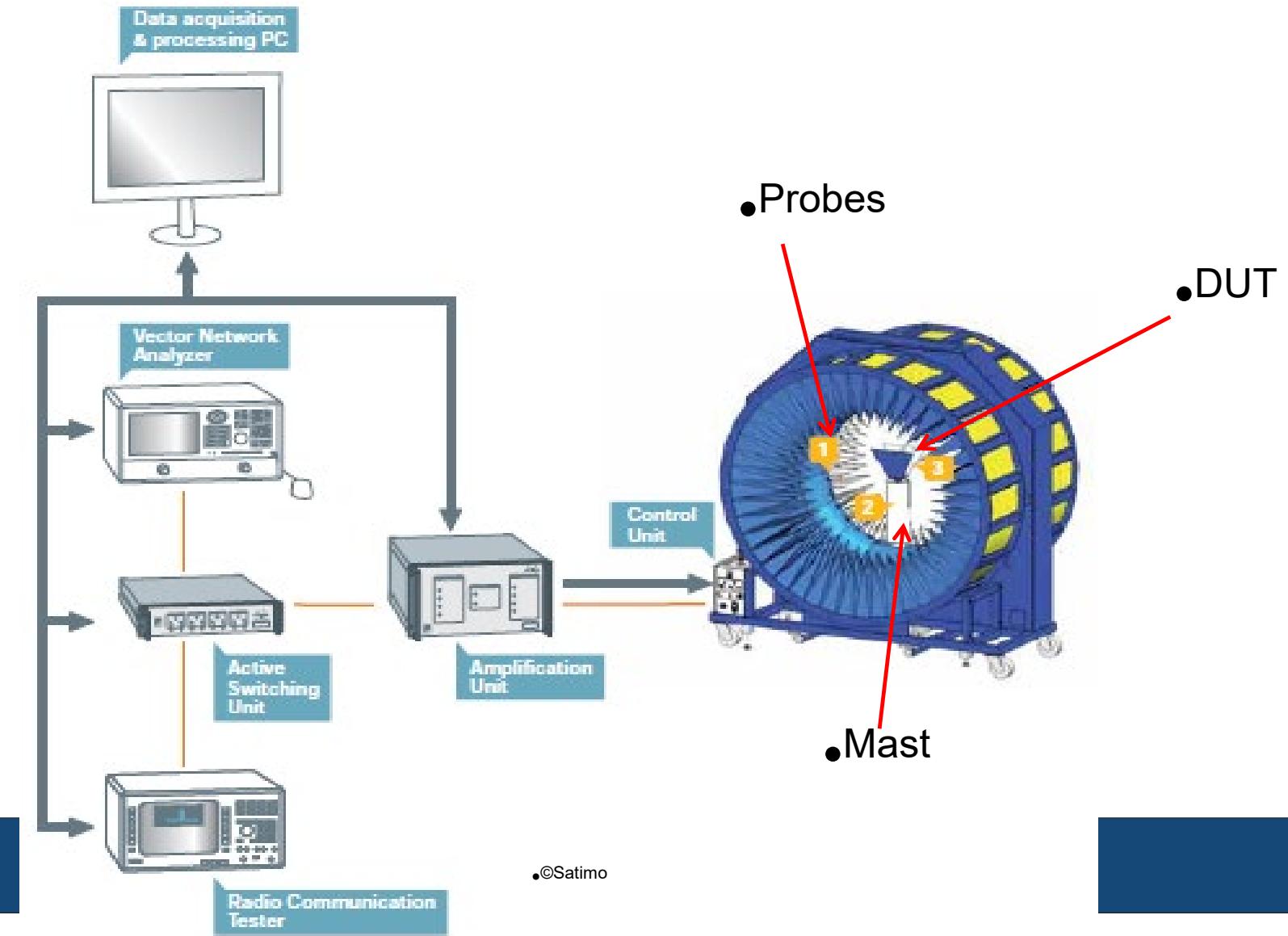


Courtesy of General Motors  
Milford Proving Grounds.

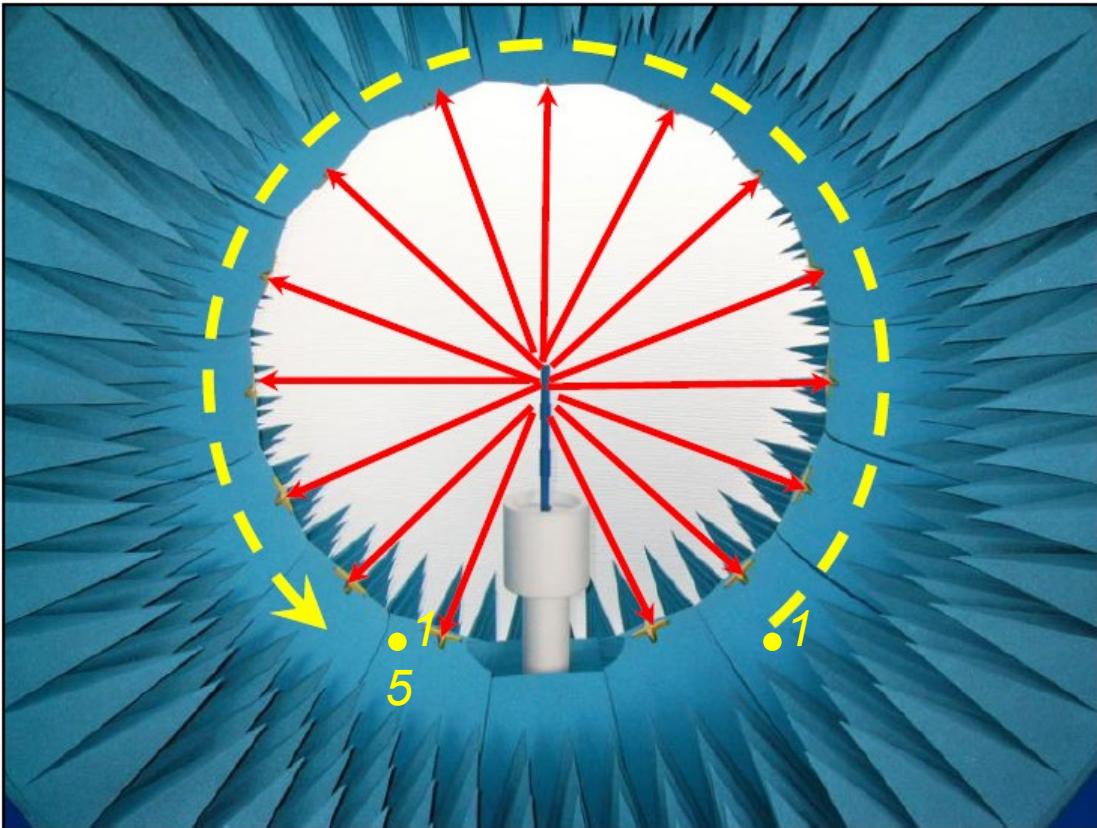
# Near-field antenna pattern measurements



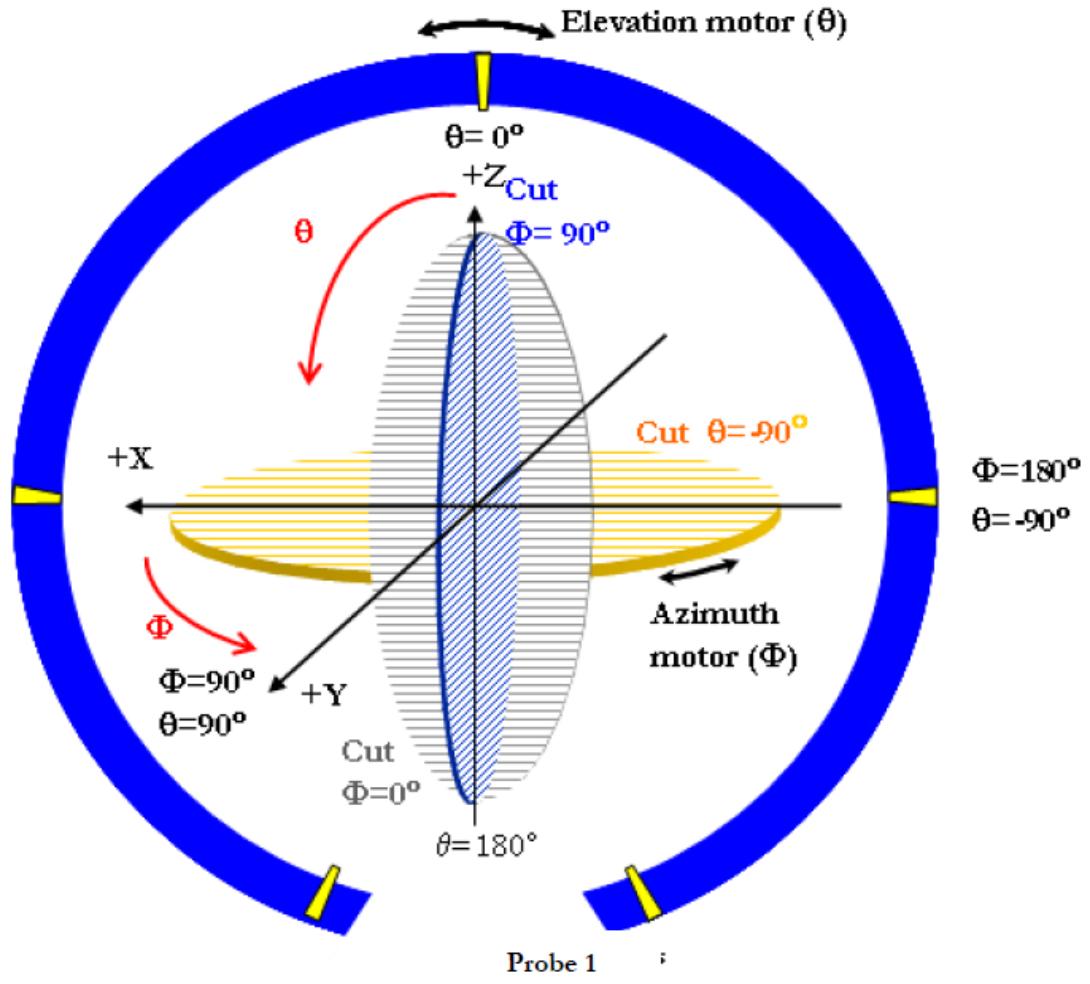
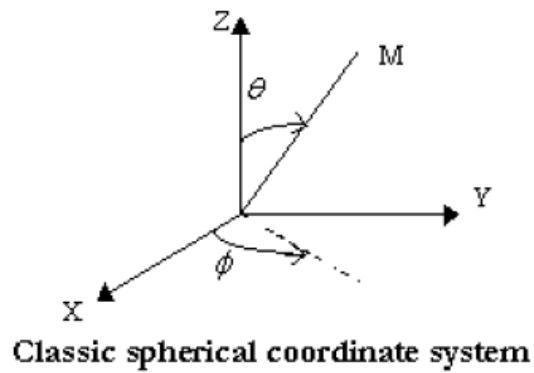
# System overview



# Working principle

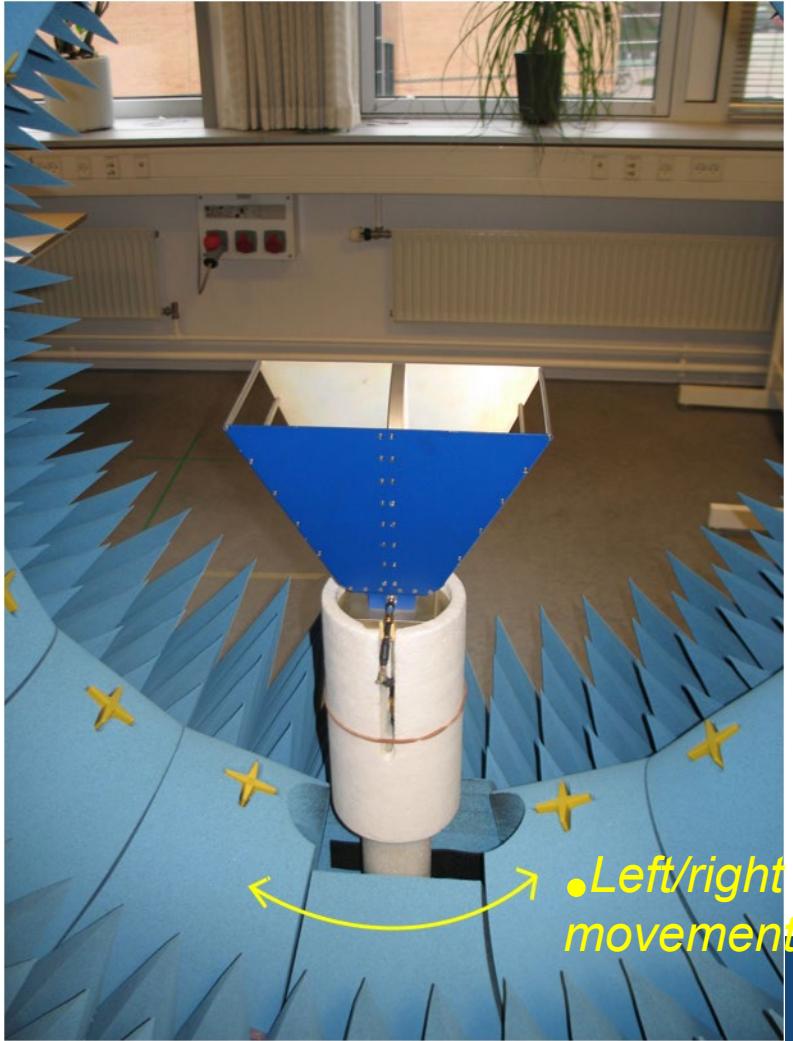


- 15 probes measure the electrical field radiated from the DUT placed in the center of the Starlab.
- The signal that is feeding the DUT is controlled by PC through the VNA (vector network analyzer)



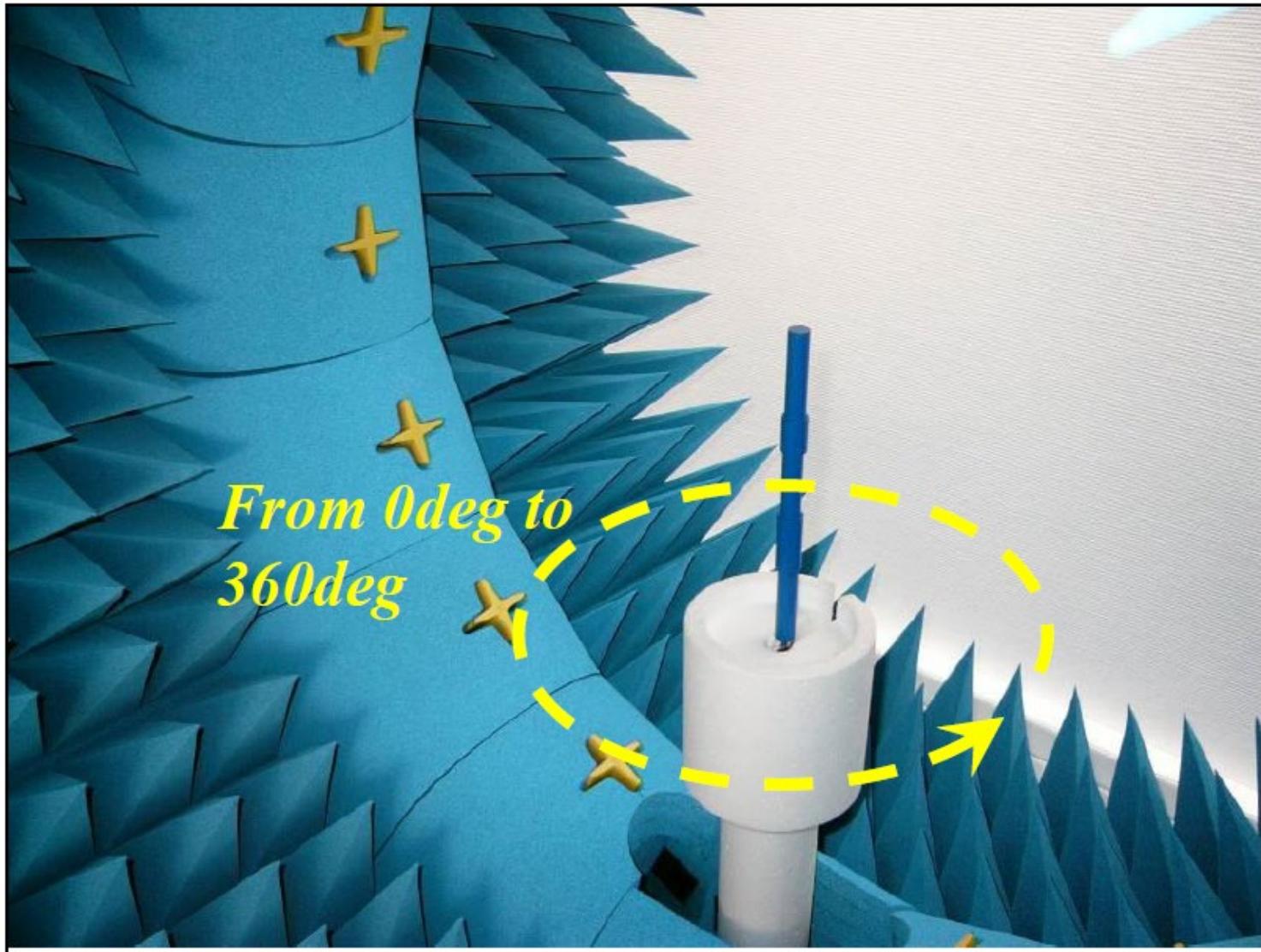
StarLab spherical coordinate system

# Elevation sampling



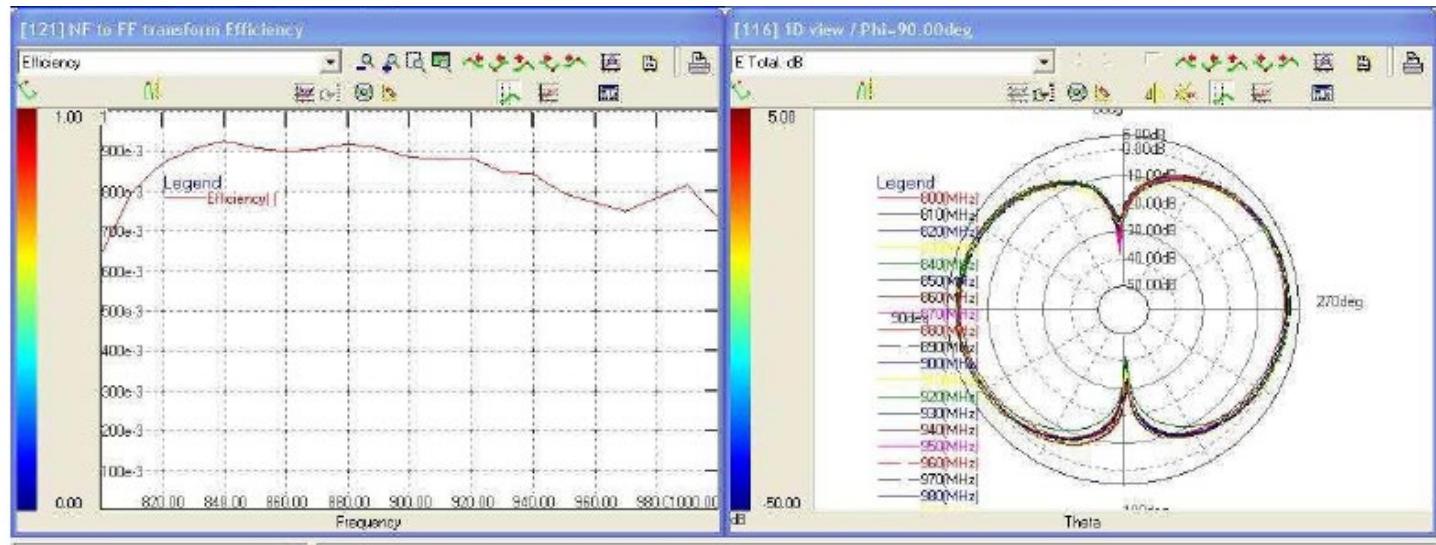
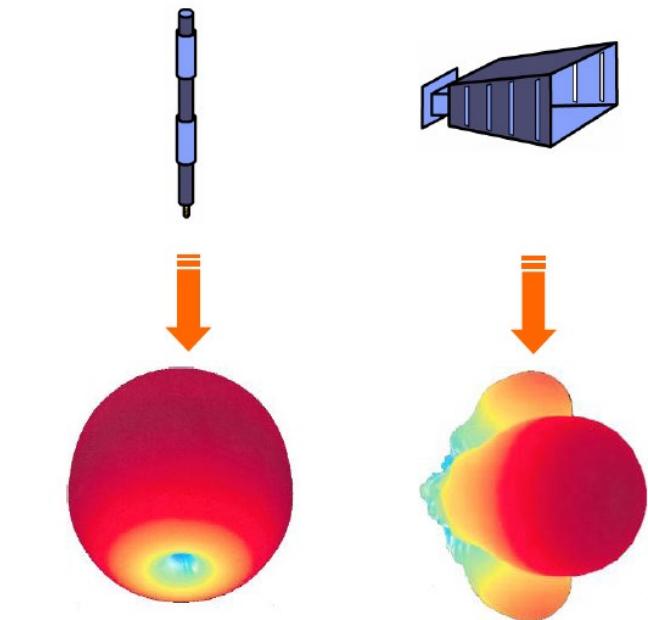
- For big devices and at low frequency more elevation measurements are needed in order to obtain accurate results
- The whole probe array rotates  $11.5^\circ$  left and right of the mast

# Azimuth Rotation

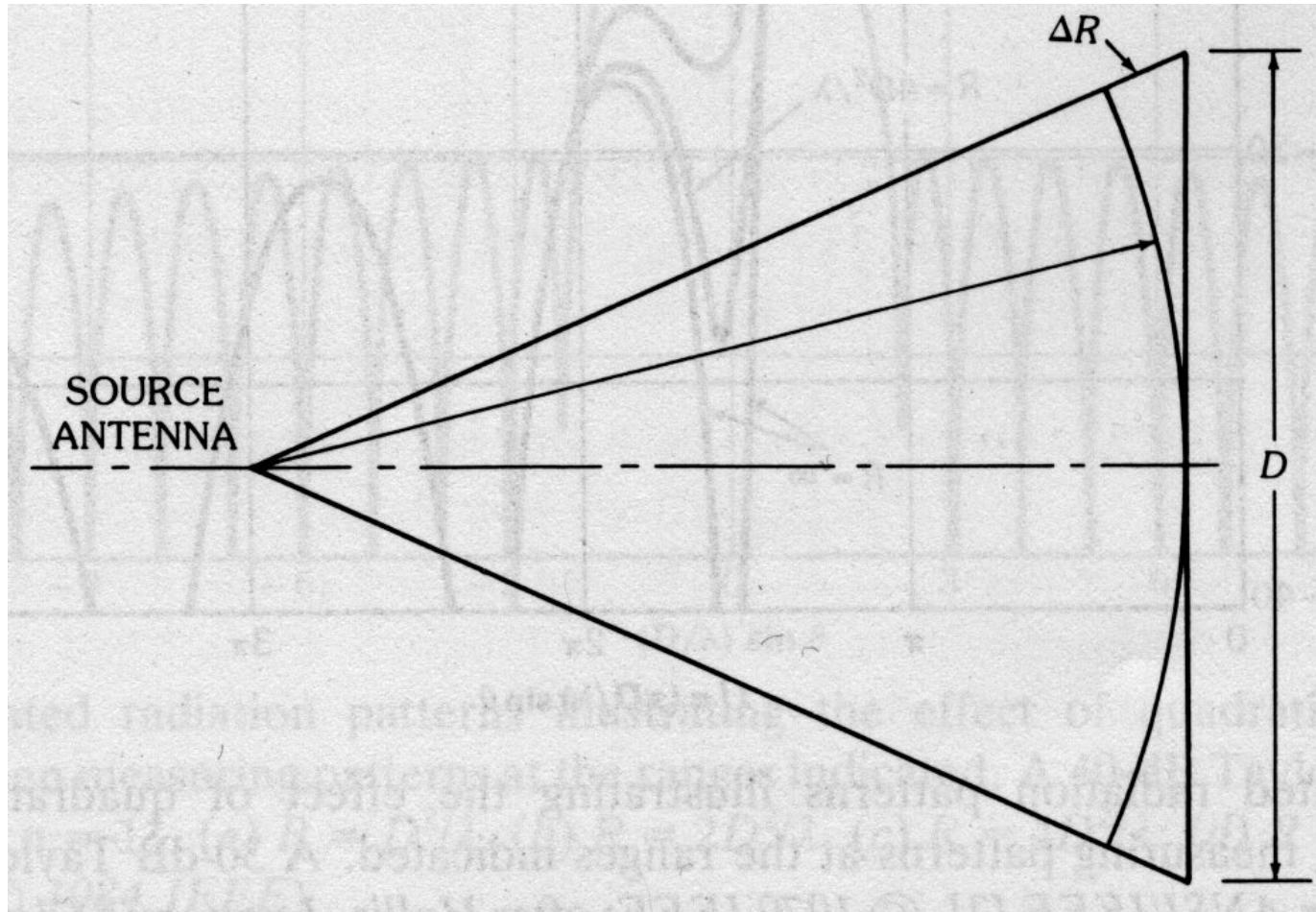


# Measuring capabilities

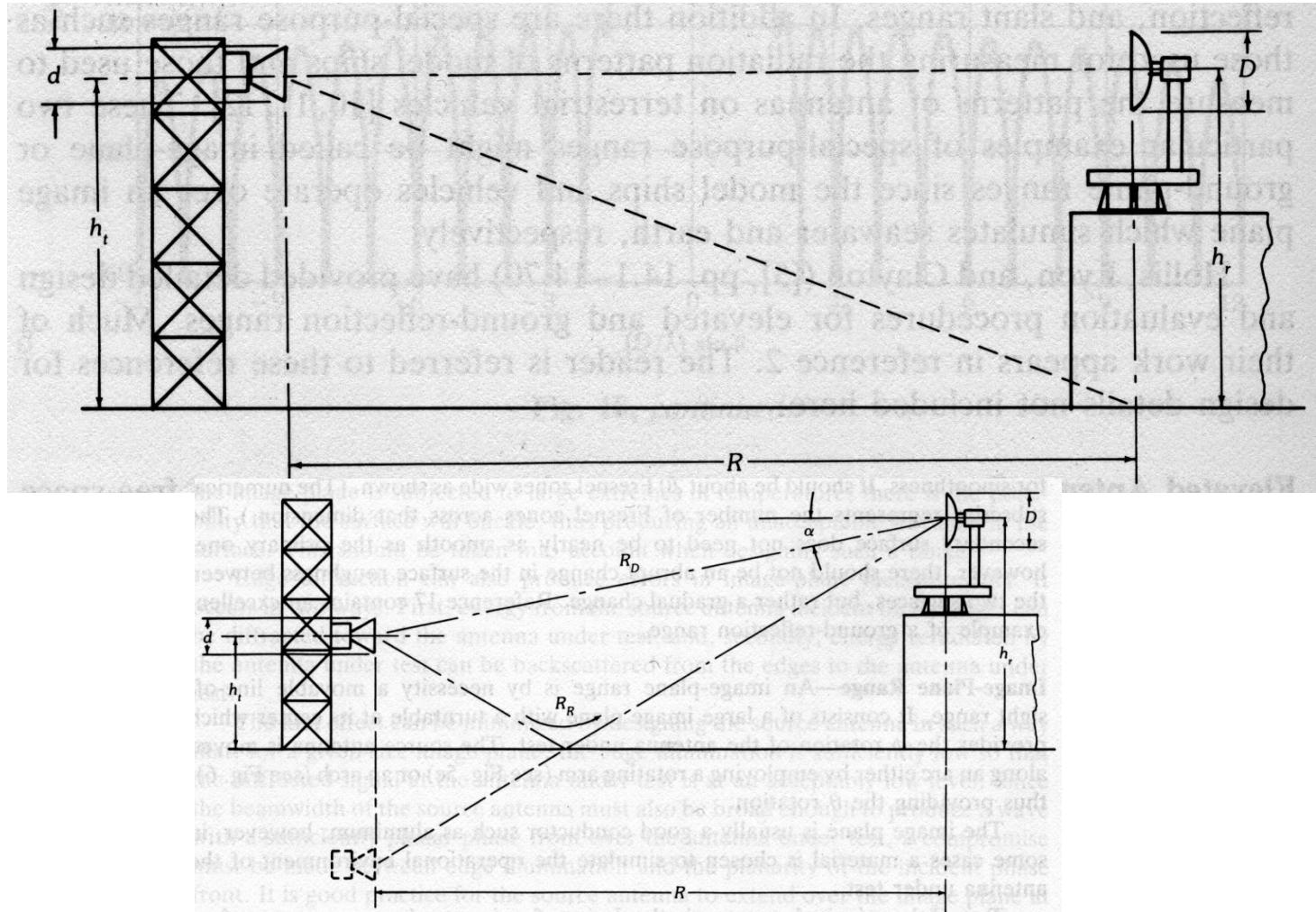
- Post-processing of the measured data is required to obtain:
  - Total Efficiency vs. Frequency
  - Complex gain pattern at different Frequencies



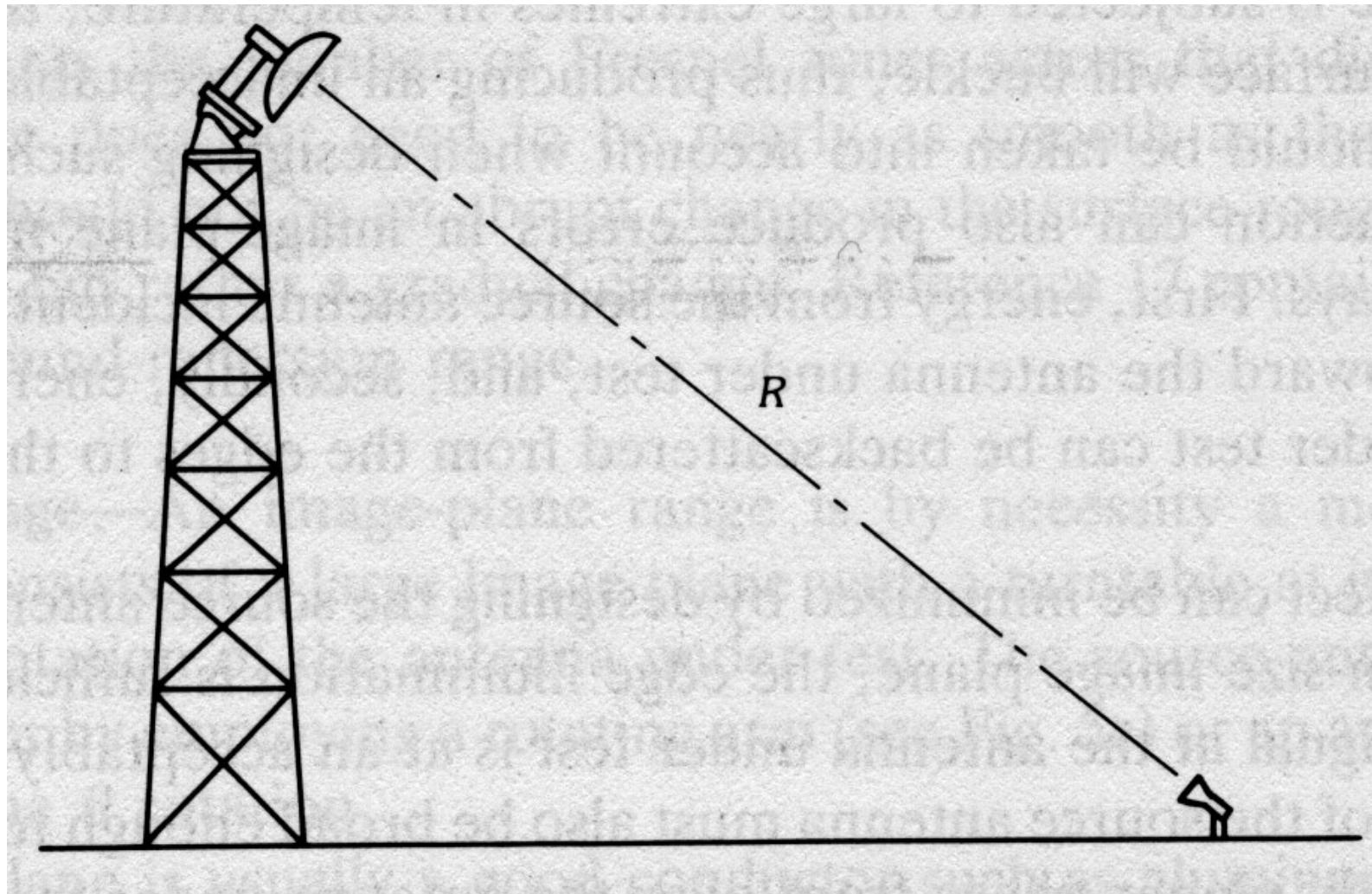
# Measurements Planewave



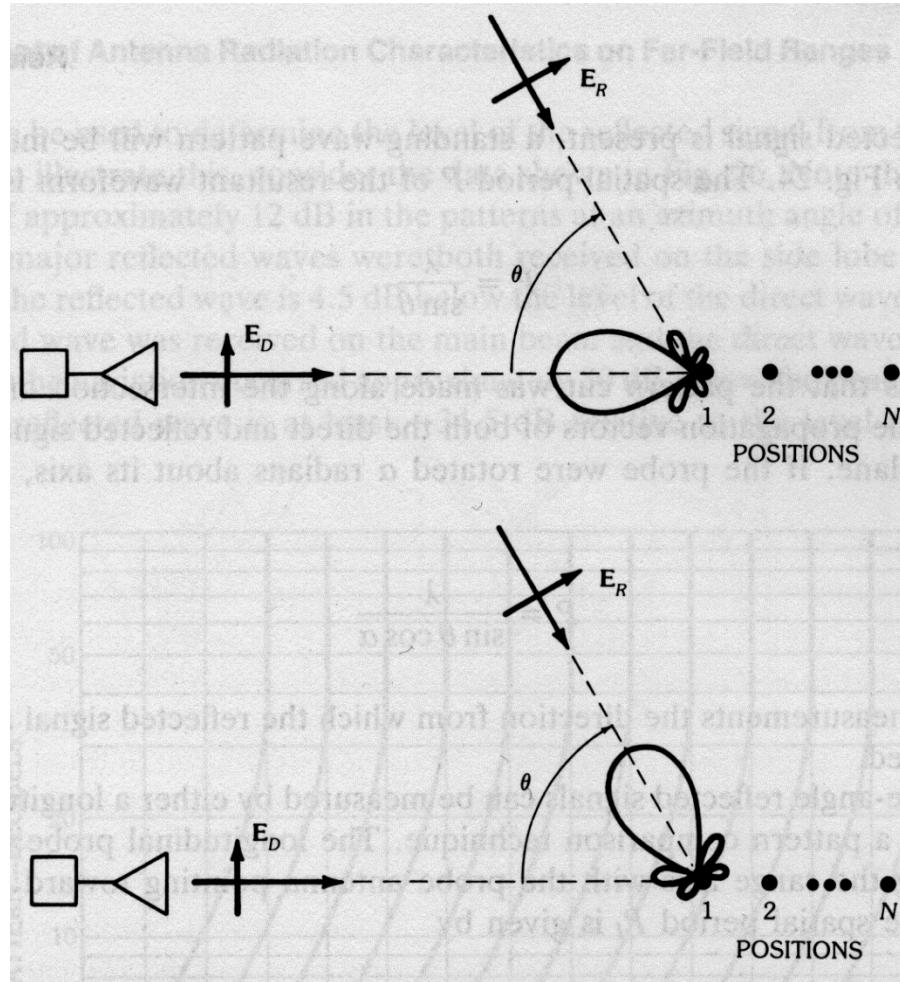
# Measurements Reflection



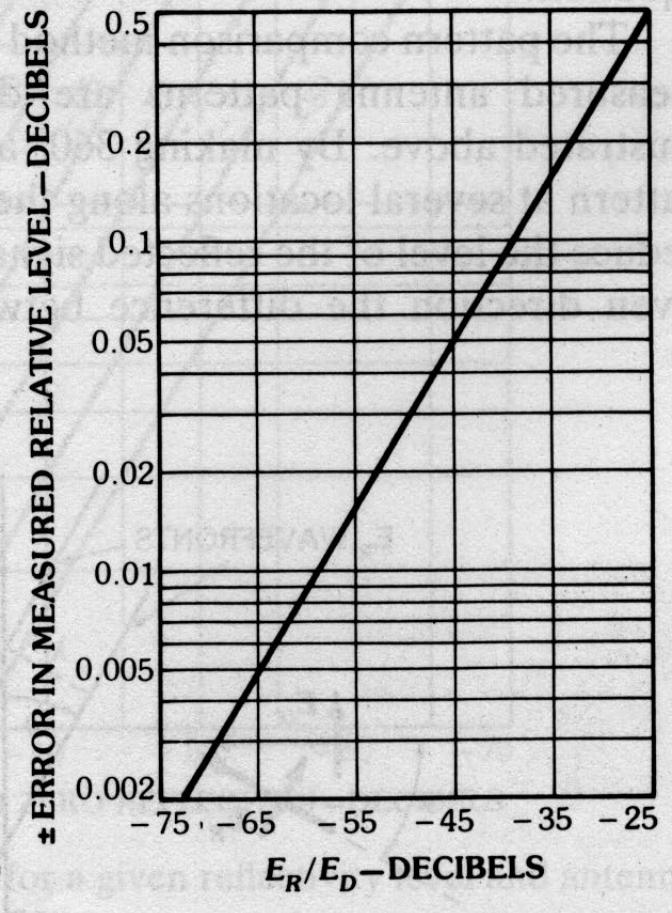
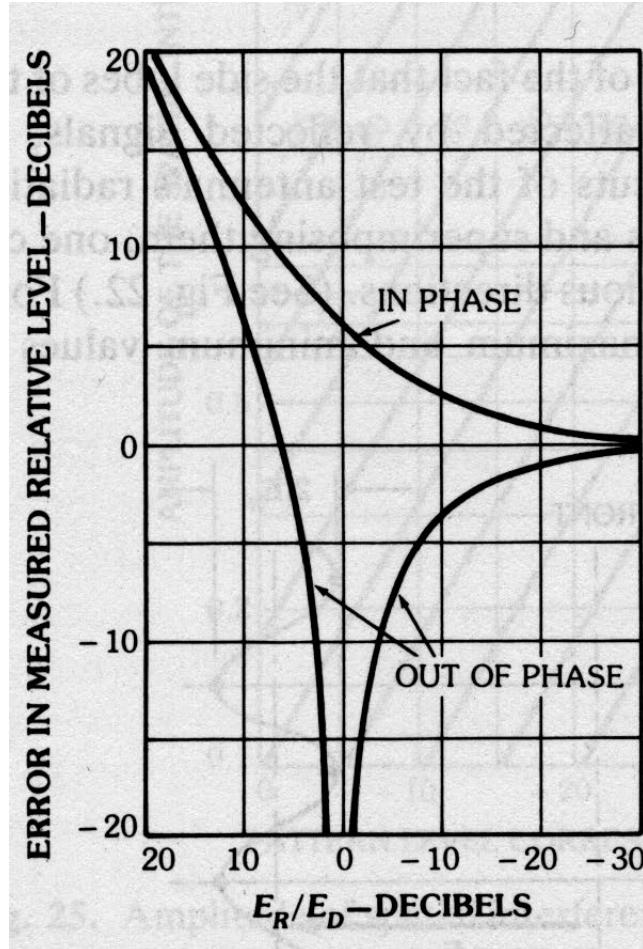
# Measurements No reflection



# Measurements small reflection

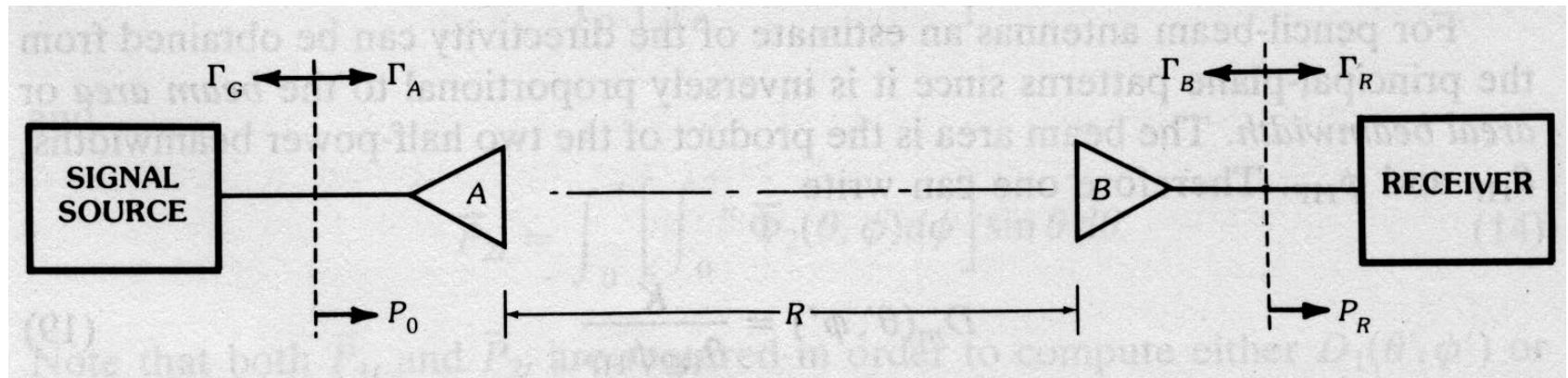


# Measurements small reflection

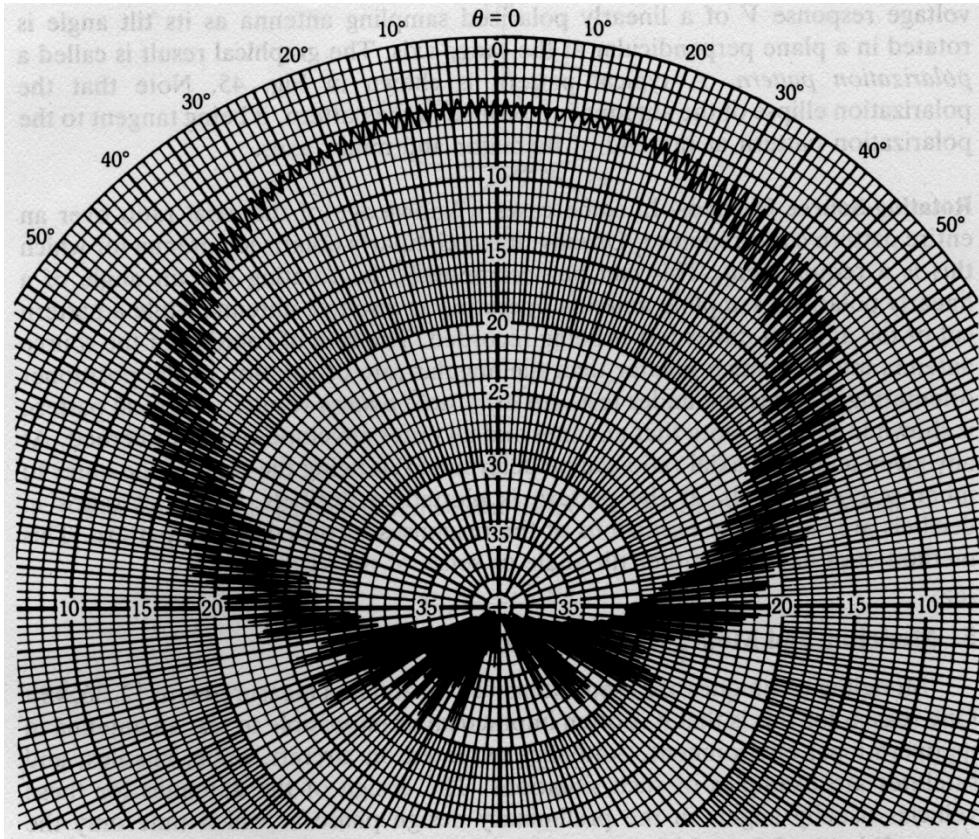
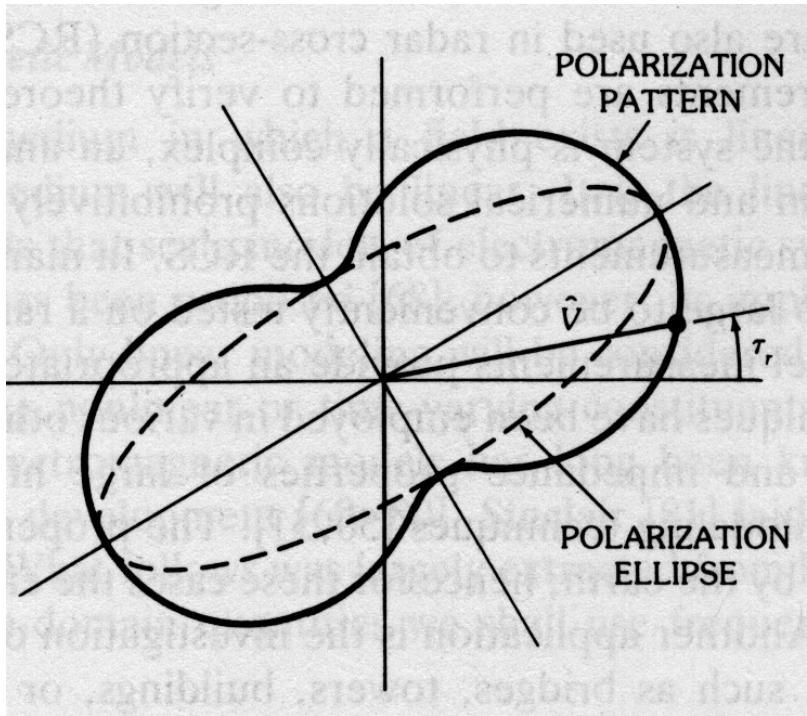


# Measurements setup – Friis law

$$P_r = (1 - |\Gamma_r|^2)(1 - |\Gamma_t|^2)G_r(\theta_r, \phi_r)G_t(\theta_t, \phi_t) \frac{\lambda^2}{(4\pi R)^2} P_t |\hat{\rho}_r \cdot \hat{\rho}_t|^2$$



# Measurements setup Polarization measurements



# Measurements setup Large objects - scaling



**Fig. 51.** A 1/48 scale model ship for hf antenna radiation pattern measurements. (*Courtesy Naval Ocean Systems Center, San Diego, Calif.*)

# Measurements setup Large objects - scaling

