Corso di Misure a Microonde

Misure di antenne

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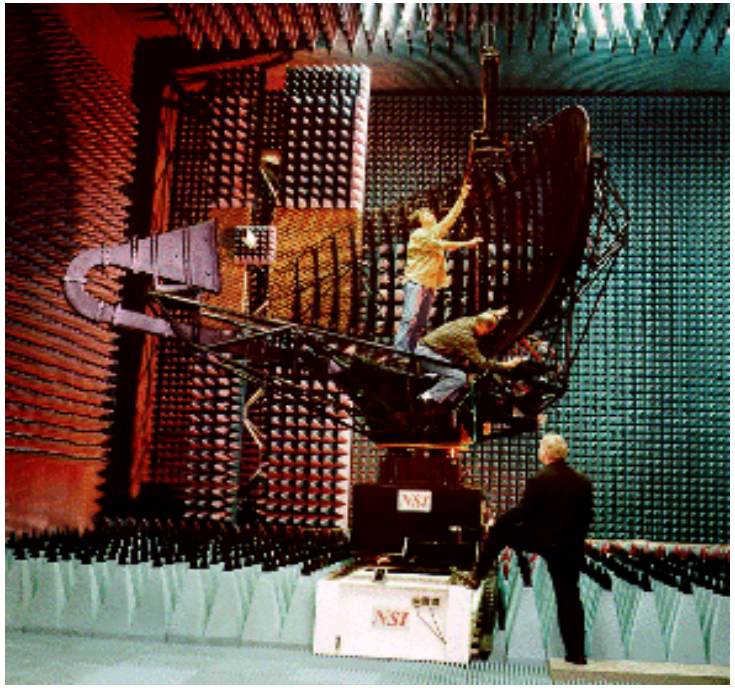
Sommario

- Perché misurarle?
- Cosa misurare?

Motivazioni e Scopo

- Verifica del progetto (rispetto normative)
- Eventuale messa a punto dei componenti assemblati
- Valutazione statistica del processo di produzione
- Verifica periodica del corretto funzionamento

→ Caratterizzazione dell'antenna sotto test (AUT)



Parametri Significativi

Caratteristiche di radiazione

- Diagramma di radiazione
  - Larghezza del lobo principale
  - Puntamento
  - Lobi laterali
  - Direttività
- Polarizzazione
  - Rapporto assiale
  - Angolo di polarizzazione

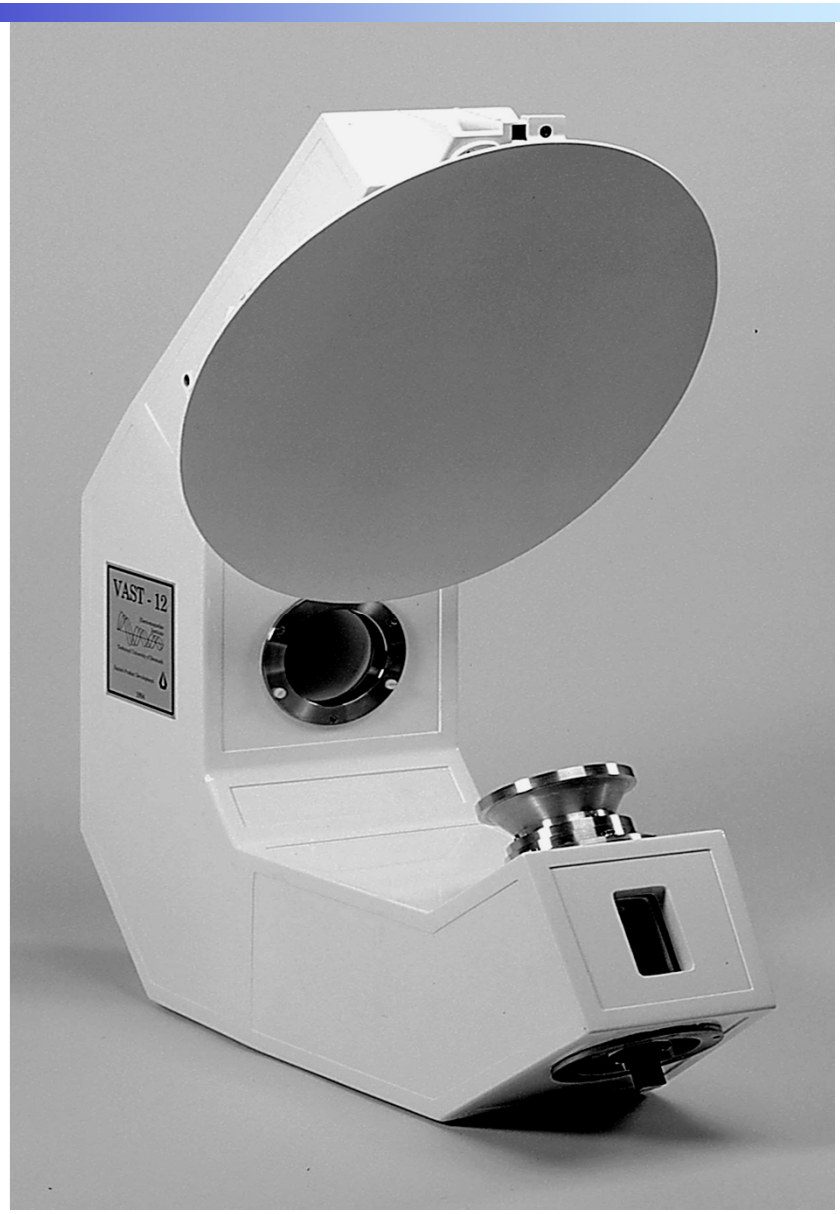
Caratteristiche in Ingresso

- Coefficiente di riflessione

Parametri di Sistema

- EIRP
- G/T

Proprietà meccaniche



Parametri Significativi

Diagramma di Radiazione

distribuzione relativa della potenza irradiata
in funzione della direzione spaziale

- Intensità di radiazione: $K(\theta,\varphi) = dP_{irr} / d\Omega$ [W / sterad]
- Direttività: $D(\theta,\varphi) = K_{max} / K_{medio}$

$$D(\theta,\varphi) = \frac{dP_{irr} / d\Omega}{P_{irr} / 4\pi}$$

- Guadagno: $G(\theta,\varphi) = \eta\, D(\theta,\varphi)$

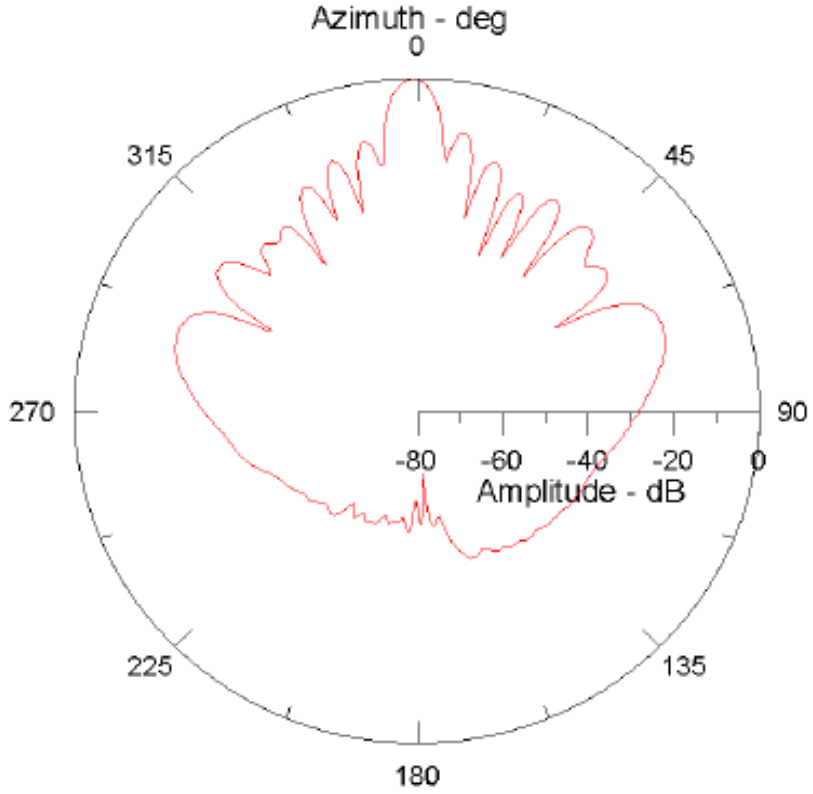
$$G(\theta,\varphi) = \frac{dP_{irr} / d\Omega}{P_{in} / 4\pi}$$

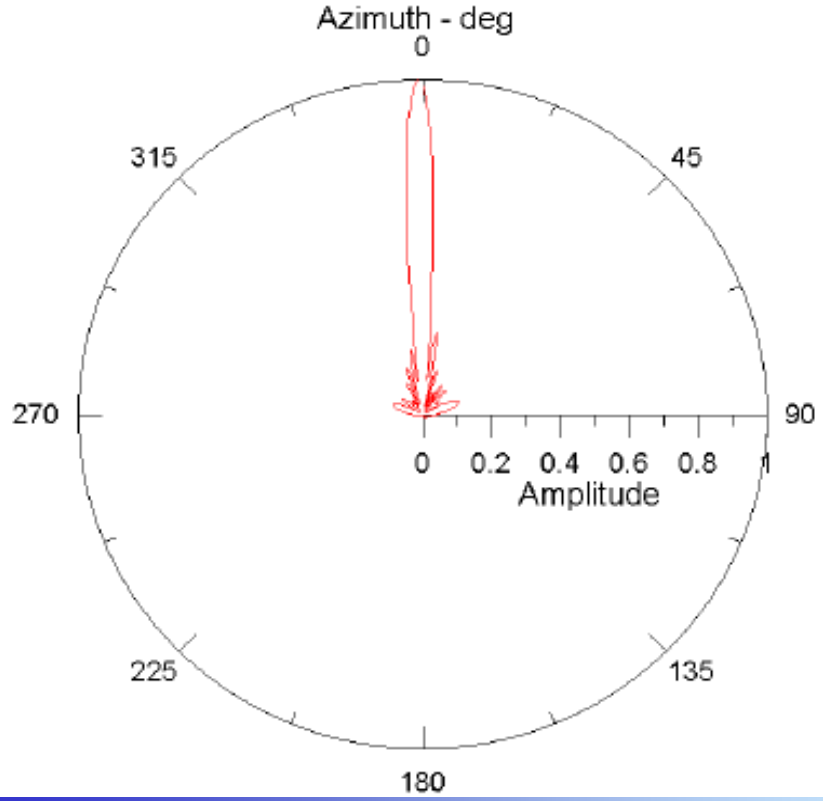
Parametri Significativi

Diagramma di Radiazione

distribuzione relativa della potenza irradiata
in funzione della direzione spaziale

- Rappresentazione in coordinate polari



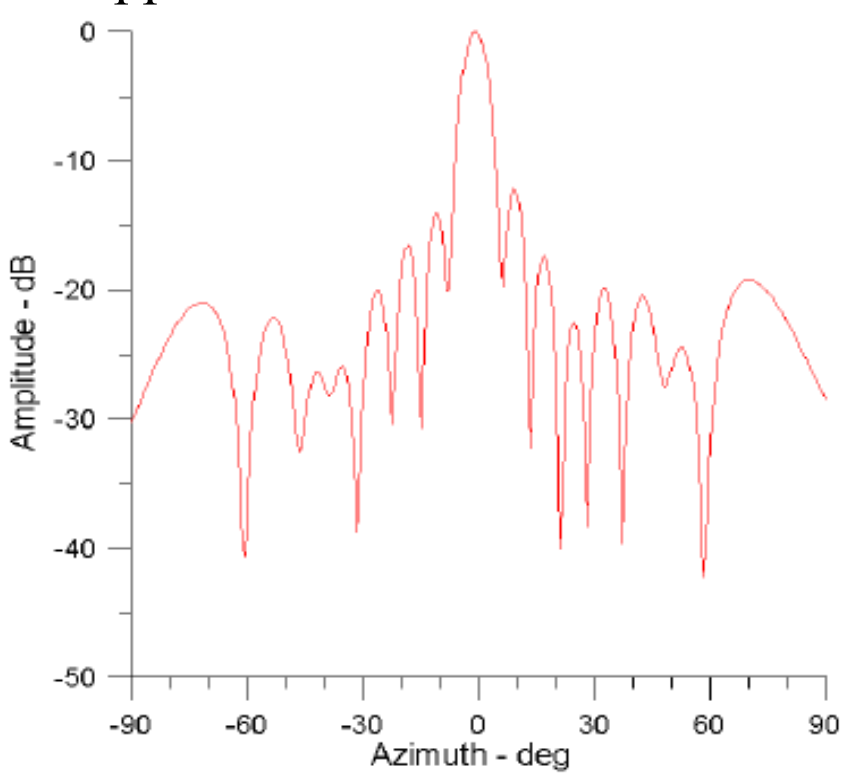


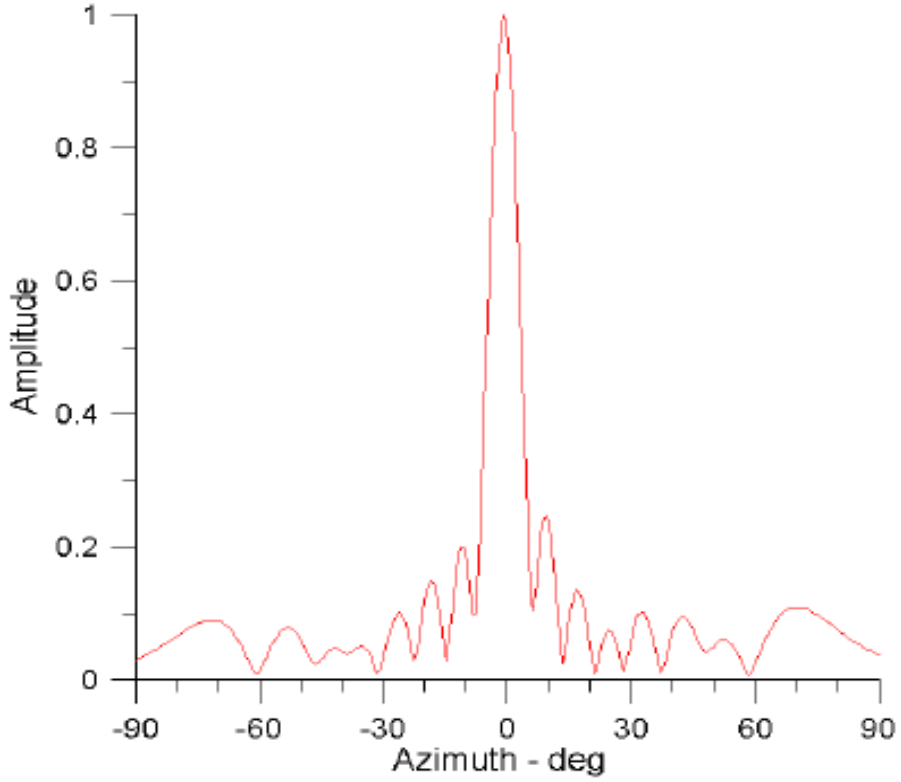
Parametri Significativi

Diagramma di Radiazione

distribuzione relativa della potenza irradiata
in funzione della direzione spaziale

- Rappresentazione in coordinate cartesiane



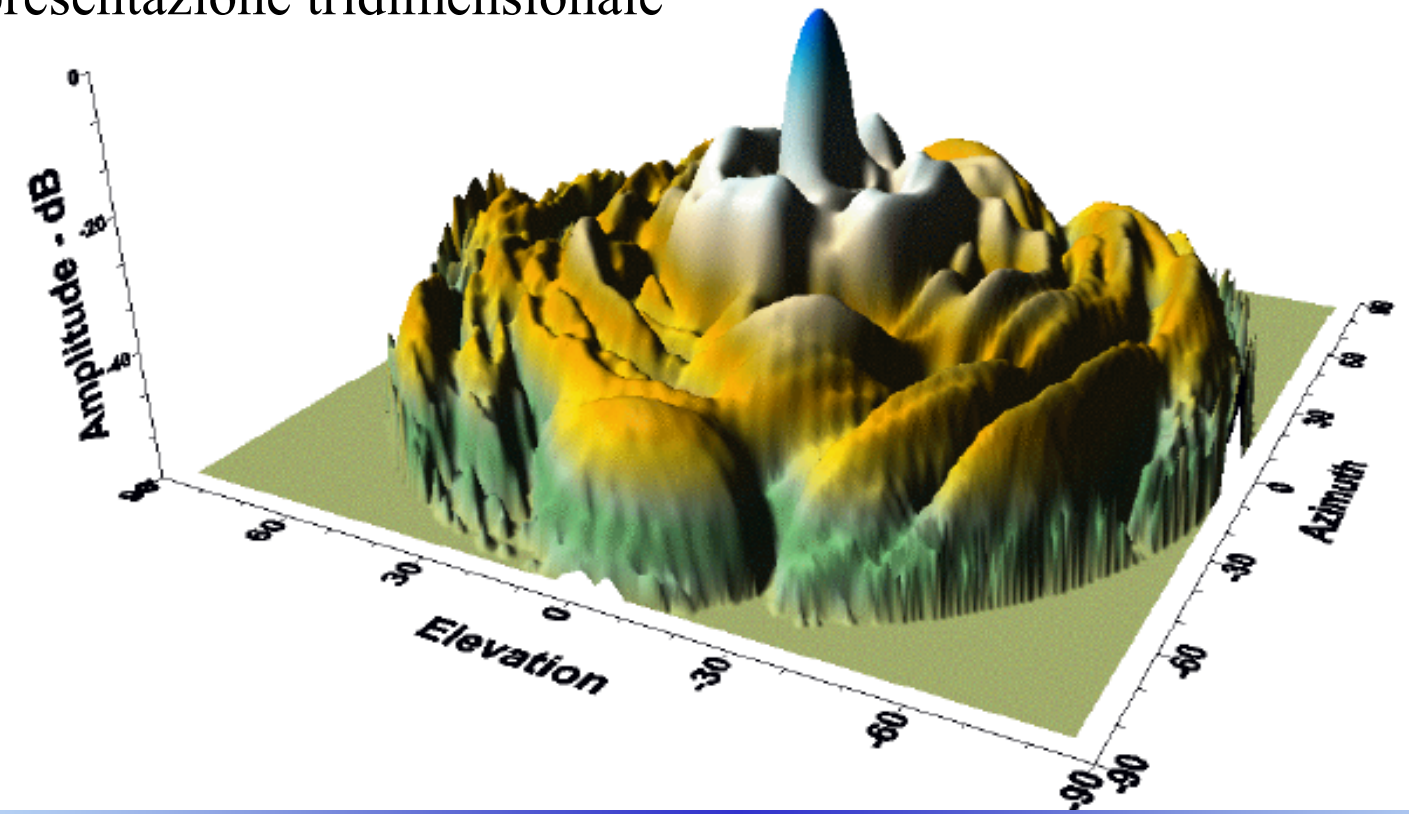


Parametri Significativi

Diagramma di Radiazione

→ distribuzione relativa della potenza irradiata in funzione della direzione spaziale

- Rappresentazione tridimensionale

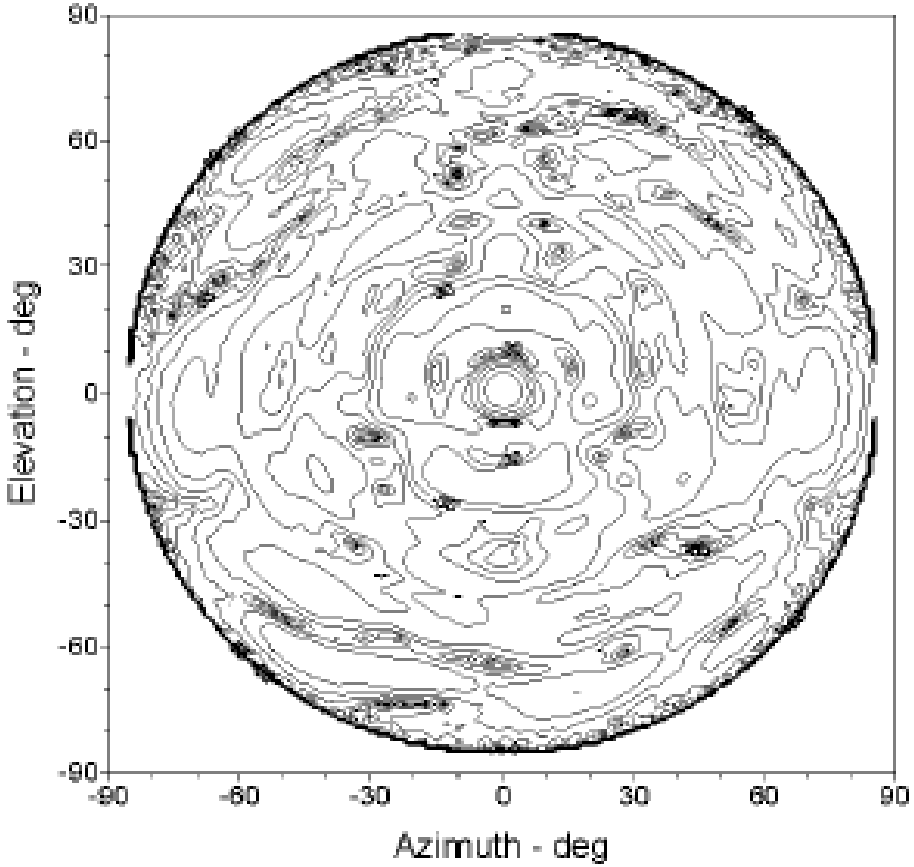


Parametri Significativi

Diagramma di Radiazione

distribuzione relativa della potenza irradiata
in funzione della direzione spaziale

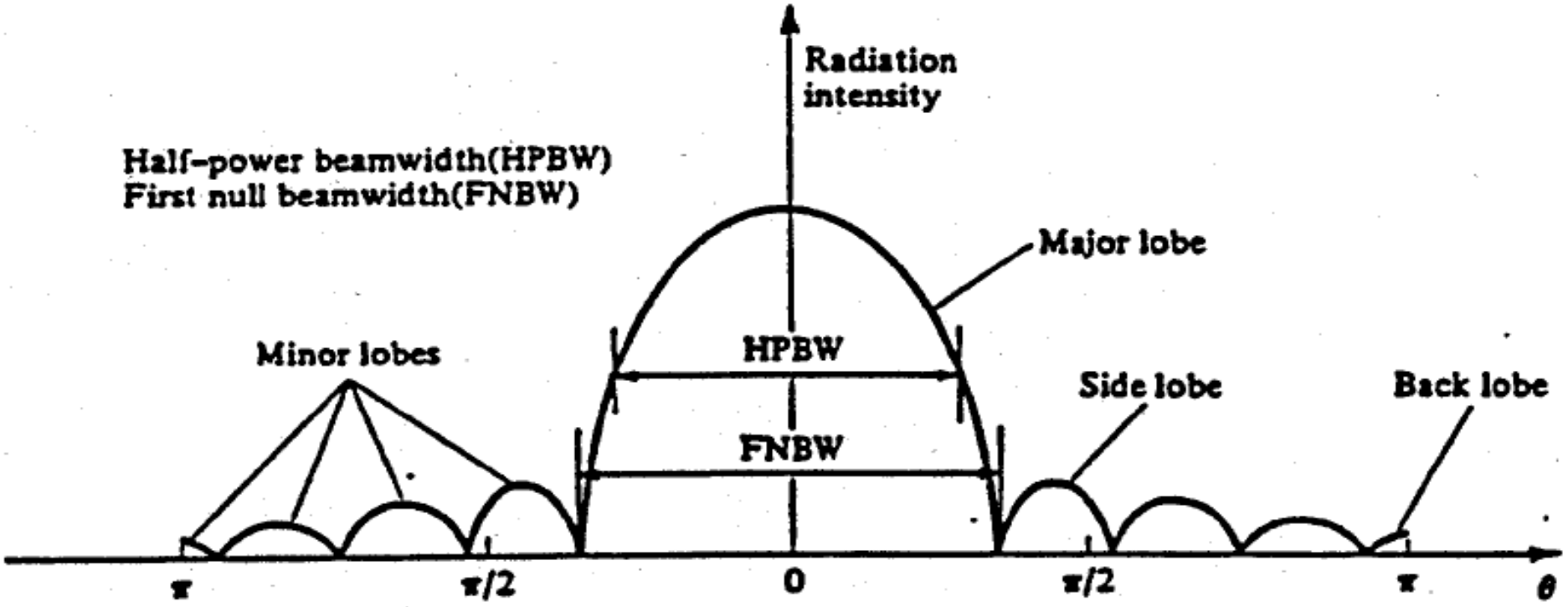
- Rappresentazione “contour plot”



Parametri Significativi

Diagramma di Radiazione

distribuzione relativa della potenza irradiata
in funzione della direzione spaziale

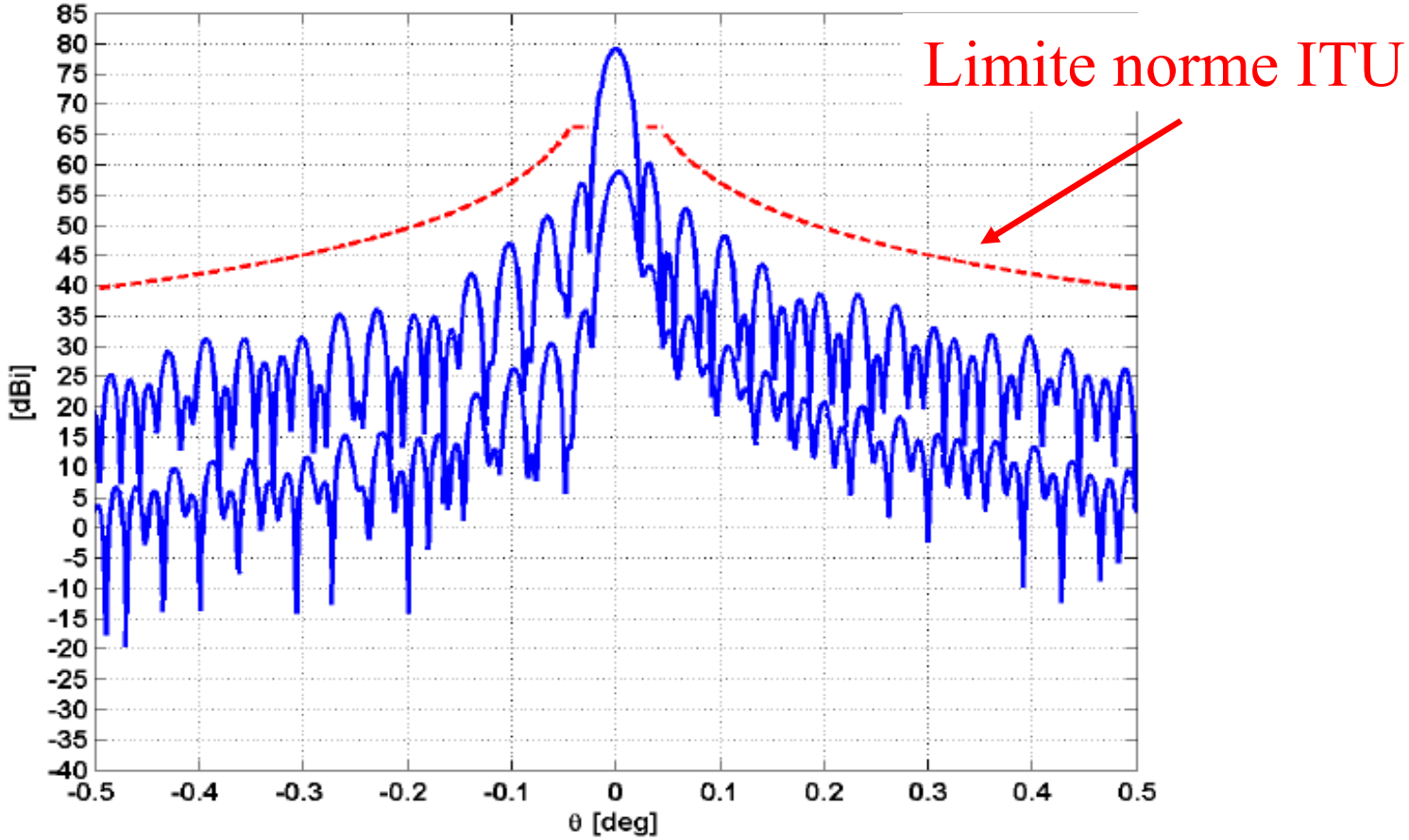


Parametri Significativi

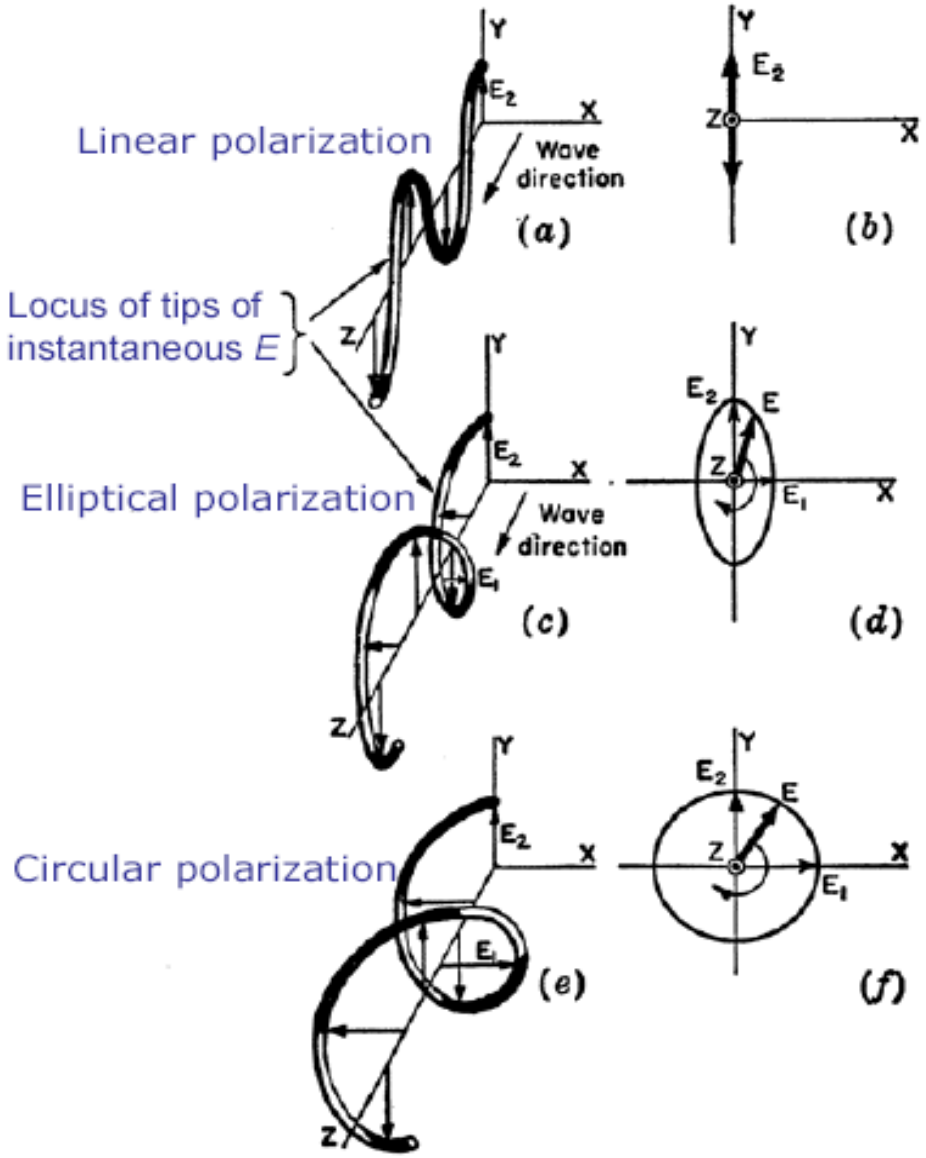
Diagramma di Radiazione

distribuzione relativa della potenza irradiata

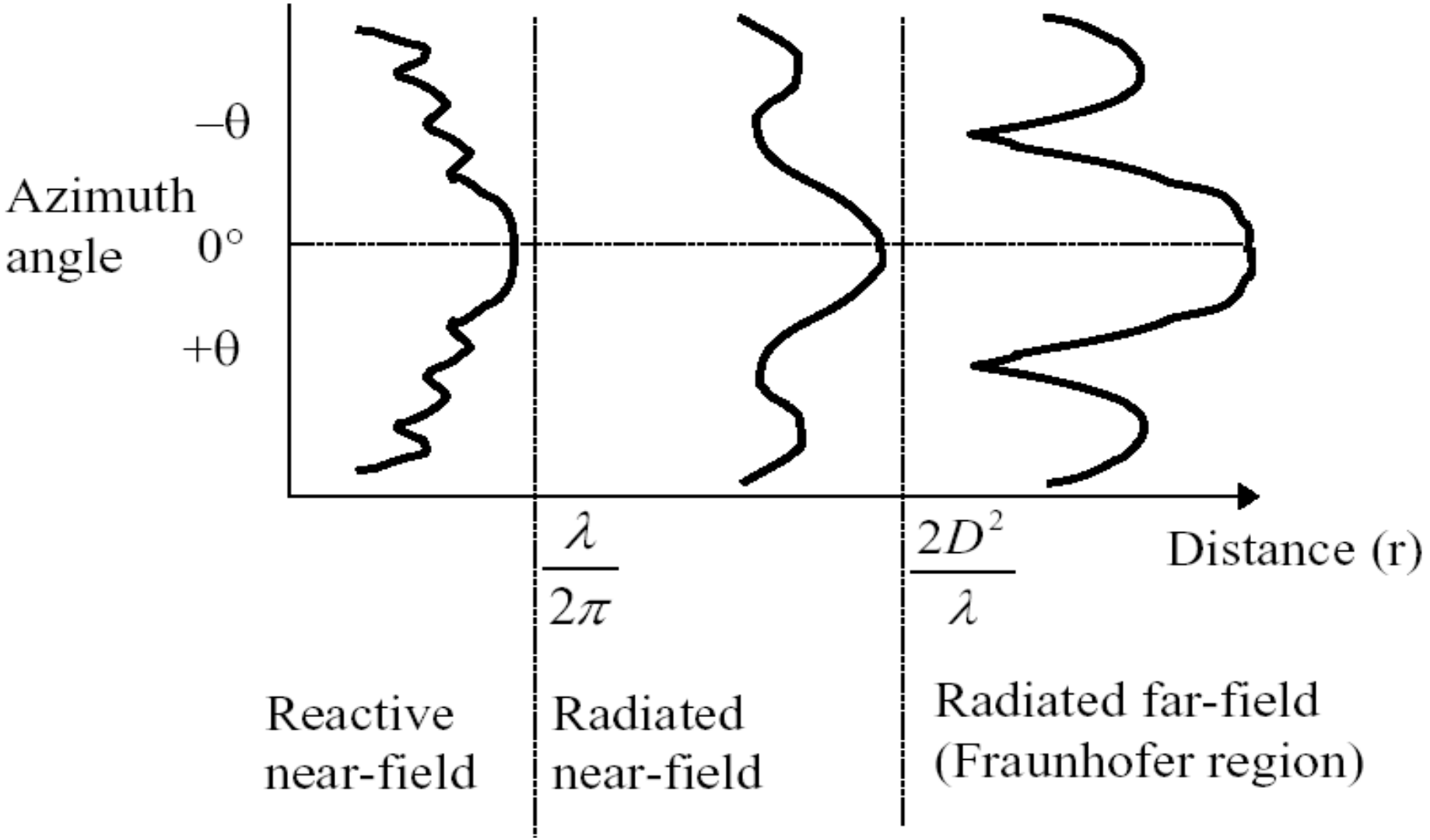
in funzione della direzione spaziale



Polarizzazione



Zone di Campo (sorgente grande)



Formula di Friis

$$\frac{P_{RX}}{P_{TX}} = \left(\frac{\lambda}{4\pi r}\right)^2 G_1 G_2 \, \tau$$

Tipologie di Misura

Outdoor

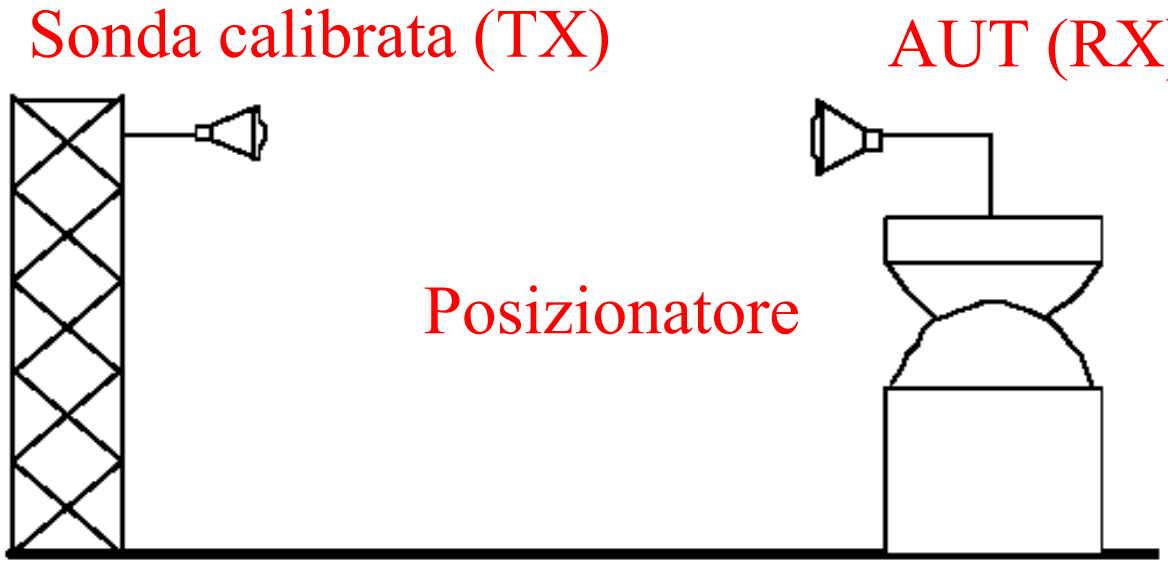
- Campo lontano
  - “Elevated range”
  - “Ground reflection range”

Indoor in camera anecoica

- Campo lontano
  - Camera anecoica tradizionale
  - CATR
- Campo vicino
  - Scansione planare
  - Scansione cilindrica
  - Scansione sferica

Outdoor – Campo Lontano

Elevated range

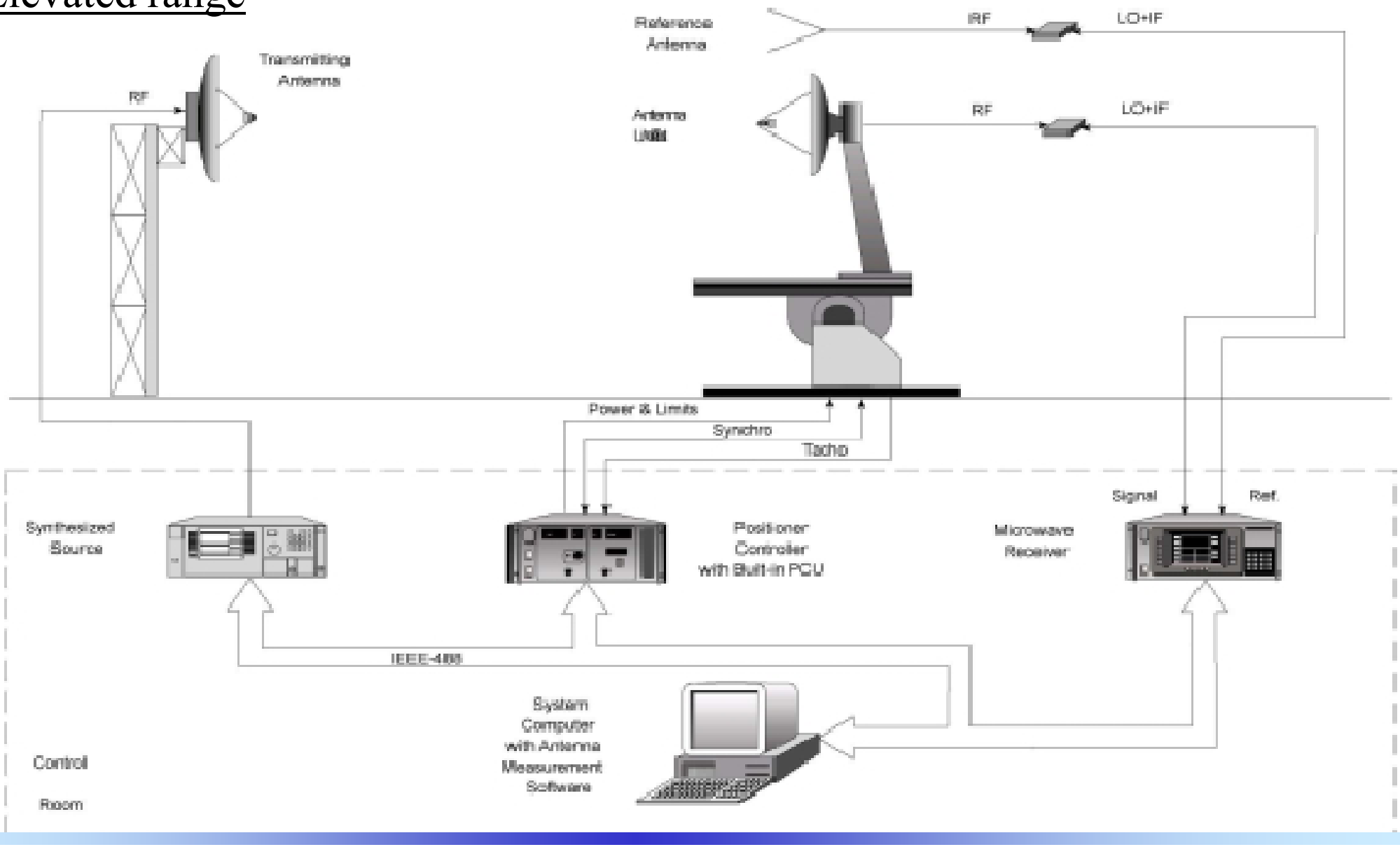


Outdoor Elevated Range

- Terreno pianeggiante
- Antenne montate su torri o palazzi
- Distanza scelta in base ai criteri di campo lontano
- Sonda scelta per avere campo più uniforme possibile sull'AUT
- Se possibile montare diffrattori sul terreno

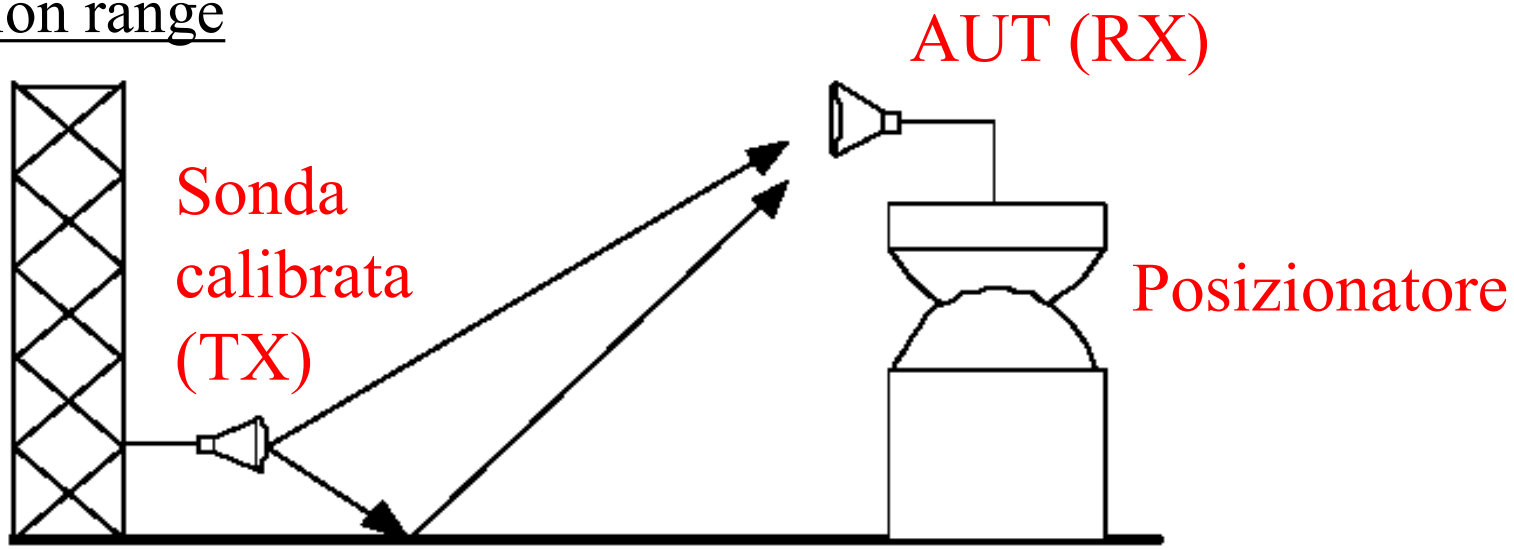
Outdoor – Campo Lontano

Elevated range



Outdoor – Campo Lontano

Ground reflection range

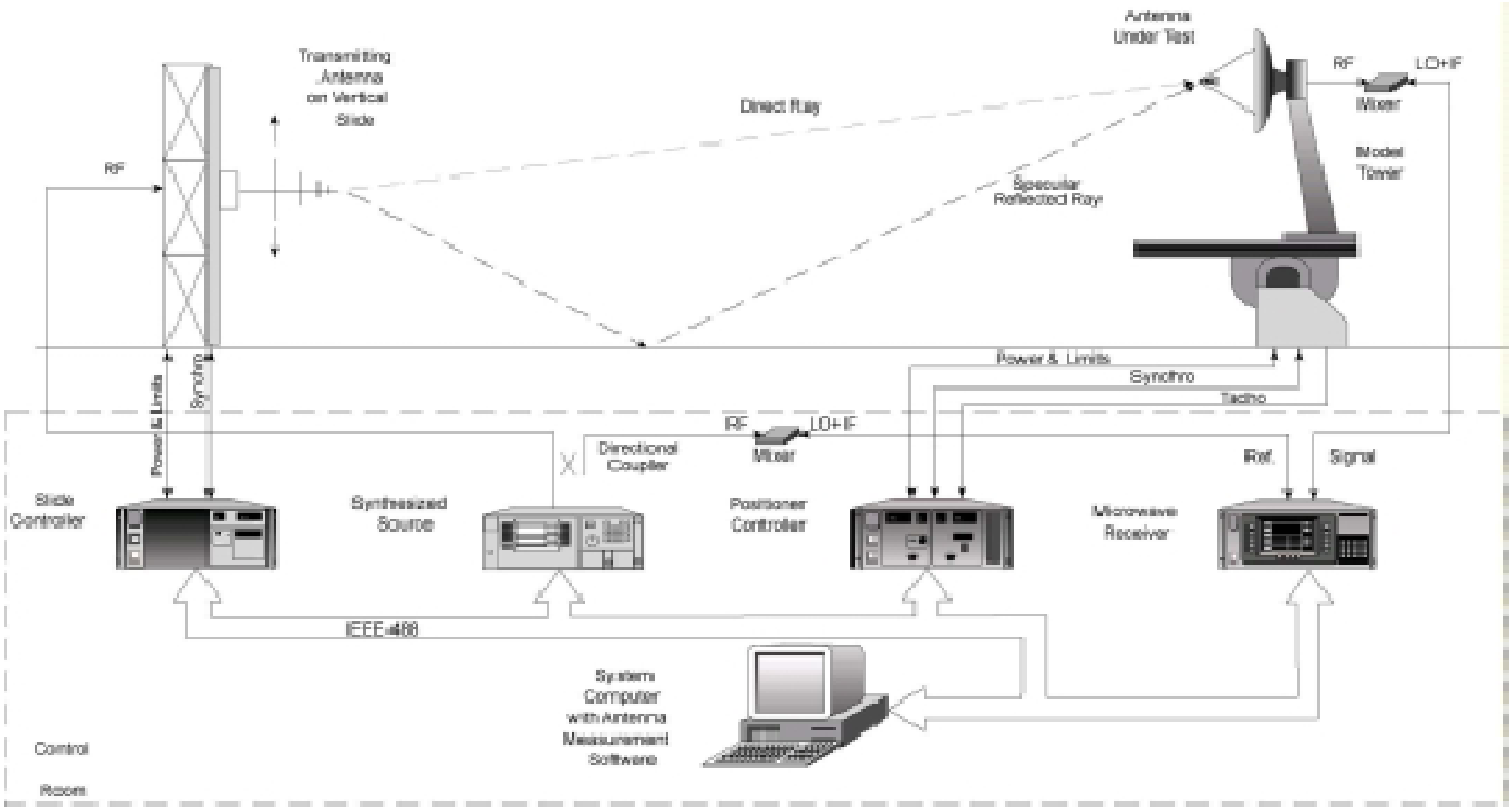


Ground Reflection Range

- La riflessione dal terreno è sfruttata per ottenere fase uniforme sull'AUT
- Necessità di terreno pianeggiante
- Distanza scelta in base ai criteri di campo lontano
- AUT posizionato sul primo lobo di interferenza tra sonda e riflessione speculare

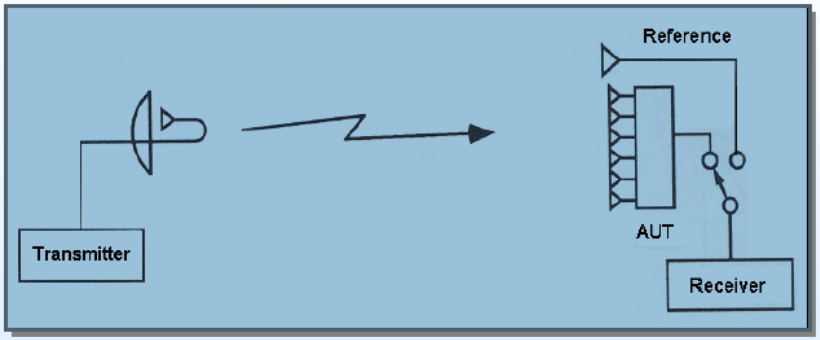
Outdoor – Campo Lontano

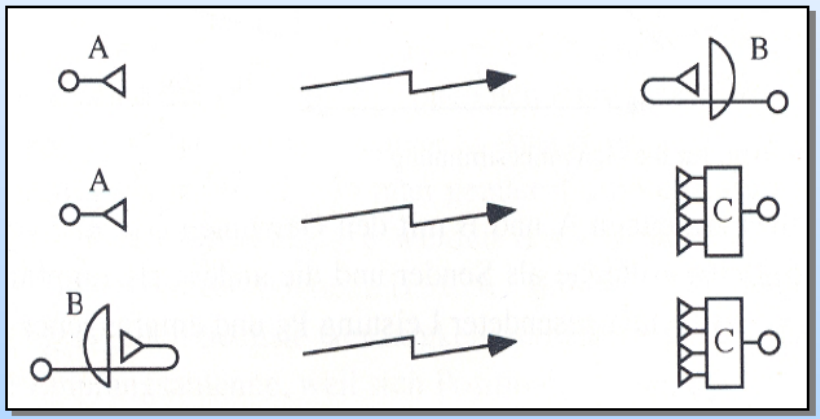
Ground reflection range

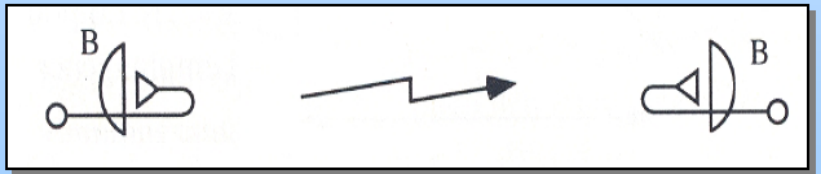


Outdoor – Campo Lontano

Calibration methods







Reference antenna method

- Difference of received power / voltage
- Arbitrary transmit antenna

- Replacement (once) of antennas: Risk of misalignment
- Calibrated reference antenna needed

Three antenna method

- Three arbitrary antennas

- Replacement (twice) of antennas: risk of misalignment
- Change of test set-up

Two antenna method

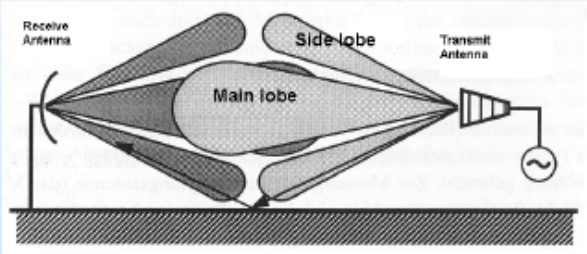
- No motion of the test set-up
- Straight forward measurement / calculation

- Two identical antennas needed

Outdoor – Campo Lontano

Vantaggi/svantaggi

- Convenient test site for "low-frequency" antennas (30 MHz – 1000 MHz), even covering those antennas that don't fit into the anechoic chamber
- Large measurement distance between antennas (up to 10 m)
- Influence of ground plane:
  - Ground reflection, impedance, …



- External interferences can affect the calibration measurements
  - ➡ Sufficient signal levels during calibration
  - ➡ Avoidance of "busy" frequencies for calibration
- Calibration measurements can cause interferences to other services
  - ➡ Minimization of required signal levels (link budget)
  - ➡ Avoidance of "busy" frequencies for calibration
  - ➡ Minimization of transmitting periods

Indoor – Campo Lontano

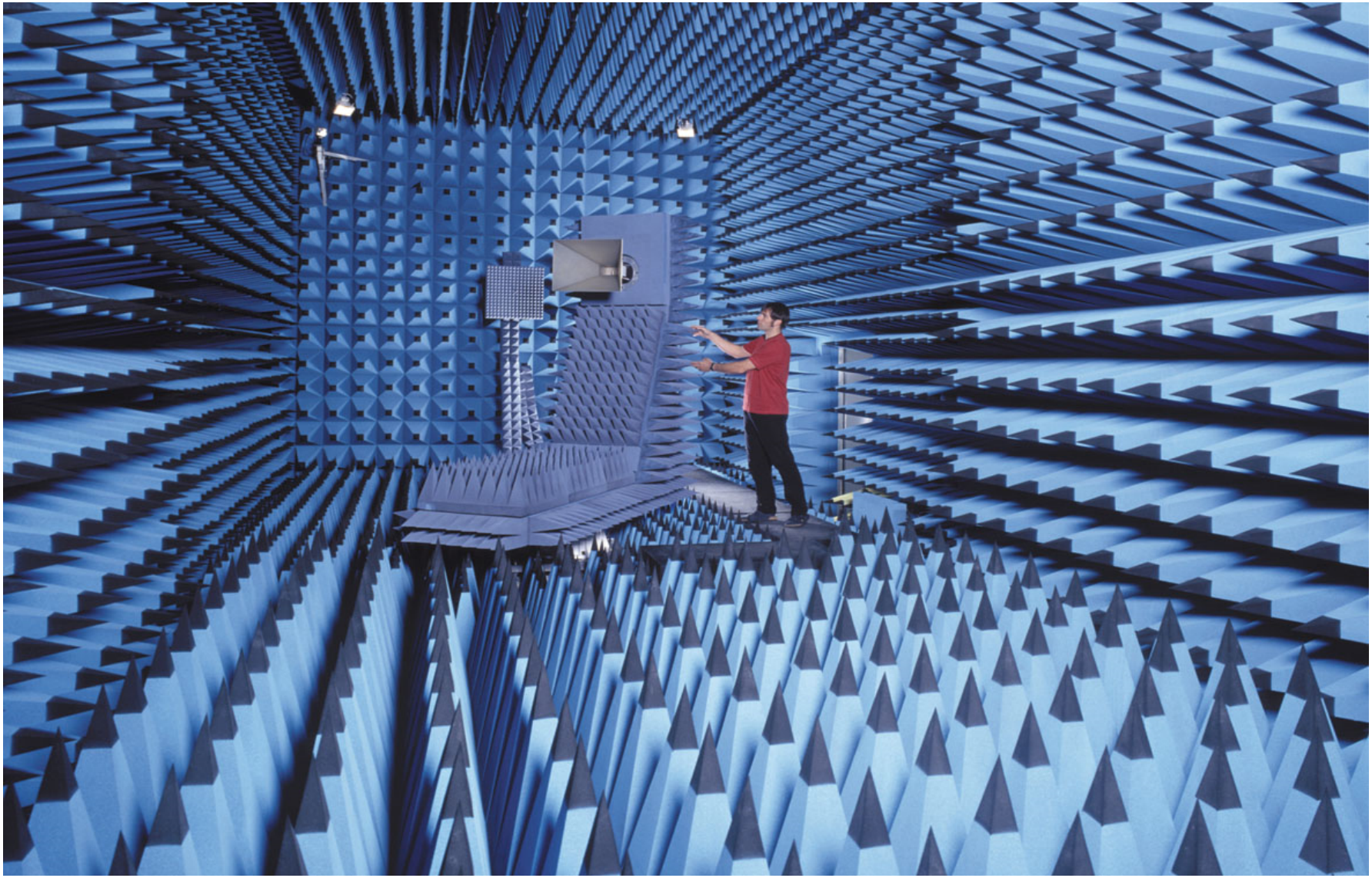
Camera anecoica

Rectangular Anechoic Chamber

- Camere completamente schermate e ricoperte da pannelli assorbenti di forma e dimensione opportuna

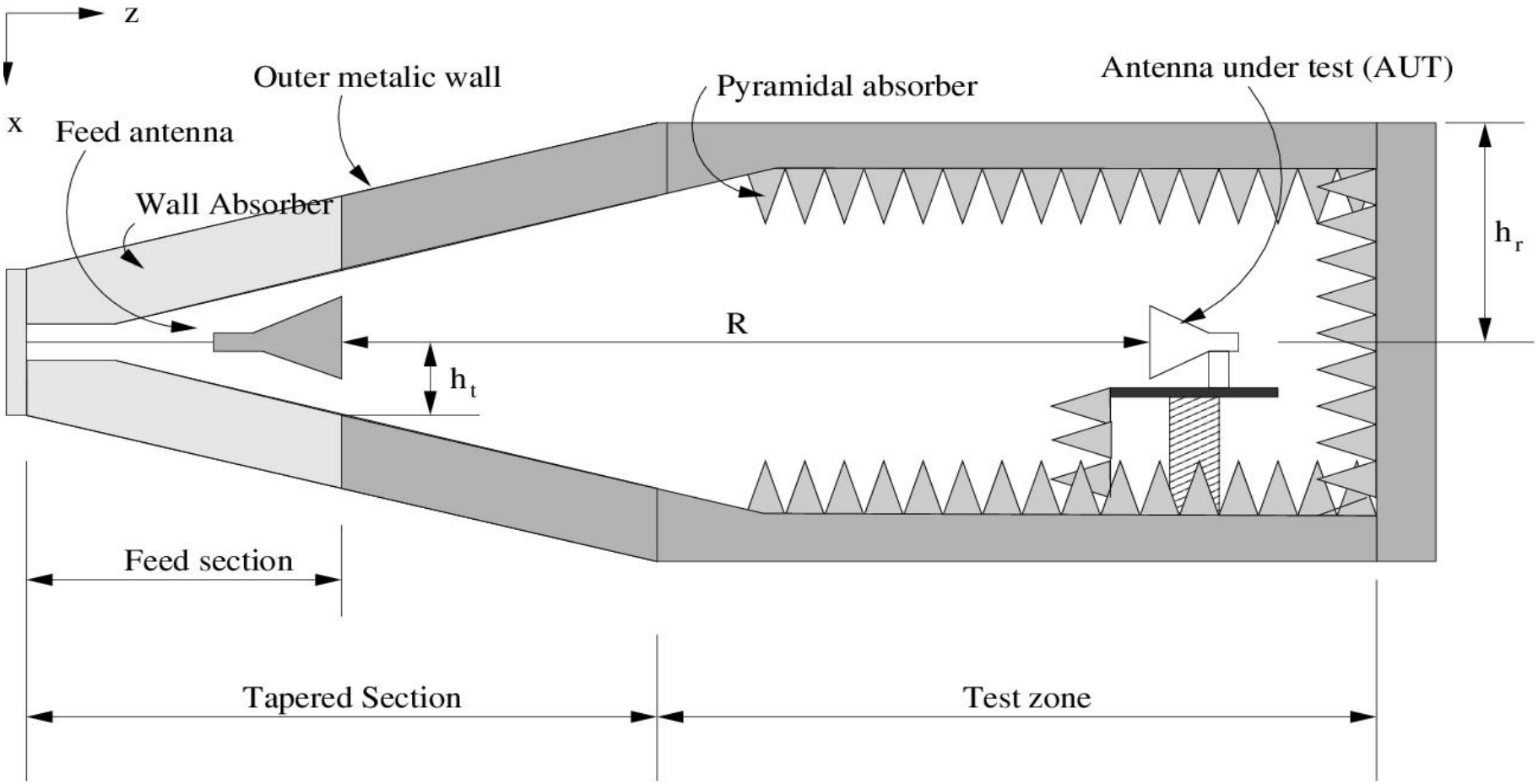
Indoor – Campo Lontano

Camera anecoica



Indoor – Campo Lontano

Camera anecoica piramidale

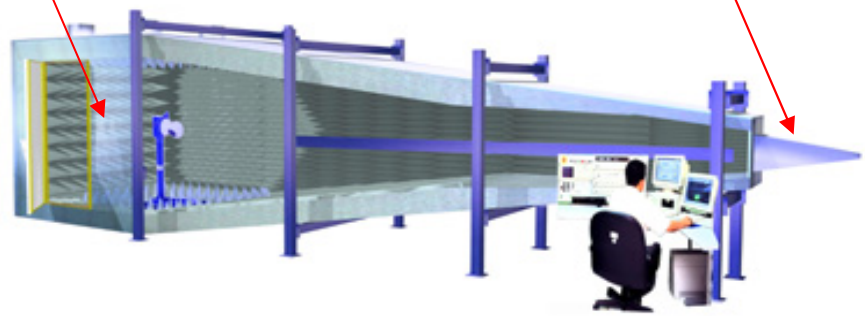


Indoor – Campo Lontano

Camera anecoica piramidale

Test zone

Feed section



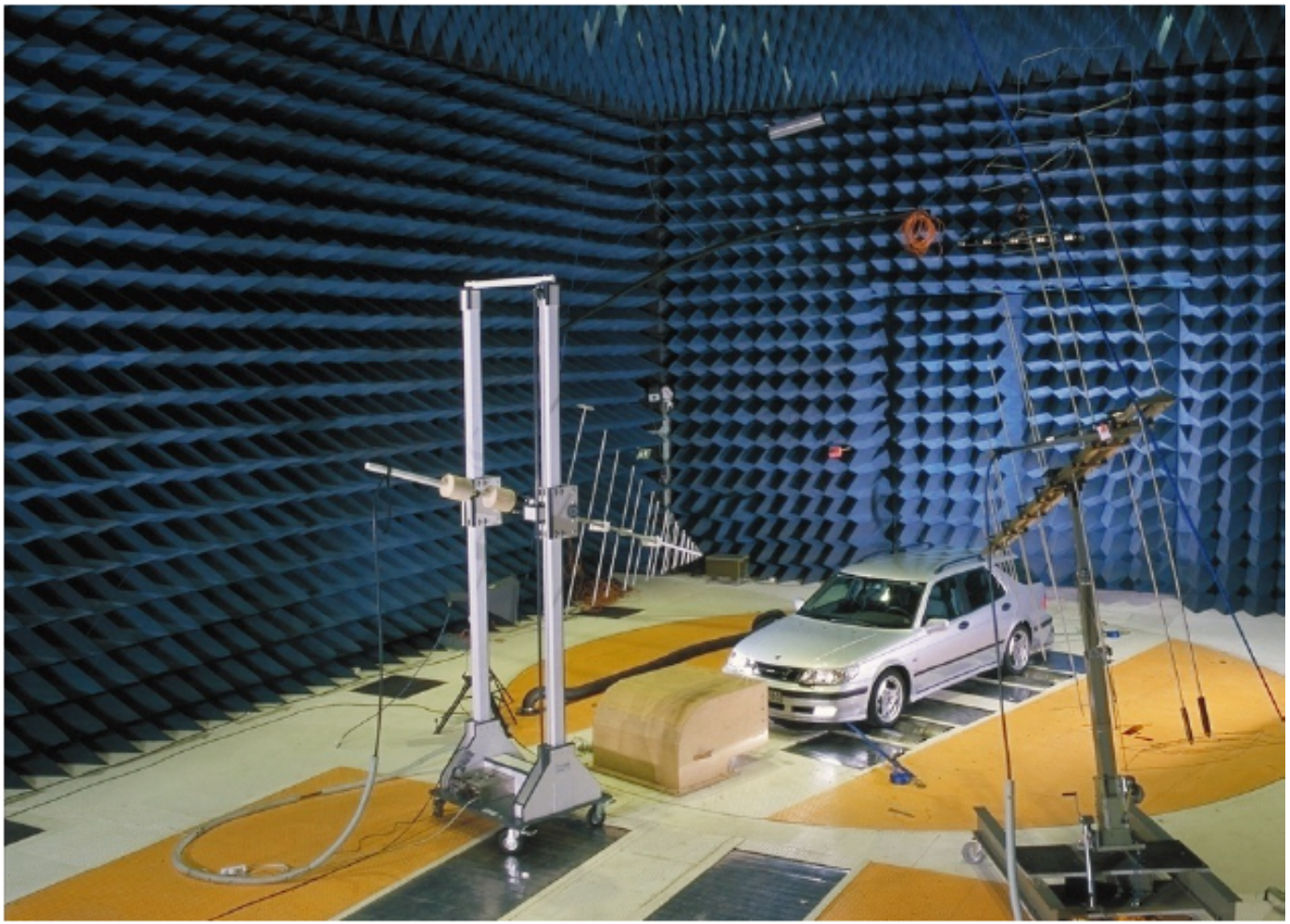
ETS-Lindgren Wireless Test Chambers
(400 MHz to 6000 MHz)

SBH feed antenna

Sat Com Electronics Antenna
Tapered Chamber
(500 MHZ 40 GHz)

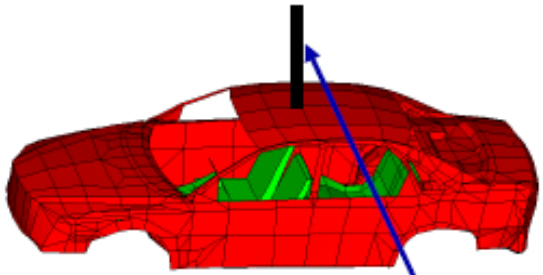
Indoor – Campo Lontano

Camera semianecoica

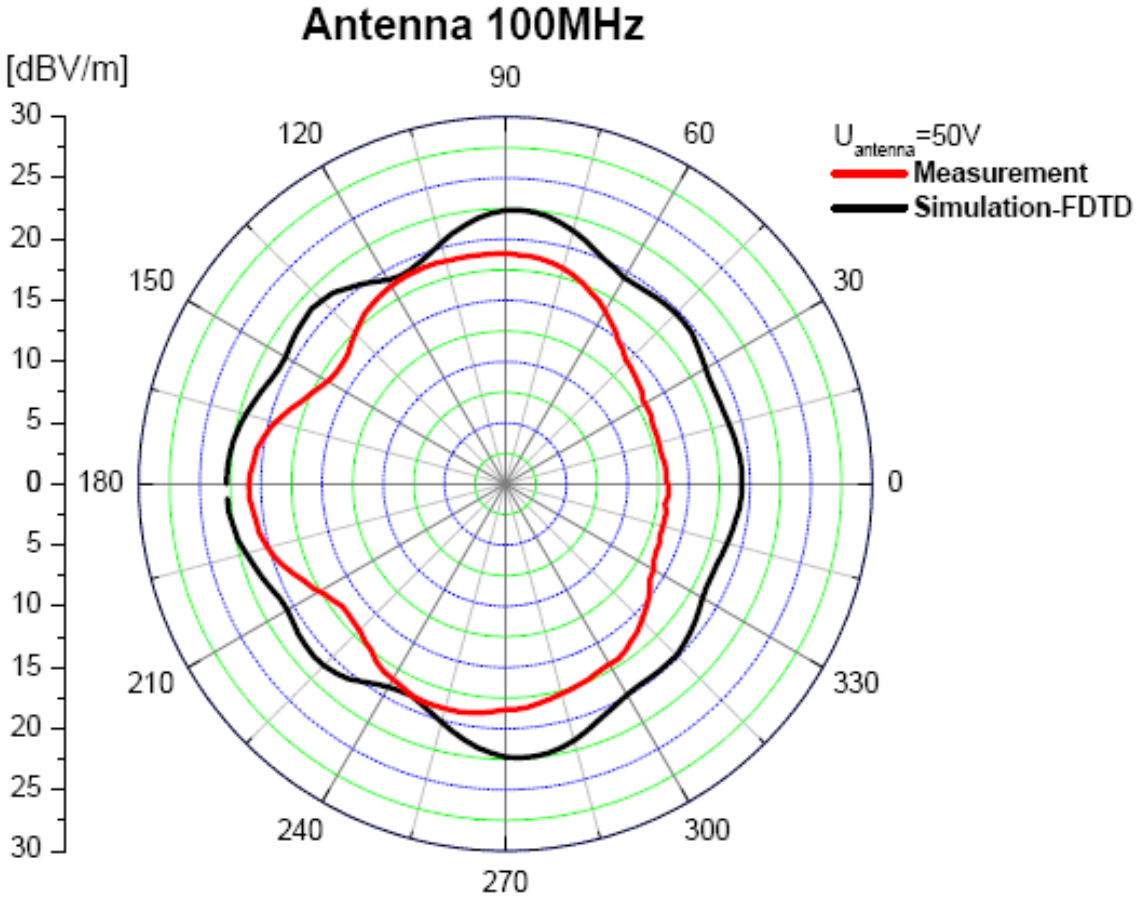


Indoor – Campo Lontano

Esempio di misura in camera semianecoica

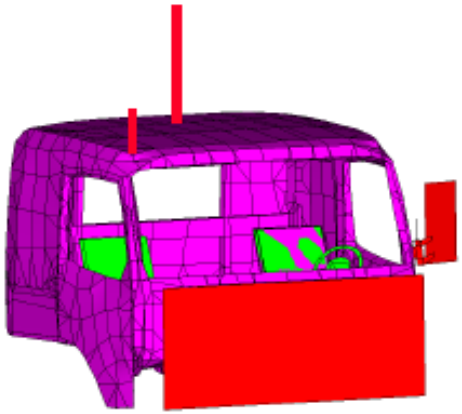


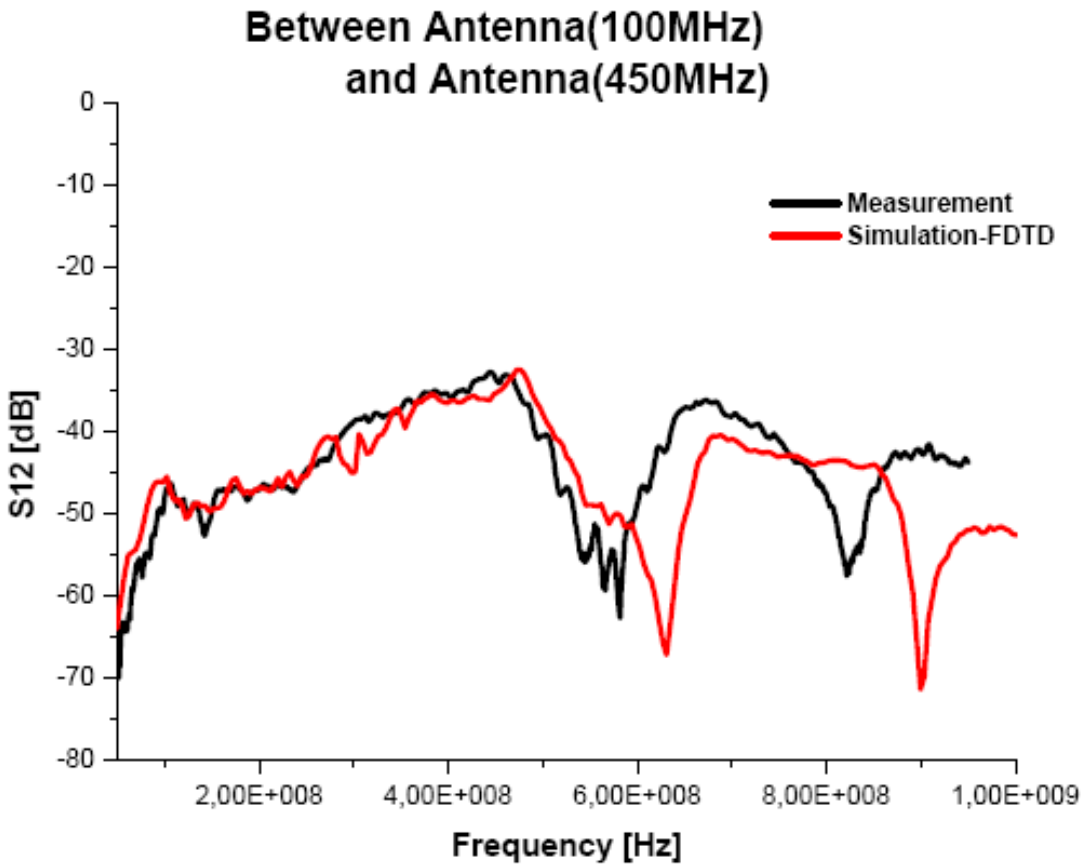
Antenna



Indoor – Campo Lontano

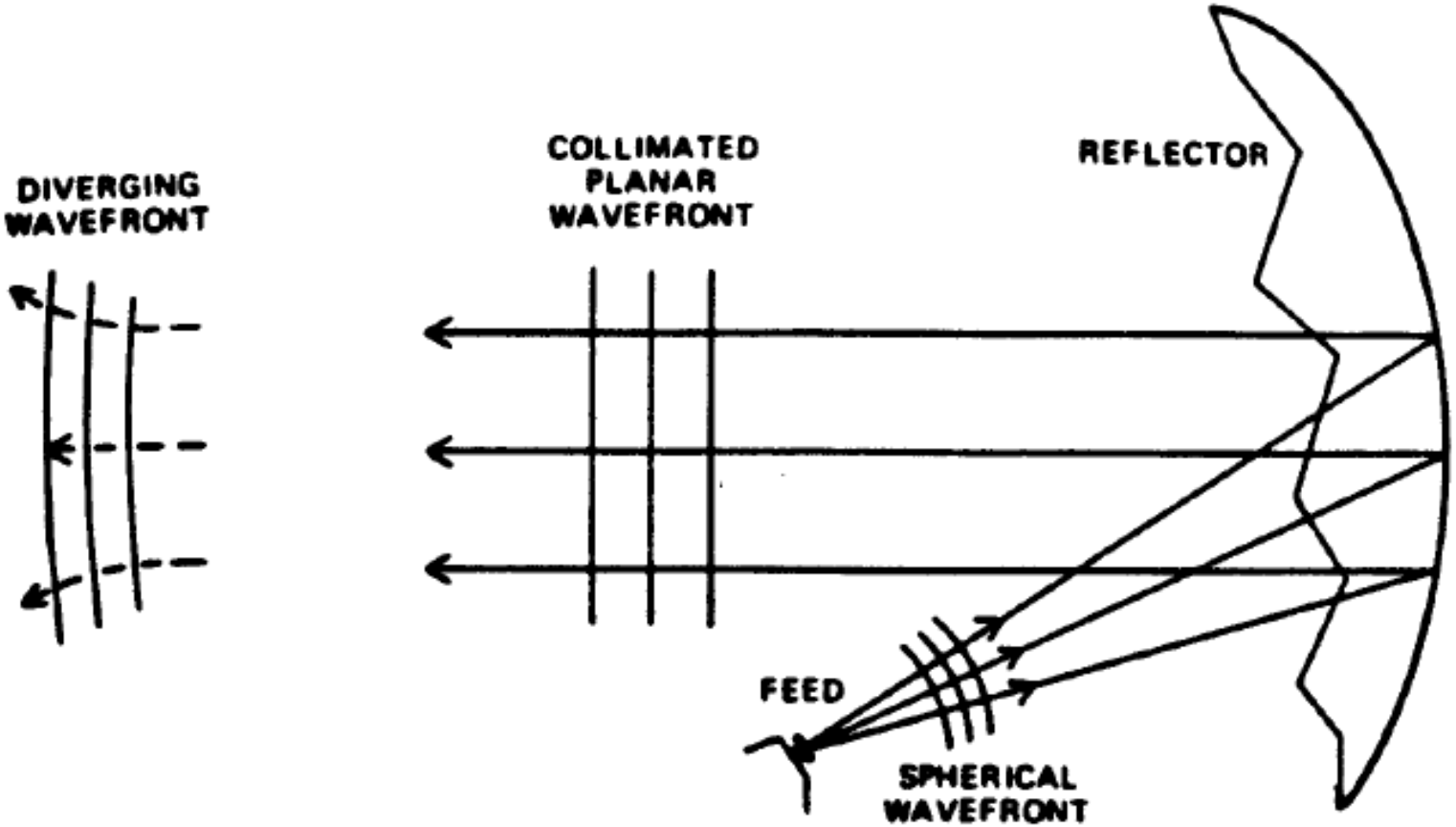
Esempio di misura in camera semianecoica





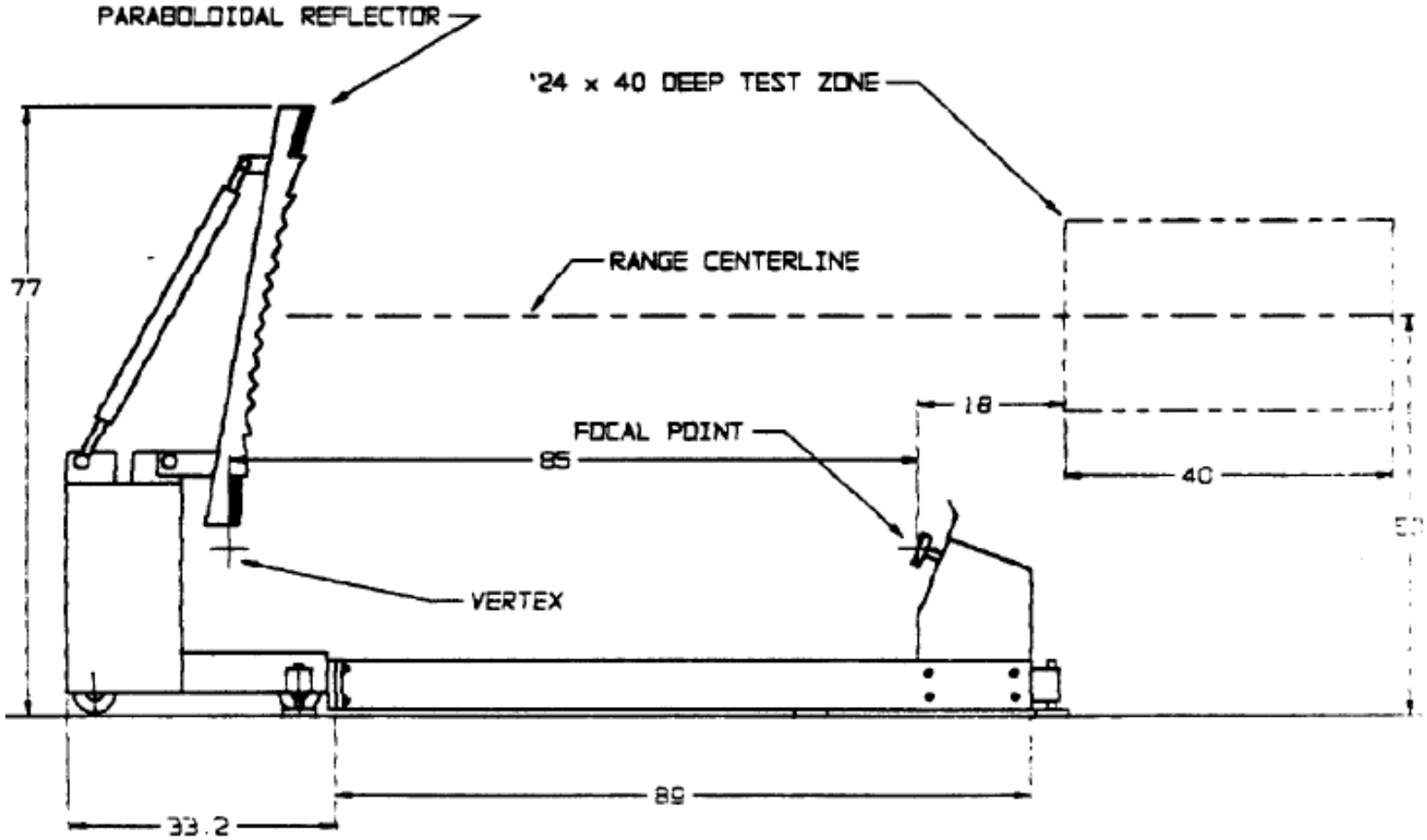
Indoor – Campo Lontano

Compact antenna test range (CATR)



Indoor – Campo Lontano

Compact antenna test range (CATR)



Indoor – Campo Lontano

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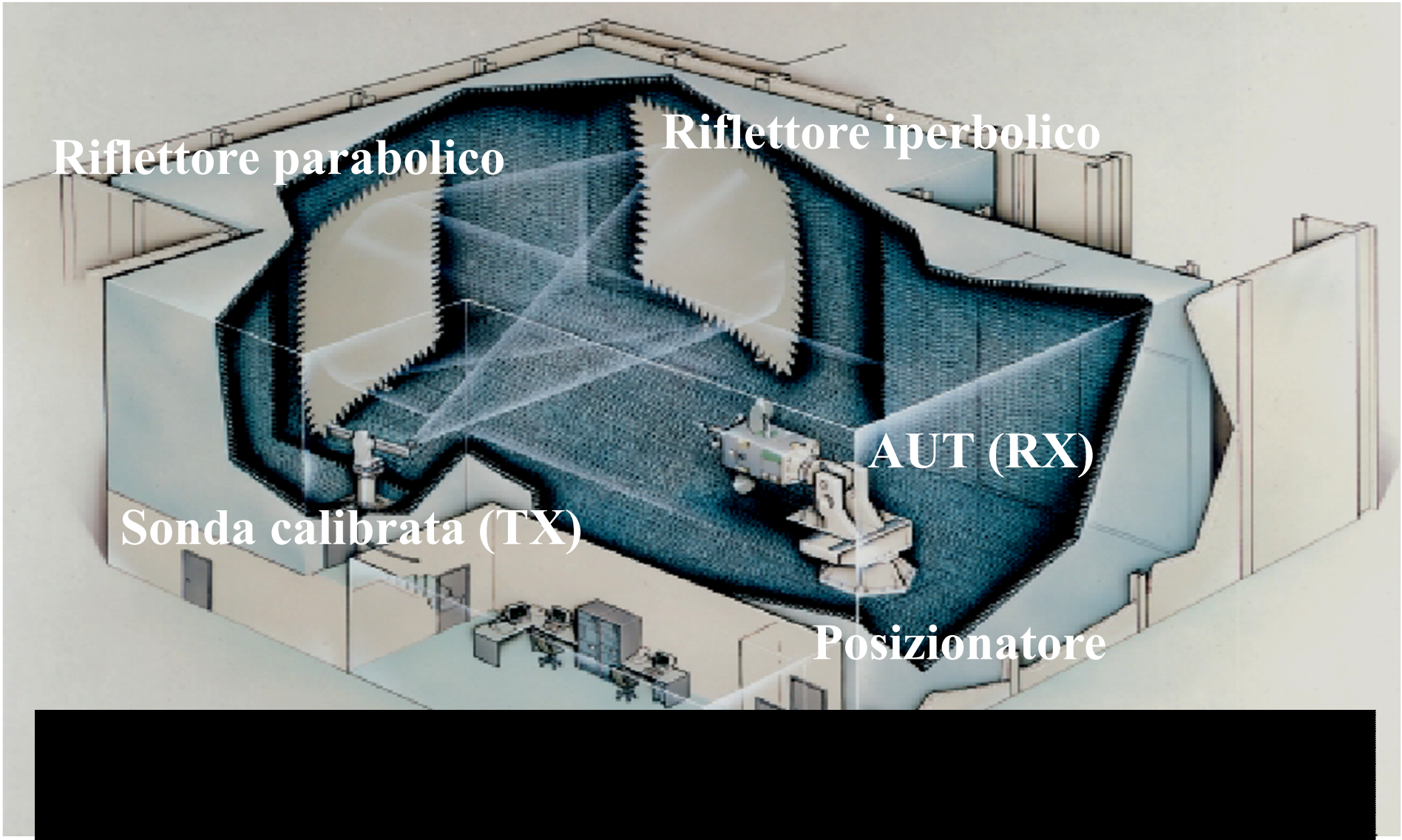
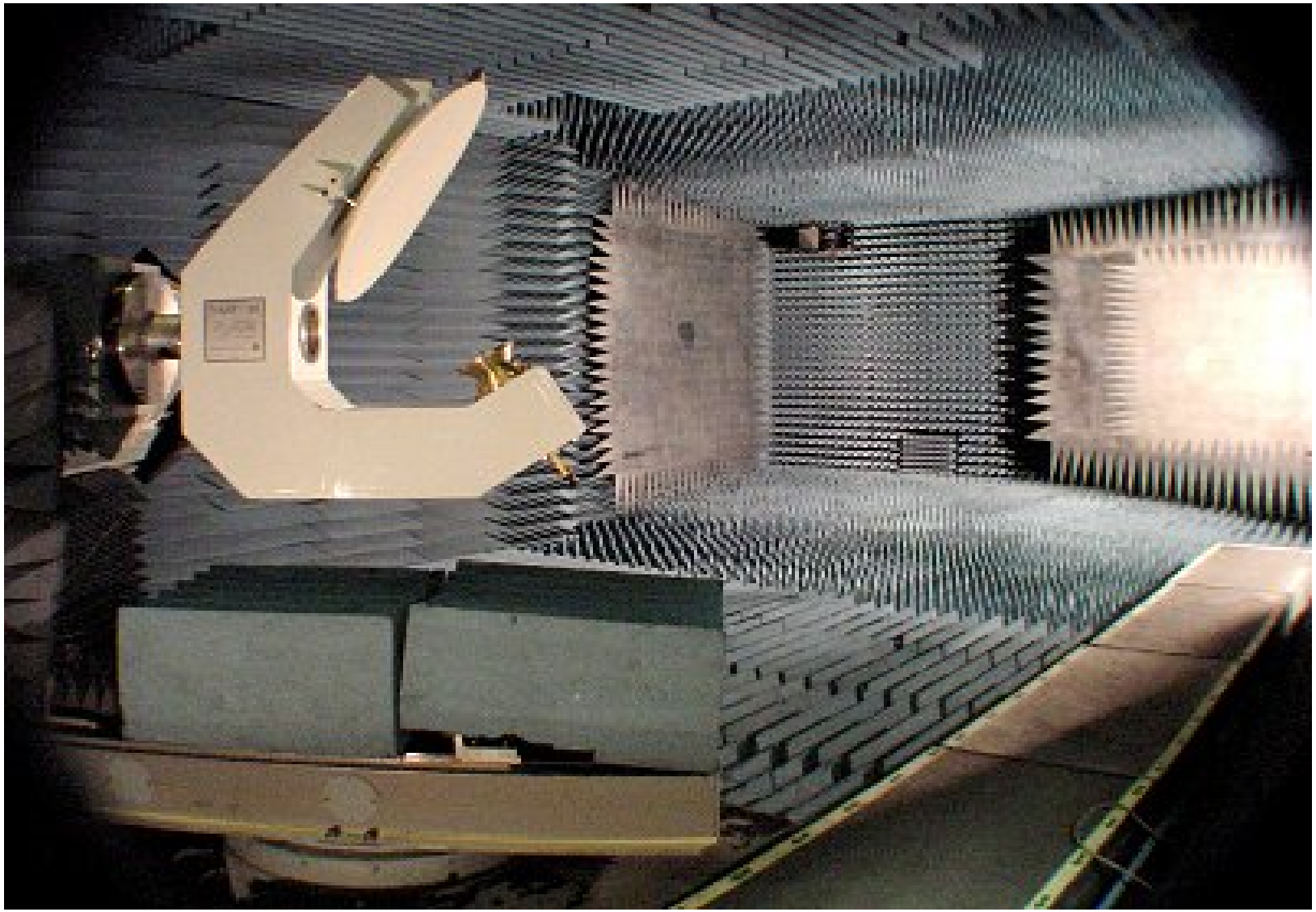


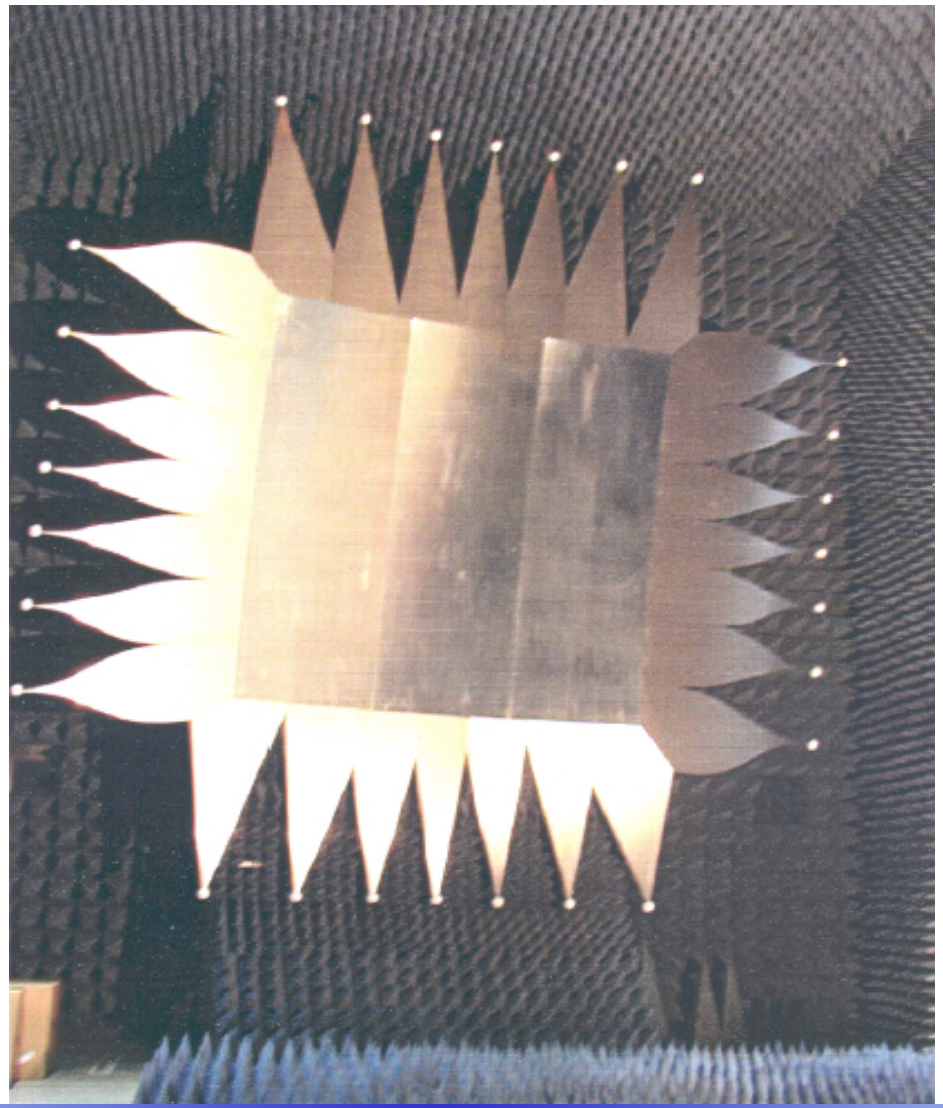
Indoor – Campo Lontano

Compact antenna test range (CATR)



Indoor – Campo Lontano

Compact antenna test range (CATR)



Indoor – Campo Lontano

Compact antenna test range (CATR)

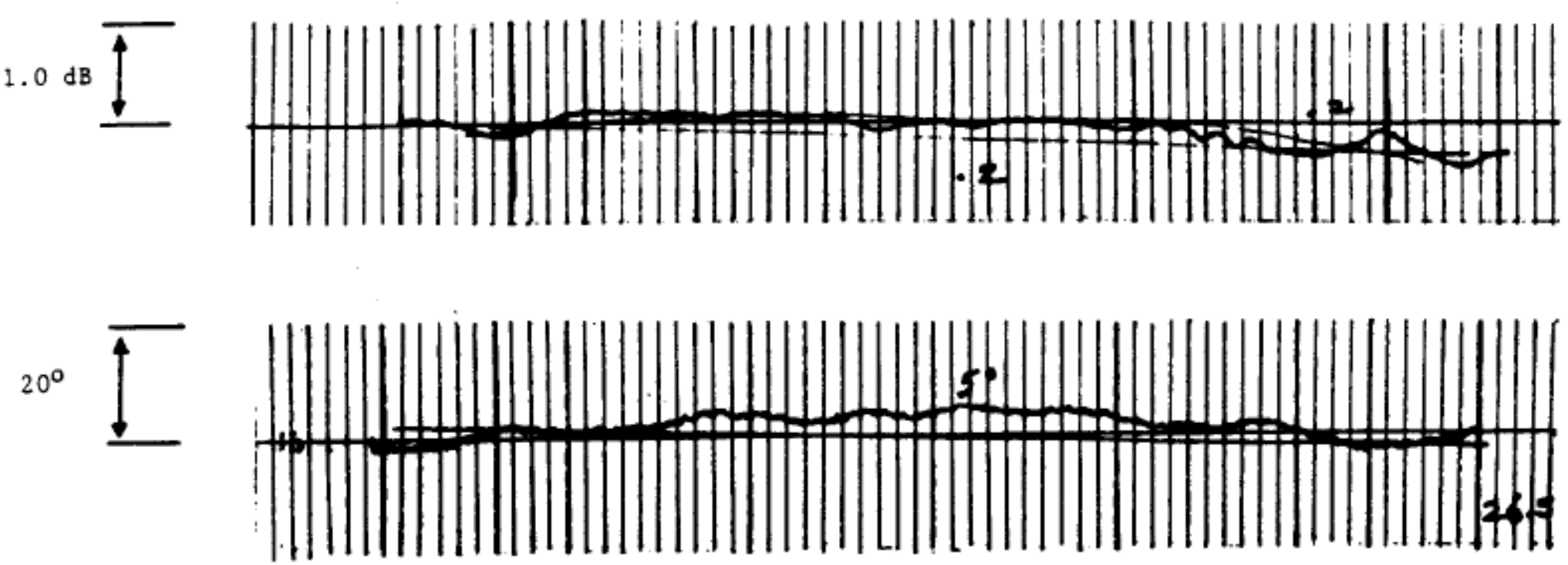


Figure 3. Amplitude and Phase at 26.5 GHz

Indoor – Campo Lontano

Compact antenna test range (CATR)

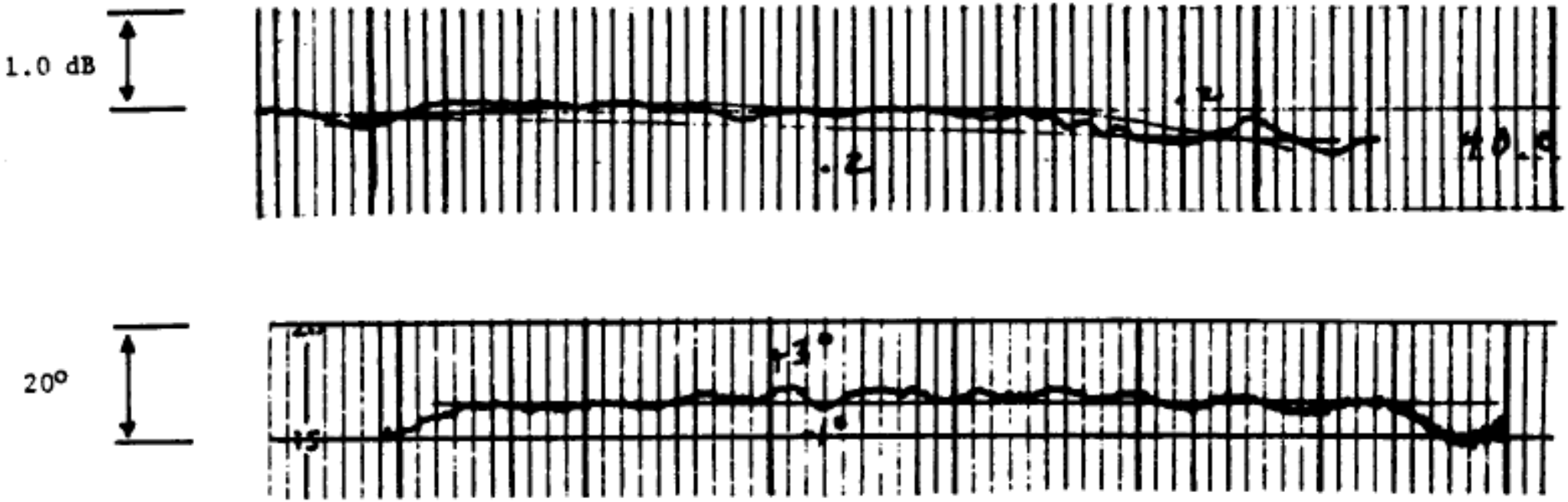


Figure 4. Amplitude and Phase at 40 GHz

Indoor – Campo Lontano

Compact antenna test range (CATR)

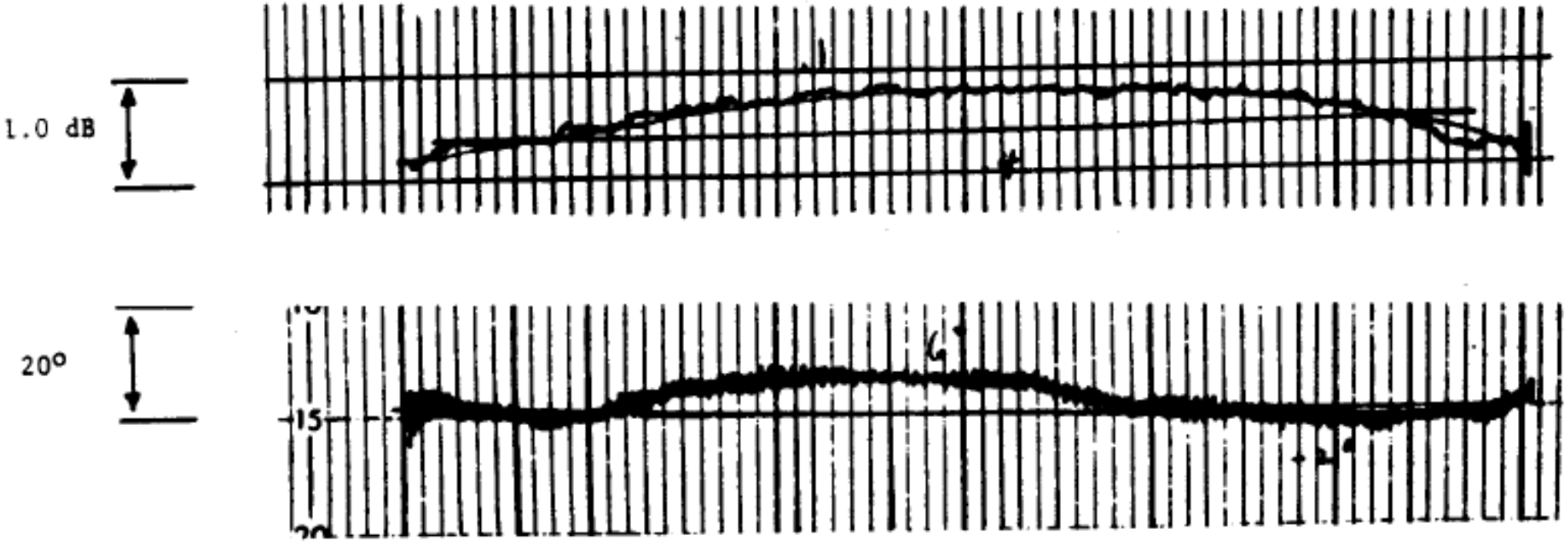
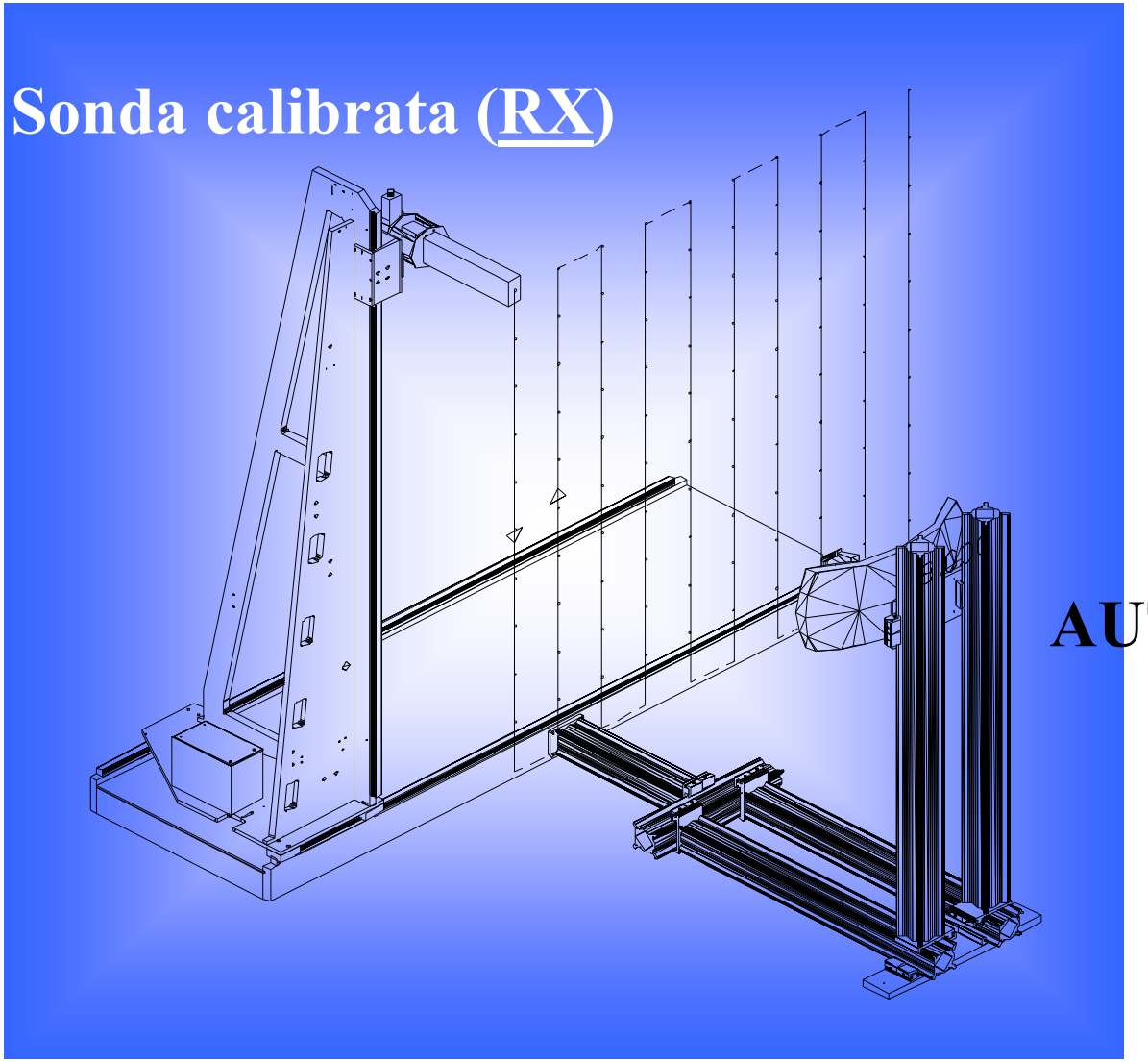


Figure 5. Amplitude and Phase at 94 GHz

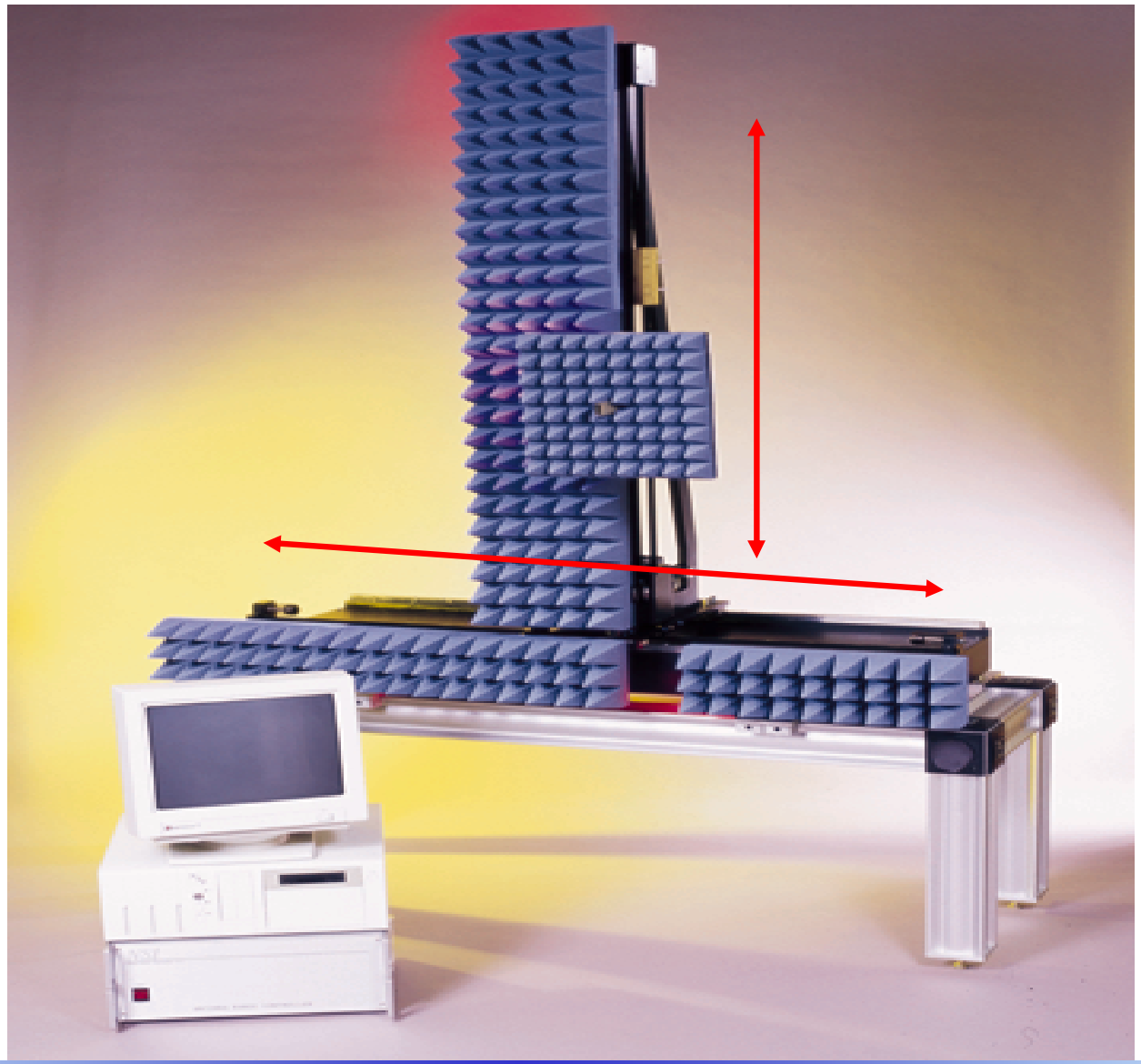
Indoor – Campo Vicino

Scansione planare



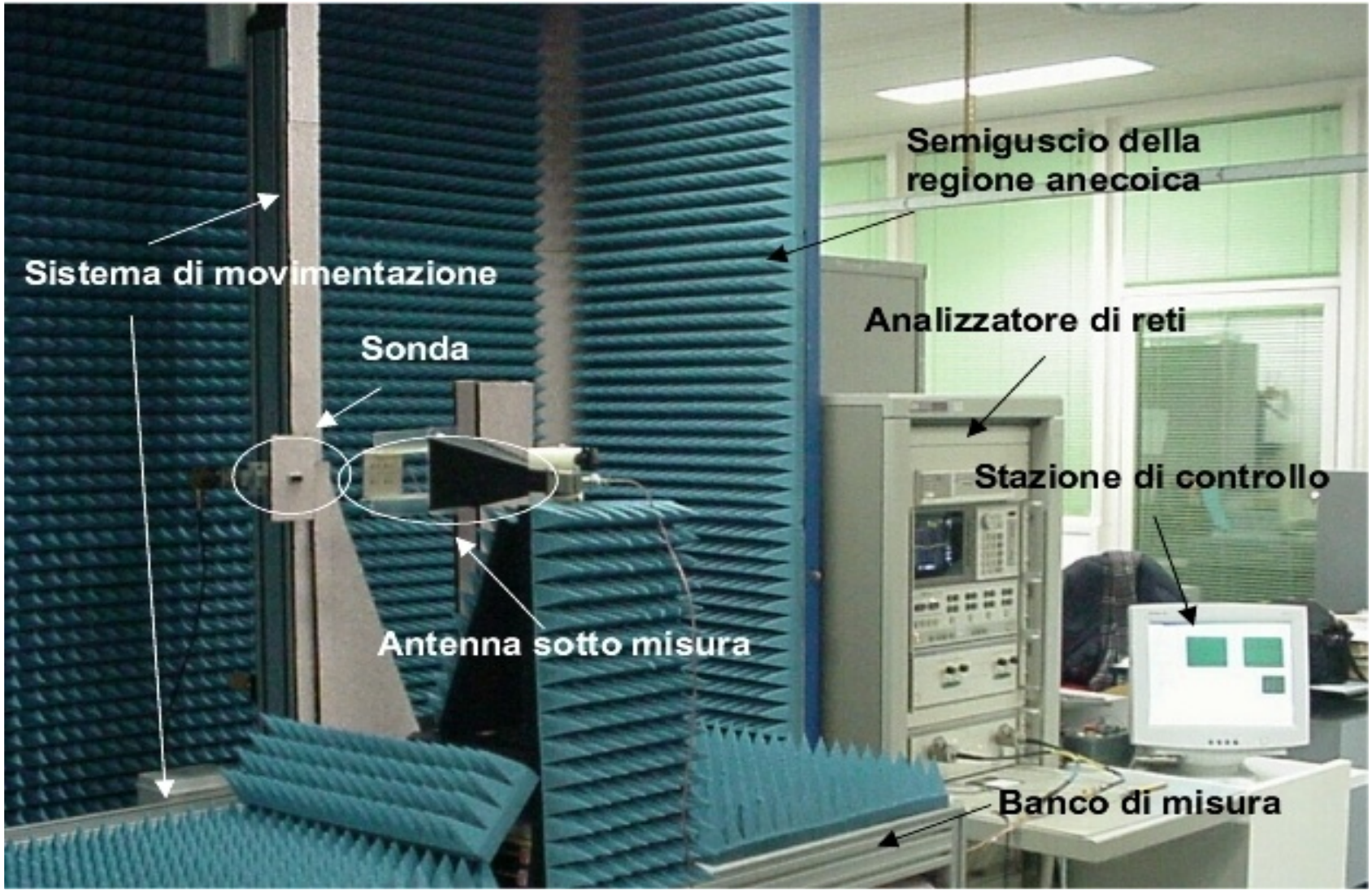
Indoor – Campo Vicino

Scansione planare



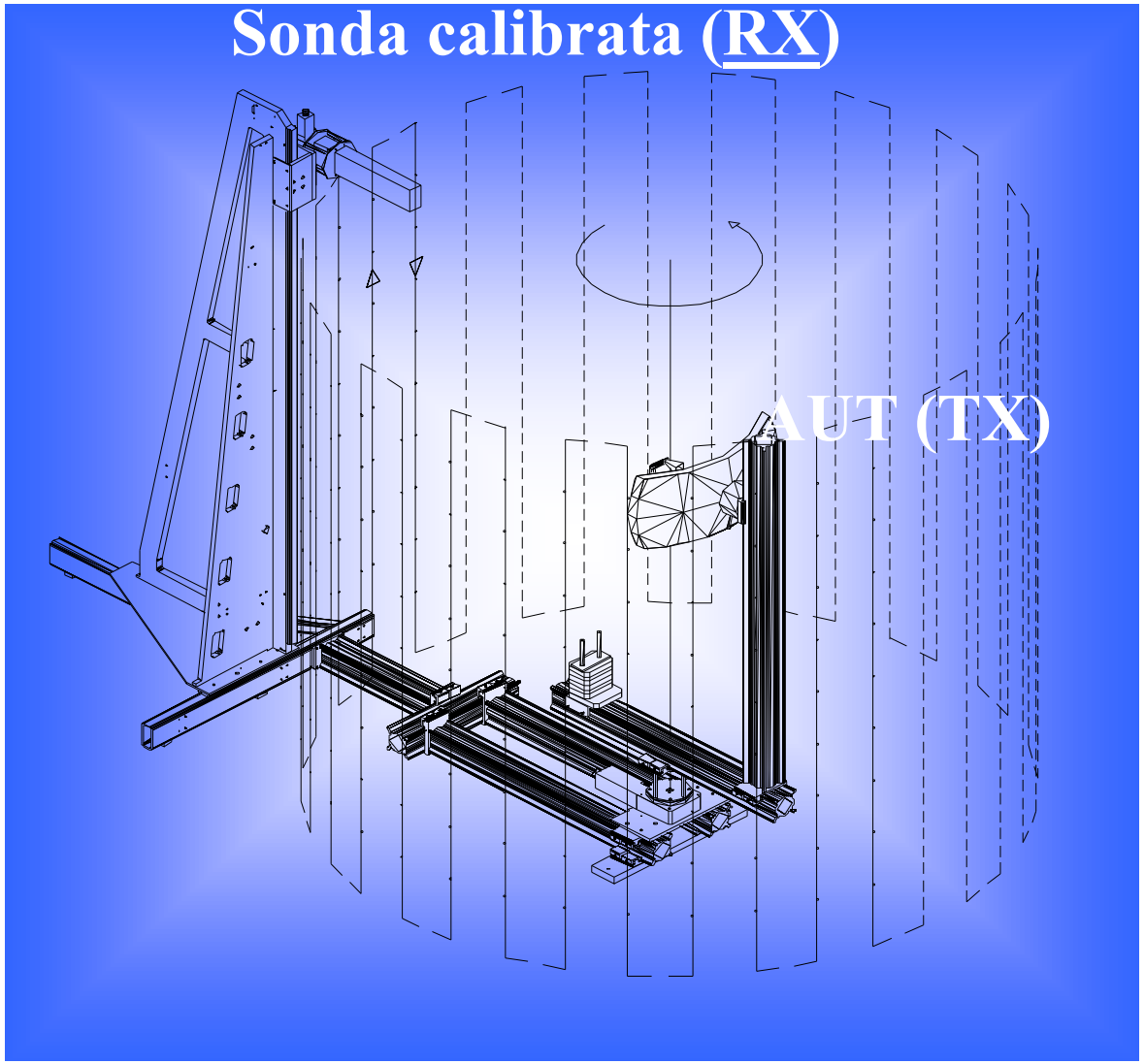
Indoor – Campo Vicino

Scansione planare



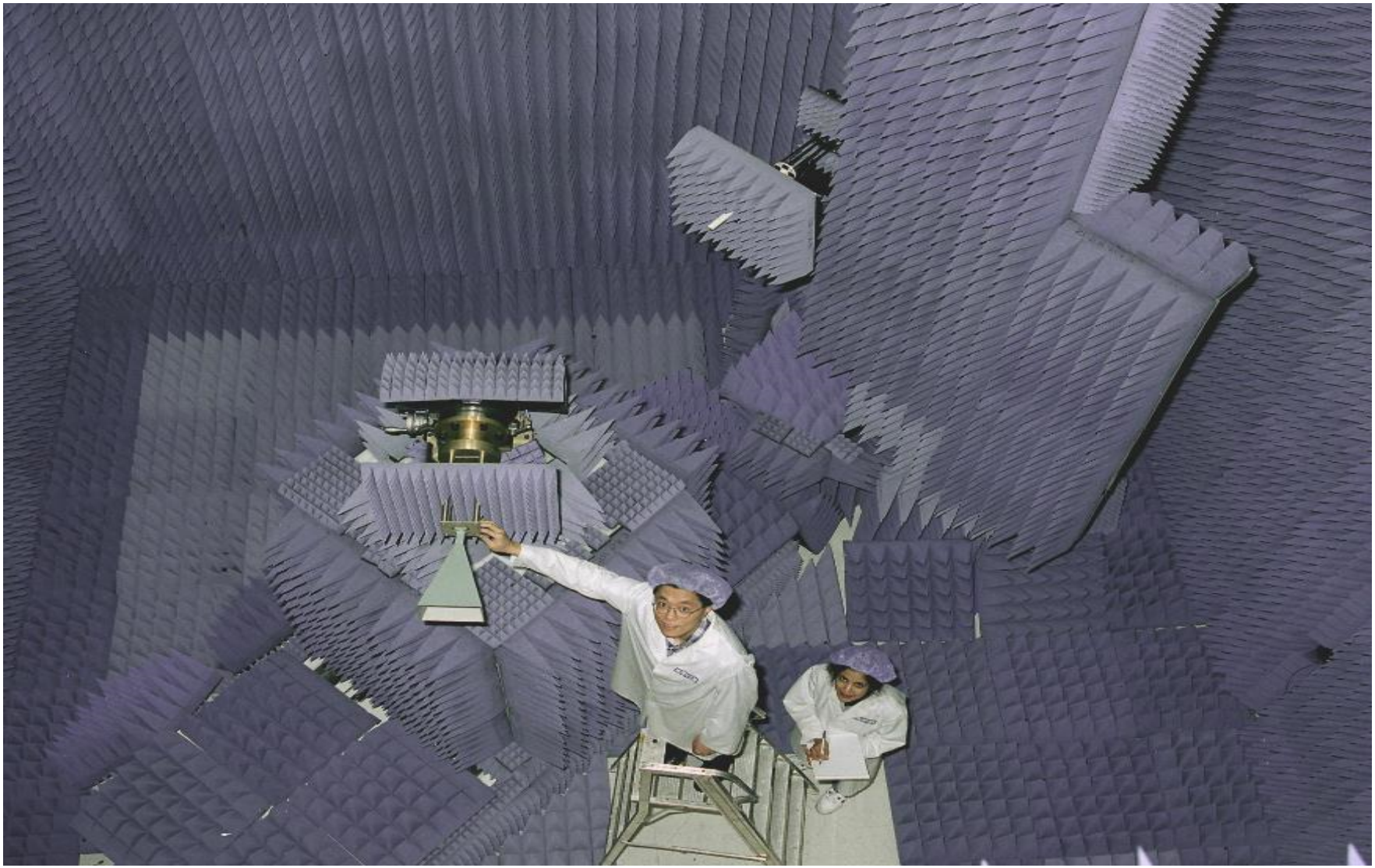
Indoor – Campo Vicino

Scansione cilindrica



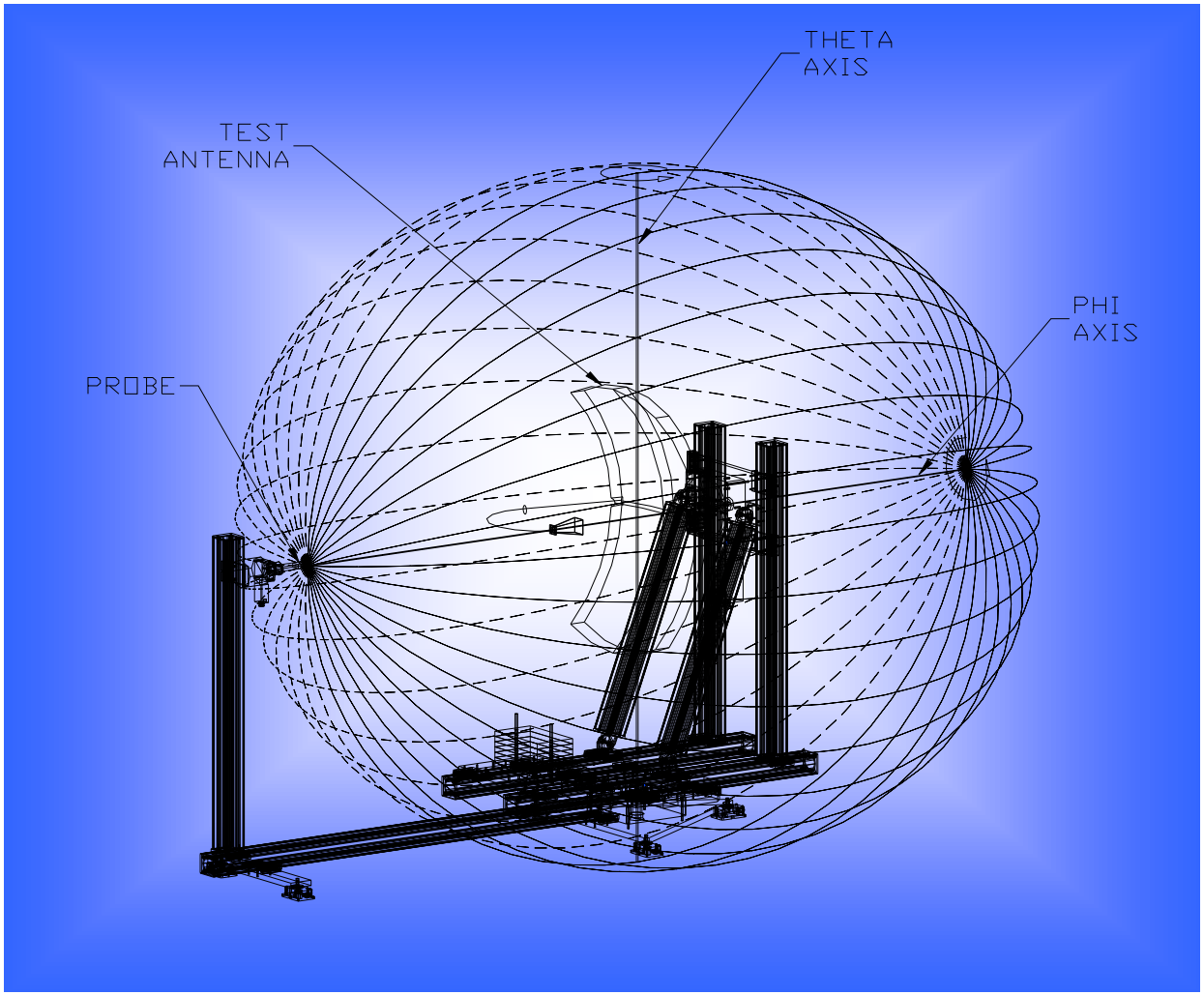
Indoor – Campo Vicino

Scansione cilindrica



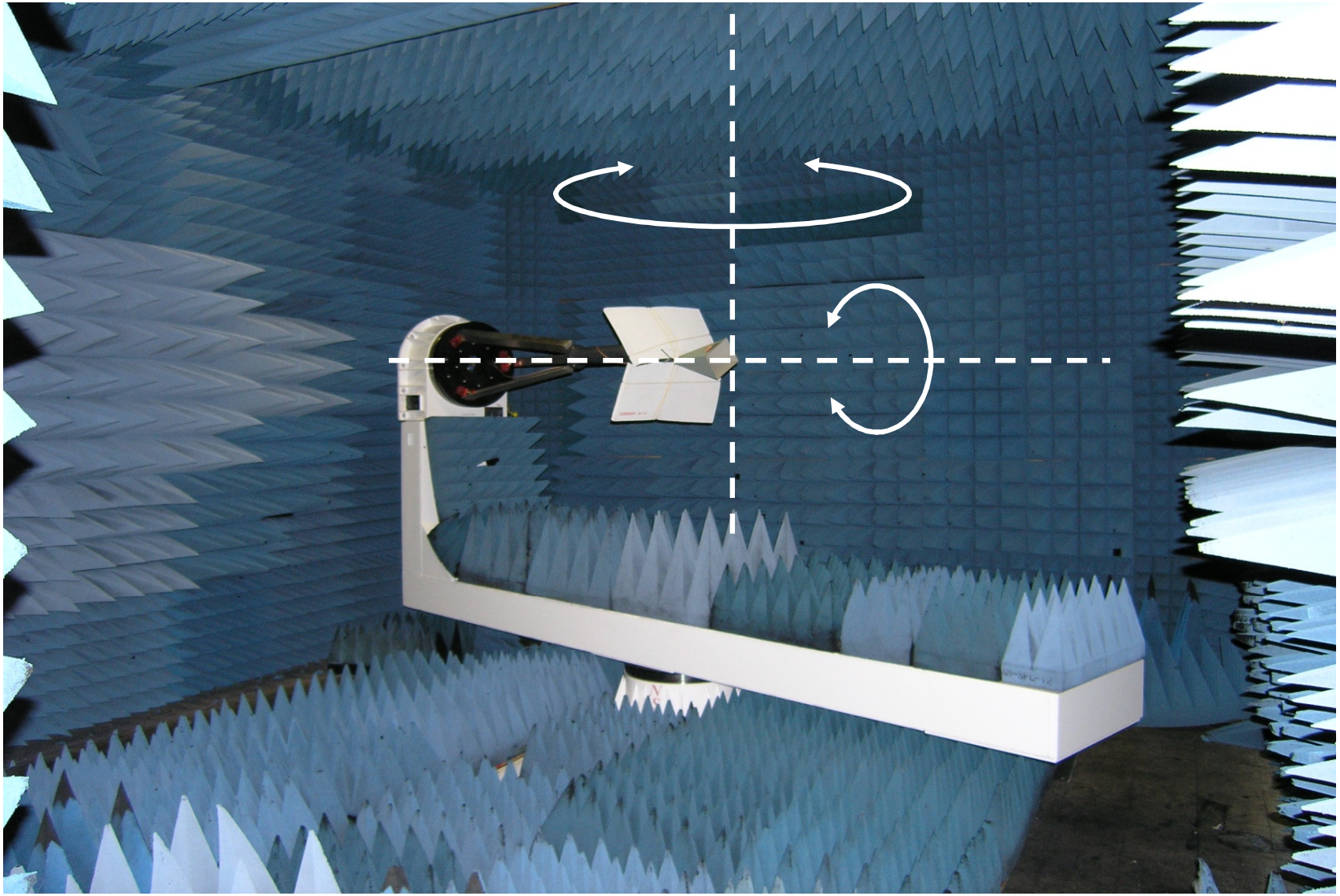
Indoor – Campo Vicino

Scansione sferica



Indoor – Campo Vicino

Scansione sferica



Indoor – Campo Vicino

Scansione sferica

Outdoor Vs Indoor

Outdoor

+ tecniche relativamente semplici
+ necessitano di un limitato post-processing
- ambiente esteso
- attenuazione del segnale
- variazioni climatiche
- interferenze elettromagnetiche

Indoor

+ ambiente controllato
  (temperatura ed umidità costanti / riproducibili)
+ assenza di interferenze
+ accuratezza
- necessità di un intenso post-processing (campo vicino)
- necessità di un numero elevato di campioni (campo vicino) - sistema di misura più sofisticato (ampiezza e fase in campo vicino)

Outdoor Vs Indoor

	NEAR-FIELD			FAR-FIELD		
	PLANAR	CYLINDRICAL	SPHERICAL	OUTDOOR RANGE	ANECHOIC CHAMBER	COMPACT RANGE
High gain antenna	Excellent	Good	Good	Adequate	Adequate	Excellent
Low gain antenna	Poor	Good	Good	Adequate	Good	Excellent
High frequency	Excellent	Excellent	Excellent	Good	Poor	Excellent
Low frequency	Poor	Poor	Good	Good	Fair	Poor
Gain measurement	Excellent	Good	Good	Excellent	Good	Excellent
Close sidelobes	Excellent	Excellent	Excellent	Good	Poor	Excellent
Far sidelobes	Adequate	Excellent	Excellent	Good	Poor	Good
Low sidelobes	Excellent	Excellent	Excellent	Variable	Poor	Good
Axial ratio	Excellent	Excellent	Excellent	Good	Poor	Good
Zero G effects	Excellent (horizontal mode)	Poor	Good (horizontal mode)	Poor	Poor	Poor
Multipath	Good	Good	Good	Adequate	Adequate	Good
Weather	Excellent	Excellent	Excellent	Poor	Excellent	Excellent
Security	Excellent	Excellent	Excellent	Poor	Excellent	Excellent
Facility cost	Low	Moderate	Moderate	High (land value)	Moderate	Very high
Operating cost	Moderate	Moderate	Moderate	High (remote)	Moderate	Moderate
Speed (complete measurements)	Excellent	Good	Fair	Fair	Fair	Fair
Speed (simple cuts)	Good	Fair	Fair	Excellent	Excellent	Excellent
Complexity	Moderate	Moderate	High	Moderate	Low	High
Mechanical surface measurements	Excellent	No	No	No	No	No
Antenna access	Excellent	Excellent	Excellent	Good	Good	Fair
Antenna alignment	Easy	Moderate	Difficult	Moderate	Moderate	Difficult

Fonti di Errore

Errori dovuti al sistema di misura

- Strumentazione
- Cavi di trasmissione
- Software utilizzati
- Errato posizionamento della sonda

Errori dovuti al setup di misura

- Riflessioni indesiderate all'interno della regione di misura
- Troncamento del piano di scansione e sottocampionamento
- Non idealità della sonda