MULTIPLE DIRECTIONS OF ARRIVAL USING CATR OTA MEASUREMENTS

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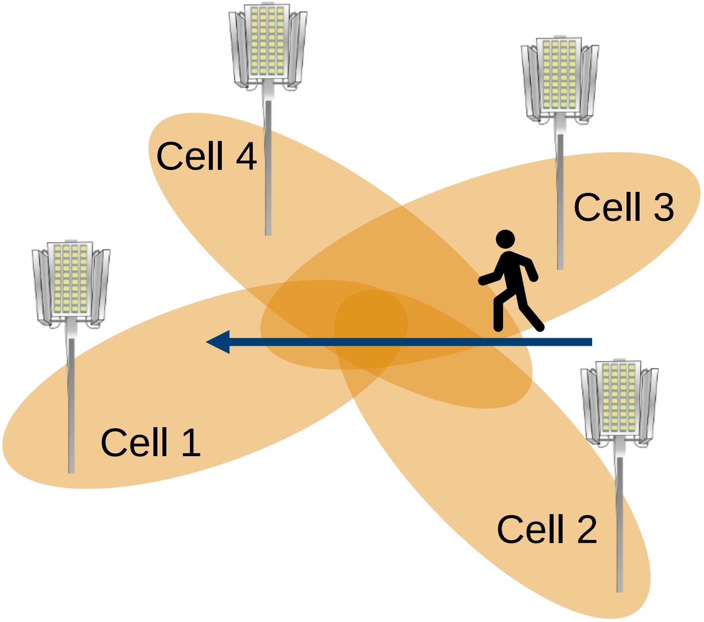
Make ideas real

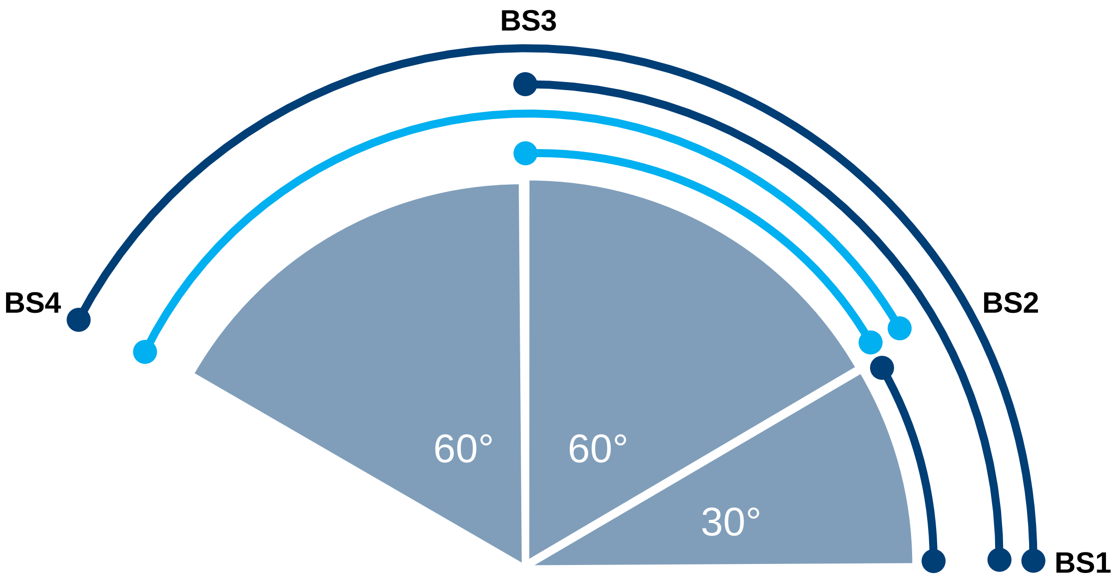
WHAT IS RADIO RESOURCE MANAGEMENT (RRM)?



When to switch mobile phone to different cells (basestations) and how to measure this scenario?

System level management of radio resources: interference, transmit power, scheduling, handover, ….

RRM PROBE PLACEMENT

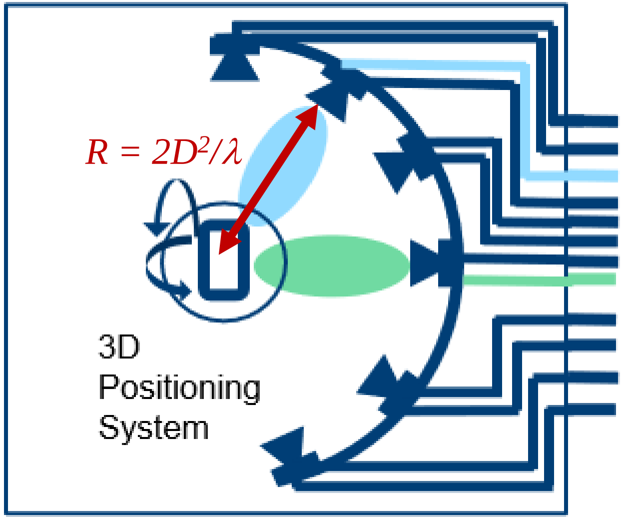


Each probe generates a far-field: simulate monitoring of signal levels for basestation handover

RRM in 3GPP FR2 standardization requires 2 angles of simultaneous arrival (3GPP TS 38.533)

- Five angular differences: 30, 60, 90, 120 and 150 degrees

DIRECT FAR-FIELD FOR RRM?



Choice 1: smaller QZ than DUT size of 30 cm
40 GHz: R = 75 cm >> QZ size of 5 cm

OR

Choice 2: QZ = DUT size
But…. additional 30 dB of path loss
40 GHz: R = 24 meters

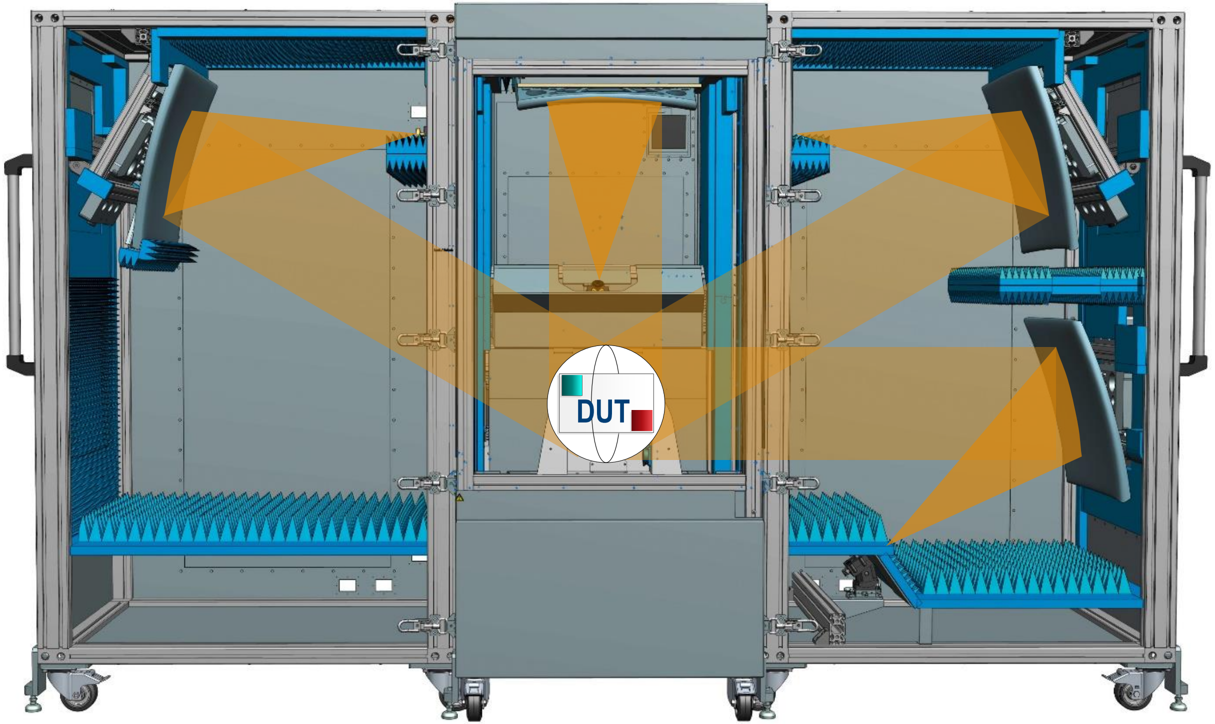
OR… ?

How much is 30 dB?

Roughly the power difference between a Porsche 911 and a nuclear power plant.

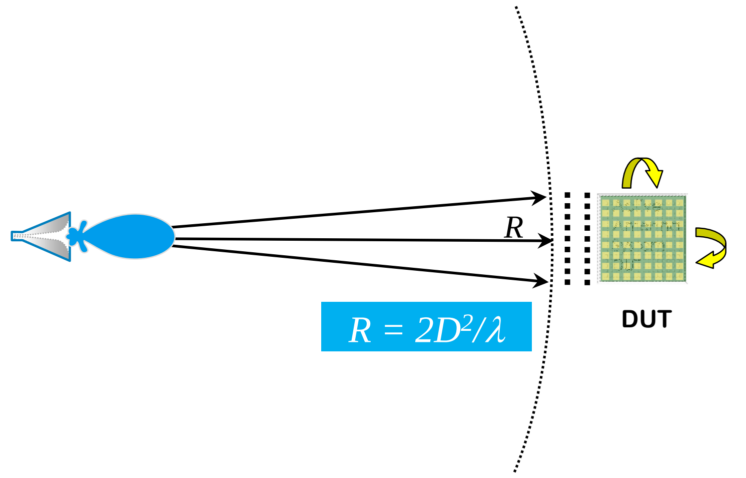
INDIRECT FAR-FIELD FOR RRM?

Choice 3: QZ = DUT size, low measurement uncertainty and no increase of path loss



How?

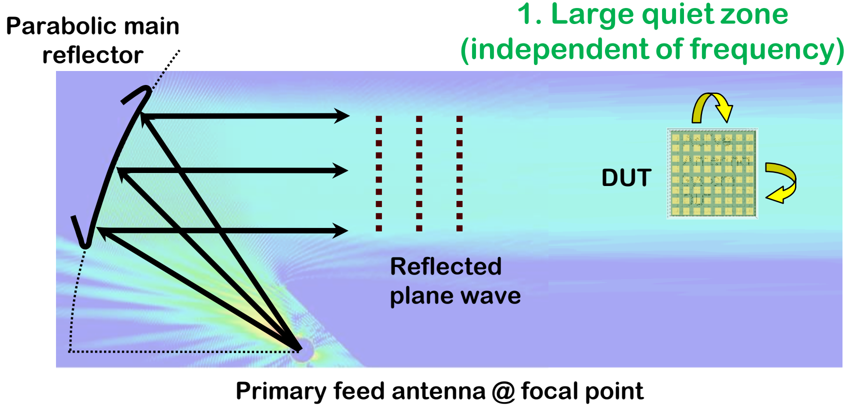
WHAT IS CATR?



Direct far-field (DFF): FSPL = 92 dB
Range length = 24 meters for 40 GHz with QZ = 30 cm

Originally developed in 1969 at Ohio State University to measure airplane radar cross section

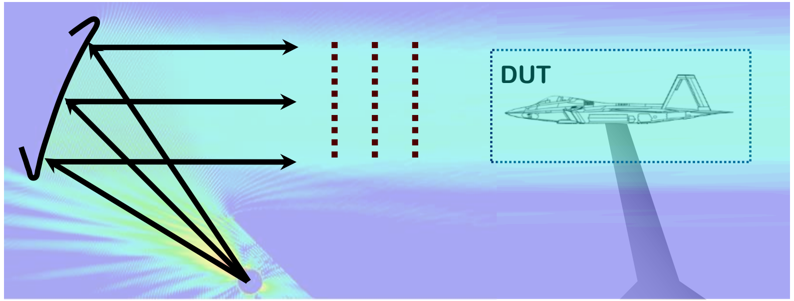
1. Large quiet zone (independent of frequency)



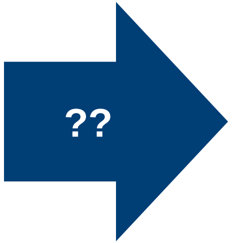
2. Low path loss: Only between feed and reflector

CATR indirect far-field (IFF): FSPL = 62 dB
Range length = 1 meter for 40 GHz with QZ = 30 cm

5G OTA DRIVING EVOLUTION OF CATR TECHNOLOGY



Premium high-grade antenna and radar measurement systems



5G OTA industry requirements

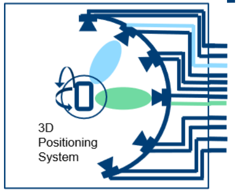
From premium to wide-spread

- Higher volumes required
- Cost and footprint reduction
- Different measurement needs / search for new optimal solutions

How can the wireless industry "re-invent" CATR?

Head and hand phantoms

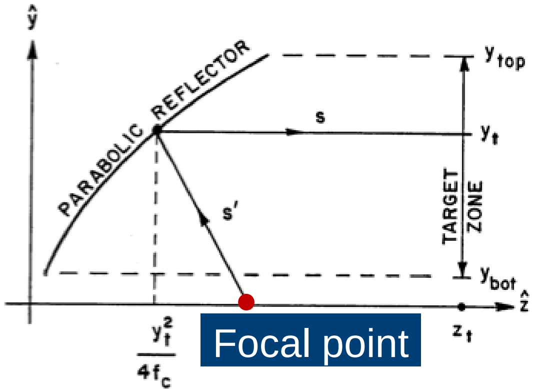
Extreme temperatures

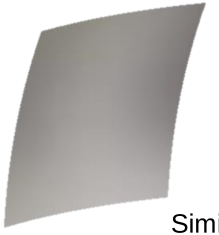


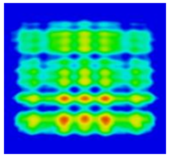
Multiple angles of arrival

CATR IFF SYSTEM REFLECTOR GEOMETRY

Paraboloid: Determines QZ size

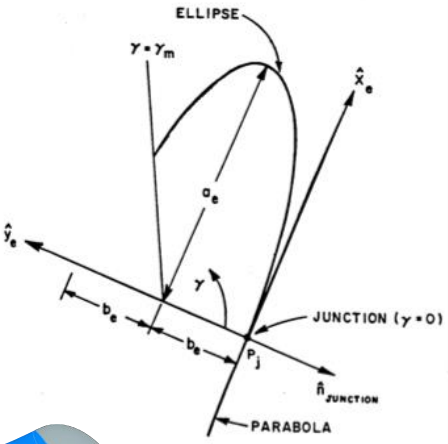


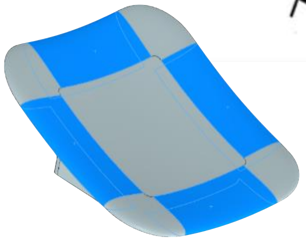


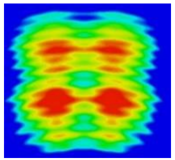


Similar to array with uniform amplitude and phase

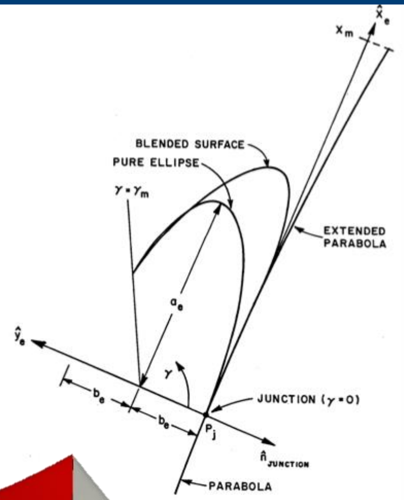
Elliptical rolled edges: Diffracts energy, but boundary has errors

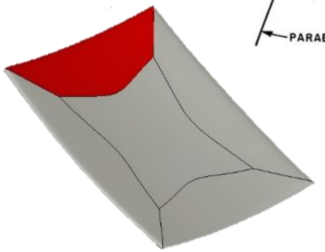


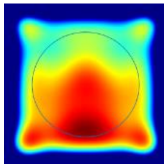




Blending functions ($d^2f/dx^2 = 0$)

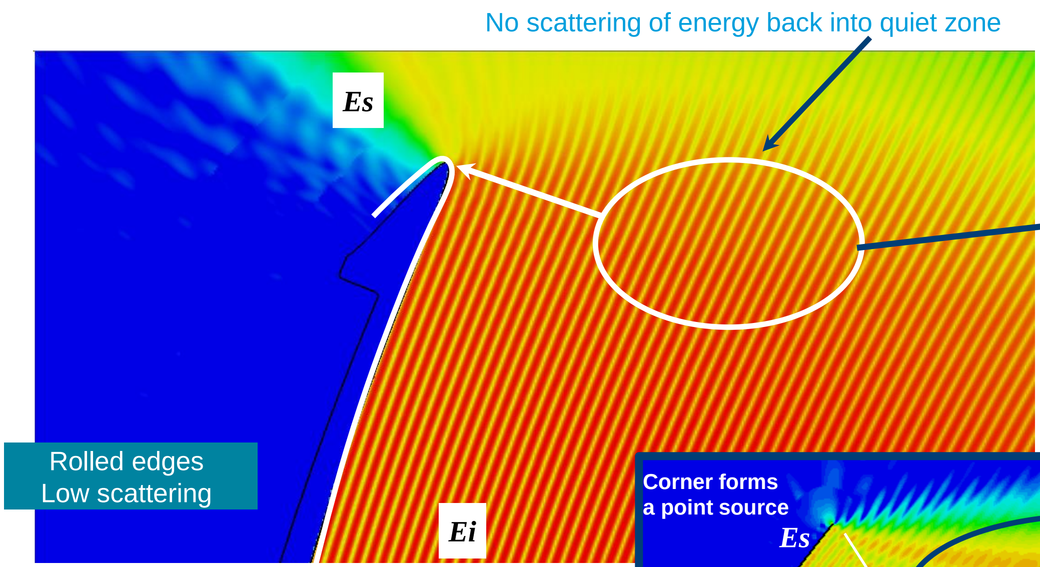


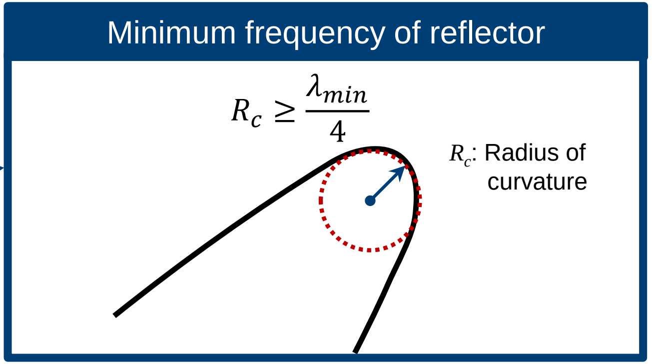




Reflector edge treatment is critical for system performance

MINIMUM FREQUENCY OF CATR IFF SYSTEM

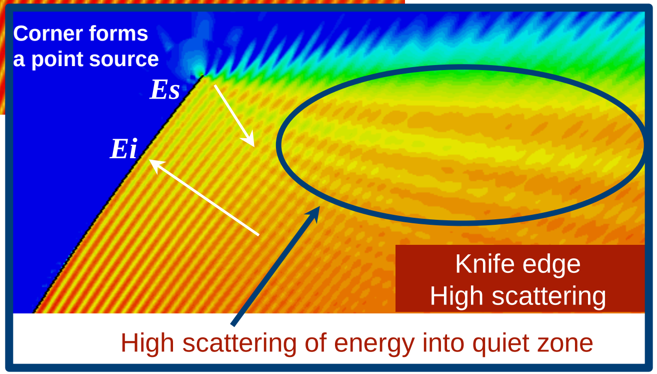




$\boldsymbol{Ei}$: Initial EM field (from feed horn)

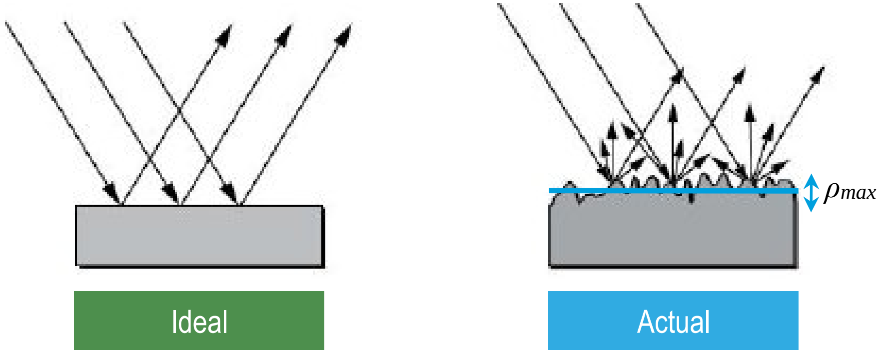
$\boldsymbol{Es}$: Scattered EM field (from edges)

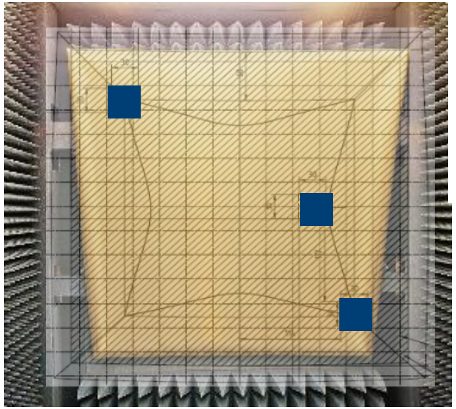
vs.

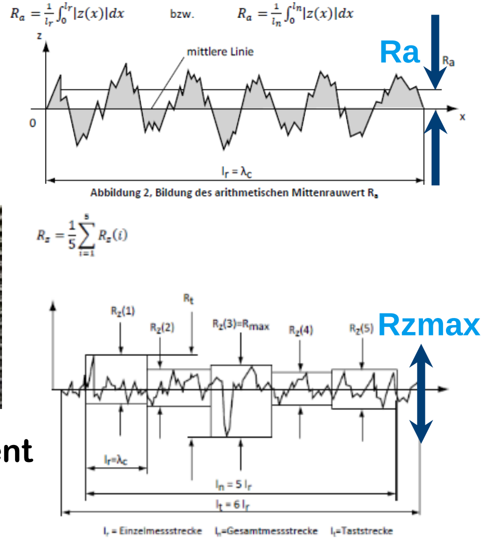


W. Burnside "Curved Edge Modification of Compact Range Reflector", IEEE 1987

MAXIMUM FREQUENCY OF CATR IFF SYSTEM







Maximum frequency	Surface roughness (microns)
28 GHz	75
43 GHz (in band)	49
87 GHz (spurious emissions)	24
220 GHz (FCC 5th harmonic)	< 1

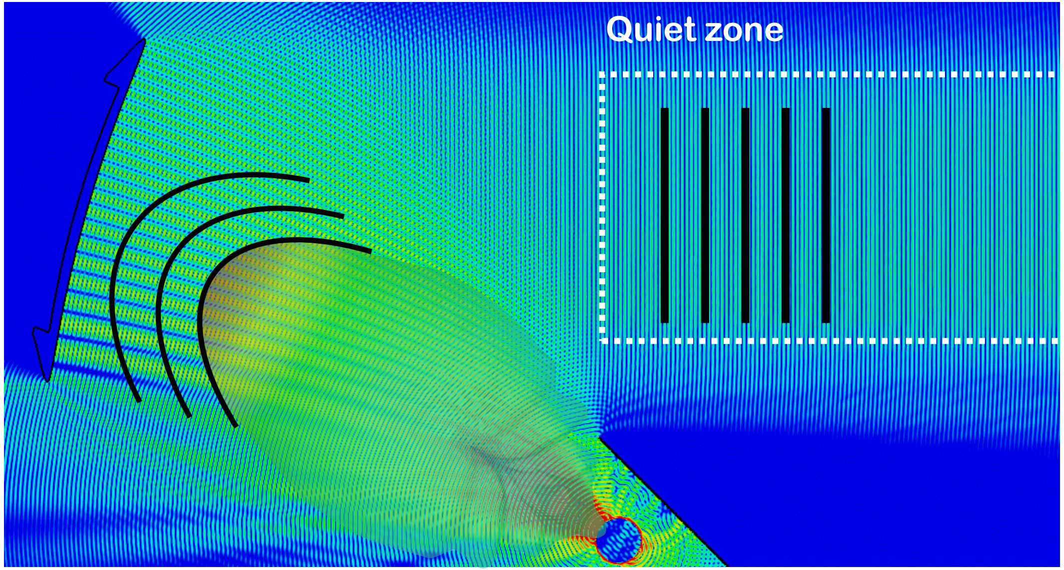
Surface roughness measurement (before and after gold-plating):

- Rqmax < 1 micron (RMS)
- Ra < 1.6 microns (arithmetic average)
- Rzmax < 45 microns (peak2peak)

Every R&S reflector receives full surface scan in factory
Course grid and fine grid (surface roughness)

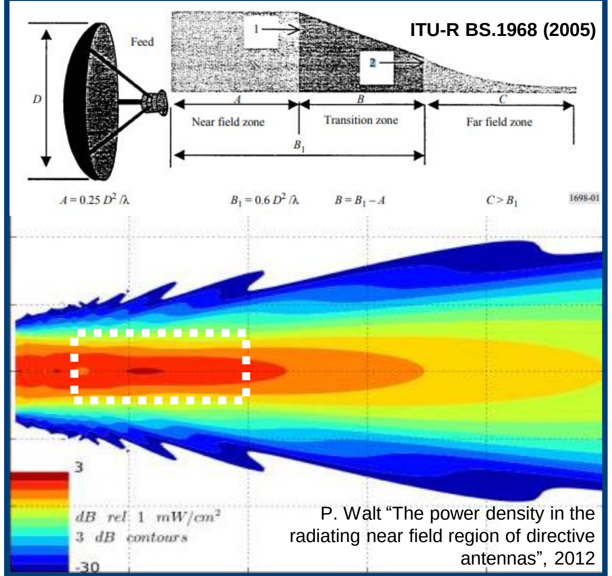
CATR IFF SYSTEM FREE SPACE PATH LOSS

Reflector near-field



Feed antenna far-field: FSPL

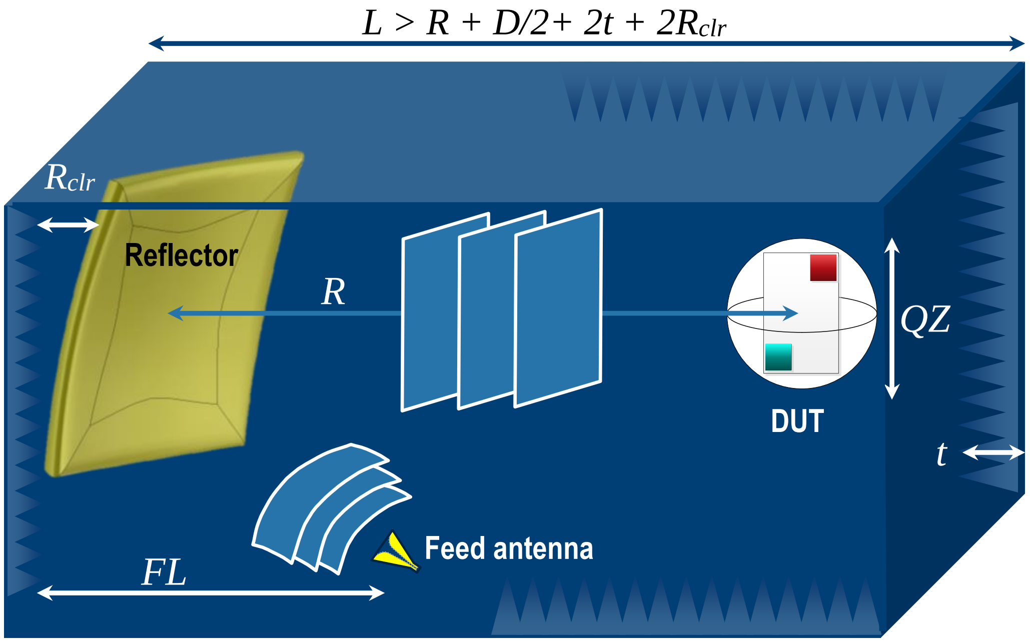
Parabolic reflector power density



Power density is constant up to: $0.25D^2/\lambda$

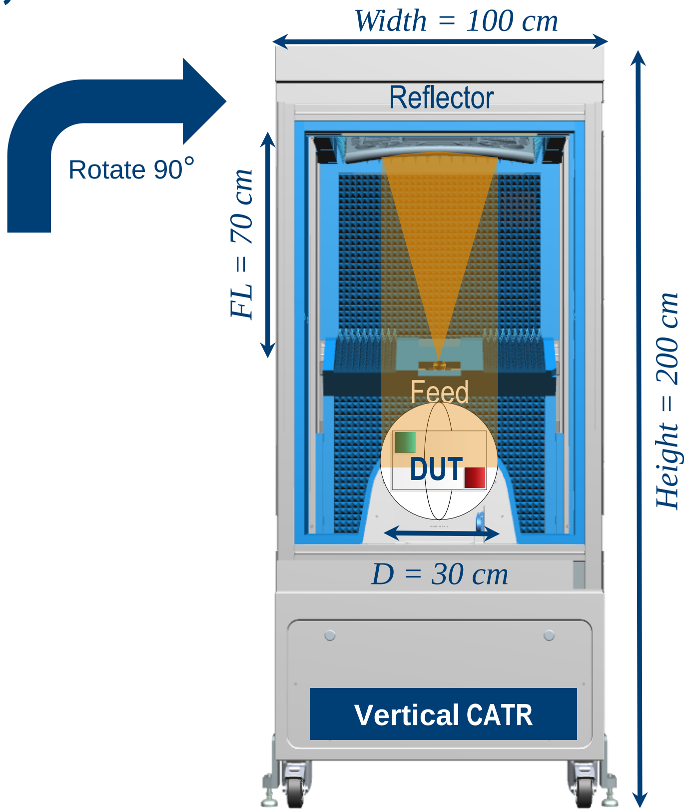
No path loss from reflector to DUT

VERTICAL CATR SYSTEM: SAME QZ, SMALLER FOOTPRINT



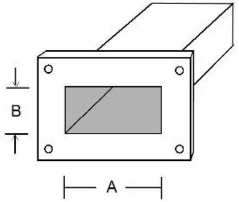
QZ = 30 cm	Reflector size	Focal length	Range length	Chamber length
Recommended	> 2QZ (60 cm)	3.5QZ (105 cm)	1.7FL (180 cm)	L = 240 cm

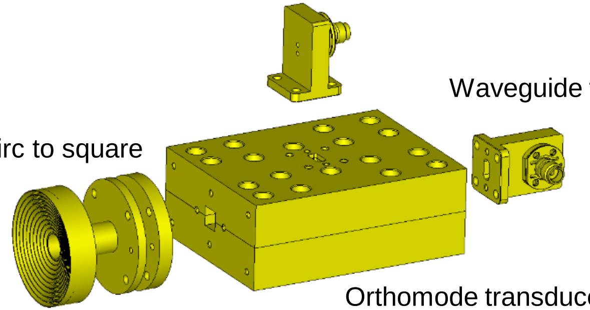
*IEEE Antennas & Propagation Magazine: Dec2016



How to compensate for the shorter focal length?

FOCAL LENGTH COMPENSATION WITH THE FEED ANTENNA





	WR34	WR28	WR22
Recommended frequency (GHz)	22 to 33	26.5 to 40	33 to 50
Typical HPBW	35 degrees		

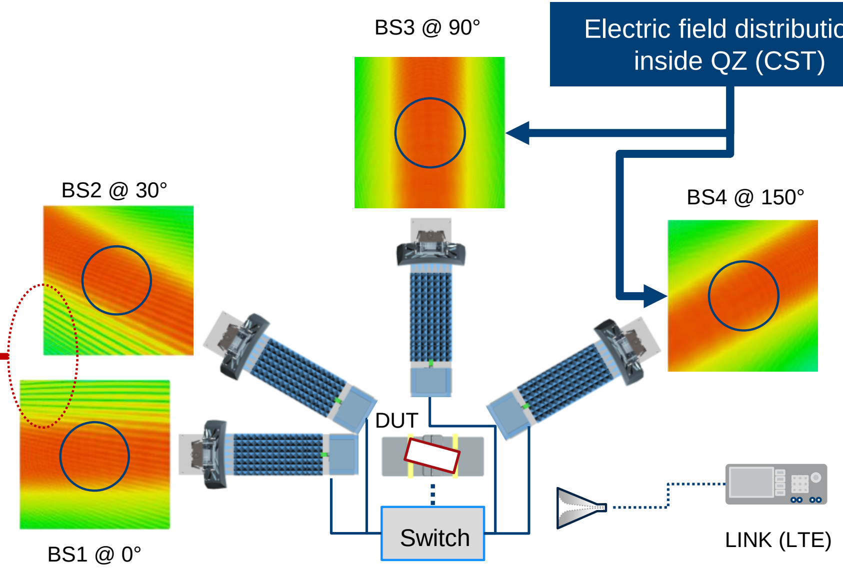
Standard waveguide sizes and HPBW
Standardized components

	WR-RS
Frequency range	23.45 to 44.3 GHz
Optimized HPBW	55 to 65 degrees

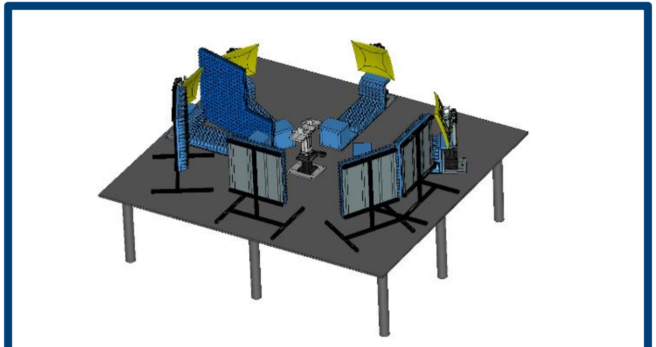
5G FR2 millimeter frequency range
Customized design from cable to horn aperture
Higher HPBW = better QZ performance

MULTIPLE ANGLES: HORIZONTAL CATR SETUP (20 cm QZ)

Electric field distributions inside QZ (CST)



Diffraction from adjacent reflectors

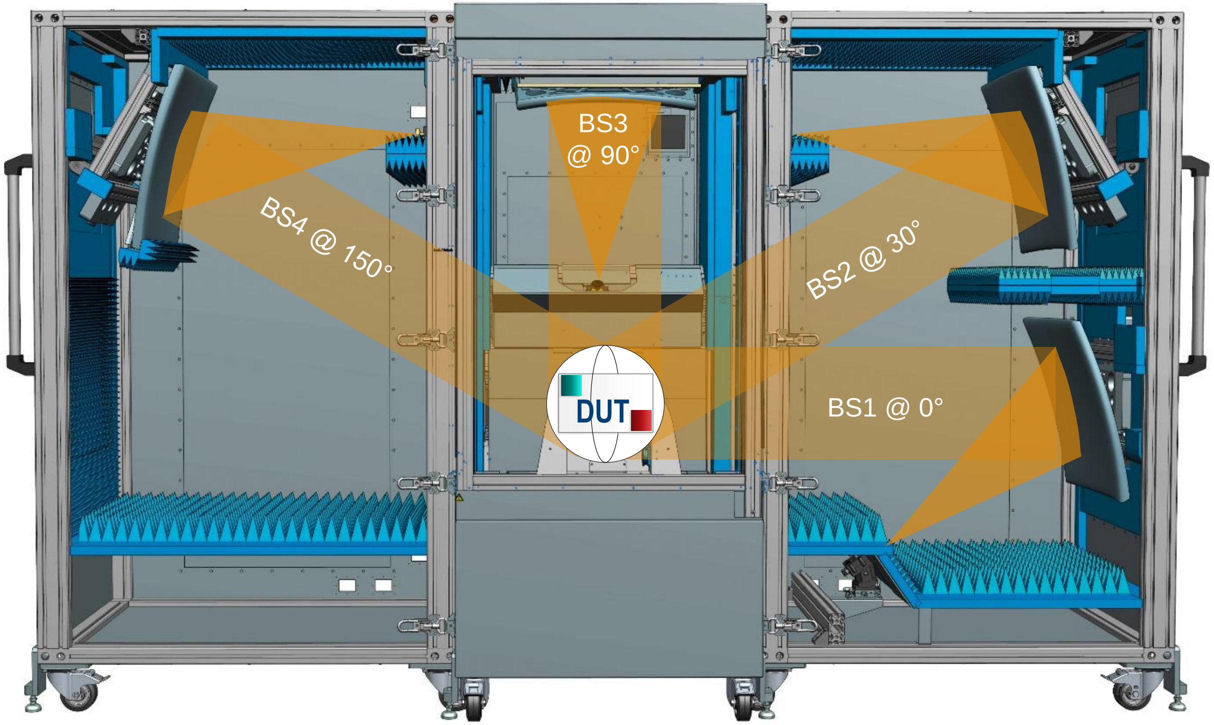


Benchtop setup with blockers
3.2 x 2.2 x 0.8 meters

Solution: Place blocker between BS1 & BS2

"CATR Reflector Measurement System with Multiple Reflectors for Multiple Angles of Arrival in Millimeter Wave Frequency Bands," AMTA 2020

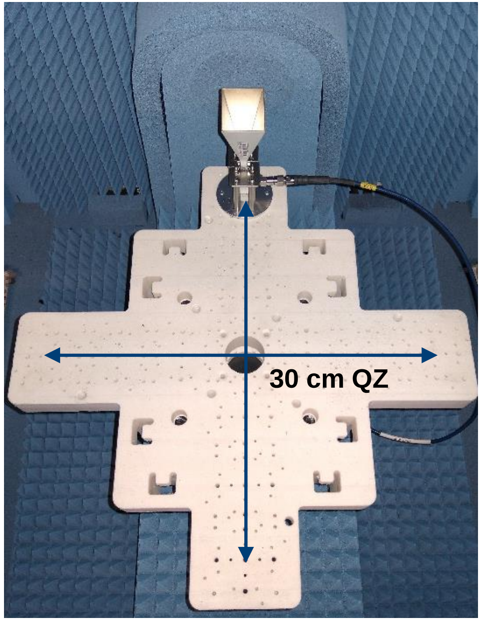
MULTIPLE ANGLES: R&S®ATS1800M VERTICAL CATR SETUP (30 cm QZ)

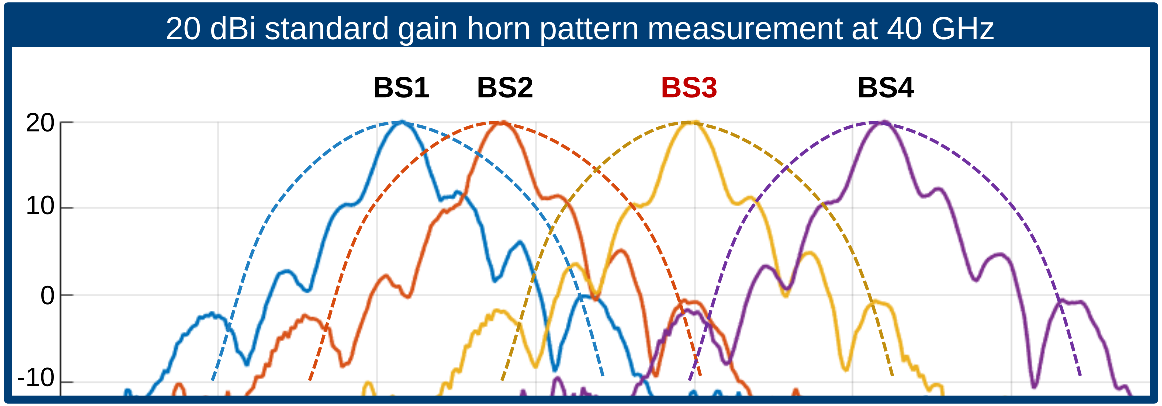


Passive antenna/device measurements
5G signal generator #1
5G signal generator #2
5G signal analyzer
R&S®OSP320 switch
Active device measurements
R&S®CMX500 radio communication tester
R&S®CMW500 for LTE link
R&S®OSP320 switch

"Multiple CATR Reflector System for Multiple Angles of Arrival Measurements of 5G Millimeter Wave Devices," IEEE Access 2020

IFF VS. DFF MEASUREMENTS FOR 30 cm QZ



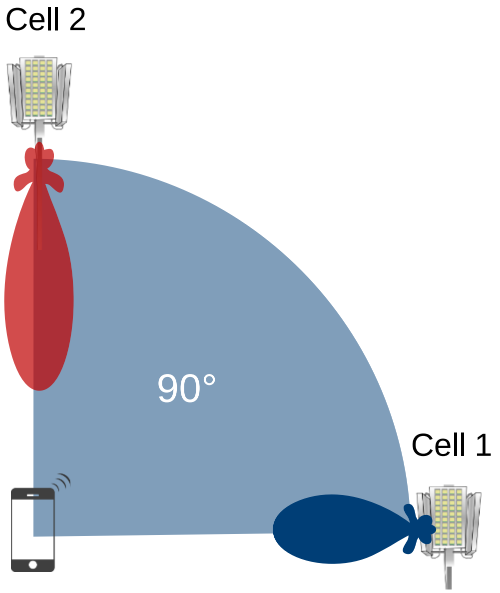


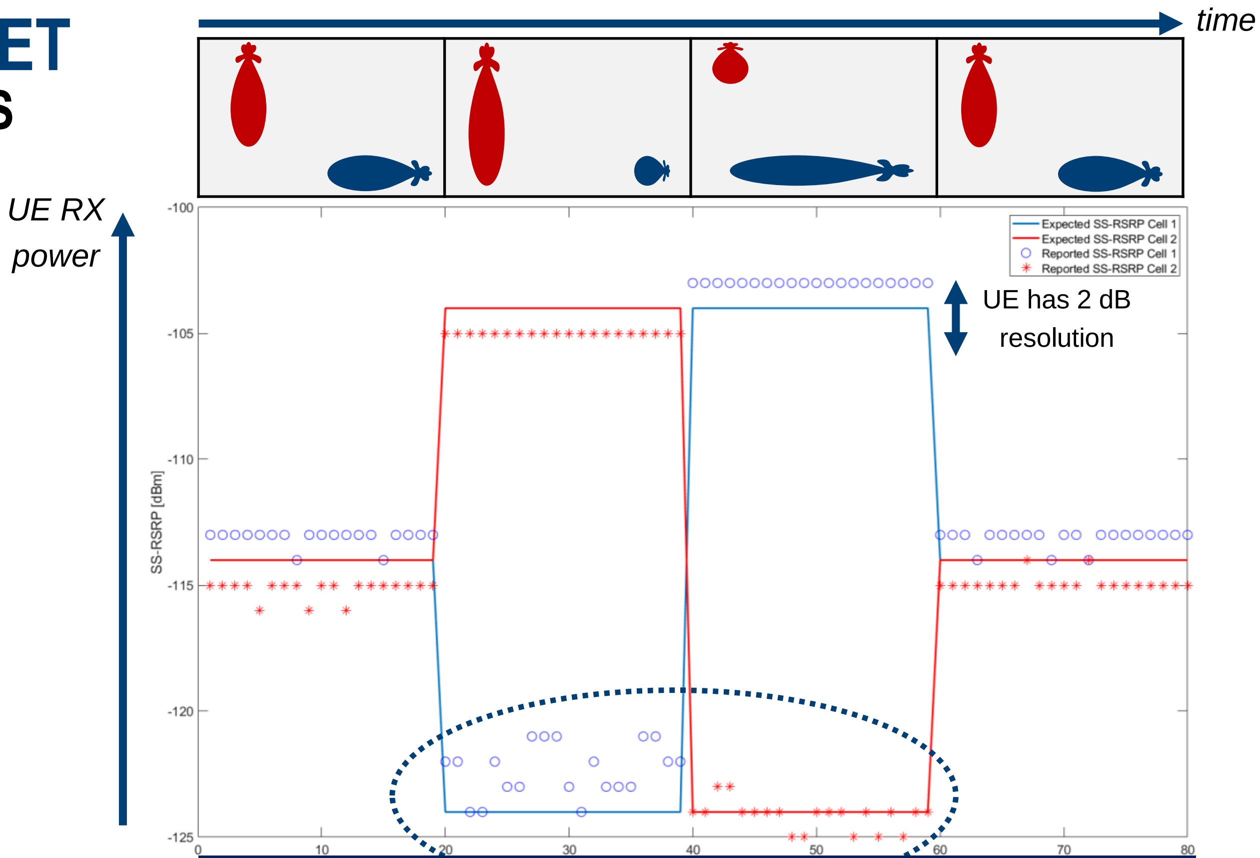
Solid lines (IFF): Measured inside R&S®ATS1800M at edge of 30 cm QZ

Dashed lines (DFF): Estimated for range = 75 cm for a 30 cm QZ
(Similar to a near field measurement without NF2FF transformation)

ACTIVE 5G HANDSET

MEASUREMENT RESULTS





DFF system with extra 20 to 30 dB path loss would measure at this MU level of received power for strongest cells only (weaker cells are not measurable)

METRIC FOR CHAMBER COMPACTNESS

System	QZ size	Footprint	Footprint to QZ ratio (normalized)
Single CATR: horizontal	30 cm	4.3 m^2	1.0
Single CATR: vertical	30 cm	1.3 m^2	0.3
Multi-CATR: horizontal	20 cm	7.0 m^2	2.4
Multi-CATR: vertical	30 cm	5.2 m^2	1.2

Vertical multiple CATR system occupies roughly same footprint as traditional horizontal single reflector CATR

CONCLUSIONS

- 5G OTA
  - A cornerstone of all testing: R&D, verification, conformance, production
  - Refresh and evolution of CATR technique
- Multiple reflector system
  - Big QZ: True 30 cm quiet zone with planar waves in far-field
  - Accuracy: -30 dB with full beam characterization (HPBW, sidelobes, nulls)
  - Dynamic: 30 dB less path loss than DFF for accurate measurement of handover

Pointing to the future of OTA: R&S®ATS1800M

MULTIPLE DIRECTIONS OF ARRIVAL USING CATR OTA MEASUREMENTS

Thank you

ROHDE&SCHWARZ

Make ideas real