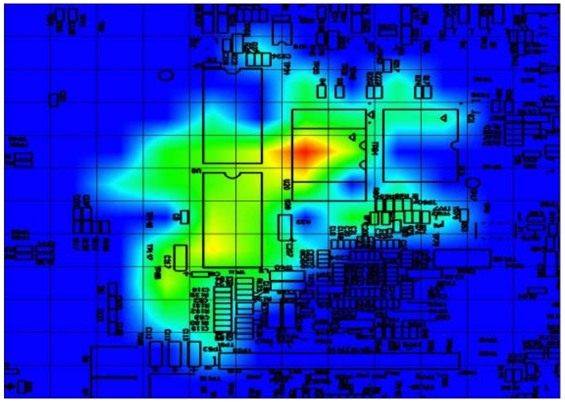
Very-Near-Field Solutions

for

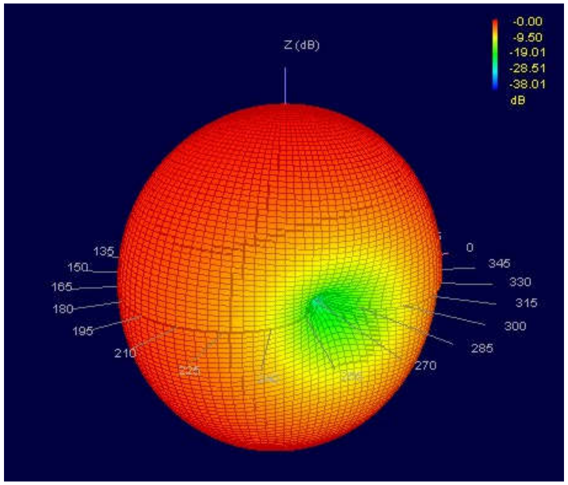
Antenna Measurement Problems

Chamber on your Desktop

- **EMxpert**
  - EMC diagnostic tool to rapidly diagnose and solve EMC/EMS/EMI problems with real-time PCB emission analysis



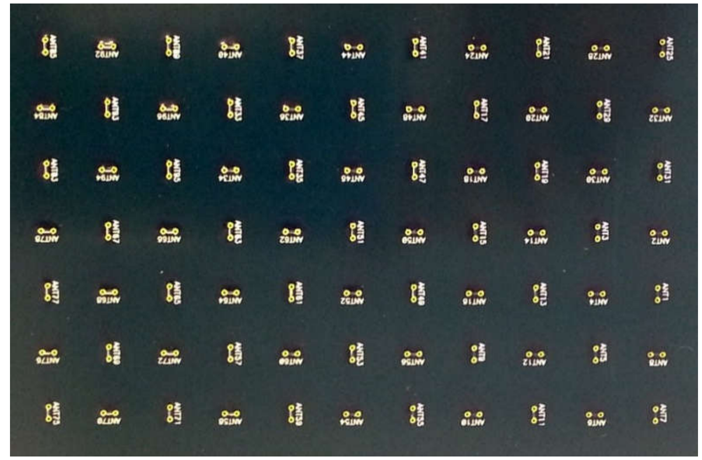
- **RFxpert**
  - APM tool enabling to quickly evaluate performance and optimize designs with real-time antenna performance characterization

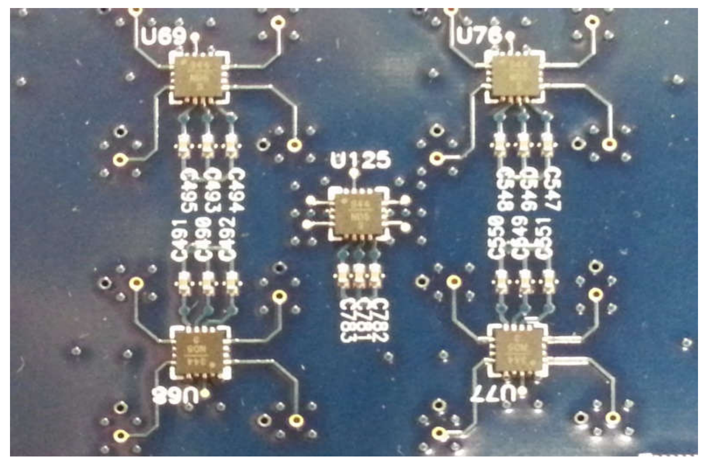


EMSCAN real-time results

Fundamentals

- High-density planar antenna array
- High-speed electronic switching
- Very-near-field measurements
- Far-field calculation
- “Real-time” real-fast
- No chamber





EM SCAN
real-time results

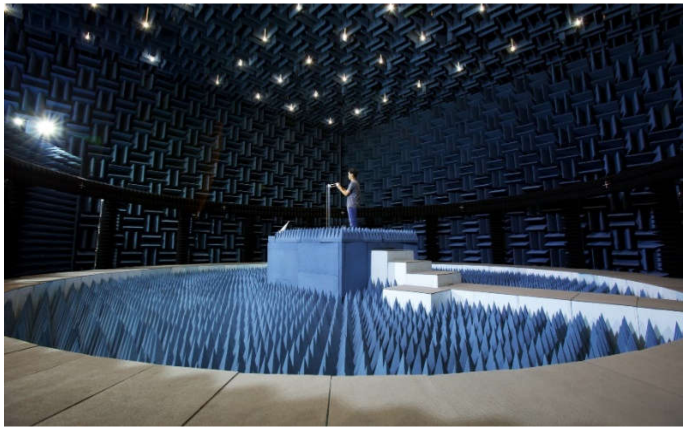
RFxpert

Introduction to Near-Field Theory

EMSCAN real-time results

Existing Solutions

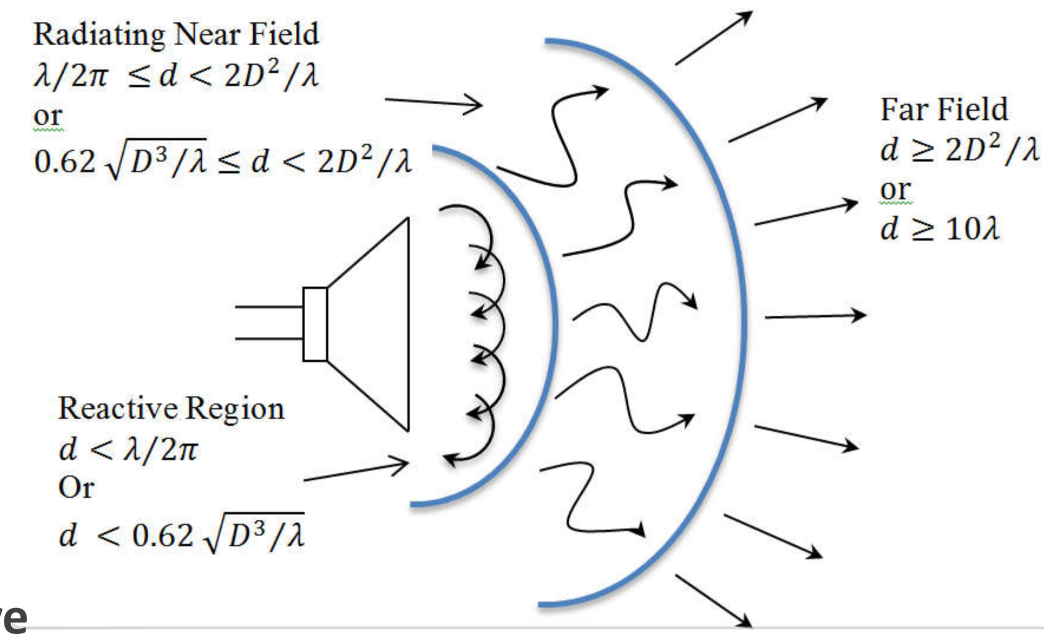
- **Anechoic Chamber**
  - Slow testing
  - High CAPEX and OPEX
  - Real-estate
  - Qualified personnel
- **Reverberation Chamber**
  - Fast testing
  - No pattern
  - Qualified personnel



EMSCAN real-time results

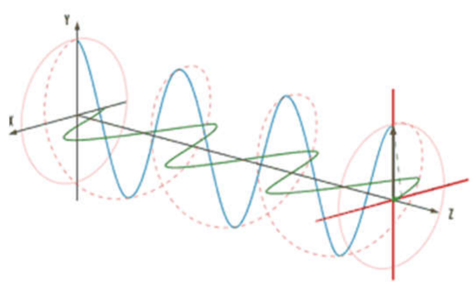
What is Near-Field?

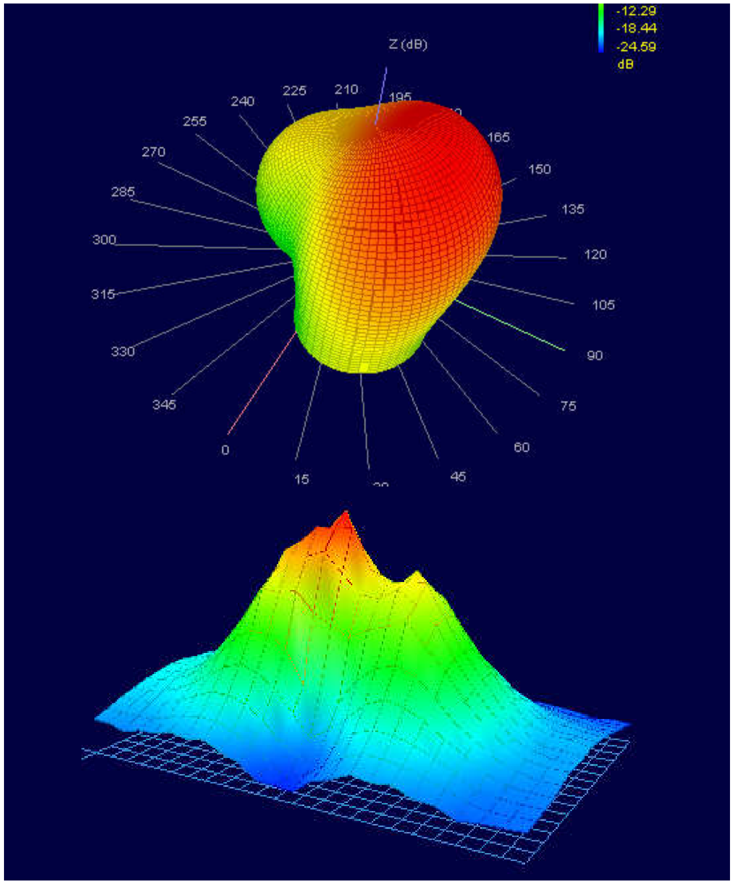
- Anything not in the far-field
- Far-field is where the pattern is not changing with the distance
- Common definitions
- Usually stay out of the reactive region



Functionality

- **300 MHz to 6.0 GHz**
- **Far-field patterns and bisections**
  – EIRP / TRP / TIS Proxy
  – Circular and linear polarization
- **Very-near-field insights**
  – Amplitude
  – Phase
  – Polarity





- **Gain and efficiency**
- **DLL programming**

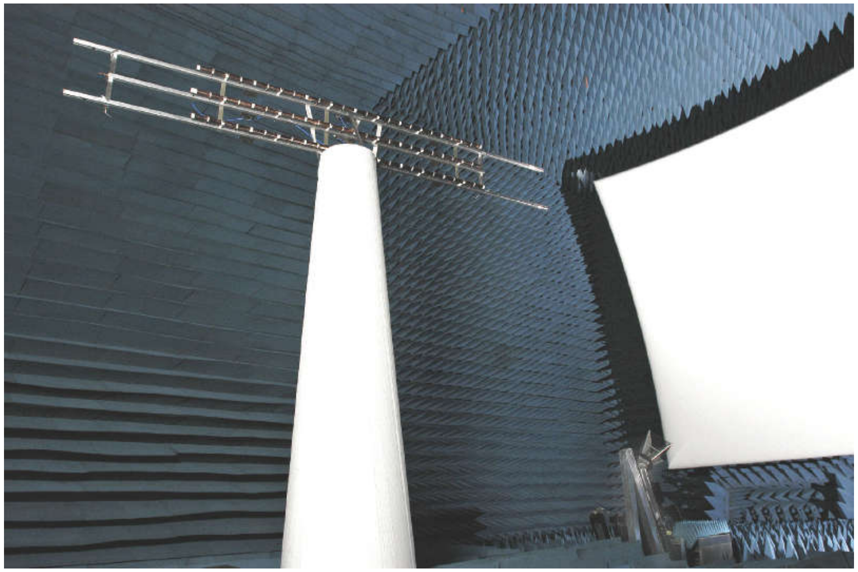
EMSCAN real-time results

RF Test Solution

- **Typically looking for far-field parameters**
  – Gain, efficiency, pattern are basic measures
  – More complex applications such as Envelope Correlation, Axial Ratio and Beam Forming
- **Debugging via near-field**

Far-Field Measurements

- **Far-field site far and demanding a large area**
- **Open-air-test-site (OATS) avoids reflections**
  - Almost impossible in an urban environment
- **Anechoic Chambers**



Near-Field to Far-Field Transformation

- **Near-field measurement**
  - Smaller footprint
  - Can be as accurate as far-field
- **Near to Far projections**
  - Plane Wave/Modal Expansion
  - Magnetic currents
  - Genetic algorithms and more

Planar Near-Field Theory

- The radiation of the antenna can be described in terms of angular spectrum of waves
- Based on Huygen's principle
- Fourier transform from near-field space to propagation vectors in far-field

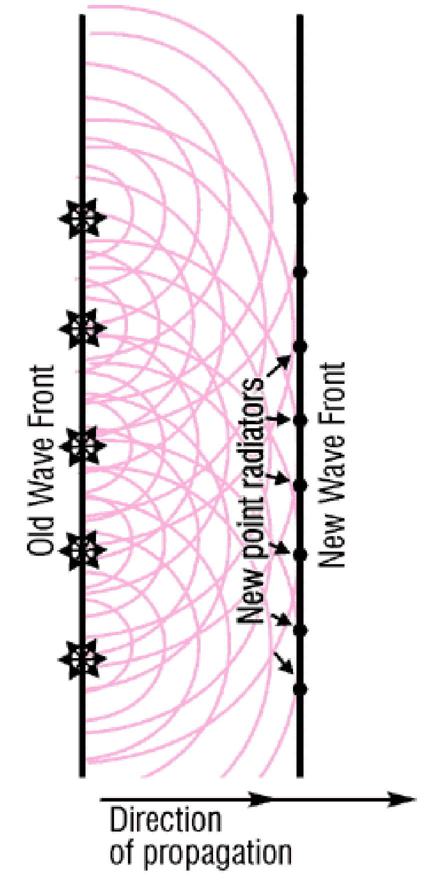
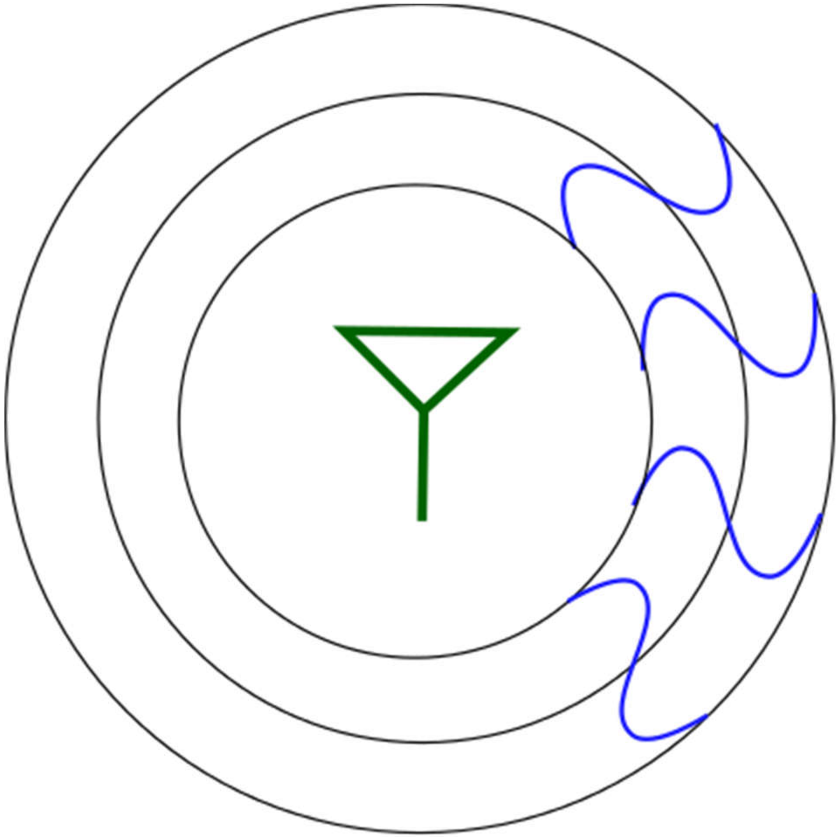


Image: www.schoolphysics.co.uk

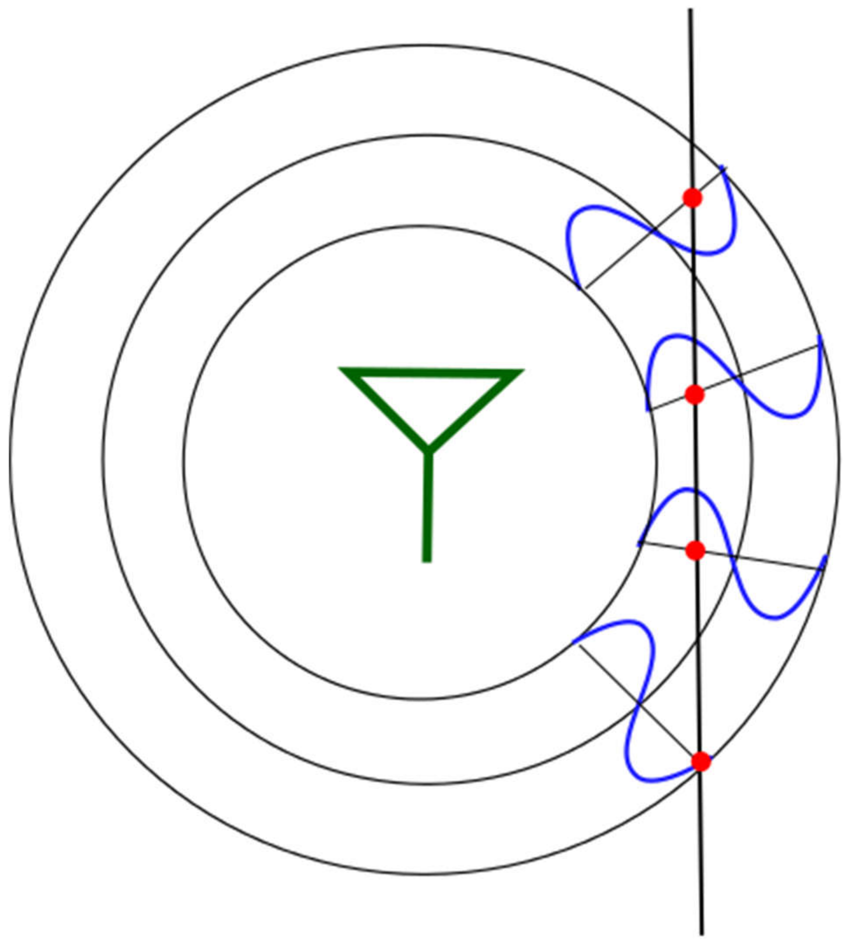
Planar Near-Field Theory

- An antenna can propagate in all directions
- The phases and amplitudes in each directions will vary
- In the near field all elements are interdependent



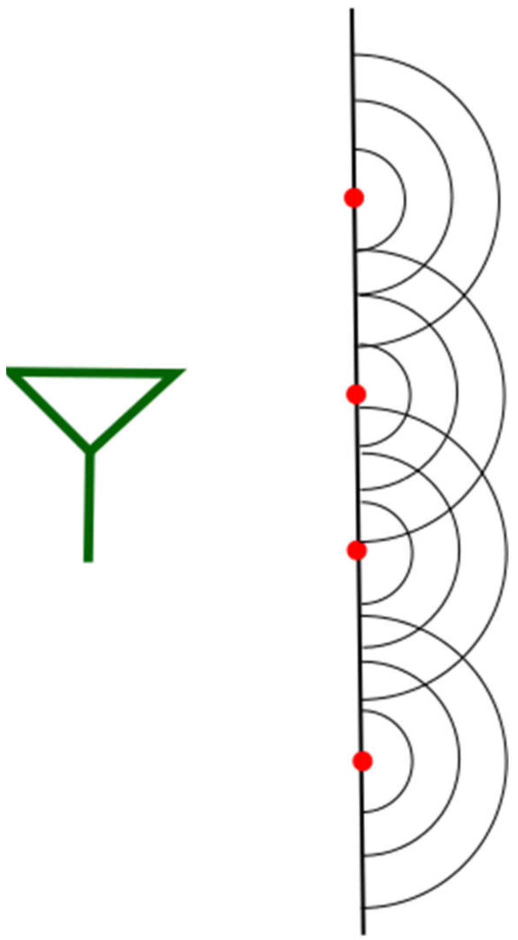
Planar Near-Field Theory

- Sample near field elements along a planar surface
- Measure amplitude and phase in each point
- Combination of phase fronts



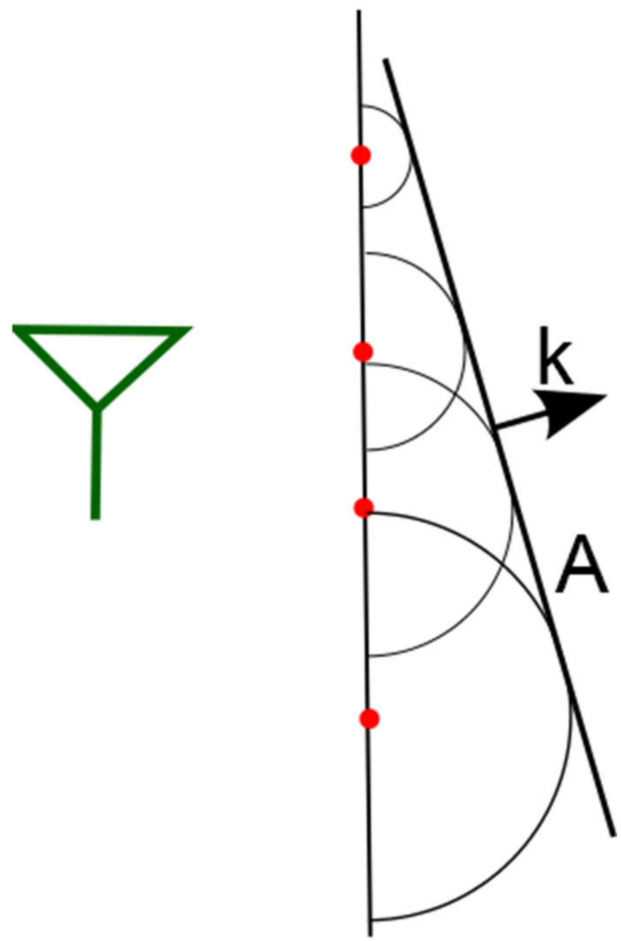
Planar Near-Field Theory

- Use sampled points to reconstruct new phase fronts
- No difference between this and the original phase front that was sampled



Planar Near-Field Theory

- Separate the various phase fronts or plane waves based on their weightings
- This set of plane waves in all directions is the plane wave spectrum

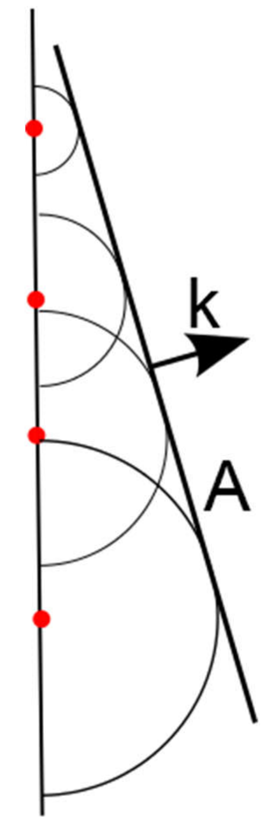


Planar Near-Field Theory

Based on Maxwell's equations and a source-less boundary condition we can construct the following equations

$$\mathbf{E}(x, y, z) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} \mathbf{A}(k_x, k_y)\, e^{-j\mathbf{k} \bullet \mathbf{r}}\, dk_x\, dk_y$$

$$\mathbf{H}(x, y, z) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} \mathbf{k} \times \mathbf{A}(k_x, k_y)\, e^{-j\mathbf{k} \bullet \mathbf{r}}\, dk_x\, dk_y$$



The term **k** may be called the wave number vector and the terms in the integration represent a uniform plane wave propagating in the **k** direction

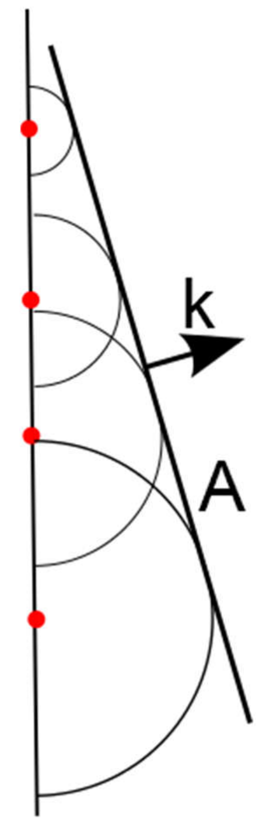
$$\mathbf{A}(k_x, k_y)\, e^{-j\mathbf{k} \bullet \mathbf{r}}$$

Planar Near-Field Theory

And $\mathbf{A}(k_x, k_y)$ can be determined by ,

$$A_x(k_x, k_y) = e^{j k_z z_t} \frac{1}{2\pi} \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} E_x(x, y, z_t) e^{j(k_x x + k_y y)} dx\, dy$$

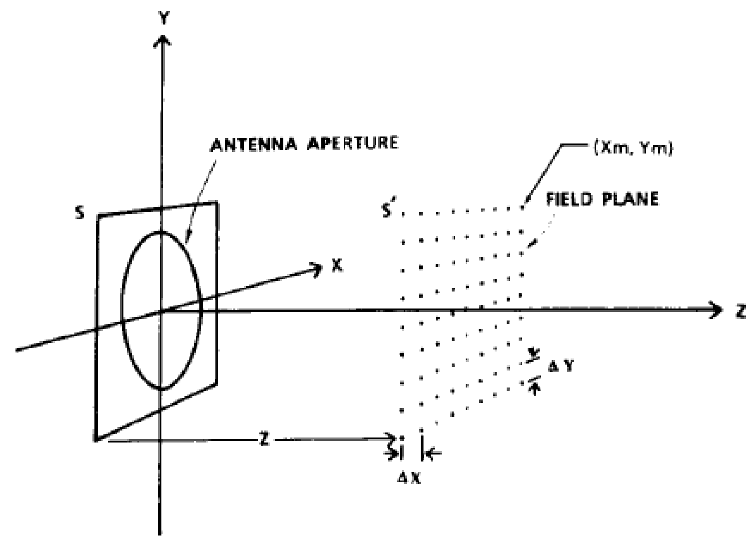
$$A_y(k_x, k_y) = e^{j k_z z_t} \frac{1}{2\pi} \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} E_y(x, y, z_t) e^{j(k_x x + k_y y)} dx\, dy$$



Planar Near-Field Benefits

$$\mathbf{E}(x, y, z) = \frac{je^{-jkr}}{r} k_z \mathbf{A}(k_x, k_y)$$

- Simple Fourier transform
- Easy to calculate quickly
- Easy to sample data



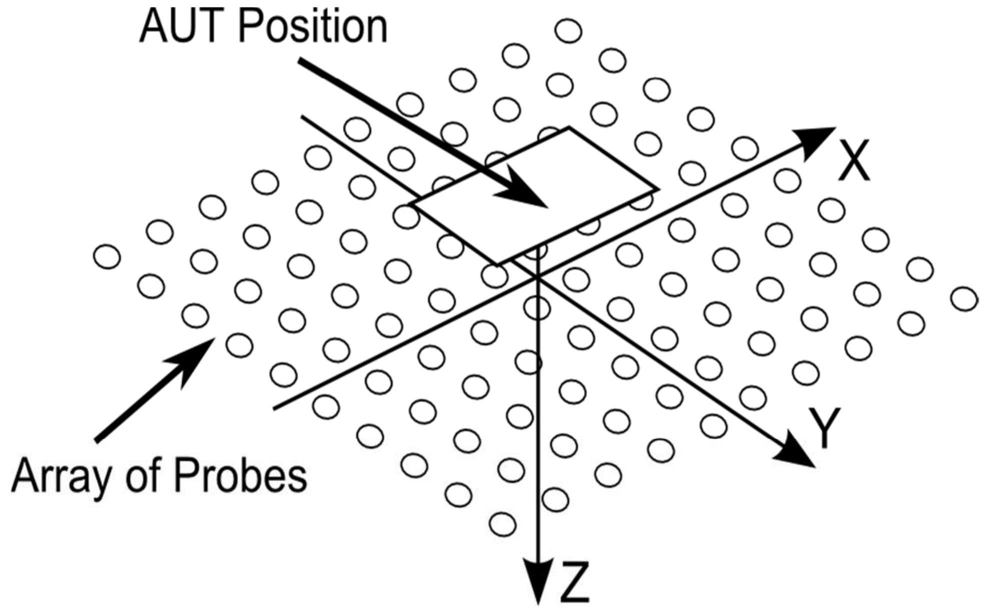
RFxpert

A Very-Near-Field Implementation

EMSCAN
real-time results

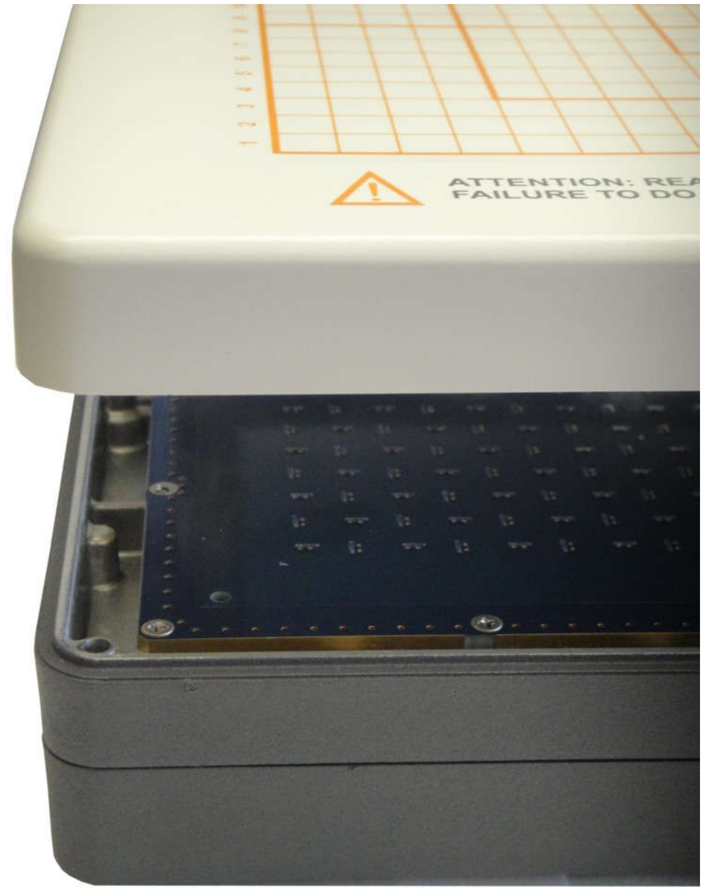
Very-Near-Field Challenges

- **Coupling unavoidable so make it predictable**
- **Static array has constant effect for each sample**

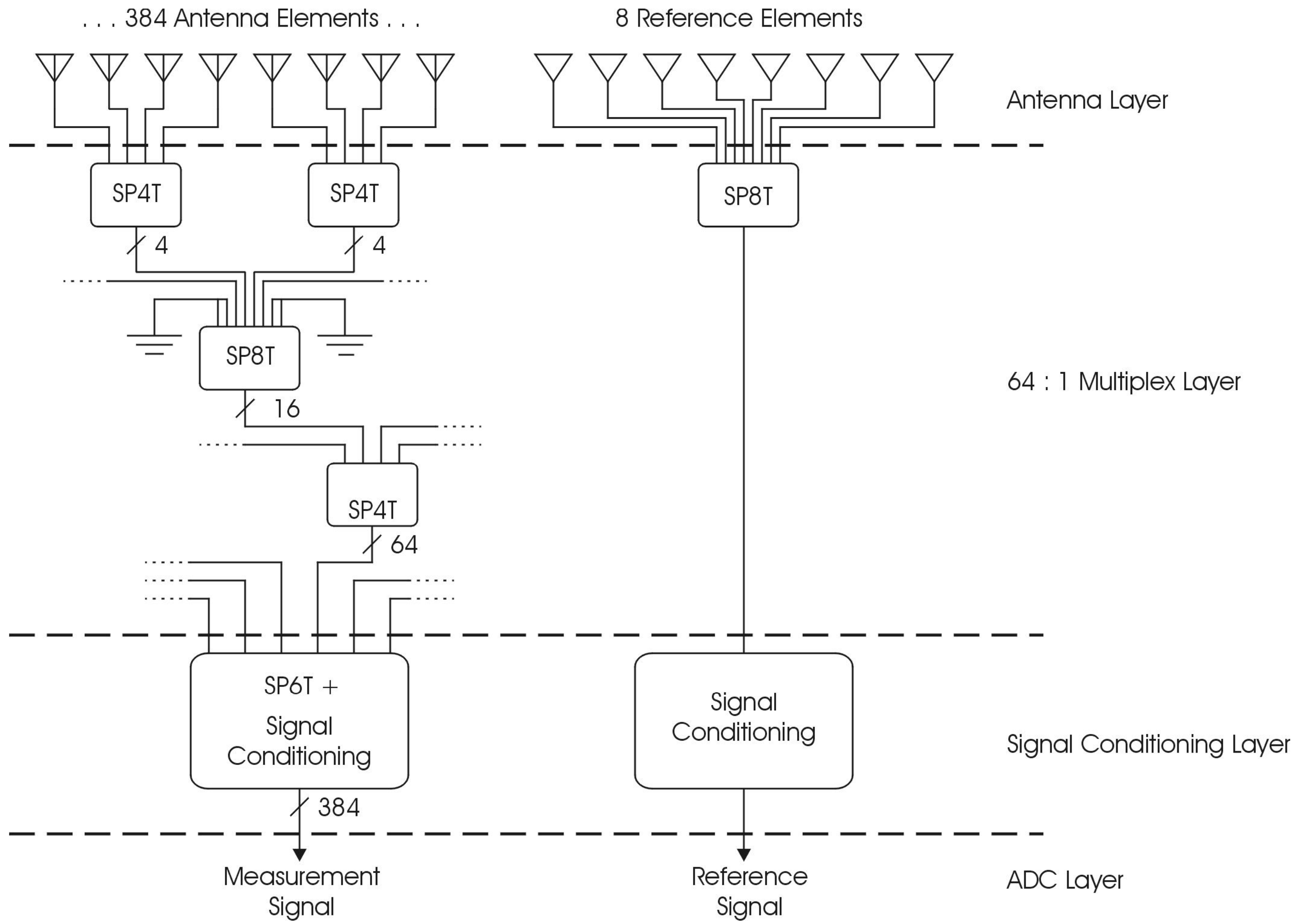


Very-Near-Field Implementation

- **Array of probes**
- **Addressable array of probes makes very-near-field sampling very fast and repeatable**
- **Small loops not sensitive but very broadband, with good isolation and polarization specifications**
- **Reference channel for phase measurement of active devices**

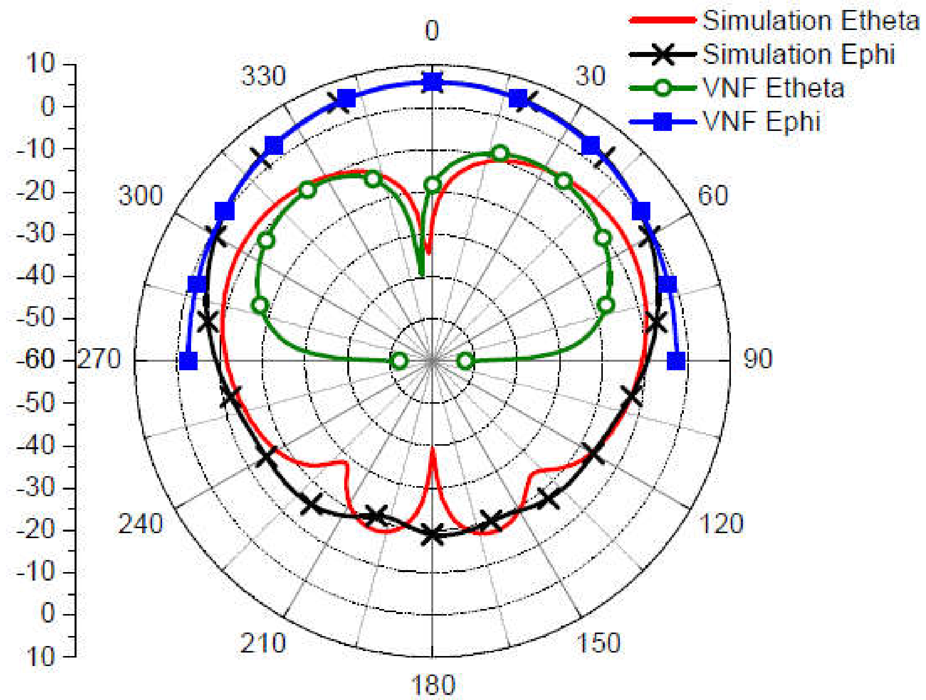


Very-Near-Field Implementation



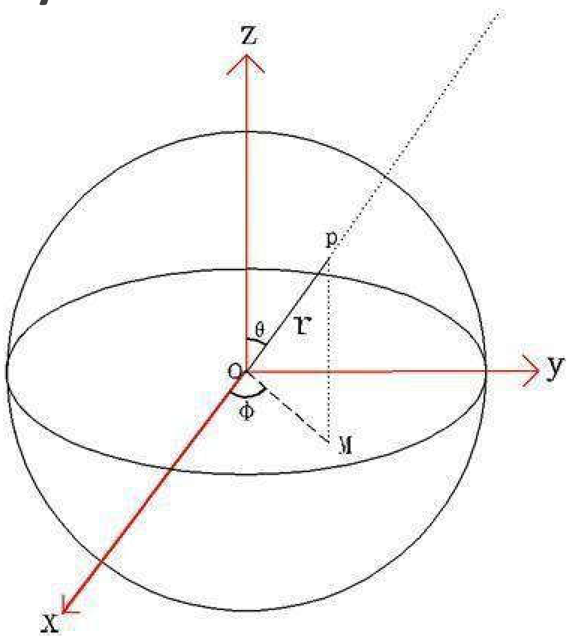
Results with Ideal Data

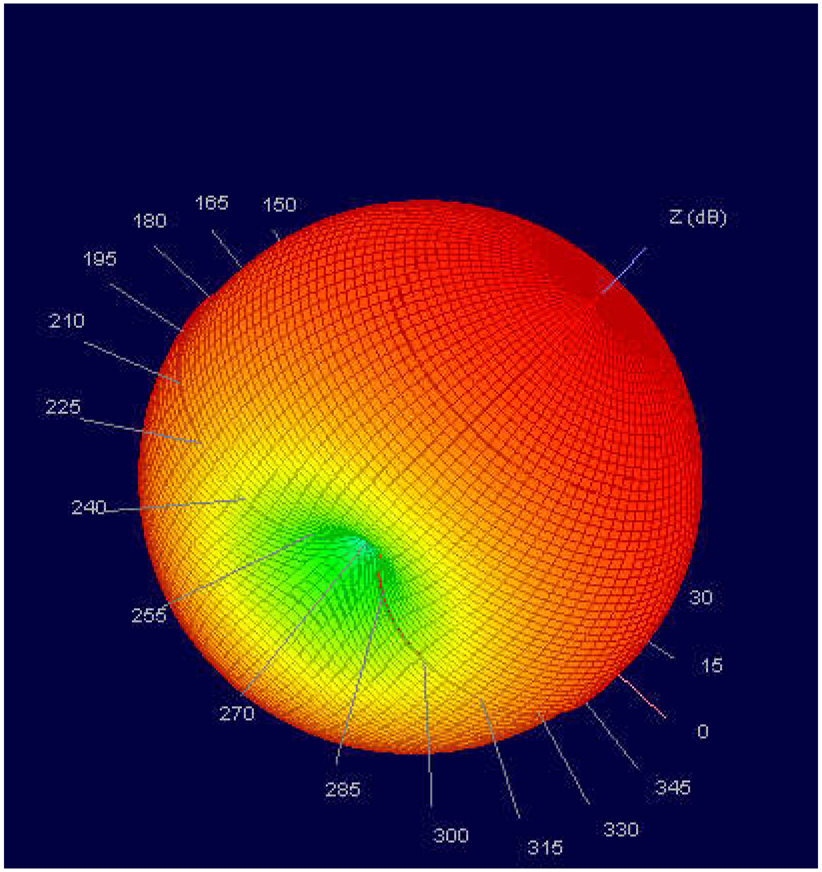
- **Still have limitations of finite planar scans**
- **Hemispherical results**
- **Limited angular coverage**
- **E-theta always reduces to zero at horizon**



Aggregate Node

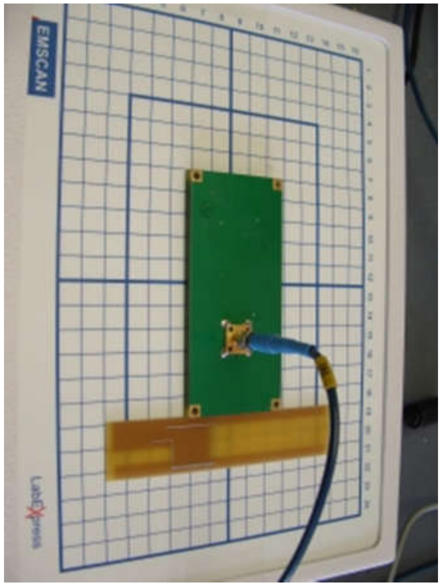
- **Combined scan results for full spherical far-field view**
- **User defined elevation for asymmetrical devices**

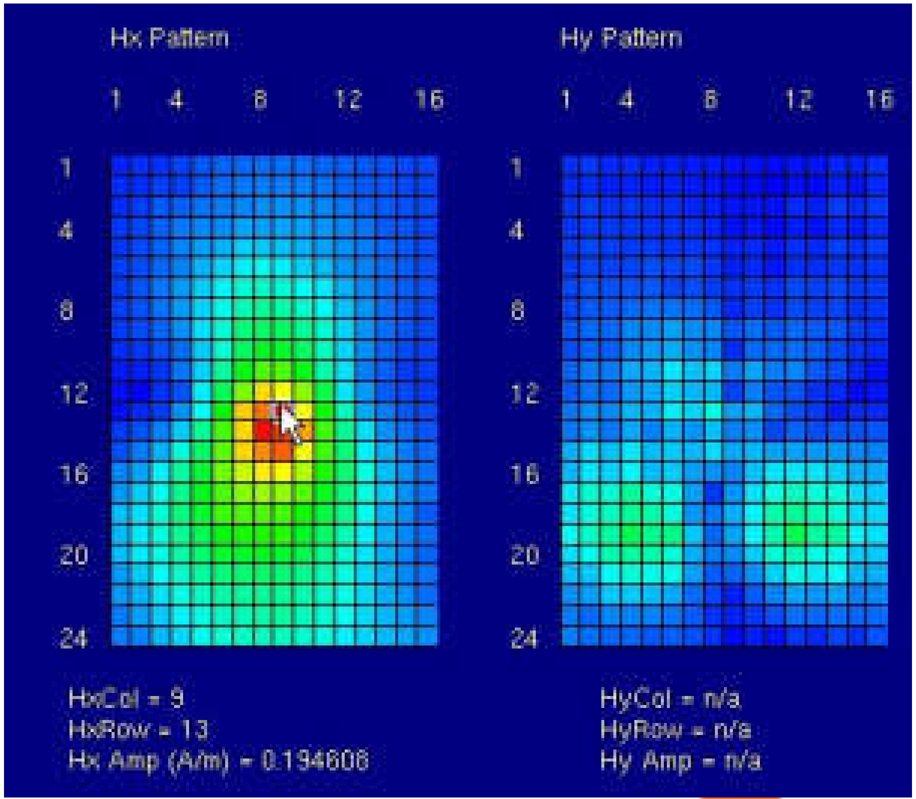




Very-Near-Field Benefits

- **Visualizing interference in the near-field**
  - Resonance and mutual coupling

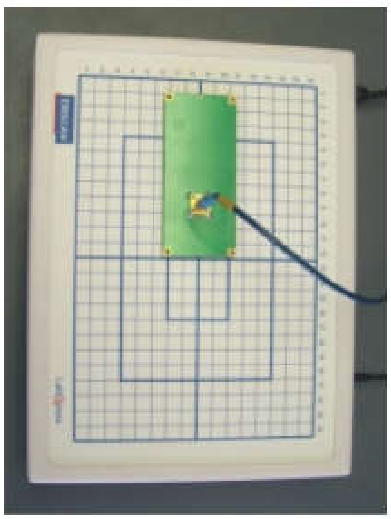
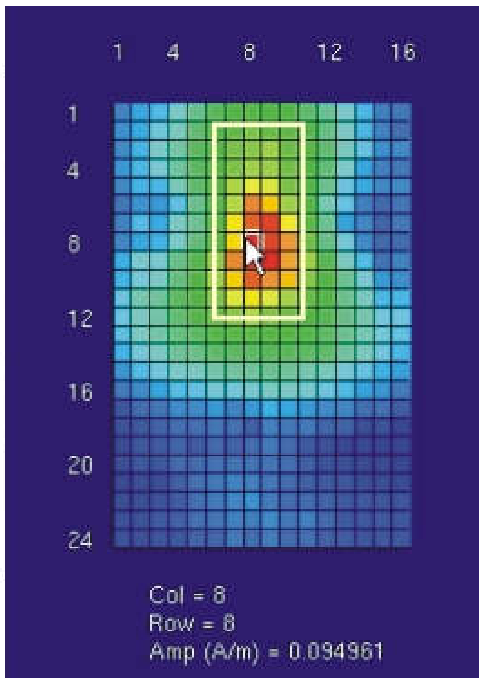


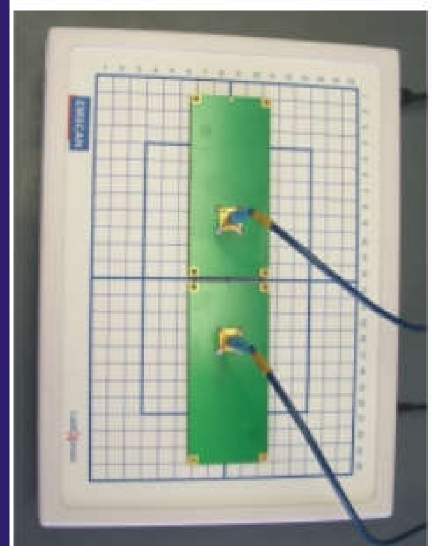
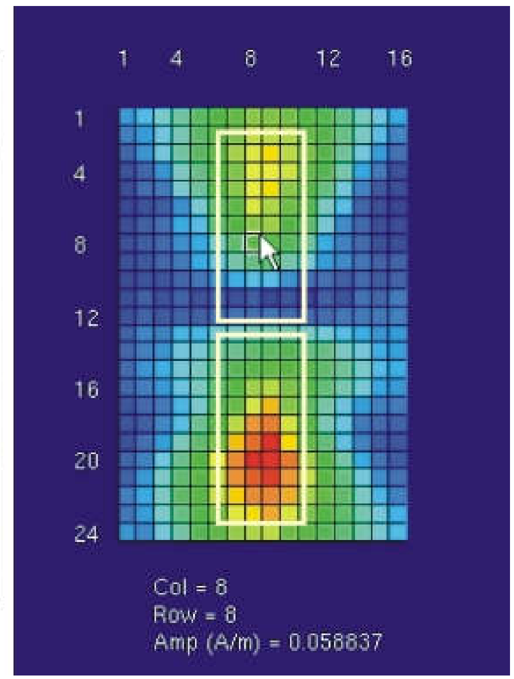


EMSCAN real-time results

Very-Near-Field Benefits

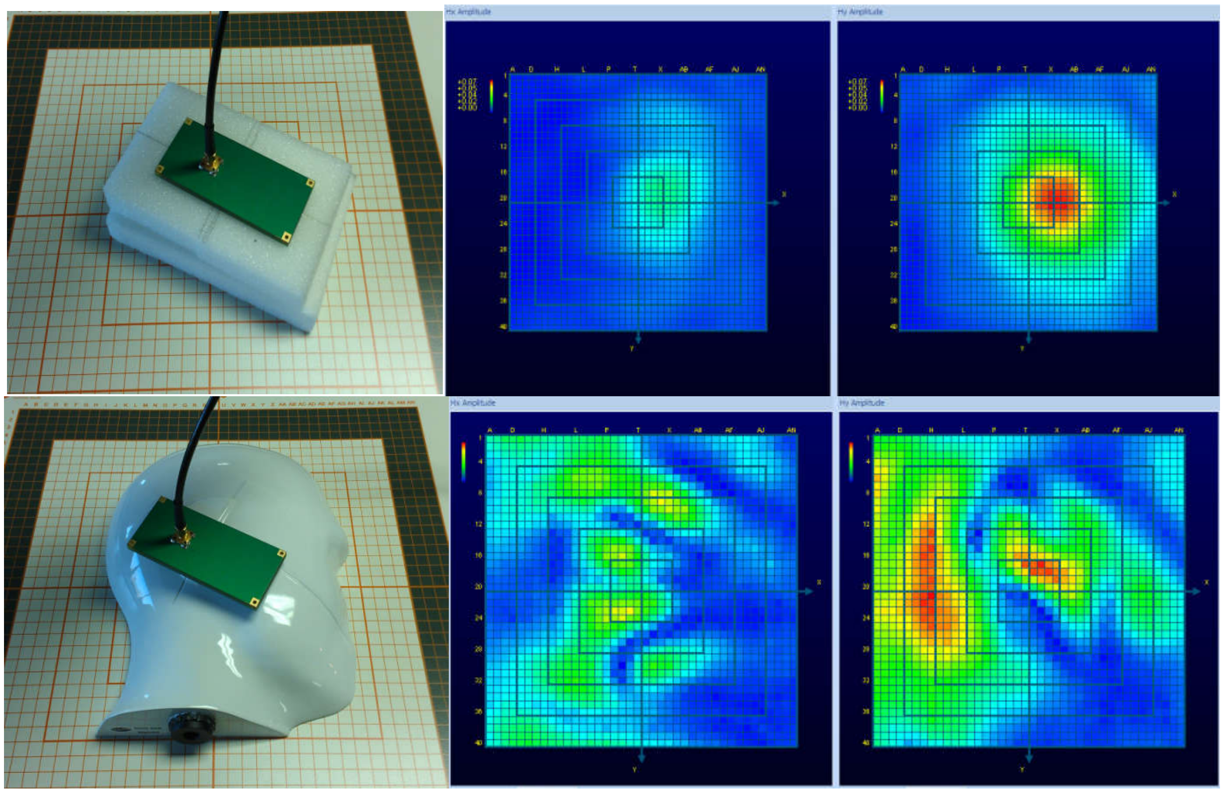
- **Antenna position**
- **Loading and field perturbation**

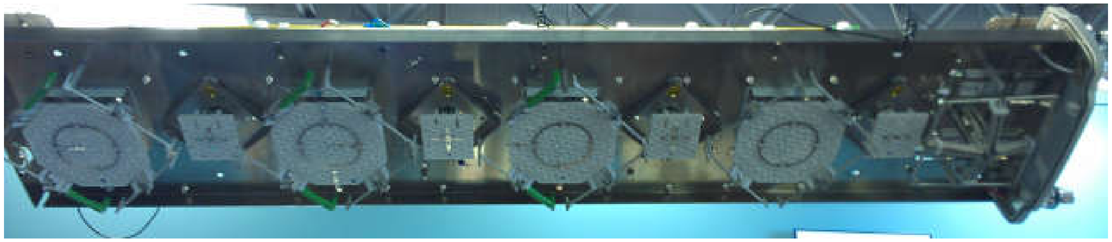
Very-Near-Field Benefits

- **Effects of Surrounding Material**

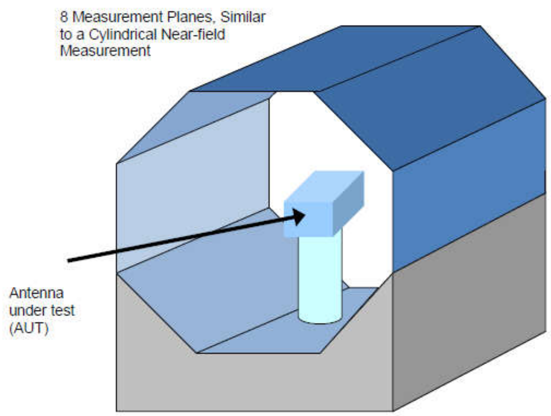


Aggregated Very-Near-Field

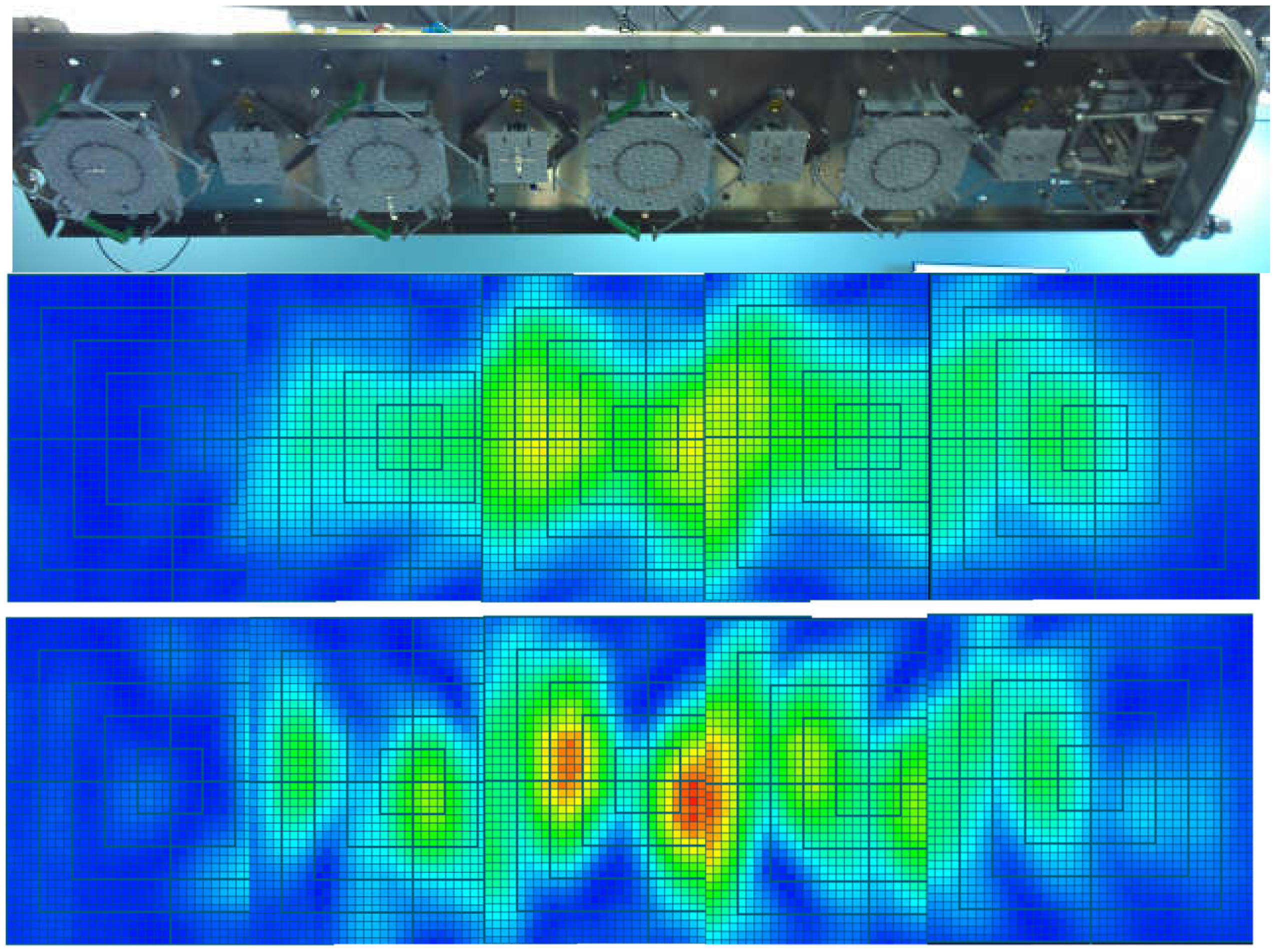
- **Multiple planar measurements combined together to provide larger effective scan area**



- **Multiple planar scans do not need to be co-planar**
  - Can used to created 3D scan surfaces or even enclosed surfaces

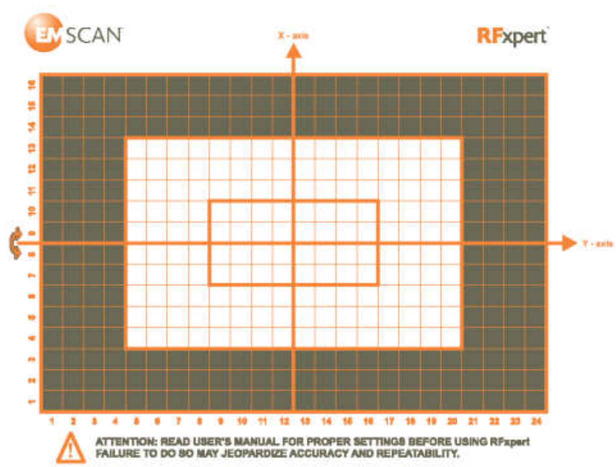


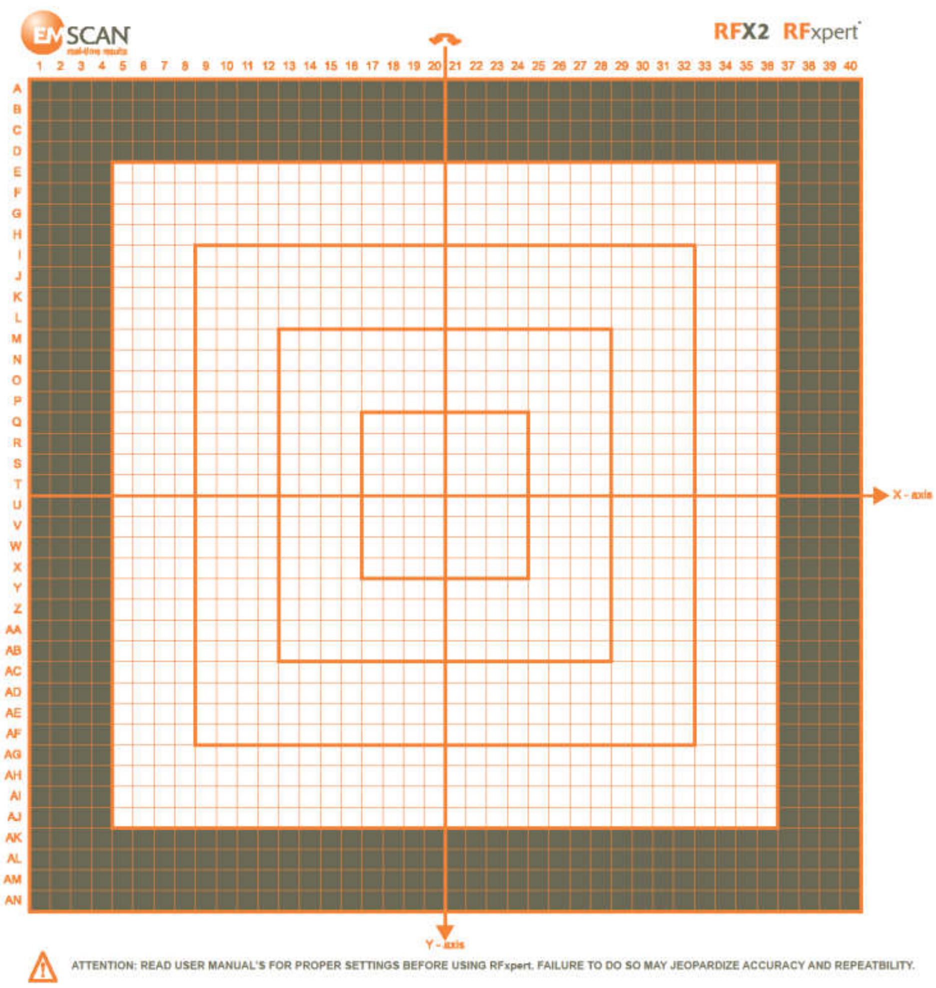
Aggregated Very-Near-Field



EMSCAN real-time results

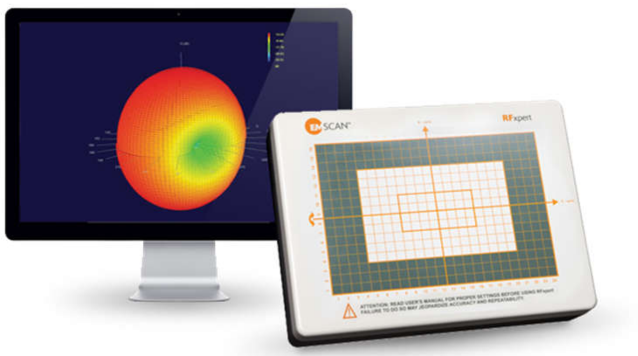
RFX and RFX2


EMSCAN
RFxpert
X - axis
Y - axis
ATTENTION: READ USER'S MANUAL FOR PROPER SETTINGS BEFORE USING RFxpert
FAILURE TO DO SO MAY JEOPARDIZE ACCURACY AND REPEATABILITY.


EMSCAN
RFX2 RFxpert
X - axis
Y - axis
ATTENTION: READ USER MANUAL'S FOR PROPER SETTINGS BEFORE USING RFxpert. FAILURE TO DO SO MAY JEOPARDIZE ACCURACY AND REPEATABILITY.

RFxpert

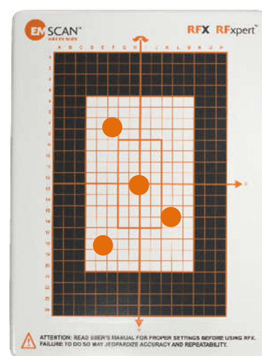
- Fast measurements
  - Continuous “real-time”
  - Single scan < 1 second



- Compact tabletop instrument
- Cost effective solution
- Easy-to-use by any engineer

High Accuracy

- **Repeatability**
  - – +/- 0.2 dB from one measurement to the next
  - – +/- 0.5 dB within the white test zone

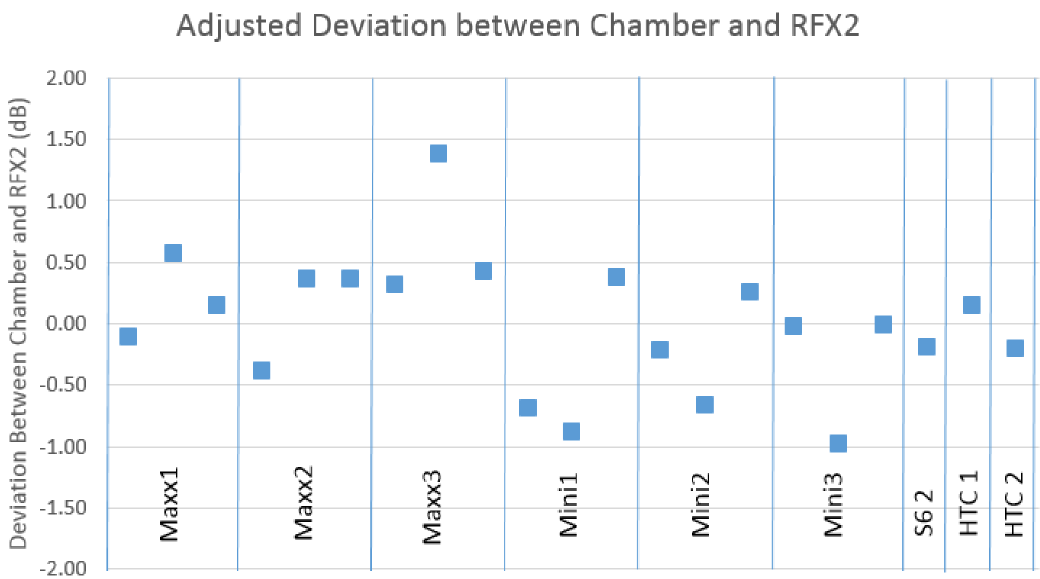


- **Relative accuracy**
  - – +/- 0.5 dB comparative measurements

EMSCAN real-time results

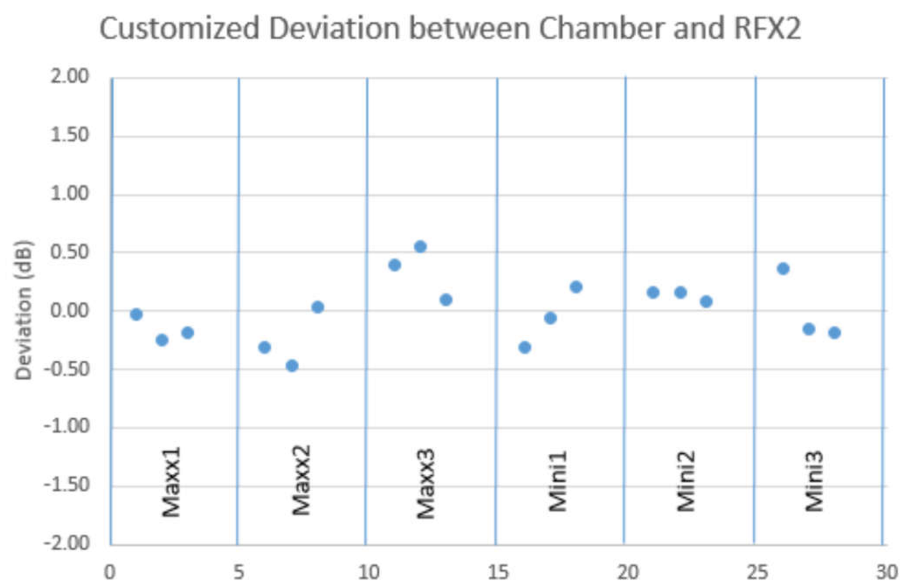
Absolute Accuracy Out-of-the-Box

- **Aligned to the Atlanta CTIA Satimo chamber**
- **Re-align your RFxpert to your chamber**
  - Portfolio of devices
  - 2σ = +/- 1.1 dB at 700 MHz (better at higher frequency)



Absolute Accuracy Out-of-the-Box

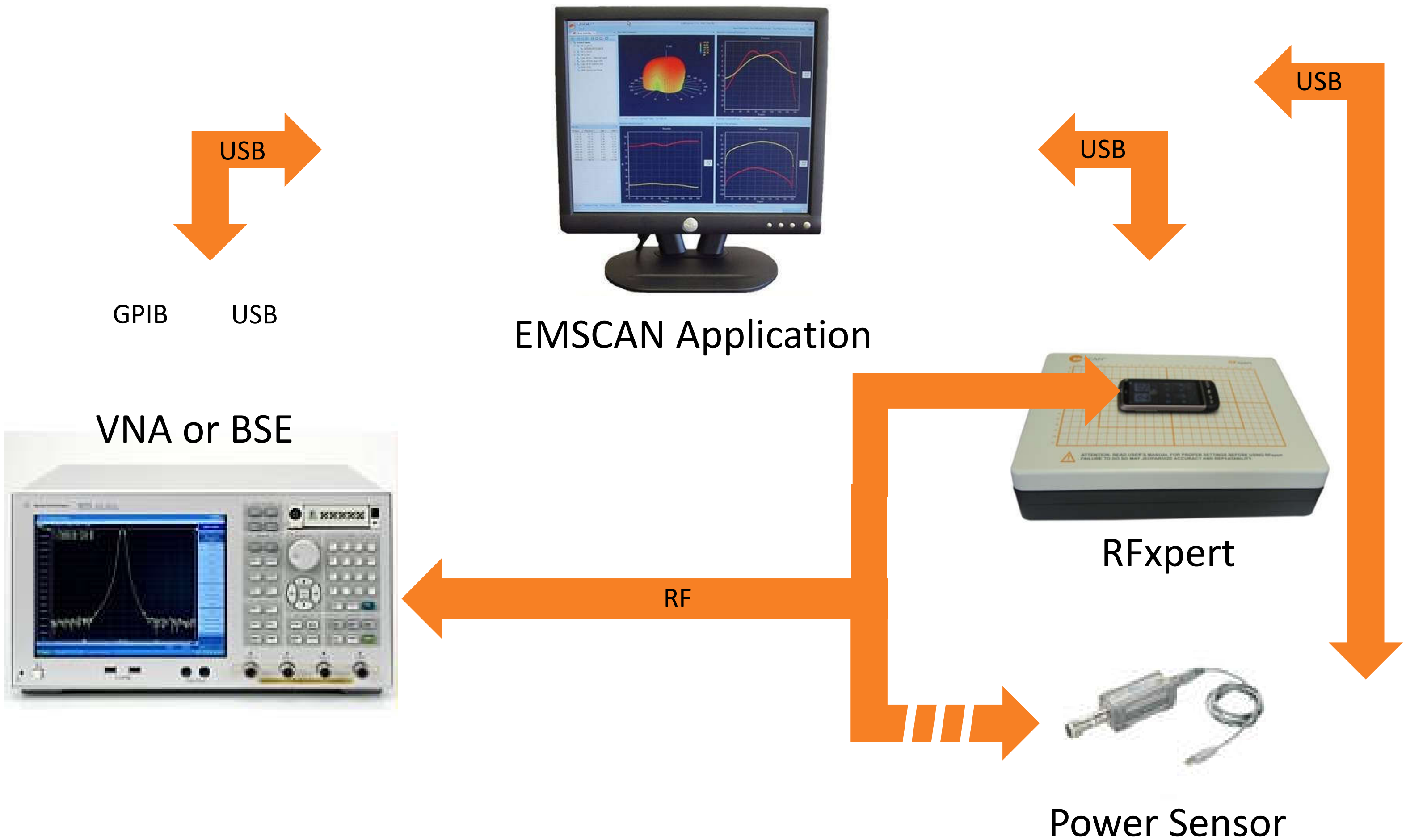
- **Aligned to the Atlanta CTIA Satimo chamber**
- **Re-align your RFxpert to your chamber**
  - One device
  - 2σ = +/-0.54 dB at 700 MHz



EMSCAN real-time results

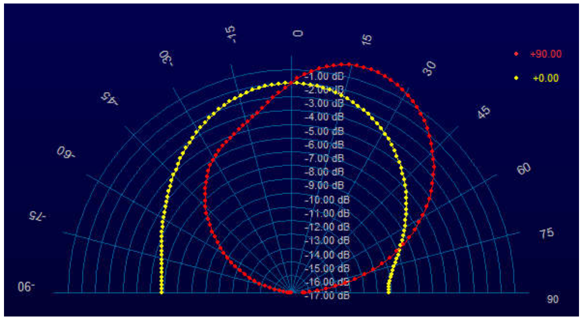
Technical Specifications

Configuration

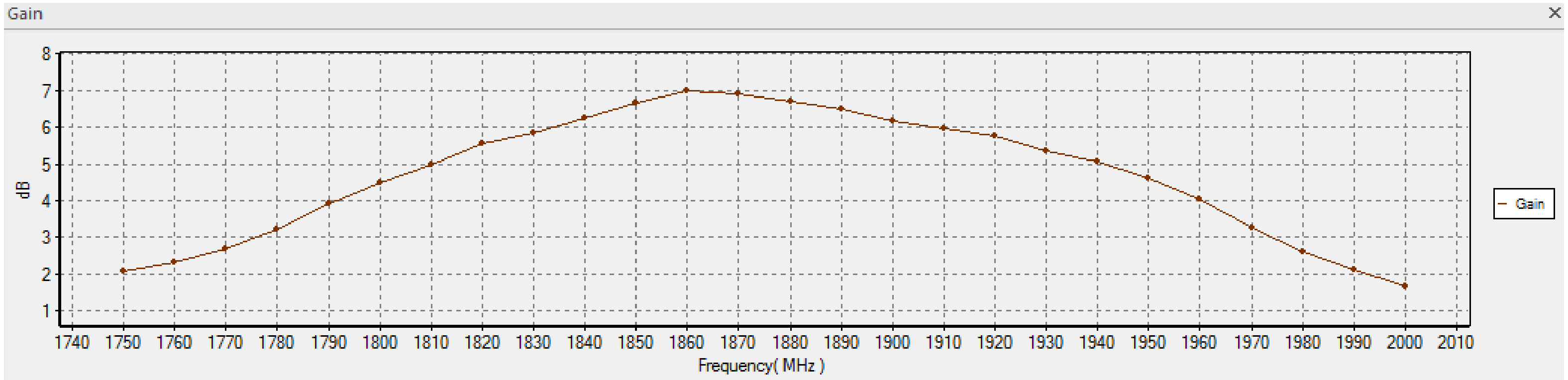


Frequency Scan

- **Gain, efficiency, EIRP and TRP of a device at a discrete frequency and across a range of frequencies through remote control of a VNA**

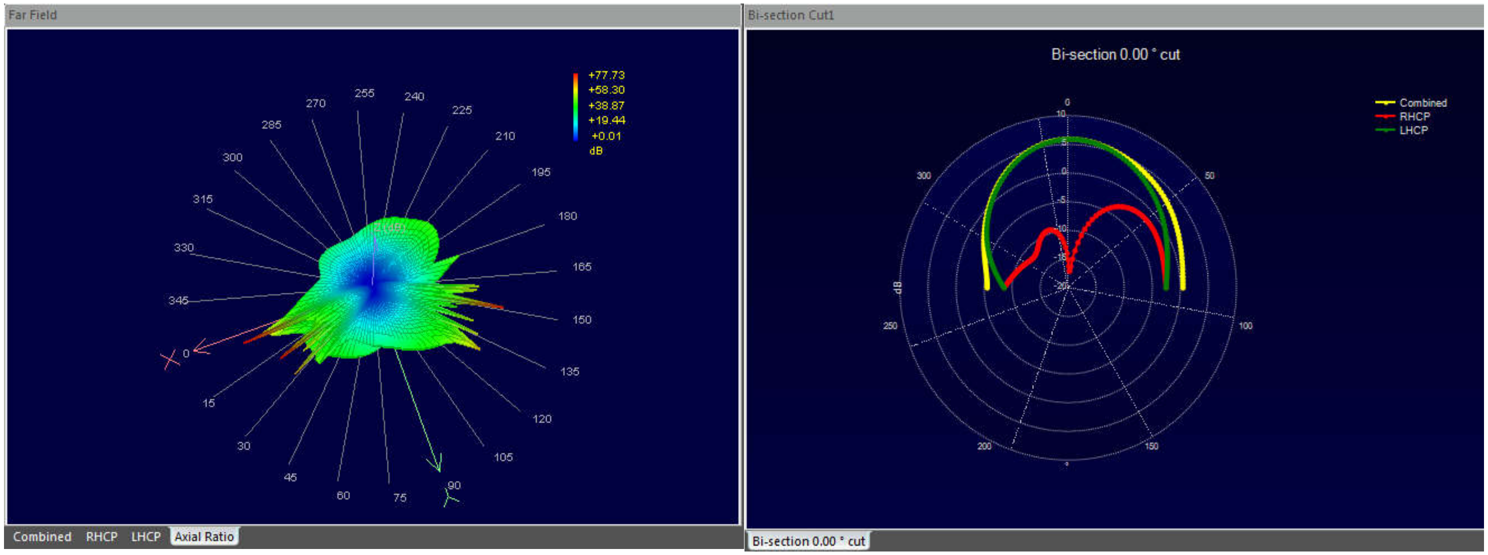


Frequency	Efficiency	Gain	EIRP
1880.00	73.91	6.66	6.66



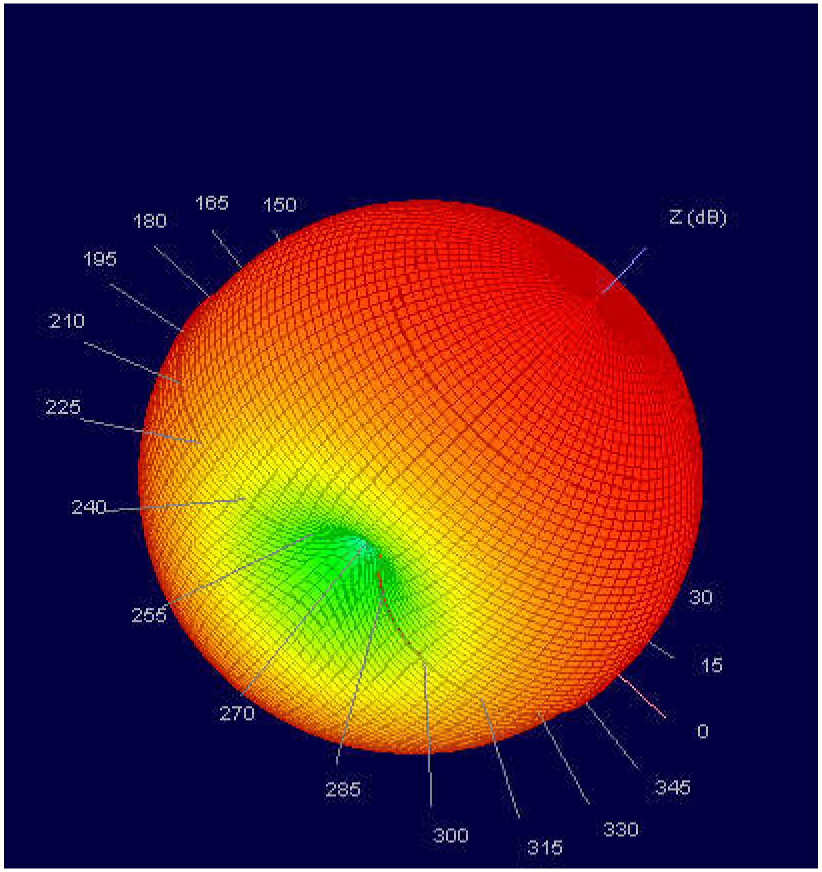
Circular Polarization

- **LHCP / RHCP / AR over a range of ±30° from the center line**



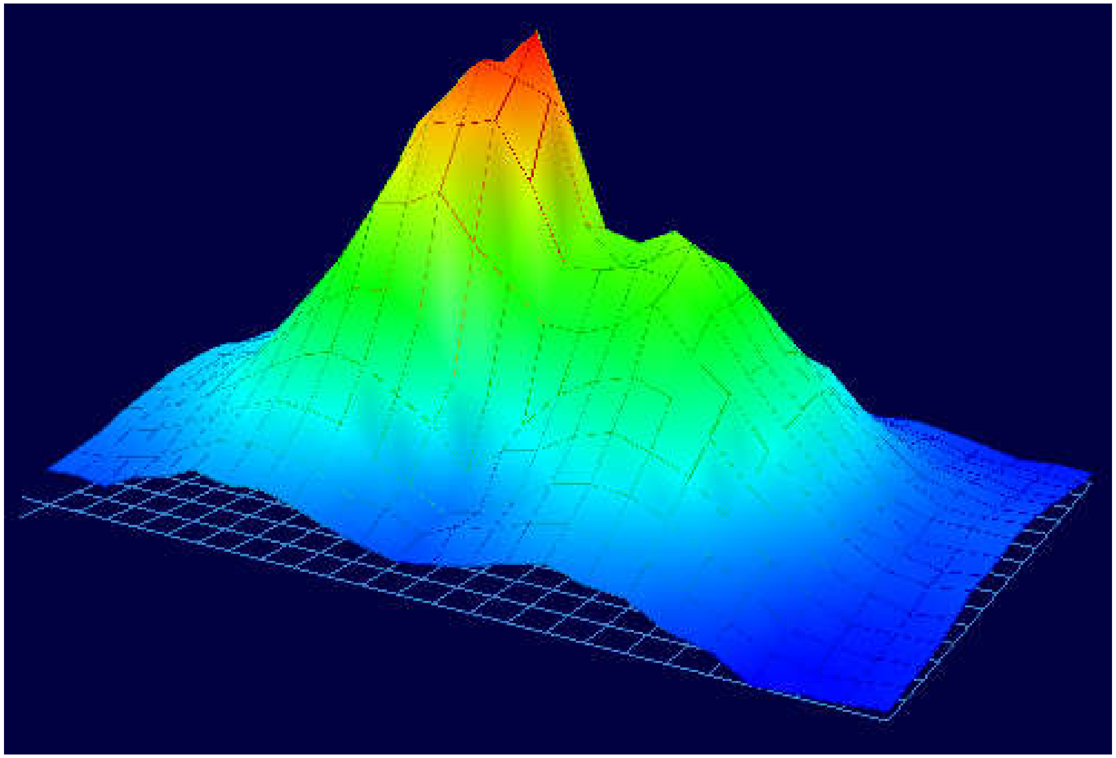
Aggregate Node

- **Combined frequency scanning results for full spherical far-field view**
- **User defined elevation for asymmetrical devices**



Very-Near-Field

- **Insights into design issues**



RFxpert

Comparison with Simulation

EMSCAN real-time results

Simulation

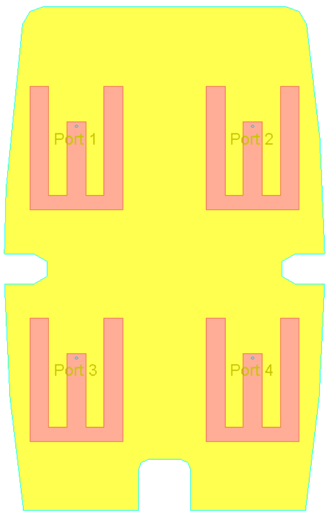
Agilent EDA simulation

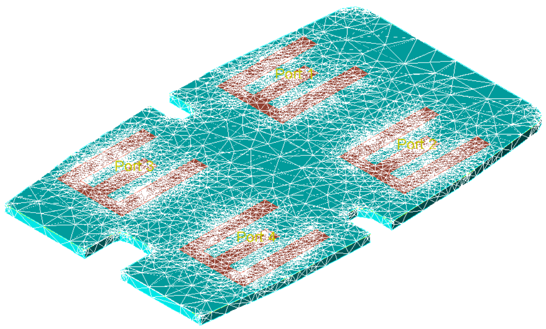
Toyo corporation (EMSCAN Representative)

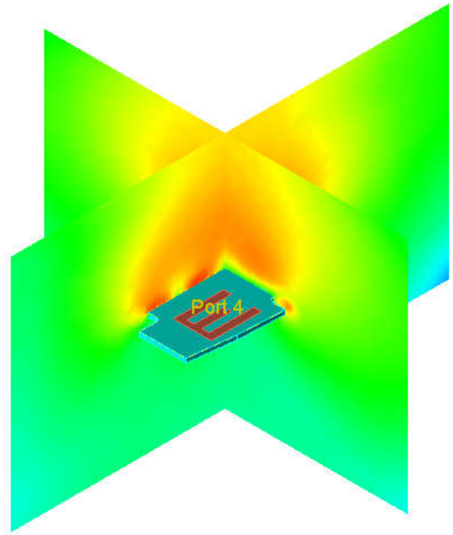
Tokyo, Japan

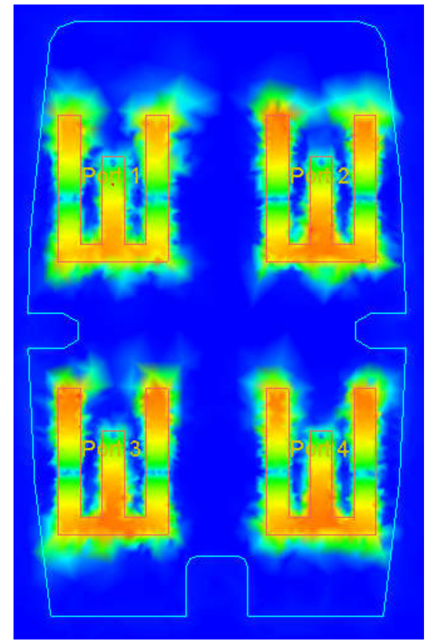
June 19, 2012

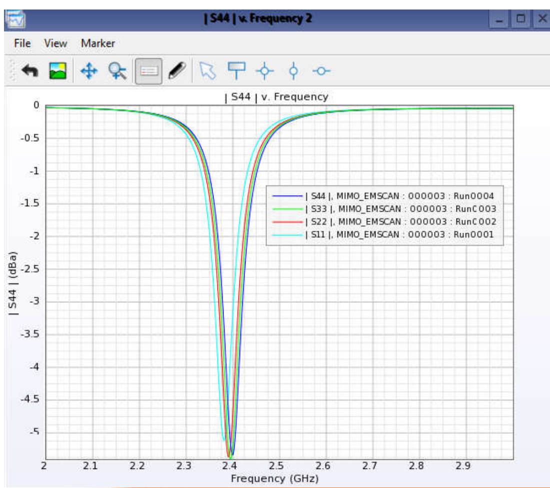
4ブランチアンテナ

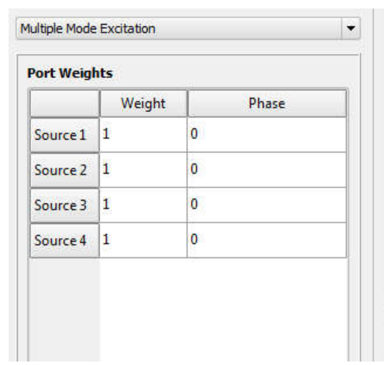




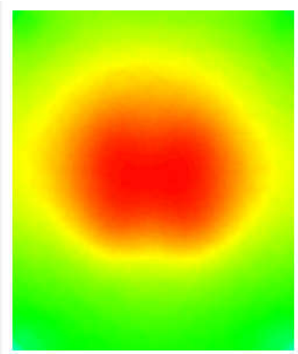




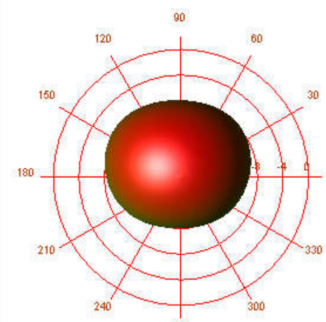




位相重みづけ



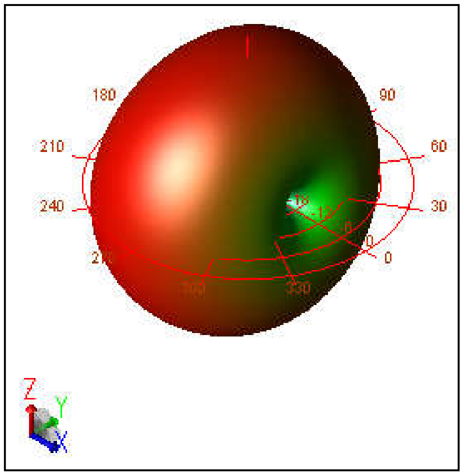
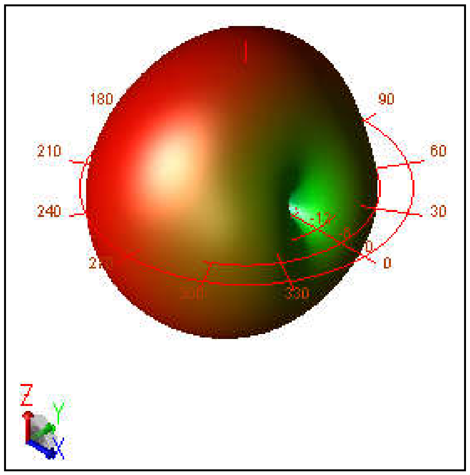
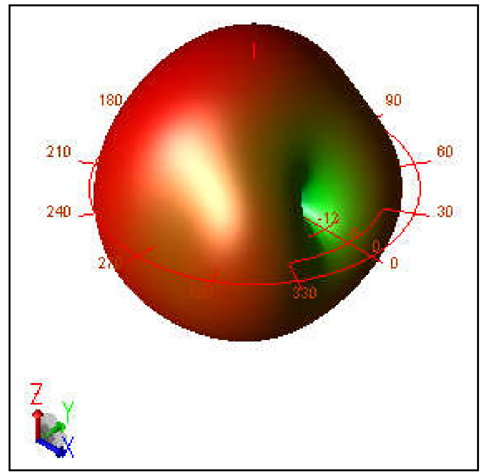
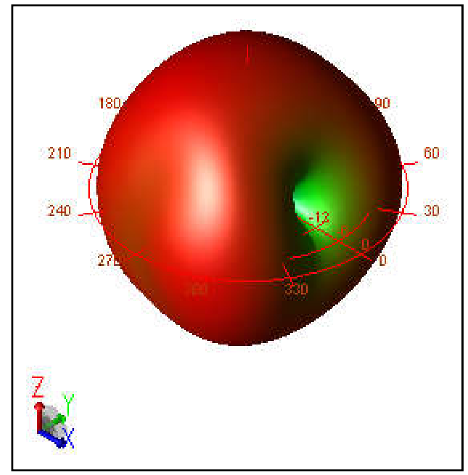
3cm上方磁界強度

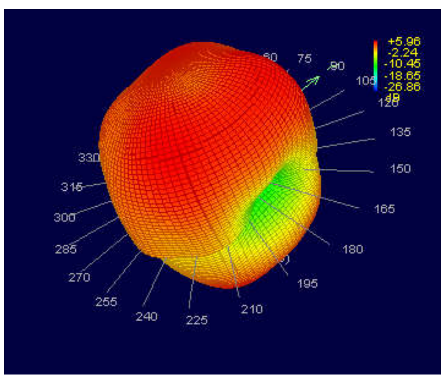
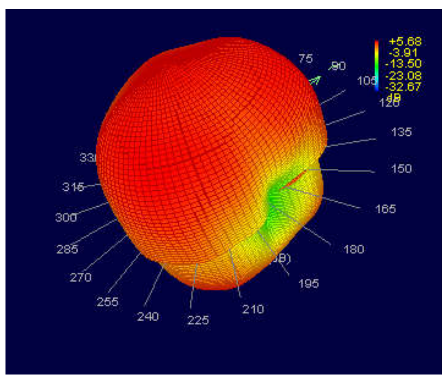
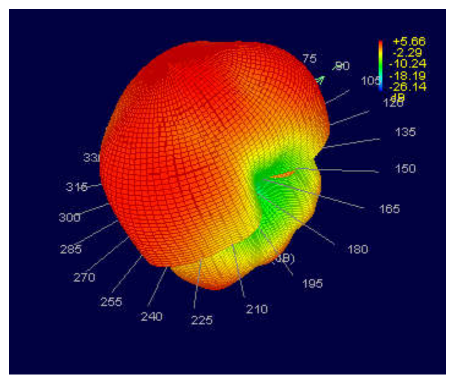
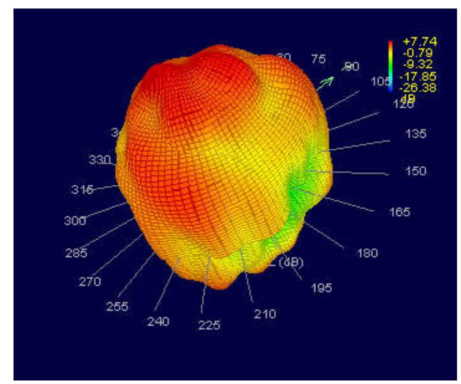


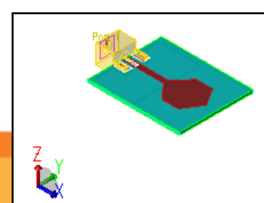
遠方界

3D Farfield

3GHz | 4GHz | 5GHz | 6GHz

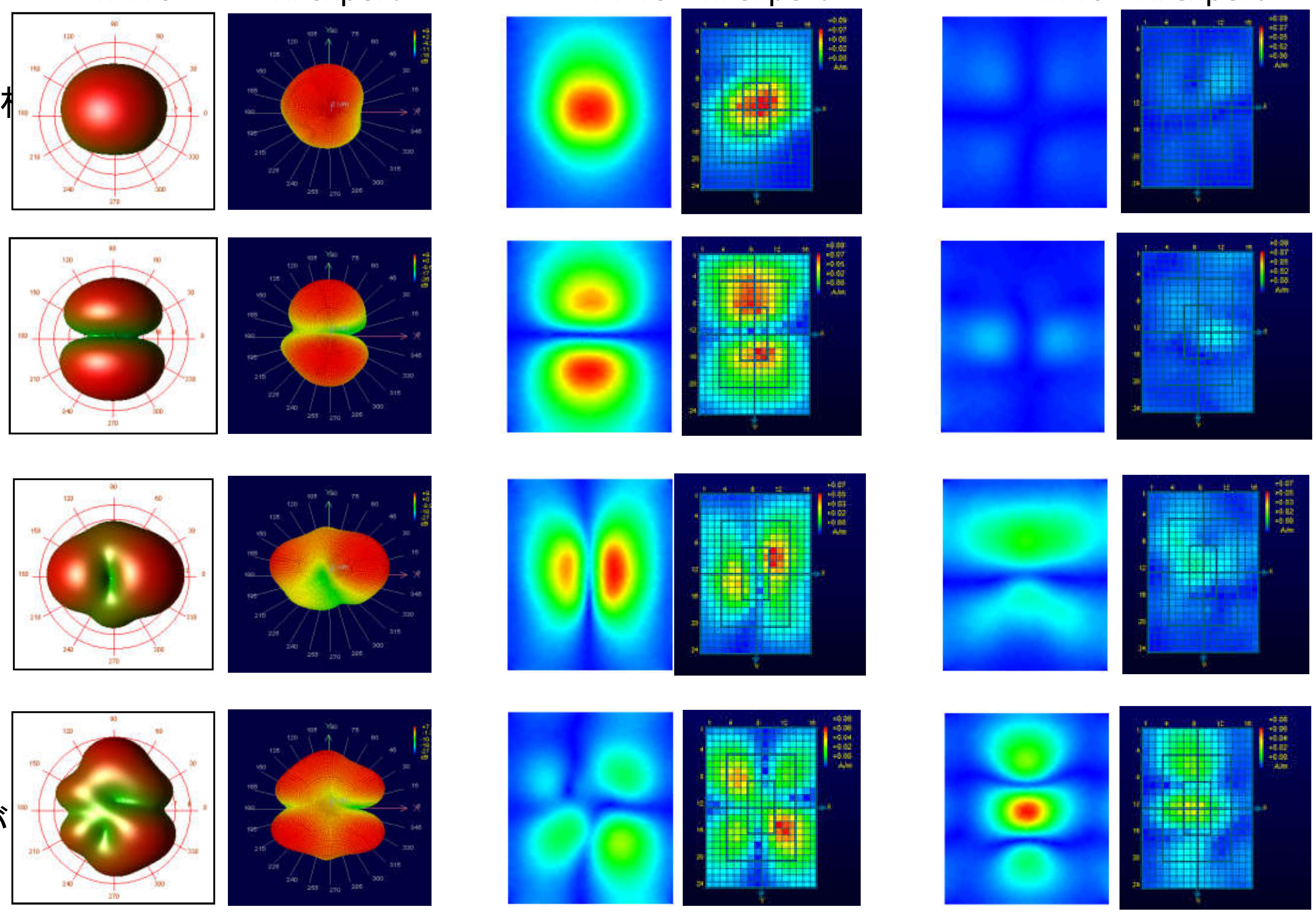







EM SCAN real-time results

	Farfield(dBi)		mag(Hx)		mag(Hy)	
	EMPro	RFexpert	EMPro	RFexpert	EMPro	RFexpert
Mode1: 4つとも同位						
Mode2: 上下で逆相						
Mode3: 左右で逆相						
Mode4: 斜め同士が						

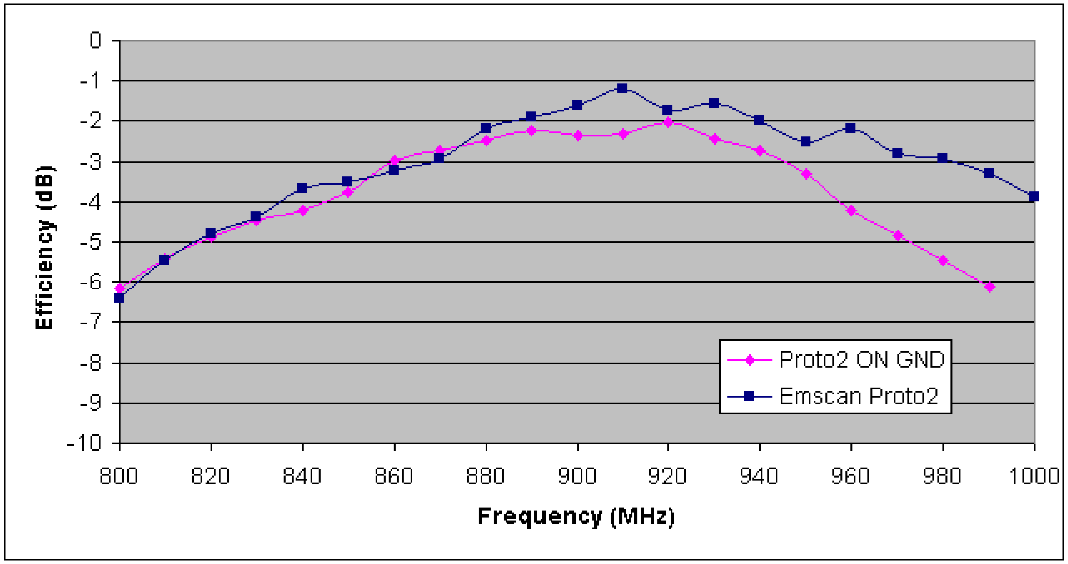


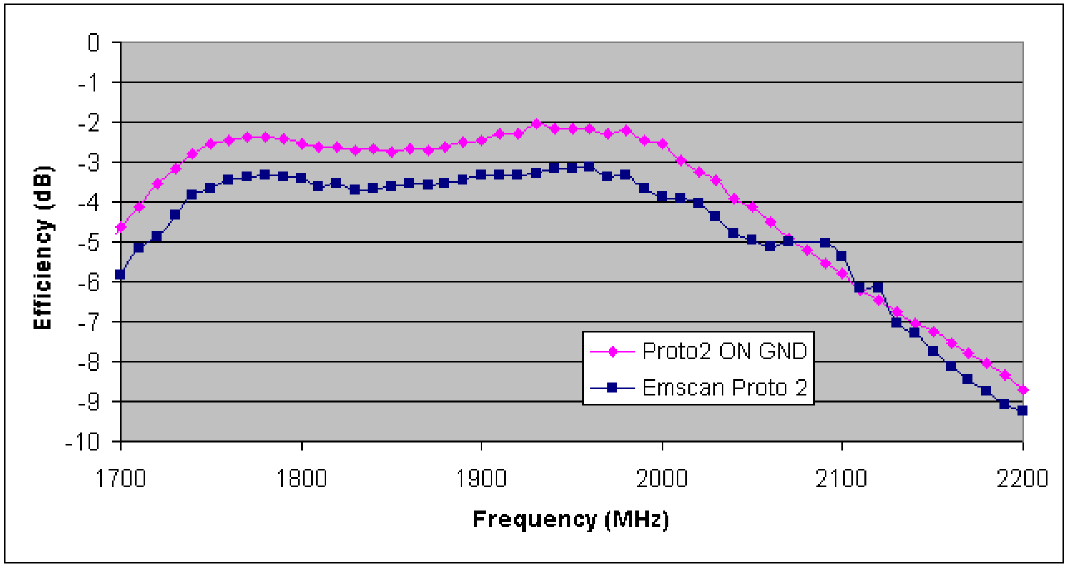
RFxpert

Comparison with Chamber Results

EMSCAN real-time results

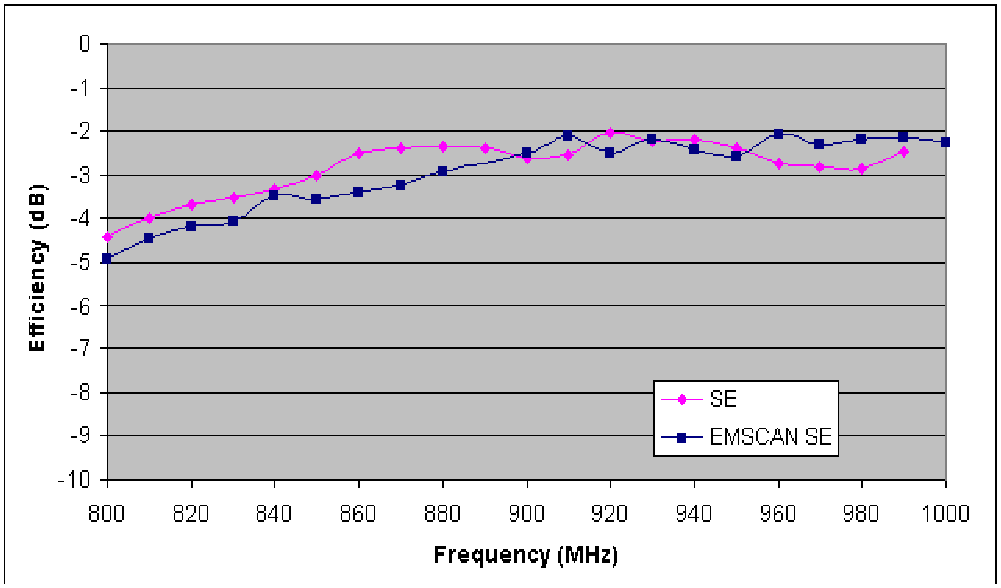
Mobile Phone Efficiency

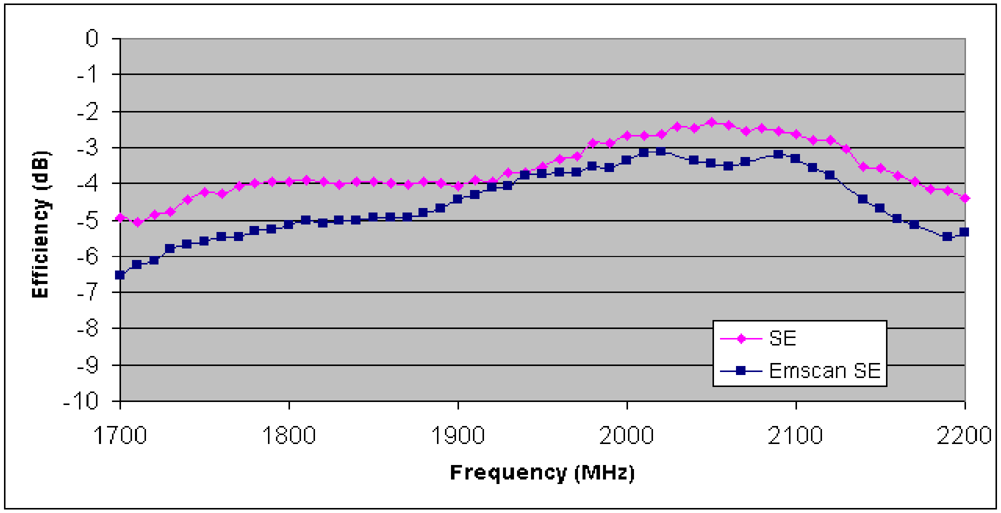




Note: Low band offset applied by customer

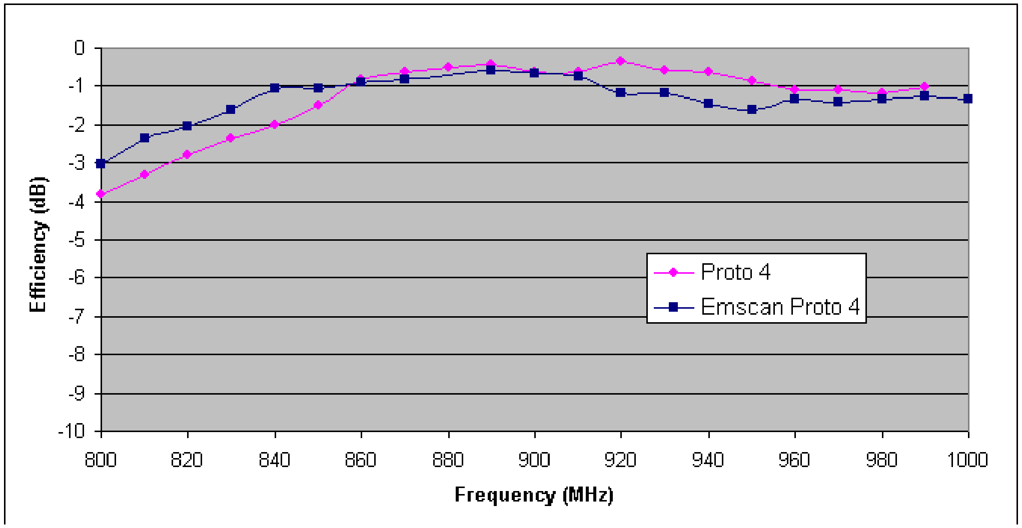
Mobile Phone Efficiency

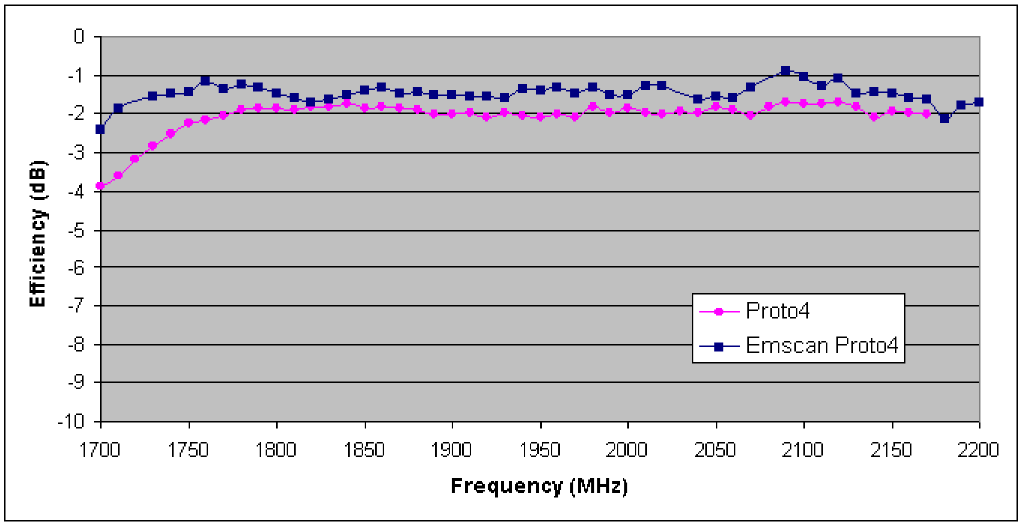




Note: Low band offset applied by customer

Mobile Phone Efficiency

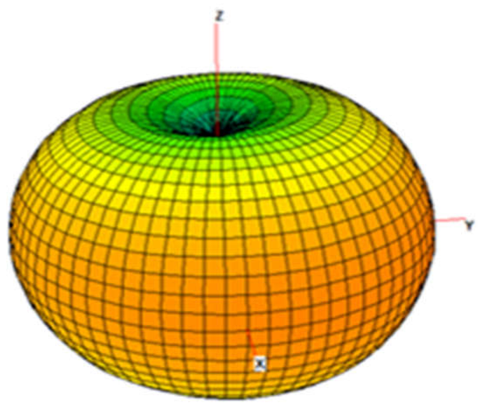




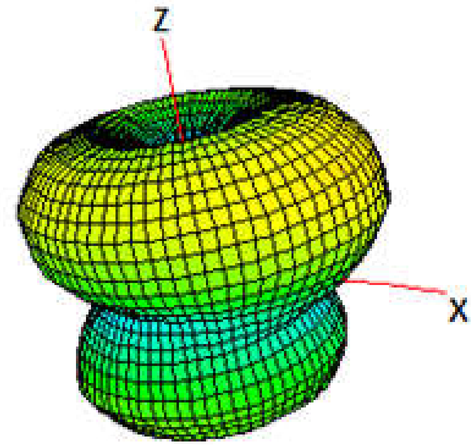
Note: Low band offset applied by customer

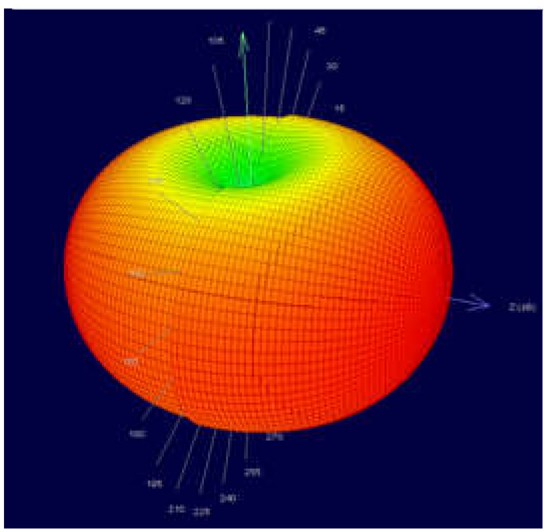
EMSCAN real-time results

Patterns of Various Mobile Phones

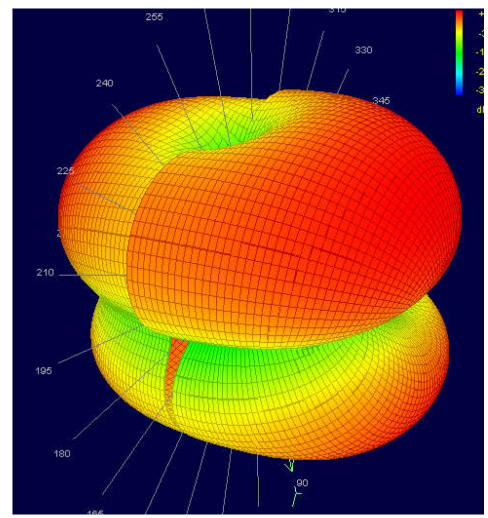


CTIA



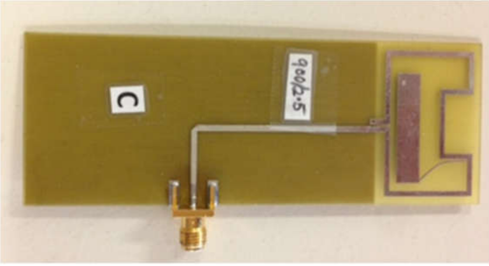


RFxpert



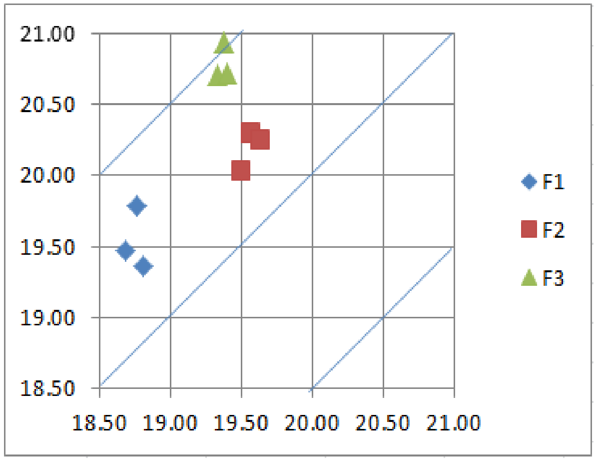
Passive Antenna Results

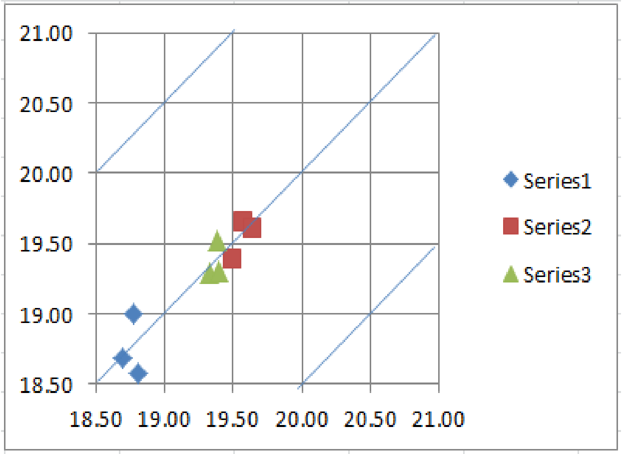
- **47 antennas measured in CTIA MVG Satimo chamber**
  - 20 PIFAs, 10 Patch designed by EMSCAN
  - 17 acquired antennas are a mix of different sorts



PRAD Offset Table

- **Re-alignment process**





	Band 5				
Freq 1	Chamber	EMSCAN	Error	Applied Error	Adjusted
1	18.81	19.36	-0.55	-0.78	18.58
1	18.77	19.78	-1.01	-0.78	19.00
1	18.69	19.47	-0.78	-0.78	18.69
2	19.49	20.04	-0.55	-0.64	19.40
2	19.56	20.30	-0.74	-0.64	19.66
2	19.63	20.26	-0.63	-0.64	19.62
3	19.33	20.71	-1.38	-1.42	19.29
3	19.40	20.72	-1.32	-1.42	19.30
3	19.38	20.93	-1.55	-1.42	19.51

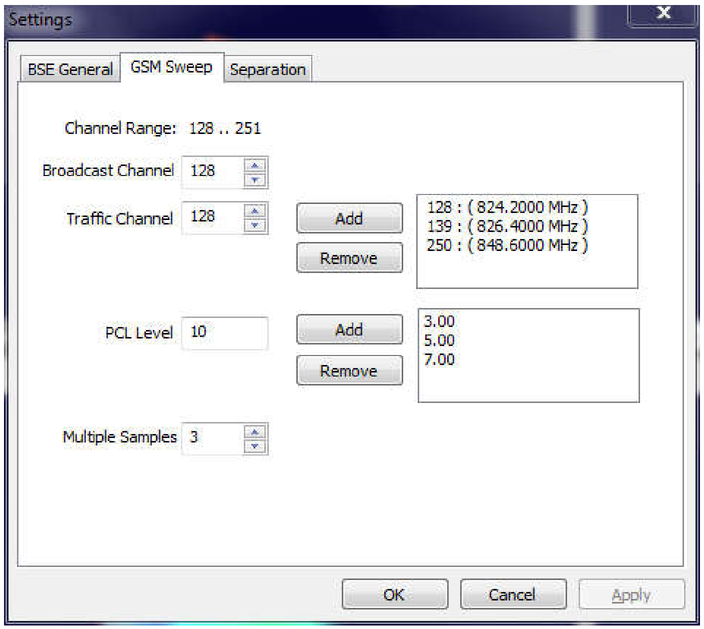
EMSCAN real-time results

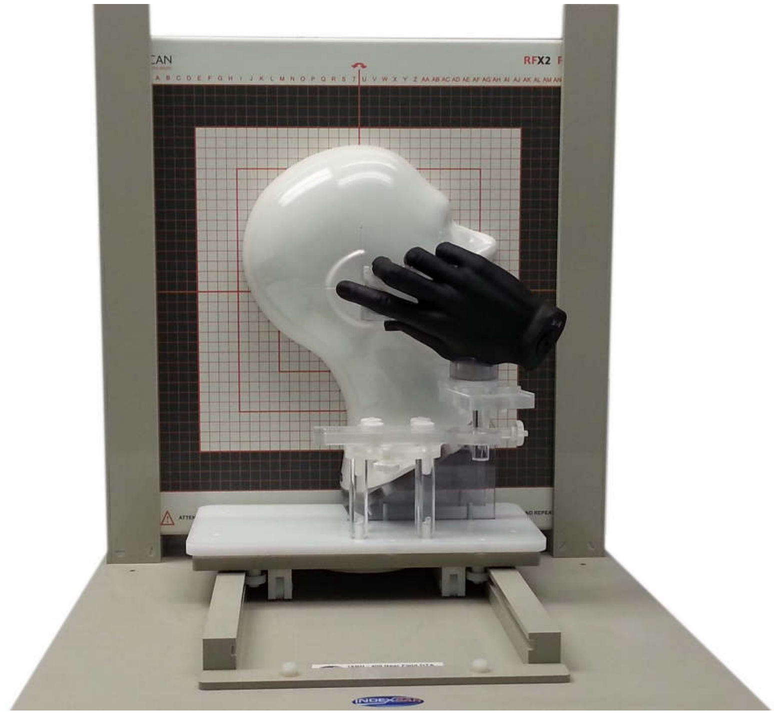
RFxpert

Test Applications

Cellular Phone

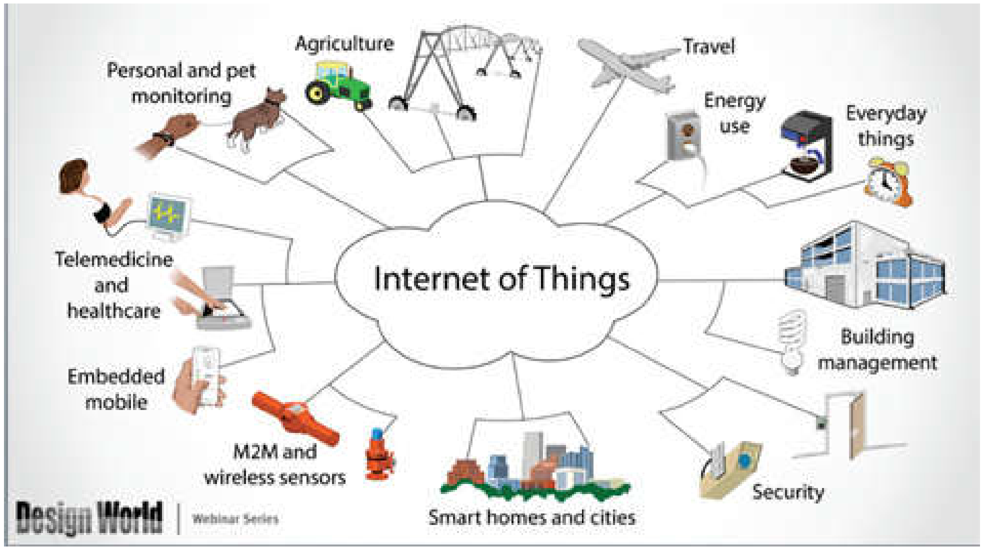
- **Power and pattern measurements at a single channel or a series of channels through the remote control of a Base Station Emulator**



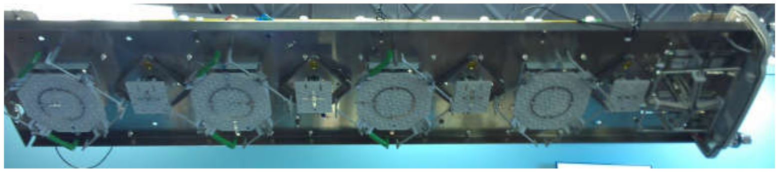


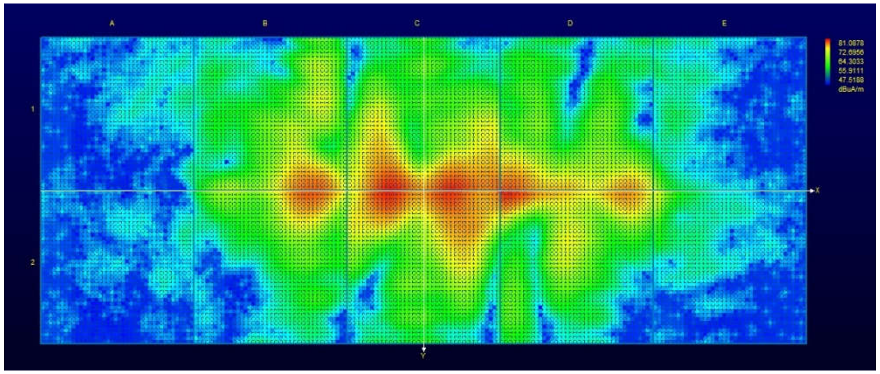
IoT

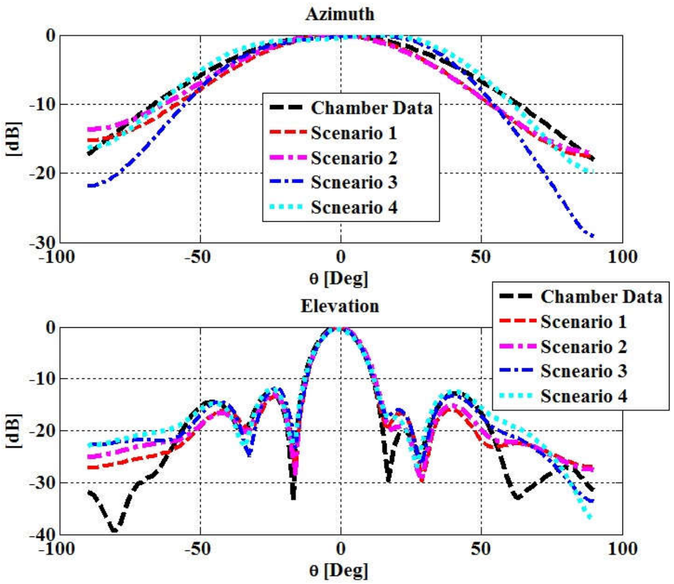
- **Fast pre-certification**



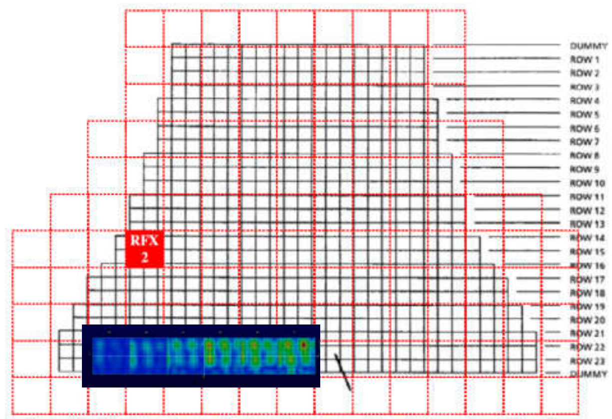
Cellular Base Station Antenna

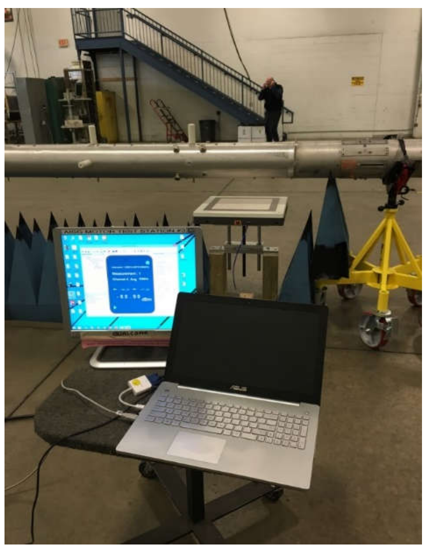




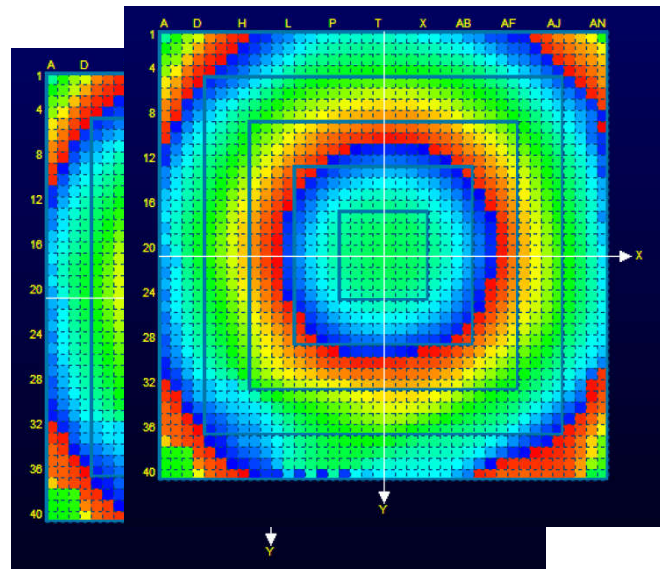


Testing of Large or Long Antennas



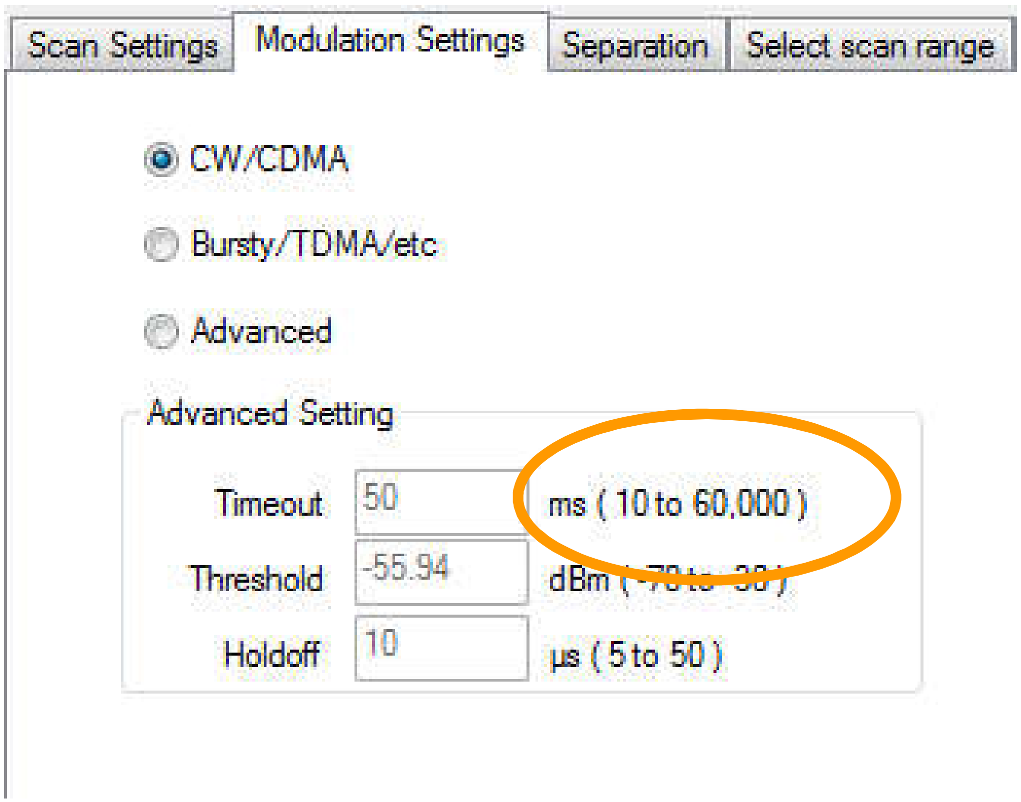


Phase Center



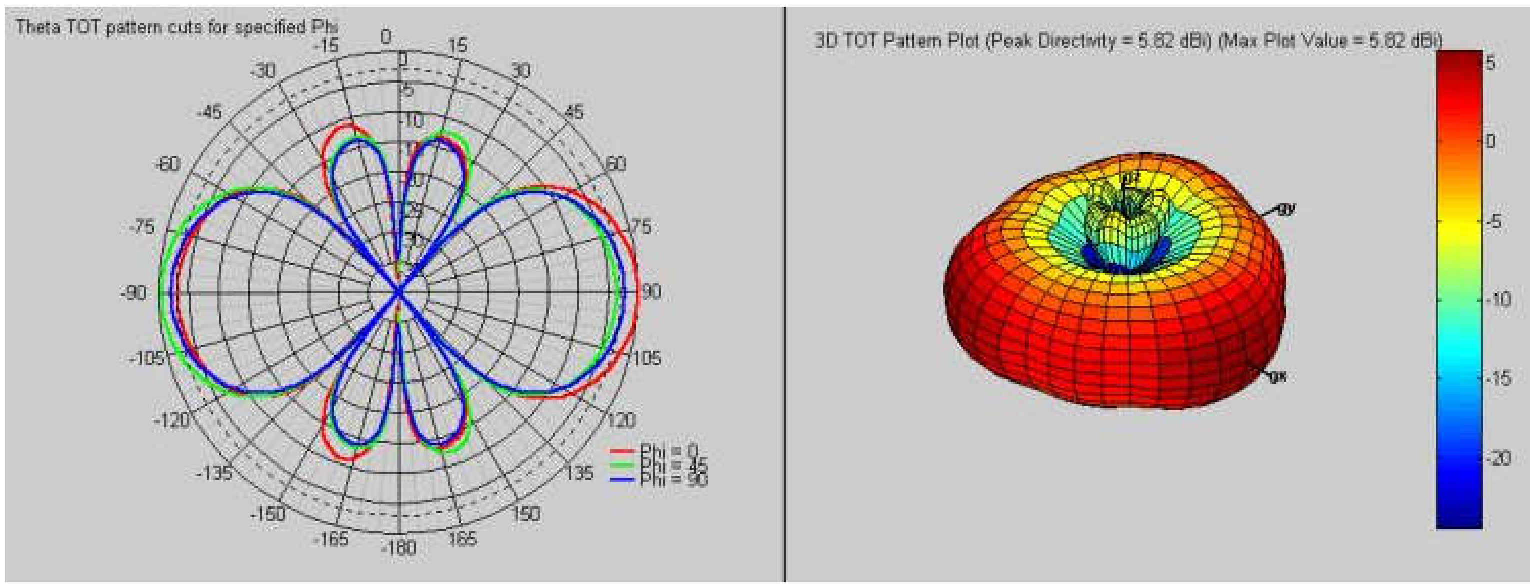
Wi-Fi

- **Any customized pulse up to 60-second timeout**



Phased Array Antenna

- **Phase balancing**



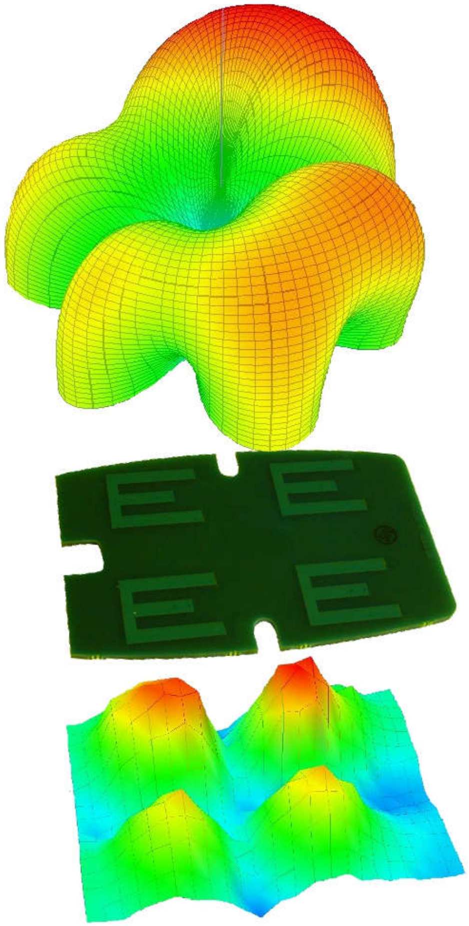
Picture from www.mathworks.com/

GPS Antenna

- **Circular Polarization**

MIMO

- **Very-near-field for antenna diversity and mutual coupling**
- **Far-field for real-time tuning**
- **Correlation**
  - Envelope and pattern correlation
    - Hemispherical RFX
    - Spherical RFX2



Smart Meters

- **Connectivity with**
  - GSM, Mobile
  - WLAN / WiFi
  - ZigBee
  - M-Bus
  - Custom
  - Others …
- **Measurement of antennas**
- **Measuring active device with long timeout**

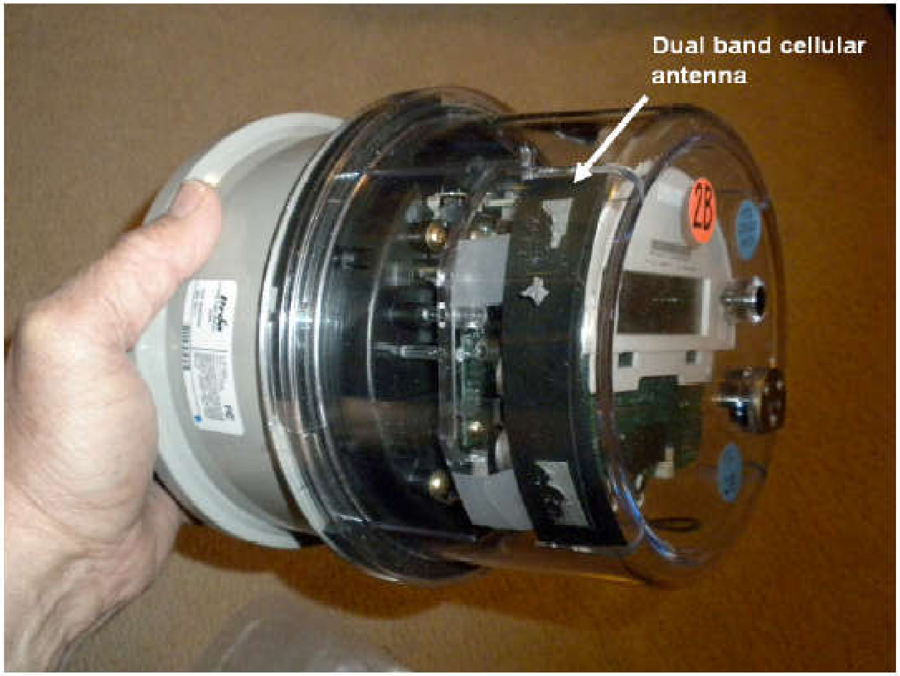


Figure 2-3
Cell relay meter with flexible, dual band (850 MHz and 1900 MHz) antenna affixed to interior surface of the meter cover.

EMSCAN real-time results

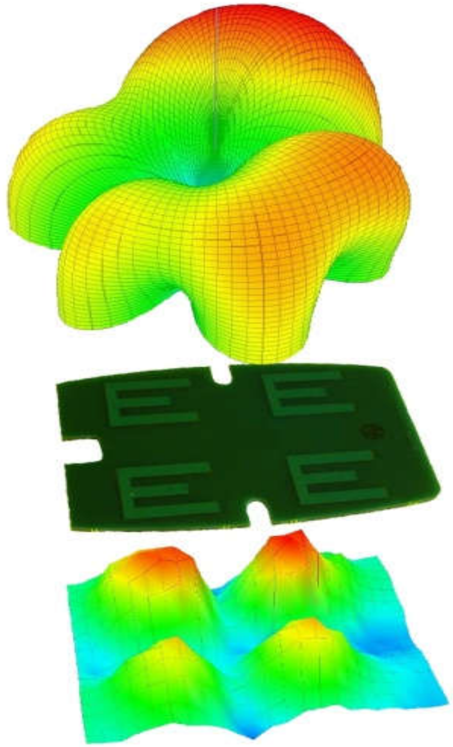
RFxpert

Conclusion

EMSCAN real-time results

Very-Near-Field Benefits

- Ability to see surface currents
- Very fast scanning
- Repeatable
- No chamber
- Low maintenance
- Easy to use



RFxpert Advantages

- Interaction effects in real-time
- Very-near-field measurements
- Fast and repeatable
- Low CAPEX

Some Customers

亚马逊 amazon.cn
ANTENNA79
at&t
Atmel
ERICSSON
GENERAL DYNAMICS
HARRIS
HUAWEI
Itron
amazon Lab126
LG
LOCKHEED MARTIN
Microsoft
MOTOROLA SOLUTIONS
motorola a lenovo company
PHILIPS Healthcare
SILICON LABS
SoftBank
Sony Mobile
ST. JUDE MEDICAL
TELSTRA
TELUS
TOSHIBA Leading Innovation >>>
verizonwireless
ZEBRA

EMSCAN real-time results

Contact Us

PCB GraphTech Vietnam
info@pcb-graphtech.com.vn
(028) 6292 1170