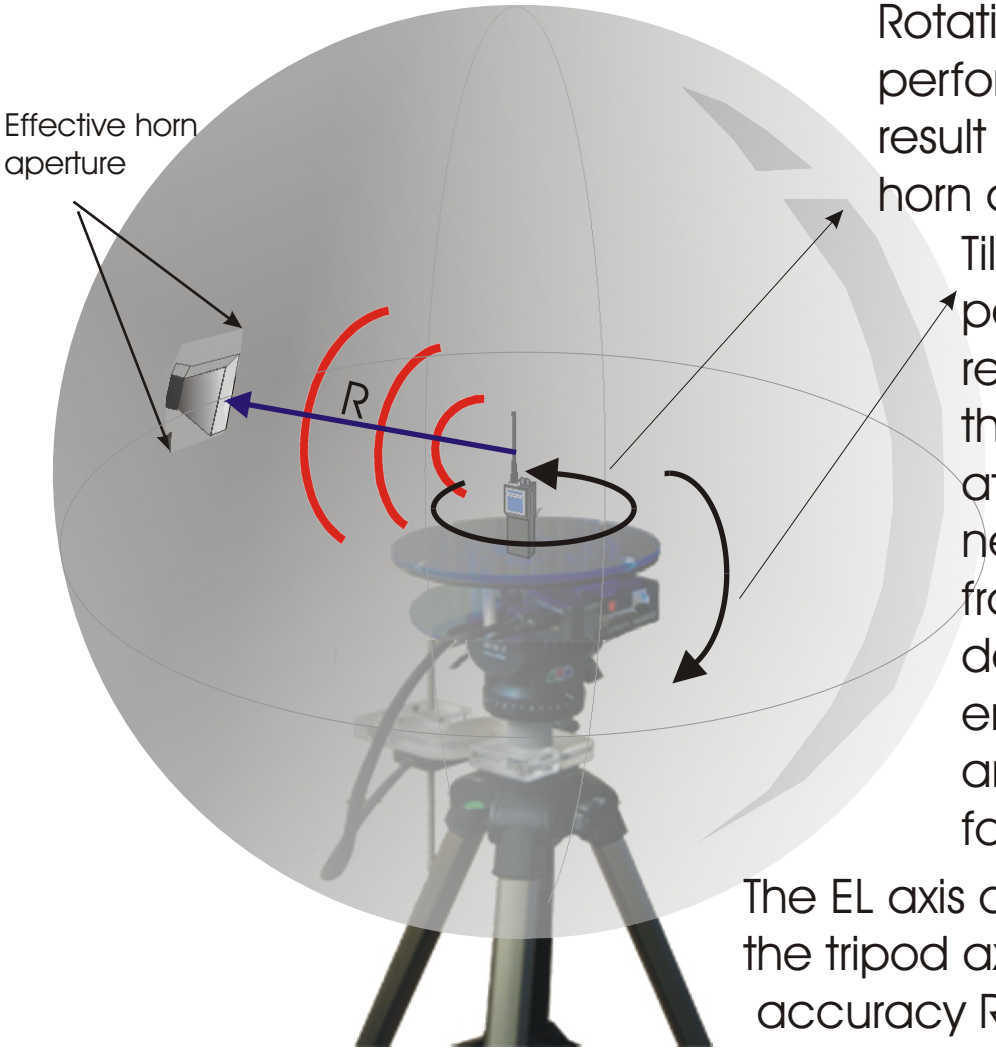
Making Great Circle Cuts For Spherical Antenna Plotting. Gain And Beam Width Measurements With The DAMs

Diamond Engineering

INTRODUCTION This application note shows how to make 3-d spherical measurements and determine the gain and associated Az or EL beam width of your antenna. Actual measurements are made with two identical patch antennas. The method also applies to substitution using a known standard.

If you take enough measurements around an antenna at a fixed radius you can establish the radiation pattern in spherical coordinates. If you know the equivalent receive aperture you can essentially establish the antenna efficiency. The DAMs provides an easy to use Scan function. The scan function can provide the former spherical plot. The efficiency is a much more complicated matter beyond the scope of this system.
The figure below shows the scan concept. A receive horn is used to measure the Tx power at a radius R from the phase center of the AUT(antenna under test).



Rotating the platform performs the same result as moving the horn at radius R.

Tilting the platform performs the same result as changing the horn elevation at radius R. It is only necessary to move from -90 to +90 degrees to scan the entire antenna provided an Az= 0 to 360 is done for each EL movement.

The EL axis of rotation is offset by the tripod axis. For EL measurement accuracy $R >> \lambda$.

Scan Summary

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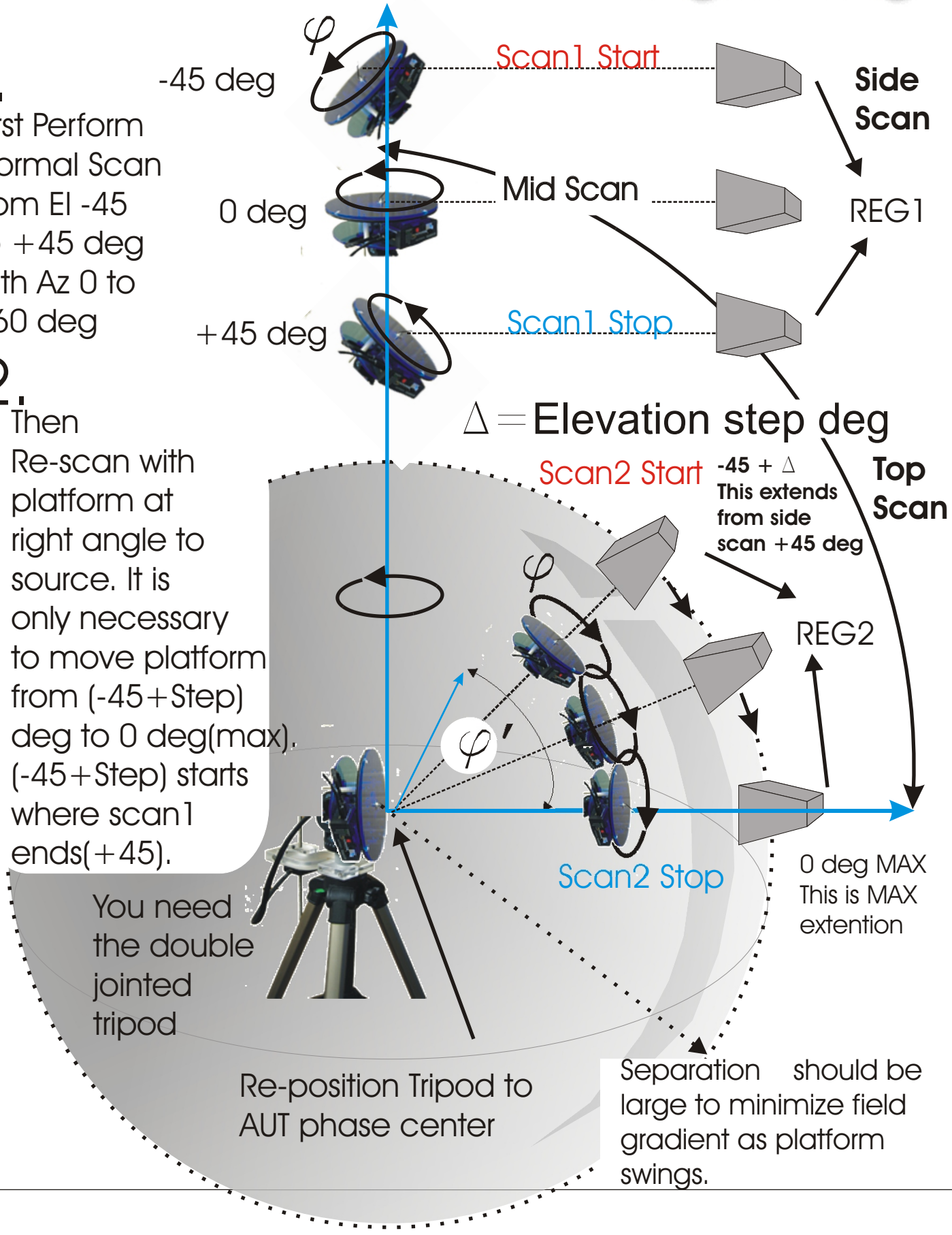
1. First Perform Normal Scan from El -45 to +45 deg with Az 0 to 360 deg

2. Then Re-scan with platform at right angle to source. It is only necessary to move platform from (-45+Step) deg to 0 deg(max). (-45+Step) starts where scan1 ends(+45).



Step by Step Procedure For Scanning Your Antenna.
SIDE SCAN

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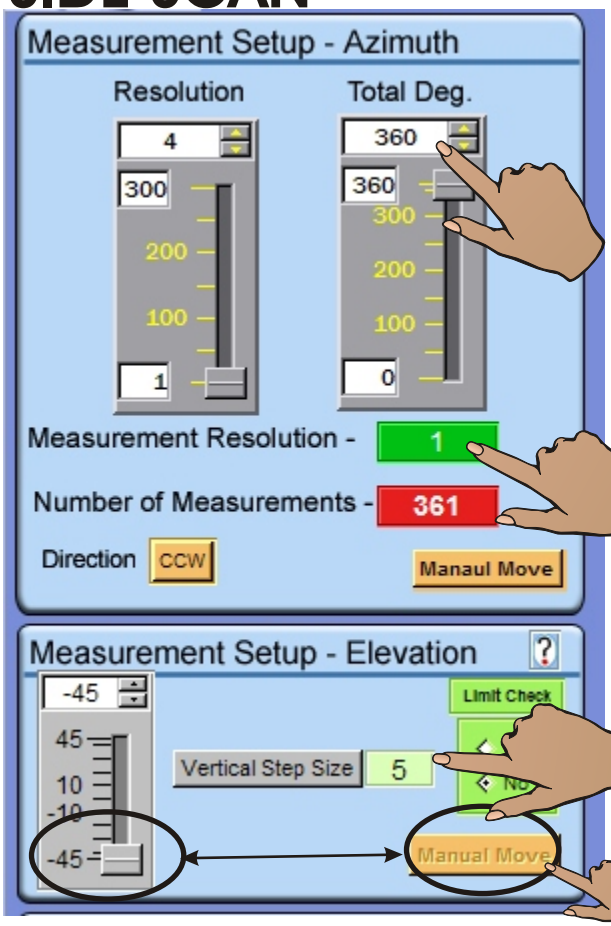


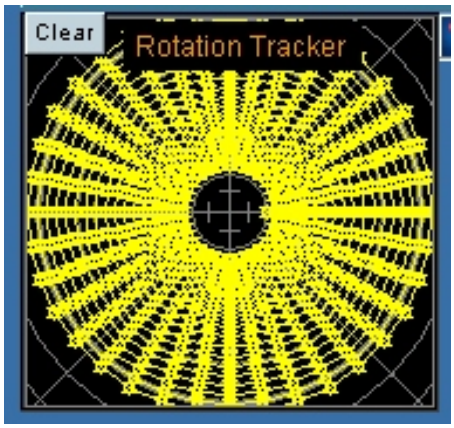
Set the Az rotation to 360 deg and the resolution to 1 degree. The DAMs will make a frequency sweep every 1 degree.

You may want to use less resolution until you master the process.

Recommend settings

Set the Vertical (EL) step size to 5 degrees and move the platform to -45 degrees.

Invoke the Scan function. The scan V-H button will stay depressed until the measurements are complete.



When the measurements are complete the tracker and platform will be as shown left.

Save Side Scan Data To REG1

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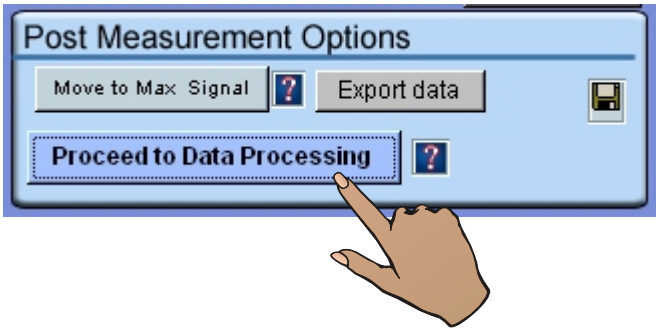
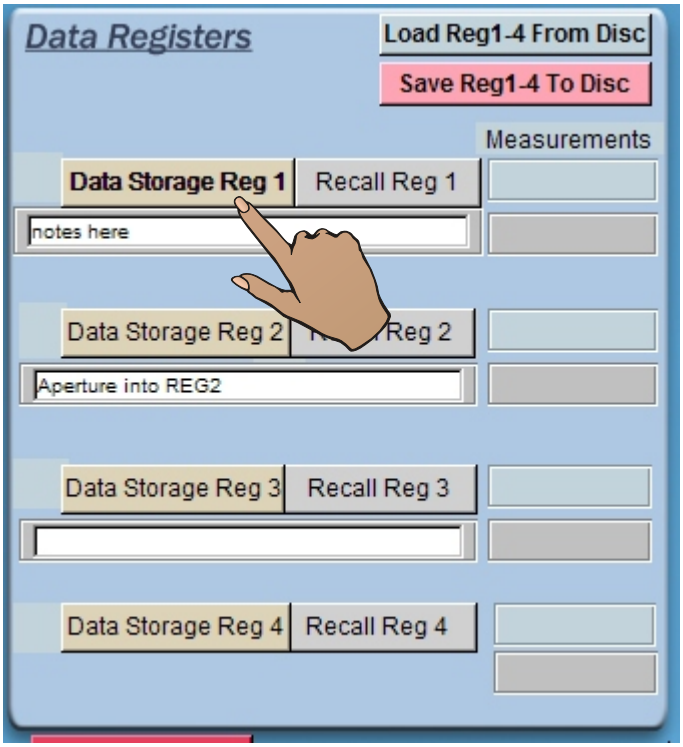
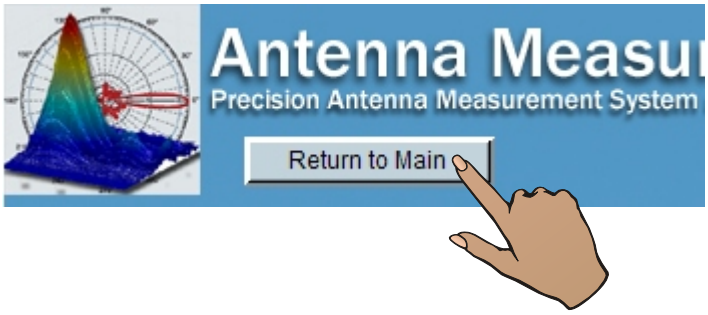


Proceed to Data Processing for storing the scan data



Save the scan data to REG1. The merge function will use REG1 and REG2 to combine side and top scan



Return to the measurement menu to make the top scan

Reset The Accumulator And Set Up For Top Scan

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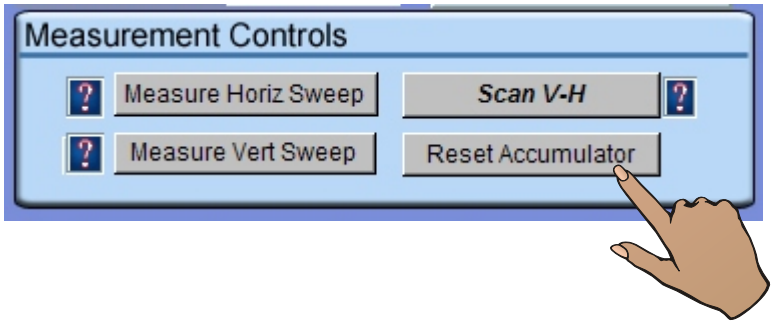
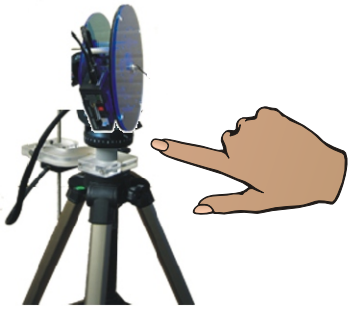
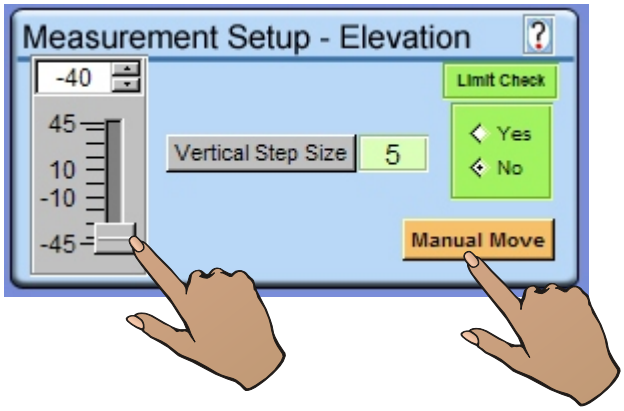


Reset the data accumulator to prepare for the top scan

Level the platform to zero degrees



Tilt the double jointed tripod to -90 degrees and reposition the tripod so that the original antenna under test phase center is maintained



Position the platform to -40 deg using the slider or the constant and "Manual Move"

Note the position is 5 deg less than the start for the side scan. This is necessary to prevent overlap.

Initiate Top Scan

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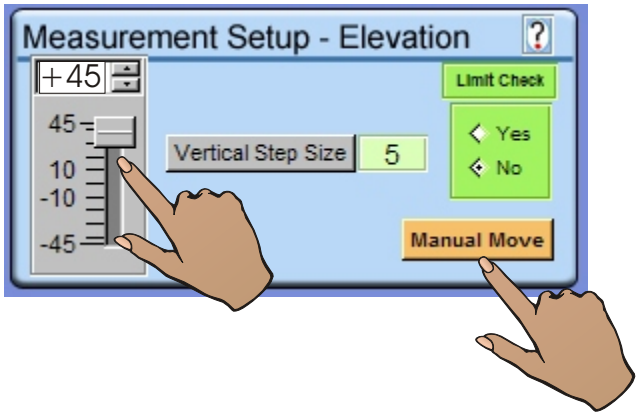
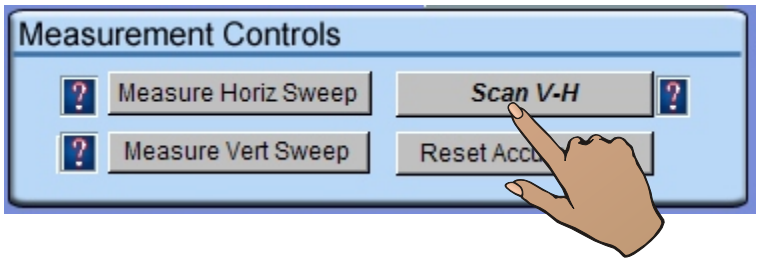
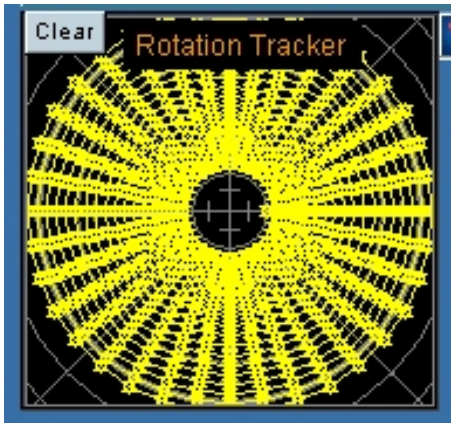


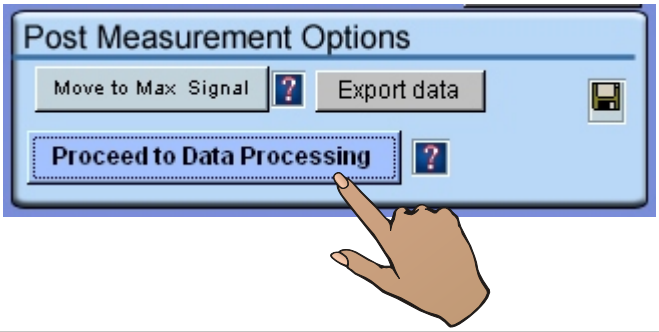
Set the Elevation slider to +40 deg. but do not move the platform. The platform will step to +45 deg during the Scan. Note that TOP SCAN stop = +45 deg is past the top of the top of the antenna. It is only necessary to end at 0 deg.



Begin the side scan



When the measurements are complete the tracker and platform will be as shown left.



Proceed to Data Processing for storing the scan data

Save Top Scan to REG2

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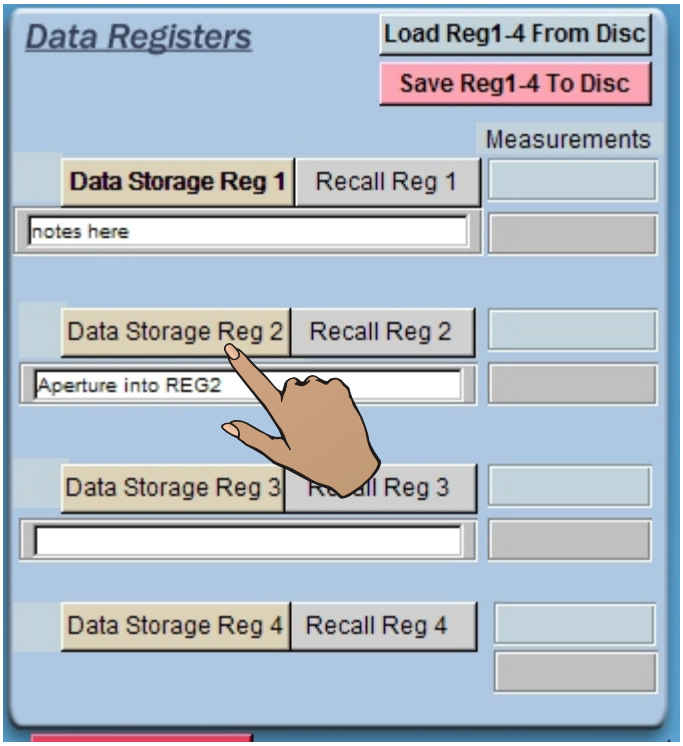
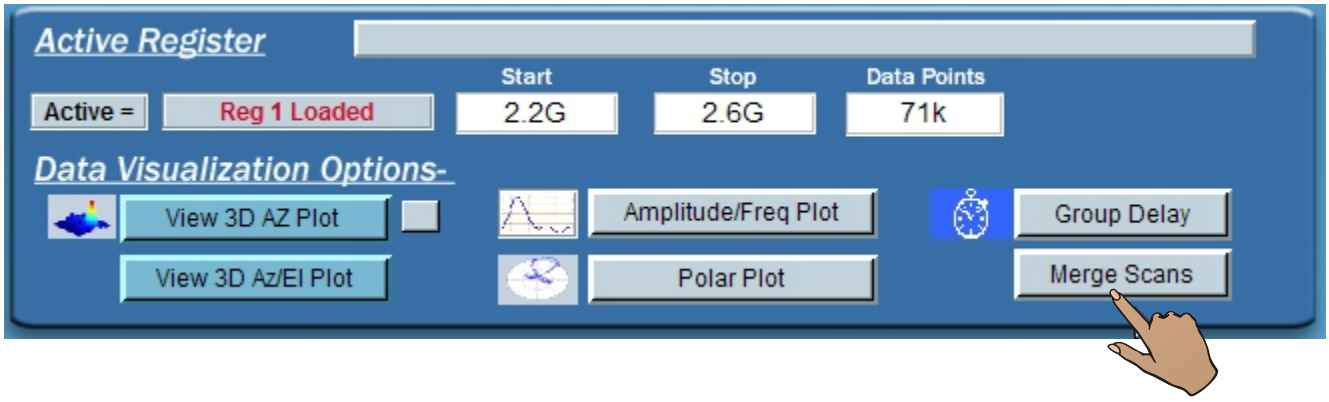
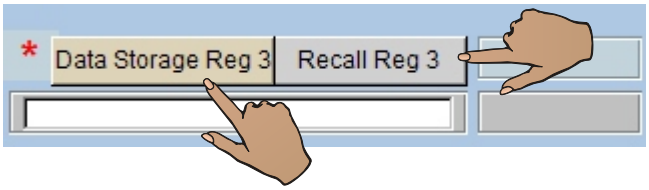


Save the scan data to REG2. Note that it is necessary to have the side scan in REG1 and the Top scan in REG2.

You may want to save the REGs to the disc for future use or data loss prevention.

Now the Merge Scans may be invoked. Merge Scan will combine the side scan and top scan into a single measurement array. When completed the data must be saved to a REG before it can be used. Recall the REG to load REG0.





Merge Scans And Save to REG3

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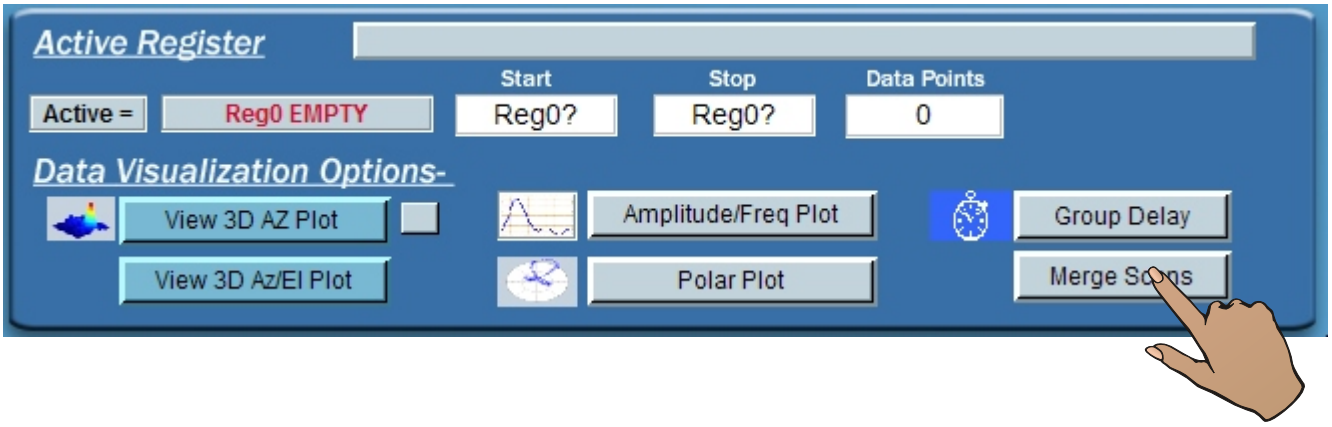
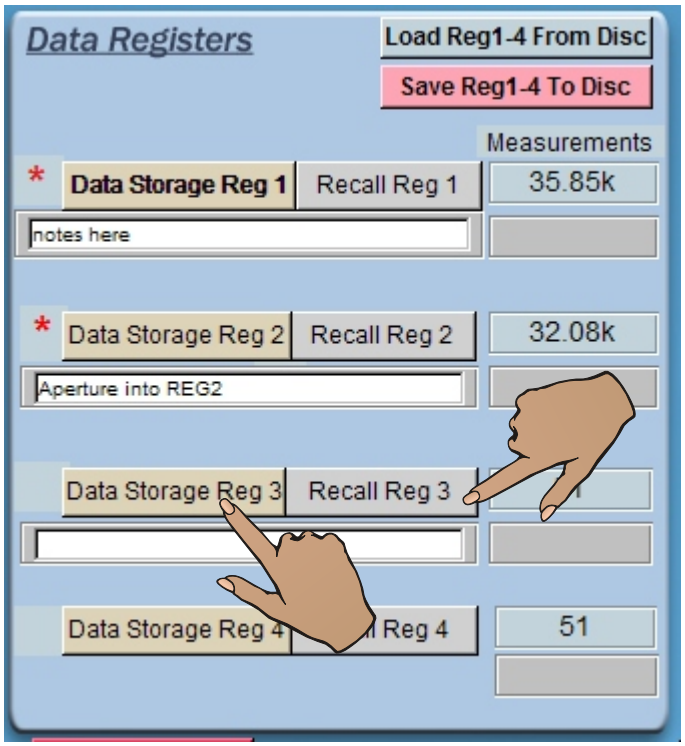
Now that he side scan resides in REG and the top scan resides in REG2 merge the scans. This can take several seconds depending on the array size. The scan button will remain pressed until the process is complete.





IMPORTANT
Be sure to save the merge into a REG. To load the active REG(0) Recall your reg. The data will appear in the calculator display windows.

Invoke the 3-d AZ-EL module

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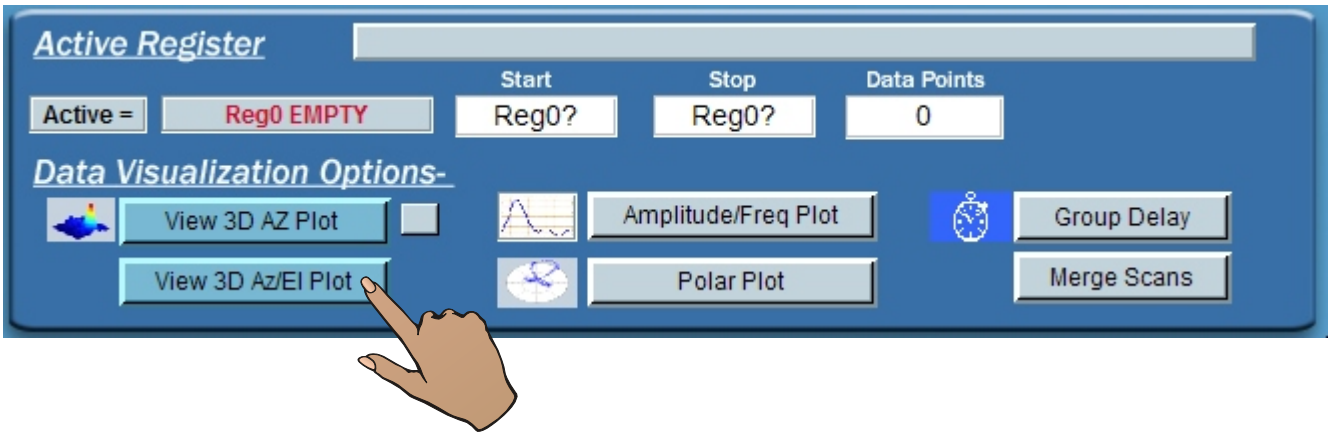

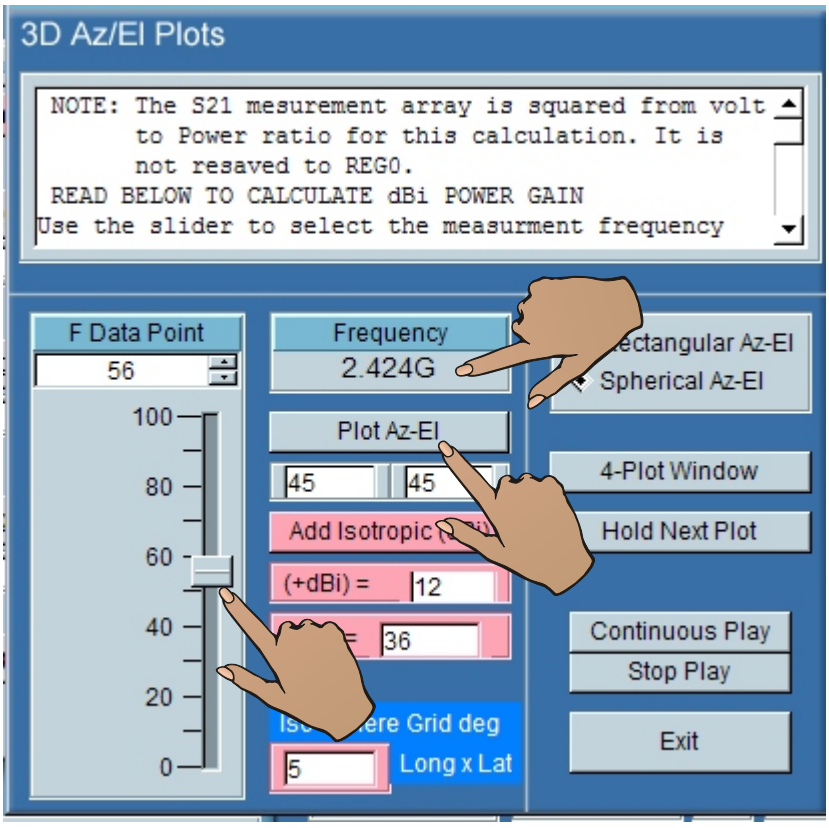

The AZ-EL plotting menu will appear. Slide the frequency slider to the desired frequency and invoke Plot Az-EL

Plot The Spherical Profile

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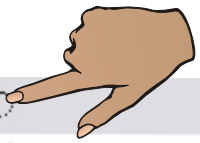
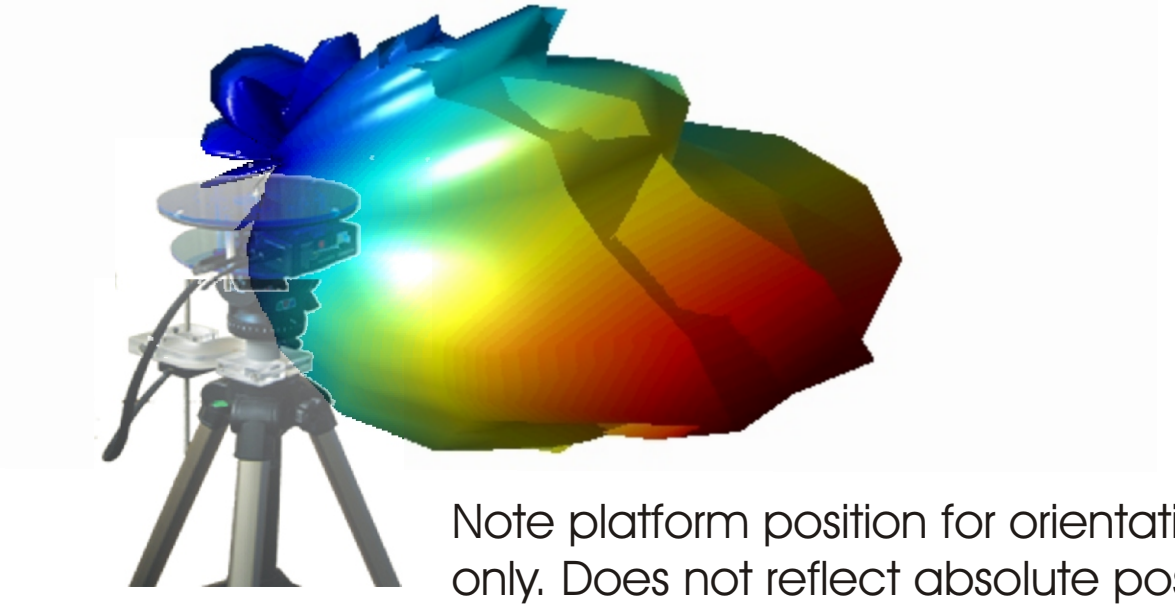


Spherical Profile. Rho,Az,El(0,0,0) is center of plot

Note the orientation of the plot relative to the platform. Rotate the plot to explore different view points.



Note platform position for orientation only. Does not reflect absolute position

IMPORTANT: The VNA measurement array scale is linear S21. The spherical Plot module uses S21 ^ 2 (power ratio).

Add an Iso Sphere

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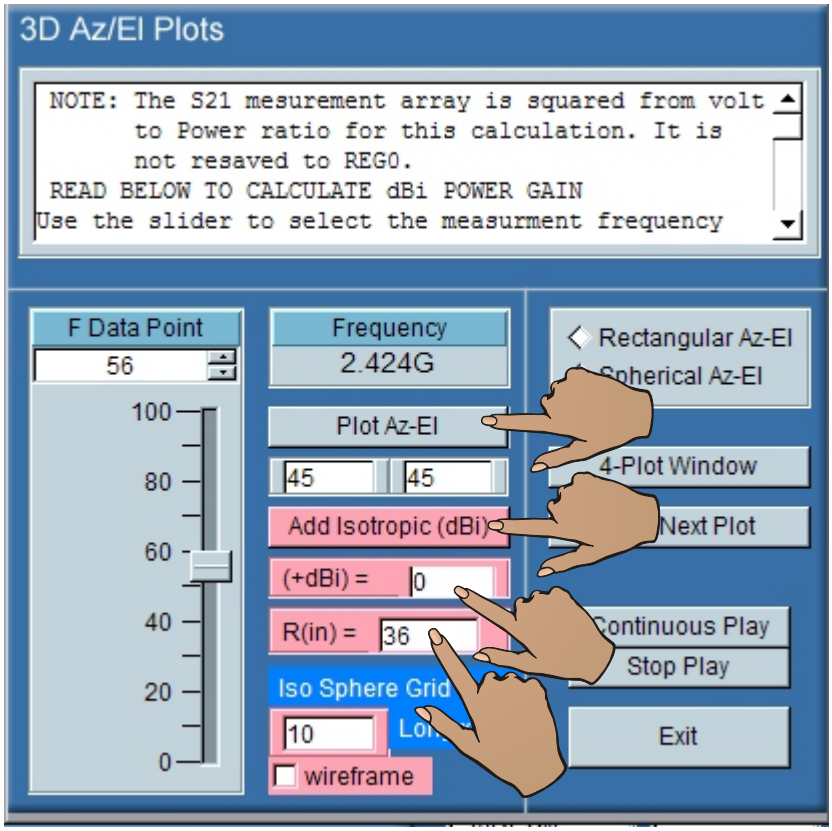
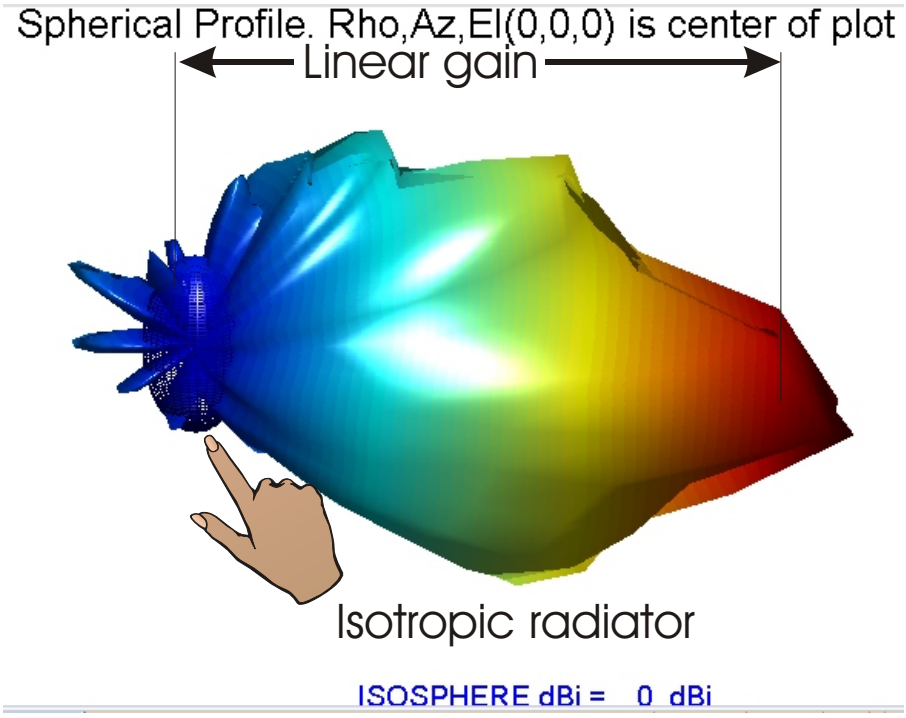


Generate an isotropic sphere by entering the antenna separation and the sphere gain 0 dBi. Depress Add Isotropic (dBi) and re-plot previous



Examples of using the isosphere to determine the gain and associated beamwidth

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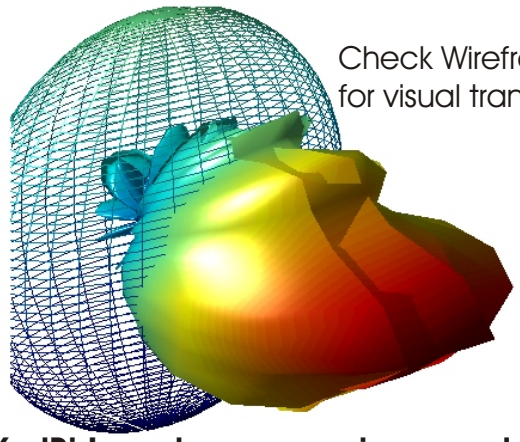
Spherical Profile. Rho,Az,El(0,0,0) is center of plot

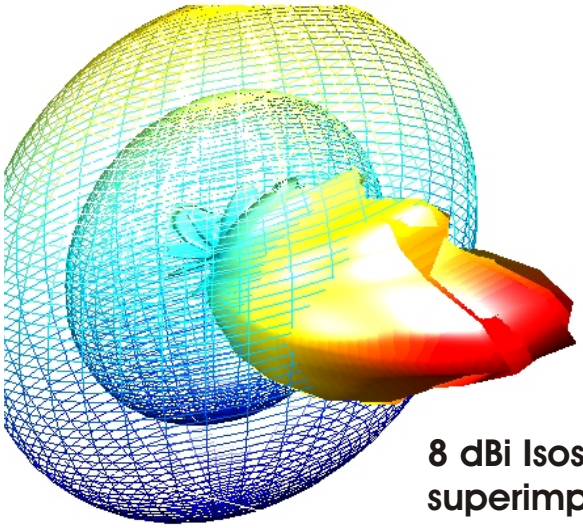


Check Wireframe for visual transparency

6 dBi Isosphere superimposed over linear S21 ^ 2 patch antenna

ISOSPHERE dBi = 6 dBi

Spherical Profile. Rho,Az,El(0,0,0) is center of plot

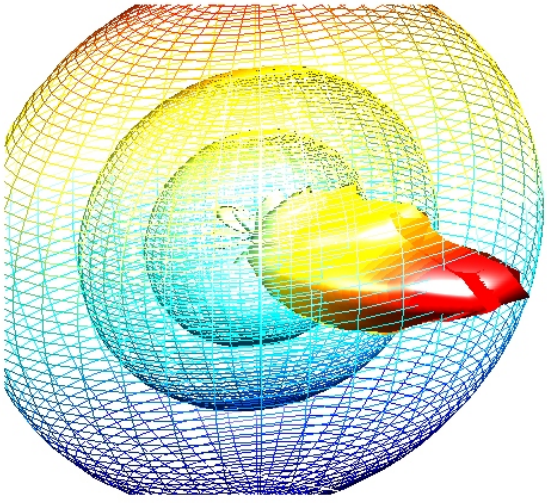


ISOSPHERE dBi = 8 dBi

8 dBi Isosphere superimposed over linear S21 ^ 2 patch antenna

Set the Isosphere latitude longitude grid, rotate the plot peak perpendicular to view beamwidths.

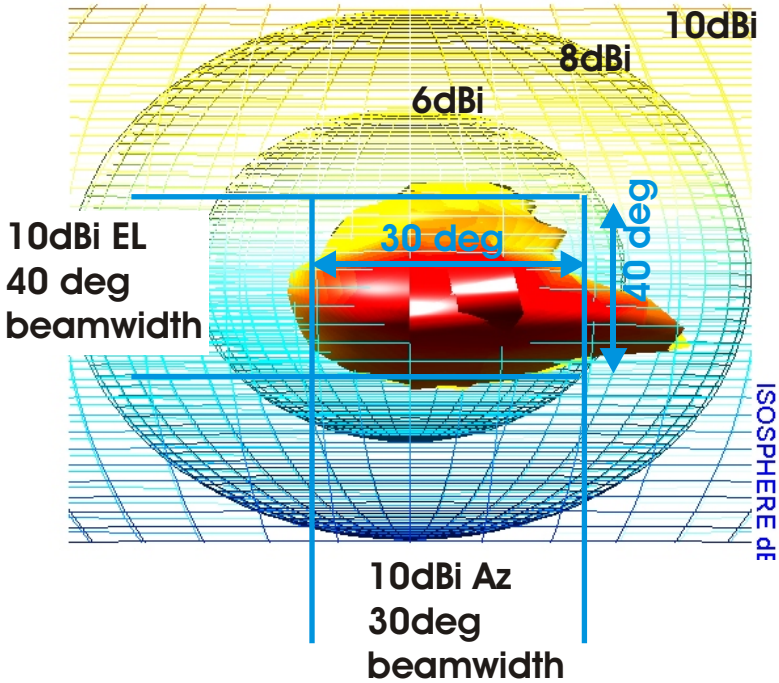
Spherical Profile. Rho,Az,El(0,0,0) is center of plot



ISOSPHERE dBi = 10 dBi

10 dBi Isosphere superimposed over linear S21 ^ 2 patch antenna

Spherical Profile. Rho,Az,El(0,0,0) is center of plot



Uncheck isosphere wireframe and view the 10dBi gain and associated beamwidth

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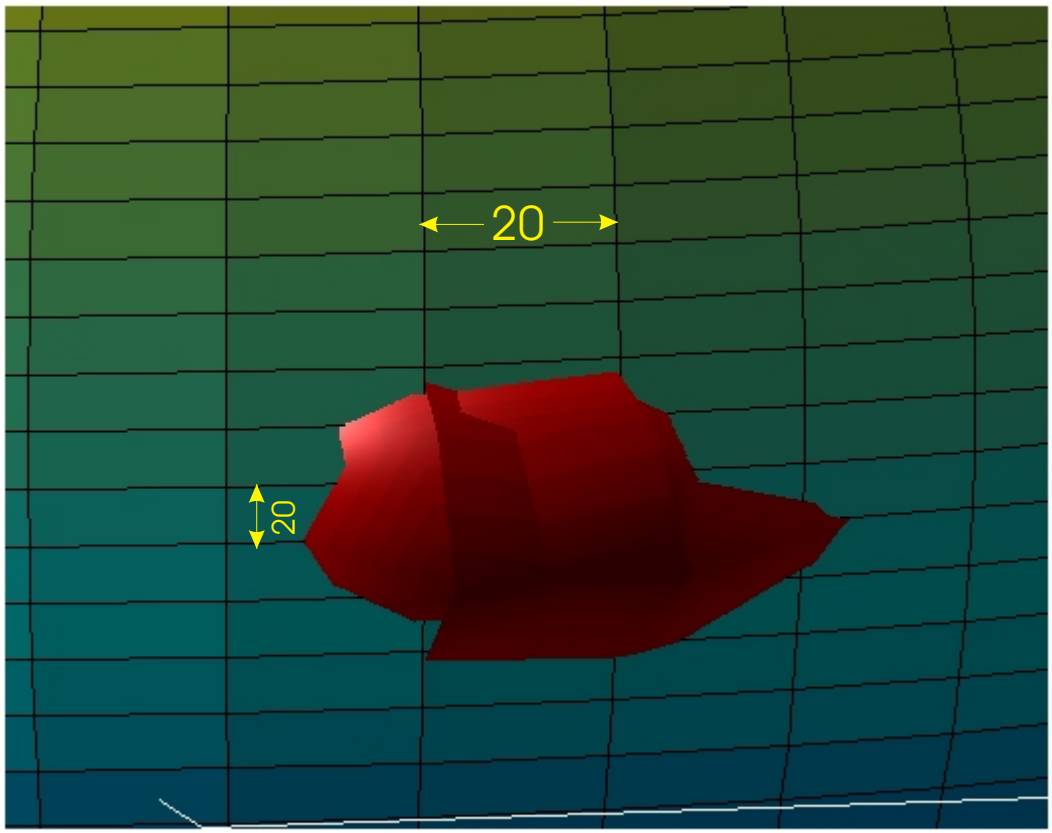
Spherical Profile. Rho,Az,El(0,0,0) is center of pl



: dBi = 10 dBi

Projecting The Scan Array on To The Measurement Sphere

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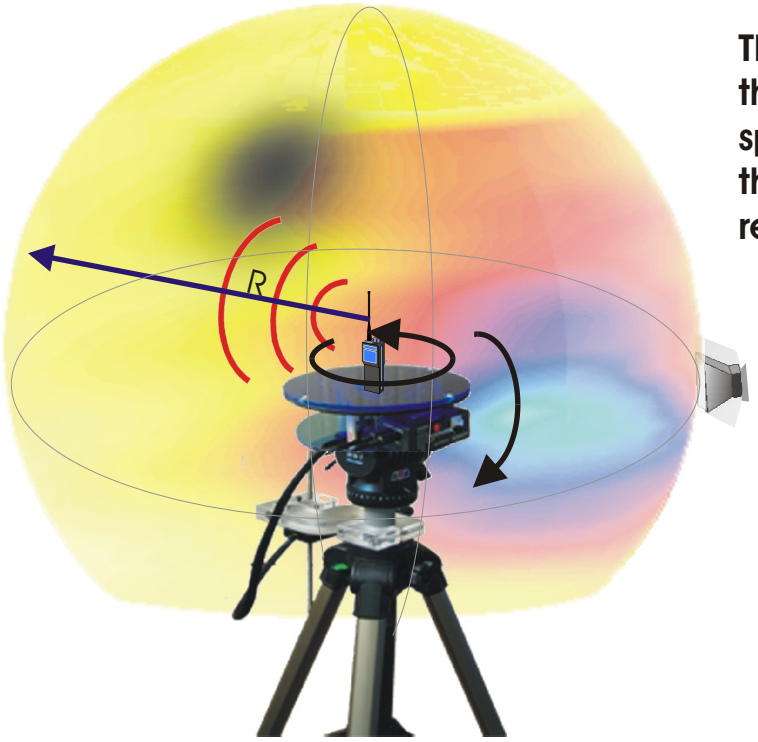
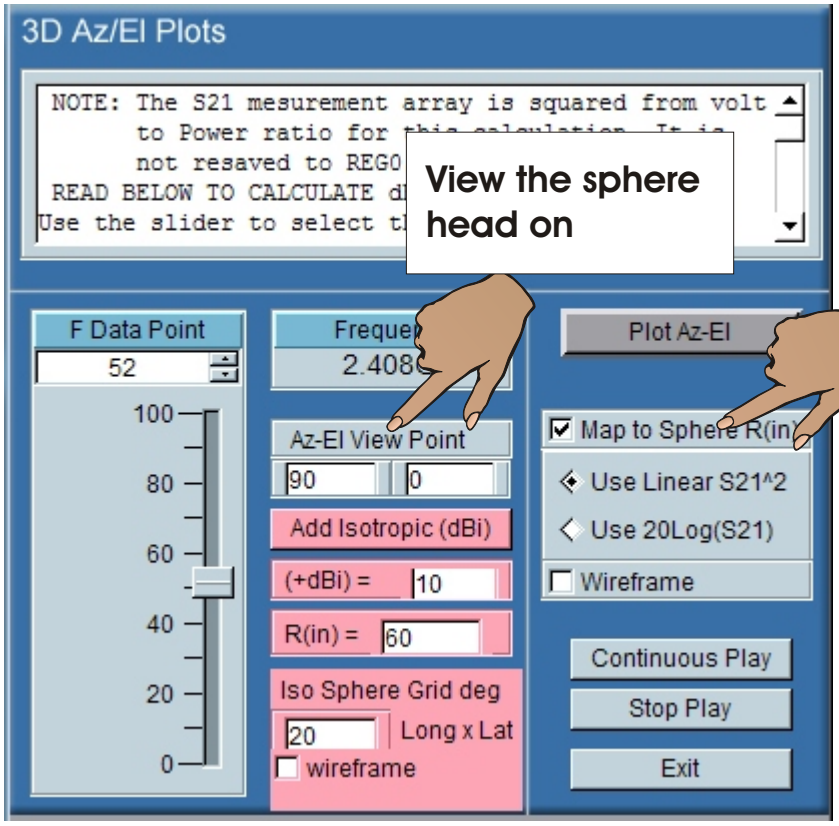
Perform a complete scan



The Map To Sphere feature projects the S21 ^ 2 response on to the unit sphere. This is useful for determining the beam width for any level relative to the maximum.

Measurement Antenna



Be sure you have scan data in REG0.
Check the Map to Sphere

Projecting The Scan Array on To The Measurement Sphere

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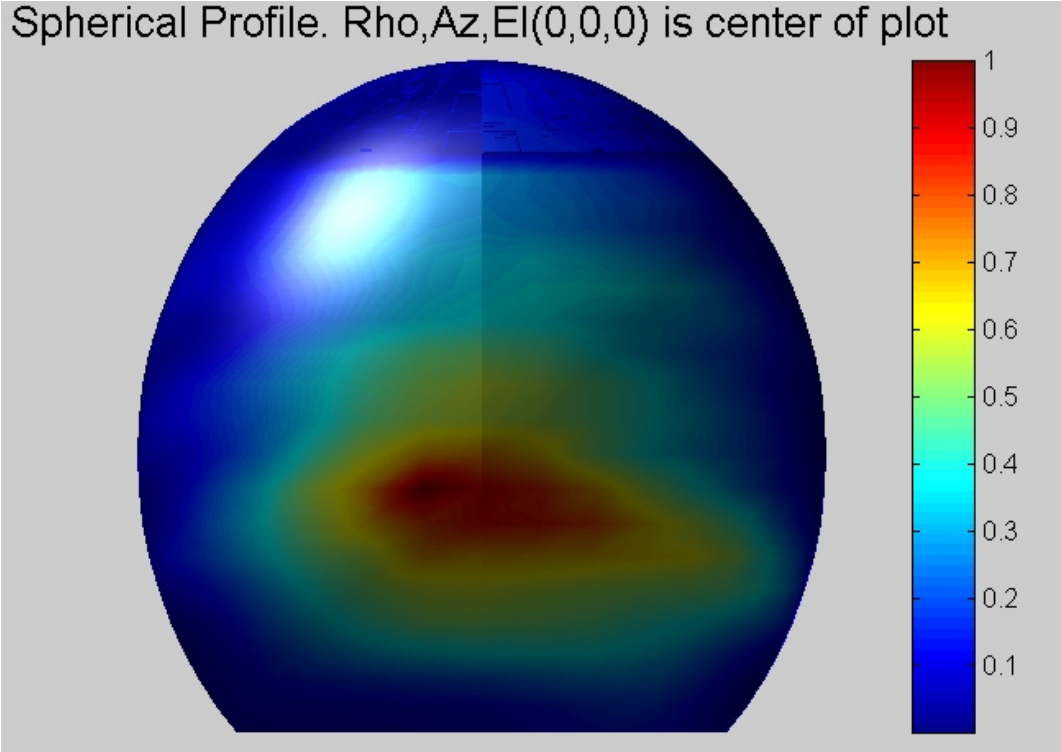
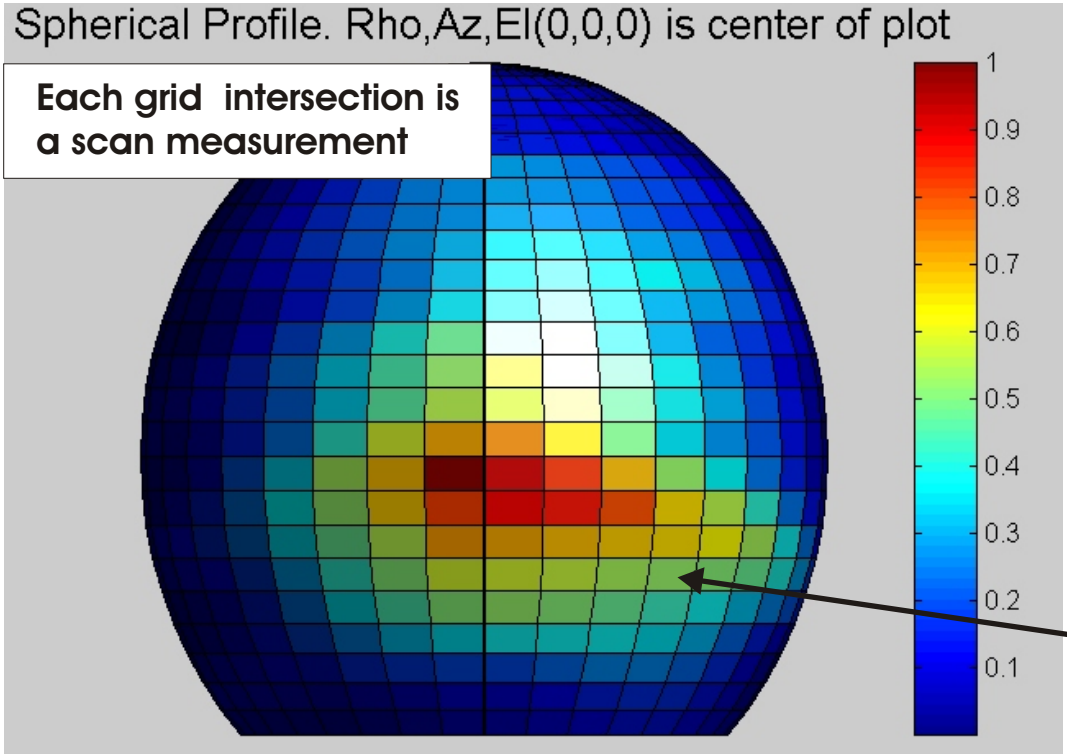
Linear data array projection on to the S21 ^ 2 unit sphere





Check the Wireframe option to view the response against the measurement profile.

NOTE: The Latitude grid = Az resolution

The Longitude grid = El resolution

The green area represents the 3dB beamwidth

Projecting The Scan Array on To The Measurement Sphere

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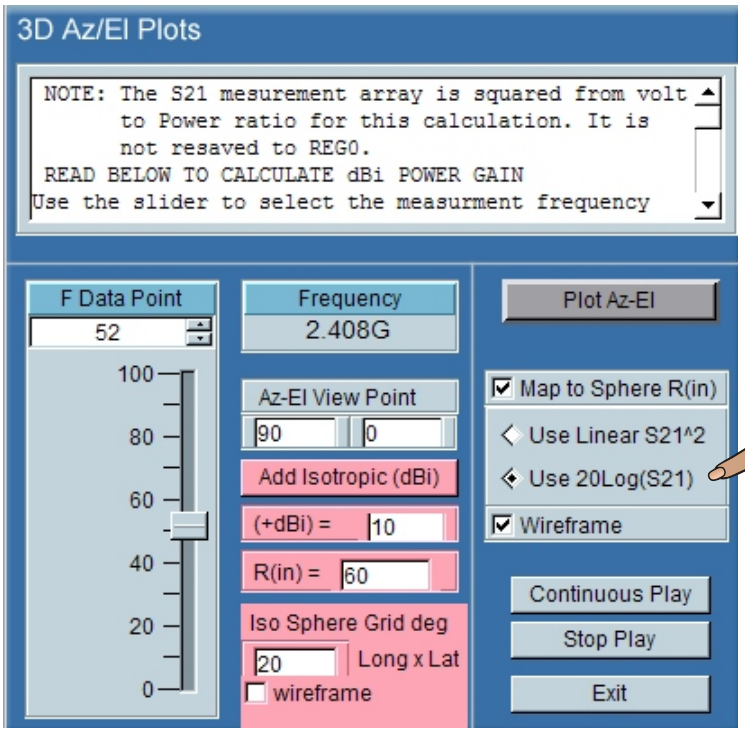
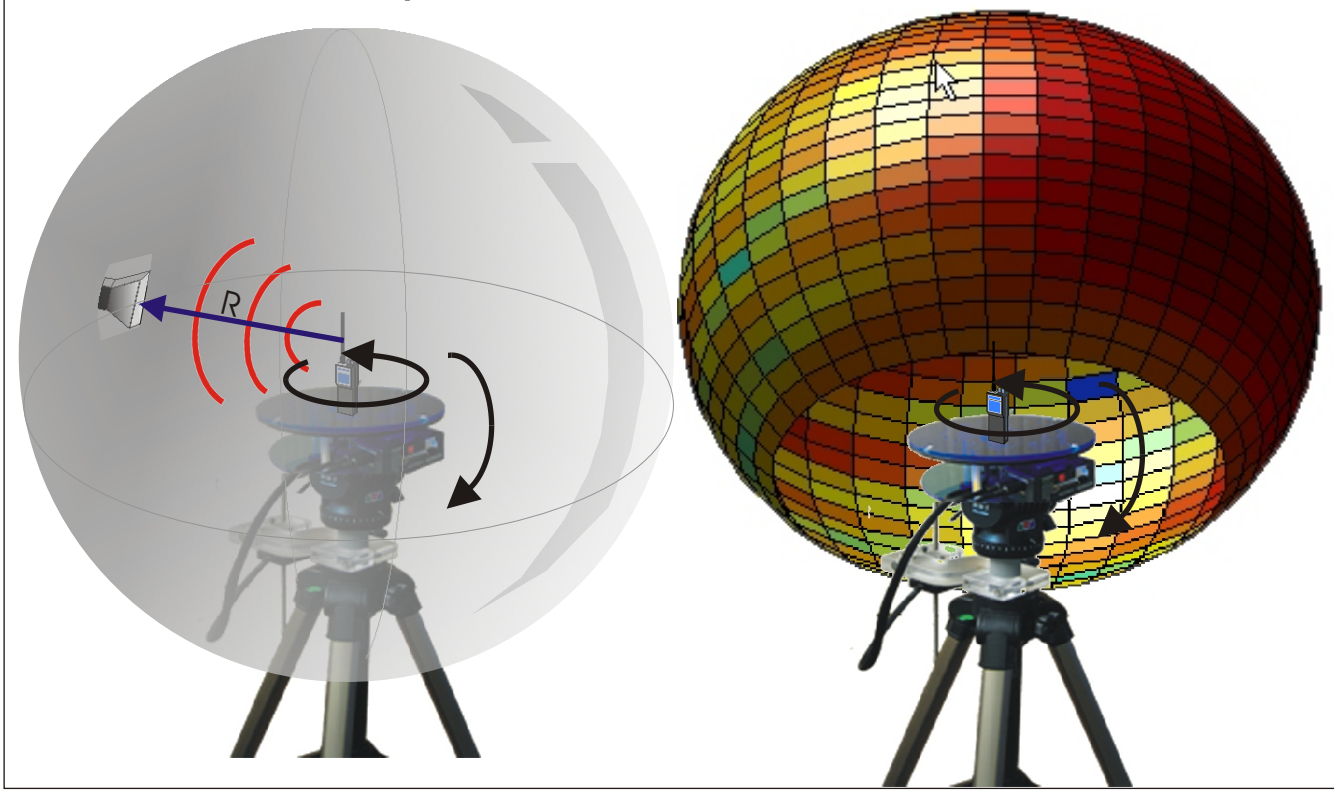


You can project the Log response by checking the Use 20Log(S21). It is actually 20Log(S21/S21max)

20Log(S21/S21max)

The figure below shows the equivalence of the projection and the measurement. The color bar is 20Log(S21). The projection sphere has be rotated up to view the adjacent side and show the platform orientation.



Projecting The Scan Array on To The Measurement Sphere

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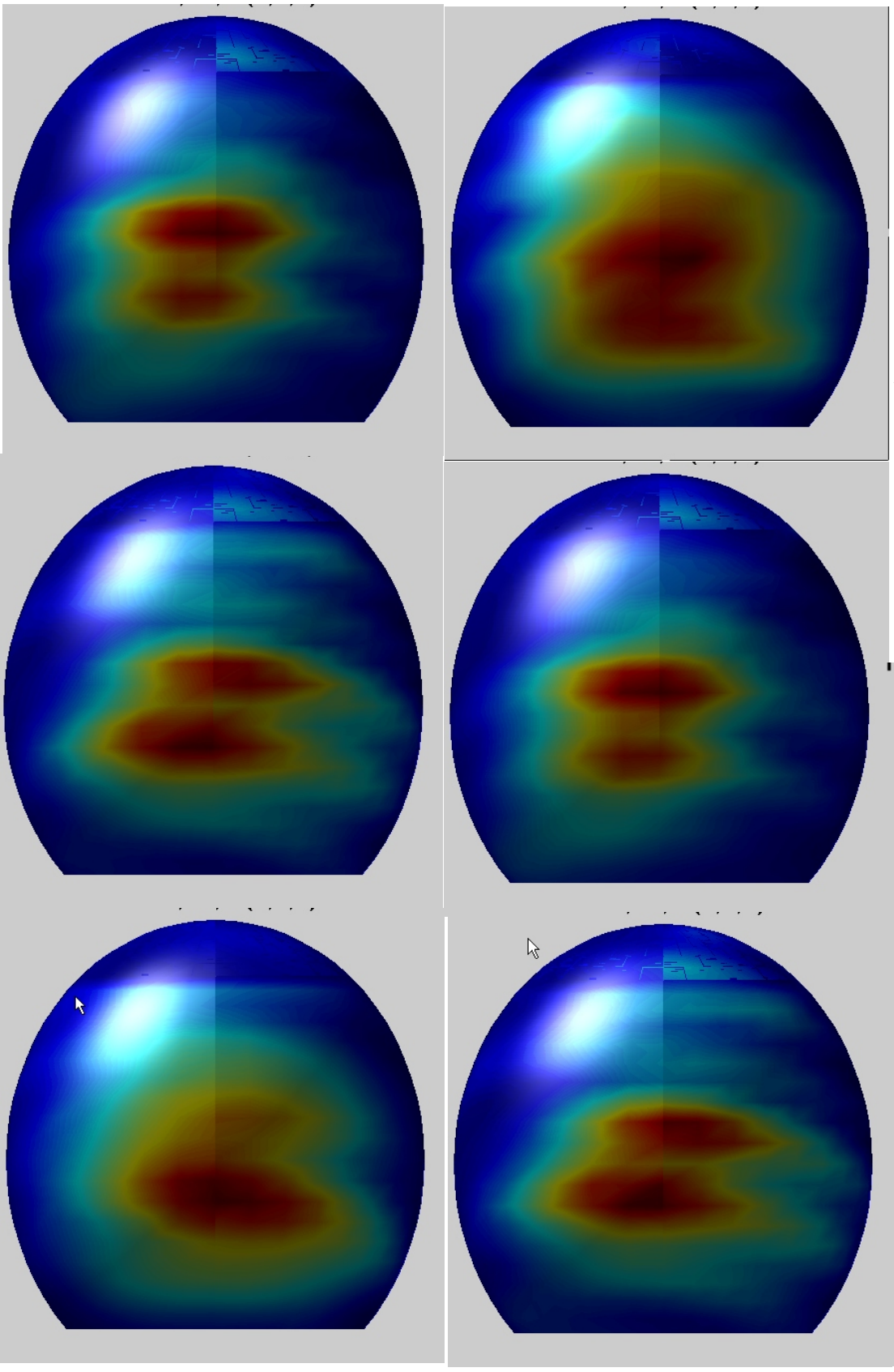

You can play any plot through the frequency array and view the highest gain or best beam width

Actual measurements of a patch antenna made by combining a top scan and a side scan and processed using the Merge Scan feature