Aspects of Achieving 10 v/m Field Uniformity over 1-6GHz with Single, Multiple and Cassegrain Antennas

Tom Mullineaux

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EN61000-4-3 Edition 3
1-6 GHz, 10 volts/meter @ 3 meters

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HEALTH WARNING

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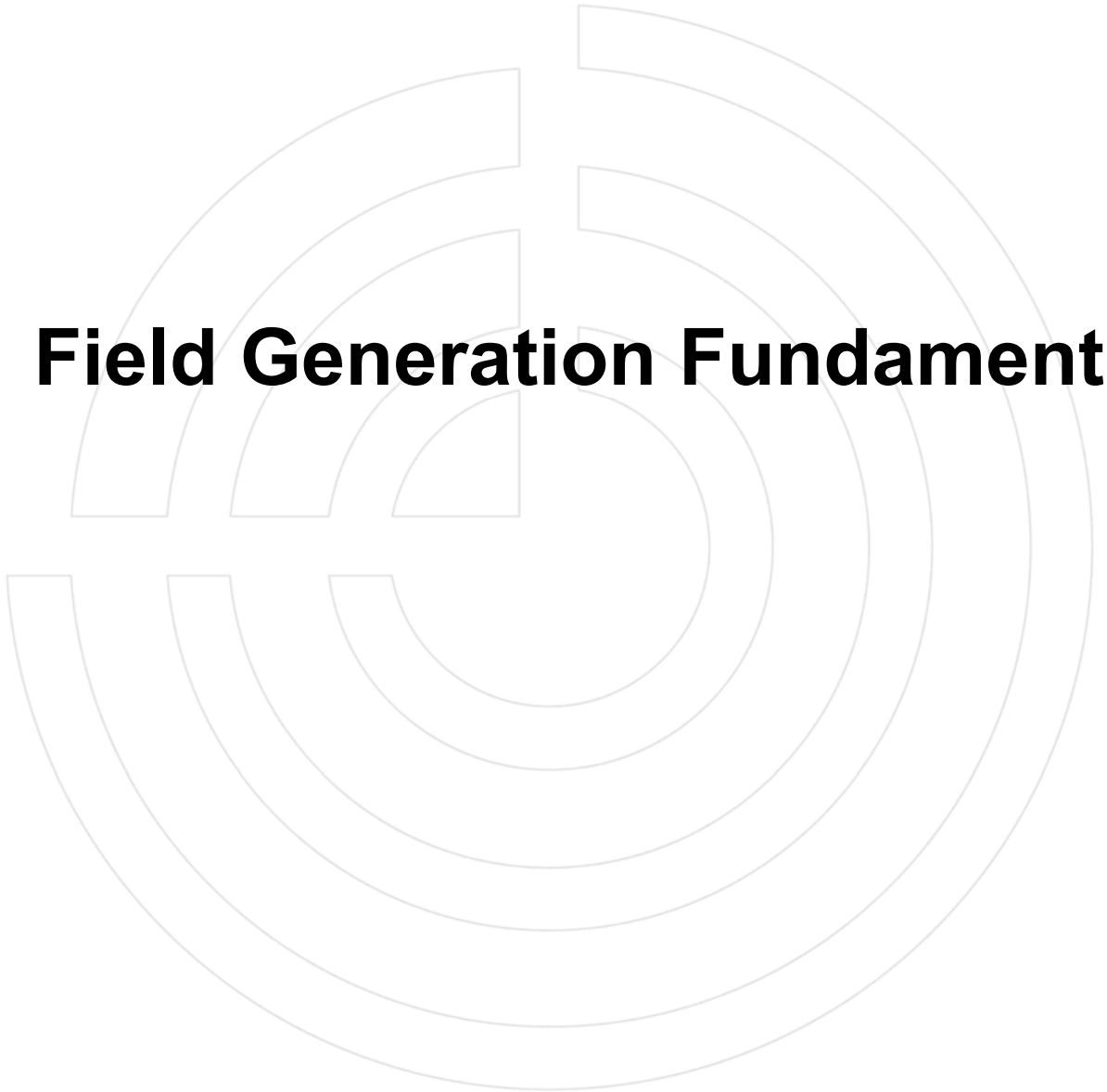
Field Generation Fundamentals



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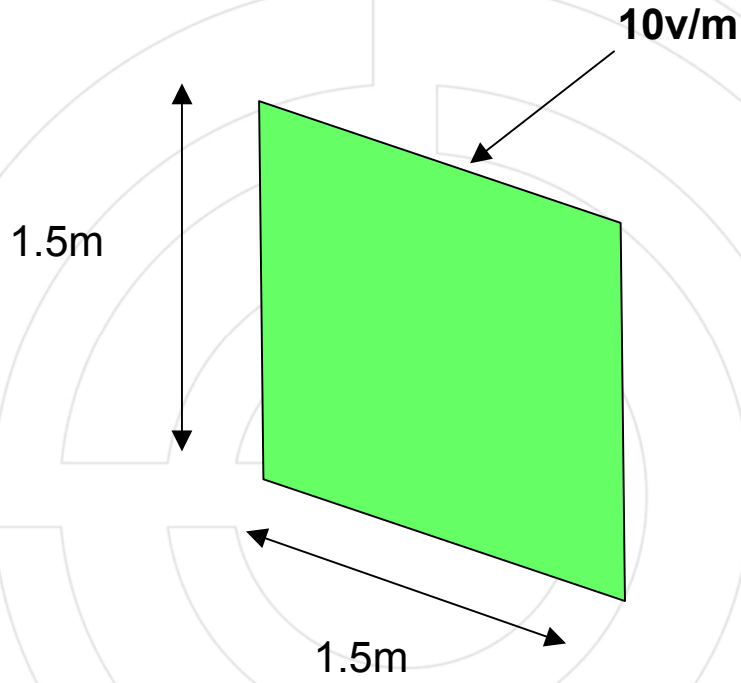
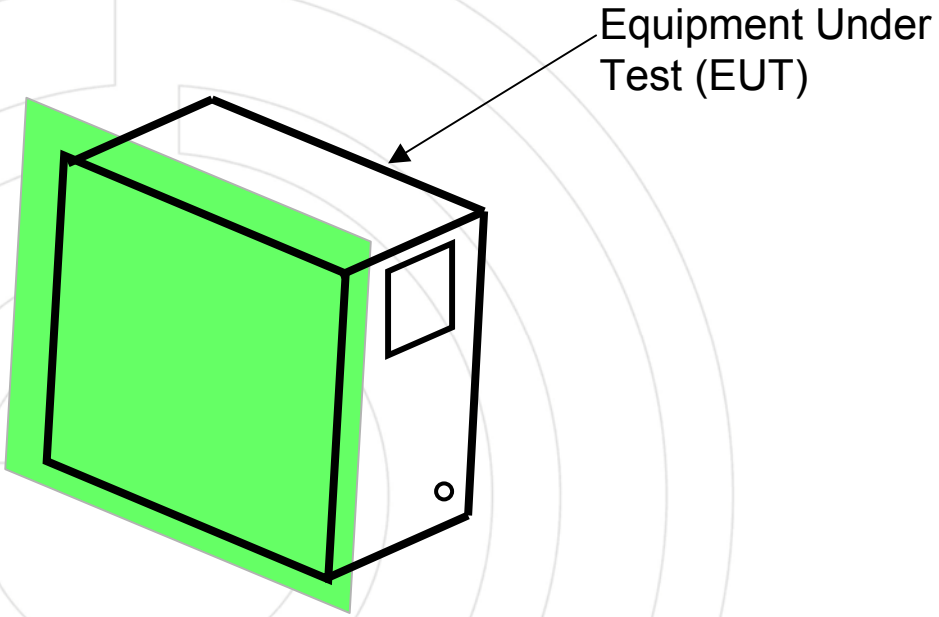


Test Field of a Prescribed Field Strength Across a Defined Plane

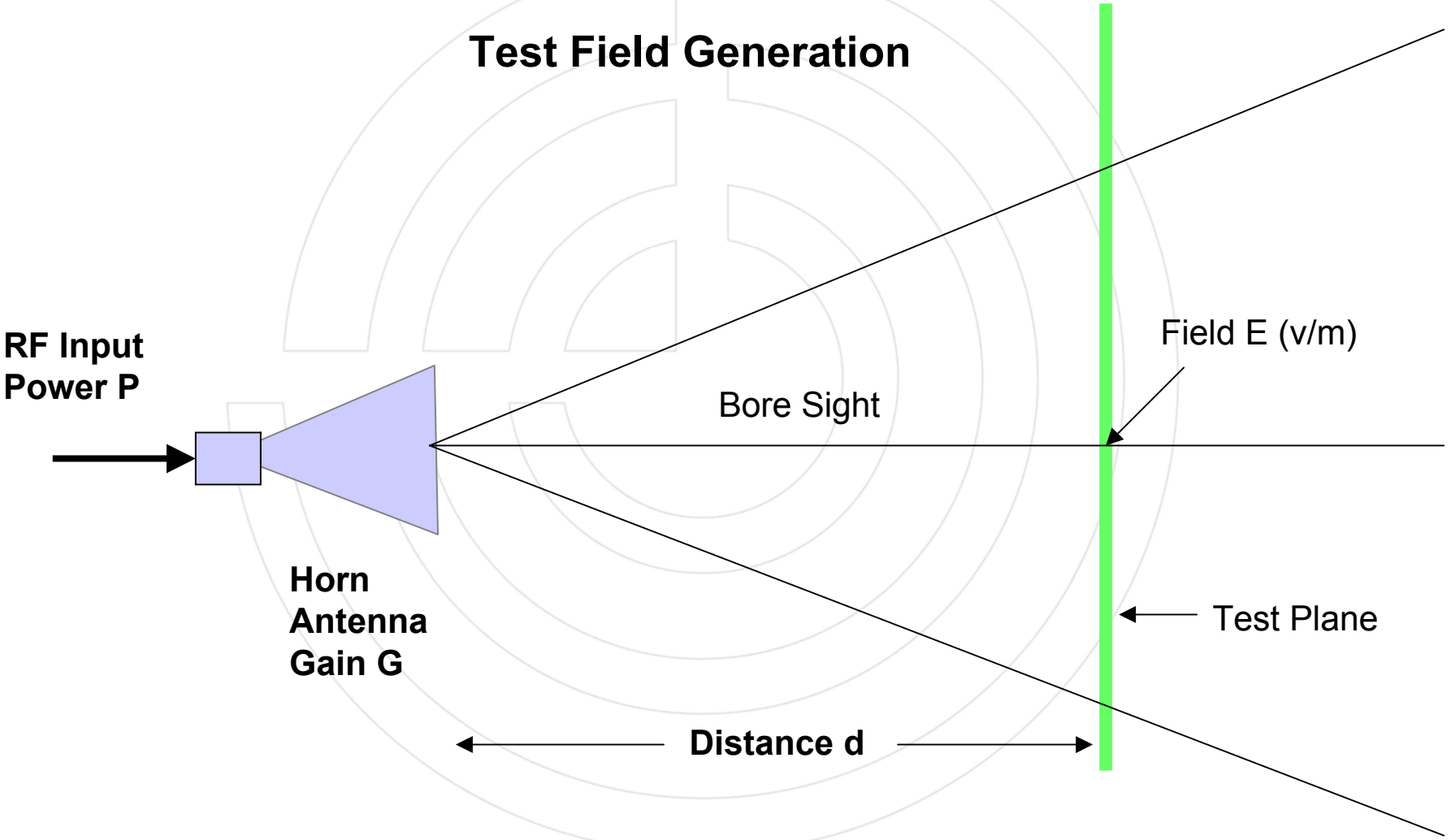


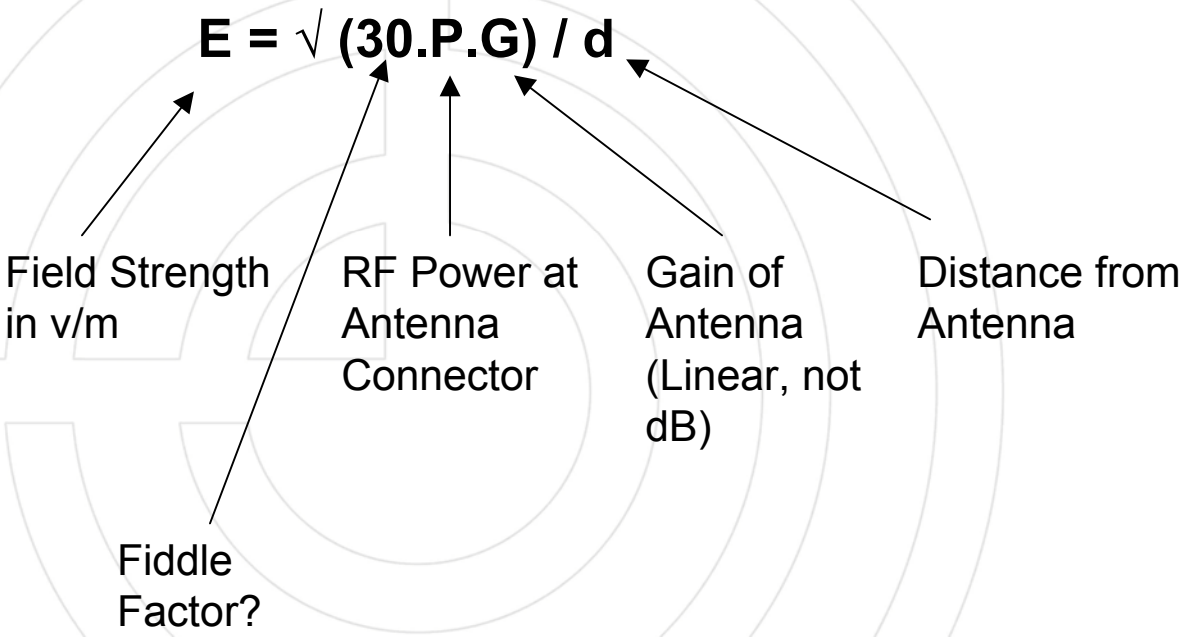
One Face of EUT is Placed at the Plane

EUT Is Monitored for Degradation in Performance when Exposed to Test Field

Repeat for All Faces

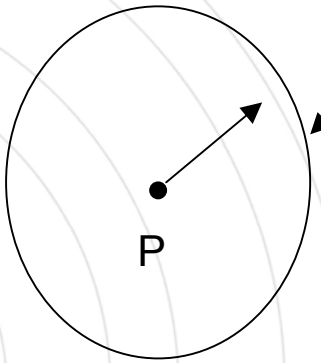
Test Field Generation




E = √ (30.P.G) / d
Field Strength in v/m
RF Power at Antenna Connector
Gain of Antenna (Linear, not dB)
Distance from Antenna
Fiddle Factor?

Area of Sphere

$4\pi R^2$



$$S = P/4\pi R^2$$

Power Density

$$S = E^2/Z_o$$

$$S = E^2/120\pi$$

Impedance of Free Space Z_o is 120π (377 Ohms)

$$P/4\pi R^2 = E^2/120\pi$$

$$E^2 = 120\pi.P / 4\pi R^2$$

$$E^2 = 30.P / R^2$$

$$E = \sqrt{(30.P)} / R$$

$$\boxed{E = \sqrt{(30.P.G)} / d}$$

$$P = d^2E^2 / 30G$$

RF Power at
Antenna
Connector

Implication: Two Times the Gain Means **Half** RF Power is Required

Characteristics of High Gain / Low Gain Antennas

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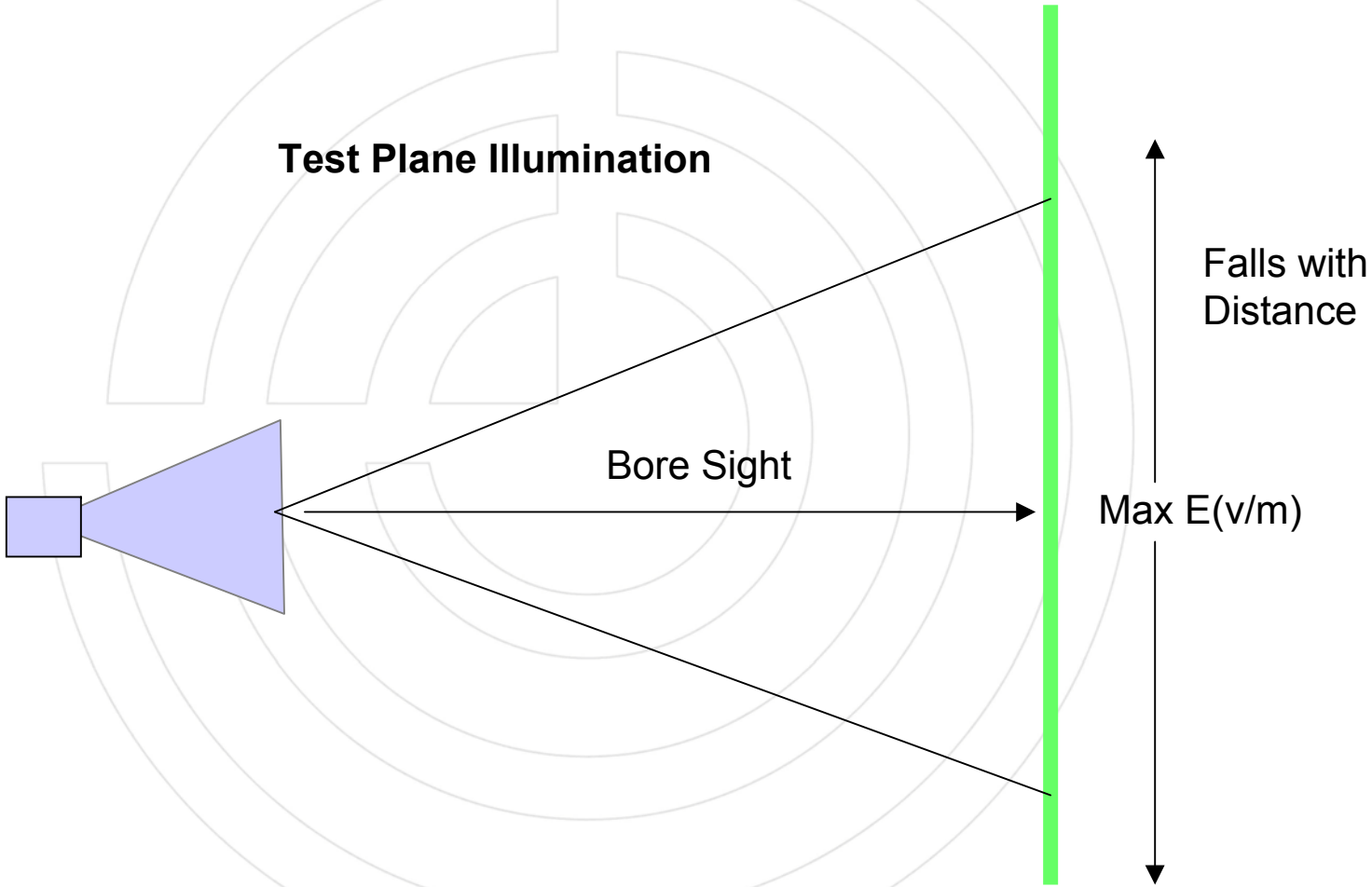
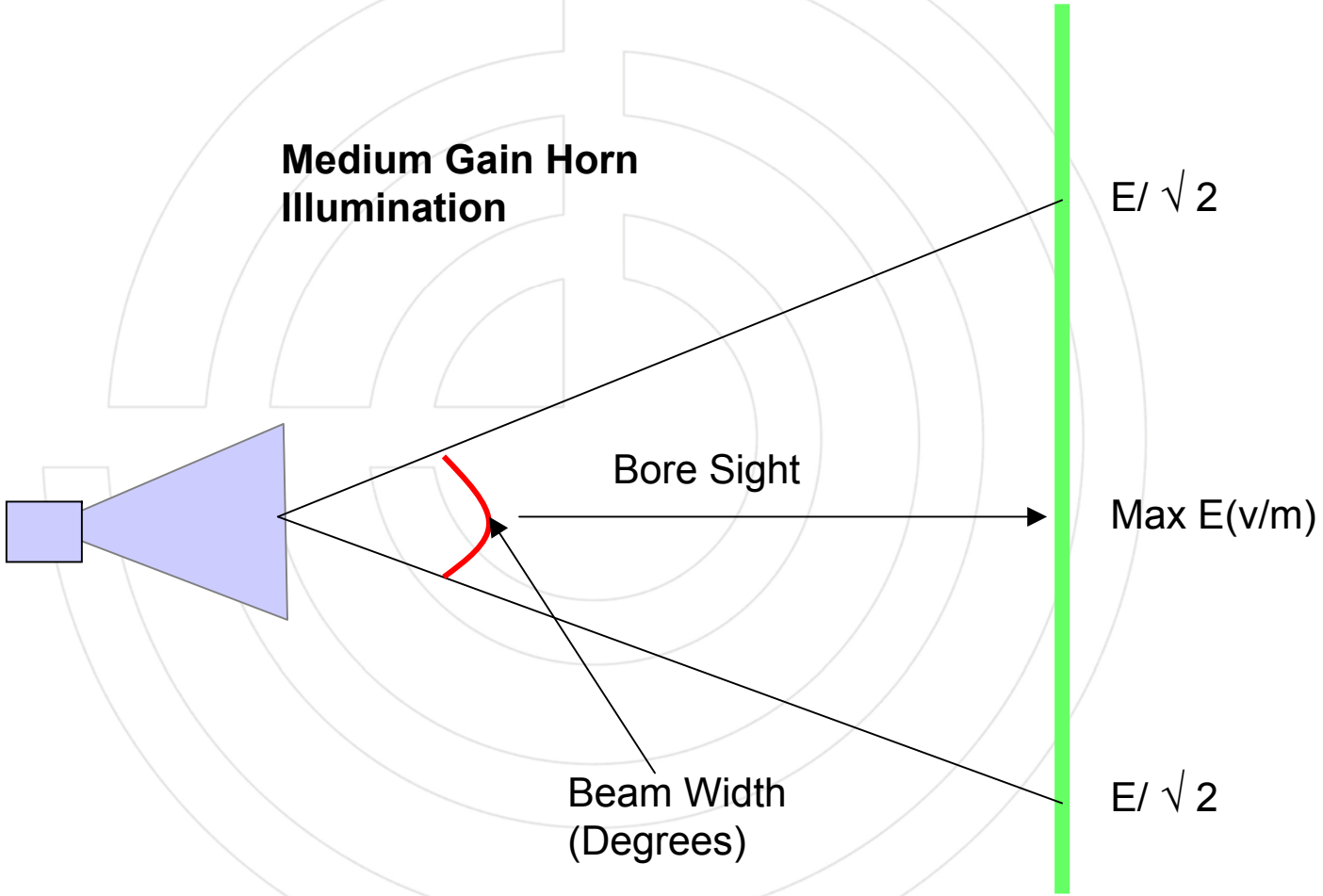
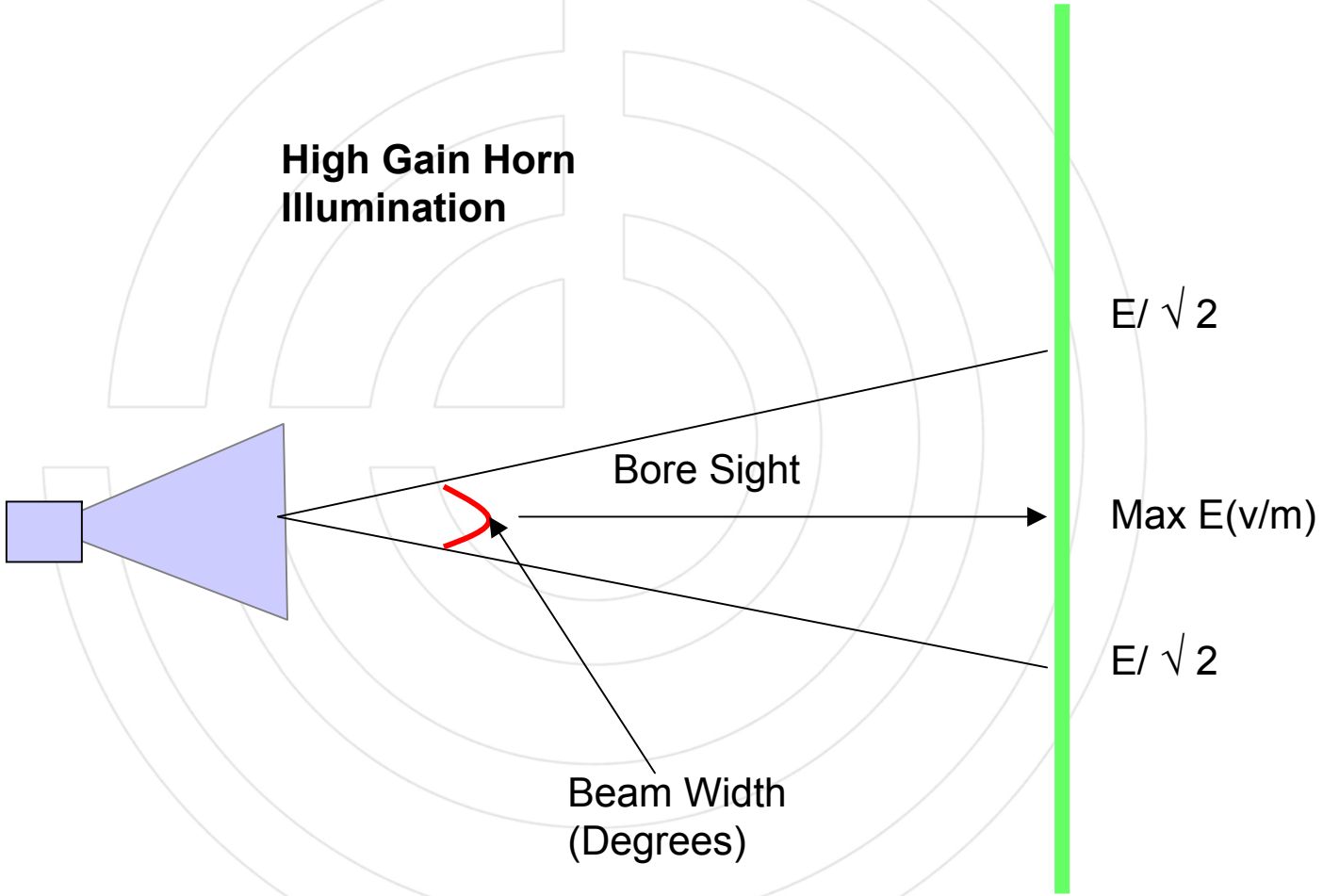

Test Plane Illumination
Falls with
Distance
Bore Sight
Max E(v/m)

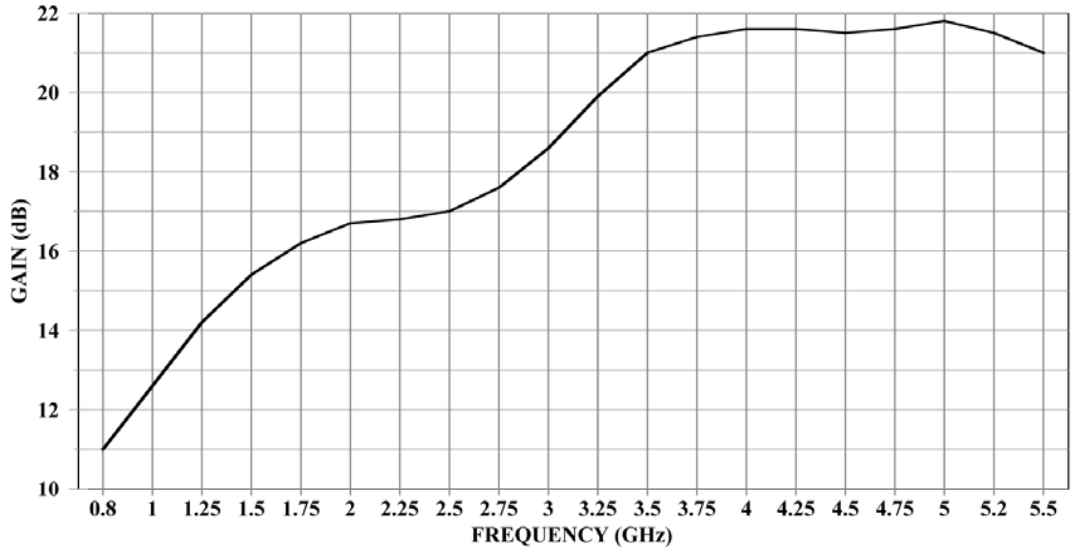
Medium Gain Horn Illumination



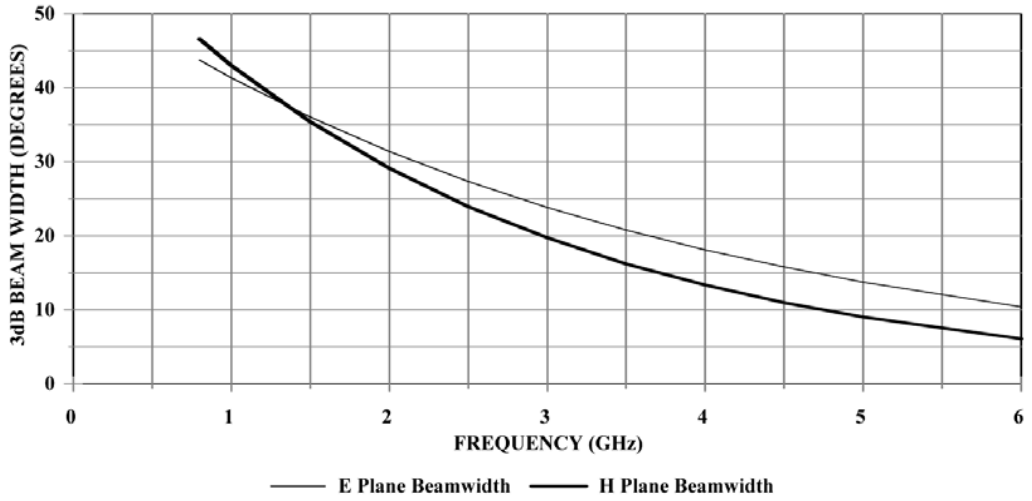
High Gain Horn Illumination

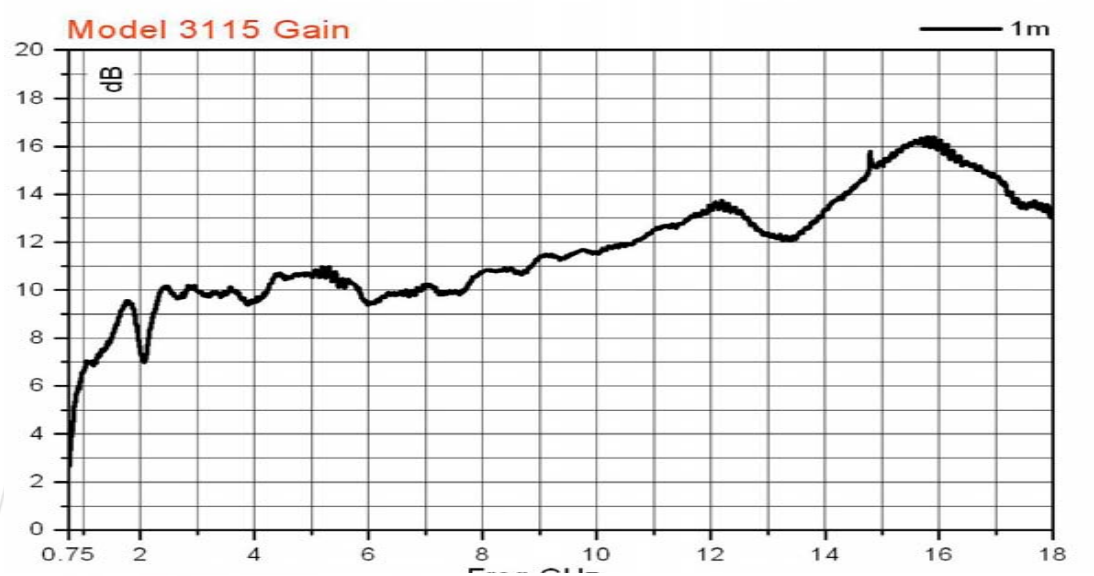


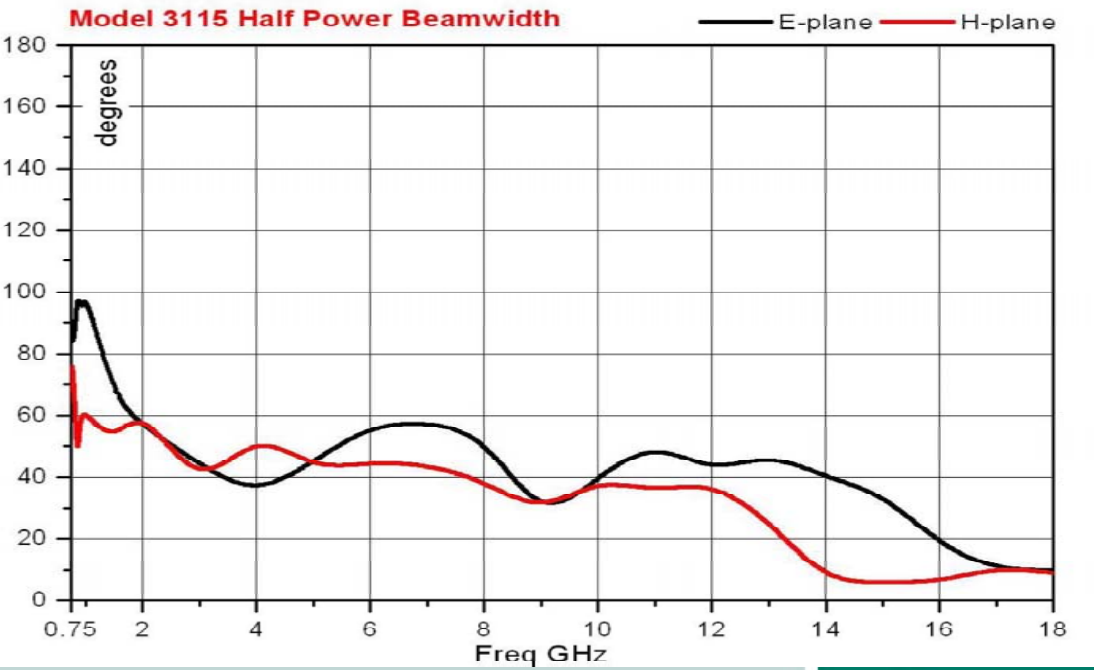
MODEL AT4002A GAIN VS FREQUENCY



Model AT4002A BEAMWIDTH VS FREQUENCY




Model 3115 Gain
1m
dB
20
18
16
14
12
10
8
6
4
2
0
0.75
2
4
6
8
10
12
14
16
18


Model 3115 Half Power Beamwidth
E-plane
H-plane
degrees
180
160
140
120
100
80
60
40
20
0
0.75
2
4
6
8
10
12
14
16
18
Freq GHz

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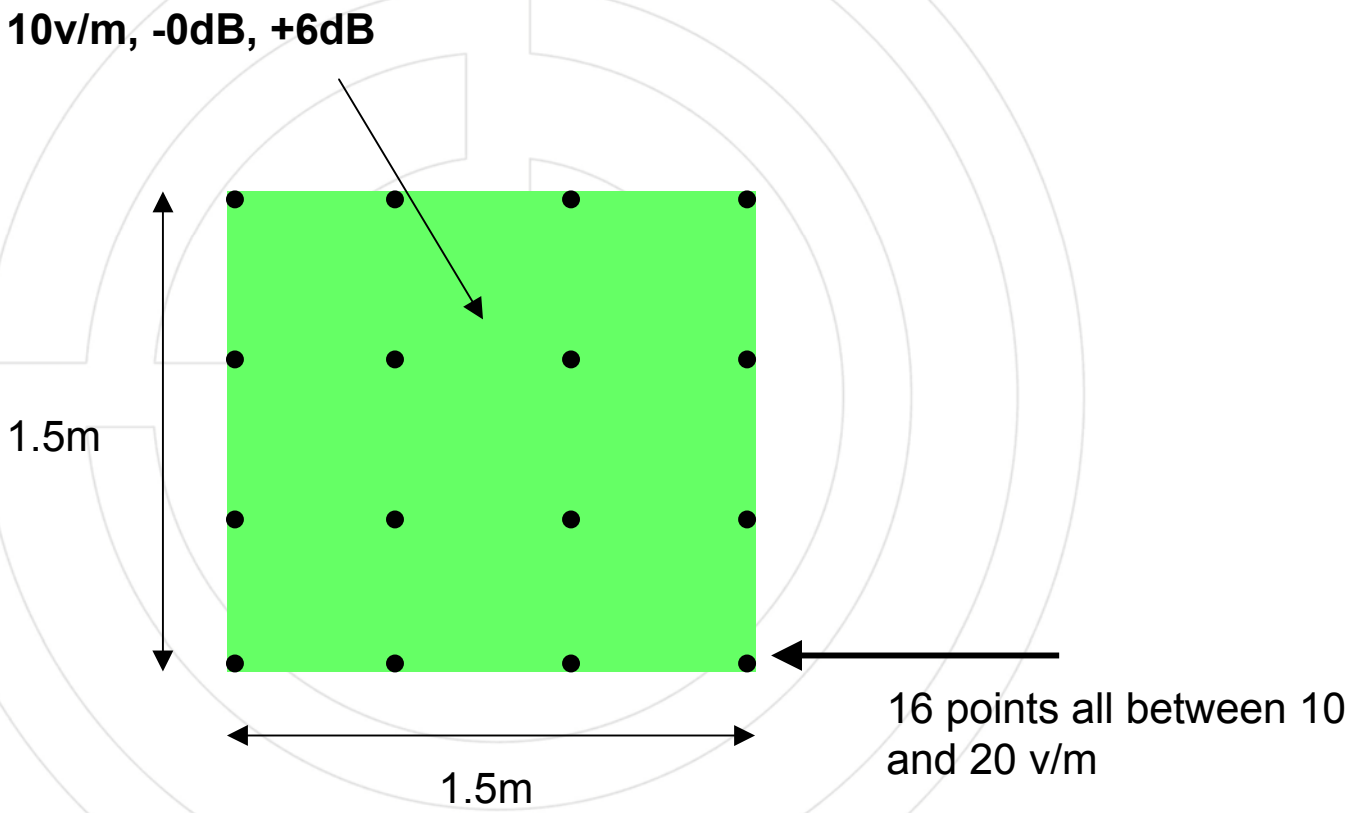
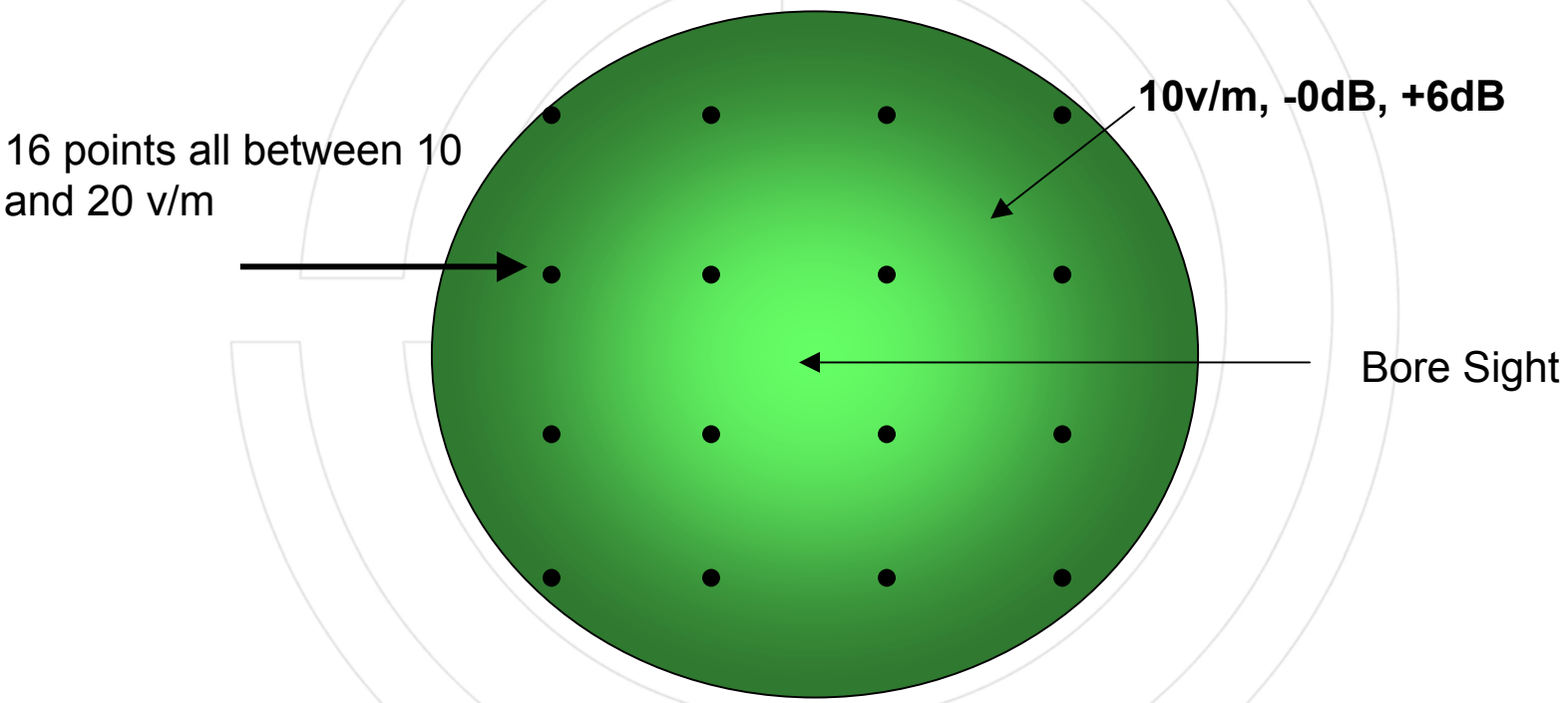
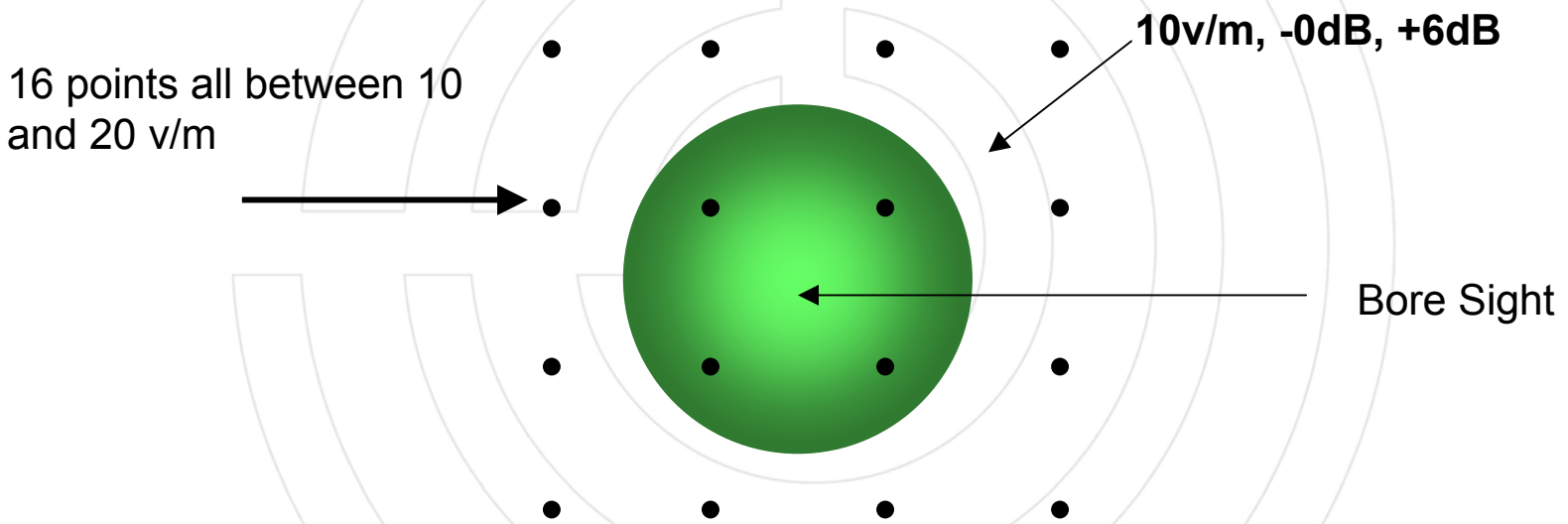
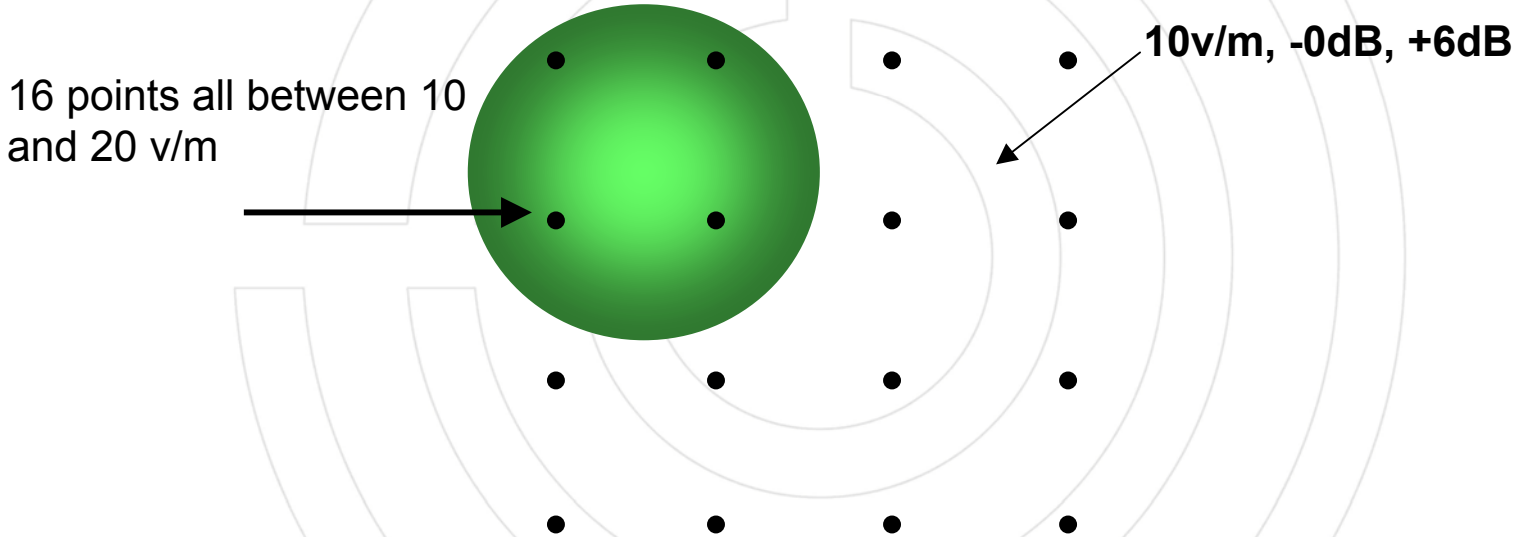

10v/m, -0dB, +6dB
1.5m
1.5m
16 points all between 10 and 20 v/m

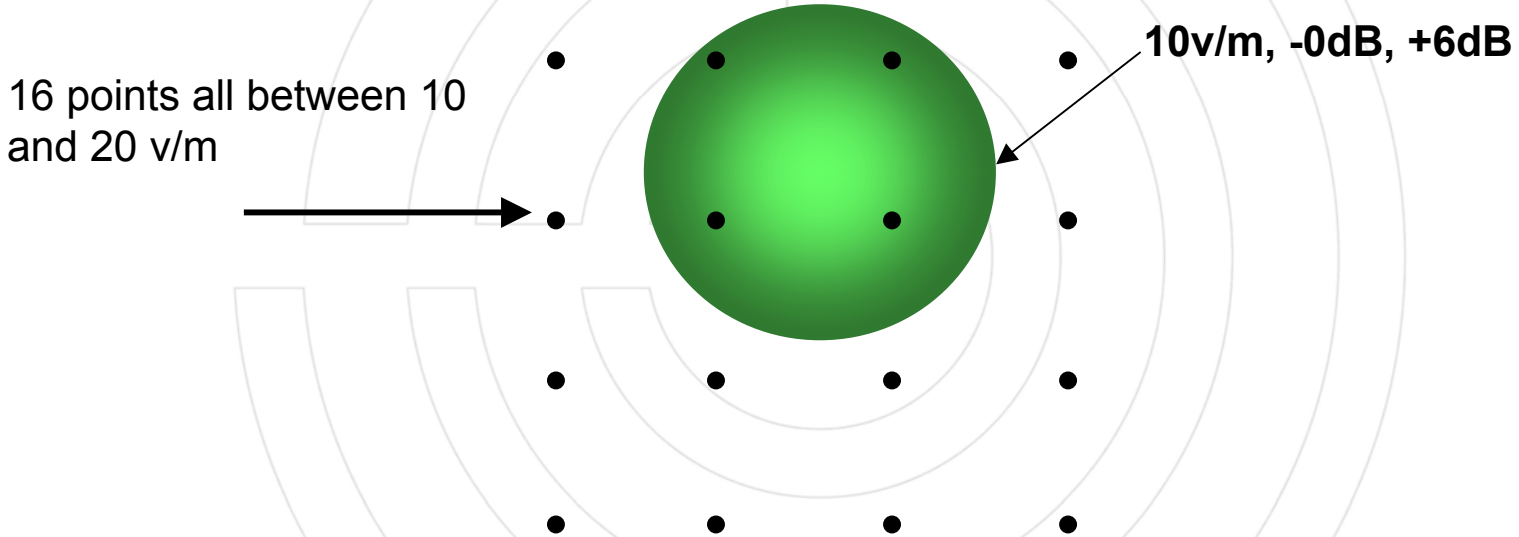
Test Plane Illumination

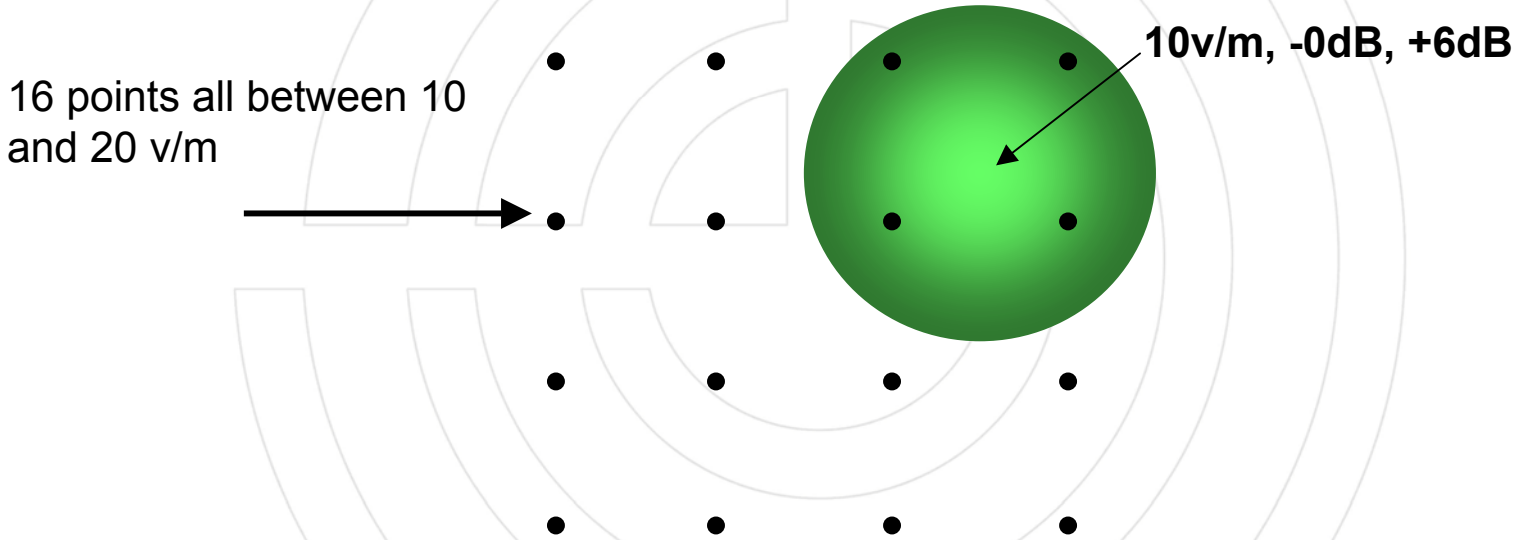


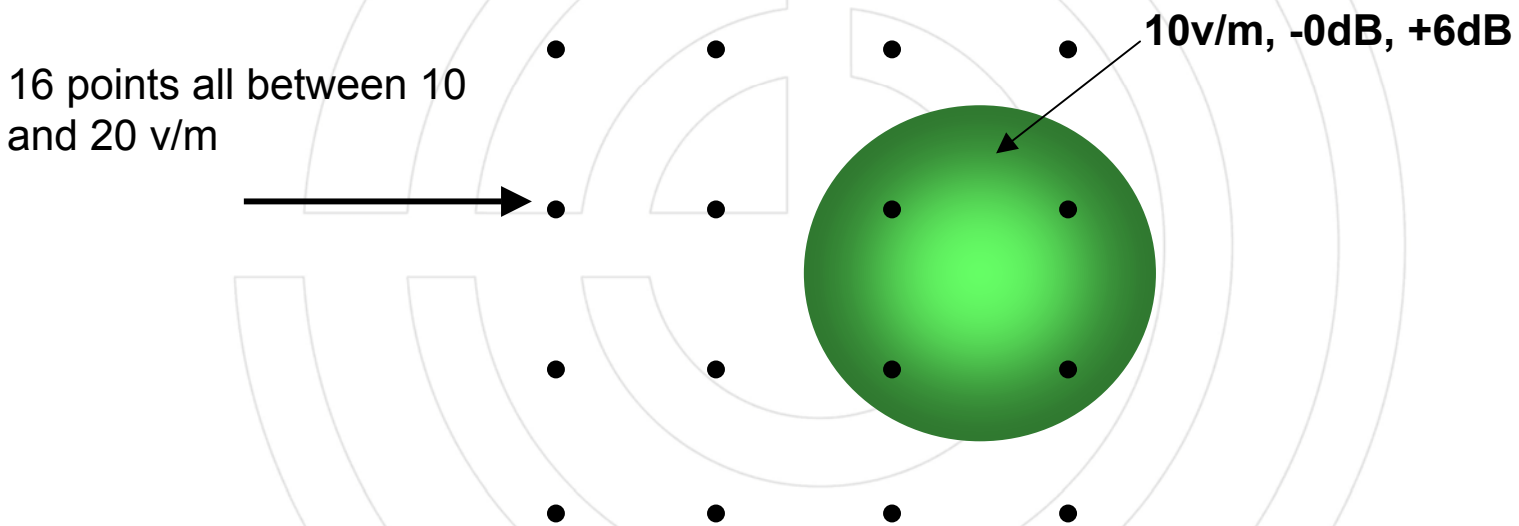
Effect of Higher Gain

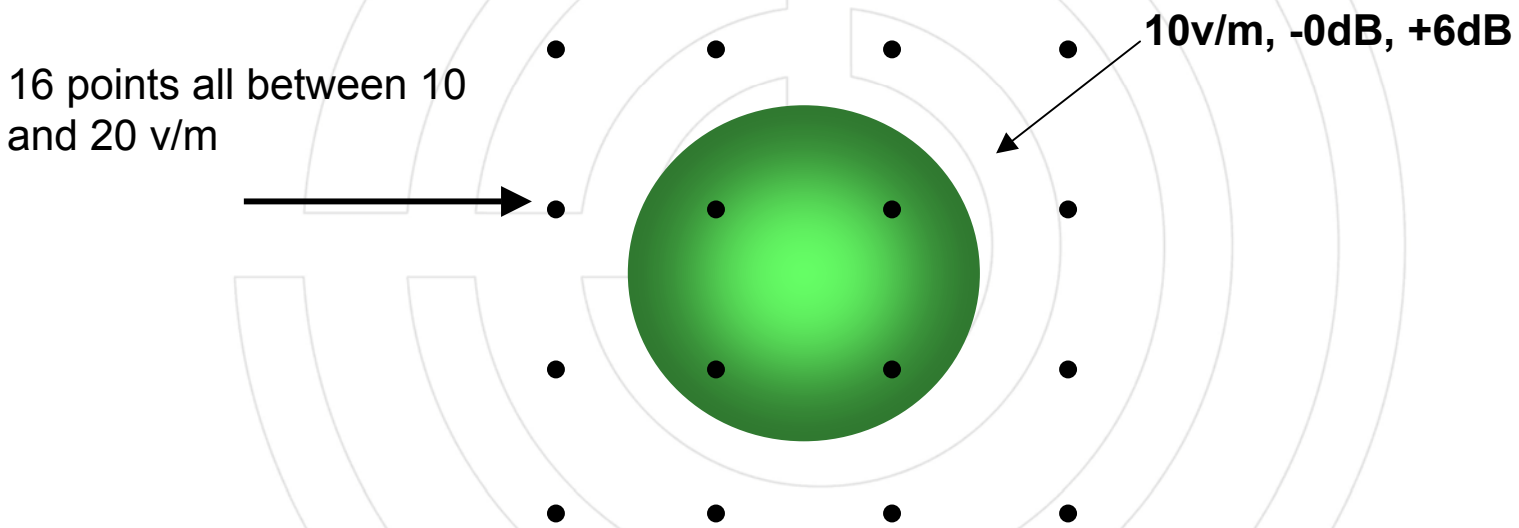


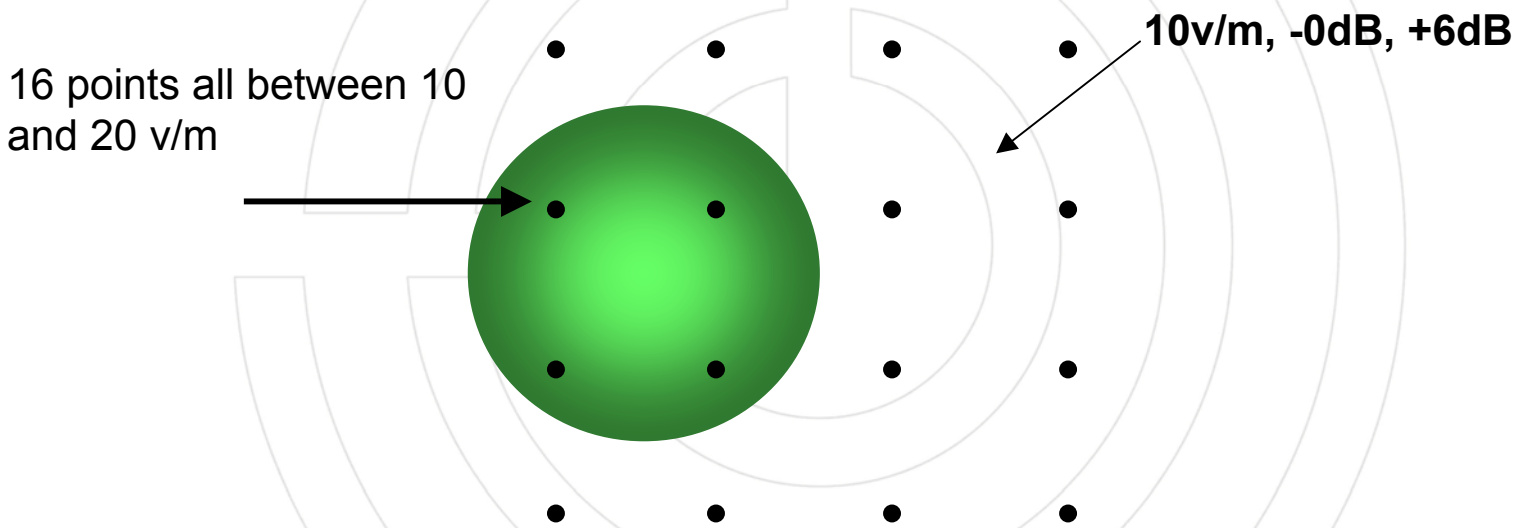

16 points all between 10 and 20 v/m
10v/m, -0dB, +6dB

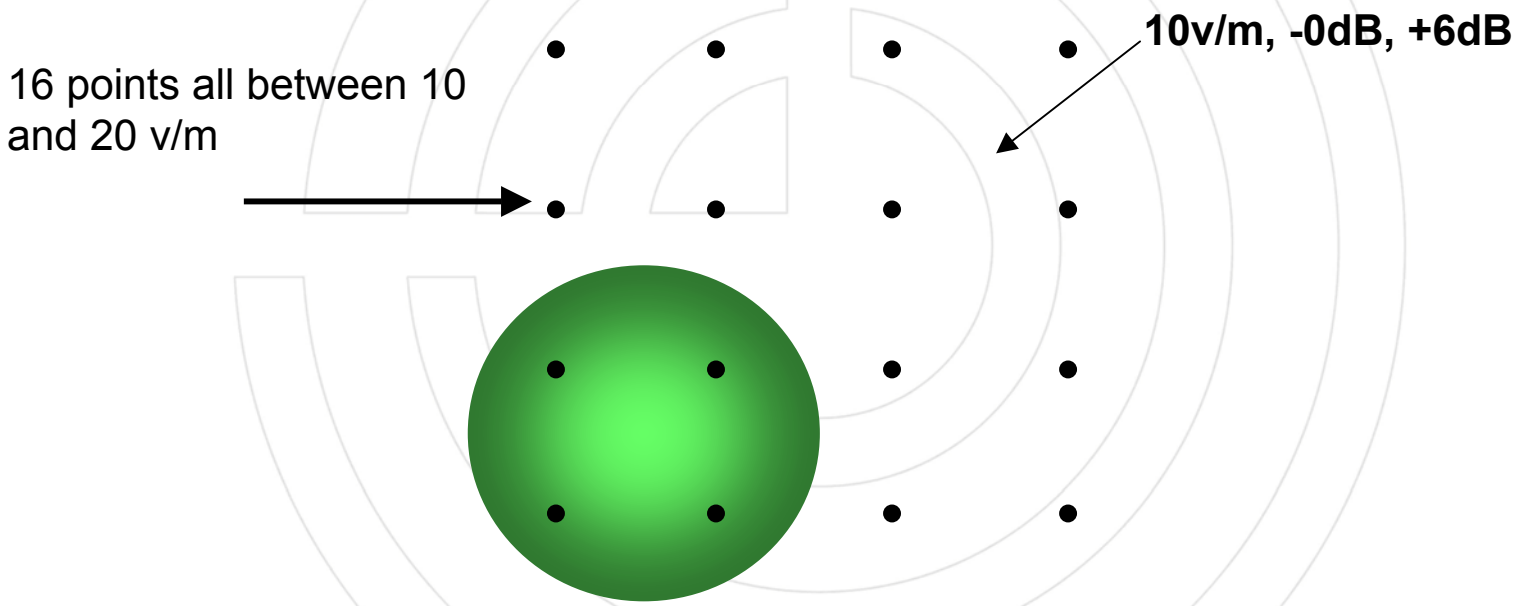

16 points all between 10 and 20 v/m
10v/m, -0dB, +6dB

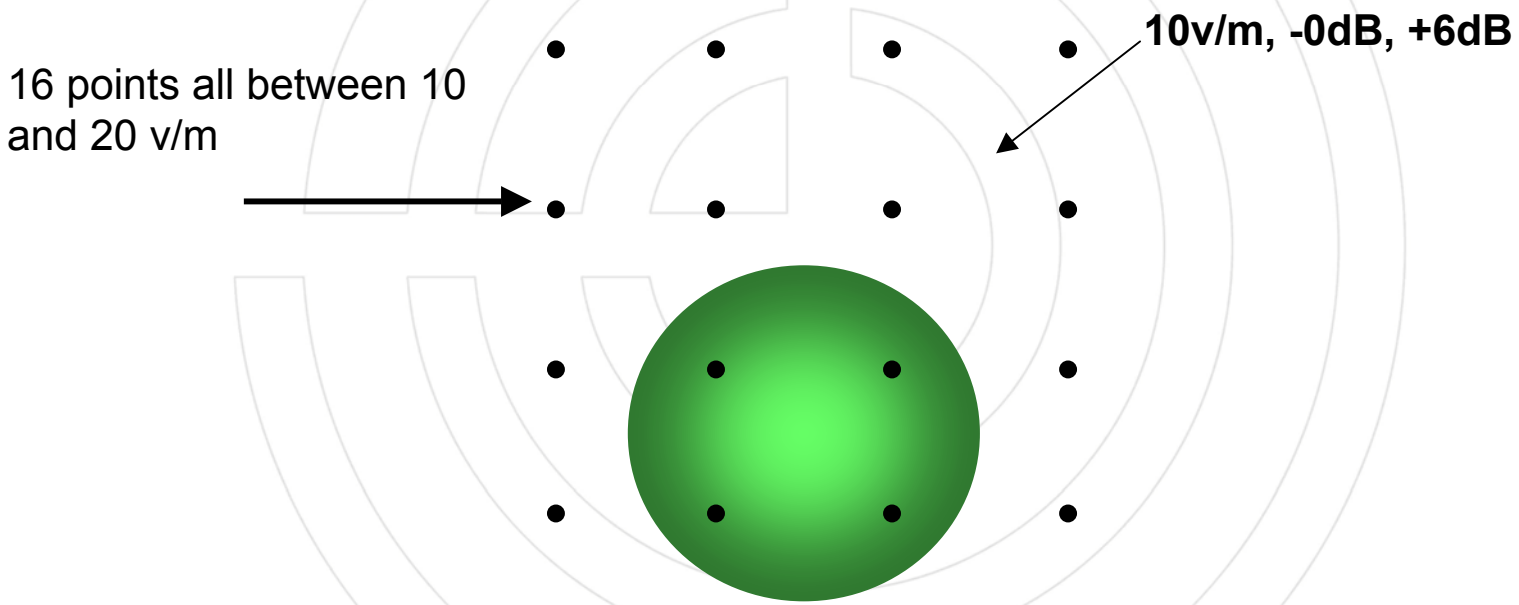

16 points all between 10 and 20 v/m
10v/m, -0dB, +6dB

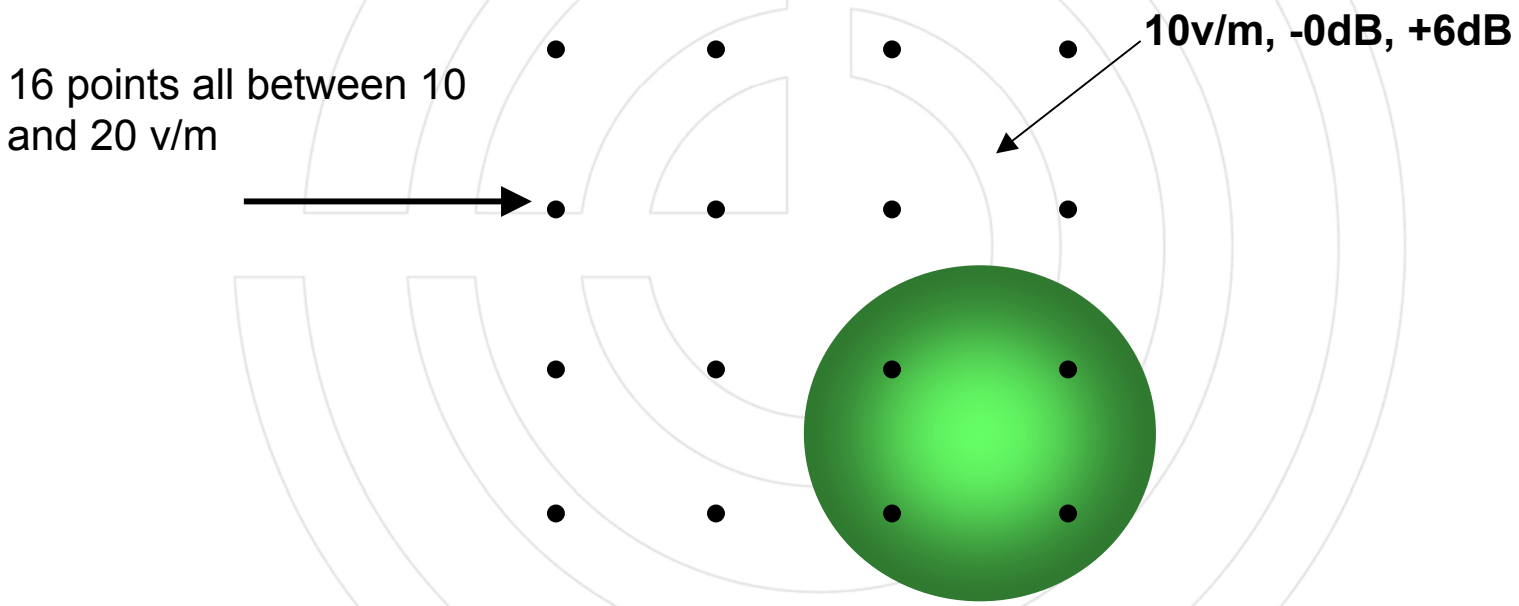

16 points all between 10 and 20 v/m
10v/m, -0dB, +6dB


16 points all between 10 and 20 v/m
10v/m, -0dB, +6dB

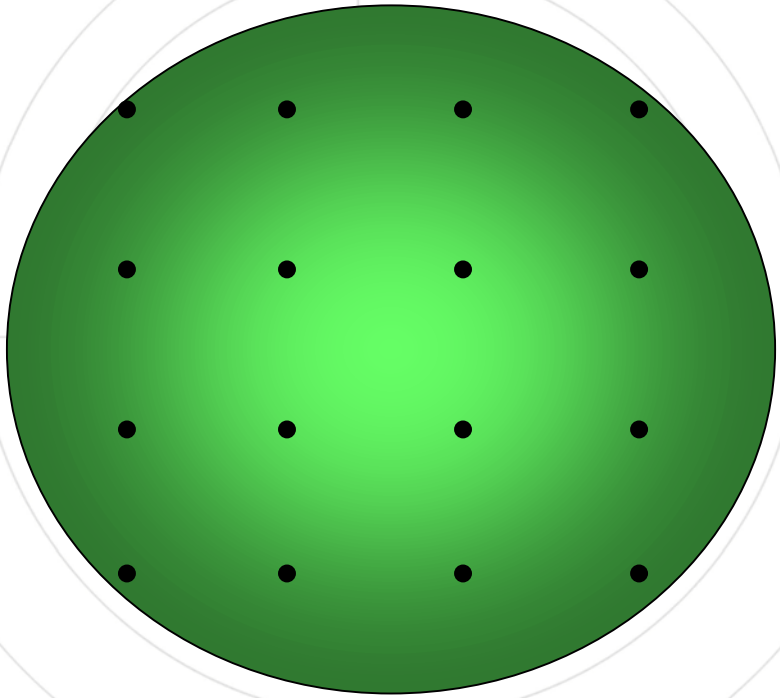

16 points all between 10 and 20 v/m
10v/m, -0dB, +6dB


16 points all between 10 and 20 v/m
10v/m, -0dB, +6dB

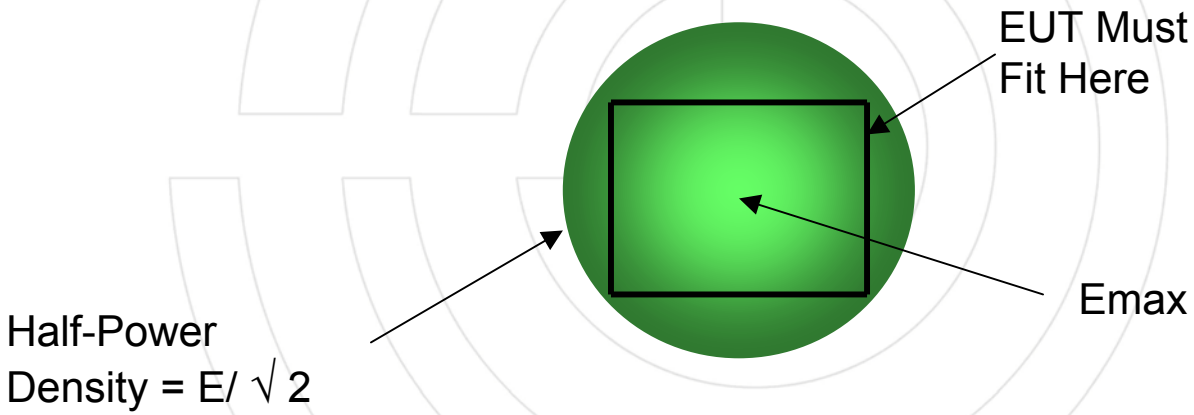

16 points all between 10 and 20 v/m
10v/m, -0dB, +6dB


16 points all between 10 and 20 v/m
10v/m, -0dB, +6dB

EQUIVALENT TO??



Beam Width is Becoming Important - Some Standards Now Insist the EUT Fits Inside the Antenna Beam Width



Advantages / Disadvantages of Each Antenna Type

High Gain Horn Advantage

Reduced RF Power Requirement

High Gain Horn Advantage

Reduced RF Power Requirement

High Gain Horn Disadvantage

Smaller Illumination Area

High Gain Horn Advantage

Reduced RF Power Requirement

High Gain Horn Disadvantage

Smaller Illumination Area (equivalent?)

High Gain Horn Advantage

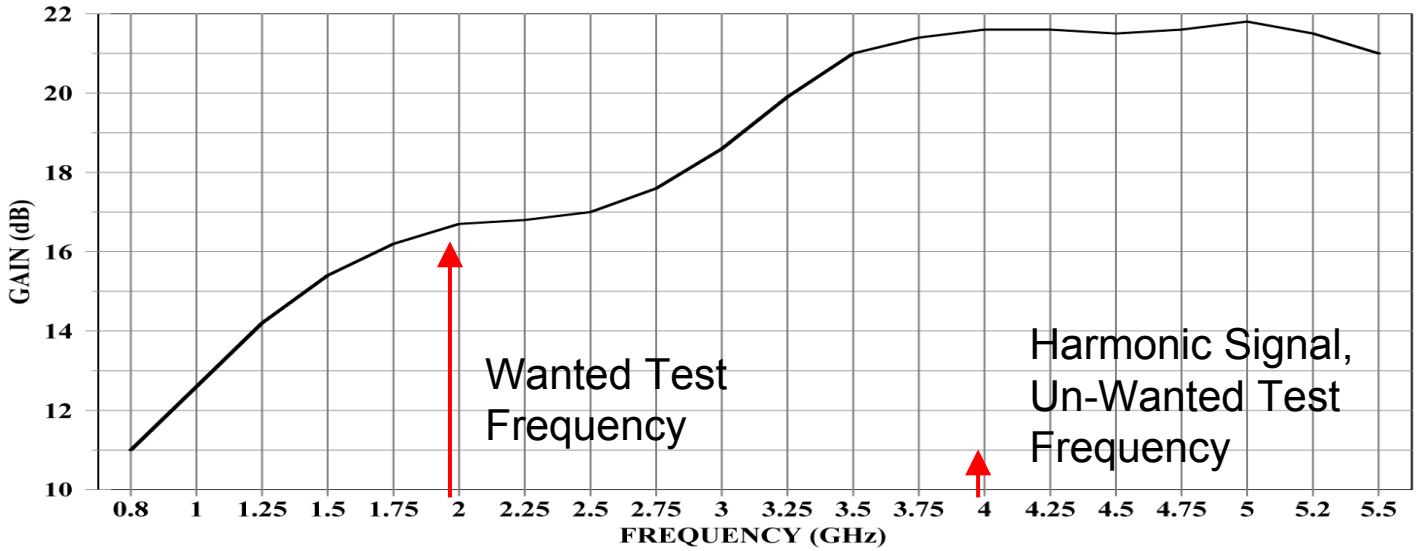
Reduced RF Power Requirement

High Gain Horn Disadvantage

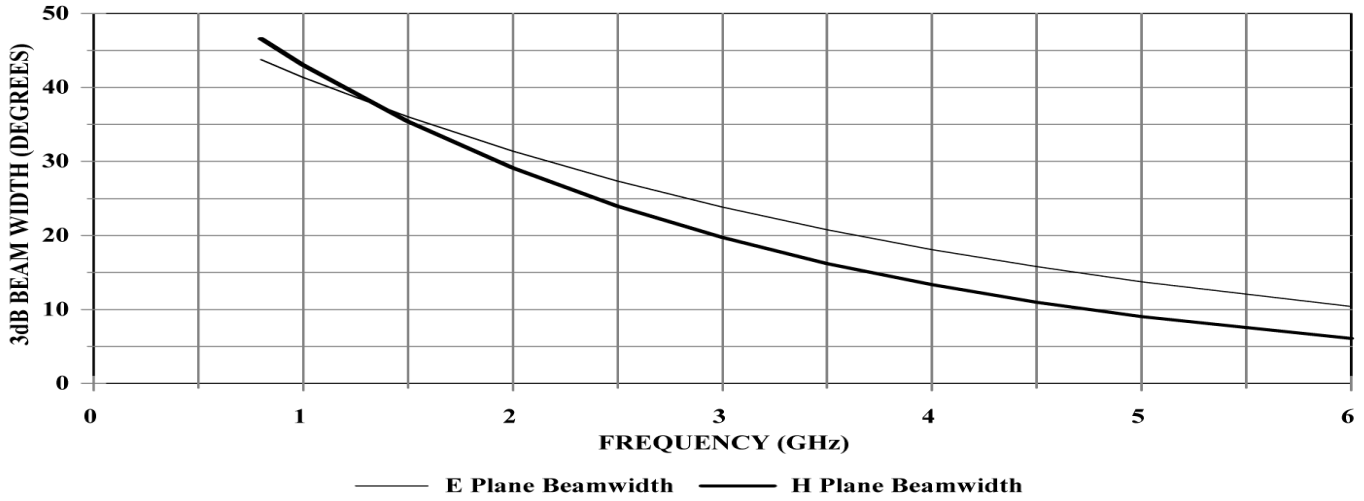
Smaller Illumination Area (equivalent?)

Higher Field Contribution from Harmonic

MODEL AT4002A GAIN VS FREQUENCY



Model AT4002A BEAMWIDTH VS FREQUENCY



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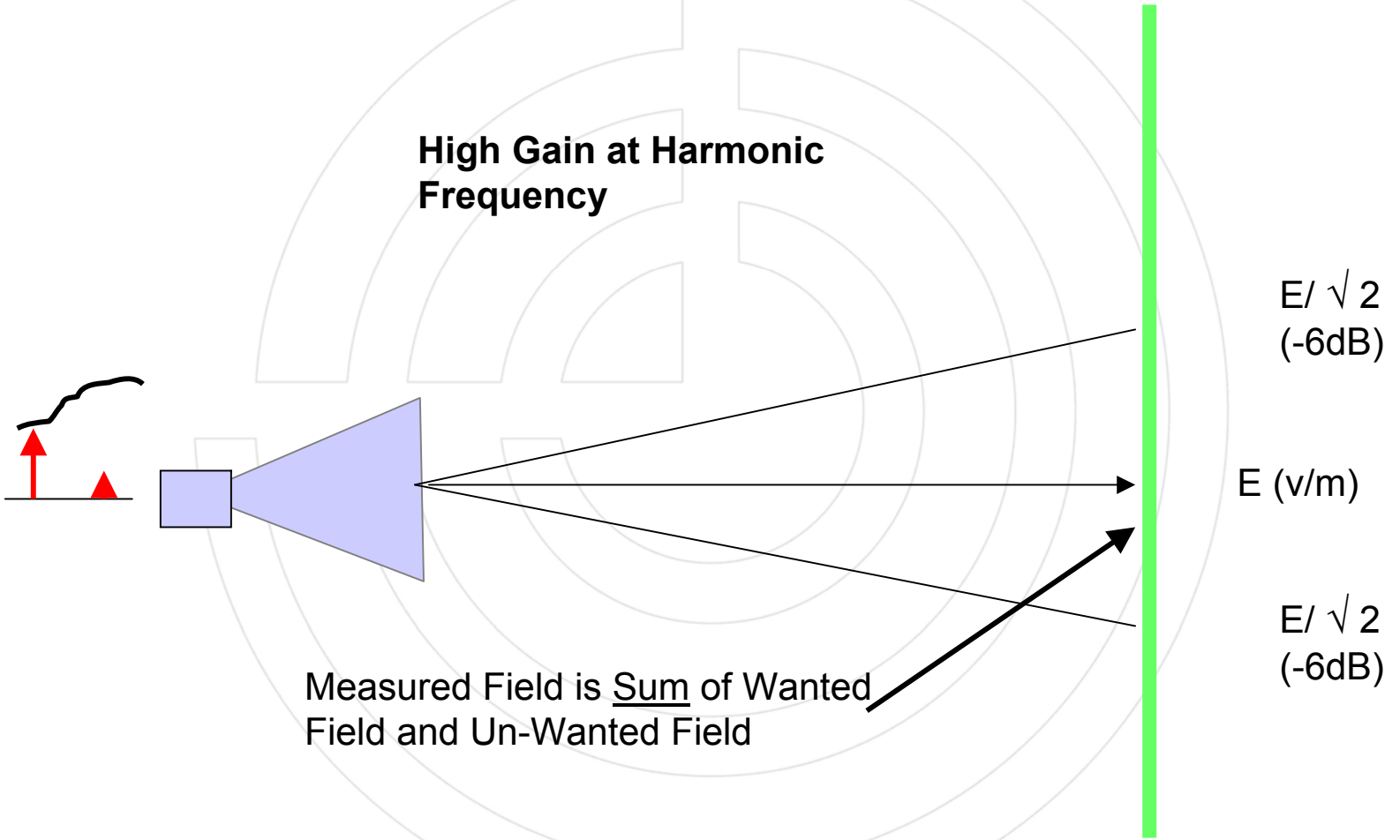
High Gain at Harmonic Frequency
E/ √ 2
(-6dB)
E (v/m)
E/ √ 2
(-6dB)
Measured Field is Sum of Wanted Field and Un-Wanted Field

High Gain Horn Advantage

Reduced RF Power Requirement

High Gain Horn Disadvantage

Smaller Illumination Area (equivalent?)

Higher Field Contribution from Harmonic

High Gain Horn Advantage

Reduced RF Power Requirement

High Gain Horn Disadvantage

Smaller Illumination Area (equivalent?)

Higher Field Contribution from Harmonic

Less Bandwidth so More Antennas Required

High Gain Horn Advantage

Reduced RF Power Requirement

High Gain Horn Disadvantage

Smaller Illumination Area (equivalent?)

Higher Field Contribution from Harmonic

Less Bandwidth so More Antennas Required

Medium Gain Horn Advantage

Large Illumination Area

High Gain Horn Advantage

Reduced RF Power Requirement

High Gain Horn Disadvantage

Smaller Illumination Area (equivalent?)

Higher Field Contribution from Harmonic

Less Bandwidth so More Antennas Required

Medium Gain Horn Advantage

Large Illumination Area

Less Field Contribution from Harmonic

High Gain Horn Advantage

Reduced RF Power Requirement

High Gain Horn Disadvantage

Smaller Illumination Area (equivalent?)

Higher Field Contribution from Harmonic

Less Bandwidth so More Antennas Required

Medium Gain Horn Advantage

Large Illumination Area

Less Field Contribution from Harmonic

Wider Bandwidth, One Antenna Required

High Gain Horn Advantage

Reduced RF Power Requirement

High Gain Horn Disadvantage

Smaller Illumination Area (equivalent?)

Higher Field Contribution from Harmonic

Less Bandwidth so More Antennas Required

Medium Gain Horn Advantage

Large Illumination Area

Less Field Contribution from Harmonic

Wider Bandwidth, One Antenna Required

Medium Gain Horn Disadvantage

Higher RF Power Requirement

Field Uniformity Through Use of Multiple High-Gain Antennas

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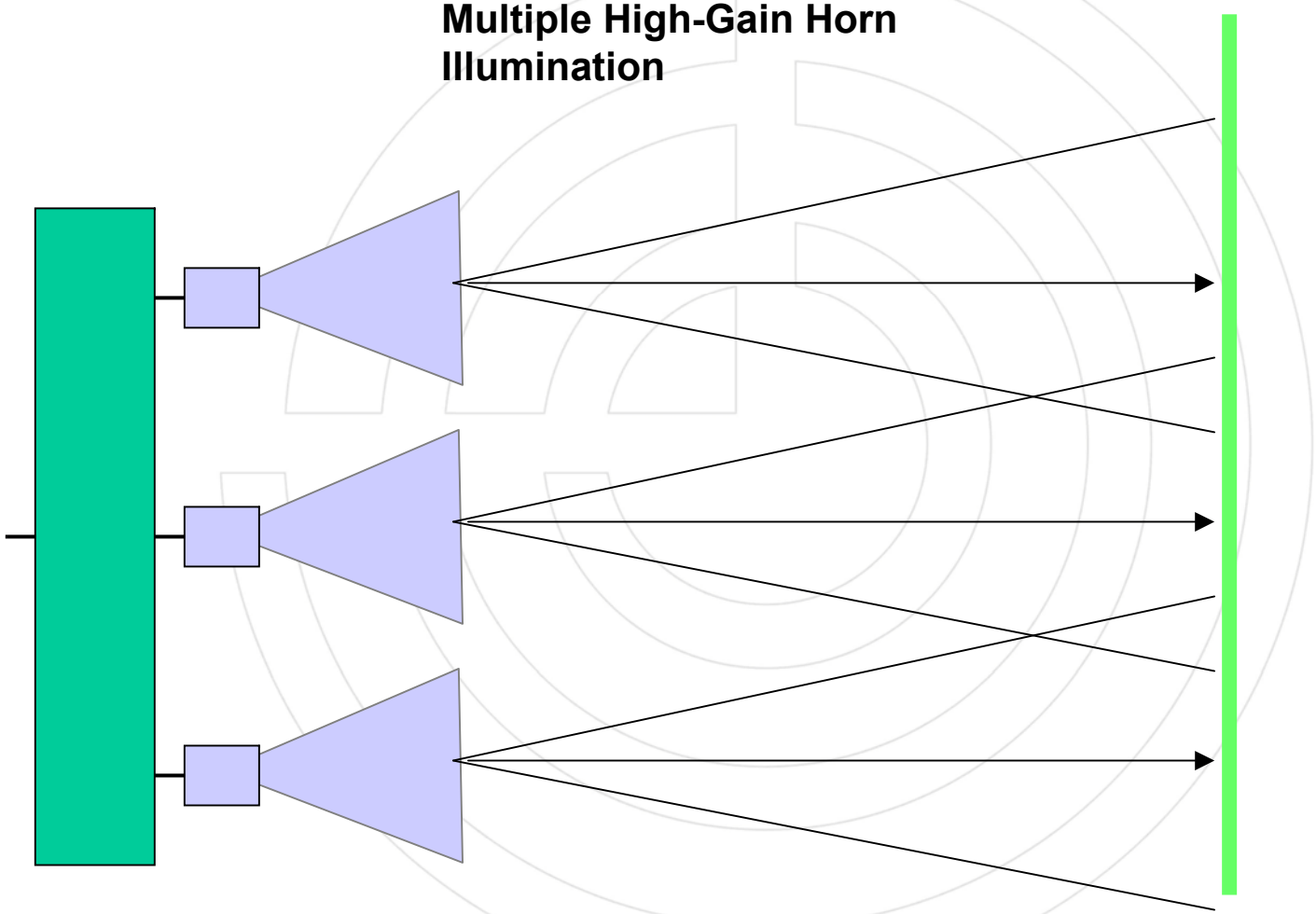
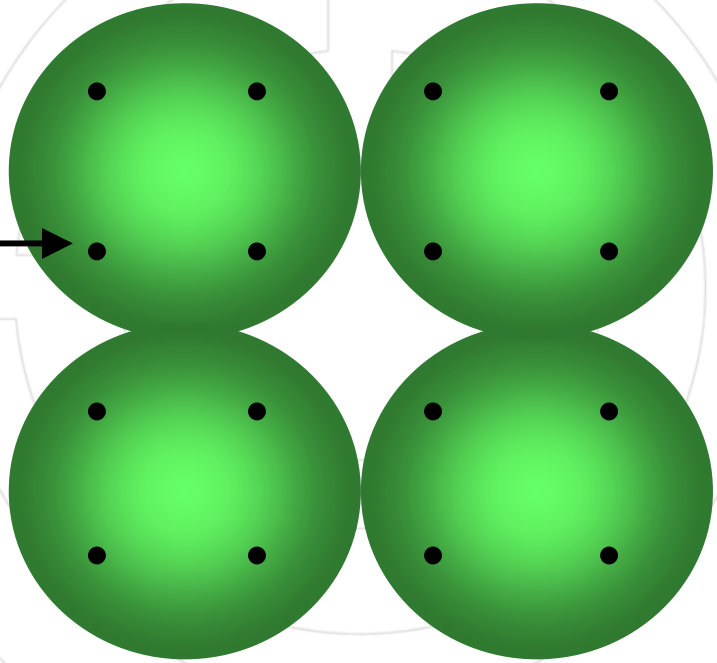
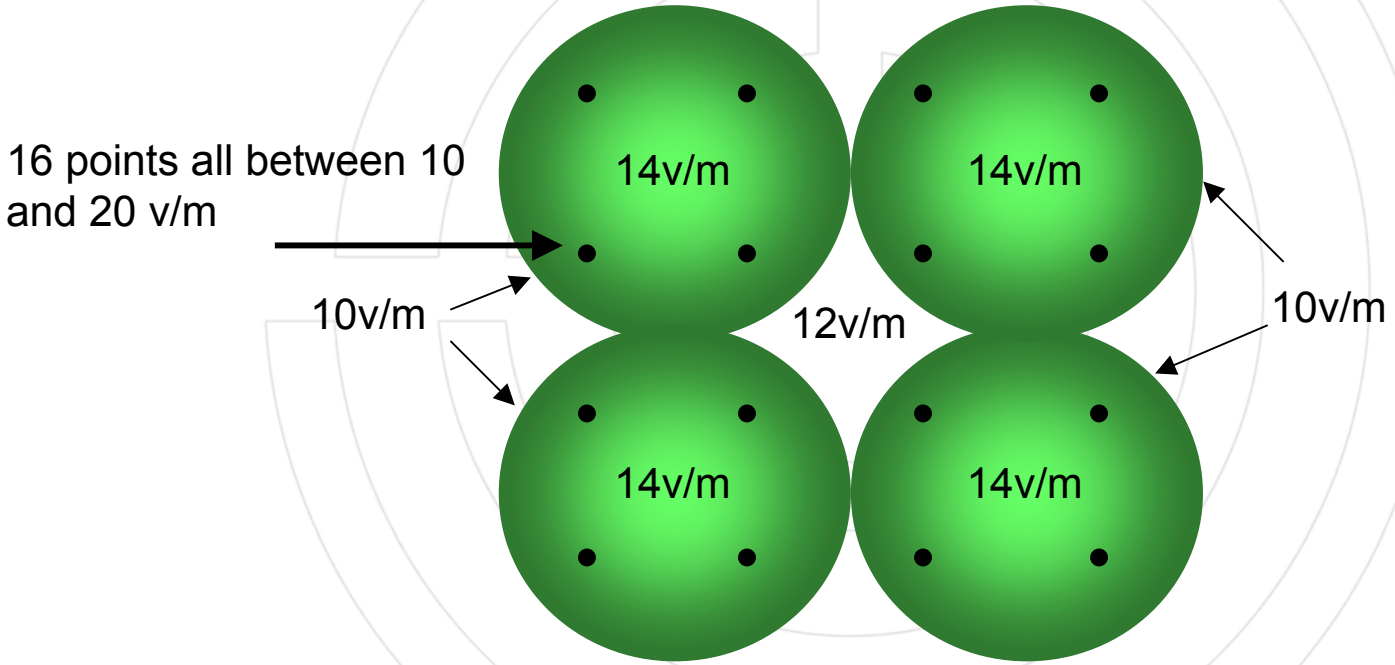
Multiple High-Gain Horn Illumination



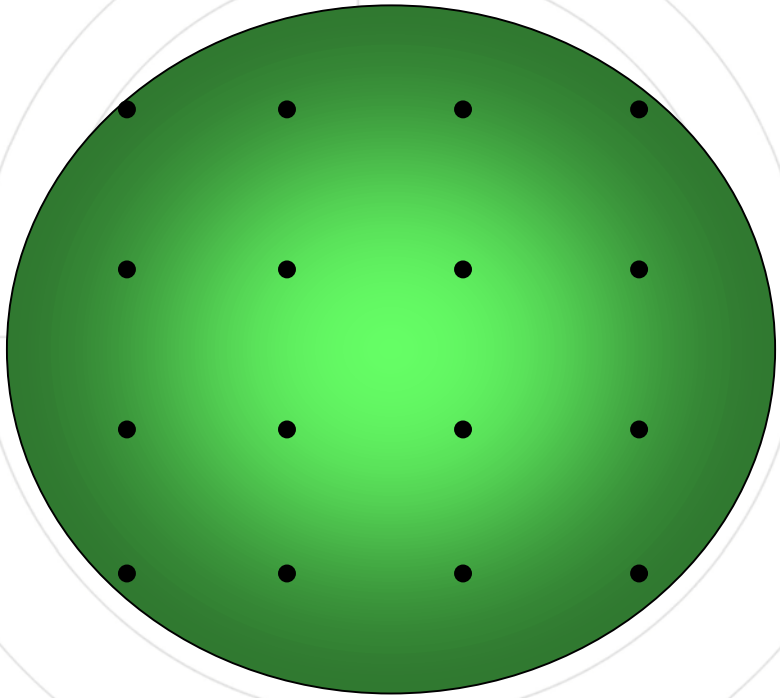
16 points all between 10 and 20 v/m



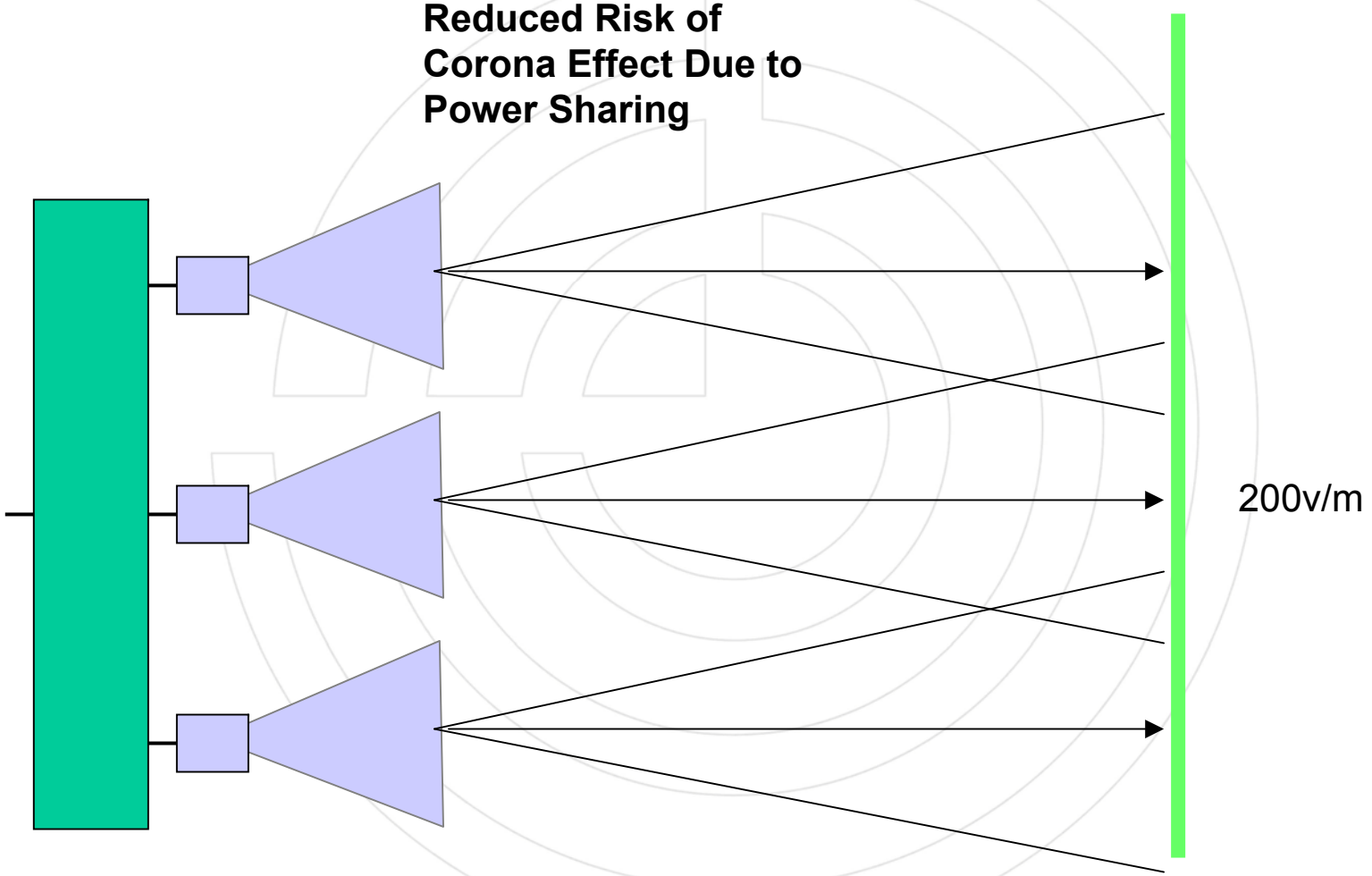


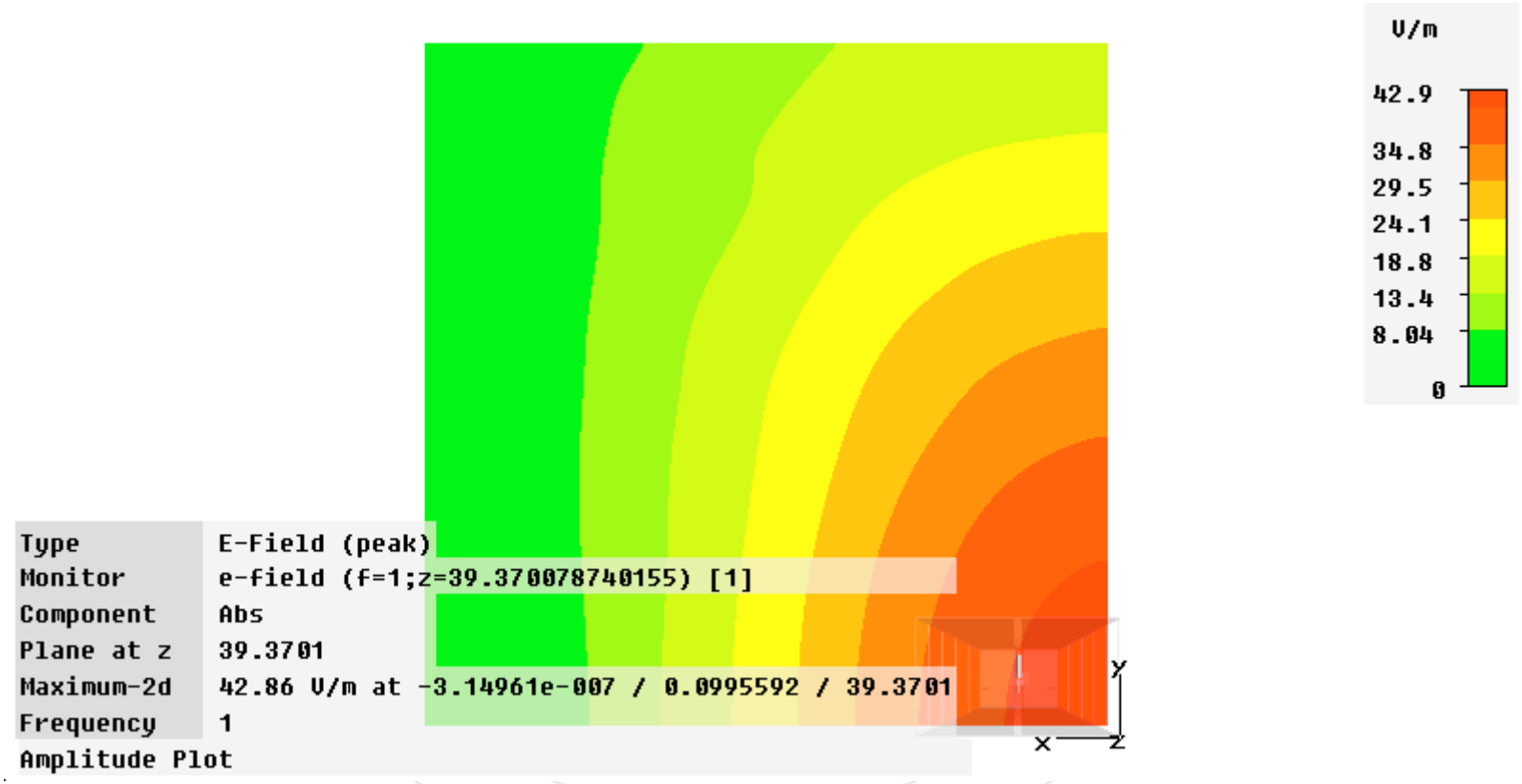
One Test Run Only

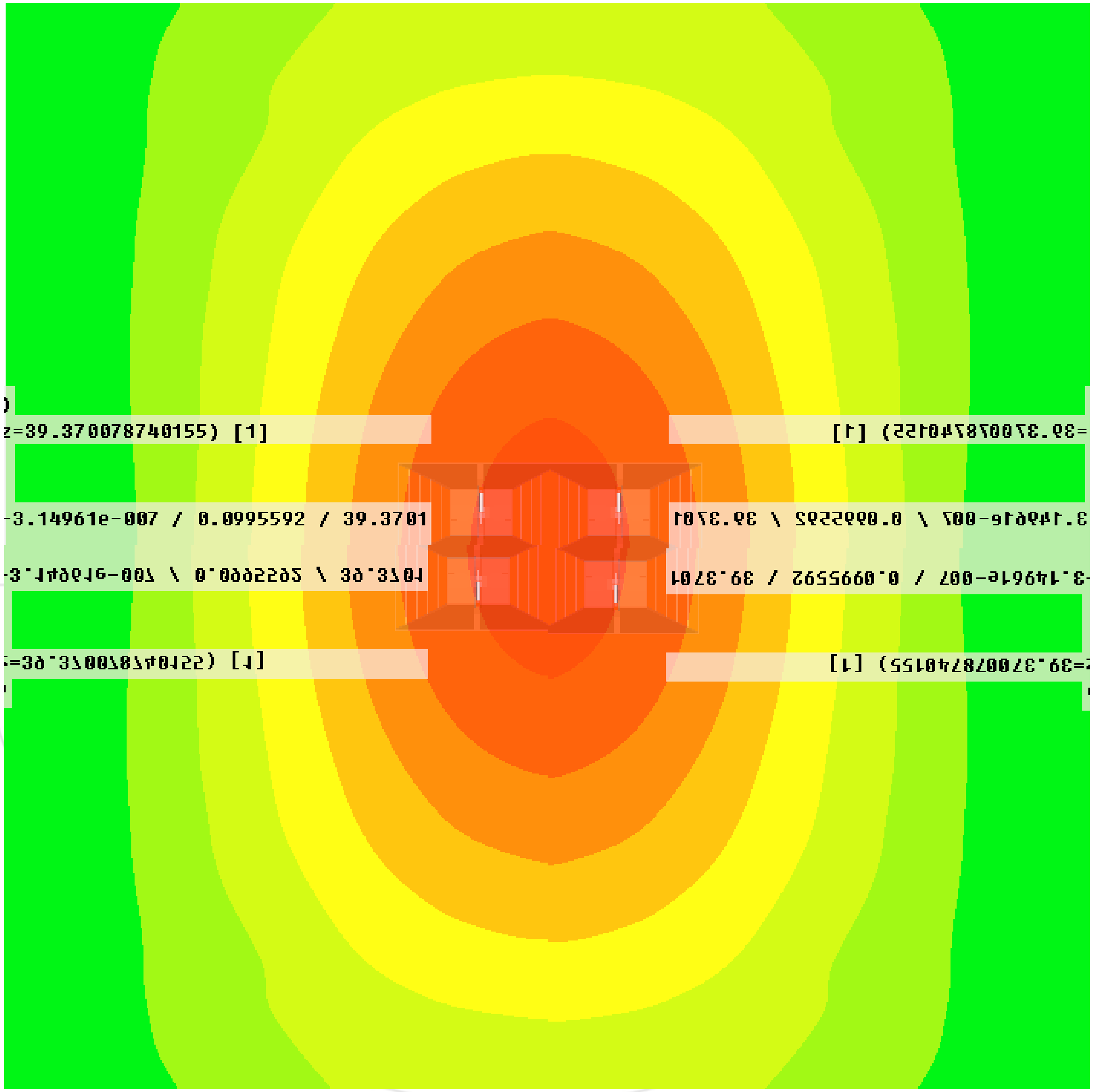
EQUIVALENT TO??

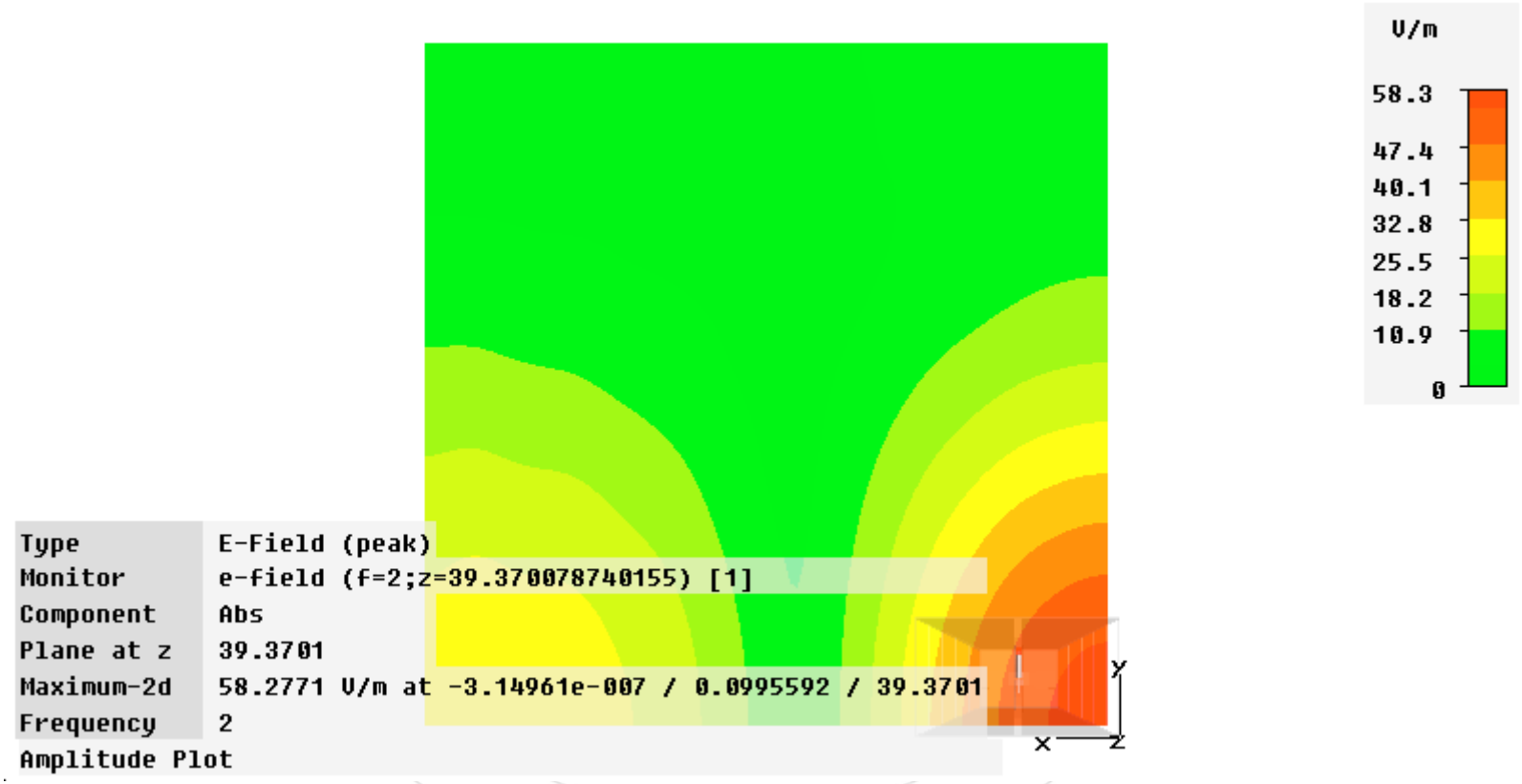


Reduced Risk of Corona Effect Due to Power Sharing



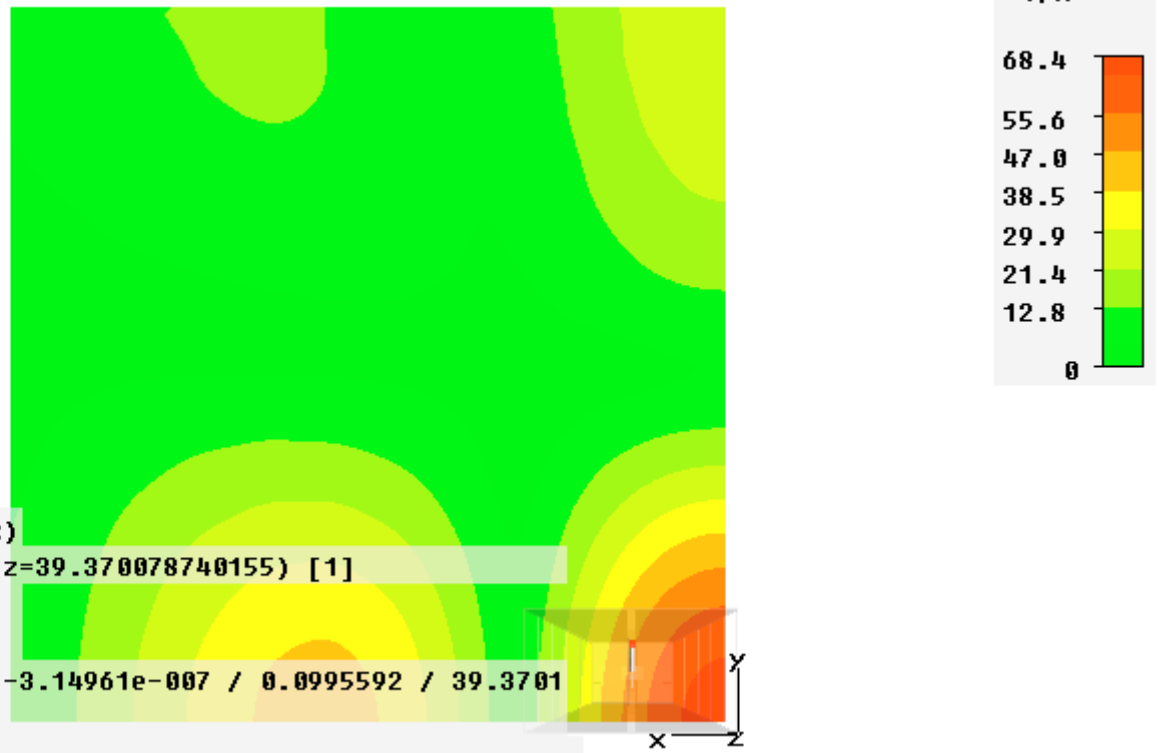

V/m
42.9
34.8
29.5
24.1
18.8
13.4
8.04
0
Type E-Field (peak)
Monitor e-field (f=1;z=39.370078740155) [1]
Component Abs
Plane at z 39.3701
Maximum-2d 42.86 V/m at -3.14961e-007 / 0.0995592 / 39.3701
Frequency 1
Amplitude Plot
y
x
z


z=39.370078740155) [1]
-3.14961e-007 / 0.0995592 / 39.3701



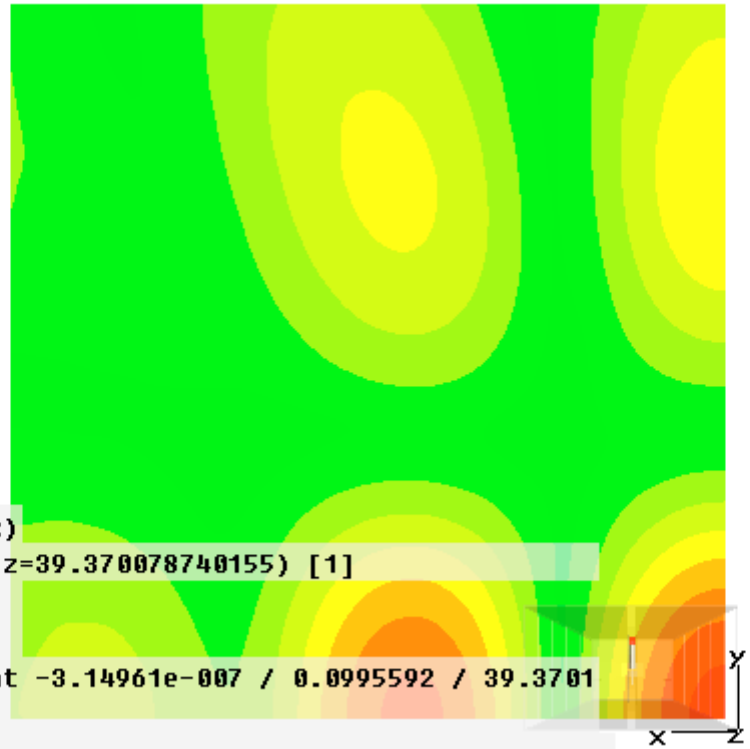
Type	E-Field (peak)
Monitor	e-field (f=2;z=39.370078740155) [1]
Component	Abs
Plane at z	39.3701
Maximum-2d	58.2771 V/m at -3.14961e-007 / 0.0995592 / 39.3701
Frequency	2

Amplitude Plot



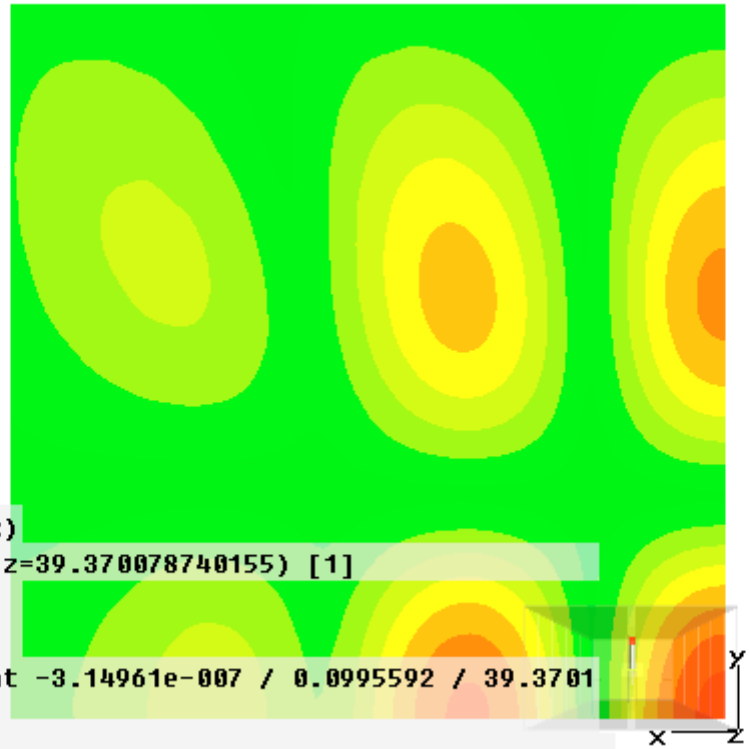
Type	E-Field (peak)
Monitor	e-field (f=3;z=39.370078740155) [1]
Component	Abs
Plane at z	39.3701
Maximum-2d	68.43 V/m at -3.14961e-007 / 0.0995592 / 39.3701
Frequency	3

Amplitude Plot



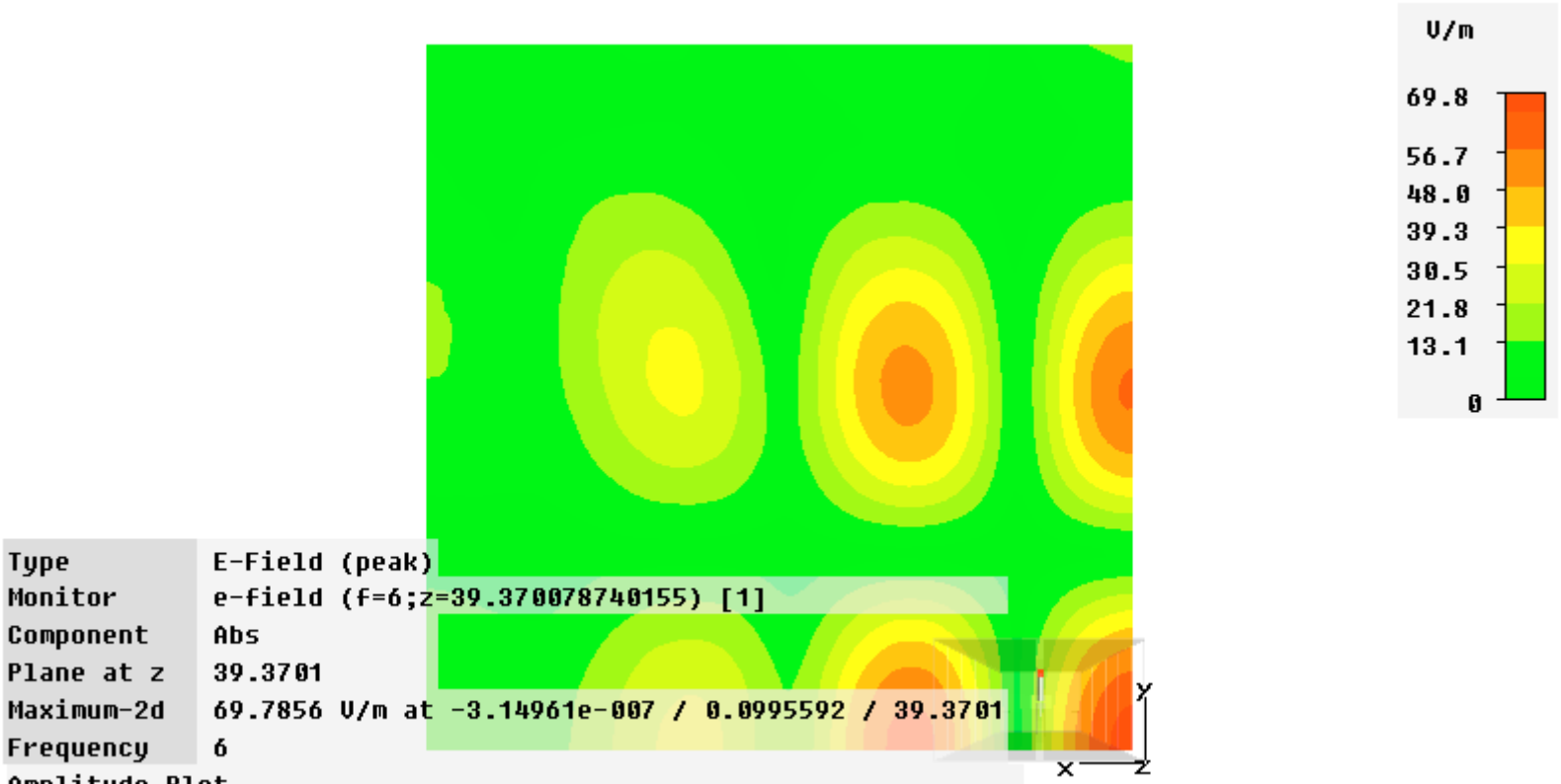
Type	E-Field (peak)
Monitor	e-field (f=4;z=39.370078740155) [1]
Component	Abs
Plane at z	39.3701
Maximum-2d	64.2603 V/m at -3.14961e-007 / 0.0995592 / 39.3701
Frequency	4

Amplitude Plot



Type	E-Field (peak)
Monitor	e-field (f=5;z=39.370078740155) [1]
Component	Abs
Plane at z	39.3701
Maximum-2d	68.3953 V/m at -3.14961e-007 / 0.0995592 / 39.3701
Frequency	5

Amplitude Plot


V/m
69.8
56.7
48.0
39.3
30.5
21.8
13.1
0
Type E-Field (peak)
Monitor e-field (f=6;z=39.370078740155) [1]
Component Abs
Plane at z 39.3701
Maximum-2d 69.7856 V/m at -3.14961e-007 / 0.0995592 / 39.3701
Frequency 6
Amplitude Plot
y
x
z

Use of Shaped Reflector Plate

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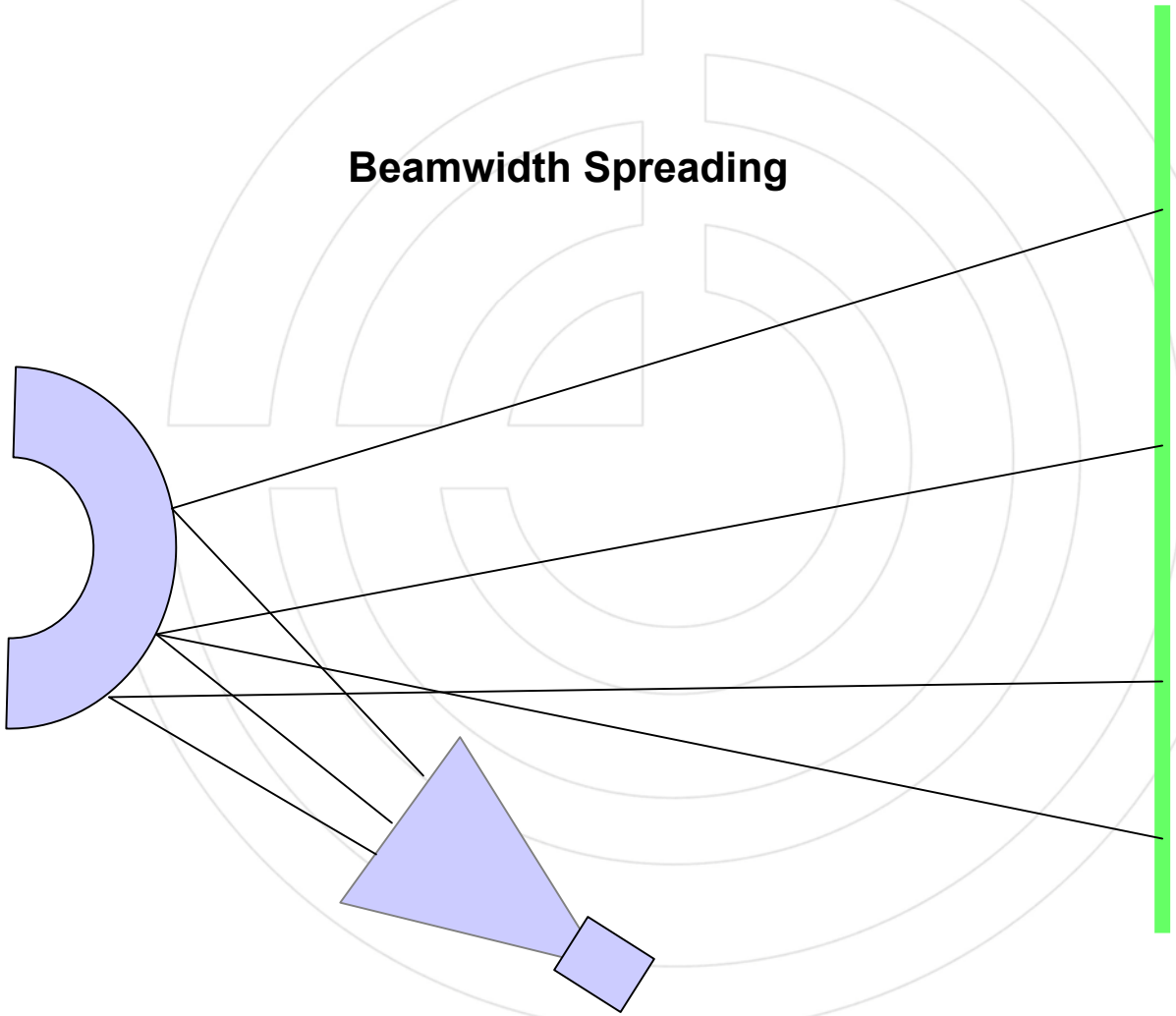
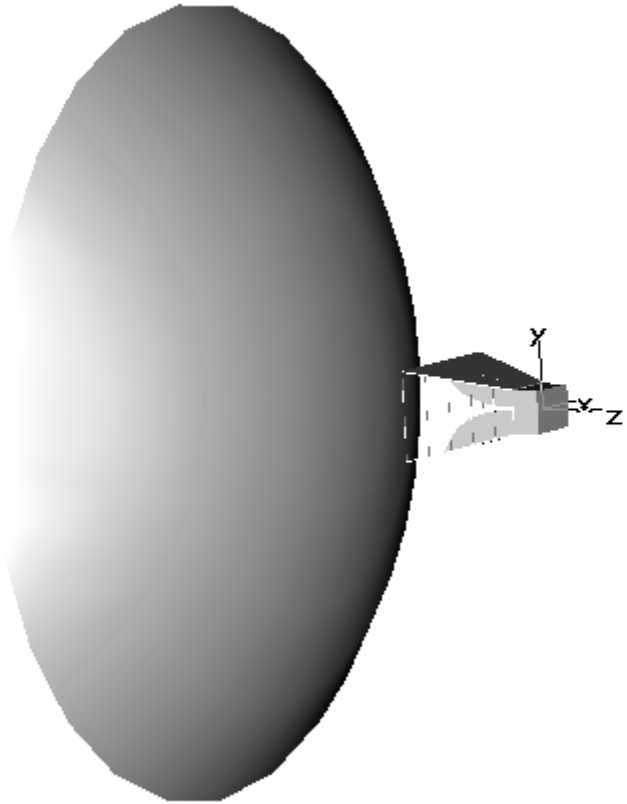
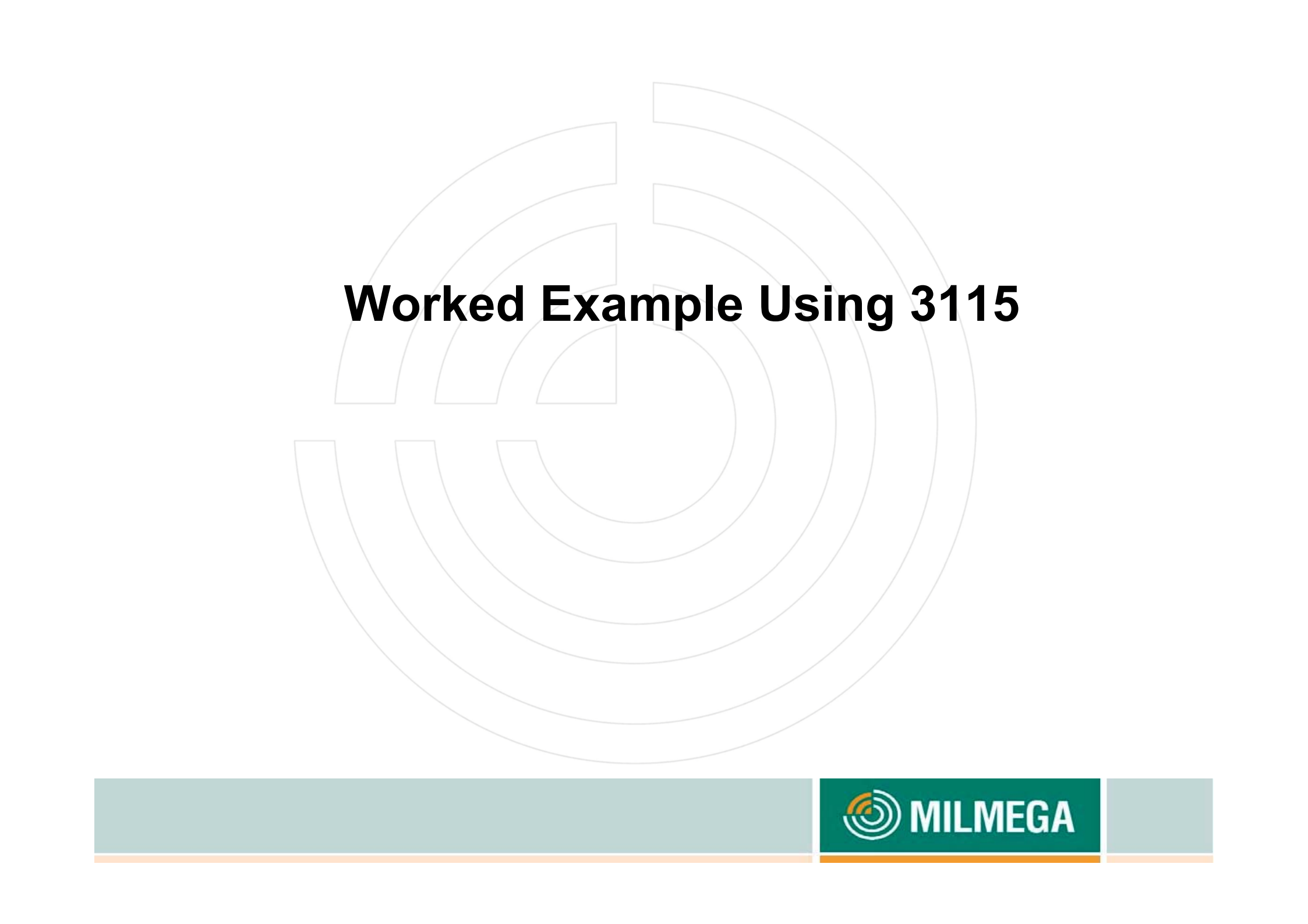
Beamwidth Spreading




Y
X
Z

Worked Example Using 3115



Issue C

61000-4-3 Field Generation 1.0-6.0 GHz 10v/m@3m

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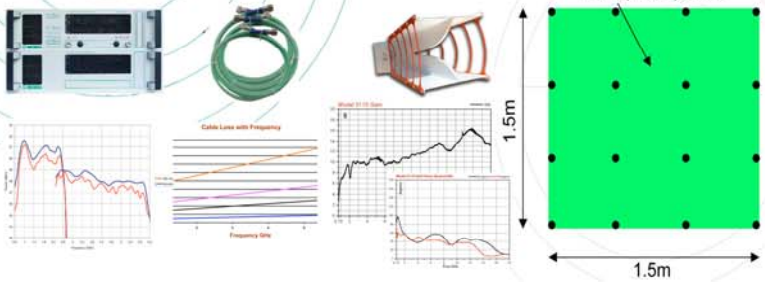
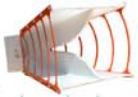
1 RF Field Generation Components

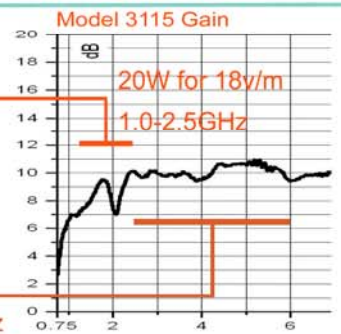


2 Power Required At Antenna Connector

$E = \sqrt{(30.G.P)} / d$

$P = d^2E^2 / 30.G$

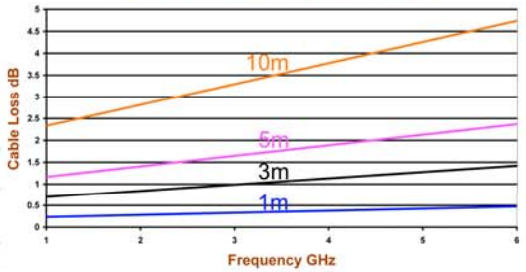




3 Impact of Cable Loss

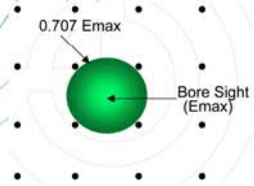
	10m	5m	3m	1m
1.0-2.5GHz	40W	28W	25W	22W
2.5-6.0GHz	30W	17W	14W	11W

Amplifier Behind Antenna in Chamber

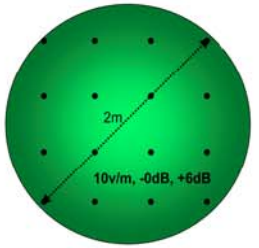


4 Impact of Antenna Beamwidth (BW)

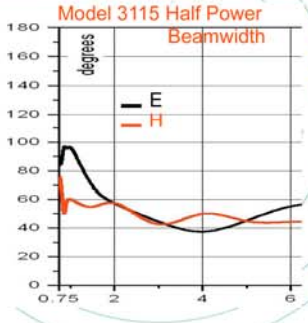
At 3m test distance the -3dB Illumination Diameter is given by D = 6 Tan BW/2



10 Degrees BW Gives 0.5m Diameter



40 Degrees BW Gives 2m Diameter

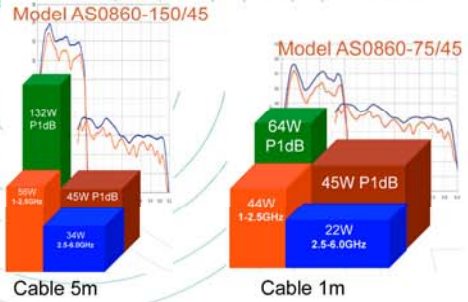


The 3115 has a BW of 40 Degrees or better over most of the 1.0-6.0GHz Band

Outer Calibration Points at 18v/m imply a boresight field strength of 25v/m

This Equates to a 3dB increase in Amplifier Power

5 Power With Overhead in Each Band



Cable Length	5m	1m
1.0-2.5GHz	56W	44W
2.5-6.0GHz	34W	22W

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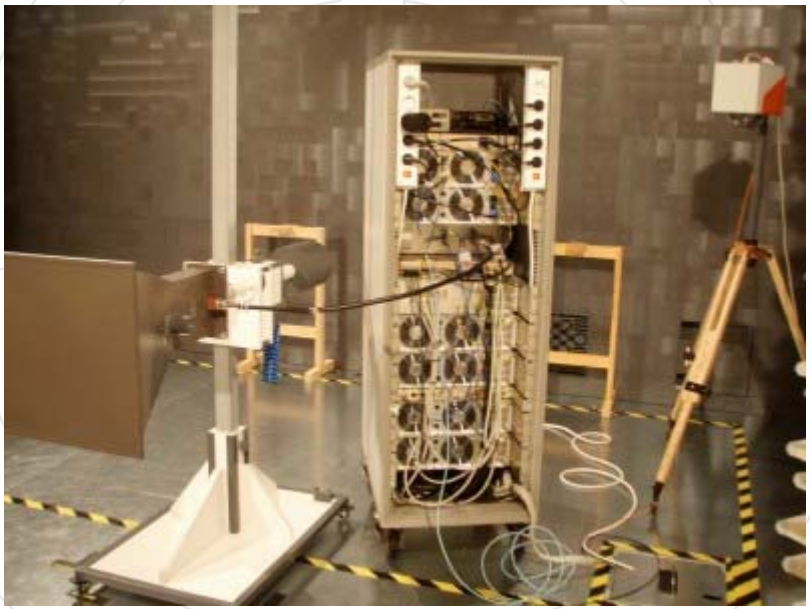

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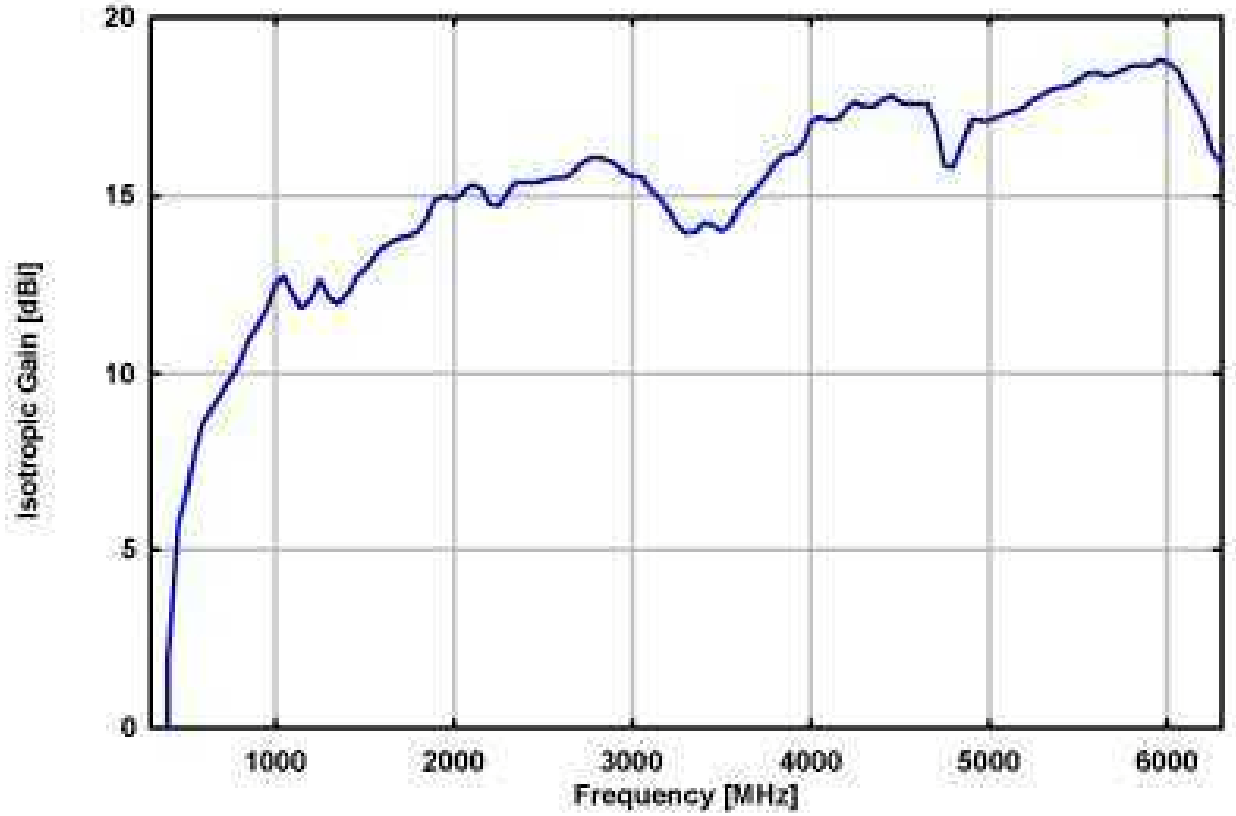
20
15
10
5
0
Isotropic Gain [dBi]
1000
2000
3000
4000
5000
6000
Frequency [MHz]

Aspects of Achieving 10 v/m Field Uniformity over 1-6GHz with Single, Multiple and Cassegrain Antennas

QUESTIONS?

Tom Mullineaux

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