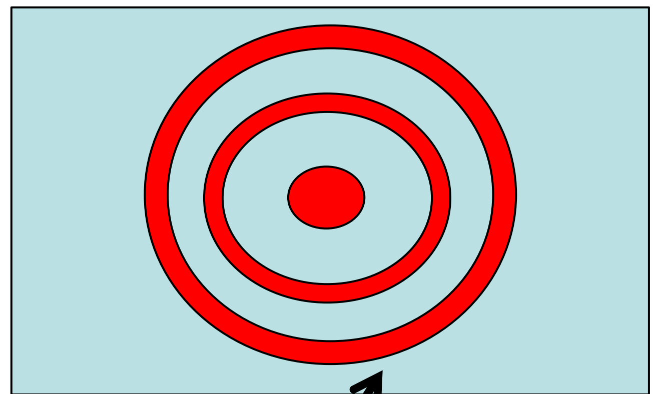
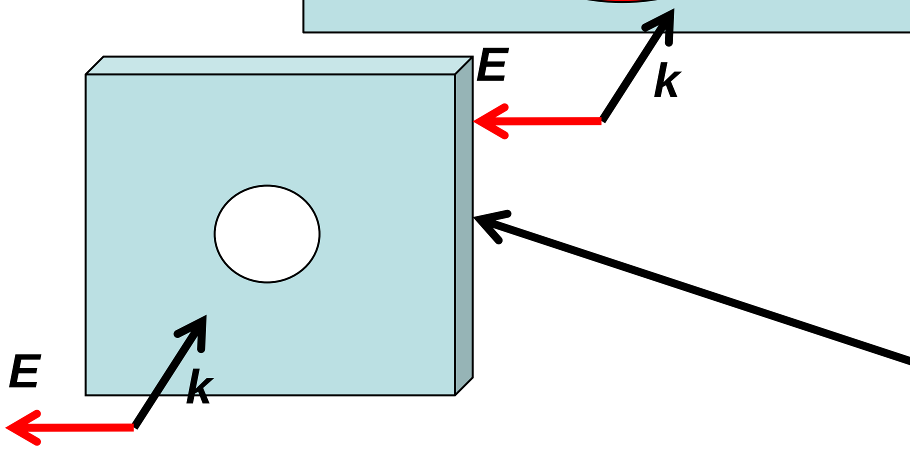
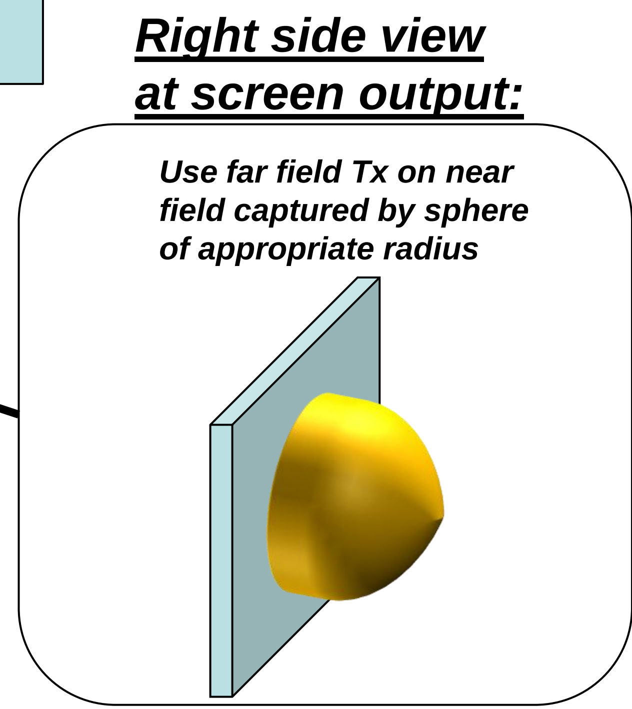
Far Field Analysis: Toy Problem

On a screen in the far field, diffraction pattern is seen: Airy rings (can see physically if a screen is placed appropriately)

Can do transformation of the fields immediately on the other side of the screen, and compute far field radiation pattern.







Plane wave incident on perfectly conducting screen with aperture of diameter ~ 5 wavelengths

Simulation Setup

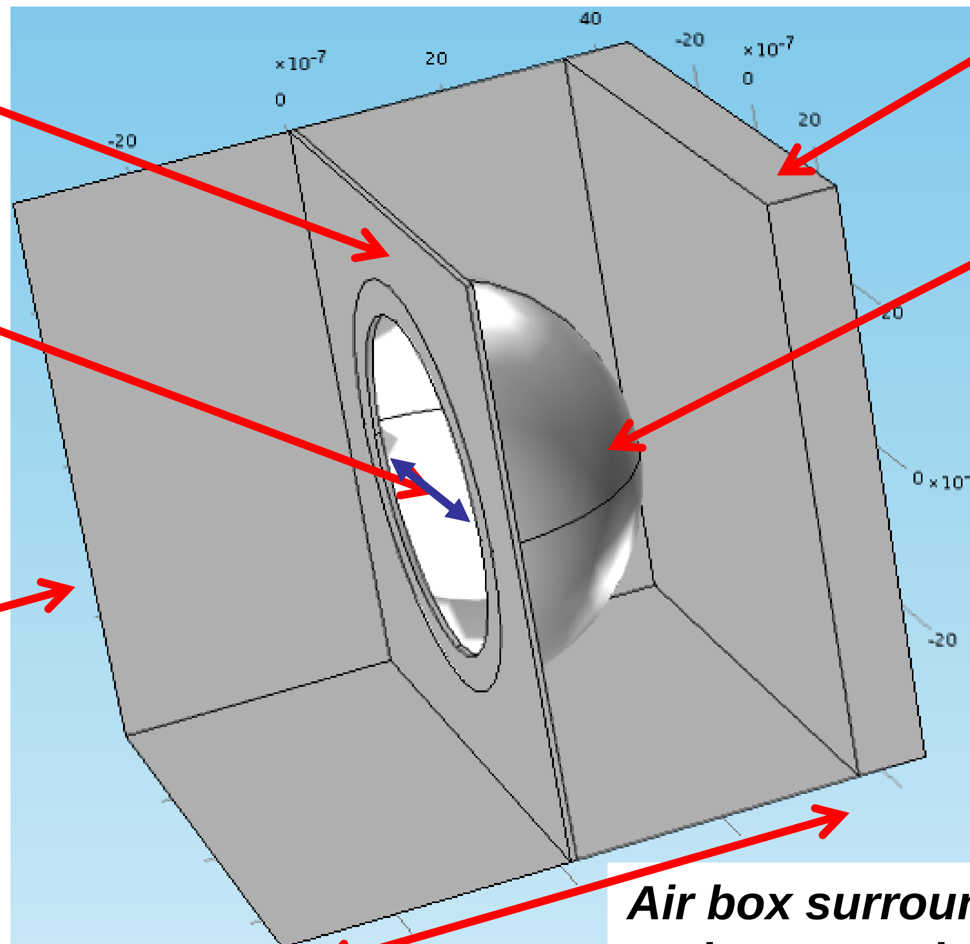
All domains air, λ = 828 nm

Thin, PEC screen (80 nm)

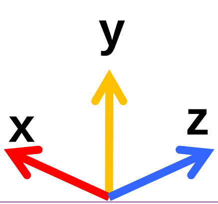
Aperture, diameter = 5λ

PML, 1λ long

Half sphere for FF Tx, R = 5 μm



Port→Plane wave excitation, x-polarized



Air box surrounding screen and aperture is 7 μm each side

Fraunhofer Approximation

- ***Under the condition that the observation point is very far away from the source, the Fraunhofer approximation for the intensity distribution of diffraction through an aperture applies***

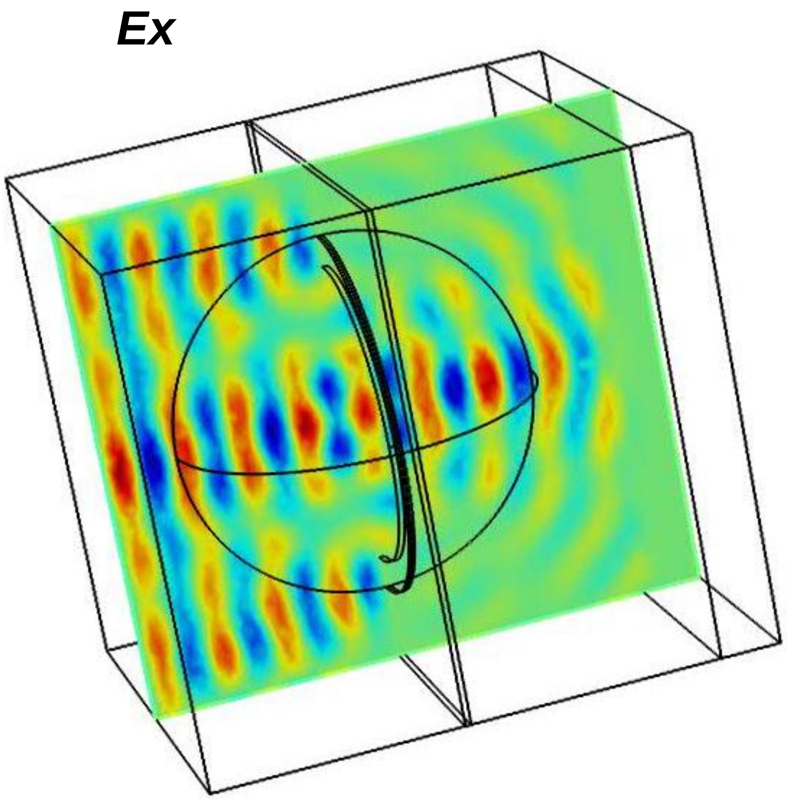
- ***For a circular this amounts to the fourier transform of the 'circ' function, up to a scaling factor***

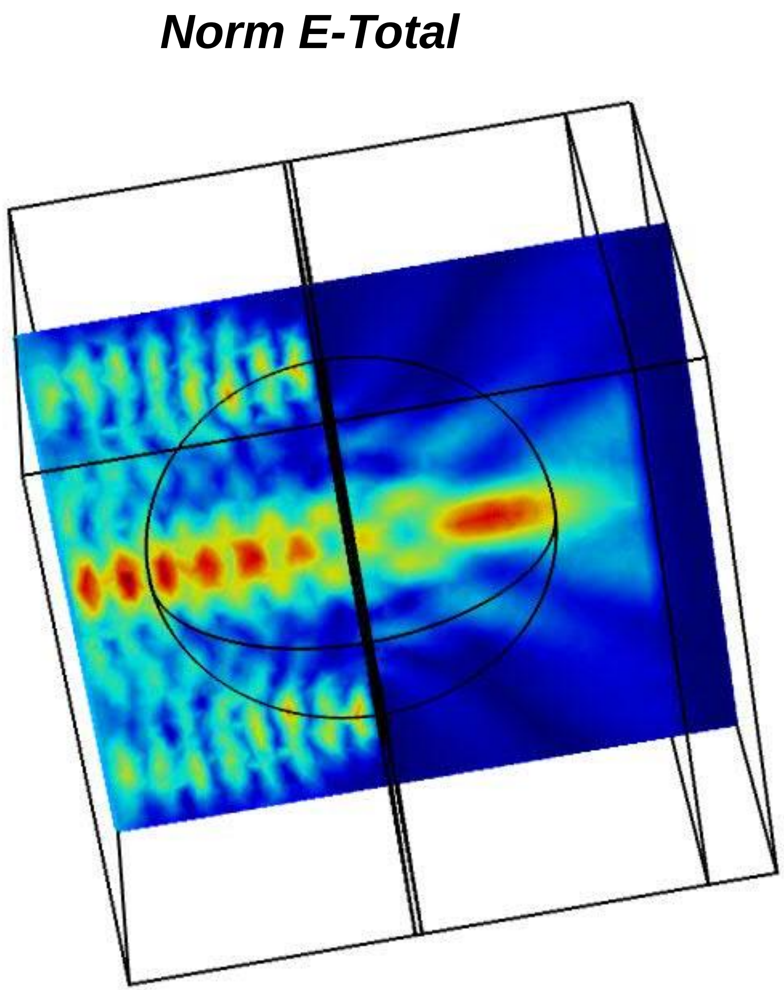
$$I(r) = \left(\frac{A}{\lambda z}\right)^2 \left[2\frac{J_1(kwr/z)}{kwr/z}\right]^2$$

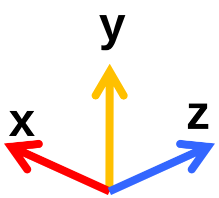
- ***Where in the above:***
  - ***A = amplitude constant***
  - ***λ = wavelength***
  - ***z = distance to observation screen***
  - ***k = 2pi/λ***
  - ***w = radius of aperture***
  - ***r = radius coordinate in observation plane***
  - ***J_1 = Bessel function of the first kind, order 1***

•**J. Goodman, <u>Introduction to Fourier Optics,</u> 2005, pp76-78**

Simulation Results: Plane Wave @ Port



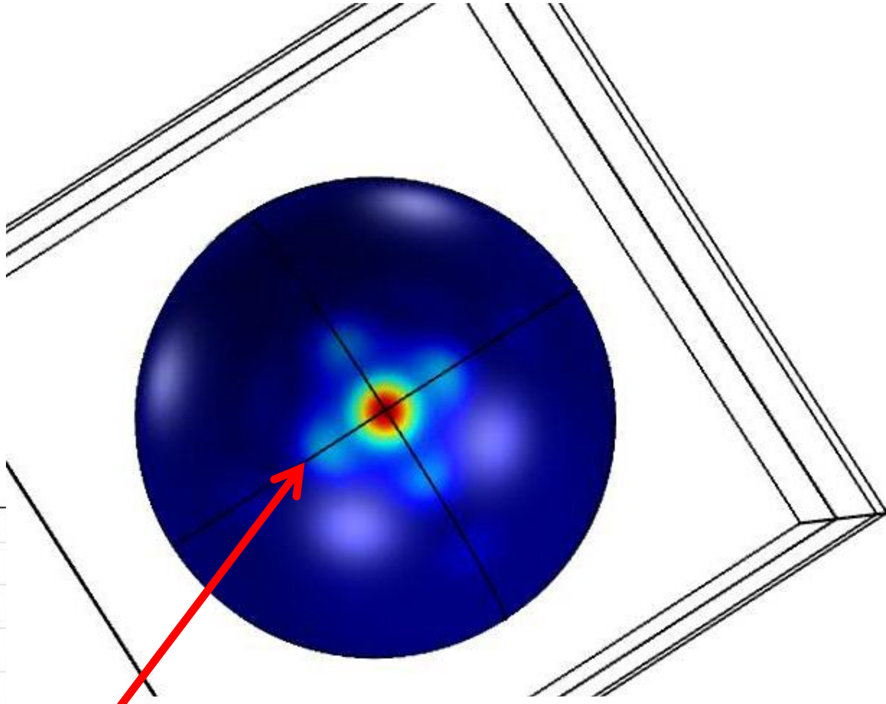




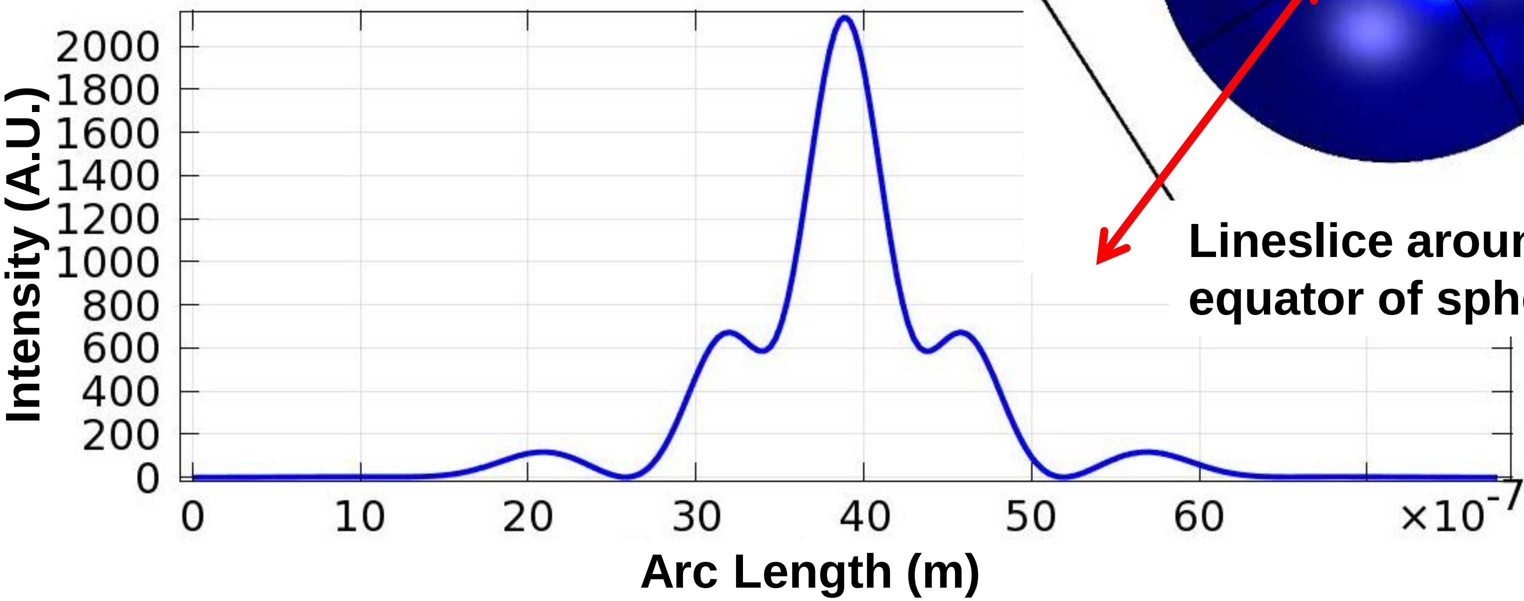
Looks reasonable so far…

Far Field Pattern: For Plane Wave @ Port Excitation

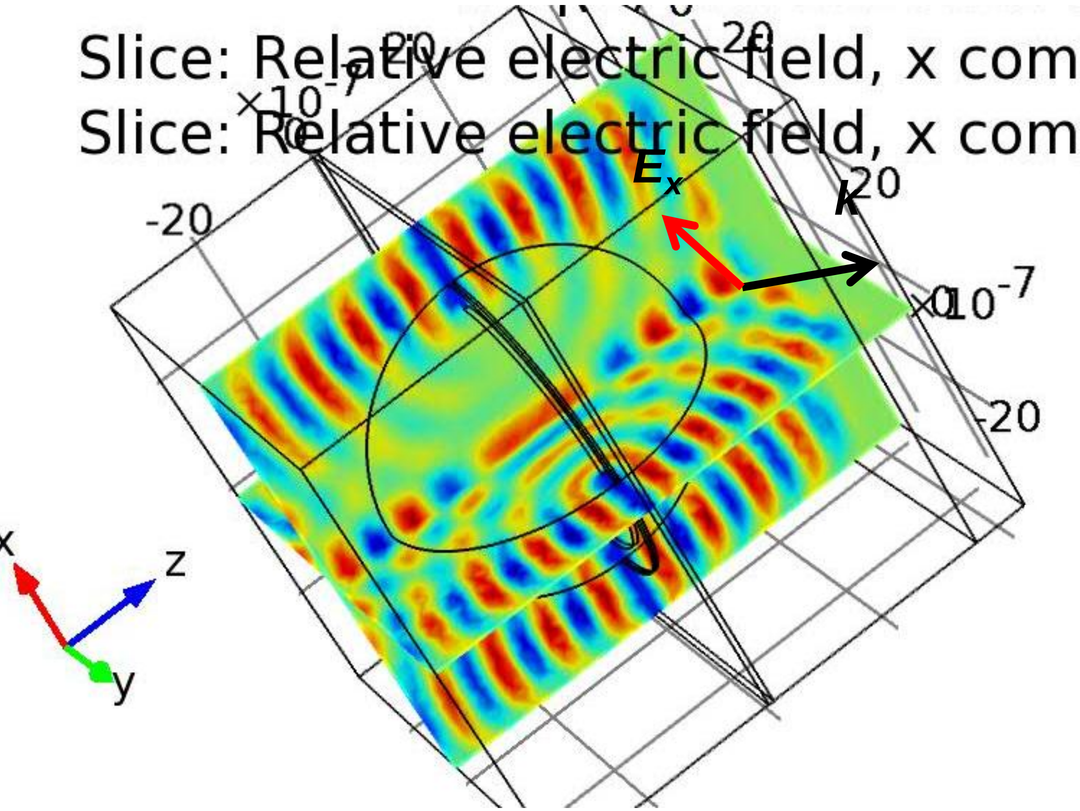
But..no Airy Rings….



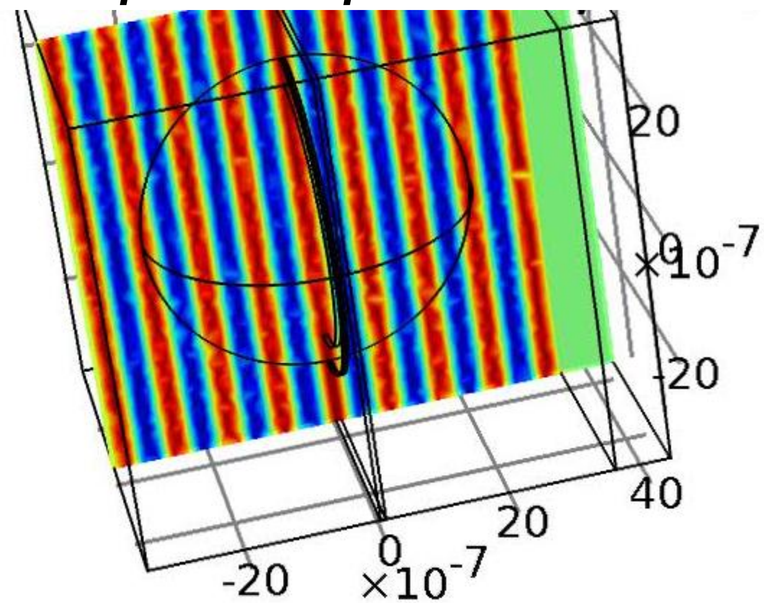
Lineslice around equator of sphere



Plane Wave Background Excitation



Background Field: x-polarized plane wave: Ex

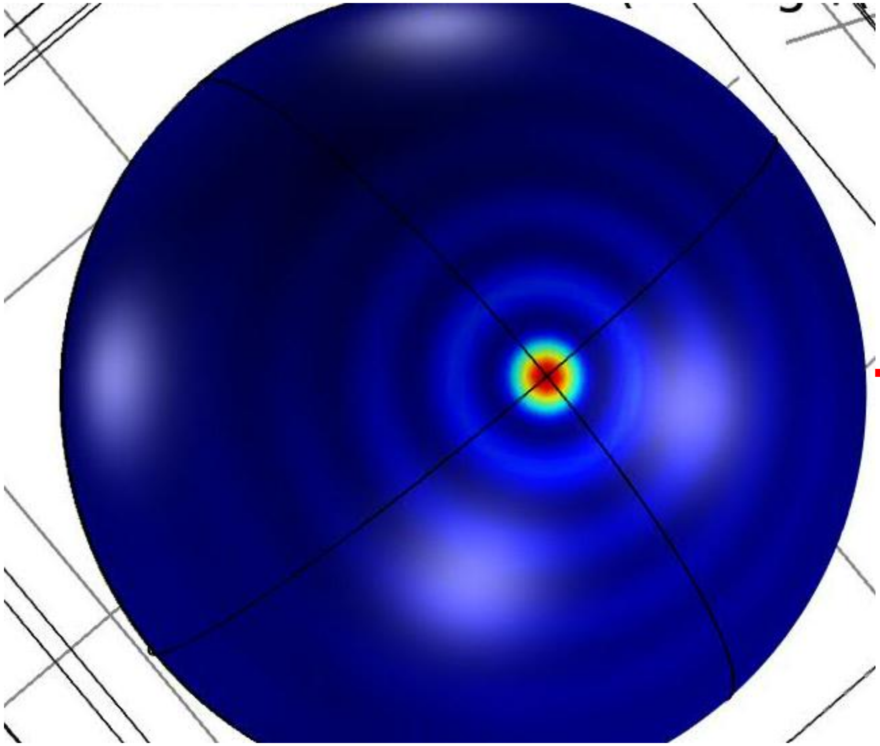


- **So I backed up and tried scattered field formulation Etot = Ebackground + Escattered**

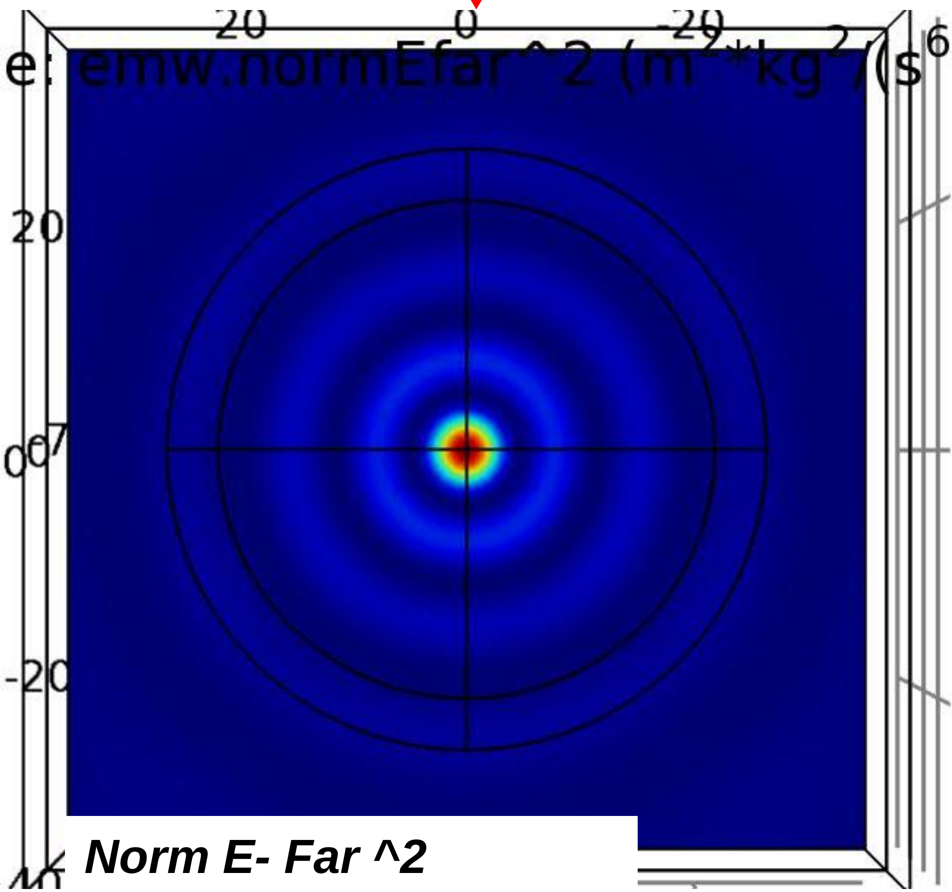
- **Fields look reasonable here, too…**

Far Field Results 2

Norm E- Far ^2, 3D half sphere



Projection onto screen in x-y plane



Norm E- Far ^2

- **At least I see rings….**

Let's Compare Prev. Slide to Fraunhofer Approximation

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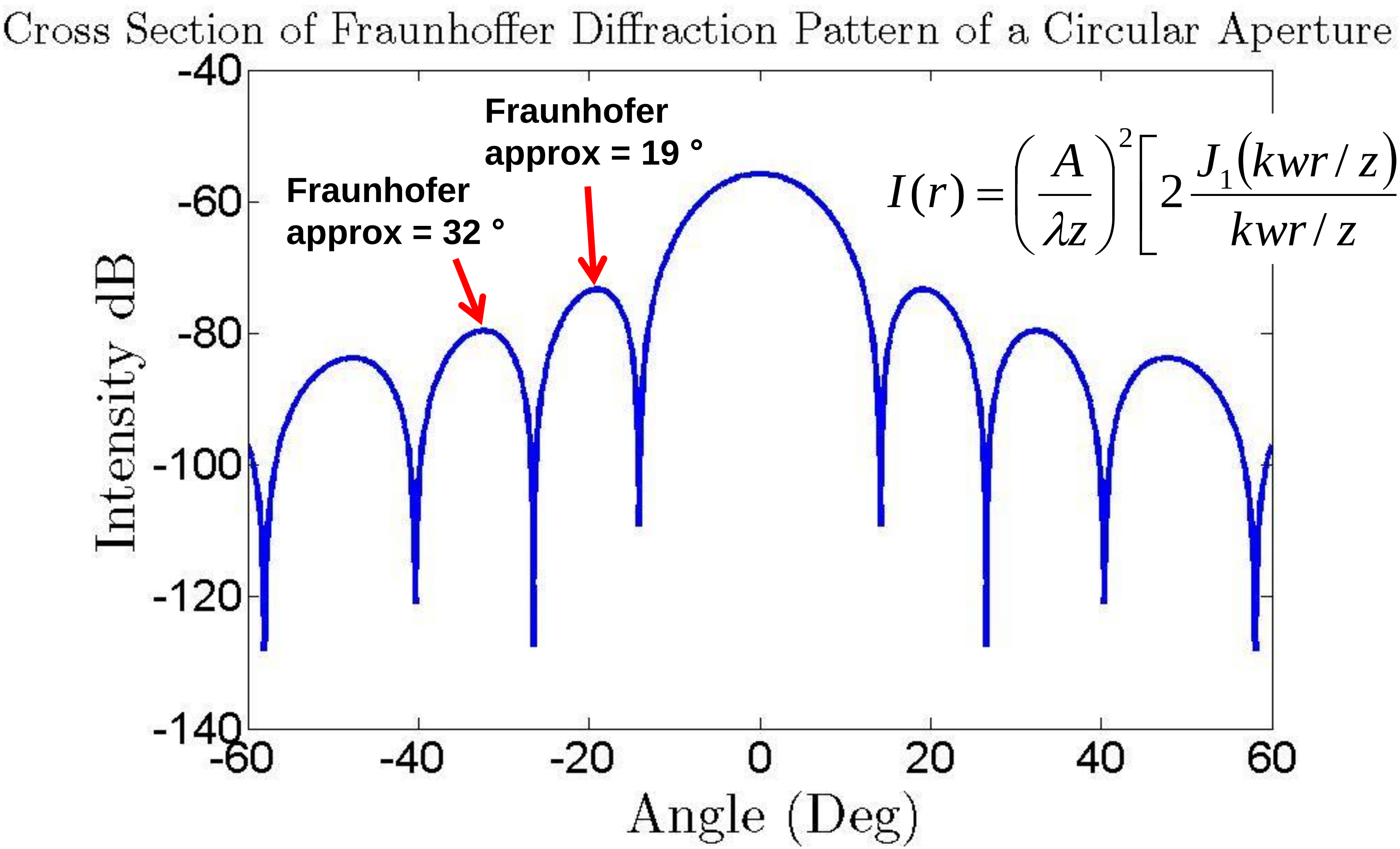
Fraunhofer Approximation: Angular Distribution and Location of Maxima (dB scale for clarity)



$$I(r)=\left(\frac{A}{\lambda z}\right)^2\left[2\frac{J_1(kwr/z)}{kwr/z}\right]^2$$

Angular Distribution: Scatt Field Formulation

- So why is the intensity larger than it should be…

- Moreover, peaks and maxima are not at their correct angle, according to slide 9