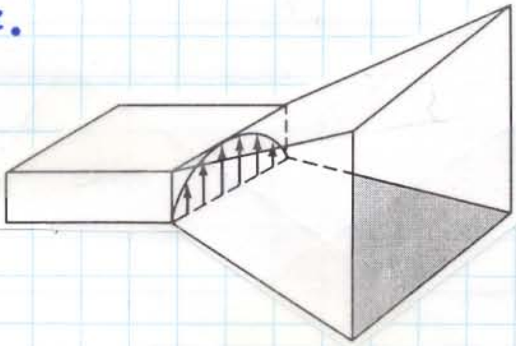
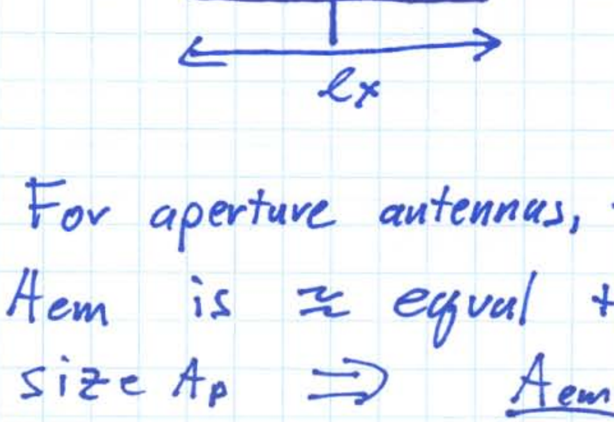
The Horn Antenna

A horn antenna is a type of <u>aperture</u> antenna.

A horn antenna
is shaped like...
a horn!!



- The size (i.e., area) of the end of the horn is the important parameter



So

Aperture Area $\doteq A_p = \ell_x \ell_y$

- For aperture antennas, the effective aperture A_{em} is $\approx$ equal to the physical aperture size A_p $\Rightarrow$ $\underline{\underline{A_{em} \doteq A_p}}$.

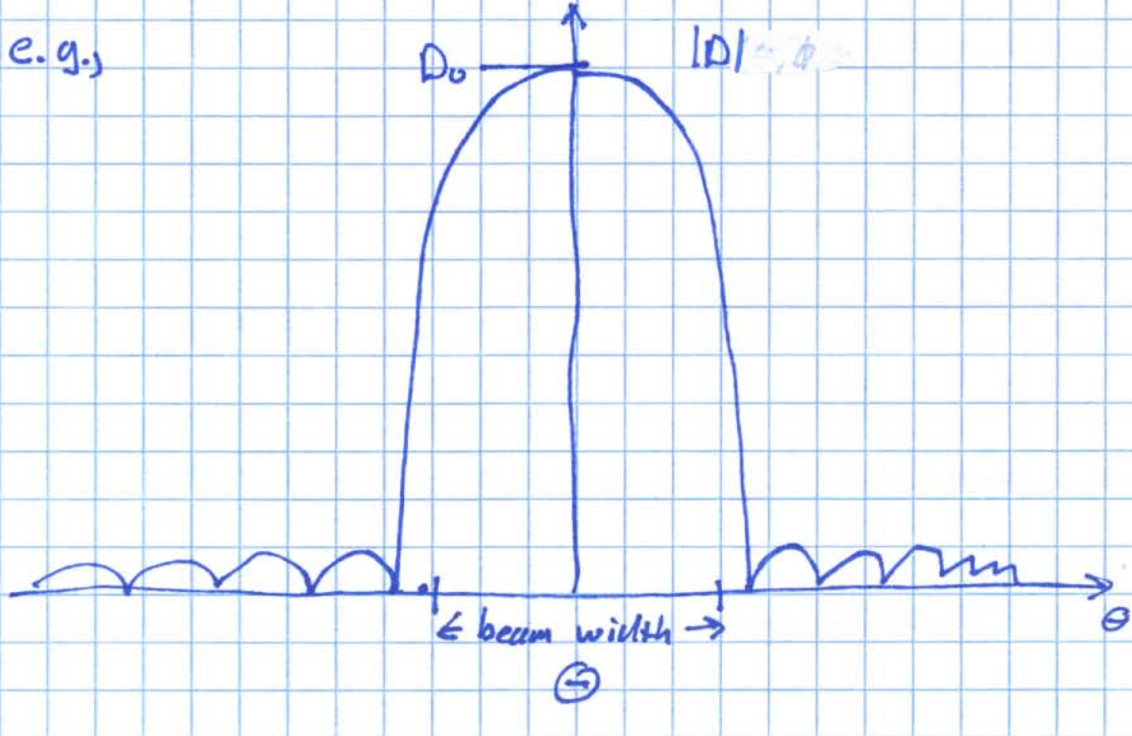
$\therefore$ If we increase the aperture size A_p, we increase A_{em}, and of course also the gain G_0.

$$\boxed{\text{i.e.,}\quad G_0 = \frac{4\pi A_{em}}{\lambda^2} = \frac{4\pi}{\lambda^2} A_p = \frac{4\pi\, \ell_x \ell_y}{\lambda^2}}$$

- Of course, as the Gain increases, the beam width must decrease.

- For a large horn antenna, the antenna pattern consists of a narrow main beam and small side lobes:

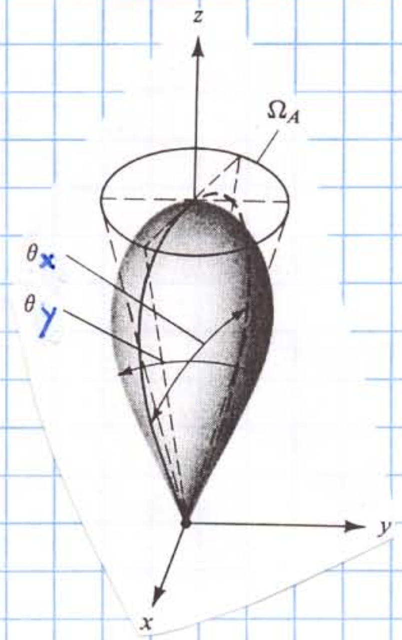
e.g.,



- Recall the main beam is a <u>solid angle</u>, defined in steradians.

- <u>But</u>, if the main beam is narrow, then we can define the beam with two angles Θ and Θ_z, representing the beam width in two orthogonal planes.

- For example, if the main beam is oriented in the z-direction, then Θ_x and Θ_y can define the beam width in the x-z and y-z planes, respectively.



- The solid angle of the main beam Ω_A, given in steradians, can be approximated as:

$$\Omega_A = \Theta_x \Theta_y \quad \text{(steradians)}$$

- We can so approximate the integral:

$$\boxed{\int_0^{2\pi}\int_0^{\pi} D(\theta,\phi)\sin\theta \, d\theta \, d\phi \approx D_o \Omega_A \approx D_o \theta_x \theta_y}$$

- But! Recall this integral is also $= \underline{\underline{4\pi}}!$

so $$4\pi \approx D_o \Omega_A \Rightarrow D_o \approx \frac{4\pi}{\Omega_A} \approx \frac{4\pi}{\theta_x \theta_y} \Bigg\|$$

- But! Recall D_o is *also* equal to:

$$D_o = \frac{G_o}{e} = \frac{4\pi}{e}\frac{A_{em}}{\lambda^2} \approx 4\pi \frac{l_x l_y}{\lambda^2} \Bigg\| \; (e \approx 1)$$

so $$\boxed{D_o = \frac{4\pi}{\theta_x \theta_y} = 4\pi \frac{l_x l_y}{\lambda^2}}$$

As a result, $\frac{1}{\theta_x} \approx \frac{l_x}{\lambda}$ + $\frac{1}{\theta_y} = \frac{l_y}{\lambda}$

or, more specifically:

$$\boxed{\underset{\text{(radians)}}{\theta_x} = \frac{\lambda}{l_x}} \quad \text{and} \quad \boxed{\underset{\text{(radians)}}{\theta_y} = \frac{\lambda}{l_y}}$$

Note as l gets larger, θ gets smaller (but G_0 gets bigger).

Advantages of Horns:

- Simple design
- Moderate band width
- High Gain/ Narrow beamwidth.

Disadvantages of Horns:

- Weight
- Wind loud
- Volume

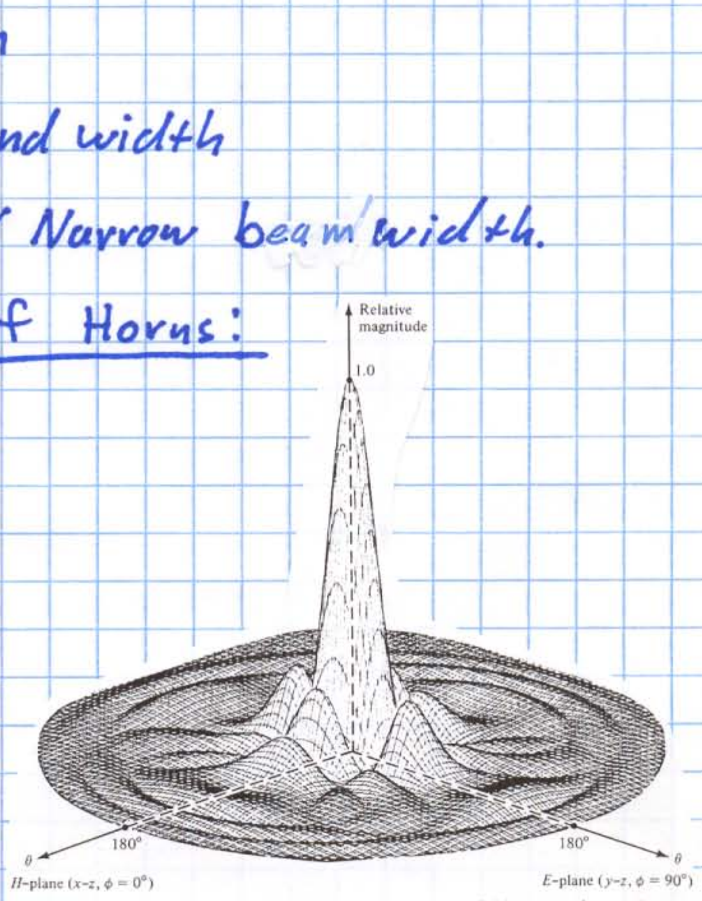


Figure 11.11 Three-dimensional field pattern of a constant field rectangular aperture ($a=3\lambda$, $b=2\lambda$).