

#91-7

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To: Holographers

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Subject: Holography artifacts and their amelioration

1] Image reconstruction sidelobes and the ripple artifacts

With uniform weighting in the square beam plane (91 x 0.032 degrees wide) the point spread function is

$$\text{Sinc}(91 \pi x / 128) \text{Sinc}(91 \pi y / 128)$$

where x and y are in units of pixels (1.16 feet). The sidelobes result in ripples which extend parallel to line structures (like the quadrapod) with periodicity of $3.3/\sqrt{2} = 2.3'$. The ripple period will change with windowing and virtually disappear with a circular window. The artifacts close to the inner quadrapod shadows do shift with windowing and are consistent with being sidelobes of the point spread function. Figure 1 shows some examples of simulations. Some of the ripple artifacts are produced by sidelobes of repeating structures in the radome which is not that random in some aspects - see Figure 2. These can be largely eliminated by using only a circular portion of the beam map and using radome corrections that are appropriate for the same circular window.

2] Backscatter from the radome hubs and spars

The radome correction model only accounts for the dominant forward scatter (usually called diffraction). Much of the energy loss from blockage is scattered into wide angles. If some of the backscattered energy is reflected back into directions close to the main beam the sidelobes may be within the beam area mapped for holography. This will produce artifacts in the holography which will be critically dependent on the direction of the satellite. Figure 3 shows the geometry of backscattered ray paths which can result in sidelobes close to the main beam. Estimates for the level of these sidelobes are as follows:

Total energy interrupted by radome spar	~	-33 dB
Relative level on beam pattern of spar refl.	~	-13 dB
Fraction of lobe within 2°	~	<u>-10 dB</u>
		-56 dB

compared with an average sidelobe level of about -70 dB as estimated from the system temperature increase due to ground pick-up. Artifact of 3 mils $p-p$ spread over 2000 sq' of antenna surface near the edge of the illumination will result from a sidelobe level of about -55 dB.

Backscatter from the radome might account for some of the lack of repeatability. If it can be shown that there are significant artifacts which show in the difference between maps taken at different frequencies (by more than 10 MHz) or different satellite positions (by more than a beamwidth) then backscatter may be involved. The backscatter might be eliminated by placing a spoiler around the prime focus to deflect the rays which could be returned close to the main beam.

3] Scatter from the quadrapod

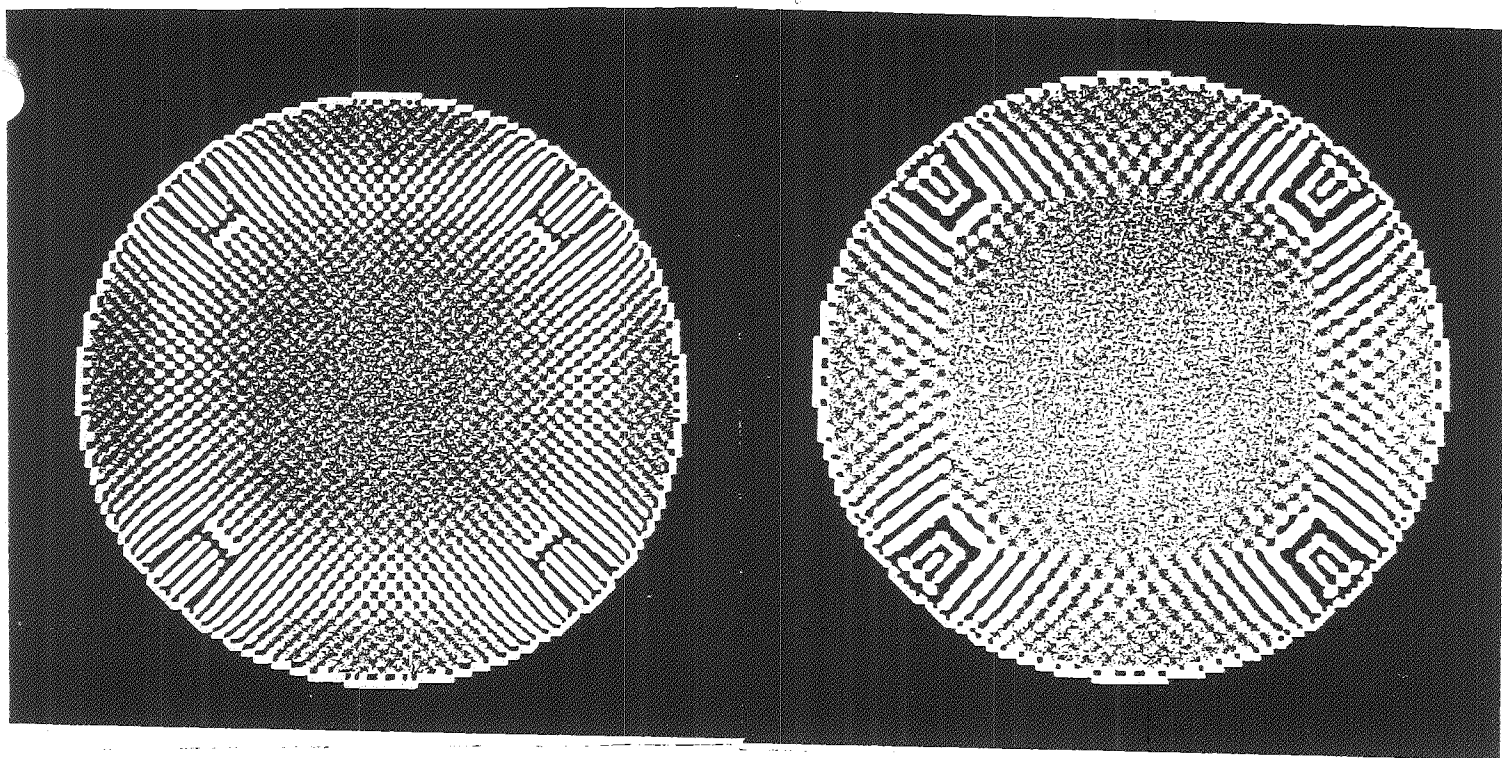
Again the corrections presently applied to the holography only account for the diffraction or forward scatter from the quadrapod and subreflector. However, I am unable to come up with any ray paths involving specular reflection from the quadrapod which would produce sidelobes closer than 6° from the main beam. Those from the quadrapod near the edge of the subreflector come closest - see Figure 4.

4] Phase errors

Phase errors in the holography arise from several sources. First is the Scott-Ryle effect which accounts for a circular motion of points on the antenna when scanned. Second are atmospheric phase fluctuations and random noise which will produce errors which do not repeat from map to map. The Scott-Ryle phase is only corrected to the splice plate and an additional 37° quadratic correction is needed for regions near the edge of the dish at 2° from the beam center.

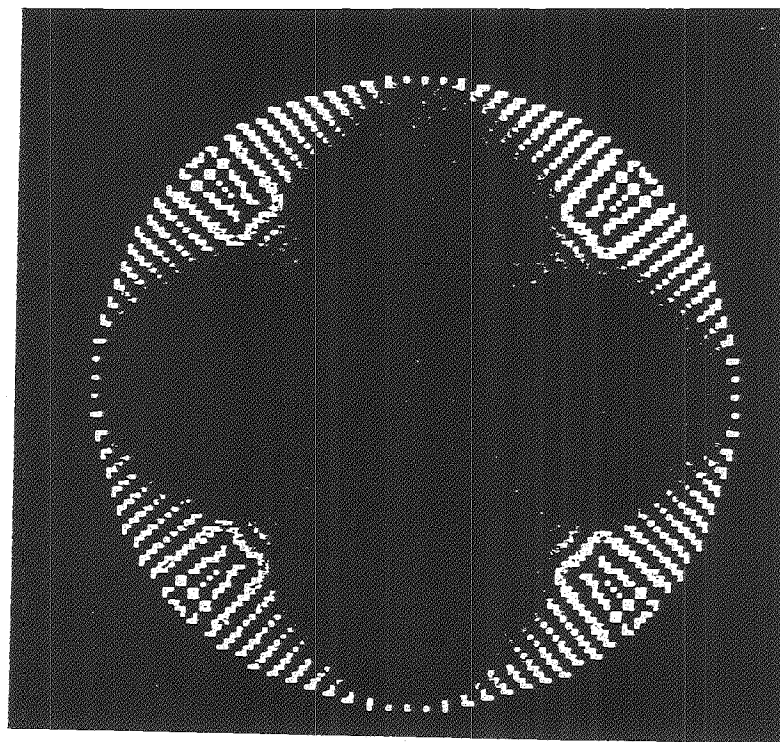
5] Multiple reflections involving the subreflector - 'Banana' artifacts

While these were reduced by spoiler, they were not completely eliminated. Rich Barvainis plans to take 2 maps with quarter wavelength difference. These artifacts are removed in the sum, and for repeated maps on the same elevation, half the difference can be used to correct maps on nights when only a single map is taken.



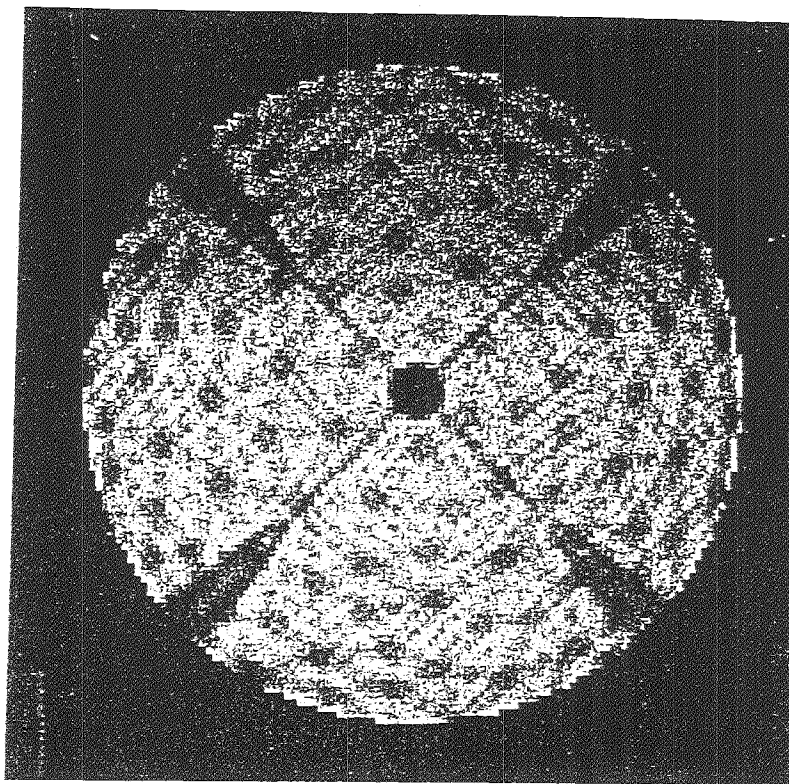
a) 91 x 91 Square Window

b) 51 x 51 Square Window



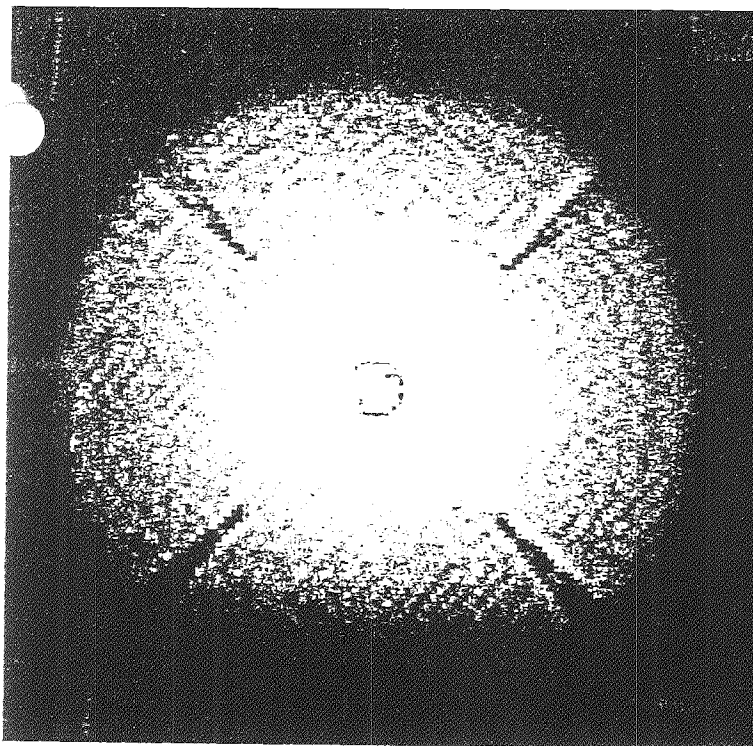
c) 91 Diam. Circular Window (contrast Enhanced to Accentuate)

FIGURE 1. SIDELOBES - SIMULATED DATA

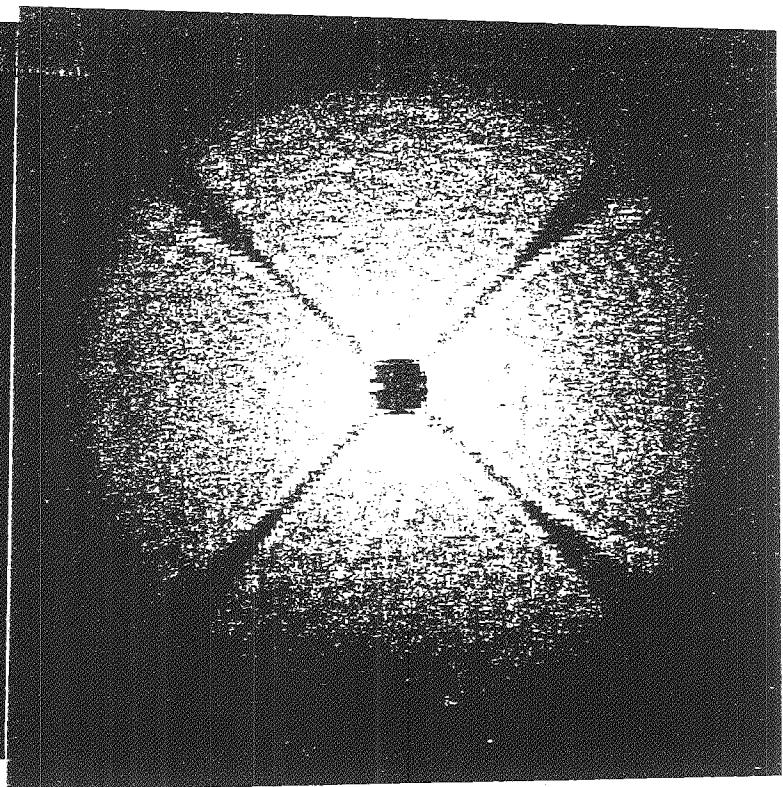


Note features which line up with this direction - have significant sidelobes.

a) Radome Correction with 91 x 91 Square Window



b) Holography with Circular Window is Overcorrected with "Square" Radome Correction



c) Holography Amplitude With Circular Window and "Circular" Radome Correction

FIGURE 2. SIDELOBES - HOLOGRAPHY DATA - (MAP 166)

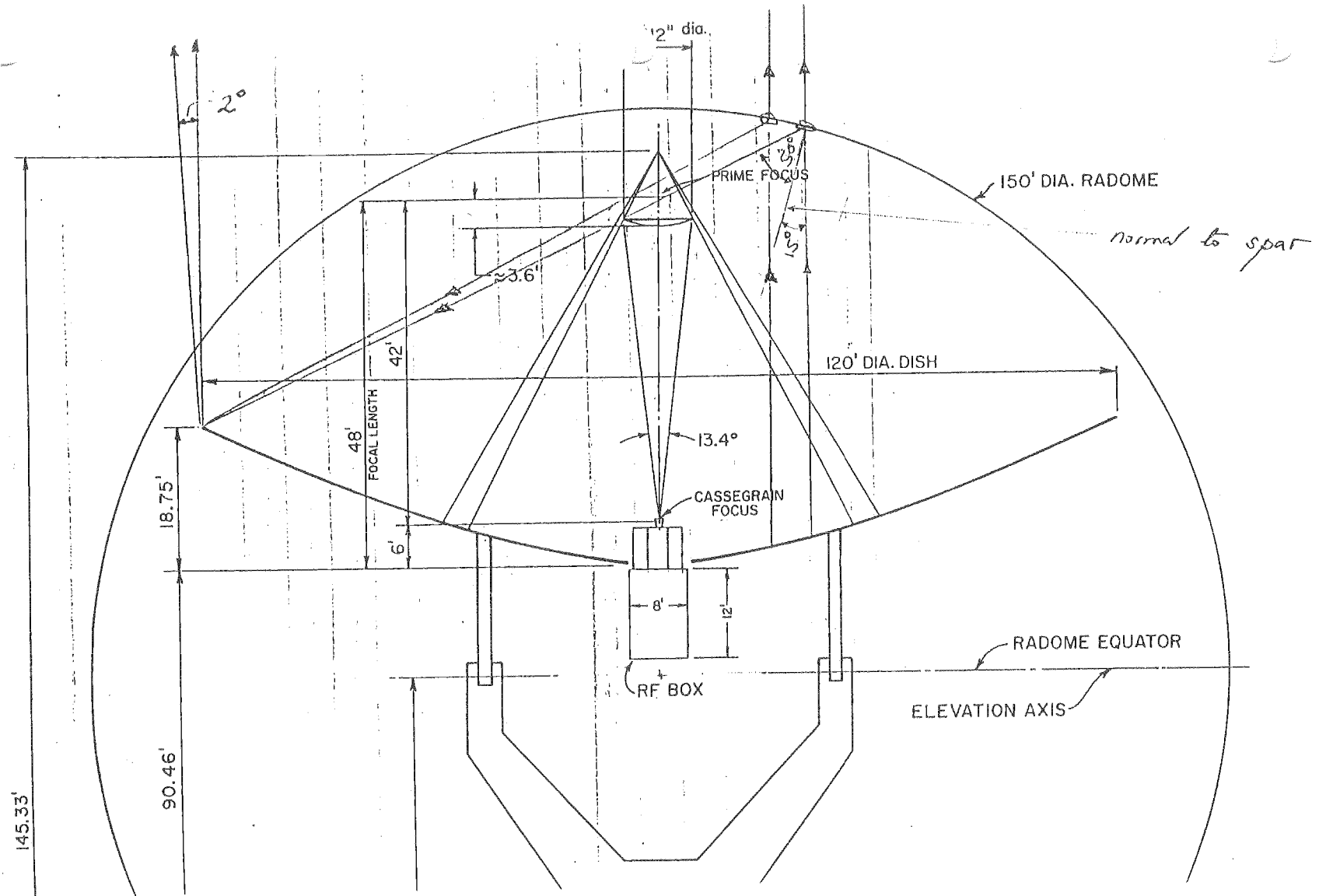


FIGURE 3. BACKSCATTER PATH WHICH CAN RESULT IN SIDELOBES CLOSE TO MAIN BEAM (RAYS PASSING NEAR PRIME FOCUS WILL BE REFLECTED INTO DIRECTIONS CLOSE TO MAIN BEAM)

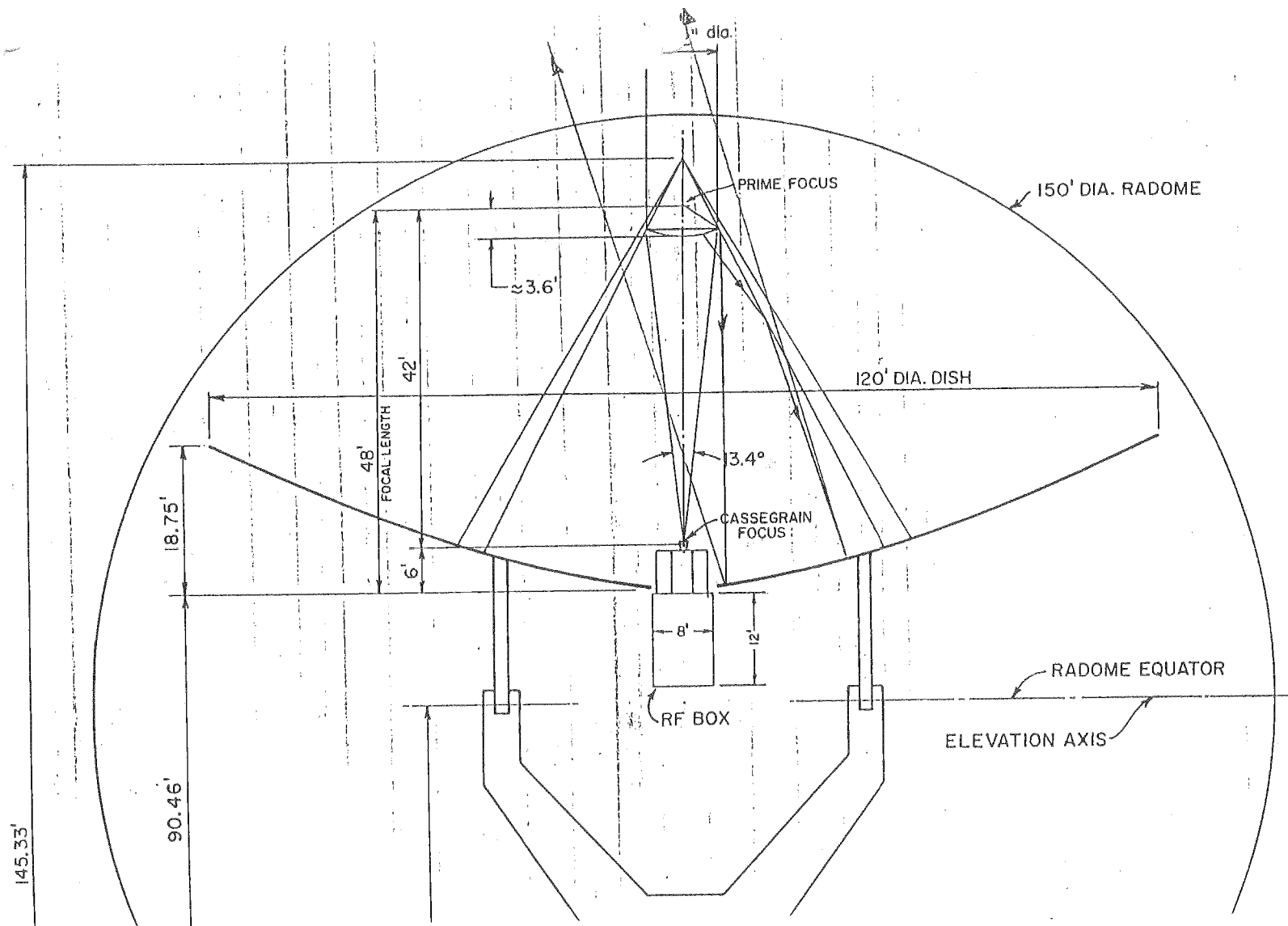


FIGURE 4. RAYS REFLECTED FROM QUADRAPOD FORM SIDELOBES WHICH ARE MORE THAN $\sim 6^\circ$ FROM MAIN BEAM