#92-10

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

HAYSTACK OBSERVATORY

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To: Holographers

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Subject: Diffraction from deformable subreflector: comparison with observation

To compare the holographic maps with subreflector deformation I have computed the diffraction as follows:

1. Integrate the wavefront phasor over an x,y plane centered on the subreflector vertex for each point on the main reflector at $(X,0)$.

2. Convolve the diffraction with the holography.

Using a rectangular coordinate system (x,y,z) centered on the parabola vertex and the geometry of the Haystack antenna (see Figure 1) the path length p is given by

$$p = d_1 + d_2 - Z - (f-h-g) - (f-h) \tag{1}$$

where

d_1 = distance from point at (x,y) on the subreflector to the feed
d_2 = distance from point on the subreflector to a point at $(X,0)$ on the main reflector
Z = distance of point on main reflector to plane through the vertex
f = parabolic focal length (576")
h = distance from subreflector vertex to prime focus (43.161")
g = distance of feed phase center to parabolic vertex (72")

From properties of the parabola

$$Z = X^2/(4f) \tag{2}$$

From properties of the hyperbola

$$Z = \left(-b + (b^2 + 4c)^{1/2}\right)/2 + f - h \tag{3}$$

where

b = 417.678"
a = 2.19271649
c = $a(x^2 + y^2)$

so that

$$d_1 = \left((z-g)^2 + x^2 + y^2\right)^{1/2} \tag{4}$$

$$d_2 + \left((z - Z)^2 + (X - x)^2 + y^2\right)^{1/2} \tag{5}$$

The angle θ in a direction normal to the subreflector is given by

$$\theta = \tan^{-1}\left[a(x^2 + y^2)^{1/2} / \left((b^2 + 4\ c)^{1/2}/2\right)\right] \tag{6}$$

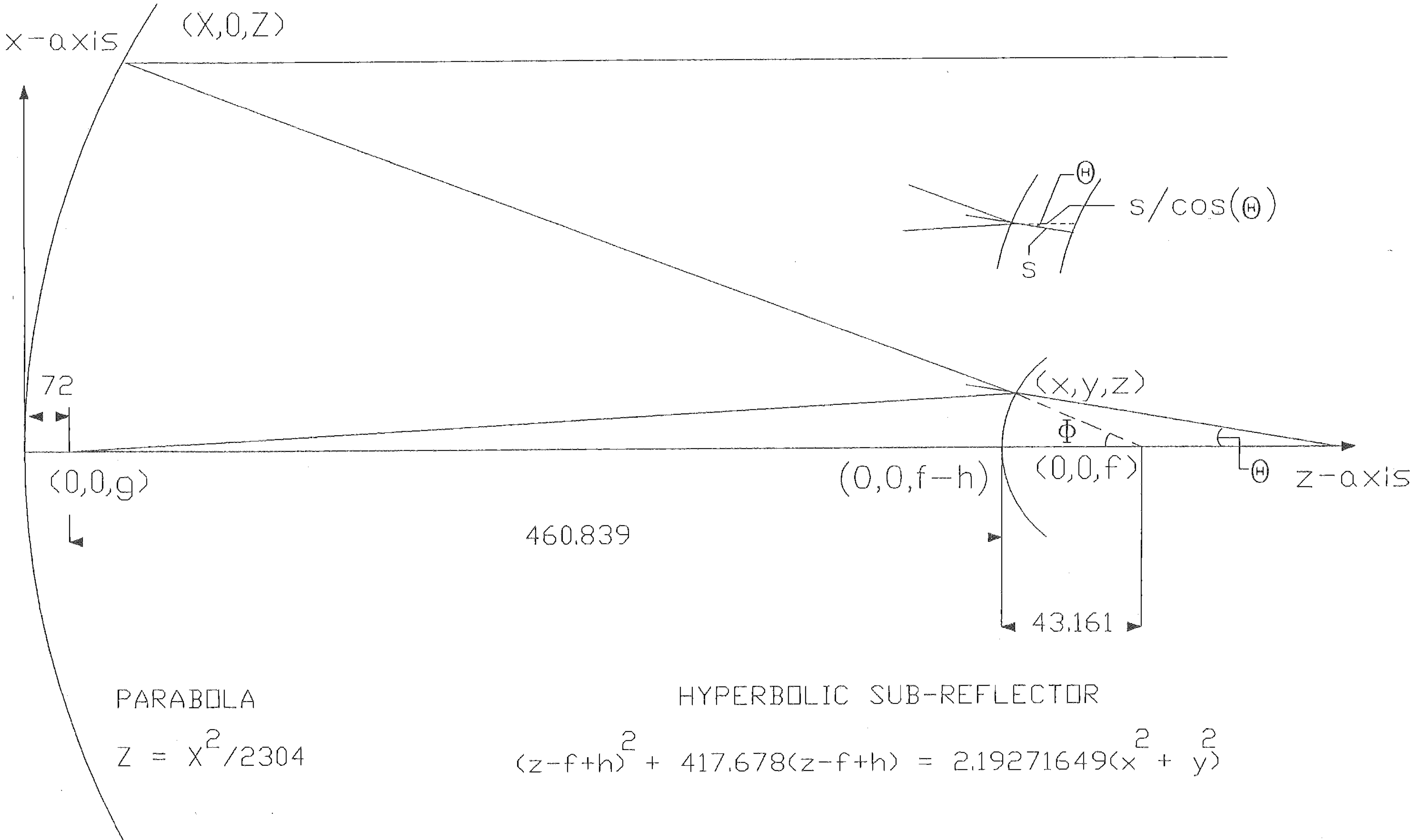
A subreflector deformation $S(\phi)$ in the direction normal to the subreflector surface alters the path length so that equation (3) becomes

$$z = \left(-b + (b^2 + 4\ c)^{1/2}\right)/2 + f - h - s(\phi)\ /\cos\theta \tag{7}$$

where

$$\phi = \tan^{-1}\left(X/(f - Z)\right) \tag{8}$$

Figure 2 shows the expected holographic measurement (at 11.8 GHz) for a ring c deformation (40 mils peak in a direction normal to the subreflector surface). The diffraction was convolved with the resolution of a 51x51 map. These results should be compared with a memo from Frank Kan (20 October 1992). The mechanical "overshoot" lobes are important in getting good agreement between holography and the mechanical model. The measured diffraction amplitude from Rich Barvainis is about 36% peak-to-peak which agrees quite well with the diffraction model of Figure 2.



GEOMETRY OF HAYSTACK

FIGURE 1

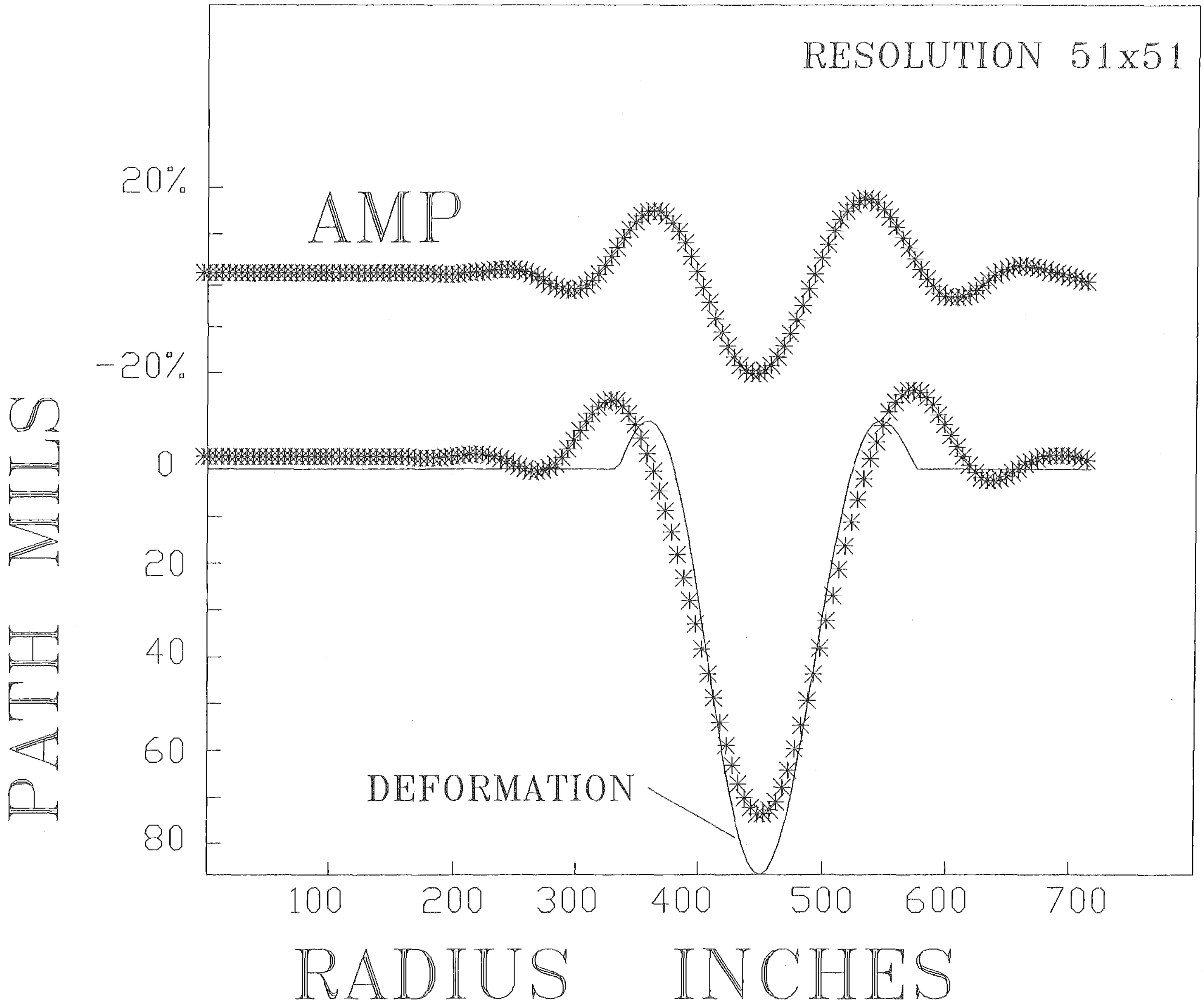

RESOLUTION 51x51
AMP
20%
-20%
PATH MILS
0
20
40
60
80
DEFORMATION
100
200
300
400
500
600
700
RADIUS INCHES

FIGURE 2

Amplitude plot from Rich Barvainis — Nov 92

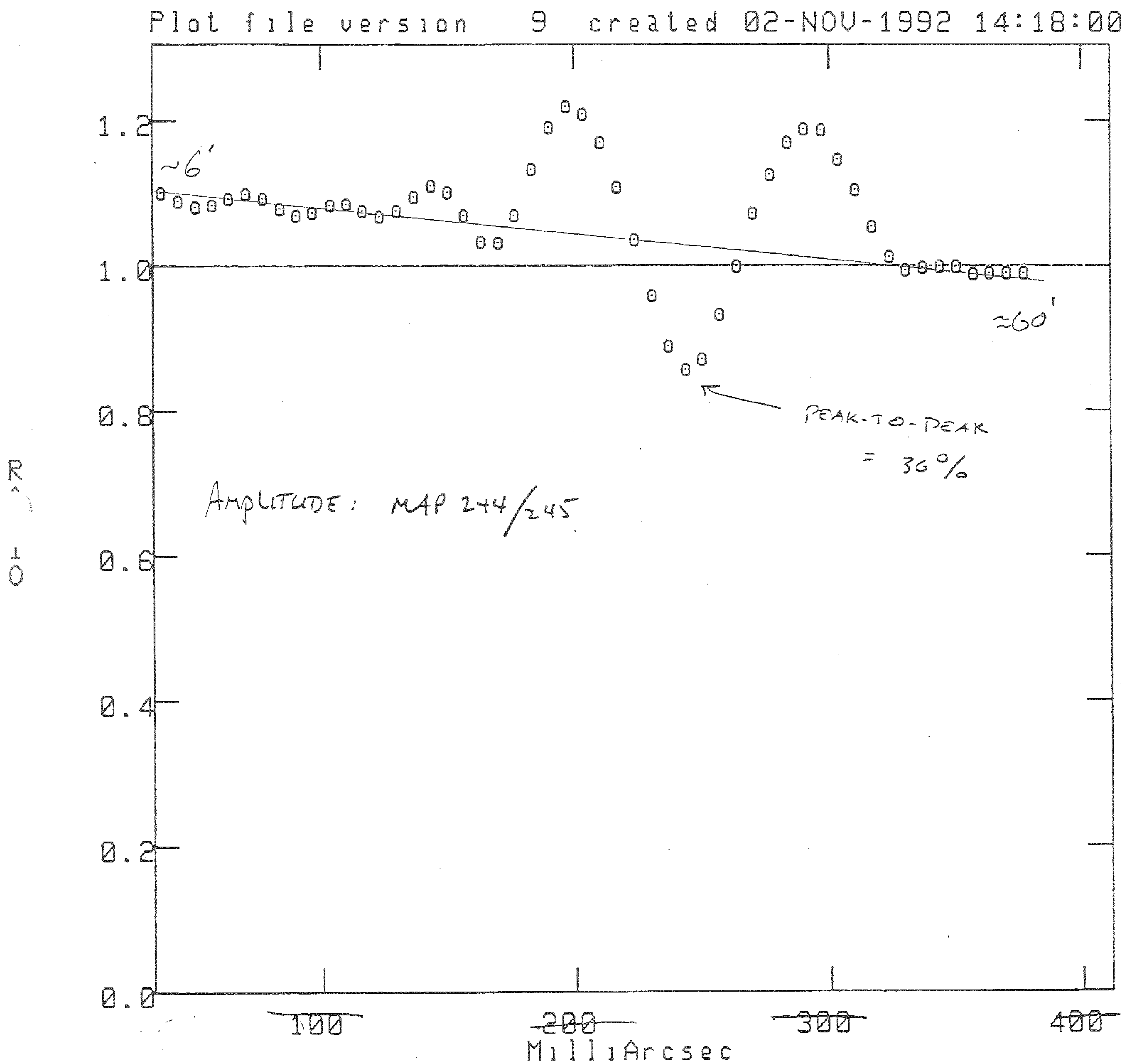


FIGURE 3