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December 27, 2017

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To: 37m Antenna Group

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Subject: Focus, tilt and pointing offsets for w-band feed

I used the "holography" model of the antenna to calculate the optimum focus, tilt and pointing offsets for the w-band astronomy feed which is offset by 32 inches above the radar feed which is assumed to be on-axis. Based on the geometric diffraction model of the 37-m antenna used for holography the optimum tilt of the subreflector about the prime focus to center the illumination and maximize the efficiency is +1.9893 degrees. The efficiency is 90.1% for a perfect dish. The 10% loss due is due to the astigmatism introduced by the subreflector tilt. The residual phase error is shown in Figure 1.

I have also used this geometric diffraction code to show that change in antenna focus, pointing offsets and lateral position of the subreflector made with an on-axis feed to correct for temperature etc. are also valid for the offset feed. This is the offsets used to correct for the offset feed can be held constant and further corrections should apply equally all feeds because the feed offset angles are small and so the differences due to antenna deformation by gravity and temperature are second order. It should be pointed out however, that the optimum pointing offsets for the offset feeds are slightly illumination dependent so that these offsets are frequency dependent to the extent that the feed patterns are frequency dependent. For example, if the antenna is under illuminated in the extreme case of illuminating only the center of the dish the pointing offset due to a lateral motion of the subreflector is 1/576 radians per inch (99.5 mdeg/Inch) for the 576" focal length of the primary dish. In practice 99.5 mdeg/inch drops to about 70 mdeg/inch for illumination with -12 dB taper at the edge.

There is a trade off between using the tilt which corrects the illumination and lower value of tilt which reduces the astigmatism introduced by the tilt

Focus (inches)	Tilt (deg)	Pointing offset (deg)	eff. %	Comments
0.015	1.9893	0.1344	90.1	Centers illumination
0.015	1.9	0.1418	90.1	
0.025	1.8	0.150	90.25	
0.050	1.5	0.1745	91.25	
0.14	0	0.2970	95.00	Minimizes aberration

Table 1. Pointing offset and efficiency for different values of tilt for w-band feed.

The values in Table 1 were obtained from a full geometric diffraction. The pointing offset can also be estimated from

$$p = -\left(p_0 + p_1 + p_2\right)$$

where $p_0 = 2A\tau/F$ shift due to tilt

$p_1 = -b\left(A/B\right)/F$ shift due to feed offset

$p_2 = -A\tau\left(1 - A/B\right)/F$

$t = tilt = \left(\frac{1}{2}\right)\left(\frac{b}{A}\right)$

(see memo 91_6 Nov. 1991)

where b = feed offset = 32”

A = distance from subreflector vertex to focus

= 43.161”

B = distance from feed to subreflector vertex

= F-72”-A

F = focal distance 576”

Tilting the subreflector introduces coma and astigmatism. The coma can be cancelled by a translation of the subreflector. Rotating the subreflector about the focus provides an equivalent translation to cancel the coma but the astigmatism remains. The astigmatism is insignificant frequencies at K and Q bands but is significant enough at W band that better efficiency might be obtained by a reduction in tilt to provide the best compromise between loss due to the imperfect illumination and the loss due to astigmatism. There is also a small focus offset introduced by the feed. The values found with the EM modelling are given in Table 1. A test of the constancy of the effects of antenna changes with feed location was made by showing that the effect of a change in subreflector tilt, subreflector translation, antenna focal length etc. produces a shift in focus and pointing that is independent of feed offset at the level of 0.1 millideg in angle and 0.01 inch in focus.

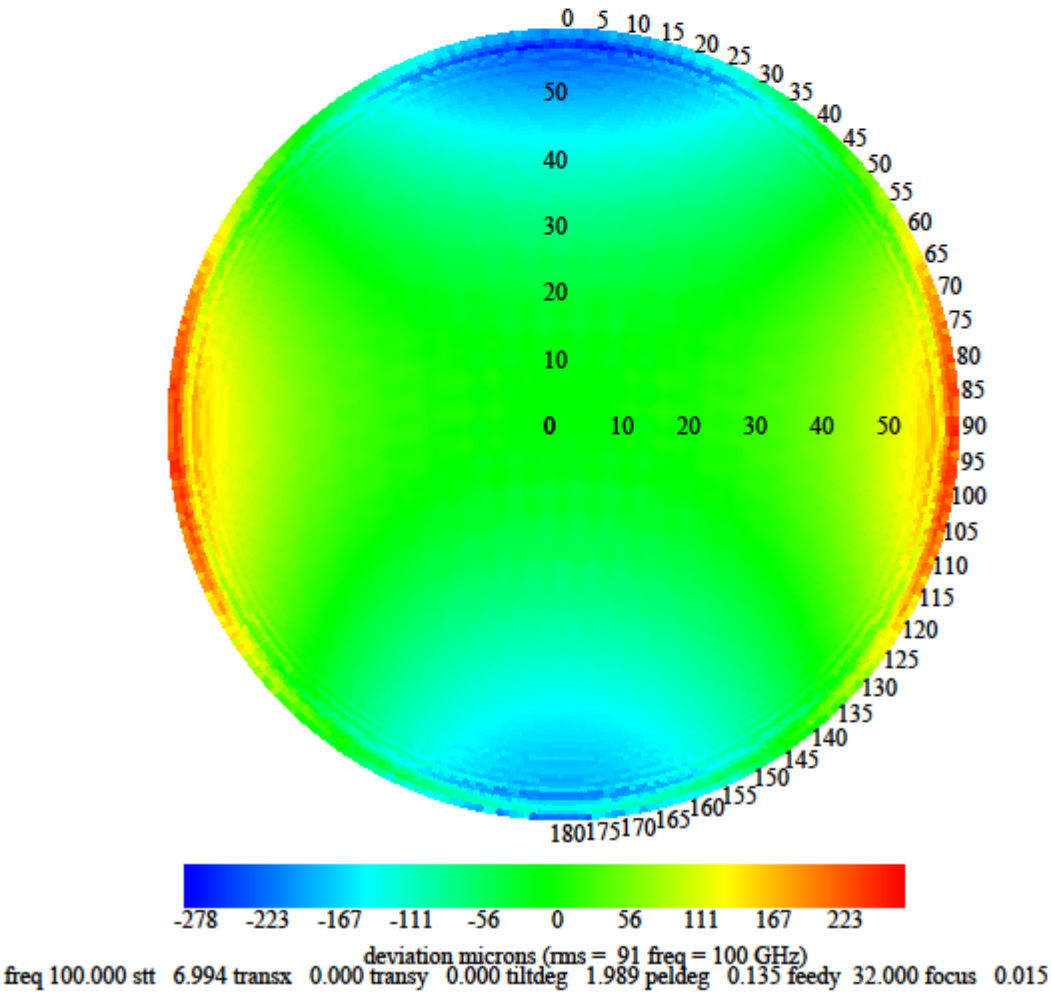

Figure 1. Residual phase errors for optimum focus and orientation of the subreflector to correct for the feed offset.