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24 May 1993

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To: Millimeter-wave VLBI Group

From: Alan E.E. Rogers AEER

Subject: Design of Off-axis Mirror

Introduction

As mentioned in a previous memo, I suggested that the off-axis mirror in the beam switch might be able to correct the illumination at 86 GHz to provide higher efficiency. Unfortunately, my first attempt was not very successful. The best efficiency achieved with the off-axis mirror was about equal to that on-axis. I have now discovered that the mirror was incorrectly oriented and misaligned by 1.5". I have now done a full diffraction analysis and think the mirror should work when correctly aligned..

Subreflector focus motion

Moving the subreflector along the "z" axis changes the focus and alters the spherical aberration as follows:

Subreflector Motion: -120 mils (towards RF box)
Focus (r^2 dependence): 100 mils path increase at edge
Spherical aberration (r^4 dependence): -32 mils path increase at edge

Moving the secondary focus back by the added path in the offset beam:

Move secondary back by 12"

Focus: -86 mils at edge
Spherical aberration: +6 mils at edge

so that the combined motion gives:

Focus: + 100 - 86 = 14 mils
Spherical aberration: - 32 + 6 = -26 mils

Shaped mirror

Without the flexibility of being able to move the receiver further out towards the subreflector the small amount of spherical aberration cannot be corrected and unfortunately the mirror shape needed to reduce the over-illumination introduces additional spherical aberration with the same sign. Even with the spherical aberration it is still possible to improve the efficiency although the phase errors limit the improvement. Figure 1 shows the amplitudes and phase, using a diffraction analysis, introduced by the mirror when illuminated with a feed with gaussian beam with -4.4 dB at the edge. The mirror improves the illumination and the table gives estimates of the efficiency improvements.

Illumination taper *dB* *(Gaussian beam)*	Best Eff. Improvement (without spherical ab.)	Best Eff. Improvement (with spherical ab.)	Present Mirror
-18	1%	-3%	-25%
-9	12%	5%	-2%
-4.4	35%	22%	21%
-2.7	68%	48%	53%

<u>Expected efficiency with mirror</u>

The best mirror shape was found to be that which produces a path reduction of 52.5 mils at a projected distance of 4.5" as shown in Figure 1. [The current mirror design reduces the path length by 73 mils and has similar performance when the feed over-illuminates the dish.] The performance of the best mirror I could find incorporates some of the beam shaping features of the Hat Creek lens described by Hudson, Plambeck and Welch. The "best" design has an increasing curvature at the edges while existing design has uniform curvature. Both designs are given in terms of projected path. [The actual contours are egg-shaped owing to the 45 degree orientation of the mirror surface.]

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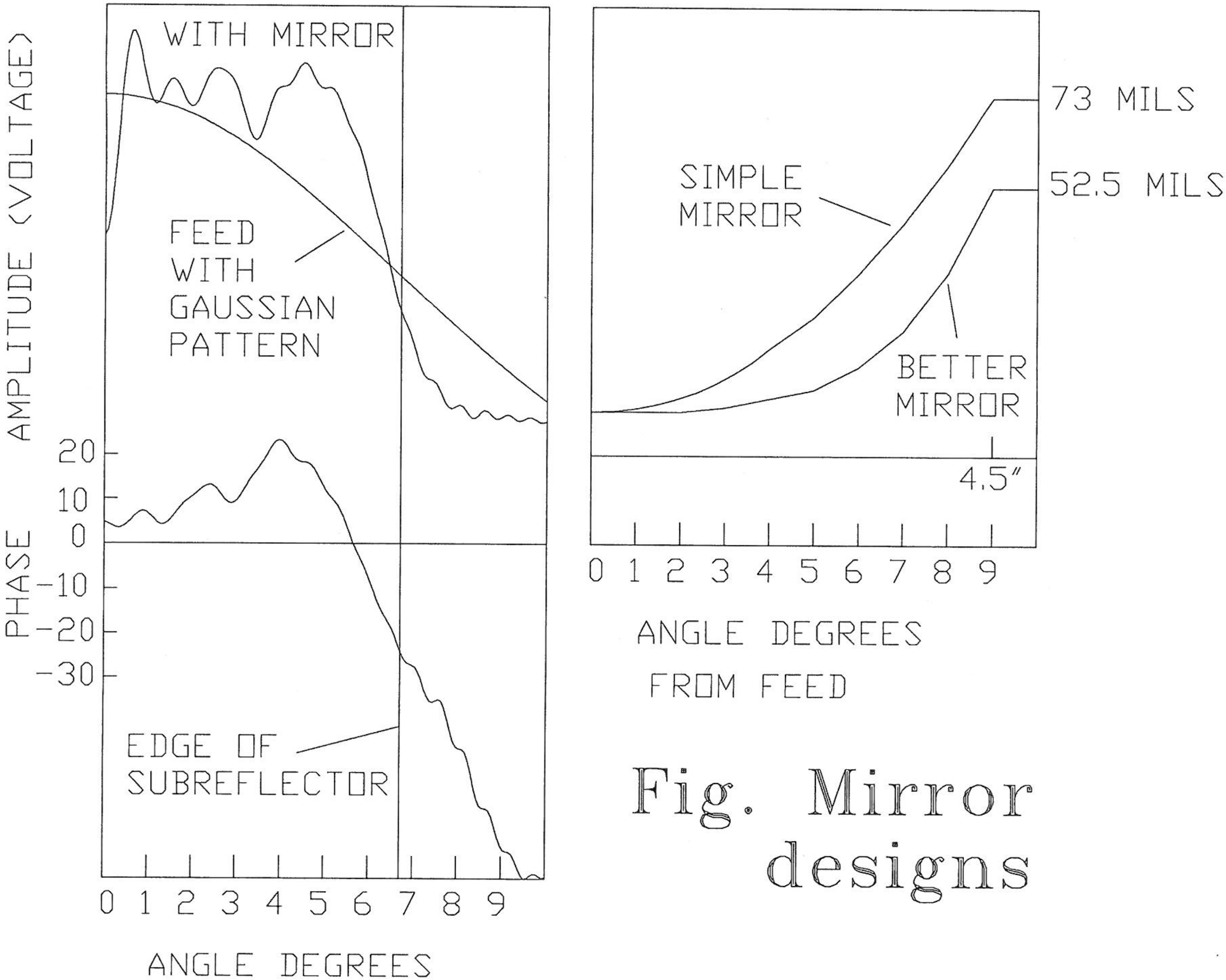

Fig. Mirror designs