GBT Commissioning Memo: Comparison of feed arm metrology with focus tracking measurements.

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Introduction

The flexing of the feed arm changes the position of the Gregorian subreflector relative to the prime focus of the main reflector. This effect can be corrected by compensatory motions of the subreflector, as described by Ghigo et al. (GBT Commissioning Memo, March 29, 2001). Direct measurements of the feed arm flexure were made by the Laser Metrology group in September 2000. In this memo the metrology measurements are compared with the focus tracking data.

Procedure

In September 2000, the Metrology group measured positions of several retro reflectors as the GBT was moved through a range of elevation angles. For this memo, we used data only for the reflector near the top of the feed arm designated "41040L", because there was a larger set of data for this target than for other nearby ones. The locations of these targets and table of measurements can be found in GBT Archive A0223.

The metrology group provided their measurements in a (u,v,w) coordinate system which is relative to the tipping structure. We have transformed these coordinates into a frame relative to the subreflector. The coordinate transformations are detailed in GBT Memo #165 (Goldman, 1997). The (u,v,w) system is Goldman's "Elevation Frame", (Xe, Ye, Ze). For the nominal telescope as designed, there is a rigid translation and rotation to the frame of the subreflector, (Xs, Ys, Zs). The origin of the subreflector frame is the vertex of the subreflector, and the Y axis of the subreflector (Ys) is tilted 36.7° to the axis of the main paraboloid (Ye).

The detailed transformations, using Goldman's Reflector frame (Xr, Yr, Zr) as an intermediate, are as follows:

$$Xr = Xe = u$$

$$Yr = Ye + 58439.11 \text{ mm} \qquad = v + 58439.11 \text{ mm}$$

$$Zr = Ze - 4999.99 \text{ mm} \qquad = w - 4999.99 \text{ mm}$$

$Xs = Yr \cos? + Zr \sin? - 34981.35$ mm

$Ys = Zr \cos? - Yr \sin? - 54112.38$ mm

$Zs = Xr = Xe = u$

(where ? = 36.7□)

The resulting values (Xs, Ys, Zs) are the coordinates of the reference position 41040L in the subreflector coordinate system. We have translated this to the vertex of the subreflector by subtracting the (Xs, Ys, Zs) value for elevation at the rigging angle of 50□. At the rigging angle, the subreflector is at its nominal zero position. Thus we transform to a new coordinate system (XS0, YS0, ZS0) as follows:

XS0 = Xs - Xs(el=50□) = Xs - (-4260.669 mm)

YS0 = Ys - Ys(el=50□) = Ys - (-3290.743 mm)

ZS0 = Zs - Zs(el=50□) = Zs - (-3166.10 mm)

The resulting values of (XS0, YS0, ZS0) are listed in Table 1, and plotted in Figures 1, 2, and 3.

Results

Comparison with the focus tracking calibration is done by plotting the negative of the focus tracking curves on Figures 1, 2, and 3. The focus tracking curves currently in use are as follows:

$dX(mm) = 231.70 - 64.24\sin(el) - 319.76\cos(el)$

$dY(mm) = -169.24 + 31.95\sin(el) + 204.37\cos(el)$

$dZ(mm) = 9.55 - 21.86\sin(el) + 11.18\cos(el)$

(X,Y,Z are in the Xs, Ys, Zs or subreflector frame)

These curves are used to compensate for the feed arm motion, so their negatives were plotted in the Figures for comparison with the metrology data.

One can note that the trend of the focus tracking curves agrees roughly with the metrology data, but that the agreement is not very close for the X and Y directions. This is to be expected because the position of the focus relative to the subreflector depends not only on the feed arm position, but also on the shape of the main reflector, whose focal point will change as gravitational distortions change with elevation. The agreement is quite good, however, for the Z direction, which should not be affected by gravitational effects on the main reflector. Note that the disagreement in the Z plot (figure 3) at elevation = 95□ probably is because no focus calibration observations were made for elevation > 85□. We have no information on whether the drop in Zs measured by metrology at high elevation is confirmed by astronomical observations, nor are we likely to, because azimuth tracking rates at high elevation make any observing impractical.

Table 1: Metrology of retro reflector 41040L, transformed to Subreflector Frame.

Target Designation	Elev(□)	XS0(mm)	YS0(mm)	ZS0(mm)
ZEG41040L_5_T	5.0	190.6	-43.5	-21.2
ZEG41040L_20_U	20.0	142.4	-38.2	-10.5
ZEG41040L_20_T	20.0	141.2	-36.6	-12.7
ZEG41040L_35_T	35.0	77.8	-21.2	-7.1
ZEG41040L_35_U	35.0	76.9	-25.5	-3.2
ZEG41040L_50_U	50.0	-1.5	-0.0	-1.4
ZEG41040L_50_T	50.0	1.5	0.0	1.4
ZEG41040L_65_T	65.0	-79.5	22.3	5.8
ZEG41040L_65_U	65.0	-83.4	18.9	6.4
ZEG41040L_80_U	80.0	-162.6	48.2	9.3
ZEG41040L_80_T	80.0	-156.4	47.1	11.2
ZEG41040L_95_U	95.0	-237.2	75.4	9.3
ZEG41040L_95_T	95.0	-233.9	79.1	5.9

Figure 1: Subreflector Xs metrology.

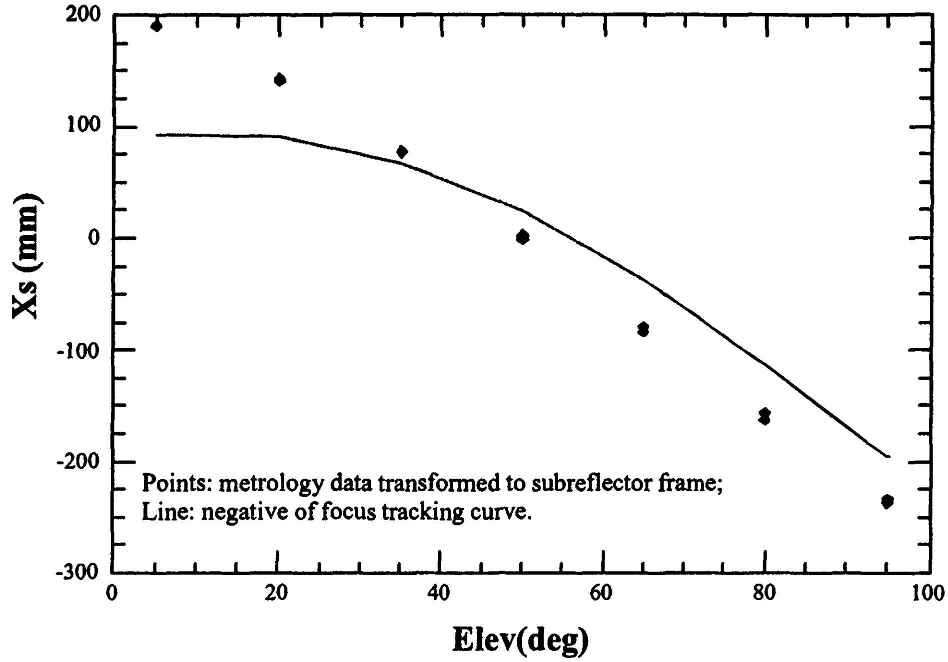

Figure 2: Subreflector Ys metrology

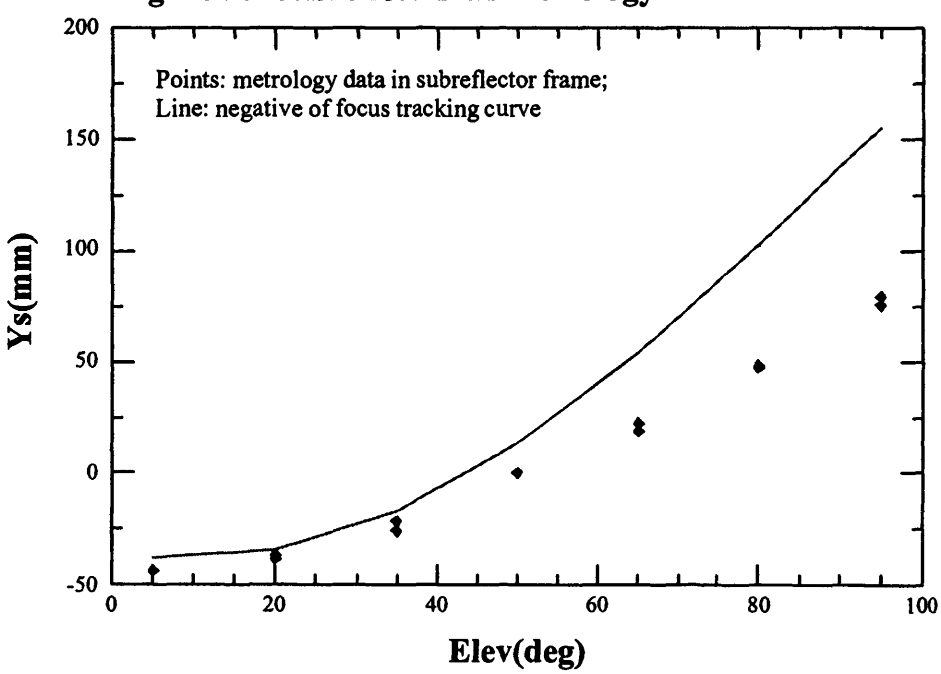

Figure 3: Subreflector Zs metrology