Interoffice

NATIONAL RADIO ASTRONOMY OBSERVATORY

TUCSON, ARIZONA

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Engineering Memo #103

To: M. A. Gordon

From: B. L. Ulich

Subject: Preliminary report on results of structural modifications to 36-foot telescope

From February 15-17 the new backup structural members were installed on the 36-foot telescope. The modified structure was designed to reduce the temperature-dependent astigmatism and to lower the telescope elevation limit. Due to gross design errors the original structure behaved like a bimetallic thermostat in the elevation plane and, as a result, the gain at 3 mm wavelength varied by more than 30% over the normal range of operating temperature. While more data are needed to accurately predict the performance of the modified telescope. I have reached some conclusions based on preliminary observational data. Hopefully enough additional data can be accumulated in the coming months to permit a more complete analysis in the form of an internal report.

The modified structure allows unhindered telescope tracking down to about 13.8^{o} elevation (old limit = 15.1^{o}). Actually some removable railings now hit the dish first, rather than the backup structure. These could be temporarily removed or modified to get down to $\sim 12.5^{o}$ elevation for special experiments.

About 130 man-hours were required to remove 1300 lb. of steel and to install 800 lb. of aluminum. A chronological summary of radiometric test data is given in Table I. After all the new backup members were installed the telescope exhibited large astigmatism. This was not unexpected since we had no means of lifting the focal point structure and feed legs. When we removed the original elevation backup struts (with the telescope at zenith), the dish sagged under the load of the feed legs, which flattened the dish and increased the focal length in the elevation plane. Installing the new elevation backup members merely preserved this residual astigmatism. Our first thought was to relieve the feed leg loading by tilting the dish away from the vertical until the center of gravity of the feed support structure was directly over the attachment point of the lower (South) feed leg. Then the bolts on the new backup members were loosened and retightened. As shown in Table I, this procedure had little effect on the astigmatism.

Our second method of correcting the dish met with greater initial success. Clearly if we could put the upper (North) and lower (South) feed legs in tension and put the side (East and West) feed legs in compression, we would deform the dish in the proper direction to cancel the elevation flattening due to the feed leg loading. This we accomplished by placing shims under the East and West feed legs. Our first attempt overcorrected and resulted in astigmatism of the same magnitude but opposite sign. Our second attempt was much closer to optimum but showed that the relationship between shim thickness and deformation was slightly nonlinear (see Figure 1). The third attempt (and the present telescope configuration) resulted in essentially zero astigmatism. From Figure 1 we can deduce that at present the side feed legs have a small compressional loading. We could probably correct this to the more proper tensional mode in the future by lifting the focal point structure, loosening and retightening the elevation backup structure, and reshimming the side feed legs. However, the compressional loading must be small and future adjustments are probably unnecessary.

I have taken some focus data with the modified telescope, and a comparison with the original structure is given in Table II. The focal length of the modified structure is 2.8 ± 0.7 mm longer than the original at the zenith. This flattening is due to the feed leg loading described previously. As shown in Table II the dependence of the average focal length on dish temperature has decreased from 0.3 mm/^{o}C to zero. The dependence of the focal length on the difference in dish temperature between the central hub and the rims has remained essentially unchanged. The astigmatism (difference in elevation and azimuth plane focal lengths) of the original structure is plotted versus dish temperature in Figure 2. The old telescope varied by about 1.4 mm/^{o}C and, based on only a few points, the modified structure appears to vary by less than 0.4 mm/^{o}C. This appears to be a significant improvement, but more data are needed at higher temperatures to confirm this result. The variation of average focal length with elevation angle is now larger than before (see Table II), but this was expected from the computer model of the structure and is allowed for in the on-line computer focusing program. The change in astigmatism from 26^{o} elevation to 70^{o} elevation was measured to be 1.3 ± 1.4 mm which translates into a negligible change in telescope gain (directly measured upper limit is ± 5%). Of course, the most important telescope parameter is peak gain, and its dependence on temperature is what we are trying to eliminate. Making accurate gain measurements is a difficult and laborious procedure. Note that the gain data in Table I are given on a relative basis because sometime before these tests the feed horn lens was misaligned, causing a reduction in efficiency which has since been corrected. The astigmatism, on the other hand, can be measured rather quickly and requires only a relative (not absolute) calibration. Thus, although I will make both gain and astigmatism measurements as often as possible in the near future, I expect the astigmatism data to be a more precise and reliable indicator of the true telescope performance. Data are needed at high temperatures to reliably assess the success of this project.

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TABLE I

DATA SUMMARY

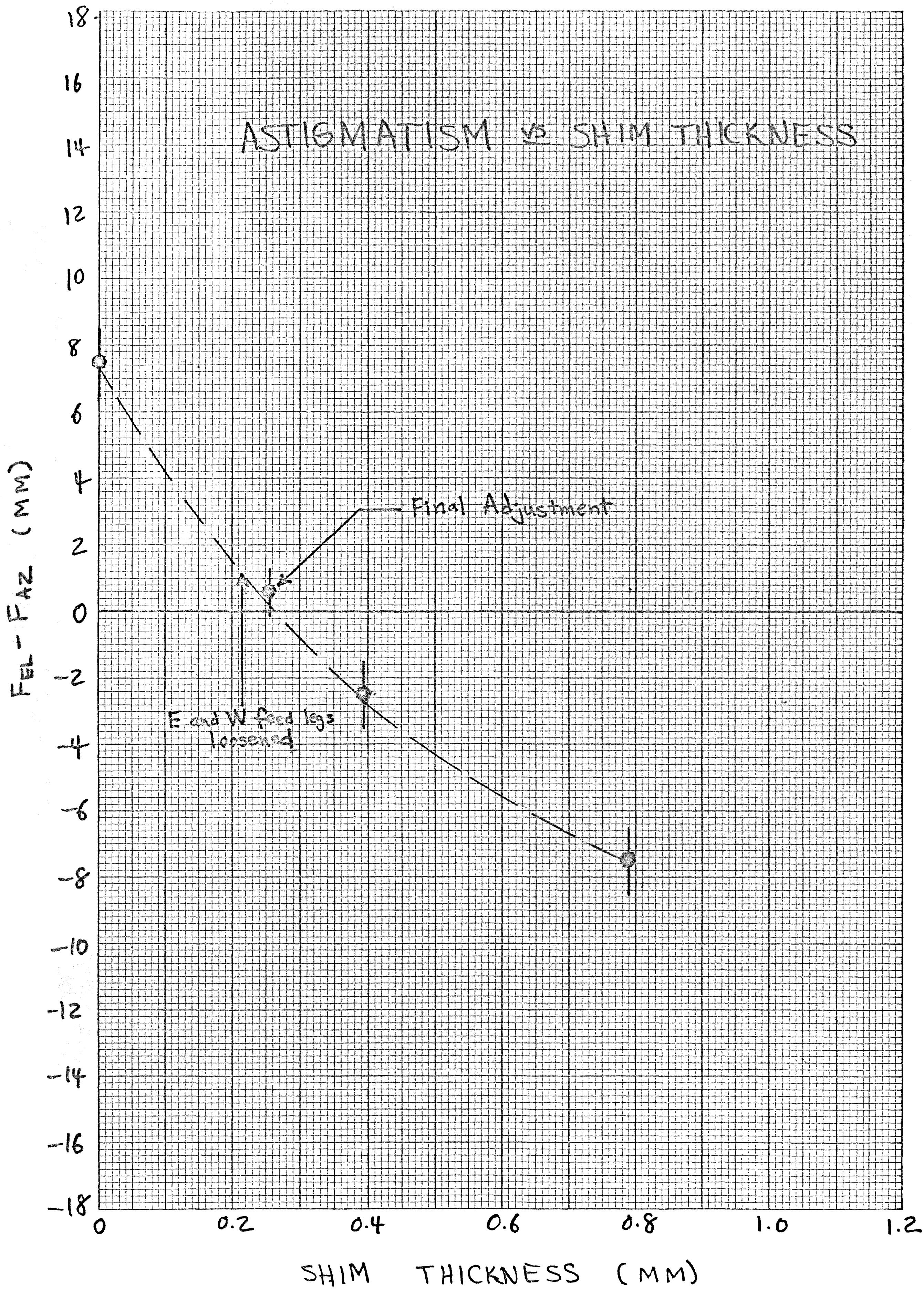
DATE	<T> (°C)	F_{EL} (mm)	F_{AZ} (mm)	$F_{EL}-F_{AZ}$ (mm)	Θ_{AZ} (′)	Θ_{EL} (′)	RELATIVE GAIN	NOTES
2/15/77	+4.8	18.9	20.8	-1.9	85	72	1	Original Structure
2/16/77	+7.4	-	-	-	83	71	1.08 ± 0.05	Central Backup Structure Replaced
2/17/77	+9.8	23.6	17.0	+6.6	86	73	0.99 ± 0.02	Backup Modifications Completed
2/17/77	+9.2	20.6	13.1	+7.5	83	72	1.01 ± 0.02	Adjust Upper Backup Bolts at 55° Elevation
2/17/77	∿9	21.8	20.7	+1.1	85	73	1.03 ± 0.05	Loosen E and W Feed Legs
2/17/77	∿8	16.6	24.1	-7.5	86	71	0.95 ± 0.05	Shim E and W Feed Legs by 0.79 mm
2/17/77	+6.9	17.3	19.8	-2.5	81	71	0.96 ± 0.05	Shim E, W, and N Feed Legs by 0.79 mm
2/26/77	-3.6	19.7	20.1	-0.4	84	72	0.98 ± 0.03	Shim E and W Feed Legs by 0.25 mm (EL = 26°)
2/26/77	-4.3	19.1	19.1	+0.0	84	71	1.03 ± 0.03	Shim E and W Feed Legs by 0.25 mm (EL = 70°)
3/01/77	+3.6	23.7	22.4	+1.3	85	73	0.95 ± 0.04	Structure Unchanged From 2/26/77

TABLE II

FOCUS DATA SUMMARY

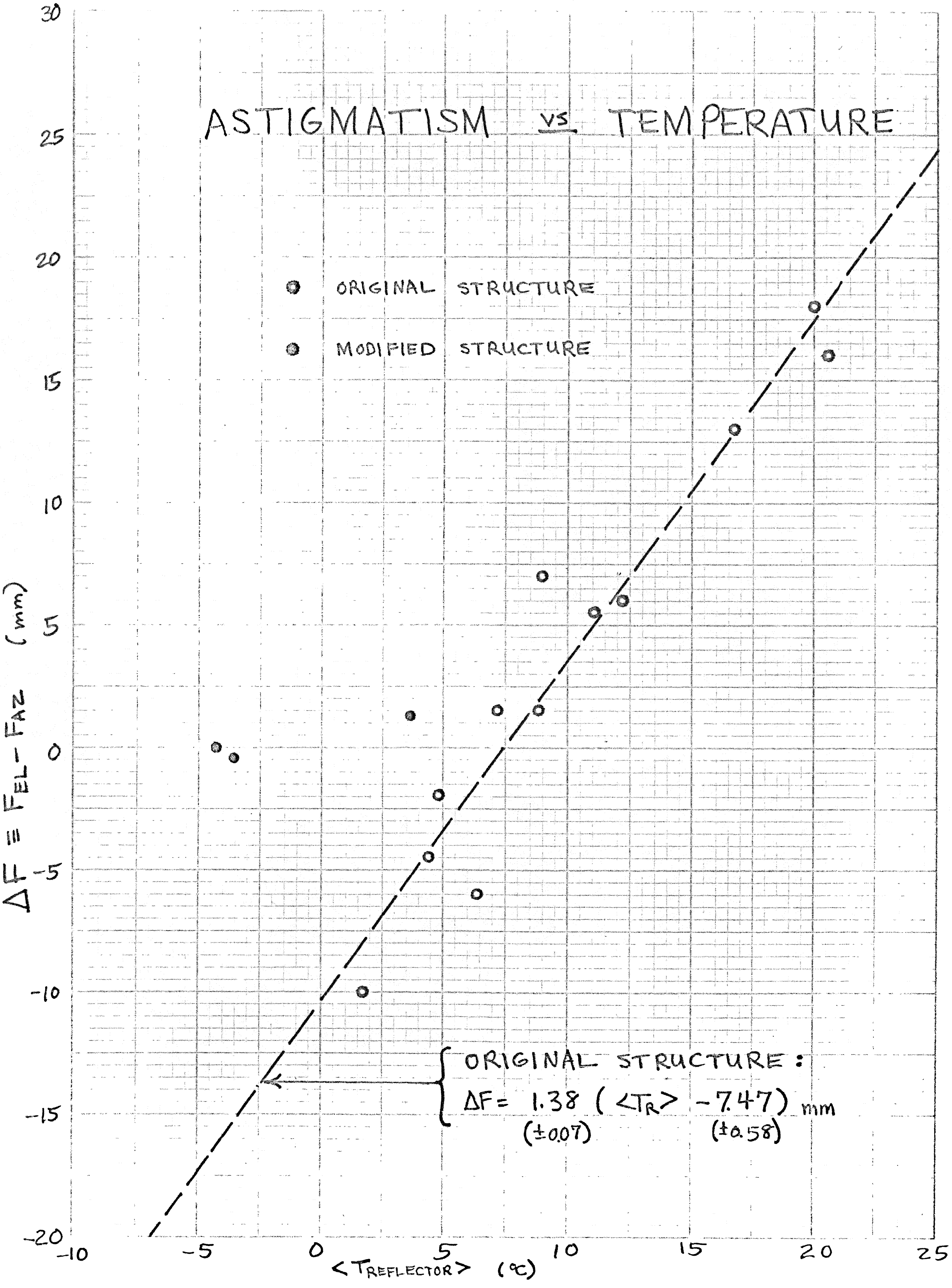
QUANTITY	ORIGINAL STRUCTURE	MODIFIED STRUCTURE
Focus (mm) (T=7.5°C, EL=90°)	28.0 ± 0.5	30.8 ± 0.5
$\frac{\Delta Focus}{<T>}$ (mm/°C)	0.3 ± 0.1	0.0 ± 0.1
$\frac{\Delta Focus}{T_{RIM}-T_{HUB}}$ (mm/°C)	1.6 ± 0.3	2.0 ± 0.2
$\frac{F_{EL}-F_{AZ}}{<T>}$ (mm/°C)	1.38 ± 0.07	Probably $\leq$ 0.4
$\frac{\Delta Focus}{\Delta SIN\ (EL)}$ (mm)	1.5 ± 1.0	3.9 ± 1.5
ΔGAIN	$\leq$ 2%	$\leq$ 5%

FIGURE 1



ASTIGMATISM vs SHIM THICKNESS
Final Adjustment
E and W feed legs loosened
FEL - FAZ (MM)
SHIM THICKNESS (MM)
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
0
0.2
0.4
0.6
0.8
1.0
1.2

FIGURE 2


ASTIGMATISM vs TEMPERATURE
ORIGINAL STRUCTURE
MODIFIED STRUCTURE
ORIGINAL STRUCTURE:
ΔF = 1.38 (<T_R> - 7.47) mm
(±0.07) (±0.58)
ΔF = F_EL - F_AZ (mm)
<T_REFLECTOR> (°C)
30
25
20
15
10
5
0
-5
-10
-15
-20
-10
-5
0
5
10
15
20
25