NATIONAL RADIO ASTRONOMY OBSERVATORY

GREEN BANK, WEST VIRGINIA

ENGINEERING DIVISION INTERNAL REPORT NO. 109

140-FT OBSERVATIONS WITH DEFORMABLE SUBREFLECTOR

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JULY 1978

NUMBER OF COPIES: 100

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Summary

Observations at the water line (λ = 1.345 cm) of seven point sources during 88 hours yielded 196 complete beam maps and 133 single RA-scans, while using subreflector deformations of various types and degrees. Our present setup is somewhat limited in the range of its astigmatic deformation, and seems not to deform much in the other three modes of deformation. Future changes are planned.

The astigmatic deformations yielded considerable improvements when pointing far south and/or east. Aperture efficiencies increased by factors of between 2 and 3 with very obvious improvements of the beam shape in this part of the sky. Little improvement was obtained far west. The best adjustment of the surface happens to be about 2 hours east, and we observed strong non-astigmatic deformations of the main reflector when pointing west where the astigmatic corrections were useless. Fortunately, however, we obtain large improvement factors from far east through the meridian and up to about 2 hours west for sources far south, where it matters most. Chains of up to 4 sidelobes, more or less away from the meridian from the main beam, were seen when pointed far west.

We suspect that the lateral positions of both the old and new subreflectors have not been optimum, and some new method for making this alignment should be devised. The maximum efficiency of the old subreflector was down by a factor of 1.75 from the new one. The new subreflector gave a maximum aperture efficiency of 25% for 3C 84 (declination 41.3°) between 3.5 and 1.5 hours east. This would mean a total surface rms deviation of about 0.9 mm.

This means zero astigmatism at an elevation of

$$\varepsilon_0 = 53.4^\circ \tag{4}$$

in sufficient agreement with the last surface adjustment of 1973, intended to give the best performance at 60° elevation on the meridian. The astigmatic rim amplitude then is, for example,

$$\begin{aligned} A = & -1.72 \text{ mm at zenith,} \\ & +4.00 \text{ mm at } \varepsilon = 20^\circ, \\ & +6.98 \text{ mm at horizon.} \end{aligned} \tag{5}$$

No dependence on hour angle was found in these measurements.

Beam mapping with point sources, at the water line of 22.3 GHz (λ = 1.345 cm), was done by B. Turner and L. Rickard with the old Cassegrain in October and December 1977 and April 1978, and at prime focus in March 1978. In all cases, the best beams were not obtained on the meridian but about 2 hours East which can be explained as a chance result of the panel adjustments. Very odd multiple beams occurred at low elevations especially far West, thus demonstrating strong additional non-astigmatic deformations.

II. Present Setup

Details of the subreflector design (W. Y. Wong), of the electronics (R. Lacasse), and the programming (B. Vance), shall be described in separate reports.

This subreflector (Figure 1) was designed mainly with the astigmatic deformations in mind. But by having 4 actuating motors, it gives us 4 degrees of freedom as explained in Figure 1, and we hoped that maybe some non-astigmatic deformations could be corrected as well.

Beam maps were made by scanning 16'/cosδ in RA at the rate of 30'/min (/cosδ) with a 1 second time constant. Scans were taken every 0$'\!.$5 in declination for a total distance of 8'.

We obtained 196 beam maps, and 133 single RA-scans. In every case, the telescope was first "peaked up" on the best position and then on the best focal length. We used various types and degrees of deformations, always with an undeformed case interspersed for comparison.

Whereas the astigmatic mode of deformation gave strong and obvious changes of beam shapes and of peak values, the other three modes (see Figure 1) unfortunately did not give significant changes. Thus, the question of their improvement-value cannot be answered at present. This will need stronger (more expensive) motors and some other changes.

IV. Results

1. Improvements from Astigmatic Deformations

We obtained improvements of the aperture efficiency by factors of between 2 and 3 for positions far south and east. Figures 2, 3, and 4 show three such cases. The good improvement is shown for peak value as well as beamshape, and always repeated on different days. However, we do not get much improvement far west, and three such cases are shown in Figure 5. They show a succession of sidelobes which clearly indicates strong non-astigmatic deformations of the main reflector, but they may also be caused by deformations of the support and suspension of the subreflector.

Figure 6 demonstrates that we need a stronger astigmatic deformation far south, especially in the east, but even up to about 2 hours west. Unfortunately, Figure 7 does not have the half-deformation far east for drawing a similar conclusion. The range between 2 hours east and 1 hour west shows agreement and it leads us to suspect that the new subreflector was better positioned with respect to the main dish than was the old one. We want to put a strong emphasis on this finding: we should look for better methods of adjustment, or we may easily loose almost a factor of 2 in efficiency. For the new maximum efficiency of 25% at 2 - 3 hours east, we find an rms surface deviation (of both main and subreflector combined) of about 0.9 mm.

Also interesting is the shift of the maximum further to the east. One would like to know the exact maximum location for prime focus observations at this declination. Furthermore, Figure 10 shows that the hour angle of the maximum efficiency depends strongly on the declination. We mention these findings but have no explanation so far.

3. Sidelobe Chains from Gravitational Deformations

Another unexplained but well determined finding is shown in Figures 11 to 15. In summary, we obtain strong sidelobes pointing away from the meridian if we observe far east or west, and a neutral or symmetric beam is seen at about 1.5 or 2 hours east. If we move further east or further west, the sidelobes do not change their distance from the main beam, but increase in strength and get more numerous forming a chain decreasing in strength outwards. Their distances from the main beam are, as accurately as we can determine, where the sidelobe-rings of the telescope ought to be at this wavelength, but instead of rings they form roundish bubbles.

Since the neutral beams occur about 2 hours east, these sidelobes are much more pronounced for western pointings. The over-all efficiency of the telescope would be considerably better if the neutral beams would occur on the meridian.

The same effect, but much smaller, is also seen far north and far south,

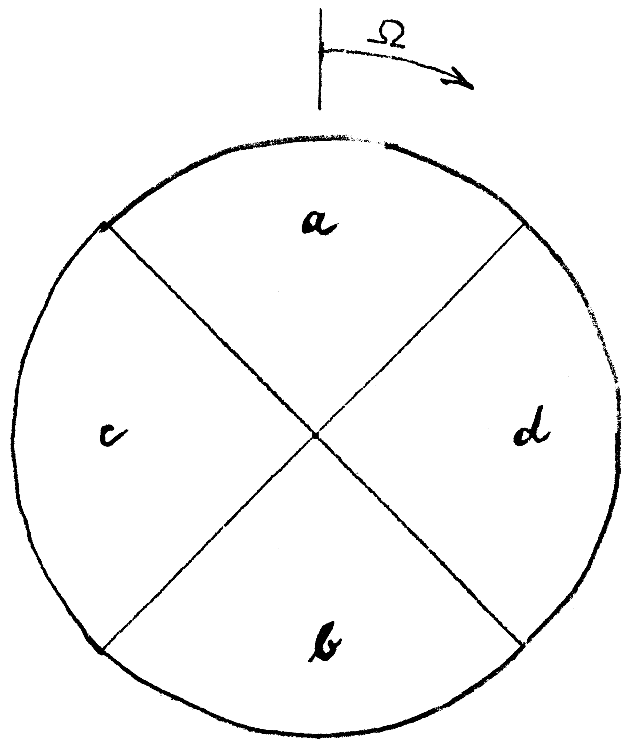


__Fig. 1.__ The deformable subreflector, with two stiff diagonals, and four actuators pushing or pulling by amaounts a, b, c and d. This yields four degrees of freedom for its use, to be called:

$p_1 = [(a + b) - (c + d)]\frac{1}{4}$ astigmatism, $\Delta z \sim \cos(2\Omega)$

$p_2 = [(a + b) + (c + d)]\frac{1}{4}$ next order, $\Delta z \sim \cos(4\Omega)$

$p_3 = (a - b)\frac{1}{2}$ vertical } shift of half-beam

$p_4 = (c - d)\frac{1}{2}$ horizontal } shift of half-beam

The displacements then are:

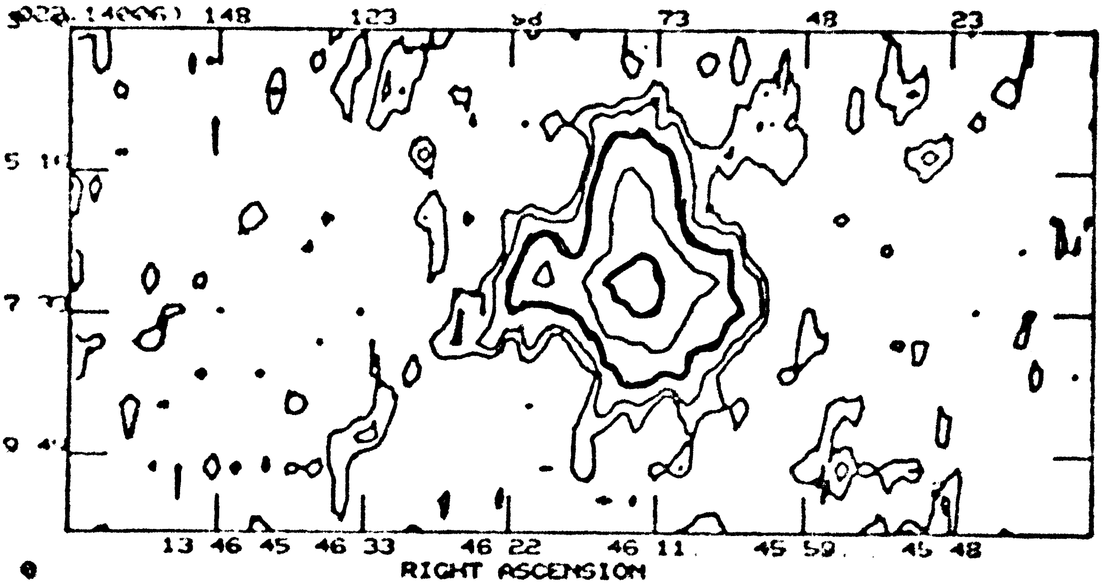
$$a = +p_1 + p_2 + p_3$$

$$b = +p_1 + p_2 - p_3$$

$$c = -p_1 + p_2 + p_4$$

$$d = -p_1 + p_2 - p_4$$

W Hya; Dec. −28.1°

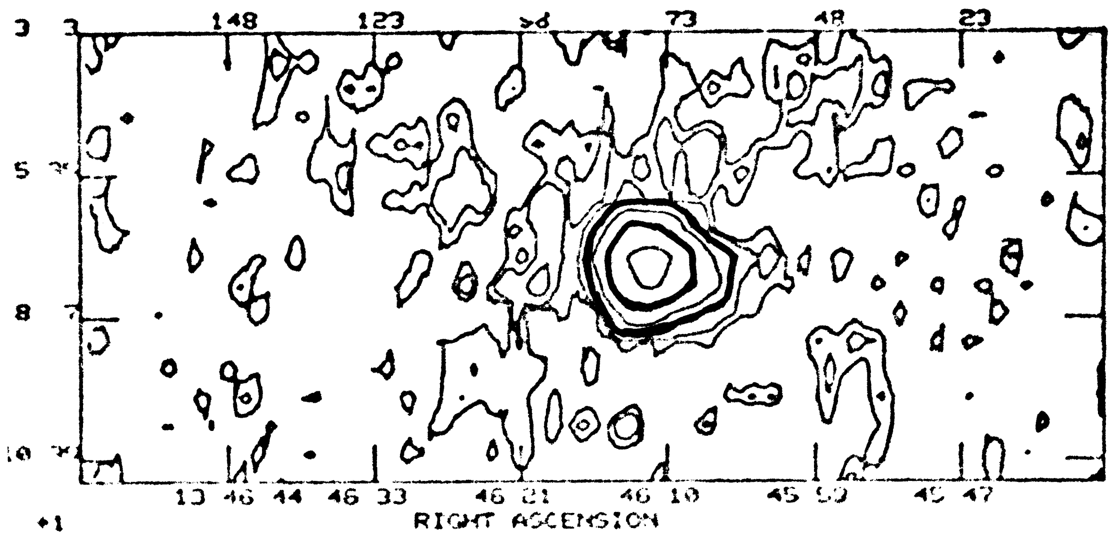


Undeformed

HA = −0:22 E

El = 23.3°

Peak = 20.4°K

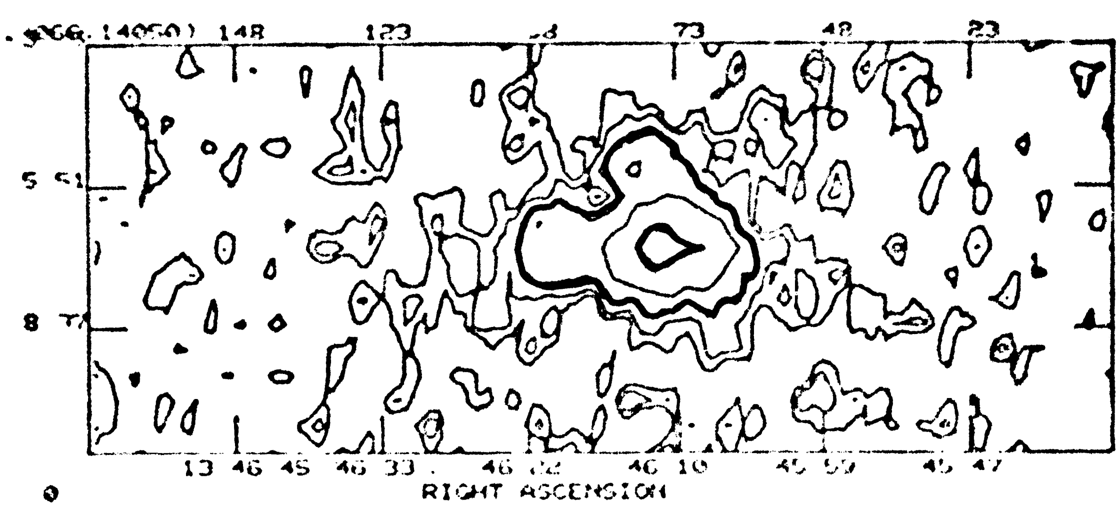


Deformed

HA = +0: 4 W

El = 23.3°

Peak = 40.0°K



Undeformed

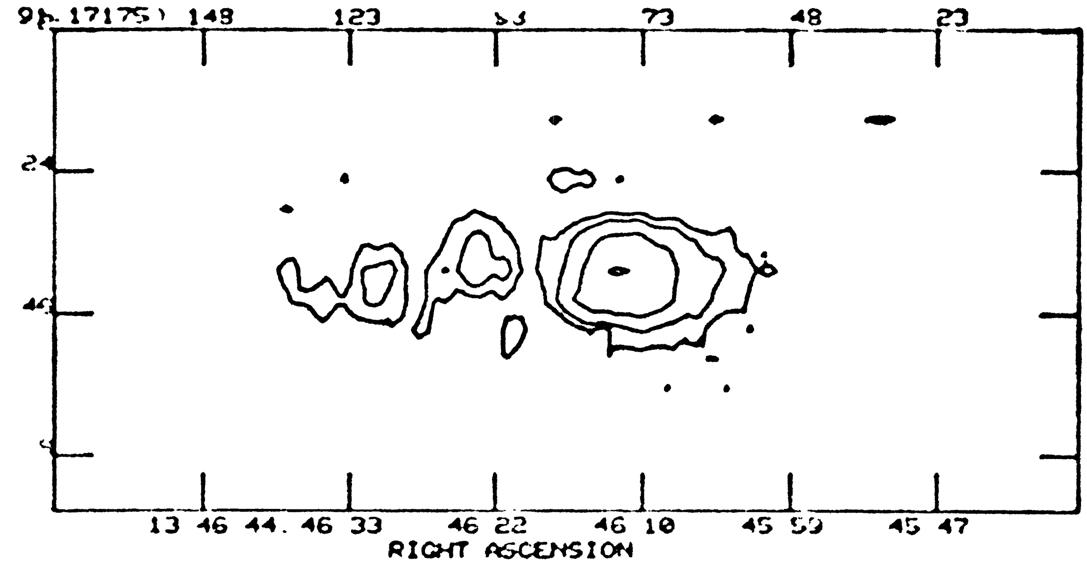
HA = +0:28 W

El = 23.0°

Peak = 19.5°K

Fig. 3. Improvement factor 2.01; far South, on Meridian.

Where Deformation did Not help:

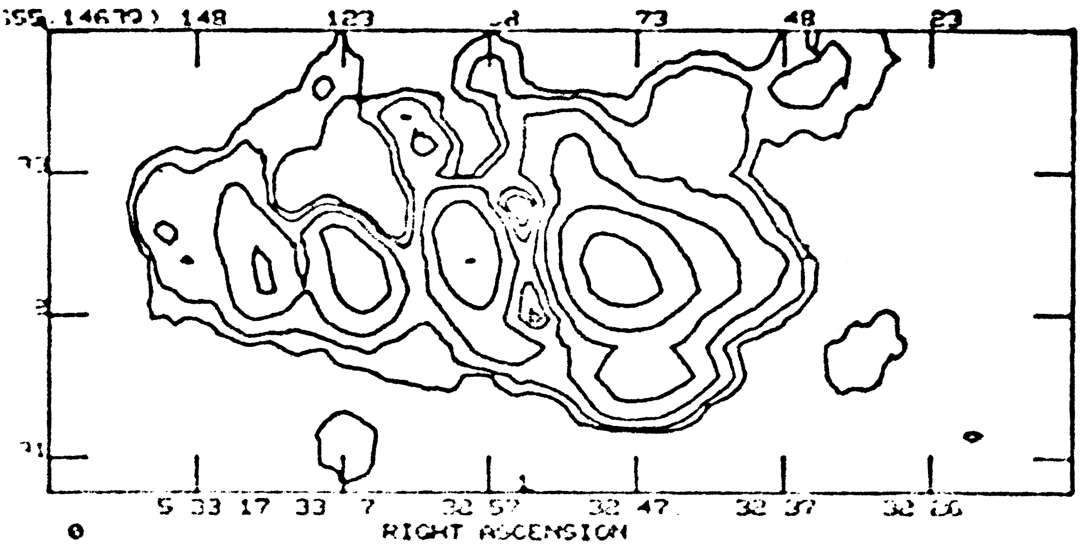


W Hya

Dec = $-28.1°$

HA = 2:7 W

El = 17.1°

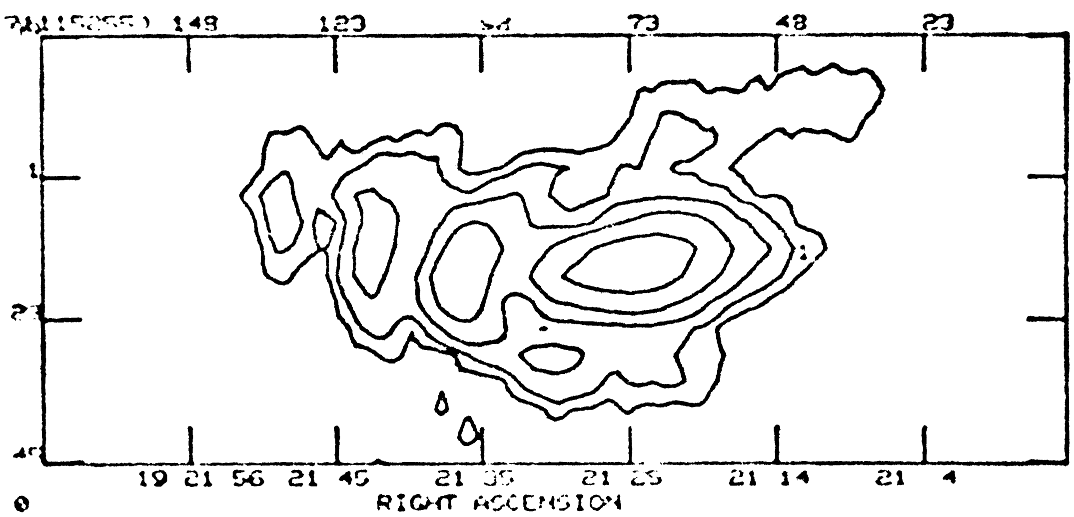


Ori A

Dec = $-5.4°$

HA = 4:26 W

El = 14.9°



W 51

Dec = $+14.4°$

HA = 3:27 W

El = 39.0°

Fig. 5. No improvement far West (shown undeformed).

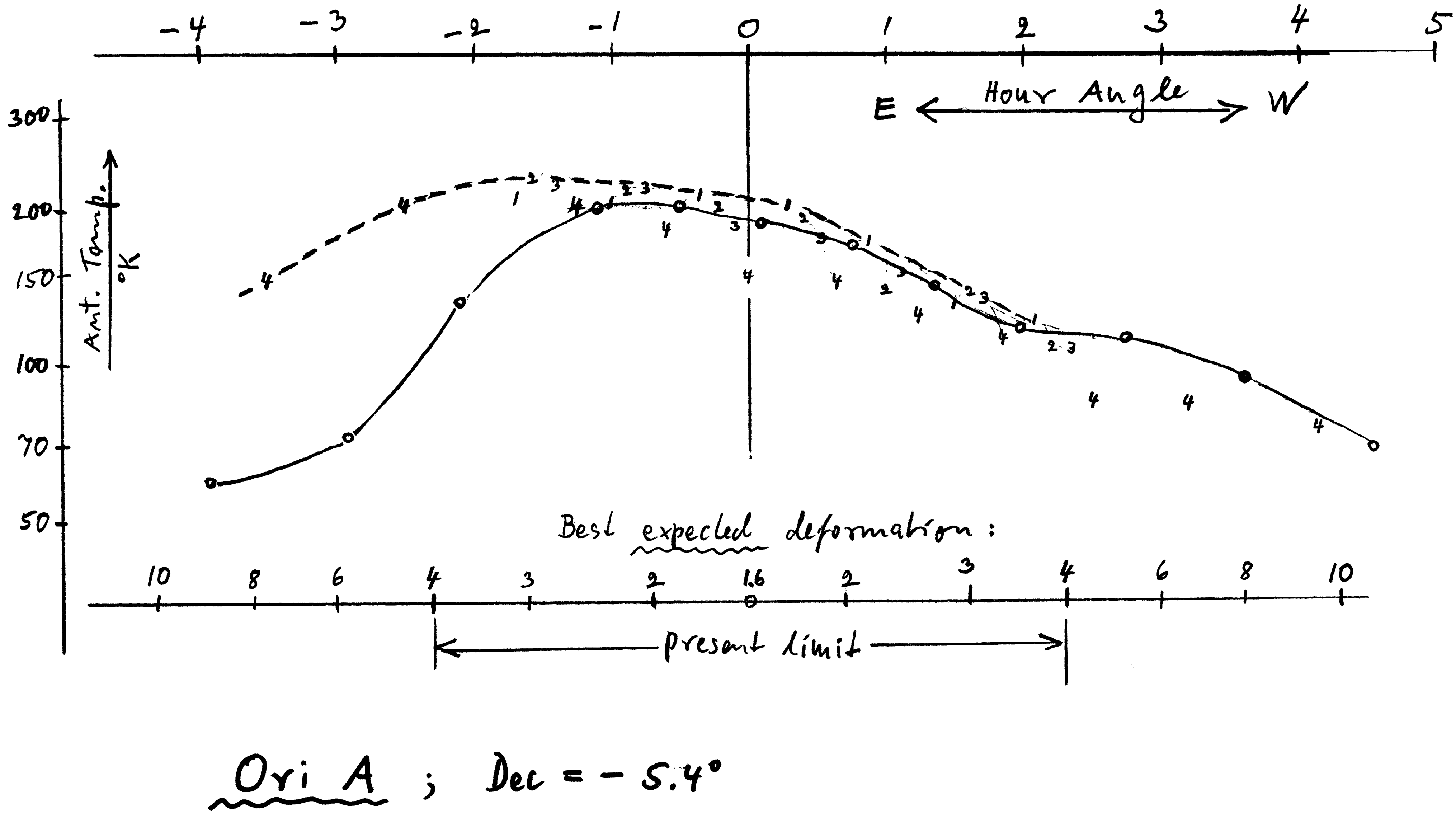


Fig. 7. Same as Fig. 6, but near equator.

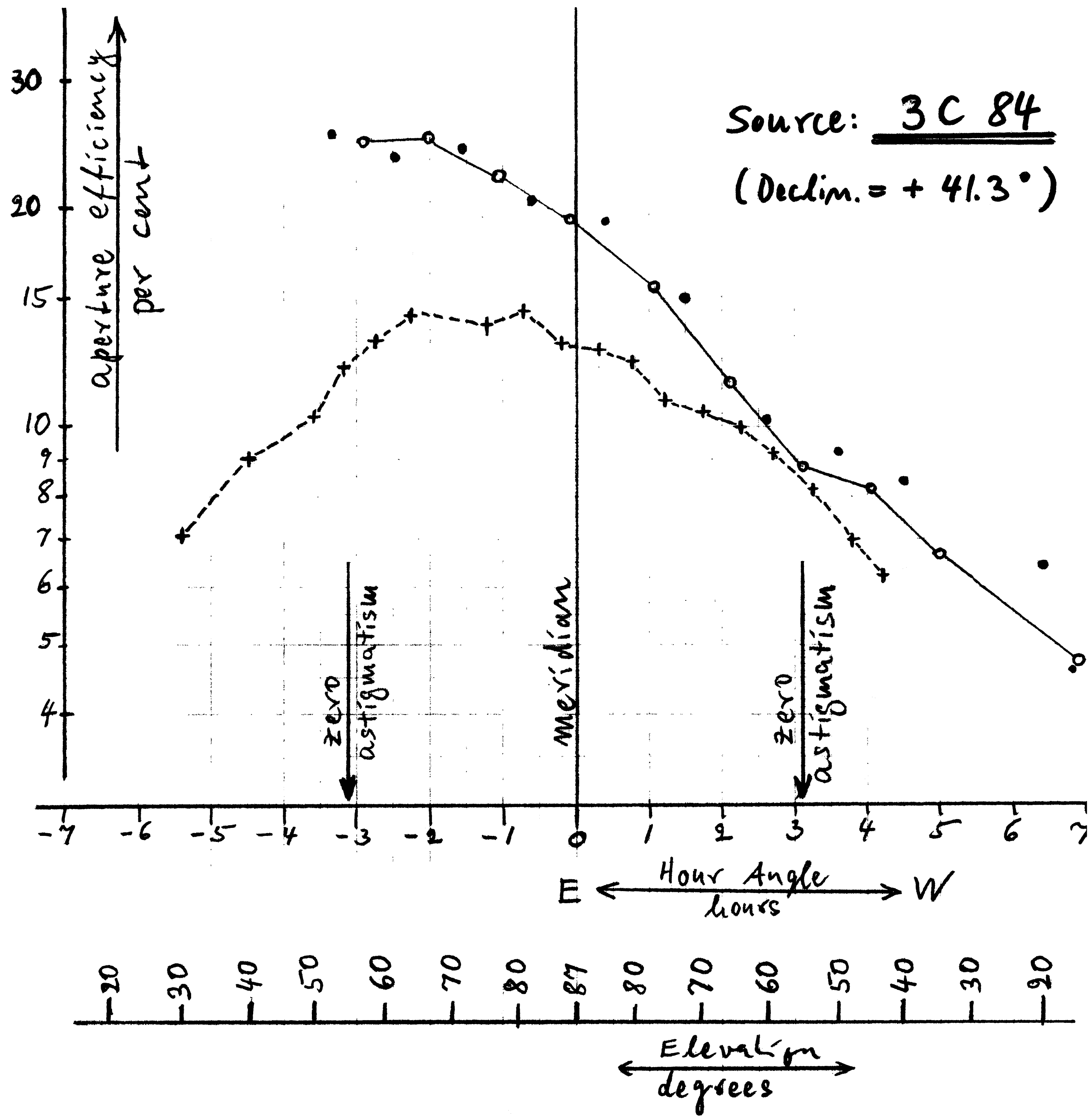


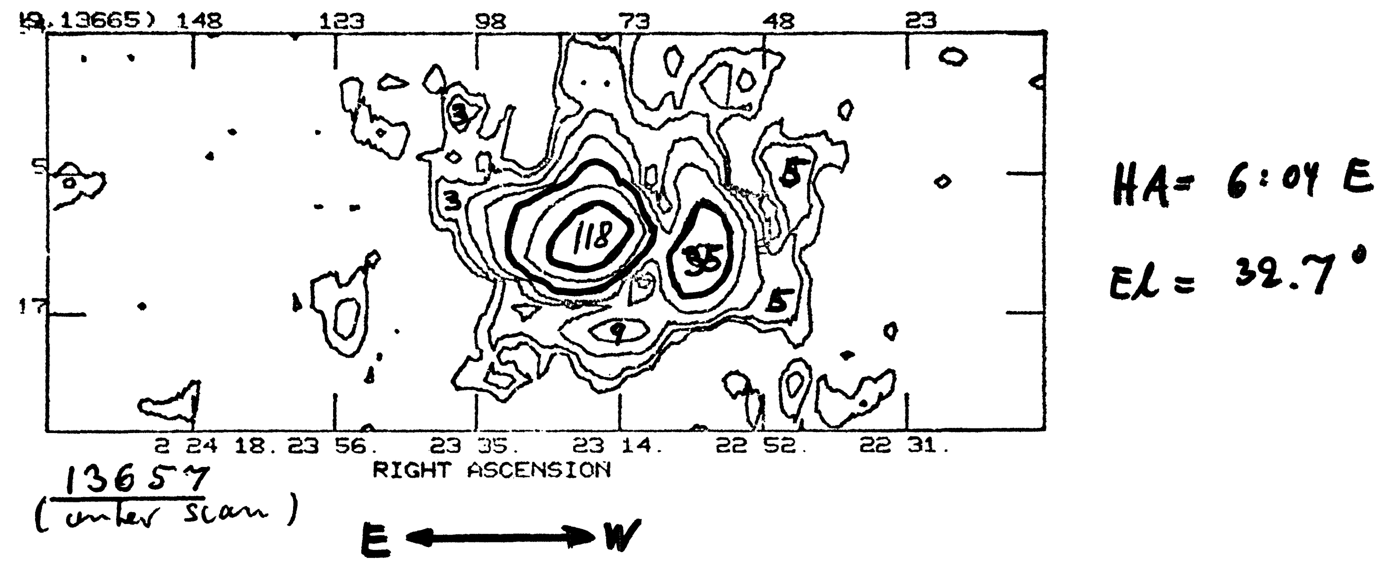
Fig. 9.

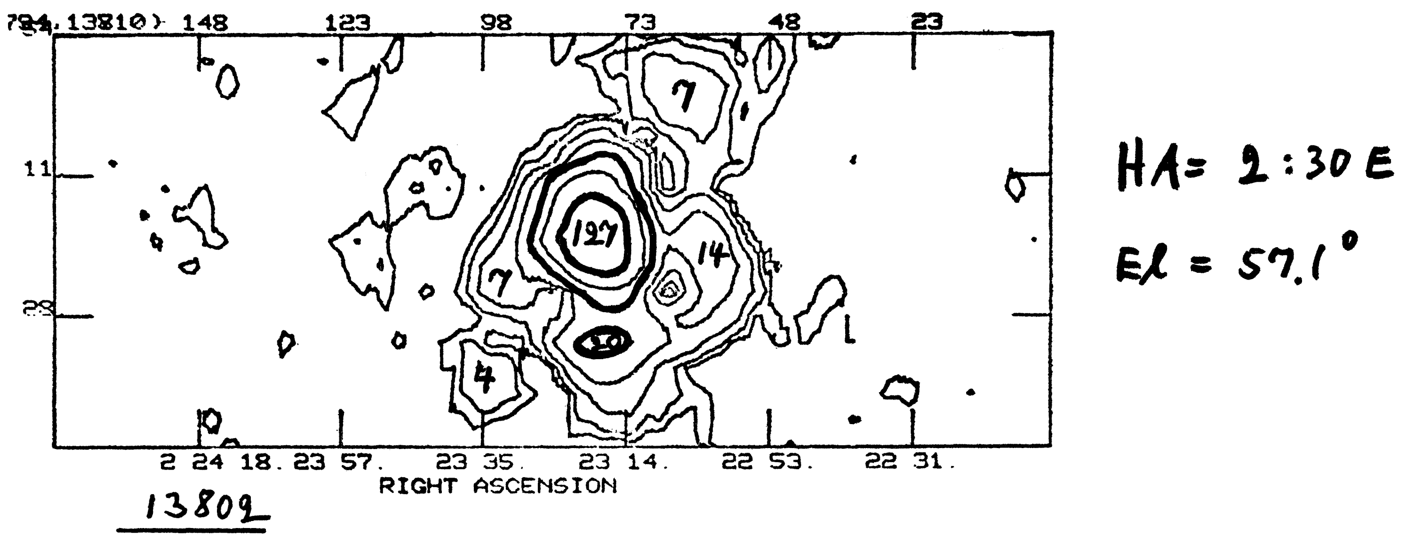
Aperture Efficiency, old and new subreflector

+ R. Fisher, old SR; Oct. 9-10, 1977 (S = 41 Jy).

o undeformed } new SR; June 12-13, 1978 (S = 36 Jy).

• deformed

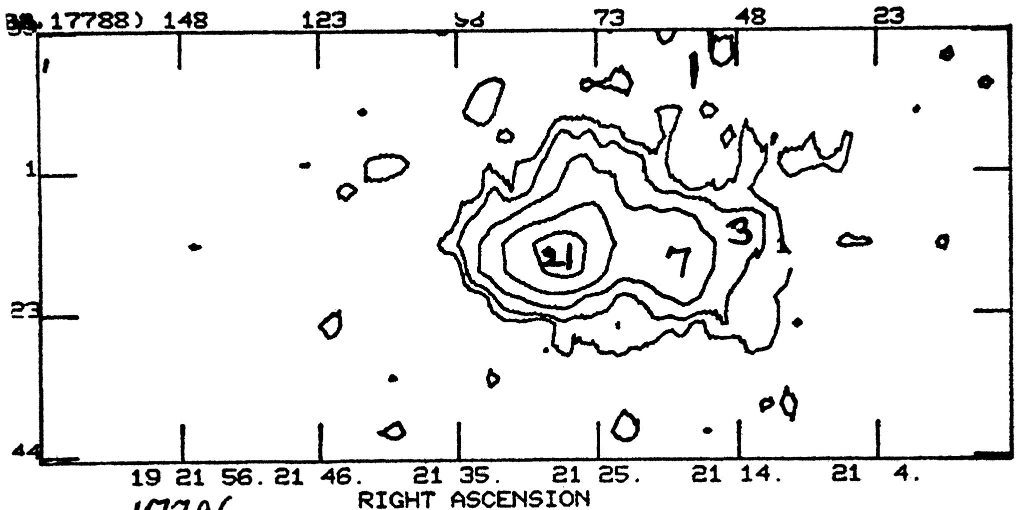




W 3 ; Dec. = + 61.6°

Fig. 11. The following figures (11 through 15) show the beamshape with the undeformed new subreflector, at extreme sky locations. Upper figure is far East, lower one far West. The middle figure is chosen at that hour angle where left and right sidelobes are about symmetrical.

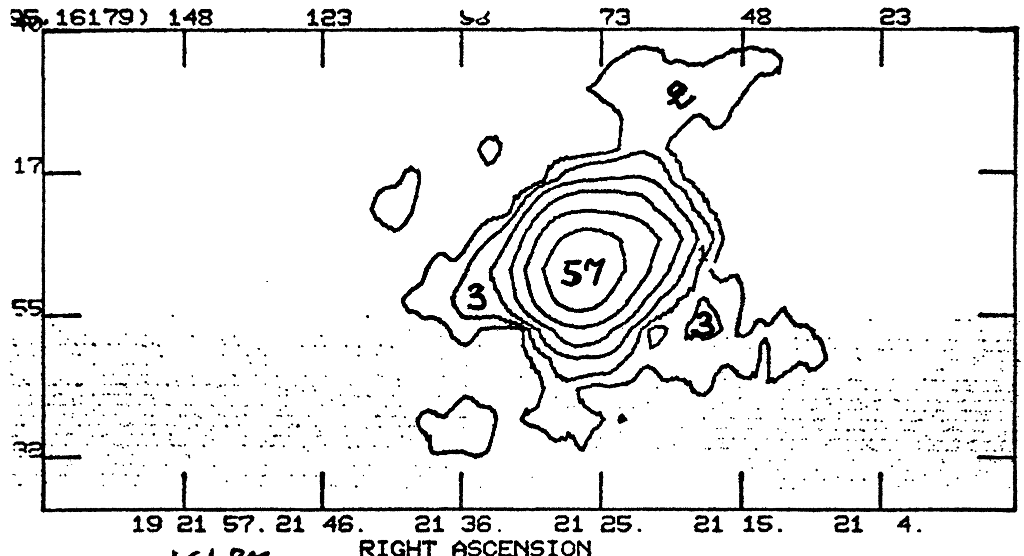
For W3, Figure 11, we do not have data West.



17796

HA = 4:33 E

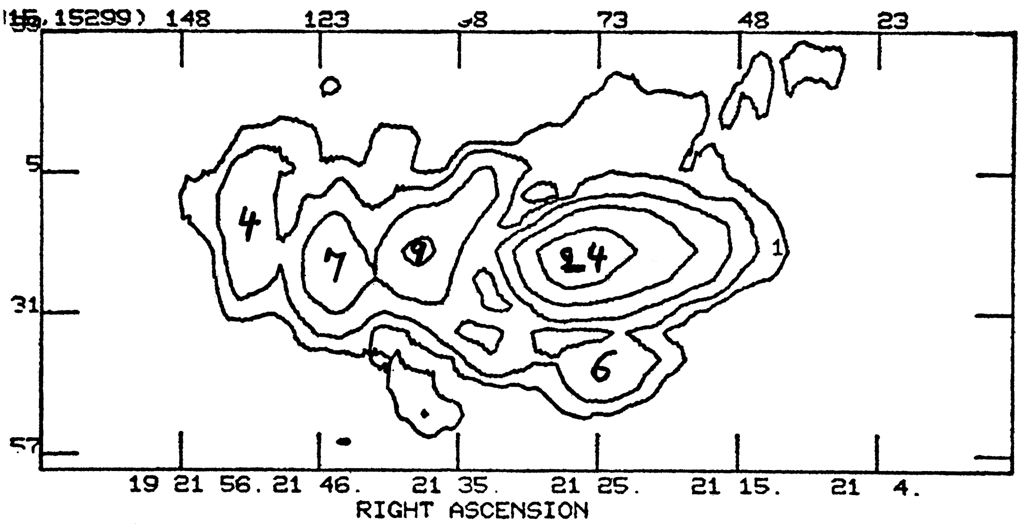
El = 25.6°



16187

HA = 1:28 E

El = 58.1°



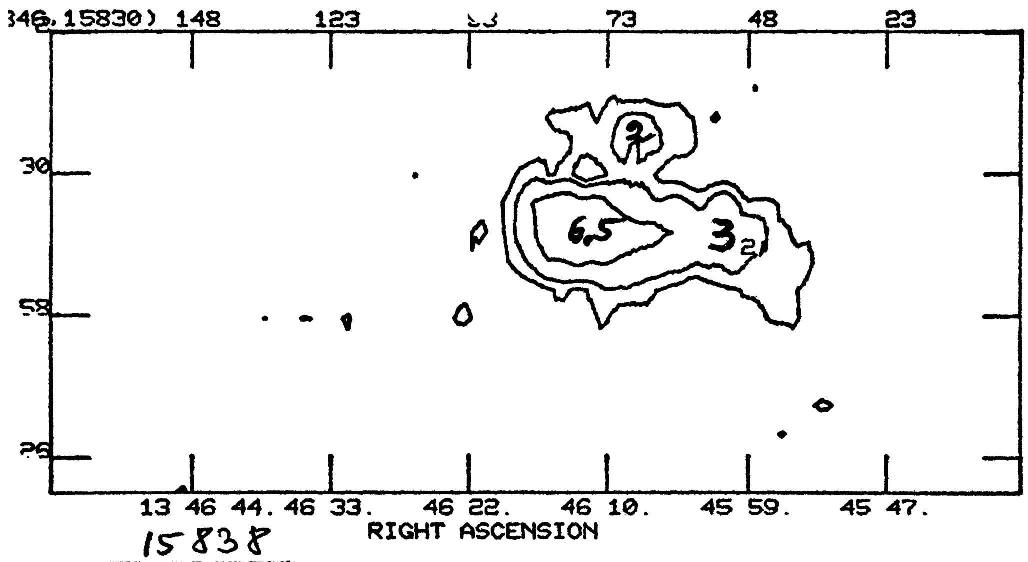
15307

HA = 4:20 W

El = 28.7°

W 51; Dec. = + 14.4

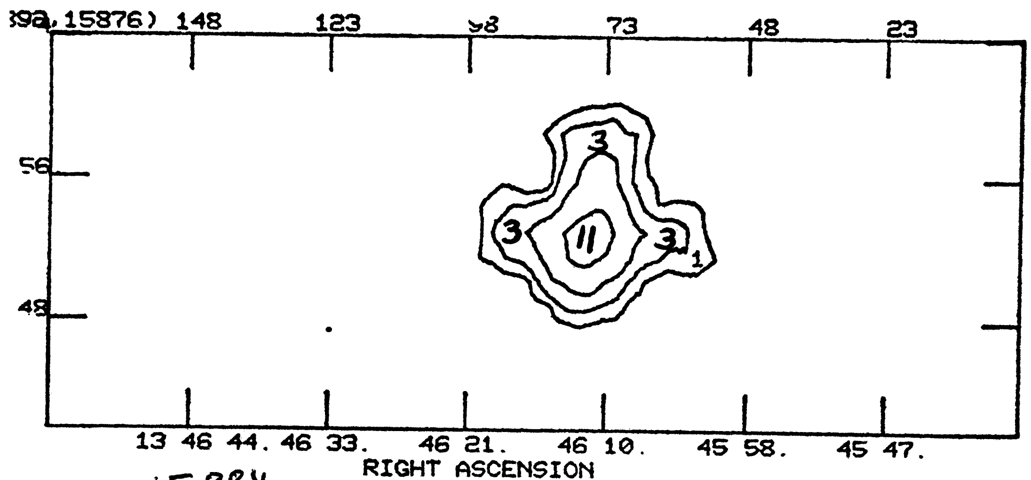
Fig. 13.



15838

HA = 2:42 E

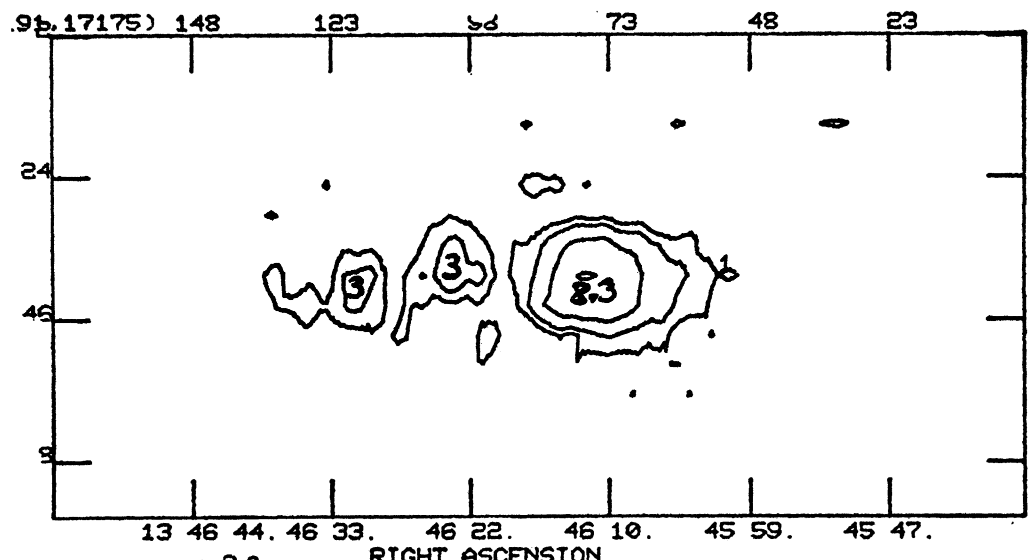
El = 13.2°



15884

HA = 1:51 E

El = 18.3°



17183

HA = 2:07 W

El = 17.1°

Fig. 15.

W Hya; Dec = −28.1°