NATIONAL RADIO ASTRONOMY OBSERVATORY

Engineering Memo No. 132

HIGH FREQUENCY PERFORMANCE OF THE 140-FOOT TELESCOPE
I: OBSERVATIONS AT 10650 MHz

Robert L. Brown
February 1979

I. The 140-Foot Telescope: An Overview

Over the past several years a significant allocation of the Green Bank resources have been focused on an attempt to improve the versatility and capability of the 140-foot telescope. Two complementary approaches have been pursued and are now coming to fruition: first, the telescope control software was re-written in a manner which allows routine tasks to be fully automated; and secondly, a new generation of low noise, maser-based Cassegrain upconverter receivers is being constructed and installed on the telescope. The former allows each astronomer to tailor the telescope control to the needs of his specific observations, and it also provides the NRAO with the capacity to implement new services to the astronomical community, e.g., in absentia VLBI observing; the latter represents a quantitatively significant improvement in the sensitivity of radio astronomical observations that can be made at frequencies between 8 and 26 GHz.

The limiting factor to further improvement in filled-aperture centimeter wave radio astronomy at the NRAO is, almost certainly, the nature of the 140-foot telescope itself. The 140-foot is a fine telescope at wavelengths of 6 cm and longer. At 3 cm wavelength the aperture efficiency in some parts of the sky is poor--this is readily apparent in 2.8 cm VLBI observations where one can easily see that the performance of the 140-foot is much worse than either the Haystack antenna or the OVRO 130-foot--while at 1.3 cm wavelength the aperture efficiency is disgracefully bad. Clearly, we have to improve the telescope performance at high frequencies.

In order to properly assess the scope of the problem, and to provide a "zero-epoch" set of observations against which future "improvements" may be compared, I undertook the 10650 MHz measurements of the 140-foot performance described below.

II. 10650 MHz Observations

My intent in these observations was to obtain a quantitatively reliable measure of the telescope sensitivity, Jy/K, across the sky. To this end I chose 10 strong sources distributed in declination between -34° and +69° and measured the antenna temperature of each of these sources over as much of a range in hour angle as possible. All the observations were made in the unassigned time during the last week of January and the first week of February 1979.

Each observations was made in the following way. I moved the telescope to the source position and "peaked-up" using the automated telescope routine PEAK. This routine updates the local telescope pointing corrections and puts the telescope precisely on source. I next measured the source temperature by doing a series of ON-OFF measurements (the ON-OFF cycle was repeated 5 times) followed by a calibration scan with the noise tube on. For these measurements I used the automated telescope routine VSRC, the output of which is written on the analysis computer's disk, for later retrieval. All the observations were made under card control, that is, without the interaction of the telescope operator.

The sources I observed, and their respective 10650 MHz flux densities, are summarized in the table below.

TABLE 1

Source Parameters

Source	Declination	10650 GHz Flux Density (Jy)	Notes
3C 371	69° 48'	2.53	1
DA 251	55° 44'	2.85	2
3C 84	41° 19'	48.6	3
3C 111	37° 54'	3.03	3
3C 286	30° 45'	4.40	
3C 274	12° 40'	37.5	
3C 273	02° 19'	36.2	4
3C 218	-11° 53'	6.77	
0834-201	-20° 06'	1.62	
1151-34	-34° 48'	1.57	5

Notes:

1. Flux density calibrated with 3C 268.1 using 1.60 Jy for 3C 268.1.
2. Flux density calibrated with 3C 295 using 2.53 Jy for 3C 295.
3. Flux density calibrated with NGC 7027 using 6.43 Jy for NGC 7027.
4. Flux density calibrated with 3C 348 using 5.30 Jy for 3C 348.
5. Flux density calibrated with 0826-37 using 4.62 Jy for 0826-37.

I observed both 3C 84 (δ = +42) and 3C 111 (δ = +38) to determine the consistency and repeatability of the measurements.

III. Results

For each of the sources observed, I obtained a measure of the telescope sensitivity in Janskys per Kelvin (Jy/K) by dividing the source flux density (Table 1) by the measured source antenna temperature. The results for each of the sources listed are plotted as a function of hour angle on the accompanying figures. On the first figure I have plotted the sensitivity vs. hour angle for all of the sources so as to provide a "quick-look" overview of the telescope performance. On subsequent figures I have plotted the sensitivity for each source individually.

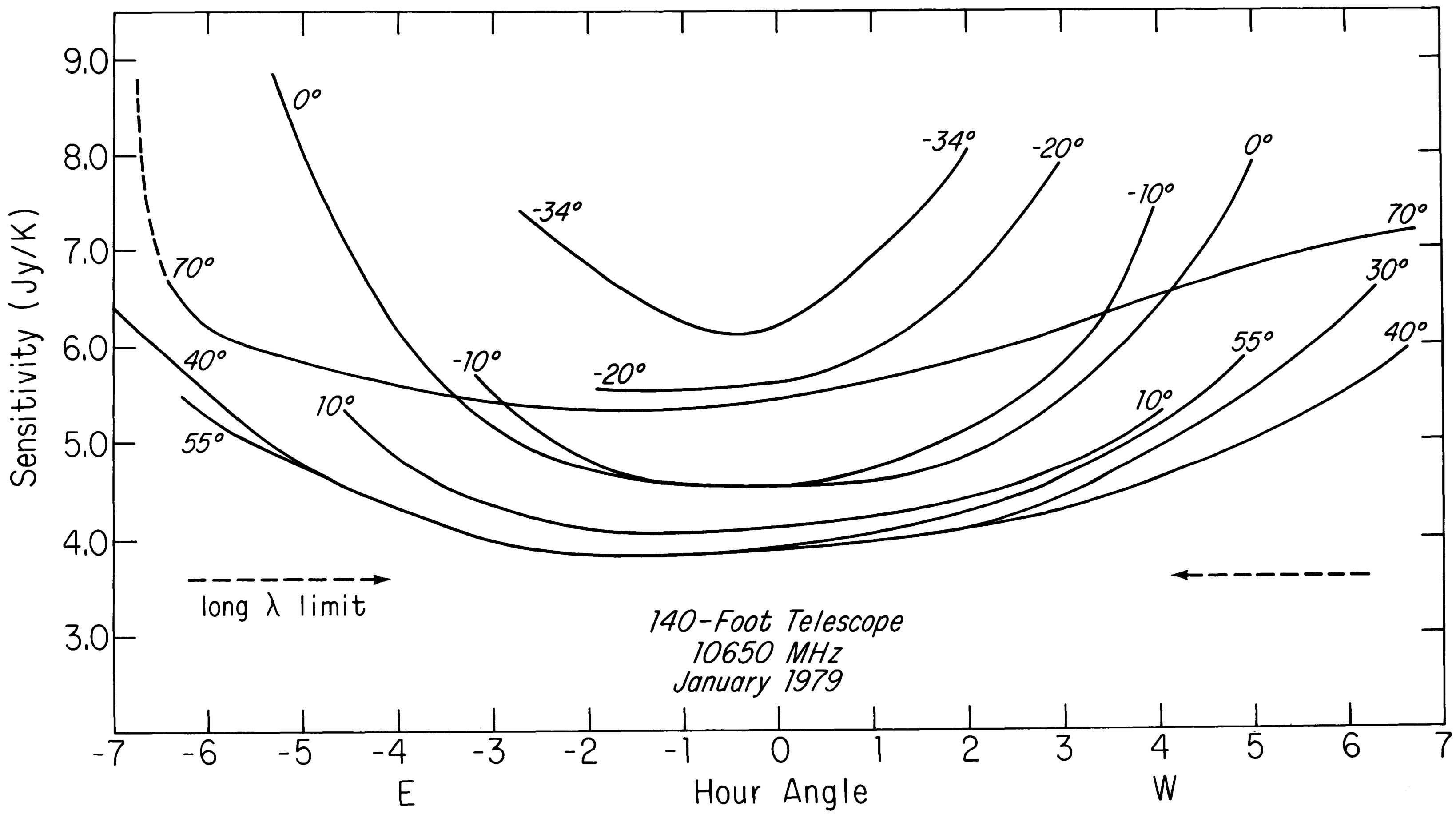
A few general remarks:

(1) There is a range of source declinations and hour angles for which the 10650 MHz performance of the 140-foot telescope is rather close to the long wavelength performance. Specifically, for sources in the declination range $\delta = +10°$ to $\delta = +55°$ that are observed at hour angles between 3^hE and 2^hW, the telescope sensitivity is 4.0 Jy/K (which compares favorably with the long wavelength limit of 3.6 Jy/K) and the sensitivity changes by less than 10% over this 5-hour interval.

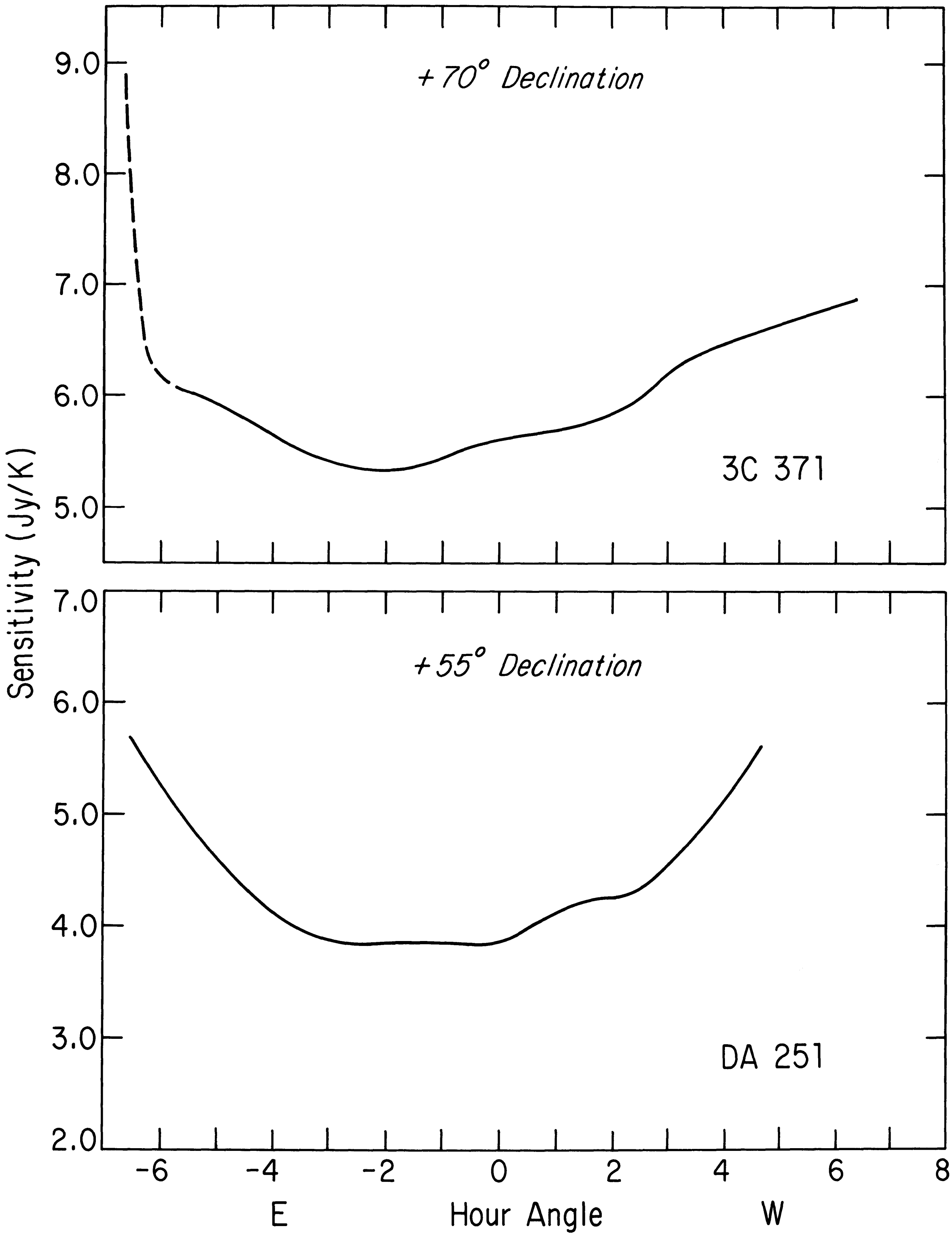
(2) At low declinations, $\delta \leq 0°$, there are two problems. First, the telescope sensitivity progressively worsens with decreasing declination. Second, the telescope sensitivity is a rapidly changing function of hour angle particularly at HA farther east than -2^h and farther west than $+1^h$.

(3) The "well-known" telescope asymmetry--the best sensitivity at a given declination is displaced slightly east of the meridian--is an effect present at all declinations but it is most pronounced at high declinations. Specifically, the best sensitivity occurs near 15^{min} East for sources at $\delta < 0$, and this point of best sensitivity moves progressively farther east for sources at higher declinations: at +70° declination the best sensitivity occurs at 2^h East.

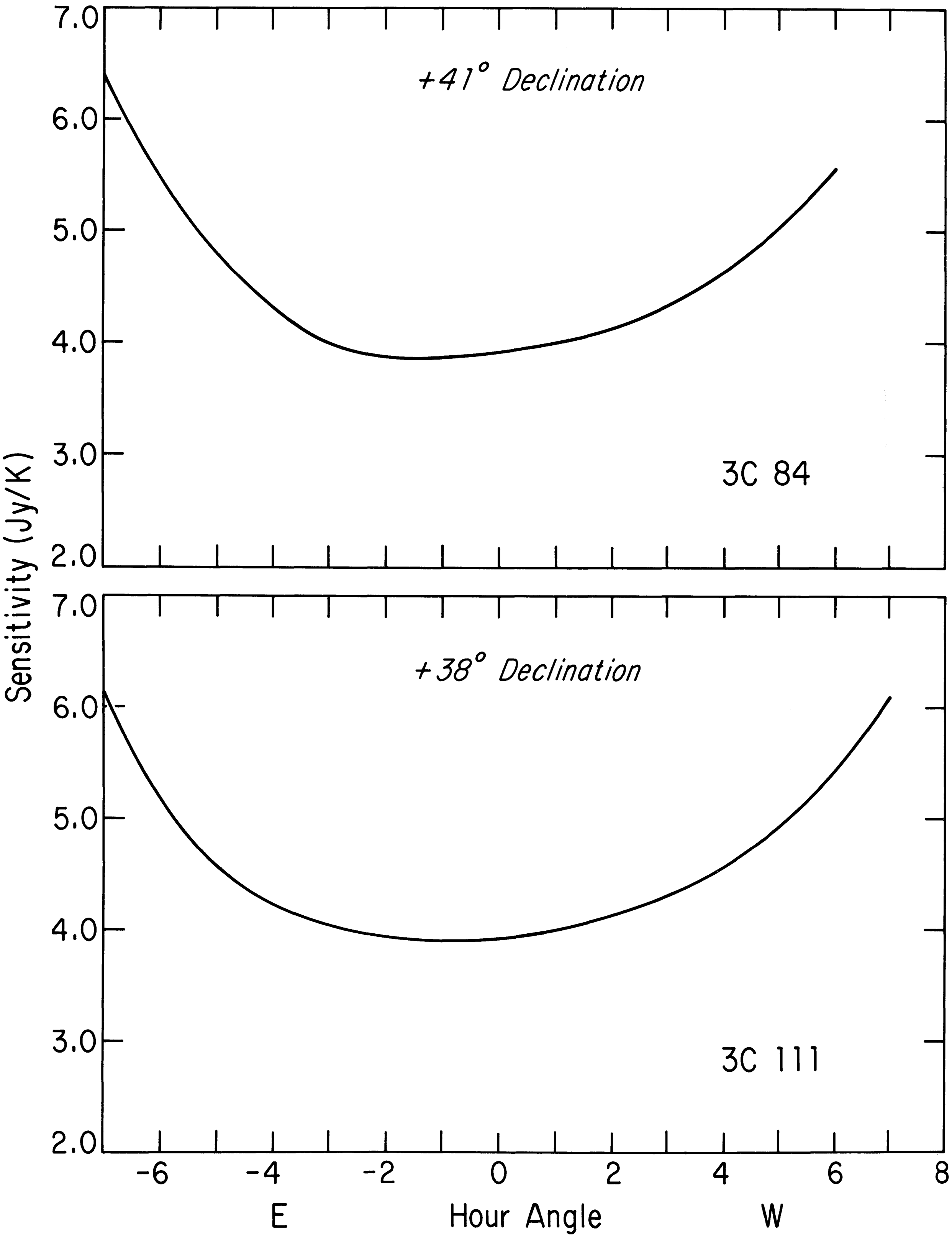
Finally, I intend to obtain a complementary set of data at 20 GHz so that I can better describe the change in telescope performance with wavelength. Moreover, I suggest that these measurements be repeated after any major structural change is made to the telescope (e.g. when the surface is adjusted) and/or when a 10650 MHz receiver is available at the Cassegrain focus.

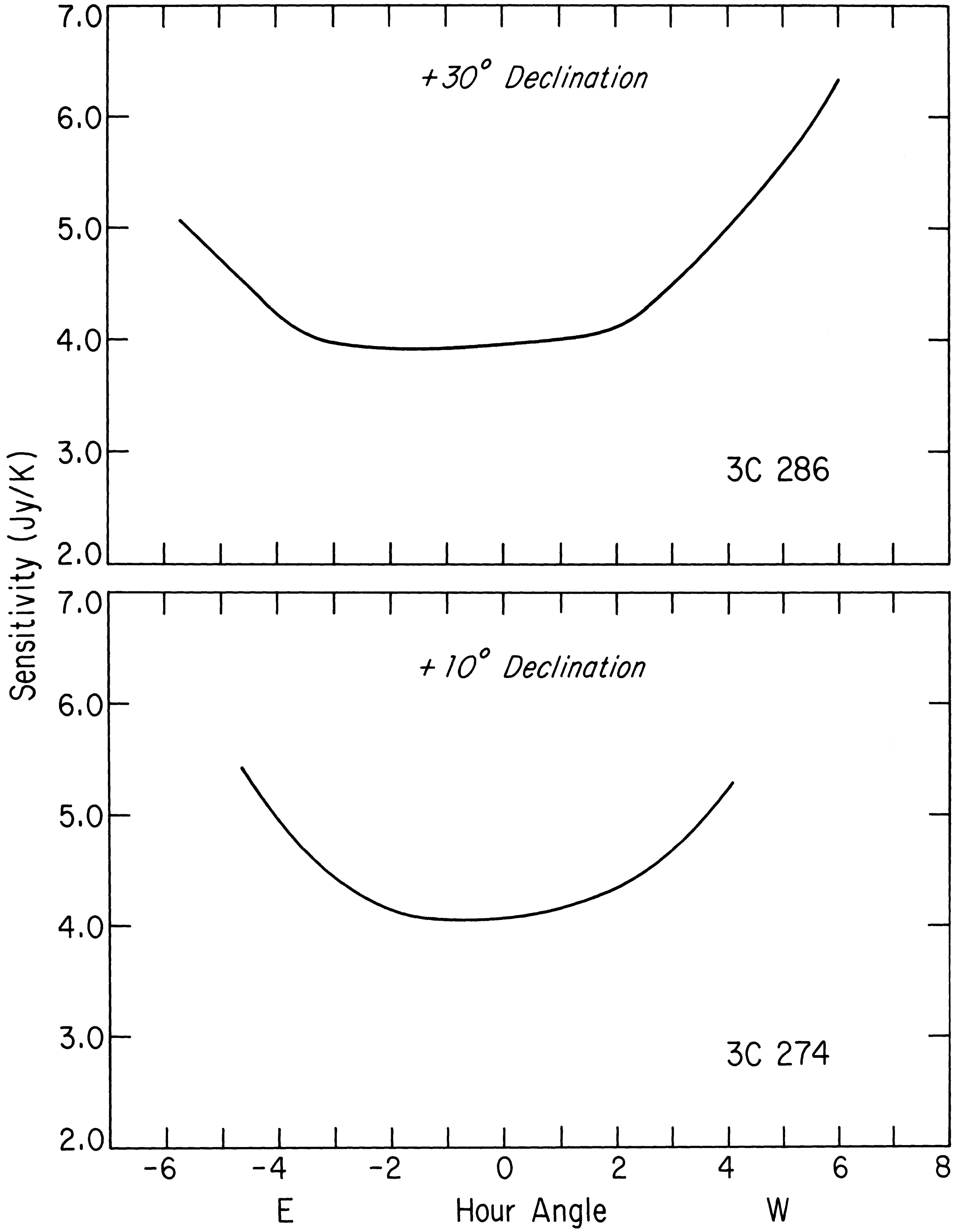


Sensitivity (Jy/K)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
Hour Angle
-7
-6
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
7
E
W
0°
-34°
-20°
-10°
70°
30°
55°
40°
10°
long λ limit
140-Foot Telescope
10650 MHz
January 1979

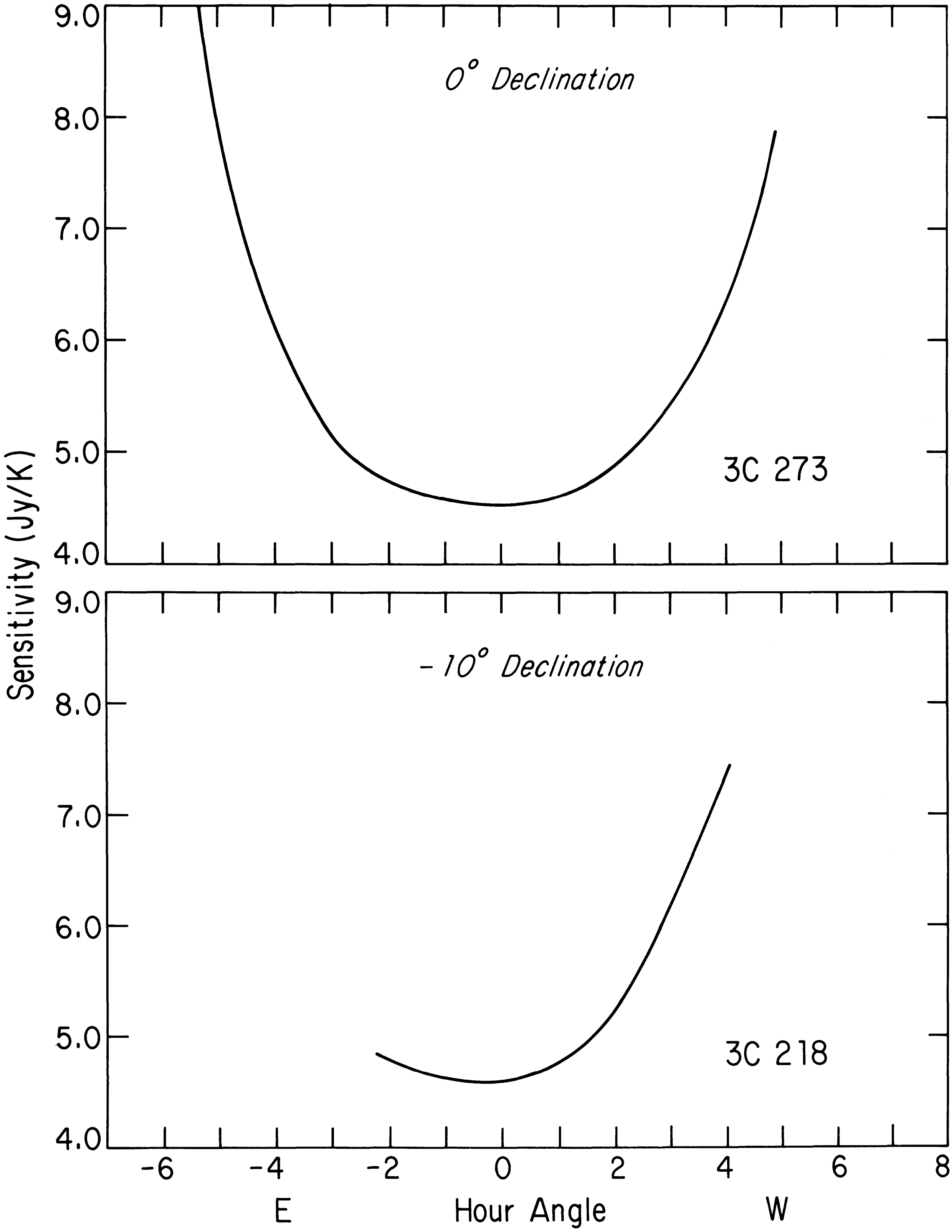


+70° Declination
3C 371
+55° Declination
DA 251
Sensitivity (Jy/K)
9.0
8.0
7.0
6.0
5.0
7.0
6.0
5.0
4.0
3.0
2.0
-6
-4
-2
0
2
4
6
8
E
Hour Angle
W

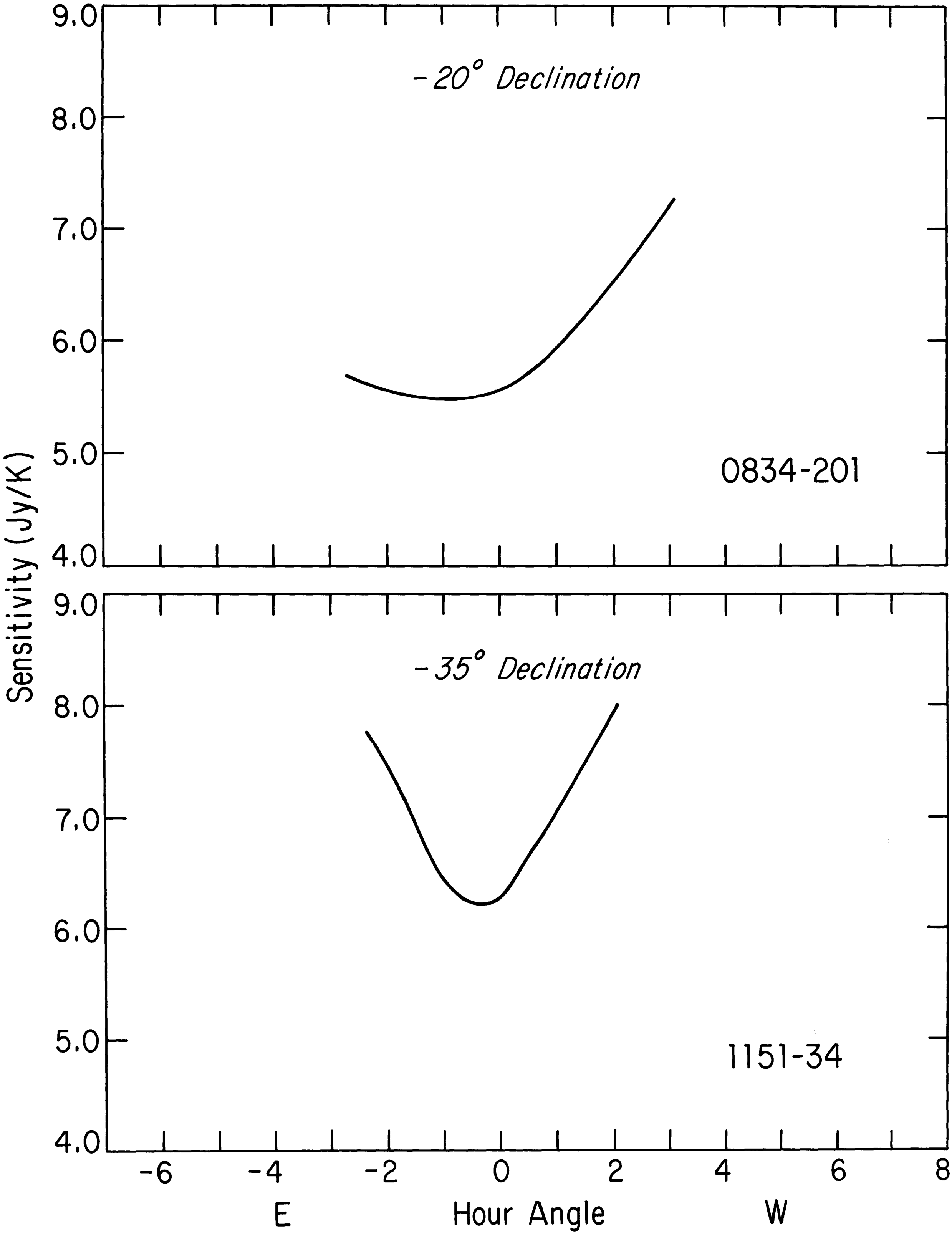

+41° Declination
3C 84
+38° Declination
3C 111
Sensitivity (Jy/K)
7.0
6.0
5.0
4.0
3.0
2.0
-6
-4
-2
0
2
4
6
8
E
Hour Angle
W



Sensitivity (Jy/K)
7.0
6.0
5.0
4.0
3.0
2.0
+30° Declination
3C 286
+10° Declination
3C 274
-6
-4
-2
0
2
4
6
8
E
Hour Angle
W



9.0
8.0
7.0
6.0
5.0
4.0
0° Declination
3C 273
-10° Declination
3C 218
Sensitivity (Jy/K)
-6
-4
-2
0
2
4
6
8
E
Hour Angle
W



-20° Declination
0834-201
-35° Declination
1151-34
Sensitivity (Jy/K)
9.0
8.0
7.0
6.0
5.0
4.0
-6
-4
-2
0
2
4
6
8
E
Hour Angle
W