

An Introduction to Radio-Astronomical Observing at Haystack

This note is intended to contain most of the information and recommendations that new investigators doing radio-astronomical observing at Haystack need to know. We assume some  knowledge of radio astronomy, of course, and some knowledge of computers and the Unix operating system. You should also be familiar with the booklet *AN INTRODUCTION TO THE HAYSTACK OBSERVATORY*, August 1994, (hereinafter *INTRODUCTION*) and with “Umbrella: A Language to Shield You from the Pointing Computer.” References herein should help find more detailed information. We have in mind primarily spectroscopy with the $\lambda 3$ -mm receiver, but most of this material applies to all our receivers.

I. Pointing

Section I.C.9 of *INTRODUCTION* contains a discussion of the pointing performance of the Haystack antenna. The best pointing sources for Haystack are probably SiO masers at 86 GHz ($\lambda 3.5$ mm). The best of these are relatively strong, small in angle compared to our beamwidth, and have well-known angular positions. We recommend using a bandwidth that matches the feature width (i.e., treat the spectral feature as a single signal), frequency switching or beam switching, and making discrete-source-scan (DSS) or five-point (FIVPT) measurements. A list of recommended SiO-maser pointing sources with positions, bandwidths, and velocities is available in a notebook at the console. Planets, another alternative, are typically weaker and larger in angle, but they avoid the necessity of tuning a receiver to 86 GHz. We recommend using beam switching and the full receiver bandwidth) typically 160 MHz) for planets.

We have had some success in using pointing measurements made at 22 GHz ($\lambda 13$ mm) toward H_2O maser sources with the K-band HEMT receiver, which is in the box with the $\lambda 3$ -mm receiver, to infer pointing at $\lambda 3$ mm. Using the same techniques as for SiO masers, the scatter in the measured positions at $\lambda 13$ mm is usually small compared to the beamwidth at $\lambda 3$ mm, and the angular offsets between these two feeds are well known. The changeover between $\lambda 3$ mm and $\lambda 13$ mm, which can be done downstairs, is shorter and easier than retuning a $\lambda 3$ -mm receiver, which requires a Haystack employee to climb to the box.

If you find a significant pointing offset, we recommend that you should not assume that it will remain constant either in angle or time. When pointing is critical, only pointing measurements made nearby in both time and angle should be trusted. Be particularly skeptical of measurements made at sunrise, sunset, or when the antenna has just been in stow position.

Results from past DSSs and five-point measurements can be viewed on the screen of an HP-2648 terminal using PROC,2,...7; ask a Haystack employee for help if need be. There are three pointing parameters (biases) that can be changed by users: one in elevation and two in azimuth. Az bias 1 corresponds to arc on the sky in the azimuth direction; Az bias 2 is an azimuth coordinate (encoder) offset. In plots of azimuth offsets using PROC,2,...7, the ordinate is arc on the sky. Thus Az bias 1 can be estimated directly from such plots, and for Az bias 2, there is a sample plot in

Appendix A. Az bias 1 and El bias can be set using UstrOffs in Umbrella, or all three pointing biases can be typed into the user offsets using MODIF,3 from an HP-264x terminal.

II. Focusing and Other Subreflector Adjustments

Our new deformable subreflector has a myriad of variables that can be adjusted as a function of elevation, temperature, and other parameters. The same program, SUB1, that talks with the subreflector's computer also talks with the computer that controls the splice plate's temperatures, which affect the antenna's shape. The most important parameters (i.e., the ones that have the largest effect on the gain) are Z focus, astigmatism, and C-ring piston motion of the subreflector. (The C ring on the subreflector corresponds to a ring just outside the splice plate on the antenna.) With strong point sources, preferably SiO masers at 86 GHz in the same mode as for pointing above, the FOCUS program can be used to determine peak settings for any of several parameters. The results can be incorporated into the focus equations using SubTrans and SubTilts in Umbrella or MODIF,17 on an HP-264x terminal. We believe, however, that measuring FOCUS parameters in this way may no longer be necessary; SUB1 probably already has nearly optimum parameters. Additional information is in the memo "Subreflector 'Tuning'," 1993 November 2.

III. Observing Modes for Spectroscopy

The Haystack system can acquire spectra in many different modes including total-power off-ons, antenna switching, beam switching, various kinds of frequency switching, and two kinds of double-Dicke switching: single beam (usually with radome retrace) and dual beam. Haystack's nomenclature is not necessarily the same as other observatories'. The following tabulation shows most of the options available and explains some of the non-standard terminology.

Abbr.	Haystack Terminology	Description and Notes
SOFFON	Total-Power Off-Ons	Single-cycle position switching (antenna points alternately off then on source). One spectrum per off-on pair. Specify half cycle in integer half minutes (30 seconds); specify off position in right ascension and declination offsets.
SAS	Antenna Switching	Same as total power above but multiple cycles combine to give a single spectrum. Most observatories call this just position switching. Specify half cycle as for TP and number of cycles.

SFS	Frequency Switching	Symmetric or asymmetric frequency offsets. Switching rate 5 to 50 Hz. Maximum frequency offset set by details of LO frequency. See additional notes below.
SBS	Beam Switching	Offset beam is $-0^{\circ}.114$ (arc) in azimuth. Switching rate 5 to 20 Hz. Available at $\lambda 3$ mm and $\lambda 7$ mm only.
DDS-DB	Double-Dicke Switching with Double beam	Beam switching (above) with the source alternately in the off-axis and on-axis beams.
SDDSSB	Double-Dicke Switching with Single Beam	Beam switching or frequency switching off source subtracted from same-mode observation on source. See Section V (below) for adverse noise implications.

The off position for total-power off-ons can be prescribed as offsets in right ascension and declination, both in degrees. The duration of each half cycle (each off and each on) can be prescribed in integer half minutes (30 seconds). Offsetting in negative right ascension by an amount equal to a half cycle plus dead time (converted to degrees) results in retracing the same azimuth-elevation track (the same part of the radome) for the on as for the off. For a total-power off-on with a 30-second half cycle and 15 seconds of dead time per half cycle, for example, try $45/240$ or $-0^{\circ}.1875$. The program suggests this as its default. Antenna switching is the same as total-power off-ons except that several cycles are combined to give a single spectrum.

Haystack's beam switcher at $\lambda 3$ mm and $\lambda 7$ mm switches at 5 to 20 Hz to a second beam off $-0^{\circ}.114$ (arc) in azimuth. We recommend using the beam switcher whenever the source is small enough in angle that the other beam has no signal. Double-Dicke dual-beam mode (DDS-DB above) involves placing the source alternately in the main and off-axis beams. Whenever a source is present in the off-axis beam, you may prescribe a focus offset of minus one wavelength at $\lambda 3$ mm or minus a half wavelength at $\lambda 7$ mm to maximize gain; use an integer half wavelength to avoid introducing baseline ripple. The SPECT program can do this focus offset for the off-axis beam automatically. An alternative that may produce better baselines, and also saves the time needed to move the subreflector, is to prescribe a fixed focus that is a compromise between the positions for the on-axis and off-axis beams.

Frequency switching at 5 to 50 Hz can shift the signal to either outside or inside the spectral bandwidth. Placing the offset signal inside the bandwidth can double the effective integration time

but halves (or worse) the effective bandwidth or spectral coverage. Frequency switching can be either symmetric (i.e., zero for signal offset and alternately plus and minus offsets for comparisons) or asymmetric (i.e., plus offset for signal, minus offset for both comparisons, or vice versa). Asymmetric frequency switching cancels the slope or linear term in the bandpass shape; symmetric frequency switching cancels also the second-order (quadratic) term at the cost of narrower frequency coverage and a bit more noise. Offsetting by an integer times 12.53 MHz may result in flatter baselines by canceling ripple caused by reflections from the subreflector. We recommend that in-band frequency-switching offsets be an integer number of Nyquists (from the tabulation in Section IV below). For the 160-MHz bandwidth and asymmetric in-band frequency switching, for example, about 5% needs to be dropped off each end of the spectrum, leaving 144 MHz to be split approximately in half. So the frequency shift for this mode should be approximately ± 36 MHz. The closest integer half period of the ripple is $6 \times 12.53 / 2$ MHz or 37.59 MHz. For a Nyquist of 0.3125 MHz (for one video converter from the tabulation in section IV below) try 120 Nyquists or ± 37.5 MHz. This means +37.5 MHz for signal and -37.5 MHz for both comparisons, or vice versa. A similar calculation for the 53.3-MHz bandwidth gives 241 Nyquists or ± 12.55208333 MHz.

Divide such frequency offsets by the local-oscillator divisor to get LORF offsets for the digi switches. This LO divisor, which is not necessarily an integer but is a tenth of an integer, is displayed during SETUP by Umbrella. This and the other LO parameters can also be calculated by the new3mm ($\lambda 3$ -mm receiver) and new7mm ($\lambda 7$ -mm receiver) programs, which run on the console_pc or on clarke, or by BLORF, which runs on an HP-264x terminal, for the K-band receiver.

For wide bandwidths, the flattest baselines usually result from double-Dicke dual-beam (DDS-DB) switching. If this is not feasible (e.g., because the source is too large in angle), try total power or antenna switching retracing the radome. For narrow bandwidths, these modes all work well; try in-band frequency switching to improve the noise performance.

IV. Spectrometer

Our autocorrelation spectrometer comprises four 160-MHz video converters and four modules each with up to 1024 lags configurable in several ways as shown in the tabulation below. Two video converters can be connected to two receivers (two polarizations) to give two simultaneous spectra that, for unpolarized sources, can be averaged together to approximately double the effective integration time. Or either two or four video converters can be offset in frequency with some overlap to place them end-to-end in frequency (the so-called hybrid mode) to give a total effective bandwidth of up to about 580 MHz. At this time, two of our video converters have only 160-MHz bandwidths. The memo "New 5000-lag Spectrometer," revised 1993 January 8, discusses this spectrometer, and the memo "Spectral Merge Preprocessor," 1993 September 16, discusses the hybrid mode. See also SetupRow, BandWidth, and, for hybrid mode, VCoffset in Umbrella.

**Haystack's New Spectrometer
Capabilities**

Label MHz	(Full) Bandwidth MHz	(8192) Point Spacing kHz	One Video Converter			Two Video Converters			Four Video Converters		
			Lags	Nyquist kHz	(Uniform) Resolution kHz	Lags (each)	Nyquist kHz	(Uniform) Resolution kHz	Lags (each)	Nyquist kHz	(Uniform) Resolution kHz
160	160.0000	19.53125	512	312.50000	377.1	256	625.00000	754.2	128	1250.00000	1508.4
53.3	53.3333	6.51042	1024	52.08333	62.85	512	104.16667	125.70	256	208.33333	251.4
17.8	17.7778	2.17014	4096	4.34028	5.237	2048	8.68056	10.475	1024	17.36111	20.95
5.9	5.9259	0.72338	4096	1.44676	1.746	2048	2.89352	3.492	1024	5.78704	6.983
1.98	1.9753	0.24113	4096	0.48225	0.5819	2048	0.96451	1.1639	1024	1.92901	2.328
0.66	0.6584	0.08038	4096	0.16075	0.1940	2048	0.32150	0.3880	1024	0.64300	0.7759

V. Integration Times and Noise

The usual rms noise calculation in radio astronomy is based on:

$$\frac{\alpha\gamma T_{\text{sys}}}{\sqrt{\beta t}}$$

where T_{sys} is the system temperature corrected, if necessary, by the same factor that the spectra are corrected (Fits5 now corrects T_{sys} whenever spectra are corrected), β is the noise bandwidth, which is only approximately equal to the resolution (for uniform weighting, the noise bandwidth is slightly wider than the resolution), t is the integration time, which is equal to the duration in the header (on plus off) in the total-power or antenna-switched observing modes but is less than (typically 80% of) the tabulated duration for Dicke-switched modes because blanking time in the switch should be (and is not) excluded from the durations. The correlator quantization correction, γ , is approximately 1.16 for our spectrometer with its modified 3×3 multiplication table and 50% clipping levels. Set α to 2 only for single switching. Set α to 4 for double-Dicke switching when the signal is present only a quarter of the time (the so-called single-beam mode, SDDSSB above); set α to $\sqrt{2}$ for asymmetric in-band frequency switching (because the signal is always present), or set α to 1.63 for symmetric in-band frequency switching (because the signal is always present but sometimes at half strength).

VI. Calibration, Absolute and Relative Gain, and Atmospheric Corrections

Section I.C.7 of the *INTRODUCTION* booklet has a discussion of antenna performance including peak aperture efficiency versus frequency, normalized gain versus elevation, and beam dilution versus angular size. The memo “Calibration Data,” 1993 November 21, contains updated and additional information. We characterize our relative gain (normalized gain or aperture efficiency versus elevation) by a three-parameter equation, and, as discussed in section VIII below, this equation with these parameters can be used to correct spectra to compensate. Appendix B shows this gain curve with the parameters in the heading, which are our best estimates for recent data using vane calibration on small-diameter sources. Noise calibration gives a slightly different gain curve, and a source whose angular size is comparable to or larger than the beamwidth will have a flatter curve (smaller S) for normalized beam dilution versus elevation.

Vane calibration, used at $\lambda 3$ mm and optional at $\lambda 7$ mm, converts the “warm” parts of the radome and atmospheric losses into system temperature. Thus vane calibration gives higher aperture efficiencies and higher system temperatures (by the same factor) compared to noise calibration, which is conventional at longer wavelengths. As an approximation, then, vane-calibrated spectra are already referred to outside the radome and atmosphere. There are, however, at least two corrections. The T_{cal} number should be the physical temperature of the vane, but at Haystack T_{cal} is usually set to 290°K. The radome environment is controlled to about 12°C (when the temperature outside is cold), so the vane is typically at about 285°K, and a correction of about $285/290 = 0.98$ is needed. Another correction is needed because the average temperature of the atmosphere at one scale height of the absorption is typically 20 to 40 C° colder than the ground, which, in winter, is typically colder than the vane. This correction has the form

$$1 + \frac{\Delta T}{T_{vane}}(e^{A\tau} - 1)$$

where T_{vane} is the physical temperature of the vane, ΔT is the temperature difference between the vane and the average atmosphere, τ is the atmospheric attenuation in nepers (perhaps calculated by the Resch model), and A is the number of atmospheres along the line of sight (approximately cosecant(elevation)). At 115 GHz, this correction is typically some 10 to 20%. We have *not* applied this correction to the data used to derive the normalized gain curve, which thus contains some approximation to the elevation dependence of this correction. Our attempts to verify this correction at $\lambda 7$ mm by comparing vane calibration with noise calibration gave discrepancies that we do not yet understand. These measurements will be discussed in a forthcoming memo.

For noise calibration, we recommend using the Resch atmospheric model to calculate and correct for atmospheric attenuation. This can be done automatically by Fits5 or DrawS as discussed in section VIII below.

To check the absolute antenna gain (aperture efficiency) on a planet, we recommend the following procedure. Usually Jupiter and Venus are available; Mars is typically weaker but also smaller in angle; and Saturn is typically confusing because of the rings. Any planet significantly larger than a beamwidth involves serious approximations in calculating gain or aperture efficiency but may yield a significant beam dilution. The other planets are weaker and usually useless.

1) Choose the widest bandwidth available (usually 160 MHz), beam switching, and do a DSS or FIVPT and an OFF-ON on the chosen planet. If you are sure of the pointing, on a weak planet, you might skip the DSS and do a much longer OFF-ON. Note the antenna temperature from the OFF-ON.

2) On an HP-264x terminal, run PROC,,15, the Resch atmospheric model. Note TAU in nepers.

3) On an HP-264x terminal, run SHO and make a note of the "Ant Temp=" "Outr," "Innr," and "Strct" temperatures. Calculate the average of these three as an approximation for the temperature of the vane. Add 273 K to get to kelvins. Call this T_{vane} .

4) Apply the two corrections noted above to the antenna temperature from 1): Multiply by $T_{vane}/(290 \text{ K})$, and multiply by the correction from the ΔT equation above to get a corrected antenna temperature.

5) On an HP-264x terminal, run EFCAL. If these are vane-calibrated data, elevation is not used; type 0 for tau in nepers. If these are noise-calibrated data, type the real elevation and TAU from the Resch atmospheric model from 2) above. Calculate the planet's diameter in beamwidths by dividing twice the "Semi-diameter (arc sec)," by the "Half-power beamwidth (arc sec)." Note

also the “Brightness Temp. (deg. K),” “Enter measured antenna temperature” corrected from 4) when asked to do so. Type N to *not* “... use gain vs. elevation.” Note the calculated efficiency.

6) This number) corrected aperture efficiency) can be compared with Figure 2 on page 14 of *INTRODUCTION* only for elevations around 40° . For such elevations, you should agree with the small circles at 86 and 115 GHz.

7) Calculate the corrected beam dilution: Divide the corrected antenna temperature from 4) by the planet’s brightness temperature also from 4).

8) This number) corrected beam dilution) can be compared with beam-dilution plots such as Figure 5 on page 18 of *INTRODUCTION* or Figures 4 and 5 in the memo “Calibration Data,” 1993 November 21 only for elevations around 40° .

As an alternative quick check on the gain, we recommend doing DSSs (for pointing) and OFF-ONs on SiO masers at 86 GHz and comparing with our previous results. There are some difficulties with this scheme; in particular, SiO masers tend to be variable over time scales of months. Our best-studied source is R Leo as shown in Figure 4 on page 17 of *INTRODUCTION* and in Figure 1 of the memo “Calibration Data,” 1993 November 21. The data in these figures have *not* been corrected as in 4) above. To duplicate data such as these, use beam switching and the same velocity and bandwidth (-2.8 km/s and 0.66 MHz for R Leo); a notebook at the console contains a list of recommended sources.

VII. Quick Look at Spectra

Several shell scripts (csh on Unix) are available to provide information about and quick looks at raw spectra. There are versions of these scripts for fourier (the spectrometer’s computer) and for Haystack Sun 4s such as *clarke*, which is located in the console area and available to visiting investigators. Most of these scripts assume either a text-mode display or, for plots, a display that can emulate a Tektronix 4014 graphics terminal. NCSA Telnet does this automatically, *xterm* under X windows has a “Tek” window, and the VT-240 (green screen) has a 4014 mode. Appendix C has a list of some of these scripts, each of which contains comments on its operation. Most of them (other than *Auto*) will print brief instructions if you type just the name. The most-used examples are probably: *Last*, which lists the name and time of the last spectra, *Index*, which lists brief (one-line) header information for a prescribed range of spectra, and *PlotAto* or *PlotAto2*, which plots the last spectrum or spectra and loops and updates the display as each new spectrum is acquired. *PlotAto* or *PlotAto2* is normally run continuously on the VT-240. If you are familiar with csh under Unix, then you might want to make copies of these scripts and modify them for your own special needs.

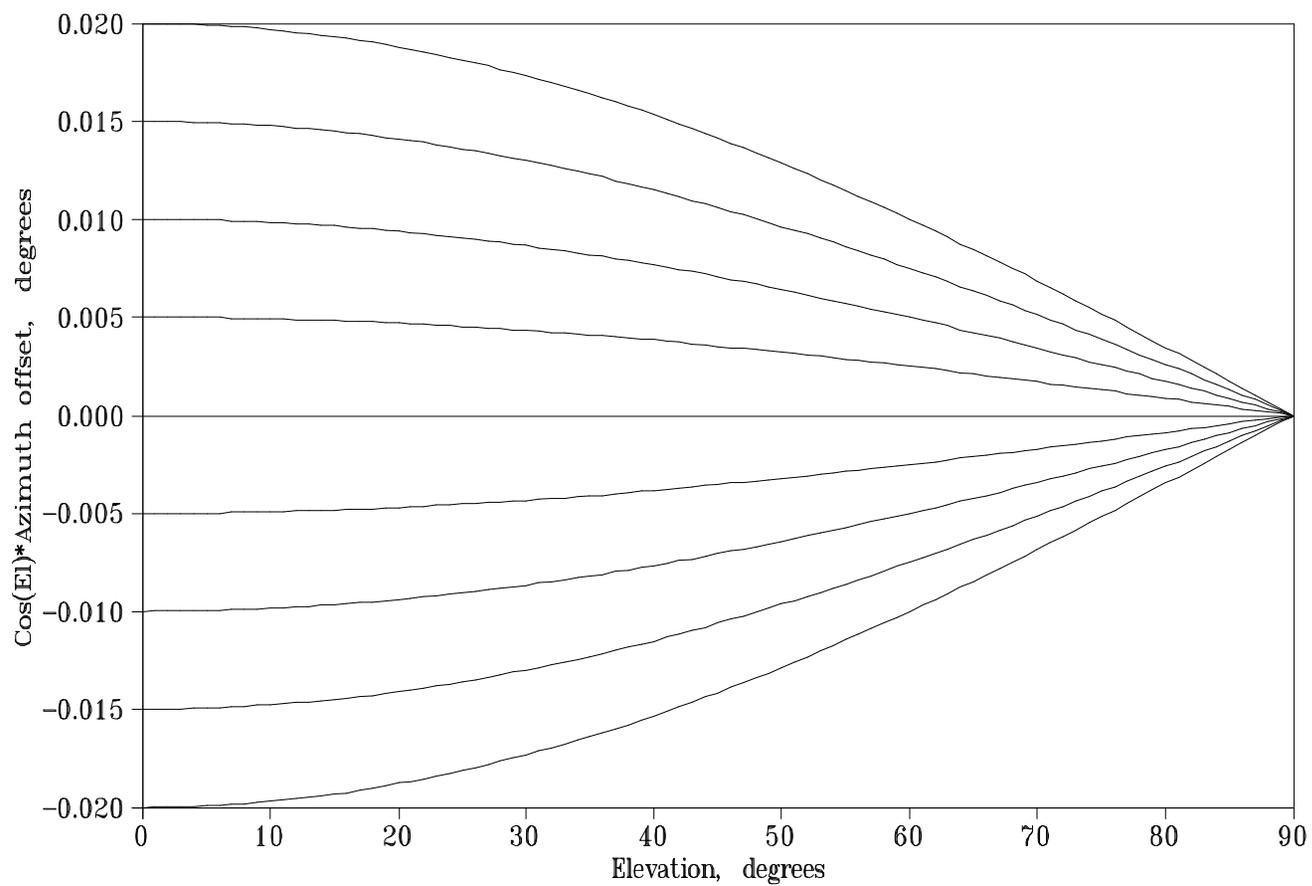
VIII. Spectra into FITS, CLASS, or DRAWSPEC Format

Haystack spectra can be converted into CLASSy FITS, CLASS, or DRAWSPEC formats. CLASS is a data-reduction package written by the Grenoble group to run on VAXes or Sun 4s.

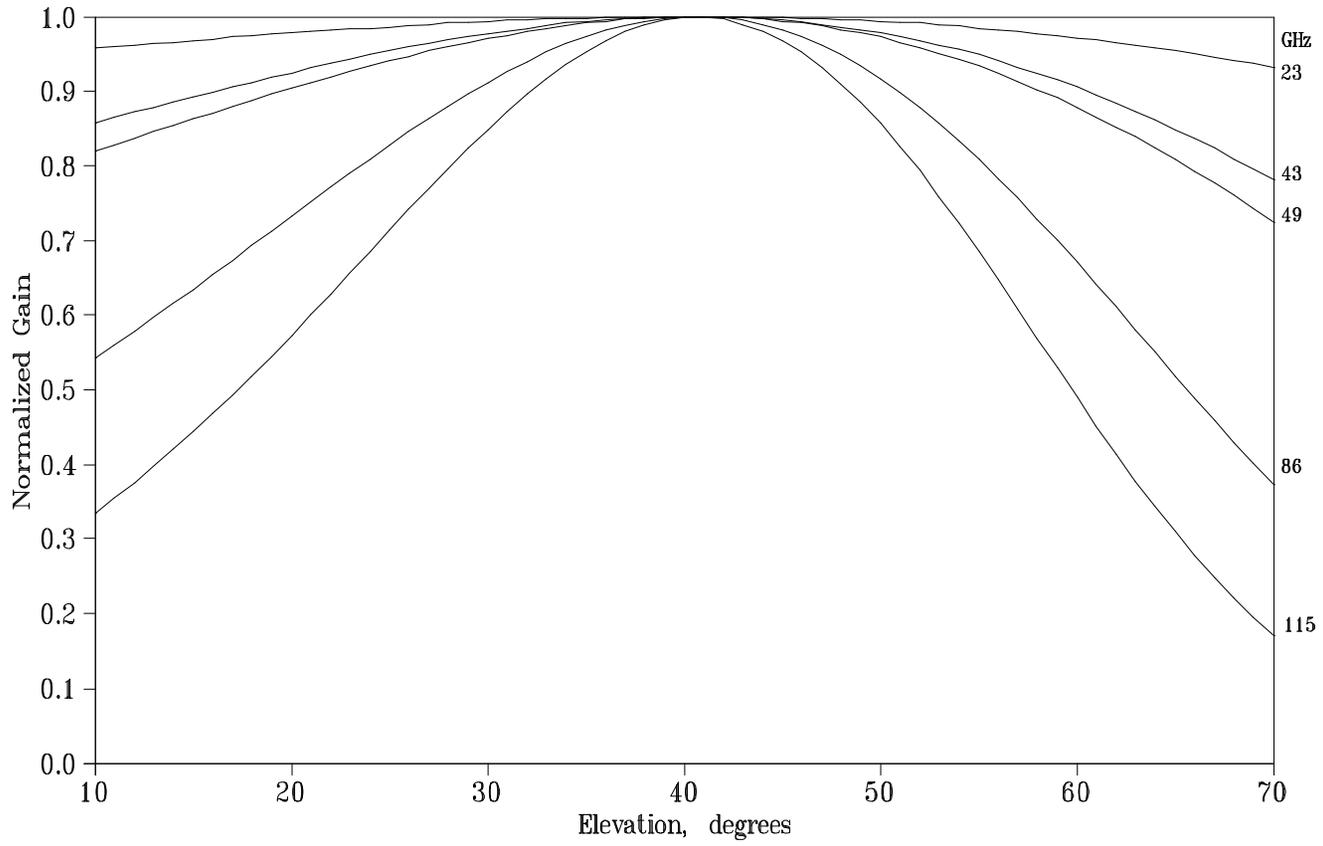
CLASS is available on clarke (in the console area and available to visiting investigators) or other Sun 4s at Haystack. Information on converting Haystack spectra to CLASSy FITS is in the memo "Having FITS," revised 1991 December 26. DRAWSPEC is a data-reduction package written at NRAO by Harvey Liszt to run on PCs under DOS. DRAWSPEC is available on public_pc (the Zenith PC in the console area and available to visiting investigators) or on many other PCs at Haystack. Information on DRAWSPEC is in the memo "DRAWSPEC Support," Revised 1992 July 24. Several shell scripts are available to facilitate converting spectra from Haystack format into CLASSy FITS, CLASS, or DRAWSPEC format. Appendix C has a list of some of these scripts, each of which contains comments on its operation. Most of them (other than Auto) will print brief instructions when you type just the name. The most-used examples are probably: AutoCLASS, which fetches all today's spectra from fourier to CLASS format and loops and waits for each new spectrum as it becomes available, GetCLASS, which fetches prescribed spectra from fourier to CLASS format, AutoDSpeC, which fetches all today's spectra from fourier to DRAWSPEC format on the NFS K: cartridge, and GetDSpeC, which fetches prescribed spectra from fourier to DRAWSPEC format on K:. Both the CLASSy FITS conversion program (Fits5) and the DRAWSPEC conversion program (DrawS), which are called from these shell scripts, accept parameters: -a for correction for atmospheric attenuation using the Resch model atmosphere (not recommended with vane calibration) and -g $EO S U V$ for correction for telescope gain versus elevation and where EO , S , U , and V are the normalized-gain parameters discussed in section VI above. Some of these shell scripts contain default gain parameters to be used if the command line is empty. If you are familiar with csh under Unix, then you might want to make copies of these scripts and modify them for your own special needs.

At the console for use by investigators, there are copies of "CLASS: Continuum and Line Analysis Single-dish Software," by T. Forveille, S. Guilloteau, and R. Lucas, "CLASS at Haystack: A user's guide," by Joel Kastner, a memo "CLASS on Suns at Haystack (memo V7.1)," Aug.24, 1993, by Joel Kastner, and "DRAWSPEC," by H. S. Liszt.

Haystack Observatory
Effect of Azimuth Bias 2



Haystack Calculated Gain Curves
E10 = 40.6, S = 1.22E-7, U = -1.11E-9



Appendix C

Following is a list of C-shell scripts that are available on clarke or on any Sun 4 at Haystack and that can be used to convert Haystack-format spectra into CLASS format, CLASSy FITS format, or DrawSpec format. Each of these has a brief description in its first few lines. The non-Auto scripts will also provide notes on their calling sequence if you type just their name. All these scripts except AutoFits provide for Fits5 or DrawS parameters on the command line; see the Fits and DrawSpec memos. Some additional and possibly useful C-shell scripts are also listed here. These are all in /home/wells/jball/bin alias ~jball/bin from csh.

AutoCLASS	1995 February 13	All today's spectra from fourier to CLASS format, all VCs into a single file. Loops and waits for each new spectrum.
AutoCLASS2	1995 February 13	Same as AutoCLASS but each VC into a separate file.
AutoCLASSf	1994 September 26	Same as AutoCLASS but saves FITS files also.
AutoCLASSm	1994 September 26	Same as AutoCLASS but merges frequency-offset VCs (hybrid) spectra into CLASS format.
GetCLASS	1994 September 26	Prescribed spectra from fourier to CLASS format, all VCs into a single file.
GetCLASS2	1994 September 26	Same as GetCLASS but each VC into a separate file.
GetCLASS2l	1994 January 2	Same as GetCLASS2 but reads spectra from local directory. Used for spectra from DAT.
GetCLASSf	1994 September 26	Same as GetCLASS but saves FITS files also.
GetCLASSl	1993 December 17	Same as GetCLASS but reads spectra from local directory. Used for spectra from DAT.

GetCLASSm	1994 September 26	Same as GetCLASS but merges frequency-offset VCs (hybrid) spectra into CLASS format.
AutoFits	1993 September 15	All today's spectra from fourier to FITS format, VC = 1 only. Loops and waits for each new spectrum. Obsolescent.
GetFits5	1994 September 13	Prescribed old-correlator spectra from HPP through gauss to CLASSy FITS format. Obsolescent.
GetFitsL	1993 September 15	Prescribed spectra from fourier to CLASSy FITS format, VC = 1 only. Obsolescent.
AutoDSpeC	1993 September 28	All today's spectra from fourier to DRAWSPEC format onto wells's K:\DSPECTRA accessible by NFS. Loops and waits for each new spectrum as it becomes available.
GetDSpeC	1993 September 28	Prescribed spectra from fourier to DRAWSPEC format onto wells's K:\DSPECTRA accessible by NFS.
GetDSpeCe	1993 December 29	Same as GetDSpeC but saving all 8192 points. Useable only with the latest version of DRAWSPEC.
GetDSpeCL	1993 September 28	Prescribed spectra from the local directory to DRAWSPEC format also into the local directory. Used for spectra from DAT.
GetDSpeCl	1993 September 28	Same as GetDSpeC but into the local directory.
GetDSpeCle	1993 October 14	Same as GetDSpeCl but saving all 8192 points. Useable only with the latest version of DRAWSPEC.

GetDSpec	1992 July 24	Prescribed old-correlator spectra from HPP through gauss to DRAWSPEC format on wells's K:\DSPECTRA accessible by NFS. Obsolescent.
GetDSpec1	1992 July 24	Same as GetDSpec but into local directory. Obsolescent.

Other possibly useful C-shell scripts, some on Suns, some on fourier, some on both:

Index	1994 October 12	One-line header for each spectrum on fourier for a prescribed date.
Index2	1994 October 12	Two-line header for each spectrum on fourier for a prescribed date. Experimental.
Index1	1994 February 27	Same as Index but reads spectra from local directory. Used for spectra from DAT.
Rstar	1994 February 2	Read a DAT tar tape and extract prescribed spectra to the local directory.
Last	1994 October 12	List names and times of last spectra on fourier.
PlotAto	1994 February 7	Plot last bandpass and spectrum to the terminal, which must be Tektronix-4014 compatible. Loop and plot each new spectrum when available. On fourier.
PlotAto2	1994 February 8	Same as PlotAto but for two-VC operation. On fourier.
PlotAto4	1994 June 23	Same as PlotAto but for four-VC operation. On fourier.
PlotFF	1991 November 13	Plot a FITS-format spectrum to the terminal as above.

PlotL	1992 April 23	Plot last bandpass and spectrum to the terminal as above.
PlotS	1993 December 17	Plot prescribed spectrum to the terminal as above.

Revised: 1995 March 20, JAB