Chapter 2

Getting Started

2.1 What to Bring to the Telescope

Your observations will be more efficient and you will achieve better results if you have thoroughly prepared for your observing run before arriving at the telescope. Most of this work should be done at the time the proposal is written (see Chapter 1). For both spectral line and continuum observations, you should prepare the following before coming to the telescope:

Source List: A source list with epoch B1950 or J2000 RA and Dec or (lII, bII) Galactic coordinates. For spectral line observations you will also need the source velocities in the LSR, optical, or relativistic velocity reference frames (see Chapter 4). Keep in mind that the beam sizes for the 12m can be quite small (~20″) at the higher frequencies so the positions should be appropriately accurate. You can save time by composing your catalog prior to your observing run. See Chapter 4 for the source catalog format.

Line Rest Frequencies: You should have line rest frequencies which are accurate to at least 10 kHz. If emission lines are weak, test line frequencies should be included. For continuum measurements, choose your observing frequencies so that no strong spectral lines lie in either of the receiver sidebands.

Observing Mode: The available observing modes for spectral line observations are

- Total Power Measurements
- Relative and Absolute Position Switching
- Frequency Switching
- Beam Switching
- Grid Mapping
- On-The-Fly Mapping

while the available observing modes for continuum observations are

- Switched or Total Power **ON/OFF's**
- Grid Mapping
- On-The-Fly Mapping

Reference Positions: The reference offset position, in angle or frequency, should also be considered carefully. If you are using beam switching, you should consider carefully the optimum beam separation. The default beam throws are ±2′ at 3 and 2mm wavelengths.

Spectrometer Configuration: For spectral line observations you need to determine how you will configure the filter banks and Millimeter Autocorrelator (MAC), including the resolution and the mode of operation. This decision hinges on the resolution and total bandwidth required. No firm rules exist, but the minimum resolution acceptable should probably give 3 - 5 channels across the line and the minimum bandwidth should have 10-20% of the band on each side of the line.

2.2 Startup Checklist

A general startup checklist for both spectral line and continuum observations is given below. Although the Observatory staff tries to provide a fully functional system and advice about calibration constants and procedures, the responsibility for the integrity of the data rests with the observer. This checklist will help insure that the system is configured properly and that variable quantities such as pointing and focus are properly set. Completion of this checklist may take an hour or more, but the time will be well-spent.

1. Have the operator tune the receiver to the desired frequency, including sideband and harmonic checks.

2. Select a strong continuum source from the list of standard sources (see Chapter 4). A bright planet (*i.e.,* Venus, Mars, Saturn, or Jupiter) is preferable. Pick one whose position is near the first program source, if possible.

3. Ask the operator to perform a five-point map of the source to check for pointing offsets. Records of recent pointing offsets are kept on graphs near the observer's console and can be used to estimate an initial value for the pointing. The operator will need to know the map grid spacing (the default value is ½ the beam FWHM) and the integration time per point. A detailed discussion of telescope pointing characteristics is given in Chapter 4. When the five-point measurement is complete, a fit will be made to the measurement on-line and displayed on the on-line data server. You can also reduce these measurements by hand using *UniPOPS* (see §2.3). If the to the five-point is poor, repeat the measurement with updated pointing.

4. Ask the operator to perform a *focalize* on the chosen continuum source. This checks for the best value of the axial focus. The focalize measurement requires that you specify a first guess for the focus position (called F0) and the spacing between the focus settings (called WL). The system will automatically set F0 to a reasonable starting value (usually around 50 mm). WL is usually chosen to be ½ the observing wavelength. When the focalize measurement is complete, a fit will be made to the measurement on-line and displayed on the on-line dataserver. You can also reduce these measurements with the *condar* analysis program. See Chapter 4 for more focus information and §2.3 for data reduction commands. If the fit to the *focalize* is poor, repeat the observation with an updated value for F0.

NOTE: Pointing and focus may change as the temperature of the dish (or parts of the dish) changes. Pointing and focus should be checked (at least) after nightfall and daybreak and more frequently if the dish is illuminated by the sun.

5. For spectral line observations, you should perform the following checks to insure that the receiver is tuned correctly, the spectrometer is properly configured, and the calibration scale is correct.

   (a) If the program line is weak and no other strong lines are in the bandpass, tune first to a strong test line that is as close by in frequency as possible. "Strong" means any line that will produce a good signal-to-noise spectrum in a 5 - 10 minute integration, for example. Standard sources are listed in the ARO standard catalog (called "standard.cat"). If possible, use the same observing setup (same spectrometer mode and observing mode) as will be used for the program observations. If the observations are of a common species, such as CO, there is no need to tune to another line.

   (b) Perform a calibration scan and check for bad channels in the filter banks. Report the bad channels to the operator, who will flag those channels in the control system software.

   (c) Observe a test line in a strong source. Observers may wish to verify the sense of the velocity/frequency scale by shifting the rest frequency or center velocity by a small amount and seeing if the line moves in the correct direction for the sideband choice.

   (d) Check that the line temperature calibration is correct. This can be done by observing a standard source, presuming that the test line has known strength. Measurements of many of the sources in the ARO standard catalog "standard.cat" have been made in the CO, ^{13}CO, and $C^{18}O$ J=1→0 and J = 2→1 transitions. Plots of these spectra can be found at the telescope and on the ARO Home Page here.

2.3 Basic Data Reduction with UniPOPS

Two other manuals, one for spectral line and one for continuum, describe the data reduction systems in use at the 12m. These are available at the telescope and upon request. The discussion below is intended only as a quick reference list to help the observer get started.

Raw data is accumulated into two data files; one which contains filter bank data and a second which contains Millimeter Autocorrelator (MAC) data. Both of these files are in the "sdd" or Single Dish Data format. Each of these files has an associated gains, or "gsdd" file which contains results for spectral line calibration scans. In the following we give a brief introduction to the analysis of the spectral line and continuum data accumulated into these data files.

Subscan	Configuration
	Filter Banks
01	IF1 inter bank 1 (series) o first half of filter bank 1 (parallel)
02	IF1 in second half of filter bank 1 (parallel)
03	IF2 inter bank 2 (series) of first half of filter bank 2 (parallel)
04	IF2 in second half of filter bank 2 (parallel)
	Millimeter Autocorrelator
11	IF1 in 2IF mode or IF1 at frequency 1 in 4IF mode
12	IF2 in 2IF mode or IF1 at frequency 2 in 4IF mode
13	IF2 at frequency 1 in 4IF mode
14	IF2 at frequency 2 in 4IF mode
	Single-Beam Continuum
01	IF1
02	IF2

Table 2.1: Subscan Codes For 12m Data

Before observations begin, the operator will set up a subdirectory containing data files. This subdirectory is private to each observing team, and is denoted by **/home/obs/ini**, where **ini** are the 3 letter initials of the lead observer. The data files in this subdirectory are also labeled with the same initials. Log into the system as username **obs** (the operator can tell you the current password for this account). You will then be prompted for your initials, discussed above. After the login process is complete, you will be in your **/home/obs/ini** subdirectory.

The spectral line system always records data from two 256 channel filter banks and up to 65536 channels from the Millimeter Autocorrelator (MAC). Each scan is composed of a number of subscans/indexdata!subscan which individually contain one filter bank or Millimeter Autocorrelator (MAC) measurement. Table 2.1 lists the subscan codes with their associated polarizations and backends.

To start the continuum analysis program from the Unix prompt, type

> **condar**

while to start the spectral line analysis program at the Unix prompt, type

> **line**

Table 2.2 lists a number of *condar* and *line* commands and their function, while Table 2.3 lists a number of basic data analysis procedures.

2.4 Alternate Data Analysis Packages

Another data analysis packages available at the 12m, which can be used to analyze 12m data, is *CLASS*.

2.4.1 CLASS

Conversion of sdd-format data to *CLASS* format is currently done on-line. All scans except continuum and OTF measurements are automatically converted to CLASS format and put in a file called *class.12m* in the observer's directory. One can also convert other sdd-format data files to *CLASS* format using a utility program called *uni2class*. To convert all data in the sdd file sdd.jgm_001, issue the following command from any Unix prompt on any of the mountain workstations:

uni2class /home/data/sys/sdd.sys_001 sdd.sys_001.class

for the filter bank data and

uni2class /home/data/sys/sdd_hc.sys_001 sdd_hc.sys_001.class

for the Millimeter Autocorrelator (MAC) data. The second parameter in *uni2class* is the output file name. The current features and limitations of this conversion are:

- Each spectrum is assigned a unique observation number in the *CLASS* file according to the prescription described in Table 2.4. For filter bank data, the nomenclature used for the *CLASS* telescope field identifier is "FB" For filter bank followed by a two-number identifier indicating which filter bank (there can be only two) and which polarization from a filter bank this scan represents. For Millimeter Autocorrelator (MAC) data, the nomenclature used is "MAC" followed by a two-number identifier indicating which rest frequency (there can be two) and which polarization from a given frequency this scan represents. *CLASS* does not support subscan numbers. The original scan number is preserved in the header.
- The *UniPOPS* backend descriptor is converted to a more useful identifier which is inserted into the *CLASS* telescope field to avoid ambiguities between subscans for a particular scan.
- Map offsets are carried over. There seem to be small (<1″) discrepancies in times and coordinates between the sdd and *CLASS* files which are perhaps due to roundoff error.

Table 2.2: Analysis Commands in UniPOPS

Command	Function
Commands Common to Both condar and line	
get scan_number.nn	Retrieves scan_number.nn into the work area.
Xx	Alias for "page show", which plots scan_number.nn following a "get".
Header	Displays the header from scan_number following a "get".
scan_number add	Adds scan_number to the stack.
beg_scan end_scan add	Adds all of the scans between beg scan and end scan to the stack.
c#	Averages all of the scans in the stack and displays the average for channel # (where # is 1 or 2).
cb	Averages all of the scans in the stack and displays the average for channels 1 and 2 combined.
tell stack	Lists scans in the stack.
empty	Empties the stack.
yrange(ymin,ymax)	Sets the vertical scale to the range ymin to ymax.
freey	Resets automatic scaling for the y-axis.
Commands Spec to condar	
scan_number.nn s	Gets and displays the continuum ON/OFF sequence scan_number.nn.
scan_number.nn s ave	Gets, displays, and prints the average and rms flux of the continuum ON/OFF sequence scan_number.xx
scan_number.nn f	Analyzes and plots a five-point map of scan_number.nn scan
number.nn focalize	Analyzes and plots a axial focus measurement of scan_number.nn. scan
number.nn sptip	Analyzes and plots a sky tip measurement.
Commands Spec to line	
fbdata	Tells line that you wish to analyze filter bank data.
hcdata	Tells line that you wish to analyze Millimeter Autocorrelator (MAC) data.
g#	Displays the most recent chopper wheel calibration array For filter bank number # (where # is either 1 or 2).
gget# scan_number	Gets and displays the calibration scan associated with filter bank # of scan_number (where # is either 1 or 2).
scan_number f	Gets and displays the first filter bank of scan_number.
scan_number s	Gets and displays the second filter bank of scan_number.
halves	Displays the average of two filter bank polarizations acquired in "parallel mode".
gcopy	Make a laser printer plot of the graphics screen.

Table 2.3: Analysis Procedures in line

Command	Function
badch	Starts interactive bad channel flagging procedure.
bset	Interactive procedure to set baseline parameters.
nfit=n	Sets the baseline order to n.
baseline xx	Fits, subtracts, and plots the resulting baseline.
gset	Interactive procedure to set gaussian parameters.
gauss	Fits gaussians.
gparts	Plots individual gaussians (for multiple gaussians) and lists height, FWHP width, and position for each gaussian.
gdisplay	Plots sum of gaussians and lists characteristics.
center scan_number fivel#	Processes the spectra for a total power spectral line five-point measurement from filter bank #, where # is either 1 or 2.

- *CLASS* and *uni2class* can access the data file at the same time. This means that you can read the *CLASS* file at the same time as you are writing to it.

- *uni2class* will overwrite existing output files without warning. Be careful!

- Only LSR and heliocentric velocities, equatorial coordinates, and the standard small-field projection are handled correctly.

- No distinction is made between radio and optical velocity definitions.

- Continuum data are not handled.

- The sdd and *CLASS* headers do not map onto each other exactly, but nearly all of the important parameters are mapped.

Table 2.4: Correspondence Between Subscan Codes and CLASS Telescope Identifiers

Subscan	CLASS Telescope Identifier
Filter Bank Data	
01	12M-FB11
02	12M-FB12
03	12M-FB21
04	12M-FB22
Millimeter Autocorrelator (MAC) Data	
2IF Mode	
11	12M-MAC11
12	12M-MAC12
4 IF Mode	
11	12M-MAC11
12	12M-MAC21
13	12M-MAC12
14	12M-MAC22

2.5 Data Archiving and Export

When you have finished your observations, an archive CDROM or DVD of the
observers' files will be made. If you submit a Data Request Form, the staff will create a
CDROM or DVD of your data and mail it to your home institution. These disks are in the
ISO-9660 format, readable by any Linux, Solaris or Windows machines.