

## 3 Observing

This chapter describes the steps necessary to observe with the ATCA. It assumes that observing strategy has been determined and schedule files created. See [Scheduling Strategy \(page 27\)](#) for information on determining observing strategy and [How to Prepare a Schedule File \(page 35\)](#) for information on creating schedule files.

In general, observing takes place in the Control Room at the ATCA site near Narrabri. It is possible to remote observe from anywhere with adequate network and phone connectivity: see <http://www.narrabri.atnf.csiro.au/observing/remote.html> for details on remote observing.

Observers are responsible for the collection of their own data and appropriate checks to ensure the quality of the data. They are also expected to ensure the safety of the array (to the best of their ability). **This is always secondary to any personal safety concerns.**

An ATNF staff astronomer or student is rostered to support observers with setting up and training new observers to use the array (the Duty Astronomer or DA). The DA should be the first point of call if there are problems or queries with observations.

The steps to observe with the compact array are:

- taking control from the previous observer
- set up and calibrate the array
- observe target source(s)
- monitor observations for problems
- end observations

### 3.1 Changeover

The programs required to observe are run within two VNC sessions:

- The XBONES session runs CAOBS, VIS, ASSISTANCE and WINDS.
- The CACCC1 session runs tasks associated with the correlator.

These should be set up before the start of observations. At Narrabri, they are set up on the PERICLES computer along with a number of additional windows with additional information and observing tasks.

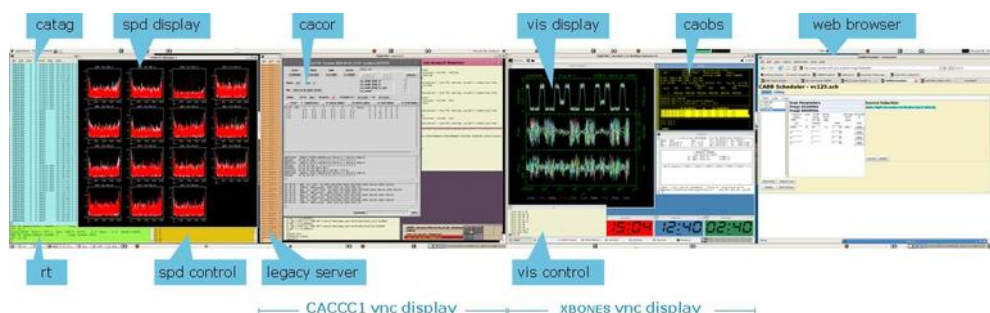


Figure 3.1: Typical display from the PERICLES desktop at Narrabri

All that is usually required for hand over is discussion with the previous observer or observatory staff. The Duty Astronomer should be on hand to help inexperienced observers set up their observations.

Remote observers need to have these VNC sessions set up before the scheduled start time of their observations. See [http://www.narrabri.atnf.csiro.au/observing/rem\\_obs.html](http://www.narrabri.atnf.csiro.au/observing/rem_obs.html) for information on setting up remote observations.

The main observing program that the observer interacts with is CAOBS. CAOBS usually runs in a black screen with yellow writing in the XBONES VNC session. Other programs that observers need to use include CACOR, VIS and MONICA.

For details on using these programs see the [caobs](#) (page 65), [cacor](#) (page 73), [spd](#) (page 81) and [vis](#) (page 87) sections.

To start observing, load a schedule with a strong calibrator into CAOBS and drive to the source:

```
CAOBS> set file sched_filename    loads the schedule file
CAOBS> track #                    drives the telescope to scan # in the schedule file
```

## 3.2 Setting up

At the start of observing, a number of procedures need to be executed to set up the array for observing. The following table summarises the tasks, and indicates the frequencies which need the various tasks.

	16,6&3cm	15&7mm	3mm	
Set Power Levels into CABB samplers	•	•	•	See <a href="#">Setting Levels</a> (page 48)
Set CABB channel ranges	•	•	•	See <a href="#">Selecting Channels</a> (page 49)
Flag interference	•			See <a href="#">Flagging Channels</a> (page 50)
Check focus		7mm only	•	See <a href="#">Focus</a> (page 51)
Calibrate Delays	•	•	•	See <a href="#">Calibrate the Array Delays</a> (page 51)
Check pointing		•	•	See <a href="#">mm Pointing at startup</a> (page 52)
Calibrate Phases	•	possibly	possibly	See <a href="#">Phase Calibration</a> (page 54)
Calibrate Gains	•	•		See <a href="#">Antenna Gain Calibration</a> (page 53)

### 3.2.1 Setting Power Levels into CABB Samplers

The rms digitiser quantisation levels (as displayed in the sampler tab of CACOR) should be close to 20 (Range: Approximately 18-22). The values in the atten section of the window show the settings of the CACOR attenuators. The CACOR attenuators have a range of 0-15 dB.

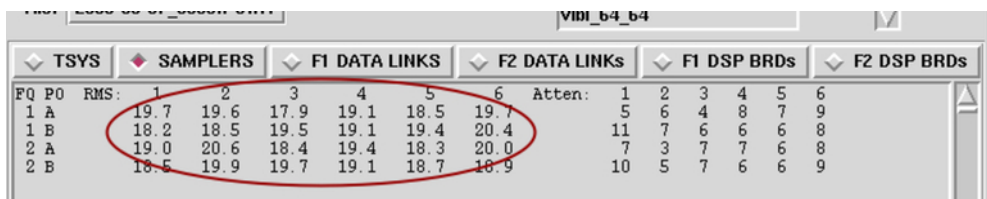


Figure 3.2: CACOR sampler level display

If the levels are not close to 20, enter the following commands in the CACOR interface:

```
CACOR > tatts[ervo] 20    set the target for the attenuator servos to 20
CACOR > atts[ervo] on     correlator servos the attenuators to adjust the levels into the
                           samplers
```

Wait for the levels to settle to around 20, then turn the adjustment off again with:

```
CACOR > atts[ervo] off
```

#### 3.2.1.1 Setting mm Attenuators

It is occasionally impossible to get values close to 20 because there is insufficient range in the CABB attenuator settings. At mm frequencies there is extra attenuation available in the mm receiver. The current settings are displayed in MONICA. To change mm attenuators:

```
CAOBS > set mm ca0# a b
```

where # is the antenna  
a is the attenuation in a pol (on both frequencies), between 0 and 15 (dB)  
b is the attenuation in b pol (on both frequencies), between 0 and 15 (dB)

### 3.2.2 Set CABB Channel Range for Calibration and Monitoring

CACOR generates an average visibility (averaged across the spectrum) that is used for  $T_{sys}$  and array calibration. Some care needs to be taken to ensure that the range of CACOR channels used for calculating this average is as wide as possible within the useable passband, but also excludes interference.

At higher frequencies, it is usually appropriate to use the central fifty percent of channels but at cm frequencies, interference means that it is often better to select non-default channels. See Table 3.1 for information on recommended channel ranges. If these channel ranges are not generating the anticipated visibility in VIS, inspect *spd* (page 81) to determine the cause of the problem.

The *tvchan* command sets the range of channels that are used for calibrating the array and for  $T_{sys}$  calculation. All unflagged channels are written to the data (RPFITS) file regardless of what the *tvchan* setting is.

(Note: Channels that are flagged are written to the file as zeroes. See the section on *Flagging Channels* (page 50)).

To check the current setting, execute the CACOR command

```
CACOR> tvch[an]
```

The first pair of numbers gives the channel range for the first frequency. The second pair of numbers gives the channel range for the second frequency.

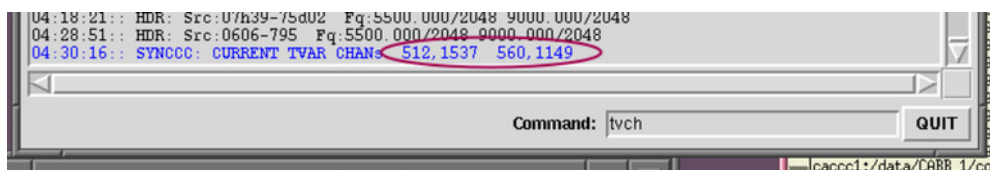


Figure 3.3: CACOR display showing the currently used tvchannels.

```
CACOR> tvch[an] default
```

sets the channel range to use the central 50% of the channels (i.e. channels 513 - 1537).

```
CACOR> tvch[an] ch1 ch2 ch3 ch4
```

sets specific channels where  $ch_1$  and  $ch_2$  are the low and high channels for frequency 1 and  $ch_3$  and  $ch_4$  are the low and high channels for frequency 2.

```
CACOR> tvch[an] f# ch1 ch2
```

sets specific channels for a single frequency, where # is the frequency (1 or 2).

The following table lists the suggested tvchan ranges for the standard continuum bands.

Band	Center Freq (MHz)	ch <sub>1</sub>		ch <sub>2</sub>
16cm	2100	300	-	1000
6cm	5500	513	-	1537
3cm	9000	560	-	1149
15mm	17000	513	-	1537
7mm	33000	513	-	1537
3mm	93000	513	-	1537

Table 3.1: Suggested tvchan ranges for each of the available ATCA bands.

(There is a wide range of valid frequency settings at mm frequencies).

### 3.2.3 Flagging Channels

Occasionally, there will be channels that, because of interference (or other issues), you may wish to completely excise from the data (i.e. not write those channels to the data file).

To check the extent of currently flagged channels:

CACOR> fflag by itself, makes CACOR display the number of channels that are current **unflagged**. In each frequency, there is a maximum of 2049 channels.

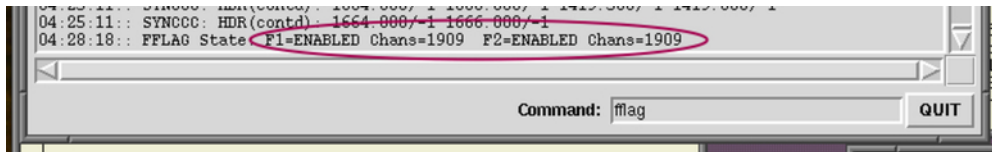


Figure 3.4: CACOR display showing the current number of channels that are unflagged.

There is no easy way to discover which channels have been flagged, and flagging will remain even with a change of project (or frequency etc.) so flagging should be checked at the start of observing. If there are more channels flagged than anticipated, flagging should be cleared then reflagged if necessary.

This is done by:

select the CACOR edit button brings up the CACOR edit screen  
 <CR> exits out of the CACOR edit screen and has cleared all flagging

To flag the set of known bad channels

CACOR> fflag f# birdies flags channel known bad channels in frequency # when using the continuum bands  
 CACOR> fflag f# default flags the central channel (and 1/4, 3/4 channels) in frequency # for 64 MHz modes

This needs to be done at both f1 and f2.

To flag explicit channels, use the command:

CACOR> fflag f# ch<sub>m</sub> flags channel ch<sub>m</sub> in frequency #  
 CACOR> fflag f# ch<sub>m</sub>-ch<sub>n</sub> flags channels ch<sub>m</sub> to ch<sub>n</sub> inclusive in frequency #

Again, this needs to be done at both frequencies.

If you know exactly which channels have been flagged, they can be unflagged with the funflag command: formats are similar to the fflag command i.e.

CACOR> funflag f# ch<sub>m</sub> unflags channel ch<sub>m</sub> in frequency #

### 3.2.4 Focus

The subreflector on each of the ATCA antennas can be raised and lowered to allow the signal to be focussed at the feed. In general, the standard observing focus is constant with frequency (and position on the sky). The exception to this is that the 3mm and 7mm focus position is different on CA01. The following table gives the best focus positions for all antenna at high frequency.

Ant	7mm	3mm
CA01	17	14
CA02	9.8	10
CA03	9	9
CA04	23	23
CA05	18.5	18.4
CA06	?	?

Table 3.2: Subreflector focus positions for each antenna at 7mm and 3mm.

To change the focus, use the command:

```
CAOBS > focus ca0# height
```

where # is the antenna and height is the height given in the table 3.2.

### 3.2.5 Calibrate the Array Delays

Delay offsets need to be determined and corrected at the start of the observation. Failure to correct for delay offsets will result in decorrelation, and complete data loss.

To calibrate the delays, track a strong unresolved source (e.g. PKS1934-638 or PKS0823-500 for cm observations; for mm observations use PKS1253-055, PKS1921-293, PKS2223-052 or PKS0537-441). PKS1934-638 is **not strong enough to calibrate at mm frequencies**.

**Correlation should be apparent before you proceed.** Phases in SPD should be stable, though they may be wrapping rapidly and delays should be flat in VIS.) Check that you have correlation in both frequencies and both polarisations.

If there is significant interference (see the amplitude plot in SPD), you will need to flag interfering channels or use `tvchan` to avoid the interference.

If working at 3mm or with significant interference, it may be necessary to average over several channels (to improve the signal/noise ratio) with the command:

```
CAOBS > corr delavg #
```

where 8 is a good initial value for # - however, if the delays are large (>50nsec), you should try a smaller value to start with.

If you still don't have correlation, check the Monitoring and Troubleshooting section at the end of this chapter, and if this doesn't resolve your problems get help.

Assuming that the phases in SPD are stable, enter the command:

```
CAOBS > corr dcal a
```

dcal calculates the required correction and 'a' applies the correction that the dcal finds. Without the 'a', delays will be determined and the offsets displayed in the correlator window, but will not actually be applied.

This command should correct the delays so that the phases across the band on the SPD plot are flat (or fairly close to flat) and the delay offsets as seen on VIS are close to 0 nsec. If the offsets were large (greater than 100nsec) it may be necessary to do this again.

**Note:** Given the scale on the delays (tens of picoseconds) it is now possible to see the effect of baseline errors and atmospheric variation in delays.

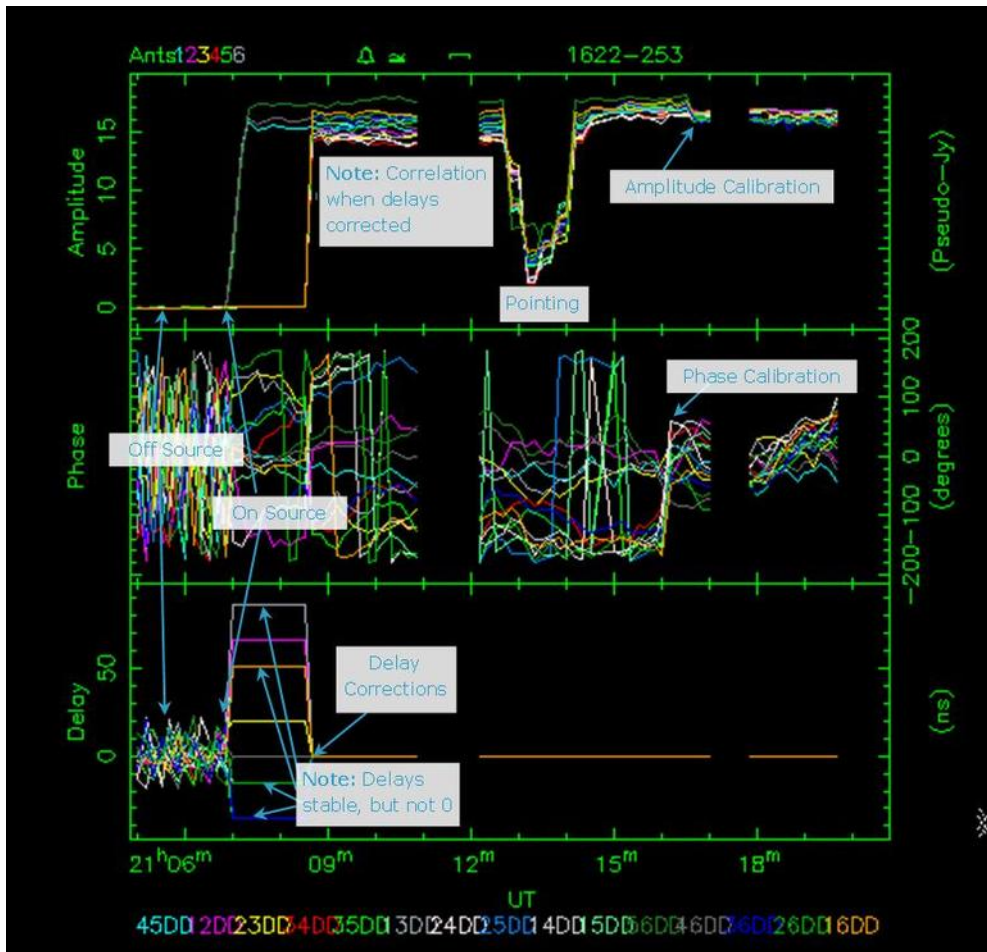


Figure 3.5: VIS display showing output during ATCA calibration

### 3.2.6 Checking Pointing for mm obs

If observing at mm wavelengths, the antenna pointing should be checked and corrected before phase and amplitude calibration. A pointing scan has six separate pointings: first on the nominal on-source position, followed by four pointings at the nominal half-power points ( $\pm$  Az,  $\pm$  El), then a pointing back on the on-source position. A separate task, *CATAG*, calculates the pointing offsets and feeds them back to the system to be implemented.

Check the pointing<sup>1</sup> page in MONICA to check that the appropriate *CATAG* parameters are set:

- User *Antenna Mask* should include all antennas that need to be used for pointing.
- User *IF Mask* should be set to include IFs that are required. 1234 uses all 4 IFs. 12 uses the two polarisations in the first frequency. 34 uses both polarisations in the second frequency. The setting 1234 can only be used if the frequencies  $f_1$  and  $f_2$  satisfy  $abs(\frac{f_1}{f_2} - 1) \leq 0.15$ .
- *Integration Cycles* defines the number of cycles spent on each step of the pointing solution. This will usually be set to 2 or 3.

<sup>1</sup> MONICA Pointing Information: MONICA → Navigator → misc → pointing

Modifying these parameters is done in caobs

```
CAOBS > set point_a a1 [a2...a6]    defines antennas to be included in pointing calculations;  
e.g. CAOBS > set point_a 12345 would use all antennas  
except CA06.
```

**Note:** Pointing using the selfcal algorithm (default mode) requires 4 or more antennas to calculate amplitudes. If using 3 or fewer antennas, holography mode is needed. To enable holography, set the Integration Cycles to the negative (e.g. -2) value.

```
CAOBS > set point_if if1 [if2...if4]    defines IFs to be included in pointing calculations;  
e.g. CAOBS > set point_a 1234 would use both frequen-  
cies, both polarisations.
```

(**Note:** If the two frequencies are different by more than 15%, the system will not let you use the second frequency. This is because the beam size is sufficiently different that problems can arise - think about the situation of a 5 and 10 GHz frequency pair. The half-power point at 5GHz is the first null at 10GHz.)

```
CAOBS > set point_p #                    where # is the number of cycles spent on each pointing  
step. # is usually 2 or 3. If using holography mode, this  
should be -2 or -3.
```

After these parameters have been set, ensure that your schedule file has a pointing scan set up. This scan will need to have 'Scan Type' set to 'Point' and the 'Pointing' parameter set to 'Update'. To start the pointing scan, you must use the 'start' command in CAOBS ('track' will simply track the on-source position):

```
CAOBS > start #                          where # is the scan number of the pointing scan.
```

Watch the amplitudes in VIS to check progress. You should see the amplitudes drop to approximately half the amplitude of the nominal center position. The difference between the plus and minus pointings give an indication of the error in the pointing.

After the pointing scan has finished, check the errors that are found in the MONICA pointing page. If any of the 'Last Az Correction' or 'Last El Corrections' is greater than 10", a second pointing should probably be considered.

For more information on offset pointing, see the [Reference Pointing Guide](http://www.narrabri.atnf.csiro.au/observing/pointing) (<http://www.narrabri.atnf.csiro.au/observing/pointing>).

### 3.2.7 Setting Antenna Gains

Once the delays have been set and pointing checked (for mm observations), the antenna gains need to be set. This calibration is somewhat cosmetic, however, it is very useful for on-line monitoring.

To set the gains:

```
CAOBS > corr acal #1 #2 a                acal calculates the required correction.  
'a' applies the correction that the acal finds.  
#1 and #2 are the fluxes of the calibrator at the first and  
second frequencies respectively.
```

If using PKS1934-638 or PKS0823-500, the fluxes are known by CAOBS and do not have to be entered, i.e.

```
CAOBS > corr acal a
```

**Do not use PKS1934-638 or PKS0823-500 for calibrating the array at mm wavelengths: they are not strong enough.**

Gain settings are used for calculating  $T_{sys}$ . This can be recalculated off-line, but some care needs to be taken.

### 3.2.8 Calibrating Phases

Phase Calibration is even more 'cosmetic' than gain calibration, however, it is sometimes useful to set the phases to zero at the start of observations to help judge the phase stability. To set the phases to zero:

```
CAOBS > corr pcal a
```

pcal calculates the required correction.  
'a' applies the correction that the pcal finds.

At this point, the array should be set up and ready for observing. Check that **all** the products in VIS look correct and that the  $T_{sys}$  values (in CACOR) are appropriate. If there are any problems, check the Troubleshooting section or get help.

## 3.3 Observing

Once setting up is complete, observations proper can start. Observations need to include calibration data, including data for flux, bandpass, polarisation and gain calibration.

### 3.3.1 Calibration

It is important that sufficient calibration data is taken to characterise the array. This means taking flux and bandpass calibration data for all observations, and leakage calibration data for polarisation observations.

This does not have to be done at the start of the observation, but should be done at some point during the observing session. If appropriate calibration sources are not above the horizon during the observing session, contact the scheduler (Phil Edwards) to discuss options.

For cm and 15mm observations, PKS1934-638 is the appropriate flux calibrator and can usually be used as a bandpass calibrator too. For mm observations, a planet is needed for flux calibration (PKS1934-638 can also be used in the 7mm band), and a strong source (e.g. PKS1921-293 or PKS1253-055) is required to calibrate the bandpass.

### 3.3.2 Monitoring

## 3.4 Troubleshooting

### 3.4.1 Stop-Start Problem

When CAOBS is first started, it is possible for the correlator and CAOBS to be out of sync. In this case, there will be no update of data in SPD or VIS and the CACOR window will have a new blue-coloured message every cycle reporting something like:

```
DELBAT . . .
```

The solution is to issue a stop in CAOBS, then restart observing.

### 3.4.2 No Correlation

There are a number of problems that may result in loss of correlation.

#### 3.4.2.1 Conversion System Out of Lock

It is possible to lose lock in the conversion system. Check the following in MONICA. Currently there isn't a standard page with these in it and you have to create your own pages in MONICA (see below).

- CL1F1 PLL Lock is locked
- CL1F1 Expected Reference Frequency (the freq the module is expected to tune to)

To create a new page in MONICA that monitors the CACOR conversion system

In MONICA choose

Window → New Window → Setup → Add panel → Time Series

This brings up the page for setting up a time series.

- Choose 12 hours

- 
- Choose CACOR in the Select Items window

Optical Power Photodiode biases need to be a reasonable value (if  $< 0.2\text{mA}$  will lead to loss of lock)

Won't get any sync errors, correlator will look ok, but no correlation because tuned to the wrong frequency.

### 3.5 cm Observing Startup Checklist

Use this checklist for starting cm observations

- check CABB attenuators
- calibrate delays
- calibrate phases
- calibrate amplitudes

### 3.6 mm Observing Startup Checklist

Use this checklist for starting mm observations

- check mm attenuators
- check CABB attenuators
- calibrate delays
- check pointing
- calibrate phases
- calibrate amplitudes

