Scheduling LBA experiments

When an LBA experiment is scheduled, the PI is sent a letter giving them the details of the observation, information on preparing a schedule, and contact details for correlator personnel. Questions related to the correlator and correlation of LBA observations should be sent to Cormac Reynolds at Cormac [dot] Reynolds [at] csiro [dot] au.

All LBA experiments should be scheduled using the “VLBA” Sched program. You can either download and install it on your own Unix workstation/laptop or use the Linux system at the ATNF.

Unless you have specific frequency requirements (e.g. spectral line experiments, specific antenna limitations, known RFI issues) please always use the standard setups. Any changes from the standard setups increase the risk of your experiment failing. Sched comes with a comprehensive manual. Please read it carefully before you start scheduling. A set of examples are distributed with SCHED ($SCHED/examples/lba*).

Antenna names

Antenna names in SCHED specify not just the physical antenna, but also the back end being used to record the data where there are multiple options. You must use the correct name for your particular experimental setup. Current names for LBA and associated stations (with notes in brackets) are:

ASKAP
ATCA
CEDUNA (LBA DAS)
CDDBBC (Ceduna with DBBC)
HART (26m Hartebeesthoek, DBBC)
HART15M (15m Hartebeesthoek, DBBC)
HOBART (Hobart 26m with LBA DAS)
HOB_MK5 (Hobart 26m with MarkIV rack and Mark5 recorder)
HOB_DBBC (Hobart 26m with DBBC)
KATHERIN
MOPRA
PARKES (LBA DAS)
PARK_MK5 (Parkes with MarkIV rack and Mark5 recorder)
WARK12M (12m Warkworth, DBBC)
WARK30M (30m Warkworth, DBBC)
YARRAGAD
DSS43LBA (Tid 70m with LBA DAS)
DSS43 (Tid 70m with DVP)
DSS34LBA (Tid 34m with LBA DAS)
DSS34 (Tid 34m with DVP)
DSS35LBA (Tid 34m with LBA DAS)
DSS35 (Tid 34m with DVP)
DSS36LBA (Tid 34m with LBA DAS)
DSS36 (Tid 34m with DVP)

Parkes observations will normally use the LBA DAS, unless there are special requirements.
Since April 2017 Hobart and Ceduna should normally be scheduled as HOB_DBBC and CDDDBBC to use the DBBC, unless otherwise instructed.

Tid antennas should usually be scheduled to use the DVP unless otherwise instructed.

**DAS Setups**

Some LBA observatories use the ATNF DAS, which is a digital filter bank. The ATNF observatories (Parkes, ATCA, Mopra) each have 2 DAS installed, while 1 is available at Hobart and Ceduna (though they normally use the DBBC). The DAS have two independent “IFPs” which sample the analogue signal and produce up to two digitised channels each, which are then recorded. The two IFPs are generally connected to the two polarisations of the receiver but can be set up to record two different frequencies of the same polarisation.

Normally the output of each IFP is either a single channel of bandwidth 2, 4, 8, 16, 32 or 64 MHz or two channels adjacent in frequency with a bandwidth of 2-16 MHz. Generally the IFPs are set to be two adjacent channels of 16 MHz bandwidth, or a single channel of 64 MHz bandwidth, except in special situations.

**LBA specific scheduling issues**

**LBADR**

Please use the latest version of NRAO SCHED to prepare your schedule files. SCHED changes regularly to reflect changes in the capabilities of the telescopes and correlator. Older versions of SCHED will not necessarily produce a correct .vex file for a current observation.

SCHED is installed on linux machines at ATNF (e.g. draco) or can be obtained from ftp://ftp.aoc.nrao.edu/pub/sched/. Example LBA .key files are distributed with the latest version of SCHED ($SCHED/examples/lba*.key). Please prepare your schedule using one of these. The lba setup files distributed with SCHED ($SCHED/setups/lba*) should cover all standard continuum modes. If your schedule requires a non-standard mode or frequency (e.g., for spectral line observations) then you will need to consult with ATNF personnel before submitting your schedule.


**Dual or Single Polarisation**

The observer sometimes needs to decide between observing dual polarisations or single polarisation with twice the bandwidth. If possible you should always choose to observe with dual polarisation, even if you are not interested in polarimetry (it removes one common mode of failure, i.e. observing the wrong polarisation). You should only observe single polarisation if some of the telescopes only have a single polarisation available or if the wider frequency coverage is essential to your scientific goals.
**Frequency setup**

Please prepare your schedule using one of the standard LBA setup files distributed with SCHED ($SCHED/setups/lba*). The lba* setup files distributed with SCHED should cover all standard continuum modes. If your schedule requires a non-standard mode or frequency (e.g., for spectral line observations) then please consult with ATNF staff before submitting your schedule.

The ATCA and Mopra LO chain generally restricts the frequency selection to 1 MHz steps. For continuum experiments this should not cause any difficulty (particularly if you use the standard setups!). For spectral line experiments, letting Sched select the Doppler frequency will be a problem. Use the DOPINCR keyword to force Sched to round the sky frequency to the nearest MHz. E.g.:

```
DOPINCR=1000
```

However, the mixed backends on the LBA, with their often mismatched filters, means that SCHED's automated Doppler setting often does not work for LBA experiments. Its use is deprecated, but if used its results should be carefully checked.

**Fringe Finders**

Normally the first **full hour** of your observation is reserved for telescope setup and fringe finding. Please schedule the first hour of your experiment on a strong fringe finder, including Mark5 transfer instructions if necessary. A list of standard fringe finders is available. This plot shows the optimal fringe finder to use at any given Parkes LST for a typical array. (It is not usually possible to fringe test Parkes and Hart at the same time, so here is a similar plot for fringe finding Hart with only a subset of the LBA).

In addition, you should always observe a few strong compact sources during your experiment, probably every three hours. The fringe finders help in the correlation process for adjusting the clock offsets and checking the correlation process is working properly. They also are good candidates for use with the real-time fringe testing software so any observational problems can be fixed immediately (see next point). Choose one which is strong at your observing frequency and has minimal slew time to your target sources. Note that if you know your target source is quite strong, you may not need to observe a separate fringe finder, but you should note this in your schedule file (using the 'note' keyword at the top of the schedule and the 'intent' keyword at the relevant scan - see below). Please always add a note in the “NOTE” section which sources are your fringe finders. The VLBA calibrator list has a list of VLBI sources, but note that it does not have good coverage for Southern declinations. Leonid Petrov's catalog [http://astrogeo.org/calib/search.html](http://astrogeo.org/calib/search.html) is typically better for LBA observations.

Please use SCHED's 'INTENT' keyword to identify your fringe finder scans. E.g.:

```
grabto='file' grabtime=2,10
dur=3:00 source='1921-293' intent='FIND_FRINGE' /
grabto='none'
dur=2:00 source='target' gap=1:00 intent='OBSERVE_TARGET' /
```

Note that you must reset the intent to some other value (e.g. OBSERVE_TARGET) on the following scan or the first intent will be inherited by all ensuing scans!
Real-time Fringe Testing

Real-time fringe testing can be run on all experiments. Periodically (generally when a strong continuum source is observed) a second or so of data is sent over the network links and correlated on the DIFX software correlator. The fringe plot is made available on the web. This allow observatories to be confident they have their observing setup correct, or identify (and hopefully correct) any problems. Scheduling a few strong sources throughout your experiment (and adding an INTENT='FIND_FRINGE' in the schedule) will increase the chance of success for your experiment.

If you are using any stations with Mark5 recorders (Hobart, Ceduna, AuScope, Hartebeesthoek, Warkworth), fringe test scans must allow a 1 minute gap after the fringe finder to allow some data to be copied off the Mark5 following these instructions (please request assistance if required).

Phase Calibrator Sources

For calibration purposes it is often beneficial to observe a calibrator in the vicinity of your target source (e.g. when phase referencing). A good source for finding these sources is the LBA calibrator survey:

http://astrogeo.org/lcs/cat/

There is also a search form:

http://astrogeo.org/vlbi/search.html

Another good source of calibrator sources for the LBA is the VLBA calibrator database:

http://www.vlba.nrao.edu/astro/calib/

Number of Scans

The control systems at ATCA and Mopra limit the number of scans in a single schedule to 699. If your schedule requires more than 699 scans for any reason, please consult with LBA staff before finalising.

Field System controlled stations (e.g. UTAS and Warkworth telescopes) have a limit of 20000 scans at the time of writing (2019 January), which is unlikely to be a significant constraint.

Scan Gaps

Sched allows you to insert a “gap” before a scan to allow for telescope slew time, etc. For schedules using only the LBA DAS (ATCA, Mopra and usually Parkes) it is recommended not to insert manual gaps. If you need to allow extra time for a long slew, increase the length of the scan instead.

If there are Mark5 stations participating in your schedule, then you must include regular gaps of at least 15 seconds in your schedule to allow the Mark5 to insert breaks in the recording. SCHED will warn you if you have insufficient gaps, but you should make them as frequent as you can without compromising your ability to get good quality phase referencing. The required frequency of the gaps
depends on the data rate, but every 15 minutes is a good guide.

**Dwell (do not use!)**

Sched has a scan type called “Dwell”. This inserts a variable gap before the start of each scan equal to the expected slew time of the slowest telescope. Don't use this option. If you are worried about long slew times, use the Sched summary option and look at the slew times and the time on source. Adjust scan times as appropriate (e.g. make scan times longer to accommodate long slew times). This has the advantage over Dwell in that you start getting data from the faster antennas as soon as they are on source. This also avoids compromising phase referencing observations with long gaps inserted to avoid predicted long slews at a single telescope (e.g. cable wraps which in any case may not be correctly predicted).

**Scan times**

Please ensure all scans lengths are rounded to the nearest 5 seconds. The ATCA observing systems run on a 5 second cycle. This is another reason not to use “dwell” observing.

**PRESTART**

SCHED has a parameter called 'PRESTART' which purports to start recording media early, but only works as described for VLBA controllers, and so should be explicitly set to 0 for LBA schedules (in some versions of SCHED it does not default to 0). Before any scans in your .key file, add the line:

```plaintext
prestart=0
```

**Scan Overhead**

There is a 3 “cycle” overhead at ATCA. This means that at the ATCA there is a always a minimum 15 sec of invalid data between scans (this includes frequency changes, two scans observing the same source at the same frequency etc). This is not additional to slew time (ie the invalid time between scans is either 15sec or the slew time, whichever is largest).

If you try and schedule very short scans (e.g. 20 GHz phase referencing) you run the risk of losing a lot of observing time.

**Sched Summary**

Sched always produces a summary file (experimentname.sum). To make this more useful you should always use the sumitem. Please use the following as a minimum selection of summary items (more are available):

```plaintext
sumitem=el1, el2, slew, dwell
```
ATCA Issues

Please keep in mind the following for any observation using the ATCA:

- The ATCA is a tied array. This significantly restricts the field of view, particularly if you happen to be scheduled with a more extended array. If you need a large field of view (more than a few arcseconds at the higher frequencies) you must take this into account. The only option is to use fewer antennas. Please make sure this is noted on the observers wiki (see below) and directly contact the observers making the observations to be sure they also know.

- If you plan to use the ATCA local interferometry data for flux monitoring please make sure to include a scan on an ATCA flux calibrator (preferably 1934-638).

- The array usually needs to be “re-phased”. At lower frequencies this may only be every hour or more, but at 20 GHz potentially every 10-20 minutes depending on the array baseline lengths and weather. It is highly recommended you discuss calibration strategies with ATNF LBA support staff. Generally recommendations would be to make sure you regularly observe an appropriate ATCA calibrator source within a few degrees of your target. These sources need to be compact enough that they have close to zero structure phase, have enough flux so the phase spread between the antennas can be quickly determined AND the scan must be long enough to allow the observer to see the phase and run calibration if required. One minute on a compact source with flux density $>\sim 200$ mJy is needed at most frequencies.

- Due to the frequent resets that are likely to happen during the fringe finder observations at the start of an observation it is strongly recommended that you do not re-phase ATCA during this part of the schedule.

It is strongly recommended to schedule so that phase recalibration happens automatically. You need to be confident the chosen source is an appropriate ATCA calibrator (if it has structure or is weak you will make things worse). You can check the suitability of your source on the ATCA calibrator database:

http://www.narrabri.atnf.csiro.au/calibrators/

In order to identify a scan in your schedule to be used for re-phasing, please use SCHED's 'INTENT' keyword to mark the relevant scans as 'AUTOPHASE_DETERMINE'. E.g.:

```
dur = 2:00 source = 'atca-cal' intent = 'AUTOPHASE_DETERMINE' /
dur = 2:00 source = 'vlbi-target' intent = 'OBSERVE_TARGET' /
```

Note that you must reset the intent to some other value (e.g. OBSERVE_TARGET) on the following scan or the previous intent will be inherited by all ensuing scans!

Amplitude Calibration

Tsys measurements from LBA telescopes are frequently missing or subject to significant errors, especially at frequencies where RFI is an issue. This is a significant complication for data analysis especially where accurate flux deck densities are required. It is strongly recommended to regularly observe a compact calibrator that is part of the ATCA calibrator monitoring program to provide amplitude calibration bootstrapping. Such a source should preferably be within approx 10 degrees of your target sources. Your phase calibrator will often be suitable.
It is also possible to use the ATCA local interferometry data to provide this calibration for a source that is not in the monitoring program. Please consult with observatory staff before committing to this strategy.

**Wiki**

The VLBI observers for the session use a wiki to keep track of the experiment setup (frequency, recorder modes, etc). The initial wiki page for each experiment is automatically generated from the experiment schedule. Please check the wiki page for your experiment to ensure that the setup is correct. Any specific observing notes must be added to the wiki (although it is recommended to email the observers as well). Please remember that if you add too much information to the wiki it may not get read! Keep your notes concise and to the point.

**Uploading Schedules**

Your schedule files (.key, .vex, .sum plus any non-standard configuration files) should be uploaded to the ftp site following the instructions in the PI letter.