Novice's Guide to Using the LBA

Version 1.5

June 13, 2012 by Philip Edwards

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Original version: January 12, 2001 by Roopesh Ojha
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Contents

1 Introduction

This document provides an introduction to the Long Baseline Array. The first versions of the document were prepared by Roopesh Ojha in the early 2000s, and this version brings the document up to date for 2012. The structure of this document is identical to a similarly named document describing the VLBA (Very Long Baseline Array). This is not a coincidence, but has been done to smooth the observer's transition from either array to the other.

2 Why use the LBA?

The LBA is the *ONLY* VLBI network located in the Southern Hemisphere, with telescopes across the Australian landmass as well as South Africa and Hawaii (see `http://www.atnf.csiro.au/vlbi/documentation/` for details of telescope locations). The core of the LBA is the ATNF telescopes at Parkes, Narrabri and Mopra, together with the University of Tasmania telescopes at Hobart and Ceduna. Telescopes from the Deep Space Network facility at Tidbinbilla also participate in LBA sessions as their spacecraft tracking commitments allow. The Hartebeesthoek telescope in South Africa and the Warkworth telescope in New Zealand are also regular partners. More recently, a single ASKAP antenna, using a single pixel feed, has participated in some LBA observations on a best-efforts basis. The LBA offers unique access to sources of astronomical interest that are located in the southern sky. It can be used for any project that requires high resolution at radio frequencies. Projects undertaken with the LBA include the study of masers, active galactic nuclei, supernova remnants, pulsar proper motions, and astrometric/geodetic observations. A list of current LBA proposals is maintained at `http://www.atnf.csiro.au/vlbi/observing/vlbi_active.html` .

Resolution ranges from ∼22 mas at 1.65 GHz for Australia-only telescopes (∼3.8 mas if South Africa and Hawaii are available) to ∼5 mas at 8.4 GHz (∼0.84 mas for the extended array). A peak brightness temperature greater than about 10^4 K is needed for source detection. A list of current LBA proposals is maintained at `http://www.atnf.csiro.au/vlbi/observing/vlbi_active.html` .
A sensitivity calculator is available from the LBA webpages to investigate the (u,v) coverage and sensitivity of planned LBA observation.

Data is usually recorded to hard disk for correlation after the event, but the ATNF telescopes, Hobart, Warkworth, and Hartebeesthoek are also able to operate in eVLBI mode, in which the data is transferred directly to a correlator.

3 Pathway from Proposal to Final Product

While broadly similar to the VLBA there are some important *differences* mostly arising from the fact that the LBA is not a full-time VLBI array. The most important difference from the VLBA — following the ATNF policy that the observers are responsible for conducting their observations — is that the PI (Principal Investigator) or a member of the proposal team is expected to be present at one of the LBA sites during an LBA session to assist with observations.

A previous requirement that the PI (or member of the proposal team) be present to correlate the data no longer applies — the data are now correlated at the Curtin University of Technology.

All steps are listed below, along with the organisation and/or individual responsible for carrying out that step. Each step is described in detail in subsequent sections.

Table 1: From Proposal to Paper

Step	Responsible Party	Comments
Proposal	PI	Assistance available
Refereeing	ATNF TAC	(Time Assignment Committee)
Observing Allocation	ATNF	
Schedule Preparation	PI	Assistance available
Observations	PI and LBA staff	
Correlation, Data Validation and Distribution	Curtin	
Calibration	PI	Assistance available
Imaging and Analysis	PI	Assistance available
Scientific Results and Publications	PI	

4 What kinds of Observations are Easy?

Observations of strong continuum sources as well as spectral line observations at centimeter wavelengths are the most common uses of the LBA. The table below lists the types of observations currently available.

Table 2: Types of observations available at the LBA			
Type	Frequencies	Available	Comments
Strong continuum source	1.4–22 GHz	Yes	Straight-forward
Weak continuum source	1.4–22 GHz	Yes	May require phase-referencing
Multi-source continuum	1.4–22 GHz	Yes	
Spectral line	1.4–22 GHz	Yes	Not difficult
Polarimetry		Yes	More involved
Spectropolarimetry		Yes	More involved

5 How to Propose

LBA proposals are handled in exactly the same way as proposals to use any ATNF telescopes. Please read these general instructions at
`http://www.atnf.csiro.au/observers/apply/applications.html` .

Proposal deadlines are June 15th and December 15th each year. A proposal consists of a cover sheet, an observations table, and a scientific justification not exceeding 3 pages (INCLUDING figures) written with a minimum font size of 10 point. Proposals must be submitted using OPAL (ATNF Online Proposal Applications & Links)
`http://opal.atnf.csiro.au/` .

6 Refereeing and Observing Allocation

An acknowledgement of receipt of your proposal will be emailed to you. The PI will be notified of the acceptance or rejection of their proposal.

An accepted VLBI proposal remains active for up to one year from the start of the scheduling term for which it was approved (accepted). For each accepted proposal the PI is notified by the TAC (Time Assignment Committee) that their proposal may be scheduled within this period and that they will be contacted by the LBA scheduler beforehand if so.

An accepted proposal ceases to be active once it is fully scheduled (within the alloted one year period). If observations cannot be scheduled within 1 year the proposal will lapse. The proposal may be resubmitted. The list of active LBA proposals is available from
`http://www.atnf.csiro.au/vlbi/observing/vlbi_active.html` .

7 Schedule Preparation

Use of the UPTIME feature in NRAO's SCHED program is recommended for planning an experiment. All you ever wanted to know about SCHED is available in the SCHED user manual, a link to which is provided from
`www.atnf.csiro.au/vlbi/documentation/`
The latest version of SCHED is installed on the ATNF computer hydra.

Once an observation has been scheduled, the PI will be contacted with details of the allocated time and telescopes. It is the PI's responsibility to prepare the schedule file using the NRAO SCHED program. Information on preparing a schedule file is available from
`http://www.atnf.csiro.au/vlbi/wiki/index.php?n=Main.LBAPINotes .`

7.1 Source Positions

The PI is responsible for providing accurate positions for the target sources. SCHED uses a default catalog which contains positions for a large number of sources, though relatively fewer southern sources are present. We recommend that the PI consult, among other databases, the VLBI astrometric catalogues available at
`http://astrogeo.org/astro/`
and the ICRF (International Celestial Reference Frame) catalog available from
`http://hpiers.obspm.fr/icrs-pc/ .`

Note that if the source position is not known with milli-arcsecond level precision, VLBI observations can still be conducted, though careful consideration is required in planning the observation depending on the goals of the observation.

7.2 Setup Files

SCHED requires setup files containing details of the telescopes participating in the observation. A link to a set of standard setup files for LBA observations is available from
`http://www.atnf.csiro.au/vlbi/wiki/index.php?n=Main.LBAPINotes .`

7.3 Fringe Calibration

As usual, observations of strong target sources are required to solve for relative delays and rates at all antennas. Weaker sources require phase referencing observations.

Most LBA observations are preceded by a fringe-test run, during which a near–real-time fringe test is done to check the end-to-end data flow at all telescopes.

However, to allow manual phase alignment of channels a strong source should be observed every 6 or so hours during the experiment. A list of standard LBA fringe-finders is available at
`http://www.atnf.csiro.au/vlbi/observing/fringefinders.html` .

7.4 Amplitude Calibration

Antenna gain files are maintained and system temperatures are logged during each observation. Information on gain and system temperature tables is provided at
`http://www.atnf.csiro.au/vlbi/wiki/index.php?n=Main.LBALogs` .

Projects that require accurate amplitude calibration can make use of the fact the internal ATCA baseline information is recorded in parallel to LBA data. Some extra care in scheduling ATCA calibrators during the observation may be required to make full use of this data.

7.5 Phase Referencing

Observations of weak sources may need to use phase referencing on a nearby, strong source. For a review of phase referencing please consult VLBA Scientific Memo 24, available from
`http://www.vlba.nrao.edu/memos/sci/`
and references therein.

Efforts to improve the grid of sources for phase referencing in the southern sky are continuing, phase referencing experiments may require a preliminary observation to do search for a suitable source in the field of interest. This must be explicitly requested in the proposal.

7.6 Polarisation Observations

As the LBA is a heterogeneous array, polarisation observing requires extra effort in careful calibration. A short report on the improved capability to use the LBA for polarisation observations, by Richard Dodson, is given on pages 26 and 27 of the October 2008 issue of the ATNF News, available from
`http://www.atnf.csiro.au/news/newsletter` .

7.7 Target of Opportunity requests

The LBA operates for $\sim$21 days a years with fixed observing blocks and so employs fixed rather than dynamic scheduling. Time critical observations can be proposed

following the standard ATNF procedures for Target of Opportunity requests, described at
http://www.atnf.csiro.au/observers/apply/too_apply.html .

7.8 Schedule Submission

When observation is scheduled, the PI of the proposal will be contacted by email with details of the time allocation. The schedule files for the observation should be submitted following instructions given in the email, generally $\sim$2 weeks before the start of the LBA observing block, so the the schedule can be checked and schedule files distributed to the participating telescopes.

8 Observations

There is no absentee observing with the LBA. A member of the proposal team is required to be present at one of the antennas for an LBA block session. Arrangements for observing will be coordinated by the LBA manager, Tasso Tzioumis.

9 Correlation, Data Validation, and Distribution

After observations the data are sent to the Curtin University of Technology for correlation using the DiFX software correlator. The PI will be contacted after the data has been correlated and checked.

The proprietary period of LBA data (as for all ATNF facilities) is 18 months after date of observation. ATNF Data Access policy is described at
www.atnf.csiro.au/observers/data.html .

10 Calibration

This is the responsibility of the observer, though advice will be provided on request.

LBA data is now output from the correlator in standard FITS format. (Previously, LBA data was in a format called RPFITS and had to be read into AIPS using a special task called ATLOD. This task is standard on versions of AIPS running on local machines. External users of AIPS can obtain ATLOD (and other important patches) from
www.atnf.csiro.au/computing/software/aips.html .)

Information on gain and system temperature tables is provided at
http://www.atnf.csiro.au/vlbi/wiki/index.php?n=Main.LBALogs .

11 Final Imaging and Analysis

This is the responsibility of the observer, though advice will be provided on request. Imaging and analysis of LBA data is identical to that of data from any VLBI array with NRAO's AIPS and Caltech's DIFMAP being the most used software packages.

12 Staff Collaboration

New users and overseas users, in particular, may wish to collaborate with a staff member. Such a collaboration has to be arranged by the users themselves by directly contacting the individual they wish to collaborate with. Availability of a staff collaborator will depend on their interest and time constraints. A list of ATNF staff members and their areas of interest is available from
http://www.atnf.csiro.au/people/staff_list.html .
Email addresses are of the form firstname.lastname@csiro.au

13 Scientific Results and Publications

Publication of results using LBA data is the responsibility of the observers. We request authors of any paper that includes LBA data to follow the instructions for acknowledgements described at
www.atnf.csiro.au/research/publications/ .

14 Students

ATNF offers graduate student projects in conjunction with Australian and overseas universities. VLBI astronomy is one of the options open to such students. Details of this program are at
www.atnf.csiro.au/research/graduate/ .

ATNF runs a summer student program open to graduate and undergraduate students. Summer students can choose a project that involves using VLBI. Details of this program are at
www.atnf.csiro.au/research/summer_vacation/ .

15 People to Contact

Please send your questions and comments on this document to any of the people listed below.

Tasso Tzioumis is Head of VLBI operations. He can be contacted for all questions except those about scheduling (see below). He can be contacted at
`Tasso.Tzioumis[at]csiro.au`

Phil Edwards is the Head of Science Operations and LBA scheduler. He can be reached at
`Philip.Edwards[at]csiro.au`