May 1, 1992

ATNF AIPS++ Technical Specifications

Neil Killeen

Australia Telescope National Facility[1]
PO Box 76,
Epping, NSW 2121
Australia

1 Introduction

This technical specification is intended to define the analysis requirements for aips++ with reference to the Australia Telescope. The Australia Telescope consists of the 6 22 m Compact Array (CA) dishes at Narrabri, a similar 22 m dish at Mopra, and the 64 m dish at Parkes. Each of these three components can be operated individually or be combined to form the Long Baseline Array (LBA). In addition, the LBA can be used with other telescopes throughout Australia to form the Australian VLBI network. Currently, these instruments work at cm wavelengths. However, it is intended that the CA and Mopra will eventually function in the 12–25 mm and 3 mm bands as well.

Areas such as basic applications, hardware support, user interfaces, display facilities, and documentation are common to all instruments and are considered outside the scope of this document. This document attempts to define those features of aips++ that are driven soley by the instrumental characteristics of ATNF telescopes. It is largely concerned with visiblity data.

2 Specification

- The basic visibility (be it auto- or cross-correlation) produced by all of the AT telescopes is multi-channel within some frequency band. This is true whether one is interested in continuum or spectral line information.

  aips++ must support multi-channel data. There should be no restriction within a visibility file, other than that imposed by the hardware, on the number of channels in a visibility. However, a typical number of channels would be of the order of 1024 and the likely maximum is 8192 per baseline per polarization. The number of channels should also be allowed to vary from visibility to visibility. Auto- and cross-correlations should be supported within the one visibility file.

- The CA, Mopra, and Parkes have linear feeds. However, the polarization of a correlation may be converted to circular by hardware hybrids, or to Stokes parameters via appropriate on-line calibration. In addition, the Australian VLBI network consists of telescopes with a variety feeds (circular, linear).

  aips++ must fully support visibilities of any polarization amongst linear (XX, YY, XY, YX), circular (RR, LL, RL, LR) and Stokes parameters (I, Q, U, V). We also require aips++ *recognize* hybrid combinations of linear and circular polarizations such as XR or YL. However, by this we mean the hooks should

[1] The Australia Telescope National Facility is operated in association with the Division of Radiophysics by CSIRO.

0 23
AT 46.3/~~021~~
May 1, 1992

ATNF AIPS++ Technical Specifications

Neil Killeen

Australia Telescope National Facility[1]
PO Box 76,
Epping, NSW 2121
Australia

1 Introduction

This technical specification is intended to define the analysis requirements for aips++ with reference to the Australia Telescope. The Australia Telescope consists of the 6 22 m Compact Array (CA) dishes at Narrabri, a similar 22 m dish at Mopra, and the 64 m dish at Parkes. Each of these three components can be operated individually or be combined to form the Long Baseline Array (LBA). In addition, the LBA can be used with other telescopes throughout Australia to form the Australian VLBI network. Currently, these instruments work at cm wavelengths. However, it is intended that the CA and Mopra will eventually function in the 12–25 mm and 3 mm bands as well.

Areas such as basic applications, hardware support, user interfaces, display facilities, and documentation are common to all instruments and are considered outside the scope of this document. This document attempts to define those features of aips++ that are driven soley by the instrumental characteristics of ATNF telescopes. It is largely concerned with visiblity data.

2 Specification

- The basic visibility (be it auto- or cross-correlation) produced by all of the AT telescopes is multi-channel within some frequency band. This is true whether one is interested in continuum or spectral line information.

  aips++ must support multi-channel data. There should be no restriction within a visibility file, other than that imposed by the hardware, on the number of channels in a visibility. However, a typical number of channels would be of the order of 1024 and the likely maximum is 8192 per baseline per polarization. The number of channels should also be allowed to vary from visibility to visibility. Auto- and cross-correlations should be supported within the one visibility file.

- The CA, Mopra, and Parkes have linear feeds. However, the polarization of a correlation may be converted to circular by hardware hybrids, or to Stokes parameters via appropriate on-line calibration. In addition, the Australian VLBI network consists of telescopes with a variety feeds (circular, linear).

  aips++ must fully support visibilities of any polarization amongst linear (XX, YY, XY, YX), circular (RR, LL, RL, LR) and Stokes parameters (I, Q, U, V). We also require aips++ *recognize* hybrid combinations of linear and circular polarizations such as XR or YL. However, by this we mean the hooks should

[1]The Australia Telescope National Facility is operated in association with the Division of Radiophysics by CSIRO.

be in place for such combinations, not that they should initially be fully implemented. A visibility file should be able to contain correlations with any of these specified combinations of polarizations.

- The CA and Mopra telescopes are all alt-az mounted with linear feeds and a noise diode to measure the phase difference bewteen the X and Y feeds.

  Some thought needs to be given to the way in which the antenna polarization ellipses (usually called the leakage terms) and the frequency and time dependent complex gains are going to be stored and applied to convert the raw polarizations to Stokes parameters. This is to some extent telescope dependent, but there is certainly plenty of common ground between instruments, even when they have differently polarized feeds. Each telescope will probably need its own application to determine the gains and leakage terms, but they should all be able to store the results in a common way so that Stokes conversion can be performed by core aips++ routines.

- The Australian VLBI network consists of telescopes with a variety of mounts (alt-az, equatorial, x–y).

  aips++ must support the above telescope types. This information might be used, for example, to know how the feeds rotate on the sky with parallactic angle.

- The AT can produce multi-channel data in up to 4 simultaneous frequency bands. These might be four 5 GHz frequencies, or two 5 GHz frequency bands and two 8 GHz frequency bands. Typically, in order to retain all the possible linear polarization combinations, we observe with two simultaneous frequency bands, but the full complement of four is possible with reduced polarizations. In addition, each of these frequency bands may be of a different total bandwidth. That is, the frequency increment for each channel may vary between bands (in sign and magnitude).

  The AT also has good temporal frequency agility. It can switch to a new group of simultaneous frequency bands every integration.

  aips++ must support an arbitary number of simultaneous frequency bands, each of which may have a different number of (varying) channels and frequency increments per channel. A typical maximum number of simultaneous frequency bands would be 4. aips++ must also support visibilities in which the frequency band may vary every integration. A typical number of time multiplexed frequency bands would be of the order of 10.

- With the CA, one could choose to observe two different spectral lines simultaneously.

  aips++ must provide full frequency support for multiple simultaneous spectral line experiments. This includes correct maintenance of rest frequencies and sky (Doppler tracked) frequencies.

- The CA can switch pointing centres every integration for mosaicing purposes. It is likely that when the CA is used at mm wavelengths, rapid pointing location switching will be especially important.

  aips++ must support visibility files in which the pointing centre may vary every integration. In addition, it must allow for a phase centre independent of the pointing centre. The maximum number of pointing centres should be without restriction, but a typical number of pointing centres might be of the order of 100.

- It is anticipated, probably at mm wavelengths, that the CA will be fitted with focal plane arrays.

aips++ should support focal plane arrays. Essentially, this requires multiple simultaneous pointing centres.

- The basic integration time of CA data is quite short, typically 10 seconds. We plan to integrate longer on short baselines than on long baselines.

  aips++ should support different integration times on different baselines.

- The CA is an east-west array,

  aips++ should fully support all the standard geometric projections. In particular, for the CA, the celestial pole projection.

- Every integration, the CA software records a variety of ancillary data. These include system temperatures, A-to-D sampler statistics, the correlation of the noise diode on each antenna, and perhaps in the future when we do mm astronomy, the round trip phase transfer system measurements. These data are of vital importance to the off-line processing.

  aips++ must support the inclusion of ancillary data associated with the visibilities. The ancillary data, as well as being independently accessible, should also be easily associated with the relevant visibility if required. For example, one may wish to make an off-line T_{sys} correction, which would require one-to-one association of the ancillary data with the visibilities.

- The addition of single-dish data to CA data is a technique we intend to take advantage of at cm and mm wavelengths.

  aips++ should allow single-dish data formats to be the same as interferometer data formats in order to facilitate their combination. This includes single-dish auto-correlations and the Fourier Transform of scanned single-dish images.

- The AT correlators are designed so that they can produce data with very fine time resolution for pulsar work. For example, consider a pulsar with a 1 second period. A standard integration of 10 seconds can be subdivided by the correlator into ten 1 second divisions, each encompassing one pulse. These divisions can then be further subdivided into, say, one hunded pulsar "bins". Each bin from each 1 second division over the 10 seconds is then averaged, so that the final output from the 10 second integration is 100 averaged pulsar bins. The data obtained in each pulse is actually a frequency spectrum.

  aips++ should support visibilities in which additional axes in dimensions other (such as pulsar bin number – really the phase of the pulse) than the standard ones can be added.

- The ATNF will be involved in space VLBI; astrometry and geodesy are applications.

  aips++ must provide sufficiently precise definitions of terms and storage of ephemeris information, to allow astrometric applications. For VLBI, this would also involve storage of the full delay-phase models used during correlation.