ASKAP Commissioning Update, December 2017

In this issue, we describe the likely origin of source position offsets that have impacted existing early science images. In addition, we report progress on commissioning the centralised fringe rotation system and plans for observing over the holiday period.

ASKAP telescope operations report

Last month ended with a commissioning campaign that was originally allocated for testing the new centralised fringe rotator control system. However, low-level tests of the system's components identified some issues that needed to be resolved prior to on-sky validation. Instead, we focused effort on another long-standing issue – the fact that ASKAP early science images have exhibited position offsets with respect to existing catalogues.

Source position offset investigation

The position offset problem was originally discovered in images made using the BETA array, but has been better quantified in recent times with the development of formal image quality metrics and reporting procedures. One of the standard quality metrics is a comparison of detected source positions with respect to existing catalogues such as SUMMS and NVSS.

Our science teams reported that this metric often shows a shift of all the sources in a field by a few seconds of arc. The shift is not always the same, but tends to be similar for observations of the same field at the same hour angle.

Many different theories were advanced to explain the position offsets, so to narrow the possibilities we began imaging our calibrator observations. By observing the phase of self-calibration solutions made on time intervals of a few minutes, we could see clear trends during a long track of a bright point source, indicating an error or omission in the model used for phase tracking. Such an omission could be due to unmodeled atmospheric or ionospheric effects, but it could also point to an error in the model parameters. The systematic nature of the observed trends strongly suggested the later, as did the lack of any clear frequency dependence.

Determining antenna positions

The delay model parameters (primarily the location of each antenna in the array) had initially been computed using long tracks of Virgo A, assuming at first that it is a point source and eventually adopting a two-component model to account for structure that we resolve on the longest baselines currently available (2.3 km). The X and Y positions of the antennas were fitted to a simple geometric path length model using the Virgo A data and the Z component of the antenna positions was then determined using short observations of other sources scattered around the celestial sphere.

It soon became clear that the Virgo A-derived delay model was not transferring well to other directions on the sky. Careful investigation of the code used to apply the model revealed that our use of standard casacore routines omitted corrections for Earth's polar motion and diurnal aberration. This error had a small impact close to the equator (on a source such as Virgo A) but a large impact towards the pole, where most of our science fields are located. The process of fitting an array model to the Virgo A data had absorbed the error into the antenna positions and transferred it to other directions.

After correcting the coordinate transformations in the code, we observed several different calibrator sources and derived new antenna positions (excluding Virgo A this time). Since Virgo A is much brighter than other Southern sources we expected that the uncertainty in the antenna positions would be larger, but we saw only a small increase in X and Y uncertainty, with an overall improvement in Z.

Adjusted antenna positions have been loaded into the array configuration and single-source tests of long-term phase stability show significant improvement. Observations of the CDFS reference field are now underway so that cross-matching tests can confirm whether the problem is indeed solved.

Centralised fringe rotator testing

One of the main goals for early in the new year will be to integrate a new fringe rotator control system into the ASKAP array. This system runs independently of data ingest and is designed to keep the array continuously phase-aligned. NASA's Calc/Solve software package will be used to determine geometric delay terms and appropriate corrections will be synchronously loaded into the fringe rotator at the boundary of each correlator integration cycle. The Calc software will also supply U,V,W data to the ingest pipeline so that it can be merged with raw visibilities. Both steps require a precise understanding of timing within the hardware and software.

As part of this work we also hope to implement support for alternative frequency channel ordering, which is necessary to commission ASKAP's 1400 – 1800 MHz band as it is inverted with respect to the others.

Low-level system verification

The first step in commissioning is to verify that the Calc machinery can drive our fringe rotator correctly. In the process, we are conducting several basic tests of the fringe rotator itself (which is implemented as part of the beamformer firmware) to verify that it behaves as expected. The previous mode of operation did not exercise all the system's features and some unexpected behaviour has already been discovered. For example, we are currently trying to understand why every coarse delay step introduces a 180-degree phase change.

Once the components have been shown to work under controlled conditions, we will integrate them with the array and test that it can correctly track an astronomical source. This step involves careful attention to timing, so the updates are synchronised with the correlator cycles and metadata stream. We must also ensure that if for some reason an update does not occur on time, the corresponding cycle is flagged in the measurement set.

Installation of 36 PAFs complete

At the end of last month, the final ASKAP Mk II phased array feed was installed on antenna 29. This means that all 36 antennas now have a PAF capable of sending signals back to the central control building. We are in the process of commissioning the control and monitoring systems on the last 6 PAFs to be installed, but will need to wait for digital backend hardware before proceeding with signal mapping tests. The remaining components should be installed in the first half of 2018, at which time we can begin to integrate all remaining antennas into the array and commence full-scale testing.

MRO staff pausing for a photo after installing the final phased array feed on antenna 29.

Roadmap for 2018

The ASKAP operations team will attempt to capture as much science data from the current 16-antenna array as possible during the next month. Observations will run from mid-December through to early January, wrapping up any early science observations that are possible with the current array configuration. Afterwards, we will shift priority to commissioning the fringe rotator system.

Upon completion, the next major task will be integration of another group of antennas. Although the next milestone is to release an 18-antenna array, it is likely that we will be able to integrate 24 or more antennas and choose a subset of 18 to operate with. This may also allow observations in special modes that exchange bandwidth or frequency resolution for additional antennas.

To avoid overflowing the available disk space at Pawsey, we plan to cap the incoming data rate at roughly the level produced by the 12-antenna early science system (if we intend to keep raw visibility data). This means that observations with a larger number of antennas will have to be done with online continuum averaging or automatic discarding of unnecessary frequency channels. Early next year we will circulate a document describing the specific modes that will be offered in the lead-up to full-scale operations, but we welcome any requests that may help prioritise our commissioning activities.

From everyone in the ASKAP team, best wishes for the new year!

FOR FURTHER INFORMATION
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