ASKAP Update, February 2021

In this issue we describe the latest plans for technical test observations and progress towards some of the key development goals required for Pilot Surveys Phase II.

Technical test progress and planning

While plans for Pilot Surveys Phase II take shape, we are gathering technical requirements from the survey science teams based on experience with Phase I data.

Technical tests (as described in the Phase II plan) are designed to demonstrate new or improved capabilities that were implemented during consolidation efforts. In some cases, development is ongoing, and these technical tests provide crucial feedback that will help resolve outstanding issues. Our goal is to ensure that the telescope's capabilities match each survey science team's expectations so that the next round of pilot surveys can focus on strategy, throughput, and science outcomes.

In previous newsletters we discussed efforts to support wider beamforming intervals and correct a problem with the fringe tracking system that occurs when operating ASKAP in high frequency resolution zoom modes. Although the beamforming interval issue is still under investigation, the underlying zoom mode problem has been identified (overflow of the fringe rate parameter in the beamformer firmware) and corrected (by increasing the size of the registers to support larger values).

Unfortunately, the re-built beamformer firmware module suffers from another outstanding issue – increased likelihood of correlator channel misalignment, leading to gaps in the recorded visibility spectra. This issue is extremely sensitive to the precise timing of signal paths within the firmware and its severity varies from one build to another (though it is always present to some degree). To utilise the corrected zoom mode firmware, we will need to fix the alignment issue as well.

CASS engineers have developed additional alignment diagnostics that are currently being integrated into the telescope control system. This week, the telescope will be dedicated to full-scale engineering tests in the hope that these tools will help identify the source of the problem.

Primary beam measurement and correction

ASKAP's phased array feed receivers provide a wide field of view by simultaneously forming 36 beams on the sky. These beams are defined by electronic weights that are constrained to maximise sensitivity in the direction of interest. We have seen that this results in higher sidelobes and greater asymmetry than is typical for a radio telescope with a mechanical feed. The main difference is elongation of the primary beam in a radial direction due to coma distortion, which becomes more significant at the edge of the field of view.

Until recently, the primary beam correction implemented in ASKAPsoft assumed a circular gaussian beam. During analysis of RACS, extensive comparison of the ASKAP flux scale with other surveys showed that the difference between actual and assumed primary beam shape was leading to flux errors of > 10% near the edges of the field. An image-plane correction was developed for RACS using holographic measurements of the true beam shape (see https://doi.org/10.1017/pasa.2020.41). Many of the survey science teams have requested that this correction be integrated into the mosaicking software and offered as a standard processing option for Pilot Surveys Phase II.

In addition to improving the ASKAP flux scale, holography data provides a measurement of off-axis polarisation leakage, which the POSSUM team wish to use for calibration purposes.

Infrastructure for the curation and management of holography beam maps must still be developed to provide full operational support. Meanwhile, we will proceed with tests of the improved primary beam models on deeper fields than the 15-minute RACS observations.

Further control system improvements

Alongside technical tests targeting specific issues, ASKAP's engineering development teams are working on other, more general improvements. This week, we released changes to the event control system that improve its robustness and reliability. The event system is responsible for triggering time-critical instructions such as fringe rotator updates, beamformer weight upload and correlator integration cycles. The latest changes decouple the event system from individual hardware time register readouts, instead using the control system server's clock for event scheduling. The more precise atomic time distribution system is still used for event triggering, but the improved scheduling and event queueing system should reduce load spikes and improve our ability to stagger critical events and bypass individual hardware failures. We are hopeful that this should reduce the instance of “late events”, where an instruction arrives after its scheduled execution time. Although rare, late events are suspected to cause signal loss on some baselines, as seen in the first RACS band and some Pilot Survey Phase I observations.

Reference clock drift

Observatory staff recently noticed a growing offset between the observatory’s time standard (based on a rubidium clock) and GPS time. Closer inspection showed that the rubidium clock was drifting outside of specifications due to a hardware fault. The problem began on January 28th, 2021 (about two weeks ago) and we have so far accumulated an offset of about 400 microseconds. Although the timing system was designed to be redundant, the spare rubidium unit had previously failed and was awaiting replacement. An off-site spare has been shipped to the MRO and should be available soon. Meanwhile, we will monitor the clock drift and are confident that it does not yet present a significant problem. A timing offset manifests as an astrometry error in the images made with a connected interferometer such as ASKAP. Presently, the magnitude of the error is less than one hundredth of an arcsecond, well below ASKAP’s typical astrometry precision.

ASKAP system paper published

Due to the high data rate produced by the telescope, ASKAP’s operations model provides astronomers with calibrated images and source catalogues rather than raw data. This has the potential to increase efficiency and reliability through standardised data processing methods, while allowing science teams to focus on astronomy. However, it also increases the separation between the observatory and astronomers. Rigorous scientific analysis requires a deep understanding of the processing methods used to gather the underlying data, so it is important to document the telescope’s systems in detail.

Documentation efforts were difficult while ASKAP was changing rapidly during commissioning. Now that we are transitioning into operations, many of the core subsystems have stabilised to a point where it is feasible to publish detailed specifications. This does not mean the rate of change has slowed, as we have described above, many technical developments and tests continue. However, the focus of activity is shifting to higher levels, fine tuning of existing features and downstream aspects of data processing.

To mark this transition into operations, we have published an extensive technical description of ASKAP (soon to appear in PASA), as built when conducting the first observations with all antennas. The paper covers everything from observatory site infrastructure to the full radio astronomy signal path. It should be a useful reference for anyone using ASKAP data.

RACS observations continue

Observations for the second all-sky pass (this time in the mid-frequency band, 1152 to 1440 MHz) are 96% complete. Tiles surrounding the position of the Sun over the last few weeks and tiles at a similar hour angle to the calibration source are all that remain unobserved. These will be completed as soon as possible. Data processing will begin after the next release of ASKAPsoft, which contains several optimisations that should address rate limiting steps from the first processing run.

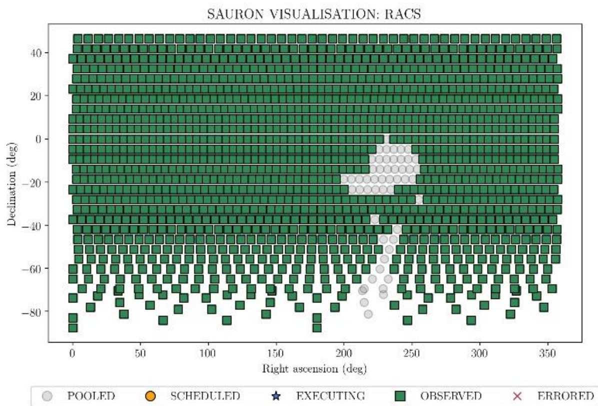

Figure 1: RACS progress map showing all tiles required to cover the survey area. The mid-band survey plan needs about 50% more tiles to cover the same area of sky as the low-band survey, due to the reduced size of the beam footprint. Image made by Vanessa Moss.

FOR FURTHER INFORMATION
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