ASKAP Commissioning Update, November 2018

In this issue, we discuss integration of the final two control system features required for Array Release 3 and pilot surveys: fringe tracking per beam and frequency zooms. We also describe the first in a series of large-scale science data processing readiness tests.

Preparing ASKAP for pilot surveys

The list of features scheduled for ASKAP Array Release 3 includes two key control system upgrades required for pilot survey observations. As described below, both have significant implications for how ASKAP data are recorded and processed, so it has taken some time to test the associated software changes.

We can now report that tests of fringe tracking per beam are underway on the telescope and will be followed by on-sky tests of fringe tracking in zoom modes to ensure that both features are ready for pilot surveys in 2019.

Fringe tracking individually per beam

All previous ASKAP early science data has been recorded with a common phase tracking centre for all beams. Although this simplifies the structure of the resulting measurement set, it means that information about the beam positions must be carried in auxiliary records and the science data processing pipeline needs to move the phase centre before imaging each beam. It also causes bandwidth smearing effects in the outer beams, which have been noticed by members of the EMU survey team.

For pilot surveys and beyond, we will operate ASKAP with a different phase tracking centre for each beam. This means that the correct phase centre must be sent to the fringe rotator in the beam-formers at the start of each correlator cycle and the beam offsets must be stored in the measurement set.

Ensuring that this additional information is handled correctly requires stringent testing. Final verification on observational data began during a commissioning campaign at the observatory two weeks ago. We have determined that the tracking coordinates and associated metadata are correctly matched with beam number and are now cross-checking the accuracy of the parameters at the arc-second level throughout the control system and against external tools.

As part of this work we are consolidating the conventions used to describe ASKAP's beam footprints and will write an ACES memo documenting the various rotation angles and coordinate systems involved. This will be a valuable reference for pilot survey planning.

Fringe tracking for zoom modes

Providing higher frequency resolution at the expense of bandwidth is essential for several of the ASKAP survey science projects, particularly for the study of neutral hydrogen in our own galaxy.

Although the firmware implementation of these zoom modes has been ready for testing for some time, it involves re-using data inside the beamformer which in turn makes fringe tracking difficult to manage.

The required code has been extensively tested in the workshop and several control system software changes have been made to correct issues arising (such as phase jumps across frequency channel boundaries).

The next major release of the telescope operating system will support fringe tracking of zoom modes and allow realistic on-sky testing of these modes for the first time. The release is scheduled to be deployed immediately after successful validation of the telescope when power works on the correlator room mains supply are complete.

Central building mains power

Following the failure of a radio frequency interference filter on the mains power link to the correlator room, inspections revealed a small number of additional issues that need to be addressed. Some of the high-current cables feeding power into the correlator room show signs of heat stress, likely as a result of poor termination. This issue is probably unrelated to the filter failure and would have been present since installation, but only recently became apparent as completion of ASKAP's digital hardware has increased the total power load.

In order to ensure the safety and longevity of the power system, we have been operating on reduced load using an array of only 12 antennas for several weeks. This has been sufficient to test fringe tracking updates, but has prevented pilot survey test observations with 28 antennas and halted integration of the final 8 antennas into the array. This week, we will be shutting down the correlator room so that the necessary wiring work can be done to restore full capacity. If all proceeds as planned, we will resume normal operations with 28 antennas next week.

Fortunately, the early integration of 28 antennas left some slack in the schedule and we hope that we can still deliver the full array in February next year, in time for pilot surveys. However, this does not leave much time for testing and verification, so it may be necessary to delay the start of the pilot surveys in favour of observing some additional verification fields. Any adjustments to the plan will be circulated to the survey science teams.

ASKAPsoft pilot survey readiness

With pilot surveys now only a few months away, the Science Data Processing (SDP) software development team is testing our readiness to process full-scale, full-resolution data using the existing pipeline. Experience has shown that real telescope data (rather than simulations) must be used to fully exercise all features of the software and we now have 28-antenna observations that provide a good test at close to full scale.

For the latest tests we used a 28-antenna, 36-beam observation of the field surrounding the Galactic Centre at 864 MHz with 15552 spectral channels and 288 MHz of bandwidth. Due to the presence of bright, extended emission, this is a challenging field to image. It therefore tests many aspects of the software's performance.

Two weeks ago, the SDP team reserved all nodes on the Galaxy supercomputer in order to run exclusive tests in single-user mode in the same way our operations team will work next year. We used the existing science data pipeline to run a full spectral resolution imaging task designed to produce the same kind of image cubes that the WALLABY survey will need, as well as all the associated continuum data products.

The test highlighted several issues similar to those experienced by the science teams during early science operations, as well as a few new ones. In general, the pipeline was observed to be much more stable in the controlled environment of a global reservation.

Issues arising during large-scale processing

The latest test confirmed that the pipeline has a lot of overhead due to serial tasks. Many of these (e.g. flagging and applying the bandpass solution) were expected to be done on-the-fly in the original processing plan and the tasks written to do these jobs offline for early science were not well optimised. We should be able to make significant improvements by adding parallel capabilities both in terms of CPU usage by a single job and by having the pipeline split the data into time slices, so it can be distributed over multiple nodes more readily.

Another limitation of the current pipeline is that it applies the same minor cycle thresholds to all self-calibration loops. A better strategy is to do a very shallow clean in the first loop and then go successively deeper in the subsequent loops as this saves time and reduces the likelihood of the solution diverging. Adding this ability will be a priority for the next development sprint cycle.

The SDP team also experimented with making the largest possible images in terms of number of pixels (a function of the field extent and pixel size). It was found that we do not have enough memory to make images as large as we would like, especially when multiple scales are used during cleaning. This could be improved by allocating a dedicated node to the coordinating task, thereby providing more memory where it is most needed. It may also be possible to make some of the imaging code more memory-efficient.

In addition, the team discovered that ASKAPsoft's pre-conditioning step is not entirely compatible with w-projection when samples build up in radial arcs in the UV plane, creating artifacts in the point spread function. Implementation of visibility-based weighting and baseline selection are being investigated as possible solutions.

In all, the team was satisfied that the problems encountered could be solved on the timescales required to begin pilot survey processing in March 2019. Large-scale tests will continue to occur every few weeks to verify changes made to the software, culminating in a full-scale test with all available antennas early next year.

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