ASTRONOMY AND SPACE SCIENCE
www.csiro.au

ASKAP Update

November 2015

Providing the latest news about commissioning and early science with CSIRO's Australian SKA Pathfinder (ASKAP) telescope. The ASKAP Update is online at www.atnf.csiro.au/projects/askap

Demonstration science with ASKAP

The ASKAP Commissioning and Early Science (ACES) team continues working with the first ASKAP antennas installed with phased array feed (PAF) receivers – this is a functioning telescope known as the Boolardy Engineering Test Array (or BETA), and initial science results have already laid the groundwork for some of the Survey Science Projects planned for the first five years of ASKAP operation.

Perhaps more importantly, BETA has been essential in helping us understand so many complex aspects of ASKAP that arise from its radical design – in particular, understanding beamforming on an interferometer.

Commissioning observations with BETA have resulted in noteworthy findings such as the 'blind' detection of HI in absorption, detection of an intermittent pulsar, and the discovery of 'dark', massive clouds of HI near the galaxy IC 5270.

What is important is that these results would not have been possible without the unique features of ASKAP, namely the wide-area field-of-view and rapid survey capability, and the radio-quiet environment of the Murchison Radio-astronomy Observatory (MRO).

Recent usage of BETA has involved:

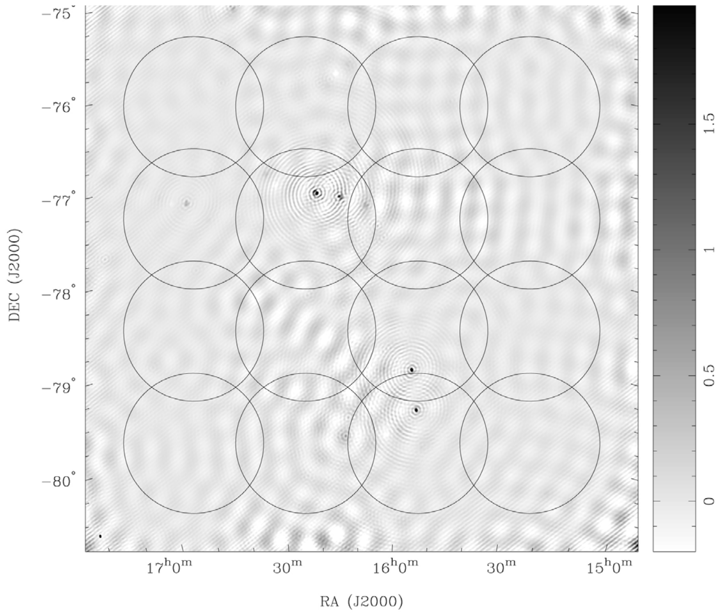
- Experimental beamforming, aiming to constrain the position and shape of beams more closely than is possible with the standard 'Maximum-Signal-to-Noise' algorithm.
- T_{sys} and antenna aperture efficiency measurements using drift scans of the Galactic Plane.
- Testing procedures being developed for calibration of antenna pointing.
- Early RFI mitigation experiments.
- Continued search for red-shifted neutral hydrogen.

Technical memoranda are posted on the ATNF website, detailing material that arises during BETA commissioning activities. Summaries of each of the memos are also available in the latest ASKAP Commissioning Update.

First multi-beam image with Mk II PAFs enables system noise estimate

Early commissioning trials of four ASKAP antennas installed with the second generation (Mk II) PAF systems (including digital spectrometers, beamformers and correlator) at the MRO have resulted in a 16-beam image of the Apus field.

Image credit: Alex Cherney/terrastro.com



> The first multi-beam image produced with three Mk II PAF systems, installed on ASKAP antennas at the MRO. The image contains 16 formed (synthetic) beams — a record for any radio telescope to date, but one that is expected to be short-lived!

The target field contains an arrangement of several strong sources – its proximity to the southern celestial pole makes it a 'standard' test field for the commissioning team – and it was the same source that produced the first multi-beam image with three BETA antennas (and software correlator) in 2013.

The observations were also used to estimate the system noise over the observing band (48 MHz, centred at 939.5 MHz), giving an estimate, averaged over all 16 beams, of $\mathbf{T_{sys}/\eta \approx 111 \pm 19K}$.

This estimate for T_{sys}/η is within 1-σ of the aperture-array measurement previously reported for the prototype Mk II PAF in late 2014.

The multi-beam image and the system noise estimate together demonstrates a working telescope and the performance of the system.

This is the first demonstration of the Mk II PAFs in an interferometer, and builds on the strong commissioning results already achieved with the Mk I receivers.

> Spanning the generations: the foreground antenna installed with the Mk II system, while antennas in the background (facing away from the camera) are installed with Mk I PAFs.

MRO renewable energy solutions take shape

Construction of the Murchison Radio-astronomy Observatory (MRO) power station has commenced; the hybrid plant will use diesel generators, photovoltaic cells and a large lithium-ion battery storage system.

Horizon Power (a wholly owned corporation of the Western Australia State Government) is installing four diesel generators (2 x 240 kW and 2 x 1005 kW), constructing a feeder cable to connect the new power station to the MRO's existing power distribution network and building an access track to the site.

Perth-based *EMC Solar Construction* are designing and building a 1.6 MW PV array comprising 5280 solar panels spread over 2 hectares (5 acres) and a battery system which delivers power at a rate of 1 MW with a storage capacity of 2.5 MWh – making it the largest lithium ion storage battery in Australia.

To protect the radio quiet environment at the MRO, the transmission cable will be shielded before it is buried and the inverter room and containerised battery system both incorporate radio frequency interference shielding.

CSIRO is constructing renewable energy solutions for the Murchison Radio-astronomy Observatory (MRO). The 'Sustainable Energy for the SKA' (SESKA) project is an initiative of the Australian Government being conducted as part of the Education Investment Fund.

3TB ASKAP data for public discovery

ASKAP demonstration data has now been released by the CSIRO ASKAP Data Science Archive (CASDA) team, a vital step in preparation for the start of ASKAP Early Science in the coming year.

The CASDA project aims to deliver the ASKAP science archive, with access provided to general users. CASDA is one of three subsystems, with the Telescope Operating System (TOS) and the Central Processor, which form the core component of ASKAP computing.

It is the primary point for storing, managing and sharing fully calibrated and science-ready data products and will provide the ASKAP Survey Science Teams with access to processed data products for analysis.

Once the full ASKAP telescope is commissioned, data will arrive for processing at the Pawsey Supercomputing Centre in Perth at rates of around 2.5 Gbps.

The initial data release in November 2015 will provide approximately 3TB of ASKAP commissioning data products, along with data validation tools and user services. At least 1500 astronomers are expected to use the data archive for various science research projects.

The plan for ASKAP commissioning

The coming year will see the ASKAP project begin the transition from an engineering test array (that is, the Boolardy Engineering Test Array and Mk I PAFs) to the ASKAP telescope, a fully functioning facility that meets performance requirements, is maintainable and ready for full science operations.

To achieve this transition, the ASKAP commissioning plan describes three major activities with substantial overlap in personnel and schedule, namely:

- Integration & Verification: ASKAP engineering commissioning activities and how the roll-out of hardware and software leads to a telescope that grows and evolves over time.
- Commissioning: demonstration of ASKAP performance requirements through a suite of scenarios that test the telescope in a representative way, resulting in a readiness for science operations.
- Early Science: exercising the science processing chain while liaising with the Science Survey Teams to maximise the overall outcomes from the Early Science program.

ASKAP commissioning strategy

Throughout commissioning there will be an iterative cycle of assembly, integration and verification followed by validation.

This is already underway, with six antennas currently installed with Mk II PAF receivers at the MRO, and promising commissioning results already validating the performance of these receivers.

The approach of verifying and commissioning in relatively minor increments allows the verification, integration and commissioning of each stage to benefit from the experience of the preceding stage.

Despite differing design features between the PAF Mk I and Mk II generations, commissioning work has already benefited significantly from experience gained with BETA; many of the commissioning activities currently underway are continuations or extensions of practices developed with the first generation receivers.

This has produced valuable lessons learned from Mk I commissioning activities and has also borne some interesting – and published! – initial science results.

Rolling out the receivers

There is a balance between adding antennas as soon as they're available to increase sensitivity, and the creation of stable platforms for commissioning work.

With the recent addition of two Mk II PAFs, and two more to be deployed before the end of the year, new antennas will be integrated into the array and made available for verification and commissioning in batches.

Learning through commissioning

There is a strong research thread running through commissioning activities that tackles beamforming and measuring, as well as calibration techniques.

It is also a valuable time to showcase ASKAP's capabilities through sharing data products publicly with the user community.

ASKAP will remain an important research platform for PAFs in radio astronomy beyond the formal end of the telescope's construction, due to the growth in understanding of how to optimally operate this new receiver technology.

ASKAP Early Science Program

ASKAP Early Science is an observing program aimed at producing scientifically useful data.

It will commence when an array of twelve ASKAP antennas fitted with Mk II PAFs (i.e. ASKAP-12) has been scientifically verified.

Early science observations will also be carried out in parallel as more Mk II PAFs are deployed on ASKAP antennas.

Prior to, and during, the ASKAP Early Science program, science demonstrations will be carried out with BETA (until it is retired and the Mk I PAFs are replaced with Mk IIs), ASKAP-6 and ASKAP-12.

A 'pilot' Early Science program will be launched in early 2016 using ASKAP-6 to acquire scientifically valuable data while also testing and characterising all aspects of the array and inform users – this demonstration data may also be used for scientific or technical research, and will be publicly released following a validation period.

Early Science – with ASKAP-12 – is now being planned on the basis that the total telescope availability will be up to 1800 hours. Central to this is the consideration of how to produce the most scientific impact, while demonstrating the unique capabilities of the new telescope.

ASKAP wins highest honour

At the annual CSIRO awards ceremony, the ASKAP team were awarded the organisation's highest honour – the 2015 Chairman's Medal.

The Chairman's Medal recognises exceptional research teams that have made significant scientific or technological advances of national, international and/or commercial importance.

"For revolutionising astronomy by developing a ***spectacular new capability*** *for observing wide areas of the sky using the* ***world's first*** *widefield imaging receivers for radio astronomy on the antennas of the* ***ASKAP radio telescope****."*

This award follows success at the 2013 *Engineers Australia Engineering Excellence Awards* and the 2014 *Australian Innovation Challenge* – validating the phased array feeds as truly innovative technology for radio astronomy.

"This is a recognition of the whole ASKAP team, and the vision, expertise and dedication that is essential to its success," said CSIRO Astronomy and Space Science Director Lewis Ball.

"Together we've built a fantastic radio telescope, the best in the world at what it does and one that's unlikely to be superseded for generations. To the whole team: Thank you. We could not have done it without you."

ASKAP2016 will be held in Sydney in June 2016.

This is an opportunity to share cutting-edge results from ASKAP and to discuss future strategies for observing and data sharing in large astronomical surveys ahead of the Square Kilometre Array.

Register now!
www.csiro.au/ASKAP2016

CONTACT US
t 1300 363 400
+61 3 9545 2176
e enquiries@csiro.au
w www.csiro.au

FOR FURTHER INFORMATION

Flornes Yuen
SKA Information Officer

t +61 2 9372 4339
e flornes.yuen@csiro.au
w www.atnf.csiro.au/projects/askap
www.atnf.csiro.au/ska