ASKAP Update

December 2013

The ASKAP Update is a regular series dedicated to conveying the latest news about the Australian SKA Pathfinder (ASKAP) project to international science and engineering communities. It is available online at www.atnf.csiro.au/projects/askap.

ASKAP PAFs achieve performance goal

Recent tests of CSIRO's innovative phased array feed (PAF) receivers, developed for radio astronomy, have achieved the goal for system performance across the entire ASKAP band. Results confirm that the second generation (MkII) PAF system design will reach performance targets.

Pre-production of the MkII PAF is now set to begin following successful verification tests using a proof-of concept scale PAF receiver system, in which the team demonstrated excellent, low noise system temperature of close to 50K across a frequency range of 0.7–1.8 GHz.

Development of the MkII receiver chain for ASKAP has been underway through a design optimisation program – ASKAP Design Enhancements (ADE) – to develop a second generation receiver that offers significant benefits in system performance across the ASKAP band.

The ADE program takes advantage of cost-effective technologies to increase efficiency, reduce manufacturing complexity, and lead to reductions in overall cost, weight and build time. A secondary benefit from the redesign is that new technology leads to a reduction in operational power requirements as well as an increase in digital processing flexibility.

Enhancements to the ADE system include improved performance across the ASKAP band for the PAF receiver, signal transmission using RF-over-fibre, direct sampling of the RF signal at the MRO Control Building, and hardware for digital signal processing that uses the latest in FPGA (field-programmable gate array) and high speed communication devices.

As part of ADE prototyping activities, the team took on the verification test program to finalise the chequerboard geometry, LNA design and front end assembly process to be used for ADE pre-production system.

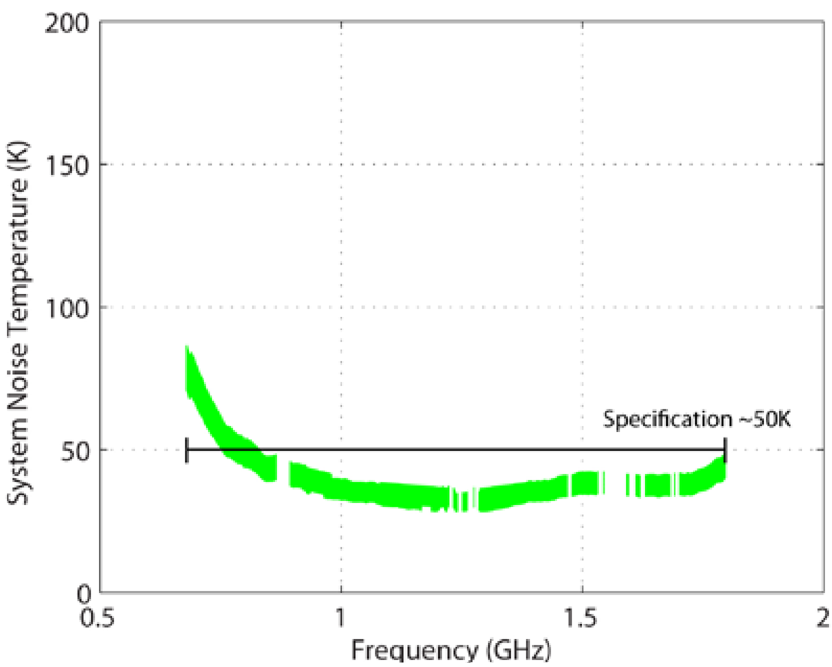
The verification tests were performed on a proof-of-concept ADE-styled chequerboard PAF (with 40 elements rather than the full 188 array) using a ground-based aperture array test facility at the CSIRO Parkes Observatory.

Performing the tests using a smaller, representative PAF reduces the test complexity while providing sufficient information to confirm understanding of the array's behaviour. The full size ADE PAF, made up of 188 elements, will perform somewhat better at the lower end of the frequency range when installed on an ASKAP antenna at the MRO.

The successful verification results now allow pre-production of a full sized ADE PAF to proceed, with deployment to the MRO expected in 2014.

The ADE program builds on the design, integration and commissioning experience the ASKAP team has already had with the first generation (MkI) PAF systems, six of which are already installed on ASKAP antennas at the MRO.

These six systems, along with associated digital systems, beamformer and hardware correlator, form the Boolardy Engineering Test Array (BETA), an engineering testbed used to prepare for the full fit-out of the ASKAP telescope.



The system noise temperature from measurements of a prototype ASKAP ADE PAF, with estimated uncertainties that are currently being refined.

The representative array has 40 elements and was tested as a directly receiving array using the Parkes 'aperture array' test facility.

The result demonstrates very good low-noise performance across the 0.7-1.8GHz frequency range required for ASKAP. A larger array will perform better at the lower end of this frequency range.

Credit: CSIRO.

BETA PAFs 'see' first multi-beam image and absorption line

The ASKAP commissioning team recently achieved a new science demonstration with the first HI absorption line measured with ASKAP 'BETA' antennas at the MRO. The result show the HI spectral line mode of ASKAP reproduces faithful results in a well-characterised astronomical region, and is an important step towards ASKAP Early Science.

These results are part of commissioning activities underway at the Murchison Radio-astronomy Observatory (MRO) throughout 2013 using ASKAP antennas installed with MkI phased array feed (PAF) receivers and the dedicated BETA hardware correlator.

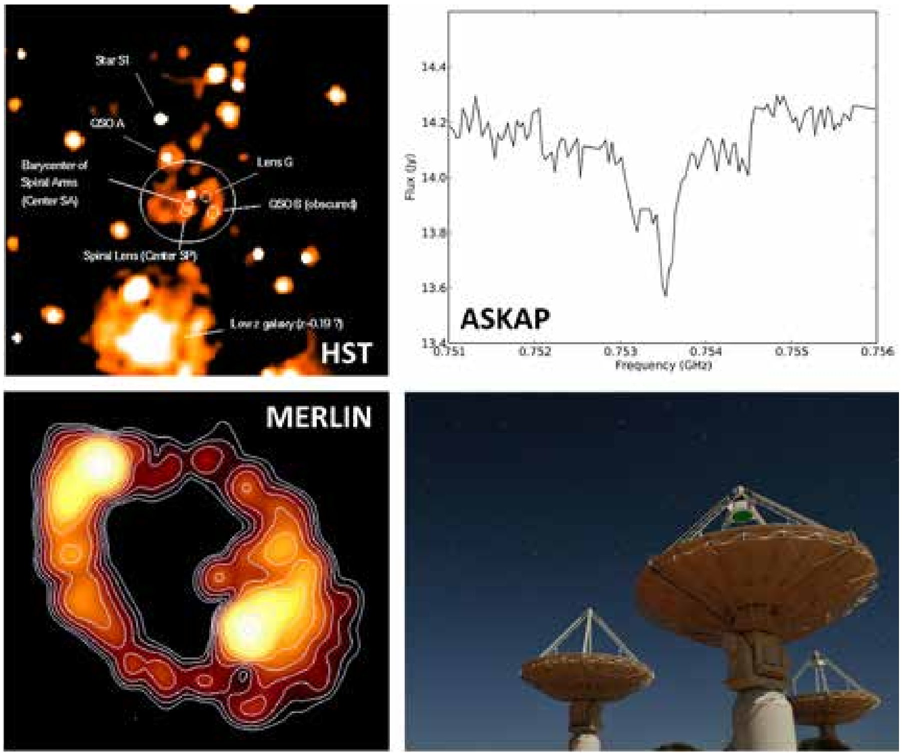
For the absorption line, a baseline-averaged cross correlation spectrum was produced of the gravitationally-lensed system PKS 1830-211 (the discovery of which was presented in a *Nature* article in 1991). This system has an absorbing galaxy at a redshift of z=0.89. Three ASKAP MkI PAFs systems were used over a six hour observation; the data were captured at full spectral resolution using the full bandwidth of the hardware correlator.

Earlier in the year commissioning tests had effectively validated the BETA system design, with the first ever multi-beam image produced with the ASKAP BETA system. Using ASKAP antennas 1, 3, and 6, a field-of-view of nine overlapping beams captured three bright extragalactic sources (PKS1610-771, PKS1549-790 and PKS1547.795), improving on an earlier image made in April (see *ASKAP Update #4*).

The success of these commissioning tests validated the BETA hardware design and cleared the way for deployment of all six MkI PAF systems to the MRO.

To complement the receivers, the commissioning team also installed all required digital electronics to support the six systems – including beamformer, digital and analogue racks and literally thousands of fibres – to tie all the elements together.

With six MkI PAFs now installed on antennas at the MRO, the team now turns their attention to the next integration phase for BETA.



A montage showing an optical image of the gravitationally lensed system (HST; Courbin et al, 2002), a picture of the Einstein Ring (MERLIN; Patnaik et al, 1994) and the ASKAP HI absorption spectrum (CSIRO).

Supercomputer launch helps Science Data Archive prep

Essential planning for a core computing component for ASKAP, the CSIRO ASKAP Science Data Archive (CASDA), has been underway over recent months.

The Science Data Archive is one of three subsystems that make up the computing components for ASKAP along with the Telescope Operating System (TOS) and the Central Processor. It is the primary point for storing, managing and sharing fully calibrated and science-ready data products. The subsystem will also provide the ASKAP Survey Science Teams with access to processed data products for analysis.

A CASDA development team has been formed to consider the scalability and performance requirements that will be necessary to process and archive data products that ASKAP produce.

A major challenge for the team is that ASKAP is still being commissioned, and the requirements for CASDA will evolve with time. Therefore, design flexibility and architecture of the CASDA system is vital for ongoing developments.

The first stage of the project, now being finalised, has focused on developing a more detailed understanding of the requirements, uses cases, workflows, architecture and design of the forthcoming ASKAP system.

The recent launch of the iVEC Pawsey Centre has allowed CASDA team members to begin establishment and development of test environments that will be used to run data archive prototypes and associated tests.

The Pawsey Centre is Australia's newest supercomputer facility, consisting of a general-purpose research system nicknamed 'Magnus', the ASKAP Central Processor - a system that will support the real-time processing needs of ASKAP – and archival storage.

Supercomputing resources at iVEC's Pawsey Centre will also be available for data-intensive projects across the scientific spectrum, including biotechnology, geosciences and nanotechnology.

CSIRO's ASKAP antennas at the Murchison Radio-astronomy Observatory (MRO) in Western Australia. The six antennas that are pointing toward the top left of the image are the BETA antennas, installed with first generation Phased Array Feed (PAF) receiver systems.

National awards recognise engineering excellence

The Engineers Australia Engineering Excellence Awards recognise world-class expertise and innovation in developing and implementing engineering solutions, and the phased array feed system has collected both divisional and national awards in 2013.

Earlier this year, the ASKAP PAF won two Sydney division Engineering Excellence Awards – in Innovations & Inventions and Research & Development. From the list of national finalists, the judging panel sought to identify unique projects that demonstrate outstanding excellence, innovation and best practice.

According to the judging panel, the PAF was awarded a national prize as for demonstrating "Australian engineering as leaders in astronomy by setting new benchmarks in technological advancement in the field with thanks to innovative engineering."

The PAF will take centre stage in the year-long Engineering Excellence Awards display at the Powerhouse Museum in Sydney, which opens early February 2014.

CSIRO's ASKAP antennas, installed with award-winning phased array feed (PAF) receivers (insert), at the Murchison Radio-astronomy Observatory (MRO) in Western Australia.

The iVEC Pawsey Centre, located in Perth, is Australia's newest supercomputer. A significant portion of supercomputing resources at the Centre will be dedicated to processing radio-astronomy data from major facilities, including CSIRO's ASKAP telescope.

Credit: iVEC

Lead role for CSIRO in SKA R&D

The Square Kilometre Array Organisation (SKAO) announced in November that CSIRO will play a lead role in the next stage of the ambitious international SKA project; the development of the world's largest radio telescope, to be located in Australia and in Southern Africa.

This SKAO allocated R&D 'work packages' to consortia from around the world, involving science institutes and industry, who will progress the design and validation processes of the SKA to a stage that will enable tendering and build of the telescope from 2017.

CSIRO will be lead or be involved in the following:

The SKA Dish Array Consortium (Lead): responsible for the design work relating to the SKA antenna dishes and receivers and the development of innovative phased array feed (PAF) receivers

Infrastructure Australia Consortium (Lead): in charge of designing and costing critical SKA infrastructure at the MRO – including the provision of power, communications, buildings, water and access to the site.

Assembly Integration and Verification Consortium (Key Partner): integration of ASKAP and the South African MeerKAT precursor telescopes into Phase 1 of the SKA telescope rollout.

As well, CSIRO will be involved in several other SKA consortia including those designing the telescope control system and the telescope's signal processing and data transport functions.

CSIRO Astronomy and Space Science (CASS) has recently established the CSIRO SKA Centre to coordinate SKA-related activities within the organisation, provide science and engineering expertise and guide engagement in the SKA project.

Construction of the first phase of the SKA will begin in 2018, with work on a second phase planned to begin in the early 2020s.

A widefield image showing the SKA Australia Survey Telescopes. These will augment the low frequency aperture array in the Australian Murchison region, and will give the SKA a high speed survey capability unprecedented in the field of radio astronomy. The SKA Survey telescope will have 96 dishes, including 36 ASKAP antennas. Credit: SKA Organisation.

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