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ASKAP Science Update

CSIRO Astronomy and Space Science December 2011

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

PAF snaps sky at Parkes Testbed Facility

In another step along the way to demonstrating the feasibility of Phased Array Receiver (PAF) technology for radio astronomy, the ASKAP team has recently released an image showing, for the first time, the raw on-sky port patterns from the first full-sized prototype PAF installed at prime focus of the Parkes Testbed Facility (PTF).

The image is a striking demonstration of successful receiver testing following the installation of the first prototype PAF on the 12-m testbed antenna at CSIRO's Parkes Observatory.

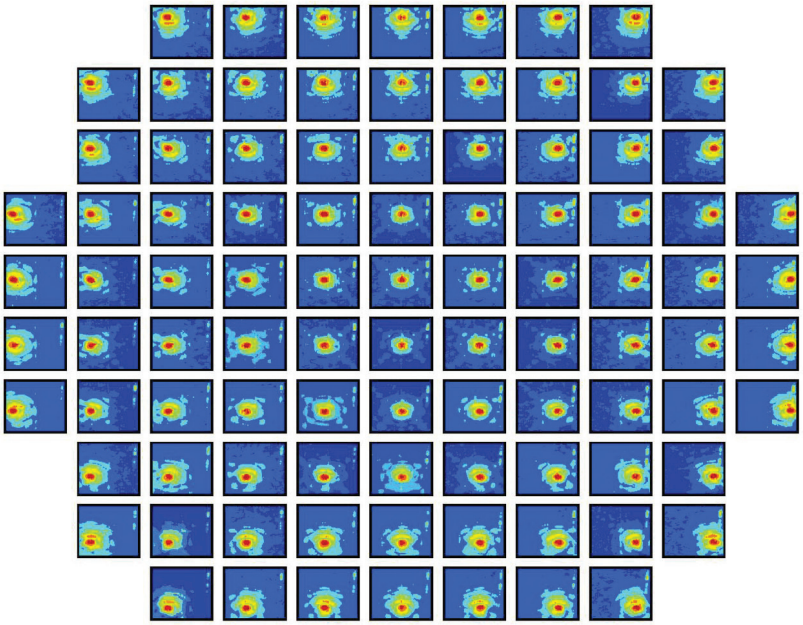
Furthermore, the image also shows that the end-to-end system of the PTF was stable over a period of five hours, and the ports have reasonable beam shape and sensitivity.

Data were collected during September–November, correlating each of 188 ports on the PTF 12-m testbed antenna with the central horn of the 20-cm multibeam receiver on the Parkes 64-metre radio telescope (the 'Dish').

The 64-m dish tracked powerful radio galaxy Virgo A while the 12-m Patriot antenna executed a raster scan about the radio source to map out a 14 square degree patch of each PAF port pattern.

The two polarisations of the central beam of the 20cm multibeam receiver on the 64-m were connected to ports 189 and 190 of the beamformer of the 12-m, using an RF over fibre (RFoF) link.

A raster scan was run to extract the correlated power of each PAF port with the appropriate 64-m polarisation from recorded ACM (Array Covariance Matrix) data, performed independently for each of the 64 frequency channels.



> A collage of 94 PAF port patterns of one polarisation, each normalised to their peak. The coloured image within each square represents the power received on that port as the antenna and PAF were scanned systematically across a 14° x 14° patch of sky centred on Virgo A. The colour scale range is approximately 55dB and each pattern is made from 40 1MHz channels spread across 1.2–1.5 GHz. Credit: Aidan Hotan, CSIRO.

Afterwards, each channel was analysed to produce two PAF port response collages, one for each polarisation.

In the resulting image, each of the 94 individual squares in the plot represents a port on the PAF feed array.

There are another 94 ports with orthogonal polarisation (not shown), making 188 in total.

Each tile appears in the position of the associated PAF element. The central ports, close to the antenna bore-sight, show the source well-centred, while in those at the edges show larger and asymmetric side-lobes, just as expected.

According to CSIRO ASKAP Project Director Ant Schinckel, the result is a culmination of cutting-edge research and development by the CSIRO Astronomy and Space Science and Information & Communication Technologies staff that make up the ASKAP team.

"Creating this image has been due to the efforts of a huge team of people; the PAF designers and builders through the data transport group, the digital backend team and the software group," he says.

Quantitative analysis will next be performed using one-dimensional slices through the images, and similar tests will be conducted with formed beams to confirm the results.

While primarily an engineering testbed, the Boolardy Engineering Test Array (BETA) may also be an entry point for preliminary scientific observations.

ASKAP Survey Science Projects

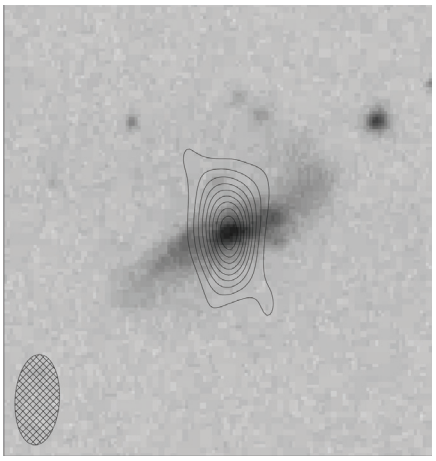
In this edition of *ASKAP Science Update* we catch up with each of the ASKAP Survey Science Projects (SSPs) and learn about the milestones and progress made.

EMU: Evolutionary Map of the Universe

The two goals of the EMU design study were to ensure (a) the survey design and data pipeline will deliver expected science and (b) science questions and analysis are prepared to reap the science as soon as the final survey data appear. Some of the Design Study questions generated new science projects; for example, the cluster experts were asked how many clusters would EMU detect? Estimates from thousands to hundreds of thousands triggered vigorous debate that still continues, resulting in several science studies. The SCORPIO project, initially designed to estimate the number of radio stars detectable by EMU, is now a key EMU pathfinder for working out how best to analyse the Galactic Plane data, and has demonstrated that the number of Galactic objects detected by EMU may revolutionise this field. Eight journal papers have been submitted as the result of the EMU design study, even before the actual survey has begun.

WALLABY: Widefield ASKAP L-Band Legacy All-Sky Blind Survey

Highlights among the WALLABY team's activities include the contribution of input data for the large ASKAP simulation released in early September, initial tests for the development of a pipeline for the automated extraction of rotation curves and mass models of spatially resolved galaxies, and the definition of the optimal sky tessellation pattern for the survey. Source-finding tests on ASKAP simulations are currently under way using the *theSkyNet* citizen science project (www.theskynet.org). The WALLABY team organised several meetings, including a three-day simulations and visualisation meeting at CSIRO headquarters in Marsfield, attended by about 40 participants from around the world. The source finding working group held two successful workshops, one at ICRAR in February and the second one at ASTRON in June.



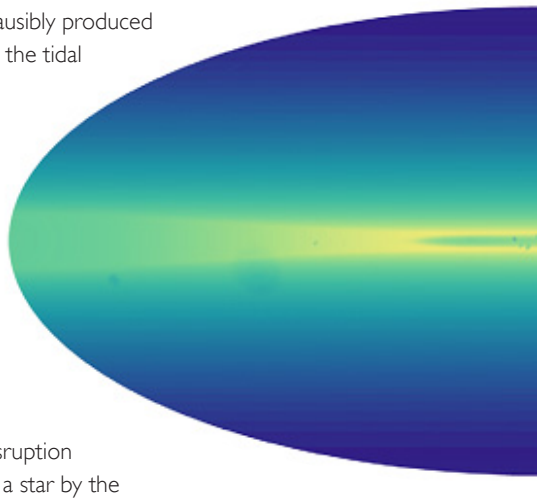
FLASH: First Large Absorption Survey in HI

The FLASH project conducted observations of 29 candidate associated HI absorption systems selected from the AT20G continuum survey with CSIRO's Australia Telescope Compact Array (ATCA). Compared with absorption due to intervening galaxies, relatively little is understood about the population of absorption systems associated with gas in the source host. An important aspect of the FLASH design study is to carry out targeted searches using existing observatory facilities, principally due to a lack of systematic study of these sources. The FLASH line-finding method was used to both assign significance to detections and parameterise the observed continuum and spectral-line components. Analysis indicated three confirmed detections, including two new detections and the known associated absorption system PKS1814-637, yielding a detection rate of 10%.

>An example source in which FLASH has detected associated HI absorption. The grey-scale image represents blue optical data from the UK Schmidt Telescope, contours represent 10% intervals in peak brightness from the ATCA continuum image. ATCA resolution is represented by the hatched region in the bottom left-hand corner. Credit: FLASH.

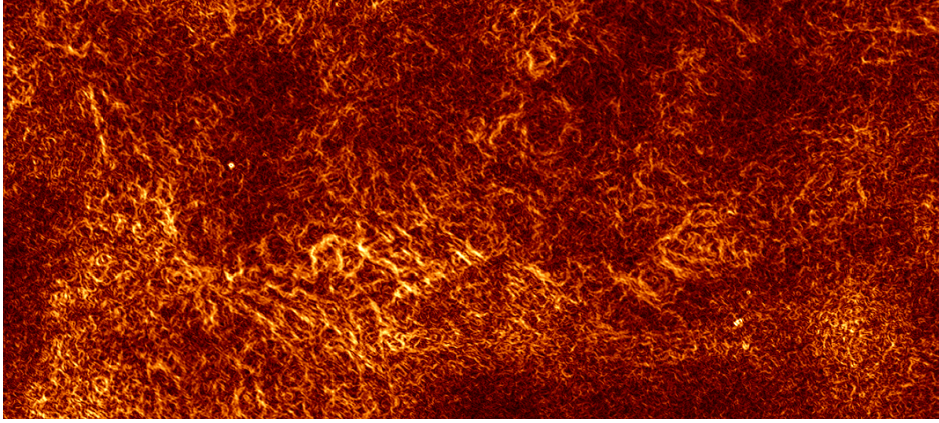
VAST: An ASKAP Survey for Variables and Slow Transients

Members of the VAST team were involved in developing a pipeline to ingest images produced by ASKAP, automatically detect sources in the sky, and extract their properties and lightcurves so that variability and transient behaviour may be assessed. As BETA comes online, the pipeline could prove to be a valuable tool for commissioning activities, able to rapidly identify calibration errors and imaging artifacts. Members of VAST were also involved in identifying new classes of radio transient and variable sources, such as pan-chromatic luminous outburst GRB 110328A/Swift J1644+57 that was plausibly produced by the tidal disruption of a star by the central black hole of a distant galaxy. Similar events may be a significant contributor to the transient event rate that we expect to detect with ASKAP.



GASKAP: Galactic ASKAP Spectral Line Survey

GASKAP made simulations of the 21-cm sky using the ASKAPSoft package to experiment with different flavours of CLEAN (a multiscale clean algorithm). The results indicated the algorithm is effective at deconvolving large-scale, diffuse emission mixed with absorption. It is critical to combine the data with single dish maps, but this combination can be made after the deconvolution step, which is computationally simpler than the alternatives. Simulations and algorithm development for OH maser source finding and deconvolution also advanced. Precursor observations with

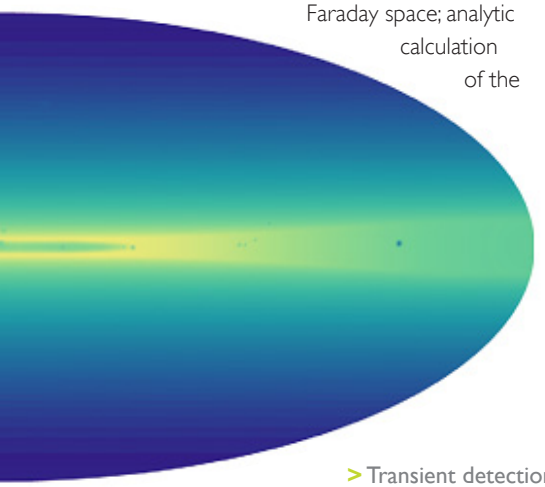


>The polarisation gradient revealing the cusps, shear and shocks of turbulence in interstellar gas. Credit: POSSUM.

Parkes and the ATCA were particularly directed toward characterising the diffuse OH brightness at a range of longitudes in the Galactic Plane, to assess the need for single dish data over the entire area of the GASKAP survey.

POSSUM: Polarisation Survey of the Universe's Magnetism

Major milestones for POSSUM included: simulating polarisation leakages of the ASKAP primary beam; identification and characterisation of polarisation calibrators for ASKAP; development of new algorithms for source-finding in Faraday space; analytic calculation of the signal-to-noise ratio of a polarised signal detected via rotation measure synthesis; and establishment of a detailed polarisation commissioning plan for BETA. Scientific results were published on broadband polarisation properties of active galactic nuclei, on the polarisation gradient as a direct probe of magnetised turbulence, and on Faraday rotation as a probe of magnetic fields in Galactic HII regions. The main focus for 2012 will be integration of the POSSUM analysis pipeline, and further simulations and involvement in testing of the polarisation performance of CSIRO's Phased Array Feeds.



> Transient detection rate modelled to include interstellar scattering and plotted in Galactic coordinates. A duration of 5ms and observing frequency of 1GHz is assumed. Colour encodes event rate, with blue being the lowest and yellow the highest. Credit: CRAFT.

CRAFT: Commensal Real-Time ASKAP Fast Transients Survey

CRAFT scientists and engineers are solving key questions at maximising transients detection rates, such as: should all the elements of a radio telescope point at the same field of view (FoV), or should they point to different parts of the sky; what is the trade-off between FoV and sensitivity; and should the signals be combined coherently, to maximise sensitivity, or incoherently, to maximise FoV? CRAFT has connected the generic properties of a population of transients and the strategy that should be used to detect them, and identified likely 'sweet spots' on the sky. The team has also considered how high time resolution hardware should best be deployed to maximise discovery rate, taking into account the cost of processing the data stream. With over 800 hours of observing time now accumulated on the VLBA (Very Long Baseline Array), and a push to deploy trailblazers on other instruments, CRAFT expects to quickly verify and refine transients observing strategies.

DINGO: Deep Investigations of Neutral Gas Origins

DINGO achieved a number of significant milestones, including the launch of *theSkyNet*, which is currently being used for HIPASS (HI Parkes All Sky Survey) and DINGO source finding tests; the submission of a PASA article comparing Duchamp with other source finders; the development of improved parametisation techniques; the creation of input for the most recent ASKAP combined extragalactic simulation; and the generation of new semi-analytic simulations to improve our understanding of the expected number of detected galaxies, their properties, confusion rates, and the impact of different evolutionary scenarios. The team also addressed survey strategy issues, such as the equatorial performance of ASKAP and dithering strategies. DINGO will continue to develop HI source finding, simulation and data management techniques in preparation for BETA.

VLBI: The High Resolution Components of ASKAP – Meeting the Long Baseline Specifications for the SKA

The VLBI team has enjoyed considerable success over the last two years. The first major highlight project was the first VLBI observation using an ASKAP antenna in 2010, leading to the first published ASKAP science and promotion of the work at the 2010 International SKA Forum in Assen, The Netherlands. The second major success, this year, was the first e-VLBI observation with an ASKAP antenna, using the recently completed optical fibre network between the Murchison Radio-astronomy Observatory (MRO) and Perth. In the immediate future, the VLBI team will support the use of ASKAP as a regular telescope of the Long Baseline Array (LBA) and will deploy the final VLBI system once the ASKAP digital backend system is installed.

COAST: Compact Objects with ASKAP – Surveys and Timing

Members of COAST made progress on simulated pulsar populations and developing algorithms to allow for wide-field pulsar searches using interferometers. A more immediately usable search method will involve the follow-up of point sources discovered in other (continuum) surveys, while another ongoing COAST project involves determining which point sources are most 'pulsar-like' and therefore suitable targets. COAST has made plans for a backend to be used on BETA, and has defined some initial targets for verification of BETA's ability to observe pulsars when tied-array beams become available on the test array.

ASKAP SSPs pass Annual Review with flying colours

An annual review of the progress of the ASKAP SSPs was held in early November at the CSIRO Astronomy and Space Science headquarters in Marsfield, NSW.

The standing ASKAP Survey Science Team (SST) internal review committee assessed the scientific and technical progress each SST has made during the second year of Design Studies.

The review also assessed readiness for accepting and processing commissioning data from BETA, which will comprise six ASKAP antennas installed with PAFs at the Murchison Radio-astronomy Observatory (MRO) in Western Australia.

Feedback from the review committee was extremely positive. The committee particularly noted the exceptional level of technical work accomplished by the teams in support of ASKAP science and in preparation for the next stage of commissioning.

First fringes at the MRO

As the Science Update went to press, first fringes were announced between a beamformed beam on a Phased Array Feed (on ASKAP Antenna 3) and a Single Pixel Feed (on Antenna 8) at the MRO. Special thanks to Juan Carlos Guzman, Craig Haskins, Douglas Hayman, Aidan Hotan, Maxim Voronkov, and the entire ASKAP System Commissioning Team.

> CSIRO's ASKAP antennas installed with PAFs at the MRO. The three antennas represent the first half of BETA. Credit: Barry Turner, CSIRO.

Forthcoming Meetings

- 219th AAS (American Astronomical Society) Meeting
  Austin, USA
  8 – 12 January 2012
- IAU Symposium 287: Cosmic masers - from OH to H_0
  Stellenbosch, South Africa
  29 January – 3 February 2012
- SKANZ 2012 – Pathways to SKA Science in Australasia
  Auckland, New Zealand
  14 – 16 February 2012
- IAU XXVIII General Assembly
  Beijing, China
  20 – 31 August 2012

If you would like to find out more or have questions about ASKAP please don't hesitate to find us, we look forward to meeting you.

For further information:

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