ASKAP Science Update

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

Assembly of ASKAP Antennas 2 - 6 Underway at the MRO

Late 2010 will see significant progress for CSIRO's ASKAP project with the building and commissioning of five antennas at the Murchison Radio-astronomy Observatory (MRO) in the Mid West region of Western Australia.

"These five antennas plus the first ASKAP antenna built in January 2010 will form BETA (Boolardy Engineering Test Array) and will be fully kitted out with PAFs (Phased Array Feeds), receivers and digital backends as work progresses through the remainder of the year and into 2011," says CSIRO's Dr Carole Jackson, ASKAP Antenna Integrated Project Team Leader.

The first antenna, officially named *Diggidumble* (a Wajarri word meaning 'table top hill'), was constructed earlier in 2010, and is now undergoing a number of retrofits to bring it as close to the production design of the remaining ASKAP antennas (2 - 36) as possible.

All 36 ASKAP antennas are being manufactured by the 54th Research Institute of China Electronics Technology Group Corporation (known as CETC54) based in Shijiazhuang, China. By the end of 2011, all 36 will be built at the MRO.

CETC54 has huge experience in antennas used for a range of applications and a selection of antenna designs ranging from ~1m to ~20m class dishes. More recently the company was awarded the contract for the new 65m Shanghai radio telescope.

"Whilst the ASKAP antennas are novel in having three axes of rotation (azimuth, elevation and polarisation), rather than just the traditional two axes, they incorporate about 85% of CETC54's standard product design" says Carole.

An important feature of the design is the ability to set the reflector accuracy at the factory acceptance test stage before shipping; this allows the antenna to be erected at the MRO, with no further adjustment required, and maintain the specified surface accuracy of 1mm.

The particular design feature represents a saving on installation time, and also matches other options such as one-piece dish production via hydroforming or composite mould infusion.

> The reflector of a new ASKAP antenna is lifted on the pedestal at the MRO. Credit: Ross Forsyth, CSIRO.

"The ASKAP antenna contract has drawn international interest for both the speed of delivery and the cost", says Carole.

"The capacity of the CETC54 team to deliver the first antenna within one year of contract signing was very impressive."

The ASKAP antennas, contrary to many concepts within the SKA antenna discussions, are conventional, steel backup-structure antennas.

Whilst the 12m diameter dishes are considered 'big' little antennas, each weighing approximately 30 tonnes, they are competitively priced at around $300,000 each.

"This is notable in that is approaching the cost target for the SKA 12m diameter dish antennas capable of operation to 20 GHz", says Carole.

A summary of the ASKAP antenna technical specifications can be found online at: **http://www.atnf.csiro.au/projects/askap/ASKAP_Antenna_public_specification_Nov08_v0.0.pdf**

> The assembly of one of five new ASKAP antennas underway in the foreground of *Diggidumble* (the first antenna), September 2010. Credit: Brayden Briggs, CSIRO.

"The resulting improvement to the angular resolution of the system allows studies of compact radio sources at a better level of detail, especially at the lower radio frequencies that ASKAP operates."

>Steven Tingay, Principal Investigator of the ASKAP VLBI project. Credit: Curtin University.

ASKAP Survey Science Projects

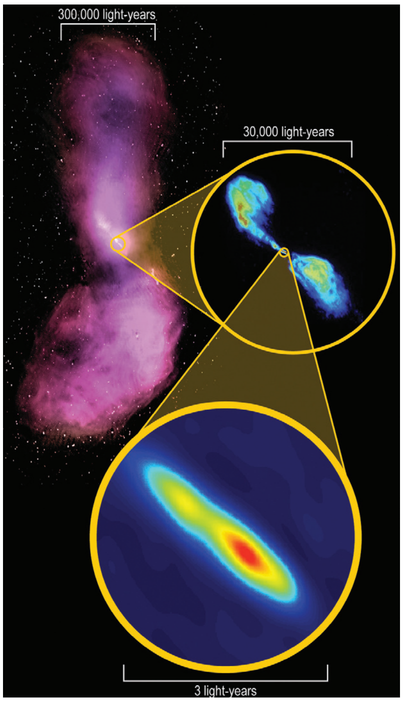
In this edition of *ASKAP Science Update* we take a detailed look at two of the projects that will make use of ASKAP during its first five years of operation.

Ultimate Resolution for VLBI

In the short year that has elapsed since ASKAP's ten Survey Science Projects were approved, the VLBI team has already achieved early science results using the first ASKAP antenna, and now continues preparations for even more sensitive observations that could be achieved as ASKAP matures.

The official title of the project, *The High Angular Resolution Components of ASKAP: Meeting the Long Baseline Specifications for the SKA*, effectively demonstrates the potential science outcomes that the project aims to achieve.

According to Principal Investigator Steven Tingay, the project is aimed at high angular resolution observations using ASKAP as an element of Very Long Baseline Interferometry (VLBI).



A primary goal will be to establish ASKAP as part of the Australian Long Baseline Array (LBA), effectively demonstrating the ability to connect radio telescopes over thousands of kilometres and process all the data in real-time.

The LBA consists of CSIRO telescopes at Parkes, Mopra and Narrabri, the University of Tasmania's telescopes at Hobart and Ceduna, and the Canberra Deep Space Communication Complex (CDSCC, now operated by CSIRO).

"The addition of ASKAP greatly extends the east-west extent of the array, which allows a greater range and depth of science," says Steven. "The resulting improvement to the angular resolution of the system allows studies of compact radio sources at a better level of detail, especially at the lower radio frequencies that ASKAP operates".

In May 2010, the team successfully performed VLBI observations using the first ASKAP antenna (*Diggidumble*), in conjunction with the LBA and the newly-installed 12m antenna at Warkworth on New Zealand's north island (operated by Auckland University of Technology).

"The increase in angular resolution that can be achieved when ASKAP is added to the LBA is significant, approximately a factor of two," Steven explains, "adding the Warkworth antenna as well results in an increase in angular resolution by approximately a factor of four."

The key outcome of the collaboration, other than being able to peer deep into the heart of the galaxy Centaurus A (pictured left), was successfully achieving "first science" with ASKAP, demonstrating the potential of the Australia – New Zealand bid to host the Square Kilometre Array (SKA) telescope.

"What excites and motivates me is that the array we are building is a significant technology step toward the SKA," says Steven.

"In particular, our plans to connect the array in real-time via high speed optical fibres, known as e-VLBI, will demonstrate key technologies for the SKA."

The main drive behind the project comes as a result of close collaboration betwen CSIRO, ICRAR (International Centre for Radio Astronomy Research) and co-investigators from New Zealand, the US, Canada, the UK and Germany.

"This collaboration is an aspect of the project which is a pleasure for me," says Steven. This is not surprising, since the working relationship between Steven and the leader of the CSIRO team, Dr Tasso Tzioumis, has developed over almost 20 years of working closely on similar projects.

Additionally, the team will work to connect the Australian array to international telescopes in India, China, Japan, the US, South America and South Africa.

"This global array would allow us the ultimate angular resolution to study galactic and extragalactic radio sources," says Steven.

>Zooming into the heart of the galaxy, Centaurus A, 14 million light years away. Credits: Whole galaxy: I. Feain, T. Cornwell & R. Ekers (CSIRO/ATNF); ATCA northern middle lobe pointing courtesy R. Morganti (ASTRON); Parkes data courtesy N. Junkes (MPIfR). Inner radio lobes: NRAO / AUI / NSF. Core: S. Tingay (ICRAR) / ICRAR, CSIRO and AUT.

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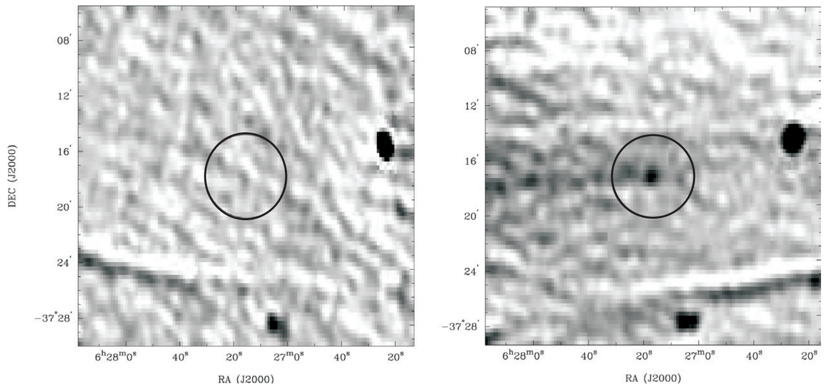

> An example of the detection of a transient source during a search of the Molonglo radio telescope archives. Credit: Keith Bannister, University of Sydney.

VAST Attractions of the Unknown

Large-scale blind surveys of the sky for transient sources in the radio band have been performed for many years, detecting known signals such as pulsars and solar bursts.

But it is the mysterious nature and origins of transient sources for which no explanation could be found that piques the curiosity of Tara Murphy and Shami Chatterjee, Principal Investigators of *ASKAP Survey for Variables and Slow Transients* (VAST).

"Our science goals are organised around the broad themes of explosions, propagation effects, magnetic fields and accretion, as well as exploration of the unknown," says Tara.

VAST aims to detect changing signals in ASKAP images of the sky, and to characterise these discoveries by figuring out how they vary over time.

"We're talking about relatively 'slow' variability, on time scales of five seconds or longer, not millisecond scales, and the transient sources at these time scales are quite enigmatic," Tara explains.

"Ultimately, the aspect we care the most about is to develop a deeper understanding of the kinds of physical processes that drive such variability."

The trade-off between sensitivity with sky coverage, and resolution with field of view, can limit the ability of radio telescopes to catch a glimpse of faint or rare transient sources. In order to observe these phenomena, astronomers usually have to choose between high sensitivity or extensive surveys with large volumes of data; ASKAP will offer both.

"ASKAP brings a large field of view to the table," says Shami. "It will be unparalleled in its effective survey speed, and that is the key advantage that makes VAST an exciting proposition."

However, the rapid survey capability of ASKAP leads to the technical challenge of VAST - processing large volumes of data in as close to real time as possible.

By sampling extremely large volumes of detection space and running in 'piggyback mode' with other ASKAP projects, the survey pipeline is essentially always 'switched on'. This will maximise both the observation area and number of times each patch of sky is observed, increasing the chance that a rare class of event can be 'caught in the act'.

A regular all-sky survey covering longer timescales, from seconds to days, weeks or months, could be a treasure trove for radio transient science. What makes VAST so compelling is the abundance of discoveries that could be made, from local to the cosmological.

Despite the large extent of discoveries that will be made available by ASKAP, the VAST team, made up of over 80 astronomers from Australia, New Zealand, the US and Europe, will not be playing favourites.

"No matter where the telescope is looking, there are likely to be sources in the field of view that are of interest to us," says Shami.

Past surveys have yielded variable sources such as active galactic nuclei and microquasars, transients such as flaring neutron stars and white dwarfs; VAST will probe unexplored regions of space where completely new classes of transient sources may be detected.

"Poets and writers describe the sky as a constant but we know now that it is filled with enigmatic variability and unexpected violence," says Shami.

"Most exciting is the prospect that we might yet run into the 'unknown unknowns', things that we don't even know that we don't know."

> The VAST team, led by Tara Murphy and Shami Chatterjee, will search ASKAP images of the sky. Credits: Flornes Conway-Derley, CSIRO and Meghan Kennedy.

CSIRO-ASTRON to Collaborate on Phased Array Feeds

During ISKAF 2010 held in the Netherlands in June, CSIRO and ASTRON agreed to cooperate on the development and testing of phased array feed (PAF) technology.

The collaboration merges world-leading expertise from ASTRON and CSIRO to develop PAFs for future radio telescopes and achieve the wide field of view capability that would fully exploit the science potential of the SKA.

CSIRO Delivers New SKAMP Digital System

A major milestone was reached for the Square Kilometre Array Molonglo Prototype (SKAMP) project with the delivery of its new digital correlator. CSIRO officially presented the SKAMP team with the completed digital system in September at the University of Sydney.

The installation of the new correlator will greatly improve the calibration of astronomical data and lead to a significantly improved image quality.

> Representatives from CSIRO, ASTRON and SPDO celebrate the signing of the Collaborative Agreement at ISKAF in June 2010. From left: Professor Richard Schilizzi (SPDO), Dr Brian Boyle (CSIRO), Dr David DeBoer (CSIRO), Wim van Cappellen (ASTRON), Dr Carole Jackson (CSIRO), Dr Mark Verheijen (ASTRON), Dr Tom Oosterloo (ASTRON), and Professor Mike Garrett (ASTRON). Credit: Hans Hordijk.

Forthcoming Meetings

Members of the ASKAP team will be attending a number of upcoming scientific meetings:

- PrepSKA WP2 Annual Meeting
  University of Oxford, UK
  27 - 30 October 2010
- Japan SKA International Workshop
  NAOJ, Tokyo Japan
  4 - 5 November 2010
- ASKAP Survey Science Teams Working Meeting
  CSIRO Astronomy & Space Science, Marsfield site, Australia
  29 November - 1 December 2010
- 217th American Astronomical Society Meeting
  Seattle, USA
  9 - 13 January 2011

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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