

# ASKAP Science Update

Australia Telescope National Facility

October 2009



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](http://www.atnf.csiro.au/projects/askap).

## What is ASKAP?

ASKAP is a next-generation telescope being developed and built by CSIRO as part of the Australia Telescope National Facility.

To be located in the extremely radio-quiet Mid West region of Western Australia, ASKAP will be a wide field-of-view, survey radio telescope with:

- 36 antennas, each 12 metres in diameter;
- Total collecting area of approximately 4000 m<sup>2</sup>;
- System temperature less than 50 K;
- Frequency range from 0.7 to 1.8 GHz;
- 300 MHz instantaneous bandwidth with high-resolution and continuum modes;
- A field-of-view of approximately 30 square degrees;
- Maximum resolution of 8 arcseconds.

The design of ASKAP is unique among radio telescopes. Its antennas feature three-axis movement and will use 'phased array feeds' rather than 'single pixel feeds' to detect and amplify radio waves, a development being pioneered by CSIRO in conjunction with colleagues in the Netherlands, Canada, United Kingdom and Germany. These attributes mean that the telescope will be able to survey large areas of sky with unprecedented sensitivity.

Construction on site is due to commence at the end of 2009. All 36 antennas, and their technical systems, will be completed in 2013.

Once built, ASKAP will operate as part of CSIRO's radio-astronomy facility for use by Australian and international scientists.

As well as being a world-leading telescope in its own right, ASKAP will be an important test-bed for the Square Kilometre Array.

## What is ASKAP's Science Path?

During ASKAP's first five years of operation at least 75 per cent of its time will be used for large Survey Science Projects, each needing more than 1500 hours to complete and designed to use ASKAP's unique capabilities.

Since 2008 an open, international process has been used to determine the key scientific questions ASKAP will address.

In September 2009, CSIRO announced that ten major science projects, representing 363 unique authors from 131 institutions, had been selected to use ASKAP in its first five years.

An international panel of expert astronomers picked the projects that will take advantage of ASKAP's survey speed and large field-of-view. These projects will address widely recognised astrophysical issues, such as the evolution of star-forming galaxies and massive

black holes, variable and transient radio sources, the interstellar medium of our own Galaxy, magnetic fields in space, and pulsars. Their results will be important for the broad astronomical community.

Of the ten projects' authors, 33% are from Australia and New Zealand, 30% from North America, 28% from Europe, and 9% from elsewhere in the world.

"ASKAP is open to projects from astronomers from all over the world, with projects determined based on their scientific merit and operational feasibility," said Professor Brian Boyle, CSIRO SKA Director.

Principal Investigators of the ASKAP Survey Science Projects will work with CSIRO through the Design Study phase. Members of the project teams, together with the ASKAP Project Scientists and other ASKAP staff, will form ASKAP working groups that will meet on a regular basis to ensure close collaboration between CSIRO and the Survey Science Projects.

The ten projects are outlined in more detail in the following pages.



> Artist's impression of ASKAP at the Murchison Radio-astronomy Observatory. Credit: Swinburne Astronomy Productions. Design Data provided by CSIRO.

## ASKAP Survey Science Projects

The ten ASKAP Survey Science Project proposals selected by the international committee were prioritised into three categories: an A Group, for which CSIRO will provide full support (EMU and WALLABY), an A- Group, for which CSIRO will make all reasonable efforts to support (FLASH, VAST, GASKAP, POSSUM, CRAFT and DINGO), and a Strategic Priorities Group (VLBI and COAST), for which CSIRO will work to ensure that capabilities are enabled to the extent possible.

### EMU: Evolutionary Map of the Universe

*Principal Investigator: Norris*

EMU is a deep (10  $\mu$ Jy/beam rms) radio continuum survey of 75% of the entire sky. EMU will probe typical star forming galaxies to redshift 1, powerful starbursts to even greater redshifts, Active Galactic Nuclei to the edge of the Universe, as well as undoubtedly discovering new classes of rare objects. The key science goals for EMU are to trace the evolution of star forming galaxies and massive black holes throughout the history of the Universe and to explore large-scale structure. EMU will create the most sensitive wide-field atlas yet made, and provide a long-lasting legacy survey.

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

*Principal Investigators: Koribalski and Staveley-Smith*

WALLABY is an extragalactic neutral hydrogen survey over 75% of the entire sky and will detect up to 500,000 galaxies to a redshift of 0.26. The fundamental aims of WALLABY are to examine the HI properties and large-scale distribution of these galaxies in order to study galaxy formation and the missing satellite problem in the Local Group, evolution

and star formation of galaxies, the role of mergers and galaxy interactions, the HI mass function and its variation with galaxy density, the physical processes governing the distribution and evolution of cool gas at low redshift, cosmological parameters relating to gas-rich galaxies and the nature of the cosmic web. WALLABY will provide the largest, most homogeneous HI sample of galaxies yet made, and will be an important pathfinder for key SKA science.

### FLASH: First Large Absorption Survey in HI

*Principal Investigator: Sadler*

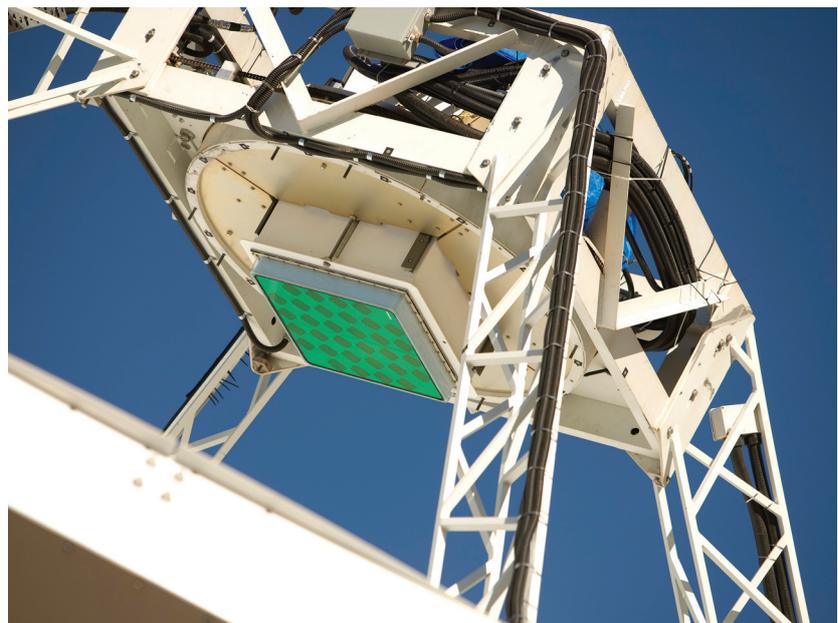
FLASH is a blind HI absorption-line survey that uses background radio continuum sources to identify and characterise foreground neutral hydrogen. FLASH science outcomes are focused on both the neutral gas content of galaxies and the cosmic HI mass density in the redshift range  $0.5 < z < 1.0$  where the HI emission line is too weak

to be detectable in individual galaxies. The observations will increase the total number of absorption line systems by an estimated two orders of magnitude, representing a significant data set to study gas assembly and galaxy formation during a time in the history of the Universe that is largely unstudied thus far.

### VAST: An ASKAP Survey for Variables and Slow Transients

*Principal Investigators: Murphy and Chatterjee*

VAST gives unprecedented opportunities to investigate the sky at radio wavelengths for transients with a timescale as short as 5 seconds. ASKAP's wide-field survey capabilities will enable the discovery and investigation of variable and transient phenomena from the local to the cosmological including flare stars, intermittent pulsars, X-ray binaries, magnetars, extreme scattering events, intra-day variables, radio supernovae and the orphan afterglows of gamma-ray



> ASKAP's prototype phased array feed is being pioneered by CSIRO in conjunction with colleagues in the Netherlands, Canada, United Kingdom and Germany. Credit: David McClenaghan, CSIRO.

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bursts. VAST will probe unexplored regions of phase space where new classes of transient sources may be detected.

### **GASKAP: The Galactic ASKAP Spectral Line Survey**

*Principal Investigator: Dickey*

GASKAP is a high spectral resolution survey of the HI and OH lines in the Milky Way and Magellanic Systems. Compared with existing data, GASKAP will achieve about an order of magnitude improvement in both brightness sensitivity and in angular resolution. GASKAP will detect and map OH masers from evolved stars and star formation regions, diffuse emission from molecular and atomic clouds, HI absorption toward background continuum sources and the structures in the gas that trace the effects of stellar winds and supernova explosions. The Magellanic Clouds will show all these processes as they appear in two other, very different environments. GASKAP will provide stunning images of the interstellar medium that will be indispensable for astronomers working at other wavelengths.

### **POSSUM: Polarization Sky Survey of the Universe's Magnetism**

*Principal Investigators: Gaensler, Taylor and Landecker*

Understanding the Universe is impossible without understanding magnetic fields. Magnetic fields are key to the non-thermal Universe, yet it is unclear how large-scale magnetic fields are generated and maintained. POSSUM will use radio source polarization, in particular the technique of rotation measure (RM) synthesis, to perform a wide-field survey that will yield a grid of RMs over a substantial fraction of the sky. The science outcomes of POSSUM will revolutionise our understanding of the ordered components of the Milky

Way's magnetic field, test dynamo and other models of magnetic field generation in galaxies and clusters, and carry out a comprehensive census of magnetic fields as a function of redshift in galaxies, active galactic nuclei, galaxy clusters and the intergalactic medium.

### **CRAFT: The Commensal Real-time ASKAP Fast Transients Survey**

*Principal Investigators: Dodson and Macquart*

CRAFT is a purely commensal survey for transient sources with timescales shorter than 5 seconds. Short-timescale transients are associated with the most energetic and brightest single events in the Universe. They provide Nature's ultimate laboratory; their emission is generated by matter under extreme conditions whose properties probe physical regimes far transcending the range achievable in terrestrial experiments. Fast timescale transients open new vistas on the physics of high brightness temperature objects, extreme states of matter and the physics of strong gravitational fields. In addition, the detection of extragalactic transients affords us an entirely new and sensitive probe on the huge reservoir of baryons in the intergalactic medium.

### **DINGO: Deep Investigation of Neutral Gas Origins**

*Principal Investigator: Meyer*

DINGO will study the evolution of neutral hydrogen (HI) from the current epoch to redshift about 0.5, providing a legacy dataset spanning cosmologically representative volumes.

Measurements will be made of key cosmological distributions, including  $\Omega_{\text{HI}}$ , the HI mass function and the halo occupation distribution function. ASKAP data will be combined with optical data to enable a thorough study of

the co-evolution of the stellar, baryonic and dark matter content of galaxies.

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

*Principal Investigator: Tingay*

ASKAP, in combination with the existing Australian Long Baseline Array, high speed data recording equipment, innovative software correlation facilities and high speed data transport networks, provides a high resolution capability that is unmatched in terms of SKA demonstrators around the world. Science outcomes include proper motion and parallax of pulsars, high resolution imaging of Active Galactic Nuclei, follow-up of transient radio sources and distances and proper motions of OH masers.

### **COAST: Compact Objects with ASKAP – Surveys and Timing**

*Principal Investigator: Stairs*

COAST will undertake an observational program of pulsar timing aimed at high profile issues in astrophysics. This includes limits on, or the detection of, a background of gravitational waves, stringent tests of the predictions of General Relativity and other theories of strong gravity and the studies of binary stellar evolution. In addition to pulsar timing, blind searches for pulsars will also be carried out which will lead to a better understanding of the Galactic neutron star population, the pulsar emission mechanism and the structure and magnetic field of the Galaxy.

## Supporting ASKAP Science

Two ASKAP Project Scientists are an integral part of CSIRO's ASKAP team.

Dr Simon Johnston and Dr Ilana Feain have played an important role in guiding the design and development of ASKAP, as well as providing updates on ASKAP to the international research community. They will also play a vital role in supporting the ASKAP Survey Science Projects by working with the science teams to refine their survey goals and strategies over coming months.

"As active researchers ourselves we have been able to help guide the development of ASKAP to ensure it meets the needs of other researchers" said Simon, who has been an astrophysicist at CSIRO's Australia Telescope National Facility since 2004. Awarded his PhD at the University of Manchester, UK in 1990, Simon took up a postdoctoral position with CSIRO from 1991 to 1993, and was at the University of Sydney from 1993 to 2004.

"We see our role as enabling the science goals of the international community through dialogue between ASKAP and the survey teams."

ASKAP's ability to mine the sky and find distant objects has made a big impression on Ilana, who completed her PhD at the University of Sydney in 2006.

"In my own research on Centaurus A, colleagues and I spent more than 1200 hours, over several years,



> ASKAP science is supported by Project Scientists Dr Simon Johnston and Dr Ilana Feain. Credit: Gabby Russell, CSIRO.

observing the massive galaxy with the Australia Telescope Compact Array telescope near Narrabri in NSW. This produced 406 individual images, which were 'mosaiced' together to make one large image," said Ilana.

"The result is the most detailed radio image ever made of Centaurus A, but gathering the same data with ASKAP would take just minutes rather than thousands of hours."

"The next stage of the ASKAP science path, the Design Study phase, is incredibly exciting because it will bring

together a large number of researchers from around the world, all focused on what we'll be able to achieve with this amazing telescope," said Ilana.

### For further information:

Gabby Russell  
Communication Officer  
CSIRO Australia Telescope National Facility  
Phone: +61 2 9372 4339  
Email: [gabby.russell@csiro.au](mailto:gabby.russell@csiro.au)  
Web: [www.atnf.csiro.au/projects/askap](http://www.atnf.csiro.au/projects/askap)

## Contact Us

Phone: 1300 363 400  
+61 3 9545 2176

Email: [enquiries@csiro.au](mailto:enquiries@csiro.au)

Web: [www.csiro.au](http://www.csiro.au)

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