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# ATNF News

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See Compact Array Broadband Backend (CABB) article on page 6.

Left to right: CABB Project Leader Dr Warwick Wilson, CSIRO Chief Executive Officer Megan Clark and ATNF Acting Director Dr Lewis Ball, with a CABB signal processing board in front of two antennas of the Australia Telescope Compact Array.

Photo: Paul Mathews Photographics


Removing the "spaghetti" of ribbon cable that fed the old correlator, from left to right, Matt Shields (obscured), Brett Hiscock, Scott Munting, Mark Leach, and Peter Mirtschin.

Photo: CSIRO

## Cover page images

CABB Project—team photo. Back row, left to right: Warwick Wilson (Project Leader), Paul Roberts, Grant Hampson, Peter Axtens, Yoon Chung. Middle row: Aaron Sanders, Dick Ferris (Project Engineer), Matt Shields, Mark Leach (Project Manager). Front row: Troy Elton, Andrew Brown, Raji Chekkala, Evan Davis. Other contributors (not in photo): Scott Saunders. (See article on page 6.)
Photo: Tim Wheeler, April 2009

The ***Sunrise*** television crew prepare to broadcast live from the grounds of the CSIRO Parkes Observatory.
Photo: Tim Ruckley, CSIRO

Installation of a 300 – 900-MHz receiver on the Parkes 64-m radio telescope. (See article on page 28.)
Photo: Maik Wolleben, CSIRO

# Contents



# Editorial

In this issue, Phil Edwards reports on the tremendous achievements that have taken place with the Compact Array Broadband Backend (CABB) project. This is an upgrade that will keep the Australia Telescope Compact Array at the forefront of radio astronomy, providing observers with much improved bandwidth allowing for more sensitive observations.

We also feature a number of articles which highlight the wide-ranging and insightful science being undertaken at ATNF facilities. Franz Bauer and collaborators report on SN1996cr, the strongest radio supernova ever discovered, while Ettore Carretti reports on the S-band Polarisation All Sky Survey (S-PASS), a project to map the diffuse polarised synchrotron emission of the entire southern sky.

In other news, George Hobbs and collaborators discuss pulsar observing with the ASKAP test-bed antenna situated at Parkes, while a history of the research undertaken at Potts Hill Field Station is examined in a paper by Harry Wendt, Wayne Orchiston and Bruce Slee.

Finally, we provide an in-depth update on ASKAP activities including a special antenna report prepared by Ross Forsyth, together with information on the SKA Forum held in Cape Town, as well as information on continuing ASKAP industry engagement.

As this issue was being prepared, we were saddened to hear of the death of John Masterson on 9 April 2009. John was an esteemed and highly respected photographer with the CSIRO Division of Radiophysics. For 40 years he made a huge contribution to a magnificent photographic archive that records the events, facilities and people that make up the history of CSIRO Radiophysics and the ATNF since the earliest days. Examples of his superb photography can be seen around the Marsfield site, ATNF Observatories and in many publications. An obituary and examples of his work will be available in the next edition of *ATNF News*.

If you would like to contribute to later editions of the *ATNF News*, please contact the newsletter team.


Tony Crawshaw and Joanne Houldsworth

The ATNF Newsletter Production Team
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# From the Director

Lewis Ball

ATNF Acting Director

This newsletter details a range of achievements by a great team of people engaged in radio astronomy activities. It is increasingly important to recognise that the makeup of that team extends well beyond the staff within the Australia Telescope National Facility (ATNF) and the astronomers who use our telescopes.

The biggest news at this time for users of the ATNF telescopes is the start of scientific operations of the Compact Array Broadband Backend, or CABB, on 22 April 2009. The system is described in articles within this newsletter. I'd like to acknowledge here the contributions of the team that have made this project possible. Warwick Wilson has led the CABB project from its inception and Warwick and the rest of the ATNF's back end engineering group have worked tirelessly on this very challenging project for the last seven years. The expertise of the group was acknowledged as being world class by the independent, international panel that conducted the ATNF Science Review in 2007. In their overview, the Science Review panel stated:

"In the area of digital signal processing, the ATNF developed the first digital frequency conversion system for Very Long Baseline Interferometry (VLBI) and their experiments in electronic-VLBI (e-VLBI) have achieved very competitive bandwidths. The advanced design and short development time of the new Compact Array Broadband Backend, which is enabled by utilising the latest Field Programmable Gate Arrays (FPGAs), is comparable with the best at other observatories. The sampling speeds and resolution of the digitisers now being tested for CABB are amongst the highest achieved at any observatory. The ATNF was the first observatory to use digital data transmission of radio astronomical data on optical fibres and their use of this technology for CABB is state-of-the-art."

Significant funding was received from the Major National Research Facilities grant from the 2001 round on the basis that the technology underlying CABB was on the development path towards the realisation of the Square Kilimetre Array (SKA). As the focus shifts from building CABB to using and operating it, the staff of the back end group will shift their efforts further towards the development of the beamformer, correlator and data transport systems for the Australian SKA Pathfinder (ASKAP), while the software and firmware gurus (Warwick Wilson and Dick Ferris) continue to work on providing different modes of operation of CABB. Operations and astrophysics staff are now in the front line of ensuring that astronomers can make the best use of the new system, and I am sure that in years to come it will result in science that we haven't predicted.

In another significant change, CSIRO recently created the new position of CSIRO SKA Director and appointed Brian Boyle to that role. Having worked closely with Brian as his Deputy since 2005 I'd like to take this opportunity to personally thank him for his outstanding efforts as ATNF Director.

Brian deserves specific acknowledgement for his leading role in the development of the Decadal Plan for Australian Astronomy in 2005, and for the rapid firming of Australia's commitment to playing a leading role in the SKA. The resulting funding of A$51.7M from the Commonwealth Government to CSIRO to expand its plans for a new telescope in Western Australia to become the Australian SKA Pathfinder is one of the largest injections of funds into Australian astronomy. This will continue to have a profound impact on Australian astronomy in future decades. Brian's new role, in which he is seconded into the Department of Industry, Innovation, Science and Research for 40% of his time, is further indication of Australia's and CSIRO's commitment to the strategic opportunities associated with radio astronomy over the decades to come. It is a privilege for me to fill the role of Acting Director of ATNF until CSIRO completes a competitive appointment process for a new Director. This is expected to occur by the end of 2009. In the role of ATNF Acting Director I continue to work very closely with Brian. I have responsibility for the ATNF Business Unit—essentially all the staff and equipment—and for the delivery of the Operation of the National Facility telescopes, the astrophysics research activities, and the technical and engineering research and development (other than ASKAP). Brian is responsible for SKA-related activities including the delivery of ASKAP as a working telescope.

This newsletter encapsulates the past, present and future through the historical article on the Potts Hill

Field Station; the excellent science of the present outlined in the science highlights and the start of CABB operations; and the potential and excitement of the future through the training and inspiration of students, the development of ASKAP, and the promise of the SKA. All these elements are important for the continued success of the ATNF, including the sometimes difficult and confronting need for change. The tremendous response from the astronomy community around the world to the call for Expressions of Interest in the major survey science projects to be undertaken by ASKAP has marked a dramatic turning point for the ATNF. The fact that 354 astronomers from around the world got together to submit Expressions of Interest for surveys that won't start for another three years or more is a very positive indicator of the potential of ASKAP to deliver transformational science. The efforts of the survey teams that are selected following the assessment of the more detailed proposals currently being prepared will be essential for the success of the ASKAP telescope, and those efforts are greatly appreciated by CSIRO.

One of the most rewarding parts of my role is seeing the results of the recruitment of new staff. Over the past few months I have been reminded again and again by new members of the ATNF that this is a great place to work and that there is a tremendous sense of excitement. Two of our new starters, Ettore Caretti and Jamie Stevens who have taken on the roles of Senior Systems Scientists at Parkes and Narrabri respectively, will become very well known to our astronomy users in the coming months. I'd like to acknowledge the enthusiasm of all our new staff members who are too numerous to mention here but who all have important roles to play and are greatly valued.

Finally, I'm sure many will be interested in the fact that CSIRO's invention of the techniques that underpin the wireless communications, now so common for connections between computers and other electronics devices, has its roots in radio astronomy. Two keystones were John O'Sullivan's push to develop FFT capable chips to use in searches for transient radio emission from predicted collapsing black holes, and his work in recognising that redundant spacing interferometry could be used to cancel phase errors introduced in signal propagation. For more, see:

*www.csiro.au/science/wireless-LANs.html*

# Brian Boyle Takes up New Role as CSIRO SKA Director

Tony Crawshaw (ATNF)

On 9 February 2009, Dr Brian Boyle stepped down as the Director of ATNF to take up a new role as CSIRO SKA Director. The role was created to strengthen Australia's bid for the international Square Kilometre Array (SKA) radio telescope mega-project.

In his new role Dr Boyle is now focused on strategic international SKA policy issues, working closely with the Department of Innovation, Industry, Science and Research.

As well as taking on a joint leadership role with senior Departmental officials in helping to develop and implement Australia's SKA strategy, he continues to be responsible for the delivery of the Australian SKA Pathfinder Telescope, ASKAP, which is being developed by CSIRO.

The new role has already allowed Dr Boyle to assume the chairmanship of the Australian SKA Co-ordinating Committee (ASCC), the inter-governmental peak body for the oversight of Australia's SKA strategy and policy. In that capacity Dr Boyle has helped to revise the working group structure for the ASCC, targeting the demonstration of SKA-readiness to the international community as a key goal over the coming two-three years.

Dr Boyle is also committed to broadening and enhancing the engagement of the ASCC with the community. As part of this approach, Prof Bryan Gaensler has been appointed to the Chair of the ASCC Science and Technology Advisory Committee.

Through the ASCC, Dr Boyle is also currently working with officials from the New Zealand Government to secure New Zealand's formal participation in Australia's SKA program.

Dr Lewis Ball (previous ATNF Deputy Director) is acting as ATNF Director until a successor is appointed.

# Compact Array Broadband Backend

Philip Edwards (ATNF)

The Australia Telescope Compact Array (ATCA) emerged recently from a six-week shutdown during which installation of the Compact Array Broadband Backend (CABB) system hardware was completed. CABB has increased the maximum bandwidth of the ATCA by a factor of 16, from 128 MHz to 2 GHz, improving the continuum sensitivity of the ATCA by at least a factor of four as well as providing a greatly enhanced spectral line performance, particularly at the higher observing frequencies. The fruition of the CABB project will provide a great boost in the capabilities of the Compact Array and is a credit to the ATNF engineering group for the development and integration of the CABB system with the existing array infrastructure. The first scheduled astronomical observations with CABB occured on 22 April 2009, a day after CSIRO's new Chief Executive Officer, Megan Clark, visited the Observatory and inspected the freshly upgraded array.

The CABB project commenced in January 2002, and had at its core a new digital signal processing system based on a novel Polyphase Digital Filter Bank (DFB) structure developed at ATNF. Key milestones on the path to completion of CABB have included provision of the MOPS spectrometer for the Mopra telescope in 2006, and the Pulsar Digital Filterbanks at Parkes. CABB has also provided a test-bed for ASKAP and future SKA technologies in its ability to provide wideband data sampling, transmission, and processing.

CABB replaces the Compact Array's original signal processing and digital correlator systems. Those systems, at the time of their design and construction in the 1980s, were "state-of-the-art" and gave the Compact Array a keen competitive edge when it began operating in 1990. The CABB project has benefited from being led by Warwick Wilson who was the designer and project leader for the original correlator. Warwick, together with Mark Leach and Dick Ferris (Project Manager and Project Engineer respectively), have led a team that, for knowledge and experience in digital signal processing for radio astronomy, has few peers around the world. The success of CABB bodes well for the ATNF's future involvement in the construction of the SKA.

Over the last year an interim CABB system has been progressively installed on the ATCA. The interim system, which ultimately provided a single 2-GHz bandwidth, with dual polarisations, for five of the six ATCA antennas, was able to be operated in parallel with the existing correlator system, allowing a valuable series of comparisons and cross-checks to be made. This capability vanished in the first week of the shutdown when the nine racks and (seemingly!) miles of ribbon cable of the old correlator were removed and the first of the three CABB racks installed in its place (See inside front cover).

In concert with the signal transmission and processing hardware changes, modules to interface the current suite of receivers to the new system have been fabricated and installed. Currently the 12-mm, 7-mm, 3-mm and 3/6-cm bands are available. Modules to enable observing with the 20-cm or 13-cm band are expected in late May.

The great advance in the array's capabilities provided by CABB is, perhaps surprisingly, accompanied by a simplification of the equipment on the antennas. The frequency conversion of the radio-astronomical signals has been simplified and is at most a two-step process, rather than four; the "fringe rotation" of the signals no longer happens in the antennas; and the analog-to-digital conversion of the signal now uses 9-bit sampling rather than 2-bit sampling, providing high dynamic range and tolerance to high levels of radio-frequency interference, an inevitable feature of wider bandwidth observations in the centimetre wavelength radio-bands. An inherent property of the digital filterbank structure is its excellent isolation between channels, so that strong interference at one frequency does not leak into neighbouring frequency channels. The wider bandwidths and finer sampling result in an increase in data flow to the central correlator by a factor of 80, from 2 to 160 gigabits per second per antenna—a data rate of just under one terabit per second for the array!

CABB will initially operate in a single observing mode, offering 2048 spectral channels across a 2-GHz bandwidth. Over the coming months the first of the "zoom modes", offering increased spectral resolution over selected portions of the 2-GHz band, will be implemented. To accommodate this progressive enhancement of observing capability, the six-month April 2009 observing semester for the ATCA has been split into two parts, with a 1-MHz spectral resolution offered for the first three months, to mid-July, and the first zoom modes offered for the latter part of the winter semester. The astronomical community's interest in CABB is apparent from the very high oversubscription rate for the first three months.

ATNF Assistant Director: Operations, Dave McConnell noted "The ATNF has always benefited from having astronomical and engineering staff co-located and in constant communication about what is both useful and technically possible in radio astronomy: in the ATNF 'the science drives the technology' and 'technology drives the science' have both been true statements, and CABB is the latest product of such a relationship."

The ATCA shutdown for the CABB installation and commissioning was scheduled to take six weeks from the beginning of March, but benefited from gaining advance access to antenna CA06, which was made available during the Long Baseline Array block at the end of February. This enabled a head-start to be made on a number of antenna-related changes, and allowed the procedures also needed on other antennas to be fine-tuned ahead of time. While the extended array downtime was primarily for CABB, a number of other maintenance tasks were also carried out: twelve antenna drive motors (each antenna has four drive motors, two for elevation and two for azimuth) were rewired and fitted with connectors to allow quick and safe disconnection and reconnection during maintenance or changeovers; two 20/13-cm receivers were warmed in readiness to change receiver packages for those with new ortho-mode transducers (improving the 13-cm polarisation capabilities); and a variety of other preventative maintenance tasks were also undertaken.

The new CABB system has also required significant changes to the array control and monitoring software, which has taken place in parallel with the hardware changes. In addition, the ATCA data analysis package, *miriad*, has required revision and extensions to enable (the significantly larger) CABB data files to be processed. The *ATCA Users Guide* is also being given a complete overhaul to bring it into the CABB era.

It goes without saying that the shutdown was a period of great activity, with a steady stream of visitors from ATNF Headquarters in Marsfield, and observatory staff, working long hours to ensure the installation and commissioning was kept to schedule. Recent studies of the scientific impact of radio-telescopes have shown the ATCA and Parkes jostle for second and third place, and CABB and its offspring DFBs at Parkes will ensure these telescopes continue to enjoy pre-eminence well into the future.

A new CABB antenna rack being lifted into an antenna for fitting.

Photo: Brett Hiscock

# Exchange Expertise

Graeme Carrad (ATNF)

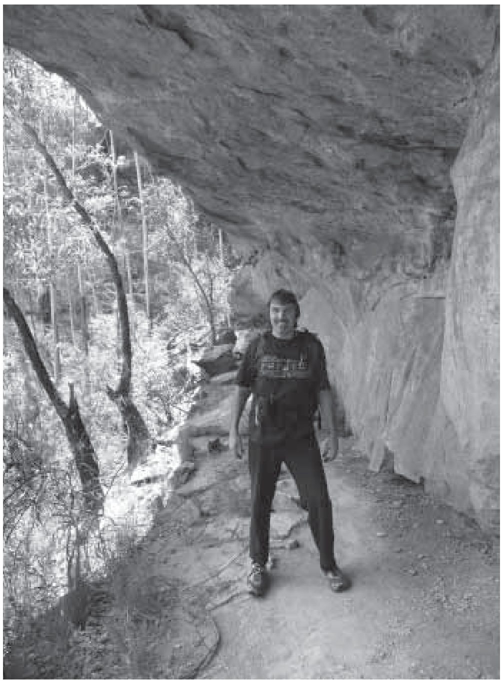
The Front End Group benefitted tremendously during the period October 2008 to January 2009 when the Italian National Institute for Astrophysics (INAF) allowed one of its engineers to donate his services to the ATNF.

Alessandro Navarrini proved his worth in developing a design for a new C-band amplifier that, if successful, has the potential to relieve the dearth of spare amplifiers needed for the Compact Array. Alessandro is based at the Cagliari Astronomy Observatory (OAC) and is involved in the design and construction of the various receivers for the 64-m diameter Sardinia Radio Telescope (SRT.)

His amplifier design uses "off the shelf" components and electromagnetic simulation of the device performance is encouraging. In addition to his electronic design efforts, Alessandro put in many dedicated hours to generate mechanical drawings of the amplifier body and circuit board. The amplifier is currently being fabricated.

It wasn't all work however and he was introduced to the Australian bush through bushwalks and a canyoning trip. His favourite pastime of snorkelling was catered for with an introduction to the fish at Shelly Beach near Manly. Having only had exposure to small fish near Sardinia, the size of the blue groper that is resident in the waters there seemed to give him cause for caution and something to remember.

The benefits of the exchange of expertise are unquestionable and may lead to further exchanges and strong links between the two institutions in the years to come.



Alessandro takes time out from work to enjoy an Australian bushwalk and canyoning trip.

Photos: Courtesy of Alessandro Navarrini.

# ATNF Distinguished Visitors

Robert Braun (ATNF)

Over the past months we have enjoyed working visits from Franz Bauer (Columbia University), Marta Burgay (Cagliari), Martin Cohen (University of California Berkeley) and Ingrid Stairs (University of British Coumbia).Current visitors include Leo Blitz (University of California Berkeley) and Phil Kronberg (Los Alomos National Laboratory/ University of Toronto). Upcoming visitors we expect include Martin Cohen (University of California Berkeley), Rick Jenet (University of Texas Brownsville) and D J Saikia (Tata Institut of Fundamental Research).

The Distinguished Visitors Program remains a very productive means of enabling collaborative research projects with local staff, adding substantially to the vitality of the ATNF research environment. Visits can be organised for periods ranging from only a few weeks up to one year. For more information please see *www.atnf.csiro.au/people/distinguished_visitors.html.* Prospective visitors should contact the local staff member with the most similar interests.

# ATNF Graduate Student Program

Baerbel Koribalski (ATNF)

We welcome the following students into the ATNF co-supervision program:

- Luke Hindson (University of Hertfordshire)—*Wide-field molecular imaging of triggered star formation* with supervisors Dr Mark Thompson (University of Hertfordshire) and Dr James Urquhart (ATNF);
- Lina Levin (University of Swinburne)—*The High Time Resolution Universe* with supervisors Dr Matthew Bailes (University of Swinburne), Dr Simon Johnston (ATNF), Dr Michael Kramer (Max-Planck-Institut für Radioastronomie, Bonn, Germany) and Dr Willem van Straten (University of Swinburne);
- Anita Titmarsh (University of Tasmania)—*Investigating the earliest stages of massive star formation* with supervisors Dr Simon Ellingsen (University of Tasmania) and Dr Kate Brooks (ATNF).

Congratulations to:

- Marcella Massardi on the successful submission of her International School for Advanced Studies of Trieste PhD thesis on *The extragalactic sources at mm wavelengths and their role as CMB foregrounds*;
- Adam Deller on the successful submission of his University of Swinburne PhD thesis on *Precision VLBI astrometry: Instrumentation, algorithms and pulsar parallax determination*; and
- Emil Lenc on the successful submission of his University of Swinburne PhD thesis on *Studies of Radio Galaxies and Starburst Galaxies using Wide-field, High Spatial Resolution Radio Imaging*.

Dr Marcella Massardi is now a postdoc at the INAF-Osservatorio Astronomico di Padova in Italy. Dr Adam Deller has started a Jansky Fellowship at the National Radio Astronomy Observatory Socorro, USA, and Dr Emil Lenc is an OCE Postdoctoral Fellow at the ATNF.

The following students recently submitted their PhD Thesis:

- Nadia Lo (University of NSW)—*A Multi-molecular Line Study of an Entire Giant Molecular Cloud*;
- Katherine Newton-McGee (University of Sydney)—*Radio Polarimetry as a Probe of Interstellar Magnetism*;
- Joris Verbiest (University of Swinburne)—*Long-Term Timing of Millisecond Pulsars and Gravitational Wave Detection*. Joris is now at the University of West Virginia.

Well done !

Clockwise from left: Luke Hindson, Lina Levin, Katherine Newton-McGee, Joris Verbiest, and Adam Deller and Emil Lenc.

Not shown: Anita Titmarsh, Marcella Massardi and Nadia Lo.

Photos: Courtesy of students.

# Highlighting our History: Potts Hill Field Station, 1948 – 1962

Harry Wendt, Wayne Orchiston (JCU Centre for Astronomy) and Bruce Slee (ATNF & JCU Centre for Astronomy)

This paper provides a summary[1] of the research carried out at the Potts Hill field station during the seminal period of Australian radio astronomy prior to 1960. This was arguably the most exciting and innovative era in the development of Australian radio astronomy. It was the era before "big science" projects emerged, a period when small-scale projects dominated and radio engineers first entered the domain of the astronomers. Most observations were carried out at a network of field stations maintained by the CSIRO's Division of Radiophysics in or near Sydney.[2] This was a unique period when—along with Britain—Australia achieved world leadership in the new field of radio astronomy. As Hanbury Brown (1993) remarked, "… golden ages in science are rare and should be recorded."

Figure 1: An aerial photograph of Potts Hill field station taken on 19 March 1954. The view is from the north looking south. The main part of the field station is in the immediate foreground. The East-West solar grating array is on the southern bank of the reservoir and the North-South array on the eastern bank. On the bottom left, three coal train carriages are visible. These were used to supply coal for the steam driven pumping station for the water supply reservoir. The main road visible on the left is Rookwood Road.

Photo: (CSIRO Radiophysics Photographic Archive: B3253-1)

The Potts Hill field station was located in the western suburbs of Sydney, 16 km from the centre of Sydney and on vacant land adjacent to a major water-distribution reservoir (see Figure 1). The site was selected in 1948 after it was necessary to find a new home for a 97-MHz swept-lobe interferometer which was being developed by Ross Trehearne and Alec Little. The building in which they were working at Bankstown aerodrome was sold and so a new location had to be found. At the same time Ruby Payne-Scott took over the project from Trehearne. Permission was kindly given by the Sydney Water Board to use the vacant land surrounding the Potts Hill No. 1 reservoir, and the Potts Hill radio astronomy field station came into being. Soon after Little and Payne-Scott had relocated to Potts Hill they were joined by W N ("Chris") Christiansen who had recently transferred from AWA

1 For a detailed discussion see Wendt, 2009.

2 For an overview of the Field Stations see Orchiston and Slee, 2005.

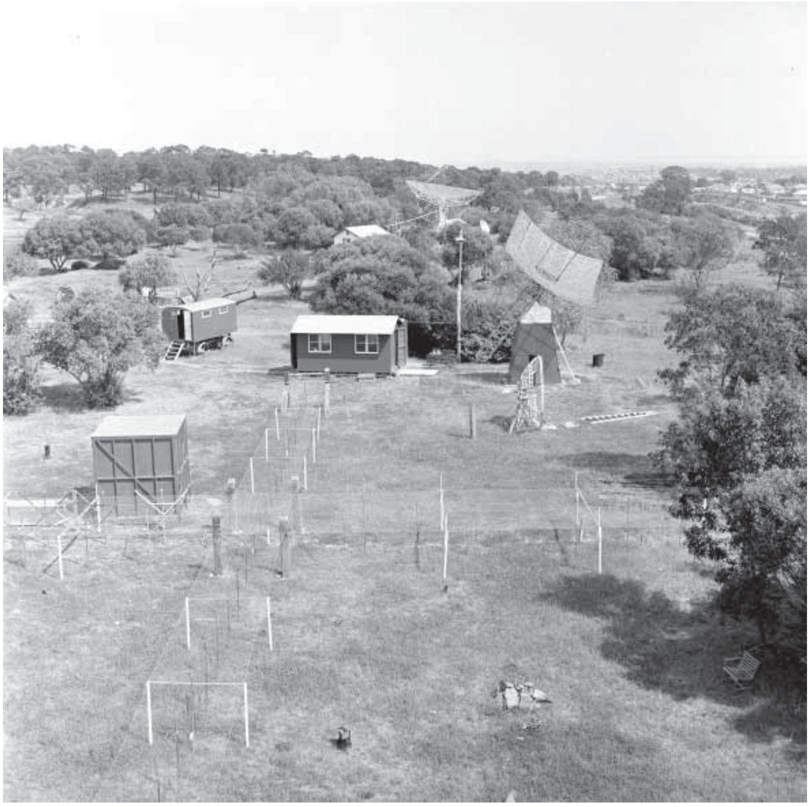


Figure 2: The Mills Cross prototype (immediate foreground) at Potts Hill field station 7 October 1953. The view is from the east looking west. Also visible in the far back ground is the 11-m Transit Telescope, the 4.9- x 5.5-m paraboloid and an ex-WWII TPS-3 aerial.

Photo: (CSIRO Radiophysics Photographic Archive: B31171-4)

to Radiophysics and was also looking for a new site where he could conduct solar observations with a 4.9- × 5.5-m paraboloid that was originally installed as an experimental radar at Georges Heights during WWII (see Figure 2).

Ten different types of radio telescope operated at Potts Hill during the 15-year life of the field station. Amongst these were several examples of world-first instruments.

The Swept-Lobe Interferometer developed by Little and Payne-Scott (1951) used a method of continuously varying the phase of the local oscillator in the heterodyne receiver to sweep the aerial beam lobes at 25 times a second. This innovation removed the restriction of having to wait for the Earth's rotation to move the source through the lobe pattern in order to produce interference fringes. Not only could the Swept-Lobe Interferometer determine the position of a short duration burst accurate to two arc minutes at 97 MHz, it could also measure the polarisation of the source. This radio telescope was designed primarily to provide accurate positional measurements of short-duration solar bursts and was successfully used to track the motion of these through the corona for the first time. In fact, several of the bursts they measured would later turn out to be Type IVs, the only type of solar burst not discovered by an Australian group. The Swept-Lobe Interferometer could also be used as a traditional interferometer by by-passing the swept phase-changer. In this mode it was used by Bernard Mills and A B Thomas in the evenings when the instrument was not required for solar observations. This was Mills' first foray into cosmic research, and he and A B Thomas tried to determine an accurate radio position for Cygnus-A (which at the time had not been associated with an optical counterpart). Mills identified a faint extra-galactic nebula near the position of the source, but was talked out of publishing this by Rudolf Minkowski, as he considered the positional error too large. When F Graham Smith (1951) later provided a more accurate position, Baade and Minkowski (1954) found the association suggested by Mills to be correct.

Christiansen relocated to Potts Hill in time to observe the 1 November 1948 partial solar eclipse. Observations were carried out at Strahan in Tasmania and at Rockbank in Victoria, as well as at Potts Hill, and this allowed the teams to use triangulation in order to determine accurate positions of the localised sources of solar radio emission at 600 MHz. The eclipse observations provided further evidence that the sources of enhanced solar radiation often originated above sunspot groups. This was Christiansen's first major solar research project (Christiansen et al, 1949). The main instrument used at Potts Hill for these observations was the 4.9- × 5.5-m paraboloid that had originally been at Georges Heights. This instrument was also used in 1951 by Christiansen and Hindman to confirm the existence of the 21-cm hydrogen line (H-line), only 15 weeks after they were notified of Ewen and Purcell's discovery in the US. Christiansen and Hindman (1952) went on to carry out the first H-line survey of the southern sky, and they produced the first radio evidence for the existence of spiral arms in our Galaxy.

To further exploit the discovery of the H-line it was decided to build a dedicated survey instrument at Potts Hill. Although initial consideration was given to purchasing a large single dish instrument, it was decided instead to build an in-house designed 11-m parabolic dish on a transit mounting. Construction was completed in 1953. Frank Kerr had been at Harvard at the time of the H-line discovery, and he returned to Sydney to lead the 21-cm program. Eventually a 4-channel receiver was bought into operation, and surveys were conducted of the Magellanic Clouds and the southern sky. The Potts Hill southern sky survey was combined with the Dutch northern sky survey to produce the famous Sydney-Leiden H-line map of our Galaxy (see Figure 3).

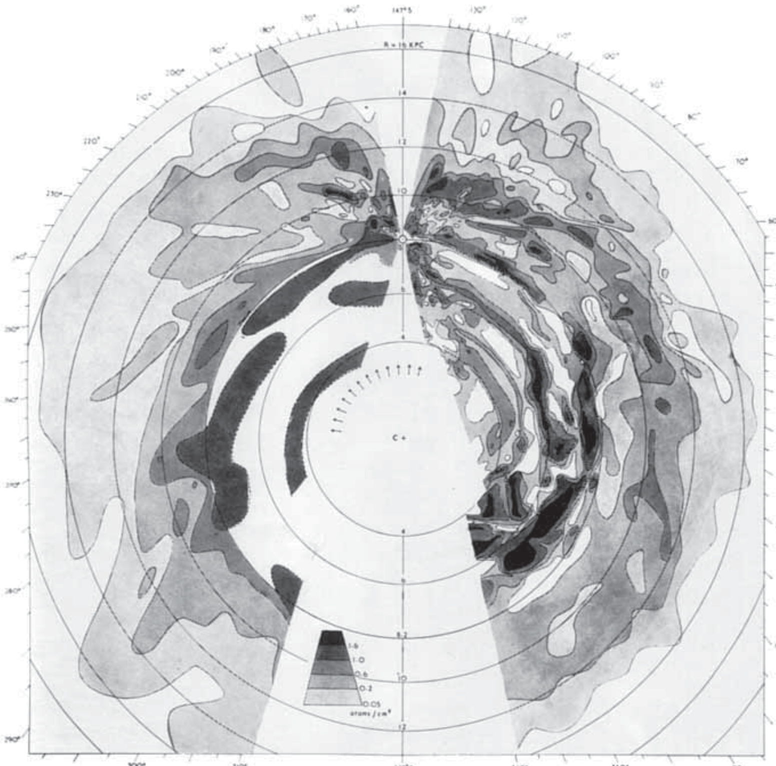


Figure 3: The combined Sydney-Leiden 21-cm map showing the density distribution of neutral hydrogen in the Galactic Plane. The maximum densities in the z direction are plotted on the Galactic Plane and the points of common density are joined by contours.

Photo: (CSIRO Radiophysics Photographic Archive; B5445)

After the initial H-line survey Christiansen returned to solar research. Spurred on by the frustration of using eclipses for high-resolution solar observations, Christiansen invented the Solar Grating Array which is analogous to an optical diffraction grating. The first array consisted of 32 × 1.7-m solid metal parabolic dishes mounted along an east-west baseline on the banks of the Potts Hill reservoir. The cost of construction was kept to under £500! The array was used to produce daily high-resolution one-dimensional scans of the solar disk at 1,410 MHz. This innovative radio telescope provided conclusive evidence of limb-brightening at 1,410 MHz and further data on the association between sunspot groups and solar radio emission. The solar work carried out at Potts Hill, together with the research on solar bursts conducted at Dapto by Paul Wild and his team ensured that Australia would play a leading role in solar radio astronomy for the next three decades.

Christiansen later added a new Solar Grating Array on a North-South baseline at Potts Hill, and by using data from both arrays over an extended period he was able to produce a two-dimensional image of the Sun at 1,410 MHz (Christiansen and Warburton, 1955). This involved the laborious hand calculation of Fourier transformations, and it took nearly six months to produce a single image! Although this was not the first reconstruction of the two-dimensional distribution of emission across the solar disk in radio astronomy, it was the first time that Earth rotational synthesis was used. The E-W grating array was later modified by Govind Swarup and R Parthasarathy to operate at 500 MHz, and ultimately the array was donated to India where it became the Kalyan Radio Telescope.

Mills' early experience with interferometers at Potts Hill and Badgery's Creek inspired him to develop a new type of radio telescope which became know as the Mills Cross. This design had the advantage of combining the high resolution and the relatively low construction cost of an interferometer (when compared to a large single parabolic dish), while still producing a pencil beam response with comparable sensitivity at metre wavelengths. In 1952 there was some scepticism within Radiophysics that Mills' design would actually work and so a prototype was built at Potts Hill (see Figure 2) to test the concept. This low-cost prototype (Mills and Little, 1953) had arms 36.6-m in length and operated at 97 MHz. Not only did the design prove viable, but the early observations produced the first detection of continuum radio emission from the Magellanic Clouds.

Although solar and H-line work dominated much of the research at Potts Hill, important continuum observations of discrete sources were also made. In 1950, Jack Piddington and Harry Minnett (1951) used the 4.9- × 5.5-m paraboloid to identify the discrete source Sagittarius-A, that is associated with the centre of our Galaxy. They also discovered Cygnus X, and made what is perhaps the first identification of an extended radio source that is associated with an HII region. In 1956 the 11-m Transit Telescope was used by Piddington and Trent for a 600 MHz continuum survey of the southern sky and their observations, together with those provided by the H-line survey formed part of the dataset that was used by the International Astronomical Union in 1960 to redefine the galactic co-ordinate system. Hindman and Wade also carried out observations of the Eta Carinae Nebula (NGC 3372) and Centaurus-A at 1,400 MHz.

Potts Hill also played a small part in part in the investigation of Jovian bursts at 19.6 MHz, in a spaced receiver experiment that was conducted by Alex Shain and Frank Gardner and also involved the Fleurs field station. Potts Hill was also used as a test site for trials of the aerial developed for the Chris Cross solar crossed-grating interferometer that would later be constructed at Fleurs field station. In addition, during the late 1950s, some early operational trials of a maser receiver were carried out at Potts Hill.

Many of the pioneers of Australian radio astronomy spent time at Potts Hill, and by 1952 it had superseded Dover Heights as the major field station of the Division of Radiophysics. Ultimately, lack of space and the encroachment of the suburbs of Sydney (with a consequential increase in radio interference) meant that research had to be shifted to other field stations. In late 1961 the last of the solar monitoring at Potts Hill was transferred to Fleurs, and the following year the Potts Hill field station was decommissioned, bringing to an end 15 extremely productive years of research and developments in instrumentation. This signalled the end of an era, and with the construction of the 64-m Parkes radio telescope, Australian radio astronomy began a new era of "big science" projects.

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# Australian Square Kilometre Array Pathfinder (ASKAP)

Diana Londish, Carole Jackson, Dave DeBoer, Juan-Carlos Guzman, Phil Crosby and Ross Forsyth (ATNF)

## ASKAP Science Survey Projects

Last November a call for Expressions of Interest (EoIs) to submit proposals for an initial set of ASKAP Survey Science Projects was released to the international astronomy community. EoIs are the first of a three stage process to define large Survey Science Projects that will utilise approximately 75% of ASKAP's observing time during the first five years of its science operations.

By the 15 December 2008 deadline a total of 38 submissions from 10 different countries (608 investigators) had been received. Following evaluation of the proposals, 29 were selected as viable Survey Science Projects and the teams have now been invited to submit a full Survey Science Project proposal. These are due on 15 June 2009 and they will be reviewed by a one-off Survey Science Project Assignment Committee.

## ASKAP Draft User Policy, Science Operations and Archive

In October 2008 a Draft User Policy for ASKAP was drawn up after consultation with the general astronomy community as well as specific input from the Australia Telescope Steering Committee. Full details can be found on the web page *www.atnf.csiro.au/projects/askap/policy.html*

A document outlining the functional requirements of the ASKAP Science Archive Facility is also in preparation, and talks to determine ASKAP Science Operations have commenced.

## ASKAP Antennas

The antenna contractor, CECT 54 in Shijiazhuang, China, have successfully concluded the design phase of the contract during which all EM, structural, mechanical and manufacturing design tasks were completed on time and to the satisfaction of the CSIRO antenna team. Manufacture of the first antenna commenced in March 2009, and is expected to be ready for factory acceptance testing in August 2009. This is a very ambitious schedule, but the milestones achieved by CETC 54 to date have given the antenna team every confidence that the remainder of the antenna delivery will also be on time and to specification. It is anticipated that the first antenna will arrive on site in Western Australia at the end of October 2009.

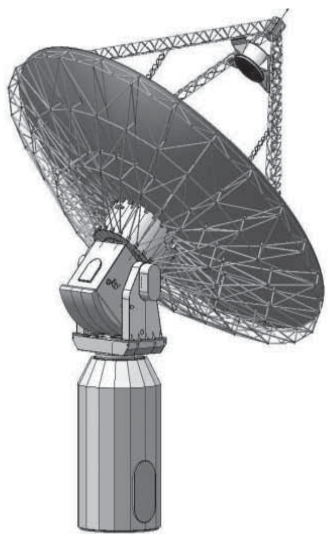
## Antenna Report

ASKAP antennas will have a conventional Alt-Az antenna mount with an additional third polarisation axis ("sky mount"). The polarisation axis bearing is located at the base of the reflector hub; thus the entire reflector, quadrupod and phased array receiver assembly can rotate as a unit. This ensures that both the phased array receiver and the antenna sidelobes maintain a constant parallactic angle on the sky during observations.

The antenna is designed to achieve a 30- arcsec pointing accuracy, with a 2-arcsec or better alignment between the optical axis and polarisation axis. The antenna will operate within specification in winds up to 45 km $h^{-1}$ and will survive at stow in winds up to 160 km $h^{-1}$.

The dish is 12 m in diameter and is an unshaped paraboloid. The f/D is 0.5; this describes the focal ratio and sets the distance from the hub to the apex (focus) as 6 m. The CSIRO developed phased array feed receiver, a package weighing about 200 kg, needs to be supported within a set of strict operating tolerances to meet the demands of high dynamic range astronomy. This stability is provided via the quadrupod feed support structure which includes a set of secondary supporting struts.

The pedestal and mounts are conventional steel fabrications and the total structure weighs around 30 tonnes. The antenna structure is designed to be sealed against the dust and sand of the very tough operating environment. All the axis drive motors, gearboxes and gears will be located on the inside of the assembly, with effective sealing of all bearings, access covers



ASKAP antenna CAD design.

Image: Ross Forsyth

SAPKAP pedestal in the Marsfield workshop.

Photo: Tony Crawshaw, CSIRO

and even the doors of the pedestal and elevation enclosure. The reflector is also of conventional mechanical design, being made up of 36 stretch-formed aluminium panels mounted on a steel truss back-up structure. The reflector surface accuracy will be at least 1 mm rms, and therefore support radio astronomy observations up to 10 GHz.

Due to the challenge of integrating a whole new system at the remote ASKAP observatory ATNF commissioned Wild Sets, a film set company, to build a model dubbed "SAPKAP" (so named because it's made of wood). SAPKAP is the ASKAP antenna integration model; it is a full-scale model of the ASKAP pedestal, mount and hub to enable the project teams to learn how to set up a working ASKAP antenna before heading out to remote Western Australia to kit out antenna one (and onwards to 36!).

## Phased Array Feeds and Digital Systems

Progress on the design and understanding of the phased array feed continues to be made using sophisticated numerical modelling of the integrated system performance, including the feed elements, integrated low-noise amplifier and receiver, and the performance within the optical system. The phased array feed has been off the 12-m Parkes Test-bed Facility (PTF) for a while to be retrofitted for better thermal regulation, as well as newly designed amplifiers. A series of comprehensive tests at the Marsfield site are on-going, after which the array will be redeployed at the PTF. In the meantime, the 12-m antenna is in use by astronomers with another feed that had been used in earlier testing.

The digital system has progressed very well. The digitiser has been fabricated and is under test, and the full firmware has been fleshed out for the digitiser and beamformer, and a prototype environment is being developed. The digital system installed on the PTF has now demonstrated a full noise covariance matrix on all channels.

## ASKAP Computing

In the first quarter of 2009 the Computing project group finalised the ASKAP monitor and control software architecture. Internet Communication Engine (ICE) middleware was chosen as the communication bus for the top-level architecture and *EPICS* was selected as the software framework for the monitoring and control system

The Central Processor has also been a major focus, and end-to-end processing of simulated ASKAP data is proceeding. Time allocated on CSIRO computing clusters is being used for testing the scaling of ASKAP software to large numbers of cores, and for large scale end-to-end tests.

In March 2009 a call for expressions of interest to collaborate with CSIRO on a Single Digital Backend (SDB) was released. If adopted the SBD would replace much of the custom digital hardware in the beamformers and correlator with a high performance computer running code written in a high level language. The thesis being tested is that for SKA we can in this way avoid building custom hardware on a massive scale.

## Murchison Radio-astronomy Observatory (MRO)

Progress on establishing the Murchison Radio-astronomy Observatory in Western Australia continues with the major land-tenure agreements to use the MRO site close to being finalised. Work is now underway to produce tender documents for the design of support and infrastructure facilities at the MRO and in Geraldton. A heritage survey of the relevant areas of the MRO was performed in mid January 2009.

Upgrades to site communications have been carried out, and include installation of a general purpose office PC and a security camera. Pastoral-use radio systems which may have caused interference to on-site astronomy experiments have been removed or replaced. Radio frequency interference monitoring is ongoing, and initial results confirm the superb radio-quietness of the site as well as the equipment currently deployed there.

In March 2009 a group of aboriginal artists paid a visit to the MRO as part of International Year of Astronomy outreach activities. Scientists from ICRAR and the local art community exchanged stories of the sky and the resultant artwork will be featured at an upcoming art fair.

## SKA Forum, Cape Town

The 2009 International SKA Forum was held in Cape Town, South Africa, in February. The Forum brought together astronomers and representatives from governments and funding agencies from around the world. Specialist meetings were also held to discuss the design, construction and science goals of the telescope.

The forum was opened by South Africa's Minister of Science and Technology, Mr Mosibudi Mangena. In his address he announced a new collaborative science program between South Africa's MeerKAT telescope and the Australian SKA Pathfinder that will enhance the scientific impact of both pathfinders and contribute to advancing the international SKA program overall.

Presentations on behalf of Team Australia were given by the Hon Troy Buswell, Western Australia's Minister for Science and Technology, Prof Brian Boyle, CSIRO's SKA Director, and Dr David DeBoer, ASKAP Theme Leader. These talks highlighted the successful development and testing of Phased Array Feed (PAF) receiver technology by CSIRO engineers, and the ongoing work to establish Australia's SKA candidate site in Western Australia. Senator Kim Carr, Federal Minister for Innovation, Industry, Science and Research, also addressed the Forum via a pre-recorded message.

The two CEOs from the Mid-West Development Commission and City of Geraldton-Greenough also attended the Forum, together with three indigenous representatives, the aim being to demonstrate Mid-West regional and community support to help secure the SKA project for Australia.

## ASKAP Industry Engagement

ASKAP's industry engagement activities continue to strengthen thanks to the ongoing support of the Australian SKA Industry Consortium (ASKAIC) which offers practical help in planning for industry involvement.

Briefings on the infrastructure plans for the Murchison Radio-astronomy Observatory (MRO) were given by ASKAP team members (Ant Schinckel, Graham Allen, Carole Jackson and Phil Crosby) in Sydney and Perth in early February, with more than 80 and 170 attendees respectively. These briefings are opportunities for discussions between industry representatives, CSIRO, associated research institutions, and Government personnel. Continuing this theme, Ministers Kim Carr, (DIISR) and Parliamentary Secretary to Treasury; Commerce, Science and Innovation, Barry House (WA Government) jointly hosted an ASKAP/SKA industry gathering at Perth's Convention Centre on 25 March 2009. This was also well attended by Western Australia's astronomy and business communities.

Several ASKAIC members attended the SKA Forum in Cape Town: The forum and its associated side meetings were relevant to industry engagement at both the pathfinder and full SKA level—in particular the PrepSKA WP5 working group which is focussed on international industry participation and procurement.

Phil Crosby at the Australia Telescope Compact Array

Photo: CSIRO

The Industry Opportunities Register is regularly updated and is available via the ASKAP industry web pages. As the project moves through various procurement stages, Requests for Tenders (RFTs) are announced on the ASKAP website together with any supporting information, as well as being listed on the AusTender website. The on-line SKA Directory is still growing with over 400 businesses now registered, indicating strong local interest and capability.

At the strategic level, industry engagement has continued apace, with:

- The Boeing Company under the CSIRO-Boeing Joint Technical agreement has advised on best practice, including a "lessons learned" session with Boeing's Geraldton facility management. An "arm's length" team (from Boeing's Korean plant) conducted stage one of a free, independent systems review of ASKAP, with stage two likely to occur in October this year;

- Raytheon Australia has generously offered places on their certified systems engineering course;
- Negotiations with Cisco have resulted in Charles Smith being seconded to ASKAP as a specialist systems engineer working with Shaun Amy;
- Horizon and Lycopodium are two WA companies assisting the ASKAP team with possible options to provide sustainable energy source(s) at the MRO.

## CSIRO provides industry specialist for SPDO

Business Strategist for CSIRO's Australia Telescope National Facility, Phil Crosby, is joining the SKA Program Development Office (SPDO) in Manchester University, UK. Phil will be the Manager - Industry Participation Strategy as an embedded specialist for at least two years. SPDO's role was formalised in 2007 to focus international efforts in the project and, in particular, to develop the science case, engineering system design, site proposal process, deployment plan, and a global industry engagement approach.

# OCE Postdoctoral Fellowship Success

Robert Braun (ATNF)

Demonstrating its research strength, ATNF was recently notified that its two latest proposals submitted to the CSIRO Office of the Chief Executive (OCE) Postdoctoral Fellowship Program had been accepted.

Since commencement of the Program in 2006 – 2007, ATNF has been awarded six OCE Postdoctoral Fellowships from just six submissions, an incredible 100% success rate. Twice a year, CSIRO Divisions and Flagships are invited to submit proposals for OCE postdoctoral fellow positions, with the OCE Science Team providing a grant of $90,000 p.a. for three years for each postdoctoral fellowship. Once a proposal has been accepted, the most qualified candidate is then recruited. The program is one of a number of CSIRO initiatives that aims to encourage, promote and support science through development of scientists and communication of science.

Robert Braun, Astrophysics Research Program Leader for the ATNF explained, "The OCE postdoctoral program provides an excellent opportunity for early career researchers to build careers in the most exciting research directions, while providing a substantial boost to the scientific productivity of our group by doubling the number of fellows that we can support. Both the opportunities and the needs are now particularly acute with the ASKAP call for large Survey Science Projects that has just been released: *wwwatnf.atnf.csiro.au/projects/askap/users.html*. Our Astrophysics group aims to provide between half and one FTE of support to each of the major areas where ASKAP surveys will be undertaken. The successful fellows from the current OCE round will have the opportunity to be involved with two of the most exciting and fundamental of topics that will be revolutionised by wide-field ASKAP surveys, namely cosmic magnetism and the evolution of neutral gas. In each of these fields we can confidently predict a 100-fold improvement in capability over that which exists today. This jump in capability represents an enormous discovery potential, of a magnitude only seldom encountered in any branch of science. Our OCE Fellows will be in a prime position to ride this wave of discovery. We expect to be able to extend our support of ASKAP surveys with several additional appointments in other research areas over the coming year."

Proposals are assessed against a number of criteria, including science potential and its importance to Australia.

### Proposal successes and Fellows

- *Pulsars*—Patrick Weltervrede (PhD, University of Amsterdam)
- *Evolution of Galaxies*—Angel Lopez-Sanchez (PhD, Instituto de Astrofísica de Canarias, Tenerife)
- *Reaching Deep into the Radio Sky*—Emil Lenc (PhD, Swinburne University of Technology)
- *Star formation through cosmic time*—James Urquhart (PhD, University of Kent)
- *Exploring the magnetic universe with the Australian SKA Pathfinder* (Yet to be recruited)
- *Mapping the HI Universe* (Yet to be recruited)

# Pulse@Parkes: A Month of Pulsar Observing with the ASKAP Test-bed Antenna

G Hobbs, R Hollow, M Kesteven, M Keith, D Champion and J Reynolds (ATNF)

More than 200 high school students have now carried out pulsar observations using the Parkes 64-m telescope as part of the PULSE@Parkes project. The students, and their teachers, have gained a basic understanding of "the life of a scientist", they have controlled an icon of Australian science and have a better feeling for the importance of their science teaching at school.

The project is on-going and we have already filled all the available observing slots for the current observing semester. However, we have had a huge interest in the project from schools around Australia that cannot come to Sydney to carry out an observing run. We are therefore planning to develop the project in three ways. First, we intend to develop the remote observing capabilities to allow us to run a PULSE@Parkes session from anywhere in Australia (and perhaps overseas). Second, we wish to provide some educational data sets allowing students around Australia to use real observations from a radio telescope. Third, the

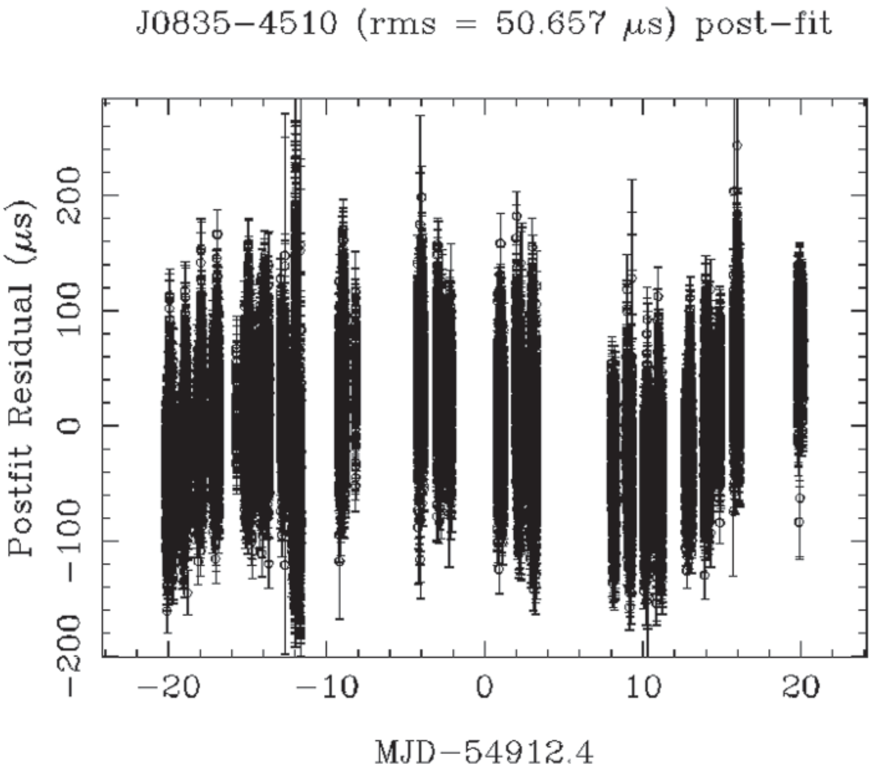



Figure 1: Vela timing residuals from observations with the ASKAP 12-m test-bed antenna The data sets will be made available on the PULSE@Parkes websites with a range of on-line projects that will let the students interact with the data. We hope that our small project will allow us to develop remote observing capabilities, obtain useful scientific data and provide a new aspect of the PULSE@Parkes project. We also are considering further educational/scientific projects that could be undertaken with the 12-m antenna, such as getting students to observe the HI line and would be interested in any other suggestions.

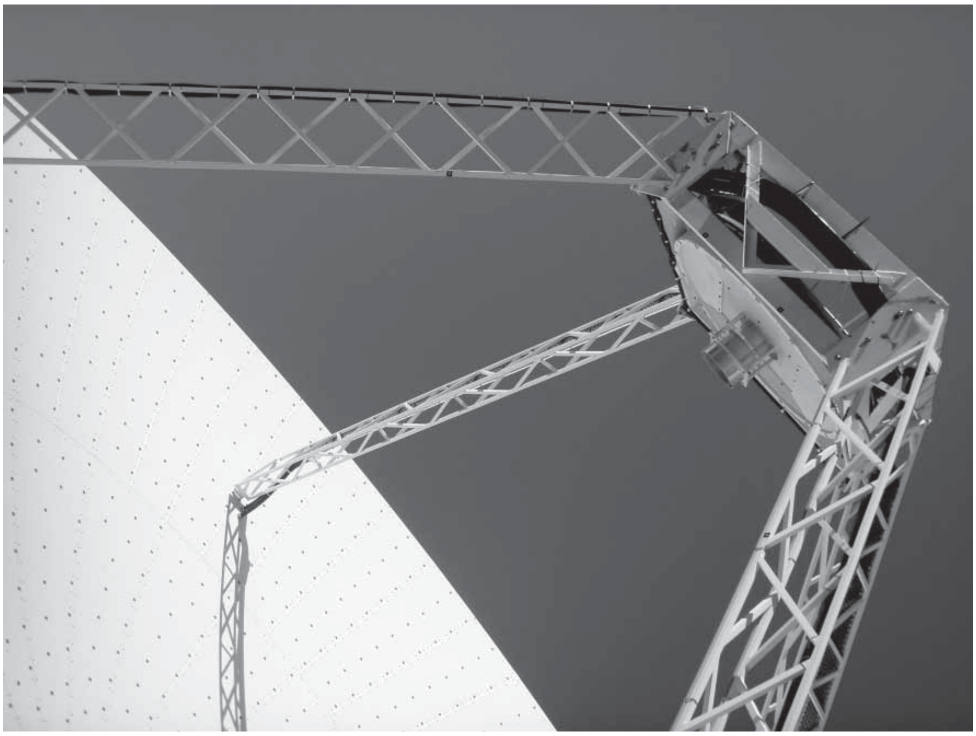


Figure 2: The 12-m ASKAP test-bed antenna at Parkes

Photo: George Hobbs

PULSE@Parkes project is a prototype for outreach projects using the Australian Square Kilometre Array Pathfinder (ASKAP) telescope.

To aid in these developments we have begun carrying out regular observations of a few, bright pulsars using the 12-m diameter ASKAP test-bed antenna situated at Parkes. Currently, this antenna has a 20-cm feed providing 20 MHz of bandwidth. This will soon be replaced with the focal plane array system being designed for the full ASKAP system. The pulsar observations are currently recorded using a refurbished ATNF digital filterbank system (PDFB2) and stored on disk at Epping.

We are developing control software that allows the standard telescope control software to drive the 12-m antenna. When complete this will allow us to enter a list of the pulsars that we wish to observe. If one pulsar has not yet risen then the software will automatically move to the next pulsar and the schedule will be repeated until the antenna is required for ASKAP testing.

We have decided to concentrate mainly on observing the Vela pulsar. This pulsar is bright (and can be detected within only a few seconds of observing) and shows interesting "slow-down" behaviour. It glitches (a sudden increase in rotation rate) and exhibits timing noise (an irregular noise-like slow-down). It was monitored almost continuously for more than 20 years using the 14-m diameter Mt Pleasant Observatory antenna in Tasmania. Unfortunately the program was stopped for a few years and so, until the observations with the 12-m antenna described here, this pulsar has only been erratically monitored. Vela's brightness allows us to determine pulse arrival times every 30 seconds (see Figure 1). If a glitch occurs we will be able to use this time resolution to study the decay of the glitch and get precise measurements of the pulsar spin up. In turn this will allow us to probe the interior of the neutron star.

# Unraveling the Mysteries Surrounding the Life and Death of the Most Massive Stars

Franz Bauer (Columbia University), Christopher Stockdale (Marquette University), Norbert Bartel (York University) and Vikram Dwarkadas (University of Chicago)

Massive stars shed significant amounts of their hydrogen envelopes prior to exploding as supernovae (SNe). The exact nature of this evolution is not well understood and can best be probed with radio and X-ray observations, which detect emission associated with interaction of the SN blast wave and the circumstellar medium (CSM) established by the progenitor star.

The emission arises from the shocked interaction region between the forward and reverse shocks; radio from the forward shock, X-rays from both. The strength of this emission scales with both to the initial blast wave velocity and the density of the CSM. Moreover, because the blast wave velocity is typically ~100 – 1000 times faster than the progenitor's stellar wind velocity, the shock can overtake substantial portions of the CSM on human timescales, acting as a "time machine" to probe the last ~$10^4$ yrs of the progenitor's mass-loss history. However, with current instrumentation only a small fraction of known SNe manifest interactions strong enough to produce detectable radio and X-ray emission; there have been less than 20 well studied core-collapse SNe, regardless of type, over the last 30 years. This scarcity makes the discovery of SN1996cr all the more exciting.

SN1996cr is one of the closest SNe to have gone off in the past three decades and the strongest radio SN ever discovered. It is located in the Circinus Galaxy, just 3.7 Mpc away from us (Koribalski et al. 2004) and thus provides exceptional observational possibilities to investigate the aftermath of the explosion of a star in detail. Figure 1 shows the Circinus Galaxy with the SN located 25" south of the nucleus. Figure 2 shows a preliminary image of SN1996cr made with the Australian Long-Baseline-Array (LBA) at 22 GHz in 2007. However, despite its proximity SN1996cr exploded unnoticed and unidentified for many years. The fact that this SN remained unknown for so long was due at least in part to Circinus' low Galactic latitude (b=4°), but also because of its unusual evolution.

SN1996cr was initially identified as a variable ultraluminous X-ray source (Sambruna et al. 2001; Bauer et al 2001), and only confirmed as a strongly-interacting SN (a so-called Type IIn) several years thereafter with the European VLT (Bauer 2007; Bauer et al. 2008). Fortunately, the Circinus Galaxy hosts a powerful Compton-thick AGN and prodigious star formation, and SN1996cr thus benefited from a wealth of radio, optical, and X-ray archival

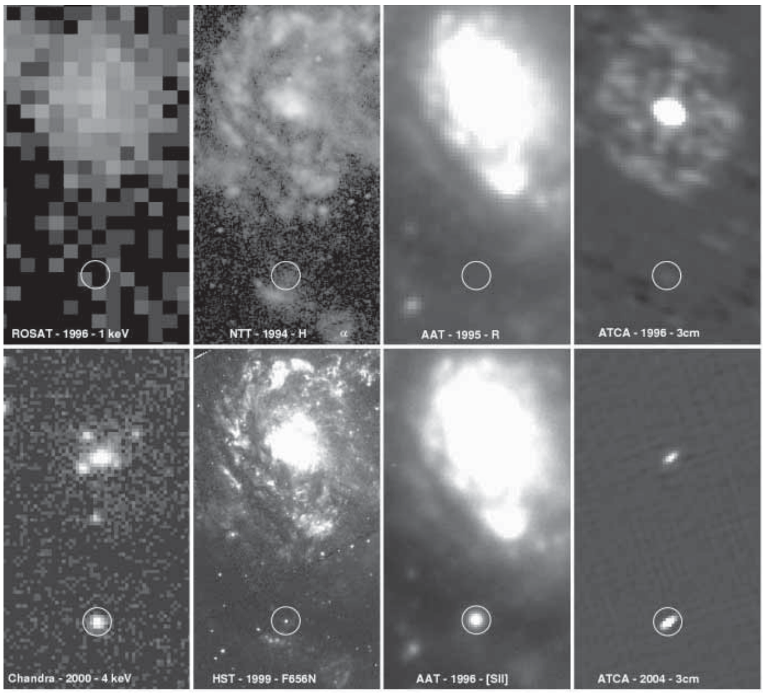



Figure 1: Observations of SN1996cr and its host galaxy at X-ray (left column), optical (middle columns), and radio wavelengths (right column) shortly before or around the time of the SN explosion (upper panel) and several years after the explosion (lower row).

data taken for other purposes. This dataset has been used to constrain the explosion date to a one year window using Anglo-Australian narrow-band imaging and reconstruct respectable radio and X-ray light curves, which are shown in Figure 3a (see next page).

When detected, the radio and X-ray light curves of core-collapse SNe typically exhibit a $\sim t^{-1.0\pm0.5}$ decline in both bands (Weiler et al. 1986, Immler & Kuntz 2005, Soderberg 2007). This standard evolution is thought to stem from the blast wave interacting with a progenitor wind of constant mass and velocity, which results in an $R^{-2}$ density profile (e.g., Chevalier 1982, Chevalier & Fransson 1994). The intrinsic radio emission is often complicated by initial free-free absorption and/or synchrotron self-absorption due to ionised circumstellar material close to the progenitor, while the soft X-rays could be absorbed by dense material anywhere along the line of sight. As the blast wave expands outward, this radio absorption decreases and leads to a frequency-dependent "turn-on" that extends over ~1 dex in the time domain.

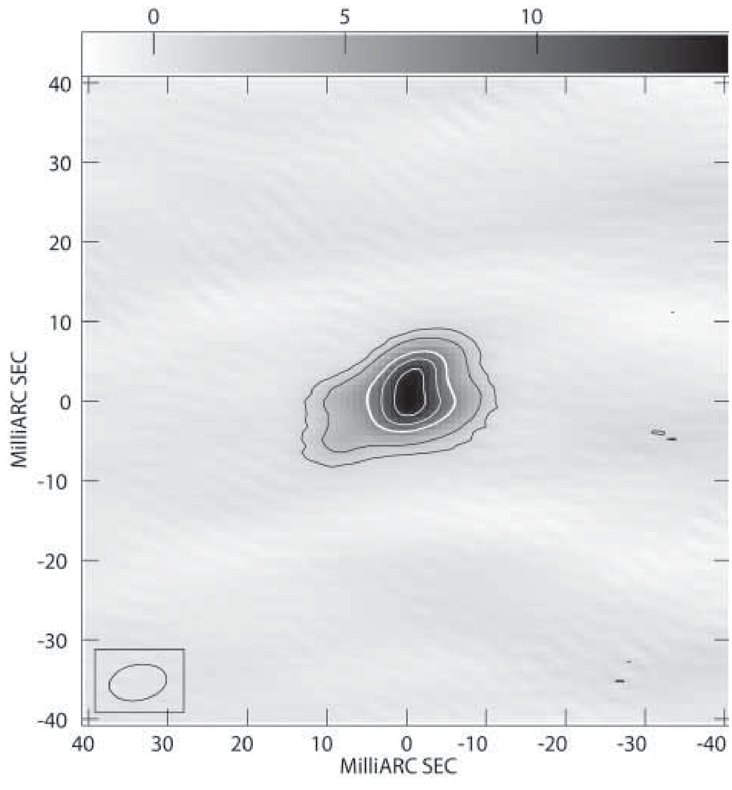



Figure 2: Preliminary Long Baseline Array image of SN1996cr at 22 GHz (Bartel et al. 2009, in preparation). The SN is resolved with a diameter of 10 mas, which equates to $\sim 5 \times 10^{17}$ cm at the distance of the Circinus Galaxy.

In Figure 3a, SN1996cr shows evidence for such a gradual "turn-on" like other radio SNe below 3 GHz, but also requires a luminosity jump of >1000 roughly two years after the explosion to adequately explain its strong, achromatic rise at 4 – 8 GHz around days 800 – 1000. A similarly unusual evolution is seen in the X-ray light curve, although its initial rise is not as well sampled. As the radio and X-ray emission both trace the surrounding CSM structure created by the progenitor, these temporal features demonstrate that the CSM density was quite sparse within $<1.5 \times 10^{17}$ cm, but must have jumped several orders of magnitude beyond this radius to perhaps $10^5$ g/cm$^3$. The only viable physical scenarios for such behavior are ones in which the progenitor either ejected a shell of material at some late evolutionary stage [e.g. a Luminous Blue Variable (LBV) explosion ~4000 yr prior to SN; Gal-Yam et al. 2007; Pastorello et al. 2007] or changed from a slow to fast wind state such that it formed a wind-blown bubble (e.g., from a red supergiant to a Wolf-Rayet star ~50 – 100 years prior to SN; Weaver et al. 1977; Dwarkadas 2005, 2007; Chugai & Chevalier 2006). Regardless of the cause, this makes SN1996cr one of a select few SNe that can be physically linked to a massive Wolf-Rayet or LBV progenitor.

From an observational standpoint, SN1996cr can be considered a prototype for late-rising, strongly-interacting SNe, and should provide important clues (and caveats) for interpreting the more distant members of this emerging SN class (e.g. 1996aq, SN2001em, 2004dk, SN2006jc; Stockdale et al. 2007, 2009; Pastorello et al. 2007). Such SNe are relatively rare. Their interaction with the ambient medium, which is presumably formed by mass-loss from the progenitor star, provides unique insight into the late-time mass-loss, and therefore the late evolutionary stages of massive stars, a period which has been difficult to study by other means. There is still much debate, for instance, over the number, duration, and sequence of various phases of stellar evolution (e.g. Lamers et al. 1991; Maeder & Meynet 2000). While our understanding of massive stars has progressed enough to offer testable (albeit model-dependent) predictions about the mass-loss history of SN progenitors (e.g. Langer et al. 1994, Heger et al. 2003), the ultimate test of such models comes from probing the CSM structure in objects like SN1996cr. With enough observational and theoretical effort, specific models tailored to these exceptional SNe should reveal the details of the mass-loss processes in their progenitors (see Figure 3b), which are in turn related to the properties of the progenitors themselves. The strong density changes inferred from these peculiar SNe over such short evolutionary timescales prior to explosion, for instance, are not predicted by stellar evolution models, and thus allow us to explore the lives of massive stars during the last waning years of their existence. When combined with the handful of detected SN progenitors and upper limits (e.g. Smartt et al. 2008), models of CSM-interacting SNe should ultimately strengthen theories of late-time stellar evolution and extend SN-progenitor mapping into the higher mass regime.

In the past year, the radio and X-ray emission of SN1996cr have both shown noticeable declines versus their extrapolated light curves, suggesting that the blast wave has now overtaken the shell. If true, we expect SN1996cr to decline precipitously in all bands. Tracking this eventual fall-off is crucial to understanding our still-emerging physical picture for SN1996cr and to setting strong limits on the initial SN shock velocity and circumstellar structure (density and morphology), which only loosely constrain hydrodynamical models at present (e.g. Dwarkadas 2007).

Because of the small number of radio-detected SNe in general, and the even smaller number of cases where we observe late-rising emission, it remains unclear how common such SNe truly are. In the near-term, the increased sensitivity of both the Compact Array Broadband Backend on the Australia Telescope Compact Array and the upgraded Expanded Very Large Array will substantially improve our ability to search for more examples, while large survey instruments coming online in the next several years such as the Australian Square Kilometre Array Pathfinder, the LOw Frequency ARray, Apertif, and eventually the Square Kilometre Array, stand to routinely detect these unusual SNe and provide more robust estimates on their relative numbers, cadences, and luminosities.

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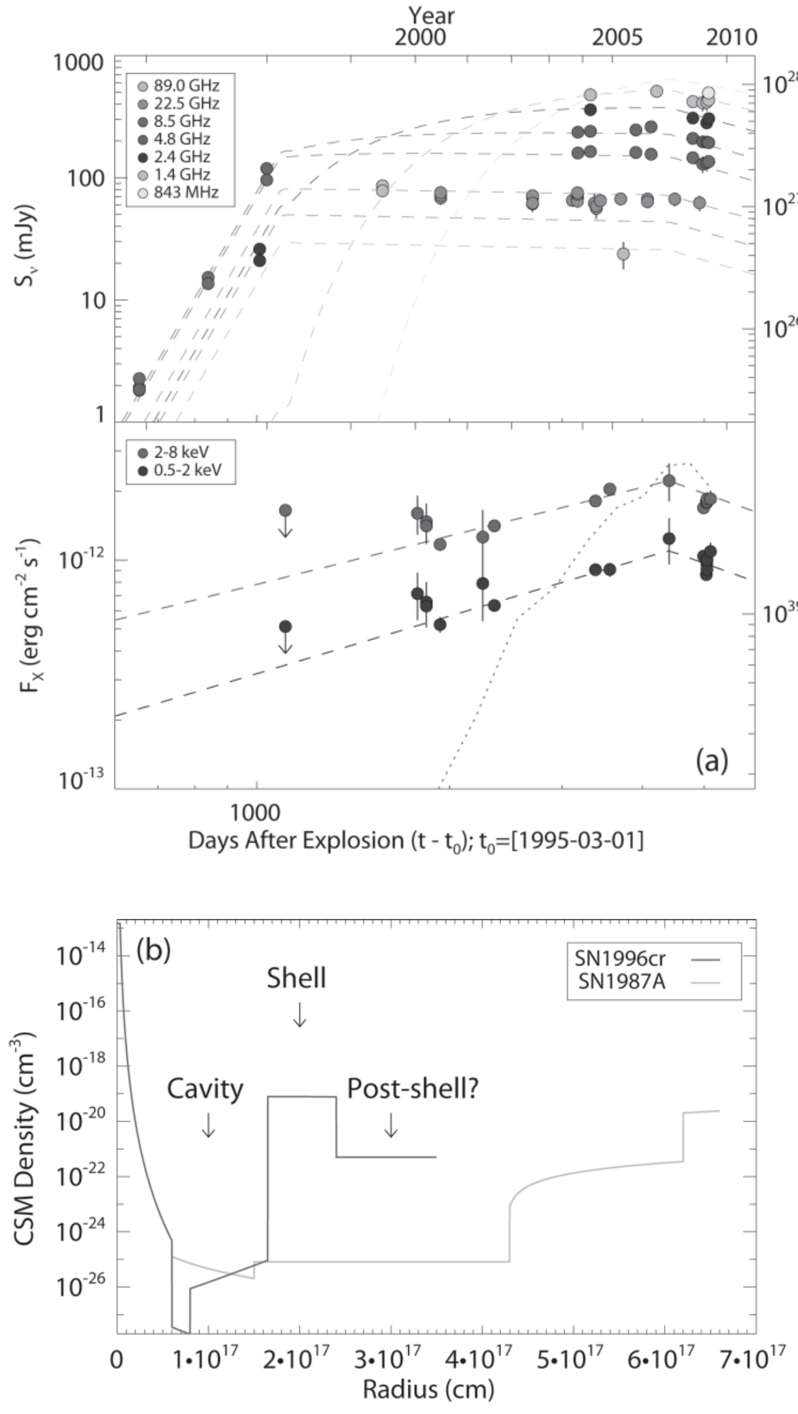


Figure 3: (a) Radio and X-ray light curves with best-fit empirical models (dashed lines) for SN1996cr (adapted from Bauer et al. 2008, with data through March 2009). SN1996cr's light curves distinguish it from other CSM-interacting SNe, which show a gradual decrease in the radio and X-ray as the SNe expand outward. SN1996cr instead shows gradually increasing radio and X-ray emission, to an extent that has not been seen in any other SNe except the famous SN1987A. This atypical emission pattern can be explained by the SN blast-wave impacting with a dense shell ~2 yrs after explosion, a picture similar to SN1987A's expansion into its circumstellar ring, albeit at least three times more compact and currently 1000 times more luminous (Manchester et al. 2002; Park et al. 2006). The dotted line in the X-ray panel shows an initial attempt to model the SN-CSM interaction, using the 1-D CSM density distribution shown in (b). The details of this CSM density distribution still need to be refined to fit the early X-ray light curve better, but since X-ray emissivity is proportional to density squared, further changes will be small compared to the many orders of magnitude shown. Because of it's thermal origin, the X-ray emission is more straight-forward to model than the non-thermal radio, which depends on a variety of poorly-constrained parameters. We show the CSM density distribution from SN1987A (Dwarkadas 2007) for comparison. In SN1987A, the collision of the ejecta with the dense equatorial ring is still being eagerly anticipated by astronomers the world over, as a prelude to a fascinating cosmic fireworks display. A recent downturn in the light curves suggests that SN1996cr may already have overtaken its high-density shell and now be interacting with lower density material again. If true, then SN1996cr should provide important clues about what to expect during the shock-ring interaction in SN1987A.

# S-PASS: the Polarised Southern Sky

Ettore Carretti (ATNF)

S-PASS is currently mapping the diffuse polarised emission of the entire southern sky aimed at investigating the CMB Galactic foreground and the Galactic magnetic field. The project has required a special set-up of the Parkes telescope and is now about 60% complete. Preliminary maps already show interesting new features and structures at all Galactic latitudes.

We report on the S-band Polarisation All Sky Survey (S-PASS), a project to map the diffuse polarised synchrotron emission of the entire southern sky at 2.3 GHz (Carretti et al. 2007). Carried out with the Parkes Telescope, the survey is aimed at investigating two cutting-edge science areas of present astrophysics research: the detection of the B-Mode of the Cosmic Microwave Background (CMB), for which the synchrotron emission is one of the most contaminant terms, and the Galactic magnetic field whose large scale structure is still a puzzle.

The B-mode of the CMB is the signature of the gravitational wave background (GWB) emitted by the Inflation. Still undetected, its level is measured in terms of Tensor-to-Scalar perturbation power ratio T/S and is proportional to the GWB intensity (Kamionkowski & Kosowsky 1998). Its detection would be evidence of both Inflation and gravitational waves and enable us to probe the high-energy physics at densities not accessible to any particle accelerator (e.g. Kinney et al. 2006, Boyle et al. 2006).

The expected signal is weak (the present upper limit is about 100 nK) and can be easily contaminated by the foreground emission of the Galaxy. This issue is so important that it is reckoned as one of the major limiting factors to probe the inflation by CMB. The synchrotron emission leads the foreground budget at low frequency and its intensity is even larger than the present upper limit of the CMB signal also at high Galactic latitudes (Page et al. 2007). An efficient cleaning is thus mandatory and asks for an accurate mapping of the Galactic component.

Also the structure of the Galactic magnetic field is still a big puzzle. The observations show that the ordered component of the disc is arranged along the spiral arms, but several details of the model are still under debate like the number and location of field reversals (e.g. Han et al. 2006, Brown et al. 2007, Sun et al. 2008). The field in the halo is even less understood, essentially for lack of data in this low emitting region. Models have been proposed (e.g. Han 2002) but large local structures like the big radio loops could introduce anomalies jeopardising the interpretation.

A first all sky polarisation survey has been recently completed at 1.4 GHz (Figure 1 and Wolleben et al. 2006, Testori et al. 2008), but it is not sufficient for such studies. Faraday Rotation effects are still relevant at this frequency up to high Galactic latitudes and the thick disc appears strongly depolarised up to $|b|\sim30°$. This prevents the study of the disc, the disc-halo transition and the use of most of the high latitudes for CMB foreground analysis. Moreover, the survey is single frequency and does not allow Rotation Measure (RM) measurements so limiting magnetic field investigations.

To fill this gap of data S-PASS is now observing the entire southern sky at 2.3 GHz with high S/N also in the halo and several frequency channels to enable RM measures. The frequency is high enough to keep under control FR effects down to disc latitudes, as shown by the precursor project Parkes Galactic Meridian Survey (PGMS, Carretti et al. 2008), while the high sensitivity enables both high efficient foreground cleanings and sensitive RM measurements (the expected sensitivity in the halo is about 2 rad/m$^2$ in combination with 1.4 GHz data).

A survey with the characteristics of S-PASS has posed several challenges to make it feasible with a large telescope like Parkes. For instance, for the scientific goals it is essential to detect the signal also in the lowest emission regions, where values of a few mK are expected. This makes the ground emission contamination a serious issue, especially because of the need to preserve the signal up to the largest angular scales for absolute calibration purposes. Another example is the angular resolution, which with its 9 arcmin is a factor four better than that of the 1.4 GHz survey. This gives far more details, but, at the same time, requires four times more scans and observing time to fully sample the sky if conducted with a standard observing mode.

To cope with these challenges a special observing strategy has been designed based on long and fast azimuth scans, whose realisation has required to push several of the telescope systems to their limits (and maybe beyond!). The azimuth scans have been chosen to minimise ground emission pick-up variations, while with their long length (about 110°) cover the entire width of the area to map in one step preserving the information on all the angular scales. This type of scan has required to define a special observing mode based on an uninterrupted sequence of back and forth scans with both no loss of tracking at the turnoff and precise timing to enable a regular gridding of the sky. Finally, the high number of scans has required a high speed to conduct the survey in a reasonable time. This has been pushed up to an unprecedented value of 15°/min, which is a significant fraction of the slewing speed (24°/min). Nevertheless, the pointing accuracy is the same as in normal tracking mode, a remarkable result for a massive 64-m telescope.

The observations started in October 2007, are currently 60% complete, and are planned to finish by end 2009. Figure 2 shows a preliminary map of Stokes Q and represents the first full view of the southern sky at this frequency and resolution. It does not include destriping and absolute calibration, which are in progress, but already shows plenty of details and structures unseen at lower frequencies. The emission is smooth

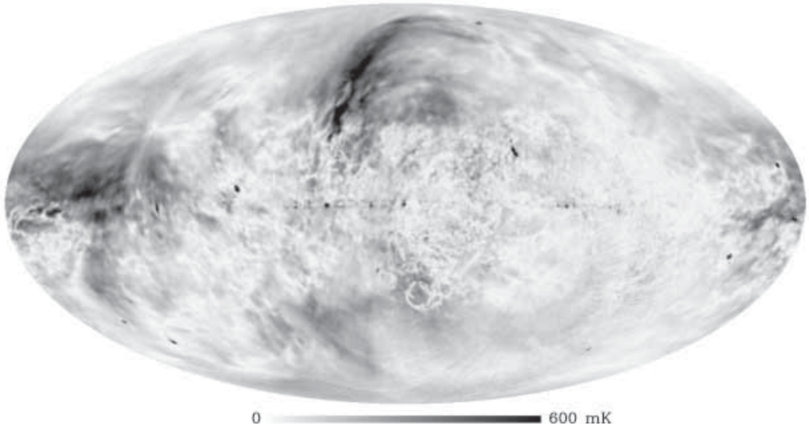


Figure 1: All-sky map of the polarised intensity emission at 1.4 GHz. The image is obtained using both the DRAO (North) and Villa Elisa survey data (South) and is plotted in Galactic coordinates centred at the Galactic Centre using the ***HEALPix*** package (Gorski et al. 2005).

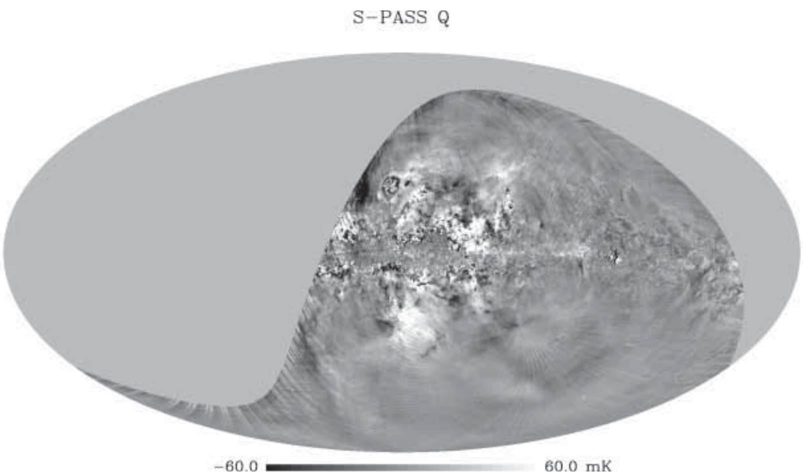


Figure 2: Preliminary Stokes Q map of the survey S-PASS with pixel size of 15 arcmin. No destriping technique is applied here so that some artefacts are still present. In spite of this plenty of details and several features are visible (see text). The application of a destriping technique is in progress and first results have proven very effective. The map is in Galactic coordinates centred at the Galactic centre.

not only at high latitudes but also in the disc down to |b| = 5°–10° even in the inner Galaxy, which enables first investigations of the disc and its transition to the halo. The smooth emission is also evidence of moderate Faraday Rotation effects already in the disc, ensuring that CMB foreground analysis can be safely conducted at high latitudes with our data. On the plane, at both sides of the Galactic Centre, there are two large areas fully depolarised corresponding to two large local $H_\alpha$ emission regions visible in the SHASSA map (Gaustad et al. 2001). At this resolution their view is dramatic: the signal is almost absent and fully depolarised, but it reappears at their edges as a narrow ring of strongly modulated emission, evidence that the FR is lower and cannot fully depolarise but can still strongly modulate the signal. After that narrow transition the signal is smooth, meaning that the FR effects are much less significant. Another region with depolarisation structures and with a counterpart in $H_\alpha$ emission is that at l~5° and b~25°. It is also visible a mottled region within l = [230°, 280°] and |b| < 15° as well as objects like Vela SNR, Centaurus A, Large Magellanic Cloud, and Fornax A. Finally, the halo is featured by very-large scale structures up to the size of the map. These are even more evident in the first maps we have obtained applying the destriping and absolute calibration procedures (which effectively remove the residual stripes) with a very good match with the structures visible in the WMAP 23 GHz data.

In summary, S-PASS is proceeding well, on schedule, and performing as expected. The preliminary results are already very encouraging and promises interesting outcomes in both fields aimed at by the project. The disc emission looks unveiled at last, and promises new insights in the study of this part of the Galaxy, while the S/N at high latitude is already much better than that provided by WMAP and promises both a big improvement in the foreground cleaning efficiency and a better understanding of the large scale Galactic field.

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# National Facility Operations

David McConnell, Jessica Chapman, Phil Edwards and Balt Indermuehle (ATNF)

## Getting ready for CABB

The Australia Telescope Compact Array (ATCA) is currently undergoing its most significant upgrade ever with the installation of the Compact Array Broadband Backend (CABB). In recent months, the preparation for, and installation of CABB has occupied many ATNF staff in the operations and engineering groups. For a report on the CABB progress, see the item in this issue by Phil Edwards (see page 6).

Here we mention a number of activities and changes that have accompanied the main development and installation. Computers and software have been upgraded to cope with both the larger datasets expected from CABB, and the large change in fractional bandwidth that will be available. The main data reduction computer at the observatory has been replaced; the new computer is still called *Kaputar* and has impressive specifications with two quad-core processors equivalent to eight 3.16- GHz CPUs, and 16 GB of memory. Its 20 terabytes of storage will hold data for immediate access by observers. The data will also be transferred over high-speed links to the Australia Telescope Online Archive (ATOA) at the ATNF headquarters in Marsfield. Another 20 terabytes of disk storage has been acquired for Marsfield to provide more user work space and for the ATOA. For CABB data reduction, the *miriad* imaging software is being enhanced to cope with larger datasets, new data flagging requirements, some changes to the data formats, and to help astronomers account for spectral index effects and the change in primary beam across the very large fractional bandwidths.

Compact Array users will notice some changes to observer interface software. Some applications such as *CAOBS* and *CACOR* will look familiar, but with some changes. Other applications, such as *CACAL* and *CAMON,* will disappear and their functions will be provided in other ways. Observing schedules, formerly created with the long-standing *SCHED* program, will be produced by a new web-based application that can support the future use of "zoom" modes in the new correlator.

The ATCA users guides are now being rewritten to take into account the changes relating to the CABB upgrades, and to update the structure and presentation of the user documentation. The new ATCA Users Guide will bring together information previously spread across rather too many documents and will be easier to access and search for relevant information.

Despite the effort going into CABB work, ATNF telescopes have continued to operate reliably over the past six months. Estimates of telescope time lost due to system failures of various kinds (Parkes: 2.1%; ATCA: 2.4%; Mopra: 3.3%) are typical for ATNF facilities and fall well below our target of 5%. The slightly higher figure for Mopra resulted from a continuing and puzzling problem within the telescopes power systems, and a particular computer-related episode that interrupted observing for some hours. This last issue has been alleviated with the replacement of Mopra's main observing computer *Bigrock*.

## Future Operations

Planning for the future ATNF operations began in 2007 in response to the anticipated changes needed for the addition of the Australian SKA Pathfinder (ASKAP). By 2012 the ATNF will be operating four world-class observatories; our current facilities, the ATCA, the Parkes and Mopra radio telescopes, and ASKAP.

The ATNF Future Operations Plans are discussed in the document *Future ATNF Operations (version 2)* available at *www.atnf.csiro.au/observers/planning/Future_ATNF_Operations_v2.pdf.*

Over the past six months planning has continued at a more detailed level, and some changes have been implemented. A central aim of the planning is to reduce operating costs by adopting common approaches across the observatories wherever possible. As an example, the visitors' lodges at Narrabri, Parkes and Marsfield are now administered using the same booking system rather than three different systems. Changes are underway towards a unified management of all observatory software; software source files and management scripts are being progressively transferred to *subversion*, a version control system that offers ready access to all members of the distributed software team.

The Future Operations plans also aim to lower operating costs by modernising, and in some cases automating, some of the systems on the Parkes telescope. These changes will make routine operations easier (for example, by giving more remote access to the focus cabin and reducing the need to climb the ladder) and increase the opportunity for remote control and monitoring of the whole observing system.

The fleet of receivers at Parkes is now being reviewed with the intention of rationalising the set of receivers, without compromising the spectral coverage offered. We are considering decommissioning some of the older packages that are becoming hard to operate and maintain, and are investigating the feasibility of the following upgrades:

- A coaxial 3/13-cm receiver produced from modifications to the existing 3-cm receiver (Mars) package;
- A 6-cm receiver (to include the 6.7 GHz methanol frequency) produced from an existing package (the K/KU receiver) with a new Low Noise Amplifier;
- An improved H-OH feed with modifications to make this receiver useful for pulsar timing projects.

These plans will be discussed with the user community in May 2009 and will be made available for comments from the full user community via the ATNF web site.

The ability to support user-supplied instrumentation on Parkes will be retained. The photograph below shows the installation of a 300 – 900-MHz receiver on the telescope late last year. This receiver was used on Parkes by Maik Wolleben and Tom Landecker of the Canadian Dominion Radio Astrophysical Observatory in their first observing session for the Global Magneto-ionic Medium Survey (GMIMS) project, which aims to measure sky polarisation over both hemispheres from 300 to 1800 MHz.

Installation of a 300 – 900-MHz receiver on the Parkes 64-m radio telescope. The wideband feed is based on the Eleven Feed, designed by Per-Simon Kildal of Chalmers University, Sweden.

Photo: Maik Wolleben, CSIRO (See also front cover page)

## Mopra remote observing

The ATNF has gained valuable experience with operating a telescope at a remote site by operating the Mopra radio telescope from the Narrabri Observatory. Since initial tests in mid-2006, most Mopra observations have been taken from Narrabri.

To provide a robust observing environment, Mopra observations are taken from Narrabri using Virtual Network Computing (VNC) connections. If a brief network disconnection occurs the observations are not interrupted and it is only necessary to reconnect the local client. For a longer disconnection, the Mopra telescope finishes the observing run and then parks itself automatically.

Protecting the telescope systems is paramount when remote observing. Some of the system safety was already provided by MAPS, the primary monitoring system (see Figure 1, the Control Loop), equivalent to the PMON system used for the Compact Array. A level of software logic (called mopra_protect) was added to implement a number of intelligent safety measures. These include fully automated generator and hardware stow control that prevent the telescope from being driven during lightning and storms.

Mopra observers are encouraged to arrive at Narrabri with enough time before their observations start

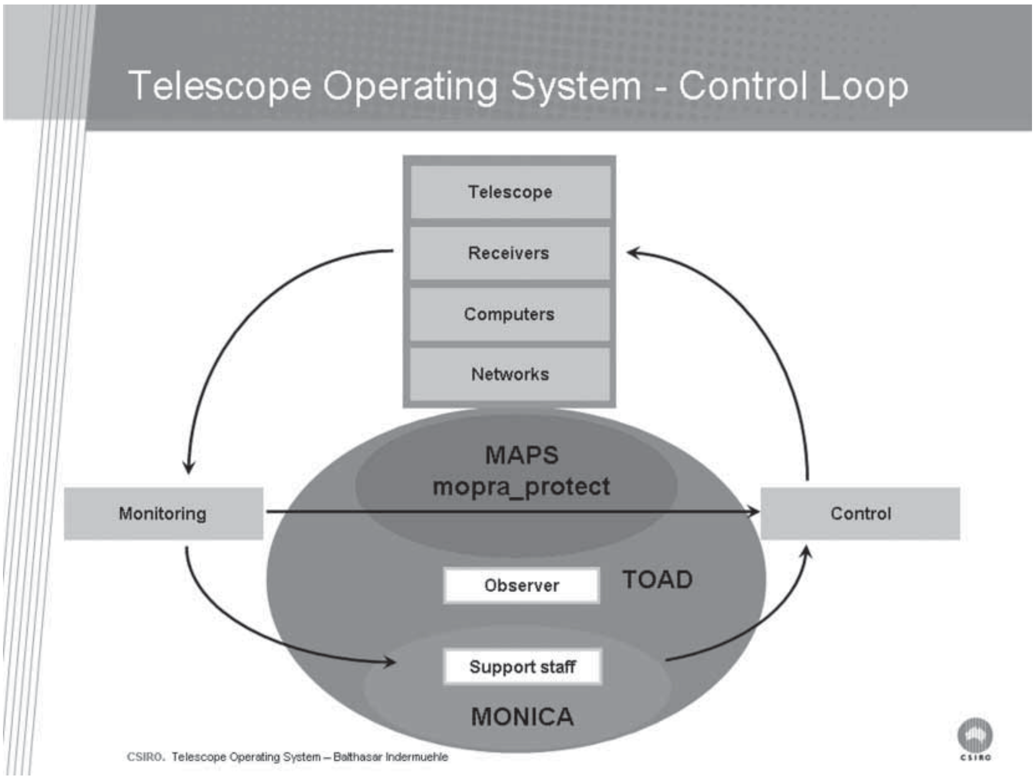


Figure 1: Mopra Telescope Operating System

to gain some experience, whilst a duty astronomer is available at the Observatory for support during the observations. It is clearly more difficult to support remote observing where the observers are based at other locations in Australia or overseas. To improve the support for observers, a new monitoring tool, The Telescope Operator Alerting Display (TOAD) has been developed using human factors guidelines developed for aircraft systems monitoring displays. This approach has taken into consideration that, in some ways, observers can be compared to pilots operating complex aircraft systems. While both observers and pilots have some understanding of the systems, they don't need to understand all of their intricacies and interdependencies. This human factors approach has proven to be very popular with the Mopra observers.

While some improvement is still required in the interface specification, in particular to improve the handovers between observers, TOAD has greatly facilitated the use of Mopra remote observing from other locations. Following the first tests in early 2008, this is now offered to users who have had some previous Mopra observing experience.

## Changes to Operations staff

Since the last edition of *ATNF News* there have been several changes to Operations staff. Probably the most significant of these to our users was John Reynolds' move from Parkes to Marsfield in December 2008. John was the Officer-in-Charge for the Parkes Observatory for 10 years and his outstanding leadership during this time contributed hugely to the overall success and scientific achievements of the Observatory. In July 2008 John took up a new role as a Senior Systems Scientist, with responsibilities for both ASKAP and the Parkes

John Reynolds

Photo: John Sarkissian

Observatory. Since then, he has gradually increased his work for ASKAP whilst also transferring some of his skills and knowledge to other Parkes staff, in particular to Ettore Carretti our new Senior Systems Scientist at Parkes.

John's outstanding achievements as Officer-in-Charge were recognised with a symposium held at the Observatory on 27 November 2008. About 70 people, including ATNF staff, astronomers and members of the local community, gathered to hear talks from invited speakers who discussed his contributions to different aspects of the telescope's scientific output. The topics reviewed included HI spectroscopy, pulsar studies, and very long baseline interferometry, highlighting the breadth of John's knowledge. The presentations were followed by celebratory drinks and a memorable dinner in The Dish Café, with several fine examples of after-dinner oratory.

Early this year we were delighted to welcome Jamie Stevens and Ettore Carretti who have started appointments as Senior Systems Scientists. Jamie studied neutral hydrogen in nearby galaxies for a PhD from the University of Melbourne and then worked at the University of Tasmania. He began his appointment at the Narrabri Observatory in January and has rapidly become closely involved with the preparations for CABB. Ettore obtained a PhD in Bologna, Italy and has held several research positions in Bologna, most recently at the Institute for Radioastronomy of the National Institute for Astrophysics. He has been a frequent visitor to Australia and has considerable experience with the Parkes 64-m radio telescope through his own observing programs. Ettore took up his appointment at the Parkes Observatory in February 2009. Although based at the Observatories, both Jamie and Ettore will also spend time working in Marsfield.

Ettori Carretti

Photo: John Sarkissian

Jamie Stevens

Photo: Margaret McFee

In March 2009 we said goodbye to Brett Dawson at a farewell lunch held at Parkes. Brett had been the Head of Engineering Operations since January 2008 and the Parkes Site Manager since July 2008. He has left the ATNF to take up a position with the National Parks and Wildlife Services. For an interim period, until replacement positions are filled, Malcolm Smith is the acting Site Manager for the Parkes Observatory, while Brett Hiscock is the acting Head of Engineering Operations. Both Brett and Mal are also continuing with their ongoing roles.

Another major change will occur in July 2009, when David McConnell the Theme Leader for Operations, will take a year's leave to spend time with his family. David will stand down from the Operations Leadership at this time but expects to return to work for the ATNF around July 2010.

We are currently recruiting for three senior positions in Operations. These are for:

- Assistant Director of Operations to lead the delivery of its radio astronomy facilities to astronomers from around the world;
- Head of Engineering Operations to lead the team of approximately 35 engineering and technical staff who provide engineering maintenance, operations and upgrades for all the ATNF radio astronomy observatories; and
- Parkes Site Manager/Engineer to ensure the smooth day to day operations of the Parkes Observatory site.

# Time Assignment Information

Philip Edwards and Jessica Chapman (ATNF)

## This semester

The Time Assignment Committee met at Marsfield in mid-February to review proposals for the 2009 April Semester (2009APRS). Proposal numbers are always higher for the winter semester, and the ATNF received 192 proposals. Of these 45 were for Mopra and 44 for Parkes. There were, as usual, a small number of proposals for Tidbinbilla (2), but a new record number, 20, for the Long Baseline Array (LBA). For Parkes, Mopra, Tidbinbilla and the LBA, the 2009APRS is now underway for a six-month period from 1 April 2009 until 30 September 2009.

As described earlier in this Newsletter, the Compact Array has just completed a six-week shutdown for the full installation of Compact Array Broadband Backend (CABB) hardware, and the 2009APRS is the first to offer the full 2-GHz CABB bandwidth in both frequency bands and on all six antennas. For this semester, CABB is available with a single observing mode that has a bandwidth of 2.048 GHz and 2048 channels, corresponding to a spectral resolution of 1 MHz. Due to the staged implementation of CABB modes, the 2009APRS for the ATCA will run from 22 April to 15 July 2009.

Eighty-one proposals were received for this period. As a result of the higher-than-usual oversubscription, 44 of these were allocated at least some of their requested time. Proposals not completely scheduled in the 2009APRS that require further observing time should be resubmitted for consideration in later semesters.

The next announcement of opportunity will be made in mid-May 2009 for the 2009 October Semester (2009OCTS). This will be a six-month semester and applications will be invited for all ATNF facilities.

## Information for the ATCA 2009JULS

Further observing modes for CABB will become progressively available. For 2009 July Semester (2009JULS) we expect that three observing modes will be available as follows:

1. A 2.048 GHz bandwidth with 2048 x 1-MHz channels (available from April 2009);
2. A 2.048 GHz bandwidth 32 x 64-MHz channels (available from mid-July 2009);
3. Option 1 with an additional zoom capability that provides for one to four spectra, each with a bandwidth of 1 MHz split into 2048 channels (available from around 1 September 2009).

Once these modes are available, two of the three observing modes can be selected simultaneously, corresponding to two independent radio frequencies. This allows for a wide range of possible configurations. For example, it would be possible to observe simultaneously in the 3-cm and 6-cm bands, using option one for the 3-cm band and option three for the 6-cm band (or vice-versa). Another option would be to select the same central frequency for both bands with a total of eight zoom modes within the same 2-GHz bandwidth.

For 2009 JULS, the array configurations 6D, 1.5A, 750D, EW352, H214, H168 and H75 will be offered. Configurations will only be scheduled if there is sufficient proposal demand for them. It is usually the case that all offered configurations are scheduled, but the shorter 2009APR and 2009JUL semesters place greater constraints on array scheduling, and not all configurations offered for 2009APRS were able to be scheduled.

In the 6- and 3-cm bands the existing front-ends allow a 2-GHz bandwidth to be used, with 4.5 to 6.5 GHz and 8.0 to 10.0 GHz being the nominal ranges. Simultaneous 6/3-cm observing will continue to be possible. In the 20- and 13-cm bands the usable bandwidth is limited by the front-ends to ~500 MHz, though radio frequency interference will reduce the usable bandwidth, particularly at 20 cm. Simultaneous observations at 20/13 cm will not be possible.

Proposers are reminded that the primary flux density calibrator for observations at 7 and 3 mm is Uranus, which for 2009JULS will be at a right ascension (RA) of 23h45m and declination of -2d30m. Observatory staff will calibrate a number of bright AGN, spread over the full range of RA, against Uranus at the standard continuum observing frequencies throughout the semester for use as secondary flux density calibrators if Uranus is not visible, or is resolved out. Proposers requiring their own observations of Uranus (at special frequencies, for example), should make this clear in the justification of their proposal.

# ATNF Publications List

Publication lists for papers which include ATNF data or ATNF authors are available on the Web at *www.atnf.csiro.au/research/publications*. This list includes refereed publications compiled since the last newsletter. Please email any updates or corrections to *Christine.VanDerLeeuw@csiro.au*.

Papers which include ATNF staff are indicated by an asterisk.


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# ATNF Outreach

Rob Hollow (ATNF)

## ATNF Teacher Workshops and PULSE@Parkes

In this the International Year of Astronomy (IYA), there has been an ever increasing awareness of, and interest in, all things astronomical by the teaching profession. Teachers have been keen for ideas on how to teach the subject matter effectively, as well as looking for ways to keep up-to-date with new and exciting discoveries.

As part of its outreach activity, ATNF has provided some of the answers by hosting over twenty teachers from across NSW for a one-day *Astrophysics for Physics Teachers* workshop held at ATNF Headquarters at Marsfield in March 2009.

Dr Jimi Green from the ATNF and Dr Stuart Ryder from the Anglo Australian Observatory (AAO)/ Australian Gemini Office gave talks covering the stages of stellar evolution from star formation to violent ends in supernovae. Once again the workshop included a *Live from Gemini* videoconference session with Gemini Outreach Scientist, Dr Scott Fisher in the control room of Gemini North in Hilo, Hawaii.

ATNF Education Officer Rob Hollow led teachers through some practical ideas and activities for classroom use and introduced the teachers to a range of software and visualisations tools available.

ATNF outreach has also been busy promoting IYA to teachers around Australia, with Rob speaking to over 300 physics teachers in Melbourne in February and at other events in Western Australia and NSW. This included workshop sessions at Sydney Observatory, as well as for the Scientists in Schools program. More workshops are planned in several states during the year.

Whilst in Perth for the *Primary Science Conference* in early April, Rob also assisted Scitech with some of their public viewing nights as part of the global *100 Hours of Astronomy program*.

ATNF is also assisting with the writing of the federally funded Australian Science Teachers Association Resource Book, *Astronomy, Science Without Limits*, for National Science Week that will be distributed to all schools in Australia in May.

The PULSE@Parkes program has now been running for over a year with students from 17 Australian schools and students from Texas controlling the Parkes radio telescope to observe pulsars. A second activity module for students is currently under development along with plans for observing sessions in NSW, WA and Victoria.

An external education evaluation of the program undertaken by Associate Professor David McKinnon and Dr Lena Danaia from Charles Sturt University has been completed and is very positive about the value of the program concluding that, "The ATNF is also to be congratulated for making available significant resources for the development of the current materials, the personnel and the telescope time. These are significant investments by the ATNF in an attempt to improve physics education at the senior high school level."

The evaluation will help guide the educational components of the program. Another exciting development is the use of the 12-m antenna of the Parkes Testbed Facility for pulsar observations and its possible inclusion in PULSE@Parkes as discussed by George Hobbs elsewhere in this newsletter.

## 2008/2009 ATNF Summer Vacation Program

ATNF welcomed nine students from across Australia in December 2008 for the 2008/2009 Summer Vacation Program. Each student spent ten weeks based at Marsfield working on a specific research project under the supervision of ATNF staff. Eight of the students worked on astrophysics/ computing projects and one on engineering with the Receiver Group.

In addition to working on their individual projects the students had a series of sessions and workshops on different aspects of radio astronomy that culminated in a five-day observing trip to the Australia Telescope Compact Array at Narrabri.

Working in groups of three, each team had a twelve-hour slot using the telescope for an observing project of their choice. They were capably guided in their endeavours by Dr Ángel Rafael López-Sánchez and other ATNF staff.

The program culminated with the annual joint ATNF/ASAO student symposium in February. This was well attended and gave students a chance to discuss their individual research projects to their peers and ATNF and AAO staff. Some of the students have continued to work with their supervisors beyond the life of the program and are keen to become co-supervised PhD students at the ATNF.


Participants at the ***2009 Astrophysics for Physics Teachers Workshop***

Photo: Rob Hollow

2008 ATNF Summer Vacation Program Scholars: Back row, left to right: Chanakya Jaiswal, Nathaniel Butterworth, Dane Kleiner, Colin Tuft. Front row, left to right: Sarah Traine, Jay Blanchard, Tui Britton, Justin Bray, Christopher Jordan.

Photo: Rob Hollow

The Parkes test-bed antenna. Used for a month of pulsar observing with data sets to be made available to students as part of the PULSE@Parkes outreach program.

Photo: David McLenaghan, CSIRO

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