CSIRO

Australia Telescope National Facility

Annual Report 2006

Front cover image: Three antennas of the Compact Array with the full moon.
Photo: Shaun, Amy, CSIRO

Annual Report 2006
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This is the report of the Steering Committee of the CSIRO Australia Telescope National Facility for the calendar year 2006.

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Aerial view of the Parkes telescope
Photo: John Sarkissian, CSIRO

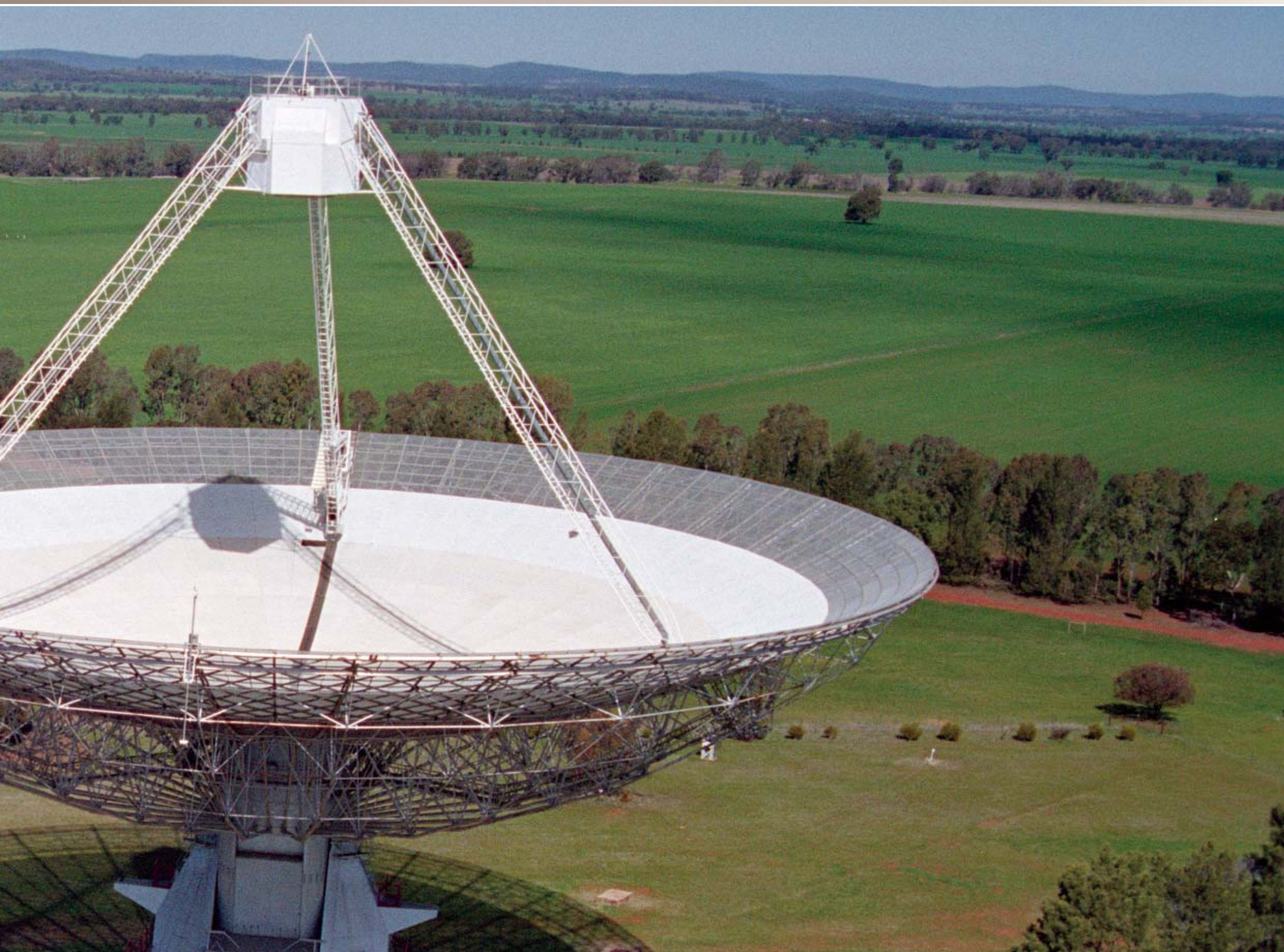


Photo: © Kristen Clarke

Dr Brian Boyle, Director of the ATNF

Director's report

2006 was another strong year for the ATNF, with a wide range of achievements and a consolidation of the foundations on which to build the future of radio astronomy both in Australia and internationally.

An important part of that future was the announcement in November 2006 of $45M of new funding for Australian astronomy as part of the National Collaborative Research Infrastructure Strategy (NCRIS) which provided some $500M in total funding for Australian research infrastructure. During the year, it was both a tremendous personal opportunity and a privilege for me to have the role of Facilitator for the NCRIS Astronomy proposal. The NCRIS funding for astronomy provides $10M to develop and update the Anglo-Australian Observatory, $19.2M for the Square Kilometre Array (SKA) Pathfinder developments in Western Australia, and a million dollars each for design and development contributing to the proposed Giant Magellan Telescope (GMT) in Chile and the Pathfinder for a Large Optical Telescope (PILOT) in Antarctica. The remaining funds will be allocated later to other strategic options. Working with the Australian astronomical community in developing the coherent and compelling infrastructure investment plan was a very rewarding experience. The coherence and vision of the community, previously encapsulated in the Decadal Plan for Australian Astronomy 2006 – 2015, remains as strong as ever.

As a further aspect of implementing the Astronomy Decadal Plan CSIRO is committed to continuing to operate its existing radio astronomy facilities to support world-class science, and at the same time aims to maximise Australia's participation in the SKA. The $19.2M NCRIS funding for SKA pathfinder developments in Western Australia complements some $20M of CSIRO funds already committed to this project. The need to evaluate and possibly restructure the ongoing operations of the ATNF facilities to meet the challenge of incorporating the new WA facility from 2011 – 2012 has been a priority for the leadership team in 2006. There is a lot of work yet to do on this but I am confident that we have the people, the commitment and the vision to get this right.

While strong organisations are stronger than the individuals that comprise them, some individuals nevertheless play a large role in determining the nature of an organisation. I'd like to pay special tribute to Lister Staveley-Smith who was Assistant Director for Astrophysics until October 2006 when he left CSIRO to take up the Premier's research fellowship in radio astronomy at the University of Western Australia. Lister's contributions to the ATNF and to radio astronomy were outstanding. His new appointment is highly prestigious, well deserved, and creates miriad opportunities to further strengthen the strategic relationship between CSIRO and Western Australia. I also welcome two new members to the ATNF Leadership Team, Robert Braun as the new Assistant Director: Astrophysics and David DeBoer as the Assistant Director: SKA Phase 1. Robert joins the ATNF from ASTRON, and David DeBoer was the Project Manager for the Allen Telescope Array – both are outstanding appointments and I am very much looking forward to their contributions to Australian radio astronomy.

As always I am very impressed and proud of the science and engineering achievements of ATNF staff and users of our facilities, some of which are outlined in this report. I am particularly pleased by the increasing demand for and scientific impact of the Mopra telescope which is a direct result of a carefully balanced effort in operational support, receiver development, the vast improvement in instrumentation offered by the MOPS spectrometer, and improved control software. At the same time, the Parkes telescope continues to produce world-class science, and the Compact Array is resisting the urge to settle into a comfortable middle age and is instead pushing the boundaries as a result of new instrumentation that has been delivered this year or is on the way. In this regard, I would like to acknowledge the role played by Bob Sault, who stood down as Narrabri and Mopra Officer-in-Charge. During his four year term in the role, Bob made an outstanding contribution to the operations of both Mopra and the Compact Array.

Finally I would like to note the efforts of ATNF staff in communicating the excitement of astronomy to the public, to teachers, and to students. It is the young students who hold the future of astronomy, of engineering, and of science more generally in their hands. The outreach efforts detailed in this report are a tribute to all those who contributed to them over the year, and the ATNF is committed to increasing its efforts in this area in the future.

Chairman's report

Professor Matthew Bailes,
Chair AT Steering Committee

I received today (in December 2007), an invitation to the Opening of the Grote Reber museum in Tasmania and it caused me to reflect on the evolution of radio astronomy as a science over the past 70 years, from Reber's home grown antenna and primitive first hand-sketched contour map of the Galaxy, to Naomi McClure-Griffith's spectacular image of neutral hydrogen shown on page 48 of this beautifully-presented annual report. Whilst the beauty of Naomi's image is clear for all to see, those of us who have struggled with instruments to make our own discoveries, appreciate Reber's image for its pioneering brilliance that opened up the field of radio astronomy.

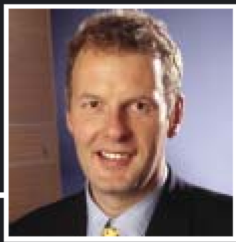
The technology behind radio astronomy continues its astonishing evolution from Reber's single-channel analogue system to the Australian SKA Pathfinder's Petaflop-scale correlator. When completed, the Australian Square Kilometre Array Pathfinder (ASKAP) will be as much a signal processing miracle as it will an engineering marvel. It is a fair bet that its greatest discoveries are beyond our imagination, and that is what makes astronomy such an exciting branch of science to be involved in. But are we ready for the data avalanche that awaits us and the needles buried in the cosmic haystack of data it will produce? Lorimer et al.'s discovery, described on page 38, of a sharp burst of radio emission hints that the radio Universe is not static, even at cosmological distances. ASKAP has the potential to open new areas of study such as the detection of more of these radio bursts, but we need to be aware of the signal processing challenges that await us. Professor Lyne, one of the most prolific and successful visitors to the Parkes radio telescope and among its most expert users, once explained to me that radio astronomy has always been about compromises. Matching ASKAP's collecting area, bandwidth, number of antennae and configuration to our signal processing budget is perhaps the greatest challenge for the ATNF in the lead up to the SKA.

The funding obtained for ASKAP's research and development has sent a clear signal to the world that Australia wants to be at the forefront of SKA research and development to strengthen our site bid. The community owes a great deal to the ATNF Director, Professor Brian Boyle, for coordinating successful applications to NCRIS and for presenting a clear and consistent case to the Federal government over many years that culminated with the announcement of extra support for ASKAP in this year's Federal budget.

Finally, the development of the WA sites requires an investment that demands a diversion of resources away from the telescopes that we, as users, depend upon for the training of our students and continuity of our research programmes. Like the balance between ASKAP's dimensions and signal processing capabilities, the resourcing of our trusted instruments against the new ones under development in WA will require compromises. The ATNF has the communication channels with the community in place to manage this era of transition via the user and steering committees.

ATNF Senior Management and Federation Fellows as at December 2006

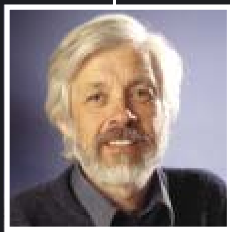
Executive Secretary
Anne Barends
Photo: CSIRO



Director
Brian Boyle
Photo: © Kristen Clarke

Deputy Director
Lewis Ball
Photo: CSIRO

Assitant Director:
xNTD/SKA Phase 1
David DeBoer
Photo: CSIRO



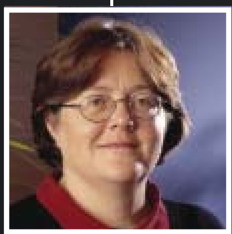
Assitant Director:
Operations
Dave McConnell
Photo: © Kristen Clarke

Assistant Director:
Astrophysics
Robert Braun
Photo: © ASTRON

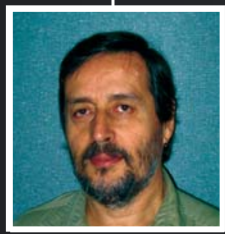
Assistant Director:
Engineering
Warwick Wilson
Photo: © Kristen Clarke

OIC Narrabri
Phil Edwards
Photo: CSIRO

OIC Parkes
John Reynolds
Photo: CSIRO

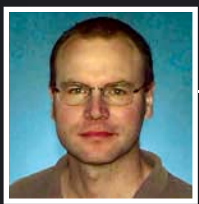


Head, National
Facility Support
Jessica Chapman
Photo: © Kristen Clarke

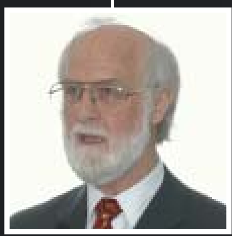


VLBI Operations
and Development
Tasso Tzioumis
Photo: CSIRO

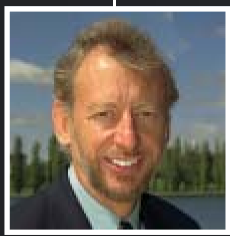
Deputy OIC
Narrabri
Brett Hiscock
Photo: CSIRO



Deputy OIC
Parkes
Brett Dawson
Photo: CSIRO



Federation Fellow
Ron Ekers
Photo: © David Smyth



Federation Fellow
Dick Manchester
Photo: © Australian Research Council

The ATNF in brief

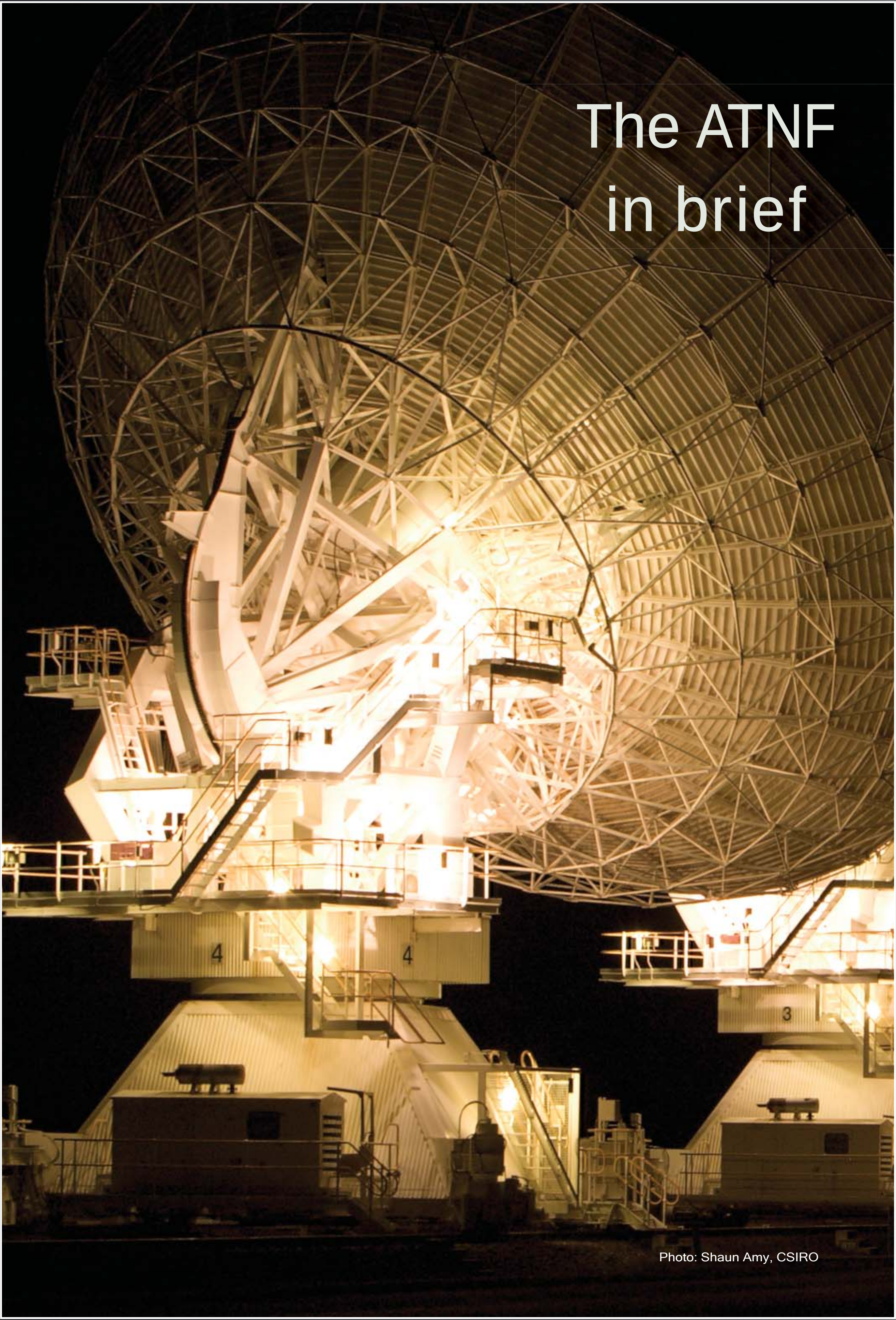


Photo: Shaun Amy, CSIRO

The ATNF is managed as a National facility by CSIRO, and is a CSIRO Division in its own right. Staffed by around 180 people, the ATNF is the largest single astronomical institution in Australia, with its Sydney headquarters co-located with those of the Anglo-Australian Observatory. In fulfilling its mission, the Facility (known as the Australia Telescope), provides a uniquely powerful view of the southern hemisphere radio spectrum.

Our mission

- To operate and develop the Australia Telescope as a national research facility for use by Australian and international researchers;
- To exploit the telescope's unique southern location and technological advantages to maintain its position as a world-class radio astronomy observatory;
- To further the advancement of knowledge.

An overview of the facility

The Australia Telescope is comprised of eight antennas and associated instrumentation located at three geographically separate locations and supported by staff and facilities at the CSIRO Radiophysics Laboratory at Marsfield in Sydney. The three observatories are near the towns of Parkes, Narrabri and Coonabarabran, all in rural NSW.

Parkes Observatory is home to the 64-metre Parkes radio telescope, a single fully steerable antenna equipped with receivers that operate in frequency ranges from 74 MHz to 22 GHz, with bands in the range from 600 MHz to 9 GHz the most commonly used. This telescope has been successfully operated since 1961 and is famous as a national symbol for Australian scientific achievement. Instrumental upgrades, including a 13-beam focal-plane array, have maintained the telescope as a state-of-the-art instrument.

Six identical 22-metre antennas make up the Australia Telescope Compact Array (ATCA), an earth-rotation synthesis telescope located at the Paul Wild Observatory outside Narrabri. Five of these antennas sit on a three-kilometre stretch of rail track running east–west, or on a 200-metre spur running north of the main track; they can be moved to different points along the track to build up detailed images of the sky. A sixth antenna lies three kilometres to the west of the main group. Each of these antennas has a reflecting surface 22 metres in diameter. After the radio signals from space are "collected" by the antennas' surfaces they are transformed into electrical signals, brought together at a central location, and then processed. The end result is usually a picture or a spectrum of the object being studied—a picture equivalent to a photograph, but made from radio waves instead of visible light. The ATCA is equipped with receivers that operate at frequencies between 1.4 and 110 GHz, with use at the highest frequencies restricted primarily to a "winter season" by atmospheric stability and transparency considerations.

The Mopra Telescope is a single 22-metre diameter antenna near Coonabarabran, used primarily for large-scale mapping projects at the higher end of the ATCA frequency range, and as part of the Long Baseline Array.

The ATNF also negotiates telescope time with the CSIRO administered DSS-43 70-metre antenna at the Tidbinbilla Deep Space Tracking station outside Canberra. NASA/JPL makes approximately 5% of time available on this telescope to astronomical research programs.

The eight ATNF radio telescopes can be used together (sometimes in conjunction with antennas operated by The University of Tasmania at Ceduna and Hobart, and the Tidbinbilla antenna) as a Long Baseline Array (LBA) for a technique known as Very Long Baseline Interferometry (VLBI). The LBA is sometimes also used as part of the Asia-Pacific Telescope which links radio telescopes in Australia, Japan, China, Hawaii and India.

Technical research and development supporting upgrades of the Facility, as well as for the new Australian SKA Pathfinder instrument (now known as ASKAP), are conducted at the ATNF's headquarters in Marsfield, Sydney.

The ATNF's activities are directed and administered from its Marsfield headquarters, with Parkes and Narrabri Observatory activities directly supervised by two site located Officers-in-Charge. Mopra is administered from the Narrabri Observatory.

Governance

The Australia Telescope is operated as a National Facility under guidelines originally established by the Australian Science and Technology Council. The ATNF is a Division of CSIRO and is responsible via the Executive to the Minister for Education, Science & Training.

Divisional policy, strategic planning and operational management is the responsibility of the Director and the ATNF Leadership Team.

ATNF policy is shaped by the ATNF Steering Committee (ATSC), an independent committee appointed by the Minister. The Steering Committee meets at least once a year to define the broad directions of the ATNF's scientific activities and longer term strategies for the development of the Australia Telescope. The Steering Committee appoints the Australia Telescope Users Committee (ATUC) and the Time Assignment Committee (TAC). ATUC represents the interests of the community of astronomy researchers who use the Australia Telescope. The committee provides feedback to the ATNF Director, discussing problems with, and suggesting changes to, ATNF operations. It also discusses and provides advice on the scientific merit of future development projects. ATUC meetings are also a forum for informing telescope users of the current status and planned development of ATNF facilities, and recent scientific results. The TAC reviews proposals and allocates observing time.

The committee members for 2006 are listed in Appendix C.

Funding

In 2005 – 2006 the organisation's total expenditure was AUD 33.1M. The total revenue was AUD 33.5M, including a direct appropriation of AUD 21.9M from CSIRO.

Engineering and technology development

The advance of radio astronomy depends crucially on exploiting the latest technological developments in a range of areas which include electronics, receiver technology, signal detection and processing, control systems, data processing and information technology. The ATNF provides a platform for the development of cutting-edge technology in Australia, and is one of the leaders in the international effort to design, build and operate the next generation of radio-astronomy facilities through its involvement with the Square Kilometre Array (SKA). The SKA is a billion-dollar global project that will provide a radio telescope with a collecting area of about one square kilometre, making it a hundred times more sensitive than any existing radio telescope.

The Australia Telescope community

As at the end of 2006 the ATNF's total complement was around 182 people. This was made up of 141 (133 FTE) paid staff (research scientists and engineers, technical and administrative support), 33 postgraduate students, three visiting scientists and five fellows. These resources are distributed across four sites within NSW and the ACT.

Australian and international observers use the Australia Telescope without charge for approximately 60% and 40% of the available time respectively. This is in accordance with general practice of the worldwide radio-astronomical community, in which telescope users from different countries gain reciprocal access to facilities on the basis of scientific merit. Such access provides Australian scientists with a diversity of instruments and leads to a rich network of international collaborations.

Observing time on the ATNF's telescopes is awarded twice a year by the Time Assignment Committee (TAC) to astronomers on the basis of the merits of their proposed research programs. Approximately 90% of the Australia Telescope's users come from outside the ATNF. Proposals for time on both the Parkes Telescope and the ATCA typically exceed the time available by a factor of 1.7. For Mopra the oversubscription rate is around 1.3. Approximately 130 proposals are received for the summer semester (October to March) and 190 in the winter semester (April to September) – the difference reflects the additional demand for millimetre observing

The Parkes radio telescope

Photo: Shaun Amy, CSIRO

The Australia Telescope Compact Array

Photo: © Michael Gal, UNSW

The Mopra radio telescope

Photo: Shaun Amy, CSIRO

The Tidbinbilla DSS43 70-m antenna

Photo: © Canberra Deep Space Communication Complex using Mopra and the Compact Array during the cooler months.

The ATNF has strong links with its primary user base, the university community, both within Australia and around the world. The "user operator" model adopted by the Australia Telescope is unusual if not unique in world terms. Members of each observing proposal operate the telescope for their allocated time and the ATNF hosts a constant stream of visiting astronomers from around the world, who come for periods of between a few days and a few weeks. This is a significant contributor to the strength of the relationship between the ATNF and the astronomers that use it. These relationships are further strengthened by the open, international and collaborative nature of astronomical research. Over the past decade 77% of Australian astronomy papers have had international co-authors.

Research scientists and engineers are heavily involved in the training of postgraduate students, an important contributor to the strength of the interactions between ATNF staff and university colleagues. ATNF staff co-supervise PhD students, most of whom are undertaking degrees at Australian universities. CSIRO provides direct financial support to most of these students, supplementing the support that they receive through their host universities. The majority of ATNF's current PhD students have an Australian Postgraduate Research Award.

The wider astronomical community & other relationships

While astronomers on the ATSC provide the ATNF Director with strategic advice from the Australian and international research community, the ATNF provides similar input to other parts of the research community via staff representation on other research community bodies and committees. ATUC provides an effective route for operational feedback and input on future directions from the research community to the ATNF as well as providing communications from ATNF to the user community.

The ATNF is a full member of Astronomy Australia Ltd, an organisation established in early 2007 as a company for the principal object of managing the National Collaborative Research Infrastructure Strategy (NCRIS) funds for astronomy.

The ATNF also has contracted links to the research community, both for the provision of equipment by the ATNF to external bodies, and for provision of research outcomes, equipment, or aspects of national facility operations by external organizations to CSIRO. Such contracts are small in number, and in the past have generally concerned the delivery of instrumentation for astronomy (and/or space tracking). The ATNF has recently entered into contracts with Australian University partners for the provision of services that contribute to the operation of the national facility. This is now the ATNF's favoured mode of engagement with universities, endorsed by the ATSC, and is preferred over the alternative of joint appointments with universities or other external partners, for reasons of transparency and effective management. This mechanism of engagement with university partners is seen as increasingly important and will continue to be actively pursued over the next five years by the ATNF as an effective means of broadening the national facility resource base, and ensuring the health of the Australian astronomy research community as a whole.

ATNF's links with the Australian and international community are increasing in complexity as the organisation progresses towards the SKA. Links within Australia are growing, with new radio astronomy groups being established at universities in Western Australia and emerging groups at Macquarie University (NSW) and James Cook University (QLD) taking interest in specific areas of SKA research and development. The ATNF is a key player in the partnerships with both new and established university groups.

International alliances are also growing, with a small number of "formal" links underlined by collaborative agreements supplemented by a larger number of informal community collaborations. The formal linkages are primarily between CSIRO and NRC-Canada, NSF-South Africa and EU-SKADS. Other key linkages are with ASTRON, PREPSKA, and research groups in the USA, India, and China.

Research themes

In 2005, CSIRO restructured its major activities and funding under "themes", with some themes including work across two or more of the Divisions. Following the changes within CSIRO, the ATNF re-aligned its activities under four separate themes. The strategic objectives of the ATNF by theme (as at end-2006) are as follows:

National Facility Operations

The Operations Group operates the National Facility observatories (the Compact Array at Narrabri, single-dish telescopes at Mopra and Parkes, and the Long Baseline Array) to maximise the scientific value of experiments conducted by Facility users.

The high impact of the ATNF will be sustained by ensuring continuous operation with very high reliability (<5% lost time) and excellent data quality – facilitating astronomical research conducted with our radio telescopes that contributes to the understanding of the Universe.

This theme also contributes to CSIRO's positive public profile by reinforcing the high interest that Australians have in science through an outreach and education program including the highly popular Visitors Centre at Parkes.

In the medium to long-term ATNF operations will prepare for the operation of ASKAP in WA.

Technologies for radio astronomy

The primary goal for this theme is to ensure that the ATNF's existing radio telescopes remain at the leading edge of world technology, securing continued demand from the astronomy research community for the ATNF's radio telescopes, with the effect that the science outcomes from astronomy conducted with the Facility are maximised.

These technological developments underpin Astronomy's position as the highest impact field of Australian science and its role in shaping our understanding of the universe.

In addition, this theme supports spacecraft tracking programs in collaboration with NASA, supplies radio astronomy instrumentation to outside organizations and undertakes strategic collaborations with other radio astronomy institutes. These secondary activities allow a broad range of specialist talent to be maintained and developed within the ATNF, provide significant external revenue for re-investment in the National Facility, and facilitate the international communication necessary to ensure that technological developments at the ATNF continue to be world class.

Spacecraft tracking programs contribute directly to the high profile within the Australian community of CSIRO's involvement in frontline science.

Astrophysics

The Astrophysics Group provides world-class science that directly influences international astronomical research and shapes our understanding of the Universe. To achieve this the group undertakes observational research projects, many of which involve sizable national and international collaborations. The success of these projects is underpinned by a deep understanding and technical knowledge of the telescope systems. In turn, the knowledge gained is used to provide the scientific case and the technical requirements for new generations of telescopes and instrumentation, ensuring that they deliver maximum scientific impact by targeting high priority science questions.

Medium-term theme goals include: (i) powerful new tests of general relativity; (ii) the study of the formation and evolution of distant galaxies; (iii) new surveys for molecules and pulsars in the heart of the Milky Way; (iv) new wide area neutral hydrogen surveys of the disk and halo of the Milky Way; (v) the study of star-formation in the Milky Way and external galaxies.

Longer-term goals (one — five years) include: (i) detection of the cosmic background of gravitational radiation; (ii) elucidating the structure and equation-of-state of neutron star interiors; (iii) measuring the gaseous evolution of distant galaxies (to a redshift of $z = 1$); (iv) measurement of the equation of state of Dark Energy; and (v) understanding the evolution of cosmic magnetic fields.

The Australia SKA Pathfinder (ASKAP)

The ASKAP theme aims to maximize Australia's involvement in the Square Kilometre Array (SKA) via (a) developing the infrastructure for a new remote observatory in WA to be located at the Murchison Radioastronomy Observatory MRO; (b) building ASKAP; and (c) participating in international SKA design efforts. Prior to a budget and scope increase in 2007, the instrument was called the "extended New Technology Demonstrator" (xNTD).

In low frequency (<3 GHz) survey applications, ASKAP will deliver a roughly 20-fold increase in speed over the ATCA.

ASKAP will provide considerable impact through:

- Addressing outstanding technology challenges along the SKA development path;
- Delivering a world-class astronomical facility at the world's best site for centimetre radio astronomy;
- Maximising Australia's participation in the SKA – a billion Euro international facility; and
- Paving the way forward to leverage significant international funds to an SKA sited in Australia.

Most significantly, this theme will exploit Australia's unique combination of global position, technical expertise and radio-quiet environment to deliver another world-leading instrument to study the southern sky and address the questions regarding the early universe.

ATNF management changes in 2006

In September 2006 Dr Robert Braun was appointed as Assistant Director: Astrophysics and took up the role in February 2007. Robert's appointment followed the departure of Lister Staveley-Smith in October 2006 to take up the Premier's research fellowship in radio astronomy at the University of Western Australia. Lister's contributions to the ATNF and more broadly to radio astronomy during his time in CSIRO, most recently as Assistant Director: Astrophysics and MNRF Director, were outstanding. His new, highly-prestigious position provides many new opportunities for building further strategic relationships between Western Australia and CSIRO.

In December 2006 Dr David DeBoer joined the ATNF as the Assistant Director; xNTD and SKA Phase 1. David's appointment followed the retirement of Colin Jacka who had led the xNTD efforts through the interesting formative stages, capping 25 years as a highly influential member of CSIRO's staff.

In November 2006 Mark McAuley left the ATNF to move to Melbourne. Mark had occupied the position of Executive Officer. Following his departure a new position of Business Strategist was created. Philip Crosby took up this position in February 2007.

In April 2006 Dr Philip Edwards joined the ATNF as the Narrabri Officer-in-Charge, replacing Dr Bob Sault who stepped down from the position in March after four years as Officer-in-Charge. Bob provided outstanding leadership in the development and operation of the Compact Array and Mopra telescope. Brett Dawson took up the role of Parkes Deputy Officer-in-Charge in July 2006.

Performance indicators

Photo: © Ettore Carretti, INAF-IRA

1 Scheduled and successfully completed observing time

For the Parkes radio telescope and the Compact Array the ATNF sets a target that at least 70% of the time available should be allocated for astronomical observations while the time lost during scheduled observations from equipment failure should be below 5%.

For Parkes and Narrabri, approximately 10% of time is made available in each semester as "Director's time". This is time that is initially reserved in the published version of the schedule, but which is later made available for approved observing projects.

Telescope usage in 2006

	Compact Array	Parkes	Mopra*
Successful astronomy observations	82.5%	80.1%	66.0%
Maintenance/test time	13.4 %	13.5%	21.0%
Time lost due to equipment	2.0%	1.0%	2.1%
Time lost due to weather	0.9%	3.6%	6.2%
Idle time	1.2%	1.8%	4.7%

*Mopra statistics are for dates between 29 April – 01 November, corresponding to the "millimetre season". The Mopra maintenance/test time includes 11 days in May 2006 used for the installation of the MOPS receiver (see page 45).

For most observing programs, observers are required to be present at the observatory for their observations. For the Compact Array, remote observing is also possible from other sites. In 2006 85.6% of Compact Array observations were taken with observers present at Narrabri, with 2.2% taken from overseas, 8.3% from Marsfield and 3.8% from other Australian locations.

2 Response of the ATNF to recommendations by the Users Committee

The ATNF Users Committee (ATUC) is an advisory group that meets twice a year, to represent the user community in the ATNF decision-making process. After each meeting, the committee presents a list of recommendations to the Director. ATUC considers matters raised by the user community, current operations and priorities for future developments.

In most cases the ATNF accepts and implements ATUC recommendations. In 2005 ATUC made 42 recommendations to the ATNF. Of these 40 were accepted, and 38 of the 40 were completed by December 2006. Of the two that were not completed: one was later resubmitted in a revised form, and the other was a minor issue related to documentation.

The ATUC members are listed in Appendix C.

3 Time allocation on ATNF facilities

The allocation of time on ATNF facilities is done on the basis of scientific merit. Two six-month observing semesters are held each year, from October to March (OCTS), and from April to September (APRS). For the period from 01 October 2005 to 30 September 2006 a total of 191 proposals were allocated time on ATNF facilities (each proposal is counted once only per calendar year although some proposals are submitted twice). Of these, 118 were for the Australia Telescope Compact Array, 34 were for the Parkes telescope, 26 were for the Mopra telescope and 13 were for the Long Baseline Array.

The ATNF also accepts proposals requesting service observations with the Tidbinbilla DSS43 70-m antenna which is operated by the Canberra Deep Space Communication Complex, as part of the NASA Deep Space Network. However, no Tidbinbilla observations were possible this year due to pointing problems on the 70-m antenna.

Figures 1 and 2 show the time allocated to observing teams on the Compact Array and Parkes radio telescope as a percentage of the total allocated time, by affiliation of the team leader.

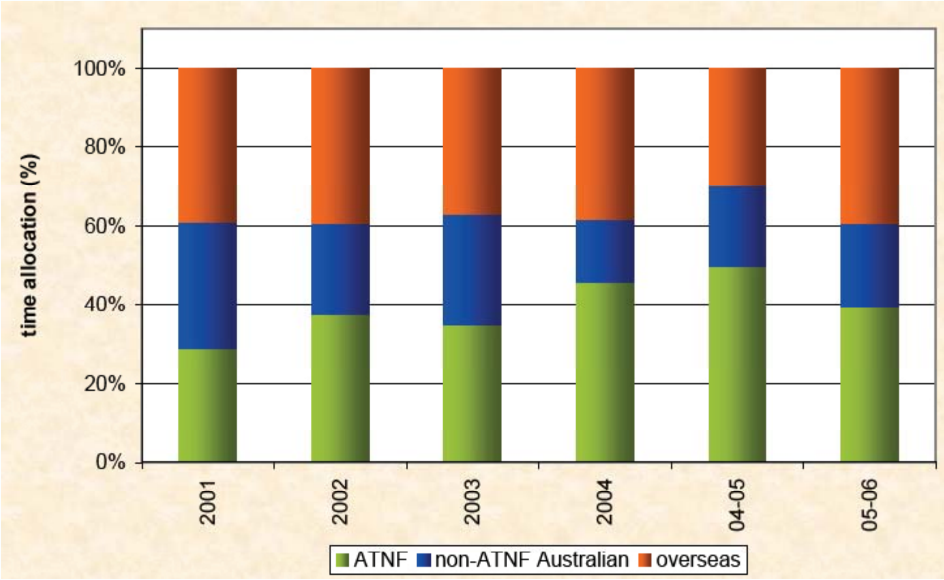


Figure 1 Compact Array time allocation, January 2001 – September 2006. For 2004 the time allocation corresponds to nine months, from January to September. For 2004 – 2005 and 2005 – 2006 the time allocation is for 12 months, from October to September.

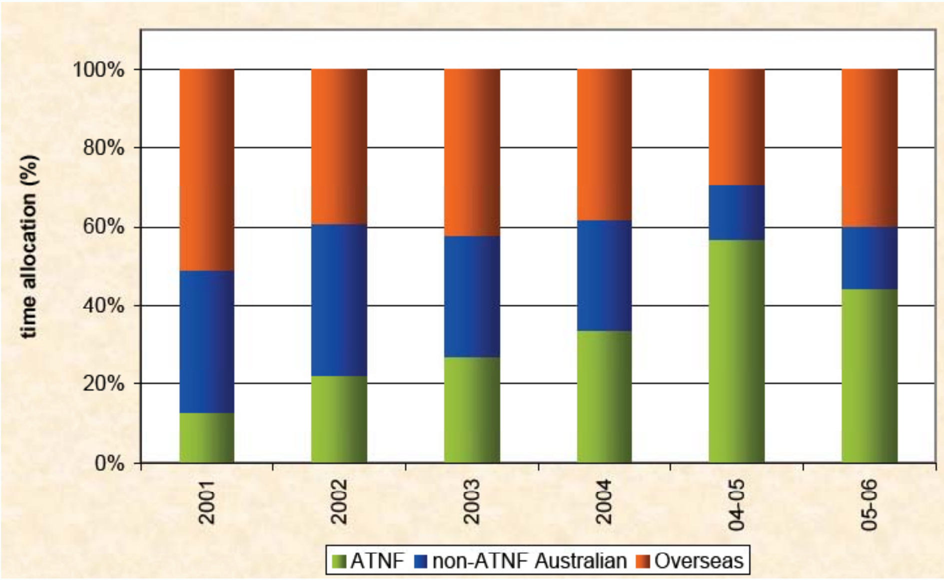


Figure 2 Parkes time allocation, January 2001 – September 2006. For 2004 the time allocation corresponds to nine months, from January to September. For 2004 – 2005 and 2005 – 2006 the time allocation is from October to September.

The ATNF facilities are able to support a broad range of science areas that include Galactic (ISM, pulsar, X-ray binaries, star formation, stellar evolution, magnetic fields), extragalactic (galaxy formation, ISM, Magellanic Clouds, cosmic magnetism) and cosmological science. The research programs involve astronomers from many institutions in Australia and overseas. Typically the proposals allocated time by the ATNF include at least 400 authors. Of these, approximately 40 authors are from the ATNF, 80 are from 14 other institutions in Australia, and 280 authors are from around 120 overseas institutions in 20 countries.

Most individual ATNF projects request a total time allocation, over the project lifetime, of less than 400[1] hours . However, a significant fraction of time is allocated to a fairly small number of Large Projects. Figure 3 shows that for the year from April 2006 to March 2007, 58% of Parkes time was allocated to Large Projects requesting 1200 hours or more, with almost no time allocated to "mid-length" projects requesting between 400 and 1200 hours. For the ATCA, 38% of time was allocated on a similar basis while 48% of time was allocated to projects requiring less than 200 hours. Approximately one-third of ATCA projects request less than 100 hours, with many projects scheduled in 12-hour blocks to maximize the imaging capability of the array.

For Parkes, by far the largest allocation of time is for pulsar proposals. Approximately 70% of submitted Parkes proposals (counted by number) were for pulsar observations, and these were allocated around 60% of the available time.

Time allocation April 2006 to March 2007

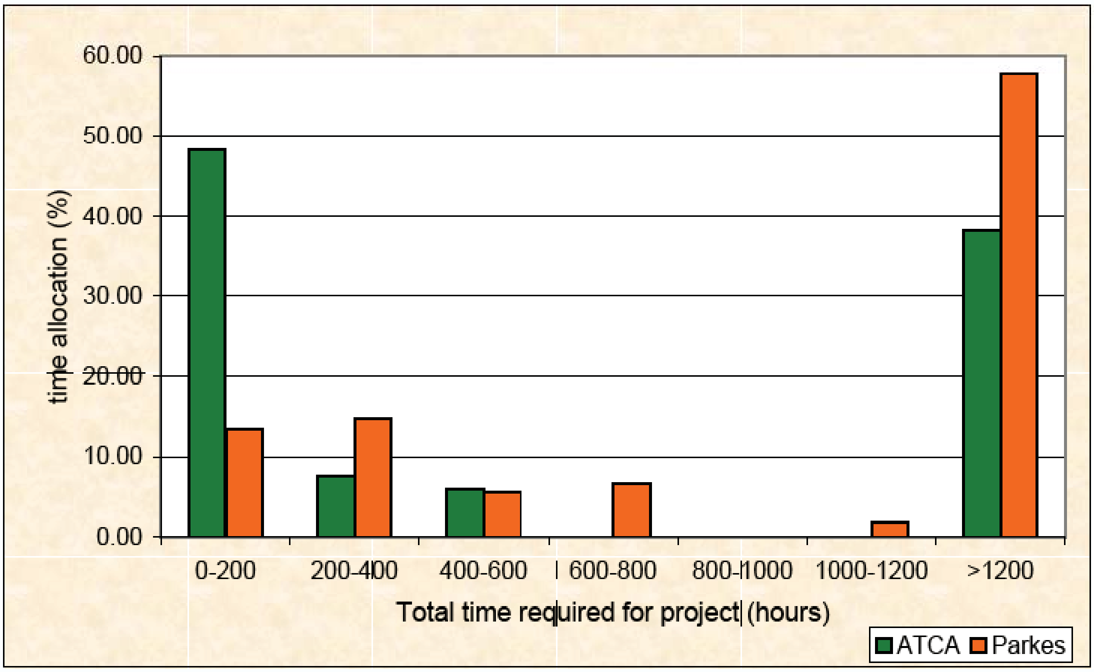


Figure 3 Time allocation by project length

4 Teaching, measured by the number of postgraduate students supervised by ATNF staff

In December 2006 there were 33 PhD students affiliated with the ATNF as well as an Australian or overseas university. Their affiliations and thesis titles are given in Appendix H. Five students were awarded PhDs during the year and their theses are listed in Appendix G.

5 Publications and citations

Publications

Figure 4 shows the number of publications in refereed journals which include data obtained with the Australia Telescope. The publication counts do not include IAU telegrams, abstracts, reports, historical papers, articles for popular magazines, or other papers by ATNF authors. In 2006 119 papers with ATNF data were published in refereed journals, the same total number as in

[1] For the period 2004 May to 2007 Sept, 88% of ATCA proposals submitted each semester requested < 100 hours. For Parkes 70% of proposals requested less than 100 hours.

the previous year. These are listed in Appendix G, which also lists 96 other papers (conference papers with ATNF data and other papers by ATNF staff). ATNF staff were included as authors on 66% of papers, while 61% of papers have a first author at an overseas institution.

Figure 5 shows ATNF publication numbers for papers that include Compact Array, Parkes, VLBI and Mopra data. A small number of papers with data from more than one facility are counted more than once.

The ATNF facilities are both cost effective and scientifically productive. Overall the ATNF is ranked second in the world behind NRAO in terms of total number of refereed publications while Parkes and the Compact Array rank second and third respectively in the world in terms of total number of citations to refereed papers. In terms of citations per paper, Parkes is now the most highly cited radio telescope in the world (Trimble & Zaich, 2006, PASP, 118, 993).

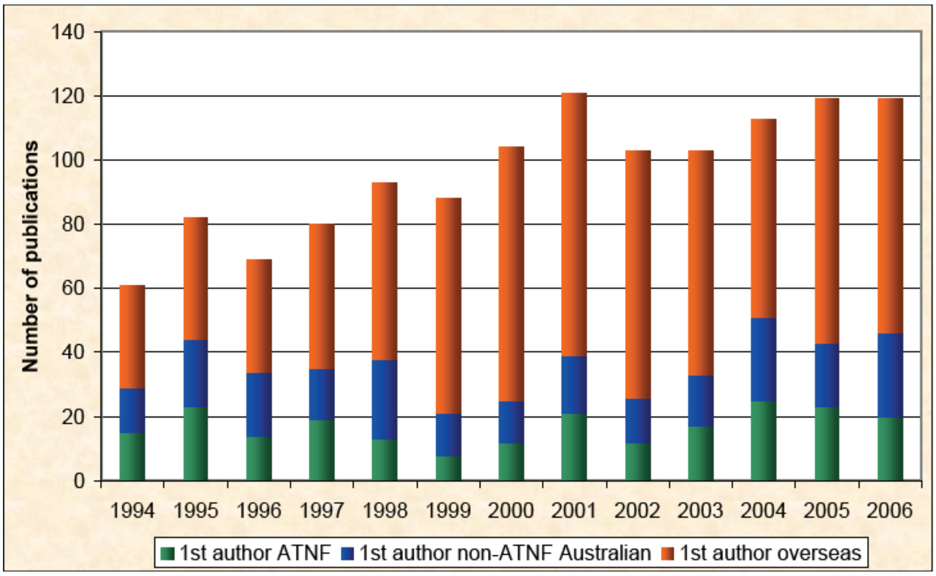


Figure 4 Publications from data obtained with the Australia Telescope, published in refereed journals.

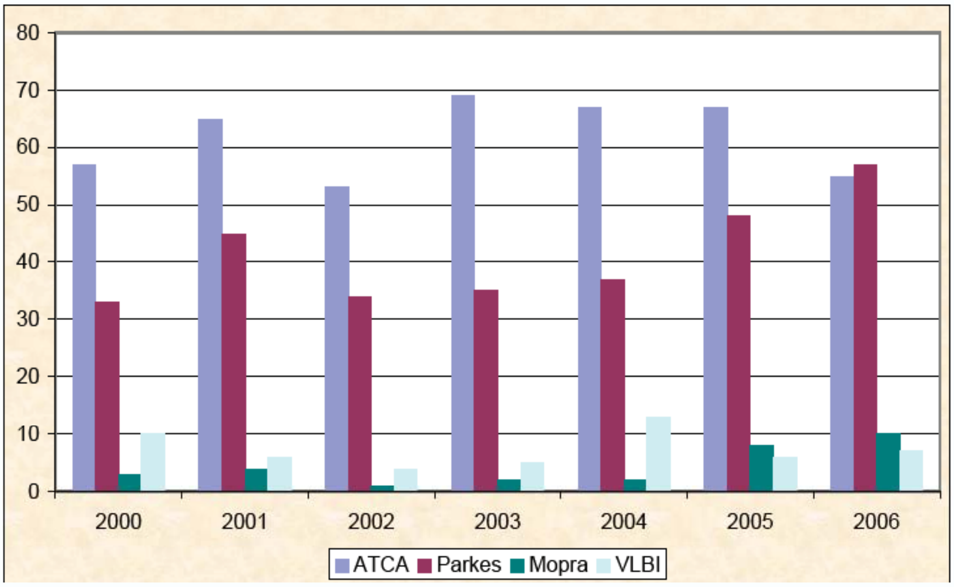


Figure 5 Publications from data obtained with the ATCA, Parkes, VLBI and Mopra, 2000 – 2006.

Since becoming a National Facility (in 1989), the ATNF has especially welcomed international visitors and this has led to the highly successful use of our facilities by international astronomers. Figures 3 and 4 show that about 40% of telescope time is allocated to observing teams with an international PI but this leads to about 70% of the refereed publications. Astronomy leads Australian science as a discipline of international standing and has a particularly high level of international collaboration. For our current facilities, the ATNF achieves the best science outcomes, in terms of publication and citation counts, when science teams include both Australian and overseas astronomers.

6 Public relations

Figure 6 shows counts for media activities for the years 2001 – 2006. During the year the ATNF issued seven media releases (Appendix F) and featured in at least 170 newspaper reports. ATNF staff gave approximately 100 TV and radio interviews and 60 public talks.

The internet is a major tool for communication with professional astronomers and the public. The number of visits to the central ATNF website (www.atnf.csiro.au) increases from year to year with 6.4 million "visits" in 2002 and 27.5 million visits in 2006. In May 2004 a new website was released for outreach and education. This received approximately 260,000 visits in 2006. The ATNF also contributes to the central CSIRO website at www.csiro.au.

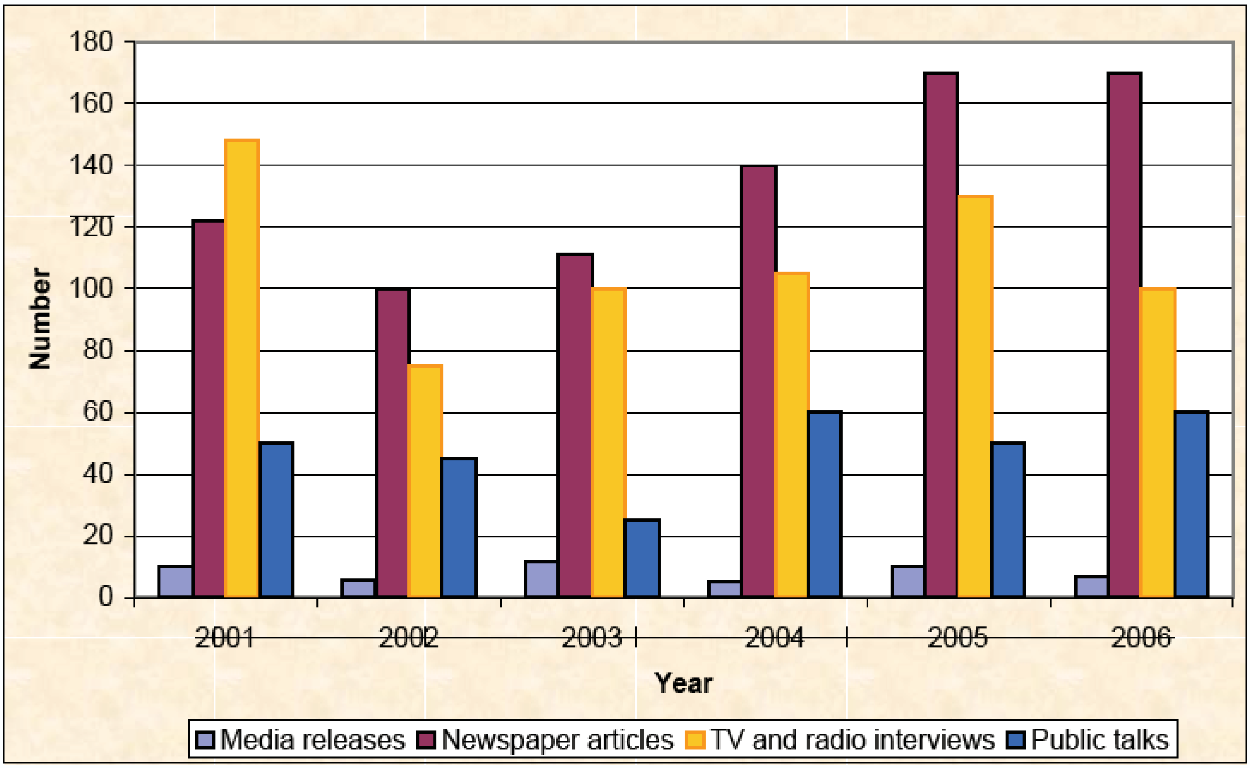


Figure 6 ATNF media activities.

Figure 7 shows the number of visitors to the Parkes and Narrabri Visitors Centres. In 2001 the visitor numbers at Parkes increased strongly, following the release of the movie *The Dish*, reaching a peak of 136,000 in 2003. The numbers have since then decreased with 94,000 visitors in 2006.

In July 2006 the Narrabri Visitors Centre was upgraded with new outdoor displays (see page 50). Approximately 14,000 visitors came to the Centre in 2006, an increase of 30% over each of the previous few years.

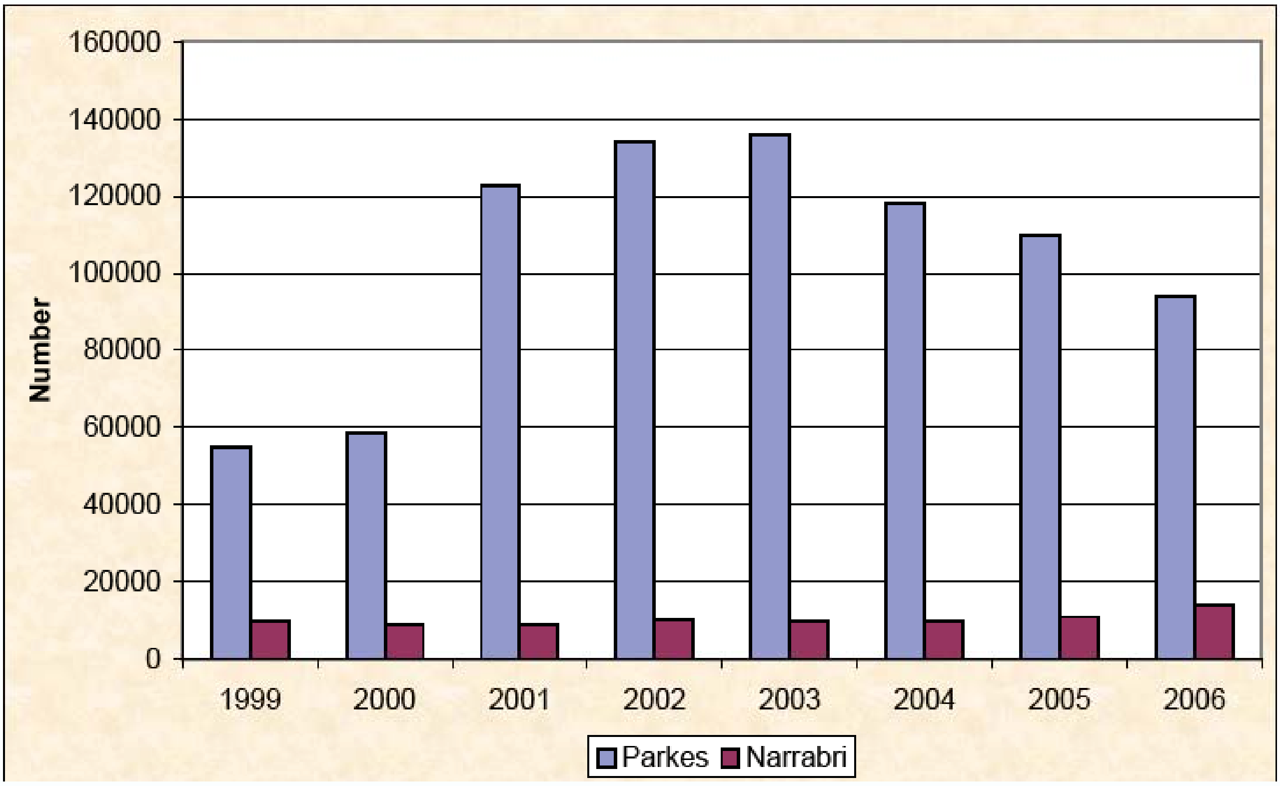


Figure 7 Number of visitors to the Parkes and Narrabri Visitors Centres.

7 User feedback at Narrabri and Parkes

Observers at the Parkes, Narrabri and Mopra observatories are asked to complete a user feedback questionnaire. Figure 8 shows the user responses for 2004 – 2006 for the Parkes Observatory. The user feedback is consistent over the three years, with an averaged response for 2006 of 87%.

Figures 9 and 10 show the user feedback for Compact Array observations taken with the centimeter and millimetre systems. The averaged responses were 88% for centimeter observing and 77% for millimetre observing.

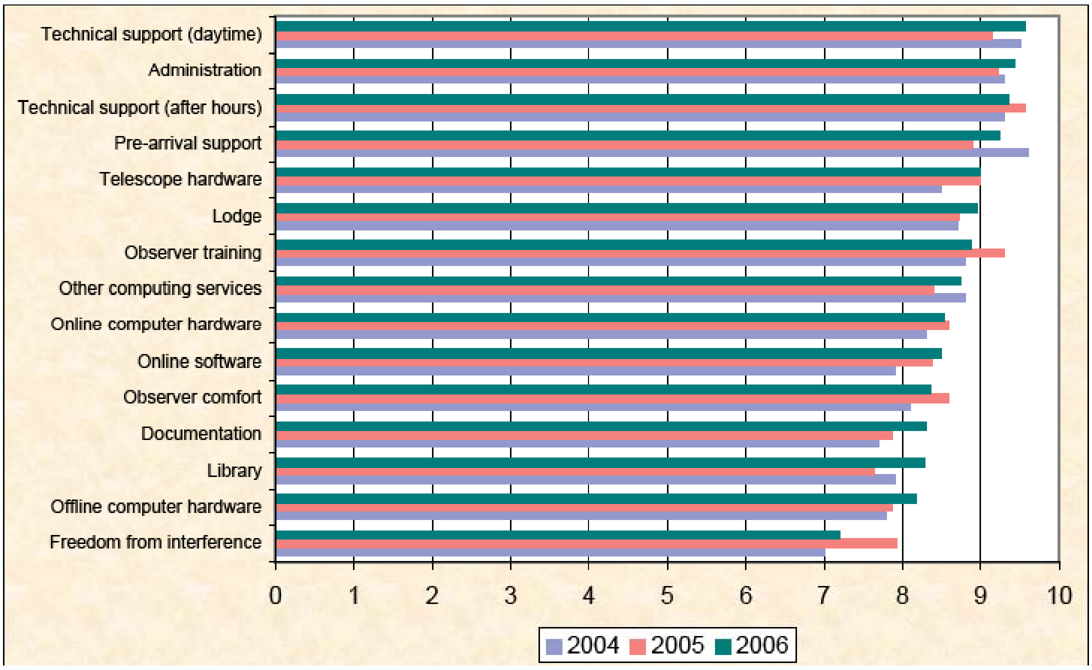


Figure 8 Parkes user feedback on a scale of 1 (poor) to 10 (excellent).

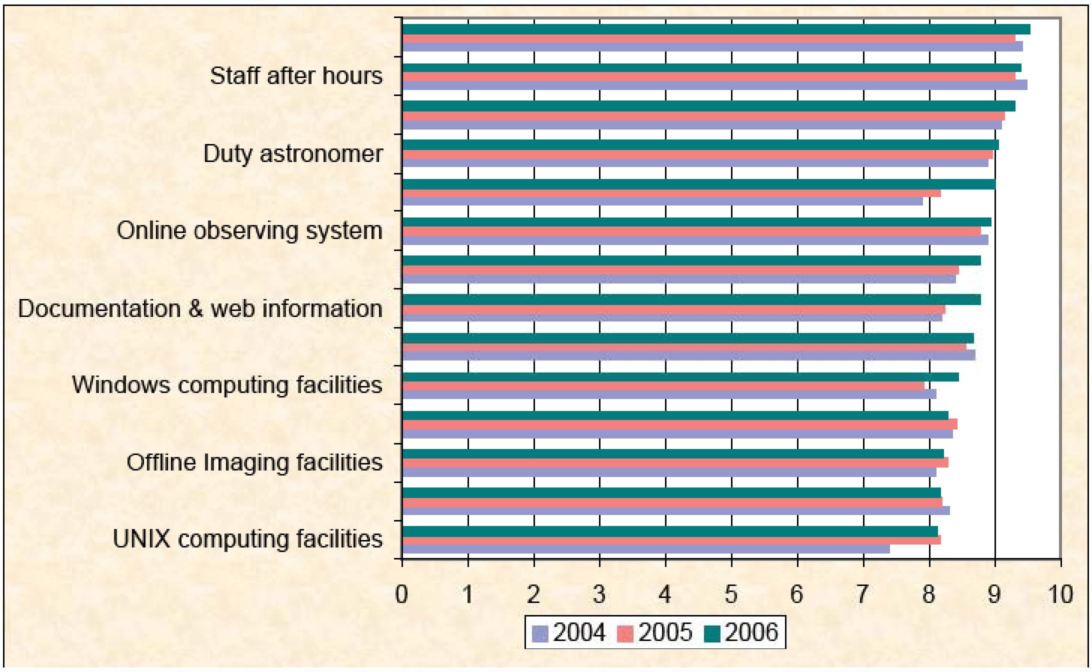


Figure 9 Narrabri user feedback for centimetre observations, on a scale of 1 (poor) to 10 (excellent).

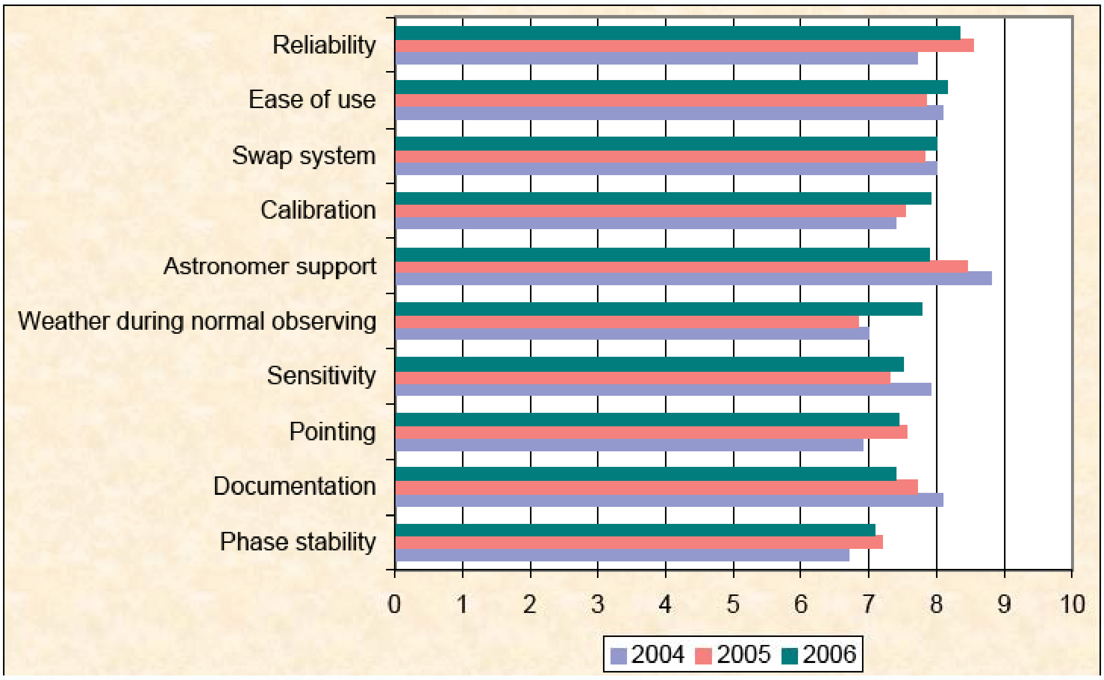


Figure 10 Narrabri user feedback for millimetre observations, on a scale of 1 (poor) to 10 (excellent).

Figure 11 shows the user feedback in 2004 – 2006 for the Mopra telescope. The averaged response for 2006 was 79%. Three items showed relatively poor responses in 2006: the on-line observing system, documentation and web information and offline data processing software and effort will be made to improve these.

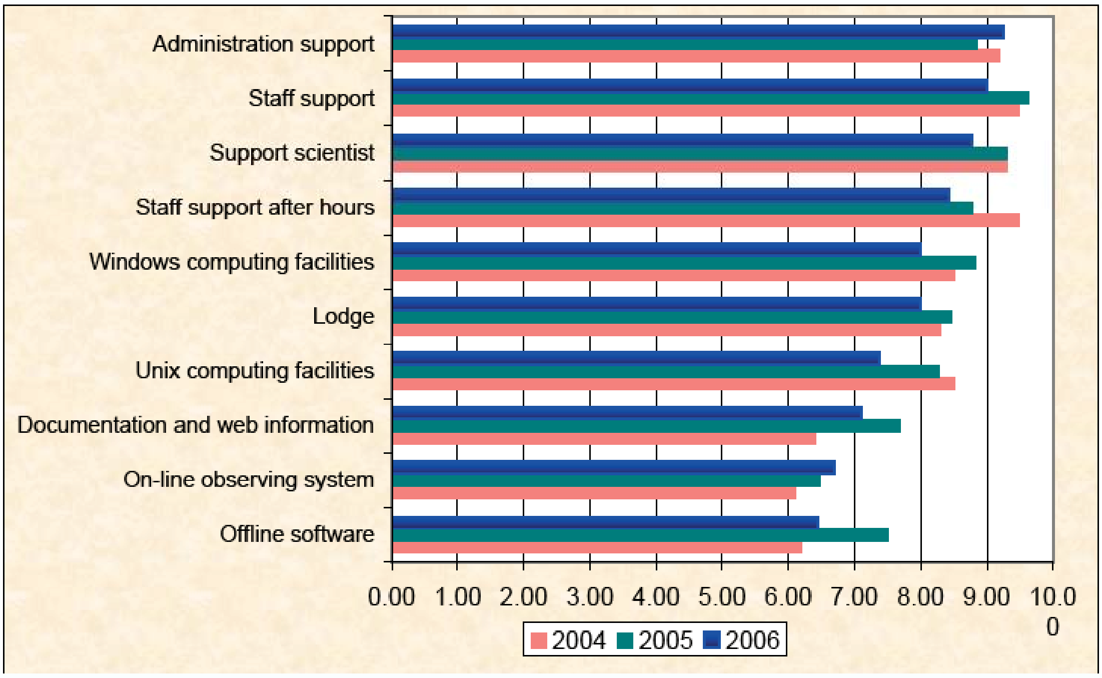


Figure 11 Mopra user feedback on a scale of 1 (poor) to 10 (excellent).

Astronomy reports

Photo: Graeme Carrad, CSIRO

The ATNF Astrophysics Group

Overview

The aim of the Astrophysics theme is:

> *To conduct world-class research in astrophysics, retaining astronomy's position as Australia's highest impact science and furthering our understanding of the Universe through innovative use of CSIRO's telescopes.*

The ATNF Astrophysics Group undertakes major observational research projects, many of which involve sizable national and international collaborations. The success of these projects is underpinned, to a large degree, by a deep understanding and technical knowledge of the telescope systems. In turn, the knowledge gained is used to provide the scientific case and the technical requirements for new generations of telescopes and instrumentation, ensuring that they deliver maximum scientific impact by targeting the highest priority science questions.

As researchers appointed within a National Facility, the group is charged with two primary responsibilities: (1) to conduct original astrophysical research and (2) to provide effective scientific support to ATNF users (both national and international) and to ATNF projects (for example in the role of project scientist for instrumental upgrades). While the division between these responsibilities varies by individual, about half of the group effort is expended in each role. In addition to the full members of Astrophysics Group, there are a substantial number of staff PhD astronomers who have primary responsibilities within other themes of the ATNF division, but who are still actively engaged (at the 10 – 50% level) in astrophysics research.

The Astrophysics Group has strong expertise in observational radio astronomy, particularly in the centimetre to metre wavelength range as well as expertise in other wavelength ranges. The group also has a very broad range of astronomical research interests. This breadth is important for National Facility support, given the diversity of the non-CSIRO user community and the range of projects supported on the facilities. Comparably broad groups are not found anywhere else in Australia.

Some of the main areas of astrophysical research that staff were involved in during 2006 were:

- Pulsar research;
- Galaxy interstellar medium and star formation studies;
- Stellar evolution;
- Nearby galaxy research;
- Active galactic nuclei and radio galaxies

Graduate student program

ATNF astrophysics (and some other) staff continue to co-supervise PhD students from (mostly) Australian Universities. The program helps strengthen training in radio astronomy science and techniques, and furthers collaboration between the ATNF and Universities. In December 2006 there were 33 PhD students affiliated with the ATNF (Appendix H). In June 2006 the students organized and held a full-day student symposium where they presented their research to fellow students and staff.

Distinguished Visitors program

The ATNF has a Distinguished Visitors program which provides some financial and other support to facilitate visits from leading researchers for extended periods from several weeks to a year. Some support for visitors is also provided through the Federation Fellowships funds.

During the year the ATNF enjoyed visits from many colleagues including:

Katherine Blundell (Oxford, UK);

Jayaram Chengalur (NCRA);

Jim Cohen (JBO, UK);

Bill Coles (UCSD, USA);

Ralf-Jurgen Dettmar (Bochum);

Ger van Diepen (ASTRON, Netherlands);

Christian Henkel (MPIfR, Germany);

Nissim Kanekar (NRAO, USA);

Uli Klein (Argelander Insitut, Germany);

Andrea Lommen (Franklin & Marshall College, USA);

Karl-Heinz Mack (Bologna, Italy);

Padelis Papadopoulus (ETH, Switzerland);

Emanuela Pompei (ESO, Chile);

Mary Putman (UMic, USA);

Nathan Smith (Colorado, USA); and

Mark Wardle (Macquarie, Australia)

The reports on the following pages describe a few of the many projects carried out by ATNF staff and National facility users during the year.

The methanol multibeam survey

James Caswell (ATNF), on behalf of the methanol multibeam survey team

The methanol multibeam (MMB) Survey is a project to completely survey the disk of our Galaxy for methanol masers at 6.6 GHz. The survey needs to be both sensitive and fast, so a purpose-built new multibeam receiver was constructed (described in the *ATNF Annual Report 2005*, when it was nearly complete). To study the whole Galaxy will require observations in both the southern hemisphere at Parkes with the 64-m telescope, and in the northern hemisphere at Jodrell Bank with the Lovell telescope. The plans are to study the southern Galaxy first, and then move the receiver to the Lovell telescope for the northern region. The receiver has been designed to require only modest (reversible) modification to permit usage on either telescope. Because the receiver has seven beams, and will be mounted on large diameter telescopes, the survey will be much more sensitive and at least an order of magnitude faster than the sample regions explored in previous systematic surveys.

The receiver was successfully commissioned at Parkes in 2006 January, and excellent survey observations were begun within a few days of the first installation (see page 46, and *ATNF News* Issue 58, February 2006). The discovery observation of the first new methanol maser is shown in Figure 1.

The principal purpose of the survey is to locate the majority of currently-forming massive stars in our Galaxy, expected to total somewhat more than 1000. Methanol masers are uniquely able to do this for two reasons:

They “turn on” while the young stars are still forming, deep inside giant molecular clouds of gas and dust, long before the stars emit visible light;

They are bright point objects at a radio frequency which can penetrate the dust and obscuration, in contrast to optical and near infrared measurements, and can thus trace the sites to great distances, at the very edge of our Galaxy.

Understanding these stars (typically 10 times more massive than our Sun) is important because they dominate the spiral arms of our Milky Way Galaxy. They are also the progenitors of other well known and much-studied exotic objects, supernovae, and the core remnants of supernovae, pulsars; our maser distribution will mimic that of the pulsars at birth, before the pulsars reach their current positions after millions of years travelling far from their birth sites.

Tracing newly-formed massive stars from their maser emission has two major benefits. Firstly, the masers have very small diameters and can therefore be located to very high precision, better than one arcsecond; such high observational accuracy is achieved from follow-up observations with the AT Compact Array, where we re-observe all detected masers and verify the genuineness of even the weakest discoveries. Secondly, as Figure 1 shows, masers not only have a precise position, but also a precise velocity, which can be used to estimate their distances. Consequently, we can see immediately that we are successfully detecting objects up to distances at the edge of our Galaxy, far from the Galactic Centre.

The survey plan is to complete the coverage of the bulk of the Galaxy visible from Parkes in 100 days of observations spread over two years. At the end of 2006, after one year, the project is well on track to achieve this, with several hundred new masers detected, together with all those previously known in the region surveyed so far.

In addition to completing the survey, the MMB team plans to begin using this resource to improve understanding of massive star formation. This will involve the search for other maser species coincident with the methanol, and for the association of quiescent clouds of molecular gas.

While the methanol survey was the trigger for building the receiver, it was also recognised that it was an opportunity to yield yet more science. So, in parallel with the methanol survey, the team is also conducting a survey for the rarer species of maser arising from the excited state of OH (the hydroxyl radical) at 6.035 GHz. The two surveys together require the recording of data from 28 signal paths from the focus cabin - a record for any Parkes receiver. The 28 cables from the receiver are mounted so as to allow rotation of the receiver, but with the other cable ends firmly attached to a fixed panel; this must be done without tangling or damaging the delicate cables and connectors – a daunting challenge ably handled by the ATNF engineers.

Pulsar observers have also noticed an opportunity to use the receiver for an efficient search for pulsars at a high radio frequency. They observe a smaller region of sky than the methanol survey, but for a longer period, so as to achieve high sensitivity. Even more opportunistically, the maser team realised that this could allow even more sensitive maser searches over the pulsar observers' small region of sky, by "piggy backing" on the pulsar survey and directing a portion of the signal to our spectral line processing correlator. Consequently a portion of the Galaxy has been searched for methanol masers that are up to four times fainter than in the main survey.

The Methanol Multibeam project is a joint collaboration of 20 UK and Australian scientists. The UK team was formed, and initially led, by Dr Jim Cohen from Jodrell Bank Manchester. Sadly, Jim died unexpectedly on 1 November 2006 (see *ATNF News* Issue 61, February 2007). Gary Fuller from Manchester has taken over leadership of the UK team. The Australian team is led by James Caswell of the ATNF.

With the loss of Jim Cohen, we are even more determined to achieve the full potential of the survey, so that it will be a fitting legacy of Jim's enormous contribution to the project. At the halfway stage of the southern observations, the survey is progressing exceptionally well and more detailed scientific results will be presented in a future annual report.

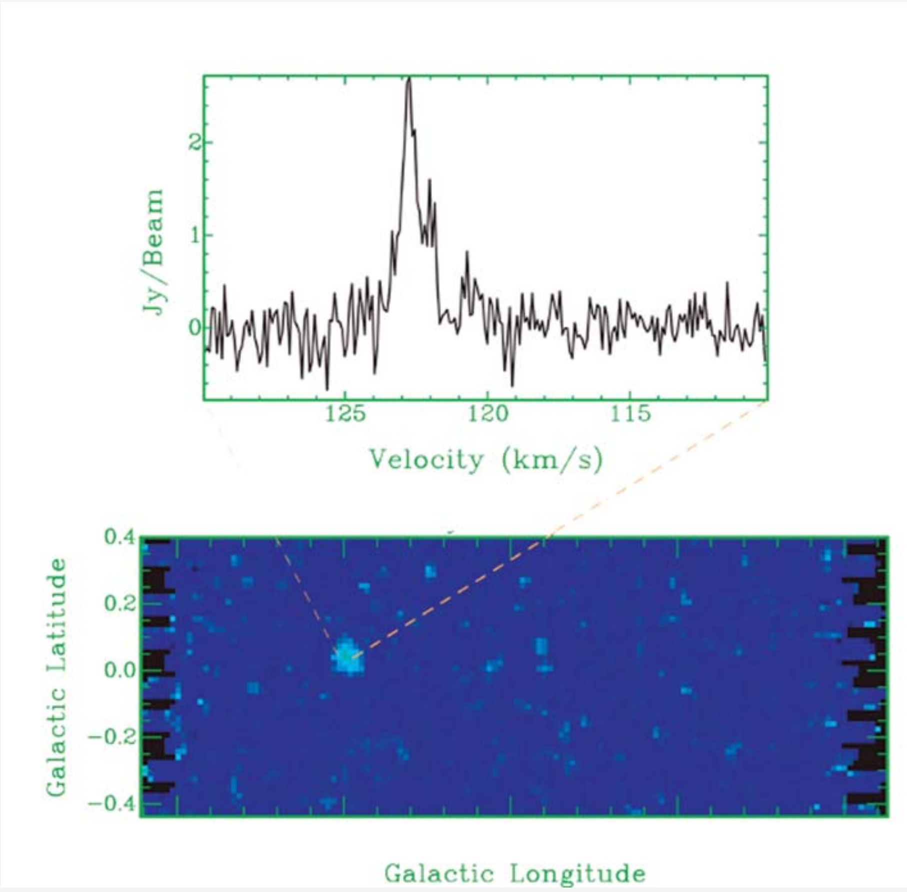


Figure 1: Discovery of the first new methanol maser in the methanol multibeam survey. The bottom panel shows an image locating the maser as a compact source clsoe to the Galactic Plane. The top panel shows a spectrum of the maser with strongest emission at a velocity of 123 kilometres per second.

Mopra observations of the molecular gas in Ara

A. Hughes (Swinburne University/ATNF), T. Wong (University of Illinois, Urbana-Champaign) & S. Maddison (Swinburne University)

Ara OB1 is a massive star-forming region situated a few degrees below the Galactic plane, at a distance of approximately four thousand light years (Arnal et al. 2003). The Ara OB1 region contains a variety of star formation phenomena, including early-type stars, molecular clouds with dense cores, embedded clusters, regions of ionised hydrogen, and compact sources of radio continuum emission. Most remarkable is the bright rim nebula, NGC 6188, which marks the eastern edge of a molecular cloud that is being eroded by the ionising radiation from two O-stars in the young open cluster NGC 6193. Based on high-resolution optical, near-infrared and millimetre observations of a 30 arcminute x 30 arcminute region around NGC 6188, Comeron et al. (2005) have proposed that the current star formation in Ara OB1 was triggered by the progress of a shock front powered by massive O-type stars in NGC 6193.

The neutral interstellar medium surrounding Ara OB1 has not been studied in detail. Low angular resolution observations of the molecular gas in Ara (Yamaguchi et al. 1999, Arnal et al. 2003) showed that there is a thin, clumpy filament of carbon monoxide (CO) emission extending over a degree to the south-west of NGC 6188. These studies suggested that the gas in the filament is quiescent and relatively diffuse, and may not be physically associated with the star forming gas in the NGC 6188/NGC 6193 region. However, single-dish neutral hydrogen observations from the Parkes Southern Galactic Plane Survey reveal an accumulation of atomic gas that is coincident (both spatially and dynamically) with the molecular filament. McClure-Griffiths et al. (2002) tentatively identified this neutral hydrogen gas as the wall of an expanding shell, GSH337+00-05, suggesting that the star formation activity in Ara may depend on large-scale dynamical processes in the interstellar medium, as well as the compression of gas in the localised shock front emanating from NGC 6193.

In mid-2006, the Mopra radio telescope was used to obtain wide-field, high angular resolution maps of the molecular filament extending south-west of NGC 6188. The installation of the new Mopra receiver, MOPS, in May 2006 provided the opportunity to observe multiple molecular line transitions simultaneously. Data were obtained for 137 adjacent fields, each covering an area of 5 x 5 arcminutes. A mosaic of the integrated ^{13}CO (J = 1–0) emission across the entire region is presented in Figure 1.

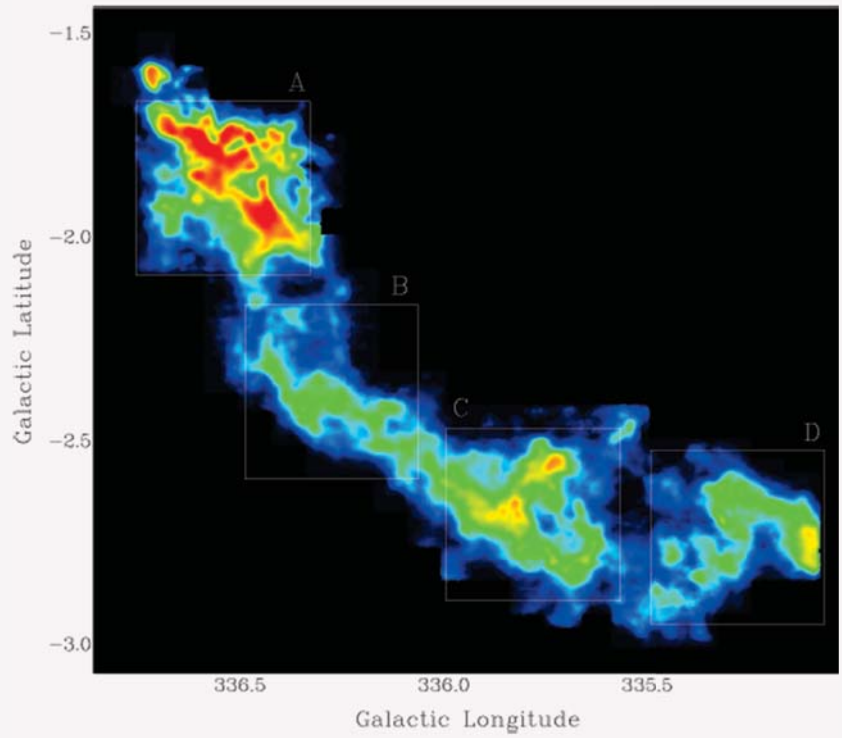


Figure 1: Integrated intensity map of the ^{13}CO (J = 1–0) emission from the molecular gas filament in Ara obtained using the Mopra Telescope. The white boxes indicate regions A to D.

Based on the Mopra observations, the total mass of the Ara molecular filament is estimated to be 6 x 10^4 $M_\odot$. Emission from low-density gas tracers, such as CO, is present across the observed region; emission from higher density gas tracers is confined to the bright peaks at the north-eastern end of the filament and a knot of bright emission (Region C). Spectral line profiles show emission from molecular gas across the velocity range from –23 to –14 kilometres per second. There is a clear velocity gradient along the gas filament, with more positive velocities occurring at the south-western tip of the cloud. The direction and magnitude of this velocity gradient is consistent with a physical connection between the filament and the gas in the NGC 6188/NGC 6193 region.

By comparing the Mopra data with infrared images from the Midcourse Space Experiment (MSX, Mill 1994) and the Parkes-MIT-NRAO radio source catalogue (Wright et al. 1994), a potential new site of star formation has been identified in Ara. The tip of the molecular gas filament closest to the NGC 6188/NGC 6193 region is coincident with a ring of 8 micron emission that encloses a ~1 Jy thermal radio source (J1641–4902) and an infrared point source (IRAS16379–4856, see Figure 2). The infrared emission is thought to occur from polycyclic aromatic hydrocarbon molecules at the interface of an ionized bubble of gas surrounding a young ionised hydrogen (HII) region and the molecular cloud. In this case, IRAS16379–4856 may be an infrared cluster containing early-type stars that drive the HII region, with the thermal radio emission arising from hot gas that has been ionised by the newborn stars. The strength of the radio emission detected from J1641–4902 suggests that the HII region is powered by a B0 star.

The variation in star-forming activity along the Ara molecular gas filament provides an unique opportunity to investigate the physical properties of star forming and non-star forming molecular gas. The team has used statistical techniques to characterise the structure and kinematics of the gas in four regions along the filament (Regions A to D). The molecular gas in the south-western tail of the filament is more diffuse than the gas in the star-forming, north-eastern tip of the cloud (Region A). Region A is also more structured than the rest of the filament, with 55 clumps identified, compared to a combined total of 59 clumps in Regions B to D. Typically, the clumps have diameters of about 3 light years with larger clump sizes in the more quiescent regions. The velocity dispersion within the clumps is fairly constant across the entire filament, at about 0.6 kilometres per second. Further analysis is required to determine whether the smaller and more numerous clumps in Region A were formed as part of the gravitational collapse that led to the onset of star-forming activity in this region, or whether the properties of these clumps are strongly affected by ionising feedback from the nascent early-type stars.

The “spectral correlation function” (SCF) is a statistical tool that has been used to test theoretical models that describe the structure and dynamics of molecular clouds. Annie Hughes and her collaborators have compared the SCF for the four regions within the Ara molecular gas filament with other CO observations of other star-forming Milky Way molecular clouds (Padoan et al. 2003). This comparison suggests that the dynamical properties of the molecular gas in Ara remain coherent over larger spatial scales than the average for Milky Way molecular clouds, perhaps because turbulent motions in the filament are relatively weak, or because the gas in the filament is being organized by a large-scale dynamical process.

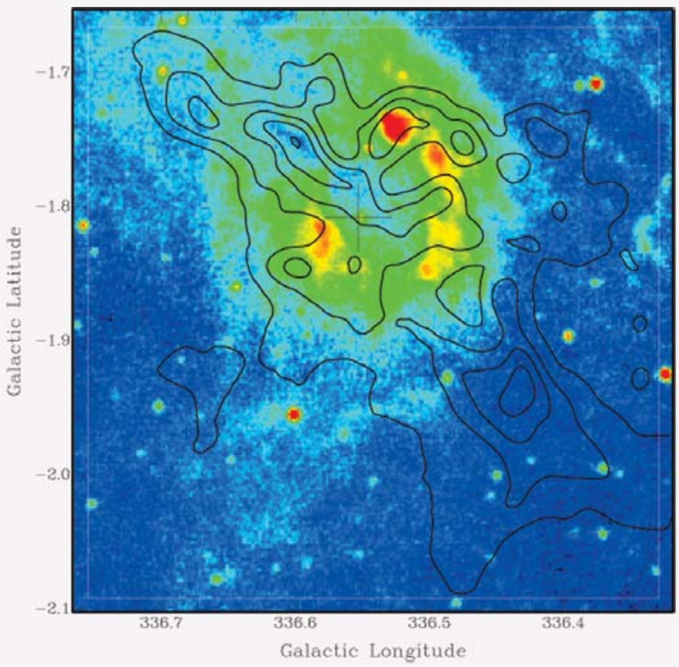


Figure 2: A ring of 8 micron emission, identified as a possible young HII region in the north-eastern tip of the Ara molecular gas filament. The integrated ^{13}CO emission from the molecular gas is shown as black contours. The white box indicates Region A.

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Supernova 1987A: 20 years old and still growing stronger!

L. Staveley-Smith (University of Western Australia), L. Ball (ATNF), B. Gaensler (University of Sydney), M. Kesteven (ATNF), R. Manchester (ATNF), A. Tzioumis (ATNF) and C. Y. Ng (University of Sydney)

The news of a new supernova in the Large Magellanic Cloud quickly swept around the world after its discovery by Canadian astronomer Ian Shelton at Las Campanas Observatory, Chile on 24 February 1987. A neutrino burst, which signified the event as a Type II core-collapse supernova, was retrospectively identified in data from the Kamiokande II detector in Japan, and other detectors at UT 07:35 on 23 February 1987.

Being the brightest supernova for 400 years, and the closest supernova since the invention of the telescope, it was an amazing event. Many astronomers not previously noted for their expertise in supernovae rapidly became inducted if they happened to be sitting at a suitably southern telescope at the time. For radio astronomers, it was unfortunate that the Compact Array was still a few years from being operational. However, the Sydney University Molonglo Observatory Synthesis Telescope and the Fleurs Synthesis Telescope were operational and, within a few days, the Australian VLBI network also swung into action. Early detections, summarised by Turtle et al. (1987, Nature, 327, 38) and Storey & Manchester (1987, Nature, 329, 421), were extremely important in understanding some of the blast wave astrophysics, including the density of the immediate circumstellar environment. Even the VLBI non-detection (Jauncey et al. 1988, Nature, 334, 412) was important in establishing that the initial shock velocity was in excess of 19,000 kilometres per second.

From the initial detection until the end of 2006 more than 1,500 refereed astronomy and

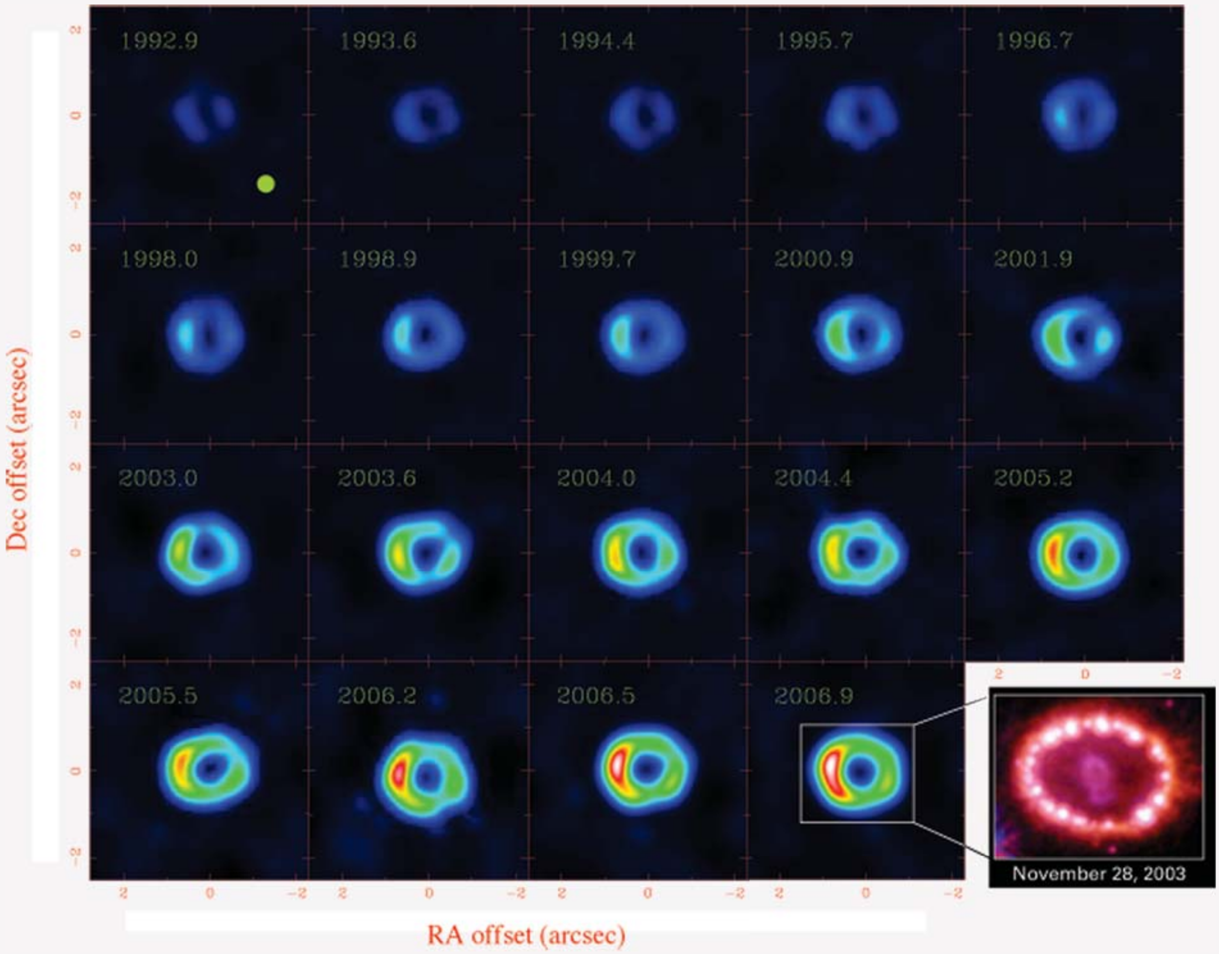

Figure 1: Compact Array images of SN1987A at a frequency of 8 GHz obtained between 1992 and 2006. The images shown have been super-resolved to a resolution of 0.5 arcsec and were taken at multiple frequencies in the 3 cm (8 GHz) band. The inset photo is a high-resolution optical image from HST-ACS, courtesy NASA, P. Challis, R. Kirshner and B. Sugerman.

physics papers, with approximately 32,000 citations, were published on SN1987A according to the NASA Astrophysical Data System! Interestingly, the publication rate has remained around 20–30 papers per year for the last decade. Why the continued interest? The answer lies in the high-density environment around the expanding shock wave which continues to create a firework display in all wavebands from the radio to the X-ray regime. Fourteen years of Compact Array imaging data shows that, rather than fading after a few weeks as has been seen in all other radio supernovae, SN1987A has considerably brightened in the intervening years.

The reason for the brightening in the radio and other regimes relates to the extremely high densities in the pre-existing circumstellar medium. This medium is most visible in the Hubble image shown in Figure 1. Unlike the radio image, the Hubble image mainly shows the pre-existing medium excited by the rapidly engulfing shock wave. However, detailed understanding of the formation of this ring-like structure is still needed.

Figure 2 shows that by December 2006 the flux density of SN1987A had exceeded 300 mJy at 1.4 GHz, while the rate of change of its flux density was also increasing. Future predictions of the flux evolution are fraught with uncertainty — partly due to poor detailed knowledge of the cosmic ray acceleration mechanism and magnetic field evolution — but mainly due to the poorly understood circumstellar density profile. The continuing interaction of the shock front with the circumstellar medium provides the power source for the generation of the synchrotron radiation responsible for the radio brightness.

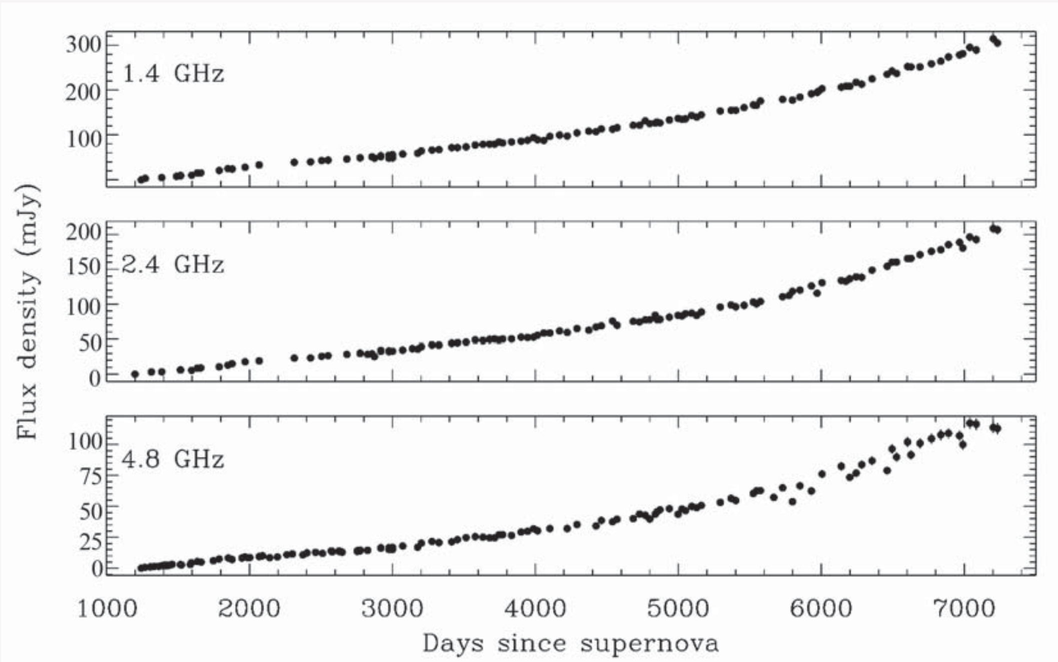

Figure 2: Seventeen years of Compact Array monitoring of SN1987A up to day 7231 (11 December 2006) showing that the flux density is not only increasing at all frequencies, but that the rate of change of flux density is also increasing.

Recent radio observations have resulted in images of even higher spatial resolution and have resulted in the first detection at 3 mm using the upgraded Compact Array (Manchester et al. 2005, ApJ, 628, L131). What does the future hold? Low frequency observations with the more sensitive eVLBI array will be useful in establishing the variation of spatial structure across an order of magnitude in frequency, which will help us better understand the acceleration mechanisms. The detection of a pulsar would be extremely important on a number of fronts — stellar evolution theories are divided between a neutron star and a black hole end-point for the remnant of SN1987A; and pulsar birth periods currently remain poorly understood. Finally, will SN1987A continue to brighten in the radio regime and perhaps one day rival that of the neighbouring giant HII region, 30 Doradus? Probably unlikely at this stage, but SN1987A has produced many surprises in the last 20 years, and more can be expected!

A new neutron star relativistic jet source in the Galaxy

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X-ray binaries are systems where a star and a compact object are gravitationally bound and in orbit around each other. The X-ray binaries are usually in a quiet state where they show little or no radio emission. However, they may also show outbursts when the X-ray emission becomes much brighter, and radio emission is detected. The increase in X-ray brightness during an outburst has been shown to be due to increased accretion of gas from the star onto a flattened disk of material that surrounds the compact object. The radio emission occurs when material is ejected away from the disk in jets that move in narrow beams at speeds close to the speed of light.

Understanding X-ray binary systems in our Galaxy provides insight into the physics of active galactic nuclei (AGN) in distant galaxies where both accretion and outflows are observed. In recent years much of the focus has been in X-ray binary systems where the compact object is a black hole. However, in some X-ray binaries the compact object is a neutron star and these neutron star binary systems are also an extremely useful group of objects for studying accretion and outflow physics.

The brightest set of neutron star X-ray binaries in our Galaxy are known, from their X-ray properties, as the “Z sources”. So far, six or seven Z sources have been identified, all of which have been known since the early days of X-ray astronomy in the 1960s and 1970s. The steady-state X-ray emission from these sources contributes a significant fraction of the X-ray energy output of the entire Galaxy. Furthermore, they are all radio sources and in two cases, Sco X-1 and Cir X-1, the radio emission has been resolved into relativistic jets.

In January 2006, for the first time in almost 30 years, a new, transient, Z source was discovered: Known (from its sky position) as XTE J1701–462, the source was rapidly identified as a member of this exclusive class from an analysis of its X-ray properties and variability (Homan et al. 2006). Following a special request to the ATNF for Director’s time, this source was observed with the Compact Array 15 times between 22 January – 20 March 2006. During this period the X-ray emission varied as expected for a Z source, while the radio source was observed to switch on and off, in a characteristic relation to the X-ray emission (Figure 1). This shows that XTE J1701–462 almost certainly follows the same pattern of disc – jet coupling as the other Z sources, alternating between phases of relativistic jet production and phases of “jet-less” accretion.

The most variable of the previously-known Z sources is Circinus X-1. Compact Array observations have shown that Circinus X-1 has extremely high-velocity relativistic jets (Fender et al. 2004), which power a parsec-scale radio nebula (Stewart et al. 1993). It is not clear how the new source, XTE J1701–462, will evolve in the future, but we do know that using the Compact Array together with X-ray observatories we have observed the activation of a powerful new jet source within our Galaxy.

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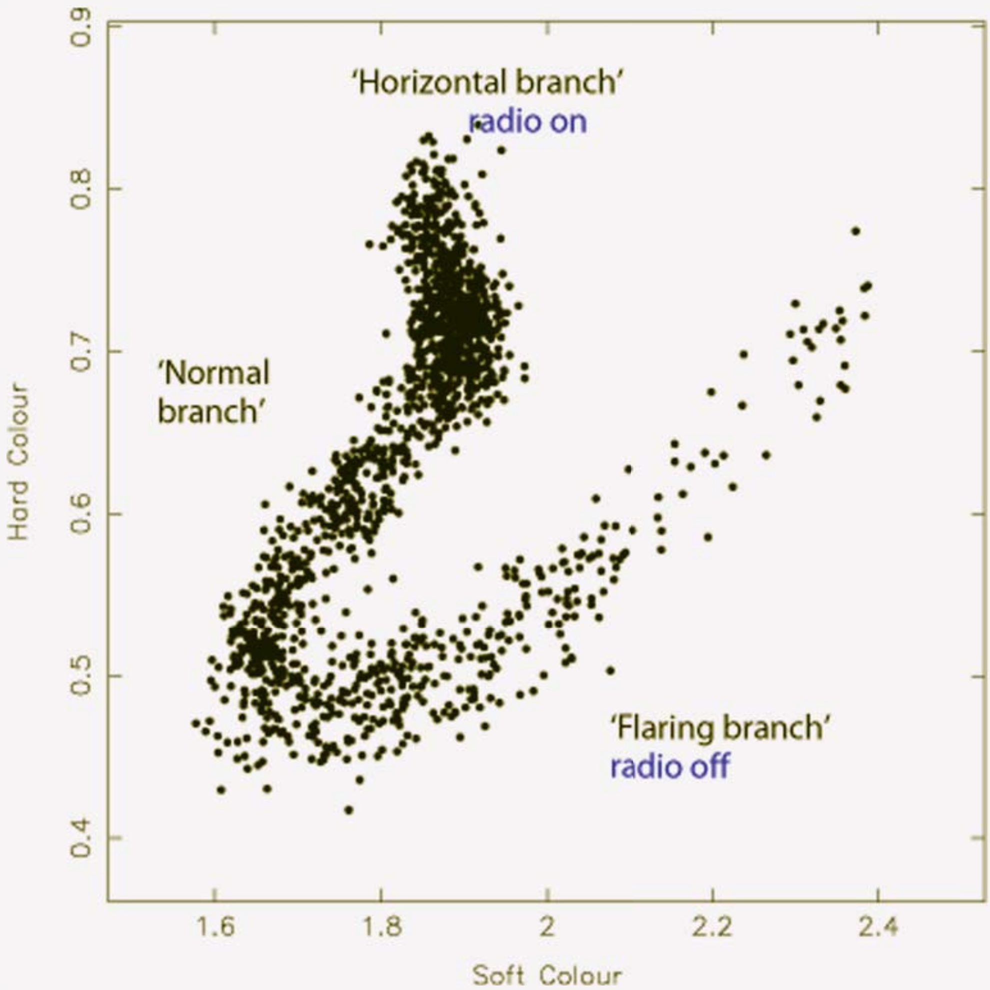

Figure 1: An X-ray colour-colour diagram for the newly-discovered source, XTE J1701–462, displaying the three branches characteristic of a Z source. Each branch corresponds to a different state of the accretion flow in the X-ray binary. There is a strong relation between the X-ray state and the detection or non-detection of radio emission. During the radio "on" phases it is likely that this source, which harbours a neutron star, is producing a transient, relativistic radio jet.

Radio Magnetar Discovered at Parkes

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On 18 March 2006 an extraordinary new radio pulsar was detected at Parkes. An observation of the anomalous X-ray pulsar (AXP) XTE J1810–197 revealed very strong radio pulses repeating every 5.54 seconds. This observation marked the first detection of magnetospheric pulsed radio emission from a magnetar and, among other implications, establishes a link between ordinary radio pulsars and magnetars.

Subsequent observations with Parkes, with the 100-metre Green Bank Telescope (GBT) and with several other telescopes around the world, confirmed the detection and established a range of remarkable properties. The discovery and preliminary results were announced in Nature (Camilo et al.) during the Prague IAU.

Magnetars, of which only a dozen are known, are young neutron stars whose very bright and highly variable X-ray emission is thought to be powered by the decay and reconfiguration of their ultra-strong magnetic fields. In this respect they differ fundamentally from the ubiquitous radio pulsars (of which more than >1700 are now known), in which the non-thermal radiation, from radio up to gamma-rays, ultimately derives from magnetic braking of the rotation of the neutron star. This energy source alone cannot power magnetars, whose X-ray luminosities greatly exceed the rotational energy available from spin-down. Despite several searches no radio emission has hitherto been detected from either AXPs or soft-gamma repeaters (SGRs), the two sub-classes of magnetars.

This object attracted concerted attention in 2003 as the first transient AXP, when its X-ray emission was found to have increased about 100-fold (Ibrahim et al.). This enhanced flux was found to have a strong periodicity at 5.54 seconds, lengthening by about 1 microsecond per day. The spin-down of isolated neutron stars is caused by magnetic torques, with the rate of slow-down proportional to the magnetic field strength. For XTE J1810–197 this implied a field of 10^{14} Gauss. The X-ray flux has been decreasing exponentially since the outburst with timescales of a few hundred days (Gotthelf & Halpern), and will soon return to the historically quiescent level which, to judge from archival data, it had maintained for at least 24 years.

The magnetar was subsequently detected as a continuum radio source, with a flux density at 1.4 GHz of 4.5 mJy, in a survey using the Very Large Array (VLA) during early 2004 (Halpern et al.). The origin of this emission remained a mystery until the detection of the remarkable radio pulsations at Parkes.

The individual pulses detected from virtually every rotation of the neutron star at low frequencies (below 1 GHz) are composed of sub-pulses of typical width <10 milliseconds that arrive mostly within a 150 millisecond-wide window. Neither this nor the high degree of linear polarization in themselves makes the radio emission from XTE J1810–197 fundamentally different from that of ordinary pulsars. However, at least four characteristics of this radiation make it unusual or unique:

1. The radio spectrum is very flat over a wide range in frequency.
2. At a given frequency there is no stable average pulse profile; different pulse components change in relative intensity and new components sometimes appear.
3. The flux changes at all frequencies. At 8 GHz at least some of this variation is due to interstellar scintillation.
4. The radio emission is transient: in 1997 and 1998 the flux was less than 10 percent of the smallest value measured in 2006. Evidently, the radio emission turned on as a result of the magnetospheric changes that occurred in XTE J1810–197 following its 2003 X-ray outburst.

The implications of these characteristics are not yet well understood. Presumably these observations contain important information about the current conditions in the corona of this magnetar. Further radio, infrared, and X-ray observations may eventually provide a fuller picture. Some of the observed X-ray emission implies the existence of currents in the magnetosphere, and the decay of this emission points to a subsidence of the currents. The radio emission may eventually cease, but whether this will take place in six months or 50 years is uncertain.

The discovery of transient (and bright) radio emission from XTE J1810-197 is a reminder that the radio sky is far from static, requiring more frequent monitoring than can generally be obtained with current instrumentation. It is also a reminder of how successful the Parkes multibeam receiver and analogue filterbank have been for the last decade in discovering new pulsars.

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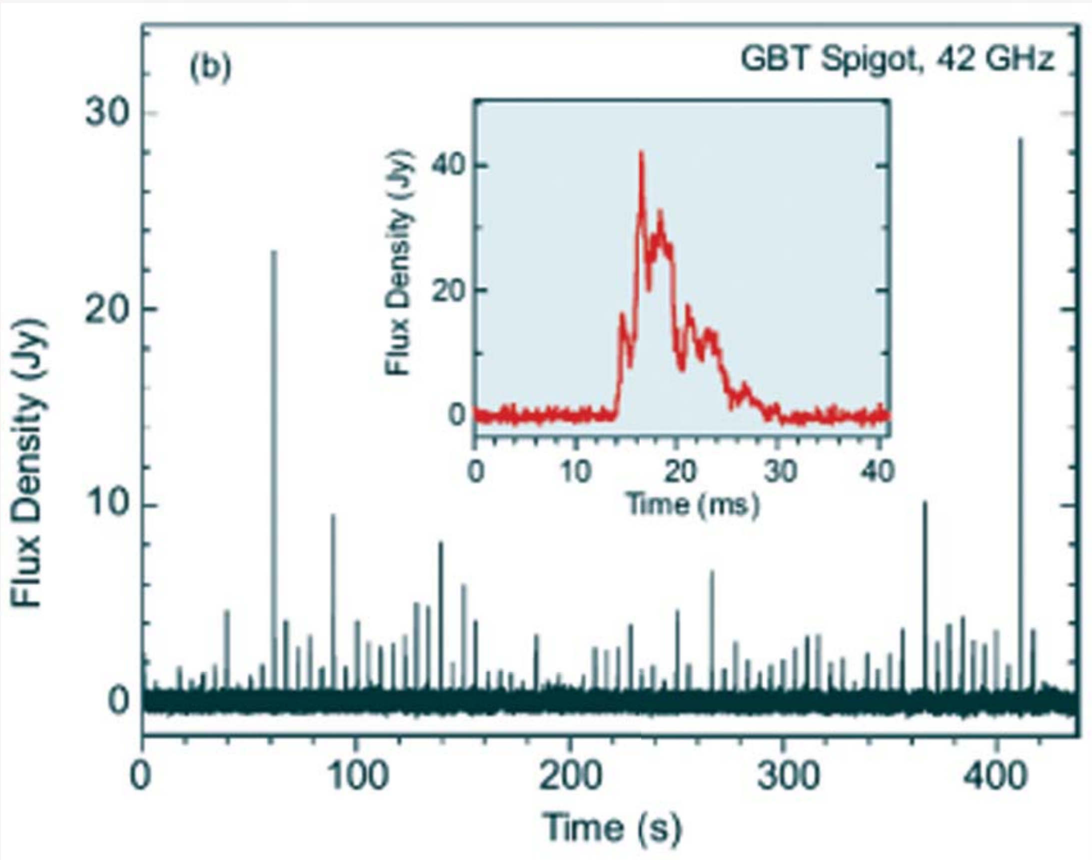

Figure 1: Single pulses from the anomalous X-ray pulsar XTE J1810–197, observed with the GBT. The main plot shows a sequence of about 80 consecutive single pulses detected at a frequency of 42 GHz. The inset panel shows a 40-millisecond detail of the brightest pulse.

Using ATLAS to find early galaxies

R. Norris (ATNF) and the ATLAS team

How were the first galaxies born? And how were they born at such an early stage of the Universe, well before the time predicted by most standard models? And why are Active Galactic Nuclei (AGN) also found at these early stages, indicating that black holes were born long before their expected gestation time?

ATLAS (Australia Telescope Large Area Survey) is one of several deep survey programs around the world aiming to answer these questions. ATLAS is a large project with the Compact Array that started life in 2002 as a radio survey of the Chandra Deep Field South (CDFS), and expanded in 2004 to encompass the fields imaged at infrared wavelengths by SWIRE (Spitzer Wide-area Infrared Extragalactic Survey). It was re-christened as ATLAS when the first results were announced in December 2005.

ATLAS differs from most other deep survey programs in several respects. Firstly, it operates at radio wavelengths (20 cm), cutting through the dust which obscures the view of the nuclei of many of these early galaxies at shorter wavelengths. Secondly, it covers a much wider area than other radio surveys. When complete it will be the widest, sensitive radio survey ever attempted, detecting sources stronger than about 50 microJy over seven square degrees of sky. One advantage of such a sensitive, wide-area survey is its ability to discover rare objects, and another is to see cosmic structure – the walls and voids of galaxies which are already well-known from optical surveys – which cannot be reliably traced optically at high redshifts because of the obscuring dust.

Results have so far been published for some 805 radio sources in a four-square degree area of the region surrounding the CDFS, reaching down to a noise level (rms) of 30 – 40 microJy (Norris et al. 2006). Conventional wisdom is that all the galaxies detected at radio wavelengths should be visible in the infrared observations taken by the Spitzer Space Telescope, as part of the SWIRE project. It was therefore surprising to find that 11 ATLAS sources were not seen in the Spitzer infrared images.

These “radio-only” objects have been dubbed the Infrared-Faint Radio Sources (IFRS). They are puzzling because any mechanism, whether starburst or AGN, which can generate radio emission should also generate sufficient infrared energy to be visible by Spitzer. It is possible that they are very high redshift radio-loud galaxies or quasars, or active galaxies buried so deeply in dust that the infrared emission is being radiated at wavelengths too long even for Spitzer. Alternatively, their explanation may be either more prosaic (e.g. radio lobes from unidentified and spatially separate host galaxies) or more exotic (an AGN which generates radio waves without generating the optical or infrared radiation). A recent detection of one of the IFRS (Norris et al 2006b) with very long baseline interferometry (VLBI) suggests that they are associated with AGN.

Because the IFRS are rare, they had not previously been identified as a class. This was one of the original justifications for the ATLAS proposal: only a survey covering such a large area is expected to uncover rare types of object. Another justification for ATLAS was that it was the first large radio survey to be conducted in conjunction with a large state-of-art infrared survey. The ATLAS survey has access to more data at other wavelengths than any other previous radio survey. As a result, each of the 761 galaxies has been carefully matched to infrared and optical data. Most of them now have infrared and optical photometry, enabling us to fit galaxy templates to their spectral energy distributions, yielding classifications and photometric redshifts. Roughly half seem to be powered primarily by star formation, and about half by AGN. In many cases, both mechanisms appear to be active, in some cases differing significantly from those seen in the local Universe.

As the project reaches completion, the number of galaxies will swell to many thousands, raising even further the potential for finding rare objects. Even more importantly, this will be the first time that a survey has enough radio objects at the tens of microJy level, with accompanying data at other wavelengths, to examine how the relative numbers of AGN and starburst galaxies change with redshift and luminosity.

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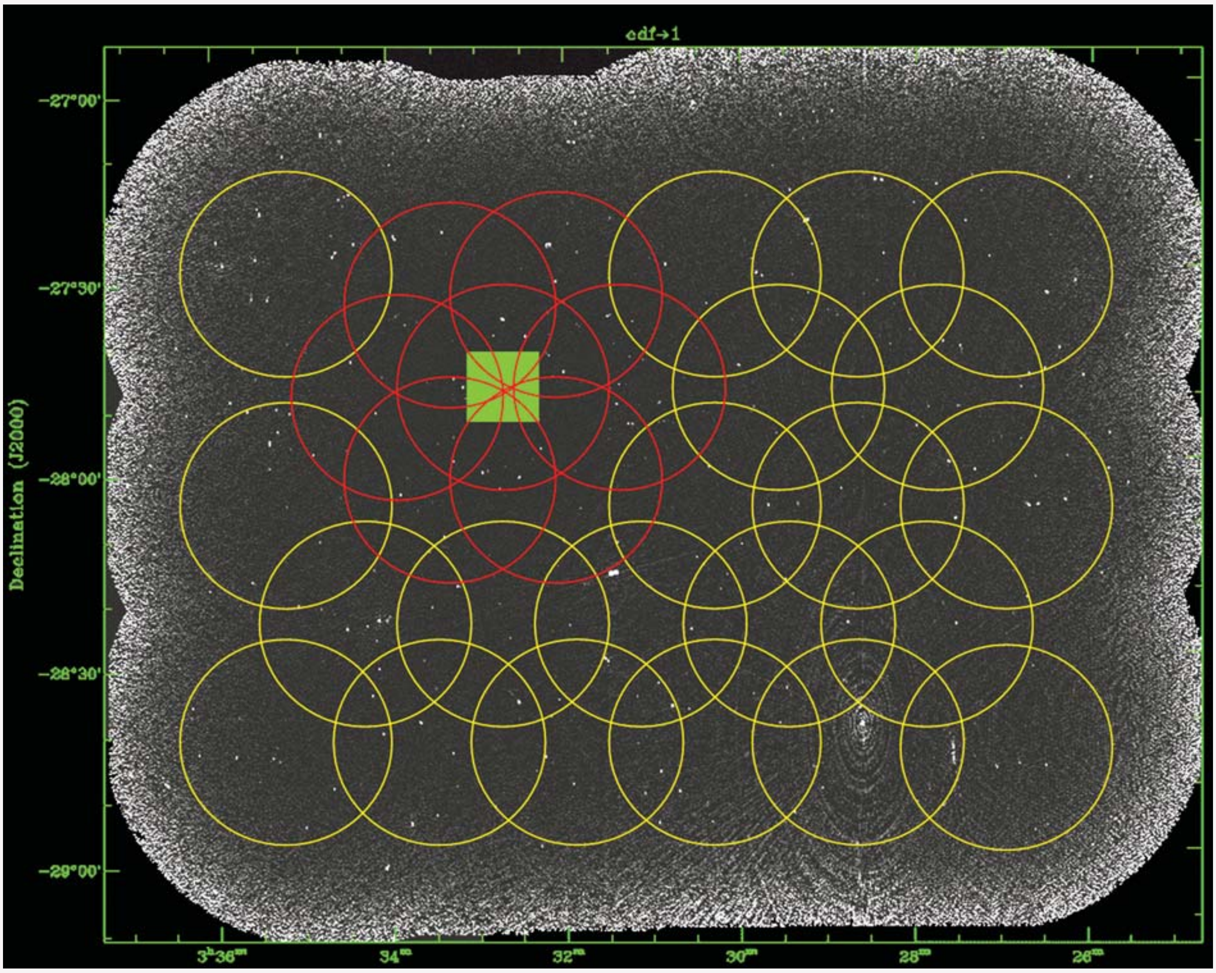

Figure 1: Compact Array radio image (greyscale) of the region surrounding the Chandra Deep Field South (CDFS). Circles show the half-power beamwidths of the Compact Array antennas for this 28-pointing mosaic. The green square at the top left shows the location of the CDFS-GOODS (Great Observatories Origins Deep Survey) field. A strong 1 Jy source, which challenges the computing algorithms used to calibrate the data, can be seen on the lower right.

A bright millisecond radio burst of extragalactic origin

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Transient radio sources, where radio emission is detected for only a brief period of time, are difficult to detect, but can potentially provide insights into a wide variety of astrophysical phenomena. Radio pulsar surveys offer one of the few opportunities to monitor the radio sky for impulsive burst-like events with millisecond durations. Motivated by the recent discovery of rotating radio transients, neutron stars which exhibit occasional sporadic bursts of emission, a team led by Duncan Lorimer at West Virginia University (WVU) have been searching for transient events in a recent Parkes survey of the Magellanic Clouds. In late 2006 a highly significant signal with a peak flux of 30 Jy, shown in Figure 1, was found by WVU student David Narkevic. The burst was so strong that it saturated the detectors used with the Parkes multibeam receiver!

Figure 1 shows two plots from the detection of this source. The larger plot shows the intensity of the signal at a range of frequencies, plotted against the arrival time of the signal. The curved shape seen in this diagram is characteristic of pulsars where high-frequency signals arrive earlier then lower frequency signals. This is due to dispersion of the signal as it travels through space. Generally, more distant sources show more dispersion. To obtain the true signal "profile" the data are "de-dispersed" and this is shown in the inset panel.

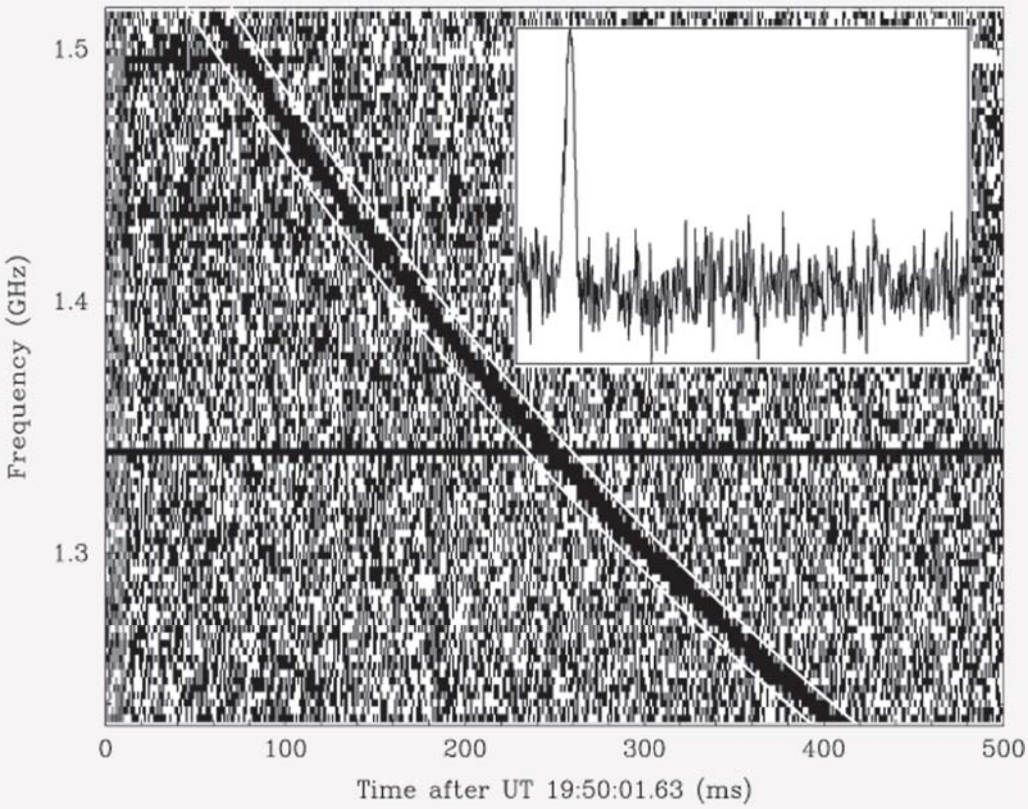


Figure 1: The frequency evolution of the transient radio burst detected in 2006 is shown as a two-dimensional "waterfall plot" of intensity as a function of radio frequency versus time. The dispersion of the signal is clearly seen. The two white lines separated by 15 milliseconds that bound the pulse show the expected behaviour for a "cold-plasma" dispersion law.

Inset: The intensity of the signal after correcting the data for dispersion. The time axis on the inner figure also spans the range 0 – 500 milliseconds.

Due to the anomalously high amount of dispersion, it is highly unlikely that the burst is associated with our Galaxy or with the Small Magellanic Cloud, located three degrees away on the sky (Figure 2). No counterparts have been found at other wavelengths and the source has not, so far, been detected again. The lack of an optical counterpart to the burst implies that it is at a distance of at least 1,800 million light years, while from models of intergalactic dispersion, the delay shown in Figure 1 is consistent with a cosmological event up to three billion light years away. The source therefore appears to represent the first millisecond radio burst ever detected from outside our Galaxy.

The origin of the source is currently unclear. Light-travel-time arguments limit the source size to less than 1,500 kilometres. This indicates, for a non-relativistic source, a coherent emission process from a compact region. Two possible scenarios that may explain the transient emission

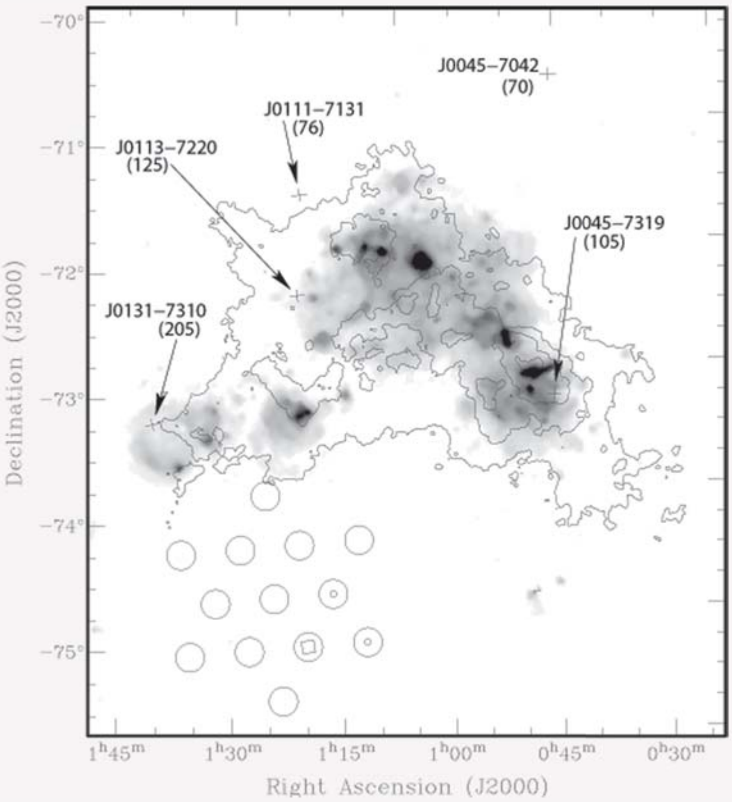


Figure 2: Multi-wavelength image of the field surrounding the burst. The gray scale and contours respectively show ionized and neutral hydrogen emission associated with the Small Magellanic Cloud. Crosses mark the positions of the five known radio pulsars in the Small Magellanic Cloud. Open circles show the positions of the 13 beams in the original survey pointing, with the square and two small circles showing the beams in which the burst was detected.

are the radio counterpart of a gamma-ray burst, or a burst of radio emission from a coalescing neutron star binary. A recent paper (Popov & Postnov 2007, astro-ph/0710.2006) posits that the burst could be a "hyperflare" from a magnetar – a neutron star with an extremely high magnetic field.

A key implication of the new discovery is that *many hundreds of similar bursts should be detectable each day, but the small field of view and limited temporal and spectral resolution of most radio telescopes has thus far rendered them largely invisible*. The team is currently searching archival data sets for further examples, and the Parkes telescope is being used to monitor the sky for other transient sources, by "piggybacking" on other observations.

Perhaps the most intriguing feature of this burst is its 30 Jy strength. The fact that it is over 100 times the detection threshold makes its uniqueness puzzling. Why have weaker transient sources not been detected? Whatever the reason, the potential of a population of radio bursts at cosmological distances to probe the ionized intergalactic medium is very exciting, especially given the construction of wide-field instruments in preparation for the Square Kilometre Array.

Operations

Photo: Shaun Amy, CSIRO

Observatory Reports

Australia Telescope Compact Array

Upgrades and Developments

The Australia Telescope Compact Array (ATCA) is a six-element interferometer, with a maximum baseline length of six kilometres. All six antennas are outfitted with receivers to observe in bands between 20 cm and 12 mm. The inner five antennas are also able to observe in the 3-mm band.

Millimetre developments

Preparations began in 2005 to add receivers to all six antennas to allow observations in the 7-mm band. This development is being co-funded by NASA, which is interested in using the ATCA as a back-up tracking station to the Tidbinbilla Deep Space Centre complex near Canberra for spacecraft transmitting at frequencies near 32 GHz. A delegation from NASA visited Narrabri in May to inspect the site and discuss planning for the installation of the 7-mm receivers. One of the issues for the satellite tracking is that during routine astronomical observing a 51 millisecond synchronisation sequence is included in every (by default, 10 second) correlator cycle. This 0.5% data loss is acceptable for astronomers, but is not to those for whom every bit counts. Tests of a modified unit that enables this “blanking” to be switched off were successfully made during the year, and production of the modified units for all antennas commenced.

The prototype 7-mm receiver was installed on antenna 6 (CA06) in August 2006 during the split array period and found to perform as expected. Unlike the inner five antennas, which were upgraded at the time of the 3-mm installation, CA06 still has perforated panels in the outer two rings of the dish. Holographic measurements and adjustments of the surface were made in November using the Optus B2 satellite 30-GHz beacon in order to tweak its performance. Several rounds of measurements and panel adjustments improved the antenna surface accuracy (rms) from 0.32 to 0.20 mm.

When the winter observing season commenced in May 2006 it was found that antenna CA05

Photo: Shaun Amy, CSIRO

had notably poorer performance than the other four antennas operating in the 3-mm band. The degraded performance was ultimately traced to subsidence and cracking of the foam plug at the top of the 3-mm feed horn. Replacement of the plug restored the performance of the receiver to its previous level, and a new material has been sourced for fabrication of these plugs in the future.

Progress was made in addressing two problems that had previously been identified with the 12-mm receivers: moisture condensing on the dewar window, and a build-up of ice inside the dewar. A bottled dry air system was tried successfully on one antenna to circumvent the first problem and this is now being extended to all antennas. The build-up of ice in the dewar requires a modification which will take place when the receivers are taken off the antennas for the installation of the 7-mm receivers in the first half of 2007. In the interim, receivers displaying this problem have been warmed as a temporary solution.

Radio frequency interference (RFI) is a well-known issue in the centimetre observing bands. This year a potentially damaging RFI source was also identified in the 3-mm band. The CloudSat satellite was launched by NASA in April to a 99-minute, near-polar orbit at an altitude of 705 kilometres above the Earth's surface. The satellite is used to study clouds and precipitation using a pulsed, narrow-band radar operating at a frequency of 94.05 GHz – near the middle frequency of the ATCA and Mopra 3-mm bands. Calculations indicated that there should be little impact on observations unless the satellite passes directly overhead while the millimetre receivers are on axis and the telescope near zenith. The Antenna Control Computers (ACCs) at the ATCA and Mopra have been modified so that the 3-mm systems are not parked on axis. Millimeter-band observers are automatically warned by email of upcoming passes near zenith to ensure they are not tracking near zenith at these times.

Narrabri systems and developments

The transition from VMS to LINUX operating systems for the main observing computers was finalised during the year.

The giga-bit links connecting the observatories to Epping were made available at the end of July, increasing the connection rate by a factor of 2,000. The higher bandwidth links provide an improved environment for remote observing, enable real time e-VLBI observations to be conducted, and will allow Compact Array data to be archived off-site without having to back-up the data to a tape or disk to be physically transported.

Generator/mains power synchronisers are now fitted to all antennas at the ATCA and Mopra. These allow seamless transfer of power between the mains and the generator for planned running such as during array reconfigurations and maintenance without affecting the cryogenic systems. The synchronisers negate the need to interrupt observing when switching between power sources and also provide improved monitoring of the antenna power systems. New Uninterruptible Power Supplies were fitted to antennas CA01 and CA06 as part of an on-going program to replace units which are no longer supported by the manufacturer.

Efforts continued to track down the cause of occasional occurrences of errors in the azimuth pointing, seen primarily on antenna CA01. These errors are most significant in the 3-mm band. Regular checking and adjustment has not been sufficient to eliminate this problem. A more detailed monitoring of the interplay between the feedback loops involved in the drive systems is underway.

A Compact Array antenna was used, together with the Hobart antenna and several other telescopes outside Australia, to observe the impact of ESA's SMART-1 satellite into the moon on 3 September. Leading up to the impact, the weather at the ATCA was particularly poor, with an approaching storm front accompanied by strong winds (which brought to mind the circumstances at Parkes leading up to the more gentle Apollo landing in 1969). However, the front passed, allowing the SMART-1 impact to be observed in relatively calm conditions.

Remote observing

During the 2006 October semester the ATNF trialled a relaxation of the requirements for ATCA remote observing. Remote observing is only granted to astronomers who have observed with the ATCA in person at Narrabri within the previous 12 months. However, other restrictions on the amount of remote observing within any given time interval were relaxed for the duration of the October semester. The trial will be assessed at the end of the semester.

Synthesis Imaging School

The 7th ATNF Synthesis Imaging School was held from 18 – 22 September 2006, with a record number of students in attendance. The Narrabri Visitors Centre was converted into a conference centre and provided a comfortable environment for the meeting.

The week included a series of lectures on the principles of interferometry, and lectures on practical synthesis imaging including calibration, sensitivity, imaging, data analysis and error recognition. More specialized topics included polarisation, wide-field imaging, VLBI, and spectral line analysis. As well as lectures, there were practical observing sessions, data reduction and scheduling tutorials and tours of the observatory. The social program included the traditional campfire night, dinner in town, and an end-of-school barbecue.

Participants at the seventh ATNF synthesis imaging school, held at Narrabri in September 2006.
Photo: Michael Dahlem, CSIRO

Site infrastructure

A project to design a major refurbishment/extension of the Narrabri Control Building was completed early this year. The plan incorporated improved RFI shielding and a number of environmentally friendly design aspects to provide a safer, more comfortable, and more efficient facility for staff and observers. However, financial pressures on CSIRO's capital investment program have led to the project being delayed. Some repairs and maintenance which had been put off under the expectation the building would proceed, such as the air-conditioning and fire alarm system in the screened room, are now scheduled for 2007.

Mopra

The Mopra radio telescope is a 22-m antenna located 20 km west of Coonabarabran. The telescope is used as a single dish, primarily for millimetre observations, and as part of the Long Baseline Array. It is maintained by Narrabri staff.

On 12 January 2006 the Mopra telescope received a major lightning strike which damaged a broad range of systems. The power surge caused some electronics chips to explode and wiring to fuse. Damage was also caused to the site Uninterruptible Power Supply, the antenna drive SWEO filters, the Antenna Control Computers, and the site PABX. The cryogenics systems failed and a large number of dataset units required repairs. Despite the severity of the strike, repairs were completed in time for the first observations at the end of April.

Several upgrades took place during the year. Mopra completed its VAX to LINUX transition prior to the commencement of the millimetre season. The VLBI run in mid-May coincided with first light for the new 12-mm observing system.

A 12-day shutdown in late May was used for the installation of the new Mopra Spectrometer, MOPS. This was designed and built by the ATNF and is owned by UNSW, which led the consortium which successfully sought ARC LIEF funding for the project. MOPS has an extremely wide bandwidth of 8.3 GHz, which is divided into four overlapping 2.2-GHz sub-bands. Each sub-band is digitised, and a digital filterbank divides the bands into a large number of independent output frequency channels. A wide-band mode provides 1024 frequency channels over each 2.2 GHz sub-band (with two polarizations), while a narrow-band "zoom" mode provides up to four narrow bands, of up to 138 MHz bandwidth, within each 2.2 GHz sub-band. Observers have been very enthusiastic about the MOPS spectometer and have found this straightforward to use.

Mopra remote observing from Narrabri began in August 2006 soon after the ATNF gigabit link connections to the AARNet3 regional network optical-fibre backbone were put in place at the observatories. A prompt move to remote observing for Mopra was made to gain as much experience with remote observing as possible before the end of the millimetre season.

Photo: Shaun Amy, CSIRO

Mopra observations are now almost entirely taken from Narrabri as it is more efficient for Narrabri staff to support Mopra observations from Narrabri and the Narrabri Lodge has far better facilities for observers. The observers' area in the Compact Array Control Building now includes an area for Mopra observers, with a four-screen display that provides access to the Mopra observing computers.

Ironically, the only disruptions to the Mopra - Narrabri link in the first months were due to outages (both planned and unplanned) at Marsfield, as the gigabit links between observatories go via Sydney. However, if the fast links are unavailable, observing can revert to the narrower direct link between Narrabri and Mopra.

These upgrades and improvements have continued the trend for improved productivity for Mopra with a significant increase in publications over the last two years. The MOPS facility, and the 12-mm observing band are expected to continue this trend.

The Mopra Observatory was opened to the public on 22 October to coincide with the annual Siding Springs Observatory Open Day. Around 40 people visited over the course of the day.

Parkes

Methanol Galactic survey

The seven-beam methanol multibeam receiver, covering the frequency range 5.9 – 6.9 GHz, was delivered and successfully installed on the 64-metre telescope in the week of 16 January 2006. The construction of the receiver was shared between ATNF and Jodrell Bank Observatory, and builds on the very productive multi-beaming technology exploited so well with the 20-cm multibeam receiver and the ATNF-built Arecibo L-band Feed Array (ALFA).

Photo: Shaun Amy, CSIRO

The new receiver is operating to specifications and is now in routine use. The receiver has two independently-tunable conversion chains, which allow full dual-frequency operation. The second frequency chain was fully commissioned shortly after the receiver was installed, with all 28 channels (with seven beams, two polarizations and two frequencies) now fully operational in both the multibeam spectral line correlator, and the pulsar analogue filterbank.

The seven-beam receiver immediately commenced the first of the two large surveys it will undertake – a complete and "blind" survey of the southern Galactic plane for methanol maser emission at 6.7 GHz, where a region of the Galactic plane will be systematically searched for maser sources (see page 26). The second major observing project to be tackled with this new receiver is a high-frequency survey for pulsars along the Galactic plane, and this commenced successfully in February. The Galactic methanol survey has been discovering new masers at close to the predicted rate, confirming the performance of the system. The second conversion chain has allowed a 6035 MHz blind survey for the OH molecule to be "piggy-backed" onto the methanol survey. This piggy-back mode makes excellent use of the partial merging of the multibeam and wideband correlators implemented initially in 2005 for the GASS survey. The methanol line survey is also able to piggy-back on the 6-GHz pulsar survey, to obtain deeper integrations over a reduced area of sky, using a new hybrid multibeam/wideband correlator configuration. The second frequency chain also doubles the total bandwidth of the pulsar survey, which is proceeding well and nearing completion of its observing phase.

It is intended that once these two main surveys are complete, the methanol multibeam receiver will be transported to the Jodrell Bank Observatory to complete the northern part of the surveys. The successful commissioning of this receiver maintains ATNF's leading position internationally in multibeam receiver systems and instruments.

Observatory broadband links

The installation of a new high-speed fibre link to the Parkes Observatory was completed in March 2006. The new link conferred a 2000-fold increase in bandwidth, with a one-Gbps link replacing the former 512 kbps link. A second one-Gbps link was also in use later in the year.

An unique opportunity to install these new links arose through the acquisition by the Australian Academic Research Network (AARNet) of two fibre pairs on the Brisbane-Melbourne trunk route formely owned by the Company NextGen. This acquisition was assisted through the Australian Research and Education Network (AREN) scheme of the Australian Government's Department of Education Science and Training (DEST). The newly acquired AARNet fibre passes, by good fortune, close to all three ATNF observatories, including Parkes. The "last mile" connections and active equipment for all the observatories were funded by CSIRO.

The new connection was soon used to great effect during the March and May Long Baseline Array (LBA) sessions, with continuous near-real-time fringe verification between Parkes, Mopra and Narrabri becoming almost routine. This has had an enormously beneficial impact on the ease and reliability of VLBI observations.

The faster link is now also available to general users and has greatly facilitated internet access and the transfer of data both between the ATNF sites and between the ATNF and the wider world.

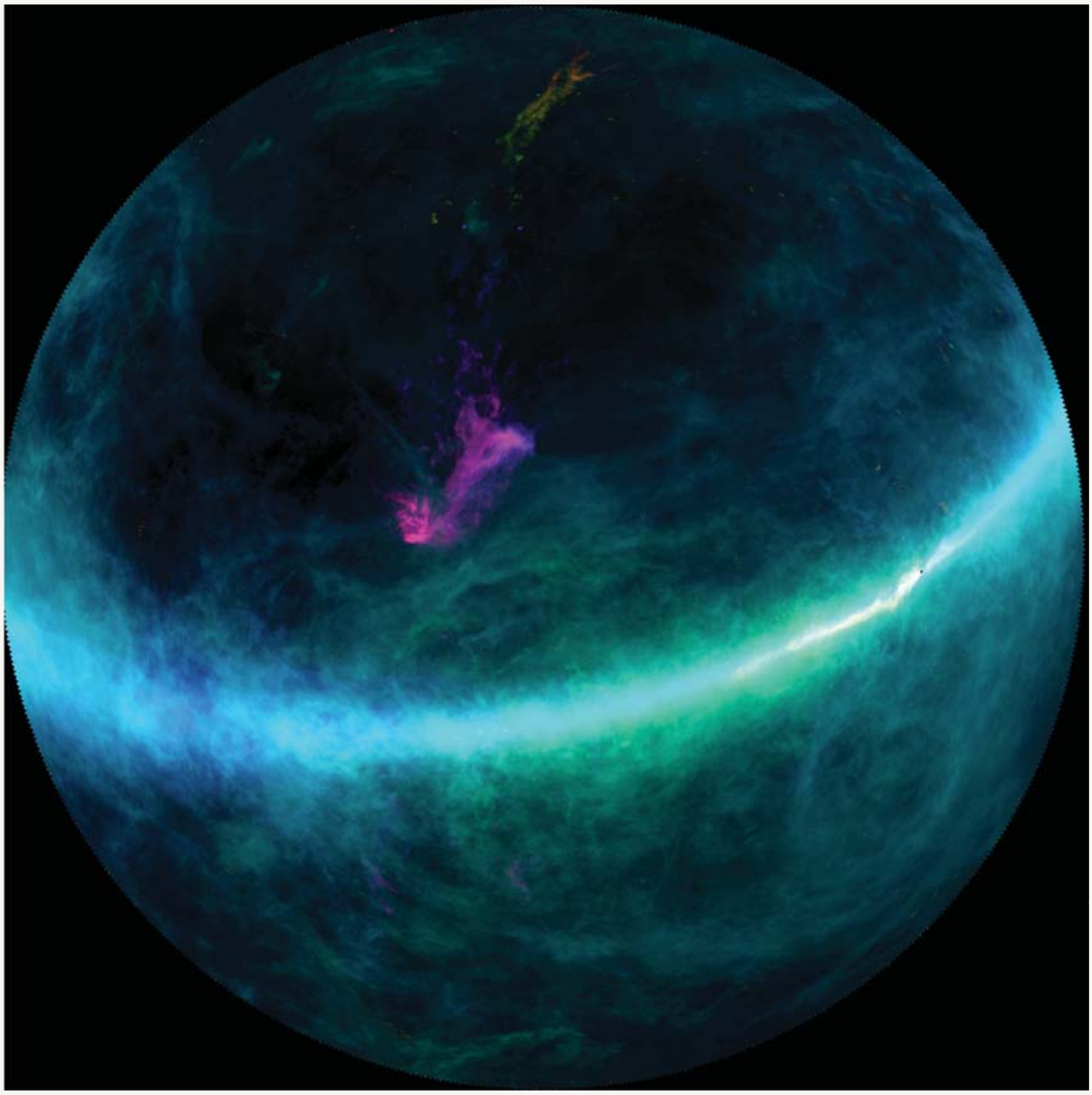
AARNet3 Launch

On 14 September 2006 the Parkes Observatory participated in the launch of AARNet3, marking the opening the Australian Academic Research Network's third-generation network. The Minister for Science, the Hon Julie Bishop MB, officially turned on the network at a ceremony at Parliament House before a large invited audience. Broadcast quality images of the Parkes telescope and a live presentation from the control room by the Officer-in-Charge (John Reynolds), were transmitted to Canberra by the new broadband links as part of the presentation. Professor Deane Terrell AO, Chairman of the AARNet board, used a laptop in Canberra to drive the telescope for a live demonstration of the sound of the Vela pulsar. The contributions from Parkes were very well received in Parliament House.

GASS

The Galactic All-Sky Survey (GASS) was completed successfully in November 2006, after almost two years and 1,700 hours of observing time on the Parkes telescope. GASS is a fully-sampled survey of neutral hydrogen (HI) in the Galaxy which covers the entire southern sky with an angular resolution of 15 arcminutes, a velocity resolution of one kilometre per second, and a sensitivity limit of 70 mJy. This survey represents a big leap forward in sensitivity and resolution over the earlier hydrogen surveys. The GASS observations commenced at Parkes in January 2005 and proceeded at regular intervals until completion in November, prior to the removal of the 20-cm multibeam receiver for the second stage of its refurbishment. Observations for this project used the multibeam correlator and pulsar wideband correlator in a combined mode to provide 2048 spectral channels for all 13 beams of the receiver, an innovation implemented specifically for this project but with potential benefits for other surveys, including the recent methanol survey.

Interim results from the GASS survey have been very promising. In particular the investigators have refined a simple and effective technique for controlling stray radiation, without the need for mapping the far-sidelobe pattern of the 20-cm multibeam system.



Atomic hydrogen (HI) image of the Milky Way and part of the Magellanic system from the Galactic All-Sky Survey. This image covers the entire southern sky with the South Celestial Pole at the centre of the image. Averages over small velocity ranges between +/- 250 km/s are colour-coded with high positive velocity (250 km/s) shown in magenta and high negative velocity (-250 km/s) in red. Milky Way gas with velocities near zero km/s is shown in green and blue.

Image: Steven Janowiecki (NRAO Greenbank), D. J. Pisano (NRAO Greenbank), Naomi McClure-Griffiths (ATNF) and the GASS team.

Gearbox refurbishment

A significant investment in the future of the 64-metre antenna was made in November 2006 with a complete refurbishment of the azimuth gearboxes. Almost all the gears in these two gearboxes were the original ones, having run faultlessly for the 45-year life of the instrument. However, some wear had become apparent in the last few years and the decision was taken to replace all moving parts together. The original drawings and documentation (much of it in German) had been carefully preserved for such an eventuality and greatly expedited the process. The new gears, the largest of which is 1200 mm in diameter and almost a tonne in weight, were manufactured by Hofmann Engineering Pty Ltd of Perth, WA, in conjunction with ATNF engineers Brian Wilcockson and Tim Wilson. The replacement was completed successfully and on time in a three-week shutdown, which also saw the 20-cm multibeam receiver removed for the second phase of its refurbishment.

RFI mitigation

Radio frequency interference (RFI) is a serious problem for radio astronomy world-wide. Many of the science goals addressed by filled-aperture (single-dish) instruments are particularly susceptible to interference, and Parkes is fortunate in having a RFI environment that is excellent by international standards. While this advantage is partly due to the well-chosen location of the Observatory, it is maintained through an active program of interference mitigation including suppression of nearby or self-generated interference, and post-observation mitigation techniques. This includes rigorous evaluation of all new equipment brought onto site and, where necessary, shielding of any potentially harmful RFI sources.

The advent of digital filterbanks with high dynamic range (eight or more bits of sampling precision) has recently disclosed a number of sources of impulsive broadband RFI that had not previously not been visible on the two- and three-level digitisers used for pulsar work. This interference typically consists of one or multiple spikes of radio energy, occurring simultaneously across a broad range of frequencies, and typically of a microsecond or less in duration. One of the most egregious sources of RFI in this category is lightning. However, a significant fraction was observed to be generated locally, particularly from mains contactors used in air conditioning systems. A program of shielding and replacing these noisy components is well underway. Algorithms are being developed for the next generation of digital filterbanks to suppress these transients “on the fly” in firmware, obviating the tedious task of manually editing this interference from the data files.

The Australian Long Baseline Array

The Australian Long Baseline Array (LBA) operates as a Very Long Baseline Interferometer (VLBI) array that uses most radio telescopes around Australia. It includes all the ATNF antennas (Parkes, Mopra, Compact Array), the Hobart and Ceduna antennas of the University of Tasmania, and antennas of NASA’s Canberra Deep Space Communications Complex at Tidbinbilla. It also frequently operates in collaboration with overseas antennas, especially the Hartebeesthoek antenna in South Africa, the Kokee Park antenna in Hawaii, the Kashima antenna in Japan and the Shanghai antenna in China.

Evolution to disk recording and software correlation

For about 15 years the LBA has used S2 VCR-based recorders and the ATNF correlator in Sydney to achieve a maximum data rate of 128 Mbps. However, this system has become difficult to maintain and it is inherently difficult to upgrade to higher data rates and hence higher sensitivity.

Over the last few years the ATNF, in collaboration with University of Tasmania and Swinburne University of Technology, has been developing new systems for the LBA. The recording systems are based on Apple Xserve RAID disks and have been installed at all LBA telescopes. These systems achieve recording data rates of 512 Mbps at all antennas and one Gbps at the ATNF telescopes. The data are correlated on a DiFX software correlator developed and run on the supercomputer cluster at Swinburne.

In 2006 the LBA changed it operations to using disk recording systems and software correlation.

A contract was developed between ATNF and Swinburne for all LBA correlation to be performed at Swinburne. The full S2 recording and correlation system was effectively shutdown in 2006 and will be officially decommissioned in 2007. For future observations the LBA partners have agreed to fund significant disk purchases to cover normal LBA operations.

The LBA archive for all LBA observations, comprising around 600 CDs, has been ported to disk and data from old observations are available on request.

e-VLBI developments

e-VLBI uses fast networks to enable disk recording systems and to correlate VLBI data directly in real-time. e-VLBI capabilities are being developed worldwide and Australia is a key participant.

In 2006 the ATNF antennas (Parkes, Mopra, Compact Array) were connected with an optical fibre network, as part of the AARNET3 Regional Network. Connectivity at 1 Gbps was tested in March 2006 and became fully available from July 2006. The network operates on a 10 Gbps “backbone” with two 1 Gbps connections to each telescope. Future upgrades to data transfer rates of 10 Gbps are planned.

The Swinburne software correlator was upgraded during 2006 to support “streaming inputs” without the need for any disk buffering. This allows for “real-time” correlation provided that the links to the correlator computer are fast enough. In addition, the DiFX correlator software is very versatile and portable and can run in real time using 30 – 50 computer nodes.

The Swinburne DiFX software was ported to a two-processor machine at Marsfield and the first e-VLBI tests in Australia were performed on 24 August 2006. This configuration supported three ATNF antennas at 128 Mbps for about 10 minutes, but with significant loss of data.

A successful VLBI workshop was organised on 23 October 2006 in conjunction with the ATNF Users Committee meeting. A proposal was discussed to develop an eVLBI real-time instrument using the ATNF antennas and the 30-node CPSR2 computer cluster at Parkes for the correlation, tentatively named PAMELA. This was strongly endorsed and will be implemented at the March 2007 VLBI session. Such an instrument has the potential to transform the way VLBI is done in Australia.

ATNF and AARNet are formal participants in the EXPReS eVLBI project in Europe, a €3M project to develop production eVLBI capabilities. The official kick-off and board meetings occurred at the end of October 2006.

Operations

The MNRF funding that supported some of the VLBI operations of Hobart and Ceduna has finished and a new contract between ATNF and University of Tasmania, for Hobart and Ceduna operational support, began on 1 September 2006.

Proposal demand for the LBA in 2006 continued to be strong, with an effective oversubscription rate of 1.4, similar to previous years. LBA observing sessions in 2006 were held from 9 – 17 March, 12 – 17 May and 13 – 19 November, with an additional day on 23 – 24 August. Of the total of 21.5 days allocated to VLBI, about one quarter of the time was devoted to disk and network tests, including setup and real-time fringe checking via the software correlator at Swinburne.

LBA time allocation

LBA allocated time	516 hours
Disk and network tests	70 hours
Total scheduled astronomy observations	446 hours
Time use for setting up observations	5%
Time lost due to weather	3%
Time lost due to other failures	5%

Overall the LBA achieved a 93% success rate, similar to previous years. Most of the telescopes continued with very high success rates (> 98%). The Parkes failure rate was again mostly due to high winds (5%). At Tidbinbilla and Ceduna about 8% of time was lost due to IDE disk failures, a problem that has been addressed by acquiring Apple Xserve RAID disk systems. At Hobart an intermittent clock distribution problem resulted in a data loss of 8% before the fault was tracked and rectified. A summary is given in the following table.

Telescope	Parkes	Compact Array	Mopra	Hobart	Ceduna	Tidbinbilla	Harte-beesthoek	Kokee	Kashima	LBA
Hours observed	427	445	432	364	267	90	112	24	24	**446**
% success	94.5	99	99	92	91	92	100	100	100	**93**

Other activities

Marsfield computing

Computing Facility Group

Following an internal review of scientific computing undertaken in 2005, the ATNF Scientific Computing Group was split into two distinct groups to provide a stronger focus in the areas of computing infrastructure (Computing Facility Group) and software (Scientific Software Group).

Since September 2006 the Computing Facility Group (CFG) has been responsible for providing the computing infrastructure and services (in collaboration with CSIRO Information Management and Technology - CIM&T) required for ATNF staff, graduate students and visiting observers. The group has four members, two based at Marsfield with one at Narrabri and one at Parkes. All staff have responsibilities outside of CFG, particularly those based at the observatories.

The CFG takes an ATNF-wide view of computing and where possible will streamline the computing systems and processes between the four ATNF sites.

Networks

A notable achievement in August 2006 was the implementation of the one-Gbps network links between Marsfield and each of the three observatories.

During 2007 the fast links will allow experiments to be performed that involve the streaming of data from the ATNF observatories to a software correlator running on a cluster of commodity PCs at Parkes. Early tests in this area, in collaboration with Swinburne University of Technology, look promising in providing a real-time VLBI array. This will initially use only the ATNF telescopes (and possibly Hobart at a lower data rate) but can easily be extended once improved connectivity is obtained to other observatories that make up the Australian Long Baseline Array.

Single-dish analysis software

Version 2 of the single-dish analysis software package, ASAP, was released in May 2006. This is now the default software reduction package for single-dish, spectral line observations taken with ATNF telescopes, including Mopra data obtained with MOPS. ASAP has also been adopted by ALMA for single dish data reduction, and is incorporated as part of the NRAO Casapy package. Version 2 includes a major redesign to support varying numbers of spectral channels in a data set and the ability to process data from many simultaneous frequencies and observing beams.

ASKAP computing

The software systems for ASKAP include scheduling of observations, monitor and control of the telescope during observations, processing of observations into scientifically useful data products, and archiving of data products.

The ASKAP project brings large data challenges to the forefront at the ATNF. The data rate from ASKAP will reach about ten terabits per hour, equaling the entire archived data from the world's radio telescopes in a few hours. ASKAP also brings challenges in remote operation and observing, and in data processing for phased array feeds. With this in mind the ATNF has engaged with the South African Karoo Array Telescope (KAT) project on a collaboration, called CONRAD, to develop software for the ASKAP and KAT. The ATNF is taking the lead on data processing, including algorithms and parallel computing, whereas KAT is taking the lead on monitor and control of the telescope. The teams are growing in staff numbers and expect to expend about 60 FTE-years on the joint development. It is expected that spin-offs from CONRAD wil be of benefit to other parts of ATNF operations, for example by providing pipeline data processing for CABB data taken with the Compact Array.

MIRIAD

MIRIAD remains the primary data reduction package used for Compact Array data. In 2006, the computing group worked to bring the MIRIAD code base (as used at the ATNF) under revision control so that it is easier to document and track software changes. Of more direct interest to users is the support now available for the operating systems on Apple PPC and Intel platforms.

Duchamp

"Duchamp" is a software tool developed at the ATNF that is used to locate radio astronomy sources within data cubes. This is intended to replace the need to "manually" search through data cubes as this can be extremely time consuming. Duchamp is also used with the Parkes methanol survey and will address the challenges of finding sources within the huge data sets that will be generated by ASKAP and the SKA.

The first version of Duchamp was released in June 2006. The program has the following features:

- Efficient three-dimensional searching and merging of detected objects;
- Optional noise-reduction prior to searching via the technique of wavelet reconstruction. This innovative procedure greatly enhances the detectability of fainter sources;
- Ease-of-use through a simple parameter file input; and
- Flexibility to control all relevant parameters such as signal-to-noise threshold or the minimum size of detections.

Outreach and Education

Teacher workshops & school visits

The ATNF holds regular workshops for high school teachers. These are intended to provide teachers with information, ideas and resources that will assist them with teaching astronomy. The workshops are always extremely well received and are supported by extensive educational material provided on the ATNF Outreach and Education website: http://outreach.atnf.csiro.au.

Three teacher workshops were held in 2006. The first was a three-day meeting held in March attended by 20 teachers from the Mid West region of Western Australia and Perth. The second, *Astrophysics for Physics Teachers,* was a one-day workshop held at Marsfield in April addressing the requirements of the senior Physics course. The third workshop, *Astronomy from the Ground Up!*, is an annual meeting held at Parkes in May for teachers of junior high school science. The Education Officer also spoke at other science teacher conferences and workshops around the country while other staff members visited schools in Canberra and Sydney.

Wildflowers in the Sky: Astronomy for Mid West Schools

The ATNF-led project *Wildflowers in the Sky* was successfully funded under the federal Australian Schools Innovation in Science, Technology and Mathematics (ASISTM) scheme. This project is a collaboration with five schools from the Mid West region of WA, Charles Sturt University, Scitech and the Department of Industry and Resources (DOIR) in WA. A project training day was held in Cue in June 2006 and in August the Education Officer and two astronomers spent a week visiting the schools. Students met with the scientists and took part in day and night time astronomy activities. As part of the project each school received an optical telescope for night time viewing, and a sunspotter telescope for looking at the Sun. Web pages for the project are provided on the Outreach and Education website.

Two students from Cue Primary School using a Sunspotter telescope during the *Wildflowers in the Sky* outreach project.

Photo: Robert Hollow, CSIRO

Summer vacation program

Six summer vacation scholars participated in the 2006/2007 program with three based in Narrabri and three at Marsfield. All undertook a research project under the supervision of an ATNF staff member. The projects covered a diverse array of topics in engineering, astrophysics and computing. The students also took part in observing projects with the ATCA. The program ended with a half-day student symposium where students presented the results of their observations and projects.

Photo: Michael Dahlem, CSIRO

ATNF summer vacation students for 2006/2007.
Front row (left to right): Sheila Kanani, Kate Randall, Dilini De Silva.
Back row: Tony Whelan, James McGeachin, Chris Lustri.

Narrabri Visitors Centre upgrade and Open Day

The Narrabri Visitors Centre received a "makeover" in December 2005 and January 2006 with the installation of new outdoor displays. This was the culmination of almost two years of planning and design by ATNF staff and the Melbourne firm *Convergence Design*. Robust, weatherproof panels lead the visitor through the story of radio astronomy, starting with the electromagnetic spectrum and ending with notable research done with the Compact Array. Large sculptures representing astronomical phenomena, such as black holes and gravitational lensing, are dotted around the garden area to one side of the Visitors Centre.

Inside the Centre, a new audiovisual installation, *ViewSpace*, was set up to run in the theatre and has been popular with visitors. Developed by the Space Telescope Science Institute (STScI), *ViewSpace* features the latest astronomy news, special reports and outstanding images from around the world, and is automatically updated via the Internet.

On 29 July an opening ceremony was held for the Visitors Centre displays, with speeches by Vikram Ravi, and the Narrabri Shire Mayor, Councillor George Sevil.

The Visitors Centre Opening was immediately followed by an Open Day, attended by approximately 600 visitors. During the day Compact Array antennas were opened to the public for guided tours and visitors were shown around the Control Building.

Vikram Ravi giving a speech during an Opening Ceremony at the Narrabri Visitors Centre.

Photo: © Bruce Tough

Spectrum Management

Spectrum management relating to the protection of radio astronomy has been an important activity for CSIRO since the 1970s. The ATNF has continued to support such activities and at present is involved in the following areas:

- Participation in national spectrum planning and protection activities through the Australian Communications and Media Authority (ACMA). This involves not only national spectrum planning issues, but also participation in ITU study groups and preparations for World Radio Conferences (WRC).
- Participation in regional and international meetings under the auspices of the International Telecommunications Union (ITU). The primary activity is the regular meetings of ITU Working Party 7D (Radio Astronomy) in Study Group 7 (Science Services). This group is responsible for all technical studies and ITU Recommendations for the protection of Radio Astronomy.
- Participation in IUCAF (Scientific Committee on the Allocation of Frequencies for Radio Astronomy and Space Sciences), an inter-union committee of the IAU, URSI and COSPAR. IUCAF has been very active in ITU meetings and has had a significant impact on Study Group and WRC deliberations.
- Participation in the Radio Astronomy Frequency Committee in the Asia Pacific region (RAFCAP), which promotes awareness of radio astronomy and protection of the radio spectrum in the Asia Pacific. RAFCAP works closely with the regional spectrum management group, the Asia Pacific Telecommunity (APT).

Activities in 2006

The focus of ITU activities in 2006 has been studies in preparation for the World Radiocommunications Conference (WRC2007), culminating in draft text in September 2006, which summarises the technical and regulatory issues for WRC2007. The main questions of interest for the Radio Astronomy Service (RAS) include satellite links near 1.4 GHz; HEO broadcast satellites in 620 – 790 MHz bands; and protection from unwanted emissions in many bands. The principal contentious issue is GLONASS interference at 1612 MHz.

The RAFCAP annual meeting in 2006 was held in Beijing, China, with participants from the Asia Pacific region and Europe. It was combined with a special two-day spectrum management school, to further develop spectrum management activities related to radio astronomy in China.

The ATNF has also been active with radio spectrum activities in COSPAR and IAU, during their general assemblies in 2006. COSPAR has initiated a special IUCAF-sponsored spectrum management session for their next meeting. The IAU continues with a strong working group on RFI mitigation.

The ACMA finalised in August 2006 a Radiocommunications Assignment and Licensing Instruction (RALI MS31), which defines “radio sensitive” notification zones around all existing Australian radio telescopes. Zone dimensions vary with frequency and reach up to 250 km radius at the 21 cm band. This is the final outcome of the implementation of the recommendations in the Productivity Commission’s report in 2002.

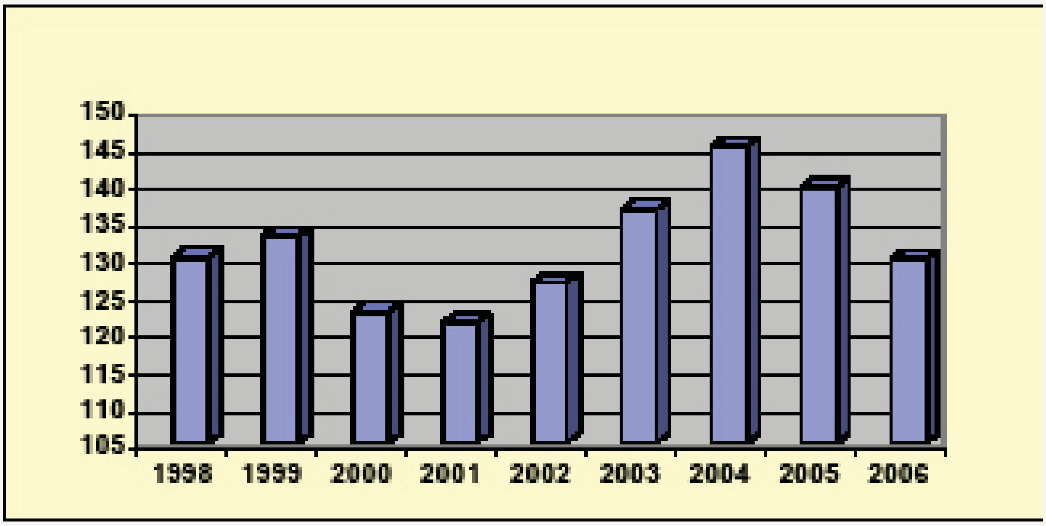
The ACMA has also published its detailed studies on the definition and requirements of a “radio quiet zone” (RQZ) at the Australian candidate SKA site in WA, as draft RALI MS32. After public comment this RALI is ready to be finalised and implemented.

To administer these radio-sensitive zones, the ATNF has set up a spectrum group, which includes mainly technical people from the observatories. This group evaluates the RFI implications of any applications for new transmitters near any radio telescope in Australia. As an interim measure, this group also evaluates any issues related to the proposed SKA RQZ in WA. The initial interactions of this group with the radiocommunications industry have been very positive.

Human resources

People are the ATNF's greatest asset. Without the continued commitment and expertise of its staff, the ATNF could not continue its widely acclaimed provision of world-class facilities for astronomical research or achieve future technological advances required for next generation astronomy.

In 2006 ATNF increased its focus on attracting and retaining outstanding individuals to complement the high calibre pool of staff currently operating across the ATNF. An essential strategy as the ATNF accelerates developments through the xNTD/SKA project whilst completing planned upgrades to current facilities. Increasing commitment to the development path aimed at achieving the next generation radio telescope, the Square Kilometre Array, has resulted in an acceleration in the rate of evolution of the division since 2005, coinciding with CSIRO's restructuring of its research activities and funding under "themes", with some themes including work across two or more of the Divisions. The Science Investment Process changed the way the ATNF sought and received funding through CSIRO and refined the theme and project based work structure aligned to the ATNF's future direction.



The total number of fulltime equivalent staff employed at the ATNF from 1998 to 2006.

A restructure of the Senior Management Team in January 2006 reflected an emphasis on strategic leadership with membership comprising the Director, Deputy Director, Executive Officer and three Assistant Directors (Astrophysics, Operations, and Engineering).

CSIRO strategy continued to drive the transition from a divisionally segmented organisation to a one-CSIRO research enterprise. In 2006, most ATNF staff experienced some effect from the change initiatives in funding, project management, research support staffing, organisational structure and technology. Staff in research support roles such as Finance, People & Culture, Libraries and Site Services experienced most impact as they were restructured into a new service model, with a corresponding drop in the number of ATNF staff. Research, observatory and engineering staff were also affected by changed administrative systems and processes, access to information and loss of support staff on site. Generally, staff adapted extraordinarily well despite initial glitches experienced while the ATNF introduced the changes. This change program continues over the next few years and aims to optimise staffing excellence and science delivery through a strong focus on staff development, performance management and provision of enhanced technology.

Health, safety and environment

The ATNF remains committed to continuous improvement of the health and safety of staff, clients and visitors whilst maintaining environmentally sustainable development. In support of CSIRO Corporate health, safety and environment (HSE) Strategic Plan (2004 – 2007), the ATNF implemented several key HSE programs including:

- Health and wellbeing strategy;
- Plant safety procedure; and a
- Musculoskeletal management strategy.

The ATNF HSE Improvement plan (2006) aimed to eliminate and reduce the risks presented by the environment and various work related activities performed across the ATNF. In addition to complementing the CSIRO HSE Strategic Plan (2004 – 2007), the ATNF targeted significant risk factors in accordance with its risk profile. This required the commitment and active participation and consultation by staff and visitors to incorporate these HSE objectives into their new and ongoing project planning and the ATNF HSE Improvement Plan (2006).

The ATNF risk profile recognises that its most significant injury risk factors are:

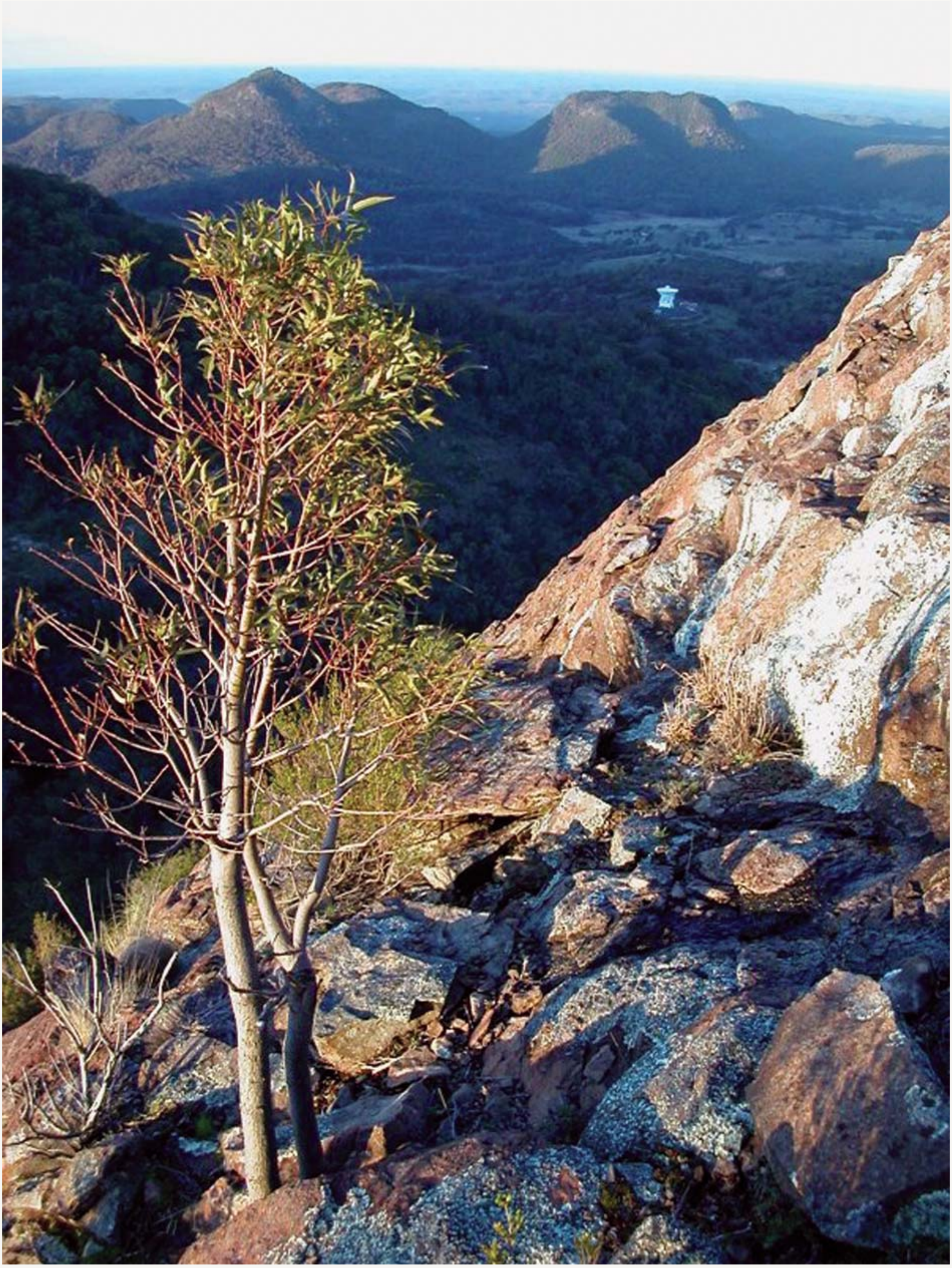
- Travel to/from Sydney to rural locations;
- Electrical Contact;
- Manual Handling & Ergonomics;
- Working at Heights; and
- Working with plant and equipment.

The Narrabri and Mopra Observatory engineering staff were recognised by CSIRO for their successful development of a specialised lifting device named “El Lifto”. At Narrabri and Mopra about 18 compressors including five external units are used as part of a closed-cycle helium cryogenic cooling setups for the low-noise astronomical radio receivers. A major problem for staff was the removal of the 84 kilogram compressors from the compressor cabinets for maintenance. Due to the size, shape and weight of the compressors there was significant risk of experiencing a manual handling injury to staff and damage to the compressor if mishandled. As a result Narrabri staff developed the El Lifto. This included a practical custom-designed clamp to fit into one of the grooves under the base of the compressor. This clamp ensures a tight fit preventing any slips or falls of the compressor and can be connected to a hoist. Now only one person is required to remove a compressor from its cabinet and replace it after maintenance.

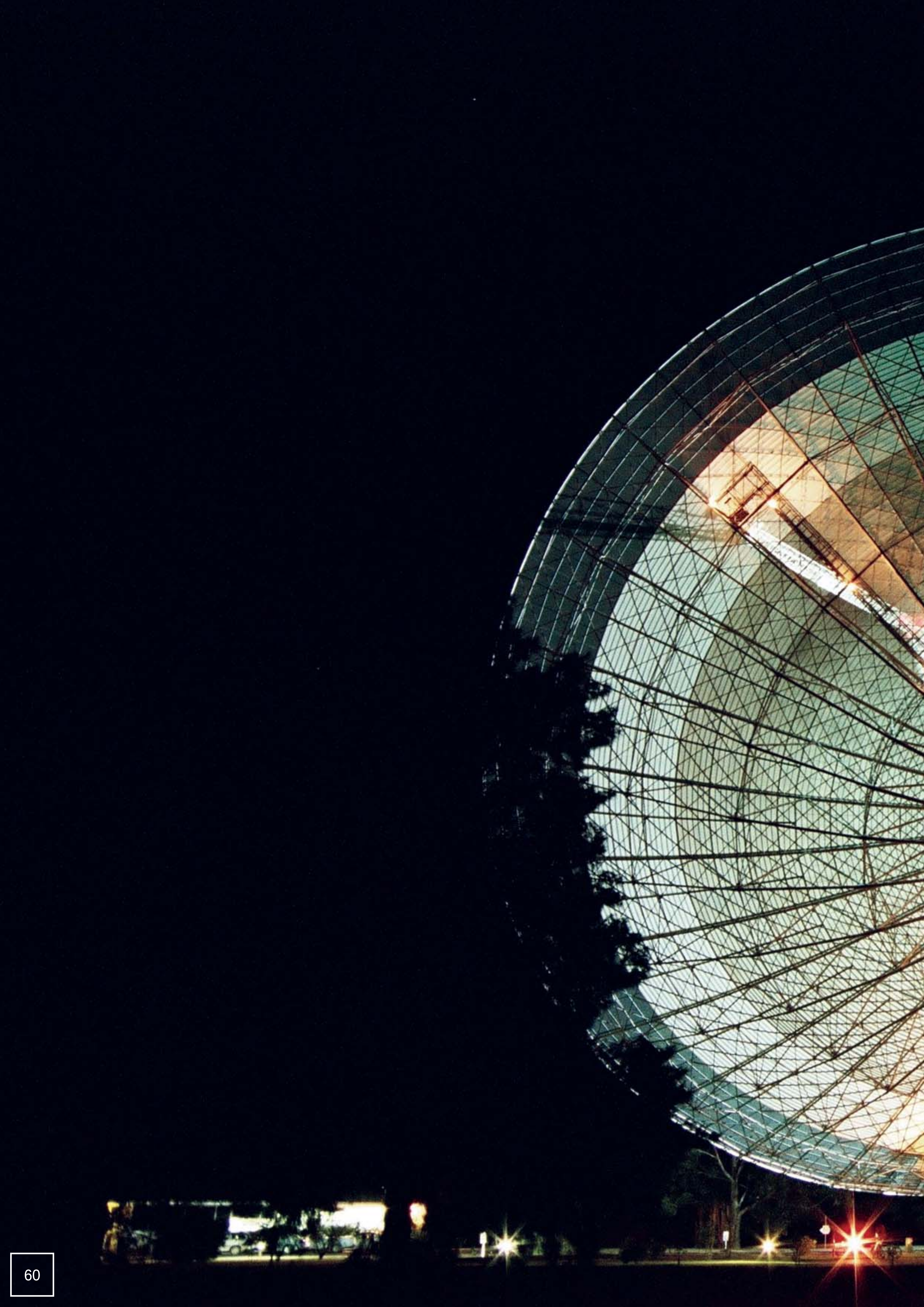
The ATNF operates an Environmental Management System at each of our sites to minimise impact on the environment from ATNF activities and promote sustainable development.

At the Radiophysics Laboratory in Marsfield staff continue to work towards a reduction in resource usage, improved recycling and waste disposal methods in conjunction with our colleagues from the CSIRO ICT Centre.

At Narrabri and Parkes, environmental initiatives address the issues presented by a rural location. At Parkes, staff extended the site’s northern boundary tree line by 200 metres. The tree line extension is designed to reduce spray drift from neighbouring properties, disrupt airflow from a nearby piggery, and perhaps reduce the wind tunnel effect which can cause the telescope to be stowed for safety. In 2006 140 trees were planted. The trees are a hybrid eucalyptus designed for drought tolerance, a fast growth and suited to the heavy soil type.



Mopra rock (near Coonabarabran) with the Mopra radio telescope in the background. Photo: Graeme Carrad, CSIRO



Engineering

Photo: John Sarkissian, CSIRO

Engineering developments

7-mm Compact Array upgrade

The signing of a collaborative agreement between the ATNF and NASA covers the outfitting of the array with receivers in the 7-mm wavelength band. It will provide NASA with a backup for their Australian tracking facility at Tidbinbilla for the new generation of spacecraft using Ka-band (32 GHz) downlinks. National Facility users will benefit from the opening up of an important new observing band covering the 30 – 50 GHz frequency range.

The upgrade involves adding components for the new frequency band to the existing 12- and 3-mm receiver packages. These receivers had been designed from the outset to accommodate such an upgrade. A new operational mode requiring an uninterrupted data stream from the array, generally not a requirement for astronomy applications but needed to meet the special requirements of spacecraft tracking, was successfully demonstrated in a series of tests involving the tracking of spacecraft with 8.4-GHz downlinks in 2005.

The contract calls for the installation of the new 7-mm band to be completed by May 2007, with acceptance tests beginning in June 2007, followed by the commencement of tracking operations in September 2007. For the period September 2007 to October 2013 the Compact Array will be available for spacecraft tracking at an average rate of 10 hours per week.

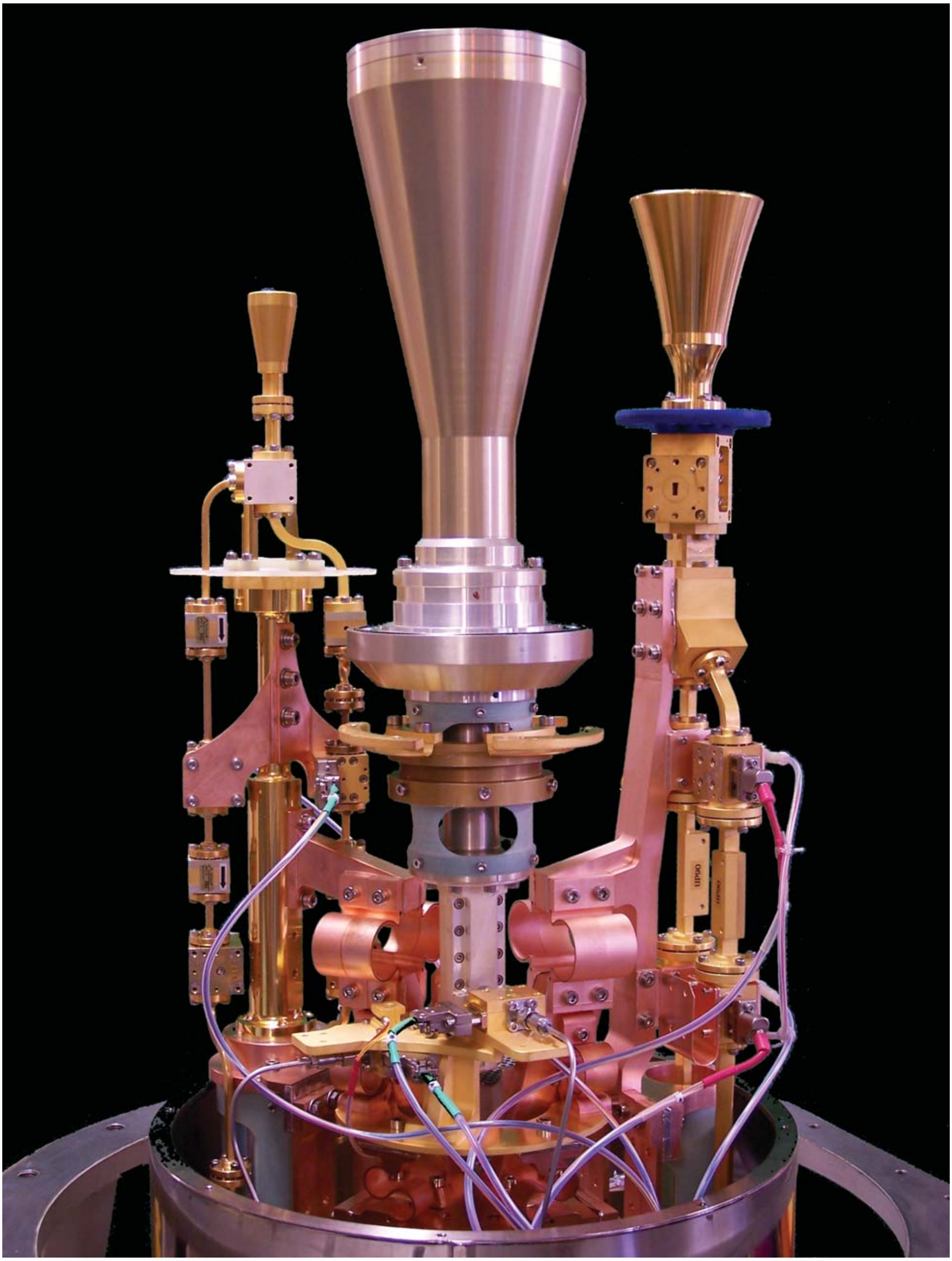
In August 2006 a prototype receiver was installed on an array antenna (CA06). It incorporated prototypes for several new, innovative devices required both in the signal path and the local oscillator/ downconversion module. These devices were developed and fabricated by ATNF staff and included cryogenic amplifiers using indium phosphide (InP) monolithic microwave integrated circuits (MMICs), an ortho-mode transducer, a power amplifier, a down-converting mixer and control and monitor electronics. Receiver sensitivity and antenna efficiency tests confirmed that the design would be able to meet the specifications required for the tracking of spacecraft as well as provide the broad bandwidth that would excite the astronomy community. A report detailing the results was presented to NASA in September and a Critical Design Review was undertaken with NASA staff in December with favourable responses.

Currently a production run of components is underway to allow the “in-lab” re-fit of the 12- and 3-mm receivers with 7-mm components. The re-fit is scheduled for February 2007 and will be undertaken at Narrabri by staff from both Narrabri and Marsfield. The array will be made unavailable for astronomy for a four week period in late March 2007 to install these new capability receivers on the antennas and conduct array system tests.

Compact Array Broadband upgrade

The Compact Array Broadband Upgrade (CABB) project is aimed at increasing the maximum bandwidth of the Compact Array from 128 MHz to 2 GHz. The recent 8-GHz bandwidth spectrometer developed for Mopra uses a CABB prototype digital signal processing circuit and has been an outstanding success. This was the first demonstration of the complex signal processing hardware and firmware that will be required for CABB. The board is by far the most complex development of its type carried out at the ATNF.

The high dynamic range demanded by the CABB system requires other significant development including a conversion system to make ready the signals from the receivers for the innovative high speed, multi-bit samplers. Additionally the sampled signal is to be transported by an optical fibre based system at rates up to 10 Gbps over distances up to four kilometres and converted by a complex transition circuit board to a form suitable for introduction to the signal processing board. Substantial effort is being undertaken simultaneously with these developments to produce the firmware to allow the Field Programmable Gate Arrays (FPGAs) that are the pivotal component of the signal processing board to perform the signal routing and processing tasks. Significant breakthroughs have been made in all these areas, despite the difficulties presented by the use of state of the art technologies, and allow the engineers to be confident that a complete prototype system’s capabilities will be able to be demonstrated in early 2007.



A Compact Array mm-wave receiver with prototype 7-mm components. From left to right are signal paths for 3-, 12- and 7-mm wavelength bands respectively. The majority of components are cooled to cryogenic temperatures through connection to a closed cycle helium refrigerator via the elegant copper metalwork. This minimises thermal noise that might otherwise mask the astronomical signal.

Photo: Russell Bolton, CSIRO

This will fit well with the plan to have the "Stage 1" CABB, a single frequency system with the antenna equipment installed in such a way as to allow parallel operation of the existing backend and the new CABB backend, available for engineering tests in July 2007.

Pulsar digital filterbank

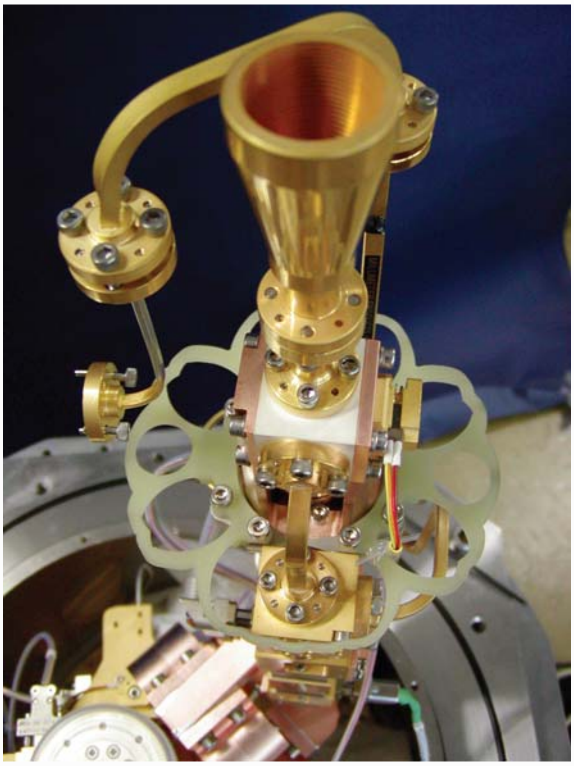
This project also builds on the experience gained in the development of digital filterbanks for the CABB project. The aim is to develop a one-GHz bandwidth, multi-channel spectrometer/ polarimeter with sufficient time resolution to resolve the fastest millisecond pulsars.

Following the successful operation of a prototype 256-MHz bandwidth pulsar digital filterbank, based on commercially available hardware, the design of the one-GHz production unit was largely completed. However, due to the unavailability of Xilinx FPGAs, an alternative design using the final CABB signal processing boards was considered to be more appropriate.

This new design is completed and the majority of hardware components have been fabricated. Firmware to provide basic functionality is substantially complete. Inevitably problems have arisen from the demands being put on the new technology however their continued resolution allows a confident estimate that the installation of the one-GHz unit will occur in the first months of 2007.

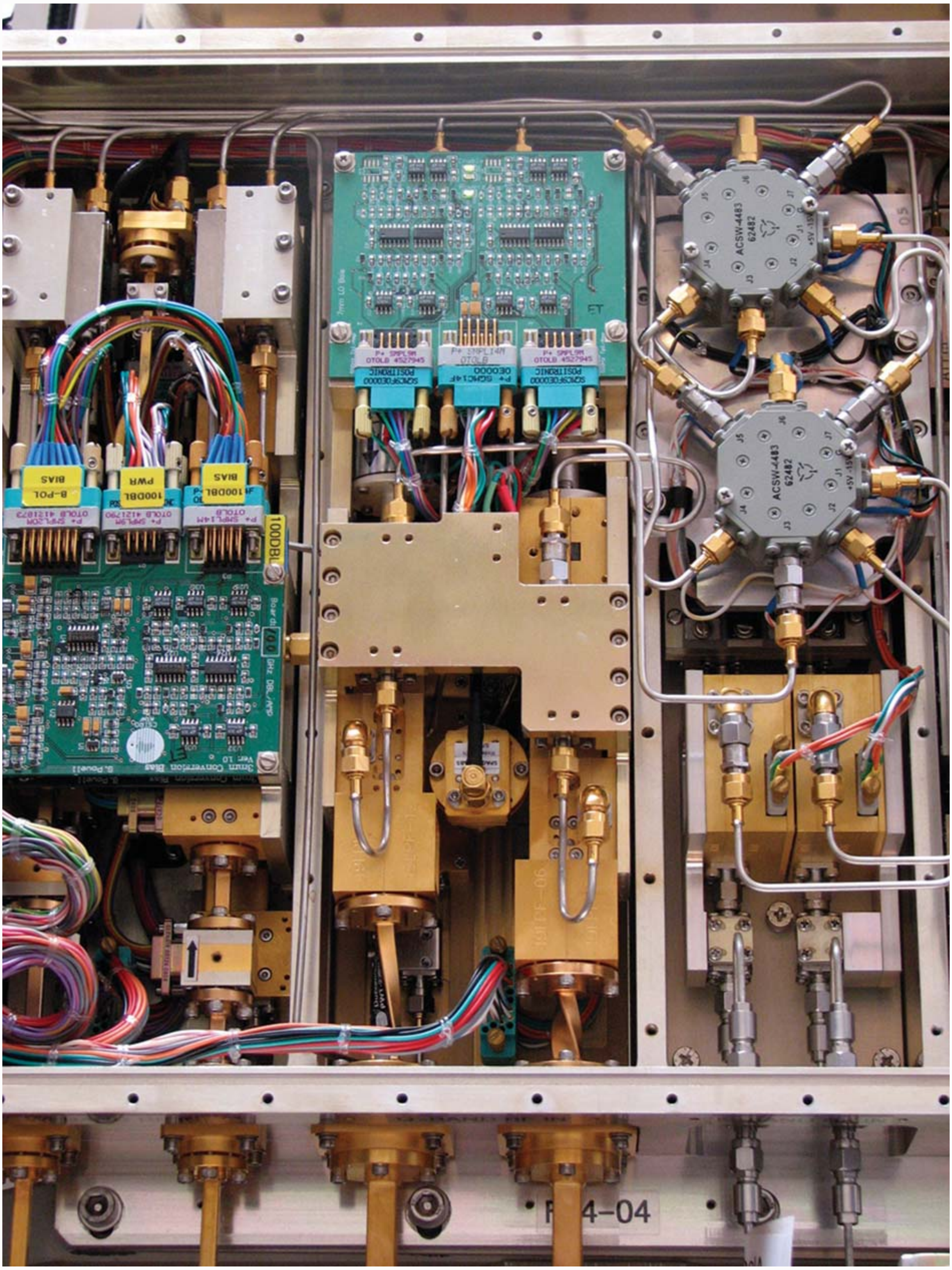
The system's capabilities make it attractive as a tool for many radio observatories and as such it has generated enquiries from the international community. Though no firm commitment has been received there is a strong indication that this project will generate external contracts.

The mm-wave receiver with a prototype 7-mm system included mounted in the turret of Compact Array antenna 6.



Feed and calibration signal waveguide of the mm-wave package for the Mopra telescope.

Photos: Graeme Carrad, CSIRO



The millimetre receiver's complex, precisely engineered and modular conversion housing. Conversion modules make ready the amplified, high frequency astronomical signal from the receiver for processing by the ATNF's backend electronics. The modules, from left to right, function in the 3-, 7- and 12-mm wavelength bands respectively. Signal path components and control and monitor electronics are visible.

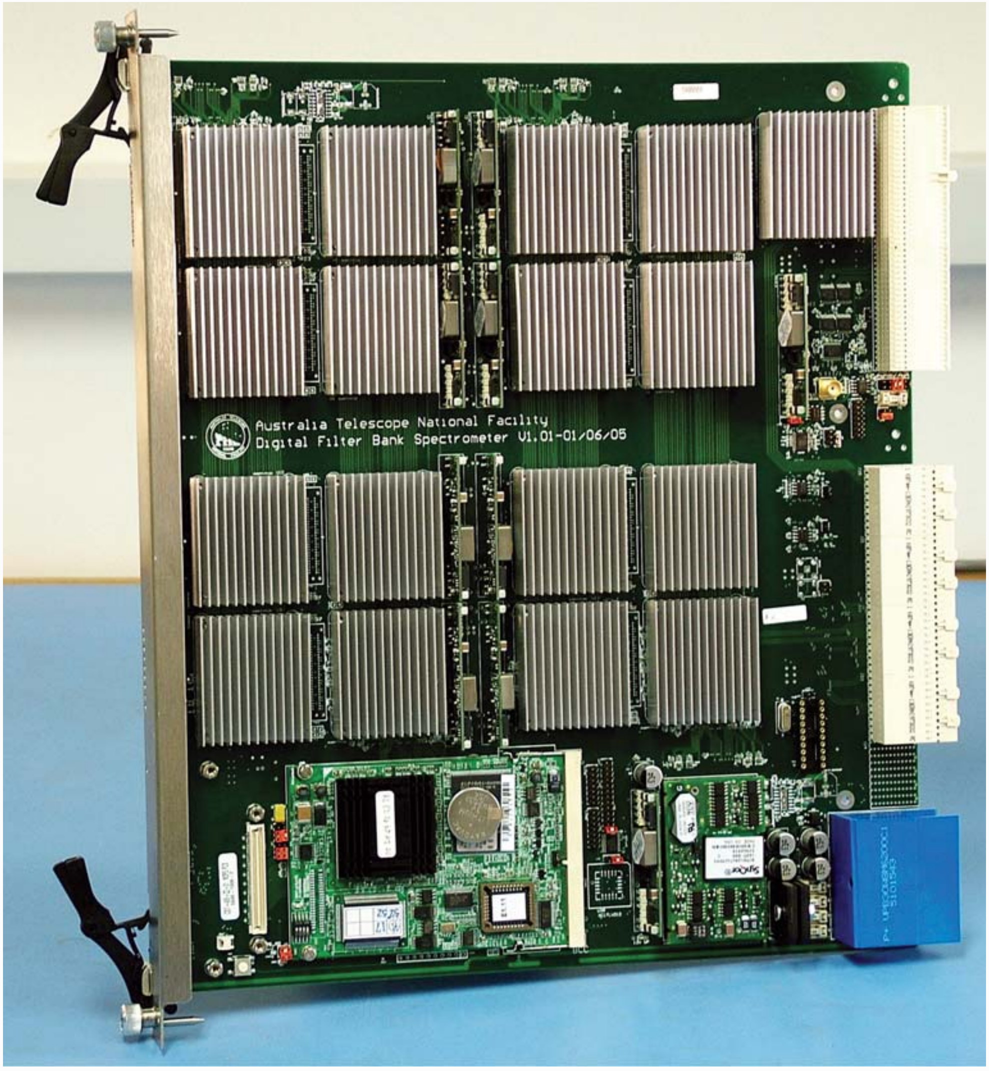
Photo: Graeme Carrad, CSIRO

Mopra 8-GHz spectrometer (MOPS)

The MOPS spectrometer is a by-product of the signal processing development being carried out as part of the broadband upgrade of the Compact Array. The instrument was funded largely by a grant from the Australian Research Council to a consortium of universities, led by the University of New South Wales, and the ATNF. Initial observations with a single 2-GHz quadrant of MOPS were carried out at Mopra in October 2005 and the results from the combination of the new MMIC receiver and this first stage of the new spectrometer in October 2005 proved to be very promising.

A significant effort to install the full spectrometer system was undertaken in May 2006 and the result is a very powerful backend system that allows astronomers access to 8 GHz of bandwidth in the millimetre frequency range. Configurations available from the system include 32,000 channels across an 8-GHz band with sixteen zoom bands, each of bandwidth 138 MHz and 4,096 channels, which allow observations of sixteen molecular transitions simultaneously.

Combined with the broadband receiver systems, MOPS has greatly enhanced Mopra's position as a major facility for millimetre-wave observations in the Southern Hemisphere, sparked enthusiasm for its use and brought much praise from both Australian and overseas users.



One of four signal processing boards for the Mopra spectrometer. The physical size of the board is approximately 40 cm x 40 cm.

Photo: Evan Davis, CSIRO

Bruce Tough (left) from Narrabri and Les Reilly (right) from Marsfield prepare the millimetre receiver, containing the prototype 7-mm components, for the lift to the turret and its final mounting position on antenna 6 of the Narrabri Compact Array.

Photo: Graeme Carrad, CSIRO

The SKA and pathfinder projects

Image credit: Chris Fluke, Swinburne University

The SKA and pathfinder projects

The ATNF is committed to the Square Kilometre Array (SKA) as its primary strategic development project. The SKA is a next generation radio telescope which will have a collecting area of approximately one square kilometre, making it one hundred times more sensitive than any existing radio telescope. It will operate at centimetre wavelengths. In 2006 the ATNF continued to make significant contributions to the SKA international project in a number of ways, primarily in the continued development of (1) an SKA pathfinder and (2) developing the International SKA Steering Committee (ISSC) short-listed Australian SKA site.

SKA Pathfinder

The ATNF continues its strong commitment to develop a technological pathfinder on the candidate SKA site in Western Australia. The pathfinder will demonstrate many aspects needed for the SKA, but has focussed on wide-field-of-view technologies, along with the associated computing and architectural needs. This has been pursued along a number of phases: the New Technology Demonstrator (NTD); the Parkes Testbed Facility (PTF); the extended New Technology Demonstrator (xNTD); and the Mileura International Radio Array (MIRA).

New Technology Demonstrator

The goal of the NTD project is to develop and demonstrate phased array feed technologies and methods that are appropriate for radio astronomy applications. This project will be completed in 2007 and ongoing tests will be conducted on the Parkes Testbed Facility (PTF). The project uses a “ThEA” tile obtained from ASTRON in the Netherlands on a reconstituted 13.7-m antenna relocated to the Marsfield campus. Another 13.7-m antenna relocated to Marsfield was equipped with a standard feed in order to conduct interferometric tests.

The two-element interferometer at Marsfield uses a 21-element beamformer and correlator to produce a single output beam, with the system controlled using a Python-based control system. Fringes on a satellite Optus B were demonstrated, showing the system functionality and demonstrating the expected beam-forming gain. Recent work has concentrated on improving the calibration, mostly by using a noise source on the surface of the antenna.

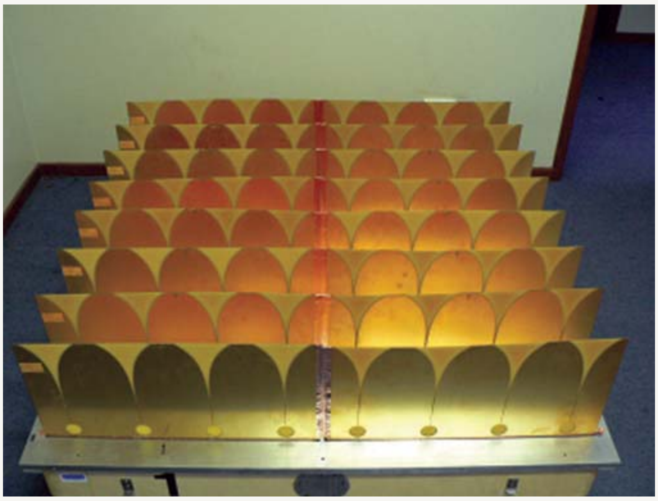
The ATNF has also developed a new design for a linear connected phased array with connected dipole-like elements. Staff have undertaken extensive modelling, and built and measured a small prototype array, which has validated the modelling. The success of the linear-connected array reinforced the confidence in the modelling and spawned a newer variant of this approach where the dipole wires have been “fattened” to be square elements arranged in a checkerboard pattern. Interestingly, this checkerboard structure is also known as a “self-complementary” screen and this leads to predicted properties which are confirmed by modelling.

Parkes Testbed Facility

A limitation in the testing under the NTD project has been the presence of strong radio-frequency interference at the Marsfield site. Given the importance of demonstrating the viability of phased-array feeds, the ATNF is constructing a 12-m antenna at the Parkes Observatory to be used as a testbed facility. A commercial antenna has been purchased from Patriot Systems (USA) and is expected to be installed and tested by late 2007. This is not a prototype antenna, but a testbed for comprehensive testing of phased array feeds, both separately and together with the Parkes radio telescope. The 12-m antenna may be reconfigured with a sub-reflector and different feed/sub-reflector supports in order to test out antenna configuration with beam-forming and processing.

Extended New Technology Demonstrator

The xNTD project is the first phase of building a pathfinder instrument for the SKA on the SKA candidate site that will also provide a powerful radio telescope as part of the National Facility. The specification for the xNTD is based on an array of dish antennas, each equipped



The THEA tile provided by ASTRON in the Netherlands.
Photo: Helen Sim, CSIRO

The THEA tile being mounted on one of the two NTD antennas on the Marsfield site.
Photo: Tony Sweetnam, CSIRO

with a room temperature phased array feed. The design and cost of the antennas are critical elements in the xNTD project. The array will be built at the Australian proposed SKA site in WA. The xNTD project aims to demonstrate that phased array feeds on small dishes can meet key cost and performance goals that are applicable to the SKA.

Work also progressed on an integrated “receiver-on-a-chip” design. Devices were delivered in September 2006. Testing confirmed that all components worked as expected, demonstrating a complete signal path of gain, frequency conversion, filtering and digitisation. This work is being continued, alongside other receiver and low noise amplifier designs, to develop a cost-effective qualified receiver for the many elements needed for the phased array feed.

In July 2006 an Australian-South African radio astronomy computing collaboration, known as CONRAD (CONvergent Radio Astronomy Demonstrator), was launched to leverage software resources at both sites towards a common software platform for the two demonstrators. The collaboration covers the areas of software architecture and design, data archives, calibration and imaging, array configuration, radio frequency interference mitigation, simulation, software engineering, monitor and control, and systems integration and testing. Several productive face-to-face meetings were held to foster the collaboration, and the group used web-based tools to further the productivity of the effort.

Major funding from CSIRO for the development of the xNTD began in July 2006, and the WA government also pledged support to help locate it at the SKA candidate site in the Mid-west region of WA. Over the second half of 2006, additional resources and partners were identified to enhance the xNTD, and the project was expanded and recast as the Mileura International Radio Array (MIRA).

Mileura International Radio Array

In 2006 the Australian Government provided additional resources from the National Collaborative Research Infrastructure Strategy (NCRIS) program to supplement the CSIRO xNTD funding, as well as for a low-frequency instrument, known as the Mileura Widefield Array (MWA), to be co-located with the xNTD. The MWA is an international project led by the Massachusetts Institute of Technology (MIT) to build a low frequency (80 – 300 MHz) array that is expected to later become part of the National Facility. In 2006 Canada's Hertzberg Institute for Astrophysics (HIA) signed a Memorandum of Understanding to participate fully in building the xNTD, primarily with their Dominion Radio Astrophysical Observatory (DRAO). The xNTD was then renamed as the Mileura International Radio Array, or MIRA. (Mileura is the region of WA where the early site-testing was conducted.)

The enhanced xNTD under MIRA has a target specification of 45 12-m antennas, each with a room temperature phased array feed, to be sited at the proposed SKA candidate site in WA. The

MIRA (now known as the Australian SKA Pathfinder) is a new telescope that will be will provide up to 45 12-m diameter antennas and will be located at the Murchison the northern end of the site with a CSIRO trailer on its way to setting up some radio

Canadians are full partners in most aspects under development and the Netherlands Foundation for Research in Astronomy (ASTRON) is a partner in software development and phased array feed studies. CONRAD is a collaboration between ATNF and the Karoo Array Telescope (KAT) group in South Africa to jointly develop software appropriate for MIRA and KAT.

The Australian SKA Candidate Site

In August 2006 the ISSC met in Dresden, Germany to evaluate the four candidate sites for the SKA; Argentina/Brazil, Australia, China and Southern Africa. Two sites, Australia and Southern Africa, were short-listed on technical grounds. The Australian site is within the region protected from new mining under Section 19 of the WA Mining Act as part of the siting effort; specifically located on Boolardy Station, a 350,000 hectare cattle property. A 70-km radius circle centered in the northwest region of the Station is in process to be protected under the WA Industry and Technology Development Act as the Murchison Radioastronomy Observatory (MRO), a radioastronomy technology park. Other protections will be pursued as appropriate, including protection as a Radio Quiet Zone under the Australian Communications and Media Authority (ACMA). Efforts to further characterise and document the excellent quality of the area continue.

Photo: Ron Beresford, CSIRO

built in Western Australia by CSIRO in collaboration with overseas partners. The array
Radio Observatory in the Mid West region of Western Australia. This photo shows
frequency interference test equipment.

SKA industry activities

Since late 2005 the Australian SKA Industry Cluster Consortium has been working collaboratively to provide a strong industry foundation for the “mega-science” SKA initiative. The consortium has since been increased with a number of new members that have expressed a keen interest in the challenges and opportunities inherent in the complex task of realising the world’s next-generation radio-telescope and its potential to foster new technologies for adjacent markets (telecoms, defence and CSIRO ICT).

The formation of the Consortium, with its associated industry-led Cluster activities, recognized the necessity for early and ongoing Australian industry engagement with SKA. Current objectives, supported by the above organisations and a grant from AusIndustry’s Industry Cooperative Innovation Program (ICIP), include the identification of projects/prototypes suitable for SKA Cluster development as well as the identification of Australian capability and the formulation of a SKA technology roadmap.

In order to meet these objectives, during 2006 the project team conducted a series of National briefings across Australia, as follows:

- Sydney (December 2005) – 60 attendees, held at the ATNF headquarters in Marsfield;
- Geraldton (March 2006) – 60 attendees, sponsored by Mid-West Development Commission (WA), held at The Africa Reef Hotel, Geraldton;
- Perth (March 2006) – about 24 attendees, sponsored by the Department of Industry and Resources (DOIR, WA), held at the UWA Technology Park, Bentley, Perth;
- Brisbane (May 2006) – 45 attendees, sponsored by and held at Boeing Australia HQ;
- Adelaide (August 2006) – about 65 attendees, sponsored by Tenix, BAE systems and the Defence Teaming centre, held at Innovation House, Mawson Lakes Technology Park, Adelaide; and
- Perth (December 2006) – about 60 attendees, sponsored by the DOIR (WA), held at the UWA Technology Park, Bentley, Perth.

These events have led to the identification of many companies with SKA-related capabilities and to a number of collaborations between CSIRO and interested companies wishing to engage with early-phase research and development.

The Australian SKA industry cluster initiative is endorsed by the Australian Government’s Electronics Industry Action Agenda led by the Australian Electrical and Electronic Manufacturers Association (AEEMA).

Trees in the Pilliga State Forest, a region near the Narrabri Observatory
Photo: © Barnaby Norris


DANGER

Appendices

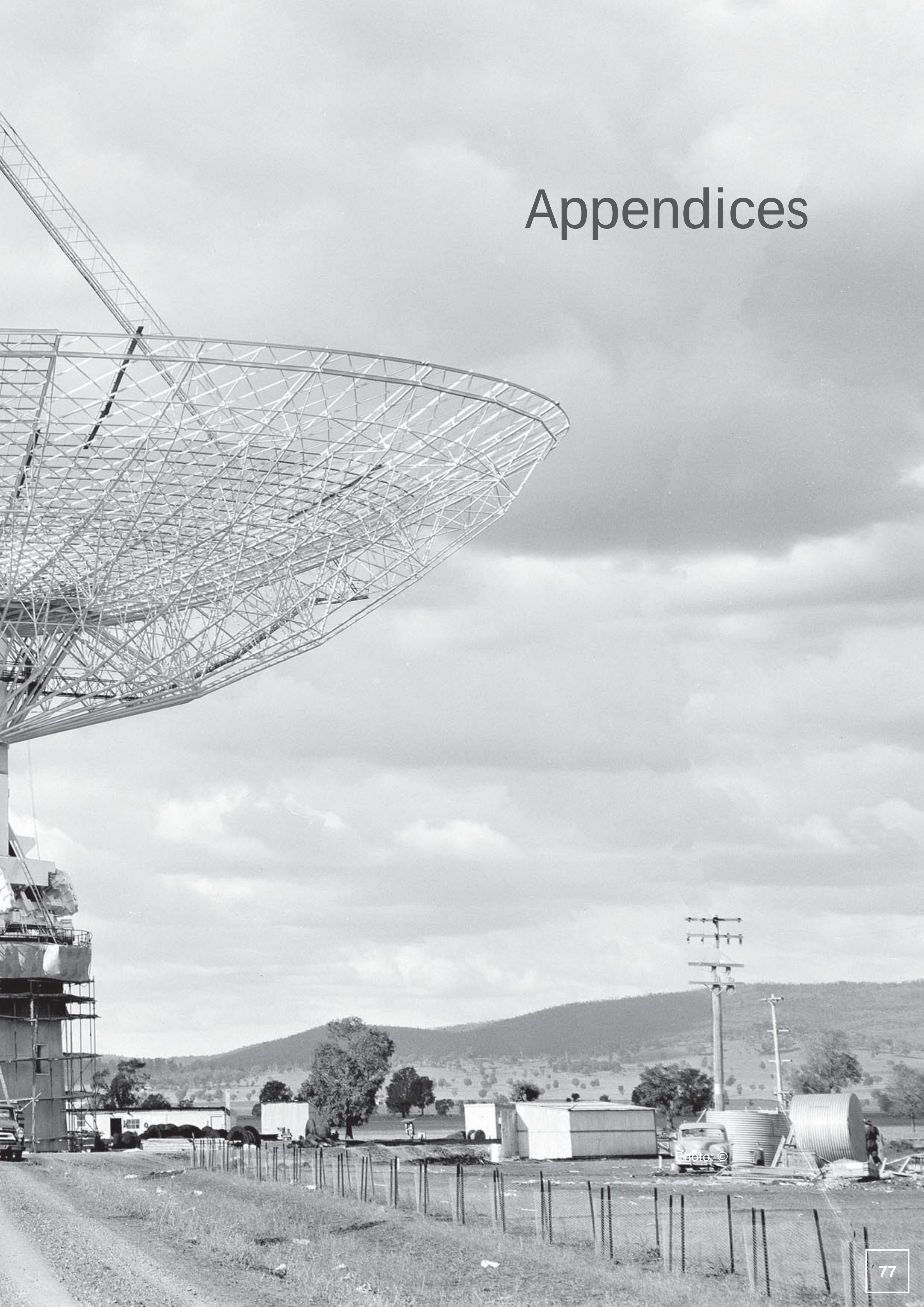


Photo: ©

A: Statement of financial performance

	Year ending 30 June 2006	Year ending 30 June 2005
Revenue	$	$
External	11,434,984	2,604,315
Interest	150,000	561,469
Appropriation	21,937,500	22,312,668
Total Revenue	**33,522,484**	**25,478,452**
Expenses		
Salaries	12,516,881	11,665,693
Travel	722,799	817,480
Other Operating	13,249,476	8,032,286
Corporate Support Services	3,177,600	3,229,968
Depreciation & Amortisation	3,414,234	4,694,109
Doubtful Expense	0	0
Total Expenses	**33,080,909**	**28,439,536**
Profit/(Loss) on sale of assets	27,779	41,914
Operating Result	**469,354**	**-2,919,170**

Notes

In 2004/05 a discrepancy in the treatment of the ATNF's external revenue was discovered and corrected. This discrepancy means that the surplus reported in 2003/04 was overstated and the deficit reported for 2004/05 is primarily due to the correction. Therefore, the reported change in financial performance of approximately 3.4 million dollars from 2004/05 to 2005/06 is not due to a major change in the actual operations of the ATNF.

Previous page: The Parkes radio telescope under construction in 1961.
Photo: © CSIRO Radiophysics Photo Archive

B: Staff list, January to December 2006

Marsfield

S Amy (Computing)
J Archer (Finance & Administration)
P Axtens (Receivers)
L Ball (Deputy Director)
A Barends (PA to Office of Director)
T Bateman (xNTD/SKA)
R Beresford (Electronics/xNTD/SKA)
R Bolton (Receivers)
P Bonvino (Machine Shop)
M Bourne (Machine Shop)
M Bowen (Receivers)
B Boyle (ATNF Director)
K Brooks (Bolton Fellow/Astrophysics)
A Brown (Electronics)
M Calabretta (Computing)
G Carrad (Receivers)
J Caswell (Astrophysics)
J Chapman (Head, National Facility Support)
R Chekkala (Electronics)
A Chippendale (Electronics/xNTD/SKA)
T Cornwell (xNTD/SKA)
G Cook (Machine Shop)
P Cooper (Machine Shop)
E Davis (Electronics)
L de Souza (SKA)
M Death (Machine Shop)
N Derwent (Finance)
P Doherty (Receivers)
V Drazenovic (National Facility Support)
A Dunning (Receivers)
R Edwards (Postdoctoral Fellow/Astrophysics)
R Ekers (Federation Fellow)
T Elton (Electronics)
I Feain (Bolton/CSIRO Fellow/Astrophysics)
R Ferris (Electronics)
D Gain (Receivers)
R Gough (Receivers)
G Graves (Receivers)
E Hakvoort (Receivers)
P Hall (On secondment to Int. SKA Project Office)
G Hampson (Electronics)
D Herne (xNTD/SKA)
G Hobbs (Astrophysics)
R Hollow (National Facility Support)
T Huynh (Machine Shop)
O Iannello (Machine Shop)
C Jacka (xNTD/SKA)
C Jackson (Business Dev. & Commer. Manager)
S Jackson (Electronics/xNTD/SKA)
S Johnston (Astrophysics/CSIRO Science Leader)
A Jones (HS&E/Human Resources Manager)
E Kachwalla (National Facility Support)
H Kanoniuk (Receivers)
M Kesteven (Astrophysics/Engineering Research)
B Koribalski (Astrophysics)
A Kosmynin (National Facility Support)
L Kedziora-Chudczer (Research Support)
M Leach (Electronics)
J Lie (Receivers)
S Little (Astrophysics/PA to Federation Fellows)
D Londish (xNTD/SKA)
S Magri (Electronics)
R Manchester (Federation Fellow)
G Manefield (PA to Executive Officer)
M Marquarding (Computing/Software)
M McAuley (Executive Officer)
N McClure-Griffiths (Astro./CSIRO Science Leader)
D McConnell (Assistant Director Operations)
V McIntyre (Computing)
E Middelberg (Bolton/CSIRO Fellow/Astrophysics)
R Moncay (Machine Shop)
G Moorey (Receivers)
E Muller (Bolton/CSIRO Fellow/Astrophysics)
R Norris (Astrophysics)
J O'Sullivan (xNTD/SKA)
R Ojha (Astrophysics)
J Ott (Astrophysics/Mopra)
S O'Toole (Human Resources)
C Owen (National Facility Support)
C Phillips (Astrophysics/LBA)
G Powell (Receivers)
R Ricci (Astrophysics)
L Reilly (Receivers)
P Roberts (Electronics)
S Saunders (Electronics)
G Scott (LBA Correlator)
M Shields (Electronics)
H Sim (National Facility Support)
L Staveley-Smith (Assistant Director Astrophysics)
M Storey (Australian SKA Project Office)

T Sweetnam (xNTD/SKA)
P Sykes (Receivers)
A Teoh (Research support)
A Tzioumis (Astrophysics/LBA)
M Voronkov (Astrophysics/xNTD/SKA)
B Wilson (Finance & Administration)
W Wilson (Assistant Director Engineering)
M Whiting (CSIRO Emerging Science Postdoctoral Fellow)
M Wright (Receivers)

Marsfield Staff shared with CSIRO Industrial Physics

S Clark (Canteen)
O D'Amico (Store)
C Duffy (Reception)
C Hodges (Reception)
A Joos (Library)
K Lambert (Store)
B Wrbik (Canteen)
W Finch (Site Services)
M McDonald (Site Services)
P Sharp (Site Services)
C van der Leeuw (Library)
B Wilcockson (Engineer/Site Services)

Narrabri

B Adamson (Administration)
P Alexander (Lodge)
R Behrendt (Electronics)
D Brennan (Lodge)
D Brodrick (Computing/Software)
M Dahlem (Operations & Astrophysics)
E Darcey (Antennas & Site Services)
P Edwards (Officer-in-Charge)
K Forbes (Administration & Finance)
M Hill (Electronics)
B Hiscock (Deputy Officer-in-Charge)
J Houldsworth (Visitor Services)
J Giovannis (Computing)
B Johnson (Antennas & Site Services)
P Kelly (Visitor Services)
M Laxen (Electronics)
B Lennon (Computing)
C Leven (Antennas & Site Services)
D Lewis (Operations)
J McFee (Electronics)
M McFee (Visitor Services)
P Mirtschin (Electronics)
S Munting (Electronics)
V Otrupcek (Mopra)
M Rees (Lodge)
L Saripalli (Operations & Astrophysics)
R Sault (Officer-in-Charge)
R Subrahmanyan (Operations & Astrophysics)
G Sunderland (Antennas & Site Services)
B Tough (Cryogenics)
E Troup (Computing/Software)
R Wark (Operations)
N Webster (Antennas & Site Services)
J Wieringa (Library)
M Wieringa (Computing/Software)
C Wilson (Lodge)
J Wilson (Cryogenics)
T Wilson (Antennas & Site Services)

Parkes

S Brady (Site Services)
J Cole (Lodge)
J Crocker (Site Services)
B Dawson (RF Systems/Deputy Officer-in-Charge)
R Eslick (Site Services)
A Evans (Site Services)
G Freeman (Administration & Finance)
J Hockings (PA/Visitors Centre)
S Hoyle (Computing/Operations)
A Hunt (Electronics/Servo)
S Ingram (Lodge/Site Services)
R Lees (Site Services)
S Mader (Computing/Operations)
L Milgate (Visitors Centre)
B Preisig (Electronics/Servo)
K Reeves (Site Services)
J Reynolds (Officer-in-Charge)
T Ruckley (Electronics/Servo)
J Sarkissian (Operations)
J Smith (Visitors Centre Manager)
M Smith (RF systems)
G Spratt (Computing)
T Trim (Visitors Centre)
B Turner (Site Services)
S Turner (Site Services)
K Unger (Visitors Centre)
J Vera (RF Systems)
T Wilkie (Visitors Centre)
L Williams (Site Services)
B Wilson (Visitors Centre)

Canberra

D Jauncey (Astrophysics)
J Lovell (Astrophysics/Tidbinbilla/LBA)

C: Committee membership

ATNF Steering Committee at April 2006

Chairman

Prof Matthew Bailes, Swinburne University of Technology

Secretary

Mrs Anne Barends, CSIRO ATNF

Members

Ex-Officio

Dr Matthew Colless, Director, Anglo-Australian Observatory

Dr Rod Hill, Executive Director, CSIRO Business Development

Dr Alex Zelinsky, Director, CSIRO ICT Centre

Astronomers

Prof Frank Briggs, Research School of Astronomy and Astrophysics, Australian National University

Prof Anne Green, School of Physics, University of Sydney

International advisers

Prof Rajaram Nityananda, National Centre for Radio Astrophysics,
Tata Institute of Fundamental Research, Pune, India

Dr Mike Garrett, Director, Joint Institute for VLBI in Europe (JIVE), Netherlands

Dr Ken Kellermann, National Radio Astronomy Observatory, Charlottesville, USA

Industry

Dr Robert Frater, Vice President, Innovation, Res Med, North Ryde

Mr Brett Biddington, Cisco Systems, Canberra

Invited

Dr Brian Boyle, Director, CSIRO ATNF

Australia Telescope Users Committee

January to December 2006

Chair

Prof E Sadler, University of Sydney

Secretary

Dr J Lovell, CSIRO ATNF (until June 2006)

Dr M Dahlem, CSIRO ATNF (from July 2006)

Members

Dr J Bland-Hawthorn, Anglo-Australian Observatory

Dr K Brooks, CSIRO ATNF

Dr R-J Dettmar, Ruhr Univerity, Bochum, Germany

Dr M Drinkwater, Univerity of Queensland

Ms A Ford*, Swinburne University

Dr G Hobbs, CSIRO ATNF

Dr H Jerjen, Research School of Astronomy & Astrophysics, Australian National University

Dr M Johnston-Hollitt, University of Tasmania

Mr S Longmore*, University of New South Wales

Ms K Newton-McGee*, University of Sydney

Dr S Maddison, Swinburne University

Dr J Ott, CSIRO ATNF

Dr S Ryder, Anglo-Australian Observatory

Dr E Sadler, University of Sydney

Mr C Senkbeil*, University of Tasmania

Mr M Wardle, Macquarie University

Dr R Webster, University of Melbourne

Dr C Wright, Australian Defence Force Academy

* student member

Australia Telescope Time Assignment Committee

January to December 2006

Chair

Prof J Dickey, University of Tasmania

Executive secretary

Dr J Chapman, CSIRO ATNF

Members

Ex-Officio

Dr J Lovell, VLBI and Tidbinbilla Scheduler, CSIRO ATNF

Dr D McConnell, Assistant Director for Operations, CSIRO ATNF

Dr J Reynolds, Officer-in-Charge, Parkes Observatory, CSIRO ATNF

Dr R Sault, Officer-in-Charge, Narrabri Observatory, CSIRO ATNF (until March 2006)

Dr P Edwards, Officer-in-Charge, Narrabri Observatory, CSIRO ATNF (from May 2006)

Voting members

Prof M Bailes, Swiburne University

Dr M Burton, University of New South Wales

Dr A Hopkins, University of Sydney

Dr S Johnston, CSIRO ATNF

Dr R Subrahmanyan, CSIRO ATNF

Dr W Walsh, University of New South Wales

D: Observing programs

Observations made with the Australia Telescope Compact Array October 2005 to September 2006

Observers	Affliations	Program	Number	Hours
Sault, Dahlem, Wong, Sadler	ATNF, ATNF, ATNF, USyd	ATCA calibrators at 3mm	C007	100
Staveley-Smith, Gaensler, Manchester, Tzioumis, Kesteven, Ball	ATNF, CfA, ATNF, ATNF, ATNF, ATNF	SNR 1987A	C015	114
White, Chapman, Koribalski	UMar, ATNF, ATNF	High-spatial-resolution images of Eta Carinae	C186	12
Gaensler, Gelfand, Slane, Hughes, Plucinsky, Ghavamian, Park, Burrows	CfA, Harvard, CfA, Rutgers Uni, CfA, JHU, PSU, PSU	Expansion of the young oxygen rich supernova Remnant G292.0+1.8	C337	51
Francis, Palunas, Colbert, Teplitz, Williger, Woodgate	RSAA, UTex, SSC, SSC, JHU, GSFC	Radio/infrared correlation at redshift 2.38	C428	48
Bourke, Wolk, Magreath	CfA, CfA, CfA	Ionised gas in the compact HII region RCW 38	C512	12
Brocksopp, Tzioumis, Corbel, Fender	MSSL, ATNF, UParis, USouth	Radio jets in recurrent and new black hole X-ray transients	C989	
Bryant, Sadler, Broderick, De Breuck, Hunstead, Johnston	USyd, USyd, USyd, ESO, USyd, USyd	High redshift radio galaxies from SUMSS	C1000	48
Chapman, Hollow	ATNF, ATNF	Summer Vacation Program 2005/2006	C1012	24
Dodson, Lewis, Romani, Ng, Golap, Brisken	ISAS, ATNF, UStan, UStan, NRAO NRAO	Imaging the PSR1706-44PWN	C1033	
Ekers, Murphy, Subrahmanyan, Staveley-Smith, Phillips, Sadler, Kesteven, Ricci, Jackson, Walker, Wilson, De Zotti	ATNF, USyd, ATNF, ATNF, ATNF, USyd, ATNF, ATNF, ATNF, ATNF, USyd, OAPd	Wideband 20-GHz sky survey (AT20G) follow-up	C1049	888.5
Fender, Jonker, Tzioumis, Tudose, Miller-Jones	USouth, CfA, ATNF, UAm, UAm	Ongoing secular evolution of the galaxy's most relativistic jet source	C1073	24
Urquhart, Thompson, Morgan	ULeeds, UHerts, GBT	Bright-rimmed clouds: tracing their ionised rims	C1093	24
Brooks, Garay, Faundez	ATNF, UChi, UChi	The ionized content of massive star-forming regions	C1112	24.5
White, Chapman, Koribalski	UMar, ATNF, ATNF	High-resolution millimeter images of the Eta Carinae system	C1167	34
McConnell	ATNF	ATNF Synthesis Imaging Workshop observing sessions	C1185	24
Staveley-Smith, McClure-Griffiths, Matthews, Putman, Thom, Gibson	ATNF, ATNF, LTu, UMich, Swinb, ULancs	The structure of the Magellanic Stream	C1197	81
McIntyre, Dickel, Amy, Gruendl	ATNF, UIL, ATNF, UIL	A 4.8 and 8.6-GHz survey of the SMC	C1207	129.5
Klamer, Ekers, Sadler, Hunstead, De Breuck	USyd/ATNF, ATNF, USyd, USyd, ESO	Cool molecular gas in z > 3 radio galaxies	C1214	100

Middelberg, Jackson, Norris, SWIRE Team, XMM Team, Koekemoer, Condon, APEX Team	ATNF, ATNF, ATNF, IPAC, UBol, STScI, NRAO, UDur	Wide-area deep radio observations of SWIRE fields	C1241	46.5
Kanekar	NRAO	A search for OH mega-masers in ultra-luminous infrared galaxies	C1257	72
Benaglia, Romero, Ribo, Combi, Koribalski, Rodriguez	IAR, IAR, CEA, UJaen, ATNF, UNAM	The origin of massive stars	C1260	12
Nielbock, Koribalski, Chini	URuhr, ATNF, URuhr	The multiplicity of protostars	C1274	22
Lundqvist, Ryder, Bjornsson, Fransson, Schmidt, Perez-Torres	StO, AAO, StO, StO, ANU, IAA	NAPA: Probing the radio emission from a young Type Ia supernova	C1303	
Wong, Dahlem, Ryder, Kohno, Buta	ATNF, ATNF, AAO, IoA, UTokyo, UAl	Circumnuclear rings: Probes of star formation and galaxy dynamics	C1328	40.5
Koribalski, Ott, de Blok, Staveley-Smith, Jerjen, Karachentsev, Kern	ATNF, ATNF, MSSSO, ATNF, RSAA, SAO, Swinb	The Local Volume HI Survey (LVHIS)	C1341	191.5
Possenti, Burgay, Murgia, Manchester, Wilson, Kramer, McLaughlin, Faulkner, Lyne, D'Amico, Camilo, Stairs	UBol, UBol, UBol, ATNF, ATNF, JBO, JBO, JBO, JBO, UBol, UClmba, UBC	Orbital mapping of the continuum flux from the double pulsar PSR J0737-3039A/B	C1312	21
Manchester, Camilo, Possenti, Burgay	ATNF, UClmba, CAO, CAO	SNR associations with Parkes multibeam pulsars	C1313	13
Koribalski, Staveley-Smith, de Blok, Freeman, Bland-Hawthorn, Kern,	ATNF, ATNF, RSAA, RSAA, AAO, Swinb	The local volume HI survey (LVHIS)	C1341	396
Buyle, De Rijcke, Michielsen, Ott, Dejonghe	UGent, UGent, UGent, ATNF, UGent	The faint end of the TF relation	C1365	84
Bignall, Lovell, Tzioumis, Ellingsen, Cimo, Kedziora-Chudczer, Jauncey, Macquart, Senkbeil, Carter	JIVE, ATNF, ATNF, UTas, UTas, USyd, ATNF, NRAO, UTas, UTas	Observations of the unique rapid scintillator PKS 1257-326	C1366	83.5
Buyle, De Rijcke, Michielsen, Dejonghe	UGent, UGent, UGent, UGent	The HI content of Fornax Cluster dwarf elliptical galaxies	C1370	48
Wong, Ladd, Mizuno, Bourke, Wright	ATNF/UNSW, UBuck, UNag, CfA, ADFA	Imaging the dense gas associated with molecular outflows in Chamaeleon	C1388	48
Brooks, Voronkov, Garay, Mardones	ATNF, ATNF, UChi, UChi	3-mm observations towards the IRAS 16547-4247 radio jet	C1390	54
Sadler, Staveley-Smith, Sault, Ekers, Ricci, Jackson	USyd, ATNF, ATNF, ATNF, ATNF, ATNF	The radio-source population at 100 GHz	C1392	36
Blomme, van de Steene, Prinja, Hodges	ROB, ROB, UCL, UCL	B-supergiant mass-loss rates, wind ionization and clumping	C1398	38.5
Mookerjea, Kramer, Vogenau, Burton, Bains, Hunts, Wong, Jones	UKoeln, UKoeln, UKoeln, UNSW, UNSW, UNSW, ATNF, ATNF	NH3 mapping study of RCW 106 complex	C1400	18
Walsh, Burton, Chapman, Wardle	UNSW, UNSW, ATNF, UMac	The chemical signatures of high mass star formation	C1402	11
Beuther, Walsh, Thorwirth, Zhang, Hunter, Megeath, Menten	CfA, UNSW, CfA, CfA, CfA, CfA, MPIA	Hot molecular gas in the massive twin cores NGC6334I & I(N)	C1407	24

Umana, Cerrigone, Trigilio, Suarez	OCat, OCat, OCat, LAEFF	Search for very young planetary nebulae	C1413	14
Newton-McGee, Gaensler, Haverkorn, Ekers, Green, McClure-Griffiths	USyd/ATNF, CfA, CfA, ATNF, USyd, ATNF	Studying magnetic fields in HII regions with Faraday rotation	C1442	50
Newton-McGee, Gaensler, Haverkorn, Ekers, Green, McClure-Griffiths	USyd/ATNF, CfA, CfA, ATNF, USyd, ATNF	Probing magnetic field structure in NGC 1310 & the "Ant"	C1443	50.5
Kilborn, Forbes, Koribalski, Mendel, Brough	Swinb, Swinb, ATNF, Swinb, Swinb	HI clouds in galaxy groups	C1446	48
Papadopoulos, Webb, Walter-Rix, Klamer, van der Werf, van Dokkum, Franx	ETH, ULeid, MPIA, USyd, ULeid, Yale, ULeid	Molecular gas in distant red galaxies	C1455	120.5
Cohen, Caswell, Voronkov, McClure-Griffiths, Walsh, Burton, Chrysostomou, Brooks, Diamond, Ellingsen, Fuller, Gray	JBO, ATNF, ATNF, ATNF, UNSW, UNSW, UHerts, ATNF, JBO, UMan, UTas, UMan	Accurate positions for methanol masers from the MMB survey	C1462	20.5
Gaensler, Gelfand, Taylor, Fender, Garrett, Kouveliotou, Wijers, Newton-McGee, Eichler, Lyubarsky, Granot, Ramierz-Ruiz	CfA, CfA, NRAO, USouth, JIVE, MSFC, UAM, USyd/ATNF, BGU, BGU, UStan, IAS	The late-time evolution of the radio afterglow of SGR 1806-20	C1457	24
Maccarone, Wijnands, Miller-Jones, Zezas, Fender, Tzioumis	UAm, UAm, UAm, CfA, USouth, ATNF	Simultaneous radio/X-ray monitoring of bright X-ray sources in NGC 253	C1458	60
Gaensler, Gelfand, Slane, Camilo, Green, Hughes, Patel	CfA, CfA, CfA, UClmba, USyd, URtug, USRA	Radio imaging of two X-ray identified pulsar wind nebula candidates	C1459	37.5
Cerrigone, Umana, Trigilio, Hora	UCat, OCat, IRA-CNR-Noto, CfA	Comparing infrared and radio properties of planetary nebulae	C1460a	26
Parise, Ceccarelli, Menten, Schilke, Henkel	MPIfR, CRAL, MPIfR, MPIfR, MPIfR,	Deuteration of methanol in IRAS16293–2422	C1461	18
Cohen, Caswell, Burton, Chysostomou plus 16 others	JBO, ATNF, UNSW, UHerts	Accurate positions of methanol masers from the MMB survey	C1462	26
Xu, Menten, Reid, Hachisuka	MPIfR, MPIfR, SAO, MPIfR	Determine absolute positions of 6.7 GHz methanol masers	C1463	10
Henkel, Whiteoak, Staveley-Smith, Ott, Darling	MPIfR, ATNF, ATNF, ATNF, CarO	A 5 and 6 cm OH survey of megamaser galaxies	C1464	36
Ramsay, Saxton, Wu	MSSL, MSSL, MSSL	Magnetic interaction between Gliese 876 and its innermost super-terrestrial planet	C1465	40
Voronkov, Ellingsen, Sobolev, Ostrovskii, Caswell	ATNF, UTas, USU, USU, ATNF	Search for 9.9 GHz methanol masers	C1466	55.5
Romani, Sadler, Ricci, Healey, Murphy	UStan, USyd, ATNF, UStan, USyd	GLAST blazars: completing the southern radio IDs	C1468	45
Dickey, Ellingsen, Churchwell	UTas, UTas, UWis	Ammonia mapping of infrared dark clouds	C1469	42
Ford, McClure-Griffiths, Gibson	Swinb/ATNF, ATNF, Swinb	Determining the detailed structure of HI cloudlets	C1470	96

Lenc, Tingay, Dahlem	Swinb/ATNF, Swinb, ATNF	ATCA 12mm follow-up observations of compact radio sources in local starbursts	C1471	24
Brooks, Smith, Koribalski, Garay	ATNF, CASA, ATNF, UChi	A search for ammonia towards the Keyhole nebula	C1472	16
Ryder, Weiler, Sadler, Stockdale, Van Dyk, Panagia	AAO, NRL, USyd, UMarq, SSC, STScI	NAPA Observations of core-collapse supernovae	C1473	
Jones, Protheroe, Ekers, Newton-McGee, Brooks	UAd, UAd, ATNF, USyd/ATNF, ATNF	Synchrotron radiation from secondary e-/e+ in molecular clouds	C1474	24
Gallo, Fender, Belloni, Tzioumis	UCSB, USouth, OABrera, ATNF	NAPA testing the unified model for X-ray binary jets	C1475	
Brooks, Garay, Madones	ATNF, UChi, UChi	Hot ammonia towards 18 massive star-forming regions	C1476	48
Miyazaki, Shen, Fletcher, Sault, Miyoshi, Tsutsumi, Tsuboi, Zhao	SHAO, SHAO, SHAO, ATNF, NAOJ, NAOJ, NRO, CfA	Monitoring IDV in Sgr A* with the ATCA at its shortest wavelength 3-mm	C1477	49.5
Sadler, Mauch, Canvin	USyd, USyd, USyd	The ages and lifetimes of radio galaxies	C1478	30.5
Meyer, Webster, Wong, Meurer, Hanish	STScI, UMelb, UMelb, JHU, JHU	Measuring the local star formation rate with SINGG Galaxies	C1480	36
Haverkorn, Bock, Gaensler, De Laney, McClure-Griffiths, Sault, Green	CfA, Caltech, CfA, CfA, ATNF, ATNF, USyd	Magnetic field strength and structure in the Vela SNR	C1481	108
McDonnell, Vaughan, Wardle	UMac, UMac, UMac	A search for 6049 MHz OH masers in supernova remnants	C1482	26
Hughes, Wong, McClure-Griffiths, Kawamura, Maddison	Swinb, UNSW/ATNF, ATNF, UNag, Swinb	A study of the neutral gas in Ara OB1	C1483	36
Patience	Caltech	ATCA observations of disks in infrared companion systems	C1484	36
Kepley, Wilcots, Zweibel	UWis, UWis, UWis	Magnetic fields in dwarf irregular galaxies	C1485	48
Schreyer, Neuhauser, Wuchterl, Guenther, Tachihara	AIU-Jena, AIU-Jen, AIU-Jena, TLS, UKobe	Chasing the disk of GQ Lupi A, B	C1486	20
Dettmar, Heesen, Dahlem, Soida	AIUB, AIUB, ATNF, UCrac	Cosmic ray propagation and magnetic fields in galactic halos	C1487	120
Muller, Ott	ATNF, ATNF	Probes of dense molecular gas in extreme metallicity environments	C1488	28
Pisano, Wilcots	NRL, UWis	Searching for M31 high-velocity cloud analogs around NGC 2997	C1490	
Macquart, Kedziora-Chudczer, Jauncey, Bennett	NRAO, USyd, ATNF, UDrake,	A sensitive test for diffractive scintillation in two IDV quasars	C1491	27

Caswell	ATNF	Polarisation calibration for OH masers	C1493	6
Voronkov, Ellingsen, Caswell, Koribalski, Nurnberger, Sobolev	ATNF, UTas, ATNF, ATNF, ESO, USU,	Class I methanol masers in NGC 3603	C1496	22.5
Emonts, van der Hulst, Morganti, Oosterloo, Tadhunter, Holt, Sadler	KI, KI, NFRA, NFRA, USheff, USheff, USyd	HI observations to trace the merger-origin of PKS 0313-36	C1497	24
Macquart, Sjouwerman, Marvel	NRAO, NRAO, AAS	Measuring Sgr A*'s Intra-Day Variability at 3mm Using Galactic Centre SiO masers	C1522	80
LaRosa, Lazio, Kassim	Kennesaw SU, NRL, NRL	Polarization of candidate Galactic Center radio filaments	C1524	23.5
Keto, Ho	CfA, CarO	The formation of bound clusters in starbursts	C1526	12
Gaensler, Mao, McClure-Griffiths, Kronberg, Zweibel, Shukurov, Madsen, Haverkorn	CfA, CfA, ATNF, Los Alamos, UWis, UNT, AAO, NRAO/UCB	Unravelling the high-latitude magnetic field of the Milky Way	C1528	123.5
Papadopoulos, Klamer, Lilly, Carollo	ETH, USyd, ETH, ETH	Dressing a 'naked' QSO	C1530	88
Fender, Tzioumis, Uttley	USouth, ATNF, GSFC	Testing black hole unification: simultaneous radio and X-ray observations of NGC 7213	C1532	26.5
Fluke, Johnston-Hollitt, Maddison, Power	Swinb, UTas, Swinb, Swinb	A pilot search for weak gravitational lensing by rich galaxy clusters at 12mm	C1535	42
Beuther, Walsh, Thorwirth, Menten, Zhang, Hunter, Megeath	MPIfR, UNSW, MPIfR, MPIfR, SAO, SAO, SAO	Dust and dense-gas emission in the massive twin cores NGC6334I & I(N)	C1536	24
Morganti, Tadhunter, Dicken, Oosterloo, Saripalli	NFRA, USheff, USheff, NFRA, ATNF	The dominant heating mechanism for the dust in powerful AGN	C1537	96
Rea, Possenti, Burgay, Govoni, Israel, Zane, Turolla, Stella, Mereghetti	SRON, CAO, CAO, IRA-CNR, OARome, MSSL, UPad, OARome, OARome	Searching for radio structures around magnetars	C1538	19.5
Murphy, Green, Ekers, Cohen	USyd, USyd, ATNF, UCB	Compact HII regions and ionisation of the ISM	C1540	24
Muller, Smoker, Keenan	ATNF, QUB, Queens	Sensitive HI spectra through the arms of the SMC	C1543	25.5
Ott, Wong, Staveley-Smith, Henkel, Cunningham, Whiteoak	ATNF, ATNF, ATNF, MPIfR, UNSW, ATNF	Dense gas in the LMC: wide-field mosaicing of the giant star forming region N159	C1544	48
Begum, Chengalur	GMRT, NCRA	A search for low column density gas surrounding a candidate "blow out'' dwarf galaxy	C1545	32
Keto, Wood, Whitney, Churchwell	CfA, USAND, SSI, UWis	Confirmation of Spitzer massive star disks	C1548	12
Horiuchi, Tingay	Swinb, Swinb	A search for parsec-scale jet precession in BL Lac objects with the ATCA	C1549	72

De Buizer, Caswell, Redman, Feldman	Gemini, ATNF, NRCC, NRCC	Mapping outflows in SiO (2-1) from young massive stars with linearly distributed methanol masers	C1553	16
Tarchi, Ott, Henkel, Castangia, Greenhill	INAF-IRA, ATNF, MPIfR, OAC, CfA	Water maser in the starburst galaxy NGC3620: disk or nuclear maser?	C1554	36
Broderick, De Breuck, Hunstead	USyd, ESO, USyd	High resolution polarimetric imaging of PKS 0529-549: A pilot study at 12 mm	C1555	12
Protheroe, Jones, Johnston, Green, Ekers, Crocker, Reinfrank	UAd, UAd, ATNF, USyd, ATNF, UAd, UAd/ATNF	'Unidentified HESS TeV gamma-ray sources: a new galactic population?'	C1557	24
Migliari, Fender, Altamirano, van der Klis, Wijnands	UCSD, USouth, UAm, UAm, UAm	Simultaneous radio/X-ray observations of the neutron star X-ray binary 4U 1820-30 at low X-ray luminosity	C1559	36
Henkel, Ott, Grasshoff	MPIfR, ATNF, EADS	The SiS maser in the late type carbon star IRC+10216	C1560	24
Walsh, Stark, Mohr, Crawford	UNSW, SAO, UIl, UChig	Dark energy from clusters: ATCA preliminaries	C1563	48
Kern, Koribalski, Kilborn, Forbes	Swinb, ATNF, Swinb, Swinb	A closer look into galaxy groups	C1564	70
Henkel, Koribalski, Ott, Cunningham, Whiteoak	MPIfR, ATNF, ATNF, UNSW, AAO	The nuclear disk in Cen A	C1565	54
Friesen, Johnstone, Di Francesco	UVIC, NRCC, NRCC	Contrasting the chemical and physical evolution of isolated and clustered pre-protostellar cores	C1566	22
Greenhill, Johnston-Hollitt, Wijnands, Giles, Galloway, Bessell, Klein-Wolt	UTas, UTas, UAm, UTas, UMelb, ANU, UAm	Radio frequency monitoring of millisecond X-ray pulsars following a thermonuclear X-ray burst	C1567	
Smith, Lommen, Wright, Lawson, van Dishoeck	ADFA, LO, ADFA, ADFA, LO	Dynamics of molecular outflows from young stars	C1568	15
Kedziora-Chudczer, Macquart, Bignall, Ellingsen, Jauncey, Senkbeil, Ojha, Cimo, McCallum	USyd, NRAO, JIVE, UTas, ATNF, UTas, ATNF, UTas, UTas	The microarcsecond structure and evolution of PKS 0405-385	C1574	132
Schoeier, Wong, Ramstedt, Olofsson	StO, ATNF, StO, OSO	Oxygen chemistry in carbon stars and S-stars	C1575	24
Lopez-Sanchez, Koribalski, Araya, Hibbard	IAC, ATNF, IAC, NRAO	HI observations of two starburst galaxies in probable interaction	C1577	22.5
Menten, Ott, Hieret, Thorwirth, Schilke, Belloche, Leurini, Comito, Mueller	MPIfR, ATNF, MPIfR, MPIfR, MPIfR, MPIfR, MPIfR, MPIfR, MPIfR	The identification of interstellar amino-acetonitrile	C1579	27
Bains, Cohen, Cunningham, Burton, Hutawarakorn-Kramer, Richards	UNSW, JBO, UNSW, UNSW, NARI, Thailand, JBO	Imaging the HII regions in the G333 cloud	C1580	48
Tarchi, Ott, Henkel	INAF-IRA, ATNF, MPIfR	A search for water maser emision in Centaurus A: the nearest active radio galaxy.	C1581	6

Bains, Cunningham, Burton, Richards	UNSW, UNSW, UNSW, JBO	High resolution imaging of bipolar molecular outflows in the G333 cloud	C1583	40
Linz, Klein, Henning, Launhardt, Looney	MPIfR, MPE, MPIfR, UII	The earliest stages of massive star formation - exploiting the ATCA-Spitzer synergy	C1587	27
Wyrowski, Menten, Schilke, Thorwirth, Bergman	MPIfR, MPIfR, MPIfR, MPIfR, ESO	Zooming into the remarkable southern hot core G327.3-0.6 and its environs	C1588	10

Observations made with the Mopra Telescope October 2005 to September 2006

Observers	Affliations	Program	Number	Hours
Wong, Fukui, Wright, Bourke, Ladd, Thomas, Onishi, Hayashi	ATNF, UNag, ADFA, SAO, UBUCK, AAS, UNag, UNag	OTF mapping of dense cores in Chamaeleon	M130	55
Muller, Kawamura, Mizuno, Mizuno	ATNF, UNag, UNag, UNag	An expanded study of molecular regions in the Magellanic Bridge	M136	100
Rathborne, Chambers, Jackson, Simon	UBos, UBos, UBos, UKoln	Kinematic distances to southern infrared dark clouds	M153	48
Cunningham, Bains, Wong, Lo, Henkel, Jones, Burton, Ladd, Kramer, Ossenkopf, Mookerjea,	UNSW, UNSW, ATNF, UNSW, MPIfR, ATNF, UNSW, UBuck, KOSMA, UMar, SRON	Investigating massive star formation: The Delta Quadrant Survey	M156	410.5
Hughes, Wong, McClure-Griffiths, Maddison, Kawamura	Swinb, ATNF, ATNF, Swinb, UNag	A ^{13}CO survey of the molecular gas in Ara OB1	M160	154
Barnes, Fukui, Wong, Ladd, Mizuno, Yonekura	USyd, UNag, ATNF, UBuck, UNag, OsPU	CHaMP - A Galactic census of high- and medium-mass protostars	M161	212
Barnes, Bourke, Myers	USyd, SAO SAO	c2d @ Mopra: The evolution of low-mass protostellar cores	M163	273
Ott, Staveley-Smith, Weiss, Henkel	ATNF, ATNF, MPIfR, MPIfR	The ATCA Galactic Center ammonia survey: Single dish follow-up	M164	97
Ott, Hughes, Wong, Staveley-Smith, Weiss, Henkel, Muller, Pineda-Galvez, Klein, Cunningham, Fukui,	ATNF, Swinb, ATNF, ATNF, MPIfR, MPIfR, ATNF, RAIUB, RAIUB, UNSW, UNSW	A 3 mm line survey along the molecular ridge close to 30 Dor in the LMC	M165	119.5
Lada, Rathborne, Alves	CfA, UBos, ESO	A dusty ring in the Coalsack: A dense core caught in the act of formation?	M166	113.5
Walsh, Burton, Beuther, Thorwirth, Chapman, Wardle	UNSW, UNSW, MPIA, MPIfR, ATNF, UMac	Line survey mapping of G305.21 and NGC6334I/I(N)	M167	40
Walsh, Burton, Beuther, Thorwirth, Chapman, Wardle	UNSW, UNSW, MPIA, MPIfR, ATNF, UMac	A 3 mm line survey towards sites of massive star formation	M168	55
Burton, Ott, Cunningham, Walsh, Menten, Schilke, Belloche, Leurini	UNSW, ATNF, UNSW, UNSW, MPIfR, MPIfR, MPIfR, MPIfR	The organic repository in the Central Molecular Zone of the Galaxy	M170	66.0

Rathborne, Chambers, Jackson, Simon	UBos, UBos, UBos, UKoln	Identifying cores within southern infrared dark clouds	M171	72
Sault, Ott	ATNF, ATNF	Mopra SiO maser monitoring	M175	24
Wu, Xue, Wong, Henkel, Guan, Wang	UPek, UPek, ATNF, MPIfR, UPek, CfA	Search for massive pre-stellar cores in MSX infrared dark clouds	M176	30.0
Ramstedt, Schoeier, Maercker, Olofsson	StO, StO, StO, OSO	The mass-loss and chemistry of S-stars	M177	36.0
Butner, Wright, Smith, Charnley, Rodgers, Buckle, Takakuwa	JAC, ADFA, ADFA, NASA-RC, NASA-RC, CL, NAOJ	The chemical state of globules in the southern Coalsack	M180	113.5
Saul, Walsh	UNSW, UNSW	Dense cores in a quiescent cloud: the Coalsack	M181	113.5
Ott, Weiss, Henkel, Pineda Galvez, Klein, Dettmar, Walter	ATNF, MPIfR, MPIfR, RAIUB, RAIUB, AIR, MPIA	Wide-field mapping of molecular gas in southern starburst galaxies	M182	144.0
Lo, Bains, Wong, Cunningham, Burton	UNSW, UNSW, ATNF, UNSW, UNSW	Stellar outflows in G333 GMC	M184	66.0
Muller, Hughes, Wong, Ott, Kawamura, Mizuno, Mizuno	ATNF, Swinb, ATNF, ATNF, UNag, UNag, UNag	Uncovering the extended molecular cloud population in the SMC	M186	87.5
Dawson, Hughes, McClure-Griffiths, Fukui, Brooks	UNag, Swinb, ATNF, UNag, ATNF	Triggered star formation in the Carina flare supershell: molecular cloud mapping and the search for dense molecular cores	M187	88
de Rijcke, Buyle, Michielsen, Pisano, Freeman, Dejonghe	UGent, UGent, UNOTT, NRL, ANU, UGent	The dense and diffuse molecular gas content of E+A galaxies	M188	89.0
Purcell, Voronkov, Hoare, Moore, Urquhart, Lumsden, Oudmaijer	UNSW, ATNF, ULeeds, LivJMU, ULeeds, ULeeds, ULeeds	The chemical evolution of massive young stellar objects	M190	144
Kawase, McClure-Griffiths, Fukui, Muller, Mizuno	UNag, ATNF, UNag, ATNF, UNag	Molecular clouds in the clouds in the furthest arm in the Milky Way	M191	90

Observations made with the Parkes Telescope October 2005 to September 2006

Observers	Affliations	Program	Number	Hours
Bailes, Ord, Manchester, Verbiest, Bhat, Teoh, Hotan, Kulkarni, Jacoby	Swinb, USyd, ATNF, Swinb, Swinb, Swinb, UTas, Caltech, NRL	Precision pulsar timing	P140	330.8
Han, Manchester, van Straten	NAOBei, ATNF, UTex	Polarization and rotation measures of recently discovered pulsars	P236	72.8
Manchester, Lewis, Sarkissian, Hobbs, Kaspi	ATNF, ATNF, ATNF, ATNF, UMcGill	Timing of young pulsars	P262	79
Manchester, Hobbs, Kramer, Lyne, Faulkner, O'Brien, Stairs, Camilo, D'Amico, Possenti	ATNF, ATNF, JBO, JBO, JBO, JBO, UBC, UClmba, CAO, CAO	Timing of multibeam pulsar discoveries	P276	48.8

Freire, Manchester, Kramer, Lyne, Lorimer, D'Amico, Camilo	AO, ATNF, JBO, JBO, JBO, CAO, UCLMBA	Timing and searching for pulsars in 47 Tucanae	P282	42
Bailes, Ord, Verbiest, Bhat, Hotan	Swinb, USyd, Swinb, Swinb, UTas	Studies of relativistic binary pulsars	P361	205.2
Camilo, Manchester, Gaensler, Lorimer, Ransom	UClmba, ATNF, CfA, JB, NRAO	Deep searches for young and "radio-quiet" pulsars	P396	107.8
Kramer, Manchester, Lyne, O'Brien, McLaughlin	JBO, ATNF, JBO, JBO, JBO	A new class of pulsar-like neutron stars	P417	31
D'Amico, Possenti, Manchester, Sarkissian, Lyne, Corongiu, Camilo	CAO, CAO, ATNF, ATNF, JBO, CAO, UCLMBA	Timing and searching millisecond pulsars in globular clusters	P427	188.7
Johnston, Kramer, Hobbs, Lyne, Weisber	ATNF, JBO, ATNF, JBO, CC	Properties of neutron star kicks	P439	55
Burgay, Possenti, Manchester, Kramer, Lyne, D'Amico, McLaughlin, Camilo, Stairs, Lorimer, Faulkner	CAO, CAO, ATNF, JBO, JBO, CAO, JBO, UCLMBA, UBC, JBO, JBO	Timing & geodetic precession in the double pulsar and two relativistic binaries	P455	116.5
Manchester, Ord, Verbiest, Sarkissian, Hobbs, Edwards, Kesteven, Bailes, Hotan, Teoh, Jenet, van Straten, You, Zhou	ATNF, USyd, Swinb, ATNF, ATNF, ATNF, ATNF, Swinb, UTas, UTex, ATNF, UTex, NAOC, NAOC	A millisecond pulsar timing array	P456	1121
McClure-Griffiths, Pisano, Staveley-Smith, Ford, Kalberla, Dedes, Gibson, Lockman	ATNF, NRL, ATNF, Swinb, UBonn, UBonn, Swinb, NRAO (GB)	GASS: The Galactic all-sky survey	P467	795.2
Camilo, Lorimer, McLaughlin	UClmba, JBO, JBO	Timing "deep multi-beam" pulsars	P471	26.8
Carretti, McConnell, McClure-Griffiths, Bernardi, Cortiglioni, Poppi, Haverkorn	IASF-CNR, ATNF, IASF-CNR, ATNF, IASF-CNR, IRA-CNR, NRAO	Parkes Galactic meridian survey (PGMS) at 2.3 GHz	P472	212.2
Lyne, Possenti, Manchester, Kramer, Hobbs, Lorimer, McLaughlin, Burgay, D'Amico, Camilo, Stairs	JBO, CAO, ATNF, JBO, ATNF, JBO, JBO, CAO, CAO, UBC, UCLMBA	The 'Perseus Arm' multibeam pulsar sruvey	P477	124.8
Titov, Lambeck, Jauncey, Ellingsen, Fey	GSC, ANU, ATNF, UTas, USNO	Improving the terrestrial and celestial reference frame	P483	175
Caswell, Phillips	ATNF, ATNF	Full stokes spectra of and 1667-MHz OH masers in SFRs	P484	50.2
Vranesevic, Manchester	USyd/ATNF, ATNF	What is special about high-latitude pulsars?	P494	39
Wardle, McDonnell, Vaughan	UMac, UMac, UMac	A search for OH 6049 MHz emission towards supernova remnants	P495	41.8
Buyle, Pisano, de Rijcke, Freeman, Dejonghe, Michielsen	UGent, NRL, UGent, ANU, UGent, UNOTT	HI detection in E+A galaxies	P498	224
Kramer, Possenti, Manchester, Lyne, Hobbs, McLaughlin, Burgay, D'Amico, Camilo, Stairs, Lorimer, Faulkner	JBO, CAO, ATNF, JBO, ATNF, JBO, CAO, CAO, UCLMBA, JBO, UBC, JBO	Timing of binary and millisecond PKSMB/PH pulsars	P501	123.8

Cohen, Caswell, Voronkov, McClure-Griffiths, Walsh, Burton, Chrysostomou, Brooks, Cox, Diamond, Ellingsen, Fuller + 8 others	JBO, ATNF, ATNF, ATNF, UNSW, UNSW, UHerts, ATNF, UCardiff, UTas, JBO, UMan	A multibeam survey of the Galaxy for methanol masers	P502	1048.8
Kilborn, Hau, Bower, Forbes, Balogh, Reda	Swinb, UDur, UDur, Swinb, UWate, Swinb	The search for transforming ellipticals: HI content	P503	44.8
Ord, Johnston	USyd, ATNF	CMa Dwarf Galaxy pulsar survey II	P505	206.5
Possenti, Burgay, Stella, Israel, Di, Salvo, D'Amico, Burderi	CAO, CAO, OARome, OARome, UPale, CAO, CAO	Are the new TeV sources associated with radio pulsars?	P507	63.8
Kilborn, Forbes, Kern, Koribalski, Tingay	Swinb, Swinb, Swinb, ATNF, Swinb	HEDGES: The HI extremely deep galaxy environment survey	P508	46
Camilo, Gaensler, Manchester, Lorimer, Ransom	UCLMBA, CfA, ATNF, JBO, NRAO	PSR J1833-1034, the very young pulsar in SNR G21.5-0.9	P509	53.8
Lorimer, Manchester, Lyne, Cordes	JBO, ATNF, JBO, Cornell	Timing and polarimetry of the relativistic binary pulsar J1906+0746	P510	47.7
McLaughlin, Possenti, Manchester, Kramer, Lyne, O'Brien, Burgay, Lorimer, Camilo, Stairs	JBO, CAO, ATNF, JBO, JBO, JBO, CAO, JBO, UCLMBA, UBC	Further investigations into a new class of radio transients	P511	202.8
Johnston, Possenti, Manchester, Kramer, Lyne, O'Brien, Hobbs, Edwards, Burgay, D'Amico, Lorimer, McLaughlin	ATNF, CAO, ATNF, JBO, JBO, JBO, ATNF, ATNF, CAO, JBO, CAO, JBO	A methanol multibeam pulsar survey	P512	640
Johnston, Ord, Manchester, Kramer, Edwards, Karastergiou, Mitra, Gupta	ATNF, USyd, ATNF, JBO, ATNF, IRAM, NCRA, NCRA	A census of pulsar emission	P535	171
Burgay, Possenti, Rea, McLaughlin, Israel, Turolla, Popov, Zane	CAO, CAO, SRON, JBO, OARome, UPad, StAI, UCL	Searching bursting radio emission from X-ray dim isolated neutron stars	P536	22.5
Koribalski, Staveley-Smith, Mader	ATNF, ATNF, ATNF	The most HI-massive galaxies	P538	37

VLBI Observations October 2005 to September 2006

Observers	Affliations	Program	Number	Hours
Ojha, Tzioumis, Ellingsen, Reynolds, Jauncey, Fey, Johnston, Dickey, Nicolson, Quick, Takahashi, Koyama	ATNF, ATNF, UTas, ATNF, ATNF, USNO, USNO, UTas, HartRAO, CRL, HartRAO, NIICT	Astrometry/imaging of southern hemisphere ICRF sources	V131	72

Lenc, Tingay, Tzioumis	Swin, Swinb, ATNF	A high resolution, high sensitivity, wide field study of jet interactions and starburst galaxies	V181	24
Dodson, Edwards,	OANMad, ISA	LBA observations of the the complicated AGN source J0743-67	V182	12
Hirabayashi, Edwards, Dodson, Lovell, Tzioumis, Jauncey, Tingay, Horiuchi, Ellingsen	ISAS, ISAS, ISAS, ATNF, ATNF, ATNF, Swinb, Swinb, UTas	Imaging the remaining VSOP 5-GHz survey sources	V183	24
Horiuchi, Tingay, West	Swinb, Swinb, Swinb	Highly polarized water maser in Orion-KL	V184	10
Godfrey, Lovell, Jauncey, Ojha, Bicknell, Schwartz, Marshall, Gelbord, Worrall	RSAA, ATNF, ATNF, ATNF, RSAA, CfA, MIT, MIT, UBr	High angular resolution imaging of PKS 1421-90	V185	12
Ojha	ATNF	Investigation of polarimetry with the LBA	V187	48
Lenc, Tingay	Swinb, Swinb	VLBI monitoring of supernova remnants in NGC 253: determining the supernova rate	V188	12
Deller, Reynolds, Tingay, Bailes, Bhat,	Swinb, ATNF, Swinb, Swinb, Swinb	VLBI parallaxes of important Southern Hemisphere pulsars	V190	50
Benaglia, Koribalski, Tzioumis, Phillips, Dougherty	IAR, ATNF, ATNF, ATNF, DRAO	The wind-collision region of HD 93129A from LBA observations	V191	6
Norris, Middelberg, Phillips, Cornwell, Appleton	ATNF, ATNF, ATNF, ATNF, Caltech	VLBI observations of radio-excess Sources in the CDFS/GOODS fields	V193	12
Edwards, Bignall, Ojha, Piner	ISA, JIVE, ATNF, WHC	The jet speed of the TeV source PKS 2005-489	V194	12
Bains, Caswell, Cohen, Cunningham, Burton, Hutawarakorn Kramer, Richards	UNSW, ATNF, JBO, UNSW, UNSW, NARI, JBO	Masers, magnetic fields and outflows in the G333 molecular cloud	V195	12

E: Affiliations

AAO	Anglo-Australian Observatory, Australia
AAR	Aarhus University, Denmark
AAS	American Astronomical Society, United States
AAT	Anglo-Australian Telescope, Australia
Acretri	Acretri Observatory, Italy
ADFA	Australian Defence Force Academy, Australia
AIPr	Astronomical Institute Prague, Czech Republic
AIR	Astronomical Institure, Ruhr University, Germany
AITub	Insititute of Astronomy, University of Tubingen, Germany
ANU	Australia National University, Australia
AO	Arecibo Observatory, United States
AOA	Osservatorio di Asiago, Italy
AOAR	Osservatorio Astrofisico di Arleti, Italy
AOK	Astronomical Observatory Kiev, Ukraine
AOUpp	Astronomiska Observatoreit, Uppsala, Sweden
ArO	Armagh Observatory, United Kingdom
ASC	Astrospace Centre, Russian Federation
ASCOTT	Agnes Scott College, United States
ASCR	Academy of Sciences of Czech Republic, Czech Republic
ASI/SAX	Agencia Spaziale Italiana/Satellite per Astronomia X, Italy
ASIAA	Academia Sinica Institute of Astronomy & Astrophysics, Taiwan
ASU	Arizona State University, United States
ATNF	Australia Telescope National Facility, Australia
BAO	Beijing Astronomical Observatory, China
BIMA	Berkeley-Illinois-Maryland Association, United States
BMGS	Blue Mountains Grammar School, Australia
BoeingSS	Boeing Satellite Systems, United States
BrU	Brandeis University, United States
Caltech	California Institute of Technology, United States
CAO	Cagliari Astronomical Observatory, Italy
CARMA	Combined Array for Research in Millimeter-wave Astronomy, United States
CarO	Carnegie Observatories, United States
CASA	Center for Astrophysics and Space Astronomy, University of Colorado, United States
CASS	Center for Astrophysics & Space Sciences, United States
CC	Carleton College, United States
CDSCC	Canberra Deep Space Communications Complex, Australia
CEA	Centre d'Etudes d'Astrophysique, Saclay, France
CEN	Centre d'Etudes Nucleaires, France
CESR	Centre d'Etude Spatiale des Rayonnements, France
CfA	Harvard-Smithsonian Center for Astrophysics, United States
Chiba	University of Chiba, Japan
CHIBAU	Chiba University, Japan
CINECA	Consorzio Interuniversitario per il Calcolo Automatico dell'Italia Nord Orientale, Italy
CITNZ	Central Institute of Technology, New Zealand
CL	Cavendish Laboratories, United Kingdom
CLancsCfA	University of Central Lancashire Centre for Astrophysics, United Kingdom
CNR	Consiglio Nazionale delle Ricerche, Italy
CO	Carter Observatory, New Zealand
Cornell	Cornell University, United States
COSSA	CSIRO Office of Space Science & Applications, Australia
CRAAE	Centro de Radio-Astronomia e Aplicacoes Espaciais, Brazil
CRAL	Centre de Recherche Astronomique de Lyon, France
CrimeaAO	Crimean Astrophysical Observatory, Ukraine
CRL	Communications Research Laboratory, Japan
CSCLtd	Computer & Science Co. Ltd, United Kingdom
CSR	Center for Space Research, United States
DABol	Department of Astronomy, University of Bologna, Italy
DAEC	Departement d'Astrophysique Extragalactique et de Cosmologie, France
DEMIRM	Departement d'Etudes de la Matiere interstellaire en InfraRouge et Millimetrique l'Observatoire de Paris, France
DRAO	Dominion Radio Astrophysical Observatory, Canada
ESA	European Space Agency, Villafranca, Spain
ESO	European Southern Observatory, Germany
ESTEC	ESTEC Astrophysics Division, Netherlands
ESTEC/ESA	European Space Technology & Research Centre, Netherlands
ETH	Swiss Federal Institute of Technology, Switzerland
Eureka	Eureka Scientific, United States
Ferm	Fermi National Accelerator Laboratory,
FURG	Fundacao Universidade Federal do Rio Grande, Brazil
GBT	Green Bank Telescope, United States
GMRT	Giant Metrewave Radio Telescope, India
GMU	George Mason University, United States
Gray	Gray Consulting, United States
GSC	Geoscience Australia, Australia
GSFC	Goddard Space Flight Center, United States
GUANU	Guangzhou University, China
GUASJ	Graduate University for Advanced Studies, Japan
HartRAO	Hartebeesthoek Radio Astronomical Observatory, South Africa
Harvard	Harvard University, United States
HatCreek	Hat Creek Radio Observatory, United States
Haverford	Haverford College, United States
HUOT	Helsinki University of Technology, Finland
IAC	Instituto de Astrofisica de Canarias, Spain
IAFE	Instituto d'Astronomia y Fisica del Espacio, Argentina
IAG	Instituto Astronomico e Geofisico, Brazil
IAI	Institute of Astrophysics, University of Innsbruck , Austria
IAP	Institute d'Astrophysique Paris, France
IAR	Instituto Argentino de Radioastronomica, Argentina
IAS-CNR	Istituto di Astrofisica Spaziale - Consiglio Nazionale delle Ricerche, Italy
IASF-CNR	Istituto di Astrofisica Spaziale e Fisica Cosmica - Consiglio Nazionale delle Ricerche, Italy
IASp	Institut d'Astrophysique Spatiale, France
IBARU	Ibaraki University, Japan
IFCTR	Instituto de Fisica Cosmica - CNR, Italy
IFM	Instituto di Fisica, Milan, Italy
IF-UFRGS	Instituto de Fisica - Universidade Federal do Rio Grande do Sul , Brazil
IGPP	Institute of Geophysics and Planetary Physics, United States
ImCol	Imperial College London, United Kingdom
INAF	Istituto di Radioastronomia , Italy

INAOE	Instituto Nacional de Astrofisica, Optica y Electronica, Mexico
INGT	Isaac Newton Grooup of Telescopes, Roque de los Muchachos Observatory, Spain
INPE	Instituto Nacional de Pesquisas Espaciais, Brazil
IoA	Institute of Astronomy, United Kingdom
IPAC	IPAC, Caltech, United States
IRAM-F	IRAM France, France
IRAM-S	IRAM Spain, Spain
ISAS	ISAS Japan, Japan
ISTS	Institute for Space and Terrestrial Science, Canada
ISU	Iowa State University, United States
IUE	International Ultraviolet Explorer, Spain
JAC	Joint Astronomy Centre, Hilo, United States
JBO	Jodrell Bank Observatory, United Kingdom
JCU	James Cook University, Australia
JHU	John Hopkins University, United States
JILA	JILA, University of Colorado, United States
JIVE	Joint Institute for Very Long Baseline Interferometry in Europe, Netherlands
JPL	Jet Propulsion Laboratory, United States
KennesawSU	Kennesaw State Uni, United States
KI	Kapteyn Institute, Netherlands
KPNO	Kitt Peak National Observatory, United States
LADM	Laboratoire d'Astrophysique de Marseille, France
LANL	Los Alamos National Laboratory, United States
LivJMU	Liverpool John Moores University, United Kingdom
LLNL	Lawrence Livermore National Laboratory, United States
LMCorp	Lockeed Martin Corp., United States
LO	Leiden Observatory, Netherlands
LSU	Louisiana State University, United States
LSW	Landessternwahrte Heidelberg, Germany
LTU	La Trobe University, Australia
MERLIN	Multi-element Radio Linked Interferometry Network, United Kingdom
MIT	Massachusetts Institute of Technology, United States
Monash	Monash University, Australia
MPE	Max Planck Inst. fuer Extraterrestrische Physik, Germany
MPIA	Max Planck Inst. fuer Astrophysik, Heidelberg, Germany
MPIfA	Max Planck Inst. fuer Astrophysik, Garching, Germany
MPIfR	Max Planck Inst. fuer Radioastronomie, Bonn, Germany
MRAO	Mullard Radio Astronomical Observatory, United Kingdom
MSFC	Marshall Space Flight Center, United States
MSSL	Mullard Space Science Laboratory, UCL, United Kingdom
MSSSO	Mount Stromlo and Siding Spring Observatories, Australia
MSU	Michigan State University, United States
MUC	Mount Union College, United States
NAIC	National Astronomy and Ionosphere Centre, United States
NAOBei	National Astronomical Observatories, Beijing, China
NAOJ	National Astronomical Observatory, Japan
NASA	National Aeronautics and Space Administration, United States
NASA-RC	NASA Ames Research Center, United States
NCAC	Nicolaus Copernicus Astronomical Center, Poland
NCRA	National Centre for Radio Astrophysics, India
NCSA	National Center for Supercomputing Applications, United States
NCSU	North Carolina State University, United States
NEROC	Northeast Radio Observatory Corporation, United States
NFRA	Netherlands Foundation for Research in Astronomy, Netherlands
NIPR	National Institute for Polar Research, Japan
NIRFI	Radiophysical Research Institute, Russian Federation
NMIMT	New Mexico Institute of Mining and Technology, United States
NOAO	National Optical Astronomical Observatory, United States
NRAL	Nuffield Radio Astronomy Laboratories, United Kingdom
NRAO (VLA)	National Radio Astronomy Observatory, Very Large Array, United States
NRAO	National Radio Astronomy Observatory, United States
NRCC	National Research Council, Canada
NRL	Naval Research Laboratories, United States
NRO	Nobeyama Radio Observatory, Japan
NWU	Northwestern University, United States
OAAI	Osservatorio Astrofisico di Arcetri, Italy
OABol	Osservatorio Astronomico di Bologna, Italy
OABrera	Osservatorio Astronomico di Brera, Italy
OAC	Osservatorio Astronomico di Capodimonte, Italy
OANMad	Observatorio Astronomico Nacional, Madrid, Spain
OARome	Osservatorio Astronomico di Roma, Italy
OAT	Osservatorio Astronomico di Trieste, Italy
OAzur	Observatoire de la Cote d'Azur,, France
Oberlin	Oberlin College Observatory, United States
OBordeaux	Observatoire de Bordeaux, France
OGR	Observatoire de Grenoble, France
OhioSU	Ohio State University, United States
OHP	Observatoire de Haute Provence, France
OMs	Observatorire de Marseille, France
ON	Observatorio Nacional, Brazil
Open	Open University, United Kingdom
OPM	Observatoire de Paris, Meudon, France
OSO	Onsala Space Observatory, Sweden
OsPU	Osaka Prefecture University, Japan
PLab	Phillips Lab, United States
PMO	Purple Mountain Observatory, China
PNL	P.N. Lebedev Physics Institute, Russian Federation
PSCHI	Paul Scherrer Institute, Switzerland
PSI	Planetary Science Institute, United States
PSU	Pennsylvania State University, United States
PUCC	Pontificia Universidad Catolica de Chile, Chile
QMW	Queen Mary and Westfield College, United Kingdom
QUB	Queens University Belfast, United Kingdom
Queens	Queens University, Canada
RAIUB	Radio Astronomy Institute, University of Bonn, Germany
RAS	Russian Academy of Sciences, Russian Federation
RGO	Royal Greenwich Observatory, United Kingdom
RMC	Royal Military College, Canada
RMIT	Royal Melbourne Institute of Technology, Australia
ROB	Royal Observatory of Belgium, Belgium

RochI	Rochester Institute of Technology, United States
ROE	Royal Observatory Edinburgh, United Kingdom
RRI	Raman Research Institute, India
RSAA	Research School of Astronomy & Astrophysics, Australia
SAAO	South African Astronomical Observatory, South Africa
SAO	Smithsonian Astrophysical Observatory, United States
SCU	Southern Cross University, Australia
SDSU	San Diego State University, United States
SDSU	San Diego State University, United States
SETI	SETI Institute, United States
SHAO	Shangai Astronomical Observatory, China
SISSA	Scuola Internazionale Superiore di Studi Avanzati, Trieste, Italy
SNATU	Seoul National University, Republic of Korea
SOGB	Sterrenkundig Observatorium, Universiteit Gent, Belgium
SRON	Space Research Organization Netherlands, Netherlands
StAI	Sternberg Astronomical Institute, Russian Federation
StBr	Stony Brook University, United States
ST-ECF	Space Telescope European Coordination Facility, United States
StO	Stockholm Observatory, Sweden
StrasbO	Observatoire astronomique de Strasbourg, France
STScI	Space Telescope Science Institute, United States
Swinb	Swinburne University of Technology, Australia
TCfA	Torun Centre for Astronomy of the Nicholas Copernicus University, Poland
TGU	Tokyo Gakugei University, Japan
TIFR	Tata Institute for Radio Astronomy, India
TITECH	Tokyo Institute of Technology, Japan
UAd	University of Adelaide, Australia
UAl	University of Alabama, United States
UAm	University of Amsterdam, Netherlands
UAO	Urumqi Observatory, China
UAz	University of Arizona, United States
UB	University of Basel, Switzerland
UBARC	University of Barcelona, Spain
UBC	University of British Colombia, Canada
UBir	University of Birmingham, United Kingdom
UBol	University of Bologna, Italy
UBonn	University of Bonn, Germany
UBORD	University of Bordeaux, France
UBos	Boston University, United States
UBr	University of Bristol, United Kingdom
UBuck	Bucknell University, United States
UCal	University of Calgary, Canada
UCam	Cambridge University, United Kingdom
UCant	University of Cantabria, Spain
UCardiff	Universiy of Cardiff, United Kingdom
UCat	University of Catania, Italy
UCB	University of California, Berkeley, United States
UCha	University of Champagne-Urbana, United States
UChi	University of Chile, Chile
UChig	University of Chicago, United States
UCL	University College London, United Kingdom
UCLA	University of California, Los Angeles, United States
UCLANCS	University of Central Lancashire, United Kingdom
UClmba	Columbia University, United States
UCLO	University of California Lick Observatory, United States
UCol	University of Colorado, United States
UCOP	University of Copenhagen, Denmark
UCSB	University of California, Santa Barbara, United States
UCSC	University of California, Santa Cruz, United States
UCSD	University of California, San Diego, United States
UCT	University of Cape Town, South Africa
UCurt	Curtin University, Australia
UDart	Dartmouth College, United States
UDrake	Drake University, United States
UDur	University of Durham, United Kingdom
UEdin	University of Edinburgh, United Kingdom
UEot	Eotvos Lorand University, Hungary
UFLOR	University of Florida, United States
UFRGS	Instituto de Fisica - Universidade Federal do Rio Grande do Sul , Brazil
UFurman	Furman University, United States
UGEN	University of Geneva, Switzerland
UGent	Universiteit Gent, Belgium
UGuan	Universidad de Guanajuato, Mexico
UHam	Universitaet Hamburg, Germany
UHawaii	University of Hawaii, United States
UHeid	Ruprecht-Karls-Universitaet Heidelberg, Germany
UHel	University of Helsinki, Finland
UHerts	University of Hertfordshire, United Kingdom
UHilo	University of Hilo, United States
UHK	University of Hong Kong, Hong Kong
UIl	University of Illinois, United States
UJAEN	University of Jaen, Spain
UKan	University of Kansas, United States
UKC	University of Kent, Canterbury, United Kingdom
UKeele	Keele University, United Kingdom
UKEELE	University of Keele, United Kingdom
UKent	University of Kentucky, United States
UKiel	Christian-Albrechts-Universitaet zu Kiel, Germany
UKiev	National University of Kiev, Ukraine
UKOBE	Kobe University, Japan
UKOELN	University of Koeln, Germany
UKok	Kokugakuin University, Japan
UKST	United Kingdom Schmidt Telescope, Australia
UKT	Kyushu Tokai University, Japan
UKyoto	University of Kyoto, Japan
ULav	Universite Laval, Canada
ULeeds	University of Leeds, United Kingdom
ULeic	University of Leicester, United Kingdom
ULeid	Rijksuniversiteit Leiden, Netherlands
ULiege	University of Liege, Belgium
UMac	Macquarie University, Australia
UMadrid	University of Madrid, Spain
UMan	University of Manchester, United Kingdom
UManit	University of Manitoba, Canada
UMar	University of Maryland, United States
UMass	University of Massachusetts, United States
UMaur	University of Mauritius, Mauritius
UMcGill	McGill University, Canada
UMelb	University of Melbourne, Australia
UMich	University of Michigan, United States
UMila	Universita degli Studi di Milano, Italy
UMILAN	University of Milan, Italy

UMinn	University of Minnesota, United States
UMIST	University of Manchester, Insitute of Science and Technology, United Kingdom
UMont	University of Montreal, Canada
UNag	Nagoya University, Japan
UNAM	Universidad Nacional Automa de Mexico, Mexico
UNC	The University of North Carolina at Chapel Hill, United States
UNHam	University of New Hampshire, United States
UNM	University of New Mexico, United States
UNOTT	University of Nottingham, United Kingdom
UNSW	University of New South Wales, Australia
UNT	University of Newcastle upon Tyne, United Kingdom
UOkayama	Okayama University, Japan
UOx	University of Oxford, United Kingdom
UPad	University of Padova, Italy
UPal	Universita degli Studi di Palermo, Italy
UParis7	Universite de Paris 7 - Denis Diderot, France
UPek	Peking University, China
UPitt	University of Pittsburgh, United States
UPot	Potchefstroom University for CHE, South Africa
UPPOB	Uppsala Observatory, Sweden
UPrince	Princeton University, United States
UPuert	University of Puerto Rico, Puerto Rico
UPune	University of Pune, India
UQld	University of Queensland, Australia
URh	University of Rhodes, South Africa
URice	Rice University, United States
URuh	Ruhr-Universitaet, Germany
URuhr	Ruhr-Universitaet Bochum, Germany
URutg	Rutgers University, United States
USAND	University of St Andrews, United Kingdom
USC	University of the Sunshine Coast, Australia
USheff	University of Sheffield, United Kingdom
USMF	Santa Maria Federal University, Brazil
USNA	US Naval Academy, United States
USNO	US Naval Observatory, United States
USouth	University of Southampton, United Kingdom
USP	Universidade de Sao Paulo, Brazil
USQld	University of Southern Queensland, Australia
USR	Universita degli Studi ‘Roma Tre’, Italy
UStan	Stanford University, United States
UStern	Sternwarte University, Germany
USU	Ural State University, Russian Federation
USuss	University of Sussex, United Kingdom
USyd	University of Sydney, Australia
UTamk	Tamkang University, Taiwan
UTas	University of Tasmania, Australia
UTex	University of Texas, United States
UTOKYO	University of Tokyo, Japan
UTor	University of Toronto, Canada
UTS	University of Technology, Sydney, Australia
UUtrecht	Universiteit Utrecht, Netherlands
UVa	University of Vermont, United States
UVal	Universitat de Valencia, Spain
UVIC	University of Victoria, Canada
UVir	University of Virginia, United States
UW	University of Wales, United Kingdom
UWA	University of Western Australia, Australia
UWash	University of Washington, United States
UWATER	University of Waterloo, Canada
UWien	Universitaet Wien, Austria
UWis	University of Wisconsin, United States
UWol	University of Wollongong, Australia
UWS	University of Western Sydney, Australia
UWS	University of Western Sydney, Nepean, Australia
UYonsei	Yonsei University, Republic of Korea
WHC	Whittier College, United States
WVU	West Virginia University, United States
WVU	West Virginia University, United States
Yale	Yale University, United States
YO	Yunnan Observatory, China
YU	York University, Canada

F: CSIRO ATNF media releases, 2006

Parkes telescope finds new kind of cosmic object	16 February 2006
CSIRO scientists elected to Australian Academy of Science	24 March 2006
Parkes finds unexpected heartbeats in a star	24 August 2006
General relativity survives grueling pulsar test	15 September 2006
Australia, South Africa short-listed for giant telescope	28 September 2006
ATNF astronomers wins 2006 Malcolm Macintosh prize	16 October 2006
Parkes gears up for another 45 years	29 November 2006

CSIRO ATNF media releases are available at www.csiro.au/csiro/channel/ichd.html

G: 2006 Publications

Papers using ATNF data, published in refereed journals

Papers which include ATNF authors are indicated by an asterisk:
C = Compact Array data, M = Mopra data, P = Parkes data, T = Tidbinbilla data, V = VLBI data.

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H. Postgraduate students co-supervised by the ATNF

As of December 2006

Bonne, N., "Investigating the dark and visible matter in the local volume", Australian National University

Bukilic, N., "Extremely wide bandwidth focal plane array receivers for radio astronomy", Curtin University of Technology

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Jones, D., "Lunar Ultra high energy neutrino astrophysics using the Square Kilometer Array (LUNASKA) and synchrotron emission from secondary electrons/positrons in Galactic molecular clouds", University of Adelaide

Kirby, E., "Turning the time arrow: an evolutionary history of the local universe", Australian National University

Knight, H., "Baseband searching for millisecond pulsars", Swinburne University

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Lewis, D., "Timing of young pulsars", University of Tasmania

Lo, N., "The Role of Turbulence in Star Formation", University of NSW

Longmore, S., "Uncovering the top end of the initial mass function", University of NSW

Massardi, M., "Observations of the large-scale structure of the universe", SISSA/ISAS Trieste, Italy

Matthews, D., "High velocity clouds around the Galaxy", La Trobe University

McCallum, J., "A Study of H_2O megamasers in AGN", University of Tasmania

McFadden, R., "Lunar Cerenkov detection", University of Melbourne

Newton-McGee, K., "The magnetic universe", University of Sydney

O'Brien, J., "Probing the shape of dark halos of thin edge-on disk galaxies", RSAA, Australian National University

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Senkbeil, C., "A study of the interstellar scintillation and intraday radio variability of active galactic nuclei", University of Tasmania

Verbiest, J., "High precision pulsar timing", Swinburne University

Vranesevic, N., "Galactic distribution and evolution of pulsars", University of Sydney

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You, X., "Pulsar timing studies", Chinese Academy of Sciences (NAOC)

Young, M., "An investigation of pulsar dynamics using improved methods of time series analysis", University of Western Australia

I. Abbreviations

AARNET	Australia's Academic and Research Network
ACA	Australian Communications Authority
ACC	Antenna Control Computer
ACMA	Australian Communications and Media Authority
AEEMA	Australian Electrical and Electronic Manufacturers Association
AGN	Active Galactic Nuclei
ALFA	Arecibo L-band Feed Array
ALMA	Atacama Large Millimetre Array
APT	Asia-Pacific Telescope
ARC	Australian Research Council
ASKACC	Australian SKA Consortium Committee
ATCA	Australia Telescope Compact Array
ATNF	Australia Telescope National Facility
ATLAS	ATNF Large Area Survey
ATOA	Australia Telescope Online Archive
ATUC	Australia Telescope Users Committee
AXP	Anomalous X-ray Pulsar
CABB	Compact Array Broadband
CDFS	Chandra Deep Field South
CFG	Computing Facilities Group
CIM&T	CSIRO Information Management and Technology
CIP	CSIRO Industrial Physics
CMOS	Complementary Metal Oxide Semiconductor
CO	Carbon Monoxide
CONRAD	CONvergent Radio Astronomy Demonstrator
COSPAR	Committee on Space Research
CPSR	Caltech-Parkes-Swinburne Recorder
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAS	Data Acquisition System
DEST	Department of Education, Science and Training
DFB	Digital Filter Bank
DOIR	Department of Industry and Resources (WA)
DRAO	Dominion Radio Astrophysical Observatory
DSN	Deep Space Network
ESA	European Space Agency
FITS	Flexible Image Transport System
FPA	Focal Plane Array
FPGA	Field Programmable Gate Array
FTE	Full Time Equivalent
GASS	Galactic All Sky Survey
GBT	Green Bank Telescope
HI	Neutral Hydrogen
HIPASS	HI Parkes All Sky Survey
HIA	Hertzberg Institute for Astrophysics, Canada
IAA	International Academy of Astronautics
IAU	International Astronomical Union
ICIP	Industry Cooperative Innovation Program
ICRF	International Celestial Reference Frame
ICT	Information and Communications Technology
IF	Intermediate Frequency
IFRS	Infrared-Faint Radio Sources
InP	Indium Phosphide
ISM	Interstellar Medium
ISPO	International SKA Project Office
ISSC	International SKA Steering Committee
ITU	International Telecommunications Union
IUCAF	Scientific Committee on the Allocation of Frequencies for Radio Astronomy and Space Sciences

IT	Information Technology
JIVE	Joint Institute for VLBI in Europe
KAT	Karoo Array Telescope
LBA	Long Baseline Array
LFD	Low Frequency Demonstrator
LMC	Large Magellanic Cloud
LNA	Low Noise Amplifier
LO	Local Oscillator
LVHIS	Local Volume HI Survey
MIRA	Mileura International Radio Array
MMIC	Monolithic Microwave Integrated Circuit
MNRF	Major National Research Facilities
MOPS	Mopra Spectrometer
MSP	Millisecond Pulsar
MWA	Miluera Wide field Array
NASA	National Aeronautics and Space Administration
NTD	New Technology Demonstrator
OPAL	Online Proposal Applications and Links
OTF	On The Fly
PCB	Printed Circuit Board
PTF	Parkes Testbed Facility
RAFCAP	Radio Astronomy Frequency Committee in the Asia Pacific Region
RALI	Radiocommunications Assignment and Licensing Agreement
RAS	Radio Astronomy Service
RFI	Radio Frequency Interference
RRAT	Rotating Radio Transient
RQZ	Radio Quiet Zone
SKA	Square Kilometre Array
SMC	Small Magellanic Cloud
SWIRE	Spitzer Wide-area Infrared Extragalactic Survey
TAC	Time Assignment Committee
UPS	Uninterruptible Power Supply
URSI	International Union of Radio Science
VLA	Very Large Array (US)
VLBI	Very Long Baseline Interferometry
VLT	Very Large Telescope (Chile)
WA	Western Australia
WBC	Wideband Correlator
WCS	World Coordinate System
WRC	World Radiocommunication Conference
xNTD	Extended New Technology Demonstrator

A Galah in the Piliga State Forest
Photo: © Barnaby Norris

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