Australia Telescope National Facility

Annual Report 2003

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This is the report of the Steering Committee of the CSIRO Australia Telescope National Facility for the calendar year 2003.

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Cover image: Sunlight on three of the Compact Array antennas
Photo: © David Smyth

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The Parkes radio telescope
Photo: © Shaun Amy

Chair's report

This year was one of many changes for the ATNF, with Professor Ron Ekers stepping down as Director in March 2003 and his successor Professor Brian Boyle (formerly Director of the Anglo-Australian Observatory) arriving in July 2003.

As the Foundation Director, Ron was responsible for shaping the culture of the Australia Telescope as a national research facility for Australian and overseas scientists. In this, he has been outstandingly successful; in 2003 the Australia Telescope facilities were used by over 400 scientists from 21 countries, and user feedback indicated an extremely high level of satisfaction with almost every aspect of telescope performance and support. Under Ron's leadership, the ATNF has become recognised as an institution which both inspires and supports excellence while at the same time being inclusive and welcoming to a wide and growing user community. As an example, the ATNF's student program now includes around 30 graduate students from Australian and overseas universities who are co-supervised by ATNF staff members.

The AT Steering Committee thanks Ron for his outstanding efforts as ATNF Director from 1988 to 2003, and wishes him well as he takes on new challenges as President of the International Astronomical Union and as a Federation Fellow. We also acknowledge the efforts of Professor Ray Norris as Acting Director for several months in 2003, and extend a warm welcome to the new Director, Brian Boyle.

2003 was another excellent year for both science and technology at the ATNF. The science highlights included the discovery of the first double pulsar, which will provide important tests for theories of strong-field gravity. The completion of the 12-mm upgrade to the AT Compact Array has opened up a new and very broad (16 – 25 GHz) region of the radio spectrum for both continuum and spectral-line imaging, and the eagerly-awaited full 3-mm system will be available by mid-2004. The ATNF continues to play a leading role in the international Square Kilometre Array (SKA) radio telescope project, both in technology development and in the planned setting up of a radio-quiet zone in a remote region of Australia.

It has been both a privilege and an education to serve on the AT Steering Committee for the past three years. My overwhelming impression is that the ATNF is a healthy and vibrant organisation which is well-positioned for an exciting future.

Dr Elaine Sadler, Acting Chair (April - December 2003),
AT Steering Committee
Photo: © University of Sydney

Director's report

2003 has been a year of great success and new directions for the ATNF. As the incoming Director, I have the pleasure and privilege of taking over the leadership of such a world-class facility. At the core of the ATNF's success is its outstanding staff, the collaborative CSIRO network in which they work, and the strong national and international astronomical community that they support. The achievements wrought by this teamwork are evident for all to see in the pages of this annual report.

Over the past year a number of major upgrades and instrumentation have been delivered to both the Compact Array and the Parkes radio telescope. This includes the 12-mm receiver at the Compact Array, already delivering important new results on molecular gas in star-forming galaxies and providing the highest resolution radio maps of SN 1987A. Two new receivers, the 8-GHz receiver built for NASA and the 10/50-cm receiver designed for pulsar timing, were also successfully commissioned on the Parkes radio telescope. However, it was the by-now venerable multibeam receiver that perhaps produced the most spectacular scientific result of the past year; namely the discovery of the double pulsar. This was a true "breakthrough" discovery that will provide a wealth of information on both pulsar systems and fundamental physics over the coming years.

As exemplified by the Parkes pulsar survey, the international nature of the ATNF's user community is another of its great strengths. Time devoted to programs with an overseas principal applicant remains at a healthy forty per cent. This open access leads to a rich network of international collaborations and knowledge exchange for the Australian community and enables the ATNF to maintain a high profile and impact amongst the world's radio astronomy facilities.

On the international stage, the highly successful IAU 2003 General Assembly in Sydney enabled the ATNF and, more broadly, the Australian community to demonstrate its talents and capabilities. An important factor in this regard was the strong support the General Assembly received from industrial partners such as Connell Wagner. This underscores the need for partnership across all key stake holders; Universities, Industry and Government, if Australian astronomy is to achieve its long-term strategic goals.

One of the key strategic goals is the Square Kilometre Array (SKA). Facilitating the Australian community's engagement in the SKA remains the primary long-term goal of the ATNF. During 2003, Australia continued to re-enforce its position as one of the leading members of the international SKA consortium. Through events such as the SKA meeting in Geraldton, Australia provided key input to the scientific and technical case for a wide-field SKA and was able to showcase the unique qualities of a remote Australian site for SKA. Further related development of SKA technology and infrastructure issues, including capitalising on new broadband-network opportunities within Australia, will remain a major focus of the ATNF's activities during 2004.

Professor Brian Boyle, Director of the ATNF
Photo: © Kristen Clarke

A Compact Array antenna
Photo: © David Smyth

The ATNF in brief

The ATNF supports Australia's research in radio astronomy, one of the major fields of modern astronomy, by operating the Australia Telescope, a set of eight individual radio telescopes.

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.

Size and funding

The ATNF employs approximately 180 staff. In 2002 – 2003 the organisation's total expenditure budget was A$19.8M, of which A$13.6M was direct appropriation from CSIRO.

Status within CSIRO

The ATNF is managed as a National Facility by Australia's largest national research institution, CSIRO. Formerly part of the CSIRO Division of Radiophysics, it became a separate division in January 1989. The Australia Telescope Steering Committee, appointed by the Minister for Science to advise the ATNF Director, also acts as the Advisory Committee for CSIRO's Radio Astronomy Sector.

Status as a National Facility

The ATNF became a National Facility in April 1990. As a National Facility, the Australia Telescope provides world-class observing facilities in radio astronomy for astronomers at Australian and overseas institutions. The Australia Telescope is operated as a National Facility under guidelines originally established by the Australian Science and Technology Council.

Users of ATNF telescopes

Observing time on the ATNF's telescopes is awarded to researchers on the basis of the merits of their proposed research programs by a Time Assignment Committee appointed by the Steering Committee. Approximately 90% of the telescopes' users come from outside the ATNF. In 2003 the proposals allocated time included scientists from 14 institutions in Australia and 120 institutions in 20 other countries.

The ATNF in the Australian context

The ATNF is the largest single astronomical institution in Australia. Approximately 90% of Australian radio astronomy is carried out through the ATNF. The organisation has strong links with its primary user base, the university community. The interests of telescope users are represented by the Australia Telescope Users Committee.

The ATNF's Sydney headquarters are co-located with those of the Anglo-Australian Observatory, an independent bi-National Facility that provides world-class optical and infrared facilities. This close association is unique, in world terms, and promotes valuable collaboration between the two organisations.

The ATNF in the global context

Of the fields of modern astronomy—X-ray, ultraviolet, optical, infrared and radio—Australia makes one of the most significant contributions to world astronomy through radio astronomy. This is a result of Australia's early lead in the field, continuous technological advances, and southern hemisphere location. The Australia Telescope is the only major radio telescope of its kind in the southern hemisphere, and thus can view part of the sky which is out of reach of northern hemisphere telescopes. It provides one of the most powerful radio astronomy facilities in the world.

Australian and international observers use the Australia Telescope without access charges. This is in accordance with a general practice of the worldwide astronomical community, in which telescope users from different countries gain reciprocal access to facilities on the basis of scientific merit. This allows Australian scientists to use telescopes in other countries as well as space-based instruments and other international facilities such as particle accelerators. Such access provides Australian scientists with a diversity of instruments and leads to a rich network of international collaborations.

The ATNF's observatories

The Australia Telescope consists of eight radio-receiving antennas, located at three sites in New South Wales. Six of them make up the Australia Telescope Compact Array, located at the Paul Wild Observatory near the town of Narrabri. Five of these antennas sit on a 3-km stretch of rail track running east–west; they can be moved to different points along the track to build up detailed images of the sky. A sixth antenna lies 3 km 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.

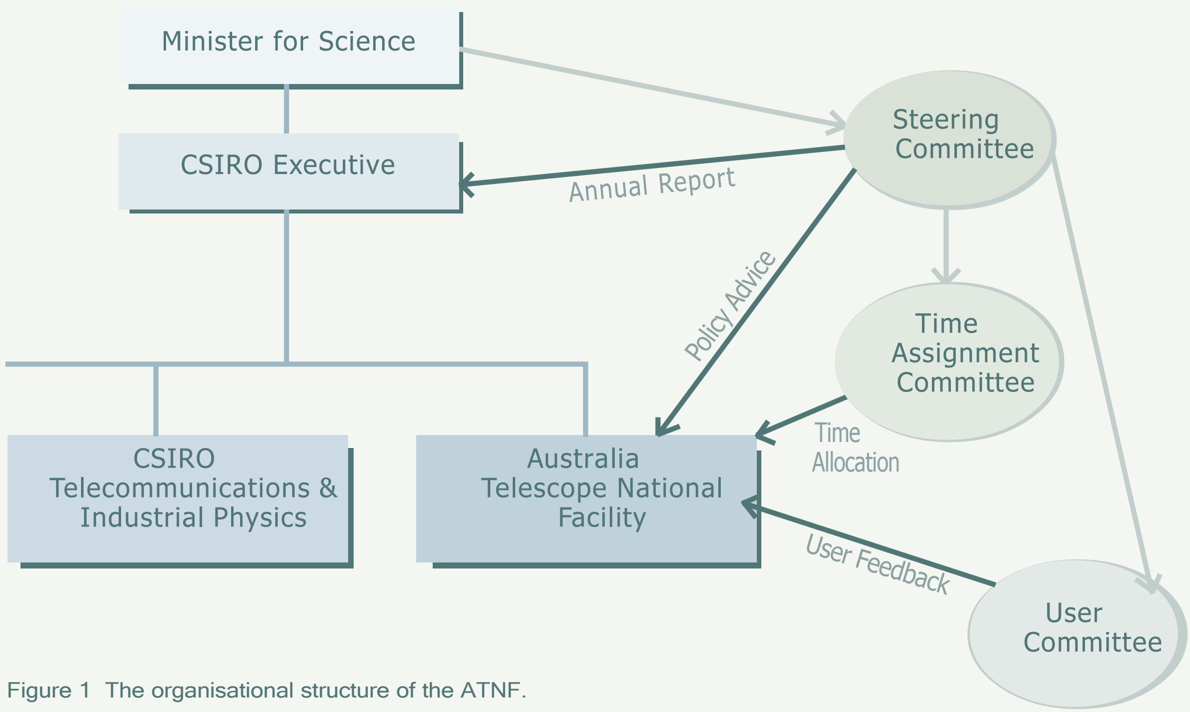


Figure 1 The organisational structure of the ATNF.

A further 22-m antenna, known as the Mopra telescope, is located near Mopra Rock in the Warrumbungle Mountains near Coonabarabran, New South Wales.

The other key component of the Australia Telescope is the Parkes 64-m radio telescope, located near the town of Parkes. This telescope has been successfully operated since 1961 and is famous as a national symbol for Australian scientific achievement. Upgrades to accommodate a 13-beam focal-plane array have maintained its world-class position as a state-of-the-art instrument.

The eight ATNF telescopes can be used together as the Long Baseline Array (LBA) for a technique known as very long baseline interferometry (VLBI) which is used to obtain high resolution images of small areas of sky.

The LBA is used as part of a larger Australian network of radio telescopes which includes the NASA satellite tracking antennas at Tidbinbilla, near Canberra, and radio antennas in Tasmania, South Australia and Western Australia. The LBA is also regularly used as part of the Asia-Pacific Telescope which links radio telescopes in Australia, Japan, China, Hawaii and India, and the VLBI Space Observatory Program (VSOP).

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.

ATNF Steering Committee

ATNF policy is determined by the ATNF Steering Committee, an independent committee appointed by the Minister for Science. The Committee helps the ATNF develop long-term strategies. The inaugural meeting of the ATNF Steering Committee was held in May 1989. Since then it has met at least once a year, to define the broad directions of the ATNF's scientific activities and the development of the Australia Telescope. It is also responsible for promoting the use of the Facility and, indirectly, for allocating observing time.

The Steering Committee appoints the Australia Telescope Users Committee (ATUC) to provide feedback and advice from the user community, and the Time Assignment Committee (TAC) to review proposals and allocate observing time. The committee members for the year 2003 are listed in Appendix C.

Australia Telescope Users Committee

ATUC represents the interests of the Australia Telescope's users. The committee provides feedback to the ATNF Director, discussing problems with, and suggesting changes to, ATNF operations; it also discusses and ranks by scientific merit various 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. ATUC discussions can be found on the web at www.atnf.csiro.au/management/atuc.

Time Assignment Committee

The ATNF receives more applications for observing time than it can accommodate: proposals for time on both the Parkes and Narrabri telescopes exceed the time available by a factor of approximately two. The proposals are assessed, and time allocated to them, by the TAC. The TAC reviews typically one hundred telescope applications at each meeting. In 2003 a decision was made to change from having three four-month observing terms per year to having two six-month observing semesters, with the change due to start in 2004.

Strategic objectives

The ATNF is one of the world's leading radio astronomy organisations. The strategic objectives for the ATNF are:

- To continue to operate the Australia Telescope in such a way as to maintain a leading international position

  The ATNF will provide access to its facilities to satisfy the needs of Australian and overseas users. At least 70% of time on the Parkes and Narrabri telescopes will be used for astronomy. Time lost during scheduled observing periods will be kept to below 5%.

- To develop and extend the performance of the Australia Telescope to maintain its competitiveness in the medium term (3 – 8 years)

  During the last six years the Narrabri and Mopra telescopes have been extensively upgraded, under the Major National Research Facilities (MNRF) program, funded in 1997, to work at shorter (millimetre) wavelengths. The upgraded telescopes use innovative devices for the detection of extremely weak millimetre-wave signals from space. These have been jointly designed by the ATNF and CSIRO Telecommunications and Industrial Physics (CTIP), a project funded by the CSIRO Executive Special Project. The MNRF upgrade also extends the Australian network of telescopes used for VLBI, which has both astronomical and geodetic applications. The MNRF upgrades will be fully completed in 2004.

- To position the ATNF to participate in major international radio astronomy projects developing over the next decade

  In the next decade radio astronomy will be dominated by two major international developments: the Atacama Large Millimetre Array (ALMA) and the SKA. These instruments will allow astronomers to pursue key questions about the early evolution of the Universe. For Australia to maintain its position in radio astronomy, it needs to have a significant role in at least one of these projects. The SKA is a billion-dollar project, the "next-generation" radio telescope with a collecting area of approximately one square kilometre. Its construction is expected to start around 2012. Australia is well-positioned to play a key role in the development of the SKA. In some respects Australia offers an ideal location for the SKA as it has a number of regions of low population density which are relatively free from radio interference. The technology development required for the SKA will have wide industrial applications and the construction will involve significant industrial contracts.

  In August 2001 the Government announced the allocation of A$155M under the MNRF-2001 program to 15 successful programs in Australia. Of these, the ATNF-led proposal, on behalf of Australian astronomy, received the largest single allocation of A$23.5M. This funding will be used to develop SKA technology and to improve access to the optical/IR Gemini telescopes. This SKA technology development will also result in a significant upgrade of the AT Compact Array.

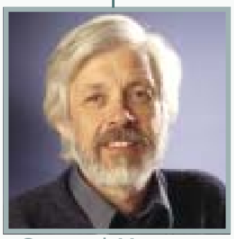
- To conduct an effective outreach program

  The ATNF operates Visitors Centres at the sites of the Parkes and Narrabri Observatories and has an active public outreach program which has several goals: to raise the national profile of astronomy and related technology in Australia; to encourage the next generation of scientists by providing educational resources targeted at high school students and their teachers; and to maintain good community relationships.

ATNF Senior Management Group and Federation Fellows in December 2003.

Director
Brian Boyle
Photo: © Kristen Clarke

Deputy Director
Ray Norris
Photo: © Kristen Clarke

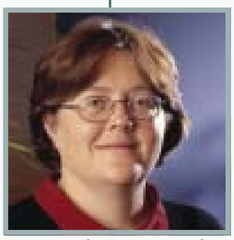


General Manager
Dave McConnell
Photo: © Kristen Clarke

OIC Parkes
John Reynolds
Photo: John Sarkissian © CSIRO

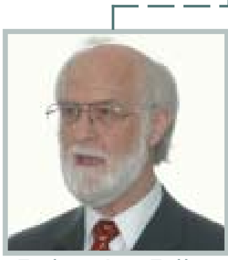
OIC Narrabri
Bob Sault
Photo: © David Smyth

Head, Astrophysics
Lister Staveley-Smith
Photo: © Kristen Clarke

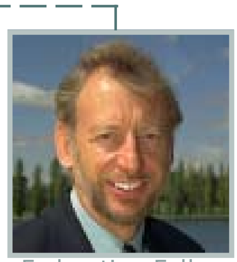


Head, National Facility Support
Jessica Chapman
Photo: © Kristen Clarke

Head, Engineering
Warwick Wilson
Photo: © Kristen Clarke



Federation Fellow
Ron Ekers
Photo: © David Smyth



Federation Fellow
Dick Manchester
Photo: © Australian Research Council

ATNF management changes and awards

The year 2003 was one of considerable change for the senior management of the ATNF. In March 2003, Professor Ron Ekers, the ATNF Foundation Director since 1988, stood down as Director, to take up a Federation Fellowship hosted at the ATNF. The Federation Fellowships are the most prestigious research positions awarded by the Australian Research Council (ARC). Professor Ekers will use the five-year position for research on star-formation processes in distant galaxies, and to conduct research on techniques for interference mitigation. In May 2003, Professor Ekers was awarded a Commonwealth Centenary Medal for services to Australian society and science in astronomy and cosmology. In July he became the President of the International Astronomical Union.

In March 2003, Dr Dick Manchester was awarded the second Federation Fellowship to be held at the ATNF. Dr Manchester took up the position in June to carry out a research project on precision pulsar timing. In May Dr Manchester was awarded a Commonwealth Centenary Medal for services to Australian science and society in astrophysics.

After an extensive international search, a new Director for the ATNF was announced in April 2003. Professor Brian Boyle, formerly the Director of the Anglo-Australian Observatory and Chair of the ATNF Steering Committee, took up the Directorship on 11 July 2003. Following the announcement, Professor Boyle ceased all chairmanship duties for the Steering Committee. Professor Boyle was also awarded a Commonwealth Centenary Medal in May, for his contribution to the advancement of astronomy.

The ATNF Deputy Director, Professor Ray Norris, took over as Acting Director during the interim period from March – July 2003. From July onwards Professor Norris continued as Deputy Director with leadership responsibilities for SKA development, the Australian Astronomy Major National Research Facilities program and other related activities.

After 37 years of service and an outstanding career, John Brooks, the Assistant Director and Engineering Manager of the ATNF, departed in February 2003 for long service leave and retirement. Shortly before leaving, in December 2002, John was awarded a CSIRO Lifetime Achievement Medal in recognition of his many contributions to ATNF and CSIRO.

A number of other changes were made to the senior management structure during the year. In March, Dr David McConnell took on a new role as ATNF General Manager with responsibilities for ATNF administration, project management procedures, site management for the Radiophysics Laboratory in Marsfield, and Occupational Health Safety & Environment . In September Dr Peter Hall completed a four-year term as the ATNF SKA Program leader. He will take up a new appointment as the first SKA International Project Engineer in early 2004.

The Parkes radio telescope seen across the neighbouring wheat field.
Photo: © Tim Ruckley

Performance indicators

This chapter describes performance indicators that are used to assess the performance of the ATNF.

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%.

The following values show the time allocation for scheduled observations in 2003:

	Compact Array	Parkes
Time allocated for scheduled observations	72.9%	64.5%
Time allocated for NASA tracking observations	–	9.4%
Downtime due to equipment failure (during scheduled observations)	1.7%	1.3%
Downtime due to weather	0.7%	3.8%

For the Parkes radio telescope, the observing time allocated to astronomical observations was lower than usual. This was mainly due to the use of the telescope for the NASA Mars tracking program and associated upgrades to the telescope in preparation for this (page 36).

For most observing programs, observers are required to be present at Parkes or the Compact Array for their observations. For the Compact Array, remote observing is also possible from other Australian sites. In 2003, 9.8% of scheduled observations with the Compact Array were taken remotely.

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 addresses ATUC issues. In 2002 ATUC made 17 recommendations to the ATNF. Of these 14 were completed by December 2003, with responses to two requests still in progress and one withdrawn by ATUC.

A significant issue for the user community in 2003 was a decision to change from four-month observing terms to six-month observing terms. Although ATUC had previously advised against this change, a decision to proceed with a change to six-month terms was made after consulting with all major stakeholders including the ATNF Steering Committee, Senior Management Group and the Time Assignment Committee.

3 Time allocation on ATNF facilities

The allocation of time on the ATNF facilities is done on the basis of scientific merit. In 2003 a total of 219 proposals were allocated time on ATNF facilities (each proposal is counted once only per calendar year although some proposals are submitted two or three times). Of these, 146 were for the Australia Telescope Compact Array, 54 were for the Parkes telescope, eight were for the Mopra telescope and 11 were for the Long Baseline Array. A summary of the observing programs is given in Appendix D.

Since January 2003, the ATNF has accepted applications for service observations with the Tidbinbilla DSS43 70-m antenna. The radio telescopes at Tidbinbilla are operated by the Canberra Deep Space Communication Complex, part of NASA's Deep Space Network. During the year, service observations were taken using the DSS43 70-m antenna for nine observing programs.

Figures 3 and 4 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 5 shows the total time allocated to all proposals observed with the Compact Array, from 1990 to 2003.

In 2003 the proposals allocated time by the ATNF included at least 410 authors. Of these approximately 45 authors were from the ATNF, 85 were from 14 other institutions in Australia, and 280 authors were from around 120 overseas institutions in 20 countries.

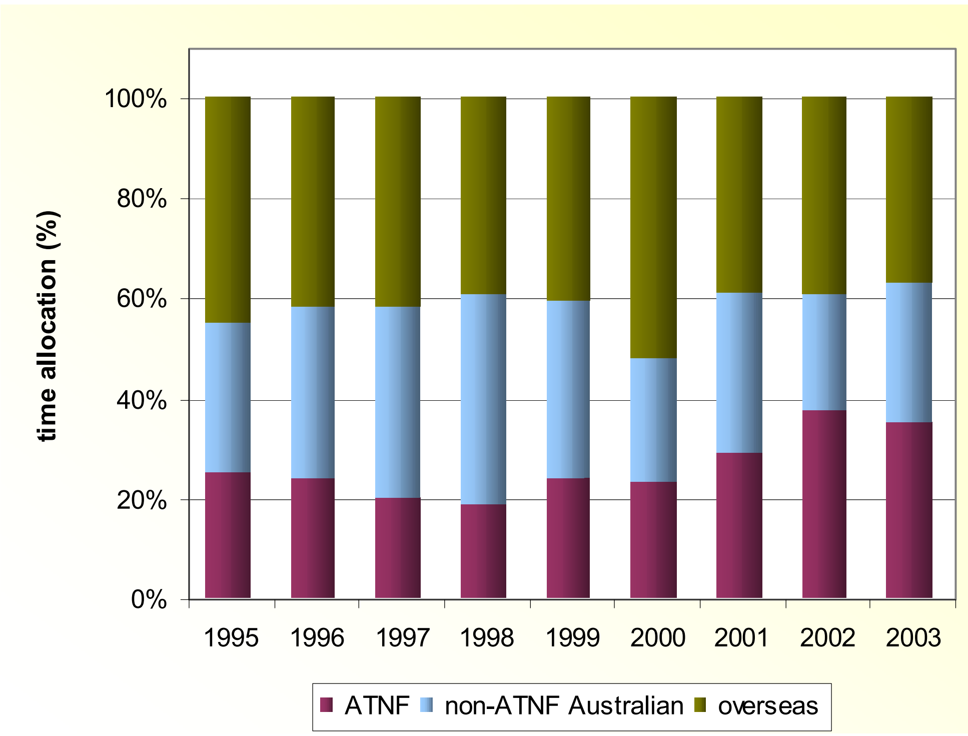


Figure 3 Compact Array time allocation, 1995 - 2003.

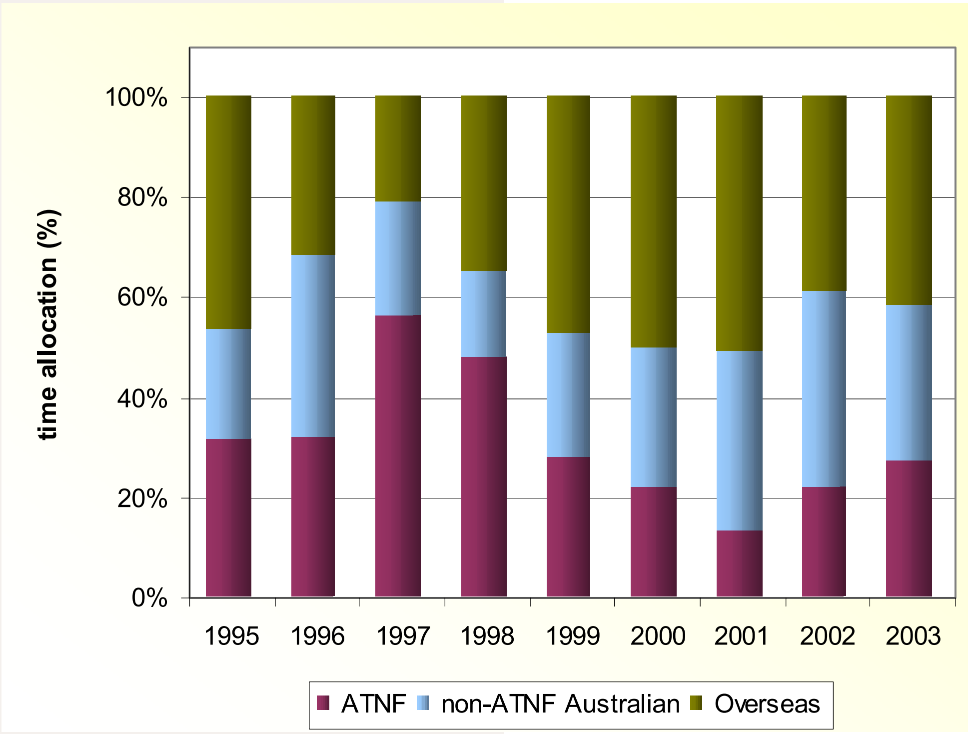


Figure 4 Parkes time allocation, 1995 - 2003.

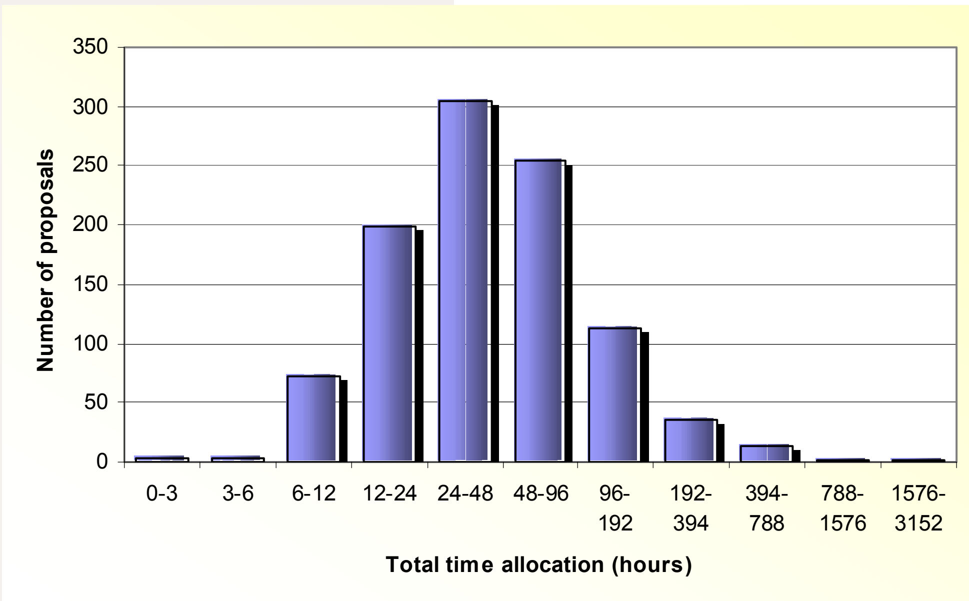


Figure 5 Compact Array time allocation, 1990 - 2003.

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

In December 2003 there were 27 PhD students affiliated with the ATNF as well as an Australian or overseas university. Their affiliations and project titles are given in Appendix H. Seven students were awarded PhDs during the year. Their theses are listed in Appendix G.

5 Publications and citations

Figure 6 shows the number of publications in refereed journals which include data obtained with the Australia Telescope. The publication counts include papers dealing with operations or data reduction but do not include IAU telegrams, abstracts, reports, historical papers, articles for popular magazines, or other papers by ATNF authors. In 2003, 103 papers with ATNF data were published in refereed journals. These are listed in Appendix G, which also lists other papers by ATNF staff, and conference papers.

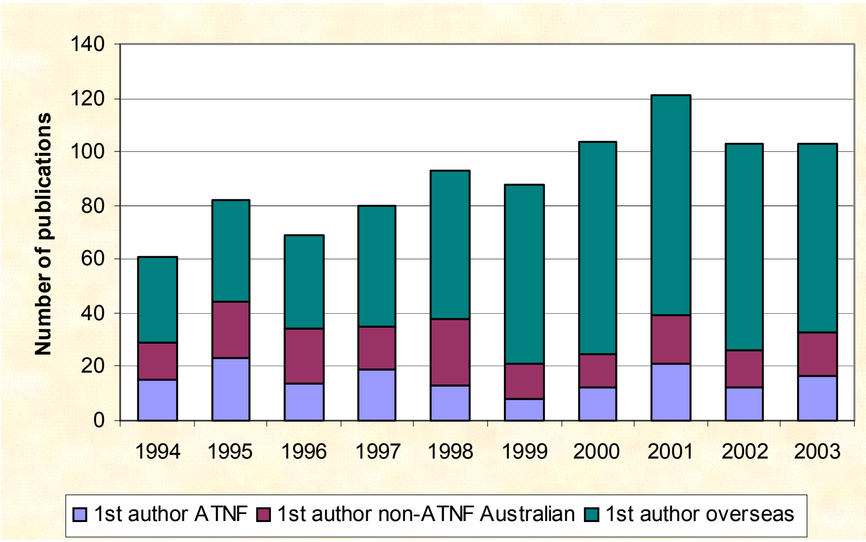


Figure 6 Papers from data obtained with the Australia Telescope, published in refereed journals.

Figure 7 compares ATNF publication counts for the ATNF with three other organisations that provide world-class facilities for radio astronomy. On the basis of the number of refereed articles, the National Radio Astronomical Observatory (NRAO)[1] clearly ranks first with ATNF second.

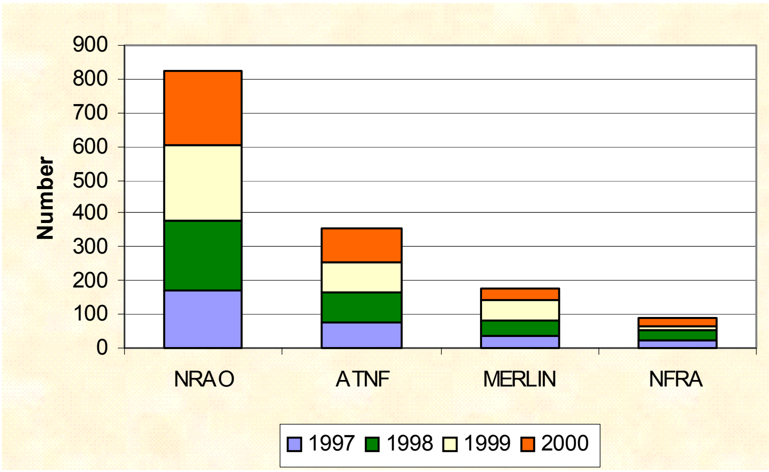


Figure 7 Publication counts 1997 - 2000, for articles published in refereed journals.

[1] The NRAO counts include publications with data from the Very Large Array and Very Long Baseline Array facilities. The counts for MERLIN include papers with data from the UK MERLIN/VLBI National facility. For NFRA (ASTRON), the counts include papers with data from the Westerbork Synthesis Radio Telescope and the Dwingeloo Radio Telescope.

6 Public relations

Figure 8 shows counts for media activities for the years 1999 – 2003. During the year the ATNF issued 11 media releases (Appendix F) and featured in more than 110 press items. ATNF staff gave approximately 100 TV and radio interviews. Figure 8 also shows the number of web hits to the central ATNF web site. The counts include internal use by staff and hits generated by external search engines. The number of web hits increases from year to year, with 22.7 million hits recorded for 2003.

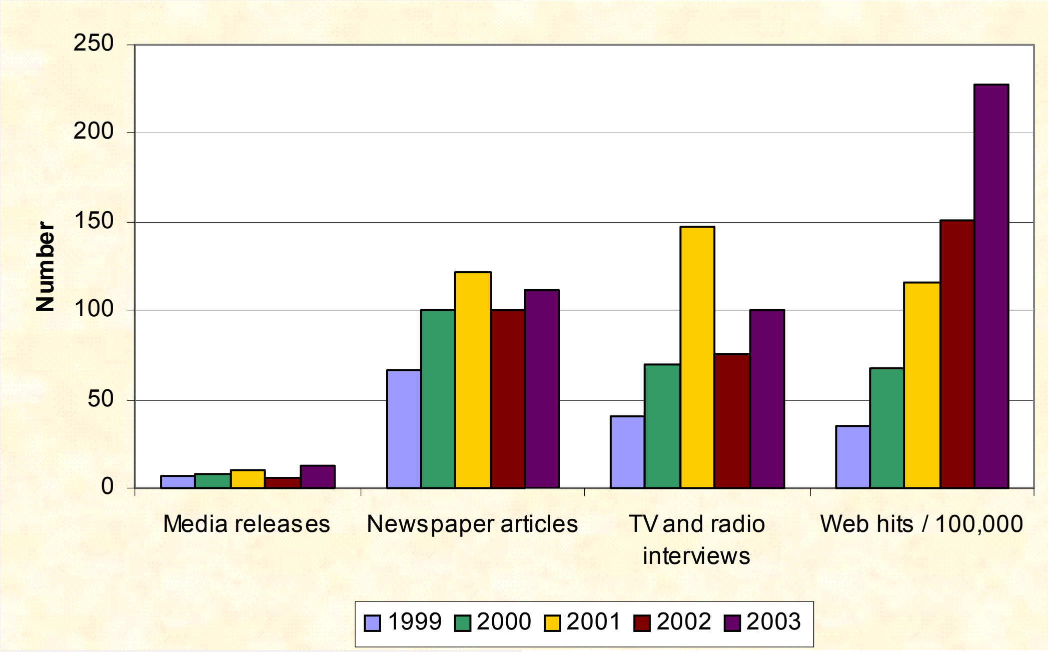


Figure 8 ATNF media activities

Figure 9 shows the number of visitors to the Narrabri and Parkes Visitors Centres. Approximately 10,000 people visit the Narrabri Visitors Centre each year. The number of visitors to the Parkes Visitors Centre increased greatly in 2001, following the release of the movie *The Dish*, and has continued to increase since then with 136,000 visitors in 2003, up from 134,000 in 2002.

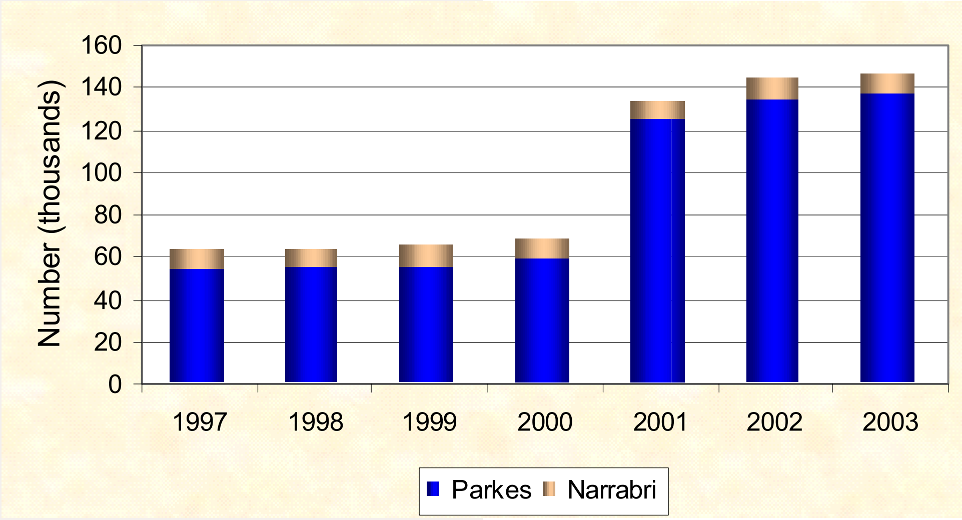


Figure 9 Number of visitors to the Parkes and Narrabri Visitors Centres

7 User feedback at Narrabri and Parkes

Observers at the Parkes and Narrabri observatories are asked to complete a user feedback questionnaire. Figures 10 and 11 show the user responses in 2002 – 2003 for general observing with the Compact Array and Parkes radio telescope. Figure 12 shows the user feedback for Compact Array observations taken in 2002 – 2003 with the 3- and 12-mm observing millimetre systems.

In general the level of user satisfaction is high. In 2003 the average over all items was 89% for the Parkes Observatory, 84% for standard observing at the Compact Array and 77% for millimetre observing at the Compact Array.

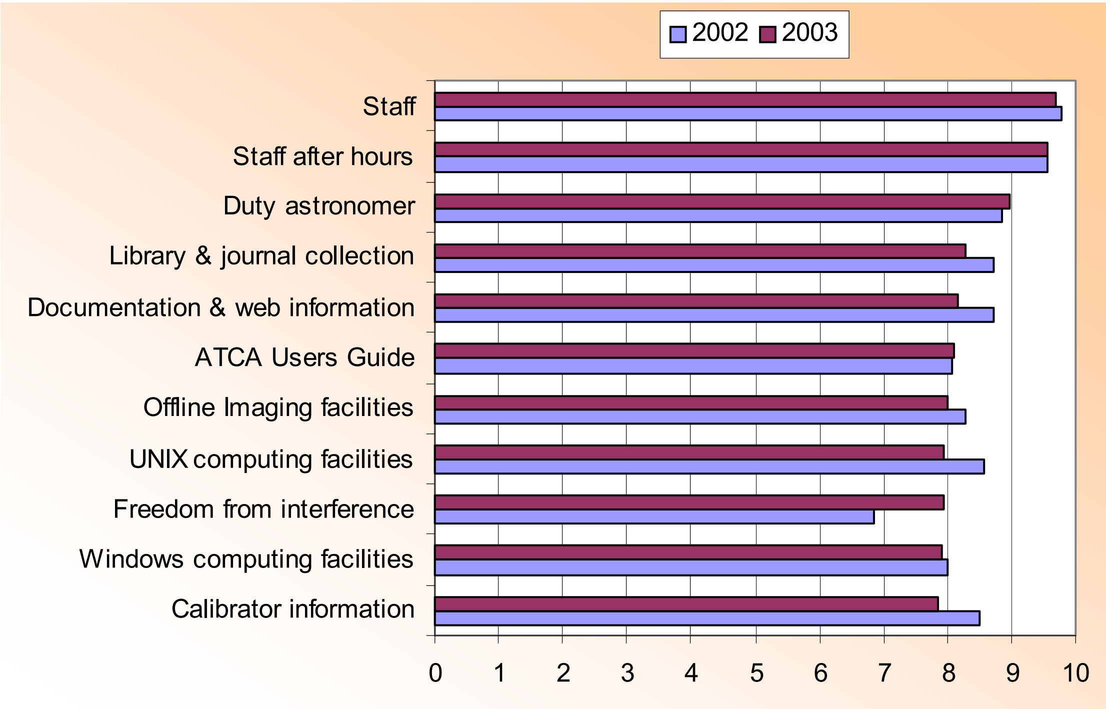


Figure 10 Narrabri general user feedback on a scale of 1 - 10 where 1 = poor and 10= excellent.

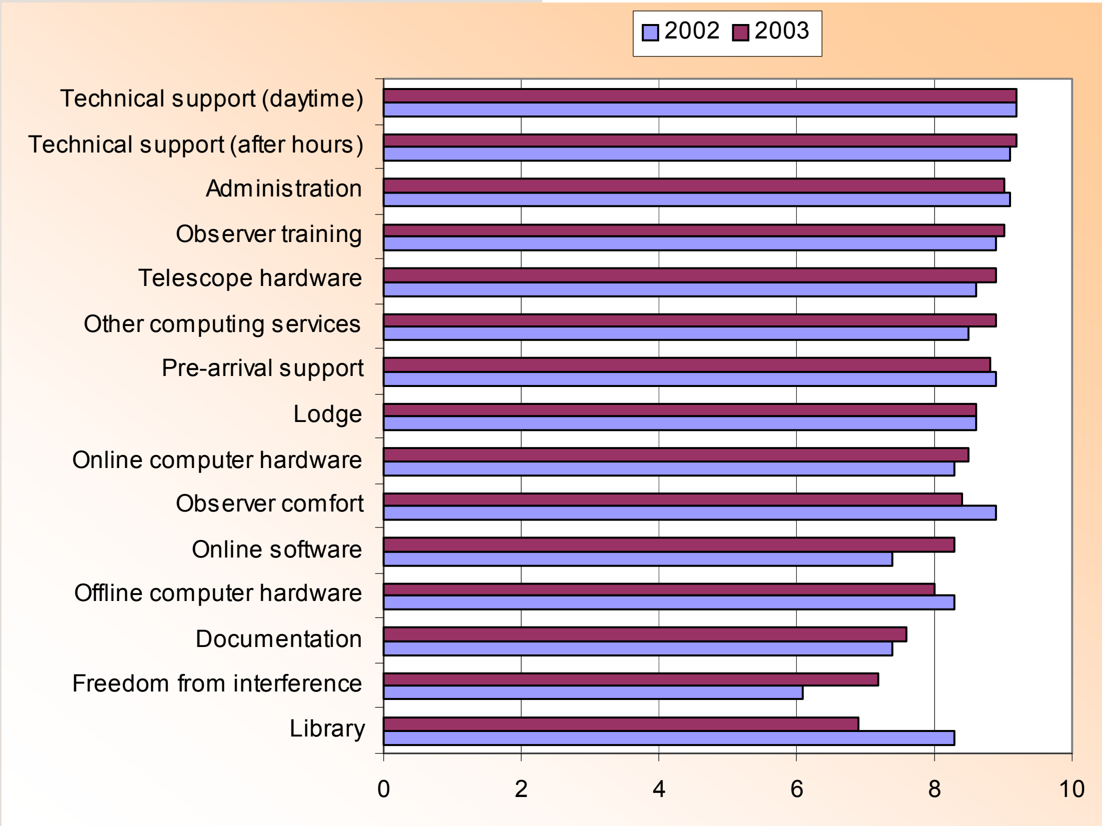


Figure 11 Parkes user feedback on a scale of 1 - 10 where 1 = poor and 10 = excellent.

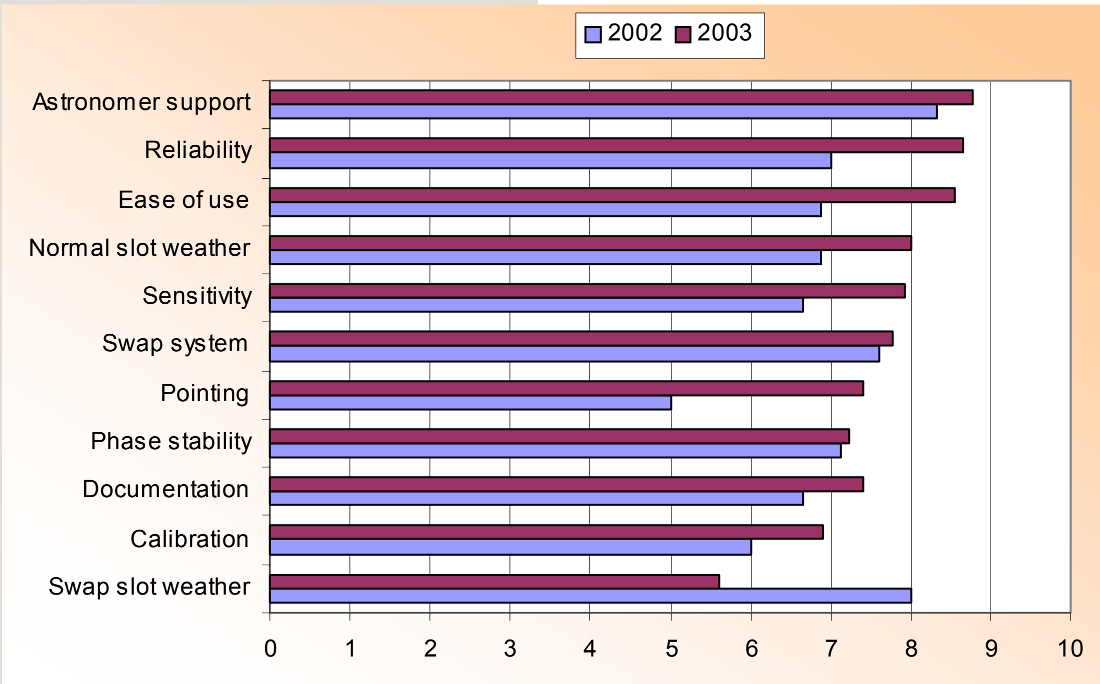


Figure 12 Narrabri user feedback for observations with the 3- and 12-mm observing systems on a scale of 1 - 10 where 1 = poor and 10 = excellent.

The Parkes Radio Telescope
Photo: © Tim Ruckley

Astronomy reports

Each year approximately 200 different proposals are allocated time to conduct astronomical research programs on ATNF facilities. This chapter describes a few of the astronomy highlights from the year.

The first double pulsar

R. N. Manchester on behalf of the Parkes High-Latitude Pulsar Survey team: M. Burgay (University of Bologna, Italy); F. Camilo (Columbia University, USA); N. D'Amico (Cagliari Astronomical Observatory, Italy); P. C. C. Freire (Arecibo Observatory, Puerto Rico); B. C. Joshi (GMRT, India); M. Kramer (University of Manchester, UK); D. R. Lorimer (University of Manchester, UK); A. G. Lyne (University of Manchester, UK); M. A. McLaughlin (University of Manchester, UK); R. N. Manchester (ATNF); A. Possenti (Cagliari Astronomical Observatory, Italy); J. Reynolds (ATNF) and J. Sarkissian (ATNF)

Pulsars have a history of new and unexpected developments – think of the first period glitch, the first binary pulsar and the first millisecond pulsar. These and other similar discoveries have had profound and wide-ranging implications, impacting not only on pulsar astrophysics, but also on stellar evolution, gravitational physics, astrometry and many other areas. This tradition has continued with the discovery of the first-known double-pulsar system at Parkes. Beginning with the famous Hulse-Taylor binary pulsar (PSR B1913+16), it has been known for a long time that in some binary systems the companion, as well as the pulsar, is a neutron star. Only five or six of the 80 or so previously known binary pulsars are believed to be double-neutron-star systems and, despite careful searches, in no case had the second neutron star been detected as a pulsar. This is not too surprising as the second-born pulsar has a much shorter lifetime than the first, which in all known systems has been "recycled" to form a rapidly spinning and weakly magnetised pulsar.

This story begins with the discovery of a 22-millisecond pulsar, PSR J0737–3039, by Marta Burgay, a University of Bologna student working with the Parkes High-Latitude Pulsar Survey team. This survey uses the Parkes multibeam receiver to search a region of sky in the third Galactic quadrant extending between latitudes of –60° and +60°. It was immediately clear that PSR J0737–3039 was a member of a binary system, which subsequent observations showed to have a period of only 2.4 hours. Furthermore, the amplitude of the Doppler shifts showed that the companion was massive and probably another neutron star. With a mean orbital velocity of 0.1 per cent of the velocity of light, this is the most relativistic binary pulsar known and many relativistic perturbations of the observed pulsar period are expected to be detectable. Indeed, the relativistic precession of periastron was observed in just a few days, implying that the sum of the masses of the two stars is about 2.59 solar masses. One of the most interesting aspects of this system is that it raises the predicted rate of detections of double-neutron-star mergers by gravitational wave detectors such as LIGO by nearly an order of magnitude. These results were published in Nature by Burgay et al. in December 2003. Figure 13 shows an artist's impression of the two pulsars.

These results were very exciting, but this system had more surprises in store. While testing a pulsar search program on a Parkes observation of this pulsar, Duncan Lorimer was astounded to see a very strong signal at a period of 2.78 s with a dispersion measure equal to that of the 22-ms pulsar. Further investigation showed that this signal had the inverted Doppler shifts of the 22-ms pulsar. There was no doubt that it was the neutron-star companion – the first time that the second neutron star in such a system had been seen as a pulsar! The emission from this pulsar, PSR J0737–3039B, is strongly modulated with orbital phase and only bright for two 10-minute intervals during the 2.4-hour orbit. At the time of the discovery-observation of the A pulsar, the B pulsar was turned off! The discovery of the B pulsar was announced in Science Express on 8 January 2004 and published in Science in the 20 February 2004 issue (Lyne et al. 2004).

Figure 14 shows the orbital modulation of the B pulsar signal. This figure shows that not only is the pulse amplitude varying with orbital phase, the pulse shape is also changing! Such modulation is unprecedented in pulsar astronomy, and is very likely due to the relativistic wind from the A pulsar penetrating deep into the magnetosphere of the B pulsar. Back-of-the-envelope calculations suggest that more than 90 per cent of the B-pulsar magnetosphere is actually blown away by the A-pulsar wind – it is amazing that the B pulsar can pulse at all!

It has also been possible to observe an eclipse of the A-pulsar signal as it passes behind the B pulsar. It turns out that the binary system is seen almost edge-on, another very fortuitous circumstance. The most direct evidence for

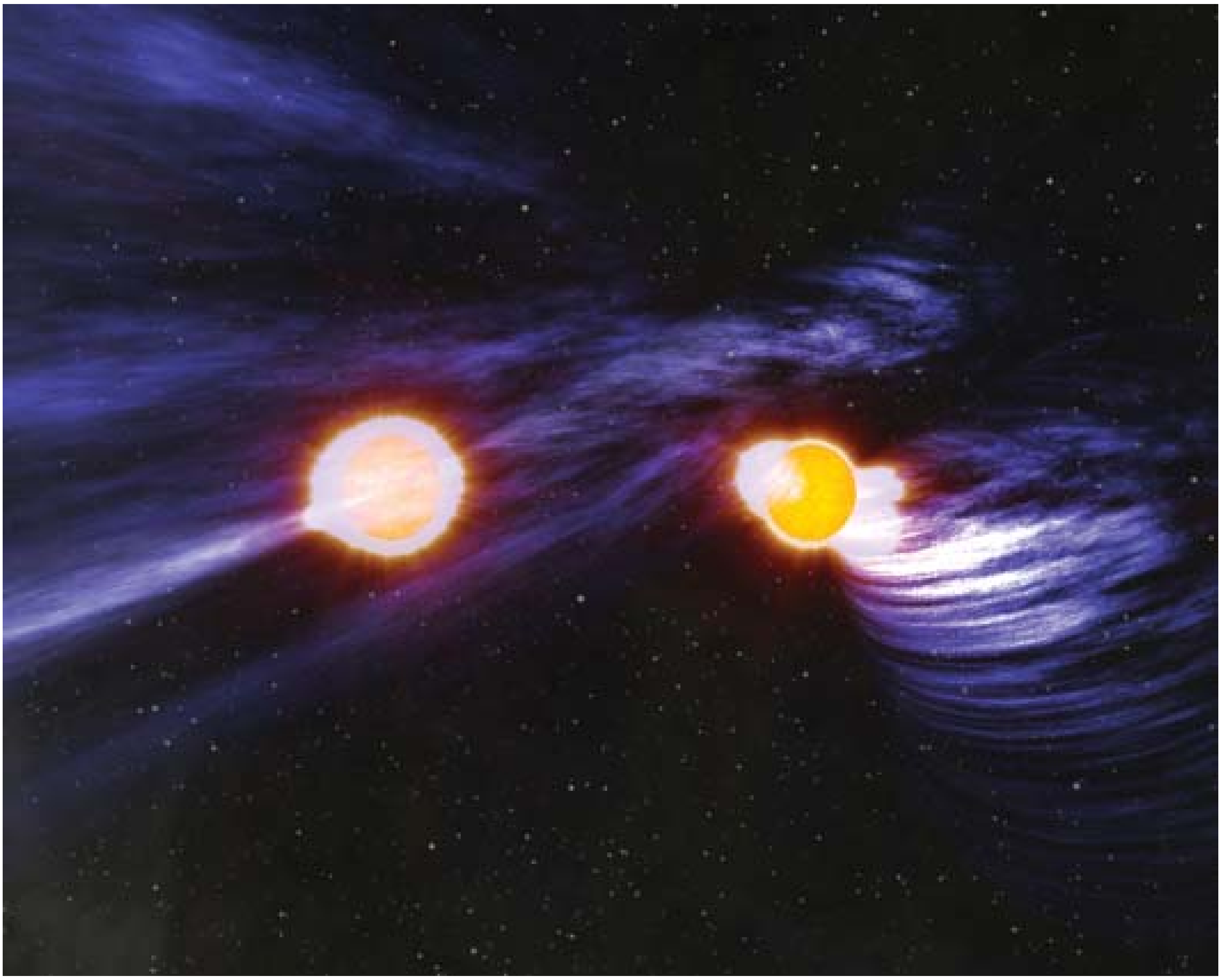


Figure 13 An artist's impression of the two pulsars orbiting around the common centre of mass. The faster rotating pulsar spins almost 3000 times a minute while the slower rotating pulsar spins only 22 times a minute. The two pulsars orbit each other once every 2.4 hours.
Image credit: John Rowe Animation

this is the detection of the so-called "Shapiro delay" in the A-pulsar signal resulting from deflection of the ray path as it passes near the companion. This has an amplitude of about 100 microseconds, implying that the orbit plane is within three degrees of being edge-on. The A eclipse is very short, lasting about 30 seconds, a duration roughly consistent with occultation by the remaining part of the B-pulsar magnetosphere.

Detection of the second neutron star as a pulsar opens up a whole new set of investigations in relativistic gravity. The ratio of the orbital Doppler shifts immediately gives the mass ratio of the two stars. Importantly, this ratio is largely independent of theories of gravity and hence it provides an important constraint on such theories. As Figure 15 shows, the mass-ratio and periastron-advance constraints are nearly orthogonal and hence accurately determine the two neutron-star masses: 1.337 +/- 0.004 solar masses and 1.251 +/- 0.004 solar masses. The three other relativistic constraints and the "mass function" constraint for the two stars are all consistent with these values, confirming the accuracy of predictions made by Einstein's general theory of relativity. In the next few years, we expect to measure several more relativistic effects, some dependent on higher-order terms in the post-Newtonian expansion. These will provide the tightest constraints yet on theories of gravity in the strong-field regime.

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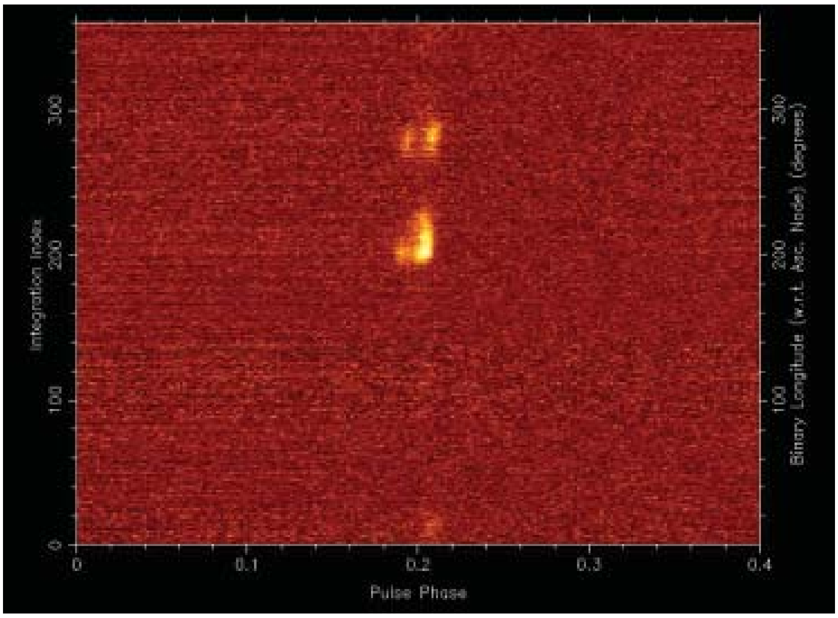


Figure 14 Intensity of PSR J0737-3039B at 3.1 GHz as a function of pulse phase and true orbital longitude. Approximately 40 per cent of the pulse period is displayed. Longitude 270° corresponds to inferior conjunction of the B pulsar when it is in front of and most closely aligned with the A pulsar. About 13.7 hours of data were averaged to form this image. The data were obtained with the recently commissioned Parkes 10/50cm receiver and analysed using the PSRCHIVE pulsar analysis package.

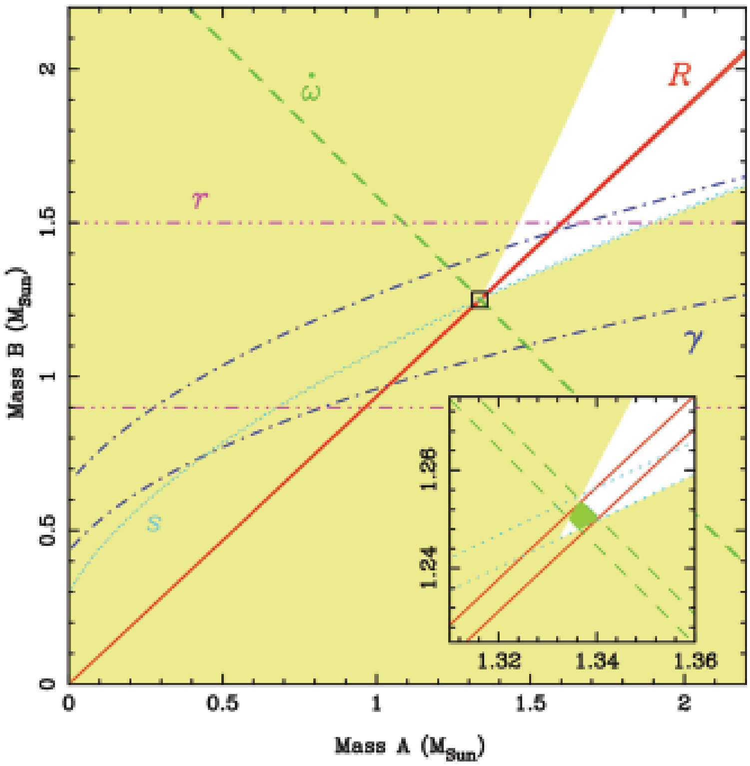


Figure 15 Constraints on the masses of the two neutron stars in the PSR J0737-3039A/B system. The yellow regions are forbidden by the constraint that the sine of the orbit inclination angle cannot exceed unity. The solid diagonal lines (marked *R*) define the limits on the mass ratio. Additional constraints are provided by the detection of relativistic effects in the timing of the A pulsar, interpreted in the framework of general relativity. The diagonal dashed lines are limits on the sum of the masses based on the observed precession of periastron and the dot-dash lines are limits based on variations in time dilation as the pulsar moves around its somewhat eccentric orbit. The other two constraints, marked *r* and *s*, are based on the observed Shapiro delay. The inset shows an expanded plot of the region of intersection of the various constraints. (Lyne et al. 2004)

Temperature maps of dense molecular gas in starburst galaxies

J. Ott (ATNF); A. Weiss (Instituto de Radioastronomía Milimétrica; Spain); C. Henkel (Max Planck Institut fûr Radioastronomie, Germany); F. Walter (National Radio Astronomy Observatory, USA)

The new 12-mm receiver system (installed at the Compact Array in April 2003) allows astronomers, for the first time, to perform interferometric observations in the southern hemisphere in this important frequency range. Within this band lie the lowest transitions of the abundant ammonia (NH_3) molecule. The specific tetrahedral structure of ammonia and the resulting metastable inversion lines can be used as an excellent thermometer of cold, dense, molecular gas - the material from which stars ultimately form. In an ongoing project, Ott and his collaborators are using this tool to compute temperature maps of the molecular cores of nearby starburst galaxies at the very high spectral and angular resolution provided by the Compact Array.

Starburst galaxies exhibit current star formation rates of tens, and in extreme cases up to hundreds, of solar masses per year. The subsequent release of mechanical energy from massive stars, in the form of strong stellar winds and numerous supernova explosions, heats the ambient gas and drives superwinds perpendicular to the gaseous and stellar disks. The ionised material of superwinds can be traced by optical spectral lines and X-ray line and continuum emission at distances of up to tens of kiloparsecs from the galaxies themselves. The fuel for these periods of extreme star formation is provided by molecular gas which is found abundantly in the starburst cores.

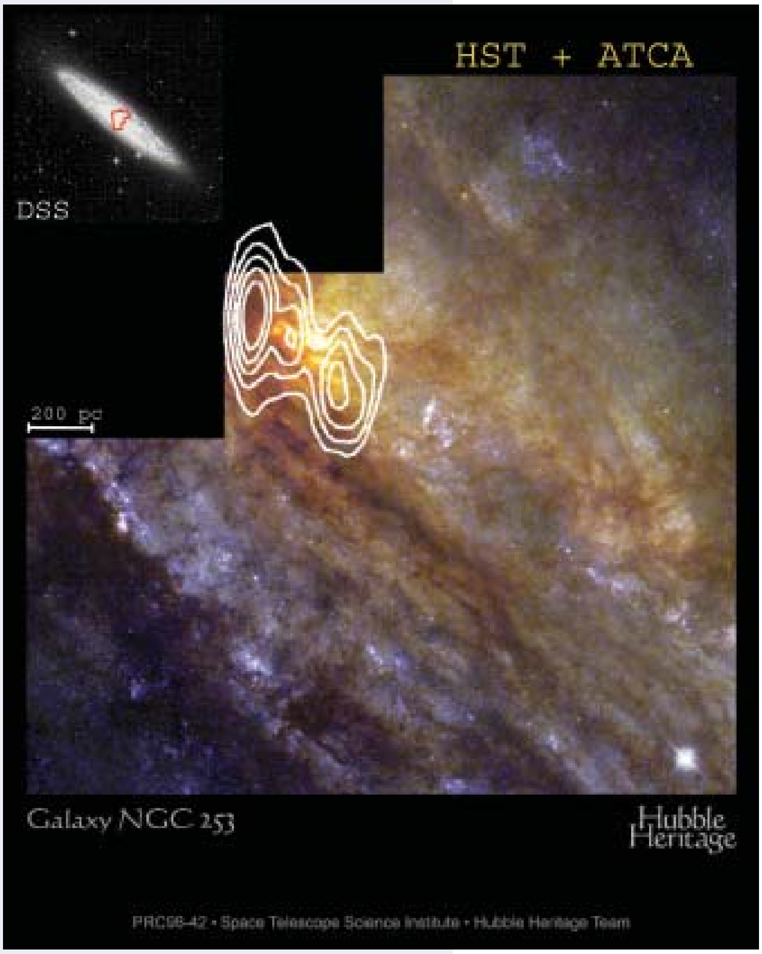


Figure 16 A Hubble Heritage Image of NGC 253. Overlaid as contours are the Compact Array observations of the NH_3 (1,1) inversion line. This traces cold and dense molecular gas that feeds a starburst region in the centre of the galaxy. The orientation and coverage of the "batwing-shaped" Hubble Space Telescope WFPC2 instrument for this observation is marked on top of the Digitized Sky Survey image of NGC 253 shown in the upper left corner. Note that the image is rotated by approximately 180° compared to the representations in Figures 17 and 19.

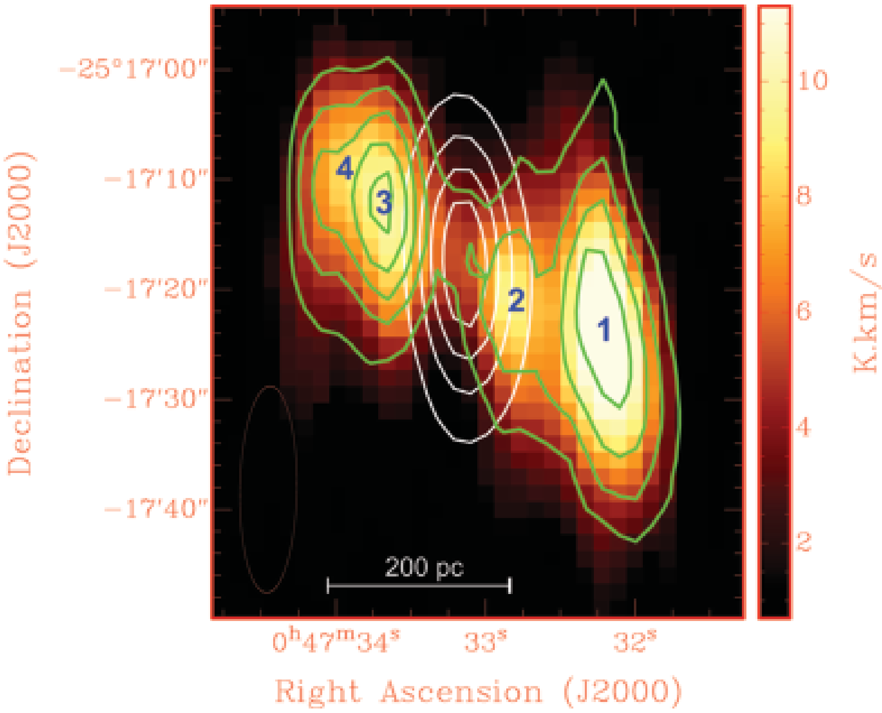


Figure 17 Maps of the ammonia (1,1) (image) and (2,2) (green contours) inversion lines toward NGC 253. The 12-mm continuum emission, which marks the high star formation rate in the nucleus, is shown as white contours. Clumps 1 – 4 are marked by numbers. The size of the synthesised beam is shown in the lower left corner.

NGC 253 is a prominent, nearby starburst galaxy. Located at a distance of only 2.6 million parsecs, it exhibits a current star formation rate of five solar masses per year, of which 3.5 solar masses per year are concentrated in the central 200 parsecs (Figure 16). This region is surrounded by vast amounts of molecular gas (30 million solar masses) and the densest parts of it (volume densities >10^4 cm^{-3}) are traced by ammonia. The brightest NH_3 emission is observed at both sides of the starburst centre decreasing toward the centre itself and toward radii larger than about 200 parsecs (Figure 17). The high angular and spectral resolution of the Compact Array allows the identification of four dense molecular complexes, two on each side of the starburst core (Figures 17 and 18). The dynamics of the clumps are quite complex as is illustrated by the position-velocity diagram displayed in Figure 18. Simple models such as a ring rotating like a solid body are not in agreement with the data.

Figure 19 shows a rotational temperature map of the dense molecular gas, calculated using the relative strengths of the NH_3 (1,1) and (2,2) inversion lines. The temperature distribution is surprisingly variable ranging from approximately 30 Kelvin close to the starburst centre and 35 Kelvin in the south-western complexes to about 60 Kelvin in the north-eastern molecular clouds. The gas temperatures and radial temperature gradients are different on opposite sides of the starburst centre. Clump 2 is probably the closest molecular complex to the starburst centre (Figure 18) and it is surprising that this cloud has the lowest temperature. It appears that heating by the weak active galactic nucleus (AGN) or by the nuclear starburst does not dominate the heating processes in the molecular clouds. Instead, cloud 2 may be the first of the four complexes to be converted into stars and to support starburst activity.

While temperatures are not consistent with a systematic trend as a function of galactocentric radius, abundances do show such a trend. The ratio of ammonia to molecular hydrogen, NH_3 /H_2, is about 5.5 x 10^{-9} in the outer molecular complexes; the central diffuse region between clouds 2 and 3 exhibits a relative abundance of only about 2.5x10^{-9}. This effect can be explained by the strong UV radiation of the star-forming region near cloud 2 which destroys ammonia in its vicinity. Alternatively, the high densities required for the excitation of ammonia might only be largely met in the molecular complexes but not in the more diffuse, central volume. The faint molecular gas component observed at the very starburst centre might therefore be part of the debris after preceding dense components collapsed into stars.

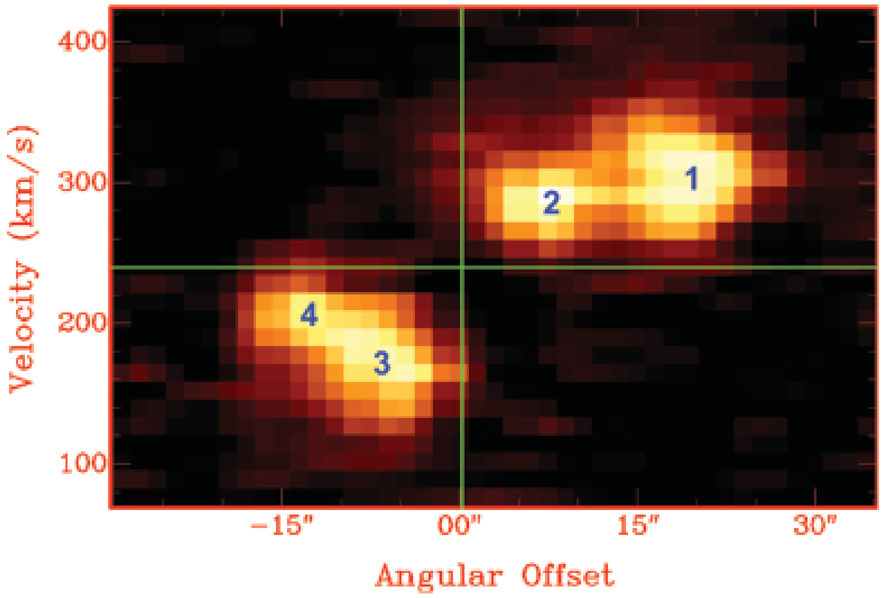


Figure 18 A position-velocity diagram showing the ammonia (1,1) emission along the minor axis of NGC 253. The green lines indicate the starburst centre in terms of position and systemic velocity. The angular offset increases toward the south-west. Individual molecular complexes are numbered as in Figure 17.

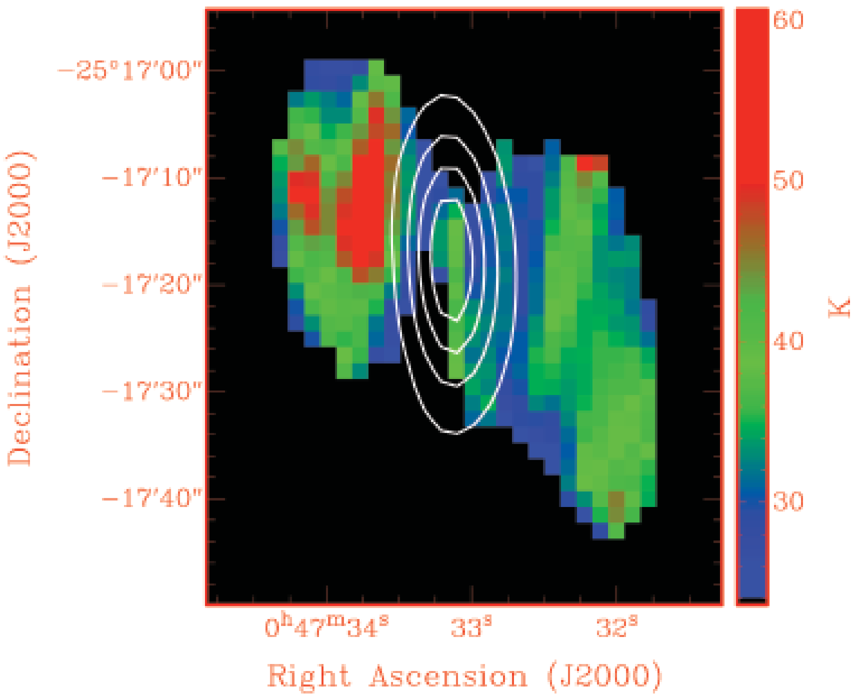


Figure 19 A rotational temperature map of the dense, cold molecular gas. This map is derived using the line ratio of the ammonia (1,1) and (2,2) transitions. The starburst centre is indicated by the 12-mm continuum emission (white contours). Note that the temperature varies by a factor of about 2 from 35 Kelvin in the south-west to 60 Kelvin toward the north-east. The lowest temperatures of around 30 Kelvin are observed at the starburst centre. This image is on the same scale as Figure 17.

What and where are the High-Velocity Clouds around the Milky Way?

D.J. Pisano (ATNF); Brad Gibson (Swinburne University of Technology); David Barnes (University of Melbourne); Lister Staveley-Smith (ATNF); Ken Freeman (Research School of Astronomy and Astrophysics, Australian National University); Virginia Kilborn (Swinburne University of Technology/ATNF)

Over 40 years ago, astronomers discovered clouds of neutral hydrogen (HI) around the Milky Way moving at velocities inconsistent with Galactic rotation; these clouds were termed "high-velocity clouds" or HVCs. Because HVCs are not in simple Galactic rotation and have no associated stars, it has been impossible to determine their distances and, hence, their masses. Without such basic information, astronomers have been limited to indirect methods to infer the origin of HVCs. Today, it appears that a variety of processes can explain the origin of HVCs, and that they, perhaps, reside over a large range in distance.

Some HVCs are probably related to a Galactic fountain. A Galactic fountain occurs when a number of supernovae in the disk of our Galaxy explode in close proximity over a short period of time. The combined energy of the explosions lifts the interstellar gas into the halo of our Galaxy, where it cools and rains back onto the disk. In this scenario, HVCs are the cooling gas falling back onto our Galaxy, residing in the near Galactic halo, only tens of thousands of parsecs from the disk.

Some HVCs are certainly tidal in origin. The Magellanic Stream is the most prominent tidal feature in the sky, a tidal tail created by the interaction between the Large and Small Magellanic Clouds and the Milky Way. Because of its association with the Magellanic Clouds, the Stream is known to be located at a distance of approximately 55,000 parsecs. Other HVCs may be related to the accretion of the Sagittarius dwarf galaxy or other satellite galaxies by the Milky Way and would reside at similar distances.

One of the original ideas as to the nature of HVCs was that they are infalling primordial gas contributing to the formation of the Milky Way. These clouds would have low metallicities, having not been enriched by supernovae, and may be located either near or far from the Milky Way. At least one large HVC complex has a measured low metallicity and a distance of at least 5000 parsecs. The idea that HVCs reside at very large distances, about one million parsecs from the Milky Way, is nearly as old as the discovery of HVCs themselves. Originally, this idea was dismissed because their inferred HI masses would not be large enough for HVCs to be stable. Recently, this idea has undergone a refinement. Leo Blitz and collaborators, as well as Robert Braun and Butler Burton, have proposed that at least some of the HVCs are associated with dark matter halos and reside at distances of up to a million parsecs from the Milky Way, and contain of order 10 million solar masses of HI.

Current models of hierarchical galaxy formation predict that the Local Group should contain roughly 300 low mass, dark matter halos; an order of magnitude higher than the number of known luminous dwarf galaxies. This is commonly known as the "missing satellite" problem. If the HVCs reside within the excess dark matter halos, then the total number of HVCs and dwarf galaxies matches the predictions of simulations, thus solving the problem. In this case, HVCs are the building blocks for the continued assembly of the galaxies contained within the Local Group. This scenario is easily tested: if HVCs are associated with galaxy and group formation, then their analogues will be visible in other groups of galaxies similar to the Local Group. If no HVC analogues are detected, then limits on their masses and their distances can be inferred.

Over the past three years Pisano and his collaborators have been using the Parkes multibeam instrument to search for HVC analogues in six loose groups of galaxies similar to the Local Group in structure and morphology. A loose group is a collection of a few large galaxies and tens of smaller galaxies that are separated by a distance much larger than the size of individual galaxies and spread over a diameter of approximately one million parsecs. The groups observed contained only spiral galaxies, just like the Local Group. The observations were sensitive to clouds with HI masses down to 10 million solar masses. An example is shown in Figure 20, which shows a map of the total HI intensity in the LGG 93 group. All Parkes HI detections were confirmed with follow-up Compact Array observations which also provided better spatial resolution to search for optical counterparts. In the three groups for which the Parkes detections have been confirmed, ten new HI-rich dwarf galaxies were detected. An example of two of these dwarf galaxies is shown in Figure 21. The Compact Array observations had the same sensitivity as the Parkes data, so even if an HI cloud was unresolved by Parkes, it would have been detected with the Compact Array. Nevertheless, no HI clouds without stars, HVC analogues, were found in the three groups using either telescope.

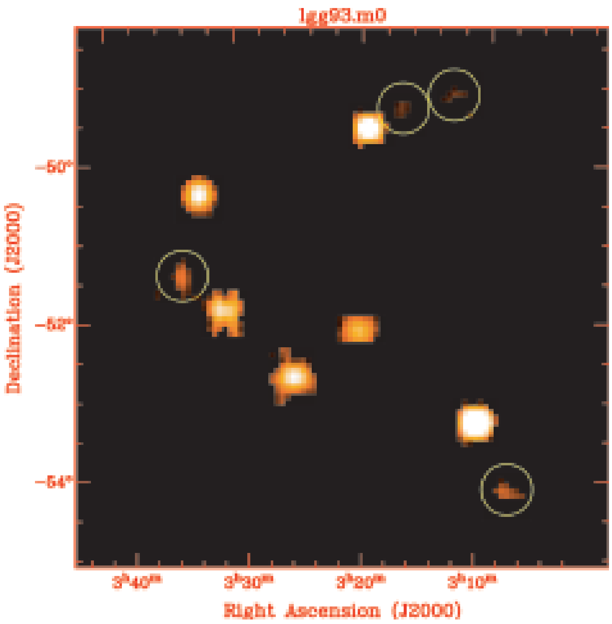


Figure 20 A total HI intensity map of the LGG 93 group obtained using Parkes multibeam data. The circles show the new detections of four dwarf galaxies.

The non-detection of HVC analogues in these three groups allows constraints to be placed on the masses of the clouds. If the HI clouds in the target groups have the same properties as the HVCs seen around the Milky Way, then a failure to detect them implies that the average HI mass of HVCs is less than 400,000 solar masses, and the clouds must be clustered within 160,000 parsecs of the Milky Way and the group galaxies. These limits are in good agreement with recent models and inferred distances to HVCs around the Milky Way made by other astronomers using a variety of different methods. They firmly rule out the original models of Blitz and collaborators and Braun & Burton, which place HVCs at a distance of one million parsecs. It does not mean that HVCs lack dark matter, but only that they are tightly clustered around galaxies and contain much less mass than these authors originally believed.

Overall, this has profound implications for the importance of HVCs in the Local Group. Namely, the total HI mass in HVCs is less than 100 million solar masses; roughly equivalent to a single gas-rich dwarf galaxy. As such, there is very little neutral matter in HVCs present in the selected groups or the Local Group that is available for accretion by the large galaxies to fuel future star formation. Furthermore, because HVCs must be tightly clustered around the Milky Way, they are not so much associated with the formation of the Local Group, but more with the formation of individual galaxies if they do contain dark matter. Unfortunately, future searches for HVC analogues in other groups to further constrain their nature will be very difficult due to the extreme sensitivity required. These observations will probably have to wait for the next generation of radio telescopes.

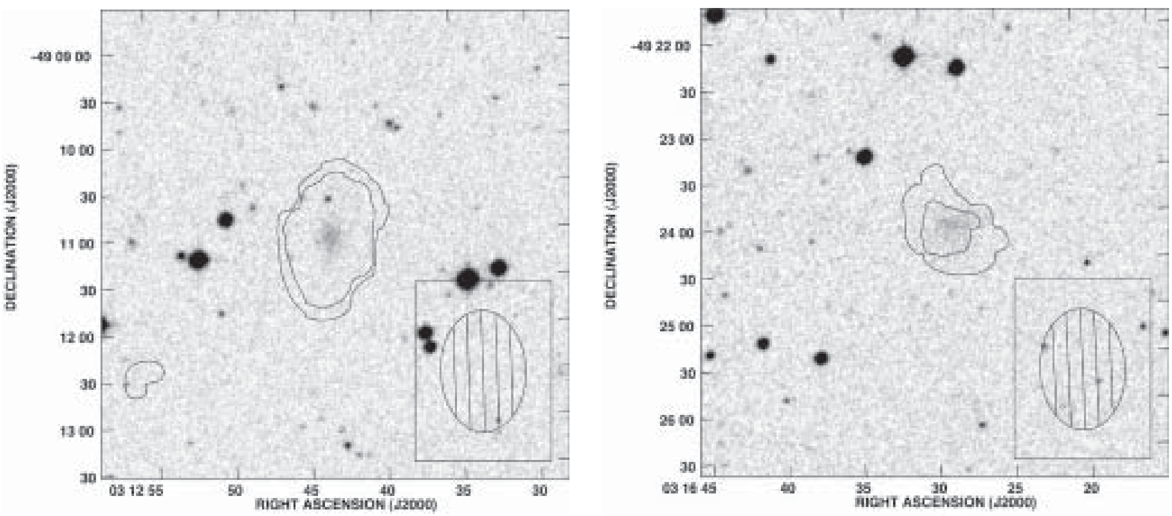


Figure 21 Two dwarf galaxies, LGG 93-1 (left) and LGG 93-2 (right), found in the Parkes multibeam survey. The contours represent the total HI intensity from the follow-up Compact Array observations. The grayscale is from the Digitized Sky Survey and illustrates that both HI detections contain stars and are, indeed, dwarf galaxies and not analogous to the high-velocity clouds. The hatched ovals represent the spatial resolution of the observations.

Gamma-ray burst jets in type Ib/c supernovae

A. M. Soderberg (California Institute of Technology, USA); D. A. Frail (National Radio Astronomy Observatory, USA) and M. H. Wieringa (ATNF)

As the most luminous objects in the Universe, gamma-ray bursts (GRBs) have grabbed the attention of both astronomers and the public. However, during the 31 years since the discovery of gamma-ray bursts, the nature and origin of these powerful collimated explosions has remained largely unknown. Recently, with the discovery of a relatively nearby gamma-ray burst event on 29 March 2003, known as GRB 030329, spectroscopic observations have provided undeniable evidence that long-duration gamma-ray bursts originate from supernovae (SNe) explosions that follow the end of nuclear burning and core collapse in massive stars.

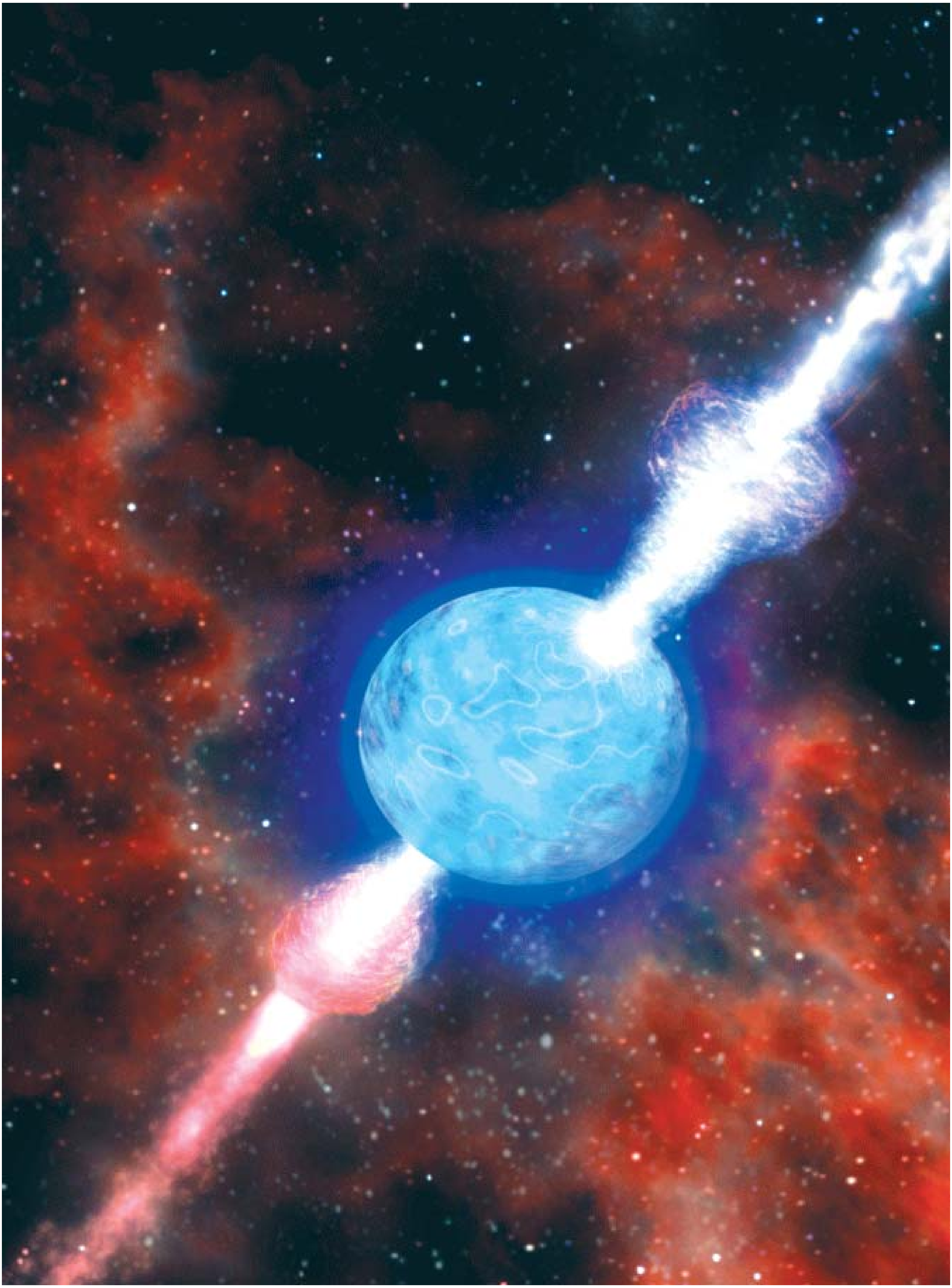
The first important observational clue that there is a link between gamma-ray bursts and the deaths of massive stars came in April 1998. Responding to a new gamma-ray burst, GRB 980425, astronomers found to their surprise an ultra-luminous Type Ic supernova, SN 1998bw, coincident with the satellite position, but located a mere 40 million parsecs away! Based on Compact Array observations, SN 1998bw was shown to be an unusually energetic supernova with properties similar to those observed in cosmological gamma-ray bursts, thus bolstering the idea that the two explosive events were related. However, while the Compact Array observations strengthened the link between gamma-ray bursts and stellar death, it produced its own puzzle: What is the connection (if any) between GRB 980425 and the much more distant cosmological gamma-ray bursts?

Despite being the nearest burst detected to date, the "afterglow" emission from GRB 980425 was under-luminous compared to all other gamma-ray bursts. Afterglow emission is produced by particle acceleration within the collimated gamma-ray burst ejecta (jet) as it sweeps up and shocks the interstellar medium. During the six years since the event of GRB 980425 the radio afterglow has been monitored with the Compact Array (Kulkarni et al. 1998). The most recent measurements in, December 2003 by Soderberg and her colleagues, showed that the radio emission continues to decay as a power-law.

These recent data are of extreme importance in determining the relation between GRB 980425 and other gamma-ray bursts. One popular theory posits that GRB 980425/SN 1998bw was a typical gamma-ray burst viewed far away from the collimation axis of the jet. In this scenario, the afterglow emission is initially beamed away from us and therefore appears sub-luminous. However, as the gamma-ray burst jet decelerates it begins to spread sideways and eventually reaches spherical symmetry on a timescale of one to ten years, depending on the density of the surrounding medium. When the jet spreads into our line-of-sight it should produce a sharp rise in the observed radio afterglow emission. However, six years after the burst, the Compact Array observations do not show any evidence for a sharp rise in the radio emission and thus no evidence that GRB 980425 was initially pointed away from our line-of-sight. This result was combined with upper limits for 15 local (less than 100 million parsecs) type Ibc supernovae between one and 20 years old to show that at most six per cent of local SNe have associated gamma-ray burst jets.

An alternative to the off-axis jet hypothesis considers the event of GRB 980425/SN 1998bw as a member of a separate class of sub-energetic explosions characterised by fainter afterglow emission. This theory is supported by the recent event, GRB 031203, the nearest burst besides GRB 980425, which similarly showed a sub-luminous afterglow and association with an ultra-luminous type Ic supernova (SN 2003lw). With the launch of the NASA spacecraft SWIFT in late 2004, to search for gamma-ray burst events, it is anticipated that a significant population of similar local sub-energetic gamma-ray burst events will be revealed.

Figure 22 (page 28) A schematic representation of a gamma-ray burst.
Image credit: Dan Berry, Skyworks Digital, USA



HI tidal tails, bridges and Clouds

B. S. Koribalski (ATNF)

Neutral hydrogen gas (HI) is abundant in most galaxies, but it is also found well outside their stellar envelopes where it contributes to the intergalactic medium. Prominent nearby examples of intergalactic gas include the Magellanic Stream and extended HI bridges in the M81 group of galaxies.

Koribalski and her collaborators are using observations taken with the Compact Array to study the HI gas found in the outskirts of galaxies and between galaxies. The data are being used to investigate how HI may be stripped by tidal forces from the parent galaxies into the intergalactic medium and how much HI is present in intergalactic gas. The smooth, extended HI disks seen in normal spiral galaxies are dynamically very different from other extended HI distributions. Galaxies with HI tails/plumes are generally peculiar and the location and kinematics of their outer HI component are shaped by galaxy collisons, mergers or tidal interactions.

One of the best resources for seeing the peculiar HI distributions in galaxies is the "HI Rogues' Gallery" compiled by Hibbard et al. (ASP Conf. Ser., 240, 659, 2001). This collection of images shows extended gas envelopes around some normal and peculiar galaxies, tidal tails/bridges in interacting or merging galaxy systems, large-scale rings around early type galaxies, and detached clouds at varying distances from associated galaxies.

Numerical simulations to study what happens to tidal debris over a long period of time have shown that a large fraction of the ejected HI gas will fall back onto the parent galaxy. The closest material falls back fastest, while more distant debris returns more slowly to accrete at larger distances from the galaxy centre. The simulations show that there is sufficient time for the slowly-returning material and any escaped gas to form bound entities and, potentially, stars. Some of these star-forming clumps may build new galaxies, such as tidal dwarf galaxies.

Some galaxies have very large HI envelopes extending way beyond their stellar distribution. The extended gas distributions show many different structures ranging from smooth disks to chaotic extensions. Because of their large extent, the outer neutral hydrogen disks are much more affected by tidal interactions than the stellar disks and are therefore an excellent tracer of the tidal forces. Collisions of galaxies with extended HI envelopes lead to large HI extensions, tails and bridges which can be found out to large distances from the galaxy centre. Recycling and re-accretion of these distant debris are important for the evolution of these systems.

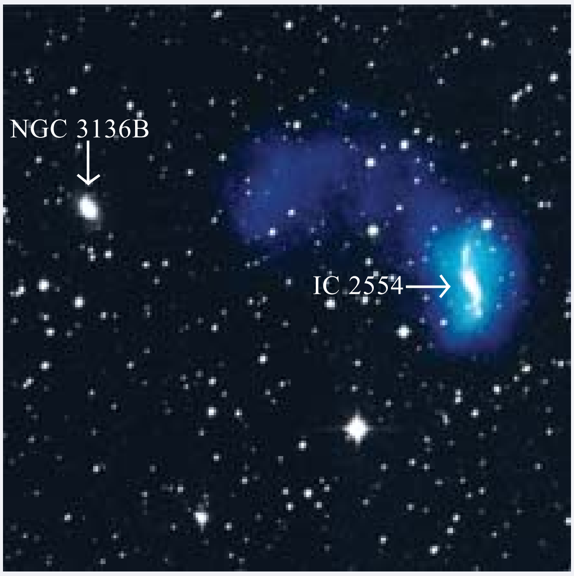


Figure 23 A Compact Array image showing the HI distribution (blue) towards the spiral galaxy IC 2554, shown overlaid on a 2MASS near-infrared (K-band) image. The large, one-sided HI plume emanating from IC 2554 possibly results from tidal interactions with a massive, elliptical galaxy NGC 3136B which is located approximately eight arcminutes to the east.
Image credit: B. Koribalski (ATNF), S. Gordon (UQld) and K. Jones (UQld).

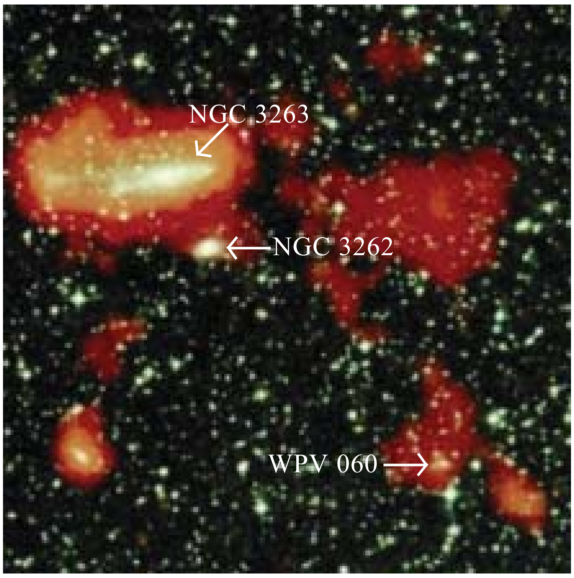


Figure 24 A Compact Array image of HI distribution (red) towards the peculiar galaxy NGC 3263, shown overlaid on a Digitized Sky Survey optical image. The spectacular HI plume to the west and south-west of NGC 3263/2 extends over approximately 175 x 200 kiloparsecs. The dwarf galaxy WPV 060 coincides with a peak in the southwest of the HI plume.
Image credit: J. English (UManit), B. Koribalski (ATNF) and K. Freeman (RSAA).

Figures 23 – 25 show Compact Array images that illustrate some excellent examples of peculiar and/or interacting galaxies. These have extended HI bridges or plumes that do not appear to have any stellar content. Figure 23 shows a one-sided, diffuse HI cloud near the peculiar spiral galaxy IC 2554 which lies at a distance of approximately 16 million parsecs from the Milky Way. The prominent plume emerging to the east of this galaxy is possibly caused by an interaction with the massive elliptical galaxy NGC 3136B. The plume has an extent of about 30 kiloparsecs and contains about a third of the total HI mass of the system (2 x 10^9 solar masses).

Figure 24 shows the HI distribution towards the peculiar spiral galaxy NGC 3263. This is a member of the NGC 3256 galaxy group at a distance of 37.6 million parsecs. Extended HI emission is seen around the galaxy itself, while a spectacular HI cloud of size approximately 175 x 100 kiloparsecs is seen to the west (right) of the galaxy. This cloud has an HI mass of approximately 10^9 solar masses. The dwarf galaxy WPV 060 which appears to be associated with an HI peak towards the south-western end of the cloud, could be a young galaxy formed out of the far-reaching tidal debris.

Detached HI clouds have been seen in many galaxy groups. These may constitute the gaseous material ejected furthest from the host galaxy and now disconnected from gas that has already returned. Figure 25 shows a spectacular example of this process. The HI distribution reveals a two-stranded bridge that spans the space between the galaxies NGC 6221 and NGC 6215, over a projected distance of nearly 100 kiloparsecs. The bridge has an HI mass of at least 1.4 x 10^8 solar masses. The NGC 6221/15 group also contains three HI-rich dwarf galaxies, one of which (Dwarf 3) is indicated in the inset of Figure 25.

The only intergalactic HI gas cloud detected in the HIPASS Bright Galaxy Catalog lies at a projected separation of 250 kiloparsecs from the galaxy NGC 2442 (distance = 15.5 Mpc) which is part of a loose group of galaxies. The cloud, HIPASS J0731-69, for which no optical counterpart has been detected, has an HI mass of 10^9 solar masses.

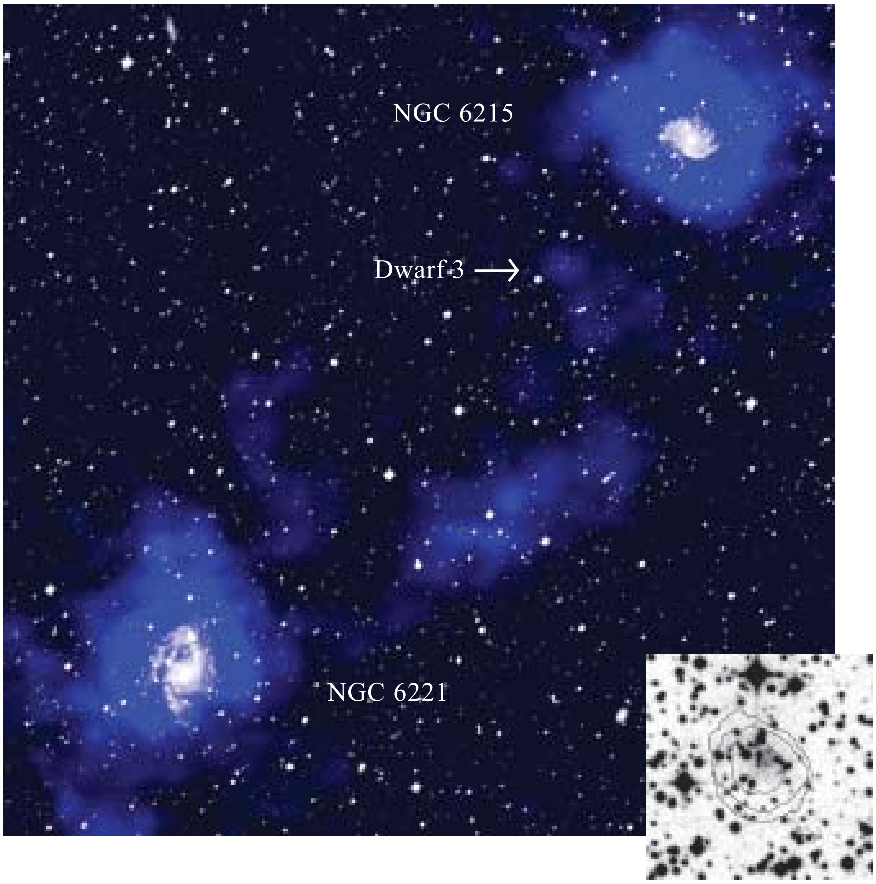


Figure 25 A Compact Array image of the HI distribution (blue) within a velocity range of 1490 to 1510 kilometres per second towards the interacting spiral galaxies NGC 6221 and NGC 6215 overlaid on a Digitized Sky Survey optical image. The narrow velocity range was chosen to emphasise a faint two-stranded HI bridge which probably resulted from NGC 6215 colliding with the outer HI disk of NGC 6221. The inset at the bottom right shows a close-up of Dwarf 3 which may have formed out of the debris.
Image credit: B. Koribalski (ATNF) and J. Dickey (UMinn).

Observatory reports

Australia Telescope Compact Array

Upgrades and developments

The primary development focus at the Compact Array for a number of years has been to upgrade the array to operate at high frequencies with two new observing bands at wavelengths of 12 and 3 mm. During 2003 many components of this upgrade process were completed. The millimetre systems are expected to be fully completed in 2004.

The 12-mm systems upgrade

The upgrade of the Compact Array for observations at 12 mm is now complete. During shutdowns in April and June 2003, new millimetre receiver packages containing the 12-mm systems were installed on antennas 1, 5 and 6, while interim 12-mm systems on antennas 2, 3 and 4 were upgraded. At the same time, installation of a high frequency local oscillator system was completed. This has broadened the accessible spectrum at 12 mm to 16 – 25 GHz. Tuning across the spectrum is now completely under computer control (previously a simple hardware change needed to be performed at each antenna). Fringes on all baselines were achieved on 16 April, and the first observation of ammonia lines at 12 mm was taken on 23 April. Common user access to the new 12-mm systems was provided immediately after the shutdown periods. This proved highly successful, with the systems producing good science within days of their installation.

New stations and array configurations

The millimetre upgrade included the construction of five antenna stations on a new 214-m long north spur line, and the addition of four new antenna stations on the main east-west track. These provide more effective compact array configurations and allow a reasonable Fourier coverage to be achieved in less than 12 hours. This is important for 3-mm observations as sources can be observed while they are still high in the sky. The north spur substantially improves the imaging capability for compact configurations for sources between DEC = 0° and -30°. For 3-mm observations, the Compact Array is now the best radio array in the world for observing sources south of the celestial equator.

In 2003 the last remaining new station was christened and the station upgrade program completed.

Antenna control system and on-line observing system

A major part of the millimetre upgrade has been a project to replace the computer hardware at the antennas, upgrade the communications infrastructure from the antennas to the control building, and rewrite the control and communications software in a modern language. A new system was required to support the new receiver packages and to remove limitations imposed by the previous antenna control system. The antenna control system upgrade was completed in May 2003.

The new antenna control system is quickly repaying the significant investment made in it. Apart from being far more reliable and easier to maintain, the system allows for new methods of monitoring and controlling the antenna systems. This has made new observing approaches possible and provided a greater understanding of the functioning of the antennas. This has allowed some long-standing problems to be understood and addressed.

Another major computing upgrade, still in progress, is for the on-line observing and monitoring systems. These systems have been based on VAX/VMS computers since the opening of the Compact Array. With ageing hardware that is expensive to maintain, upgrading these systems to a PC/LINUX-based environment is a priority. The monitor system also needs to be enhanced to exploit the power of the new antenna control computers. The new observing and monitoring systems are now being developed with the first successful observations achieved in September 2003.

Signal distribution upgrade

The completion of the local oscillator and antenna control systems upgrade, and the prior completion of the data return upgrade, means that essentially all communications infrastructure between the antennas and control building is now on single-mode optical fibre. The single-mode fibres have a much greater capacity than is currently used and are a strategic investment in future wideband upgrades of the array.

The only communication channels to the antennas not on fibre are the telephone lines and some "primary monitor" signals used as failsafe indicators of the basic health of the antennas.

Antenna structure

At 3-mm wavelength the reflecting surfaces of the antennas need to be accurate to tolerances that are ten times smaller than required at 3 cm. Two effects need to be attended to in order to maintain good beam efficiency and beam shape: firstly the main panels must be set to the good tolerance while secondly, account must be made of the change in the gravitational deformation of the antennas as a function of elevation. The deformations of interest include changes to the main dish shape as well as movement of the subreflector and receiver package.

During telescope shutdowns in April and June, holographic surveys and panel adjustments were performed on all antennas other than antennas 2 and 6 (similar work was performed on antenna 2 in December 2002). This improved the alignments of the panels to a surface accuracy (rms) of 0.16 mm.

Following photogrammetric analysis performed in 2002, a project was initiated to allow two-axis adjustment of the subreflector. This is to maintain good antenna efficiency and beamshape where gravitational distortions are present.

During early 2003, during a structural check of the antennas, small cracks were discovered in a structural part of several antennas. These cracks probably developed over several years. During the year, the cracks were repaired and the parts strengthened on all antennas during the shutdowns. Additionally the shutdowns were used to overhaul the elevation gearboxes on all antennas.

Operations

The millimetre observing season of 2003 (May to October) was the second year where common user observations were taken using the 3-mm systems on three antennas, and the first where the full 12-mm system was available. Given the number of new systems that were installed during 2003, and the swiftness of bringing them into common use, there was some trepidation that teething problems might cause the downtime to increase significantly. Happily the reverse happened, with successful astronomical observations and little downtime.

The Compact Array in a compact configuration
Photo: © David Smyth

Averaged over the entire year, the fraction of observing time undertaken at 12- and 3-mm wavelengths was 18% and 8% respectively. Approximately half of all projects scheduled during the millimetre season used the millimetre receivers. Not surprisingly the amount of 12-mm observing increased markedly in 2003, whereas the 3-mm use remained constant (in 2002 the fractions were 7% and 8% respectively).

Visitors

In addition to astronomers and the general public, the Observatory regularly receives professional visitors. A highlight of the year was a visit in February from the Minister for Science, Peter McGauran, and a group of his staff. The Minister visited an antenna vertex room, walked on an antenna surface, talked with Narrabri High School students working with the SEARFE project and toured the Control Building.

At the time of the IAU General Assembly, the Observatory encouraged a number of groups and individuals to visit the Compact Array as part of their stay in Australia. Approximately 70 professional astronomers attending the IAU visited the Observatory in July 2003. Many of these astronomers do not work in radio astronomy and had little knowledge of the Observatory before their visit.

Each year the Observatory's "work experience" program hosts several high school students for a week. The Observatory also hosts a smaller number of undergraduate students in the final years of their science or engineering degrees. These students stay for longer periods and become involved in projects of value to the ATNF. During 2003, the Observatory hosted Nicholas Ebner, Marija Vlajic and David Jones. Nicholas studied the frequency dependence of the illumination pattern of the antennas at 12 mm, Marija worked on the halos of edge-on spirals and David worked on high-resolution imaging of a class of extended radio galaxies.

Synthesis Imaging Workshop

The sixth ATNF Synthesis Imaging Workshop was held at the Observatory on 12 – 16 May 2003. The workshop had a greater focus on millimetre-wavelength astronomy than in previous years. Prior to the new millimetre facilities at the Compact Array, the Australian astronomical communities involved in radio interferometry and millimetre-wavelength astronomy involved distinct groups; the Synthesis Workshop serves an important role in bringing them together.

In addition to "traditional" lectures on interferometric techniques and lectures on scientific topics, practical sessions were held where students were able to use the Compact Array and practise data reduction. There were 70 participants in total, of which about half were presenters. Of the non-presenters, two-thirds were postgraduate or undergraduate students and approximately half had no previous experience with radio astronomy or synthesis data.

The Minister for Science, Peter McGuaran, with ATNF staff and Narrabri high school students at the Narrabri Observatory. From left to right: Ray Norris, Vikram Ravi, James Tolson, Peter McGauran, Bob Sault, Brian Boyle and Michelle Storey
Photo: © CSIRO

Staff

The number of staff at the Narrabri Observatory and the mix of expertise remained largely unchanged during the year. A systems scientist, Mopra operations scientist and a postdoctoral fellow joined the observatory early in the year. These, in part, made up for departures in 2002. At the end of the year Brett Hiscock was appointed as Deputy Officer-in-Charge. Brett was previously the head of the Electronics Group at the Observatory and brings to the position a wealth of experience leading large groups of engineers and technicians.

A group of IAU delegates on a visit to the Narrabri Observatory
Photo: © CSIRO

Ravi Subrahmanyan with invited speaker Rick Forster (University of California, BIMA) at the Narrabri millimetre synthesis imaging workshop.
Photo: © CSIRO

Mopra

Development

New developments for the Mopra radio telescope are closely tied to those at the Compact Array. In some cases, the Mopra telescope is used as a testbed for new technology, whereas at other times, technology is first used at the Compact Array and then transferred to Mopra. This synergy is well illustrated by two major developments currently underway at Mopra: a new 3-mm wavelength receiver package and a new 8-GHz correlator. While the millimetre receiver package will duplicate much of the design of the Compact Array systems, it is hoped that it will contain the next generation of low-noise amplifiers with improved performance. The 8-GHz filterbank reuses some of the design of the Parkes wideband correlator, but also uses technology that will be used for a wideband Compact Array correlator. Both these systems are in a development stage with completion due in 2004.

Other significant developments during the year included the adjustment of the subreflector to reduce a coma-lobe problem, the readjustment of the antenna surface to improve the surface accuracy to approximately 0.16 mm, and some improvements in the tuning software.

At the end of the millimetre observing season, the antenna control system successfully installed at the Compact Array was also installed at Mopra. The first spectrum, taken using the new Mopra antenna control computer was obtained in late November. Work also began on the development of a mapping package to improve the efficiency of the telescope.

The Mopra radio telescope
Photo: © CSIRO

Operations

In 2003 Mopra was again operated in partnership with the University of New South Wales. As in 2002, the use of Mopra was restricted to Very Long Baseline Interferometry (VLBI) and millimetre observations. VLBI observations were taken as part of the Long Baseline Array (LBA), for a total of 21 days. In previous years, Mopra has been used to take data for the VSOP project, a Japanese-led space-VLBI experiment. However a failure in the VSOP spacecraft caused the cancellation of most VSOP observing during 2003.

The Mopra millimetre observing season was scheduled from 2 June – 7 October 2003. Millimetre single-dish observations were taken using the 3-mm SIS receiver system. A total of 59 days were allocated by the ATNF Time Assignment Committee as National Facility time. An additional 53 days were allocated to the University of New South Wales.

As in previous years a two-day workshop was held at Mopra at the start of the observing season. This so-called "Mopra Indoctrination Weekend" aimed at introducing observers to the facilities and to the use of the telescope. Nine people took part in this workshop in 2003.

Support for Mopra was enhanced in 2003 by the appointment of a Mopra Operations Scientist. Although based in Narrabri, this position requires significant presence at Mopra during the observing season. The technical improvements to the telescope and higher level of support led to a signficiant improvement in Mopra's productivity.

Engineering support for Mopra continued to be provided by Narrabri staff with some additional support from engineering personnel at the Anglo-Australian Observatory.

Parkes

NASA tracking agreement

An agreement between NASA and CSIRO to provide tracking support at Parkes commenced in earnest in 2003. The support was intended to assist NASA's Deep Space Network (DSN) during their "Asset Contention Period" over the New Year period 2003/2004, during which time the DSN was heavily subscribed with many simultaneous deep-space missions, most notably those to Mars.

The agreement was for three principal items to be delivered by ATNF: an upgrade to the surface of the Parkes 64-m radio telescope; a new cryogenically-cooled receiver, including feedhorn, for 8.4-GHz observations designed specifically for the project, and, thirdly, approximately 1000 hours of tracking time on the Parkes telescope itself. The total value of the contract was approximately A$3M.

The upgrade to the antenna surface was undertaken during March and April 2003, and involved removal of half the remaining coarse steel mesh panels, beyond a diameter of 45 metres, and replacing them with precision panels of perforated aluminium sheet, out to a diameter of 55 metres. The laborious process of removing the 360 old panels and installing new panels, all by hand, was undertaken by staff from Sydney Engineering, the manufacturers of the panels, supervised and assisted by ATNF staff. The repanelling took approximately five weeks, with another week for final alignment and testing. Holography at 12 GHz was used to fine-tune the panel adjustment. The results were excellent, with a surface precision (rms) of 0.8 mm achieved over the 55-m diameter inner surface, completed within budget and on time.

This upgrade to the antenna surface yields an improvement in efficiency of approximately 30% at 8.4 GHz, and potentially greater yields at frequencies up to 26 GHz, once appropriately redesigned feeds become available.

The new 8.4-GHz receiver was designed and constructed by the Marsfield receiver group and commissioned on the telescope in August. The receiver employed some novel features designed for the lowest possible system temperature, and ultimately exceeded this specification by a considerable margin, with an on-sky system temperature of 25 Kelvin. Together with the surface upgrade, the telescope is now about two and a half times more sensitive at 8.4 GHz than before the upgrade, a new capability which will be of great value, particularly within the Australian VLBI network.

Tracking operations began smoothly in September, after installation and testing of telemetry and network equipment by personnel from the Canberra Deep

ATNF operations scientist, John Sarkissian, in the Parkes control room during NASA tracking.
Photo: © John Sarkissian

Space Communications Complex, Tidbinbilla. Daily tracking support of six – eight hours began in October, scheduled to run until mid February 2004.

The agreement with NASA drew much favourable press coverage, particularly of the official opening of the tracking operations on 31 October by the US Ambassador to Australia.

Double pulsar

The discovery at Parkes of the first double-pulsar system was published in Science Express in January 2004, following closely on a publication in Nature in December 2003 of the detection of the first pulsar in this close binary system, also made at Parkes. The discovery of the double pulsar is exciting for several reasons, including the possibility of new tests of gravity, and the chance to probe deeply into the immediate environments and emission mechanisms of pulsars. The discovery attracted favourable press coverage both within Australia and for the several international groups collaborating in the discovery (page 19).

Performance and time use

The percentage of time scheduled for astronomy in 2003 was significantly lower than in previous years (64.5% of all time, compared to 82.0% in 2002). This drop was due to a one-month shutdown to install the new surface under the NASA contract, and to the time scheduled for NASA tracking itself. (In addition to the 64.5% scheduled time, a significant quantity of time requested and paid for by NASA as 'hot-standby' time was picked up for astronomy, though often at relatively short notice).

Performance statistics for the NASA tracking were very good, with only 2.8% of scheduled time lost (mostly to high wind). The figure for all scheduled operations in 2003 was 5.1% of time lost, comprising 1.3% lost to equipment faults and 3.8% lost to high wind. These figures are very similar to those for 2002. As expected, the repanelling of the 64-m surface has not measurably increased the susceptibility of the telescope to high wind.

User feedback

The web-based fault reporting and user-feedback system continue to serve critical roles in monitoring and maintaining Observatory performance levels. A healthy increase in the number of user responses in 2003 again confirmed generally excellent scores across most categories. Radio frequency interference (RFI) remains the area of greatest concern with users.

Multibeam refurbishment

The 21-cm multibeam receiver was removed in October 2003 for replacement of all 26 low-noise amplifiers (LNAs), to return it to original (or better) performance specifications. The receiver had run essentially non-stop for seven years, a testament to the quality of its design and construction. It is planned to return it to service as soon as possible in 2004 for HI imaging, further pulsar surveys, and numerous other projects which require it.

New 10/50-cm receiver

A new 10/50-cm dual-frequency receiver, designed and built by staff of ATNF and CTIP, at the Radiophysics Laboratory in Marsfield, was successfully commissioned in October 2003 with assistance from Observatory staff. The receiver was immediately put to good use observing the newly-discovered relativistic binary pulsar system J0737-3039 (page 19).

The new receiver is designed primarily for precision pulsar timing measurements, a field in which Parkes Observatory currently holds a pre-eminent international position. The receiver will also be used for pulsar searches, mainly for observations at a wavelength of 50 cm, though the task of avoiding RFI in this band is becoming increasingly onerous. The arrival of the new 10/50-cm dual-frequency receiver coincided with a further degradation of the RFI environment in the 50-cm band due to the rollout of Digital TV services.

RFI mitigation

Significant resources continue to be committed in this area across the ATNF, addressing the problem on several parallel fronts including advanced software excision techniques using reference antennas, regulatory protection and local mitigation measures such as shielding.

Site

A major renovation of the Parkes Observatory access road, at a total cost of A$1.2M, is about to begin. The road has deteriorated badly over the last few years, and, with the increasing number of visitors to the Observatory, has become a serious hazard. Parkes Shire Council has committed 50 per cent of the funding required from its Federal "Roads to Recovery" funding allocation. CSIRO Corporate Property will fund the remaining 50 per cent of the cost of reconstructing 2.5 km of the road most in need of repair during 2004/2005.

The Australian Long Baseline Array

The Australian Long Baseline Array operates as a VLBI array using 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, in particular the Hartebeesthoek antenna in South Africa, the Kokee Park antenna in Hawaii and the Kashima antenna in Japan.

Operational support

In 2003, casual operators were employed for the LBA correlator. The operators succeeded in correlating all observations between sessions, as well as making significant progress in correlating some of the backlog of earlier LBA observations. This has allowed the reuse of many VCR tapes. With the addition of about 1000 surplus Canadian tapes from the Penticton correlator at the Dominion Radio Astrophyscial Observatory, the tape stock of unrecorded tapes is now sufficient to obviate the need to acquire any new VCR tapes.

The University of Tasmania saw the official retirement of Professor Peter McCulloch, who has been instrumental in the development of the LBA. However, Professor McCulloch will continue some involvement with the observatories and the LBA. The ATNF agreed to assist the Tasmanian group with Ceduna operations and supported one session in 2003. In late 2003 an arrangement was set up for the Ceduna antenna to be supported by a local operator from 2004. Operating the Ceduna telescope is now straightforward and reliable.

Work in progress to replace some of the panels on the surface of the Parkes radio telescope, in preparation for the NASA Mars tracking program.
Photo: © Tim Ruckley

VSOP

The VSOP satellite operated only intermittently in 2003. Altitude control of the spacecraft was lost in January 2003 and operations did not resume until August. Control was lost again in October and was not recovered again before the end of the year. In August 2003, the Dominion Radio Astrophyscial Observatory ceased providing correlation support for VSOP and correlations have since been done at Mitaka in Japan.

The main VSOP program in 2003 was the mission-led survey of active galactic nuclei, with Mopra, Hobart and Hartebeesthoek as the main ground-based antennas. The observations typically involved one or two short tracks of up to six hours per week during the short periods of VSOP operation.

Technological developments

New technologies for VLBI are under development world-wide, with implications for the future of the LBA. A one-day meeting was held at the ATNF in March 2003 to review the LBA status and discuss possible future developments.

An important overseas development was the adoption of disk-based recording systems to replace tapes, increasing the bandwidth and reliability. Some tests were carried out to implement network transfers of the data, potentially leading to direct connectivity without recorders (e-VLBI).

The Hobart antenna was converted to a Mk5a disk system for its astrometry observations. Tests were done on the LBA with disk-based systems provided by the Swinburne University of Technology. Data were recorded at Parkes and the Compact Array, transferred slowly over the internet and correlated on the Swinburne supercomputer. "First fringes" were detected on the Vela pulsar in November 2003.

The LBA also participated in worldwide network tests for e-VLBI, led by the Haystack observatory. A

permanent connection was provided at ATNF. The network tests are continuing.

Proposals and scheduling

Proposal demand for the LBA in 2003 was strong, with an effective oversubscription rate of 1.9, similar to previous years. A significant amount of time was allocated to the ATNF-USNO astrometric program.

Access to the Tidbinbilla facilities for LBA observations, especially for the large and sensitive 70-m antenna, remained difficult. However, in 2003 the ATNF-USNO astrometric program established a new agreement for regular access to the 70-m antenna and the first observations under this agreement were taken in August 2003. The VLBA program SCHED was adopted as the recommended scheduling program for the LBA, and this has become the standard scheduling program for all VLBI networks worldwide. A set of templates and examples for common LBA modes was also provided to assist users. These developments will facilitate VLBI scheduling.

The LBA scheduler changed in 2003. After more than a decade of scheduling the LBA, John Reynolds passed this responsibility to Jim Lovell.

Operations

There were four major LBA observing sessions in 2003, the usual one-week sessions in February and November and two shorter four-day sessions in June and August. The August session was severely affected by strong winds at multiple sites and many of the projects had to be repeated.

Tidbinbilla spectroscopy

Starting with the 2003 January term, time allocated to ATNF at the Tidbinbilla 70-m antenna was made available as a National Facility for single-dish observations. The time, provided under a Host Country agreement with NASA, was used in a service observing mode for spectroscopic observations.

The 70-m antenna is equipped with 1, 3, 13 and 18-cm receivers. In particular the 1-cm system is the most sensitive in the southern hemisphere, covering 18.0 to 26.5 GHz at a system temperature of 60 Jy. Tidbinbilla is equipped with an ATNF multibeam correlator block capable of two polarisation products, with up to 2048 channels, each with 32 or 64 MHz bandwidth, or up to four polarisation products with a total of 8192 channels and bandwidth of 16 MHz or less.

In 2003 a total of 320 hours were available for spectroscopy observations. Of that, 62 hours were used for test observations, 36 hours were lost due to hardware problems or weather and 222 hours of observations were successfully completed for 8 proposals. The times available for service observations in 2003 were generally restricted to times when Mars was below the horizon, due to the high priority given by NASA to Mars tracking. Unfortunately, Mars was close to the direction of the southern Galactic plane for most of 2003. As the majority of proposed targets were Galactic the observing efficiency was low. It is expected that this situation will improve as Mars moves away from the Galactic plane direction. The oversubscription rate during 2003 was approximately 2.0.

General activities

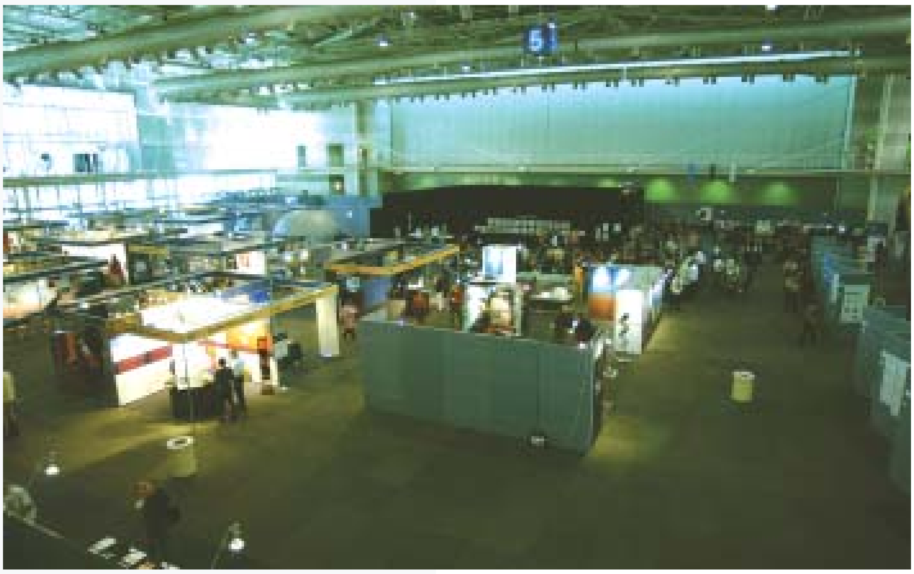
IAU GA 2003

The 25th General Assembly of the International Astronomical Union (IAU GA) was held during 13 – 26 July at the Sydney Convention and Exhibition Centre (SCEC) in Darling Harbour. The Assembly was hosted by the National Committee for Astronomy of the Australian Academy of Science, together with the Astronomical Society of Australia. The local organisation was managed by a National Organising Committee, co-chaired by Dr John Whiteoak (ATNF) and Professor Harry Hyland (James Cook University). Much of the local organisation, including registration and accommodation bookings, was contracted to a professional meetings management organisation, ICMS Australasia Pty Ltd.

The meeting was generously supported by two major sponsors, CSIRO and Connell Wagner and by grants from the Australian Federal Government. In addition, AARNet and GrangeNet provided support for the internet traffic, the Gruber Foundation provided support for the Opening Ceremony, and Sydney's Lord Mayor provided a welcome reception. The UNSW, Donovan Trust and British Council supported some of the associated events. Significant travel grant support for participants was provided by the European Southern Observatory and NASA in addition to the IAU travel grants.

The GA was attended by more than 2000 IAU members, invited participants and other guests who came to Australia from at least 65 countries. A spectacular opening ceremony was held at the Opera House on 15 July 2003. The ceremony included an organ recital by Australia's chief scientist Robin Batterham and the formal presentation of the Gruber cosmology prize to Rasheed Sunyaev (Space Research Institute, Russian Academy of Sciences, Moscow). The closing ceremony was held on 24 July, during which Professor Ron Ekers became the IAU President for the period 2003 – 2006.

The scientific meetings held during the IAU GA included six Symposia, 21 Joint Discussions, four Special Sessions, including one on Education, three invited discourses and numerous working group and ad-hoc meetings. In addition, at least 1,300 poster papers were on display throughout the meeting. Scientifically, the Assembly was an outstanding success. Those attending the General Symposia were treated to excellent talks and meetings, Sydney's best weather and an excellent venue. Locals and visitors renewed old acquaintances, met new people and formed new collaborations. The General Assembly was also an excellent place to showcase Australian astronomy. Many ATNF staff were involved in the organisation of the scientific programs. Four of the symposia had



The IAU Astro-Expo at the Sydney Convention and Exhibition Centre in Darling Harbour
Photo: © Shaun Amy

ATNF co-chairs or SOC members (IAU216 Maps of the Cosmos; IAU217 Recycling Intergalactic and Interstellar Matter; IAU218 Young Neutron Stars and their Environments; IAU220 Dark Matter in Galaxies).

Two different Special Sessions on the history of radio astronomy were held during the GA. These were organised jointly by Commissions 40 (Radio Astronomy) and 41 (History of Astronomy). A one-day meeting featured poster and oral papers about Australian radio astronomy, 1945 – 1988, presented mainly by retired radio astronomers from Australia and overseas. An additional half-day event on "Pioneering Observations in Radio Astronomy" included papers on early radio astronomy developments in Australia, France, Japan, Russia and Sweden, and presentations about the "founding father" of radio astronomy, Grote Reber, and the first two female radio astronomers, Elizabeth Alexander (NZ) and Ruby Payne-Scott (Australia). ATNF staff co-chaired the Organising Committees of both meetings.

Other activities during the GA included an "Industry Day" and an "Astro-Expo". The Industry Day was funded by the Commonwealth Department of Industry, Tourism and Resources. This was a one-day workshop, attend by 125 representatives from 75 organisations. Presentations on the needs for future astronomical instrumentation, and opportunities for industry, were made by an international group of IAU participants. The Astro-Expo was available to both participants and the general public; it contained 45 individual displays, including one showcasing the ATNF's work. Part of the exhibition was an "Australia Pavilion", aimed at presenting Australian science to an international audience. It was funded by a grant for international showcasing from the Commonwealth Department of Education, Science and Training.

Many outreach activities were held in association with the IAU GA. The "Festival of Astronomy" provided a month-long program of public events that included a series of public talks, a Schools' Day, a Teachers' Workshop Day and "Science in the Pub". The website for the Festival of Astronomy was provided by the ATNF. The "Astronomy on the Go" program, organised by the UNSW, toured more than a dozen schools in regional NSW as well as several schools in Sydney.

The Descedance dance group performing in the Sydney Opera House at the Opening Ceremony of the IAU General Assembly.
Photo: © Vincent McIntyre

The ATNF oversaw the operation of the press room at the meeting – the main point of contact with the media. Working with the home institutions of researchers attending the meeting, eleven media releases were issued highlighting science results and other significant developments. Sheets of media highlights were presented to the media, culled from the programs of the meeting's symposia and joint discussions and potential interviewees, picked for their media attractiveness. Sixteen press room staff – mainly university students studying public relations and related fields – worked in shifts to answer phone queries, schedule face-to-face interviews, accompany visiting television crews, and act as "runners" to retrieve delegates from the individual sessions.

Two hundred and ten media stories were identified that related to the Assembly or the science discussed. More than 80% appeared in print or on the web; slightly less than half of the stories recorded (94) came from Australian media outlets.

The public relations goals for the meeting included raising the Australian public's awareness of Australia's past and present standing in world astronomy, and updating the public's knowledge of how astronomy is practised; and, for Australian "opinion formers", to present astronomy as one of Australia's most successful and technologically innovative sciences, and to emphasise the benefits of Australia's participation in large international ventures such as the SKA or Extremely Large Telescope projects. The media coverage focussed on the "straight" science being presented at the meeting; nevertheless, the coverage of the SKA and ELTs, the science stories originating in Australia, and of the meeting as a whole, gave a positive picture of the state of astronomy in Australia.

The ATNF also oversaw the production of the in-house conference newspaper, *The Magellanic Times*. This appeared every week day of the Assembly, informing delegates of changes to the program and official announcements from the IAU, and highlighting interesting people and projects. Delegates were so keen to contribute material that the newspaper ran to eight tabloid pages a day. The Editor, Seth Shostak, and graphic artist, John Tierney, were housed in the press room, and were able to call on the press room staff to interview delegates and report on sessions – experience that the student workers enjoyed.

One aspect, coordinated by ATNF staff, that contributed to the overall success of the IAU GA was the provision of a comprehensive data communications network throughout the SCEC. Reliable and high performance networking is a necessity at any major conference involving the physical sciences.

The network was configured and tested at the CSIRO Radiophysics Laboratory during the week leading up to the IAU GA. With the assistance of the SCEC Network Manager, David Tattersall, a small group of ATNF, CTIP and CMIS staff and a few student volunteers, deployed the bulk of the network over the course of a very long Sunday. The network consisted of many kilometres of fibre optic cable and unshielded twisted pair cabling. Around 15 ethernet switches were interconnected using Gigabit ethernet with each switch providing numerous switched 100Mbit/s connectivity to various locations throughout the venue such as the Internet cafe, meeting rooms, media centre and the exhibition floor.

For the first time at an IAU GA a wireless communications network was provided. Using nine access points and a variety of antennas, distributed throughout the main areas of the SCEC, around 120 users could be simultaneously connected to the network from their wireless-enabled laptop computers and hand-held devices. As well as reducing demand on fixed terminals, this technology enabled conference delegates to access network resources from various locations in and around the conference and exhibition areas. Feedback received suggested the provision of the wireless network was a resounding success.

In addition to the impressive network installed throughout the venue, a Gigabit ethernet link was provided to connect the IAU GA to the Internet. This high-bandwidth wide-area link enabled real-time demonstrations of technologies such as grid-based computing and access to multiple astronomical databases using Virtual Observatory tools.

Astrophysics group

Astrophysics events

Whilst the major focus of the year was the IAU General Assembly and the associated scientific symposia, several other astrophysics events happened during the year to which the ATNF was able to contribute. These included a workshop on the Low-Frequency Universe at the University of Sydney, a joint AAO/ATNF symposium at Mount Stromlo, the sixth Synthesis Imaging Workshop at Narrabri, the Annual Student Symposium, a workshop on the Variable Radio Universe workshop, held at Parkes to mark the occasion of Dave Jauncey's 65th birthday, an International SKA workshop in Geraldton, the Third Annual Millimetre Science workshop and an "Astrofest" at the end of the year.

Staff

Several postdoctoral positions at the ATNF are shared appointments with other institutions. In 2003 two new postdoctoral appointments were funded through a new ARC/CSIRO scheme – Virginia Kilborn (Swinburne/ATNF) and Tony Wong (UNSW/ATNF, formerly a Bolton Fellow) – while Nina Wang's continuing postdoctoral appointment is shared with the University of Sydney. Mark Walker left his joint ATNF/University of Sydney fellowship to be supported entirely by the University, though he remains a frequent visitor. D.J. Pisano will remain at the ATNF as a postdoctoral fellow for a further year, his two-year tenure as a NSF MPS Distinguished International Postdoctoral Research Fellow having concluded.

Other term appointments in 2003, for staff with an astrophysics background but with a different primary functional area, were Michael Dahlem and Maxim Voronkov at Narrabri and Carole Jackson and Tara Murphy in Marsfield.

The appointment of two Federation Fellows in 2003, Ron Ekers and Dick Manchester, is a significant boost for astrophysics research at the ATNF. Ron and Dick will lead two highly focused research groups in the respective areas of: (1) high-redshift star formation, SKA and interference mitigation; and (2) precision pulsar timing.

Visitors program

The IAU General Assembly provided an opportunity for many of the world's astronomers to visit Sydney in 2003. Some of these were able to spend some time at the ATNF and other institutes in Australia, increasing our usual number of visitors. Under the auspices of the Distinguished Visitors scheme, it was a pleasure to host visits during the year from Joe Taylor (Princeton University, USA), V. Radhakrishnan (Raman Research Institute, India), Rajaram Nityananda (National Centre Radio Astrophysics, India), S. Ananthakrishnan (Giant Metrewave Radio Telescope, India), Ken Kellermann (National Radio Astronomical Observatory, USA) , Jayanne English (University of Manitoba, Canada), Ned Ladd (Bucknell University, USA), Brent Tully (Institute for Astronomy, Hawaii), Namir Kassim (Naval Research Laboratory, USA), John Dickey (University of Minnesota, USA), Don Melrose (University of Sydney), Arnold van Ardenne (ASTRON, The Netherlands), Bill Imbriale (Jet Propulsion Laboratory, USA), Dan Stinebring (Oberlin College, USA) and Esko Valtaoja (Tuorla Observatory, Finland).

Marsfield scientific computing group

The Marsfield scientific computing group provides scientific computing and information technology (IT) support for National Facility users. The IT infrastructure is managed by the CTIP computer services group (CSG) and many IT services are contracted to the CSG.

The group was lead by David McConnell from January – June 2003. Following a secondment to CTIP, Neil Killeen resumed the leadership role from July 2003.

Information technology

The open-source operating system Linux is used at the ATNF in a variety of systems. In 2003 the ATNF continued to invest in scientific Linux systems, using the Debian distribution, mainly for its excellent maintenance tools. The ATNF now has a tailored Linux system that can be installed on a range of systems in a uniform way. For desktop systems, a good working environment is now available. For laptops, it is more difficult to provide a stable working environment because laptop hardware evolves very rapidly.

IT in CSIRO continues to evolve towards a centralisation of services and management. CSIRO is preparing a One-IT development plan in which IT resources across the organisation are expected to be used more effectively. ATNF is an active participant in the planning processes.

In 2003 the computer networks at Parkes and Narrabri were renumbered to be consistent with the rest of CSIRO in New South Wales. This change enabled a better separation of online and offline systems, with improved security.

Virtual Observatory software

Over the last decade astronomy has changed into a data-rich discipline. To be able to manage, analyse and make sense of the large volumes of data now flowing from telescopes, new data handling paradigms are needed. The ATNF is a founder-member (2002) of the Australian Virtual Observatory (Aus-VO), which in turn is a member of the International Virtual Observatory Alliance (IVOA). Aus-VO is contributing to the effort to provide a distributed, uniform interface to data, and specifically to the data archives of Australia's major astronomical observatories. In November 2003 the ATNF hosted the second Aus-VO workshop and this proved very successful. ATNF staff also attended IVOA conferences.

Two VO software projects were started in 2003. The first project, funded through an ARC grant, is for a "Remote Visualisation Server (RVS)". This distributed (CORBA) system takes an image in "FITS" format and transfers it to a server. The image is then processed by the AIPS++ Display Library on the server and displayed on the client's desktop. In 2003 a prototype RVS was successfully developed and it is expected that this will be in use for various image archives in 2004.

The second VO project, funded through CSIRO Emerging Science, is a collaboration between the ATNF and the CSIRO ICT Centre. This project aims to make the Compact Array archive data available online to astronomers. In 2003 the archive data was transferred from Narrabri to hardware at the ICT Centre in Canberra. Software was developed for searching and retrieving the data. In 2004 the archive will be made available through a simple web interface system. Work also began to provide a "pipeline processor" to generate images from the archive. This pipeline will enable non-expert users to process Compact Array data.

AIPS++

AIPS++ is an astronomical data processing environment. Until 2003, AIPS++ was developed by an international consortium. In early 2003 the AIPS++ international software project underwent a review. Although the review was positive about the project, the international consortium was dissolved soon after. Since that time, ATNF and NRAO have sought a less formal means of collaborating and taking advantage of each others' expertise. The ATNF is now focussed on using AIPS++ for specific software projects, such as the RVS described above, and less involved in generic development.

Outreach & education

One of the strategic objectives of the ATNF is to conduct an effective outreach program. Astronomy generates a high level of public interest and is ideally suited to promoting science and to encouraging the next generation of students towards a science-based career. The key outreach goals for the ATNF are: to attract young people into science; raise the profile of astronomy and science in Australia; and maintain and foster good relations with local communities. In 2003 these were promoted through a range of activities as described below.

A celebration at Dover Heights

Rodney Reserve, on the cliff tops at Dover Heights in the eastern suburbs of Sydney was one of the most remarkable and important astronomical sites in New South Wales. Between 1946 and 1954, this former WWII radar station was the leading field station of the CSIRO Division of Radiophysics, and was home to a succession of different radio telescopes that were used to make outstanding advances in radio astronomy. Using converted radar equipment from the Second World War, John Bolton, Gordon Stanley and Bruce Slee discovered the first extragalactic radio sources. They identified them as galaxies Virgo A, Centaurus A and Cygnus A, millions of light-years away. This revolutionised space exploration. By looking at the radio waves emitted by objects in space, we can probe deeper and reveal the very distant universe. These Dover Heights discoveries showed that radio waves could be used to study the universe "from the solar system to the Cosmos" and firmly established Australia as a world leader in the emerging science of radio astronomy.

A full size replica of an 8-element Yagi array that was used at Dover Heights during 1951 - 1952. This was one of several Yagi arrays that were used on the site as a "sea interferometer". In this technique, an interference pattern was recorded by combining radio waves detected directly from the source and from a reflection off the sea. The replica antenna has been installed on the cliff top next to the original mount, as a scientific memorial.
Photo: © Barnaby Norris

To celebrate the history and achievements of the Dover Heights site, in November 2002, the ATNF submitted an application to the Waverley Council to build a scientific memorial on the site, consisting of a full-size replica of one of the early radio telescopes, a display panel with information about the site and a commemorative plaque. This application was approved by the Council in June 2003.

On 20 July 2003 a ceremony was held on Rodney Reserve to open the new memorial. The ceremony was timed to coincide with the historical sessions of the IAU General Assembly and many international and Australian visitors with a keen interest in the history of radio astronomy gathered for the event. Guest of honour at the ceremony was Her Excellency, Professor Marie Bashir, Governor of New South Wales. Other invited speakers were Professor Woody Sullivan (University of Washington, USA), Professor Ron Ekers (ATNF) and Mr Paul Pearce, Mayor of the Waverley Council.

Media relations

Media relations at the ATNF are coordinated by the Communications Manager, Helen Sim. The ATNF has a strong media profile. Typically the ATNF issues 10 media releases a year and features in approximately 100 press items and 50 radio and TV interviews. From late 2002 through to July 2003 most of the ATNF's efforts in this area were directed towards preparing for and publicising the IAU General Assembly.

Education

Each year the ATNF coordinates a summer vacation program and hosts approximately eight undergraduate students. The 2003/2004 program was held jointly with CTIP and the ICT Centre; 280 applications were received for a total of 18 student positions. The students worked for 10 weeks on a research project under the supervision of a research scientist or engineer. They also used the ATNF radio telescopes to take observations, and gave presentations on their work at a student symposium.

For younger students, the Parkes and Narrabri Observatories provide a work experience program. Typically, 15 high-school students per year spend a week doing work experience at the Parkes Observatory while three or four students visit Narrabri. The Parkes Observatory also provides professional development weeks for school teachers and receives an increasing number of requests for such support.

Professor Marie Bashir, Governor of New South Wales, and Professor Ron Ekers at the Dover Heights celebration on 20 July 2003
Photo: © David Smyth

CSIRO Summer vacations students on the Parkes radio telescope.
From left: Lap-hang Ho (CTIP), Ryan Clements (ATNF),
David Jones (ATNF) and Marija Vlajic (ATNF).
Photo: © Robert Hollow

Several new educational initiatives began in late 2003, following the appointment of Rob Hollow as Education Officer in October. An online web-based resource for high school students and their teachers is being developed which will provide content for the NSW high school Higher School Certificate astrophysics course. The web resource will be provided in 2004 and will later be expanded to cover a range of ages and skill levels. Another initiative is to provide workshops for high school teachers. A three-day workshop targeting teachers of Year 7-10 Science will be held at Parkes in May 2004, with others planned to follow.

SEARFE

The SEARFE Project (Students Exploring Australia's Radio Frequency Environment) aims to give senior high-school students practical experience in the value and use of the radio-frequency spectrum, an overview of the scientific objectives of the next generation radio telescopes and a practical understanding of why these telescopes have to operate in radio-quiet areas. In 2003 the project was in a pilot phase, with participating schools in Sydney, Canberra, Narrabri, Kimba (South Australia) and Geraldton (Western Australia). A SEARFE kit was also installed at the Parkes Visitors Centre for staff to show to visiting high school students and other groups.

The SEARFE project received considerable media during the year with several television and newspaper reports. Leading up to the IAU General Assembly, the SEARFE Project was a major feature in the University of New South Wales-led "Astronomy on the Go" program that toured more than a dozen schools in regional NSW and several schools in Sydney. During the Assembly, students from Abbotsleigh School in Sydney demonstrated the project.

Students from the high school Nagle Catholic College presented their work on the project to conference delegates at the International SKA 2003 conference held in Geraldton. The University of Technology Sydney displayed SEARFE at the "Science in the City" exhibition at the Australian Museum in Sydney and again for "Science in the Bush" in Tamworth.

The SEARFE project receives support and sponsorship from the University of Sydney and its Science Foundation for Physics, CSIRO ATNF, University of Technology Sydney, University of NSW, IBM Australia, BAE Systems Australia, Engineers Australia, Perth Observatory and Australian Geographic. Details on the SEARFE Project are available at www.searfe.atnf.csiro.au.

Geraldton Nagle Catholic College students Alice Wenderling, Hoanh Hoang, Adam Harvey and Kylie Judd explaining their work on the SEARFE Project to International SKA Steering Committee Chair Jill Tarter (left) and other conference delegates at the International SKA 2003 Conference in Geraldton.
Photo: © Barnaby Norris

ATNF photoarchive

The ATNF historic photographic archive dates from 1939 to the mid-1990s and comprises over 100,000 individual negatives or slides, and associated prints. The collection includes images of many of the key figures in Australian radio astronomy, photographic records of key events in the history of Australian radio astronomy and images of the radio telescopes and field stations used by the Division of Radiophysics and the ATNF.

The photographic archive is being systematically scanned to create a digital archive of historic images. In 2003, approximately 2,000 images, covering the years 1965 – 1970 were scanned, bringing the digital collection to around 4,500 images in total. The scanned images are catalogued and organised using an asset-management database program, Cumulus with detailed information on the images entered into the database.

The digital archive is being developed as a resource for research on the history of Australian astronomy and for exhibitions, education and public relations. In 2003, the collection was used to provide pictorial support for detailed biographical papers about two pioneering radio astronomers, Bruce Slee and the late Gordon Stanley, and to illustrate ten different historical papers presented at the IAU General Assembly. A selection of images from the photographic archive also appeared on the display panels prepared for the Dover Heights heritage project, and in a paper about the Chris Cross at Fleurs which was published in a conference proceedings. This same volume also contained a well-illustrated paper about the photographic archive.

Parkes outreach

In 2003 the Parkes Visitors Centre hosted 136,000 members of the public, slightly more than in 2002 (134,000 visitors). This is a remarkable result given that other tourist attractions in the region reported substantial down-turns in visitor numbers over summer 02/03 due to the exceptionally dry hot weather associated with the El-Nino related drought. The majority of visitors continue to be families on holiday in the region, travellers along the Newell Highway and school and coach groups. With these visitor numbers Parkes Observatory remains CSIRO’s most significant point of personal contact with the public.

As the prominence of the movie *The Dish* fades, providing a positive and notable experience to visitors becomes crucial to sustaining numbers. A significant step taken in this direction during 2003 was the opening of the *Dish Cafe* on March 28. The cafe is located in a dramatic new building adjacent to the Visitors Centre and offers a spectacular view of the telescope. During the official opening on 9 April Ron Ekers, then Director, made a symbolic first cup of coffee. The cafe is operated by independent lessees and has had a positive effect on the experiences of visitors to the Observatory. Visitors are now staying longer and many locals report having visited the Observatory for the first time in years. The cafe caters to groups and hosts evening functions by prior arrangement, leading to an increasing number of requests to open the Visitors Centre in the evening.

Staff and visitors at the opening of the *Dish Cafe* at the Parkes Visitors Centre. Coffee with a view!
Photo: © John Sarkissian

Special visitors during 2003 included the Federal Minister for Science, Peter McGauran, the US Ambassador Thomas Schieffer, and the NSW Minister for Small Business and for Regional Development, David Campbell. Peter McGaurin visited with a number of his staffers in February as part of an astronomy tour of Coonabarabran, Narrabri and Parkes, where the Federal member for Parkes, John Cobb, joined the group. The US Ambassador's visit marked the official start of the tracking of spacecraft for NASA using the Parkes Telescope over a particularly busy period associated with the close approach of the planet Mars. David Campbell made a presentation from the Department of State and Regional Development to the cafe operators Andrea and Michael Carter.

Other notable events included the hosting of the release of a new four-wheel-drive vehicle to motoring journalists and two days of filming of a Korean TV romance drama.

After 17 years of sterling service, Rick Twardy, the manager of the Parkes Visitors Centre, left to pursue new challenges. John Smith took up a new role as Parkes VC Manager and Coordinator of the Parkes and Narrabri Visitors Centres in August 2003. Visitors continue to provide strong feedback that their interactions with the friendly and knowledgeable staff are a significant contributor to their positive impressions of their visits.

Revenue was down slightly in 2003 due to a large drop between February and April, compared with the previous year, but then recovered, with most subsequent months stronger than in 2002. A continuing partnership with Swinburne University to produce 3D audio-visuals remained very positive. Planning for new displays and improved services to visitors is well underway, after a full day meeting in December 2003 devoted to identifying outreach priorities. The operation of the Visitors Centre and other outreach activities at Parkes continues to be strongly supported by other observatory and ATNF staff, the local council and other tourism operators and businesses in the region.

US Ambassador Thomas Schieffer and Parkes Officer-in-Charge John Reynolds pose for the cameras at the Parkes Mars tracking launch on 31 October. In a reference to the film *The Dish*, CSIRO presented the Ambassador with a cricket bat signed by ATNF staff; the Ambassador, former manager of a US baseball team, reciprocated with a baseball bat.
Photo: © John Sarkissian

Narrabri and Mopra outreach

The Narrabri Visitors Centre hosted approximately 10,000 visitors in 2003, a similar number to previous years. The Visitors Centre also held several star-gazing evenings for community groups and local staff. Several of these were timed to coincide with the close approach of Mars.

In October, an Open Day was held at the Observatory as part of the township's Spring Festival. The main attractions of the day were visits to the Control Room, the Visitors Centre and the vertex of an antenna. Approximately 300 visitors attended, with 200 climbing to an antenna vertex room.

Work began on a long-needed revamp of the Visitors Centre. Several new displays were added, and new brochures were produced. New landscaping of the area around the Visitors Centre was completed near the end of the year.

An Open Day was held on the site of the Mopra radio telescope in October as part of the annual Coonabarabran "Festival of the Stars". Approximately 130 visitors toured the telescope vertex room and control room. Tours and demonstrations of the telescope were also given to two high school groups for the "Cosmology Distinction Course" and an "Astro Camp" during the year.

Spectrum management

Spectrum management relating to the protection of radio astronomy has been an important activity for CSIRO for more than 30 years. 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 Authority (ACA).
- 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.

ATNF Staff members John Smith, Michael Dahlem and Euan Troup (wearing blue safety hats) and visitors at the Narrabri Open Day in October 2003.
Photo: © CSIRO

- Participation by Federation Fellow Professor Ekers in the Working Party meetings of the OECD megascience forum where an international task force was set up to investigate radio-frequency interference and protection measures. The final report was produced in late 2003 and approved by the OECD science ministers.
- 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). This committee participated vigorously in Asia-Pacific Telescope (APT) meetings and helped establish regional WRC positions supporting the protection of radio astronomy.

The major focus of activity for the year was the World Radio Conference, WRC2003, held in Geneva in June – July 2003. Despite strong commercial pressures on the radio spectrum, radio astronomy protection was maintained. However, to ensure such protection, it became necessary to register all radio telescopes and operating bands with the ITU. Although ITU registration has always been possible, no astronomy stations worldwide had been registered since the 1960s. This registration can only be done by each country's spectrum administration; all Australian telescopes have now been registered through the ACA.

The Productivity Commission recommended in its review in 2002 that "radio sensitive sites" be established around existing radio astronomy facilities. The ACA has agreed to implement this recommendation and is working closely with ATNF to develop appropriate guidelines.

The new 50-cm receiver at Parkes has highlighted considerable interference in this band from the digital TV rollout in Australia. The interference level is expected to increase. The Australian Broadcasting Authority (ABA) has been very helpful in identifying the sources of this interference to assist with interference mitigation efforts.

New web pages were developed in 2003 to coordinate ATNF spectrum management activities and provide a single point of contact for outside organisations interested in this area. These are available at
http://www.atnf.csiro.au/spectrum.

Human resources

Staff satisfaction survey

The ATNF remains an employer of choice. Responses to the 2003 CSIRO Insight Staff Satisfaction Survey placed the ATNF as the top Division of CSIRO for the third year running. Furthermore, the staff satisfaction within the ATNF is considerably higher than that across comparative Global R&D organisations surveyed by the consultants International Survey Research.

The overall ATNF results for 2003 were essentially the same as in 2002, remaining very positive across all 21 categories of questions. The greatest strengths of the ATNF are our staff and our clear focus on operating world-class facilities to support astronomical research, and leading-edge technology development for future facilities. The strong team spirit of ATNF staff is an enormous asset and is clearly reflected in the survey results.

ATNF project management and resource allocation associated with the large number of internal and external projects underway (including large initiatives such as the SKA) were raised as concerns in the staff survey. These issues are being addressed through a commitment from the Senior Management to implement better resource planning for internal and external projects.

Equal employment opportunity

The ATNF has an EEO group with five EEO contact officers. Two are based in Sydney, two are at Narrabri and one is at Parkes. Staff at any of the sites can contact any of the EEO officers and are assured that all discussions will be held in confidence. The EEO officers work to promote good workplace relations, to provide information and advice

to staff and management on EEO policies, and to support staff involved in complaints procedures. EEO talks are given at each of the ATNF sites and are also given to summer vacation students and to new staff. The group maintains web pages at
www.atnf.csiro.au/overview/management/eeo/.

Occupational health, safety and environment

In line with CSIRO's Occupational Health and Safety Policy, ATNF sites are systematically undertaking risk management activities under an OHS Management System to ensure that work environments and systems of work present no risk of injury or illness to ATNF staff or visitors. Some points of interest with regard to this in 2003 are as follows:

Brett Preisig (HSR) and Tom Lees (Site Safety Officer) received a Divisional Award for their efforts in conducting safety inductions at the Parkes Obervatory for staff, visiting astronomers, contractors, and work experience students, and for their efforts in developing and maintaining the site safety manual. While the Divisional Awards singled out Brett and Tom, they represent an endorsement of the efforts of many staff throughout the ATNF to promote a safe OHS&E culture.

A number of training and awareness programs were implemented in 2003 including presentations to staff on positive OHS&E culture, cryogenic and gas safety, supervisor safety, fire safety, working safely on roofs, safe operation of elevated work platforms, safe use of overhead cranes, defensive driver training, first aid and ergonomics.

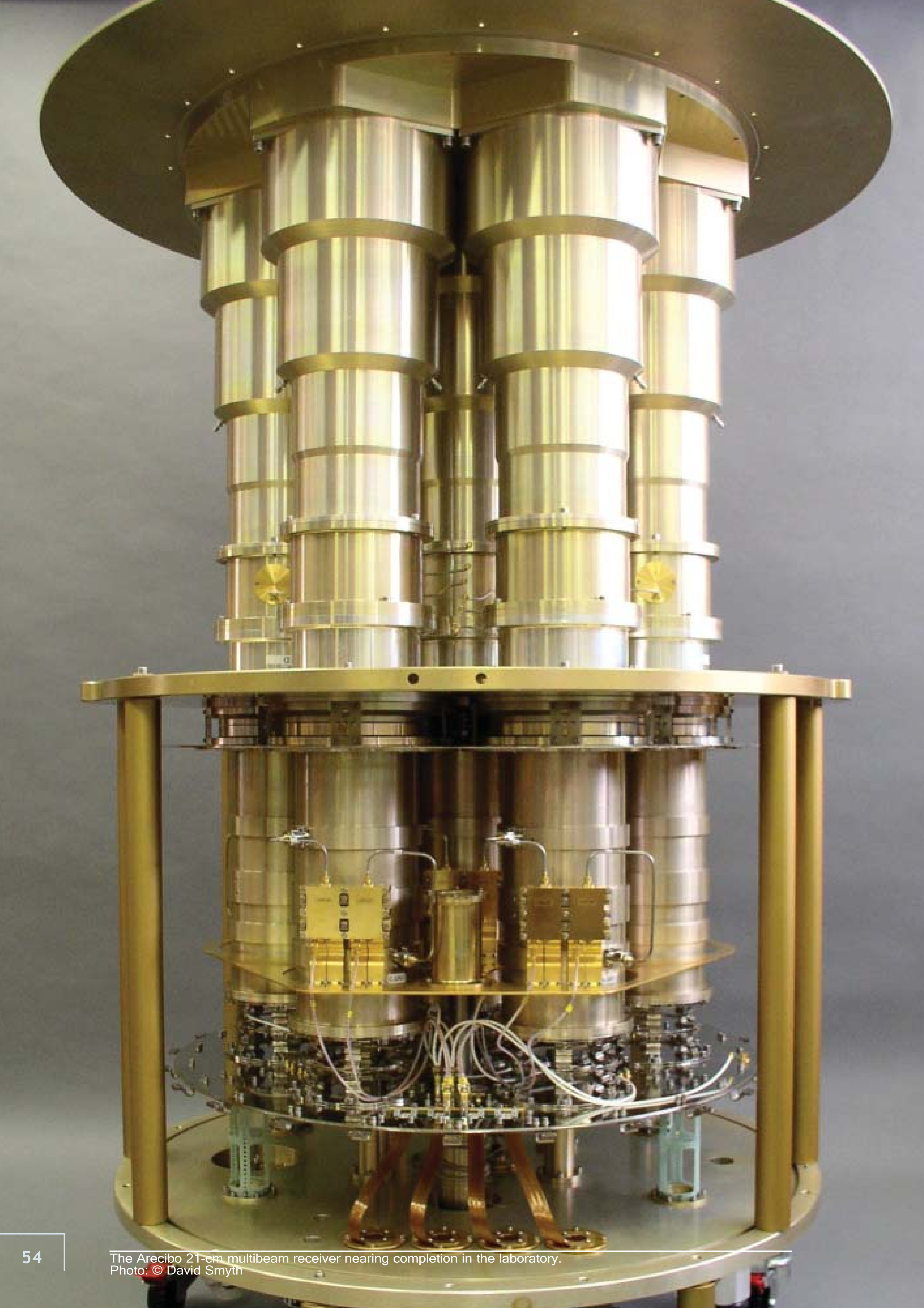
Four incidents in 2003 required notification to COMCARE: a falling ceiling tile, a dog bite, a car accident and a minor electric shock. Incident data reveal an increase in occupational overuse/manual-handling-related injuries and increased travel-related incidents.

In 2004, the systematic review of the key risks facing ATNF staff in their workplace will continue. This includes addressing safety issues presented by work-related travel, electrical usage, manual handling, and slip, trips and falls and reviewing safety practices associated with work at heights.

New OHS&E initiatives include the purchase of an elevated work platform for the Marsfield antenna range and the installation of a roof safety line and anchor points for use with a safety harness roofer's kit and appropriate training. Both initiatives will reduce the risks associated with working at heights.

Under the CSIRO Environment Policy, all ATNF sites are implementing an Environmental Management System to minimise the impact on the environment by the activities of ATNF and its staff. The current focus in Marsfield is to reduce resource usage such as electricity, water and paper, whereas in Narrabri and Parkes a different range of environmental initiatives exist.

Environmental initiatives include the remediation of some past poor land practices and the control of weed infestation at the Narrabri site, and tree planting to create an animal corridor and prevent soil erosion at the Parkes site.



The Arecibo 21-cm multibeam receiver nearing completion in the laboratory.
Photo: © David Smyth

Technology developments

Marsfield engineering developments

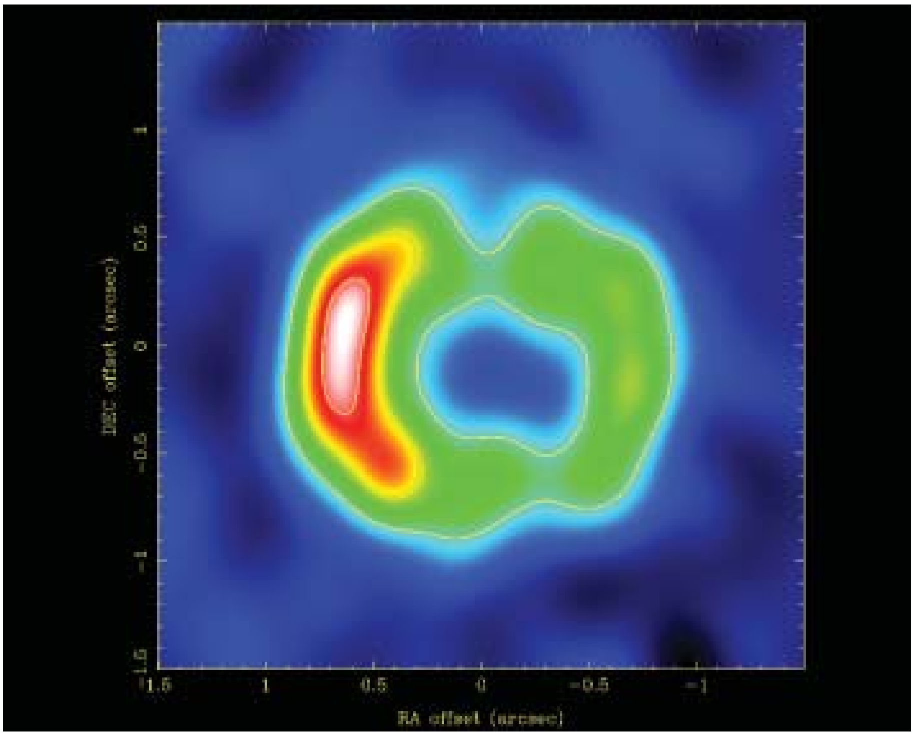
MNRF-1997

The ATNF, together with the University of Tasmania, is approaching completion on a set of substantial projects under the Commonwealth Government's Major National Research Facilities (MNRF) program, governed by a contract signed with the Government in February 1997. The major part of this contract was to upgrade the Australia Telescope Compact Array to work at high (millimetre-wave) frequencies in the 3- and 12-mm observing bands. Most of this work has now been completed with the full millimetre capabilities expected to be available from mid-2004.

12/3-mm receiving systems for the Compact Array and Mopra

A major milestone in the MNRF-1997 program was achieved in June 2003 with the installation of 12-mm receivers in all six Compact Array antennas, providing a frequency range from 16 – 25 GHz. The existing prototype 12/3-mm receivers on three of the antennas were supplemented by three production receiver packages on the remaining antennas. The new packages are designed to provide coverage of three wavelength bands, 12, 7 and 3 mm, but are currently fitted out for the 12-mm band only. The 3-mm systems are planned to be installed in mid-2004 when final production units will also replace the three prototype 12/3-mm receivers. The 7-mm system is not part of the MNRF1997 project and funding to provide a 7-mm system is being sought elsewhere.

The new mm-wave receiver package installed at Narrabri. The 12-mm feed is in the centre. The 3-mm feed will be enclosed inside the dewar extension on the left and behind. The position for an eventual 7-mm feed is on the right.
Photo: © CSIRO



The completion of the 12-mm system has provided an exciting new capability for the Compact Array. The increased resolution of the instrument was splendidly demonstrated by this image of SN 1987A from the first observations taken using all six antennas at 12 mm.

3-mm receiver developments

A major effort for the 3-mm systems has been the design of the final local oscillator (LO) chain. A significant difference between the prototype and production systems occurs in the first conversion stage, with the final system required to provide a considerably wider frequency coverage. This could be achieved only by replacing the largely commercial components in the prototypes with specially-developed custom components. Most of these components use purpose designed MMIC circuits. The longer-than-expected development time of these specialised components has resulted in the delayed completion of the 3-mm systems.

Components developed for the LO chain and first conversion stage include:

- Frequency doubler MMICs, in both gallium arsenide (GaAs) and indium phosphide (InP), from 25 – 50 GHz and from 50 – 100 GHz.
- High power amplifier MMICs in GaAs in the frequency ranges 48 – 52 GHz and 96 – 104 GHz, designed by CSIRO CTIP.
- Wideband single sideband mixer MMICs in InP covering a radio frequency (RF) range of 84 – 116 GHz.

Initial results of tests on the performance of the 3-mm first conversion stage, using an LO produced with the prototype of the final LO chain, show good performance across the full frequency range from 84 – 116 GHz.

Another significant development for the 3-mm receivers is a new InP MMIC coplanar waveguide low noise amplifier (LNA). Extensive tests at cryogenic temperatures carried out late in the year show that these circuits perform well up to 115 GHz. There is still some uncertainty in the noise measurements above 107 GHz, due to limitations in the test setup, but the performance is very promising. Although it will not be possible to use these

A diffraction-limited 12-mm image of SNR 1987A obtained on 31 July 2003 using the Compact Array in the 6D configuration.
Image: Dick Manchester, ATNF

LNAs in the initial outfitting of the Compact Array, they could be installed in a later upgrade to extend the current upper frequency limit of 105 GHz to 116 GHz. Initially they will be installed in a new 3-mm receiver for the Mopra radio telescope, matching the frequency coverage of the current SIS system which will be replaced in late 2004.

Compact Array local oscillator upgrade

The final task in this project, the installation of the tuneable high frequency local oscillator reference system for the millimeter-wave receivers was completed in May 2003.

MNRF-2001

In early 2001 the government announced, as part of a new innovation statement, a Major National Research Facilities program. The Australian astronomical community decided to combine their two highest priorities for future growth into one proposal for MNRF funding. These priorities, as identified by the Australian astronomical community in the report *Beyond 2000: The Way Ahead*, are additional access to the optical/infrared telescopes of the Gemini project and development of the Square Kilometre Array (SKA) – the next generation radio telescope. The MNRF-2001 proposal was submitted to AusIndustry in May 2001. On 21 August 2001 the Minister for Industry, Science, and Resources, Senator Nick Minchin, announced the allocation of A$155M under the MNRF-2001 Program to fifteen successful proposals. Of these, the ATNF-led proposal was granted the largest single allocation, A$23.5M. The major goals of the MNRF-2001 program are to increase Australia's share in the International Gemini Telescopes, and to develop enabling technologies for the SKA.

Compact Array broadband upgrade

This project has the aim of developing new signal processing techniques for the SKA and applying them in a significant upgrade for the Compact Array. This will provide a significantly enhanced facility for National Facility users whilst also providing a test bed for SKA developments. The upgrade will increase the bandwidth of the Compact Array by a factor of 16 to a total bandwidth of 8 GHz.

At the heart of the new backend being developed for the Compact Array is a polyphase digital filterbank (DFB). This device is used to split the intermediate frequency (IF) signals from each antenna into many narrow

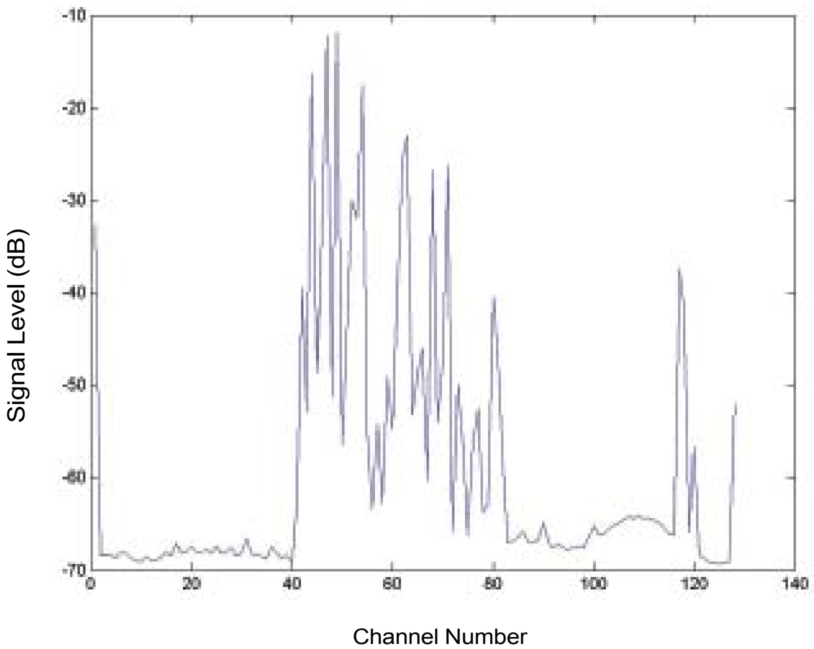


Figure 26 An early spectrum, showing radio frequeny interference, taken with the prototype polyphase digital filterbank. The channel width is 0.5 MHz, and the spectrum is centred on approximately 100 MHz. The spectrum has a large dynamic range of 60 dB.

frequency channels prior to the correlation processes which form the interferometer outputs. A great deal of effort has gone into developing tools to assist in the highly complex DFB design process. The DFBs are implemented in large reconfigurable logic circuits called field programmable gate arrays (FPGAs). An important milestone was reached at the end of 2003 when the first operational DFB was demonstrated. This initial design, having just 128 frequency channels over a 64-MHz bandwidth, falls well short of the 2048 channels over 2 GHz required for the final Compact Array system but is a significant first step towards that goal.

Already some excellent characteristics of the DFB have been demonstrated with this first design, in particular a large dynamic range and spectral purity. This can be seen in Figure 26, which is a measurement of the local radio frequency environment taken with a test antenna centred on approximately 100 MHz.

The next stage in the development of the DFB will be a 600-MHz bandwidth system which will be installed at Mopra as an interim spectrometer for the 2004 mm-wave observing season. This will provide a full functional test of the DFB in an operational observing environment, as well as a much enhanced spectral line performance compared to the existing Mopra correlator.

MMIC developments

A number of new designs were prepared for an InP HEMT fabrication run with Velocium in February 2003. ATNF obtained access to this run through its participation in the Faraday (FP5) collaboration with EU based partners. The wafers were returned in September and wafer tests will be completed in early 2004. Of particular interest are a number of wideband LNA designs aimed at a possible future upgrade of the Compact Array cm-wave systems. The goal is to replace the existing 20/13-cm LNAs by one device covering the range 1 – 3 GHz, and, similarly, the 6/3-cm LNAs by a single 4 – 12 GHz device. Not only will this extend the frequency coverage at cm wavelengths, but it is expected to give significantly lower noise performance as the lossy frequency diplexers will no longer be needed. On-wafer tests of these designs have shown very promising performance, although the full story will not be known until the MMICs are packaged and tested at cryogenic temperatures.

Also in the MMIC development area, a new project was started in mid-year aimed at developing a fully integrated receiver system on a chip. This work looks ahead to the requirements of large systems such as focal plane arrays and the SKA. Initially, radio-frequency CMOS technology will be used to integrate a complete receiver, including LNA, filtering, down conversion, analogue to digital conversion and parallel to serial processing onto a single MMIC. The design will cover the frequency range 500 – 1700 MHz, with an instantaneous bandwidth of 500 MHz. Fabrication is planned to begin in September 2004.

In December 2002 the ATNF/CTIP MMIC team, John Archer, Mal Sinclair, Russell Gough, Paul Roberts and Oya Sevimli, was awarded a Medal for Scientific Achievement for their role in designing advanced InP MMICS for radio astronomy and telecommunications. ATNF staff member Henry Kanoniuk contributed considerable expertise in the testing and initial applications of these MMIC designs.

Other developments

New pulsar instrumentation at Parkes

A significant step towards the completion of the new pulsar observing system at Parkes was taken in late October 2003 with the installation of the new dual-band 10/50-cm receiver. This receiver offers simultaneous operation at two frequency bands, with 1-GHz bandwidth at 10 cm (3.1 GHz) and 64-MHz bandwidth at 50 cm (680 MHz). When combined with existing backend systems it provides a powerful new facility for pulsar observing at Parkes.

Early tests show that the sensitivity of the system is meeting specifications, although the full 1-GHz bandwidth at 10 cm has not yet been achieved due to problems in both the receiver and wideband correlator.

Extension of wideband analogue correlator on the Compact Array

Following the success of the single baseline 4-GHz bandwidth analogue correlator system in a trial 20-GHz survey in 2002, a new enhanced system was developed and installed in October 2003.

The new system is a three-antenna, three-baseline instrument with a nominal bandwidth of 8 GHz. The original 4-GHz analogue lag correlator, made from commercial multiplier circuits, was replaced by a new design employing wideband InP multiplier MMICs designed at ATNF and fabricated under the CSIRO Executive Special Project program.

Although the wideband optical data transmission and correlator worked very well and were shown to be providing the full 8-GHz bandwidth, problems were encountered in compensating for the very steep slope across the band in the 12-mm receiver IFs. With the limited dynamic range of the data transmission, this resulted in an overall effective bandwidth of the system of only 2 GHz. Despite this disappointing result, the system was used in a successful pilot 20 GHz survey. A modification is planned to achieve the full 8-GHz bandwidth before the survey begins in earnest in 2004.

External contracts

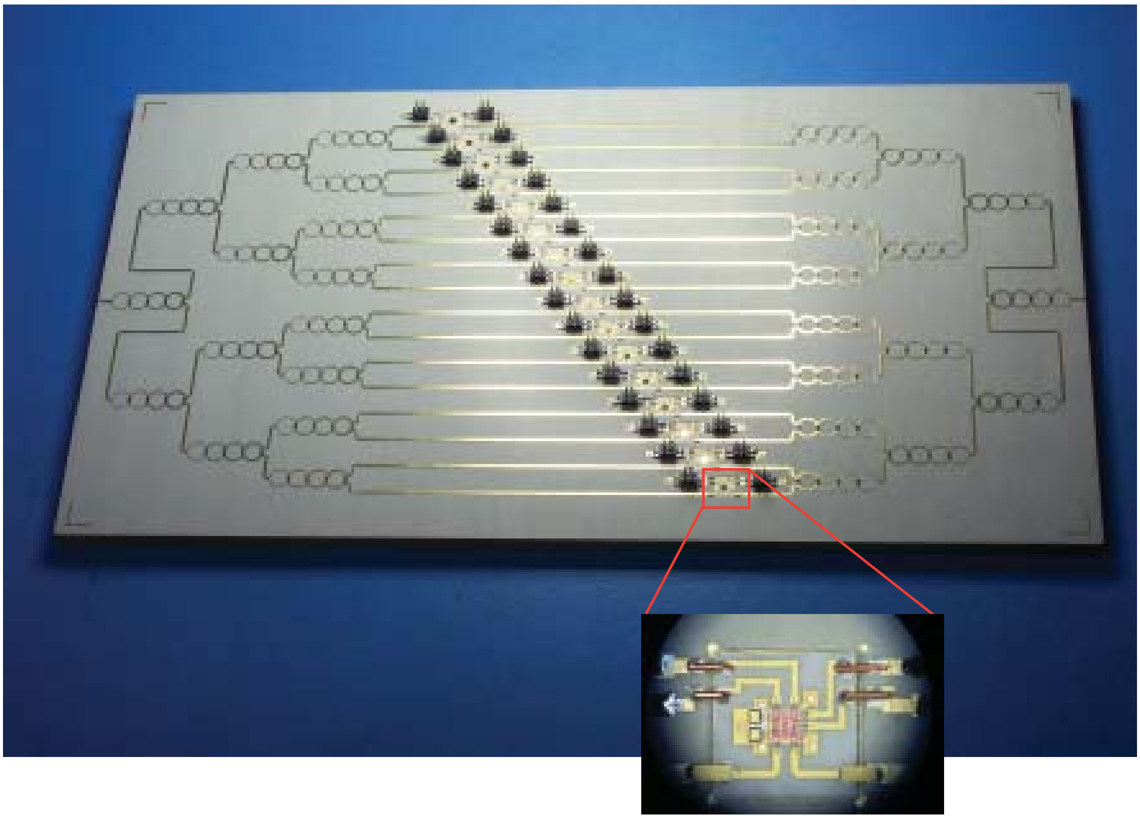
Arecibo 21-cm multibeam receiver

The seven-beam 21-cm multibeam receiver being built under contract to NAIC for the Arecibo radio telescope was nearing completion by the end of 2003. This receiver is an adaptation of the successful Parkes 13-beam 21-cm multibeam receiver. It is due for delivery to Arecibo in March 2004.

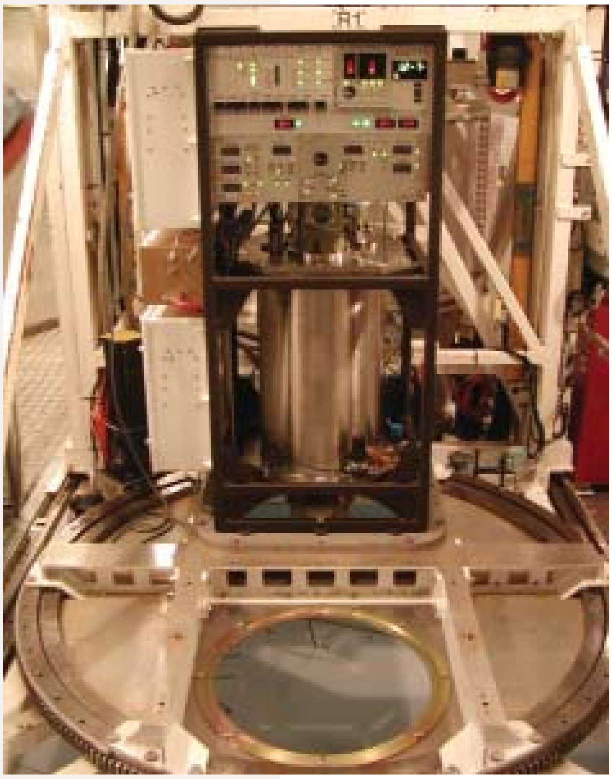
The LNAs in this receiver are an ATNF development based on the Jodrell Bank units used in the Parkes 21-cm multibeam receiver. After seven years operation the Parkes receiver was removed from the telescope in October 2003. Part of the refurbishment which will occur over the coming months will be a replacement of all LNAs with the new design.

NASA Mars tracking

The upgrade of the surface of the Parkes antenna, providing new panels in the 44 – 54 m diameter region was completed in March 2003. The new purpose-built 8.4-GHz receiver was installed at Parkes in August 2003. Overall system acceptance testing showed that the NASA gain/temperature specification was exceeded by almost a factor of two. The measured antenna gain was very close to the expected value for the upgraded surface, but the receiver noise was well below specification. Regular tracking of the Mars spacecraft began as planned in September 2003.



A wideband 0 – 12 GHz analogue correlator using indium phosphide MMIC multipliers.
Photo: © CSIRO



The 8.4-GHz NASA Mars receiver in the aerial cabin of the Parkes dish.
Image: © CSIRO

The Square Kilometre Array and next-generation radio telescopes

Overview

The ATNF is committed to the SKA as its primary strategic development project. The SKA is a next-generation radio telescope which will have a collecting area of one square kilometre, making it one hundred times more sensitive than any existing radio telescope. It will operate at centimetre wavelengths. Construction is expected to start about 2012, with full operation in 2020. The SKA is so ambitious that international collaboration is mandatory in its design, construction and operation.

The International SKA Consortium is headed by an International SKA Steering Committee (ISSC), and managed by the International SKA Director. Within Australia, SKA activities are coordinated by the Australian SKA Consortium Committee (ASKACC), and the ATNF is one of several institutions who contribute to ASKACC activities.

ATNF is contributing to the international SKA project in a number of ways, including the development of technology and the evaluation of potential locations within Australia. The selection of the location of SKA will take place in 2006, and a great deal of testing is taking place in Australia leading up to that date.

The ATNF is also exploring the possibility of building a low-frequency SKA pathfinder facility. The drivers for this include:

- Cutting-edge science drivers which could be successfully addressed by such an instrument;
- A demonstration of the credibility of Australia as a potential host country for SKA;

- Development of technology (e.g. signal transmission, correlator, software, and infrastructure) for the pathfinder telescope which is well-aligned to that needed for SKA;
- A shorter-term goal to focus and maintain the momentum and enthusiasm of those working on SKA.

SKA technology

ATNF SKA technology developments (in collaboration with other CSIRO divisions) include the goal of a wideband, multibeam technology demonstrator, incorporating the core technologies of:

- wide field-of-view microwave lenses ("Luneburg lenses") or phased-array antennas;
- optical fibre signal transport;
- sustainable energy provision to stations in remote locations.

A trial assembly of the Luneburg lens components.
Photo: © CSIRO

The Luneburg Lens prototyping work is progressing well, and a new feed translator system for the Lens has been designed and manufactured. A new artificial dielectric material has been developed, and the manufacturing process for this has been patented.

November 2003 saw the completion of the "proof-of-concept" prototype spherical lens at CSIRO MIT in Clayton, Victoria, and delivery of the lens to the Radiophysics Laboratory in Sydney. The lens comprises four spherical shells, each one made from moulded foam spherical diamonds, with a fibreglass protective shell. The lens was attached to its mounting successfully, and we have now started testing its performance in the antenna test range.

Remote area power provision has been identified as a crucial design factor for SKA and LOFAR, particularly for the proposed Australian sites and also for remote areas in the other proposed SKA sites. Australia is a world leader in remote area power provision and it is expected that this project will demonstrate advanced remote area power provision compatible with the extreme radio requirements of the next generation radio telescopes. A workshop was held in early September 2003 which brought together Australian research and industry experts to address this topic, resulting in several continuing collaborations.

LOFAR

In 2003 the ATNF was actively engaged in discussion with the international LOFAR consortium about the possibility of building LOFAR (Low Frequency Array) in Australia. In May, at the invitation of the international LOFAR consortium (consisting then of ASTRON (NL), MIT (US), and NRL (US)), ATNF, in collaboration with the Government of Western Australia (WA), submitted a detailed siting proposal for LOFAR in Australia. The ATNF and the WA Government decided to explore full participation rather than merely locating LOFAR in Australia, and engaged in fruitful and positive discussions with the LOFAR consortium. In early 2003 representatives from the LOFAR consortium visited the proposed site at Mileura in outback Western Australia, and in September 2003 an international site evaluation process chose Mileura as being the optimum site for LOFAR, based on scientific and technical considerations. Discussions then commenced between Australia and the international LOFAR consortium to develop plans for implementation of LOFAR in Western Australia.

At the same time a consultation process was started within the Australian astronomical community, to gauge the level of interest for LOFAR science within the community. In December 2003 the National Committee for Astronomy endorsed the recommendations of the Australian LOFAR working group that Australia should seek to become full members of the LOFAR consortium, on the basis that the telescope was sited in WA and that LOFAR helped to facilitate Australian astronomy's longer term goals, including the SKA.

In November 2003 ASTRON received funding of €52m for development of LOFAR, with the funding linked to infrastructure development in The Netherlands. In early 2004 it became clear that ASTRON funds would not be available for an international project on a site in WA. The ATNF therefore decided not to proceed with the LOFAR project, while remaining committed to the development of the SKA.

Industry collaborations and other activities

The ATNF has several formal industry collaborators in the SKA and LOFAR projects, including Connell Wagner, CEA, and Australia Powder Technologies, each of whom has kindly agreed to contribute resources towards the projects. We are also in discussion with a larger number of other industry partners who are contributing in various other ways to the projects.

The Luneburg lens installed in the CSIRO ICT Centre's antenna test range at the Radiophysics Laboratory in Sydney.
Photo: © CSIRO

After the IAU General Assembly held in July 2003, an international SKA Meeting was held in Geraldton, Western Australia. This included an SKA conference, a meeting of the ISSC, and several meetings of specialist SKA groups. It also included visits by the ISSC to the Mileura station site, which, as well as being the optimum LOFAR site, is also one of the candidate sites for SKA. The meetings were initiated by a collaboration between CSIRO ATNF and the Government of Western Australia, and also received assistance from the Mid West Development Commission. They were also supported by several industry sponsors, including Cray Australia, Stott and Hoare, Connell Wagner, SGI Australia, Telstra Countrywide and the WA branch of the Institute of Engineers.

SKA siting

Australia offers some of the most radio-quiet locations on Earth. Australian site studies for SKA began in 1997, and have been strongly supported by several State Governments. In 2003 ASKACC submitted an Initial Site Analysis Document to the International SKA Steering Committee on behalf of Australia. The document was jointly prepared by ATNF and Connell Wagner, and analysed and highlighted many of the features of an Australian siting for the SKA.

A meeting was held on 30 October 2003, to which officials of all State and Territory Governments were invited. Representatives of WA, SA, NSW and NT attended. Mileura station in WA has been adopted as a reference site for international testing, and other Australian sites will be compared with this.

Appendices

A: Financial information

Expenditure (actual) 2002-2003[1]	A$1,000s
Operation of the Narrabri (Paul Wild) Observatory[2]	3,384
Operation of the Parkes Observatory[3]	2,609
Research support Marsfield (ATNF contribution)[4]	1,901
Engineering, development and asset replacement	3,522
External contracts	1,411
Office of Director	934
Astrophysics program	1,657
Computing	1,000
National Facility support	659
MNRF-1997	1,136
MNRF-2001	1,246
Federation Fellowships	161
Corporate repairs and maintenance	205
TOTAL	**19,825**

Revenue (actual) 2002-2003

Direct appropriation[5]	13,589
Research and services revenue	5660
Other external revenue	458
Asset replacement reserve draw down	1,324
Corporate repairs and maintenance	160
TOTAL	**21,191**

Notes:

1. Expenditure includes capital but excludes depreciation.
2. Includes the operation of the observatory’s Visitors Centre and the Mopra Observatory.
3. Includes the operation of the observatory’s Visitors Centre.
4. The ATNF shares its Sydney headquarters with CSIRO Telecommunications and Industrial Physics.
5. Excludes A$4.8M depreciation appropriation.

B: Staff list, January to December 2003

ATNF staff

Marsfield

J Archer (Administration)
P Axtens (Receivers)
A Barends (Office of Director- PA)
R Beresford (Electronics)
R Bolton (Receivers)
P Bonvino (Machine Shop)
M Bourne (Machine Shop)
M Bowen (Receivers)
B Boyle (ATNF Director)
J Brooks (Assistant Director, & Engineering Manager)
W Brouw (Astrophysics/Computing)
H Burchey (Electronics)
M Calabretta (Computing)
G Carrad (Receivers)
J Caswell (Astrophysics)
A Chandra (Computing)
J Chapman (Head, National Facility Support)
R Chekkala (Electronics)
A Chippendale (Electronics)
D Craig (Electronics)
G Cook (Machine Shop)
E Davis (Electronics)
M Death (Machine Shop)
V Drazenovic (National Facility Support)
A Dunning (Receivers)
B Egan (Machine Shop)
J Ekers (Office of Director)
R Ekers (ATNF Director until April, then Federation Fellow)
T Elton (Electronics)
R Ferris (Electronics)
J Flores (Machine Shop)
G Gay (Receivers/overseas)
R Gough (Receivers)
G Graves (Receivers)
E Hakvoort (Receivers)
P Hall (Electronics)
G Hobbs (Bolton Fellow/Astrophysics)
R Hollow (National Facility Support)
P Howson (Divisional Secretary)
T Huynh (Machine Shop)
O Iannello (Machine Shop)
C Jackson (Business Development Manager)
S Jackson (Electronics)
P Jones (Computing/LBA)
E Kachwalla (National Facility Support)
H Kanoniuk (Receivers)
M Kesteven (Astrophysics/Engineering Research)
V Kilborn (Swinb/ATNF/ARC CSIRO Fellow)
N Killeen (Head, Computing)
B Koribalski (Astrophysics)
M Leach (Electronics)
J Lie (Receivers)
S Little (Astrophysics/Federation Fellow PA)
M Marquarding (Computing)
S Magri (Electronics)
R Manchester (Federation Fellow from June)
G Manefield (Engineering PA)
D McConnell (General Manager)
N McClure-Griffiths (Bolton Fellow/Astrophysics)
V McIntyre (Computing)
M McMullen (Electronics)
G Moorey (Receivers)
T Murphy (Computing)
R Norris (Deputy Director)
R Ojha (Astrophysics)
W Orchiston (National Facility Support)
J Ott (Bolton Fellow/Astrophysics)
S O'Toole (Administration)
C Phillips (Bolton Fellow/Astrophysics/Engineering)
D Pisano (NFS-MPS/Bolton Fellow/Astrophysics)
G Powell (Receivers)
L Reilly (Receivers)
P Roberts (Electronics)
S Saunders (Electronics)
H Sim (National Facility Support)
L Staveley-Smith (Head, Astrophysics)
M Storey (SKA)
P Sykes (Receivers)

A Tzioumis (Astrophysics/LBA)
M Walker (ATNF/USyd Research Fellow)
N Wang (ATNF/USyd Postdoctoral Fellow)
G Warr (Electronics)
B Wilson (Administration)
W Wilson (Head, Electronics)
T Wong (Bolton Fellow, UNSW/ATNF, ARC/CSIRO Fellow)
A Wright (National Facility Support)

Marsfield Staff shared with CSIRO Telecommunications and Industrial Physics

S Clark (Administration)
O D'Amico (Administration)
C Duffy (Administration)
C Hodges (Administration)
K Lambert(Administration)
B Wrbik (Administration)
P Cooper(Engineering Services)
W Finch (Engineering Services)
M McDonald (Site Services)
R Moncay (Machine Shop)
B Parsons (Assistant Engineering Manager)
P Sharp (Engineering Services)
J Uden (Site Services)
B Wilcockson (Assistant Engineering Manager)
M Wright (Machine Shop)
A Joos (Library)
C van der Leeuw (Library)

Narrabri

D Aboltin (Electronics)
R Behrendt (Electronics)
D Brennan (Lodge)
D Brodrick (Computing)
D Brooke (Electronics)
M Dahlem (Operations)
E Darcey (Antennas & Site Services)
A Day (Electronics)
O Dowd (Antennas & Site Services)
K Forbes (Administration)
C Gay (Administration)
J Giovannis (Computing)
M Guest (Lodge)
M Hill (Electronics)
B Hiscock (Electronics)
J Houldsworth (General Services)
B Johnson (Antennas & Site Services)
T Kennedy (Visitors Centre)
S Koljatic (Electronics)
C Leven (Antennas & Site Services)
J McFee (Electronics)
M McFee (General Services)
S Munting (Electronics)
C Murphy (Antennas & Site Services)
L Nuygen (Computing)
B Reddall (Electronics)
M Rees (Lodge)
S Robertson (Operations)
D Rowe-McDonald (General Services)
R Sault (Officer-in-Charge)
L Saripalli (Astrophysics)
J Stump (Library)
R Subrahmanyan (Operations)
G Sunderland (Antennas & Site Services)
B Tough (Electronics)
E Troup (Computing)
M Voronkov (Computing)
R Wark (Operations)
N Webster (Antennas & Site Services)
J Wieringa (Library)
M Wieringa (Computing)
C Wilson (Lodge)

Parkes

L Ball (Deputy Officer-in-Charge/HR Manager)
D Catlin (RF systems)
J Cole (Lodge)
J Crocker (Site Services)
B Dawson (RF Systems)
R Eslick (Site Services)
G Freeman (Administration)
C Grover (Site Services)
A Hockings (Site Services)
J Hockings (PA/Visitors Centre)
S Hoyle (Computing)
A Hunt (Electronics/Servo)
S Ingram (Lodge/Site Services)
B Lanzarini (Administration Trainee, 2003)

R Lees (Site Services)

D Lewis (Operations)

S Mader (Operations)

L Milgate (Visitors Centre)

B Preisig (Electronics/Servo)

L Price (Visitors Centre)

K Reeves (Site Services)

J Reynolds (Officer-in-Charge)

T Ruckley (Electronics)

J Sarkissian (Operations)

J Smith (Visitors Center Manager)

M Smith (RF systems)

G Spratt (Computing)

T Trim (Visitors Centre, Casual)

B Turner (Site Services)

S Turner (Site Services)

R Twardy (Visitors Centre)

K Unger (Visitors Centre)

R Walker (Visitors Centre)

T Wilkie (Visitors Centre)

L Williams (Site Services)

Canberra

F Briggs (ANU/ATNF, Astrophysics/SKA)

D Jauncey (Astrophysics)

J Lovell (Astrophysics/Tidbinbilla)

C: Committee membership

ATNF Steering Committee at 31 December 2003

Chairman

Prof Matthew Bailes, Swinburne University of Technology

Secretary

Mrs Anne Barends, ATNF

Members

Ex-Officio

Prof Brian Boyle, Director, ATNF

Dr Gerry Haddad, Chief, CSIRO Telecommunications and Industrial Physics

Dr Ron Sandland, Deputy Chief Executive, CSIRO

Astronomers

Prof Frank Briggs, Research School of Astronomy and Astrophysics

Prof Anne Green, School of Physics, Sydney University

International advisers

Dr Norio Kaifu, Director General, National Astronomical Observatory of Japan, Tokyo, Japan

Prof Phil Diamond, Director, Merlin and VLBI National Facility, Jodrell Bank, UK

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

Industry

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

Dr Stephen Rotheram, Managing Director, Networks Cable & Wireless Optus, Australia

MNRF Technical Advisory Committee

Dr S Guilloteau, Institut de Radio Astronomie Millimetrique (France)

Dr P Napier, National Radio Astronomy Observatory (USA)

Dr R Padman, Mullard Radio Astronomy Observatory (UK)

Dr A Young, CSIRO Telecommunications and Industrial Physics (Australia)

Dr N Whyborn, Space Research Organisation Netherlands (The Netherlands)

Australia Telescope Users Committee
January to December 2003

Chair

Dr C Jackson, Research School of Astronomy & Astrophysics, Australian National University

Dr S Tingay, Swinburne University

Secretary

Mr V McIntyre, ATNF

Dr J Lovell, ATNF

Members

Dr D Barnes, University of Melbourne

Dr J Bland-Hawthorn, Anglo-Australian Observatory

Dr S Ellingsen, University of Tasmania

Dr B Gibson, Swinburne University

Mr A Hotan*, Swinburne University

Dr M Hunt, University of Sydney

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

Dr S Johnston, University of Sydney

Mr D Lewis*, University of Tasmania

Dr N McClure-Griffiths, ATNF

Dr M Meyer, University of Melbourne

Dr M Wardle, Macquarie University

Dr T Wong, ATNF

Dr C Wright, Australian Defence Force

Dr M Zwaan, University of Melbourne

* student member

Australia Telescope Time Assignment Committee January to December 2003

Chairman

Prof B Schmidt, RSAA, Australian National University

Secretary

Dr J Chapman, ATNF

Members

Ex-Officio

Prof B Boyle, Director, ATNF

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

Dr B Sault, Officer-in-Charge, Narrabri Observatory, ATNF

Voting members

Dr P Francis, RSAA, Australian National University

Dr A Green, University of Sydney

Dr A Melatos, University of Melbourne

Prof R Norris, ATNF (Acting Director)

Dr S Ryder, Anglo-Australian Observatory

Prof J Storey, University of New South Wales

Dr L Staveley-Smith, ATNF

D: Observing programs

Observations made with the Australia Telescope Compact Array January to December 2003

Observers	Affiliations	Program Title	Number	Hours
Manchester, Gaensler, Staveley-Smith, Tzioumis, Kesteven	ATNF, CfA, ATNF, ATNF, ATNF	SNR 1987A	C015	111.5
Ryder, Smith, Bottcher	AAO, URice, OSU	The 1978 supernova in NGC 1313	C184	15.5
Duncan, Koribalski, White	ATNF, ATNF, UMar	High-spatial-resolution observations of Eta Carinae	C186	26
McClure-Griffiths, Dickey, Gaensler, Haverkorn, Green	ATNF, UMinn, CfA, CfA, USyd	The SGPS II: the Galactic Center	C596	321.5
Frail, Subrahmanyan, Kulkarni, Berger, Wieringa, Wark, Price, Schmidt	NRAO, ATNF, Caltech, Caltech, ATNF, ATNF, RSAA, RSAA	Radio afterglows of GRBs: a clue to the progenitors	C651	NAPA
Benaglia, Koribalski	IAR, ATNF	The radio spectrum of HD 93129A	C678	38
Stappers, Gaensler, Getts	NFRA, CfA, ATNF	Continuum radio emission from accretion powered MSP's	C751	NAPA
Fender, Corbel, Gallo, Tzioumis	UAm, CEA, UAm, ATNF	The large-scale relativistic jet of GX 339-4	C767	86
Beaulieu, Freeman, Bureau, Carignan, Meurer	ULav, RSAA, UClmba, UMont, JHU	Triaxial halos and the outer HI disks of spiral galaxies	C819	12
Minchin, Disney, de Blok, Garcia, Grossi	UCardiff, UCardiff, UCardiff, UCardiff, UCardiff	ATCA identification of HIDEEP 21-cm multibeam detections	C822	94
Fender, Sault, Pooley, Spencer, McCormick	UAm, ATNF, MRAO, JB, JB	Circular polarisation of radio-bright X-ray transients (NAPA)	C857	NAPA
Minier, Barnes, Myers, Herpine, Bontemps, Ellingsen, Elitzur, Norris, Booth	UNSW, UNSW, CfA, OBordeaux, OBordeaux, UTas UKent, ATNF, OSO	Methanol masers: exclusive signposts or massive star formation?	C893	62
Caswell	ATNF	Rise and fall of an OH maser flare	C906	16
McIntyre, Staveley-Smith, Milne, Sault, Dickel, Chu, Meixner, Dickey, Klein, Plante	ATNF, ATNF, ATNF, ATNF, UIL, UIL, UIL, UMinn, RAIUB, NCSA/ UIL	A 5- and 8.6-GHz survey of the LMC with the ATCA	C918	110
Bignall, Jauncey, Macquart, Tzioumis, Lovell, Kedziora-Chudczer	NFRA, ATNF, KI, ATNF, ATNF, USyd	The microarcsecond-scale structure and evolution of PKS 1257-326	C927	70.5
Reynoso, Green, Dubner, Giacani, Johnston, Goss	USyd/IAFE, USyd, IAFE, USyd, NRAO, NRAO	The interstellar medium towards peculiar neutron stars	C940	42.5
Hunstead, Cotter, Tzioumis, Safouris, Bicknell	USyd, IoA, ATNF, RSAA, RSAA	The extraordinary radio Galaxy MRC B1221-423	C956	11.5
Johnson, Pisano, Indebetouw	NRAO, ATNF, UWis	Searching for infant globular clusters	C958	95
Subrahmanyan, McClure-Griffiths, Kanekar	ATNF, ATNF, KI	Determining the temperature of the warm neutral medium	C962	40
Beasley, Staveley-Smith, Claussen, Marvel, Boboltz	Caltech, ATNF, NRAO, AAS, USNO	Water masers in the Magellanic Clouds	C973	25.5

Manchester, Staveley-Smith, Gaensler, Kesteven, Tzioumis	ATNF, ATNF, CfA, ATNF, ATNF	SNR 1987A at 12mm	C981	79.5
Brocksopp, Corbel, Fender, Hannikainen, Tingay, Tzioumis	LivJMU, CEA, UAm, UHel, ATNF, ATNF	NAPA Radio jets in recurrent and new x-ray transients	C989	NAPA
Bourke, Wilner, Wright, Wong, Dishoeck, Jorgensen	CfA, CfA, ADFA, ATNF, LO, LO	Observations of pre-planetary disks at 3 mm	C996	47
Hunstead, Sadler, De Breuck, Klamer, Rocca-Volmerange	USyd, USyd, IAP, USyd, IAP	High redshift radio galaxies from SUMSS	C1000	48
Dahlem, Ehle, Ryder, Haynes, Peart	ESO, ESA, AAO, UTas, UTas	HI observations of galaxies with radio halos	C1005	90
Temporin, Staveley-Smith, Weinberger	IAI, ATNF, IAI	Radio continuum in the compact galaxy group CG J1720-67.8	C1026	21.5
Dodson, Lewis, de Jager, Edwards	ISAS, UTas, SRU, ISAS	Imaging the PSR1706-44 pulsar wind nebula	C1033	36
Koekemoer, Mobasher, Dickinson, Norris, Jackson, Cram, Webster, Goods, + CDSF Teams	STScI, STScI, STScI, ATNF, RSAA, USyd, UMelb, STScI	Ultra-deep radio imaging of the Chandra Deep Field South	C1035	28
Wayth, Webster	UMelb, UMelb	Snapshots of southern gravitational lens candidates	C1037	72
Bernardi, Carretti, Cortiglioni, Sault, Subrahmanyan, Poppi, McConnell, Kesteven	IASF-CNR, IASF, IASF, ATNF, ATNF, IRA, ATNF, ATNF	Polarisation observations in the BOOMERANG field at 13cm	C1039	36
Warren, Koribalski, Jerjen, Staveley-Smith	RSAA/ATNF, ATNF, RSAA, ATNF	The nature of nearby high HI mass-to-light ratio field galaxies	C1046	120.5
Ekers, Jackson, Kesteven, Ricci, Sadler, Staveley-Smith, Subrahmanyan, Walker, Wilson, Zotti	ATNF, RSAA/ATNF, ATNF, OAT, USyd, ATNF, ATNF, ATNF/USyd, ATNF, OAP	Wideband 20-GHz sky survey	C1049	308
Slee, Drake, Orchiston, Willes	ATNF, GSFC, ATNF/AAO, USyd	Radio emission from the Parkes List of Active Stars	C1056	22
Duncan, Koribalski	ATNF, ATNF	The circumstellar nebulae of Wolf-Rayet Stars	C1059	11.5
Bignall, Jauncey, Lovell, Tzioumis, Kedziora-Chudczer, Macquart	UAd, ATNF, ANTF, ATNF, UNSW, KI	Measurement of the ISM velocity towards the IDV PKS 1257-326	C1060	24
Ryder, Sadler, Subrahmanyan, Weiler	AAO, USyd, ATNF, NRL	The radio-luminous supernova 2001ig	C1066	37
Hunt, Jones, Godfrey, Cragg, Burton, Minier, Bolza	UNSW, ATNF, Monash, Monash, UNSW, UNSW, UNSW	Biomolecules in the interstellar medium	C1077	34
Minier, Purcell, Hill, Burton, Hunt, Balasubramanyam, Wong	UNSW, UNSW, UNSW, UNSW, UNSW, RRI, ATNF	High resolution observations of hot molecular cores	C1082	16
Corbel, Fender, Tzioumis, Mitchell, Kaaret, Tomsick, Miller, Wijnands	CEA, UAm, ATNF, ATNF, CfA, UCSD, MIT, MIT	The jet/ISM interactions around the black hole XTEJ1550-564	C1087	49.5
Hoare, Lumsden, Busfield, Oudmaijer, Burton	ULeeds, ULeeds, ULeeds, ULeeds, UNSW	Massive star formation in the Galaxy: red MSX sources	C1088	82.5
Harnett, Beck, Ehle, Haynes	UTS, MPIfR, ESA, UTas	Magnetic fields in central regions of barred galaxies	C1092	24

Urquhart, Thompson, White, Morgan	UKC, UKC, UKC, UKC	Bright-rimmed clouds: tracing their ionised rims	C1093	52
Whiteoak, Hunt	ATNF, UNSW	The molecular lords of the rings in the nucleus of NGC 4945	C1094	13
Jones	ATNF	Flaring FR I jets in radio galaxies B1308-441 and B0546-329	C1096	26.5
Pisano, Barnes, Gibson, Staveley-Smith	ATNF, UMelb, Swinb, ATNF	Intragroup HI in local group analogs	C1107	104.5
McConnell, Subrahmanyan, Carretti, Cortiglioni, Poppo, Sault	ATNF, ATNF, IASF-CNR, IASF-CNR, IRA-CNR, ATNF	Sky polarisation at 5 GHz	C1109	79.5
McCallum, Ellingsen, Lovell, Greenhill, Kondratko	UTas, UTas, ATNF, CfA, CfA	Searching for extended structure in ESO 269-G012	C1110	12
Moffett, Reynoso, Hughes	UFurm, USyd, URutg	Measuring the expansion of SN1006	C1114	32
McClure-Griffiths, Benjamin, Putman, Ekers, Johnston-Hollitt	ATNF, UWis, CASA, ATNF, UAd/ATNF	Magnetic fields in high velocity clouds	C1115	24.5
Lee, Lim, Kwok	UCal, ASIAA, UCal	Search for ionized jets in southern narrow-waist bipolar nebulae	C1121	27.5
Churchwell, Sewilo, Watson, Araya, Hofner, Kurtz	UWis, UWis, UWis, UPuert, UPuert, UNAM	Resolution of distance ambiguities in the Inner Galaxy	C1123	49
Garay, Brooks, Rodriguez, Mardones	UChi, UChi, UNAM, UChi	A collimated jet associated with an O-type protostar	C1124	6.5
Staveley-Smith, Donley, Koribalski, Henning, Kraan-Korteweg, Schroeder	ATNF, ATNF, ATNF, UNM, UGuan, ULeic	A massive galaxy in the Zone of Avoidance	C1125	25
Phillips	ATNF	Testing a bandwidth switching calibration scheme	C1126	16
Phillips, Messineo, Sjourwerman, Habing, Menten	ATNF, LO, NRAO, LO, MPIfR	Stellar SiO Masers as probes of Galactic bulge binematics	C1127	24
Ott, Walter, Brinks, Staveley-Smith	ATNF, NRAO, INAOE, ATNF	Gone with the wind: dwarf galaxies blown away	C1128	73.5
Vergani, Pizzella, Corsini, Ott	RAIUB, OAP, OAP, ATNF	Accretion events in spiral galaxies with nuclear stellar disks	C1129	72
Reynoso, Green	USyd/IAFE, USyd	The nature of the radio source G332.5-5.6	C1130	23
Whiteoak, Hunt	ATNF, UNSW	HCO+ and HCN imaging of the LMC complex N159	C1131	12
Hunt, Whiteoak	UNSW, ATNF	Imaging the 18-GHz J=2-1 transition of HC3N in Sgr B2	C1132	25
Bouchard, Jerjen, DaCosta, Staveley-Smith, Freeman	RSAA, RSAA, RSAA, ATNF, RSAA	HI survey of dwarf galaxies in the CenA and Sculptor Group.	C1133	73.5
Sadler, Mauch	USyd, USyd	Were PKS 2225-253 & MRC 2220-700 radio hypernovae?	C1135	24.5
Irwin, English, Harnett	Queens, UManit, UTS	Extra-planar radio emission in NGC 4945	C1137	25
Barnes, Myers, Minier, Purcell, Burton, Longmore	USyd, CfA, UNSW, UNSW, UNSW, UNSW	An ammonia survey of medium- and high-mass protostars	C1138	95.5
Bruens, Westmeier, Kerp, Mebold	RAIUB, RAIUB, RAIUB, RAIUB	HI observation of compact high-velocity clouds	C1139	37.5

Minier, Lineweaver, Norris	UNSW, UNSW, ATNF	A search for water masers toward extrasolar planetary systems	C1140	14.5
Sarkissian, Sault, Reynolds	ATNF, ATNF, ATNF	A search for extra-solar radio planets	C1141	10
Wong, Minier, Forster	ATNF, UNSW, HatCreek	Deuterated ammonia in NGC 6334 I (N)	C1143	22
Gurovich, Staveley-Smith, Freeman, Jerjen, de Blok	RSAA, ATNF, RSAA, RSAA, UCardiff	Investigating the Baryonic Tully-Fisher Law with a HIPASS sample	C1144	74
Hill, Burton, Hunt, Minier, Purcell	UNSW, UNSW, UNSW, UNSW, UNSW	Dust emission from protostellar cores	C1145	40
Lazendic, Whiteoak, Wardle, Green	CfA, ATNF, UMac, USyd	A study of OH absorption lines in SNRs	C1146	25
Purcell, Minier, Barnes, Burton, Hunt, Hill, Wong	UNSW, UNSW, UNSW, UNSW, UNSW, UNSW, ATNF	HCO+ observations of massive young stellar objects	C1147	18
Smith, Robinson, Corbett, Axon, Gallimore	UHerts, UHerts, AAO, RochI, UBuck	Radio axes and the optical polarization of Seyfert galaxies	C1148	14
Rosenberg, Stocke, Ryan-Webber, Shull, Keeney	CASA, CASA, UMelb, CASA, CASA	Mapping a "Gaseous-Halo Selected" Galaxy sample at 21 cm	C1149	51
Buxton, Bailyn, Tzioumis, Weldrake	Yale, Yale, ATNF, RSAA	NAPA Jet energetics in low-mass x-ray binaries	C1150	NAPA
Ivison, Greve, Papadopoulos, Couch, Smail	UEdin, UEdin, UCL, UNSW, UDur	Dense molecular gas at high redshift	C1151	21
Drinkwater, Doyle, Ryder, Koribalski, Ryan-Weber, Webster, Zwaan, Meyer, Harnett, Kilborn	UQld, UQld, AAO, ATNF, UMelb, UMelb, UMelb, UMelb, UTS, JB	Star formation efficiency and environment	C1154	96
Vaughan, Parker, Acker, Cohen	UMac, UMac, StrasbO, UCB	A large sample of newly discovered planetary nebulae	C1155	25
de Buizer, Minier	Gemini (Chile), UNSW	Observations of outflows from YSOs with methanol masers	C1156	17
Minier, Burton, Caswell, Wong, Jones, Purcell, Hill, Hunt, Bontemps, Herpin, Motte, Ellingsen	UNSW, UNSW, ATNF, ATNF, ATNF, UNSW, UNSW, UNSW, OBordeaux, OBordeaux, CEA, UTas	A multi-frequency survey of NGC 3576	C1158	26
Kaaret, Corbel, Tzioumis	CfA, CEA, ATNF	Radio emission from an ultraluminous x-ray source	C1159	37.5
McCallum, Ellingsen, Lovell, Greenhill, Kondratko	UTas, UTas, ATNF, CfA, CfA	Locating the water megamaser in NGC 6300	C1161	12
Sobolev, Voronkov, Ellingsen, Ostrovskii	USU, ASC, UTas, USU	6.7 GHz and 25 GHz methanol masers at OMC-1	C1162	10
de Blok, McGaugh, Bosma	UCardiff, UMar, OMs	The origin of dark matter cores in LSB/Dwarf Galaxies	C1164	96
Stevens, Webster, Barnes, Pisano	UMelb, UMelb, UMelb, ATNF	Is NGC 4936 a compact group merger remnant?	C1165	23
White, Duncan, Koribalski, Chapman	UMar, ATNF, ATNF, ATNF	Motions in the Eta Carinae binary system	C1167	46.5
Bernardi, Carretti, Cortiglioni, Sault, Subrahmanyan, Poppi, McConnell, Kesteven	IASF-CNR, IASF-CNR, IASF-CNR, ATNF, ATNF, IAR-CNR, ATNF, ATNF	Observations of galactic polarisation in the DASI field at 20 cm	C1168	69.5

Blanton, Clarke, Sarazin	UVir, UVir, UVir	The radio source/ISM interaction in the S0 Galaxy NGC 1553	C1169	12
Emonts, Morganti, Oosterloo, van der Hulst, Tadhunter, Sadler	KI, NFRA, NRFA, KI, USheff, USyd	Neutral hydrogen and the origin of radio galaxies	C1170	53.5
Hardcastle, Kraft, Worrall	UBr, CfA, UBr	Centaurus A at 1.2mm: spectral index and polarization	C1171	24
Brown, Harper, Brown, Ayres	CASA, CASA, Caltech, CASA	Radio emission from Southern A and F supergiants	C1172	36
Maddison, Burton	Swinb, UNSW	A search for protostellar disks at millimetre wavelengths	C1173	24
Bourke	CfA	Ammonia emission from the protostellar outflow BHR 71	C1175	14
Barnes, Yonekura, McClure-Griffiths, Mizuno	USyd, UOsaka, ATNF, UNag	A pilot project for a galactic plane ammonia survey	C1177	47.5
Kewley, Wells, Thornley, Kennicut SINGS collaboration	CfA, IASp, UBuck, UAz	Star formation in SINGS Galaxies	C1179	59.5
Kewley, Wells, Thornley, Kennicut, SINGS collaboration	CfA, IASp, UBuck, UAz	HI and star formation in SINGS Galaxy: IC 4710	C1181	24.5
Nurnberger, Koribalski, Reimer	ESO (Chile), ATNF, URuh	High angular resolution 3 mm observations of NGC 3603	C1182	24
Sadler, Hunstead, Jackson, Couch, Bekki	USyd, USyd, ANU, UNSW, UNSW	Timescales for triggering radio galaxies	C1183	75.5
Johnston-Hollitt, Ekers, Hunstead	LO, ATNF, USyd	Search for Central Halo and 6cm observations of A3667	C1184	34
Wong, Sault, Staveley-Smith, O'Brien, Purcell, Muller	ATNF, ATNF, ATNF, ATNF, UNSW, ATNF	ATNF Synthesis Imaging Workshop observing sessions	C1185	44
Wong, Whiteoak, Hunt, Ott, Chin	ATNF, ATNF, USW, ATNF, UTamk	Molecular lines in N113: probing photon-dominated regions?	C1186	24
Ott, Wong, Mizuno, Weiss, Johansson	ATNF, ATNF, UNag, IRAM, OSO	Ionization fractions of dense molecular cores in the Magellanic Clouds	C1187	72.5
Caswell	ATNF	Precise positions of 22-GHz water masers in SFRs (star formation regions)	C1190	26
Koribalski, Manthey, Duc	ATNF, URuhr, CEA	Gas dynamics of the massive Galaxy ESO 390-G004	C1191	20.5
Johnston, McClure-Griffiths, Koribalski	USyd, ATNF, ATNF	12 mm observations of SNR G328.4+0.2 and Kepler's SNR	C1192	25.5
Koribalski, Reimer, Johnston	ATNF, URuhr, USyd	ATCA 12 mm imaging of the giant HII region NGC 3603	C1193	24
Deacon, Chapman, Green	USyd, ATNF, USyd	Polarisation study of planetary nebulae precursors	C1195	32.5
Staveley-Smith, Bruens, Gibson, Thom, Putman, McClure-Griffiths	ATNF, RAIUB, Swinb, Swinb, CASA, ATNF	The structure of the Magellanic Stream - pilot survey	C1197	163.5
Roberts, Baes, Davies, de Rijcke, Zeilinger, Prugniel, Michielsen, Dejonghe	UCardiff, SOGB, UCardiff, SOGB, UWien, CRALOL, SOGB, SOGB	The HI content of Fornax Cluster Dwarf Ellipticals	C1198	32.5
Corbel, Fender, Tzioumis, Kaaret, Orosz, Tomsick	CEA, UAm, ATNF, CfA, UCSD, UCSD	Searching for large scale radio jets in microquasars	C1199	12

Dickel, McIntyre, Milne, Seward, Williams, Gruendl, Chu, Park	UIL, ATNF, ATNF, CfA, UIL, UIL, UIL, UPenn	Imaging of the SNRs 0104-723 and 0103-726 in the SMC	C1200	13
Waugh, Webster, Drinkwater	UMelb, UMelb, UMelb	Evolution of Galactic HI in and around the fornax Cluster	C1202	55.5
Williams, Gorham, Hankins, Saltzberg, Naudet, Liewer, Ekers, Subrahmanyan	UCLA, UHawaii, UHawaii, UCLA, JPL, JPL, ATNF, ATNF	CELENE Cherenkov lunar emission by neutrinos experiment	C1203	37.5
Ryan-Weber, Webster, Freeman, Putman, Meurer	UMelb, UMelb, RSAA, UC, JHU	The HI environment of intergalactic HII regions	C1204	35.5
Dickel, Jones, Lazendic, Gotthelf	UIL, ATNF, CfA, UClmba	Imaging of the pulsar wind nebula in the SNR N 157B	C1205	37.5
Tingay, Edwards	Swinb, ISAS	The spectral variability characteristics of three GHz peaked radio sources	C1206	14
Ziljstra, Ruffle, Bedding, Gesicki	UMIST, UMIST, USyd, CO	The extinction law towards the Galactic Bulge	C1208	34.5
Bower, Tzioumis	UCB, ATNF	Intra-day variability of Sagittarius A* at 1.3 cm	C1210	24
Harju, Hotzel, Walmsley	UHel, UHel, OAAI	Before stellar birth - ammonia sounding of pre-stellar condensations	C1212	47.5
Klamer, Sadler, Ekers, Hunstead, De Breuck	USyd, USyd, ATNF, USyd, IAP	A search for cool molecular gas in the early universe	C1214	89
Subrahmanyan, Saripalli, Ekers	ATNF, ATNF, ATNF	Giant radio galaxies and the intergalactic medium	C1217	50
Chung, van Gorkom, Bureau	UClmba, UClmba, UClmba	A kinematic study of spirals with counter-rotating gas	C1218	25
Dahlem, Ekers, Whiteoak	ATNF, ATNF, ATNF	Hidden star formation in NGC 253 and NGC 4945	C1219	18
Kanekar, Chengalur, Subrahmanyan	KI, NCRA, ATNF	Constraining the variation of fundamental constants using OH lines	C1220	48
Purcell, Caswell, Hill, Longmore	UNSW, ATNF, UNSW, UNSW	Water masers and massive star formation	C1221	13.5
Johnston-Hollitt, Fleenor, Rose, Christiansen, Hunstead	LO, UCSU, UCSU, UCSU, USyd	Dynamical interactions of tailed galaxies in an in-falling group	C1222	24
Jogee, Ott, Norris, Wiklind, Jackson, Huynh, Koekemoer, Mobasher	STScI, ATNF, ATNF, STScI, RSAA, RSAA, STScI, STScI	Molecular gas in the reionization era	C1223	95.5
Ott, Henkel, Weiss, Walter	ATNF, MPIfR, IRAM, NRAO	Temperature variations of dense molecular gas in central starburst cores	C1224	24
Wong, Ott, Koribalski, Sault	ATNF, ATNF, ATNF, ATNF	Flux calibration of millimetre wavelengths	C1225	25.5
Barnard, Wong, Blain, Pierce-Price, Richer	JAC, ATNF, Caltech, JAC, Cavendish	HCO+ (1-0) and 3mm continuum observations of an isolated prestellar fragment	C1226	20
Olofsson, Wong, Schoier, Lindqvist, Kerschbaum	StO, ATNF, StO, OSO, UWien	Thermal SiO emission as a probe of circumstellar grain formation and dynamics	C1227	39
Caswell	ATNF	OH Masers and absorption towards		

		NGC 3576	C1228	14
Blank, Harnett	UWS, UTS	Search for radio emission from epsilon Indi B	C1229	13
McClure-Griffiths, Pisano, Chapman + approx 9 students	ATNF, ATNF, ATNF, ATNF/CTIP	Vacation student observing session	CSVP007	36
Wong	ATNF	Orion flare	CX041	6
Tingay	ATNF	New GPS source	CX042	1.5
Dahlem	ATNF	HI observations of early type Galaxies	CX043	3.6
Gaensler	CfA	IGR J16358-4726	CX044	10.5
Tingay	ATNF	GPS spectral indices	CX046	1.5
Klamer	USyd	CO in high redshift quasars	CX047	10.5
Manchester	ATNF	Position of PSR J0738-3033	CX048	6
Dahlem, Harnett	ATNF, UTS	12 mm observations of nearby starburst galaxies	CX049	7.5
Tingay	Swinb	Baseband data taking tests	CX050	1.5
Progrebenko, Sault	JIVE, ATNF	Sources in the Huygens-Tintan encounter field	CX051	8
Boyle	ATNF	Radio quiet blazar	CX052	12
Chapman	ATNF	IRAS 17317	CX053	9

Observations made with the Parkes radio telescope January to December 2003

Observers	Affiliations	Program Title	Number	Days
Erickson, McConnell, Briggs	UTas, ATNF, ATNF/RSAA	Low-frequency carbon recombination lines	P104	3.13
Kaspi, Manchester	UMcGill, ATNF	Long-term monitoring of PSR J0045-7319	P138	5.78
Bailes, van Straten, Ord, Knight, Hotan, Manchester, Anderson, Kulkarni, Jacoby, Sarkissian	Swinb, NFRA, Swinb, Swinb, Swinb, ATNF, Caltech, Caltech, Caltech, ATNF	High precision pulsar timing	P140	27.48
Manchester, Hobbs, Lewis, Sarkissian, Kaspi, Bailes	ATNF, ATNF, UTas/ATNF, ATNF, UMcGill, Swinb	Timing of young pulsars	P262	4.61
Knight, Ord, van Straten, Kulkarni, Bailes	Swinb, Swinb, Swinb, Caltech, Swinb	Baseband searching for ultrafast pulsars	P263	3.51
Lyne, Kramer, Manchester, Camilo, Stairs, Hobbs, D'Amico, Possenti, Kaspi, Faulkner	JB, JB, ATNF, UClmba, UBC, ATNF, CAO, CAO, UMcGill, JB	Pulsar multibeam survey	P268	12.87
Manchester, Hobbs, Camilo, Lyne, Kramer, Faulkner, Stairs, Kaspi, D'Amico, Possenti	ATNF, ATNF, UClmba, JB, JB, JB, UBC, UMcGill, CAO, CAO	Timing of multibeam pulsar discoveries	P276	17.42

Johnston, Koribalski, Wilson	USyd, ATNF, ATNF	Small scale structure in the interstellar medium	P280	1.35
Freire, Lyne, Kramer, Manchester, Lorimer, Camilo, D'Amico	AO/CORNELL, JB, JB, ATNF, JB, UClmba, CAO	Timing and searching for pulsars in 47 Tucanae	P282	4.99
Manchester, Kaspi, Crawford, Lyne	ATNF, UMcGill, Haverford, JB	Timing and confirmation of Magellanic Cloud pulsars	P294	5
McKay, Mundell, Forbes, Barnes	LivJMU, LivJMU, Swinb, UMelb	Formation and evolution of galaxies in groups - the role of HI	P352	1.15
Staveley-Smith, Koribalski, Henning, Kraan-Kortweg, Harnett, Sadler, Schroeder, Stewart, Price, Green, Donley	ATNF, ATNF, UNM, UGuan, UTS, USyd, OAzur, ULeic, UNM, USyd, ATNF	A bulge extension to the ZOA survey	P357	7.01
Ord, Bailes, van Straten, Hotan, Knight	Swinb, Swinb, NFRA, Swinb, Swinb	Studies of a relativistic binary pulsar	P361	3.88
Johnston, Romani	USyd, UStan	A search for giant pulses in PSR J0537-6910	P365	0.56
Burgay, McLaughlin, Kramer, Lyne, Joshi, Pearce, D'Amico, Possenti, Manchester, Camilo	OABol, JB, JB, JB, UPune, JB, CAO, CAO, ATNF, UClmba	Parkes multibeam high-latitude pulsar survey	P366	8.59
Briggs	RSAA/ATNF	Calibration for the HIPARK survey	P367	0.47
Gurovich, de Blok, Freeman, Staveley-Smith, Jerjen	RSAA, UCardiff, RSAA, ATNF, RSAA	Investigating the Baryonic Tully-Fisher law with a HIPASS sample	P370	1.81
de Blok, Freeman, Disney, Garcia, Minchin, Kilborn, Zwaan, and HIPASS team	UCardiff, RSAA, UCardiff, UCardiff, UCardiff, JB, UMelb	Completeness and reliability of HIPASS northern extension	P387	15.29
Stevens, Webster, Barnes, Pisano	UMelb, UMelb, UMelb, ATNF	The HI content of compact groups of galaxies	P388	0.5
Manchester, Hotan, van Straten	ATNF, Swinb, NFRA	Polarisation of the Vela and Mouse pulsars	P393	2.01
Camilo, Manchester, Sarkissian	UClmba, ATNF, ATNF	Timing two young and energetic pulsars	P395	4.77
Camilo, Arzoumanian, Manchester, Gaensler, Lorimer	UClmba, GSFC, ATNF, CfA, JB	Deep searches for young and "radio-quiet" pulsars	P396	4.28
Pisano, Gibson, Barnes, Stevens, Staveley-Smith, Freeman	ATNF, Swinb, UMelb, UMelb, ATNF, RSAA	An HI study of loose groups	P399	7.25
Kramer, Lyne, Stairs, Kaspi, Manchester, Camilo	JB, JB, NRAO, UMcGill, ATNF, UClmba	Geodetic precession in PSR J1141-6545	P400	0.66
Roberts, Ransom, Kaspi, Hessels, Tam, Livingstone, Crawford	UMcGill, UMcGill, UMcGill, UMcGill, UMcGill, UMcGill, Haverford	A search for pulsars in mid-latitude EGRET error boxes	P406	5
Deacon, Green, Chapman	USyd, USyd, ATNF	The origin of planetary nebulae morphology	P414	2.29
Johnston, Nicastro, Ord, Johnston	USyd, CNR-IFCAI, Swinb, USyd	Interstellar scintillation studies of radio pulsars	P420	1.58
Caswell	ATNF	Search for 13 GHz OH masers in star formation regions	P421	5.26

Barnes, Calabretta, Staveley-Smith, Briggs	UMelb, ATNF, ATNF, RSAA	Characterising the on-source continuum response of HIPASS	P424	6.15
Mitra, Johnston, Karastergiou, Kramer	MPIfR, USyd, USyd, JB	Intrinsic rotation measure variations in pulsars	P425	1.54
D'Amico, Lyne, Manchester, Sarkissian, Possenti, Corongiu, Camilo	CAO, JB, ATNF, ATNF, CAO, CAO, UClmba	Timing and searching millisecond pulsars in globular clusters	P427	6.27
van Leeuwen, Johnston, Stappers, Karastergiou	UAI, USyd, UAm, USyd	Subbeam-carousel rotation times in radio pulsars	P428	2.04
McClure-Griffiths, Lockman	ATNF, NRAO	Galactic halo HI clouds	P430	1.71
Ryan-Weber, Webster, Impey, Marble, Petry	UMelb, UMelb, UAz, UAz, UAz	Gas-rich galaxies and the low redshift Lyman-alpha forest	P431	3.29
Garduno, Brinks, Dahlem	INAOE, INAOE, ATNF	HI content of early-type galaxies as a function of environment	P432	2.02
van Loon, Wood, Marshall, Zijlstra, Matsuura, Whitelock	UKeele, RSAA, UKeele, UMIST, UMIST, SAAO	The wind velocity in Magellanic OH/IR stars	P433	3.39
Burgay, Paladini, Possenti, D'Amico, Manchester	UBol, CAO, CAO, CAO, ATNF	A deep search for isolated millisecond pulsars in NGC 6266	P434	0.86
Matthews, Bourke	UCB, CfA	Towards an understanding of magnetic fields in the Pipe nebula	P435	2.1
McClure-Griffiths, Subrahmanyan, Kanekar	ATNF, ATNF, KI	Determining the temperature of the warm neutral medium	P437	1.07
Crawford, McLaughlin, Cordes	Haverford, JB, Cornell	A search for giant radio pulses from PSR J0537-6910	P438	
Hobbs, Kramer, Johnston, Lyne	ATNF, JB, USyd, JB	Properties of neutron star kicks	P439	0.94
Briggs, Kanekar, Staveley-Smith, Ord	RSAA/ATNF, KI, ATNF, Swinb	Hydrogen 21 cm line absorption at z = 1 against high redshift radio sources	P440	3.34
Hobbs, Dickel, Manchester	ATNF, UIL, ATNF	Searching for pulsars in SNRs N206 and B0453-685	P441	1.08
Knight, Bailes, Ord, Jacoby, Kulkarni	Swinb/ATNF, Swinb, Swinb, Caltech, Caltech	Searching for Globular Cluster MSPs at 50cm	P442	1.34
Knight, Bailes, Kulkarni, Ord	Swinb/ATNF, Swinb, Caltech, Swinb	Giant pulses from a millisecond pulsar	P443	0.33
Wilcots	UWis	Multibeam observations of IC 1613	P446	0.13
Jacoby, Kulkarni, Bailes, Ord, Hotan	Caltech, Caltech, Swinb, Swinb, Swinb	Timing the Swinburne intermediate latitude pulsars	P447	5.07
Di Salvo, Burderi, Burgay, Possenti, D'Amico, Manchester	MPO, UAm, UBol, CAO, CAO, ATNF	Search for radio pulsations from four x-ray msec pulsars	P448	1.31
Karastergiou, Johnston, Ord	USyd, USyd, Swinb	Single-pulse observations of southern pulsars at 50 cm	P449	0.83
Johnston, Romani, Marshall, Zhang	USyd, UStan, GSFC, GSFC	X-ray and radio observations of giant pulses in PSR B0540-69	P450	0.82
Johnston, Romani, Marshall, Zhang	USyd, UStan, GSFC, GSFC	Dual frequency observations of giant pulses in PSR B0540-69	P451	0.63
Wang, Johnston, Manchester	ATNF/USyd, USyd, ATNF	Monitoring the interstellar medium with pulsars	P453	1.68

Burgay, D'Amico, Possenti, Lyne, McLaughlin, Kramer, Manchester, Sarkissian	UBol, CAO, CAO, JB, JB, JB, ATNF, ATNF	Timing of two exotic millisecond pulsars	P455	1.31
McClure-Griffiths, Pisano, Chapman + approx 9 students	ATNF, ATNF, ATNF, ATNF/CTIP	Vacation student observing session	PSVP007	1.5

Observations made with the Mopra radio telescope January to December 2003

Observers	Affiliations	Program Title	Number	Hours
Ladd, Fuller	UBuck, UMist	The evolution of dense cores forming the youngest protostars in Ophiuchus	M118	144
Hoare, Lumsden, Busfield, Oudmaijer, Burton	ULeeds, ULeeds, ULeeds, ULeeds, UNSW	Massive star formation in the Galaxy: Red MSX sources	M121	232
Hirabayashi, Edwards, Lovell, Tzioumis, Tingay, Fomalont, Moellenbrock, Horiuchi, Scott	ISAS, ISAS, ATNF, ATNF, ATF, NRAO, NRAO, JPL, UCal	Continued use of Mopra for VSOP survey observations	M122	24
Kim, Burton	UIL, UNSW	Search for southern massive molecular outflows	M123	288
Matthews, Bourke	UCB, Harvard	Kinematics of the pipe nebulae	M124	168
Yonekura, Mizuno, Fukui, Barnes	UOsaka, UNag, UNag, USyd	Search for candidates of massive protostars in Carina	M125	192
Thompson, Urquhart, White	UKC, UKC, UKC	Star formation in bright-rimmed clouds - is it induced?	M126	240
Wong, Kesteven, Ladd Ryder, Knapen, Buta, Grouchy	ATNF, ATNF, UBuck, AAO, UHerts, UHerts, UAl, UAl	On-the-fly mapping with the Mopra telescope	M127	96
Reynoso, Burton, Green, Johnston	USyd, UNSW, USyd, USyd	Molecular gas associated with the SNR RCW 103	M129	48

VLBI observations - January to December 2003

Observers	Affiliations	Program Title	Number	Hours
Greenhill, Kondratko, Moran, Ellingsen, MCulloch, Lovell, Jauncey, Reynolds, Tzioumis	CfA, CfA, CfA, UTas, UTas, ATNF, ATNF, ATNF, ATNF	What type of accretion disk lies in NGC 4945 - thick or thin?	V120	12
Ojha, Reynolds, Fey, Johnston, Tzioumis, Jauncey, Ellingsen, Cimo, Nicolson, Quick	ATNF, ATNF, USNO, USNO, ATNF, ATNF, UTas, UTas, HartRAO, HartRAO	Astrometry/imaging of southern hemisphere ICRF sources	V131	120
Beasley, Claussen, Ellingsen, Reynolds, Tzioumis	OVRO, NRAO, UTas, ATNF, ATNF	Measuring the mass of the Galaxy - IV	V135	24

Greenhill, Kondratko, Moran, Ellingsen, McCulloch, Lovell, Jauncey, Reynolds, Tzioumis, McGregor	CfA, CfA, CfA, UTas, UTas, ATNF, ATNF, ATNF, ATNF, RSAA	Does the ESO 013-G012 H20 Megamaser originate in an Accretion Disk?	V138	9.3
Huynh, Norris, Jackson, Ojha	RSAA, ATNF, RSAA, ATNF	Phase related observations of galaxies in the Hubble Deep Field South	V153	13.5
Dodson, Johnston, Reynolds, Karastergiou	ISAS, ATNF, USyd, USyd	Distance and proper motion of PSR B1259-63	V156	34
Kondratko, Greenhill, Moran, Lovell, Jauncey, Kuiper, Ellingsen, McCulloch, Tzioumis, Reynolds	CfA, CfA, CfA, ATNF, ATNF, JPL, UTas, UTas, ATNF, ATNF	Mapping water megamasers newly discovered at DSS43	V159	12
Dodson, Johnston, Ord, Reynolds, Lewis	ISAS, USyd, Swinb, ATNF, UTas	Pulsars: where are they from, where are they going?	V162	25
Tingay	ATNF	Wide field, high resolution imaging of jet interaction	V165	12
Dodson, van Straten, Reynolds, Quick, Bailes	ISAS, Swinb, ATNF, HartRAO, Swinb	The LBA millisecond pulsar timing array	V166	46.8
Fomalont, Geldzhaler, Bradshaw, Fender, van der Lis, Stella	NASA, GMU, UAm, UAm, UAm, OARome	VLBI/INTEGRAL 48-hour observations of Sco X-1	V167	12
Tingay, Forbes	Swinb, Swinb	LBA imaging of extragalactic supernova remnants and jet interaction regions	V168	24
Hunstead, Cotter, Tzioumis, Safouris, Bicknell	USyd, UCam, ATNF, RSAA, RSAA	The extraordinary radio galaxy: MRC B1221-423	V169	24.5
Edwards, Tingay	ISAS, Swinb	The parsec-scale morphology of new GPS cources	V170	18

Tidbinbilla Observations- January to December 2003

Observers	Affiliations	Program Title	Number	Hours
Valdettaro, Chapman, Massi, Palla	OAAI, ATNF, MPIfR, OAAI	Star formation in bright rimmed clouds: any water masers?	T001	13.7
Phillips, Lovell, Beuther	ATNF, ATNF, MPIfR	Methanol masers: tracer of high mass protostars and discs?	T002	33.1
Ellingsen, Cragg, Lovell, Godfrey	UTas, Monash, ATNF, Monash	Class II methanol masers at 19.9 GHz	T003	14.2
Ellingsen, Lovell, McCallum, Greenhill, Jauncey	UTas, ATNF, UTas, CfA, ATNF	The Circinus Galaxy - simply scintillating?	T004	51.4
Deacon, Chapman, Green	USyd, ATNF, USyd	The origin of planetary nebulae morphology	T005	8.8
Sridharan, Bourke, Zhang, Balasubrahmanyam, Beuther	CfA, CfA, CfA, RRI, MPIfR	A systematic study of isolated high-mass protostars	T007	7.2
Kondratko, Greenhill, Moran, Lovell, Jauncey, Kuiper	CfA, CfA, CfA, ANTF, ATNF, JPL	Monitoring of water megamasers newly discovered at DSS43	T010	13.0
Curran, Whiting, Wiklind Webb, Murphy	UNSW, UNSW, STScI UNSW, IoA	High redshift molecular absorption in optically faint quasars	T011	8.5

E: Affiliations

AAO	Anglo-Australian Observatory, Australia
AAS	American Astronomical Society, USA
ADFA	Australian Defence Force Academy, Australia
ANU	Australia National University, Australia
ASC	Astrospace Centre, Russia
ASCR	Academy of Sciences of Czech Republic, Czech Republic
ASIAA	Academia Sinica, IAA, Taiwan
ATNF	Australia Telescope National Facility, Australia
BIMA	Berkeley-Illinois-Maryland Association, USA
Caltech	California Institute of Technology, USA
CAO	Cagliari Astronomical Observatory, Italy
CASA	CASA, University of Colorado, USA
Cavendish	Cavendish Laboratory, UK
CEA	Centre d'Etudes d'Astrophysique, Saclay, France
CfA	Center for Astrophysics, Harvard University, USA
CITNZ	Central Institute of Technology, New Zealand
CO	Carter Observatory, New Zealand
Cornell	Cornell University, USA
CNR	Consiglio Nazionale delle Richerche, Italy
CRALOL	CRAL Observatoire de Lyon, France
CSR	Center for Space Research, USA
CTIP	CSIRO Telecommunications & Industrial Physics, Australia
ESA	European Space Agency, Spain
ESO	European Southern Observatory, Germany
ESO (Chile)	European Southern Observatory, Chile
Gemini (Chile)	Gemini Observatory, Chile
GMU	George Mason University, USA
GSFC	Goddard Space Flight Center, USA
HartRAO	Hartebeesthoek Radio Astronomical Observatory, South Africa
Harvard	Harvard University, USA
HatCreek	Hat Creek Radio Observatory, USA
Haverford	Haverford College, UK
IAI	Institute of Astrophysics, Innsbruck, Austria
IAP	Institute d'Astrophysique Paris, France
IAR	Instituto Argentino de Radioastronomica, Argentina
IASp	Institut d'Astrophysique Spatiale, France
IFCAI	Istituto di Fisica Cosmica con Applicazioni all' Informatica, CNR, Italy
INAOE	Instituto Nacional de Astrofísica, Optica y Electronica, Mexico
IoA	Institute of Astronomy, UK
IRA-CNR	Institute of Radio Astronomy, CNR, Bologna, Italy
ISAS	Institute of Space and Astronautical Science, Japan
JAC	Joint Astronomy Centre, Hilo, USA
JBO	Jodrell Bank Observatory, UK
JHU	Johns Hopkins University, USA
JIVE	Joint Insititute for VLBI in Europe, The Netherlands
JPL	Jet Propulsion Laboratory, USA
LivJMU	Liverpool John Moores University, UK
LO	Leiden Observatory, The Netherlands
MERLIN	Multi-element Radio Linked Interferometry Network, UK
MIT	Massachusetts Institute of Technology, USA
Monash	Monash University, Australia
MPIfA	Max Planck Inst. für Astrophysik, Germany
MPIfR	Max Planck Inst. für Radioastronomie, Germany
MPO	Monte Porzio Astronomical Observatory
MRAO	Mullard Radio Astronomical Observatory, UK
NASA	National Aeronautics and Space Administration, USA
NCRA	National Centre for Radio Astrophysics, India
NCSA	National Centre for Supercomputing, USA
NFRA	Netherlands Foundation for Research in Astronomy, The Netherlands
NRAO	National Radio Astronomy Observatory, USA
NRL	Naval Research Laboratories, USA
OAAI	Osservatorio Astrofisico di Arcetri, Italy
OABol	Osservatorio Astronomico di Bologna, Italy
OAP	Osservatorio Astronomico di Padova, Italy
OARome	Osservatorio Astronomico di Roma, Italy
OAT	Osservatorio Astronomico di Trieste, Italy
OAzur	Observatoire de la Cote d'Azur, France
OBordeaux	Observatoire de Bordeaux, France
OMs	Observatoire de Marseilles, France
OSO	Onsala Space Observatory, Sweden
OSU	Ohio State University, USA
OVRO	Owens Valley Radio Observatory, USA
Queens	Queens University, Canada
RAIUB	Radio Astronomy Institute, University of Bonn, Germany

RochI	Rochester Institute of Technology, USA
RRI	Raman Research Institute, India
RSAA	Research School of Astronomy & Astrophysics, Australia
SAAO	South African Astronomical Observatory, South Africa
SISSA	Scuola Internazionale Superiore di Studi Avanzati, Trieste, Italy
SOGB	Sterrenkundig Observatorium, Belgium
StO	Stockholm Observatory, Sweden
StrasbO	Strasbourg Observatory, Austria
STScI	Space Telescope Science Institute, USA
Swinb	Swinburne University of Technology, Australia
UAd	University of Adelaide, Australia
UAl	University of Alabama, USA
UAm	University of Amsterdam, The Netherlands
UAz	University of Arizona, USA
UBC	University of British Columbia, USA
UBol	University of Bologna, Italy
UBr	University of Bristol, UK
UBuck	Bucknell University, USA
UC	University of Colorado, USA
UCal	University of Calgary, Canada
UCam	Cambridge University, UK
UCB	University of California, Berkeley, USA
UCardiff	Universiy of Cardiff, UK
UChi	University of Chile, Chile
UCL	University College London, UK
UCLA	University of California, USA
UClmba	Columbia University, USA
UCSD	University of California, San Diego, USA
UCSU	North Carolina State University, USA
UDur	University of Durham, England
UEdin	University of Edinburgh, UK
UFurm	Furman University, USA
UGuan	University de Guanajuato, Mexico
UHel	University of Helsinki, Finland
UHerts	University of Hertfordshire, UK
UIL	University of Illinois, USA
UKC	University of Kent, UK
UKeele	University of Keele, UK
UKent	University of Kentucky, USA
ULav	Universite Laval, Canada
ULeeds	University of Leeds, UK
ULeic	University of Leicester, UK
UMac	Macquarie University, Australia
UManit	University of Manitoba, Canada
UMar	University of Maryland, USA
UMcGill	McGill University, Canada
UMelb	University of Melbourne, Australia
UMinn	University of Minnesota, USA
UMIST	University of Manchester, Insitute of Science and Technology, UK
UMont	University of Montreal, Canada
UNag	Nagoya University, Japan
UNAM	Universidad Nacional Autonoma de Mexico, Mexico
UNM	University of New Mexico, USA
UNSW	University of New South Wales, Australia
UOsaka	Osaka Prefecture University, Japan
UPenn	Pennsylvania State University, USA
UPuert	University of Puerto Rico, USA
UPune	Pune University, India
UQld	University of Queensland, Australia
URice	Rice University, USA
URuh	Ruhr-Universitaet, Germany
URutg	Rutgers University, USA
USheff	University of Sheffield, UK
USNO	US Naval Observatory, USA
UStan	Stanford University, USA
USU	Ural State University, Russia
USyd	University of Sydney, Australia
UTamk	Tamkang University, Taiwan
UTas	University of Tasmania, Australia
UTS	University of Technology, Sydney, Australia
UUAI	Utrecht University (Astronomical Institute), The Netherlands
UVir	University of Virginia, USA
UWien	Universitat Wien, Austria
UWis	University of Wisconsin, USA
UWS	University of Western Sydney, Australia
Yale	Yale University, USA
YU	Yunnan Observatory, China

F: ATNF media releases, 2003

Australian-raised researcher is new head of international mega-telescope project	01 January
Astronomers make first unbiased census of local galaxies	09 January
WA outback may open new window on the Universe	29 January
Gas clouds make new "telescope"	09 April
Cosmic dandruff mystery solved	06 May
New head for Aussie dishes	08 May
Australian lands top job in astronomy	24 July
World astronomers planning major new telescope	25 July
US Ambassador launches Parkes space tracking	31 October
Pulsar find boosts hope for gravity-wave hunters	05 December
A new arm for our Galaxy?	17 December

ATNF media releases can be found on the web at http://www.atnf.csiro.au/news

G: 2003 publications

Papers using ATNF data, published in refereed journals

Papers which include ATNF authors are indicated by an asterisk.

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H: Postgraduate students co-supervised by the ATNF

As of December 2003

Name, project title and affiliation

Babic, B., "Mass distributions in rich clusters of galaxies", University of Queensland.

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I: Abbreviations

ACA	Australian Communications Authority
AIPS	Astronomical Image Processing System
ALMA	Atacama Large Millimeter Array
APT	Asia-Pacific Telescope
ARC	Australian Research Council
ASKACC	Australian SKA Consortium Committee
ATNF	Australia Telescope National Facility
ATUC	Australia Telescope Users Committee
Aus-VO	Australian Virtual Observatory
COSPAR	Committee on Space Research
CSG	Computer Services Group
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTIP	CSIRO Telecommunications and Industrial Physics – a Division of CSIRO partly co-located with the ATNF
DFB	Digital Filter Bank
DSN	Deep Space Network
EEO	Equal Employment Opportunity
ELT	Extremely Large Telescope
FITS	Flexible Image Transport System
FPGA	Field Programmable Gate Array
GA	General Assembly
GaAs	Gallium Arsenide
GRB	Gamma-ray Burst
HEMT	High Electron Mobility Transistor
HI	Neutral Hydrogen
HIPASS	HI Parkes All Sky Survey
IAU	International Astronomical Union
IF	Intermediate Frequency
InP	Indium Phosphide
ISSC	International SKA Steering Committee
IT	Information Technology
ITU	International Telecommunications Union
IUCAF	Inter-Union Commission for the Allocation of Frequencies

IVOA	International Virtual Observatory Alliance
LBA	Long Baseline Array, used for Australian VLBI observations
LNA	Low Noise Amplifier
LO	Local Oscillator
LOFAR	Low Frequency Array
MERLIN	Multi-Element Radio Linked Interferometer Network
MMIC	Monolithic Microwave Integrated Circuit
MNRF	Major National Research Facilities
NASA	National Aeronautics and Space Administration. The US space agency
NSW	New South Wales
NT	Northern Territory
OECD	Organisation for Economic Cooperation and Development
OHS&E	Occupational Health Safety and Environment
RAFCAP	Radio Astronomy Frequency Committee in the Asia-Pacific Region
RFI	Radio Frequency Interference
RVS	Remote Visualisation Server
SA	South Australia
SCEC	Sydney Convention and Exhibition Centre
SEARFE	Students Exploring Australia's Radio Frequency Environment
SIS	Semiconductor-Insulator-Semiconductor
SKA	Square Kilometre Array
SOC	Scientific Organising Committee
TAC	Time Assignment Committee
URSI	International Union of Radio Science
USNO	United States Naval Observatory
VLBI	Very Long Baseline Interferometry
VSOP	VLBI Space Observatory Program
WA	Western Australia
WRC	World Radiocommunication Conference

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