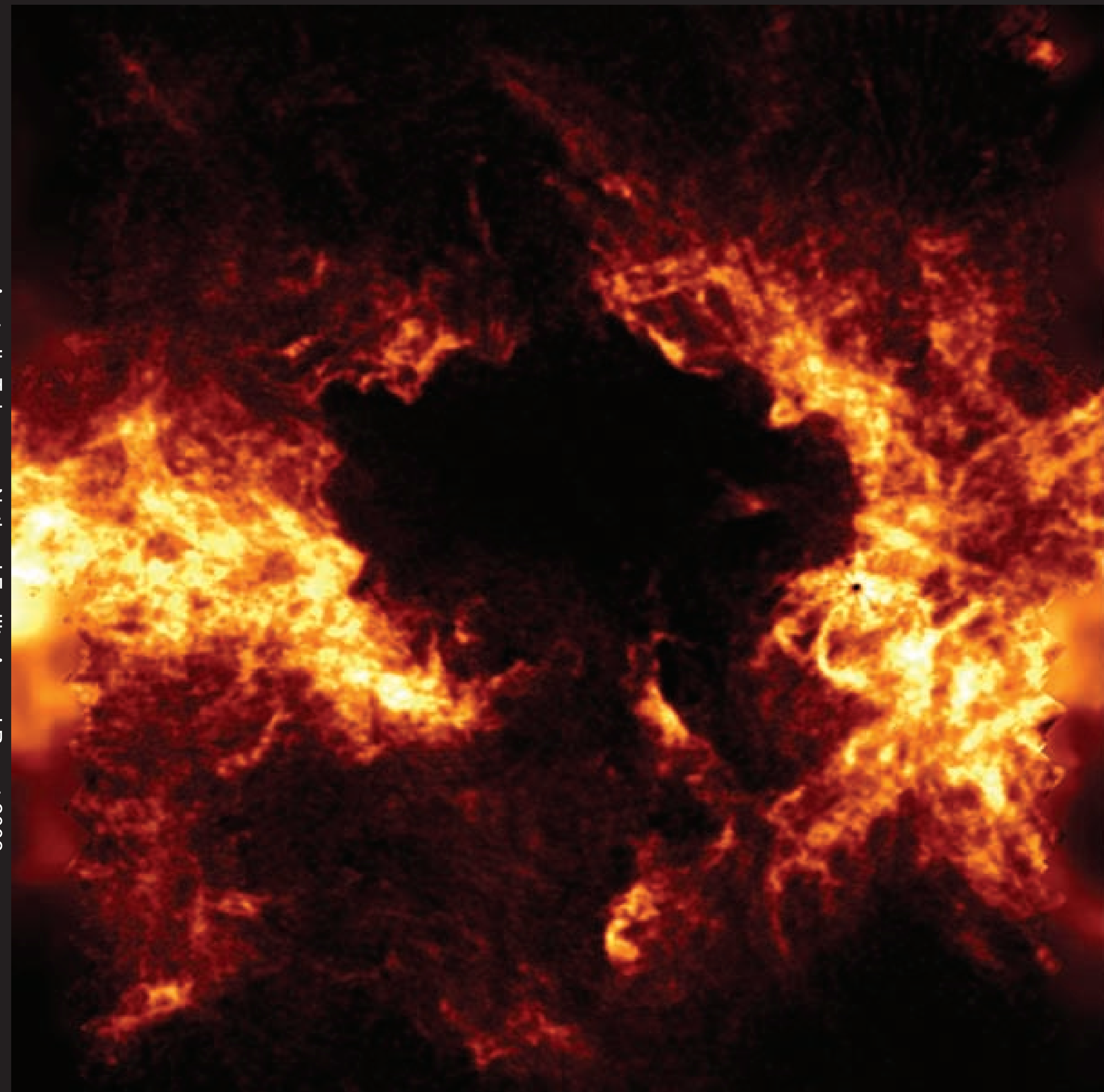
Australia Telescope National Facility



Australia Telescope National Facility Annual Report 2002

Annual Report 2002

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This is the report of the Steering Committee of the CSIRO Australia Telescope National Facility for the calendar year 2002.

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Cover image: Warm atomic hydrogen gas is a major constituent of our Galaxy, but it is peppered with holes. This image, made with the Australia Telescope Compact Array and the Parkes radio telescope, shows a structure called GSH 277+00+36 that has a void in the atomic hydrogen more than 2,000 light years across. It lies 21,000 light years from the Sun on the edge of the Sagittarius-Carina spiral arm in the outer Milky Way.

The void was probably formed by winds and supernova explosions from about 300 massive stars over the course of several million years. It eventually grew so large that it broke out of the disk of the Galaxy, forming a "chimney". GSH 277+00+36 is one of only a handful of chimneys known in the Milky Way and the only one known to have exploded out of both sides of the Galactic plane. It extends more than 3,000 light years out of the disk of the Galaxy.

Image credit: *N. McClure-Griffiths (ATNF);*
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Chairman's report

Over the past year, it is been a delight and a privilege to chair the Australia Telescope National Facility (ATNF) Steering Committee. As is evident from the pages of this annual report, the ATNF has had an excellent year. The strengths of the organisation derive from the excellence of its staff, coupled with its clear vision to play a world-leading role in radio astronomy.

In this regard, the ATNF's continuing pro-active role in the international Square Kilometre Array (SKA) project has been particularly impressive. The ATNF has not only been involved in the development of a number of key design technologies, but has also carried out important work in relation to the potential siting of the SKA in Australia. The ATNF has also continued to contribute at a high level to the science goals of the SKA program. Perhaps one of the most important opportunities to emerge from the ATNF's SKA work during 2002 was the approach made by a US-Dutch consortium to investigate siting LOFAR, a next-generation low-frequency radio telescope, in Australia.

Photo: Kristen Clarke

Professor Brian Boyle, Director of the Anglo-Australian Observatory and Chairman of the ATNF Steering Committee.

The ATNF's strong international profile is underpinned by the continued outstanding performance of its own facilities: the Compact Array at Narrabri and the Mopra and Parkes radio telescopes. During 2002, it was particularly encouraging to see some of the first scientific results emerging from the prototype 12- and 3-mm systems on the Compact Array. The Parkes multibeam receiver system also continues to produce world-leading research, including important new discovery of pulsars associated with supernovae remnants and the results from the surveys for neutral hydrogen emission from galaxies.

These scientific successes would not be possible without the technological innovation that has seen the ATNF maintain its telescopes at the forefront of the world's radio astronomy facilities. The successful completion of the monolithic microwave integrated circuits program this year again demonstrates that the ATNF remains at the cutting edge of technology. In this regard, the ATNF has benefited greatly from its strategy of further enhancing links with other CSIRO divisions and industrial partnerships.

The link between astronomy and technology is a fundamental one. Some of the big questions for astronomy to answer over the coming decade will require the development of new technologies, particularly those in signal processing, information technology and communications, with applications far beyond the astronomical community. The ATNF has positioned itself well to take full advantage of these new opportunities, maintaining Australia not just at the forefront of an inspiring area of scientific endeavour, but also as a world leader in cutting-edge technology for society.

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 135 staff. In 2001 – 2002 the organisation's total expenditure budget was A$17.3M, of which A$12.9M 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.

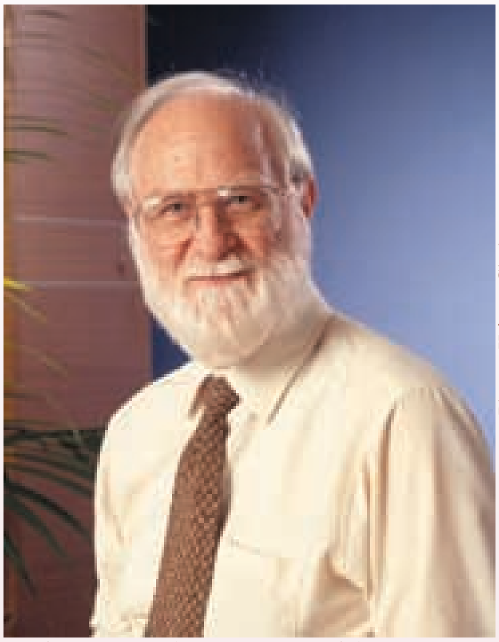

Photo: Kristen Clarke

Professor Ron Ekers, Director of the ATNF

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 2002 the proposals allocated time included scientists from 14 institutions in Australia and 126 institutions in 24 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, ultra-violet, 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 telescope without access charges. This is in accordance with a general practice of the world-wide 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 and international facilities such as particle accelerators and space-based instruments. 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

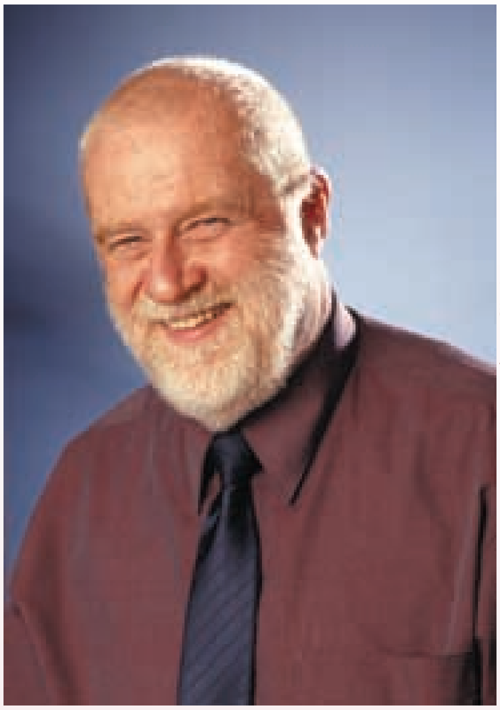

Photo: Kristen Clarke

John Brooks, Assistant Director of the ATNF

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 light.

A further 22-m antenna, known as the Mopra telescope, is located near Mopra Rock, in the Warrambungle 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. Recent 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 CSIRO to develop the ATNF's long-term strategy. 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 2002 are listed in Appendix C.

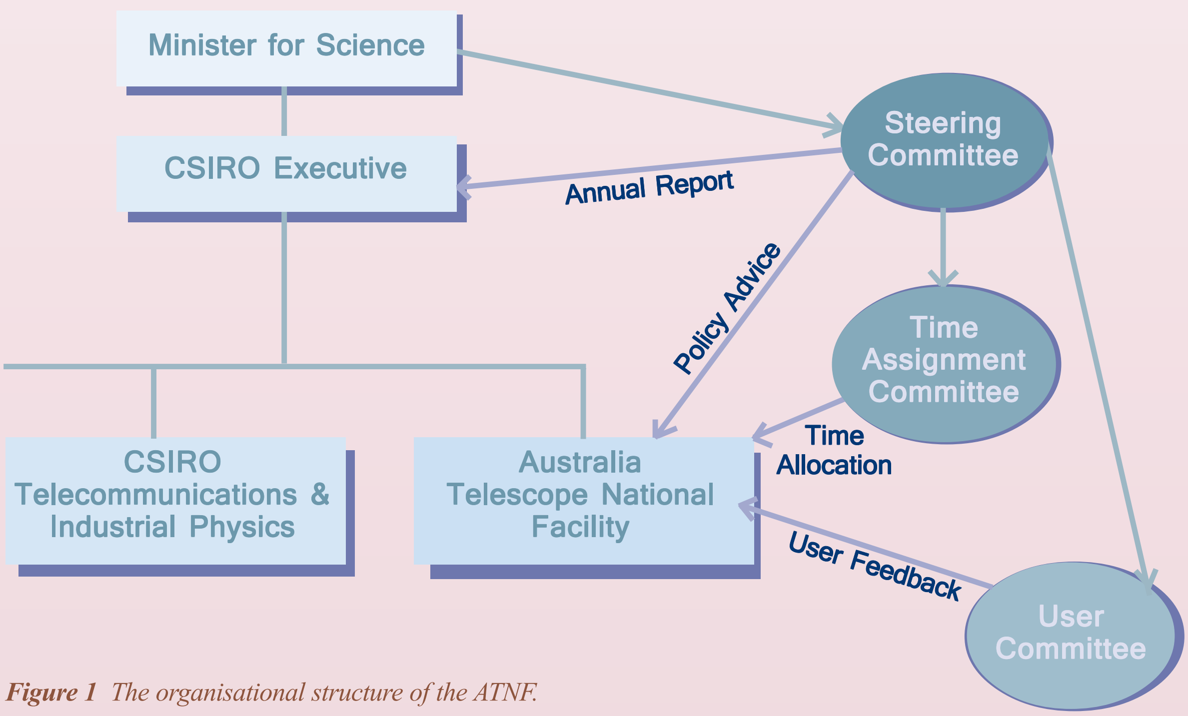

__Figure 1__ The organisational structure of the ATNF.

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 AT 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 meets three times a year and reviews approximately one hundred telescope applications at each meeting.

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%.

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

  During the last five 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**

  The MNRF upgrade will allow the ATNF to maintain a leading position for the next eight to ten years. Beyond that, 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 signficiant 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 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 for SKA development, and improved access to the optical Gemini telescopes, received the largest single allocation of A$23.5M. Initial funding under this award was received in 2002.

- **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 targetted at high school students and their teachers; and to maintain good community relationships.

ATNF management changes in 2002

The ATNF Director, Professor Ron Ekers, was on leave of absence from July 2001 until April 2002 to take up a Miller Professorship at the University of California Berkeley astronomy department. During his absence, and for much of the remainder of 2002, Professor Ray Norris took over as the Acting Director of the ATNF with John Brooks continuing as Assistant Director.

In July 2002 the Australian Research Council announced that Professor Ekers was awarded a Federation Fellowship, one of the most prestigious and richest publicly-funded research positions ever offered in Australia. One of the conditions of this fellowship is that Professor Ekers will cease to have a role in the management of the ATNF for the

Professor Ray Norris, Deputy Director of the ATNF five-year term of the fellowship from March 2003. Following this announcement, ATNF and CSIRO processes were put into motion to find and appoint a new Director.

In May 2002 Dr Lewis Ball was appointed as Deputy Officer-in-Charge of the Parkes Observatory and Human Resources Manager for the ATNF as a whole. In December 2001, Dr David McConnell completed his term as Officer-in-Charge of the Narrabri Observatory and returned to Marsfield to take up a management position as Head of Special Projects. Mr Ron Beresford, the Deputy Officer-in-Charge at Narrabri, also moved to Marsfield. Dr Bob Sault took over as the Narrabri Officer-in-Charge on 1 January 2002 bringing to the observatory a broad range of expertise in engineering, astronomy and computing.

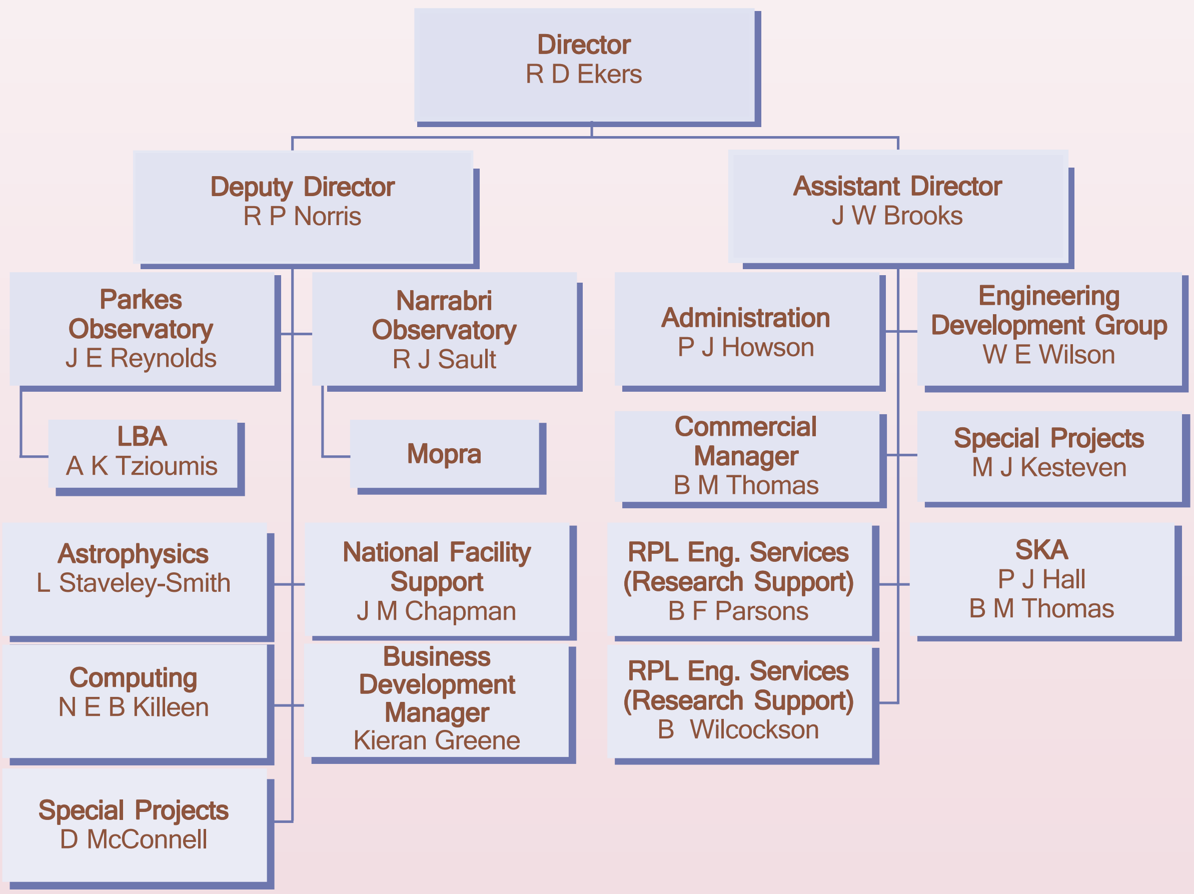

Figure 2 *The management structure of the ATNF in July 2002.*

Performance indicators

The ATNF assesses its performance through key performance indicators, based on those used generally by CSIRO but adapted to be appropriate for a National Facility.

Dr Jessica Chapman
Head, ATNF National Facility Support Group

1 Scheduled and successfully completed observing time

For the Parkes and Narrabri Observatories, the ATNF sets a target that at least 70% of the time available should be allocated for astronomical observations. (The remaining 30% is needed for maintenance and upgrading the facilities.) A second target is that the time lost during scheduled observations from equipment failure should be below 5%.

The following values show the use of time for the year 2002:

	Narrabri	**Parkes**
Time allocated for scheduled observations	79.1%	82.0%
Downtime during scheduled observations	2.4%	5.2%

The downtime for the Parkes telescope includes time lost for wind stows (3.8%).

2 Response of the ATNF to recommendations by the Users Committee

The ATNF Users Committee (ATUC) 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 and current operations, and sets priorities for future developments. Typically, 90% of ATUC recommendations are followed up by the ATNF.

3 Adoption by users and organisations of practices, instruments and processes developed by CSIRO

This indicator lists a selection of hardware and software developments at the ATNF which are now in use at other organisations. Some examples are:

- **Karma visualisation software** developed at ATNF is used by more than 30 astronomical institutions.
- **Miriad data reduction software** jointly written at the ATNF and BIMA, is in routine use at radio astronomy institutions around the world.
- **ATNF digital correlator hardware and control software** are in use at the Tidbinbilla, Hobart, Ceduna, Hartebeesthoek, Jodrell Bank and SEST Observatories.
- **Multibeam observing techniques and data management systems** developed for the Parkes Observatory have been adopted by Jodrell Bank.
- **Components of AIPS++ software** including visualisation routines and fundamental measures, written at ATNF, are being used by several institutions including the Herzberg Institute for Astrophysics (Canada), Jodrell Bank and the Joint Institute for VLBI in Europe (JIVE).
- **Indium phosphide MMIC chips** are an essential component of the FARADAY (Focal-plane Arrays for Radio Astronomy: Design, Access and Yield) project, funded by the European Union. This is a co-operative program between the UK, The Netherlands, Poland, Italy and Australia that aims to produce prototypes of intergrated focal plane arrays and to study large arrays for future implementation.
- **ATNF engineers** are building a multibeam receiver for the Arecibo L-band Feed Array (ALFA). This seven-feed system, operating near 1.4 GHz, will allow extremely high sensitivity surveys to be conducted using the 305-m Arecibo telescope in Puerto Rico.

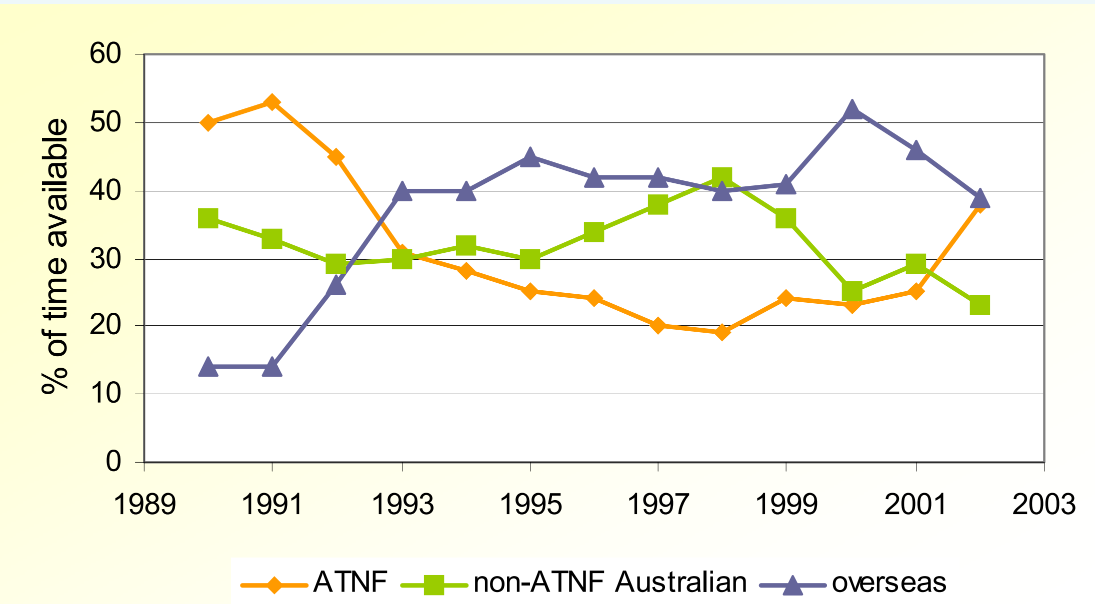

Figure 3 *Compact Array time allocation, 1990 – 2002.*

4 Time allocation on ATNF facilities

The allocation of time on the ATNF facilities is done on the basis of scientific merit. In 2002 a total of 205 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, 138 were for the Compact Array, 48 were for the Parkes telescope, six were for the Mopra telescope and 13 were for the Long Baseline Array. A summary of the observing programs is given in Appendix D. 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.

In 2002 the proposals allocated time on ATNF facilities included a total of 416 different authors. Of these, 42 authors were from the ATNF, 83 were from 13 other Australian institutions and 297 were from 126 overseas institutions in 24 countries. Figure 5 shows the number of authors from each country in 2002. Figure 6 shows the total number of institutions, authors and countries for the years 1999 – 2002.

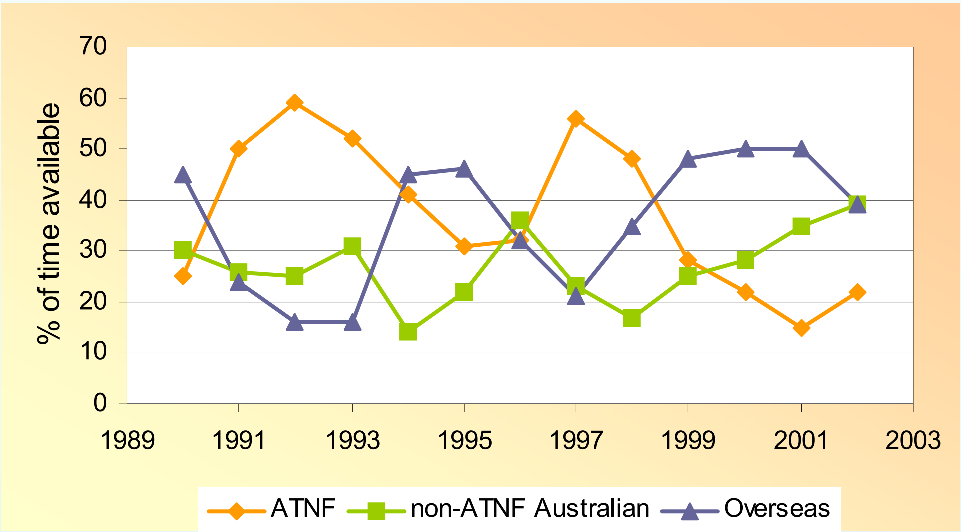

Figure 4 *Parkes time allocation, 1990 – 2002.*

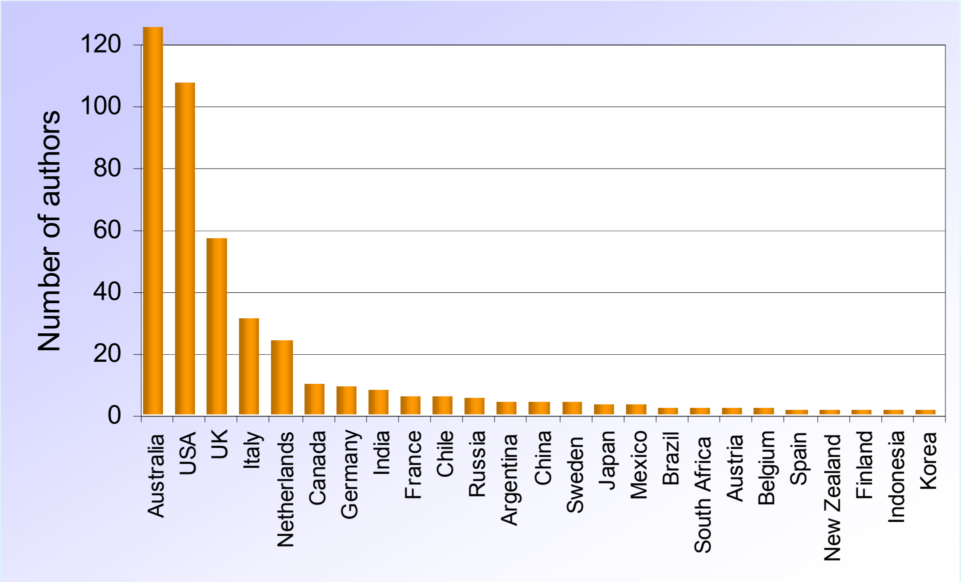

Figure 5 *Australian and overseas participation, 2002.*

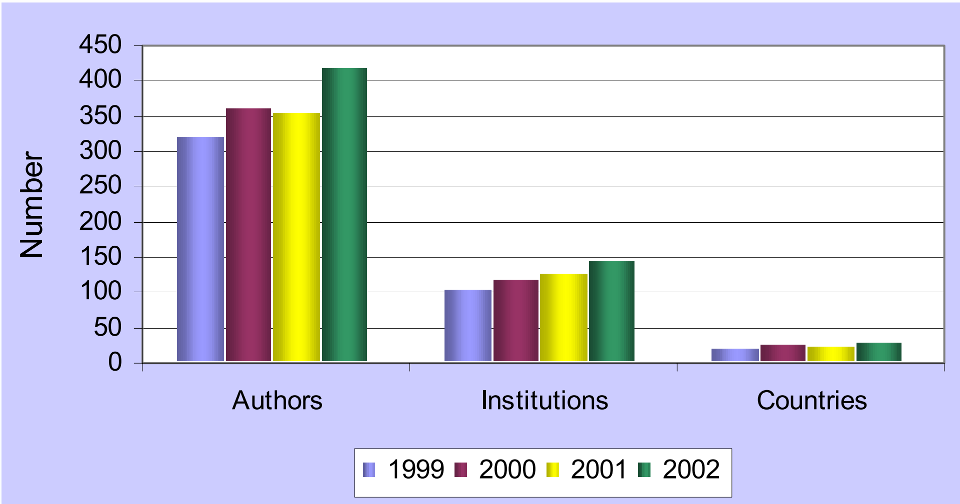

Figure 6 *Australian and overseas participation in 1999 – 2002.*

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

In December 2002 ATNF staff were co-supervising 26 PhD students. Their affiliations and project titles are listed in Appendix H.

6 Number of publications

Figure 7 shows the number of publications in refereed journals and conference proceedings, that 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. Appendix G lists the 103 papers published in refereed journals and the 76 papers published in conference proceedings in 2002.

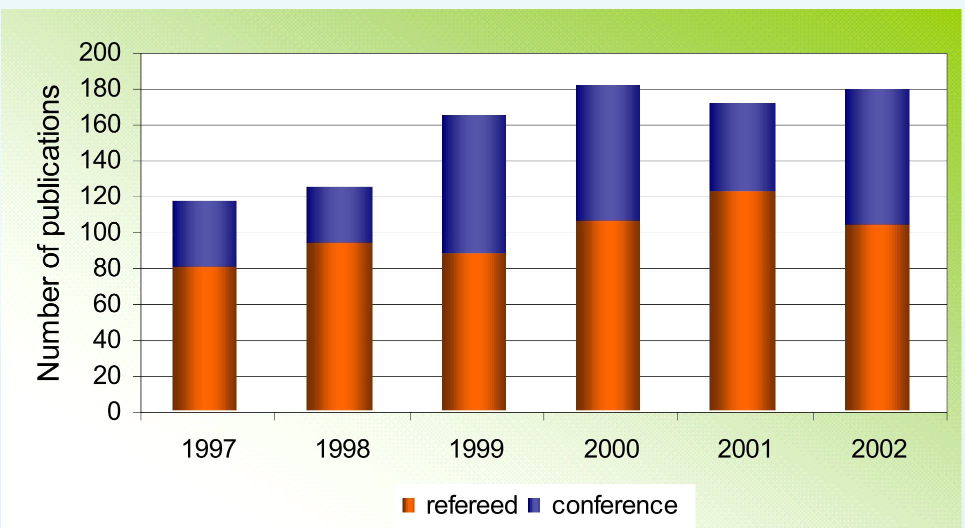

Figure 7 *Papers from data obtained with the Australia Telescope, published in refereed journals and conference proceedings.*

7 Public relations activities

Figure 8 shows public relations activities for the years 1999 – 2002. During the year the ATNF issued six media releases (Appendix F) and featured in at least 100 press items. ATNF staff gave at least 30 television interviews and 45 radio interviews while approximately 45 talks were given to school, university and community groups.

The numbers shown in Figure 8 have been verified where possible. However, the numbers for media reports (television, radio, newspapers) for all years are likely to have been undercounted.

Figure 8 also shows the number of web hits to the central ATNF website. This includes internal use by staff and hits generated by external search engines. The number of web hits increases from year to year, with 15.1 million hits recorded for 2002.

Figure 9 shows the number of visitors to the Narrabri and Parkes Visitors Centres. Approximately 10,000 people visited the Narrabri Visitors Centre in 2002. The number of visitors to the Parkes Visitors Centre increased greatly in 2001, following the release of the film *The Dish* in October 2000 and the opening of the new Visitors Centre building and upgraded facilities in March 2001. The increased number of visitors continued throughout 2002.

The Visitors Centre at the Narrabri Paul Wild Observatory attracts approximately 10,000 visitors each year.

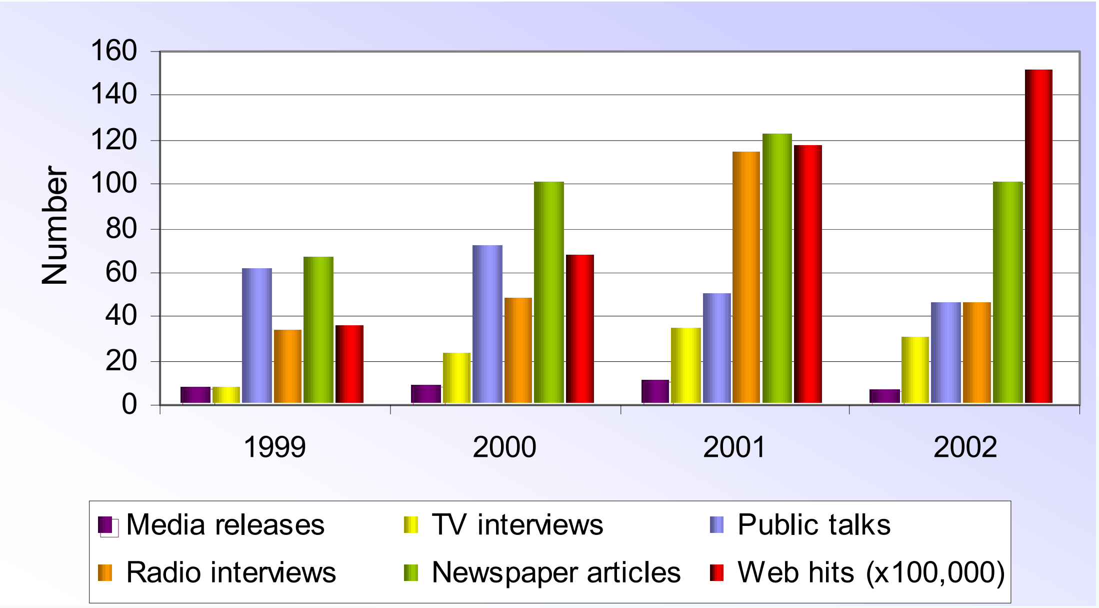

Figure 8 *ATNF public relations activities.*

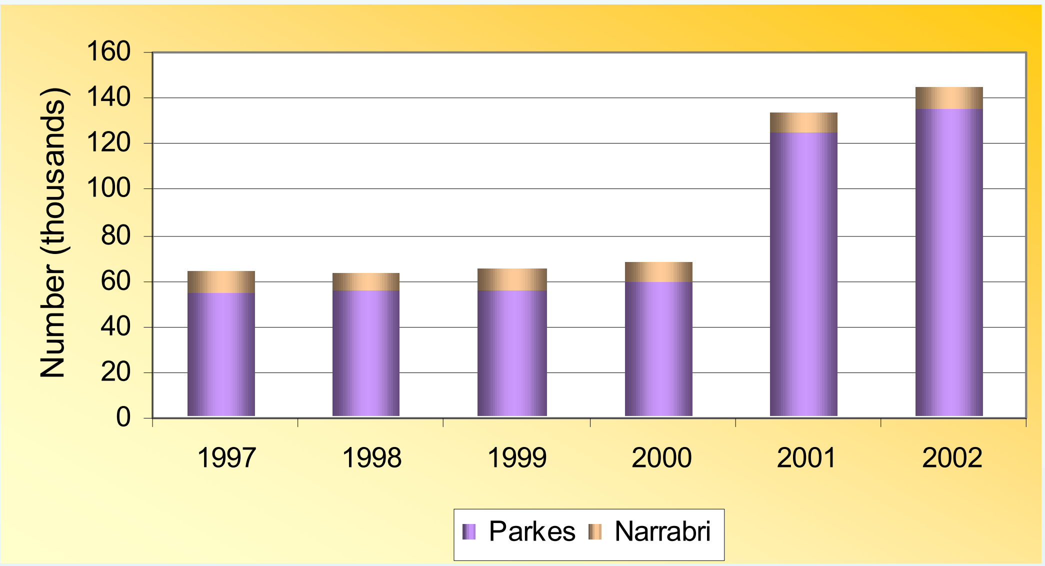

Figure 9 *Number of visitors to the Parkes and Narrabri Visitors Centres.*

8 User feedback at Narrabri and Parkes

Observers at the Narrabri and Parkes Observatories are asked to complete a user feedback questionnaire. Figures 10 and 11 show that the level of satisfaction with facilities provided is generally high. In 2002 the average over all items ranked was 85% for the Narrabri Observatory and 84% for the Parkes Observatory.

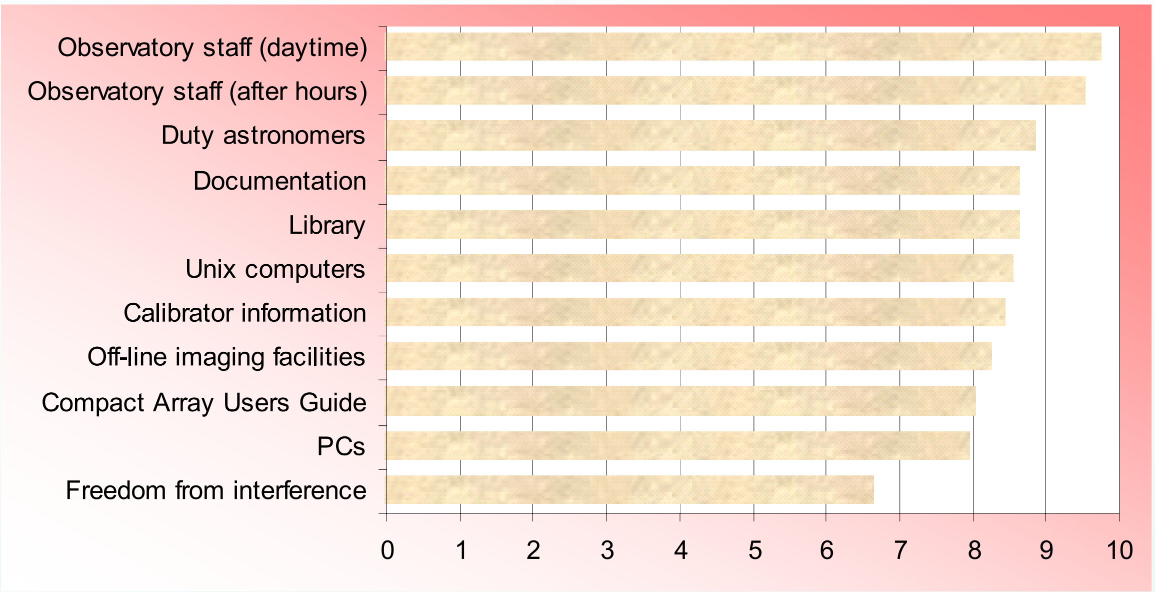

Figure 10 *Narrabri user feedback on a scale of 1 – 10 where 1 = poor and 10 = excellent.*

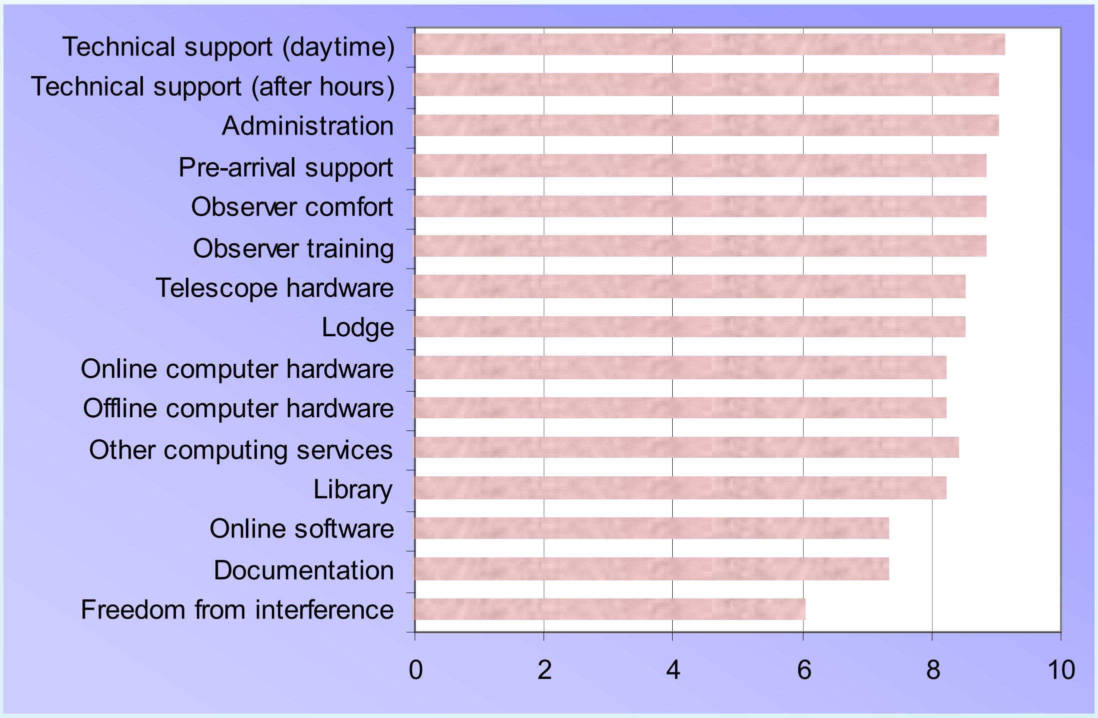

Figure 11 *Parkes user feedback on a scale of 1 – 10 where 1 = poor and 10 = excellent.*

The Parkes radio telescope observed during a solar eclipse on 4 December 2002

Astronomy reports

Millimetre observations of circumstellar disks around the young stars TW Hya and HD 100546

D. Wilner, T. Bourke (CfA, USA); C. Wright (ADFA); J. Jörgensen, E. van Dishoeck (Leiden, The Netherlands); T. Wong (ATNF)

Many young stars exhibit emission from circumstellar dust disks with properties similar to the early Solar System. Observations at millimetre wavelengths are especially important for characterising the physical properties of these disks because the disk material beyond a few stellar radii is at temperatures ranging from a few tens to a few hundreds of degrees, and the physical and chemical conditions can be probed in detail in this part of the spectrum.

The recent upgrade of the Compact Array with receivers for the 3-mm atmospheric window provides a new opportunity for high resolution imaging of protoplanetary disks located in the southern sky. We have observed the dust continuum and HCO^+ ($J = 1 - 0$) line emission at 89 GHz (3.4 mm) from two young southern disk targets, TW Hya, the closest known classical T Tauri star, and HD 100546, a nearby Herbig Be star whose infrared spectrum shows crystalline silicates, indicative of comet-like dust. These were observed using two compact antenna configurations of three antennas, with an angular resolution of about two arcseconds.

TW Hya is isolated from any molecular cloud but retains a face-on disk visible in scattered light that extends to a radius of at least 3.5 arcseconds, equivalent to a linear size of approximately 200 astronomical units (AU). Its disk has been detected in a number of molecular lines at submillimetre wavelengths using single dish telescopes. Modelling all available data suggests the TW Hya disk is substantially evolved, with indications of significant particle growth, i.e., evolution toward planet-sized objects.

HD 100546 is a nearby Herbig Be star and shows a disk-like scattered light distribution of substantial size, about 8 arcseconds (8,000 AU), as well as strong millimetre emission from dust. Mid-infrared spectroscopy shows remarkably strong crystalline silicate bands, similar to those observed in comet Hale-Bopp and indicative of substantial processing of the dust within the disk.

Figure 12 shows the 89 GHz continuum emission detected from TW Hya and HD 100546. The flux observed from TW Hya agrees well with expectations from its spectral energy distribution. Models that reproduce the far-infrared emission of HD 100546 using only an extended envelope do not account for the flux observed at 1.2 mm which suggests that a circumstellar disk component must be present in the system. The Compact Array observations provide the first direct evidence for this compact disk component.

Figure 13 shows the HCO^+ ($J = 1 – 0$) spectrum of TW Hya, integrated over the continuum position. The velocity and line-width of the narrow emission line are in agreement with single dish observations. The HCO^+ ($J = 1 – 0$) line emission from the TW Hya disk is spatially resolved, with a fitted Gaussian size of 3.2 arcseconds. Since the critical density of the HCO^+ ($J = 1 – 0$) line for collisional excitation is approximately 6 x 10^4 cm^{-3}, the detection of extended emission indicates high densities must be present to large radii, independent of any detailed physical and chemical model for the disk. No HCO^+ ($J = 1 – 0$) emission was detected toward HD 100546, a surprising result. Observations of the more abundant species CO in the 110 – 115 GHz range are needed.

Previous modelling of the TW Hya disk suggests that species like CO and HCO^+ are depleted due to a combination of photodissociation in the warm surface layers and freezing-out in the cold parts of the disk shielded from stellar activity. These models, based either on a radiatively-heated accretion disk structure or a passive two-layer disk structure, are consistent with the Compact Array observations, for both the size scale and the absolute intensity of the HCO^+ line. The models all have disk masses of 0.03 solar masses and disk radii of 200 AU. High depletion has been observed in other young disks of varying size and indicates that substantial depletion occurs throughout the disk, as expected for planet formation through accretion.

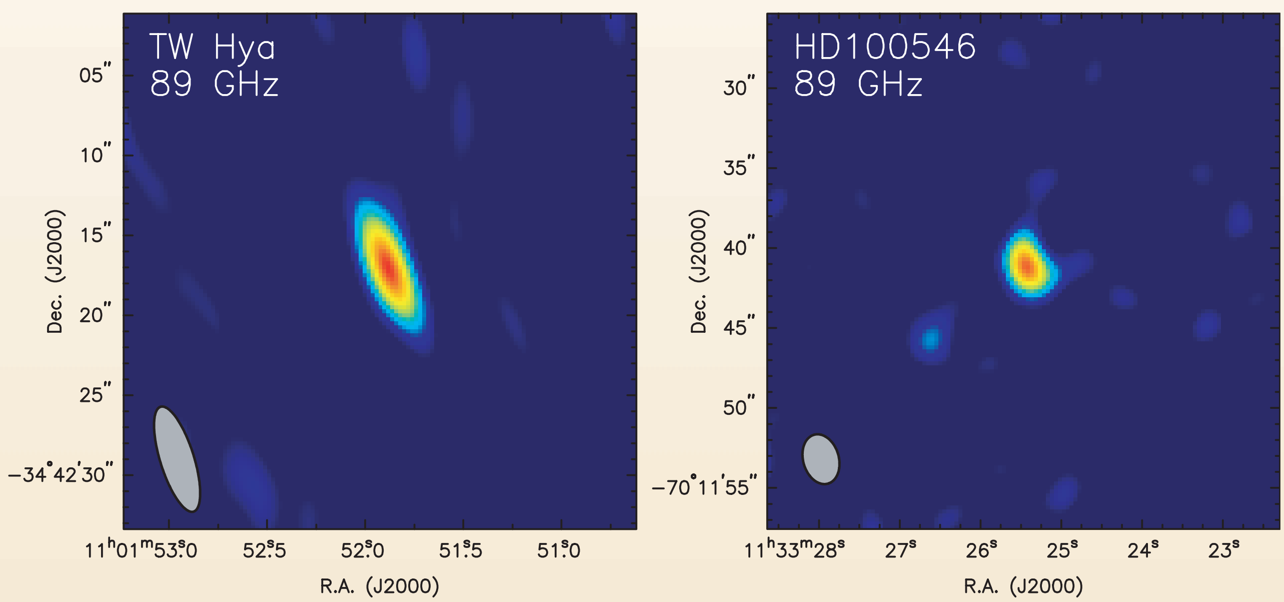

Figure 12 *Images obtained with the Compact Array showing radio continuum emission at 89 GHz from the young stars TW Hya and HD 100546.*

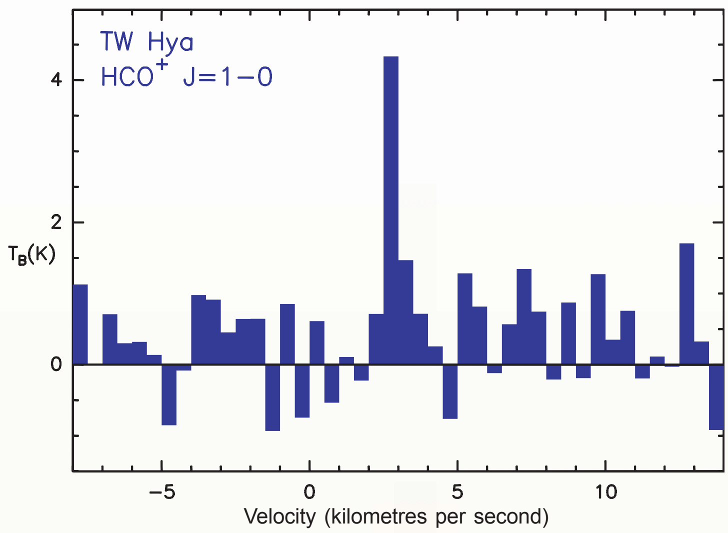

***Figure 13** HCO^+ spectrum of TW Hya showing the detection of a narrow emission line centred at a velocity of 3 kilometres per second.*

Imaging HCN emission around R Scl

T. Wong (ATNF); F. L. Schoeier (Leiden Obseratory, The Netherlands & Stockholm Observatory, Sweden); M. Lindqvist, H. Olofsson (Stockholm Observatory, Sweden)

One of the first targets for the Compact Array 3-mm system was the carbon-rich red giant star R Sculptoris, which is believed to be encircled by a detached shell of molecular gas and dust. For a dying star to be losing mass in a slow stellar wind is quite typical, but the presence of a thin detached shell indicates that at some point in the past there was a sudden increase in the rate of mass loss, perhaps due to the sudden onset of helium shell burning. By observing molecular emission in the shell at high angular resolution, one can determine not only the expansion velocity of the shell, but also the time scale of the mass-loss variation (related to the shell thickness) and the degree of isotropy of the wind (related to the symmetry of the shell). Notwithstanding their scientific interest, circumstellar shells also make ideal "test sources" for the current 3-mm system because they are relatively simple structures of small angular size (compared, for instance, to molecular clouds).

Although the previous single-dish observations that had indicated the presence of a shell around R Scl were made in a CO emission line with the Swedish-ESO Submillimetre Telescope (SEST), the Compact Array's restricted frequency range led us to observe the HCN $(J = 1 – 0)$ line at 88.6 GHz. We observed R Scl in several compact configurations of three antennas, with baselines ranging from 31 – 413 m, between June and October 2002. We found that the HCN emission is extremely compact, with a Gaussian full width at half maximum (FWHM) of about one arcsecond, so that even our high-resolution imaging only partially resolves the source (Figure 14). The total Compact Array flux is consistent with the SEST flux within the calibration uncertainties. Thus, it appears that the HCN emission is associated with an attached envelope resulting from recent mass loss rather than the older (and hence larger) detached shell inferred from the CO data. The difference in geometry is corroborated by higher-transition, single-dish HCN spectra, which indicate that the HCN envelope is expanding more slowly than the bulk of the CO emission. The lack of HCN in the detached shell is most likely due to its photodissociation into CN, as has been observed in several other sources.

A detailed radiative transfer code, based on the Monte Carlo method, has been used to jointly model the Compact Array and single-dish HCN data. The main inputs to the model are the current mass-loss rate (in solar masses per year) and the stellar radiation field. With reasonable assumptions for these, we have calculated the best-fit values for the HCN abundance (relative to H_2) and envelope size, using the HCN data (both single-dish and interferometer) as constraints. The best-fit envelope size is about 1,000 AU, whereas modelling the Compact Array data alone yields a size of only 300 AU (comparable to the size of the emission region in our high-resolution maps). Thus a single set of model parameters cannot simultaneously fit both the single-dish and interferometer data. Possibly the high optical depth of the HCN lines makes the emission very sensitive to changes in the physical conditions of the inner envelope (such as clumping in the mass distribution) that are not accounted for in our model.

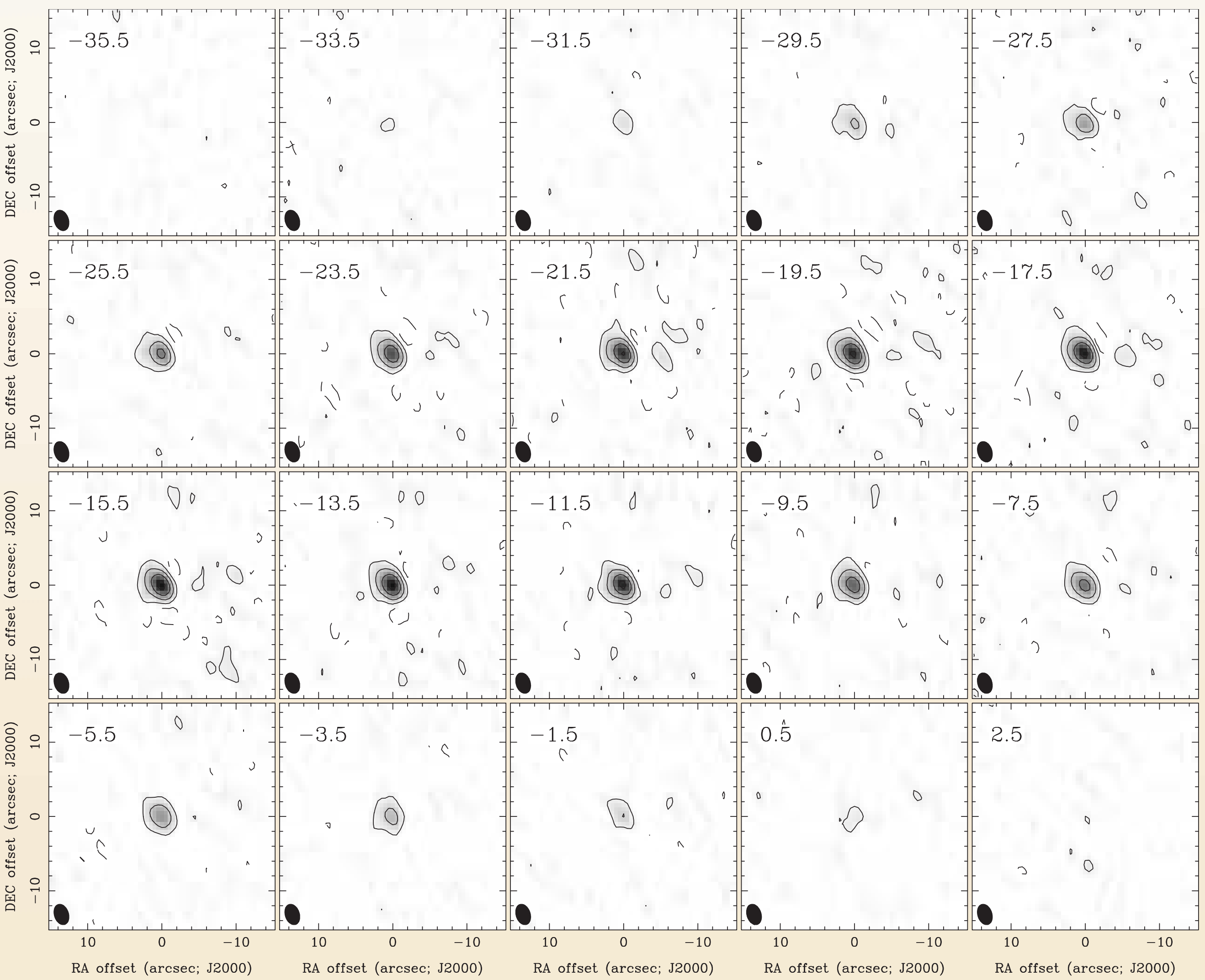

Figure 14 *Channel maps of HCN (J =1 – 0) emission from R Scl. The beam size is 2.7 x 1.8 arcseconds. The velocity channels (given relative to the local standard of rest) have been binned to 2 kilometres per second.*

Planetary nebulae and butterfly wings

R. Deacon (University of Sydney); J. Chapman (ATNF); A. Green (University of Sydney)

Planetary nebulae are the remnants of low-to-middle mass stars. When stars, like our own Sun, run out of core-burning hydrogen, they go through a sequence of structural changes. The outer layers greatly expand while the stellar cores decrease in size and become hotter. Of particular interest in the "giant" stages is that most stars shed a large fraction of their mass through slow, dense stellar winds. Such winds transfer more than half of a star's original mass back into the interstellar medium. After most of the outer layers of gas have been blown away, stars change from losing mass in slow dense winds to losing mass in hot, low-density, fast winds. The hot winds sweep up the remaining material surrounding the stars and the swept-up shells may then be seen as glowing ionised nebulae. Stars in this stage are known as planetary nebulae.

Planetary nebulae can be spectacularly beautiful and reveal many different forms. While some appear circular, others have the shapes of butterfly wings, or show elliptical or bipolar shapes, in some cases with complex, filamentary structures. The causes for this proliferation of geometries are not yet known, but several different theories are being debated. One possible explanation is that magnetic fields from the stars constrain the stellar winds to flow in some directions only. Alternatively, companion stars or planets may cause gravitational effects, or rotation of the central stars may be important.

We are studying a sample of stars that are the immediate precursors to planetary nebulae. These stars are known as post-asymptotic giant branch (post-AGB) stars and have evolved beyond the second giant phase known as the AGB. The different geometries seen in planetary nebulae are also seen in post-AGB stars and it seems likely that the shaping of non-spherical planetary nebulae winds begins early in the post-AGB phase of stellar evolution. By studying the post-AGB stars we may be able to determine what causes the butterfly-wing geometries and other complicated structures seen in some planetary nebulae.

To investigate this question, we have selected a well-defined sample of 85 post-AGB stars from a previous study of OH maser sources in the Galactic plane (Sevenster et al.). For this sample, we are observing radio emission from hydroxyl, water and silicon monoxide molecules that are located in the outflowing stellar winds. Each molecule requires different physical conditions to exist and provides information on the physical gas conditions in a layer around the central star. The radiation from these molecules is produced by a maser effect—the microwave equivalent of lasers. The maser spectra also provide accurate information on the wind speeds, and on whether the winds are likely to be spherically symmetrical or distorted.

Figure 15 shows examples of OH maser spectra, for sources in our sample, at a frequency of 1612 MHz. We have classified the spectra using six different categories, depending on the shape of the spectral profiles. Of the 85 sources, 57 exhibit a classic double-peaked spectrum ("D-type") at 1612 MHz, with steep outer edges and sloping inner edges between the two peaks. This spectral profile is characteristic of an expanding spherical shell, with the two peaks being emitted from small "caps" on the front and rear of the shell. In our sample we see several variations on the classic double-peaked profiles: The "De" spectra have one emission peak which is very much stronger than the other—this shows that the maser emission is much stronger on one side of the star than on the other. The "Dw" stars have OH 1612-MHz spectra with sloping outer edges as well as sloping inner edges. These are expected to be stars with bipolar shells. More unusual is the "DD" source with four emission peaks. Only one other source with this characteristic is known.

In our sample we also find five "S-type" sources. These show only a single peak of maser emission, but otherwise have characteristics in common with AGB and post-AGB stars. Finally the "I" or irregular spectra have multiple emission peaks and a larger than usual velocity range. Post-AGB stars with such irregular spectra are usually associated with exotic envelope geometries.

From our maser data, together with still-to-come measurements of the stellar magnetic fields and detailed radio images of the outflowing winds, we hope to clarify why some stars evolve to have asymmetric winds and others do not.

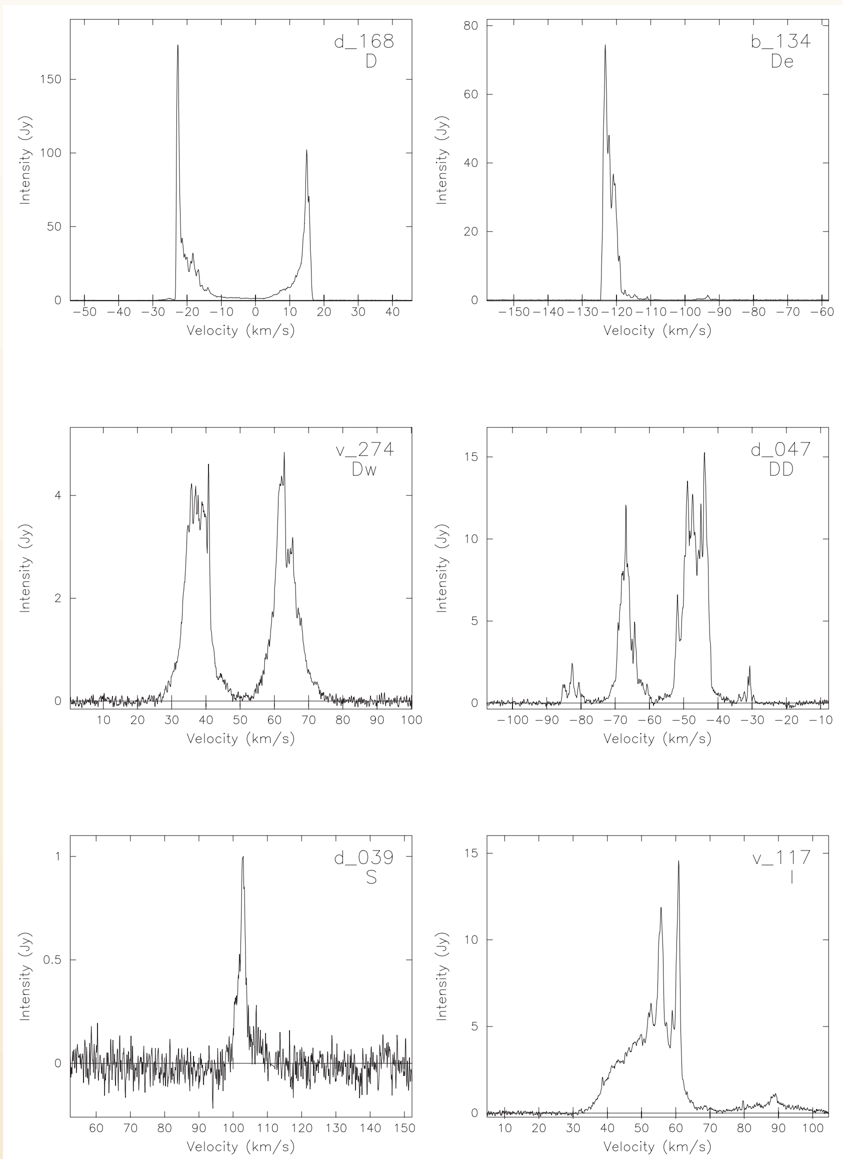

Figure 15 *Some examples of OH 1612 MHz spectra of post-AGB stars, obtained from data taken with the Parkes radio telescope in September 2002. The catalog name of each star is given in the top right-hand corner with a category type given below the name. The 85 stars in this study have been classified into six different types depending on whether the OH maser profiles are double (D, De, Dw and DD-types), single (S-type) or irregular (I-type).*

Figure 16 *M2-9 is a striking example of a "butterfly" or bipolar planetary nebula. This image, taken with the Hubble Space Telescope, shows a pair of high-speed "jets" of gas moving away from the centre of the nebula at super-sonic velocities of more than 300 kilometres per second.*

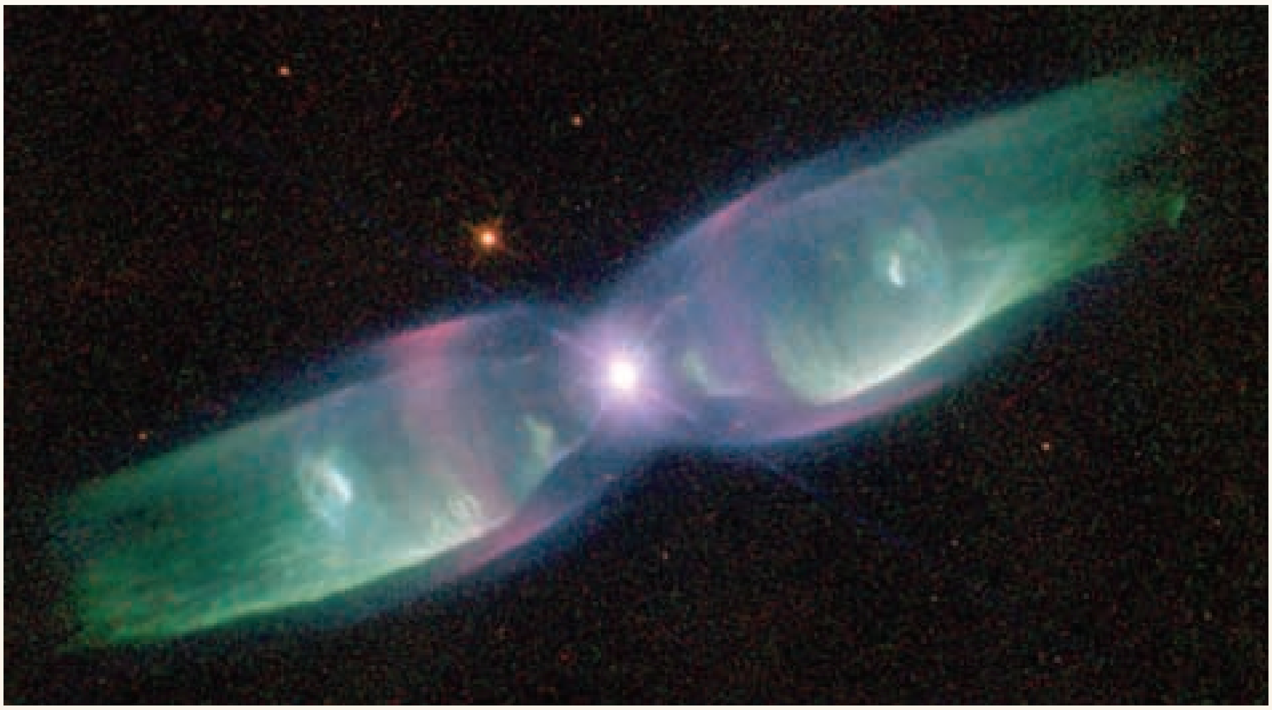

Photo credit: B. Balick (University of Washington, USA); V. Icke (Leiden University, The Netherlands); G. Mellema (Stockholm University, Sweden); NASA (USA)

Image reference: Image STScI-PRC1997-38

The Compact Array captures a "baby" supernova

S. Ryder (Anglo-Australian Observatory); R. Subrahmanyan (ATNF); E. Sadler (University of Sydney); K. Weiler (Naval Research Laboratory, USA)

On the evening of 10 December 2001, the Rev. Robert Evans was conducting his regular supernova patrol from his backyard in the Blue Mountains west of Sydney, when he came across an interloper in the nearby late-type spiral galaxy NGC 7424. In an era when the vast majority of supernova discoveries are made by robotic telescopes, or as part of the high-redshift supernova search programs, Evans' trained eye, photographic memory, and trusty 12-inch telescope have allowed him to maintain a proud record of supernova discoveries. Supernova 2001ig was his 39th discovery, and the 241st supernova discovery of 2001.

Since its commissioning, the Compact Array has played a leading role in the monitoring of several supernovae at radio wavelengths, most notably SN 1987A and SN 1978K. Radio emission from Type II supernovae is typically not detected (or even searched for) until weeks, months, or even years after the outburst. On the evening of Saturday 15 December 2001, we made use of six hours of unallocated time on the Compact Array to make images of SN 2001ig at frequencies of 8.6, 4.8, 2.5 and 1.4 GHz. Somewhat to our surprise, there was a positive detection at the highest frequencies. On New Year's Eve, it was detected at 18.8 GHz using the prototype 12-mm receiver system on three Compact Array antennas.

Figure 17 shows an image of the field at 4.8 GHz from Compact Array observations taken on 17 February 2002. SN 2001ig is the upper of the two bright sources shown as contours; the source to the southwest is an unrelated background source. Figure 18 shows the results from our Compact Array monitoring program; for clarity, only the 8.6 and 4.8 GHz data are shown. The radio "light curve" of a supernova can be divided into three phases—a rapid turn-on with a steep spectral index, due in large part to a decrease in the line-of-sight absorption; a peak in the flux density which is first seen at the higher frequencies; a more gradual decline in an optically-thin phase. By March 2002, SN 2001ig had begun to fade at 5 and 8 GHz, but then abruptly doubled in flux and remained that way for three weeks, before resuming its decline. In late August, it again briefly halted its decline. Such dramatic excursions from a smooth decline are rare, and generally thought to be associated with the interaction of the blast ejecta with a dense and rather inhomegenous circumstellar medium.

SN 2001ig is one of only a half dozen or so known examples of a "Type IIb" supernova, in which the hydrogen lines seen in their early optical spectra soon fade away, suggesting that much of their outer layers were shed before the star exploded. Two possible mechanisms for this, which could also account for the bumps in the radio light curve, are thermal pulses due to carbon/helium flashes in the core of a 5 – 10 solar mass asymptotic giant branch progenitor star, occurring on periodic time scales of around 500 years, or a modulation of a red supergiant progenitor wind due to eccentric orbital motion about a massive binary companion, leading to a pinwheel-like clumping in the circumstellar medium. Efforts are now underway to model the observed behaviour in the context of these scenarios, while Compact Array monitoring of SN 2001ig will continue throughout 2003.

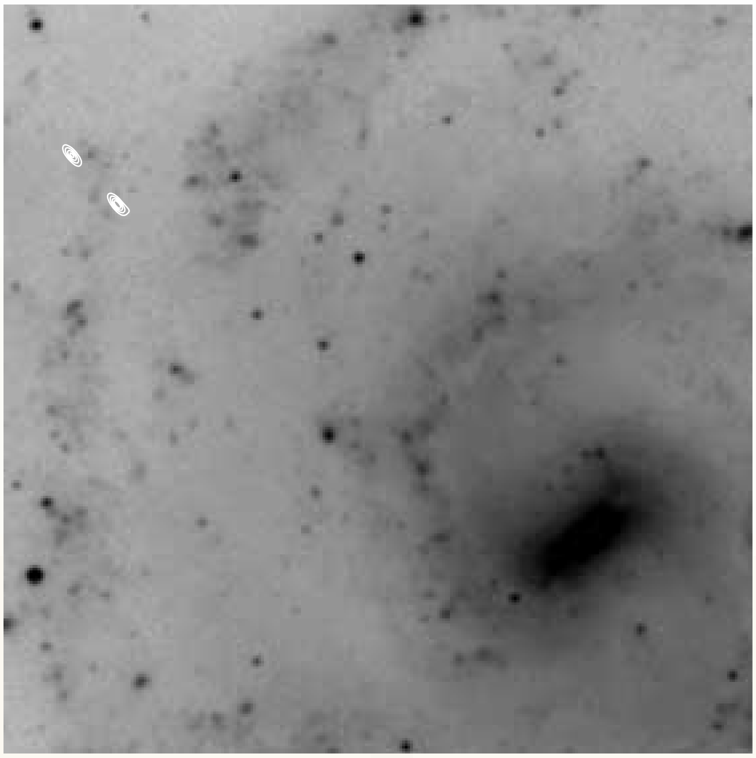

__Figure 17__ Contours showing the 4.8-GHz radio emission from the region around SN2001ig, overlaid on an image of the outskirts of the galaxy NGC 7424 from the Digitized Sky Survey. SN2001ig is upper left of the two radio sources. The lower radio source is an unrelated background source.

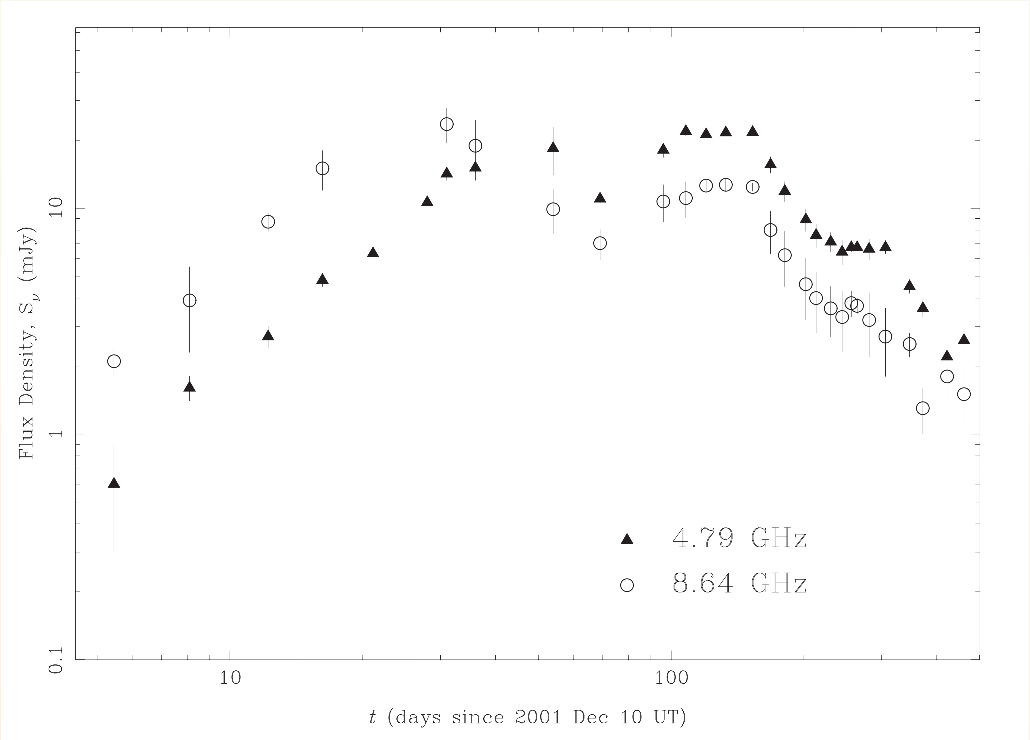

__Figure 18__ The radio light curve of SN2001ig, showing the change in intensity of the radio emission at frequencies of 4.8 and 8.6 GHz over a period of approximately 400 days.

Pulsar discoveries at Parkes

F. Camilo (Columbia University, USA); B. M. Gaensler (Harvard University, USA); D. R. Lorimer (University of Manchester, UK); R. N. Manchester (ATNF)

2002 yielded a remarkable vintage of young pulsar discoveries, with the Parkes telescope playing a central role.

Young pulsars are objects of interest for a variety of reasons. The physics of core collapse in evolved stars can be inferred from observations which provide the initial spin period, space velocity, and magnetic field distributions of neutron stars, while measurements of their beaming properties, luminosities, and spectra are crucial for determining the Galactic population and birthrate of pulsars. Young pulsars frequently exhibit period glitches, and emit substantial amounts of X- and gamma rays—these can be observed to learn about the internal composition of neutron stars, and the pulse emission mechanisms. In addition, young neutron stars are embedded in compact non-thermal radio and/or X-ray pulsar wind nebulae where the ambient medium confines the relativistic pulsar wind, or otherwise interact with their host supernova remnants. The embedded pulsars are unique probes of their immediate environment and the local interstellar medium.

A natural location to search for young pulsars is the Galactic plane and more specifically in supernova remnants. However, establishing bona fide associations between Galactic pulsars and supernova remnants has been a painfully slow business: two were known by 1970 (those of the Crab and Vela), five by 1985, and only 10 by 2000, although more than 200 supernova remnants and 1,400 pulsars are known. Searches for associations have not been immensely productive in this regard—a survey of 88 supernova remnants in the 1990s netted zero associated pulsars!

More recently the Parkes multibeam pulsar survey of the Galactic plane, using a 13-beam receiver system at a frequency of 1,400 MHz, covered a very large area with sensitivity broadly comparable to that of the best previous surveys of supernova remnants. This survey has been extraordinarily successful, discovering approximately 700 pulsars, but to date has yielded only one new association between a pulsar and a supernova remnant (for a discussion of this pulsar, PSR J1119–6127, in the supernova remnant G292.2–0.5 see the ATNF Annual Report 2000).

We have used a method to detect young pulsars that relies on the premise that the existence of a pulsar wind nebula must also indicate the presence of an energetic and reasonably young pulsar. We decided to search pulsar wind nebulae *as deeply as possible*, to look for new detections of young pulsars. A complication with this approach is that it is not always clear whether a particular compact object is a pulsar wind nebula. However, recent X-ray images from the *Chandra* X-ray Observatory can, in some cases, unambiguously identify a pulsar wind nebula and its embedded pulsar even when pulsations are not detected.

One such example is provided by the beautiful *Chandra* observation of SNR G292.0+1.8, shown in Figure 19. The X-ray data of this source reveal a two arcminute pulsar wind nebula within which is located a point source. While this supernova remnant had been searched previously without a pulsar detection, the *Chandra* results encouraged new efforts. In a 10-hour integration at Parkes using the central beam of the multibeam system, we detected PSR J1124–5916, with a pulse period of 135 milliseconds, a moderate dispersion measure (330 pc cm^{-3}), and a characteristic age of 2,900 years. PSR J1124–5916 is a *very weak* source, with a flux density at 1,400 MHz of 80 microJansky and a low radio luminosity. X-ray pulsations were detected subsequent to and with the help of the radio discovery.

Following this discovery, many more pulsar wind nebulae were searched as deeply as possible with the Arecibo, Green Bank, Jodrell Bank and Parkes telescopes. In all, six very weak and energetic young pulsars, associated with wind nebulae (in some cases within supernovae), have been detected in the past two years, and the searches continue. The newly discovered objects are being investigated in follow-up studies at radio and X-ray wavelengths, and a careful analysis of the sensitivity and selection effects relevant to these searches is underway and should yield useful constraints on the combination of luminosity distribution and beaming fraction of young pulsars.

Our study has shown that many young pulsars beam towards the Earth. However, many of them do so with luminosities that are detectable with the best present-day radio telescopes only when using integration times of a day or so, if at all! While X-ray astronomers have long been used to spending a day obtaining a handful of photons from astronomical sources of interest, such as young pulsars, this is a relatively new lesson for radio pulsar observers to learn.

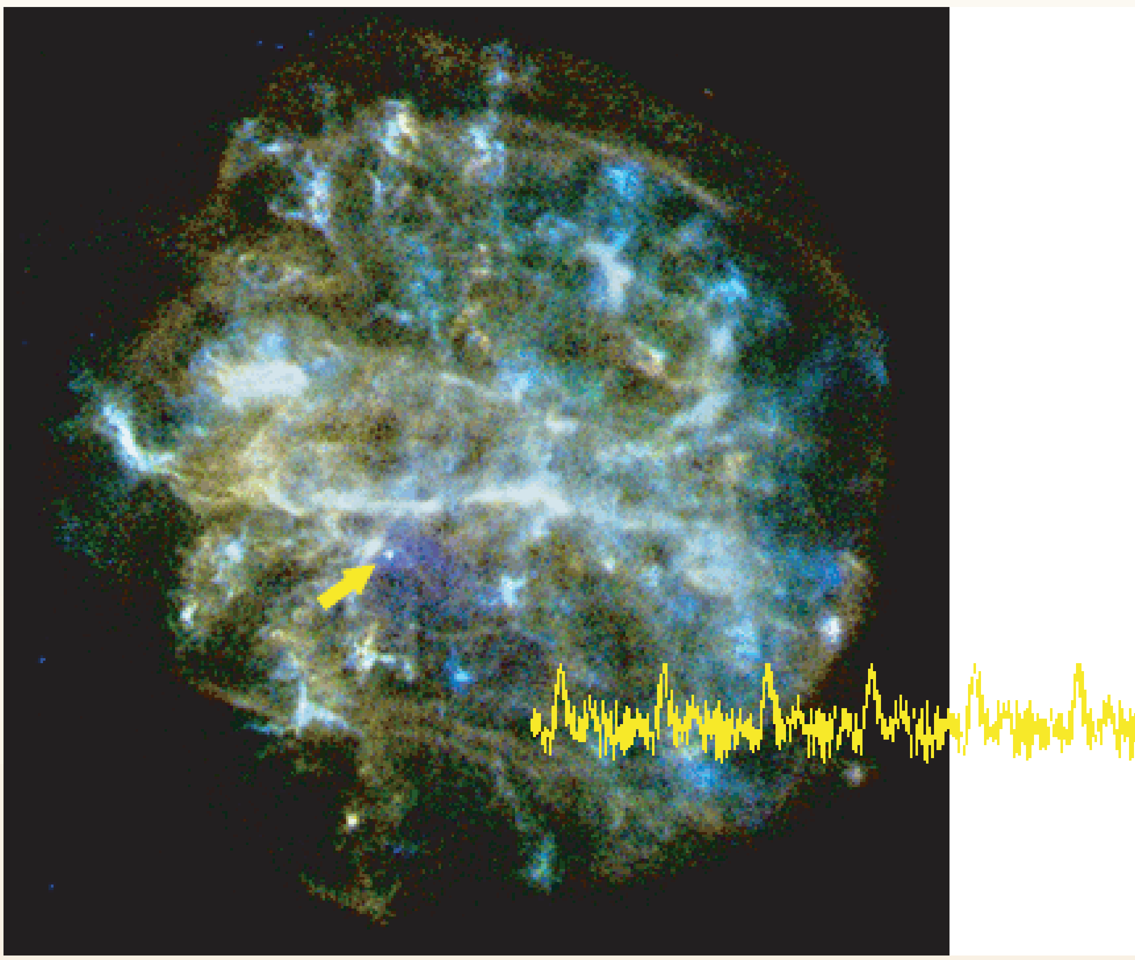

Image credit: NASA/Rutgers/J. Hughes et al.

Figure 19 *Chandra X-ray image of the oxygen-rich 1,700 year old composite SNR G292.0+1.8. The position of the pulsar is indicated by the arrow and the mean pulse profile of PSR J1124–5916, obtained from Parkes data, is overlaid.*

Discovery of a super-massive spiral galaxy

J. Donley, B. Koribalski (ATNF); R. Kraan-Korteweg (University of Guanajuota, Mexico); A. Schroeder (University of Leicester, UK); L. Staveley-Smith (ATNF) and the ZOA team

How massive can a spiral galaxy become? Current theoretical models predict that spiral galaxies like the Milky Way form from the merger of smaller galaxies at times when the Universe was between 25% and 50% of its current age. This merger process is thought to create a population of present-day spiral galaxies whose number densities decline exponentially at masses higher than a characteristic value, M*. Observational evidence (e.g. from HIPASS, see page 32) support this theory and set M* to a neutral hydrogen (HI) mass of approximately $6x10^{9}$ solar masses. The density of galaxies much more massive than this characteristic value is poorly constrained, however, as these super-massive galaxies are very rare.

Through a large survey that utilised the Parkes multibeam receiver, we have discovered a super-massive spiral galaxy at a distance of 140 Megaparsecs. Data from the Parkes telescope suggest that the galaxy HIZOA J0836–43 has an HI mass of $7x10^{10}$ solar masses and a total dynamical mass of $1.5x10^{12}$ solar masses. This HI mass is 20 times that of our own Milky Way Galaxy and the total mass is at least five times the Milky Way's mass! This places HIZOA J0846–43 among the most massive spiral galaxies known, with only a handful of galaxies whose HI and/or total dynamical masses are comparable. Some such galaxies include Malin I, ISOHDFS 27, UGC 1752, UGC 12591, and NGC 1961.

Follow-up high-resolution observations with the Compact Array confirmed that HIZOA J0836–43 is in fact a single system, with a disk radius of 66 kiloparsecs and an inclination-corrected rotational velocity of 312 kilometres per second. The galaxy's rotation curve, the rotational velocity as a function of radius, is constant at large radii. This suggests that, like normal spiral galaxies, HIZOA J0836–43 has a large dark matter halo extending well beyond the disk radius, a property also predicted by current hierarchical clustering models of galaxy formation. This galaxy is so large and massive that, if formed at the very beginning of the Universe, it would only have had time to complete 10 rotations! In addition to giving us insights into the HI properties of HIZOA J0836–43, our observations at the Compact Array have also provided radio continuum data. From these data, we have determined that J0836–43 is probably forming stars at a rate of about 26 solar masses per year.

We have also observed HIZOA J0836–43 with the Anglo-Australian Telescope (AAT) in the near-infrared K and H bands. Because HIZOA J0836–43 is located behind the plane of the Milky Way in a region known as the Zone of Avoidance, the optical B-band emission originating from the galaxy is obscured by nearly 12 magnitudes of dust extinction, preventing us from obtaining an optical image of the galaxy. Luckily, the effect on infrared emission is much less severe than that on the optical light. The AAT observations have therefore allowed us to determine both the inclination of the galaxy, 65 degrees, as well as the distribution of its old stellar population. Both a galactic bulge and disk can be inferred from the infrared emission. The bulge has a central surface brightness of 15 magnitudes per square arcsecond and a scale length of 2 kpc. The disk has a scale length of 4 kpc and can be detected out to a radius of 20 kpc, even through 1 magnitude of extinction in the infrared K band.

The galaxy HIZOA J0836–43 is one of the most massive spiral galaxies ever detected. Although a nearby galaxy can be seen in the AAT image, there is no evidence that the two galaxies are interacting. The velocity field and integrated emission of HIZOA J0836–43 show no disturbances, suggesting that it is a normal, albeit very massive, galaxy. The detection of a super-massive galaxy such as HIZOA J0836–43 helps us to answer fundamental questions that arise when formulating theories of galaxy evolution.

Large-scale blind surveys with receivers such as the Parkes multibeam receiver provide one of the best ways to detect such hidden giants.

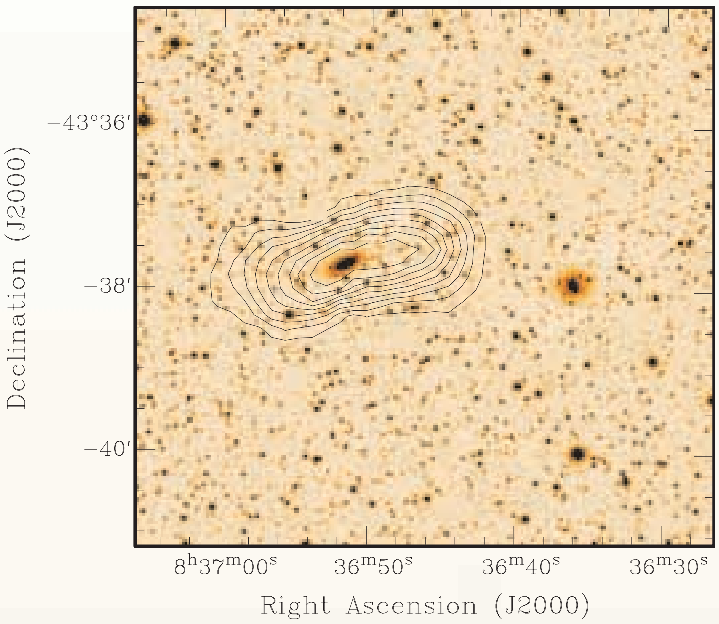

Figure 20 *A K-band image of HIZOA J0836–43 from the Anglo-Australian Telescope with the HI contours, obtained from Compact Array data, overlaid. The contour levels show the HI emission from 10% to 90% of the peak value, in increments of 10%.*

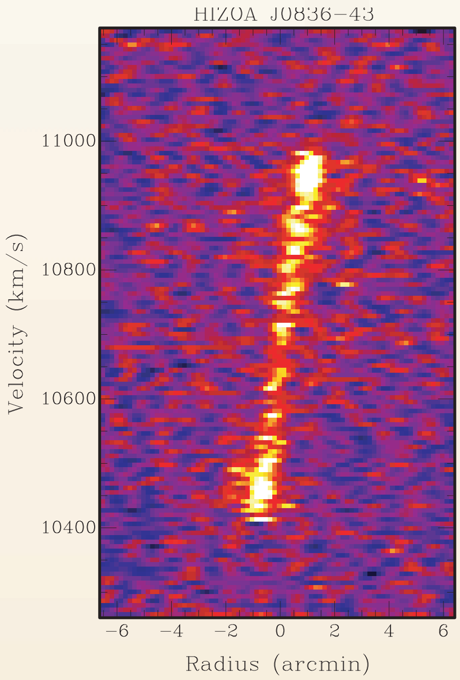

Figure 21 *A "position–velocity" diagram for HIZOA J0836–43 along the major axis of the galaxy. The galaxy is seen as the bright strip extending over velocities from approximately 10,400 to 11,000 kilometres per second.*

Astronomy reports

First results from the Compact Array 18 GHz pilot survey

Elaine Sadler (University of Sydney) for the 20-GHz survey team; Roberto Ricci (SISSA, Italy); Ron Ekers, Mike Kesteven, Lister Staveley-Smith, Ravi Subrahmanyan, Warwick Wilson (ATNF); Mark Walker (ATNF/University of Sydney); Carole Jackson (ANU); Gianfranco De Zotti (Padova Observatory, Italy)

In September 2002, as a pilot study for an all-sky radio imaging survey at millimetre wavelengths, we observed 1,216 square degrees of the southern sky at 18 GHz using a novel wideband (4 GHz bandwidth) analogue correlator on one baseline of the Compact Array. Several imaging surveys of the radio sky have already been carried out at frequencies between 0.3 and 5 GHz, where the source population is dominated by powerful radio galaxies and fainter starburst galaxies, but at frequencies above 5 GHz only small areas of sky have been studied in detail. This is mainly because large radio telescopes typically have small fields of view (one to two arcminutes) at high frequencies, making it extremely time consuming to observe large areas of sky. Measuring the high-frequency properties of extragalactic radio sources is crucial for interpreting the high-sensitivity and high-resolution maps of the cosmic microwave background that are now being produced by satellite missions like WMAP and is also important for studies of active galaxies and their cosmic evolution.

The observing team present at Narrabri for the September pilot survey. From left to right: Lister Staveley-Smith, Ron Ekers, Jennifer Donley, Kate Smith, Mike Kesteven, Elaine Sadler, Carole Jackson, Warwick Wilson. In the background, antennas CA02 and CA03 are seen observing the meridian between declinations of –60 and –70 degrees.

The survey is made possible by using the new Compact Array 12-mm receivers in combination with a 4 GHz bandwidth prototype correlator recently developed at ATNF (the standard Compact Array correlator has a bandwidth of 128 MHz). The increased bandwidth means that the continuum sensitivity is high even for short integration times, allowing large areas of sky to be observed in a fast-scanning mode. On 13 – 17 September 2002, we scanned the region of sky between declinations of –60 and –70 degrees using two antennas of the array as a two-element interferometer with the wide-band correlator. We covered roughly 15 square degrees per hour to a detection limit of 60 milliJansky. The Compact Array was used in a “split array” mode, so that regular synthesis imaging could be carried out at the same time with the antennas which were not being used for fast scanning.

Follow-up radio imaging of the sources detected in the survey was carried out in October 2002, giving more accurate positions and flux densities. Almost half the 226 detected sources lay within five degrees of the Galactic plane, and can be identified with Galactic HII regions, supernovae and planetary nebulae. The remainder are extragalactic sources, made up of candidate quasars (60%), radio galaxies (20%) and faint optical objects or blank fields (20%).

The 18 GHz survey will continue in 2003.

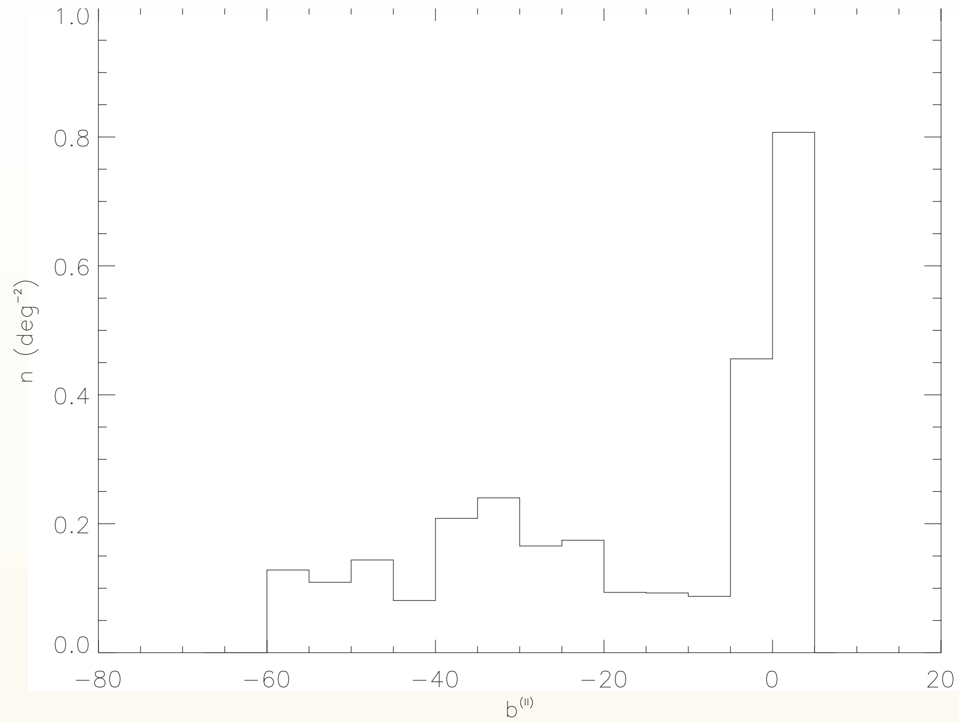

Figure 22 *A histogram showing the detected source density from the 18 GHz Pilot Survey in five-degree bins in Galactic latitude. The peak near latitude zero corresponds to the population of Galactic disk sources such as HII regions. The smaller excess at latitudes of –30 to –40 degrees is due to sources associated with the Large Magellanic Cloud.*

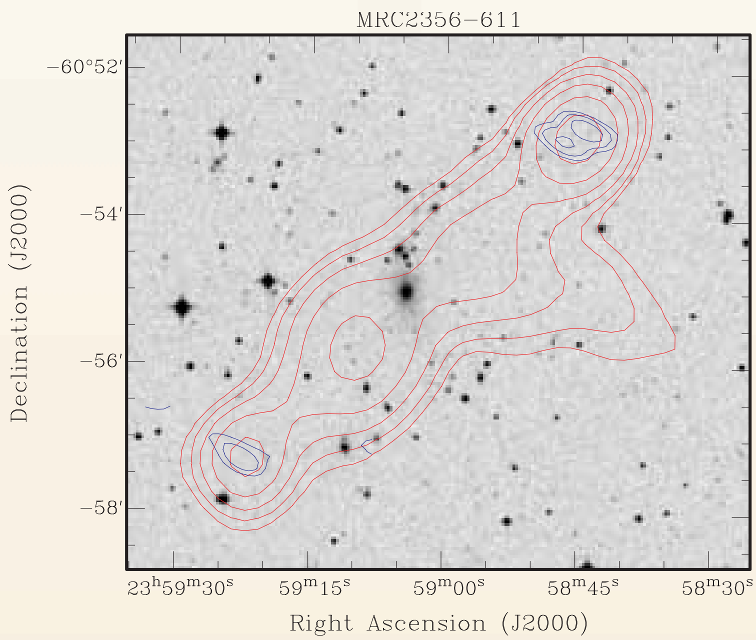

Figure 23 *While many of the sources detected in the Pilot Survey are associated with distant quasars, some, like the radio galaxy shown here (an elliptical galaxy at z=0.0963) are relatively nearby. Here the red contours show low-frequency (843 MHz) radio emission from the SUMSS survey. The blue contours show the 18 GHz emission imaged in the Pilot Survey, overlaid on an optical image from the Digitized Sky Survey. The high-frequency radio emission is concentrated at the hotspots (roughly one million light years from the parent galaxy) where relativistic jets of plasma from the galaxy's nucleus terminate and dump their energy.*

An unbiased census of hydrogen in the local Universe

M. Zwaan, M. Meyer, R. Webster (University of Melbourne); L. Staveley-Smith, B. Koribalski (ATNF) and the HIPASS team

In 1997 an international team of astronomers set out to survey the entire southern sky for neutral hydrogen (HI) emission using the Parkes radio telescope equipped with the 21-cm multibeam receiver. This instrument is a very efficient survey tool, allowing us to conduct the first large-scale blind neutral hydrogen survey, both in the intermediate neighbourhood of the Milky Way Galaxy, and out to distances of 170 Megaparsecs. The data taking for this survey, known as HIPASS (HI Parkes All Sky Survey), was finished in 2002, and since then much effort has gone into analysing the large dataset. Here, we concentrate on some of the progress that has been made for the extragalactic component of HIPASS.

The HIPASS data consists of 530 cubes, which each cover eight by eight degrees on the sky, and velocities from –1,200 to 12,700 kilometres per second. Together these cubes comprise almost two thirds of the sky, from declination –90 to +25 degrees. So far, most attention has been directed to the 388 southern cubes south of declination 2 degrees. Our first task after creating the data cubes is to identify extragalactic HI 21-cm emission line signals in the noisy background. It was found that this was most efficiently done using two independent automatic finder scripts, the results of which were merged. Galactic high-velocity clouds and detections at frequencies known to be polluted by man-made interference were removed from the list of detections. The remaining 130,000 potential detections were subjected to a series of manual checks for verification by three different individuals. After this process, we were left with approximately 4,300 HI selected galaxies, almost a twenty times larger sample than any existing HI selected sample.

Figure 24 shows the sky distribution of the HIPASS sources. The dashed line at b = 0 indicates the plane of the Galaxy. All optical redshift surveys suffer from severe extinction close to this line, which hinders the identification of extragalactic sources over a large region of sky, and hence leads to an incomplete picture of the large-scale structure of galaxies. The figure clearly shows that HIPASS is not affected by extinction and measures the galaxy distribution equally efficiently in all regions of the sky. This illustrates the power of HIPASS to study the large-scale structure in the local Universe.

A more quantitative analysis of the large-scale structure is possible with a tool known as the two-point correlation function. This measures the excess probability of finding another galaxy at a given distance from any galaxy in the sample. For optically selected galaxies, this function has been studied extensively and has been shown to be dependent on galaxy luminosity, morphological type, and star formation activity. Figure 25 shows a two-dimensional form of the correlation function of HIPASS galaxies. The vertical and horizontal axes correspond to separations between galaxies orthogonal and parallel to the line of sight, respectively. Integrating along vertical lines, and applying some mathematics, finally leads to a measurement of the real space correlation function, which is shown in Figure 26. For comparison, the correlation function from the 2dF galaxy redshift survey, at the Anglo-Australian Telescope (AAT), of optically selected galaxies is also shown. This diagram shows that our sample of HI-selected galaxies, representing a population of more slowly evolving galaxies, is less strongly clustered than the optically-selected sample. Possibly, two effects are at play here. These gas-rich galaxies might only survive in regions without too many interactions with neighbouring galaxies, which could trigger star formation and burn up the HI. Another explanation is that the HI-rich galaxies are actually formed in lower density regions.

Apart from studying the large-scale structure, HIPASS is useful for measuring exactly how HI is distributed over galaxies of different masses. An analysis of one of the first products of HIPASS, the Bright Galaxy Catalogue containing the 1,000 brightest detections, resulted in the most accurate measurement of the HI mass function to date. This new HI mass function is in good agreement with earlier, much poorer determinations, and allows for a precise evaluation of the neutral gas mass density at the present epoch. Expressed as a fraction of the critical density of the Universe, the neutral gas mass density is only 0.038%. This is approximately five times lower than at the time when the Universe was only 10% its present age, indicating the gradual conversion from neutral gas to stars in the disks of galaxies.

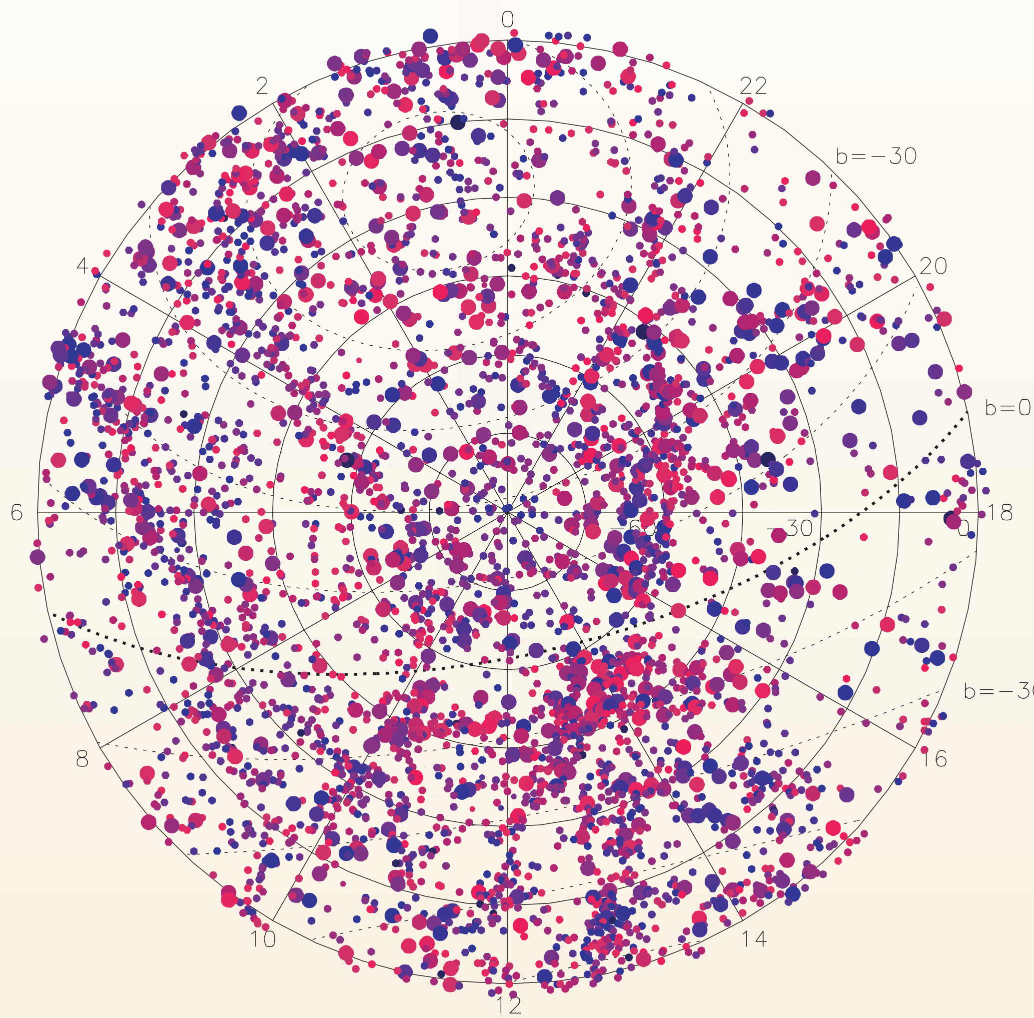

Figure 24 The distribution of extragalactic HIPASS sources in the southern skey. The colour coding corresponds to the distances of the sources, in the sense that redder colours correspond to higher distances. The symbol size indicates the neutral hydrogen mass of the sources. The dashed line marked with b = 0 is the Galactic plane. The south celestial pole is in the centre of the image.

Astronomy reports

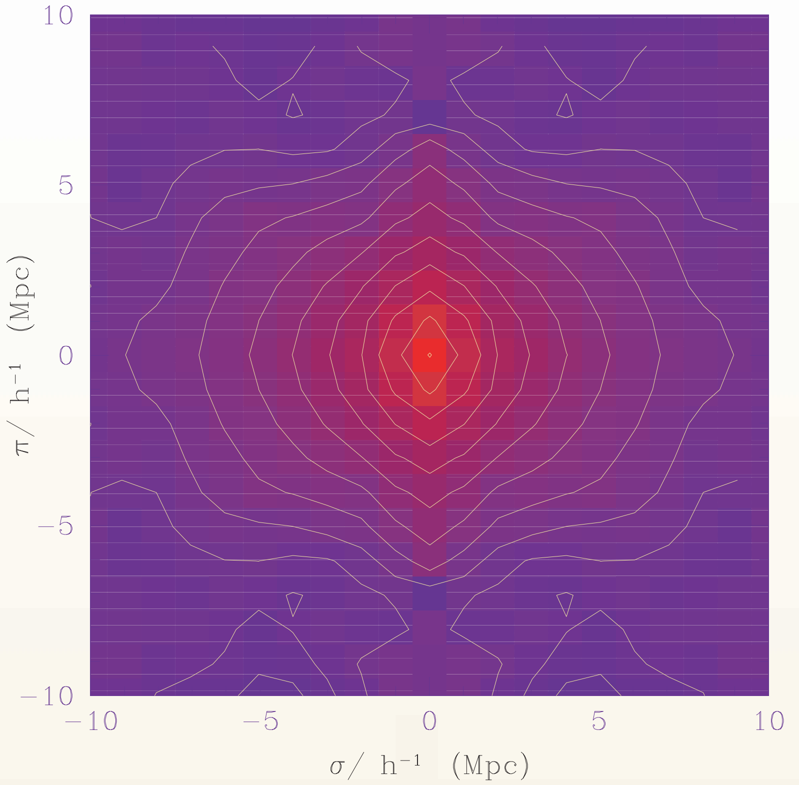

Figure 25 *The two-point correlation function for HIPASS galaxies, plotted as a function of transverse (σ) and radial (π) pair separation.*

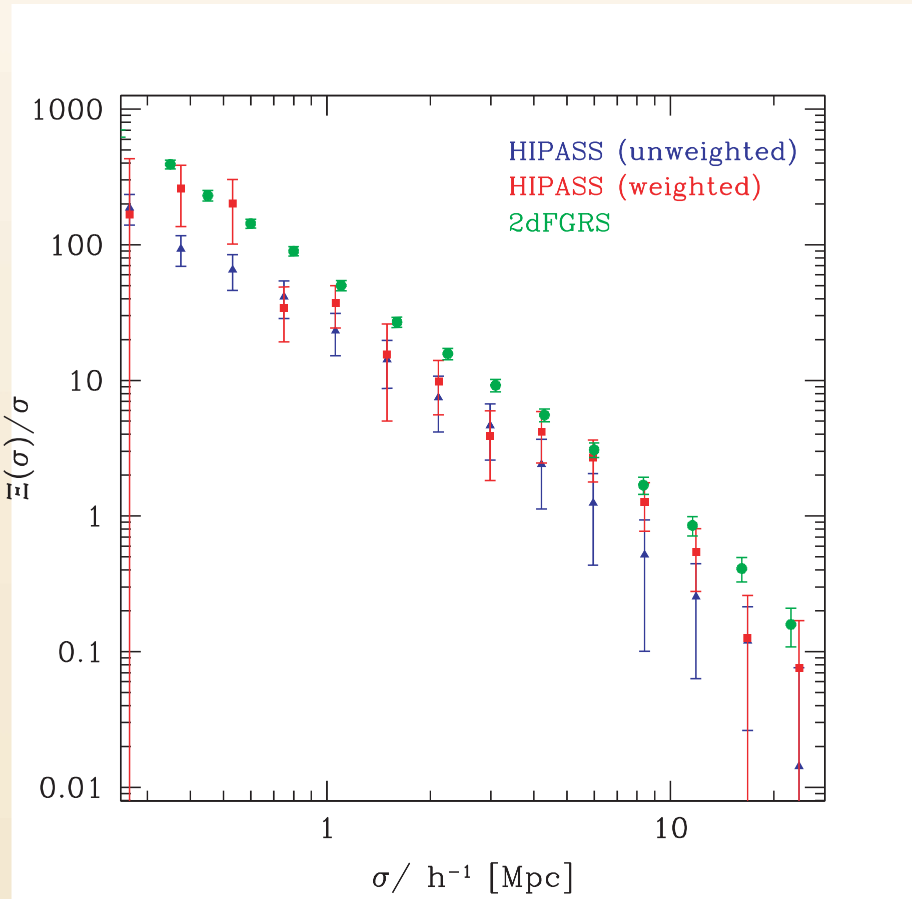

Figure 26 *The projected real space correlation function for HIPASS and 2dF galaxies. The HI-selected galaxies are less strongly clustered than galaxies found in the 2dF galaxy survey.*

The Southern Galactic Plane Survey

N. McClure-Griffiths (ATNF); J. Dickey (University of Minnesota, USA); A. Green (University of Sydney); B. Gaensler (Harvard University, USA)

The Milky Way provides the closest laboratory for studying the physics of the interstellar medium (ISM). Despite some 50 years of studies with radio telescopes, our knowledge of the dynamics and thermodynamics of the atomic phase of the ISM is remarkably limited. However, for the past five years the ATNF has been involved in a large-scale survey of the ISM in the Southern Milky Way. This project, the Southern Galactic Plane Survey (SGPS), aims to image the 21-cm continuum emission and atomic hydrogen spectral line in a region of 335 square degrees in the plane of the Milky Way. The first part of the survey, SGPS I, covered an area of 210 square degrees centred on the Galactic midplane (Galactic latitudes –1 to +1 degrees), spanning Galactic longitudes from 253 to 358 degrees. In 2002 we began a second phase, SGPS II, which covers a 100 square-degree region around the Galactic Centre and extends along the Galactic midplane to longitude +20 degrees. The SGPS II is in progress, with completion anticipated in mid-2004.

The SGPS constitutes more than an order of magnitude improvement in both angular resolution and sensitivity over previous surveys of this region. Additionally, the combination of high-resolution data from the Compact Array and short spacing information from the Parkes radio telescope provides a dataset that is sensitive to all angular scales from two arcminutes to several degrees, as illustrated in Figure 27. The general goals of the survey are to understand the structure, dynamics, and thermal distribution of the neutral hydrogen component of the ISM. We also have full polarisation information in the continuum that we are using to study the magnetic field structure of the Milky Way and the magneto-ionic medium. The SGPS data has been combined with two surveys of the northern hemisphere Galactic plane made with telescopes in Canada, the USA, and Germany to form the International Galactic Plane Survey. The ultimate goal of this collaboration is to construct an atlas of the HI in the entire Galactic plane with an angular resolution of one arcminute, a spectral resolution of one kilometre per second and a sensitivity limit of one Kelvin.

The SGPS is producing many new and exciting results. The work includes studies of HI shells, bubbles and chimneys (including the one on the cover of this report), which are some of the largest objects in the ISM. These objects, which are believed to be formed by the combined effects of stellar winds and supernovae, can break out of the Galactic plane and expel hot gas from the disk into the halo. The chimney shown on the cover, GSH 277+00+36, was discovered in the SGPS I; it is more than 600 parsecs in diameter and extends over a kiloparsec above and below the Galactic plane. Along the walls of this shell we have detected gas instability structures on scales of only a few parsecs. It is through these instabilities that gas returns to the cool phase and these may account for much of the small scale structure in the ISM.

Using data from the entire SGPS I region we have created a new longitude–velocity diagram of HI emission, shown in Figure 28. We combine almost 10,000 spectra for this high-resolution image of HI in the plane. These data allow us to trace spiral features out to Galactic radius 30 kiloparsecs. There are a number of interesting features in this image. At large, positive velocities (<100 kilometres per second) we detect the edge of the HI disk as a thin ridge of emission. This may be a distant extension of the outer spiral arm.

From the SGPS data we have measured the rotation curve of the inner Galaxy, shown in Figure 29. This is the most densely sampled HI rotation curve ever produced; it shows a number of new results. In particular we see strong departures from smooth circular rotation associated with the spiral arms, which are marked with dotted lines. According to spiral density wave theory we expect that gas approaching a spiral arm from the inner Galaxy side should show a decrease in circular velocity before the arm and then an increase as the gas passes through the arm. This is almost exactly what we see in the Milky Way.

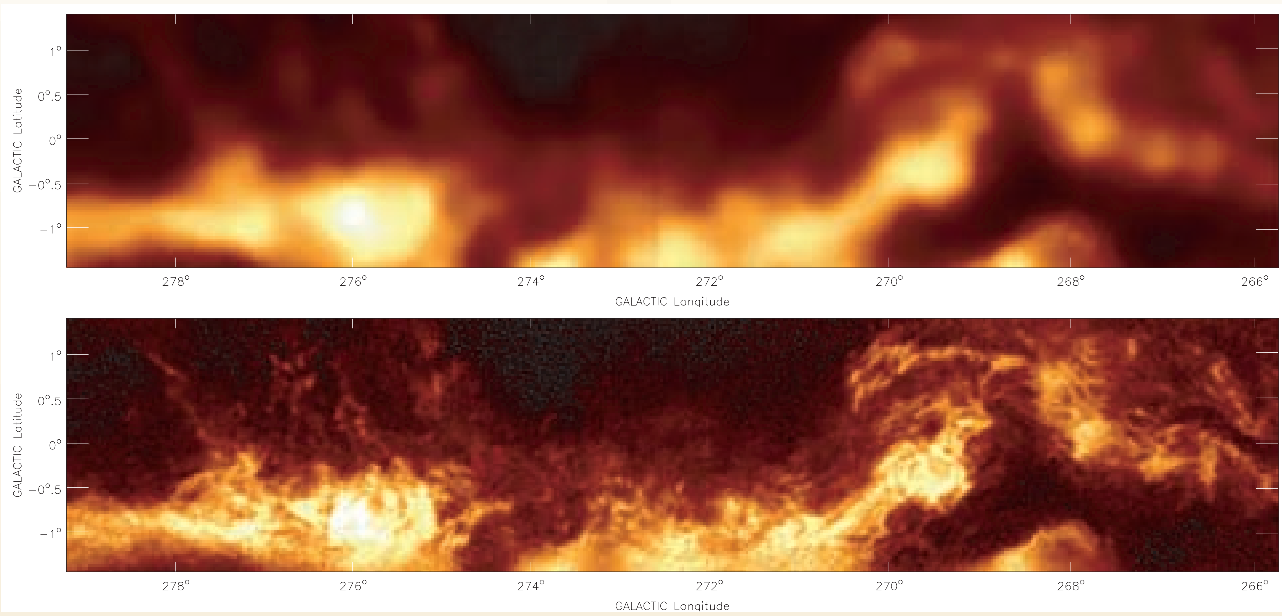

Figure 27 *A cross-section of the Milky Way as seen at a wavelength of 21 cm. The upper figure is an image made by the Parkes telescope with the multibeam receiver observing the 21 cm line with an angular resolution of 14 arcminutes. The area covered is from Galactic longitudes of 266 to 280 degrees, and latitudes of –1.5 to +1.5 degrees at a local standard of rest velocity of +73 kilometres per second. The lower image shows the same area as seen with a combination of Parkes plus Compact Array data, with an angular resolution of 2 arcminutes. In both images, the light yellow colour corresponds to bright emission from atomic hydrogen, while black shows no emission. This velocity plane traces the outer Galaxy, far outside the solar circle, where the disk is warped toward negative latitudes in this longitude range (note that the bright ridge does not align with zero latitude). The broad, dark channel that bisects the disk on the right-hand side is a superposition of many giant shells resulting from stellar winds and explosions.*

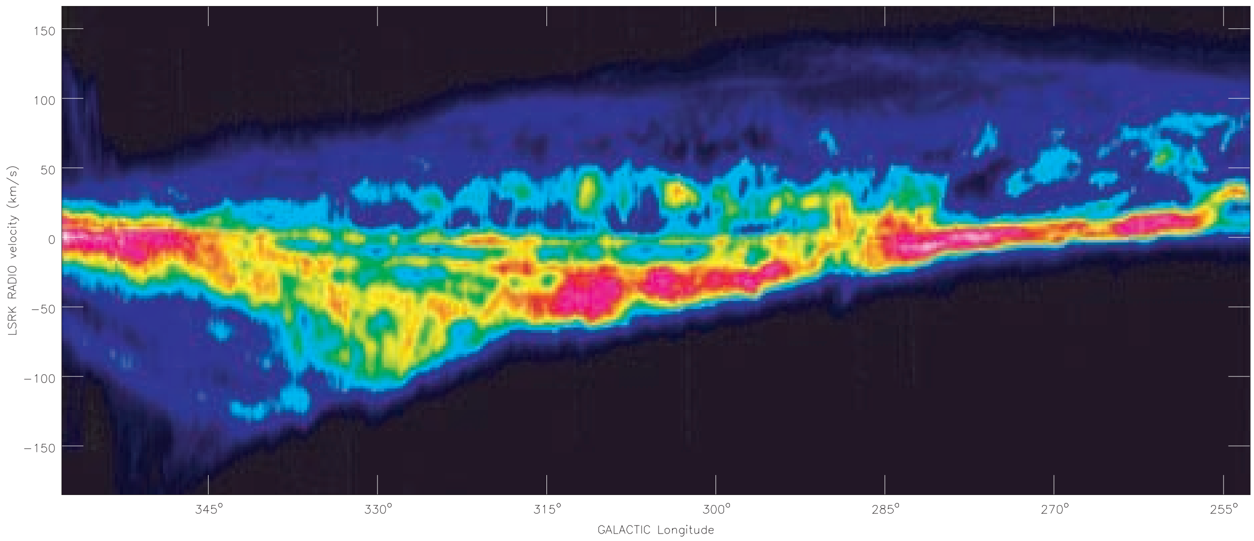

Figure 28 *Longitude–velocity image of the HI emission in the Galactic plane over the entire SGPS I region. There are approximately 10,000 pixels along the longitude axis. Positive velocities correspond to gas outside the solar circle, whereas negative velocities show gas in the inner Galaxy. Using this image we can search for the outer edge of the HI disk (at large positive velocities). We are also able to trace the outermost spiral arms. The Sagittarius-Carina spiral arm is apparent as a loop of strong emission (very pink) crossing near longitude 280 degrees.*

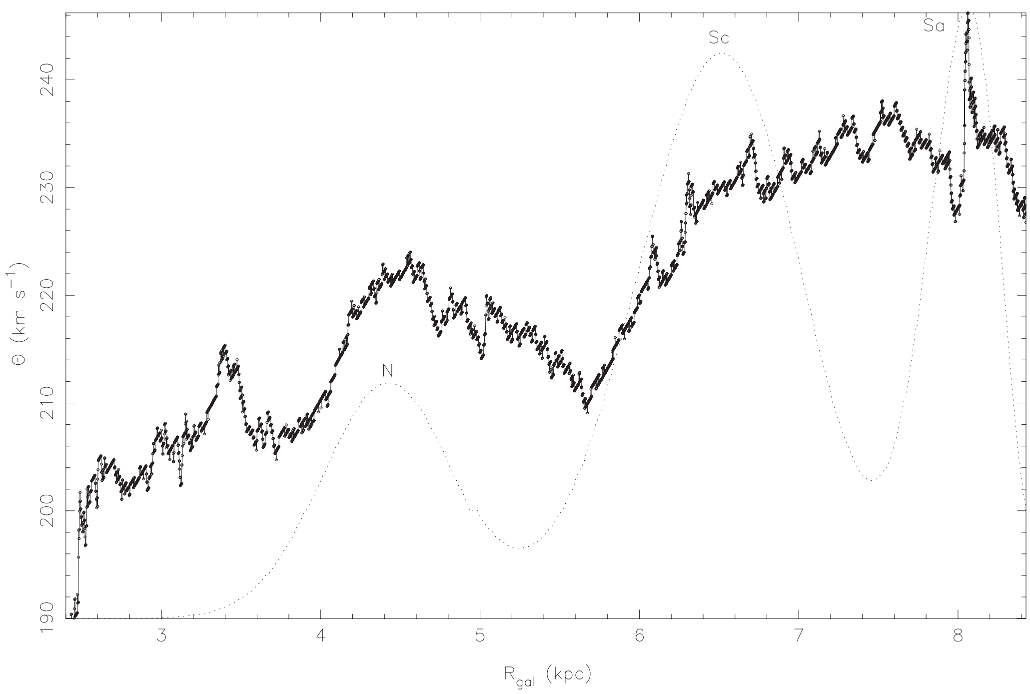

Figure 29 *HI rotation curve for the inner Galaxy (fourth quadrant), sampled every arcminute. The dotted line shows the approximate positions and widths of the spiral arms which are labelled from left to right as Norma arm (N), Scutum-Crux arm (Sc) and the Sagittarius-Carina arm (Sa). The rotational velocity decreases as the gas enters a spiral arm and then begins to increase as the gas passes through the arm.*

Lightning strike near one of the Compact Array antennas

Photo: ©Robert Della-Piana 2002

Observatory reports

Australia Telescope Compact Array

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 (millimetre-wave) frequencies, with two new observing bands at 12 and 3 mm. This upgrade has been funded under the Commonwealth Government's Major National Research Facilities program, under a contract signed in February 1997 (MNRF-1997).

The first millimetre-wave observations at the Compact Array were taken in November 2000 using two antennas on a single baseline. In 2001, interim 12- and 3-mm receiver packages were installed on antennas 2, 3 and 4 and the first millimetre images were obtained using data taken with these three antennas. Rather than extend the interim system to all antennas it was decided in 2002 to concentrate engineering development on the design and construction of the final systems. Installation of the final 12-mm receivers on all antennas is due in 2003 with the 3-mm systems expected to follow in 2004. Millimetre observing during 2002 continued to be available with three antennas and interim systems only.

As well as developing the new receiver packages, the millimetre upgrade requires a myriad of changes to the telescope hardware, software and operation. During 2002, considerable development work took place in these areas.

Dr Bob Sault, Officer-in-Charge at the Narrabri Paul Wild Observatory

New stations and array configurations

To optimise the Compact Array configurations (with antenna spacings up to several hundred metres) and to provide better arrays for high brightness sensitivity observations, nine new antenna stations have been constructed as part of the MNRF-1997 program. The new configuration include configuration EW214, which has a maximum spacing of 214 m, and two complementary configurations, EW352 and EW367, with maximum spacings of approximately 360 m. The millimetre upgrade also includes the construction of a north spur line, 214-m long with five antenna stations. This is intended for very compact configurations, and allows a reasonable Fourier coverage to be achieved in less than 12 hours. This is an important consideration at millimetre wavelengths where it is undesirable to observe sources at low elevations—at these wavelengths the data quality is reduced at low elevations due to increased atmospheric opacity and poorer phase stability.

Following the completion of optical fibre work on the new antenna stations in April 2002, several new array configurations, EW367, EW214, H75 and H168, were scheduled and successfully used during the June to October period. The reconfiguration to the H75 array, on 12 August 2002, was the first astronomical use of the new north spur.

Signal distribution

A major task of the MNRF-1997 program was the upgrade of the signal distribution system throughout the array as well as an upgrade of the local oscillator system. The upgraded signal paths use single-mode optical fibres, which replace copper wires, coaxial cables and multi-mode fibres.

The local oscillator system now distributes two frequency references: a low frequency one used at centimetre wavelengths and a high frequency one for use in conjunction with the new millimetre receiver packages.

The installation of the new single-mode optical fibre signal distribution system was completed mid-year. Fibre splicing work was completed on all antennas and to all station posts, as well as to a patch panel in the screened room. Upgraded fibre modems were installed to eliminate a synchronisation problem that had previously caused an occasional loss of data. Shortly thereafter all six antennas were switched over to regular operations using the new reference frequency distribution system. By the end of the year all signals, including time frame, ethernet communications and intermediate-frequency return data links, were running on the new fibres.

The one remaining task for the signal distribution system, making the high frequency local oscillator reference system tuneable, is due for completion in May 2003.

Antenna structure

The efficiency of the telescope antennas depends partly on the accuracy of their surfaces. At millimetre wavelengths the antenna optical surfaces need to be maintained within tolerances that are 10 times more stringent than at centimetre wavelengths. This is a challenging engineering requirement. The ATNF has an ongoing program to improve and monitor the surface accuracies of the antennas.

Two factors are important in achieving good beam efficiency and beam shape: firstly, the antenna surface panels must be set to within a specified tolerance; 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 the year two studies were initiated to understand these issues.

A holographic image of the surface of antenna 2 was obtained using a 30 GHz geostationary satellite as a reference signal. This showed that the panels were aligned to an accuracy (rms) of 0.21 mm, with the poorest accuracy occurring in the innermost ring of panels.

One of the shortcomings of standard holography is that it uses geostationary satellite signals. This means that the holography is performed at a single, fixed elevation. An alternative method of surveying the antenna optical surfaces is by using photogrammetry. This is an advanced form of surveying where reflectors are placed at many points on an antenna surface. The three-dimensional positions of the reflectors can be deduced by photographing the surface and reflectors from many aspects. An advantage of photogrammetry is that it can be performed at arbitrary elevation, and so the gravitational effects on the antenna can be studied.

In February 2002, a photogrammetric examination was undertaken on antenna 2, for antenna elevations between 15 and 90 degrees. The results showed that the main antenna deformation at low elevations occurs in the main reflector surface, while the subreflector remains close to its design location. Additionally, analysis showed that the beam shape changes and gain/elevation effects implied by these deformations agreed with those observed astronomically. The gain loss and beam shape degradation can be recovered, however, with a two-axis adjustment to the axial and tilt motions of the subreflector. Following these findings, a study was initiated during the year to design a two-axis subreflector adjustment system.

Antenna control computers

The existing antenna control computers (PDP 11/73 machines) are showing their age in terms of reliability and their inflexibility in supporting the more stringent requirements needed for the new millimetre systems. As a consequence these computers are being replaced, and the control software rewritten using object-oriented programming. During 2002 all antennas were outfitted with the new hardware. The first interferometric observations using the new control software were achieved in March 2002 and the first scientific observations using the new computers were taken in September 2002.

Early morning at the Australia Telescope Compact Array

Photo: David Smyth

Millimetre operations

During the winter observing period from May to October 2002, the interim 12- and 3-mm systems on three antennas were offered to observers. Approximately 17% of the observations made use of the 3-mm systems. To optimise the antenna spacings and sky coverage the three antennas were "shuffled" in some array configurations, with the north spur used as a shunting yard. The initial millimetre observations provided essential testing of the array performance and system capabilities at mm-wavelengths whilst also enabling observers to gain millimetre-observing experience.

To provide some robustness against poor weather during millimetre observations, a flexible scheduling scheme was tried. In this scheme, a millimetre observing program was swapped with a program for observations at centimetre wavelengths when the weather was too poor to obtain good millimetre data. The millimetre program was then rescheduled a few days later.

An analysis of meteorological data from 1996 to 2002 showed that during the winter months the swap scheme was expected to improve the probability of observing in good weather from approximately 65% to 85%. In practice the swap scheme proved reasonably successful, with only three hours of millimetre observing lost due to poor weather. A total of six out of a possible 27 swaps were initiated. This was lower than expected from the weather analysis and reflected the extreme drought conditions experienced in the Narrabri region in 2002.

Compact Array wideband analogue correlator

With the advent of the millimetre receivers and the new single-mode optical fibres, it became feasible to develop a very wideband interferometer at the Compact Array. The major technical challenges were the transfer of broadband (up to 8 GHz) signals from the antennas to the central site and the development of a correlator to process these signals. Both of these challenges were met by resorting to purely analogue techniques. A broadband analogue signal transmission system was developed. This is capable of transferring the 4 to 12 GHz first intermediate-frequency signals from the millimetre receivers to the central site. The correlator used was the 4 GHz bandwidth analogue correlator developed by ATNF as part of the AMiBA prototype project. Eventually it is planned to replace this unit with a new analogue correlator capable of processing the full 4 to 12 GHz band.

The system was installed on the Compact Array in July 2002 as a survey instrument. It used a 30-m east-west baseline in the 12-mm band and operated as a transit instrument. This avoided the requirement for delay and phase tracking. The system was employed in September 2002 in a successful point source survey observation.

Compact Array data archive project

Since the start of operation of the Compact Array, almost all observations have been routinely archived. Although there are frequent requests for data from this archive, the archive is a valuable asset that is under-used. During 2002, an index of the list of files available in the archive was made available online. Together with the online "projects" and "positions" database, this has allowed archive requests to be more specific. In collaboration with CSIRO Mathematical and Information Sciences, work began to place the archive data online with access to be provided via a web-based interface. This process was well advanced by the end of 2002. In 2003 the archive facilities will be further improved by adding a data reduction front-end to the online archive, and by some integration of the archives with the developing Australian "virtual observatory" projects.

Observatory improvements

A significant amount of building work took place during the year to improve the site amenities. The receiver laboratory was extended so that all members of the Electronics Group, and their equipment, can be located in a single building. The reception area in the control building was renovated to make better use of available space, and to give a more welcoming entrance. Other significant jobs on site included refurbishing the men's bathroom in the Lodge, bringing some aspects of the control building and Visitors Centre up to current building safety standards, drainage work around the Lodge, replacing insect screens in many of the site houses and rebuilding a garage as a storage area.

Staff

A new systems scientist and three new staff members in the electronics group were appointed during 2002. Overall, staff numbers at Narrabri have increased by one person, with funding for a new postdoctoral position from Corporate CSIRO.

Mopra

Operations

Use of Mopra this year continued to be restricted to VLBI and millimetre observations. VLBI observations were taken as part of the Long Baseline Array as well as in conjunction with the VSOP project. The millimetre single-dish observations for all programs were taken using the 3-mm SIS receiver system. The millimetre observing time, scheduled in June – November 2002, was split between time allocated for National Facility observations (41 days) and time allocated to the University of New South Wales (71 days). In total, 39% of the year was used for National Facility and UNSW observations.

Staff

There are no permanent staff at Mopra. Most of the engineering support is provided from Narrabri and Sydney. In 2002 an arrangement was established with the Anglo-Australian Observatory to provide limited engineering support at short notice. This allowed for a more timely response to minor problems at the observatory. Additionally three people in the Mopra area were employed on a casual basis to support VSOP observations and to perform housekeeping functions.

During the 3-mm observing season, visiting astronomers were supported by a UNSW-funded "Friend of the Telescope" and two ATNF-funded casual observing assistants. At the end of 2002, a Mopra operations scientist was appointed. This position will be stationed in Narrabri, but with a focus on assisting with Mopra operations and upgrades.

Photo: University of New South Wales

The Mopra antenna, with Siding Spring Mountain and part of Mopra Rock in the background. The smaller antenna is used for 12 GHz holographic measurement of the main dish surface.

Parkes

Performance and time use

The fraction of time scheduled for all observations in 2002 was 82.0%, unchanged from the two previous years. This was better than expected, given a lengthy maintenance shutdown during September and October for telescope refurbishment. Some additional time for observations was made possible by scheduling night-time observing during the shutdown for a specialised zenith-strip HI survey (HIPARK).

The fraction of time lost to equipment faults in 2002 was 1.4%, a slight increase on the previous year. However, an extraordinary period of bad weather towards the end of the year resulted in a total time lost due to high winds of 3.8%, significantly higher than in any recent year.

There were no outstanding technical problems with any important telescope systems. Minor problems with the heavily-used multibeam receiver continued, culminating in a failure of one of the 26 channels. A refurbishment of this receiver is planned for 2003.

User feedback

The web-based user feedback and fault reporting systems is an essential tool for the successful operations at the observatory. In total, 26 user feedback responses were received in 2002, slightly lower than for the previous year (34), in part due to the lengthy maintenance shutdown. The responses received were generally very positive, with radio frequency interference again emerging as the single most important issue flagged by observers. Considerable resources are now committed each year to identifying, and where possible eliminating, sources of interference.

Elevation drive refurbishment

The telescope had a shutdown period of six weeks in September – October 2002 to allow time for major refurbishment of the elevation drive system. All moving parts in the two elevation gearboxes, many of them original, were replaced and the two large sector gears were reground by hand into the correct figure. This was only the second occasion in the 40 year life of the telescope that the gearboxes had been removed.

Dr John Reynolds, Officer-in-Charge at the Parkes Observatory

The Parkes radio telescope © CSIRO

This work went extremely smoothly and the new systems should give many more years of useful life to the telescope. During the shutdown period, the nights were put to good use by observing a narrow strip of the sky repeatedly, with the telescope parked and pointed at the zenith. The aim of this project is to create an extemely sensitive image of neutral hydrogen emission.

Major activities

The Parkes multibeam pulsar survey, a major survey of the Galactic plane using the 20-cm multibeam receiver and dedicated pulsar filter banks, was nominally completed on 14 March 2002. This survey, a collaboration between Jodrell Bank, ATNF and the University of Bologna, commenced in 1997 and has been one of the observatory's principal research activities in the intervening five years.

The success of the survey has exceeded all expectations, with the discovery of more than 600 new pulsars and another 100 or so expected to be revealed when the data are reprocessed. The survey will then have roughly doubled the number of pulsars known, with around two thirds of all known pulsars discovered with the Parkes telescope. Follow-up observations of the newly-discovered pulsars will continue well into 2003.

A new-generation baseband recording system was commissioned late in the year. Known as CPSR2 (Caltech Parkes Swinburne Recorder 2), the new system is an order of magnitude leap forward in baseband recording technology, capable of recording a data rate of one Gigabit per second for sustained periods. The new system extends the very precise pulsar timing measurements currently being made to a much larger number of fainter pulsars, and maintains Parkes' leading international position in this area.

The wide-bandwidth, high time-resolution correlator, initially installed at Parkes in April 2002, produced its first pulsar spectrum in October 2002. This instrument will eventually provide bandwidths up to 2 GHz with up to 1,024 frequency channels and full polarisation capability. By the end of 2002 the correlator was operating somewhat below its ultimate capability, but upgrades to be installed in early 2003 should redress this situation. This instrument will become the main observatory "workhorse" for pulsar timing, where sensitivity and polarisation are more critical than high time resolution.

A collaborative project with the Urumqi Astronomical Observatory in China reached a very successful conclusion in August with the commissioning of a cryogenically-cooled 18-cm receiver on the Urumqi telescope. ATNF staff travelled to China to assist in the installation.

One of the cleaned Parkes radio telescope zenith axis racks. The racks were cleaned prior to a dye being applied that highlighted the elevated regions on the rack teeth for later grinding.

One of the new zenith axis gears, manufactured by Crown Engineering of Brisbane.

The new receiver is the first cryogenic receiver to be installed on the 25-metre Urumqi telecope, and was constructed at Parkes by local staff working with two visiting Chinese engineers.

NASA Mars tracking support

An agreement with CTIP, acting on behalf of NASA, for the upgrade and use of Parkes for support of NASA spacecraft tracking in 2003/4 was signed in August 2002. The major components of this agreement are:

- An upgrade of the surface of the Parkes antenna providing new panels in the 44 to 54 m diameter range.
- Provision of a new 8.4 GHz receiver.
- Antenna acceptance testing.
- Up to nine hours per day tracking in the period September 2003 to March 2004.

A contract for the supply of the panels was signed in August with Sydney Engineering and installation of the new panels is scheduled in March 2003. The design and manufacture of the receiver is proceeding. The feed was manufactured and successfully tested in October. Of the other components, the design is complete and manufacture is proceeding. The total value of the contract is approximately A$3M.

Future developments

In addition to the NASA-related work, a new receiver specifically designed for pulsar timing observations will be commissioned in the second half of 2003. Work on this project has proceeded more slowly than expected, owing to commitments in other areas, such as the NASA contract.

Photo: John Sarkissian

Robert Semlitzky (centre), Senior Project Engineer with Svenska Kullager Föreningen (SKF) Australia, Steve Broadhurst (right) and Jon Crocker (left) replacing one of the bearings of the zenith axis gears.

The Australian Long Baseline Array

LBA report 2002

The Australian Long Baseline Array (LBA) operates as a very long baseline interferometer (VLBI) array utilising most radio telescopes around Australia. It includes all the ATNF antennas (Parkes, Mopra, Compact Array), the Hobart and Ceduna antennas of the University of Tasmania, and antennas of NASA's Canberra Deep Space Communications Complex at Tidbinbilla. It also frequently operates in collaboration with overseas antennas, especially the Hartebeesthoek antenna in South Africa and the Kokee Park antenna in Hawaii.

22 GHz operations

In 2002 a technical problem with the 22 GHz receiver system on the 70-m Tidbinbilla antenna was resolved and the telescope became available for extremely sensitive observations in the 12-mm (22 GHz) observing band. The new 22 GHz facilities greatly enhanced the operation of the LBA network in this band. Tidbinbilla is now the most sensitive radio telescope in the southern hemisphere for observations at 22 GHz.

A large proportion of LBA observations during May – August 2002 were at 22 GHz, utilising the Compact Array, Mopra, Parkes, Tidbinbilla, Hobart and Ceduna. A new observing mode was tried successfully for one project. In this mode, two water maser lines were recorded simultaneously, and the system switched around four pairs of spectral lines. In addition, spectral line data were recorded at the Compact Array and autocorrelations were recorded at all telescopes.

Towards the end of 2002, arrangements were put in place for a fraction of time on the Tidbinbilla 70-m antenna to be allocated for single-dish observations. This time, provided under a Host Country agreement with NASA, will be used in a service observing mode for spectroscopic observations. This new facility was advertised to the Australian and international community with service observations expected to start in the first observing term of 2003.

VSOP

The VSOP satellite continued to operate into its sixth year. However, NASA support was discontinued in February 2002 and operation continued only at the Penticton and Mitaka correlators. The main VSOP program has been the mission-led survey of active galactic nuclei and this has been done using primarily S2 data recording systems. Mopra and Hobart have been the main ground antennas. Operations in 2002 involved one or two short observations (up to six hours) per week with these antennas. The Mopra antenna provided reduced support for VSOP during the southern winter months because of commitments to millimetre observing. Continued VSOP support is contingent on the scientific case been approved each term by the ATNF Time Assignment Committee.

Proposals and scheduling

There was continued strong proposal demand for the LBA in 2002, with an effective over-subscription rate of about two, similar to previous years. A significant amount of time was scheduled for the ATNF-USNO astrometric program. However, access to the Tidbinbilla facilities remains difficult, especially for the 70-m antenna.

Operations

There were three major LBA observing sessions in 2002, with an allocation as usual of one week per term. Overall the LBA achieved an 89% success rate, a 5% improvement on the previous two years. Most of the telescopes continued with success rates over 97%. However, a single system failure of a motor drive at Ceduna led to significant time losses in one session and affected the overall array performance.

Current activities

Astrophysics group report

Photo: Kristen Clarke

Dr Lister Staveley-Smith
Head, ATNF Astrophysics Group

Staff

Three new Bolton fellows joined the ATNF in 2002 to carry out research programs of their choice. George Hobbs arrived from the University of Manchester (Jodrell Bank), Juergen Ott from the University of Bonn and Chris Phillips from the Joint Insititute for VLBI in Dwingeloo. Several postdoctoral fellows also departed. Erwin de Blok took up a PPARC Advanced Fellowship at the University of Wales, Cardiff. Diah Setia-Gunawan completed a one-year joint CSIRO/Indonesian postdoctoral position and returned to The Netherlands. At the end of the year, Steven Tingay left the ATNF to take up a position as the SKA manager at Swinburne University.

The ATNF astrophysics activities in Canberra were reorganised during the year. Staff members Dave Jauncey and Jim Lovell moved from their CSIRO COSSA offices to offices located with the ANU staff at the Research School of Astronomy and Astrophysics (RSAA), Mount Stromlo Observatory.

In October 2002 Jim Lovell was appointed to a new permanent position at CSIRO, the first permanent astrophysics position in a number of years. Professor Frank Briggs also joined the Canberra group with joint funding from the ATNF and the RSAA. One aim of the move to the Mount Stromlo location is to stimulate interactions between the radio and optical research communities in Australia and to increase collaborations between ATNF staff and RSAA staff and students.

ATNF visitor program

The ATNF was fortunate to have several extended astrophysics-related visits, under the auspices of the ATNF visitor program, from Thijs van der Hulst (Kapteyn), Russ Taylor (Calgary) and Rogier Windhorst (Arizona State). Such visits are not only stimulating for ATNF staff, but are useful for encouraging interactions with Australian universities through seminars and scientific meetings.

CSIRO awards

A new CSIRO scheme to provide postgraduate scholarships was introduced in 2002. Under this initiative, exceptional postgraduate students receive a prestigious top-up scholarship award. Two postgraduate students from Swinburne University, Aidan Hotan and Haydon Knight, received scholarships in 2002. Both students then joined the

ATNF studentship scheme with joint supervision between Swinburne and the ATNF. Significant interest was also shown in other new initiatives for CSIRO and ARC-CSIRO postdoctoral fellowships, and several appointments are expected in 2003.

Astrophysics events

There were several astrophysics events in 2002. A series of research talks was held during an "astrofest" on 5 June 2002 to celebrate Dick Manchester's 60th birthday and his outstanding career in pulsar astronomy. An inaugural Bolton Symposium, showcasing the research activities of ATNF postdoctoral fellows (and some other staff and students) was held on 11 December 2002. On 18 December 2002, as part of the growing interest in the LOFAR project (page 64), a workshop was held on *Detecting the Epoch of Reionisation*. This provided an opportunity for interested astronomers to start engaging in the promising, but challenging, field of low-frequency radio astronomy research. Other meetings held during the year included a joint ATNF-AAO symposium and a student symposium.

Computing

Marsfield computer services

The ATNF provides information technology (IT) support for National Facility users, and manages ATNF-specific computing at the Marsfield site. The IT infrastructure is managed by the CTIP computer services group (CSG).

AIPS++

AIPS++ is an astronomical data processing environment being developed by an international consortium of radio observatories. The package has been developed using "object-oriented" software techniques and presents users and applications developers with a toolkit of astronomy-oriented functions. The ATNF has four staff members contributing part-time to the development of AIPS++.

During 2002 an Australian AIPS++ Users Group was formed with group members drawn from a number of Australian radio astronomy groups. The group discusses AIPS++ usage and advises the AIPS++ development team on priorities for further software development and implementation.

Linux operating system

The open-source operating system Linux is becoming increasingly important in ATNF computing. Linux is available for a wide variety of computers from personal laptop machines to multiprocessor cluster systems. In 2002 ATNF efforts concentrated on providing a uniform set up for Linux users and dealing with the conflicting requirements of rapid support for new hardware and stable operation.

World coordinate systems

A highlight of the year was the publication of a paper describing the world coordinate systems for representing celestial coordinates in the commonly-used astronomical data format known as FITS (Flexible Image Transport System). A key aspect of FITS-format files is the use of "header" information that describes the kind of data that exists in the files and how software should interpret the data. It is of great importance to have a standard format for representing celestial coordinates. This publication, the result of years of work by ATNF staff member Mark Calabretta, is the result of international collaboration, much excellent mathematical and software development, and extensive international negotiations to get a general acceptance of the new standard.

Summer vacation program

Each summer the ATNF coordinates a summer vacation program for undergraduate students who have completed at least three years of their degrees.

The 2002/2003 program was held jointly with CTIP. Over 300 applications were received for 19 positions, eight with the ATNF and 11 with CTIP. Six of the ATNF students were located at the Marsfield headquarters with the other two at the Narrabri Observatory.

The vacation program provides the students with an opportunity to experience working in a research team. Each of the students worked for about 12 weeks on a research project with supervision from a research scientist or engineer. As in previous years, a highlight of the program was an observatory trip where the students spent four days at either the Parkes or Narrabri Observatory and worked in small teams on observing projects. Each group was allocated approximately 10 hours for observations with the telescopes, with observing support provided by ATNF postdoctoral fellows. The students also received safety and telescope training provided by staff at the observatories.

The program concluded with a student symposium, with a presentation given on each of the diverse research topics. At the end of their work experience, many of the students commented that they had greatly enjoyed the CSIRO work environment and that the program had attracted them to consider further study or research careers.

Photo: Barnaby Norris

2002/2003 ATNF summer vacation students

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.

In 2001 – 2002, a thorough assessment was made of the contents of the entire collection to determine which parts are worth retaining, and the collection was relocated to a purpose-built room where the temperature and relative humidity are maintained at accepted levels for long-term conservation of photographic material. Following the assessment, in 2002 approximately 2,500 images, covering the years 1939 to 1964, were scanned to create digital files, using a high-quality film scanner purchased for the project.

Sheep in the paddock *This photograph, taken in 1964, is one of thousands available in the ATNF photoarchive. The Parkes 64-m and Kennedy 18-m radio telescopes can be seen. The Kennedy antenna was transferred from Fleurs to the Parkes site in 1963.*

The photographic negatives are scanned at a resolution of approximately 10 million pixels per image. The high resolution digital files 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. The archive is being systematically extended and will provide at least 6,000 digital images representing six decades of radio astronomy in Australia. In 2002, work also began on a separate image archive of more recent images.

ATNF website

The ATNF website is used as a primary communications tool, in particular to provide information and resources for the national and international community of astronomers who use the ATNF's facilities. The web is also used to promote public outreach activities and to document research and future development work. The ATNF website is extremely large and complex, with many technical documents and online applications, some of which are critical to the operations of the observatories.

After consultation with users, a major effort was put into improving the structure and design of the ATNF website, with the replacement of the central site in March 2002.

The new design incorporates significant structural and technological changes. These include the dynamic listing of current news and events as well as greater compliance to current web standards, for example in the use of metadata "tags" in web files. New online tools include facilities for staff to create their own web pages, a travel form to facilitate arrangements for staff going overseas, and online survey forms to collect feedback from observers at the Narrabri Observatory.

Public outreach

Astronomy is a subject that generates a high level of public interest. As such it is ideally suited to promoting science and to encouraging the next generation of students towards a science-based career. The ATNF has, and will continue to maintain, a strong public profile. The primary public outreach goals for the ATNF are to attract young people into science, to raise the profile of science in Australia, and to maintain and foster good relations with our local communities. Public outreach is promoted through a range of activities which include the operation of Visitors Centres located at the Parkes and Narrabri Observatories, educational programs, publications and promotional materials, public talks and media interviews, and special events such as Open Days.

The following sections describe some of the public relations activities held during the year.

SEARFE and the SKA

A signficant educational initiative in 2002 was the launch in June 2002 of SEARFE—Students Exploring Australia's Radio Frequency Environment. This project provides spectrum monitoring and logging equipment to high schools and their students. The students monitor and

Catriona Rafael (left) and Eileen Lee (right) from Abbotsleigh School using the SEARFE equipment analyse the radio spectrum in their local areas and compare their results with other groups of students elsewhere in the country. Over time, the SEARFE project will build up a database of radio frequency usage and interference levels around Australia, and this information will make a valuable contribution to the SKA project (page 60).

The SEARFE results acquired by the schools are posted on the website, www.atnf.searfe.au. This site provides information to the schools and also hosts an active discussion forum for students, teachers and project organisers. The project is growing with a number of schools expected to join in 2003.

The SEARFE project receives support and sponsorship from the University of Sydney, University of Technology Sydney, University of NSW, IBM Australia, BAE Systems Australia, Perth Observatory and Australian Geographic. In 2002 several schools joined the project including Abbotsleigh (NSW), Dickson College (ACT), Narrabri High School (NSW) and Kimba Area High School (SA).

Parkes outreach

In 2002, the number of public visitors to the Visitors Centre continued to rise. The centre hosted 135,000 visitors over the 2002 calendar year, up from a long-term average of around 55,000 prior to the year 2000 (page 13). The rate of increase slowed over the very dry Christmas 2002 period but has since recovered its momentum. With the increasing public profile of the observatory comes a steady flow of requests to host special events. Highlights in 2002 included a concert for around 500 attendees at a national meeting of car enthusiasts held in Parkes over Easter 2002 and a dinner for more than a hundred Women in Local Government representatives in May.

Revenue taken through the Visitors Centre has increased in line with the number of visitors. A new three-dimensional show, *Elyseum 7* (detailing a spaceflight to Mars), and another audiovisual *The Invisible Universe*, have proved popular with visitors. A dramatic new cafe and associated barbecue area now graces the site of the old hexagonal barbecue shelter adjacent to the Visitors Centre. Construction work started in earnest just prior to Christmas 2002. The motivation for the building of the cafe is to broaden the range of attractions that bring visitors to the observatory, provide more activities for them when they are there, and to extend the average length of their stay.

Narrabri and Mopra outreach

The Narrabri Visitors Centre hosted approximately 10,300 visitors in 2002, somewhat more than in previous years. The Visitors Centre also ran several star-gazing evenings for community groups and official delegations. The observatory featured in two television programs during the year—the ABC's science program *Catalyst* and the Nine Network's travel program *Getaway!*

As part of the annual Coonabarabran *Festival of the Stars* weekend, the Mopra radio telescope was open to the public on 27 October 2002. Approximately 110 visitors toured the telescope vertex room and control room. During the year a number of tours of the Mopra telescope were conducted for student groups.

Spectrum management

CSIRO, initially through the Division of Radiophysics and later through ATNF, has been involved in activities related to spectrum management and the protection of radio astronomy for more than 30 years. The areas in which the ATNF are currently involved include:

- Participation in national spectrum planning and protection activities through the Australian Communications Authority (ACA). In 2002 the focus of the activities was the preparations for the World Radiocommunication Conference (WRC) in 2003.
- Participation in regional and international meetings under the auspices of the International Telecommunications Union (ITU). These include regular meetings of ITU Study Group 7 (Science Services) and in 2002 the Conference Preparatory Meeting, with focus on WRC 2003.
- Participation by the ATNF Director 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. A report was produced in 2002 and will go to a future meeting of the OECD science ministers.
- Participation in IUCAF (Inter-Union Commission for the Allocation of Frequencies) a 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), a new regional spectrum management committee for radio astronomy. RAFCAP participated actively in Asia-Pacific Telescope (APT) meetings in 2002 and has raised significantly the radio astronomy profile and awareness in this region.

A major spectrum management event in 2002 was the Australian Productivity Commission inquiry into the Radio Communications Acts. ATNF produced a submission and appeared before the Commission. This resulted in the following recommendation (Rec 10.4) in the Commission's report:

> Radio astronomy facilities should be designated as "radio sensitive sites" under the Australian Radio-frequency Spectrum Plan. These facilities must be notified that another user has applied for a transmitter licence wholly or partially within the bands specified in footnote AUS87.

The Productivity Commission's report and the Government's response were submitted to the Australian Parliament. The ACA has advised that the recommendation will need to be implemented in a different manner from the suggestion put forward by the Productivity Commission and has undertaken to consult with the ATNF to develop appropriate guidelines to assist with managing interference risk at radio astronomy facilities. The ACA, in consultation with key stakeholders, is committed to achieving an outcome in 2003 that is acceptable to all parties. Meetings are continuing between the ACA and the ATNF on this issue.

In addition, discussions have been held between the ACA and ATNF regarding the possible establishment in Australia of a radio-quiet reserve, an area where existing levels of radio frequency signals are low, and where any increase in radio frequency signals could be controlled into the future.

Staff satisfaction survey

The ATNF is an employer of choice. In 2002, responses to a CSIRO *Insight Staff Satisfaction Survey* placed the ATNF as the top Division of CSIRO while staff satisfaction within the ATNF is considerably higher than across the comparative Global R&D Norm surveyed by the consultants International Survey Research. The staff responses to the survey questions were especially favourable for questions associated with "leadership and management" and "job security and organisational stability". High staff morale is one of the ATNF's greatest strengths.

Equal Employment Opportunity

The ATNF has an active 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 extensive web pages at www.atnf.csiro.au/overview/management/eeo/.

Occupational health and safety

Each ATNF site has its own occupational health and safety committee, which meets at least four times a year to review issues and identify any new hazards. Each workplace is assessed annually by a member of the local committee, and a formal report made. Training programs in a number of areas such as ergonomics, correct lifting techniques, electrical safety and defensive driving are offered throughout the year.

Over a number of years the ATNF's rate of occupational health and safety incidents has been in line with that of similar institutions, such as the Anglo-Australian Observatory and the Very Large Array. In 2002, ATNF staff and visitors recorded a total of 22 incidents with a total time lost of 2.1 weeks and six compensation claims accepted by Comcare.

Technology developments

Marsfield engineering developments

Executive Special Project

In December 1997 CSIRO's Chief Executive Officer, Dr Malcolm McIntosh, announced a number of projects to be undertaken by large research teams within CSIRO. One of these projects was a joint proposal of the ATNF and CTIP to develop high frequency integrated circuits for radio astronomy and telecommunications. The circuit designs are developed within ATNF and CTIP and are fabricated in the USA by the foundry TRW using their leading edge indium phosphide foundry process. Devices produced under the program include monolithic microwave integrated circuits (MMICs) and high-speed digitiser circuits.

This project was effectively completed with the delivery in April 2002 of the diced chips from the third and final TRW wafer fabrication run, labelled CSR15. As well as containing production quantities of proven MMIC designs from the initial CSR8 run from 2000, CSR15 also included a new design for a 3-mm band coplanar waveguide indium phosphide HEMT low noise amplifier. Initial tests indicate that this amplifier has the potential to extend the frequency coverage of the Compact Array 3-mm receivers to above 112 GHz.

The Executive Special Project has proved highly successful, not only in providing state-of-the-art components for a number of ATNF projects, but also in giving ATNF engineers the opportunity to develop expertise in the design of a wide range of high frequency MMICs.

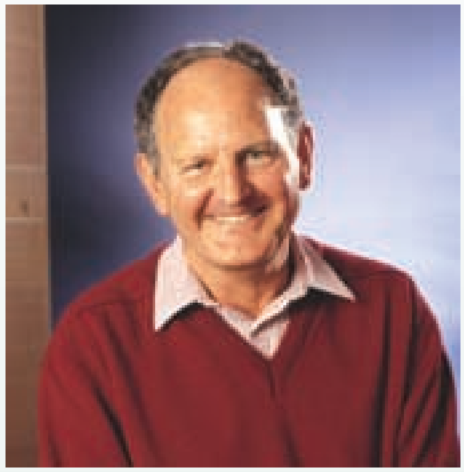

Photo: Kristen Clarke

Dr Warwick Wilson
Head, ATNF Engineering Development Group

12- and 3-mm receiver developments

A major effort was put into the detailed design of the final conversion systems for the new Compact Array 12-mm receivers. A new approach was taken in which significant sections of the system were integrated into modules combining a number of functions, with the aim of reducing packaging and cabling costs. Although this approach involved a significant learning curve in developing the basic techniques, the effort was considered to be worthwhile given the savings involved and the potential enhancements in performance and reliability offered for this and future projects.

As part of the upgrades to the 3-mm systems at the Compact Array, a new method of manufacturing the 3-mm feed horns, using precision machining rather than electro-forming, proved to be very successful and has significantly reduced the cost and complexity of manufacture.

A new design for a 3-mm OMT (orthomode transducer) polariser was completed. The design gives a significant improvement in performance over the commercial devices used in the 3-mm prototype receivers.

Local oscillator upgrade

As part of the Compact Array upgrade to operate at 3-mm wavelength, a new local oscillator (LO) chain is being developed to produce a reference near the observing frequency from the signal distributed from the central site. Two indium phosphide MMIC chips developed for this LO chain under the Special Executive Project were packaged and tested. These were a sideband separating mixer and a frequency doubler. In each case performance was shown to be well within specifications.

Three other components required for the 3-mm LO chain, a 25 – 50 GHz frequency doubler, a 50 GHz power amplifier and a 100 GHz power amplifier proved to be difficult to source from commercial suppliers. A gallium arsenide MMIC fabrication run with TRW was undertaken in July 2002 to address this problem. The designs for the power amplifiers were provided by CTIP, the doubler by ATNF. Wafers from this run were returned in October 2002. Initial on-wafer tests showed that the performance of the MMICs was probably adequate, although final results will not be available until the designs are packaged in early 2003. This development has significantly delayed the installation of the 3-mm systems, which is now unlikely to take place before mid-2004.

Parkes 10/50 cm receiver

Most of the mechanical design and manufacture of the 10/50 cm pulsar receiver was completed by the end of 2002. This included a dual frequency coaxial feed, designed by CTIP, which was successfully tested after integration with other ATNF designed components. A test installation to check the mechanical interface to the telescope will take place in early 2003.

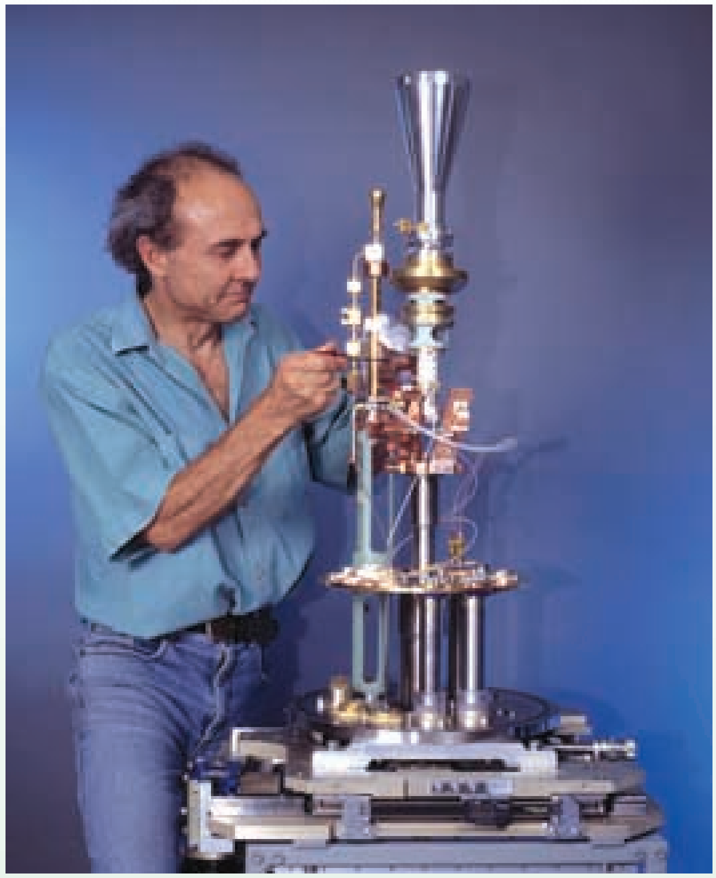

Photo: David Smyth

ATNF engineer Russell Bolton with the wideband-prototype 3-mm, and production-phase 12-mm receiver systems

FARADAY

The FARADAY project, funded by the European Union, is a co-operative program between the UK, The Netherlands, Poland, Italy and Australia that aims to produce prototypes of integrated focal plane arrays and to study large arrays for future implementation.

As part of the FARADAY collaboration, the ATNF acquired access to approximately 40% of an indium phosphide HEMT fabrication run to be undertaken at TRW in early 2003. Part of this allocation will be used to provide production quantities of previous designs developed under the Executive Special Project (page 57). In addition, a number of new designs were undertaken, both in response to immediate requirements, such as a 50 GHz frequency doubler for the 3-mm LO system, but also aimed at possible future requirements of a more speculative nature. The latter included a 60 – 90 GHz low noise amplifier and broadband low noise amplifiers in the 1 to 12 GHz range. The broadband low noise amplifiers were devised in the context of a possible future upgrade for the ATCA cm-wave systems.

A new 8 GHz bandwidth spectrometer for Mopra

In October 2002, the University of NSW was successful in obtaining funding from the ARC to enable the development of an 8 GHz spectrometer for the Mopra telescope. This will be a collaborative project, with UNSW, ATNF and Sydney and Monash Universities providing additional funding. The instrument will be built by ATNF using the polyphase digital filter bank designs being developed for the MNRF-2001 Compact Array broadband upgrade project. The system is planned to be installed and operating in mid-2004.

AMiBA prototype correlator

As part of a collaborative agreement between ATNF and ASIAA Taiwan, ATNF provided a prototype analogue correlator and data acquisition system to ASIAA for the two-element AMiBA CMB Prototype telescope. The correlator system was delivered to Taiwan in April. The prototype telescope was installed on Mauna Loa in September and first fringes were obtained in October 2002.

Arecibo 21-cm multibeam receiver

A contract with the National Astronomy and Ionisphere Center, USA (NAIC) was signed in April 2002 for the supply of a seven-beam 21-cm multibeam receiver for the Arecibo radio telescope. The receiver design will be an adaptation of the successful Parkes multibeam receiver. ATNF will supply the front-end receiver package, including the feed array, the cryogenic system, the low noise amplifiers and the receiver rotation mechanism. The design of the feed array has been subcontracted to CTIP. ATNF personnel attended a design review meeting at Arecibo in September 2002.

Photo: David Smyth

ATNF technical officer Pat Sykes with the Parkes 10/50cm receiver during its construction phase in Marsfield

MNRF-2001

In early 2001 the Government announced, as part of a new innovation statement, a new *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 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 15 successful proposals. Of these the ATNF-led proposal was granted the largest single allocation, A$23.5M.

The specific aims of the MNRF-2001 program are to:

- **Increase Australia's share in the International Gemini Telescopes (currently 5%).** The MNRF funds will be used initially to purchase an additional share of Gemini. This program will not only provide Australian astronomers with a bigger share of Gemini observing time, but will also improve the capabilities of the Gemini telescopes, and advertise Australia's expertise in instrument building.
- **Develop enabling technologies for the SKA.** The ATNF is one of a consortium of major radio astronomy institutions in eleven countries now planning the world's next-generation large radio telescope, the SKA. This instrument's one million square metres of collecting area will make it 100 times as sensitive as the best present-day instruments: this area will be distributed across many hundreds, perhaps thousands, of kilometres in a location yet to be decided. Using a combination of technologies, the SKA will cover frequency ranges from 100 MHz to above 10 GHz. The SKA project is currently the world's largest radio astronomy initiative and will cost around A$2B. Construction of the instrument is expected to start by 2012.

  Australian SKA activities are coordinated through the Australian SKA Consortium Committee (ASKACC). This committee aims to provide a single interface between Australia and the international SKA project. To achieve this ASKACC coordinates SKA research and development within Australia, with the establishment of national working groups for different SKA activities. ASKACC also consults with the wider Australian astronomical community, promotes the SKA to the public and to Government and industry, and appoints Australia's members to the International SKA Steering Committee.

Compact Array broadband upgrade project

This project has the aim of developing new signal processsing technologies for the SKA and applying them in a significant upgrade of the Compact Array. The Compact Array will become, in effect, a test bed for SKA developments, but in so doing will profit from important extensions to its observational capabilities. In the short term, National Facility users will have access to a significantly enhanced instrument, while the longer term goals of the SKA are addressed.

The upgrade will increase the bandwidth of the Compact Array by a factor of 16 to a total of 8 GHz. A new polyphase digital filter bank structure will provide increased frequency resolution in a highly flexible format. This is a major upgrade to the Compact Array, replacing the existing frequency conversion systems, the samplers, the data transfer, the delay system and the correlator.

The Square Kilometre Array

The ATNF is a very active player in the international and Australian SKA consortiums and, in collaboration with Australian universities and other Divisions across CSIRO, is making major contributions to the design of the array in several key areas including the antenna elements, the receivers, signal processing, site investigations, array configurations and interference mitigation.

SKA antennas

Antennas are the highest profile components in the various SKA concept designs. The SKA goal is to have many simultaneous, widely separated beams which can be "placed" in different directions on the sky. Three types of antenna design are being considered in Australia. These involve Luneburg lens antennas, cylindrical reflectors, and phased-array antennas. In 2002, good progress continued to be made in a joint project between four CSIRO divisions (ATNF, CTIP, Molecular Science and Manufacturing Science & Technology) to investigate and develop composite, low-loss, dielectric material for use in Luneburg lenses and other electromagnetic engineering applications. The material is being developed primarily within CSIRO Manufacturing and Infrastructure Technology and a patent will be finalised by mid-2003. The current work on antenna prototype design will determine the choice of technology for Australian SKA demonstrator antennas; this choice will be made by mid-2004.

The ATNF is also contributing to the development of highly-integrated receiver solutions for the SKA and its demonstrator antennas. As part of this work, in 2002 the ATNF completed a design for an uncooled wideband GaAs MMIC low-noise amplifier. This has been delivered to international collaborators and will be used with SKA laboratory prototypes.

SKA site investigations

Radio frequency interference testing and site investigations at possible SKA sites remains high on the Australian agenda. Extensive tests have been carried out at the Mileura Station in Western Australia (ATNF Annual Report 2001). In December 2002, a first-round inspection and preliminary interference measurements were made at a potential SKA site near Murnpeowie, in outback South Australia. Radio frequency interference measurements have shown Murnepowie to be an excellent radio-quiet site although a detailed radio frequency interference survey using more sensitive equipment and analysis tools will need to be undertaken. Further site testing is also planned for a site in western New South Wales. The combined site investigations from these two sites and the well-characterised Mileura site in Western Australia will form part of the submission of an initial Australian SKA siting proposal during 2003.

SKA meetings

An international SKA meeting was held in Groningen, The Netherlands, in August 2002. A highlight of the meeting was the presentation and discussion of SKA concept proposals, or White Papers. Two White Papers were presented by the Australian SKA Consortium, one based on Luneburg lens antennas and the other describing a cylindrical reflector solution. Both proposals were "end-to-end" descriptions, giving representative designs from the antennas through to the data processing. Other Australian contributions included submissions on new receiver concepts and SKA data transport requirements. Several issues emerged from the discussions at Groningen. In particular it was evident that at present no single SKA antenna design meets all the project science goals. The available antenna designs provide for either high frequency observations (>20 GHz) or for observations taken using multiple fields of view, but not both. This issue is complex; the SKA science community is currently divided with some groups favouring high frequency observations and other groups favouring multiple fields of view. The Australian antenna designs may offer a compromise solution with options for observations at frequencies near 10 GHz using up to 10 beams.

An international SKA workshop will be held in Geraldton, Western Australia, in July 2003.

Photo: Robert Jenkins

The Murnpeowie site in South Australia is one of several Australian sites being tested as a possible location for the SKA.

***Emu in the Sky* © 2002 Charmaine Green**

This painting, *Emu in the Sky*, by Charmaine Green, was commissioned by the ATNF in 2002 for the international SKA workshop to be held in Geraldton, Western Australia in July 2003. The original painting is acrylic on canvas.

Charmaine Green is a local member of the Marra Art Collective in Geraldton. The ATNF is working with the Marra Art Collective to produce parallel interpretations of the sky, presenting both the indigenous and astrophysics views together.

Warlu Time (story provided by Charmaine Green)

In our region the Yamaji people use the stars (seven sisters) and the Milky Way (emu image) to know when is time to go out for emu eggs. This is called Warlu Time.

This story refers to the fact that the obscuring dust clouds in the Milky Way make the shape of an emu. At a certain time of year, the emu shape appears to be sitting, and the local Aborigines, the Yamaji people, know that this is the time to collect emu eggs for eating. At Warlu time, the constellation of Pleiades (seven sisters) is low above the horizon.

Industry collaboration

The MNRF-2001 proposal includes industry partnerships with Advanced Powder Technologies Pty Ltd, CEA Technologies Pty Ltd and Dell Computers Pty Ltd. In 2002, a new partnership was established in a collaborative agreement with Connell Wagner Pty Ltd, one of Australia's largest engineering consultancies. This agreement provides additional SKA funds of $A0.5M for SKA research and development in 2003. Connell Wagner will contribute engineering resources in a variety of areas, including an engineering infrastructure study of possible SKA sites within Australia. In making the offer, Connell Wagner's NSW regional manager, Tony Barry, noted that the SKA will provide many opportunities for Australian engineering in coming years as well as leading to exciting achievements in radio astronomy. The new collaborative program will be directed by Steve Negus (Connell Wagner) and Peter Hall (ATNF).

Photo: Dietrich Georg and Engineers Australia Magazine

Connell Wagner Pty Ltd NSW Regional Manager Tony Barry (front left) and ATNF Director Ron Ekers (front right) sign the SKA collaborative agreement in December 2002. Standing: Steve Negus (Connell Wagner, left) and Peter Hall (ATNF).

LOFAR

LOFAR (LOw Frequency Array) is the first of the next-generation radio telescopes based on geographically distributed, but connected, systems of array stations. LOFAR is being designed to operate at frequencies from approximately 10 to 250 MHz and will be operational in initial form within the next five years. The LOFAR array will contain thousands of antennas distributed over a 400-km region. In many respects LOFAR is a low-frequency prototype version of the SKA, and is a direct step in the development of the SKA. However, the LOFAR antennas are designed to operate at lower frequencies and over much smaller bandwidths, allowing for simpler receiving systems than the SKA. LOFAR is expected to start initial operations around the time of the next solar minimum in 2006 – 2008, with an estimated cost of A$200M. Further information is available from the LOFAR website at www.lofar.org.

As a result of an initial White Paper submission in 2001, the international LOFAR Consortium short-listed inland Western Australia, along with two other sites (in the USA and The Netherlands), as a possible LOFAR site. The ATNF, in collaboration with the Government of Western Australia, submitted a second, more detailed, proposal in October 2002; this proposal outlined the many advantages of a location in Western Australia.

The scientific potential of LOFAR was discussed at a meeting held at the ATNF in December 2002: *Detecting the epoch of reionisation*. A second two-day meeting, *The low frequency Universe*, is scheduled for January 2003 at The University of Sydney.

In February 2003, a delegation from the LOFAR Consortium will visit Australia to discuss possible collaborations and Australian involvement with LOFAR. The delegation will also visit the potential site in Western Australia and will meet with the representatives of the Government of Western Australia, as well as advisers in the Australian Government. A decision on the location of a site for LOFAR is expected to be made by the end of 2003.

Appendices

A: Financial information

Expenditure (actual) 2001-2002[1] A$1,000s

Operation of the Narrabri (Paul Wild) Observatory[2]	2,897
Operation of the Parkes Observatory[3]	2,497
Research support Marsfield (ATNF contribution)[4]	2,119
Engineering and development	3,790
Office of Director	708
Astrophysics program	1,558
Computing	990
National Facility support	892
MNRF-1997	1,066
MNRF-2001	329
Square Kilometre Array	359
Corporate repairs and maintenance	103
TOTAL	**17,308**

Revenue (actual) 2001-2002

Direct appropriation[5]	12,959
Research and services revenue	1,338
Other external revenue	299
Asset replacement reserve draw down	1,308
Corporate repairs and maintenance	160
TOTAL[6]	**16,064**

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.
6. The shortfall in revenue is funded from ATNF reserves which include MNRF-1997 deferred revenue.

B: Staff list, 2002

ATNF staff
January to December

Sydney

T Adams (Electronics)
J Archer (Administration)
P Axtens (Receivers)
J Barends (Astrophysics/Computing PA)
R Beresford (SKA)
R Bolton (Receivers)
M Bowen (Receivers)
M Bromley (National Facility Support)
J Brooks (Assistant Director, & Engineering Manager)
W Brouw (Astrophysics/Computing)
M Calabretta (Computing)
G Carrad (Receivers)
J Caswell (Astrophysics)
A Chandra (Computing)
J Chapman (Head, National Facility Support)
R Chekkala (Electronics)
A Chippendale (SKA)
D Craig (Electronics)
E Davis (Electronics)
E de Blok (Bolton Fellow, Astrophysics)
V Drazenovic (National Facility Support)
A Dunning (Receivers)
J Ekers (Office of Director)
R Ekers (ATNF Director)
T Elton (Electronics)
R Ferris (Electronics)
G Gay (Receivers/overseas)
T Getts (LBA)
R Gough (Receivers)
G Graves (Receivers)
E Hakvoort (Receivers)
P Hall (Head, SKA Program)
G Hobbs (Bolton Fellow/Astrophysics)
P Howson (Divisional Secretary)
S Jackson (Receivers)
P Jones (Computing/LBA)
E Kachwalla (National Facility Support)
H Kanoniuk (Receivers)
L Kedziora-Chudczer (AAO/ATNF Postdoctoral Fellow, Astrophysics)
M Kesteven (Astrophysics/Engineering Research)
N Killeen (seconded to CTIP)
B Koribalski (Astrophysics)
M Leach (Electronics)
J Lie (Receivers)
S Little (Administration)
M Macquarding (Computing)
S Magri (Electronics)
I Manchester (Electronics)
R Manchester (Astrophysics)
G Manefield (Engineering PA)
A McConnell (LBA)
D McConnell (Head, Computing)
N McClure-Griffiths (Bolton Fellow/Astrophysics)
V McIntyre (Computing)
G Moorey (Receivers)
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R Ojha (Astrophysics)
W Orchiston (National Facility Support)
J Ott (Bolton Fellow/Astrophysics)
S O'Toole (Administration)
E Pacey (Director's PA)
C Phillips (Bolton Fellow/Astrophysics)
D Pisano (Bolton Fellow/Astrophysics)
G Powell (Receivers)
L Reilly (Receivers)
P Roberts (Electronics)
N Rolph (Administration)
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H Sim (National Facility Support)
L Staveley-Smith (Head, Astrophysics)
M Storey (SKA site Studies/PASA)
P Sykes (Receivers)
B Thomas (Engineering Research)
A Tzioumis (Astrophysics/LBA)
M Walker (ATNF/USyd Research Fellow)
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G Hughes
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R Moncay
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P Sharp
J Uden
B Wilcockson (Assistant Engineering Manager)
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C van der Leeuw

Narrabri

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R Walker (Visitors Centre)

Canberra

F Briggs ANU/ATNF (Astrophysics/SKA)
D Jauncey (Astrophysics)
J Lovell (Astrophysics/Tidbinbilla)

C: Committee membership

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Australia Telescope Users Committee 2002

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

Secretary

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Members

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Dr F Briggs[*], Research School of Astronomy & Astrophysics, Australian National University

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Dr S Ellingsen, University of Tasmania

Ms T Getts[#], University of Sydney (until April 2002)

Dr B Gibson, Swinburne University

Dr M Hunt[*], University of NSW

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Mr D Lewis[#], University of Tasmania

Dr N McClure-Griffiths[*], ATNF

Mr M Meyer[#], University of Melbourne

Mr D Mitchell[#], University of Sydney

Dr S Tingay[*], ATNF

Dr T Wong[*], ATNF

Dr M Walker, University of Sydney (until April 2002)

Dr T Wong, ATNF

Dr M Zwaan, University of Melbourne

*** New member in 2002**

 # Student member

Australia Telescope Time Assignment Committee 2002

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Prof B Schmidt, RSAA, Australian National University (Chairman from November 2002)

Acting Chair

Dr R Manchester, ATNF (Acting Chairman for meetings held in March 2002 and July 2002)

Secretary

Dr J Chapman*, ATNF

Members

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Dr A Melatos, University of Melbourne (from November 2002)
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Dr B Schmidt, RSAA, Australian National University
Prof J Storey, University of New South Wales (from November 2002)
Dr L Staveley-Smith, ATNF (from November 2002)
Dr M Wardle, University of Sydney (to July 2002)

*** non-voting members**

D: Observing programs

Observations made with the Australia Telescope Compact Array January to December 2002

Observers	Affiliations	Program Title	Number	Hours
Manchester, Gaensler, Staveley-Smith, Tzioumis, Wheaton, Kesteven, Reynolds	ATNF, MIT, ATNF, ATNF USyd, ATNF, ATNF	SNR 1987A	C015	103.5
Ryder, Staveley-Smith, Schlegel	AAO, ATNF, SAO	The 1978 supernova in NGC 1313	C184	25
Duncan, White	ATNF, UMar	High-spatial-resolution observations of Eta Carina	C186	26
Reynolds	ATNF	Absolute flux density calibration of the ATCA	C393	11.5
Oosterloo, Morganti, Sadler, van der Hulst	NFRA, NFRA, USyd, KI	HI in elliptical galaxies	C530	52
Drake, McGregor, Dopita	RSAA, RSAA, RSAA	Intermediate radio-loud IRAS galaxies	C539	62.5
McClure-Griffiths, Dickey, Taylor, Gaensler, Haverkorn, Green	ATNF, UMinn, UCal, CfA, CfA, USyd	The southern Galactic plane survey: phase II	C596	276
Kedziora-Chudczer, Jauncey, Wieringa, Reynolds, Tzioumis, Nicolson	ATNF, ATNF, ATNF, ATNF, ATNF, HartRAO	Monitoring observations of PKS 0405-385 (cont)	C611	15.5
Filipovic, Pietsch, Haberl, Pannuti, Staveley-Smith, Wolleben	ATNF, MPE, MPE, MIT, ATNF, MPIfR	Supernova remnants (SNRs) in the Magellanic Clouds	C634	27.5
Frail, Kulkarni, Berger, Price, Schmidt, Wieringa, Wark, Subrahmanyan	NRAO, Caltech, Caltech, RSAA, RSAA, ATNF, ATNF, ATNF	Radio afterglows from gamma ray bursts	C651	NAPA
Clark, Dougherty, Waters, Goodwin, Chapman	UCL, NRC/DRAO, UAm, UCardiff, ATNF	Mass-loss rates of the WR stars in the massive cluster Wd1	C652	24
Stappers, Gaensler, Getts	NFRA, CfA, ATNF	Continuum radio emission from accretion powered MSPs	C751	NAPA
Corbel, Fender, Nowak, Wilms, Tzioumis	CEA, UAm, JILA, AITub, ATNF	NAPA observations of GX 339-4 in unusual X-ray states	C767	NAPA
de Blok, Zwaan, Briggs, Freeman	ATNF, UMelb, KI, RSAA	An extended high-resolution HI survey of the Cen A Group	C779	113
Beaulieu, Freeman, Bureau, Carignan, Meurer	UVIC, RSAA, CLMBA, UMont, JHU	Triaxial halos and the outer HI disks of spiral galaxies	C819	12
Ellingsen	UTas	Measuring the polarisation of 6.7 GHz methanol masers	C834	11.5
Roy, Rao, Subrahmanyan	TIFR, TIFR, ATNF	Magnetic field in the Galactic Centre: RM observation of extragalactic sources	C846	10.5
Fender, Sault, Pooley, Spencer, McCormick	UAm, ATNF, MRAO, NRAL, NRAL	NAPA circular polarisation of radio-bright x-ray transients	C857	NAPA
Umana, Trigilio, Cerrigone	CNR, CNR, UCatania	The radio properties of a very young PN	C858	23.5
Lovell, Marshall, Jauncey, Tingay, Murphy, Preston, Schwartz, Perlman	ATNF, MIT, ATNF, ATNF, JPL, JPL, CfA, UMar	Radio, X-ray and optical emission from quasar jets	C890	111.5
O'Brien, Freeman, Bosma, Staveley-Smith, Kalnajs	ATNF/RSAA, RSAA, OMs, ATNF, RSAA	The shape of dark matter halos in edge-on late-type galaxies	C894	98
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, UMin, RAIUB, NCSA/UIL	A 5- and 8.6-GHz Survey of the LMC with the ATCA	C918	239

Appendices

Bignall, Jauncey, Rayner, Lovell, Kedziora-Chudczer, Macquart, McCulloch, Nicolson, Tingay, Tzioumis, Dodson	UAd/ATNF, ATNF, ATNF, ATNF, ATNF, USyd, UTas, Hart, RAO, ATNF, ATNF, UTas	Microarcsecond structure and polarisation of flat spectrum radio sources	C927	186
Corbel, Fender, Tomisck, Kaaret, Tzoumis	CEA, UAm, CASA/UCSD, CfA/SAO, ATNF	NAPA observations of soft x-ray transients in the low-hard state	C932	NAPA
Reynoso, Green, Dubner, Giacani, Johnston, Goss	USyd, USyd, IAFE, IAFE, USyd, NRAO	The interstellar medium towards peculiar neutron stars	C940	36
Sadler, Oosterloo, Morganti, Barnes, de Blok, Koribalski, Staveley-Smith, van der Hulst, Ekers	USyd, NFRA, NFRA, Swinb, ATNF, ATNF, ATNF, KI, ATNF	An unbiased study of the HI properties of early-type galaxies	C950	42
Caswell	ATNF	Search for 1720 MHz OH masers in star formation regions	C952	35.5
Rosenberg, Putman, Stocke, Shull, Ryan-Weber	CASA, CASA, CASA, CASA, UMelb	An HI study of the Lyman alpha absorber/galaxy connection	C960	44.5
McClure-Griffiths, Dickey, Gaensler, Green	ATNF, UMinn, CfA, USyd	Studies of Galactic chimneys: high resolution	C961	97
Zwaan, Drinkwater	UMelb, UMelb	The HI content of high Z galaxies and the evolution of omega-HI	C966	60.5
Indebetouw, Johnson, Churchwell	UWis, UWis, UWis	Ultracompact HII regions in the Magellanic Clouds	C967	36
Disney, Minchin, Knezek, Kilborn, Freeman, Gallagher, Grossi, Davies, Boyce, de Blok, Garcia	UCardiff, UCardiff, KPNO, JB, RSAA, UWis, UCardiff, UCardiff, UBr, ATNF, UCardiff	The evolution of extreme gas-rich galaxies	C970	12
Beasley, Staveley-Smith, Claussen, Marvel, Boboltz	CaltechOv, ATNF, NRAO, AAS, USNO	Water masers in the Magellanic Clouds	C973	74
Brocksopp, Clark	LivJMU, UCL	Radio jets in supergiant x-ray binary systems	C974	23
Saripalli, Hunstead, Subrahmanyan	ATNF, USyd, ATNF	SUMSS giant radio galaxy candidates	C977	24
Setia Gunawan, Chapman, Duncan, Koribalski, White, Cheung	ATNF, ATNF, ATNF, ATNF, UMar, UAd	Millimetre observations of Eta Carina	C978	8
Horellou, Koribalski	OSO, ATNF	HI in the gigantic interacting galaxy NGC 6872	C979	26
Manchester, Staveley-Smith, Gaensler, Kesteven, Tzioumis	CfA, ATNF, ATNF, ATNF, ATNF,	SNR 1987A at 12mm	C981	43
Brocksopp, Corbel, Fender, Tingay	LivJMU, CEA, UAm, ATNF	Radio jets in recurrent x-ray transients	C989	NAPA
Becker, Schaudel Filipovic, Jones, Weisskopf, Aschenbach	MPE, MPE, UWS, UWS, MSFC, MPE	A radio follow-up of x-ray selected SNR candidates	C992	25
Bourke, Wilner, Wright, Wong, Dishoeck	CfA, CfA, ADFA, ATNF, LO	Observations of pre-planetary disks at 3mm	C996	43
Buttery, Cotter, Hunstead, Sadler	CL, CL, USyd, USyd	Cluster searches with SUMSS	C1004	72
Dahlem, Ehle, Ryder, Haynes	ESO, ESA, AAO, UTas	HI observations of galaxies with radio halos	C1005	13
Padovani, Landt, Perlman, Tzioumis, Bignall	STScI, STScI, UMar, ATNF, UAd	ATCA observations of the jet of MH 2136-428	C1009	13
Bignall, Padovani, Landt, Perlman, Tzioumis	UAd, STScI, STScI, UMar, ATNF	ATCA imaging of a faint sample of BL Lacerate objects	C1010	27.5
Dubner, Giacani, Dickel, Reynoso, Green	IAFE, IAFE, UIL, USyd, USyd	Study of the HI in the environs of the SNR G315.1-2.3	C1011	12.5
Sault, McClure-Griffiths, plus 9 students	ATNF, ATNF	Vacation student Narrabri observing session	C1012	36
Kedziora-Chudczer, Sault, Macquart, Rickett	AAO/ATNF, ATNF, KI, UCSD	Intraday variability of radio sources at 22 GHz	C1013	50.5
Wilcots, Pisano, Zabludoff, van Gorkom, Mulchaey	UWis, ATNF, UArzna, UClmba, CarO	Evolution of the HI content of poor groups of galaxies	C1015	97.5

Pisano, Wilcots	ATNF, UWis	A survey of the extended HI environment of ESO 39-2	C1016	39
Thompson, Morgan, Urquhart, White, Miao	UKC, UKC, UKC, UKC, UKC	A 20 cm imaging survey of bright-rimmed clouds	C1017	26.5
Berger, Kulkarni, Frail	Caltech, Caltech, NRAO	GRB host galaxies: A new perspective into cosmic star formation	C1018	67.5
Macquart, Sault, Morris, Bafanoff	KI, ATNF, UCLA, MIT	Connected millimetre and X-ray variability in Sgr A*	C1019	70
Gruppioni, Zotti, Prandoni, Sault, Ricci	IAP, IAP, IRA, ATNF, SISSA	18.5 GHz polarisation observations of southern Kuhr sources	C1023	48
Sung, Staveley-Smith, Freeman, Rhee, McIntyre	RSAA, ATNF, RSAA, UYonsei, ATNF	HI environment and kinematics of blue compact dwarf galaxies	C1024	24.5
Boomsma, Oosterloo, van der Hulst, Sancisi	KI, NFRA, KI, OAB/KI	Galactic fountain HI in NGC 253, part III	C1025	48
Temporin, Staveley-Smith, Weinberger	IAI, ATNF, IAI	HI content of the compact galaxy group CG J1720-67.8	C1026	24
McKay, Mundell, Forbes, Barnes, Ponman	LivJMU, LivJMU, Swinb, Swinb, UBir	Formation and evolution of galaxies in groups - The role of HI	C1027	51
Liu, Barlow, Yates	UCL, UCL, UCL	3cm continuum and line maps of NGC 7009 and NGC 6153	C1028	48
de Blok, Davies	ATNF, UCardiff	Enigmatic gas-rich galaxies in nearby groups	C1030	38
Mitchell, Sault	ATNF, ATNF	S2 observations of GLOBALSTAR satellite interference	C1032	4
Dodson	UTas	Imaging the PSR1706-44 pulsar wind nebula	C1033	36
Tingay, de Kool	ATNF, RSAA	Determining the spectral variability and polarisation characteristics of PKS 1718-649	C1034	38.5
Koekemoer, Mobasher, Dickinson, Webster, Norris, Cram, The GOODS Collaboration	STScI, STScI, STScI, UMelb, ATNF, USyd	Ultra-deep radio imaging of the Chandra Deep Field South	C1035	178.5
Perez, Fux, Freeman, Kalnajs	RSAA, RSAA, RSAA, RSAA	The dynamics of the ring galaxy NGC1291	C1036	27
Wayth, Webster, Trott	UMelb, UMelb, UMelb	Observing candidate gravitationally lensed radio lobes	C1037	52.5
Venturi, Dallacasa, Bardelli, Morganti, Hunstead, Tzioumis	IRA-CNR, IRA-CNR, OAB, NFRA, USyd, ATNF	Search for HI emission in the merging complex A3558	C1038	24
Bernardi, Carretti, Cortiglioni, Poppi, Sironi, Sault, Kesteven	IRA-CNR, IRA-CNR, IRA-CNR, IRA-CNR UMila, ATNF, ATNF	Observations of galactic polarisation at 6 and 20cm	C1039	75
Poppi, Carretti, Cortiglioni, Bernardi, Sault, Kesteven, Vinyajkin, Krotikov, Nicastro	IRA-CNR, ISAF-CNR, ISAF-CNR, ISAF-CNR ATNF, ATNF, NIRFI, NIRFI, ISAF-CNR	Polarised emission from the Moon	C1040	25
Possenti, Burgay, D'Amico, Manchester, WIlson, Johnston	OABol, OABol, CAO, ATNF, ATNF, USyd	Multifrequency contemporary observations of the eclipsing millisecond pulsar J1740-5340	C1043	24.5
Camilo, Gaensler, Manchester	UClmba, CfA, ATNF	A new 5000-yr-old pulsar: the "Mouse" counterpart?	C1044	13
Koribalski, van der, Hulst, Johnston	ATNF, KI, USyd	HI gas near the giant radio galaxy Centaurus A	C1045	47
Warren, Koribalski, Jerjen, Staveley-Smith	RSAA/ATNF, ATNF, RSAA, ATNF	The nature of nearby high HI mass-to-light ratio field galaxies	C1046	139
Wong, Lindqvist, Olofsson, Schoier	ATNF, OSO, StO, LO	Imaging the detached shell around R Sculptoris	C1048	53.5
Ekers, Dopita, Jackson, Kedziora-Chudczer, Kesteven, Ricci, Sadler, Staveley-Smith, Subrahmanyan, Walker, Wilson, de Zotti	ATNF, RSAA, RSAA, ATNF, ATNF, SISSA, USyd, ATNF, ATNF, ATNF, ATNF, OAP	A pilot 20 GHz survey	C1049	220.5

Caswell, McClure-Griffiths, Cheung	ATNF, ATNF, UAd	SNR G292.2-0.5: A faint young supernova remnant	C1052	9
McClure-Griffiths, Dickey, Gaensler	ATNF, UMin, CfA	Galactic HI polarimerty	C1053	74.5
Koribalski	ATNF	HCO+ emission and absorption in Centaurus A	C1054	27.5
Cheung, McClure-Griffiths	UAd, ATNF	Supernova remnants from the Southern Galactic Plane Survey	C1055	14
Slee, Drake, Budding, Orchiston	ATNF, GSFC, CO, ATNF/AAO	Verification of the Parkes list of active stars	C1056	43
Wilson, Kesteven, Leach, Roberts, et al	ATNF, ATNF, ATNF, ATNF	Installation and initial testing of 3.5 GHz analogue correlator/interferometer	C1057	39
Caswell	ATNF	Recombination lines to distinguish SFR from SNR	C1058	16.5
Duncan, Koribalski	ATNF, ATNF	High-dynamic-range imaging of the circumstellar nebulae of four Wolf-Rayet stars	C1059	35
Bignall, Jauncey, Lovell, Tzioumis, Kedziora-Chudczer, Macquart	UAd, ATNF, ANTF, ATNF, ATNF, KI	Measurement of the ISM velocity towards the IDV PKS 1257-326	C1060	10
Curran, Wong, Webb, Murphy, Pihlstrom	UNSW, ATNF, UNSW, UNSW, NRAO	Highly redshifted molecular lines in damped Lyman alpha absorbers	C1061	16.5
Burgasser, Putman	UCLA, CASA	Radio emission in cool dwarf stars and brown dwarfs	C1062	83.5
Curran, Staveley-Smith, Rantakyro, Murphy, Webb	UNSW, ATNF, ESO, UNSW, UNSW	Millimetre fluxes of QSOs illuminating damped Lyman alpha absorbers	C1063	28
Dwarakanath, Subrahmanyan, Mohan, Srinivasan	RRI, ATNF, RRI, RRI	OH absorption towards the Galactic Centre	C1064	12
Ryder, Sadler, Subrahmanyan, Weiler, Stathakis	AAO, USyd, ATNF, NRL, AAO	The radio-luminous supernova 2001ig	C1066	104.3
Baes, de Blok, Dejonghe, Davies	SOGB, ATNF, SOGB, UCardiff	The mass distribution and dynamical history of disk galaxies	C1069	70
Fender, Spencer, Tzioumis, Wu, Johnston, van der Klis, Jonker	UAm, JB, ATNF, UCL, USyd, UAm, IoA	The ultrarelativistic jet of Cir X-1	C1073	87.5
Gaensler, Hendrick, Manchester, Reynolds, Borkowski	CfA, NCSU, ATNF, NCSU, NCSU	A new pulsar-powered supernova remnant in the LMC	C1074	39
Martin, Koribalski, Mader	UHawaii, ATNF, ATNF	Radio emission from our nearest L-dwarf neighbour (NAPA)	C1075	23
Price, Salvo, Schmidt, Kulkarni, Frail, Subrahmanyan	RSAA, RSAA, RSAA, Caltech, NRAO, ATNF	What makes a gamma-ray burst? : A search for GRB signatures in supernovae	C1076	NAPA
Hunt, Jones, Wong, Burton, Minier, Godfrey, Cragg	UNSW, UWS, ATNF, UNSW, UNSW, Monash, Monash	Biomolecules in the interstellar medium	C1077	41.5
Lazendic, Whiteoak, Slane, Wardle, Green	CfA, ATNF, CfA, USyd, USyd	Methanol maser search toward 1720-MHz OH sites in SNRs	C1078	13.5
Jones, Hunt-Cunnigham	ATNF, UNSW	Star formation in molecular cloud G291.3-0.7	C1079	12
Jones, Hunt-Cunnigham	ATNF, UNSW	Kinematics of G291.3-0.7: Cloud-cloud collision or outflow	C1080	12
Minier, Ellingsen, Burton, Wong, Hill	UNSW, UTas, UNSW, ATNF, UNSW	Dust emission from protostellar clusters	C1081	16
Purcell, Minier, Burton, Hunt, Balasubramanyam, Wong, Hill	UNSW, UNSW, UNSW, UNSW, UNSW, ATNF, UNSW	High resolution observations of hot molecular cores	C1082	27.5
Sadler, Jackson, Cannon, Couch, Deeley	USyd, RSAA, AAO, UNSW, UNSW	PKS0019-338 and the AGN-starburst connection	C1083	12
Hunt, Whiteoak	UNSW, ATNF	SiO, CH_3OH and HC_3N in G1.6-0.025	C1084	30

Waugh, Webster, Drinkwater, Ekers, Nulsen	UMelb, UMelb, UMelb, ATNF, UWol	Galaxy evolution in the Fornax cluster	C1085	22
Balasubramanyam, Schultz, Subramanyan	RRI, UNSW, ATNF	Imaging the disks around two young stellar objects	C1086	19
Corbel, Fender, Tzioumis, Mitchell, Kaaret, Tomsick, Miller, Wijnands	CEA, UAm, ATNF, ATNF, CfA, UCSD, MIT, MIT	The jet/ISM interactions around the black hole CTEJ1550-564	C1087	117
Hoare, Lumsden, King. Oudmaijer, Burton	ULeeds, ULeeds, ULeeds, ULeeds, UNSW	Massive star formation in the Galaxy: Red MSX sources	C1088	24
Waters, van den Ancker, Dougherty, Tzioumis	UAm, CfA, DRAO, ATNF	Resolving the dusty disks in southern Herbig Ae/Be systems	C1089	37
Hannikainen, Kuulkers, Sault, Wu	UHel, ESA, ATNF, MSSL/UCL	Catching the next outburst of 4U 1630-47	C1090	NAPA
Church, Balucinska-Church, Hannikainen, Spencer	UBir, UBir, USouth, JB	Studying the possible outflow in the LMXB X1624-490	C1091	8.5
Harnett, Beck, Peart, Ehle, Haynes	UTS, MPIfR, UTas, ESA, UTas	Magnetic fields in central regions of barred galaxies	C1092	52
Thompson, Urquhart, White	UKC, UKC, UKC	Bright-rimmed clouds: tracing their ionised rims	C1093	36
Hunt, Whiteoak	UNSW, ATNF	The molecular Lords of Rings in the Nucleus of NGC 4945	C1094	13.5
Johnston	USyd	Radio pulsations from isolated neutron stars?	C1097	22
Reynoso, Green	USyd, USyd	An HI study of G318.9+0.4	C1098	11
Bains, Redman, Bryce, Meaburn, Gledhill	UHerts, UCL, JB, JB, UHerts	Radio observations of the 'Ant Nebula', Mz 3	C1101	36
Punsly, Clarke, Colbert, Tingay	Boeing, NRAO, JHU, ATNF	The kpc scale morphology of IXO 37 - a possible intermediate mass black hole	C1102	12
Buta, Ryder, Meyer	UAl, AAO, UMelb	HI in the leading arm spiral galaxy NGC 4622	C1103	48
Minier, Burton, Purcell, Ellingsen, Cragg, Sobolev, Wong	UNSW, UNSW, UNSW, UTas, Monash, USU, ATNF	Multi-transition observations of methanol masers	C1104	8
Manthey, Huttemeister, Aalto	URuhr, URuhr, OSO	Large scale HI distribution of moderate luminosity mergers	C1105	73
Oosterloo, Sadler, Morganti, Ferguson, Jerjen	NFRA, USyd, NFRA, KI, RSAA	Unravelling the nature of HIPASS J0352-6602	C1106	66.5
Barnes, Pisano, Gibson, Staveley-Smith	UMelb, ATNF, Swinb, ATNF	Intragroup HI in the Local Group analogue for LGG 93	C1107	48
Curran, Wong, Webb, Murphy, Kanekar	UNSW, ATNF, UNSW, UNSW, NCRA	Molecular absorption lines in high redshift quasars	C1108	12.5
McConnell, Subrahmanyan, Carretti, Cotiglioni, Poppi	ATNF, ATNF, ISAF-CNR, ISAF-CNR, IAR-CNR	Sky polarisation at 5GHz	C1109	25
Kondratko, Greenhill, Lovell, Jauncey, Kuiper, Moran	CfA, CfA, ATNF, ATNF, JPL, CfA	Follow-up continuum imaging of southern H_2O masers detected with the DSN	C1110	24
Pihlstrom, Vermeulen, van Langevelde	NRAO, NFRA, JIVE	Search for excited OH in NGC1052 and Centaurus A	C1111	24.5
Faundez, Bronfam, Garay, Brooks	UChi, UChi, UChi, ESO (Chile)	The ionised content of massive star forming regions	C1112	12
McClure-Griffiths, Benjamin, Putman, Ekers, Johnston-Hollit	ATNF, UWis, CASA, ATNF, UAd/ATNF	Magnetic fields in high velocity clouds	C1115	12
Beasley, Claussen	CaltechOv, NRAO	A search for water masers in Carina	C1116	11
Whiteoak, Hunt, Wong, Lazendic	ATNF, UNSW, ATNF, USyd/ATNF	Imaging the HCO+ molecular cloud associated with N113	C1118	13
Ryder	AAO	SN2001ig	CX033	62.5

Tingay, McClure-Griffiths	ATNF, ATNF	Henz-90	CX034	6
Deacon, Chapman	USyd/ATNF, ATNF	22.235 GHz maser observations of post-AGB Stars	CX036	12
Lewis	UTas	PSR 1055-52	CX038	8.5
Boyle	AAO	Gravitational lens candidate	CX039	12
Hannikainen	UHel	X-ray XTE J1450-603	CX040	10
Harnett	UTS	Radio observations of NGC 986	CX1001	12

Observations made with the Parkes radio telescope January to December 2002

Observers	Affiliations	Program Title	Number	Days
Kaspi , Manchester	UMcGill, ATNF	Long-term monitoring of PSR J0045-7319	P138	1.08
Bailes, van Straten, Ord, Knight, Hotan, Manchester, Sarkissian, Anderson, Kulkarni	Swinb, Swinb, Swinb, Swinb, Swinb, ATNF, ATNF, Caltech, Caltech	Precision pulsar timing	P140	33.5
Han, Manchester, Lyne, Hoyle	NAO(Beij), ATNF, JB, ATNF	Polarisation and Farady rotation of southern pulsars	P236	9.69
Manchester, Lewis, Sarkissian, Kaspi, Bailes	ATNF, UTas, ATNF, UMcGill, Swinb	Timing of young pulsars	P262	3.03
Knight, Ord, van Straten, Kulkarni, Bailes, Edwards, Stapper	Swinb, Swinb, Swinb, Caltech, Swinb, UAm, UAm	Baseband searching for ultrafast pulsars	P263	5.82
Lyne, Kramer, Manchester, Camilo, Stairs, Hobbs, D'Amico, Possenti, Kaspi, Joshi	JB, JB, ATNF, UClmba, NRAO, UMan, OABol, OABol, UMcGill, UMan	Pulsar multibeam survey	P268	15.4
Manchester, Camilo, Lyne, Kramer, Hobbs, Stairs, Kaspi, D'Amico, Possenti	ATNF, UClmba, JB, JB, UMan, NRAO, UMcGill, OABol, OABol	Timing of multibeam pulsar discoveries	P276	18.6
Camilo, Lyne, Kramer, Freire, Manchester, Lorimer, D'Amico	UClmba, JB, JB, JB, ATNF, NAIC, UBol	Timing and searching for pulsars in 47 Tucanae	P282	4.23
Manchester, Kaspi, Crawford, Lyne	ATNF, UMcGill, LMCorp, JB	Timing and confirmation of Magellanic Cloud pulsars	P294	10.4
D'Amico, Lyne, Manchester, Sarkissian, Possenti, Camilo	UBol, JB, ATNF, ATNF, UBol, UClmba	Search and timing of pulsars in globular clusters	P303	14.3
Lyne, Stairs, Athanasiadis, Kramer, Manchester	JB, JB, JB, JB, ATNF	Magnetospheric changes in PSR B1828-11	P340	1.06
Crawford, Pivovaroff, Kaspi, Manchester	Haverford, MIT, UMcGill, ATNF	Timing of pulsars discovered in a search of SNRs	P342	0.54
McKay, Mundell, Forbes, Barnes	LivJMU, LivJMU, LivJMU, Swinb,	Formation and evolution of galaxies in groups - the role of HI	P352	10.6
Staveley-Smith, Koribalski, Henning, Kraan-Kortweg, Harnett, Sadler, Schroeder, Stewart, Price, Green	ATNF, ATNF, UM, UGuan, UTS, USyd, Nice, ULeic, UNM, USyd	A bulge extension to the ZOA survey	P357	7.65
Jacoby, Bailes, Ord, Kulkarni, Anderson	Caltech, Swinb, Swinb, Caltech, Caltech	A high-latitude millisecond pulsar survey	P360	14.1
Ord, Bailes, van Straten, Hotan	Swinb, Swinb, Swinb, Swinb	Studies of a relativistic binary pulsar	P361	2.1
Burgay, McLaughlin, Joshi, Lyne, Kramer, Pearce, D'Amico, Possenti, Manchester, Camilo	UBol, UMan, JB, JB, JB, JB, UBol, UBol, ATNF, UClmba	Parkes multibeam high-latitude survey	P366	10.3
Furuya, Testi, Cesaroni, Kitamura	OAAI, OAAI, OAAI, ISAS	Multi-epoch H_2O maser survey towards southern YSOs (II)	P368	1.25

Gurovich, de Blok, Freeman, Staveley-Smith, Jerjen	RSAA, ATNF, RSAA, ATNF, RSAA	Investigating the Baryonic Tully-Fisher law with a HIPASS sample	P370	4.85
Rosenberg, Putman, Stocke, Shull	CASA, CASA, CASA, CASA	An HI study of the Lyman alpha absorber/galaxy connection	P372	2.23
Caswell	ATNF	Spectra of 1720-MHz OH masers in SFRs	P383	1.06
Zwaan, Webster, Drinkwater, Meyer, Ryan-Weber, HIPASS team	UMelb, UMelb, UMelb, UMelb, UMelb	Completeness & reliability of HIPASS	P387	18.3
Meyer, Webster	UMelb, UMelb	Narrow band observations of HIPASS edge-on spirals	P389	9.53
Curran, Webb, Murphy, Flambaum, Kanekar	UNSW, UNSW, UNSW, UNSW, NCRA	A search for HI in damped Lyman alpha absorbers	P391	4.11
McClure-Griffiths, Sault	ATNF, ATNF	Vacation student Parkes observing session	P392	1.54
Manchester	ATNF	Intrinsic polarisation of the Vela pulsar	P393	0.59
McLaughlin, Kramer, Lyne, Lorimer, Kaspi, Tam, Manchester	JB, JB, JB, JB, UMcGill, UMcGill, ATNF	A search for radio emission from magnetars	P394	2.95
Camilo, Manchester, Sarkissian	UClmba, ATNF, ATNF	Timing two young and energetic pulsars	P395	3.82
Camilo, Arzoumanian, Gaensler, Lorimer, Machester	UClmba, GSFC, CfA, UMan, ATNF	Deep searches for young and "radio-quiet" pulsars	P396	11.8
Johnston, Ball, Rickett, Walker	USyd, ATNF, UCSD, ATNF/USyd	Monitoring scintillation in southern pulsars	P398	3.37
Pisano, Gibson, Barnes, Staveley-Smith, Freeman	ATNF, Swinb, Swinb, ATNF, RSAA	An HI study of loose groups	P399	10.2
Kramer, Lyne, Stairs, Kaspi, Manchester, Camilo	JB, JB, NRAO (GB), McGill, ATNF, UClmba	Geodetic precession in PSR J1141-6545	P400	1.17
Roberts, Kaspi, Tam	UMcGill, UMcGill UMcGill,	A pulsar search for four Egret sources in the Galactic halo	P401	0.21
Stootman	UWS	High resolution profiles of OH lines	P402	3.85
Possenti, Burgay, D'Amico, Manchester, Wilson, Johnston	UBol, UBol, UBol, ATNF, ATNF, USyd	Multifrequency observations fo the eclipsing millisecond pulsar J1740-5340	P404	0.96
Stairs, Kramer, Lyne, Manchester	NRAO (GB), JB, JB, ATNF	A search for a pulsar companion to a main-sequence star	P405	0.5
Roberts, Kaspi, Tam, Ransom, Crawford	UMcGill, UMcGill, UMcGill, UMcGill, Haverford	A search for pulsars in mid-latitude EGRET error boxes	P406	7.06
Burderi, Di Salvo, Burgay, Possenti, D'Amico, Manchester	UAm, UAm, UBol, UBol, CAO, ATNF	Why no radio pulsation from SAX J1808.4-3658 so far?	P407	0.83
Anderson, Staveley-Smith, Filipovic	ATNF, ATNF, ATNF	Galactic HI imaging of southern hemisphere regions	P408	1.6
McClure-Griffiths, Gaensler, Haverkorn, Dickey, Green	ATNF, CfA, ULeid, UMinn, USyd	Diffuse polarisation from the Galactic plane: single dish observations	P409	1.14
Castelletti, Dubner, Mader	IAFE, IAFE, ATNF	Single dish observations of SN1006 at 20cm	P410	0.3
Roberts, Ransom, Kaspi	UMcGill, UMcGill, UMcGill	A possible sub-millisecond gamma-ray pulsar	P413	0.23
Deacon, Green, Chapman	USyd, USyd, ATNF	The origin of planetary nebulae morphology	P414	2.14
Kramer, Lyne, Wang, Manchester, Stairs, Camilo, Joshi, Hobbs, Possenti, Lorimer	JB, JB, UAO, ATNF, NRAO, UClmba, JB, UMan, UBol, JB	More members of a new class of pulsars	P417	3
Ransom, Kaspi, Manchester	UMcGill, UMcGill, ATNF	A deep 20-cm search for pulsations from Supernova 1987A	P419	1.56
Johnston, Nicastro, Ord	USyd, CNR-IFCAI, Swinb	Interstellar scintillation studies of radio pulsars	P420	3.41

Caswell	ATNF	Search for 13 GHz OH masers in star formation regions	P421	1.08
Barnes, Staveley-Smith	UMelb, ATNF	Wombat II: a mini Malin I	P423	0.17

Observations made with the Mopra radio telescope January to December 2002

Observers	Affiliations	Program Title	Number	Days
Walsh, Myers, Burton, Barnes	CfA, CfA, UNSW, UNSW	Do stars form by stationary collapse or moving accretion?	M116	2
Ellingsen, Cragg, Godfrey, Minier	UTas, Monash, Monash, UNSW	Bright class II methanol masers	M117	12.92
Ladd, Fuller	UBuck, UMIST	The evolution of dense cores forming the youngest protostars in Ophiuchus	M118	7.71
Jiang, Balasubramanyam, Omont	NAO(Beij), RRI, IAP	Search for SiO maser stars in an ISOGAL field - m18.63+00.35	M119	2.96
Hoare, Lumsden, King, Oudmaijer, Burton	ULeeds, ULeeds, ULeeds, ULeeds, UNSW	Massive star formation in the Galaxy: red MSX sources	M121	10.67
Hirabayashi, Edwards, Lovell, Tzioumis, Tingay, et al.	ISAS, ISAS, ATNF, ATNF, ATNF	Continued use of Mopra for VSOP survey observations	M122	19

VLBI observations January to December 2002

Observers	Affiliations	Program Title	Number	Hours
Dodson, Reynolds, Legge, Lewis	UTas, ATNF, UTas, UTas	PSR proper motions from observations with the LBA	V088	44
Ojha, Reynolds, Fey, Johnston, Tzioumis, Jauncey, McCulloch, Dodson, et al.	ATNF, ATNF, USNO, USNO, ATNF, ATNF, UTas, UTas	Astrometry/imaging of southern hemisphere ICRF sources	V131	203
Corbett, Norris, Dopita, et al.	AAO, ATNF, RSAA	LBA imaging of two bright Cola galaxies (part A)	V133	14
Beasley, Claussen, Ellingsen, Reynolds, Tzioumis	CaltechOV, NRAO, UTas, ATNF, ATNF	Measuring the mass of the Galaxy - II	V135	24
Greenhill, Moran, Norris, et al.	CfA, CfA, ATNF	Tracking the acceleration of H_2O masers in Circinus	V137	20
Drake, McGregor, Norris	RSAA, RSAA, ATNF	Intermediate radio-loud IRAS Galaxies	V143	22
Tingay, Ojha, Tzioumis	ATNF, ATNF, ATNF	Wide-field imaging of NGC 7552 with the LBA	V150	12
Huynh, Norris, Jackson Ojha	RSAA, ATNF, RSAA ATNF	Phase referenced observations of galaxies in the Hubble Deep Field South	V153	14
Kewley, Corbett, Norris, Dopita, Smith	CfA, AAO, ATNF, RSAA, CfA	Do mergers stop monsters?	V155	30
Dodson, Johnston, Reynolds, Lewis	UTas, USyd, ATNF, UTas	Distance and proper motion of PSR B1259-63	V156	44
Tingay, Tzioumis, Reynolds, Jauncey	ATNF, ATNF, ATNF, ATNF	Core activity and proper motions in GPS galaxies PKS 1718-649 and PKS 1934-638	V160	14
Morganti, Oosterloo, Tzioumis, Reynolds, Tingay, et al.	NFRA, NFRA, ATNF, ATNF, ATNF	HI absorption around the young radio galaxy PKS 1549-79	V161	24
Tingay	ATNF	Wide field, high resolution imaging of jet interaction regions	V165	24

E: Affiliations

AAO	Anglo-Australian Observatory, Australia
AAT	Anglo-Australian Telescope, Australia
ADFA	Australian Defence Force Academy, Australia
AIPr	Astronomical Institute Prague, Czech Republic
AITub	Insititute of Astronomy, University of Tubingen, Germany
ANU	Australia National University, Australia
AO	Arecibo Observatory, USA
AOK	Astronomical Observatory Kiev, Ukraine
AOUpp	Astronomiska Observatoreit, Uppsala, Sweden
ArO	Armagh Observatory, UK
ASC	Astrospace Centre, Russia
ASCR	Academy of Sciences of Czech Republic, Czech Republic
ASIAA	Academia Sinica, IAA, Taiwan
ATNF	Australia Telescope National Facility, Australia
BAO	Beijing Astronomical Observatory, China
BIMA	Berkeley-Illinois-Maryland Association, USA
Caltech	California Institute of Technology, USA
CAO	Cagliari Astronomical Observatory, Italy
CASA	CASA, University of Colorado, USA
CDSSC	Canberra Deep Space Communications Complex, Australia
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
COSSA	CSIRO Office of Space Science & Applications, Australia
CRALOL	CRAL Observatoire de Lyon, France
CSR	Center for Space Research, USA
CTIP	CSIRO Telecommunications & Industrial Physics, Australia
DEMIRM	Département d'Etudes de la Matière interstellaire en InfraRouge et Millimétrique l'Observatoire de Paris, France
DRAO	Dominion Radio Astrophysical Observatory, Canada
ESO	European Southern Observatory, Germany
ESTEC	ESTEC Astrophysics Division, The Netherlands
GBT	Green Bank Telescope, USA
GMU	George Mason University, USA
Gray Data	Gray Data Consulting, USA
GSFC	Goddard Space Flight Center, USA
HartRAO	Hartebeesthoek Radio Astronomical Observatory, South Africa
Harvard	Harvard University, USA
HatCreek	Hat Creek Radio Observatory, USA
IAC	Instituto de Astrofisica de Canarias, Spain
IAFE	Instituto d'Astronomia y Fisica del Espacio, Argentina
IAG	Instituto Astronomico e Geofisico, Brazil

IAP	Institute d'Astrophysique Paris, France
IAR	Instituto Argentino de Radioastronomica, Argentina
IASp	Institut d'Astrophysique Spatiale, France
IFCTR	Instituto de Fisica Cosmica - CNR, Italy
ImCol	Imperial College London, UK
INPE	Instituto Nacional de Pesquisas Espaciais, Brazil
IoA	Institute of Astronomy, UK
IPAC	IPAC, Caltech, USA
IRA-CNR	Institute of Radio Astronomy, CNR, Bologna, Italy
ISA	ISAS, Japan
ISU	Iowa State University, USA
JAC	Joint Astronomy Centre, Hilo, USA
JBO	Jodrell Bank Observatory, UK
JHU	John Hopkins University, USA
JILA	JILA, University of Colorado, USA
JPL	Jet Propulsion Laboratory, USA
KI	Kapteyn Institute, Netherlands
KPNO	Kitt Peak National Observatory, USA
LivJMU	Liverpool John Moores University, UK
LLNL	Lawrence Livermore National Laboratory, USA
LO	Leiden Observatory, The Netherlands
LSW	Landessternwahrte Heidelberg, Germany
MSFC	Marshall Space Flight Center, USA
MERLIN	Multi-element Radio Linked Interferometry Network, UK
MIT	Massachusetts Institute of Technology, USA
Monash	Monash University, Australia
MPE	Max Planck Inst. für Extraterrestrische Physik, Germany
MPIfA	Max Planck Inst. für Astrophysik, Germany
MPIfR	Max Planck Inst. für Radioastronomie, Germany
MRAO	Mullard Radio Astronomical Observatory, UK
NAIC	National Astronomy and Ionosphere Centre, USA
NAOJ	National Astronomical Observatory, Japan
NASA-RC	NASA Ames Research Center, USA
NFRA	Netherlands Foundation for Research in Astronomy, The Netherlands
NOAO	National Optical Astronomical Observatory, USA
NRAO	National Radio Astronomy Observa-tory, USA
NRL	Naval Research Laboratories, USA
NRO	Nobeyama Radio Observatory, Japan
NWU	Northwestern University, USA
OAAI	Osservatorio Astrofisico di Arcetri, Italy
OABol	Osservatorio Astronomico di Bologna, Italy
OARome	Osservatorio Astronomico di Roma, Italy
OAT	Osservatorio Astronomico di Trieste, Italy
OCat	Osservatorio Astronomico di Catania, Italy
OHP	Observatoire de Haute Provence, France
OMs	Observatorire de Marseille, France
ON	Observatorio Nacional, Brazil

Open	Open University, UK
OPM	Observatoire de Paris, Meudon, France
OSO	Onsala Space Observatory, Sweden
PLab	Phillips Lab, USA
PMO	Purple Mountain Observatory, China
PUCC	Pontificia Universidad Catolica de Chile, Chile
Queens	Queens University, Canada
RAIUB	Radio Astronomy Institute, University of Bonn, Germany
RMC	Royal Military College, Canada
ROB	Royal Observatory of Belgium, Belgium
ROE	Royal Observatory Edinburgh, Scotland
RRI	Raman Research Institute, India
RSAA	Research School of Astronomy & Astrophysics, Australia
SETI	SETI Institute, USA
ShO	Shangai Observatory, China
SISSA	Scuola Internazionale Superiore di Studi Avanzati, Trieste, Italy
StO	Stockholm Observatory, Sweden
STScI	Space Telescope Science Institute, USA
Swinb	Swinburne University of Technology, Australia
TGU	Tokyo Gakugei University, Japan
TIFR	Tata Institute for Radio Astronomy, India
UAd	University of Adelaide, Australia
UAl	University of Alabama, USA
UAm	University of Amsterdam, The Netherlands
UBir	University of Birmingham, UK
UBonn	University of Bonn, Germany
UBos	Boston University, USA
UBr	University of Bristol, UK
UC	University of Colorado, USA
UCal	University of Calgary, Canada
UCB	University of California, Berkeley, USA
UCardiff	Universiy of Cardiff, UK
UCha	University of Champagne-Urbana, USA
UChi	University of Chile, Chile
UChig	University of Chicago, USA
UCL	University College London, UK
UClmba	Columbia University, USA
UCLO	University of California Lick Observatory, USA
UCSB	University of California, Santa Barbara, USA
UCSC	University of California, Santa Cruz, USA
UCSD	University of California, San Diego, USA
UDur	University of Durham, England
UEdin	University of Edinburgh, UK
UEot	Eotvos Lorand University, Hungary
UGuan	University de Guanajuato, Mexico
UHel	University of Helsinki, Finland
UHerts	University of Hertfordshire, UK
UHilo	University of Hilo, USA
UHK	University of Hong Kong, PR China
UIL	University of Illinois, USA
UIow	Iowa State University, USA
UKok	Kokugakuin University, Japan
UKST	United Kingdom Schmidt Telescope, Australia
UKT	Kyushu Tokai University, Japan
UKyoto	University of Kyoto, Japan

Appendices

ULeeds	University of Leeds, UK
ULeic	University of Leicester, UK
UMac	Macquarie University, Australia
UMan	University of Manchester, UK
UMar	University of Maryland, USA
UMaur	University of Mauritius, Mauritius
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 Automa de Mexico, Mexico
UNM	University of New Mexico, USA
UNSW	University of New South Wales, Australia
UOx	University of Oxford, Oxford
UPenn	Pennsylvania State University, USA
UPitt	University of Pittsburgh, USA
UQld	University of Queensland, Australia
URh	University of Rhodes, South Africa
URuh	Ruhr-Universitaet, Germany
USMF	Santa Maria Federal University, Brazil
USNA	US Naval Academy, USA
USNO	US Naval Observatory, USA
USouth	Southampton University, UK
UStan	Stanford University, USA
UStern	Sternwarte University, Germany
USU	Ural State University, Russia
USuss	University of Sussex, UK
USyd	University of Sydney, Australia
UTas	University of Tasmania, Australia
UTex	University of Texas, USA
UTor	University of Toronto, Canada
UTS	University of Technology, Sydney, Australia
UVir	University of Virginia, USA
UW	University of Wales, UK
UWA	University of Western Australia, Australia
UWash	University of Washington, USA
UWis	University of Wisconsin, USA
UWol	University of Wollongong, Australia
UWS	University of Western Sydney, Australia
Yale	Yale University, USA
YU	Yunnan Observatory, China

F: ATNF media releases, 2002

Astronomers find star stretched to bursting point	14 February
Gamma-ray burst mystery solved: exploding stars the culprit	16 May
Equipment built at "the dish" goes to China	17 May
Black holes' fatal attraction triggers galaxies' change of heart	02 August
CSIRO to help ease NASA's "traffic jam"	06 September
Mini black holes may help explain massive ones	04 October

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

G: 2002 publications

Papers using ATNF data, published in refereed journals

Papers which include ATNF authors are indicated by an asterisk.

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Hunt, M., "Molecular spectral line observations of sourthern molecular clouds", PhD thesis, University of Western Sydney

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H:Postgraduate students co-supervised by the ATNF

As of December 2002

Name, project title and affiliation

Matthew Young, “An investigation of pulsar dynamics using improved methods of timed series analysis”, University of Western Australia

Scott Gordon, “Star formation in interacting galaxies: A multiwavelength study”, University of Queensland

Boris Babic, “Mass distributions in rich clusters of galaxies”, University of Queensland

Hayley Bignall, “Multiwavelength studies of blazars”, University of Adelaide

Melanie Johnston-Hollitt, “Examining magnetic fields through Faraday rotation measures”, University of Adelaide

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Erik Muller, “The kinematics and structure of the Magellanic Bridge”, University of Wollongong

Paul Roberts, “Components for wide bandwith signal processing in radio astronomy”, University of Sydney

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Emily Ryan-Weber, “Column density distruction function of the local Universe”, University of Melbourne

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Dion Lewis, “Timing of young pulsars”, University of Tasmania

Daniel Mitchell, “Interference mitigation in radio astronomy”, University of Sydney

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Bradley Warren, “The Nature of nearby high HI mass-to-light radio field galaxies”, Australian National University

Meryl Waugh, “Galaxy populations, dynamics and evolution of the Fornax cluster”, University of Melbourne

Rachel Deacon, “Planetary nebulae - origin of morphology”, University of Sydney

Aidan Hotan, “Pulsar observation and timing”, Swinburne University of Technology

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Haydon Knight, “Baseband searching for millisecond pulsars”, Swinburne University of Technology

Natasa Vranesevic, “Galatic distribution and evolution of pulsars”, University of Sydney

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Aaron Chipendale, “High dynamic range imaging with many baseline synthesis interferometry”, University of Sydney

Catherine Drake, “Intermediate radio-loud IRAS galaxies”, Australian National University

I: Abbreviations

AAO	Anglo-Australian Observatory.
AAT	Anglo-Australian Telescope.
ACA	Australian Communications Authority.
AGB	Asymptotic Giant Branch.
ALFA	Arecibo L-band Feed Array.
AIPS	Astronomical Image Processing System.
ALMA	Atacama Large Millimetre Array.
AMiBA	Array for Microwave Background Anisotropy.
APT	Asia-Pacific Telescope.
ARC	Australian Research Council.
ASKACC	Australian SKA Consortium Committee.
ATCA	Australia Telescope Compact Array.
ATNF	Australia Telescope National Facility.
ATUC	Australia Telescope Users Committee.
BIMA	Berkeley-Illinois-Maryland Association.
COSPAR	Committee on Space Research.
CSG	Computer Services Group.
CPSR	Caltech-Parkes-Swinburne Recorder.
CSIRO	Commonwealth Scientific and Industrial Research Organisation.
CTIP	CSIRO Telecommunications and Industrial Physics – a Division of CSIRO partly co-located with the ATNF.
EEO	Equal Employment Opportunity.
FARADAY	Focal-plane Arrays for Radio Astronomy: Design, Access and Yield.
FITS	Flexible Image Transport System.
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.
ISM	Interstellar Medium.
IT	Information Technology.
ITU	International Telecommunications Union.
IUCAF	Inter-Union Commission for the Allocation of Frequencies.
JIVE	Joint Institute for VLBI in Europe.
LBA	Long Baseline Array, used for Australian VLBI observations.
LO	Local Oscillator.
LOFAR	Low Frequency Array.
MIRIAD	Multichannel Image Reconstruction Image Analysis and Display.
MMIC	Monolithic Microwave Integrated Circuit.
MNRF	Major National Research Facilities.
NASA	National Aeronautics and Space Administration. The US space agency.
OECD	Organisation for Economic Cooperation and Development.
OMT	Orthomode Transducer.
PPARC	Particle Physics and Astronomy Research Council.
RAFCAP	Radio Astronomy Frequency Committee in the Asia Pacific Region.
SEARFE	Students Exploring Australia's Radio Frequency Environment.
SEST	Swedish-ESO Submillimetre Telescope (Chile).
SGPS	Southern Galactic Plane Survey.
SIS	Semiconductor-Insulator-Semiconductor.
SKA	Square Kilometre Array.
SUMSS	Sydney University Molonglo Sky Survey.
TAC	Time Assignment Committee.
TCS	Telescope Control System.
URSI	International Union of Radio Science.
USNO	United States Naval Observatory.
VLBI	Very Long Baseline Interferometry.
VSOP	VLBI Space Observatory Program.
WMAP	Wilkinson Microwave Anisotropy Probe.
WRC	World Radiocommunication Conference.
ZOA	Zone of Avoidance.