CSIRO ASTRONOMY AND SPACE SCIENCE
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CSIRO Australia Telescope National Facility

Annual Report
2011

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Front cover image: The 50th anniversary of the CSIRO Parkes radio telescope was celebrated in October 2011 with public open days and a science symposium
Credit: John Sarkissian, CSIRO.

Inner cover image: CSIRO's Australian Square Kilometre Array Pathfinder at the Murchison Radio-astronomy Observatory.
Credit: Terrace Photographers.

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Credit: Wheeler Studios

Director's Report

2011 was a fascinating and intense year in CSIRO Astronomy and Space Science (CASS). The science output from the ATNF facilities continued to impress, as well as to increase. This report provides a snapshot of some of the major results to have appeared during the year; others have been highlighted in *ATNF News*, which continues to be published on a regular basis. The delivery of such science is only possible through the dedication of the engineering and operations teams, assisted by a strong and dynamic support group. It is a privilege to lead such a talented team.

Maintaining the continued excellence of the current ATNF facilities is, in itself a major job, but CASS staff and colleagues from our sister CSIRO Division, the ICT Centre, have also been busy designing and constructing ASKAP, a revolutionary telescope that will be one of the most powerful survey radio astronomy instruments on the planet.

In early 2011 we finalised a bottom-up review of the ASKAP construction program and developed the first version of the operations model for ASKAP, as an intrinsic component of the ATNF. This resulted in the realisation that we had some significant financial challenges in front of us to complete the ASKAP development, and that we had to adjust our operational models to enable the delivery of ASKAP as a fully functional telescope.

Therefore, in October 2011, I announced a rescope of ASKAP construction, with a focus on delivering the six-antenna Boolardy Engineering Test Array (BETA); the implementation of a design and construction process for six Mark II phased-array feeds, a significant enhancement on the six Mark I systems under construction for BETA; and the need to seek ~$15m additional funding to complete the project. I was pleased to announce in late April 2012 that CSIRO will provide an additional $4m to fund another six Mark II systems, meaning we have eighteen PAF systems now funded. The search for additional funds continues.

In the same October announcement I discussed our plans to move the Parkes telescope, over time, to a remote operations model and to seek external funding for Mopra from October 2012. Both changes are necessary to enable CASS to find the resources to operate ASKAP, a $170m facility, at an appropriate level. Indeed, 2012 sees the beginning of the transition of ASKAP from a construction project to an operational telescope as the commissioning process begins in earnest.

As I write this report discussions around the site selection process for the SKA continue apace; I am hopeful of a positive outcome in the near future. The outcome of these deliberations will have a strong bearing on the long-term future of the ATNF and radio astronomy in Australia.

I would also like to take this opportunity to thank the members of our various committees: the Steering Committee for their invaluable advice and support; the Users' Committee for their strong advocacy and advice; and the Time Assignment Committee for their tireless work, especially as the number of proposals continues to increase. We could not run the ATNF without the dedication of such people.

To conclude, I look forward to the future and the changes that we are implementing to ensure our successful ongoing delivery of world class astronomy facilities to researchers from around the world. I hope you enjoy this year's annual report.

Philip Diamond

ATNF DIRECTOR

CHIEF, CSIRO ASTRONOMY AND SPACE SCIENCE

Chairman's Report


Credit: ICRAR

Having been associated with the ATNF, firstly as a CSIRO employee for 16 years, and now as Chair of the Steering Committee, it strikes me that 2011 has been one of the most challenging years for the organisation. Almost simultaneously, there have been major challenges to be overcome in a variety of areas, including: developing a new operations model around all facilities; construction of a new observatory in a remote location; development of functional phased array feeds; and decisions around the future of Mopra. All this is in the context of the perennial uncertainty of the future location of the CASS headquarters and, of course, the discussion around the siting of the SKA.

The pressure on CASS staff and management has therefore been higher than usual, and I thank them for the continued delivery of a world-class facility to the astronomy community. It's especially pleasing to see the continued innovation and continuing strong utilisation of the Compact Array and Parkes telescopes. The exciting results I see in this Annual Report around, for example, the new broadband backend and new wideband feeds testify to the former. It's also pleasing to see the first bits of data flow from the MRO into the VLBI network. Although only a fraction of the ASKAP torrent to come, it served as an excellent capability demonstration during the international SKA forum. I'd therefore like to take the opportunity to thank the ATNF Director, Phil Diamond, for the achievements of the ATNF over the last year, and for guiding the organisation through the challenges mentioned above. Phil of course has duties beyond the operations of the ATNF. These include the management of CDSCC and, since joining CASS, the management of ASKAP construction. A formidable set of duties for anyone.

I was privileged to be able to participate in the Parkes 50th birthday symposium in early November. What a fantastic symposium! There was of course a historical session that was well attended. But the symposium was mostly about cutting-edge science taken with what is still very much a world-class telescope. Moreover many of the speakers were young students, co-supervised by CASS staff, and early career researchers. The 'old lady' is not only at the cutting edge of research, but is doing her bit to train the next generation of astronomers. I thank the organisers and participants of this meeting for arranging such an interesting event.

Finally, I thank my fellow members on the Steering Committee for their valuable input throughout the year, mainly at the annual two-day meeting but also via conference calls at other times. The members bring a depth of experience to the table which is much appreciated by myself and, hopefully, by CASS management.

Lister Staveley-Smith

CHAIR, AUSTRALIA TELESCOPE STEERING COMMITTEE

Senior Management

ATNF DIRECTOR AND CHIEF CSIRO ASTRONOMY AND SPACE SCIENCE
Philip Diamond

CSIRO SKA DIRECTOR
Brian Boyle

DEPUTY CHIEF
Sarah Pearce
(from February 2011)

CHIEF SCIENTIST
Robert Braun

ASSISTANT DIRECTOR, OPERATIONS
Douglas Bock

ASSISTANT DIRECTOR, ENGINEERING
Graeme Carrad

ASSISTANT DIRECTOR, ASKAP
Antony Schinckel

ASSISTANT DIRECTOR, ASTROPHYSICS
Simon Johnston

OPERATIONS RESEARCH PROGRAM LEADER
Jessica Chapman

STRATEGIC PLANNING AND MAJOR PROJECT SPECIALIST
Phil Crosby

1. The ATNF in Brief

CSIRO astronomer George Hobbs received the 2011 UNSW Medal for the Young Tall Poppy of the Year for NSW, for his pulsar research and outreach work.
Credit: John Sarkissian, CSIRO.

The ATNF in Brief

CSIRO's radio astronomy observatories are collectively known as the Australia Telescope National Facility, or ATNF. This consists of a set of radio telescopes provided as a national research facility for use by Australian and international researchers that offer a unique view of the southern hemisphere radio spectrum. CSIRO's Division of Astronomy and Space Science (CASS), CSIRO's provider of technology and services for radio astronomy, spacecraft tracking and space sciences, has direct responsibility for the successful operation of the ATNF. CASS headquarters is located at the CSIRO Radiophysics Laboratory in Marsfield, Sydney. This report covers ATNF-related activities of CASS over the whole 2011 calendar year.

OUR MISSION

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

CSIRO Astronomy and Space Science manages and operates the ATNF. Facilities are located in New South Wales, on the east coast of Australia, and in the Mid West region of Western Australia.

AN OVERVIEW OF THE ATNF

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

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

Six identical 22-m antennas make up the Australia Telescope Compact Array (ATCA), an earth-rotation synthesis telescope located at the Paul Wild Observatory outside Narrabri. The ATCA is equipped with receivers that operate at frequencies between 1.4 GHz and 110 GHz, with use at the highest frequencies restricted primarily to a 'winter season' by atmospheric stability and transparency considerations.

The Mopra radio telescope is a single 22-m diameter antenna near Coonabarabran, used primarily for large-scale millimetre-wavelength mapping projects and as part of the Long Baseline Array.

CASS also manages the astronomy use of the CSIRO-administered Canberra Deep Space Communication Complex 70-m and 34-m antennas at Tidbinbilla. NASA/JPL makes approximately 5% of 70-m antenna time available to astronomical research programs.

The eight ATNF radio telescopes can be used together (sometimes in conjunction with antennas operated by the University of Tasmania at Ceduna and Hobart, the Tidbinbilla 70-m antenna, and a new 12-m antenna operated by Auckland University of Technology at Warkworth, NZ) as a Long Baseline Array (LBA) for a technique known as Very Long Baseline Interferometry (VLBI).

CASS is in the process of building a next-generation radio telescope, the Australian Square Kilometre Array Pathfinder (ASKAP), which will become part of the ATNF following its commissioning. ASKAP will be a wide field-of-view survey telescope made up of 36 antennas, each 12 metres in diameter. It is located at the Murchison Radio-astronomy Observatory, a superbly radio-quiet area in the Mid West region of Western Australia, and will be a key demonstrator instrument for new technologies for the international Square Kilometre Array (SKA) project. The Murchison Radio-astronomy Observatory Facility in Geraldton supports the development and operation of the Murchison Radio-astronomy Observatory. An ASKAP antenna has participated in LBA observations during the past year.

Technical research and development supporting upgrades of the Facility, as well as for the new ASKAP instrument, are conducted at CASS headquarters in Marsfield.

GOVERNANCE

The Australia Telescope is operated as a national facility under guidelines originally established by the Australian Science and Technology Council. Until 30 November 2009 the ATNF undertook this activity as a division of CSIRO in its own right. On 1 December 2009, ATNF activity became the responsibility of a new division, CSIRO Astronomy and Space Science (CASS), through which it is responsible via the CSIRO Executive to the Minister for Tertiary Education, Skills, Science and Research. The Chief of CASS is also the Director of the ATNF.

Divisional policy, strategic planning and operational management are the responsibility of the CASS Executive, comprising the Chief (Philip Diamond), the Deputy Chief (Sarah Pearce), Chief Scientist (Robert Braun), Assistant Directors (Graeme Carrad, Douglas Bock, Simon Johnston, Antony Schinckel), CDSCC Director (Len Ricardo, acting), Operations Research Program Leader (Jessica Chapman) and Strategic Planning and Major Project Specialist (Phil Crosby).

Divisional plans reflect CSIRO's 2007–2011 Strategic Plan, the new CSIRO Strategic Plan 2012–2015, and the ATNF's mission statement.

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

The ATSC, TAC and ATUC members for 2011 are listed in Appendix A.

CASS MANAGEMENT CHANGES IN 2011

In February, Sarah Pearce was appointed Deputy Chief of CASS. Sarah arrived from Queen Mary, University of London, where she had been Project Manager for GridPP, the UK computing grid for particle physics. Her previous experience includes time as a science advisor in the UK Parliament, and a PhD in X-ray astronomy.

Graeme Carrad, who had been Acting Deputy Chief of CASS prior to Sarah's appointment, returned to his roles as Research Program Leader for Engineering and Theme Leader for Technologies for Radio Astronomy.

In June 2011, Robert Braun was appointed as CASS Chief Scientist. Robert had been Assistant Director – Astrophysics since 2007, a role he took up after leading the scientific staff at ASTRON. In 2011 Robert was also named an Honorary Professor of The University of Sydney.

The role of Assistant Director – Astrophysics was filled by Simon Johnston, who was previously a Science Leader in the Astrophysics theme.

Phil Crosby returned to CASS in 2011 from a two-year secondment to the SKA Program Development Office in Manchester where he had been leading SKA activities on industry engagement. At CASS, Phil's main roles are around strategic planning and working with industry.

FUNDING

In financial year July 2010 – June 2011 CSIRO's total expenditure for radio astronomy activities was A$37.0m; total revenue was A$43.6m, including a direct appropriation of A$36.4m from CSIRO. A summary of finances for the year is given in Appendix B.

THE AUSTRALIA TELESCOPE COMMUNITY

At the end of 2011 the total staff complement of CASS was around 300 people, of which 183 people were primarily associated with the ATNF. This was made up of paid staff (research scientists and engineers, technical and administrative support), but excludes casuals, contractors and students. These resources are distributed across five sites within NSW and the ACT, and Geraldton in Western Australia. A list of all staff who worked for CASS on radio astronomy related activities during 2011, including staff from other CSIRO divisions, is given in Appendix C.

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

Observing time on ATNF telescopes is awarded twice a year to astronomers on the basis of the merits of their proposed research programs as judged by the Time Assignment Committee. Approximately 90% of the Australia Telescope's users come from outside CSIRO. Proposals for time on the Compact Array typically exceed the time available by a factor of 2.0–2.5, while Parkes and Mopra proposals typically exceed the time available by a factor of around 1.3. The proposals for Parkes and Mopra are commonly fewer and request more time. In total, approximately 150 proposals are received for the summer semester (October to March) and 200 in the winter semester (April to September) – the difference reflects the high demand for winter millimetre observing using Mopra and the Compact Array.

The ATNF has strong links with its primary user base, the university community, both within Australia and around the world. The 'user–operator' model adopted by the Australia Telescope is unusual, if not unique, in world terms. Members of each observing proposal operate the telescope for their allocated time and the ATNF sites host a constant stream of visiting astronomers from around the world who come for periods of between a few days and a few weeks. This is a significant contributor to the strength of the relationship between CASS and the astronomers that use the ATNF. These relationships are further strengthened by the open, international and collaborative nature of astronomical research: 77% of Australian astronomy papers published in 1998–2002 (the most recent period for which figures are available) had international coauthors, an increase from 55% for the previous five years (Biglia and Butler 2005, New Horizons: Volume II—*A Bibliometric Analysis of Astronomical Sciences Publications*). Although this model is not suited to the survey-mode observing of ASKAP, the ATNF intends to retain it for the Compact Array, while we move over time to a remote operations model for Parkes and Mopra.

Research scientists and engineers are heavily involved in the training of postgraduate students, an important contributor to the strength of the interactions between CASS staff and university colleagues. In 2011 CASS staff co-supervised 29 PhD students, most of whom were undertaking degrees at Australian universities. CSIRO provides direct financial support to most of these students, supplementing the support that they receive through their host universities. The majority of current PhD students with CASS have an Australian Postgraduate Research Award.

THE WIDER ASTRONOMY COMMUNITY AND OTHER RELATIONSHIPS

The Australia Telescope Steering Committee provide the ATNF Director with strategic advice from the Australian and international research community, and CSIRO provides similar input to other parts of the research community via staff representation on other research community bodies and committees. The Australia Telescope User Committee also provides an effective route for operational feedback and input to CSIRO on future directions as well as providing communications from CSIRO to the user community.

CSIRO is a full member of Astronomy Australia Ltd, an organisation established in early 2007 as a company with the principal objective of managing the National Collaborative Research Infrastructure Strategy (NCRIS) funds for astronomy. CSIRO is also an organisational member of the Astronomical Society of Australia.

CASS also has contracted links with the research and space community, both for the provision of equipment and for provision of research outcomes, data, or aspects of ATNF operations to organisations external to CSIRO. Such contracts are small in number, and in the past have generally concerned the delivery of instrumentation for astronomy, and/or space-craft tracking services. CSIRO has also entered into contracts with Australian university partners for the provision of services that contribute to the operation of the ATNF, and this is now the favoured mode of engagement at CASS. Engagement with university partners is seen as increasingly important and will continue to be actively pursued over coming years by CASS as an effective means of broadening the ATNF resource base, and ensuring the vitality of the Australian astronomy research community as a whole.

CASS links with the Australian and international community are increasing in complexity as the organisation progresses towards the SKA. CAASTRO (the ARC Centre of Excellence for All-sky Astrophysics) was formed in 2011 as a partnership and collaboration between several Australian and international universities and research institutions, including CSIRO. ICRAR (the International Centre for Radio Astronomy Research, which comprises Curtin University and the University of Western Australia) has provided links to Western Australian universities.

As a component of CSIRO's management of the Murchison Radio-astronomy Observatory (MRO), CSIRO has a Collaboration Agreement with the Western Australian Government. A now funded project from the Sustainability Round of the Commonwealth Government Education Investment Fund will enable CASS, in collaboration with CSIRO's Energy Group and several industry partners, to improve energy efficiency and provide sustainable power for the MRO and for ASKAP's supercomputing requirements at the Pawsey Centre for SKA Science in Perth.

International alliances are also growing, with a small number of 'formal' links underlined by collaborative agreements supplemented by a larger number of informal community collaborations. In 2011 CSIRO joined RadioNet3, a collaboration to coordinate radio astronomy facilities to benefit European astronomers. AUT University (Auckland, New Zealand) joined regular VLBI observing with its 12-m Warkworth telescope. Other formal linkages include those between CSIRO and EU-PrepSKA, NRC-Canada, ASTRON in The Netherlands, the international SKA Program Development Office (SPDO), the Australia – New Zealand SKA Coordination Committee (ANZSCC), INAF in Italy, and research groups in the USA, New Zealand, India, and China.

Finally, as CASS moves through the design, development and construction phases of the ASKAP project, industry will play a crucial role in the delivery and through-life support of the technologies and infrastructure required. The scale of ASKAP and the consequent requirement to 'productionise' many of its components continues to draw on the engagement of industry at new levels. Such relationships with industry continued to develop through 2011 with engagement occurring at the research collaboration level and more strategically via the Australasian SKA Industry Consortium (ASKAIC).

THEMES

The strategic goals and purpose of CASS by theme (as at the end of 2011) are as follows:

Astrophysics

Theme goal
To deliver world-class science that directly influences international astronomical research and shapes our understanding of the Universe.

Theme purpose
To conduct world-class research in astrophysics, retaining astronomy's position as Australia's highest impact fundamental science and furthering our understanding of the Universe through innovative use of CSIRO's telescopes. The primary research deliverables of the theme are refereed papers in high impact international journals. Current outputs are based, to a large extent, on data obtained with the ATNF telescopes, a hardware investment of about A$200m made over the past 50 years. About half of theme effort is directed at maximising the scientific return of current and future facilities through the provision of scientific support. This has been directed largely at the ATNF telescopes, but now also extends to the Australian Square Kilometre Array Pathfinder, a A$150m facility now under construction in Western Australia, from about 2013 onward. The theme is also fully engaged in planning for science outcomes from the A$2.5b international Square Kilometre Array, which will provide revolutionary science capabilities from about 2018.

Australia Telescope National Facility Operations

Theme goal
To continue to operate the most productive radio astronomy facility in the southern hemisphere in order to serve the Australian and international scientific community.

Theme purpose
This theme operates the National Facility observatories (the Compact Array near Narrabri, the single-dish Mopra telescope, the Parkes radio telescope, the radio astronomy activities at NASA's Canberra Deep Space Communication Complex at Tidbinbilla, and the Long Baseline Array) to maximise the scientific value of experiments conducted by ATNF users. From 2013, the theme will operate a new telescope – the Australian Square Kilometre Array Pathfinder (ASKAP) – in Western Australia, which is being developed under the ASKAP theme. Operational aspects of activities in Western Australia started to be transitioned to the theme on 1 July 2011.

The high impact of the ATNF will be sustained by ensuring continuous operation with very high reliability (<5% lost time) and excellent data quality, facilitating astronomical research conducted with our radio telescopes that contributes to the understanding of the Universe. The scientific impact of the theme is measured by the output of CSIRO astronomers (Theme 1069) and the astronomers worldwide who use the facility. A primary measure is the publication record of CSIRO and non-CSIRO facility users.

Technologies for Radio Astronomy

Theme goal
To develop frontline technology for the advancement of radio astronomy in Australia.

Theme purpose
To ensure that CSIRO's existing radio telescopes remain at the leading edge of world technology, securing continued demand from the astronomy research community for the CSIRO's radio telescopes, with the effect of maximising the science outcomes from astronomy conducted with the ATNF.

This directly complements the development of a new radio telescope undertaken in the sister theme, the Australian Square Kilometre Array Pathfinder.

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

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

The window of opportunity for success is considered to be more medium term than short term and governed by those facilities in the world that might compete in the astronomy field. Timescales for planned work allow sufficient time for good science prior to competing facilities coming online.

The Australian Square Kilometre Array Pathfinder

Theme goal
To maximise Australia's participation in the Square Kilometre Array (SKA).

Theme purpose
The purpose of the Australian Square Kilometre Array Pathfinder (ASKAP) theme is to develop a world-leading survey radio telescope to explore the history of the Universe, through development and deployment of innovative receiver and data processing technologies, and establishment of a radio-quiet observatory in Western Australia. Embedding the theme developments in the international SKA program is aimed at maximising Australia's participation in the SKA, to take advantage of the opportunity to be a 'key player' in the SKA domain.

ASKAP will provide impact through:

- Delivering a world-leading instrument to study the southern sky and address the biggest questions regarding our knowledge of the Universe. The complete ASKAP telescope will deliver a roughly 20-fold capability increase in survey speed compared with any radio telescope in the world.
- Establishing a world-class astronomical observatory at the world's best site for metre and centimetre radio astronomy, attracting science engagement and further international investment to Australia, including (hopefully) the SKA
- Maximising Australia's participation in the SKA – a multi-billion Euro international facility due for full delivery in about 2025, and
- Development of innovative phased array feeds along the SKA development path.

The ASKAP theme deliverables are timed aggressively to influence site choice and technology choice for the SKA, in order to promote Australian opportunities.

Canberra Deep Space Communication Complex

Theme goal
To participate as a US National Aeronautics and Space Administration (NASA) partner in the exploration of our Solar System and beyond.

Theme purpose
This theme manages the operation and maintenance of the Earth station facilities at the Canberra Deep Space Communication Complex (CDSCC) as an element in NASA's Deep Space Network (DSN). The DSN is an international network of antennas that supports interplanetary spacecraft missions, and radio and radar astronomy observations for the exploration of the Solar System and the Universe. The network also supports selected Earth-orbiting missions. The DSN is managed by NASA's Jet Propulsion Laboratory (JPL). CSIRO NASA Operations looks after NASA's other interests in Australia including the management and operations of a balloon science facility in Alice Springs.

The DSN activity places CSIRO as an active participant in NASA's exploration of space, extending from the near-Earth environment to deep space, with spacecraft distances out beyond 14 billion km. CDSCC is also utilised for a limited number of hours per year as an asset for use by host country radio astronomers and is also utilised as a precise fiducial reference point in VLBI activities.

Capability Development

Theme goal
To build CASS's capability in astronomy, technology, operations and space science.

Theme purpose
This theme focuses on building capability in four areas:

- Development of capability to lead Australia's SKA site bid and participation in the SKA
- Development of innovative 'phased array' technology, in particular looking at manufacturing the technology for the SKA radio telescope
- Supporting the ten high priority ASKAP Survey Science Projects, and
- Developing a space science strategy for CSIRO.

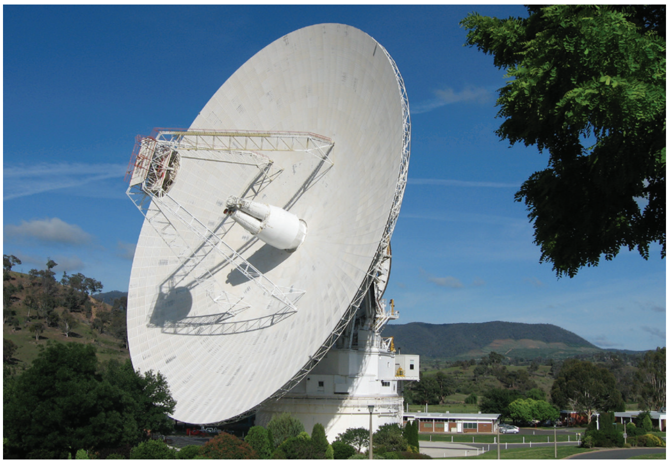
Telescopes

AUSTRALIA TELESCOPE COMPACT ARRAY
Credit: David Smyth, CSIRO.

MOPRA RADIO TELESCOPE
Credit: John Masterson, CSIRO.

AUSTRALIAN SQUARE KILOMETRE ARRAY PATHFINDER
Credit: Terrace Photographers.

PARKES RADIO TELESCOPE
Credit: David McClenaghan, CSIRO.



CANBERRA DEEP SPACE COMMUNICATION COMPLEX DSS-43 70-M ANTENNA
Credit: Canberra Deep Space Communication Complex.

2. Performance Indicators

Almost 100,000 people visited Parkes Observatory in 2011. On 8 and 9 October, the 50th anniversary of the observatory was celebrated by around 5,000 people during an open weekend. Credit: Rob Hollow, CSIRO.

Performance Indicators

1 SCHEDULED AND SUCCESSFULLY COMPLETED OBSERVING TIME

For the Compact Array and Parkes radio telescope, the ATNF target is that at least 70% of time should be allocated for astronomical observations while the time lost during scheduled observations from equipment failure should be below 5%. For the Compact Array and Parkes, approximately 10% of time is made available as 'Director's time'. This is time that is initially not allocated in the published version of the schedule, but, if not allocated at the discretion of the Director, is later made available for approved observing projects.

For most projects, the proposing astronomers are required to be present at the observatory for their scheduled time. For the Compact Array, remote observing is also possible from other sites. In 2011, 32% of Compact Array observations were taken by observers not present at Narrabri. All Mopra observations are now taken remotely from the telescope site. In 2011, approximately 50% of Mopra observations were taken from Narrabri or Sydney and the other 50% from locations including North America, Japan, and Europe

The telescope usage figures are similar to those for recent years. For Mopra, the period 1 April – 31 October corresponds to the period when the majority of observing in the 3-mm band was carried out (the 'millimetre season'). In recent years, Mopra use has extended, at a somewhat lower level, into the 'shoulder season' preceding the 3-mm season for observations in the 7-mm and 12-mm bands.

2 RESPONSE TO RECOMMENDATIONS BY THE USER COMMITTEE

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

In most cases ATUC recommendations are accepted and implemented. In 2010, ATUC made 25 recommendations to the ATNF. Of these, 22 were accepted and were completed by May 2011.

The ATUC members are listed in Appendix A.

TABLE 1:
Telescope usage in 2011.

	COMPACT ARRAY	PARKES	MOPRA*
Successful astronomy observations	77%	74%	70%
Maintenance/test time	17%	20%	6%
Time lost due to equipment failure	3%	3%	2%
Time lost due to weather	1%	2%	10%
Idle time	2%	1%	12%

* Mopra statistics are for dates between 1 April and 31 October, corresponding to the 'millimetre season'.

3 TIME ALLOCATION ON AUSTRALIA TELESCOPE FACILITIES

The allocation of time on Australia Telescope facilities is done on the basis of scientific merit. Two six-month observing semesters are scheduled each year, from October to March (OCTS) and from April to September (APRS). For the period from 1 October 2010 to 30 September 2011 a total of 203 proposals were allocated time on ATNF telescopes (each proposal is counted once only per calendar year although some proposals are submitted twice). Of these, 116 were for the Compact Array, 36 were for the Parkes telescope, 34 were for the Mopra telescope and 17 were for the Long Baseline Array. Observing programs allocated time on ATNF facilities are listed in Appendix D.

Proposals requesting service observations with the Canberra Deep Space Communication Complex DSS-43 (70-m) and DSS-34 (34-m) antennas at Tidbinbilla, which are part of the NASA Deep Space Network, are also accepted. Eight Tidbinbilla projects were observed during the year.

Figures 1, 2 and 3 show the time allocated to observing teams on the Compact Array, Parkes and Mopra telescopes as a percentage of the total allocated time, determined by affiliation of the team leader.

Figures 4, 5 and 6 show the time allocated to observing teams as a percentage of the total allocated time, determined using the affiliations of all team members. In these plots the time allocated to each proposal has been divided evenly between all authors on the proposal. Including all authors on the proposals, CASS staff were allocated approximately 28% of observing time during the year for the Compact Array, 29% for the Parkes telescope and 10% for Mopra. Mopra continued to have a larger involvement by international investigators, who have been allocated about 70% of observing time in recent years.

ATNF telescopes are able to support a broad range of science areas that include Galactic (ISM, pulsar, X-ray binaries, star formation, stellar evolution, magnetic fields), extragalactic (galaxy formation, ISM, Magellanic Clouds, cosmic magnetism) and cosmological science. The research programs involve astronomers from many institutions in Australia and overseas. Typically the proposals received each semester include approximately 600 authors. Of these 50 are from CASS, 80 are from other Australian institutions and 470 are from around 175 overseas institutions in 26 countries. The three countries with the largest numbers of proposers are the USA, UK and Germany.

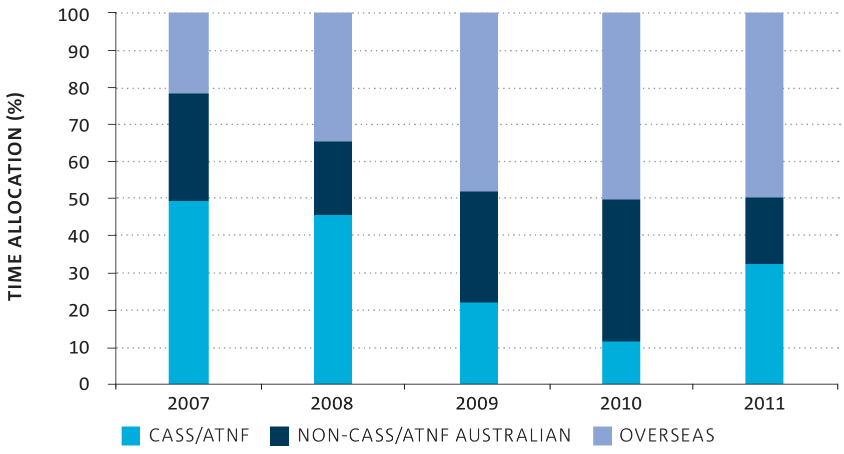


FIGURE 1:
Compact Array time allocation by primary investigator, October 2007 – September 2011. For each year the time allocation is for 12 months from October to September.

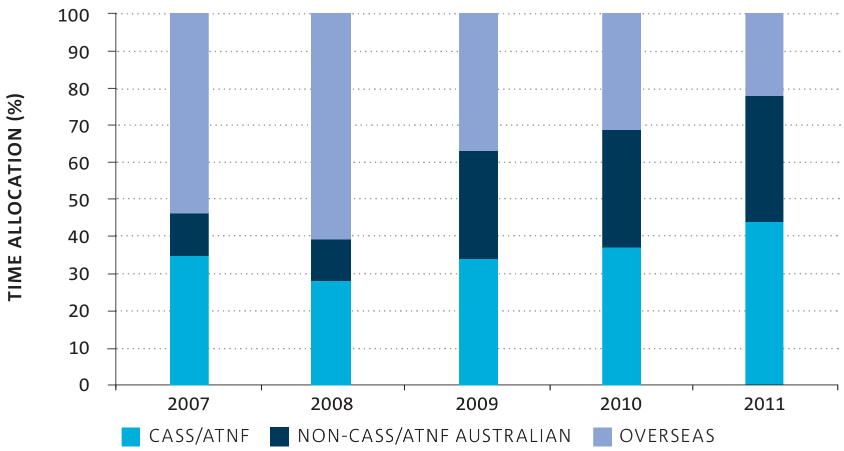


FIGURE 2:
Parkes time allocation by primary investigator, October 2007 – September 2011. For each year the time allocation is for 12 months from October to September.

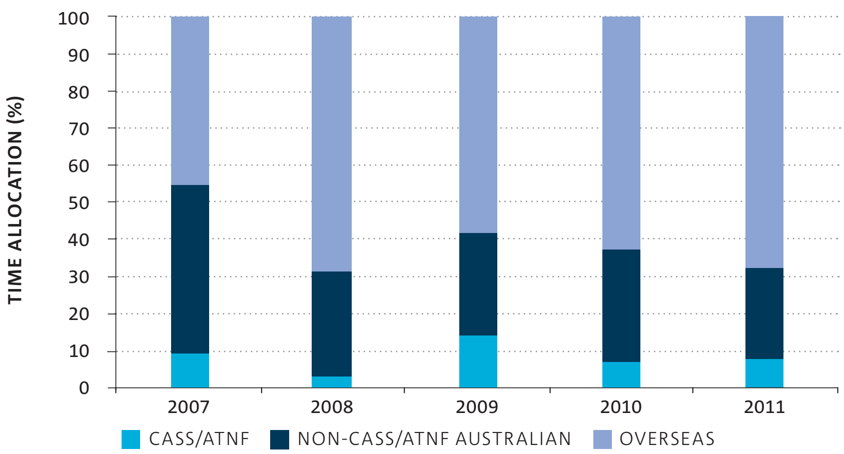


FIGURE 3:
Mopra time allocation by primary investigator, October 2007 – September 2011. For each year the time allocation is for 12 months from October to September.

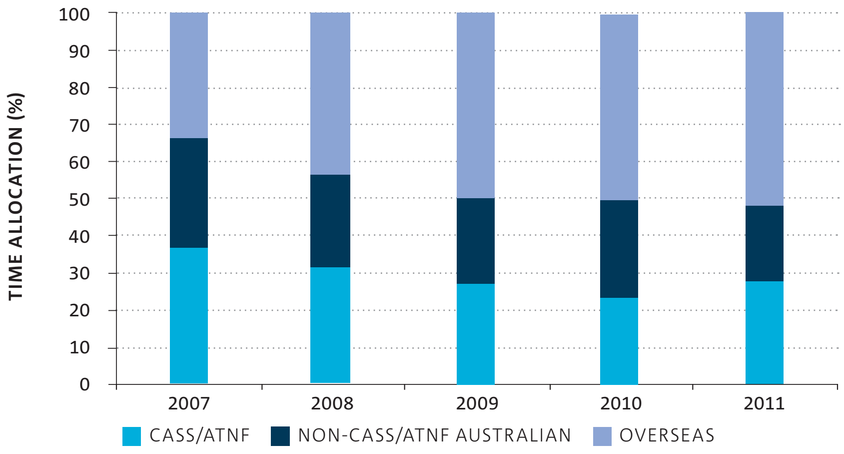


FIGURE 4:
Compact Array time allocation by all investigators.

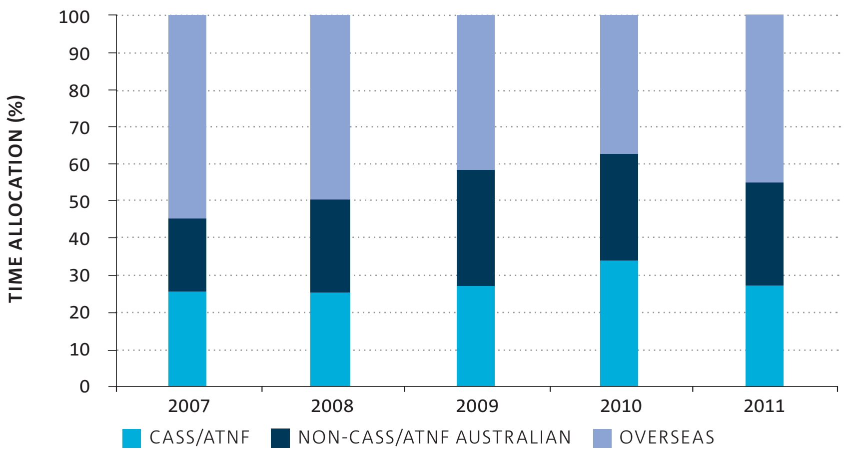


FIGURE 5:
Parkes time allocation by all investigators.

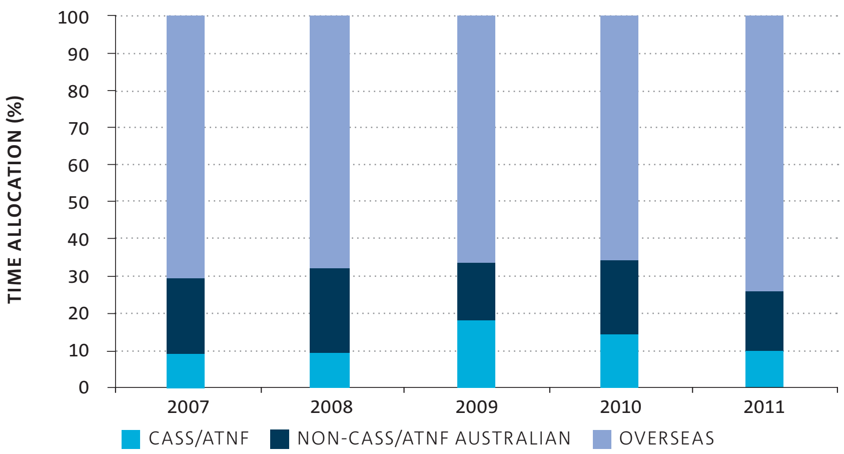


FIGURE 6:
Mopra time allocation by all investigators.

4 TEACHING

In December 2011, there were 29 PhD students being co-supervised by CASS staff; in addition, there was one undergraduate Honours student being co-supervised by CASS staff. Their affiliations and thesis titles are given in Appendix E. Nine students were awarded PhDs during the year and their theses are listed in Appendix F.

Figure 7 shows the numbers of PhD students affiliated with CASS. Figure 8 shows the institutions at which CASS-affiliated students were enrolled in 2011. Most students were enrolled in Australian universities, with the majority of these at The University of Sydney, Swinburne University of Technology, the University of Tasmania, the University of New South Wales and the University of Adelaide.

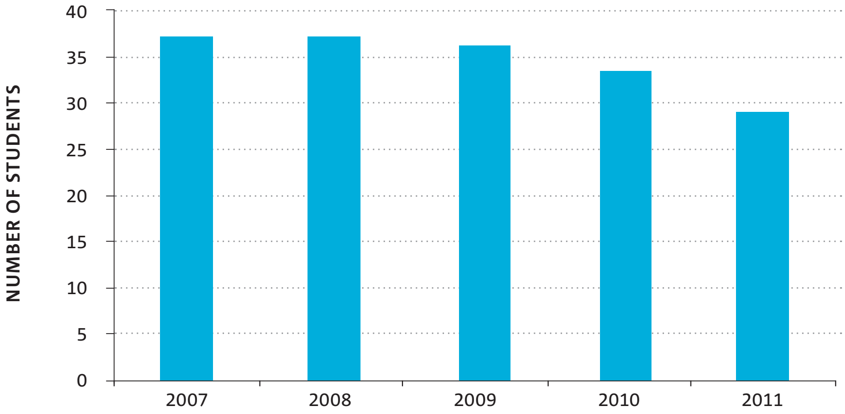


FIGURE 7
Numbers of postgraduate students affiliated with CASS.

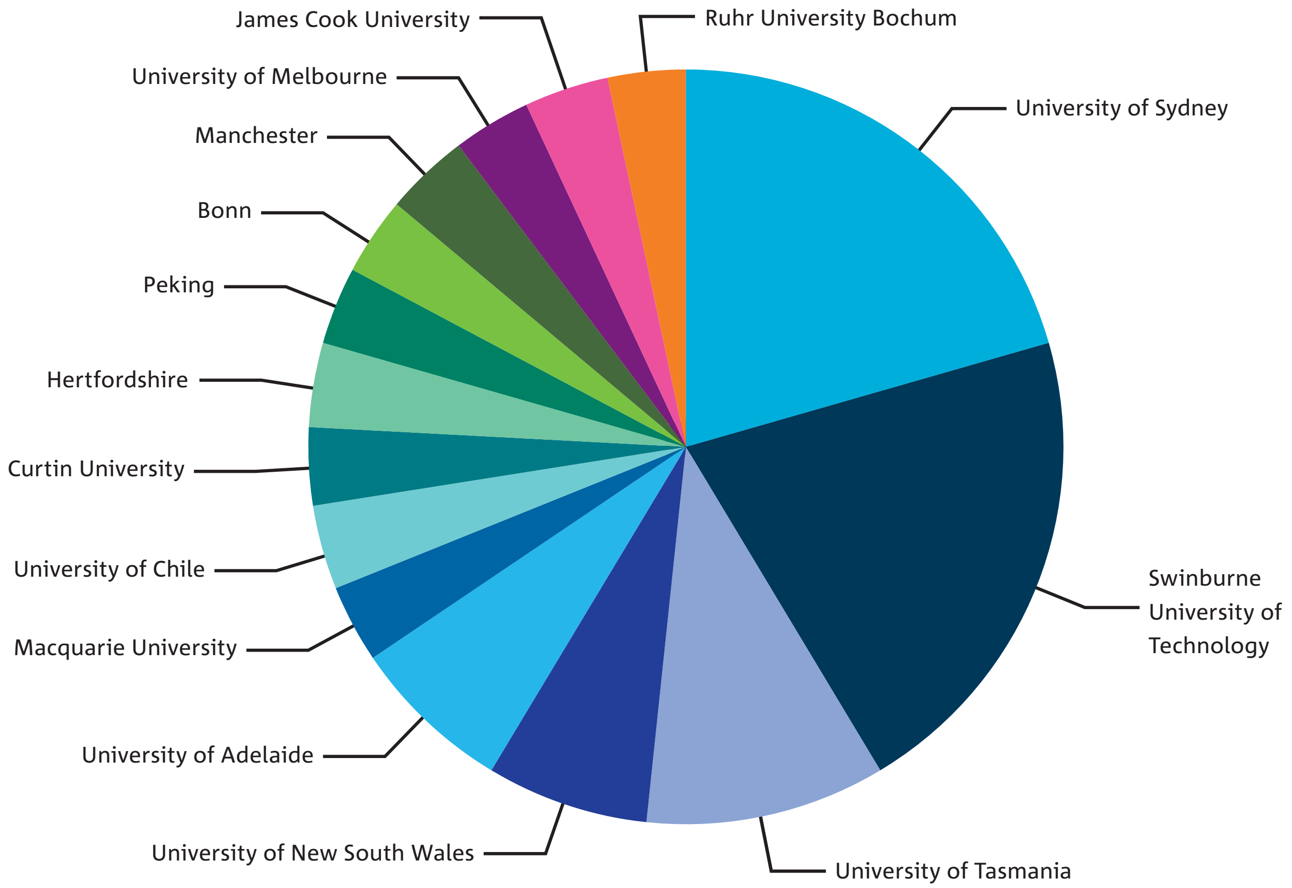


FIGURE 8:
Postgraduate student affiliations 2011.

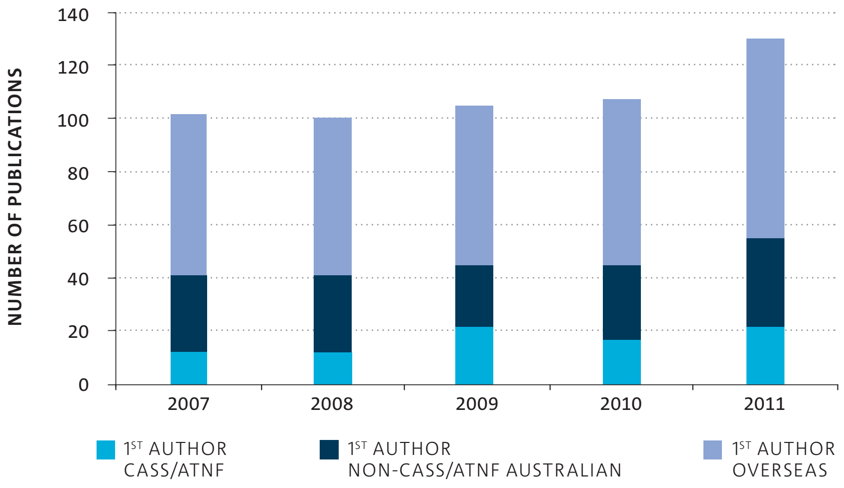


FIGURE 9:
Publications from data obtained with all Australia Telescope facilities (Compact Array, Mopra, Parkes, Tidbinbilla and VLBI), published in refereed journals.

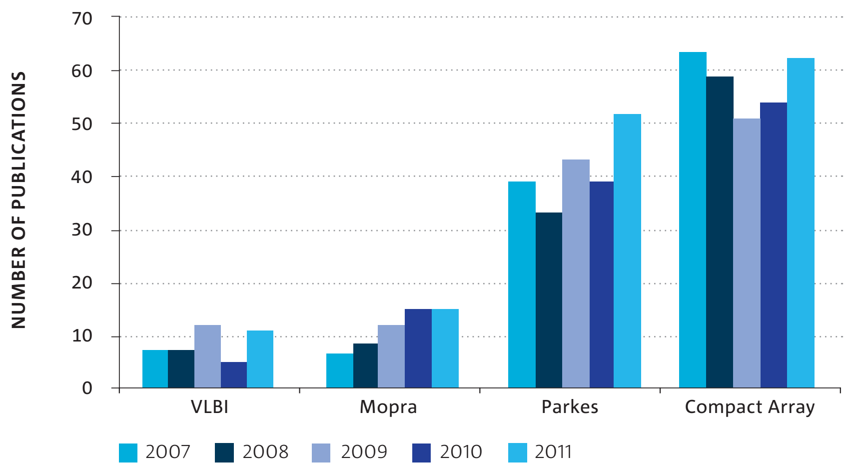


FIGURE 10:
Publications from data obtained with the Compact Array, Parkes, Mopra and VLBI in 2007 – 2011.

5 PUBLICATIONS AND CITATIONS

Figure 9 shows the number of publications in refereed journals that include data taken with all ATNF facilities. The publication counts do not include IAU telegrams, abstracts, reports, historical papers, articles for popular magazines, or other similar papers by CASS authors. In 2011, 130 papers with ATNF data were published in refereed journals. This is the highest number ever and highlights the continuing strength of the facilities provided by CASS. CASS staff were included on 60% of papers published in refereed journals during the year. As shown in Figure 9 the number of refereed publications increased for all three groups with first authors at CASS, other Australian institutions and overseas, showing strength across the user community.

Refereed publications by CASS staff have almost doubled in the period 2007–2011, from a total of 84 in 2007 to 163 in 2011, while the number of publishing research staff within CASS has only undergone a modest increase. This increase in research productivity has not come at the expense of a reduction in impact, as the median number of citations per paper remains about three times higher than that of all refereed astrophysics publications tabulated by the Astrophysics Data System.

The refereed papers are listed in Appendix G, which also lists 112 other papers (conference papers with ATNF data and other refereed papers by CASS staff).

Figure 10 shows publication numbers for papers that include Compact Array, Parkes, Mopra and VLBI data respectively. A small number of papers with data from more than one facility are counted more than once. For the Compact Array, Parkes and VLBI the number of papers in 2011 was higher than in 2010. For Mopra the number of publications (15) remained the same.

The ATNF is both cost effective and scientifically productive. Overall the ATNF is ranked second in the world behind the NRAO in terms of total number of refereed publications while the Compact Array and Parkes rank second and third respectively in the world in terms of total number of citations to refereed papers (Trimble and Cega 2008, *Astron. Nachr.* 329, 632–647). In terms of citations per paper, Parkes is the second most highly cited radio telescope in the world in its class after Ryle (which has a higher citation/paper ratio but a significantly smaller total number of papers than Parkes).

Astronomy leads Australian science as a discipline of international standing and has a particularly high level of international collaboration. For our current facilities, the ATNF achieves the best science outcomes, in terms of publication and citation counts, when science teams include both Australian and overseas astronomers.

6 PUBLIC RELATIONS

Figure 11 shows the count of public relations activities for the years 2007–2011. During 2011 CASS issued eight radio astronomy related media releases (see Appendix H for a full list), featured in at least 769 print and online articles (including at least 163 online articles in languages other than English), and 158 television and radio programs. CASS staff delivered at least 169 public lectures during the year to the general public, education, industry and amateur astronomy audiences.

Overall, there was a marked increase in public relations activities during 2011:

- The record amount of media coverage received by CASS in 2010 was surpassed in 2011. This large volume of media coverage was driven by strong ongoing interest in the construction of the Australian Square Kilometre Array Pathfinder, Australia and New Zealand's bid for the Square Kilometre Array (SKA), the 50th anniversary of the Parkes radio telescope, and a number of well-targeted media releases related to astronomy research conducted by CASS staff and other researchers using the ATNF.
- The large number of public talks delivered by CASS staff, which included presentations given as part of the 'Discover SKA' initiative led by the Australia – New Zealand SKA Coordination Committee, almost reached the record number delivered by staff during the International Year of Astronomy in 2009.

In 2011 there were approximately 906,000 'visits' (37.2 million 'hits') to the central ATNF website (www.atnf.csiro.au). During the year there were also approximately 536,000 visits (15.1 million hits) to the outreach and education website. CASS also contributed to the central CSIRO website at www.csiro.au.

Figure 12 shows the number of public visitors to Parkes Observatory and the Australia Telescope Compact Array.

Visitor numbers at the Parkes Observatory Visitors Centre have stabilised at around 100,000 visitors each year. In 2011, 96,609 people visited the centre. Promotional activities surrounding the telescope's 50th anniversary helped to generate additional media attention and boosted attendance in the second half of the year. Improving visitor satisfaction has been the focus of development activity for the centre which has included upgrading the 3D theatre to high definition and increasing the screen size, and establishing the 'Bowen Room', a special exhibition and conference facility housing a Parkes radio telescope 50th anniversary photographic exhibition.

Approximately 13,951 people visited the Australia Telescope Compact Array Visitors Centre in 2011. Tour groups continue to be popular with 27 groups bringing a total of 583 visitors to the centre during the year.

The declining domestic tourism industry in NSW is a challenge faced by both centres.

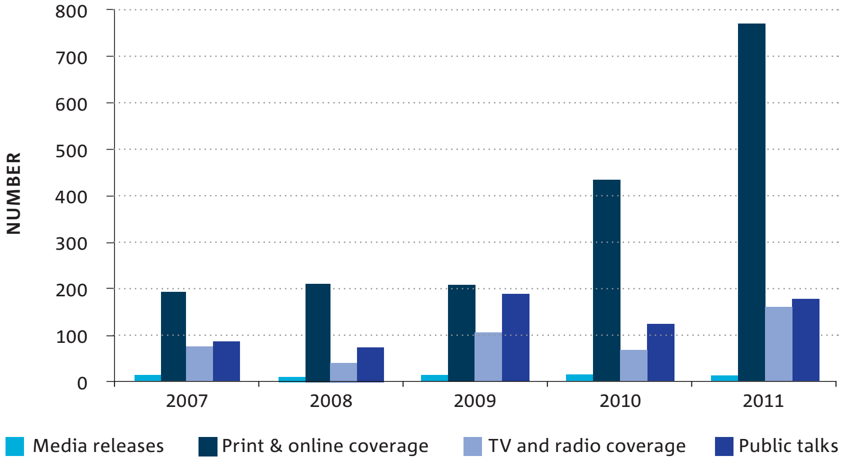


FIGURE 11:
ATNF public relations activities.

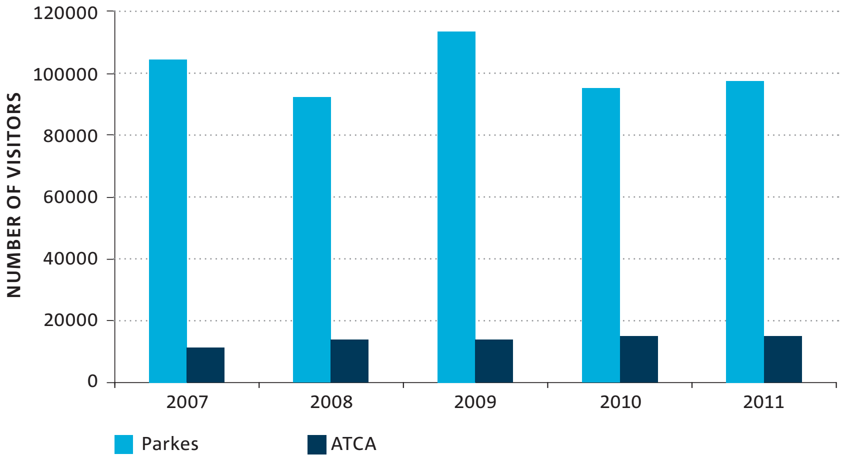


FIGURE 12:
Visitors Centre statistics.

7 USER FEEDBACK

Observers at the Parkes, Compact Array and Mopra telescopes are asked to complete a user feedback questionnaire with responses given on a scale of 0 (low) to 10 (high).

Figures 13 and 14 show the results of user feedback questionnaires (from 2009 to 2011) for Parkes and the Compact Array, respectively. Table 2 indicates the average user responses for 2009 to 2011.

Feedback from observers at the Parkes telescope was comparable in most categories to 2010. The biggest change is a significant improvement in feedback relating to online computer hardware, which can be attributed, at least in part, to the deployment of the radio-frequency switch matrix to quickly and reliably change the signal path between different observations. There were, as in 2010, insufficient responses to provide a statistically meaningful score on the library, which is used less frequently by visitors now that most journals are available online.

Figure 14 shows that in 2011 the feedback from observers using the Compact Array was generally consistent with that given in 2010. The biggest changes were a decrease in the freedom from radio-frequency interference, which is a result of a number of instances of strong broadband interference in the 16-cm band rendering observing impossible. The scores for 'web information' and 'online observing system' also fell from the previous year, which in these cases is due to low grades submitted by a small number of observers who encountered problems (and whose feedback was promptly acted upon). As with Parkes in 2010, there were insufficient responses on the 'library and journal collection' and 'offline imaging facilities' to be included.

The fact that a small number of negative responses can appreciably affect the overall feedback score for the year reflects the fact that fewer observers have been completing the feedback forms in recent years. This is highlighted by the fact that too few observers completed the Mopra feedback forms in 2011 to provide a valid grade in any of the categories, despite all observers being explicitly asked to complete the feedback form. It is likely that the increased amount of remote observing is a contributing factor, as many of the categories on the form are less relevant to remote observers than those observers on site. It is also clear than there are sociological factors: observers are more likely to complete the forms if they have found some aspect of their visit not to their satisfaction. Additionally, first-time visitors are also more likely to complete the forms and use the opportunity to express their gratitude for the assistance they received. It appears frequent visitors to the observatories are much less likely to complete feedback forms, unless something out of the ordinary occurred during their stay or they were contacted soon after their visit with a personalised request to complete the forms.

As a result of these experiences we are looking to revise the categories in the feedback forms, and also be more proactive in encouraging feedback from all observers.

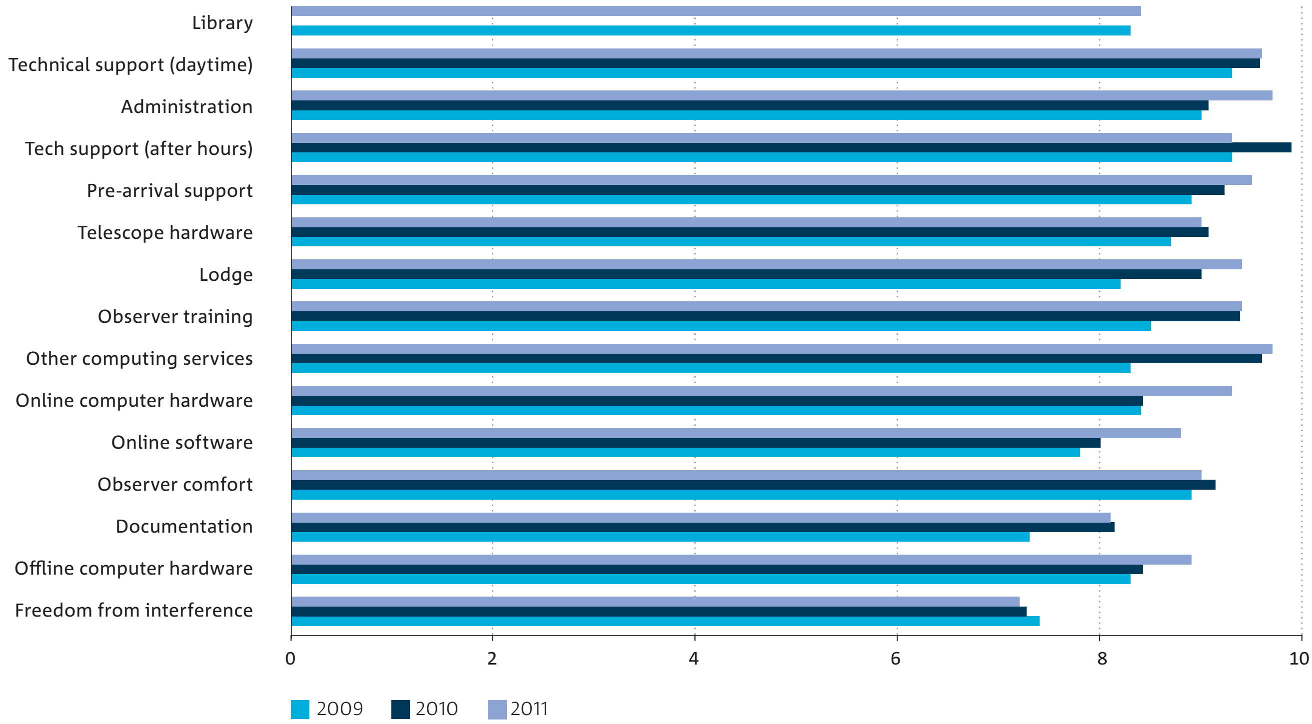


FIGURE 13:
Parkes user feedback on a scale from 1 (poor) to 10 (excellent).

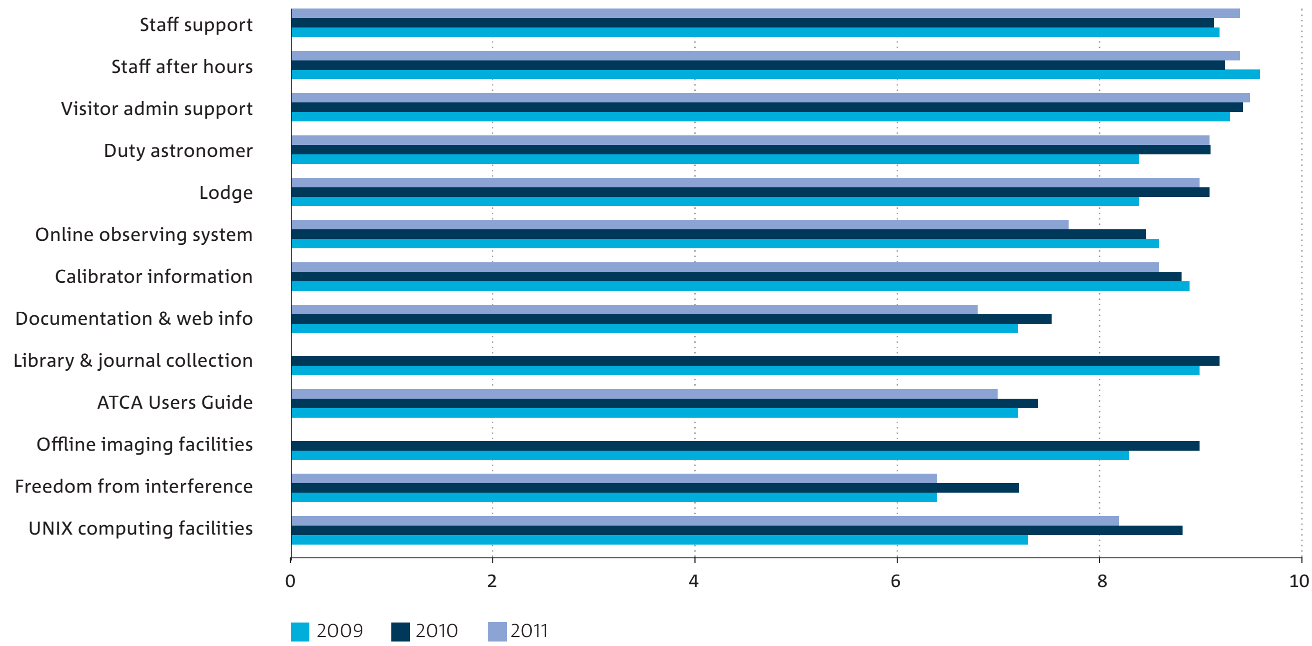
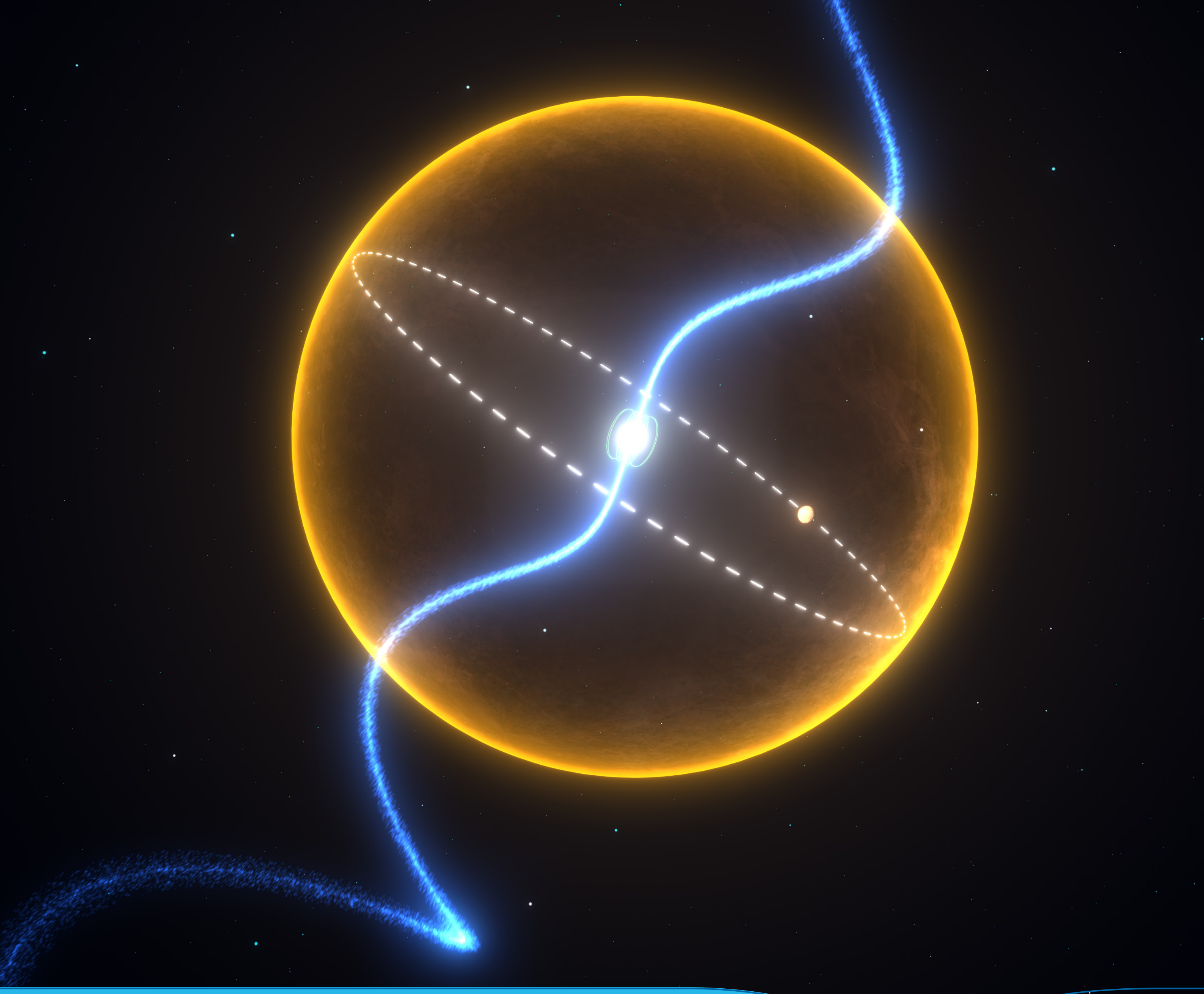


FIGURE 14:
Compact Array user feedback on a scale from 1 (poor) to 10 (excellent).

TABLE 2:
Average telescope user feedback questionnaire satisfaction score on a scale from 1 (poor) to 10 (excellent).

TELESCOPE	2009	2010	2011
Parkes	8.5	8.9	9.0
ATCA (cm)	8.3	8.7	8.3
Mopra	8.9	8.8	N/A



3. Astrophysics

The discovery of a millisecond pulsar with a planetary-mass companion, made using the CSIRO Parkes radio telescope, was published in *Science* in September 2011. Credit: Swinburne Astronomy Productions.

Astrophysics

OVERVIEW

The CASS Astrophysics Group is a vibrant research group with a wide range of expertise and technical knowledge in radio astronomy and associated techniques. The group consists of postgraduate students, postdoctoral staff and ARC Fellows, permanent staff and retirees encompassing a broad range of interests and delivering maximum scientific impact by targeting the highest priority science questions. This breadth of science is important for ATNF support, given the diversity of the non-CSIRO user community and the range of projects supported on the facilities. The recent Science Review of CASS, conducted by an independent panel led by Professor Anne Green (The University of Sydney), noted that staff are global leaders in astrophysical research and have publication and citation rates above benchmark expectations. For more information on CASS staff publications, see page 18 of the 'Performance Indicators' chapter.

During 2011, two new staff appointments were made. Jill Rathborne joined the group in May, adding significant expertise in star formation as one of the leaders of the MALT90 project. Ilana Feain became sole ASKAP Project Scientist from July. We were fortunate to obtain Nick Seymour as an ARC Future Fellow in May. Nick brings significant infrared expertise to the group in the starburst and AGN area. A plethora of postdoctoral staff arrived in 2011. These include the ARC Super Science Fellows Tom Franzen and Ivy Wong, a VLBI postdoctoral researcher Yiannis Gonidakis, CSIRO Office of the Chief Executive Postdoctoral Fellows Julie Grant, Alex Hill, and Sebastian Haan, and the Bolton Fellow Keith Bannister. It is fantastic to see this diverse group of people passionate about their science. James Urquhart, Dominic Schnitzeler and Sarah Burke-Spolaor departed for postdoctoral positions in Europe and the USA.

A number of challenges lie ahead in 2012 and beyond. The Astrophysics Group will play a large part in the scientific commissioning of the Australian Square Kilometre Array Pathfinder (ASKAP) as 2012 sees the first phased array feeds rolled out on the antennas at the Murchison Radio-astronomy Observatory. This marks an exciting phase for the project and an ideal learning platform for our postdoctoral staff. The upgrades to the correlator capability at the Australia Telescope Compact Array will strongly enhance the scientific possibilities with that instrument, and the upcoming millimetre season at Mopra will be crucial for the large projects underway there. The new operational plan at Parkes and the phasing in of remote observing will require a new set of observational strategies (for more information on operational plans, see page 36 of the 'Operations' chapter).

GRADUATE STUDENT PROGRAM

Astrophysics staff continue to co-supervise PhD students enrolled at Australian and overseas universities. The program helps strengthen training in radio astronomy science techniques, and furthers collaborations between CSIRO and universities. In December, there were 29 PhD students and one undergraduate Honours student affiliated with CASS (see Appendix E). In June, the students organised and held a full-day student symposium where they presented their work to fellow students and staff.

DISTINGUISHED VISITORS PROGRAM

CASS has a Distinguished Visitors Program that provides some financial and other support to facilitate visits from leading researchers for extended periods (from several weeks to a year). During 2011 the Astrophysics Group hosted month-long visits from 11 Distinguished Visitors from around the world.

CONFERENCE AND WORKSHOPS

In 2011 Astrophysics staff and collaborators organised and hosted a large number of conferences and workshops. An Australian ALMA community workshop was held in May to bring the community up to speed with tools and techniques in advance of the early science call. The first 'Women in Astronomy' meeting was also held in May with the general aim of raising the awareness of issues that impact on decisions to continue in a research-focused career. The 'Bolton Symposium', held jointly with the Australian Astronomical Observatory over three days in December, showcased the research of early career researchers from around the country. The regional IAU meeting, APRIM2011, held in Thailand in July was well attended by Astrophysics staff with a number of excellent talks over a range of topics.

One of the year's major events was a symposium held at the Parkes Observatory Visitors Centre during the week of 31 October to celebrate the 50th anniversary of the opening of the Parkes radio telescope. A fascinating series of talks were given describing the people, the methods and the stories behind the construction of 'The Dish' and its early years of operation. Nostalgia and telling tall tales were the theme of the first couple of days which then moved into the highlights of the great science Parkes has enabled over the past 50 years, before the students and postdoctoral staff outlined the fantastic new ideas they had planned for this Australian icon. All in all, an excellent week was had by all participants.

SCIENCE HIGHLIGHTS

The reports on the following pages describe a few of the many projects carried out by CASS staff and ATNF users with the Compact Array, Mopra radio telescope and Parkes radio telescope during 2011.

Unveiling the high-frequency radio sky with the Australia Telescope 20 GHz (AT20G) Survey

Elizabeth Mahony (University of Sydney, CASS) on behalf of the AT20G Survey Team*

Until recently, the radio sky above frequencies of approximately 5 GHz was relatively unexplored. This has been addressed with the completion of the Australia Telescope 20 GHz (AT20G) Survey, a blind survey of the southern sky at 20 GHz. The AT20G Survey provides the first large sample of high-frequency radio sources, offering new insights into the nature of the high-frequency radio source population.

Selecting sources at high radio frequencies preferentially selects flatter spectrum radio sources whose emission comes from the central core of active galactic nuclei (AGN), thus providing insight into the most recent activity. As such, the AT20G Survey provides a unique dataset, allowing us to study the physics of the central engine and the role it plays in the evolution of galaxies.

The survey was carried out using the Australia Telescope Compact Array (ATCA) from 2004 to 2008. The conventional approach of completing a blind survey with standard synthesis observing procedures is unfeasible at high frequencies due to the small field-of-view and, therefore, the large amount of observing time required. To overcome this, an innovative setup was developed using a custom made, analogue wideband correlator originally developed for the Taiwanese CMB instrument AMiBA (Array for Microwave Background Anisotropy; Lo et al. 2001). The large 8 GHz bandwidth of the correlator led to increased sensitivity, thereby enabling the sky to be scanned rapidly in a basket-weaving fashion. A more detailed description of this scanning survey is presented in Hancock et al. 2011.

To obtain accurate positions and flux density measurements, sources detected in this scanning mode were then followed-up in pointed observations using the conventional ATCA setup (with the 2x128 MHz bandwidth available at the time). In this follow-up phase only targets outside the Galactic plane (|b|>1.5°) were re-observed due to the large number and complexity of sources close to the plane. In addition, within one month of the follow-up 20 GHz observations, confirmed sources were re-observed at 4.8 and 8.6 GHz providing reliable, near-simultaneous spectral index information.

The final AT20G catalogue consists of 5890 sources above a flux density limit of 40 mJy (this flux density limit was determined by the initial blind scanning survey). Of these, 3766 sources also have 4.8 and 8.6 GHz information[1]. The source distribution of the AT20G catalogue is shown in Figure 1 divided into separate flux density bins. The AT20G Survey comprises almost solely radio-loud AGN, but also includes a small number of planetary nebulae and HII regions.

Near-simultaneous measurements at 4.8, 8.6 and 20 GHz allowed us to also study the spectral index properties of high-frequency selected radio sources without being strongly affected by variability. In addition, by calculating the ratio of flux densities measured on the short ATCA baselines compared to the 6 km baselines, we were able to classify AT20G sources as being either compact or extended on scales of ~0.15 arcsec. Flux density ratios close to 1 indicate that the source is unresolved on all baselines, and therefore compact. Conversely, flux density ratios much less than 1 signify that there is significantly more flux on the short baselines, indicative of an extended object. A value of 0.86 was determined to be the dividing line distinguishing compact from extended sources (Chhetri et al. 2012). Plotting this ratio against the spectral index (Figure 2)

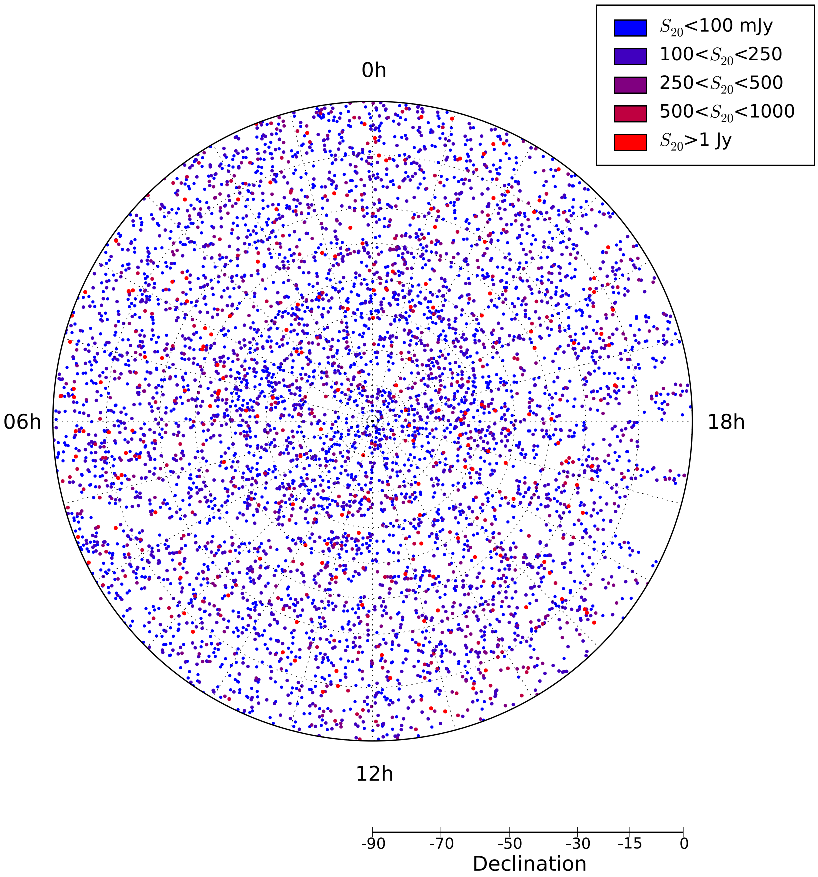


FIGURE 1:
The AT20G source distribution. The empty strip across the bottom of the plot is the Galactic plane (|b| < 1.5°) which was excluded in the follow-up survey. The empty patches on the right are areas that were affected by poor weather in the follow-up observations.

[1] Due to the elongated beam shape towards the equator, only sources south of -15° have multifrequency observations.

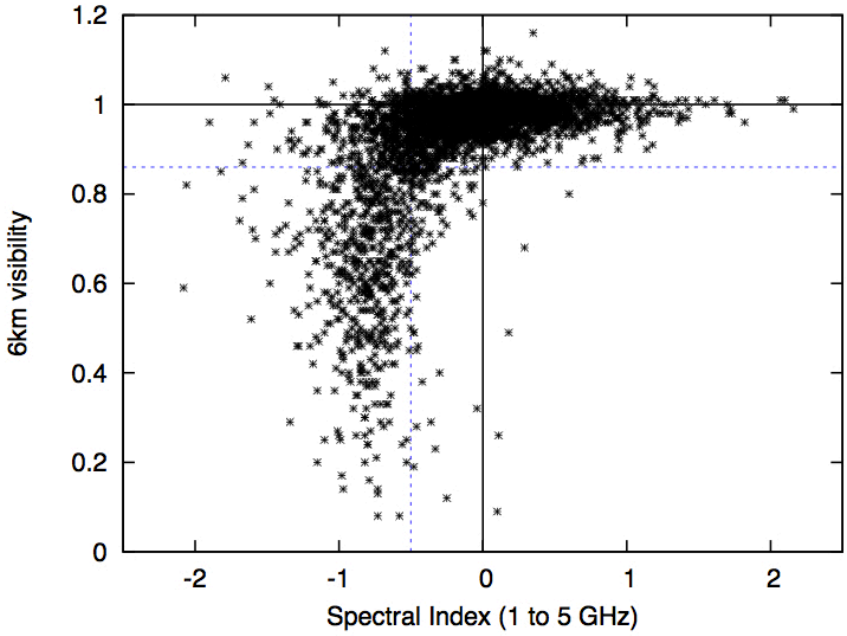


FIGURE 2:
Spectral index against flux ratio of long/short baselines (here termed the 6 km visibility). Objects above the horizontal blue dashed line are classified as compact and sources to the right of the vertical blue dashed line have a flat spectrum (α>-0.5 where $S_\nu \propto \nu^\alpha$). Figure from Chhetri et al. 2012.

shows that the AT20G Survey is dominated by compact, flat-spectrum sources.

A comprehensive overview of the observations and resulting catalogue is presented in Murphy et al. 2010a, with a detailed analysis of the 20 GHz source population given in Massardi et al. 2011. Although only recently completed, the AT20G Survey has already led to a number of publications. These include a study of ultra-compact HII regions selected from the AT20G Survey (Murphy et al. 2010b), a sample of gigahertz peaked spectrum (GPS) and compact steep spectrum (CSS) sources (Hancock et al. 2010), the gamma-ray properties of high-frequency radio sources using the Fermi Gamma-ray Space Telescope (Mahony et al. 2010), investigating the optical properties of AT20G sources (Mahony et al. 2011) and using the AT20G Survey to investigate the high-redshift cutoff of compact AGN (Chhetri et al. 2012).

The AT20G Survey provides an unprecedented view of the high-frequency radio source population and, as such, will remain a legacy survey for many years to come.

*Members of the AT20G Survey Team

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New insights into the Faraday rotation measure structure of active galactic nuclei

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Results from the Australia Telescope Compact Array (ATCA) using the newly upgraded 1.1–3.1 GHz receivers have shown that the Faraday rotation measure of unresolved active galactic nuclei (AGN) may be a lot more complicated than we previously thought.

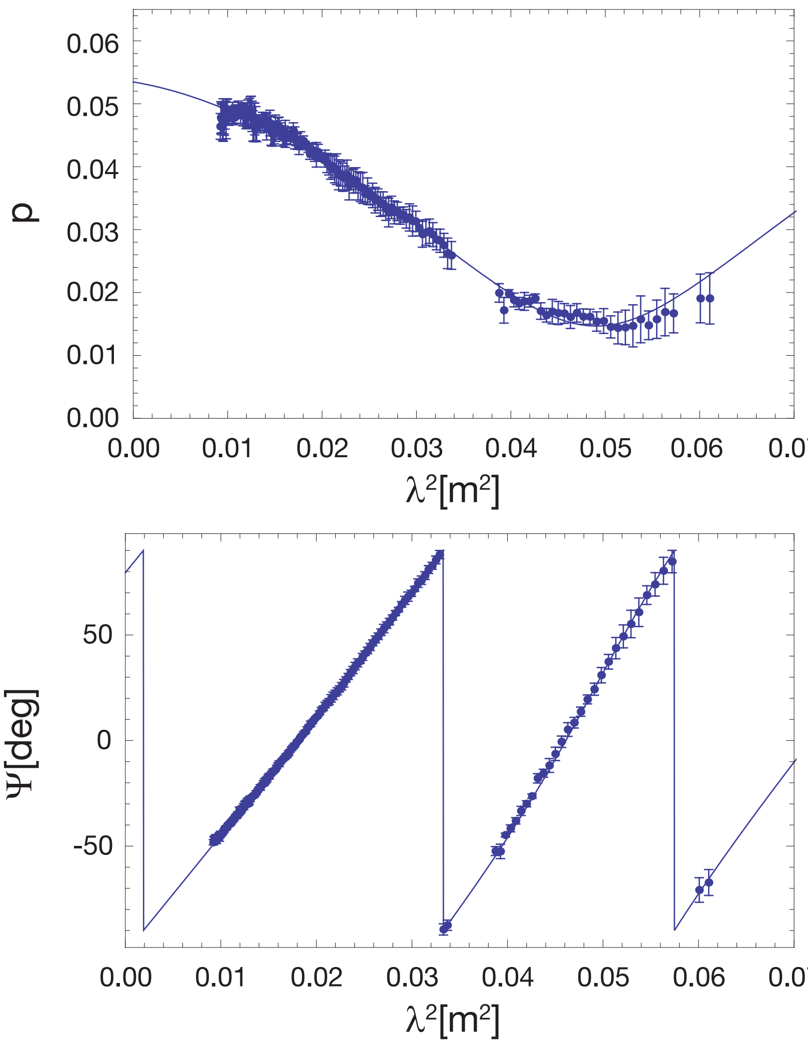
Radio-loud AGN eject powerful jets of relativistic plasma from their nucleus, with a supermassive black hole at the centre of the galaxy considered as the engine providing the power. They have been detected across the entire electromagnetic spectrum from radio to gamma-rays and are the most powerful steady emitters of radiation in the Universe. Their jets emit polarised non-thermal synchrotron radiation which is readily detected in the radio spectrum and provides an important avenue to study their emission structure and magnetic field properties.

Of further importance is that the polarised emission can also be used as a probe of magnetic fields along the entire line of sight between us and the source through an effect known as Faraday rotation. The Faraday effect causes rotation of the plane of polarisation of an electromagnetic wave as it propagates through a region with free electrons and a magnetic field. In the simplest case, the effect is manifest as a linear dependence of the observed polarisation angle with wavelength squared. However, in some cases complicated distributions of polarisation intensity and polarisation angle with wavelength squared can be observed. One way in which this occurs is if there are multiple regions of polarised emission with different Faraday rotation measures on scales smaller than the resolution provided by our telescope beam.

Many studies have used AGN as background sources to study the strength and structure of magnetic fields in our Galaxy, other galaxies and in galaxy clusters. Future studies using new revolutionary instruments such as the Australian Square Kilometre Array Pathfinder (ASKAP) and the Square Kilometre Array (SKA) will rely on these background sources to probe the strength, structure and evolution of cosmic magnetism in unprecedented detail. As part of the planned Polarisation Sky Survey of the Universe's Magnetism (POSSUM) survey on ASKAP we have been developing efficient algorithms to accurately extract the polarisation and rotation measure (RM) properties of individual sources. POSSUM will measure the RMs of approximately three million extragalactic radio sources across the entire southern sky requiring automated techniques that need extensive testing on real datasets. The Compact Array Broadband Backend (CABB) using upgraded receivers covering 1.1–3.1 GHz is an ideal instrument for this purpose, whilst also providing new and unique insights into the RM and polarisation structure of extragalactic sources due to its wide bandwidth and high spectral resolution.

Figures 1 and 2 display data from two AGN (PKS B1610-771 and PKS B1039-47, respectively) that are spatially unresolved with the ATCA but whose polarisation and RM structure has been spectrally resolved for the first time. Through modelling of both the polarisation angle and degree of polarisation we find that the PKS B1610-771 data are best described by two regions of polarised emission with different RMs

FIGURE 1:
Polarisation data for PKS B1610-771, with the corresponding best-fit two RM-component model (RM_1 = +107.1 +/- 0.2 rad/m^2 and RM_2 = +78.7 +/- 0.4 rad/m^2). The top panel shows the degree of polarisation versus wavelength squared while the bottom panel shows the polarisation angle data versus wavelength squared, where in both cases the data are over-plotted with a solid line corresponding to the best-fit model.



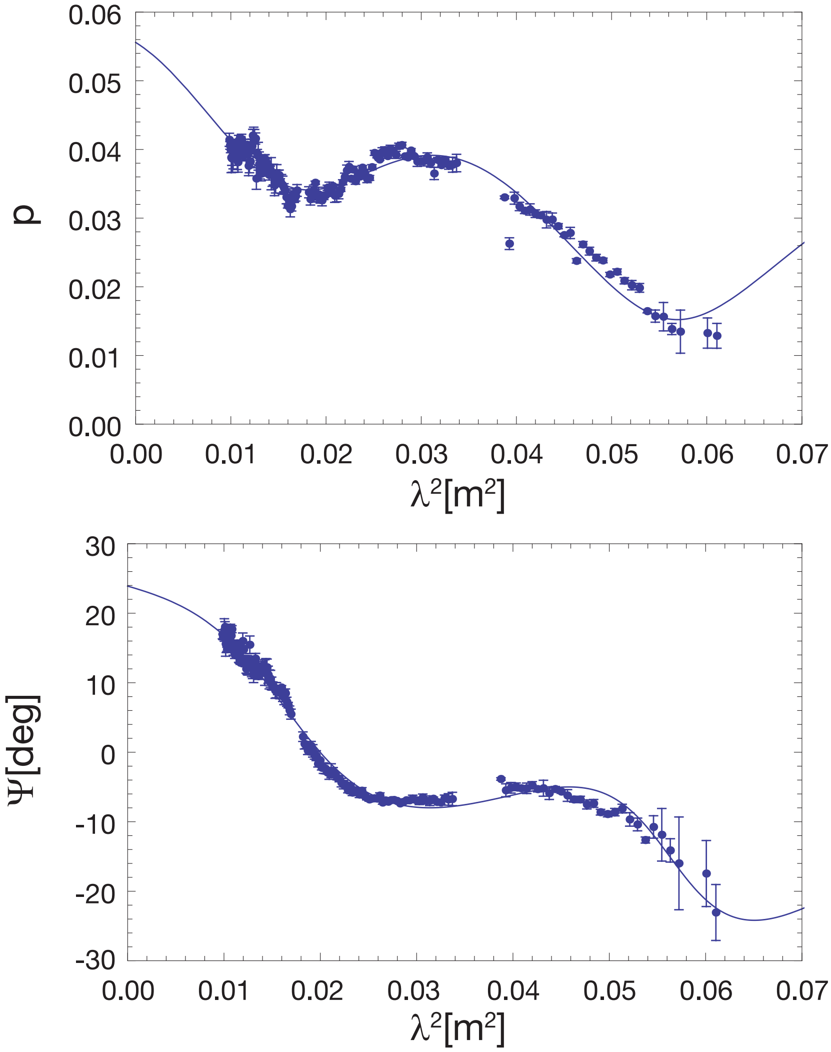


FIGURE 2:
Polarisation data for PKS B1039-47, with the corresponding best-fit three RM-component model (RM_1 = -13 +/- 1 rad/m², RM_2 = -30 +/- 2 rad/m² and RM_3 = +68 +/- 2 rad/m²). Layout as described in Figure 1.

(that is, two RM components) while for PKS B1039-47 we find that the data are best described by a three RM-component model. The most likely origin for the additional RM components in both these AGN is from the compact inner jet regions on parsec scales. This leads us to suggest that RM time-variability in unresolved AGN might be due to the evolving polarised jet structure on parsec scales which illuminates different parts of an inhomogeneous magneto-ionic medium in the immediate vicinity of the jet.

Follow-up observations of these particular sources using the high spatial resolution of the Australian Long Baseline Array will enable us to directly test our predictions. If the results from both these types of observations can be linked then we can open up a new area of study using multi-epoch polarisation observations with wide-bandwidth facilities like the ATCA to map out the parsec-scale evolution of polarised components as well as the Faraday rotating environment in AGN jets. In the near future, combining data collected using ASKAP from 0.7 to 1.8 GHz with data from the ATCA at higher frequencies will provide an exquisite probe of the polarisation properties of a much larger sample of AGN.

A paper describing this work is in press (O'Sullivan et al. 2012).

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Supershells and molecular cloud formation: the influence of large-scale stellar feedback on the molecular interstellar medium

Joanne R. Dawson (University of Tasmania)

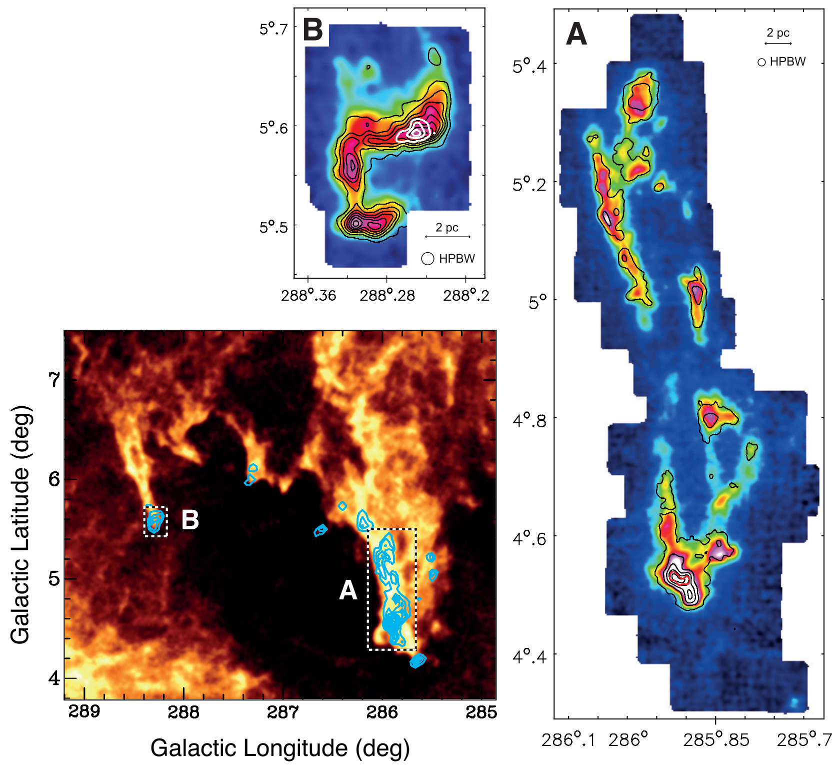
The formation of molecular clouds from the atomic interstellar medium (ISM) is a key link in the lifecycle of material in galactic systems, but one that remains poorly understood. The currently popular paradigm emphasises the importance of large-scale shocks and flows in the molecular cloud formation process positing that colliding streams of turbulent gas compress, cool and fragment the diffuse atomic medium to produce clumpy sheets and filaments of cold material that are the seeds of future molecular clouds. As more material is piled into the convergence zone it can become both molecular and self-gravitating, and can quickly progress to the star-forming stage of its evolution (see review by Vázquez-Semadeni 2010).

Within the scope of physical systems covered by this theory are supershells — large loops, shells and cavities, often hundreds of parsecs in diameter, that are formed by the energy input from high-mass star clusters (for example, Heiles 1979; McCray and Kafatos 1987). Stellar winds and supernovae drive a shock front into the surrounding medium, which can persist over large enough size-scales and timescales that the transition from atomic to molecular gas may occur in the material of the swept-up shell. In 2011, observations of two Milky Way supershells with the ATCA, Parkes and NANTEN telescopes provided the first direct observational evidence of increased molecular cloud production due to the influence of supershells. By observing HI and CO in these two colossal structures (each spanning over ~ 100 square degrees on the sky) we were able to confirm an enhanced level of molecularisation over the volumes of both objects (Dawson et al. 2011a) when compared to their immediate surroundings. However, our observations also highlighted another long-recognised fact — that supershells may also be disruptive to molecular clouds on local scales by shredding and dissociating any pre-existing clouds caught in their path.

In order to further investigate the interplay between these positive and negative influences we carried out in-depth follow-up observations of molecular clouds in the wall of the supershell GSH 287+04–17. We used the Mopra telescope to observe the $^{12}CO(J=1–0)$, $^{13}CO(J=1–0)$, and $C^{18}O(J=1–0)$ lines in regions in which the molecular–atomic transition was thought to be progressing in opposite directions, achieving spatial resolutions approximately four times better than previous work (Dawson et al. 2011b). The three lines probe different density regimes within the molecular gas and provide vital information on its mass, distribution and velocity structure, allowing us to look for the signatures of cloud formation or disruption, and enabling a greatly improved discussion of the relationship between the molecular gas and the wider environment in which it resides.

Figure 1 shows the two molecular clouds examined in this case study and their location in the atomic shell wall. To the right, a large mass of molecular gas embedded within the HI shell is revealed as a collection of diffuse ^{12}CO filaments that terminate in a dense star-forming nucleus. This molecular cloud (Cloud A) forms a coherent and co-moving part of the shell wall, is well-shielded from dissociating UV photons, and appears to be associated with a large mass of CO-dark molecular gas (Dawson et al. 2011a) — factors that combine to make it a very promising candidate site for molecule formation in the swept-up gas. The wispy, quiescent filaments weave through the shell wall, closely mimicking structure seen in HI, and are well interpreted as material that is part way along the evolutionary pathway from atomic to star-forming molecular gas. Where they join the star forming nucleus marks a transition zone in which the properties of the ISM switch from being

FIGURE 1:
Section of the wall of supershell GSH287+04–17. The bottom left panel shows Hi data taken with the Parkes and ATCA telescopes (coloured image) overlaid with $^{12}CO(J=1–0)$ data from the NANTEN telescope (blue contours). Dotted boxes mark the regions observed with the Mopra telescope, shown enlarged in Panels A and B. In these images $^{12}CO(J=1–0)$ is shown in colour, $^{13}CO(J=1–0)$ is shown as black contours, and $C^{18}O(J=1–0)$ is shown as red contours in Panel A and white contours in Panel B.



determined by the global characteristics of the swept-up material to being dominated by the local influence of the stellar sources forming within it. We are able to state that this critical stage in the process of triggered star/cloud formation is currently ongoing in the walls of GSH 287+04–17, approximately 10^7 years after its birth. Finally, the star-forming nucleus hosts a young (2.1 ± 0.3 Myr), massive cluster whose largest member is of spectral type B0V (Dutra et al. 2003). The formation of such massive stars is highly unusual at this Galactic altitude (z ~ 200 pc), and the identification of this region as part of an expanding superstructure highlights the importance of supershells in providing star-forming material to the upper regions of the Galactic Disk.

The second molecular cloud (Cloud B in the figure) is a very different object. Located at the tip of a finger-like extension of HI, the configuration of the ISM strongly suggests the sweep-over and subsequent entraining of a pre-existing dense cloud. Our new observations support this interpretation by revealing hitherto unseen morphological signatures of disruption and possible shock interaction. A dense head with a sharp intensity gradient at its leading edge closely delineates the curved front rim of the long HI feature, while a tail of more diffuse material trails behind. The molecular gas forms a classic bow-like shape, a characteristic signature of a shocked cloud. The pace of the disruption at the present epoch, however, is likely to be slow. The interior of the shell, in which the cloud is now entrained, is presumed to be extremely diffuse and will have a comparatively small effect on the dynamical and thermal state of the cloud. Similarly, although a lack of material for shielding implies that the gas cannot survive in molecular form, high peak column densities and an absence of nearby sources of far ultraviolet photons suggests potentially long survival times.

In summary, supershells formed by large-scale stellar feedback can have both a constructive and a destructive effect on the molecular ISM. Although in the shells we have studied the dominant influence appears to be constructive, it is still not clear whether this holds true on global scales or how well observations match with model predictions on small scales. Several upcoming surveys, including GASKAP (Dickey et al. 2010) and SPLASH (the Southern Parkes Large-Area Survey in Hydroxyl), will study the atomic-to-molecular transition across the whole Milky Way Disk, ensuring the ATNF will play a key role in this science over the next decade.

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Quantifying high-mass star formation evolutionary schemes using methanol masers

Shari Breen (CASS) and Simon Ellingsen (University of Tasmania)

High-mass stars (> $8M_{\odot}$) have dramatically influenced the characteristics of our Galaxy, as well as those of other galaxies throughout the Universe. Throughout their short lifetimes they infuse their immediate environments with immense amounts of energy through their powerful outflows, ultraviolet radiation, and finally, as energetic supernovae. Through their eventual demise as supernovae they inject heavy elements into the interstellar medium. The important role that high-mass stars play is undeniable, and yet little is known about the mechanism through which they are able to form. One of the difficulties in understanding the process through which high-mass stars form is the lack of sequential signposts in identifying different evolutionary stages of star formation, especially during the early stages while the young stellar objects are still deeply embedded in their natal molecular clouds.

Masers are the best candidates to provide an evolutionary timeline for high-mass star formation. They are relatively common, intense and because they arise at centimetre wavelengths, are not affected by the high extinction that plagues observations in other wavelength ranges. Methanol masers have some advantages over the other maser species as they show a large number of transitions at easily observable wavelengths, and since these transitions trace varying physical conditions they have the potential to make excellent evolutionary probes. Some methanol masers are very common, like the 6.7 and 12 GHz methanol transitions, while others are rare, such as the 37.7 GHz and 107 GHz methanol masers. Masers are created under a very specific set of physical conditions so those that are common and strong likely trace conditions that arise commonly and persist, while those that are rare likely trace unusual or short-lived phases in the evolution of these regions.

We have used the Parkes radio telescope to search for 12 GHz methanol masers towards 6.7 GHz methanol masers detected in the Parkes Methanol Multibeam Survey (MMB; Green et al. 2009). The MMB Survey made a complete and sensitive search of the Galactic plane in the longitude range 186° (through the Galactic centre) to 60° with a latitude extent of ± 2°, resulting in approximately 1000 detections. We targeted a statistically complete sample of 580 6.7 GHz masers and detected 250 12 GHz counterparts (a detection rate of 43%). More than half of the detected 12.2 GHz masers are new discoveries. These observations have allowed us to overcome the biases introduced in previous targeted 12 GHz surveys and have allowed us to gain a much more complete picture of these sources.

Through statistical analysis of complementary data (such as OH maser emission, dust and centimetre radio continuum emission and mid-infrared emission) we were able to show that 12 GHz emission is associated with the second half of the 6.7 GHz maser lifetime, allowing us to present the first quantitative evolutionary timeline for the common maser species in high-mass star formation regions (see Figure 1). Further investigation (reported in Breen at al. 2011, 2012) showed strong evidence that the properties of the maser emission could offer finer evolutionary details than merely the presence or absence of a 12GHz counterpart. Most notably, we showed that both the intensity and velocity range of detected maser emission increases as the star forming region evolves, albeit at a relatively slower rate in the case of the 12 GHz emission. This effect is shown in Figure 2 where there is an overall increase in both velocity range and flux density of 6.7 GHz methanol masers through the association

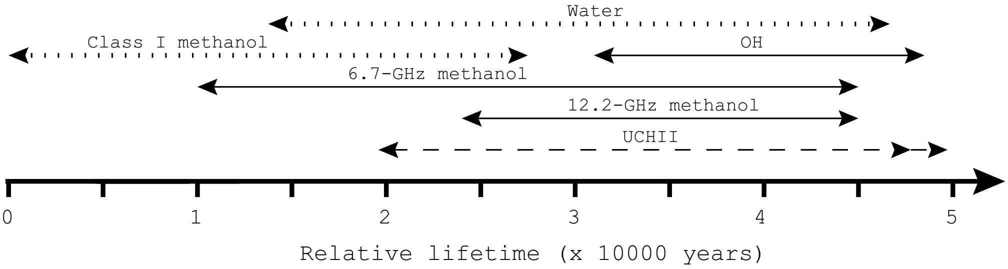

FIGURE 1:
Proposed evolutionary timeline for the common maser species found towards high-mass star formation regions (Breen et al. 2010).

categories (from least to most evolved) of: 6.7 GHz only, to 6.7 GHz with associated 12 GHz emission, to 6.7 and 12 GHz sources that are also associated with OH masers.

Other methanol masers can lend further insight into the evolution of high-mass star formation regions. We have conducted Mopra observations of rare 37.7 GHz methanol masers (Ellingsen et al. 2011) towards a subset of the 6.7 and 12 GHz methanol masers. These observations have shown that the 37.7 GHz masers may signal the end of the methanol maser phase – and hence we have labelled them 'Horsemen of the Apocalypse' for the methanol maser phase. Figure 3 shows that these 37.7 GHz methanol masers are associated only with the most luminous 6.7 and 12 GHz methanol masers, which combined with the rarity of these objects is consistent with them being associated with a short-lived phase towards the end of the 6.7 and 12 GHz methanol maser lifetime.

From our Parkes and Mopra observations we have been able to show that certain transitions of methanol masers make excellent evolutionary tracers of high-mass star formation. We are currently embarking on a range of observations of other maser transitions (for example, water masers and other types of methanol masers with the Australia Telescope Compact Array), which will allow us to produce a more accurate and detailed evolutionary timeline for high-mass star formation. Such a timeline promises to be an important tool for future studies of these regions, hopefully enabling the big overriding question of how these big stars form to be answered.

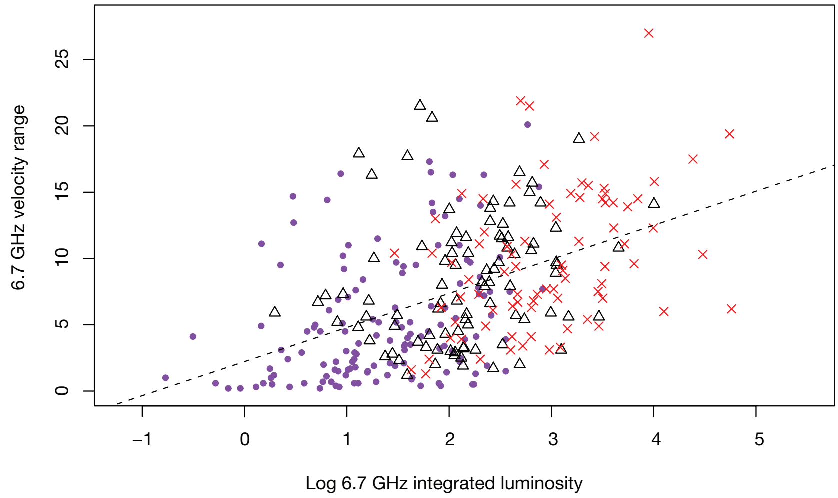

FIGURE 2:
Log of the 6.7 GHz integrated luminosity (Jy km s^{-1} kpc^2) vs. the 6.7 GHz methanol maser velocity range (km s^{-1}) (Breen et al. 2011a). Shown on the plots are three categories of sources: 6.7 GHz sources with no associated 12 GHz methanol or OH masers (136 purple dots); 6.7 GHz methanol masers with detectable 12 GHz methanol masers but no associated OH masers (93 black triangles); and 6.7GHz methanol masers with both 12 methanol and OH maser counterparts (81 red crosses).

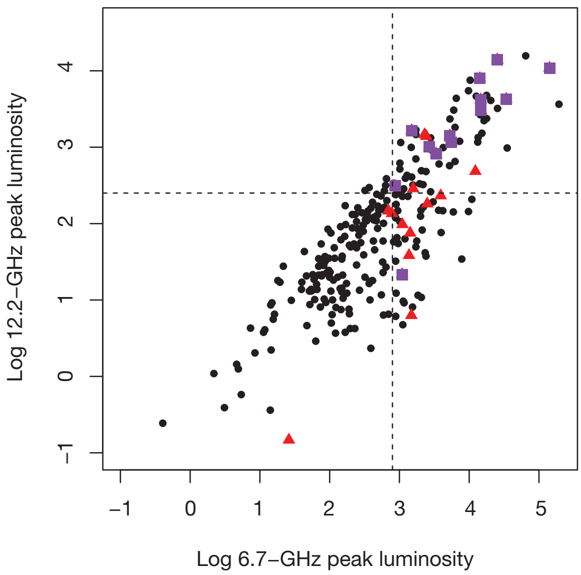

FIGURE 3:
Luminosity of the 12 GHz methanol masers versus luminosity of the 6.7 GHz methanol masers (black dots). Sources that also exhibit emission from 37.7 GHz methanol masers are shown by purple squares (Ellingsen et al. 2011).

Acknowledgements

We acknowledge contributions to this work by members of the MMB Team, in particular: James Caswell, James Green, Maxim Voronkov, Gary Fuller, Lyshia Quinn and Adam Avison.

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The High Time Resolution Universe Surveys

Matthew Bailes (Swinburne University of Technology)

The Parkes Multibeam Receiver, conceived at CSIRO's Australia Telescope National Facility over 10 years ago, has enabled pulsar surveys that have revolutionised our knowledge of the radio pulsar population. The receiver fed a massive array of analogue filterbanks that enabled the process of 'dedispersion' to differentiate true extraterrestrial radio pulses from an increasingly hostile environment containing interfering signals that contaminate the radio spectrum. The main survey at the Parkes 64-m radio telescope discovered some 700 pulsars, and scoured the galaxy using 35 minute deep pointings out to 5 degrees from the plane. This survey also discovered the RRATs, isolated radio pulses from a new class of neutron stars — dubbed the Rotating RAdio Transients (McLaughlin et al. 2006). Shallow flanking surveys uncovered many millisecond pulsars now central to the pulsar timing arrays (for example, Jacoby et al. 2009), and finally, the double pulsar was discovered in a large-scale survey of a large patch of sky using the instrument (Burgay et al. 2003).

Despite all these wonderful successes, the analogue system used in the first generation surveys had some limitations. Distant millisecond pulsars were invisible to it, as their signals suffered enough dispersion in a single frequency channel to turn the pulsed signal into a continuum source. Also, the 1-bit digitiser made narrow bursts of radio emission impossible to identify due to a limited dynamic range. In late 2006 scientists from Swinburne University of Technology, CSIRO Astronomy and Space Science, the University of Manchester and INAF-Osservatorio Astronomico di Cagliari began investigating how a fully-digital pulsar backend could be devised that would enable the multibeam receiver to once again scour the skies for once-invisible millisecond pulsars.

The Berkeley Wireless Research Center at the University of California developed a simple and inexpensive board, known as the iBOB (for 'Internet Break-out Board'), using field programmable gate arrays that could produce two 1024-channel spectra every 3 microseconds with 8-bit resolution. Using a combination of the iBOB and dedicated servers, a fully digital solution was developed for the multibeam receiver that could deliver eight times the frequency resolution of the old analogue system.

A dedicated fibre link between Swinburne and the Parkes telescope meant that the five terabytes of data generated each day could be sent to the Swinburne supercomputer for near real-time analysis. In late 2009, the High Time Resolution Universe Legacy Surveys commenced. Now in their third year of discovery, and strengthened by a large observing team that now includes the Max Planck Institute for Radio Astronomy, the 'HTRU' Surveys are proving remarkably prolific at discovering the fastest of the radio pulsar population, the millisecond pulsars.

Fifty megabytes per second of data is archived and later processed with varying algorithms to search for short millisecond-duration radio flashes as well as periodic signals from pulsars. In 2011 the survey passed the '100 new pulsars' milestone and published data from a remarkable object, PSR J1719-1438, a millisecond pulsar with a planetary-mass companion.

PSR J1719-1438 is a radio pulsar that rotates every 5.7 milliseconds. Soon after its discovery it was found to be a member of a binary system with a very low mass companion. The orbital period of the binary (a little over two hours) and the displacement of the pulsar enabled the collaboration to determine the probable mass of the companion, just 10% higher than that of Jupiter. Remarkably, the entire system would fit inside the Sun and a simple relation enabled the scientists to determine that the companion 'planet' must have a density of at least 23 grams per cc. At these densities hydrogen and helium planets are ruled out, meaning the

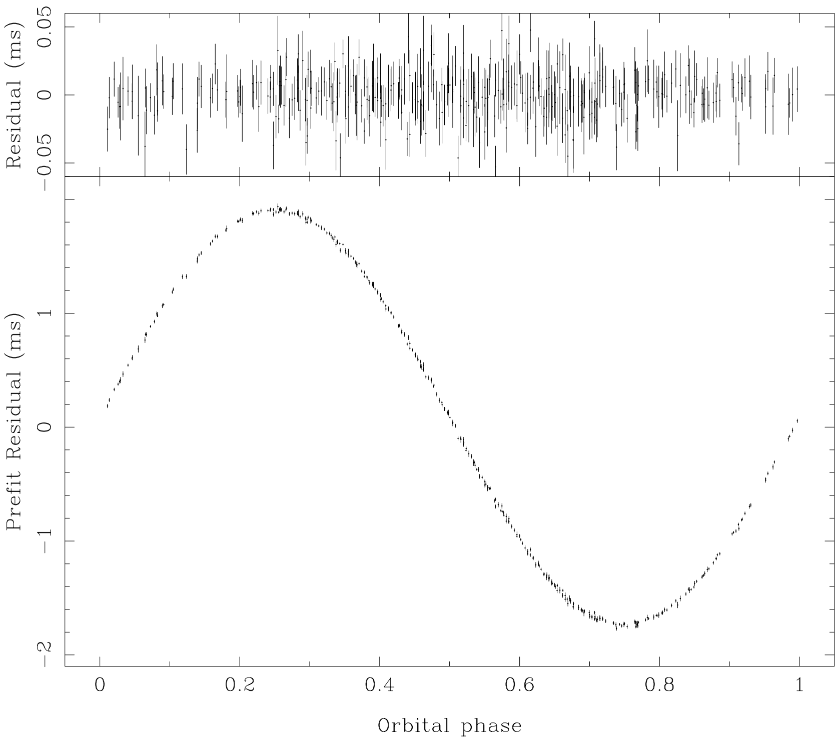

FIGURE 1
Displacement of the pulsar due to the presence of the planetary companion. Upper panel: Post-fit timing residuals after removal of a sinusoid. Lower panel: Displacement of the pulsar due to presence of the orbiting planetary-mass companion.

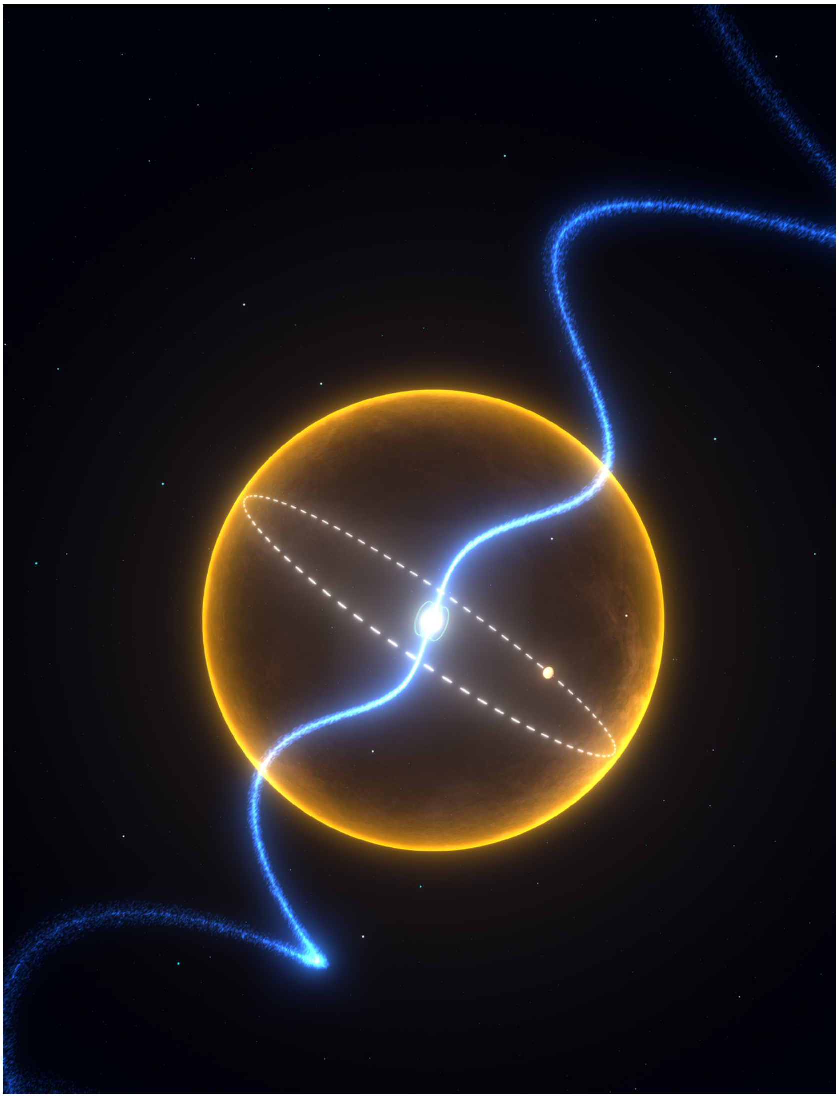

FIGURE 2:
Artist's impression of the pulsar–planet system and how the whole thing would fit inside the Sun.

companion must be comprised of carbon or higher elements. Theoretical mass-radius relations suggest that it is a carbon white dwarf that was once a massive star that has been 'eaten' by the companion pulsar, spinning the latter up to its 170 Hz speed and spiralling out from what was once a very 'ultra-compact' low-mass X-ray binary system.

This evolutionary link to the class of stars known as ultra-compact low-mass X-ray binaries, the novelty of the system, and the very low mass led to the publication of the discovery in *Science* (Bailes et al. 2011). The probable lattice structure of the carbon core of the planet led to a connection with terrestrial diamond — the system was referred to by the popular press as the 'diamond planet', leading to an astonishing amount of media attention.

The HTRU Surveys comprise a medium latitude survey of the sky within 15 degrees of the plane using 9 minute pointings, an ultra-deep survey of the galactic plane with 70 minute pointings, and a shallow snapshot of the remaining sky with just 4.5 minute pointings.

The medium latitude survey has just had all of its data processed, scrutinised and candidate pulsars re-observed. This has been a massive computational effort and consumed many hundreds of thousands of central processing unit hours at Manchester, Cagliari and Swinburne. Over nine million candidate pulsars were produced, and 25 millisecond pulsars were ultimately discovered in follow-up observations. Burke-Spolaor et al. (2011) also detected a large number of RRATs and highly nulled pulsars.

Bates et al. (2011) reported the discovery of the first five millisecond pulsars (MSPs) including an unusually active system where the pulsar is eclipsed for much of its orbit, sometimes for weeks on end. Keith et al. (2012) have reported the discovery of six further MSPs, all of which are members of binary systems. Two are unusual in that they have relatively long spin periods of approximately 25 milliseconds and yet have short orbital periods and extremely small inferred companion masses. Another two were associated with Fermi sources and appear to have gamma-ray pulsations that we presented for the first time. We speculated that emission heights in MSPs are a substantial fraction of the light cylinder, leading to a large fraction of MSPs showing emission from both poles. One pulsar, PSR J1017-7156, is aiding in the search for gravitational waves as part of the Parkes Pulsar Timing Array.

Less than one sixth of the total survey data is currently processed, and the collaboration has ambitious plans to search for 'ultra-relativistic' pulsars using acceleration searching. The surveys are a great example of how new technologies can enable even the 50-year old Parkes telescope to continue to shine.

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4. Operations

The Compact Array upgrade program continued to make substantial improvements to the telescope's instrument functionality during 2011. Credit: David Smyth, CSIRO.

Operations

This year has seen the adoption of significant changes to the operating model for the ATNF, in preparation for a transfer of some operational funding from existing telescopes to the Australian Square Kilometre Array Pathfinder (ASKAP) beginning in mid-2012.

At the observatories, some significant upgrades were completed. At the Compact Array, the new 16-cm receiver system was installed, and further CABB modes were released to observers. With these systems the Compact Array has received a major 'mid-life' boost to sensitivity and flexibility. At Parkes, remote observing infrastructure was commissioned and work to improve the power reliability continued. A project to deliver remote observing for Parkes was launched.

In preparation for ASKAP, the first version of the ATNF Operations Plan for the ASKAP era was produced. The plan describes the model for ATNF Science Operations with ASKAP and explains how the operation and maintenance of ASKAP will be done from the new base in Geraldton, Western Australia. This plan will be revised in the period leading up to full ASKAP operations to include experience gained during the construction period.

New operating model

Under the planned operating arrangements the Compact Array will retain the 'user–operator' model, with on-site observing supported and encouraged. Remote observing will continue to be available to trained users that are able and willing to cope with a lower level of support.

The Parkes radio telescope model will be amended to reduce operating costs. Under the new model, the Parkes telescope will be reconfigured by late 2012 as a facility devoted primarily to remote observing with a limited suite of instruments. Remaining instrumentation will be decommissioned or mothballed to reduce operating costs and system complexity.

Support for Parkes users will in future be limited, with observing teams expected to be largely self-supporting. Although observing at the telescope will still be possible in some situations, on-site support will be more limited. Technical support for reconfigurations or instrumental problems will typically be available only during working hours. CSIRO anticipates that over several years the Parkes operating budget will be reduced by approximately 40%, or $2m per annum.

During the year the astronomy community was advised that CSIRO financial support for Mopra is planned to cease in October 2012. CSIRO begin working with potential partners to develop a sustainable model for supporting Mopra beyond that date.

CONSULTATION AND DECISION-MAKING PROCESS

In developing the model, CSIRO presented several options to the astronomy community. CASS staff briefed and consulted with the user community through a series of forums in Sydney, Melbourne, Canberra, Hobart and Perth during the period 28 October to 23 November. Additional consultation sessions were conducted with staff and written input was solicited from the entire user community.

CASS also sought advice from the Australia Telescope Users Committee (ATUC). An open ATUC meeting on the changes was held at the CASS HQ at Marsfield on 25 October. ATUC was provided with written background information and a draft of the Science Operations plan for the ATNF. ATUC in turn consulted the community in various ways. The ATUC report was provided on 30 November and is available on the ATNF website.

In adopting the final scenario, CSIRO took into account the following factors:

- User feedback preferring the proposed scenario to alternative scenarios presented
- The broader science scope and the larger, more diverse user base of the Compact Array compared with Parkes
- The opportunities for the Compact Array to provide high frequency follow-up observations to surveys conducted with ASKAP
- The viability of a strong science case for Parkes, through high-impact projects, even with the changed model
- The remarkable regeneration of the Compact Array through upgrades to the front ends (20/13-cm receivers, 3/6-cm receivers, high frequency capability) and backend (the flexibility and bandwidth coverage of CABB)
- Community support for retaining the user–operator model and on-site observing for current facilities
- Community support for enabling remote observing with the Parkes telescope, and
- The strategic importance of the Long Baseline Array to Australia and New Zealand's Square Kilometre Array bid, and of the linkages with the Australian and New Zealand university community.

The ATNF Steering Committee endorsed the strategy at its meeting on 13 December.

Science Operations

The Science Operations Group consists of four projects: Computing Infrastructure, Scientific Computing and Archives, the Visitors Services Group, and Telescope Operations and Science Services.

COMPUTING INFRASTRUCTURE

The Computing Infrastructure Team provides general account, security and password related computing activities in support of observers. The team undertook a major reconfiguration of the computing racks at Narrabri early in the year, with over 20 terabytes of storage added and a storage area network implemented. Additionally, many of the Ethernet switches at Narrabri were replaced with new hardware to support the planned installation of Internet protocol (IP) telephony. At Marsfield, new fibre-channel switches were commissioned to handle all connections between the hosts and storage arrays. A major re-organisation of the Marsfield storage array network was also undertaken, allowing the three oldest Apple RAID arrays to be retired from service and newer, larger capacity disks to be installed in some of the remaining older arrays.

These upgrades have been necessitated by the increased data rates from the Compact Array Broadband Backend (CABB) 'zoom' modes and the expansion of the Australia Telescope Online Archive (ATOA) to include survey data products.

In early 2011, the optical fibre connection between the AARNet trunk fibre along the Newell Highway and the Paul Wild Observatory suffered significant attenuation in several places as the reactive soil in the area shifted with changes between wet seasons and prolonged dry periods. AARNet arranged some temporary fixes that have kept the links alive but more work will be required in the coming year to provide a longer-lasting solution to these problems.

SCIENTIFIC COMPUTING AND ARCHIVES

The online 'ATCA Forum', set up in 2010 to enable discussion among users on the best way to reduce datasets, has proven to be a successful means of encouraging and documenting debate on approaches for handling CABB data. Each advance with CABB, such as the expansion of the 64 MHz mode to the full 32 'continuum' channels in addition to (currently) the one zoom mode in each IF band, requires the online CABB scheduler to be extended to enable the new modes to be appropriately scheduled. The scheduler has also been modified so that it no longer requires an ATNF account to access the scheduler: new users (without a CSIRO account) can now use the scheduler and save their files to their local disk while planning observations.

A review of the data reduction packages available for processing Compact Array data in the CABB era was undertaken during the year. Miriad will continue to be the main data reduction package and will be suitable for the majority of Compact Array observations, and is continuing to be enhanced to improve its capabilities for handling CABB data. For projects requiring multi-frequency, multi-scale cleaning, both the ASKAPsoft and CASA packages have some advantages and ATNF staff have been gaining experience in the use of these packages so that advice can be provided for observers needing to make use of these capabilities.

Processed data from the first year of the Millimetre Astronomy Legacy Team 90GHz (MALT90) Survey, a large international project characterising high-mass dense cores with Mopra, were released through ATOA in August. The data release comprised the 499 dense cores mapped during the first MALT-90 observing season (June – September 2010). For each core, processed (l,b,v) cubes and (l,b) moment and error maps for all 16 of the emission lines observed have been made available through ATOA at http://atoa.atnf.csiro.au/MALT90. Mopra data products were also provided for the Mopra Central Molecular Zone Survey. This survey provides data cubes from the rich molecular region in the inner few hundred parsecs of the Galaxy.

For more information on CABB, see also page 39 of the 'Operations' chapter and page 51 of the 'Technology' chapter.

The Australian National Data Service (ANDS)/ATNF Data Management Project was completed early in 2011. This project produced a public archive of several large Parkes pulsar datasets and established the framework for including all Parkes data in the future. The data can be accessed at http://datanet.csiro.au/dap and complements the ATCA and Mopra data already available in ATOA. The success of the project was recognised with the award of the CSIRO Medal for Support Excellence to the team made up of staff from CASS and CSIRO Information Management and Technology. For more details on the award, see page 47 in the 'Human resources' section.

The CASS Online Proposal Applications and Links (OPAL) system was extended to provide additional tools for the Time Assignment Committee. These upgrades have made the handling of proposals and reports much more streamlined and efficient. Almost all time assignment processes are now handled fully electronically.

The CASS search engine, Arch, was developed further to make use of the open source software package SOLR which provides powerful tools for Intranet web environments. Arch was first released in 2010 and has a strong international web presence. In 2011, the software was downloaded approximately 1,000 times.

VISITORS SERVICES GROUP

The Visitors Services Group continued to take care of the steady stream of observers, staff and other visitors to the observatories and the Marsfield site. The Marsfield Lodge was closed for two weeks in the first half of the year while the bathrooms were repaired and refurbished. Group members from all three sites met in Mudgee in May to discuss changes and improvements.

TELESCOPE OPERATIONS AND SCIENCE SERVICES

With the relocation of Mopra Operations Scientist Balt Indermuehle to Sydney at the beginning of 2011, Mopra observers were offered the choice of observing from Marsfield or Narrabri. Observing from either location enabled observers to qualify for remote observing for the next year from further afield. As described in the 'Engineering Operations' section (see page 41), Mopra was equipped with an all-sky web camera at the beginning of the April semester, which observers have found to be a very useful addition. Changes to the Mopra Spectrometer (MOPS) in late 2010 enabled 'fast-mapping' observations to be made, with a correlator cycle time of 256 milliseconds rather than the standard 2 seconds, for a reduced number of MOPS zoom bands (no more than four is recommended). In order to allow a seamless transition between fast-mapping observations and regular observations, the cycle time for all Mopra observations was changed from the previous 2.0 seconds to 2.048 seconds. Mopra users were informed of the changes and observing software was amended to ensure that old observing scripts (assuming a 2.0-second cycle time) were handled gracefully.

Time Assignment Committee

Increasing demand for observing time using ATNF facilities has increased the load on the eight members of the Time Assignment Committee (TAC), with a team of international 'readers' now supporting the TAC members. The readers supply grades and comments on a number of proposals within their area of expertise but do not attend meetings or have full access to all proposals. The TAC readers (listed in Appendix A) are appointed by the ATNF Director for a term of three years.

The TAC convened at Marsfield over three days in early February to consider the 212 proposals for the 2011 April semester, and met again over two days in late July to review and grade the 138 proposals received for the 2011 October semester. With ongoing enhancements to OPAL the Committee now has better access to proposals and TAC comments from previous semesters, and is paying closer attention to ensure resubmitted proposals have addressed the comments made on previous submissions. A resubmission that does not consider any of the feedback provided by the TAC is unlikely to be reviewed favourably.

In the past, proposal teams were notified individually about their proposals on two separate occasions: once following the review of their proposal by the TAC, and again once observing schedules had been released. From April 2011, two general messages are sent to all proposers: the first message (sent soon after the TAC has met) advises all proposers that the TAC grades and comments are available in OPAL, and the second message notifies all proposers that observing schedules have been released and provides links to detailed information available on the ATNF website. Abstracts of all accepted proposals are now also available in the NASA Astrophysics Data System (ADS).

Long Baseline Array

The Long Baseline Array (LBA) uses the technique of Very Long Baseline Interferometry (VLBI) to image radio sources with milli-arcsecond-scale angular resolution. The LBA includes the Parkes, Mopra, and ATCA telescopes, the Hobart and Ceduna antennas of the University of Tasmania, and, on occasions, antennas at the Canberra Deep Space Communication Complex at Tidbinbilla. It also sometimes operates in collaboration with overseas antennas such as Hartebeesthoek (South Africa), TIGO (Chile), and O'Higgins (Antarctica). In February, CSIRO and Auckland University of Technology (AUT) formally agreed to collaborate on VLBI observations. As a result, the AUT 12-m Warkworth radio telescope is now available for VLBI sessions at 20-cm, 13-cm, and 3-cm wavelength bands. A single ASKAP antenna is also sometimes available at 20-cm or 3-cm wavelength bands.

Hobart and Ceduna VLBI operations continued to be supported under a contract between CASS and the University of Tasmania. Correlation of most LBA observations recorded is performed under contract by Curtin University in Western Australia. Most data is transferred

TABLE 1:
ATNF antenna observation time and success rates.

TELESCOPE	PARKES	ATCA	MOPRA	HOBART	CEDUNA	TIDBINBILLA	LBA
Hours scheduled	404	423	447	461	441	155	447
% success	82	98	99	98	95	99	92

electronically to the correlator with the cooperation of the Australian Research Collaboration Service (ARCS).

During 2011 there were four major LBA sessions, in April, July, August, and November, and two shorter sessions in January and February. An extra session was also held in May in response to a triggered NAPA (Non A Priori Assignable) LBA proposal to observe Circinus X-1 in a flaring state. Observations in 2011 were made in all LBA wavelength bands (20-cm, 13-cm, 6-cm, 3-cm and 1-cm), with the 3-cm band again accounting for just over half of the observing time. A total of 25 days observing, which included time for testing and development, was carried out. Successful electronic Very Long Baseline Interferometry (e-VLBI) tests were carried out at 512 Mbps between ATNF telescopes and Warkworth, Hobart and Hartebeethoek in the early part of the year, and fringes were found in recorded VLBI tests between Australia and the Giant Metre-wave Radio Telescope in India during the year.

In 2011 the LBA achieved a 92% success rate, with the success rates of most ATNF telescopes greater than 95%. (The figures do not include the ASKAP or Warkworth antennas, which participated on a best-efforts basis in the early part of the year while their systems were still being developed.) The largest contribution to lost time was from Parkes, due primarily to a problem with the Mk5 recorder during one session, and compounded by the telescope being wind stowed for most of another observation. A summary of ATNF antenna observation time and success rates is given in Table 1.

In July 2011 the RadioAstron space VLBI satellite was launched into orbit, carrying the 1.6 GHz receiver designed by CSIRO and built by British Aerospace Australia and Mitec 20 years ago. CSIRO participation in RadioAstron formally dates to December 1987, when a Memorandum of Understanding was signed with the Space Research Institute of the USSR Academy of Science. Single dish in-orbit tests with the receiver, one of four on the satellite, were successful, and VLBI fringes were found at 1.6 GHz to a network of northern hemisphere telescopes before the end of the year.

e-VLBI developments

In addition to the e-VLBI tests described above, the first e-VLBI demonstration was performed between CSIRO's ASKAP telescope in Western Australian and other radio telescopes across Australia and New Zealand during the International SKA Forum held in July in Banff, Canada. Using the newly commissioned optical fibre links between the Murchison Radio-astronomy Observatory and Perth, a single ASKAP dish was combined with Mopra, Parkes, Hobart and Warkworth to observe a radio source, PKS 0637-752, a quasar that is more than 7.5 billion light years away. Data from the sites were streamed in real time to the Curtin University node of the International Centre for Radio Astronomy Research in Perth, where processing took place using the DiFX software correlator.

CASS is participating in NEXPReS (Novel Explorations Pushing Robust e-VLBI Services), a three-year project funded by the European Community that commenced in July 2010. NEXPReS will build upon the successes of the EXPReS project, which ran from 2006 to 2009, and will continue to develop the next generation of e-VLBI tools and processes.

Engineering Operations

In addition to day-to-day operational maintenance, routine receiver changes and ongoing scheduled maintenance programs for the Compact Array, Mopra and Parkes radio telesopes, a sustained ongoing effort has been maintained on telescope site development projects. The common driver, consistent with ATNF Operations plans, for the development projects is the achievement of operational efficiencies and reliability improvements needed for future telescope operations in the ASKAP era.

While continuing to support significant upgrades to the Compact Array, the main focus for Engineering Operations in 2011 concerned the upgrading and refurbishment of the many systems at Parkes, including extended efforts by Narrabri-based staff undertaking regular project work on the 64-m radio telescope's systems. As detailed in the following pages, the scope of these projects extends from telescope instrumentation (receivers and backends) and antenna drive systems to essential support systems such as maser timing, electrical power and cooling.

COMPACT ARRAY DEVELOPMENTS

In addition to the regular preventive maintenance program, additional maintenance effort was directed towards improving antenna tracking and addressing data fibre integrity concerns arising from soil movement due to reactive soil. The Compact Array upgrade program continued during 2011, with installation and support of new and improved receiver and signal processing instrumentation developed by the Technologies for Radio Astronomy theme at Marsfield. Engineering Operations staff provided close support throughout the year in coordinating the planning and installation of a number of substantive upgrades, including:

- Centimetre (20/13- and 6/3-cm) wave receivers

- Further enhancements to Compact Array Broadband Backend (CABB) system zoom mode capabilities, and
- Water vapour radiometers.

These upgrades represent substantial improvements to the Compact Array instrument functionality. For more information on these developments, see page 50 of the ‘Technology’ chapter.

PARKES RADIO TELESCOPE DEVELOPMENTS

Parkes drive system upgrade

A major milestone for Parkes was the successful conclusion of the Parkes Drive Control Project. In March, the Parkes radio telescope was shut down for the replacement of the old manual control panel with a completely new and remotely operable ‘master control panel’ or MCP. While retaining the ‘retro’ appearance of the old MCP, the new MCP is fully duplicated and documented, consolidating software controllable telemetry and telecommand for all of the functionality needed to stow and unstow the 64-m antenna under remote control (unless deliberately locked out under local manual control).

Tim Ruckley (at left) and Andrew Hunt demonstrating the new Parkes master control panel. Credit: Erik Lensson, CSIRO.

In practice, two complete new MCPs were designed, fabricated and installed at Parkes Observatory as part of the project. Following the completion of the project, Andrew Hunt retired from CSIRO with 42 years’ service but continues to provide support for the drive system SERVO software upgrades through a CSIRO Fellowship.

Consistent with the project plans, the second MCP unit is considered the ‘spare’ unit and provides an offline simulator suitable for drive system software development and testing. Upgrades to the low-level SERVO software and integration with TCS application software were completed by the conclusion of the project in June.

Parkes control and monitoring upgrades

Following the success of the Parkes Backend Switching Matrix commissioned in 2010, the Parkes Equipment Control and Monitor (PECM) Project has delivered a range of new remote control functionality and improved monitoring of the 64-m radio telescope signal path and critical support systems. The scope of this multi-year project included remote power and standby switching, multi-beam receiver sideband switching, focus cabin temperature monitor, correlator level limiting and reliability improvements such as standby power synchronisation, to name a few. As a result, the number of MoniCA system monitoring points at Parkes has expanded by 100%, to approximately 2,000 points. As mentioned in the ‘Technology’ chapter (see page 51), the project is substantially complete and is expected to close in the first quarter of 2012.

For more information on the telescope site development projects, see page 51 of the ‘Technology’ chapter.

Further monitoring and control work at Parkes is expected to continue into 2012 as part of regular Engineering Operations projects, including issues identified within the scope of the Remote Access to the Parkes Telescope Project. This (mainly software) operations project is intended to deliver the access protocols and related software applications needed to safely and reliably operate the 64-m radio telescope from a remote location. Some additional hardware, such as the proposed dedicated 64-m antenna drive system uninterruptible power supply that will provide for autonomous stowing of the dish under adverse weather or other unusual conditions, may be needed.

Parkes electrical infrastructure

Engineering Operations, in liaison with CSIRO Property Services (CPS), remains in the middle of a multi-year electrical infrastructure refurbishment and upgrading program. At Parkes in particular, some of the site electrical infrastructure is up to 50 years old. For example, the main (11 kV) high voltage (HV) power transformer and related electrical infrastructure are demonstrably nearing the end of their service life (by contrast, all of the receiver hardware, conversion systems and signal processors have undergone many generations of changes).

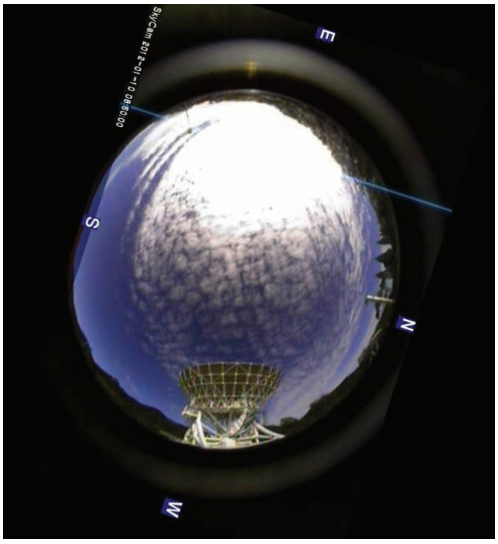
The scope of the Parkes electrical systems’ refurbishment includes the 11 kV HV transformer, HV voltage regulator, HV switchgear, as well as the low voltage (LV) switchboards and related site LV electrical power reticulation. Telemetry senders for transformer core temperature and status monitoring, which will allow for quick identification of internal faults versus upstream (that is, essential energy) HV problems using the CASS MoniCA system, were included as part of HV equipment specifications. Approximately 6,000 kg of new equipment (750 kVA transformer and switchgear) were delivered to Parkes in November with further equipment to be delivered in 2012. CPS selection processes are underway for contracting an approved service provider, ahead of equipment installation in May 2012.

UNINTERRUPTIBLE POWER SUPPLY SYSTEM UPGRADES

The shutdown of the Parkes telescope in March for the MCP installation also provided the opportunity to upsize the telescope's essential bus uninterruptible power supply (UPS) capacity from 200 Ah to 450 Ah. This action, coupled with the essential bus load audit, has increased the UPS uptime from approximately 14 minutes to about one hour. Subsequently, the Thycon UPS systems at Parkes, ATCA and Mopra were all provided with an electronics upgrade in July.

MOPRA SKYCAM

The installation and commissioning of the Mopra 'SkyCam' in June has provided an online real-time view from an all-sky camera (available at http://www.narrabri.atnf.csiro.au/mopra/skycam.html). The camera's dynamic range permits the saturation effects from the Sun during the day to be minimised but remains sensitive enough to see stars at night, allowing observers to infer a qualitative measure of the degree and location of cloud cover at Mopra at any time.



A Mopra SkyCam all-sky image of *Altocumulus floccus* clouds. Credit: Peter Mirtschin, CSIRO.

GUEST INSTRUMENTATION

Work progressed on HIPSR, a new 400 MHz spectrometer and coherent dedisperser using a combination of field-programmable gate arrays, central processing units and graphics processing units. Engineering Operations continued to be active in supporting the collaboration between the International Centre for Radio Astronomy Research, Swinburne University of Technology and the University of Oxford that is developing HIPSR with funding from an Australian Research Council Linkage, Infrastructure, Equipment and Facilities grant. 'First light' from HIPSR was reported on 4 October and further development is expected in 2012. Consistent with the CASS plans for Parkes instrumentation, HIPSR is considered a future replacement for the multibeam correlator and possibly other Parkes signal processing backends.

FUTURE OPERATIONS PLANNING

Engineering Operations continued to work closely with ASKAP theme staff, including providing 'hands on' support for the Parkes Testbed Facility that is used for testing ASKAP's systems, developing an appropriate maintenance model for ASKAP once it is operational, and providing input into staff recruitment for the Murchison Radio-astronomy Observatory Support Facility in Geraldton.

Planning work is also continuing towards realising a practical and cost effective future operating model for the Parkes and Mopra radio telescopes. In particular, the need to cut the ongoing operating costs at Parkes makes it essential to review the short- and long-term issues related to instrumentation, including the capital investments in infrastructure needed to retain the reliability and science output of a world-class instrument. Accordingly, issues of operational reliability and maintainability must be factored into planning processes, which will continue into 2012.

PREPARATIONS FOR FUTURE WORK

Major Engineering Operations preparations ahead of planned installation and commissioning works (again mainly at Parkes) during 2012 include:

- Parkes 250 kVA standby generator: To be replaced with a 'modular' 350 kVA Cummins generator set. The new Cummins set has been fitted with appropriate monitoring and control systems, pending its anticipated installation in February 2012.
- Parkes HV installation: Delivery of a new HV regulator is expected in April 2012, with planning progressing ahead of major 11 kV HV infrastructure replacement works expected in May 2012. Further electrical infrastructure related works include the site HV and LV electrical switchboards, expected for a later 2012 or early 2013 shut down event.
- Narrabri standby power: The recovered Parkes 250 kVA generator set will be refurbished during 2012, ahead of installation at the Compact Array control building.
- Parkes maser hut: The existing airconditioning system and building floor are unserviceable. A 'modular' planning approach minimises risk and outage of the 64-m telescope's instrument timing system. Pending installation and commissioning in 2012, an insulated shipping container has been fitted out off site that incorporates a new airconditioning system and fibre-based timing chain connectivity to the 64-m antenna tower.

Other activities

SPECTRUM MANAGEMENT

Spectrum management relating to the protection of radio astronomy has been an important activity for CSIRO since the 1970s. CASS has continued to support such activities and was involved in the following areas in 2011:

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

CSIRO Chief Executive Megan Clark addressed visitors to the Parkes Observatory's 50th anniversary open weekend. Credit: Rob Hollow, CSIRO.

The next World Radiocommunications Conference (WRC-12) will be held in January – February 2012. A major ITU-R activity in 2011 was the two-week Conference Preparatory Meeting (CPM), which finalised the CPM report on agenda items for WRC-12. Many WRC agenda items impact on radio astronomy but the issue of most concern is Agenda Item 1.6 on 'Spectrum usage by passive services between 275 and 3000 GHZ, and procedures for free-space optical communications links'. CASS has been coordinating this agenda item in the Australian processes (led by ACMA) and also in the APT. The CPM report presents a broad international consensus on Agenda Item 1.6 with favourable outcomes for radio astronomy.

Regional positions for WRC-12 were decided in the APT Preparatory Group meeting held in South Korea (29 August – 3 September). CSIRO attended this meeting and was a vigorous participant in all agenda items of interest to radio astronomy.

ITU-R Working Party 7D (WP7D) held a meeting in September 2011. The new ITU-R Report on Radio Quiet Zones was finalised by WP7D and forwarded to Study Group 7 for adoption. CSIRO participants played a key role in the development of this report.

Spectrum management was also represented at the regional IAU meeting, APRIM2011, held in Thailand in July, where an invited discourse presented by CSIRO was very well received. CSIRO also participated in the URSI General Assembly held in Turkey in August, with extensive discussions on spectrum management, radio frequency interference mitigation, ITU-R liaison and IUCAF. The URSI membership in IUCAF, including the CSIRO representative, was reconfirmed.

OUTREACH AND EDUCATION

Parkes Observatory's 50th anniversary open weekend

A big occasion calls for a special celebration. On 8 and 9 October, the 50th anniversary of Parkes Observatory was celebrated by around 5,000 people during an open weekend.

Visitors were treated to behind-the-scenes tours of the famous 'Dish' along with the opportunity to meet our astronomers, engineers, technicians and other support staff. The 50th anniversary was marked with addresses by CSIRO Chief Executive Megan Clark and CASS Chief Phil Diamond. Singing of 'Happy Birthday' was lead by local soprano Helen Barnett before canons fired confetti over the crowd.

The weekend's gala event, attended by around 2,000 people, was a fundraising concert held under the telescope on the Saturday evening. The concert raised $45,000 for the McGrath Foundation and was the initiative of soprano Helen Barnett, one of the four soloists who performed along with the Macquarie Philharmonia orchestra. Guests of

Over 2,000 people attended 'Opera at the Dish' as part of Parkes Observatory 50th anniversary celebrations. Credit: Tony Crawshaw, CSIRO

honour included Her Excellency Quentin Bryce the Governor-General of Australia, and the US Consul General Niels Marquardt who read out a congratulatory letter from NASA. 'Opera at the Dish' won the Parkes Shire Community Event of the Year Australia Day Award and has been nominated for various cultural awards in the central NSW region.

Discover the SKA

In March and April many CASS staff were involved in 'Discover the SKA' events across Australia. This nationwide initiative, led by the Australia – New Zealand Square Kilometre Array Coordination Committee and coordinated by Questacon, aimed to inform the Australian public about the Square Kilometre Array (SKA) and the joint Australia – New Zealand bid to host the telescope. CSIRO SKA Director Brian Boyle, Carole Jackson, Lisa Harvey-Smith and Rob Hollow, among others, gave talks in most capital cities and other locations.

PULSE@Parkes

'PULSE@Parkes' marked four years of operation in December 2011 with another successful year:

- 175 students from 14 Australian schools, as well as a number of UK schools, used the Parkes radio telescope remotely to observe pulsars
- The first school-based session was held at Penrith Anglican College in February with students from that school, Glenmore Park High School and Caroline Chisholm College coming together to observe
- An interstate session was held in Melbourne at the Victorian Space Science Education Centre in August with three schools involved, and
- Following the DotAstronomy3 conference in the UK in April, Project Coordinator Rob Hollow, assisted by former CASS staff member David Champion, ran an observing session for English high school students during their holidays. The Physics Department at the University of Oxford provided great support for this initiative.

The PULSE@Parkes team was joined by Queensland teacher Stephen Broderick, who was awarded a scholarship to spend a week at CASS headquarters in Marsfield and then develop educational support materials for the program. These new materials will be available in 2012 from the PULSE@Parkes website.

CASS Summer Vacation Scholarship Program

The 2011–2012 CASS Summer Vacation Scholarship Program had ten scholars, nine from Australia and one from New Zealand, who undertook a diverse range of research projects — in fields including astrophysics, engineering, operations support and outreach — under the supervision of CASS staff. Eight students were based in Marsfield, one at Parkes and one at Narrabri. In addition to completing their own projects the students participated in a trip to Narrabri, coordinated by Astrophysics staff Shari Breen and Russell Jurek, to use the Compact Array for a short observational project and participate in a program of talks about radio astronomy, specific astrophysics topics and engineering.

As part of the CSIRO Information Sciences Group, the CASS students gave a presentation about their work at the 'Big Day In' held at Macquarie University. The program ended with the students presenting their work at a joint CASS, Australian Astronomical Observatory and Australian Gemini Office Student Symposium in Marsfield.

Other education and outreach activities

For the first time, CASS education activities were held in every Australian state and territory during the year.

The popular three-day 'Astronomy from the Ground Up' teacher workshop held at Parkes in May was fully subscribed and a great success. We welcomed our first overseas teacher from the International School in Ho Chi Minh City, Vietnam. The participants at this workshop were also certified as Galileo Teacher Training Program teachers, an international initiative from the International Year of Astronomy 2009.

Education Officer Rob Hollow ran professional development workshops for teachers in Sydney, Melbourne and Brisbane in collaboration with the Victorian Space Science Education Centre, Scienceworks and the CSIRO Science Education Centre in Brisbane. Rob also presented sessions at science teacher conferences in Sydney, Darwin and Melbourne. As part of 'National Science Week' Rob presented several sessions about the SKA and ran teacher professional development at Ogilvie High School in Hobart. He also discussed the SKA and science careers for students at the Australian Science and Mathematics School in Adelaide before being a keynote speaker at the 'Science Alive' schools' day and the South Australian launch of National Science Week held at Adelaide Showground.

A highlight of the year was the inaugural 'Murchison Astrofest' held at Murchison Settlement in Western Australia during National Science Week. This event saw several hundred people from across the region and further field gather to hear a range of talks on astronomy, gaze at the wonderful dark night sky through telescopes operated by the Geraldton Astronomy Club and dine in style. CASS staff including ASKAP Director Ant Schinckel, John O'Sullivan, Shane O'Sullivan and Rob Hollow all gave presentations. This event was jointly organised by Murchison Shire and staff at the CASS Geraldton office, including Priscilla Clayton, Robin Boddington and Barry Turner.

Western Australia remained a focus for CASS education initiatives during the year:

- Rob Hollow toured schools at Sandstone, Mt Magnet and Mullewa where he conducted daytime presentations, activities and teacher professional development followed by community viewing evenings. All schools in the Murchison region have now been visited by CASS outreach staff and the intention is that each school will be visited every few years.
- On-air lessons for students at Meekatharra School of the Air were provided by CASS staff visiting Geraldton
- Rob Hollow worked with Year 10 students from around the region at the Mid West Youth Science Forum and conducted professional development for science teachers from several schools in Geraldton, and
- Students from Pia Wadjarri Remote Community School had their second visit to the Murchison Radio-astronomy Observatory to take part in the naming ceremony for the first six Australian SKA Pathfinder (ASKAP) antennas. They met with CSIRO SKA Scientist Lisa Harvey-Smith to learn more about ASKAP and toured the site.

Several CASS staff members also participated in the 'Scientists in Schools' program administered by CSIRO. Each scientist is teamed with a school and they work with one or more teachers at the school, visiting classes and talking with students.

CASS outreach and education activities were highlighted during an invited talk presented by Rob Hollow at the 11th Asian-Pacific Regional IAU Meeting held in Chiang Mai, Thailand in July, and PULSE@Parkes featured at the first Office of Astronomy for Development meeting held in Cape Town, South Africa, in December.

CASS astronomer Shane O'Sullivan participating in a lesson at Meekatharra School of the Air in Western Australia. Credit: Rob Hollow, CSIRO.

HEALTH, SAFETY AND ENVIRONMENT

CASS continues to strive for 'zero harm': no injuries, no illnesses and environmentally sustainable operations for our staff members, affiliates, contractors and visitors.

It was an extremely busy year from a health, safety and environment (HSE) perspective following the launch in December 2010 of CSIRO's new HSE framework for standards, procedures and guidelines. CASS developed a plan to review all 36 new procedures over the next three years to ensure that all divisional practices are aligned with the framework. As a result, 2011 started with a strong focus on risk management, emergency preparedness, electrical safety and health and wellbeing, all of which align well with CSIRO's updated HSE Strategy for 2011–15 (released in June 2011).

HSE support across CASS stabilised from mid-2011 with all HSE positions filled, following a restructure that occurred in late 2010. HSE Officer resourcing at Narrabri was increased from 0.2 to 0.4 full-time equivalents in recognition of the need for, and benefits from, additional HSE support. The HSE Officer recruited to work on the Australian Square Kilometre Array Pathfinder (ASKAP) project relocated from Marsfield to Geraldton in February. This proved to be extremely beneficial for providing timely and on-the-ground HSE support to the developing Murchison Radio-astronomy Observatory (MRO) and Geraldton sites.

Positive performance indicators (inductions in the first 24 hours, incidents fully investigated, risk assessments completed and supervisors trained in last three years) all remained in the 'excellent' range during 2011, which is indicative of the focus CASS places on HSE.

Incidents and injuries

CASS had no lost time injuries in 2011.

CASS, excluding Canberra Deep Space Communication Complex staff, had three 'medical treatment injuries' in 2011 (CSIRO's definition of medical treatment injury was amended in May 2011):

- One of the medical treatment injuries was notifiable to Comcare as a 'serious personal injury', which resulted from a snake bite to a visiting observer/co-supervised student at the Narrabri site. The student was transported to hospital for observation and returned to site the next day. The snake bite most likely occurred in the observers area of the control building and, as such, snake traps were set, foliage near the site buildings was cleared, snake awareness posters were distributed that included reminders on snake bite first aid, first aid officers were retrained in snake bite response and a safety alert was distributed across all CSIRO sites. The first aid responders are to be highly commended for their prompt and skilful response to this incident, which occurred on a Saturday evening, and is indicative of robust emergency response systems in place on the site.
- The two other medical treatment injuries both required short-term physiotherapy treatment: for a swollen knee most likely caused by a bump to the knee from a suitcase during a long-haul flight; and for a soft tissue neck strain following working in an awkward position at a computer desk with three computer screens. As a result of the ergonomic injury, a full program of ergonomic assessments was launched across CASS in late 2011. The program utilised an external consultant to conduct assessments for those using multiple screens and trained HSE Officers to conduct ergonomic assessments for all CASS staff, with the goal of completing all assessments by mid-2012.

CASS made three incident notifications to Comcare in 2011, one for a serious personal injury for a snake bite (discussed above) and two for 'dangerous occurrences':

The first dangerous occurrence was reported following a staff member receiving a small electric shock from a capacitor discharge at the Parkes site. A review of electrical practices was undertaken on site and staff reminded that capacitors have the potential to hold a charge for a period of time following disconnection from mains electrical power. As a result, a full-day workshop was undertaken with key Parkes and Narrabri staff in October. The workshop covered a review of the electrical practices within CASS, the implementation of revised CSIRO HSE procedures, and potential changes as a result of the health and safety legislation change to occur on 1 January 2012. An action plan was developed and is being implemented as a result of this electrical review.

The second dangerous occurrence was reported following the detachment of a wheel from a four-wheel drive vehicle that was travelling at approximately 40 km/hr at the MRO. The investigation identified that, as a result of a recent flat tyre, a combination of alloy wheel rims and steel wheel rims were on the vehicle. Following a further flat tyre an incompatibility between steel wheel nuts and alloy wheel rims caused the wheel nuts to work loose and the tyre to detach from the vehicle. All staff were informed about this incompatibility and a detailed technical safety alert was distributed across CSIRO. In addition, the Geraldton-based tyre repair company involved was informed of this issue. Vehicles now have full sets of either alloy wheel rims or steel wheel rims.

Environmental awareness programs

In April some CASS sites participated in a CSIRO electronic waste, or 'e-waste', clean up. Together, the Marsfield and Parkes sites disposed of more than 3,870 kg of e-waste, which included computer hard drives, screens, monitors, TVs, printers, phones, PCBs, network computing equipment, power supplies and many more; the Narrabri site donated e-waste to the local community. All e-waste was disassembled into appropriate recycling streams to minimise the amount of waste going to landfill and all computer hard drives were securely destroyed to ensure that priority and/or personal information was not able to be accessed by others. The table below shows the breakdown of commodity components as a result of this e-waste disposal project.

During late 2011 CASS launched a program to review environmental sustainability practices at all CASS sites. The first review was conducted at the MRO and identified only minor opportunities for improvement. At the Marsfield site a target of a 5% reduction in energy use during November 2011 (when compared with November 2010) was set; the site exceeded this target with a 7% reduction during the month. This program will be extended further and there are plans to implement motion sensors in key areas around the Marsfield site to see if further energy reductions are possible. The Marsfield site also continued to support 'Earth Hour' in 2011.

TABLE 2:
Electronic waste collected at the Marsfield and Parkes sites in 2011.

COMMODITY	WEIGHT (KG)
Metal	1903.4
Plastic	878.6
Glass	802.9
Printed circuit boards	221.8
Toner cartridges	7.8
Packaging	62.0
Total disposal weight	3876.5

Health and wellbeing programs

CASS implemented a health and wellbeing program in mid-2011 that focused primarily on psychological health and wellbeing, but extended across all domains. Components of the program included:

- Promotion of the Employee Assistance Program and the associated Managers Help Line
- Briefing presentations to the CASS Executive on the importance of psychological health and wellbeing and the implications in the workplace
- Visits by psychologists to the Parkes and Narrabri sites to deliver presentations and provide counselling services for staff, and
- Resilience training for people managers designed specifically to ensure that managers are able to look after themselves and others during the changes taking place within CASS.

Flu vaccination clinics were again held at all CASS sites with excellent attendance. At the Marsfield site this was combined with a 'Health and Wellbeing Day' that offered seminars on ergonomics, healthy food choices and stress management through gardening.

CASS launched a 'Sun Safety and Work Outdoors' campaign in late 2011, however, due to ongoing wet weather in the eastern states of Australia much of this campaign was held over until early 2012. A particular focus will be staff travelling to the MRO, given the need to work outdoors with little shade in temperatures sometimes exceeding 40°C.

CASS also continued to promote 'Ride to Work Day' at Marsfield with a healthy morning breakfast for all participants.

Continuous review and improvement initiatives

During 2011 CASS led a major review of the emergency preparedness at the Marsfield site. The Emergency Management Plan was thoroughly reviewed and updated, members of the Emergency Planning Committee, Emergency Control Organisation and Emergency Responders were all trained, and emergency awareness training was offered to all occupants at the Marsfield site. This project took most of 2011 to complete and would not have been possible without the committed efforts of the CSIRO 'Corporate Citizens' undertaking emergency response roles on a voluntary basis over-and-above their other responsibilities. The HSE Team is extremely appreciative of the input of all involved, and will be using this model across other CASS and CSIRO sites. The other CASS sites commenced their reviews of site emergency preparedness in late 2011 and are progressing well to completion by mid-2012.

Commitment to HSE as part of the ASKAP project remained strong during 2011. Work continued on developing the ASKAP HSE documentation suite: in addition to the HSE Manual for Staff and Affiliates, and the HSE Manual for Contractors, a HSE Manual for Guest Users was developed to specifically address their needs and ensure that CSIRO has extended its duty of care to the others using the Murchison Radio-astronomy Observatory site. A peer reviewed 'health check' of the ASKAP project in late 2011 rated HSE as best practice, which is excellent external endorsement of a system that is working well.

HUMAN RESOURCES

Staffing levels

CASS staffing levels have, overall, remained relatively constant since 2010 despite some significant changes impacting our people and structures.

During 2011 there was a notable decrease in recruitment activity with 17 new appointments compared with 30 in 2010. These new staff took up positions in Astrophysics (8), ASKAP/Project Specialists Group (4), Observatory Operations (2), Support (2) and Management (1). Astrophysics was the only group to experience an increase in staffing levels with the appointment of seven Postdoctoral Fellows and one ARC Future Fellow bringing the total number of staff to 27 at December 2011. An additional Postdoctoral Fellow was appointed to the ASKAP/Project Specialists Group to assist with ASKAP commissioning. The remaining Project Specialists were appointed to newly created positions in Geraldton to support construction activity at the Murchison Radio-astronomy Observatory. There are now eight staff and an Indigenous Liaison Officer based at the Murchison Radio-astronomy Observatory Support Facility in Geraldton.

There were a number of key appointments to the Management Group during the year. Sarah Pearce commenced as Deputy Chief in February, and Robert Braun and Simon Johnston were appointed to the positions of Chief Scientist and Assistant Director – Astrophysics, respectively, effective from July. Earlier in the year, Phil Crosby returned from his secondment to the SKA Program Development Office at the University of Manchester to focus on the development of CASS strategy and major project capability. We also increased resourcing to support ASKAP with the appointment of Kate Brooks to the role of ASKAP Executive Officer in June.

Recruitment activity has largely been offset by staff cessations. A total of 16 staff ceased employment during 2011 due to resignation (5), retirement (4), term employment ending (4), redundancy (2) and other reasons (1). The increase in cessation volumes is forecast to continue with further retirements and a number of redundancies to take effect in 2012. These staffing losses will continue to have most impact on our Engineering and Project Specialists groups. To minimise this impact we will need to ensure priority is given to succession planning and staff development. In a number of cases we have been able to continue our association with retirees through Honorary Fellowships. In 2011 Honorary Fellowships were established with John O'Sullivan from Engineering and Andrew Hunt from Operations.

TABLE 3:
Staff levels.

GROUP	TOTAL STAFF 2009*	TOTAL STAFF 2010*	TOTAL STAFF 2011*
ASKAP/Project Specialists	7	15	15
Astrophysics	21	25	27
Communications and Outreach	8	9	9**
Engineering	57	63	59
Management	9	9	9
Operations	59	58	58
Support	4	4	5
Total	165	183	183

*Total staff at December excluding casuals, contractors and students.

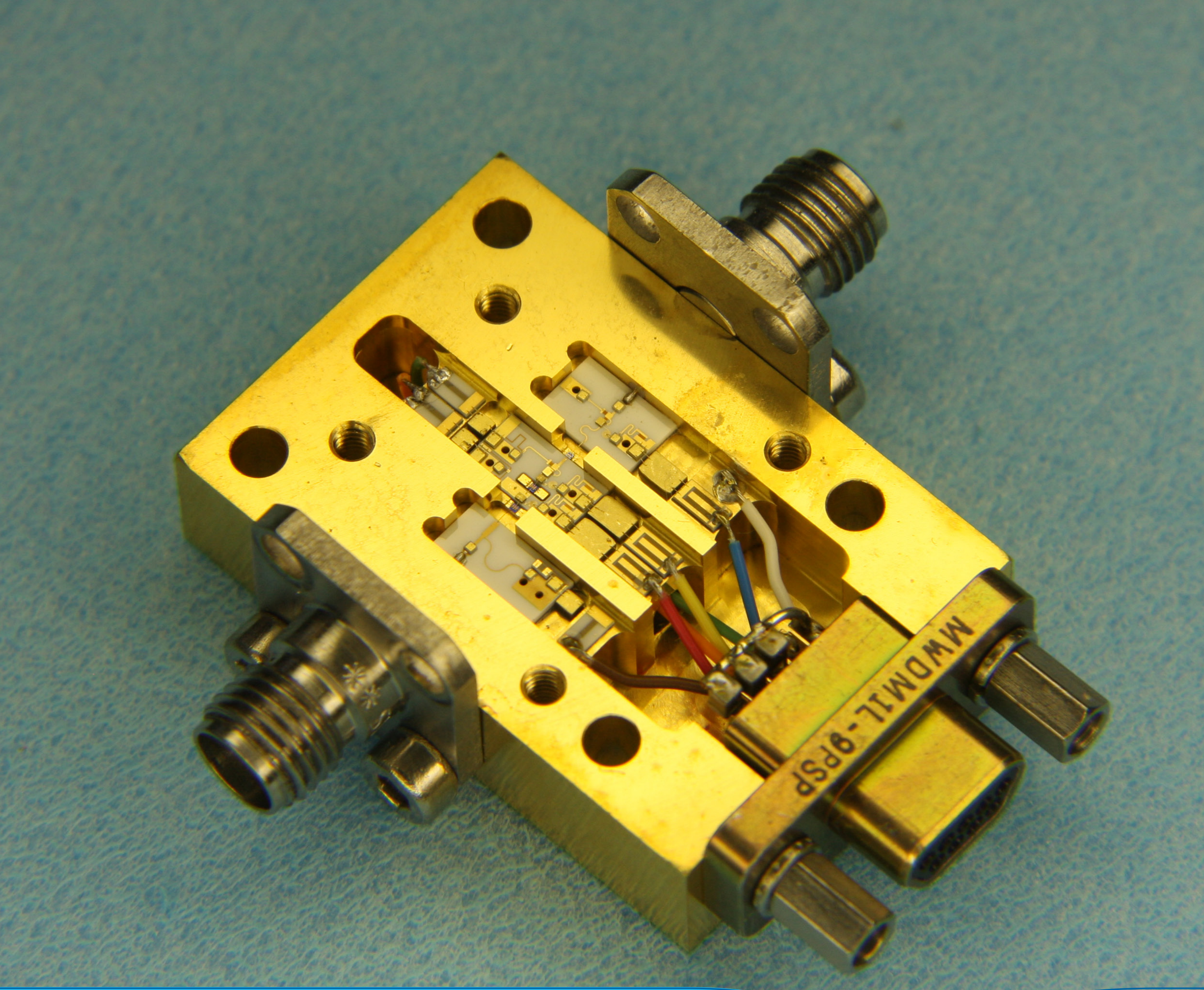
**Transferred to CSIRO Information Sciences Communications Group in July 2011.

Staff awards

The expertise of existing staff has again been recognised through internal and external awards.

In October, the CSIRO Medal for Support Excellence was presented to the Parkes Observatory Pulsar Data Archive Team for a joint CASS and CSIRO Information Management and Technology project. The Medal was awarded 'For the development of a ground-breaking new archive for pulsar radio astronomy data from the CSIRO Parkes radio telescope and making this available for scientific research and education'. The CASS team members included George Hobbs, Jessica Chapman, Jonathan Khoo, Arkadi Kosmynin, Richard Manchester, Vincent McIntyre, Tim Cornwell, Michael Keith and Emil Lenc.

In November, CASS astronomer George Hobbs received the 2011 UNSW Medal for the Young Tall Poppy of the Year for NSW in recognition of his work in the field of pulsar research and his involvement in outreach activities such as the PULSE@Parkes program. The Young Tall Poppy Science Awards, given each year by the Australian Institute of Policy and Science, recognise excellent early career research and passion in communication and community engagement.

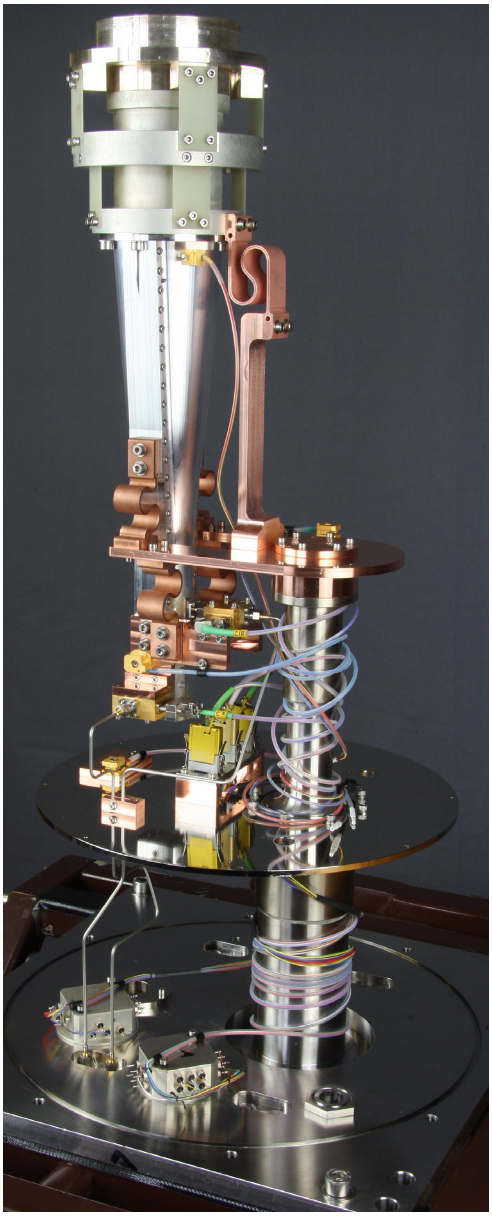


5. Technology

An internal view of the new 4–12 GHz amplifier for the Australia Telescope Compact Array centimetre receiver upgrade project. Credit: Alex Dunning, CSIRO.

Technology

The most significant achievement of the Technologies for Radio Astronomy theme in 2011 has been the completion of the Australia Telescope Compact Array (ATCA) 20/13-cm receiver upgrade and the substantive progress made on upgrades to the ATCA 6/3-cm receivers. Further enhancements to the zoom capability of the Compact Array Broadband Backend (CABB) system have not been delivered as quickly as anticipated with the inherent complexity of the system proving to be a great challenge. Telescope site development projects made progress towards the goal of remote observations at Parkes with a new drive system installed and significant progress made in control and monitoring systems. The support of current instrumentation at the ATNF observatories and at other institutions has again been a focus of the theme.



An internal view of the Compact Array proof-of-concept 4–12 GHz receiver for the centimetre receiver upgrade project. The large, tapered, silver-coloured metal component is the new orthomode transducer. Credit: Alex Dunning, CSIRO.

COMPACT ARRAY 20/13- AND 6/3-CM RECEIVER UPGRADE

The upgrade of the existing ATCA centimetre receivers will enable the full capability of CABB at centimetre wavelengths to be used. With the successful installation of a complete suite of '16-cm' receivers covering the 1–3 GHz band, this project has now achieved the first part of its goal to transform the piecemeal coverage of the 1–12 GHz observing spectrum to almost complete coverage in the 1–3 GHz and 4–12 GHz frequency bands.

With the retrofitting of the 20/13-cm system's orthomode transducer fins completed in 2010, the development of all other receiver elements — cryogenically coolable 1–3 GHz low noise amplifiers (LNAs), broadband RF modules, hardware and electronics to effect the required modifications to the receiver cryogenic components, control and monitor circuitry — led to the last of the suite of six 1–3 GHz receivers being installed on the Compact Array antennas in December 2010. These receivers utilised the original control and monitor circuitry. In 2011, the delivery of a spare receiver completed the receiver cryostat build. Production versions of new control and monitor electronics were installed on all receivers by mid-2011 following the successful testing of a prototype earlier in the year.

The receivers, now designated as 16-cm systems, have performed flawlessly since installation and ensured (through their sensitivity and reliability) that the Compact Array continues to enable the best science in the 1–3 GHz frequency window. They are a tribute to the Front End Group and Operations theme personnel who fabricated, installed and commissioned them.

Expectations are high that the upgrade to the 6/3-cm receivers, to cover the 4–12 GHz band, will deliver both a performance step and excitement in the astronomy community to mirror that of the 16-cm systems. Funding for the third phase became available late in 2009 through a grant from Astronomy Australia Ltd. A high performance three-stage low LNA has been developed following a more rigorous design path than traditional methodology with each stage being designed, fabricated and tested in the cryogenic environment in which it will eventually operate. A prototype two-stage 4–12 GHz LNA was assembled and tested during early 2011, followed by the prototype three-stage LNA in mid-2011. Its performance was indeed encouraging and, while suitable, some small modifications are envisaged to make its performance characteristics even better. A proof-of-concept receiver was constructed and saw its first light in early December. The performance was nothing short of excellent and this bodes well for the production run of receivers that will start to be rolled out in 2012.

The goal of wider bandwidth for these systems challenged the performance of existing components. Besides the amplifiers, both the 6/3-cm receiver feed horn and orthomode transducer (OMT), a device to separate the two different polarisations of the incoming signal and transition them from waveguide to coaxial cable, had poorer than acceptable performance at the low and high ends of the 4–12 GHz band. Computer-aided design techniques including three-dimensional electromagnetic simulation were employed to design a new OMT and the result has been a device that exceeds the specifications required to cover the desired band. Further investigations continue into methods to address the less than optimal performance of the feeds by utilising expertise in other CSIRO divisions and external partners.

COMPACT ARRAY BROADBAND BACKEND UPGRADE

The implementation of zoom modes that will enhance the functionality of the Compact Array Broadband Backend (CABB) upgrade continues to challenge our experienced staff. A continuum mode (available since commissioning in 2009) and the 1 MHz mode with its full complement of 16 zooms (available since December 2010) are the two most used configurations.

A single 64 MHz mode with one zoom (of the planned 16 zooms) and pulsar binning configurations that can achieve bin times down to 20 microseconds continue to cater for VLBI and millisecond pulsar research, respectively.

It was hoped that all 16 zooms for the 64 MHz mode would have been implemented before the 2011 winter observing season. Resourcing for this development has suffered from an insufficient number of available and expert staff and the 2012 winter observing season is a more practical and achievable target. An extra staff member has been engaged for 2012 to troubleshoot some of the 'bugs' that have, until now, been unable to be addressed.

Additionally, Bob Sault, a former Officer-in-Charge of the Compact Array, has been engaged to undertake software tasks that would normally have fallen to Warwick Wilson as founder and linchpin of the CABB upgrade project. Warwick's desire for continued involvement in a less formal role following his retirement has been met, though his contributions seem not to have diminished to any great extent from when he was a member of staff.

For more information on CABB, see also pages 37 and 39 of the 'Operations' chapter.

TELESCOPE SITE DEVELOPMENT PROJECTS

Projects seeking to introduce efficiencies into telescope operations in preparation for operation of the Australian Square Kilometre Array Pathfinder continued to be hosted by the Technologies theme but have been managed and undertaken by personnel from the Operations theme. Focusing primarily on Parkes, the projects seek to improve the ability for remote observing through improvements in drive control, overall control and monitoring and receiver rationalisation.

The Parkes Drive Control Project delivered a reliable and more serviceable control system for Parkes during a multi-week shutdown in March. It is a real feather in the cap of the site staff that, despite the distractions of maintaining a world-class instrument in their 'operations' roles, they were able to deliver and commission a system on time, on brief and on budget. The success of this project was critical for maintaining observational milestones and the Division's reputation. The extensive planning for the system changeover ensured it was smooth and fault free, allowing a rapid return to routine observing after the shutdown period.

The Parkes Equipment Control and Monitor Project is a conglomeration of smaller projects predominantly utilising staff from Parkes and Narrabri. Following the commissioning of a backend switching matrix in October 2010, attention this year focused on other elements including the focus cabin remote power switching, focus cabin temperature monitor and the power backup diesel/UPS control and monitoring. Substantial progress has been made on all items and it is envisaged that this project will have achieved its goals in the first quarter of 2012.

The other projects within CASS meant that resources for receiver rationalisation were again unavailable to allow any progress. With two years elapsing since the rationalisation was planned, other options have eventuated and these are being explored to both maintain Parkes' status as a world-class instrument and reduce the need for multiple receiver changes.

For more information on telescope site development projects, see also page 39 of the 'Operations' chapter.

WATER VAPOUR RADIOMETERS

Water vapour radiometers are instruments that sample the atmosphere above the antennas of the Compact Array and generate corrections that are applied to observational data to improve the integrity of the astronomical signal degraded by the effects of water vapour. Equipping the Compact Array antennas with these devices was primarily funded by the University of New South Wales. Characterisation of these units has been ongoing throughout the year, prior to their availability for data correction. Some modifications to observational software and significant modelling have been required and estimated sensitivities are expected to be achieved by mid-2012.

THE FAST MULTIBEAM PROJECT

Throughout 2011 staff from the Technologies theme, in collaboration with engineering staff from the Jodrell Bank Centre for Astrophysics, have been engaging with engineers from the National Astronomical Observatory Chinese Academy of Sciences to realise a 19-pixel receiver operating in the 1–1.5 GHz band for the Five Hundred metre Aperture Spherical Telescope (FAST) under construction in Guizhou, China. Despite experience in such multi-pixel receivers, this project will require innovative elements to achieve the design specifications and a feasibility study to be undertaken in 2012 will be the first step towards an instrument for new science.

6. The SKA and the Australian SKA Pathfinder

CSIRO SKA Project Scientist Lisa Harvey-Smith and one of the ASKAP antennas at the Murchison Radio-astronomy Observatory. Credit: Dragonfly Media.

The SKA and the Australian SKA Pathfinder

Development of the Australian Square Kilometre Array Pathfinder (ASKAP) and participation in the international Square Kilometre Array (SKA) program continued to be strategic priorities for CASS during 2011.

The ASKAP project has four principal goals:

- To establish the Murchison Radio-astronomy Observatory (MRO) as an observatory to ultimately host the SKA
- To develop new technology to advance radio astronomy and to demonstrate the technology's viability for the SKA
- To deliver high quality science, in particular to establish and explore science themes that will be fully exploited by the SKA, and
- To foster the next generation of astronomers and engineers who, ultimately, will become the users and builders of the SKA.

Key objectives for ASKAP to achieve these goals are to deliver:

- Thirty-six antennas with phased array feed (PAF) receivers and signal processing
- Development of these advanced receiver systems and associated technology for radio astronomy
- The MRO Control Building and all support infrastructure
- An on-site power plant with a significant renewable component
- The MRO Support Facility (MSF) in Geraldton, and
- An SKA-capable optical fibre network linking the MRO to the MSF in Geraldton and on to iVEC's Pawsey Centre in Perth.

Following the successful construction of the first six ASKAP antennas at the MRO in 2010, the overall technical build made rapid progress with nine antennas constructed on site, and the parts for many more delivered and waiting assembly by the end of the year.

The ASKAP project achieved a number of major milestones in 2011:

- The first full-sized prototype PAF delivered to the Parkes Testbed Facility (PTF), where data from the 188-element receiver was collected and calibrated using the 64-m Parkes radio telescope as a reference
- The first PAF designed for the ASKAP antennas was deployed to the MRO in October, followed by another two systems in preparation for single dish and beamformer testing, and progressively, interferometric and phase closure demonstrations of ASKAP at the MRO in 2012
- First light was achieved on the 380 km MRO to Geraldton optical fibre link, allowing 1 Gbps data transmission for a real-time VLBI observation demonstrated at the International SKA Forum in Banff, Canada
- First science fields for the Boolardy Engineering Test Array (BETA) were characterised using the Australia Telescope Compact Array
- Accepted as 'early adopters' of iVEC's new 'Epic' supercomputer at Murdoch University, the ASKAP Computing Team was the first to use this computer and simulate how ASKAP data will be processed, and
- Remote drive of ASKAP antennas and systems at the MRO was achieved using ASKAPsoft.

Additionally, CSIRO's ASKAP team was involved in:

- Construction of infrastructure at the MRO including roads, fibres, power distribution and a world-leading radio frequency interference-shielded control building, including an energy efficient, geothermal cooling system
- Ensuring a strict legislative framework exists for radio spectrum management in the Mid West Radio Quiet Zone
- The development and validation of the use of leading-edge 'RF-over-fibre' technology into a single, integrated, economical package, and
- A major collaborative effort between 47 agencies to prepare a response to a request for information on the joint Australia – New Zealand bid to host the SKA.

SKA ACTIVITIES

CASS continued to participate in a number of national and international partnerships, including those with industry, science organisations and governments, to support the joint Australia – New Zealand bid to host the international SKA telescope and to progress the international development of the SKA.

Throughout the year CASS actively participated in the early planning stages of the SKA through the European Union's Preparatory Phase Studies for the SKA (PrepSKA) program. This focused on SKA-related research and development such as dish arrays, digital systems, computing, signal transport and systems. CSIRO coordinated the development of the SKA PAF Concept Descriptions, which were key inputs to the Concept Design Reviews (CoDRs) during 2011.

CSIRO was involved, along with Australian Government and Western Australian Government, in discussions on radio-quiet protection requirements with the Australian Communications and Media Authority (ACMA). In July, ACMA announced enhanced protection for the Mid West Radio Quiet Zone (RQZ). The new Frequency Band Plan provides greater legislative certainty for the protection of radio quiet, and extends the frequency range of the Mid West RQZ to support the development of radio astronomy activities. The Band Plan extends to a radius of 150 km, as for the previous Embargo, and a new inner zone of 70 km radius was created within which radio astronomy is the primary service. The Mid West RQZ coordination zone still extends to 260 km radius via the ACMA RALI MS 32 introduced in 2007.

CSIRO also facilitated two workshops (hosted by the International Centre for Radio Astronomy Research (ICRAR)) focused on preparedness for next phase SKA Work Packages for power, and for signal transport and networking. The power workshop drew interest from power-providing utilities, regional planners and consultants, and a strong commitment emerged from the group to support the imminent SKA pre-construction phase, as well as preparedness for later contractual involvement.

Australia – New Zealand SKA Coordination Committee

CSIRO is an active member of the Australia – New Zealand SKA Coordination Committee (ANZSCC), the intergovernmental body overseeing Australia and New Zealand SKA strategy and policy.

A delegation from Australia's science and technology community visited the USA at the start of 2011 for a series of meetings on bilateral science collaboration, including the inaugural USA – Australia Joint Commission Steering Committee Meeting on Science and Technology. As part of the visit, representatives also met with SKA project stakeholders in the USA and Canada.

In July, CASS representatives attended the International SKA Forum 2011 in Banff, Canada. The Australia – New Zealand delegation was led by Senator the Hon. Kim Carr, Australia's (then) Minister for Innovation, and included senior representatives from the Australian, New Zealand and Western Australian governments as well as SKA scientists and key industry representatives. Minister Carr's keynote speech was capped off by a video message from the Prime Ministers of Australia and New Zealand, and the Premier

Significant infrastructure construction activities took place at the MRO in 2011. Here, street signs point in the direction of ASKAP antennas. Image credit: Rob Hollow, CSIRO.

The first six ASKAP antennas, as well as roads and other significant structures, were bestowed with traditional Wajarri Yamatji names during a local community event held at the MRO in June. Credit: Dragonfly Media.

of Western Australia, in support of the Australia – New Zealand site bid. This was followed by a presentation from CSIRO SKA Project Director Brian Boyle that included contributions from CSIRO SKA Project Scientist Lisa Harvey-Smith and ICRAR Deputy Director Steven Tingay.

During 2011, CSIRO was deeply involved in the preparation of a response to a request for information on the joint Australia – New Zealand bid to host the SKA. The submission was the result of a major collaborative effort between 47 agencies across the two countries, and was submitted to the international project in September 2011.

During the SKA Founding Board meeting in November, Australia and New Zealand, along with China, Italy, The Netherlands, UK and South Africa, established the new UK-based SKA Organisation that will govern the SKA and make the host site selection, due in early 2012.

MURCHISON RADIO-ASTRONOMY OBSERVATORY ACTIVITIES

The MRO welcomed a number of special guests including The Hon. John Day, Western Australia's Minister for Science and Innovation, in May; and CSIRO Chief Executive Megan Clark, and CSIRO Board Members Simon McKeon and Eileen Doyle, in June.

A local community event was also held in June, at which the first six ASKAP antennas were officially given Wajarri Yamatji names. The antenna names, chosen by the Wajarri Yamatji people and bestowed by representatives of seven Aboriginal families at a naming ceremony at the MRO, are Bilyarli (which means galah and is also the name of a past Wajarri Elder, Mr Frank Ryan, Bundarra (stars), Wilara (the Moon), Jirdilungu (the Milky Way), Balayi (a lookout, as this antenna looks down westward to others) and Diggidumble (a nearby table-top hill, or 'breakaway').

Roads and other significant structures will also be given Wajarri names, such as Ngurlubarndi (the Wajarri name for Mr Fred Simpson, a past Wajarri Elder and father of Wajarri Elder Mr Ike Simpson). Further naming of the remaining 30 antennas will take place as more are installed on site, and eventually all 36 ASKAP antennas will be honoured with a Wajarri name.

MRO infrastructure

Construction of supporting infrastructure at the MRO advanced significantly during the year. The project was undertaken by McConnell Dowell Constructors (Australia) Pty Ltd and involved construction of several kilometres of access roads and tracks, power and data infrastructure, a central control building and 30 radio antenna concrete foundations, as well as ancillary works. The infrastructure supports all MRO facilities including ASKAP, the Murchison Widefield Array (MWA) and Experiment to Detect the Global Epoch of Reionization Signature (EDGES) projects.

The MRO Control Building was delivered to site in October by 13 trucks each carrying a 15-metre hi-tech steel module from Lonsdale, South Australia, built by subcontractor Robert Johnson Engineering. The building is thermally efficient and will house complex digital systems including ASKAP beamformers and correlator, while also providing very high level shielding to radio frequency interference to ensure we maintain the pristine radio-quietness of the MRO site. It also acts as the local technical support facility for the site, with operations rooms as well as electronic and mechanical workshops.

By year's end, the 380 km fibre optic cable from the MRO to Geraldton and power transmission cabling had been completed, and antenna foundations, the main access road, antenna access tracks, an upgrade of the MRO airstrip, and bores and plumbing for the control building's geothermal cooling system were close to completion.

NEW ASKAP FRAMEWORK

Early in 2011 ASKAP went through a significant process of project evaluation and internal review. This included a 'bottom up' budget evaluation including schedule and risk reviews.

Working with the ASKAP Steering Committee, the ASKAP team explored different options for the project, including a change in the ASKAP construction strategy to maximise efficient use of the available budget and best align with the pathway to the international SKA project.

A revised plan for the delivery of ASKAP was developed and presented separately to the ASKAP Steering Committee and the CSIRO Board in June.

The revised plan has three main components:

- CSIRO plans to deliver a fully functional MRO and 36 ASKAP antennas, six of them equipped with PAFs to make up the Boolardy Engineering Test Array (BETA)
- This component includes the establishment of the MRO as an operational observatory with support infrastructure and power station; the construction of the Murchison Radio-astronomy Observatory Support Facility (MSF) in Geraldton; the construction of the SKA-capable fibre optic network linking the MRO to the MSF; and the establishment of the radio-quiet zone and governance arrangements for CSIRO management of the MRO.
- BETA will include the electronic fit-out (PAF plus all subsystems) for six antennas using 'Mark I' PAF technology, along with supporting systems (beamformers and correlator) and all aspects of observatory support such as networking and remote observing capability. Commissioning of BETA will be followed by the implementation of some science-capable observing modes.
- The next generation of PAFs, known as 'Mark II', will be developed and installed on another six ASKAP antennas at the MRO through the ASKAP Design Enhancement (ADE) Program.
- The scope of the ADE Program includes improved performance of the PAF, improved packaging, and implementation of evolving technologies such as RF-over-fibre (RFoF) signal transmission and the newly announced V7 family of field-programmable gate arrays from Xilinx, allowing significant reduction of the space and power required for the digital systems.
- The resulting Mark II design is expected to be completed in 2012. The Mark II PAFs and their signal transport and digital systems will be more closely aligned with the SKA, and present a better path for the future development of PAFs for radio astronomy.
- In parallel, additional funding will be sought expeditiously to build PAFs, along with their supporting digital systems, for the remaining 24 ASKAP antennas. If additional funds cannot be founds, CASS will build and install these PAFs progressively as internal funds allow.
- The ADE Program and the delivery of six new PAF Mark II systems (with associated data transmission and new beamformer and correlator systems) will be implemented during 2012–2013. This will allow the commissioning of ASKAP with PAFs to continue, with limited 'shared risk' science commissioning time available during this period, and the percentage of science versus commissioning time increasing steadily. The remaining 24 antennas may be fitted with single pixel feeds while funds are sought to install PAFs.

ASKAP SCIENCE

Throughout 2011, cooperation continued between CASS and members of the ten large ASKAP Survey Science Projects (SSPs) that have been allocated observing time in the first five years of ASKAP operation. An annual review of the ten SSPs was held in early November. An internal review committee, led by CASS Chief Philip Diamond, assessed the scientific and technical progress made during the second year of the Design Studies phase and assessed the readiness of the teams for accepting and processing commissioning data from BETA. Feedback from the review committee was extremely positive, particularly around the level of technical work accomplished by the teams in support of ASKAP science and in preparation for the next stage of commissioning and early science.

In May and June, the Compact Array was used for characterisation observations of two well-known radio sources in preparation for the first science with BETA. Two seven-day periods of 24-hour-a-day observations resulted in a 30 square degree image with equivalent angular and spectral resolution, sensitivity and frequency coverage to that of BETA. The results will be used as controls to test ASKAP's imaging pipelines and calibration systematics.

During the International SKA Forum in July in Banff, Canada, the first e-VLBI demonstration was performed between an ASKAP antenna and other radio telescopes in Australia and New Zealand. Using the newly commissioned optical fibre links between the MRO and Perth, six telescopes, including ASKAP, were used together to observe a radio source, PKS0637-752, a quasar more than 7.5 billion light years away. During the experiment all the telescopes were remotely controlled over the Internet from Sydney. Data from the sites were streamed in real time to Curtin University in Perth, where processing took place using a system built by a research team led by Steven Tingay.

Three editions of a tri-annual publication, *ASKAP Science Update*, were produced in 2011 to inform the international astronomy community on the progress of ASKAP and the SSPs.

ASKAP TECHNOLOGIES

End-to-end BETA PAF system development

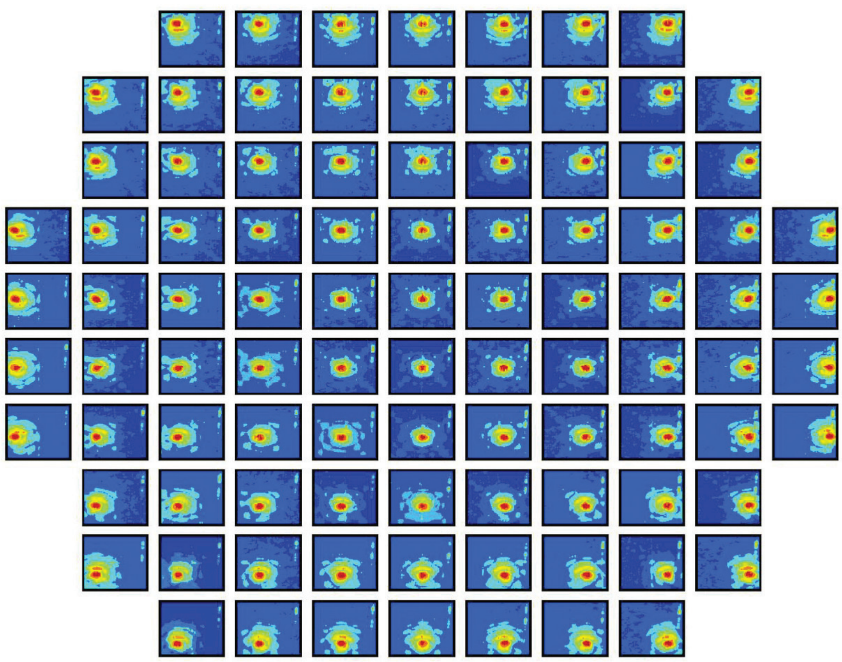
The ASKAP phased array feed (PAF) is the first 'chequerboard' planar phased array specifically built for radio astronomy, with 188 active elements to allow the reconstruction of many separate, simultaneous beams and provide ASKAP with a wide field-of-view. This will allow ASKAP to map the sky far more quickly than alternative technologies.

The first full-sized chequerboard PAF with its supporting analogue and digital systems was transported to the Parkes Testbed Facility (PTF) in June where initial ground-based tests confirmed the array achieved results consistent with both the theoretical model and results of tests conducted in 2010 with a smaller 'proof-of-concept' receiver.

With the PAF installed on the 12-m Patriot antenna at the PTF and a carefully validated signal path, 'first light' was achieved with the PAF by correlating data from all 188 elements with the single beam of the 64-m Parkes telescope while observing radio-galaxy PKS1934-638.

In December, a further milestone was achieved when an image was released that showed the raw port patterns from the PAF (installed at the prime focus of the PTF) produced while observing power radio galaxy Virgo A.

Raw port patterns from the PAF installed on the 12-m antenna at the Parkes Testbed Facility (PTF). The image was produced by correlating each of the 188 ports of the 12-m antenna with the central horn of the Parkes radio telescope's 20-cm multibeam receiver. While the 64-m telescope tracked Virgo A, the PTF executed a raster scan about the radio source to map out a 14 square degree patch of each PAF port pattern. The two polarisations of the central beam of the 20-cm multibeam receiver on the 64-m telescope were connected to ports 189 and 190 of the beamformer, using an RF-over-fibre link.



This was the first time detailed tests on the entire system, from antenna to the digital signal processing hardware, had ever been performed for a chequerboard PAF and ensured robust basic functionalities of the system prior to deployment on an ASKAP antenna at the MRO. The result matched the expected performance of the system and further validated chequerboard PAFs as rapid imaging devices for radio astronomy.

Once the first ASKAP PAF was successfully deployed to the MRO in October, work continued on the remaining five BETA PAFs back in Marsfield. The Marsfield ASKAP Test Engineering System (MATES) allows for testing at CASS headquarters in Sydney, as it duplicates a complete ASKAP antenna system, from the PAF, through RF analogue signal conditioning, digital conversion, channelisation and beamforming, with full system control and monitoring managed through the telescope operating system. Additionally, the MATES timing reference systems, network equipment, power distribution and data transport hardware allow the ASKAP antenna functions and interfaces to be tested to a high degree.

ASKAP Design Enhancements Program

The ASKAP Design Enhancements (ADE) Program is based on following up the rapid developments of technologies associated with the PAF, and initial feasibility studies into signal transport using RF-over-fibre and direct sampling of the radio frequency signal rather than using a heterodyning approach.

The proposed ADE Program includes a phase of design and validation to take place in 2012, followed by a phase of initial production from late 2012 to early 2013. A Concept Design Review held in August successfully demonstrated the feasibility of the initial ADE design to a review panel of senior CASS engineers.

The year was punctuated by the Preliminary Design Review, in which the team successfully demonstrated a complete preliminary design to a distinguished review panel comprising senior CASS engineers and managers, as well as external experts in photonics and signal processing.

Computing

Successful first testing of the ASKAP telescope operating system took place at the end of September, when two ASKAP antennas at the MRO were driven simultaneously. The antennas are now able to be driven remotely from CASS headquarters in Marsfield.

The ASKAP Computing Team released an ASKAP Science Processing document which describes, in detail, the complete end-to-end processing steps required to produce scientifically useful end products. The team also introduced a new hybrid algorithm for wide-field imaging (snapshot and projection) and the implementation and testing of a multi-scale, multi-frequency deconvolution algorithm.

ASKAP was accepted as an 'early adopter' of iVEC's Pawsey Centre 'Epic' supercomputer at Murdoch University in Perth. As part of the program, all processing was moved from the ATNF to the Pawsey 1A system (one million hours was granted on the Stage 1A system for the second half of 2011, and eight million hours was granted for the first half of 2012). The team also participated in setting requirements for the Stage 2 petascale system.

The ASKAP Computing Team was the first to use 'Epic' to simulate how ASKAP data will be processed to create images of the radio sky for the ASKAP Survey Science Projects. The mega-simulations generated more than 1.5 terabytes of data, producing images and cubes that covered 10 square degrees of sky (a third of ASKAP's field-of-view) and up to 4,096 channels (one quarter of that possible with ASKAP).

Leading up to BETA, the readiness of the science processing code is being tested by instituting a nightly 'data challenge'. The aim of this is to simulate, as fully as possible, the flow of data from BETA at the MRO down the optic fibre connection to Geraldton and then to the Pawsey Centre where it will pass through calibration, imaging, and source-finding software. Running the simulation nightly tests reliability and robustness, and tracks performance improvements. When BETA switches on, the data path will be switched from simulated to real data.

Antenna design and construction

Comprehensive site acceptance tests and initial commissioning activities were fully completed at the start of the year on the six antennas built at the MRO in 2010. This included the fit-out of internal parts such as the support floor, mezzanine and internal cable trays for the antennas.

An important feature of the antenna design is the ability to set reflector accuracy at the factory acceptance test stage. This allows the antenna to be erected at the MRO, with no further surface adjustment required, while maintaining a specified surface accuracy. This ability is an important step on the path to developing SKA antennas, where the need to assemble thousands of mid-size antennas quickly and with minimal adjustments is critical to keeping their cost down to an acceptable level.

The reflector dishes are specified to a surface accuracy of 1.0 mm, which allows for astronomy-capable operation up to 10 GHz. However, the surface accuracy actually achieved on the first six dishes constructed at the MRO was closer to 0.5 mm, allowing for astronomy-capable operation to be doubled to 20 GHz in the future.

By the end of 2011, three phased array feed receivers were installed on ASKAP antennas at the MRO. Credit: Barry Turner, CSIRO.

Members of the ASKAP Antenna Team visited the CETC54 factory in China to oversee ongoing factory acceptance testing of the production line of all 36 ASKAP antennas.

INDUSTRY AND OTHER STAKEHOLDER INVOLVEMENT

CSIRO's ASKAP and SKA industry engagement activity continued to strengthen through an ongoing program of briefings, publications and tender updates, and early phase research and development collaborations.

The ASKAP team's engagement with industry representatives in Western Australia's Mid West region continued through regular participation in industry events organised by the Mid West Chamber of Commerce and Industry, and the City of Geraldton-Greenough.

CSIRO continued to be an active member of the Australasian SKA Industry Consortium (ASKAIC), a self-funded group of companies with a strong interest in ASKAP and the SKA. ASKAIC offers both practical help and excellent guidance in shaping plans for industry involvement.

Four editions of a quarterly publication, *ASKAP Technical Update*, were produced to keep industry and other interested stakeholders informed about the progress being made on technical aspects of ASKAP. Requests for tender were announced via the 'ASKAP and SKA News for Australia Industry' e-newsletter and on the AusTender website.

Strategic engagements between CSIRO, industry partners and other stakeholders included:

- Development of a low-cost, ultra-high bandwidth 'system-on-a-chip' receiver with Silanna (previously Sapphicon Semiconductor). The chip integrates much of the electronics required to process one channel's worth of data in a phased array feed or aperture array receiver into a single integrated channel, minimising external components and leading to a reduction in size, weight, power and overall cost.

- Delivery of major components of the ASKAP digital systems, such as signal processor boards, by Puzzle Precision, a supplier of high-end digital systems. These components are vital to the development of the ASKAP digital system's flagship board, the Redback-2 Digital Signal Processor, a highly complex circuit board which pushes the limits of manufacturability.
- Working with Xilinx to develop field-programmable gate arrays (FPGAs) to meet ASKAP requirements of approximately 2 peta operations/second with 100 Tbit/second communications. The FPGAs provide an economical solution for both power consumption and capital cost compared with other alternatives, such as high-performance computing.
- Continued work with Horizon Power in Perth on the development of hybrid solar–diesel power generation for the MRO
- Signing of an MoU between the Fraunhofer Institute of Solar Energy, Max Planck Institute for Radio Astronomy and CSIRO to promote scientific and research cooperation in renewable energy capture, storage and management for the SKA. Additionally, the MoU looks to advance collaboration on the development of renewable energy systems for ASKAP and the MRO.
- Working with AARNet (and major sub-contractors CCTS and North Coast Holdings) to provide high-speed data communication services from the MRO to the Pawsey Centre in Perth
- Close cooperation with AARNet, the Australian Government's Department of Broadband, Communications and the Digital Economy, NextGen and NBN Co on the installation of the National Broadband Network link from Geraldton to Perth
- Selection of McConnell Dowell Constructors (Australia) Pty Ltd as the successful tender for the construction of support infrastructure at the MRO in late 2010 saw work commence in early 2011
- Collaboration with Aurecon, McConnell Dowell and Adelaide-based business Robin Johnson Engineering on the development of the specialised MRO Control Building
- Award of the design tender for the Murchison Radio-astronomy Observatory Support Facility (MSF) in Geraldton to Aurecon in 2010, and award of a tender for the construction of the MSF to Merym Pty Ltd (trading as EMCO Building) in late 2011, and
- Further increased engagement with the Murchison Shire Council through participation in regular Council meetings and discussions.

COLLABORATOR PROJECTS

Two radio astronomy experiments, other than ASKAP, made use of the superbly radio-quiet environment at the MRO in 2011: the Murchison Widefield Array (MWA) and the Experiment to Detect the Global Epoch of Reionization Signature (EDGES).

The MWA is an international collaboration between US, Australian and Indian institutions, including CSIRO, to build a wide-field dipole array at the low frequency range (80–300 MHz) of the SKA specification. Final deployment of the MWA was approved in 2011. Following completion of infrastructure work at the MRO, the MWA antennas, beamformers and receivers will be deployed to the MRO.

The EDGES project was deployed at the MRO in 2009. A collaboration between Arizona State University and MIT/Haystack Observatory, and funded by the US National Science Foundation, the EDGES project 'went live' on a newly installed fibre network connection in 2011, making it possible to watch progress of the experiment in real time.

CSIRO staff also continued their close collaboration with The University of Sydney on the Square Kilometre Array Molonglo Prototype (SKAMP) project, which aims to develop new technology for the SKA by producing a completely new digital signal pathway on the existing mechanical superstructure of the Molonglo Observatory Synthesis Telescope.

7. Appendices

Three of the antennas that will make up ASKAP at the Murchison Radio-astronomy Observatory (MRO). At the end of 2011, nine of ASKAP's 36 antennas had been assembled and a further five were under construction at the MRO. Credit: Ant Schinckel, CSIRO.

A: Committee membership

ATNF Steering Committee in 2011

CHAIR

Professor Lister Staveley-Smith, ICRAR

MEMBERS

Ex-officio
Dr Matthew Colless
Director, Australian Astronomical Observatory

Dr Alex Zelinsky
Group Executive, CSIRO Information Sciences Group

Dr Ian Oppermann
Director, CSIRO ICT Centre

Astronomers
Professor Rachel Webster
University of Melbourne

Professor Brian Schmidt
Research School of Astronomy and Astrophysics, ANU

International advisers
Professor Michael Kramer
Director, Max-Planck-Institut für Radioastronomie, Germany

Professor Nan Rendong
National Astronomical Observatories, China

Professor Jacqueline N Hewitt
Director, MIT Kavli Institute for Astrophysics and Space Research, USA

Broader community
Mr Alan Brien
Chief Executive Officer, Scitech Discovery Centre

Mr Jim Noble
Australian Goverment Department of Defence (retired)

Invited
Dr Philip Diamond
Chief, CSIRO Astronomy and Space Science;
Director, CSIRO Australia Telescope National Facility

Australia Telescope User Committee in 2011

CHAIR

Dr Sarah Maddison, Swinburne University of Technology (2009–2011)

SECRETARY

Dr Chris Phillips, CSIRO Astronomy and Space Science (October 2010 – May 2013)

MEMBERS

Dr Simon Johnston, CSIRO Astronomy and Space Science (October 2010 – May 2011)

Dr Hayley Bignall, Curtin University (October 2008 – May 2012)

Dr Tara Murphy, University of Sydney (October 2008 – May 2011)

Dr Tim Robishaw, University of Sydney (October 2010 – June 2011)

Dr James Urquhart, CSIRO Astronomy and Space Science (October 2008 – May 2011)

Professor John Dickey, University of Tasmania (October 2009 – May 2012)

Dr Chris Springob, Australian Astronomical Observatory (October 2009 – May 2012)

Dr James Allison, University of Sydney (October 2011 – May 2014)

Dr Virginia Kilborn, Swinburne University of Technology (October 2011 – May 2014)

Dr Ryan Shannon, CSIRO Astronomy and Space Science (October 2011 – May 2014)

Dr Stephen Ord, Curtin University (October 2011 – May 2014)

STUDENT MEMBERS

Justin Bray, University of Adelaide (October 2010 – May 2011)

Jacinta Delhaize, University of Western Australia (October 2010 – May 2011)

Giovanna Zanardo, University of Western Australia (October 2011 – May 2012)

Kathrin Wolfinger, Swinburne University of Technology (October 2011 – May 2012)

The Australia Telescope Steering Committee appoints members to the Australia Telescope User Committee. New members usually start their three-year term with the October/November meeting in their first year and finish their term after the May/June meeting in their last year. Students are appointed for one year (two meetings). Dates of first and last meetings are given.

Australia Telescope Time Assignment Committee in 2011

CHAIR

Dr Lisa Harvey-Smith, CSIRO Astronomy and Space Science

MEMBERS

Ex-officio

Dr Jessica Chapman, CSIRO Astronomy and Space Science

Dr Philip Edwards, CSIRO Astronomy and Space Science

Dr Douglas Bock, CSIRO Astronomy and Space Science

TAC members

Dr Simon Ellingsen, University of Tasmania

Dr Jimi Green, CSIRO Astronomy and Space Science

Dr Helen Johnston, University of Sydney

Dr Emil Lenc, CSIRO Astronomy and Space Science

Dr Jim Lovell, University of Tasmania

Dr Jean Pierre Macquart, Curtin University

Dr Martin Meyer, University of Western Australia

Dr Jill Rathborne, CSIRO Astronomy and Space Science

Dr Willem van Straten, Swinburne University of Technology

Dr Andrew Walsh, James Cook University

Readers

Dr Ettore Carretti, CSIRO Astronomy and Space Science

Dr Maria Cunningham, University of New South Wales

Dr Gary Fuller, University of Manchester, UK

Dr Jose Gomez, Instituto de Astrofisica de Andalucia, Spain

Dr Richard Hunstead, University of Sydney

Dr James Jackson, Boston University, USA

Dr Virginia Kilborn, Swinburne University of Technology

Dr Maura McLaughlin, West Virginia University, USA

Dr Enno Middelberg, Ruhr University, Germany

Dr Vincent Minier, University of Paris, CEA Saclay, France

Dr Rafaella Morganti, Netherlands Foundation for Research in Astronomy, The Netherlands

Dr Juergen Ott, National Radio Astronomy Observatory, USA

Dr Gavin Rowell, University of Adelaide

B: Financial summary

The table below summarises the revenue and expenditure applied to CSIRO's radio astronomy activities, also including related activities resourced from the CSIRO ICT Centre.

	Year ending 30 June 2009 (A$'000)	Year ending 30 June 2010 (A$'000)	Year ending 30 June 2011 (A$'000)
Revenue			
External	1,269	966	7,181
Appropriation	31,801	33,031	36,419
Total revenue	33,070	33,997	43,600
Expenses			
Salaries	12,140	12,500	14,046
Travel	975	976	1,080
Other operating	4,173	5,091	5,028
Overheads*	12,012	10,282	12,914
Corporate support services	0	0	0
Depreciation and amortisation	3,363	3,925	3,953
Doubtful debt expense	0	0	0
Total expenses	32,663	32,773	37,021
Profit/(Loss) on sale of assets	0	0	0
Operating result	407	1,223	6,579

CSIRO implemented SAP in July 2008. The financial reporting represents matrix reporting for the output side of the matrix, outputs are portfolios and themes.

*Overheads include corporate support services and business unit support services.

C: Staff list

ALL STAFF WHO WORKED FOR CASS ON RADIO ASTRONOMY RELATED ACTIVITIES IN 2011

MARSFIELD		
Allen	Graham	Engineering
Amy	Shaun	Operations
Axtens	Peter	Engineering
Banfield	Julie	Astrophysics
Bannister	Keith	Astrophysics
Barends	Anne	Executive Secretary
Barry	Samantha	Operations/Project Support
Bateman	Tim	Engineering
Beresford	Ronald	Engineering
Bock	Douglas	Operations
Bolton	Russell	Engineering
Bourne	Michael	Engineering
Bowen	Mark	Engineering
Boyle	Brian	Portfolio Leader SKA
Braun	Robert	Astrophysics
Breen	Shari	Astrophysics
Brooks	Kate	Astrophysics
Brown	Andrew	Engineering
Brown	Shea	Astrophysics
Calabretta	Mark	Software Development
Carrad	Graeme	Engineering
Castillo	Santiago	Engineering
Caswell	James	Astrophysics
Chapman	Jessica	Operations
Chaudhary	Ankur	Astrophysics
Chekkala	Raji	Engineering
Cheng	Wanxiang	Engineering
Chippendale	Aaron	Engineering
Chung	Yoon	Engineering
Conway-Derley	Flornes	Communications and Outreach
Cook	Geoffrey	Engineering
Cooper	Paul	Engineering
Cornwell	Tim	Software Development
Crawshaw	Tony	Communications and Outreach
Crosby	Phil	Business Strategy
Dangi	Binduben	Engineering
Davis	Evan	Engineering
Death	Michael	Engineering
Diamond	Phil	CASS Chief and ATNF Director
Dixon	John	Engineering
Doherty	Paul	Engineering
Drazenovic	Victoria	Operations
Dunning	Alexander	Engineering
Edwards	Leanne	Operations
Edwards	Philip	Operations

Ekers	Ron	Astrophysics
Elton	Troy	Engineering
Emonts	Bjorn	Astrophysics
Feain	Ilana	Astrophysics
Ferris	Richard	Engineering
Forsyth	Ross	Engineering
Fraser	Vicki	Project Support
Franzen	Thomas	Astrophysics
Frost	Gabriella	Project Specialist
Gonidakis	Yiannis	Astrophysics
Gough	Russell	Engineering
Gough	Sarah	Engineering
Green	James	Astrophysics
Guzman	Juan-Carlos	Software Development
Hakvoort	Eliane	Engineering
Hampson	Grant	Engineering
Haan	Sebastian	Astrophysics
Hartmann	Carmel	Project Support
Harvey-Smith	Lisa	Astrophysics
Haskins	Craig	Software Development
Hill	Alexander	Astrophysics
Hobbs	George	Astrophysics
Hollow	Robert	Communications and Outreach
Humphreys	Benjamin	Software Development
Hotan	Aidan	Project Specialist
Huynh	Minh	Engineering
Jackson	Suzanne	Engineering
Jackson	Carole	Project Specialist
Jeganathan	Kanapathippillai	Engineering
Johnston	Simon	Astrophysics
Jurek	Russell	Astrophysics
Kachwalla	Elsa	Operations/Project Support
Kanoniuk	Henry	Engineering
Keith	Michael	Astrophysics
Kesteven	Michael	Engineering
Khoo	Jonathan	Astrophysics
Kiraly	Dezso	Engineering
Koenig	Ronald	Engineering
Koribalski	Baerbel	Astrophysics
Kosmynin	Arkadi	Operations
Lauter	Benjamin	Engineering
Leach	Mark	Engineering
Lee	Jennifer	Project Support
Lenc	Emil	Software Development
Lie	Jennifer	Engineering
Mackay	Simon	Engineering
Macleod	Adam	Project Specialist
Maher	Anthony	Software Development
Manchester	Dick	Astrophysics, Federation and CSIRO Fellow
Manefield	Gwenyth	Project Support

Marston	Michiko	Project Specialist
Marquarding	Malte	Software Development
McClure-Griffiths	Naomi	Astrophysics
McConnell	David	Operations
McIntyre	Vincent	Operations
Mickle	Samantha	Engineering
Moncay	Ray	Engineering
Morison	Neale	Software Development
Neuhold	Stephan	Engineering
Ng	Alan	Project Specialist
Ng	Andrew	Engineering
Norris	Ray	Astrophysics
O'Sullivan	John	Engineering
O'Sullivan	Shane	Astrophysics
Pearce	Sarah	CASS Deputy Chief
Petroff	Emily	Astrophysics
Phillips	Chris	Operations
Pope	Nathan	Operations
Rathborne	Jill	Astrophysics
Reilly	Leslie	Engineering
Reynolds	John	Operations
Roberts	Paul	Engineering
Roxby	Daniel	Engineering
Russell	Gabby	Communications and Outreach
Sanders	Aaron	Engineering
Schinckel	Antony	Project Specialist
Schnitzler	Dominic	Astrophysics
Shannon	Ryan	Astrophysics
Seymour	Nicholas	Astrophysics
Shields	Matthew	Engineering
Sim	Helen	Communications and Outreach
Smith	David	Project Specialist
Spolaor	Sarah	Astrophysics
Storey	Michelle	Policy Strategy
Tesoriero	Julie	Project Support
Troup	Euan	Operations
Tuthill	John	Engineering
Tzioumis	Tasso	Operations
Urquhart	James	Astrophysics
Vera	Jeffrey	Engineering
Voronkov	Maxim	Software Development
Whiting	Matthew	Software Development
Wilson	Warwick	Engineering
Wong	Oiwei	Astrophysics
Wormnes	Kjetil	Engineering
Wu	Xinyu	Software Development
Xue	Gordon	Project Specialist
MARSFIELD RESEARCH SUPPORT		
Agnostino	Damiano	Finance
Broadhurst	Sue	Reception

D'Amico	Andy	Stores
Derwent	Neil	Finance
Fraser	Kylie	Health, Safety and Environment
Joos	Arianna	Library
Levers	Helen	HR
Lee	Olivia	Finance
Looi	Chee Kong	Health, Safety and Environment
Merrick	Sarah	Finance
Poshoglian	Meg	Reception
Randell	Sandra	Finance
Suidgeest	Hayley	HR
Van der Leeuw	Christine	Library
Wilson	Briony	Finance
NARRABRI		
Adamson	Belinda	Operations
Bateman	John	Operations
Brem	Christoph	Operations
Brennan	Donna	Operations
Brodrick	David	Operations
Dodd	Susan	Operations
Forbes	Kylee	Operations
Hill	Michael	Operations
Hiscock	Brett	Operations
Hiscock	Jennifer	Operations
Houldsworth	Joanne	Operations
Indermuehle	Balthasar	Operations
Kelly	Pamela	Operations
Kelly	Rosslyn	Operations
Lennon	Brett	Operations
Madden	Brian	Operations
Martin	Heather	Operations
McAllister	Kelly	Operations
McFee	John	Operations
McFee	Margaret	Operations
McKay	Ben	Operations
Mirtschin	Peter	Operations
Munting	Scott	Operations
Rees	Margaret	Operations
Stevens	Jamie	Operations
Sunderland	Graeme	Operations
Tough	Bruce	Operations
Wark	Robin	Operations
Webster	Norman	Operations
Wieringa	Mark	Operations
Wilson	Christine	Operations
Wilson	John	Operations
Wilson	Tim	Operations
NARRABRI RESEARCH SUPPORT		
Johnson	Brian	Property Services
Leven	Clarence	Property Services

PARKES		
Armstrong	Brett	Operations
Black	Laura	Operations
Carretti	Ettore	Operations
Cole	Janette	Operations
Craig	Daniel	Operations
Crocker	Jonathan	Operations
Dawson	Brett	Operations
Dean	Andrew	Communications and Outreach
Evans	Anne	Operations
Hockings	Julia	Operations
Hollingdrake	Chris	Communications and Outreach
Hoyle	Simon	Operations
Hunt	Andrew	Operations
Ingram	Shirley	Operations
Laing	Alan	Operations
Laing	Jenny	Property Services and Operations
Lees	Tom	Operations
Lensson	Erik	Operations
Mader	Stacy	Operations
Marshall	Margaret	Operations
McRobert	Ian	Operations
McFarland	Matthew	Property Services and Operations
Milgate	Lynette	Operations
Preisig	Brett	Operations
Reeves	Ken	Operations
Ruckley	Timothy	Operations
Sarkissian	John	Operations
Smith	Malcolm	Operations
Spratt	Gina	Operations
Trim	Tricia Lee	Communications and Outreach
Unger	Karin	Communications and Outreach
Wilson	Beverley	Communications and Outreach/Operations
PARKES RESEARCH SUPPORT		
Brady	Scott	Property Services
GERALDTON		
Clayton	Priscilla	Project Specialist
Boddington	Robin	Project Specialist
Briggs	Brayden	Health, Safety and Environment
Harding	Alexander	Project Specialist
Morris	John	Project Specialist
Puls	Lou	Project Specialist
Reay	Michael	Project Specialist
Turner	Barry	Project Specialist
Whiting	Gemma	Project Specialist

The staff list includes staff from CSIRO Astronomy and Space Science (CASS) and other divisions who worked for CASS on radio astronomy related activities in the period January to December 2011.

D: Observing programs

The observations listed are those that were allocated time through the Time Assignment Committee's processes. A small number of 'Target of Opportunity' observations are not listed.

OBSERVATIONS MADE WITH THE AUSTRALIA TELESCOPE COMPACT ARRAY

October 2010 to September 2011

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
Stevens, Edwards, Wark, Wieringa	CASS, CASS, CASS, CASS	ATCA calibrators	C007
Staveley-Smith, Gaensler, Tzioumis, Kesteven, Ball, Ng, Zanardo, Potter	UWA, USyd, CASS, CASS, CASS, UMcGill, UWA, UWA	Supernova remnant 1987A	C015
Johnston, Karastergiou, Roberts, Ray, Grundstrom, Abdo, Parent, Grove	CASS, UOx, Eureka, NRL, UVAND, NRL, NRL, NRL	Unpulsed transient Emission from the PSR B1259-63 System	C326
Brocksopp, Tzioumis, Corbel, Fender	MSSL, CASS, UParis7, USouth	Radio jets in recurrent and new black hole X-ray transients	C989
Ubach, Maddison, Menard	Swinb, Swinb, OGR	Observations of the beginnings of planet formation	C1173
Hoare, Voronkov, Urquhart, Lumsden, Purcell, Maud	ULeeds, CASS, MPIfR, ULeeds, USyd, ULeeds	High resolution continuum observations of massive YSOs	C1176
Corbel, Tzioumis, Fender, Kaaret, Tomsick, Orosz	UParis7, CASS, USouth, IOWA, UCSD, SDSU	Large scale radio/X-ray jets in microquasars	C1199
Lundqvist, Ryder, Bjornsson, Fransson, Schmidt, Perez Torres	StO, AAO, StO, StO, ANU, IAAC	Probing the radio emission from a young Type Ia supernova	C1303
Ryder, Weiler, Stockdale, Van Dyk, Panagia, Amy, Argo, Immler, Covarrubias	AAO, NRL, UMARQ IPAC, STScI, CASS, UCurt, GSFC, AAO	NAPA observations of core-collapse supernovae	C1473
Stark, Walsh, De Breuck, Crawford, Marrone, Mcintyre, Vieira, Carlstrom, Greve, Bleem, Holzapfel, Ashby, Fassnacht	CfA, CfA, ESO, UChig, UAz, CASS, Caltech, UChig, UCOP, UChig, UCB, CfA, UChig	Accurate positions for rare and bright dusty star forming galaxies discovered with the South Pole Telescope	C1563
Ekers, Phillips, Reynolds, Protheroe, Mcfadden, James, Roberts, Bray	CASS, CASS, CASS, UAd, CASS, UAd, CASS, CASS	A radio search for UHE particles from Centaurus A	C1637
Prandoni, Ricci, Parma, De Ruiter	IRA-INAF, INAF, IRA-INAF, INAF	Assessing the AGN component in the faint radio population	C1661
Schnitzeler, Chapman, Lopez-Sanchez, Hollow	CASS, CASS, AAO, CASS	CASS Summer Vacation Programme 2010/2011	C1726
Edwards, Macquart, Lovell, Ojha, Kadler, Hungwe, Stevens, Blanchard, Mueller, Wilms, Boeck	CASS, UCurt, UTas, GSFC, GSFC, HartRAO, CASS, UTas, ROandECAP, ROandECAP, ROandECAP	ATCA monitoring of gamma-ray loud AGN	C1730
Westmeier, Koribalski, Staveley-Smith, Braun, Bekki	UWA, CASS, UWA, CASS, UWA	Structure formation in the Sculptor group: NGC 247 and NGC 7793	C1757
Delhaize, Gaensler, Staveley-Smith, Sadler, Kesteven, Subrahmanyan, Meyer, Boyle, Driver	UWA, USyd, UWA, USyd, CASS, RRI, UWA, CASS, USAND	Galaxy evolution - A pathfinder study	C1805
Britton, Caswell, Voronkov, Sobolev, Ellingsen, Salii	CASS, CASS, CASS, USU, UTas, USU	Class I methanol masers and shocks	C1820
Eckart, Sjouwerman, Straubmeier, Kunneriath, Witzel, Schoedel, Garcia-Marin, Valencia-s.	UKOELN, NRAO, UKOELN, AIPr, UKOELN, IAAC, UKOELN, UKOELN	Coordinated observations of SgrA* in 2011	C1825
Lumsden, Voronkov, Brooks, Hoare, Garay, Urquhart, Purcell, Guzman, Maud	ULeeds, CASS, CASS, ULeeds, UChi, MPIfR, USyd, UChi, ULeeds	Ionised winds and jets from massive young stellar objects	C1862
Voronkov, Caswell, Green, Sobolev, Ostrovskii, Ellingsen, Goedhart, Gaylard	CASS, CASS, CASS, USU, USU, UTas, HartRAO, HartRAO	Understanding periodic flares of the methanol masers	C1929
Edge, Sadler, Salome, Hatch, O'Dea, Fabian, Hamer, Johnstone, Wilman, Hogan, McNamara, Hlavacek-Larrondo	UDur, USyd, IRAM-F, LO, Rochl, IoA, UDur, UCam, UMelb, UDur, UWATER, UCam	The compact cores of central cluster galaxies	C1958
Soria, Broderick, Pottschmidt, Kuulkers, Cadolle Bel	UCL, USouth, GSFC, ESA Villafranca, ESA Villafranca	Jet variability in the Galactic microquasar GRS J1758-258	C1963
Agliozzo, Trigilio, Buemi, Umana, Noriega-Crespo, Leto	OCat, OCat, OCat, OCat, IPAC, OCat	Luminous blue variables in the Large Magellanic Cloud	C1973

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
Hoare, Rathborne, Burton, Brooks, Green, Fuller, Fender, Ellingsen, Moore, Green, Cesaroni, Urquhart, Dougherty, Churchwell, Lumsden, Walsh, Thompson, Zijlstra, Kurtz, Purcell, Paladini, Umana, Pandian, Molinari, Wieringa, Marti, Jackson, Cotton, O'Brien, Paredes, Diamond	ULeeds, CASS, UNSW, CASS, CASS, UMan, USouth, UTas, LivJMU, USyd, OAAI, MPIfR, DRAO, UWis, ULeeds, JCU, UHerts, UMan, UNAM, USyd, IPAC, OCat, MPIfR, IRA-INAF, CASS, UJAEN, UBos, NRAO, JBO, UBARC, CASS	The coordinated radio and infrared survey for high-mass star formation: CORNISH-South	C1977
Corbel, Edwards, Sadler, Thompson, Gehrels, Tingay, Wieringa, Grenier, Chaty, Dubus, Cameron, Abraham	UParis7, CASS, USyd, GSFC, GSFC, UCurt, CASS, UParis7, UParis7, OGR, UStan, PSU	ATCA follow-up of unidentified flaring Fermi gamma-ray sources	C2051
Emonts, Sadler, Morganti, Norris, Tadhunter, Ekers, Feain, Oosterloo, Miley, Stevens, Mao, Carilli, Villar-Martin, Mahony, Saikia, Rottgering, van Moorsel, Berciano	CASS, USyd, NFRA, CASS, USheff, CASS, CASS, NFRA, LO, CASS, UTas, NRAO, IAA, USyd, NCRA, LO, NRAO, NFRA	CO content of protocluster radio galaxies in the early Universe: a CABB study	C2052
Coppin, Weiss, Van Der Werf, Menten, De breuck, Walter, Loenen, Edge, Emonts, Huynh, Swinbank, Smail, Schinnerer, Greve, Chapman, Danielson, Knudsen, Dannerbauer, Brandt, Strom, Berciano	UMcGill, MPIfR, LO, MPIfR, ESO, MPIA, LO, UDur, CASS, UWA, UDur, UDur, MPIA, UCOP, UCam, UDur, UBonn, CEA, PSU, UCam, NFRA	Constraining the excitation conditions of the molecular gas in the most distant submillimetre galaxy at z=4.76	C2089
Kepley, Gaensler	UVir, USyd	Magnetizing the Universe: the role of compact groups	C2103
Walsh, Voronkov, Lo, Jones, Cunningham, Burton, Brooks, Hoare, Phillips, Green, Longmore, Urquhart, Thompson, Purcell, Breen, Harvey-Smith, Indermuehle, Quinn, Hindson, Britton, Lowe	JCU, CASS, UChi, UNSW, UNSW, UNSW, CASS, ULeeds, CASS, CASS, CfA, MPIfR, UHerts, USyd, CASS, CASS, CASS, UMan, UHerts, CASS, UNSW	Accurate water maser positions for HOPS	C2148
Edge, Sadler, Whiting, Curran, Hamer, Wilman, Hogan	UDur, USyd, CASS, USyd, UDur, UMelb, UDur	Atomic hydrogen in the cores of clusters of galaxies	C2152
Walsh, Beuther, Longmore, Fallscheer	JCU, MPIA, CfA, MPIA	High mass accretion disks: ATCA's potential for deep impact II	C2164
Titmarsh, Caswell, Voronkov, Burton, Brooks, Fuller, Ellingsen, Walsh, Thompson, Breen	UTas, CASS, CASS, UNSW, CASS, UMan, UTas, JCU, UHerts, CASS	Water maser follow up of the methanol multi-beam survey	C2186
Ellingsen, Caswell, Voronkov, Sobolev, Breen	UTas, CASS, CASS, USU, CASS	Rare class II methanol masers: physical and evolutionary probes for high-mass star formation regions	C2191
Koribalski, Ryder, Lopez-Sanchez, Karachentsev	CASS, AAO, AAO, RAS	Examining the spiral galaxy NGC7531 and its ghost	C2196
Purcell, Lo, Jones, Cunningham, Burton, Minier, Longmore, Herpin, Walsh, Hill, Redman, Indebetouw, Lowe	USyd, UChi, UNSW, UNSW, UNSW, CEA, CfA, OBordeaux, JCU, CEA, NUI, NRAO, UNSW	Dissecting a very young massive star-forming clump in NGC3576	C2197
Aravena, Bertoldi, Feain, Ivison, Papadopoulos, Wagg	NRAO, UBonn, CASS, ROE, UBonn, ESO	Testing the ULIRG/QSO transition hypothesis	C2247
Benbekhti, Westmeier, Richter, Winkel	AIFA, UWA, UPOT, MPIfR	Low-column density gas in the halo of the Milky Way	C2267
Green, Caswell, Voronkov	CASS, CASS, CASS	Is there correlated day-to-day variability in CH3OH and OH maser emission in G12.889+0.489?	C2287
Green, Caswell, McClure-Griffiths, Harvey-Smith, Robishaw	CASS, CASS, CASS, CASS, USyd	MAGMO: Mapping the Galactic magnetic field through OH masers	C2291
Bannister, Gaensler, Murphy, Hancock	CASS, USyd, USyd, USyd	Follow-up of transients and variables from the Molonglo Observatory Synthesis Telescope	C2292
Doyle, Slee, Budding, Antonova, Umana, Hallinan, Ramsay, Innis	ArO, CASS, CO, ArO, OCat, NUI, ArO, BRO	Assessing the extent of coherent emission events in active stellar systems	C2294

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
Doyle, Antonova, Hallinan, Golden, Yu, Harding, Kuznetsov	ArO, ArO, NUI, NUI, ArO, NUI, ArO	Denis 1048-3956 & LP 944-20: Diagnosing their emission mechanism and hence field strength	C2295
Ott, Henkel, Meier, Feain, Martin-Pintado, Israel, Impellizzeri	NRAO, MPIfR, NMIMT, CASS, IEM, LO, NRAO	The ATCA CABB Line survey on Centaurus A: Properties of the molecular gas from the dust lanes to the central engine	C2298
Bagchi, Paul, Malu	IUCAA, IUCAA, RRI	ATCA mapping of giant ringlike radio structures around galaxy cluster Abell 3376	C2302
Tudose, Tzioumis, Belloni, Altamirano, Linares, Mendez, Hiemstra	NFRA, CASS, OABrera, UAm, UAm, KI, KI	The disc-jet coupling in the neutron star X-ray binary 4U 1728-34	C2312
Suarez, Gomez, Miranda, Rizzo, Guerrero, Ramos-Larios	OAzur, IAAC, IAAC, ESA Villafranca, IAAC, IAM	The first water fountain in a planetary nebula	C2315
Cluver, Koribalski, Appleton, Jarrett, Kraan-Korteweg, Emonts	AAO, CASS, Caltech, Caltech, UCT, CASS	Uncovering the star formation mechanism in the hidden HI-massive galaxy, HIZOA J0836-43	C2325
Jarrett, Tsai, Norris, Wright, Emonts, Benford, Blain, Lonsdale, Yan, Eisenhardt, Cutri, Stanford	Caltech, Caltech, CASS, UCLA, CASS, GSFC, Caltech, NRAO, Caltech, JPL, Caltech, LLNL	Radio continuum observations of hyper-luminous infrared galaxies discovered by the Wide-Field Infrared Survey Explorer	C2328
Zapata, Williams	MPIfR, UHawaii	Radio observations of the Carina Nebula: A study of the proplyds in extreme environments	C2334
Leurini, Cunningham, Wyrowski, Pillai, Schuller, Testi, Stanke	MPIfR, UNSW, MPIfR, Caltech, MPIfR, ESO, ESO	Temperature distribution in the infrared dark cloud G351.77-00.51	C2336
Coutens, Vastel, Bottinelli, Caux	CESR, CESR, CESR, CESR	Tracing propyne in the surroundings of the low-mass protostar IRAS16293	C2337
Popping, Oh, Braun	UWA, MSSSO, CASS	HI detections of the cosmic web	C2351
Hill, Jones, Cunningham, Minier, Pinte	CEA, UNSW, UNSW, CEA, LAG	High resolution ammonia observations of young massive protostars	C2357
Remijan, Jones, Cunningham, Thorwirth, Menten, Schilke, Belloche, Meier, Walsh, Kurtz, Bruenken, Mccarthy, Liu, Pate, Corby, Steber	NRAO, UNSW, UNSW, MPIfR, MPIfR, UKOELN, MPIfR, NMIMT, JCU, UNAM, UKOELN, CfA, ASIAA, UVir, UVir, UVir	Investigating the local physical and chemical environments toward the Galactic Center Region - SgrB2(N)	C2358
Webb, Lenc, Corbel, Fender, Heywood, Farrell, Barret, Cseh, Godet	CESR, CASS, UParis7, USouth, UOx, USyd, CESR, CEA, CESR	Verifying the intermediate mass black hole nature of the ultraluminous X-ray source HLX-1 associated with ESO 243-49	C2361
Lumsden, Caselli	ULeeds, ULeeds	Are FeLoBAL quasars intrinsically young?	C2365
Bojicic, Payne, Filipovic, Cohen, Parker, Crawford, De Horta	UMac, JCU, UWS, UCB, UMac, UWS, UWS	The bright end of the radio PNe luminosity function	C2367
Urquhart, Hoare, Moore, Morgan, Figura	MPIfR, ULeeds, LivJMU, LivJMU, WBC	Probing the environments of young massive stars	C2369
Kraus, Menten, Schilke, Wyrowski, Bergin, Wienen, Weigelt	UMich, MPIfR, UKOELN, MPIfR, UMich, MPIfR, MPIfR	Zooming in on high-mass star formation with combined VLTI near-infrared interferometry and ATCA millimeter interferometry	C2377
Robbins, Gaensler, Murphy, Green, Moss	USyd, USyd, USyd, USyd, USyd	Identifying young Galactic supernova remnants	C2407
Cannon	MAC	Exploring the relations Between radio continuum and PAH emission in metal-poor galaxies	C2421
Peters, Ken, van der Kruit	KI, ANU, KI	The vertical variation of HI velocity dispersion in disk galaxies	C2422

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
Partridge, Massardi, Hughes, Sanchez, Marriage, Marsden, Reese, Lin, Moodley	Haverford, INAF, INAOE, INAOE, JHU, UPENN, UPENN, IPMU, UKZN	Observations at 7mm of a complete sample of 148 GHz sources	C2423
Marriage, Massardi, Partridge, Hughes, Sanchez, Marsden, Reese, Lin, Moodley	JHU, INAF, Haverford, INAOE, INAOE, UPENN, UPENN, IPMU, UKZN	ACT-ATCA study of 148 and 218 GHz selected sources	C2424
Scaife, Ekers, Green	DIAS, CASS, MRAO	Microwave emission from spinning dust in circumstellar disks	C2426
Ott, Hughes, Wong, Henkel, Muller, Meier, Looney, Indebetouw, Pineda, Seale, Anderson	NRAO, MPIA, UIl, MPIfR, NAOJ, NMIMT, UIl, NRAO, JPL, STScI, NMIMT	The physics and chemistry of star formingcClumps in the LMC	C2429
Sadler, Morganti, Zwaan, Whiting, Curran, Bland-Hawthorn, Oosterloo, Allison, Emonts, Reeves	USyd, NFRA, ESO, CASS, USyd, AAO, NFRA, USyd, CASS, USyd	A search for HI and OH absorption in young compact radio galaxies	C2434
Fontani, Dodson, Burton, Cesaroni, Brand, Molinari, Sanchez-Monge, Rioja, Beltran	Acretri, UWA, UNSW, OAAI, INAF, IRA-INAF, Acretri, UWA, OAAI	Investigating the earliest stages of high-mass star formation	C2435
O'Sullivan, Gaensler, McClure-Griffiths, Carretti, Harvey-Smith, Landecker, Taylor, Robishaw, Clarke, Schnitzeler, Brown, Possum collaboration	CASS, USyd, CASS, CASS, CASS, DRAO, UCal, USyd, NRL, CASS, CASS, USyd	A search for primary polarization calibrators for ASKAP	C2437
Kilborn, Meurer, Bekki	Swinb, UWA, UWA	The star formation efficiency of galaxies in groups	C2440
Rushton, Maccarone, Conway, Laing, Black, Spencer, Cawthorne	ESO, USouth, OSO, ESO, OSO, JBO, CLancsCfA	Multi-wave studies of the jet in SS 433	C2442
Cerrigone, Menten, Wiesemeyer	MPIfR, MPIfR, MPIfR	IRAS 15452-5459: a rare rapidly evolving post-AGB star with a double-peaked SiO maser?	C2443
Pestalozzi, Evangelista, Campana	UHerts, IASF-CNR, IASF-CNR	Search for radio emission from the elusive gamma-ray source 3EG J1837-0423	C2444
Cordiner, Wright, Smith, Purcell, Charnley, Wirstrom	GSFC, ADFA, ADFA, USyd, GSFC, GSFC	The distribution of organic molecules in the very young protostar Chamaeleon MMS-1	C2447
Fukui, McClure-Griffiths, Yamamoto, Dawson, Kawamura, Furukawa, Akio, Okuda, Sato, Sano	UNag, CASS, UNag, UTas, NAOJ, UNag, UNag, UNag, UNag, UNag	HI observations of the TeV gamma-ray SNR RX J0852.0-4622 (Vela Jr.)	C2449
Greve, de Breuck, König, Ivison, Papadopoulos, Kovacs	UCOP, ESO, UCOP, ROE, UBonn, UMinn	Probing the cold molecular gas reservoir in a proto-cluster at z=4.11	C2450
Ao, Henkel	MPIfR, MPIfR	Search for ammonia absorption lines in the distant galaxies	C2452
Fender, Tzioumis, Kawai, Calvelo	USouth, CASS, TITECH, USouth	Probing the inner jet and core of Circinus X-1: the most relativistic source in our galaxy	C2453
Ohm, Urquhart, Skilton, Hinton, Domainko	ULeic, MPIfR, ULeeds, ULeic, MPIFK	Search for non-thermal radio emission from Eta Carina's outer blast wave with ATCA	C2455
Possenti, Burgay, Israel, Wieringa, Rea, Esposito	CAO, CAO, OARome, CASS, IAAC, CAO	Continuum radio emission from magnetars in outburst	C2456
Baker, Hughes, Marriage, Aguirre, Braglia, Das, Hernandez-Monteagudo, Infante, Lima, Lindner, Menanteau, Sehgal	URutg, URutg, JHU, PUCC, UBC, UCB, MPIfA, PUCC, IPMU, URutg, URutg, UStan	ATCA mapping of two galaxy clusters in a mass-selected sample	C2457
Lopez-Cruz, Bertoldi, Bremer, Birkinshaw, Johansson, Muller, Black, Papadopoulos, Horellou, Wall, Ibarra-Medel, Castillo	INAOE, UBonn, UBr, UBr, OSO, OSO, OSO, UBonn, OSO, INAOE, INAOE, INAOE	The nature of the brightest sub-mm source behind the bullet cluster	C2459
Jenet, Stevens, Wieringa, Creighton	UTex, CASS, CASS, UTex	Rapid radio follow-ups of LIGO gravitational wave events	C2461
Murphy, Turner, Schinnerer, Scaife, Condon, Helou	CarO, UCLA, MPIA, DIAS, NRAO, Caltech	A microwave survey of star formation and anomalous dust emission in nearby galaxies	C2468

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
Green, Caswell	CASS, CASS	Is the elusive linearly polarized Zeeman pi component present in excited-state OH masers?	C2471
Cohen, Edwards, Stevens	UCB, CASS, CASS	A study of cool giant chromospheres and a search for absolute mm stellar calibrators	C2476
Stevens, Johnston, Bannister	CASS, CASS, CASS	Variability in the BETA science fields	C2478
Feain, Johnston	CASS, CASS	ATCA characterisation of first BETA fields	C2479
Melis, Maddison	UCSD, Swinb	Toward a VLBI probe of PZ Tel's inner planetary system	C2487
Brooks, Gaensler, Voronkov, Rathborne, Garay, Green, Robishaw, Smith, Reiter	CASS, USyd, CASS, CASS, UChi, USyd, USyd, ASU, ASU	CARPARC - Carina Parkes-ATCA radio continuum survey	C2489
Ricci, Brooks, Testi, Maury	Caltech, CASS, ESO, ESO	Investigating dust grain growth in very young stellar objects with ATCA	C2491
Soria, Long, Winkler, Kuntz, Blair	UCL, STScI, MC, JHU, JHU	Compact radio sources in the spiral galaxy M83	C2494
Van loon, Staveley-Smith, Zanardo, Lakicevic	UKeele, UWA, UWA, UKEELE	Preparing for ALMA: the millimetre appearance of SNR1987A	C2495
Emonts, Sadler, Norris, Ekers, Feain, Miley, Mao, Villar-Martin	CASS, USyd, CASS, CASS, CASS, LO, UTas, IAA	Mapping the wide-spread molecular gas in a z~2 radio galaxy	C2498
Regis, De blok, Bouchard, Richter, Colafrancesco, Profumo, Ullio	UCT, NFRA, UCT, URh, ASI/SAX, UCSC, SISSA	Continuum and HI emissions from local group dwarf spheroidal galaxies	C2499
Welty, Murphy, Xue, Wong	UIl, USyd, UIl, UIl	Absorption from diffuse molecular gas in the LMC	C2504
Muller, Curran, Beelen, Aalto, Combes, Guelin, Black, Horellou	OSO, USyd, IASp, OSO, OPM, IRAM-F, OSO, OSO	Measurements of the CMB temperature at z=0.89	C2506
O'Sullivan, McClure-Griffiths, Green, Sault, Norris, Feain, Harvey-Smith, Gabuzda, Vitrishchak	CASS, CASS, CASS, UMelb, CASS, CASS, CASS, UCC, StAI	Determining the generation mechanism for circularly polarized emission in active galactic nuclei	C2510
Miller-Jones, Migliari, Diaz Trigo	UCurt, UBARC, ESO	Probing the disc wind-jet connection in black hole transients	C2514
Umana, Johnston-Hollitt, Lazio, Hobbs, Norris, Slee, Trigilio, Guirado, Budding, Thompson, Buemi, Mao, Keller, Hallinan, Doyle, Ramsay, Leto, Leone, Bunton	OCat, VUW, JPL, CASS, CASS, CASS, OCat, UVal, CO, UHerts, OCat, UTas, MSSSO, NUI, ArO, ArO, OCat, UCat, ICT	Stellar radio emission in the SKA era	C2515
Stecklum, Voronkov, Ellingsen, Linz, Schreyer	TLT, CASS, UTas, MPIA, AIU	Methanol masers in the disk and outflow of IRAS13481-6124	C2518
Massardi, Van Der Werf, Norris, Ekers, de Zotti, Michalowski, Birkinshaw, Andreani, Emonts, Ivison, Maiolino, Eales, Bonavera, Ibar, Cooray, Buttiglione, Danese, Gonzalez-Nuevo Gonzalez, Lapi, Vaccari, Rodighiero, Negrello, Jarvis, Leeuw, Temi, Lopez-Caniego, Herranz	INAF, LO, CASS, CASS, OAPd, ROE, UBr, ESO, CASS, ROE, OARome, UCARDIFF, SISSA, ROE, UChig, OAPd, SISSA, SISSA, UDSR, UPad, UPad, Open, UHerts, URh, NASA-RC, IFCA, IFCA	Spectroscopic high-resolution observation of candidate lensed galaxies at 2.2< z< 2.6	C2522
Ricci, Maddison, Wilner, Testi	Caltech, Swinb, CfA, ESO	Investigating the large grains in the Fomalhaut debris disk with ATCA	C2524
Csengeri, Wyrowski, Hill, Motte, Bontemps, Schneider, Wienen, Hennemann	MPIfR, MPIfR, CEA, CEA, OBordeaux, CEA, MPIfR, CEA	Comparing dust and gas temperature of pre/protostellar cores in the Rosette molecular complex	C2528
Pantin, Maddison, Wilner, Menard, Pinte, Gonzalez, di Folco, Morel, Thi	CEA, Swinb, CfA, OGR, OGR, CRAL, CEA, CEA, OGR	Radial dust migration in the TW Hydra protoplanetary disk	C2529
Bremer, Stanway, Birkinshaw, Lehnert, Davies, Lopez-Cruz, Smith, Squitieri	UBr, UBr, UBr, OPM, UBr, INAOE, UBir, UBr	A deep look at high redshift CO emission	C2531

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
Ricci, Brooks, Testi, Goddi, Isella	Caltech, CASS, ESO, ESO, Caltech	Constraining the long wave emission of Southern Herbig Ae/ Be with ATCA	C2534
Miller-Jones, Tzioumis, Maccarone, Jonker, Nelemans, Sivakoff	UCurt, CASS, USouth, SRON, RUN, UVir	Constraining black hole formation with triggered LBA astrometry	C2538
Miller-Jones, Tzioumis, Phillips, Fender, Nicolson, Tingay, Moin, Reynolds	UCurt, CASS, CASS, USouth, HartRAO, UCurt, SHAO, UCurt	Triggered LBA imaging of the relativistic jets in Circinus X-1	C2540
Coriat, Corbel, Belloni, Miller-Jones, Soleri	USouth, UParis7, OABrera, UCurt, UAm	Following the decay of the black hole candidate X-ray binary SWIFT J1753.5-0127	C2541
Ireland, Tuthill, De Gregorio Monsalvo, Huelamo, Lacour, Kraus	UMac, USyd, , ESO (Germany), OPM, UHawaii	The T Cha transition disk: A site of Active planet formation?	C2543
Stanway, Tanvir, Davies, Levan, Perley	UBr, ULeic, UBr, UWARWICK, UCB	Are dark GRBs hosted in dusty starburst galaxies?	C2544
Struve, Conway, Pihlstrom, Muller, Black, Elitzur	OSO, OSO, UNM, OSO, OSO, UKent	The search for atomic and molecular TORUS gas in Seyfert 2 galaxies	C2547
Bock, Ekers, Massardi, Stevens	CARMA, CASS, INAF, CASS	Refining the millimetre flux density scale	C2548
Zechlin, Voronkov, Lobanov, Horns	UHam, CASS, MPIfR, UHam	Dark Fermi sources: A different AGN population, or signals from dark matter?	C2551
Muller, Guelin	OSO, IRAM-F	Chemical complexity in the z = 0.89 molecular absorber in front of PKS1830-211	C2557
Linz, Krause, Vasyunina, Pavlyuchenkov	MPIA, MPIA, UVir, RAS	The onset of massive star formation - How ATCA can pinpoint the smoking gun	C2558

OBSERVATIONS MADE WITH THE PARKES RADIO TELESCOPE

October 2010 to September 2011

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
van Straten, Possenti, Manchester, Johnston, Kramer, Hobbs, Camilo, Bailes, Bhat, Ransom, Keith, Burke-Spolaor, Stappers, Levin, Oslowski	Swinb, CAO, CASS, CASS, MPIfR, CASS, UClmba, Swinb, Swinb, NRAO, CASS, CASS, JBCA, Swinb, Swinb	Precision pulsar timing	P140
Freire, Manchester, Kramer, Lyne, D'Amico, Camilo, Lorimer	MPIfR, CASS, MPIfR, JBO, CAO, UClmba, JBO	Timing and searching for pulsars in 47 Tucanae	P282
Bailes, Verbiest, Bhat, Van straten	Swinb, MPIfR, Swinb, Swinb	Studies of relativistic binary pulsars	P361
D'Amico, Possenti, Manchester, Johnston, Kramer, Sarkissian, Lyne, Burgay, Corongiu, Camilo, Bailes, van Straten	CAO, CAO, CASS, CASS, MPIfR, CASS, JBO, CAO, CAO, UClmba, Swinb, Swinb	Timing of millisecond pulsars in globular clusters	P427
Burgay, Possenti, Manchester, Kramer, Lyne, Mclaughlin, D'Amico, Stairs, Lorimer, Ferdman	CAO, CAO, CASS, MPIfR, JBO, WVU, CAO, UBC, JBO, UMan	Timing and geodetic precession in the double pulsar and two relativistic binaries	P455
Hobbs, Manchester, Verbiest, Sarkissian, Bailes, Bhat, Jenet, Keith, Burke-Spolaor, van Straten, Yardley, Oslowski, Hotan, Champion, Khoo, Shannon, Chaudhary	CASS, CASS, MPIfR, CASS, Swinb, Swinb, UTex, CASS, CASS, Swinb, CASS, Swinb, UCurt, MPIfR, RP, CASS, CASS	A millisecond pulsar timing array	P456
Titov, Lovell, Dickey, Jauncey, Ellingsen, Reynolds, Fey, Tingay, Hase	GSC, UTas, UTas, CASS, UTas, CASS, USNO, UCurt, BKG	Improving the terrestrial and celestial reference frame through southern hemisphere geodetic VLBI observations	P483
Eatough, Possenti, Manchester, Verbiest, Kramer, Lyne, Hobbs, Burgay, Camilo, Stairs, Keith, Lorimer	JBO, CAO, CASS, MPIfR, MPIfR, JBO, CASS, CAO, UClmba, UBC, CASS, JBO	Timing of binary and millisecond PKSMB/PH pulsars	P501
Shannon, Possenti, Manchester, Johnston, Hobbs, Keith, Romani, Thompson, Thorsett, Roberts, Weltevrede	CASS, CAO, CASS, CASS, CASS, CASS, USTAN, GSFC, UCSC, Eureka, UMan	Pulsar timing and the Fermi and AGILE missions	P574

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
Camilo, Johnston, Sarkissian, Reynolds, Ransom, Halpern, Andrews	UClmba, CASS, CASS, CASS, NRAO, UClmba, UClmba	The remarkably active radio magnetar 1E 1547.0-5408	P602
Wolleben, Gaensler, Mcconnell, McClure-Griffiths, Dickey, Carretti, Haverkorn, Han, Fletcher, Landecker, Leahy, Reich, Taylor	DRAO, USyd, CASS, CASS, UTas, CASS, NFRA, NAOBei, UNT, DRAO, UMan, MPIfR, UCal	Parkes 300 to 900 MHz rotation measure survey	P617
Burgay, Possenti, Sarkissian, Israel, Rea, Esposito	CAO, CAO, CASS, OARome, IAAC, CAO	Searching for radio pulsations triggered by the X-ray outburst of magnetars	P626
Bailes, Possenti, Johnston, Kramer, Burgay, D'Amico, Bhat, Keith, Burke-Spolaor, van Straten, Stappers, Bates, Levin, Milia, Ng	Swinb, CAO, CASS, MPIfR, CAO, CAO, Swinb, CASS, CASS, Swinb, JBCA, UMan, Swinb, CAO, MPIfR	The high time resolution Universe	P630
Camilo, Decesar	UClmba, UMar	New pulsar identifications of TeV gamma-ray sources	P654
Keane, Kramer, Lyne, Mclaughlin, Eatough, Stappers	MPIfR, MPIfR, JBO, WVU, JBO, JBCA	The search for and confirmation of nearby RRAT Candidates	P661
Ekers, Phillips, Reynolds, Protheroe, Mcfadden, James, Roberts, Bray	CASS, CASS, CASS, UAd, CASS, UAd, CASS, CASS	A radio search for UHE particles from Centaurus A	P668
Keith, Johnston, Camilo, Bailes, Ransom, Ray, Kerr, Ferrara, Shannon	CASS, CASS, UClmba, Swinb, NRAO, NRL, UStan, GSFC, CASS	Revealing pulsars in unidentified Fermi sources	P675
Andersson, Bhat, Crutcher, Vaillancourt	JHU, Swinb, UIl, SSC	The magnetic field in Tapia's Globule 2	P736
Hobbs, Manchester, Carretti, Johnston, Sarkissian, Reynolds, Bailes, Keith, van Straten, Oslowski, Jameson, Khoo, Shannon	CASS, CASS, CASS, CASS, CASS, CASS, Swinb, CASS, Swinb, Swinb, Swinb, RP, CASS	Instrumental calibration for pulsar observing at Parkes	P737
Crawford, Mclaughlin, Lorimer, Ridley	Haverford, WVU, JBO, WVU	Confirmation and timing of new Magellanic Cloud pulsars	P775
Bourke, Friesen, Mader, Myers, Hedden	SAO, NRAO, CASS, SAO, SAO	The initial conditions for star formation in clusters: temperature	P776
Possenti, Manchester, Johnston, Kramer, Sarkissian, Lyne, Burgay, Corongiu, D'Amico, Camilo, Bailes, van Straten, Milia	CAO, CASS, CASS, MPIfR, CASS, JBO, CAO, CAO, CAO, UClmba, Swinb, Swinb, CAO	A new deep search for millisecond pulsars in globular clusters	P778
Burke-Spolaor, Possenti, Johnston, Kramer, Burgay, D'Amico, Bailes, Bhat, Keith, van Straten, Stappers, Bates, Levin, Milia, Ng	CASS, CAO, CASS, MPIfR, CAO, CAO, Swinb, Swinb, CASS, Swinb, JBCA, UMan, Swinb, CAO, MPIfR	New rotating transients at high Galactic latitude	P780
Keith, Johnston, Levin	CASS, CASS, Swinb	Observations of the magnetar J1622–4950 and other pulsars at 13-mm	P781
Camilo, Decesar	UClmba, UMar	Obtaining timing solutions for two gamma-ray millisecond pulsars	P783
Bendjoya, Gomez, Suarez, Chesneau, Domiciano de Souza, Niccolini	UNOCA, IAAC, OAzur, OAzur, UNOCA, UNOCA	WAMBe: The survey for water masers around B[e] stars	P784
Keane, Johnston, Kramer, Lyne, Mclaughlin, Burke-Spolaor, Eatough, Stappers, Miller, Palliyaguru, Young	MPIfR, CASS, MPIfR, JBO, WVU, CASS, JBO, JBCA, WVU, WVU, JBO	Transient radio neutron stars	P786
Keith, Possenti, Manchester, Johnston, Verbiest, Kramer, Hobbs, Burgay, Camilo, Stairs, Bailes, Bhat, Burke-Spolaor, Ferdman, Eatough, Lorimer, van Straten, Stappers, Bates, Levin, Champion, Ng	CASS, CAO, CASS, CASS, MPIfR, MPIfR, CASS, CAO, UClmba, UBC, Swinb, Swinb, CASS, UBC, JBO, JBO, Swinb, JBCA, UMan, Swinb, MPIfR, MPIfR	Timing of binary and millisecond pulsars discovered at Parkes	P789
Camilo, Decesar	UClmba, UMar	Monitoring known X-ray magnetars for intermittent radio emission	P791
Keane, Kramer, Lyne, Stappers	MPIfR, MPIfR, JBO, JBCA	A second extragalactic radio burst: The beginnings of a population	P793
Verbiest, Kramer, Antoniadis, Tauris	MPIfR, MPIfR, MPIfR, UBonn	The mass of PSR J1933-6211	P794

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
Battistelli, Carretti, de Bernardis, Masi	UROME, CASS, UROME, UROME	Unveiling the anomalous microwave emission process: The case of 36396 and RCW175	P795
Cunningham, McClure-Griffiths, Jones, Dickey, van Loon, Gibson, Kerton, Jones, Arce	UNSW, CASS, UNSW, UTas, UKeele, WKU, ISU, UTas, Yale	OH in the G333 region - Parkes observations	P797
Mader	CASS	A 3GHz survey for dark gas in Musca	P798
Westmeier, Koribalski, Thom	UWA, CASS, STScI	The ionised component of the Magellanic Stream	P799
Blyth, Woudt, Mutabazi	UCT, UCT, UCT	Galaxy dynamics and the distance to the Norma Cluster	P800

OBSERVATIONS MADE WITH THE MOPRA RADIO TELESCOPE

October 2010 to September 2011

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
Tothill, Burton, Chapman, Wardle, Walsh, Millar, Purcell, Horiuchi	UWS, UNSW, UMac, UMac, JCU, QUB, USyd, CDSCC	Do the cyanopolyynes provide a chemical clock for hot molecular cores?	M347
Lowe, Bains, Lo, Jones, Cunningham, Minier, Urquhart, Hill, Zavagno, Bontemps, Motte	UNSW, Swinb, UChi, UNSW, UNSW, CEA, MPIfR, CEA, OMs, OBordeaux, CEA	Characterising star formation in the Vela molecular ridge	M401
Maxted, Fukui, Burton, Kawamura, Rowell, Walsh, Horachi, Lazendic-Galloway, Nicholas, Dawson	UAd, UNag, UNSW, NAOJ, UAd, JCU, UNag, Monash, UAd, UAd	A 7mm survey of the gamma-ray-intense northern region of supernova remnant RX J1713.7-3946	M407
Indermuehle, Edwards, Brooks, Urquhart	CASS, CASS, CASS, MPIfR	Maser and flux monitoring at 3mm, 7mm and 12mm	M426
Burton, Rathborne, Simon, Urquhart, Stark, Rowell, Tothill, Pineda, Storey, Langer, Martin, Walker, Kulesa, Stutzki, Hollenbach	UNSW, CASS, UKOELN, MPIfR, CfA, UAd, UWS, JPL, UNSW, JPL, Oberlin, UAz, UAz, UKOELN, SETI	The Mopra–STO–Nanten2 atomic and molecular gas survey: The formation of giant molecular clouds	M446
Burton, Jones, Cunningham, Walsh, Tothill	UNSW, UNSW, UNSW, JCU, UWS	The central molecular zone at 7 millimetres	M447
Quinn, Ward-Thompson, Barnes, Bourke, Di Francesco, Myers, Tothill, Lee, Evans	UCARDIFF, UCardiff, UFLOR, SAO, NRCC, SAO, UWS, SU, UTex	The evolution of low-mass dense cores	M510
Jackson, Lo, Rathborne, Jones, Muller, Cunningham, Brooks, Fuller, Barnes, Menten, Schilke, Garay, Mardones, Minier, Longmore, Wyrowski, Herpin, Hill, Bronfman, Deharveng, Finn, Schuller, Motte, Peretto, Bontemps, Wienen, Contreras, Lenfestey, Foster, Sanhueza, Claysmith	UBos, UChi, CASS, UNSW, NAOJ, UNSW, CASS, UMan, UFLOR, MPIfR, UKOELN, UChi, UChi, CEA, CfA, MPIfR, OBordeaux, CEA, UChi, LAM, UBos, MPIfR, CEA, CEA, OBordeaux, MPIfR, UChi, UMan, UBos, UBos, UBos	Millimetre Astronomy Legacy Team 90 GHz survey (MALT 90)	M516
Thompson, Urquhart, Clark, Hindson, Davies	UHerts, MPIfR, Open, UHerts, ULeeds	Mapping the molecular environment of the G305 Giant HII region	M525
Barnes, Lo, Muller, Cunningham, Fuller, Longmore, Brogan, Indermuehle, Caselli, Molinari, Tan, Lowe, O'Dougherty, Bania	UFLOR, UChi, NAOJ, UNSW, UMan, CfA, NRAO, CASS, ULeeds, IRA-INAF, UFLOR, UNSW, UFLOR, UBos	ThrUMMS: the Three-mm Ultimate Mopra Milky way Survey - A MALT110 demonstrator	M566
de Wilt, Fukui, Burton, Kawamura, Rowell, Walsh, Aharonian, Dawson	UAd, UNag, UNSW, NAOJ, UAd, JCU, DIAS, UAd	The dense and disrupted gas towards the interacting SNR G359.1-0.5 and the TeV gamma-ray source HESSJ1745-303	M569
de Wilt, Fukui, Burton, Kawamura, Rowell, Walsh, Aharonian, Dawson, Eger	UAd, UNag, UNSW, NAOJ, UAd, JCU, DIAS, UAd, UEN	Investigating the dense molecular material towards the unidentified TeV gamma-ray source HESS J1626-490	M570
Anderson, Jones, Cunningham, Deharveng	LADM, UNSW, UNSW, LAM	The morphology and expansion of infrared dust bubbles	M572

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
Urquhart, Hoare, Morgan	MPIfR, ULeeds, LivJMU	The RMS survey: resolving kinematic distance ambiguities in the fourth quadrant	M573
Fuller, Peretto, Lenfestey	UMan, CEA, UMan	Probing the distance and mass distribution of clouds	M576
Morgan, Moore, Urquhart	LivJMU, LivJMU, MPIfR	Triggering mechanisms in Galactic HII regions	M578
Wong, Hughes, Ott, Muller, Looney, Chu, Gruendl, Pineda	UIl, MPIA, NRAO, NAOJ, UIl, UIl, UIl, JPL	Molecular gas near high-mass YSOs in the LMC	M579
Pineda, Hughes, Wong, Ott, Muller, Langer, Velusamy, Goldsmith	JPL, MPIA, UIl, NRAO, NAOJ, JPL, JPL, JPL	A Mopra search for diffuse CO emission in Magellanic Clouds lines-of-sight traced in C+ and C by Herschel	M580
Chitsazzadeh, Keto, Bourke, Di Francesco, Sadavoy, Pineda	UVIC, CfA, SAO, NRCC, UVIC, UMan	N2H+ observations of a super-Jeans prestellar core in L1689	M581
Hughes, Wong, Ott, Muller, Bolatto, Hony, Pineda, Rubio	MPIA, UIl, NRAO, NAOJ, UCB, CEA, JPL, UChi	Molecular gas and star formation at low metallicity: the Magellanic Clouds as benchmarks	M583
Rahman, Jones, Cunningham, Moon, Matzner, Murray	UTor, UNSW, UNSW, UTor, UTor, CITP	Mapping the natal molecular cloud of the Dragonfish cluster	M584
Zhou, Wang, Chen, Su	PMO, NJU, NJU, PMO	Search for molecular gas associated with two southern-sky Galactic SNRs (Kes 41 and CTB 37B) with CO-line observations	M585
Cordiner, Wright, Smith, Purcell, Charnley, Wirstrom	GSFC, ADFA, ADFA, USyd, GSFC, GSFC	Probing the evolution of molecular complexity in low-mass star formation	M588
Maercker, Vlemmings, Purcell, Lundgren, Ramstedt, Decin, Justtanont, Olofsson, Schöier, Longmore, de Beck, Khouri Silva, Lombaert, L Leal Ferreira, Perez-Sanchez	ESO, OSO, USyd, OSO, UBonn, LEUVEN, OSO, OSO, OSO, ESO, LEUVEN, UAm, LEUVEN, UBonn, RAIUB	3MOLINOS - A 3mm molecular inventory of old stars	M589
Cordiner, Wright, Smith, Charnley, Wirstrom	GSFC, ADFA, ADFA, GSFC, GSFC	Chemical characterisation of the extremely young protostar Chamaeleon MMS1	M590
de Wilt, Fukui, Burton, Kawamura, Rowell, Aharonian, Dawson	UAd, UNag, UNSW, NAOJ, UAd, DIAS, UAd	Investigating the connection between star forming regions and unidentified TeV gamma-ray sources	M591
Lumsden	ULeeds	Dense gas in nearby Seyferts	M595
Cormier, Hughes, Hony, Viti, Madden, Lebouteiller, Galliano, Galametz, Barlow, Karczewski, Isaak	CEA, MPIA, CEA, UCL, CEA, CEA, CEA, IoA, UCL, UCL, ESTEC/ESA	Probing the molecular gas in dwarf galaxies	M596
Tsitali, Parise, Belloche	MPIfR, MPIfR, MPIfR	The dynamical state of the first core candidate CHA-MMS1	M597
Tremblin, Cunningham, Minier, Hill, Schneider, Motte, Audit	CEA, UNSW, CEA, CEA, CEA, CEA, CEA	The link between star formation, filaments, and pillars in the Rosette molecular cloud	M598
Vasyunina, Voronkov, Linz, Henning, Zinchenko, Britton, Pirogov, Vasyunin	UVir, CASS, MPIA, MPIA, RAS, CASS, RAS, OhioSU	Search for the youngest clumps in infrared dark clouds	M600
Thompson, de Zotti, Urquhart, White, Gomez, Eales, Cooray, Baes, Leeuw, Temi, Joncas, Bracco, Dunne	UHerts, OAPd, MPIfR, Open, UCARDIFF, UCARDIFF, UChig, SOGB, URh, NASA-RC, ULav, UCI, UNOTT	Molecular cirrus in the Herschel-ATLAS	M601
Chen, Muller, Indebetouw	UVir, NAOJ, NRAO	Massive star formation under tidal influence - the case of the Magellanic Bridge	M605
Fukui, Yamamoto, Kawamura, Torii, Furukawa, Akio, Okuda, Enokiya, Nakamura, Furuhashi	UNag, UNag, NAOJ, UNag, UNag, UNag, UNag, UNag, UNag, UNag	Molecular gas toward the Trifid Nebula M20 and its ionizing star: a scrutiny of formation of the very young star cluster	M609

VLBI OBSERVATIONS

October 2010 to September 2011

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
Guirado, Marti-Vidal, Marcaide, Reynolds, Jauncey, Lestrade, Preston, Jones	UVal, UVal, UVal, CASS, CASS, OPM, JPL, JPL	Follow-up observations of AB Doradus: a possible radio binary in ABDorB	V186
Deller, Tingay, Bailes	Swinb, UCurt, Swinb	Improving the VLBI astrometry of PSR 0437-4715	V190
Ojha, Lovell, Edwards, Kadler, Monitoringteam, Tingay	GSFC, UTas, CASS, GSFC, UCurt	Physics of gamma ray emitting AGN	V252
Ellingsen, Caswell, Voronkov, Dodson, Phillips, Green, Dawson, Menten, Shen, Reid, Hachisuka, Goedhart, Walsh, Brunthaler, Chen, Fujisawa, Rioja, Zhang, Xu, Zheng, Honma	UTas, CASS, CASS, UWA, CASS, CASS, UTas, MPIfR, SHAO, SAO, MPIfR, HartRAO, JCU, MPIfR, SHAO, MPIfR, UWA, MPIfR, PMO, NJU, NAOJ	Astrometric observations of methanol masers: determining Galactic structure and investigating high-mass star formation	V255
Petrov, Murphy, Tzioumis, Phillips, Sadler, Kim, Burke-Spolaor, Bietenholz, Pogrebenko, Bertarini, Booth, Fomalont, de Witt	GSFC, USyd, CASS, CASS, USyd, KASSI, CASS, HartRAO, JIVE, MPIfR, HartRAO, NRAO, HartRAO	LBA calibrator survey	V271
de Witt, Phillips, Bietenholz, Petrov, Booth	HartRAO, CASS, HartRAO, GSFC, HartRAO	Full LBA measurements of potential VLBI southern hemisphere radio calibrators at 2.3 GHz	V278
Mao, Norris, Lovell, Ekers, Middelberg, Emonts, Saikia, Sharp, Lenc	UTas, CASS, UTas, CASS, AIR, CASS, NCRA, AAO, CASS	VLBI observations of large radio sources hosted by spiral galaxies	V293
Tingay, Edwards, Phillips, Sadler, Deller, Hancock	UCurt, CASS, CASS, USyd, NFRA, USyd	VLBI observations of a low luminosity GHz-peaked spectrum sample from the AT20G survey	V308
Beasley, Ellingsen	NRAO, UTas,	Methanol maser proper motion measurement of the LMC: II	V316
Deller, Loinard, Forbrich	NRAO, UNAM, CfA,	The distance to the Coronet Cluster in Corona Australis	V329
Zanardo, Staveley-Smith, Tzioumis, Ng, Tingay, Potter	UWA, UWA, CASS, UMcGill, UCurt, UWA	High resolution observations of SNR 1987A	V389
Reines, Deller, Johnson	NRAO, NFRA, UVir	Probing the enigmatic nuclear source in the dwarf starburst galaxy Henize 2-10 with the LBA	V429
Maccarone, Deller, Miller-Jones	USouth, NFRA, UCurt	Astrometric observations of the X-ray binary GX~339-4	V430
Moldon, Dodson, Johnston, Karastergiou, Keith, Ribo, Paredes	UBARC, UWA, CASS, UOx, CASS, UBARC, UBARC	VLBI monitoring of the periastron passage of PSR B1259-63	V434
Voronkov, Caswell, Phillips, Green, Ellingsen, Breen, Britton, Weston	CASS, CASS, CASS, CASS, UTas, CASS, CASS, AUT	Pilot VLBI observations of the 25-GHz methanol masers	V440
Chen, Dodson, Ellingsen, Shen, Gaylard, Gan, Hachisuka, MacLeod, Liu	SHAO, UWA, UTas, SHAO, HartRAO, SHAO, SHAO, DST, SHAO	Probing associations among class II methanol masers, outflows and magnetic fields	V443
Deller, Johnston, Burke-Spolaor, Romani, Kerr	NFRA, CASS, CASS, UStan, UStan	LBA parallaxes to probe gamma-ray pulsar physics	V444

TIDBINBILLA OBSERVATIONS

October 2010 to September 2011

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
Dickey, Horiuchi	UTas, CDSCC	Ammonia in infrared dark clouds	T017
Burton, Jones, Cunningham, Horiuchi, Tothill,	UNSW, UNSW, UNSW, CDSCC, UNSW	Hot ammonia in Sagittarius B2	T195
Tarchi, Castangia, Horiuchi, Panessa	OAC-INAF, MPIfR, CDSCC, IRA-INAF	Water maser and hard X-ray emission in AGN: the complete INTEGRAL sample	T196

OBSERVERS	AFFILIATIONS	PROGRAM	NO.
De Gregorio Monsalvo, Gomez, Brooks, Anglada, Walsh, Osorio	ESO (Chile), IAAC, CASS, IAAC, JCU, IAAC	Water masers in Bok globules: looking for signposts of star formation	T197
Horiuchi, Cimo, Gurvits, Pogrebenko, Molera Calves	CDSCC, JIVE, JIVE, JIVE, AUMRO	Water maser emission in the Saturnian system	T198
Tothill, Burton, Horiuchi	UWS, UNSW, CDSCC	The physical conditions of the Lupus clouds	T199
Lowe, Lo, Jones, Cunningham, Burton, Urquhart, Hill, Redman, Horiuchi, Tothill	UNSW, UChi, UNSW, UNSW, UNSW, MPIfR, CEA, NUI, CDSCC, UWS	Temperatures of dense cores in the G333 giant molecular cloud	T200
Bendjoya, Gomez, Rizzo, Suarez, Chesneau, Niccolini, Abe, Rivet, Stee	OAzur, IAAC, ESA Villafranca, OAzur, OAzur, OAzur, OAzur, OAzur, OAzur	Water maser survey in young debris disks for exoplanet detection	T202

E: Postgraduate students

PHD STUDENTS CO-SUPERVISED BY CASS STAFF IN 2011

NAME	UNIVERSITY	PROJECT TITLE
Craig Anderson	University of Sydney	Radio polarimetry and rotation measure synthesis as probes of inner AGN structure
Jay Blanchard	University of Tasmania	Linking the radio and gamma-ray properties of blazars
Justin Bray	Adelaide University	Ultrahigh energy neutrinos and their detection with the lunar Cherenkov technique
Tui Britton	Macquarie University	Methanol masers in star forming regions
Rajan Chhetri	University of New South Wales	The study of the large scale mass distribution in the Universe using gravitational lensing
Yanett Contreras	Universidad de Chile	Study of filamentary structures in the southern galactic plane
Paul Coster	Swinburne University of Technology	Accelerated searches for the most relativistic binary pulsars using next-generation instrumentation
Helga Denes	Swinburne University of Technology	Global HI properties of galaxies in the southern sky
Phoebe de Wilt	Adelaide University	Investigating the connection between star forming regions and unidentified TeV gamma-ray sources
Chris Hales	University of Sydney	Radio polarisation and the origin of galactic and intergalactic magnetic fields
Luke Hindson	Hertfordshire University, UK	Wide area molecular imaging of giant HII regions
Christopher Jordan	James Cook University	CS(1-0) observations with MALT-45: A 7-mm survey of the southern Galaxy
Lina Levin	Swinburne University of Technology	The high-time resolution Universe
Vicki Lowe	University of New South Wales	The environments of massive star formation
Minnie Mao	University of Tasmania	Cosmic evolution of radio sources
Vanessa Moss	University of Sydney	Low and intermediate velocity HI clouds in the Milky Way
Stefan Oslowski	Swinburne University of Technology	High precision pulsar timing and the formation and evolution of binary pulsars
Hayden Rampadarath	Curtin University	Application of wide-field VLBI
Kate Randall	University of Sydney	Discriminating between active galactic nuclei and star forming galaxies in the Australia Telescope Large Area Survey
Vikram Ravi	University of Melbourne	Evincing the history of massive black hole and galaxy populations with gravitational waves
Sarah Reeves	University of Sydney	HI and OH absorption line studies of nearby galaxies
Dan Thornton	University of Manchester, UK	Pulsar and transient search with GPUs
Anita Titmarsh	University of Tasmania	Investigating the earliest stages of massive star formation
Catarina Ubach	Swinburne University of Technology	Observations of grain growth in protoplanetary disks
Marion Wienen	University of Bonn, Germany	Multi-wavelength follow-ups to the APEX Telescope Large Area Survey: the Galaxy
Kathrin Wolfinger	Swinburne University of Technology	The effect of environment on the evolution of nearby gas-rich spiral galaxies
Meng Yu	Peking University, China	Timing for radio pulsars
Rai Yuen	University of Sydney	Investigation on pulsar magnetosphere
Zinn Peter-Christian	Ruhr University Bochum, Germany	New avenues in galaxy evolution studies: large-scale magnetic fields and properties of high-redshift radio emitters

HONOURS STUDENTS CO-SUPERVISED BY CASS STAFF IN 2011

NAME	UNIVERSITY	PROJECT TITLE
Tye Young	Australian National University	Mapping ammonia emission in star forming regions

F: PhD theses

PHD THESES OF STUDENTS CO-SUPERVISED BY CASS STAFF IN 2011

Bannister, Keith (University of Sydney, November 2011). “Radio transients: Surveys and techniques”.

Bonavera, Laura (SISSA, September 2011). “Spectra of extragalactic radio sources after Planck”.

Guzman, Andres (Universidad de Chile, November 2011). “Ionised jets in massive young star objects as sign of accretion dominated process in their formation”.

Hayman, Douglas (Macquarie University, August 2011). “Beamforming and evaluation of focal plane arrays for radio astronomy”.

Hughes, Annie (Swinburne University, March 2011). “Molecular gas in the interstellar medium of the Large Magellanic Cloud”.

Mahony, Elizabeth (University of Sydney, November 2011). “Unveiling the high-frequency radio source population”.

Mao, Sui-Ann (Harvard University, September 2011). “Magnetic fields in the Milky Way and Magellanic Clouds”.

Moin, Aquib (Curtin University, August 2011). “e-VLBI science with LBA. Exploring science applications for the long baseline component of ASKAP”.

Yardley, D. (University of Sydney, August 2011). “Studying gravitional waves with pulsars: Results from the Parkes Pulsar Timing Array”.

G: Publications

PAPERS USING ATNF DATA, PUBLISHED IN REFEREED JOURNALS

* Indicates publication with ATNF staff

C = Compact Array data, M = Mopra data, P = Parkes data, T = Tidbinbilla data, V = VLBI data, S = ASKAP- or SKA-related

Anderson, G.E.; Gaensler, B.M.; Kaplan, D.L.; Posselt, B.; Slane, P.O.; Murray, S.S.; Mauerhan, J.C.; Benjamin, R.A.; Brogan, C.L.; Chakrabarty, D. and 8 coauthors. “Identification of a Population of X-ray-emitting Massive Stars in the Galactic Plane”. ApJ, 727, 105 (2011). (C)

Aversa, A.G.; Johnson, K.E.; Brogan, C.L.; Goss, W.M.; Pisano, D.J. “Very Large Array and ATCA Search for Natal Star Clusters in Nearby Star-forming Galaxies”. AJ, 141, 125-125 (2011). (C)

*Bailes, M.; Bates, S.D.; Bhalerao, V.; Bhat, N.D.R.; Burgay, M.; Burke-Spolaor; D’Amico, N.D.; Johnston, S.; Keith, M.J.; Kramer, M.; Kulkarni, S.R.; Levin, L.; Lyne, A.G.; Milla, S.; Possenti, A.; Spitler, L.; Stappers, B.; van Straten, W. “Transformation of a star into a planet in a millisecond pulsar binary”. Science, 333 1717-1720 (2011). (P)

*Banfield, J.K.; George, S.J.; Taylor, A. R.; Stil, J.M.; Kothes, R.; Scott, D. “Polarized Radio Sources: A Study of Luminosity, Redshift, and Infrared Colors”. ApJ,733, 69, (2011). (V)

Barnes, P.J.; Yonekura, Y. Fukui, Y.; Miller, A.T.; Mühlegger, M.; Agars, L.C.; Miyamoto, Y.; Furukawa, N.; Papadopoulos, G.; Jones, S.L.; Hernandez, A.K.; O’Dougherty, S.N.; Tan, J.C. “The Galactic Census of High- and Medium-mass Protostars. I. Catalogs and First Results from Mopra HCO+ Maps”. ApJS, 196, 12 (2011). (M)

*Bates, S.D.; Mailes, M.; Bhat, N.D.R.; Burgay, M.; Burke-Spolaor, S.; D’Amico, N.; Jameson, A.; Johnston, S.; Keith, M.J.; Kramer, M.; Levin, L.; Lyne, A.; Milia, S.; Possenti, A.; Stappers, B.; van Straten, W. “The High Time Resolution Universe Pulsar Survey – II. Discovery of five millisecond pulsars”. MNRAS, 416, 2455-2464 (2011). (P)

*Bates, S.; Johnston, S.; Lorimer, D.R.; Kramer, M.; Possenti, A.;Burgay, J.; Stappers, B.; Keith, M.J.; Lyne, A.; Bailes, M.; McLaughlin, M.A.; O’Brien, J.T. & Hobbs, G. “A 6.5-GHz Multibeam Pulsar Survey”. MNRAS, 411, 1575-1584 (2011). (P)

*Bell, M.E.; Tzioumis, T.; Uttley, P.; Fender, R.P.; Arévalo, P.; Breedt, E.; McHardy, I.; Calvelo, D.E.; Jamil, O.; Körding, E. “X-ray and radio variability in the low-luminosity active galactic nucleus NGC 7213”. MNRAS, 411, 402 (2011). (C)

Bhat, N.D.R. “Searches for radio transients”. BASI, 39, 353-375 (2011). (P)

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H: Media releases

CASS/ATNF MEDIA RELEASES ISSUED IN 2011

Working together to take the pulse of the Universe (2 February)

Using the Parkes radio telescope, CSIRO astronomers are working closely with NASA to unlock one of astronomy's great enigmas — the science behind pulsars.

http://www.csiro.au/news/Working-together-to-take-the-pulse-of-the-universe

Aboriginal community names CSIRO telescope (2 June)

The first six antennas of CSIRO's Australian SKA Pathfinder telescope in Western Australia will today receive names in the local Wajarri language.

http://www.csiro.au/news/Aboriginal-community-names-CSIRO-telescope

Big step forward for SKA (7 July)

The discovery potential of the future international SKA radio telescope has been glimpsed following the commissioning of a working optical fibre link between CSIRO's Australian SKA Pathfinder (ASKAP) telescope in Western Australia, and other radio telescopes across Australia and New Zealand.

http://www.csiro.au/news/Big-step-forward-for-SKA

Galaxies are running out of gas (22 August 2011)

The Universe forms fewer stars than it used to, and a CSIRO study has now shown why - the galaxies are running out of gas.

http://www.csiro.au/news/Galaxies-running-out-of-gas

'The Dish' finds a 'diamond planet' (26 August)

Astronomers using 'The Dish' — CSIRO's radio telescope near Parkes, NSW — believe they've found a small planet made of diamond, orbiting an unusual star.

http://www.csiro.au/news/The-Dish-finds-a-diamond-planet

Churning galaxy is a snake pit (6 October)

The violent swirling of the gas between the stars has been captured for the first time with a CSIRO telescope.

http://www.csiro.au/news/Churning-galaxy-snake-pit

Parkes 50th anniversary open days (6 October)

CSIRO's Parkes radio telescope — 'The Dish' — turns 50 on 31 October and will celebrate with public open days on 8 and 9 October.

http://www.csiro.au/en/Portals/Media/Parkes-Telescope-50th-Anniversary.aspx

CSIRO astronomer wins top Tall Poppy prize (4 November)

CSIRO astronomer Dr George Hobbs has become the 2011 Young Tall Poppy of the Year for NSW.

http://www.csiro.au/en/Portals/Media/CSIRO-astronomer-wins-top-Tall-Poppy-prize.aspx

I: Abbreviations

AAL	Astronomy Australia Ltd
AAO	Australian Astronomical Observatory
AARNet	Australia's Academic and Research Network
ACMA	Australian Communications and Media Authority
ADASS	Astronomical Data and Software Systems
AGN	Active Galactic Nuclei
AIPS	Astronomical Image Processing System
ALFA	Arecibo L-band Feed Array
ALMA	Atacama Large Millimetre Array
ANZSCC	Australia – New Zealand SKA Coordination Committee
APSR	ATNF Parkes Swinburne Pulsar Recorder
ARC	Australian Research Council
ASCC	Australian SKA Coordination Committee
ASDAF	ASKAP Science Data Archive Facility
ASKAIC	Australasian SKA Industry Consortium
ASKAP	Australian Square Kilometre Array Pathfinder
ATCA	Australia Telescope Compact Array
ATLAS	Australia Telescope Large Area Survey
ATNF	Australia Telescope National Facility
ATSC	Australia Telescope Steering Committee
ATUC	Australia Telescope User Committee
BETA	Boolardy Engineering Test Array
CABB	Compact Array Broadband Backend
CALOSIS	Centaurus A Synthesis Imaging Survey
CASS	CSIRO Astronomy and Space Science
CDSCC	Canberra Deep Space Communication Complex
CDF-S	Chandra Deep Field South
CMIS	CSIRO Mathematical and Information Sciences
CSOF	CSIRO Officer
CONRAD	Convergent Radio Astronomy Demonstrator
CoRE	Cosmological Reionization Experiment
COSMOS	Cosmological Evolution Survey
COSPAR	Committee on Space Research
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAS	Data Acquisition Systems
DFB	Digital Filterbank
DBCDE	Department of Broadband, Communications and the Digital Economy
DIISRTE	Department of Innovation, Industry, Science, Research and Tertiary Education
DSN	Deep Space Network
EIF	Education Investment Fund
EDGES	Experiment to Detect the Global Epoch of Reionization Signature
ELAIS	European Large Area ISO Survey
e-MERLIN	Extended Multi-Element Radio Linked Interferometer
EPICS	Experimental Physics and Industrial Control System
ESO	European Southern Observatory
EU SKADS	European SKA Design Study
FARADAY	Focal-plane Arrays for Radio Astronomy: Design, Access and Yield
FIR	Far Infrared
FITS	Flexible Image Transport System
FPA	Focal Plane Array
FPGA	Field Programmable Gate Arrays
FTE	Full Time Equivalent
GASS	Galactic All Sky Atomic Hydrogen Survey
GW	Gravitational Wave
HEMT	High Electron Mobility Transistor
HI	Neutral Hydrogen
HIPASS	HI Parkes All Sky Survey
HIZOA	HI Zone of Avoidance
HPC	High Performance Computing
HSE	Health, Safety and Environment
HVC	High Velocity Clouds
IAU	International Astronomical Union
ICIP	Industry Cooperative Innovation Programme
ICRAR	International Centre for Radio Astronomy Research
ICTC	Information and Communications Technology Centre
IEEE	Institute of Electrical and Electronics Engineers
IFRS	Infrared Faint Radio Sources
InP	Indium Phosphide
ISM	Interstellar Medium
ISSC	International SKA Steering Committee
IT	Information Technology
ITU	International Telecommunications Union
IUCAF	Scientific Committee on the Allocation of Frequencies for Radio Astronomy and Space Sciences
IVS	International VLBI Service
JIVE	Joint Institute for VLBI in Europe
JPL	Jet Propulsion Laboratory
KAT	Karoo Array Telescope
LBA	Long Baseline Array, used for Australian VLBI observations
LFD	Low Frequency Demonstrator
LNA	Low Noise Amplifier
LO	Local Oscillator
LOFAR	Low Frequency Array
LOFAR DMT	Low Frequency Array Dark Matter Telescope
LVHIS	Local Volume HI Survey
MASIV	Micro-Arcsecond Scintillation-Induced Variability
MIRIAD	Multichannel Image Reconstruction Image Analysis and Display
MIT	Massachusetts Institute of Technology
MMBS	Methanol Multibeam Survey
MMIC	Monolithic Microwave Integrated Circuit
MNRAS	Monthly Notices of the Royal Astronomical Society
MNRF	Major National Research Facilities
MOPS	Mopra Spectrometer
MRO	Murchison Radio-astronomy Observatory

MSF	Murchison Radio-astronomy Observatory Support Facility
MSP	Millisecond Pulsar
MWA	Murchison Widefield Array
NASA	National Aeronautics and Space Administration
NCRIS	National Collaborative Research Infrastructure Strategy
NRAO	National Radio Astronomy Observatory
NRC-HIA	National Research Council Canada – Herzberg Institute of Astrophysics
NOT	Nordic Optical Telescope, Spain
NSF	National Science Foundation
OCE	CSIRO's Office of the Chief Executive
PAF	Phased Array Feed
PAPER	Precision Array to Probe Epoch of Reionization
PDFB	Pulsar Digital Filterbank
PMPS	Parkes Multibeam Pulsar Survey
PPTA	Parkes Pulsar Timing Array
PrepSKA	Preparatory Phase Studies for the Square Kilometre Array
PTF	Parkes Testbed Facility
RAFCAP	Radio Astronomy Frequency Committee in the Asia Pacific
RFI	Radio Frequency Interference
RSAA	Research School of Astronomy and Astrophysics
SCG	Southern Compact Group
SEST	Swedish-ESO Submillimetre Telescope, Chile
SINGS	Spitzer Infrared Nearby Galaxies Survey
SKA	Square Kilometre Array
SKAMP	SKA Molonglo Prototype
TAC	Time Assignment Committee
THEA	Thousand Element Array
TIGO	Transportable Integrated Geodetic Observatory
UCSD	University of California, San Diego
UNSW	University of New South Wales
URSI	International Union of Radio Science
USNO	United States Naval Observatory
VLA	Very Large Array
VLBI	Very Long Baseline Interferometry
VO	Virtual Observatory
VSOP	VLBI Space Observatory Program
WDM	Wavelength Division Multiplexed
WLAN	Wireless Local Area Network
WRC	World Radio Conferences

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