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ATNF News

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CSIRO Astronomy and Space Science — Undertaking world-leading astronomical research and operating the Australia Telescope National Facility.

Front cover image

CSIRO's Australia Telescope Compact Array – celebrating 25 years of achievement in 2013.

Editorial

Welcome to the October 2013 issue of *ATNF News*.

Monday 2 September was the 25th anniversary of the formal opening of the Compact Array. We report on the public Open Day, formal ceremony and science symposium held to mark this milestone, and Phil Edwards examines the telescope's scientific impact.

While the Compact Array celebrates its maturity, work continues apace on our newest telescope, the Australian SKA Pathfinder. The sixth and final first-generation phased array feed (PAF) has been installed on an ASKAP antenna at the Murchison Radio-astronomy Observatory, and commissioning tests continue. In July came welcome news of a $6m SIEF grant from the Australian Government and a further $6m from CSIRO: together, these sums will fund the construction and installation of additional PAFs, bringing the total to 30. In more good news, the PAF technology has won awards for its engineering excellence.

The larger SKA project also passed an important milestone this year, with the SKA Office announcing the international work-package consortia. CSIRO has received funding from the Australian Government that will enable it to lead two of the consortia and participate in others.

Observing from the Science Operations Centre in Marsfield is now in full swing for the Parkes telescope and VLBI sessions, as our Operations report notes. The same report gives a reassuring update on the Mopra telescope, which was swept by bushfire in January.

ATNF facilities are used by a thriving astronomical community. Three science articles in this issue present:

- a study of the 'superwind' in NGC 253 that combined observations from Mopra and ALMA (the Atacama Large Millimeter/submillimeter Array);
- a new source catalogue, derived from the AT20G survey, that should prove useful for selecting populations for future studies and identifying high-quality calibrators; and
- a study of shells and shocks in a star-forming region, RCW 49.

In other news, CASS's Naomi McClure-Griffiths has received a major award from CSIRO for her scientific achievements, and the Tidbinbilla 70-m antenna has acquired new capabilities. CASS says 'hello' to a bumper crop of new science appointments and 'goodbye' to the Parkes Analogue Filterbanks, finally switched off after many years of service. And there are our regular updates on graduate students, education and outreach, engineering developments and publications, along with a new section on meetings, past and future.

We hope you enjoy this issue of *ATNF News*. Your comments and suggestions are always welcome. If you would like to contribute to a future issue, please contact the newsletter editors, below.

Helen Sim and Tony Crawshaw

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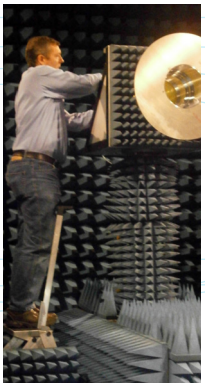
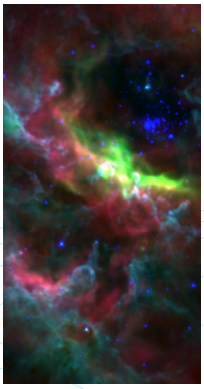
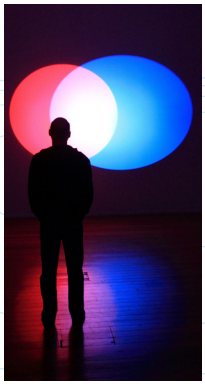


From the Chief of CSIRO Astronomy and Space Science

LEWIS BALL (CHIEF OF CASS)

This newsletter comes at a very exciting time as CASS, and especially the ATNF, looks both forward with anticipation and backward with pride. The Australia Telescope Compact Array is 25 years young and the astronomical community has celebrated its scientific achievements so far with events in Narrabri and at the observatory itself in September, with some of the talks from the 'birthday' symposium being presented again for a second time in Marsfield. The latest upgrades to the Compact Array, the 4–12 GHz receivers, are performing well, and the observatory is continuing to deliver world-class science that is changing our understanding of the Universe. In recent times the ATNF has also developed other new capabilities, such as remote operability of Parkes, the Science Operations Centre in Marsfield coming into full use, and the implementation of On-the-Fly mapping using the Tidbinbilla 70-metre antenna and a new wide-band 20-GHz receiver system. Of course, adopting new ways of doing things usually involves, or even requires, moving on from the old ways. The decommissioning of the Parkes analogue filter banks is an example of a phenomenally successful instrument that has played its role and now makes way for new technologies.

The science stories in this newsletter demonstrate the value of ATNF's complementary capabilities. A new catalogue from the AT20G survey made with the Compact Array will be useful for many further studies. The study of NGC 253 shows how single-dish data can complement that from a synthesis array, with Mopra data filling in the gaps of observations made with the world's largest and most capable millimetre observatory, the $1.6 billion Atacama Large Millimeter/submillimeter Array. And the RCW 49 science demonstrates how observations in completely different wavebands (radio, X-ray, optical) can tell us so much more than observations in one band alone.

The success of the ATNF arises from three sources: its people and their expertise, its facilities and their capabilities, and its relationships. This newsletter welcomes a number of exceptional new staff, who bring fresh ideas, energy and relationships with them. It also welcomes Jim Jackson as a Distinguished Visitor, notes a number of conferences and workshops, and details the graduate-student program and a range of outreach activities. These people and interactions are important aspects of ATNF's role as a National Facility and support both the astronomical community and the practice of astronomy.

We also note a range of developments associated with the new kids on the block, ASKAP and the MWA, and the path to the SKA. After years of work by many dedicated people ASKAP is getting close to delivering data that will lead to new science. It has taken its first tentative steps towards the measurement of the radio sky, and although we will all need to be patient, we can now start to see the radio waves at the end of the tunnel. And while ASKAP will deliver outstanding science, it is a stepping-stone to even bigger things to be enabled by the SKA. With the start of SKA pre-construction work and the establishment of CSIRO's SKA Centre, led by CASS's Deputy Chief Sarah Pearce, we are well and truly on that train now. I hope you find this newsletter informative and exciting, and are looking forward to the challenges and opportunities of 2014 as much as the staff of the ATNF.

ATCA 25th Anniversary Science Symposium

PHIL EDWARDS (CASS)

The Compact Array. Photo: David Smyth

Following a successful public Open Day on Sunday 1 September, and on-site commemoration of the opening of the Compact Array on Monday 2 September (both described on page 6), we celebrated the Compact Array's 25th Anniversary with a three-day Science Symposium.

The meeting was held in one of the cinemas at the Crossing Theatre in the town of Narrabri. Top billing on the first day was given to Bob Frater, who led the construction project ("Prime Minister, we have delivered!") and John Brooks, the Project Engineer ("Project Management ATNF Style"). Further insights into the history, and pre-history, of the Compact Array were provided by Dick Manchester, Mal Sinclair, Warwick Wilson, and Mark Bowen, with Ron Ekers describing the opportunities and challenges presented by Australia's first National Facility, the ATNF.

The workshop covered all the major fields of research that the Compact Array has contributed to, including HI studies, the early mosaiced images of the LMC and SMC, masers, gamma-ray burst afterglows, supernovae, star formation, polarimetry, intra-day variability, pulsars, clusters, Very Long Baseline Interferometry, and surveys large, deep and wide.

Peter Tuthill described the Narrabri Stellar Intensity Interferometer, the forerunner to the Sydney University Stellar Interferometer (SUSI) that now lives alongside the Compact Array. Robin Wark gave an entertaining review of Compact Array operations, and showed an early memo from Officer-in-Charge Graham Nelson which noted that the expected mode of operations was that observing schedules would be loaded up in the afternoon and the array left to run unattended overnight – a mode still yet to be realised! Robin also recognised the efforts of generations of Duty Astronomers who have provided front-line observing support, identifying Vince McIntyre as the person who had done the largest (documented) number of DA shifts, with Maxim Voronkov and Naomi McClure-Griffiths following close behind.

Among the other interesting snippets, facts, and opinions that emerged during the meeting were:

- that there was an early proposal for an additional two antennas between the Compact Array and Mopra, which went unfunded;
- that it was Dave Jauncey (CASS) who had proposed the name 'the Australia Telescope';
- that the design and production of 3,000 VLSI (very-large-scale integration) chips for the correlator was recognised with the issue of an Australian postage stamp in 1987;
- John Brooks' 'three people happy' and 'man-month myth' rules*; and
- a recurring appreciation of the fact that the Compact Array is 'a child-friendly observatory', allowing families to be accommodated on site and, through its remote-observing capability, providing a means of observing from one's home institution (or indeed, home!) when travelling to the Observatory would be disruptive to family life.

Compact Array-themed crosswords were provided to participants on the first two days, with the first correct entries drawn being presented with a bottle of wine: Dave McConnell and Stuart Ryder were the successful cruciverbalists.

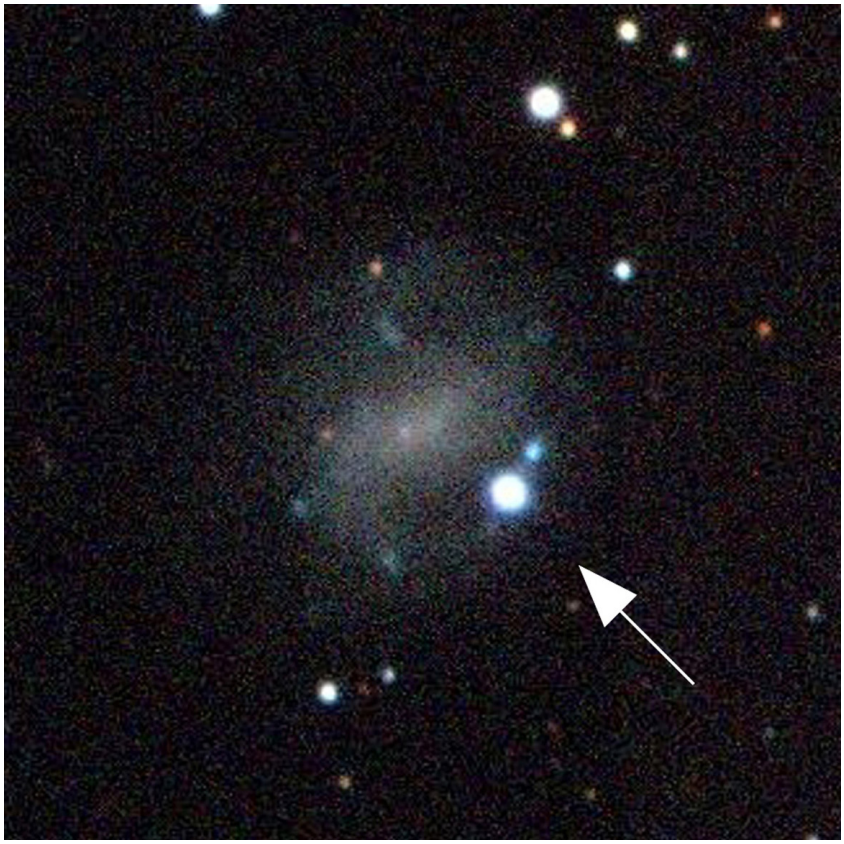
The symposium was well attended, with over 60 registered participants. An encore performance has now been held at Marsfield, allowing those who were unable to attend to hear these key talks. All presentations will be archived online, and discussion is under way as to how best to capture in one document both the information presented at the symposium and contributions from those who could not be there.

The smooth running of the meeting was thanks to the behind-the-scenes efforts of staff at Narrabri and Marsfield, with Margaret McFee and Amanda Gray deserving special mention.

**This requires some explanation. On the first point, John used to tell disgruntled workers that "if you resign, you'll make three people happy: you, your boss and your replacement". On the second, John said that if a job takes one person X months, it will take X people more than one month. (Ed.)*

25 years of Compact Array science

PHIL EDWARDS (CASS)



Supernova 1998bw, the subject of the Compact Array's most highly cited paper. Image: ESO

The ATCA 25th Anniversary Science Symposium provided the opportunity to look back over the scientific productivity of the Compact Array. It should be noted up front that the 25th Anniversary of the official Compact Array opening does not exactly coincide with the start of regular astronomical observing: operations formally began in 1990, but useful data was being taken the previous year during the testing and commissioning phase.

One measure of the Compact Array's productivity is the number of refereed papers produced, and last year this reached a new high, with seventy-six papers published. A better measure of impact is the number of citations to those papers, and this was the approach adopted on the occasion of the Compact Array's 20th birthday: see *ATNF News* no. 65, October 2008. Cumulative citation counts naturally favour older papers, and so not surprisingly, the most highly cited papers from five years ago remain some of the most highly cited papers today. The exercise was repeated for the 25th symposium, with the NASA/ADS database used to determine the citations, from all sources, for refereed publications in the ATNF publications database. From this, papers presenting new Compact Array results were selected.

Radio emission from the unusual supernova 1998bw and its association with the gamma-ray burst of 25 April 1998, (Kulkarni *et al.*, 1998, Nature) remains the Compact Array's most highly cited paper, as it was in 2008, with over 380 citations. However, the order has changed after that.

The large-scale HI structure of the Small Magellanic Cloud (Stanimirovic *et al.*, 1999, MNRAS) is currently the second most highly cited paper, but with *Studies of ultracompact HII regions – II. High-resolution radio continuum and methanol maser survey,* (Walsh *et al.*, 1998, MNRAS) breathing down its neck! A list of the 25 most highly cited papers includes several other papers on gamma-ray bursts, and other papers on HI imaging of the Small and Large Magellanic Clouds, as well as several papers on radio observations of X-ray binary systems. There are also many papers which are not primarily Compact Array papers but for which Compact Array observations have been important: for example, *The 1000 Brightest HIPASS Galaxies: HI Properties*, (Koribalski *et al.*, 2004, AJ) is based on almost 5,000 hours of Parkes observations, but with the addition of Compact Array observations of a number of fields to clarify identifications with optical galaxies. Similarly, *PSR 1259-63 – A binary radio pulsar with a Be star companion,* (Johnston *et al.*, 1992, ApJ) used Parkes to discover the pulsar, but relied on pinpointing its position with the Compact Array to associate its companion with a Be star.

The bias against younger papers inherent in cumulative total counts can be overcome by considering citation count rate with time, and this reveals three outstanding recent papers. The first, *Extragalactic Millimeter-wave Sources in South Pole Telescope Survey Data: Source Counts, Catalog, and Statistics for an 87 Square-degree Field* (Vieira *et al.*,

2010, ApJ) uses Compact Array follow-up of the South Pole Telescope discoveries to help characterise the sources. *The Australia Telescope Compact Array Broadband Backend: description and first results,* (Wilson *et al.*, 2011, MNRAS) combines a detailed description of the CABB system with examples of the science it is enabling. (The high citation rate of this paper was acknowledged in a recent email from the journal to the authors, which noted it had helped raise the journal's impact factor.) Finally, *The Australia Telescope 20 GHz Survey: the source catalogue,* (Murphy *et al.*, 2010, MNRAS) is likely to become one of the Compact Array's most highly cited papers in absolute terms, in the same way that the paper describing the NRAO VLA Sky Survey is by far the most highly cited paper produced by the Very Large Array.

The ATNF Annual Report for 2011 noted that "*... the ATNF achieves the best science outcomes, in terms of publications and citation counts, when science teams include both Australian and overseas astronomers",* and this is borne out by the list of highly cited Compact Array papers. Twenty-two of the top 25 papers have overseas-affiliated co-authors, and 21 have ATNF-affiliated co-authors. The majority also have a 'non-ATNF Australia' affiliated co-author and, not surprisingly, the largest class of such a breakdown, constituting almost half the top 25, includes ATNF, *and* other Australian, *and* overseas-affiliated authors.

We look forward to revisiting these studies in five years' time!

THE COMPACT ARRAY'S 25 MOST HIGHLY CITED PAPERS

Radio emission from the unusual supernova 1998bw and its association with the gamma-ray burst of 25 April 1998
Kulkarni + 8, Nature, 395, 663 (1998) – 389 citations

The large-scale HI structure of the Small Magellanic Cloud
Stanimirovic + 4, MNRAS, 302, 417 (1999) – 306 citations

Studies of ultracompact HII regions – II. High-resolution radio continuum and methanol maser survey
Walsh + 3, MNRAS, 301, 640 (1998) – 304 citations

The cored distribution of dark matter in spiral galaxies
Gentile + 4, MNRAS, 351, 903 (2004) – 275 citations

An HI Aperture Synthesis Mosaic of the Large Magellanic Cloud
Kim + 6, ApJ, 503, 674 (1998) – 266 citations

Correlated X-Ray Spectral and Timing Behavior of the Black Hole Candidate XTE J1550-564: A New Interpretation of Black Hole States
Homan + 8, ApJS, 132, 377 (2001) – 242 citations

Optical and Radio Observations of the Afterglow from GRB 990510: Evidence for a Jet
Harrison + 19 ApJ, 523, L121 (1999) – 241 citations

Relativistic motion in a nearby bright X-ray source
Tingay + 19, Nature, 374, 141 (1995) – 235 citations

Radio/X-ray correlation in the low/hard state of GX 339-4
Corbel + 4, A&A, 400, 1007 (2003) – 213 citations

A common origin for cosmic explosions inferred from calorimetry of GRB030329
Berger + 10, Nature, 426, 154 (2003) – 195 citations

Quenching of the Radio Jet during the X-Ray High State of GX 339-4
Fender + 10, ApJ, 519, L165 (1999) – 192 citations

Coupling of the X-ray and radio emission in the black hole candidate and compact jet source GX 339-4
Corbel + 6, A&A, 359, 251 (2000) – 194 citations

HI Shells in the Large Magellanic Cloud
Kim + 3, AJ, 118, 2797 (1999) – 182 citations

The Radio Structures of Southern 2 Jy Radio Sources
Morganti + 2, MNRAS, 263, 1023 (1993) – 177 citations

The 1000 Brightest HIPASS Galaxies: HI Properties
Koribalski + 39, AJ, 128, 16 (2004) – 173 citations

The Deep X-Ray Radio Blazar Survey. I. Methods and First Results
Perlman + 6, AJ, 115, 1253 (1998) – 165 citations

A Survey for OH (1720 MHz) Maser Emission Toward Supernova Remnants
Frail + 5, AJ, 111, 1651 (1996) – 166 citations

The extended radio emission in the luminous X-ray cluster A3667
Rottgering + 3, MNRAS, 290, 577 (1997) – 154 citations

The Southern Galactic Plane Survey: HI Observations and Analysis
McClure-Griffiths +5, ApJS, 158, 178 (2005) – 152 citations

*1E 1547.0-5408: A Radio-emitting Magnetar with a Rotation Period of 2 Se*conds
Camilo + 3, ApJ, 666, L93 (2007) – 148 citations

A high-sensitivity survey of radio continuum emission from Herbig Ae/Be stars
Skinner + 2, ApJS, 87, 217 (1993) – 145 citations

A Long, Hard Look at the Low/Hard State in Accreting Black Holes
Miller +7, ApJ, 653, 525 (2006) – 141 citations

An HI aperture synthesis mosaic of the Small Magellanic Cloud
Staveley-Smith + 4, MNRAS, 289, 225 (1997) – 141 citations

Synthesis images of 6.7 GHz methanol masers
Norris +4, ApJ, 412, 222 (1993) – 140 citations

Chandra Discovery of a 100 kiloparsec X-Ray Jet in PKS 0637-752
Schwartz + 20, ApJ, 540, 69 (2000) – 140 citations

Celebrations at the Compact Array

HELEN SIM (CASS)

'Einstein' about to make a big bang with a hydrogen balloon.

A 'full house' for Phil Edwards' talk on the Compact Array.

Robin Wark explaining the control room displays.

Jamie Stevens overseeing the solar viewing.

Albert Einstein doesn't go to many birthday parties these days, but he came to the Compact Array's on Sunday 1 September. After all, this was a special event: a public Open Day to celebrate the 25th anniversary of the telescope's formal opening on 2 September 1988. Einstein (played by Patrick Helean of Questacon) was just one of more than 800 visitors. The others were members of the general public, mostly from northwest NSW, who enjoyed themselves by taking guided tours of antennas and the control building, viewing the Sun through solar telescopes, listening to presentations about astronomy, being entertained by Einstein, and talking with CASS staff. The anniversary also allowed CASS to engage with the community (both local and national) through the media, promoting the telescope's scientific contributions. Chris Hollingdrake, former manager of the Parkes Observatory's visitors centre, was responsible for organising the Open Day, but it couldn't have happened without the contributions of 50-odd volunteers, mostly CASS staff, many of whom travelled from Sydney and Parkes. The staff at the Paul Wild Observatory put in an especially large effort, shouldering most of the load.

The following day, Monday 2 September, the observatory also hosted a formal 'marquee' event for invited guests. Most attendees had strong connections to the Compact Array, having built, worked at, or been users of the telescope. Arriving mid afternoon, guests mingled and renewed their acquaintance with both each other and the inside of a Compact Array antenna. In the early evening a representative of the local Gomeroi community, Ms Jody Sevil, gave a Welcome to Country: speeches followed from Brett Hiscock (Site Manager – Paul Wild Observatory), Simon Johnston (CASS Assistant Director – Astrophysics), Ron Ekers (ATNF Foundation Director), Elaine Sadler (past chair of the National Committee for Astronomy) and Bob Frater (former Chief of CSIRO's Division of Radiophysics, and responsible for leading the telescope's construction). Douglas Bock (CASS Assistant Director – Operations) was the master of ceremonies. The formalities finished with a three-minute slideshow, heroically compiled by CASS's Robin Wark, which covered life at the Compact Array over the last 25 years. Finger food, birthday cake and champagne rounded off the evening. Again, the success of this event was largely due to the hard work of the Narrabri staff.

These celebrations were followed by the ATCA's 25th birthday symposium, held in Narrabri, which is described on page 4.

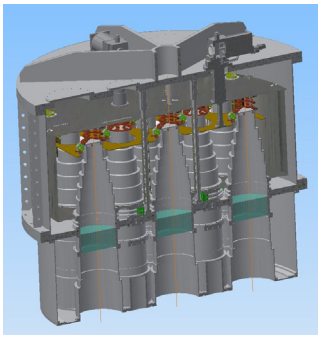
Sarah Pearce welcoming the crowd on behalf of CASS.

Mark Bowen explaining the mysteries of receivers.

Bob Frater (who led the Compact Array's construction) cutting the telescope's birthday cake.

Engineering update

GRAEME CARRAD (CASS)



A 3D rendering of the test receiver for the FAST telescope.

In recent months, CASS Engineering resources have largely been focussed on aspects of the ASKAP project, but that is by no means all that they have been committed to.

Compact Array 4–12 GHz receivers

The Compact Array antennas got their new 4–12 GHz (6-cm) receivers in a timely fashion; however, the spare parts, including a suite of amplifiers, had to wait for that delivery before they could be given much attention. An entire spare receiver was delivered in July and other spares will soon be completed. Documentation also went on the back-burner while we were getting the receivers on the telescope: we are now focussed on completing this too.

FAST Multibeam Receiver Feasibility Study

The FAST Multibeam Receiver Feasibility Study has progressed, and three engineers from the National Astronomical Observatories, Chinese Academy of Sciences (NAOC) visited in October in connection with the project. The receiver is a weighty part of the receiver suite for the 500 m-diameter dish currently under construction, and the visitors were keen to discuss the findings of the feasibility study and take part in measurements of a single-pixel receiver fabricated from parts representative of those that might be used in the final 19-pixel receiver. Of similar form to other hydrogen-line multibeams, this 1.05–1.45 GHz design has had its feed and orthomode transducer designed by CASS's sister division, now known as CSIRO Computational Informatics. All other elements have been designed by CASS engineers and made in the CASS workshops. The low-noise amplifier design resulted in modules with noise temperatures of around 5 K. Commercial transistors, whose performance was never expected to match that of the indium phosphide 'specials' currently used in CASS receivers, were used in this application. All indications point to the receiver being realisable: a receiver noise temperature of 7 K has been achieved; a structural analysis of the cryostat housing indicates that the design is robust; and thermal calculations show that the receiver package will be able to maintain the required cryogenic environment. We will deliver a final feasibility report to the FAST project team in the near future.

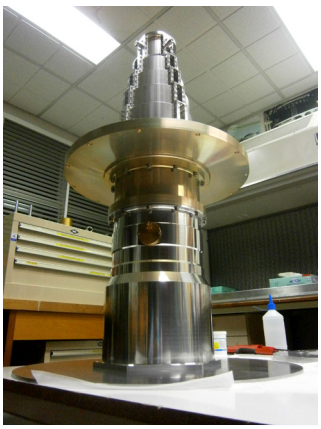
Parkes receivers

Effort has also been directed toward studies into possible receivers for Parkes that fit well with the operating model of more remote control and fewer receiver changes. Under consideration are a 700 MHz–4 GHz receiver, a 4–24 GHz receiver, and a Phased Array Feed. The sensitivity of any new receivers must match or excel that of the current receiver suite. We are investigating designs for the receivers and back ends, considering both the technologies needed to achieve the wide bandwidths and digitise signals at the receiver and the strategies needed to cope with radio-frequency interference (RFI).

Visits and visitors

Alex Dunning recently travelled to the US to meet with Sander Weinreb, a recognised 'guru' of radio astronomy instrumentation. On the same trip he visited NRAO's facilities on the east coast, where his interactions with the staff engendered enthusiasm in both him and them.

October seemed dominated by international visitors as CASS played host to three engineers from the Max Planck Institute for Radioastronomy (MPIfR) in Germany. Discussions with the MPIfR representatives, Gundolf Wieching, Günter Knittel and Pablo Tornes Torres, were focussed on making an ASKAP Design Enhancements (ADE) Phased Array Feed for use on the 100-metre dish at Effelsberg. MPIfR have been keen to install a PAF, and discussions centred on the response of a PAF to the challenging RFI environment at Effelsberg, and how the receiver might be modified to work with the observatory's existing infrastructure and electronic systems. Members of the ASKAP commissioning team were able to convey valuable insights into beamforming and Brian Jeffs, a visitor from Brigham Young University (USA) at CASS for 11 months, was able to share ideas on dealing with RFI using beamformers.



The input waveguide assembly for the FAST test receiver.

Measuring the feed pattern of the FAST test receiver in an anechoic chamber.

Awards

TONY CRAWSHAW AND HELEN SIM (CASS)

Aaron Chippendale (L) (CSIRO Astronomy and Space Science) and Stuart Hay (CSIRO Computational Informatics) with a national Engineering Excellence Award for CSIRO's Phased Array Feed. Photo: Engineers Australia

Naomi McClure-Griffiths, winner of the 2013 Newton Turner Award.

CSIRO Phased Array Feeds win engineering awards

CSIRO's new phased array feed (PAF) receiver system, developed specifically for ASKAP and radio astronomy, has now won awards for its engineering at both the State and national levels.

Earlier this year the PAF was entered in the Engineering Excellence Awards (Sydney division) of Engineers Australia, winning the *Innovations & Inventions* category and receiving an 'honourable mention' in the *Research & Development* category.

As a category winner, the PAF was eligible for entry to the national finals. In late-breaking news, it has received a national Engineering Excellence Award – an award given to recognise world-class expertise and innovation.

The PAF is the first chequerboard receiver built specifically for radio astronomy.

Six first-generation ASKAP PAF systems are already installed on ASKAP antennas at the Murchison Radio-astronomy Observatory (MRO) in Western Australia, along with associated digital systems, beamformers and a hardware correlator. Continued commissioning tests have already produced the first multibeam image with a three-PAF system, as well as the first detection of a spectral line with an ASKAP system, another step in validation of the use of PAFs for radio astronomy.

The PAF systems were developed through a close collaboration between two areas of CSIRO: Astronomy and Space Science, and Computational Informatics.

Newton Turner Award for Naomi McClure-Griffiths

Dr Naomi McClure-Griffiths, Deputy Astrophysics Group Leader at CSIRO Astronomy and Space Science, has received CSIRO's prestigious Newton Turner Award for 2013–2014.

The Award is designed to further the scientific careers of exceptional senior scientists in CSIRO, and recipients receive a grant to assist their professional development.

Naomi obtained her doctorate in 2001 from the University of Minnesota and joined CSIRO Astronomy and Space Science that year, initially as a Bolton Postdoctoral Fellow. She has more than 90 refereed papers to her name and has received a number of previous awards, most notably the 2006 *Prime Minister's Malcolm McIntosh Prize for Physical Scientist of the Year.*

Naomi's research speciality is the interstellar medium (ISM) of our Galaxy; she also makes occasional forays into Galactic structure and the Magellanic System. During the time she's been studying the ISM, the greatest change, she says, has been our ability to use molecular tracers to better understand the Galaxy's 'ecosystem': how its stars and gas interact over time. "The more you learn, the more you realise how complex it is," Naomi says.

Naomi has led two major surveys, the Southern Galactic Plane Survey (SGPS) and the Parkes Galactic All-Sky Survey (GASS). She will co-lead the Galactic Australian SKA Pathfinder Survey (GASKAP), one of ASKAP's large Survey Science Projects, and will also lead its northern hemisphere counterpart, the Galactic and Magellanic Evolution Survey (GAMES), which is to be carried out with the Westerbork Synthesis Radio Telescope.

To make progress on the understanding the life cycle of the ISM, Naomi will use the funding provided by the Newton Turner award to bring together a select group of observational astronomers and theoreticians in two tightly focused meetings in Australia. The first of these, *Phase transitions in the diffuse ISM* in late 2013, will address the participants' areas of common interest and create collaborations; the second meeting will build on those collaborations.

The Newton Turner Award, named after CSIRO geneticist Dr Helen Alma Newton Turner (1908–1995), was established by CSIRO in 2008. Dr Turner's work was focused on genetic improvement of sheep for wool production, and had national and international impact.

Meetings

SIMON JOHNSTON (CASS)

Recent meetings and workshops

The ATNF has hosted and/or played the major part in organising six international meetings and workshops in the six months from April 2013.

A NEAPOLITAN OF MASERS: VARIABILITY, MAGNETISM AND VLBI, 20–22 MAY

This meeting, held at the ATNF's Sydney headquarters, brought together experts to review the current state of important branches of maser research. It attracted some 50 participants, from 14 countries, and was followed by two days of informal discussion aimed at developing collaborations. CASS's Shari Breen, Jimi Green and Ioannis Gonidakis led the organisation of the meeting.

www.atnf.csiro.au/research/workshops/2013/maserworkshop2013/index.html

RFI AND ITS IMPACT ON THE NEW GENERATION OF HI SPECTRAL-LINE SURVEYS, 17–18 JUNE

This technical workshop was held at the ATNF's Sydney headquarters and was attended by 55 scientists and engineers. It covered spectrum management, the effects of RFI, and mitigation techniques. Two CASS staff, Lisa Harvey-Smith and Tim Shimwell, chaired the program organising committee and local organising committee respectively.

www.atnf.csiro.au/research/conferences/2013/rfi2013/index.html

ASKAP EARLY SCIENCE WORKSHOP, 5 AUGUST

ASKAP Early Science will be a program of observations that explore new scientific parameter-space with ASKAP before the construction of the array is complete. The Early Science workshop, with 70 participants, was held to generate input to the program from the astronomical community. CASS's Lisa Harvey-Smith (ASKAP Program Scientist) was the organiser.

www.atnf.csiro.au/projects/askap/ASKAP_EarlyScience_Workshop.html

AUSTRALIA TELESCOPE COMPACT ARRAY 25TH BIRTHDAY SYMPOSIUM, 3–5 SEPTEMBER

A three-day science meeting was held in the town of Narrabri as part of the celebration of the Compact Array's 25th anniversary. It was prefaced by a formal celebration at the Compact Array on the evening of Monday 2 September (described on page 6). The science meeting was attended by over 60 people, and balanced 'the old' – recollections of the telescope's construction – with 'the new' – the plans of early-career scientists to use the telescope and, in particular, exploit the capabilities of the Compact Array Broadband Backend (CABB). Simon Johnston (CASS Assistant Director – Astrophysics) chaired both the scientific organising committee and the local organising committee. This meeting is described in more detail on page 3.

www.atnf.csiro.au/research/conferences/ATCA25th/index.html

EVOLUTIONARY PATHS IN GALAXY MORPHOLOGY, 23–26 SEPTEMBER

Galaxy Zoo, the popular citizen-science program, was the trigger for this meeting. Held at Sydney's Powerhouse Museum, it attracted 94 participants, from several

Professor Brian Schmidt (ANU) addressing participants at the ASKAP Early Science workshop.

countries. While being a 'regular' meeting on galaxy evolution, it also incorporated a good deal of science generated by *Galaxy Zoo* and its spinoffs (the *Zooniverse*), covered how *Galaxy Zoo* is evolving, and examined how the automation of galaxy classifications is progressing. The formal science meeting was complemented by an evening *Zooniverse* community workshop for teachers and educators, run by Rob Hollow (CASS) and Kelly Borden (Adler Planetarium). CASS's Ivy Wong and Julie Banfield led the local organising committee for the meeting.

www.atnf.csiro.au/research/conferences/2013/gzo/index.html

AUSTRALIAN ALMA COMMUNITY WORKSHOP, 30–31 OCTOBER

This workshop was held to prepare the Australian astronomical community to respond to the forthcoming call from ALMA (the Atacama Large Millimeter/submillimeter Array) for Cycle 2 proposals. It brought together four ALMA experts (representing North America, East Asia and Europe) with 40 Australian participants who ranged from postdocs to senior researchers. The workshop covered ALMA's science capability and completed observing projects, and trained participants in the use of the tools (such as simulators) needed to write ALMA proposals. CASS's Jill Rathborne chaired the organising committee.

www.atnf.csiro.au/research/workshops/2013/alma/ALMA_workshop.html

Future meetings and workshops

PHASE TRANSITIONS IN THE DIFFUSE ISM, 25–27 NOVEMBER 2013

Wentworth Falls, NSW

www.atnf.csiro.au/research/workshops/2013/phasetrans/

ASTROINFORMATICS 2013: KNOWLEDGE FROM DATA, 9–13 DECEMBER 2013

Sydney, NSW

www.atnf.csiro.au/research/workshops/2013/astroinformatics/

POWERFUL AGN AND THEIR HOST GALAXIES ACROSS COSMIC TIME, 16–20 JUNE 2014

Port Douglas, Queensland, Australia

www.atnf.csiro.au/research/workshops/2014/SouthernCrossVII/

Participants of the Galaxy Zoo meeting, held at Sydney's Powerhouse Museum in September. Photo: Rob Hollow

ASKAP and SKA news

FLORNES CONWAY-DERLEY (CASS), KATE CHOW (CASS), CAROL WILSON (CASS), STEVEN TINGAY (ICRAR/CURTIN) AND JUDD BOWMAN (ARIZONA STATE UNIVERSITY)

The ASKAP team has seen plenty of activity since the last edition of *ATNF News*, with the sixth first-generation (Mk I) phased array feed (PAF) receiver installed onto ASKAP antennas at the Murchison Radio-astronomy Observatory (MRO); continuing commissioning activities bearing encouraging results and validating PAFs for radio astronomy; and further progress on the Mk II PAF as part of the ASKAP Design Enhancements (ADE) project.

While these commissioning activities continue, planning is also underway for the ASKAP Early Science and CSIRO ASKAP Science Data Archive (CASDA) programs, with SKA planning and pre-construction work continuing to ramp up over time.

More recently, the potential of PAFs for radio astronomy has been recognised by Engineers Australia through its Engineering Excellence Awards (see page 8) for more details), and additional funding has been secured to ensure that ASKAP can deliver the scientific capability it needs to achieve the best possible scientific impact and lasting benefit to Australia.

First spectral-line detection

In October ASKAP made its first-ever detection of a spectral line: an exciting milestone, given the importance of spectral-line surveys in achieving ASKAP's science goals. CSIRO researchers performed the observation remotely from CASS's Science Operations Centre in Marsfield, Sydney. They used three ASKAP antennas, equipped with the first-generation phased array feed (PAF) receivers, to observe the source S9 IAU, a cloud of neutral gas in our Galaxy often used as a calibrator for HI spectral-line observations. While testing of the spectral-line capabilities with BETA is still at a preliminary stage and there are many more tests to complete, the commissioning team is pleased to have made this important step towards the goal of producing spectral-line image cubes with ASKAP.

ASKAP telescope receives SIEF grant

In July ASKAP was awarded a $6m grant from the Australian Government's Science and Industry Endowment Fund (SIEF). To achieve its full scientific potential, ASKAP requires one PAF for each of its 36 antennas. The SIEF funding, complemented by an additional $6m commitment from CSIRO, will be used to fund the construction and installation of additional PAFs on the ASKAP antennas at the Murchison Radio-astronomy Observatory (MRO), bringing the total to 30, and increasing ASKAP's survey speed by a factor of almost four.

News from the MRO

FINAL BETA PAF INSTALLED

The sixth and final first-generation ASKAP phased array feed (PAF) system has been installed on ASKAP antennas at the MRO in Western Australia, along with its associated digital systems and beamformers. The six antennas equipped with the first-generation PAFs constitute the Boolardy Engineering Test Array (BETA), which will be used by the commissioning teams to prepare for the full fit-out of all 36 ASKAP antennas.

Phased array feeds have been installed on all six ASKAP antennas that form the Boolardy Engineering Test Array (BETA).

HARDWARE CORRELATOR INSTALLED

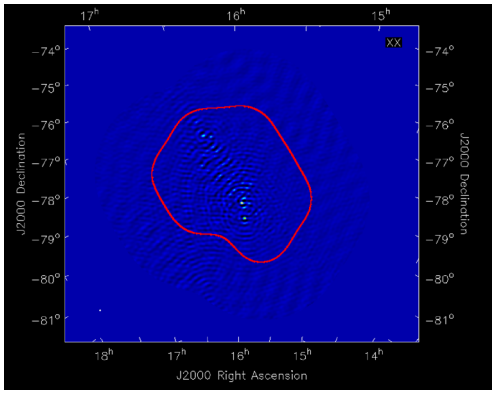
The new ASKAP hardware correlator and associated firmware have also been installed at the MRO, making possible the first tests of the ASKAP Science Processing Pipeline. The correlator and firmware provide greater sensitivity, bandwidth and spectral resolution than were previously available. They were developed, tested and validated at CASS's Marsfield headquarters.

The new ASKAP hardware correlator, installed at the MRO.

FIRST MULTIBEAM IMAGE WITH BETA

Following first correlation and phase closure of an astronomical source using the BETA hardware correlator, in July the ASKAP team produced the first multibeam image made with the ASKAP BETA system. Unlike the earlier multibeam image (reported in *ATNF News* April 2013), this test used the BETA hardware correlator rather than the interim data-capture and software correlator system.

The new image was made with ASKAP antennas 1, 3 and 6, close to the core of the array, which are fitted with the first-generation PAF receivers, along with the associated digital systems, beamformer and hardware correlator.



The first multbeam image made with the ASKAP BETA system. The nine overlapping beams are confined to the central region inside the red contour. Three bright extragalactic sources (PKS1610-771, PKS 1549-790 and PKS 1547-795) are clearly visible.

The field of view of these antennas comprises nine overlapping beams, improving on the three beams used for the first ASKAP multibeam image produced in April 2013.

The success of these initial correlator tests validated the BETA hardware design and cleared the way for the tests to be repeated using all six first-generation PAF systems now installed on the ASKAP antennas. However, using six PAFs rather than three makes these tests more complex.

ASKAP Early Science Program

In May 2013, a program of 'early science' observations on ASKAP was announced, and the astronomical community was asked for input on the design of the program.

The Early Science Program will consist of a series of science-focused observations, carried out by the ASKAP commissioning and early science team, using an array of 12 ASKAP antennas equipped with CSIRO's second-generation phased array feed receivers.

The first step in the consultation and planning process was a community workshop, held early in August at CASS headquarters in Marsfield. This attracted 70 registered participants, from 14 institutions in five countries. (See page 9 for more details.)

Discussions at the workshop covered ground-breaking scientific questions that could be addressed using ASKAP's 12-antenna array, and scientific and technical issues related to survey planning, data acquisition, and data access and distribution to the ASKAP Survey Science Teams (SSTs).

For more information about the Early Learning Science Program, please see *www.atnf.csiro.au/projects/askap/science.html*.

Science Data Archive

Planning has also been under way for the CSIRO ASKAP Science Data Archive (CASDA). This is one of three subsystems that make up the computing components for ASKAP (the others being the Telescope Operating System and the Central Processor).

The Science Data Archive is the primary mechanism for storing, managing and sharing fully calibrated and science-ready data products. It will provide the ASKAP Survey Science Teams with access to processed data products for analysis.

The team developing the Science Data Archive is drawn from CSIRO Astronomy and Space Science and CSIRO Information Management and Technology.

An important challenge is that ASKAP is still being commissioned and the demands

on the Science Data Archive will increase with time, meaning that its design and architecture need to be flexible.

The first stage of the project, which will run until the end of 2013, is to define the requirements the system must meet.

News from Geraldton

MRO SUPPORT FACILITY OFFICIALLY OPENED

July saw the new support hub for the Murchison Radio-astronomy Observatory, the MRO Support Facility (MSF), opened in Geraldton, Western Australia.

The MSF is located within the Geraldton Universities Centre complex, and will act as the 'home base' for CSIRO staff whose primary role is to provide remote-operations services for ASKAP. It will also provide support services for other international projects at the MRO, such as the Murchison Widefield Array and the future Square Kilometre Array (SKA) telescope.

The MSF has an Operations Room, in which researchers can remotely operate and monitor projects at the MRO; a Portal Room for regional researchers awarded time on iVEC's Pawsey Centre supercomputer in Perth; workshops for repairs of ASKAP equipment; and meeting and conference facilities.

As well as being the official opening of the MSF, July's event was an opportunity to thank regional stakeholders who have been crucial in the establishment of the MRO, ASKAP and the MSF itself.

ASKAP Project Director Ant Schinckel (L) and CASS Chief Lewis Ball at the opening of the MRO Support Facility in Geraldton.

CASS staff at the opening of the opening of the MRO Support Facility.

STARSTRUCK AT THE MURCHISON ASTROFEST

The Murchison Astrofest – a one-day astronomy festival held at the Murchison Settlement in Western Australia – ran as part of National Science Week in August.

The crowd at the Murchison Astrofest.

Setting up the telescopes at the Astrofest.

Both professional and amateur astronomers turned out for it. CSIRO's Lisa Harvey-Smith (ASKAP Project Scientist) and the Australian National University's Professor Ken Freeman (winner of the 2012 Prime Minister's Prize for Science) gave keynote talks. Other daytime activities included guided walks with Wajarri 'bush professor' Alan Egan; sampling a selection of Aboriginal bush foods, including an Emu-egg omelette; and looking at an exhibition of local artworks from Wajarri and non-Aboriginal artists.

In the evening a special night-viewing session was held with telescopes set up by the Geraldton Astronomy Group, Geraldton Grammar School, ICRAR (the International Centre for Radio Astronomy Research) and the Astronomy Group of Western Australia. CASS's Education Officer Rob Hollow led a 'sky tour', interpreting the Murchison skies to the haunting sounds of the didgeridoo.

The Murchison Astrofest is run by the Murchison Shire Council, with support from CSIRO and other sponsors.

Astrofest was followed by a tour of the MRO for a number of volunteers and radio-astronomy enthusiasts. This tour was immensely popular, with the response of the enthusiastic amateurs a reminder of the huge step forward the telescopes at the MRO represent for radio astronomy.

Ant Schinckel leading a tour of the MRO after the Astrofest.

SKA activities

SKA PRE-CONSTRUCTION UPDATE AND PLANNING WORK

The last six months have been a busy time for SKA-related activities at CASS, with the planning and pre-construction work increasing. A huge variety of work has been completed, from funding and hosting agreements and consortium negotiations to policy decisions and updates.

CSIRO as an enterprise has been providing invaluable help: CSIRO Legal, for instance, has assisted with the SKA hosting agreements and Memoranda of Understanding, and CSIRO International has helped facilitate contacts with European entities over the SKA power studies.

The CSIRO SKA Centre, hosted by CSIRO Astronomy and Space Science and led by CASS Deputy Chief Sarah Pearce, was established to coordinate CSIRO's activities in SKA. Dr Mark McKinnon joined CASS in late September (on secondment from the US National Radio Astronomy Observatory) to lead the SKA Dish Array Consortium, after Dr Carole Jackson, the previous lead, accepted a WA Fellowship and moved to Curtin University to be a Professor of Astrophysics. Dr Kate Chow joined the SKA Team in CASS, working for Michelle Storey as the Executive Officer for CSIRO SKA Site & Infrastructure, after her previous role as an OCE Postdoctoral Fellow with Ray Norris.

Carol Wilson was transferred to CASS from CSIRO Computational Informatics (CCI) in September and will be responsible for spectrum and radio interference issues. CASS will continue to support Carol's ITU (International Telecommunication Union) work on radio standards, which also benefits CCI and other CSIRO divisions.

CSIRO PARTICIPATION IN SKA WORK-PACKAGE CONSORTIA

The SKA Organisation Request for Proposals (SKAO RfP) closed in June. During the RfP process, the Department of Industry (then the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, DIICCSRTE) ran its own process to conditionally allocate the $18.8m SKA pre-construction funding to Australian entities, to allow them to participate in the consortia bids. This process built on the Expressions of Interest requested by DIICCSRTE in November 2012 from potential industry partners.

The proposals for grants closed on 15 April, and the results were announced on 28 May, with eight entities being awarded funds. CSIRO received $9m of the total available funding of $18.8m, to allow it to lead two consortia ('Dish Array' and 'Infrastructure Australia'), and participate in several others including 'Assembly, Integration and Verification' and 'Signal and Data Transport'.

Mark McKinnon, who will lead the SKA 'Dish Array' consortium.

On 27 July the SKA Office announced the outcomes of its RfP process. All the RfPs in which CSIRO was involved were successful. Negotiations began in September between the SKA Organisation and the all the SKA pre-construction consortia to finalise the Statements of Work for the consortium bids.

The 'Dish Array' work-package is an $80m project to manage the research and design of the dishes and receivers for the SKA: the consortium includes research and industry partners from South Africa, Canada, China and Italy. As noted above, Dr Mark McKinnon joined CSIRO in September to lead this consortium. He is on secondment from the US National Radio Astronomy Organisation (NRAO), where he has been North American Project Director for ALMA (the Atacama Large Millimeter/submillimeter Array) and has coordinated $600m worth of ALMA construction. Mark brings a wealth of experience in radio astronomy, international collaboration, and interacting with industry, all of which will be necessary to deliver one of the world's largest science facilities.

RADIO QUIET ZONE POLICY AND STAKEHOLDER RELATIONS

Since 2005, the Australian Communications and Media Authority (ACMA) and the Western Australian Government have introduced a number of regulatory measures to protect the radio quietness of the Mid West site for the SKA and precursor telescopes. The CSIRO Radio Quiet Zone team has worked with DIICCSRTE (now the Department of Industry) to evaluate the scope of these measures and identify any additional requirements.

As these regulatory measures have been publicised or updated, government and industry stakeholders have raised questions about the effect on their activities. The RQZ team and DIICCSRTE staff have spent considerable time over the past six months undertaking technical analyses, writing briefing documents, and meeting with WA Government representatives to explain the need for these regulatory measures and the effect they may have on industry in the Mid West.

Collaborator projects

MWA SCIENCE OPERATIONS UNDER WAY

In the April 2013 issue of this newsletter it was noted that the MWA had called for observing proposals from the community for the first semester of science operations, scheduled to be undertaken in the second half of 2013 (2013B semester).

It is pleasing to report that a set of very high-quality proposals was received by the deadline at the end of April.

The MWA Time Allocation Committee (TAC), six independent experts from around the world, considered and ranked the proposals, awarding 620 hours of observation time across nine approved projects.

The successful projects are listed at *http://mwatelescope.org/index.php/astronomers*.

Professor Steven Tingay (Curtin University) and Senator Kim Carr, at the operations launch of the MWA in July.

The 620 hours of observation are enough to generate approximately 1.5 PB of data during 2013B. Further, importantly, the 620 hours of observations include 507 hours of 'dual-use' observing, where multiple science programs can be pursued in a commensal fashion. This is an important and unique characteristic of the MWA that flows from its extreme wide-field capabilities.

To celebrate the fact that the MWA is the first of the three SKA Precursors to enter the full science operations phase, an operations launch event was held during the annual meeting of the Astronomical Society of Australia (ASA) in July, at Monash University in Melbourne. The (then) Minister for Innovation, Industry, Science and Research, Senator Kim Carr, officiated at the launch, which was attended by international VIPs and delegates from the ASA meeting.

The 2013B observing schedule was initiated in early August and the MWA has been operating in a robust manner since that point, extremely well supported by power and communications infrastructure and operational staff at CSIRO's Murchison Radioastronomy Observatory (MRO) and facilities at the recently commissioned and opened iVEC Pawsey Centre in Perth, as well as by the iVEC staff operating the Pawsey infrastructure.

Very large volumes of data are now flowing over the 800 km between the Murchison and Perth and radio astronomy in Australia has well and truly entered the Big Data regime. The MWA science teams are working hard to keep up with the data flow, and early imaging and calibration results look extremely good.

The second Call for Proposals, for semester 2014A (first half of 2014), closed in October. Whereas the 2013B call was restricted to Guaranteed Time (GT: for MWA Individual Members and institutions only), the 2014A call now covered both GT and Open Access (OA: open to any astronomer from any institution in the world) time allocations.

As the MWA is now moving into its full science operations phase, the regular six-monthly MWA Project Meetings will now change focus to being largely scientific meetings to review progress with the different science projects, disseminate research outcomes, and discuss future scientific possibilities with the MWA.

These meetings are open to all interested members of the community and the next meeting will take place in Wellington, New Zealand, in December 2013.

Full details, including registration details, are available at *http://mwatelescope.org/index.php/team/project-meetings/121-project-meeting-wellington-2013*.

Recent publications of note from the MWA include: a study of the potential for the MWA to be used as a facility for tracking space debris, by Prof. Steven Tingay *et al.*; a comprehensive study of the lobes of Centaurus A at 118 MHz, by PhD student Mr Ben McKinley *et al.*; a 2400-square-degree polarisation survey at 189 MHz, by Dr Gianni Bernardi *et al.*; and the full science case description for the MWA, by Dr Judd Bowman *et al.* (published in PASA).

EDGES

EDGES continued to collect data between 80-200 MHz at the MRO during the year to provide a long-term baseline measurement of low-level radio-frequency interference and ionospheric conditions. The Arizona State University (ASU) team visited the site in March and November 2012 to update the installation. MRO staff have continued to provide on-site support, including monitoring of fuel, power, and network connectivity. MRO staff have also performed several minor hardware repairs for the EDGES team.

In parallel with the operation of the existing instrument, the EDGES team has been preparing a new instrument (EDGES-2) that aims to improve on performance of the existing experiment by a factor of 10. This development is supported by a new three-year research grant from the U.S. National Science Foundation (award number: AST-1207761) awarded in May 2012 to Principal Investigator Judd Bowman at ASU and Co-Investigator Alan Rogers at MIT/Haystack.

The first deployment of the new system will begin in late October 2013. In 2012, one postdoc, two postgraduate students, and three undergraduate students at ASU assisted in EDGES data analysis, instrument design, and testing.

The MRO and EDGES infrastructure was used in 2012 to support testing of a prototype receiver and antenna for the Dark Ages Radio Explorer (DARE) NASA mission concept. DARE mirrors the goals and techniques of EDGES and is being developed as collaboration between the EDGES group and a team led by Professor Jack Burns at the University of Colorado.

Hardware for DARE was implemented at JPL, NRAO, and ASU and deployed by the ASU group to MRO in March 2012. The instrument has been collecting data in the 40-150 MHz band throughout the year to characterise the hardware and test absorption models of the ionosphere.

End of an era: the decommissioning of the Parkes Analogue Filterbanks

DICK MANCHESTER AND PHIL EDWARDS (CASS)

On 16 September the Parkes analogue filterbank (AFB) systems were formally decommissioned, bringing to an end a remarkably successful and productive series of pulsar observations. While filterbank systems had been constructed for earlier pulsar searches, the most significant system was that designed to work with the Parkes 13-beam 20-cm ('Multibeam') receiver.

The Multibeam receiver was originally conceived with the goal of mapping the sky in the HI spectral line. However, the pulsar group quickly realised that with some small modifications to the receiver specifications, mainly increasing the available bandwidth, it would also allow more efficient pulsar searches. Handling the data from all 13 beams simultaneously, however, required the construction of a new, dedicated, filterbank system. As Figure 1 shows, dispersion in the interstellar medium causes pulses to arrive progressively later at lower frequencies. To obtain the necessary sensitivity, all pulsar observations must compensate for this delay. The simplest way to do this is to filter the signal into a number of channels corresponding to different frequencies and to 'de-disperse' the pulse in offline processing. For pulsar searches a large number of possible dispersions must be searched, but for pulsar timing the data are de-dispersed using the known dispersion measure (DM) of the pulsar.

The filterbank system for the Multibeam receiver consisted of 26 identical filterbanks, each with ninety-six 3-MHz channels. Each feed of the 13-beam system has two orthogonal probes recording the total power of incoming signal and so 26 filterbanks were needed. Construction of the system was an international collaboration between Jodrell Bank Observatory (JBO), the Osservatorio Astronomico di Bologna and the ATNF. The filterbanks and one-bit digitiser system were designed by Andrew Lyne and Tim Iken of JBO, and constructed at JBO and Bologna during 1996. The design was based on earlier filterbank systems constructed at JBO for the Parkes 20-cm survey (Johnston *et al.*, 1992, MNRAS, 255, 401), the Parkes 70-cm pulsar survey (Manchester *et al.*, 1996, MNRAS, 279, 1235) and the globular-cluster searches (e.g., Manchester *et al.,* 1991, Nature, 352, 219).

The local oscillator/down-converter system was designed and constructed at ATNF. It employed an up-down conversion system to split the incoming 288-MHz-bandwidth signal for each polarisation/beam into three bands, each between 64 and 160 MHz, which were fed to separate filterbank boards. Consequently there were 78 filter boards, which is why the system required almost three racks in the old control room at Parkes.

After detection, signals from corresponding orthogonal polarisations were summed and then high-pass filtered, integrated and sampled by a one-bit digitiser. These samples were then packed and recorded on magnetic tape or disk for offline analysis. The one-bit digitiser system was also designed at JBO and constructed there and at Bologna. It proved to be very efficient for pulsar searching because it was relatively immune to impulsive radio-frequency interference. Furthermore, it kept data rates from the 13-beam receiver to levels that were readily manageable at the time. The data-acquisition system (PMDAQ) was developed by David Loone and Fernando Camilo, the observation-control program (PMCTRL) by Dick Manchester, the observer GUI interface by Andrew Lyne, and the monitoring program (PMMON) by Nichi D'Amico. The Parkes 13-beam pulsar-search system is described in detail in the paper by Manchester *et al.* (2001, MNRAS, 328, 17).

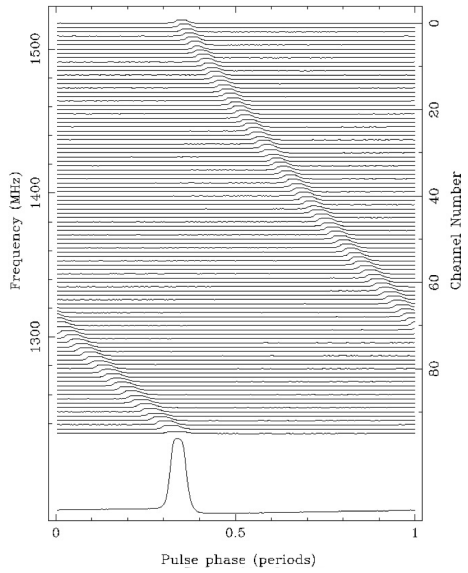


Figure 1: Pulse phase versus radio frequency (ν) for the strong, highly dispersed pulsar PSR B1641-45, recorded using one of the 96 x 3-MHz filterbanks built for the 20-cm Multibeam system. The dispersive delay is proportional to ν^{-2}.

New capabilities for the Tidbinbilla 70-m antenna

SHINJI HORIUCHI (TIDBINBILLA)

The Tidbinbilla 70-m antenna

The Tidbinbilla 70-m radio telescope, also known as Deep Space Station 43 (DSS-43), is one of antennas at the Canberra Deep Space Communication Complex (CDSCC) at Tidbinbilla near Canberra. The CDSCC is one of three stations that make up NASA's Deep Space Network (DSN), and the primary purpose of station's antennas is to track spacecraft and space probes for NASA and other space agencies. Some antenna time not used for space communication is scheduled for Host Country radio-astronomy observations and is open to the astronomical community. The Tidbinbilla 70-m dish is the most sensitive single-dish antenna in the southern hemisphere. It is used in VLBI experiments to increase imaging sensitivity and for single-dish projects such as the observation of water-maser sources and ammonia emission lines.

Despite its superb sensitivity, two factors have limited the 70-metre's effectiveness for some kinds of science: a lack of an On-the-Fly (OTF) mapping mode, and the restricted bandwidth of its analogue spectrometer. But those limitations have now been overcome.

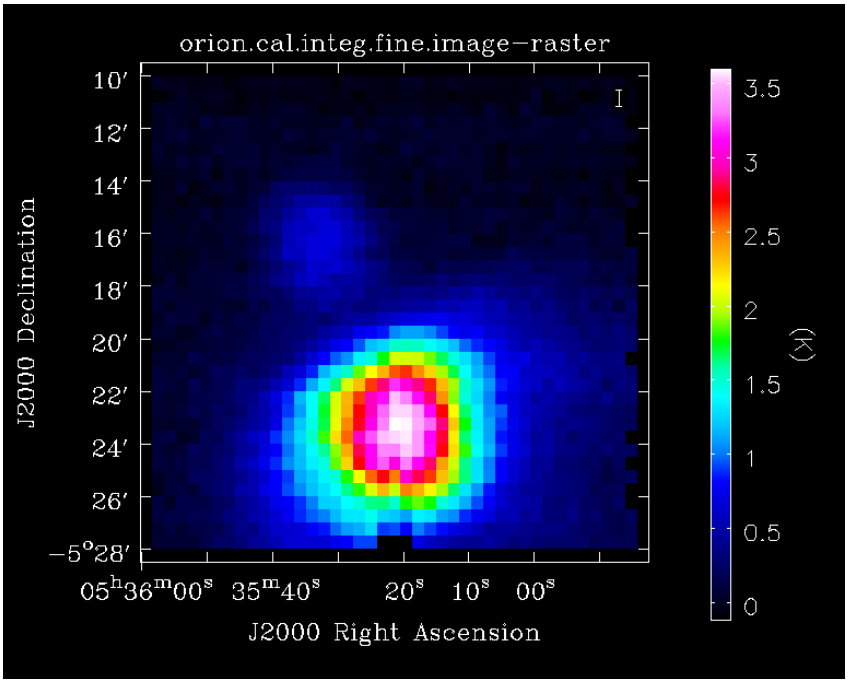


Figure 1: An observation of the Orion Nebula – one of the first On-the-Fly maps made with the Tidbinbilla 70-m antenna. (See text for details.)

TIDBINBILLA AMMONIA MAPPING PROJECT

The first moves towards an On-the-Fly mapping system began in late 2010, when a Summer Vacation Student, Mr Tye Young, started work on a project to demonstrate the 70-metre's spectral-line mapping capability and apply the technique to observations of Galactic star-forming regions. Under the supervision of Shinji Horiuchi and Jimi Green, Tye made test observations of three large molecular clouds in the Orion Nebula, Sagittarius B2 and the Carina Nebula, and succeeded in obtaining ammonia molecular-line maps for all of them. Ammonia is a powerful tracer of the characteristics of molecular clouds and acts as a natural thermometer, allowing us to measure the temperature of the gas – one of key parameters in studying star-formation activity. The Orion Nebula and Sagittarius B2 have been well studied and can be good targets for test observations. Carina, however, can be seen only from the southern hemisphere, and ammonia lines had not been previously detected in this source. But we were able both to make the first detection of the ammonia and to map it (Young *et al.*, 2013, MNRAS, 435, 3568). These observations have highlighted the potential of the Tidbinbilla 70-m antenna for sensitive large-scale mapping of ammonia.

THE FIRST TIDBINBILLA 70-M ON-THE-FLY MAPPING

The Carina mapping project was conducted using position-switching observations. That was appropriate for this source as the ammonia emission is very weak. Each data point was sampled with frequent position switching between 'on source' and 'off source' to subtract atmospheric and instrumental effects, with an integration time of eight minutes in each position. We mapped a 2.5 x 4.5 arcminute field over a total of 15 hours. However, for stronger sources and a wider field, the On-the-Fly (OTF) mapping method, sampling data during a raster scan, would be more efficient. Graeme Wong from the University of Western Sydney worked with us recently to develop the Tidbinbilla OTF as part of his PhD project. The OTF data were calibrated and mapped with ASAP and CASA, thanks to Dr Kanako Sugimoto who developed the CASA single-dish program and supported a workaround script to transform the Tidbinbilla data format into one suitable for CASA. Figure 1 is one of the first OTF maps, an observation of the Orion Nebula for the radio recombination line of hydrogen at 8.30937 GHz. Here 42 x 35 pixels were sampled over 2.4 hours (the time includes reference point scans and overhead), with a three-second integration per point. This is significant improvement in efficiency.

NEW K-BAND SYSTEM ON DSS-43

NASA's Jet Propulsion Laboratory has invested in new wideband K-Band receiver systems for the Deep Space Network's 70-m dishes. These systems have two beams, with dual-polarisation feeds for each beam. The Tidbinbilla 70-m has now been outfitted with its new receiver, plus a new wideband down-converter. The system currently covers 21-25 GHz: this is likely to be extended to 17-27 GHz in coming years. In addition, the Smithsonian Astrophysical Observatory has funded a new wideband spectroscopy backend for Tidbinbilla. The first project to use this new backend with the K-band frontend will be the Tidbinbilla AGN Maser Survey (TAMS) project led by Dr Lincoln Greenhill (Harvard-Smithsonian Center for Astrophysics). We expect that this new system will contribute to future multi-transitional mapping projects.

New science appointments

SIMON JOHNSTON (CASS)

Since the April 2013 edition of *ATNF News* was published, CASS has welcomed another seven scientific staff: Joanne Dawson, Laura Gonzalez Gomez, Ian Heywood, Megan Johnson, Matthew Kerr, Amy Kimball and Paolo Serra. Here they tell us, in their own words, about their research interests.

JOANNE DAWSON

Bolton Fellow
PhD: Nagoya University, Japan, 2010

"My primary interest is the interstellar medium in the Milky Way and nearby galaxies, with particular focus on the mechanisms by which atomic gas is processed into molecular clouds. My research has addressed the role of supernova feedback in molecular cloud formation, seeking quantitative observational evidence of molecular gas formation in the walls of giant 'supershells' in the Galaxy and Large Magellanic Cloud. I am joint Primary Investigator of a large Parkes project, SPLASH (the Southern Parkes Large-Area Survey in Hydroxyl), a large-scale, sensitive and unbiased survey of ground-state OH lines in the Southern Galactic Plane. I am a also member of the GASKAP project, which will use ASKAP to map the Galactic Plane and Magellanic system in HI and OH to unprecedented angular resolution."

LAURA GONZALEZ GOMEZ

Australis Postdoctoral Fellow
PhD: MPIfR and University of Bonn, 2012

"My research is concerned with understanding the chemical and physical properties of clumps associated with infrared dark clouds, in the context of the earliest stages of high-mass star formation. To this end, I have made use of existing archival data from the Spitzer Space Telescope in the mid infrared regime to create a catalog of IRDC candidates, and carried out observations with both single-dish telescopes and interferometers toward some of those clumps. I have also measured proper motions in star-forming regions, using VLA radio continuum observations. As Australis Fellow, I have spent a year working in Santiago at the University of Chile before coming to CASS."

IAN HEYWOOD

Senior Research Scientist
PhD: University of Manchester, 2005

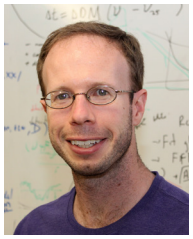
"My PhD was in stellar astrophysics, observing and modelling the evolving radio emission from classical nova explosions, and from there I moved into the field of somewhat more energetic accretion-powered outflows, namely the jets from active galactic nuclei. At present I'm focusing on AGN, star formation and galaxy evolution across cosmic time, mainly using continuum and spectral-line observations at radio wavelengths. I also maintain a strong interest in new techniques for the calibration and imaging of data from connected radio-telescope arrays. At CASS I will be contributing to the commissioning of ASKAP, and I also have a role as Project Scientist for the CSIRO ASKAP Science Data Archive, an exciting cross-disciplinary collaboration between CASS and CSIRO Information Management and Technology."

MEGAN JOHNSON

Office of the Chief Executive Postdoctoral Fellow
PhD: Georgia State University, 2011

"I study the evolution of dwarf galaxies: my current interests are in understanding the mechanism that triggers starbursts in these galaxies and how the environment affects

their interactions and mergers. At CASS I hope to gain a deeper understanding of the role of neutral hydrogen, especially how it connects dwarf galaxies to their environments. I'm involved in several surveys, including LITTLE THINGS and CHANG-ES (both using the VLA), LVHIS (led from CASS) and WALLABY (the HI all-sky survey to run on ASKAP)."



MATTHEW KERR

Office of the Chief Executive Postdoctoral Fellow
PhD: University of Washington, Seattle, 2010

"As a PhD student, I studied optimal methods for characterizing the spectra of gamma-ray sources using data from the Fermi Gamma-ray Space Telescope. My work was applied – with success – to searching for pulsations from gamma-ray pulsars and selecting promising unidentified Fermi sources for radio pulsation searches. Before coming to CASS I worked at Stanford University on models of pulsar emission and on the challenging spectral analysis of pulsars at energies from 1 MeV to 100 MeV. I'm currently studying the timing properties of both gamma-ray and radio pulsars, with hopes of understanding the timing noise that hampers efforts to detect gravitational waves with arrays of millisecond pulsars."

AMY KIMBALL

Office of the Chief Executive Postdoctoral Fellow
PhD: University of Washington, Seattle, 2010

"My main research area is the study of large samples of powerful active galactic nuclei (AGNs) using multi-wavelength data from deep-sky surveys in the radio, optical, and infrared. I am interested in learning how the radio emission of quasars relates to their properties at other wavelengths, and understanding the origins of radio-jet production. My current research projects include observations of host galaxies of ultra-luminous quasars, exploring the low-frequency radio properties of high-redshift galaxies, and investigating the origin of radio emission from radio-quiet quasars."

PAOLO SERRA

Office of the Chief Executive SL (Science Leader) Research Scientist
PhD: Kapteyn Astronomical Institute, The Netherlands, 2008

"Before joining CASS, I worked at the Kapteyn Institute and ASTRON in the Netherlands. My main research interest is galaxy evolution, in particular the processes that determine the structure, shape and content of galaxies. Gas is a major player in these processes and my research is strongly centred on the observation of HI gas in galaxies in different environments. I combine these observations with data at other wavelengths, and with simulations, to study the interplay between the different components of galaxies and test our theoretical understanding of galaxy evolution. I lead a number of HI surveys using interferometers such as the Westerbork Synthesis Radio Telescope, MeerKAT and, more recently, the Compact Array. At CASS I'll work on these projects and on WALLABY, and I hope to be strongly involved with the commissioning of ASKAP."

Graduate student program

GEORGE HOBBS (CASS)

The CASS graduate student program continues to attract high-quality students from around the world to study a huge array of different astrophysical problems. Current students are researching galaxies, masers, pulsars, supermassive black holes, high-velocity clouds, stars and the interstellar medium. Details of the program are available at *www.atnf.csiro.au/research/student/*.

We congratulate the students who have recently completed their PhDs :

Jay Blanchard (University of Tasmania):
Linking the radio and gamma-ray properties of blazars

Justin Bray (University of Adelaide):
Ultra-high-energy neutrinos and their detection with the lunar Cherenkov technique

Xinping Deng (National Space Science Center, Beijing, China):
Pulsar timing and its application in spacecraft navigation

Dan Thornton (Jodrell Bank Centre for Astrophysics):
Pulsar and transient searching with GPUs

Jingbo Wang (Xinjiang Astronomical Observatory, China):
Searching for the gravitational-wave memory effect in pulsar datasets

Caterina Ubach (Swinburne University of Technology):
CABB millimetre observations of proto-planetary disks

We also welcome the following students into the program:

Andreas Herzog (Ruhr University, Bochum, Germany):
The broadband spectra of infrared-faint radio sources

Courtney Jones (University of Tasmania):
The Southern Milky Way

Aina Musaeva (University of Sydney):
Intermediate-mass black holes in dwarf galaxies

Glen Rees (Macquarie University):
Cosmology using next-generation radio telescopes

Elise Servajean (Universidad de Chile):
The physical and kinematical structure of massive and dense cold cores

Tye Young (Australian National University):
Multiwavelength properties of dwarf galaxies in the local volume.

If you are interested in joining the program, or wish to learn more about it, visit *www.atnf.csiro.au/research/student* or contact George Hobbs *(George.Hobbs@csiro.au)*.

Scientific visitors

NAOMI MCCLURE-GRIFFITHS (CASS)

The CASS visitors program is designed to provide financial and logistical support to facilitate working visits. As noted in the April newsletter, the program is now open to researchers at all levels.

Financial support for visits typically covers the cost of on-site accommodation at CASS headquarters in Marsfield or its equivalent (approximately A$500 per week). Visits funded through the program should be for at least two weeks and could last for up to one year. Visitors may be located at any of the ATNF sites and are expected to deliver at least one colloquium or seminar during their stay at the CASS.

We also encourage extended visits of six or twelve months. For these longer visits it is possible to seek additional funds through CSIRO. Please contact the Chair of the Visitors Committee, Naomi McClure-Griffiths, for more information. Potential visitors should make contact with a local member of staff or the Chair of the Visitors Committee to develop a proposal. Proposals to the program should include a brief description of a collaborative project to be conducted during the visit, an estimate of the dates of the visit and support required, a current CV and a list of publications. Proposals are reviewed quarterly (in February, May, August and November).

For more information, see *www.atnf.csiro.au/people/scientific_visitors.html*.

CSIRO Distinguished Visitor, Professor James Jackson of Boston University. Professor Jackson is taking a year's sabbatical at CSIRO Astronomy and Space Science in Marsfield, from September 2013 to August 2014. His stay is funded through CSIRO's Distinguished Visiting Scientist program. Professor Jackson will be working with the star-formation group at CASS, analysing data collected for the MALT90 project with the Mopra telescope and other data taken with ALMA, and working on new proposals.

The superwind of NGC 253

STEVEN WARREN (UNIVERSITY OF MARYLAND)

Mopra data has complemented data from ALMA in a study of the 'superwind of NGC 253.

Galaxy 'superwinds' are thought to help shape the galactic mass function, play a critical role in galaxy evolution, and pollute the intergalactic medium with heavy metals (e.g., Veilleux *et al.* 2005; Baldry *et al.* 2008; Oppenheimer *et al.* 2010; Dave *et al.* 2011). These winds are feedback from either active supermassive black holes (an active galactic nucleus, AGN) or strong starbursts. Detailed studies of nearby systems frequently focus on the warm or hot phases of the wind, visible in X-ray or Hα emission. However, most of the mass in the outflowing material is thought to be in the form of neutral atomic and molecular gas (Walter *et al.* 2002; Rupke *et al.* 2005, 2013; Ferglio *et al.* 2010; Alatalo *et al.* 2011). Until recently, observations of the cooler gas phases have been hindered by the lack of facilities sensitive to the low-surface-brightness emission as well as the necessary spatial scales to connect the superwind with either the AGN or stellar processes (for example, supernovae).

The ionized superwind of NGC 253 emerges from the central ~200 pc, filling a cone with an opening angle of ~60°, and extends ~10 kpc from the nucleus. It is unclear whether NGC 253 hosts an accreting black hole, but the low-luminosity AGN would be energetically sub-dominant to the extreme star-formation activity. Lobes of Hα, UV, and X-ray emission fill the outflow cone. Imaging of the central region with the Hubble Space Telescope reveals dark lanes due to dust entrained in the outflow, suggesting the wind may also carry significant amounts of molecular gas.

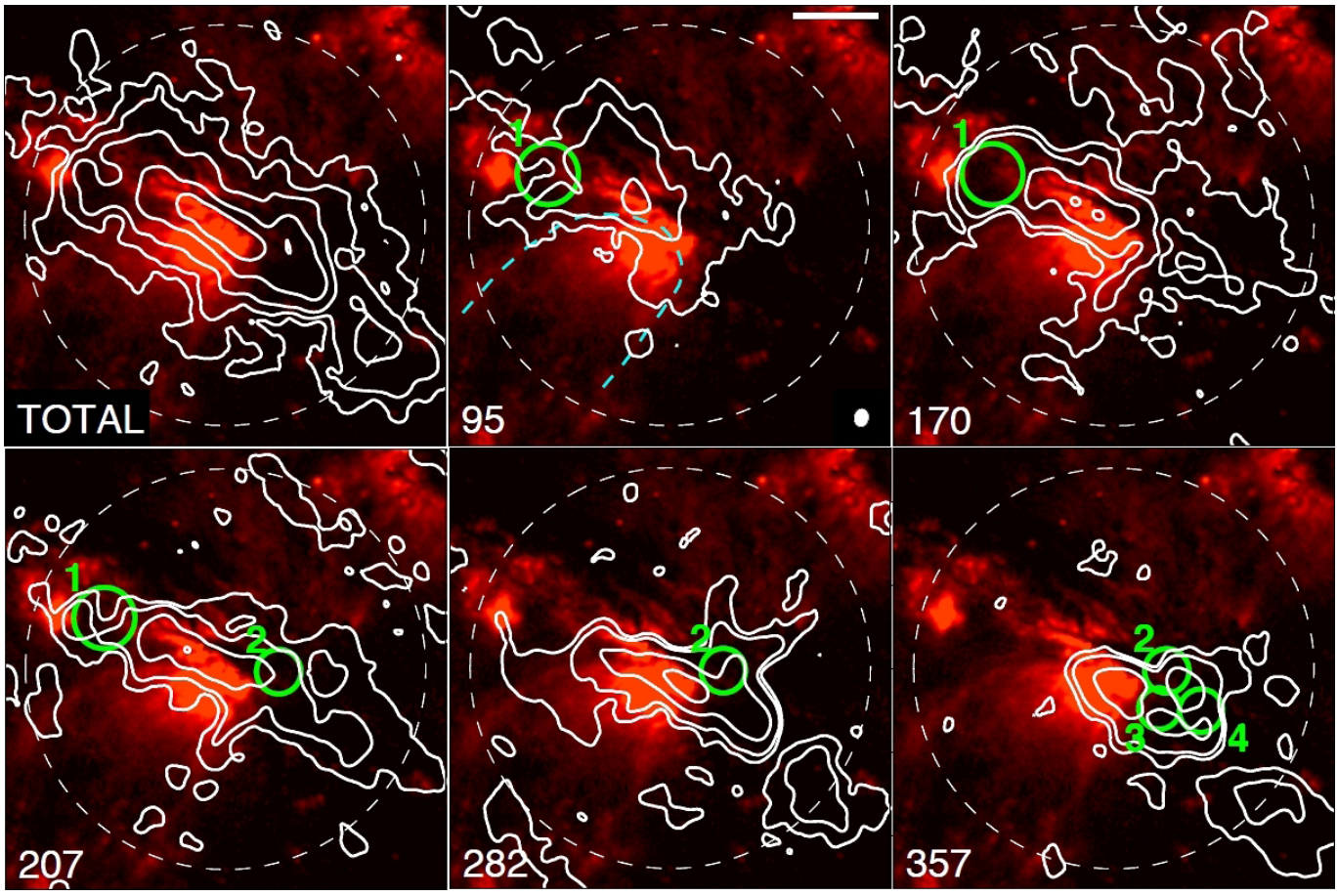


Figure 1: The inner 1.5' of NGC 253. Hα background image (red) with white CO contours (SCOΔv=5, 10, 25, 100, 250 Jy km s-1 per beam). Expanding molecular shells are shown as green circles. The CO barycentric velocity is shown at the lower left in each panel. The beam and a 200-pc scale bar are shown in the top middle panel. The dashed white circle shows the ALMA primary beam. The dashed blue line in the top middle panel denotes the approximate edge of the Hα outflow cone. Extra-planar CO emission is apparent at the edges of this cone throughout the different channel maps, and it appears connected to the expanding shells.

We recently observed the nuclear star-bursting galaxy NGC 253 in CO (J=1-0) with ALMA (the Atacama Millimeter / Submillimeter Array) at 50 pc resolution (Bolatto *et al.* 2013). Our ALMA (observations reveal CO emission spatially coincident with the previously observed ionized outflow, as well as possible launching mechanisms via stellar-wind and supernova-driven expanding shells. However, the lack of short spacing information in the ALMA observations limits our extended flux recovery and results in strong 'negative bowls' in the images.

In order to improve the quality of the observations, the ALMA data (shortest baselines ~20.2 m) were successfully combined with observations previously obtained with the 22-m Mopra single dish (Principal Investigator, Jürgen Ott). The data were combined in the image plane with the MIRIAD software package, using a feathering technique coded in the immerge routine. The combined image was then used as an input model in CASA's CLEAN algorithm. This process significantly reduced the impact of the negative bowls. The final imaging reveals striking CO filaments perpendicular to the main molecular bar, coincident with the edges of the outflow cone, and appear to be spatially and spectrally associated with observed supernova-driven superbubbles (see Figure 1).

We use the observed CO luminosities and velocities to estimate the mass, mass-loss rate, and energetics of the molecular wind. To compute a lower bound for the molecular mass in the wind, we adopt an optically thin conversion factor $\alpha_{CO} \approx 0.34\ M_{sun}$ (K km s^{-1} $pc^2)^{-1}$, about an order of magnitude lower than the value characteristic of the Milky Way disk. We compute an outflow mass of $M_{mol} \sim 6.6 \times 10^6$ M_{sun}. The observed projected velocities of the CO filaments range from ~30 to 60 km s^{-1}, resulting in a mass loss rate of ~9 M_{sun} yr^{-1}. This rate is uncertain, but we show that it takes extremely pessimistic assumptions for the mass-loss rate to become as low as ~3 M_{sun} yr^{-1}. The nuclear region of NGC 253 has a star-formation rate of ~3 M_{sun} yr^{-1}, resulting in a mass-loading parameter $\eta \sim 1$-3. It is not immediately clear if the outflowing gas will escape the halo or eventually rain back onto the disk. What is clear is that NGC 253 will exhaust its nuclear star-forming gas in ~60-120 Myr at its current mass-loss rate, cementing the superwind as an important contributor in the evolution of NGC 253.

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The AT20G high-angular-resolution catalogue

RAJAN CHHETRI (UNSW/ATNF), RON EKERS (CASS) PAUL JONES (UNSW), ROBERTO RICCI (INAF)

We have produced a catalogue of high-angular-resolution data for all the sources in the Southern hemisphere selected at 20 GHz in the AT20G survey. This catalogue is derived from previously unexploited data obtained with the ATCA's 6-km antenna during the survey. In the hybrid configurations of the ATCA, the five antennas in the compact configuration and the 6-km antenna provide maximum baselines of between 4,300 and 4,500 m. These baselines provide an angular resolution 20 times greater than that of the main survey. The large gap between the compact configuration of five antennas and the 6-km antenna provides only sparse coverage of interferometer spacings, so imaging is not possible. However, non-imaging analysis in the visibility domain – in effect, comparing the visibilities of the sources at long and short baselines – can still be used to separate sources by size.

Using this approach, we can separate the compact Active Galactic Nuclei or AGNs (which are 77% of the sources in the AT20G catalogue) from sources that have extended components at an angular scale of ~ 0.15 arcsec. The catalogue also identifies compact steep-spectrum sources; an interesting class of objects that are flat-spectrum but extended; and a population of thermal sources in both the Milky Way and the Large Magellanic Cloud.

Our cross-correlations with surveys made at other wavelengths with instruments such as Fermi, ROSAT and WISE give us multiwavelength insights into the spectral properties of AGNs. Using this work, we have shown that compact sources (usually associated with flat-spectrum sources) show spectral curvature at rest-frame frequencies (~30 GHz). Our search for gravitational lenses in the southern hemisphere based on the catalogue identified one source that is probably a gravitational lens, and a further three lens candidates that require further follow-up. A similar search could be made for supermassive binary black-hole systems resulting from galaxy mergers.

We expect that this work will be important for a range of applications, including the selection of different populations for studies (e.g. to refine models of flat-spectrum and steep-spectrum sources) and the identification of high-quality calibrators for high-frequency radio telescope arrays and VLBI observations.

Doi: 10.1093/mnras/stt975

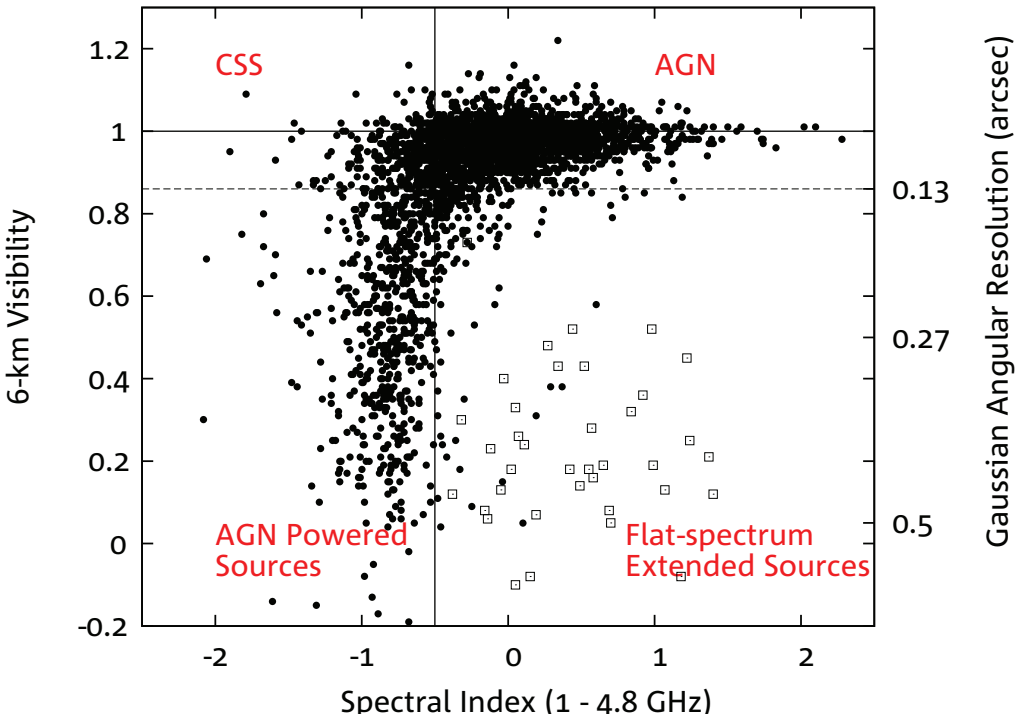

Figure 1: A visibility-spectra plot using the lower-frequency spectral index for AT20G sources and 6-km visibility. The dotted line at a 6-km visibility of 0.86 marks our separation between compact and significantly extended populations. The Y-axis on the right-hand side shows angular scale corresponding to 6-km visibility. The 'compact' source population is strongly correlated with the 'flat-spectrum' population, and the 'extended' source population is strongly correlated with the 'steep-spectrum' population, as the figure clearly shows. A small number of flat-spectrum extended thermal Galactic sources detected in the AT20G are marked with open squares. The negative values of 6-km visibilities are a consequence of a statistical bias correction.

Shells and shocks in the Galactic star-forming region RCW 49

PAULA BENAGLIA & BÄRBEL KORIBALSKI

RCW 49, also known as G284.4-0.3 (Goss & Shaver 1970), is a very bright, complex and extended HII region (~ 40' × 50'), largely imaged at radio continuum and recombination lines. Recent studies using Spitzer data pointed to the super star cluster Westerlund 2 as RCW 49's ionizing agent and confirmed that star formation is taking place there (Churchwell *et al.* 2004). Using Chandra data, Tsujimoto *et al.* (2007) cataloged hundreds of cluster members, mostly young stellar object (YSO) candidates and early-type stars.

Whiteoak & Uchida (1997) obtained radio continuum maps with the Compact Array at 1.4 and 2.4 GHz and the Molonglo Observatory Synthesis Telescope (MOST) at 843 MHz. They identified two shell-like structures, shown in Figure 1: one to the south around the bright star WR 20b (in purple), and one incomplete shell in the north surrounding Westerlund 2 (in magenta), with a possible 'blister' toward the west.

A couple of open questions

At least three high-energy objects were recently detected superimposed on RCW 49: the bright, extended TeV source HESS J1023-575, and two GeV Fermi sources (2FGL J1022.7-5741 or Fermi-1, 2FGL J1023.5-5749c or Fermi-2). Despite 50 hours of dedicated monitoring with the High Energy Stereoscopic System (HESS), and a number of studies focused on determining the nature of the HESS object, no conclusive result was achieved. Figure 1 displays the main objects present in the field.

The distance to the ionized region and the super cluster remains highly controversial. Studies of the stars at different evolutionary stages, and of the gas from various transitions/frequency bands, yield values from 2.5 to 8 kpc (see, for instance, Vargas Álvarez *et al.* 2013 and references therein).

Observing with the ATCA CABB system

We carried out Compact Array observations toward RCW 49 in Feb 2012 using the Compact Array Broadband Backend (Wilson *et al.* 2011) in two array configurations, 6A and 750D, 12 h each. Data at 5.5 GHz and 9.0 GHz were obtained simultaneously, with a bandwidth of 2 GHz each. The band selection allowed us to attain very-high-resolution images (relative to the 1.4 and 2.4 GHz ones) at frequencies where any potential non-thermal emission could still be detected. With those settings we could probe structures of 1–100 arcseconds in extent. The results are presented in a paper by Benaglia, Koribalski, Peri, Marti, Sanchez-Sutil, Dougherty & Noriega-Crespo (2013, A&A, 559, A31).

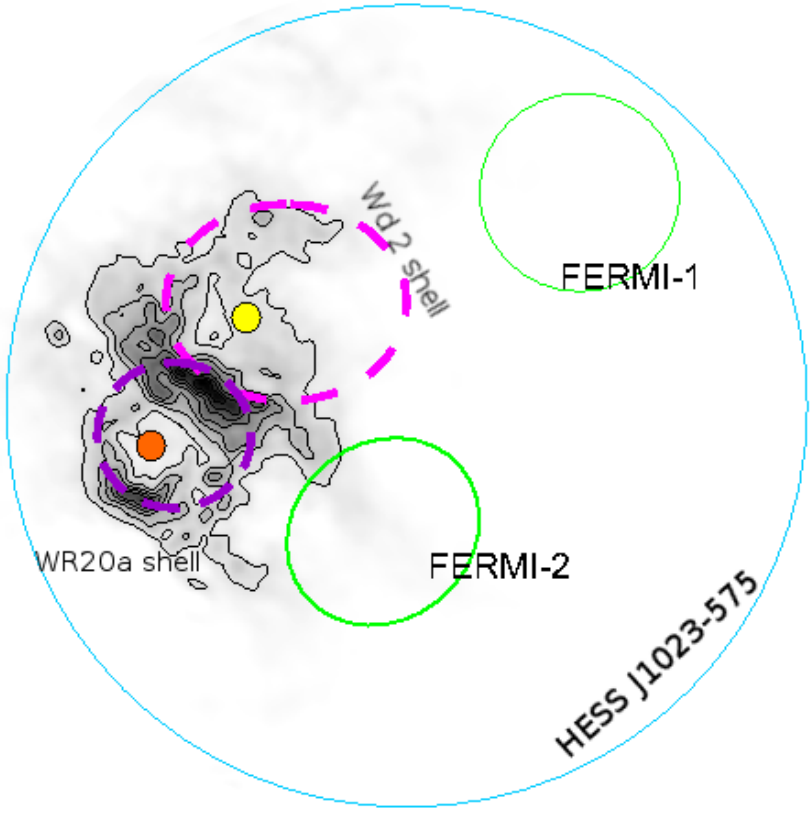

Figure 1: The Galactic star-forming region RCW 49 at 843 MHz (greyscale and contours). The yellow and orange circles mark the core of the cluster Westerlund 2 and the position of the star WR 20b, respectively, while the ellipses in dashed lines represent the shells proposed by Whiteoak & Uchida (1997). Green and cyan rings represent the location of FERMI and HESS high-energy sources.

The observations were centered on RCW 49 and covered an area of 30 square arcminutes. The observing strategy consisted of building a mosaic with 41 pointings, ensuring Nyquist sampling at the higher frequency band. The integration time for each pointing was approximately 13 minutes.

Data editing, calibration, and image reconstruction were performed with the multichannel image reconstruction, image analysis and display (MIRIAD) routines (Sault *et al.* 1995). We had to deal with a very extended radio source, of high dynamic range and substructure sizes at various scales, and data along 2-GHz bandwidths. We tried various approaches for constructing the images. The maximum-entropy deconvolution methods proved to be the best for both minimizing side lobes and dealing with different levels of radio luminosity from the various pointings.

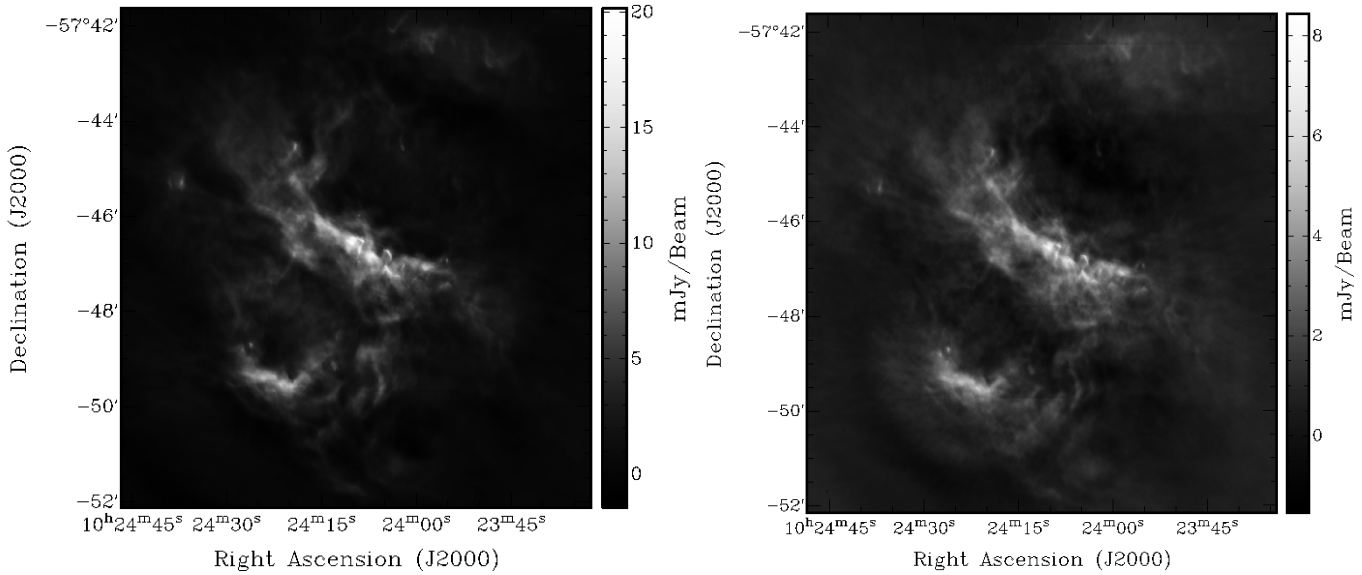

Figure 2: Images of RCW 49 in radio continuum. Left: at 5.5 GHz, with 2-GHz bandwidth. Right: at 9 GHz, with 2-GHz bandwidth. The region of the bridge and part of the southern shell are clearly visible.

Figure 2 shows the final images, with an rms noise of 0.6 mJy/beam, equivalent to three times and twice the theoretical rms values at 5.5 and 9 GHz, respectively. Using the Parkes radio telescope, Churchwell *et al.* (1974) measured an integrated flux density from RCW 49 of 180 Jy at 5 GHz. The integrated flux density from CABB data at 5.5 GHz, above 3σ, is 160±15 Jy. A comparison between the two values shows that the interferometer gathers about 90% of the flux measured by a single-dish telescope, at that frequency.

The CABB-ATCA zoom modes allowed us to perform a pilot observation of a radio recombination line. The central frequency was 5005 MHz, where the H137β transition is expected. The final line data covered 270 channels, of 0.5 km/s width.

Results

The main reason to observe simultaneously at two frequencies was to derive information about the spectral index. With the 5.5 and 9 GHz data sets we obtained the spectral index (α) distribution, assuming S proportional to ν^{α}. The results showed that the bulk of the emission in the region RCW 49 has a value of approximately zero, consistent with the optically thin thermal plasma expected from such a large HII region. Nonetheless, the spectral-index maps hint that some of the plasma in the bridge region may have spectral-index values that are significantly steeper than -0.1, suggesting the presence of nonthermal emission due to relativistic electrons.

Despite the relatively short exposure, the high quality of the data allowed a 3-sigma detection of the RRL H137β transition toward the regions with maximum continuum brightness. The area corresponds to the so-called bridge, at which the two shells proposed by Whiteoak & Uchida (1970) would be interacting. The RRL emission peaked at 15 km/s.

Previous detections of RRLs in RCW 49 include H109α, centered at 0 km/s (Caswell & Haynes 1987), and He109α, with a central velocity of −4 ± 1 km/s (Churchwell *et al.* 1974), collected with the single-dish Parkes telescope. Paladini *et al.* (2013), using narrowband receivers (pre-CABB ATCA, in 2009), measured clear H109α emission toward two sub-regions of the bridge: they found central velocities of 14.5±1.8 km/s, in full agreement with that of H137β.

The central velocity of the H137β emission that we detected is similar to CO-line components (see Ohama *et al.* 2010 and references therein). The velocity of +15 km/s corresponds to a kinematic distance of ~6 kpc, according to the rotation curve in the outer galaxy derived by Brand & Blitz (1993). The emitting ionized gas corresponds to the brightest continuum features that form the RCW 49 region. The fact that the ionized gas and part of the CO gas have similar velocities suggests that the ionized and the molecular components are physically associated.

The molecular studies already mentioned allow the detection of line emission characterized by velocities around 0 km/s. Furukawa *et al.* (2009), for instance, proposed that there are two main clouds, differentiated by the velocity (0 and 15 km/s), and that the region could have been formed by collision of the two clouds. A way to check the hypothesis of 'two molecular clouds that collided' is to trace the velocity field of the ionized gas by means of radio recombination lines, over the whole of RCW 49, and compare velocities of the molecular and radio lines.

Radio vs IR emission

Perhaps the most amazing result is the close match or interplay between radio and IR (Spitzer-GLIMPSE) emission. Figure 3 represents intensity at two IR bands (3.6 μm in blue and 8 μm in green) overlaid onto CABB-ATCA data at 9 GHz (in red).

The radiation is free-free emission from the ionized gas in the radio and near-IR, and dust (PAH) emission. The Westerlund 2 stars stand out as the blue agglomerate onto the dark background. There is intense 8-μm emission (green) in the bridge region. The PAH emission peaks in this band. Bright emission accounts for a dust-rich region, with the consequent effect of radiation reddening.

The structures revealed by means of CABB-ATCA data are very similar to those observed by GLIMPSE. The northern and southern shells, and the bridge described by Whiteoak & Uchida (1997) are very evident. It is clear that the HII region is not in an area of uniform density, with a lack of near-IR emission on the west side of RCW 49 suggesting lower material density to the west. This explains the possible source of the radio blister structure on the west side of RCW 49. The next step will be to study the physical relation between the radio and the IR-emitting gas, eventually making spectroscopic studies in both regions of the spectrum.

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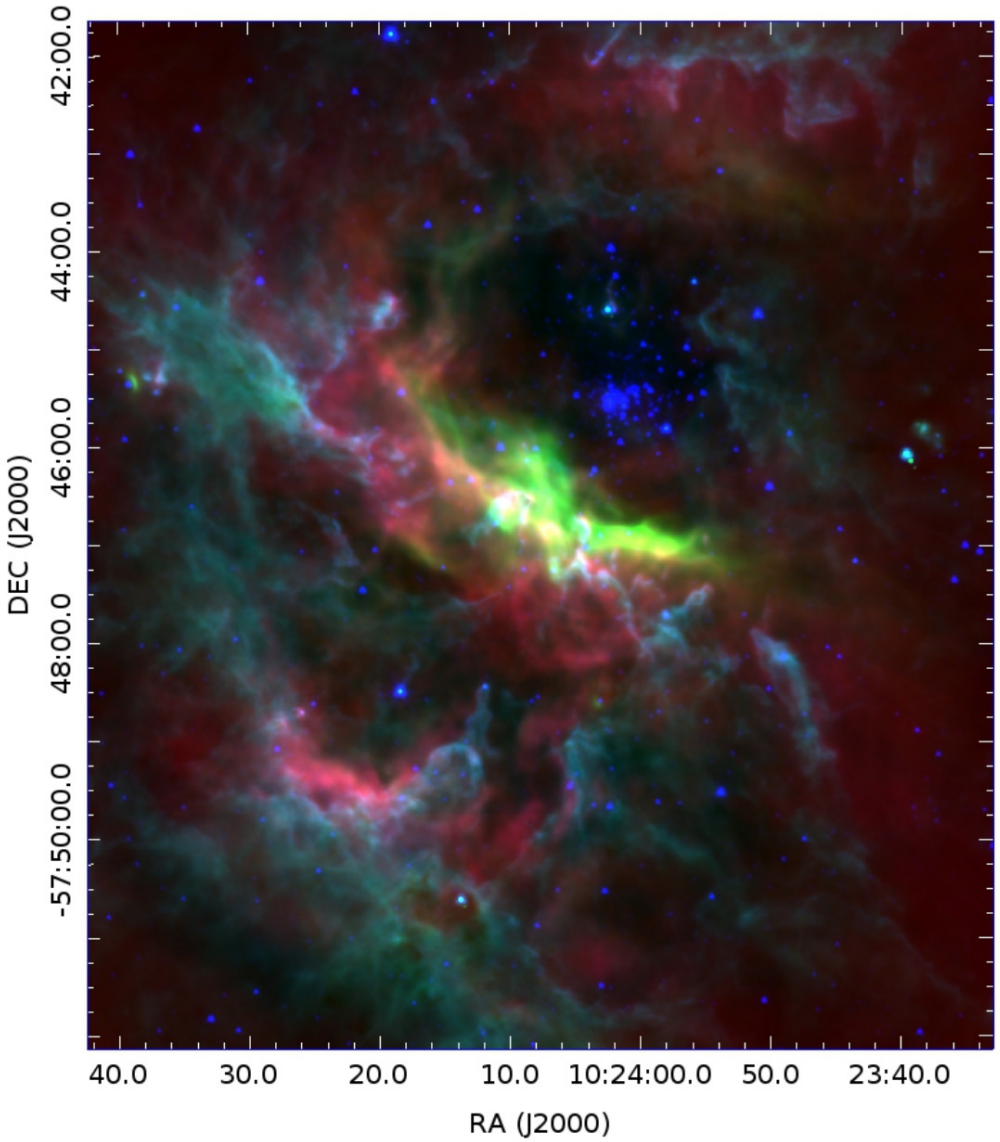


Figure 3: The core of RCW 49, seen at radio continuum (9 GHz, in red) and NIR bands (3.6 mm, in blue and 8 mm, in light green).

Education and outreach

ROB HOLLOW (CASS)

CASS staff have been busy over recent months with a diverse range of outreach and education activities, both in Australia and overseas.

PULSE@Parkes

PULSE@Parkes has now reached over 1000 students. In May, Rob Hollow and Dr Ryan Shannon spent two weeks in Japan running *PULSE@Parkes* observing sessions with Japanese high-school students. Funded by a grant from the Australia-Japan Foundation, they toured the region affected by the recent earthquake and tsunami, and several astronomy and space facilities around Tokyo. Observing sessions were held at the National Astronomy Observatory of Japan's Mizusawa VLBI Observatory and the Koriyama Space Park.

For schools in Australia, observing sessions for *PULSE@Parkes* now usually use the Science Operations Centre and the Interaction Space at Marsfield. These provide a flexible working area for the sessions, and plenty of space in which the visiting students can hold discussions with the project astronomers and our co-supervised PhD students. But, for a change, in August we conducted our first *PULSE@Parkes@Parkes* session, in which students from Parkes High School took part in a PULSE@Parkes session in the telescope itself. In early September we ran a session with students from two schools in Geraldton, WA, at the new Murchison Radio-astronomy Support Facility in that town.

Clear skies at the Murchison Astrofest in August.

Teacher training and support

The annual *Astronomy from the Ground Up* teacher workshop took place at Parkes Observatory in early May. The workshop was booked out, with educators from several states participating in the three-day event. As well as touring 'the Dish' and listening to a variety of speakers, the teachers also had the opportunity to control a model Mars rover at Sydney's Powerhouse Museum over the Internet. Rob Hollow ran further astronomy-education workshop sessions at the national science teachers' conference in Melbourne in July and the NSW science teachers' conference in September. In National Science Week in August Rob also spent a couple of days giving talks and running activities at Townsville State High School for students from several local schools.

Several CASS staff have been involved with CSIRO's *Scientists in School* program. In this they are teamed with a school, work closely with teachers and run activities with students. Other CASS staff have used our small optical telescopes to run viewing evenings at their local or their children's schools.

Dr Lisa Harvey-Smith, Dr Yanett Contreras and Rob Hollow received Mentor Training in Geraldton prior to visiting Pia Wadjarri Remote Community School near the Murchison Radio-astronomy Observatory in August after the *Murchison Astrofest* (an event described on page 14). This tour formed part of on ongoing mentorship program linking CASS staff with the school.

An exciting new initiative is CASS's formal participation in a new education program that involves a collaboration of six universities headed by Macquarie University; CASS; the Australian Astronomical Observatory; and Las Cumbres Observatory Global Telescope Network. *Opening Real Science* is a three-year program designed to improve the quality of pre-service and current science and mathematics teaching by exposing current and trainee teachers to real science with astronomy as a key context. An initial scoping workshop involving participating institutions was held in late September. The scheme will use existing CASS programs, such as PULSE@Parkes, and will also open up new opportunities to present CASS's work to teachers and students.

Other outreach

This year CASS hosted an artist-in-residence, Michaela Gleave. Michaela presented her exhibition *A Day is Longer than a Year,* inspired by her time at CASS, at the Fremantle Arts Centre in June and July. She also curated an evening of activities at the Museum of Contemporary Art Australia, in which CASS staff participated. (See below for more about the artist-in-residence program.) In August CASS supported an event called *Journey to the Planets*: Sydney's Willoughby Symphony Orchestra presented Holst's orchestral suite, *The Planets*, and CASS ran solar viewing and hands-on activity for children ahead of the concert. CASS PhD students Vanessa Moss and Glen Rees worked with Rob Hollow on this event.

Management change at Visitors Centres

Chris Hollingdrake, Manager of the Visitors Centre at the Parkes and Paul Wild Observatories, left CASS in the middle of the year (but was engaged to continue work on the preparations for the Compact Array's 25th anniversary celebrations). In August Glen Nagle, Manager of the Visitors Centre at the Canberra Deep Space Communication Complex (CDSCC), was appointed as Manager of all three CASS Visitors Centres. This will allow for a more strategic and coordinated approach to the management of the VCs. Glen will be based at CASS's Marsfield headquarters but will spend much of his time at the other sites.

CASS artist-in-residence

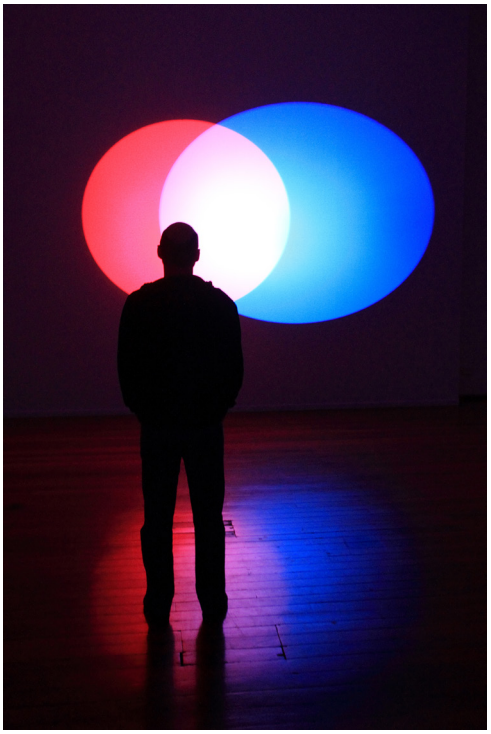
HELEN SIM (CASS)

In September Sydney artist Michaela Gleave completed a six-month stint as an 'artist-in-residence' at CSIRO Astronomy and Space Science in Marsfield.

Michaela works across a range of media including installation, performance, photography and video. Her creations often question our relationship to space, matter and time, and involve natural phenomena and tricks of perception. She has exhibited extensively across Australia and in Germany, Austria, Hong Kong, Korea and Mexico.

The two main outcomes of her time with CASS were an installation at the Fremantle Arts Centre in Western Australia and a curated evening event at the Museum of Contemporary Art Australia in Sydney. The latter included a ballet based on constellations, a lecture on Indigenous astronomy, CSIRO telescopes on the roof, and a re-imagining of the Moon landing.

Reflecting on her experience at CASS, Michaela says:



Michaela Gleave's installation at the Fremantle Arts Centre, 'A Day is Longer than a Year', consisted of two theatre spotlights hung from ceiling, their circular beams slowly orbiting the peripheries of the room. One red, one blue, they travelled in alternate directions and at differing speeds. The beams circled one another as binary stars, eclipsing at varying points. "The work reflected upon our shifting understanding of matter, time and space, oscillating between intimate experience and a constantly expanding knowledge of the universe," says Michaela Gleave.
Photo credit: Michaela Gleave. Image courtesy the artist and Anna Pappas Gallery.

[It] has been a remarkable experience and I feel extremely fortunate to have been allowed access into this world. ... Finding a common ground and a common language in this environment was a challenging but immensely interesting process, and whilst I was barely able to scratch the surface of the field I learned a lot from the process and came out with quite different impressions than when I went in.

Michaela's residency at CASS was assisted by the Australian Government through the Australia Council, its arts funding and advisory body.

Operations

DOUGLAS BOCK, PHIL EDWARDS, TASSO TZIOUMIS AND DAVE MCCONNELL (CASS)

The most visible recent activities of the Operations group have been restoring Mopra after the bushfire and enabling remote observing with the Parkes Telescope. However, we continue to grow our group in Geraldton (there are now 13 staff supporting ASKAP and the MRO) while consolidating the new wideband capabilities at the Compact Array. On page 17 we honour the retirement of the Parkes Analogue Filterbanks.

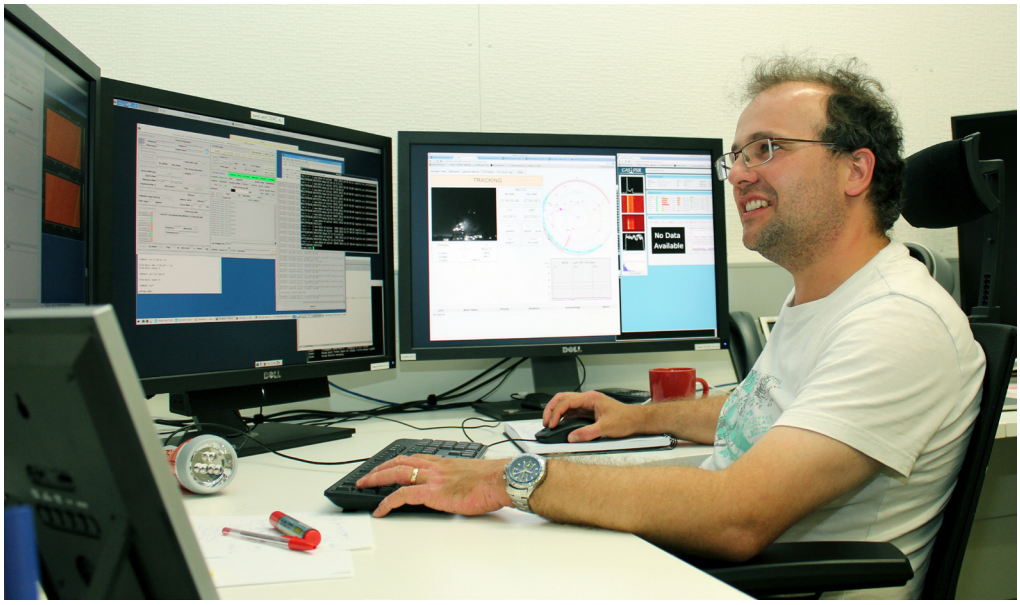
Parkes radio telescope and Marsfield Science Operations Centre

The Parkes telescope can now be routinely operated remotely without any person at the telescope, and the Science Operations Centre in Marsfield is the standard observing location. The use of the SOC has increased steadily since remote observing became available in mid July. The only observers who now visit the telescope routinely are those using non-standard modes that require local interaction with instrumentation.

The remote observer accesses the telescope observing systems by connecting to a VNC session. Two new facilities aid remote observing. The Remote Observing *PORTAL* is a web-browser-based interface allowing observers and support staff to communicate through a 'chat' window, and holds schedules of up-coming remote observers and the rostered support. Meanwhile, *FROG* presents basic information about the current state of the telescope, and issues warnings derived from both the general monitoring system and the new *Telescope Protection System (TPS)*. The TPS monitors the systems critical to telescope safety, contacts Parkes-based staff, and when necessary interrupts observations to take control of the telescope and place it in a safe configuration. Under these circumstances the observer will receive an automated notification on the *FROG* interface, and should expect to be contacted by the responding staff member a short time later.

Parkes observations can (and have been) made from any location with a suitable Internet connection. However, CASS requires observers to conduct their first remote observations from the Science Operations Centre (SOC) at the Radiophysics Laboratory, Marsfield, and to conduct at least one observing session a year from the SOC to retain 'remote qualification'.

Observers are also using the SOC to operate the Mopra telescope and the Compact Array. Feedback from observers at the SOC has been very positive but we welcome input as we continue to develop the environment.



George Hobbs (CASS) observing with the Parkes telescope from the Science Operations Centre in Marsfield.

Long Baseline Array

The LBA session on 14–19 August 2013 broke new ground: for the first time all VLBI observing at ATNF antennas was conducted from the SOC. The four workplaces allocated to each of the ATNF telescopes were used simultaneously for VLBI observing. The VLBI session ran continuously over five days, with shifts around the clock. Jamie Stevens (who normally runs the VLBI at Narrabri) was visiting Sydney and hence all ATNF antennas ran remotely without any local VLBI experts at the telescopes. Local staff and the Duty Astronomer provided observatory support, as for all other ATNF remote observations.

Remote connections were also established to other LBA antennas: the University of Tasmania's Hobart and Ceduna antennas, the UTas-operated AuScope VLBI antennas at Katherine and Yarragadee, and the Warkworth antenna in NZ operated by the Auckland University of Technology. For the August run these connections were used just to monitor the status at each site, but all these telescopes may be controlled from the SOC. The Tidbinbilla antennas and the Hartebeesthoek antennas in South Africa were also monitored from the SOC.

Monitoring this many antennas is difficult and one would need skates to get around all the SOC stations! However, the Smart board at the SOC was also utilised to project an LBA monitoring webpage and view operations at all telescopes in real time. The webpage uses the *Monica* monitoring system to check the telescope status and monitor the VLBI recorders. This system is very versatile and without it VLBI observing from the SOC would have been difficult.

We intend this to be the normal LBA observing mode in the future. We would also like to invite VLBI co-investigators, staff, and students, who in the past could not get to the observatories, to participate in their observations from the SOC.

Australia Telescope Compact Array

The 4-cm band upgrade was completed earlier this year, with a single 4–12 GHz band replacing the previous 'C' and 'X' bands. Observers of the methanol 6.7-GHz line in particular are delighted with the improved sensitivity provided by the new receivers. Work on the CABB 16-MHz mode is continuing, as are efforts to understand why reprogramming CABB into its zoom modes can be such a time-consuming task. Most recently, some trials have been undertaken to implement an RFI recognition and rejection algorithm into the CABB system, which offers the possibility of censoring, in real-time, impulsive or low-duty-cycle but deleterious RFI. As this may last only a fraction of a second, its excision would allow the remainder of each (nominally) 10-second cycle to be salvaged. In parallel, a complementary approach to reduce the impact of 'always-on' RFI is also being investigated.

We continue to study the use of CASA to reduce ATCA data, recognizing that certain widefield, multifrequency synthesis observations will be better handled in CASA – for instance, observations made in hybrid arrays (H214, H168 or H75) that include CA06 in the imaging, for which w-term effects can be significant (see the ATCA forum, *https://atcaforum.atnf.csiro.au/,* for more details). Miriad continues to be quicker, easier and more familiar to most users for many ATCA observations, but the development of pipelines and documentation for CASA reduction will allow users more flexibility in their data reductions in the future.

Mopra radio telescope

As described in the April issue of *ATNF News*, the Mopra control building suffered significant damage in the January bushfire, but the equipment in the screened room and on the antenna was unscathed. During April mains and generator power was restored, and the electronic equipment was professionally cleaned. Tests in early May confirmed that the telescope was again operational. Under the new operations model, 20 weeks over the winter season were allocated to the National Astronomy Observatory of Japan and a consortium of Australian universities led by UNSW and the University of Adelaide. Operations have gone smoothly over the winter. The L/S receiver has yet to be reinstalled, but this affects only VLBI observing, and LBA scheduling has been able to accommodate this.

Time Assignment Committee

The Time Assignment Committee met in July to review proposals for the 2013OCT semester. Strong interest in VLBI observations resulted in the LBA being the most heavily oversubscribed facility for the 2013OCT semester, with some of the increased demand arising from the requested participation of ground-based telescopes in RadioAstron space-VLBI observations.

Some projects that met the ATNF definition of a 'large project' (a total of more than 400 hours over the projected lifetime of the project) did not include the required sections in their scientific justification addressing data analysis and timeline plans, data-release plans, and a recommended public outreach plan. Large projects (only!) are allowed a five-page limit so that these additional topics can be described. The requirements for large projects are clearly set out in section 3.4 of the OPAL users guide (*www.atnf.csiro.au/observers/docs/opal/guide.html*), and the TAC considers all aspects of the proposal in the grading process.

Publications

The following list of publications includes published refereed papers that use ATNF data or are by CASS authors: the list has been compiled since the publication of the April 2013 issue of *ATNF News*. Papers that include CASS authors are indicated by an asterisk. Please email any updates or corrections to this list to *Julie.Tesoriero@csiro.au*.

Publication lists of papers that include ATNF data or CASS authors are also available on the ATNF website at www.atnf.csiro.au/research/publications.

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Sunset at the Murchison Radio-astronomy Observatory. Photo: Rob Hollow

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