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ATNF News

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CSIRO Astronomy and Space Science – undertaking world leading astronomical research and operator of the Australia Telescope National Facility.

The Parkes Phased Array Feed (PAF) package, partially rotated, showing the chequerboard array minus the weather cover. The ability to invert the PAF package during and after assembly enables efficient final construction and, most importantly, safe transport and readiness for sky testing.

Credit: Russ Bolton, CSIRO

Cover page image

Australian Square Kilometre Array Pathfinder (ASKAP) antenna construction.

Credit: Antony Schinckel, CSIRO

Contents

Editorial

Welcome to this the April edition of *ATNF News* for 2011. Once again we bring you articles and news items of interest, all associated with the operation of our National Facility.

In a feature packed issue, Miller Goss captures the past, detailing Ruby Payne-Scott's pioneering work in radio astronomy and the first use of a radio astronomical interferometer at Dover Heights on Australia Day, 1946.

We're then back to the present day with a number of science articles focused on the latest in radio astronomical research. This includes an article by CASS scientist Ettore Carretti who provides his latest update on the *S-band Polarisation All Sky Survey (S-PASS)*. The survey has mapped the diffuse polarised emission of the entire southern sky with the Parkes radio telescope at 2.3 GHz.

In other science reports we feature a report on the Sunyaev-Zel'dovich effect in galaxy clusters and we look at some new science emerging via the new "zoom" modes of the Compact Array spectrometer.

We then talk with new CASS Deputy Chief Sarah Pearce who joins us from GridPP (the UK computing grid for particle physics, set up to deal with data from CERN's Large Hadron Collider). Welcome aboard Sarah!

In other news, Mark Bowen reports on receiver upgrades at the Compact Array, CASS Teacher Scholar Stephen Broderick enjoys his week with the *PULSE@Parkes* project team, and we report on this year's Grote Reber Gold Medal Award recipient — Jocelyn Bell Burnell.

As always, we provide our regular in-depth update on CSIRO's ASKAP and SKA related activity. It's a busy year at the Murchison Radio-astronomy Observatory with the construction of support infrastructure and ASKAP's remaining antennas both under way.

To conclude, we finish with our regular Operations report.

We hope you enjoy the issue. Your comments and suggestions are always welcome. If you'd like to contribute to future editions of the *ATNF News*, please contact the newsletter team.

Tony Crawshaw and Joanne Houldsworth

The ATNF Newsletter Production Team (newsletter@atnf.csiro.au)

From the Chief of CSIRO Astronomy and Space Science

Phil Diamond

Chief of CASS

This, the 70th edition of the ATNF Newsletter, again demonstrates the breadth of science undertaken with the ATNF facilities; the quality of the engineering that supports the telescopes and the professionalism of the operations and other support staff that enables the whole endeavour to work at a continuing high level.

This sentiment is strongly supported by the ATNF Steering Committee, which met on the 10 – 11 May at Parkes. The Committee was keen to travel to one of the telescopes, and will continue to do so in the future, ensuring that it rotates around all CASS/ATNF sites in time. The Committee has a varied membership, with three astronomers from Australian institutes, three from the international community—currently from China, Germany and the USA; two other members are non-astronomers representing the broader Australian community and there are two ex-officio attendees from CSIRO, and the Director of the Australian Astronomical Observatory (AAO). The membership can be found on the ATNF web site.

The Committee's principal role is to offer advice to the ATNF Director. I can safely say that they are not shy in providing such advice, but it is always done in a friendly and positive manner. At the recent meeting the agenda covered those topics that you would expect to be discussed, such as a report on recent science results from the ATNF, an update on the status of engineering projects and on operations. A major focus of the meeting was a presentation of the first complete version of the science and engineering operations plan for the Australian Square Kilometre Array Pathfinder (ASKAP). It is expected that the plan will evolve as we receive input from bodies such as the Steering Committee, the Users' Committee, the ASKAP Science Survey Teams and CASS staff.

The Committee also received a presentation, and entered into a discussion on the proposed four-year budget for the ATNF and CASS as a whole. This budget will not be final until the CSIRO Board formally approves it on 29 June.

The second day of the meeting started with an update of the status of the Square Kilometre Array (SKA) project; this was enhanced by the very welcome announcement by the government in the previous evening's budget of $40.2m for the pre-construction stage of the SKA, scheduled to run from January 2012 until December 2015. The delivery of the full amount is contingent upon a successful outcome for Australia–New Zealand in the site selection process.

I am sure that the highlight of the meeting for the Committee was the so-called "hay ride" on the Parkes telescope itself. The telescope was lowered to almost 0 degrees elevation, the committee stepped onto the surface and were then raised above the observatory as the dish returned to point at the zenith. The trick is to walk down the dish surface as the local horizontal changes! All Committee members managed to do so and were later seen safely to the bus to whisk them off to the airport. A great finale to the day!

New Deputy Chief for CASS

Tony Crawshaw (CASS)

Dr Sarah Pearce
Credit: Tony Crawshaw, CSIRO

ATNF News Editor Tony Crawshaw spent some time speaking with Dr Sarah Pearce, new CASS Deputy Chief.

Hi Sarah. Welcome to CSIRO and more specifically to CASS.

Thank you very much. I'm very happy to be here!

We're happy as well. Could you tell us something of your background?

I was project manager for GridPP, which runs the UK computing grid for particle physics, set up to deal with data from CERN's (European Organisation for Nuclear Research) Large Hadron Collider. I worked for them for six years, first of all in a dissemination role and then as project manager. It was very exciting to work as (a small) part of such a large and high profile project, and I was impressed with how well managed and organised the particle physics community is. GridPP was a distributed project, at 16 UK sites and CERN, so it was good preparation for working in CASS.

And prior to that?

Before I started with GridPP, I worked in policy for the UK government and Parliament. Parliament was particularly interesting; I was a science adviser, writing briefing material on policy questions to do with IT and physics. I covered some controversial topics, including missile defence, internet regulation and nuclear power.

It was fascinating to see behind the scenes how politics worked, though in the end I found the adversarial nature of the system a bit limiting. So I moved back to science, where I think we all work together much more effectively.

You're obviously well qualified. Where did you study?

I have a degree in physics from Oxford, then a PhD from Leicester University. For my PhD I worked on calibrating the microchannel plate detectors for the Chandra X-ray observatory, using the Daresbury synchrotron in the UK. I also went to International Space University for the summer session in 1994, where I had an amazing 10 weeks in Barcelona—I'd highly recommend it to anyone who is interested in space science, engineering or astronomy.

And your inspiration in joining CASS?

Working for GridPP, I really enjoyed being part of one of the world's largest science projects. I'd also been aiming to move back to astronomy: although I liked working in particle physics, it was never really "my" field. Living in Australia and looking to work in astronomy, CASS was the obvious choice. As well as the world-class work at Parkes and the Compact Array, there is ASKAP construction and then operations to look forward to. And if the SKA comes to Australia, CASS will be at the centre of that process, playing a key role in Australia's largest science facility.

So in your role as CASS Deputy Chief what are your key responsibilities?

My position on the management team is focussed towards CASS as an organisation, rather than externally. So I'm responsible for issues such as staffing, Health Safety & Environment and communications. I'm also working closely on the budget: we're currently in the midst of preparing a four year plan as part of the Strategic Investment Process, which takes in ASKAP construction and the start of operations, so it's a very useful time to join CASS and work towards that goal.

And what do you hope to achieve in the role?

I hope to help guide CASS through the changes that are coming in the next few years. With ASKAP, and potentially the SKA, this period is a very dynamic one for radio astronomy in Australia. This is an unprecedented investment, which will mean new ways of working and doing science. We need to make sure we can move towards this new era without losing the expertise and excellence that has led to CSIRO's leading position in radio astronomy.

I know it's only been a short while, but what are your first impressions of CASS?

I'm very impressed with the dedication of all the staff at CASS. They are at the cutting edge in their fields, whether that's engineering, astronomy, or computer science, and they are all keen to do an outstanding job that delivers world-class science. I'm particularly impressed with how long staff seem to work for CASS—there have been several long service awards since I got here! I also appreciate the collegiate atmosphere: everyone I've met has been extremely helpful and welcoming.

Finally, what in particular excites you about the field of astronomy and space science?

I've been fascinated with astronomy in all its facets since I was in school. It started with some of the popular books on cosmology, such as *In search of the big bang* by John Gribbin and Steven Weinberg's *The first three minutes*. I found, and still find, the scale of astronomy compelling. As Douglas Adams said: "Space... is big. Really big. You just won't believe how vastly hugely mindboggingly big it is..." I think that's what I like about it: astronomy dwarfs all the other sciences, both in scale and in some of the concepts it explores.

Thanks for your time Sarah.

My pleasure.

Distinguished Visitors

Robert Braun (CASS)

Over the past months we have enjoyed working visits from Aris Karastergiou (University of Oxford, UK) and Bill Coles (University of California San Diego, USA)

Upcoming visitors we expect include Patricia Henning (University of New Mexico, USA), Jose Gomez (Instituto de Astrofísica de Andalucía, Grenada, Spain), Dale Frail (National Radio Astronomy Observatory, USA), Paul Nulsen (Harvard-Smithsonian Center for Astrophysics, USA), Martin Cohen (University of California, Berkeley, USA) and Jim Jackson (Boston University, USA).

The Distinguished Visitors program remains a very productive means of enabling collaborative research projects with local staff, adding substantially to the vitality of the research environment. Visits can be organized for periods ranging from only a few weeks up to one year.

For more information please see

www.atnf.csiro.au/people/distinguished_visitors.html

Prospective visitors should contact the local staff member with the most similar interests.

Graduate Student Program

Baerbel Koribalski (CASS)

We would like to officially welcome the following students into the ATNF co-supervision program.

- Paul Coster (University of Swinburne)—*Accelerated searches for the most relativistic binary pulsars using next-generation instrumentation* with supervisors Dr Willem van Straten (University of Swinburne), Dr Simon Johnston (CASS) and Dr Mike Keith (CASS).
- Phoebe de Wilt (University of Adelaide)—*Investigating the connection between star forming regions and unidentified TeV gamma-ray sources* with supervisors Dr Gavin Rowell (University of Adelaide), Dr Kate Brooks (CASS) and Dr Jill Rathborne (CASS).
- Stuart Weston (University of Auckland, NZ)—*Development and Astrophysical Applications of the High Performance Radio Astronomical Image Processing Pipeline for e-VLBI* with supervisors Dr Sergei Gulyaev (University of Auckland, NZ) and Dr Tim Cornwell (CASS).

Congratulations to the award of their PhD degree and best wishes for their future career goes to the following students.

- Annie Hughes (University of Swinburne)—*Molecular Gas in the Large Magellanic Cloud*.
- Joanne Dawson (University of Nagoya, Japan)—*Supershells as Molecular Cloud Factories in the Evolving ISM: Observations of HI and 12CO in the Galactic Supershells GSH 287+04-17 and GSH 277+00+36*.
- Sarah Burke-Spolaor (University of Swinburne)—*Supermassive Black Hole Binaries and Transient Radio Events: Studies in Pulsar Astronomy*.
- Natasa Vranesevic (University of Sydney)—*Galactic distribution and evolution of pulsars*.

Dr Annie Hughes is now a postdoc at the Max Planck Institute in Heidelberg, Germany. Dr Sarah Burke-Spolaor is now a Bolton Fellow at CSIRO Astronomy and Space Science. And Dr Jo Dawson is now an Australian Research Council Super Science Fellow at the University of Tasmania.

Well done !

A summary of the ATNF Graduate Student Program, current and past students,as well as new application forms can be found at

http://www.atnf.csiro.au/research/graduate/scholars.html

Natasa Vranesevic

Sara Burke-Spolaor

Grote Reber Gold Medal Awarded

Ken Kellerman (NRAO)

The 2011 Grote Reber Gold Medal for lifetime innovative contributions to radio astronomy will be awarded to Dr Jocelyn Bell Burnell who is currently a Professor of Astrophysics at Oxford University in England. Burnell is being honored for her dramatic 1967 discovery of pulsars which has had a major impact on the second half of 20th century astrophysics and her continuing contributions to astrophysics and education.

Jocelyn Bell Burnell received her first degree in Physics in 1965 from Glasgow University in Scotland and her PhD from the University of Cambridge in 1968. Following a two year Science Research Council Fellowship, she held a Teaching Fellowship at the University of Southampton followed by research and management positions at the University College, London and the Royal Observatory in Edinburgh. After a ten year period as a Professor of Physics at the Open University of the United Kingdom where she studied X-ray sources, she served as Dean of Science at the University of Bath.

Bell Burnell is best known for her role in the discovery of pulsars. As a research student in Cambridge she was heavily involved in the construction and operation of a long wavelength radio telescope built to study interplanetary scintillations at 4-m wavelength. Later, while inspecting the output chart records, she noticed a peculiar form of a signal which had a periodic pulse rate close to one second. Like Grote Reber, she initially had to convince her better established colleagues that her observations were important for astronomy and not due to external interference or to a spurious instrumental effect.

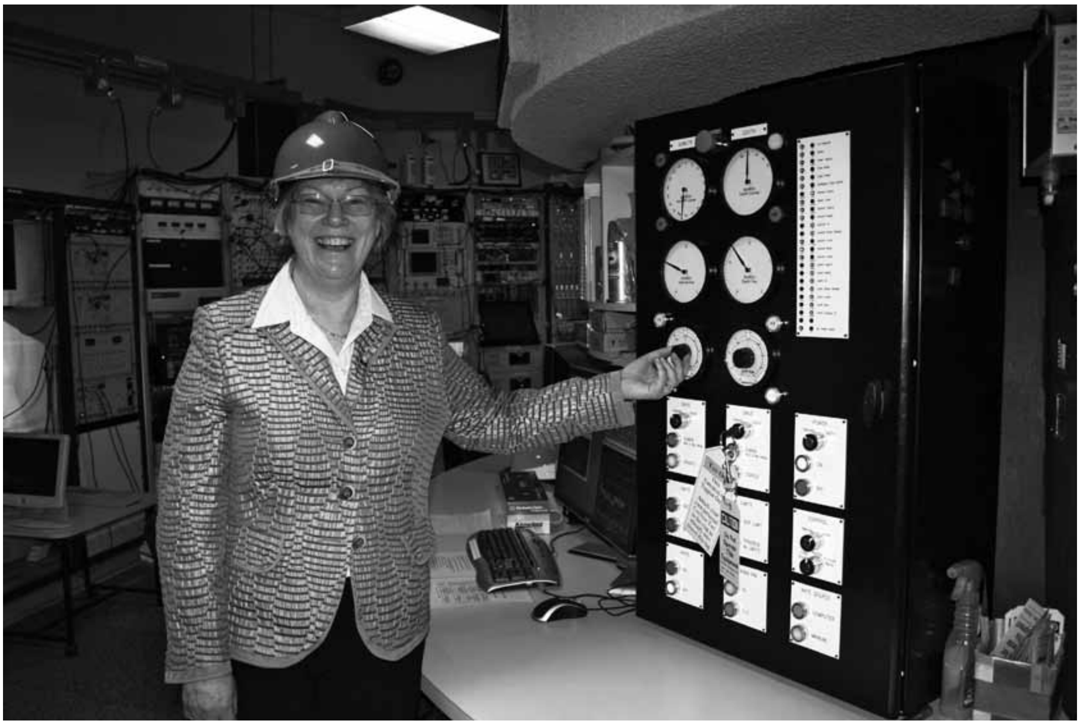
She has previously been honored by many prizes and recognitions, including the Albert Michelson Medal of the Philadelphia Franklin Institute, the J Robert Oppenheimer Memorial Prize from the Miami Center for Theoretical Studies, the Tinsley Prize from the American Astronomical Society, and the Herschel Medal from the Royal Astronomical Society. She has served as President of the Royal Astronomical Society, is a Fellow of the Royal Society, is currently the President of the Institute of Physics, and in June 2007, she was made Dame Commander of the British Empire (DBE) by Queen Elizabeth II.

Jocelyn Bell Burnell
Credit: University of Bath

The 2011 Reber Medal will be presented to Dame Jocelyn in August 2011 at the XXX URSI General Assembly in Istanbul, Turkey. The Reber Medal was established by the Trustees of the Grote Reber Foundation to honor the achievements of Grote Reber and is administered by the Queen Victoria Museum in Launceston, Tasmania. Nominations for the 2012 Medal may be sent to Martin George, Queen Victoria Museum, Wellington St, Launceston, Tasmania 7250, Australia or by email to: *martin@qvmag.tas.gov.au* to be received no later than 15 October 2011.

CSIRO Chief Visits Parkes

Erik Lensson (CASS)



CSIRO Chief Executive Megan Clark at Parkes. Credit: John Sarkissian, CSIRO

CSIRO Chief Executive Megan Clarke visited the Parkes Observatory on 21 March 2011, accompanied by her husband Trent. The visit included an inspection of the refurbished Visitors Centre, as well as discussion of astronomical observing trends with ATNF Science Operations and Astrophysics staff.

A site tour with Engineering Operations included the 12-m ASKAP Test Bed and a discussion with Andrew Hunt and Tim Ruckley about the new Parkes 64-m antenna Master Control Panel (MCP), a key achievement for the Parkes Observatory March 2011 shutdown. Megan appreciated the retro look whilst noting the all new computer controllable electronics and agreed that there is still a place for the analogue human interface. She was also interested in the new Parkes backend switch, its impact on existing and future observing and how remote observing might develop with systems providing tactile feedback and virtual reality technology. Ken Reeves took Trent up the dark central column for a look at the "Cricket Pitch" on the surface of the Dish. Megan and Trent then enjoyed informal discussions and morning tea with staff at Parkes Quarters.

Ruby Payne-Scott: First Interferometry in Radio Astronomy: Australia Day 1946

Miller Goss (NRAO)

At sunrise on Australia Day 1946 (26 January), Ruby Payne-Scott (Figure 1) observed the sun at Dover Heights, the first use of a radio astronomical interferometer.

Figure 1: Ruby Payne-Scott as a young student in the 1930s, possibly while she was a student at the University of Sydney 1929 – 1932, working on a BSc degree in physics. Goss and McGee have written a biography : *Under the Radar: The First Woman in Radio Astronomy: Ruby Payne-Scott*, published by Springer, 2009. The book was launched in Sydney and Canberra in late 2009, sponsored by the University of Sydney School of Physics and CSIRO. (Photo from the Bill Hall family collection)

She had been employed by the Council for Scientific and Industrial Research, Division of Radiophysics since 1941. Payne-Scott used a 200-MHz antenna, a portion of a shore defence radar system (Figure 2), constructed during the early years of World War II (WWII). By early 1946 the Australian Army had allowed the Radiophysics Laboratory (RPL) to use the receiving aerial for radio astronomy research. A "Lloyds mirror" interference pattern was observed by recording the intensity variations as the rising sun appeared over the sea. Interference occurred between the direct and reflected rays from the sea, leading to a series of maxima and minima ("lobes"). With the cliff height of about 90 metres, the fringe separation was slightly less than the size of the quiet sun. The effective baseline of the interferometer is twice the cliff height.

Radio astronomical observations of the active sun had, however, already begun in October, 1945. J L Pawsey, Ruby Payne-Scott and L L McCready had started observations of the sun using the Royal Australian Air Force 200-MHz aircraft warning radar antenna at Collaroy, north of Dover Heights. During these observations (published in Nature in early 1946), the solar emission was detected with the single antenna system only. No fringes or lobes were detected due to the wide distribution of the sunspots over the sun's surface. The RPL group did determine that the brightness temperature far exceeded the expected temperature of the quiet sun at 200 MHz. In addition, the radio intensity was closely correlated with the sunspot area as observed at the Commonwealth Solar Observatory at Mt Stromlo.

On Australia Day 1946, the situation was quite different; a compact group of sun-spots dominated the sun. The lobe pattern was observed as the sun rose shortly after 5 am local time. The radio sun actually rose about eight minutes earlier than optical sunrise due to the increased refraction at radio wavelengths compared to optical refraction. The

Figure 2: RPL field station, Army Reserve, Dover Heights; the Fortress Fire Command Post was in this reserve, 2.2 km south of the Macquarie Lighthouse and 2 km north of Bondi Beach. The location is 7 km east of the centre of Sydney. Date, 18 February 1943. This 200-MHz antenna, associated with the main blockhouse, was used for the solar radio astronomy sea-cliff observations on Australia Day, 1946. The view is to the north with North Head clearly visible. Note the ships possibly waiting for the submarine net at the entrance to Sydney harbour. (ATNF historical photographic archive B81-1)

radio lobe pattern was observed for about an hour due to the large primary beam of the radio antenna (about 10 degrees). The presence of deep minima implied a small angular size of less than about 7 arc min, with a resultant brightness temperature in excess of a billion degrees. About two weeks later (7 February 1946), a prominent sunspot appeared, one of the major sunspots in recorded history (about 0.5 per cent of solar surface was covered by the spot). The 200-MHz radiation increased in intensity by a factor of ten compared to a few weeks earlier. Numerous observations were obtained until the end of March 1946. In addition to the limit on the size, the location of the radio emission from the sun could be determined with an accuracy of a few arc min. The RPL group found that the emission originated from a region on the sun apparently coincident with the major optical sunspot. Based on current knowledge, Type I bursts were being detected. These can be associated with fundamental frequency plasma emission, in the presence of enhanced magnetic fields near sunspots.

The "Lloyd's mirror" or sea-cliff interferometer made use of the techniques used during World War II for "radio direction finding" using radars for aircraft warning at metre wavelengths. This remarkable radio interferometer consisted of a single antenna; a major drawback was that observations could only be carried out at sunrise or sunset when radio refraction effects were quite pronounced. The techniques used by Payne-Scott in early 1946 used the same methodology pioneered by numerous groups in Australia, the UK and the US during WWII for use in radar. In Australia, John Jaeger, an applied mathematician who worked at RPL, had worked out the theory of the lobe patterns in 1943. In the UK, both J A Ratcliffe and Fred Hoyle had independently carried out similar studies.

In the publication of the exciting results from the sea-cliff interferometry from 1946 (publication August 1947), Pawsey, Payne-Scott and McCready suggested, for the first time, the principles of aperture synthesis using the method of Fourier summation.

Figure 3: The most commonly published photograph of Ruby Payne-Scott. This was taken at the Potts Hill Reservoir, likely in late 1948. "Chris" Christiansen is to the right with Alec Little in the middle. Payne-Scott and Little were working on observations of the sun at 97 MHz using the newly constructed swept-lobe interferometer. (ATNF Historical Photographic Archive: B14315 and Hall family collection)

The other group that made rapid advances in the 1945 – 1946 era was the Cavendish Laboratory of the University of Cambridge, under the leadership of Ratcliffe and Martin Ryle. After a remarkably short period of instrumental developments in early 1946, Ryle and Vonberg were ready to observe the sun in July 1946, when another prominent sunspot appeared. They observed the sun at 175 MHz with a "Michelson" interferometer with a variable spacing up to 140 wavelengths (240 metres). They found that the solar emission was less than 10 arc min in size, and associated the radio emission with the sunspot due to the compact size of the radio emission. In contrast to the Sydney data, the position on the sun was not determined. In agreement with other groups in the UK and Australia, Ryle and Vonberg detected circular polarisation from Type I bursts at this time. In the next decades, the Michelson interferometer became the instrument of choice for radio astronomers.

Figure 4. A photo of a number of the RPL staff at Potts Hill circa 1950. From left to right, Ruby Payne-Scott (drinking a cup of tea), Alec Little, George Fairweather (a technician standing in the door), possibly Alan Carter and Joe Pawsey. The location is in front of one of the trailers used for instrumentation of the radio telescopes at Potts Hill. This photo is damaged with numerous spots, likely ink. Some colleagues that knew this group disagree with the identification of Alan Carter. (Bill Hall family collection)

The life of Ruby Payne-Scott has recently been summarised by W M Goss (NRAO) and R X McGee (Division of Radiophysics , retired). *Under the Radar: The First Woman in Radio Astronomy: Ruby Payne-Scott* was published by Springer in 2009. A number of highlights of her life and career (CSIR and CSIRO from 1941 to 1951) are described, including a detailed account of the first recorded radio astronomy observations in Australia carried out in March 1944 by Pawsey and Payne-Scott. The most innovative period of her career as a radio astronomer was the period 1949 – 1951, working at the Potts Hill (Sydney) site with Alec Little as they developed the swept lobe interferometer. The motions of the Type IV outbursts were tracked in real time by observing the sun 25 times per second. In Figures 3 and 4, two group photos of some of the individuals at the Potts Hill site from this period are shown. Prominent radio astronomers of this era were present: Pawsey, Christiansen, Payne-Scott and Little. Advances in techniques in this immediate post War period have had a major impact on the development of radio astronomy in the 20th century. The major sunspot activity of 1946 – 1947 was a major stimulus as radio interferometry development accelerated.

A book about Payne-Scott for a non-scientific audience is currently in preparation by Goss: *Making Waves: The Story of Ruby Payne-Scott: Australian Pioneer Radio Astronomer.*

Operations Engineering Cadetship Experience

Peter Mirtschin (CASS)

During the 2010 calendar year, Operations undertook a cadet engineer program. This program was targeted at giving two third year engineering students industrial engineering work experience at CASS observatories.

An emphasis was for the cadets to gain an "end-to-end" appreciation of operational radio astronomy systems engineering under the guidance of a professional mentor/supervisor. The project work was not limited to operational systems, but could involve engineering research or development work in line with the development projects underway at the Observatories. Another goal was to provide a benefit to CASS operations in an area that might not otherwise occur by carrying out a defined project that aligned with the interests of both the cadet and CASS.

Cathy Mitchell was the successful candidate located at Parkes. Her project entailed some investigative work in the area of vibration analysis. The ultimate aim of this work is to develop an automated system which can monitor the vibration signature of a telescope in operation. Should something detrimental occur, such as a failed bearing, the vibration signature change can be detected and reported to operators in a timely manner. Currently this function is carried out by the observer noticing abnormal noises. With automation and observers being located remotely, this new monitoring method becomes important for maintaining the integrity of the structures. Her efforts have been a great first step.

Ben McKay was the successful cadet assigned to Narrabri and his project was to provide improved monitoring interfaces between the observatory computing environment and real world monitor points that are dispersed throughout the observatories. These points are crucial for the ongoing operation of the observatory.

Ben's initial focus was to provide improved methods for MoniCA to access Australia Telescope (AT) serial dataset buses. MoniCA is a software application used at the observatories for monitoring and archiving of telescope monitor points. AT datasets are interface hardware which enables computers to monitor physical measurements of key parameters within the observatory. AT datasets are integral in the existing observatories and there is a growing need for multiple stakeholder software applications to have simultaneous access to these dataset buses. A standalone RPC (Remote Procedure Call) server application has been completed which enables this to take place. In addition, it also provides the option for Modbus (an industry request and reply protocol) controllers to monitor AT dataset monitor points, if required. The second stage of the project was to enable MoniCA to access Modbus devices directly. This has enabled MoniCA to very easily access any commercial off the shelf Modbus equipment that may be installed at an observatory. Of course, there are the usual criteria, such as Radio Frequency Interference testing, that has needed to take place before installing commercial equipment.

Specifically at Parkes, with the completion of this software, MoniCA & LOboss software suites are now able to transparently and simultaneously access the same dataset buses with no perceived degradation in performance of either application. LOboss continues to be the application for configuring the Parkes conversion rack.

At this point in time, Modbus equipment that has been installed at the observatories includes generator and mains control and monitoring as well as several temperature and humidity sensors. The software developed is designed to be sufficiently generic

Cathy Mitchell
Photo: Peter Mirtschin, CSIRO

Ben McKay
Photo: Peter Mirtschin, CSIRO

that it could be implemented on most Linux platforms.

So thanks to the work of Ben we have seen several improvements. Firstly, the observatory software can now have reliable multiple access to the underlying monitoring hardware. At Parkes this has enabled the number of points monitored by MoniCA to be doubled whilst retaining the existing purpose written observing tools. Looking forward to the future it will facilitate a central monitoring system without complex integration into the observing software. Secondly, by enabling an industrial standard protocol to be used with MoniCA the current control and monitoring hardware can easily be expanded by the use of commercial equipment,

These achievements have been a bonus for the Developmental Project, Parkes Equipment Control and Monitor (PECM), as it moves towards completion. There are plans to further extend the number of points monitored by MoniCA at Parkes in the coming months.

Thanks to Euan Troup for some early work on this software and also to John Reynolds for software changes to LOboss to enable MoniCA access.

I would also like to thank all those involved in enabling the cadetship program. It has been a great success in its first year.

ASKAP and SKA News

Flornes Conway-Derley (CASS)

Members of CETC54 in front of an ASKAP antenna at the MRO in October 2010. Credit: Terrace Photographers.

2011 will be a critical year in the development of CSIRO's Australian Square Kilometre Array Pathfinder (ASKAP). Following the successful construction of the first six ASKAP antennas at the Murchison Radio-astronomy Observatory (MRO) in 2010, the overall technical build of ASKAP continues to ramp up.

ASKAP Antennas

During late 2010, five new ASKAP antennas were delivered and installed at the Murchison Radio-astronomy Observatory (MRO) in Western Australia, bringing the total number of antennas on site to six. At the same time, the first antenna (built in early 2010) underwent a number of retrofits to bring it as close as possible to the production design of the remaining ASKAP antennas.

Comprehensive site acceptance tests and initial commissioning activities were also completed on the new antennas, including the fit-out of internal parts such as the support floor, mezzanine and internal cable trays.

An important feature of the antenna design is the ability to set reflector accuracy at the factory acceptance test stage; this allows the antenna to be erected at the MRO, with no further adjustment required, while maintaining a specified surface accuracy.

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

Not only does this design feature allow for an increased range of operation, but it also dramatically saves on installation time. The guarantee of "in-the-field" surface alignment provides a reliable

Trench digging underway near the Boolardy homestead.
Credit: Barry Turner, CSIRO

and fast build process for a "traditional panel" style antenna.

All 36 ASKAP antennas are being manufactured by the 54th Research Institute of China Electronics Technology Group Corporation (known as CETC54) based in Shijiazhuang, China. Members of the ASKAP Antenna team recently visited the CETC54 factory in China to perform factory acceptance testing. The next batch of antennas will arrive at the MRO in May, with all 36 antennas expected to be built by the end of 2011.

ASKAP General

Key ASKAP updates since the previous issue of the ATNF News went to print include:

- Installation of 390 km of optical fibre cable between the MRO and Geraldton began in October 2010. In April 2011, one of four segments was fully completed, with partial completion in the other areas. The high capacity link will be used to transmit large volumes of data from the MRO for processing;
- A dry fit-up of the first full-sized Phased Array Feed (PAF) was completed in December 2010, and two full (analogue and digital) receiver systems are being assembled in preparation for preliminary system integration tests at the Parkes Testbed Facility (PTF) and on an ASKAP antenna at the MRO;
- Integration has commenced on the MATES (Marsfield ASKAP Test Engineering System) during the first half of 2011, which includes a skeletal PAF receiver with partial monitoring and control functions; dummy heat loads and temperature monitoring have provided a useful testbed for the PAF water cooling system;
- The first meeting of ASKAP PIs (Principal Investigators) for 2011 was held at Marsfield in February. Following a successful one year review in November, the teams have been working on source finding and simulation algorithms with the ASKAP Computing team ;

Aaron Saunders, Paul Cooper and Eliane Harkvoort with dry fit-up PAF. Credit: Wheeler Studios

- ASKAP was included as part of the Pawsey Centre's early adopters program, chosen as a large project that could use the additional computing power to open new avenues of research;
- A new version of the ASKAP software imaging package (ASKAPsoft) was released in February; the upgrade includes enhancements to the virtual test operating system, a weather station emulation and digital receiver engineering GUI. The test package will be used to test observations and measurements made during integration of the new full-sized PAF installed on the PTF in the coming months.

At the MRO

In December 2010, senior staff from China Electronics Technology Group Corporation (CETC) visited the CSIRO Astronomy and Space Science headquarters in Sydney.

Both parties were keen to recognise the success of the ASKAP antenna contract to date with CETC54's capacity to fully assemble and precision align all antennas in their factory in Shijiazhuang before shipping to Australia; resulting in a fast build-time and with no adjustment of the reflector surfaces being required once on-site at the MRO.

"This was an excellent opportunity to show the antennas to the CEO of CETC and to continue to explore China's expertise in producing low-cost antennas at a cost-specification for the SKA," says Carole Jackson.

Also in late 2010, the MRO had visits from the MRO Indigenous Land Use Agreement (ILUA) Liaison Committee as well as students from Pia Wajarri, a remote community located near Boolardy.

The MRO ILUA Liason Committee Meeting coincided with a visit to the MRO by CASS chief Dr Phil Diamond and CSIRO's ASKAP Project Director Ant Schinckel, which provided the opportunity to meet informally with the Wajarri representatives. At the conclusion of the Meeting, ILUA members viewed, for the first time, the six newly installed ASKAP antennas on a tour of the MRO. The Wajarri people have provided CSIRO a list of Wajarri names that will be used for key infrastructure at the MRO in the future.

Industry Engagement News

The tender for the construction of support infrastructure was recently awarded to McConnell Dowell Constructors (Aust.) Pty. Ltd., representing a significant milestone in the ongoing development of the MRO site. The project commences immediately, and involves the construction of several kilometres of access roads and tracks, power and data infrastructure, a central control building and 30 radio antenna concrete foundations, as well as ancillary works.

The design tender for the Murchison Support Facility (MSF)

Mr Tu Tianjie, President of CETC54, with Chief of CSIRO Astronomy and Space Science, Dr Philip Diamond. Credit: Tony Crawshaw, CSIRO.

at Geraldton was awarded to Aurecon and final detailing for the design works are underway.

The first two Redback-2 digital signal processor boards will soon be ready for full integration testing over the coming months. Puzzle Precision, a supplier of high-end digital systems, are currently delivering the major components of the ASKAP digital systems, upon delivery the boards are fully tested and ready for ASKAP systems integration.

SKA Activities

Work Package Discussions Continue

Discussions with international partners on SKA Technology Work Packages (PrepSKA WP2) continue, focussed on SKA-related research and development such as dish arrays, digital systems, computing, signal transport and systems. CASS is coordinating the development of the PAF SKA Concept Descriptions, which will be key inputs to the Concept Design Reviews (CoDRs) due to take place between April and October 2011.

First Silicon-on-Sapphire Prototype SKA Receiver Chip

A significant milestone was achieved in the development of a radio receiver on a chip, with the first chip design now fabricated as part of collaboration between CASS and Silanna (formerly Sapphicon Semiconductor). The chip is being manufactured at Silanna's foundry in Sydney, and integrates much of the electronics required to process one channel's worth of data in a Phased Array Feed (PAF) or Aperture Array (AA) receiver into a single integrated circuit.

"The chip, which measures just 2.8 × 2.8 mm, also includes precision bias circuitry and digital control," says Suzy Jackson, ASKAP electronics engineer. "This minimises the number of external components needed to build a receiver, which also leads to a reduction in size, weight, power and cost."

Once fabricated, the chips will be tested and integrated into a demonstrator array that will perform the entire analogue processing in the phased array feed package, and contribute significantly toward development of receivers for the SKA.

Compact Array 20/13 cm and 6/3 cm Receiver Upgrade

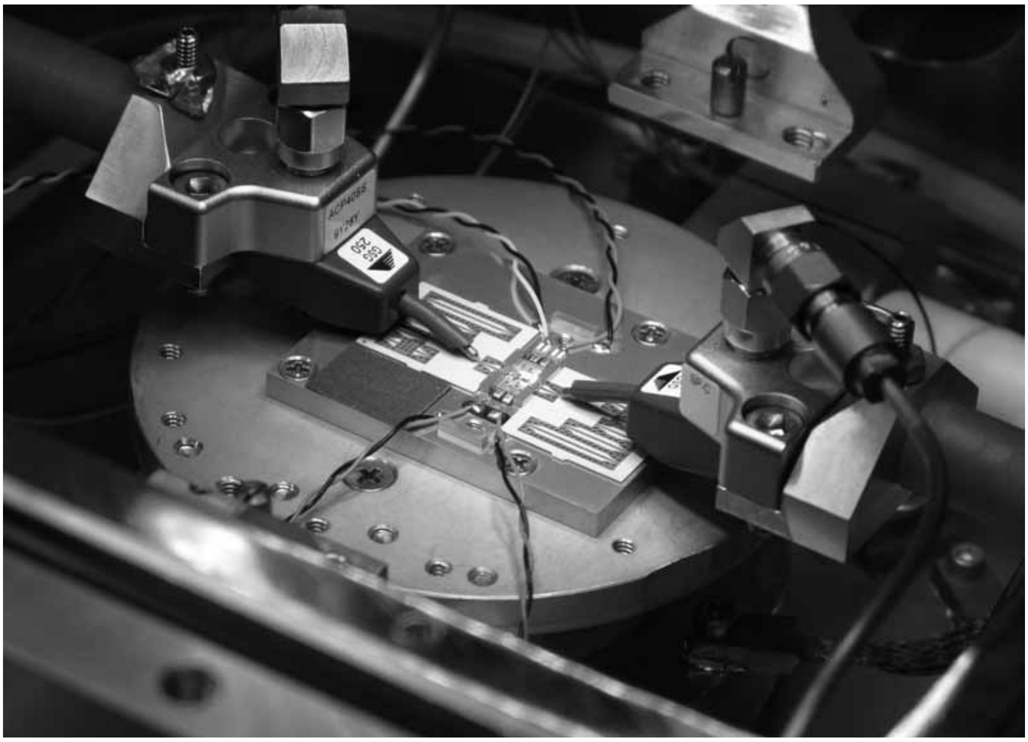
Mark Bowen (CASS)

In December 2010 the installation of two upgraded 1 – 3 GHz receivers on the Compact Array heralded the substantive completion of the second phase of the Compact Array 20/13 cm and 6/3 cm receiver upgrade. Though the RF signal path of the receivers is complete, an upgrade of the receiver control and monitor electronics is still underway. The existing receiver electronics packages are over 20 years old and the upgrade will modernise them in line with the current millimetre-wave systems, ensuring our ability to support them into the future. This work will be completed during the first half of 2011 and can be accomplished on the antennas without removal of the receivers.

Santiago Castillo installing an upgraded 1 – 3 GHz receiver system.
Credit: Henry Kanoniuk, CSIRO.

After the successful demonstration of a prototype 1 – 3 GHz receiver in late 2009, the roll out of fully upgraded receiver systems was commenced in June 2010. A further two receivers were installed in August, with the installation of these two receivers also bringing the first phase of the upgrade project to a conclusion. The 20/13 cm and 6/3 cm upgrade has three stages; the first of these included, among other things, the retrofit of new fins to the 20/13 cm receiver orthomode transducers (OMTs). The OMT refit was designed to improve the beam shape in the upper half of the receiver frequency range.

The discovery of low frequency bias oscillation between pairs of Low Noise Amplifiers (LNAs) in some upgraded receivers during September resulted in a hiatus in the installation of the remaining receiver systems while a suitable fix was developed. Modifications to the LNA bias circuitry cured the problem and subsequent receivers were modified prior to installation. The remaining unmodified receivers



Initial testing of the gain stages, part of a 4 – 12GHz Low Noise Amplifier.
Credit Alex Dunning, CSIRO.

are being retrofitted during the first half of 2011 as part of normal scheduled maintenance.

The performance of the upgraded receivers has exceeded expectations. The system temperature (Tsys) has been measured at ~ 20K over the band 1.1 – 3.0 GHz, an improvement in overall noise performance of between 25% - 30% over the original ATCA L/S receiver systems. Jamie Stevens has also characterised the beam patterns of the upgraded ATCA antennas between 1.1 – 3.1 GHz. The primary beams are symmetrical within 6%, independent of frequency. These upgraded receivers are now designated as ATCA 16-cm receiver systems.

The third and final phase of the project is an upgrade of the 6/3-cm receiver systems which will follow a similar development path to the 16-cm receiver systems. The provision of A$1.471M from Astronomy Australia Limited (AAL) as part of the Education Investment Fund (EIF) is funding the completion of this phase of the project. The AAL funding will commence in July 2011 ending in June 2013 when the project will be completed. The development of cryogenic 4 – 12 GHz LNAs is currently underway. To ensure the feasibility of the third phase of the project, this work is being carried out by CASS as part of the second phase. Substantial progress toward a suitable LNA has been made with testing of a prototype scheduled for early 2011.

When completed, the upgrade of the existing Compact Array centimetre receivers will enable the use of the full capability of the Compact Array Broadband Backend (CABB) at centimetre wavelengths. The upgrade will transform the piecemeal coverage of the 1 – 12 GHz observing spectrum delivering almost complete coverage in two frequency bands 1 – 3 GHz and 4 – 12 GHz.

S-PASS: S-band Polarisation All Sky Survey

Ettore Carretti (CASS)

Abstract

The S-band Polarisation All Sky Survey (S-PASS) has mapped the diffuse polarized emission of the entire southern sky with the Parkes radio telescope at 2.3 GHz with a resolution of 9'. Aimed at investigating the CMB Galactic foreground and the Galactic magnetic field, the project has required a special setup to cover half a sky with such a resolution. The observations are now completed and the data reduction is in progress. With their huge spatial dynamic range (360° to 9') and high frequency, S-PASS maps deliver a completely new view of the polarised sky showing interesting new features and structures at all Galactic latitudes.

Here we are again two years later to talk about the beautiful polarised sky of S-PASS (see April 2009 issue). At that time S-PASS was 60% complete and the data reduction still in an embryonic stage, but the first results were showing the high potentiality of this project already. Now, two years later, the survey is completed and the resulting maps show the diffuse polarised sky with an unprecedented combination of angular scale dynamic range, sensitivity, and frequency, delivering a new view of the polarised sky. Unlike previous lower frequency surveys affected by severe Faraday depolarisation, the diffuse emission from the Galactic disc is now unveiled (expect for a few degree across the Galactic Plane) opening a new powerful window to investigate the magnetic field of our own Galaxy.

But let's step back a bit and introduce the project first. The S-band Polarisation All Sky Survey (S-PASS) is a project to map the diffuse polarised synchrotron emission of the entire southern sky at 2.3 GHz (Carretti et al. 2007). Carried out with the Parkes radio telescope, the survey is aimed at investigating two cutting-edge cases of the present astrophysics research: the Galactic magnetic field, whose large scale structure is still a puzzle, and the detection of the B-Mode of the Cosmic Microwave Background (CMB) polarised component, for which the synchrotron emission is one of the strongest foreground contaminants.

The structure of the Galactic magnetic field is still largely unknown. The observations show that the ordered component of the disc is aligned along the spiral arms, but several details of the model are still under debate, like number and position of field reversals (field reversal means that the field direction is preserved, but a complete reversal of the heading occurs). Many data sets are consistent with one reversal only, which would make our Galaxy similar to the external galaxies observed so far (e.g., Sun et al. 2008, van Eck et al. 2010), while some authors find that reversals might occur at any spiral arm to inter-arm region transition, which would make our Galaxy unique (e.g. Han et al. 2006). Moreover, some recent results seem to challenge the alignment with the spiral arms in the outer Galaxy where the field could just take a ring-like shape (e.g. Van Eck al. 2010). The field in the Galactic halo is even less understood, essentially for lack of data in this low emitting region. Models have been proposed (e.g., Han 2002, Sun et al. 2008) and the asymmetry recently discovered in the vertical component of the local field (Mao et al. 2010) has suggested that a combination of dipole and quadrupole components might describe well the large scale field. However, all the proposed models are poorly constrained both by the lack of data and the contamination by large local structures, like the big radio loops, that can introduce anomalies.

More data are thus necessary to understand how the Galactic magnetic field is arranged. One of the goals of S-PASS is to help cover this gap, measuring the polarised synchrotron emission of the entire southern sky. The diffuse polarised emission encodes a wealth of information on the magnetic field by Rotation Measure (RM), polarisation angle, polarisation fraction, and RM-synthesis, which can unlock how the emission is organised along the line of sight delivering a 3D view of the interstellar medium (ISM). The coverage of the entire southern sky allows investigation of the field in all the possible environments: plane, disc, halo, disc-halo transition.

The other goal of S-PASS is to study the polarised component of the CMB, which carries the signature of the Gravitational Wave Background (GWB) emitted at the Inflation time (Kamionkowski & Kosowsky 1998, Kinney et al. 2006, Boyle et al. 2006). This is the only radiation that can travel the Universe from its very early stages (10^{-34} s after the Big Bang) up to us mostly untouched and gives us the chance to probe the physics of the Big Bang at energy densities so high, that no particle accelerator on Earth can parallel.

The CMB signal is weak, however (100 nK the current upper limit), weaker than the foreground Galactic synchrotron emission, which thus needs to be removed for a successful detection of the cosmological signal. It is something like peering through the fog of our Galaxy to a have an unobstructed view of the far end of the visible Universe. The goal of S-PASS is to measure with high precision the Galactic emission to make possible CMB detections with the lowest possible error.

To realise such goals S-PASS has observed the entire southern sky at 2.3 GHz with high signal-to-noise ratio also in the lowest emission regions of the halo. The observations have been conducted from October 2007 to January 2010 for a total of about 2000h, keeping the team busy observing all night long for six months in two and a half years — almost a retreat! The frequency is high enough to keep Faraday Rotation effects under control down to disc latitudes, as shown by the precursor project Parkes Galactic Meridian Survey (PGMS, Carretti et al. 2010), while the high sensitivity enables both high efficient foreground cleanings and sensitive rotation measute (RM) measurements (the expected sensitivity in the halo is some 2 rad/m^2 when combined with 1.4 GHz data).

A project like S-PASS has posed several challenges, primarily to minimise the ground emission contamination and to enable absolute calibration, and a special scanning strategy based on long Azimuth (Az) scans has been developed to this purpose. Ground emission is mostly elevation dependent, and Az scans are ideal to minimise it. Long azimuth scans (115°) can cover the entire Declination range of interest in just one go thus preserving the information on all angular scales. The mapping of all the desired Right Ascension range is ensured by the Earth rotation, that in combination with AZ scans, lets the telescope draw zig-zag patterns in the sky each day. The full coverage of the sky is realised by precisely timing the scan start each night, so that day after day the zig-zags are appropriately spaced to ensure a uniform sky coverage.

The vast area to observe and the small pixel size (4.5') have required a high scan speed to conduct the survey in a sensible time duration. The scan rate has been pushed up to 15°/min, a significant fraction of the slewing speed (24°/min): not a bad performance for a 1000-tons 64-m telescope nearly 50 years old!

To recover the power on all angular scales a "basket weaving" technique (scan crossing) is required. Basket weaving is a tricky job with azimuth scans. However, the same Dec range can be observed either when the sky rises or sets, but with a different path in the sky. Two sets of scans has then been observed, one eastward and one westward, whose combination realises an effective scan crossing (Figure 1). This, along with the modulation of the signal by parallactic angle variation along the scan, has permitted full recovery of the emission on all angular scales (for details see Carretti 2011, Carretti et al. 2011).

As example, Figure 2 shows the final map of Stokes Q. This is absolutely calibrated and at full resolution delivering a spatial dynamic range of 2400 (360° to 9'), maybe one of the highest ever obtained in radio astronomy. Thanks both to the high resolution and high frequency that reduce Faraday Rotation effects, the map shows an unprecedented amount of detail. The emission is smooth both at high Galactic latitude and in the disc down to 5°–10° from the plane even in the inner Galaxy, symptomatic that Faraday depolarisation is marginal almost down to the Galactic plane. This unveils the disc, which was strongly depolarised up to latitude |b| ~ 30° in previous surveys taken at 1.4 GHz (Figure 3). S-PASS thus opens a new window to investigate the magnetic field in the disc with polarised diffuse emission.

Very large scale structures are visible at high Galactic latitudes. The most obvious is the vertical structure along longitude l=0° that

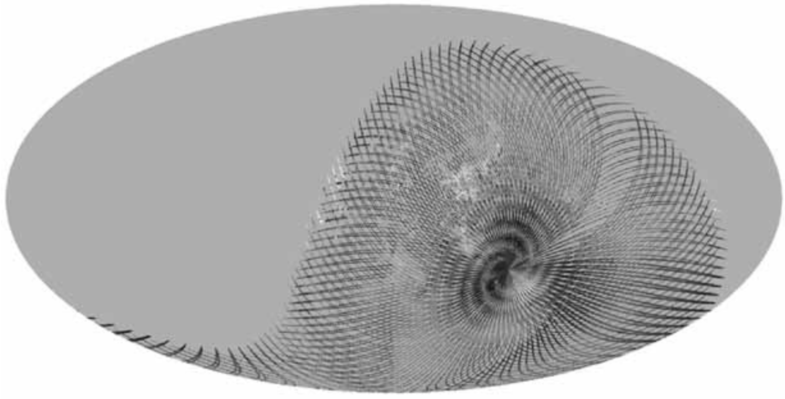


Figure 1: Combination of east and west scans. The two sets span the same Declination range but with a different path in the sky. The resulting crossing enables an effective basket weaving.

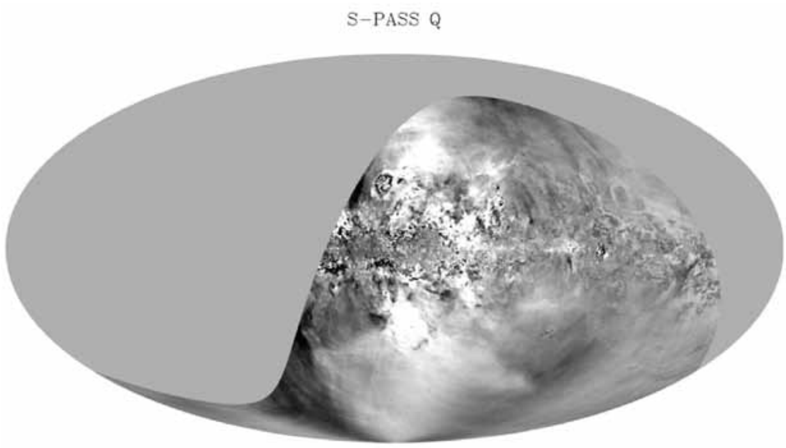


Figure 2: S-PASS Stokes Q map. Galactic coordinates centred at the Galactic Centre are used. Longitude increases leftward.

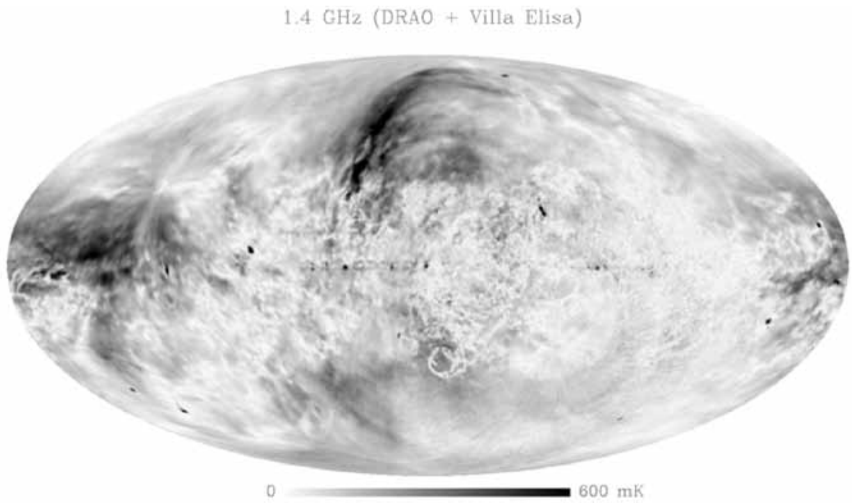


Figure 3: All-sky map of polarised intensity emission at 1.4 GHz. This image is combination of the Dominion Radio Astrophysical Observatory (north) and Villa Elisa survey (south) and is in Galactic coordinates centred at the Galactic Centre. Longitude increases leftward.

stretches from the south Galactic pole up to the north end of the map for a total length of nearly 150°. Bright extended emission made of several ridges is also obvious in the inner Galaxy at north latitudes (b ~ 0°–30°) and west of l=0°. In the outer Galaxy the polarised emission is detected down to the Galactic plane, even if modulation by Faraday Rotation is obvious. Prominent features in the disc are two heavily depolarised regions on either sides of the Galactic centre and the Gum nebula in the outer Galaxy. The formers well match bright HII regions whose high electron column density is the likely cause of the depolarisation. The latter is centred at l~260° and stretches for 30°–40° in longitude and +/- 15° in latitude and closely follows the Hα emission associated to the Gum Nebula. In the same area the Vela Nebula is also clearly visible.

At high Galactic latitudes the emission is smooth and weak. The large scale emission closely follows that of Wilkinson Microwave Anisotropy Probe (WMAP) maps, even though with much higher S/N. The S-PASS emission is thus mostly free from Faraday Rotation effects and its analysis will give a sounding basis to estimate and clean the Galactic emission contamination in CMB data. Moreover, the lowest emission regions that will be identified in S-PASS can be ideal targets for CMB ground based experiments, which seek for the cosmic signal in small sky areas. Foreground emission is also a strong contaminant for Epoch of Reionisation experiments like Murchison Widefield Array, whose observations might be conveniently pointed to the S-PASS lowest emission regions as well.

Now the time of data analysis and investigations starts. A first catalogue of nearly 5000 point source RMs has been extracted already, while RM analysis of the diffuse emission and CMB foreground analysis will start soon.

In summary, S-PASS observations have been successfully completed in two and half years of long observing nights. The disc emission looks unveiled at last and promises new insights into the study of this part of the Galaxy, while the high S/N at high latitude promises both a big improvement in the foreground cleaning efficiency and a better understanding of the large scale Galactic field. The data analysis has now begun and the next time we write on these pages we hope to report on the new findings that this project will have carried out. Stay tuned.

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CABB Zoom Modes Produce New Science

Maxim Voronkov, James Caswell and James Green (CASS)

The eagerly anticipated "zoom" modes of the new Australia Telescope Compact Array spectrometer (also known as CABB) became operational mid 2010 and have begun to yield new scientific results.

Recently put into press is a maser study which demonstrates the capability of simultaneously observing eight spectral lines at very high spectral resolution (Voronkov et al., MNRAS, in press; *http://dx.doi.org/10.1111/j.1365-2966.2011.18297.x)* including a new type of methanol maser at 23.4 GHz. These results are shown in Figure 1. The top full spectral lines are a related

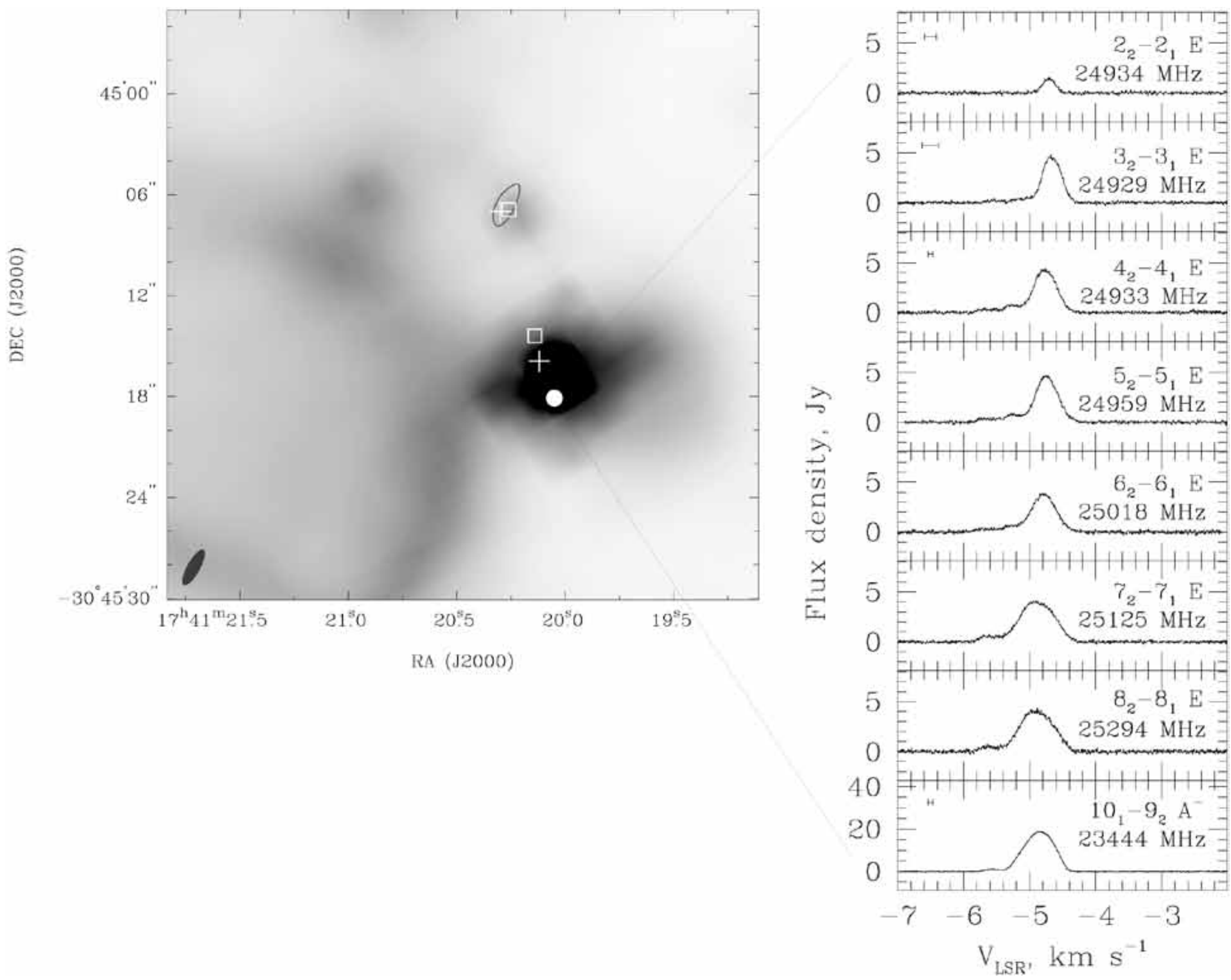

Figure 1: Background map is the 8.0 micron IInfrared Array Camera (IRAC) Spitzer Space Telescope image of 357.97-0.16 on which we have marked the radio measurements of various maser species (circle and squares show class I and class II methanol masers, respectively; crosses show water masers). Alongside the map we show the eight spectra of the class I masers taken simultaneously in CABB high resolution multiple zoom mode.

series of methanol transitions well known as masers, and clearly reveal the slowly changing properties (amplitude and structure) as we pass down the series. The bottom line is a transition of methanol not previously known as a maser, and it can be seen to be the strongest of all the lines. The new modes also allowed a study of an enigmatic OH maser showing both strong circular and linear polarisation, now recently published (Figure 2, and Caswell & Green, 2011, MNRAS, 411, 2059; *http://dx.doi.org/10.1111/j.1365-2966.2010.17856.x*). This project demonstrates the new capability of recording full polarization at a spectral resolution eight times better than was possible before. Furthermore, the full zoom mode capabilities are being exploited in a survey of the magnetic fields in high-mass star formation regions (entitled "MAGMO"), which aims to determine the magnetic fields across the Galaxy through the measurement of Zeeman splitting of OH masers. This survey will observe four transitions of OH masers simultaneously, with a large frequency coverage at each transition (equivalent to ~300 km/s), in all four Stokes parameters.

The new zoom modes are currently being used in a wide variety of projects ranging from the studies of periodic maser flares to the mapping of HI in nearby galaxies.

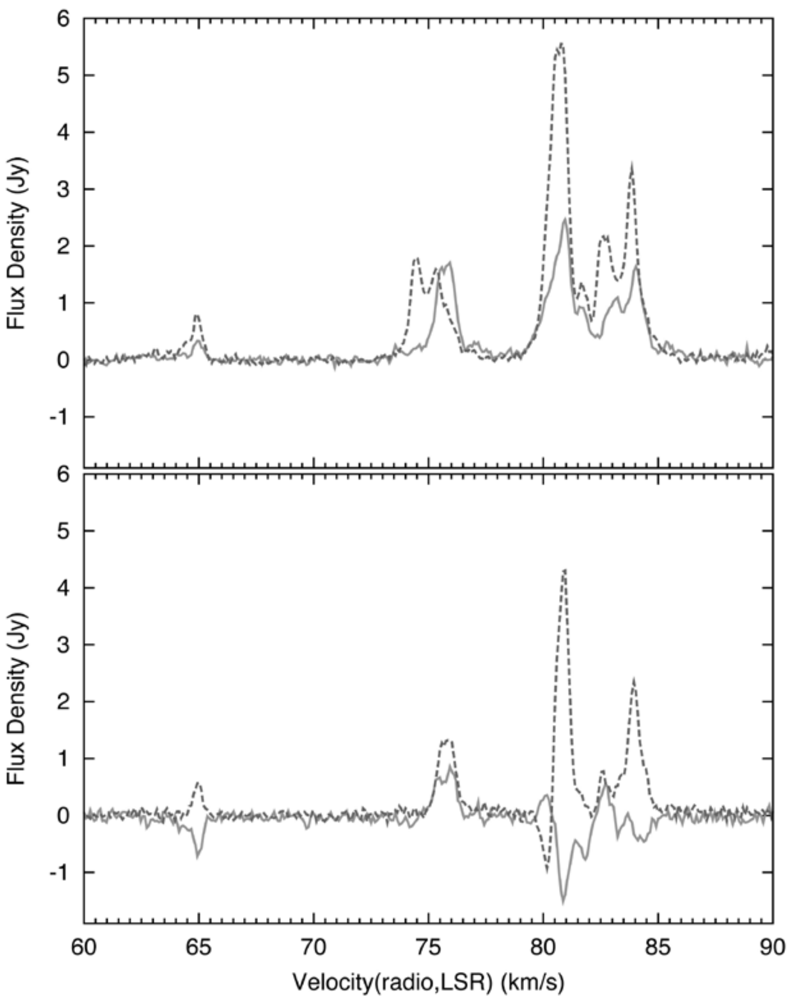

Figure 2: Detailed spectra of the 1667-MHz OH transition towards OH24.329+0.145 (2010 July). The upper panel shows RHC(solid) and LHC(dashed) polarisations. The lower panel shows the Stokes parameters Q(solid) and U (dashed) revealing significant linear polarisation.

ATCA Discovers an Ionised Jet Associated With a Young High-mass Star G345.5+01.5

Andres Guzman (PhD student, University of Chile/CASS)

We have discovered, using ATCA, a very good example of an ionised jet associated with a very young high-mass star. The presence of this jet forms important observational evidence that constrains the theory of high-mass star formation.

An intriguing datum about the process of forming high-mass stars (greater than 8 solar masses) is the common presence of massive and fast-moving molecular bipolar outflows, typically of several solar masses and velocities in excess of tens km/s. Are these more powerful versions of the outflows that are readily observed toward very young low-mass stars and consequently do they imply one generic disk-mediated accretion formation process for all stars across the stellar mass spectrum? Confirmation of this would be via direct observation of an accretion disk surrounding a high-mass star. Unfortunately the sites of high-mass star formation hamper such observations because they are located far from Earth, embedded in dense, dusty molecular clouds, and evolve on fast time-scales. Observation of ionised jets offer an alternative, albeit indirect, means to confirm a disk-accretion formation process.

So far there are about a dozen reported detections of ionised jets towards young high-mass stars. If these ionised jets are analogues to their low-mass counterparts then these jets are intimately linked to the accretion-disk formation process and power the observed massive molecular bipolar outflows.

An ionised jet towards a high-mass young stellar object (HMYSO) can be observed through its radio continuum emission at centimeter wavelengths. This thermal free-free continuum emission is more commonly associated with the ionised gas that surrounds more developed, but still young, high-mass stars (referred to as ultra-compact HII regions). We are able to distinguish this type of emission from jets using a combination of spectral and detailed morphological information. The wide spectral coverage (1 to 100 GHz) and the high-angular resolution of the Australia Telescope Compact Array (ATCA) make it well-suited to getting this information. In fact the ATCA has already discovered one of the best examples of an ionised protostellar jet (IRAS 16547-4247, Brooks et al. 2003).

We are nearing to completion a systematic search using the ATCA to look for more detections of ionised jets toward HMYSOs. Here we report on the discovery of an ionised protostellar jet towards the source G345.4938+01.4677 (hereafter G345.5+01.5).

G345.5+01.5 is associated with the Infrared Astronomical Satellite (IRAS) source 16562−3959, and is believed to be a high-mass star in formation at a distance of 1.6 kpc. The principal source is detected by several infrared surveys (e.g. Midcourse Space Experiment (MSX), Spitzer-GLIMPSE [Galactic Legacy Infrared Mid-Plane Survey Extraordinaire]) from which we deduce it has ~ 60,000 times the solar luminosity, and the central object corresponds to a star of 15 times the mass of the Sun. The object is also associated with a massive (~ 1000 solar masses) and dense (10^4 -10^5cm^{-3}) core of cold gas and dust.

Figure 1 shows an image of the ATCA 8.6-GHz continuum emission. The image shows five sources roughly aligned and symmetrically offset with respect to the central source, which we identify as the ionised jet. We interpret the outer four sources as lobes where the high-velocity gas ejected from the jet has impacted the surroundings, generating shock-ionised gas (Guzmán et al. 2010). They are the radio equivalent of optical Herbig-Haro objects. All of the five emission sources were observed at four different frequencies.

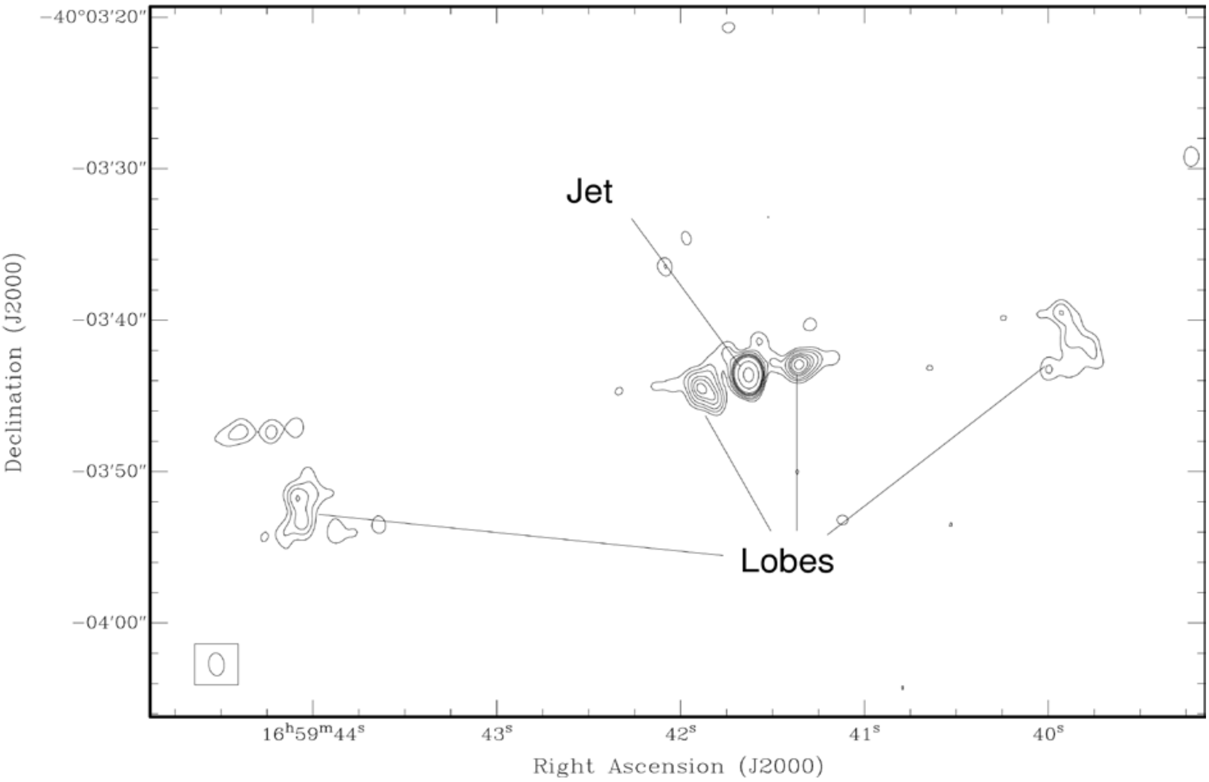

Figure 1: ATCA 8.6-GHz continuum emission image of the newly discovered thermal ionised jet system in the high-mass star-forming site G345.5+01.5. Data were taken on June 2008, October 2008 and February 2009. The synthesised beamsize is 1.62" x 1.01" and indicated in the bottom left corner.

This allows us to obtain spectra towards each of the lobes and the jet, the latter being a power law with a spectral index equal to +0.85 and consistent with free-free emission from a thermal jet.

Using the Atacama Pathfinder EXperiment (APEX) telescope in Chile we have also discovered a CO molecular outflow that extends in the jet direction and has its blue-shifted part towards the east, coincident with the eastern radio lobe (Guzmán et al. 2011)

Of the small list of HMYSOs known to harbor a thermal ionised jet, G345.5+01.5 has taken the lead as the most luminous. In second place is IRAS 16547-4247. Both of these jets were discovered with ATCA and we look forward to their follow-up studies at higher frequencies using the Atacama Large Millimeter/submillimeter Array (ALMA).

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SZ and X-ray Peaks Don't Correspond

Helen Sim, CASS

Two independent studies have been made with the Compact Array of the Sunyaev-Zel'dovich (SZ) effect in galaxy clusters. They show that the relationship between the SZ effect and X-ray brightness is complex, suggesting that we have much more to learn about the processes involved in cluster mergers.

When Cosmic Microwave Background (CMB) photons encounter a cloud of electrons, they undergo inverse Compton scattering. For frequencies above 218 GHz, the CMB brightness increases, while for frequencies below that value, it decreases. This spectral distortion is known as the Sunyaev-Zel'dovich effect. The amplitude of the distortion depends only on the properties of the electron cloud: in the case of thermal electrons, it is proportional to both the electron density and the electron temperature. The hot, dense, ionised gas found in galaxy clusters is a source of such electrons.

Hot cluster gas is commonly studied through its thermal X-ray emission: this, however, is more dependent on electron density, but less dependent on temperature, than the SZ effect. As a result, the SZ effect will tend to trace the hot, low-density gas in a cluster (which may be a better indicator of the cluster's large-scale structure), while the X-ray luminosity will be a better tracer of clumpiness (and thus perhaps highlight short-term activity in the cluster).

Two teams have used the capabilities offered by the Compact Array Broadbank Backend (CABB) to make the first subarcminute-resolution observations of the SZ effect in galaxy clusters undergoing mergers. They have then compared these to X-ray emission maps.

In one study, Marcella Massardi, Ron Ekers, Simon Ellis and Ben Maughan targeted the cluster CL J0152-1357. This is one of the most massive clusters known (with a total mass of 10^{15} solar masses), and lies at a redshift of 0.83. Previous studies have shown that clusters with $z \geq 5$ are more structurally complex, and less virialized, than clusters at low redshifts; and that clusters of $z > 0.8$ tend to be clumpy, suggesting they are closer to the epoch of cluster formation.

The team had observed this cluster in 2005, before the advent of CABB, with the Australia Telescope Compact Array (ATCA) in its most compact configuration (H75, with baselines from 30 m to 75 m). They detected a (negative) peak in the SZ effect in the cluster's northeast subclump, displaced about 35 arcsec to the northwest of the X-ray peak. The offset was unexpected and, as the detection was at a level of just 3.5 σ, it was not convincing. In 2009, after the upgrade to CABB, they repeated the observation of the X-ray peak in the northeast subclump. Again, they saw the peak in the SZ effect offset from the X-ray peak—by about 45 arcsec to the north; and this time, the detection was at a very convincing 10 σ level.

An Active Galactic Nuclei (AGN) could have locally heated the gas in the region of the SZ effect minimum. But there is no sign of an X-ray or radio AGN in the region, and the cluster galaxies present in this region are subluminous, so such heating seems unlikely. The team has also ruled out astrometric errors as an explanation for the offset.

In the second study, Siddharth Malu, Ravi Subrahmanyan, Mark Weiringa and Delampady Narasimha examined the well-known Bullet Cluster, a cluster collision (or merger) with a redshift 0.296. The strongest SZ feature was again significantly offset from the X-ray emission peak; indeed other SZ features in this cluster were all offset from the lesser peaks in X-ray emission. This implies that, in this cluster, the peak in intracluster gas temperature is offset from the peak in gas density.

Through the higher-resolution SZ observations made possible by CABB, these two studies have shown, for the first time, that the SZ effect does not correspond well to X-ray brightness in non-virialised clusters. The finding implies that the physics of cluster mergers is more complicated than our current models provide for, and throws into question the combined use of X-ray and SZ observations to derive cosmological parameters.

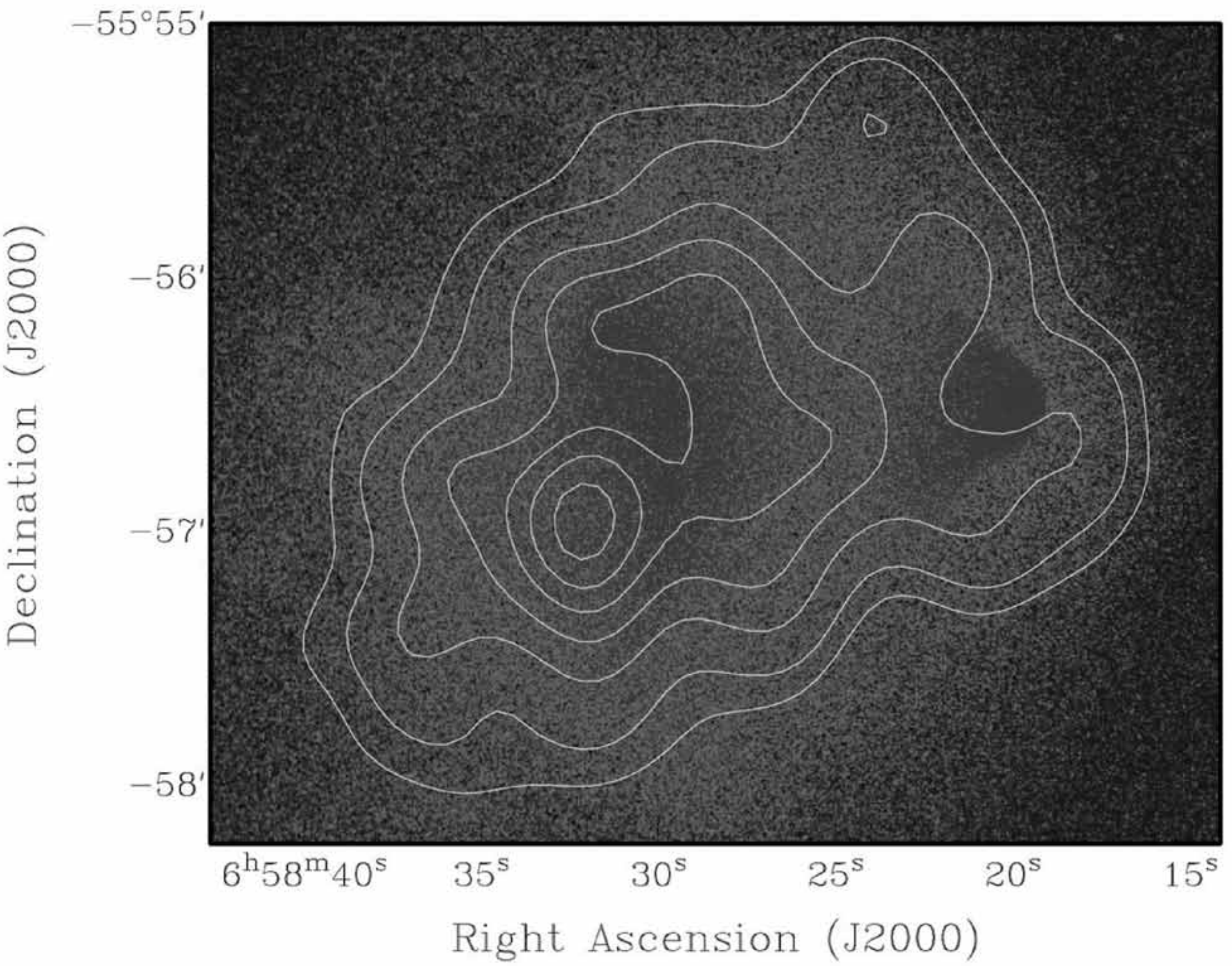

Figure 1: A false-colour X-ray image from the Chandra X-Ray observatory of the Bullet Cluster, with superimposed contours of the pressure/temperature distribution in the gas, determined from SZ observations with the Australia Telescope Compact Array. The hottest gas, seen by the SZ observations (contours), is displaced from the densest gas regions, which are traced by the X-ray emission (grey-scale tones). Only two other clusters are known to show such a displacement, which may indicate an energetic cluster merger. Interferometers are best suited for such SZ observations and the Compact Array is the only one capable of these measurements for southern clusters such as the Bullet Cluster. Credits: ATCA data: S. Malu et al. Chandra data courtesy of the Chandra X-ray Observatory Center, operated by the Smithsonian Astrophysical Observatory on behalf of NASA.

NB: For reference, please see the colour image published on the inside back page of this newsletter.

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M. Massardi, R.D. Ekers, S.C. Ellis, and B. Maughan. *High Angular Resolution Observation of the Sunyaev-Zel'dovich Effect in the Massive z ≈ 0.83 Cluster CL J0152 – 1357. ApJ Letters*, 718: L1-L5 (2010)

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Education and Outreach

Rob Hollow (CASS)

PULSE@Parkes

A milestone marked the start of the fourth year of CSIRO's *PULSE@Parkes* project, with the first ever session held from a school taking place in February 2011. Hosted by Penrith Anglican College, students from Glenmore Park High School, Caroline Chisholm College and Penrith Anglican College took direct control of the Parkes radio telescope from a control desk set up in the school's music performance space. CASS staff members, Dr George Hobbs and Rob Hollow were assisted by PhD student Stefan Ozlowski from Swinburne University. The session was a great success and provided a wonderful opportunity for students and teachers from the three local schools to meet and interact.

In March, the first *PULSE@Parkes* Teacher Scholar, Stephen Broderick from St Ursula's College in Toowoomba, spent a successful week at CASS headquarters at Marsfield. He worked with the project team in developing new outreach related resources. Stephen's article about his time with CASS can also be seen in this issue of the *ATNF News*.

In a further update, Alex Mathews from University of Western Australia spent ten weeks as a CASS Summer Vacation Scholar working on *PULSE@Parkes* modules and science. He has developed a new module that allows students to determine the period of a pulsar. It is currently being tested by an external group of teachers and should go live soon.

CASS Summer Vacation Program

Ten scholars from across Australia spent their summer based either at Marsfield or Parkes, working on a diverse range of projects under the supervision of CASS staff. The students also had the opportunity to use the Australia Telescope Compact Array in January for short observing proposals of their own choosing during an observing trip to Narrabri.

Every student gave a presentation of their work at a joint symposium with summer vacation students from the Australian Astronomical Observatory and the Australian Gemini Scholars based in Chile.

The CASS students then finished their program by participating in the *Big Day In* at Macquarie University with other summer students from across the CSIRO Information Sciences Group. CASS Director Dr Phil Diamond gave the keynote address at this two-day event, inspiring the students with developments in radio astronomy including the Australian Square Kilometre Array Pathfinder (ASKAP) and the Square Kilometre Array (SKA).

Other Education and Outreach Activity

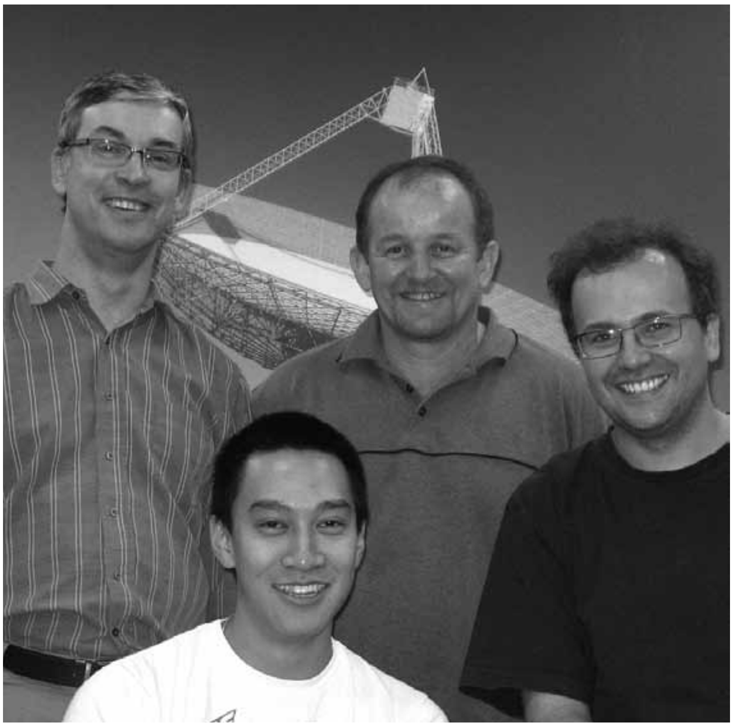
The annual one-day *Astrophysics for Physics Teachers* workshop was held at Marsfield in late March 2011. Participating teachers from across NSW learnt about new ways and activities to engage and challenge students. Speakers included Dr Jimi Green, Dr George Hobbs and Rob Hollow from CASS, Dr Fred Watson from the AAO and Geoff Wyatt from Sydney Observatory. Rob also presented sessions to teachers at the Sydney Observatory as well as at the Science Teachers' Association of Victoria Physics Teacher Conference in February.

The students and staff from Pia Wadjarri Remote Community School toured the Murchison Radio Observatory to inspect the first six dishes of ASKAP in December. This was the first site visit by the students. Work is continuing on an Indigenous Education resource for the Wadjarri Yamatji community in conjunction with the building of ASKAP.

CASS Teacher Scholarship

Stephen Broderick

Teacher Stephen Broderick was the recipient of the first CASS Teacher Scholarship. The scholarship provided Stephen with the opportunity to work alongside the PULSE@Parkes team in a research environment. He spent a week at the CASS Marsfield site, meeting with scientists and outreach staff, and learning about the program and the ATNF more generally. Stephen will also develop astronomy related educational resources in the coming months and will have the opportunity to remain involved in future PULSE@Parkes activity. An account of his enjoyable week follows:



Robert Hollow, Jonathan Khoo, Stephen Broderick and Dr George Hobbs. Credit: Helen Sim, CSIRO

I have been teaching mathematics and science at St Ursula's College in Toowoomba for 25 years, so I saw the CSIRO Teacher Scholarship as a unique opportunity to combine my love of astronomy and mathematics. After arriving at the CSIRO main gate in Marsfield, (reminiscent of a scene out of *Mission Impossible*), I proceeded to turn a combination lock (successfully I might add) in various directions using the secret number until my key and instructions on how to reach the lodge were revealed. The lodge was my on site accommodation for the week. Two overseas post graduate students and a visiting professor from Melbourne were also staying at the lodge. The lodge would rival any three or four star motel. Everything you could possibly imagine was available in the lodge, including toothpicks, bicycles, and combination locks, puncture kits, etc.

The Marsfield site is very picturesque and is nestled amongst lots of gum trees which consequently attract many varieties of parrots, native birds and exotic insects. The spectacular sunsets from my window in the lodge were framed by the two iconic 12-metre radio telescopes.

On Monday Rob Hollow gave me a tour of the CSIRO facilities which included the Astronomy and Space Science division, library, canteen and various workshops which included full scale models of various sections of the 12 metre radio telescopes currently being constructed in Western Australia as part of the Australian Square Kilometre Array Pathfinder (ASKAP) telescope. The hallways are decorated with eye catching educational posters which show a progression in technology and precision depending on which direction you travel in.

Later in the day we met with George Hobbs and Jonathon Khoo to discuss my role which was mainly working on the web based PULSE@Parkes student modules. My knowledge of pulsars was greatly enriched hour by hour and one of my favourite astronomical objects is now the pulsar PSR J0437-4715 (my students also know about PSR J0437-4715 and are familiar with its sound file).

On Wednesday I was privileged to be involved in a meeting chaired by Robert Braun who was the head of the Astrophysics section. The meeting showcased various developments on site, including the progress of several projects and the research findings by post graduates was also shared. Discussions were encouraging and illuminating, providing alternative solutions and more questions than answers. The robustness of some well known standard theories was also questioned. It was breathtaking witnessing the level of thinking and reasoning within the room. It was science in the making.

On Wednesday afternoon, electrical engineer Mark Bowen gave me a guided tour of the engineering section. He explained what happened to the radio signal after it arrived at the focus cabin and entered the multibeam receiver. For example the multibeam receiver at Parkes (which was built in the CSIRO workshop) can look at 13 points in the sky simultaneously. Each receiver uses vacuum and liquid helium to amplify the signal. Eventually the integrity of the vacuum breaks down and the receivers need to be resealed.

On Thursday I attended a lecture at the Australian Astronomical Observatory on the distribution of dark matter. The lecture was very interesting and generated lots of discussion. Once again there were more questions than answers and plenty of food for thought. (Speaking of food, the CSIRO canteen provided a huge range of culinary delights and lunch time was always enjoyable listening to various scientists and computer programmers speaking about their triumphs.)

Friday was my last day and I felt contented that I had learnt a lot in such a short time; however, my journey with pulsars has only just begun. I am very grateful to all of the staff at the CSIRO Marsfield site especially Rob Hollow, George Hobbs and Jonathon Khoo for allowing me to work with them. All of the staff at CSIRO appeared focused on a common goal — the advancement of scientific knowledge. I feel confident that I can give my students accurate career advice about what a scientist at CSIRO does and I have also registered St Ursula's College in the Scientist in Schools project as I see the connection between schools and scientists as an enterprising and positive step in Australian Education. My week at CSIRO has certainly been the highlight of my teaching career to date and I look forward to reading about future achievements in CSIRO newsletters.

Operations

Douglas Bock (CASS)

Several upgrades are coming to their conclusion this year.

Upgraded "16 cm" receivers replacing the 20 cm and 13 cm receivers are now available on all Australia Telescope Compact Array (ATCA) antennas (see report elsewhere in this issue). The new receivers have increased sensitivity and bandwidth to complement CABB, the Compact Array Broadband Backend. Meanwhile, the 64-MHz mode for CABB is now being released. This will substantially improve the capability for extragalactic millimetre-wave observations this winter. Together the upgrades are a major enhancement to the ATCA. Installation of the University of New South Wales water vapour radiometers has also recently be completed. These will be charactised during the coming winter.

During March, Parkes was shut down for four weeks to enable the MCP (Manual Control Panel) to be replaced. While the front panel still looks largely the same, the internal workings of the MCP have been completely overhauled. This, together with the "switch matrix" installed last year (that automates signal chain reconfiguration) will enable remote observing with the Parkes Telescope. Also supporting remote observing are significant upgrades to the Parkes power supply and distribution systems, which are underway and will continue for the next few years.

In February, CSIRO and the Auckland University of Technology (AUT) formally agreed to collaborate on Very Long Baseline Interferometry (VLBI) observations. As a result, the AUT 12-m Warkworth radio telescope is now commonly available for VLBI sessions at 20, 13, and 3 cm. A single ASKAP antenna is also sometimes available at 20cm. These antennas are requested explicitly in proposals.

The Australian National Data Service (ANDS)/ATNF Data Management Project has recently been successfully completed. This project produced a public archive of several important Parkes pulsar datasets and established the framework for including all Parkes data in the future. This will complement the ATCA and Mopra data already available in the Australia Telescope On-line Archive. The data may be accessed at *http://datanet.csiro.au/dap/*. For more details, see the report in the April 2010 News.

April 2011 Time Assignment

The Time Assignment Committee (TAC) met at Marsfield on 2 – 4 February to consider proposals for the 2011 April semester (2011APRS). A total of 212 proposals were reviewed; 132 for the Compact Array, 38 for Mopra, 29 for Parkes, 12 for the Long Baseline Array (LBA) and one for Tidbinbilla.

With ongoing enhancements to OPAL (ATNF Online Proposal Applications & Links), the Time Assignment Committee now has better access to proposals and TAC comments from previous semesters, and is paying closer attention to ensure resubmitted proposals have addressed the comments made on previous submissions. A resubmission that does not consider any of the feedback provided by the TAC is unlikely to be reviewed favourably!

In the past, proposal teams have been notified individually on the outcome of their proposal review by the TAC, and again once the schedules have been released. From

April 2011, a single message is being sent to all proposers. The first, soon after the TAC has met, advises all proposers that the TAC grades and comments are available in OPAL. The second notifies all proposers that the schedules have been released and provides links to the detailed information available from the schedule webpages.

Abstracts of all accepted proposals are now available in ADS.

Notes on the Compact Array

The 2011APRS will commence with the "standard" CABB 1 MHz continuum mode available, and with up to 16 zoom bands per IF (intermediate frequency) available in the 1M-0.5k mode. The 64-MHz CABB mode will, for the first few weeks, have a single 64-MHz band in each IF, which will have 2048 channels across it. (Thus, if the 64-MHz mode is selected for an IF, the total bandwidth in that IF will be 64 MHz and not 2 GHz). For continuum plus spectral line studies, having one IF set with the 64-MHz mode and the other with the standard 2048 1-MHz-wide channel is possible. For spectral line studies, 64 MHz is available in both IFs — with separations up to 7 GHz between the two 64-MHz channels possible. It is expected that the 64-MHz mode will be expanded with the full thirty-two 64-MHz channels available per IF early in the semester.

Work has commenced on the 6/3 cm ("C/X") upgrade, which will provide coverage over the range 4.0 –12.0 GHz and thus fill the gap between the existing 6 cm and 3 cm bands. The first prototype receiver may be ready for installation toward the end of the 2011APRS.

Two weeks during the semester have been allocated for C2479 *ATCA Characterisation of the first BETA fields*, in order to characterise the two 30 square degree fields that will become the first science fields observed on BETA (the first six antennas of ASKAP). The fields are centred on the Circinus galaxy and the Fornax cluster (and including Fornax A).

The "Science Operations Centre" pilot observing mode trialled last year for Mopra (see October 2010 ATNF News) will be extended to selected ATCA projects this year.

Notes on Parkes

The 2011APRS schedule for Parkes has a three-week shutdown period, from Monday 23 May to Friday 10 June, primarily for refurbishment of the focus cabin translator rails. It is expected that all receivers will be removed from the focus cabin for this work to be undertaken.

Notes on Mopra

Owing to the relocation of Balt Indermuele to Sydney, most Mopra support will now be delivered from Marsfield. In the 2011APRS, "on-site" observing will be supported from Marsfield (where a dedicated observing room will be set up) or at Narrabri.

Recent changes to the Mopra Spectrometer (MOPS) have enabled "fast mapping" observations to be made, with a correlator cycle time of 256 milliseconds rather than the standard 2 seconds, for a reduced number of MOPS zoom bands (no more than four is recommended). In order to allow a seamless transition between fast-mapping observations and regular observations, it is intended from early 2011APRS to change the cycle time for all Mopra observations from the current 2.0 seconds to 2.048 seconds. We will ensure that all Mopra users are made aware when this change is made, and that old scripts (assuming a 2.0 sec cycle time) will be handled gracefully.

Publications List

Publication lists for papers which include ATNF data or CASS authors are available on the Web at *www.atnf.csiro.au/research/publications*. Please email any updates or corrections to this list to *Julie.Tesoriero@csiro.au*

This list includes published refereed papers compiled since the October 2010 issue of *ATNF News*. Papers which include CASS authors are indicated by an asterisk.

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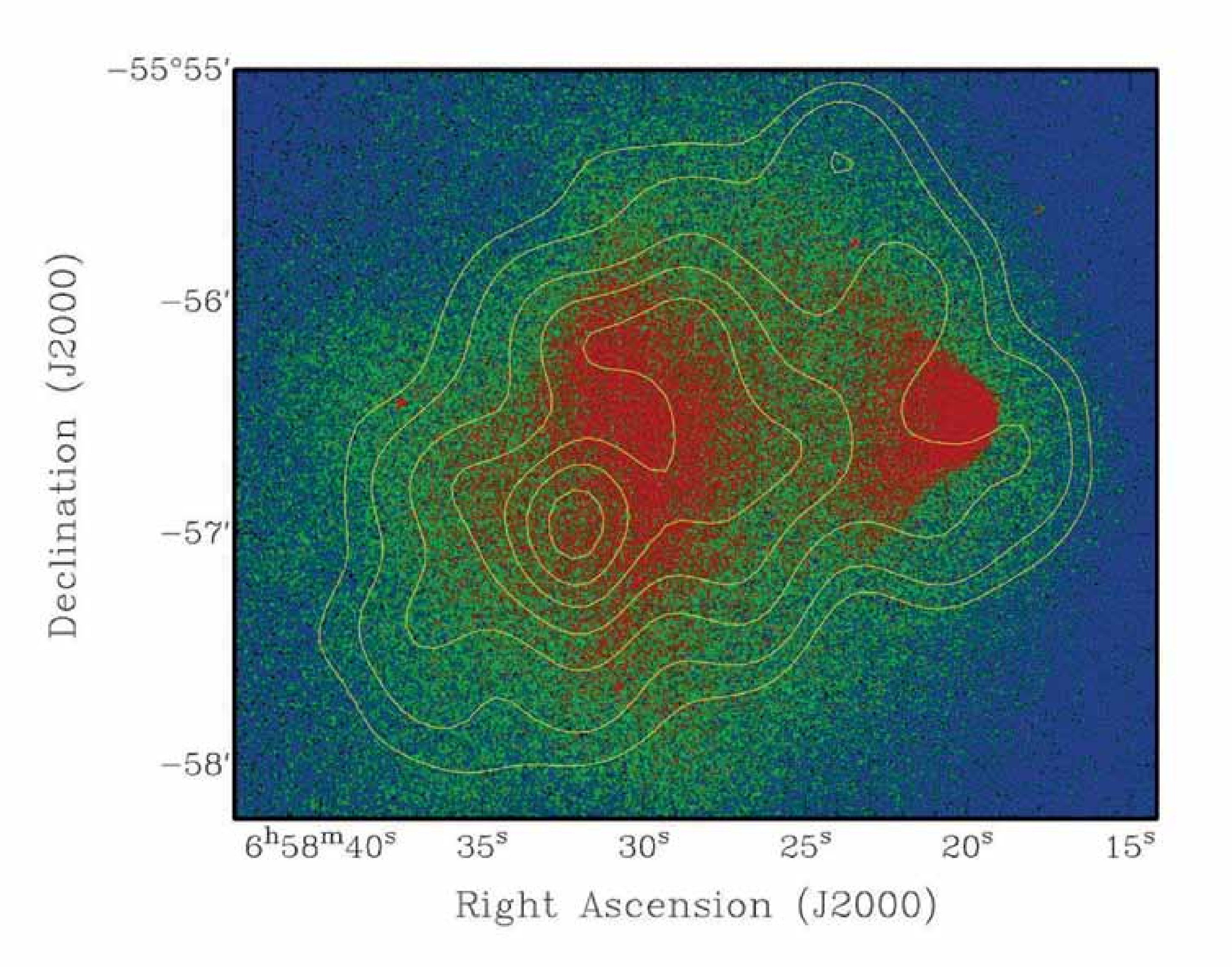
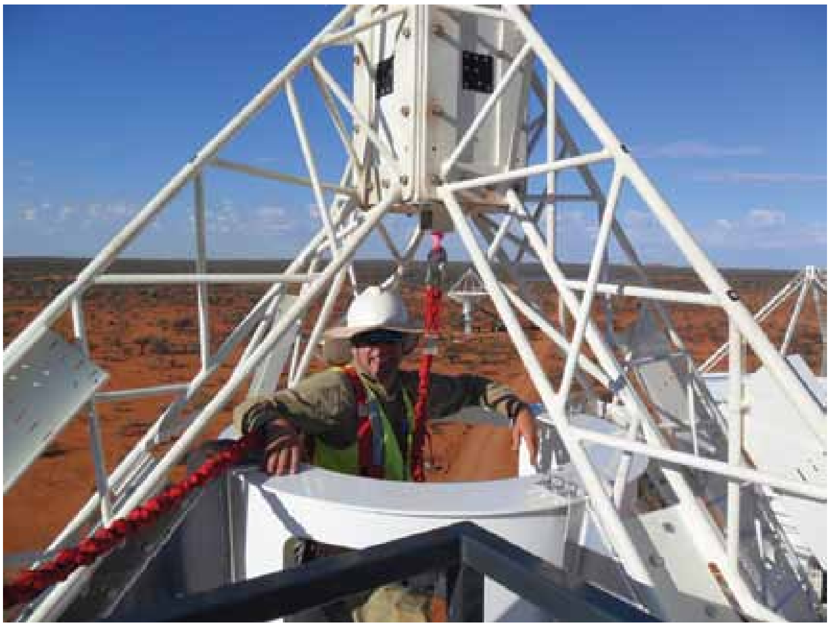


Figure 1: A false-colour X-ray image from the Chandra X-Ray observatory of the Bullet Cluster, with superimposed contours of the pressure/temperature distribution in the gas, determined from SZ observations with the Australia Telescope Compact Array. See page 31 for further details.



Ross Forsyth stands in the receiver cage of one of the Australian Square Kilometre Array Pathfinder antennas at the Murchison Radio-astronomy Observatory.
Credit: CSIRO

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