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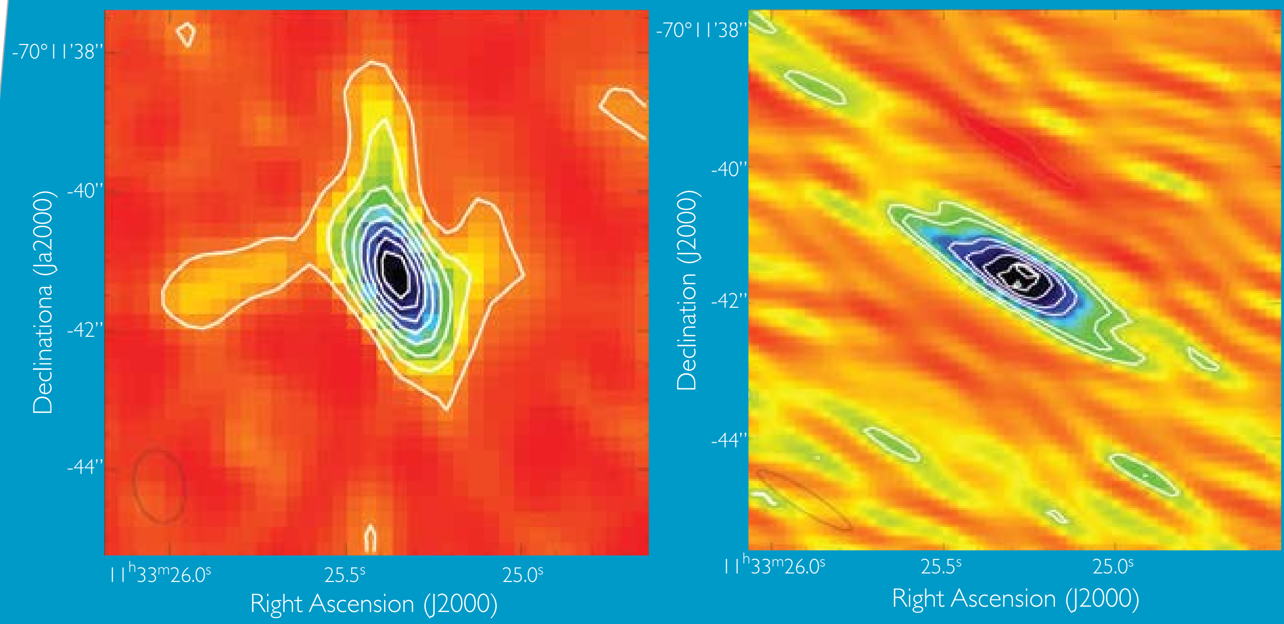

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ATNF News

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

An artist's impression of the new DSS35, 34-metre Beam Wave Guide antenna to be constructed at the Canberra Deep Space Communications Complex, Tidbinbilla. Credit: CDSCC/NASA

Assembly of the first ASKAP antenna at the Murchison Radio-astronomy Observatory made rapid progress in January 2010. Credit: Carole Jackson, CSIRO.

Cover page images

See article on page 24: Resolving Structure in the HD100546 Disk—Signatures of Planet Building?

Figure 3a: HD100546 map at 94500 MHz with natural cleaning, observed with the 750A array in May 2008 with 500 minutes integration on source. The extension to the west is coincident with the HST/ACS "structure 2" of Ardila et al. (2007).

Figure 3b: HD100546 map at 94500 MHz with natural cleaning, observed with the 1.5B array in June 2008 with 125 minutes integration on source. The beam size is 1.6 x 0.3" (P.A. 58.2°), with a resolution of about 30 AU (FWHM) along the disk major axis.

Contents

Editorial

Welcome to the April issue of *ATNF News* for 2010. The observant amongst you will have noticed some minor changes to the magazine including its cover. These reflect the recent structural changes within CSIRO and the creation of our new Division—CSIRO Astronomy and Space Science (or CASS as its becoming known). CASS has responsibility for operating the Australia Telescope National Facility, as well as for other space tracking and space science activities (most notably the management of the Canberra Deep Space Communications Complex).

As part of this restructure, a new Chief of CSIRO Astronomy and Space Science has been recently appointed—Dr Philip Diamond. Previously Director of the Jodrell Bank Centre for Astrophysics at the University of Manchester in the United Kingdom, he will begin his new role on 1 June 2010. We provide a brief profile on Philip Diamond and his career to date.

On a science front, we feature several articles highlighting the great research that is being undertaken at ATNF observatories. Sarah Maddison and collaborators report on a multi-frequency observing program of the enigmatic Herbig Be star HD100546, with the Australia Telescope Compact Array (ATCA); and Peter Barnes and collaborators report on the identification of a young massive star-forming cloud as it undergoes a large-scale gravitational collapse, utilising observations made with the Mopra telescope.

In other news, we talk to John O'Sullivan, winner of the 2009 Prime Minister's Prize for Science; we report on the Canberra Deep Space Communications Complex (CDSCC) as it formally transitions into CASS; we feature a paper by Ronald Stewart and collaborators, *Highlighting Our History: The World's First Solar Radiospectrograph*; and we report on the Parkes Observatory as it wins an Australia Day Award.

As always, we provide our regular update on the Australian Square Kilometre Array (ASKAP) and Square Kilometre Array (SKA) activity with some notable milestones achieved!

If you would like to contribute to later 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

Lewis Ball

Acting Chief, CASS

This newsletter marks a watershed for radio astronomy and space science in CSIRO. Since the last newsletter the division has changed its name (From ATNF to CASS), has more-or-less doubled in size (from around 180 staff to 300 staff, and from an annual budget of around $25M to one of $50M), and has broadened its remit considerably. The Division's new Chief, Phil Diamond, will join CSIRO soon after this newsletter is published and by the time of the next newsletter Phil will be starting to set the new course for CASS.

The change of name of the Division, from the Australia Telescope National Facility to CSIRO Astronomy and Space Science occurred on 1 December 2009, bringing together CSIRO's radio astronomy activities and its responsibility for the oversight of the Canberra Deep Space Communications Complex (CDSCC). Then at the end of February 2010 the CDSCC activities were brought wholly within CSIRO, and all the staff at CDSCC who had been employed by the subcontracting company, Raytheon Australia, accepted offers of employment from CSIRO.

This has created a very exciting and dynamic environment as staff from CDSCC and ATNF have started to build relationships and understanding of the much broader range of people, activities, skills, and opportunities that now sit within the new Division. In February, at the height of the transition from Raytheon, CDSCC achieved its highest ever performance in successful data capture at 99.996%, and for the first time in 40 years did not generate a single Discrepancy Report. This is an outstanding testament to the professionalism and dedication of all the people involved.

Other exciting topics detailed in this newsletter include some of the history of the Division and its roots in studies of our Sun, and some outstanding science results from the Mopra telescope and from the Compact Array now equipped with the amazingly capable Compact Array Broadband Backend. Implementing all the planned capability for CABB continues to be a challenge, but good progress is being made and a major new mode providing 1MHz wide "zoom" bands is about to enter operation.

This newsletter highlights some of the outreach and education activities that CASS is involved in. It is remarkable that this Division is now home to Visitor Centres that host more than 200,000 members of the public each year, a tremendous point of interaction with the Australian public. Events such as the Parkes Open Days provide a specific focus on such activities, but the ongoing dedication of our communications and education staff who are actively engaging the public all year are fundamentally important. We play a significant role in inspiring future generations in the fact that Australia and Australian's have a leading role to play in answering some of the biggest questions about our Universe, and developing some of the technology and prompting innovations that can change the lives of millions of people as has resulted from the wireless LAN developments featured in the article about John O'Sullivan's well-deserved Prime Minister's Science Prize.

I'd like to make special mention of a new arrival to CASS, Dr Douglas Bock, who joined the management team in the role of Assistant Director: Operations in January. Douglas is an outstanding example of the quality of the staff that CASS continues to recruit, and he is a tremendous addition to the group of senior leaders that will continue to steer CSIRO's Astronomy and Space Science activities. Many other new staff have joined since the last Newsletter and it is a pleasure to welcome them all.

Many of the new recruits are involved in the delivery of ASKAP. The registration of the Indigenous Land Use Agreement (ILUA) covering the new site indicates the breadth of activity currently being undertaken by CASS. The support of the indigenous Wajarri Yamatji people is very important to CSIRO and the successful negotiation of the ILUA is something we are very proud of. Another major milestone for ASKAP occurred in January with the assembly of the first antenna at the Murchison Radio-astronomy Observatory in Western Australia, providing real physical evidence that this is a new site for radio astronomy and that it is a major part of the CASS Division. The fact that "first light" followed so quickly is a tribute to CETC54, the company building the antennas, and to the expertise and dedication of the CSIRO staff involved.

To finish, I'd like to take this opportunity to thank the many people who have made the last 17 months—during which I have been responsible for CSIRO's radio astronomy and space tracking activities—so rewarding for me. While it has been a very demanding time which has seen considerable change, it has been one of the most exciting periods of my career.

New Chief of CSIRO Astronomy and Space Science Appointed

Tony Crawshaw (CASS)

After an extensive international search, Dr Philip Diamond has been appointed Chief of CSIRO's Astronomy and Space Science Division. He will begin his role formally on 1 June 2010.

CSIRO Astronomy and Space Science's new Chief, Dr Philip Diamond.. Credit: CSIRO

His key area of focus will be to continue to foster Australia's reputation for exceptional radio astronomy while strengthening the linkages between astronomical and space sciences. Dr Diamond will also work closely with Dr Brian Boyle, CSIRO SKA Director to support Australia's international SKA bid.

In his previous position as Director at the Jodrell Bank Centre for Astrophysics at the University of Manchester (UK), Dr Diamond was responsible for the organisation's strategic research and management, with his role also including the coordination of PrepSKA, the important Preparatory Phase study for the A$2.5billion international Square Kilometre Array project.

Prior to his appointment at Manchester University, Dr Diamond was the Director of the MERLIN and VLBI National Facility at the Jodrell Bank Observatory.

Dr Diamond holds a Bachelor of Science degree (majors in Physics and Astrophysics) from Leeds University, and a PhD in Radio Astronomy from Manchester University, both in the UK. Since gaining his PhD he has worked at the Onsala Space Observatory in Sweden, the Max-Planck Institute for Radioastronomy in Bonn, Germany and spent 12 years in various positions within the National Radio Astronomy Observatory in the USA.

Lewis Ball remains Acting CASS Chief until 1 June 2010.

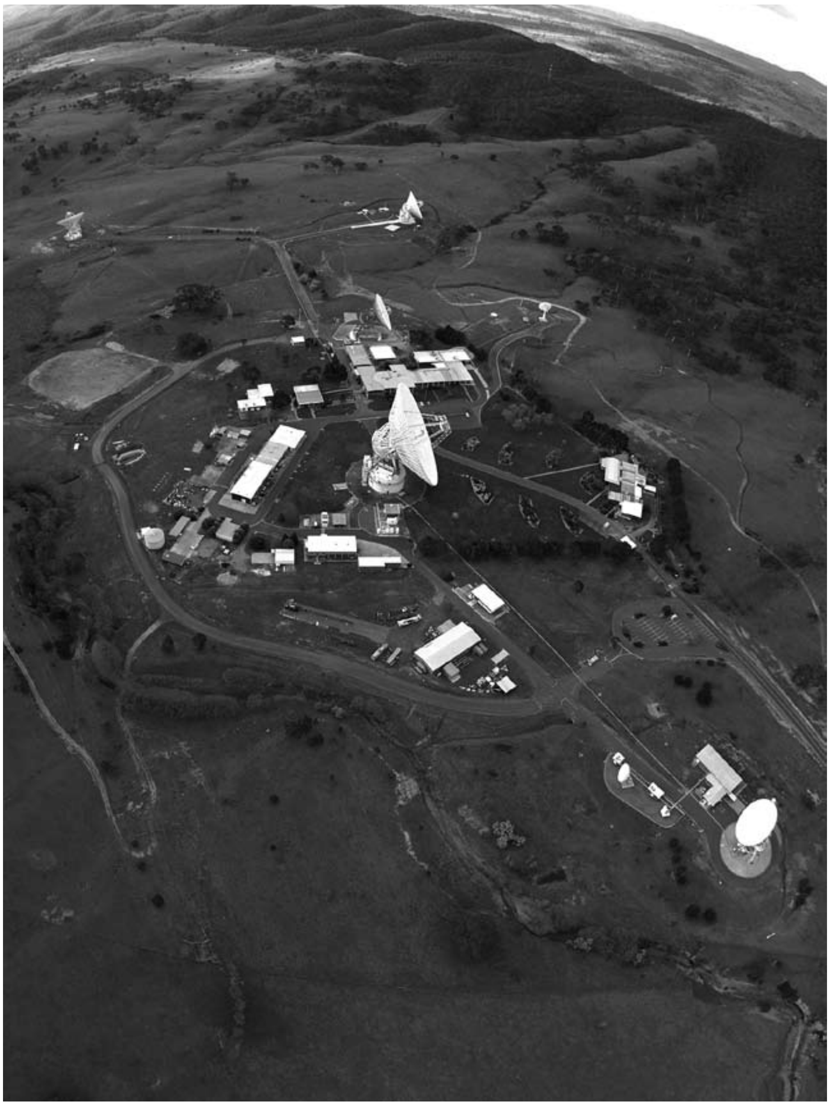
CDSCC Joins CASS

Tony Crawshaw (CASS)

On 27 February 2010, the Canberra Deep Space Communications Complex (CDSCC) formally transitioned into CSIRO as part of the CSIRO Astronomy and Space Science Division, or CASS. The CDSCC, located at Tidbinbilla just outside Canberra, is one of three components of NASA's Deep Space Network, which allows for constant observation and communication with NASA spacecraft throughout the solar system.

CSIRO's move to directly managing and operating the CDSCC is the latest step in a long relationship that has existed between NASA and CSIRO since the early 1960s. Activities common to both organisations have taken place over the years including spacecraft tracking and expertise related to CSIRO's astronomy activities.

Strategically, the new arrangement is consistent with CSIRO's identification of the management of National Facilities and Collections as a core activity for the organisation. The move also aligns with Government policy which has flagged "Space Science and Astronomy" as one of three Super Science areas.



An aerial view of CDSCC.
Credit: CDSCC

Recently, CSIRO and NASA celebrated their 50 year partnership, as part of the US-Australia collaboration on space communication. A number of special events were held featuring senior CSIRO, Australian Government and NASA officials.

As part of the anniversary celebrations, NASA announced that construction would begin on two new 34-m antennas at Tidbinbilla. The two new antennas known as DSS35 and DSS36 will be "beam wave guide" antennas, and will feature improved flexibility over existing antennas, allowing the network to operate on several different frequency bands within the same antenna.

John O'Sullivan Awarded Top Science Award

Tony Crawshaw (CASS)

On 28 October 2009 (just after the previous issue of ATNF News went to print), CSIRO's John O'Sullivan was recognised with Australia's pre-eminent science award—the 2009 Prime Minister's Prize for Science. The Prize is one of the nation's most highly regarded awards and is the premier national award for scientific achievement. It is awarded for an outstanding specific achievement or series of related achievements in any area of science advancing human welfare or benefiting society.

PM Kevin Rudd and Senator Kim Carr congratulate John O'Sullivan (middle) on his achievement on being awarded the 2009 Prime Minister's Prize for Science. Photo Credit: CSIRO

John O'Sullivan was awarded the prize for his ground breaking work on Wireless LAN technologies. As Project Leader of CSIRO's successful Wireless LAN Research Team—he helped develop wireless local area networking technology that now underpins wireless communication systems across the world.

The origins of that group's wireless success can be traced all the way back to John's work in astronomy and his application of Fourier Transforms (mathematical equations) to help think about and solve the problems posed by atmospheric seeing and dispersion in astronomical data. John's role in developing a chip specifically to do Fast Fourier Transforms, while heading up the Signal Processing Group in CSIRO's Division of Radiophysics led ultimately into the technology that we now know today as wireless LAN.

When asked to comment on the magnificent achievement, John responded, "It was a great honour and a real buzz to be awarded this prize in the Great Hall of Parliament House by the Prime Minister. The diverse backgrounds and skills of the WLAN project team working with me were hugely important in us coming up with the solution to high speed wireless networking. This is also a reminder of the role of pure science in the innovation process leading to commercial outcomes."

John O'Sullivan's latest efforts are directed towards the development of an innovative radio camera (or phased array feed) with a uniquely wide field-of-view for ASKAP, CSIRO's next generation radio telescope, currently being constructed in the Murchison Radio-astronomy Observatory site in Western Australia.

Highlighting our History: The World's First Solar Radiospectrograph—Penrith 1948–1949

Ronald Stewart, Harry Wendt, Wayne Orchiston, Centre for Astronomy, James Cook University, Townsville, and Bruce Slee, CASS and Centre for Astronomy, James Cook University, Townsville.

Introduction

The first radio observations of the Sun made by Lindsay McCready, Ruby Payne-Scott and Joe Pawsey from the CSIR's Division of Radiophysics were conducted at 200 MHz from October 1945 using wartime radar installations at Collaroy, North Head and Dover Heights (Orchiston et al., 2006). The earliest chart recordings showed two distinct types of sporadic activity referred to as ***isolated bursts*** and ***outbursts*** which differed in their intensity and duration. A third type of persistent activity, called ***noise storm*** bursts, was reported by Cla Allen (1947a), who was observing at the Commonwealth Solar Observatory on Mt Stromlo.

On 8 March 1947 John Bolton, Gordon Stanley and Ruby Payne-Scott observed an intense ***outburst*** that lasted for some 15 minutes at 200, 100 and 60 MHz. Payne-Scott et al. (1947) speculated that the outburst might be caused by particles travelling outwards through the corona with sufficient speed to initiate an auroral display seen from Sydney on the following evening.

In late 1947 Payne-Scott moved from Dover Heights to Hornsby Valley where she conducted observations of the Sun at 85, 65 and 60 MHz but she was not able to confirm the earlier result that outbursts show time delays of several minutes. She wrote:

"However, on the question of longer delays, the present author has never since, in the recording of hundreds of bursts, obtained any evidence for delays of the order of minutes. Either, this case reported earlier was very unusual, or the record was misinterpreted; as the relative amplitudes of different portions of a complex burst may be different on different frequencies, such an interpretation of a single case is quite possible." (Payne-Scott, 1949).

Clearly what was required in order to answer the delay question was a spectrum analyser that made simultaneous observations over a wide frequency range.

In this paper[1] we follow the development of the world's first radiospectrograsph by examining early archival material and relevant publications. We were fortunate also to be able to interview John Murray who was one of the original members of the team that designed and operated the instrument.

Bowen's Recollections

In his recollections of the early days E.G. ("Taffy") Bowen (1984), who was the Chief of the CSIR Division of Radiophysics at that time, recalled that WWII receivers, which had been used for surveillance of enemy radio and radar transmissions, were "quickly pressed into service" to make spectral observations.

Although it is true that the radiospectrograph was built on the principles developed earlier for wartime radar, a search of archival records and publications reveal Bowen's claim was not entirely correct because the existing spectrum analysers were found to be unsuitable for solar observations. New equipment including a broadband rhombic antenna matched to a swept-frequency receiver coupled to a photographic display had to be designed and constructed before being installed at the Penrith site in 1948.

Planning and Development of the Radiospectrograph

McCready began work in September 1947 on designing equipment to examine the frequency-time distribution of the solar bursts. He was joined soon afterwards by two new recruits Paul Wild and John Murray. In the minutes of the Solar Noise Group meetings (Pawsey, 1946) it is noted that the surplus war equipment was unsuitable for solar observations and was replaced by a 70-130 MHz receiver, designed by Wild, which used semi-butterfly tuning condensers from one of the WWII P58 receivers. Murray (2007) was given the task of completing the design and construction of the display, as well as helping Bill Rowe assemble the receiving equipment.

Operation of the Penrith Radiospectrograph

The site selected for the installation of the radiospectrograph was within easy walking distance (about 300 metres north) of the Penrith railway station. The site was chosen for its easy access from Sydney and because it was relatively free from radio interference (Murray, 2007).

The radiospectrograph operated for about 8 hours per day from February to July 1949. Burst radiation from the Sun was collected with a broad-band rhombic aerial connected to a receiver which was rapidly tuned or 'swept' over the 70 to 130 MHz frequency range. The tuner was mechanically-driven so that the frequency sweep occurred in 0.07 second, and repeated about three times per second, giving a time resolution for recording of 4 scans per second. The spectrum was displayed on a cathode-ray tube in the form of a graph of received power (vertical axis) ***versus*** frequency (horizontal axis), called in radar terms an "A-scan", and then photographed by a hand-held 8-mm Zeiss movie camera.

The antenna was designed by Wild, and was constructed with a wooden frame under the supervision of Keith McAlister, a mechanical and electrical engineer who became well known over the years for the design and construction of low-cost antennas at various Radiophysics astronomy sites. Wild derived the theoretical affective receiving area or "gain" of the aerial from first principles with some help from W.N. (Chris) Christiansen (see ***Appendix I*** in Wild and McCready, 1950a).

During observations the aerial's principal axis was pointed towards the Sun in order to receive maximum signal. This was achieved by moving the aerial by hand every twenty minutes using a rope and pulley system. The large rhombic aerial can be seen in Figure 1, along with its supporting ropes.

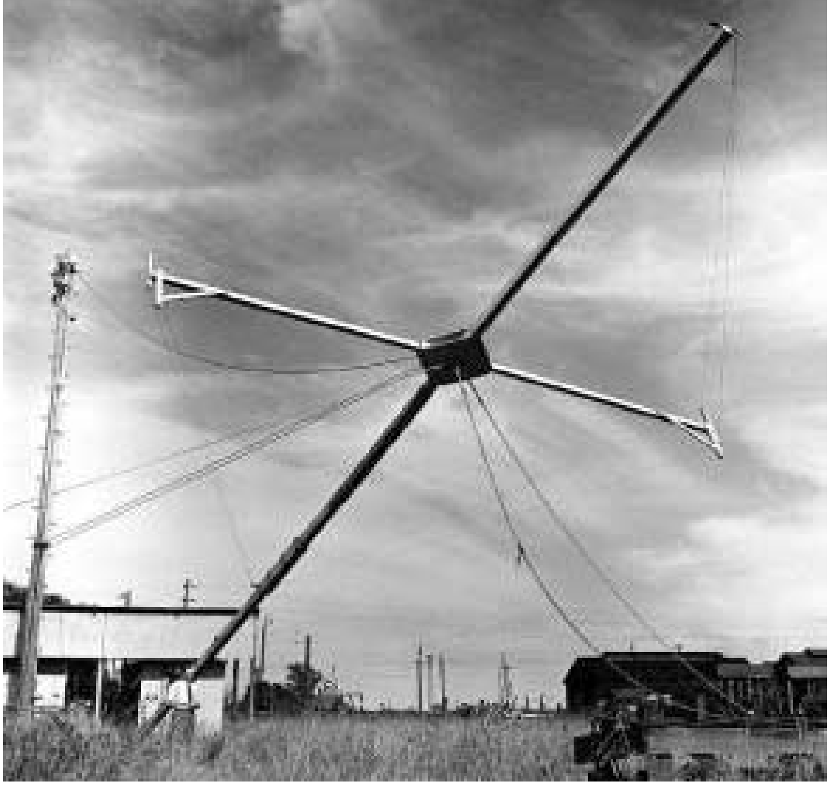


Figure 1: Photograph of the aerial and pulley system with Bill Rowe standing nearby. In the background on the RHS can be seen the railway locomotive shunting sheds (Courtesy of the ATNF Historical Photographic Archive).

The aerial was rotated about a polar axis embedded in a concrete footing. The principal axis was tilted in declination every few days to keep the Sun in the main lobe of the aerial. At night the aerial was lowered onto the supporting trestle shown in the bottom right-hand corner of Figure 1 (Murray, 2007).

According to Wild and McCready (1950a):

"The receiver was of conventional superheterodyne design with a single stage of radio-frequency amplification. The local oscillator and the input circuits of the radio-frequency amplifier and the mixer were tuned by slit-stator (sic) condensers on a single shaft which was rotated by a motor at about three revolutions per second … By using split-stator condensers, the need for making electrical contacts with rotating shafts was avoided."

Spectral Classification of Solar Bursts

Wild converted the photographic records by hand into time-frequency diagrams, as shown by the examples

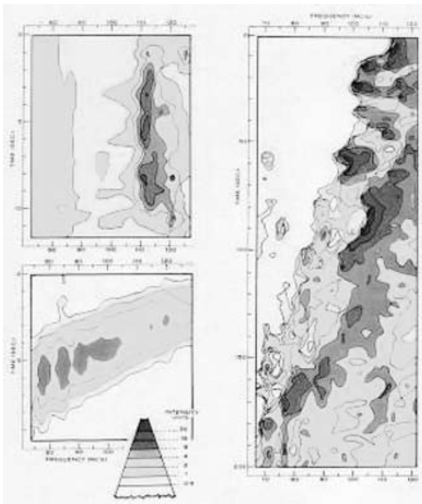


Figure 2: Dynamic spectra of *Type I* (top left), *Type III* (bottom left) and *Type II* (right) bursts (after Wild and McCready, 1950: Plate 2)

in Figure 2. Intensity contours were plotted on a logarithmic scale. In a subsequent paper Wild (1950a) referred to these diagrams as ***dynamic spectra*** because they showed variations in intensity with time.

The most outstanding result from this ground-breaking investigation was the ability to recognize three quite different types of solar bursts. According to Wild and McCready

(1950) the dynamic spectra of the observed bursts were often complicated by widely-different features, but analysis showed that many conformed to one of three specific spectral types which they named ***Types I, II*** and ***III***. Typical examples of the three types are reproduced here in Figure 2.

Detailed Analysis

Type I Bursts

The Penrith dynamic spectra of Type I bursts (Figure 2) showed their intrinsic narrow bandwidth which explained why these bursts were not correlated on spaced frequency records such as those obtained by Payne-Scott (1949). Wild (1951) then investigated the possibility that the enhancements accompanying Type I bursts was merely a composite of many unresolved bursts. He concluded that more observations of noise storms were needed to resolve this question.

Type II Bursts

Wild (1950a) analysed the frequency drift of four of the five Type II bursts recorded at Penrith. Martyn (1947) had suggested that solar bursts were due to plasma oscillations and this suggestion had been adopted by Payne-Scott et al. (1947) in their analysis of the outburst of 8 March 1947. Wild used this ***plasma hypothesis*** to interpret the frequency drift rate of the Type II bursts. He identified the low frequency edge of the outburst with the local plasma frequency, f_0, where the refractive index for electromagnetic waves reduces to zero. In the absence of a magnetic field, f_0 is given by $f_0^2 = e^2 N / \pi m$ where N is the electron density of the medium (cm^{-3}), e is the electronic charge (e.s.u.), and m is the electronic mass (gm).

Values of N, obtained from an optically-derived electron density model for a spherically-symmetrical corona by Baumbach and modified by Allen (1947b), were used to produce height versus time plots.

Wild (1950a) concluded that Type II bursts were associated with the fast particles, known to be emitted from the Sun at the time of flares, travelling with speeds of the order of 500 km/sec, causing geomagnetic storms with sudden commencements about a day later.

Type III Bursts

Wild (1950b) considered three possible mechanisms for the rapid frequency drift of maximum intensity towards lower frequencies which is characteristic of Type III bursts such as shown in Figure 2:

1. Selective group retardation of the radiation from a localized, instantaneous disturbance in the corona. Jaeger and Westfold (1949) had found that such a disturbance may be capable of producing a radio burst of short duration at the Earth, where the higher frequencies would arrive before the lower ones, due to group retardation effects near the plasma level.
2. The outward motion, through the corona, of a localised source that excites plasma oscillations of continuously decreasing frequency (similar to the mechanism discussed above for Type II outbursts).
3. Some mechanism in which the wave frequency is controlled by an external magnetic field.

Wild dismissed mechanism (3) as a possibility because of the absence of observed circular polarization in Type III bursts. To decide between (1) and (2) he analysed the decay rate and frequency drift of the simple Type III bursts observed.

As noted by Wild, the time profiles of simple isolated bursts showed a gradual rise to a maximum value followed by slower decay which appeared to be approximately exponential in form (as found earlier by Payne-Scott 1949). Wild showed that the mean value of the normalized decay constant for 12 Type III bursts tended to decrease with decreasing frequency.

This result could not be easily explained by mechanism (1) above but it could be explained by mechanism (2) if it was accepted that the decay constant was related to the electron-atom collision frequency (Westfold, 1949) which would decrease as the disturbance moved outwards through the corona (Smerd,1950).

From the above analysis Wild (1950b) concluded that:
"With the assumed electron density distribution, velocities of between about 2×10^4 and 10^5 km./sec would be required to account for the observed drift rates … Corpuscular streams with these velocities have not been observed in the solar atmosphere, but in any case such streams would likely to be highly ionised and may consequently escape optical detection."

Prologue

Following its success at Penrith, a new radiospectrograph, extended to cover the 40–240 MHz frequency range, was installed at Dapto in 1952, (Wild, Murray and Rowe, 1954). Fundamental and second harmonic structure was observed in both Type II and Type III bursts, lending support to the ***plasma hypothesis*** and Wild's interpretation of the frequency drifts. Later confirmation came from direct measurement of transverse velocities using the Dapto 40-70 MHz swept-frequency interferometer (Wild and Sheridan, 1958).

Thus the dynamic spectra, when converted to height-versus-time plots gave an instant snapshot of coronal activity when other means of observing the corona were not available. Later observations from spacecraft identified the Type III electron streams and the Type II shock waves as they travelled out into interplanetary space. Today, radiospectrographs are still used as part of the global watch on space weather, because of the disruptive effects massive solar ejections can have on communication and GPS satellites.

The Dapto Field Station was closed on 1 March 1964 to make way for the construction of the radioheliograph at Culgoora, the present site of the Australia Telescope, at what is now known as the Paul Wild Observatory.

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Australian Square Kilometre Array Pathfinder (ASKAP)

Gabby Russell (CASS)

ASKAP Antenna Receives First Signal

The first of 36 antennas that will make up the Australian Square Kilometre Array Pathfinder (ASKAP) radio telescope has received its first radio signals.

The antenna was assembled over the Australian summer at the Murchison Radio-astronomy Observatory (MRO) in the Mid West region of Western Australia.

The first radio signals were received from a satellite as part of a project to measure the shape of the antenna's surface using holography. This involves combining a satellite test signal reflected from the antenna's surface with the same signal received by a small reference dish, producing an image that shows if the antenna's surface deviates from the "perfect" shape. The test results show that the antenna is working beyond specifications.

The first ASKAP antenna, now erected at the MRO in Western Australia. Photo Credit: Dave DeBoer, CSIRO.

The antenna has been designed and built by the 54th Research Institute of China Electronics Technology Group Corporation (known as CETC54). Local contractors also assisted the team. Additional CSIRO-made components, including feeds, receivers and data processing systems, will also be installed on the antenna's structure.

Construction of ASKAP's next five antennas will proceed quickly. The first six antennas are due to be operational by 2011 and the complete ASKAP system is expected to be completed by 2013. Once built, ASKAP will be operated by CSIRO as part of the Australia Telescope National Facility.

For the latest news on the development and construction of ASKAP visit *www.atnf.csiro.au/projects/askap*.

Indigenous Land Use Agreement Complete

Before construction of ASKAP began at the MRO an Indigenous Land Use Agreement (ILUA) was signed with traditional owners, the Wajarri Yamatji People.

The ILUA between the Yamatji Marlpa Aboriginal Corporation, the Wajarri Yamatji People, the Government of Western Australia, Commonwealth Government and CSIRO was officially registered by the National Native Title Tribunal on 13 November 2009.

Registration of the ILUA means that CSIRO's lease over the Murchison MRO has formally taken effect. It also provides a range of practical and financial benefits to the Wajarri Yamatji People, including education and training opportunities.

The ILUA was one of the fastest ever negotiated, due to the support of the Wajarri Yamatji People and all levels of government. It demonstrates the ongoing and successful development of ASKAP, as well as providing additional support for the Australia – New Zealand bid to host the SKA.

Representatives of the Wajarri Yamatji People, Yamatji Marlpa Aboriginal Corporation and CSIRO at a special event at Parliament House in Perth on 26 November 2009 to celebrate registration of the ILUA. (Front row, from left) Elizabeth Papertalk, Ike Simpson, Ross Boddington, Ron Simpson, Malcolm Ryan. (Second row, from left) Phillip Vincent (Barrister for Yamatji Marlpa Aboriginal Corporation), Pam Mongoo, Robin Boddington, Matthew Punch (Yamatji Marlpa Aboriginal Corporation), Janie Ronan. (Third row, from left) David DeBoer (CSIRO), Gloria Merry, Anthony Dann, Gavin Egan, Gordon Fraser. Photo Credit: WA Department of Commerce.

MRO–Geraldton Fibre Tender Published

Australia's Academic and Research Network (AARNet), CSIRO's nominated telecommunications carrier for 380 km of fibre optic cable that will connect the MRO and Geraldton, published a tender request for installation of the cable in February 2010. The fibre optic cable will form essential data transmission infrastructure connecting ASKAP to CSIRO and its research partners in Australia and around the world.

The tender period closed on 15 March and it is expected that installation of the fibre will be completed by the end of 2010.

CSIRO, Sapphicon to Develop Receiver on a Chip

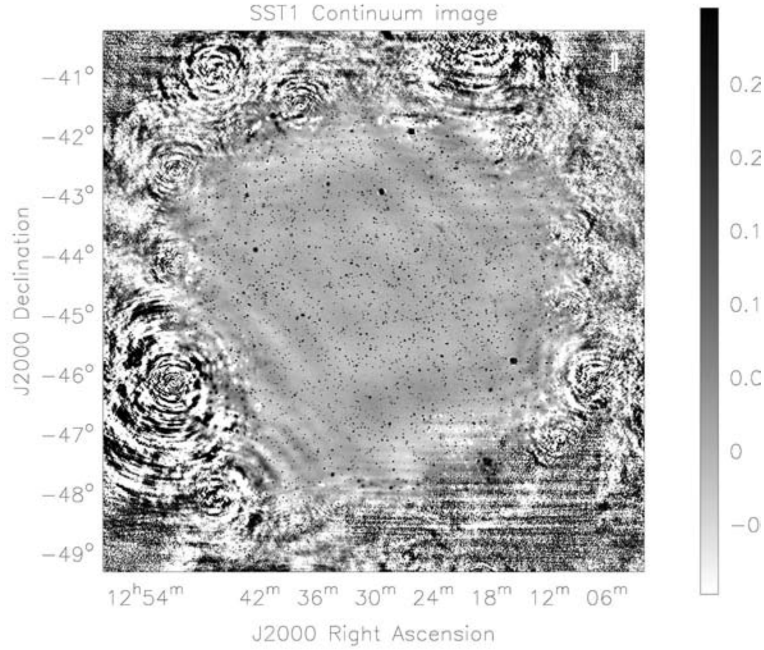
CSIRO and Australian company Sapphicon Semiconductor Pty Ltd have signed an agreement to jointly develop a complete radio receiver on a chip measuring just 5 mm x 5 mm that could eventually be used in mobile phones and other communications technologies.

Able to sample about 600 MHz around a central frequency of around 1400 MHz, the chip's first test will be in ASKAP's innovative phased array feed (PAF) that sits at the focal centre of each dish to receive incoming cosmic radio waves. The chip will minimise the size and weight of the PAF, reduce cost and power, and facilitate maintenance. It will be developed using Sapphicon Semiconductor's Silicon-on-Sapphire CMOS process.

The "system on a chip" device is also a potential technology for the SKA. No other group is developing a fully integrated single-chip receiver.

The project will take about two years to complete and will involve a number of stages of sub-component development and testing.

Following its collaboration with Sapphicon and CSIRO on earlier proof-of-concept projects, the Centre for Technology Infusion at La Trobe University in Melbourne will work with Sapphicon and CSIRO in the development of the novel chip.



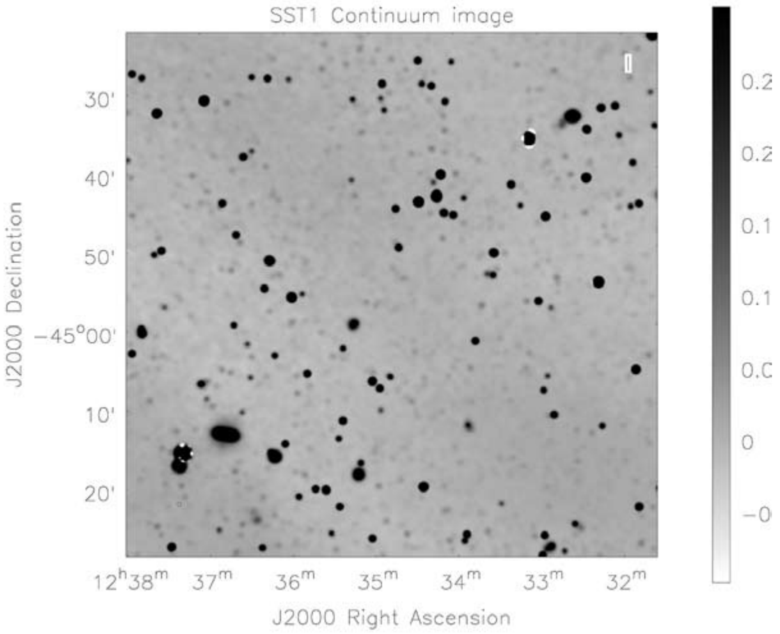
Technology Update

As the development of ASKAP progresses, the project has met several key technological milestones:

- The mechanical design of the ASKAP prime focus receiver package is almost complete and many parts have been fabricated.
- The initial design for ASKAP's digital system has been put into production for the first antenna and is nearing completion.
- Further software versions for monitoring and controlling the Parkes Testbed Facility's 12-metre antenna have been released.
- Design of the unit for controlling the antennas' local oscillator, timing signals and internal communications has continued to be refined and scripts have been developed for ethernet communications to the unit via the built-in digital systems control card.
- Testing of ASKAP's prototype phased array feed took place at the Parkes Testbed Facility in early December 2009 and measurements are ongoing at CSIRO's Marsfield site prior to the next phase of testing at Parkes.
- Development of the ASKAP testbed system at CSIRO's Marsfield site, which includes electronics and receiver systems for a complete ASKAP antenna integrated with a full-scale wooden model of an antenna pedestal, has progressed.
- Trialling of a prototype geothermal cooling system at Marsfield has commenced. This will be used to assess whether this technology offers an efficient and cost-effective option for cooling ASKAP's electronics and reducing the telescope's overall demand on power.
- Work continued with consultants Aurecon on the design of MRO support infrastructure including roads, power distribution, the control building and its cooling system.

Survey Science Projects Start Design Studies Phase

The ten major science project teams that will use ASKAP in its first five years of operation (see ATNF News October 2009) have started their Design Studies phase. This stage has involved



Two images showing a simulation of a typical ASKAP observation of the broadband emission from the sky, with the centre at 1.37 GHz (the image on the right is a "zoomed in" version of the image on the left). The dark line shows the edge of the ASKAP phased array feed sensitivity. This simulation includes a number of effects including thermal noise from the receivers and wide field-of-view imaging corrections. Image Credit: Tim Cornwell, CSIRO.

testing the projects' source-finding algorithms on simulated images created by the ASKAP Computing team, and (for those teams that will supply external hardware to enhance ASKAP's capabilities) assessing their power and space needs at the central ASKAP site.

The image simulations use a realistic sky model for both spectral-line and continuum observations, which are then passed through the ASKAP imaging software to produce output images. This initial simulation work has been made possible by the loan of a pre-production computer by Intel Australia.

Industry Engagement News

In late October 2009 CSIRO hosted the third in its special technical ASKAP and SKA industry discussion series on the development of sensitive, ultra-wideband phased array receivers for radio astronomy. Fifteen industry representatives from ten companies participated in the session, which included discussion on the challenges faced in the development of receivers for ASKAP and the SKA, building the world's first "chequerboard" phased array feed receivers, and the next-generation receiver—an L-band "system on a chip".

SKA-related News

CSIRO staff participated in international meetings held in November 2009 and March 2010 in Manchester, UK, which aimed to progress the world-wide development of the SKA. ASKAP team members also participated in SKA science and industry meetings held in New Zealand in February 2010.

Cisco generously seconded a full-time network systems engineer into the ASKAP team to work with the SKA Program Development Office (SPDO) on issues related to monitor and control, and networking, while CSIRO provides logistical support to the role. CSIRO has also signed a statement of intent to work with IBM on a prototype single digital backend for the SKA.

Over recent months Australian engineers, along with colleagues from SPDO and South Africa, have been working to define radio-quietness specifications to inform the potential placement of SKA array stations outside the SKA core site. The goal is to produce "mask maps" of each candidate site that indicate where array stations could be placed.

Technologies for Radio Astronomy

Graeme Carrad (CASS)

Photo of the retrofitted L/S receiver with new amplifier in place.Credit: Eliane Hakvoort, CSIRO

Following the installation of CABB instrumentation there is a now focus on supplying a 1-MHz zoom mode. The task of routing signals through the complex signal processing boards and sharing the data between the 16 boards is significant and the generation of the algorithms that allow the functionality envisaged is a major challenge. It is anticipated that an "engineering" mode will be available in April with a mode able to be incorporated into normal observing following soon after. The CABB web page will detail the latest progress.

The successful demonstration of new capability for the original ATCA L/S band receivers is pleasing and an exciting development in the effort to maintain the Compact Array's systems at a level that allows world class science to be conducted.

Amplifiers that cover the 1-3 GHz band have been developed by Alex Dunning and a Compact Array L/S receiver retrofitted with one in each polarisation. A perceived risk at the beginning of the centimetre upgrade project was that the targeted increase in bandwidth (the original amplifiers cover 1.2-1.8 GHz and 2-2.3 GHz) would come at the cost of increased amplifier noise temperature. The wideband amplifiers allow for the removal of the passive diplexer, used to separate the L and S signals, so it was anticipated the noise temperature performance might remain at a level comparable with existing systems. The superior performance of the new amplifiers is such that the system temperature has been measured to be approximately 25% better than the original systems. Production of components is currently underway to supply the staged replacement of the existing systems with the next retrofit of a receiver scheduled for June. The equally important OMT fin replacement to provide improved antenna beam performance continues in parallel with this effort.

As 2009 drew to a close, the pleasing news that funding had been secured for the C/X component of the ATCA centimetre receiver upgrade was a welcome Christmas present. Considerable astronomy community consultation giving consideration to a number of projects was conducted in a short space of time with the C/X upgrade receiving the support required to be nominated as a project worthy of monies being offered by Astronomy Australia Limited (AAL) following a grant to that organisation from the Education Infrastructure Fund (EIF), an initiative of the Federal Government. The funding will become available in financial year 2011/2012.

The obvious linkages between the activities undertaken in the Technologies theme and the tasks being undertaken in the three Development projects to support the automation and remote operation of Parkes has led to those projects being brought under the umbrella of the Technologies theme from the Operation theme. Progress on the Parkes Drive Control is encouraging with the modular drive control systems that will replace the existing systems substantially complete. "Dummy" drives are near to completion and will allow testing of systems prior to their deployment on the Parkes telescope. A new Master Control Panel is taking shape and may see service before years end. A multi-week shutdown will be required for this work so careful consideration of the scheduled installation date will be required when there is more certainty of the new system's completion date.

The Parkes Electronic Control and Monitor Project is a conglomeration of many tasks and a number of these are being undertaken in parallel. An RF switching matrix, essentially a number of rack mountable, programmable switching modules, has been ordered and will replace the multitude of cables that adorn the front of the racks in the upper control room at Parkes. After so many years of fiddling with cables it may be prudent to have a "dummy" rack with cabling to allow the older generation of engineers and astronomers to continue their unplugging and plugging pretending they are reconfiguring the signal path. Cameras have been fitted to areas around the aerial cabin and will be used sparingly to avoid corrupting data with their self generated RFI.

Receiver rationalisation is a multi-stage project and the H-OH receiver phase has commenced with a contract awarded to BAE systems to design a new feed for the existing receiver.

The delivery by the technology company ASTROWAVE of water vapour radiometers to the Compact Array has been welcomed however a readjustment of each instrument's gain is needed to fine tune their performance. ASTROWAVE is currently undertaking this work and the Front End Group in Marsfield is busy completing feeds and input waveguide as well as metalwork that will allow a calibration 'paddle' to be installed on the units.

CSIRO Parkes Observatory wins Australia Day Award

Chris Hollingdrake (CASS)

The strong relationship between CSIRO and the Parkes community was further demonstrated as the Parkes Observatory was presented with an Australia Day Award for the "Parkes Shire Community Event of the Year". At a special event hosted by the Parkes Shire, the Observatory was awarded the honor for the success of its 2009 "Open Weekend".

CSIRO's Chris Hollingdrake accepts the award on behalf of the Observatory. Credit: John Sarkissian, CSIRO

Attracting over 6,500 visitors, the Parkes Open Weekend showcased the achievements of the Parkes Radio Telescope as a world-leading astronomical telescope, as well as its roles in supporting some of the most significant space missions in history. A particular focus of the event was the celebration of the International Year of Astronomy (IYA) and the 40th anniversary of the NASA Apollo 11 moon landing.

The Open Weekend, as well as allowing members of the public a rare opportunity to tour the Parkes telescope, is said to have generated approximately one million dollars in additional business to the local region, through increased accommodation, food and fuel sales.

Chris Hollingdrake accepted the award on behalf of CSIRO and the Observatory and thanked the Shire and the local community for the event recognition and their ongoing support.

The Mayor of Parkes, Councillor Ken Keith had previously presented an award to Acting ATNF Director Dr Lewis Ball during the Open Weekend, expressing the Council's appreciation of the work conducted at the Observatory and CSIRO's efforts in attracting visitors to the region to view the iconic "Dish".

Patronage of the Parkes Observatory Visitors Discovery Centre was significantly improved during 2009 with 113,000 visitors walking through the centre's doors, up from 92,000 in 2008. Increased media interest surrounding IYA and the moon landing anniversary, together with lower fuel prices are thought to have contributed to the increased visitor count.

The Parkes Observatory Visitors Discovery Centre is estimated to have welcomed 2,416,000 visitors through its doors since its opening in February 1969.

Education and Outreach

Rob Hollow (CASS)

Teacher Workshops and School Events

CSIRO Astronomy and Space Science (CASS) Education Officer, Rob Hollow visited Yulga Jinna, Meekatharra and Cue in Western Australia to conduct community viewing nights on a tour with astronomers from Curtin University in November. He then assisted in the first weekend camp for the *Follow the Dream* program for gifted and talented Indigenous students from the Mid West region. Held at Murchison Roadhouse, students took part in a range of activities including two stunning viewing nights under wonderfully dark skies.

The annual *Astrophysics for Physics Teachers* workshop, held at Marsfield in March attracted nearly 20 teachers. Speakers included CASS staff members Dr Jimi Green and Rob Hollow plus Prof Fred Watson from the Anglo-Australian Observatory (AAO), Dr Stuart Ryder from the Australian Gemini Office and Geoff Wyatt from Sydney Observatory. Participants learned about stellar evolution, observational techniques, cosmology and how to effectively convey many of these concepts in the classroom. They also had the chance to try several visualisation and online astronomical tools. Rob Hollow also presented a session at the *STAV/AIP Physics Teachers Conference* in Melbourne in February.

PULSE@Parkes

PULSE@Parkes went international in late 2009. Project Coordinator Rob Hollow presented an invited talk about the project at the DotAstronomy conference in Leiden in November. In keeping with the theme of the conference his talk was also transmitted live over the internet for viewers around the world to see and respond to. Following this conference Rob went to Cardiff University for a first international observing session. Students from three Welsh high schools took control of the Parkes radio telescope on a Monday evening, their time when it was dawn at Parkes. Dr David Champion, former ATNF staff member came across to Cardiff from Bonn to assist with the observations. The event generated a lot of local interest with coverage on BBC Radio Wales. The online module for distance determination went public in late March, allowing anyone to access all the observations and analyse the data.

2009/2010 ATNF Summer Vacation Program

We welcomed nine students from across Australia in December 2009 for the 2009/10 Summer Vacation Program. Eight of the students were based at CASS headquarters at Marsfield working on specific research projects in Astrophysics under the supervision of CASS staff. The ninth student was based at Parkes Observatory over the summer, developing and presenting public talks and writing a new booklet that will soon be available for the public to buy at the Visitors Centre.

The students had a series of sessions and workshops on different aspects of radio astronomy that culminated in a five-day observing trip to the Australia Telescope Compact Array at Narrabri mid-January. Each group had a twelve-hour slot on the telescope for an observing project of their choice. They were capably guided in their endeavours by Dr Ángel Rafael López-Sánchez and other CASS staff.

The program culminated with the annual joint CASS/AAO/AusGO student symposium in February. This was well attended and gave students a chance to discuss their individual research projects to their peers and CASS and AAO staff. Two of the students then backed-up the next day to give their talks at the CSIRO *Big Day In* and Macquarie University.

ATNF Graduate Student Program

Baerbel Koribalski (CASS)

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

- Laura Bonavera (SISSA/ISAS, Italy): *Planck-ATCA Coeval Observations* with supervisors Prof Carlo Baccigalupi, Prof Gianfranco De Zotti, and Prof Ron Ekers (ATNF).
- Catarina Ubach (University of Swinburne): *Observations of grain growth in protoplanetary disks* with supervisors Dr Sarah Maddison (University of Swinburne), Dr Chris Wright (ADFA), and Dr Baerbel Koribalski (ATNF).
- Meng Yu (Peking University, China): *Timing for Radio Pulsars* with supervisors Prof Guojun Qiao, Prof Renxin Xu (both Peking University), Prof Dick Manchester and Dr George Hobbs (both ATNF).
- Tui Britton (Macquarie University): *Methanol masers in star forming regions* with supervisors Prof Mark Wardle, Assoc Prof Orsola de Marco (both Macquarie University), and Dr Maxim Voronkov (ATNF).

Congratulations to

- Rebecca McFadden on the successful submission of her University of Melbourne PhD thesis on *UHE neutrino detection using the Lunar Cerenkov technique*,
- Attila Popping on the successful submission of his University of Groningen PhD thesis on *Diffuse Neutral Hydrogen in the Local Universe*,
- Leith Godfrey on the successful submission of his Australian National University PhD thesis on *Dynamics of large-scale extragalactic jets: a multi-wavelength study of X-ray bright jets*, and
- Jamie McCallum on the successful submission of his University of Tasmania PhD thesis on *Scintillation in Circinus*.

Dr Attila Popping is now a postdoc at the University of Marseille, France.

Dr Rebecca McFadden continues as a postdoc at the University of Melbourne, and Dr Jamie McCallum at the University of Tasmania.

The following students recently submitted their PhD Thesis.

- Paul Hancock (University of Sydney): *The Australia Telescope 20 GHz Survey and the Search for Young Radio Galaxies*.
- Emma Kirby (ANU): Sharing the Baryons: *Stars and Gas in Local Volume Galaxies.*
- Alyson Ford (University of Swinburne): *The HI Cloud Population in the Lower Halo of the Milk Way.*
- Natasa Vranesevic (University of Sydney): *Galactic distribution and evolution of pulsars.*

Well done !

Distinguished Visitors

Robert Braun (CASS)

Over the past months we have enjoyed working visits from Paula Benaglia (Instuto Argentino de Radioastronomía , Argentina), Jean-Luc Starck (CEA Saclay, France) and Daniel Pfenniger (University of Geneva, Switzerland).

Upcoming visitors we expect include Jianping Yuan (Urumqi Observatory, China), Martin Cohen (University of California, Berkeley, USA) and Bill Coles (University of California, San Diego, 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 ATNF 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.

Discovery of Large-scale Gravitational Infall in a Massive Protostellar Cluster

Peter Barnes (University of Florida), Yoshi Yonekura (IBaraki University), Stuart Ryder, Andrew Hopkins (Anglo-Australian Observatory), Yosuke Miyamoto, Naoko Furukawa, and Yasuo Fukui (Nagoya University.)

From Anglo-Australian Telescope (AAT) and Mopra observations, we have identified a young massive star-forming cloud as undergoing a large-scale gravitational collapse, likely on the way to forming a massive young star cluster. Both the size scale and the mass infall rate may be new records among Galactic starforming regions. This object promises to be an important testbed for refining theories of massive cluster formation.

Massive Star Formation in the Milky Way

Compared to our understanding of how Sun-like ("low-mass") stars form out of cold, molecular gas, the formation of massive stars and star clusters, which may dominate and drive the Galactic ecology with their high luminosities, massive winds, and chemically enriched ejecta, is not nearly so well understood. This enigma has three causes: the relative rarity of massive star formation, the rapidity of massive star evolution, and the confusing phenomenology of the formation process itself.

Because of the first two reasons, the typical massive star formation site lies more than 10 times further away than many low-mass protostars, further limiting our ability to decipher the phenomena we see.

Thus, there is little clear consensus on even the basic formation mechanism, whether through gravitationally-powered accretion disks (e.g. McKee & Tan 2003), competitive accretion of ambient cluster gas (Schmeja & Klessen 2004), or more radical theories. A vast range of parameters, such as formation timescale or accretion rate, are debated: e.g., is the overall timescale for starcluster formation a few (Elmegreen 2007) or many (Tan, Krumholz & McKee 2006) free-fall times? The influence of feedback in setting both the stellar initial mass function (IMF), including its upper limit, and the efficiency of star formation in clusters, is uncertain, as is the universality or variability of the IMF (Hoversten & Glazebrook 2008).

CHaMP

To address these issues, we designed the *Census of High- and Medium-mass Protostars* as the largest, most uniform, and least biased survey of massive Galactic star-forming regions to date.

We reasoned that only with an unbiased survey could we hope to construct a comprehensive paradigm for massive star- and cluster-formation, including the identification of all significant stages in massive star formation, *and their lifetimes*. CHaMP was based on the Nanten molecular cloud surveys (Yonekura et al 2005) of a large portion of the southern Milky Way in Carina, Vela, & Centaurus, completely covering a 20°×6° window that samples approximately 5% of the total star formation of our Galaxy (Figure1). Using the Nanten maps as 3′-resolution finder charts, we identified 209 massive, dense molecular clumps that must include all likely sites of massive star formation in this window. We then used the ATNF's Mopra antenna to zoom in, at 36″ resolution, to the 118 brightest of these.

BYF 73 and Infall Modelling

Among these clumps, we noticed very unusual spectral line profiles of the HCO^+ molecule in one source, the 73rd on our list. They showed the classic (Zhou et al 1994) inverse P Cygni profile seen in lower-mass protostars undergoing gravitational collapse, but on a parsec-wide scale and over a much larger velocity range than usually seen (Figures 2, 3). When we modelled these line profiles with a radiative transfer code that allows for infall motions (De Vries & Myers 2005), we found most of the ~20,000 $M_\odot$ clump to have a high infall speed that implied a mass infall rate that was either a new record, or close to it: 3.4×10^{-2} $M_\odot$/yr. Moreover, gravitational infall in the gas seems to be the only option for BYF 73: it is far too massive to obtain sufficient support from any reasonable estimates of rotational, thermal, or magnetic field pressure.

IRIS2 Images

By itself, the molecular data and modelling would have been an interesting result. But the clincher came when we combined our Mopra

Figure 1: Integrated intensity image of C18O over a 20°x6° window towards the Carina arm, observed by the Nanten telescope. Note that the C18O emission only covers ~2% of the Galactic Plane, much less than ^{12}CO or ^{13}CO. With Nanten maps as "finder charts", CHaMP at Mopra has been able to efficiently map the dense gas tracers in >100 molecular clouds at high resolution and sensitivity.

Figure 2: Mopra HCO^+ J=1-0 integrated intensity from BYF 73 over an 11' field, on the Ta* scale as given by the colourbar. The integration is over the range -23.20 to -16.63 km/s or 58 channels, yielding an rms noise level 0.16 K km/s: hence the widespread low-level emission above ~0.5 K km/s is real. (Contours) Mopra $H^{13}CO^+$ J=1-0 integrated intensity in Ta*, levels are (grey) -0.5, -0.35, (black) 0.35, 0.5, 0.7, 0.9, and 1.1 K km/s. The integration is from -21.94 to -17.86 km/s, giving an rms noise level 0.12 K km/s. The smoothed Mopra HPBW for both datasets (40") is shown for reference in the lower-left corner.

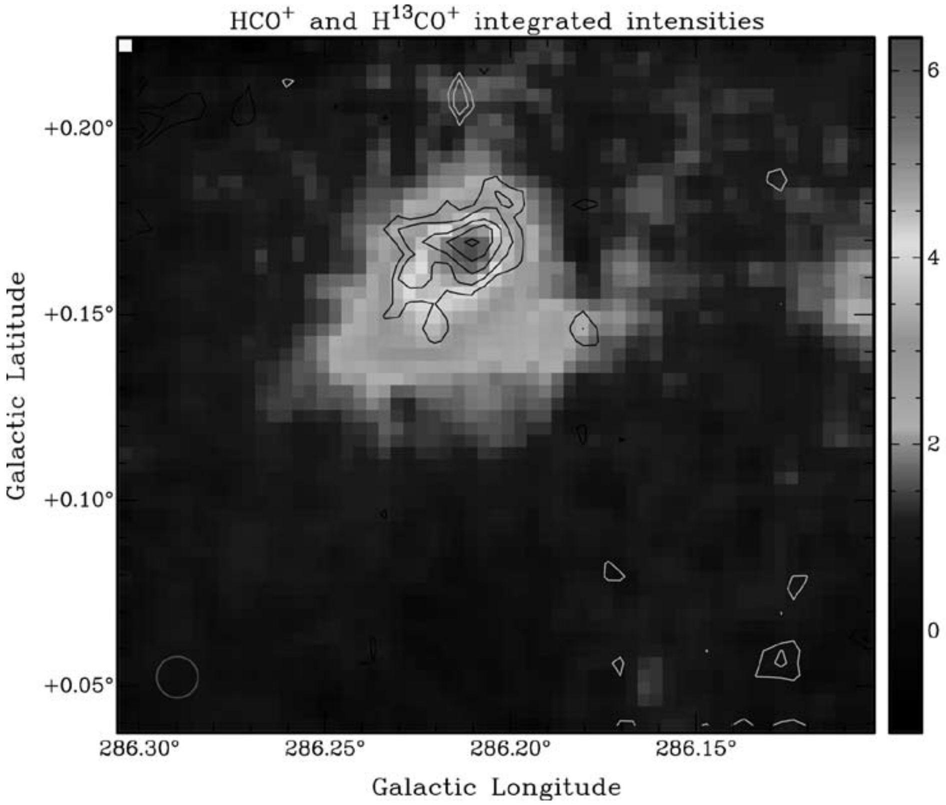
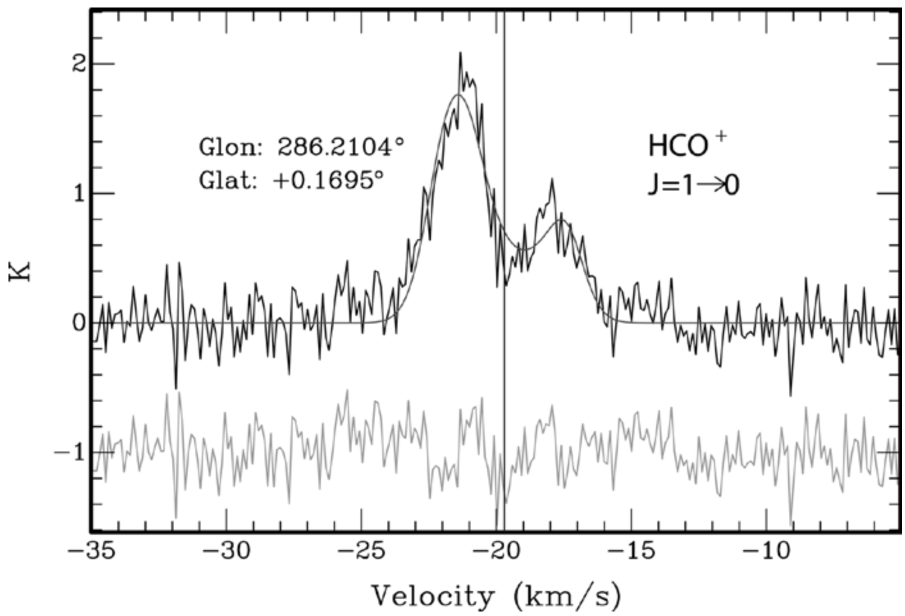


Figure 3: Sample Mopra HCO^+ J=1-0 spectrum of BYF 73 in black at the peak $H^{13}CO^+$ position. The radiative transfer model fit at this point (De Vries & Myers 2005) is shown in red, and the residual spectrum (data-model) is shown in green, offset 1 K below the HCO^+ spectrum. The vertical blue line indicates the systemic velocity at V(LSR) = -19.7 km/s, also from the model fits.



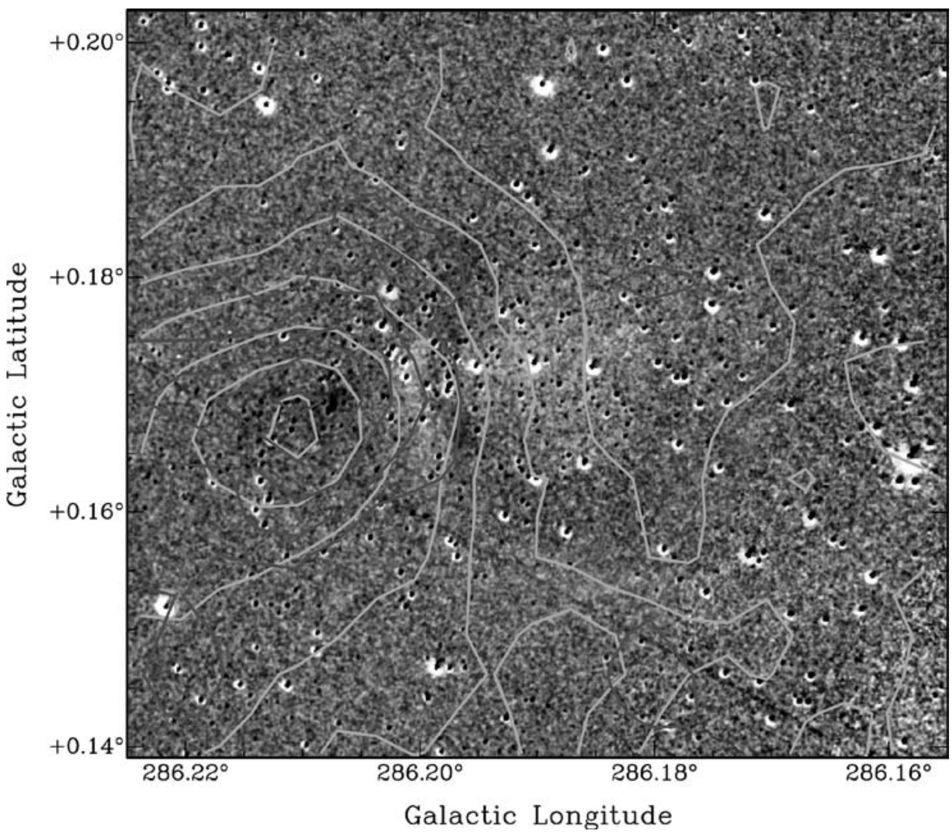


Figure 4: RGB-pseudocolour image of BYF 73 in K-band spectral lines. Here Br-gamma is shown as red, and H_2 S(1) is shown as green (v=1-0) & blue (v=2-1). Contours are overlaid from Mopra HCO^+ (gold) and $H^{13}CO^+$ (red) integrated intensities (levels as in Figure 2).

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

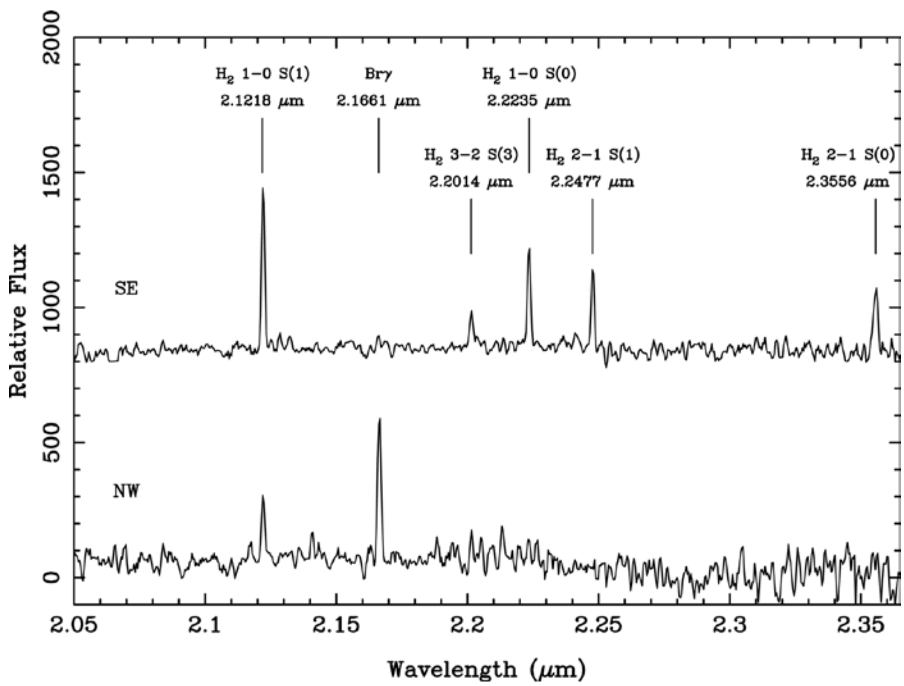


Figure 5: Sample spectra from an IRIS2 long-slit spectral image, on a relative flux scale to indicate line ratios. The upper spectrum (labelled "SE") is close to the bright H_2 interface between the HII region and the cold molecular cloud, while the lower spectrum (labelled "NW") is near the peak of the HII region.

data with narrowband 2μm imagery using the AAT's IRIS2 camera. Using only a few hours of Service Time to image BYF 73 and a few other interesting CHaMP sources, we obtained snapshots of Br-γ, H_2 S(1) v=1–0 & v=2–1, and an equivalent narrowband image of line-free continuum near 2.3μm. When we aligned, calibrated, and subtracted the continuum from the line images, we obtained the remarkable result in Figure 4, where we have overlaid the Mopra HCO^+ & $H^{13}CO^+$ contours with the 3-colour near-IR image.

This combined image shows, in a very clean way, the formation of an HII region at the edge of a molecular cloud, surrounded by a cocoon of presumably shocked H_2 ahead of the ionisation front, driven from the already-revealed massive young stars in the Br-γ nebula. An IRIS2 long-slit spectrum across these features (Figure 5) reveals several more H_2 lines, whose ratios indicate a temperature in the pre-ionised molecular gas that may exceed 4000 K. But most significant is the location of the centre of the molecular infall revealed in the Mopra maps: this is precisely where we have a very deeply embedded IR nebula, and stars with very unusual colours.

Status of the Cloud

Indeed, at mid- and far-IR wavelengths we can see that this infall centre is the most luminous source of the whole cloud, and is extremely red even at mid-IR wavelengths. We calculate that the release of gravitational energy alone accounts for at least 4% of the total luminosity. If the star formation in BYF 73 turns out be as efficient as in other massive, dense molecular clouds, then we might expect ~6,000 $M_\odot$ of gas to be turned into stars. Even at a fraction of this efficiency, what we seem to have in BYF 73 is the precursor to a massive, rich, young stellar cluster, before nearly all of the usual hallmarks of such a cluster have had time to develop. However, the speed of the infall, ~1 km/s, is ~20× less than in a purely dynamical collapse, and so the timescale for cluster formation (i.e., until the infalling gas supply runs out) is quite long, ~0.6 Myr, compared to what is predicted by some "prompt" models of massive cluster formation. These results on BYF 73 have just appeared in MNRAS (Barnes et al 2010).

Next Steps

During our IRIS2 Service Time, we also imaged a few other CHaMP clumps in the same way.

Preliminary comparisons of these images with our Mopra data contains more surprises. We see several instances of cocooning, and sometimes filamentary, H_2 emission surrounding other Br-γ nebulae, many of which are associated with bright HCO^+ emission. At the same time, we see stand-alone H_2 emission nebulae at positions away from HCO^+ emission peaks. This suggests some systematic evolutionary effects, although we will need to perform a complete near-IR survey of our CHaMP clumps to more precisely characterise these interrelationships. We are planning to use IRIS2 in the near future to do this, and anticipate that the AAT will make a major contribution to CHaMP's goal of better understanding many aspects of massive star formation.

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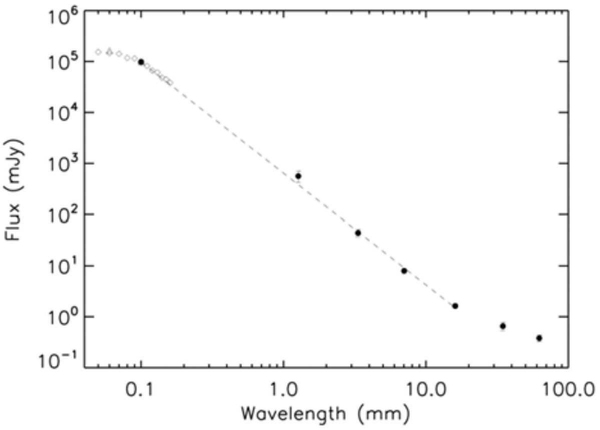
Resolving Structure in the HD100546 Disk—Signatures of Planet Building?

S T Maddison (Swinburne University), C M Wright (University of New South Wales and Australian Defence Force Academy), D Lommen (Leiden Observatory), M Burton (University of New South Wales), D Wilner (Harvard-Smithsonian Centre for Astrophysics), T Bourke (Harvard-Smithsonian Centre for Astrophysics)

In order to understand the first steps of the planet formation process, we need to determine the physical conditions of protoplanetary disks to see where, when and how grains begin to grow in size. Here we report on a multi-frequency observing program of the enigmatic Herbig Be star HD100546 with the Australia Telescope Compact Array (ATCA).

There are several lines of evidence which suggest that planet formation may well be underway within the circumstellar disk of HD100546, including a cleared inner cavity (Liu et al. 2003; Grady et al. 2005), spiral structure and dark lanes (Grady et al. 2001; Ardila et al. 2007), and similar dust mineralogy as seen in our own solar system (Malfait et al. 1998). At a distance of just 103 pc (van den Ancker et al. 1997) subarcsecond-resolution observations can probe the inner few 10 AU of the disk. To learn more about the processes occurring in this disk we conducted multi-frequency observations with ATCA, with the aim of obtaining millimetre fluxes from thermal emission to determine the spectral energy distribution (SED) index, which can be used to constrain grain sizes in resolved disks. To determine the emission mechanism at longer wavelengths we conducted centimetre monitoring, and the gas content of the disk was studied via molecular line observations.

At 3, 7 and 16 mm we have resolved the emission region, which appears to consist of a compact dust disk of size ~ 50-100 AU (FWHM). Integrating over the entire extent of the emission in the three millimetre bands, and accounting for the free-free contribution to the 16-mm emission, we found that the millimetre slope of the SED is $\alpha \sim 2.3$ (see Figure 1), suggesting a dust opacity index $\beta \sim 0.3$, where $\kappa \propto \nu^{\beta}$. From spatially resolved and temporally stable emission over several years (see Figure 2), we conclude that the flux at 3, 7 and 16 mm is dominated by thermal emission from dust grains up to several tens of centimetre in size.



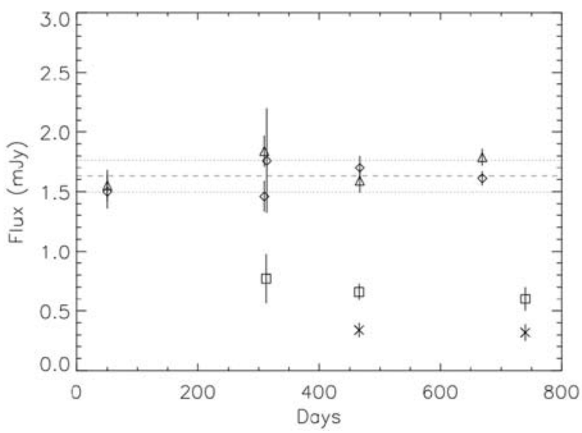


Figure 1: (Left) Spectral energy distribution of HD100546 from the FIR to centimetre regime. The IR data is from IRAS and ISO, the 1.3-mm from SEST (Henning et al. 1999), and all other data points from this work with ATCA. The dashed line is a composite fit to the SED assuming thermal dust emission with α_{mm}~2.2 dominates at 0.1 to 16 mm. There is a break in the centimetre slope, consistent with an increasing contribution from free-free emission.

Figure 2: (Right) Temporal monitoring of the flux of HD100546 at 16 mm (triangles: 18.496 GHz; diamonds: 18.625 GHz), 3 cm (squares), and 6 cm (asterisks). Error bars are indicated with each symbol. The dashed line at 1.62 mJy is the average of the 16 mm data

The mm flux suggests a dust disk mass of several 10 Earth masses.

At all millimetre wavelengths the peak emission is centred ≤ 0.5″ west of the optical stellar position. There is however structure in the emission, especially at 3 mm where we detect extensions to the north, east and west (which appear as discrete comps when cleaned with super-uniform weighting)—see Figure 3a. The extension to the west is coincident with features seen in HST ACS images (Ardila et al. 2007). Subarcsecond-resolution 3 mm images show a deficit of emission at the centre of the disk (Figure 3b), in agreement with the inner cavity seen in infrared observations. Such an emission deficit is also seen in our 7-mm when the resolution is 0.3" or less, which is consistent with the 10-15 AU radius gap inferred from HST data of Grady et al. (2005).

The longer wavelength 3.5 and 6.2 cm emission is relatively stable on the time scale of months and years (squares and asterisks in Figure 2 respectively), and the break in the slope of the SED is consistent with the centimetre emission arising from free-free processes. We find that the 3.5 cm emission is elongated orthogonal to the millimetre disk emission, suggestive of a wind, with the data indicating a wind mass loss rate of ~ 10^{-8} solar masses per year.

Observations at 89.19 GHz detected $HCO^+(1 \rightarrow 0)$, demonstrating the presence of dense molecular gas in the disk, which is supported by our $^{12}CO(4 \rightarrow 3)$ and $^{12}CO(7 \rightarrow 6)$ detections with NANTEN2. The

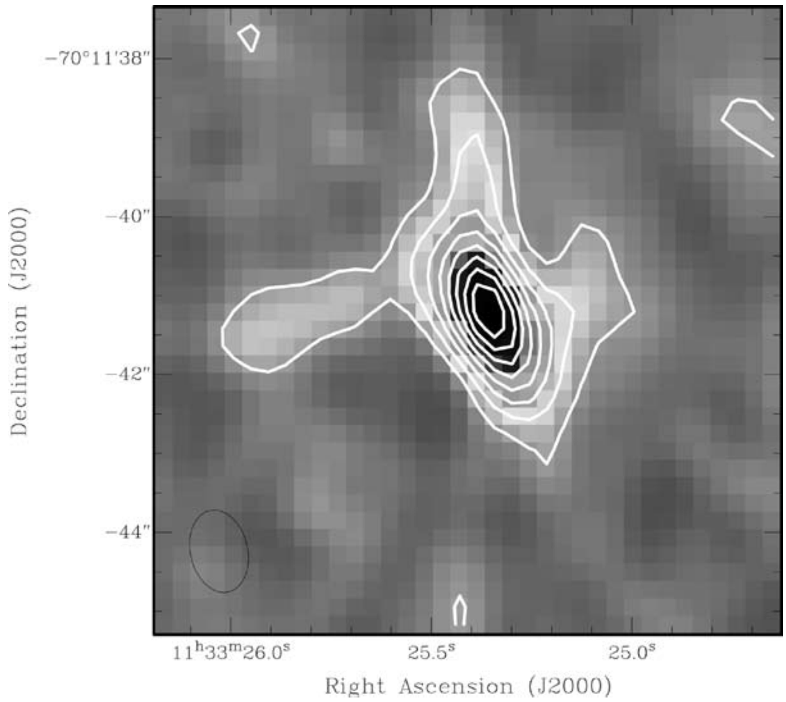


Figure 3a: HD100546 map at 94500 MHz with natural cleaning, observed with the 750A array in May 2008 with 500 minutes integration on source. The extension to the west is coincident with the HST/ACS "structure 2" of Ardila et al. (2007).

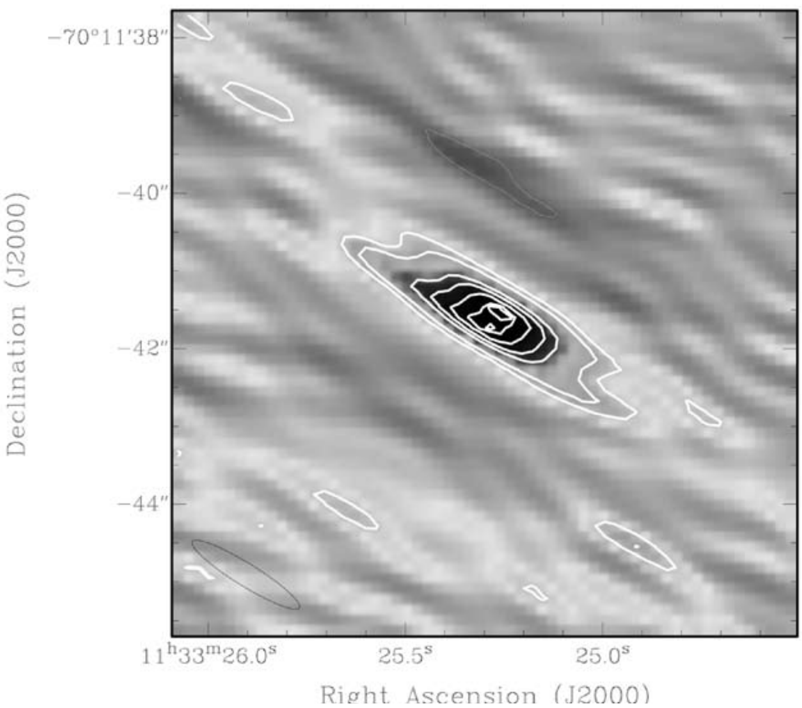


Figure 3b: HD100546 map at 94500 MHz with natural cleaning, observed with the 1.5B array in June 2008 with 125 minutes integration on source. The beam size is 1.6 x 0.3" (P.A. 58.2°), with a resolution of about 30 AU (FWHM) along the disk major axis.

HCO^+ line profile is double-peaked, with component velocities at 3.5 and 7.0 km/s, in agreement with APEX $^{12}CO(3\rightarrow2)$ data. Each component is coincident with the position of HD100546, but with a slight spatial offset approximately along the disk major axis. If interpreted as Keplerian rotation, the radius of the molecular gas emission is ~350 AU, with the south-east side approaching and the north-west side receding from Earth.

Our new results show that the pebble-sized grains in the disk of HD100546 are amongst the largest yet observed, and combined with the cleared inner dust cavity might suggest that planet formation is indeed well underway, or that grain sizes are so large that they are becoming invisible at millimetre wavelength. The detection of a large molecular gas disk and a wind, along with ultraviolet accretion signatures (Grady et al. 1997), would suggest that the system is still quite young. The evolutionary status of HD100546 remains an open question.

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Time Assignment Information

Phil Edwards and Jessica Chapman (CASS)

The Time Assignment Committee (TAC) met in early February to review the proposals for the 2010 April Semester (2010APRS). For this semester 220 proposals were received in total. The oversubscription rate was especially high for the Compact Array (a factor of 3.2), reflecting the strong interest in using the new Compact Array Broadband Backend (CABB) and the higher demand for the winter semester when observing at millimetre wavelengths is available.

The TAC has eight voting members who attend the meeting. They are supported by 16 external Readers who send input prior to the meetings. The input received for each proposal is reviewed at the TAC meeting and a final comment and grade is then returned to the proposers. Most of the TAC processes are now handled through *Online Proposal Applications & Links* (*OPAL*) and TAC meetings have become remarkably paper free!

Proposers are reminded that any member of a proposal team can update, or withdraw a proposal that has been submitted to *OPAL*. This caused a couple of problems recently when incorrect files and/or project numbers were used to update proposal submissions. We can add some checks in *OPAL* to try to prevent this happening in future but ask all teams to be careful to upload the correct files when updating a proposal that has already been submitted!

The TAC has reviewed the proposal requirements for Large Projects that require more than 400 hours over the lifetime of the project. Some changes to the requirements will be introduced from the next semester (2010OCTS). In particular we advise that Large Project proposals will be allowed up to five pages for the science case in ***each*** semester. In addition, we require that the science teams for ***all*** Large Projects provide a web link to information about the project. For further information and links to current Large Projects please see

www.atnf.csiro.au/observers/apply/large_projects.html.

CABB Progress and Schedules for the 2010APRS Semester

Schedules for 2010APRS have been released for Parkes and Mopra.

The first year of ATCA observing with CABB has seen a lot of exciting science enabled by the new system, as well as gradual improvements in the reliability and user-friendliness of the system. As noted in the preface to the ATCA User Guide, available at *www.narrabri.atnf.csiro.au/observing/users_guide/html/atug.html*, a wiki and a discussion forum have been set up to enable users to share their experiences and discuss matters relating to CABB observing and data reduction. Contributions to these are welcome.

Good progress is being made toward the introduction of the first CABB "zoom" mode and testing of this is in progress. However, there are still technical issues to be resolved and time required to complete the installation is somewhat uncertain. For this reason the 2010APRS schedule will be released in stages, to make most effective use of the CABB modes as they become available.

For information about CABB and a description of the zoom modes, please see *www.narrabri.atnf.csiro.au/observing/CABB.html*. The first six-week portion of the ATCA schedule, comprising projects that do not require CABB zoom modes, was released in early March. We are committed to scheduling the rest of the semester at least one month in advance of observations as per normal practice.

After the *CFB 1M–0.5k* zoom mode has been implemented, it is expected that either *CFB 64M–32k* or *CFB 16M–8k* will follow. The decision on which of these modes will be implemented first will be based on the experience gained from the implementation of the *CFB 1M–0.5k* mode as well as the scientific requirements. In either case, the fine resolution will be available initially with up to four "zoom" bands in each IF band.

The ATCA 20/13 cm Upgrade

In November 2009, a prototype for the new 20/13 cm ("L/S") receiver was installed on CA03. This provides an instantaneous frequency coverage of 1.1 to 3.0 GHz, and an improved sensitivity over the existing, separate, 20- and 13-cm receivers.

During 2010APRS it is expected that additional 20/13 cm receivers will be removed from antennas and modified with installation of the new receivers. This may result in periods when the array has only five antennas available for observations in the band. It is anticipated that the first production 20/13 cm receiver will be installed in June. Thus from mid-June until early next year, it is likely that only five antennas will be available at 20/13 cm. This process will also see the remainder of the 20/13 cm receivers outfitted with improved ortho-mode transducers, improving the polarisation purity, particularly in the 13-cm band.

Parkes Backends

With the older digital filterbanks (DFBs) DFB1 and DFB2 effectively decommissioned, DFB3 and DFB4 have become the digital workhorses. DFB4 contains one CABB processor and one digitiser rather than the dual digitisers and processors in DFB3. DFB4 has similar characteristics and performance to DFB3 for normal pulsar timing, except for short period pulsars, where DFB3 has an advantage owing to the extra processing power. DFB3 can be used in time-binning mode for time resolutions down to 0.25 seconds with up to 8192 (single IF) or 4096 (dual IF) channels. Both spectral line and continuum observers are encouraged to use the digital filter banks for their observations: DFB3 and DFB4 can be used as spectrometers in both simple and time-binning modes. DFB3 for example can be used as a two-frequency, dual-polarisation spectrometer with 8192 spectral channels over two 256-MHz bandwidth bands.

As noted in the call for proposals, the pulsar baseband recorder CPSR2 (Caltech-Parkes-Swinburne Recorder Mark 2) is planned to be phased out in 2010, once the APSR (ATNF Parkes Swinburne Recorder) baseband system has been commissioned and has been run in parallel with CPSR2 for a suitable overlap period. APSR uses DFB3 as a front-end to sample a single pair of inputs (two polarisations, single frequency) of up to 1 GHz bandwidth and record the baseband data at an aggregate rate of up to 8 Gbit/s. It has been found that APSR data contains a subtle artefact, visible most clearly in observations of the 1.6 ms pulsar, which is currently being addressed. It is currently expected that, pending timely resolution of this issue, CPSR2 will be decommissioned around the end of June.

The new 13-beam digital filterbank, the Berkeley-Parkes-Swinburne Recorder (BPSR) will be available during 2010APRS on a shared-risk basis. The system allows higher time resolution, and much greater spectral resolution than the analogue 13-beam filterbanks (400 kHz versus 3 MHz) and also provides more bits of precision in sampling. Efforts are underway to increase the flexibility of BPSR and broaden the support for this instrument so it can be offered as a fully supported National Facility instrument.

National Facility Operations Report

Douglas Bock (CASS)

This is my first report as head of National Facility Operations. My first few months have been a whirlwind of activity as I've met CASS staff and learned (or re-learned) about the ATNF telescopes and other CASS activities. I look forward to meeting or seeing again many of you in the coming months, and to hearing your ideas and suggestions for future ATNF operations.

Over the last six months, operations staff have begun detailed planning for ATNF operations in the ASKAP era, and this will be a key activity for me as well. As part of the planning, Jessica Chapman (Operations Research Program Leader), Erik Lensson (Head of Engineering Operations) and I visited the ASKAP site (the Murchison Radio-astronomy Observatory), Boolardy Homestead and the future MRO support facility site Geraldton. Erik and Jessica also spent a day in Perth, where the ASKAP image pipeline and archive will be located. It was striking to experience the remoteness first hand. Our trip helped has us place the planning for remote operations in context.

One aspect of preparing for the ASKAP era is the continuation of our planning for a Science Operations Centre in Sydney. This centre will support users of all ATNF telescopes. Parkes in particular requires some substantial upgrades to support routine remote observing, and the status of these is reported on in the Technologies section of the *ATNF News*. In the coming months we will be implementing a high quality video and voice link between Marsfield and the Mopra control desk at Narrabri to support remote observing of a large survey project this semester.

A number of development projects are underway to enhance observing capabilities: the main ones are the Compact Array Broadband Backend (CABB) and the ATCA 20/13-cm receiver upgrade. The 6/3-cm receiver upgrade has also just been funded and will begin in the new financial year. A new H-OH receiver for Parkes is being designed as part of the Parkes receiver rationalisation project. The status of these projects is also described elsewhere in the *ATNF News*. However, as we go to press, test observations with the first 1-MHz zoom modes (4 zoom bands, each of 2048 channels across 1-MHz, for both IF bands) have been made. There are currently still some issues to be resolved with reconfiguring CABB to and from zoom modes, and with performance of all baselines in all zoom bands, and work is progressing on these. We plan to release the 64-MHz mode next. This semester, the ATCA schedule is being released in stages to align with the release of CABB zoom modes. More details may be found in the Time Assignment Report.

User facilities

To help users handle the higher volumes of data from CABB, a new data processing machine called *serpens* has been installed at Marsfield. It has two quad-core processors and 16GB of RAM running a 64-bit version of the LINUX operating system. This has led to the milestone of decommissioning the last Solaris data processing server.

A new server with much higher performance is also expected to take over the *Australia Telescope On-line Archive (ATOA)* and *OPAL* tasks before the next call for proposals. As well, additional disk storage has been added to the *ATOA* to allow for the increasing volume of CABB and Mopra data.

The remote observing area in Marsfield (rm 23) has been upgraded and expanded. A new machine with improved screen "real estate" was set-up for the ATCA and, recognizing the increased Sydney-based observing with Mopra, a separate machine was prepared for that. Remote observing for both facilities is conducted via *VNC* sessions, simplifying the hand over between observers and assisting in trouble-shooting during remote observing, as observers and local staff are able to view the same displays simultaneously. The experience gained with Marsfield remote observing is helping guide planning for the Science Operations Centre.

Preparations are underway at all sites for the move to the latest version of *MoniCA*. The new version does control as well as monitoring and will let us integrate a lot of the small helper programs littering our on-line

First operations visit to the MRO. Credit: Douglas Bock, CSIRO

Douglas Bock
Credit: Tony Crawshaw, CSIRO

systems into *MoniCA*. Improvements have been made to *TCS* and *MultibeamVis* to better support pulsar and fast binning modes.

The *ATOA* includes essentially all ATCA data, and Mopra data from mid-2006. Recently, the Parkes spectral line data archive has been copied to Marsfield for inclusion in *ATOA*. Elsewhere in this issue you will find a report on the ANDS *ATNF Data Management Project*. Selected Parkes pulsar datasets are currently being readied for community access under this project. Our intention is to provide a single port of call for all ATNF data, including ASKAP.

Visitors to Parkes should note that the Quarters staff hours have changed to 8:00-4:30pm. This change means that dinners are now left in the fridge for re-heating, as at Narrabri. The Narrabri Lodge now has individual air-conditioning units in each bedroom, and an upgraded air conditioner in the dining room. The visitors' questionnaire form is now online. Comments and suggestions are encouraged! The form can be found on the visitors' homepage, *http://www.atnf.csiro.au/observers/visit/feedback.html.*

Staff notes

Phil Edwards and Euan Troup have moved from Narrabri to the Marsfield site. As part of the restructure of ATNF operations in 2008, Phil took on the position of Head of Science Operations. Phil was previously Officer in Charge at Narrabri. Phil's move to Sydney is a key part of the strategy to consolidate science operations for all sites from Sydney. Euan will continue his work on ASKAP and in operations science computing. Euan's major achievement during his time at Narrabri was moving us out of the *VMS* era and into the world of *Linux*.

Barry Turner has just started work (initially in Sydney) as the Geraldton/ Murchison Radio Observatory site manager. He will be moving to Geraldton in early July. While Barry's efforts will initially focus on ASKAP construction, his appointment is a key milestone in the startup of operations in Western Australia. Some of you may have met Barry during his time (1995–2008) at Parkes.

Douglas Bock

At the beginning of January, Douglas Bock took up his role as CASS Assistant Director – Operations, with responsibility for ATNF operations. He joins us from the University of California, Berkeley, where he was Project Manager and Assistant Director for Operations for CARMA (the Combined Array for Research in Millimeter-wave Astronomy). Prior to CARMA, he was a postdoc at Berkeley, and System Scientist for the Allen Telescope Array. Douglas has worked on instrumentation and system design for millimeter and centimeter-wave interferometers. His recent observational interests have included variable and transient sources at millimeter wavelengths. Douglas obtained his PhD (Physics) and undergraduate degrees in Science and Electrical Engineering from the University of Sydney.

The ANDS *ATNF Data Management Project:* Establishing a new archive for pulsar astronomy data

Jessica Chapman, George Hobbs and Arkadi Kosmynin (CASS), Cynthia Love and Dan Miller (CSIRO Information Management and Technology)

In this news item we discuss a project that is underway to establish a new archive for radio astronomy data. This will include data recorded during pulsar observations with the Parkes 64-m radio telescope and will allow for the later addition of data sets from other facilities.

Approximately 60 per cent of observing time with the Parkes 64-m radio telescope is allocated to observing programs that involve observations of pulsars. These include extensive surveys for previously unknown pulsars, and timing observations that require monitoring known pulsars over an extended period of time. These Parkes observations have led to many outstanding astronomical results including the discovery of more than half of all known pulsars, the discovery of the first double-pulsar system, and have even provided constraints on the black hole mass function. The other 40 per cent of Parkes telescope time is used, also very successfully, for spectral line observations for a range of science goals that include studies of stars and the interstellar medium in our Galaxy and other galaxies.

The ATNF has a general policy that data are "restricted" for a period of 18 months from the date of observation. During this embargo period, the data are available to the science team responsible for the observing program. After 18 months the data are "public access" and in principle are available to any professional astronomer. For the Compact Array and Mopra, data are provided through the *Australia Telescope Online Archive (ATOA)* and this will be extended in 2010 to include the spectral line "non-pulsar" Parkes observations.

A different approach is now underway to provide an archive of the Parkes pulsar observations. CSIRO IM&T and ATNF are being funded by the Australian National Data Services (ANDS) to establish an archive that initially includes Parkes pulsar observations and can be extended at a later stage to include data from other telescope facilities.

The ANDS *ATNF Data Management Project* is funded as a nine-month project. The project goals are to:

- Provide metadata and data from a subset of Parkes pulsar projects to the astronomy community. For the initial release the archive will be restricted to a subset of around five projects that have been chosen to be of high scientific importance and/or to represent different observing modes and data formats.

- Establish that the archive software can handle all of the different data formats used for Parkes pulsar data taken since 1990.

- Demonstrate that the archive is extensible. The software will be developed in a modular way so that it can later be extended to include other Parkes data and data from other facilities. In principle, any astronomy data set could be potentially considered.

- Provide an easy-to-use user interface to the archived data. This interface is likely to be similar to the simple form interface in use by the *ATOA* but with additional fields required for pulsar searches.

- Provide metadata for a CSIRO registry that will be used with the "Australian Research Data Commons" (see below).

Once the archive has been established it will be maintained by the ATNF and will be extended to include data from other Parkes pulsar projects. A significant problem associated with this is that, unlike Mopra and the Compact Array, Parkes pulsar data have not been routinely kept by the ATNF. However, for many projects, the data are expected to be recoverable on request to the Australian and overseas science teams who took the observations. In the near future we will begin contacting observing teams to request transferring data back to the ATNF for inclusion in the pulsar data archive.

Looking at the bigger picture, the provision of national data archives is of increasing importance in the "Super Science" era. For the next generation of major facilities such as ASKAP and the SKA, astronomers will interact with data and data products entirely through such archives. ANDS is funded by the Australian Government's Department of Innovation, Industry, Science and Research (DIISR) to provide resources for research archives of national significance. It also aims to establish an Australian Research Data Commons (ARDC) infrastructure that will be used to provide a cohesive collection of national data archives. We anticipate that CSIRO will continue to seek collaborations through ANDS and other Government funded programs to further develop our data management services. Ultimately we envisage an integrated facility that provides access to all ATNF facilities, including ASKAP, and also includes data archives from other parts of CSIRO. The experience gained through this project is a step on the way!

For further information please see:

ANDS:

www.ands.org.au

Research Data Australia:

services.ands.org.au/home/orca/rda/index.php

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 *christine.vanderleeuw@csiro.au*

This list includes published refereed papers compiled since the October 2009 newsletter. Papers which include CASS staff are indicated by an asterisk.

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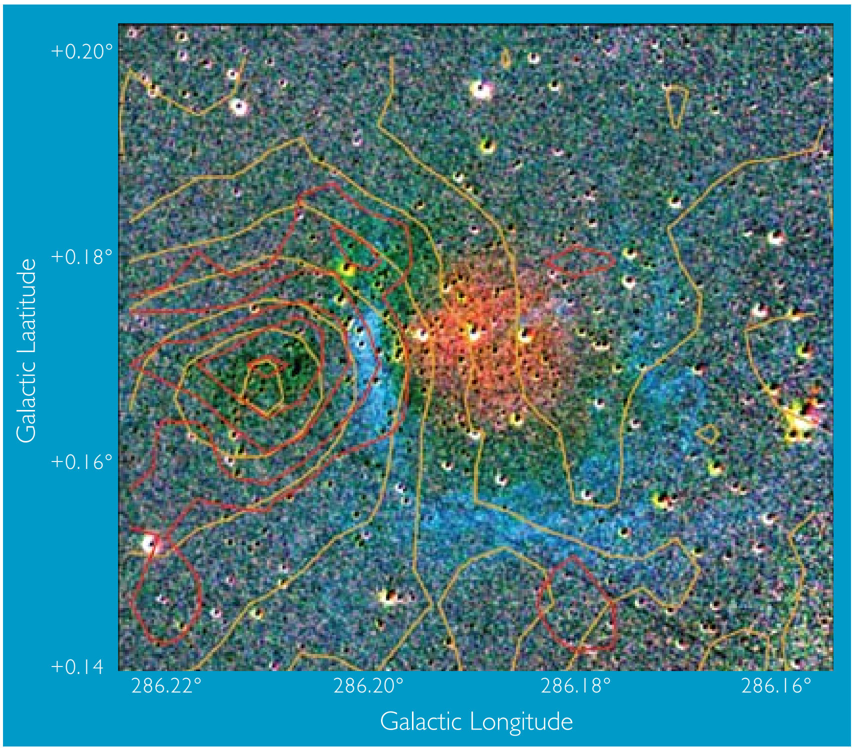
ASKAP Antenna #1 Construction Images

Ben Lauter from the main workshop tightening the last bolts, 17m in the air in the basket of the telehandler..
Credit: R Forsyth, CSIRO

The completed feed installation.
Credit: R Forsyth, CSIRO

First ASKAP antenna is up!
Credit: Phil Dawson, CSIRO



Discovery of Large-scale Gravitational Infall in a Massive Protostellar Cluster.
See page 20, Figure 4..

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