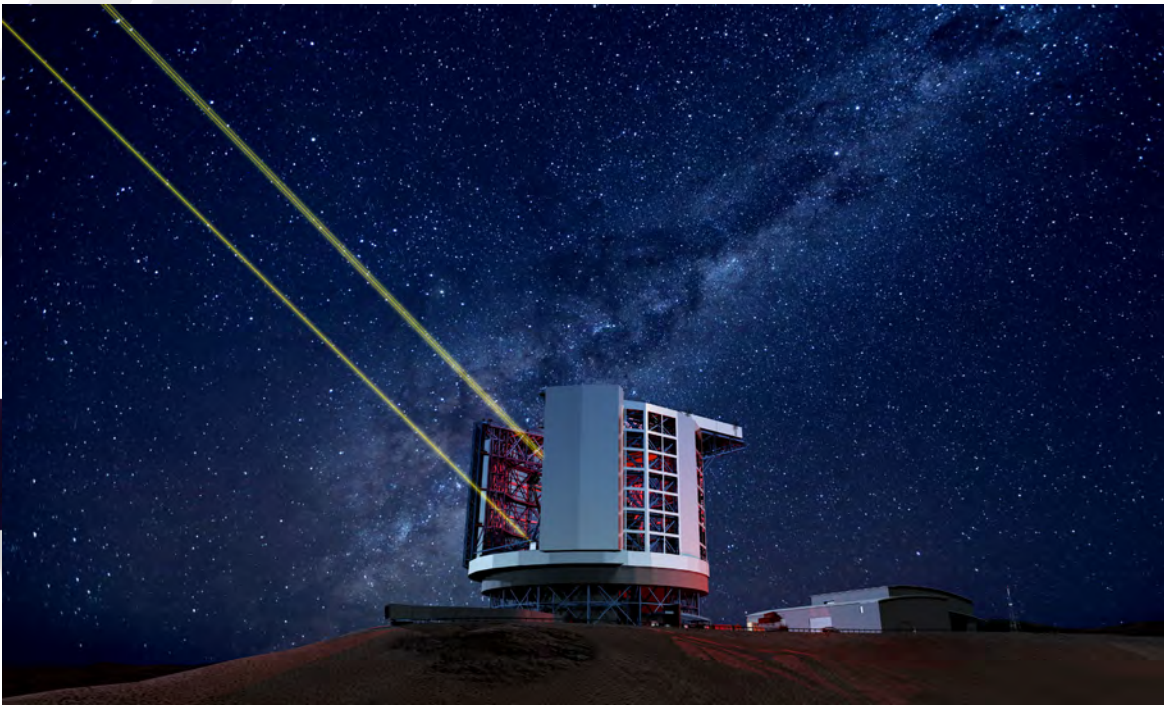




Astronomy  
Australia  
Ltd.

# 2014 / 15 Annual Report





# Astronomy Australia Limited

## Vision

**Australian-based astronomers will have access to the best astronomical research infrastructure.**

## Mission

AAL will achieve its vision by engaging with astronomers in support of the national research infrastructure priorities of the Australian astronomy decadal plan, and advising the Australian Government on the investments necessary to realise those priorities.

## Principles

1. Access to major astronomical research infrastructure should be available to any Australian-based astronomer purely on scientific merit.
2. The concept of national astronomical research infrastructure includes participation in international facilities.
3. AAL recognises the roles of other organisations in Australia that manage components of the national astronomical research infrastructure.

## Who we are

Astronomy Australia Limited (AAL) is a not-for-profit company whose members are all the Australian universities and research organisations with a significant astronomical research capability. AAL works with Australia's National Observatories, relevant infrastructure providers, astronomers at Australian Universities, and the Australian Government to advance the infrastructure goals in the Decadal Plan for Australian Astronomy.

## What we do

Since its incorporation in 2007, AAL has coordinated the Australian astronomy response to, and managed the funding for, a number of national schemes and projects, including the Australian Government's investments in astronomy infrastructure through the National Collaborative Research Infrastructure Strategy (NCRIS), the Education Investment Fund (EIF), and the Collaborative Research Infrastructure Scheme (CRIS). AAL also manages funding for, and represents Australia's interests in, a number of international projects - including the Giant Magellan Telescope project, access to 8-metre class telescopes such as the Gemini, Keck and Magellan telescopes, and represents Australia's interests in a range of international partnerships.

## Our Values

AAL is committed to equity and diversity and endeavours to create an environment in which every individual is treated with dignity and respect.

Background image: An SDSS-gri composite image of a galaxy cluster at redshift = 0.08, within a 1.5x1.5 degree field-of-view, rendered using the All-Sky Virtual Observatory's Theoretical Astrophysical Observatory image module.

Front cover image: An artist's impression of the GMT. In June 2015, the Giant Magellan Telescope Organization announced its approval to commence construction of the GMT. Image credit: GMTO

## AAL Membership as of 30th June 2015



Australian  
National  
University



Curtin University

MACQUARIE  
UNIVERSITY



MONASH  
University



THE UNIVERSITY  
OF ADELAIDE  
AUSTRALIA



THE UNIVERSITY OF  
MELBOURNE



UNSW  
THE UNIVERSITY OF NEW SOUTH WALES



THE UNIVERSITY  
OF QUEENSLAND  
AUSTRALIA



THE UNIVERSITY OF  
SYDNEY



THE UNIVERSITY OF  
WESTERN AUSTRALIA  
*Achieve International Excellence*



University of  
Western Sydney





# AAL Members and Facilities

AAL has supported construction, upgrades, instrumentation development, maintenance and operations at a number of facilities located around Australia. AAL also manages, represents and supports the interests of Australian astronomers in a number of international projects and facilities. These activities are made possible by support from the Australian Commonwealth Government via programs such as the National Collaborative Research Infrastructure Strategy (NCRIS).

## National Facilities

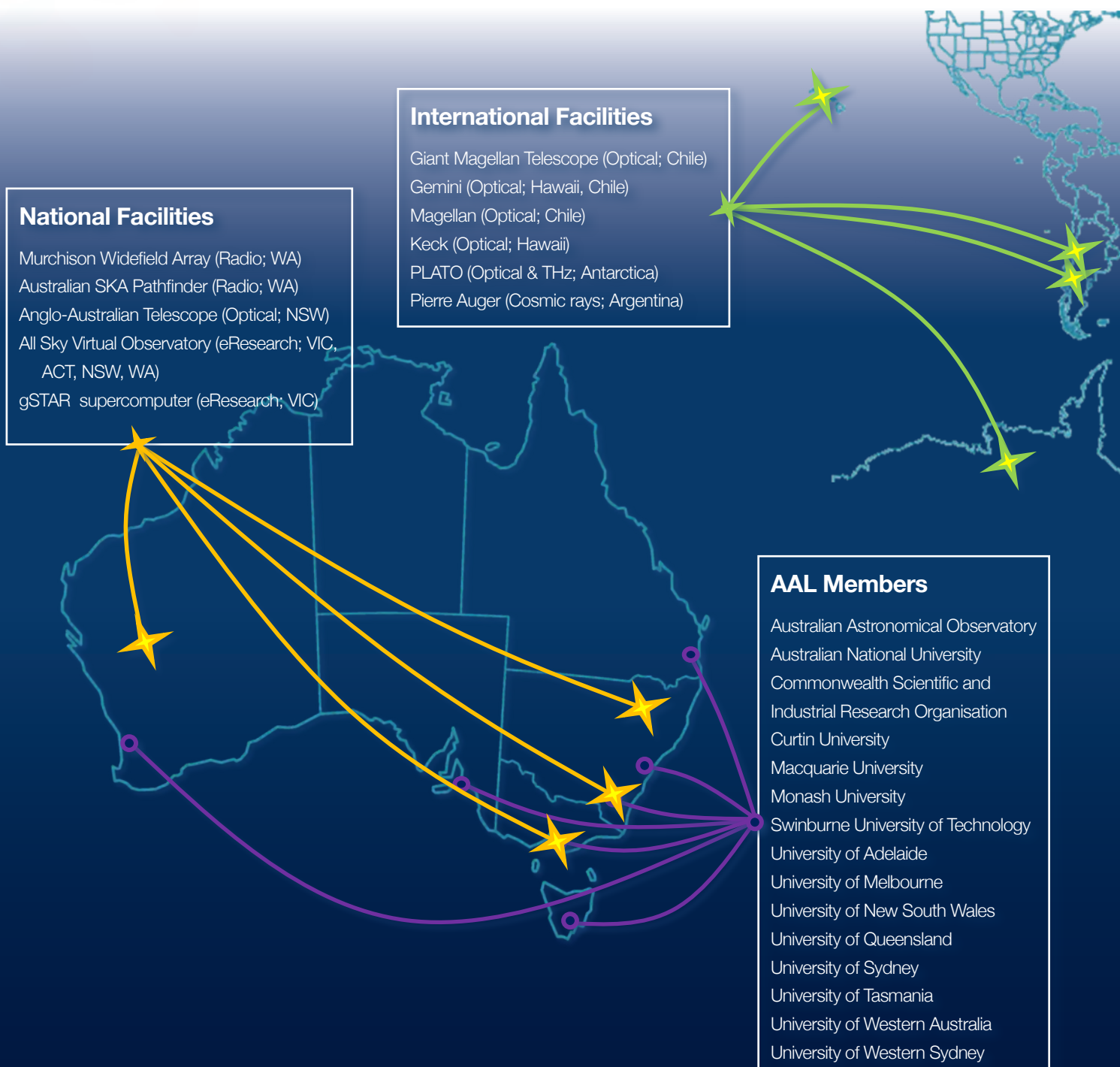
Murchison Widefield Array (Radio; WA)  
Australian SKA Pathfinder (Radio; WA)  
Anglo-Australian Telescope (Optical; NSW)  
All Sky Virtual Observatory (eResearch; VIC, ACT, NSW, WA)  
gSTAR supercomputer (eResearch; VIC)

## International Facilities

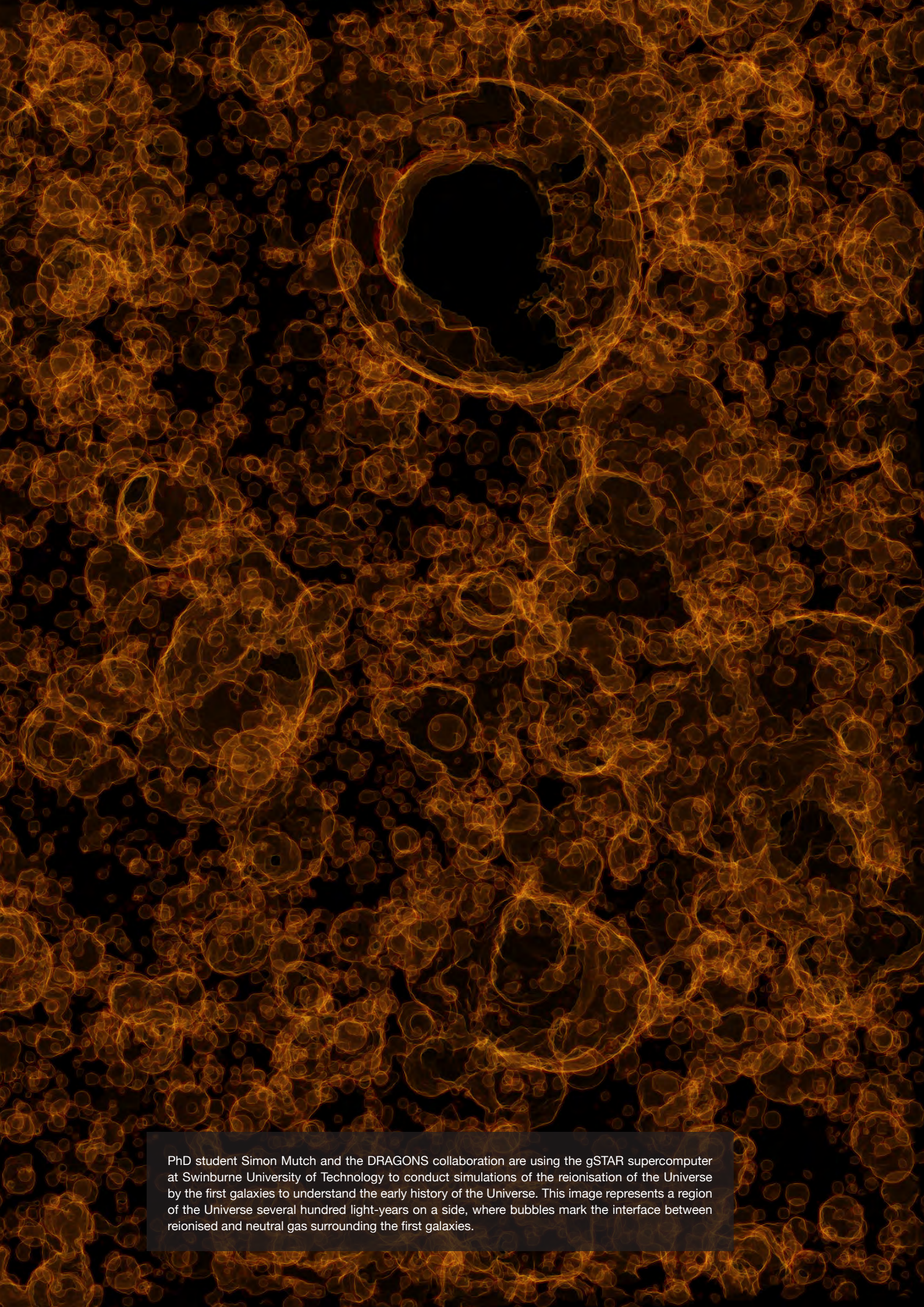
Giant Magellan Telescope (Optical; Chile)  
Gemini (Optical; Hawaii, Chile)  
Magellan (Optical; Chile)  
Keck (Optical; Hawaii)  
PLATO (Optical & THz; Antarctica)  
Pierre Auger (Cosmic rays; Argentina)

## AAL Members

Australian Astronomical Observatory  
Australian National University  
Commonwealth Scientific and Industrial Research Organisation  
Curtin University  
Macquarie University  
Monash University  
Swinburne University of Technology  
University of Adelaide  
University of Melbourne  
University of New South Wales  
University of Queensland  
University of Sydney  
University of Tasmania  
University of Western Australia  
University of Western Sydney







PhD student Simon Mutch and the DRAGONS collaboration are using the gSTAR supercomputer at Swinburne University of Technology to conduct simulations of the reionisation of the Universe by the first galaxies to understand the early history of the Universe. This image represents a region of the Universe several hundred light-years on a side, where bubbles mark the interface between reionised and neutral gas surrounding the first galaxies.



# Contents

<b>A message from the Chair</b>	2
<b>A message from the CEO</b>	4
<b>Snapshot</b>	6
<b>The Year in Highlights</b>	9
Science	10
Industry and Commercialisation	14
Engagement with China	16
Outreach	18
<b>Facilities and Projects</b>	21
Giant Magellan Telescope	22
8-metre Telescope Access	24
Anglo-Australian Telescope	26
SKA Pathfinders	28
gSTAR	32
All Sky Virtual Observatory	34
PLATOs	35
Pierre Auger	36
<b>AAL Organisation and Governance</b>	37
AAL Community Engagement	38
Organisational and Governance Structure	39
Directors	40
Committees	42
Financial Summary	44
<b>Acronyms</b>	48



# A message from the Chair

2014/15 was an exciting year for AAL-supported projects and facilities. The scientific output from new facilities such as the Murchison Widefield Array (MWA) and the gSTAR supercomputer is climbing dramatically, as they mature and reach their full scientific potential. I am also delighted to see the number of examples of excellent science being led by Australian students in this year's Annual Report. The ability to provide students opportunities to work with world-class facilities is a key attraction of Australian universities and access to these resources allows us to provide essential training for the next-generation of world-leading scientists. AAL-supported facilities are also involved in numerous outreach and education activities, including several featured in this report, which serve an important role inspiring the public and young people to learn more about science and technology.

As highlighted in this report, many projects are working closely with industry to develop advanced solutions to astronomy and non-astronomy challenges, ranging from instrumentation to Big Data. It is a pleasure to congratulate CSIRO on receiving two Australian Innovation Challenge Awards for the Australian Square Kilometre Array Pathfinder (ASKAP) in 2014/15; winning both the Manufacturing, Construction and Infrastructure category and the overall National award. The awards provided well-deserved recognition of the ASKAP team's technological innovation in partnership with industry.

The projects and facilities featured in this report have received significant funding from the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS). I was therefore personally delighted to participate in an event organised by the Department of Education and Training at Parliament House in September 2014, to help showcase the benefits from NCRIS investments to both the public and politicians. I also welcomed the announcement in May 2015



Prof Brian Schmidt, Chair,  
AAL Board of Directors.

of the Government's commitment of a total of \$300M of NCRIS funding for 2015/16 and 2016/17.

I would like to congratulate the Australian Academy of Science's National Committee for Astronomy on its efforts consulting with the community and developing the new 2016–2025 Decadal Plan for Australian astronomy, Australia in the era of global astronomy. This community document presents a vision of Australian astronomical excellence in an era of global astronomy. A key part of AAL's current activities is developing a 5-year strategic plan to use its current and future NCRIS funding to invest in infrastructure to realise the plan's goals, delivering benefits to Australian researchers, universities, industry and the public.

One of the biggest highlights for the AAL team this year was receiving a Bronze Pleiades Award by the Astronomical Society of Australia's Chapter for Women in Astronomy, in recognition of our proactive commitment to gender balance and flexible working arrangements. We are pleased that the steps AAL has taken to date have been successful in supporting female participation, and we continue to strive to improve equity and diversity more broadly.

At the 2014 AGM, AAL Director and former Chair and Deputy Chair Stuart Wyithe retired from the AAL Board. I thank Stuart personally and on

behalf of AAL for his tremendous contributions to AAL during his three years on the Board. AAL was delighted to welcome its newest Director, Lisa Kewley, a Professor and Associate Director at the Research School for Astronomy & Astrophysics at the Australian National University. Lisa brings a comprehensive knowledge of the Australian and international astronomical landscape to the Board, with her astronomy expertise spanning theory and computation and optical, infrared, and radio observations.

At the 2014 AGM, I was honoured to be re-appointed to the AAL Board and re-appointed as Chair. Following my appointment as Vice-Chancellor of ANU commencing in 2016, I have chosen to retire from the AAL Board at

the conclusion of the 2015 AGM. It has been a privilege to serve on the Board since AAL was incorporated in 2007 and to Chair the Board for the last two years. I offer my thanks and best wishes to the Members, Board and staff, and wish AAL continued success in serving the Australian Astronomical community to make sure it continues to have access to the best astronomical research infrastructure.



Prof Brian Schmidt  
Chair

## Pleiades Award

AAL is committed to equity and diversity and endeavours to create an environment in which every individual is treated with dignity and respect. This commitment was recognised by the Astronomical Society of Australia (ASA) with the presentation of a Bronze Pleiades Award to AAL in 2014. The Pleiades Award recognises organisations in Australian astronomy that take active steps to advance the careers of women through focused programs and strive for sustained improvement

in providing opportunities for women to achieve positions of seniority, influence and recognition.

The AAL Board's requirement that the total female representation on AAL's committees exceeds the Australian astronomical community demographics was first achieved at the beginning of 2013 and continues to be maintained. As of June 2015, three of AAL's seven Board members are women. In addition, AAL has always operated with comprehensive flexible working arrangements for all staff that has contributed to a sustained return rate from parental leave and the retention of employees.



AAL Deputy Chair Prof Anne Green being officially presented with the organisation's Bronze Pleiades Award by Sarah Brough, Chair of the Women in Astronomy Chapter of the ASA. Credit: Andy Green.



# A message from the CEO

A major highlight of the year was the Giant Magellan Telescope construction announcement. Following the successful completion of the preliminary design, along with the required revisions to the legal and financial frameworks which underpin the project, this billion-dollar project to build a next generation observatory was ready to enter its construction phase. Australian partnership in this exciting project is already providing a wealth of opportunities for technical engagement, including the design and development of first generation scientific instruments. On a personal note, my membership of the Board of the Giant Magellan Telescope Organization has been a rewarding and educational experience. During my four years of service, I particularly enjoyed contributing as Chair of the Board's finance committee. However, it is important to renew such positions, and therefore I requested to retire from the Board in June 2015.

The Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS) received considerable attention during the year. It was re-assuring that in May 2015 the Government agreed to release the \$150M

of 2015/16 NCRIS funds, of which AAL secured \$8.6M for astronomy facilities. AAL also secured \$2.7M in grants from the Department of Industry and Science and \$0.5M in eResearch grants. AAL was guided by the 2016–2025 Decadal Plan for Australian astronomy, *Australia in the era of global astronomy*, in its recommended allocation of these funds. The major allocations involved \$5M to the Australian Square Kilometre Array (SKA) pathfinders and \$4.1M towards accessing large optical telescopes located overseas.

In the past year the Department of Education and Training undertook multiple NCRIS reviews to consider matters including infrastructure performance, scientific output, governance, and the effectiveness of the various eResearch capabilities. In addition, a major review was conducted to plan for future Australian Government investment in research infrastructure, chaired by Philip Clark. AAL was reviewed twice, and contributed to the eResearch and Clark reviews. I was delighted that KPMG's governance and management review classified AAL as "optimised", KPMG's highest category in their project maturity assessment model.

During the year AAL worked closely with the Australian National University and Swinburne University of Technology on the matter of access to the W. M. Keck Observatory. By June 2015 we had agreed to combine our respective access to Keck and form the Keck Time Allocation Committee (KTAC). KTAC will provide a single interface for Australian-based astronomers who wish to request access to the forty-five Keck-nights available per year in 2016 and 2017. This model is designed to facilitate larger programs and broader collaborations to maximise the scientific-return from Australia's engagement with the Keck telescopes. While more work is required to secure a long-term engagement with an overseas observatory, the establishment of KTAC, along with ongoing access to the



Mark McAuley AAL CEO, visits the Mt Wilson Observatory during the GMTO Board meeting in August 2014.



An artist's impression of the GMT.  
Image credit: GMTO

Magellan telescopes, is timely as Australia will cease its full partnership status in the Gemini Observatory at the end of 2015.

With the publication of *Australia in the era of global astronomy*, AAL needs to review its scope and identify the investments that will most effectively realise the research infrastructure priorities of the Decadal Plan. In particular the growing importance of data-intensive and computational-intensive astronomy require AAL's attention.

The Decadal Plan re-affirms the critical importance of the SKA and its precursors to Australian astronomy. I was delighted to be invited by the Department of Industry and Science to join the Australian-New Zealand SKA Coordination Committee, and will use that experience to help AAL to build closer links with SKA activities in Australia.

Mr Mark McAuley  
Chief Executive Officer

## GMT construction announcement

On track to be the first in the next generation of extremely large optical telescope to begin science observations, the Giant Magellan Telescope (GMT) is being built by a global scientific collaboration involving institutional partners in Australia (AAL and ANU), Brazil, Korea, the United States, and in host nation Chile.

In June 2015, the GMT Organization was delighted to reach one of its most significant milestones, with the announcement that they had secured financial commitments for over US\$500 million and could give the green light to begin construction of the telescope.

The GMT aims to discover Earth-like planets around nearby stars and the tiny distortions that black holes cause in the light from distant stars and galaxies. It will reveal the faintest objects ever seen in space, including extremely distant and ancient galaxies, the light from which has been travelling to Earth since shortly after the Big Bang, 13.8 billion years ago.



# 2014/15 Snapshot

**\$8.1M** invested

*Infrastructure funding*

AAL invested \$8.1M in 2014/15, giving Australian researchers access to facilities worth over \$500M.

*Scientifically productive*

**publications 282**

282 refereed journal papers were published in 2014/15 from collaborative research projects using AAL-supported facilities. This is over 100 more than in 2013/14, and is evidence of the growing scientific output of Astronomy-NCRIS facilities as they mature.

**86%** collaborating internationally

*Inspiring collaborations*

Australian astronomers are exceptionally collaborative, with 86% of the publications in 2014/15 from AAL-supported facilities involving Australian-international collaborations. This is a key factor driving Australia's high level of research impact and productivity in astronomy.



## 38% student usage

### *Commitment to training*

Over a third of Australian users of AAL supported facilities in 2014/15 were students, demonstrating the importance of these resources in building the skills and expertise of the next-generation of world-leading scientists.

### *Demand for facilities*

users >1500

Over 1500 astronomers used AAL funded facilities in 2014/15, of whom 36% were Australian-based researchers and 64% were international collaborators.

## 173% subscription

### *Highly competitive*

Access to AAL-supported facilities is highly sought-after and competitive, with users applying for almost twice as much time as was available in 2014/15, via merit-based time allocation processes.





Using a long-exposure and the light of the full moon to illuminate the landscape, the image shows one of the 128 'tiles' of the Murchison Widefield Array and a distant 'breakaway' beneath a star-studded Murchison sky. Image credit: Pete Wheeler, the International Centre for Radio Astronomy Research.





# AAL: the year in highlights





# The Year in Highlights: Science

2014/15 has seen some outstanding science outcomes resulting from work undertaken by Australian researchers using nationally available, NCRIS- and EIF-funded astronomical infrastructure. The ability to train the next generation of scientists with world-class facilities is a key strength of Australian astronomy, and this year saw a number of ground-breaking works being led by students.

## Australian student discovers “Plasma Tubes” that can affect satellite-based navigation systems

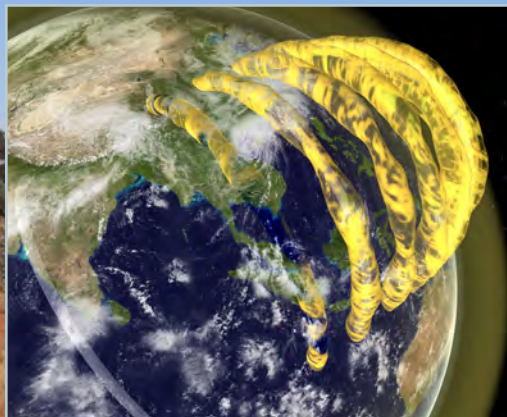
University of Sydney undergraduate student Cleo Loi, used the Murchison Widefield Array (MWA) to detect and image huge plasma tubes in the inner layers of Earth’s magnetosphere. Structures in the ionosphere create unwanted signal distortions, affecting a variety of terrestrial and spaced based technologies including, civilian and military satellite-based navigation systems.

This result is significant as it affirms the barely-tapped potential of the MWA and other next-generation radio telescopes, but is also

an example of how radio-astronomy can have real-world benefits.

The combination of MWA’s unique capability and novel analysis techniques allowed Ms Loi to confirm the existence of the structures that scientists had theorized ‘must exist’ for more than 60 years. Rather than utilizing the MWA’s 128 tiles all together Ms Loi split them into two halves, east and west, and used the two-halves—like a pair of human eyes—to allow the MWA ‘see’ in 3D. This technique allowed the ionosphere above the MWA to be viewed with unprecedented precision, and for structures within it to be directly imaged for the first time.

Ms Loi won the Astronomical Society of Australia and Australian Academy of Science’s 2015 Bok Prize for her research.



Inset: An artist's impression of plasma tubes in the ionosphere. Image credit: CAASTRO and the Murchison Widefield Array.



Cleo Loi at the MWA. Image credit: CAASTRO and the Murchison Widefield Array.



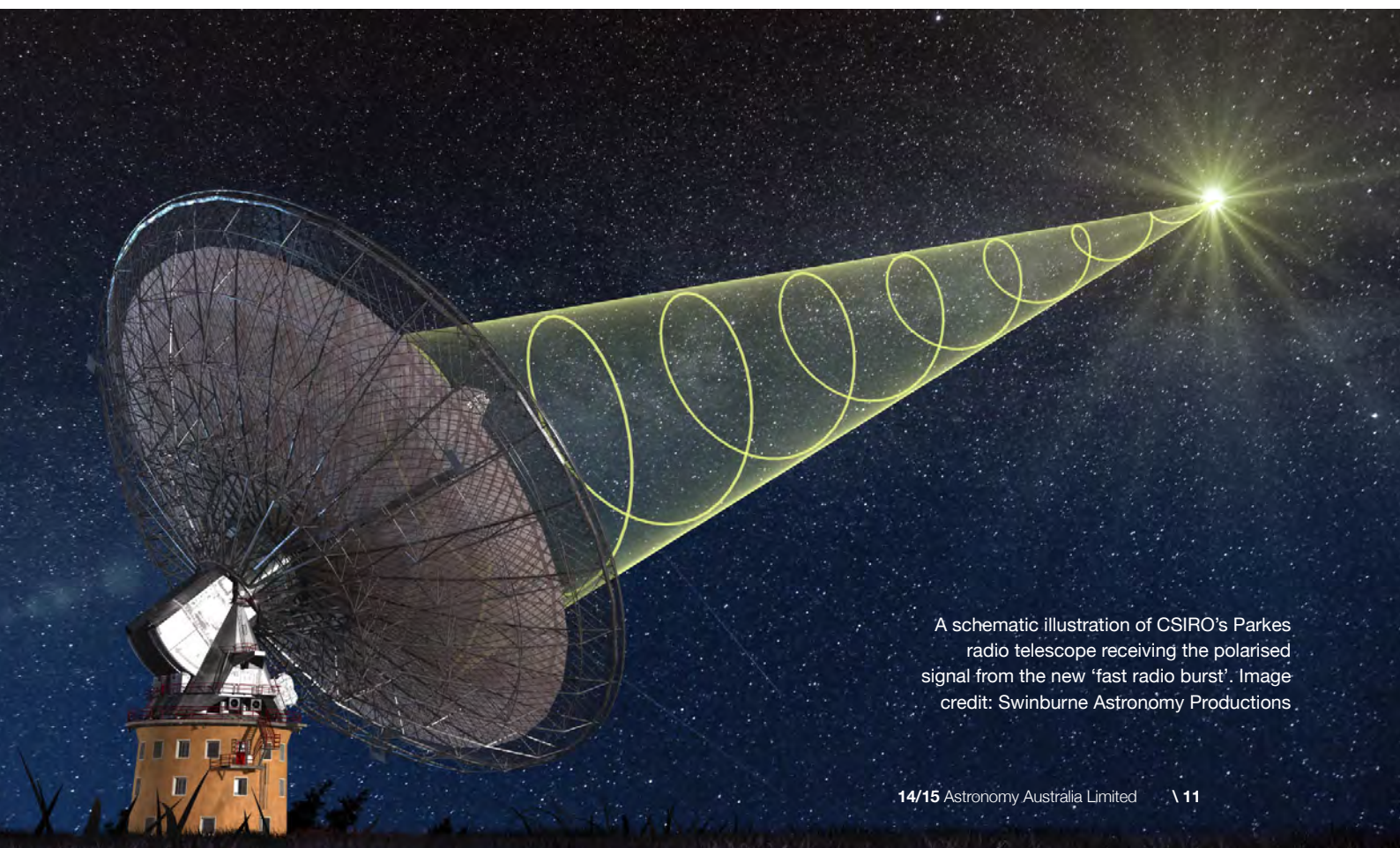
## Mysterious radio bursts witnessed by Australian researchers for the first time

In 2014, Swinburne University of Technology PhD student Emily Petroff and her team were the first to capture a 'fast radio burst' (FRB) happening live, using CSIRO's Parkes radio telescope in New South Wales. The energetic burst may have come from an unidentified, but catastrophic, event in the distant universe. If astronomers can detect the source of FRBs with telescopes at other wavelengths to pinpoint their origins and nature, it would be possible to use these phenomena to determine the "weight" of the Universe.

Part of the problem in detecting and following up these events lies in the length of the burst – FRBs last just milliseconds, and to date only a handful have ever been discovered (mostly in archival data). Ms Petroff and the team at Parkes immediately alerted international collaborators of the FRB, and within a few hours, telescopes around the world and in


space were taking follow-up observations. While nothing has been observed that pinpoints the FRB's location or origin, they have been able to rule out several possible progenitors, such as a local superluminous supernovae, a nearby type Ia supernova or a slow transient source.

The next step is to establish global collaborative networks to enable more detections and even faster follow-up observations from telescopes around the world. The most comprehensive effort currently underway is the Survey for Pulsars and Extragalactic Radio Bursts (SUPERB) at Swinburne University. SUPERB involves the real-time streaming of Parkes data to the AAL-supported gSTAR supercomputer at the Swinburne University of Technology, and the survey is highly dependent on gSTAR's graphics processing unit (GPU) technology. Testing has now been completed on gSTAR for the first simultaneous coordinated radio-optical observations (and UV-X-ray capability) which will provide rapid follow-up to FRB detections.



A schematic illustration of CSIRO's Parkes radio telescope receiving the polarised signal from the new 'fast radio burst'. Image credit: Swinburne Astronomy Productions





Artistic representation of the potentially habitable Super-Earth Gliese 832c with an actual photo of its parent star, taken on June 25, 2014 from Aguadilla, Puerto Rico. Image credit: Efrain Morales Rivera / Astronomical Society of the Caribbean / PHL / UPR Arecibo.

## Potentially habitable Super-Earth found in nearby star system

A team of astronomers led by Dr Robert Wittenmyer of the University of New South Wales has discovered a “Super-Earth” planet orbiting the red-dwarf star GJ832 in a region where temperatures are just right for liquid water to exist; the so-called “habitable zone”.

The potentially rocky planet has a mass 5.4 times that of Earth and its “year” is only 35.68 days. It is ranked in the top ten of most Earth-like planets found to date according to the Earth Similarity Index, and is the closest of the top ten to Earth at just 16 light years away.

The system was already known to harbour a Jupiter-like planet, further out from the star. With a giant outer planet and a smaller terrestrial planet closer in, the system looks like a miniature version of our Solar System.

The discovery was made by observing slight wobbles of the host star, caused by the gravitational pull of the planet. The team used the Anglo-Australian Telescope, the 6.5-metre Magellan Telescopes in Chile, and the European Southern Observatory 3.6-metre telescope in Chile.

## Modelling planetary systems to determine target candidates for future habitable low-mass planet searches

As the number of planets and candidate planets astronomers have discovered around other star systems now reach into the thousands, astronomers looking for potentially habitable extra-solar planets need to make targeted selections for further investigation.

One criterion that could determine whether a planetary system could develop life is the long-term stability of an Earth-like planet within the habitable zone of a star – the region around a star where a planet could support liquid water at its surface.

Swinburne University PhD student, Elodie Thilliez, used the gSTAR supercomputer to perform a dynamical study of the three-planet system HD 204313 to determine whether it could harbour an Earth-like planet within its habitable zone for a sufficient time to develop life. Two semi-stable regions were found in the system, but neither proved stable for long enough for a terrestrial planet to develop life. The investigations suggest that overlapping weak and high order resonances may be responsible for these semi-stable regions. The study has established a framework for a larger project that will investigate the dynamical stability of the habitable zone of multiple planet systems, providing a list of interesting targets for future habitable low-mass planet searches.



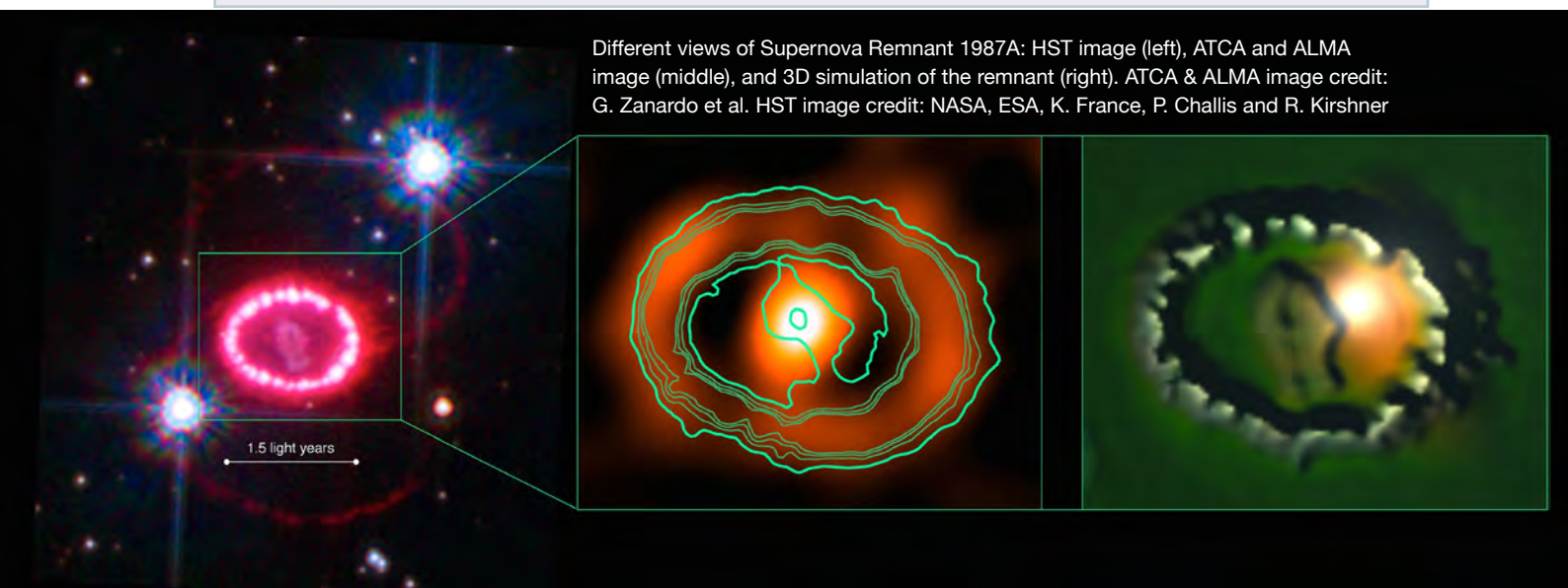
## Dissecting the remains of a supernova

PhD candidate Giovanna Zanardo, from ICRAR-UWA, led a team that peered into the remains of the supernova SN1987A and discovered the first signs of a central remnant, which could be a pulsar wind nebula, driven by a spinning neutron star, or a pulsar.

The team observed the supernova core using the

Atacama Large Millimeter/submillimeter Array (ALMA) in Chile and the Australia Telescope Compact Array (ATCA), which had recently undergone a major upgrade, including an AAL-supported upgrade of the C/X receiver.

This significant result was published in the *Astrophysical Journal* and also reported as a Research Highlight in the prestigious *Nature* journal.



Different views of Supernova Remnant 1987A: HST image (left), ATCA and ALMA image (middle), and 3D simulation of the remnant (right). ATCA & ALMA image credit: G. Zanardo et al. HST image credit: NASA, ESA, K. France, P. Challis and R. Kirshner



# The Year in Highlights: Industry and Commercialisation

Australian astronomical science, technology and instrumentation have a long history of industry engagement, particularly through the development of new technologies and the procurement of goods and services, including the following highlights from 2014/15.

## Environmental applications

The cloud cameras developed and operated by Australia as part of the Pierre Auger Observatory international collaboration are being used in a number of academia-industry collaborations involving the Adelaide City Council, Flinders University, Landscape architects, and agriculturalists. In 2014/15, these collaborations included a study of clear-sky infra-red radiation

(greenhouse) levels throughout the Adelaide CBD, to gain insight into the formation of “urban heat islands”, which impact on our health and industry cooling costs during summer periods.

This technology is also currently being used in an industry partnership to improve methods of frost mitigation in agriculture, and there is potential to develop cloud monitoring systems for solar power plants to provide warning of cloud cover, which can rapidly decrease incoming solar power.

## Big Data Challenges

As the first operational SKA precursor telescope, the AAL-supported Murchison Widefield Array (MWA) is on the front lines of the Big Data challenge, and was a key factor in bringing the latest ‘Cisco Internet of Everything Innovation Centre’ (CIIC) to Curtin University. Cisco and foundation partners Curtin and Woodside Energy have committed approximately \$30M to establish the centre, which brings together start-ups, industry experts, developers and researchers to create innovative solutions to industry problems.

The first challenges to be tackled by the centre include: designing more efficient processing plants with artificial intelligence, data analytics and advanced sensors and control systems, and addressing education challenges to allow more connected and remotely accessible labs and teaching spaces.

The centre will interconnect with a global network of Cisco centres, including a second Australian node to be launched in Sydney, based at SME SICRA.



MWA Director, Professor Steven Tingay outlines the utility of the IoE to the MWA at the launch CIIC at Curtin University. Image credit: Curtin University



## SKA pathfinders seeding industry-academia partnerships

Building the next-generation Australian SKA Pathfinder (ASKAP) poses complex technical challenges, such as the requirement for a specially designed 'ground plane' for the new phase array feed receivers, in order to maintain a low and stable system temperature. CSIRO has been working with Thermacore Europe to design a solution that will meet

ASKAP's unique and strict requirements, to allow more accurate scientific observations, while reducing power consumption and operating costs. This is one of many examples of industry partnership that contributed to the ASKAP project receiving the prestigious 2014 Australian Innovation Award, which cited the success of the project in taking expertise in the R&D of cutting-edge low-cost technologies, and working together with industry to put these technologies into production.

## Space Debris Management

The Advanced Instrumentation and Technology Centre (AITC) was established at ANU to develop instrumentation for next-generation telescopes such as the Giant Magellan Telescope. However, the AITC's expertise is also being used in a range of non-astronomy industry partnerships, including a Space Environment Management Cooperative Research Centre that was funded in 2014 to monitor and manage space debris to

protect satellites and the space environment. Participants in the centre include the ANU, RMIT, EOS Space Systems, Optus, Lockheed Martin, and NASA.

Seeded by this work, EOS Space Systems, in partnership with ANU, were awarded a \$6.4M contract from the Korean Astronomy and Space Science Institute to build a laser-ranging facility with adaptive optics, and in 2014/15 they entered into an agreement with Lockheed Martin to establish a space object tracking site in Western Australia.

## Renewable Energy

The Australian PLATO project to build and operate robotic observatories in the harsh Antarctic environment helped seed a spin-off company Fulcrum 3D. This growing Australian company builds "Sodars", a portable wind monitoring unit optimised for the wind energy industry, and based on technology developed at UNSW as part of the PLATO project. More than twenty Sodars are now deployed in the field, and in 2014/15, Fulcrum 3D delivered

a Sodar to the Subaru telescope on Hawaii, and two Sodars to the National Astronomical Observatories of the Chinese Academy of Sciences. In 2014/15, Fulcrum 3D continued to expand, entering the European market and developing new products. One such new technology resulted in Fulcrum 3D being shortlisted as a semi-finalist in the Australian Technologies Competition 2015, which recognises Australian companies that are industry leading innovators. The winners of the award will be announced in October 2015.



# The Year in Highlights: Engagement with China

As astronomy moves into the era of large, multi-national infrastructure projects, fostering strong international relationships is crucial if Australian astronomy wishes to retain a strong voice in the direction of future facilities and remain globally competitive in astronomical research.

Australia and China have been collaborating on astronomical science and infrastructure projects for over fifty years. Both countries are key partners in the Square Kilometre Array (SKA), and China has contributed to the Australian SKA Pathfinder (ASKAP) - a Chinese company constructed the telescope's 36 radio dishes.

## Collaborating with China on the 'big dish'

CSIRO has world-leading expertise, developed over decades, in the design of the sophisticated systems called 'receivers' that amplify the faint radio signals from the cosmos and convert them to electrical signals. It designs and creates these systems both for its own telescopes — such as the Australian Square Kilometre Array Pathfinder in Western Australia — and for observatories around the world.

China is now constructing the Five Hundred Meter Aperture Spherical Telescope (FAST). This is a 500-metre diameter surface that sits in a natural hollow in the ground. When completed it will be the world's largest single-dish telescope.

In 2013 CSIRO completed a contract from the

National Astronomical Observatories, Chinese Academy of Sciences to investigate the feasibility of a '19-beam' receiver for FAST. A 'beam' is the region of sky that the telescope 'sees'. Traditionally, radio telescopes have had only single beams but a 'multibeam' receiver lets the telescope see more sky at once. CSIRO has built a 13-beam receiver for its own Parkes telescope and a seven-beam receiver for the giant Arecibo telescope in Puerto Rico: the FAST receiver is the largest it has tackled.

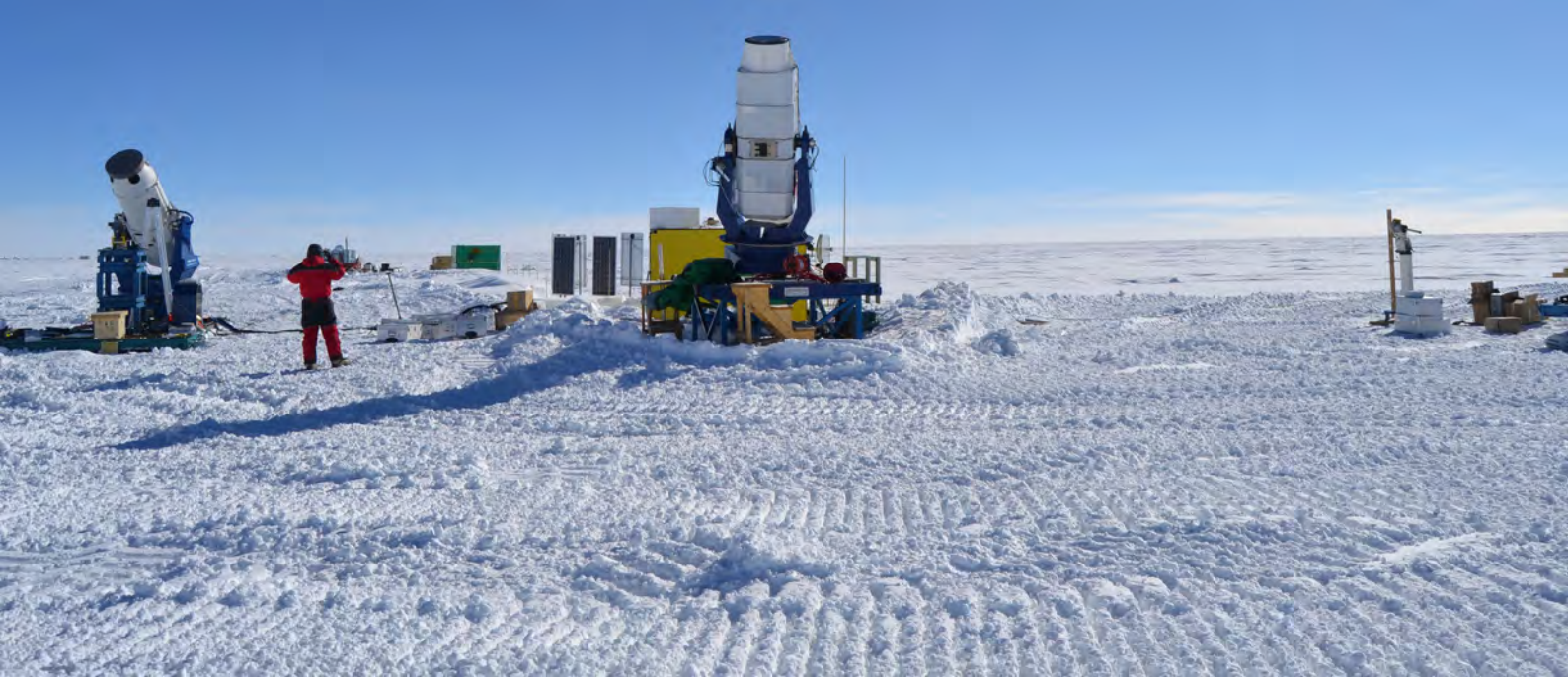
The working parts of the receiver must be cooled to cryogenic temperatures and housed in a dewar maintained under high vacuum. The challenge was to design a system with a large dewar (about 1.6 metres across) but minimise the total weight. The design report for the system was formally accepted, and CSIRO is now negotiating a contract to build the full 19-beam receiver system for FAST.

Attendees at the AST3 science meeting at the University of Hong Kong in March 2015.  
Image credit: The University of Hong Kong.





Installation of the AST3-2 telescope (left) at Dome A, Antarctica during the Chinese-led summer service mission. The AST3-1 telescope (middle) was installed in 2012. Image credit: Fujia Du, PRIC traverse team.



## Collaboration in Antarctica

Collaboration on Antarctic astronomy is a key component of the Australia-China relationship, with a number of activities undertaken in the 2014/15 period. In November 2014 the Chinese Xuelong icebreaker docked in Hobart, Tasmania en route to Antarctica and was toured together by the President of China, Xi Jinping, and the Prime Minister of Australia,

Tony Abbott. Amongst the equipment carried by the icebreaker down to Antarctica were service mission components for the Australian-constructed PLATeau Observatory (PLATO). This Australian technology supports the optical telescope facility being established by the Chinese at Dome A, on the Antarctic Plateau. The lead scientist on the PLATO project, Prof Michael Ashley (UNSW), was invited to attend a reception for Chinese President and the Australian Prime Minister prior to their tour of the icebreaker.

The Australian presence was strong at the 2015 International Collaboration Meeting on Antarctic Survey Telescopes at the University of Hong Kong in March 2015, with a number of delegates from multiple Australian institutions, including a representative from AAL in attendance. During the meeting, Prof Michael Ashley and Prof Jeremy Mould (Swinburne University) were invited to join lead Chinese researchers from the Purple Mountain Observatory and University of Hong Kong to participate in a press conference to publicise the project and led to a number of publications in Chinese media in the following days.





# The Year in Highlights: Outreach

In 2014/15 AAL-supported facilities undertook a large number of science outreach activities that directly connected the public with world-class astronomical infrastructure. These activities serve to encourage the next generation of scientists, engage the community with the exciting science being undertaken by Australian astronomers, and demonstrate to the general public the importance of the investments made into research and research infrastructure using tax-payer funding.



The BBC Horizons program spent time on the MWA site during FY2014/15 filming for a documentary on the 'early universe'. The MWA will feature prominently in the documentary which is currently in production and scheduled to air later in CY2015. Image credits: Steven Tingay, Curtin University and Charmaine Green, Yamaji Art.

## Telescopes and Indigenous Art

Beautiful images of celestial objects are not the only way astronomers bridge the gap between science and art. The Murchison Widefield Array antennas featured in the Shared Sky art/astronomy exhibition at the John Curtin gallery at the Curtin University in Western Australia. The exhibition—

launched to coincide with an international SKA meeting held in Fremantle—brings together Indigenous artists from Western Australia and South Africa, connected by the SKA. MWA Director, Professor Steven Tingay hosted a story-telling in the Murchison that inspired many of the artworks produced by local indigenous artists for the exhibition.



Winning image from the 2014 Australian Gemini Schools Astronomy Contest, showing the galaxy NGC 7727 plus tidal debris from the interaction with a companion galaxy. Image credit: Ivanhoe Girls Grammar School Astronomy Club, Samuel Carbone (Trinity College), Travis Rector (University of Alaska Anchorage), and AAO.

## Large telescopes and student imaging contests

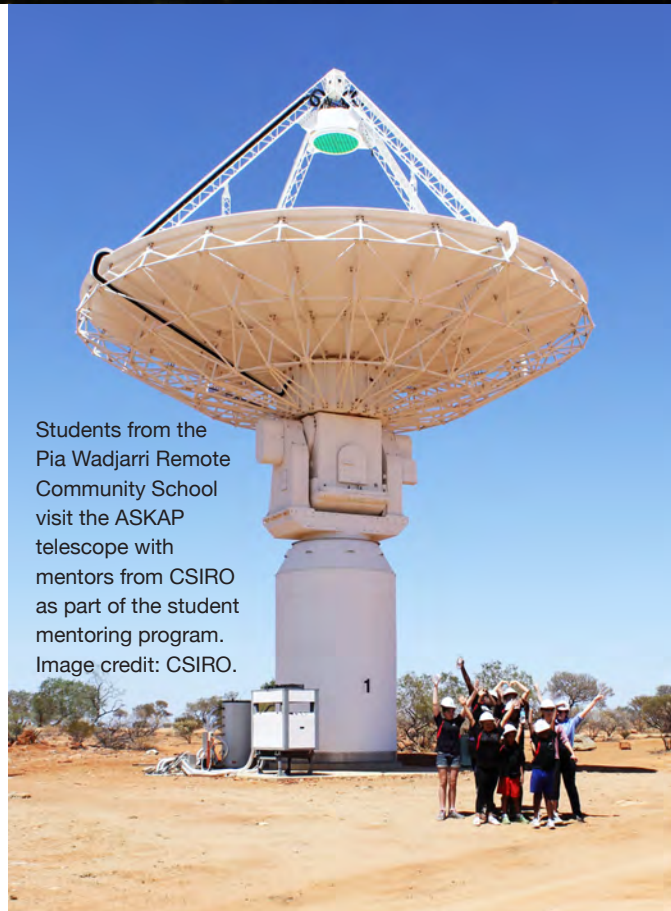
The International Telescopes Support Office at the Australian Astronomical Observatory runs the yearly Australian Gemini Schools Astronomy Contest. In 2014 the contest was won jointly by Ivanhoe Girls Grammar School Astronomy Club (supervised by

Mr Paul Fitzgerald) and Samuel Carbone of Trinity College (supervised by Mr William Cooper). They each proposed to image the merging galaxy system NGC 7727, which was subsequently observed with the Gemini South 8-metre telescope in green, red, and near-infrared filters to yield a dramatic image, dubbed “Cosmic Candy Floss”.

## Mentoring Students in Rural Communities

Through a mentoring program with the Pia Wadjarri Remote Community School, located around 350 km inland from Geraldton, Western Australia, and 80 km from the Murchison Radio-astronomy Observatory (MRO), CSIRO astronomers and outreach specialists are engaging students in interactive classroom activities that explore relationships between the earth and sky, the land and animals of the region, the nearby telescopes and the Wadjarri language. The mentors thoroughly prepare themselves for the engagement by undertaking in-depth cultural awareness training and familiarising themselves with regional opportunities for further education to deliver relevant and tailored advice to the students about academic and training options. As a result, the program is providing a targeted and sustained program for students who would otherwise have limited exposure to external subject matter experts and the world-class scientific facility offered by the MRO, the site of Australia's SKA pathfinder telescopes. The program has given a whole generation of students a great understanding and appreciation for science and introduced lasting educational resources that support key curriculum outcomes.

Students from the Pia Wadjarri Remote Community School visit the ASKAP telescope with mentors from CSIRO as part of the student mentoring program. Image credit: CSIRO.





CSIRO staff work on connecting the third Mk II Phased Array Feed (PAF) to be installed on the ASKAP antennas at the Murchison Radio-astronomy Observatory. Image credit: CSIRO.







# Facilities and Projects

AAL facilitates access to a range of national and international facilities for Australian astronomers and supports projects building infrastructure that align with the national research infrastructure priorities of the Australian Astronomy Decadal Plan. The following pages outline facilities and projects to which AAL committed funding in 2014/15.



# Optical Telescopes: Giant Magellan Telescope

The Giant Magellan Telescope (GMT) is a next generation optical/infra-red telescope that is being built in Chile. At 25 metres in diameter, it will have over six times the collecting area of the largest telescopes currently in existence, and will be critical in enabling Australian-based astronomers to tackle many of the key science questions identified in the 2016-2025 Decadal Plan for Australian astronomy. The Australian National University (ANU) and AAL are both 5% partners in the international consortium that is building GMT. Australia's participation is made possible through the Australian Government's Education Investment Fund (EIF) and National Collaborative Research Infrastructure Strategy (NCRIS) programs.

## Progress and current status

2014/15 saw the GMT project reach one of its most significant milestones, with the announcement in June 2015 that its 11 international partners had committed over US\$500 million to begin construction of the telescope. In addition, in 2014/15 the consortium was delighted to welcome its newest partner, Universidade de São Paulo, Brazil.

Even prior to the construction announcement, the GMT Organization (GMTO) had started laying the groundwork at the telescope site and in 2014/15

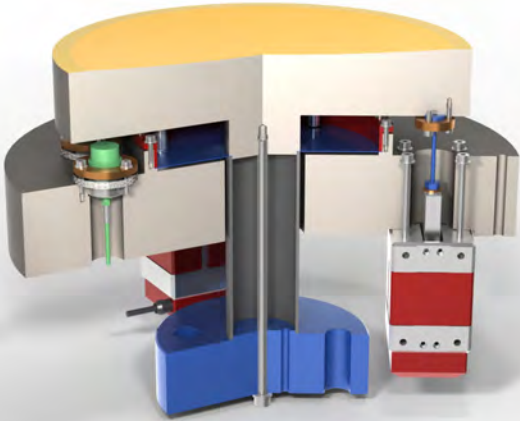
they continued work on fabrication of some of the telescope's seven enormous mirror segments.

In 2014/15, GMTO continued to engage closely with the astronomy community, and in October 2014 they held the 2nd Annual GMT community science meeting in Washington DC. Attended by over 130 scientists, the 3-day meeting covered topics including gamma-ray bursts as probes of the early universe, supernova explosions, the discovery potential of large-scale optical and radio time-domain surveys, and electromagnetic follow-up of gravitational-wave sources.

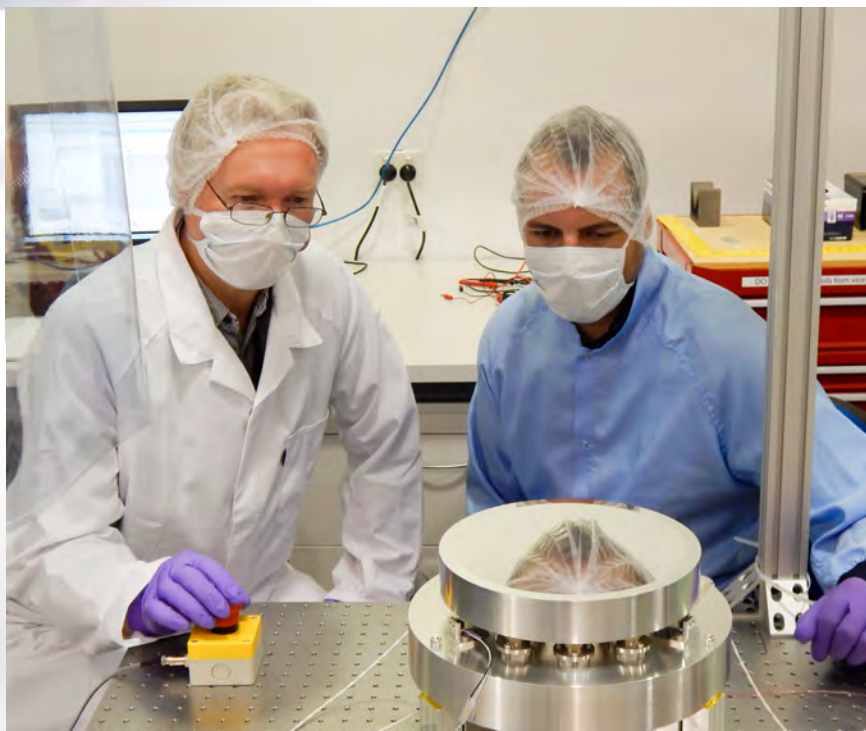


An artist's impression of the GMT.  
Image credit: GMTO.





The GMTIFS adaptive optics beam steering mirror. The design of this component was identified as a key technology risk in the early design phase. Prototyping activities have demonstrated the required milliarcsecond precision over a high dynamic range are achieved.



ANU technical team members John Davies and Rob Boz testing prototype components for GMTIFS. Image credit: ANU.

## Australian instrumentation

Australia is playing a key role in the development of instrumentation for GMT. The GMTIFS (GMT Integral Field Spectrograph) instrument from the ANU has been chosen as one of six GMT first-light instruments for which design studies are being undertaken. The GMTIFS Preliminary Design Study continued to progress in 2014/15. Work has focussed on prototyping of key technologies to reduce project risk, and on repackaging of the instrument to reduce its risk, mass, manufacturing costs, and cooling requirements. A detailed analysis of the instrument has allowed a 30% reduction in linear size without comprising performance.

GMTIFS will be used with the GMT's Laser Tomography Adaptive Optics system, which the ANU is also contracted to develop.

In addition, the AAO proposed MANIFEST (MANY-Instrument FibrE SysTem) is a general-purpose fibre-positioning system, to feed the GMT instruments such as GMACS (a multi-object spectrograph), NIRMOS (a near-infrared multi-object spectrograph) and G-CLEF (a high

resolution optical Echelle spectrograph). In 2014/15, the AAO has continued to undertake the MANIFEST Prototyping Design Study. The key activities during this period have included the development of a functioning fibre positioning telescope demonstrator based on Starbugs technology. This demonstrator is planned for deployment on the UKST during 2015/16. Other efforts have focused on developing the MANIFEST instrument concept with emphasis on the telescope and instrument interfaces in collaboration with the Giant Magellan Telescope Office, and the GMACS and G-CLEF instrument teams.

## The future

The approval for construction has given the green light to begin work on the telescope's core structure and scientific instruments. The project can also begin to address the detailed design of the telescope, which has already successfully passed through several rigorous preliminary design and cost reviews. The current construction schedule would see first light in 2021 and project completion in 2024.



# Optical Telescopes: 8-metre Telescope Access

Access to the world's large 8-metre class optical telescopes remains crucial to the Australian astronomical community and features prominently in the new 2016 - 2025 Decadal Plan for Australian Astronomy as one of the top five infrastructure priorities. AAL investment has provided Australian astronomers access to ~16% of an 8-metre telescope in 2014/2015. In recent years, the majority of this access has been secured through Australia's membership in the International Gemini Partnership, giving guaranteed time on the twin Gemini Telescopes. The new Decadal Plan clearly highlights partnership in an 8-metre telescope as preferred to the purchase of time on the "spot-market". However, as Australia's participation in the Gemini partnership will cease at the end of 2015, all Australian access to large telescopes in 2016 and beyond, through AAL's investments, has been secured through spot-market purchase or agreements. AAL continues to explore potential funding sources and partnership options with a number of facilities.

To provide some transition to the otherwise abrupt end to Gemini access in 2015, AAL has secured 7 nights on the Gemini Telescopes in 2016. AAL has also secured 15 nights/year on the 10-metre twin Keck telescopes in Hawaii in 2016 and 2017, as well as ensured the current access of 15 nights/year on the 6.5-metre Magellan telescopes in Chile continues until December 2017. This access amounts to a total of 37 telescope nights, or ~15.5% of an 8-metre telescope in 2016.

In addition to securing this access, AAL has been working with the ANU and Swinburne University, who each have access to a further 15 nights/year on Keck, to establish a national program to manage all Australian access to the Keck telescopes. The Keck Time Allocation Committee will provide a single interface for Australian-based astronomers who wish to request access to the total of forty-five nights available on Keck in 2016. The process is designed to facilitate larger programs and broader collaborations to maximise the scientific return from Australia's engagement with the Keck telescopes.

## International Telescopes Support Office

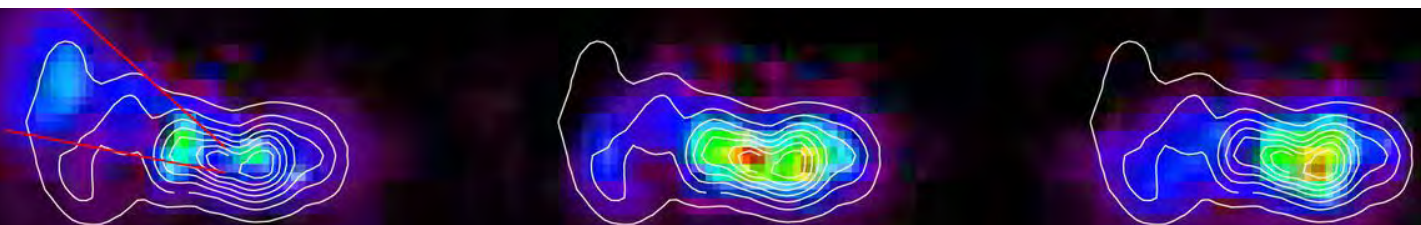
The Australian Gemini Office (AusGO) has been hosted by the Australian Astronomical Observatory (AAO) since 2008, and is responsible for coordinating Australia's usage of its 6.2% share of the Gemini telescopes, from proposal submission to technical assessment, through to observation planning, assistance with data reduction, and publicising of results. In recognition of the fact that the AAO has been and will continue to support the use of many offshore telescopes in addition to Gemini, AusGO became the International Telescopes Support Office (ITSO) in January 2015. ITSO continues to manage AAL's access to 15 nights per year on the Magellan telescopes, and from 2016 will also be supporting

the 15 nights per year on the Keck telescopes negotiated by AAL, and managing the new joint Australian Keck Time Allocation Committee.

In 2014/15 AAL have supported the staffing and operations of ITSO using \$0.4M of the Commonwealth government's funds. The total funding invested to date, through NCRIS, EIF and other research infrastructure programs is \$2.2M.

### Progress and current status

Following the first very successful Australian Gemini and Magellan science symposium in 2012, ITSO hosted a similar event in May 2015 at the AAO in



Australian Gemini Undergraduate Summer Student Rebecca Davies used the Gemini Multi-Object Spectrograph to look at a galaxy which shows a quasar ionisation echo from an extended gas reservoir surrounding the central accreting black hole. Image credit: Davies et al. 2015, MNRAS, 449, 1731.



<b><i>Gemini</i></b>	<b><i>Magellan</i></b>	<b><i>Keck</i></b>
The 8-metre diameter twin Gemini telescopes are located in on Mauna Kea in Hawaii (Gemini North) and in Cerro Pachon Chile (Gemini South). Australian astronomers have access to 6.19% of the available time on these telescopes until December 2015. A further 7 nights have been purchased on the telescopes in 2016.	The twin Magellan telescopes, the 6.5-metre Baade and Clay telescopes, are located at Las Campanas Observatory in Chile. Australian astronomers have access to 15 nights a year on Magellan through to December 2017.	The 10-metre twin Keck telescopes are located on Mauna Kea in Hawaii. Australian astronomers have access to 15 nights a year on these telescopes in 2016 and 2017.

Sydney. This meeting also featured Australian science being conducted with the Keck telescopes, in recognition that users at Swinburne University of Technology and the Australian National University already enjoy access to these telescopes, as will the entire Australian community from 2016. Participants were introduced to the full “smorgasbord” of instrumentation they will have access to on Gemini, Magellan, and Keck from next year.

The Australian Gemini Undergraduate Summer Studentship (AGUSS) program offers talented undergraduate students the opportunity to spend 10 weeks working at the Gemini South observatory in La Serena, Chile, on a research project with Gemini staff. They also assist with queue observations at Gemini South itself, and visit the Magellan telescopes at Las Campanas Observatory. The 2014/15 AGUSS program saw the largest number of applications to the program ever. The two successful students were Rhiannon Gardiner from Monash University and Conor O'Neill from the University of Queensland. Gardiner worked on a spatially-resolved spectral analysis of planetary nebulae, while O'Neill worked on understanding why neighbouring galaxies contain vastly different numbers of globular clusters.

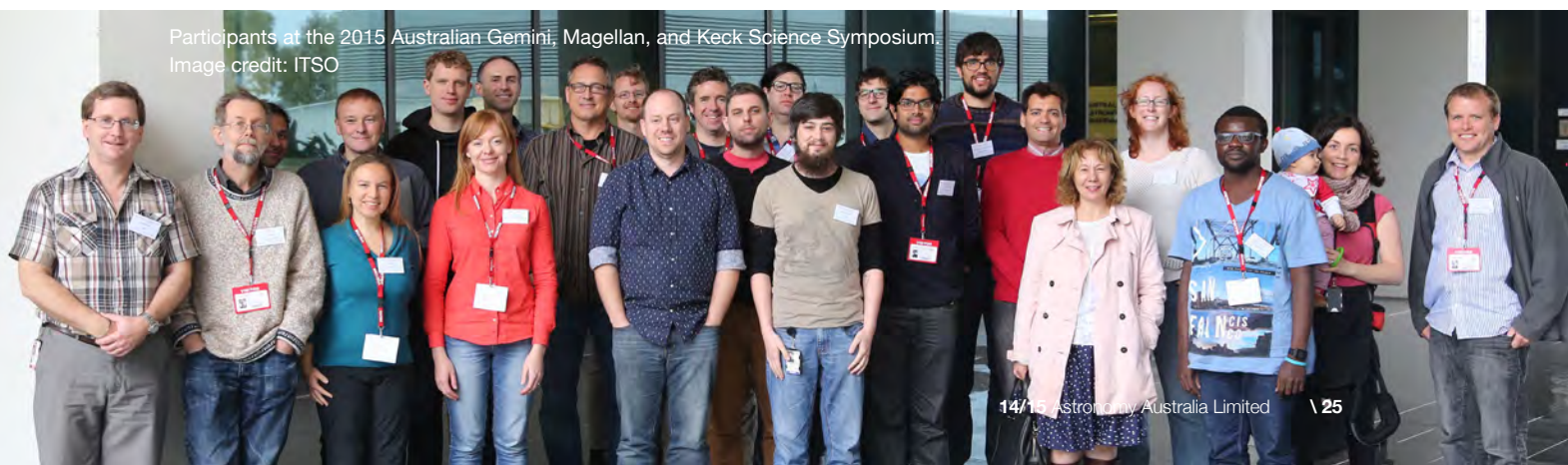
ITSO have been concerned in the past two years with an apparent decline in demand for Gemini and Magellan. However, 2015B (the last full semester in which Australia is a full partner in Gemini) has seen a significant turnaround, with demand the highest it has been over the past 5 years. ITSO have been active in promoting awareness of 8-metre access opportunities in 2015–2017, undertaking a “road show” of major astronomy institutions in Sydney, Melbourne, Canberra, Brisbane, and Perth in March 2015. Additionally, new instruments and modes being offered both at Gemini (non-redundant masking in the Gemini Planet Imager; high-resolution spectroscopy) and Magellan (natural guide star adaptive optics; multi-fibre spectroscopy) have broad appeal to the Australian community.

## The future

One of AAL's highest priorities is to continue pro-actively exploring funding and partnership opportunities to deliver on the community's 8-metre telescope aspirations in the new Decadal plan.

We will also continue to support ITSO in 2015/16 to administer the National time allocation process for overseas optical telescopes and enable user travel, observing and training.

Participants at the 2015 Australian Gemini, Magellan, and Keck Science Symposium.  
Image credit: ITSO





# Optical Telescopes: The Anglo-Australian Telescope

The Anglo-Australian Telescope (AAT) is Australia's front-rank National optical/infrared facility, comprising an exceptionally high-quality 4-metre telescope equipped with a suite of state-of-the-art instrumentation, including the HERMES and AAOmega spectrographs. Operated by the Australian Astronomical Observatory (AAO), the AAT was constructed in Australia so that astronomers could explore in detail some of the most exciting regions of the sky, including the centre of our own Milky Way Galaxy and its nearest neighbours the Magellanic Clouds. Some of the finest globular clusters and nearest radio galaxies can only be seen with difficulty from northern latitudes, if at all. The AAT has provided a foundation for Australia's excellence in optical astronomy since it was commissioned almost four decades ago, and the ongoing maintenance and new instrumentation has allowed the AAT to continue producing leading science.

In 2014/15, AAL supported the upgrade and maintenance of AAT through NCRIS funds (\$0.3M). AAL has a long history of supporting AAO to develop innovative new AAT instrumentation as well as undertake vital maintenance of the AAT building, allocating over \$12.5M of funding from the Commonwealth government's NCRIS and EIF and other infrastructure programs since 2007.

## AAT Survey Highlights

### *GALAH Survey*

The HERMES spectrograph is the EIF/NCRIS-funded fibre-fed optical High Resolution Multi-Element Spectrograph, which provides a unique and powerful facility for multi-object spectroscopy that is unrivalled by any other telescope in the world. HERMES is performing to specification and is available as a common user facility instrument on the AAT. The primary science objective of HERMES is to unravel the Milky Way's formation history through a major survey of up to a million stars using chemical tagging and velocity measurements, called the Galactic Archaeology survey with HERMES (GALAH). The GALAH Survey is now well underway and on track to achieve its scientific goal of unravelling the history of our Galaxy. HERMES has also been available to the observing community as a general user instrument since early 2014.

### *OZDES survey*

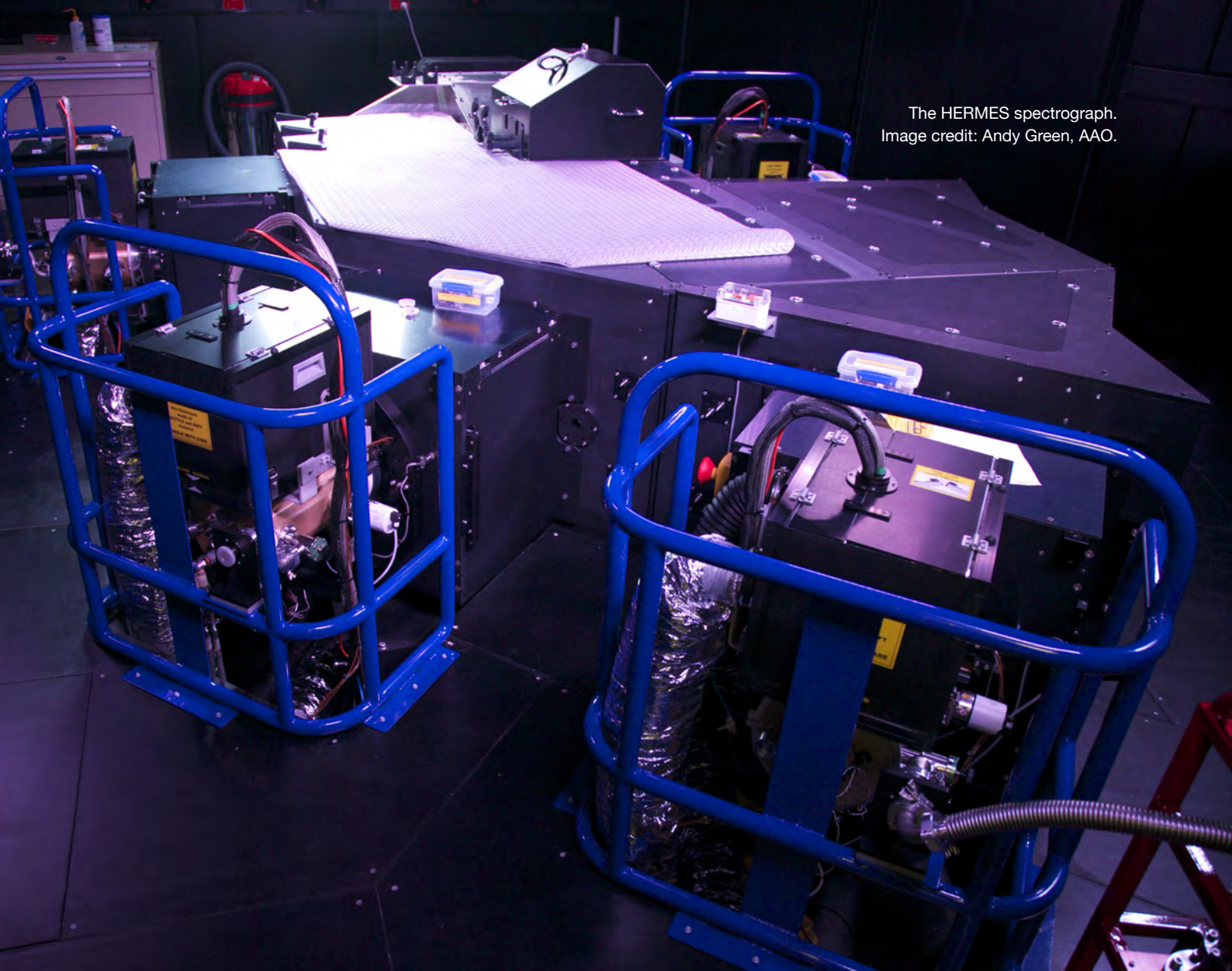
The Australian Dark Energy Survey, OzDES, galaxy redshifts will measure the redshifts of tens of thousands of galaxies to make the most detailed measurement of the Universe's expansion history and will lead to a better

understanding of the physics behind the acceleration of the Universe. In its first two years OzDES has obtained the host galaxy redshifts of thousands of transients, identified dozens of supernovae, and monitored hundreds of Active Galactic Nuclei. OzDES is just about to complete the second year of observations. OzDES has used over a quarter of its 100 night allocation and will continue until 2017. As at February 2015, 165 unique targets had been observed, and redshifts obtained for 11,424.

### *SAMI Survey*

SAMI is a Multi-object Integral-Field Spectrograph that allows a unique view of how stars and gas zoom around inside distant galaxies. The first 235 galaxies observed by the SAMI survey were used to investigate if a unified dynamical scaling relation for galaxies of all types exists. The results have illustrated how the combination of dispersion and rotation velocities can produce a general and robust dynamical scaling relation. This represents a unique tool for investigating the link between galaxy kinematics and baryonic content. With the completion of the SAMI survey it will soon be possible to gain further insights into the origin of this new dynamical scaling relation.





The HERMES spectrograph.  
Image credit: Andy Green, AAO.

## Progress and current status

It was a busy year for the AAO as it undertook important upgrades to its instrumentation suite to keep it at the forefront of scientific capability, along with maintenance of the AAT infrastructure to allow it to continue functioning reliably and safely. Work completed or commenced during 2014-15 included:

- Upgraded the AAOmega spectrograph with two new CCDs substantially improving the sensitivity of both the blue and the red ends of the spectrum.
- Worked commenced on an upgrade of the 2dF fibres, which feed the AAOmega. A further throughput gain is expected from the new 2dF fibres that will be installed with the HERMES fibres. Together with the ongoing refurbishment of the 2dF positioner, the AAOmega will continue to be highly

competitive and sought after for a wide variety of wide field and integral field unit spectroscopic programs for at least the next five years, and very likely longer.

- Replacement of the telescope hydraulic oil system
- Replacement of the AAT main dome shutter and windscreen controls
- Windscreen platform maintenance

## The future

AAL's NCRIS 2015/16 funding will support critical major maintenance of the fibre cable system that channels light into the two most heavily used AAT spectrographs: HERMES and AAOmega. Replacing the fibre cable will increase the reliability and the availability of HERMES and AAOmega and assist in keeping the technical downtime below the target of 3%.



# Radio Telescopes: SKA Pathfinders

The multibillion dollar Square Kilometre Array (SKA) will be built by an international partnership and located in Australia and South Africa, resulting in infrastructure worth hundreds of millions of dollars being developed and operated in Australia, with strong involvement from local industry. Australia has invested in two SKA precursor telescopes, the Australian SKA Pathfinder (ASKAP – capital value \$188M) and the Murchison Widefield Array (MWA – value \$50M). These precursors are acting as test-beds for advanced technology solutions for the SKA and demonstrating the exceptional conditions in outback Western Australia for radio astronomy. In addition, they are scientifically powerful instruments in their own right, serving data to more than a quarter of Australian astronomers and hundreds of international collaborators.

## Murchison Widefield Array

The Murchison Widefield Array (MWA) is a low-frequency radio telescope, located at the Murchison Radio-astronomy Observatory (MRO) in Western Australia where the future Square Kilometre Array (SKA) low-frequency array will be built, and is one of three telescopes designated as a Precursor for the SKA. The MWA is a collaboration between 13 research institutions in four countries (Australia, India, New Zealand and the United States) and is led by Curtin University.

The telescope collects radio waves with low frequencies between 80 and 300 MHz via 4,096 antennas, split up into 128 groups of 32 called 'tiles' that are spread as far as 3 km apart. It is designed to have a wide field of view on the sky and to be highly versatile and adaptable through signal processing rather than through moving parts.

The MWA is performing large surveys of the entire Southern Hemisphere sky and acquiring deep observations on targeted regions. It enables astronomers to pursue four key science objectives. The primary endeavour is the hunt for intergalactic hydrogen gas that surrounded early galaxies during the cosmological epoch of reionization. The MWA will also provide new insights into our Milky Way galaxy and its magnetic field, pulsing and exploding stellar objects, and the science of space weather that connects our Sun to the environment here on Earth.

During 2014/15, AAL supported MWA operations through \$0.6M of NCRIS funding. AAL has previously provided \$8.6M to enable MWA construction and early operations, using Commonwealth funding under NCRIS, EIF and other infrastructure programs.

### Progress and current status

In 2014/15 the MWA completed its third and fourth six-month observing campaigns. A total of 4010 hours of observing were completed, with 4 petabytes of data collected. Since commencing operations in July 2013, the MWA has completed 5635 hours of observing and collected 5.7 petabytes of data in support of the science programs awarded time on the telescope.

The MWA archive—including commissioning data and products—now contains more than 6 petabytes of data. This is an unprecedented

research resource that will support the radio-astronomy community for decades to come. 2014/15 saw the first public release of MWA data, and in line with its open-skies philosophy, data collected during the MWA's inaugural observing campaign in the second half of CY2013 is now freely available to anyone who wants to use it.

MWA's voltage capture capability was successfully implemented and offered for the first time in 2014/15. The commissioning of this observing mode improves the MWA's utility for observing pulsars and other transient





phenomena. This will allow the MWA to play an important role in validating this approach to meeting an increasingly important SKA1-low science use case.

MWA's science output has accelerated significantly, as evidenced by the recognition of eight MWA researchers at the 2015 Thompson Reuters Citation and Innovation awards. For such a new facility, this is a remarkable achievement.

## The future

AAL's NCRIS funding for 2015/16 will support continued MWA operations until mid-2016. This equates to a further 3000-4000 observing hours and includes new capabilities and observing modes becoming available to users. In addition

to routine operations, the NCRIS 2015/16 funds will also provide a vital boost to the level of maintenance and spare parts in order to protect this \$50M facility from damage and downtime.

The early success of the MWA has generated enthusiasm within the radio-astronomy community for its continued development. Community consultation and planning for extensions and upgrades to the MWA were progressed through 2014/15, culminating with the submission of a funding proposal to the Australian Research Council to double the number of tiles in the MWA and to double the array size from 3 km to 6 km. Subject to a successful and timely funding outcome, an extended MWA could be operational for observing from CY2017.

## Thompson Reuters Citation and Innovation Award

The 2015 Thompson Reuters Citation and Innovation awards recognises outstanding contributions to research and excellence in innovation. Eight MWA researchers received this prestigious award in the Space Science category for science output in cited publications. The MWA Collaboration productivity has accelerated significantly with 35 papers published in refereed journals; seven papers published in refereed conference proceedings; five papers submitted to refereed journals; five papers under collaboration review; and 19 live paper proposals posted for collaboration review.

In further recognition of the growing body of work produced by MWA researchers, the journal Publications of the Astronomical Society of Australia, produced a special library and glossy digest of MWA papers they have published.



At the Thompson Reuters Citation and Innovation awards, from left to right, Professor Frank Briggs, Dr Randall Wayth, Professor Steven Tingay, Professor Rachel Webster and Ms Kate Gunn.





## Australian SKA Pathfinder

CSIRO's Australian Square Kilometre Array Pathfinder (ASKAP) located at the Murchison Radio-astronomy Observatory (MRO) in Western Australia, is designed to be one of the world's fastest and most powerful radio telescopes, with a large field-of-view and novel phased-array feed (PAF) systems. The telescope is made up of 36 antennas, each 12 metres in diameter, working together as a single instrument and will allow astronomers to answer fundamental questions about our Universe, such as the nature of cosmic magnetism and the evolution and formation of galaxies.

A world-leading telescope in its own right, ASKAP is pushing the boundaries of scientific and engineering innovation, developing revolutionary technologies that will transform radio astronomy, and prepare for the future Square Kilometre Array telescope – an international project to build the world's largest and most sensitive radio telescope.

In 2014/15, AAL supported early operations of ASKAP with \$4.1M of NCRIS and CRIS funding to CSIRO. AAL has previously provided a total of \$16.6M under the Commonwealth government's NCRIS, EIF and other research infrastructure programs to support ASKAP construction and operations.

### Progress and current status

2014/15 saw a number of exciting early science results coming out of operations activities with the first generation (Mk I) phased array feed (PAF) receivers (known as BETA). These initial science results – including the detection of distant radio signals from a galaxy five billion light-years away, the discovery of 'dark clouds' around a galaxy, and observations of an intermittent pulsar – have been prepared for publication in scientific journals. Each paper demonstrates a unique

capability of ASKAP, and provides a glimpse into the scientific potential of the full ASKAP telescope.

In parallel with the early science operations, there has been an acceleration in the production of the next-generation (Mk II) PAFs, with three completed Mk II PAFs systems installed at the MRO in 2014/15. Preliminary measurements of the on-dish performance of the prototype Mk II PAF show significant improvement over the Mk I PAF. The Mk II PAF achieves low-noise performance across the full ASKAP band (700





- 1800 MHz). Above 1400 MHz, sensitivity has been doubled and survey speed quadrupled and the Mk II achieves a minimum system-temperature-on-efficiency of 78 K at 1230 MHz and is <95 K from 835 - 1800 MHz (the Mk I PAF is <95 K only from 735 - 1200 MHz).

The ASKAP team's efforts developing the phased array feeds were recognised through success at the 2014 Australian Innovation Awards. The award cited the scientific, technical and logistical success of the project, in taking expertise in the research and development of cutting-edge low-cost technologies, and working together with industry to put these technologies into production.

A major challenge for ASKAP will be processing and archiving the data that will flow at ever increasing rates as more Mk II PAFs are installed on the telescope. During 2014/15, this challenge was being tackled by the ASKAP Commissioning and Early Science team (ACES); a think-tank of astronomy synthesis data specialists who are developing data calibration solutions to transform the raw ASKAP data into a scientifically usable and meaningful data product.

This data will be used by the ten ASKAP Survey Science Projects, which collectively will make use of at least 75% of the telescope time during the first 5 years of operations. These highly collaborative Projects involve 363 investigators from 131 institutions around Australia and the world, and were designed to exploit the telescope's unique capabilities to gain new scientific insights.

To ensure close consultation with ASKAP users during the early science planning, the team has established the ASKAP Early Science Forum, which has met monthly since March 2015. These supplement the annual Early Science Workshops, through which about 100 people have been involved in the discussions so far.

## The future

2015/16 will see ASKAP early science continue in parallel with construction and commissioning. The early science activities will be supported with AAL's NCRIS 2015/16 funding, and will include a series of observing programs using arrays of Mk II PAFs, which will continue to be installed on the ASKAP antennas (funded by CSIRO through non-NCRIS funds).



# eResearch: gSTAR

Astronomy is an increasingly computationally and data-intensive discipline, requiring world-class high performance computing (HPC) and software capability to power large theoretical simulations and to process enormous data sets from next-generation telescopes. Moreover, theoretical and computational astrophysics has grown to become a focus across all areas of strength in Australian astronomy research, and represents approximately one third of research impact, according to the 2016-2025 Decadal Plan for Australian Astronomy. Australian astronomers use a range of HPC infrastructure, including the peak facilities at the National Computational Infrastructure and the Pawsey Centre, as well as the AAL-funded GPU-supercomputer at Swinburne University of Technology, which provides National astronomy-dedicated time.

The GPU Supercomputer for Theoretical Astrophysics Research (gSTAR) provides the Australian astronomy community with a next-generation computing cluster based on graphics processing unit (GPU) technology, which offer an affordable path to a massive boost in processing power. The key objectives of gSTAR are:

- i. to provide national access to a large-scale GPU-based supercomputer;
- ii. to keep Australian astronomers at the cutting-edge of theoretical research and processing of Big Data;
- iii. enhance the capacity of the national astronomy community to undertake world-leading research and provide scientific innovation;
- iv. facilitate training to graduate students in this emerging area of computation.

During 2014/15, AAL supported ongoing operations of gSTAR using NCRIS funding (\$0.2M). AAL has previously supported the construction and operations of gSTAR, with a total of \$1.2M of funding being provided to this facility under the Commonwealth government's NCRIS, EIF and other research infrastructure programs. gSTAR is fully operational and the overall capital value is ~\$3.5M.

## Progress and current status

During 2014/15, national astronomy researchers had access to a minimum 40% of the total compute capability on the Swinburne supercomputer and a minimum 200 terabyte of storage, with dedicated staff for support and training. In total there are over 2000 CPU-cores and ~200 GPUs. In the past year Swinburne has spent ~\$600K to upgrade the capabilities of the Lustre filesystem and expand the capacity from 1.8 to 3.0 Petabytes. Swinburne has also added a separate 400 terabyte storage area (nfs filesystem).

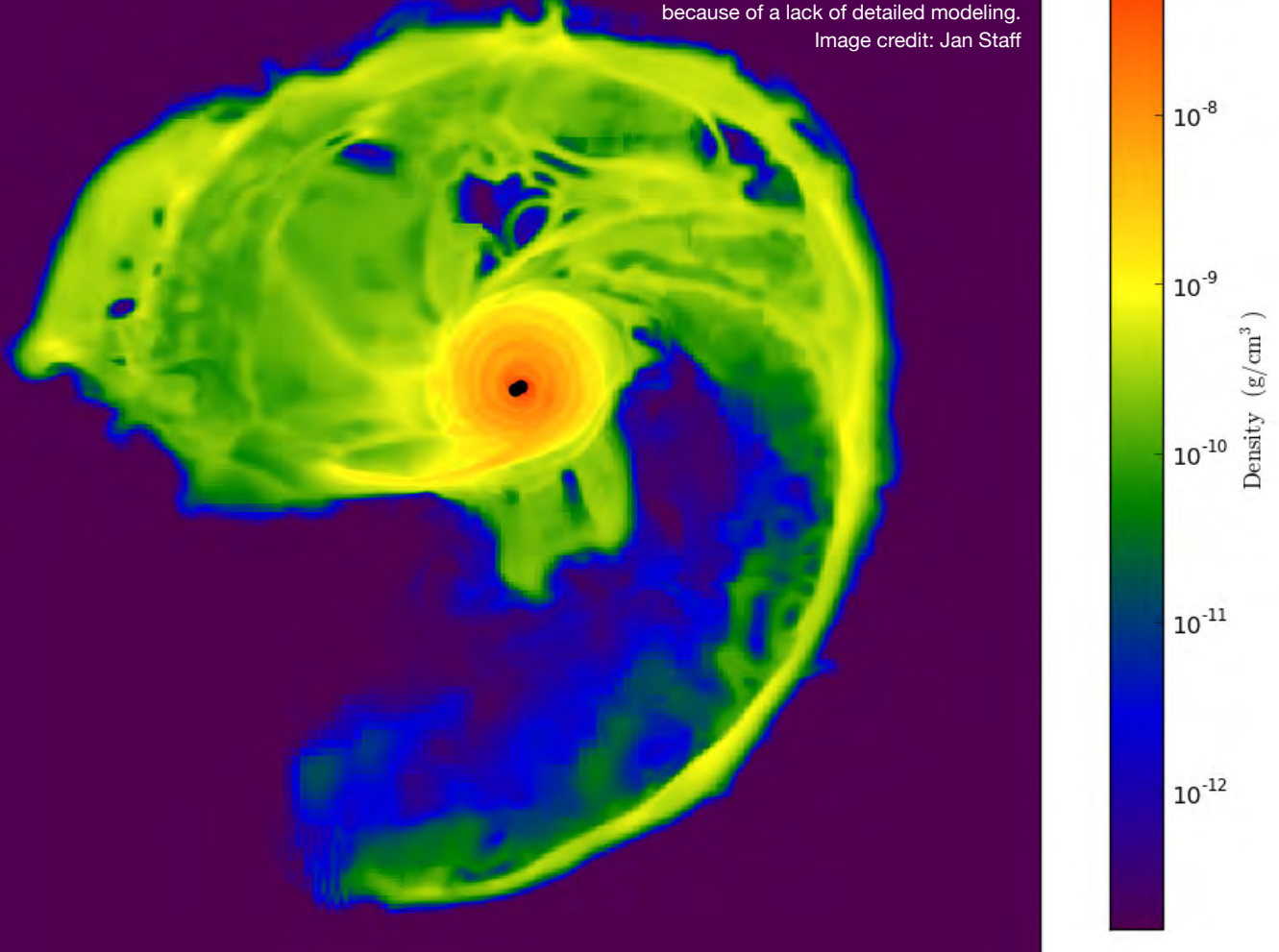
Two web servers have been added to the facility which now host an upgraded facility website and provide the data-sharing capability. Two gSTAR projects have been enabled for data-sharing: a Fast Radio Burst archive and the GERLUMPH microlensing maps.

Due to the increase in support staff over the 2014/15 year, the facility remained readily accessible to astronomers for greater than 98% of the time and usage of the facility grew steadily. A user tutorial on software development/debugging for HPC was created and presented as a webinar to the community. This became the first in a series of recorded HPC webinars made available on the facility website. A two-day user workshop focussed on GPUs and the CUDA programming language was delivered at Swinburne University. This education and assistance relating specifically to GPUs was provided to the national community and GPU-usage increased by 13%. A survey of users was conducted with overall user satisfaction (including support experience) greater than 90% that shows a direct measure of the effectiveness of the facility support team.



Simulations of the interactions and mergers of binary stars are shedding light on the mysterious process of common-envelope evolution, where a giant star and a Sun-like star spiral together within the diffuse envelope of the giant, producing either a merger of the stars or a close binary system. The production of many exotic binaries and events, such as X-ray binaries and type Ia supernovae, depend on this process but to date little is understood about the likely outcomes because of a lack of detailed modeling.

Image credit: Jan Staff



gSTAR has become a very scientifically productive facility. In 2014/15, 69 facility-related refereed astronomy journal articles were published, involving 120 Australian-based and over 300 international co-authors, from 12 Australian and >100 international institutions (across 26 countries). These papers also included 141 student co-authors. The past year saw 250 astronomy users of the facility, comprising ~200 Australian-based and ~50 international researchers.

In 2014/15, AAL continued to support efforts in this area through the management of the Astronomy Supercomputer Time Allocation Committee (ASTAC) that uses a merit-based allocation process to assign time for astronomy projects at these three facilities.

Over the past year, gSTAR resources were directly utilised in 5 successful ARC grants, and

12 ongoing grants and fellowships. gSTAR is being utilised to benchmark the Square Kilometre Array (SKA) central signal processing pulsar search sub-element algorithms and software as part of the SKA Pre-construction grant awarded to Swinburne. gSTAR also continues to be a pivotal component of the All-Sky Virtual Observatory (ASVO) e-Research project, and is the host of the Theoretical Astrophysical Observatory node of ASVO.

## The future

AAL's NCRIS 2015/16 will help support continued operations of gSTAR/SwinSTAR and to allow the team to provide targeted training and support to help other capabilities and industry get more value from gSTAR/SwinSTAR. These funds will also keep the Swinburne-based theory "Node" of the All Sky Virtual Observatory operating.



# eResearch: All-Sky Virtual Observatory

Astronomical telescopes are increasingly producing data in volumes that are pushing the limits of both hardware and software. To extract the most science from the data requires moving to a model of distributed storage and seamless query tools, to allow users to access, compare and combine different types of datasets across the wavelength spectrum. This approach is currently being implemented within the All-Sky Virtual Observatory ([www.asvo.org.au](http://www.asvo.org.au)), funded by the Australian government, via the National eResearch Collaboration Tools and Resources (NeCTAR) program, with additional support via NCRIS, EIF, and other research infrastructure programs. In 2014/15, AAL invested \$0.5M of funding to ASVO development and operations. A total of \$2.8M of Commonwealth government funds has been provided to ASVO.

## Progress and current status

ASVO comprises a growing number of “Nodes”:

**ASVO-TAO Node:** The Theoretical Astrophysical Observatory (TAO | [tao.asvo.org.au](http://tao.asvo.org.au)), deployed at Swinburne University and launched in March 2014, houses simulation datasets and galaxy formation models, alongside tools such as the “telescope simulator”, that enables researchers to create mock universes to compare with real observations. During 2014/15, the number of TAO users grew to almost 250, of whom half are international users. Work commenced in 2014/15 to make it easier for TAO users to share and publish their data and workflows, made possible through funding from NeCTAR and the Australia National Data Service.

**ASVO-SkyMapper Node:** Deployed at ANU this Node provides access to data from the SkyMapper telescope, which is producing the most detailed and sensitive map of the southern sky at optical wavelengths. In mid-2015, ANU unveiled enhanced data services over the top of a test data release, to let the community trial the new tools and protocols. The first fully calibrated data release is expected by early 2016.

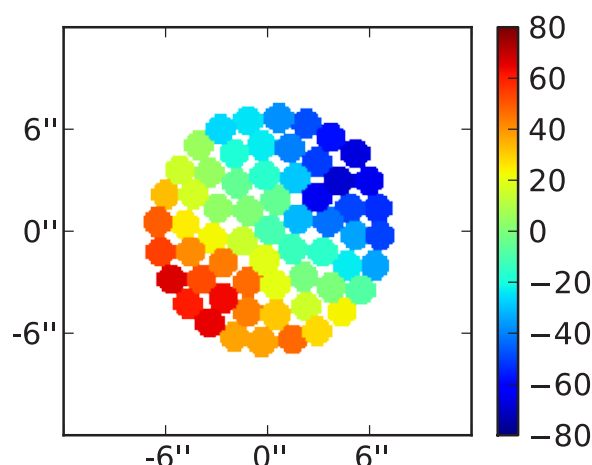
**ASVO-AAT Node:** In the early stages of development, the ASVO-AAT Node will give users access to key

optical datasets from the AAT, beginning with: 1) the Galaxy And Mass Assembly survey that itself brings together multi-wavelength data from a range of telescopes to study the evolution of galaxies and the Universe, and 2) the Sydney-AAO Multi-object Integral-field (SAMI) spectrograph survey that puts 13 fused hexabundles, each containing 61 fibres, across a square-degree field of view to survey 5000 galaxies and obtain a spatially-resolved view of galaxy evolution.

**ASVO-MWA Node:** AAL is currently funding a design study to determine the requirements for building the first radioastronomy Node of ASVO, which would support access to the complex data from the AAL-supported Murchison Widefield Array telescope. MWA is a precursor to the future Square Kilometre Array (SKA) and has already collected over 5 petabytes of data and is proving to be a valuable test bed for both the telescope hardware and the associated eResearch infrastructure.

## The future

AAL’s NCRIS 2015/16 funding will support the running costs of the operational ASVO Nodes and activities to continue optimizing data support and federation. AAL will also work with eResearch capabilities such as NeCTAR, ANDS and RDS to improve the cross-connectivity between astronomy datasets and services.



The ASVO-AAT node will give access to data from the SAMI galaxy survey. The image shows Galaxy ESO 185-G031 observed with SAMI (circle = SAMI hexabundle footprint). Image credit: Fogarty et al. 2012.



# Antarctic Astronomy: PLATOs

The high Antarctic Plateau is one of the best sites in the world to undertake optical and infrared astronomy, due to the cold, dry and stable atmospheric conditions. In addition, it is the only ground-based site from where terahertz observations can be made. AAL has supported Australian activities in the field of Antarctic astronomy for several years. Key aspects have included the development and operation of a series of robotic observatories called PLATOs ("PLATeau Observatory") that have now been deployed to several locations on the high Antarctic plateau (Dome A, Dome Fuji, Ridge A) in collaboration with Chinese, Japanese, and US institutes and Antarctic logistics agencies.

In 2014/15 AAL invested \$0.1M towards the costs of operations and servicing of PLATOs using NCRIS funding. AAL has previously supported the construction and operations of PLATOs and associated instrumentation, bringing the total of Commonwealth funding to approximately \$1.7M.

## Progress and current status

The PLATO robotic observatories are the primary support platforms for a number of telescopes and scientific instruments on the Antarctic Plateau.

PLATO-R supports the 0.6-metre aperture terahertz telescope, HEAT, at Ridge A. The telescope is being used to create a spectroscopic map of the Milky Way Galaxy at terahertz frequencies. The critical spectral emission features of dominant forms of carbon at terahertz frequencies can be used to probe star formation in the Galaxy.

PLATO-A is based at China's Kunlun Station, Dome A. It supports a number of experiments, including the first two of three Antarctic Survey Telescopes (AST3) - wide-field, high-precision optical survey instruments, whose main science goals include the search for extra-solar planets and supernovae. The second AST3 telescope was deployed to the Kunlun Station over the past 2014/2015 Antarctic summer. During 2014/15, both the Ridge A and Dome A service missions were highly successful. At Ridge A, staff from the AAO and UNSW along with staff from the

University of Arizona with the support of US National Science Foundation logistics, serviced the PLATO-R module, upgraded the HEAT instrument, and installed the Near Infrared Sky Monitor (NISM) instrument. At Dome A, logistics personnel from the Polar Research Institute of China and two astronomy personnel from Nanjing Institute of Astronomical Optics and Technology and the Purple Mountain Observatory, under direction from UNSW and AAO staff, performed maintenance on the PLATO-A module, repaired the AST3-1 telescope, installed the new AST3-2 telescope, and installed the Near-Infrared SPECTrometer (NIRSPEC). Currently PLATO-A and PLATO-R are fully operational. All the UNSW instruments and the University of Arizona HEAT telescope have been working all year and acquiring good data. The AST3-1 & 2 telescopes have experienced problems with icing of one or more optical surfaces, which has limited the amount of data that could be taken.

## The future

AAL's NCRIS 2015/16 funding will support the continued operations and servicing of PLATO-A at Dome A to provide critical power and data support to the Chinese partners' AST3 telescope and instrumentation in Antarctica.



AAO engineer Nic Bingham installing the NISM near-infrared sky monitor on the PLATO-R observatory at Ridge A in January 2015. Image Credit: Matthew Freeman.



# High-Energy Astrophysics: Pierre Auger

Australian scientists and engineers make unique and valued contributions as minor partners in a number of large, international facilities and collaborative projects. Small investments that support Australian involvement in such partnerships can often be an effective way to gain access to cutting-edge facilities. AAL has adopted this approach in supporting Australian interest in high-energy astrophysics projects.

Australian involvement in the Pierre Auger Observatory in Argentina is through the University of Adelaide, based on their long experience in high energy astrophysics and, particularly, in the atmospheric fluorescence techniques employed by the optical detectors of the Observatory. With AAL-support, the University of Adelaide built cloud monitoring systems for the Observatory that were commissioned in 2013. In 2014/15, AAL used NCRIS funds to continue supporting operations and servicing of these critical cloud camera systems, bringing the total amount of funding provided to the project through the Commonwealth's EIF and NCRIS schemes to \$0.1M.

## Progress and current status

The Pierre Auger Observatory, located in Argentina is devoted to the study of ultra-high energy cosmic rays. It operates as a hybrid observatory with two major components, a ground-based system of 1660 large-area radiation detectors, plus a system of 27 4-metre diameter UV telescopes which track cosmic ray cascades as they pass through the atmosphere at distances of up to 40 km, on clear moonless nights. The Observatory is a scientific collaboration between 18 countries around the world, including Australian scientists.

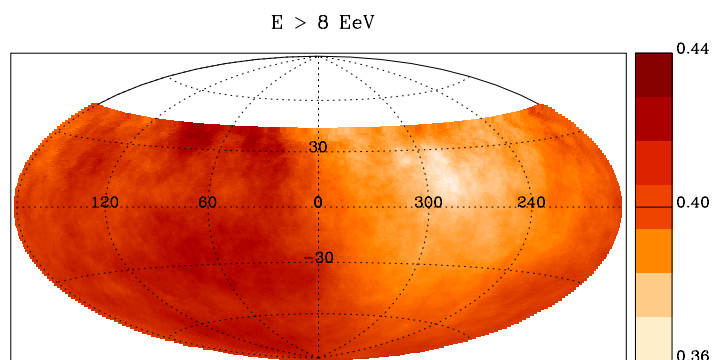
The infra-red cloud cameras purchased through AAL funding have proved to have excellent performance and reliability. Each of the four new long-wave infra-red cameras scan the sky at 15 minute intervals to provide real-time data on cloud conditions. The images produced provide both data on cloud cover for each fluorescence telescope pixel and real-time all-sky cloud images for observers. Four cameras operate on each shift night, one supporting each telescope site. Those sites are located with spacings of about 60 km.

The data from the large telescopes are presently being used to determine the composition of the cosmic rays which are detected at the highest energies. This is a major success for the Observatory and depends heavily on reliable atmospheric monitoring (including cloud). It had not been expected to be possible at these energies where the composition of nuclei at typical distances of 40 km is commonly required. These data are now being used to interpret the directional properties of the cosmic ray beam which result from the structure of galactic and inter-galactic magnetic fields combined with the composition properties of the beam.

## The future

AAL has assigned NCRIS 2015/16 funds to support continued operations of the Pierre Auger cloud cameras. Beginning in 2015/16, AAL will also support Australian involvement in a complementary high-energy astrophysics project; the Cherenkov Telescope Array (CTA). CTA is a 200M-Euro project for ground-based gamma-ray astronomy now entering its pre-production phase. Australia's role in this project includes the design of observing procedures and analysis and of key science projects in large-scale surveys. The project has to date attracted over 1000 scientists in over 25 countries. The CTA-Australia consortium comprises six institutions, led by the University of Adelaide.

AAL will also be establishing a multi-messenger advisory committee in 2015/16 to explore global developments and opportunities within high-energy astrophysics and gravitational wave physics facilities.



A sky map of cosmic rays as recorded by the Pierre Auger Observatory. Recent results have shown a large-scale directional flow past the Earth of the highest energy cosmic rays ( $>8 \times 10^{18}$  eV). Image Credit: Aab et al. (2015, The Astrophysical Journal 802:111)





# AAL Organisational and Governance Structure



# AAL Community Engagement

## July

- AAL staff gave a presentation at the Harley Wood Winter School
- AAL sponsored and participated in the Astronomical Society of Australia's Annual Scientific Meeting in Sydney
- AAL Chair update on AAL activities to the National Committee for Astronomy

## August

- AAL staff attended the Women in Astronomy workshop in Canberra

## September

- AAL participated in the annual National Collaborative Research Infrastructure Strategy (NCRIS) forum in Canberra
- AAL exhibited at the NCRIS Showcase at Parliament House, Canberra

## October

- Publication of AAL's 2013/14 annual report
- AAL sponsored and attended the Murchison Widefield Array future workshop in Sydney
- AAL attended the Australian SKA Pathfinder early science planning workshop in Sydney
- AAL staff gave a presentation on the All Sky Virtual Observatory at the eResearch Australasia conference in Melbourne

## November

- AAL's Annual General Meeting at the University of Sydney

## December

- AAL's 2013/14 annual report and cover letter sent to the DVC-R or head of each AAL member institution
- AAL was awarded a Bronze Pleiades Award 2014 by the ASA's Chapter for Women in Astronomy

- AAL staff gave presentation at the Australian Academy of Science, Frontiers of Science symposium in Canberra
- AAL CEO update on AAL activities to the National Committee for Astronomy
- AAL staff participated in an NCRIS eResearch Infrastructure workshop hosted by the Department of Education and Training in Canberra

## February

- AAL staff attended Giant Magellan Telescope Organisation dinner in Sydney, with GMTO Board, parliamentarians, Australian astronomers and media
- AAL Chair and Deputy Chair attended Science Meets Policymakers event in Canberra
- AAL staff attended the Decadal Plan Roadshow sessions in Sydney, Canberra, Perth, Melbourne and Hobart, taking the opportunity to speak with member representatives about AAL's role in implementing the new Decadal Plan
- AAL Board met with the Pro Vice-Chancellor (Research and Innovation), Dean of the School of Computing, Engineering and Mathematics and the astronomy group at AAL's newest member, the University of Western Sydney

## March

- AAL staff gave presentation at the NeCTAR eResearch workshop in Melbourne
- AAL participated in AST3 Antarctic Astronomy collaboration meeting in Hong Kong
- AAL shared a booth with the Australian National Data Service to promote NCRIS at the Universities Australia Higher Education Conference in Canberra.

## April

- AAL attended the OzSKA workshop in Melbourne.

## May

- AAL Board met with the ANU astronomy group in Canberra
- The AAL-funded Australian Gemini, Magellan, and Keck Science Symposium was held in Sydney

## June

- AAL participated in an announcement about the Giant Magellan Telescope Organization's approval to commence construction of the Giant Magellan Telescope.

AAL Board and staff meet astronomers at the University of Western Sydney.  
Image credit: Graeme Wong





# Organisational and Governance Structure



## Members:

AAL is very proud that its membership comprises all institutions in Australia with a significant astronomy research program. There are currently 15 institutional members of AAL and each member has a nominated representative who attends the Annual General Meeting to elect Board Directors and Chair. Member representatives are also consulted throughout the year on key astronomy infrastructure and investment decisions.

## Committees:

AAL has three advisory committees, whose members are appointed to provide the relevant breadth of expertise, and an appropriate mix of gender, seniority, and institutional diversity. AAL committee members meet quarterly and are encouraged to engage with their colleagues in order to understand and reflect the views of the wider astronomy community. AAL relies on its committee members to monitor and assess the progress of all projects and subprojects, evaluate key performance indicators, and advise on opportunities for collaboration and improving project outcomes.

## Board:

The independent, skills-based Board of Directors comprises seven individuals with an appropriate breadth of expertise in astronomy, management and finance. The Board meets quarterly to review progress of programs under AAL's contractual arrangements, set strategic goals, and approve financial allocations. The AAL Board makes key decisions about projects based on the committees' recommendations, the Board's own considerable and diverse expertise, and in consideration of the priorities and recommendations in the Australian Astronomy Decadal Plan.

## Staff:

AAL executive and staff have responsibility for financial management, oversight of the programs under AAL's contractual arrangements, reporting to the AAL Board on the status of projects, and liaising with the Advisory Committees, AAL Board, project leaders, Members, Government Departments and other key stakeholders.

These governance and management arrangements have led to very successful outcomes from AAL-managed NCRIS, EIF and other Commonwealth Government's infrastructure programs since 2007.



# Information about Directors



## **Prof. Brian Schmidt AC**

BSc (Physics & Astronomy), A.M. in Astronomy, PhD (Astronomy), FAA, NAS, FRS

Appointed 18 April 2007, reappointed 30 September 2008, 11 November 2011 and 11 November 2014

*Special responsibilities - Board Chair and member of the Executive Remuneration Committee and Audit and Risk Management Committee.*

Prof Brian Schmidt is an ARC Australian Laureate Fellow at the Australian National University. He is the Project scientist for the new SkyMapper Telescope which is undertaking a comprehensive optical survey of the southern sky. His research has focused on the physics of distant exploding stars to trace the expansion of the Universe. He has received a variety of awards over his career culminating in his sharing the 2011 Nobel Prize for Physics. He has been an active member of several national astronomy and science bodies including the Major National Research Facilities selection panel, Australian Square Kilometre Array Steering Committee, Australian Decadal Working group on International Facilities and Mid-Term Review of the Australian Astronomy Decadal Plan. He is currently a member of the Commonwealth Science Council.



## **Prof. Brian Boyle**

BSc(Hons), PhD, PSM, FAA

Appointed 5 November 2009, reappointed 2 November 2012

*Special responsibilities - Member of the Audit and Risk Management Committee and observer on Magellan Council.*

Prof. Brian Boyle is Director of Research Strategy at the University of New South Wales. Previously, he was Acting Australian SKA Director for the Department of Industry, and had roles at CSIRO as SKA Director and Director of the Australia Telescope National Facility (2003-2009) where he initiated the construction of ASKAP. He was also Director of the Anglo-Australian Observatory (1996-2003). His main research interests are cosmology, active galactic nuclei and quasars. During his career he has overseen the successful commissioning of world-class instruments and has led many international scientific collaborations. As Chairman of the National Committee for Astronomy, he led the development of the Decadal Plan for Australian Astronomy 2006-15. He was also the facilitator for the NCRIS investment plan for optical and radio astronomy.

## **Prof. Ronald Ekers**

BSc(Hons), PhD (Astronomy), FAA, FRS  
Appointed 19 November 2013

*Special responsibilities - until November, a member of the Optical Telescope Advisory Committee 2014 and from February 2015 a member of the Radio Telescope Advisory Committee.*

Prof. Ron Ekers is a CSIRO Fellow and was the Director of the Australia Telescope National Facility from 1988 to 2003. He graduated from the University of Adelaide in 1963 and gained his PhD in astronomy at the Australian National University in 1967. His professional career has taken him to the California Institute of Technology, the Institute of Theoretical Astronomy in Cambridge, UK, the Kapteyn Laboratory in Groningen, The Netherlands and the National Radio Astronomy Observatory, New Mexico USA. He was director of the VLA, the major national radio telescope in the USA, from 1980 until 1987. He was elected a Fellow of the Australian Academy of Science, a Foreign Member of the Royal Dutch Academy of Science in 1993, a Foreign Member of the American Philosophical Society in 2003 and a Fellow of the Royal Society in 2005. He is past President of the International Astronomical Union (IAU). His research interests include extragalactic astronomy, especially cosmology, galactic nuclei, ultra high energy particle physics and radio astronomical techniques.



## **Dr Ian Chessell**

BSc(Hons), PhD (Physics), FTSE

Appointed 5 November 2010, reappointed 19 November 2013

*Special responsibilities - Member of the Executive Remuneration Committee and Audit and Risk Management Committee.*

Dr Ian Chessell followed a career in the Defence Science and Technology Organisation, retiring as Australia's Chief Defence Scientist in 2003. Dr Chessell served as a member of the Prime Minister's Science, Engineering and Innovation Council (2001-2003) and in 2003 he was awarded the Centenary Medal for services to defence science. He was elected a Fellow of the Australian Academy of Technological Sciences and Engineering in 2003. He was Chief Scientist of South Australia from 2008-2010. He is a member of the Board of QinetiQ Pty Ltd (Australia) and is Chair of the Goyder Institute for Water Research. He has chaired a number of science reviews including Commonwealth reviews of National ICT Australia in 2005, the Anglo-Australian Telescope in 2006, and CSIRO's Climate Adaptation Flagship in 2011.



**Prof. Lisa Kewley**

BSc(Hons), PhD (Astrophysics), FAA  
Appointed 11 November 2014

*Special responsibilities – from November 2014, a member of the Optical Telescope Advisory Committee and an observer on the Keck Science Steering Committee.*

Prof. Lisa Kewley is Professor and Associate Director at The Research School of Astronomy and Astrophysics, in the ANU College of Physical and Mathematical Sciences. She obtained her PhD in 2002 and was then a Harvard-Smithsonian Center for Astrophysics fellow and a NASA Hubble Fellow. She received the American Astronomical Society Annie Jump Cannon and Newton Lacy Pierce Awards, and an NSF Early Career Award. She was a 2011-2015 ARC Future Fellow at the ANU RSAA and in 2014 was elected to the Australian Academy of Science. She is currently an ARC Laureate Fellow. Lisa's current policy roles include the Australian Astronomical Observatory Advisory Committee, the Keck Science Steering Committee, the National Committee for Astronomy, the Academy of Science Committee for Physics and Astronomy, and the Editorial Board of the 2015-2026 Australian Astronomy Decadal Plan. She leads a large ambitious research program to understand the star formation and chemical history of the universe. Her research comprehensively covers theory, computation, and observation, including optical, radio and infrared.

**Prof. Robyn Owens**

BSc(Hons), MSc (Mathematics), PhD (Mathematics), FACS, GAICD, FTSE  
Appointed 2 November 2012

*Special responsibilities – a member of Astronomy eResearch Advisory Committee.*

Prof. Robyn Owens is Deputy Vice-Chancellor (Research) at the University of Western Australia (UWA) and has responsibility for research policy development and leadership of the University's research activities, postgraduate education, industry liaison, intellectual property and commercialisation. Previously she was the Head of the School of Computer Science & Software Engineering at UWA and has also lectured in Australia and internationally in mathematics and computer science. She has an extensive background in mathematical analysis and research with a focus on computer vision, including feature detection in images, 3D shape measurement, image understanding, and representation.

**Prof. Anne Green**

BSc(Hons), PhD, FTSE, FASA, FAIP  
Appointed 5 November 2010,  
reappointed 19 November 2013

*Special responsibilities - Deputy Chair from 11 November 2014 and until February 2015 a member of the Radio Telescope Advisory Committee.*

Prof. Anne Green is a Professor at the University of Sydney, and is a collaborator on a project to upgrade the Molonglo Telescope as a multi-tasking transient source detector that will be a pathfinder instrument to advance science and technology for the next generation of radio telescopes. Previously, she was the Head of the School of Physics, the Director of the Physics Foundation, and the Director of the Molonglo Observatory, all associated with the University of Sydney. Her research career spans more than 20 years in radio astronomy, with a focus on the structure and ecology of the Milky Way Galaxy. She has been an active member of several national and international astronomy advisory committees. She is currently a Member of the Australian Astronomical Observatory Advisory Committee and a Member of the Science Advisory Board of the Max Planck Institute for Radioastronomy, in Germany. Since 2007, she has been a Graduate Member of the Australian Institute of Company Directors.

**Prof. Stuart Wyithe**

BSc(Hons), PhD  
Appointed 11 November 2011, retired  
11 November 2014

*Special responsibilities – Deputy Chair until 11 November 2014 and a member of Gemini Board and Finance Committee.*

Prof. Stuart Wyithe is an ARC Australian Laureate Fellow and a Professor at The University of Melbourne. Previously, he was University Associate Dean in the Melbourne School of Graduate research (2009-2011). A cosmologist and author of over 100 scientific publications, he has a history of collaboration at the national and international level, encompassing both theory and observation. He has received many awards, including the Pawsey Medal from the Australian Academy of Science and the Malcome McIntosh prize. He served as MWA Science Council Chair (2010-2011), during which he developed and implemented project policies. He has contributed to the running of a range of national bodies and is the current Chair of the Australian Academy of Science's National Committee for Astronomy.





# AAL Committees

## Committee membership as of 30th June 2015

### Astronomy eResearch Advisory Committee (AeRAC)

Geraint Lewis (Chair), University of Sydney, until 31 December 2015

Chris Power, University of Western Australia, until 31 December 2015

Christopher Fluke (Deputy Chair), Swinburne University of Technology, until 31 December 2015

Simon O'Toole, AAO, until 31 December 2016

Jessica Chapman, CSIRO, until 31 December 2016

*Ex-officio:*

Lindsay Botten, NCI Director

Jarrold Hurley, Swinburne University of Technology Supercomputer Manager

Jenni Harrison, Pawsey Centre Head of Data

Robyn Owens, Astronomy Australia Ltd Board representative

### Optical Telescopes Advisory Committee (OTAC)

Martin Asplund (Chair), the Australian National University, until 31 December 2015

Michael Drinkwater (Deputy Chair), University of Queensland, until 31 December 2016

Simon Driver, University of Western Australia, until 31 December 2015

Andy Sheinis, Australian Astronomical Observatory, until 31 December 2015

Peter Curran, Curtin University, until 31 December 2016

Peter Tuthill, University of Sydney, until 31 December 2016

Emma Ryan-Weber, Swinburne University of Technology, until 31 December 2016

*Ex-officio:*

Lisa Kewley, Astronomy Australia Ltd Board representative

Sarah Martell, AAL's Gemini STAC Representative

Warrick Couch, Director, Australian Astronomical Observatory

Stuart Ryder, Head of International Telescopes Support Office

### Astronomy Supercomputer Time Allocation Committee (ASTAC)

Orsola De Marco (Chair), Macquarie University, until 31 December 2016

David Parkinson, University of Queensland, until 31 December 2016

Matthew Whiting, CSIRO, until 31 December 2015

Alexander Heger, Monash University, until 31 December 2016

Randall Wayth, Curtin University, until 31 December 2016

*Ex-officio:*

NCI Representative - Roger Edberg

Pawsey Representative - Chris Harris

Swinburne Supercomputer Manager - Jarrold Hurley

*Advisors:*

NCI user consultant - Roger Edberg

Swinburne supercomputer user consultant - Luke Hodgkinson

Secretary, Amr Hassan, Swinburne University of Technology

### Radio Telescopes Advisory Committee (RTAC)

Naomi McClure-Griffiths (Chair), Australian National University, until 31 December 2015

Carole Jackson, Curtin University, until 31 December 2015

Nick Seymour (Deputy Chair), Curtin University, until 31 December 2015

Rachel Webster, University of Melbourne, until 31 December 2016

Sarah Maddison, Swinburne University of Technology, until 31 December 2016

Michael Burton, University of New South Wales, until 31 December 2016

Stuart Ryder, AAO, until 31 December 2016

Simon Ellingsen, University of Tasmania, until 31 December 2016

*Ex-officio:*

Ron Ekers, Astronomy Australia Ltd Board representative

Douglas Bock, Research Director, ATNF Operations, CSIRO

## Committee Meetings

A total of 12 Advisory Committee meetings were held in 2014/15; one meeting per quarter, for RTAC, OTAC and AeRAC Advisory Committees. ASTAC held two meetings in 2014/15.

# Members and their representatives as of 30th June 2015

Australian Astronomical Observatory  
Australian National University  
Commonwealth Scientific and Industrial Research Organisation  
Curtin University  
Macquarie University  
Monash University  
Swinburne University of Technology  
University of Adelaide  
University of Melbourne  
University of New South Wales  
University of Queensland  
University of Sydney  
University of Tasmania  
University of Western Australia  
University of Western Sydney

Prof Warrick Couch  
Prof Matthew Colless  
Dr Lewis Ball  
Prof Steven Tingay  
Prof Mark Wardle  
Prof Alexander Heger  
Prof Karl Glazebrook  
Dr Gavin Rowell  
Prof Rachel Webster  
Prof John Storey  
Prof Michael Drinkwater  
Prof Joss Bland-Hawthorn  
Prof John Dickey  
Prof Peter Quinn  
A/Prof Miroslav Filipovic

## Nomination Committee (For the 2014 AGM election)

Ian Chessell (Chair)  
Warrick Couch  
Gavin Rowell  
Alexander Heger  
John Storey

Astronomy Australia Limited  
Australian Astronomical Observatory  
University of Adelaide  
Monash University  
University of New South Wales

## Nominations to Overseas Committees

### Giant Magellan Telescope

#### Board

- Prof Warrick Couch, Australian Astronomical Observatory
- Mr Mark McAuley, Astronomy Australia Ltd

#### Governance Committee

- Mr Mark McAuley, Astronomy Australia Ltd

#### Science Advisory Committee

- Prof Chris Tinney, University of New South Wales

### Magellan

#### Magellan Council (Observer)

- Prof Brian Boyle, Astronomy Australia Ltd

#### Science Advisory Committee (Observer)

- Dr Gayandhi De Silva, Australian Astronomical Observatory

### Gemini

#### Board

- Prof Stuart Wyithe, University of Melbourne

#### Finance Committee

- Prof Stuart Wyithe, University of Melbourne

#### Science and Technology Advisory Committee

- Dr Sarah Martell, University of New South Wales

#### AURA Oversight Committee

- Mr Mark McAuley, Astronomy Australia Ltd

### W.M. Keck Observatory

#### California Association for Research in Astronomy (CARA) Board (Observer)

- Prof Lisa Kewley, Astronomy Australia Ltd,  
Australian National University

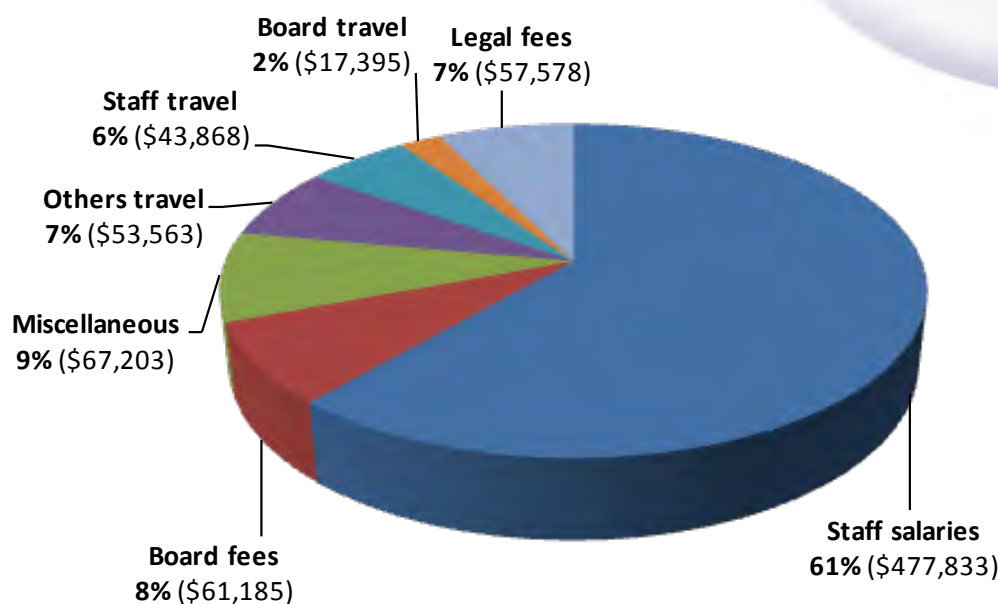


# Financial Summary

The following summary highlights the key financial transactions (exclusive of GST) for the 2014/15 financial year. The audited financial accounts are available on the AAL website at <http://www.astronomyaustralia.org.au/publications>.

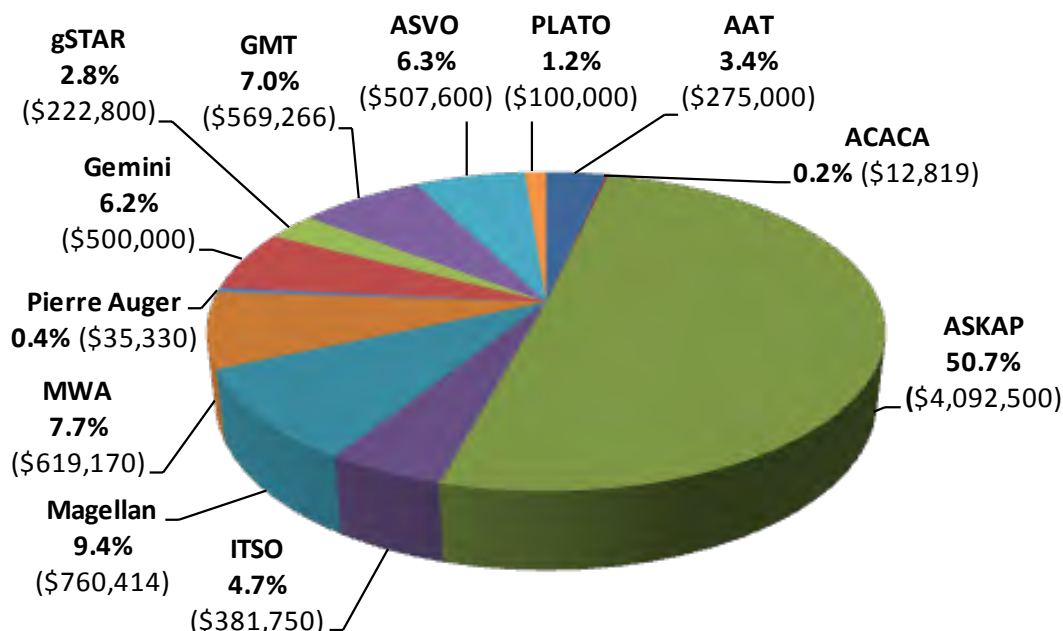
## AAL Operating Expenses

Actual operating expenses for 2014/15 were \$778,625. The breakdown of costs is similar to last financial year.



## Grants Paid to Projects during 2014/15

Total grants paid in 2014/15 were \$8,076,649.



## Grants Received and Balance of Grants held as at 30 June 2015

Grant	Grants Received	Closing Balance
AAO Grant	-	\$347,371
DIICCS RTE – Aust China scholarships Grant	\$10,103	\$17,284
NCRIS 2013 Grant	\$6,823,768	\$2,627,092
AAO 2014 Grant	-	\$520,000
ANDS Grant	\$135,000	\$2,000
NeCTAR EIF Grant	\$100,000	-
NeCTAR NCRIS Grant	\$215,100	\$15,500
DoIS 2015 Grant	\$2,700,000	\$2,700,000
	<b>\$9,983,971</b>	<b>\$6,229,247</b>

## Reserves

During 2014/15 AAL maintained two reserves with the net interest earned to be used for projects associated with the relevant funding agreement. There were the following transfers to and from Reserves:

Reserve	Net Interest	Transfer from Reserve	Purpose of Funds	Closing Balance
Overseas Optical Reserve*	\$69,932	\$52,795	AAL management fee	\$2,656,874 <sup>#</sup>
NCRIS 2013 Reserve	\$13,012			\$36,287

\*The Overseas Optical Reserve is primarily used to cover shortfalls in payments to overseas optical telescope facilities.

<sup>#</sup> \$168,364 of Overseas Optical Reserve is committed for future Magellan payments.



## Statement of profit and loss and other comprehensive income for the year ended 30 June 2015

	2015 \$	2014 \$
<b>Revenue</b> including Government Grants	8,970,548	8,243,260
<b>Expenses</b>		
Depreciation	(1,698)	(2,535)
Grants paid	(8,072,689)	(7,605,101)
Direct grant project expenses	(4,223)	(12,165)
Employee benefits expenses	(539,017)	(519,910)
Other expenses	(237,910)	(217,013)
<b>Surplus (Deficit) before income tax attributable to members of the entity</b>	<b>115,011</b>	<b>(113,464)</b>
Income tax		-
<b>Surplus (Deficit) after income tax attributable to members of Astronomy Australia Ltd</b>	<b>115,011</b>	<b>(113,464)</b>
Other comprehensive income		
<b>Total comprehensive income for the year attributable to members of Astronomy Australia Ltd</b>	<b>115,011</b>	<b>(113,464)</b>

The Company is an income tax exempt charitable institution.

## Statement of changes in equity for the year ended 30 June 2015

	Retained Surpluses	NCRIS Reserve Account	Overseas Optical Reserve Account	EIF Reserve Account	NCRIS 2013 Reserve Account	Total Equity
	\$	\$	\$	\$	\$	\$
<b>Balance at 30 June 2013</b>	<b>96,032</b>	<b>316,256</b>	<b>2,583,105</b>	<b>26,210</b>	<b>-</b>	<b>3,021,603</b>
Surplus attributable to equity members	(113,464)	-	-	-	-	(113,464)
Allocated to Reserves	(151,967)	18,624	108,407	1,661	23,275	-
Transfers from Reserves	414,526	(334,880)	(51,775)	(27,871)	-	-
<b>Balance at 30 June 2014</b>	<b>245,127</b>	<b>-</b>	<b>2,639,737</b>	<b>-</b>	<b>23,275</b>	<b>2,908,139</b>
Surplus attributable to equity members	115,011	-	-	-	-	115,011
Transfer to Reserves	(82,944)	-	69,932	-	13,012	-
Allocation from Reserves	52,795	-	(52,795)	-	-	-
<b>Balance at 30 June 2015</b>	<b>329,989</b>	<b>-</b>	<b>2,656,874</b>	<b>-</b>	<b>36,287</b>	<b>3,023,150</b>

## Statement of Financial Position as at 30 June 2015

	2015 \$	2014 \$
<b>Current Assets</b>		
Cash and cash equivalents	9,892,249	6,626,571
Trade and other receivables	6,810	1,268,300
<b>Total Current Assets</b>	<b>9,899,059</b>	<b>7,894,871</b>
<b>Non-Current Assets</b>		
Property, plant and equipment	2,468	4,166
<b>Total Non-Current Assets</b>	<b>2,468</b>	<b>4,166</b>
<b>Total Assets</b>	<b>9,901,527</b>	<b>7,899,037</b>
<b>Current Liabilities</b>		
Trade and other payables	6,838,336	4,943,257
Employee benefits	40,041	47,641
<b>Total Current Liabilities</b>	<b>6,878,377</b>	<b>4,990,898</b>
<b>Total Liabilities</b>	<b>6,878,377</b>	<b>4,990,898</b>
<b>Net Assets</b>	<b>3,023,150</b>	<b>2,908,139</b>
<b>Equity</b>		
Reserves	2,693,161	2,663,012
Retained surpluses	329,989	245,127
<b>Total Equity</b>	<b>3,023,150</b>	<b>2,908,139</b>

The complete audited financial accounts are available on the AAL website at:  
<http://astronomyaustralia.org.au/publications>.



# Acronyms used in this report

2dF	Two Degree Field	FRACI	Fellow of the Royal Australian Chemical Institute
AAL	Astronomy Australia Limited	FRAS	Fellow of the Royal Astronomical Society
AAO	Australian Astronomical Observatory	FRB	Fast Radio Burst
AAT	Anglo-Australian Telescope	FTE	Full time equivalent
ACACA	Australia-China Astronomy Collaboration Award	FTSE	Fellow of the Australian Academy of Technological and Engineering Sciences
ACES	ASKAP Commissioning and Early Science	GALAH	GALactic Archaeology with HERMES
AeRAC	Astronomy eResearch Advisory Committee	GAMA	Galaxy And Mass Assembly
AGUSS	Australian Gemini Undergraduate Summer Studentship	GMACS	GMT Wide-Field Optical Spectrograph
AITC	Advanced Instrumentation and Technology Centre	GMT	Giant Magellan Telescope
ALMA	Atacama Large Millimeter/submillimeter Array	GMTIFS	GMT Integral Field Spectrograph
ANDS	Australian National Data Service	GMTO	Giant Magellan Telescope Organization
ANU	The Australian National University	GPU	Graphics Processing Unit
ARC	Australian Research Council	GST	Goods and Services Tax
ASA	The Astronomical Society of Australia	gSTAR	GPU Supercomputer for Theoretical Astrophysics Research
ASKAP	Australian Square Kilometre Array Pathfinder	HEAT	High Elevation Antarctic Terahertz (telescope)
ASTAC	Astronomy Supercomputer Time Allocation Committee	HERMES	High Efficiency and Resolution Multi-Element Spectrograph
AST3	Antarctic Survey Telescopes	HPC	High Performance Computing
ASVO	All-Sky Virtual Observatory	ICRAR	International Centre for Radio Astronomy Research
ATCA	Australia Telescope Compact Array	ITSO	International Telescope Support Office
ATNF	Australia Telescope National Facility	KTAC	Keck Time Allocation Committee
AURA	Association of Universities for Research in Astronomy	MANIFEST	MANY-Instrument FibrE SysTem
AusGO	Australian Gemini Office	MRO	Murchison Radio-astronomy Observatory
BETA	Boolardy Engineering Test Array	MWA	Murchison Widefield Array
CAASTRO	ARC Centre of Excellence for All-sky Astrophysics	NCA	National Committee for Astronomy
CASS	CSIRO Astronomy and Space Science	NCI	National Computational Infrastructure
CCD	Charge-coupled device	NCRIS	National Collaborative Research Infrastructure Strategy
CIIC	Cisco Internet of Everything Innovation Centre	NeCTAR	National eResearch Collaboration Tools and Resources
CPU	Central Processing Unit	NIRMOS	Near Infrared Multi-Object Spectrograph
CRIS	Collaborative Research Infrastructure Strategy	NIRSPEC	Near Infrared Spectrograph
CSIRO	Commonwealth Scientific and Industrial Research Organisation	NISM	Near Infrared Spectrograph Monitor
CTA	Cherenkov Telescope Array	LTAO	Laser Tomography Adaptive Optics
CUDA	Compute Unified Device Architecture	OOR	Overseas Optical Reserve
DIICCSRTE	Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education	OTAC	Optical Telescopes Advisory Committee
DoIS	Department of Industry and Science	OzDES	Australian Dark Energy Survey
DVC-R	Deputy Vice-Chancellor, Research	PAF	Phased Array Feed
EIF	Education Investment Fund	PLATO	Plateau Observatory
ELT	Extremely Large Telescope	PRIC	Polar Research Institute of China
EoR	Epoch of Reionization	RDS	Research Data Services
ESO	European Southern Observatory	RTAC	Radio Telescopes Advisory Committee
FAA	Fellow of the Australian Academy of Science	SAMI	Sydney-AAO Multi-object Integral-field
FAICD	Fellow of the Australian Institute of Company Directors	SKA	Square Kilometre Array
FAIP	Fellow of the Australian Institute of Physics	SME	Small and Medium Enterprise
FASA	Fellow of the Astronomical Society of Australia	STAC	Science and Technology Advisory Committee
FAST	Five Hundred Meter Aperture Spherical Telescope	SUPERB	Survey for Pulsars and Extragalactic Radio Bursts
FIEAust	Fellow of the Institution of Engineers Australia	swinSTAR	Swinburne Supercomputer for Theoretical Academic Research
FIEChem	E Fellow of the Institution of Chemical Engineers	TAC	Time Allocation Committee
		TAO	Theoretical Astrophysical Observatory
		UNSW	University of New South Wales
		UWA	University of Western Australia
		UWS	University of Western Sydney



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