AAO OBSERVER

THE AUSTRALIAN ASTRONOMICAL OBSERVATORY NEWSLETTER

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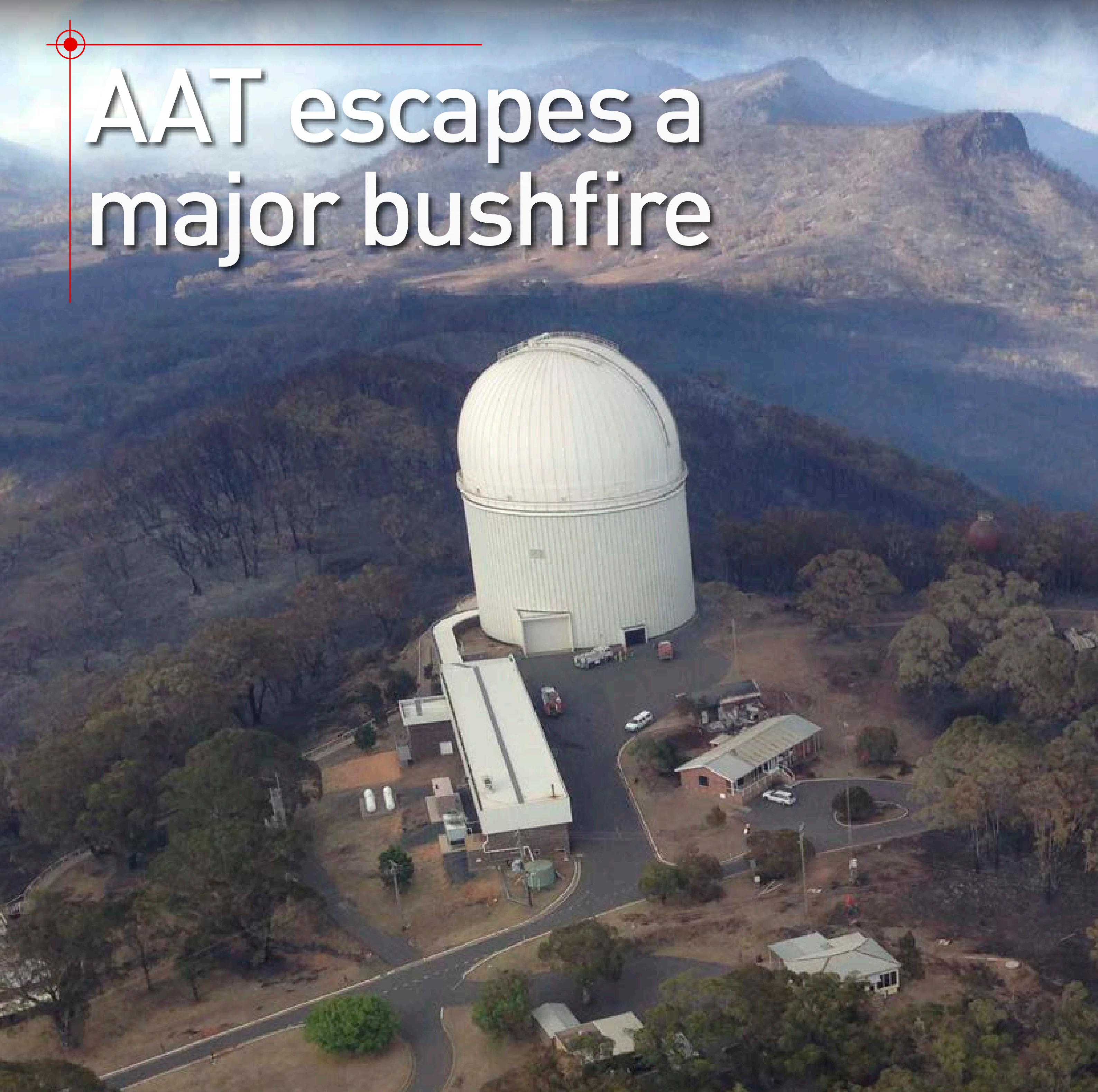
AAT escapes a major bushfire



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Director's message

Trial by fire. This is a phrase not often used literally in astronomy, but it has been the experience for the AAO in recent weeks. In the afternoon and evening of Sunday 13 January 2013, one of the largest bushfires of the season (ultimately encompassing a massive 55000 hectares in and around the Warrumbungle National Park) swept over the Siding Spring Observatory. The fire was amazingly destructive, and over 50 homes in the Coonabarabran area were destroyed. Thankfully no lives were lost. The AAO is incredibly grateful for the efforts of the NSW Rural Fire Service and the other Emergency Services teams who worked tirelessly to contain the fire and protect lives and properties. The AAO is also especially grateful for the many concerned colleagues and friends from around Australia and internationally who have written to express their support and offers of help. These kind thoughts have been immeasurably valuable in keeping the spirits of AAO staff high, and we thank everyone for their support.

On the mountain, the astronomers' lodge and the Director's cottage were destroyed, but otherwise most buildings, including all the telescopes, survived. The fires made international news, and Prime Minister Julia Gillard visited the site on Thursday 17 January, to talk with those affected by the fires and convey her sympathy and support. The Prime Minister spoke with a number of AAO staff at the AAT.

At the time of writing we are awaiting the outcome of safety assessments at the site, before staff return to the telescopes to begin the process of cleaning up and restoring normal operations. From preliminary assessments inside the telescope buildings, we expect that any damage is minimal, and we anticipate a return to observing by mid- to late-February. With the destruction of the lodge there will be interim accommodation arrangements made for visiting observers, and we will be advising observers of these in advance. I would like to express a personal message of thanks to all AAO staff for their hard work, dedication and perseverance through this trying time, and for the work to come in getting the facilities back on sky. The status of the Siding Spring Observatory and the recovery effort is being regularly updated on the main AAO web page, http://www.aao.gov.au/ , and I encourage everyone to check there periodically.

I would also like to thank the staff of the ANU who have been coordinating very closely with the AAO staff during this time. The evacuation of the site and subsequent activities have been very much a joint effort, with both AAO and ANU teams working together to ensure the safety of staff and facilities. The recovery effort will also be very much a joint venture, with close consultation on all fronts, and we look forward to a continued close working relationship between the AAO and ANU. We are confident that the AAT and Siding Spring Observatory will rapidly be back to business as usual, and are excited about the new technology developments underway for the AAT.

During this time, the activities of the AAO have not stopped, and "business as usual" has been our goal. The SAMI survey is expected to begin in earnest, after successful pilot observations of about 100 target galaxies during 2012, with observations beginning in late February and March. We continue to plan for HERMES to be commissioned at the AAT beginning in May, and are anticipating exciting early results. We have, in addition, new AAOmega CCDs to install, the KOALA IFU to commission, and starbugs to develop for a new positioner on the UK Schmidt Telescope, among many other projects for the year. We are excited about the recent results from the DECam observations, through the ongoing time-swap arrangement between AAO and NOAO/CTIO (p10) and the insights into galaxy evolution continuing to come from the GAMA survey (p11), among the many other scientific successes of the past six months.

To close on a high note, and with a very positive outlook for the AAO, I'm very pleased to announce that the AAO will have a new Director from 29 April. The sixth Director of the AAO will be Professor Warrick Couch, currently the Director of the Centre for Astrophysics and Supercomputing at Swinburne University. Warrick has had a long and close working relationship with the AAO from his involvement as Chair of the AAO Advisory Committee, and prior to that as Chair of the AAT Board. He has also, of course, been a regular user of the AAT for many years, through the WiggleZ Dark Energy survey and the 2dF Galaxy Redshift Survey, among many other projects. We all look forward to welcoming Warrick to the AAO!

Postscript added 25 February 2013

I am very pleased to be able to report that, one month to the day after the fires, the ANU approved reoccupation of the Siding Spring site for observing. The following day (Valentines Day, a fitting signifier for our love of the skies, I'm sure) we resumed observations with the AAT. Since then we have been observing with remote observers at North Ryde, supported by our technical staff at the telescope. I am very proud of the dedicated efforts by the AAO staff in both bringing the telescope back on line so quickly, and in coordinating the remote observing mode that has aided in resuming regular operations.

KOALA – A new Integral Field Spectroscopic facility for the AAT

Quentin Parker (MQ/AAO) on behalf of the KOALA team

KOALA (Kilofibre Optical AAT Lenslet Array) is the new 1000 element common-user Intergral-Field-Unit-Spectroscopic (IFU) facility on the AAT. It is on track for commissioning in mid-late 2013. The traditional Australian fauna based acronym for new instruments or surveys is adopted though in this case it is surprisingly descriptive of the instrument itself (unlike some others I could mention). It will provide the Australian community with a potent, on-shore IFU observing capability on the AAT suited to the detailed spectroscopic study of large, resolved objects of varying surface brightness. KOALA will be highly complementary to the SAMI system currently also under development, which has a multi-IFU capability but at the expense of fewer resolution elements and lower individual areal coverage per IFU. Both instruments feed the existing AAOmega spectrograph. KOALA will be housed on the new "CURE" AAT Cassegrain instrument mount point which is common to both KOALA and CLYCOPS2 and that also incorporates an acquisition and guiding system.

The $1,000,000 KOALA instrument under construction at the AAO came about thanks to a large ARC LIEF grant led by Macquarie University but with strong financial backing and support from the AAO and the Universities of Macquarie, Sydney, Swinburne and Melbourne. Although Macquarie University will own the facility, KOALA will be on permanent loan to the AAO, which will operate and maintain the instrument at the AAT as part of routine operations. After commissioning, the university partners will have no guaranteed time on the facility and KOALA will be a standard common user instrument from the outset. KOALA incorporates many design enhancements and technology and material advances compared to the existing SPIRAL facility that will significantly improve the efficiency, operation and maintenance of this new AAO IFU capability. The basic properties of the instrument are summarised in Table 1 taken from Ellis S.C. et al., 2012, SPIE, 8446.

Table 1. Properties of the KOALA instrument with the AAOmega spectrograph.

KOALA	
Number of elements	1000
Format	40 × 25
Spatial resolution	0.7 or 1.25"
Field of view	24" × 18" = 434 sq. arcsec. or 43" × 32" = 1385 sq. arcsec
Throughput (3727Å)	0.52
Throughput (6562Å)	0.66
AAOmega	
Total wavelength coverage	3700 – 9500Å
Spectral resolution	1300 – 10000
Single shot wavelength coverage	400 – 3200 Å

A key difference with the current SPIRAL IFU is the ability to rapidly change the spatial resolution of the instrument to cover, in a rectangular 1.6:1 format field, either 434 square arseconds at 0.7 arseconds resolution (typically to be used in excellent conditions and/or for smaller resolved sources) or to cover 1385 square arseconds at more typical 1.25 arcseconds resolution for larger objects. This is combined with improved wavelength coverage and fibre transmission, particularly in the blue, that will take advantage of the upgraded blue sensitive AAOmega detectors also in the pipeline for 2013. KOALA thus permits decent coverage of the important blue [OII] 3727A emission line doublet often strong in various kinds of Galactic and local group galaxy optical emission nebulae, including Supernova remnants and Planetary Nebulae, as well as in star-forming low redshift galaxies where the lines remain in the blue. The orientation of the KOALA IFU assembly can also be adjusted to better match the projected position angle of asymmetric and elongated celestial sources including, of course, galaxies, bi-polar planetary nebulae, emission jets and supernova remnant optical filaments.

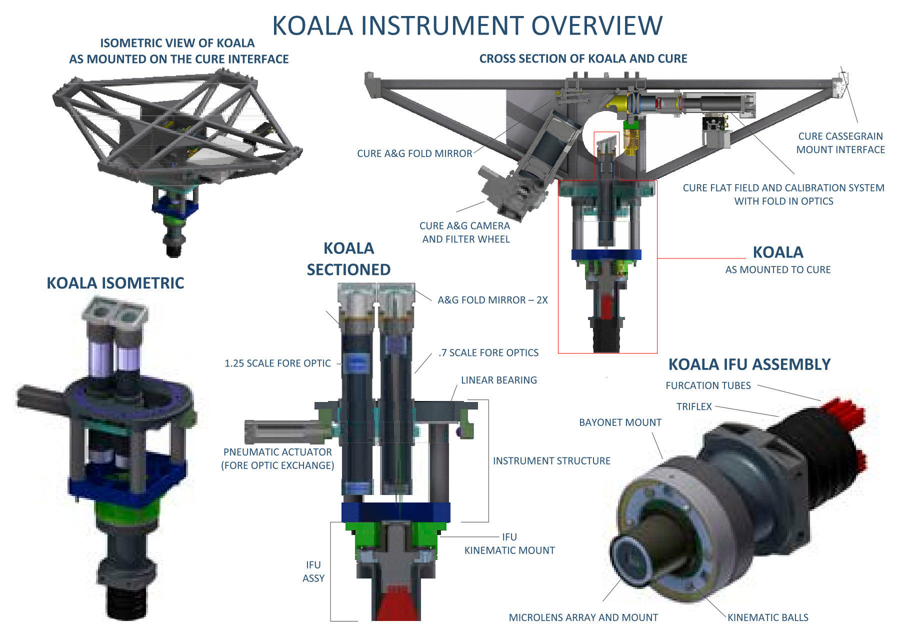


Figure 1. Rendered overview of the various components of the KOALA instrument assembly including its interface to the CURE system. Figure courtesy of KOALA project team.

The need for KOALA

A common user integral field unit spectroscopic (IFU) facility is an important capability for any modern observatory as far as the efficient spectroscopic and kinematical study of individually resolved or tight groupings of astronomical objects are concerned. This is especially germane now the AAO has become Australia's national optical observatory with a responsibility to provide an instrument suite suited to our national constituents. At the AAT this capability has been partially filled by the rudimentary SPIRAL 500 lenslet/fibre IFU system. Since SPIRAL was re-commissioned (see Sharp, R., 2006, AAO Newsletter 110, 24), a wide variety of science projects have been undertaken that benefit from an areal spectroscopic capability. Despite the considerable difficulties with supporting this instrument on the telescope and the associated observing overheads and inefficiencies that such a technology demonstrator inevitably possessed, excellent science drivers led to significant allocations (typically 5-15 nights annually) of SPIRAL observing time on the AAT.

Unfortunately, SPIRAL falls well short of realizing the full potential of an IFU system on the AAT and is too costly to maintain, too difficult to support and now too inefficient to merit telescope time regardless of pent-up Australian demand. In order for the AAT is to deliver a world class IFU capability, worthy of the AAO of the new decade, SPIRAL needed replacement. This is why the KOALA instrument concept was born.

IFU spectroscopy is a powerful astronomical technique able to efficiently tackle a wide range of astrophysical research problems by providing spatially resolved spectroscopic data over a contiguously sampled field of view. Over the last decade, advances in technology have brought IFUs into the mainstream of astronomy, opening up new lines of research that would otherwise be impossible or exceedingly inefficient if undertaken with traditional long-slit spectroscopic techniques. Every major observatory is now equipped with an integral-field spectrograph (e.g., Gemini *Focus*, Dec 2009, p. 17) and our national observatory is no exception. This fact recognises the inherent power and efficiency of areal (or *3D*) spectroscopy for observing low-surface-brightness, spatially extended objects or compact groups of objects. These objects include the diverse family of galaxies, the various types of gaseous nebulae in our own and neighbouring galaxies and multiple individual objects in compact star clusters and galaxy groups.

Additionally, the KOALA IFU facility will offer a powerful synergy with the higher-spatial-resolution instrumentation available on larger telescopes, such as Gemini-GMOS and Magellan-IMACS. For example, the light gathering power of KOALA will provide the often needed sensitivity to detect the low-surface-brightness outskirts of galaxies (which hold the key signatures of merger events and provide the baseline for abundance gradient studies) while GMOS provides the high-resolution observations required to interpret the complex nuclear kinematics, making the two facilities complimentary. When operational in 2013, the Australia Square Kilometre Array Pathfinder (ASKAP) radio telescope will provide unprecedented detail in mapping the cold neutral-hydrogen gas associated with nearby galaxies. However, these cold-gas measurements alone are insufficient to properly interpret the complex feeding and replenishment cycles involved in galaxy formation and evolution. The maps of associated warm ionised gas that KOALA will provide will be key to understanding the physical processes associated with the accretion and reprocessing of neutral material during the life cycle of galaxies.

A schematic of the kind of spectroscopic sampling possible across resolved objects like the famous Cartwheel galaxy is provided in the figure below, which was generated by team member Rob Sharp (RSAA) as part of our original Australian Research Council submission. It shows the absorption spectrum of the old stellar population in the centre and an emission spectrum from the star-forming regions generated by the bulls-eye collision in the external ring. Such strong differences in spectral

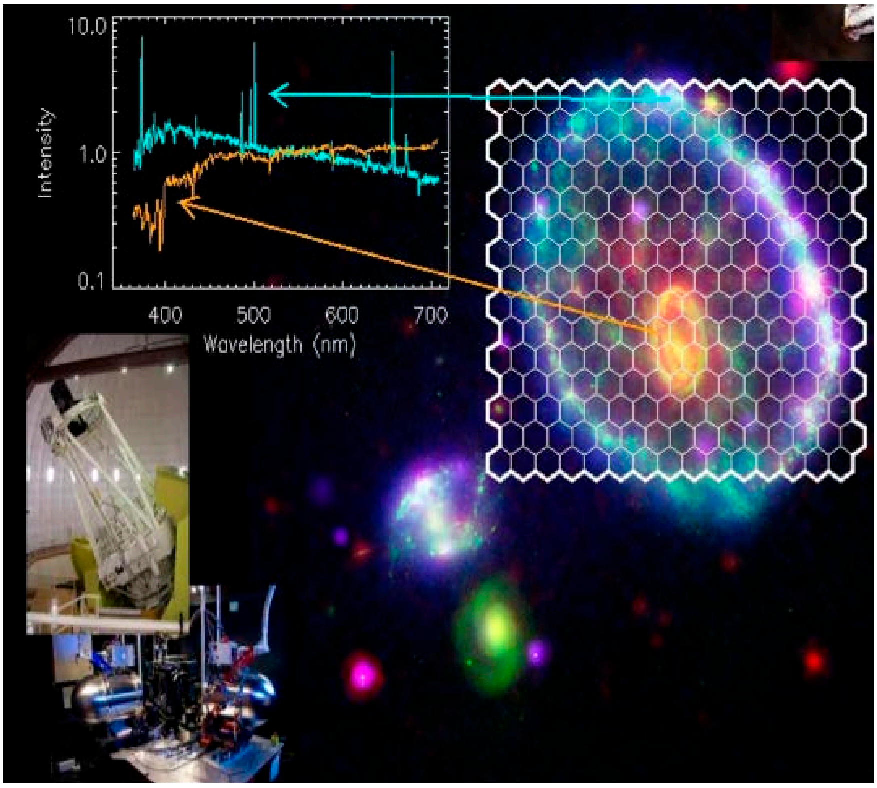


Figure 2. Schematic representation of the areal spectroscopic function of an IFU like KOALA, which highlights the very different spectral signatures obtained from two different "spaxels" (spatial pixels) of the IFU sampled from very different regions of the underlying object (the Cartwheel galaxy). Note the background image combines data from four different observatories: the Chandra X-ray Observatory (purple); ultraviolet light from the Galaxy Evolution Explorer satellite (GALEX, blue); visible light from the Hubble Space Telescope (green); and infrared light from the Spitzer Space Telescope (red). The unusual shape of the Cartwheel Galaxy is likely due to a collision with one of the smaller galaxies on the lower left several hundred million years ago. Credit: Composite: NASA/JPL/Caltech/P. Appleton et al. X-ray: NASA/CXC/A.Wolter & G.Trinchieri et al.

signature may well be hidden when using traditional long-slit observations.

Anticipated KOALA Performance

Once KOALA is commissioned later this year, detailed performance calculations, comparisons and the usual S/N calculators will be provided to the user community. Until then, our estimates come from realistic evaluations of the known properties of the various optical components (fibres, lenslets, fore-optics, etc.) that constitute the KOALA assembly. Figure 3 below, again taken from the Ellis et al. (2012) SPIE paper, provides our current best estimates for total internal transmission as a function of wavelength and a comparison with SPIRAL. Figure 3a is a plot of the internal transmission of the KOALA fore-optics compared to those from SPIRAL. Figure 3b gives the internal transmission of the fibres while Figure 3c shows the combined effect of the fore-optics and fibres. Finally in Figure 3d an overall efficiency comparison between the KOALA and SPIRAL instruments is presented. Note this plot includes a factor of 1.2 improvement in the focal-ratio matching of the incoming beam that is injected into the lenslet array. This figure will be updated to reflect the actual achieved performance once KOALA is commissioned.

KOALA also offers exceptional value for money. It will provide a timely, needed capability and instrumentation option for the Australian community at a fraction of the cost normally associated with a new facility. This is because it powerfully leverages the Australian Astronomical Observatory's multi-million dollar investment in the existing AAOmega spectrograph that KOALA will feed. It also takes advantage of 20 years of fibre instrument development expertise embodied by the 2dfdr fibre-spectroscopy data processing software that can be adapted straightforwardly and at low cost to KOALA. As for any common user facility time will be competitively awarded through the AAT Time Allocation Committee. Currently, users of the SPIRAL instrument win about 10% of the available telescope time each semester. We anticipate that demand could grow substantially as the significantly enhanced KOALA capability gets put to good use for a variety of exciting science projects, including those that formed the basis of the LIEF bid. An increase from 30-40 to 40-50 nights per year seems likely.

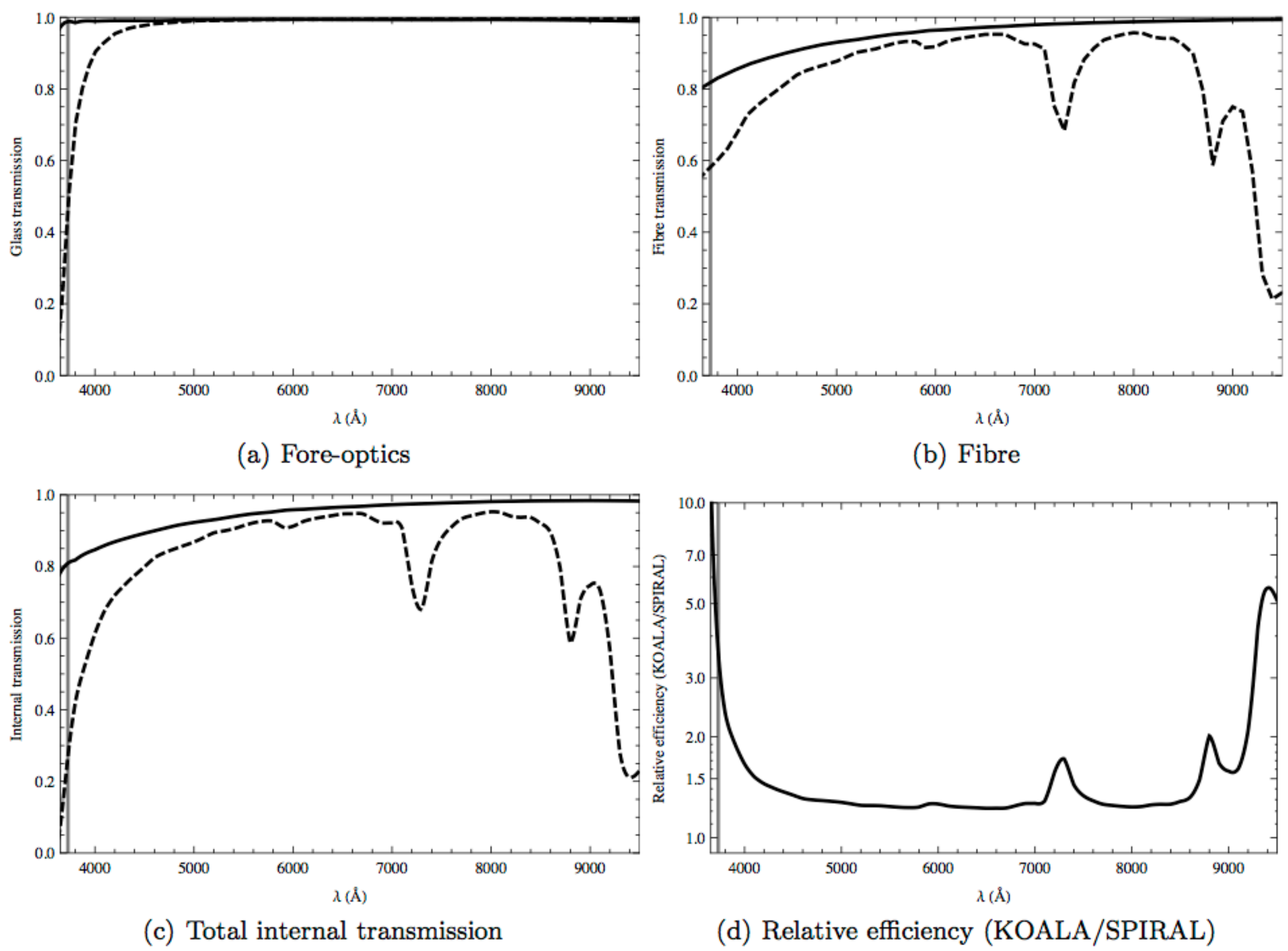


Figure.3. The internal losses of the fore-optics and fibres for KOALA (continuous line) and SPIRAL (dashed line) as a function of wavelength. The vertical grey line at the far left marks the position of [OII] 3737A. The bottom plots show the overall improvement in internal transmission and com parison with SPIRAL. The figure is taken from Ellis et al. (2012).

The Global Jet Watch observatories

Steve Lee (AAO) and Katherine Blundell (University of Oxford)

As we write this article, we are travelling to a boarding school in southern India in the north of the state of Karnataka. The Government of India founded this school so that the bright children of rural families in this state might receive a good education (for some of these families, the children are the first generation to receive a formal education). This school is important to us because it is host to a telescope we have installed, pictured in Figure 1, which is one of four optical telescopes that underpin the Global Jet Watch project. These four telescopes are located at sites that are distributed in longitude around the globe in order that, at all times, one of them is in darkness.

The Global Jet Watch project was instigated in order to make round-the-clock observations of important black hole systems in our Galaxy, known as *microquasars*, of which SS433 is the most famous example. The behaviour of microquasars is particularly fruitful to explore for anyone interested in how matter behaves in the vicinity of a black hole. It is crucial to understand such behaviour if we are to ultimately discern the hitherto elusive nature of feedback from supermassive black hole systems such as quasars on the formation of structures such as galaxies. Matter and energy are lost from quasars fairly persistently via winds and fairly intermittently via jet ejection episodes (lasting in the case of quasars for some 10^8 years) as explored by e.g. Nipoti et al 2005. However the relevant physics governing the attraction and repulsion of matter near black holes is *scale-free* – i.e. it is independent of black hole mass. Many of the relevant physical processes scale favourably with mass, in the sense that for the lower mass black holes in the Galactic disc these timescales are speeded up onto *human friendly* timescales. For example, the timescales on which evolution is observed in the accretion disc characteristics and in jet launching events in microquasars are days and hours and hence they are eminently observable *in principle*. These behaviour patterns can be observed in exquisite detail for microquasars (in a way that is not possible for quasars) if sub-24-hour observations can be routinely obtained. Global Jet Watch was designed to be the means by which such time-series data are secured *in practice.*

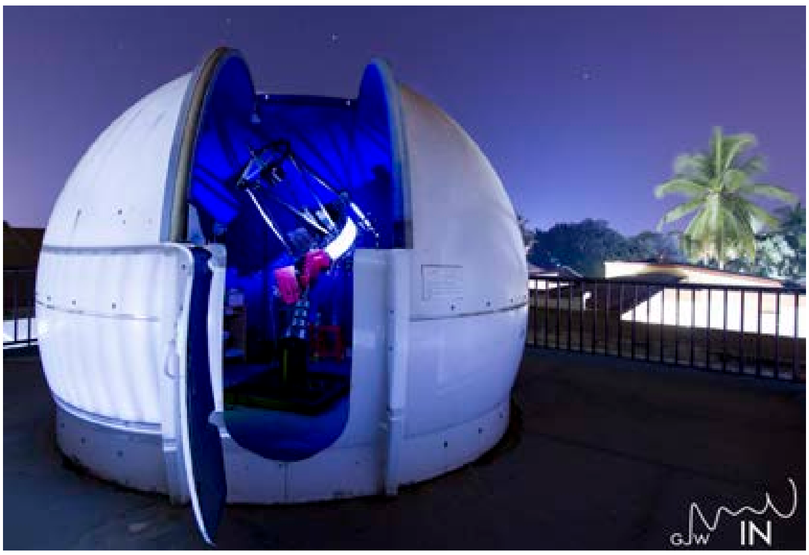


Figure 1: The Global Jet Watch observatory at the India school.

The four Global Jet Watch observatories are located in South Africa, Chile, Australia and India. Where possible, commercial off-the-shelf hardware was used. The domes came from Astrodomes in Australia, the mounts are Software Bisque Paramount ME and we have 0.5-metre Ritchey-Chretien telescopes from RCOS; amateur level CCDs from SBIG and Atik provide imaging capability. The Global Jet Watch telescope at the Chile school is pictured in Figure 2. The observatories are connected back to HQ in Oxford via hardware VPNs kindly donated by Sophos that mean each dome computer simply behaves as though it is connected to Oxford University via a rather long Ethernet cable.

Figure 2: Telescope at the Chile school.

The real power of studying microquasar systems comes from time-series *spectroscopy* as detailed in Figure 3. Spectra with a resolution of a few Angstroms reveal the rich dynamical behaviour of these systems: ejecta from **jets** moving at speeds comparable with the speed of light, as well as **winds** from the **accretion disc** and **circum-binary disc**. The interplay between these three modes of mass loss, both during quiescence and flaring, is intricate and beautiful. Glimpses into the evolution of these three modes before, during and after a major flare in SS433 were witnessed by Blundell et al 2011 using the ESO 3.6-m telescope for 5 minutes per night for a couple of months, but finer time-sampling than this is required to fully map the richness of the phenomena at play. Successively sampling four times per 24 hours will improve matters considerably!

Figure 3

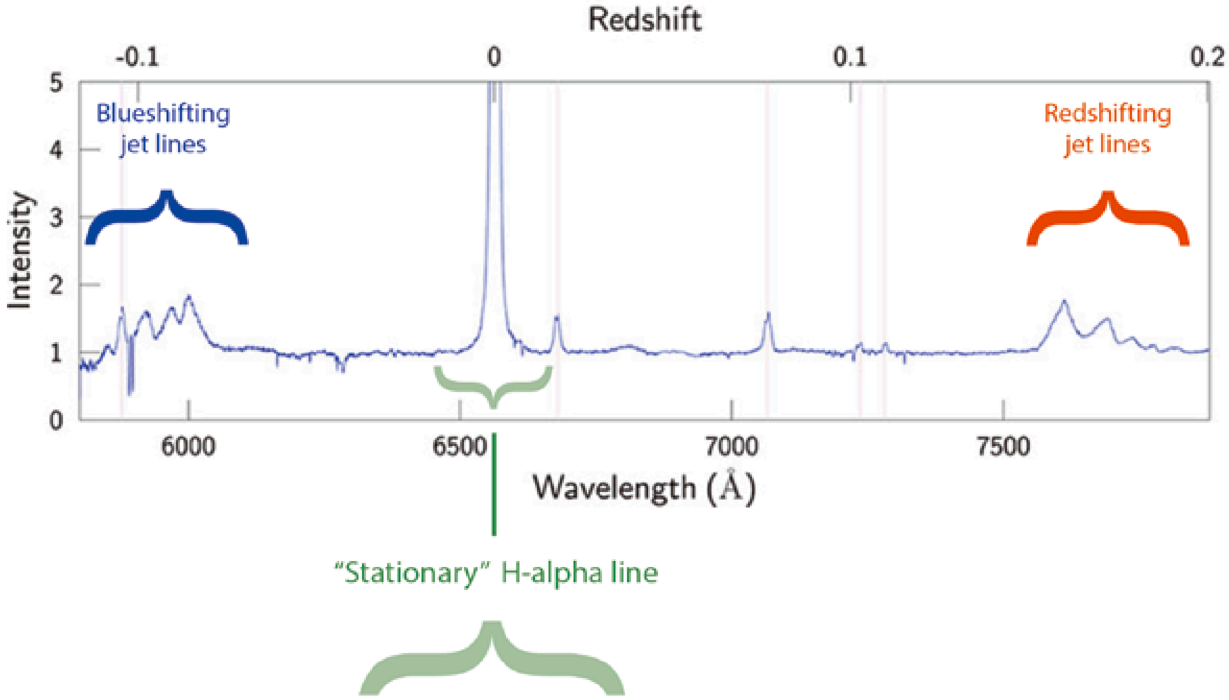
The equations below show the **jet launch speed** is easily derived from the sum of the simultaneously measured redshift and blueshift from the oppositely directed jets. (Blundell & Bowler 2005).

$$z_+ = -1 + \gamma[1 + \beta \sin\theta \sin i \cos\phi + \beta \cos\theta \cos i]$$

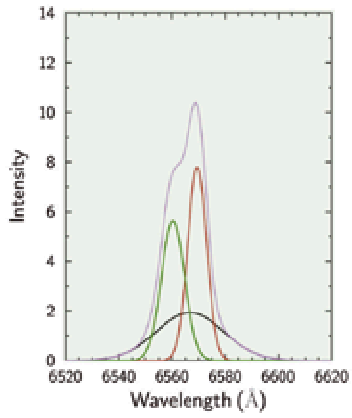
$$z_- = -1 + \gamma[1 - \beta \sin\theta \sin i \cos\phi - \beta \cos\theta \cos i]$$

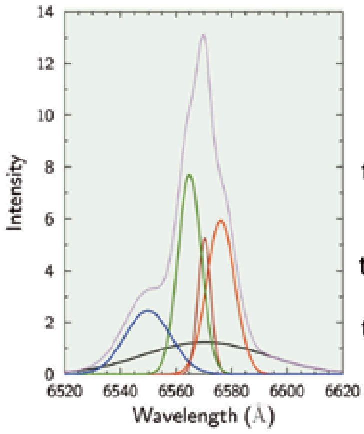
Sum these: $z_+ + z_- = -2 + 2\gamma$

Hence, derive **jet launch speed** = $\beta = \left[1 - \left[1 + \frac{z_+ + z_-}{2}\right]^{-2}\right]^{1/2}$ from Lorentz factor γ



In quiescence:	***A few days prior to the onset of jet flaring:***
black: accretion disc wind	black: accretion disc wind (wider = faster!)
green & brown: circumbinary disc wind	green & brown: circumbinary disc wind
no direct view of accretion disc	blue & red: accretion disc lines appeared!





The colours of these lines correspond to the arrows on the components depicted in the cartoon shown in Figure 1. The green figures to the left show a zoom of the "stationary" H-alpha line (lilac colour) and the de-blended lines arising from the accretion disc rotation, the accretion disc wind, and the circumbinary disc.

Figure 3: Decomposition of the spectra of the prototypical microquasar SS433, whose transverse motion gives rise to the zigzag-corkscrew appears that forms part of the project logo and whose line-of-sight kinematics are revealed by spectroscopy.

A suitable spectrographic capability is therefore a key requirement for the Global Jet Watch project. We investigated the performance of commercially available off-the-shelf spectrographs for the high-end amateur market, kindly loaned to us by Shelyak of France, at the Global Jet Watch telescopes in India and in Chile. Subsequent to this, a higher-throughput fibre-fed spectroscopic solution was designed by Steve Lee and Peter Gillingham (AAO). This design largely makes use of off-the-shelf components including a small telescope from Williams Optics used as a collimator and a Canon 85mm F/1.2 lens. A custom Volume Phase Holographic (VPH) grating disperses the light fed into the spectrograph. Syzygy Optics supplied the VPH gratings; we are very grateful to Chris Clemens of the University of North Carolina who runs Syzygy Optics and kindly gave us a free sample with which to develop the prototype spectrograph shown in Figure 4. Construction and deployment of the four spectrographs will take place during 2013.

The deployment of these observatories around the planet, when equipped with the four VPH spectrographs following their construction, will give fine spectral resolution over a long wavelength range, fine time resolution observations (every few hours) over a long time duration (many years), and hence give exquisitely fine detail on the cause and effect processes that govern accretion and jet launch that will inform the big picture of how matter behaves in the vicinity of black holes. In addition to the primary research goals relating to black holes, and the discovery of new microquasar systems in our Galaxy, the Global Jet Watch project also has significant educational spin-offs (Figure 6) with internet connectivity for the schools and interaction with astronomers and the scientific method being major benefits for the students.

It is a pleasure to thank AAO and especially Matthew Colless for their support of Steve Lee's activity in this project, thus ensuring that AAO's tendrils truly reach around the planet.

References:

Blundell, Schmidtobreick & Trushkin 2011, MNRAS, 417, 2401 *"SS433's accretion disc, wind and jets: before, during and after a major flare"*

Nipoti, Blundell & Binney 2005, MNRAS, 361, 633 *"Radio-loud flares from microquasars and radio-loudness of quasars"*

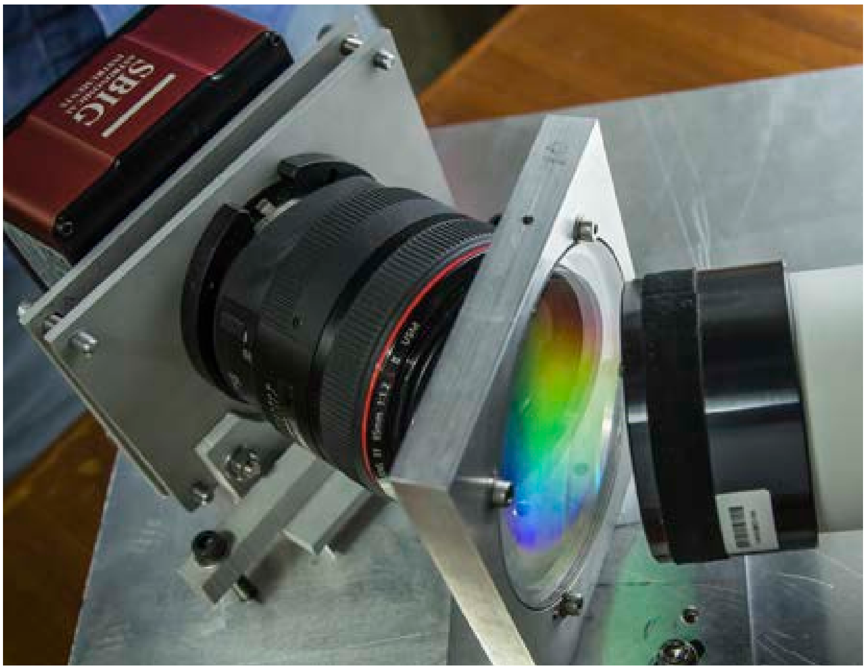


Figure 4: Prototype spectrograph constructed by Steve Lee with R~4000 and 2400Å wavelength coverage.

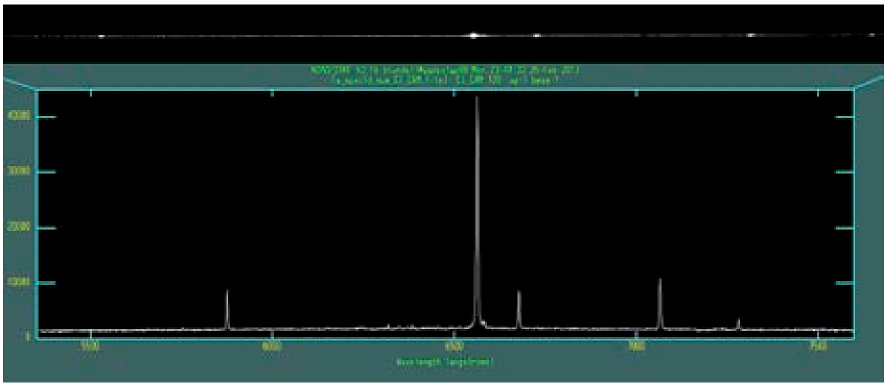


Figure 5: A first light target for the prototype spectrograph on the GJW-IN was CI Cam, observed in February 2013: the spectrum plotted is 5 X 120-second exposures.

Figure 6: Katherine Blundell (project leader) giving a talk at the school in India.

DECam is an infrared camera too

Jeremy Mould (Swinburne University)

It began with a committee meeting ten years ago. An NOAO committee recommended to the director (me at the time) that CTIO's Blanco telescope needed a new instrument. This is the sort of recommendation a director likes. Everyone knows new instruments are where discoveries come from. So my next visit to the La Serena campus included a scientific staff meeting on this topic. What should the next instrument be? I thought I knew; multiobject spectroscopy had brought fame and fortune to the AAT. "Surely, this is what the Blanco needs?" I said. But the staff, with Nick Suntzeff as their spokesman, had a different opinion. What the Blanco needed was a new camera. The Mosaic cameras on both the Blanco and the Mayall telescopes had been real winners and found supernovae for the High-z and Supernova Cosmology teams. But these cameras exploited only a fraction of field of the 4m telescopes' prime foci.

An announcement of opportunity followed. Whoever could supply the Blanco and its community with a new instrument would be rewarded with generous guaranteed project time. The winning proposal, selected by an independent committee, was Fermilab's Dark Energy Camera. This was an exceedingly bold proposal: not just a new camera, but also a new prime focus corrector. The proposal was not only for a new camera, but a new camera with a larger focal plane larger than the original design. Not only would the camera be a half gigapixel, but it would also have pipeline. Even the NOAO Users Committee was sufficiently impressed not to be too worried about the loss of competitive time.

The Fermilab team set about the project as only experimental particle physicists can do. The following winter, I visited this national laboratory, hosted by former director, John Peoples. We drove out to the "silicon area". This was where the CCDs would be tested and the focal plane assembled. Alistair Walker should tell the story from CTIO's perspective after that.

To my great good fortune, I was able to reenter the picture this year with the award by the Australian Time Allocation Committee of the first community time on DECam, December 1, 2012. ATAC time came about through a time-swap: Blanco imaging for AAT MOS time. Our project, deep red/infrared fields with DECam, is imaging two circumpolar deep fields, looking for the tip of the galaxy-luminosity function at high redshift and for luminous high-redshift supernovae. Our second night was January 12, 2013, also photometric.

I can report to future users that DECam is highly efficient and a pleasure to use, even from a remote observer's view of the system. Our 2012 night was bright time, but moon is not a huge issue at one micron, and conditions were photometric with good seeing. Tim Abbott of CTIO was observer and Robert Barone-Nugent, PhD student at University of Melbourne, was script writer. There was hardly any closed-shutter time from twilight to dawn. The community pipeline promptly delivered flattened images with a world-coordinate system for stacking. The people who have made this extraordinarily powerful system are too numerous to mention here, but you know who you are, and thank you all very much.

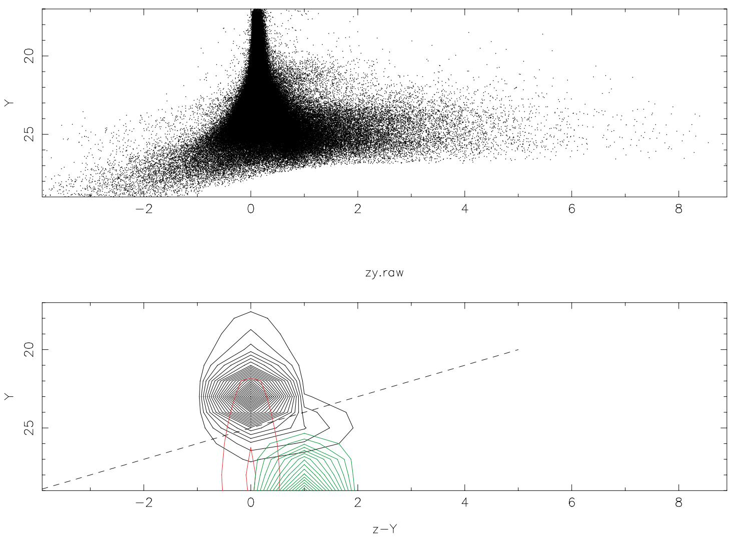


Figure1. For a third of the field and 140 minutes of stacked Y band, the accompanying plot shows objects detected in a zY colour-magnitude diagram with a completeness (dashed) line drawn in at z = 25. Galaxy counts taken from the Hubble UDF (but without colour information) are contoured in green for a unit interval in redshift around 6. Star counts in red from the Bahcall-Soneira model (also without colours) are an order of magnitude lower than the object counts. Two full nights' data can be expected to carry us well into the epoch of reionization. Wide field coverage may allow us to detect the fabled pair instability supernovae, a feature of the high-redshift universe.

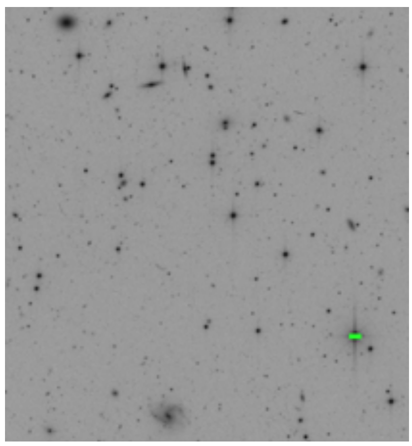


Figure2. A stack (140 minutes) by NOAO of a small piece of the 5hr DECam Deep Field (25 sq arcmin) in Y band (1.035 microns). FWHM = 0.8 arcsec for stellar images. Detections at the 2.3-sigma level on this image are Y = 25.45 mag (Vega system). An M* galaxy at z = 6 has Y = 24.0 mag. Credit: First community time 2012/1/12. Mould/Lidman/Wyithe.

On the 3D Structure of the Mass, Metallicity, and SFR Space for SF Galaxies

Maritza A. Lara-López (AAO), Angel R. López-Sánchez (AAO, Macquarie University), Andrew M. Hopkins (AAO)

In the last few years it has been found that the stellar mass (M), gas metallicity (Z), and star formation rate (SFR) are strongly interrelated. Analyzing galaxy measurements from the Sloan Digital Sky Survey (SDSS), Ellison et al. (2008) found that the mass-metallicity (M-Z) relation for star-forming (SF) galaxies depends on the SFR.

Subsequently, Lara-Lopez et al. (2010) reported the existence of a Fundamental Plane (FP) between these three parameters. These authors confirmed that the M-Z and M-SFR relations are just particular cases of a more general relationship. Lara-López et al. (2010) fitted a plane and derived an expression for the stellar mass as a function of the gas metallicity and SFR (M=f(Z,SFR)), finding that this combination reduces the scatter significantly compared to any other pair of correlations. In a parallel and independent study, using the same SDSS data, but different Z and SFR estimations, Mannucci et al. (2010) found a similar fundamental relationship, but instead expressed metallicity as a combination of stellar mass and SFR (Z=f(M,SFR)) with a substantially different quantitative relationship, obtaining a curved surface for the same 3D space. They refer to this correlation as the Fundamental Metallicity Relation (FMR).

The main difference of both studies relies on the different metallicities and methodologies used by each authors. While Lara- López et al. (2010) used the metallicities of Tremonti et al. (2004, hereafter T04) and fitted a plane using regression to the 3D space; Mannucci et al. (2010) final metallicities are an average between the N2 and R_{23} methods, and analyzed this 3D space binning the data (first they constructed a grid on the M-SFR face, and estimated the median metallicity in every square of the grid).

To unveil the true structure of the space formed by the metallicty, stellar mass, and SFR, we analyze different metallicity methods (see Section 1), and three different approaches to find the best representation of this 3D space (see Section 2). Our analysis is developed using SDSS-DR7 data and star forming galaxies using the classification by Kauffmann et al. (2003).

Section 1. Metallicity estimate issues

Since the calculation of metallicity is a particularly challenging process, the most accurate and reliable measurements available should be used whenever possible. Approximating metallicity estimates through simple parameterisations can be a valuable tool when only limited information is at hand, but such approximations have significant limitations and uncertainties.

We analyse several metallicity indicators, including the empirical calibrations used by Mannucci et al. (2010) of Nagao et al. (2006, hereafter N06), which are cubic fits between the R_{23}=[OII]3727+[OIII]4959,5007/Hb and the N2=[NII]6584/Ha parameters and the T04-derived metallicity. However, the use of the N2 index to derive metallicities is not valid in the high metallicity regime. This can be appreciated in Figure 1, which shows the relationship between the T04-derived metallicity and the N2 parameter and metallicity, respectively. It is clear that the N2 index saturates for metallicities higher than 8.8 dex.

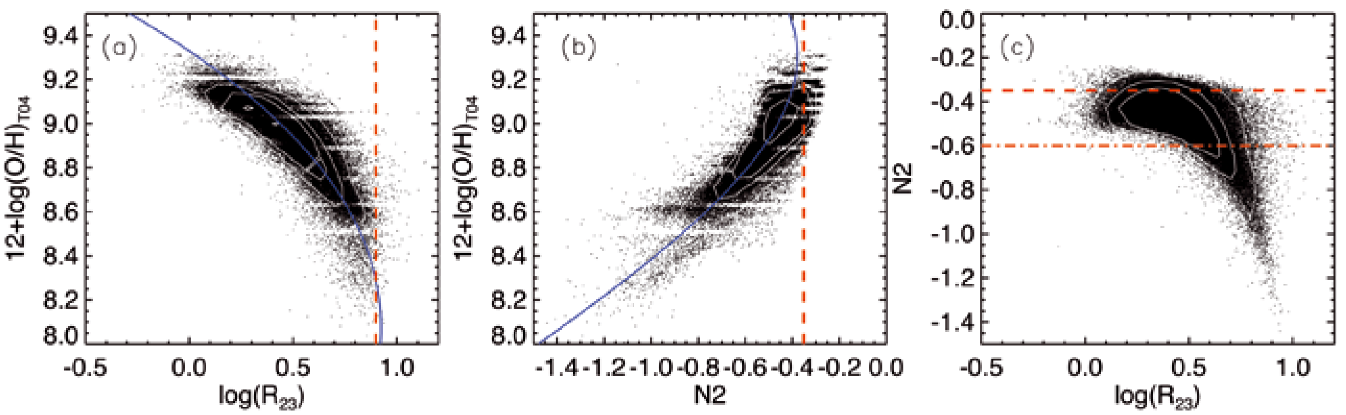


FIGURE 1. Panels (a) and (b) compare the log(R_{23}) and N2 parameters with the T04 metallicities, respectively. The blue line gives the N06 calibrations, while the red dashed line indicates the limit imposed by Mannucci et al. (2010) to their cubic fits. Panel (c) compares the R_{23} and N2 indexes. The red dashed line indicates the limit of panel (b), while the dot-dashed line shows the limit in which the N2 method should be avoided (N2>-0.6).

Section 2. A 3D analysis of the M, Z, and SFR space

Here we aim to identify the most compact representation of the data distribution in the 3D space of M, Z and SFR. We examine three methodologies: (i) fitting a plane to the 3D distribution using PCA, (ii) fitting a plane through regression (Lara-López et al. 2010), and (iii) binning in SFR and M to obtain the median Z in each bin (Mannucci et al. 2010).

The PCA shows that this 3D space can be adequately represented in only two dimensions, i.e., a plane, however, PCA relies on the covariance matrix, which is less robust against outliers, and hence the plane obtained through PCA does not provide the most robust result. We next explore regression to represent our 3D data distribution. Regression aims to explain one variable in terms of the others, and uses robust methods that are less affected by outlying observations. Using regression we fit three different planes, one for every variable, finding that the fit that gives the best χ^2 is the one to the stellar mass as a function of SFR and Z, M=f(Z,SFR). Finally, we find that the distribution resulting from the median values in bins for our data gives the highest χ^2. All those representations can be seen in Figure 2.

Section 3. Discussion and conclusions

The use of a reliable metallicity estimator is crucial, for this reason, we recommend that the estimator of N06 be used with caution, and limited to the range (12+log(O/H)<8.8) where the saturation of the N2 parameter is not a problem.

We analysed the 3D distribution of M, Z, and SFR using three different approaches: (i) fitting a plane using PCA, (ii) fitting a plane through regression (Lara-López et al. 2010), and (iii) binning in SFR and M to obtain the median Z of each bin (Mannucci et al. 2010). For the five methods used, we estimated the Ð^2 as a measure of goodness of fit. We find that the best representation of the data is the plane defined by regression on the stellar mass, as proposed by Lara-López et al. (2010).

The SFR of a galaxy relates to the amount of gas currently being converted into stars, and correlates with the current mass in stars, while metallicity is a measure of the number of times that the gas has been reprocessed by stars, and also correlates with the current mass in stars in a galaxy. The fact that we can represent M as a linear combination of SFR and metallicity suggests that the stellar mass of a galaxy can be thought as the rate at which a galaxy is currently forming stars (SFR), plus a measure of the star formation history, here represented by the metallicity (Z), corresponding to the amount of reprocessing of the gas by past stellar generations. The SF history and current SFR of a galaxy are closely linked to stellar mass.

The full version of this paper is published as Lara-López, M.A., López-Sánchez, Á.R., and Hopkins, A.M., 2013, ApJ, 764, 178.

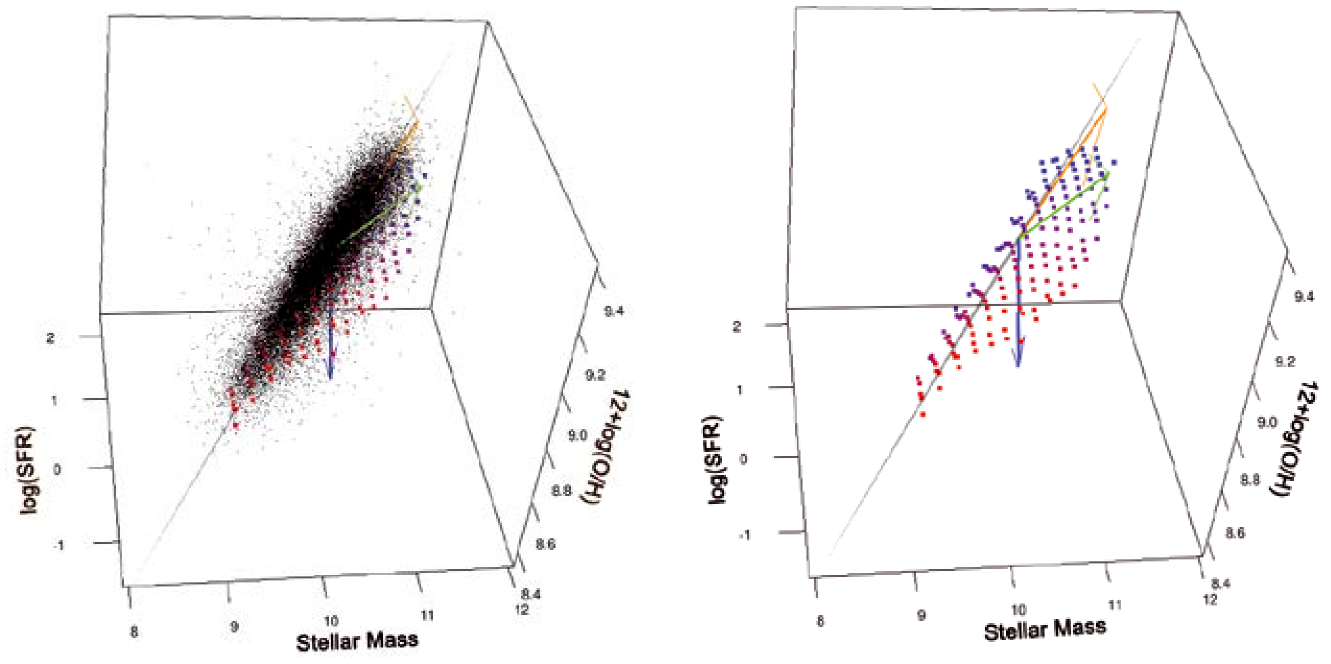


FIGURE 2. Different orientations of the 3D space formed by M, SFR, and Z. The left panels show our derived FP (shaded), while the coloured square points show the median metallicity taken in bins of SFR and M (as for the FMR, Mannucci et al. 2010). Square points are colour-coded from low (red) to high (blue) SFR. Black data points are the full sample. The vectors show the first PCA component in yellow, the second in green, and the third in blue. The right panel show the same orientation as the left panels but omitting the underlying sample of SDSS galaxies.

AAT follow-up of the Supernova Survey Fields of the Dark Energy Survey

Chris Lidman[1], Rob Sharp[2], Syed Uddin[3], Karl Glazebrook[3], Chris Blake[3], Matthew Colless[2], Tamara Davis[4], Jeremy Mould[3], Greg Poole[5], and Brian Schmidt[2] (The OzDES consortium), and Filipe B. Abdalla[6], Chris D'Andrea[7], Manda Banerji[6], Rachel Cane[8], Carlos Cunha[17], Ricardo Covarrubias[9], David Finley[10], Joshua Frieman[10, 11], John A. Fischer[8], Ravi Gupta[8], Stephanie Jouvel[12], Alex Kim[13], Huan Lin[10], Bob Nichol[7], Richard McMahon[14], Andreas Papadopoulos[7], Kathy Romer[15], Philip Rooney[15], Eli Rykoff[16], Masao Sako[8], Rollin Thomas[13], Douglas Tucker[10], Risa Wechsler[17], William Wester III[10], and Harry Wilcox[7]

Dark Energy

The key goal of observational cosmology for the current decade is to constrain the nature of dark energy through the detailed, accurate, and unbiased measurement of the Universe's expansion history. A non-zero cosmological constant, in which the dark energy equation of state is exactly -1 and is constant in space and time, is fully consistent with recent results [1-4]; however, so are several competing models that are as fundamentally different to each other as they are to the cosmological constant. Although we do not yet know which of these models, if any, will survive as datasets get larger and more precise, it is certain that in our effort to understand dark energy, our understanding of the nature of space-time, gravity, and the quantum vacuum will change profoundly.

The Dark Energy Survey

The Dark Energy Survey (DES) is a new survey that will provide the tightest constraints yet on the nature of dark energy. In fact DES, through its use of multiple probes (galaxy clusters, weak gravitational lensing, large scale structure, and type Ia supernovae), will be able to test alternatives to dark energy, such as modifications to Einstein's theory of general relativity.

1 AAO
2 ANU
3 Swinburne University
4 University of Queensland
5 University of Melbourne
6 University College London
7 University of Portsmouth
8 University of Pennsylvania
9 University of Ilinois
10 Fermi National Accelerator Laboratory
11 University of Chicago
12 Institut de Ciencies de l'Espai (IEEC/CSIC)
13 Lawrence Berkeley National Laboratory
14 University of Cambridge
15 University of Sussex
16 SLAC National Accelerator Laboratory
17 Stanford University

DES has been allocated 525 nights over the next 5 years to perform two major new surveys of the southern sky: a 5,000 square degree survey around the Southern Celestial Cap, and a new transient search, consisting of 10 pointings covering a total of 30 sq. degrees, focused on finding thousands of new type Ia supernovae (SNe Ia) between z=0.2 and z=1.2. The data will be taken with DECam, a new 520 megapixel camera on the Blanco Telescope in Chile (see Fig. 1 for an image taken with DECam), which saw first light in September 2012.

Over the lifetime of the survey, DES will obtain about 4,000 high-quality SNe Ia lightcurves [5]. This is an order of magnitude larger than the number of SNe Ia that are in the full 5-year data set of the Supernova Legacy Survey (SNLS). DES will be the largest and most accurately calibrated SN survey for at least the next decade.

Real-time spectroscopic follow-up of all of the SNe Ia in the DES survey is unrealistic. In the SNLS, for example, the real-time spectroscopic follow-up of about 400 SN Ia required more than 1,000 hours of time on 8-10m class telescopes. The SNe in the SNLS had to be observed one at a time, as usually there was only one SN Ia visible at any given time within the fields of view of the instruments that were being used to do the spectroscopic follow-up. Adopting the same strategy to follow all 4,000 SNe Ia in DES would require 10 times as much time, i.e. 10,000 hours. Obtaining such a large amount of time on 8-10m class telescopes is unlikely to succeed.

Instead, the DES SN survey will forego the real-time follow-up of the bulk of the SNe Ia and will use a strategy that has been tested with data from SDSS-II [6] and SNLS [9-11]. The central plank of the strategy is to obtain redshifts from the SN host galaxies, from which a large sample of photometrically-classified SNe Ia can be constructed with sufficient purity (the percentage of SNe Ia in the sample that are actually SN Ia) for the cosmological analysis. The SDSS sample of photometrically-classified SNe Ia has a purity of 96% [6], thereby demonstrating the feasibility of obtaining samples of SNe Ia with high purity using the photometry of the SNe and the redshifts of the host galaxies.

There are two major advantages to this approach: i) it is much easier to get the redshift from the host galaxy than to spectroscopically confirm the SN, and ii) one can observe many host galaxies simultaneously, rather than one SN at the time, since the observations are no longer time critical and one can wait until there are sufficient number of host galaxies to observe. Using photometric redshifts of the host galaxies is not an option as there are concerns that such photometric redshifts would be precise enough or sufficiently unbiased.

AAT Follow-up and First Results

The 2dF fibre positioner and AAOmega spectrograph on the AAT, with its wide field of view, multi-object capability, and wide spectral coverage, is the ideal instrument to obtain redshifts for most of the SN hosts in the DES SN fields.

There will be no shortage of transients from DES. Within a single observing season, there will be as many transients per DES field as there are fibres in 2dF. About one-fifth of these will be SNe Ia with high-quality multi-colour light curves.

Over the last couple of years a number of improvements to the instrument and the data processing have greatly increased the grasp of 2dF and AAOmega. Most notable are the new fibres, which have eliminated the problem of fringing (see Fig. 1 in [7], for an example of fringing), and the implementation of a new recipe – based on principal component analysis (PCA) of the residuals left after

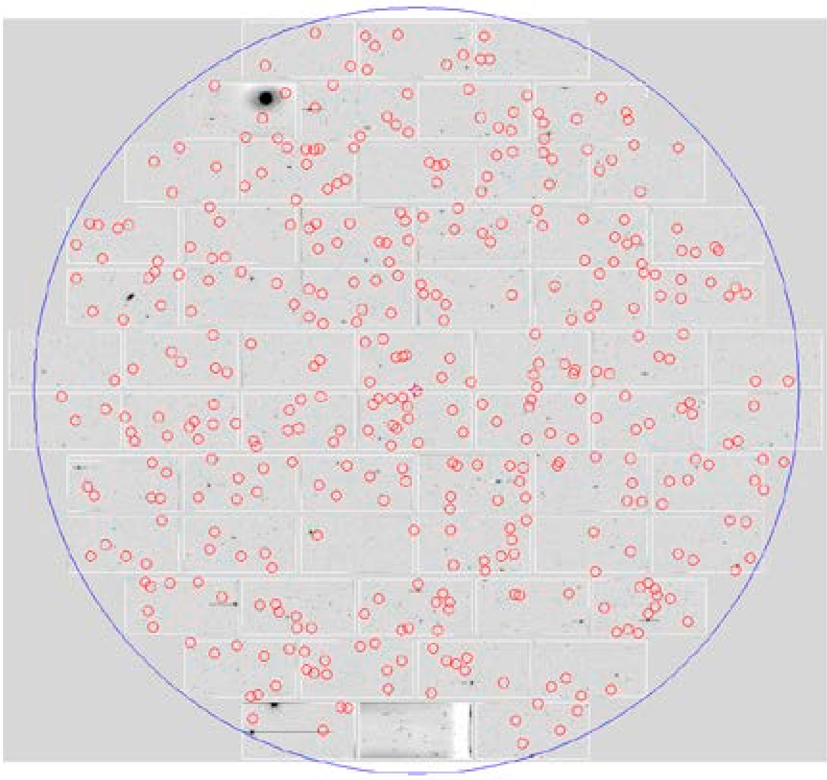


Fig. 1. Two perfectly matched fields of view. A DECam image of the DES C1 field, with the 2.1-degree diameter patrol field of the 2dF fibre positioner (large blue circle) and DES targets (small red circles) overlaid. The focal plane of DECam is paved with 62 CCDs.

sky subtraction – to better remove the sky [8]. These improvements are set to continue with the installation of new CCDs with better cosmetics and higher quantum efficiency during 2014.

Even before the new fibres were available, we showed that we can use 2dF and AAOmega to obtain redshifts for objects that are as faint as R=23.5 (most of the SN hosts in the DES survey will be brighter than this), with greater than 50% completeness in integrations lasting 10 to 20 hours [9,10]. With the new fibres, we expect the PCA sky subtraction routine to do even better job of removing the sky, thus allowing one to increase the completeness at these faint magnitudes.

During two AAT runs in December 2012 and January 2013, we targeted 5 of the 10 DES SN fields with the 2dF fibre postioner and AAOmega spectrograph. As shown in Fig.1, the patrol field of the 2dF positioner is well matched to the field-of-view of DECam. The DECam data were taken as part of DES science verification program.

While most of the fibres during our two runs were allocated to galaxies, there were several SNe that were bright enough to be observed with the AAT and typed directly. Confirming the SN type for a subsample of SNe is an important part of the strategy, as it enables us to enhance the purity of the photometrically selected SNe Ia sample.

During our two observing runs, we spectroscopically confirmed several SNe Ia from DES, including the first SN from DES to be spectroscopically confirmed as a SN Ia (see Fig. 2). Using the AAT, we were able to confirm SN Ia up to z=0.3 [12,13]. If we can better remove the spectral discontinuity that often appears when the spectra from the red and blue CCDs are spliced together, we believe that it should be possible to use the AAT to confirm Type Ia SNe from DES up to z~0.5.

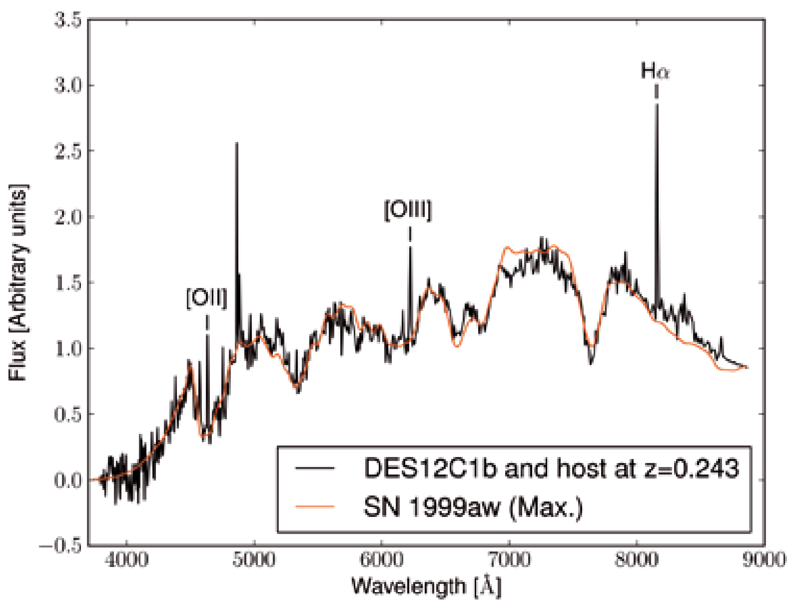


Fig. 2. The spectrum of DES12C1b, the first spectroscopically confirmed SN Ia discovered by DES [12]. The spectrum of the SN (in black) is compared to that of a nearby SN Ia (in red). Broad lines from silicon, calcium, and sulphur from the SN Ia and narrow emission lines from the host galaxy (as marked in the figure) are readily apparent. The total integration time was 200 min. The spectrum is not flux calibrated.

Future Plans

OZDES is a consortium of Australian-based researchers that are in the process of signing a memorandum of understanding with the DES collaboration with the principal aim of advancing DES science. The long-term plan of OzDES is to conduct a 100-night survey with 2dF on the AAT targeting the 10 DES SN fields. The survey would be spread over the five years that DES runs. We would start with a relatively small number of nights in the first year, starting in semester 2013B, and then gradually ramp up the number of nights that are requested over the years that follow. Over the course of the survey, we expect to spend 50 hours per DES field and to obtain redshifts for over 2000 SN host galaxies.

Our plans are not limited to SN hosts or live transients: other targets will be selected. During our two observing runs, we observed a broad range of targets, including luminous red galaxies, cluster galaxies, quasars, DA white dwarfs, and field galaxies that will be used to calibrate photometric redshifts. The redshift distributions of selected classes of galaxies from our two observing runs are shown in Fig. 3.

These targets are used to address a number of questions that are directly relevant to constraining dark energy. For example, DA white dwarfs potentially provide a more accurate way of calibrating SN fluxes, which currently is the largest systematic uncertainty in SN cosmology, spectroscopic redshifts for photo-z sources help reduce the impact of large scale structure in the photo-z training set, as well as allowing one to use the cross-correlation method [14] to determine the true redshift distribution of the DES photometric sample, and clusters of galaxies are used to constrain the properties of dark energy and to test alternatives to general relativity. One of the great advantages of using galaxy clusters as cosmological probes with a photometric survey is the incredibly precise photometric redshifts that are achievable by using a large number of similarly coloured cluster galaxies. Achieving this precision requires a precise calibration of the cluster red sequence via spectroscopy of the central galaxies. Fortunately, these central galaxies (the redmaPPer galaxies in Fig. 3) are the brightest galaxies at a given redshift, and thus are suitable targets for AAOmega.

In closing, we are very pleased with the results from the AAT. We believe that the AAT will play a pivotal role in enabling DES science and we look forward to using it to target DES fields in the years to come.

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[14] Matthews D. J. and Newman J. A., ApJ, 721, 456

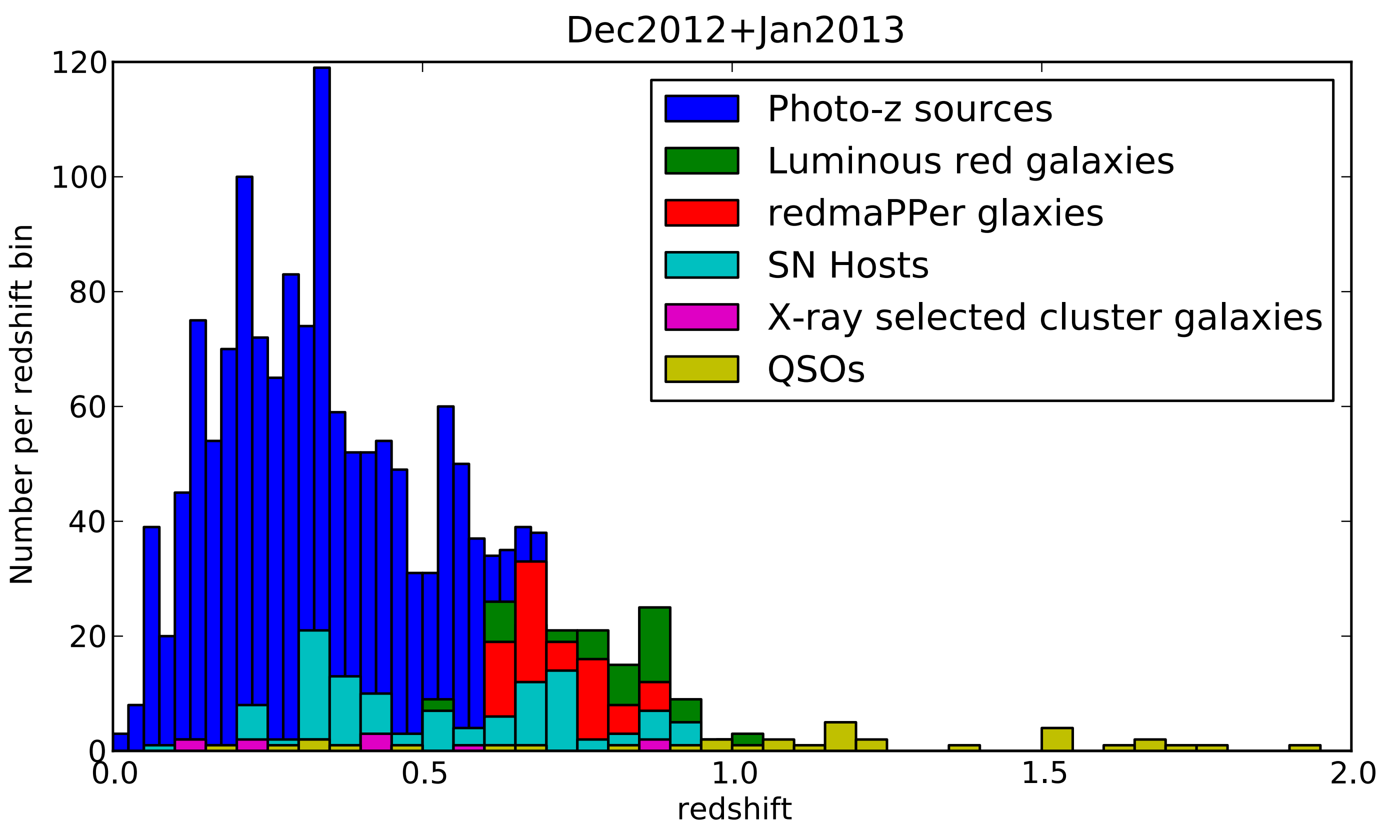

Fig. 3. Redshift histogram of objects targeted during our two observing runs. Different colours represent different targets, each of which has been selected for a specific purpose and to cover specific redshift intervals. For aesthetic reasons, QSOs beyond z=3 are not shown and photo-z sources are binned with finer binning. The redmaPPer galaxies are the brightest galaxies of optically selected galaxy clusters.

Galactic Archaeological Surveys: Past, Present and Future

Sydney, Australia, 23 – 27 July 2012

Gayandhi De Silva (AAO)

During the last week of July 2012, a group of 55 astronomers (28 from overseas, many in Australia for the first time) gathered at the heart of Sydney CBD for a workshop on Galactic Archaeology surveys. The four day workshop was held at the Sydney Masonic Center and was funded primarily by the Department of Innovation Scholarship Award with supplementary contributions from Macquarie University. A welcome reception was held on the 23rd July, and the science sessions started on the 24th July.

The meeting started by highlighting the HERMES instrument and introducing the associated GALAH survey. It quickly progressed into an active science program along the workshop theme of what we have learnt from past surveys, what we are now learning with present research, and what we want to learn when planning for future surveys. The talks and discussions were on both characterizing the Milky Way, as well as technicalities of carrying out successful large-scale surveys.

The four days were filled with engaging presentations of our latest knowledge of the observed Galactic sub-structures, simulation that agree (or not) with those observations, limitations and unanswered questions, technicalities of software and data handling to lessons learnt from past large-scale surveys. Each day ended with lively discussion sessions on the various topics covered at the meeting, from what are the missing observations to the usefulness of theoretical models, from defining accuracy versus precision to managing large-scale surveys. Some of the key lessons learned from discussion on the final day included "calibrate, calibrate, calibrate", a "Darwinian" approach to allocating workloads, managing the reverse dataflow for scope creep, and minimising bureaucracy.

The teas and lunches provided at the venue allowed participants time to chat informally and break out into mini-lunchtime meetings. In the evenings, most participants based in the CBD networked socially, enjoying the variety of cuisines Sydney has to offer. On a mild evening on the 23rd July, the delegates enjoyed a scenic ride on the famous Sydney ferries with iconic views and excellent food at the Sails restaurant for the workshop dinner.

The workshop would not have been possible without the hard work of the local and scientific organising committees, the members of which are listed below. Thank you also to Vanessa Bugueno (AAO) for the financial admin work before, during, and after the workshop. Thanks to Jane McGowan (DIISRTE) for helping with the departmental scholarship award processes, and Helen Woods (AAO) for her help with many last minute items.

Workshop Group photo. Can you spot the Galahs?

Credit: Simon O'Toole

Scientific Organising Committee: Martin Asplund, James Binney, Joss Bland-Hawthorn, Gayandhi De Silva, Sofia Feltzing, Ken Freeman, Eva Grebel, Jennifer Johnson, Heather Morrison, Daniel Zucker

Local Organising Committee: Daniela Carollo, Valentina D'Orazi, Gayandhi De Silva, Arik Mitschang, Simon O'Toole, Daniel Zucker

Sparking Interest in Science

Amanda Bauer (AAO)

Holding a burning sparkler in one hand and a microphone in the other, I carefully explained how galaxies in the crowded centre of a distant galaxy cluster grew to maturity faster than in its outskirts, without being able to use the words "galaxy," "cluster," or "grow," before the sparkler burned out. This was just one of the challenges we "freshies" faced during our week at the *Fresh Science*[1] national finals held in Melbourne in October last year.

One dozen finalists were selected among early-career researchers across Australia, studying any field of science, based on the ability to describe recently published science results to a popular audience. As finalists, we traveled to Melbourne to receive four days of intense science-communication training, to speak to school groups, to entertain the public at a "Science in the Pub" event, and ultimately, to put out a press release on our work and be interviewed by a variety of news-media representatives.

Talking about science to a general audience is not a skill that comes naturally to most scientists, yet it is very important and a skill that can be improved upon with training and practice. One dramatic, yet useful experience came on the first day of our science-communication training. We each stood in front of the group to summarise our research in three minutes. Our pitches were recorded, then we all watched the videos and critiqued each other.

Watching ourselves talk, recognising the use of unhelpful jargon, hearing our unnecessary "ums" and voice clicks, was embarrassing and uncomfortable, but ultimately, the feedback greatly improved our ability to entertain the audience with our science. I think that is a critical point to take away from this experience: when presenting to the media or students or the general public, it's not about giving them the "hard facts," it's about telling an engaging story that expresses the thrill of scientific discovery and delivers an exciting piece of new knowledge for them to take away.

An entertaining and surprising statistic I came away from the training with is that during any presentation, only 12% of the audience is paying attention at any given moment. 20% is indulging in sexual fantasies, 20% is reminiscing, and the rest is worrying, daydreaming, thinking, etc.

So how do you keep an audience engaged? Here are some useful tips:

- Memorise the opening and closing lines because they make the most impact. Actually, super-practice the introduction to give yourself a confident start.
- No matter the length of the presentation, the audience will only take away 3 pieces of information. Choose those three items wisely and focus on arguing/telling the story of those three throughout the entire presentation.
- Change the focus every few minutes: vary the tone of your voice, use audience participation, pause, use the Power-Point-"B" key to provide a blank screen and bring the attention back to you.

I learned throughout the week that despite the recent decrease in science journalists across Australia, newspapers want to print science stories. Newspapers make money from advertisements, and since ads they sell on their websites make much less money, the online stories that get "click-throughs" are the ones that get promoted.

The ability of scientists to tell their stories in exciting snippets using attention-grabbing images, working with media officers to create catchy headlines and flashy images, is a good way for scientists to start promoting their research more successfully to the public. Not only do scientists benefit by having more attention on their research, but visibility helps politicians and the public understand how science funding is used.

The final surprise challenge that the Fresh Science organisers threw us at the "Science in the Pub" event was to write a haiku or limerick about our research with help from the audience members sitting at our table. Technical details aside, I was pleased with the limerick we created:

The Universe was once made of gas.
Stars formed due to gravity and mass.
Galaxies are collections of these suns,
I found 50 new ones!
But there are billions, as the Universe is unfathomably vast.

1 http://freshscience.org.au

Perspectives from the AAO Planning Day

John Collins, Vanessa Bugueno and Andy Green (AA)

In the last week of November, AAO staff from Sydney and Canberra travelled to Coonabarabran for a chance to meet, see the telescope and all that happens at Siding Spring Observatory, and discuss the future of the AAO. The day began with a fantastic welcome at the AAT, followed by short presentations to illustrate day-to-day work both at the AAT and in North Ryde. Separating the talks was a fabulous spread of homemade treats for morning tea. Matthew Colless officially opened the room that will house the new HERMES instrument. After lunch with staff from across the mountain, guided tours of the AAT, UK Schmidt, SkyMapper, and ANU 2.3m telescopes showed everyone around the mountain. In the evening, the AAO staff wished Matthew farewell over dinner.

FIGURE 1. Staff presented their activities in the shadow of the 3.9 m AAT on the dome floor. Credit: James Gilbert

One of the primary goals of the day was to help bring AAO staff from our widely spaced sites closer together. Below are perspectives on the day from Vanessa Bugueno, one of our admin

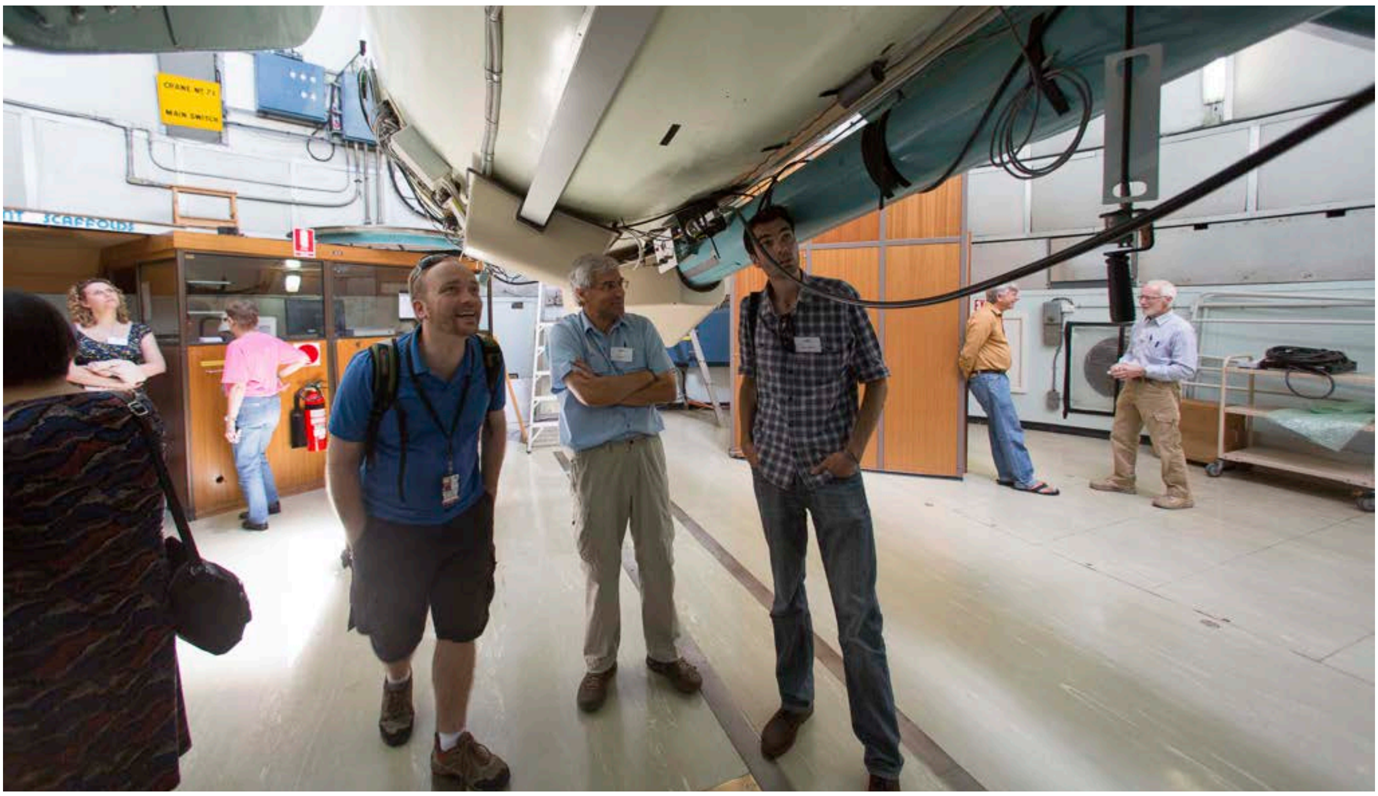

FIGURE 2. Paul Cass describes the functionality of the UK Schmidt Telescope to other staff touring the mountain. Credit: Andy Green

staff at North Ryde, and John Collins, one of the technicians at the AAT.

From John—

Well, that was worth doing I reckon, I thought as the big bus headed back to the big smoke.

The best thing for me was to see so many people made the effort to come together and maybe get to know each other a little better. There was no way you could get around and meet everyone but to mix in a social setting is a lot different to interacting through work and it was definitely a whole lot more fun.

The tucker was great, those pink butterfly cupcakes are the best, the wines out at Blowfly wines just kept on getting better and better and I have to say the ladies put us blokes to shame when it came to the fashion stakes.

I also think the talks were well received on both sides, sometimes it feels like we up here at the AAT are a bit left out of all the exciting stuff and it is easy to fall into a bit of a routine of pulling instruments on and off the telescope. So I think it was great for the Sydney crew see some of the bigger projects that have happened up here at site and the clever people behind them.

The talks from the guys and girls from Sydney were great too, to get a better insight on what they are up to on a day to day basis helps a lot I think to build that spirit of being one big team with a common purpose and to break down that '*us* and *them*' mentality.

And who can't help but get excited when you see cool new stuff like starbugs and all the other innovative research that is going on at the moment.

So I say well done to everyone who participated and I hope you all enjoyed yourself at the telescope and in our little town, hope the next Planning Day works just as well.

From Vanessa—

The trip began with a coach full of staff leaving from North Ryde. Many onboard spend much of their time at site; however as someone who has not visited the telescope often, I was both excited and a little unsure of what to expect (a little like leaving on the bus for school camp).

The Planning Day presentations were very enlightening. The topics were well presented in a clear and concise manner and the enthusiasm shown by the speakers was contagious. By the end I could not believe that time had passed so quickly.

It was great to learn from Sarah Brough what some of the colourful graphs and images represent. I now know that the blue coloured galaxies have ongoing star formation, while the red have stopped forming stars and are now passive. By the end of the presentations, I could not believe that time had passed so quickly.

After a lovely lunch and too many delicious cakes we were able to tour the grounds and other telescopes onsite.

When viewing the 2.3m telescope, I was advised that the telescope is 'fixed' and it's actually the building that rotates. However I did not expect to be underground when the building began to shift. Although the building doesn't rotate at a fast speed, I still had to ensure I wasn't collected by one of the beams whilst trying to record the experience on camera.

Once back at the AAT, I was pleased to view SAMI, CURE and CYCLOPS and learn about their place on the telescope. I may not fully understand how these instruments work but I'm certainly familiar with the components and materials—that is, the cost of the materials, the task numbers they were applied to, the payment methods used, the suppliers, their creditor codes, as well as related issues concerning international wire transfers and freight. It was nice to see the end result. It was also rewarding in that by providing support to the managers and their teams the admin team and I were able to contribute to the building of these instruments—even in a small and indirect manner.

My favourite part of the Planning Day was watching the AAT rotate. The sheer magnitude of the telescope is such a sight and I was simply in awe. It never fails to impress and I am sure that next time I will find it just as exciting.

It was so wonderful to see familiar faces once more and meet a few new ones. Everyone had such a great time, and I cannot wait to visit again.

FIGURE 3. Matthew Colless views the setting sun using Steve Lee's telescopes and special solar filters. Credit: James Gilbert

CYCLOPS2 & CURE Commissioned

1Anthony Horton (AAO), C.G. Tinney (UNSW), Scott Case (AAO), Tony Farrell (AAO), Luke Gers (AAO), Damien Jones (Prime Optics), Jon Lawrence (AAO), David Orr (AAO), Nick Staszak (AAO), Minh Vuong (AAO), Lew Waller (AAO) and Ross Zhelem (AAO)

CYCLOPS2 [Horton et al] is an upgrade for the University College London Echelle Spectrograph (UCLES) [Diego et al], the high resolution optical spectrograph of the AAT. By replacing the 5 mirror Coudé train with a Cassegrain mounted fibre-based image slicer CYCLOPS2 simultaneously provides improved throughput, reduced aperture losses and increased spectral resolution. Sixteen optical fibres collect light from a 5.0 arcsecond^2 area of sky and reformat it into the equivalent of a 0.6 arcsecond wide slit, delivering a spectral resolution of R= 70000 and up to twice as much flux as the standard 1 arcsecond slit of the Coudé train. CYCLOPS2 also adds support for simultaneous ThAr wavelength calibration via a dedicated fibre.

UCLES has been one of the longest serving, most successful, and most productive of the AAT's instruments, and remains in demand due to its ability to contribute to a number of important scientific areas such as exoplanetary science [Tinney et al, Vogt et al], metallicity and abundance studies, and astroseismology [Bedding et al, Bedding et al]. By increasing both the overall efficiency and spectral resolution the CYCLOPS2 upgrade will ensure the continuing competitiveness of UCLES in these areas.

CYCLOPS2 consists of three main components, the fore-optics unit, fibre bundle and slit unit. The fore optics unit incorporates magnification optics and a lenslet array and is designed to mount to the CURE Cassegrain instrument interface. The fibre bundle transports the light from the Cassegrain focus to the UCLES spectrograph at Coudé and also includes fibre agitators to suppress modal noise. The slit unit consists of the fibre slit and relay optics to project an image of the slit onto the entrance aperture of the UCLES spectrograph. Figure 1 illustrates these components schematically while Figure 2 is a photograph of the actual fibre feed shortly after assembly.

Calibration, acquisition and guiding facilities for CYCLOPS2 are provided by the new CURE facility. CURE is an add-on to the Cassegrain instrument interface of the AAT, which is intended to simplify and streamline the implementation of fibre-fed and other compact instrumentation with fields of view up to 3 arcminutes in diameter. It does this by providing a suitable standard mechanical interface as well as improved acquisition, guiding and calibration facilities so that CURE-compatible instruments will not have to incorporate such facilities themselves. The instruments expected to make use of CURE, in addition to CYCLOPS2, are the KOALA IFU for the AAOmega spectrograph [Ellis et al], the PRAXIS OH suppression spectrograph [Horton et al] and a number of visitor and/or experimental instruments.

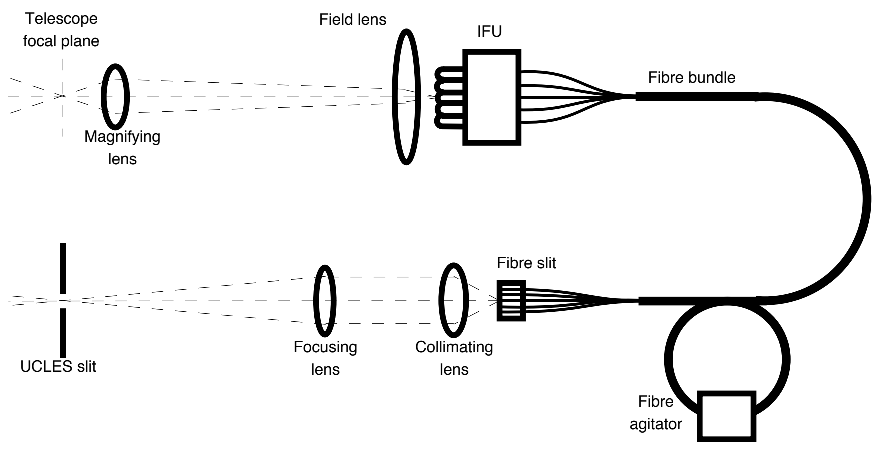

Figure 1: Schematic showing the main elements of the CYCLOPS2 fibre feed. Not shown are the calibration, acquisition & guiding components which are part of the CURE facility.

Figure 2: The CYCLOPS2 fibre feed in Epping in the process of being packed for transport to the AAT. The structure in the foreground is the fore optics assembly, plus the 'f-8 telescope simulator' (used to emulate the illumination from the telescope during fibre alignment) which has been temporarily attached to the input end, towards the right. The grey box is a spare fibre length box used to facilitate assembly, and on top of that is the conduit containing the simultaneous wavelength calibration fibre. The main fibre conduit and the fibre slit assembly are packed in the cardboard box.

CURE is shown in Figure 3, a photograph of the facility installed at the AAT. The instrument interface at the base of CURE is designed to allow easy instrument exchange with repeatable alignment. An acquisition and guide camera looks down on the telescope focal plane via an optical relay and fold mirror, this 'slit viewer' configuration uses either a beamsplitter (as in CYCLOPS2) or a mirrored entrance aperture built into the attached instrument to view the sky. The camera itself is a cooled interline CCD camera equipped with a set of UV, B, V, R, Ic, clear and blank filters, and is suitable for both rapid fire guiding exposures and deep acquisition images. The calibration assembly includes a quartz-tungsten halogen lamp for flat fielding and ThAr, CuAr and FeAr hollow cathode lamps for wavelength calibration. The lamps evenly illuminate an area of the telescope plane equivalent to 1.5 arcminutes in diameter on-sky and the relay optics have been designed so that the illumination closely mimics that from the telescope, including the central obstruction of the telescope pupil. Additional calibration options are available using the existing discharge lamps in the AAT's acquisition and guiding unit and chimney.

CYCLOPS2 is the second fibre feed for UCLES. There were two main reasons for building a second fibre feed. First, difficulties during the assembly of the original CYCLOPS fibre feed resulted in 3 of the 15 fibres being damaged and as a result CYCLOPS had only 12 operational fibres. This resulted in higher aperture losses than intended and unfortunately repair of the damaged fibres would not be possible without rebuilding the entire IFU, fibre bundle and fibre slit assembly. The second main reason for replacing CYCLOPS was to make the fibre feed compatible with the CURE facility. Replacing the fibre feed also provided an opportunity to add a dedicated fibre for simultaneous wavelength calibration and further increase the number of science fibres to 16.

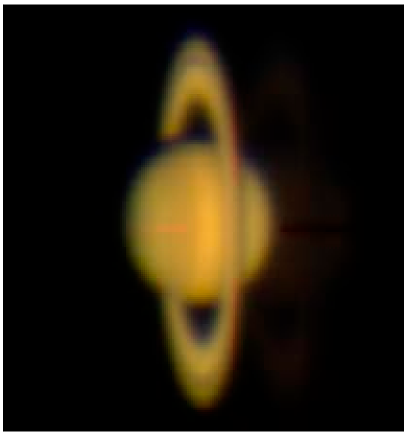

Figure 4: Colour composite image of Saturn obtained with the CURE acquisition and guide camera during the first commissioning run in July 2012. Single 1 second exposures through each of the Johnson-Cousins B, V and R_C were used, each dark subtracted and flat fielded but with no other processing. The CURE acquisition and guide camera was not designed for imaging use and presents some issues with flat fielding and ghosting however with some care useful astronomical data could be obtained.

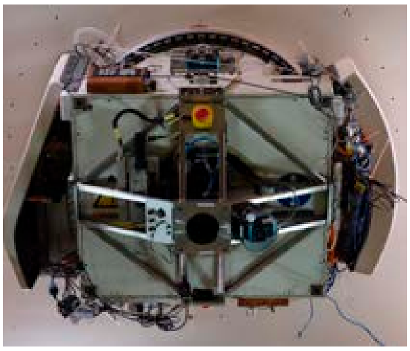

Figure 3: The CURE facility attached to the AAT's main Cassegrain focal station. The CURE instrument mounting interface is the plate with the circular aperture in the centre. To the right the acquisition and guiding camera can be seen, together with its filter wheel. On the left side is the calibration lamp housing, mounted on a linear actuator to enable each of the four lamps to be selected. A separate electronics and pneumatics enclosure is mounted on the Cassegrain cage wall (not shown).

CYCLOPS2 and CURE were commissioned during two runs in July and August/September of 2012. Only minor issues were identified during commissioning and all have since been rectified. Both facilities meet their specifications and provide the intended improvements to throughput, aperture losses, spectral resolution and operational efficiency. CYCLOPS2 has been demonstrated to be better than CYCLOPS in all respects and so the original fibre feed has now been decommissioned. At the time of writing five CYCLOPS2 science runs had already taken place since commissioning and a further four runs are scheduled to take place before the end of semester 2013A.

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Figure 5: The CYCLOPS2 fibre agitators installed near the UCLES pre-slit room. The bar on top of the rectangular structure is the moving part of the low frequency agitator, this oscillates back and forth with adjustable throw and frequency. On the left is high frequency agitator, consisting of a loop of fibre conduit with an eccentrically weighted motor attached. This vibrates the conduit at an adjustable frequency.

Chasing Shadows

Amanda Bauer (AAO)

Last November, I traveled to Far North Queensland to witness one of the most amazing astronomical events accessible to earthlings: a total solar eclipse. My perspective was unlike most amateur and professional astronomers who traveled from afar to feel the chill of the Moon's shadow, because I camped out at a music festival that occurred along the path of eclipse totality. From our location, the eclipse, when the Moon passes exactly in front of the Sun, was perfect.

The energy among the crowd the night before the eclipse was intensifying. Many festival-goers stayed up all night, listening to the continuous music from any one of six stages. I opted to wake up early, before sunlight brightened the horizon, in preparation for the 6:38 am beginning of totality. I walked to the main open area of the festival park, along with thousands of other excited people.

When the Sun finally broke above the line of distant mountains, the crowd basked in a crisp orange sunrise glow. We all cheered with the recognition that the Moon was already covering a tiny sliver of the Sun. Our anticipation grew as the Moon slowly slipped in front of the sun, and the pair rose slightly higher above the horizon.

About 40 minutes later, the light around us started to fade and grow noticeably redder. The temperature had risen with the sunrise, but dropped down several degrees as the Moon covered more and more of the Sun. We looked through our solar glasses, awaiting the big event.

And then it happened. The otherworldly moment when the Moon's shadow swept over us, and the very bright, eye-damaging yellow photosphere we recognise as our star disappeared. A dark orb hung in the sky, unrecognisable as the Moon, backlit by huge, unfamiliar, shimmering rays of white light.

The sight felt so strange, so eerie. The excited crowd settled into a stunned silence, before erupting in a collective rumble of appreciation and awe. What must ancient people who witnessed this event have thought when the sun faded to black so unexpectedly, only to pop back to normal mere minutes later?

Intellectually, I thought I knew the feeling I would be experiencing, since this would be the second total solar eclipse I would witness, after an eclipse in China in 2009, but I was completely overwhelmed. As soon as the darkness set in, the Sun's corona stretched so unbelievably far out around the tiny black moon, my mouth stuck itself in a goofy grin of pure pleasure, and tears came instantly to my eyes - much to my annoyance, because they blurred my vision!

During totality, I was overcome with a feeling that I was more unified with the universe. Despite knowing the fact that we live on a giant sphere of rock, zooming around a big ball of fire at an unfathomable pace, witnessing this event made me feel that power. For two full minutes we sat wonderstruck, staring at the surreal object hanging in the sky, yelling out insufficient adjectives while feeling the chilled air on our skin.

And then it was over. The brightness of the edge of the Sun crept around the Moon. The small black circle disappeared in a flash and we were instantly back to normalcy. How quickly the vision of the bright Sun snapped us out of our revelries. Home again, more connected to the cosmos.

Most of us sat still, watching the Moon finish its path across the Sun's face, reflecting on the experience and its unexpected intensity. After another 30 minutes, the music started playing again and many entranced witnesses began dancing in the restored morning sunlight.

I have not seen a single photograph or video that has captured the pure magic feeling of witnessing a total solar eclipse. It's an unexplainable life event. It's a lucky coincidence that our Moon and our Sun happen to appear as the exact same size in our sky and even cross paths once every 18 months or so. Incredibly inspiring.

I'm already excited for the possibility of chasing the Moon's shadow and witnessing another eclipse, despite the knowledge that earthly weather could prevent the success of such an endeavor. The feeling is worth the effort. I'm officially hooked!

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http://www.cosmosmagazine.com/blog/6179/chasing-shadows

AusGO Corner

Stuart Ryder (Australian Gemini Office, AAO)

Changes within Gemini and AusGO

The international Gemini partnership bid farewell to the United Kingdom as a partner at the end of December 2012. While the observatory has been preparing for this milestone for some time, it is with some regret that we sever formal ties with our valued colleagues. The UK was a founding 25% partner in the Gemini Observatory and made a number of outstanding contributions, particularly in the form of the workhorse GMOS and the mid-infrared Michelle instruments. The UK Gemini Support Group at Oxford University provided valuable expertise in these and a range of areas including the ability to design GMOS masks from pre-existing images or catalogs. Although the UK will no longer be able to allocate time on Gemini, we are confident that our UK colleagues will continue to make substantial intellectual contributions to existing and new collaborations.

The past few months have seen changes in AusGO staffing as well. The last two Magellan Fellows completed their full-time research year in Australia. Dr Shane Walsh has decided to study medicine in Perth, while Dr Francesco Di Mille has returned to his role as a technical officer at the Asiago Observatory in Italy. Dr Christopher Onken's term as an RSAA-based Deputy Gemini Scientist came to an end in December, but we are pleased that he will remain on Mt Stromlo in a new role supporting the operations of the SkyMapper telescope, and coordinating the activities of the new Australia-New Zealand Institute for Theoretical Physics. Chris has kindly agreed to remain involved in organising the highly successful Australian Gemini School Astronomy Contest. We thank Shane, Francesco, and Chris for their outstanding service to the Australian Gemini and Magellan user community these past few years.

Dr Simon O'Toole's term as a Deputy Gemini Scientist also came to an end in December, but he has kindly agreed to stay on a little longer while recruitment of two new AusGO Research Fellows is underway. These Research Fellowships will combine the current Gemini and (non Chile-based) Magellan support roles, with 50% of their time available for research. It is hoped the first of these new Fellows will be in place at the AAO in the second quarter of 2013.

Australian membership of Gemini post-2015

A recent announcement from the Gemini Board regarding the Gemini partnership beyond 2015 (http://www.gemini.edu/node/11912) appears to have caused some confusion within the community about whether Australia will be withdrawing from Gemini at that time. The following statement from Australia's Gemini Board member Prof. Stuart Wyithe is intended to clarify the situation:

"Australia is a member of the Gemini partnership whose current agreement concludes at the end of 2015. An assessment point was conducted during the most recent Gemini Board meeting in November, where partner countries were asked to commit to a continued Gemini partnership covering the years 2016-2018. Australia was unable to do so.

"Australia's position on continued involvement in Gemini beyond the current agreement is influenced by two primary factors. Firstly, the Mid-Term Review of the Australian Astronomy Decadal plan specifies membership of ESO as the highest priority for gaining access to large optical telescopes. Secondly, investment in Australian national access to research infrastructure in the near future will be via the Collaborative Research Infrastructure Scheme (CRIS), which is only available for funding of infrastructure operations up until the end of 2014. Thus there is currently no identifiable funding for continuing in a post 2015 Gemini partnership.

"Australian participation in the Gemini partnership is managed through Astronomy Australia Ltd. (AAL), and the Gemini assessment point was discussed during the most recent AAL AGM on November 2 (with input from AAL's Optical Telescopes Advisory Committee). The AAL member representatives endorsed the Australian Gemini Board member to declare that at this time Australia is unable to commit to continued membership of the Gemini partnership post-2015.

"Over the last decade Australian astronomers have made great contributions to Gemini, both technically and scientifically, and the current situation is regrettable. *It should be noted that Australia has not withdrawn from Gemini*, and that AAL will continue to explore ways of facilitating the option for continued Australian involvement with Gemini in the future."

Proposal Statistics

For Semester 2013A ATAC received a total of 32 Gemini proposals, of which 12 were for time on Gemini North, 3 for exchange time on Subaru, 15 were for time on Gemini South, and 2 were for time on both Gemini North and Gemini South. The oversubscription for Gemini North went from 2.5 in 2012B to 1.8, while demand for Gemini South (driven by interest in GSAOI) was up from 1.6 in 2012B to 1.9. Magellan time in 2013A was oversubscribed by a factor 2.6, with 10 proposals. It may be that the sustained oversubscription of >3 for the previous 4 semesters has been a disincentive; notably all but one proposal requested the 2 night minimum (which will be relaxed to half a night in future). Interestingly the f/5 instrument MegaCam displaced MIKE as the most-requested instrument, followed by the Planet Finding Spectrograph.

In 2012A, all but one of the 12 Band 1 programs were completed or had insufficient Target-of-Opportunity (ToO) triggers; 4 of the 5 Band 2 programs were completed/triggered; and 2 of 4 Band 3 programs were completed/triggered. The fraction of allocated time observed (65%), and of time used for programs that were completed (79%) were both up on Semester 2011B.

AGUSS

The Australian Gemini Undergraduate Summer Studentship (AGUSS) program is sponsored by a grant from DIISRTE. It offers talented undergraduate students enrolled at Australian universities the opportunity to spend 10 weeks over summer 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 two AGUSS recipients for 2012/13 are Stephanie Pointon from the University of Adelaide, and Benjamin Prout from the Australian National University (Figure 1). Ben is working with Pascale Hibon and Benoit Neichel on defining the accuracy and astrometric performance of GeMS with images taken with GMOS, while Stephanie is working with Rodrigo Carrasco to calibrate data from GSAOI. They will be presenting their results to the other AAO and CASS summer students in Sydney by video in early-February shortly before their return to Australia.

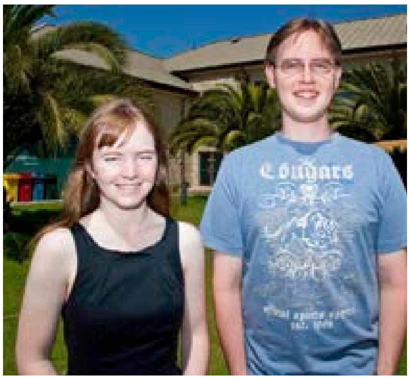


Figure 1: AGUSS recipients for 2012/13 Stephanie Pointon and Benjamin Prout, shortly after their arrival at Gemini South

2012 Australian Gemini and Magellan Science Symposium

Australian astronomers have had access to the twin Gemini Observatory 8m telescopes for just over a decade, and to the twin Magellan 6.5m telescopes for almost half as long. Australian access to Gemini is now assured through until the end of 2015, and funding has been secured for an extension of Magellan access beyond mid-2013. A suite of new instruments including GSAOI, FLAMINGOS-2, GRACES, GPI, and new CCDs for GMOS will become available on Gemini in 2013. It is therefore timely to reflect on the scientific highlights from Australian usage of these facilities, and to consider new and innovative ways to exploit these facilities technologically and strategically.

To that end, the inaugural Australian Gemini and Magellan Science Symposium was held at Swinburne University of Technology on 22–23 October 2012. There were about 40 participants (including 13 students and 8 postdocs) on each of the two days, with a total of 27 speakers presenting scientific highlights on everything from the first stars, to first results from GeMS. A couple of special sessions were also scheduled. The first was a forum on the near-term future of 8m access at which Stuart Wyithe gave an overview of the next three years from the Gemini Board perspective; Karl Glazebrook talked about the Gemini Science and Technology Advisory Committee's Long Range Plan process; and Chris Tinney summarised the alternate 8m access options that AAL's Optical Telescopes Advisory Committee has discussed. The second of these was an ATAC forum hosted by incoming ATAC Chair Tamara Davis, where new Gemini Director Markus Kissler-Pattig's proposal for a fast-turnaround, peer-review proposal system for Gemini was outlined, and a reduction in the minimum Magellan request was agreed upon.

AusGO is grateful to Swinburne for providing the theatre, and to AAL for sponsoring the symposium dinner. It is proposed to hold such a symposium every second year, alternating with a data reduction workshop.

Figure 2: Participants at the 2012 Australian Gemini and Magellan Science Symposium.

Instrumentation Update

- **FLAMINGOS-2**: All lens mountings have been modified to reduce thermal stresses, and the optics and OIWFS realigned. Following flexure and acceptance tests in the lab, FLAMINGOS-2 recommissioning in imaging and long-slit spectroscopy modes should get underway in May 2013.
- **GeMS/GSAOI**: Problems with the GeMS laser power and the GSAOI filter wheel were resolved in time for a quite successful commissioning run straight after Christmas, with the first of the System Verification (SV) programs being executed. Fully ¼ of the available 60 hours of SV time went to Australian-led programs. Furthermore 1/3 of the available GSAOI time allocated in Semester 2013A went to Australian-led proposals, emphasising the high level of interest within the Australian community in exploiting this unparalleled new capability.
- **GMOS CCDs**: Due to the heavy workload on the Engineering staff with commissioning and scheduled shutdown activities it has been decided to postpone the installation of the new Hamamatsu CCDs into GMOS-South until 2013B, with GMOS-North to follow in 2014A.
- **GPI**: A new Lyot mask to cover a failed actuator in the deformable mirror has been installed allowing the continuation of system characterisation. Delivery to Gemini South is currently scheduled for mid-2013.
- **GRACES**: Focal ratio degradation within the 280m-long fibre-feed from Gemini North to the ESPaDOnS spectrograph at CFHT is being worked on. A limited block of community access time may be offered in July 2013 once commissioning results are available.

The Wambelong Fire

Andy Green and Amanda Bauer (AAO)

12:30 pm, Tuesday, 8 January, Siding Spring Observatory, Andy Green

Andy: I'm driving to the AAT on an unusually hot day. Temperatures in Sydney are expected to reach 43°C, and several regions of the state have had their bush fire danger rating set to "Catastrophic." This new rating has been introduced in Australia after the 2009 "Black Saturday" fires in Melbourne's north-east in which 173 people died, and are used to describe days in which the fire risk is so extreme that should a fire start, one is unlikely to escape.

Several bushfires are burning near Cooma in the far southwest of the state. I listen to the unfolding situation with interest on the car radio. Perhaps most terrifying is the two regions where the emergency advice to leave immediately changes to the more fateful advice, "it is now too late to leave; shelter in place as the fire impacts."

4:00 pm, Wednesday, 9 January

Andy: I'm looking for Bob Dean to try to solve a readout problem with AAOmega when Doug Gray calls me into his office. He explains that the ANU has decided to evacuate the Siding Spring Observatory should a "Catastrophic" fire danger rating be declared for the region. He feels we should do the same. "It could happen this weekend," he says. I agree, explaining that I had thought about various scenarios in the car on the way up, and I felt that leaving early was really the only option on truly bad days for fire. John Collins, for whom it is his last day at the AAO, also agrees.

6:00 pm

Andy: Over dinner there is some discussion of fire in Australia. Indigenous peoples have burned the countryside for thousands of years to ease hunting. I comment on the frightening legacy that years of fire suppression have left in the American southwest—a fuel load so large it is difficult even to do controlled burning. We discuss the Black Saturday fires, and how fast fire can move through the Australian bush.

4:30 pm, Friday, 11 January

Andy: Doug Gray again calls me into his office. It seems there has been some confusion on the timing of an evacuation for a Catastrophic fire day between him and the ANU. The declarations are generally made after 4 pm on the preceding day. He explains that the highest danger is during the daytime of the declared day. Therefore an evacuation will be decided during the evening, but effected after the nights observing. I am happy with this arrangement, which means such an evacuation will not be entirely unexpected.

The Rural Fire Service (RFS) has also visited the mountain, and commented on our emergency shelter. The centre pillar of the AAT dome would provide excellent protection should we become trapped on the mountain.

5:45 pm

Andy: The fire danger rating for Saturday is set at Very High, three levels below the dreaded Catastrophic. I'm somewhat relieved that we won't be evacuating Saturday morning. However, the temperature is expected to reach 45°C both Saturday and Sunday.

8:45 pm

Andy: We can see a thunderstorm in Queensland, about 200 kilometres from the AAT. The mountain of cloud on the horizon resembles the snowy summits of Mt Fuji. Even at this distance we can see lightning.

4:05 pm, Saturday, 12 January

A fire is reported burning near the Wambelong Creek campground in the Warrumbungle National Park, approximately 8 kilometres from Siding Spring Observatory.

4:20 pm

Andy: Going out to check the weather and enjoy the scenery, I see the smoke rising from the fire. I watch it for a little while, with many thoughts running through my mind. Will we evacuate soon? How quickly will they begin to fight the fire? The fire seems small and unobtrusive for the moment, but I know that could change. I check the RFS website for any information, mention the fire to my observers, and consider calling triple-zero, before Rob Patterson arrives, similarly concerned. We again go out on the catwalk to check the situation and he tells me it has already been reported. I comment that it looks like someone's campfire or cigarette has gotten away, but Rob says the park is closed.

4:45 pm

Andy: We drive to the other end of the mountain to see if we can get any different view from the other end of the mountain, but the view is largely the same. Just as we're about to get in the car to return, Rob decides to take a picture. "Might be the last time we see the national park as it is," he says.

5:15 pm

Andy: Rob gets a call in the control room from Doug. Apparently some of RFS volunteers from the AAO are at the fire, which is burning through dense bush on a steep hillside. I understand a decision has been made not to fight the fire immediately. Rob and I agree the inaccessibility of the fire in its current position would make fighting it from the ground very difficult. Rob understands the Timor[1] road through the park is blocked by fire.

5:45 pm

Andy: Power is lost on the mountain, giving me a decided jolt. Battery backup keeps the computers running in the control room, but it is a short while before the lights come on with the generators. I realise just how anxious the burning fire has made me.

6:00 pm

Andy: Conversation at dinner is not particularly unusual, but the fire is mentioned many times. The fire danger rating for Sunday has been set at Extreme, still below the dreaded Catastrophic that will signal an early departure from the mountain. We decide the power cut is probably due to lightning from a thunderstorm to the south. Power comes back on while we eat.

1 Timor is pronounced "tie-more", not like the island north of Australia.

Saturday, 10:26 pm

10:26 pm

Andy: A large thunderstorm is raging north and east of Coonabarabran. Although it has some rain associated with it, the shear number of lightning strikes suggests it will start many new fires. The lightning is so spectacular that we find it far more interesting to watch from the catwalk than the fire on the other side.

2:24 am, Sunday, 13 January

Andy: The weather, which had looked unlikely during dinner, clears, and we are having a fairly good night observing. I record the first seeing estimate of less than 2.0 arcseconds for the run next to a note that the fire is growing. In the cool of the moon-less evening, it is visible from the catwalk as dull red glow that is slowly burning over a couple small hills from where it originally started. I also note that it is not quite photometric, probably due to smoke blowing up from the fires earlier in the week over 500 kilometers to the south.

4:30 am

Andy: Back in my room after the night's observing, I consider my options. I'm tired, and the prospect of a mid-morning knock on my door announcing the fire has worsened and I must evacuate is large in my mind. I decide to stack the odds in my favour. I pack everything for an urgent departure. My bicycle stands unused in my room, waiting for the weather to cool. It must be disassembled to fit in the car, so I decide that if the evacuation is urgent, I'll just leave it where it is.

10:30 am

Andy: I awake after a few hours' poor sleep. I check the fire situation on my mobile. At 10 am the fire was reported as covering 10 or so hectares, and in the process of being contained. However, a host of new fires are burning through north-eastern New South Wales, no doubt the result of last night's lightning storm. Somewhat relieved, I sleep another few hours.

2:30 pm

Andy: Having gotten up, unpacked some clothes to wear, and eaten the usual bowl of cereal, I head up to the AAT Control Room. The observers are already there, and tell me the fire is a bit bigger than the day before. Out on the catwalk, I see that the fire has grown, but not so much so as to raise any real alarm. The fire is in the process of burning over the top of Belougary Split rock, opposite the campground where it started. Just the previous Easter, I had camped in that campground with friends, and we had walked up to the summit of the Split Rock. I wondered how long Parks would keep this national park shut after the fire.

I go back into the control room to check the RFS website. The last update, at 10:45 am, said the fire was fully contained. I go back out on the catwalk, and watch, wondering if it is really still fully contained.

The building alarm is going off, and I investigate to find that AAOmega has not filled its liquid nitrogen dewar. I leave it be. Rob can deal with it when he comes in.

3:00 pm

Andy: The wind is picking up about the AAT; the weather station reports gusts over 40 kph. Smoke from the fire now forms a long plume southeast from the fire itself. Rising into the humid air, the particles encourage condensation, and a large pyrocumulus cloud is forming from the smoke. To the north and west, rain is falling from a large thunderstorm, but no rain seems likely to come our way for some time. The best hope is a band of clouds and light rain, which has been moving up from the southwest since yesterday. That weather won't do the observing much good, but I'm much more interested in putting the fire out than the observing.

3:26 pm

Andy: Gusts of wind of more than 60 kph pass over the mountain. I notice a spot fire burning some distance downwind from the original fire. Looking yet again at Google Maps, I work out the spot fire is only about 4 km from the observatory. The observers again come out to have a look.

The observers for the evening are searching for quasars. Tom Shanks and his student Ben Chehade have flown all the way from the UK just for this observing. Stephen Fine has flown in from South Africa. Only David Parkinson is comparatively local, having come from Queensland. As their support astronomer, I want them to get the best data they can, but also feel responsible for making sure they understand the danger of the fire and the reasons for an evacuation should it become necessary.

I continue to watch this spot fire, mostly hidden from view by the smoke, as another one starts near the first. The steady stream of small planes overhead assures me this has not gone unnoticed. I wish Rob Patterson, the afternoon technician, would arrive so I could get a second opinion on what I'm seeing. I decide that if the wind moves around to the south or southwest, it will be time to leave.

Paradoxically, a few large drops of rain fall, but unfortunately rain will not come.

3:40 pm

Neville Legg receives a call in Sydney from John Collins (former AAO) and Chris McCowage (AAO), who are at the Warrumbungles National Park visitor centre fighting the fire. They say the conditions are bad and they don't know what will happen.

3:43 pm

Andy: Anxiously, I decide to send one of the pictures I've just taken to the AAO staff email list. The pyrocumulous cloud forming from the smoke plume is too close to fit into a single photo, so I instead decide to show the fire with the railing of the catwalk for context. I also note in the email the likelihood of an imminent evacuation. Of course being a weekend, there is not the immediate response I had expected.

3:51 pm

Andy: I ring Doug Gray. His wife answers, and says he is just looking for a campsite. They have driven down to Sydney. I ask Doug to call me back right away. He calls me a couple of minutes later. "How is it going?" he asks.

"This fire is getting pretty close. I'm a little concerned, " I tell him. "If the wind changes, then I think we'll be leaving."

"Okay, well keep me posted."

I go in to tell the observers that an evacuation is probably immanent. They're a little surprised and come out to see the fire. The weather station shows the wind slowly moving from a northwesterly, to a westerly. Outside, the smoke is starting to blow closer to the mountain.

4:05 pm

Andy: Out on the catwalk, I'm relieved to hear the door open, but surprised to see not only Rob Patterson, but also Steve Chapman. "We're evacuating the mountain," he tells me. I'm immediately relieved. The situation down in the valley is clearly worsening, and I am ready to leave.

I mention the dome air conditioning. I explain that it should probably either be turned to maximum (to try to cool down everything as much as possible should an inferno come), or turned off (to avoid sucking the fire into the building). Steve comments that it shouldn't draw anything into the building. I leave the decision to them while I go in side to tell the others.

I rapidly pack up my stuff in the control room. I pack my camera, as I figure it will be most useful to document anything that happens. Unsure how long I might be away, I decide to pack my laptop as well.

The astronomers ask how much they should take. I explain that it is probably best to take everything since it is their last night and they may not have a chance to return before they leave.

Steve asks if I'm taking my point of view camera, which has been taking a time-lapse from the catwalk. I decide to dash out and take it, though Steve does comment that it might take a very interesting set of pictures if left.

4:18 pm

Andy: The observers and I crowd into the lift. Outside the dome, Rob Patterson's wife asks where he is. I explain that he should be right behind me. Understandably, she looks quite distressed.

Smoke and cloud are now intermittently covering the sun, and for the first time there is a faint smell of smoke in the air.

4:20 pm

Andy: Putting my laptop in the car, I find Scott in his full RFS fire suit. "Do you have my mobile number?" he asks. I say I don't and that I should get it. Just as I start to type it in Doug Gray calls again.

"Have you called Lisa Fogarty?" he asks.

"I haven't gotten that far yet, but I will." Doug is organising accommodation at the Acacia for us, and wants to make sure Lisa, who is driving up to the AAT to observe, knows what's happening.

"When are you evacuating?" Doug asks.

"NOW!" both Scott and I respond.

I dash off to get the rest of my stuff from my room. I throw the stuff I had unpacked back into my bag, and have a quick look around. I think I have everything, except my bike. It will take a few minutes to disassemble it and put it in the car. I decide I can go a few days without my bike. "I'll be back in a day or two," I think to myself.

Back at the car, I put everything in and ask David Parkinson if the rest of his observing team is ready. Tom Shanks is missing. Another orange suited figure tells us that the fire has reached the bottom of the mountain. The situation is becoming urgent. I find which room Tom Shanks is in, and race off to find him just coming out the door.

I clarify again that we will meet at the Acacia in Coonabarabran and get in the car. Knowing that I'm now very excited and anxious, I consciously force myself to calm down. "An accident driving down the mountain just won't do" I tell myself.

At the boom gate next to the Exploratorium, Peter Verwayen is waiting. I explain that my four astronomers are in the car just behind me. We wait a moment for their white car to come into view behind me, and then I'm off.

Sunday, 4:30 pm, Sydney

Amanda: It was about this time late Sunday afternoon that I nonchalantly checked my email in Sydney before heading out for an evening run. I found, along with all AAO staff, an email from Andy with a disturbing photo of dark smoke rising up from the Warrumbungle National Park attached. Worried, I quickly read the next message in my inbox, which was from the acting director, Andrew Hopkins, notifying us that Siding Spring Observatory was being evacuated immediately.

Uh oh, I thought.

I quickly sent a text message to Lisa Fogarty asking where she was, knowing she was driving up to Siding Spring to prepare for our collaborative research project that was awarded 4 nights of AAT time, scheduled to begin the next night.

Next, I checked twitter, the NSW Rural Fire Service webpage, and the Facebook pages of astronomers and my AAO colleagues to see if there was any more news. I would not be running that evening. I was glued to the computer, waiting, worrying, hoping.

4:30 pm, Siding Spring Observatory (SSO)

Peter, the last to leave the mountain, is also getting quite anxious waiting for everyone to get moving. As he closes the boom gate, he can hear the crackling of the fire.

4:35 pm

Andy: Driving down the mountain, I watch the smoke closely, and look out for any spot fires that may be around. Thick dark smoke is billowing over the hillside, and lit with an eerie red glow. At one section, the road comes very close to the ridge, and I wonder if we will be forced to turn around. But I see no fire all the way down the mountain. I am relieved when I get to the intersection with Timor Road. In my mind, that was the most dangerous section of any potential escape.

In the clearing just below the intersection is a chopper. Although I really have no idea of its true purpose, I think perhaps it is waiting there should the road be cut and staff need to be evacuated via chopper from the mountain.

4:39 pm, Timor Road

Tom Shanks, one of the observers leaving the mountain with me, stops along Timor Road to take a photo back towards the AAT.

4:41 pm

Driving along the road back towards Coona, I know there should be several places where I can see the AAT dome, and I'm hoping for a photo with the smoke in the background. But, I can see nothing but smoke at any of the likely spots.

4:59 pm

An RFS volunteer in a chopper flying over the mountain photographs fire coming rapidly up the mountain towards the AAT and ANU Lodge.

Moments later the telescope rain alarm is triggered as water is dropped on the telescopes.

Amanda: This view of a wall of dark, thick smoke overtaking the telescope I so frequently use, sent me into instant tears. I knew in moments the fire would reach over the mountain top, burn, and suffocate Siding Spring. Of course memories of the Mt. Stromlo fires from almost exactly 10 years before haunted my imagination and left me filled with dread.

Slight relief came from the thought that the major damage was done. Or so I thought.

5:00 pm

In Coonabarabran, quite a number of people are milling about outside the Acacia. Inside, the lady behind the desk has a rather hastily compiled list of the people she's expecting from the Observatory. I help her to organise the chaos, and get the visiting astronomers sorted into their rooms.

5:10 pm, Sydney

Amanda: I started monitoring the AAT temperature gauges online. I felt somewhat relieved that they were still reporting measured values, but my anxiety grew as the temperature gradually rose and rose.

I received a message from Lisa to say she was still driving to Coonabarabran from Sydney and had heard from Doug and Andy. She was heading to the rendezvous point in Coonabarabran, where all the observatory staff were meeting. Finally, some good news: all staff had evacuated the mountain safely! What a relief that was to hear.

View from Timor Road. Credit: Tom Shanks

5:15 pm, Acacia Lodge, Coonabarabran

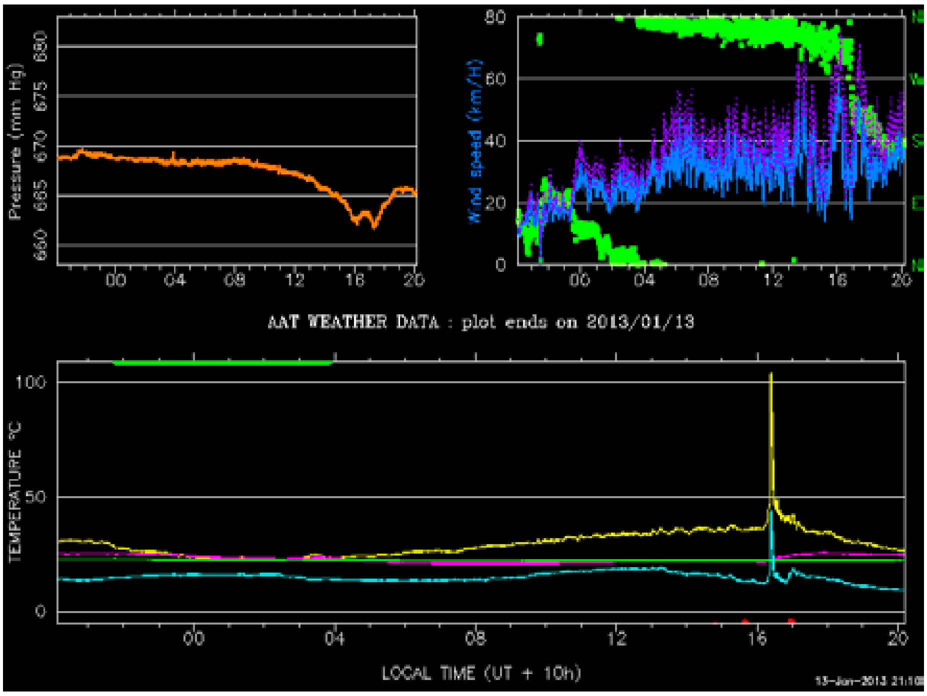
Scott Coleman, the Siding Spring Site Manager from the ANU, receives a text message informing him the fire alarms on the mountain are going off. Scott has already begun the difficult task of trying to bring in as much help as he can to try to minimise the damage to the facilities on the mountain, and is constantly on the phone.

5:24 pm

The AAT weather station records an ambient temperature of 104.2°C. The temperature remains above 50°C for six minutes.The reading is probably spurious, but still alarming.

Andy: I log in to the AAT Weather data to see the temperature at 65°C, and I fear

Image Credit: Rural Fire Service



the worst. The all sky camera is still providing images, though, and the dome air temperature is still only 24°C. Shortly thereafter, the connection seems to die.

5:46 pm

Andy: We receive reports of fires visible from webcams on the summit. Fearing the worst, I send a brief note to Acting Director Andrew Hopkins via email.

6:05 pm

The first good news comes when I realise that the AAT weather data is again available. The temperature spike I saw earlier was very short, and the temperature is now about 35°C but cooling steadily. Nothing unusual is visible on the all sky camera, either. The dome internal temperature has only risen slowly, presumably because the dome air conditioning has been switched off.

6:20 pm, Sydney

Amanda: Many people around the world are conversing about the situation at Siding Spring Observatory through various social media sites, sharing information and concern for the people and facilities at the observatory and around Coonabarabran. Several of the 12 telescopes on site are robotically operated and have web-cameras installed, displaying current photos from the observatory.

We receive images from various webcams of heavy smoke over the summit, but gradually, the views lightened as white clouds became visible and blue sky even peaked through occasionally. Reports were coming through about whether astronomers could remotely talk to various telescopes at site, and most of the news was still positive.

We were left to watch webcams, speculate, and wait. I felt very apprehensive, but still remained hopeful.

7:00 pm, Coonabarabran

Andy: In our makeshift command centre at the Acacia, we begin to take advantage of the many live web cams on the mountain. The view from the Hat South web cam, which would subsequently appear on the local television news, shows a lot of smoke in the air, but leaves on the trees and no flames.

When Lisa Fogarty and Ned Taylor finally arrive in Coonabarabran, they report that they have been following the situation anxiously on Twitter and Facebook, in addition to the viewing through their windscreen an amazing column of smoke, reaching 15 km into the atmosphere, twice as high as most airliners fly.

7:25 pm

Steve Lee captures a view of the massive column of smoke from his house near Coonabarabran.

7:30 pm, Sydney

Amanda: I decide to post a quick entry on my blog, astropixie, collating the incredible images I'd seen so far, and providing a summary of the situation at Siding Spring for anyone worldwide that might be interested. As I received reliable news about Siding Spring and the nearby MOPRA radio telescope, I updated the blog post accordingly.

Very quickly I noticed that the blog post was getting a lot of traffic and astronomers, friends and journalists alike, were sending me personal updates and inquiries about the situation.

The sun began to set, and dramatic images of small flames speckled across the site became visible on the webcams. It was soon after this that I received requests from the Rural Fire Service via Lisa in Coonabarabran that we should stop using the webcams in order to allow enough bandwidth for the fire service to use them to monitor the situation.

Some of the cameras images were mirrored to other sites, so I received

Image Credit: Steve Lee

updates and posted those images for everyone else to see.

8:00 pm, Coonabarabran

Andy: The Acacia has very kindly organised some dinner for us. Although not the same as the Lodge dinners, I am unusually hungry and have seconds and thirds!

8:20 pm

Andy: As the sun sets, light from other sources becomes more visible in the various web cams. In the AAT all sky camera, the dome is lit by what is undoubtedly a large fire burning around or in the ANU Lodge. Flames may even be directly visible at the edge of the fish-eye field of view.

9:15 pm

A regular storm of embers is blowing over the mountain. The Hat South web cam captures an eerie long exposure of the embers blowing past.

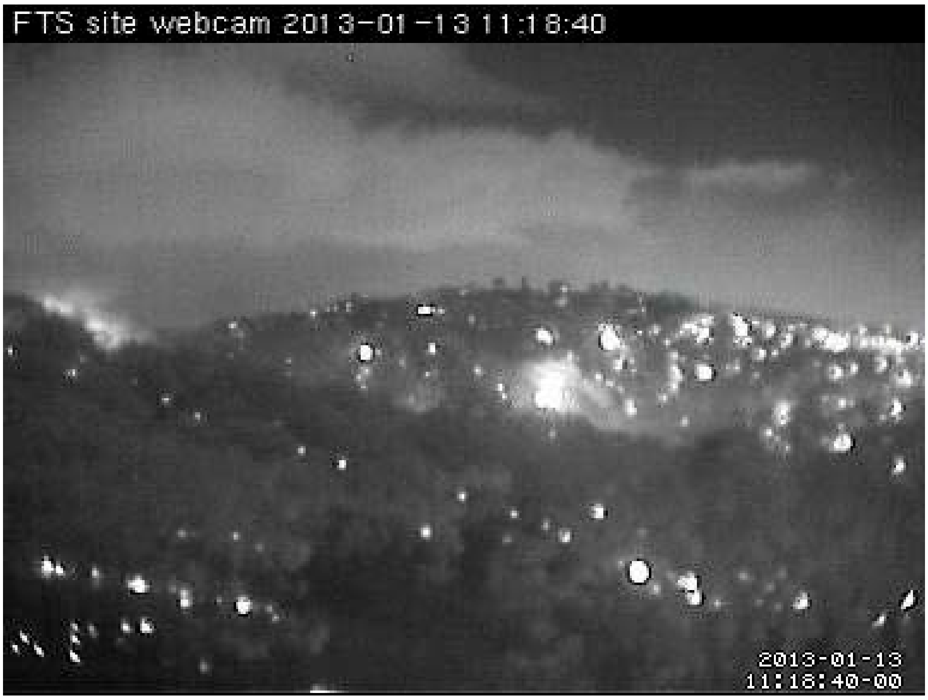
approximately 10:30 pm

The shed housing the pumps that bring water to the mountain is destroyed, and the pumps themselves damaged. The water line up the mountain also bursts in several places. There are, however, several million litres of water remaining in storage tanks on the mountain.

11:20 pm

Andy: One of the web cameras on the Faulkes telescope proves the most useful, because it can be remotely reoriented. The images it returns are upsetting. Much of the mountain is covered in small fires. Looking west, we are able to identify Mopra by the line dividing fires burning in the bush from its bald, rocky summit. Trees can be seen burning across the road from the Faulkes.

Andy: But, at the same time the images give us a lot of hope. A neat row of cottages surrounded by trees



still potentially bearing their leaves leads up to the AAT, which shows no visible damage. The building of the UK Schmidt looks untouched, with a light left on in the tea room.

12:00 am Monday, 14 January

Andy: I'm exhausted. Despite the various web cams and sensors, there is really nothing I can do about the situation unfolding on the summit. I'm now just waiting for Doug to arrive before going to bed.

We get reliable reports that the Lodge is a complete loss, but that the telescope buildings are at least superficially okay. The danger, however, is far from over with a stream of burning embers still blowing over the mountain.

12:15 am, Sydney

Amanda: I felt amazed at how much concern members of the international community were showing regarding the potentially devastating situation at Siding Spring. I left a final update on the blog post just as it had received 15,000 hits worldwide. I was worried about the level of damage the observatory had sustained and knew the next day would be a long one.

12:45 am, Coonabarabran

Andy: Doug Grey arrives, having driven from Dubbo to Sydney that morning, and then all the way back to Coonabarabran. He is surprisingly perky despite all that's happened. He and Scott are scheduled to meet with RFS at 6:30 am for an update on the situation. Exhausted, I go to bed.

7:30 am

Andy: I wake to a sunny morning in Coonabarabran. Thankfully, the massive plume of smoke is now largely absent from the horizon.

7:45 am, Sydney

Amanda: Soon after the sun rose, I woke up automatically to see the first images available at Siding Spring. I saw show positive signs of buildings standing where we saw evidence of small fires last night. The main 4-meter telescope dome appeared to have survived the flame, which was good, considering it is the designated fire evacuation area on the mountain.

8:00 am, Coonabarabran

Andy: Over breakfast, I learn that Doug and Scott are on the mountain looking at the damage. Soon after, photos appear on the Rural Fire Service Facebook page of the summit. They show the lodge is completely destroyed, but surprisingly little damage otherwise (particularly given some of the images from the night before). In many ways, despite the devastation, particularly to the surrounding countryside, the images are a relief.

8:45 am

Andy: Doug calls from the summit. He has been through the AAT, and says that there is no obvious damage, although he mentions some fire debris. He asks if there is anything I want from the summit. "I left some log sheets on the desk in the control room, but they are not important. And I left my bicycle in the Lodge." He tells me that the bike is gone.

He adds that getting diesel fuel to the generators will be the most important task to minimise further damage to the instruments and telescopes.

"Go home," he says.

9:00 am, Sydney

Amanda: We are all very relieved to see buildings still standing and to know that nobody was injured in the fires. The data my group was supposed to collect using the AAT will not be gathered this year, but we will apply for time again next year.

The 4:59 pm image of the AAT with the wall of smoke behind it is on the front page of the Sydney Morning Herald—

Image Credit: Alex King - NSW Rural Fire Service

not the way I hoped the telescope would make front-page news.

When I arrived at work in North Ryde, I received many emails of support for the regular updates provided on the situation from both internal AAO and external people.

10:00 am

Amanda: Andrew Hopkins held a meeting from North Ryde to discuss the situation and ironically, the fire alarms sounded soon after the meeting started. We all looked around at each other shocked, and left the building without delay. It was a false alarm, though.

When the meeting reconvened, Andrew updated us on the situation and announced that observing would be suspended for at least two weeks while safety and damage was assessed and the clean up effort commenced.

11:00 am, Coonabarabran

Approximately 40,000 hectares of the Warrumbungle National Park and surrounding countryside have burned in 18 hours.

11:30 am

Andy: Although I'm tired, Lisa says she will ride back to Sydney with me to keep me awake. Part of me very much would like to stay, but I know there is nothing I can do, and the rooms at the Acacia will be in high demand as more and more people are displaced from their homes. So I start back to Sydney, a rather sudden and unexpected end to my run supporting the AAT.

Tuesday, 16 January, Sydney

Amanda: By the second day after the fires, over 25,000 people had visited my blog posts for updates. I learned that organizations and institutions were officially referring their staff to that website to receive updated information. In addition, AAO staff told me that they gave people a link to the blog instead of having to repeatedly recount the situation around Coonabarabran. In this situation, I benefited from social media and members of AAO emailing me directly with updates. I greatly appreciated the communication because I was able to uniquely share the information with the community in an efficient way by providing a single source of thoroughly updated news.

11:30 am, Thursday 17 January

Australian Prime Minister Julia Gillard visits SSO. Rural Fire Service volunteers and AAO staff Kristin Fiegert and Wayne Clarke walk with her. The remains of the Directors Cottage can be seen in the background. Julia also meets Doug Gray and Neville Legg, as well as various other members of the greater Coonabarabran community during her visit.

Tuesday, 29 January

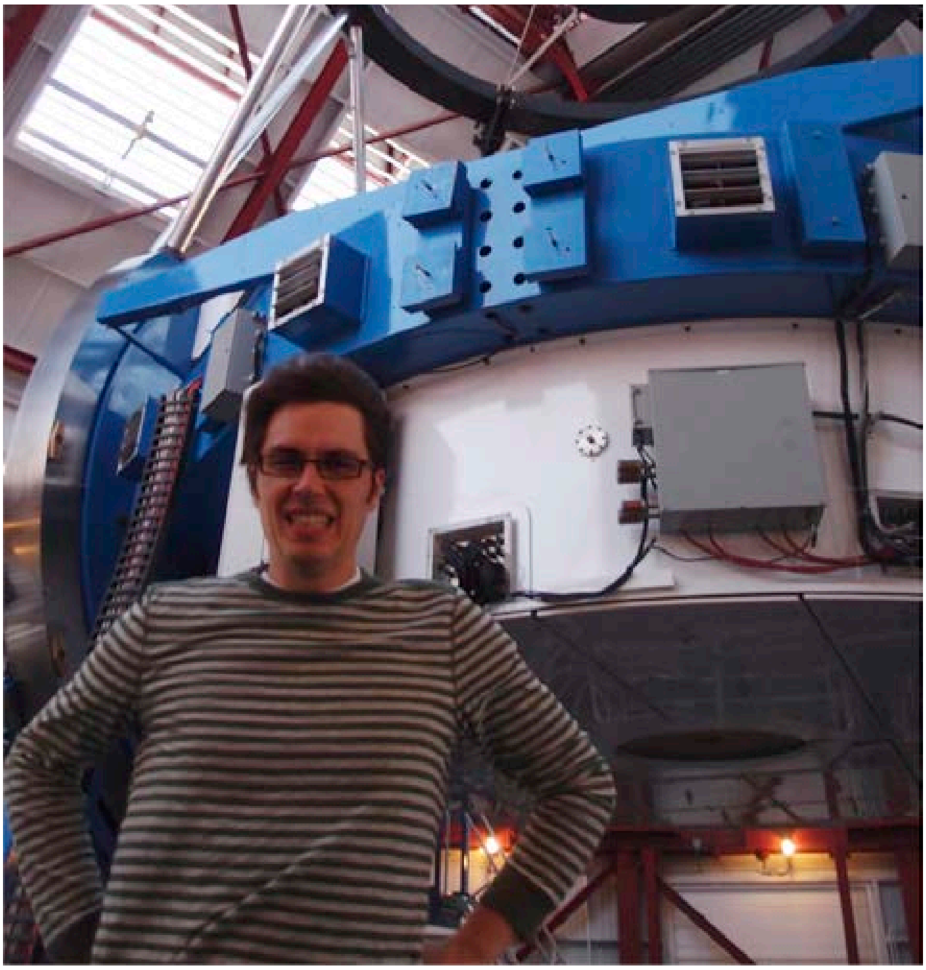
AAO staff return to the AAT to asses the situation. Although there is some damage to the computer battery backup system, all of the instruments and equipment seem to be in good order. There is quite a bit of cleanup work to be done, however.

News from North Ryde

A treasured member of our staff has moved on. **Ed Penny** has retired. He is thinking of moving to the UK and buying either a Pub or a river boat. After many years at the AAO, we wish Ed the best for his future.

Joining the astronomy group is **Dr Lee Spitler**. Lee is based jointly at the AAO and Macquarie University. Previously he was at Swinburne University in Melbourne, where he did his PhD in astrophysics and completed a post-doctoral research associate position. Lee's research is varied and has taken an interesting turn recently when he discovered the most distant galaxy cluster currently known! Generally, he hopes to understand how galaxies form and evolve using optical and infrared images of galaxies. Lee grew up in California and studied computer science for his undergraduate at the University of California in Santa Cruz.

The software group also has a new member, **Nuria Lorente**. Nuria was previously at NOAO, where she worked on software for ALMA. **Gabriella Frost** is exploring echidna style fibre positioners for future large scale surveys as part of the instrumentation group. At the AAT, we have a new electrician, **Glenn Zaneson**.



Lee Spitler at the Magellan Telescopes.

AAT Remote Observing

From Semester 13B the AAO will be offering remote observing from AAO headquarters as an option for two of the AAT instruments. Remote observing from the AAO's North Ryde headquarters has been successfully demonstrated for both UCLES and IRIS2. The AAT Call for Proposals for Semester 2013B will invite experienced users of UCLES and IRIS2 to carry out their observing runs remotely from North Ryde. We expect this opportunity to be taken up mainly by Sydney-based observers in the first instance. We are developing a framework for offsite remote observing at a later stage, in order to allow astronomers across Australia to observe from their home institutions. Until that system is ready, observers who wish to travel to Sydney to carry out remote observations can continue to access the existing Travel and Accommodation support offered to AAT observers. Scheduled UCLES and IRIS2 observers for semester 13B who wish to carry out their observations remotely should contact the Acting Director, Andrew Hopkins, at director@aao.gov.au.

Instrumentation

The 2dF upgrades in preparation for HERMES have been completed. The fibre runs have been completely replaced, and the new slit and fibres have been commissioned for AAOmega. This new fibre bundle is affected much less by fringing than the previous fibres, which should improve data quality. The fibre throughput is consistent with the previous fibres, but the range in throughputs is much reduced.

CYCLOPS2 has been commissioned for use with UCLES (see article page 19 of this issue). Because the new fibre feed is superior to the old one in all respects, CYCLOPS has been decommissioned.

Construction of the new fibre hexa-bundles for the SAMI instrument is also going smoothly. Once commissioning is complete, we expect to make SAMI available as a facility instrument.

The HERMES blue channel has had first engineering light, and the results meet with expectations.

Letter from Coona

Katrina Hartley (AA)

Well it has been an eventful six months for all and it's difficult to remember the events that occurred before the fires that ripped through.

Firstly, we said goodbye to a few people, including John Collins, Malcolm Hartley and Guy Andrews. Although it was sad to see them all go, the Social Club managed to organise a great combined send-off for Jac and Malcolm at "South Burloo" in January. It was a fantastic night with a few ending up in the pool, clothes and all.

Glenn Zaneson is our new Electrician, he is settling in well and currently living on the Mountain. Zoe Holcombe, who some of you may know from working at the Acacia, has been doing some casual cleaning for us and she has been a great help especially during the clean up after the fires.

The AAO Planning Day was held in November, with a lot of planning and effort, the site staff managed to pull off two great days and it was rewarded seeing everyone who participated enjoying themselves on-site and we're all looking forward to the next Planning Day.

It is now a very different outlook seeing the black valleys with just bare tree trunks standing. It's hard to imagine what it once looked like. It's amazing to see how the environment is responding with the regrowth on the trees coming through and the grass trees jumping back to life after the rain. The wildlife is also slowly returning which is great to see—just the other day we saw a number of Wedged Tailed Eagles flying around the dome.

John Collins and Darren Stafford in the pool at the Blowfly

A Rainbow from the Catwalk of the AAT

AAO Super-science Fellow Amanda Bauer enjoys the view of the Warrumbungles National Park from the catwalk of the AAT. The AAO is planning an exhibit titled "Stories of Siding Spring Observatory", which will run 17th April to mid-July, 2013. The exhibit will help to remind us of what we have even after much of the park has been ravaged by bushfire.

The rainbow is the symbol of the International Year of Light, which will be celebrated in 2015.

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