A Workshop on the Future of the AAT
UNSW, Sydney, 31 Oct 2019

Notes on the meeting

- 10:00 House-keeping (Sarah Brough)
- 10:05 Introduction (Chris Tinney)

Chris elucidates the new optical landscape. Reiterates AAT Council, $3.25M AAT funding. Reiterates ATAC, User Committee roles, etc.
Notes 7 years of funding, but review needed within 4 years, and expected to start in year 2 or year 3 of transition. Rationale for this meeting.
Compares old and new AAO… in terms of cost of telescope operations. No support astronomers, no travel except students. Less tech support, including instrument documentation. No funding for instrument construction, testing, commissioning, documentation. No contingency for the unexpected, including systemic failure. No ten percent contingency.
Selling 10% time to NASA and Stanford – max determined by Council.
Questions for the community: what happens after 7 years?
Will consortium continue to support it?
Hector will still be new, Veloce still scientifically valid
2dF – can it continue to be supported?
New science capability, SOXS?
Leverage AAT access to LSST?
Need to sell more time if Consortium members drop out?
SSO Director mandated to solicit community input.

- 10:20 The mid-term review of the Decadal Plan for Astronomy 2016-2025 (Chris Tinney)

Chris speaks on mid-term review. Reviewing progress on strategic priorities
30% of 8-m, SKA precursors all met, 10% of 30-m partially met
Capability within national observatories retained, high performance computing partially met
MTR White papers, as discussed on Monday. Include AAT/SSO

- 10:35 AAT operations, the future of SSO, and the status of 2dF (Chris Lidman)

Shows AAT and rest of world timeline to 2027. Consortium reshaped 2022? Ends 2025?
Hector 2022, 4MOST 2023
Reiterates 6 key science question from decadal plan. AAT has been used to address them all
Shows 2013-2017 Crabtree productivity analysis.
User base will narrow without new or refurbished instruments… current lull is not an anomaly.
Shows AAT usage per number of investigators.
Challenge is to identify the right mix of funding (national, international and/or non-traditional sources) to ensure the AAT has a productive scientific future beyond 2025.
At SSO there are 40 telescopes, a dozen or so are part of global networks – SSO itself has a future due to its longitude.
2/3 of site costs covered by AAT but will come down to 40% as other site costs increase (i.e. to what it should be!)
Scenarios 1-6 discussed at Town Hall meetings:
Two dismissed already:
1 Status quo until 2025…
5 Ends as a scientific facility

Accepted is:
4 look at other instruments

Summary of 2dF status. Three cancelled runs.
Hardware faults with gripper PMAC cards lead to catastrophic failure ∵ they have uncovered a long-term software fault. Now fixed. Hardware fault still exists but simple to recover from.
Old instrument with old solder (whiskers forming). No spares for many components, e.g. PMAC cards. Needs refurbishment with obsolete components replaced. Strongly supported by community – a plan to be presented and submitted to AAT Council.
How long will 2dF be off the telescope? ~Few months off sky about 12 months from now.
How will refurbishment be funded – DIIS grant… under continuity of service category. Use part of these funds. Replace PMAC and consequent software.
These plans need much consultation and planning – who will plan and do the work, etc.? How will it impact the 50% of sold telescope time that uses 2dF for extragalactic science (other half uses Veloce – for exoplanets). Matthew Colless is willing to package other SSO telescopes for a deal getting access to LSST.
Future of 10 nights sold to Opticon, NAOA exchange nights? These will continue – although Opticon needs to pay more. Not just covering costs, but increase by factor ~2?

11:00 - 11:30 Morning tea

- 11:30 The scientific case for a highly-efficient single object spectrograph (Karl Glazebrook)

Based on the new era of transient astronomy. Karl is merely plugging the idea rather than offering to lead a project…
Reviews AAT spectroscopy.
Why go back to classical spectroscopy? The new transient astronomy era. Shows a plot from the LSST science book (2009) – long section on transient astronomy. Unknown phase space represented by transients lasting <1 day. Suggest ~10,000 optical transients (per year??) to m=20.
Points out key location of SSO: sunrise in Chile = sunset at SSO
Proposes a 'follow-up workhorse' to XSHOOTER 0.3-2.5μm (3-arm spectrograph) with R=5000
This is SOXS (Son of X-shooter) with slightly lower capability.
Also mentions Next Generation Palomar Spectrograph (NGPS) – high efficiency up to 1μm. Commissioning July 2021.
TripleSpec4 (NIR only). Being moved from Blanco Telescope to SOAR
Also Veloce Rosso – resolution too high (75,000) but could use on-chip binning
Costs: SOXS 5.7M Eur, TSpec4 ~$7M, NGPS $2-3M, new one ~$few million
Cost scale is of order of proposed Aus LSST buy-in. Dovetails nicely with their follow-up need.
What does the community want – optical vs NIR vs both, resolution (~5000 favoured)
A Target of Opportunity instrument needs to be kept available, and interoperate with 2dF and Hector…
Concludes this may be a good opportunity – optical-only cost is on the scale of a LIEF grant plus selling AAT time (NGPS looks interesting)

Julia B comments that HECTOR could have a red-arm added which would extend throughout to the whole optical waveband. Fibre feed, so that it's always available.

- 11:50 Exosolar planets: Current status and future opportunities (Duncan Wright)

With particular focus on AAT.
Globally > 4000 altogether; 2600+ from Kepler, 29 confirmed from TESS but ~1100 candidates, ~770 from RVs.
Characterisation vs discovery. Smaller planets, and multi planet systems are under investigated.
Characterisation needs large ground based or space based telescope, AAT not a good fit.
Polarimetry – can be done, claims of detections of exoplanet polarization signals refuted by UNSW team at AAT. Very challenging area.
Spectroscopy – needs space-based or ELT. Modelling atmospheres will be a big focus of them.
Formation and evolution can be done with AAT – Doppler tomography or Rossiter McLaughlin effect. Plus multi-planet systems.
Planet discovery – large telescopes can use both Doppler RVs and direct imaging. Medium (e.g.

AAT) Doppler, transits, microlensing. Space telescopes – transits, imaging…
Push to look for smaller planets. Transit surveys and Doppler (1-10 cm/sec level). Earth RV amplitude ~10 cm/s, whereas stars themselves have intrinsic variability at 1 m/sec level. Need huge number of data points over many years.
For AAT we have the instrument we need – Veloce. Can do transit spectroscopy and precision Doppler velocities (~30 cm/s) down to B~11
HARPS at ESO is essentially a single-task instrument because ESO has a suite of large telescopes available

- 12:10 Galactic Science with 2dF up to 2025 (Sarah Martell)

Look at the middle ground in astronomical studies – our Galaxy. Big surveys have revolutionised our view, and they are accelerating through 2025.
GALAH – running through 2023
APOGEE-2 – through 2020
WEAVE – start 2020
SDSS-V – start 2020
4MOST – start 2023
MSE – after 2025
2dF is used for other projects with HERMES than GALAH, and S5 uses AAOmega for stellar streams follow-up (from imaging surveys). NOAO and Opticon time also include galactic astronomy, usually with AAOmega.
GALAH phase 1 took a broad sample of everything. 700,000 stars with excellent data quality.
GALAH data analysis has been at the forefront of methods development. (E.g. structure in big spaces: chemical space, etc.)
GALAH phase 2 will look at time evolution – i.e. looking carefully at age. Can now do this because of Gaia parallaxes, giving absolute magnitudes. Will go to lower galactic latitude. This can be done right now, unlike APOGEE, and before WAVE, 4MOST (which will have 5× GALAH's data rate). Will give new insights into the evolution of our galaxy. Look at age evolution in different components of the Galaxy.
Galactic archaeology, study of star stream kinematics to weigh the dark matter halo, stream progenitors and halo assembly, etc.

FunnelWeb on UKST is now dead – Chris T has given the money to another project, and the Gaia spectrograph can do all that needs to be done. Its time was 3 years ago.

12:30-1:30 Lunch

- 1:30 Extragalactic Science with 2dF up to 2025 (Luke Davies, ICRAR)

3 different flavours of extragalactic astronomy: cosmology, structure evolution, transients
All three varieties have been carried out using 2dF since 1997 – 2dF has measured 80% of all southern redshifts.
DEVILS is the only current extragalactic large program on the AAT. Extension to higher redshift up to z~1. Targeting deep fields down to y=21.2 with 95% completeness. New HI surveys align with DEVILS. Have lost 30% of allocated time since 2018b due to 2dF failures.
DEVILS up to 2021/2.
4MOST will do similar science with similar targets. 2023-2028.
MOONS is VLT NIR MOS instrument
WEAVE similar to 4MOST
DESI will come online very soon on Mayall Telescope – similar science.
PFS MOS for Subaru, similar science.
AAT needs to do something different.
Be first – do early science before other surveys, cf DEVILS vs WAVES Deep. Undertake more of WAVES/TiDES science before 4MOST operations.
Be fast – Target of Opportunity LSST observing with 12h bonus over 4MOST
Be different. Identify samples that no-one else is targeting. E.g. follow up HI or radio continuum

sources, ot eRosita sounrces. Other populations?
Be cheap – sell lots of nights, and nationally keep the AAT+2dF for small proposer-led projects
Be dedicated – large project follow up. From other facilities, LSST/ASKAP/MWA
Be flexible – explore interesting new sources which are discovered. But is SOXS better than 2dF?

- 1:50 The Hector galaxy survey (Julia Bryant)

A big part of the future of the AAT. Hector was voted as next main dark time instrument. Evolution of SAMI. Hector Science Team has over 40 members. Will keep the AAT cutting edge and productive. There's no ESO facility on which we'd be awarded time to do a 15,000 IFS Survey (= Hector Galaxy Survey). Unique capability. Potential precursor to Aus instrument on ELT or GMT.
R>3000 blue; >5000 in red. Bundles 15"-27", 21 Hexabundle IFUs.
Could extend to 1μm
Hector key science:
Galaxy stellar mass
Host dark matter halo mass
Accretion and merger history
Halo location (central vs. Satellite)
Large-scale topological environment.
(What makes galaxies different from each other? What are the key impacts behind how they look?)
Julia gives examples of science unique to Hector
The Hector Survey will have synergies with the WAVES team. Instrument has a new positioner and a new spectrograph with its own room.

- 2:10 Synergies with LSST (Sarah Brough)

LSST first light commissioning camera mid-2020, main camera mid-2021, fully operational 2023. 6.7-m effective aperture. Ten year Wide-Fast-Deep main survey.
Wide: 18,000 sq. deg., 189 CCD's 9.6 deg sq., ugrizy 0.32-1.00 μm. Each field will have >800 visits. 1 million transient alerts per night.
Deep: psf ~0.7" – ten year depth in r: 27.5, ~30 per arcsec. Specific deep-drilling fields, will maybe achieve an additional magnitude in depth.
AAL has signed an MOU for 10 named PIs.
Model has now changed from dollars to an in-kind contribution. Suits Australia as cash-poor but in-kind rich.
Why should Aus join LSST? We only have access to Skymapper contiguous digital optical imaging in the south. Aus astronomers are interested in all the science that LSST will do, and it perfectly overlaps with decadal plan science questions.
What should our in-kind contribution be?
Operations offset (unlikely)
Other resources (Facilities, data sets)
Added value (contributed scientific efforts)
Our geographical location provides a unique capability to the partnership.
Inventory of Dark Energy Science Collaboration includes MOS, daily imaging, IFU spectra, radio (although some of our radio facilities are already open-access).
Most obvious in-kind option is to offer AAT time. 55 nights per year? Perhaps there could be additional funding to the AAT from people interested in LSST astronomy?

- 2:30 Synergies with ASKAP and MWA (Elaine Sadler with Melanie Johnston-Hollitt)

SKA Precursors at MRO. Radio quiet – best on Earth for low frequency radioastronomy. Covers the area of the Netherlands with 80 people. MWA science goal is epoch of re-ionisation signature, plus GLEAM (completed in 2017).
ASKAP at mid frequency with PAFs. Each has 188 receivers 30sq deg.
Surface density of common objects between optical and 843MHz is low.
Only 2-3 percent of 2dF galaxies are radio sources

MWA and AAT synergies:
Not many historically, density of radio and optical sources different
Optical and radio monitoring of radio stars – but MWA needs upgrade
Deep MWA Observations of the GAMA fields
AAOmega follow-up of merging clusters with diffuse emission
ASKAP Survey Science Projects (10):
Continuum and polarisation (EMU, large spectroscopic data sets for machine algorithm training)
Transient and variable radio sources
HI spectral line surveys (WALLABY out to z~0.2, KOALA and HECTOR synergies; gas content, stellar kinematics and metal enrichment. Also DINGO, all of whose fields are within GAMA.)
EMU
WALLABY is much better matched to Taipan on the UKST
On the AAT, AAOmega, HECTOR and SOXS are of greatest interest for radio community

3:05-3:25 Afternoon tea

- 03:25 Discussion and concluding remarks (Chris Tinney)

Impossible to lower the operational cost of the telescope below ~$2.5M. Better with $3M.
If the HECTOR survey runs beyond 2025, will the science team members be able to continue funding it? Julia – maybe.
The AAT needs to look exciting and attractive to Australian VCs.
Question from Aaron re LSST – what's the critical science for Australians? Other than transient science, few science cases need proprietary access of one year. Is it worth 55 nights of AAT time (= 28 clear nights) BUT isn't transient data freely accessible immediately?
If it's AAT nights going to LSST, can we still sell time to LSST partners in the UK, for example. We need a model to put forward.
Chris T suggests a SOXS-like instrument is attractive for transient science. But operation needs to be as simple as sending a command that flips fibres and/or a mirror.
Chris T suggests there's a science case for Doppler follow-up of exoplanets, because the longer you observe, the more you learn.
For extragalactic science, the window for 2dF closes around 2023-2025 (∵ only 400 objects – not competetive in the area of 4MOST)
Hector's survey will extend beyond 2025 – does the Hector positioner remain, and how can it be used to make the telescope sufficiently scientifically attractive? A unique and world leading dark time instrument. (The instrument is less complicated than 2dF.)
Re LSST again – what is the optimal instrument, given 4MOST and MOONS on ESO telescopes? And US astronomers are likely to collaborate to gain access to ESO facilities. Maybe around 2025, DESI might swop places with DECam.
Radio field is not driving new optical facilities.

Summary
2022 – 4 year review
2025 – 7 year milestone
2dF's role goes away – beyond 2025 a 400-fibre positioner is not competitive, but there are roles for transient follow-up, Veloce, HECTOR.
If at 2025 there isn't $3M per year coming from the Consortium, Chris T suggests turning to the user-pays UKST model.
If a SOXS like instrument is decided on, a LIEF grant will be necessary to build it – and make it happen. The timescale is short if you want to do LSST follow up.
Need switchable fibre feeds, perhaps.

04:00 End

Summarised by Fred Watson