AST3 Exoplanets - How we can help.

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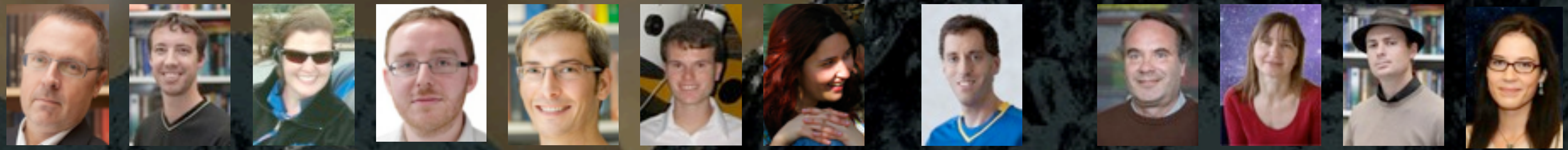
Never Stand Still | Science | Exoplanetary Science at UNSW

Exoplanetary Science at UNSW

- **Doppler "Wobble" Planet Searches**
  - **Anglo-Australian Planet Search, Pan-Pacific Planet Search, Habitable-zone M-dwarf Planet Search + Kepler K2 Host-star Charaterisation**
- **Transit Planet Follow-up**
  - **Confirmation for HATSouth, KELT, AST3, CSTAR**
  - **Spin-Orbit Alignment by Rossiter-McLaughlin Doppler Anomaly**
  - **Secondary Transit Detection in the infrared**
- **Y-type 300K brown dwarfs from NASA *WISE*. Dust and Debris disks with ESA *Herschel.* Direct Imaging with Gemini NICI, GPI, VLT Sphere**
- **New Facilities : *Veloce* and *FunnelWeb***



AST3

- 0.5m robotic telescope
- Optical CCD detector at 1”/pixel with 1.5˚ × 2.9˚ field

- This is *not* a unique capability.
- Its advantage for new science comes from its site.

Antarctic Advantages

Exoplanets AST3

- ✓ ✓ Continuous diurnal coverage for 1-3 months
- ✓ Continuous diurnal availability for $\delta < -30$ (i.e. fast overrides)
- ~~Low water vapour and low infrared background~~
- ~~Images 0.25” in some periods when boundary layer drops.~~
- ✓ ✓ Low scintillation & stable (i.e. absent) water vapour > high precision photometry

Exoplanet Science

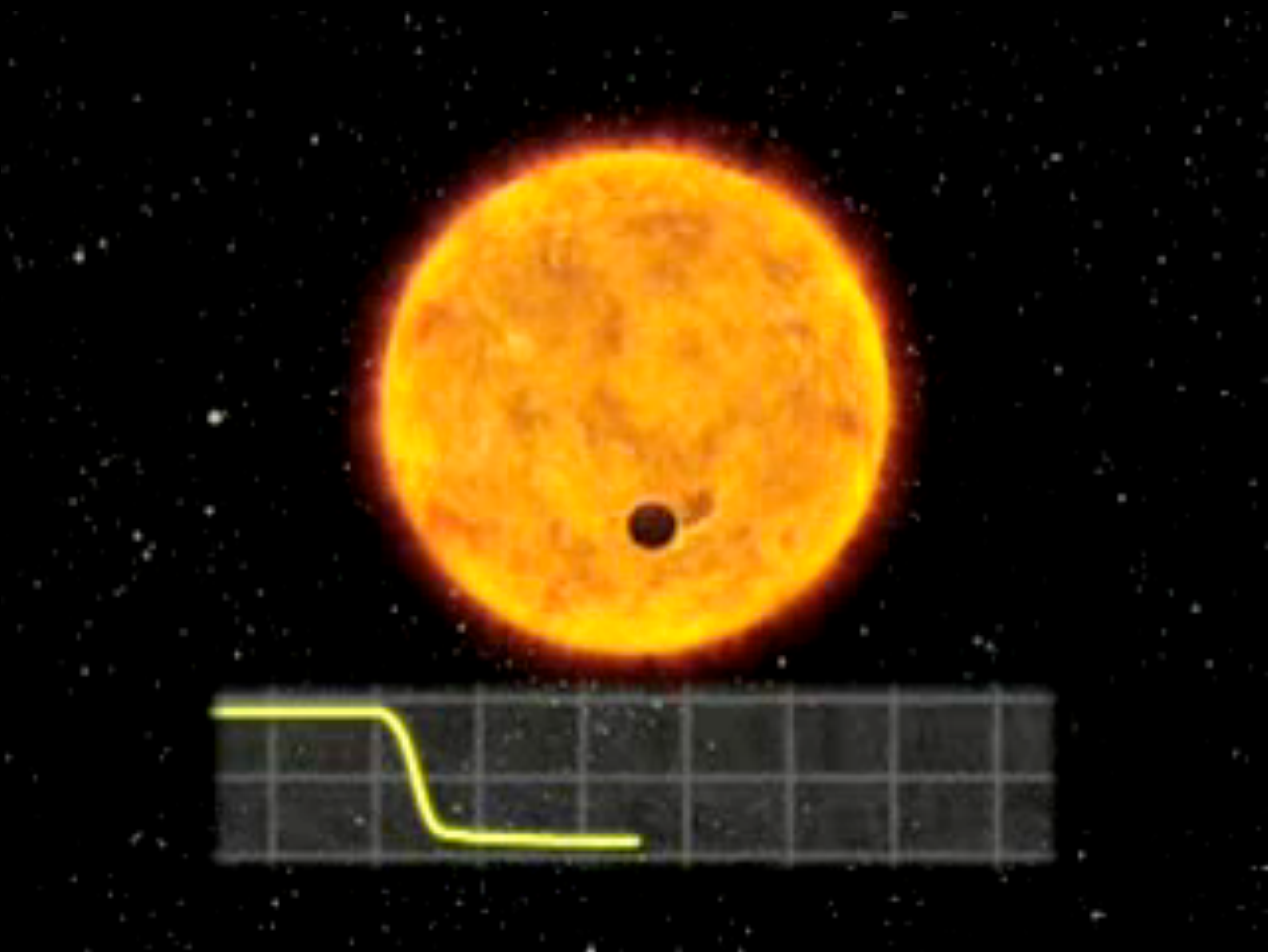
- "In principle" Dome A should be one of the best places in the world to do exoplanetary transit detection because.
    - No diurnal window function - potential to find very short (P<1d) and long (P>4d) planets.
    - Photometric "state of the art" from ground is ~1 mmag, and is limited by the atmosphere.
    - Low scintillation, low water vapour absorption and excellent seeing *should* mean better photometry at Dome A than the state of the art at temperate sites.

Why is precision important?

- Fractional flux for transit dips

  1% = 10mmag ➙ Jupiter ($11R_{Earth}$),
  0.5% = 5mmag ➙ Neptune ($4R_{Earth}$),
  0.1% = 1mmag ➙ Super-Earth ($2R_{Earth}$)

- AST3 can do ground-breaking science, <u>if the detector is stable enough</u> to do better than 1mmag precision.



“If you cheat on the calibration you get all the trouble you deserve.”

Jeremy Mould (circa 1990)

“If you cheat on the commissioning you get all the trouble you deserve.”

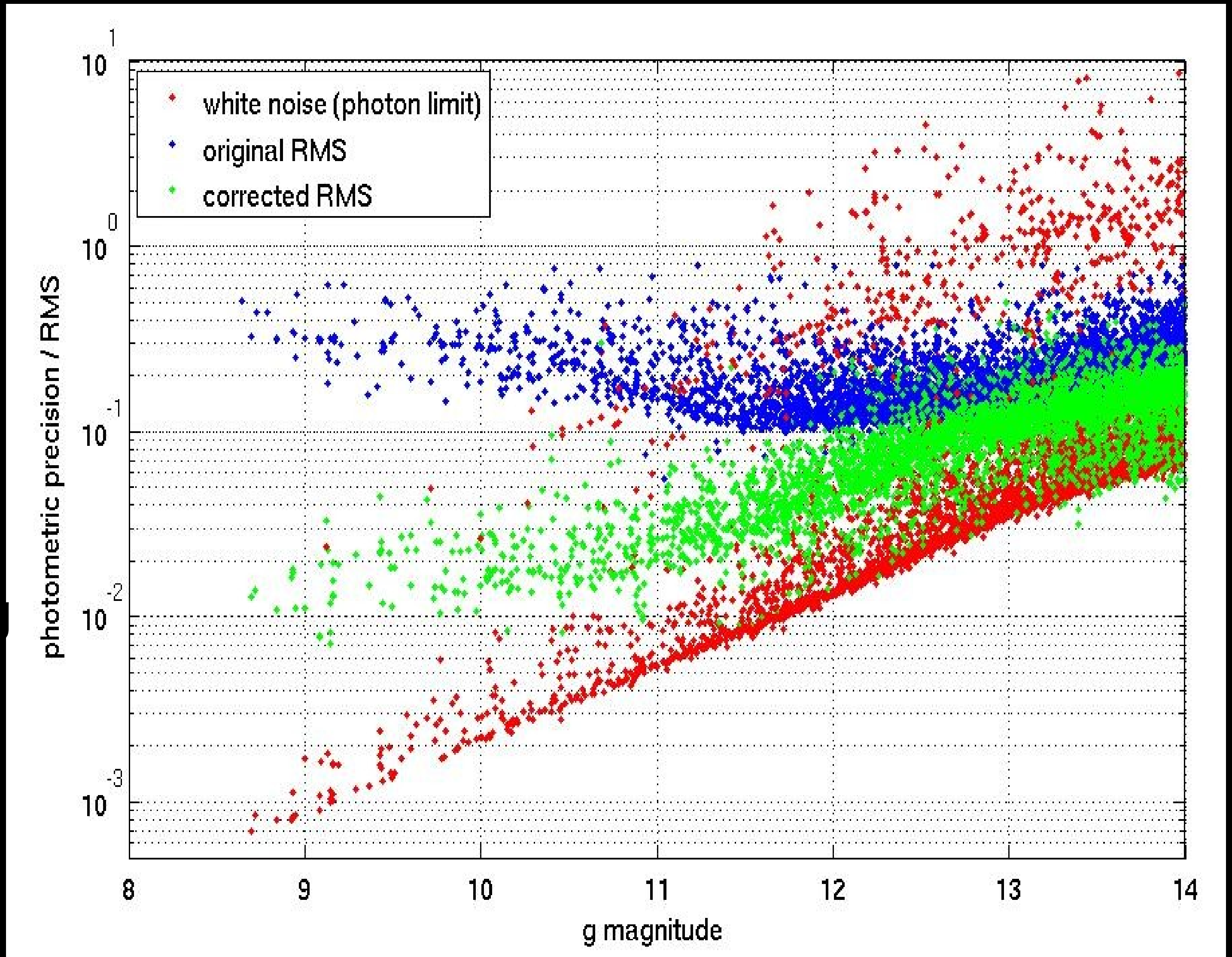
Chris Tinney (circa 2000)

Exoplanet Science with AST3

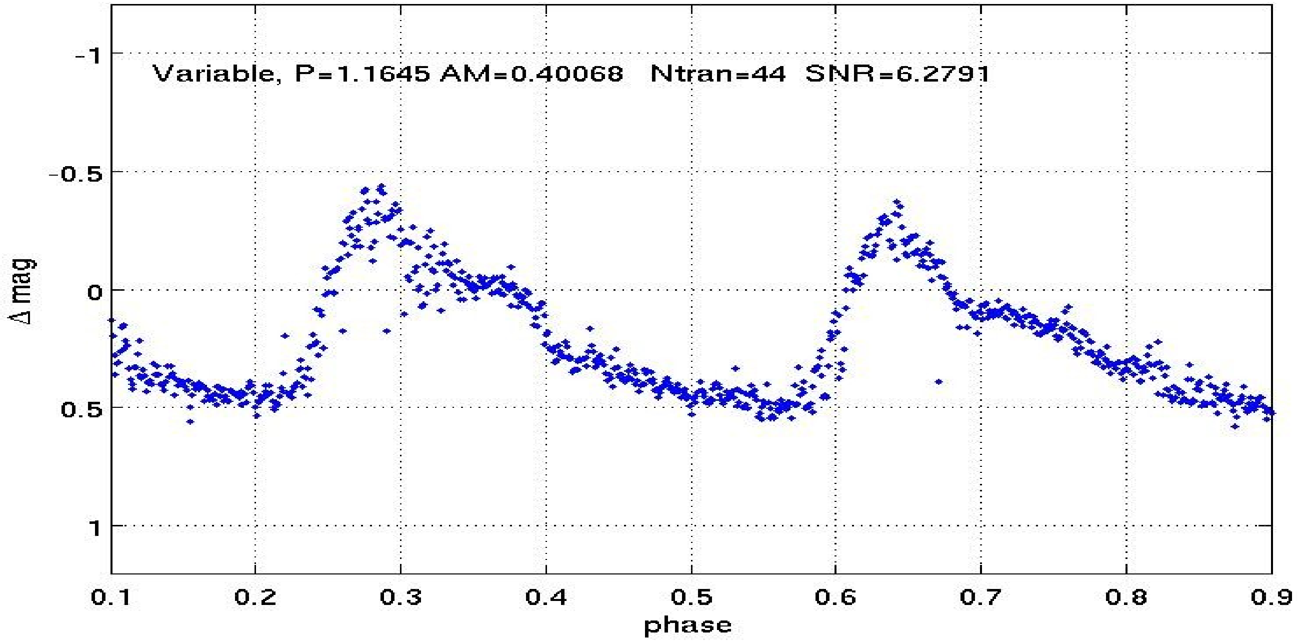
- <u>Is hard !</u> Much harder than SNe, variable stars, or EBs
- You need a <u>stable</u>, <u>calibrated</u> and <u>quantified</u> detector system - i.e. you must *know*
  - gain, linearity, cross-talk, CTE, dark current, etc as a fn of the detector's temperature (because it is not stable, or at least not necessarily at the temp you did a single test at)
- And know this before you ship.
- These things are all *infinitely* harder with an infrared system!

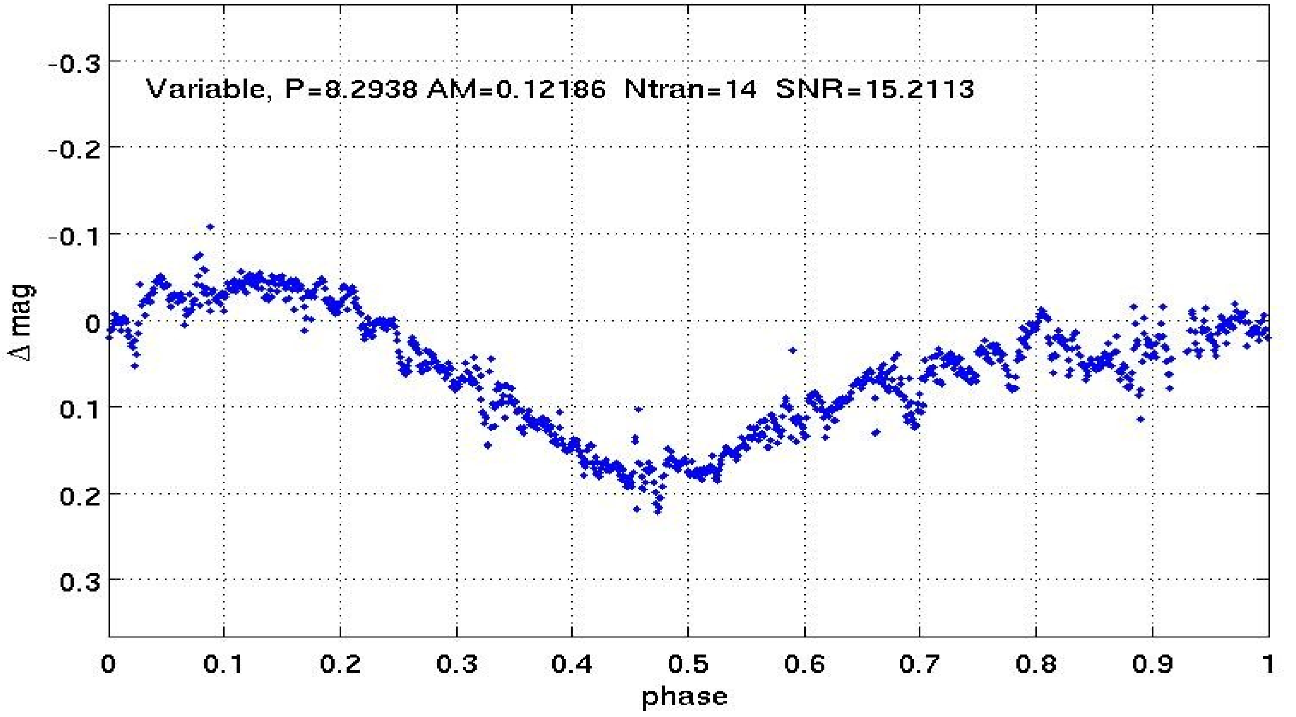
Why do you need all this?

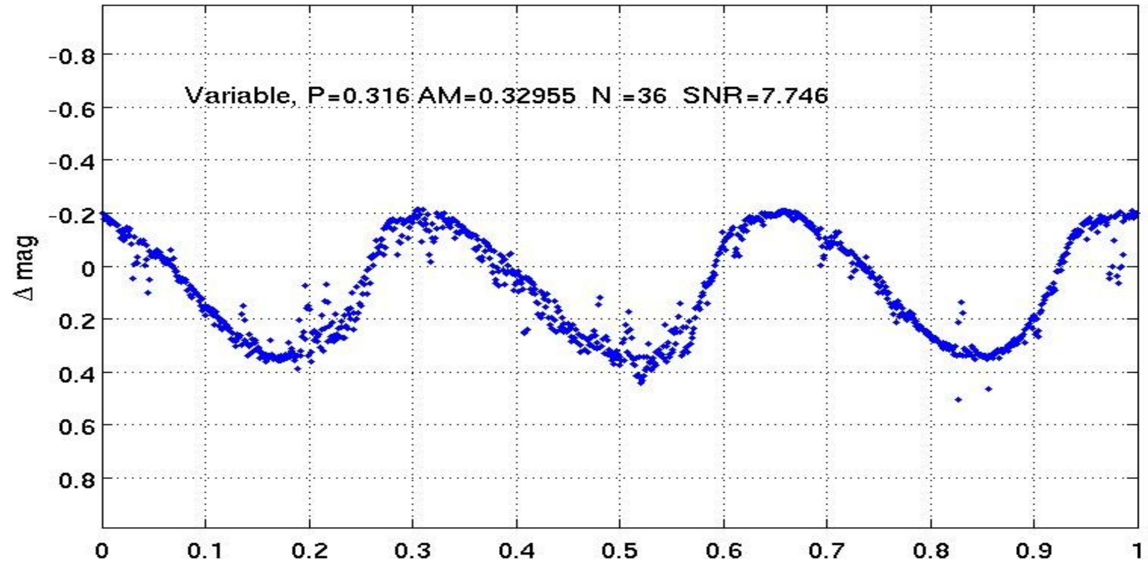
- BPST = CSTAR-II tests during Northern Winter at
- Data binned to 2 min (blue)
- Decorrelated against airmass sky, zero-point (green)
- Aperture mag uncertainty as fn of brightness (red)
- This system has so much “red noise” it can’t reach photon-counting limit even for bright targets.

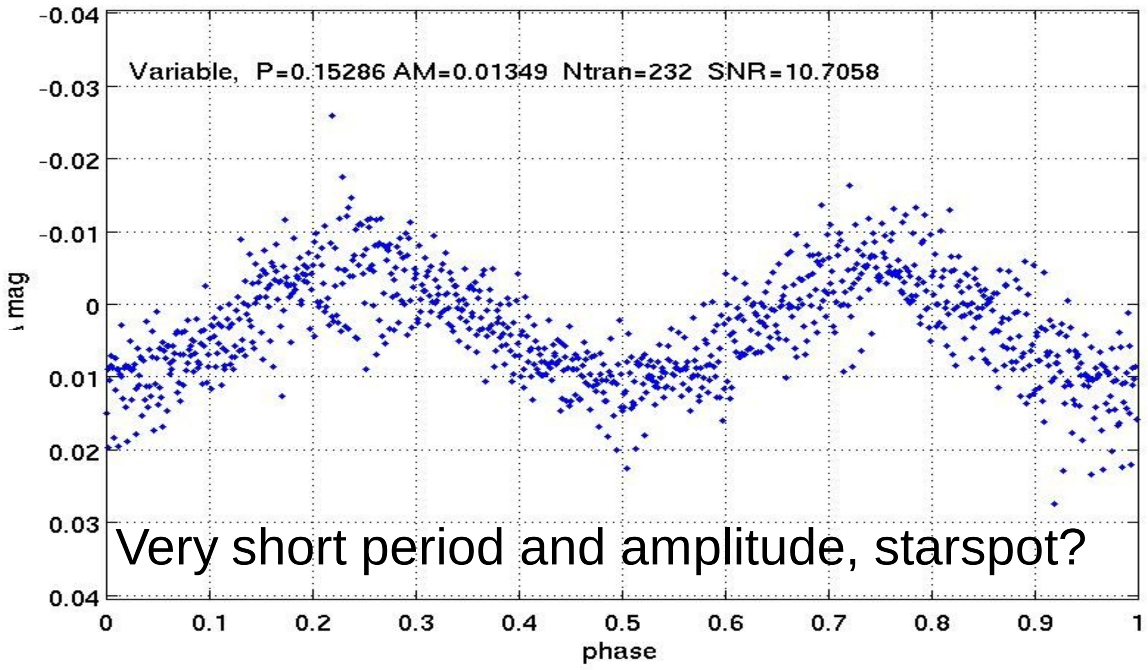


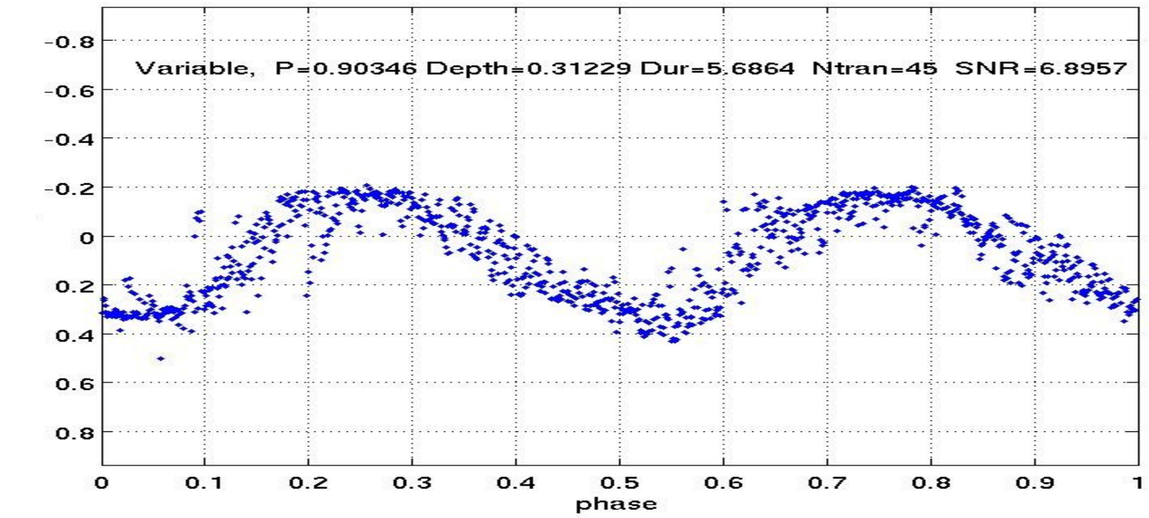
Variable stars



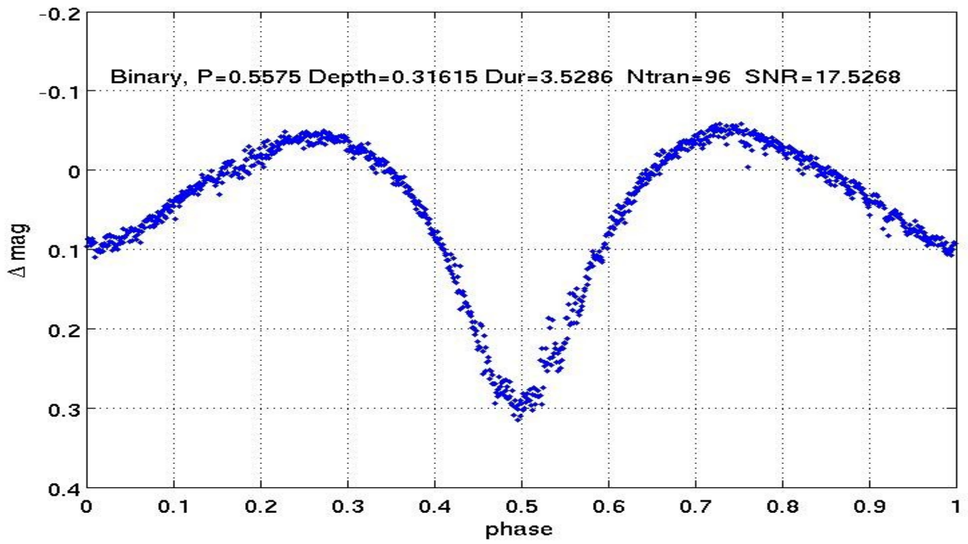


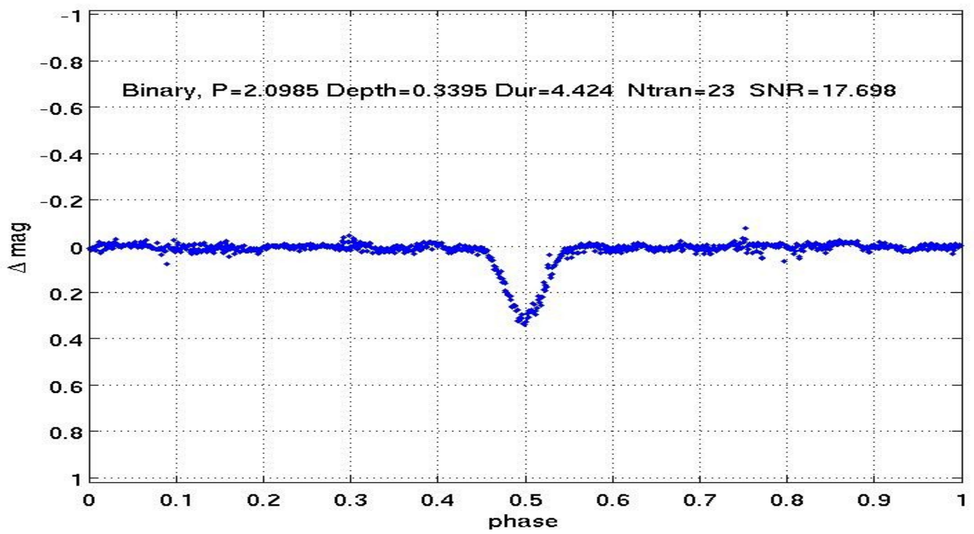


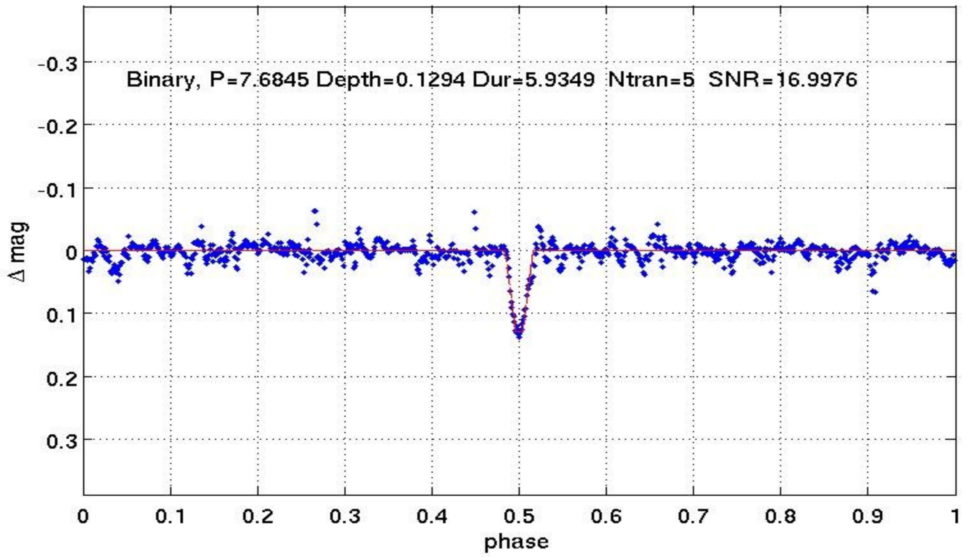


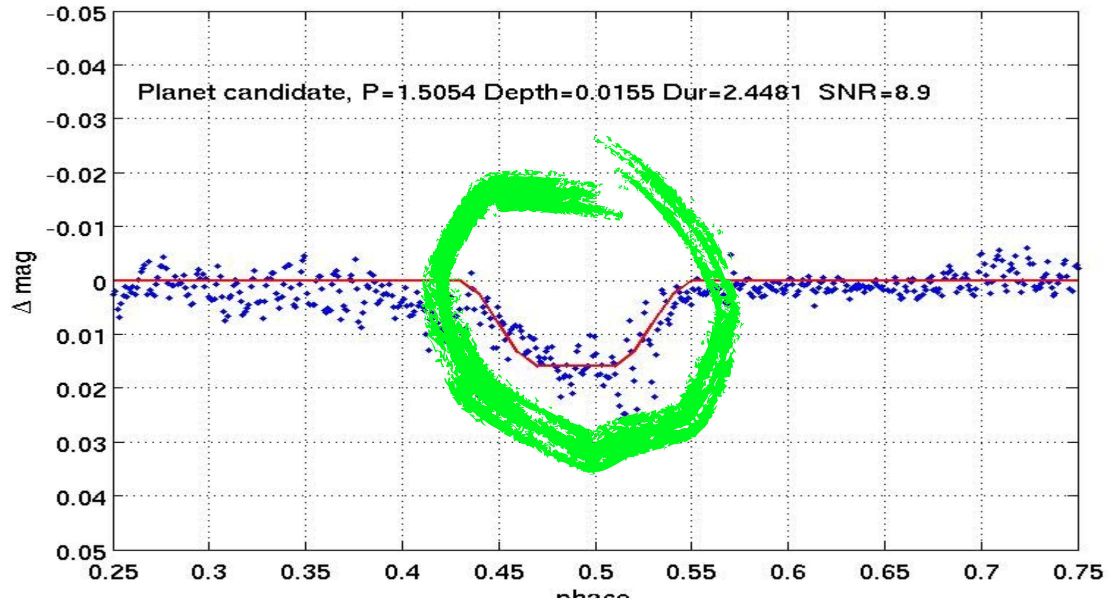


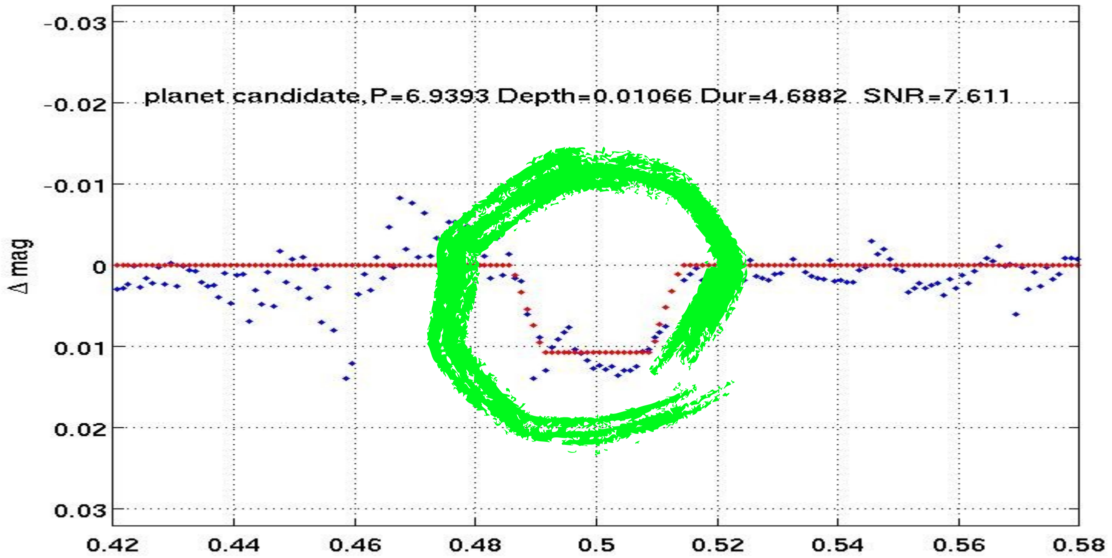
Binaries. Planets?

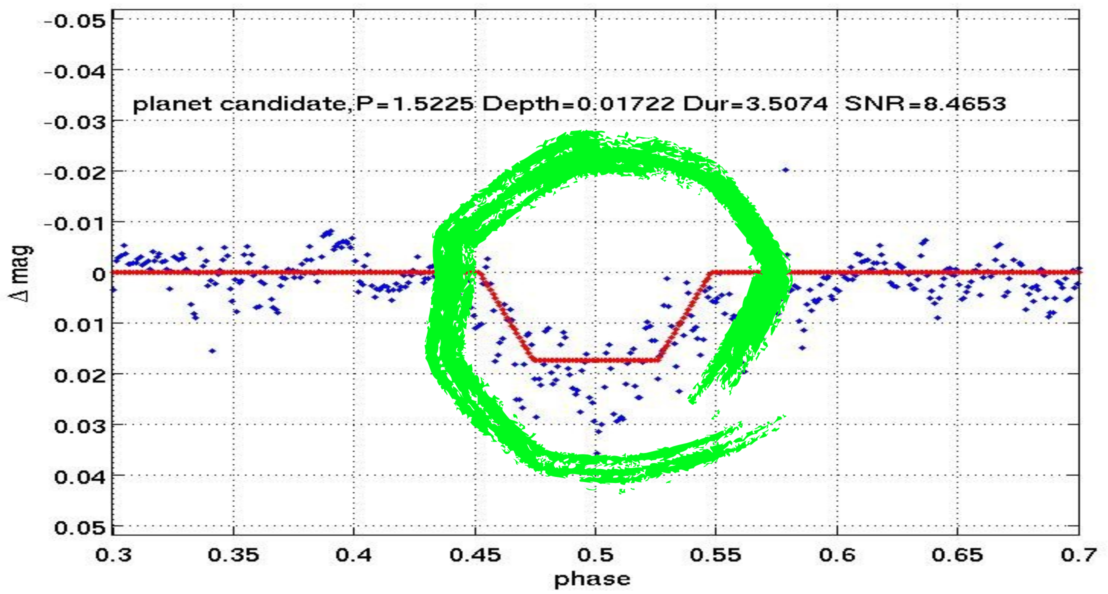










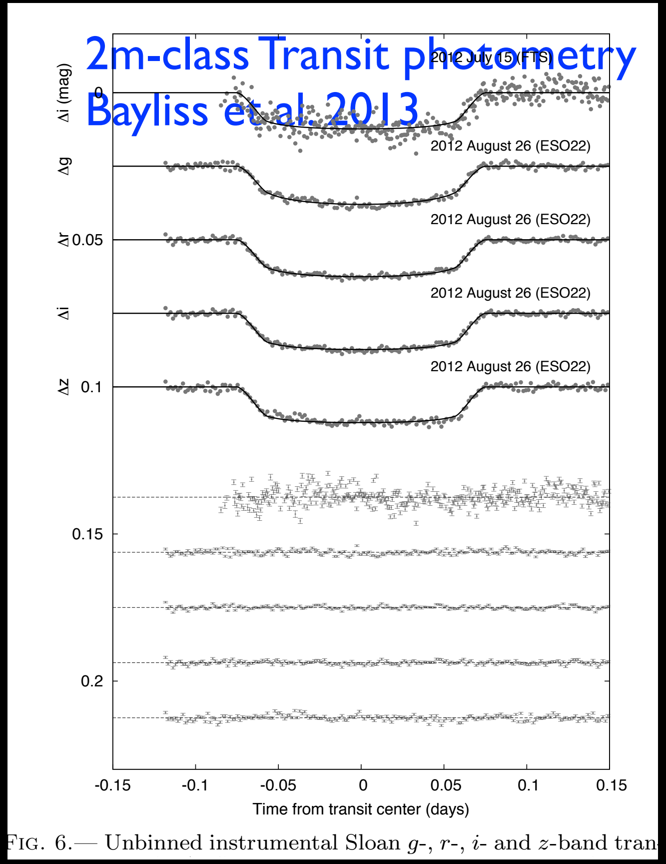


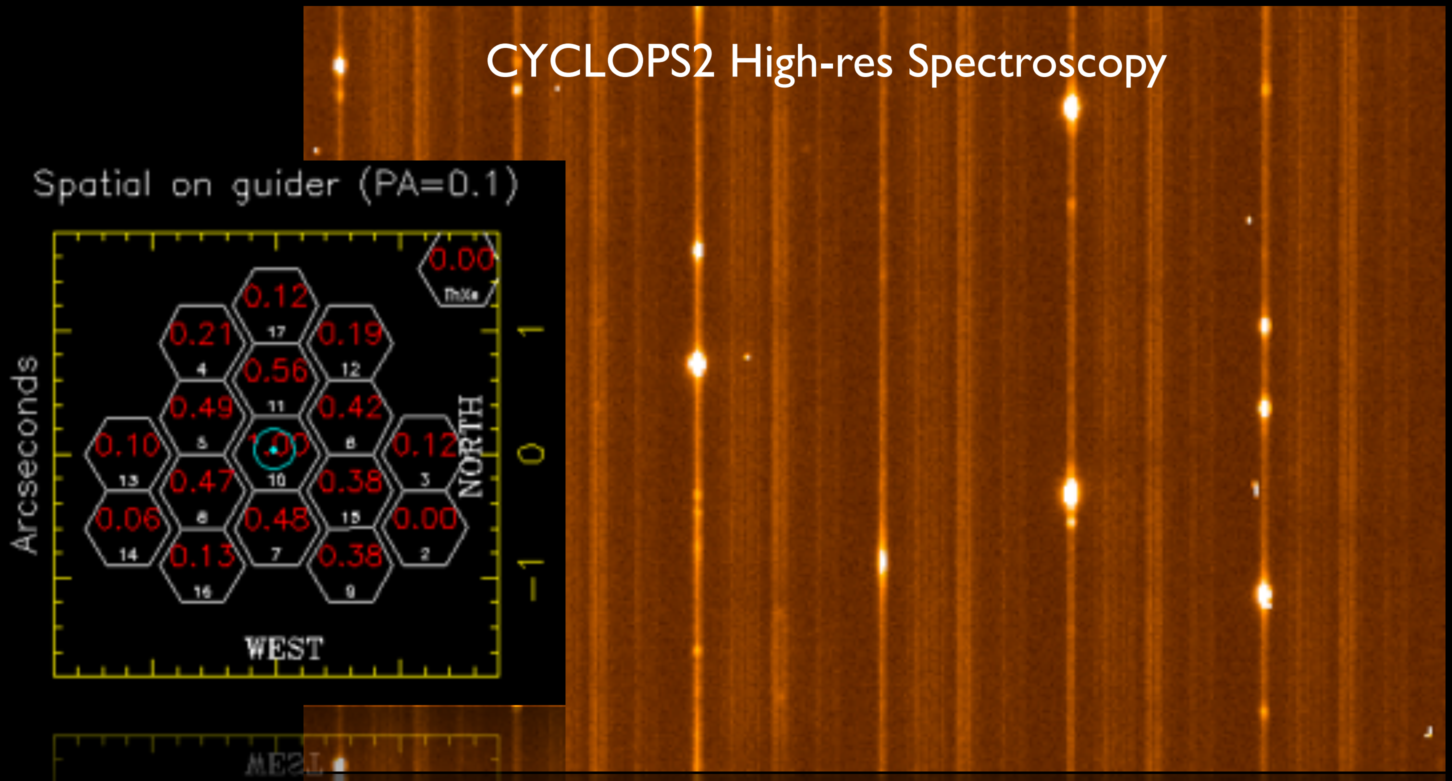
What we can do for you ...

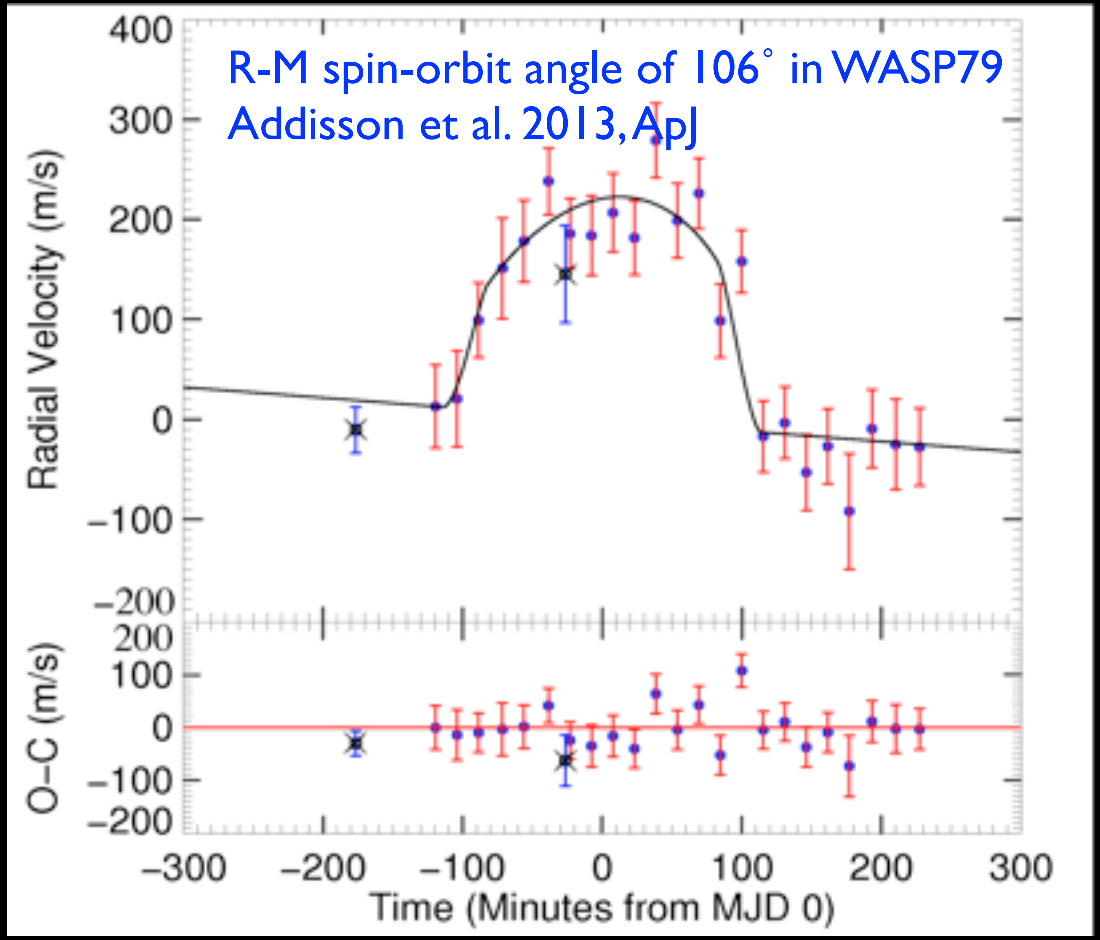
- Ground-based transit searches *rely* on follow-up observations to confirm candidates.
- "Chaff" outnumbers "seeds" by much more than 10:1.
  - Transit Recovery: 1-2m telescope to recover transit at higher S/N.
  - Low-res spectra : ANU 2.3m+WiFeS to reject giants, obvious SB2s and >10km/s velocity variation.
  - High-res spectra (one-shot) : AAT+CYCLOPS2+UCLES to reject more SB2s, rapid rotators
  - High-res spectra (4-to-6-shots) : AAT+CYCLOPS2+UCLES

What we can do for you … now

- We have been doing similar work for some time now with targets from HATSouth and KELT, so we are "ready to roll" with AST3 or CSTAR-II planet candidates.
- 10-20m/s precision for V<13 targets

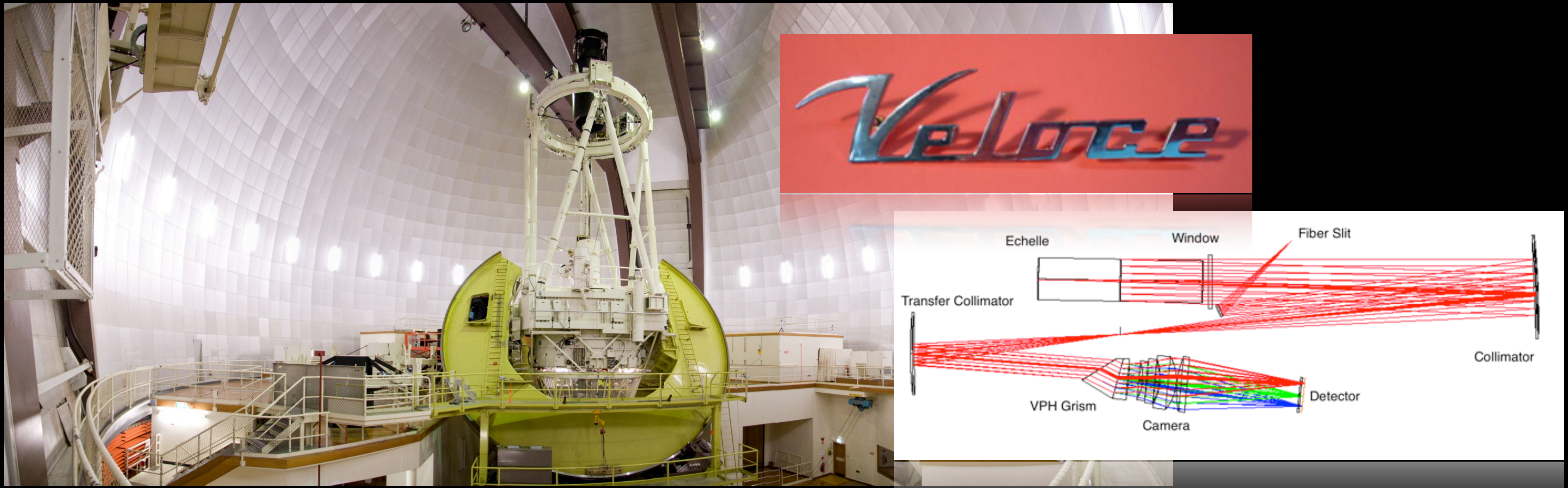






What we can do for you … soon

- Replacing UCLES with a $1.65m purpose-built *Veloce* Doppler spectrograph at AAT which will deliver higher stability and precision (late 2016)



What we can do for you … soon

- Provide a spectrum of every star brighter than 12th magnitude at δ < +30 from the *FunnelWeb Survey* (starting mid-2016 and running for 3 years)

Table 1 – *Galaxia* model (Sharma et al. 2011) star counts in FunnelWeb

Class	Number of objects in Survey			
	I<12		I<14	
All Stars	**2,130,000**		9,840,000	
<100Myr	**9,700**		17,500	
<10Myr	**800**		1,200	
Sp Type	Dwarfs	Giants	Dwarfs	Giants
B	8,500	0	8,600	0
A	76,100	300	121,000	2,800
F	548,000	500	2,800,000	5,300
G	281,000	61,400	2,380,000	404,000
K	67,100	1,030,000	779,000	3,260,000
M	2,800	52,000	**24,500**	**60,100**