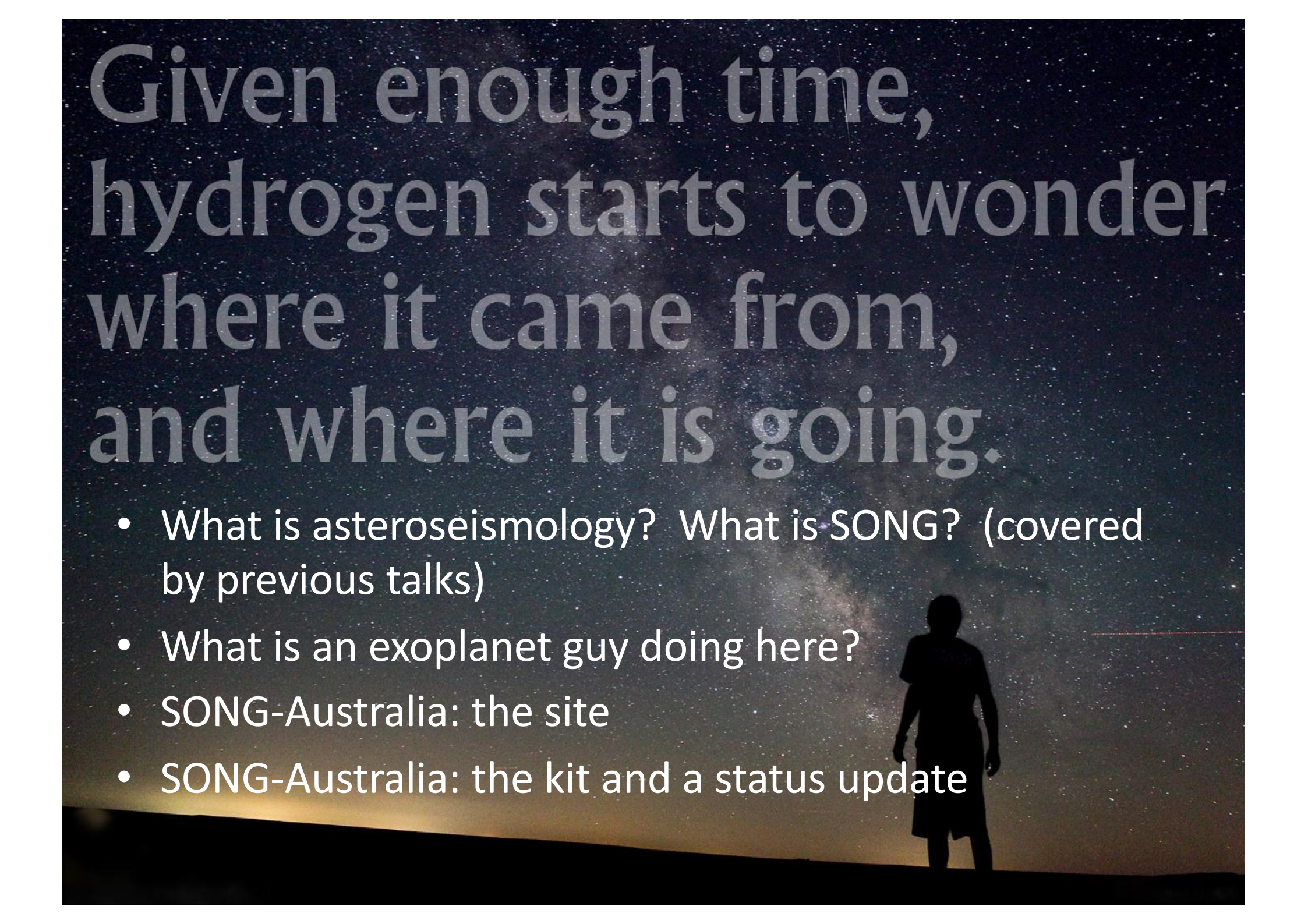


SONG-Australia at the University of Southern Queensland

Rob Wittenmyer
University of Southern Queensland

rob.w@usq.edu.au

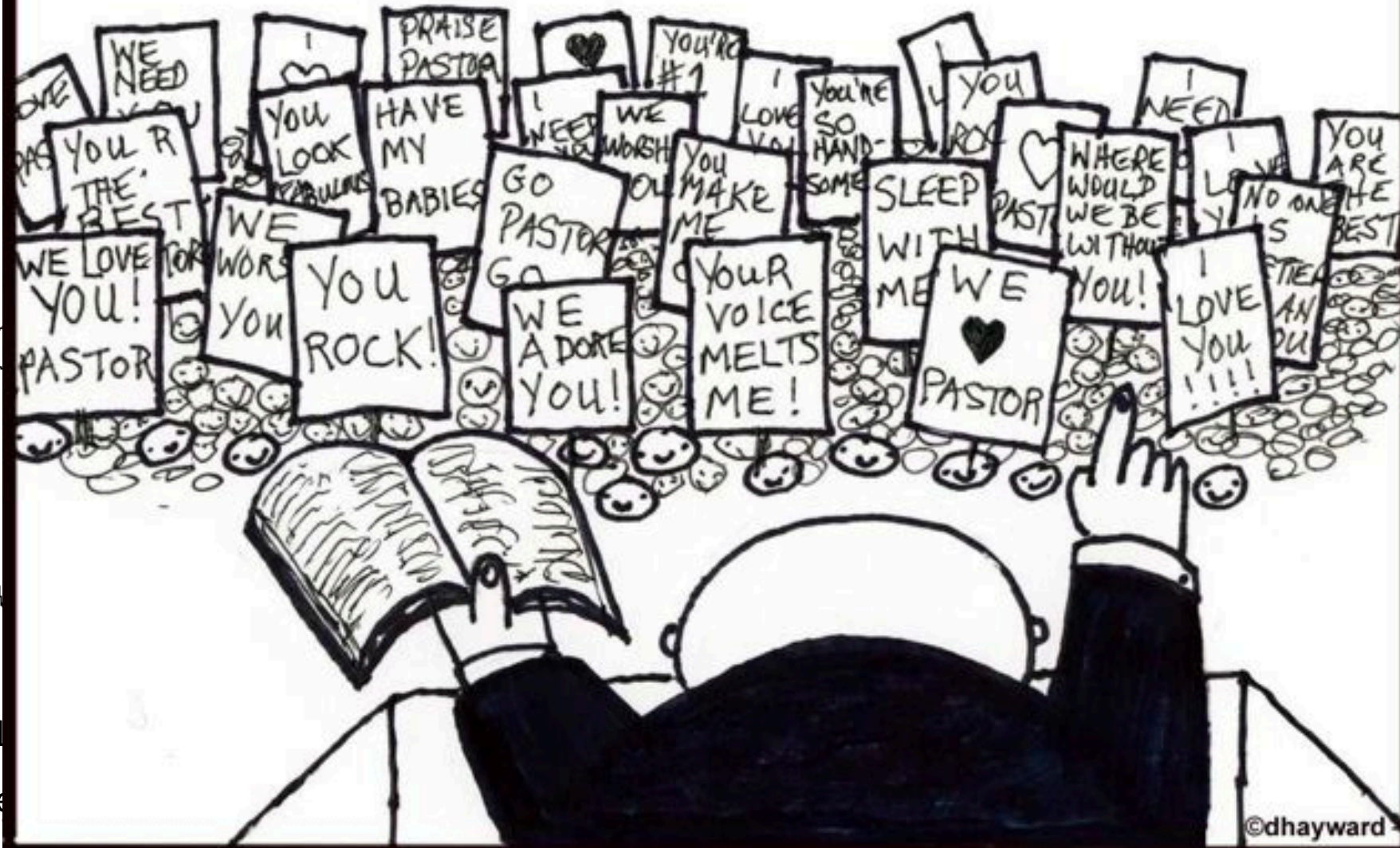
2018 Oct 23



Given enough time,
hydrogen starts to wonder
where it came from,
and where it is going.

- What is asteroseismology? What is SONG? (covered by previous talks)
- What is an exoplanet guy doing here?
- SONG-Australia: the site
- SONG-Australia: the kit and a status update

PREACHING TO THE CONVERTED



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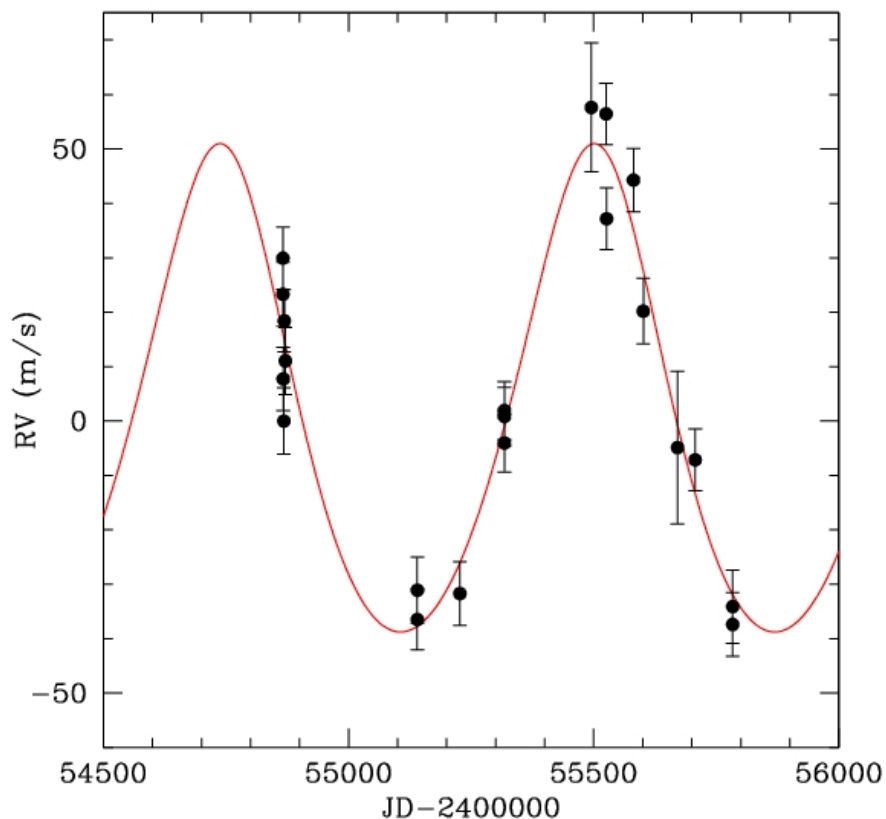
What is an exoplanet guy doing here?



What we know about planets depends heavily on what we know about the host star!

Doppler velocity measurements:

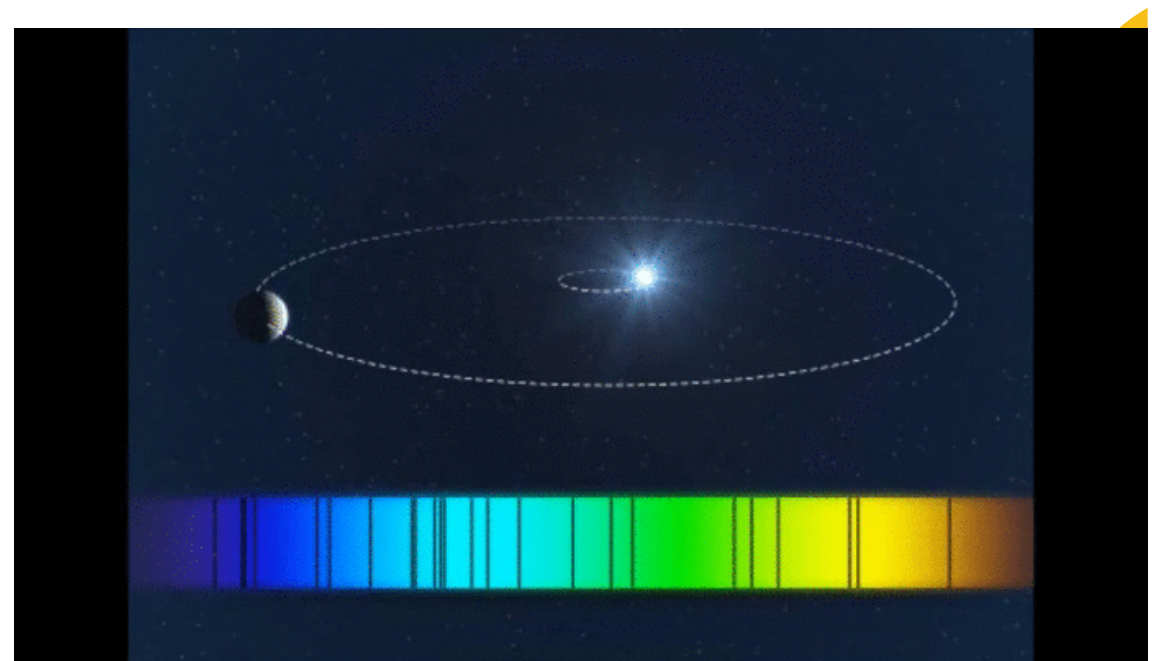
You get a velocity amplitude and a mass function dependent on the star's mass.



HD 47205b

$K=45$ m/s, $M_{\text{star}} = 1.52 M_{\text{sun}}$

$\rightarrow M_{\text{planet}} = 2.6$ Jupiter masses



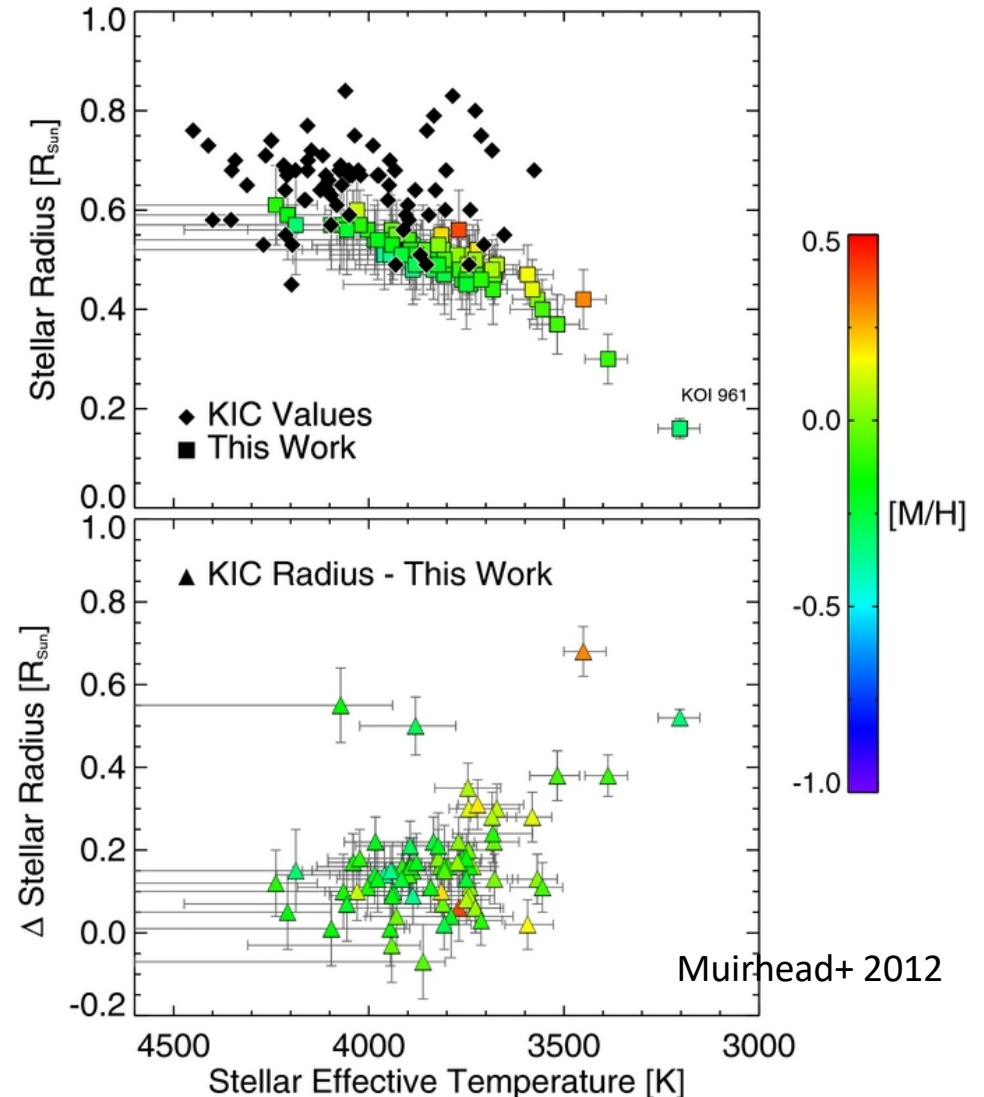
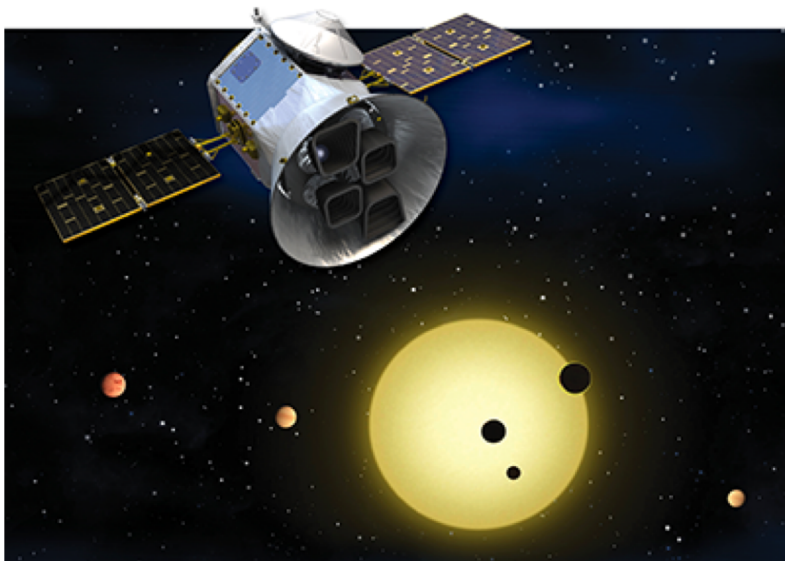
What is an exoplanet guy doing here?



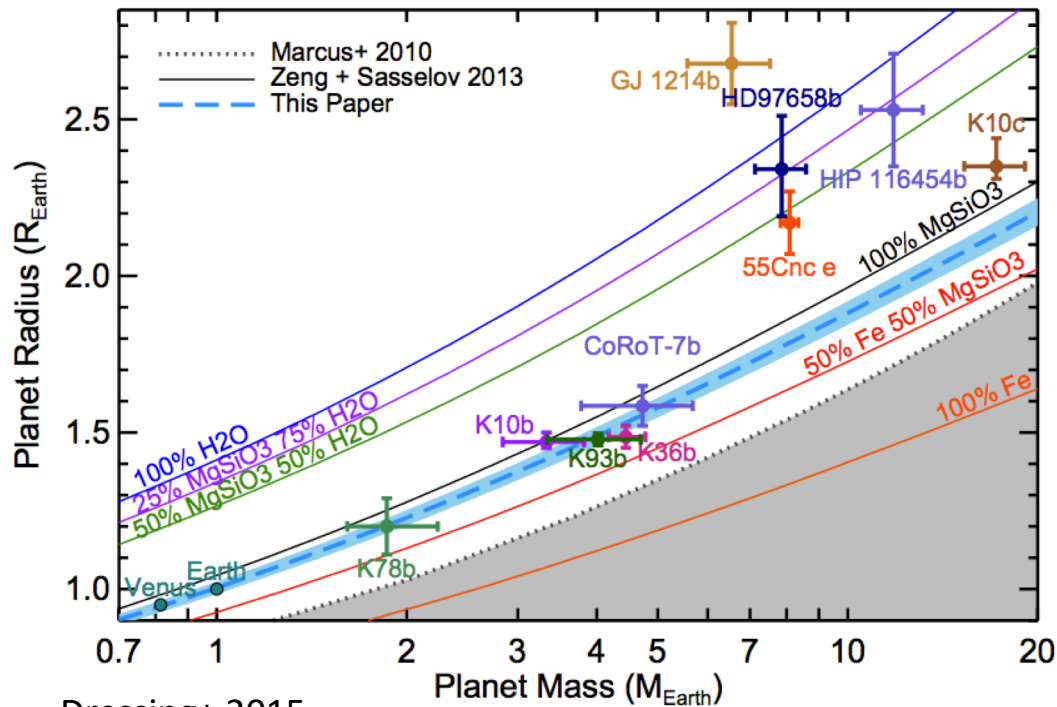
Transits: You measure a planet radius as a function of the star's radius (by the flux lost in transit)

Better get the stellar radius right!!

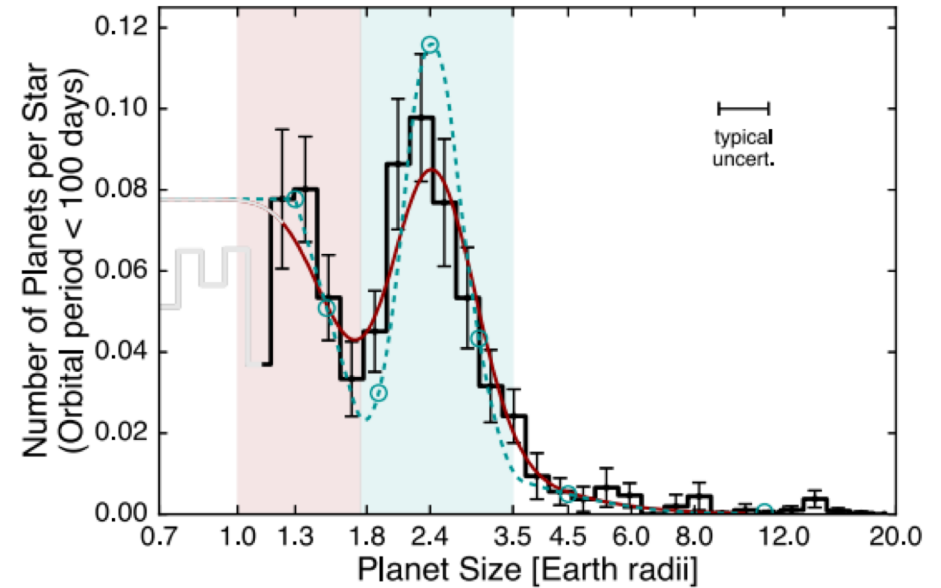
“Super Earths” can become Neptunes!



Super-Earths: Need accurate **masses** and **radii**



Dressing+ 2015



Fulton+ 2017

Few super-earths with “good” mass measurements (better than 20% precision). The transition between Earth-like and Neptune-like compositions remains poorly understood.

We get good radii from better stellar parameters.

J. Johnson+ 2017, Wittenmyer+ 2018, D. Johns+ 2018

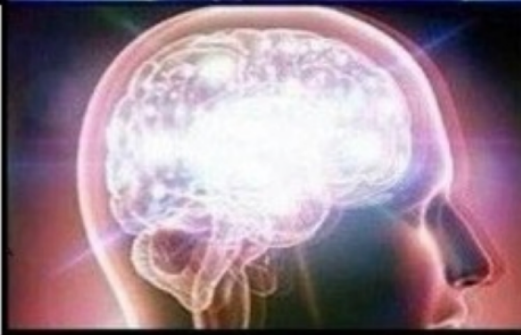
**ALL STARS
ARE ONE
SOLAR MASS**



**MASS AND
RADIUS
FROM PHOTOMETRY**



**MASS AND
RADIUS
FROM SPECTRA**



**MASS AND
RADIUS
FROM SEISMOLOGY**

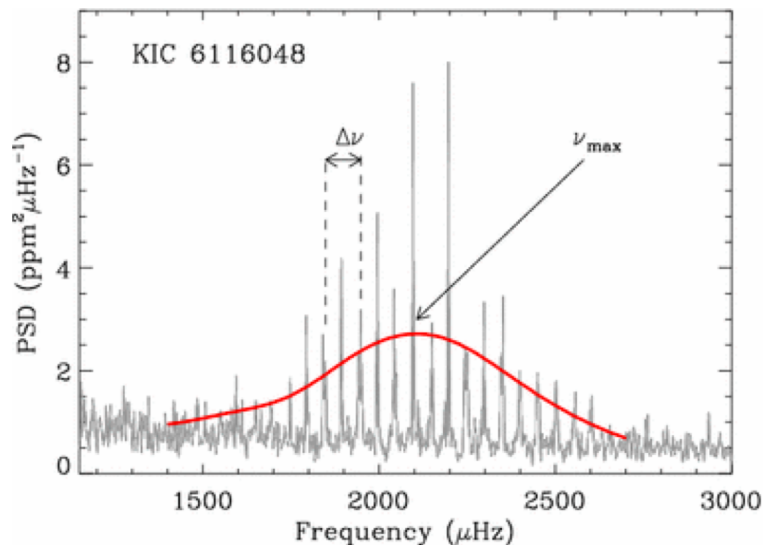


The planet hunter's dilemma:
How to get good masses
for field stars?



Exoplanet people want masses and radii

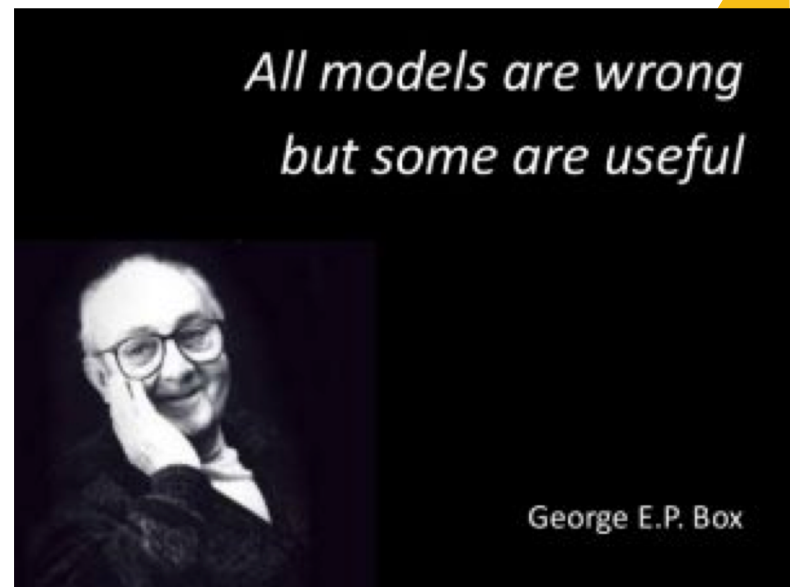
Seismology delivers the most precise (model-independent) measurements of stellar masses and radii.



$$\frac{M}{M_{\odot}} \approx \left(\frac{\nu_{\text{max}}}{\nu_{\text{max},\odot}} \right)^3 \left(\frac{\langle \Delta\nu \rangle}{\langle \Delta\nu_{\odot} \rangle} \right)^{-4} \left(\frac{T_{\text{eff}}}{T_{\text{eff},\odot}} \right)^{3/2}$$

$$\frac{R}{R_{\odot}} \approx \left(\frac{\nu_{\text{max}}}{\nu_{\text{max},\odot}} \right) \left(\frac{\langle \Delta\nu \rangle}{\langle \Delta\nu_{\odot} \rangle} \right)^{-2} \left(\frac{T_{\text{eff}}}{T_{\text{eff},\odot}} \right)^{1/2}$$

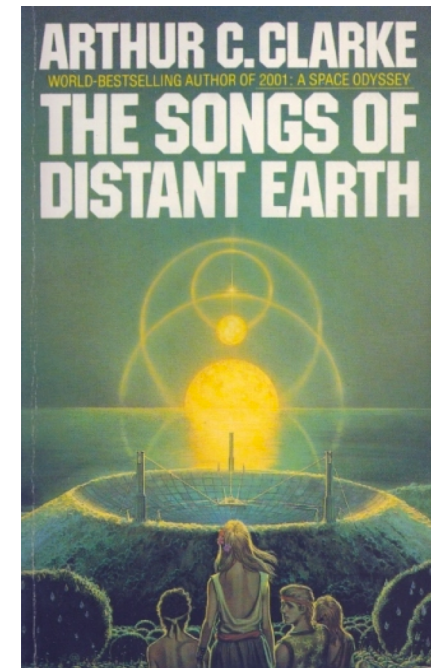
Result: masses and radii at precisions of 1-3%
e.g. Silva Aguirre et al. 2015



SONGs of distant Earths

(With apologies to Clarke)

- TESS planets will have radii and masses dependent on their host stars' radii and mass.
- Seismology can give the most accurate and precise stellar, and hence planetary, masses and radii!
- SONG data can help get better stellar parameters for TESS planet hosts.



SONG-Australia at Mount Kent



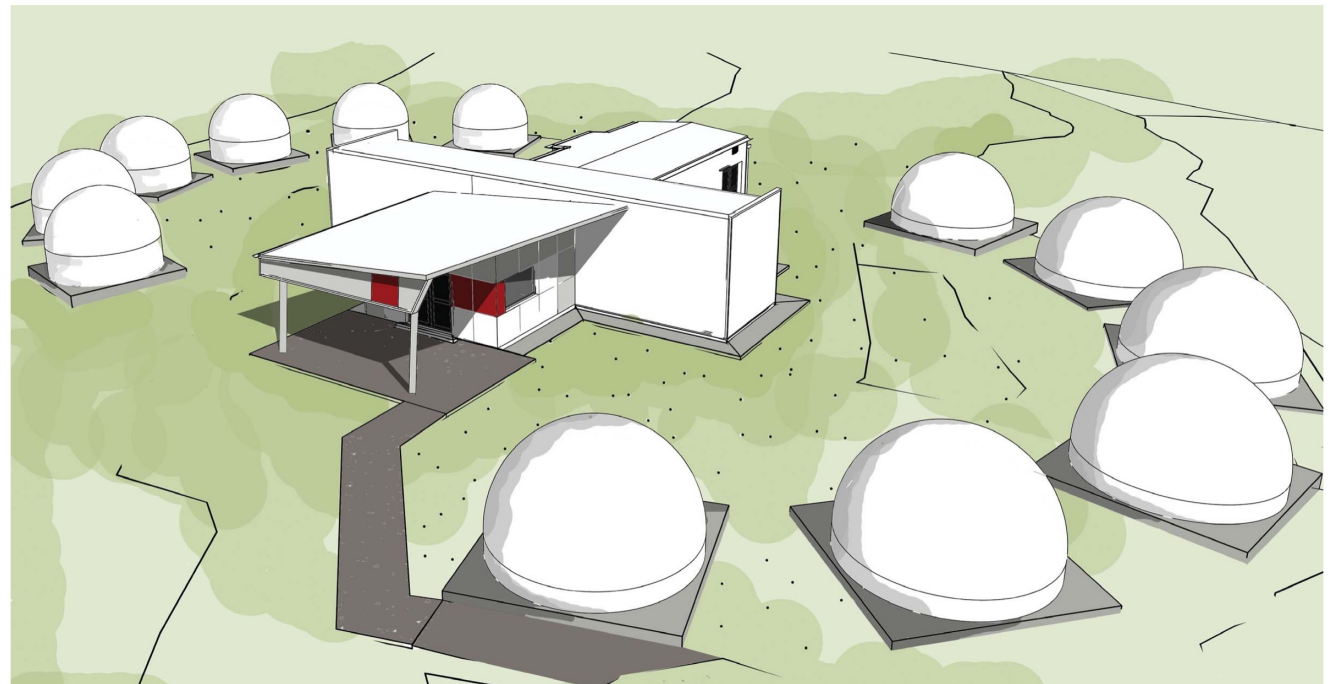
The SONG site is ready for up to six 1m class telescopes



SONG-Australia at Mount Kent

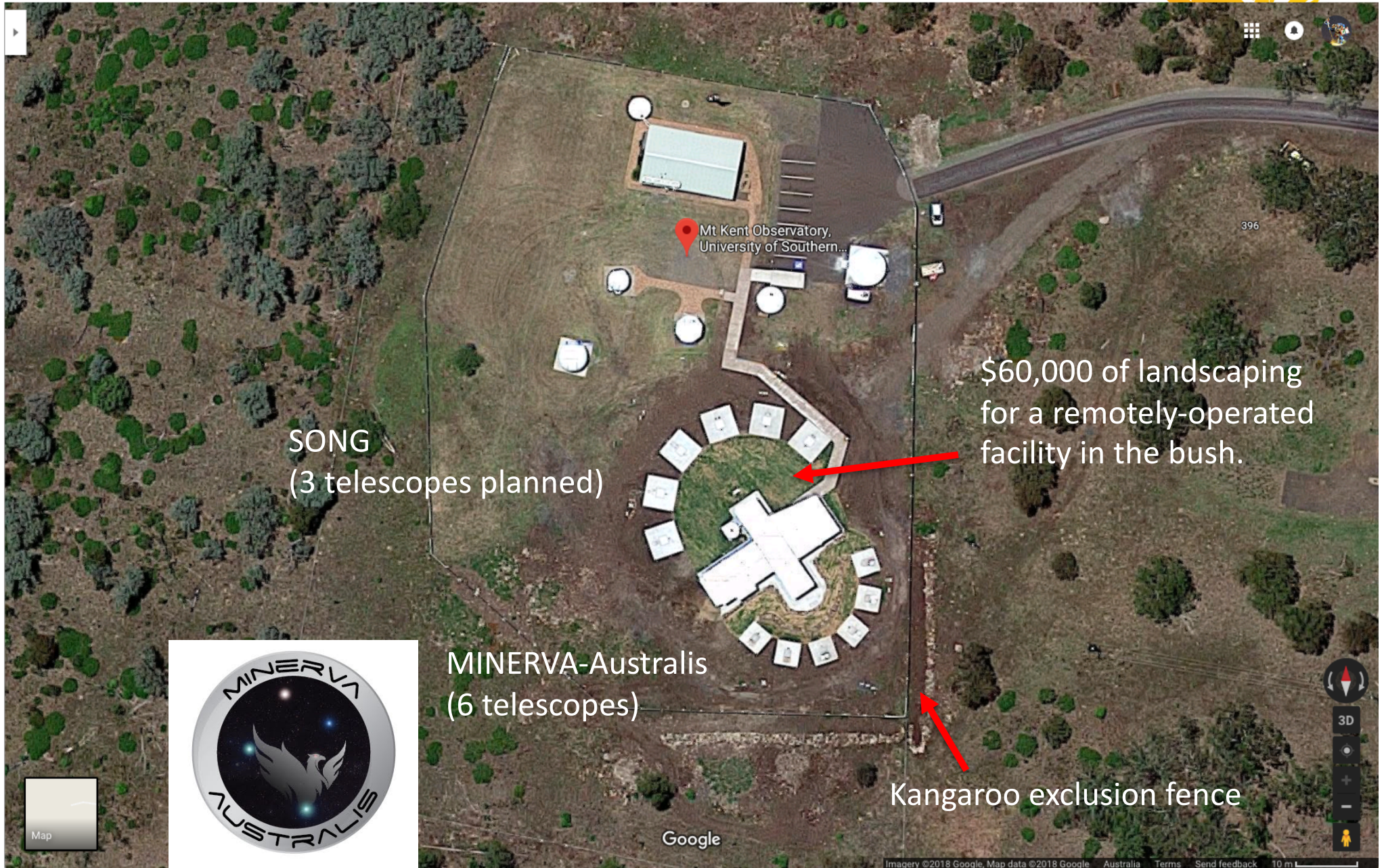


- We built the site to accommodate a SONG node.
- Extend longitude coverage.
- Overlaps significantly with Northern targets since we are at only 28 South.





SONG-Australia at Mount Kent

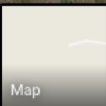


SONG
(3 telescopes planned)

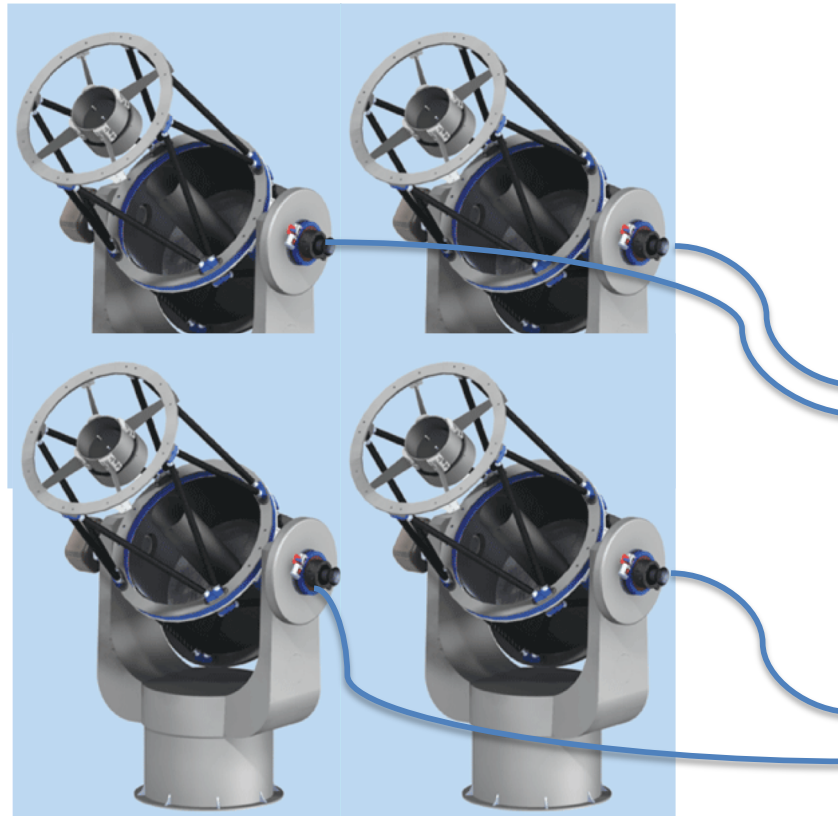
\$60,000 of landscaping
for a remotely-operated
facility in the bush.

MINERVA-Australis
(6 telescopes)

Kangaroo exclusion fence



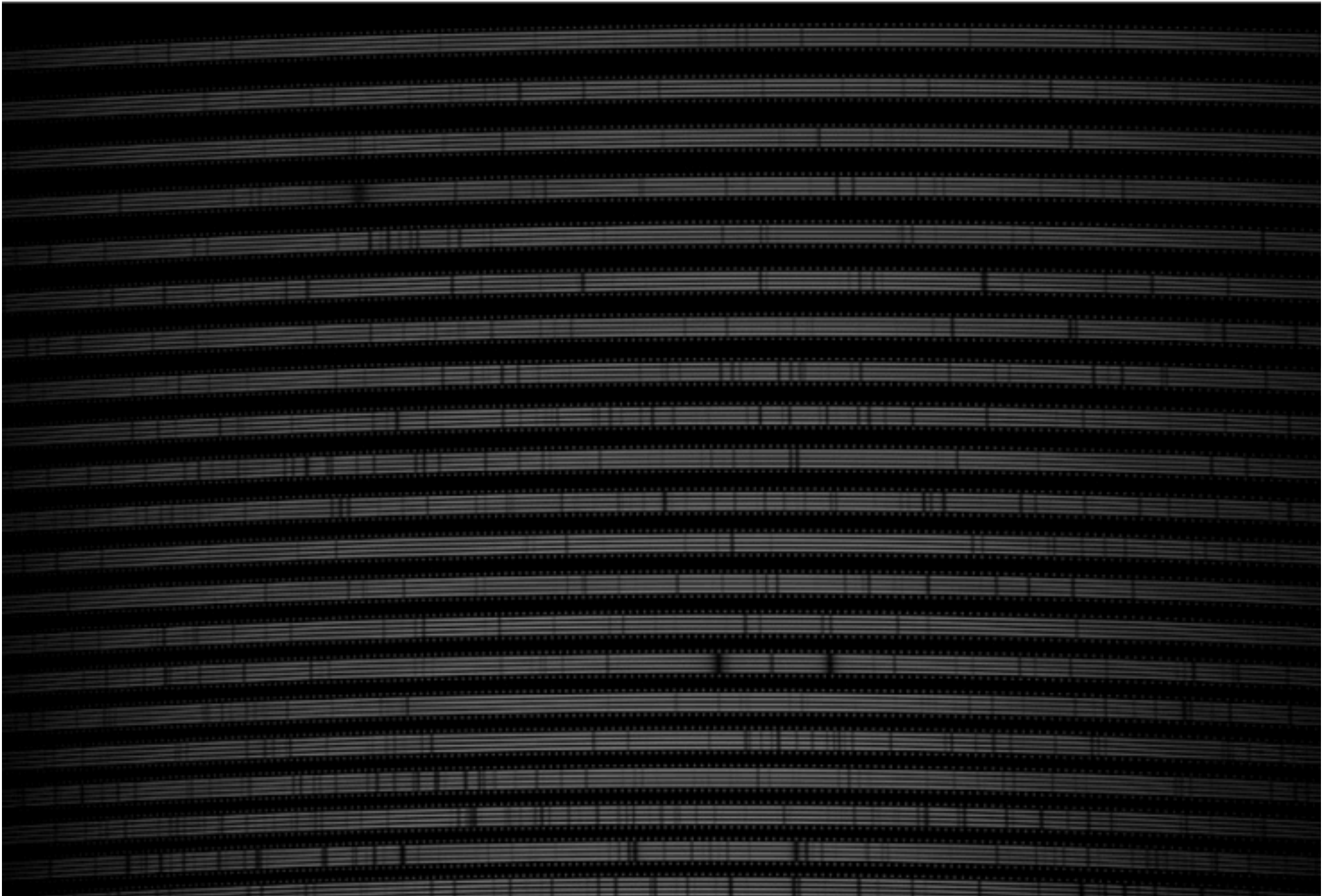
“MINERVA”-like design: Feed a single spectrograph with many small telescopes



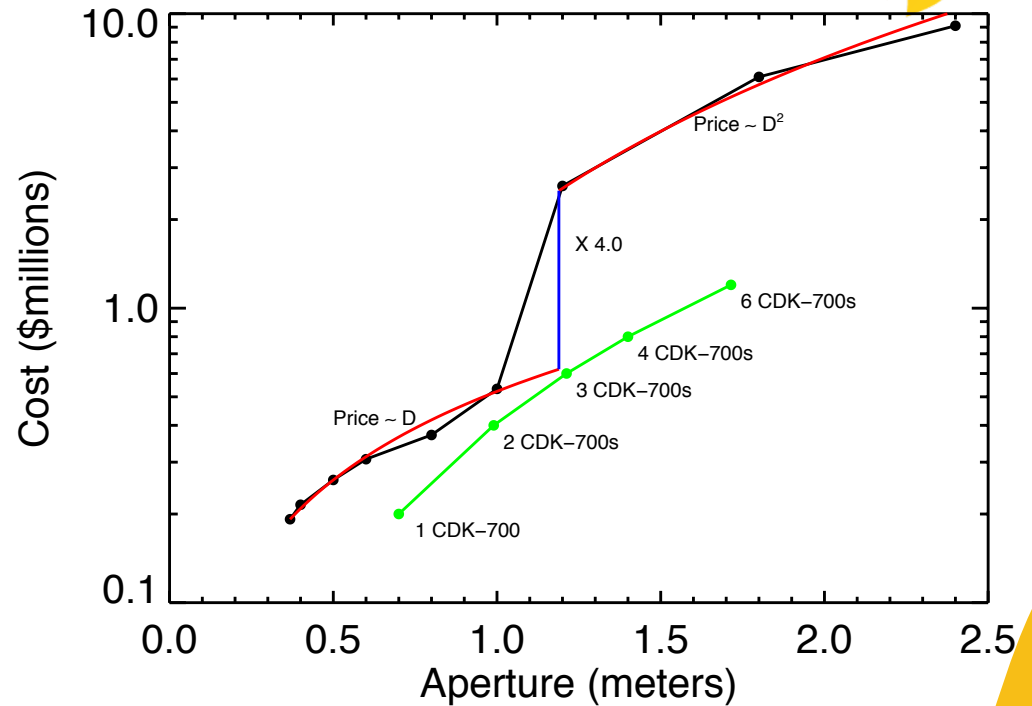
Spectrometer



How does it work? (4 telescopes → 4 separate spectra of same star)



Own the future



Many small telescopes are more cost-effective than a single larger one.

Retire risk by using off-the-shelf products.

Planewave CDK-700 70cm telescopes

SONG-Australia at Mount Kent

- Identical to MINERVA design: many 0.7m telescopes feed a single high-resolution spectrograph.
- Funded by Carlsberg Foundation and Aarhus University. Australian grant result expected ~2 weeks.
- Spectrograph being built now.
- Telescope 1 donated by local philanthropist.
- On-sky starting late 2019.



AARHUS UNIVERSITY



Summary: Do not weep, but rejoice!

UNIVERSITY
OF SOUTHERN
QUEENSLAND
AUSTRALIA



Alexander wept when he heard Anaxarchus discourse about an infinite number of worlds, and when his friends inquired what ailed him, "Is it not worthy of tears," he said, "that, when the number of worlds is infinite, we have not yet become lords of a single one?"

- Plutarch, *De Tranquillitate Animi*

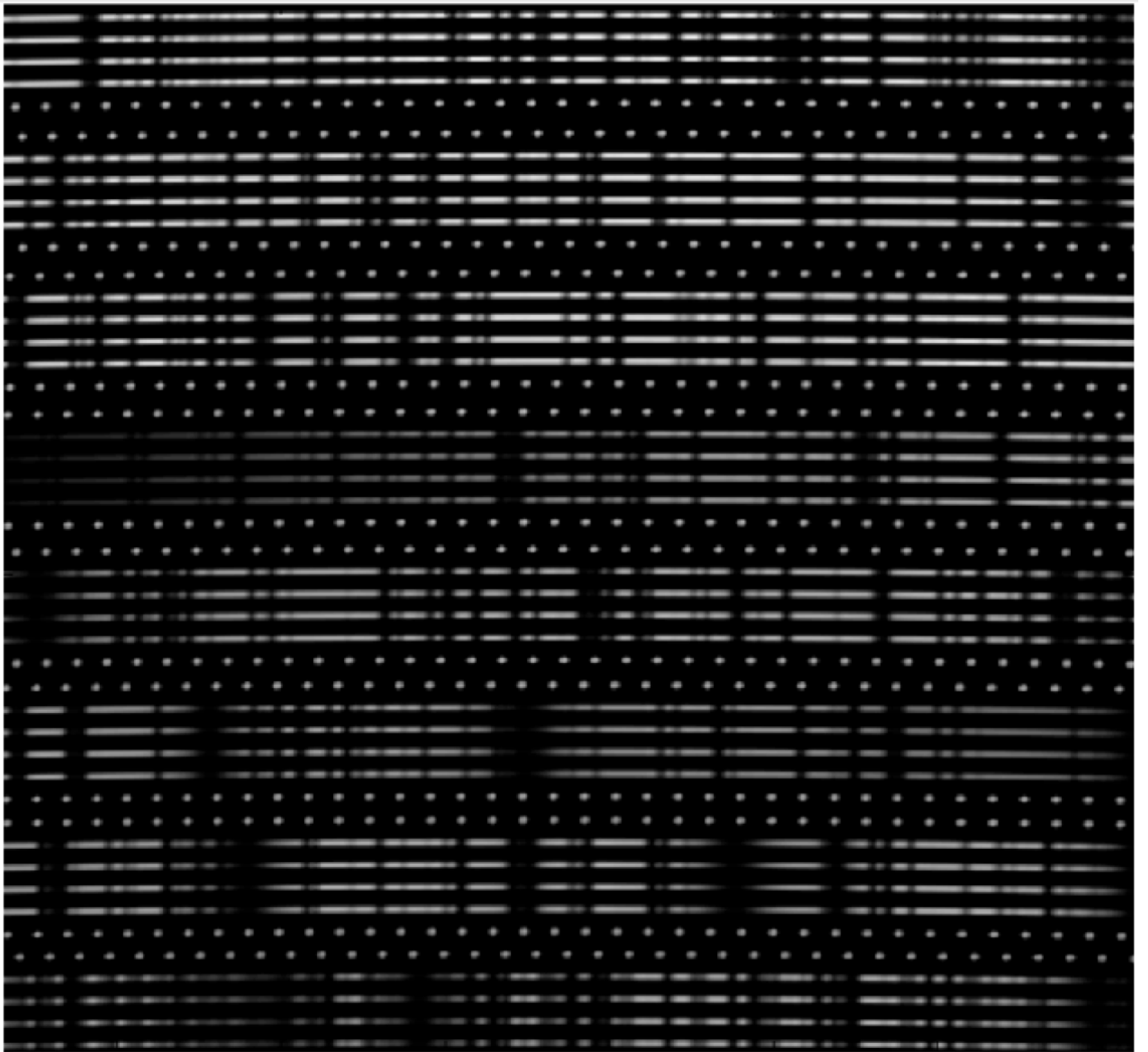
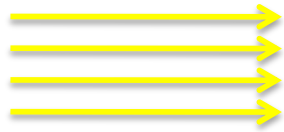


- The Australian SONG node will open up Southern targets and complement Northern observations.
- MINERVA-Australis at USQ is the world's only fully dedicated TESS Southern follow-up facility.
- With the combined power of SONG and MINERVA, Mount Kent Observatory aims to be Australia's premier optical astronomy facility in the 2020s and beyond.

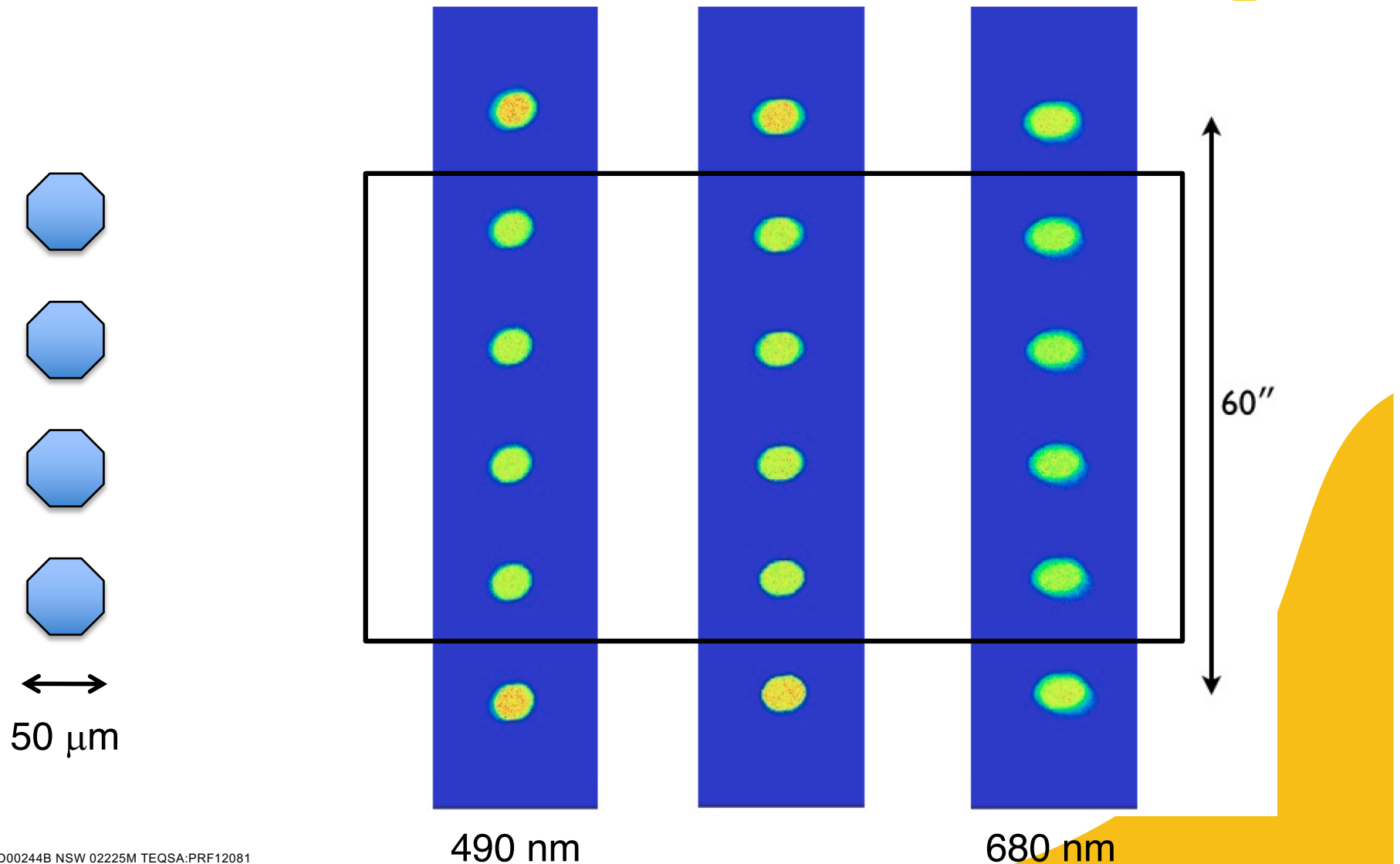
rob.w@usq.edu.au

Backup slides





The optical fibers are stacked at their termination to feed the spectrometer.



The spectrometer is vacuum enclosed to increase instrument stability.

