The Terra Hunting Experiment

A ten-year-long radial velocity survey for terrestrial planets.

Tim Naylor (Exeter), on behalf of the Terra-Hunting consortium.

Who are we?

- Consortium of 10 institutes.

  University of Cambridge, University of Exeter, Geneva University, Instituto de Astrofísica de Canarias, The Netherlands Research School for Astronomy, Uppsala University, Flatiron Institute, Princeton University, Queen's University Belfast, University of Oxford.

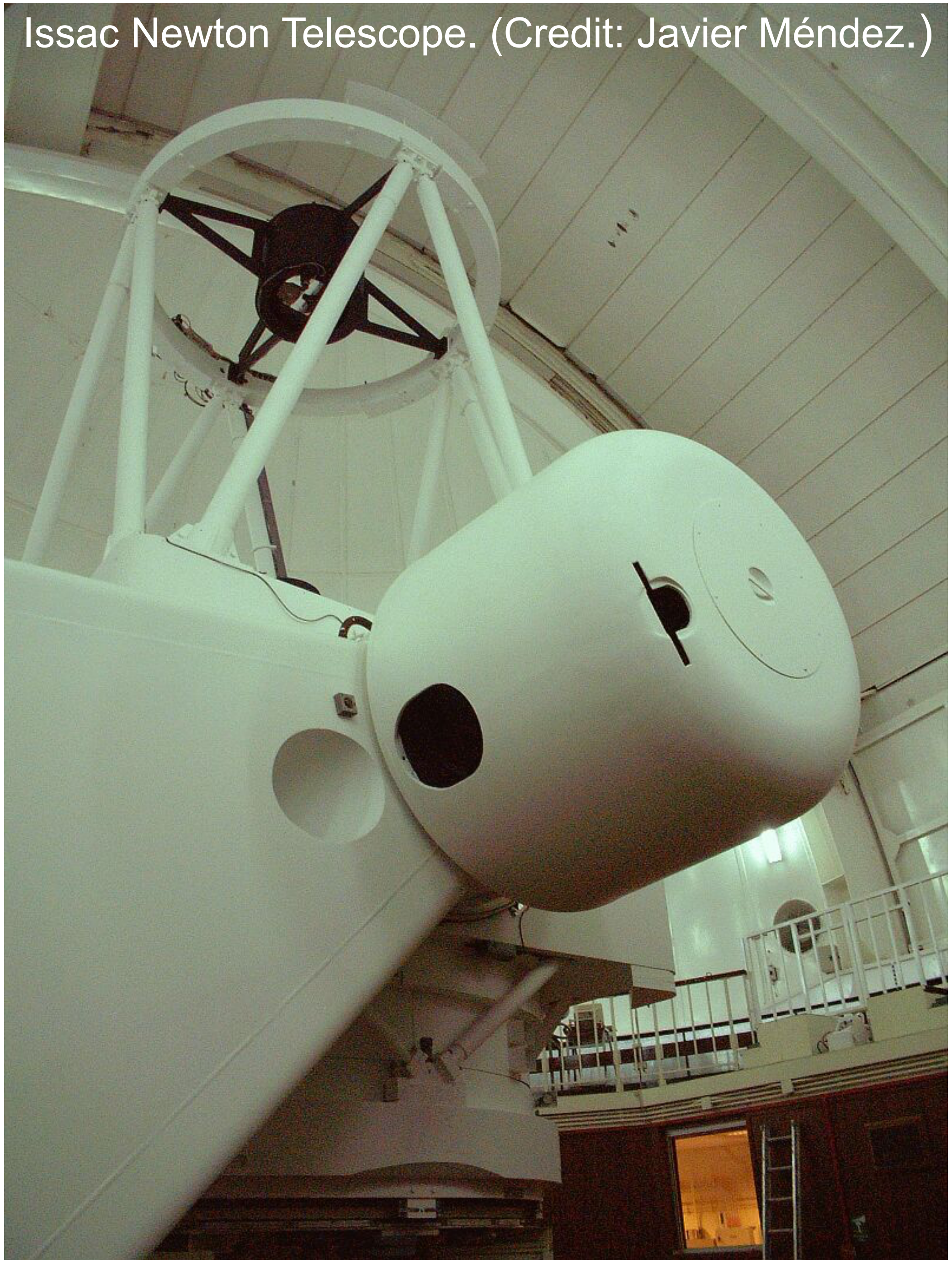
- Isaac Newton Group - La Palma.
- Some funding from STFC and NWO.
- Didier Queloz, Sam Thompson, Annelies Mortier, Carmen Gomez, Cecilia Farina, Chris Watson, Clark Baker, Damien Segransan, Dan Mills, Danuta Sosnowska, David W Hogg, Diego Cano Infantes, Don Carlos Abrams, Ernst de Mooij, Eugene Seneta, Fabio Tenegi Sangines, Francesco Pepe, Frans Snik, George Neal, Ian Hughes, Ian Wellaway, Ignas Snellen, Isabelle Baraffe, Jan Rinze Peterzon, Jan Kragt, John Young, Jonay Gonzalez Hernandez, Josh Winn, José Peñate Castro, Julien Spronck, Manuel Amate Plasencia, Marc Balcells, Martin Fisher, Martyn Brake, Megan Bedell, Michel Fleury, Mike Tacon, Nikolai Piskunov, Patrick Dorval, Peter Kunst, Raine Karjalainen, Ramon Navarro, Raphaelle Haywood, Richard Hall, Rik ter Horst, Roy Preece, Samuel Yee, Suzanne Aigrain, Vinesh Maguire-Rajpaul, Xiaowei Sun.

The Science Goals.

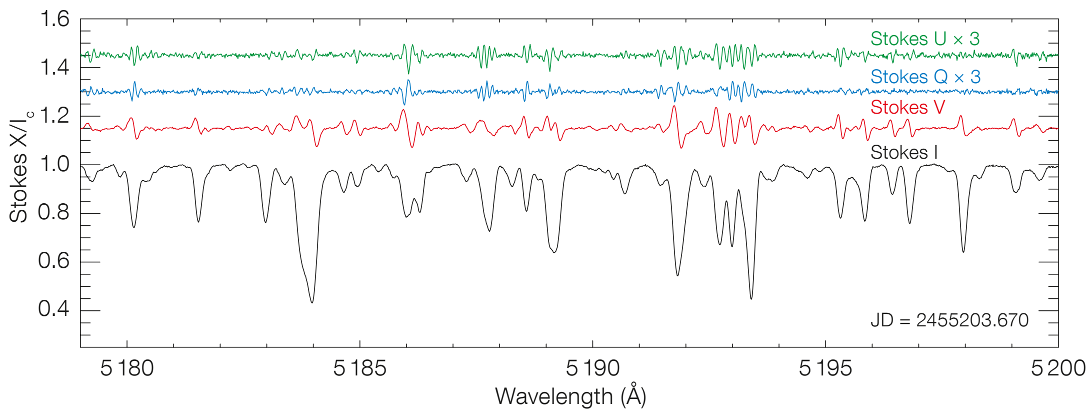
- First Priority - Discover planets that “resemble” Earth.
  - Target G and K dwarfs.
  - Periods of 60 to 300 days.
  - “Earth-mass” requires enough data to detect a reflex semi-amplitude of 10 cm s^{-1}.
- Second Priority - Determine planet occurrence rate.
  - (Within the parameter space defined by the above.)
  - Well defined selection rules.
  - Sample likely small (perhaps 30-50 well-covered stars).
- Deliver data, methods and results to the community.
  - Data releases (including higher-level products).
  - Open about survey design, strategy, scheduling methodologies.

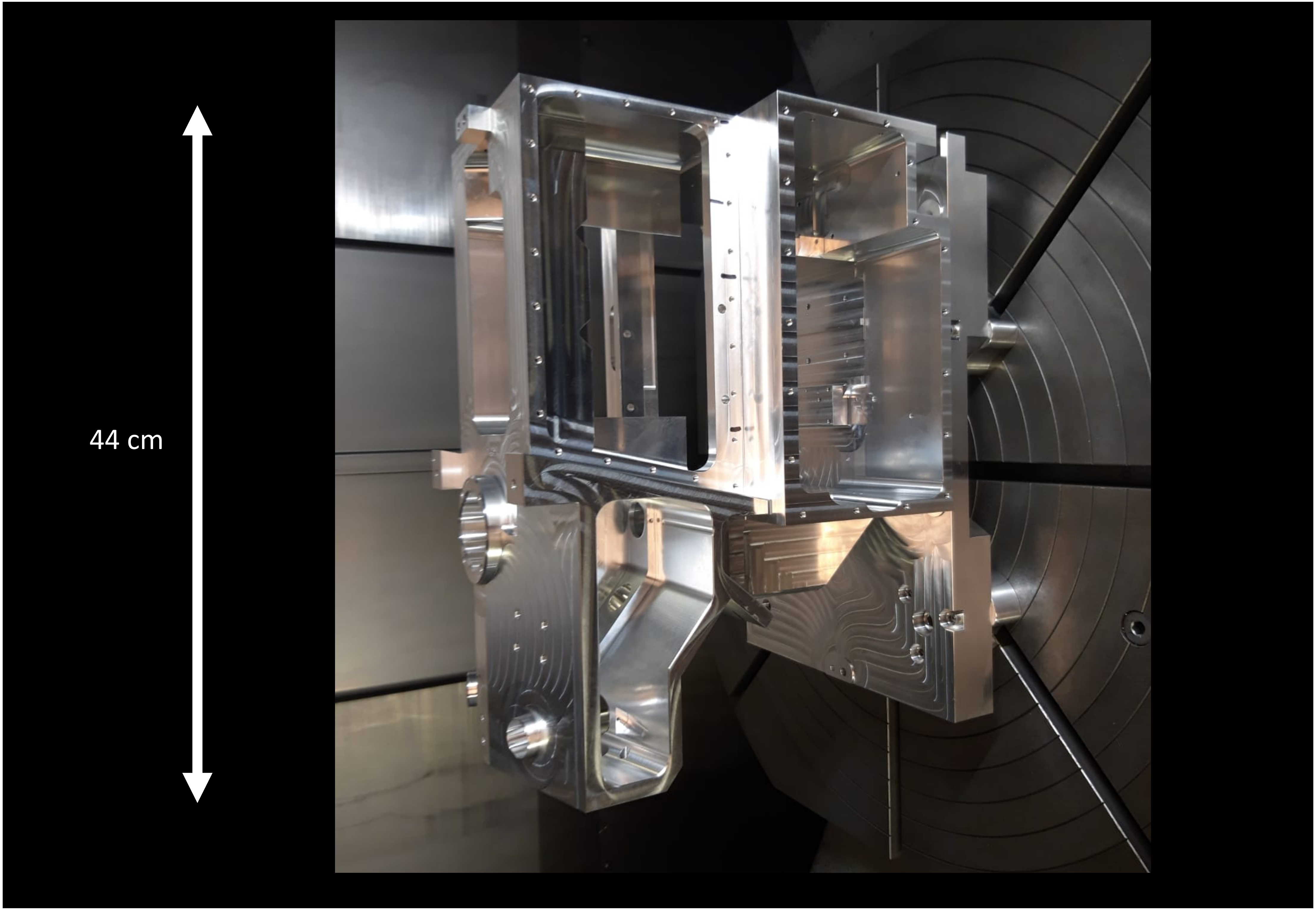
The logic

- The problem is the intrinsic stellar RV variation.
- Working at planetary orbital periods of perhaps 10x stellar rotation period.
- But still need to sample at better than stellar rotation period.
- 10 samples cycle^{-1} => around one observation per night or per every two nights.
- This implies 100-200 observations per year.
- Then need 1000-2000 observations to detect 10 cm s^{-1} signal (Hall et al 2018 – MNRAS 479 2968).
- This implies a 10-year survey. (Which also means you cover at least 5 planetary orbital cycles.)
- Need perhaps 15 minute observations to average out p-modes.
- You can get about 10,000 such observations/telescope-year - fixes sample size at 50-100 targets per telescope-year.
- But you don't need a very big telescope.


Issac Newton Telescope. (Credit: Javier Méndez.)

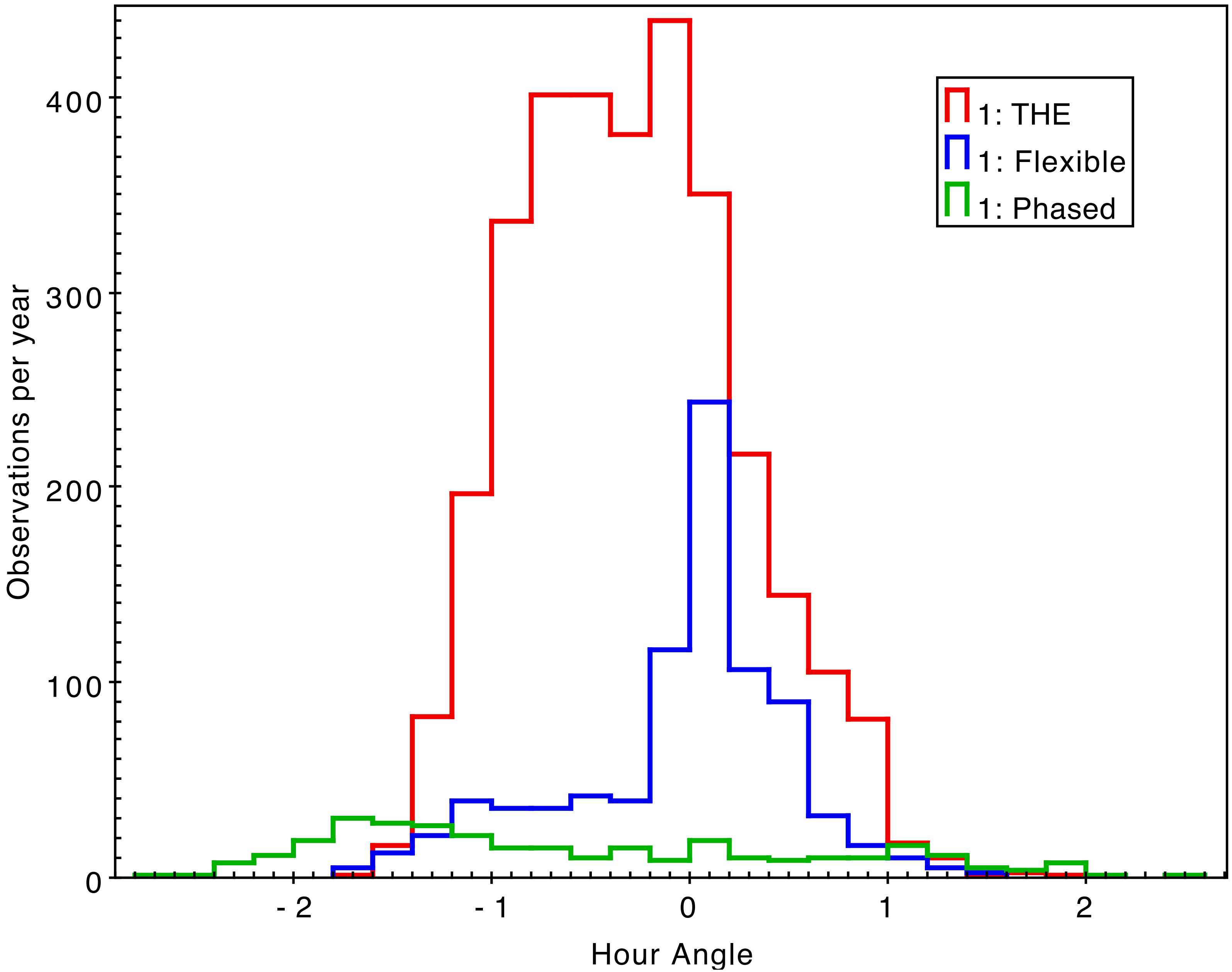

HARPS. (HARPS3 will be a close copy, credit:ESO.)
VESSEL LIFTING POINT
LOADED OR UNLOADED


Stokes U × 3
Stokes Q × 3
Stokes V
Stokes I
JD = 2455203.670
Stokes X/I$_c$
Wavelength (Å)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
5 180
5 185
5 190
5 195
5 200


44 cm

Also-known-as RoboHARPS

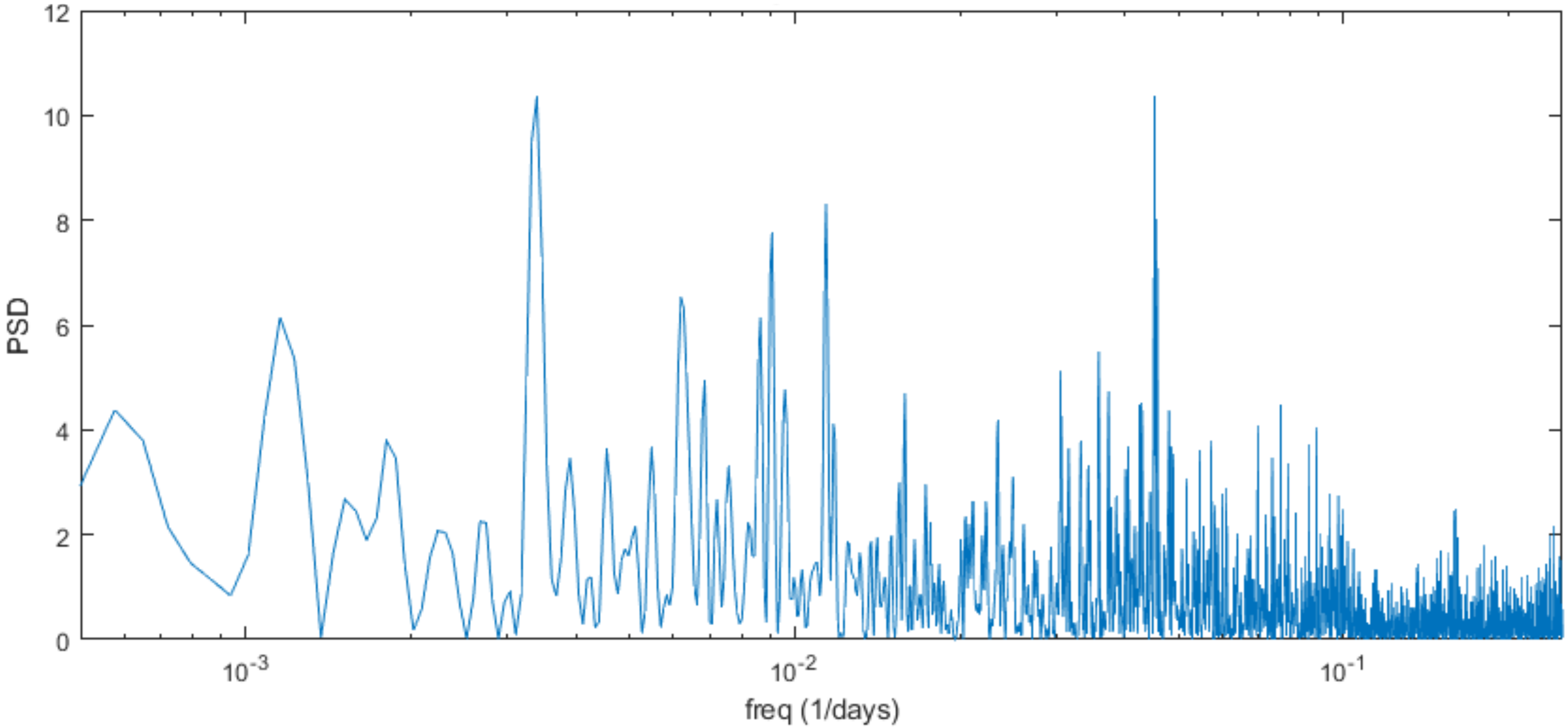
- End-to-end robotic system.
- Mix of THE observations and open time.
- Advantages for both programmes.
  - Monitoring transits.
  - Catch-up from weather outages.
- Automated scheduler.
  - A must - simulate the survey.
  - Good - it removes bias the scheduling.
  - Bad (?) - means you have to define the rules beforehand.



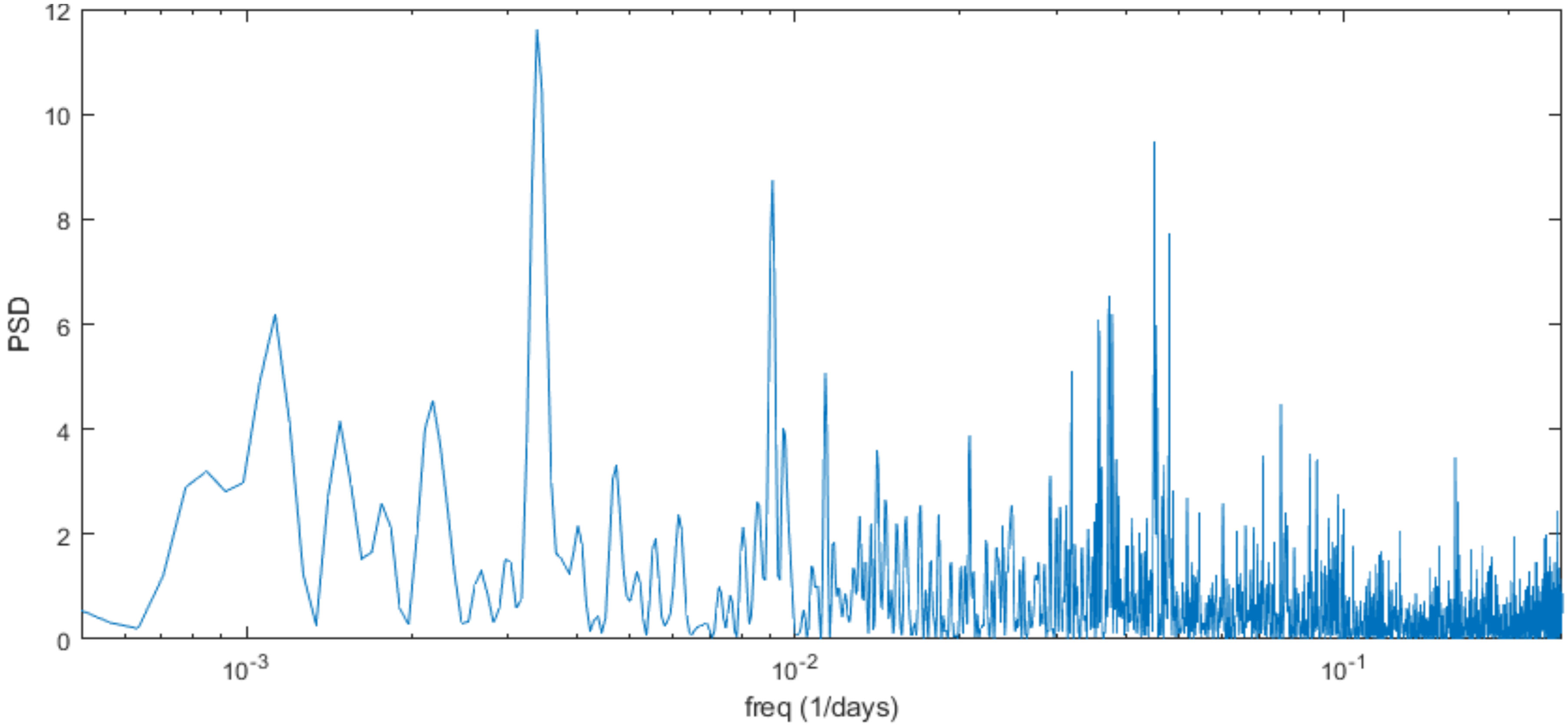
1: THE
1: Flexible
1: Phased
400
300
200
100
0
- 2
- 1
0
1
2
Observations per year
Hour Angle

An object Season.

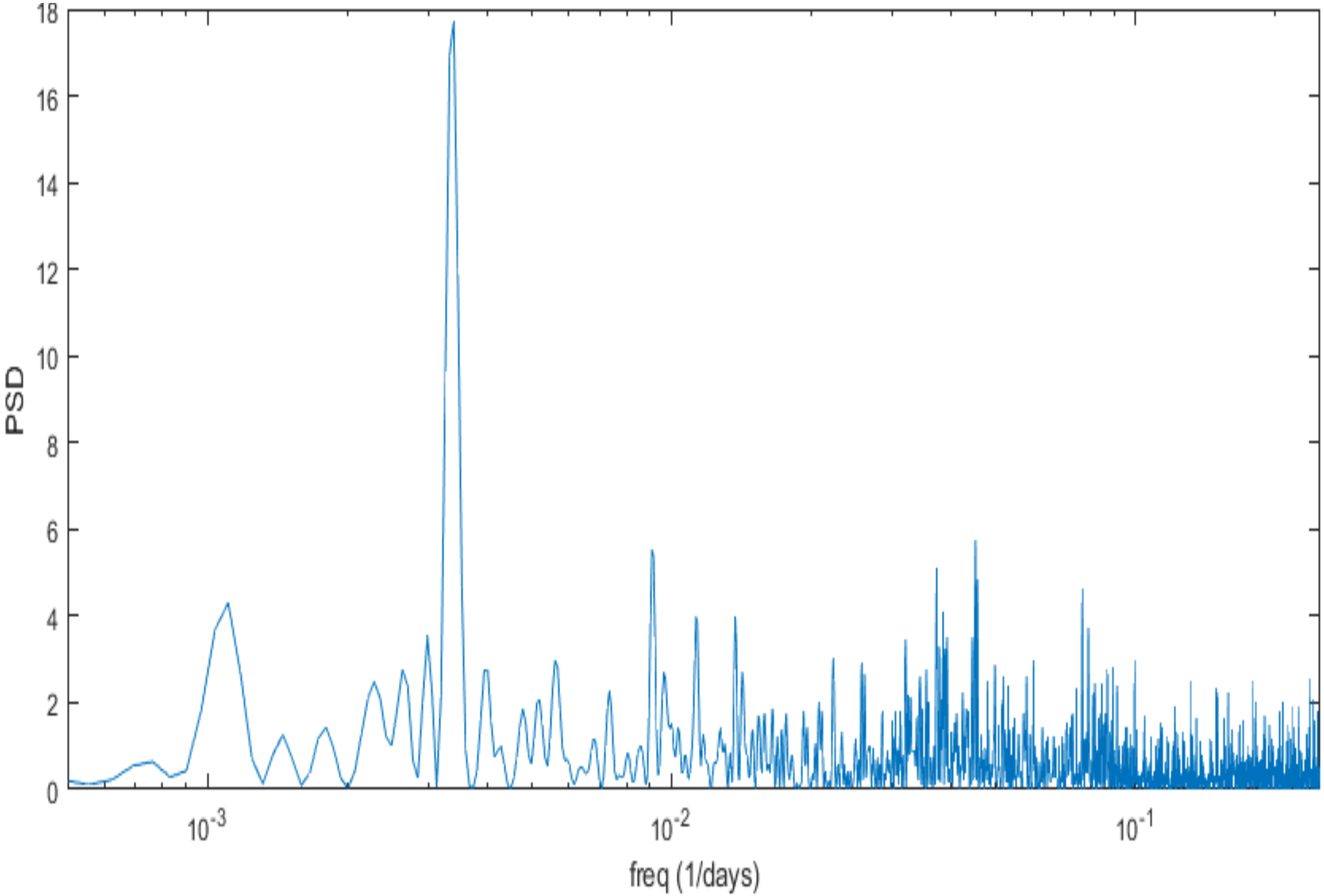
- Traditional object season is < 6 months, but P might be 293 days.
- 180 observations in 180 nights × 10 years (Sam Thompson, based on Hall et al 2018).

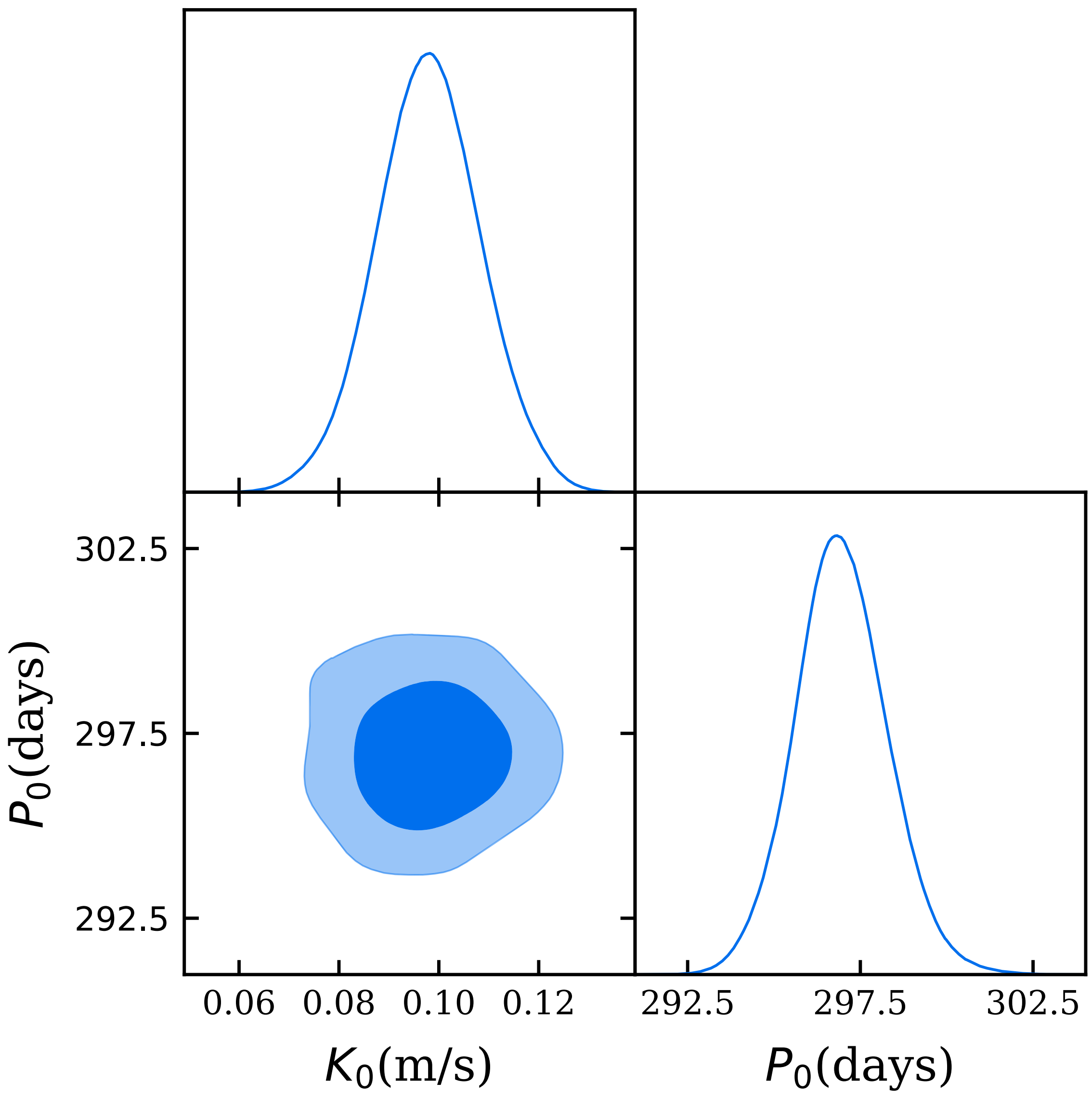


- Traditional object season is < 6 months, but P might be 293 days.
- 180 observations in 260 nights × 10 years (Sam Thompson, based on Hall et al 2018).



- 180 observations in 320 nights × 10 years - achievable for δ=+60 “summer” targets
- Have to scrape them off horizon at start/end of season.





302.5
297.5
292.5
P_0(days)
0.06
0.08
0.10
0.12
K_0(m/s)
292.5
297.5
302.5
P_0(days)

Summary

- A 10 year RV survey covering perhaps 30-50 objects.
- Around 200 observations per season.
- Uses the 2.5-m Isaac Newton Telescope on La Palma.
- Plus HARPS3 (close copy of HARPS and HARPS-N).
- Plus spectropolarimeter.
- Targeting 10 cm s^{-1} accuracy and precision.
    - Hence designing programme around mitigating stellar noise.
- On sky in 2022?