HARPS3 and opportunities for RV follow-up of PLATO targets

Presenter: Clark Baker (ceb234@cam.ac.uk), University of Cambridge.

Consortium of 11 Institutions: University of Cambridge, University of Exeter, Geneva University, Institute of Astrophysics of the Canaries, The Netherlands Research School for Astronomy, Uppsala University, Flatiron Institute, Princeton University, Queen's University Belfast, University of Oxford and University of Warwick.

Isaac Newton Group.

PI of the project: Prof. Didier Queloz, Project manager: Dr. Samantha Thompson, PI of Science Team: Prof. Tim Naylor.

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  - *50% Open Time.*
  - *Automated Scheduler.*

Why are we building HARPS3?

Terra Hunting Experiment

Primary Science Goal: - To find the RV Signal of an "Earth-twin"

- Target G and K dwarfs.
- RV Semi-amplitude K = 10 cm/s.
- Signals of 60 to 400 days.

Achieved by Optimised and Intensive Observing Strategy:

- 10 year, nightly, observation program to enable the detection of K = 10 cm/s signals (Hall et al. (2018), MNRAS 479 2968).
- Targets observed every (other) night, 1000+ measurements per star, to combat intrinsic stellar RV variations and overcome aliasing.
- >20 (perhaps 30-50) targets with Gmag < 7.5.

HARPS3

- Close-copy of HARPS/HARPS-N (proven <60cm/s long term stability).

- Stable, fibre-fed, high-resolution spectrograph (R = 115,000, λ range 380 – 690 nm).

- Number of iterations for improved stability performance (→10cm/s).
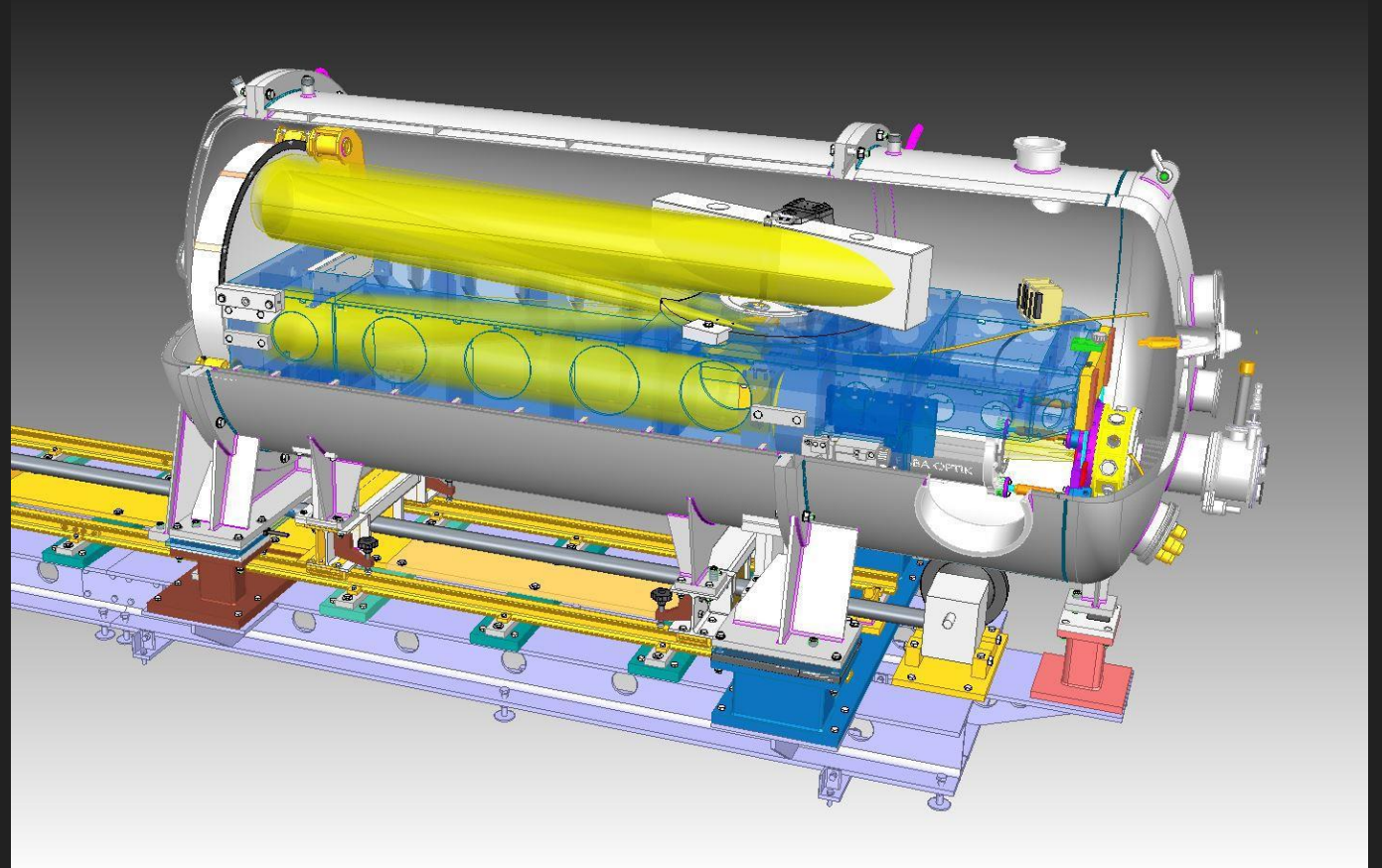
HARPS-N. Picture courtesy of Observatoire de l'Université de Genève.

Roboticised INT

The 2.54m Isaac Newton Telescope (INT) in La Palma, Canary Islands.

- Refurbished and roboticised to facilitate efficient and optimised collection of data.

- Nightly access for 10 years (~50% time per night on average).

- Fibre at Cassegrain focus (1.4" on-sky).

- Dedicated Coudé room (shorter fibre, improved blue efficiency).
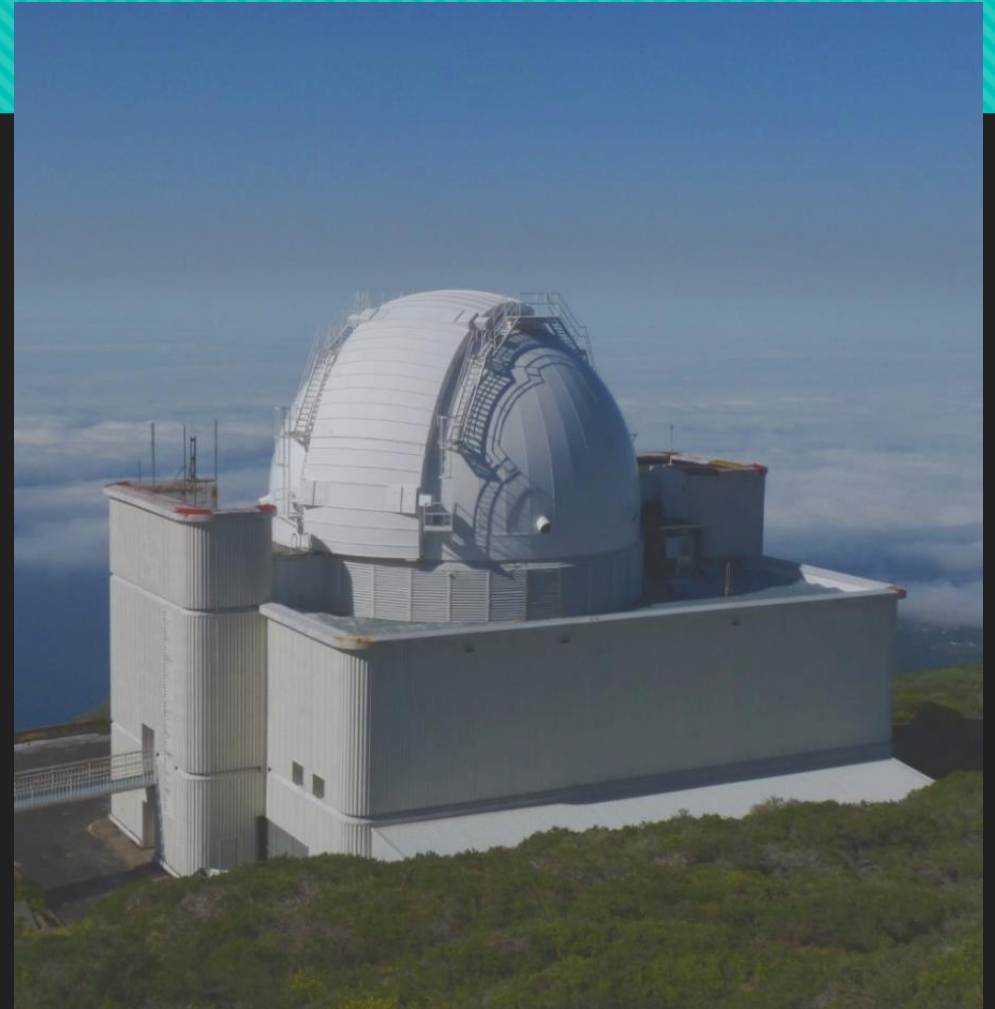
HARPS3 Stability

- A robust scrambling solution - octagonal fibres, double scramblers and a fine pointing system with 0.05" RMS accuracy over the length of an exposure.

- Echelle grating substrate is Zerodur Class 0 SPECIAL: CTE $0\pm0.010 \times 10^{-6}$ ppm/K and has been aged to minimise drift.

- Nested active thermal enclosure system: stable to 0.01K. This houses the vacuum vessel: internal pressure of 5×10^{-3} mbar.

- Full suite of environmental sensors: pressure sensors, accelerometers and temperature sensors near key components → Characterise effects.

- Miniaturised ESPRESSO CCD cryostat design: 1 mK RMS stability with a vacuum pressure of 2×10^{-6} mbar.
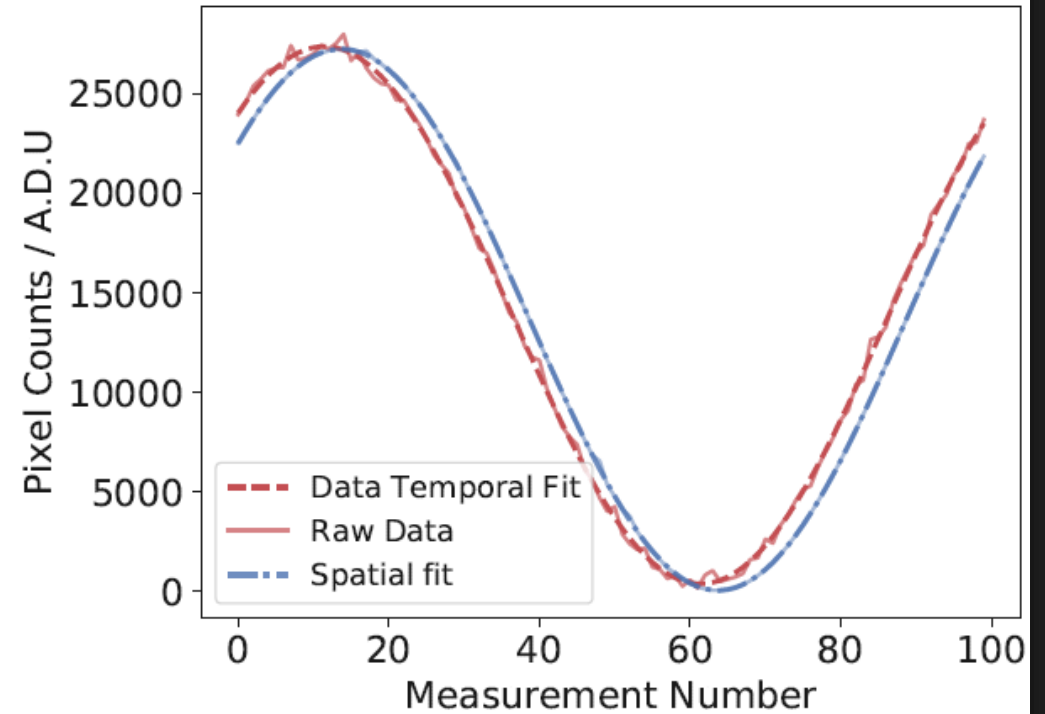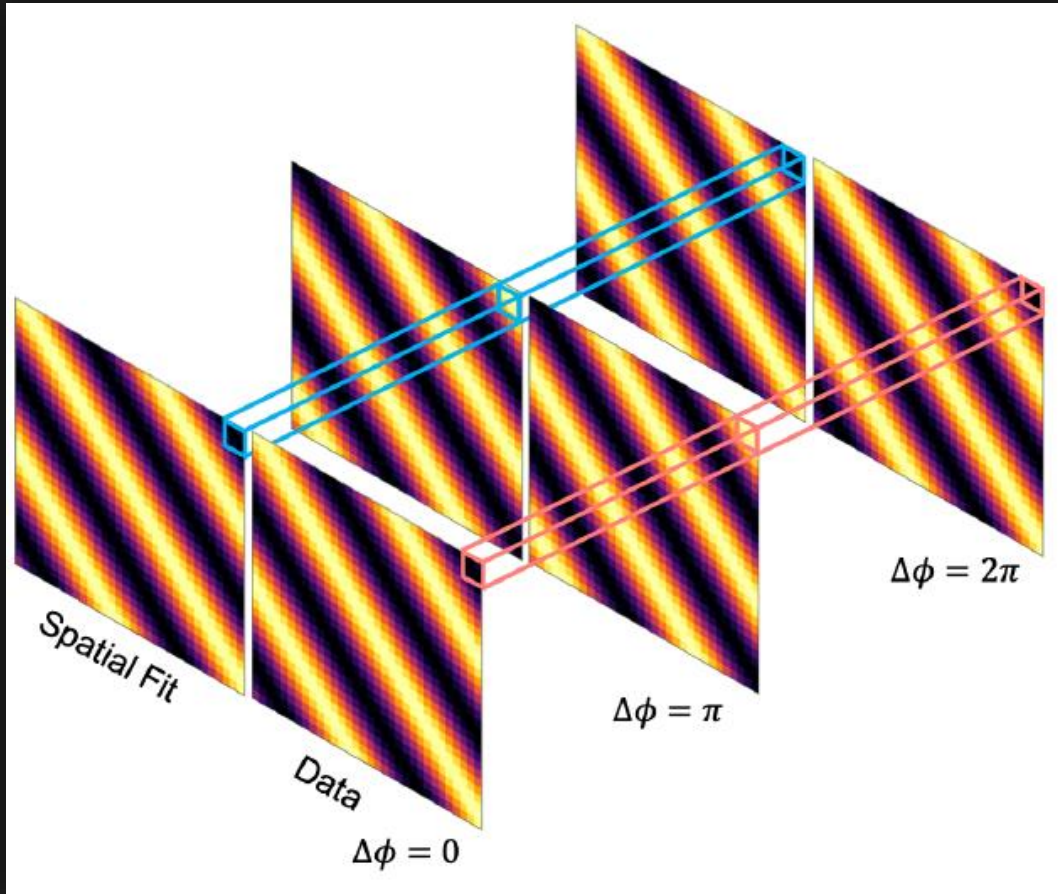

HARPS3 Vacuum Vessel.

→ CCD Characterisation.

CCD Mapping

e2V chip: CCD231 84 0 G57

R. Hall et al. (2016), Proc. SPIE 991525

Further Features of HARPS3@INT

- Full Stokes, dual beam polarimeter → stellar activity.

- Calibration unit with 8 slots: ThAr lamp (+spare), UrNe lamp, Halogen lamp (+spare), Fabry Perot etalon.

- Under development, laser frequency comb (1-2cm/s RV accuracy, covering a broadband (380nm-690nm) wavelength range).
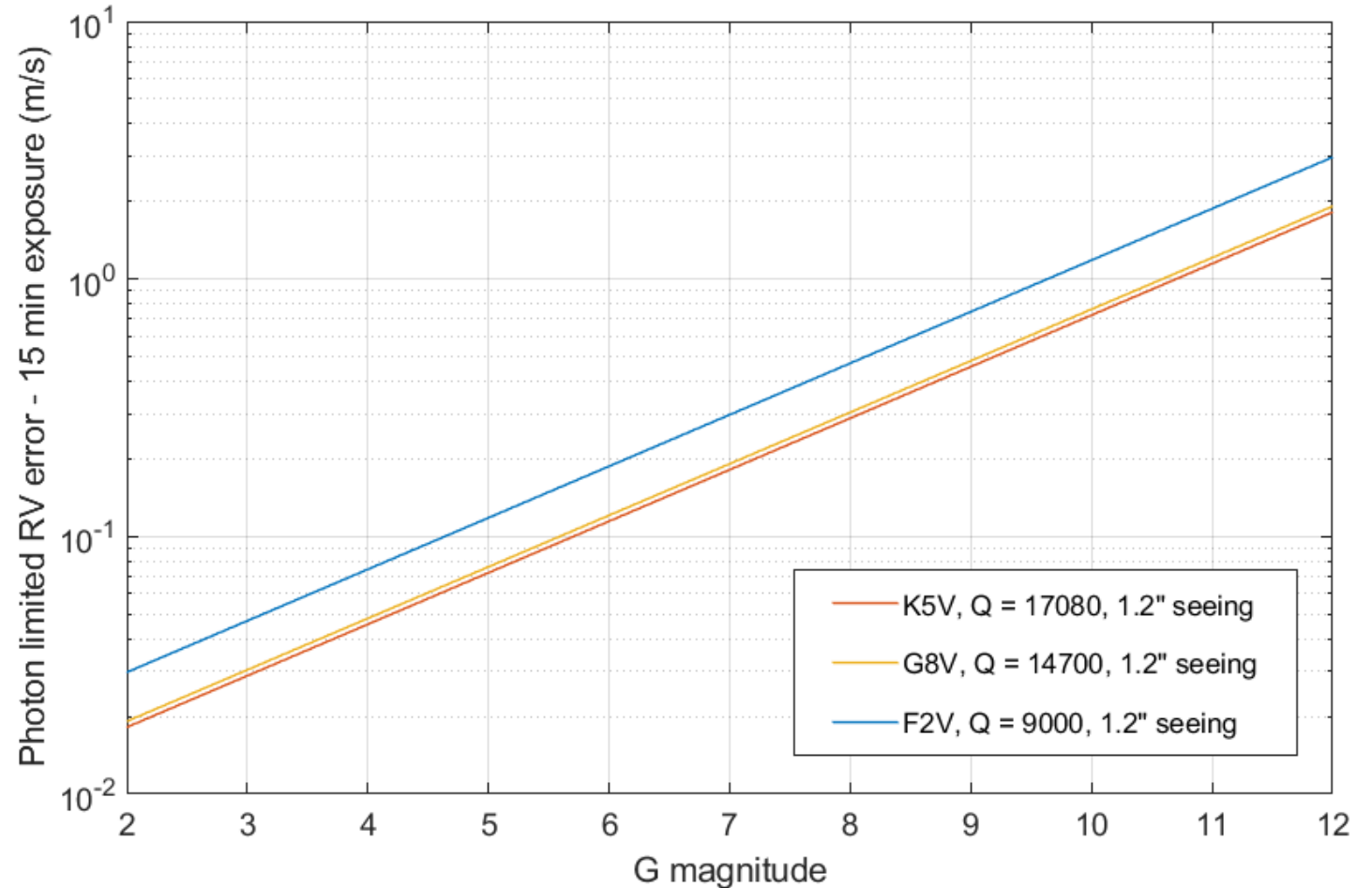
- In design, Solar telescope with polarization capability.
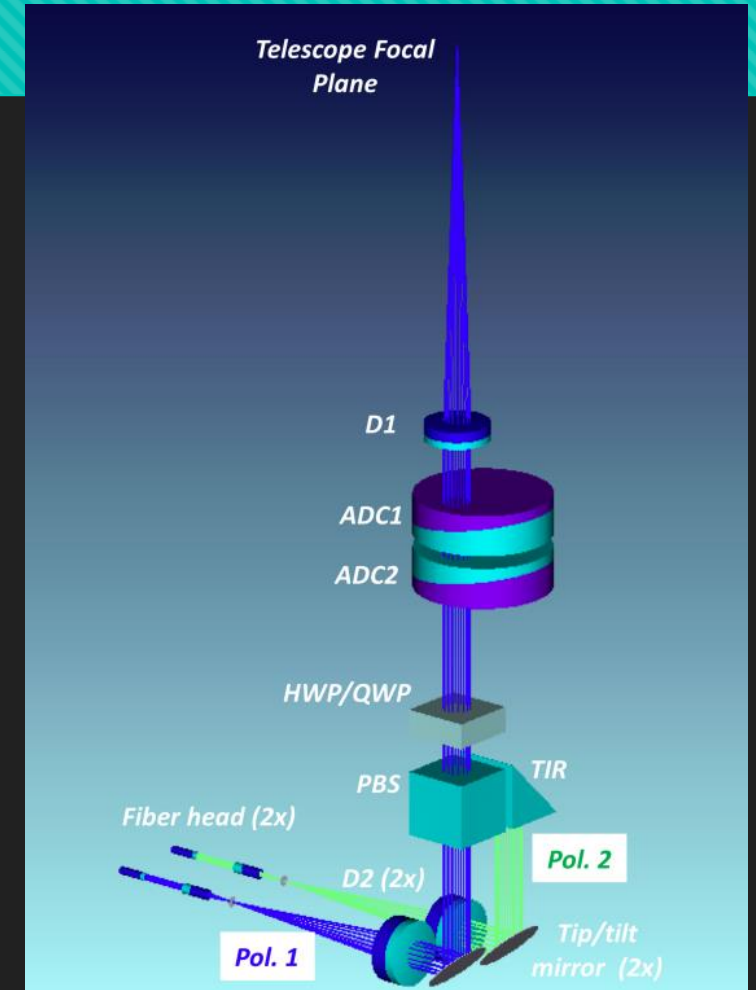
Polarimeter integrated into the Cassegrain adapter.

S. J. Thompson et al. (2016), Proc. SPIE 99086F

Expected Performance and Observation Opportunities

Expected Performance

- Predicted <u>efficiency</u> of HARPS 3 (not considering slit efficiency) averages at **10%** (5% at 380nm, 13% at 550nm).

- Short term <u>instrumental error</u> is expected to be <**10cm/s** - instrument's sensor suite and calibration strategy will allow the tracking of systematics and long-term drift.

- Predicted that HARPS3@INT will have a <u>photon limited RV error</u> of **0.25m/s** for a 15 minute exposure of a G=7.5 G8V star in 1.2'' seeing conditions.

Legend: K5V, Q = 17080, 1.2" seeing; G8V, Q = 14700, 1.2" seeing; F2V, Q = 9000, 1.2" seeing

Terra Hunting Experiment: Survey Strategy and Design, S. J. Thompson et al. (in prep).

Opportunities for follow-up of PLATO Targets

- Approximately **50% open-time** is expected to be available on HARPS3.

- Automated scheduler: enable the **flexible** scheduling of observations that will be interleaved with the rest of the night's observations, enabling **efficient** observing strategies that maximise the use of an observers allocated telescope time.

- Trusted and proven data-reduction pipeline, adapted from the ESPRESSO pipeline, for **straightforward** and **reliable extraction** of radial velocity data.

Conclusions

First light expected in **2023**.