

Exoplanets

Lecture 09
MFF UK
28 November 2025

Outline

- PLATOSPec
- Future missions and instruments



Ground-based support
for exoplanetary
space missions.

<https://stelweb.asu.cas.cz/plato/index.html>

PLATO searching for another Earth

New ESA mission
will launch in 2026

PLATO will provide
the key information on planets
(planet radii, mean densities,
stellar irradiation, and architecture
of planetary systems) needed to
determine habitability

The satellite will have 26 onboard
telescopes to observe thousands
of stars and changes in light caused
by orbiting planets.

The satellite is kept
in stable position
as it follows the earth's
orbit around the sun

Sun

150 million km

Earth

Moon

1.5 million km

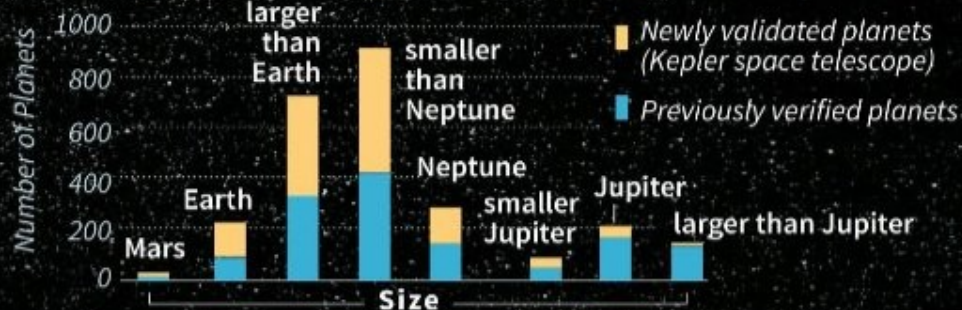
Known planets orbiting
stars like our Sun

Planet sizes in our Solar system

Mars Earth

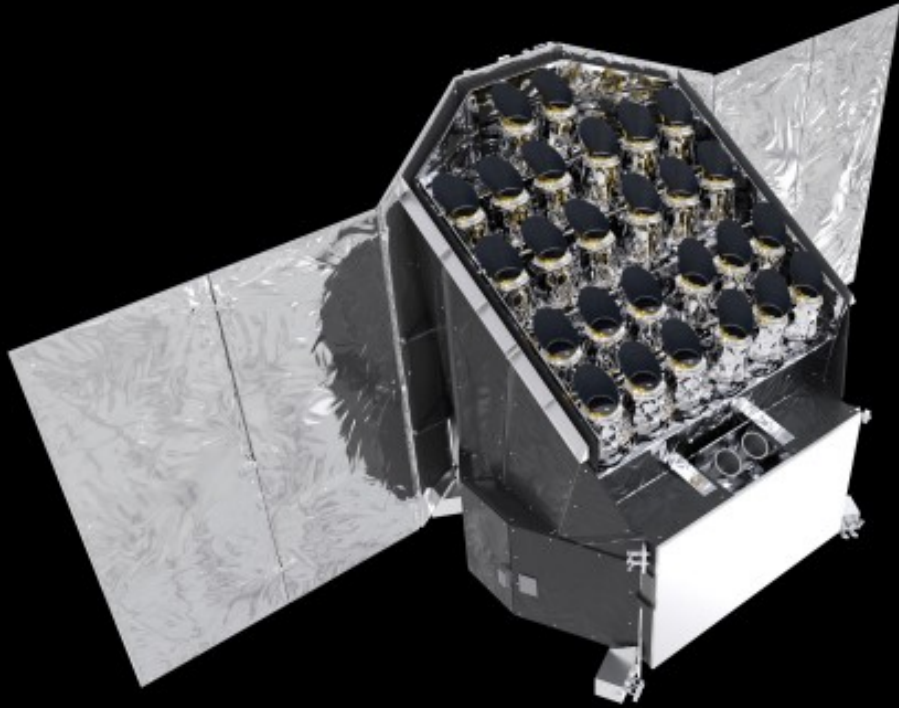
Neptune

Jupiter



Will join NASA's
Kepler space
telescope in the hunt
for earth-like planets

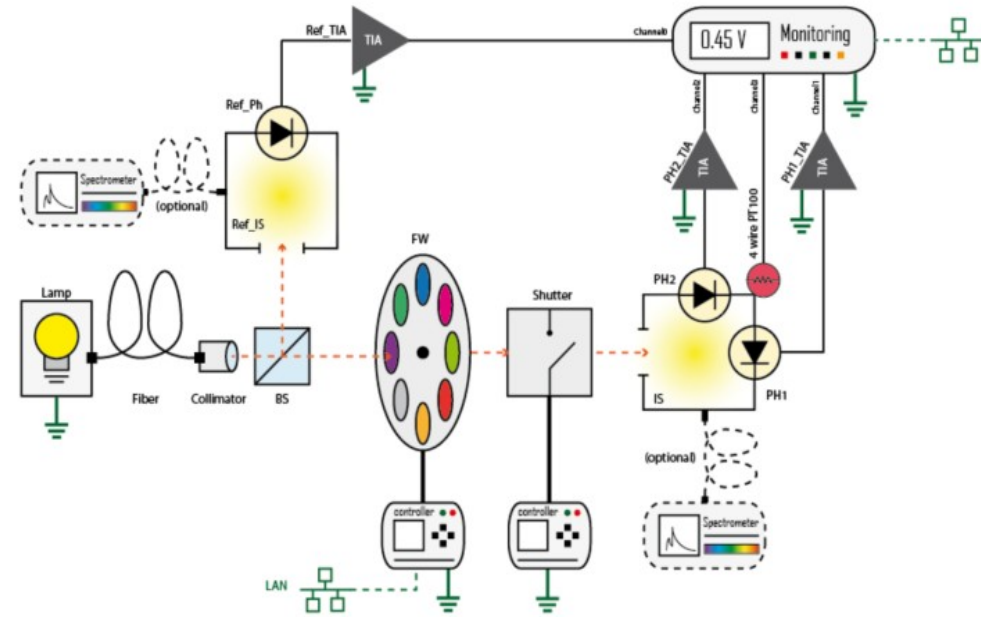
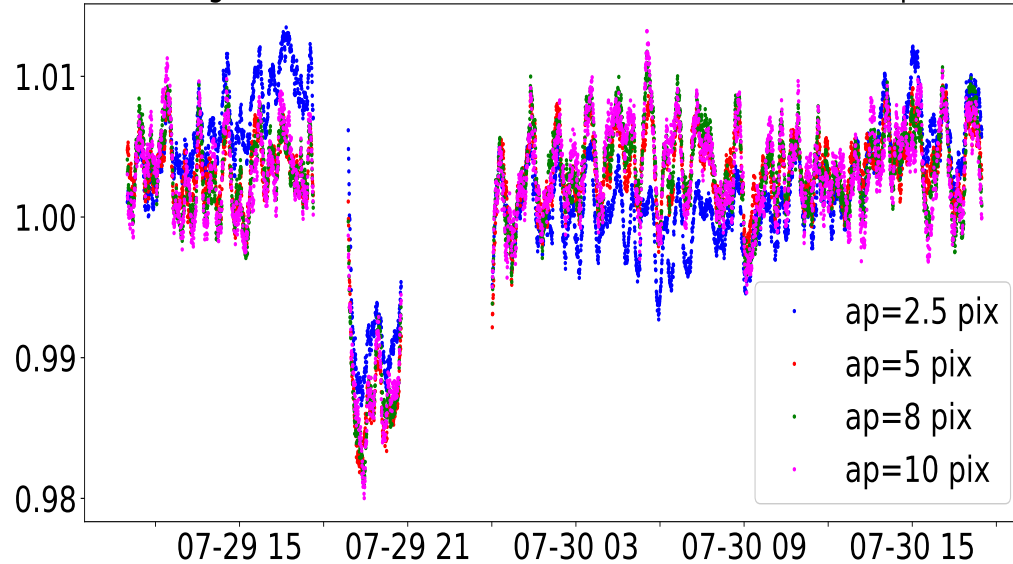
Czech participation in PLATO



Containers and service module chassis delivered by SAB Aerospace,
test CCDs delivered by Moaravian Instruments

Czech participation in PLATO

Running mean of normalized corrected flux from small spot n.2



Jiří Žák, Marek Skarka, Marie Karjalainen

PLATO 2025



PLATO 2025

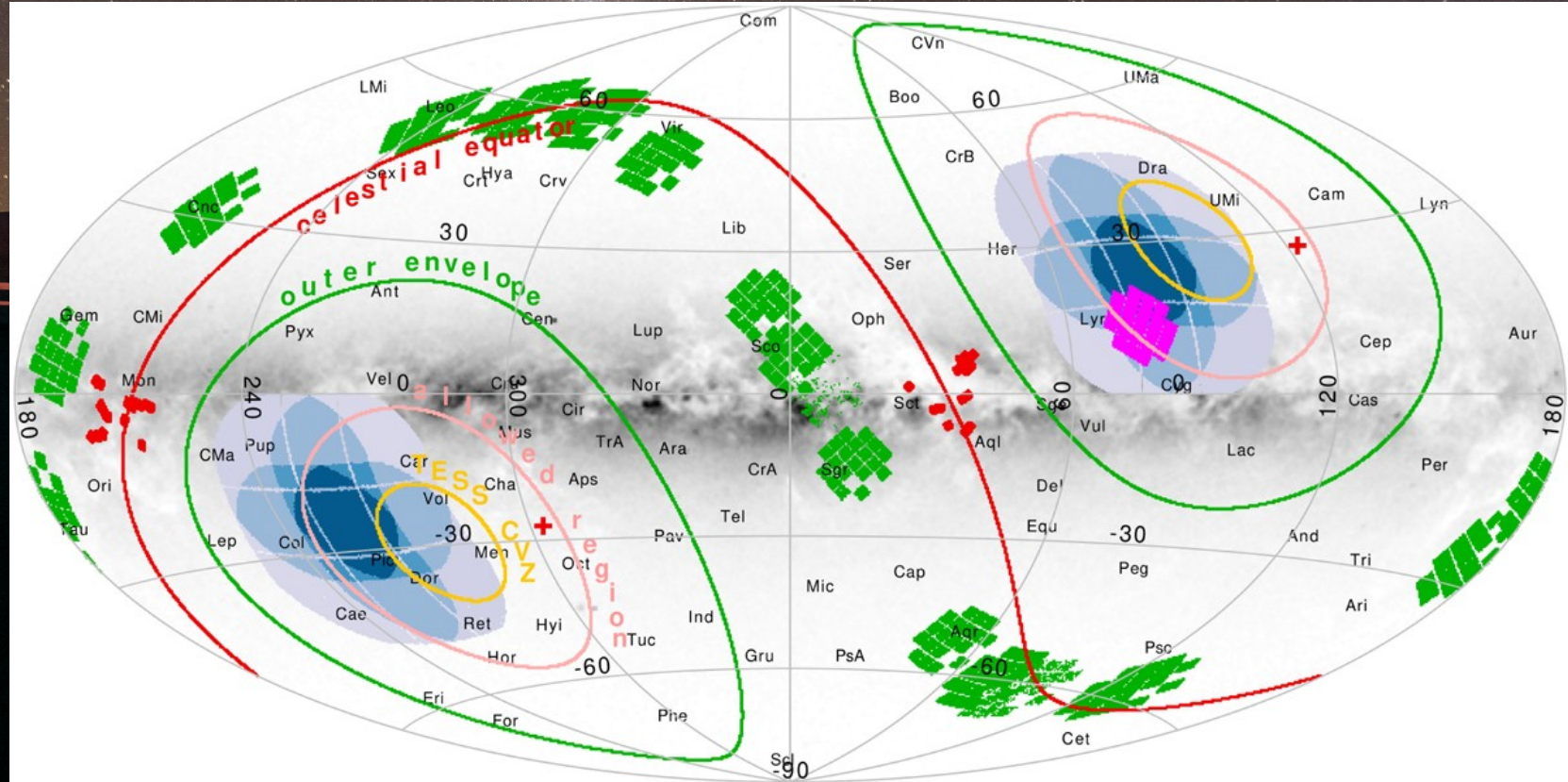


<https://platomission.com/2019/06/03/plato-lego-model/>

PLATO LOPS2 (what`s in?)

The PLATO field selection process - II. Characterization of LOPS2, the first long-pointing field

V. Nascimbeni,Â G. Piotto,Â J. Cabrera,Â M. Montalto,Â S. Marinoni,Â P. M. Marrese,Â C. Aerts,Â G. Altavilla,Â S. Benatti,Â A. BÄ¶tmer,Â M. Deleuil,Â S. Desidera,Â L. Gizon,Â J. Goupil,Â V. Granata,Â A. M. Heras,Â D. Magrin,Â L. Malavolta,Â J. M. Mas-Hesse,Â H. P. Osborn,Â I. Pagano,Â C. Paproth,Â D. Pollacco,Â L. Prisinzano,Â R. Ragazzoni,Â Ramsay,Â H. Rauer,Â A. TkachenkoÂ andÂ S. UdryA&A, 694 (2025) A313DOI: <https://doi.org/10.1051/0004-6361/202452325>



LOPS2

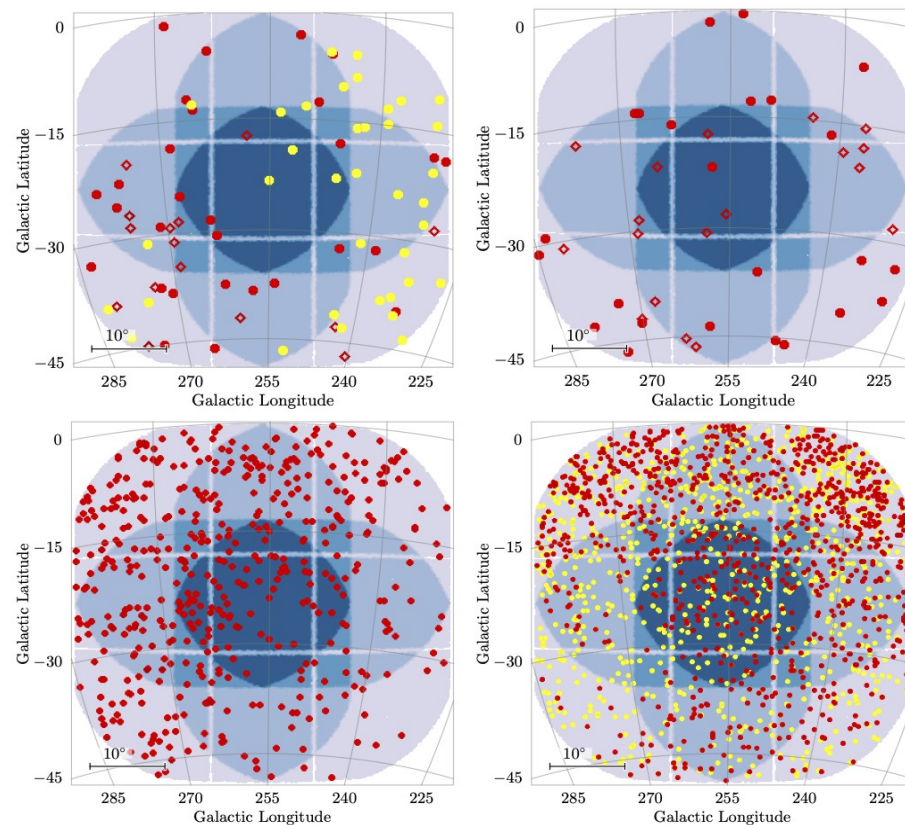
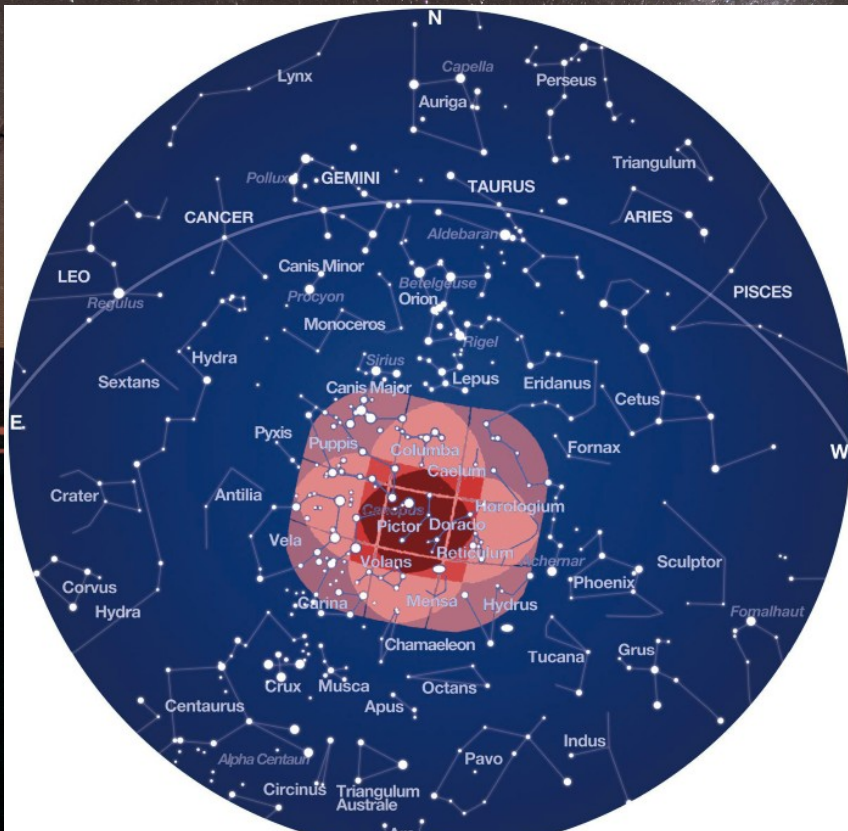


Figure 12. Top Left: Stars hosting at least one transiting planet in the LOPS2 field. Planets detected by *TESS* are coloured red, Planets detected by other ground-based facilities are yellow. Multiplanetary systems are marked with a diamond, single planet systems with a circle. Top Right: Stars hosting planets detected by radial velocity in the LOPS2 field. Stars with only one detected planet are marked with a circle, stars hosting more than one confirmed planet are marked with a diamond. Bottom Left: *TESS* planet candidates (TFOPWG Disposition 'PC') in the LOPS2 field. Bottom Right: Eclipsing binaries in the PIC. Eclipsing binaries found by *TESS* (Prapontnik Brdnik et al. 2025, in prep) are marked in red, eclipsing binaries flagged by GAIA's NSS flag (Mowlavi et al. 2023) (NSSflag=4 in PIC) are marked yellow.

α [hms]

06:21:14.5

ICRS (

δ [dms]

-47:53:13

ICRS (

LOPS2 – TESS & PLATO

Host Star	# Planets	VMag	R _S (R _⊙)	M _S (M _⊙)	Teff (K)	TESS Sectors	PLATO Cameras	Paper
GJ 163	3	11.79	0.4	0.4	3500	5	12	Bonfils et al. (2013)
HD 25912	2	8.2	1.0	1.1	5921	5	12	Feng et al. (2022)
HD 27894	3	9.36	0.9	0.8	4875	29	6	Moutou et al. (2005) ; Trifonov et al. (2017)
HD 30177	2	8.41	1.0	1.0	5580	34	12	Tinney et al. (2003) ; Wittenmyer et al. (2017)
HD 39194	3	8.09	0.8	0.7	5205	42	6	Unger et al. (2021)
HD 40307	5	7.17	0.7	0.8	4956	40	6	Mayor et al. (2009) ; Tuomi et al. (2013)
HD 41004 A	2	8.65	0.8	1.0	5310	7	24	Zucker et al. (2004)
HD 41004 B	2	8.61	1.0	0.4	5036	7	-	Zucker et al. (2003)
HD 43197	2	8.98	1.0	1.0	5508	3	12	Naef et al. (2010) ; Feng et al. (2022)
HD 45184	2	6.38	1.1	1.0	5869	3	12	Udry et al. (2019)
HD 45364	2	8.08	0.9	0.8	5466	3	12	Correia et al. (2009)
HD 47186	2	7.63	1.1	1.0	5657	4	6	Bouchy et al. (2009)
HD 50499	2	7.21	1.4	1.2	6102	6	12	Vogt et al. (2005) ; Rickman et al. (2019)
HD 51608	2	8.17	0.9	0.8	5358	29	24	Udry et al. (2019)
HD 65216	2	7.97	0.9	0.9	5612	37	12	Mayor et al. (2004) ; Wittenmyer et al. (2013)
TOI-1338 A	2	11.72	1.3	1.1	6050	41	18	Kostov et al. (2020) ; Standing et al. (2023)
TOI-431	3	9.12	0.7	0.8	4850	3	6	Osborn et al. (2021)
TOI-500	4	10.54	0.7	0.7	4440	9	24	Giacalone et al. (2022a) ; Serrano et al. (2022)
bet Pic	2	3.85	2.0	1.8	7890	9	-	Lagrange et al. (2009, 2019)

Table A5. Confirmed multiplanetary systems in the LOPS2 field with at least one planet that has only been detected through radial velocity. Stellar parameters and the planet radius and the orbital period of each confirmed planet are obtained from the Exoplanet Archive ([NASA Exoplanet Archive 2024](#), accessed on 24. May 2024) and the number of *PLATO* cameras the stars will be observed with are obtained from the LOPS2 PIC. For planets that are currently not in the LOPS2 PIC the number of cameras is marked with a minus.

PLATO LOPS2 (what`s in?)

The PLATO field selection process - II. Characterization of LOPS2, the first long-pointing field

V. Nascimbeni, G. Piotto, J. Cabrera, M. Montalto, S. Marinoni, P. M. Marrese, C. Aerts, G. Altavilla, S. Benatti, A. BÅrmer, M. Deleuil, S. Desidera, L. Gizon, J. Goupil, V. Granata, A. M. Heras, D. Magrin, L. Malavolta, J. M. Mas-Hesse, H. P. Osborn, I. Pagano, C. Paproth, D. Pollacco, L. Prisinzano, R. Ragazzoni, Ramsay, H. Rauer, A. Tkachenko and S. Udry A&A, 694 (2025) A313 DOI: <https://doi.org/10.1051/0004-6361/202452325>

8235 P1 targets, that is, FGK dwarfs and subgiants with NSR ≤ 50 ppm in one hour and $V_{\text{mag}} < 11$;

699 P2 targets, that is, FGK dwarfs and subgiants with NSR ≤ 50 ppm in one hour and $V_{\text{mag}} < 8.5$;

12 415 P4 targets, that is, M dwarfs with $V_{\text{mag}} < 16$;

167 149 P5 targets, that is, FGK dwarfs and subgiants with $V_{\text{mag}} < 13$.

The total sample of available targets in LOPS2 is therefore 179 564 FGKM stars

PLATO LOPS2

47 hot Jupiters (HJ; $R_p > 6 R_\oplus$, $P < 10$ d). This sub-sample is unlikely to increase significantly in the future, given the almost perfect sensitivity of TESS and the existing groundbased surveys in this region of the parameter space. Notably, there are three ultra-hot Jupiters (UHJs; $T_{eq} > 2200$ K): WASP-121b (Delrez et al. 2016), KELT-25b (Rodríguez Martínez et al. 2020), and the already mentioned HATS-70b. WASP-121b is of particular interest since it spawned an impressively vast literature on its atmospheric characterization, including the study of its optical phase curve (Bourrier et al. 2020; Daylan et al. 2021) and claims of temporal variability as well (Wilson et al. 2021);

14 warm or cool Jupiters (WJ/CJ; $R_p > 6 R_\oplus$, $P > 10$ d), eight of them on orbital periods longer than 50 d. The longest period planet of our whole LOPS2 sample belongs to this sample: TOI-4562b, a temperate Jupiter analog on a $P \approx 225$ d orbit (Heitzmann et al. 2023) recently claimed to show TTVs by Fermiano et al. (2024);

24 Neptunians and mini-Neptunes ($1.7 R_\oplus < R_p < 6 R_\oplus$), including at least one planet undoubtedly within the “hot Neptune” desert (Mazeh et al. 2016; gray area in Fig. 8): NGTS-4b (West et al. 2019) plus two other more marginally so (TOI-451b, TOI-269b);

23 rocky planets ($R_p < 1.7 R_\oplus$), including four ultra shortperiod ones (USP; $P \leq 1$ d): TOI-206b ($P = 0.74$ d; Giacalone et al. 2022), LHS 1678b ($P = 0.86$ d; Silverstein et al. 2024), TOI-431b ($P = 0.49$ d; Osborn et al. 2021) and TOI-500b ($P = 0.55$ d; Serrano et al. 2022). The latter will be observed close to the center of LOPS2 through 24 NCAMs, so PLATO will be able to gather at least ~ 1300 full phase curves at NSR ≈ 33 ppm in one hour.

PLATO LOPS2

7787 eclipsing binaries (including 3017/2155 with explicit detached/contact-type classification);

6111 long-period variables (LPV);

268 gamma Cassiopeiae stars;

185 chemically peculiar stars;

47 cataclysmic variables (CV);

700 delta Scuti pulsators;

651 Cepheids and 699 RR Lyr;

29 slowly pulsating B stars (SPB);

17 beta Cephei stars (BCEP);

Seven gamma Doradus stars (GDOR).

How many do we find?

Estimated yield of planets with $0.5 R_{\oplus} \leq R_p \leq 1.5 R_{\oplus}$ in the HZs around Sun-like stars from PLATO's P1 sample.

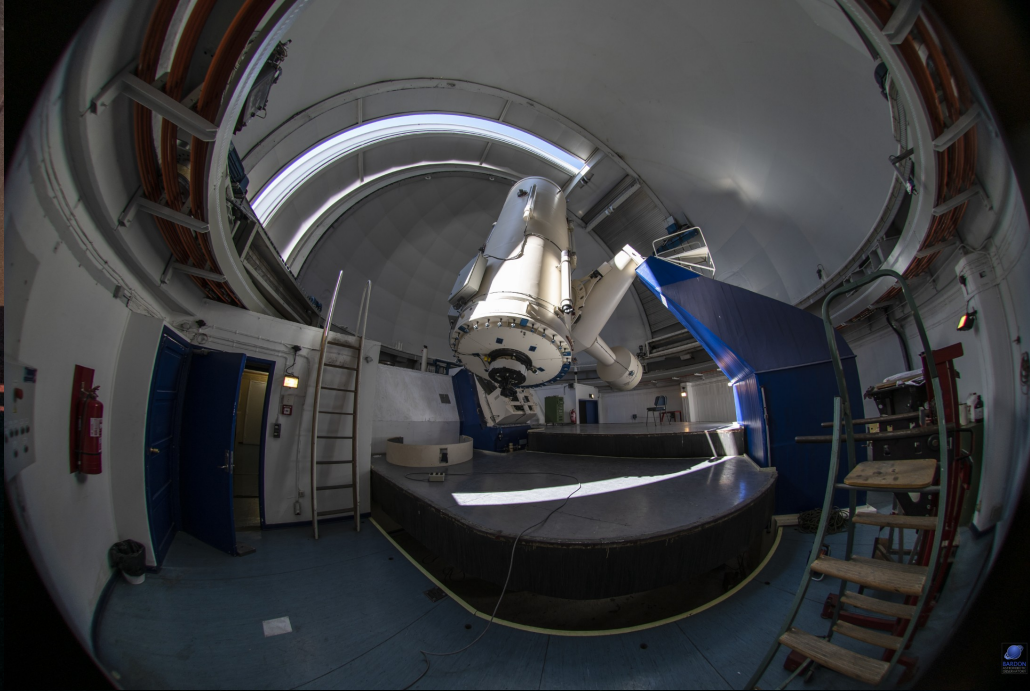
Observing strategy	m_V	Conservative scenario	Optimistic scenario
2 yr + 2 yr	8	1.2	3.4
	9	2.2	6.9
	10	4.4	14.0
	11	3.0	9.6
Total		10.7	33.8
3 yr + 1 yr	8	0.8	2.4
	9	1.4	4.3
	10	3.4	10.8
	11	2.5	7.9
Total		8.0	25.4

Heller et al. 2021 [A&A, 665 \(2022\) A11](#)

The PLATOSpec project



E152 telescope

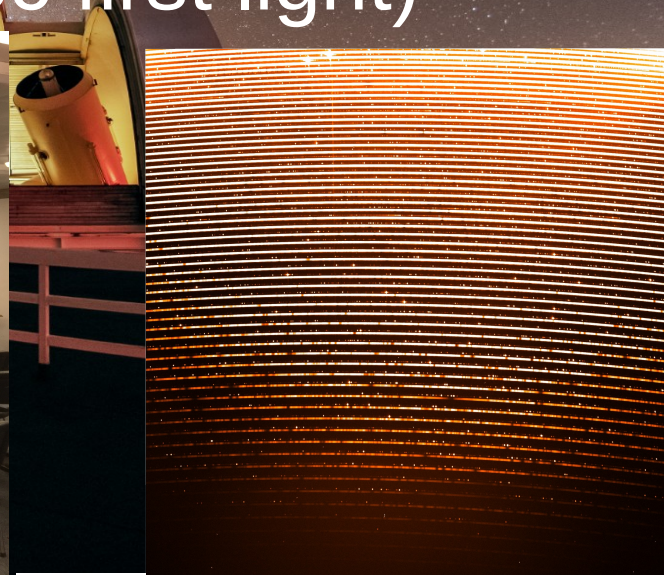


The PLATOSpec project

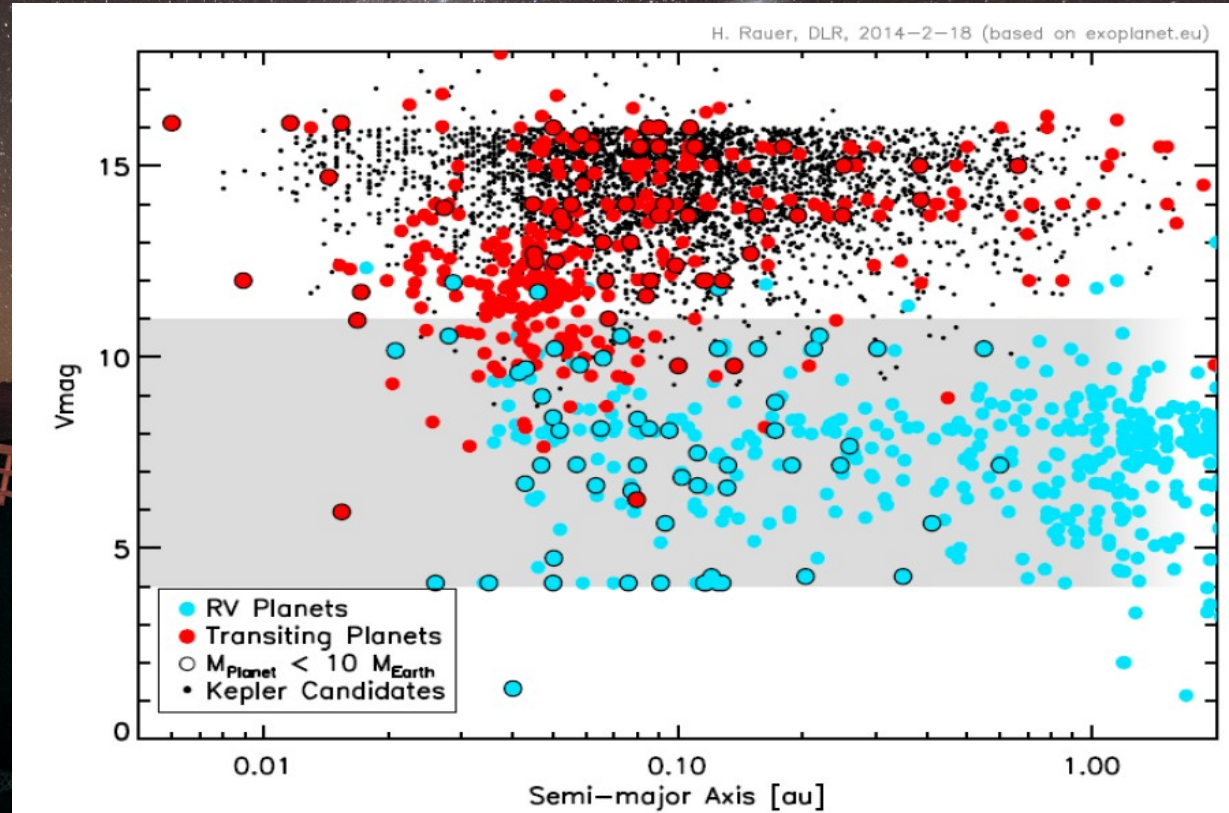
- Astronomical Institute of Cz. Academy of Sciences - Petr Kabath (PI)
- Thüringer Landessternwarte Tautenburg - Artie Hatzes
- Universidad Católica de Chile - Leonardo Vanzi
- Universidad Adolfo Ibáñez (Chile) – Rafael Brahm
- Masarykova univerzita (CZ) – Jan Janík
- Inst. for Plasma Physics of the Cz. Academy of Sciences - Pavel Pintr

From an idea to an instrument

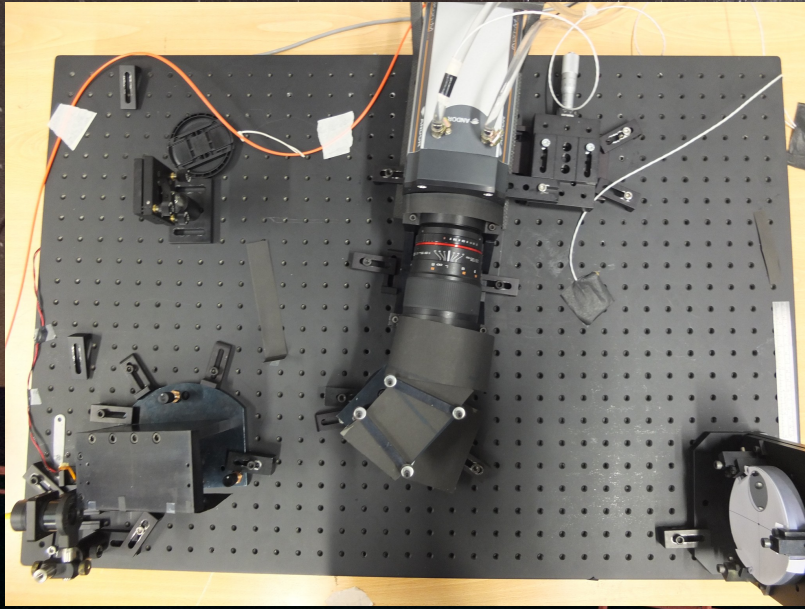
- 2017 (Ondřejov Summer School)
- 2024 (PLATOSpec first light)



PLATOSpec in support of PLATO



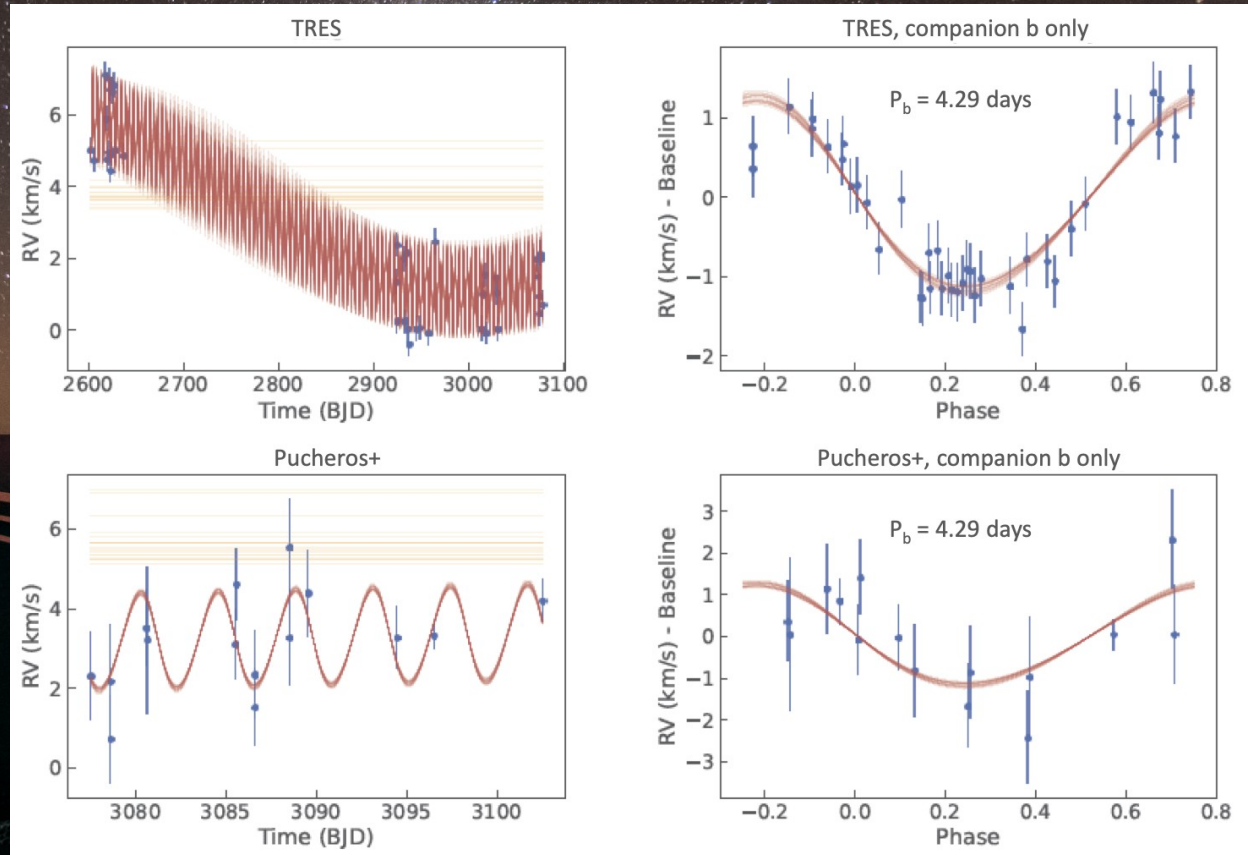
Interim spectrograph PUCHEROS+



Wavelength coverage	390-730 nm
Spectral resolution	18k
Thermal stability	0.5deg
RV precision	20m/s (nightly 5 mag star)
Calibration	ThAr (not simultaneous)

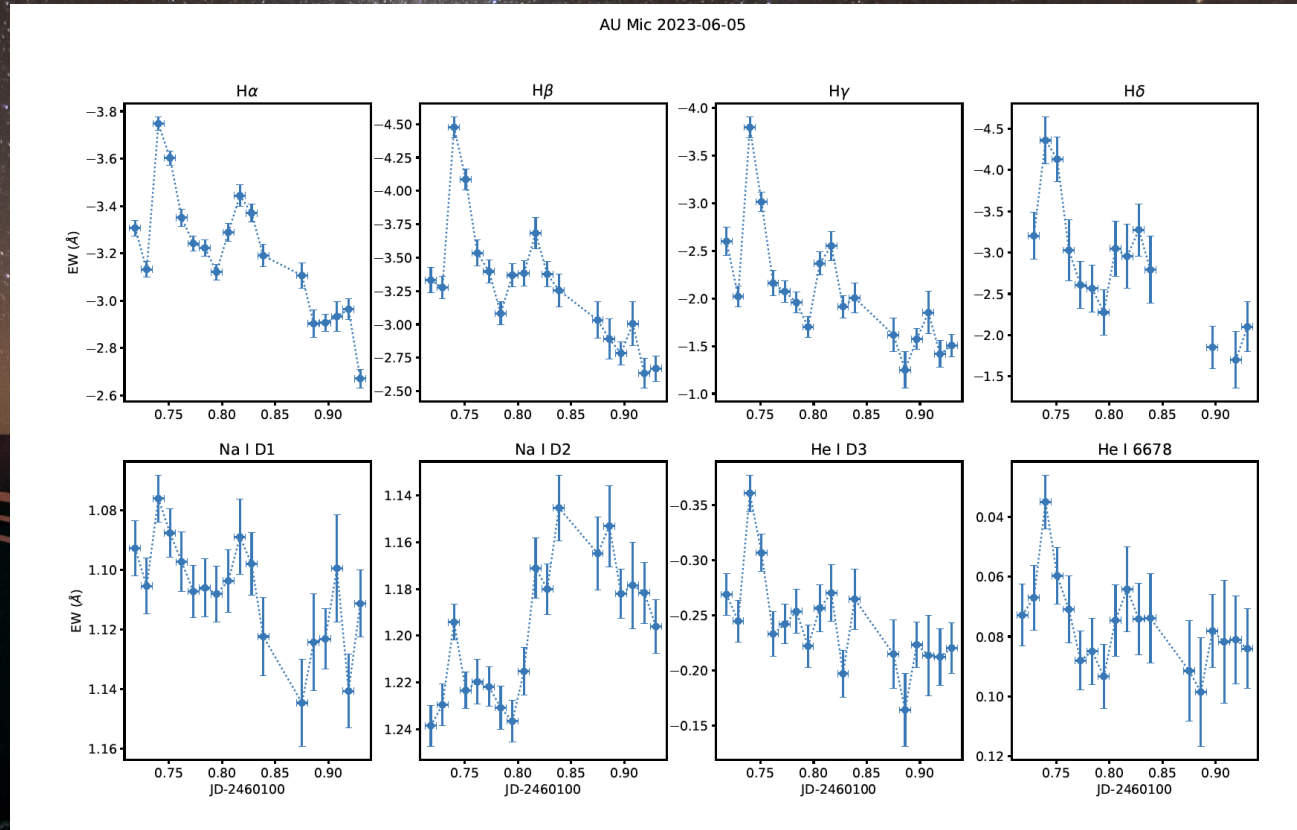


Interim spectrograph PUCHEROS+



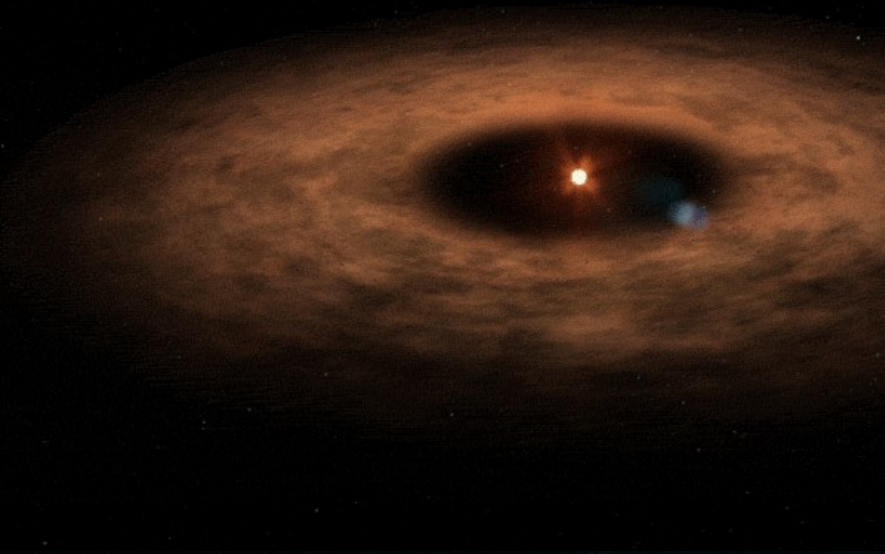
Šubjak et al. 2024, A&A

Interim spectrograph PUCHEROS+



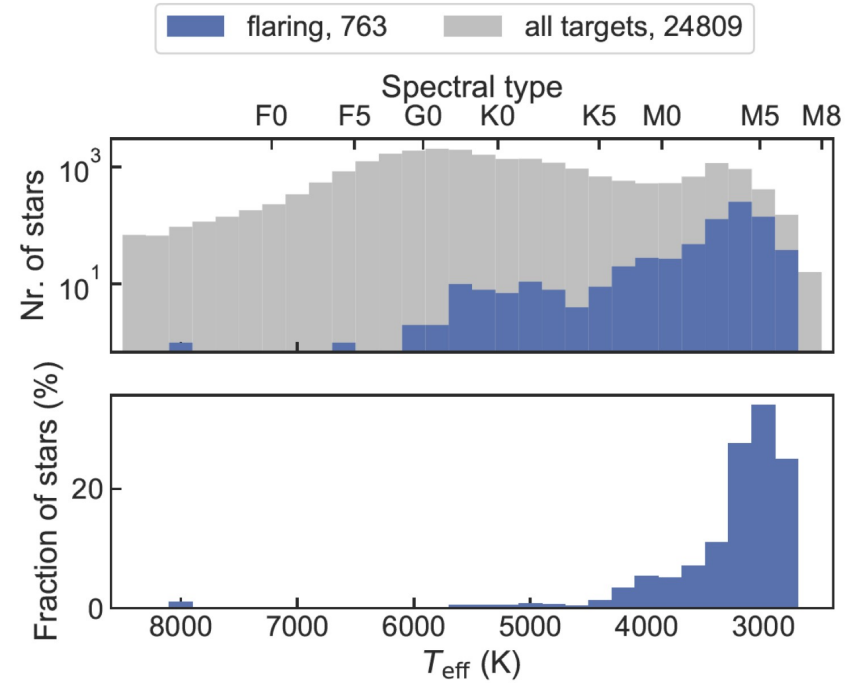
Odert et al. 2024, MNRAS

Interim spectrograph PUCHEROS+



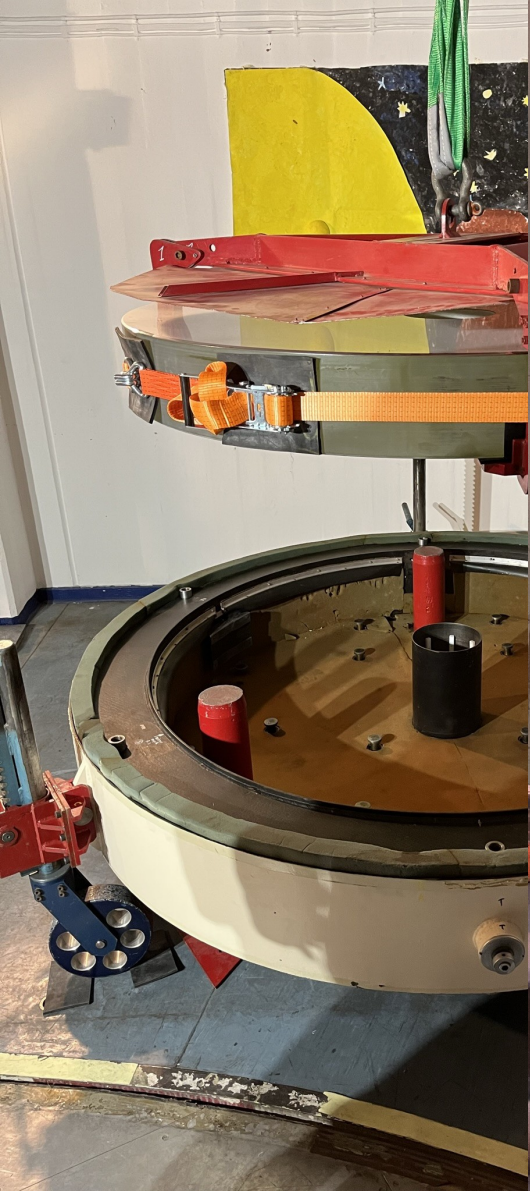
<https://www.nasa.gov/universe/nasas-tess-spitzer-missions-discover-a-world-orbiting-a-unique-young-star/>

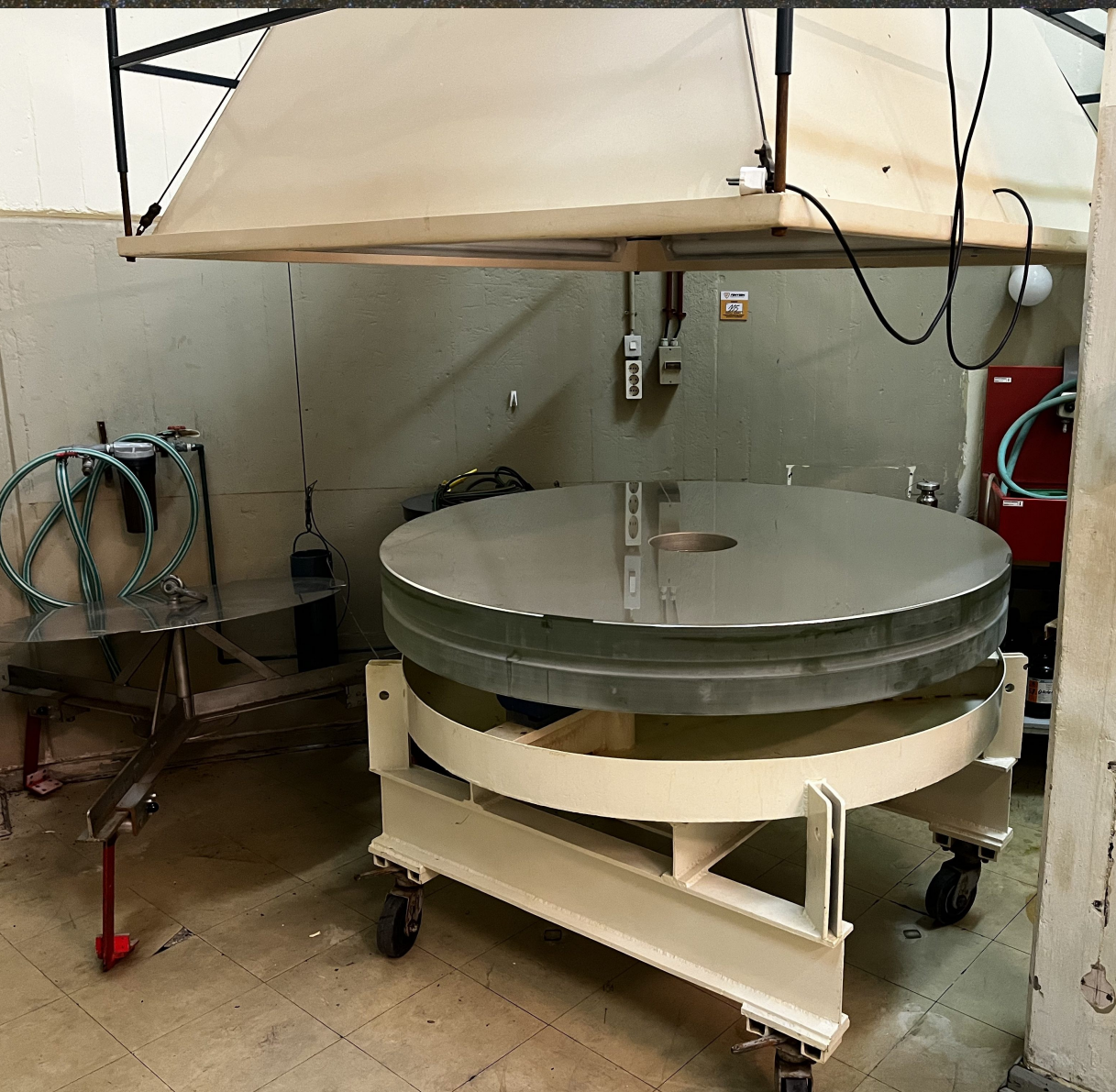
Interim spectrograph PUCHEROS+



<https://tspace.library.utoronto.ca/bitstream/1807/97060/1/dzombetapercyflarestars.pdf>



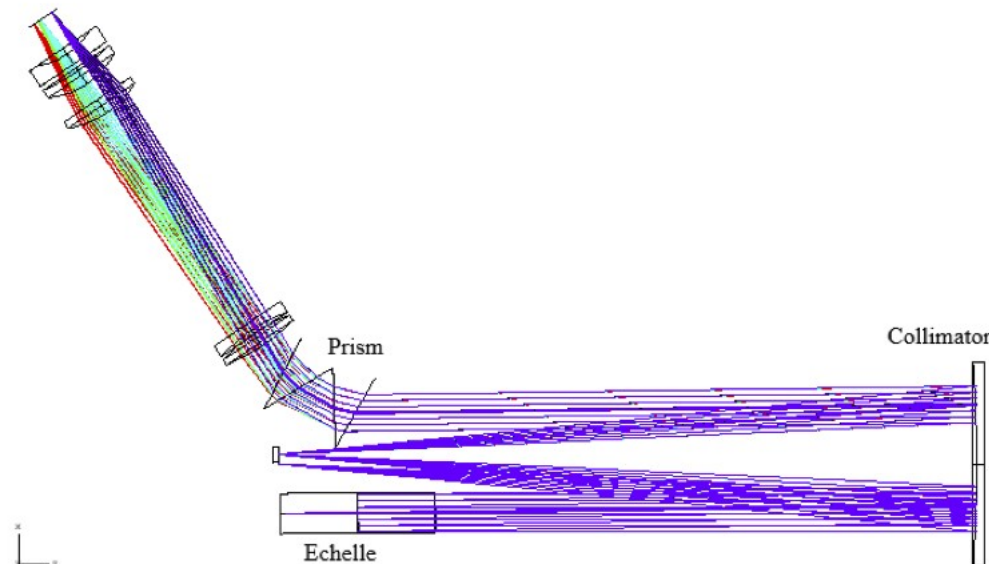






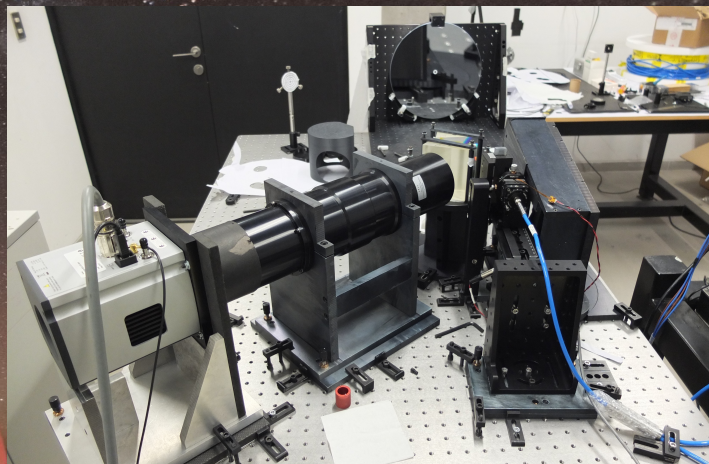
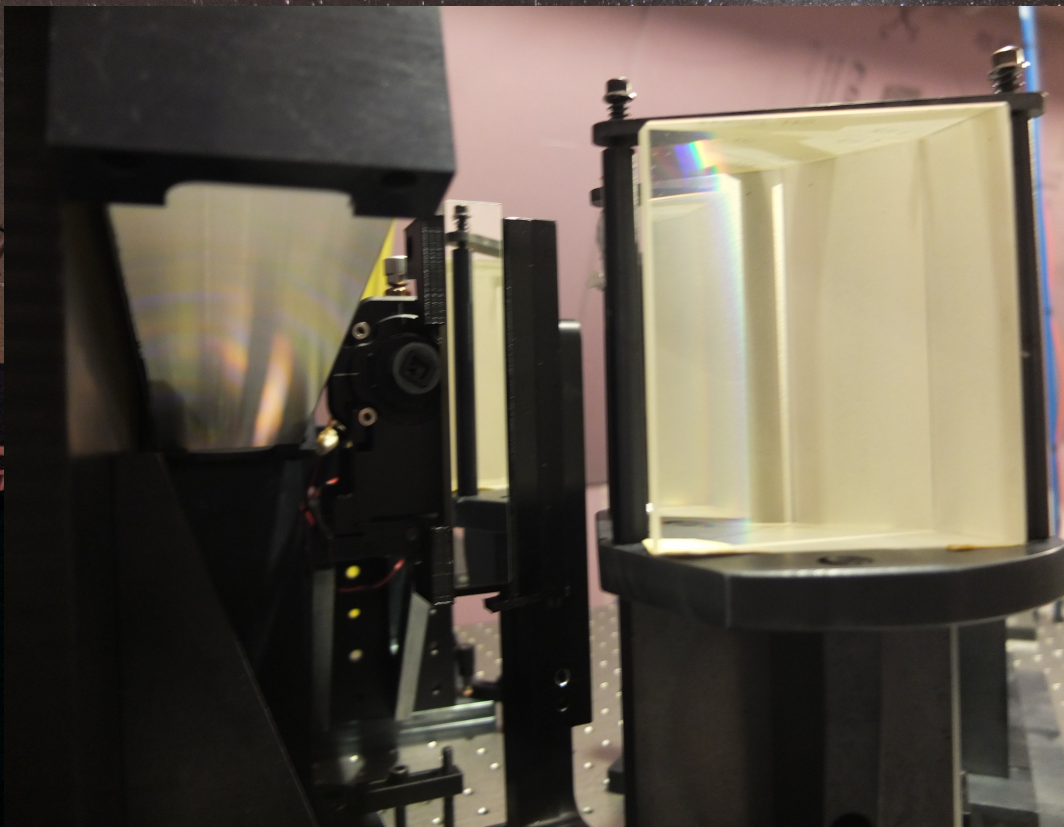
PLATOSpec parameters

Wavelength coverage	360-680 nm
Spectral resolution	70k
Thermal stability	0.1deg
RV precision	3m/s
Calibration	ThAr+Iodine cell

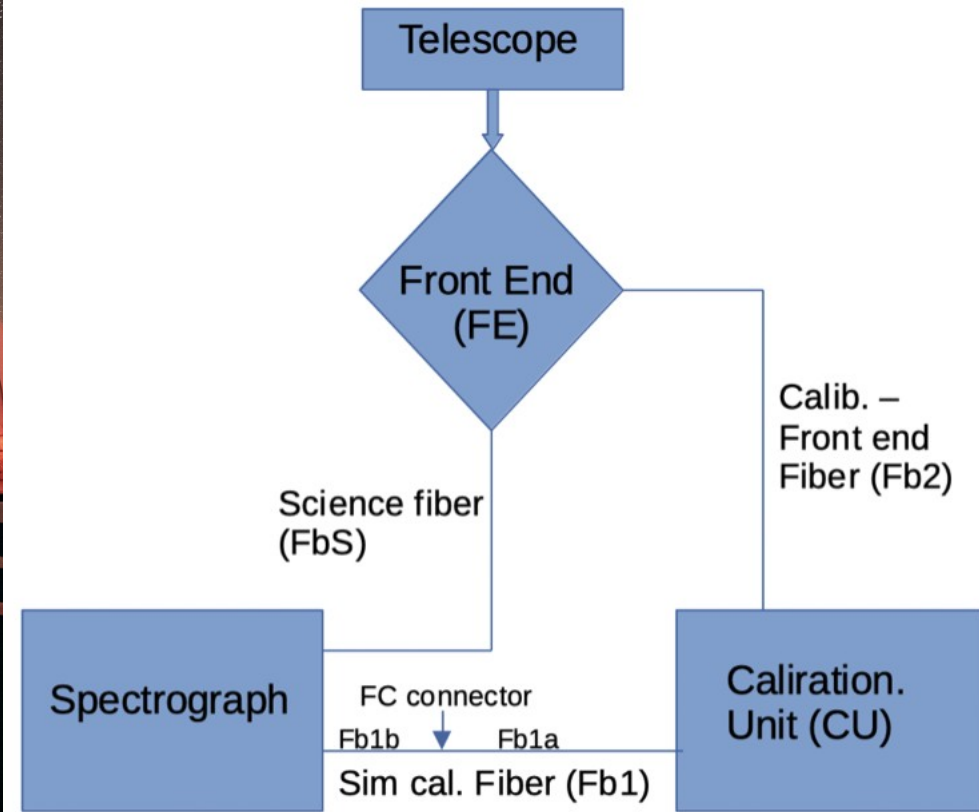
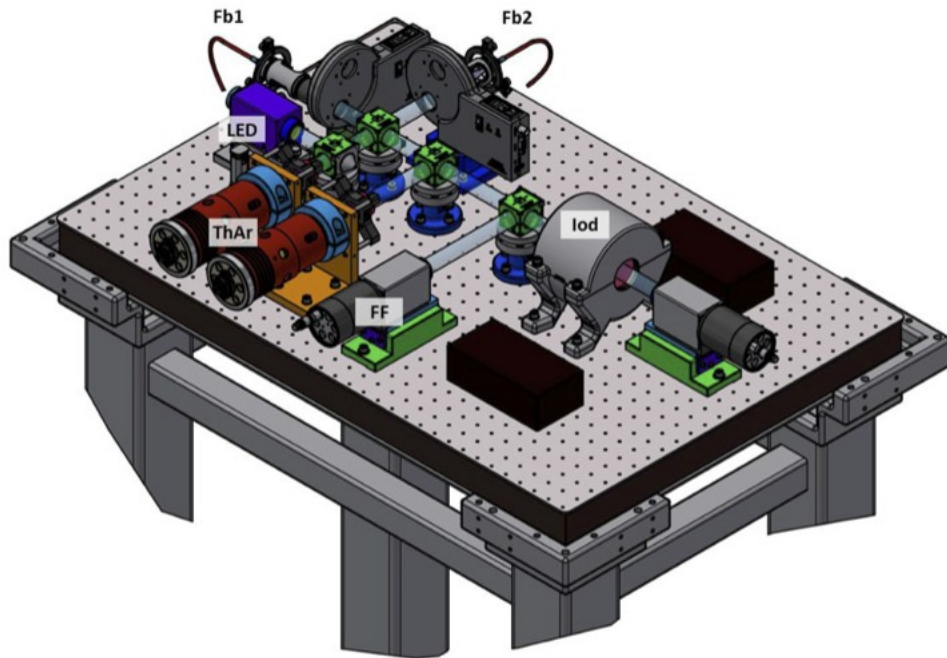


Kabath et al. 2025, MNRAS accepted

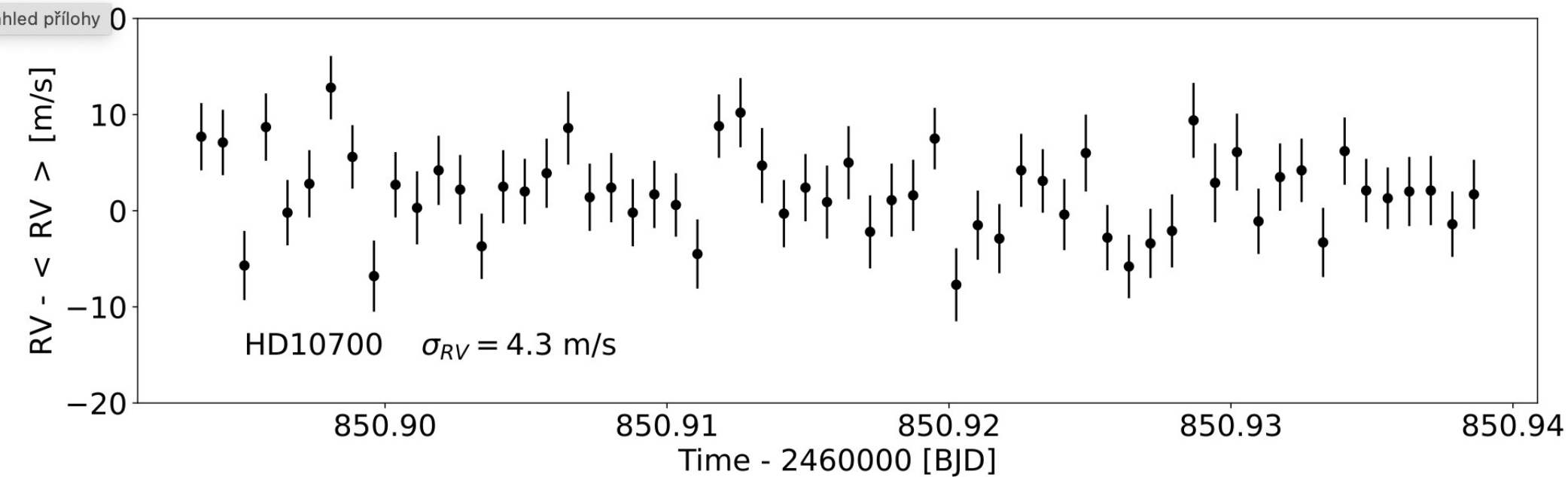
PLATOSpec parameters



PLATOSpec

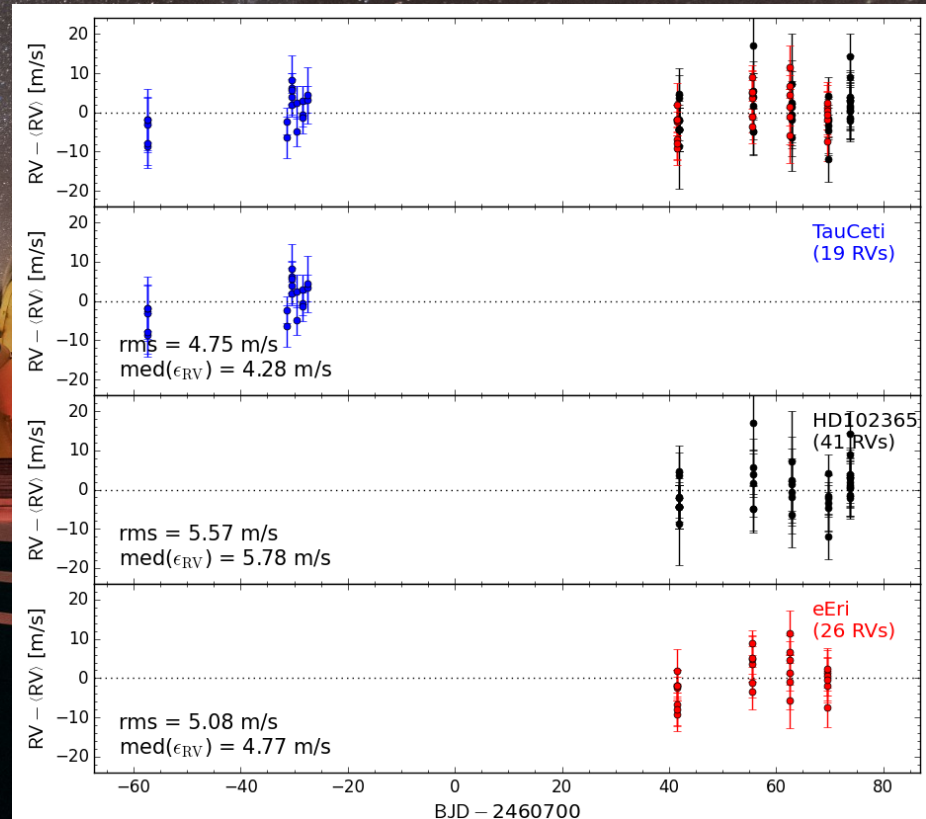


First results

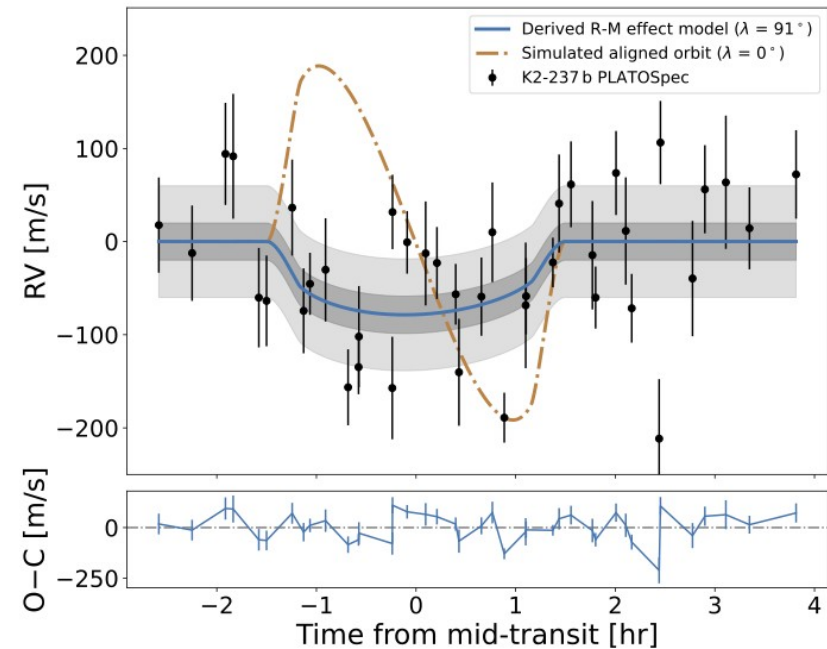
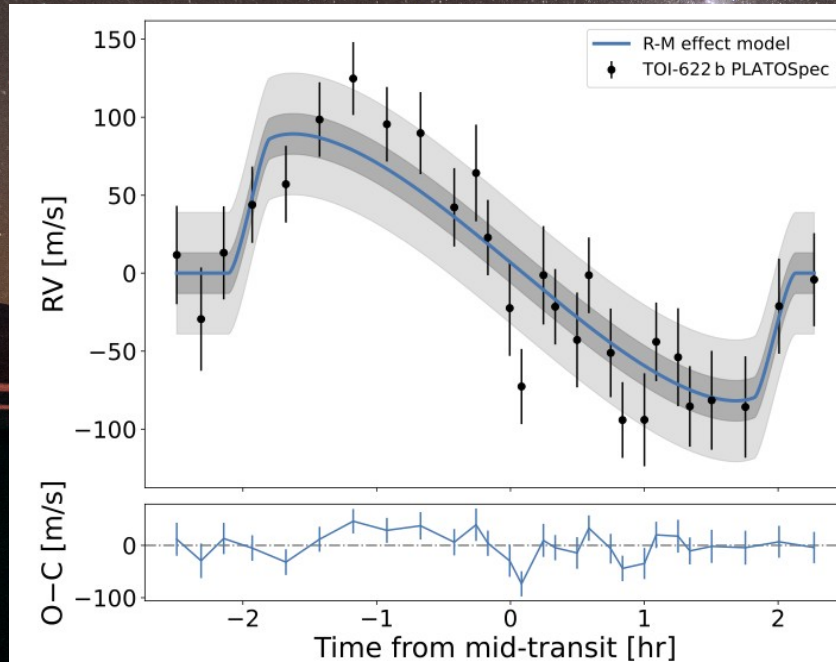


PLATOSpec first light

- Simultaneous Icell
- VIPER pipeline
(Koehler et al.)
- Unique method

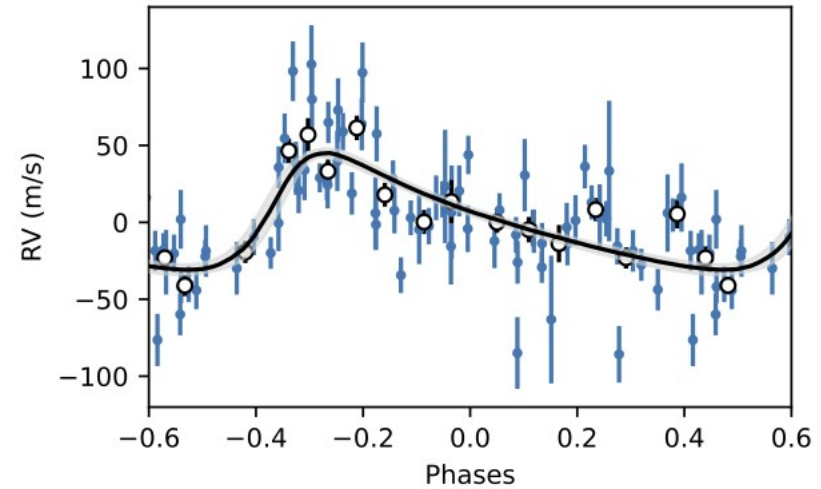
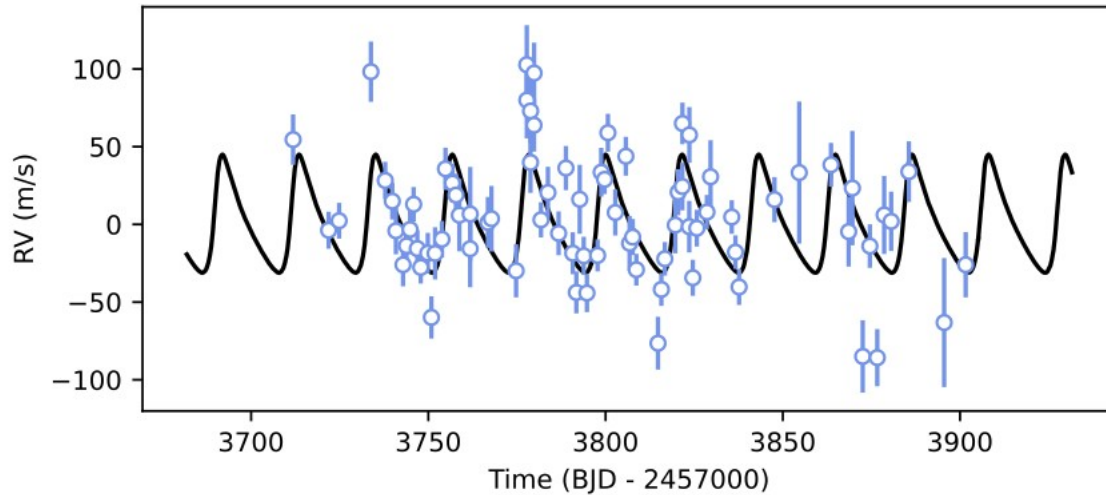


PLATOSpec early science



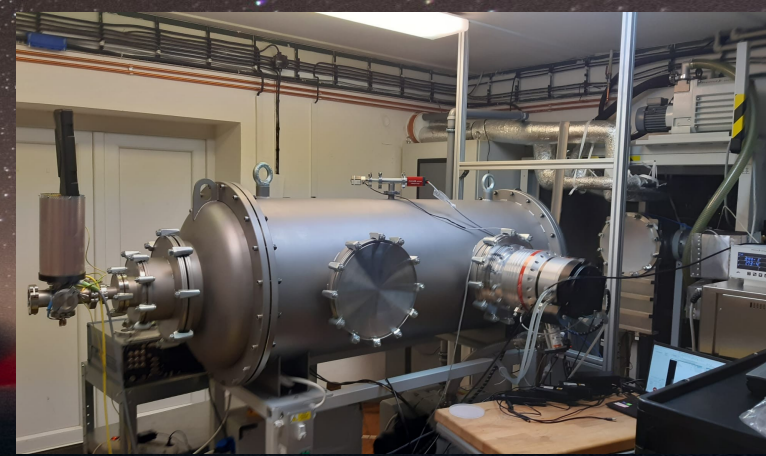
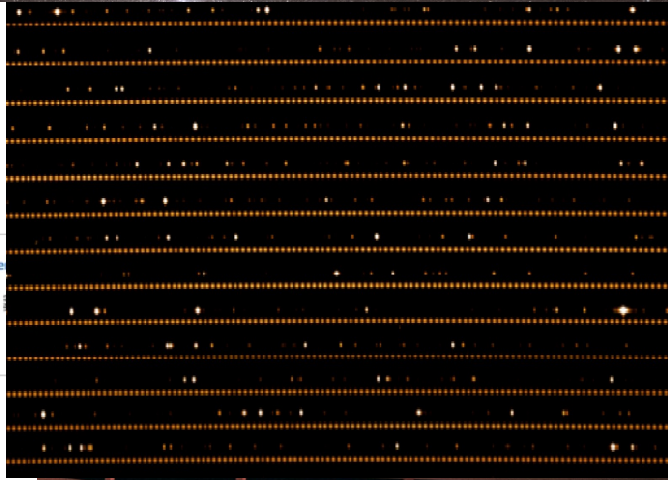
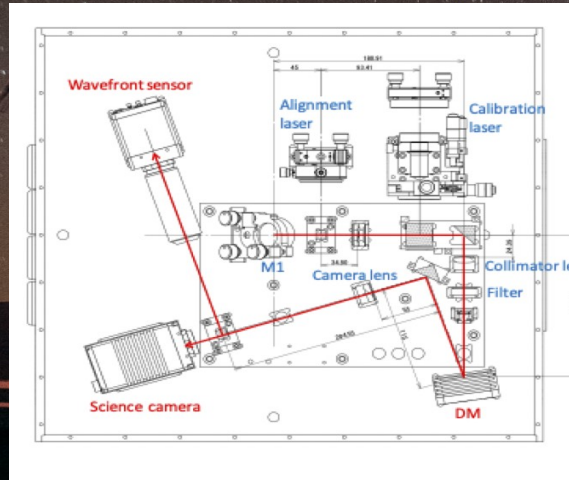
Žák et al. 2025, A&A

PLATOSpec early science



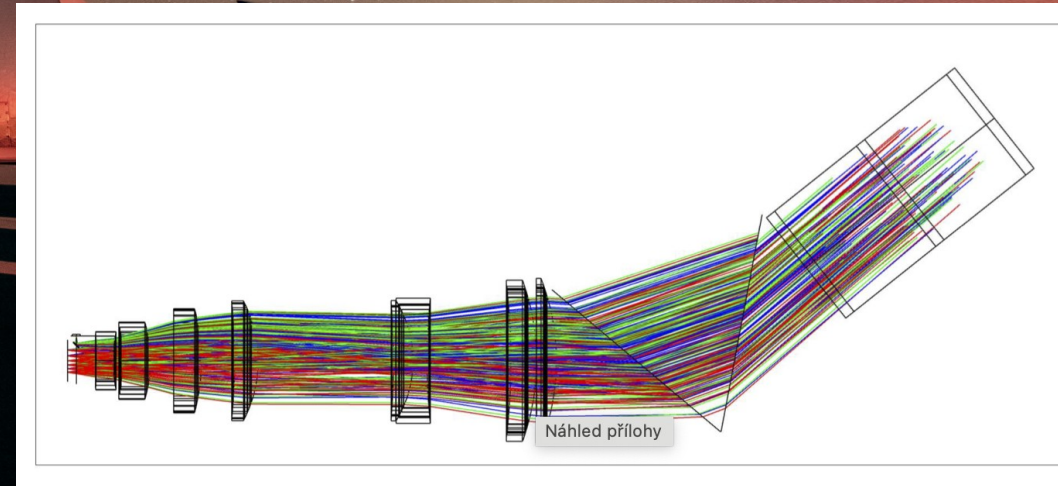
Gajdoš et al. 2025, A&A in prep.

Pushing the limits



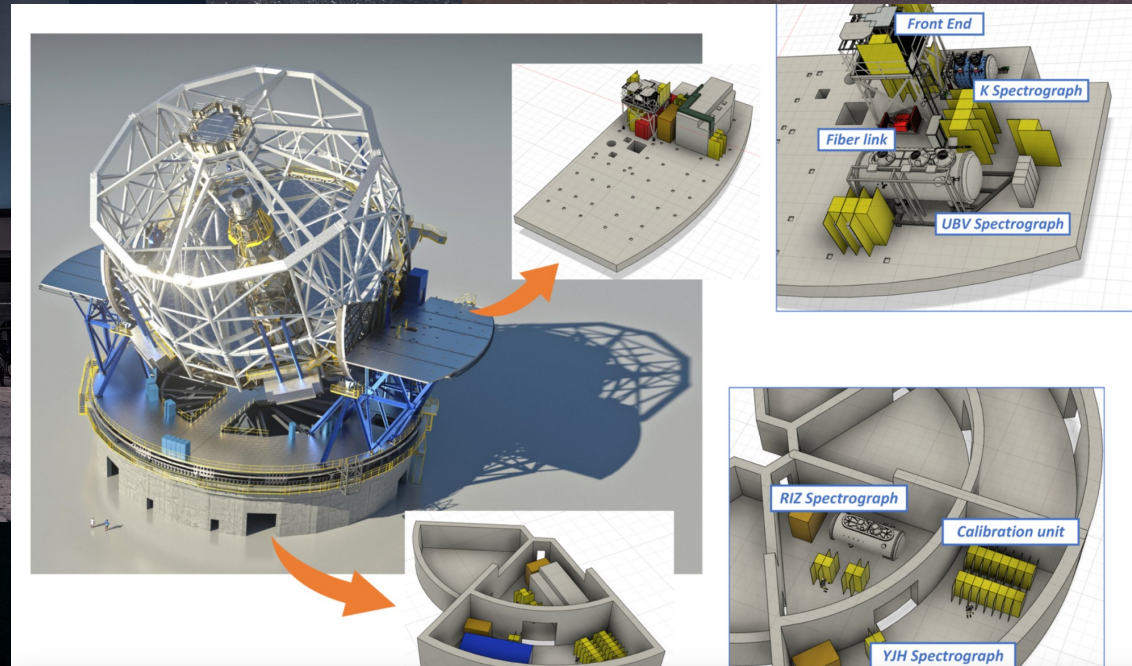
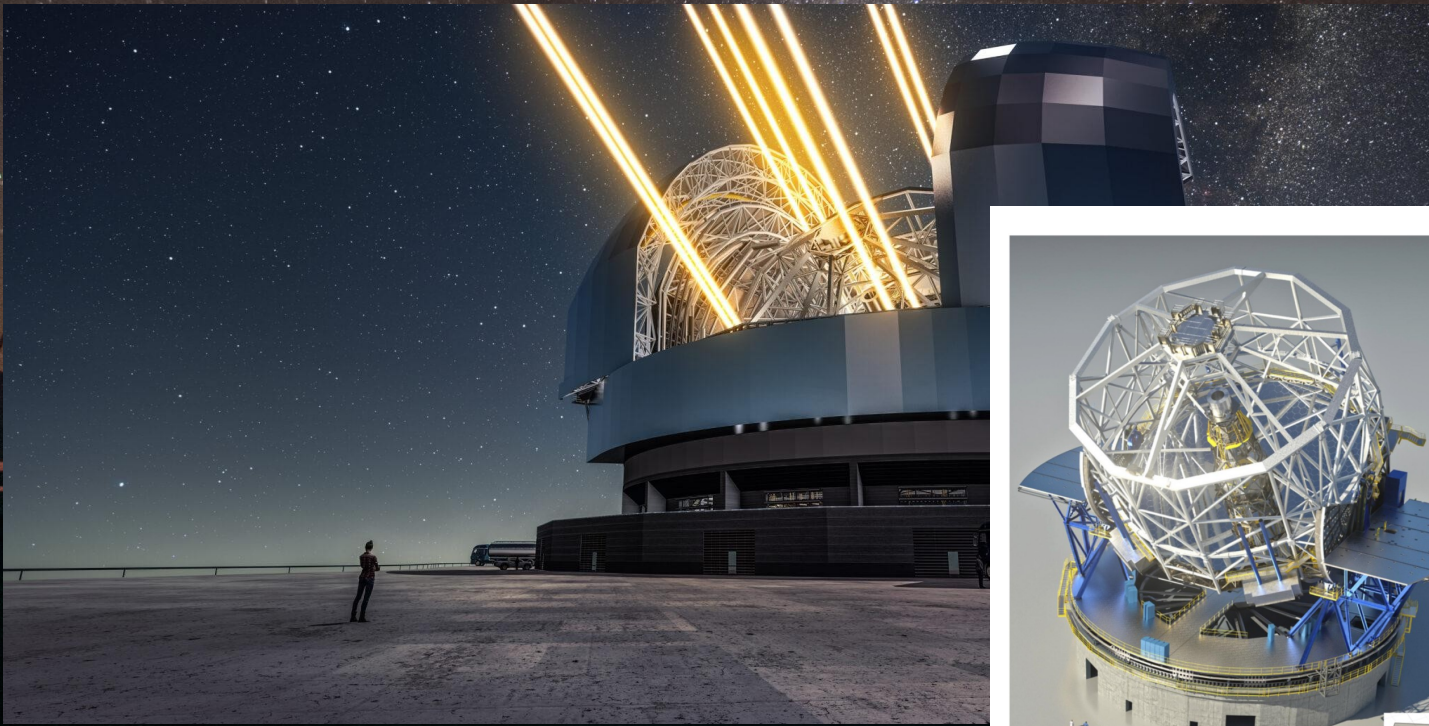
OES+

- New precise spectrograph for Perek telescope
 - 2 fibers mode – sky, object
 - Sim calibrations
- Resolving power 40k



TOPTEC and OES+ team.

ANDES and the Czech Republic



ARIEL

- Spectrograph
- Exoplanetary atmospheres of large planets and SuperEarths
- Launch around 2029
- Czech PI: M. Ferus



LIFE, WHO and beyond

- Space interferometer to visualize habitable worlds – 2040+ (PI: Sascha Quanz – ETH Zurich)



2030+

Goddard Space Flight Center
asd.gsfc.nasa.gov/luvair/

National Aeronautics and
Space Administration



LUVOIR

Large Ultraviolet / Optical / Infrared Surveyor

LUVOIR is a concept for a highly capable, multi-wavelength observatory with ambitious science goals. This mission would enable great leaps forward in a broad range of astrophysics, from the epoch of reionization, through galaxy formation and evolution, to star and planet formation. Powerful remote sensing observations of Solar System bodies will also be possible. LUVOIR will study a wide range of exoplanets in depth, including those that might be habitable – or even inhabited.



Simulated high-contrast image of
the Solar System at 10 parsecs

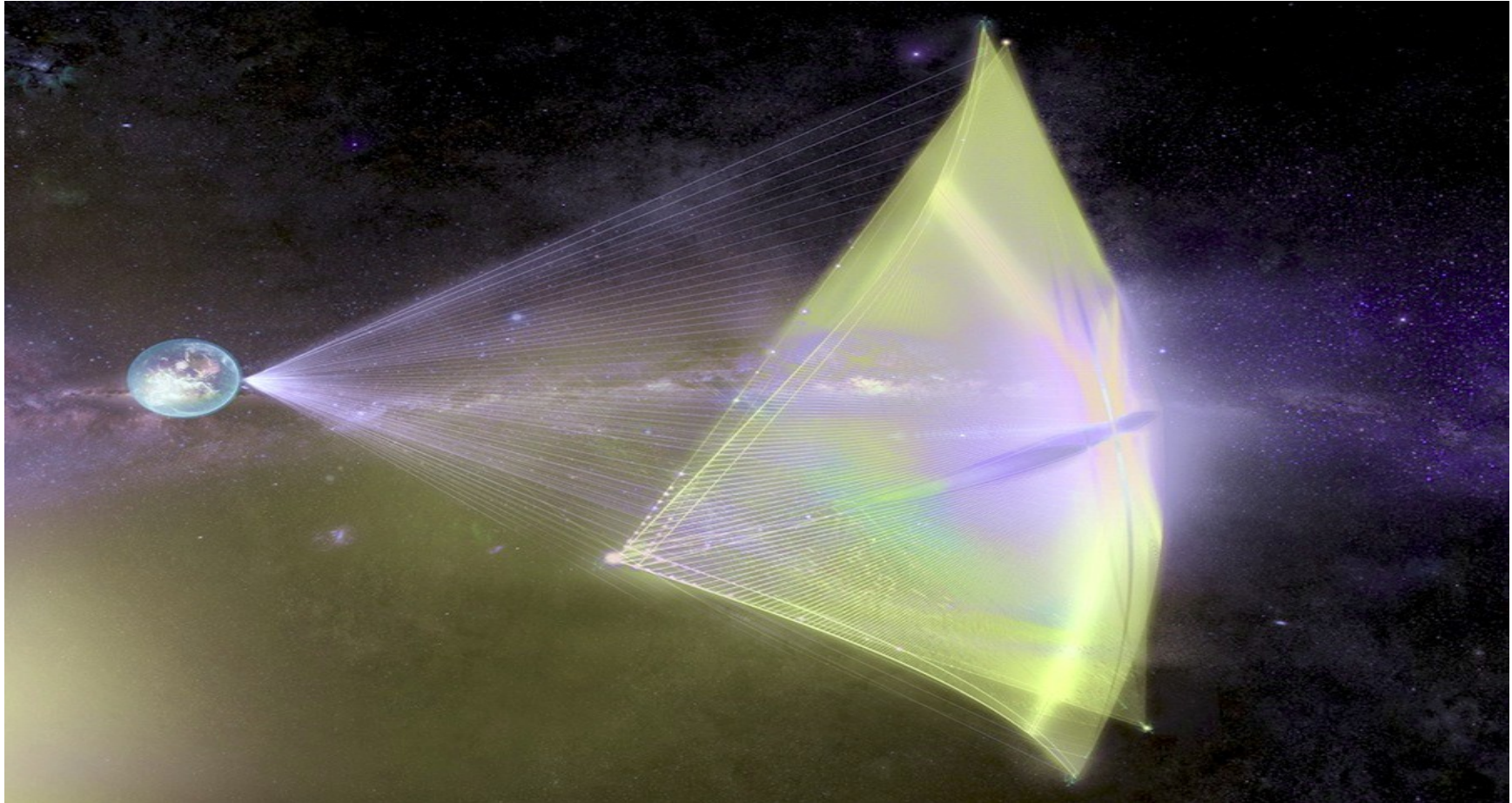


LIFE, WHO and beyond

<https://habitableworldsobservatory.org/home>



The Breakthrough initiative Starshot



Projects at AsÚ

- Investigating the extreme precise instrumentation for the future
- PLATOSpec – test bench for pushing of the limits
- LIFE space mission?