Exoplanetary research made in the Czech Republic

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Workshop 10 years of CZ at ESA,
14.11.2018

Where are we now?

- http://exoplanets.asu.cas.cz/index.html
- Almost no coordinated exoplanets effort in CZ before 2015!
- 2016/2017 Exoplanet ground based instrument PLATOSpec idea was born
- 2018 official exoplanet group

Group and collaborations

- **Astronomical Institute Ondřejov**

  P. Kabáth, T. Klocová, M. Skarka,

  M. Blažek, J. Šubjak,

  M. Špoková, J. Dvořáková,

  D. Dupkala

- **Collaborations**

  DLR Berlin

  ESO

  Universidad de Chile and Univ. Valparaiso

  Thueringer Landessternwarte Tautenburg

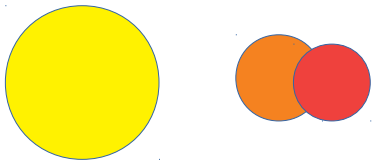
  IAC

PlatoSpec

Motivation example

False positives

- Eclipsing binaries
- Triple systems
- Background eclipsing binaries
- Background eclipsing BD/WD
- False positives estimates Santerne et al. 2012 – around 40% for close-in giant planets Kepler candidates (from observing)
- Santerne et al. 2013 evaluates global false positive probability to about 11% for Kepler candidates



Characterization of exoplanets

- Transits

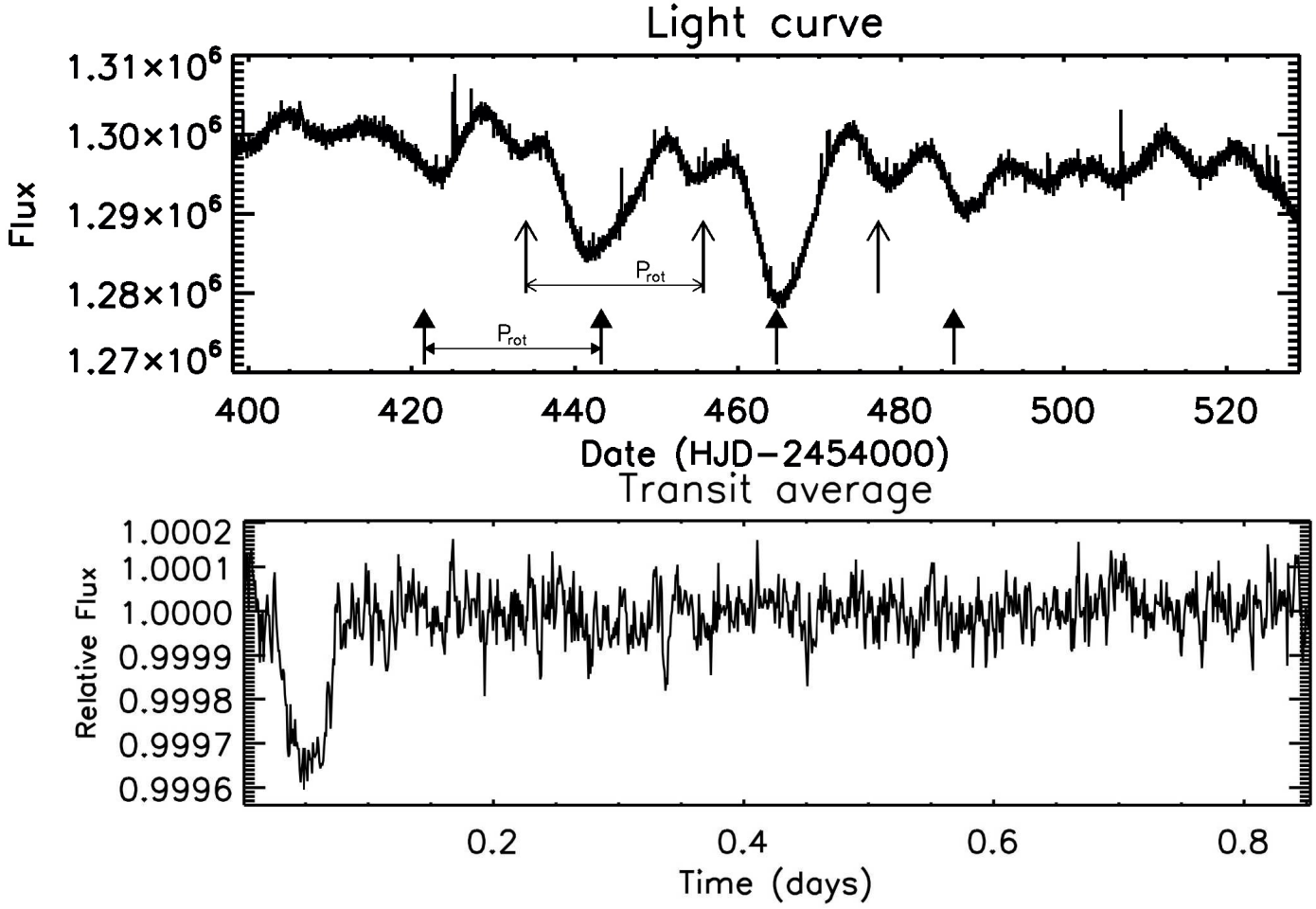
  Radius of the planet

- Spectroscopy

  Mass limit

- STELLAR PARAMETERS NEEDED (spectroscopy)

The case of CoRoT-7b



CoRoT-7b

Orbital Period 0.85 days

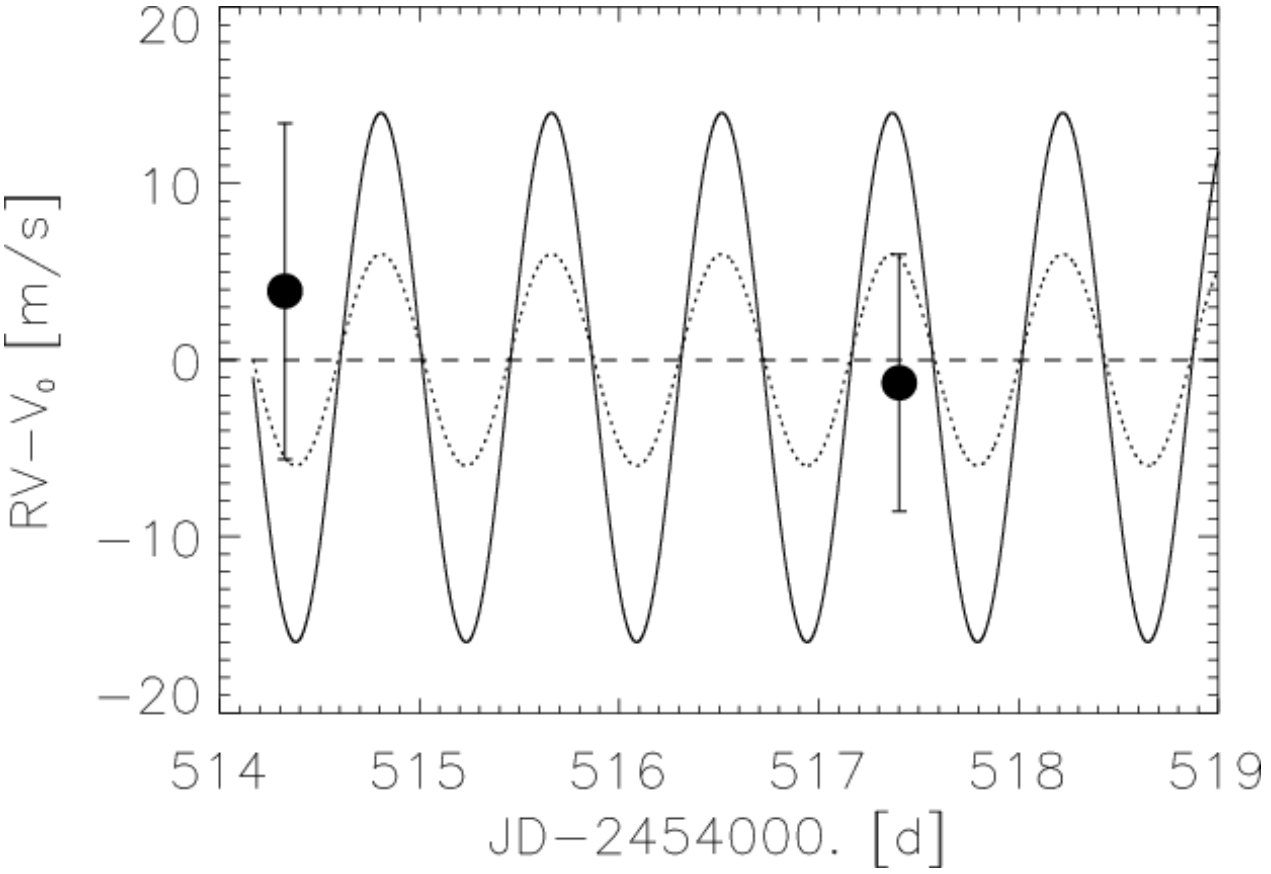
Mass $<9M_{Earth}$

Radius $1.51R_{earth}$

From Leger et al. 2007, A&A

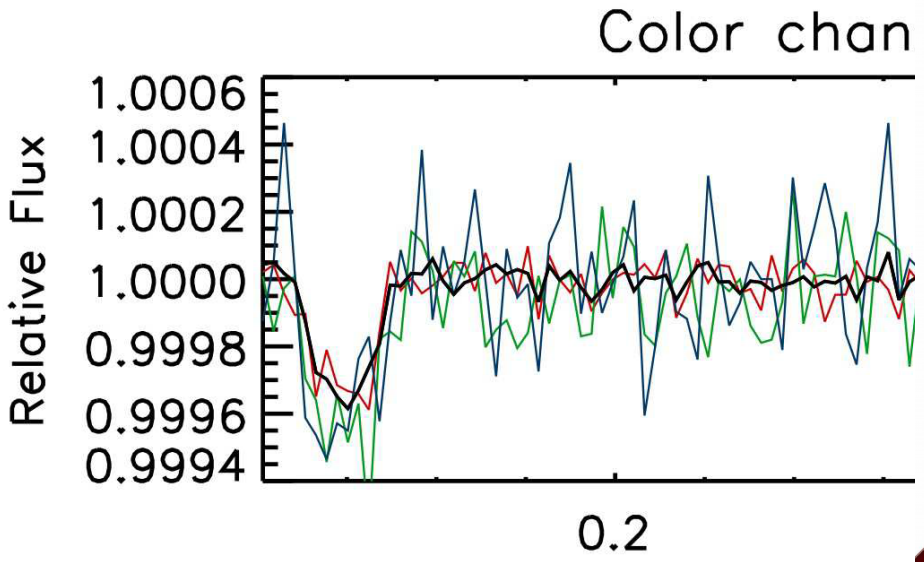
CoRoT-7b

- SOPHIE at OHP
- Excluded large companion
- Case for small telescope

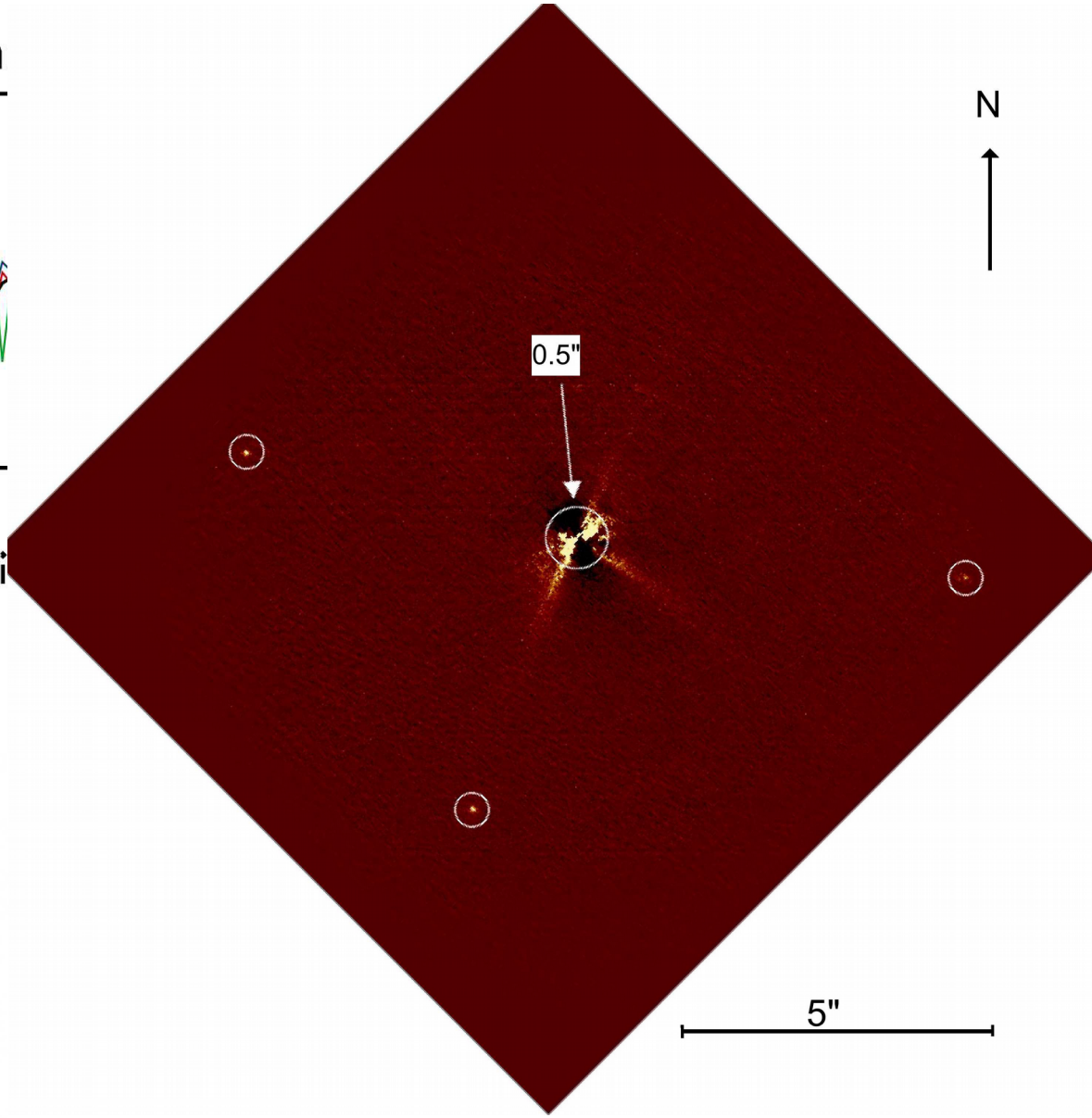


From Leger et al. 2007, A&A

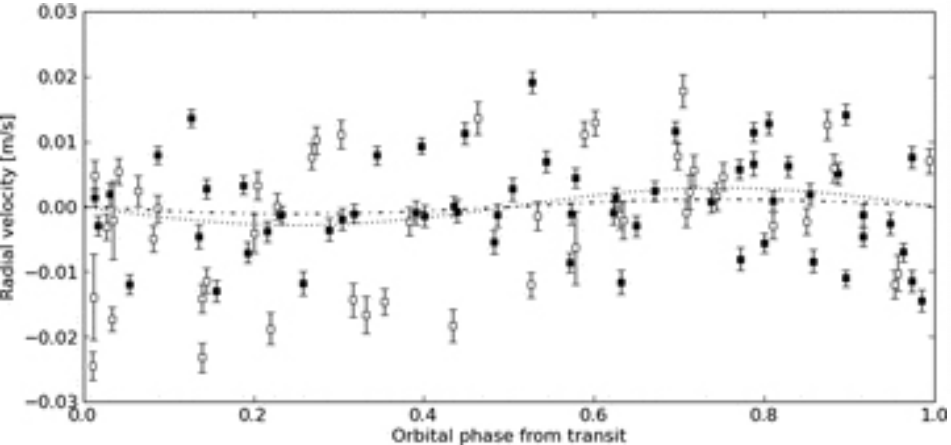
CoRoT-7b



From Leger et al. 2007, A&A

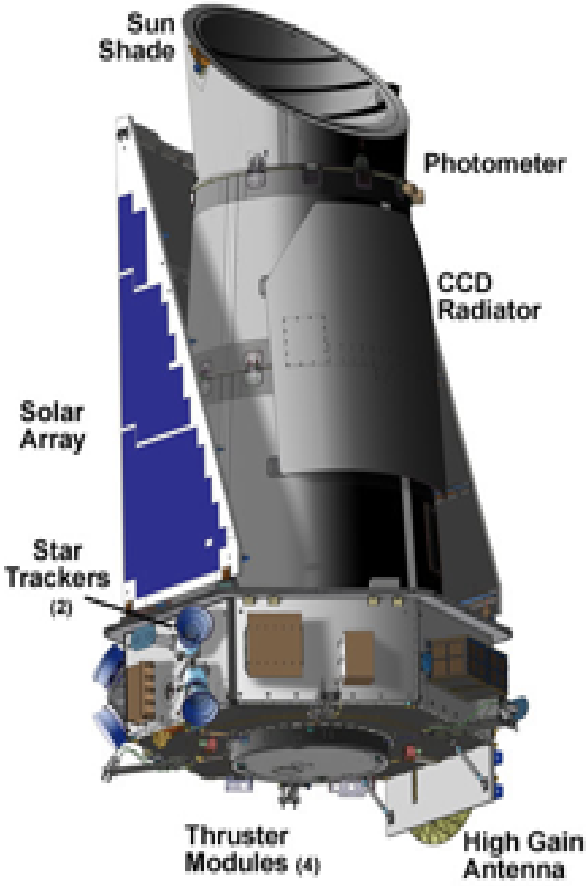


Bottom from F. Pont 2011, MNRAS

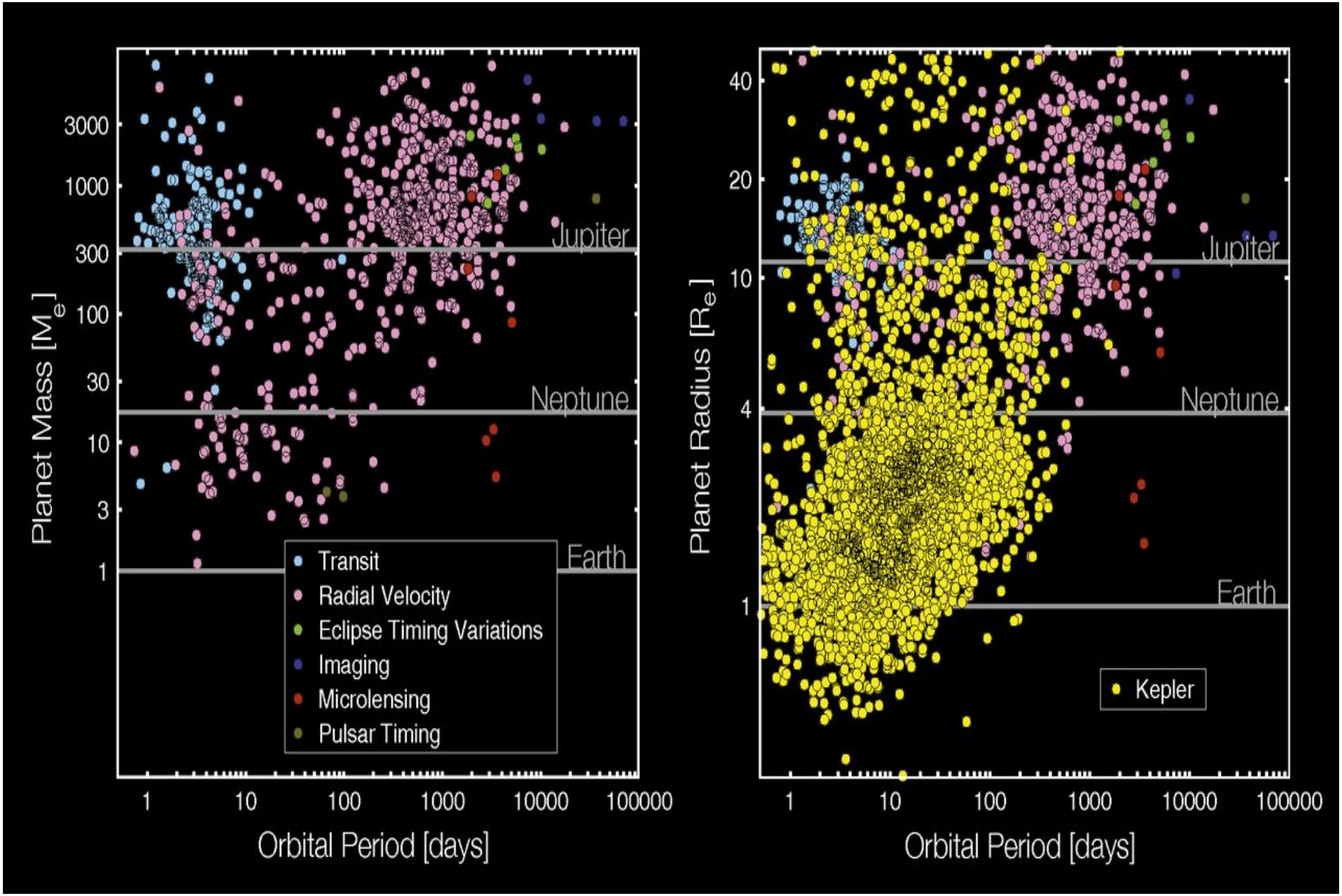


The era of Kepler

- Detections of exoplanets
- Launched 2009
- 1.4-m primary mirror
- Monitored 100k stars in Cygnus
- Around 2000 planets
- K2 continuation with different observing strategy
- Many stars were faint 13+ mag!

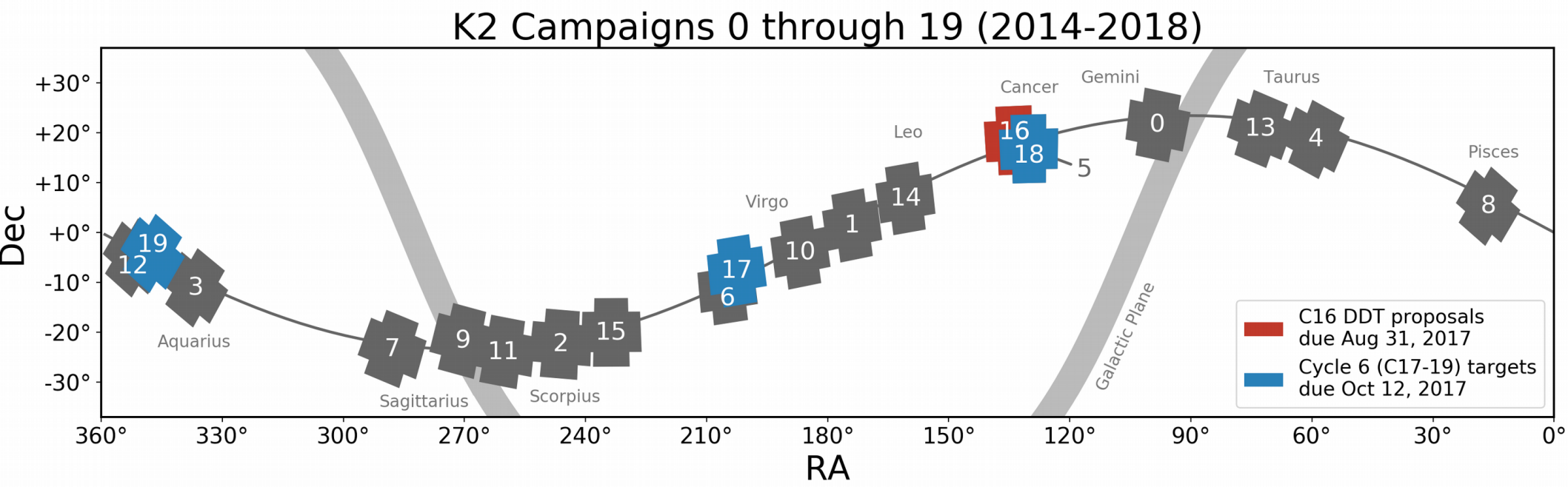


KEPLER planets



Credit: NASA

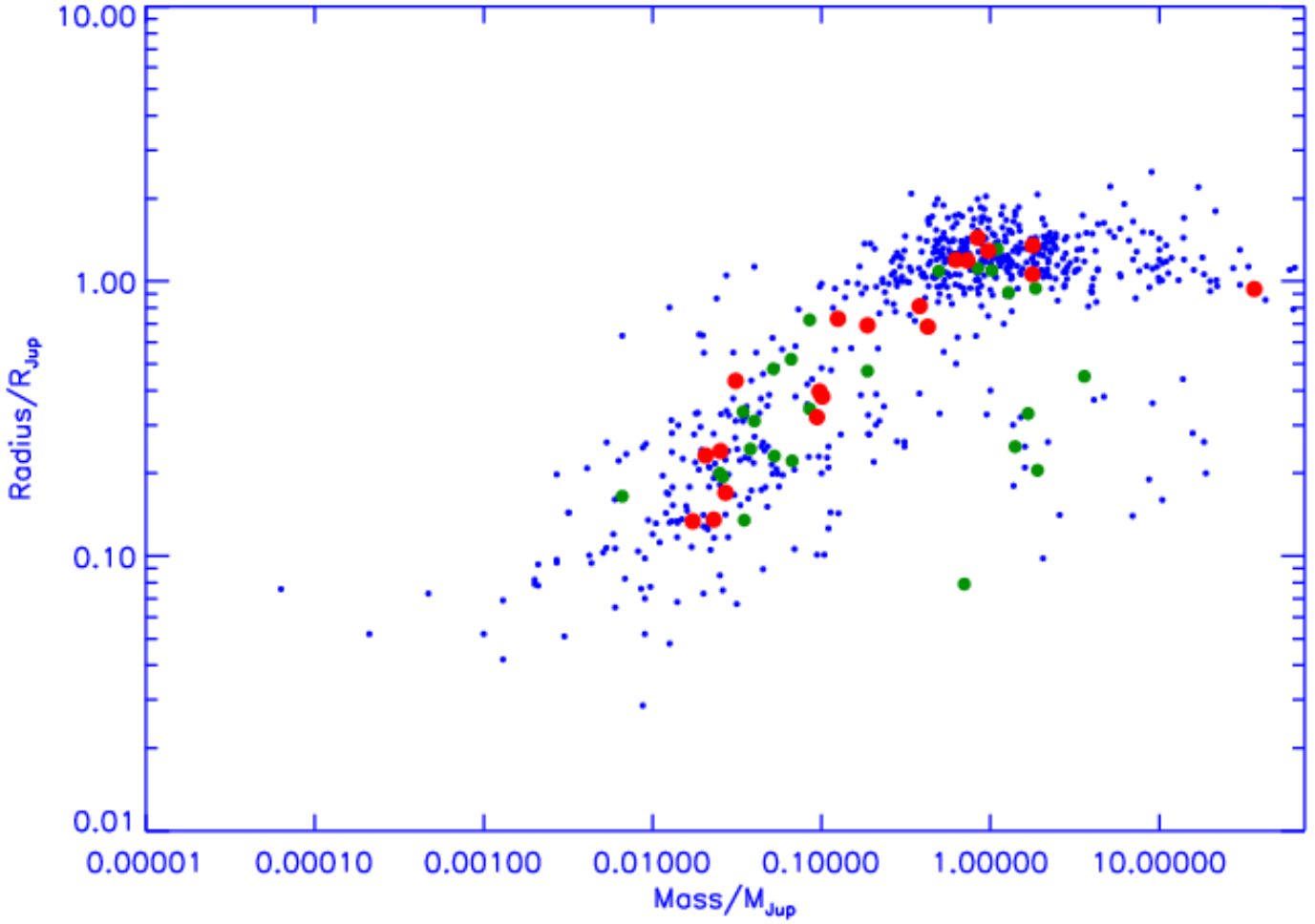
K2 continuation of Kepler



Credit: Nasa

- Nowadays 325 planets from K2 (Sep 2018)
- About 400 candidate (Sep 2018)
- Need for ground-based RV

Great but…..



In Sep. 2017 – approx. 120 K2 planets

Blue – all planets around 4000
Green – K2 planets with masses (40)
Red – KESPRINT (21)

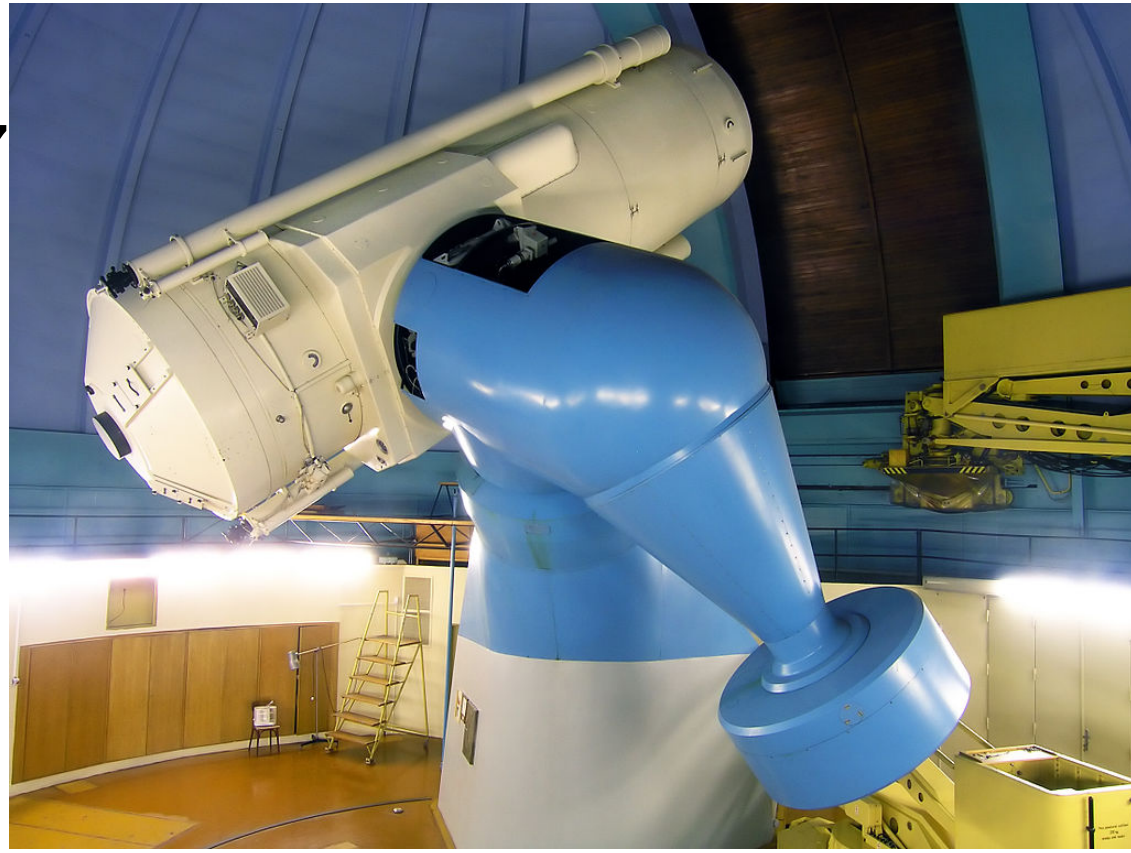
Numbers from Csizmadia et al. 2017

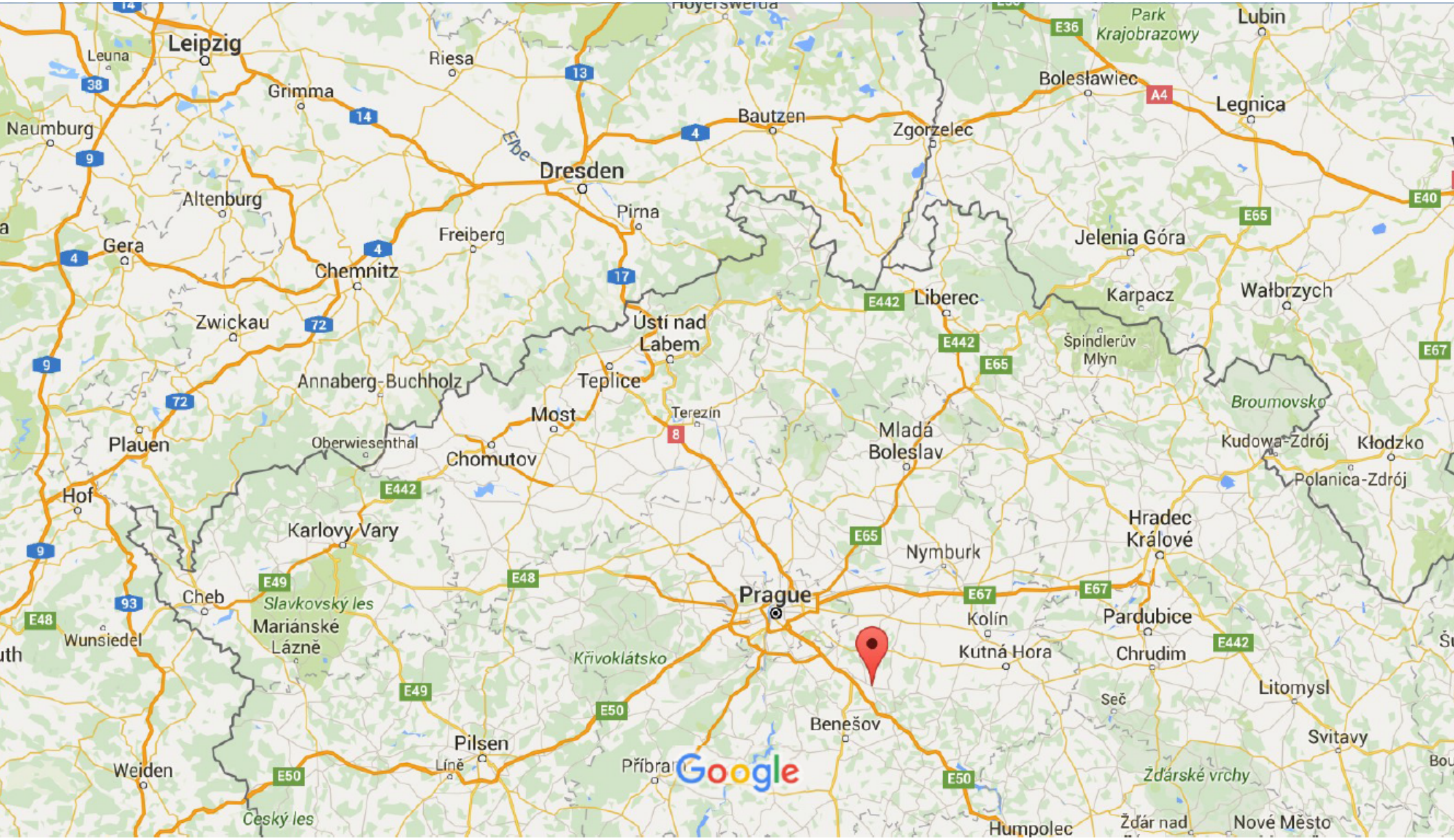
From Csizmadia et al. Plato mission conference 2017

Perek 2-m telescope

Astronomický ústav AV ČR

- 2-m telescope – Zeiss opened in 1967
- Twin of TLS 2-m
- Operates in Coude
- Equipped with slit spectrograph and with an Echelle spectrograph (OES)

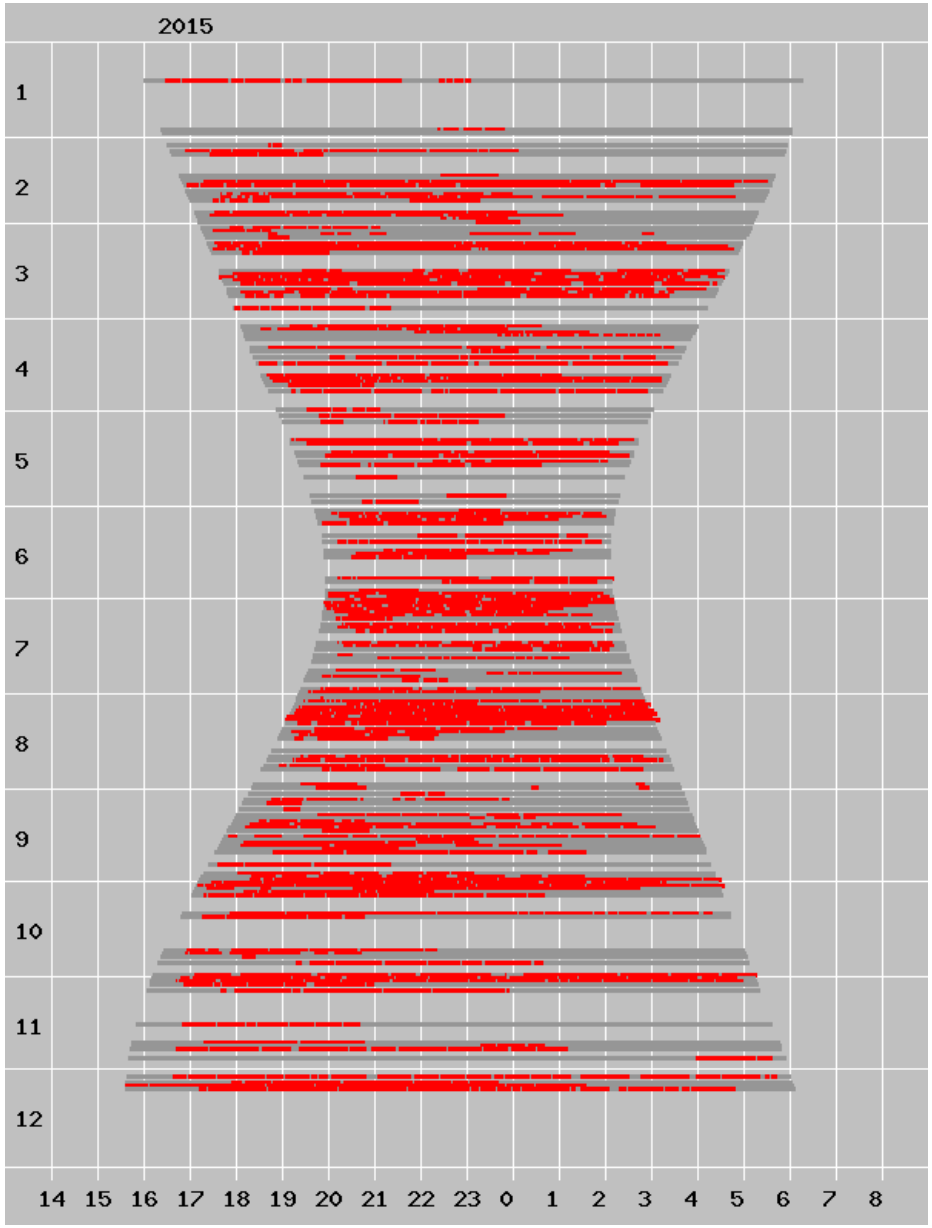




Map data ©2015 GeoBasis-DE/BKG (©2009), Google 20 km

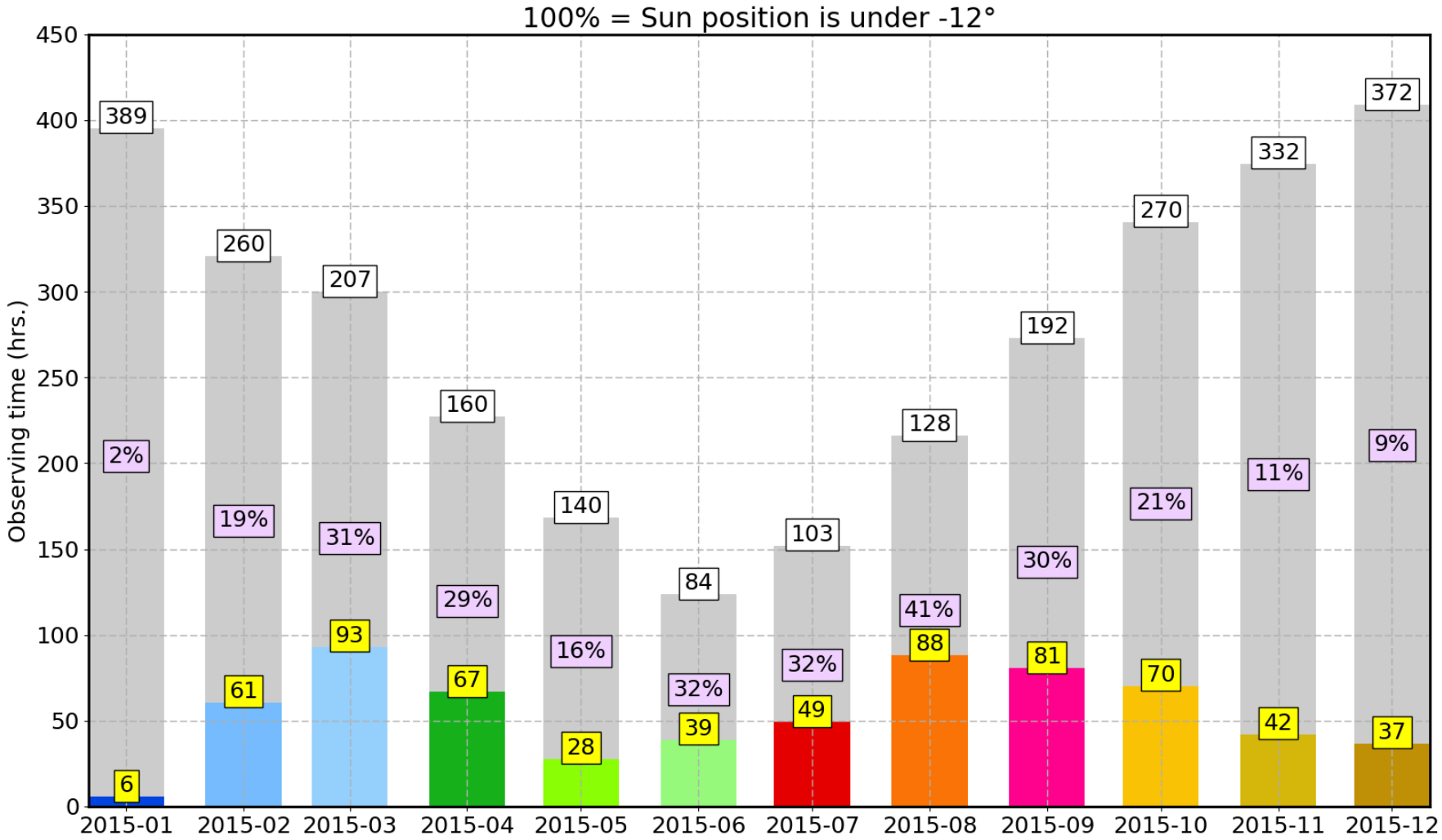
Ondrejov observing stats 2015

Astronomický ústav AV ČR



Astronomický ústav AV ČR

Statistics during the year



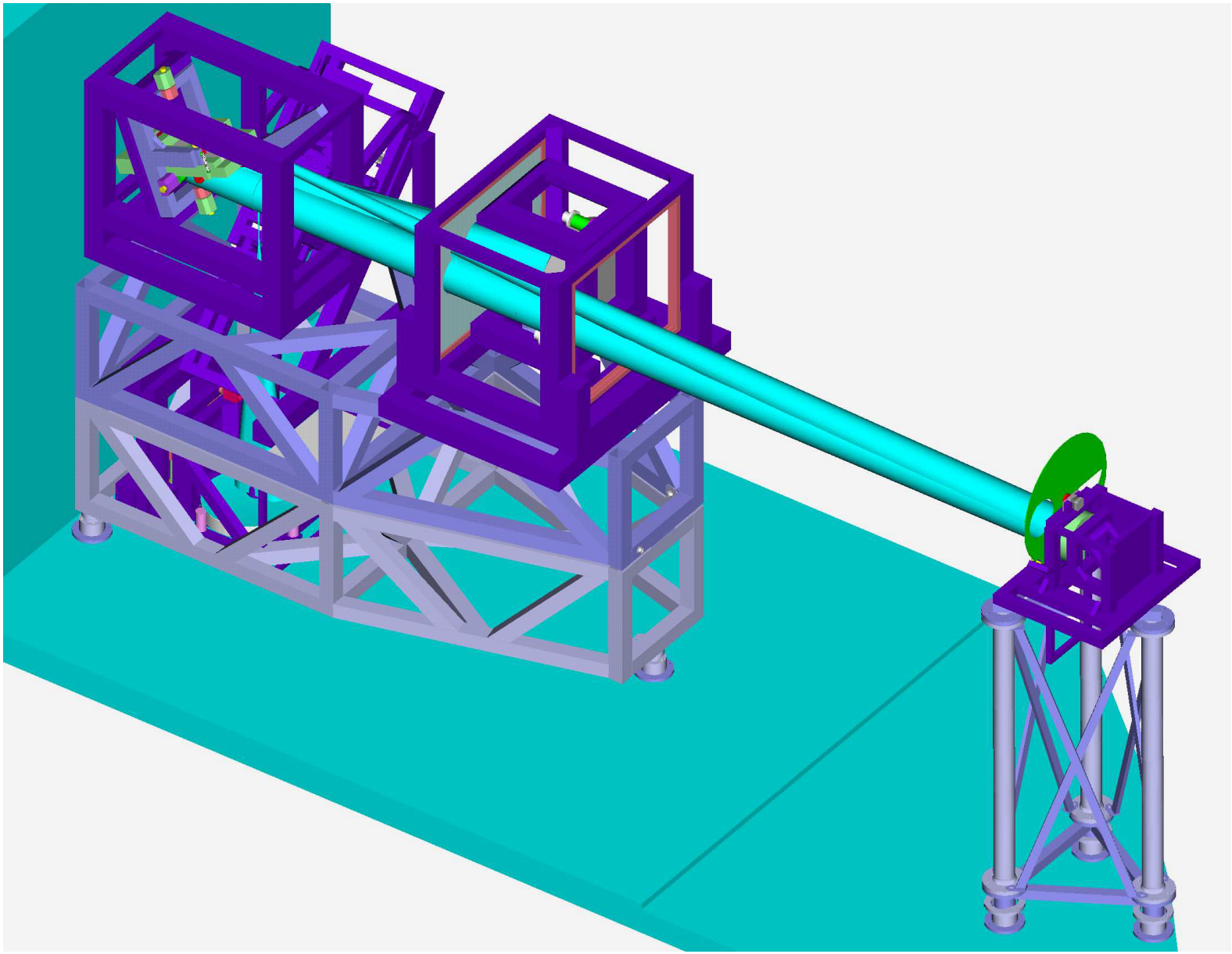
Echelle spectrograph OES

Astronomický ústav AV ČR

- 2k x 2k detector cooled by liquid nitrogen
- Wavelength coverage – 370-850 approx.
- R = 44000
- RV accuracy down to 10 m/s w. Iodine cell
- Limiting magnitude 13 (12,5 mag SNR 7 1.5hrs exposure)
- Iodine cell from Tautenburg
- Coude light path with 6 mirrors (light loss)

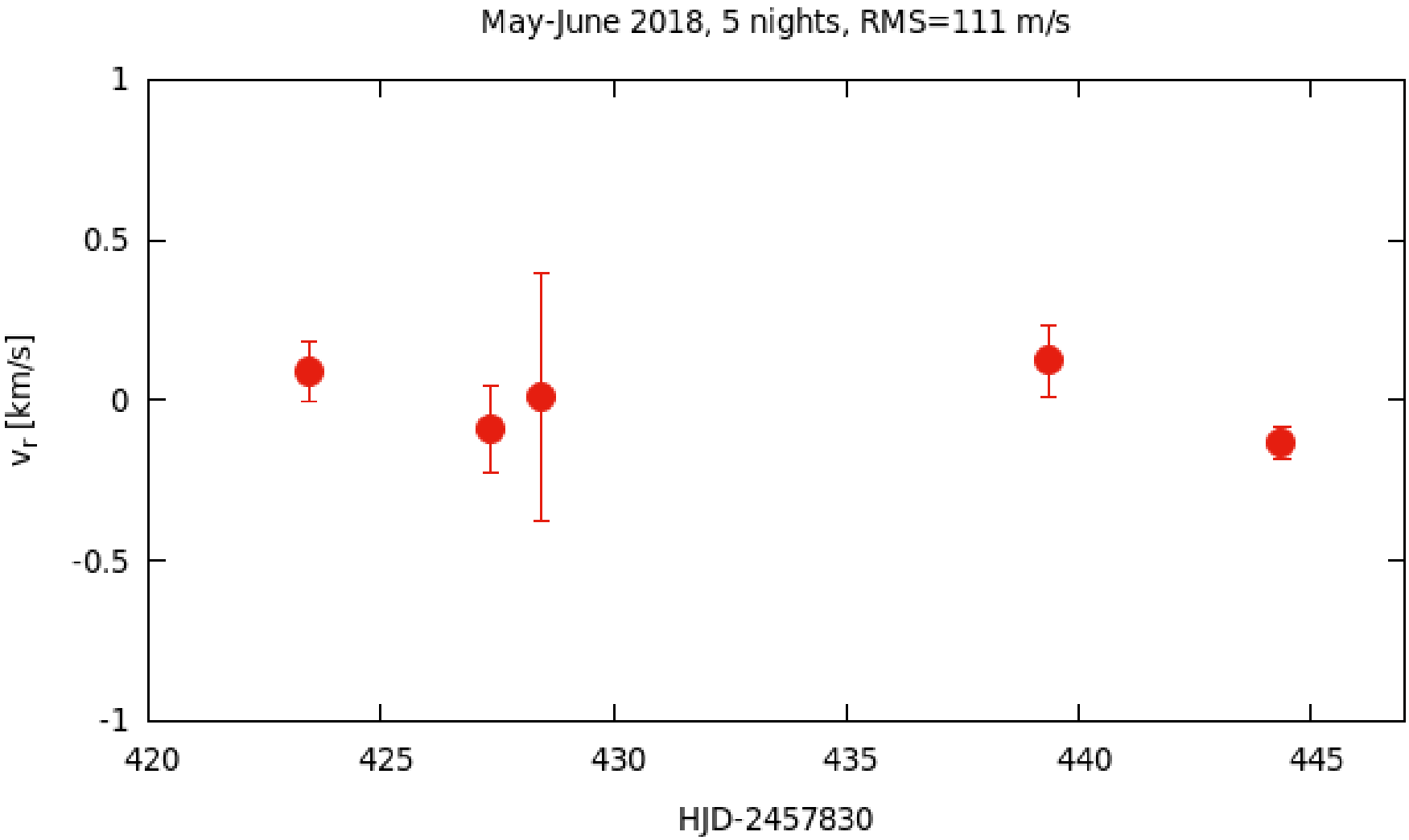
Astronomický ústav AV ČR

OES



From Koubsky et al. 2005

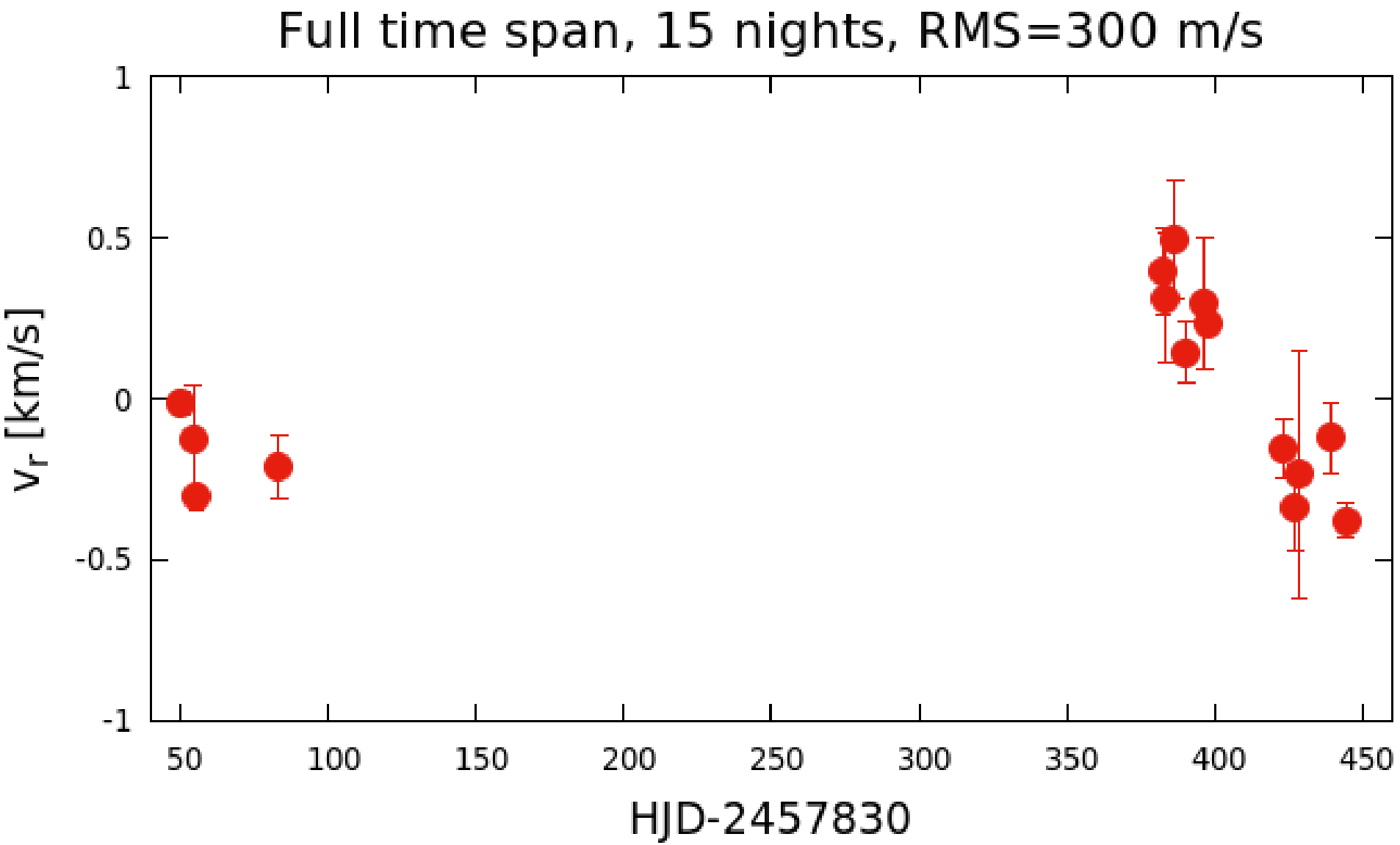
OES stability (nightly)



RVs below 100 m/s

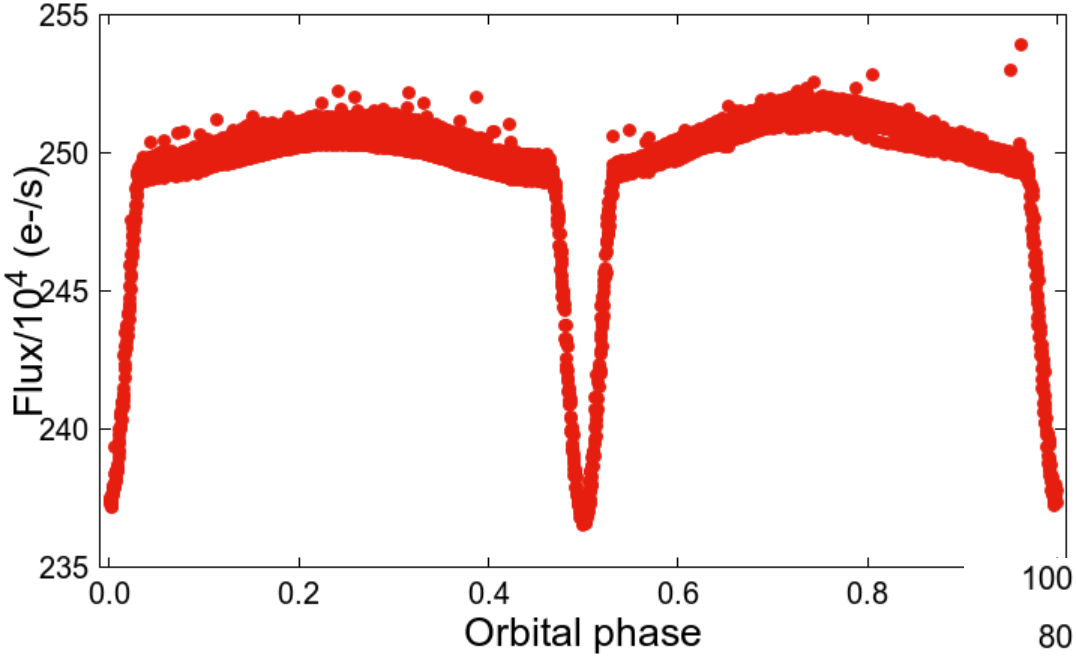
From Kabath et al in prep 2018

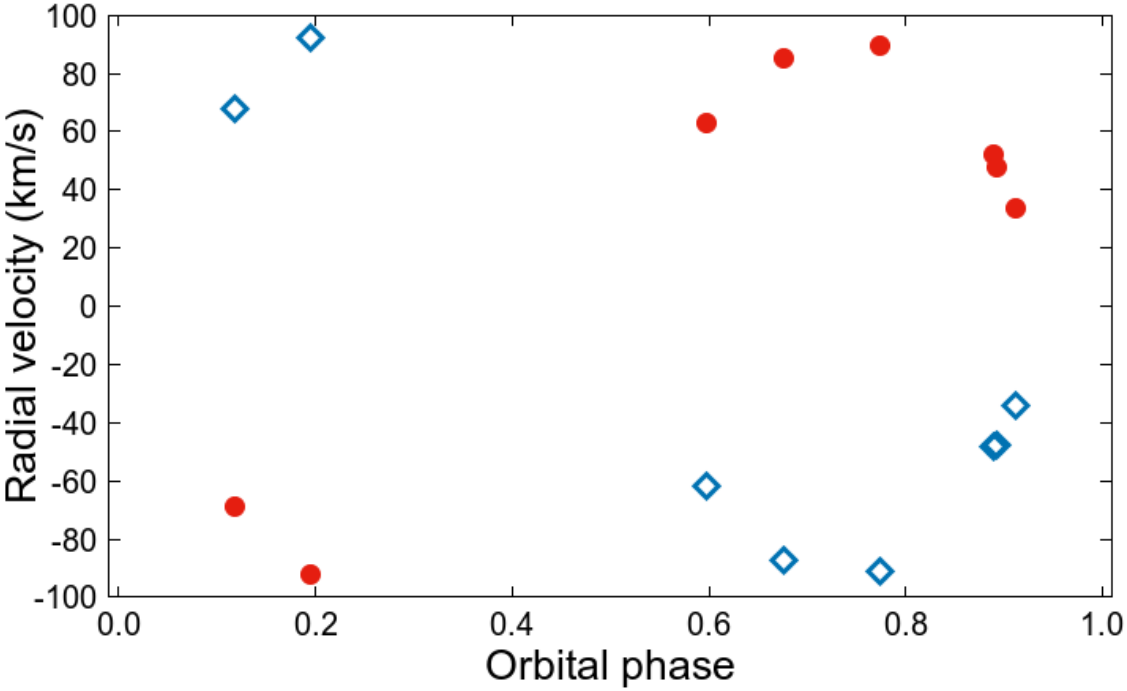
OES Stability (long)



From Kabath et al in prep 2018

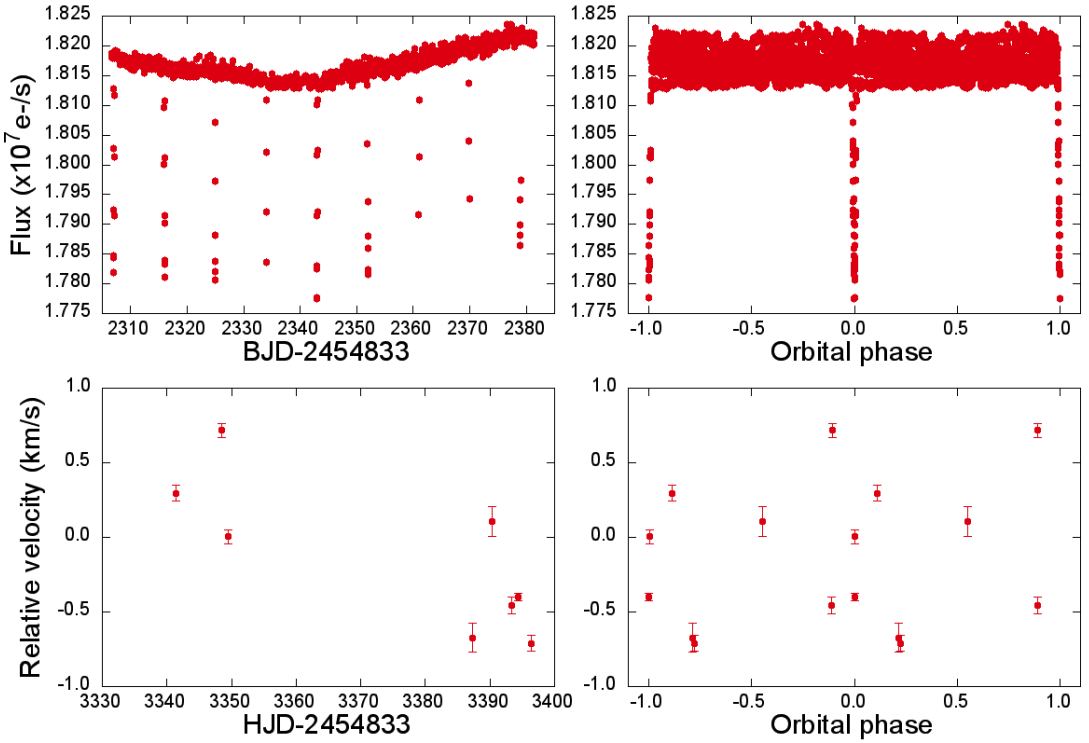
K2 examples

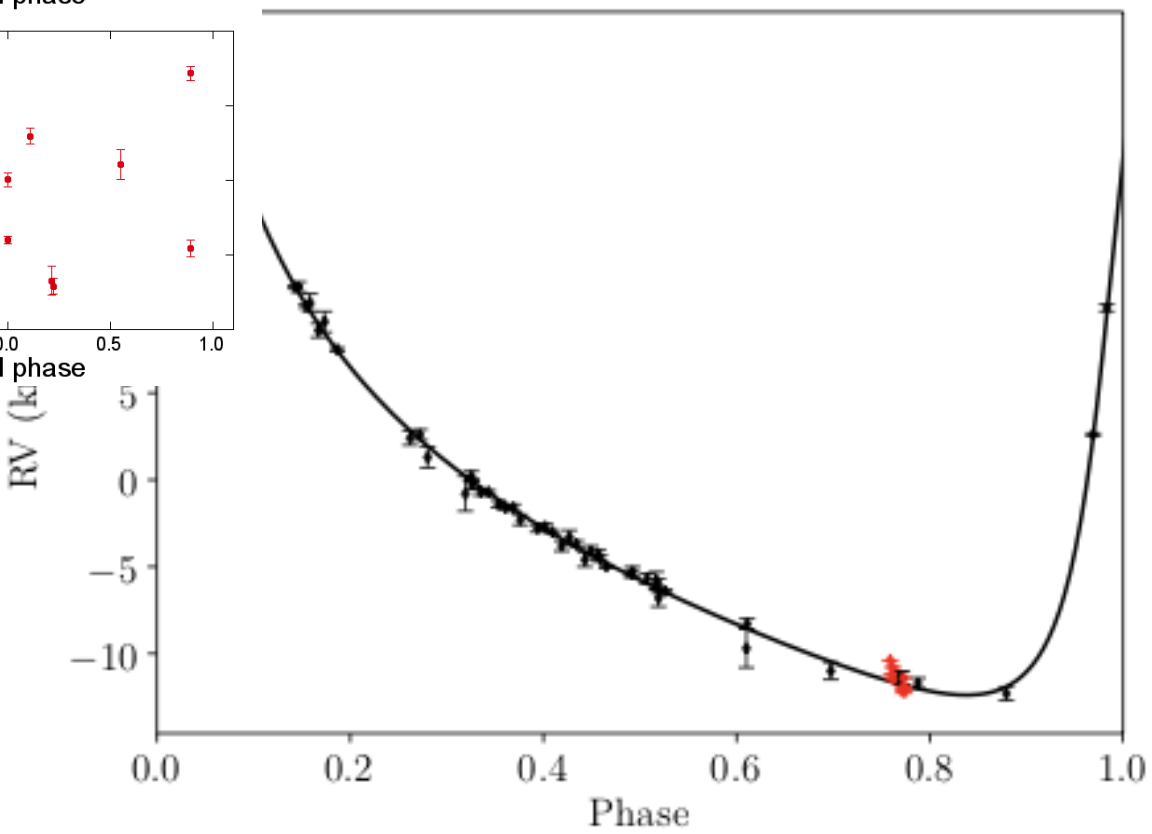




From Kabath et al submitted to AJ 2018

K2 candidates





Kabath et al. 2018

Observing program

- YES, WE CAN'T WAIT FOR TESS!!!

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

PLATOSpec Consortium

- Astronomical Institute of Czech Academy of Sciences
  (Petr Kabath)

- Thüringer Landessternwarte Tautenburg
  (Artie Hatzes)

- Universidad Católica de Chile
  (Leo Vanzi)

Plato Space mission

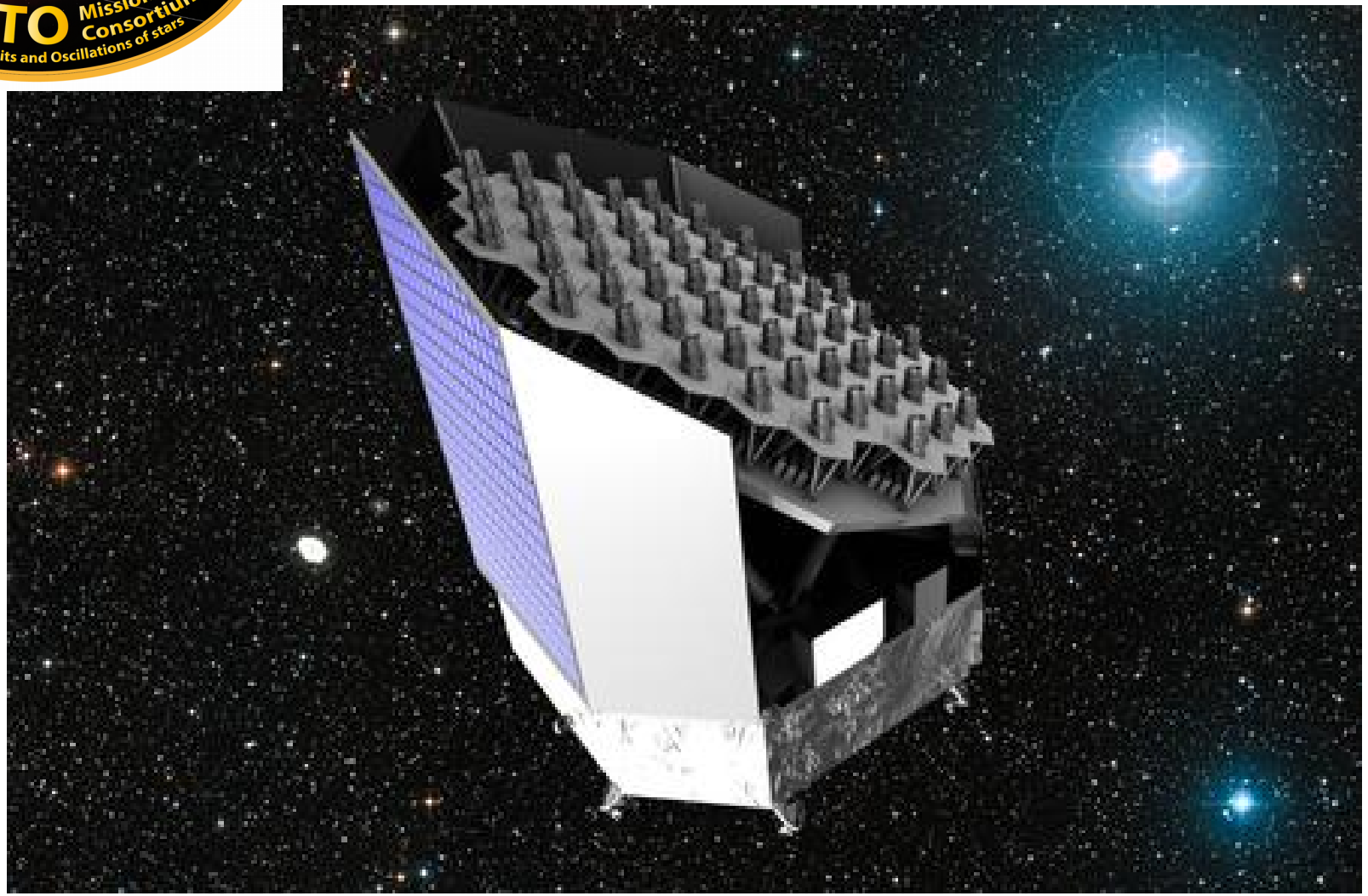


Fig.1: *PLATO Space mission is the motivation for PLATOSpec. PLATO will need large amount of ground based support. Credit: Thales Alenia Space*

PLATO Space mission

- Monitoring of 1 million bright stars
- Need for extensive RV follow-up
- ***Minimum*** 50 nights/year on 1-2 m facilities
- **Every spectrograph on a 1-2 m class telescope will be needed!**
- **PLATOSpec will have 365 – 10% of Chilean time available!**
- **Contribution to TESS space mission is foreseen too!**

PLATOSPec specs

- Stellar parameters
- Initial screening of candidates
- Rejection of false positives
- Characterization of hot Jupiters
- Exoatmospheres
- Asteroseismology
- Additional science

- RV measurements
  - accuracy 5-10 m/s
  - for stars 4-11 mag
  - SNR 30-40 in max. 1 hrs (est.)

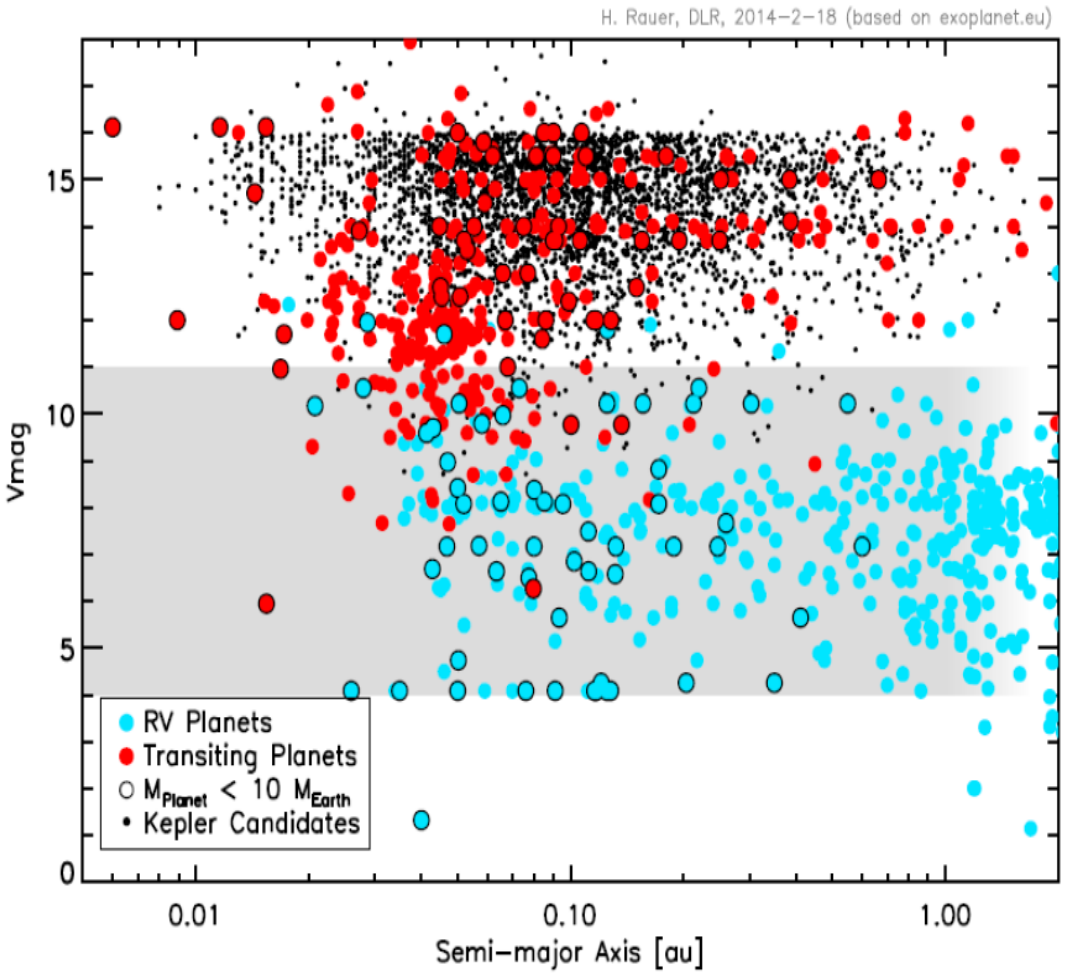
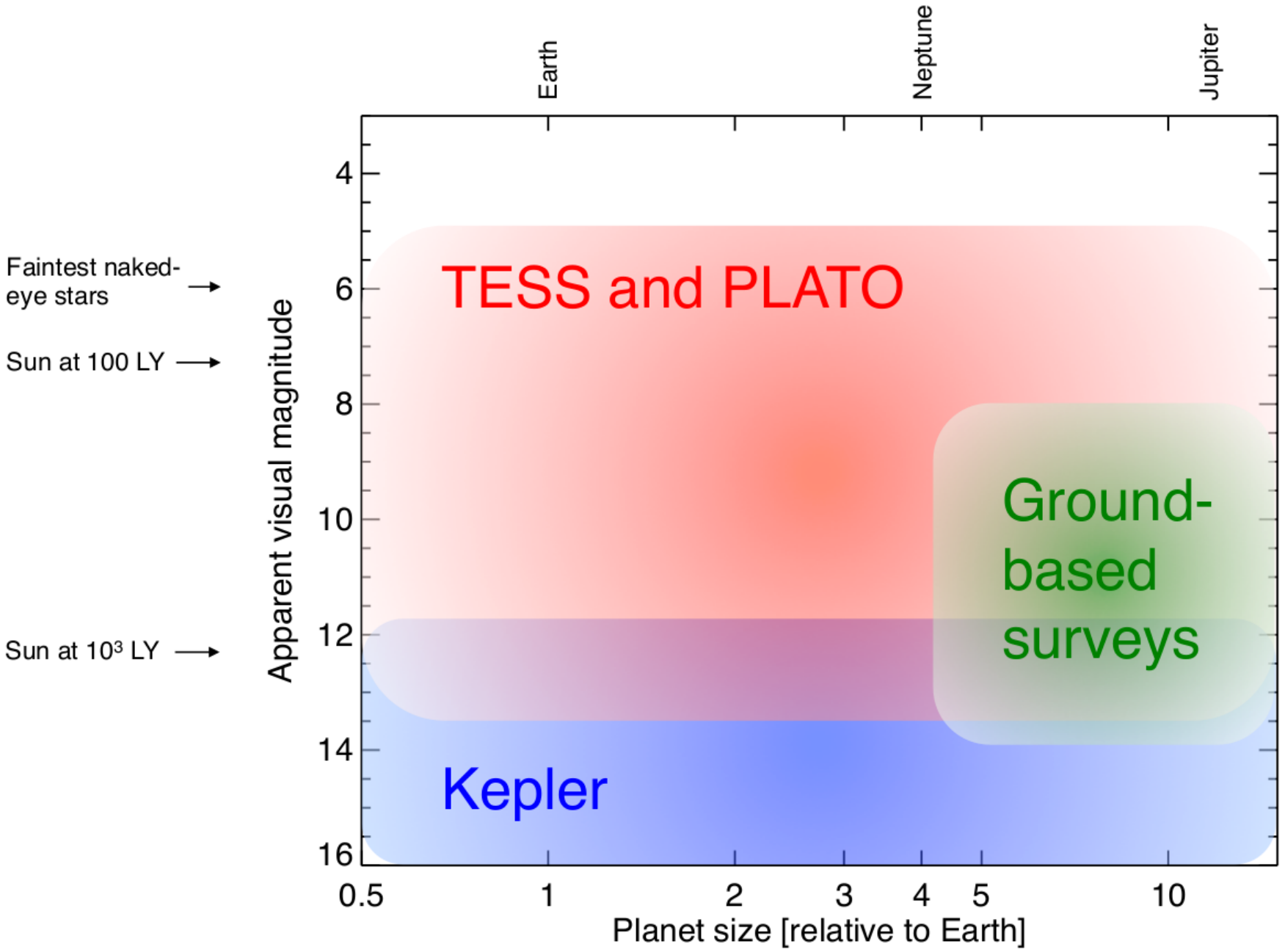


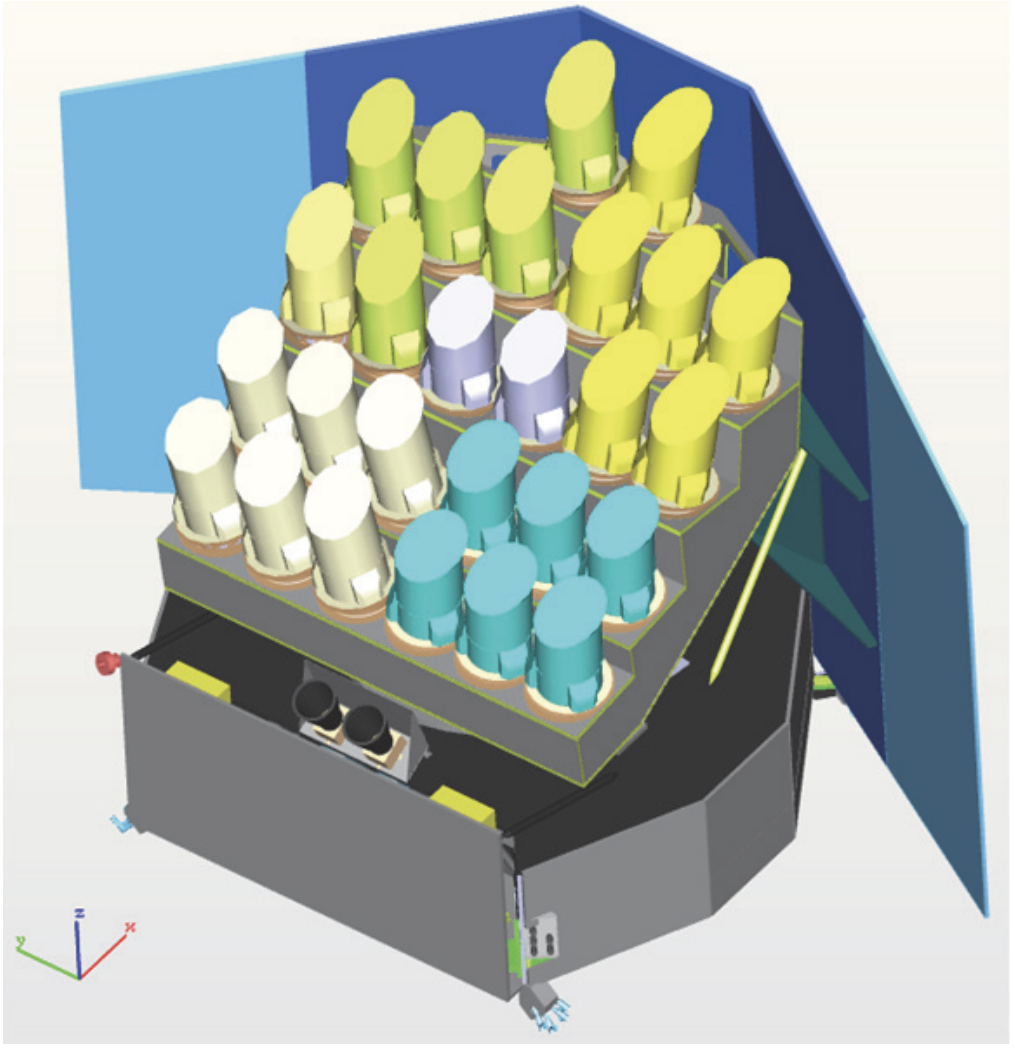
Fig. 2: *PLATO space mission will provide photometric measurements for about 1 million Stars in the grey area of the Figure. From Rauer et al. 2012*


Earth
Neptune
Jupiter
Faintest naked-eye stars
Sun at 100 LY
Sun at 10³ LY
Apparent visual magnitude
4
6
8
10
12
14
16
TESS and PLATO
Ground-based surveys
Kepler
0.5
1
2
3
4
5
10
Planet size [relative to Earth]

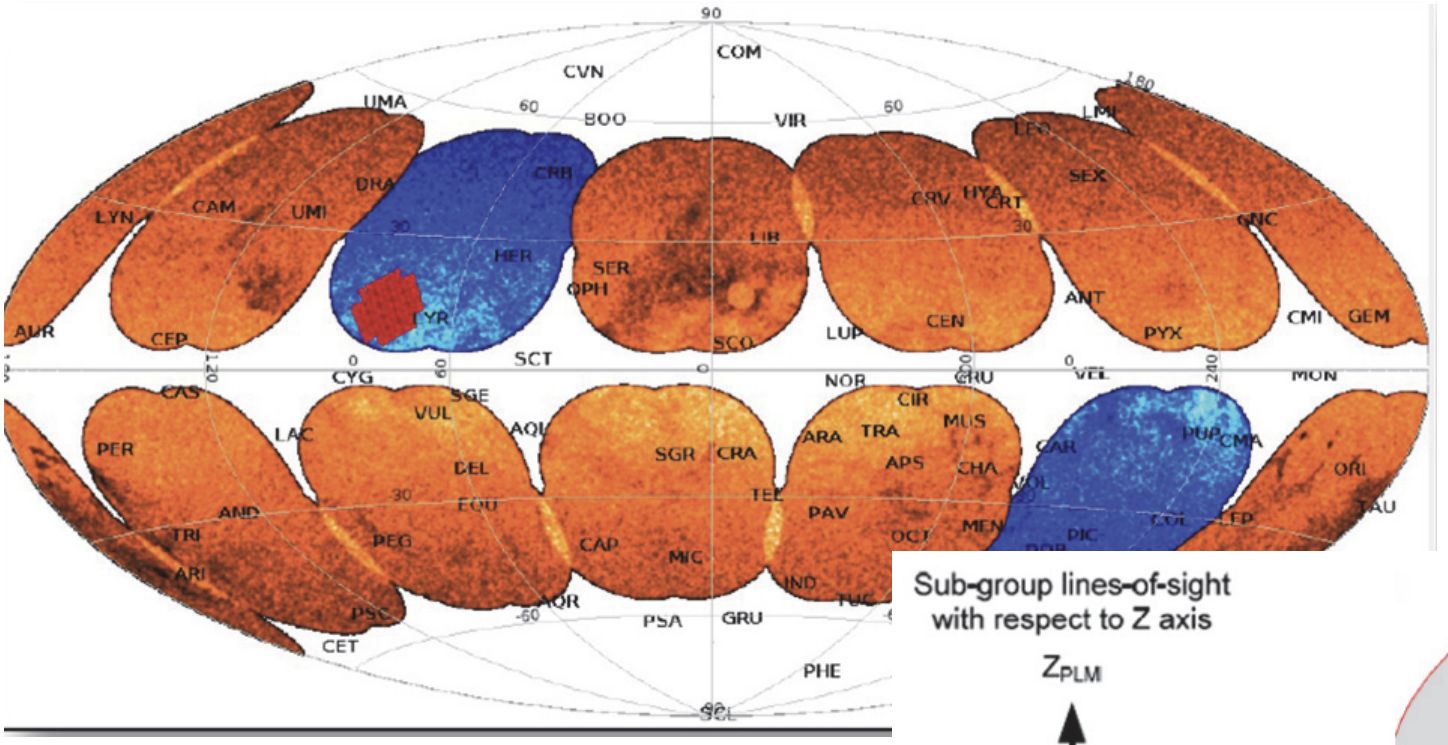
PLATO observing strategy

Observing strategy:

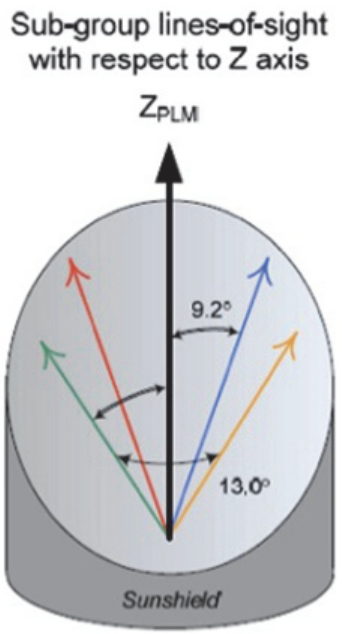
- Baseline: 2 long pointings of 2 years
- Alternative: 3 years + 1 year step-and-stare phase

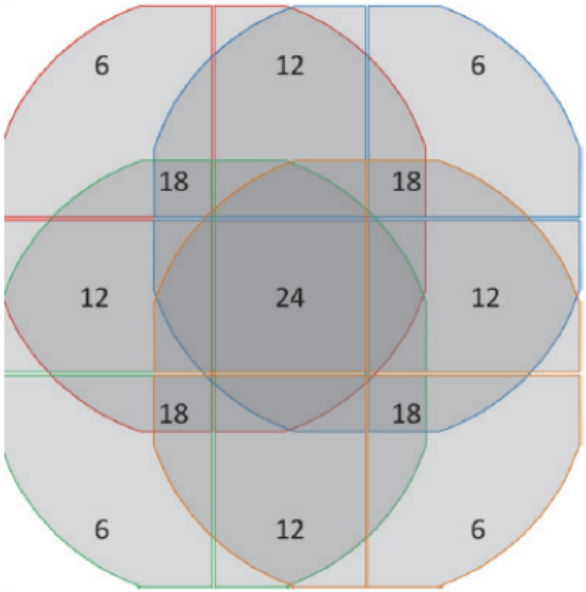


PLATO observing strategy



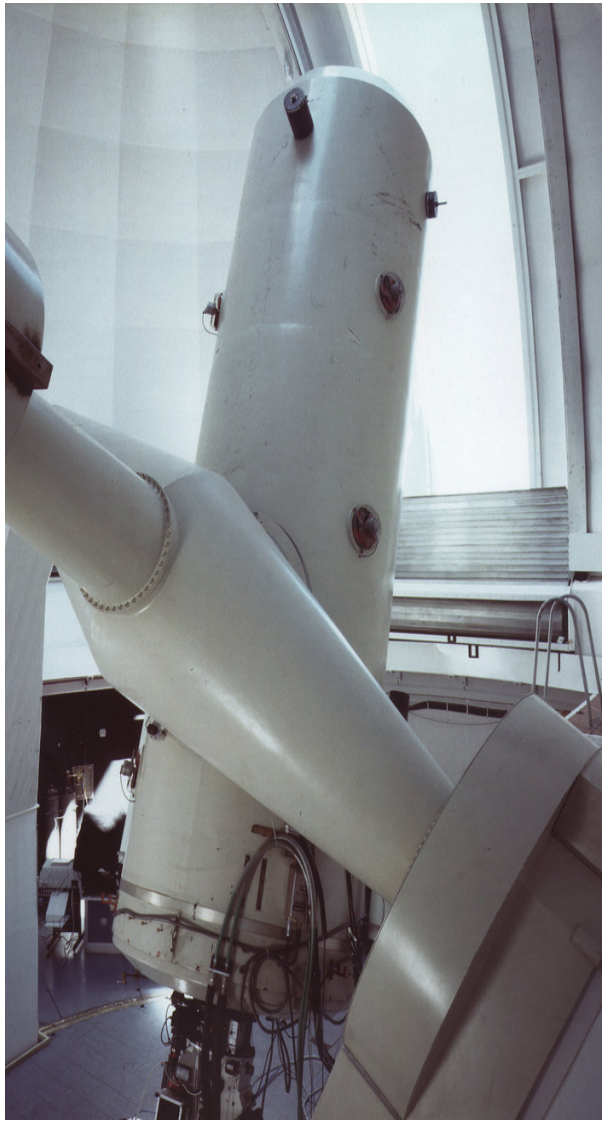
Approx 40% sky coverage





PlatoSpec

The Telescope

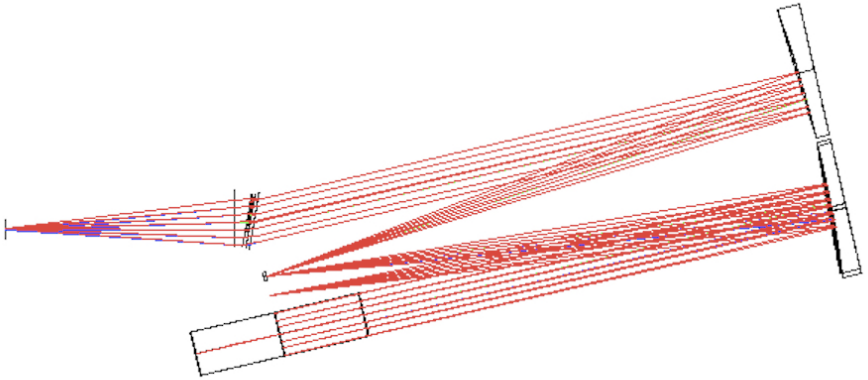


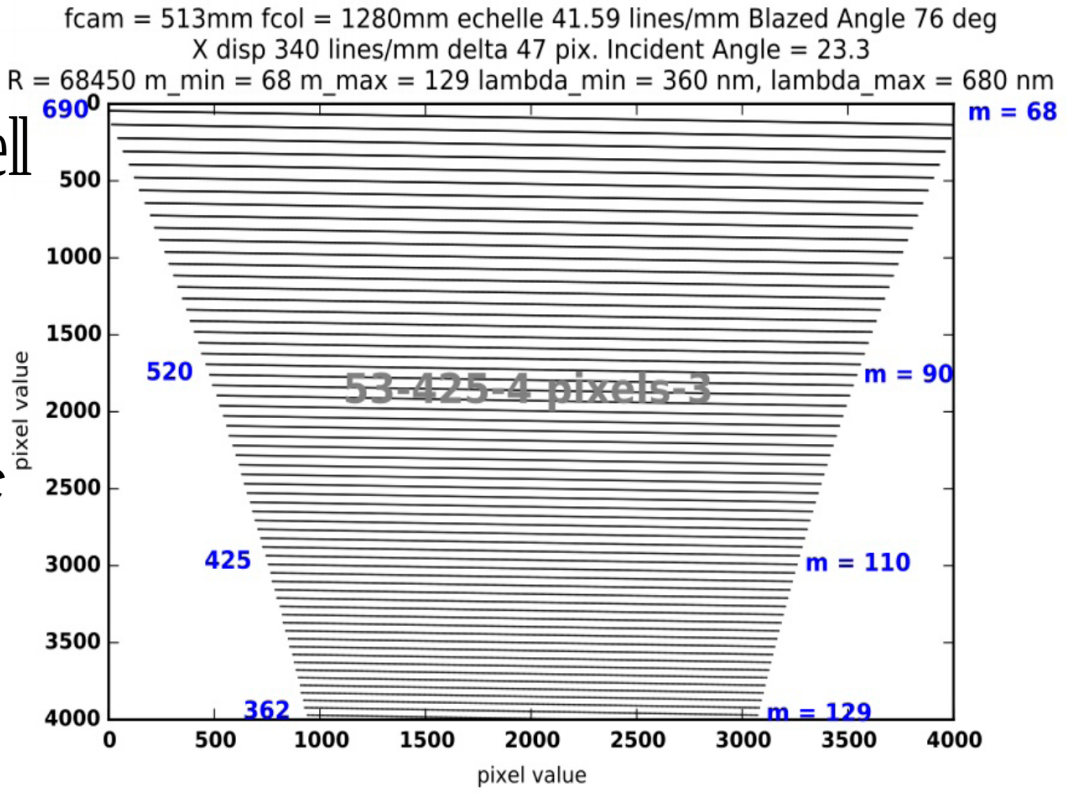
1.52-m former ESO telescope at La Silla

The instrument

Table 1: Main paramateres of the spectrograph

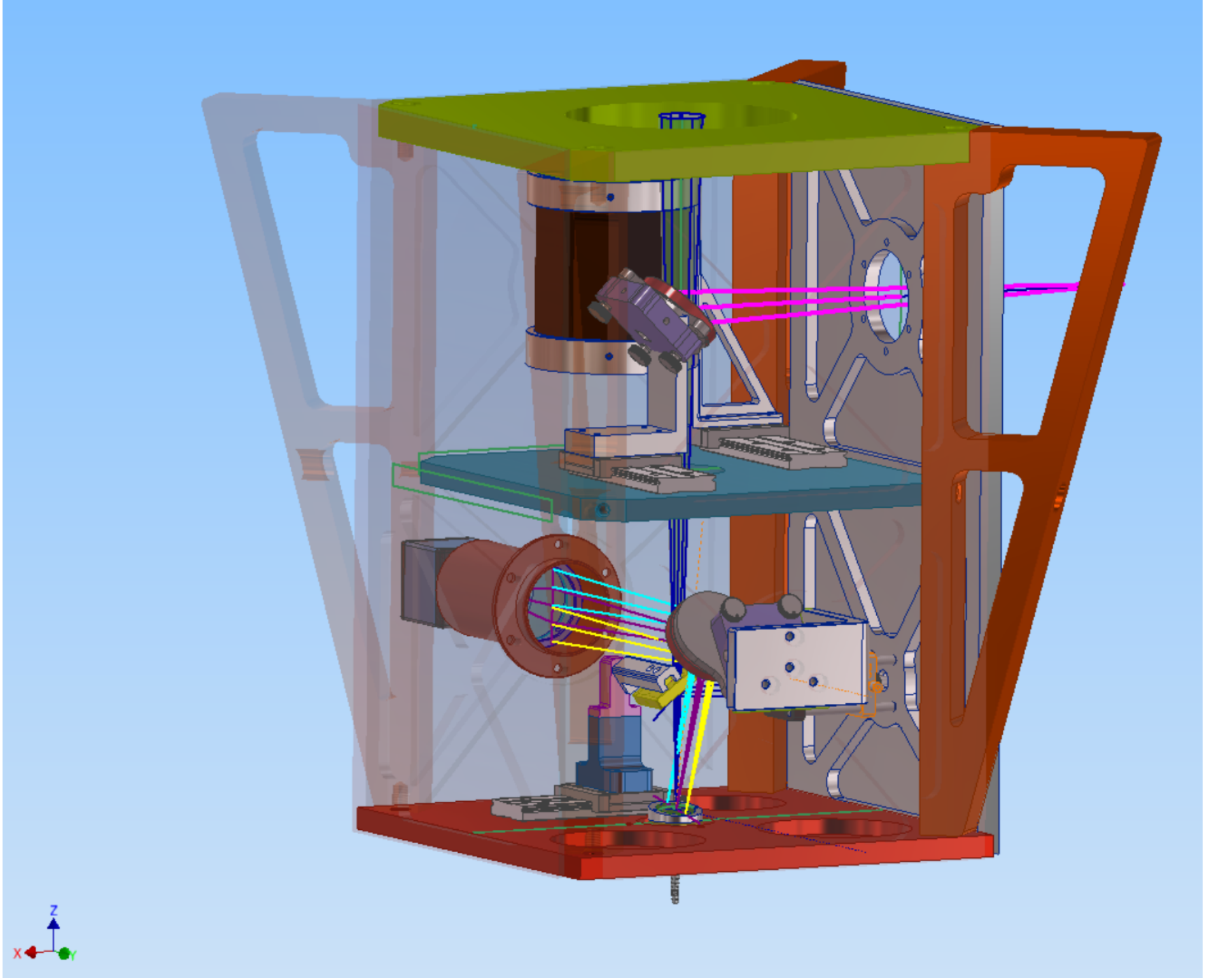
Echelle spectrograph	Parameter value
Wavelength coverage	360-680 nm
Spectral resolution	70k
Thermal stability	0.1deg
RV accuracy	3m/s
Calibration	ThAr+Iodine cell





Figures and Table from:

PLATO science justification report - ESO STC


Z
X
Y

The timeline and operations

- Operation is foreseen in remote/automatic mode
- Project should be operational from 2023 at least till 2033 and beyond!

Table 1	YEAR																			
	2017				2018				2019				2020				2021				2022			
PHASE	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Administrative			X	X	X	X	X	X																
Negotiation w ESO							X	X																
Instrument design				X	X	X	X																	
Funding proposals					X	X	X	X																
Instrument building										X	X	X	X	X	X	X	X	X	X	X	X	X		
Robotization/Dome											X	X	X	X	X	X	X	X	X	X	X			
Commissioning																				X	X	X		
Observing phase																							X	X

Current status

- ESO STC recommended PLATOSpec science program to the ESO Council as Hosted telescope in April 2018
- More info (clickable link):

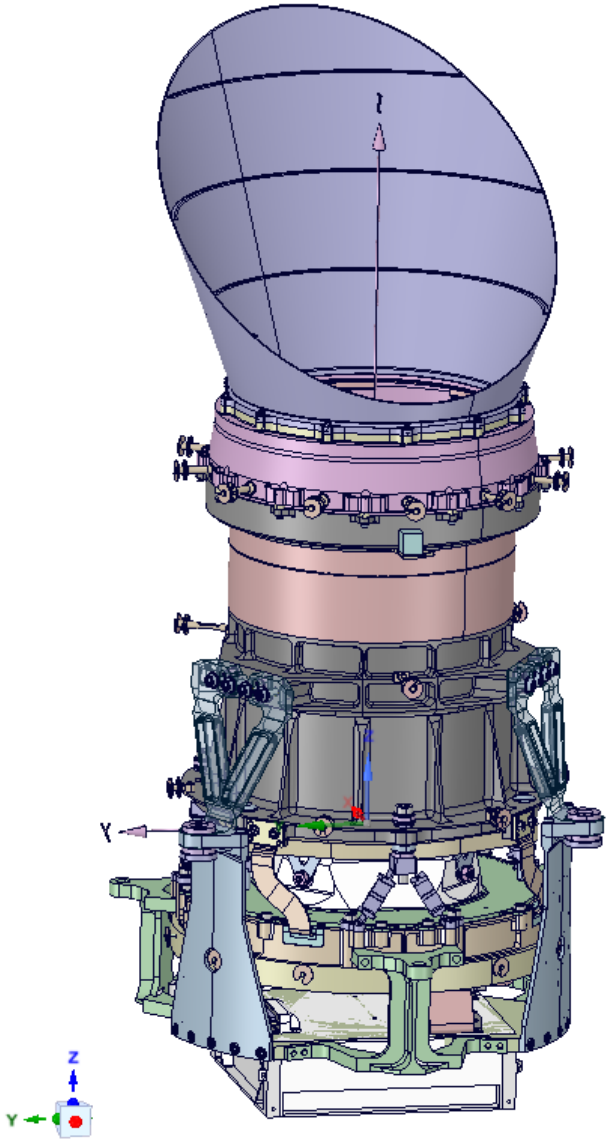
  STC Recommendation Text
- **Consortium agreement on the way**
- **Partner search for Consortium**
- **PLATOSpec workshop – AI, Ondrejov, CZ, 29.-30.10.2018**

  - more info: https://stelweb.asu.cas.cz/plato/index.html (events TAB)

Czech contribution to PLATO?

- PRODEX proposal
- Software development to analyze the data from PLATO
- Camera transport containers

PLATO camera



What comes next?

- CZ contribution is being defined
- Leaders: ÚFCHJH S. Civis and M. Ferus
- For AsU Kabath

Elliptical primary mirror:Â 1.1 x 0.7 metres

Conclusions

- We have 2-m class telescope with an Echelle spectrograph close to Prague which can observe for 80-120 nights a year (10 m/s)
- We will have a PLATOSpec in Chile on 1.52-m telescope which will be able to observe about 310 nights a year (few m/s)!
- PLATOSpec will be sensitive in blue
- Long term monitoring will be possible
- PLATO Consortium application on the way!
- ARIEL Consortium contribution planned!
- Interested students, feel free to contact us!