

# Exoplanety v éře mise PLATO AV21



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12.11.2021

# Exoplanets as a topic for AV21

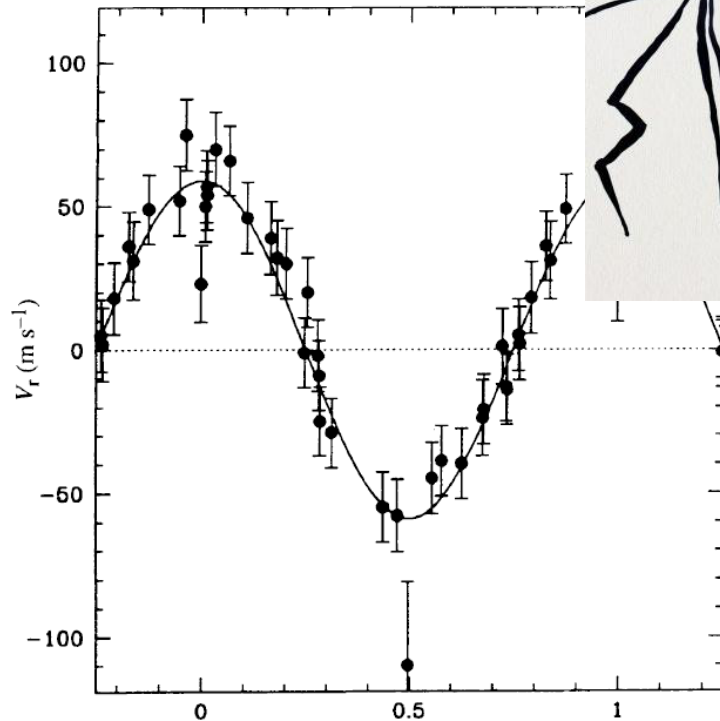
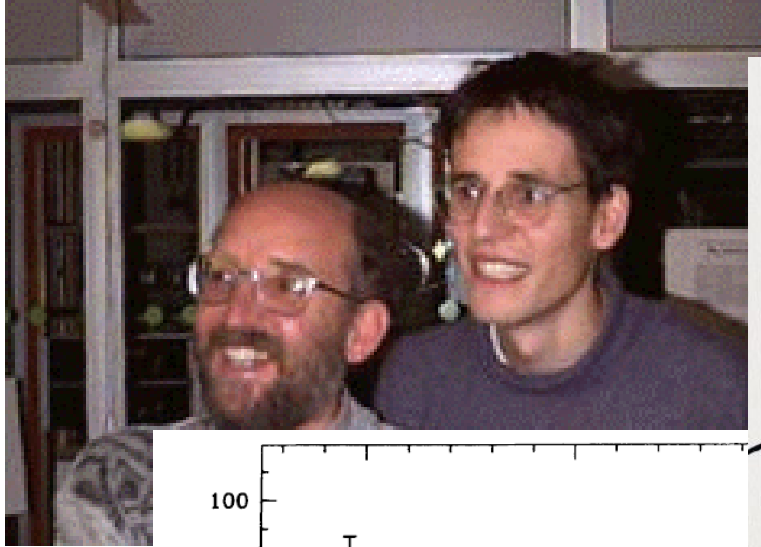


Image from Mayor and Queloz, 1995, Nature

# Main questions

- Physics Nobel Prize winning theme ( $1/2$ )
- Detection of the first exoplanet around a Sun like star
- Seeking for our place in the Universe
- In the Czech Republic there was no working group on the new topic

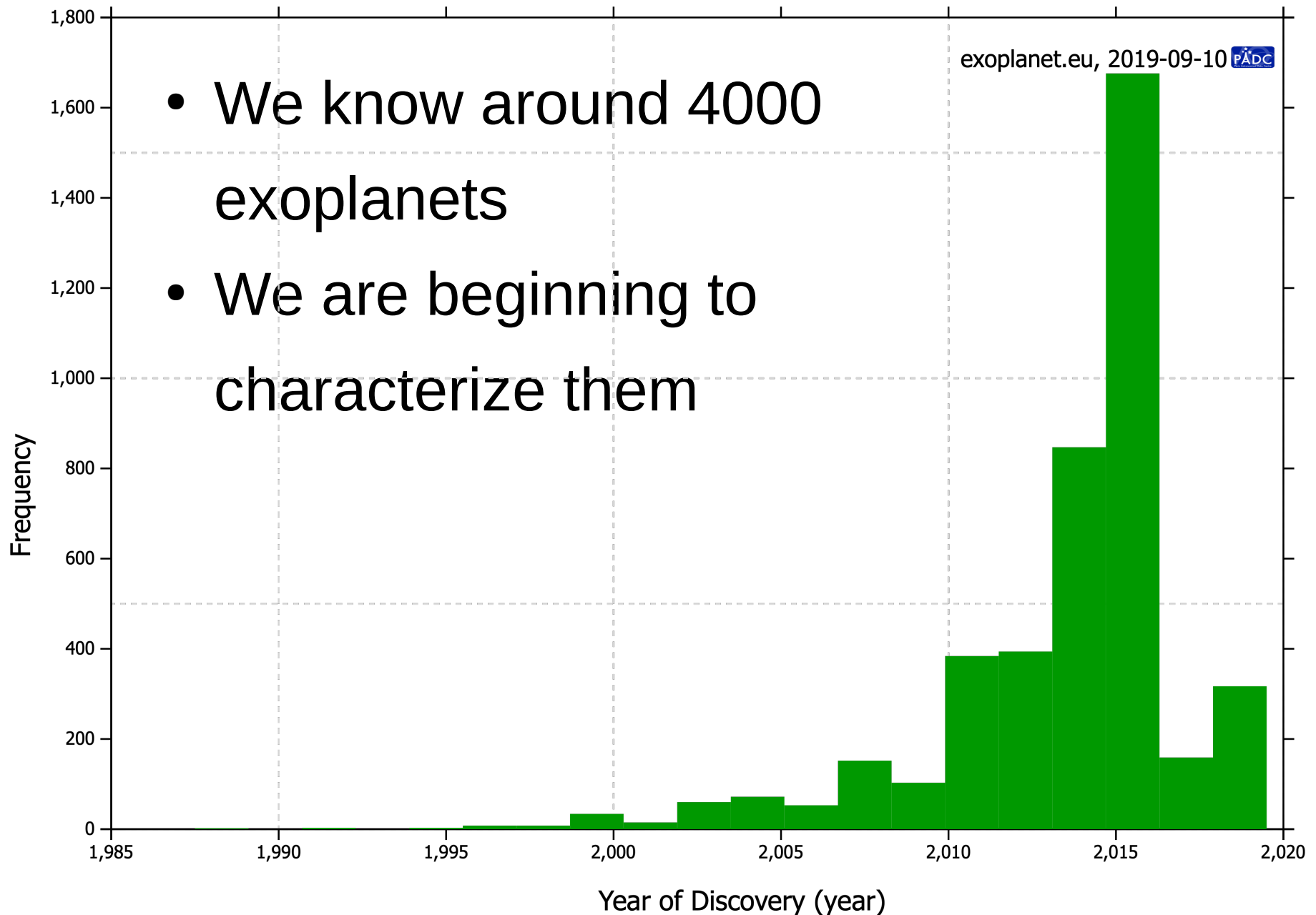
# Exoplanetary Science Questions

- We are eager to understand statistical distribution of exoplanets in the Universe
- How do exoplanetary systems evolve?
- How do exoplanets compare to the Solar system?
- Uniqueness (or not) of our Solar system
- Life in the Universe



# Where are we now?

- We know around 4000 exoplanets
- We are beginning to characterize them

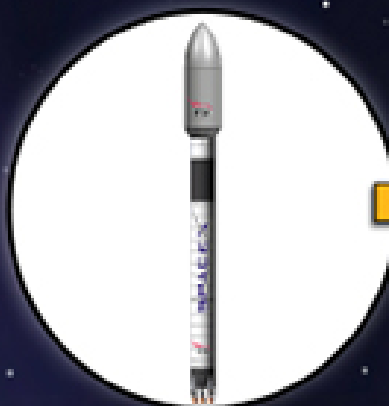


# TESS



## Transiting Exoplanet Survey Satellite

### Launch Vehicle



- SpaceX Falcon 9 v1.1
- High Earth Orbit (HEO)
- 2:1 Resonance with Moon's Orbit

### Observatory



- Orbital LEOStar-2
- Instrument-in-the-loop attitude control

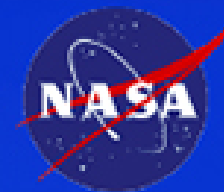
### Science Instrument



- Four Wide Field-of-View CCD Cameras
- 24°x 24° Field-of-View
- Well defined spacecraft interfaces

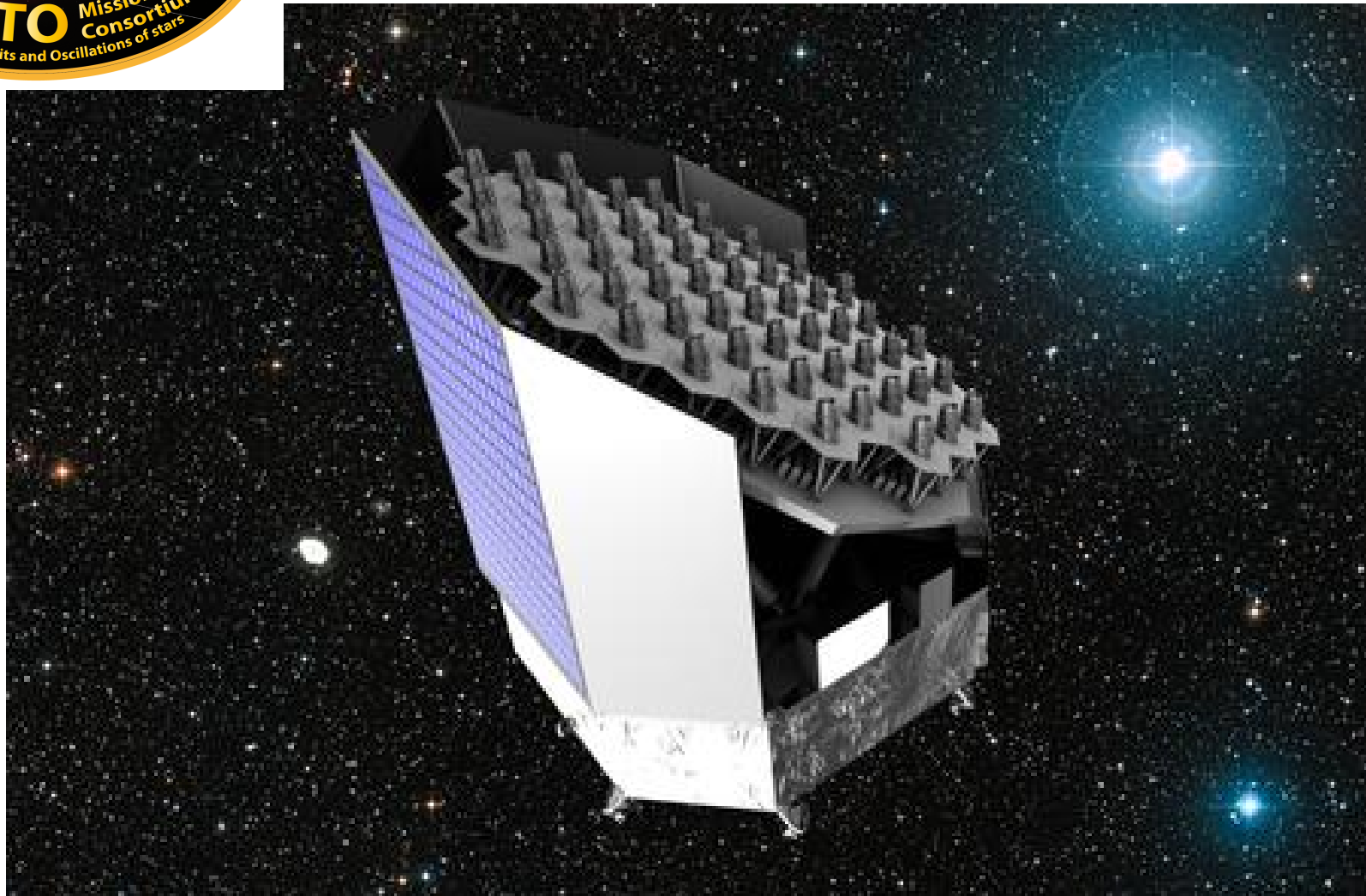
## Project Overview

- Transiting exoplanet discovery mission
- 2 month Commissioning period
- 2 year all-sky survey (3 year science mission)
- Identifies best targets for follow-up characterization
- Deep Space Network (DSN) primary support
- Category II, Class C
- Planned Launch Readiness Date: August 2017
- PI Cost Cap: \$228.3 M (RYS)





# Plato Space mission



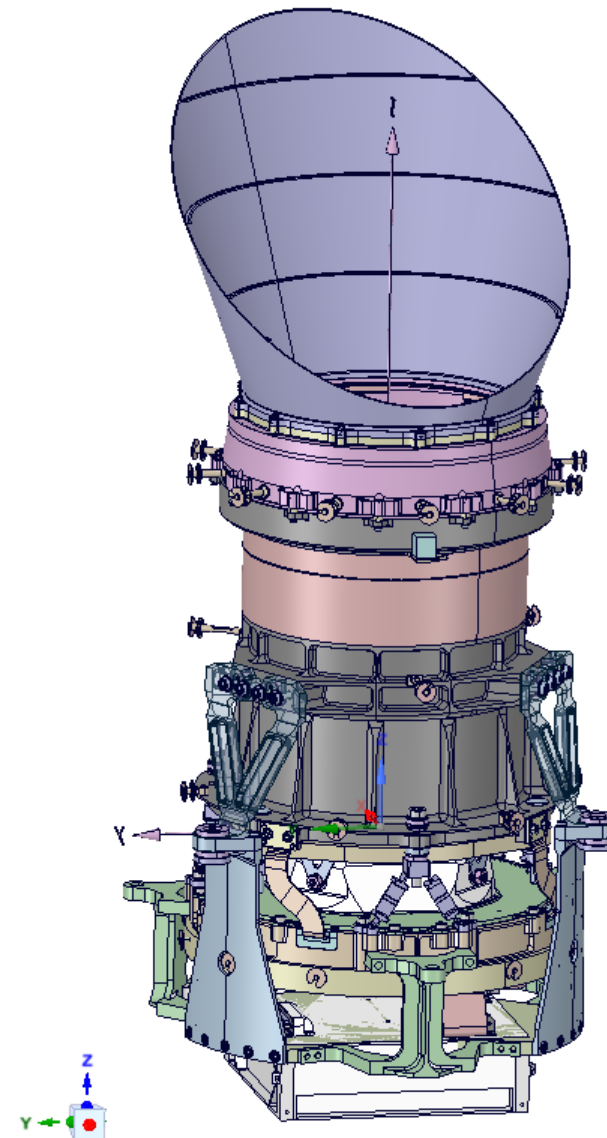
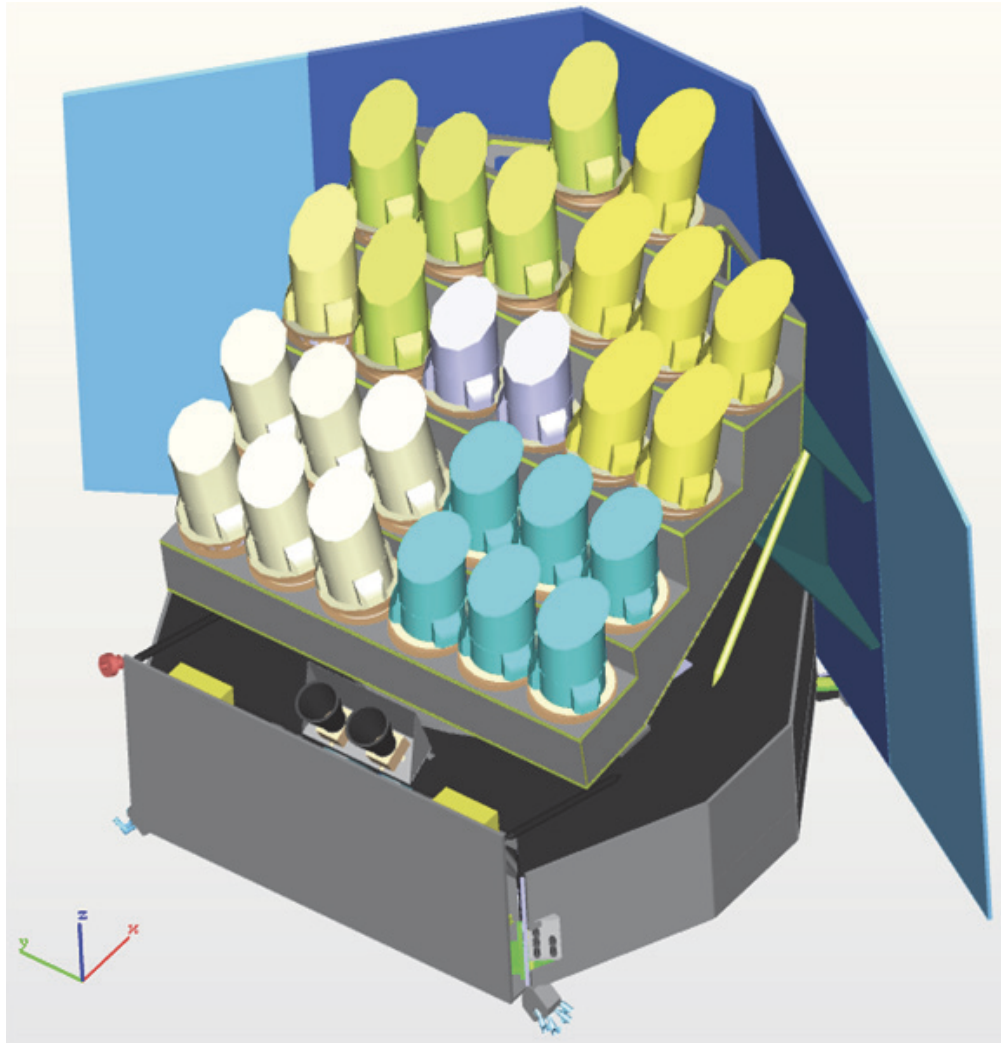
**Fig.1:** *PLATO Space mission is the motivation for PLATOSpec. PLATO will need large amount of ground based support. Credit: Thales Alenia Space*



# PLATO Space mission

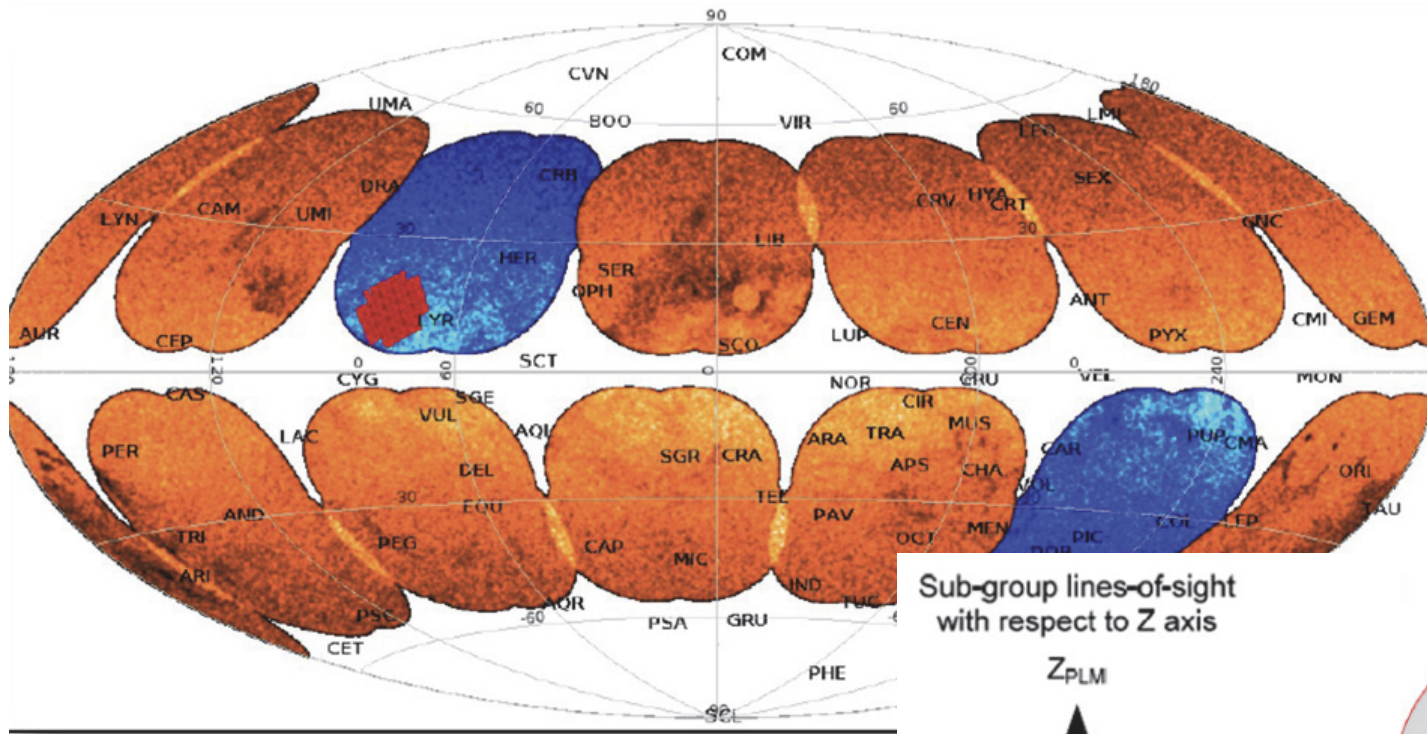
- Monitoring of 1 million bright stars
- Need for extensive RV follow-up
- *Minimum* 50 nights/year on 1-2 m facilities
- **Every spectrograph on a 1-2 m class telescope will be needed!**
- **Thousands of planets in total**
- **Earth-sized planets**
- **Launch 2026**

# PLATO setup

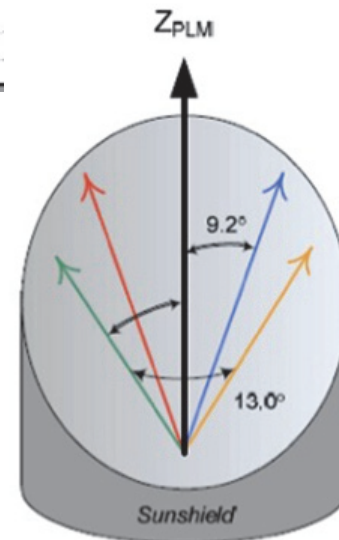




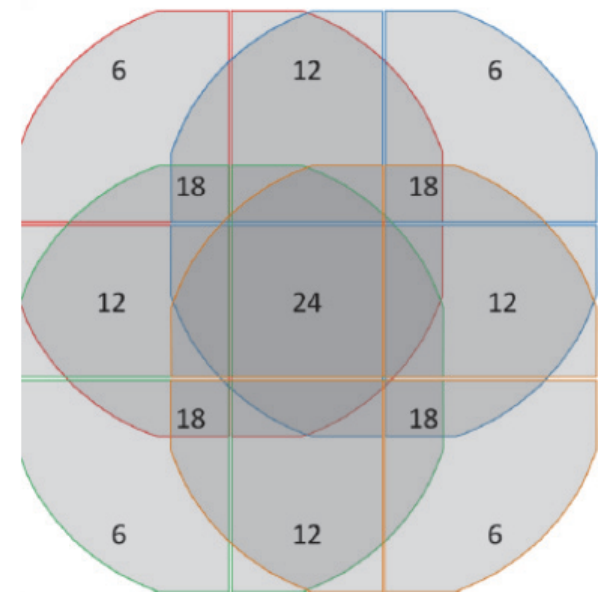
# PLATO observing strategy



Sub-group lines-of-sight with respect to Z axis



Approx 40% sky coverage



# Participation in Ariel

- CZ contribution is being defined
- Leaders:  
ÚFCHJH  
S. Civis and  
M. Ferus
- P. Kabath and  
R. Karjalainen is in  
WG Stellar charac.



Elliptical primary mirror: 1.1 x 0.7 metres



# The need for a robust ground based segment

- On a smaller telescope?
- Initial screening, false positives 2x20 minutes
- Now let`s count:

Number of stars X 40 minutes = hundreds of days (clear days!!!)

- I guess the answer is YES there is a huge need for new instruments!

# Exoplanets Research Group

- **AsÚ Ondřejov**

P. Kabáth (head), M. Skarka, M. Karjalainen, R. Karjalainen

T. Klocová (maternity)

M. Blažek (Phd student), J. Šubjak (Phd student),

M. Špoková (Phd student),

D. Dupkala (Msc. student), J. Žák (Msc. student),

J. Dvořáková (observer), A. Grigerová (Bsc. student)

- **Collaborations**

**Prof Artie Hatzes (TLS), Dr. Eike Guenther (TLS),**

**Prof. Heike Rauer (DLR), Dr. Henri Boffin (ESO),**

**Dr. Valentin Ivanov (ESO), Dr. David Jones (IAC),**

**Dr. Paul Beck (Graz), Prof. Leo Vanzì (PUC),**

**Dr. Marie Karjalainen and Dr. Raine Karjalainen (IAC)**



European  
Southern  
Observatory

[www.eso.org](http://www.eso.org)



# It is all about people!

- Huge amount of work done by the observers/technicians:

*Eva Kortusová, Luděk Řezba, Jan Sloup, Jan Fuchs, Radek Novotný, Jiří Zeman*

- Help with presentation of our results:

*Pavel Suchan*

- Thanks to all of you!



And instrumentation

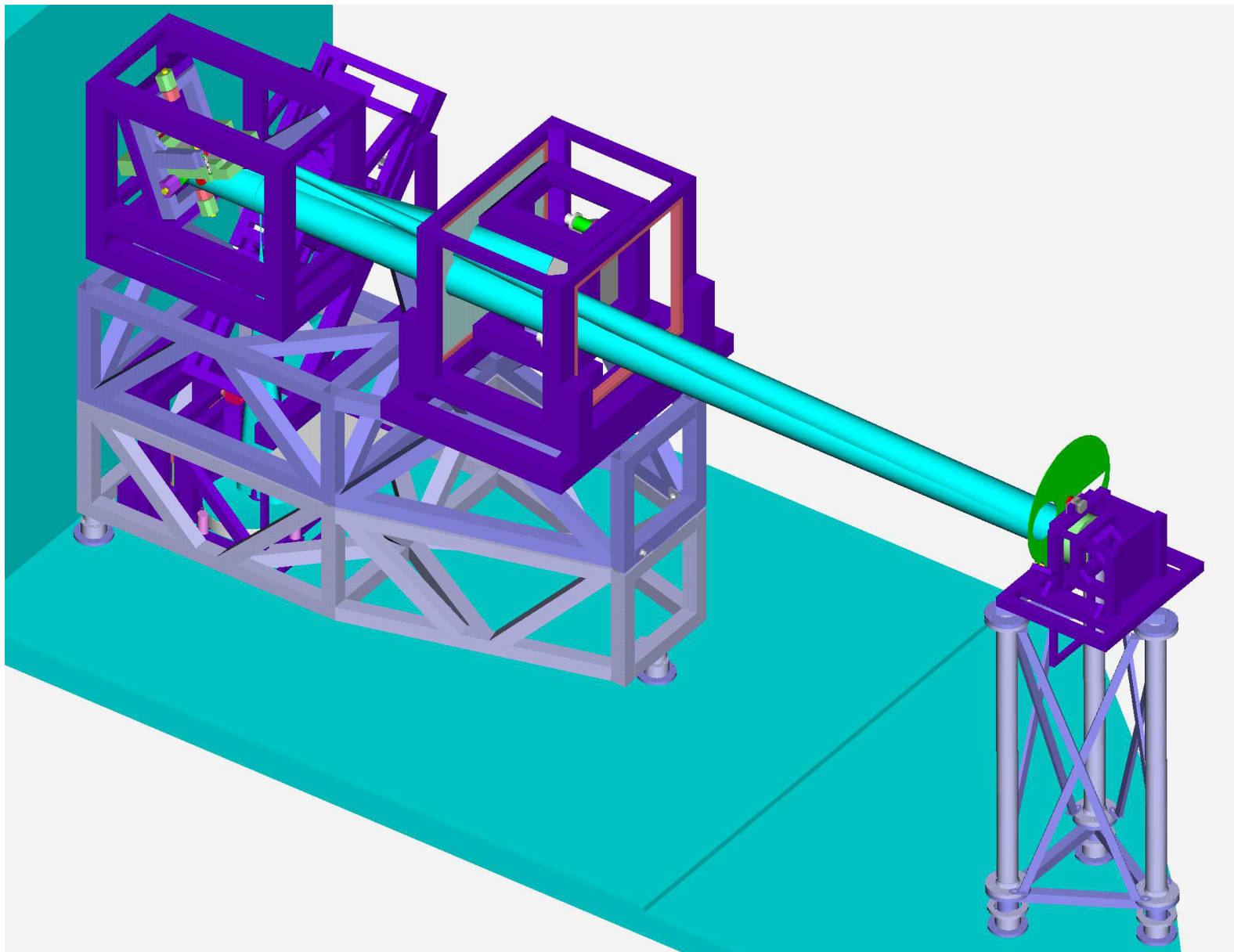


# Echelle spectrograph OES

- 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)
- 2019 upgrade to fiber fed spectrograph

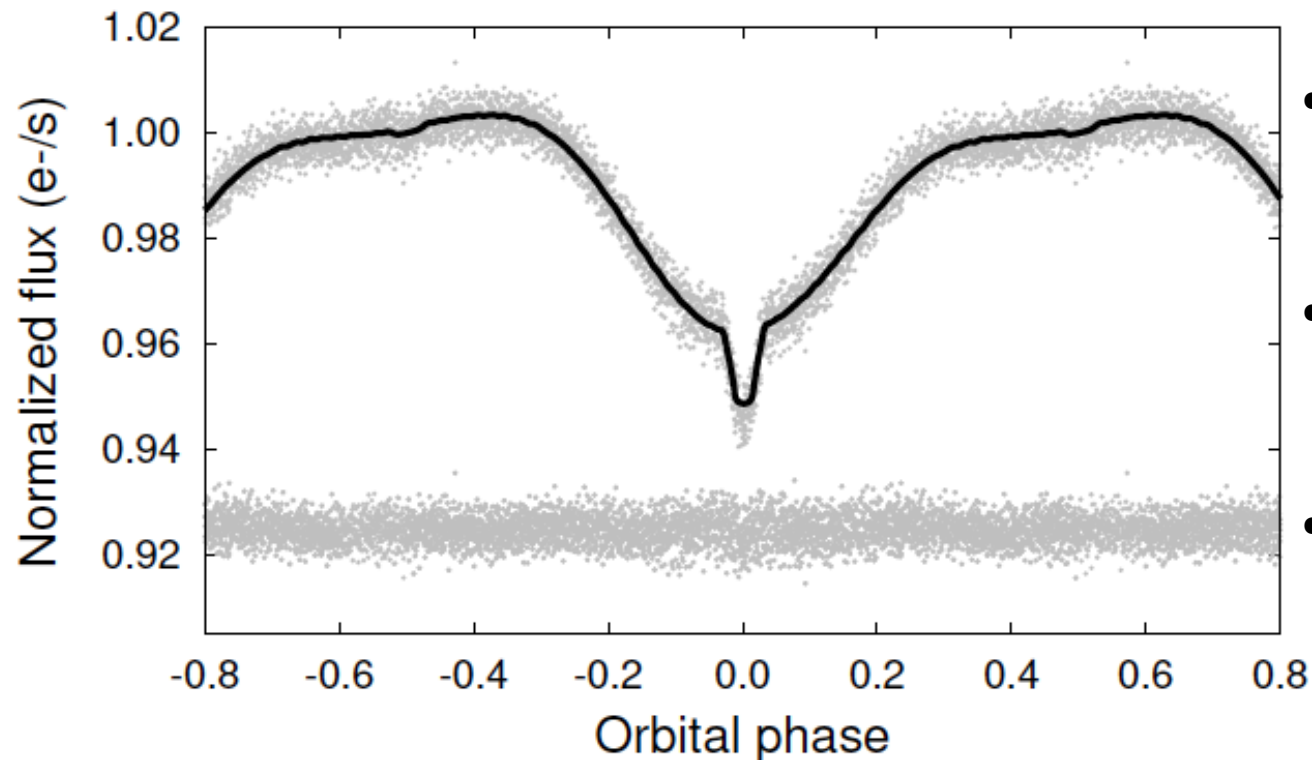


# OES



From Koubsky et al. 2005

# Intriguing system?

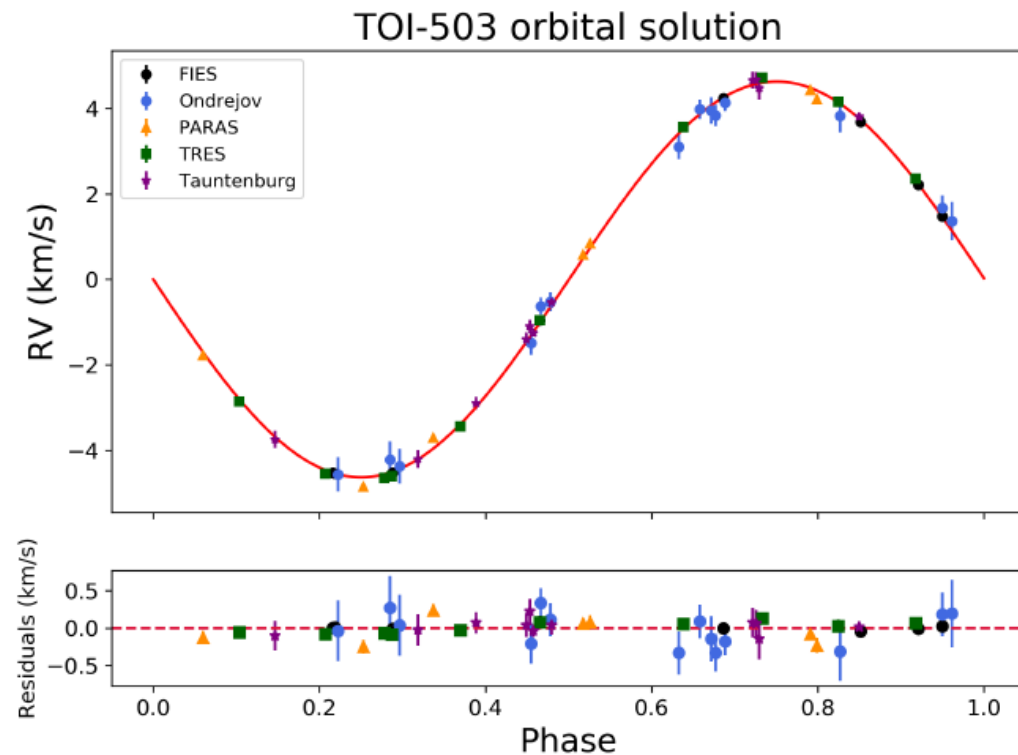
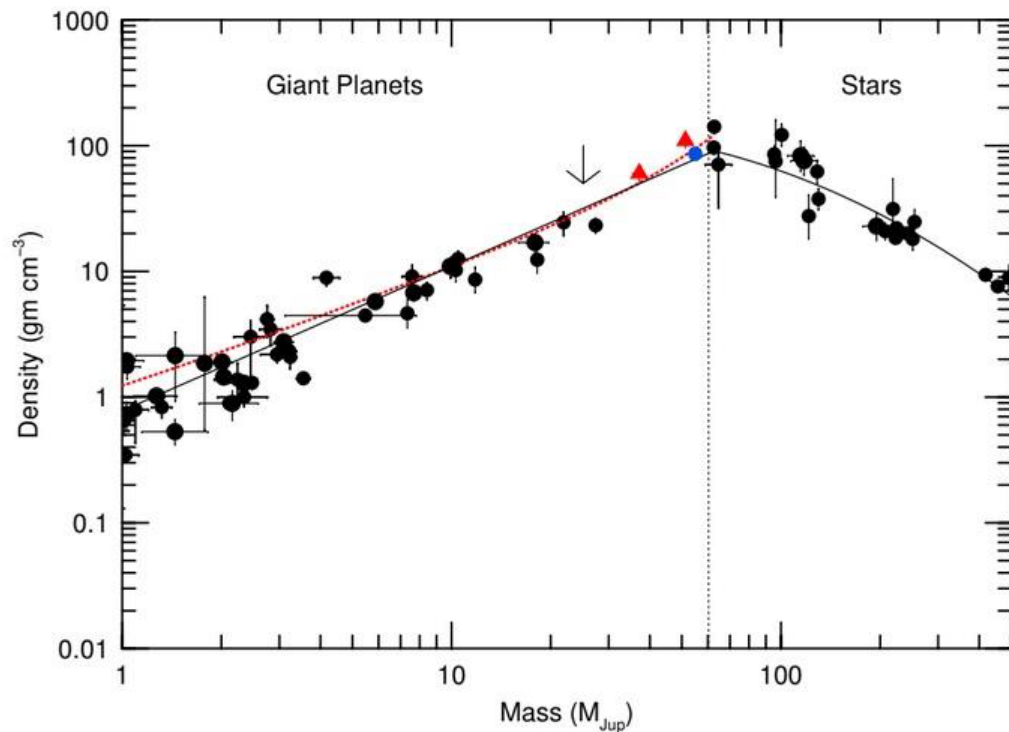


- Kepler candidate for Jupiter-sized planet
- Observing with OES and at Stará Lesná, SK
- Short period binary, magnetic star with DSCT pulsations and spots
- NO EXOPLANET



# First Brown Dwarf from Ondřejov

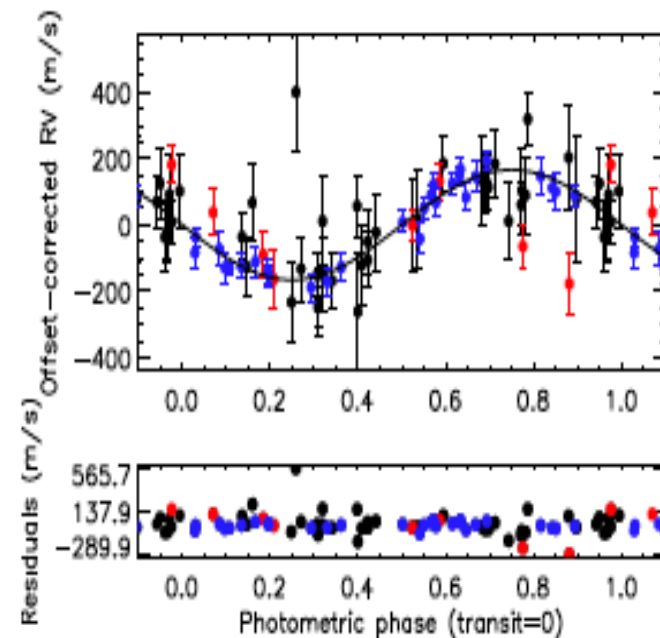
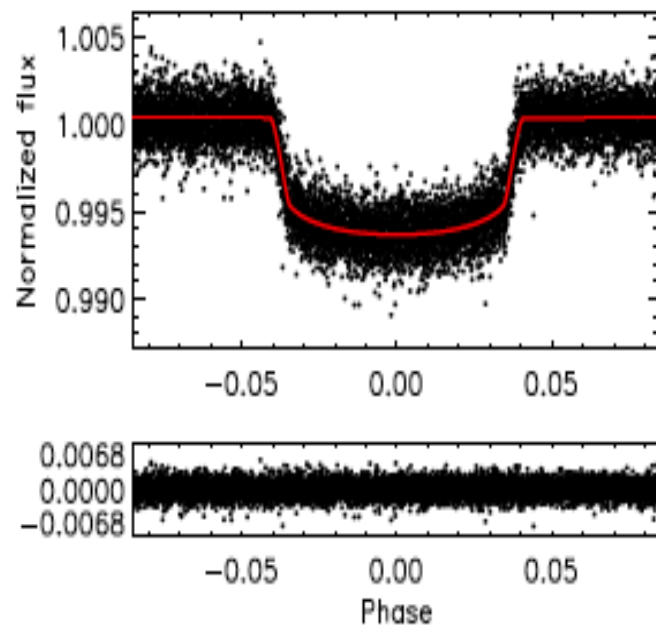
- Mass – 53 Jupiter masses
- Radial velocities between -5 a +5 km/s



# Hot Jupiters from Ondrejov

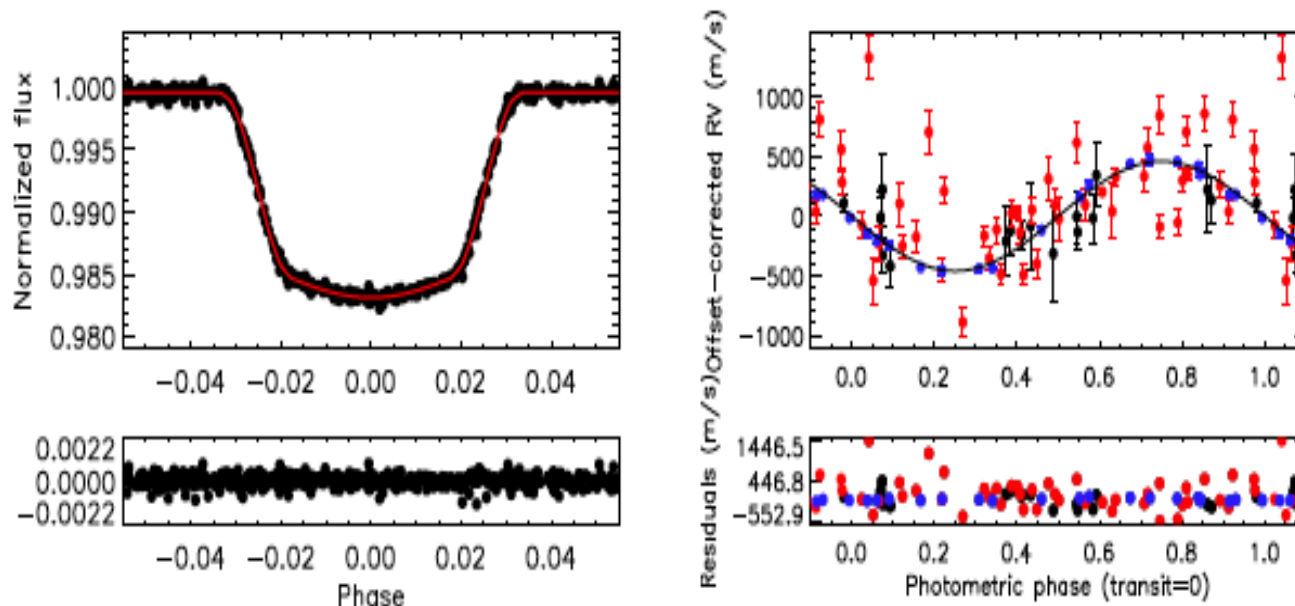
# TOI-1181b

- A hot Jupiter around a G subgiant star
- Period 2.1 days
- Radius  $1.3 R_{\text{Jupiter}}$  and Mass  $1.18 M_{\text{Jupiter}}$



# TOI-1516b

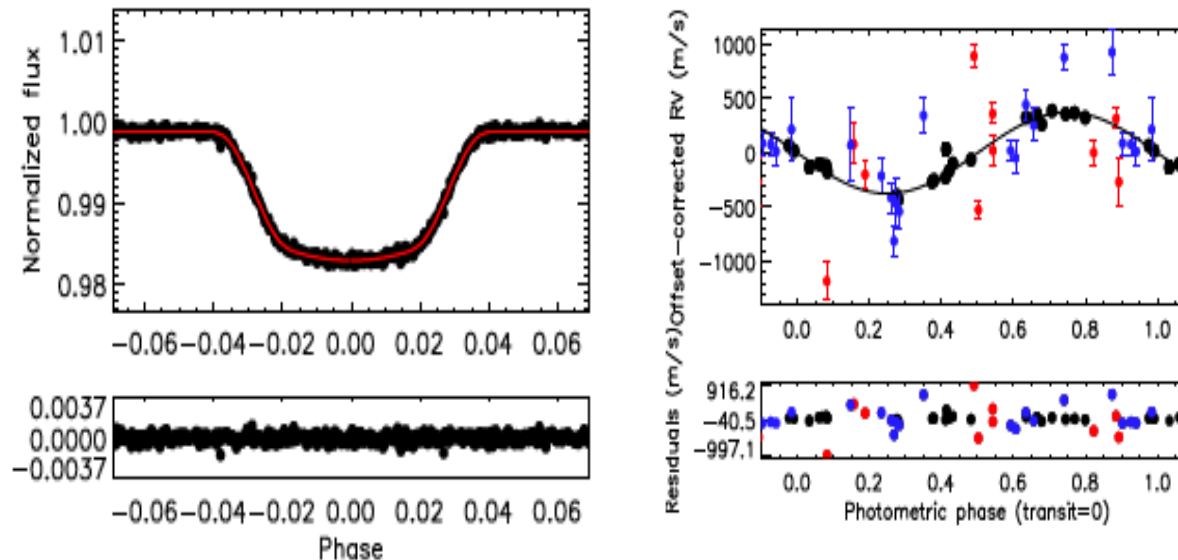
- A regular hot Jupiter
- Period 2.06 days
- Radius  $1.36 R_{\text{Jupiter}}$  and Mass  $3.16 M_{\text{Jupiter}}$



From Kabath et al. 2021 MNRAS, submitted

# Hot Jupiter around young star, TOI-2046b

- Young system perhaps 100-400 Myr (Li line)
- Period 1.5 days
- Radius  $2.44 R_{\text{Jupiter}}$  and Mass  $2.3 M_{\text{Jupiter}}$



# Instrumentation and Space Czech contribution - AV21

# Czech contribution to PLATO

- PRODEX funding about 900k EUR over 5 years
- Software development to analyze the data from PLATO
- Camera transport containers
- PLATOSpec about 30mil CZK
- AV21 – helped to get all the above funding!



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

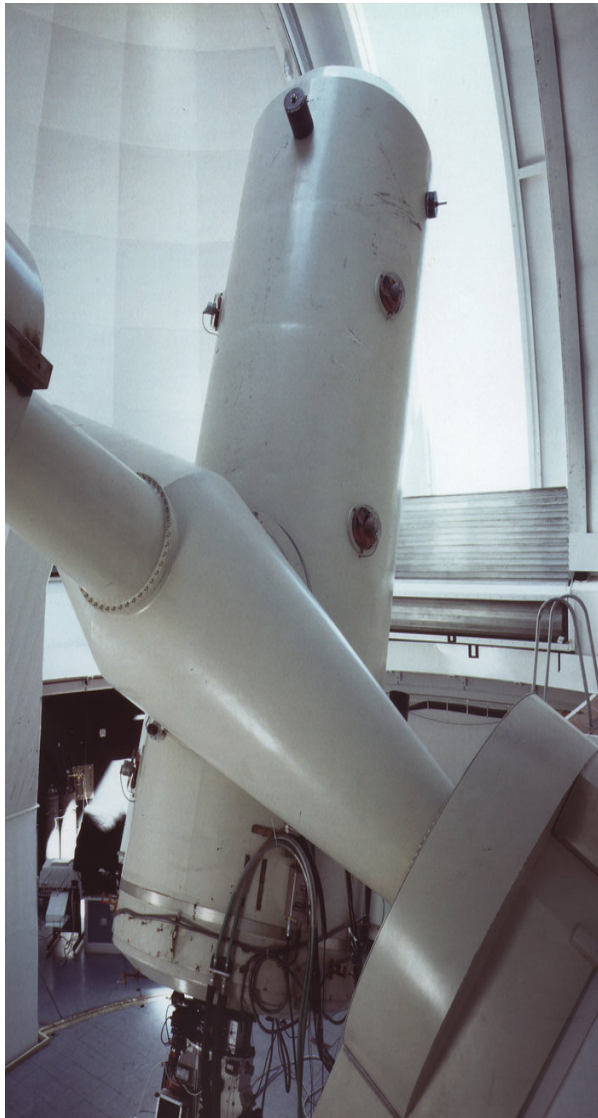


- Thüringer Landessternwarte Tautenburg  
(Artie Hatzes)



- Universidad Católica de Chile  
(Leo Vanzi)



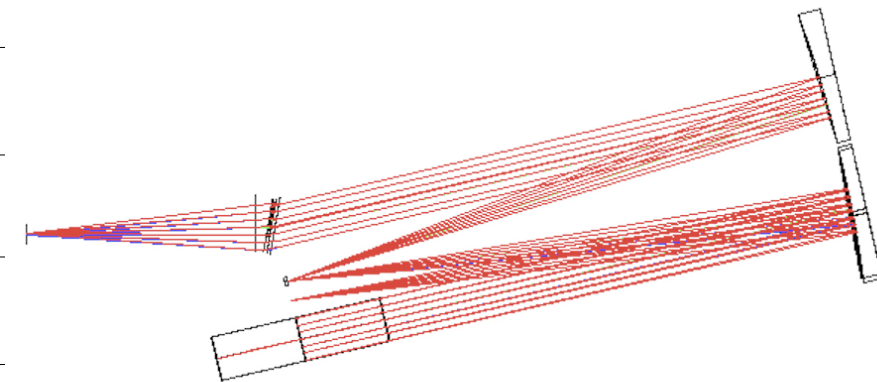


1.52-m former ESO telescope at La Silla

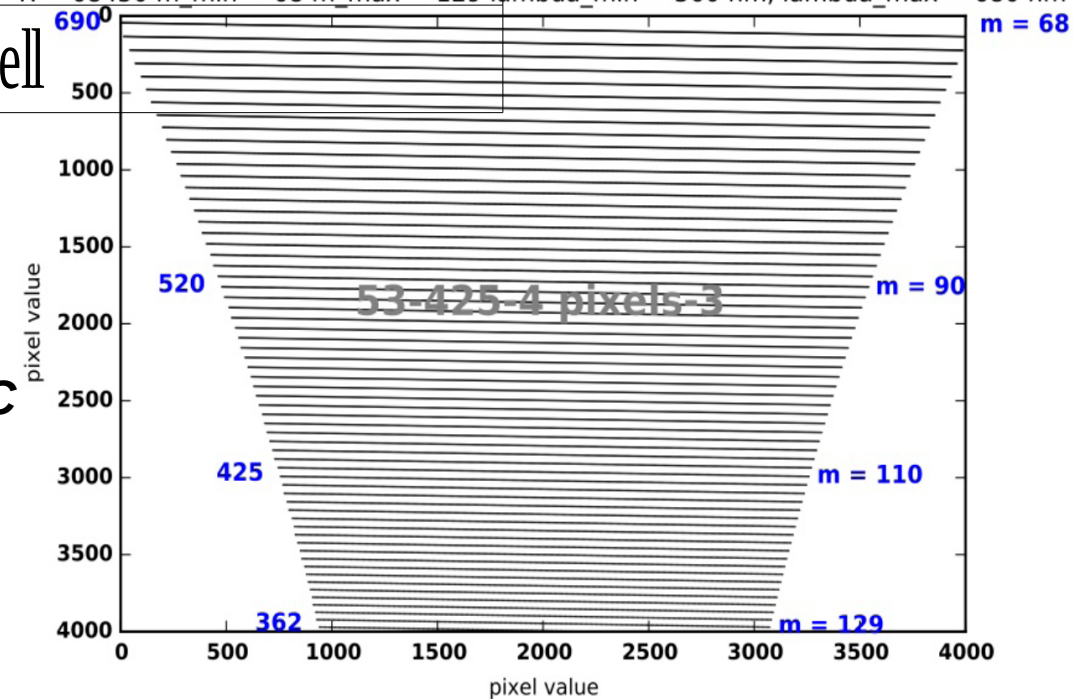
# The instrument

**Table 1: Main parameters 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



fcam = 513mm fcol = 1280mm echelle 41.59 lines/mm Blazed Angle 76 deg  
X disp 340 lines/mm delta 47 pix. Incident Angle = 23.3  
R = 68450 m\_min = 68 m\_max = 129 lambda\_min = 360 nm, lambda\_max = 680 nm



**Figures and Table from:**

**PLATO science justification report - ESO STC**

**CZ funding 10.2 million CZK**

# PLATO mission participation

- In cooperation with SAB aerospace
- First two containers delivered 2020
- A new batch ready now!
- SAB is doing pretty good job even with the crisis environment and rising prices!



Courtesy of M. Florian SAB

# PLATO SW

- We are part of PLATO PCOT team
  - Marie Karjalainen, Petr Kabath
- Development of SW tools to detrend CCD frames from PLATO (long term stability)
- We will help to reach a few ppm stability of the light curves!
- We will help to find the 2<sup>nd</sup> Earth!



# And how AV21 helped?

- We were able to participate in instrumentation oriented workshops, with no science
- We were able to get the PLATO project funded
- We were able to get the PLATOSpec project funded
- We are collaborating closely with colleagues from UFCHJH on ARIEL
- We started the industry collaboration with SAB aerospace, TOPTEC and ProjectSoft HK a.s.

# What are our outputs?

- Data correction software for PLATO
- PLATOSpec implementation, preinstallation, commissioning
- Tautenburg cooperation on instrument development
- Scientific papers (about 6 Jimp/year)
- Collaboration with the industry
  - SAB aerospace
  - ProjectSoft HK a.s.
  - TOPTEC



- This all would not be possible without support from AV21!

Thank you