Exoplanets in Ondrejov ground based support of space missions - first results

Petr Kabáth

ING, La Palma 05 September 2018

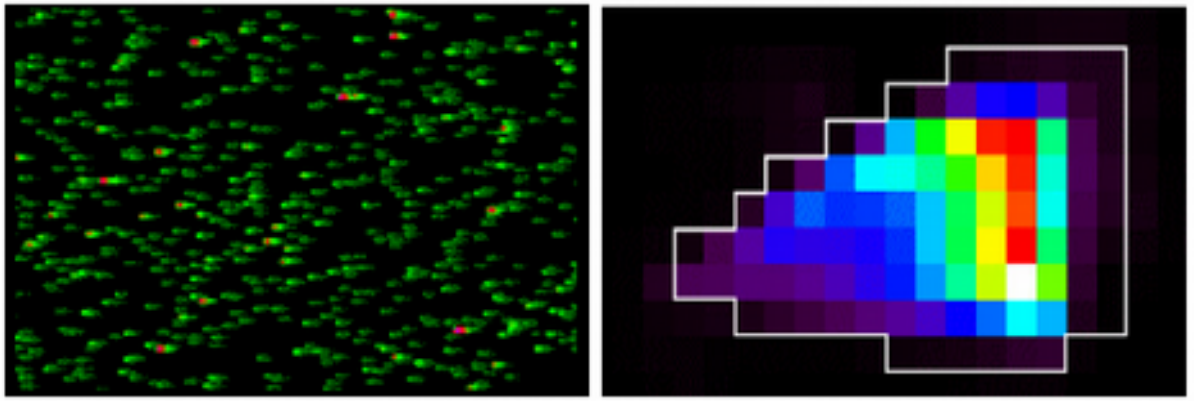
Astronomický ústav AV ČR

Need for ground based follow-up CoRoT space mission

- Ground based support of CoRoT
- Contribution to the follow-up observations
- Observations of the CoRoT target fields about 1 year ahead of CoRoT
- Contribution to additional science programme

Need for ground based follow-up

Up to 12000 masks for objects



Angular resolution of CoRoT: 2.3 “/pixel

↓

Broadening of stellar PSF due to prisms

↓

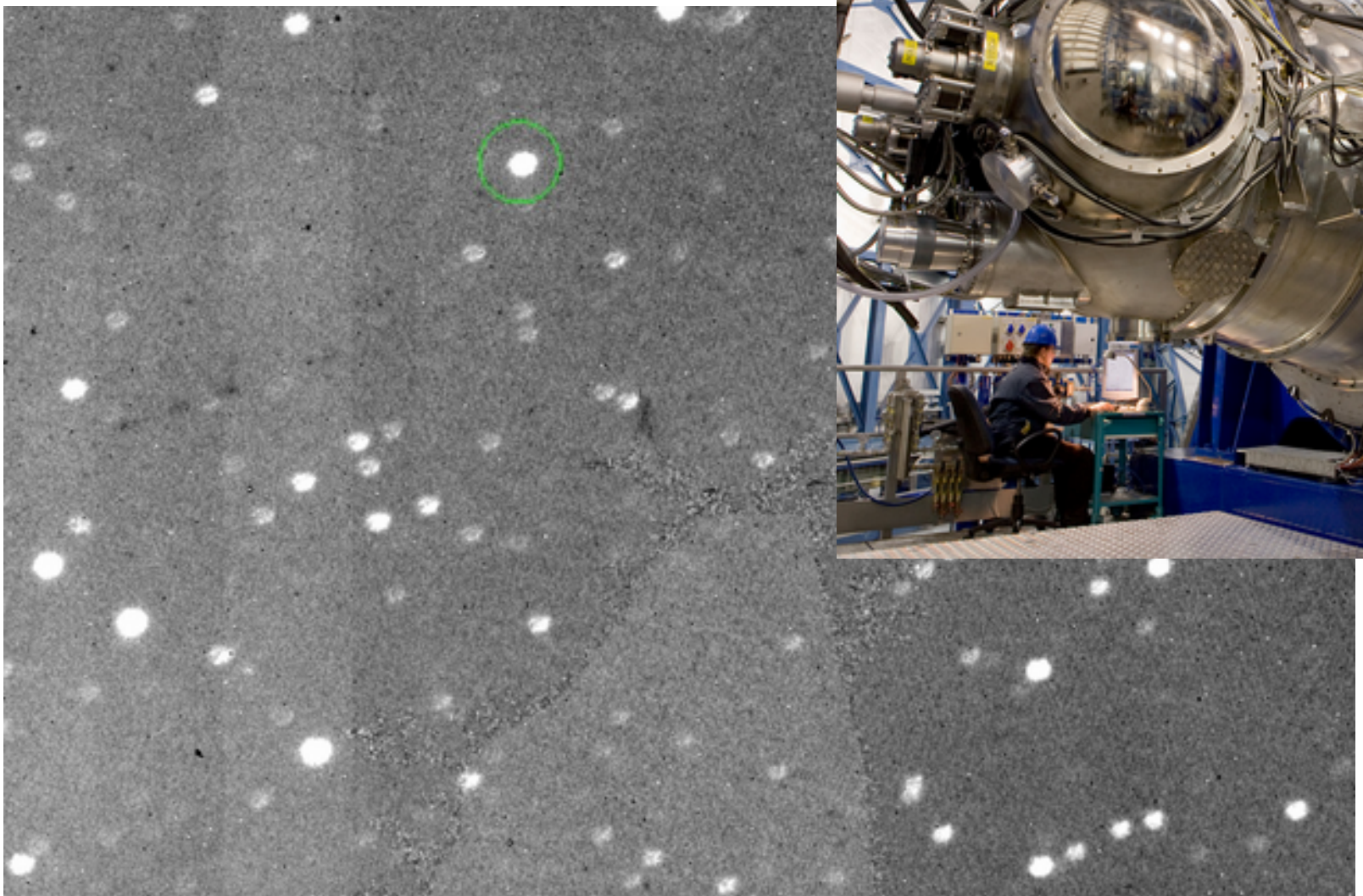
FLASE POSITIVE ALARMS

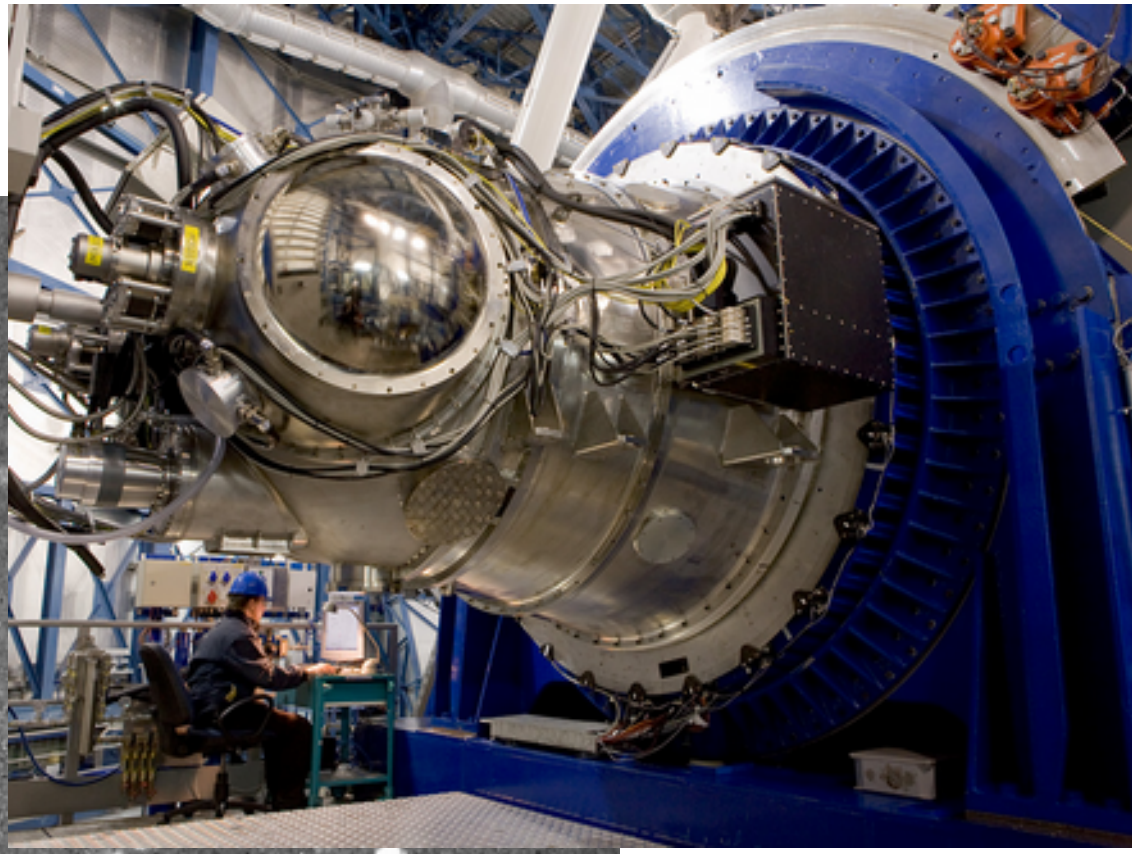
↓

GROUND BASED FOLOW-UP

Small telescope BEST II

Large telescopes ESO (2009-2015)





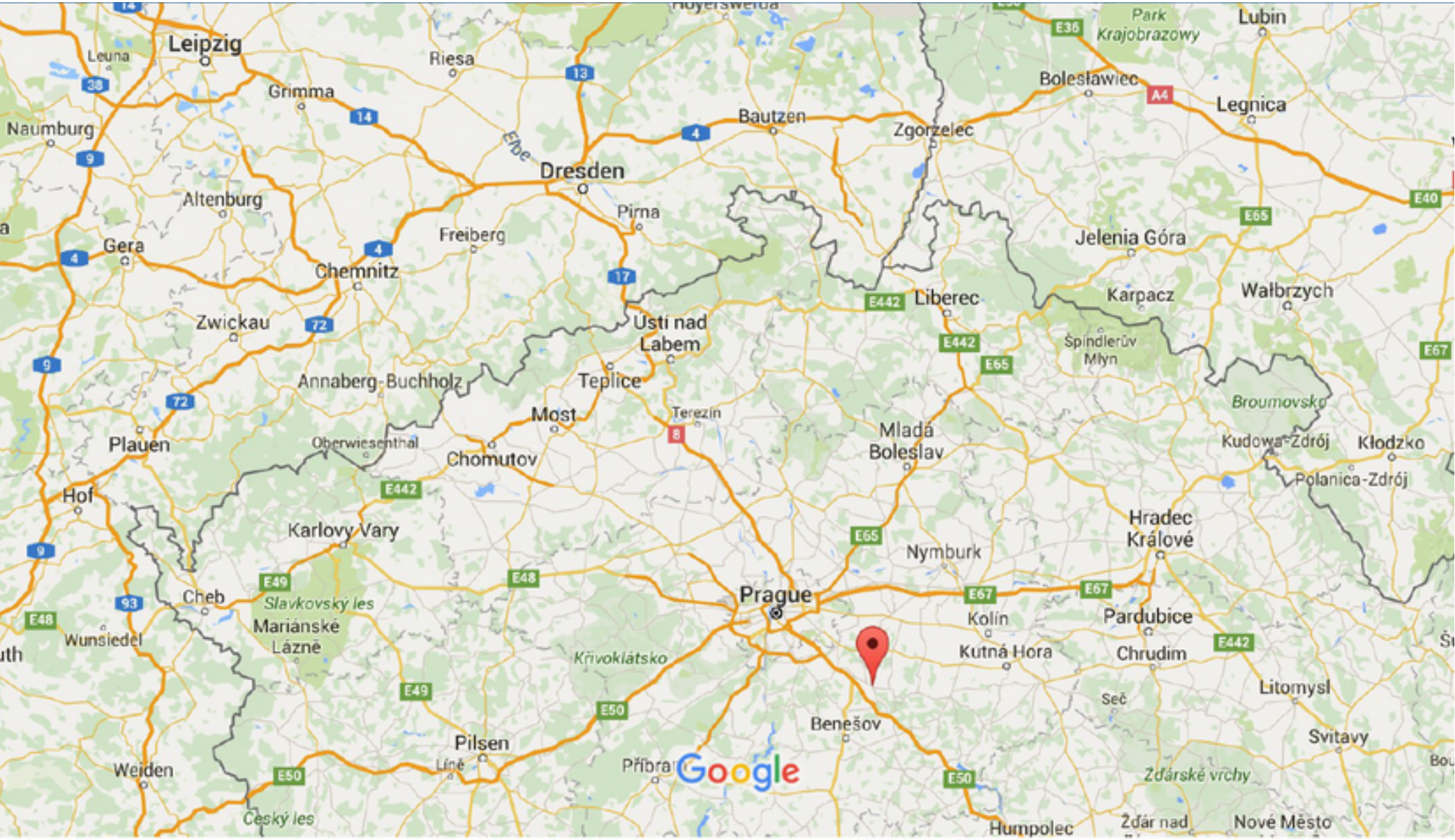
Astronomický ústav AV ČR

Outline

- Exoplanetary group (started 2015)
- OES spectrograph and results
- PLATOSpec
- Summary

Astronomical Institute Ondřejov

- **Institute of Czech Academy of Sciences**
- **Largest astronomical institute in CZ**
- **Headquarters about 30 kms south of Prague**
- **A few departments located in Prague**
- **Operates 2-m twin telescope of Tautenburg**
- **About 120 science staff**
- **Variable stars, solar physics, galaxies, relativistic astrophysics**
- **Space missions: Solar orbiter**


Leipzig
Leuna
Riesa
Grimma
Naumburg
Bautzen
Zgorzelec
Dresden
Elbe
Pirna
Altenburg
Freiberg
Gera
Chemnitz
Zwickau
Ústí nad Labem
Teplice
Annaberg-Buchholz
Most
Terezín
Oberwiesenthal
Chomutov
Plauen
Hof
Karlovy Vary
Cheb
Slavkovský les
Mariánské Lázně
Wunsiedel
Křivoklátsko
Pilsen
Líně
Příbram
Weiden
Český les
Prague
Nymburk
Mladá Boleslav
Liberec
Jelenia Góra
Bolesławiec
Legnica
Lubin
Park Krajobrazowy
Karpacz
Wałbrzych
Špindlerův Mlýn
Broumovsko
Kudowa-Zdrój
Kłodzko
Polanica-Zdrój
Hradec Králové
Pardubice
Kolín
Kutná Hora
Chrudim
Litomyšl
Seč
Benešov
Svitavy
Žďárské vrchy
Žďár nad
Nové Město
Humpolec
Google
Map data ©2015 GeoBasis-DE/BKG (©2009), Google
20 km

Central Bohemia region – Ladův kraj

Astronomický ústav AV ČR

Google Maps Ondřejov

Astronomický ústav AV ČR

Google Maps Ondřejov

Imagery ©2015 Google, Map data ©2015 Google 50 m

Group and collaborations

- **Astronomical Institute Ondřejov**

  P. Kabáth (head), T. Klocová, M. Skarka,
  M. Blažek (PhD), J. Šubjak (PhD),
  M. Špoková (PhD), J. Dvořáková (BSc),
  D. Dupkala (BSc)

- **Collaborations**

  DLR Berlin

  ESO

  Universidad de Chile and Univ. Valparaiso

  Thueringer Landessternwarte Tautenburg

  IAC

Astronomický ústav AV ČR

Perek 2-m telescope

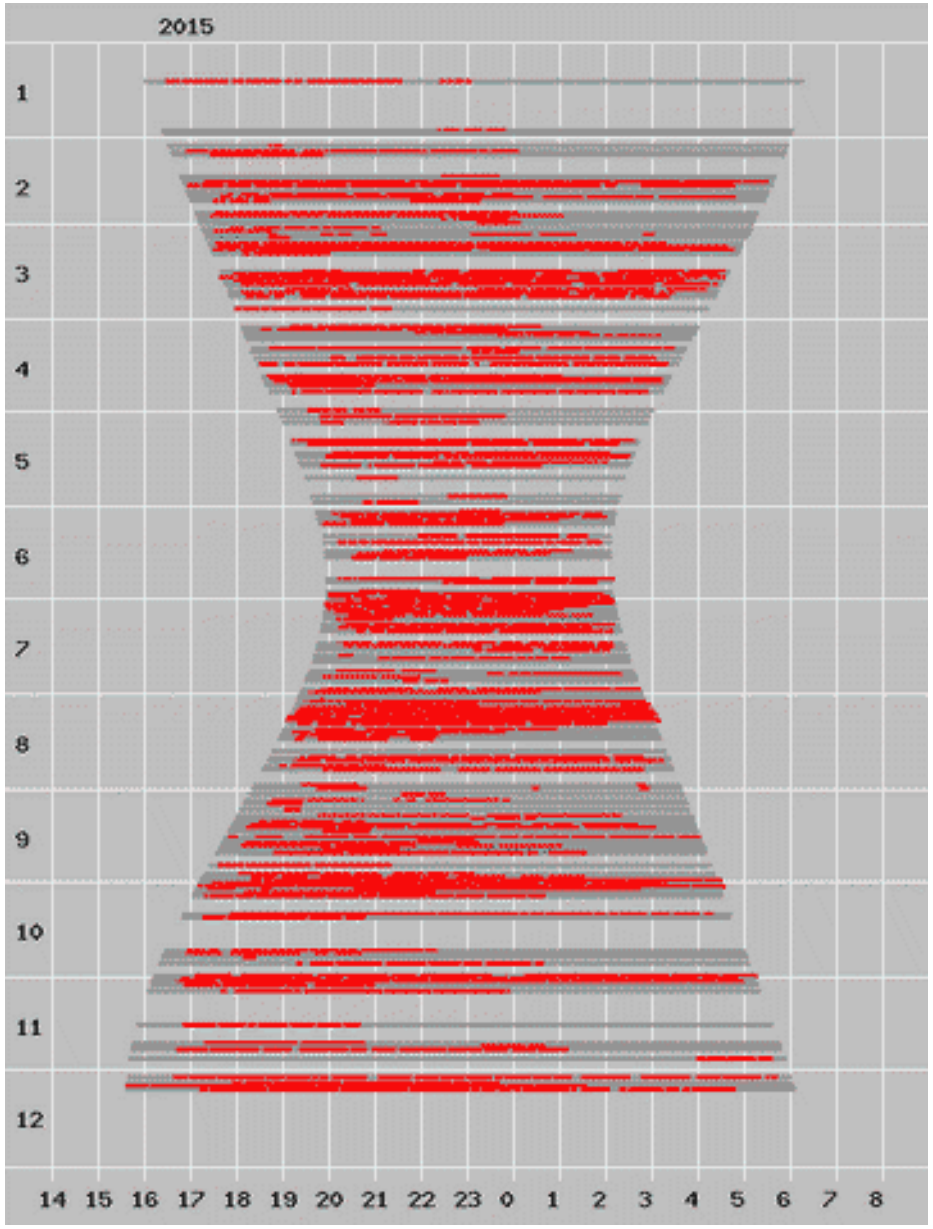
Perek 2-m telescope

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)

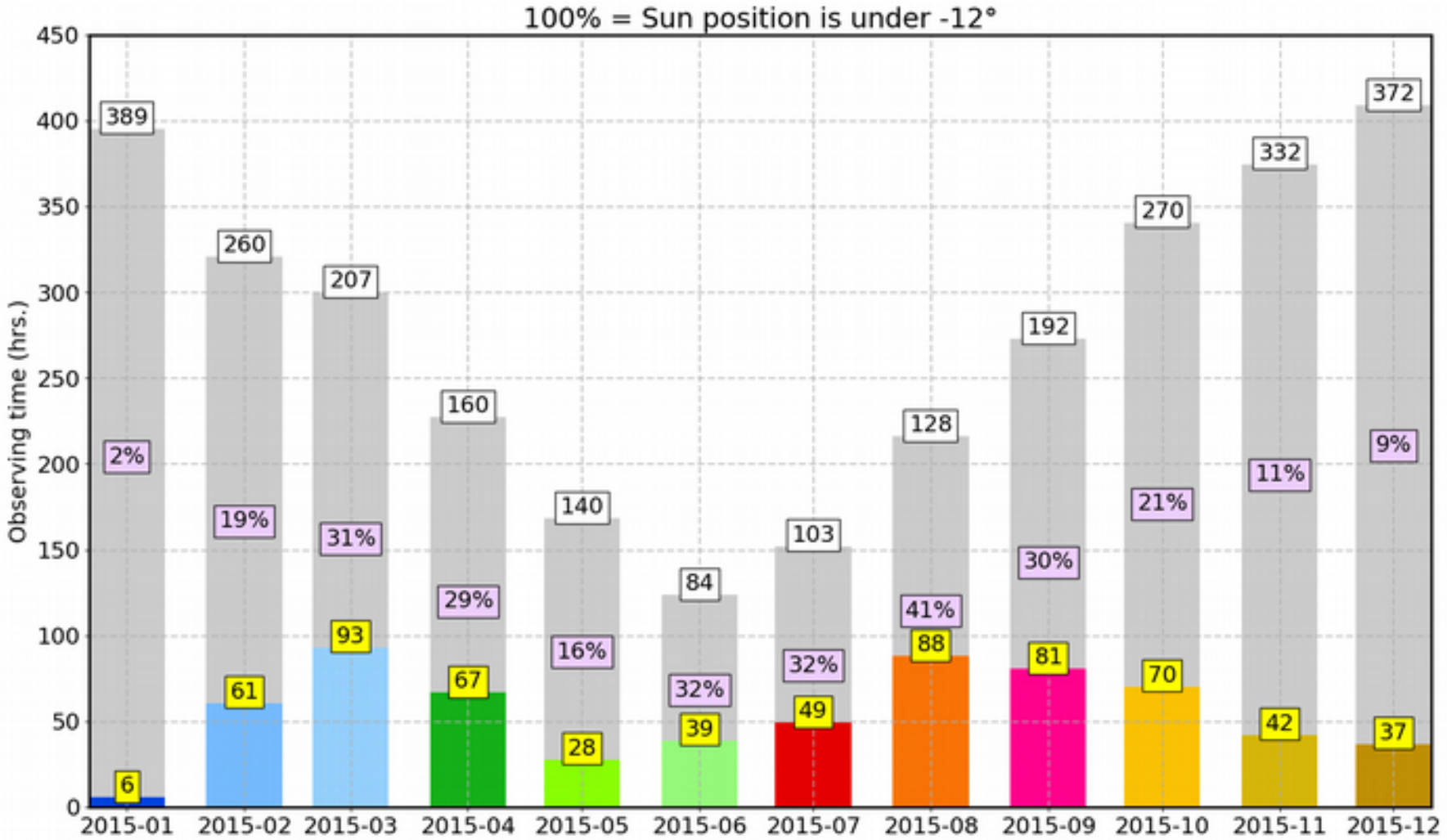
Ondrejov observing stats 2015

Astronomický ústav AV ČR



Astronomický ústav AV ČR

Statistics during the year

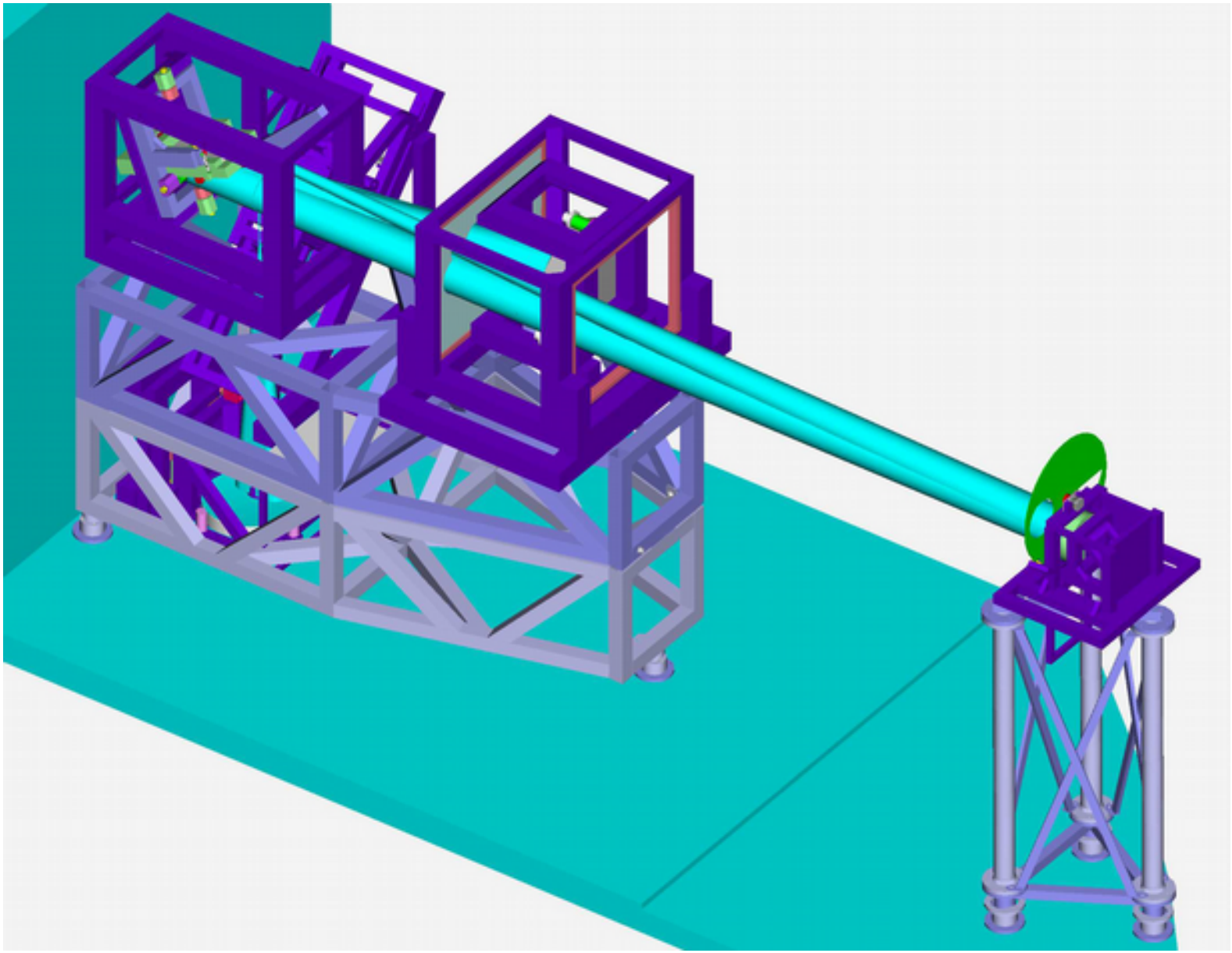


Echelle spectrograph OES

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)
- 2019 upgrade to fiber fed spectrograph

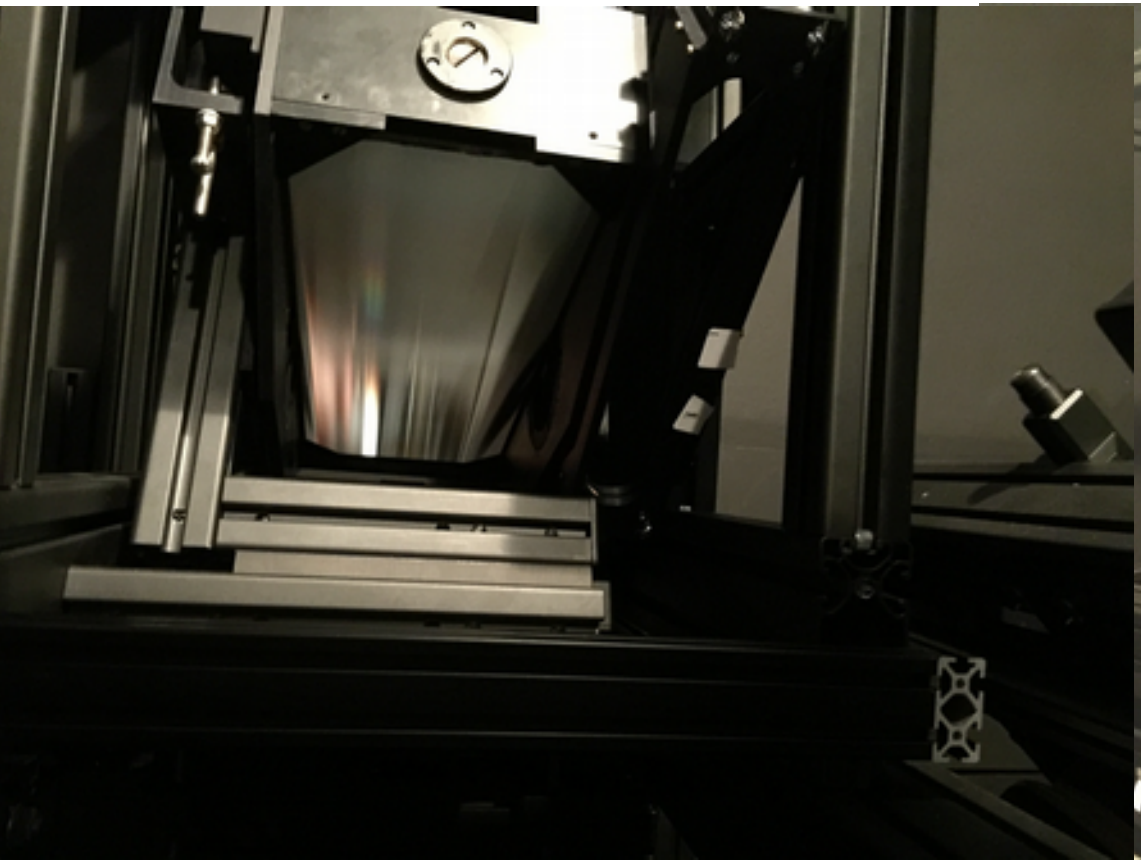
OES



From Koubsky et al. 2005

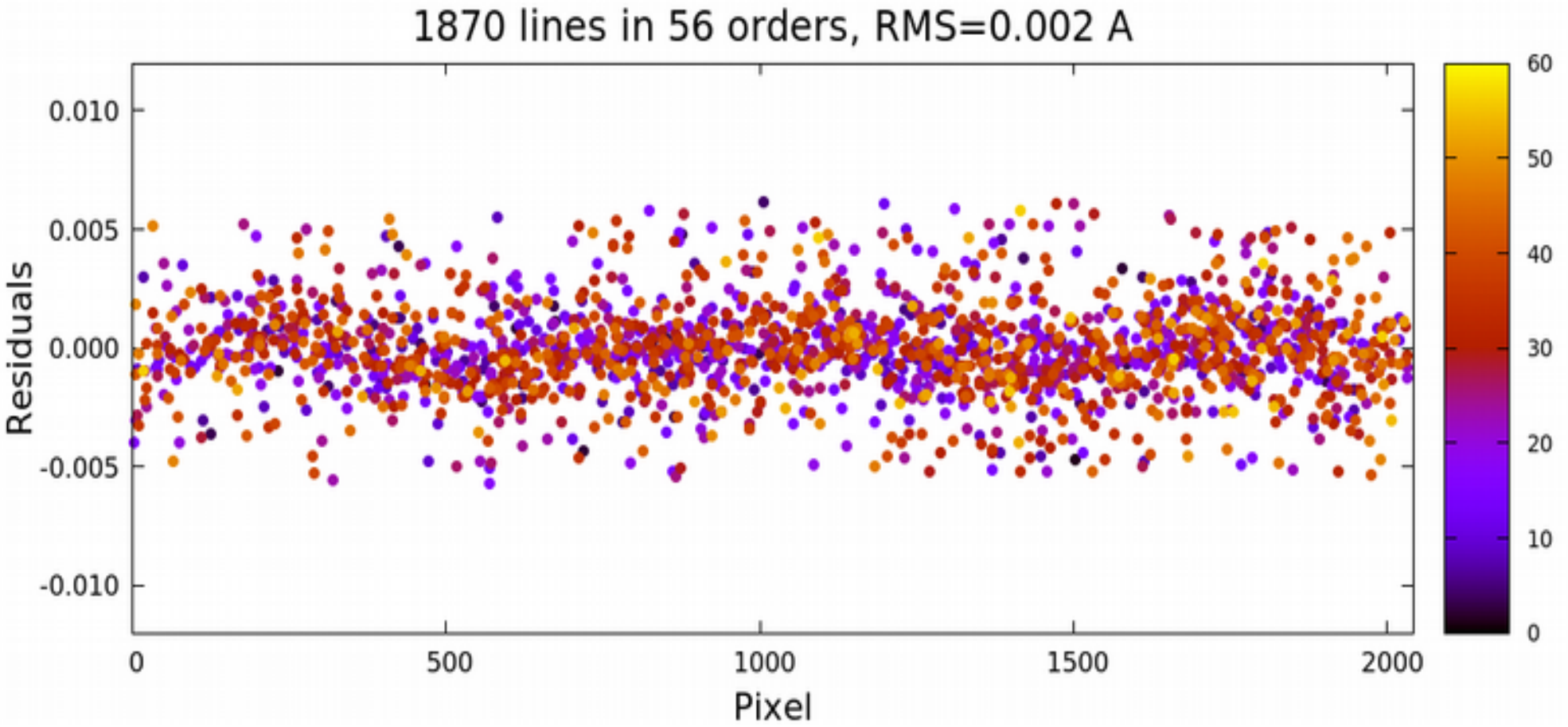
Astronomický ústav AV ČR

OES echelle grating



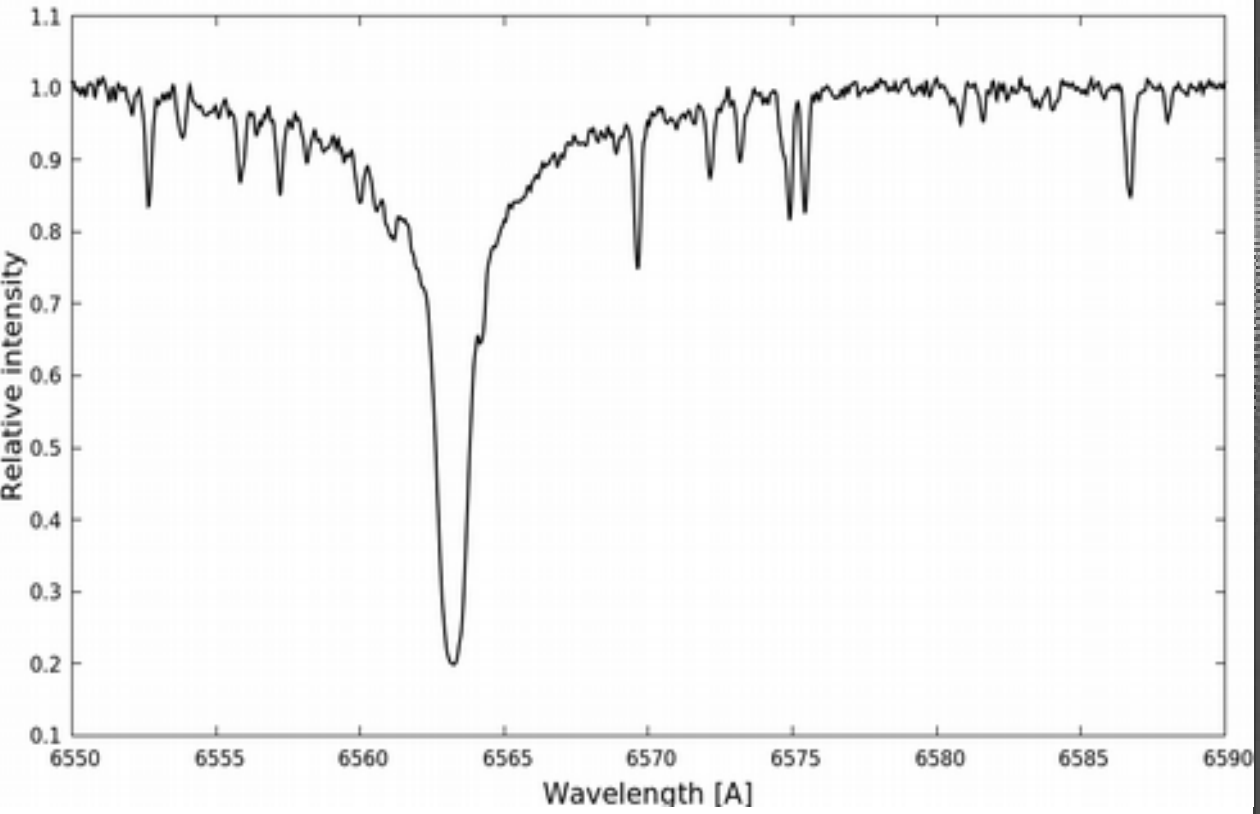
Astronomický ústav AV ČR

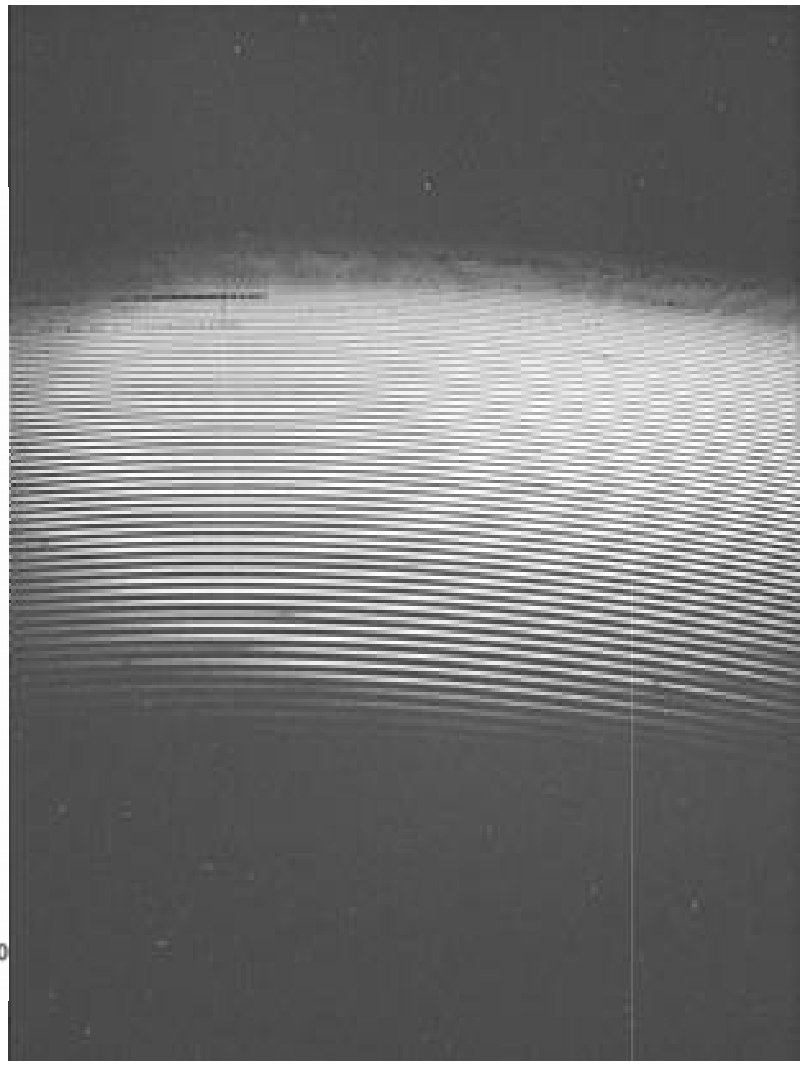
Wavelength solution OES



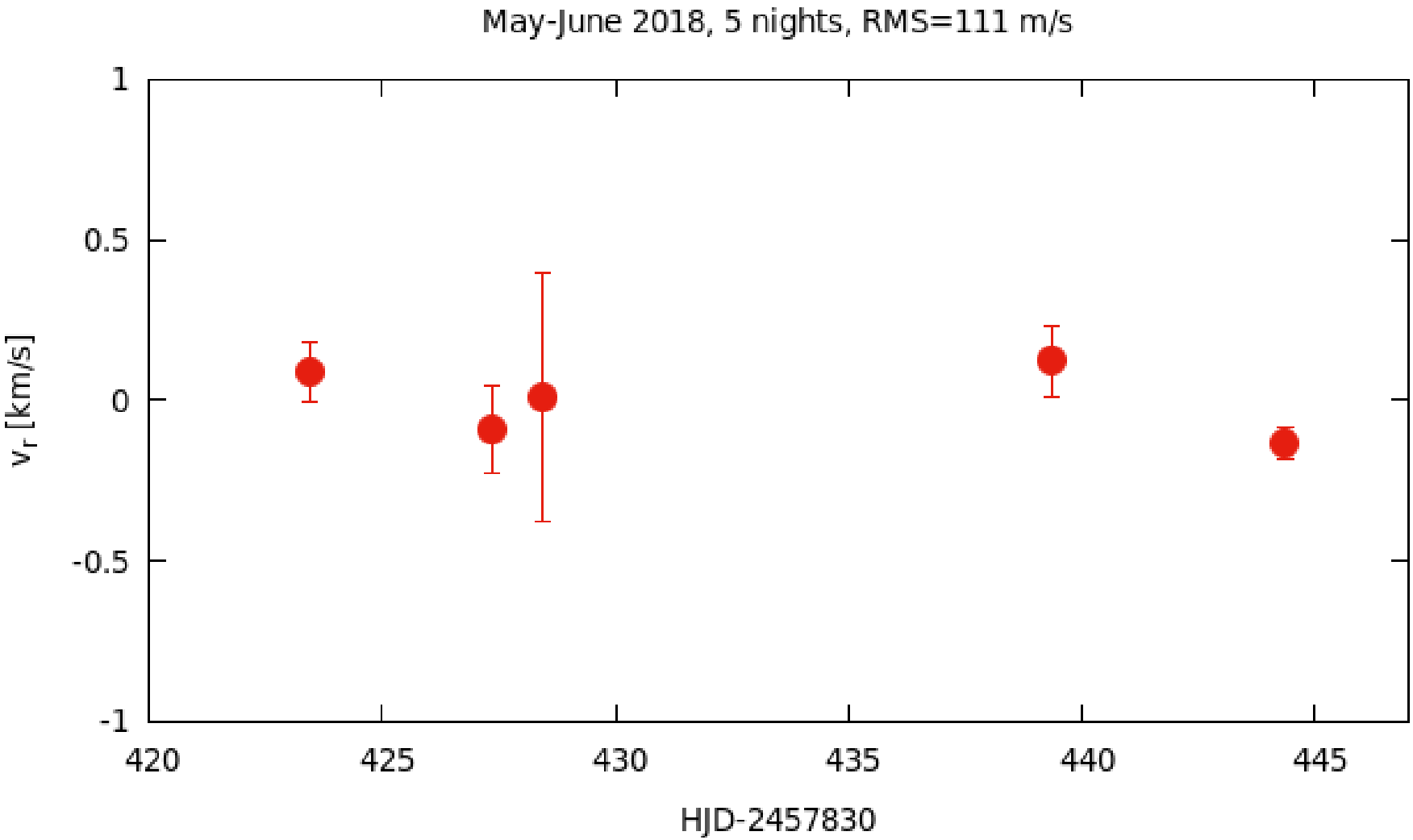
From Kabath et al in prep 2018

OES Spectrum





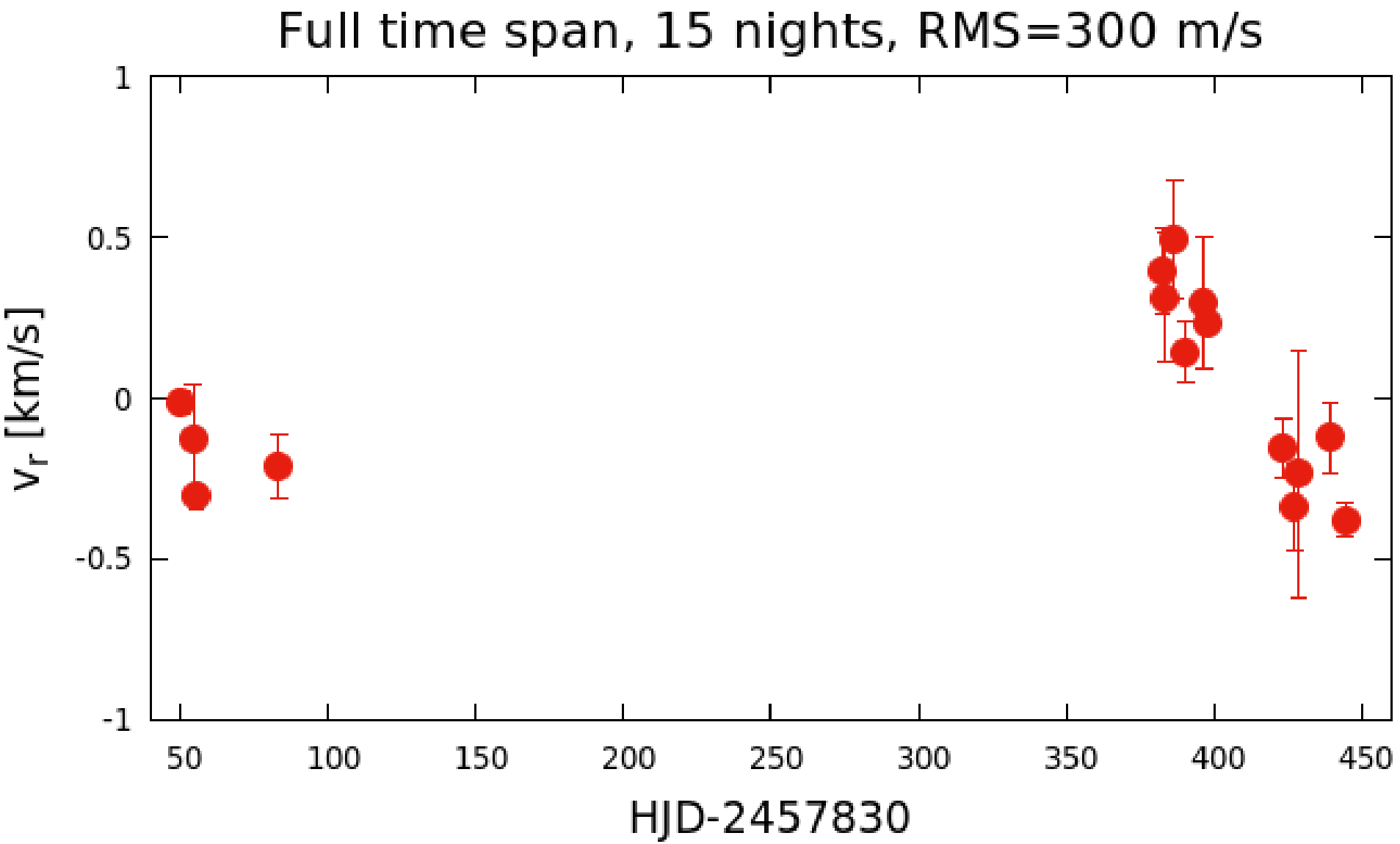
OES stability (nightly)



RVs below 100 m/s

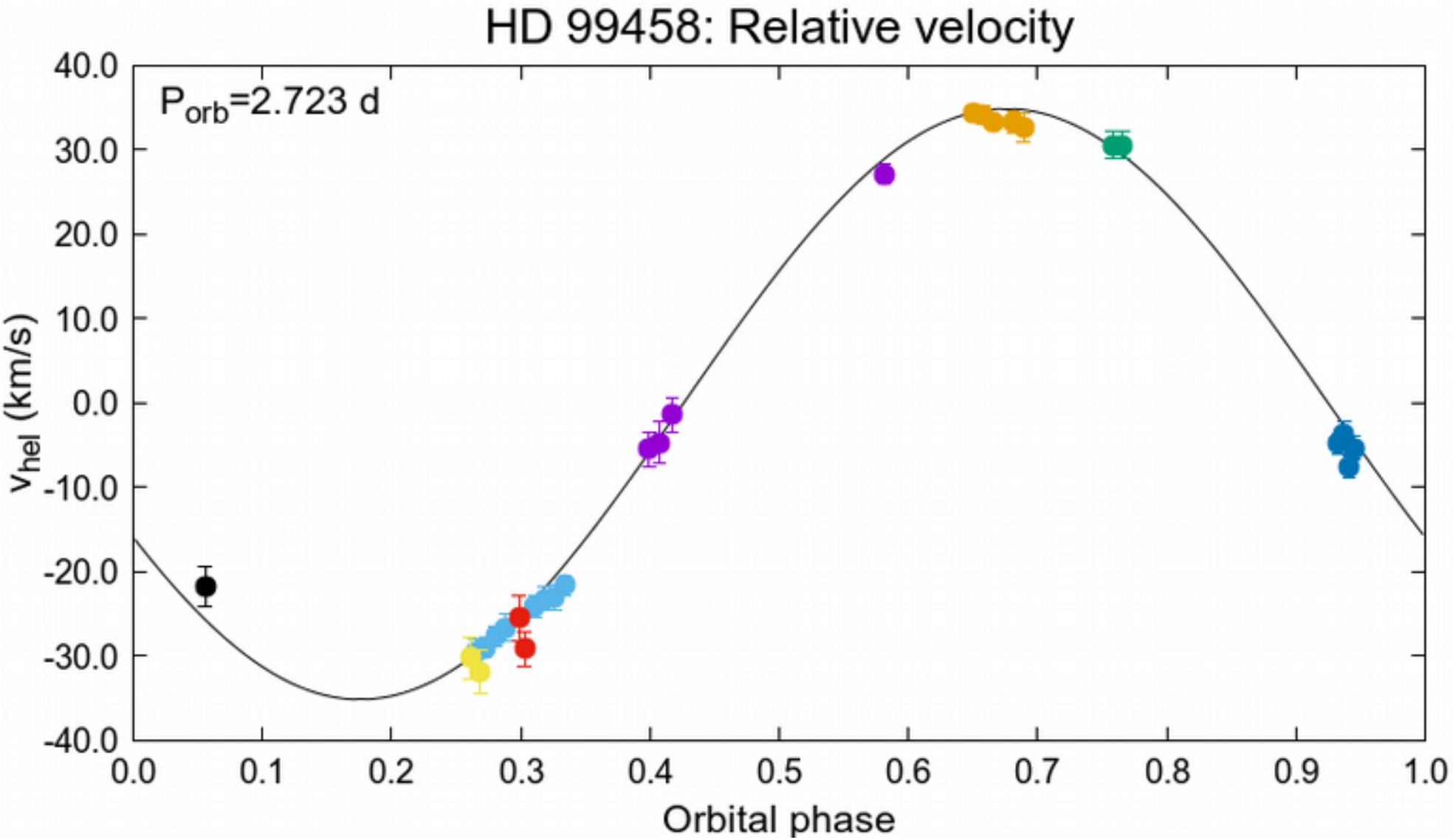
From Kabath et al in prep 2018

OES Stability (long)



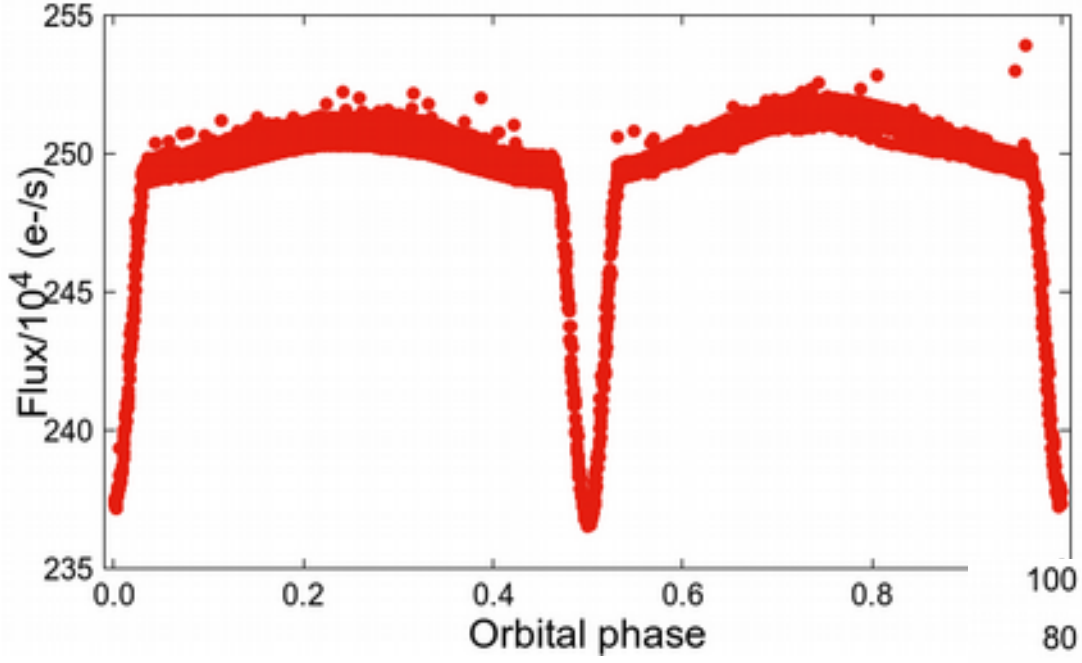
From Kabath et al in prep 2018

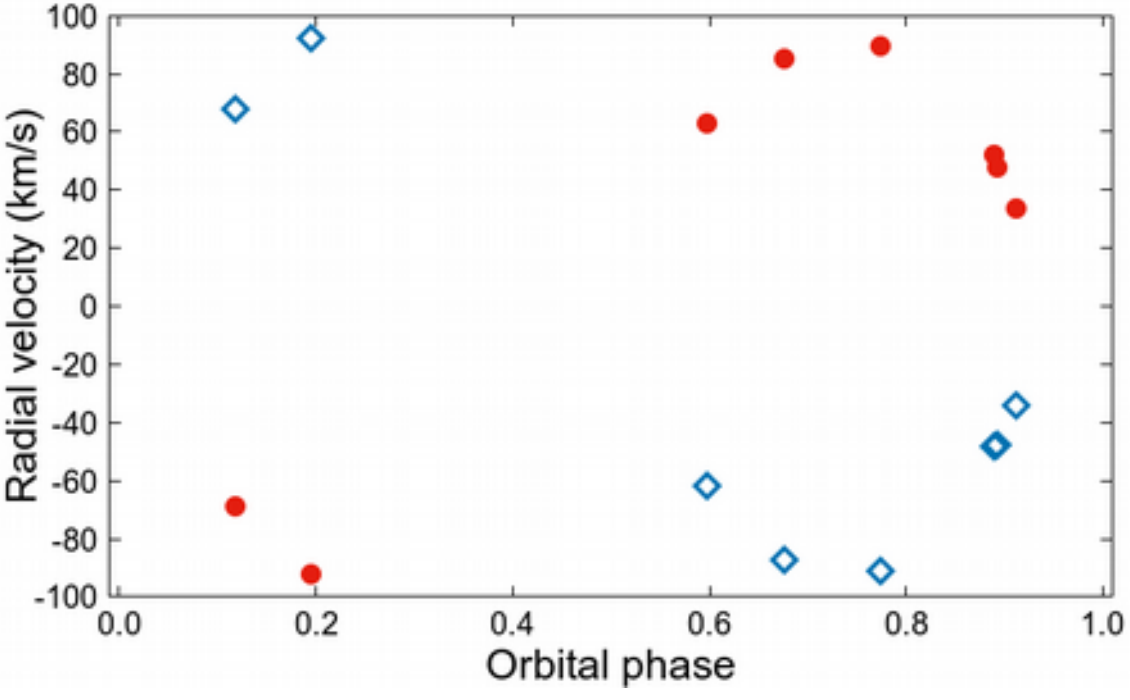
K2 candidates



Skarka et al in prep. 2018

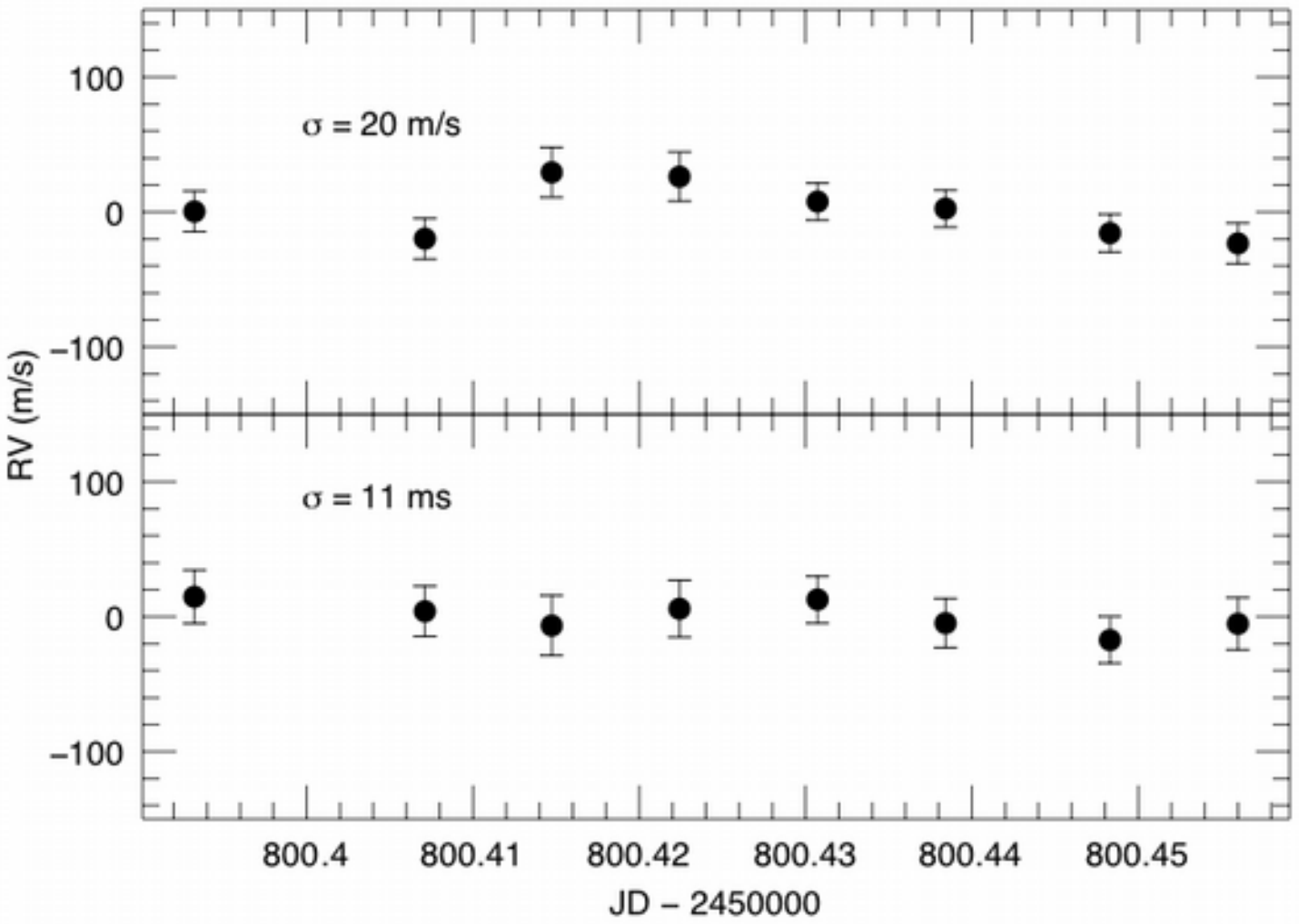
K2 candidates





From Kabath et al in prep 2018

OES & Iodine cell



Reduced with Radial by A. Hatzes

OES in numbers

- OES can measure RVs well below 100 m/s for bright stars
- OES can measure RVs down to 10 m/s with Iodine cell
- BUT 8 hrs. exposure can have an accuracy of about 20 m/s – 5 mag star!!!
- Long term stability below 100 m/s
- We can perform initial screening (physical parameters)
- We can safely remove background binaries

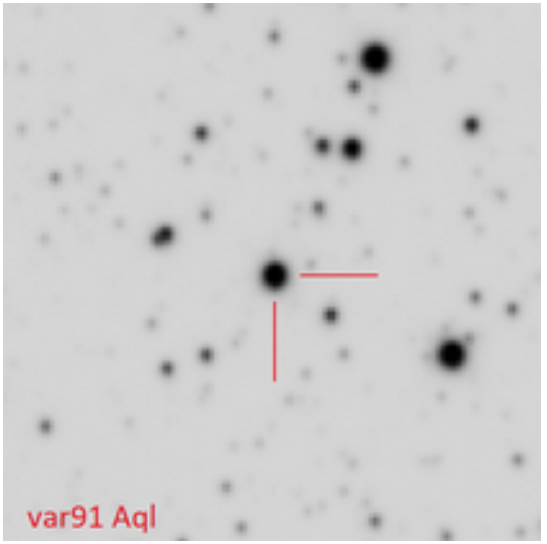
Observing Program

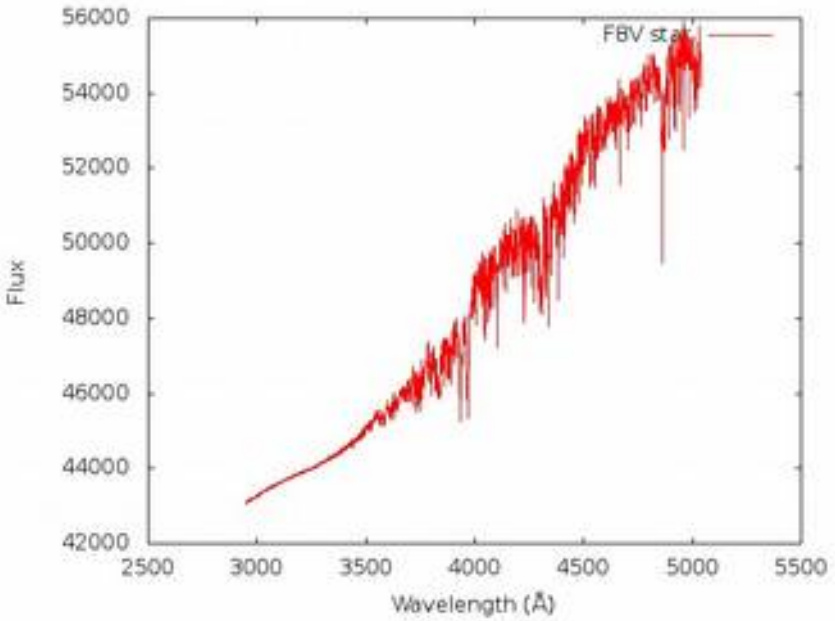
- Cooperation with Tautenburg (2-m Alfred Jensch telescope) – A. Hatzes, E. Guenther
- Monitoring of K2 canidates
- Monitoring of A stars with planetary candidates
- Monitoring programs of BD objects
- TESS follow-up
- Planetary atmospheres of bright planets
- Summary: Ideal for RV follow-up of bright stars with planets to reject false positives

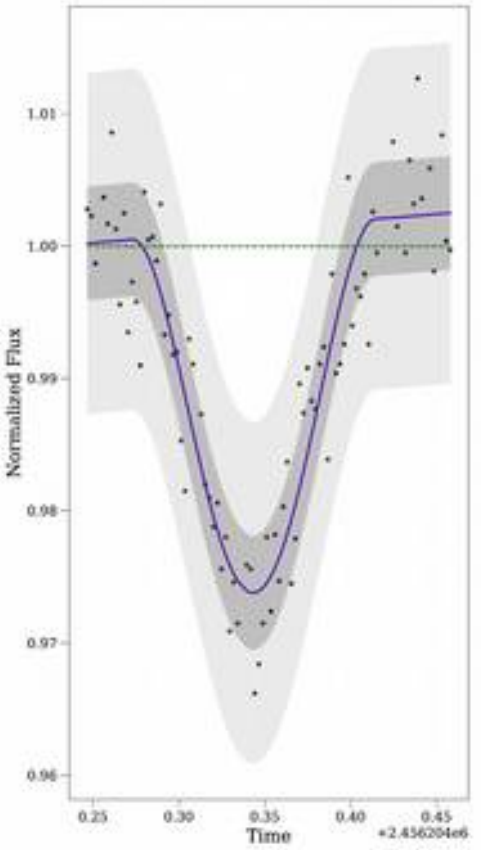
Observing program

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

Exo-candidates (TCMT)







Parameters VAR91AQL
P= 1.61 days
b= 0.99
Rp/Rstar=0.285
a/Rstar = 3.11
Rplanet approx. 3.4-3.8 Rjupiter

Spectral typing done with IDS at INT

Transmission spectroscopy high spectral resolution

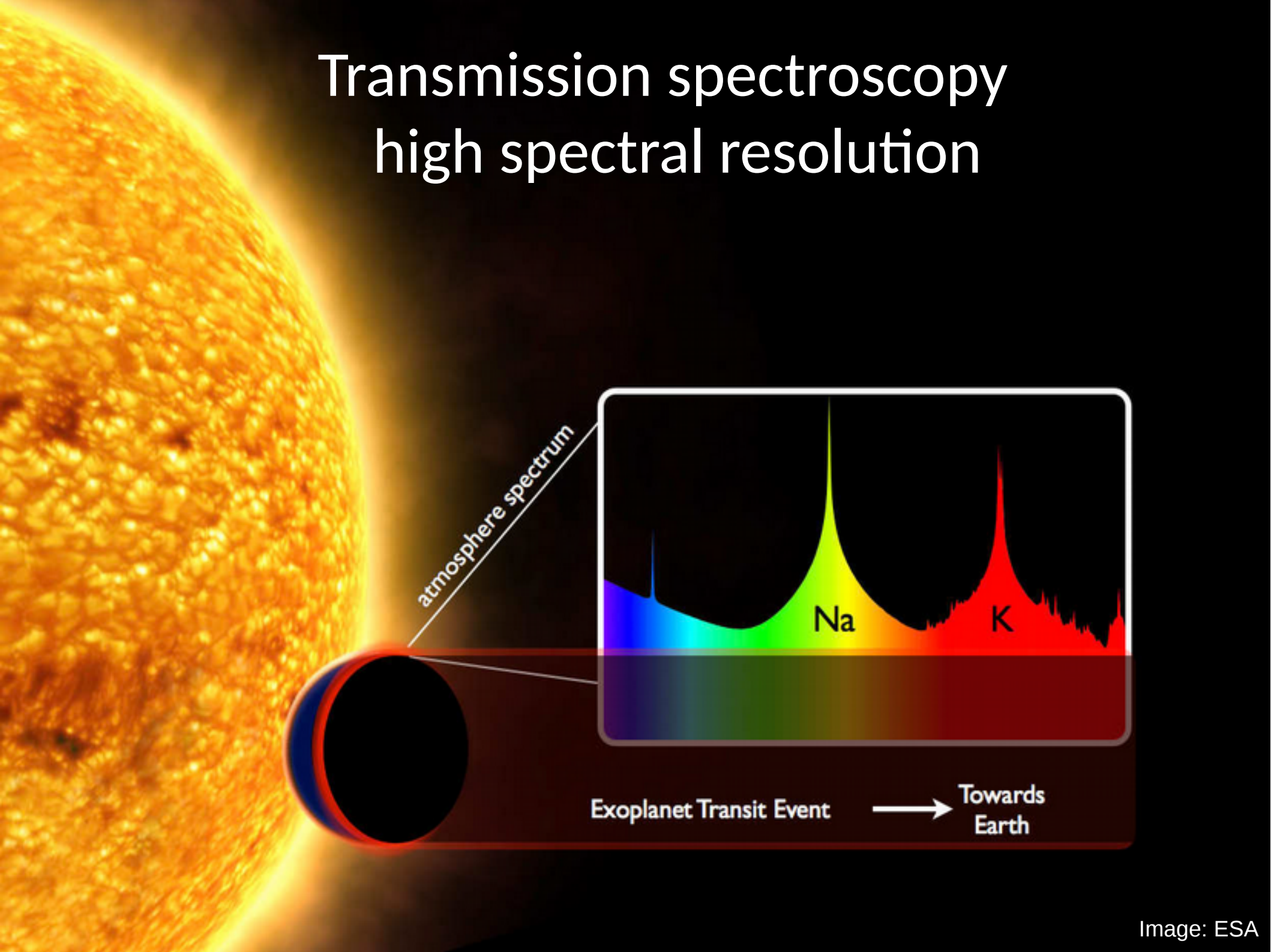
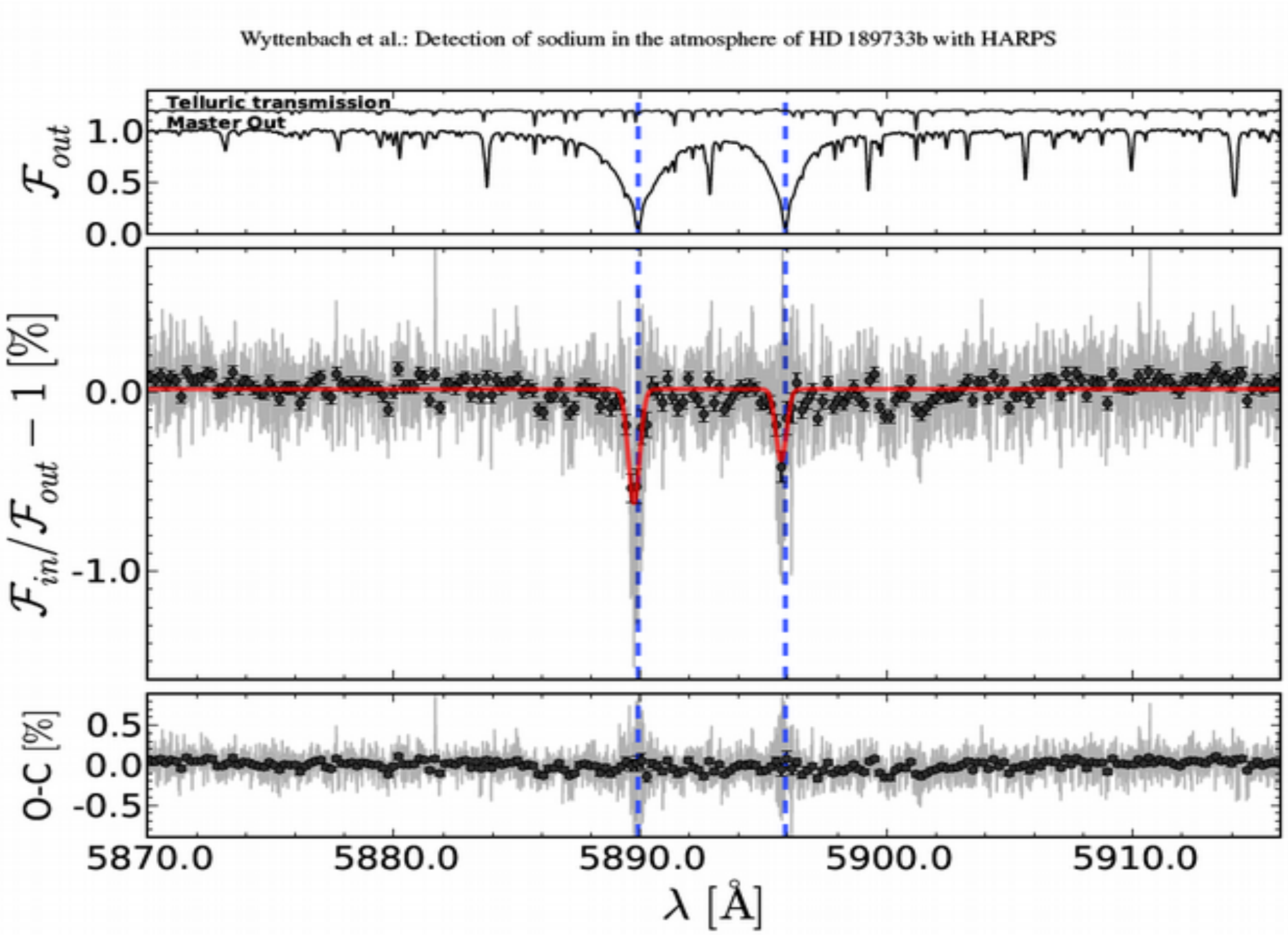


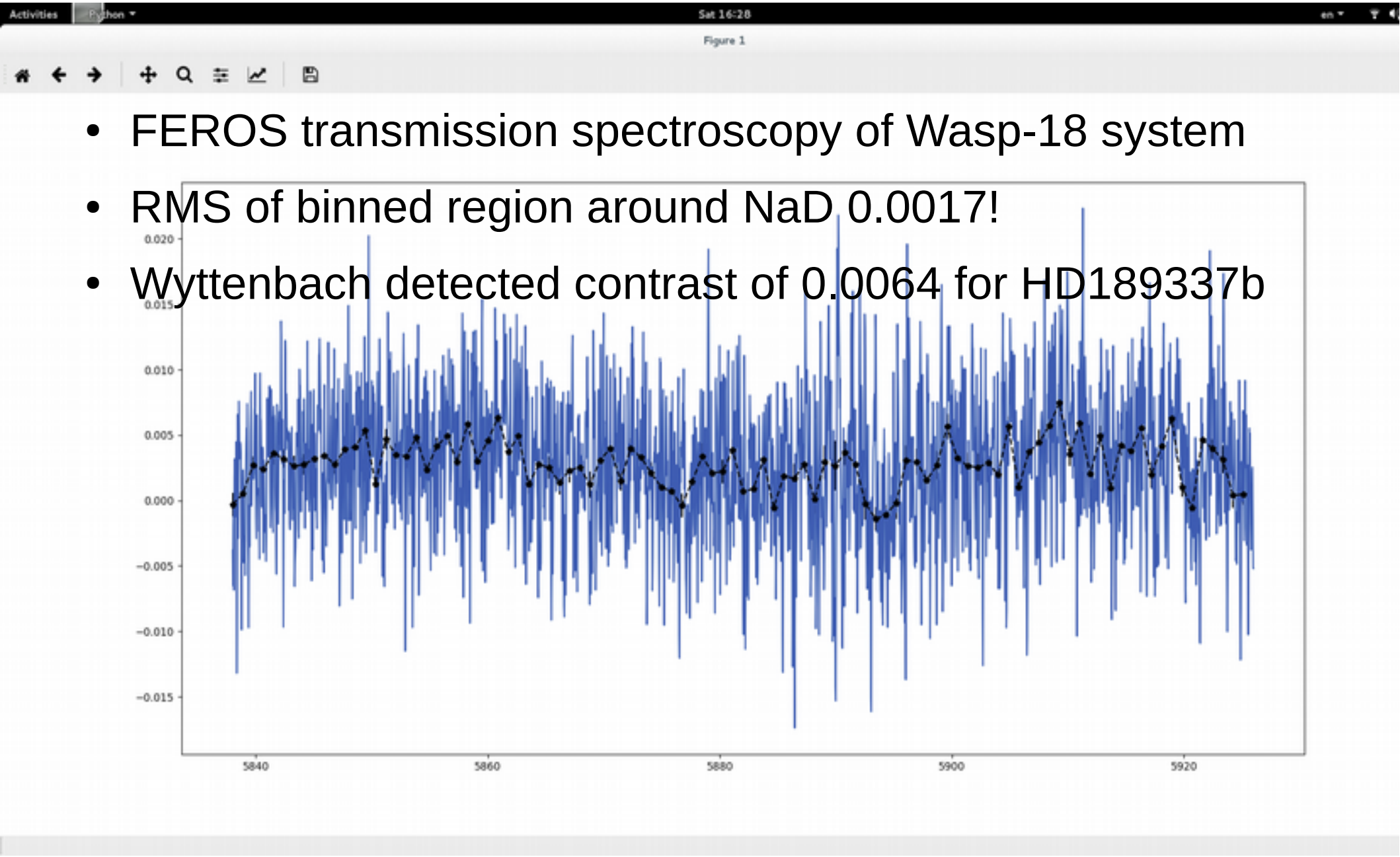
Image: ESA

Atmospheres with small telescopes



Atmospheres with 2m telescopes

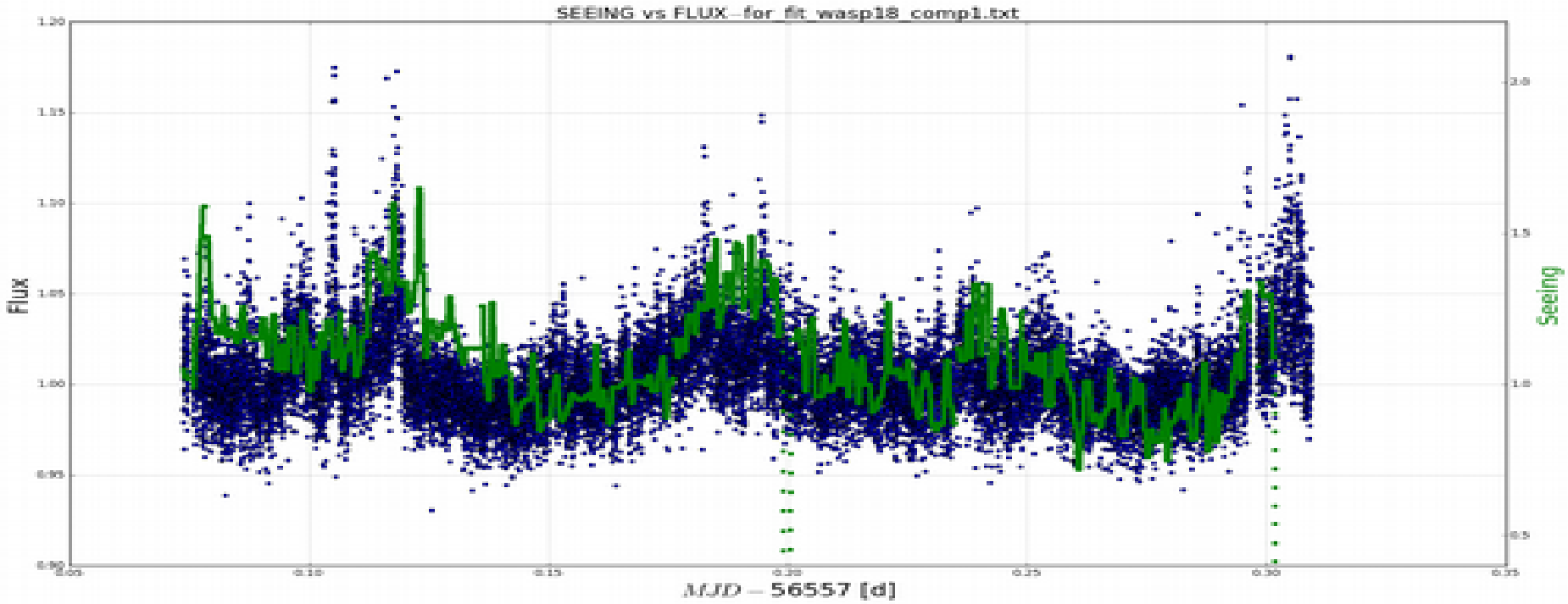
- FEROS transmission spectroscopy of Wasp-18 system
- RMS of binned region around NaD 0.0017!
- Wyttenbach detected contrast of 0.0064 for HD189337b



Kabath & Žák et al., 2018 in prep

Atmospheres with large telescopes

- Msc student M. Blazek wrote a pipeline for HAWKI data reduction → data crunching of ESO archives for occultations (plenty of data available)

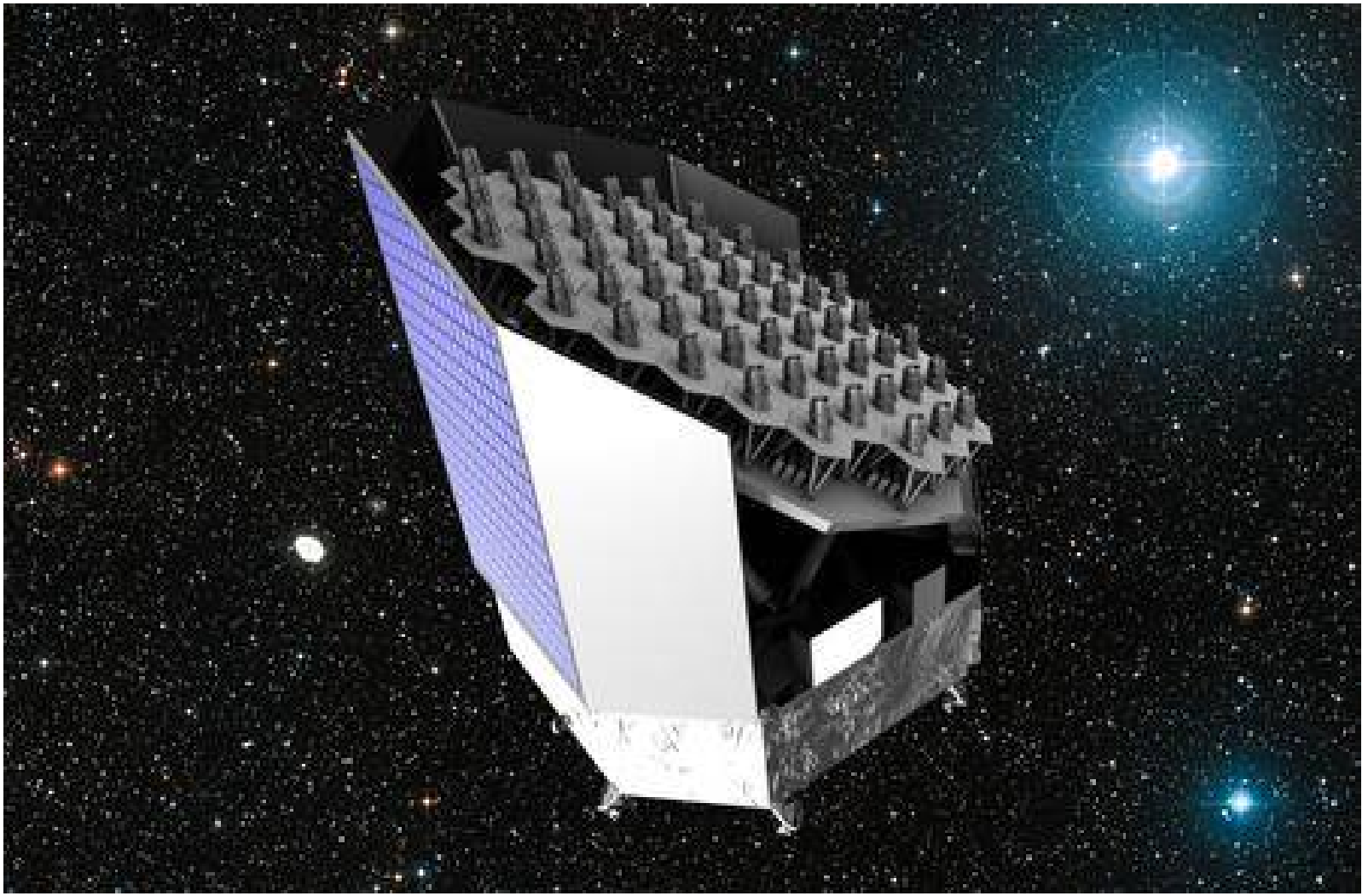


Outlook OES

- RV follow-up of K2, Kepler – DFG/GACR 2017 with Tautenburg
- TESS follow-up
- Long term monitoring program BDs
- Stellar flares with Tautenburg
- Cooperation with amateur astronomers
- Exo-atmospheres tests
- Courses for students – summer/autumn school
- Looking forward at PLATO

2018+: PLATOSpec joint project of AI ASCR, Tautenburg observatory and Universidad Catolica de Chile

Plato Space mission



Credit: Thales Alenia Space

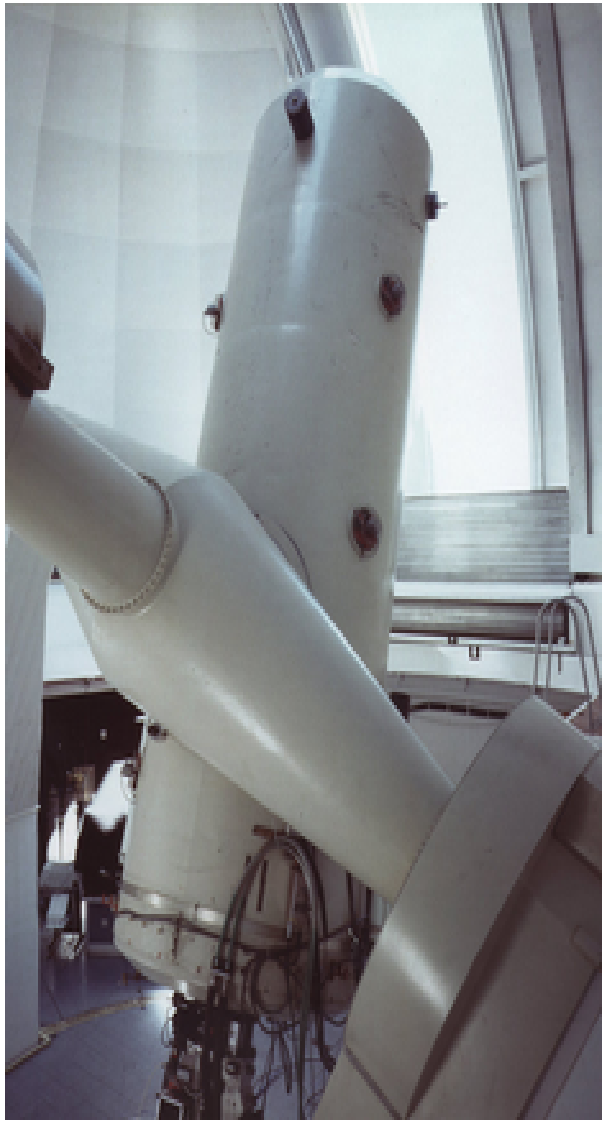
PLATOSpec Consortium

- Astronomical Institute of Czech Academy of Sciences (PI: Petr Kabath)
- Thüringer Landessternwarte Tautenburg
- Universidád Católica de Chile

Current status:

- ESO STC recommended PLATOSpec for implementation
- Councils of the institutes approved the project
- Funding proposals underway!

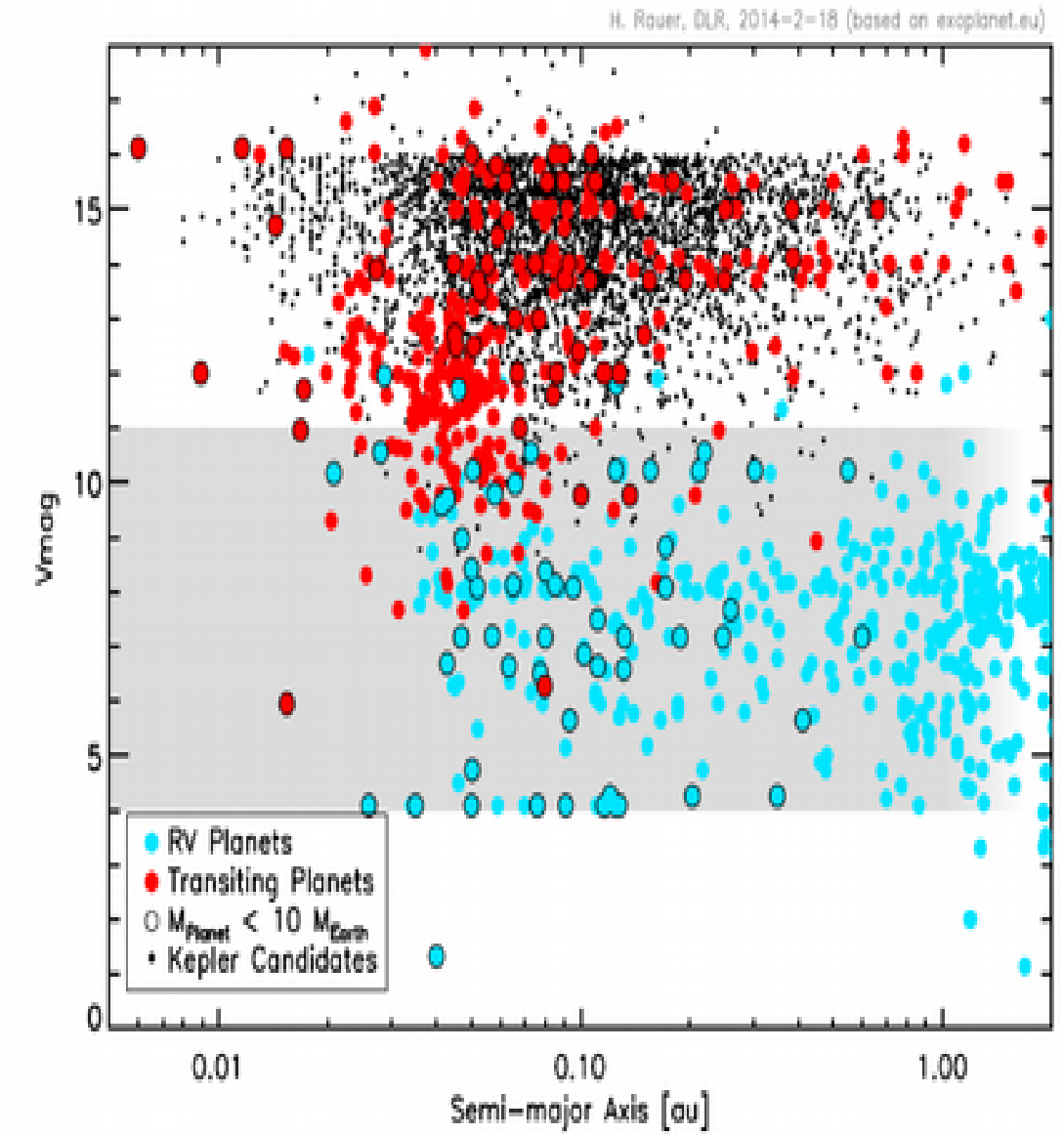
La Silla, Chile - 1,52m dalekohled



PLATOSPec motivation

- Stellar parameters
- Initial screening of candidates
- Rejection of false positives
- Characterization of hot Jupiters

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



From Rauer et al. 2012

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

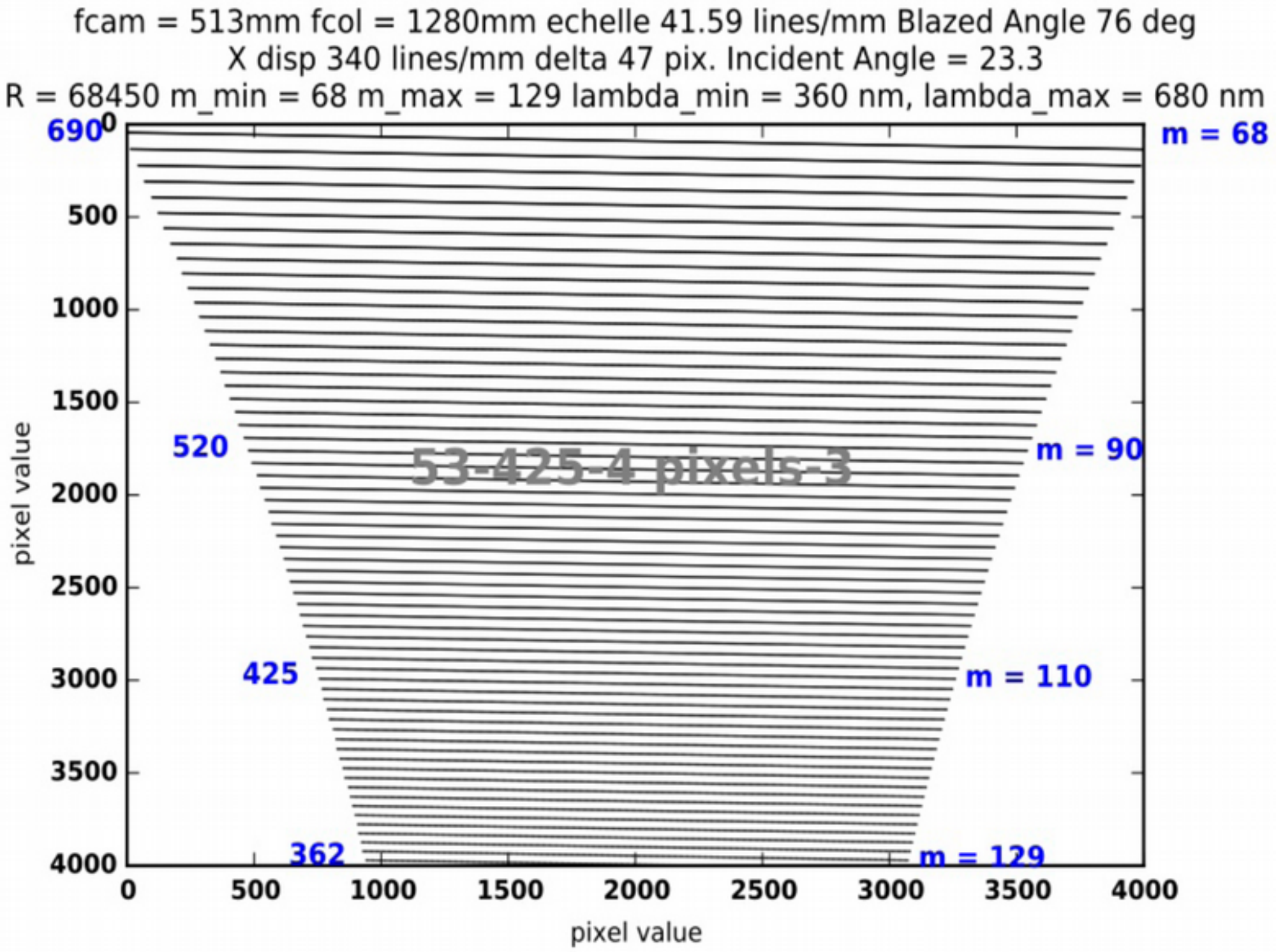
PLATO follow-up

- Numbers from S. Udry
- - mV<11 stars, with average level of activity, assuming 15 min x 15-20 obs. per star
- - 1-2m-class telescopes: 10m/s ; giant planets on short/medium orbits 1750 stars : ~900 nights = ~50 nights/year x 6 years x 3 telescopes
- - 4m-class telescopes: 1 m/s ; giant planets on long orbits, super-earths on short/medium orbits
- 1400 stars : ~700 nights = ~40 nights/year x 6 years x 3 telescopes
- - 8m-class telescopes: 10cm/s ; super-earths on long orbits, earths on short/medium orbits, earths on long orbits around brightest stars (mV < 10)
- 550 stars : ~240 nights = ~40 nights/year x 6 years x 1 telescope
- - ELT: earths on long orbits around faintest stars (mV~11)

Astronomický ústav AV ČR

PLATOSpec spectrograph

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


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
690
520
425
362
m = 68
m = 90
m = 110
m = 129
53-425-4 pixels-3
pixel value
pixel value
0
500
1000
1500
2000
2500
3000
3500
4000

PLATOSpec timeline

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

Ground based support for space missions

Astronomický ústav AV ČR

- PLATOSpec will contribute to PLATO candidates follow-up
- We will work on Initial screening
- We could characterize hot Jupiters
- We will have all the time = long term monitoring possible! → cold Jupiters?
- PLATOSpec can contribute to ARIEL too!

Summary

- OES is a great facility for ground based support of exoplanetary space missions at bad observing sites!
- PLATOSpec will be a great facility for ground based support of exoplanetary space missions, namely PLATO and ARIEL!
- 2m class telescopes can be used also for characterization of atmospheres!
- Importance of 2m class telescopes for exoplanetary missions!

Summer schools

Astronomical News

Report on the ESO/OPTICON/IAU Summer School

Modern Instruments, their Science Case, and Practical Data Reduction

held at Masaryk University, Brno, Czech Republic, 31 August–12 September 2015

Petr Kabath[1]
Michel Dennefeld[2]
Michela Gerbaldi[3]
Ernst Paunzen[3]
Vladimir Karas[1]

[1] Astronomical Institute of Czech Academy of Sciences, Ondřejov, Czech Republic
[2] Institut d'Astrophysique de Paris, France
[3] Department of Theoretical Physics and Astrophysics, Masaryk University Brno, Czech Republic

The Astronomical Institute of the Czech Academy of Sciences organised, jointly with its local partners from Masaryk University, and international partners OPTICON, ESO and the IAU, a two-week practical training course in astronomy for young researchers. The summer school is briefly summarised: lectures covered a wide range of theoretical and observational topics and the emphasis of the practical work was on the analysis of archival data.

Introduction

The Czech Republic is an active but relatively young ESO Member State, having joined in 2007. Therefore, it is extremely important to broaden the expertise of young Czech astronomers with regard to the newest available instrumentation and observing facilities. In 2014, the first workshop with this goal, entitled "Seven Years in Chile: The Accomplishments and Goals of Czech Astronomers at ESO", brought together Czech researchers at Villa Lanna in Prague (see Kabath et al., 2014). It was decided that the next step would be the organisation of a summer school, potentially with international participation.

In early 2015, the Optical Infrared Co-ordination Network (OPTICON) agreed to join forces and to co-organise an event within the traditional framework of the Network of European Observatories in the North (NEON) schools, aimed at the education of early-stage researchers in astronomy. Usually, the format of OPTICON schools comprises observing, archival data analysis or awareness-raising courses. The latter topics were chosen, with a special focus on a hands-on approach to archival data, together with presentations of other European telescopes accessible via the OPTICON Access programme. Finally, to broaden participation even further, the help of International Astronomical Union (IAU) was also obtained, within the International School for Young Astronomers (ISYA) scheme (sponsored by the Norwegian Academy of Sciences and Letters), to sponsor the participation of a few more students from outside the European Union.

The summer school took place in Brno, Czech Republic, on the modern campus of Masaryk University between 31 August and 12 September 2015. Over the course of two weeks, the campus lecture hall witnessed a series of education sessions presenting the modern observatories of Europe, be it ESO, La Palma, Observatoire de Haute Provence (OHP), Calar Alto, Pic du Midi or other facilities, along with their instrumentation and the most recent scientific highlights, ranging from the theoretical background to modelling and astrophysical interpretation. The school was organised under the auspices of the Czech Ministry of Education, Youth, and Sports, and the presence of the Czech Ambassador to Chile enhanced the recognition of the event.

Figure 1. All the participants at the summer school photographed on the steps of the lecture theatre at Masaryk University, Brno.

The school was attended by 39 participants representing astronomy Masters and PhD students, and also several young postdoctoral researchers, mainly from EU Member States, supported by OPTICON. Additionally, nine students received support from the Czech Republic from local funding schemes. Moreover, IAU grants allowed the participation of seven non-EU students, from Armenia, Egypt, Iran and Ukraine. In total, 17 states were represented.

Programme

The school opened on 1 September 2015 with a speech from the Deputy Minister of Education, Youth and Sports of the Czech Republic, Robert Plaga, followed by welcoming speeches from the organising institutions. The Czech vice-president of the ESO Council, Jan Palouš, gave a lecture about the Czech road to becoming an ESO member.

The scientific part of the programme was supported by 15 lecturers from leading European institutions, including ESO, Institut d'Astrophysique de Paris (IAP), Instituto de Astrofísica de Canarias (IAC)

Workshop PLATOSpec

- Autumn 2018 in Ondrejov 2.5 days workshop on ground based follow-up
- 29-30 October, dates FIXED now!

ERASMUS+

- Strategic partnership of IAC, AI SAV, UK Bratislava, MU Brno led by AI of Czech Academy of Sciences (ES, SK, CZ)
- Short exchanges for experienced visitors
- Long term exchanges for students (mainly Phd)
- 2 summer schools – mainly archival data

  - 1st school at Slovakia 18 – 27 June 2019!

WEB: www.erasmus.asu.cas.cz

Thank you for your attention