SPECTROSCOPIC AND PHOTOMETRIC OBSERVATIONS AT MOLĖTAI AO FOR THE ESA PLATO SPACE MISSION: FIRST RESULTS

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Vilnius University

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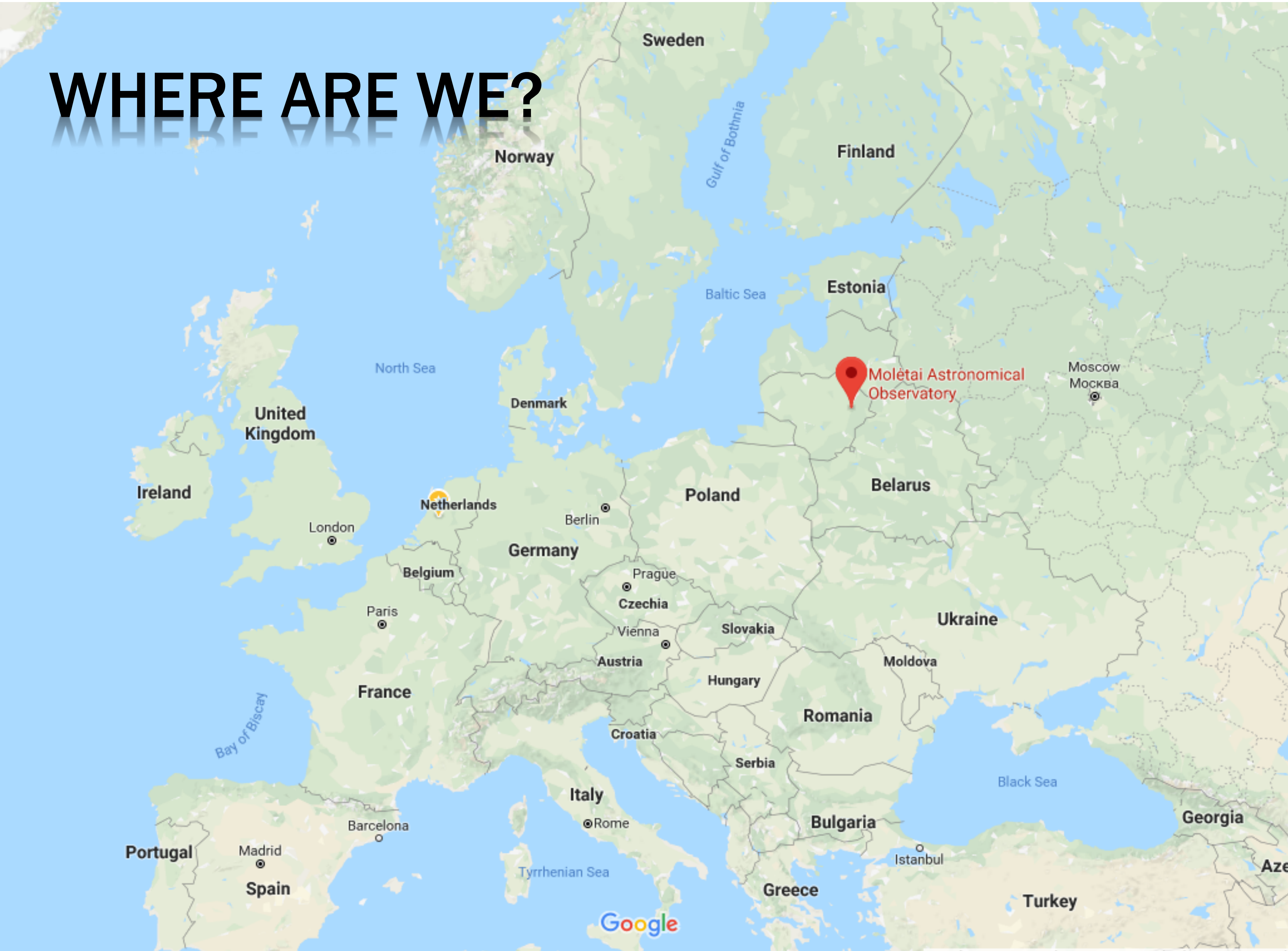
(LAT-08/2016)

MAO: MOLĖTAI AO, LITHUANIA

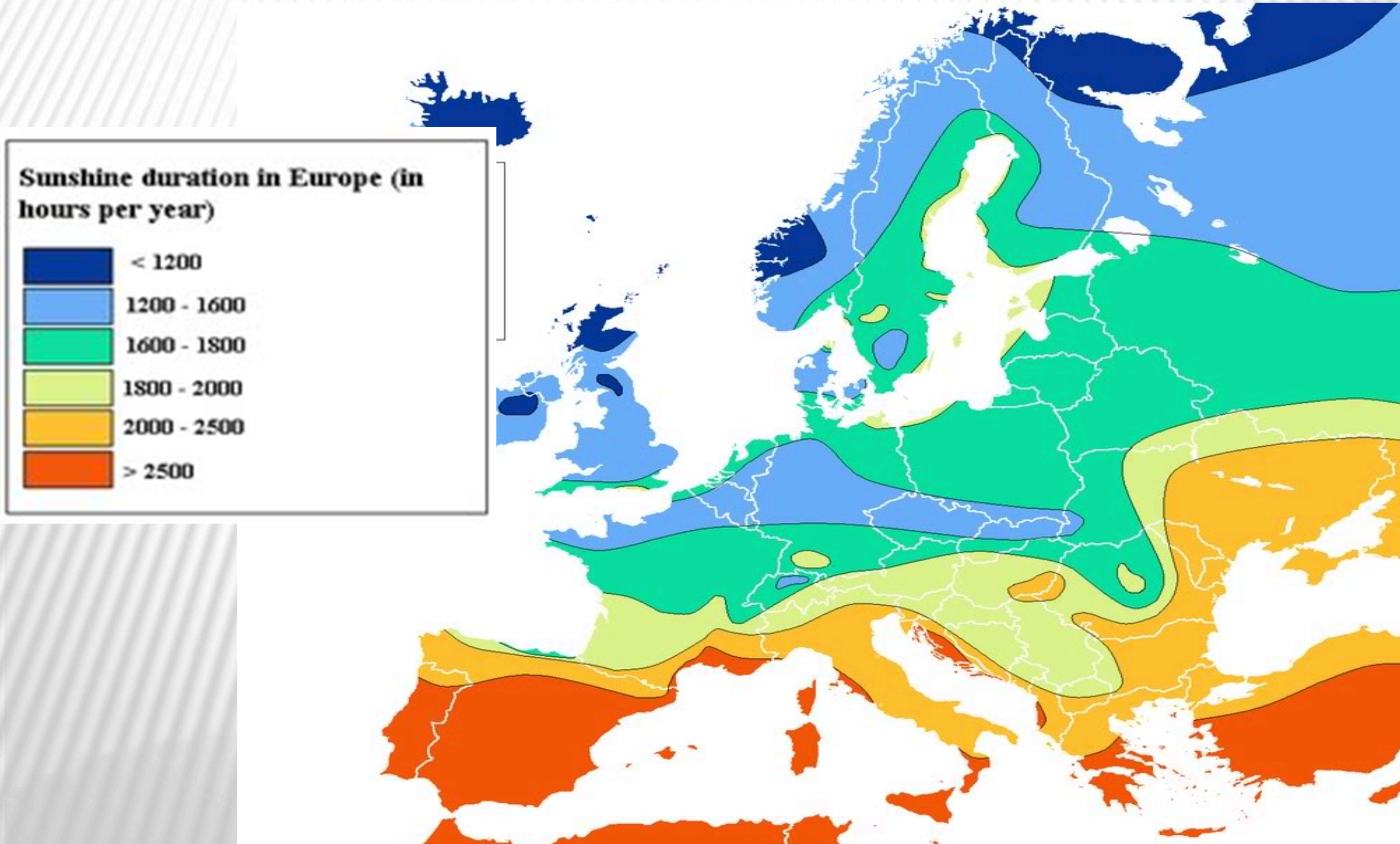
WHERE ARE WE?


Sweden
Norway
Gulf of Bothnia
Finland
Estonia
Baltic Sea
North Sea
Denmark
Molėtai Astronomical
Observatory
Moscow
Москва
United
Kingdom
Ireland
Netherlands
London
Berlin
Poland
Belarus
Germany
Belgium
Prague
Czechia
Paris
Vienna
Slovakia
Ukraine
Austria
Moldova
Hungary
France
Romania
Bay of Biscay
Croatia
Serbia
Black Sea
Italy
Bulgaria
Georgia
Barcelona
Rome
Istanbul
Portugal
Madrid
Azer
Spain
Tyrrhenian Sea
Greece
Turkey
Google

WHERE ARE WE?

Norwegian Sea
Iceland
Sweden
Finland
Norway
Baltic Sea
Latvia
North Sea
Denmark
United
Ireland
Belarus
Ukraine
France
Black Sea
Turkey
Azerbaijan

NIGHTS?



Sunshine duration in Europe (in hours per year)
< 1200
1200 - 1600
1600 - 1800
1800 - 2000
2000 - 2500
> 2500

TELESCOPES

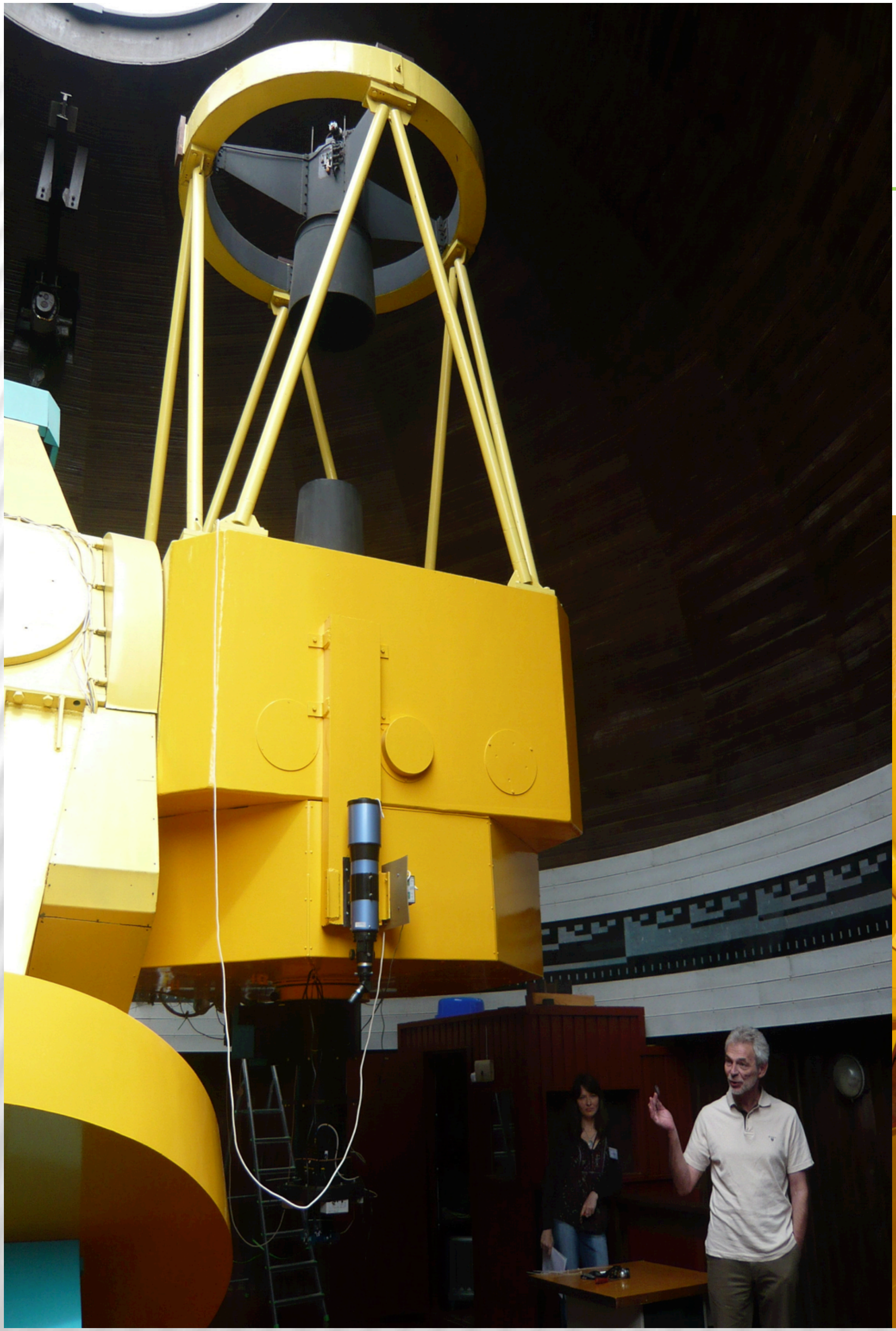
1.65 m Ritchey-Chretien

0.63 m Cassegrain

0.35/0.51 m wide field Maksutov

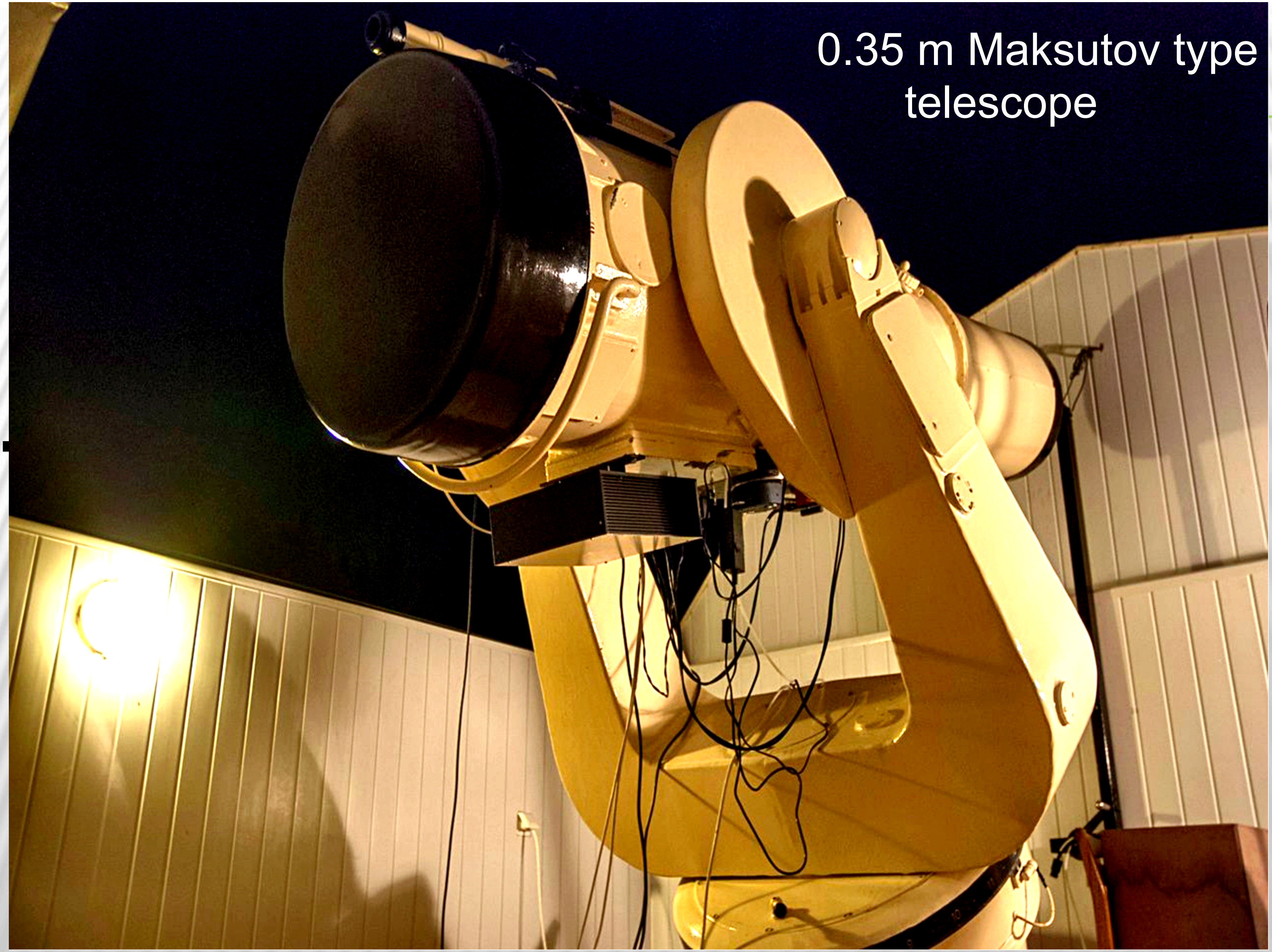
Telescopes at Molėtai AO

1.65 M TELESCOPE RITCHEY-CHRETIEN



Telescopes at Molėtai AO

0.35/0.51 m Maksutov type telescope
Diameter of FOV may reach 2^{o}


0.35 m Maksutov type
telescope

INSTRUMENTS

1.65 m Ritchey-Chretien

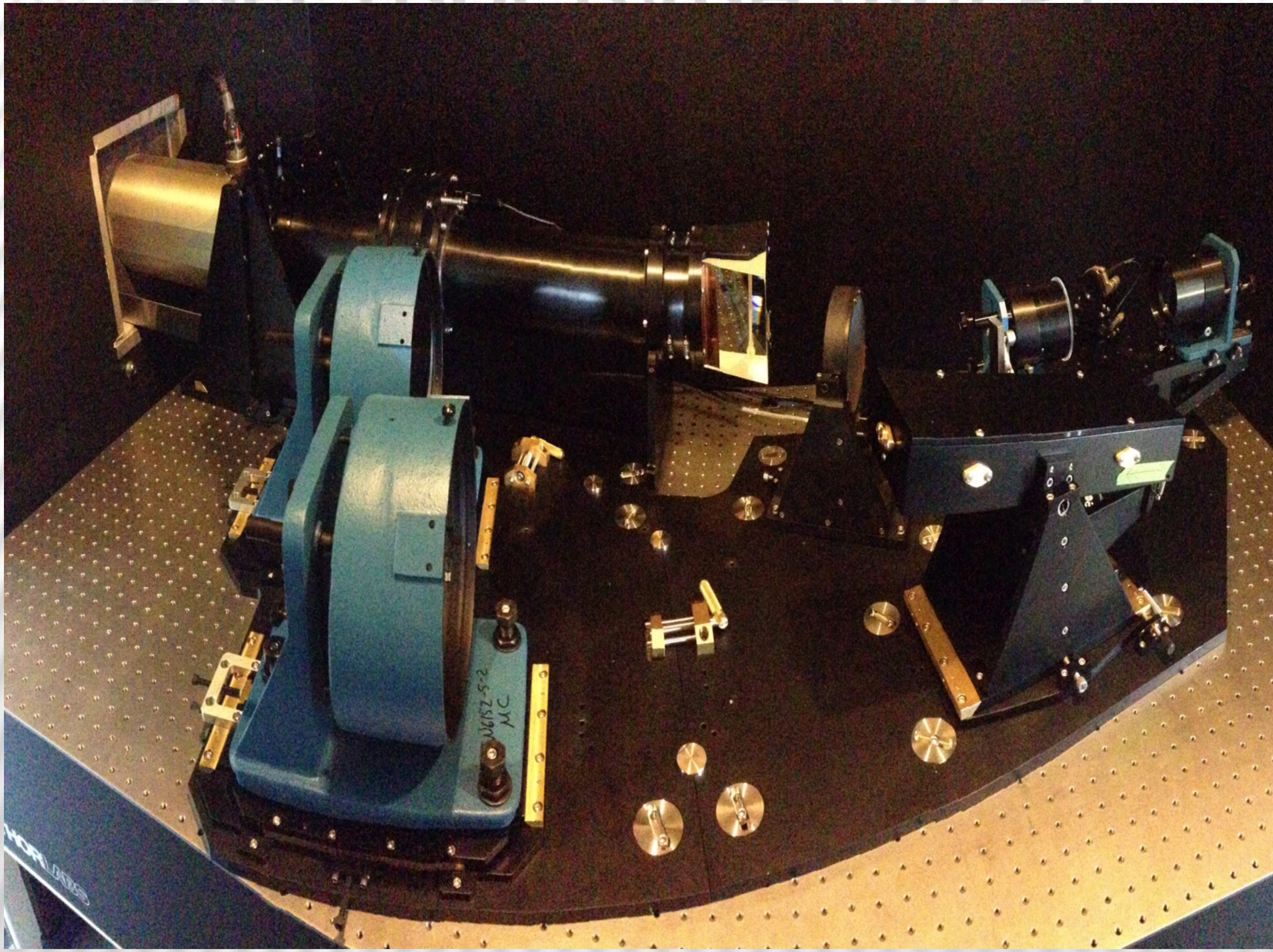
High resolution spectrograph
+ CCD camera (photometry)

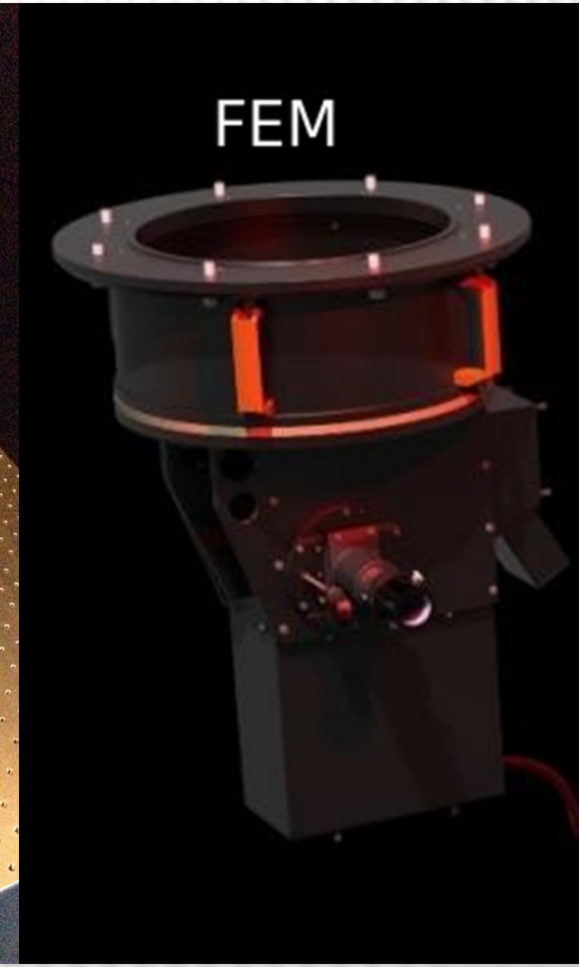
0.63 m Cassegrain

0.35/0.50 m wide field Maksutov

CCD camera (photometry)

VILNIUS UNIVERSITY ECHELLE SPECTROGRAPH (VUES)





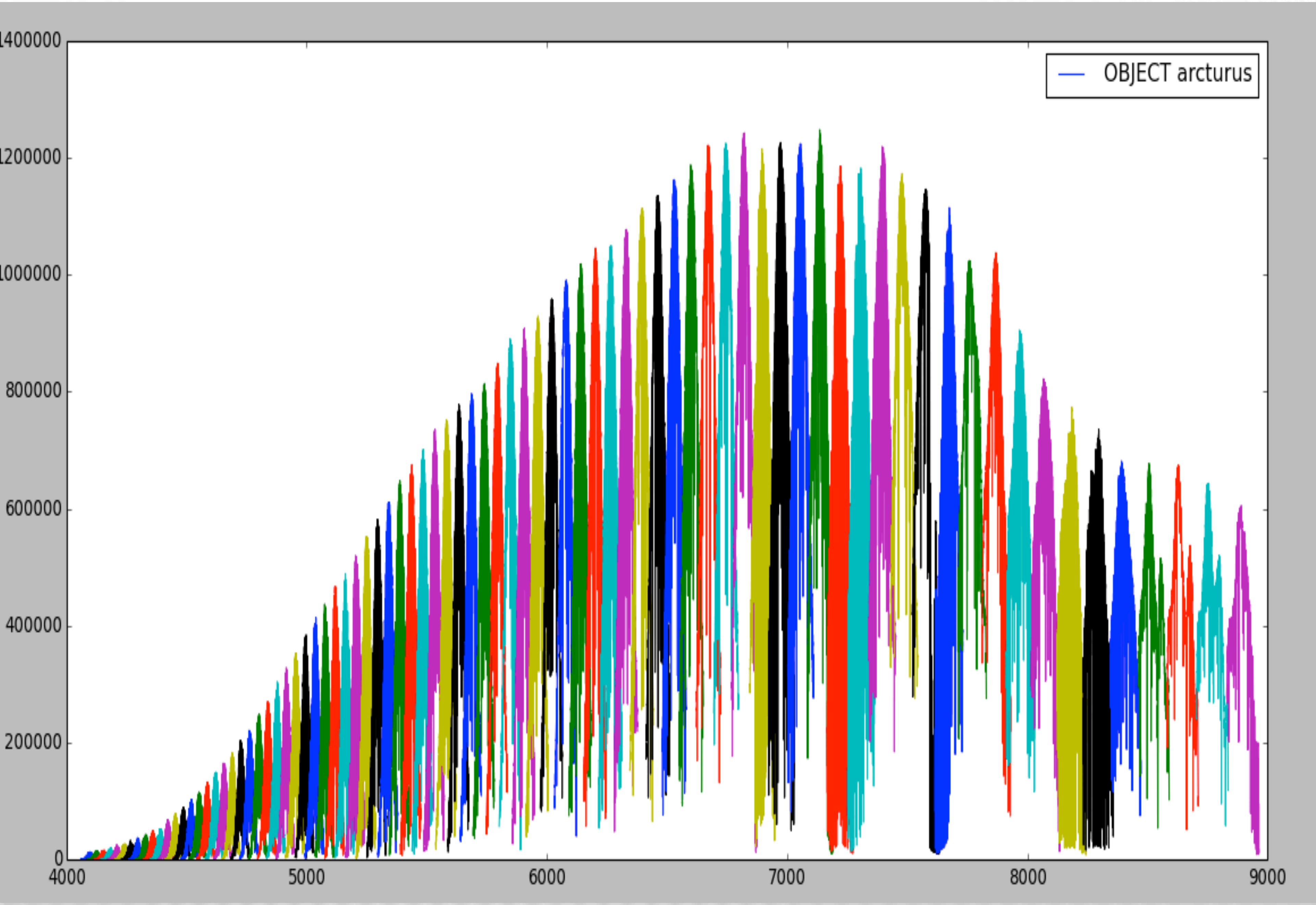
Designed, built, and delivered by the Yale Exoplanet Laboratory

Vilnius University Echelle Spectrograph (VUES)

Key parameters of the spectrograph:

Wavelength Range	λ = 400–880 nm
Spectral Resolution Modes, λ / $\delta\lambda$	30000; 45000; 60000
Echelle spectrum	70 – 153 raws
Ešele difrakcinė gardelė	31.6 grooves/mm
Instrumental Throughput	25%, λ = 543 nm
Broad-spectrum optical fiber (FBPI)	fiber, Φ = 100 µm, l = 16 m
On-sky Fiber Aperture	2.5 arcseconds
Spectrograph Detector	4k x 4k x 15 µm pixel pitch
Temperature	-94ºC

The faintest objects can be observed with VUES: 9-10 mag


1400000
1200000
1000000
800000
600000
400000
200000
0
4000
5000
6000
7000
8000
9000
OBJECT arcturus

VUES COMPARISON WITH OTHER SPECTROGRAPHS

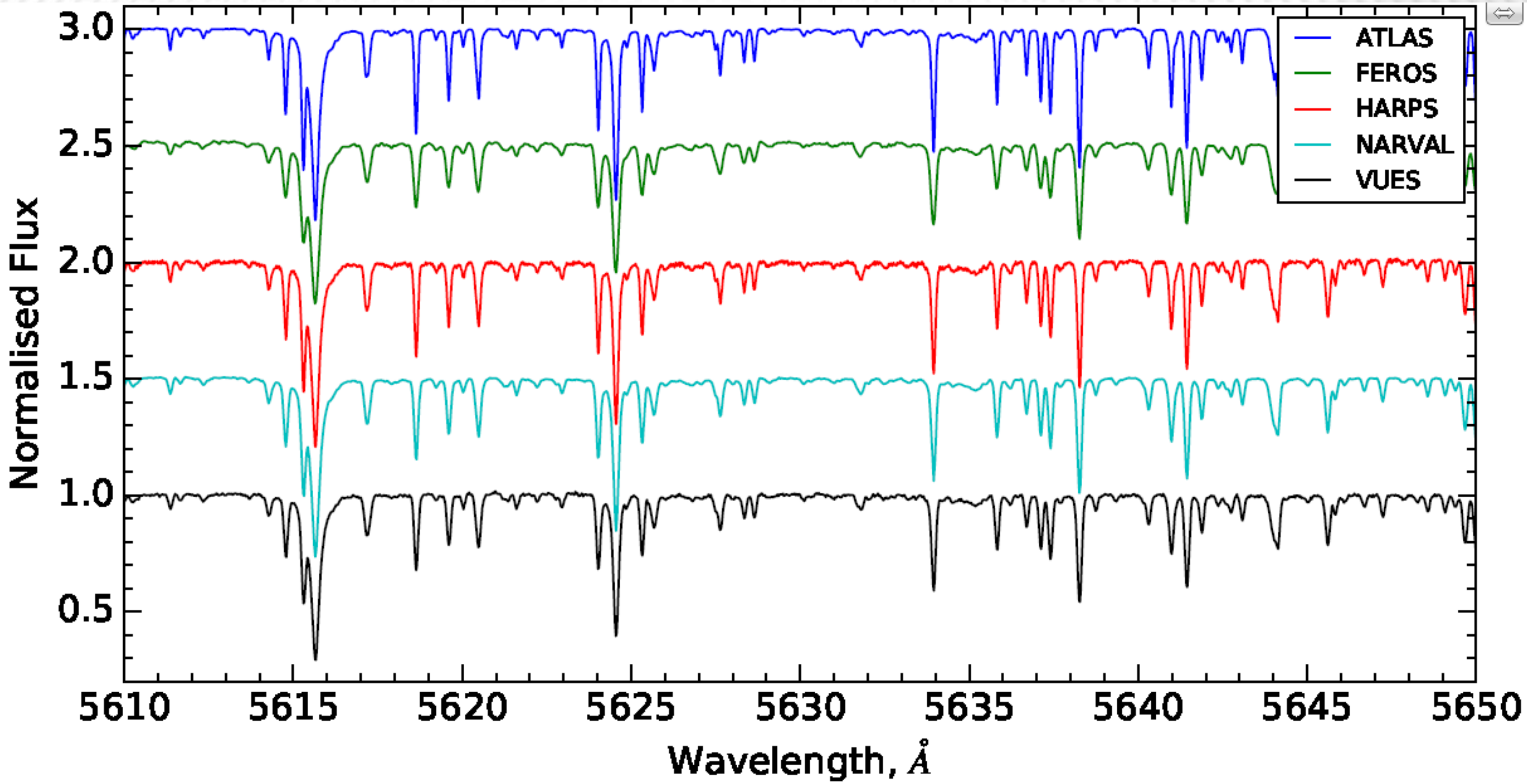
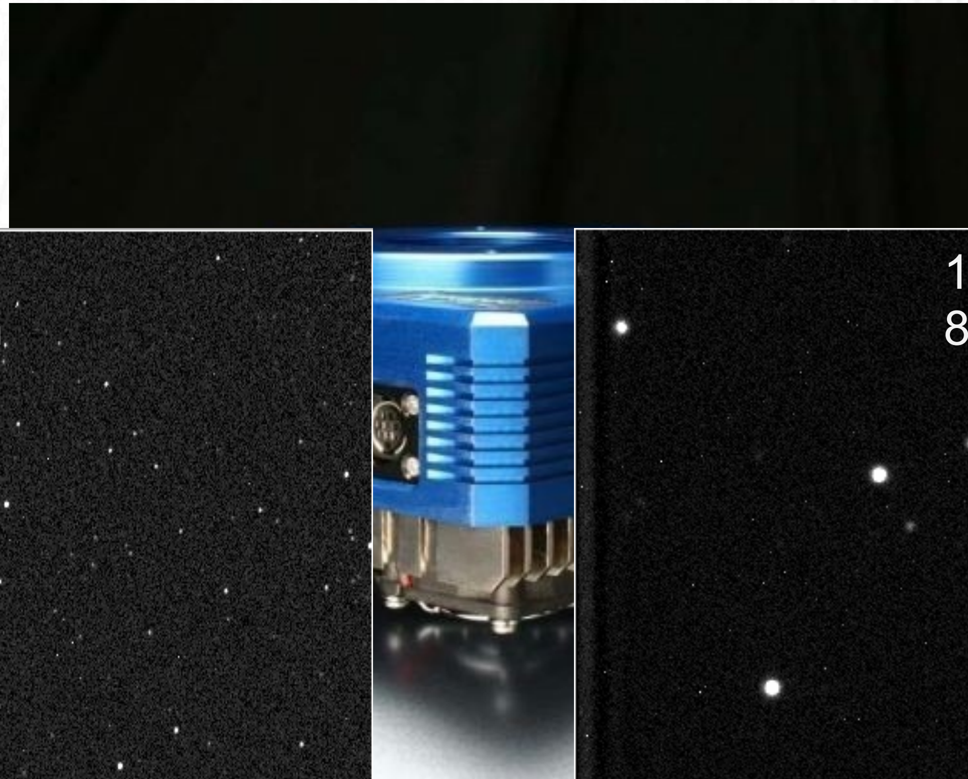
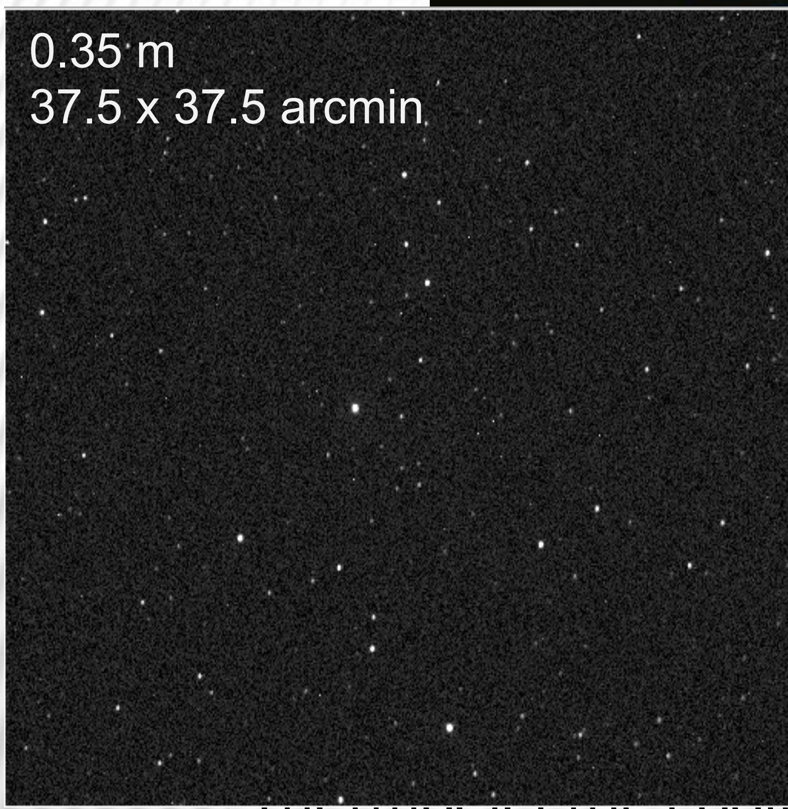
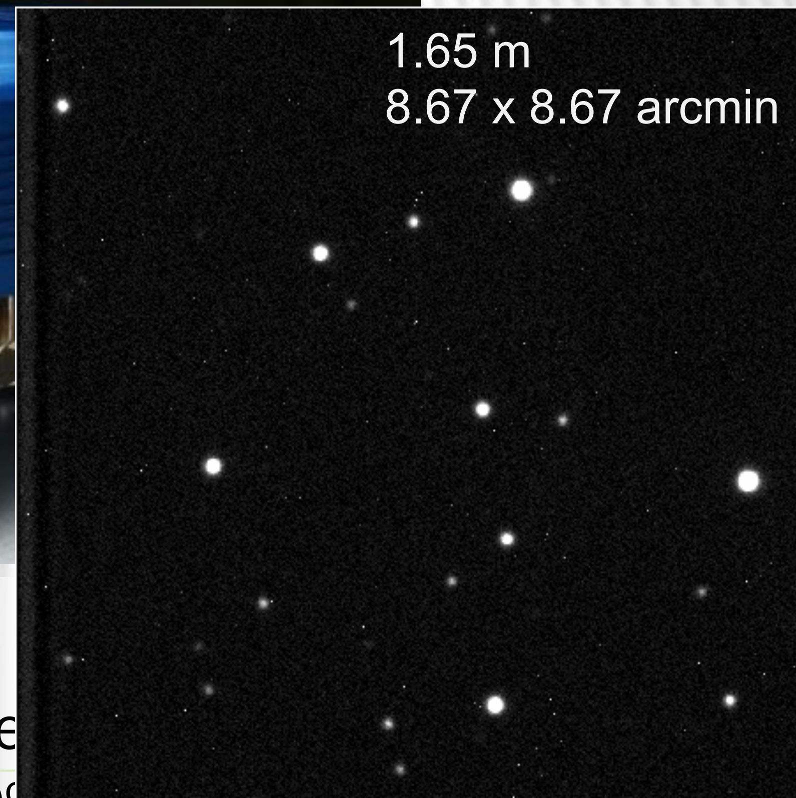


Fig. 3. Examples of the Solar spectra observed with the ATLAS, FEROS, HARPS, NARVAL and VUES spectrographs.

Photometric observations







CD came

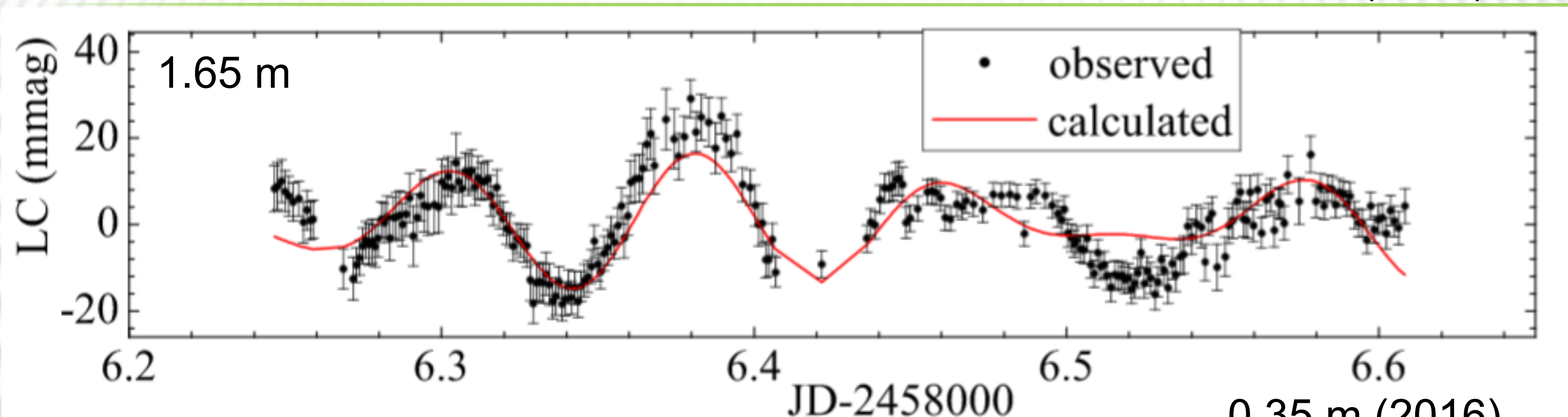
Thermoelectric cooling (-30°C)

Array Size (pixels)1024 x 1024

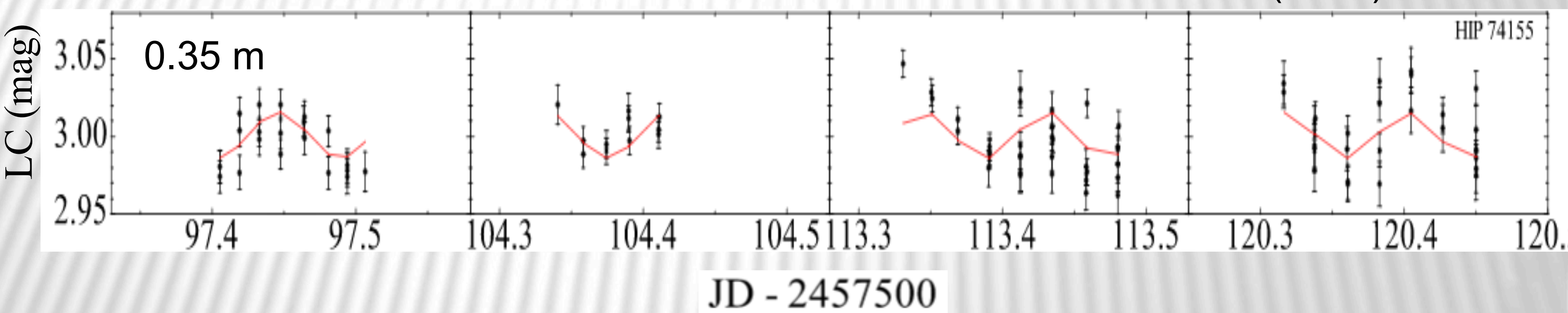
Pixel Size 13 x 13 microns

EXAMPLES OF LIGHT CURVES

1.65 m (2017)

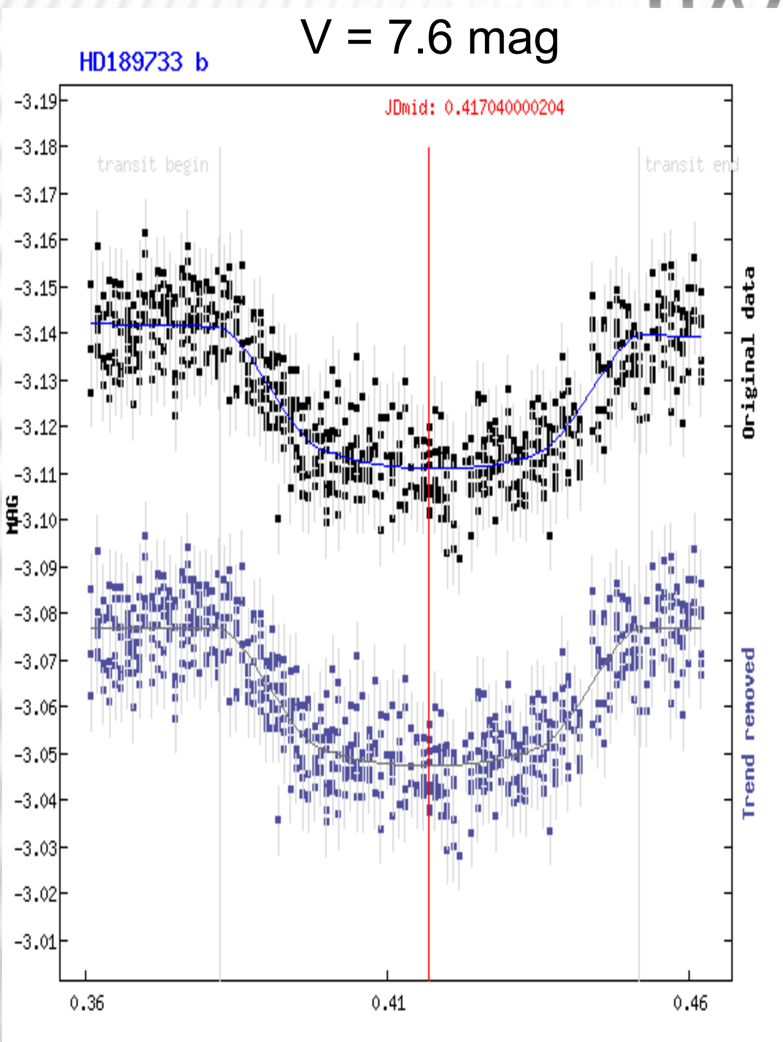


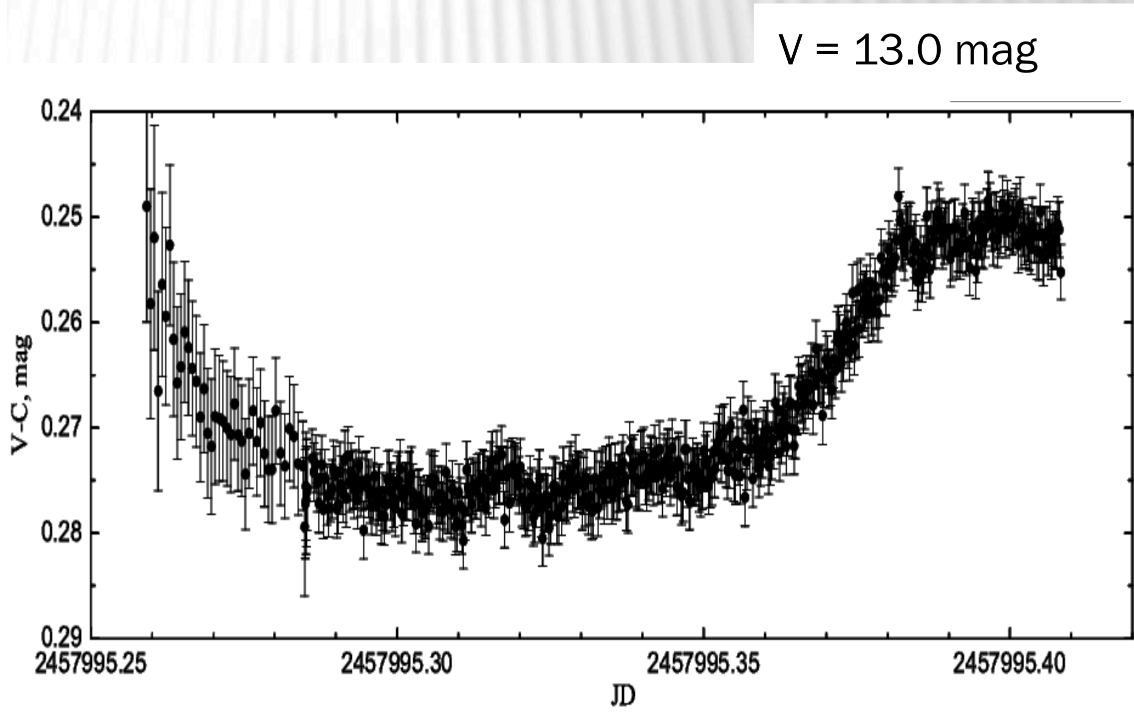
0.35 m (2016)



V = 7.12 mag
Differential photometry done with Muniwin
program of the software package C-Munipack 1 (Hroch 2014),
which is based on a software package DAOPHOT (Stetson 1987).

EXOPLANETARY TRANSITES





Limiting magnitudes?

mao.tfai.vu.lt

Deadlines

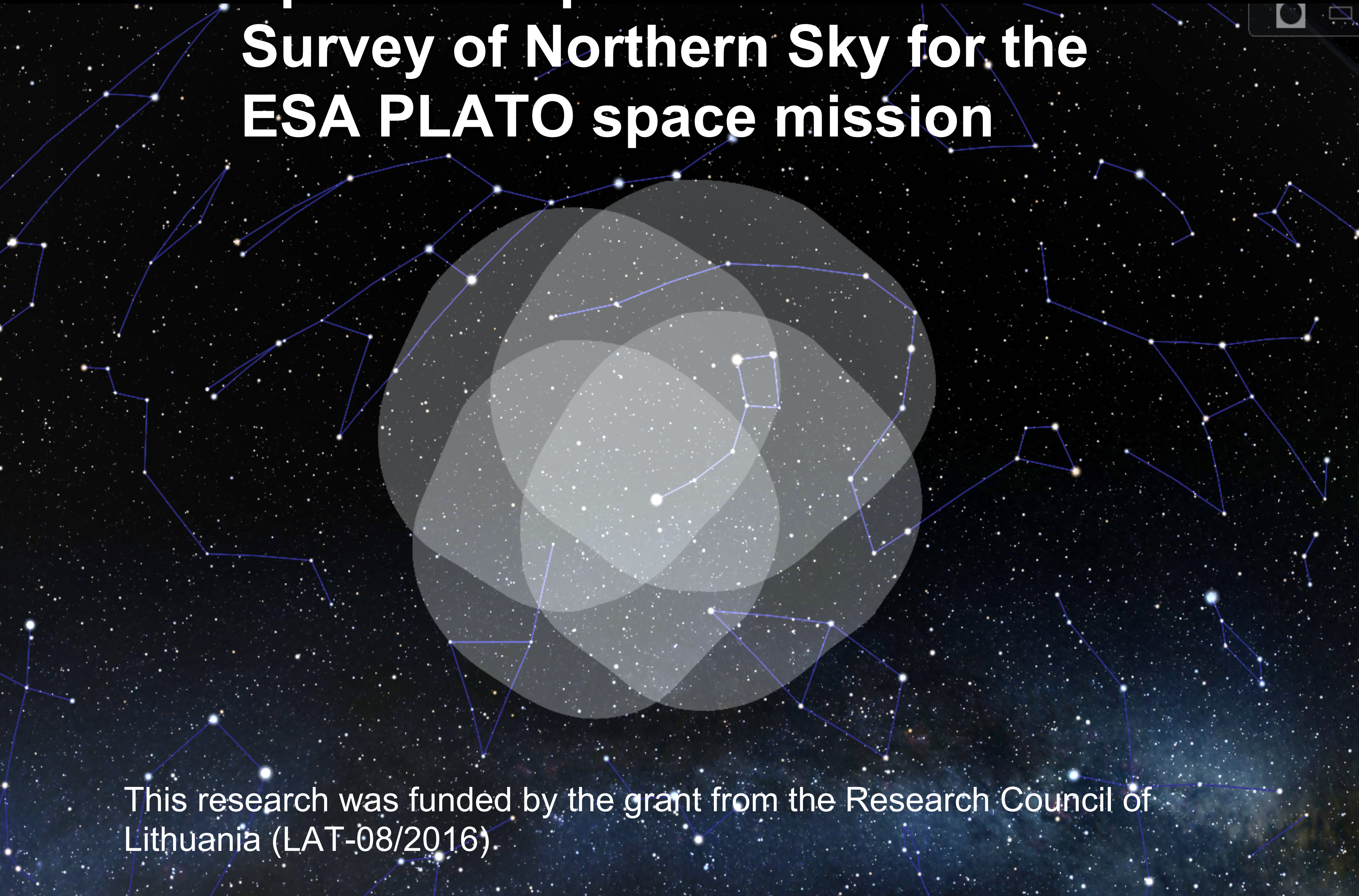
For the normal proposal cycle*	Submission Deadline
December to February	31of October
March to May	31 of January
June to August	30 of April
September to November	31 of June

*Proposals are reviewed in 15 days after the submission deadline

- Instruments
- Apply for observing time
  - Allocated observations
  - Application form
- Observing conditions

- Dr. Julius Sperauskas
- Habil. dr. Gražina Tautvaišienė
- Prof. dr.(HP) Vladas Vansevičius

Spectroscopic and Photometric Survey of Northern Sky for the ESA PLATO space mission



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MOTIVATION

- Need of stellar variability and spectroscopic information that is necessary for a development of the PLATO input catalog
- Current photometric catalogs and spectroscopic surveys are not enough

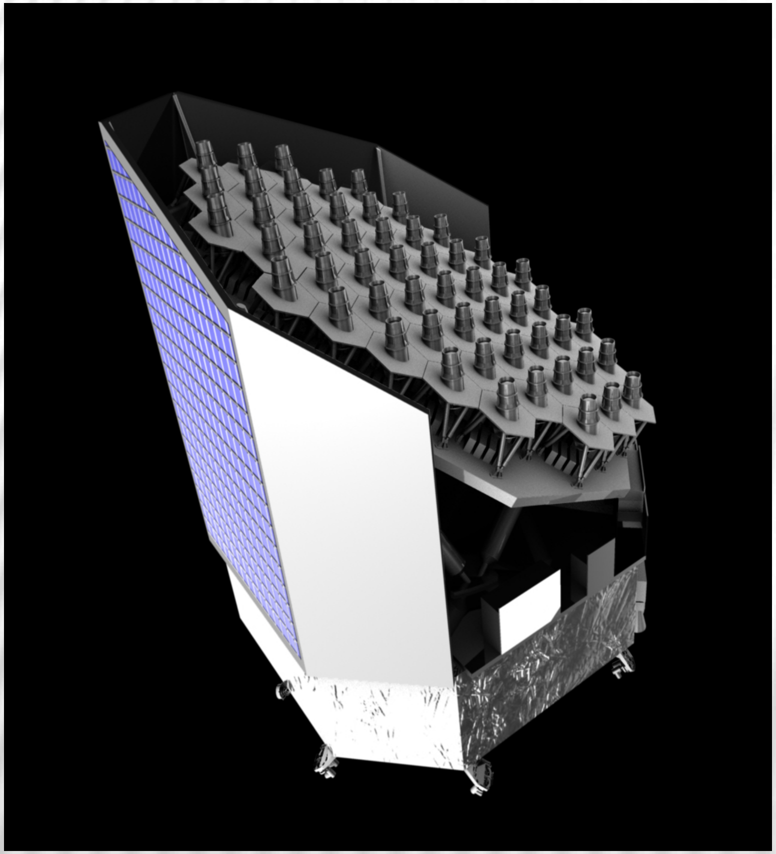
• Spectroscopy was never done before for 73% of FGK bright stars (V<8 mag) in STEP2 .
More stars have photometric magnitudes V&B.

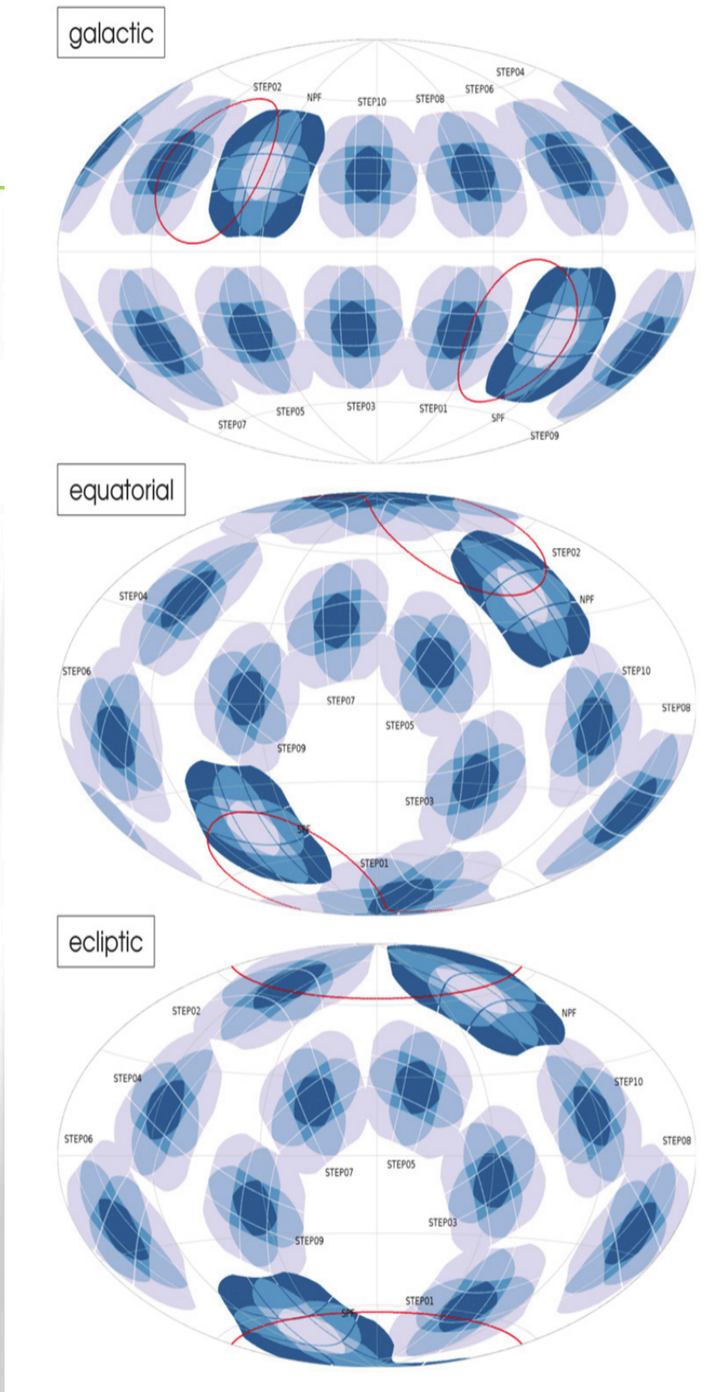
MOTIVATION

- The largest telescope in the northern Europe (1.65 m) with a high resolution spectrograph @ latitude N 55.3^{o}

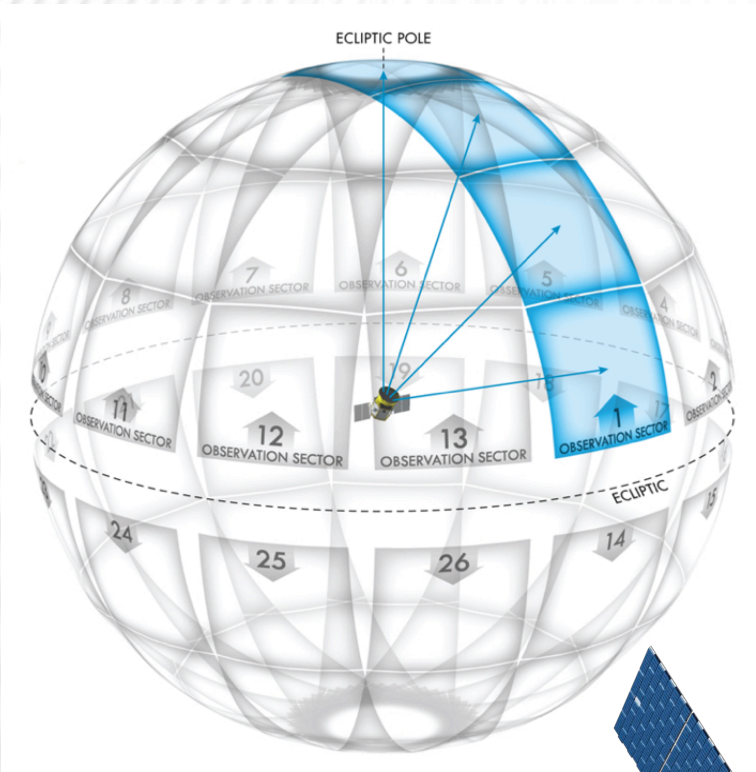
  (most spectroscopic surveys were done from southern hemisphere)
- Polaris region accessible
- Important for PLATO and TESS missions

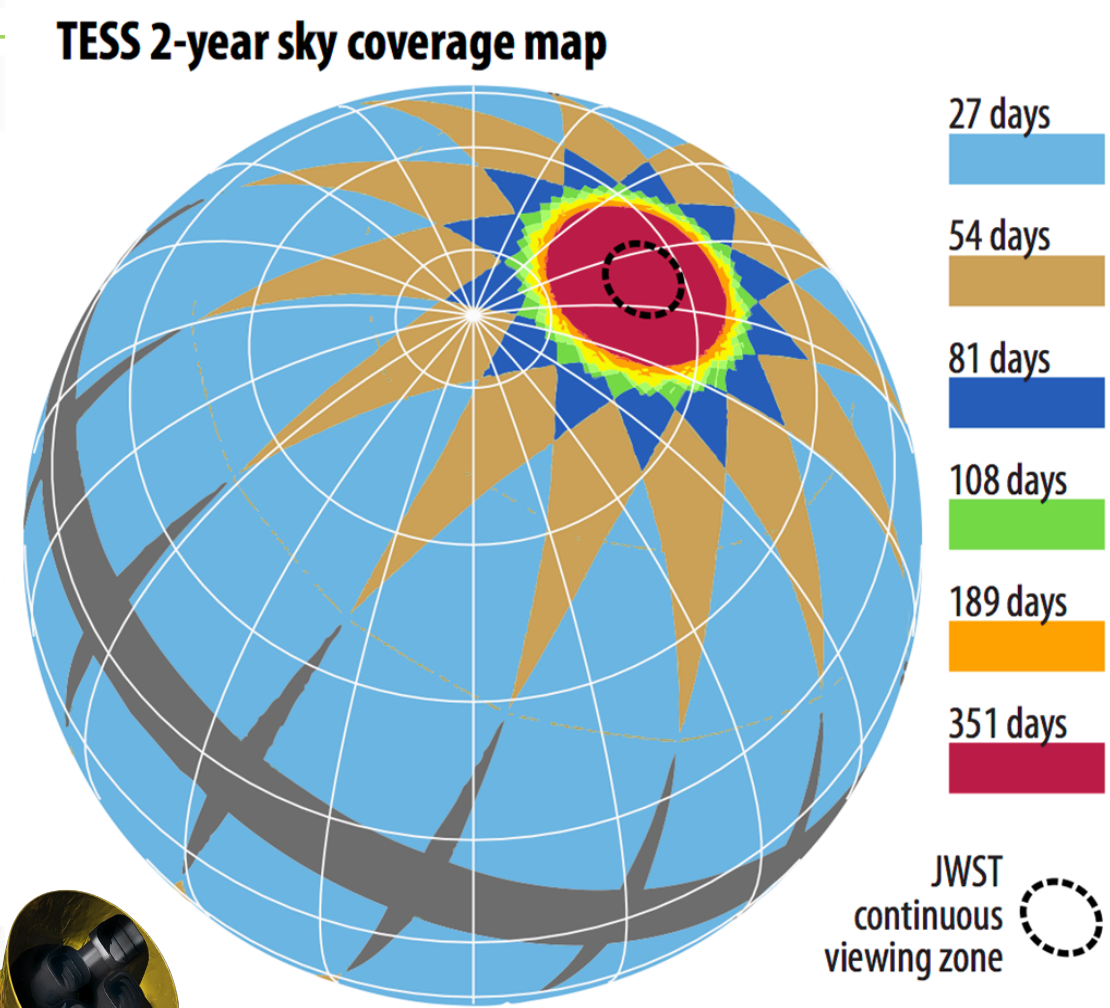
PLATO NORTHER SKY

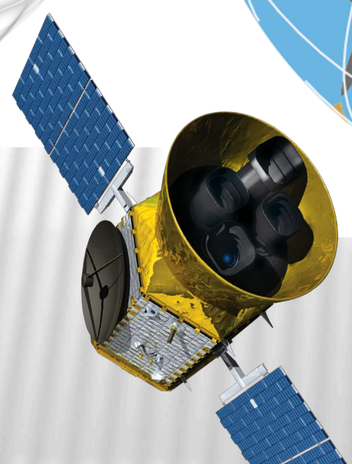




TESS NORTHERN SKY







Spectroscopic Survey in PLATO fields

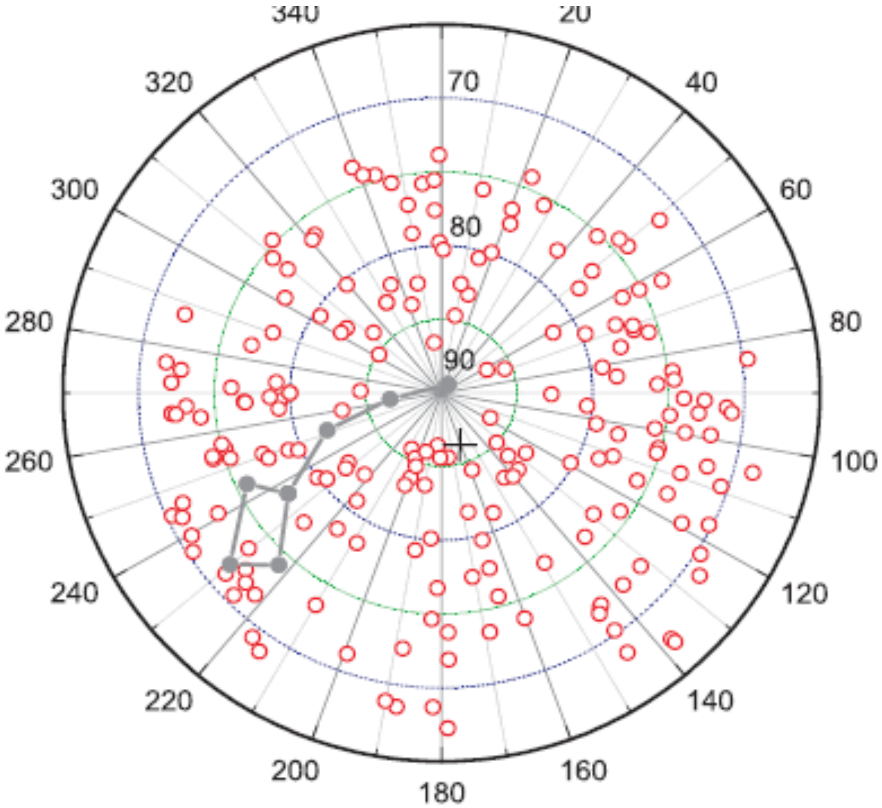


Fig. 2. Postitions of the programme stars (red open circles) in the PLATO STEP02 field. The centre of the field is shown as the black cross.

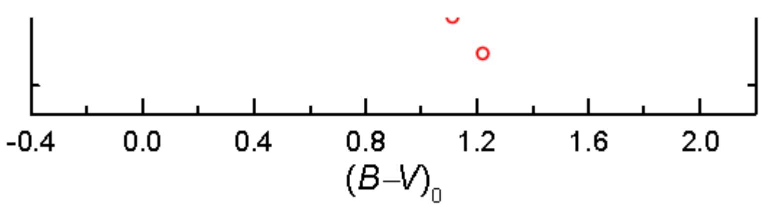


Fig. 1. Colour-magnitude diagram of stars in the PLATO STEP02 field. The FGK dwarfs observed in this programme are presented as the red open circles.

Selected bright dwarfs and sub-giants (V<8mag) of F5 and cooler spectral types (~200 in a field)

Observed 213 stars with magnitude up to V=8 mag in the northern sky.

Derived spectroscopic atmospheric parameters (effective temperature, surface gravity, metallicity) for 140 slow rotating stars.

Other stars were either fast rotators or double line binaries (will be analyzed using different techniques)

Found: 7 new spectroscopic binary candidates

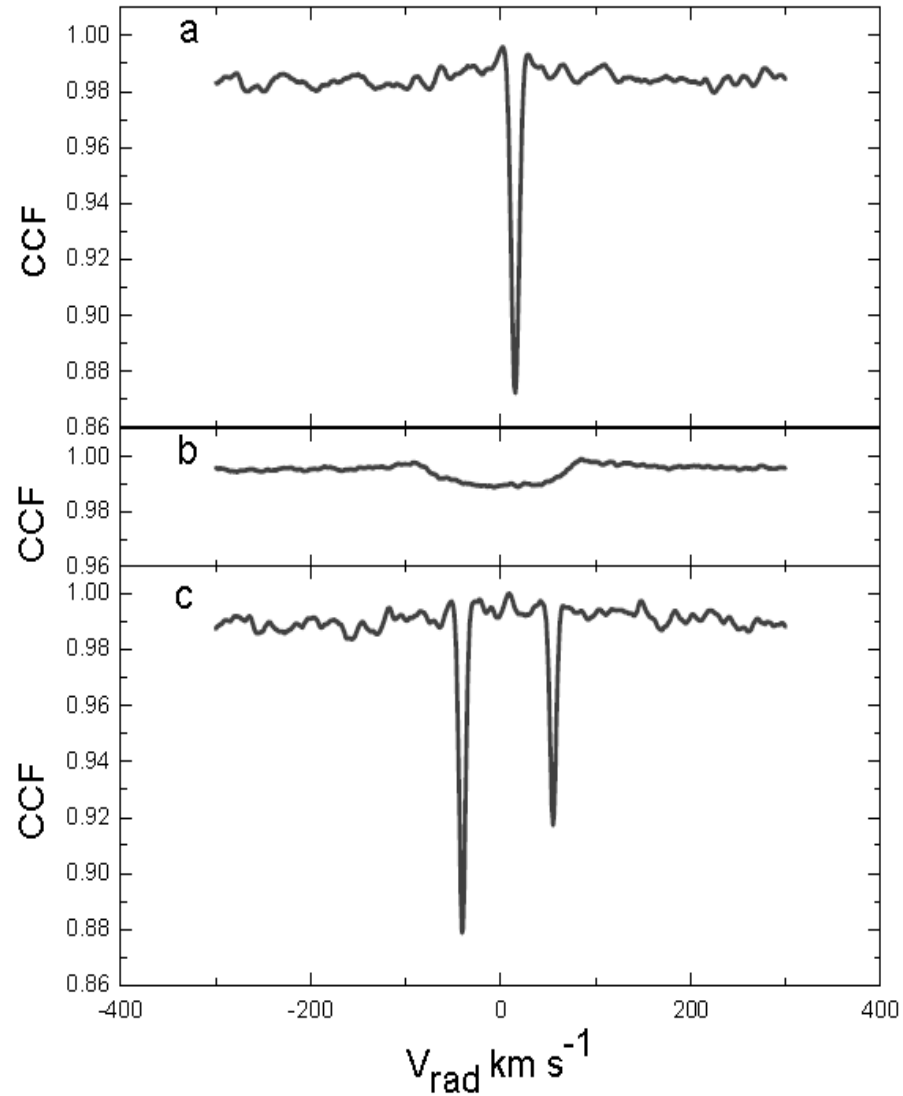


Fig. 4. CCFs produced for calculating the radial velocities and detection of double-line binary stars: a) the typical slow-rotating star, b) the fast-rotating star, c) CCF of the double-line spectroscopic binary TYC 4602-552-1 (HIP 117712), showing two profiles.

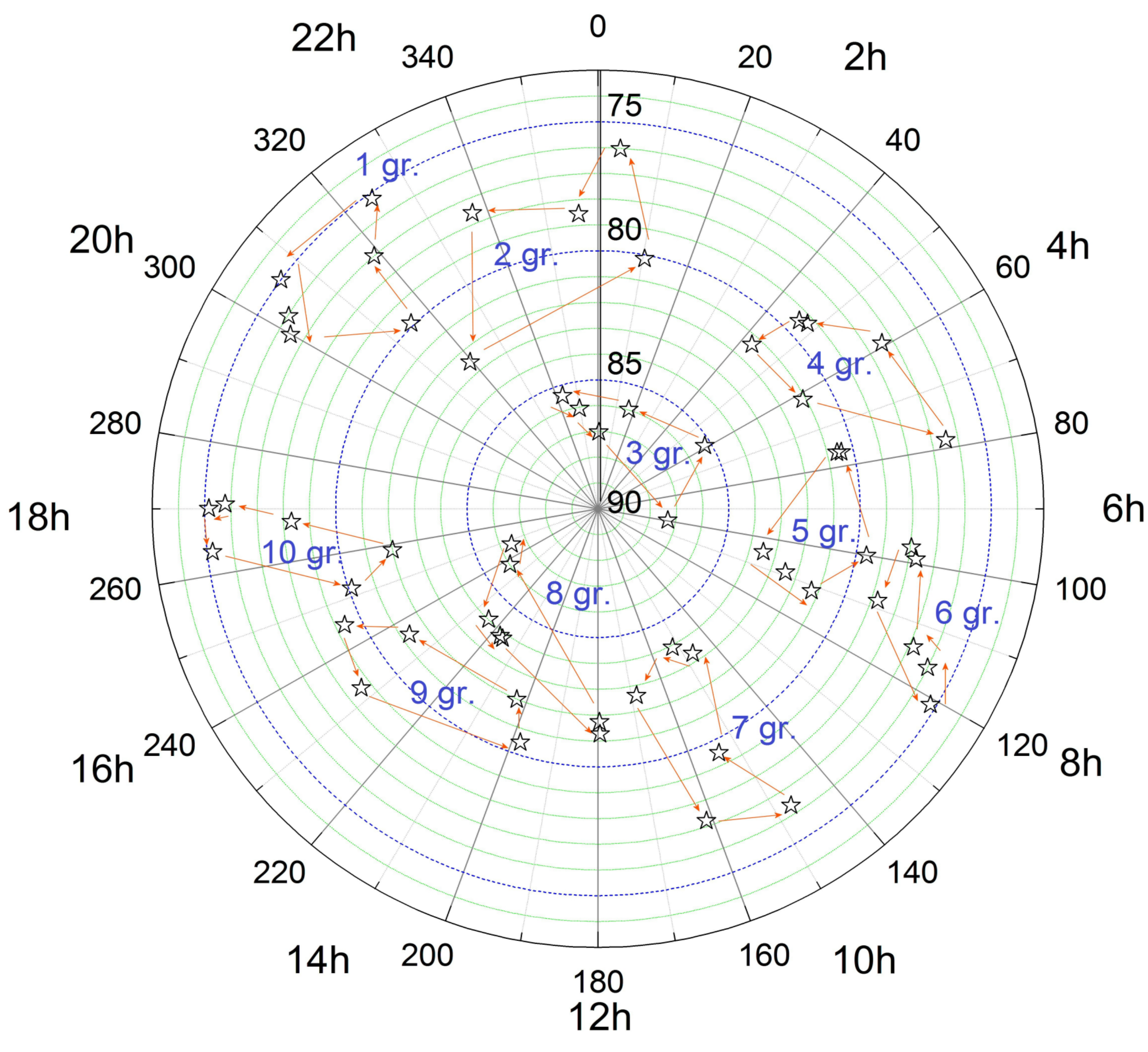
Table 3. The atmospehric parameters of the sample stars.

TYC identification	$T_{\rm eff}$ K	$\sigma_{T_{\rm eff}}$ K	$\log g$	$\sigma_{\log g}$	[Fe/H]	$\sigma_{\rm [Fe/H]}$	$v_{\rm t}$ km s^{-1}	$\sigma_{v_{\rm t}}$ km s^{-1}	$V_{\rm rad}$ km s^{-1}	$\sigma_{V_{\rm rad}}$ km s^{-1}	$FWHM_{V_{\rm rad}}$ km s^{-1}
1-1496-1	6353	54	4.24	0.35	0.01	0.08	1.39	0.24	−2.97	0.05	10.23
1-589-1	6711	93	4.18	0.36	−0.10	0.12	1.76	0.34	13.00	0.01	15.47
)-145-1	6042	31	3.77	0.22	0.10	0.08	1.33	0.24	−63.52	0.01	10.31
9-586-1	5650	28	4.41	0.25	−0.13	0.09	0.85	0.24	26.68	0.01	8.11
3-326-1	6423	147	4.05	0.46	0.02	0.01	1.28	0.32	−13.11	0.01	15.00
)-2068-1	6111	33	3.83	0.25	0.07	0.09	1.29	0.23	−28.79	0.01	9.07

Typical precision $\sigma_{T\rm eff}$=55K, $\sigma_{\rm logg}$=0.3 , $\sigma_{\rm [Fe/H]}$=0.1dex
Values of atmospheric parameters are in good agreement with photometric and other spectroscopic determinations.
The table with all 140 analyzed stars will be available online

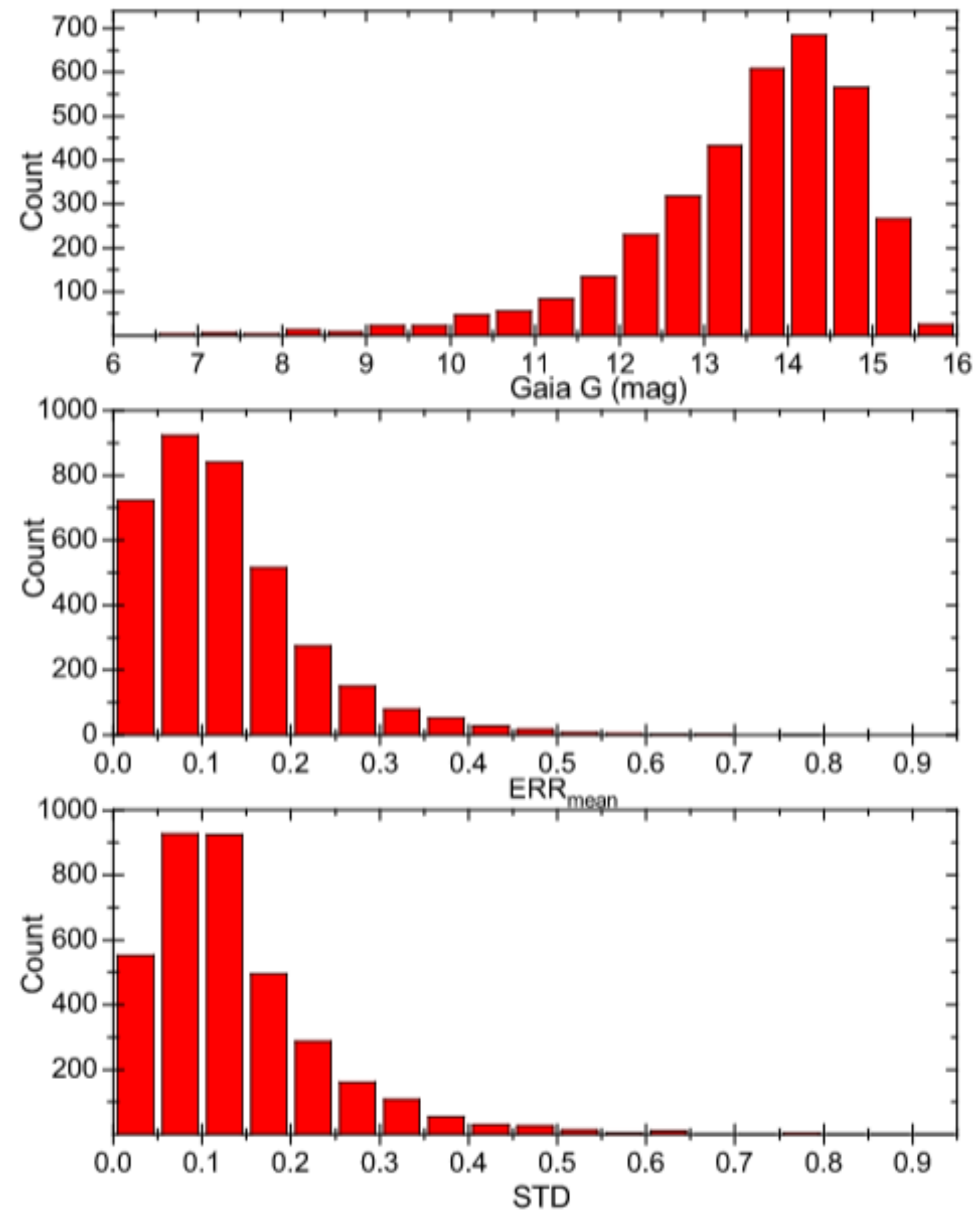
Results of chemical composition analysis is going to be ready soon.

PHOTOMETRY WITH 0.35 M TELESCOPE

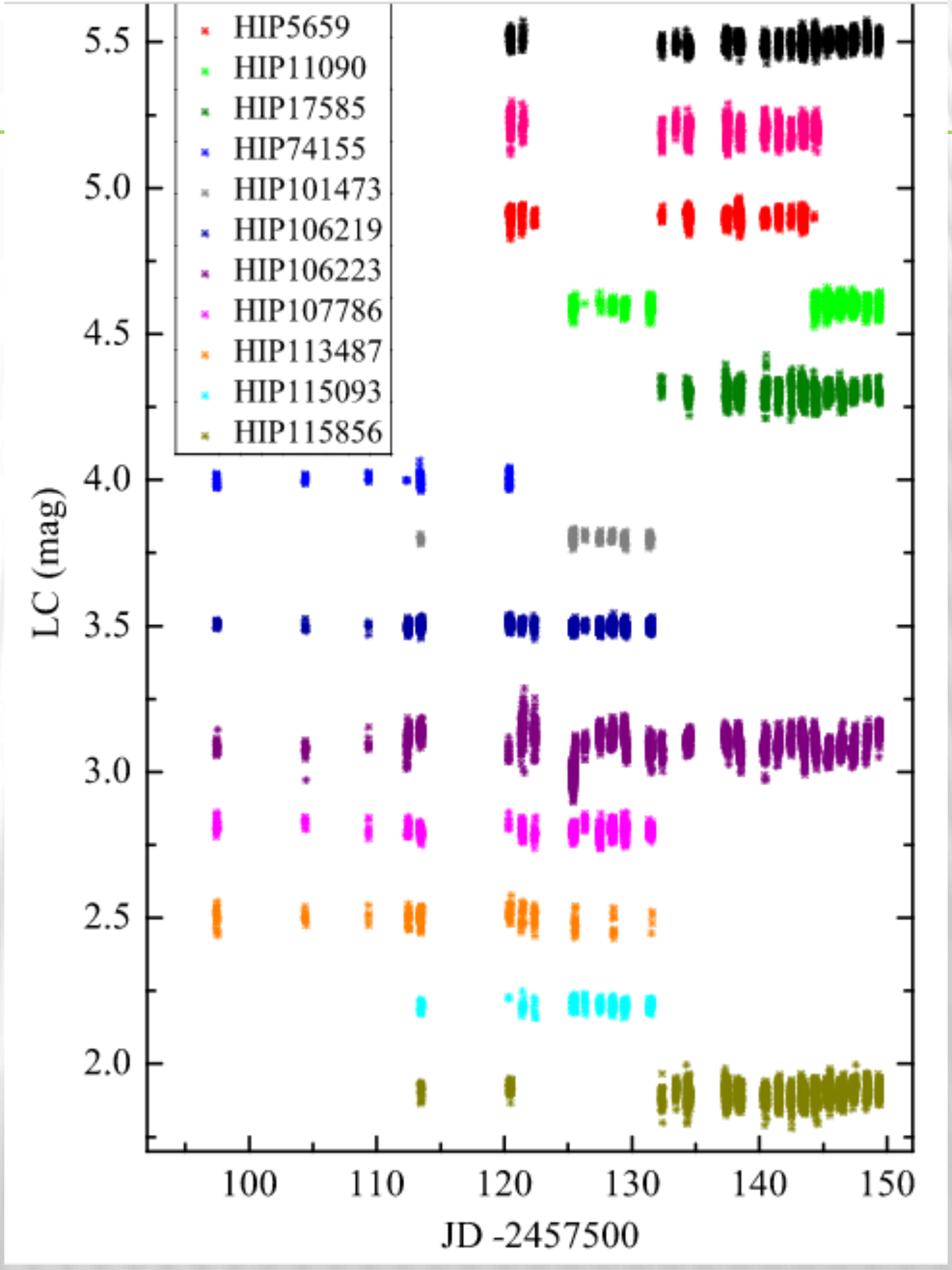


OBSERVATIONS WITH 0.35 M MAKSUTOV TELESCOPE

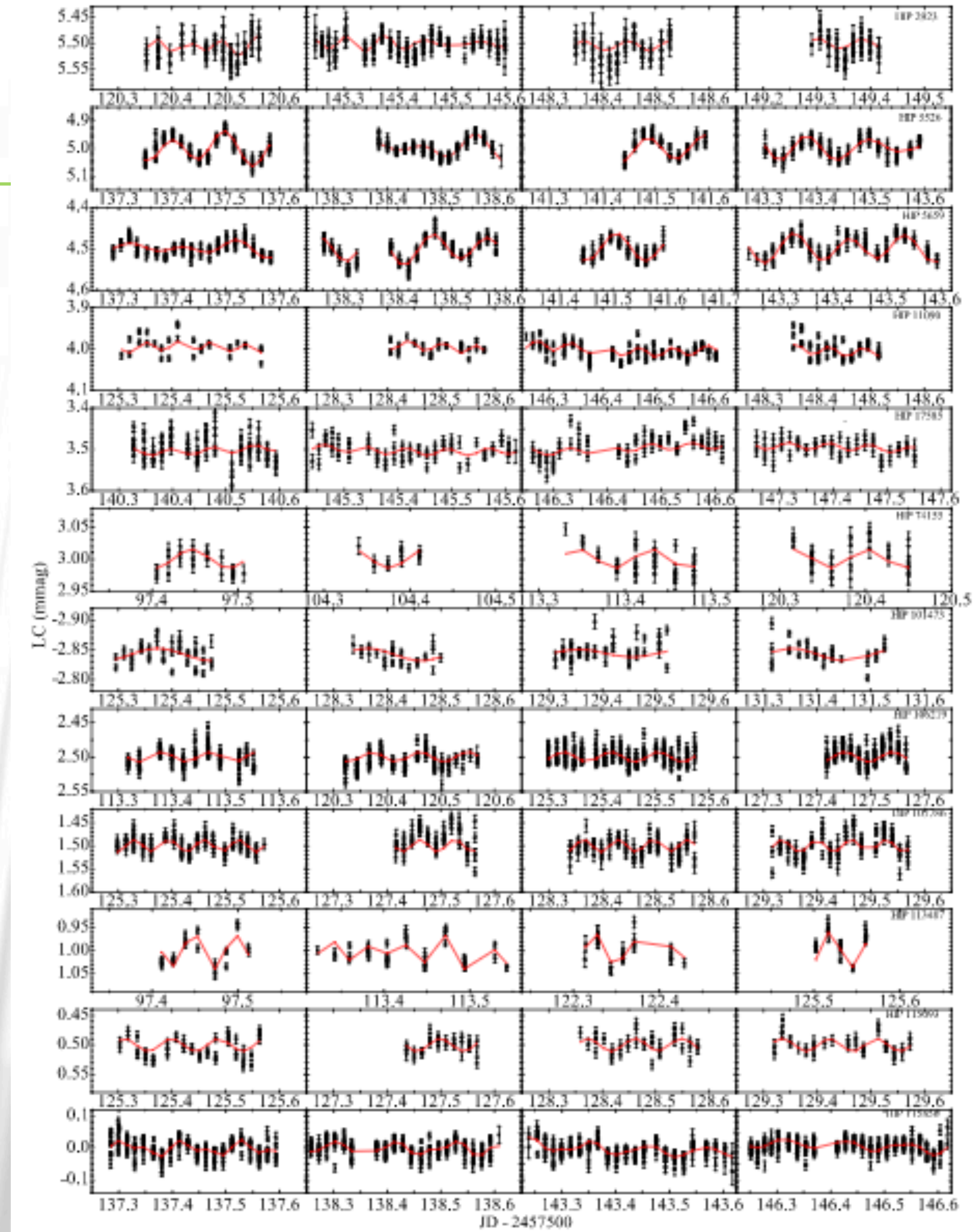
- Analyzed 3617 stars in 13 different fields with candidates to δ Scuti stars.



LIGHT CURVES OF CANDIDATES TO δ SCUTI STARS

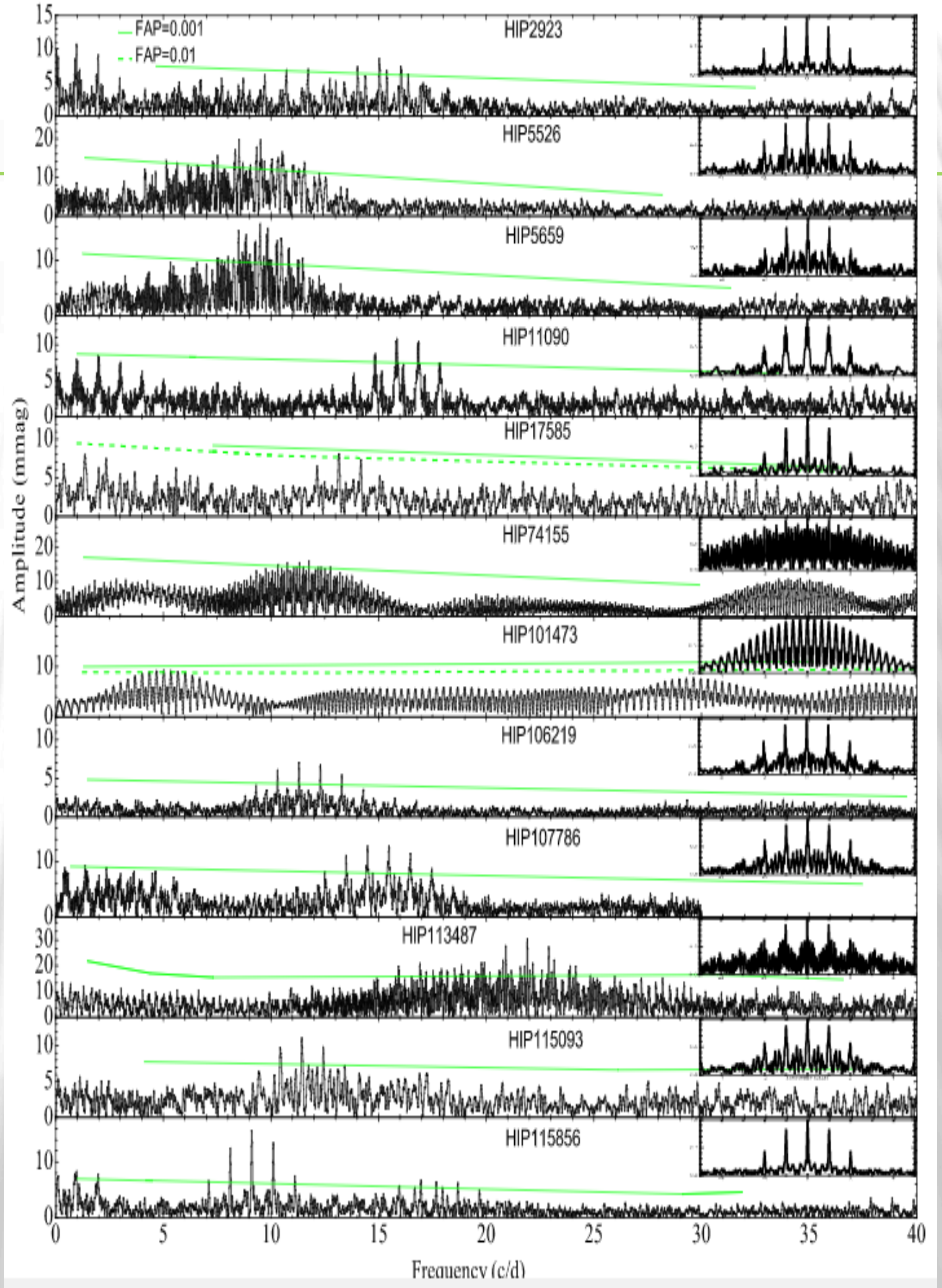


LIGHT CURVES OF CANDIDATES TO δ SCUTI STARS



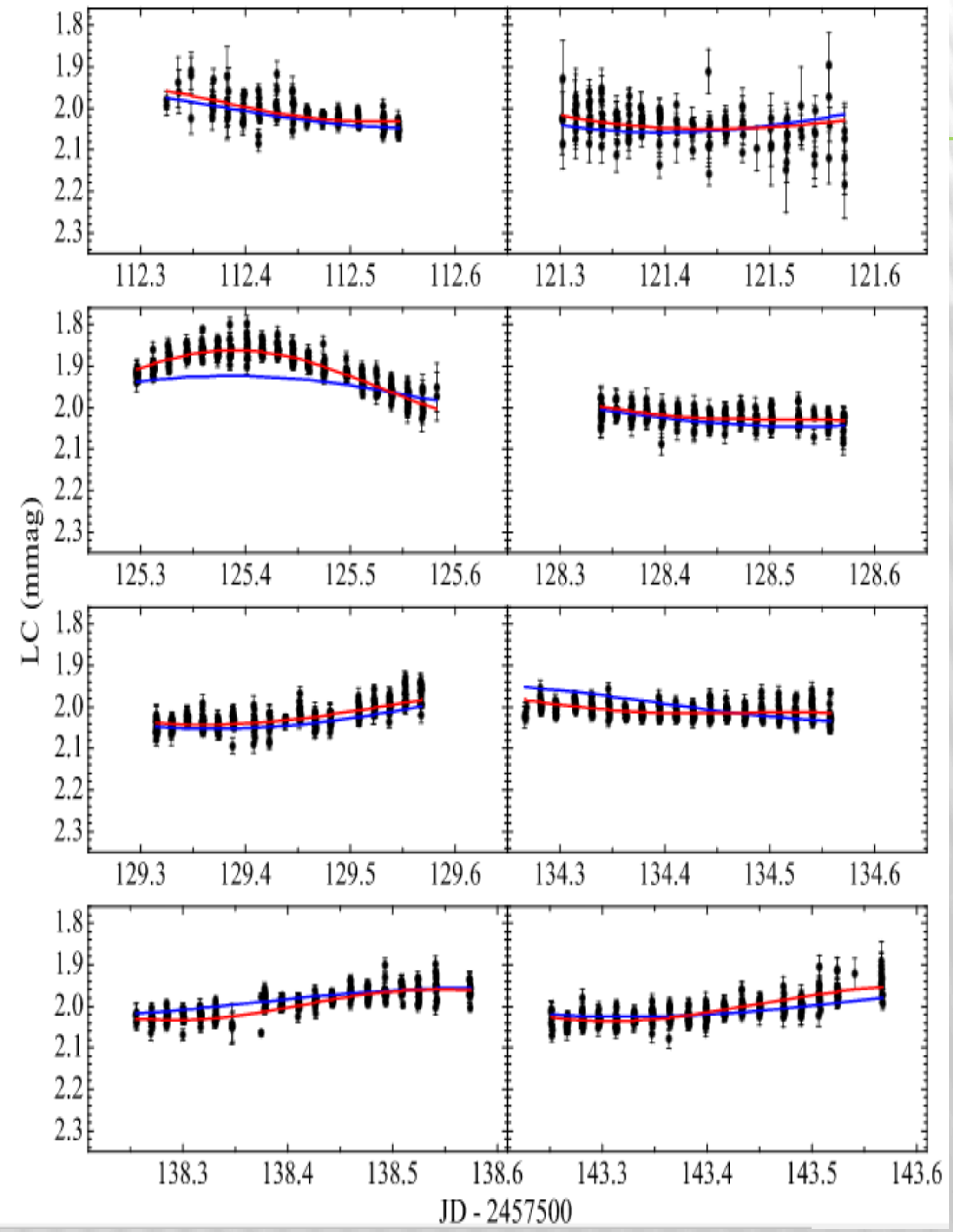
FT SPECTRA OF CANDIDATES TO δ SCUTI STARS

- We confirmed, that 12 candidates have brightness variation frequencies which are typical for δ Scuti stars.



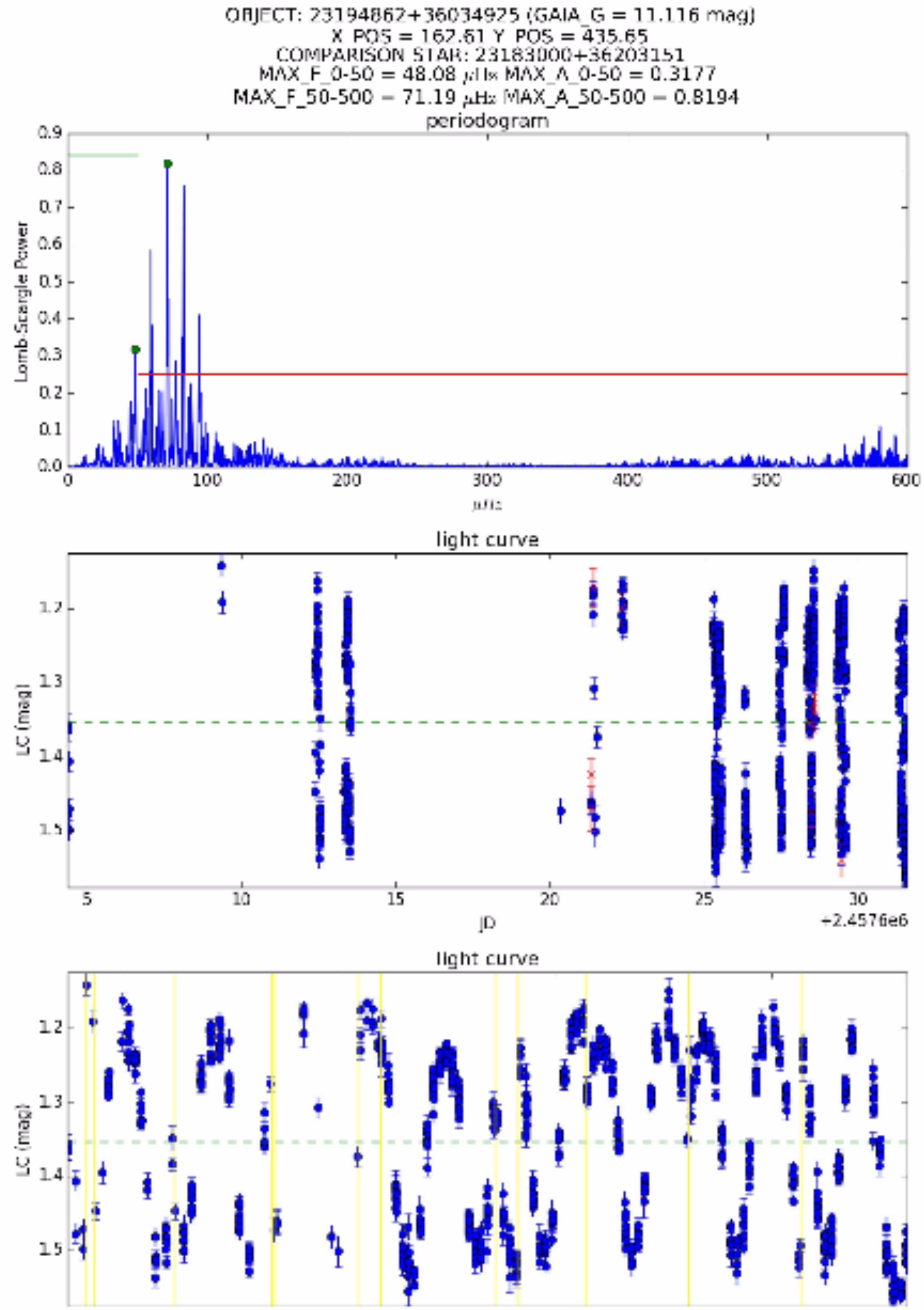
NOT A δ SCUTI?

- One of the candidates had much longer periods of variations.
- The dominant frequency is 1.142 c/d with the amplitude of 43.38 mmag.
- Possibly it is a massive star ($M>2M_{sun}$) evolving from the main sequence towards the giant region across the instability strip.



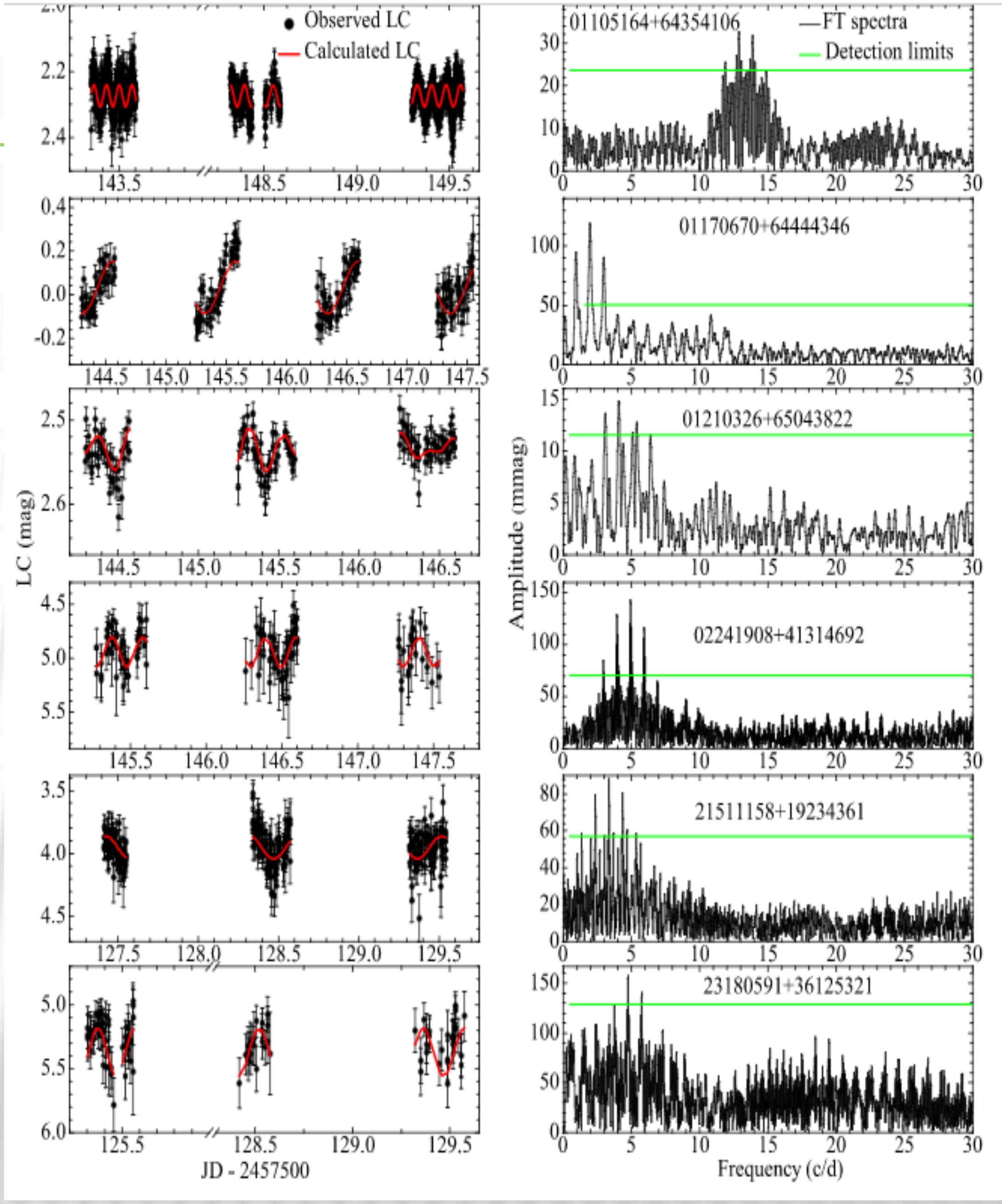
OTHER VARIABLE STARS IN THE FIELDS

- Shortperiodic stars

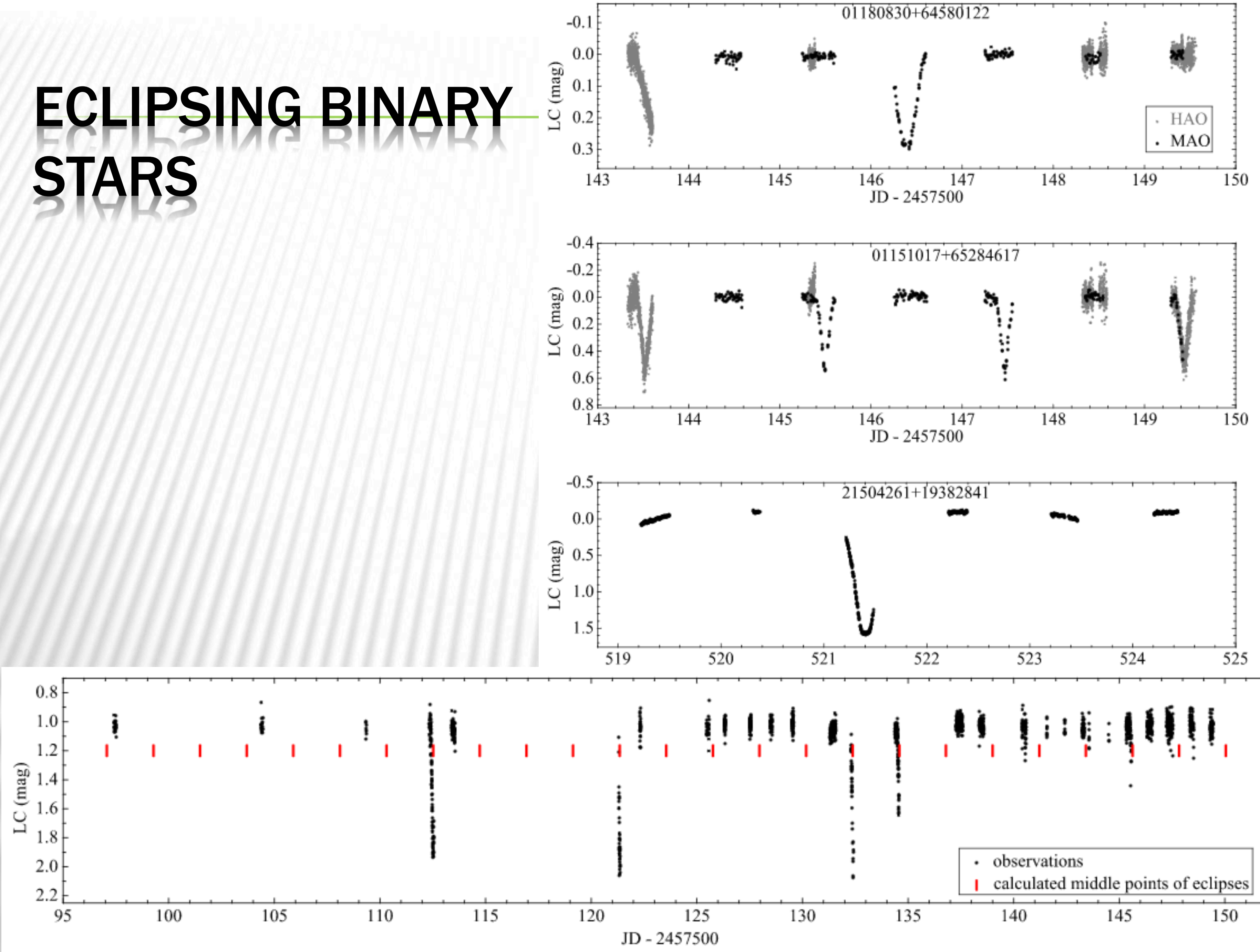


EXAMPLES OF NEW FOUND SHORT PERIODIC VARIABLES OF UNKNOWN TYPE

- Found 35 candidates to short periodic variables.

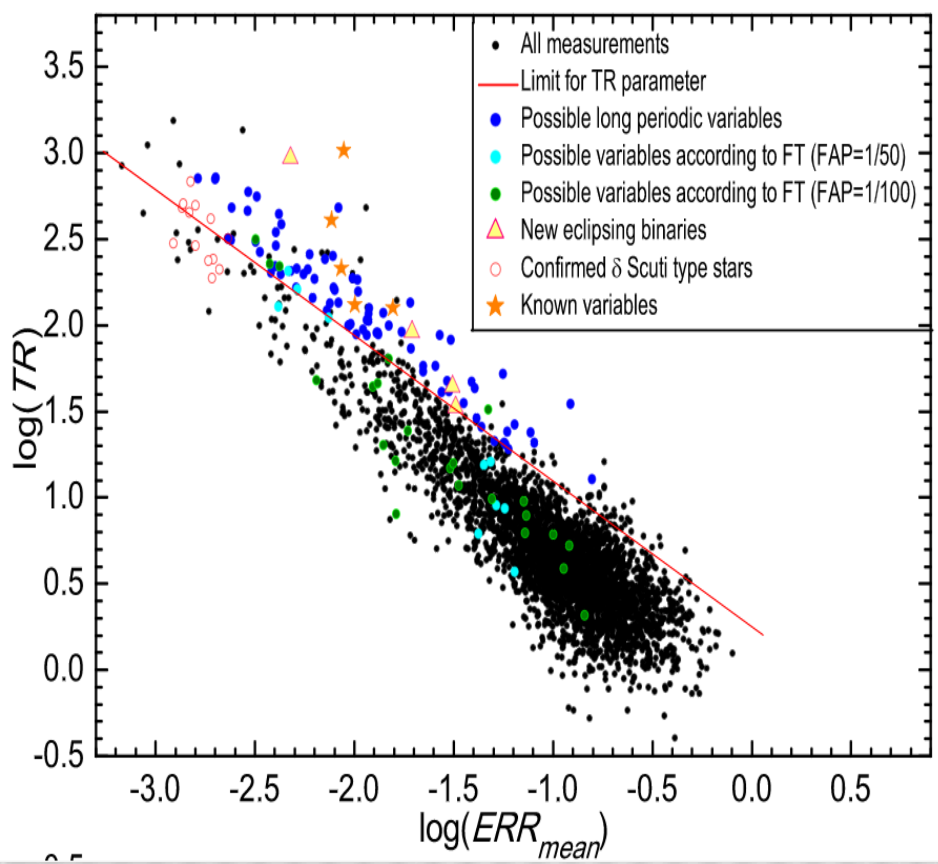


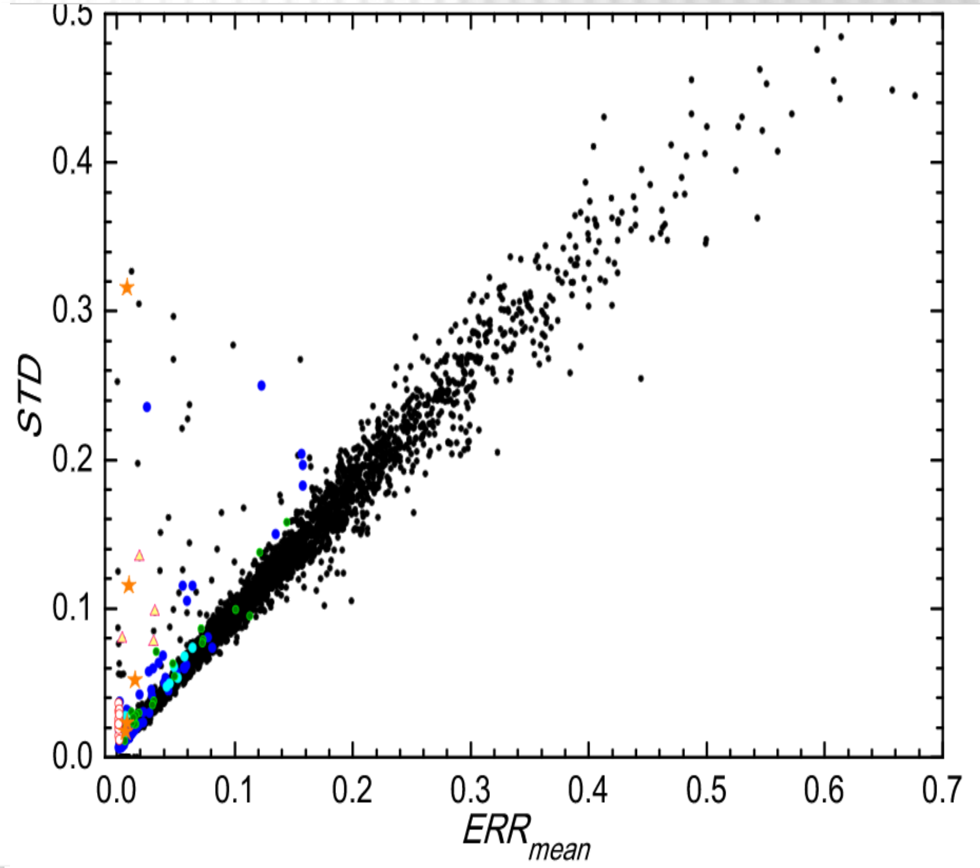
ECLIPSING BINARY STARS

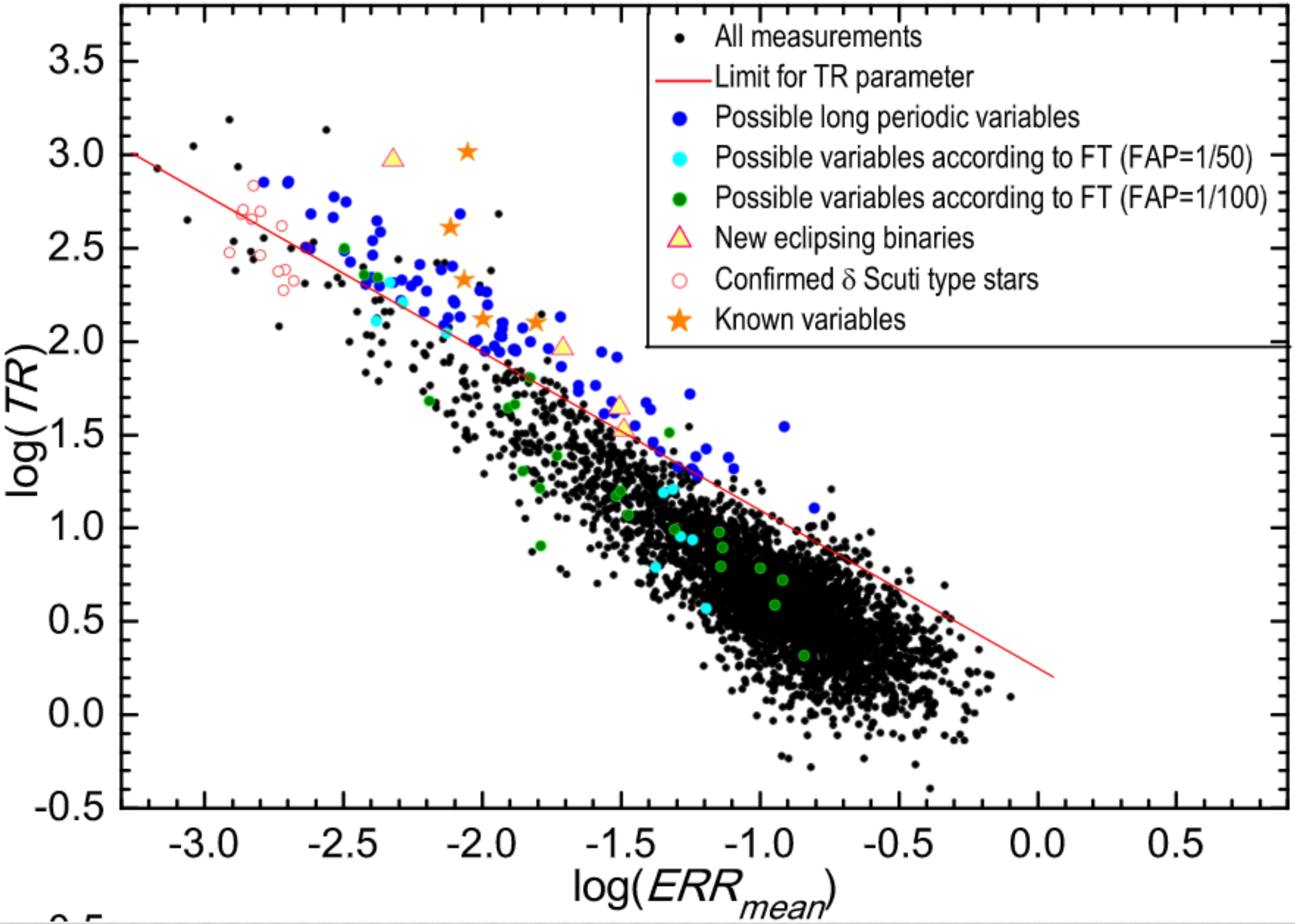


TRENDING (LONGER PERIODIC) STARS

- Trending parameter $$TR = \frac{mag_{max} - mag_{min}}{STD_{LC} * ERR_{mean}},$$

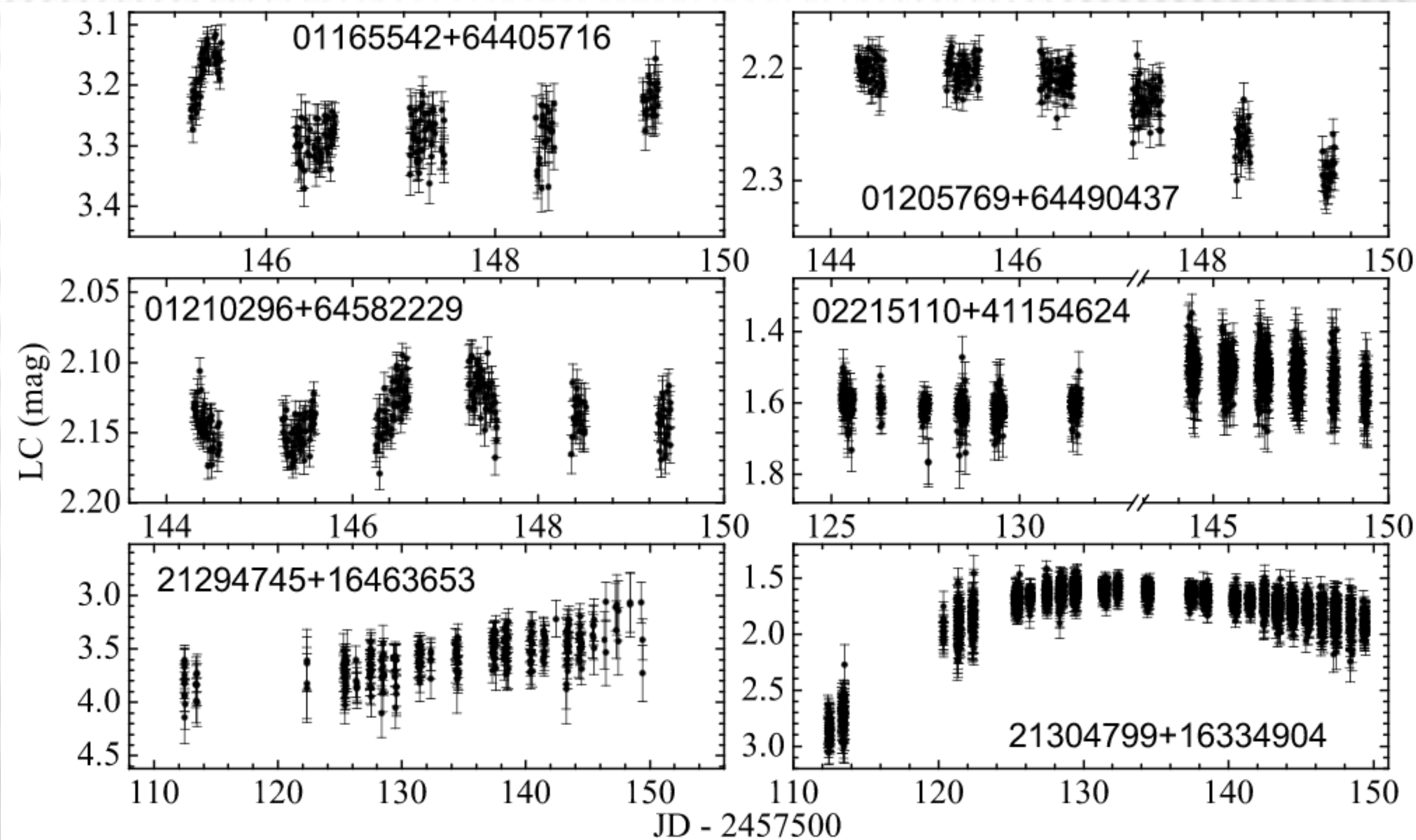






All measurements
Limit for TR parameter
Possible long periodic variables
Possible variables according to FT (FAP=1/50)
Possible variables according to FT (FAP=1/100)
New eclipsing binaries
Confirmed δ Scuti type stars
Known variables
log(TR)
log(ERR_mean)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-3.0
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
0.5

Examples of variable stars found using trending parameter TR. Periods left undetermined

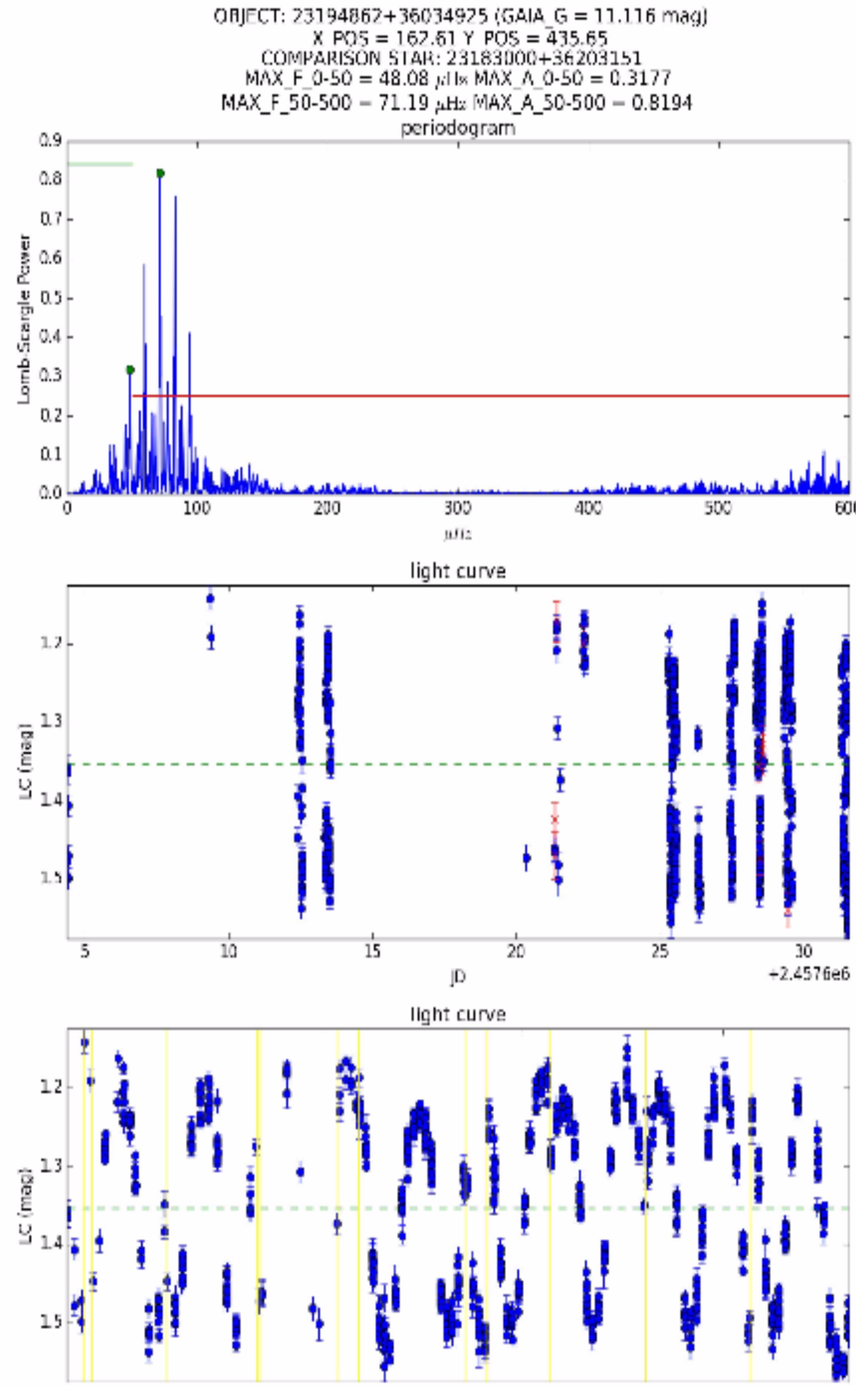


FINAL CONCLUSION OF PHOTOMETRIC ANALYSIS

- Confirmed 12 variable δ Scuti stars
- Found 4 new eclipsing binaries
- 35 candidates to short periodic
- 83 candidates to longer periodic variable stars of so far undefined type
- We also present data of 5 known variable stars in the investigated fields.

DATA ARE GOING TO BE AVAILABLE ONLINE

- Reduced CCD images
- Light curves of 3617 stars
- Files with graphs of observed LCs and their Lomb-Scargle periodograms .
- Tables with information about analyzed stars and variability parameters (CNAME,GAIA ID, MAIN ID, SP TYPE, OTYPE, coordinates, FIELD NAME, X and Y position, GAIA G mag, STD, F with MAX A at F(0-50), MAX A at F(0-50), DETECT LIM at F(0-50), F with MAX A at F(50-500), MAX A at F(50-500), DETECT LIM at F(50-500), NO OF POINTS)



We continue our observations and analysis

Thank you!