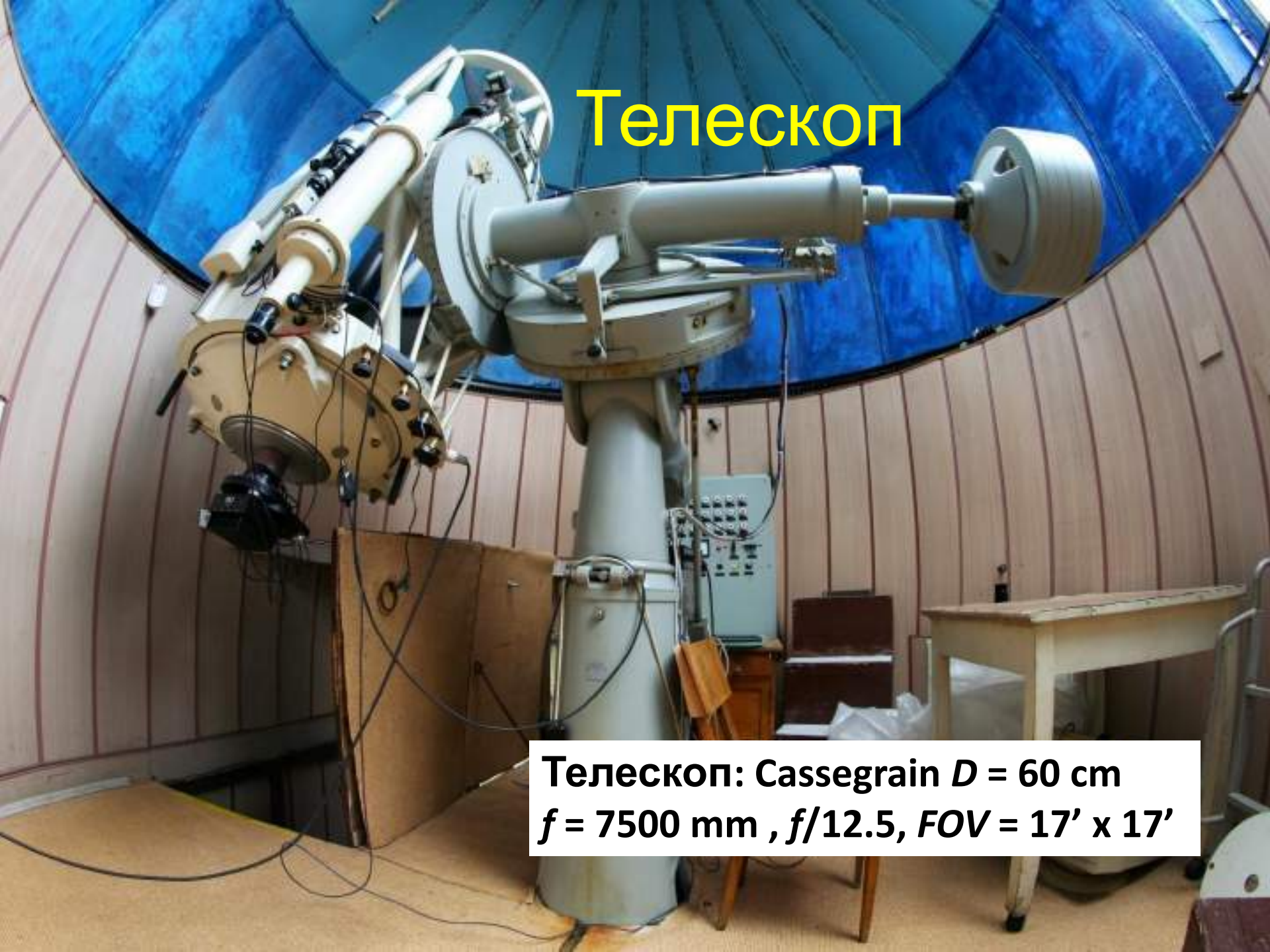
XVIII годишна конференция
на Съюза на астрономите в България
15 – 16 май 2025 г.,
Гр. Белоградчик, България

Трансформационни коефициенти към стандартната фотометрична система Bessell (UBVRI) за Шмидт телескопа на НАО Рожен

Г. Латев[1,2], Н. Антонов[4], В. Генков[2], П. Маркишки[1,3] и С. Боева

[1]Институт по астрономия с НАО – БАН, [2]Астрономическа асоциация София,
[3]Катедра по астрономия на Фзф-СУ, [4]Обсерватория “Мещица”, [5]Институт за съвременни физически изследванния

АО Белоградчик: общ изглед


Телескоп
Телескоп: Cassegrain D = 60 cm
f = 7500 mm , f/12.5, FOV = 17’ x 17’

АО Белоградчик: CCDs

До 2020 г.: FLI 09000 PL
3056 x 3056 pix, 12 x 12 µm, scale =0.33’’/pix

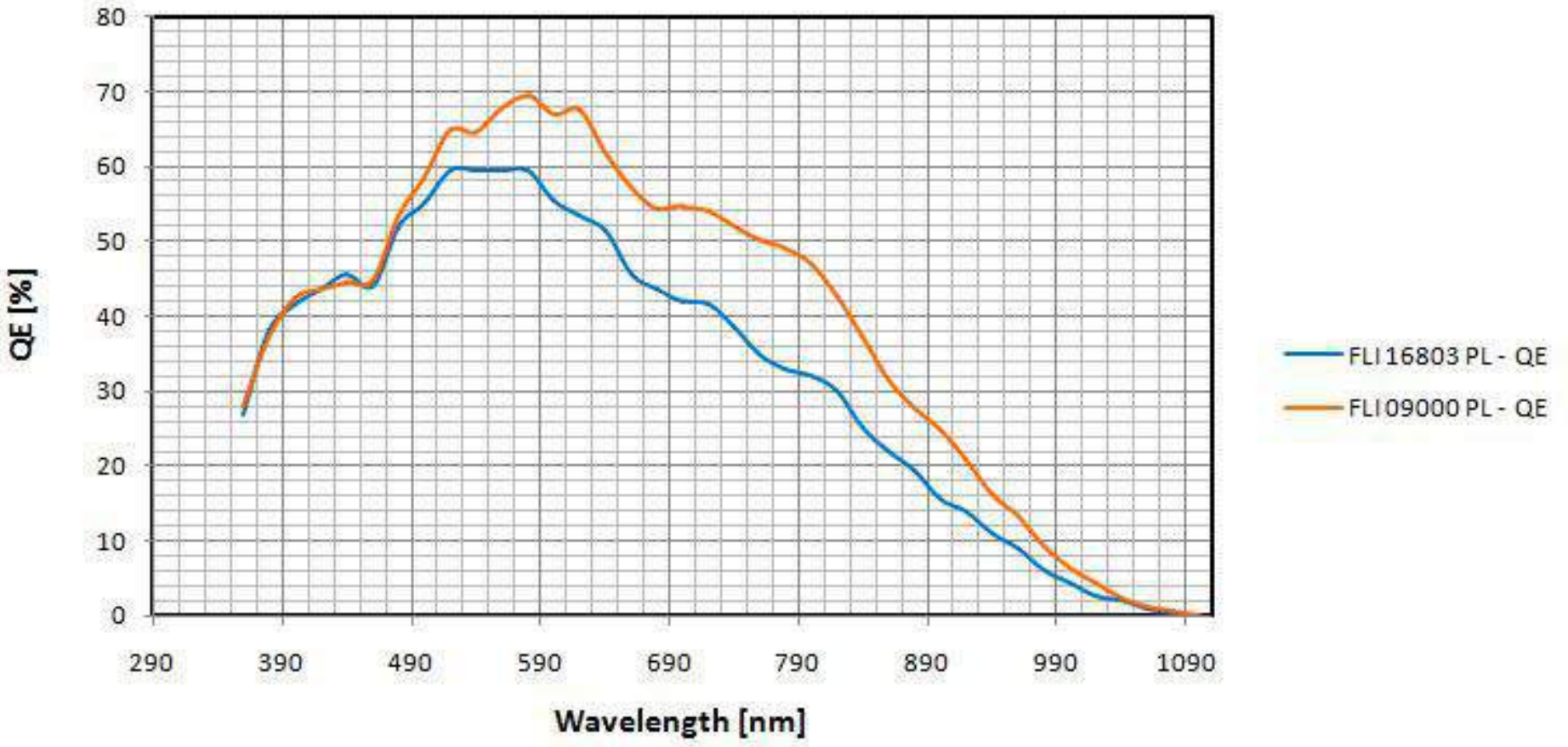
След 2020 г: FLI 16803 PL
4096 x 4096 pix, 9 x 9 µm, scale = 0.25”/pix

FLI 09000 PL: Квантова ефективност

FLI 16803 PL: Квантова ефективност

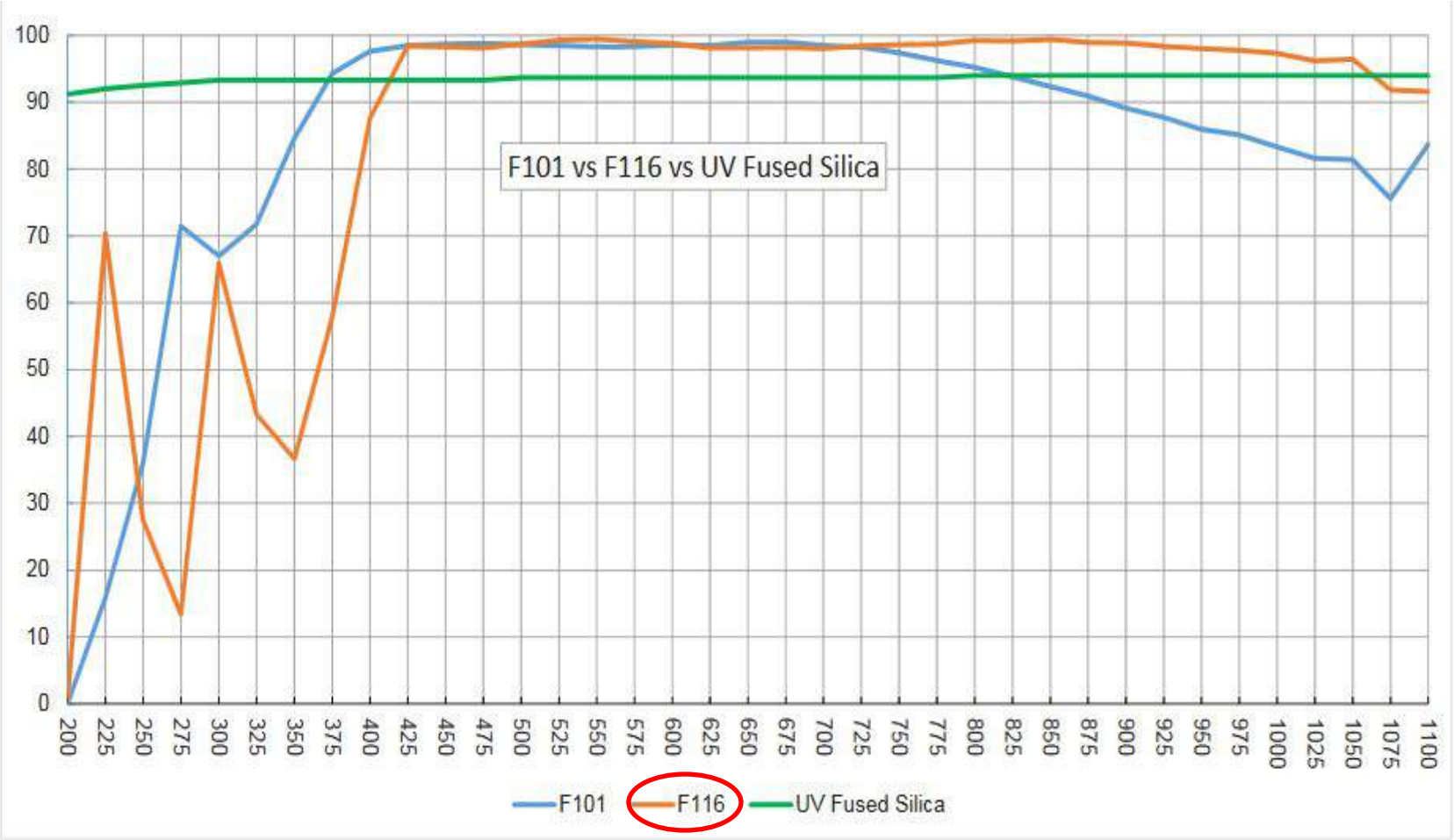
АО Белоградчик: CCDs

КВАНТОВА ЕФЕКТИВНОСТ - СРАВНЕНИЕ

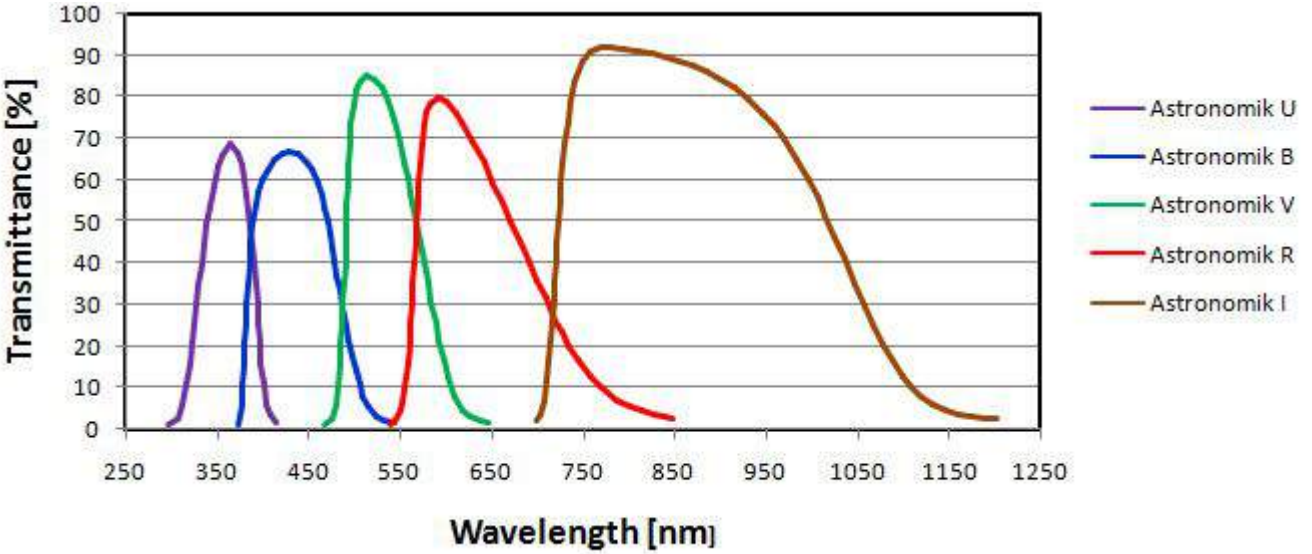


АО Белоградчик: CCDs

“КВАРЦОВО”
ПРОЗОРЧЕ

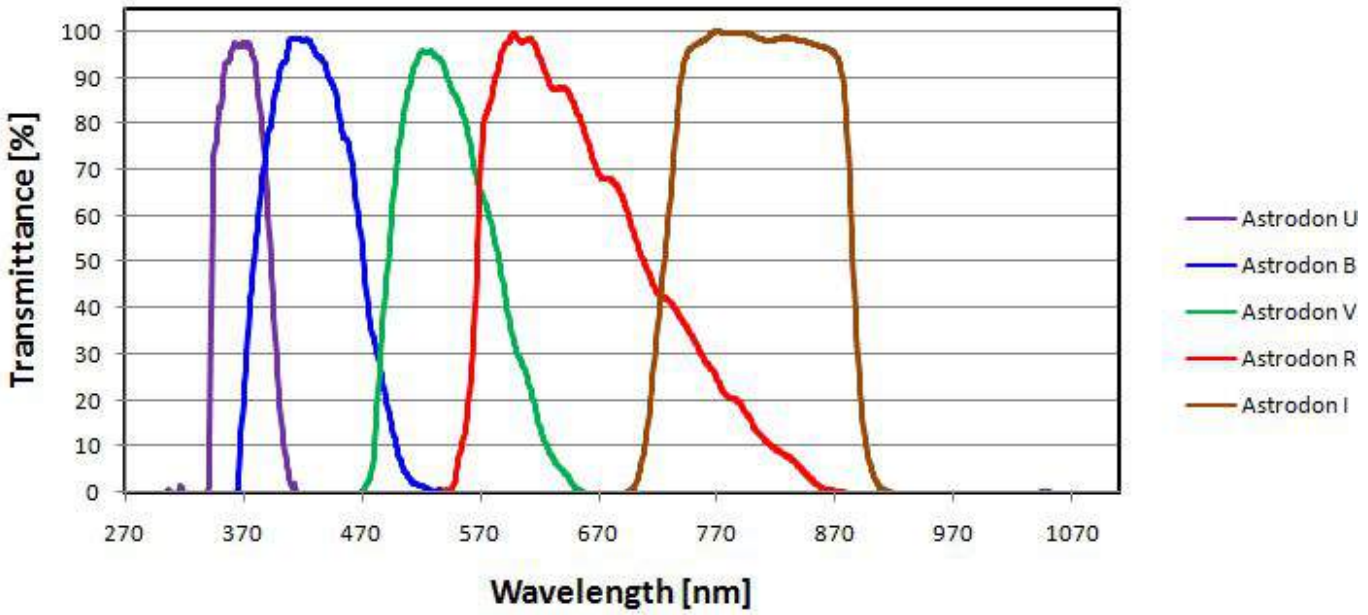


АО Белоградчик: UBVRI филтри



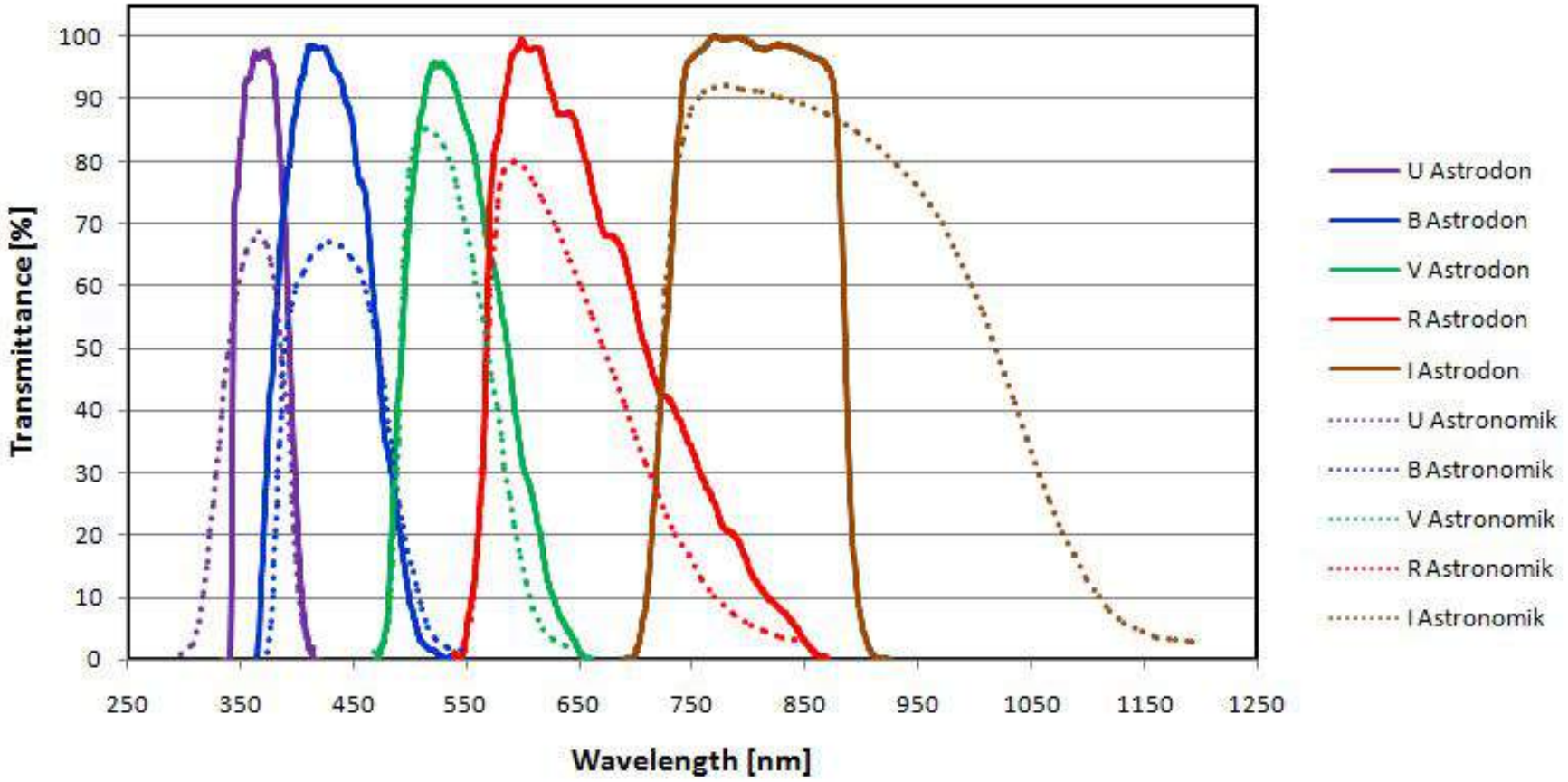
До 2020 г.:
Astronomik UBVRI

След 2020 г.:
Astrodon UBVRI

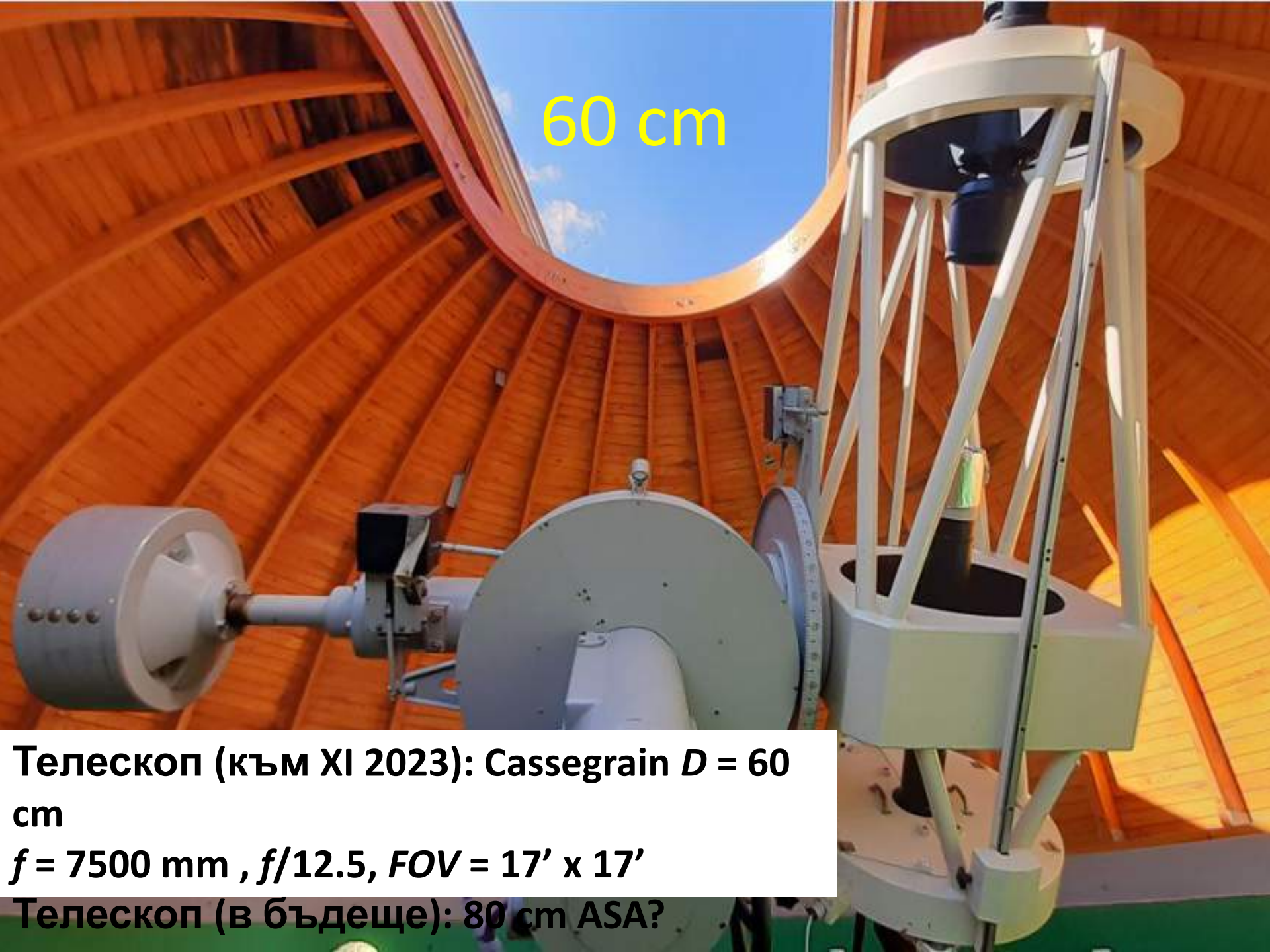


АО Белоградчик: UBVRI филтри

ПРОФИЛИ - СРАВНЕНИЕ




НАО Рожен: 60 cm



Телескоп (към XI 2023): Cassegrain *D* = 60 cm

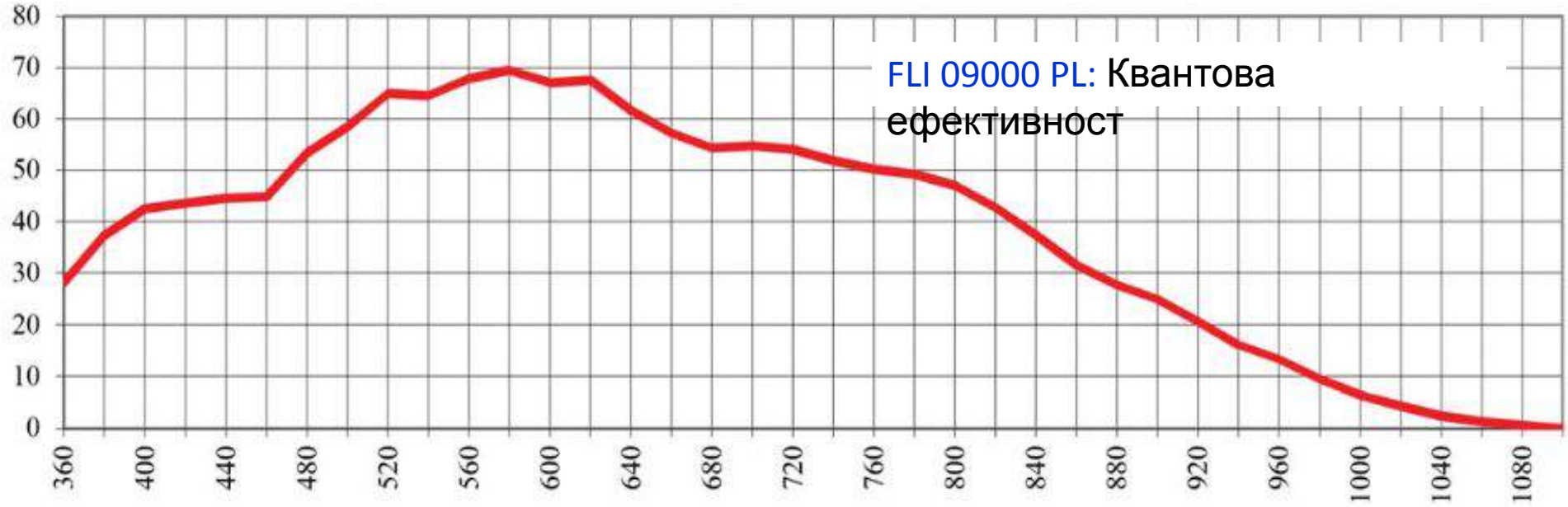
***f* = 7500 mm , *f*/12.5, *FOV* = 17’ x 17’**

Телескоп (в бъдеще): 80 cm ASA?

60 cm Cassegrain: CCD

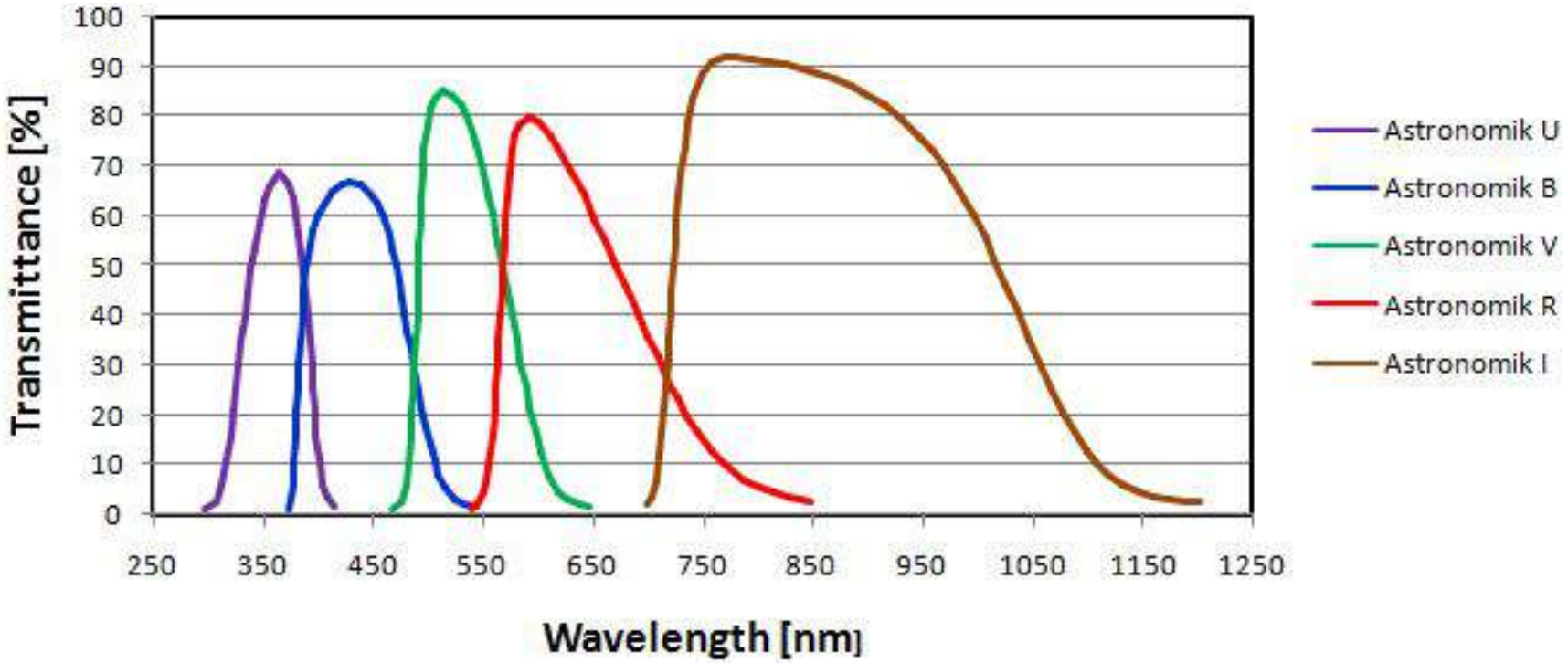
Към момента (XI 2023) FLI 09000 PL
3056 x 3056 pix, 12 x 12 µm, scale =0.33’’/pix

Бъдеще: Неясно



FLI 09000 PL: Квантова ефективност

60 cm Cassegrain: UBVRI Филтри



Към настоящия момент (XI 2023): Astronomik UBVRI филтри
Силно увреден филтър V!


НАО Рожен: 50/70 cm

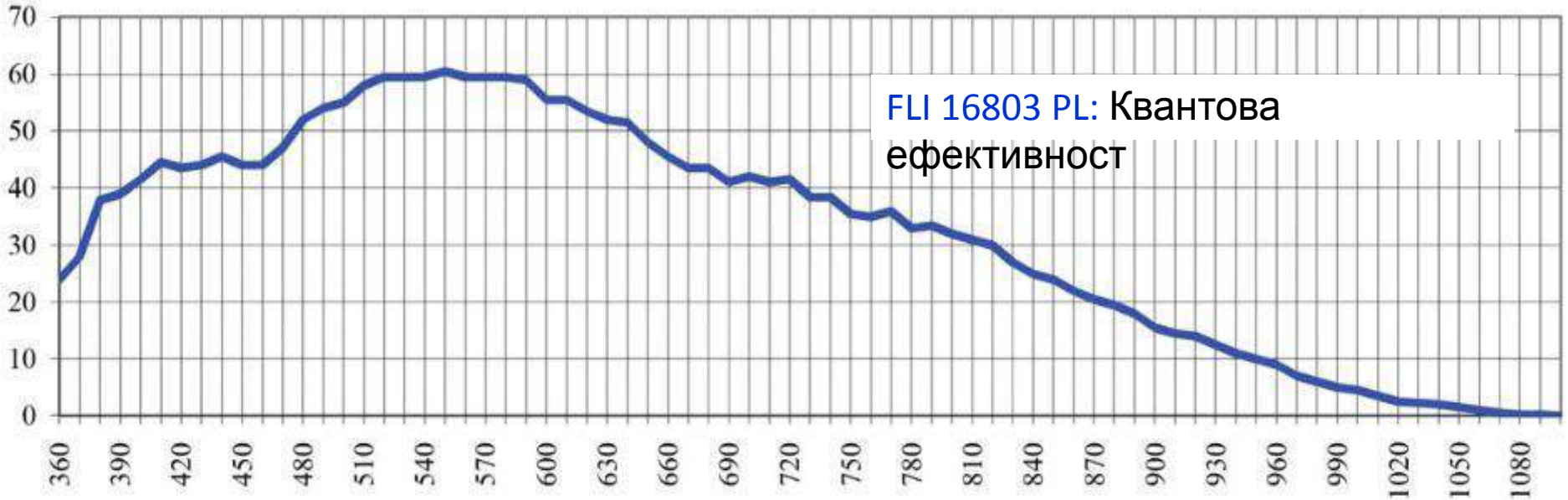
50/70 cm Schmidt

Телескоп (към XI 2023): Schmidt *Dm* = 70 cm
Dp = 50 cm, *f* = 1720 mm , *f*/3.44, *FOV* = 72’ x 72’

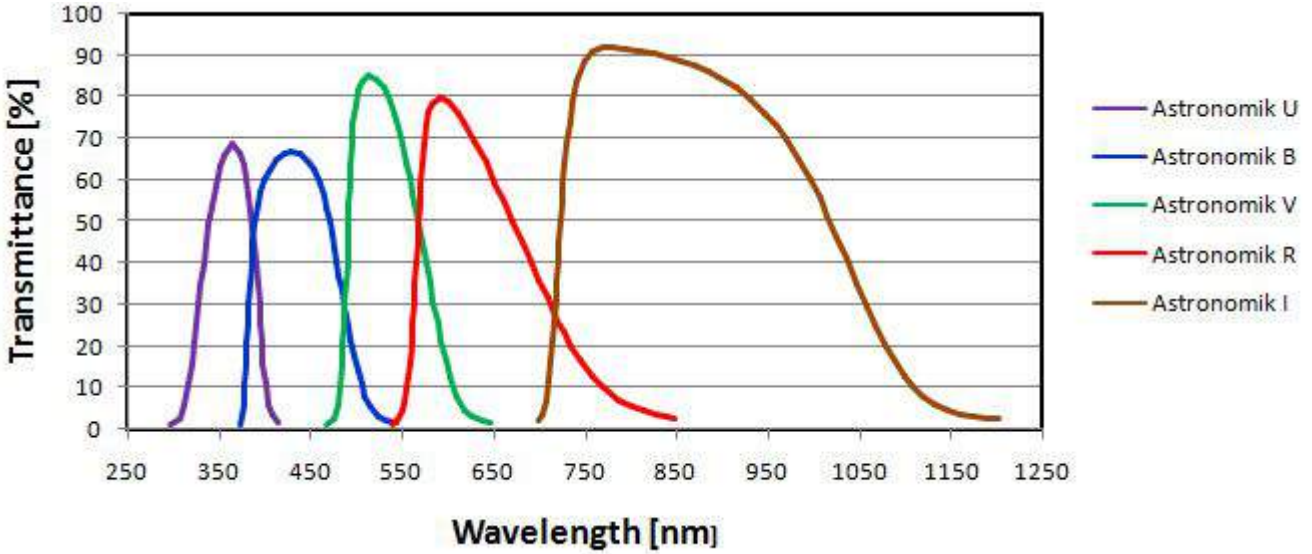
50/70 cm Schmidt: CCDs

До 08.2019 г.: FLI 16803 PL (old)
4096 x 4096 pix, 9 x 9 µm, scale = 1.08”/pix

След 08.2019 г.: FLI 16803 PL (new)
4096 x 4096 pix, 9 x 9 µm, scale = 1.08”/pix

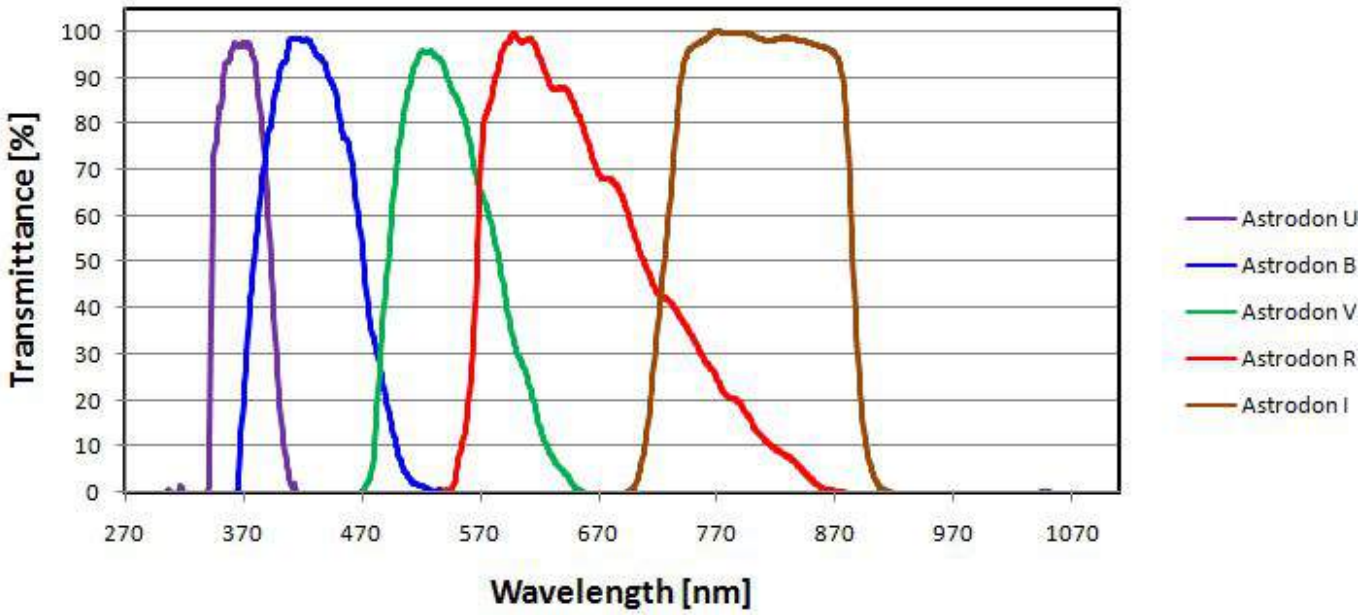


50/70 cm Schmidt: UBVRI филтри



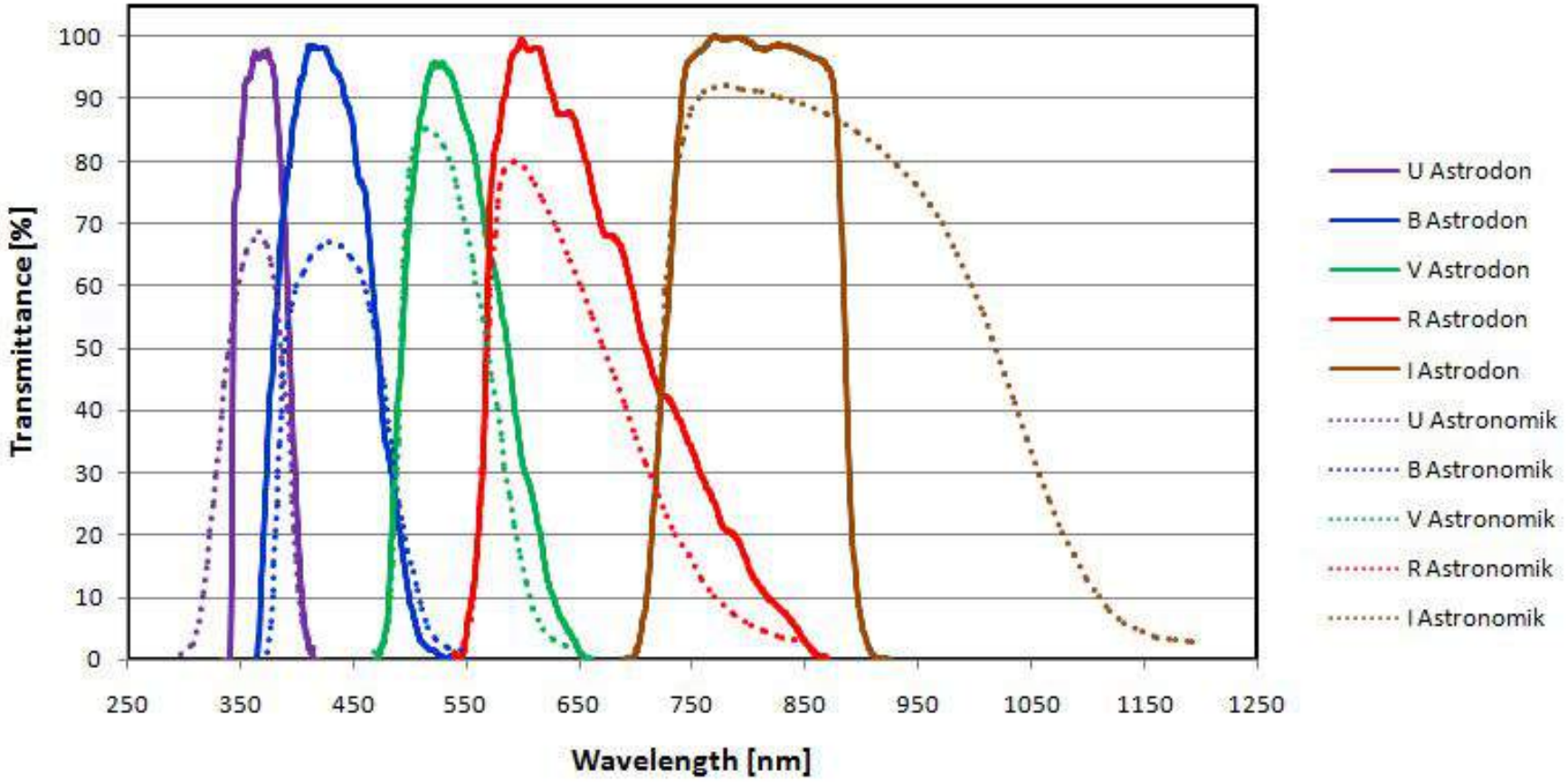
До 08.2019 г.:
Astronomik UBVRI

След 08.2019 г.:
Astrodon UBVRI



50/70 cm Schmidt: UBVRI филтри

ПРОФИЛИ - СРАВНЕНИЕ



НАО Рожен: 1.5 m RC Nesmit

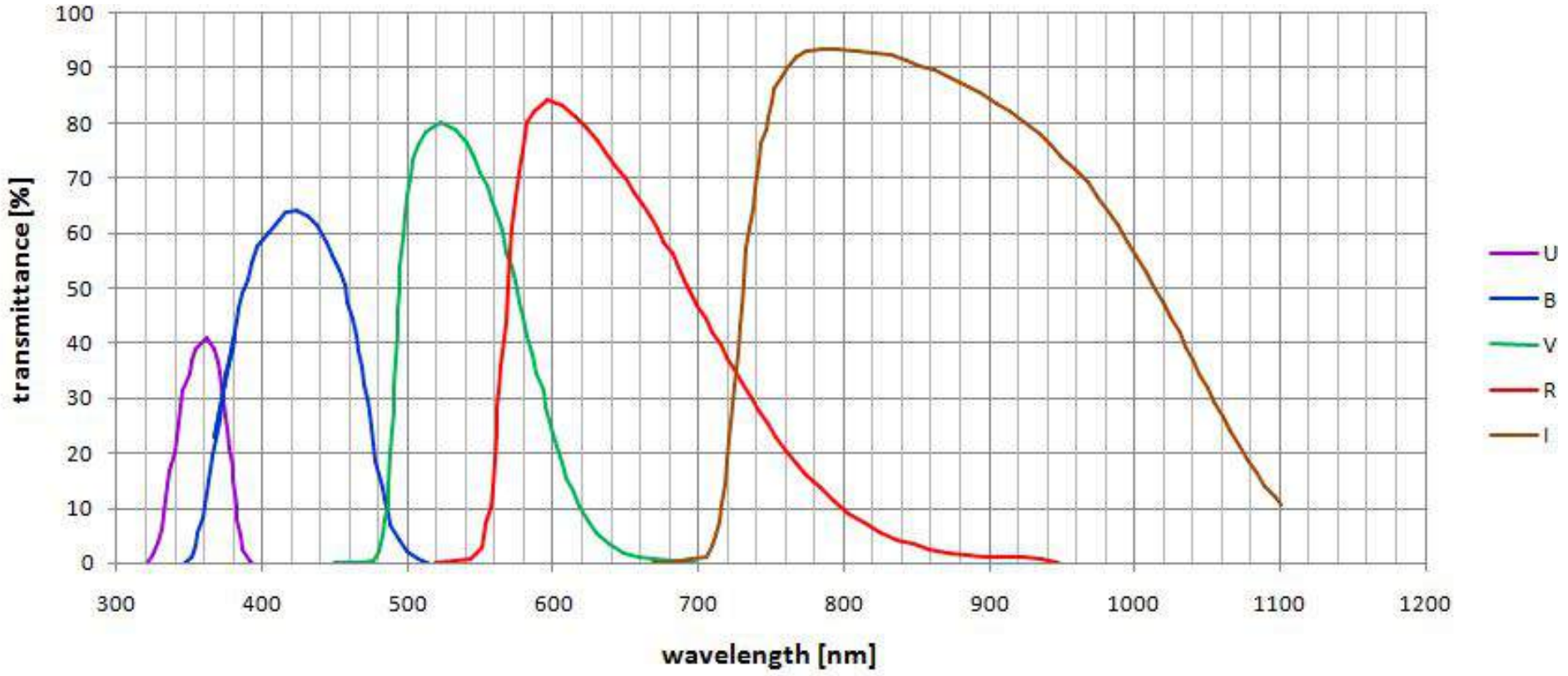
Телескоп : AZ RC ASA, *D* = 1.5m
***f* = 9000 mm , *f*/6, *FOV* = 72’ x 72’**

1.5 m RC ASA: CMOS/CCD

Към момента (XI 2023г.): Moravian Ins.
C3-61000 CMOS, SONI IMX 455
9600 x 6388 pix, 3.76 x 3.76 µm, scale =
0.086”/pix, FOV = 13.8’ x 9.2’

След 1 година?: Andor iKon-XL 231 CCD
4096 x 4108 pix, 15 x 15 µm, scale = 0.34”/pix
FOV = 23.2’ x 23.2’, e2v CCD231-84

1.5 m RC: UBVRI филтри



Профили на UBVRI филтри, технология = color glass, IPP, TOPTEC – Turnov,
Любезно предоставени от Pavel Cagas, 23. 06. 2023 (private

НАО Рожен: 2m RCC and FoReRo2

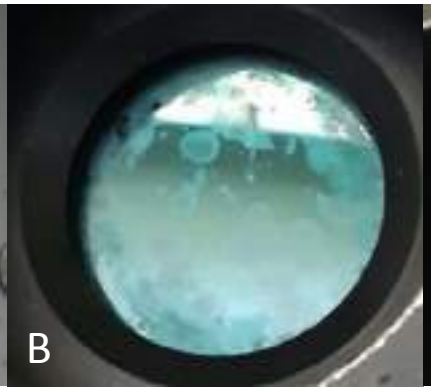
НАО Рожен: 2m RCC / FoReRo2

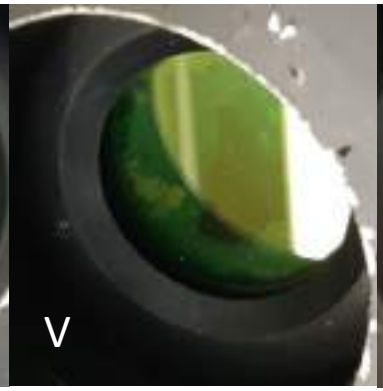
Телескоп : 2m RCC, *D* = 2m
***f* = 16000 mm , *f*/8, *FOV* = 10’ x 10’**
***f* = 5600, *f*/2.8, *FOV* = 15’ x 15’**

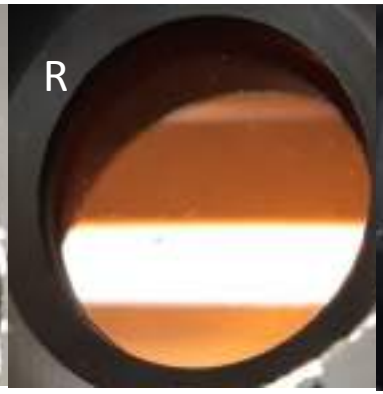
2m RC: CCD + UBVRI филтри

Към момента (XI 2023г.) в режим RC се монтира: Andor iKon-L CCD 15 685 (старата (2013) ешелна “червена” камера със синя лента 😊)
2048 x 2048 pix, 13.5 x 13.5 µm,
scale = 0.17”/pix, FOV = 6’ x 6’

UBVRI филтрите са в лошо експлоатационно състояние (особено B и V)








Филтър
V


Филтър
B

2m FoReRo2: CCD + UBVRI филтри

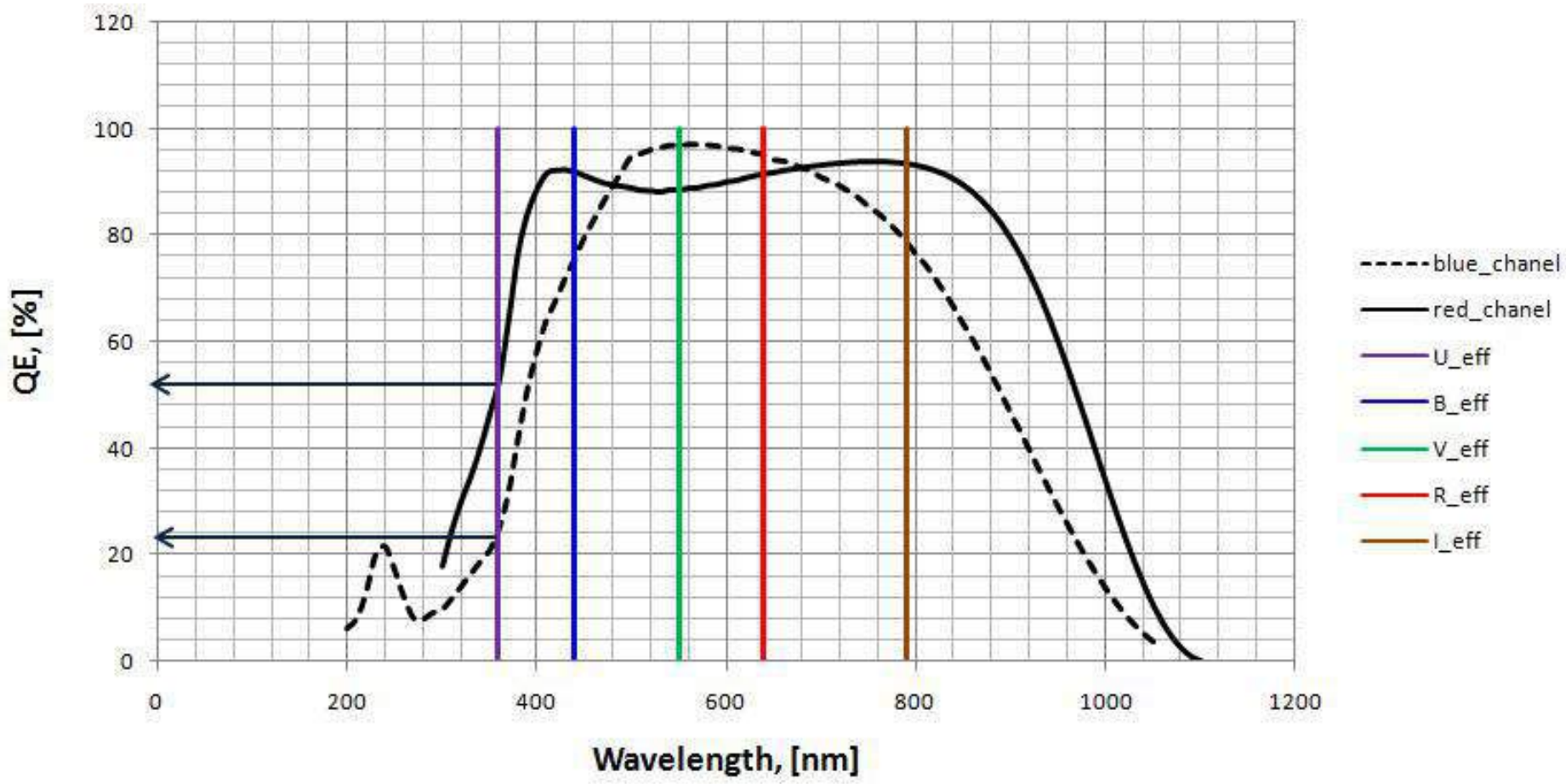
Към момента (XI 2023г.) в режим FoReRo2 се монтират:

Син канал: Andor iKon-L CCD 15 685 (старата (2013) ешелна “червена” камера със синя лента 😊)
2048 x 2048 pix, 13.5 x 13.5 µm,
scale = 0.5”/pix, FOV = 17’ x 17’

Червен канал: Andor iKon-L CCD 21 703 (една от двете нови (2018) “сини камери, 2048 x 2048 pix, 13.5 x 13.5 µm,
scale = 0.5”/pix, FOV = 17’ x 17’

Фотометричната система е “скъсана” на две или с един телескоп имаме две фотометрични системи.

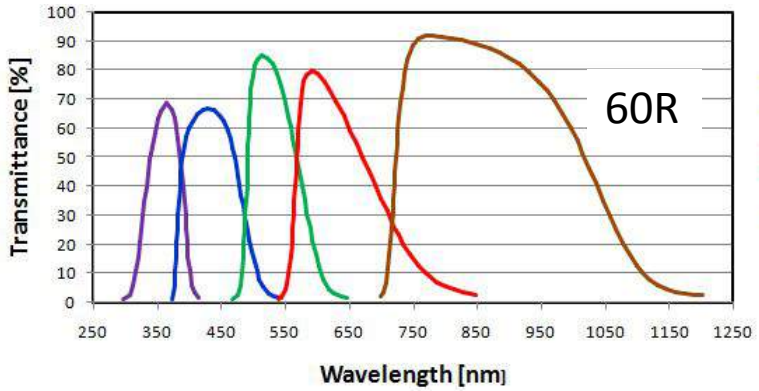
2m FoReRo2: CCDs - QE

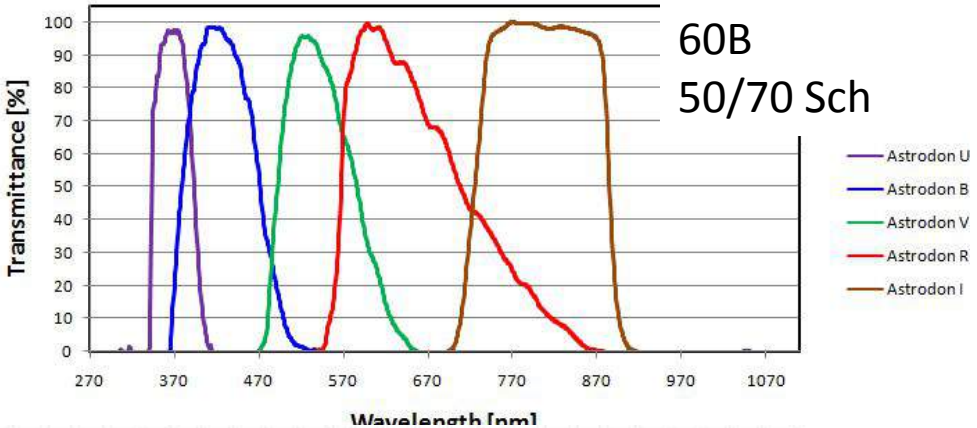


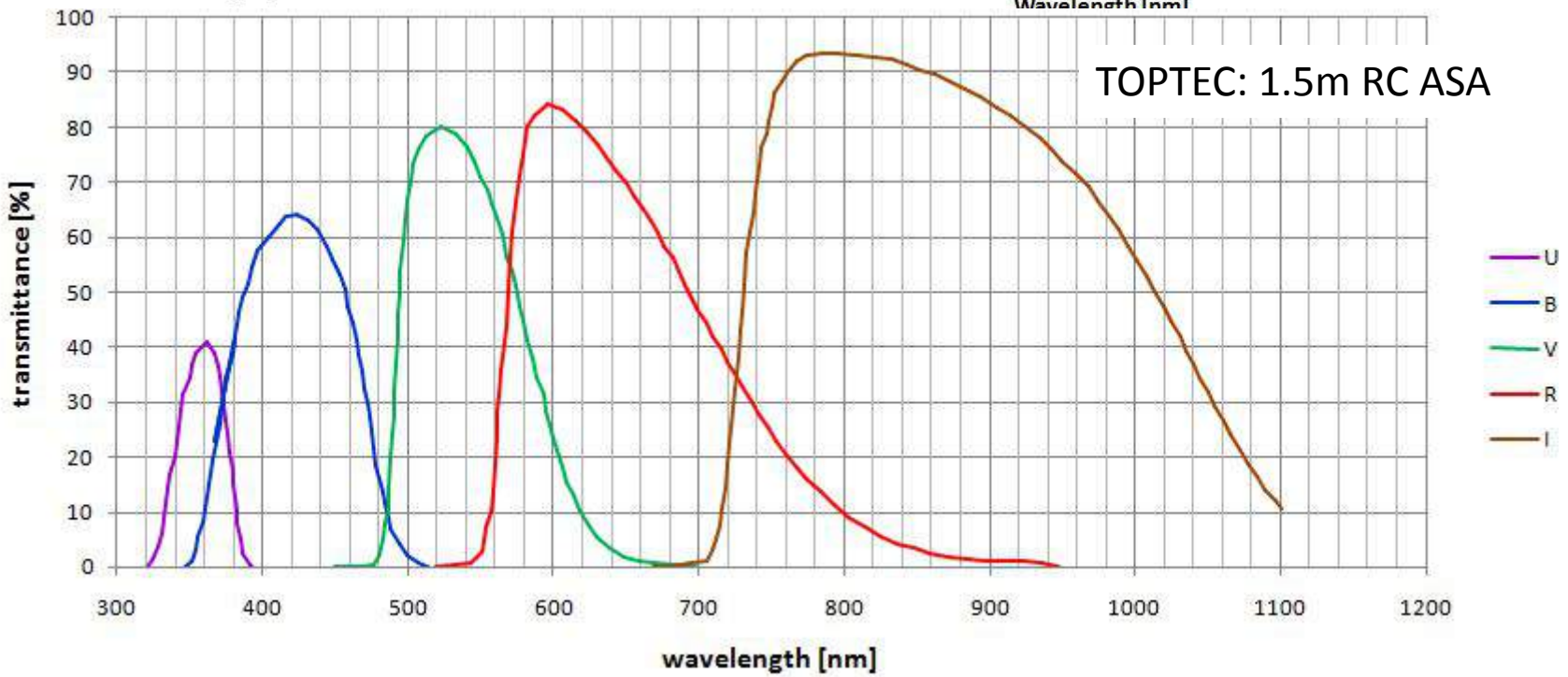
Син канал: Andor iKon-L 15 685CCD (стара ешелна, 2013): **DZ936N-#BV**

Червен канал: Andor iKon-L 21 703 CCD (една от двете нови, 2018): **DZ936N-BEX2-DD**

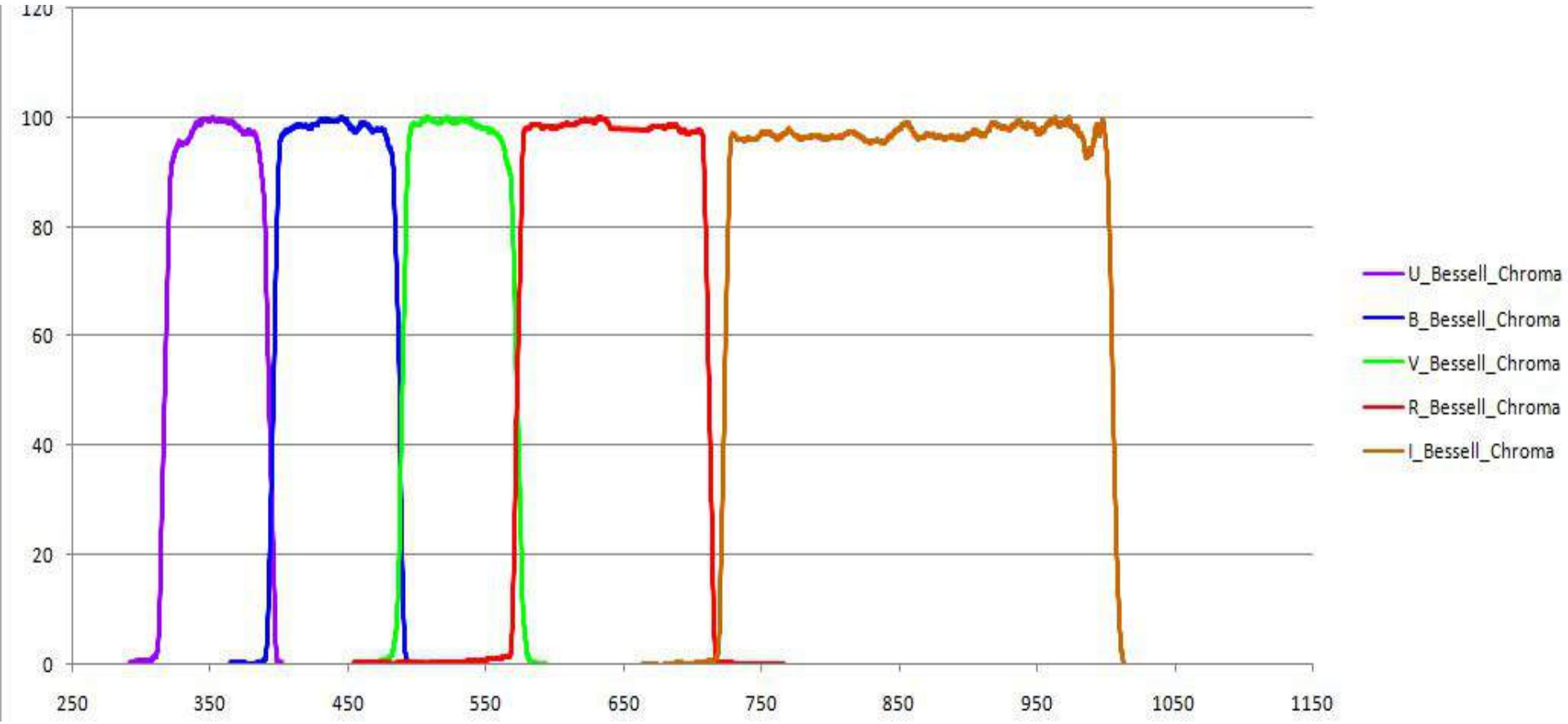
UBVRI: “Стандартни” многообразия





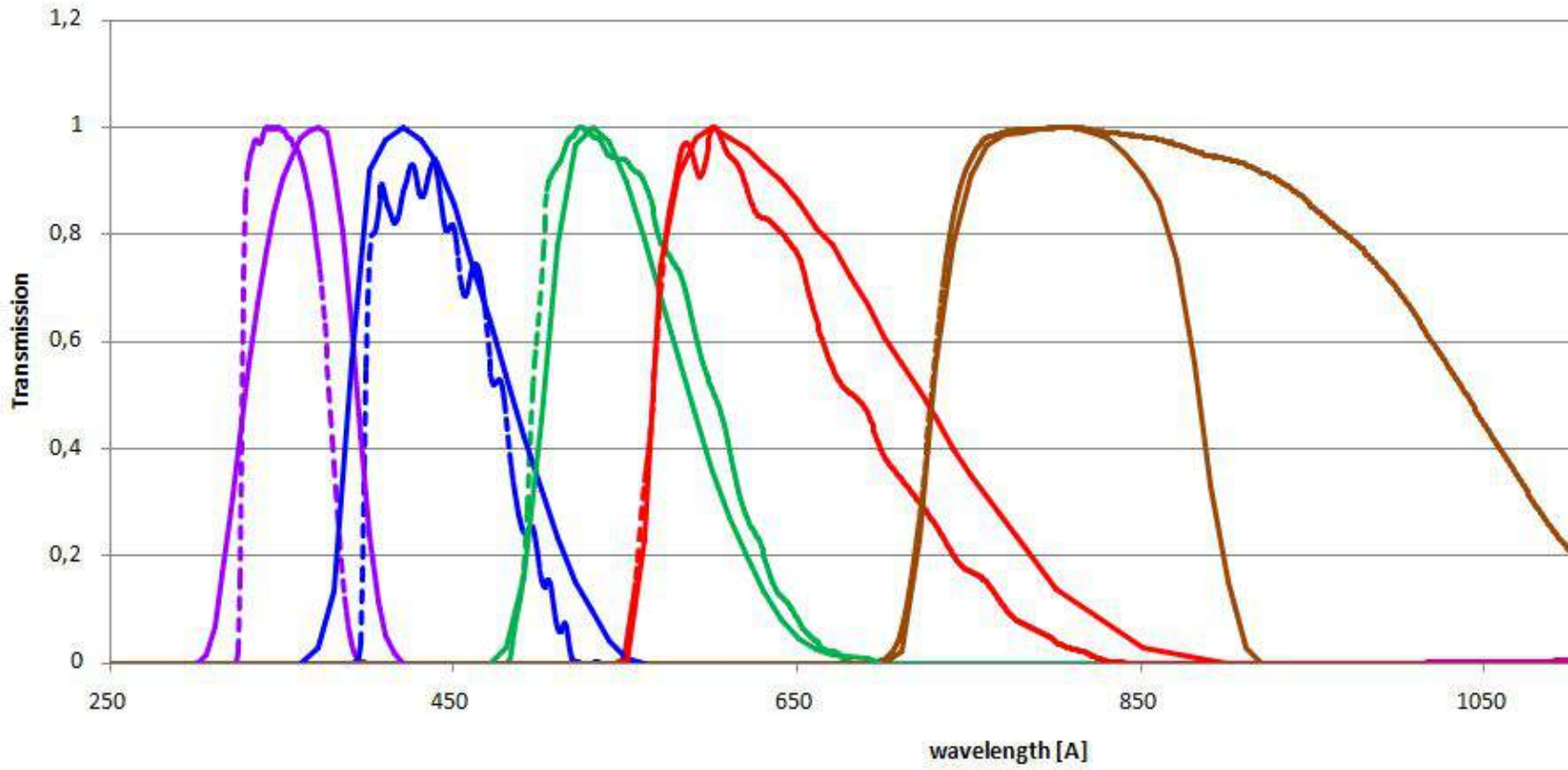


UBVRI: “Стандартни”Hroma, Bessell

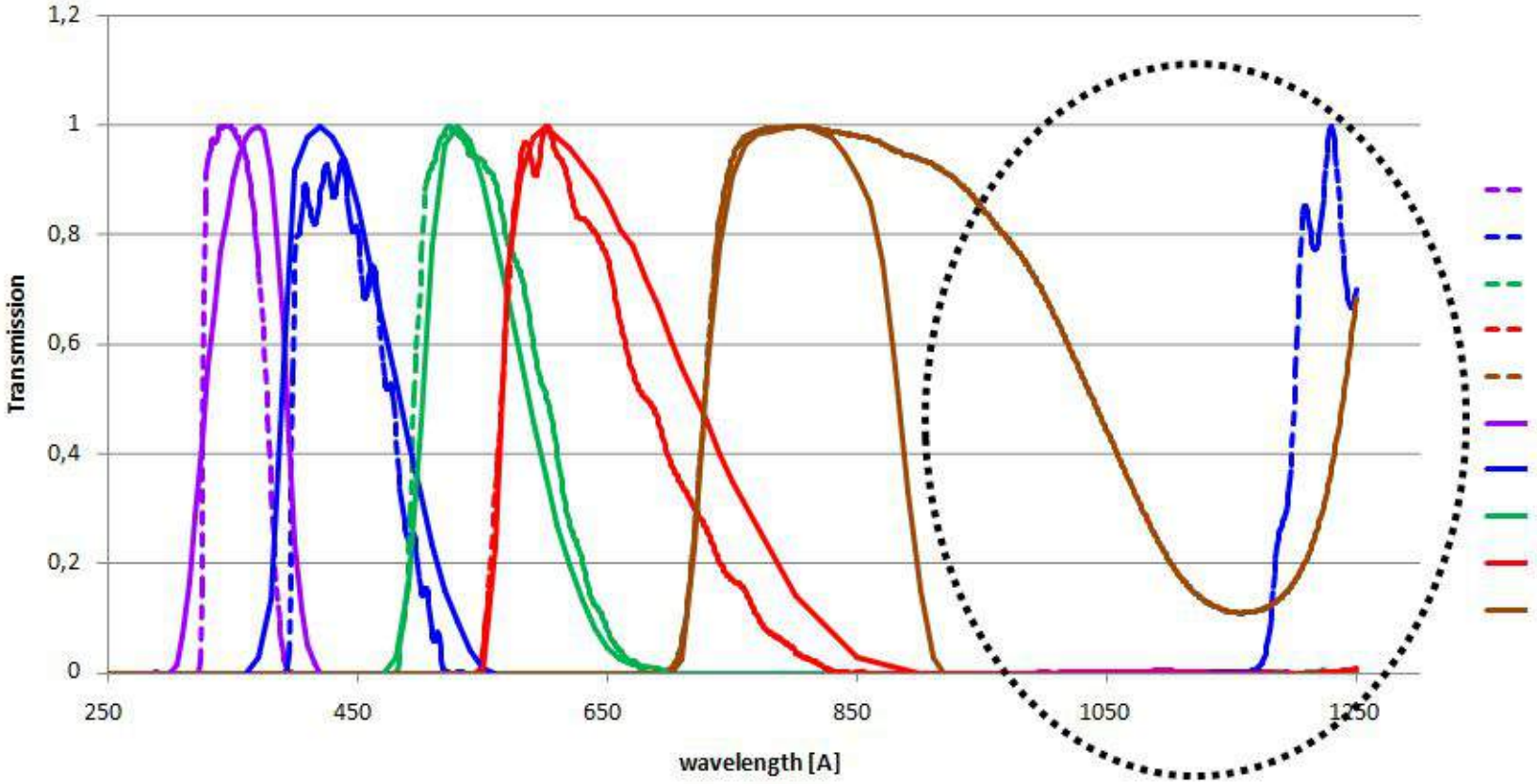


Имахме и такива, но за кратко: Филтрите за 50/70 Schmidt - Първата доставка !

UBVRI: “Стандартни” Baader



UBVRI: “Стандартни” Baader



Има ли ги в BG: Да, филтърен сет за 60 cm ASA – АО Шумен

Филтрите – защо да внимаваме?

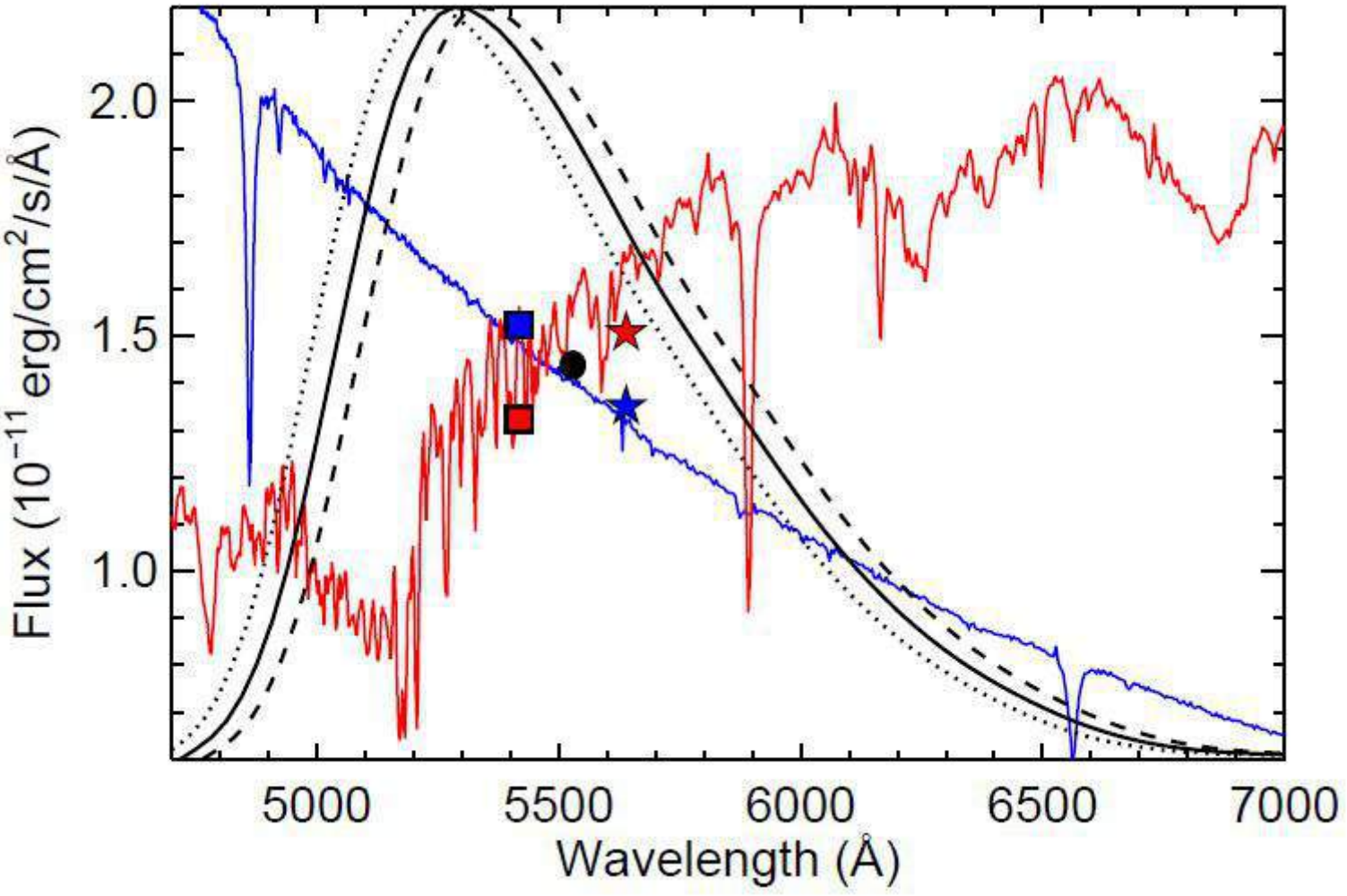
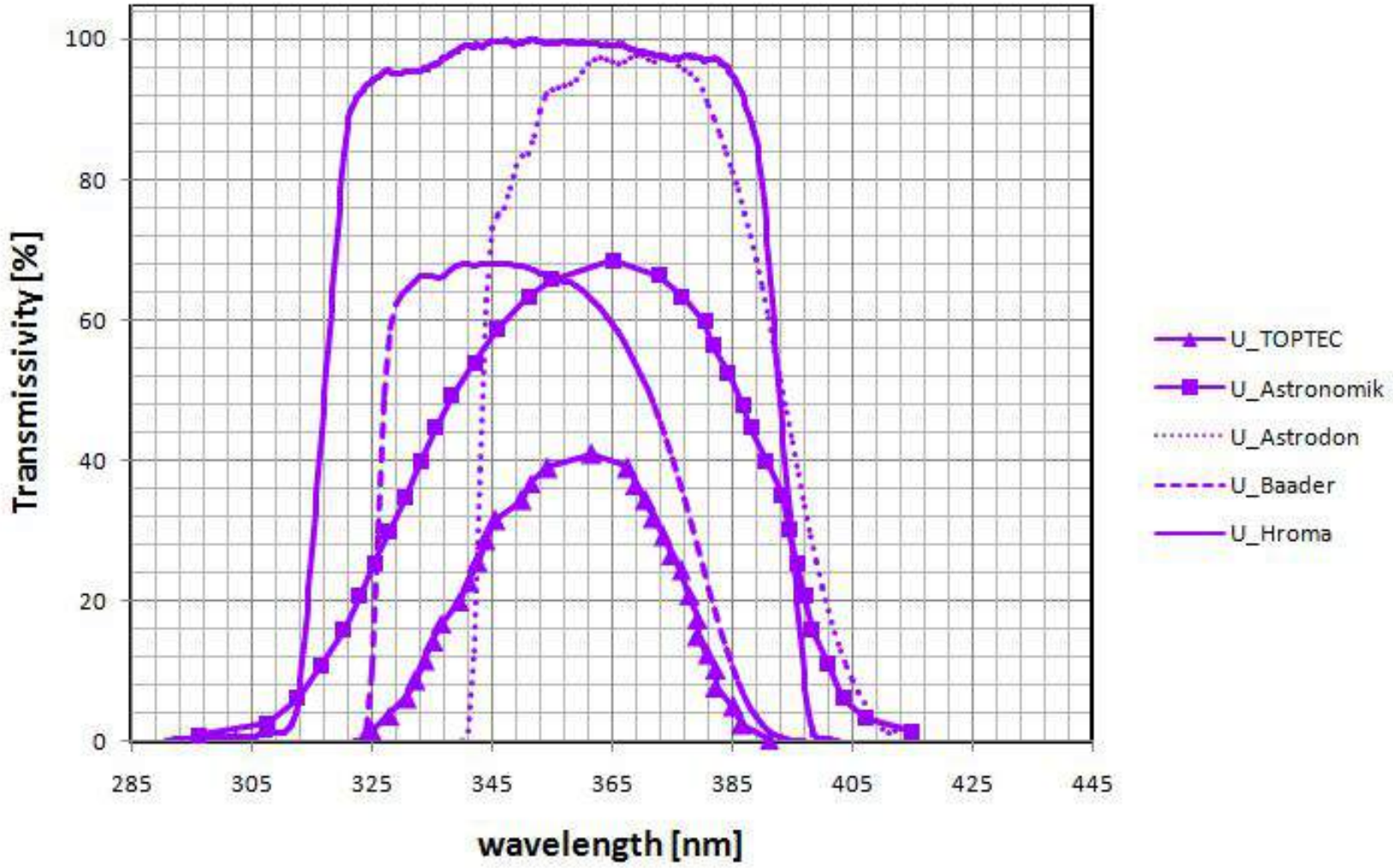


Fig.5. от Andrew Mann & Kasper Braun (2015, PASP, 127, 102)

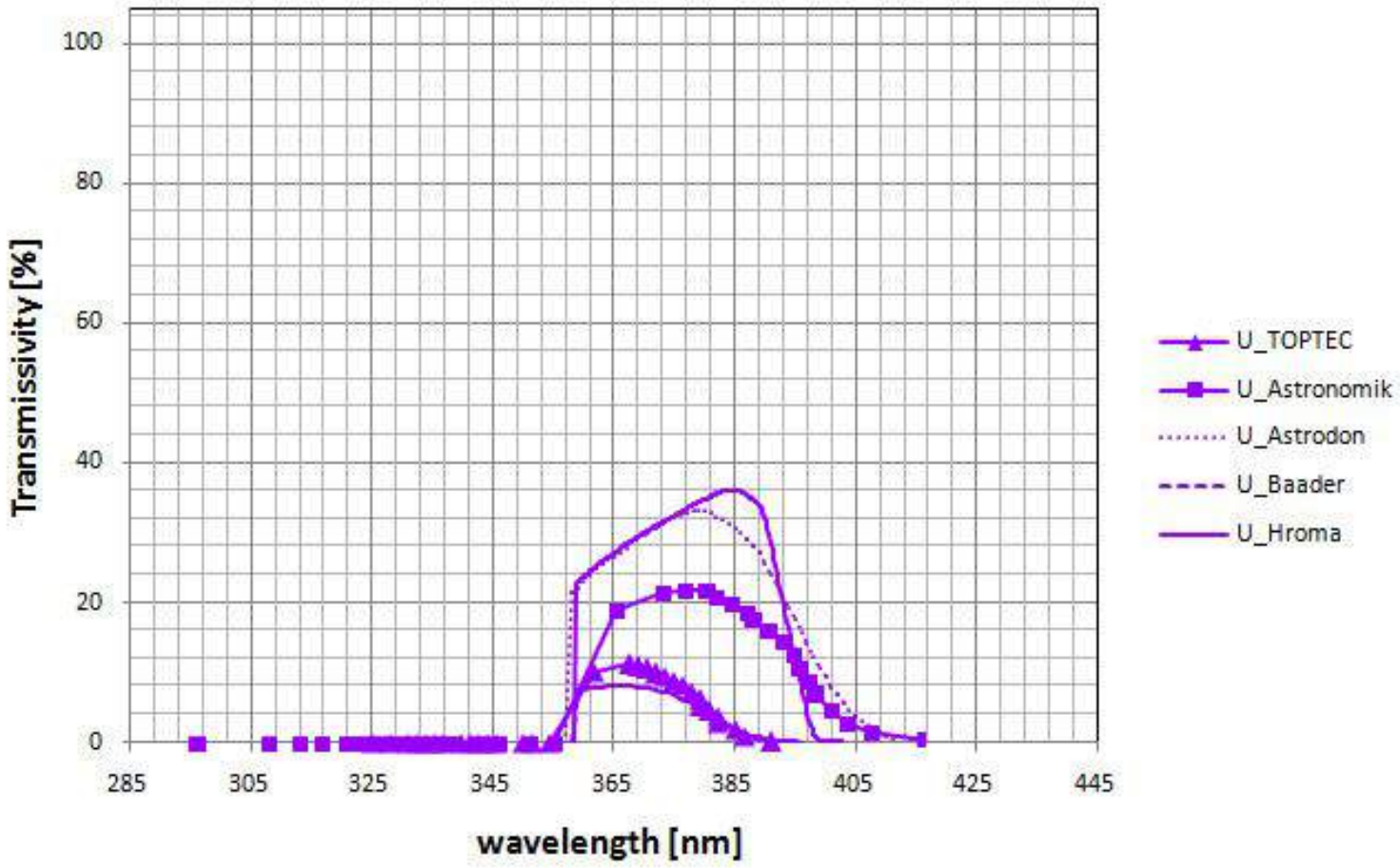
U: “Стандартни” многообразия



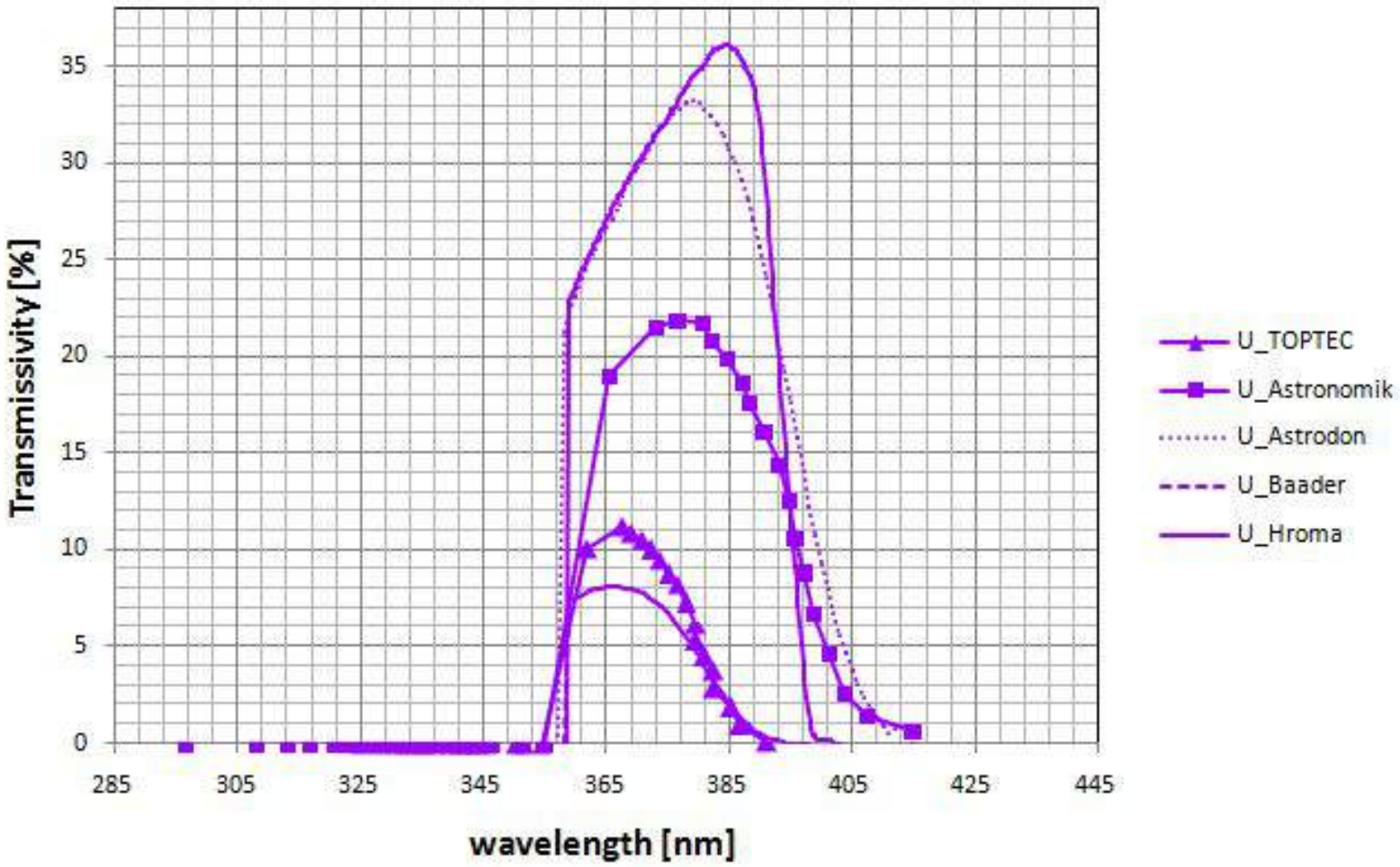
U: “Стандартни x QE” многообразия

Крива на квантовата ефективнос за CCD чипа на Kodak – KAF 16803. Към момента Такива чипове се използват в CCD кмаерите на 60 cm Cassegrain (60B) телескоп на АО
Белоградчик и на 50/70 cm Schmidt (50/70 Sch) телескоп на НАО Рожен (FLI 16803 PL).

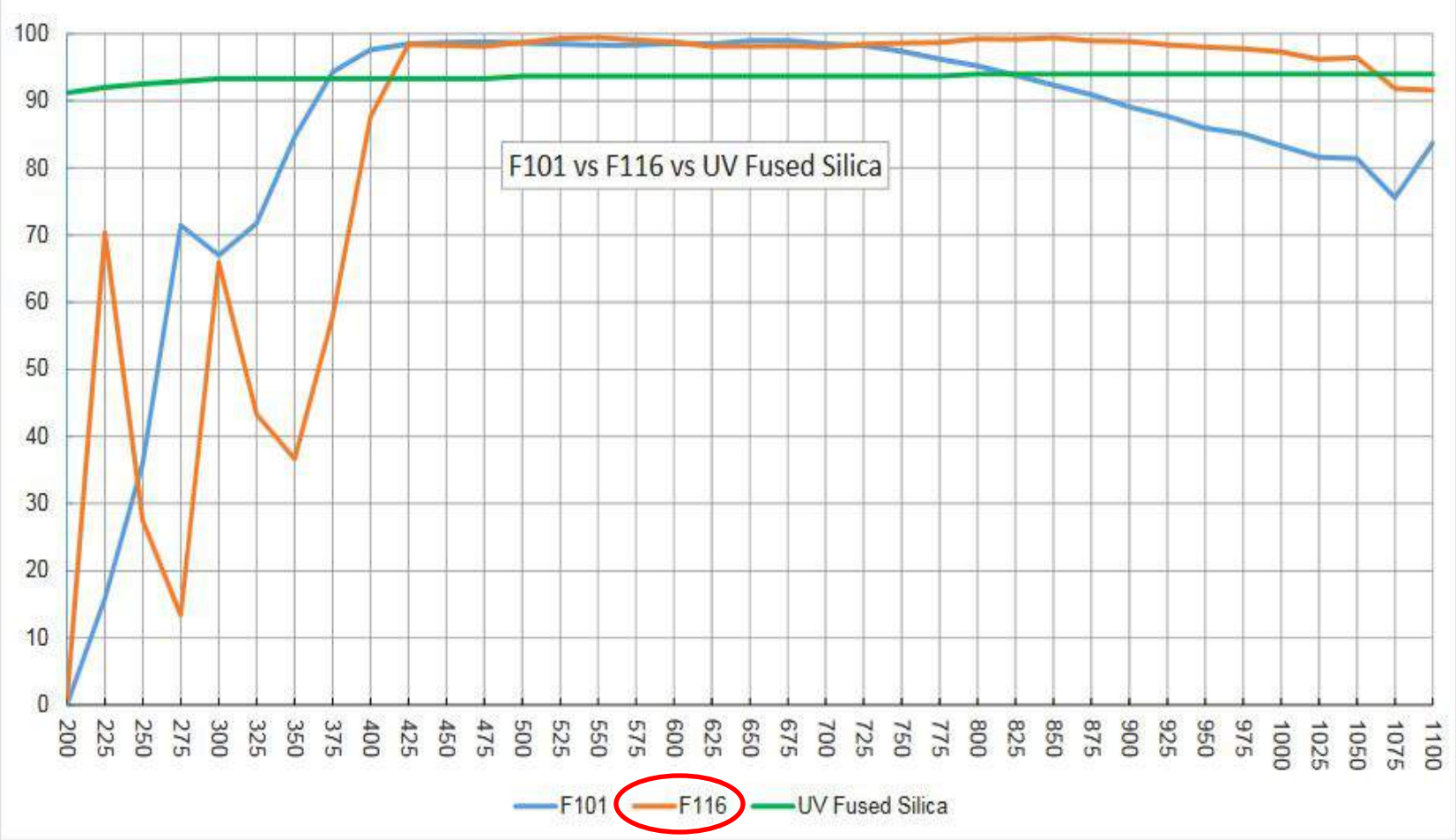
U: “Стандартни x QE” многообразия



U: “Стандартни x QE” многообразия

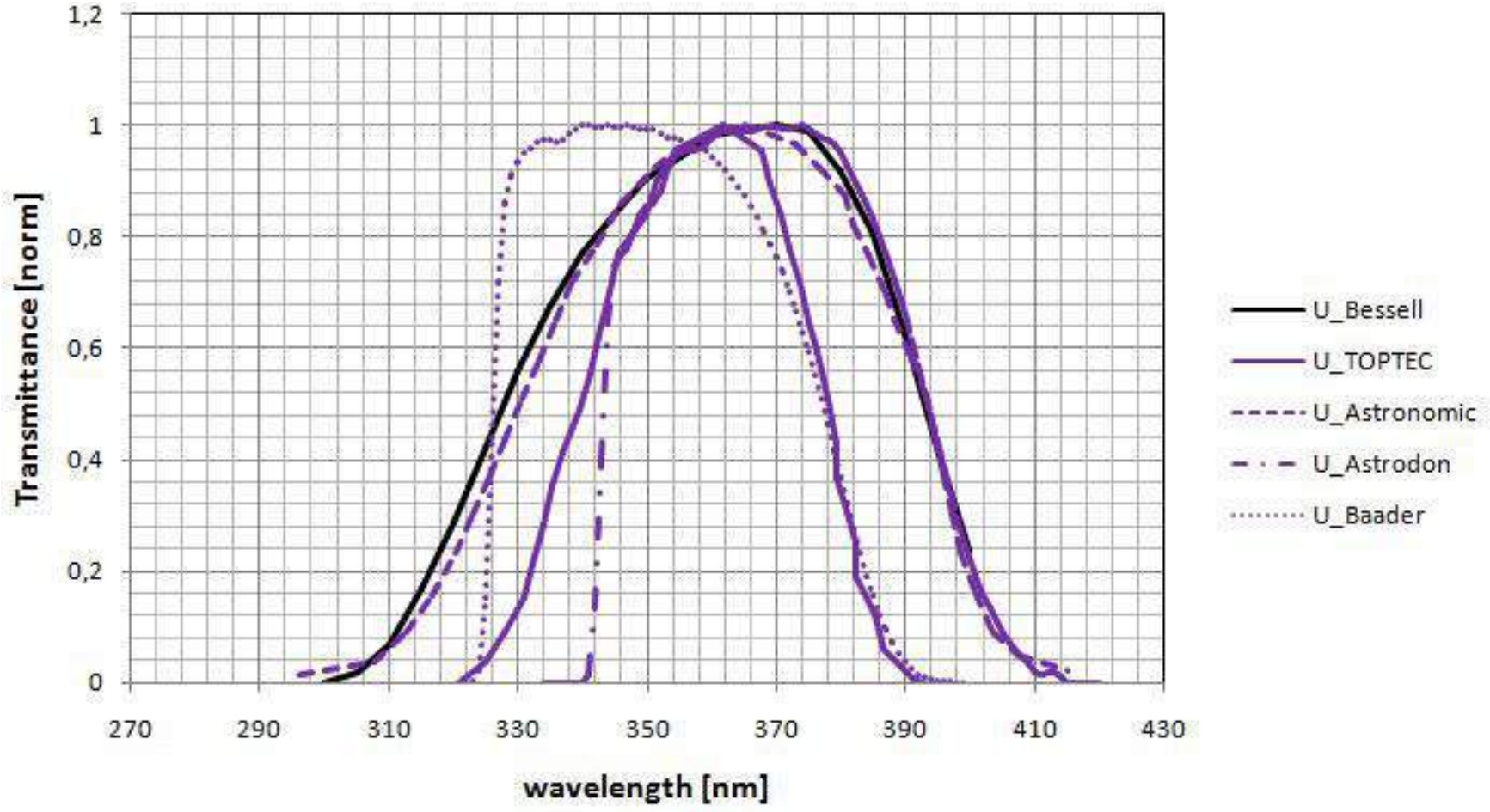


U: Ами “кварцовото” прозорче



Криви на пропускане на прозорчето пред CCD чипа. За CCD камериите FLI 16803 PL (60B
50/70 Sch) ние сме си “избрали” възможно най-лошото – F116 ;(

U: “Нормирани стандартни” многообразия



U: малко синтетика...

$$F_{tot} = \int_{\lambda_1}^{\lambda_2} B(\lambda) f(\lambda) d\lambda$$

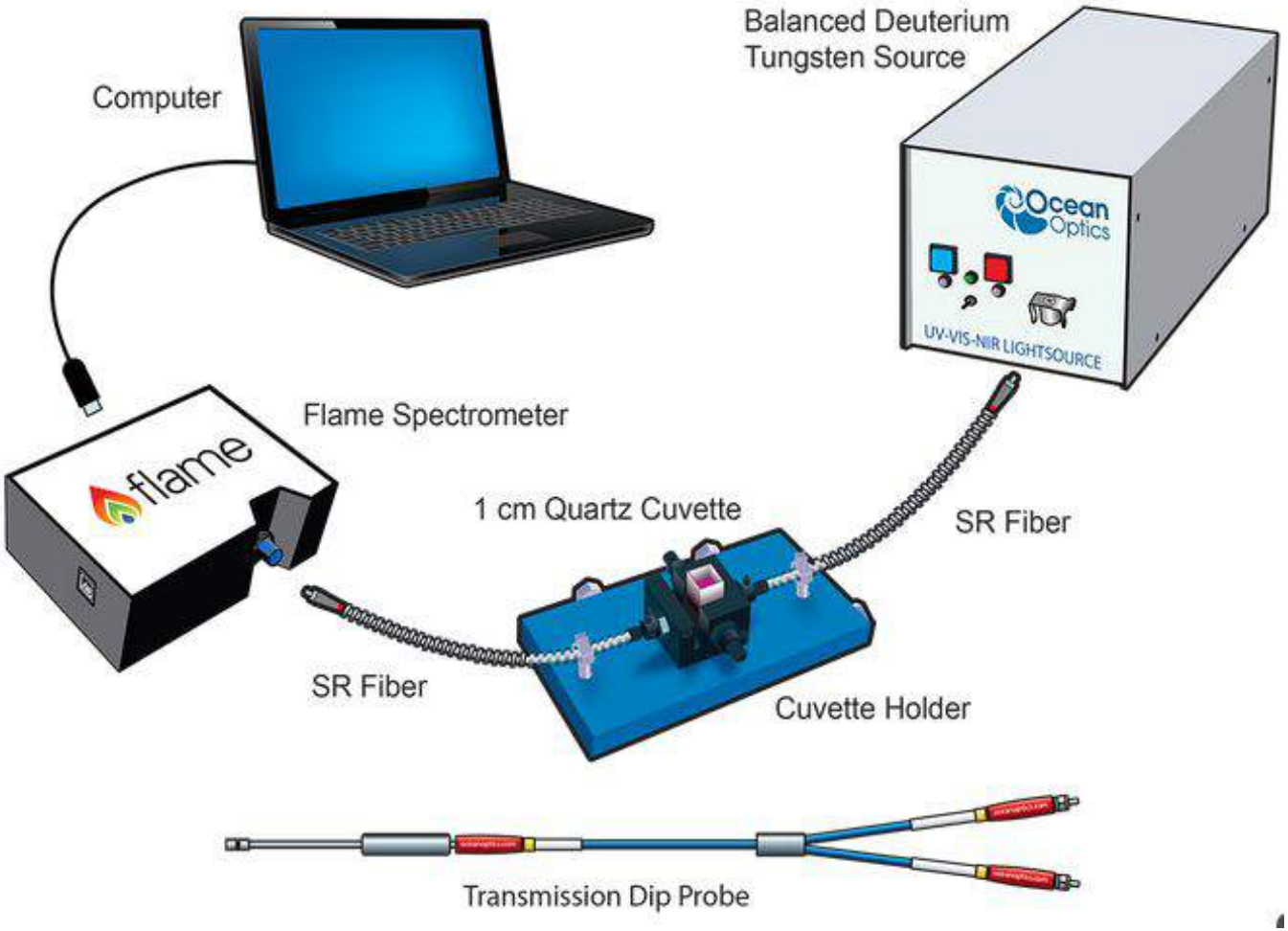
$$F_{wav} = \frac{\int_{\lambda_1}^{\lambda_2} B(\lambda) f(\lambda) d\lambda}{\int_{\lambda_1}^{\lambda_2} f(\lambda) d\lambda}$$

B (λ) – Планков имтезитет при T= 50 000 K

U filter	F_tot	f(λ)_tot	Fwav	(F_tot / F_max)[%]
Bessell	105,58	64,04	1,65	100,00
Toptec	62,46	37,73	1,66	59,16
Astronomik	100,92	61,30	1,65	95,58
Astrodon	71,59	48,32	1,48	67,81
Baader	87,10	49,32	1,77	82,50

Решението?

1. Регулярни хомогенни измервания на профилите на филтрите



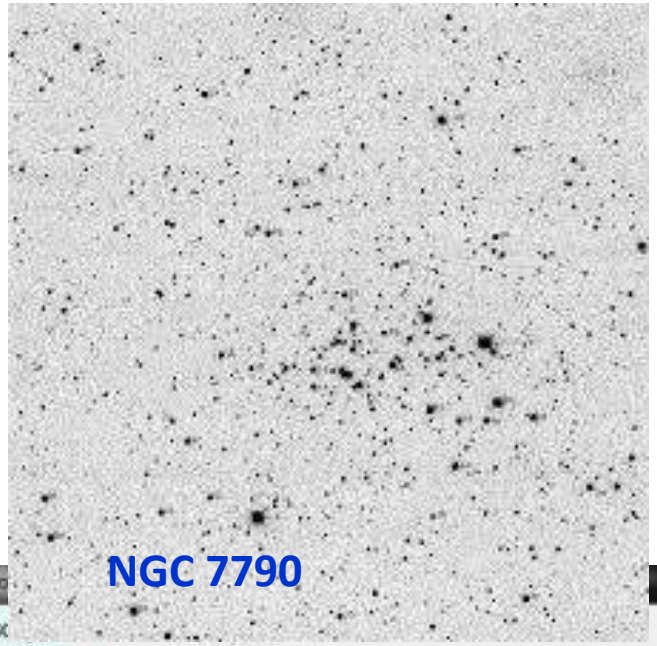
Решението?

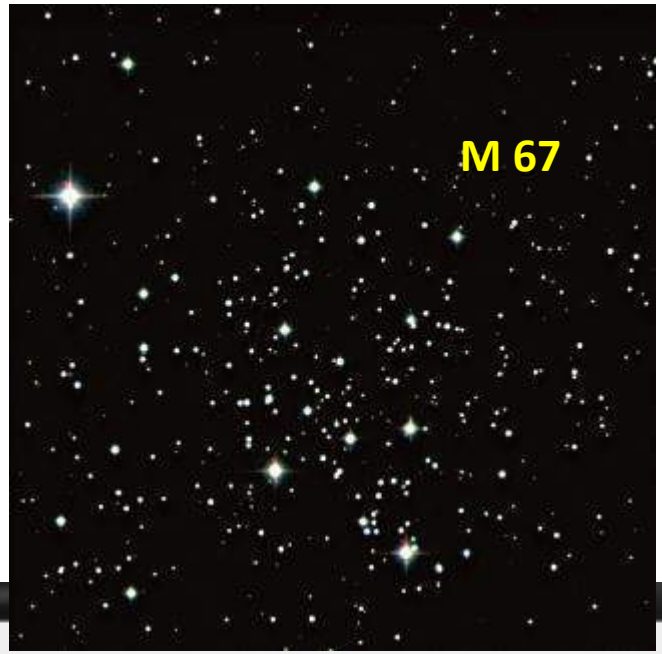
2. Определяне на базови характеристики на измерените профили

http://svo2.cab.inta-csic.es/theory/fps/

Решението?

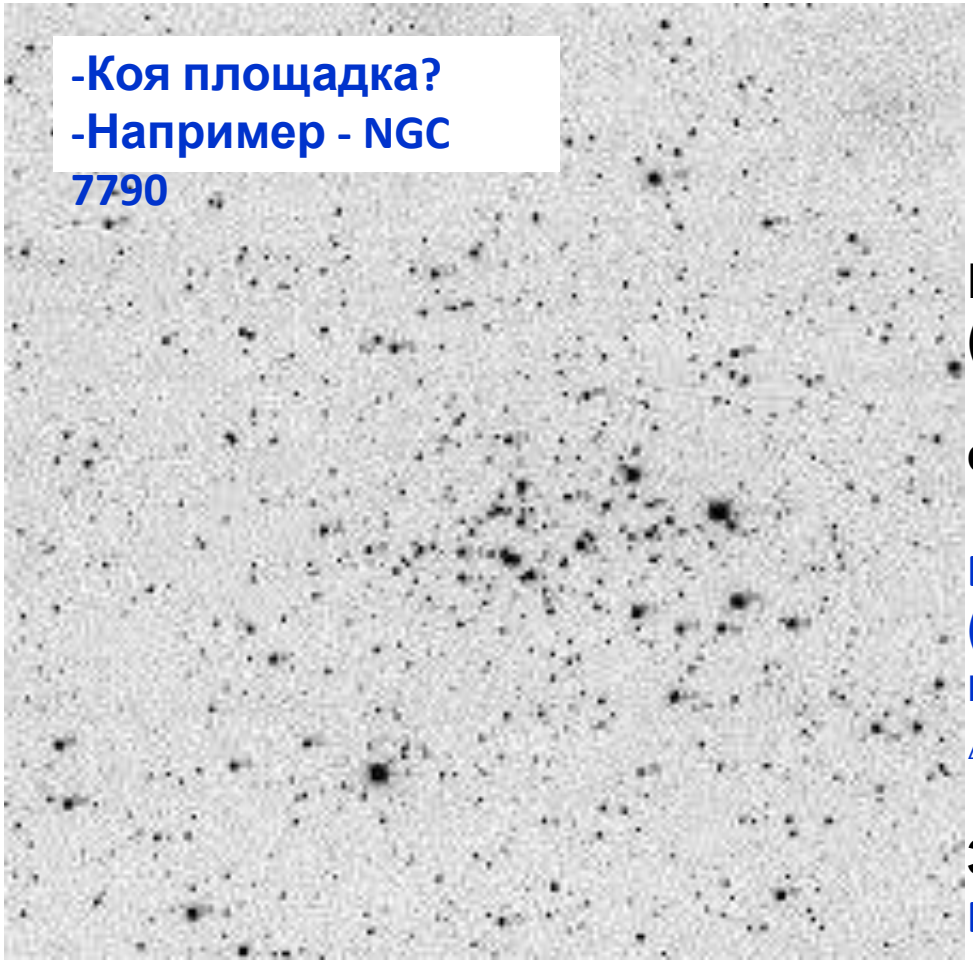
3. Измерване на “стандартни” площадки за коефициенти





AAVSO Transformation Generator

т.3 - Измерване на“стандартни” площадки за коефициенти – да опитаме!



Кои коефициенти?

Hardie 1962, Da Costa 1992:

$$B = b - k'_b X - k''_{bbv} X(B-V) + T_{bbv}(B-V) + Z_b$$

При диференциална фотометрия (обект и стандарт в един и същи кадър при еднаква въздушна маса):

$B_{var} = \Delta b + T_{bbv}\,\Delta(B-V) + B_{comp}$

($B_{var} = \Delta b + B_{comp}$ **– без отчитане на кофиц.)**

$\Delta(B-V) = T_{bv}\,\Delta(b-v)$

За пълнота:

$B_{var} = \Delta b + T_{bbv}\,T_{bv}\,\Delta(b-v) + B_{comp}$

Warner 2009, Boyd 2012

т.3 - Измерване на“стандартни” площадки за коефициенти – да опитаме!

$$B_{var} = \Delta b + T_{bbv}\, T_{bv}\, \Delta(b\text{-}v) + B_{comp}$$
$$\Delta b = b_{var} - b_{comp}$$
$$\Delta(b\text{-}v) = [(b\text{-}v)_{var} - (b\text{-}v)_{comp}]$$

T_{bbv} се определя по звездите от стандартната площадка от зависимостта

(B-b) vs. (B-V)

T_{bv} се определя по звездите от стандартната площадка от зависимостта

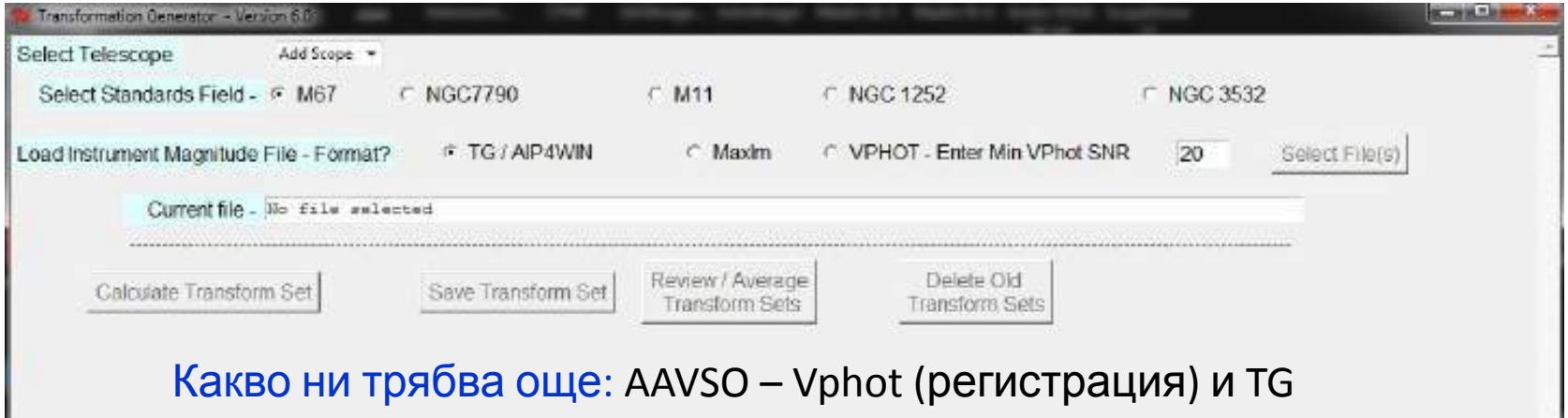
(b-v) vs. (B-V)

Определяне на коефициентите: Да опитаме за ШмиТа

Наблюдения (до сега, 14.11.2024 г.) на NGC 7790 със Schmidt телескопа на НАО Рожен:

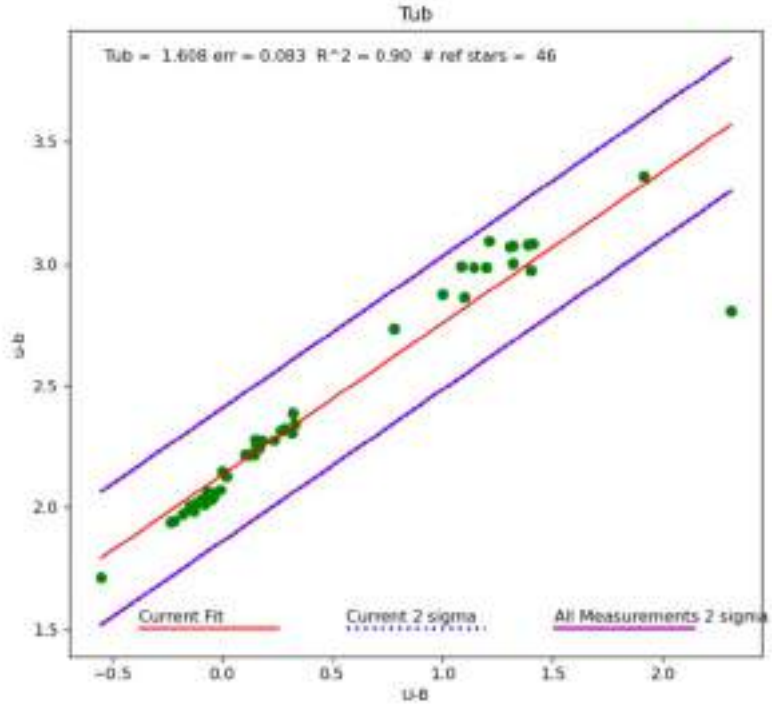
23.07.2022
11.08.2024
08.10.2024
05.11.2024
06.11.2024

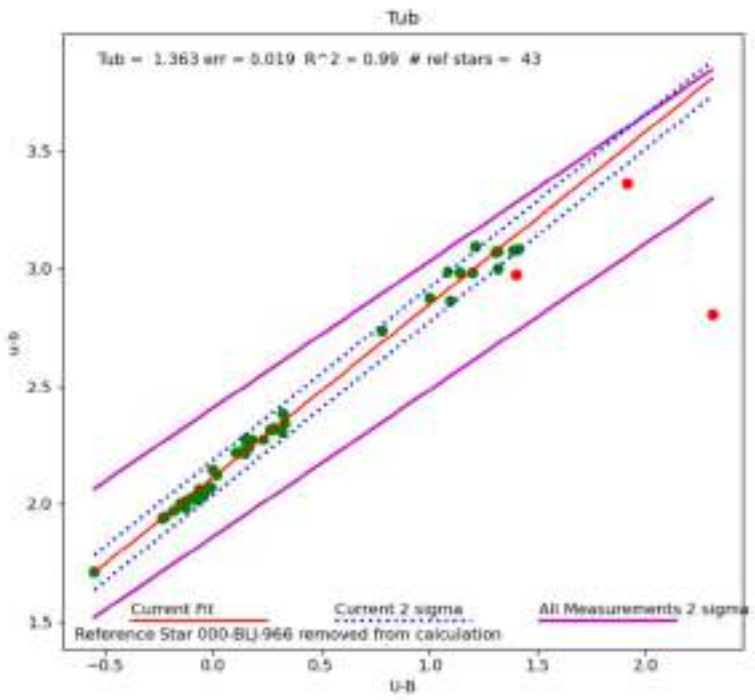
5 x UBVRI (с редуване), при airmass = 1.09-1.01 – отнема 15 минути!



Какво ни трябва още: AAVSO – Vphot (регистрация) и TG

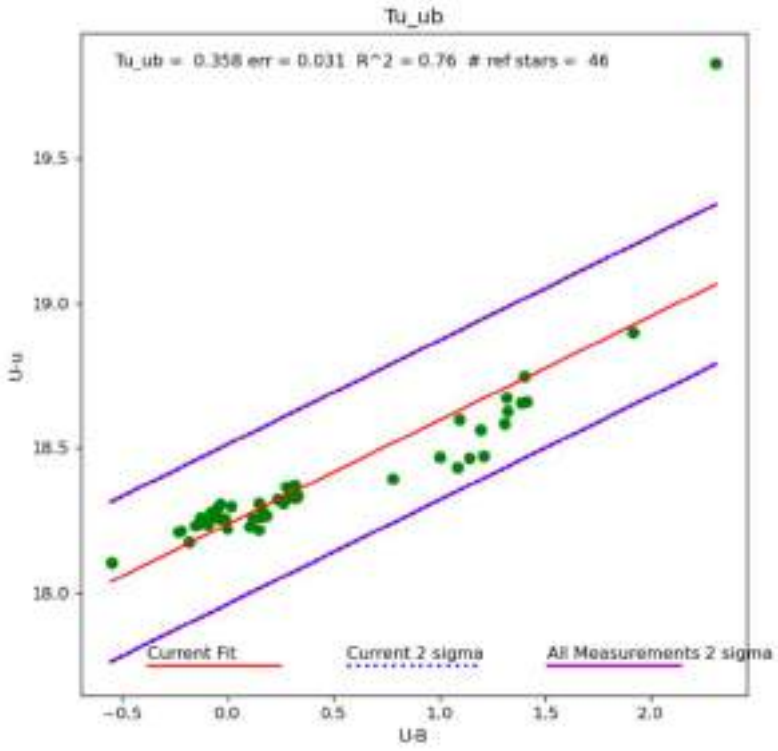
Определяне на коефициентите: AAVSO Vphot + TG

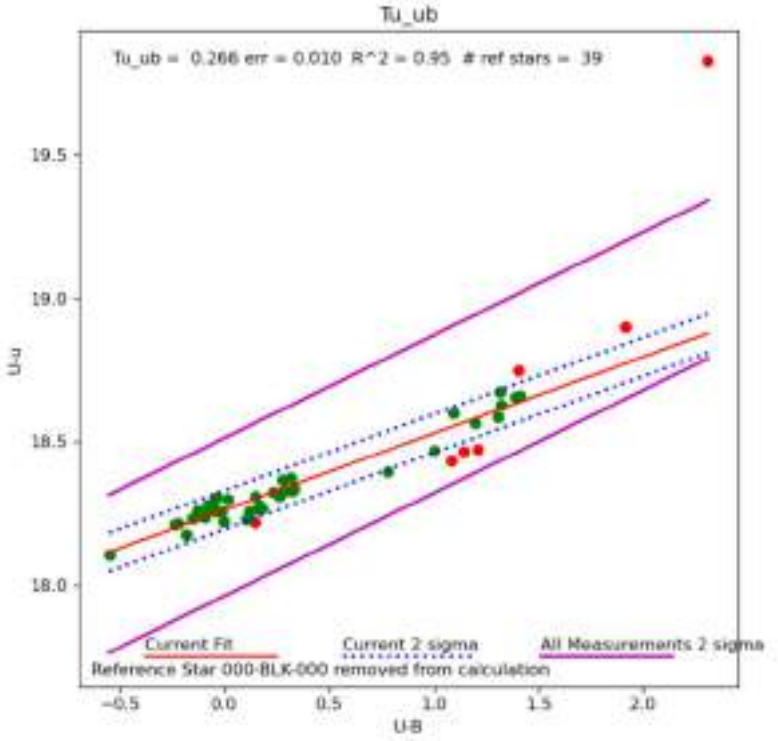




Определяне на “цветния” коефициент T_ub

Определяне на коефициентите: AAVSO Vphot + TG





Определяне на трансформационния коефициент Tu_ub

Определяне на коефициентите:
резултати за 11.08.2024 Schmidt

Filter Band Coefficients (eg Tb_bv)

T =	0.314	+/-	0.019	Band:	U	Color Index:	U	-	B		✕
T =	-0.034	+/-	0.004	Band:	B	Color Index:	U	-	B		✕
T =	-0.047	+/-	0.008	Band:	B	Color Index:	B	-	V		✕
T =	-0.03	+/-	0.005	Band:	B	Color Index:	B	-	R		✕
T =	-0.023	+/-	0.004	Band:	B	Color Index:	B	-	I		✕
T =	-0.016	+/-	0.007	Band:	V	Color Index:	B	-	V		✕
T =	-0.027	+/-	0.013	Band:	V	Color Index:	V	-	R		✕
T =	-0.09	+/-	0.012	Band:	R	Color Index:	V	-	R		✕
T =	-0.098	+/-	0.013	Band:	R	Color Index:	R	-	I		✕
T =	-0.008	+/-	0.013	Band:	I	Color Index:	R	-	I		✕
T =	-0.014	+/-	0.007	Band:	V	Color Index:	V	-	I		✕
T =	-0.003	+/-	0.006	Band:	I	Color Index:	V	-	I		✕
T =	-0.047	+/-	0.006	Band:	R	Color Index:	V	-	I		✕

Colorindex Coefficients (eg Tbv)

T =	1.419	+/-	0.023	Color Index:	U	-	B	✕
T =	0.973	+/-	0.009	Color Index:	B	-	V	✕
T =	1.004	+/-	0.006	Color Index:	B	-	R	✕
T =	0.98	+/-	0.005	Color Index:	B	-	I	✕
T =	1.084	+/-	0.015	Color Index:	V	-	R	✕
T =	0.923	+/-	0.014	Color Index:	R	-	I	✕
T =	0.988	+/-	0.007	Color Index:	V	-	I	✕

Определяне на коефициентите:
резултати за 11.08.2024 Schmidt

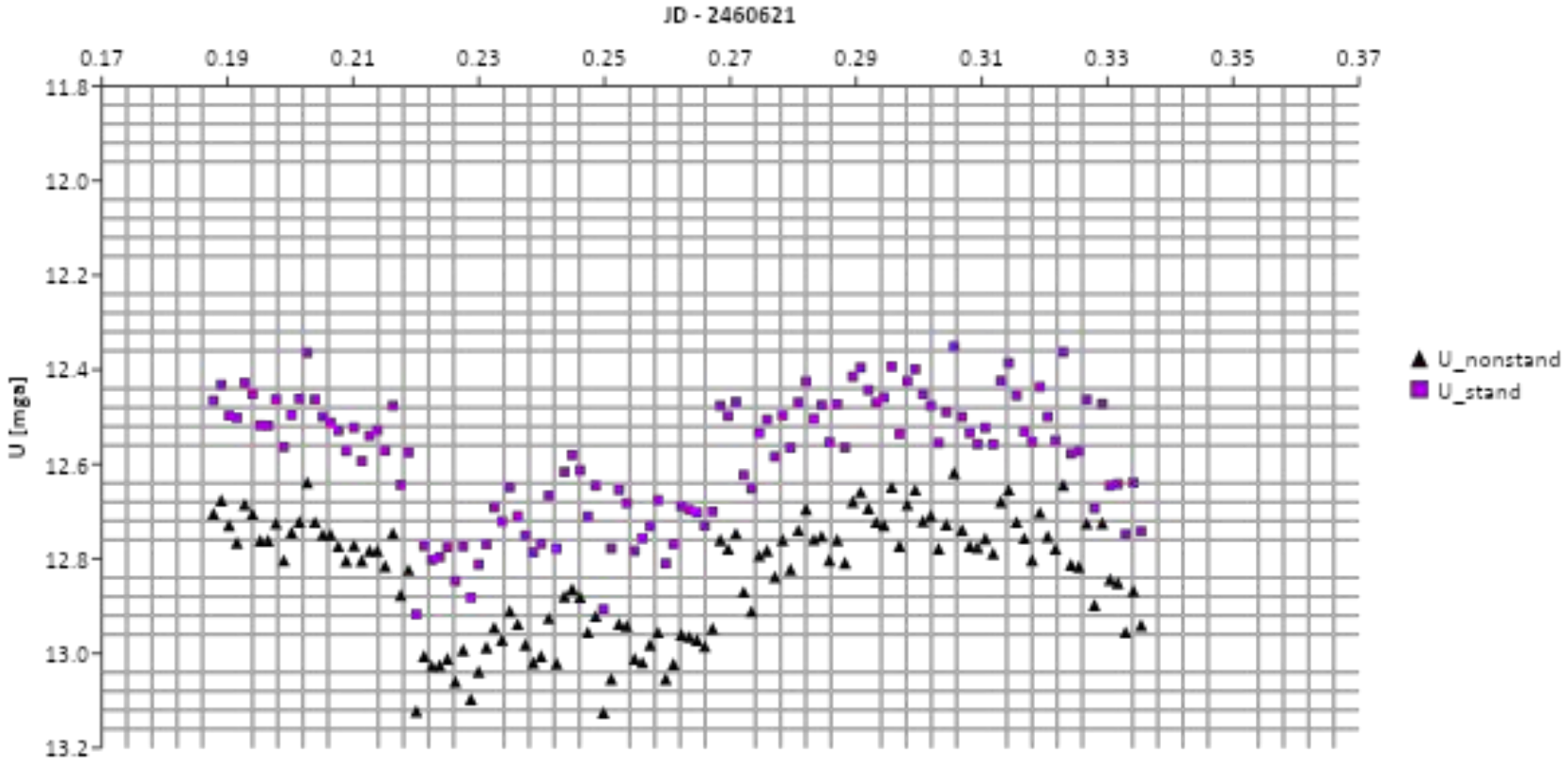
Filter Band Coefficients (eg Tb_bv)

T =	0.314	+/-	0.019	Band:	U	Color Index:	U	-	B			
T =	-0.034	+/-	0.004	Band:	B	Color Index:	U	-	B			
T =	-0.047	+/-	0.008	Band:	B	Color Index:	B	-	V			
T =	-0.03	+/-	0.005	Band:	B	Color Index:	B	-	R			
T =	-0.023	+/-	0.004	Band:	B	Color Index:	B	-	I			
T =	-0.016	+/-	0.007	Band:	V	Color Index:	B	-	V			
T =	-0.027	+/-	0.013	Band:	V	Color Index:	V	-	R			
T =	-0.09	+/-	0.012	Band:	R	Color Index:	V	-	R			
T =	-0.098	+/-	0.013	Band:	R	Color Index:	R	-	I			
T =	-0.008	+/-	0.013	Band:	I	Color Index:	R	-	I			
T =	-0.014	+/-	0.007	Band:	V	Color Index:	V	-	I			
T =	-0.003	+/-	0.006	Band:	I	Color Index:	V	-	I			
T =	-0.047	+/-	0.006	Band:	R	Color Index:	V	-	I			

Colorindex Coefficients (eg Tbv)

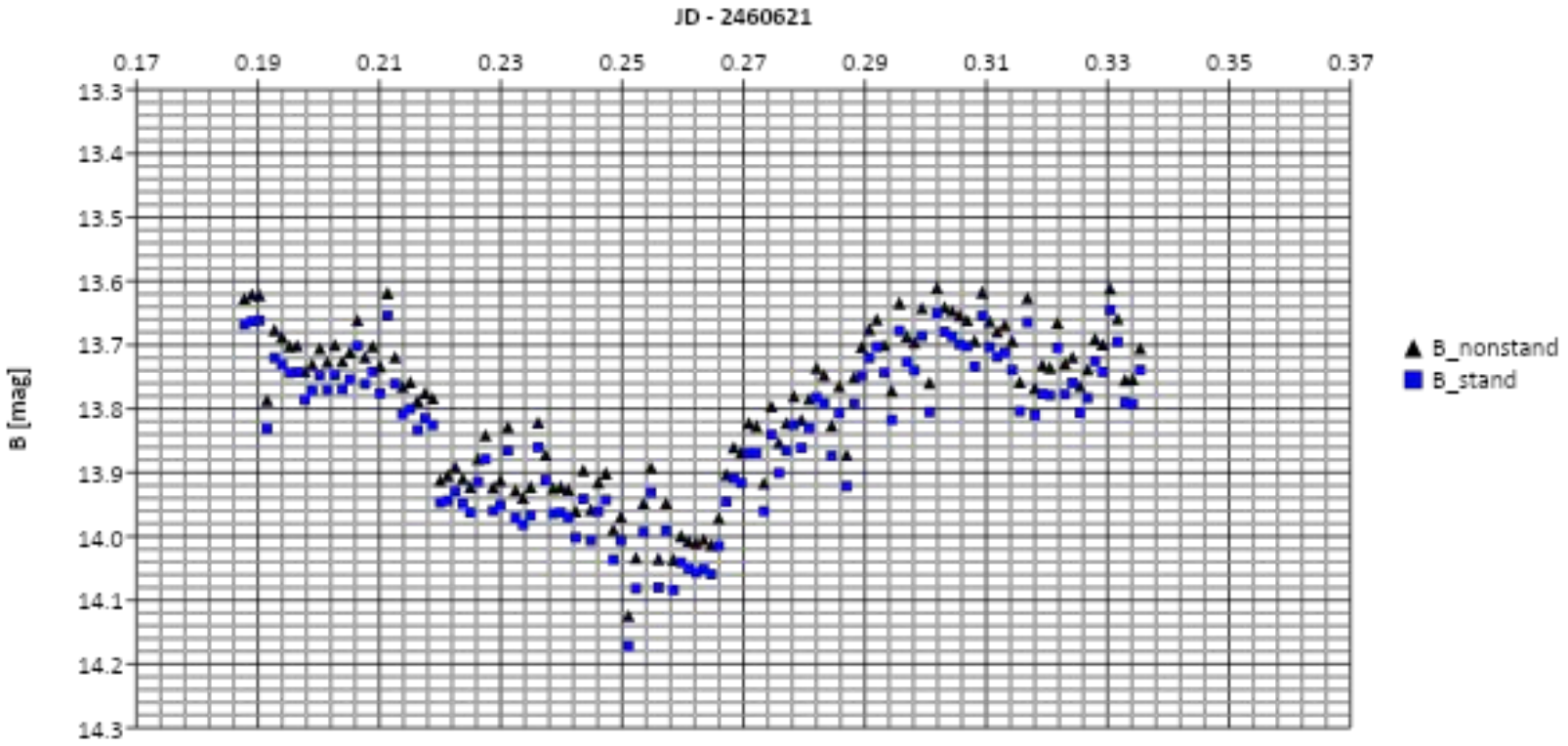
T =	1.419	+/-	0.023	Color Index:	U	-	B					
T =	0.973	+/-	0.009	Color Index:	B	-	V					
T =	1.004	+/-	0.006	Color Index:	B	-	R					
T =	0.98	+/-	0.005	Color Index:	B	-	I					
T =	1.084	+/-	0.015	Color Index:	V	-	R					
T =	0.923	+/-	0.014	Color Index:	R	-	I					
T =	0.988	+/-	0.007	Color Index:	V	-	I					

Прилагане на коефициентите:
пример от 06.09.2024 г.



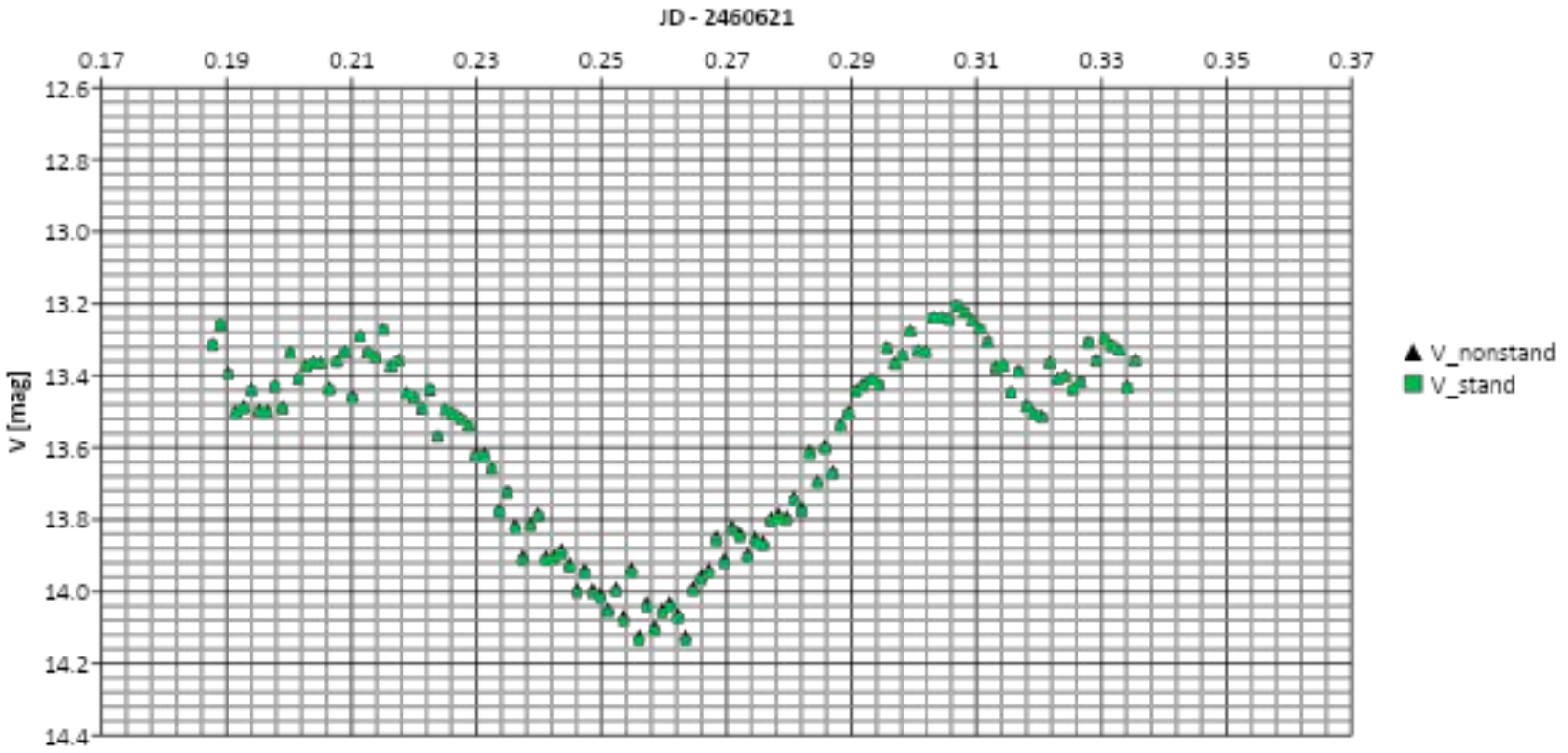
Средна разлика: Δ(Ustand – Unonstand) = -0.248 mag

Прилагане на коефициентите:
пример от 06.09.2024 г.



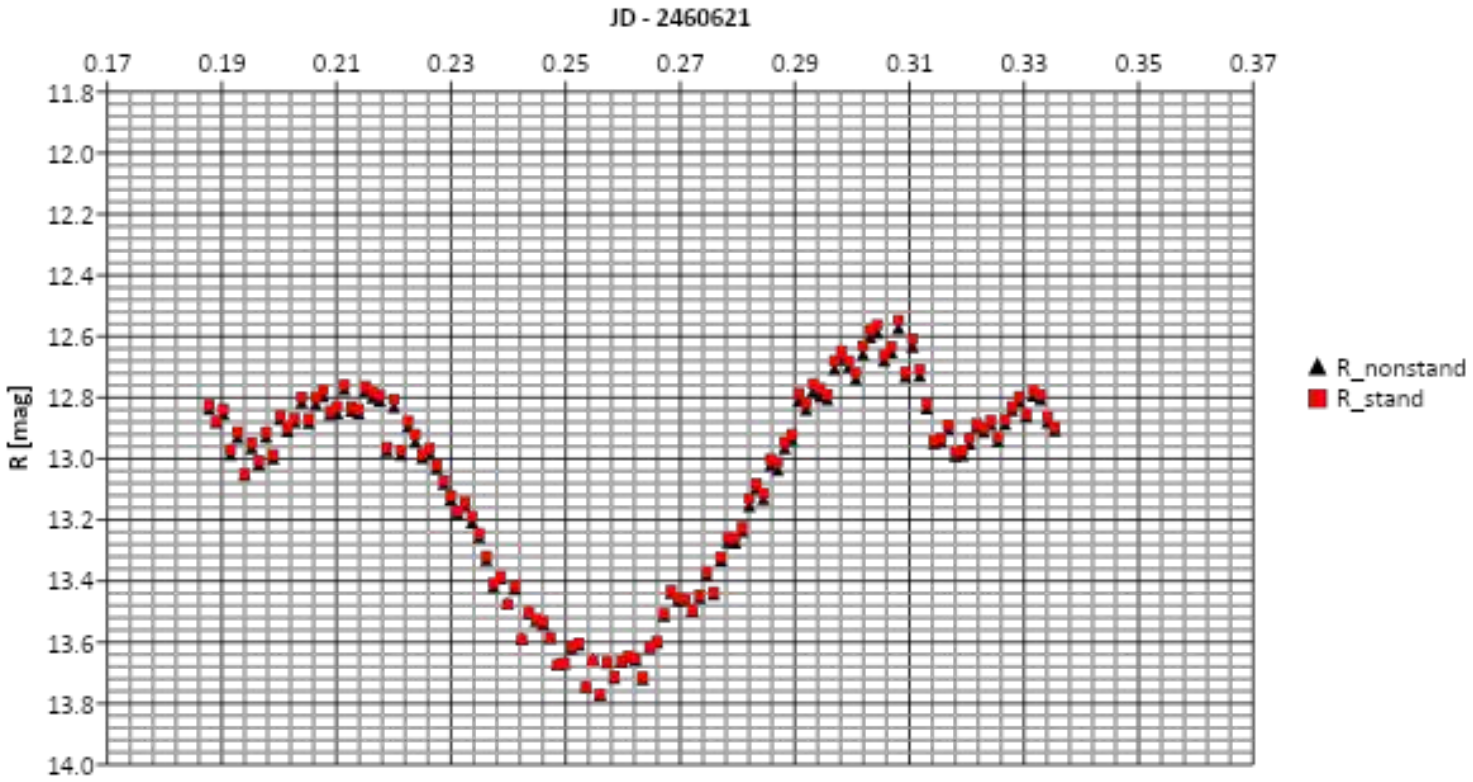
Средна разлика: Δ(Bstand – Bnonstand) = 0.043 mag

Прилагане на коефициентите:
пример от 06.09.2024 г.



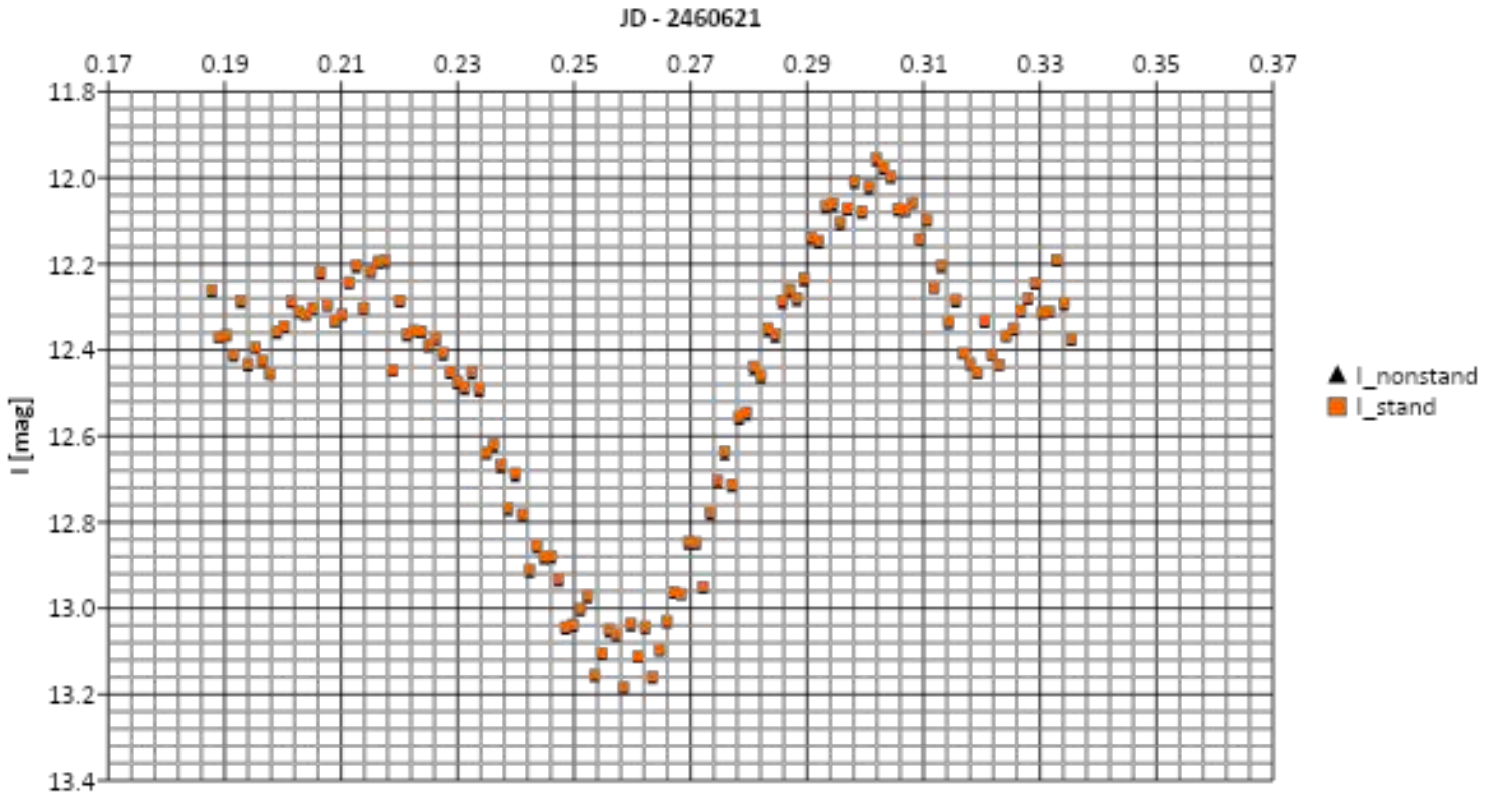
Средна разлика: Δ(Vstand – Vnonstand) = 0.009 mag

Прилагане на коефициентите:
пример от 06.09.2024 г.



Средна разлика: Δ(Rstand – Rnonstand) = 0.012 mag

Прилагане на коефициентите: пример от 06.09.2024 г.

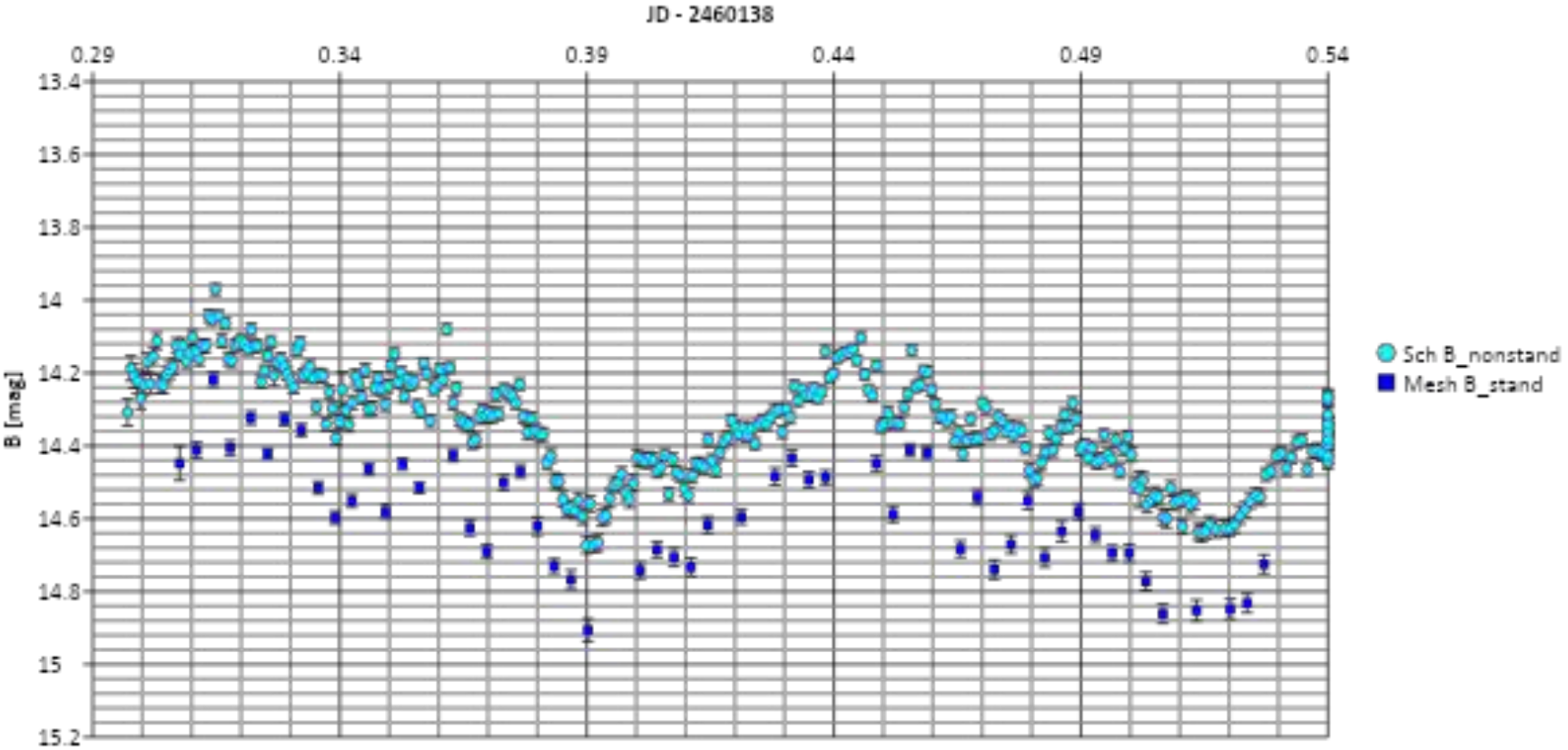


Средна разлика: Δ(Istand – Inonstand) = 0.006 mag

Прилагане на коефициентите:

25 cm Meshtica и 50/70 cm Schmidt

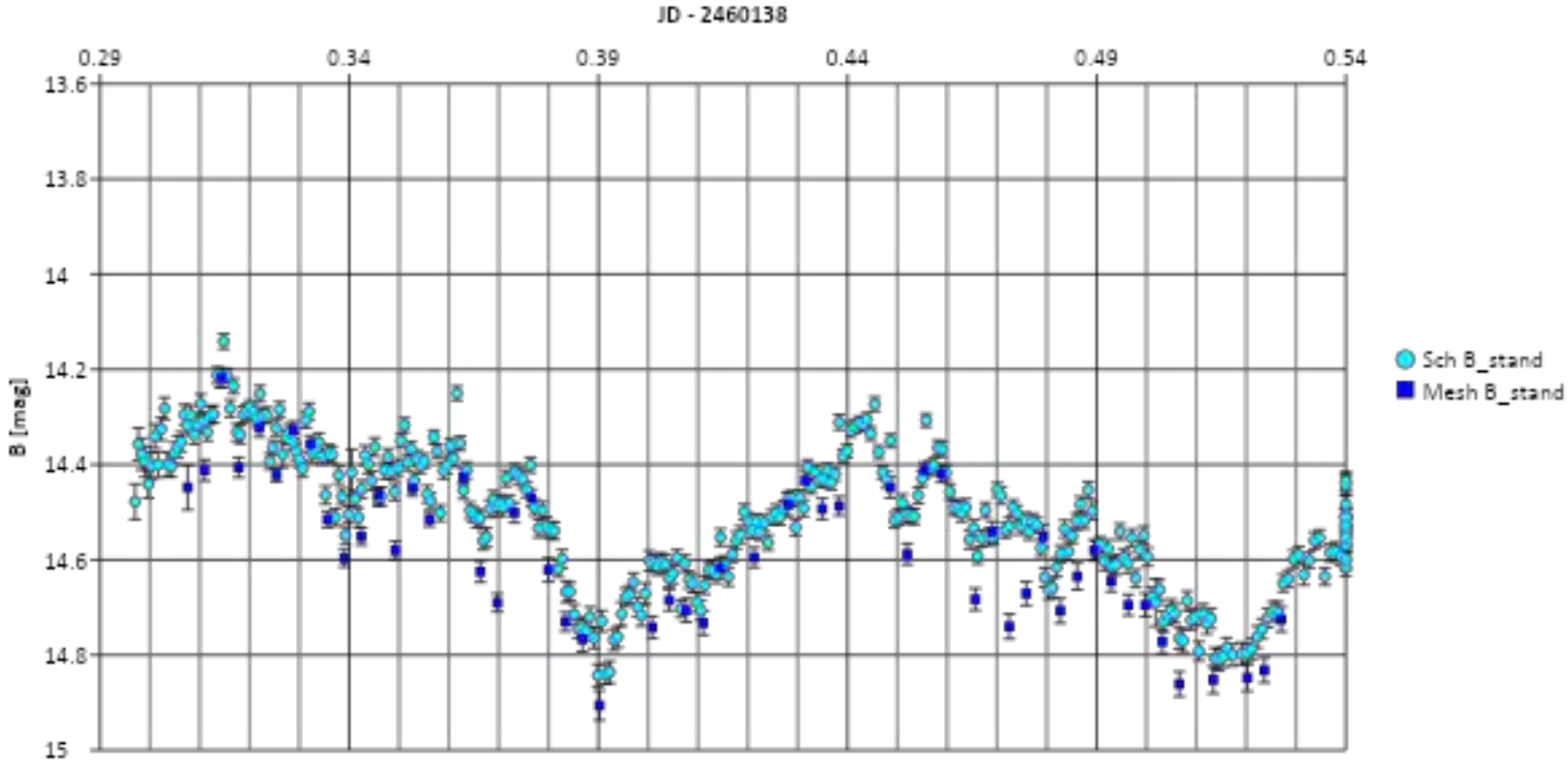
Дата: 11.07.2023, **Обект:** AM Her



Прилагане на коефициентите:

25 cm Meshtica и 50/70 cm Schmidt

Дата: 11.07.2023, **Обект:** AM Her



Прилагане на коефициентите: (не)приятности

-Чрез специално зададено правило в TA на AAVSO

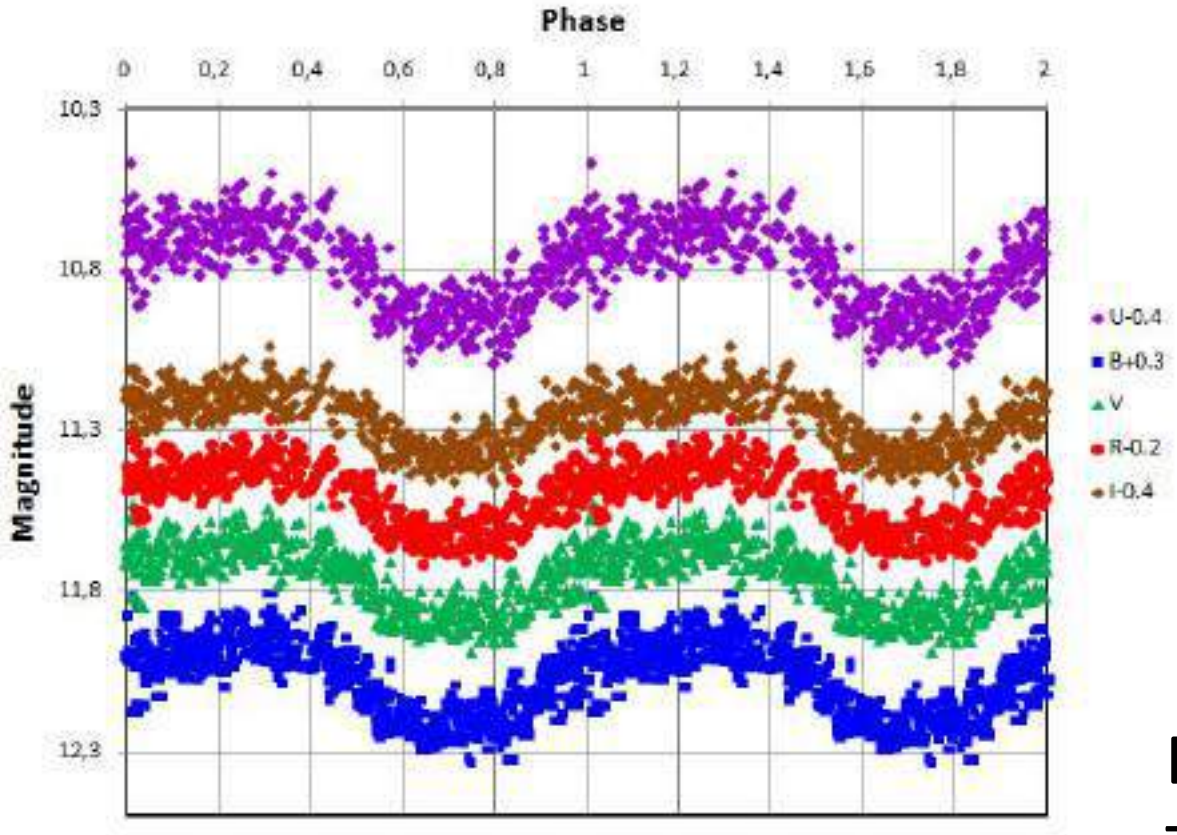
-Няма диретни опции за това в пакетите за фотометрия – *Astro Image J, MaxIm DL, IRAF и т.н.*

-За определяне на зв. вел. в даден филтър е необходимо едновременно
заснемане в съседен филтър – например B изисква и набл. във V заради
отчитането на инструменталния цветови индекс (b-v) на стандарта и обекта

-Невъзможност за прилагане на “ансамблова” фотометрия

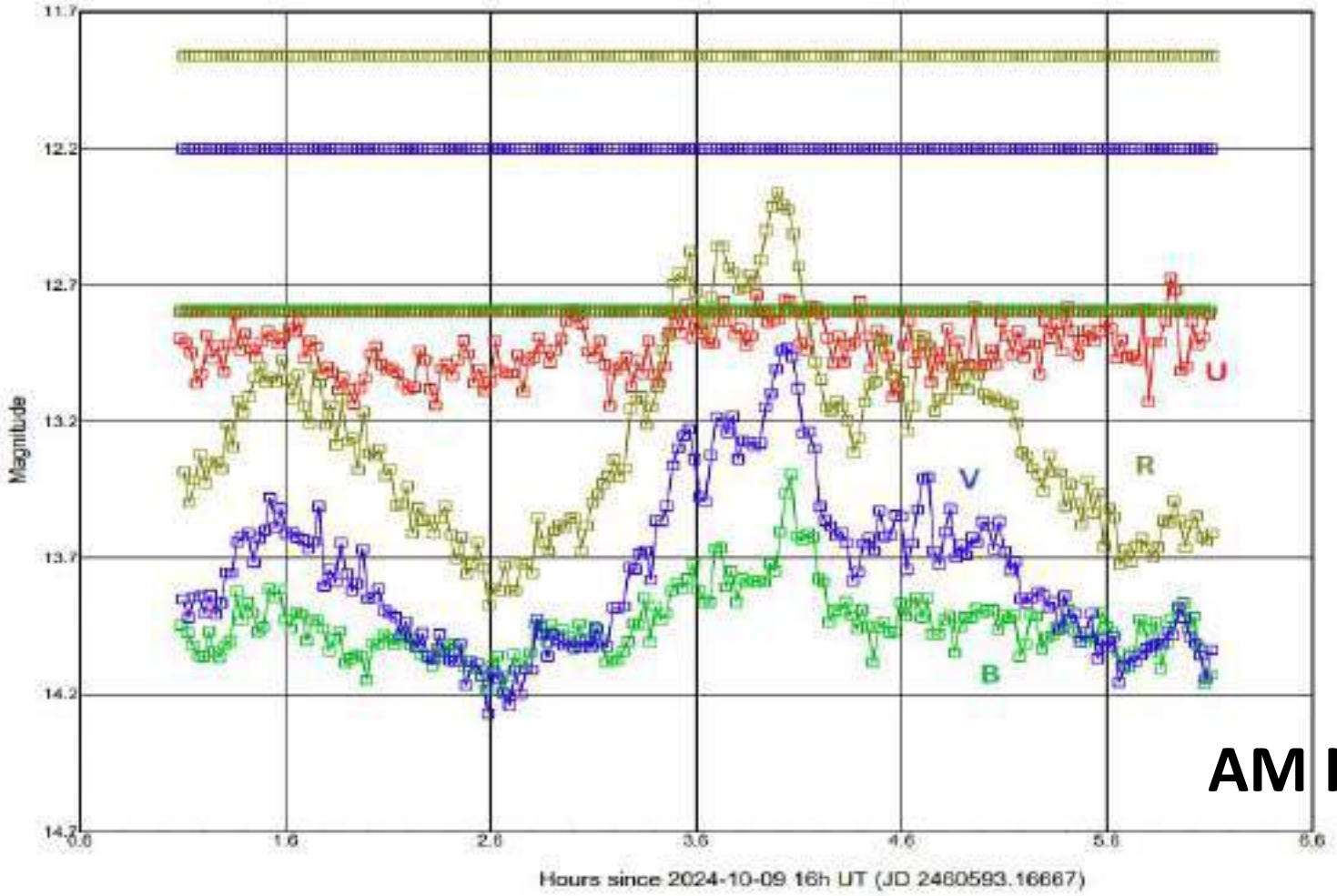
-Квазисинхронност и евентуално дълго времево разминаване между кадрите в два съседни филтъра (понякога над 10 минути)

Прилагане на коефициентите: наблюдения в 1 филтър с допускане за “константен цвят”



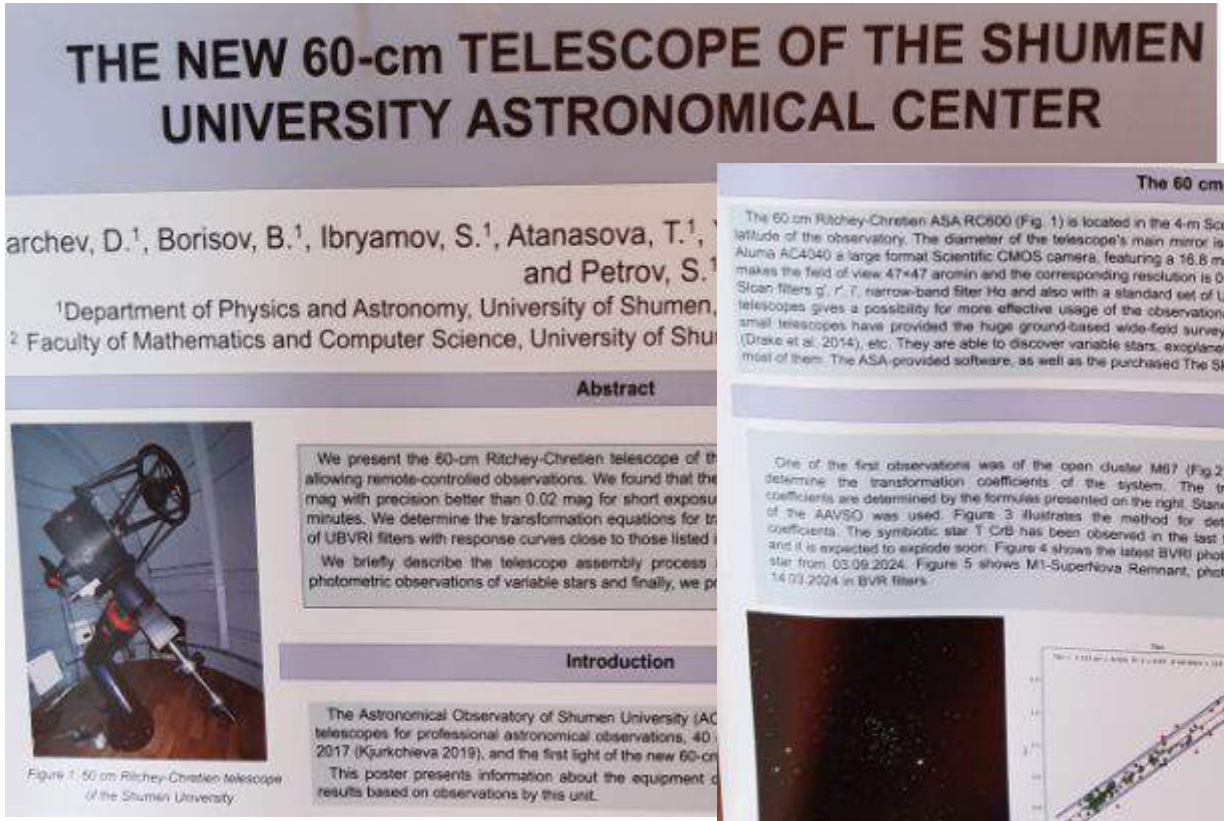
BG Tri

Прилагане на коефициентите:
наблюдения в 1 филтър с допускане за “константен цвят”



AM Her

Определяне на коефициентите:
Да действаме, че ни изпреварихa 😍



THE NEW 60-cm TELESCOPE OF THE SHUMEN UNIVERSITY ASTRONOMICAL CENTER

archev, D.[1], Borisov, B.[1], Ibryamov, S.[1], Atanasova, T.[1], and Petrov, S.[1]

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[2] Faculty of Mathematics and Computer Science, University of Shu

Abstract

We present the 60-cm Ritchey-Chretien telescope of th allowing remote-controlled observations. We found that the mag with precision better than 0.02 mag for short exposu minutes. We determine the transformation equations for tr of UBVRI filters with response curves close to those listed i

We briefly describe the telescope assembly process photometric observations of variable stars and finally, we p

Figure 1. 60 cm Ritchey-Chretien telescope of the Shumen University

Introduction

The Astronomical Observatory of Shumen University (AO telescopes for professional astronomical observations, 40 2017 (Kjurkchieva 2019), and the first light of the new 60-cr

This poster presents information about the equipment results based on observations by this unit.

The 60 cm telescope and its equipment

The 60 cm Ritchey-Chretien ASA RC600 (Fig. 1) is located in the 4-m Scope-Dome. The ASA DDM200 equatorial mount is fixed on a custom pole specially designed for th latitude of the observatory. The diameter of the telescope's main mirror is 60 cm. Its focal length is 4200 mm with a relative aperture of f/7. The main detector is an SBI Aluma AC4040 a large format Scientific CMOS camera, featuring a 16.8 megapixel sensor (4096 px x 4096 px) with 9 micron pixels. The presence of a focal reducer (x0.64 makes the field of view 47×47 arcmin and the corresponding resolution is 0.69 arcsec/pixel. The telescope is equipped with an AFW-10-50SQ filter wheel with squared 50-mm Sloan filters g', r', i', narrow-band filter Hα and also with a standard set of UBVRI filters with response curves close to those listed in Bessell (1990). The remote control of the telescopes gives a possibility for more effective usage of the observational time and saving of human time, efforts and financial resources (Iliev 2014). Remote-controlled small telescopes have provided the huge ground-based wide-field surveys: ASAS (Pojmanski 1997), ROTSE (Akerlof 2005), Super- WASP (Pollacco et al. 2006), CRTS (Drake et al. 2014), etc. They are able to discover variable stars, exoplanets, transient and other interesting celestial objects, as well as to carry out follow-up observations of most of them. The ASA-provided software, as well as the purchased The Sky 10 Pro and MaXimDL 7.0, provide remote viewing of the telescope, dome, camera and filter unit.

Observations

One of the first observations was of the open cluster M67 (Fig.2) in order to determine the transformation coefficients of the system. The transformation coefficients are determined by the formulas presented on the right. Standard software of the AAVSO was used. Figure 3 illustrates the method for determining the coefficients. The symbiotic star T CrB has been observed in the last three months and it is expected to explode soon. Figure 4 shows the latest BVRI photometry of the star from 03.09.2024. Figure 5 shows M1-SuperNova Remnant, photographed on 14.03.2024 in BVR filters.

Transformation formulas

$$B_{var\,transf} = b_{var} - b_{comp} + T_{b,bv} * T_{bv} * [(b_{var} - v_{var}) - (b_{comp} - v_{comp})] + B_{comp}$$

$$V_{var\,transf} = v_{var} - v_{comp} + T_{v,bv} * T_{bv} * [(b_{var} - v_{var}) - (b_{comp} - v_{comp})] + V_{comp}$$

$$R_{var\,transf} = r_{var} - r_{comp} + T_{r,vr} * T_{vr} * [(v_{var} - r_{var}) - (v_{comp} - r_{comp})] + R_{comp}$$

$$I_{var\,transf} = i_{var} - i_{comp} + T_{i,vi} * T_{vi} * [(v_{var} - i_{var}) - (v_{comp} - i_{comp})] + I_{comp}$$

Figure 2. The open cluster M67 photographed with the 60-cm telescope on 03.03.2024 (BVRI-filters)

Figure 3. The graph for determining one of the coefficients (Tbv)

Figure 4. BVRI photometry of the T CrB from 03.09.2024

Figure 5. The M1 photographed with the 60-cm telescope on 14.03.2024 (BVR-filters)

Acknowledgements: The research was supported partly by projects RACIO funded by the Ministry of Education and Science of Bulgaria (support for the Bulgarian National Roadmap for Research Infrastructure), as well as by project RD-08-137/2024 of Shumen University. We express our gratitude to V. Popov for the processing and presentation of images in true colors obtained with the presented telescope.

XIV SERBIAN-BULGARIAN ASTRONOMICAL CONFERENCE 23 – 27 September 2024, Vrnjačka Banja, Serbia

Marchev et al., 2024

XIV SBAC, 23-27.09.2024
Vrnacka Banja, Sebia

Към наблюденията с внимание;)

БЛАГОДАРИЯ ЗА ВНИМАНИЕТО!

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