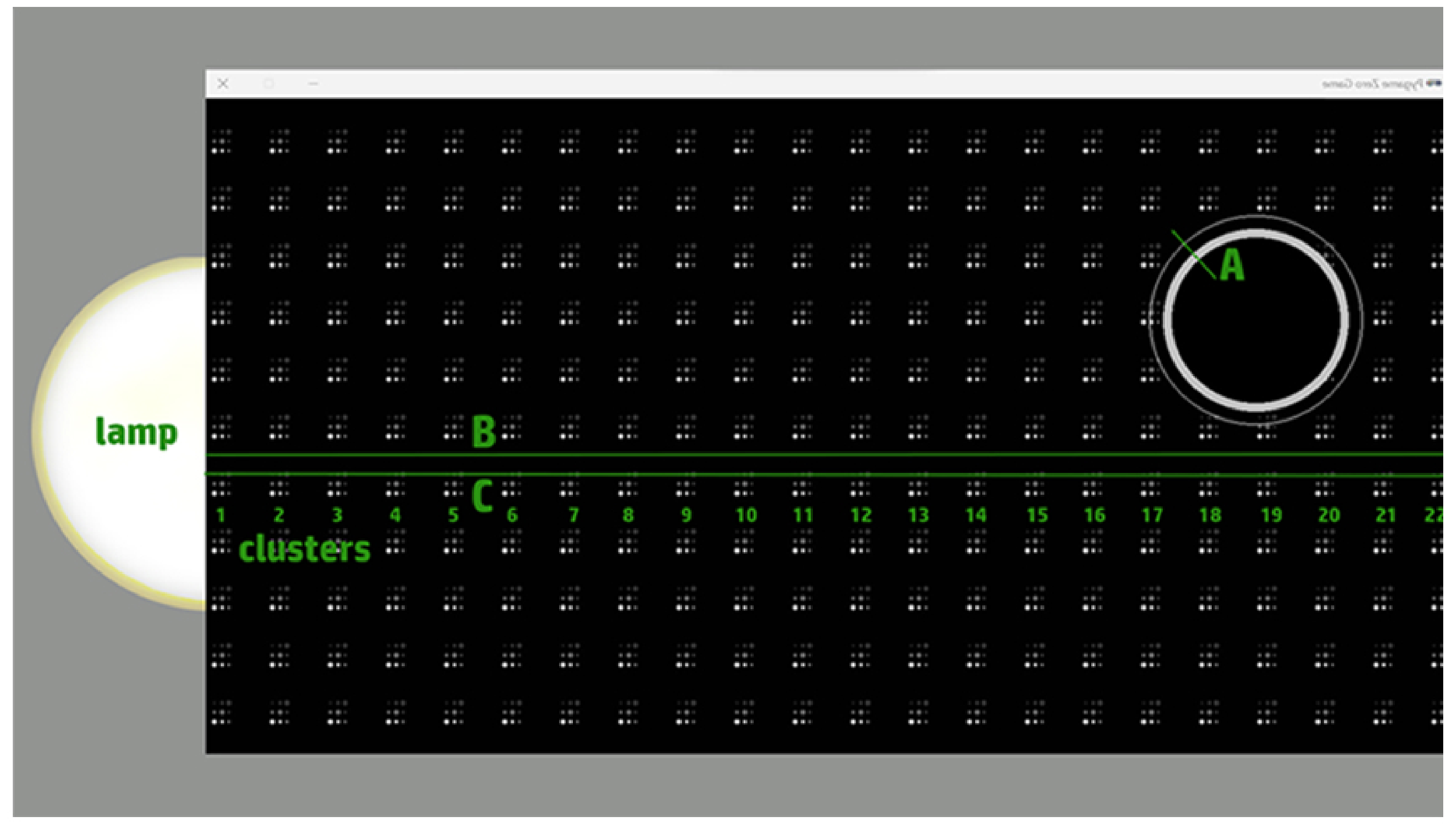
Artificial Lunar Flashes as an useful tool in benchmarking small optical telescopes

M. Żołnowski(1),M. Gędek(1), T. Santana-Ros((2,3) - affiliations on the bottom of the poster

In these tests we focused on four telescopes with different technical designs, apertures and budgets. We wanted to compare some basic results obtained during registration of artificial Lunar Flashes generated on the screen of the computer.

Telescope	Orion Optics AG16	Celestron RASA 36	Takahashi TOA-150	Bresser Messier 152
Construction	Newtonian w/ corrector	Rowe-Ackermann Schmidt Astrograph	Triplet Orto Apochromat	Petzval Achromat
Focal length (mm)	1520	790	1100	760
Diameter (mm)	400	356	150	152
FL/Diameter	3,8	2,2	7,3	5,0
Scale (arcsec/pixel)	0,80	1,54	1,10	1,59
FoV (arcmin)	25x16	49x31	35x22	51x32
Price (Euro)	14k	22k	15k	0,8k

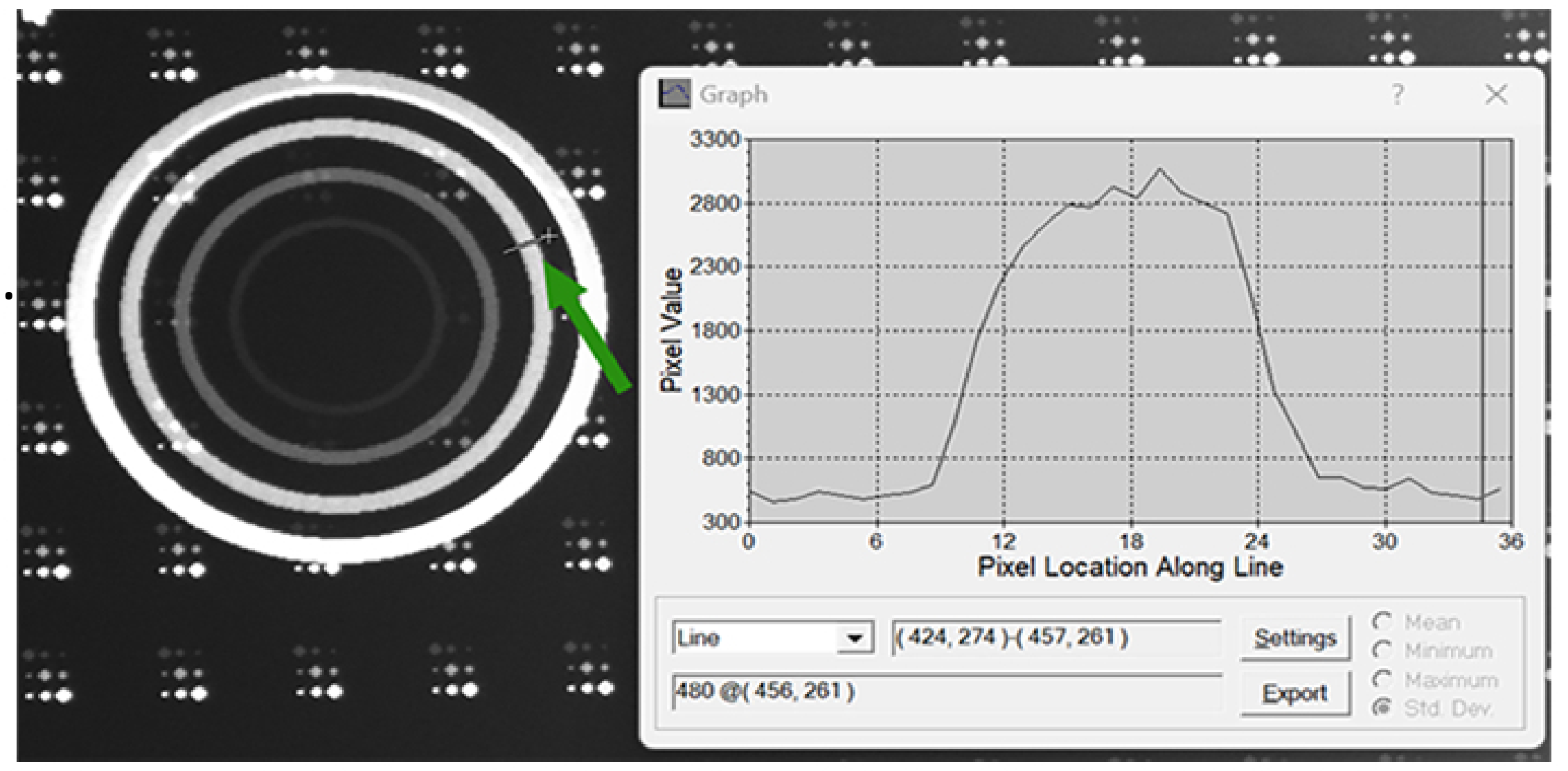
To simulate the bright part of the Moon we used a LED lamp, while to simulate the dark part we used the screen of a Lenovo X1 Carbon laptop. In every setup we used the same sCMOS QHYCCD 174GPS camera. The distance between artificial Moon and the optics was 32 meters.



This figure describes where tests A, B and C were performed on laptop's screen in relation with the lamp- simulating the bright part of the Moon.

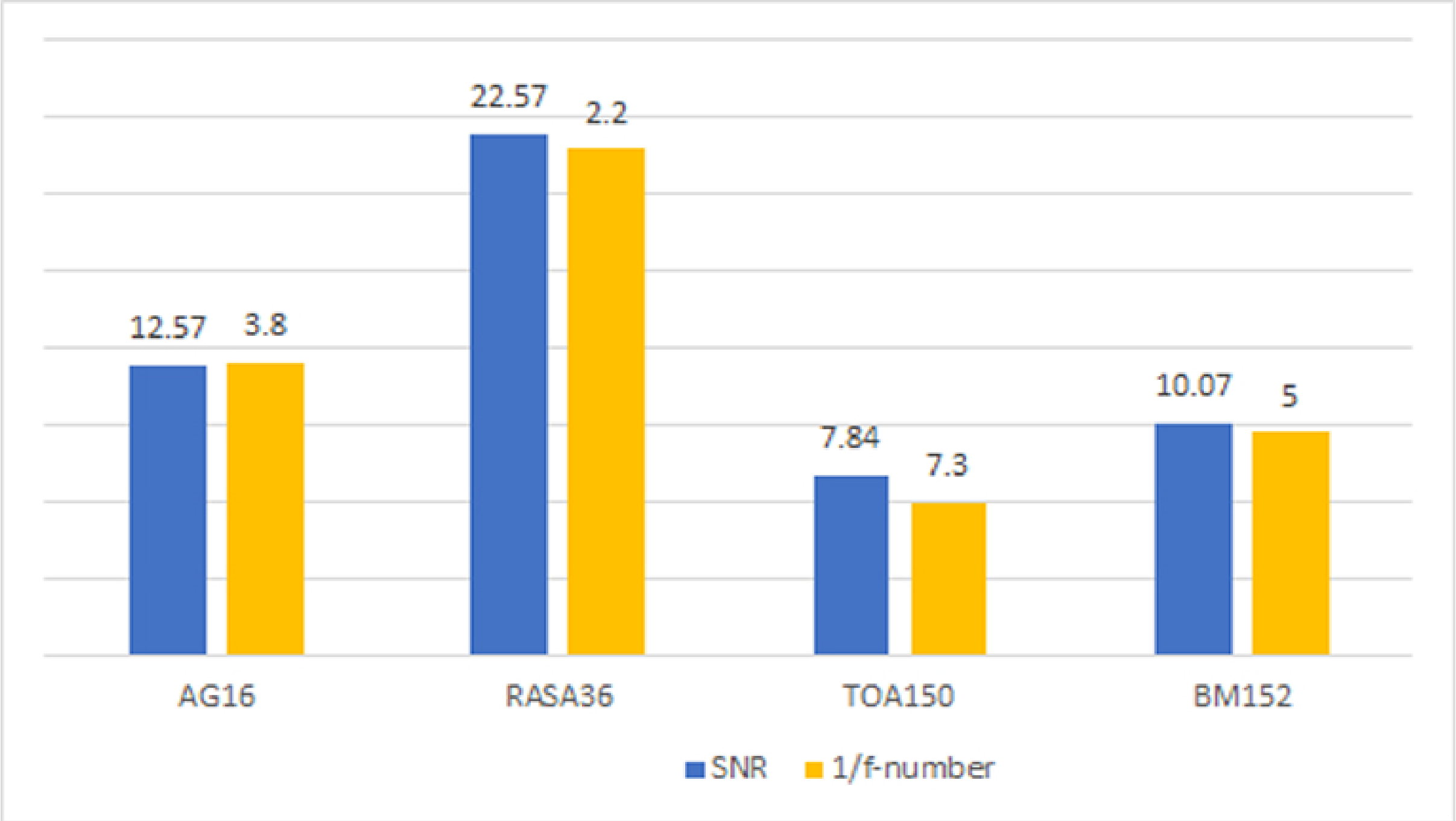
Test A

We compared the signal to noise while recording fast blinking rings (40ms) in exposures of 50 ms.



[(424, 274)-(457, 261)]

480 @(456, 261)

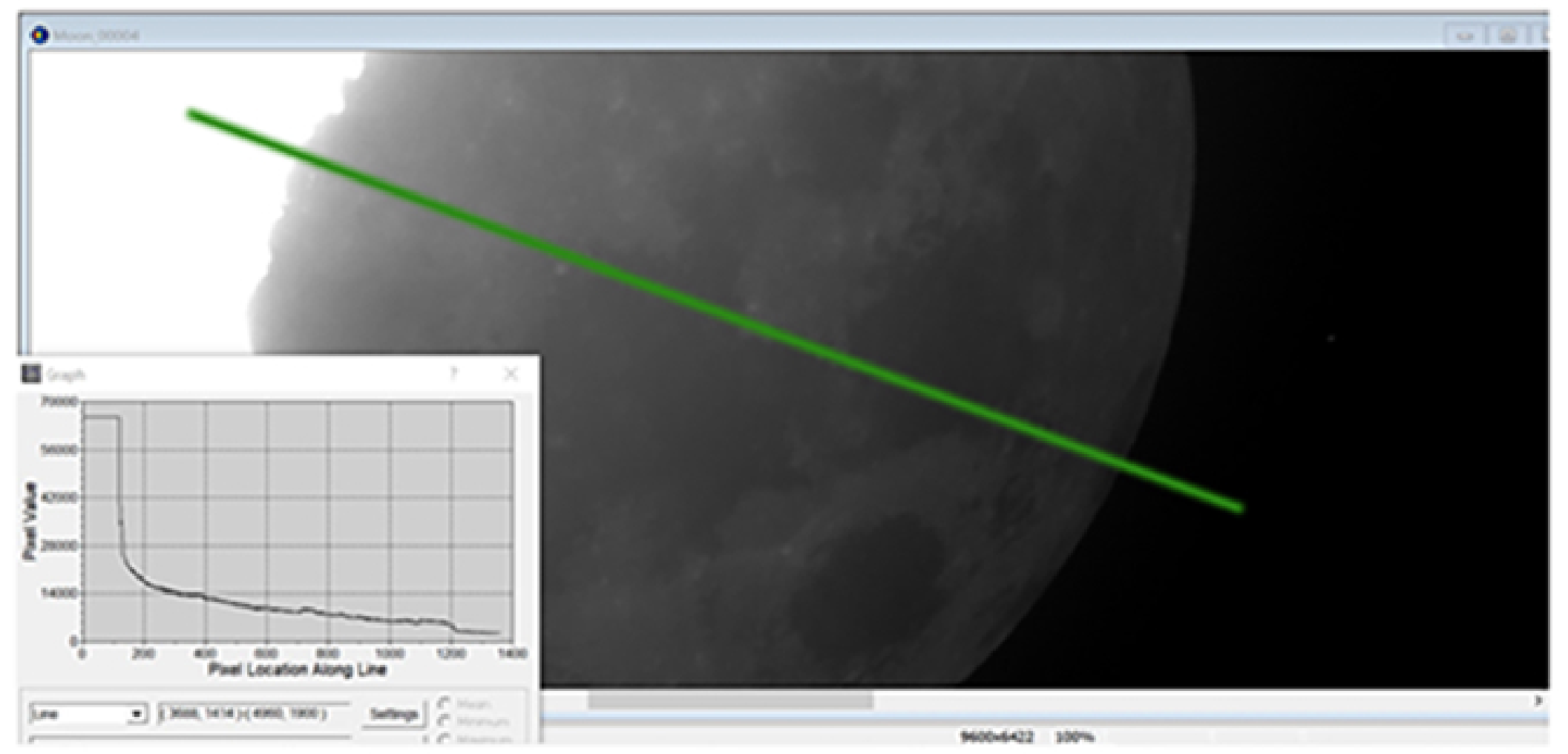


On top of the blue bars SNR values are shown while on the top of the yellow bars indicate the f-numbers specified by the producers. It is interesting how neatly this two sources of data confirm relationship between them. The relations between measured SNR values is almost identic as the relations between 1/f-numbers.

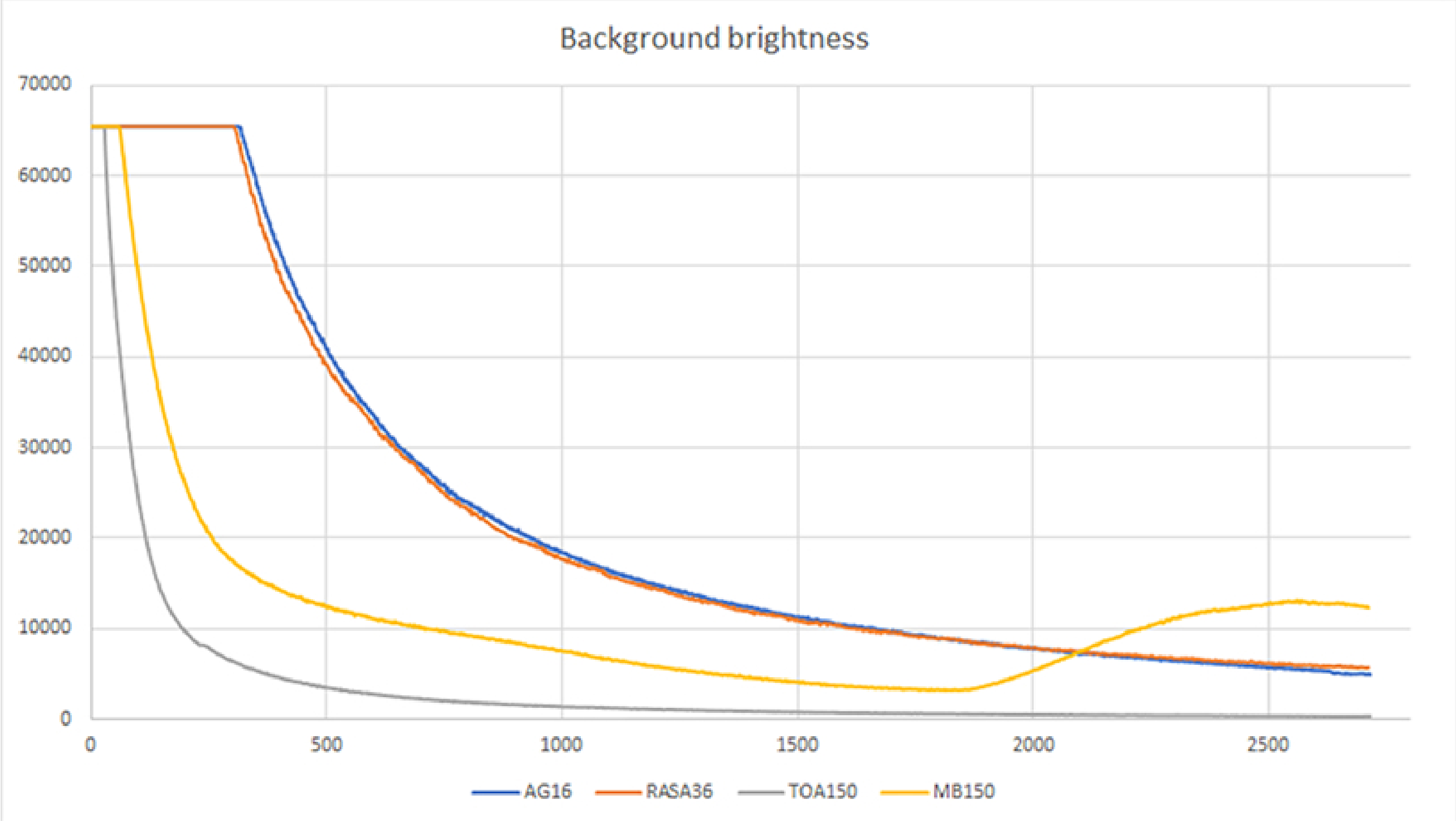
The highest SNR value was for the fastest RASA36 telescope. On other end the lowest SNR value was for the slowest TOA130 telescope.

Test B

We evaluated the changes in the background brightness across the screen.



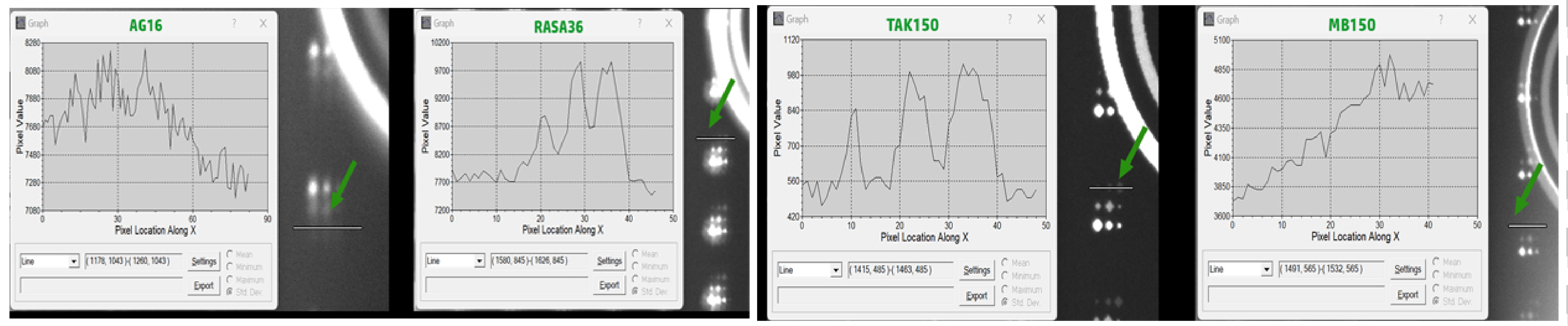
We confirmed that the artificial LFs' brightness curves are similar to the curves for natural Moon proving that applied method is acceptable for these purposes.



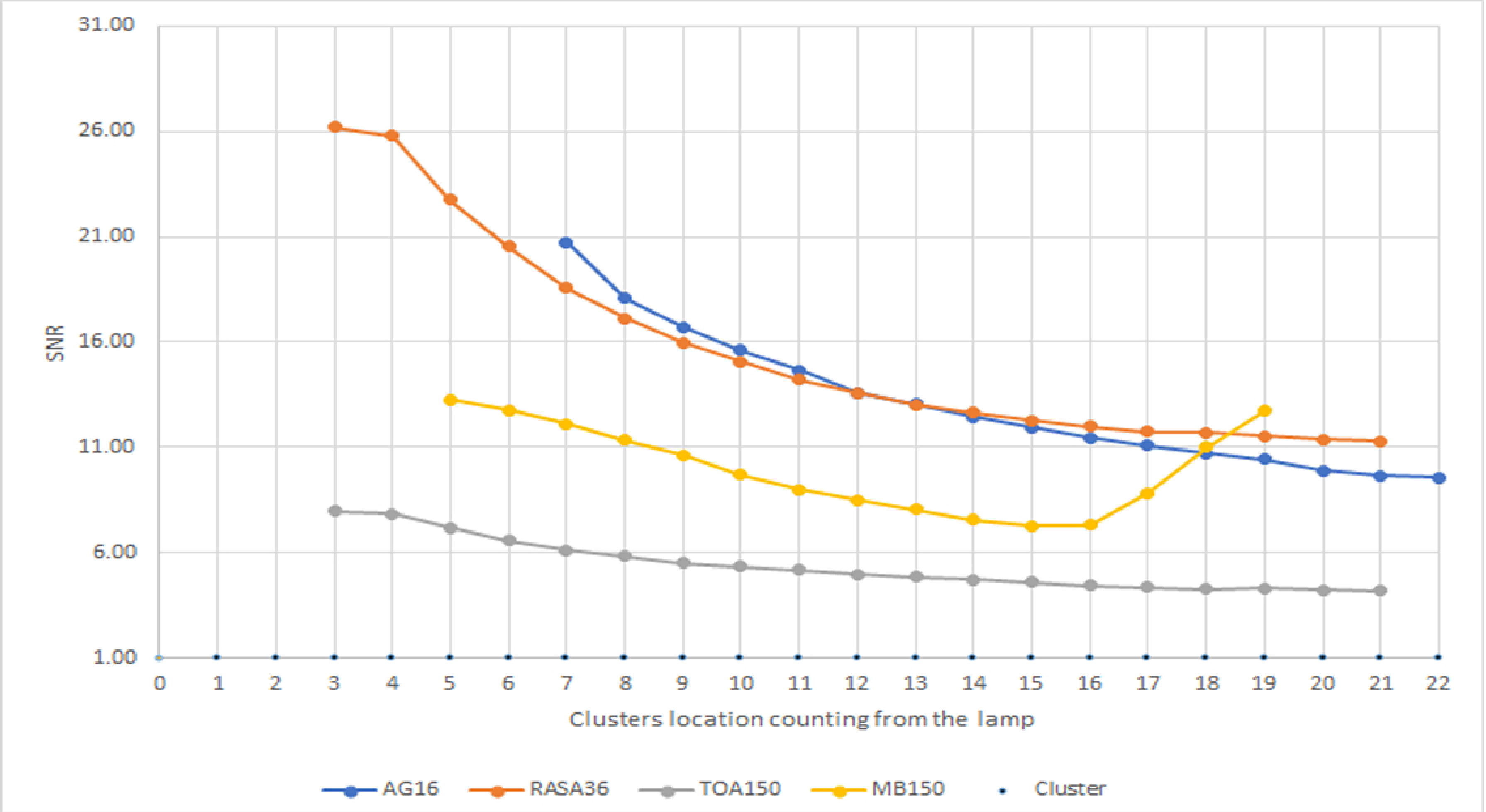
It is noteworthy that for two refractors (TOA150 and BM150) the numbers of saturated pixels are more than 10 times lower then for RASA36 and AG16. It is interesting that curves and number of saturated pixels for RASA36 and AG16 are very similar despite the significant difference in the f-numbers and designs. RASA36 accumulates 3 times faster light than AG16 but for both instruments number of saturated pixels was similar.

Test C:

In this test we analyzed SNRs in ADU values for the series of artificial LFs across the screen.



ADUs profiles for four chosen clusters of artificial lunar flashes.



SNR of measured clusters for four tested telescopes. On X-axis are the clusters' positions counted from the lamp on the left.

Conclusions:

Two factors are important for efficient LFs recording.

The first factor is the minimum distance from the terminator where we can detect the clusters. Here we see that TOA150 and RASA36 allowed for measurement starting from 3rd clusters. Unfortunately 1st and 2nd clusters drowned in the background light. For BM150 and AG16 it was 5th and 7th cluster respectively, what is obviously worse result comparing to TOA150 and RASA36.

The second important factor is SNR. The higher the SNR is, the higher chance for a LF detection. Here we see that AG16 and RASA36 produce much higher SNR values compared to the rest of the designs.

RASA36 produces the highest SNR values and at the same time allows for measurements for the closest clusters, despite the fact that there is a significant amount of saturated pixels. The separation between very bright background and the LF occurs right after the end of saturation zone. On the other hand AG16 provides acceptable results, when observing further from the terminator. We should underline that SNR measured close to the terminator may be influenced by lamp illumination and therefore its values are affected by significant errors.

Final remarks:

For three setups the telescopes were settled on astronomical mounts about 1.5 meter above the ground and the artificial Moon 1.0 meter above the ground. Due to technical limitations bulky AG16 was placed right on the ground. After the session with AG16 the material was analyzed revealing poor quality of the images, what probably caused worser than expected results for test C, therefore the test with LFs should be repeated for AG16 in stable environment.

We have shown that with the use of simple software observers can recreate complicated events on the laptops' screen simulating artificial LFs. It can be interesting challenge to design elaborated dynamic patterns testing the limits of optical setups and detection software.

(1)6ROADS Ltd., Godebskiego 55a, 31999 Cracow, Poland, michal.zolnowski@6roads.com.pl, marcin.gedek@6roads.com.pl, (2)Departamento de Fisica, Ingeniería de Sistemas y Teoría de la Señal, Universidad de Alicante, Carr. de San Vicente del Raspeig, s/n, 03690 San Vicente del Raspeig, Alicante, Spain
(3)Institut de Ciències del Cosmos (ICCUB), Universitat de Barcelona (IEEC-UB), Carrer de Martí i Franquès, 1, 08028, Barcelona, Spain tsantanaros@icc.ub.edu