RAPAS

Atelier RAPAS 8-9 octobre 2022
Observatoire de Paris

RAPAS
Spécifications, conceptions et réalisations des filtres

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Atelier de lancement 8-9 octobre 2022

RAPAS

Réseau Amateurs Professionnels pour les Alertes Scientifiques

- Besoins, la FOM des instruments
- Gaia, l'idée induite
- Les systèmes de filtres et de catalogues
- Les bandes de Gaia et son catalogue
- Définir les spécifications des filtres
- Lignes directrices de la spécification des filtres
- Les courbes de transmission des filtres A, B et C
- Test sur SA51, SA57, SA 64

Needs

There is an increasing number of programs delivering astronomical alerts.
These are related to SSO or Galactic objects or extra-Galactic events

The angular designation often requires a large FOV and deep magnitude search mode with limited exposure. The telescope Figure Of Merit in a search mode could be :

telescope FOM = f(lim mag) . FOV square degree / exposure mn

Amateurs with their respective observatory spread over wide longitude and latitude range and behind independant cloud coverage conditions provide optical search mode to deliver AD and Dec localisation of optical candidates with a classification to allow the photometric or even spectrometric tracking function with large telescopes.

The needs could be summarised in :

- An array of instruments spread over large territory
- Wide Field Of View Instruments >1°²
- High magnitude detection limit >20 in 1min exposure or assessed lim mag vs exposure
- Unified methodology and uniform photometric data deliveries and low latency to up load data

This could provide an amateur network meeting several alerts prgm requirements

A new ProAm collaboration :

Le Réseau Amateurs Professionnels pour les Alertes Scientifiques (RAPAS)

Amateurs-Professionnals Network for Scientific Alerts

- RAPAS project is aiming to build such a network
- We are inviting amateurs to register in this network with preliminary data related to their observatory facility.
- A workshop is scheduled on october 8th and 9th 2022 at Paris Observatory
- We will deliver to observers a filter set to unify the photometric data.
- Then the purpose is to assess the photometric accuracy of the network for the end of the year 2022.

The Gaia induced idea :

Gaia mission delivers alerts :

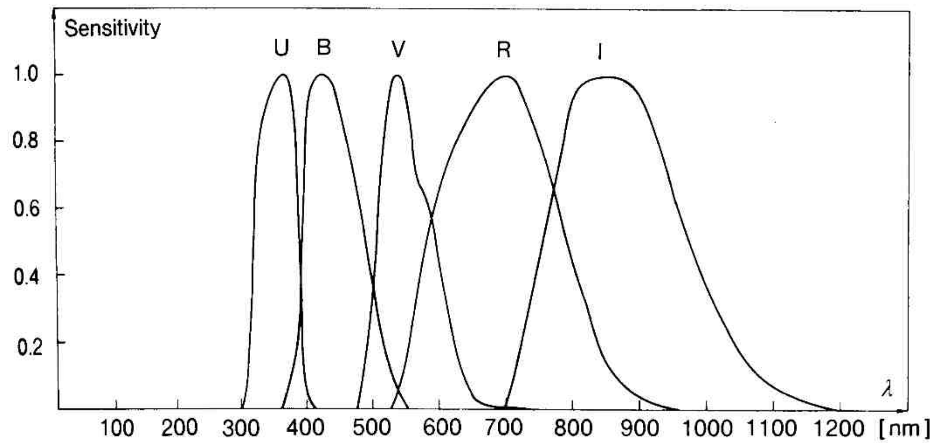
- https://gaiafunsso.imcce.fr/
- http://gsaweb.ast.cam.ac.uk/alerts/home

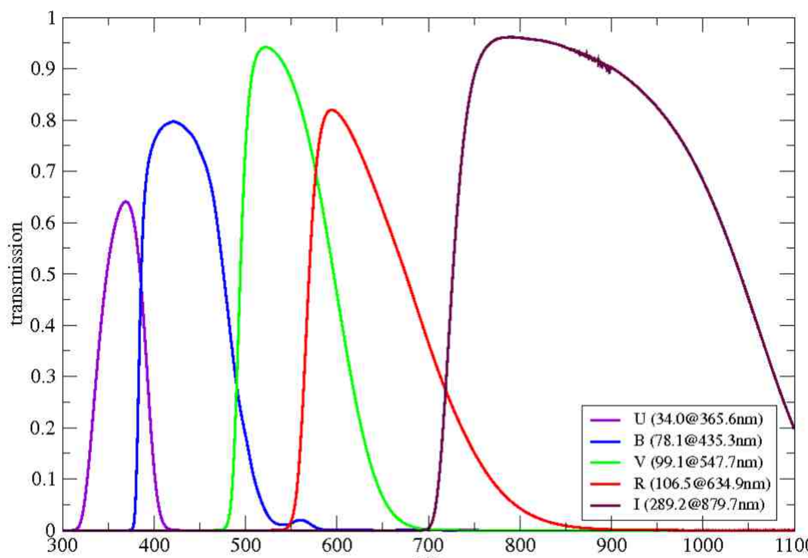
In addition Gaia provides an updated photometric catalog up to 20-21 magnitude in three wide spectral bands. This photometric system may enhance SNR and limiting magnitude of amateur telescopes and allows data reduction with this catalog.

Gaia DR3 is released on June the 13th 2022

Discrepancies between photometric systems

- From Johnson and Cousins U B V R I J K L M N...





...r Letter	Effective Wavelength Midpoint λ_{eff} For Standard Filter[2]	Full Width Half Maximum[2] (Bandwidth $\Delta\lambda$)	Variant(s)	Description
...aviolet				
	365 nm	66 nm	u, u', u*	"U" stands for ultraviolet.
...ble				
	445 nm	94 nm	b	"B" stands for blue.
	551 nm	88 nm	v, v'	"V" stands for visual.
			g, g'	"G" stands for green (visual).
	658 nm	138 nm	r, r', R', R_c, R_e, R_i	"R" stands for red.
Near-Infrared				
I	806 nm	149 nm	i, i', I_c, I_e, I_j	"I" stands for infrared.
Z	900 nm[3]		z, z'	
Y	1020 nm	120 nm	y	
J	1220 nm	213 nm	J', J_s	
H	1630 nm	307 nm		
K	2190 nm	390 nm	K Continuum, K', K_s, K_{long}, K^8, nbK	
L	3450 nm	472 nm	L', nbL'	
Mid-Infrared				
M	4750 nm	460 nm	M', nbM	
N	10500 nm	2500 nm		
Q	21000 nm[4]	5800 nm[4]	Q'	

Les catalogues stellaires

GSC V1.1		13 et 16	15millions	216MO	précision 1,5 as ancien, inclus dans Prism6-10
GSC ACT		de 9 à 13-14	18 819 291	291MO	precis 1 as Plus récent, inclus dans Prism7-10
GSC 2.3					
DSS				102 CD	Digital Sky Survey compress x10 digitised POSS
Realskycd	1996			20CD	compress x100 digitised POSS
AC2000					
AGK2					
2MASS		infrarouge			
XSC	1999	infrarouge			
DENIS		infrarouge			
USNO SA1		20 reg espacées	55millions	1CD	
USNO SA2					idem SA1 en plus précis
USNO A1		20 B R	550millions	10CD	
USNO A2		20 B R			idem A1 en plus précis préférables aux GSC
USNO-B1.0		21 photographic 5 colors	1 045 913 669		80GO accessible en ligne préférable aux USNO-AX
UCAC 1					petit domaine du ciel Sud, Obsolète
UCAC 2		de 7,5 à 16 R	48millions		-90° +50°, magnitude entre B et R, obsolète
SDSS DR5	2005	de 14.5 à 19.5 ugriz	North hors Voie Lactée		SLOAN Digital Sky Survey with several Data Releases
PPM			380 000		précision 0,3 as
PPMX	2008		18 088 919		Roser S.
UCAC 3	2009	mag 8 à 16 BRI		8GO+ (2DVD)	1% de bug, obsolète
PPMXL	2010	mag 20 V	910 468 710	4DVD 37GB zip	combine USNO-B1.0 & 2MASS précision 0.3as /Vizier
UCAC 4	2013	mag 8 à 16.3V-R	113 780 093	8GO (2DVD)	20mas, photométrie 2MASS, APASS en B, V, g, r, i
UCAC 5	2017	mag 16	107 106	5,25GO	Match GAIA DR1 & TGAS 1 à 5 mas
Nomad	v1			environ 100GO	des anomalies sur les magnitudes

Les catalogues stellaires

CCMC 14					
CMC15					
DASCH	2014			500 000 Plaques digitalisées de Harvard de 1885 à 1992	
All WISE	2012	3.4, 4.5, 12, 22µm 563 921 584			the Wide-field IR Survey Explorer at IPAC
RAVE DR5	2013	9<I<12	457 588 South Hem		Radial Velocity Spectra Catalog 841.0 - 879,9 nm
URAT		18	20mas		USNO Robotic Astrometric Telescope
URAT1		2015 3-18.5 R	228millions 10 – 30 mas 18GB		VizieR Hemisphere Nord à –15° 2013.5 5mas/yr CDS
URAT2		2016			
Gaia DR1	2016	mag20+	1.14 109	10GO	mag 21 1-2 mas de précision 14–134mas/yr 80% stars
TGAS	2016		1,9 106		mag 12 pos motion parallaxe
Gaia14		2017Q1	17,6 106	Experiment	D. Herald Occult Gaia matching to UCAC4
HSOY	2017				Hot Stuff for One Year : Gaia with PPMXL
PS1 DR1		mag 23.2g grizy			Pan-STARRS North Hem -30°
PS1 DR2	2019				
SkyMapper DR2					
APASS DR9					
Gaia DR2	2018Q2	mag 3V- 21V	1.69 109 objets		G=12-17 Précision 7 µas 1.3109 speed 14099astéroids
GRAPPA	2018	G, bp, rp	1.69 109 objets	64GO	extraction GAIA DR2 de Marc Serrau pour Prism10
Gaia EDR3	2020Q4	22 G BP RP	1.8 109 objets	600GO	DR3 preliminaire
GRAPPA2					extraction GAIA EDR3 de Marc Serrau pour Prism 11
Gaia DR3	2022 juin	20,7 G BP RP	1.8 109 objets		150 000 orbites d'astéroïdes, qq 100 000 étoiles multip
GRAPPA3					extraction GAIA DR3 de Marc Serrau pour Prism 11
Gaia DR4	2025		109 objets		+ Variable, Multi, unresolved, stars, quasars
Gaia DR5	2028				
Gaia FR					Final Release avec prolongement de la mission

Combinaisons de filtres alternatifs

- Johnson Cousins : UBVRI
- Bessell,
- Sloan Digital Sky Survey (SDSS) : ugriz de 14.5 à 19.5
- u’g’r’i’z’
- Pan-STARRS gp1, rp1, ip1, zp1, yp1
- RGB

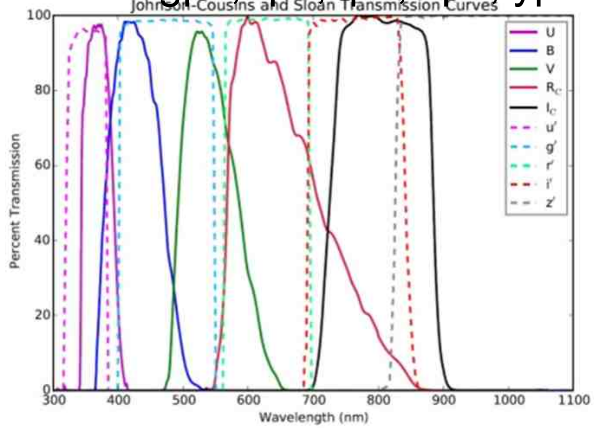
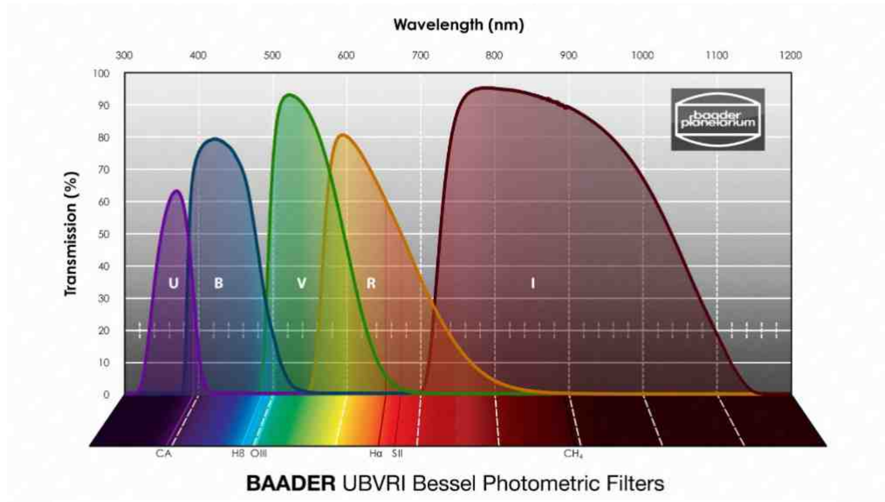
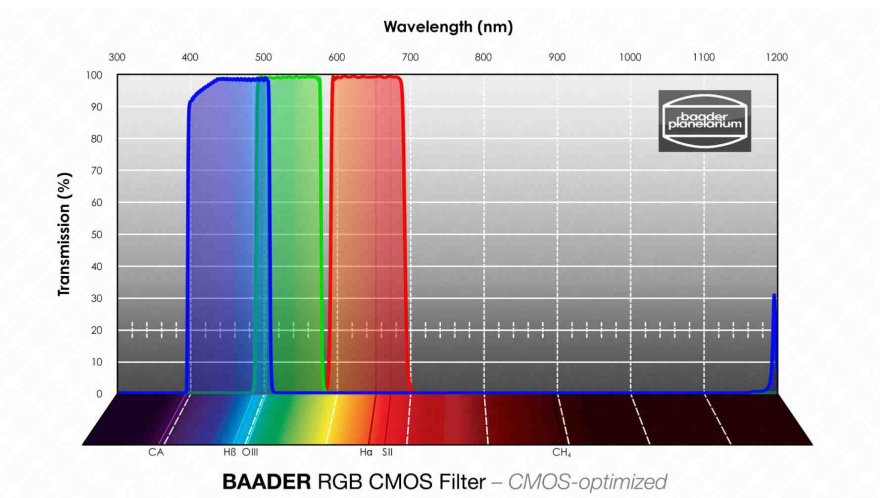
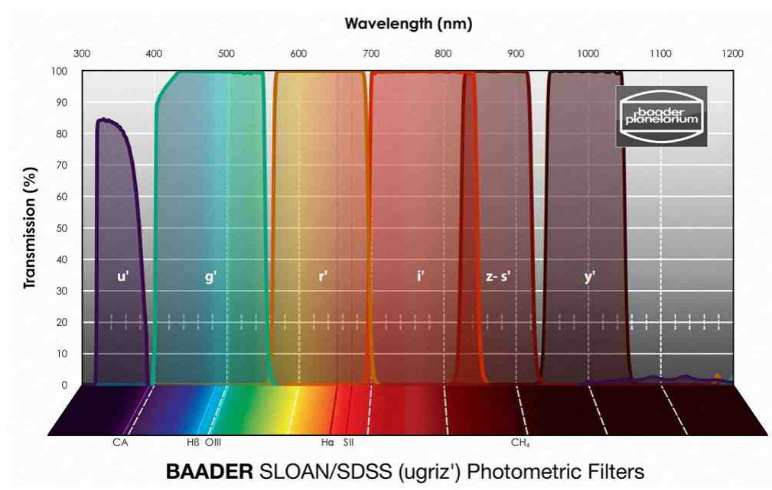


Fig. 4. Astrodon transmission curves for the Johnson-Cousins ($UBVR_CI_C$) and the Sloan ($u'g'r'i'z'$) photometric systems.

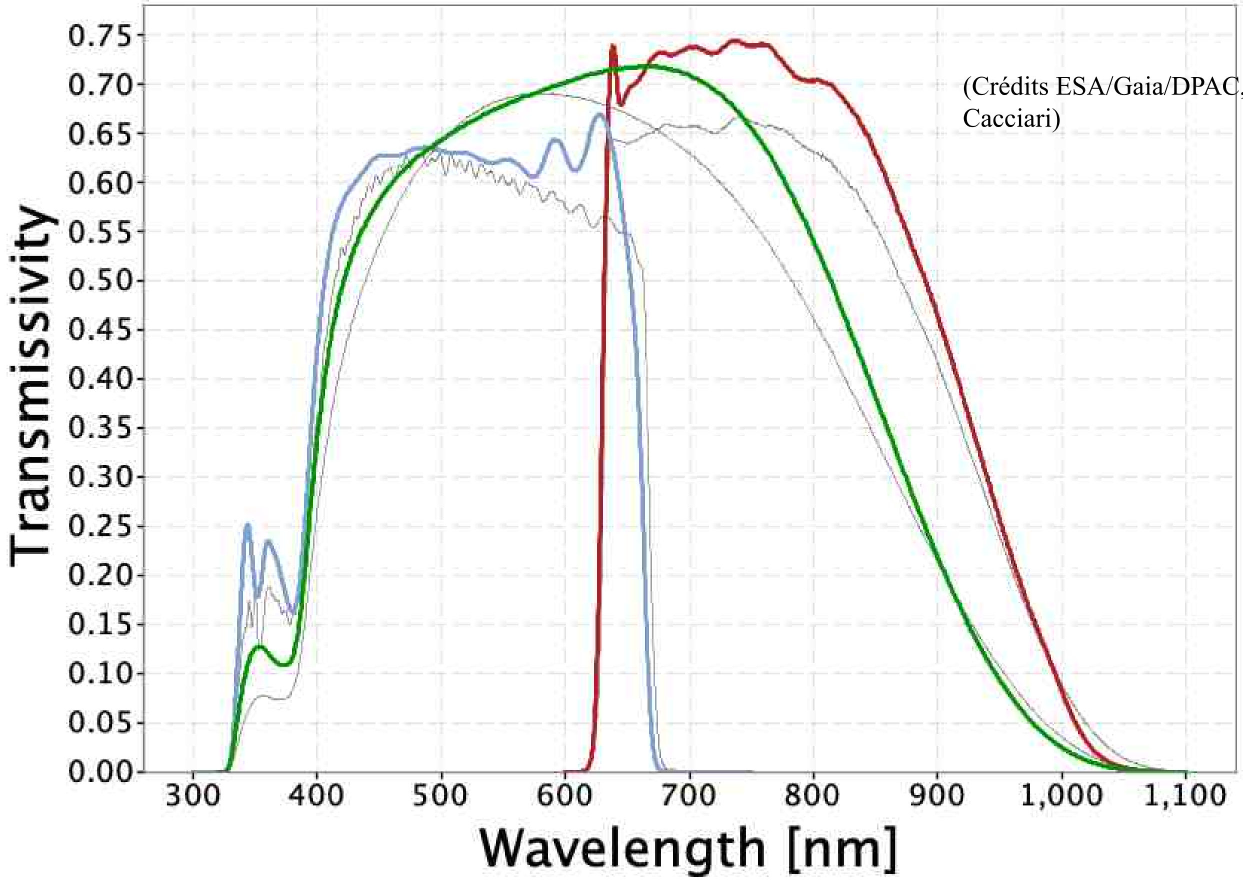




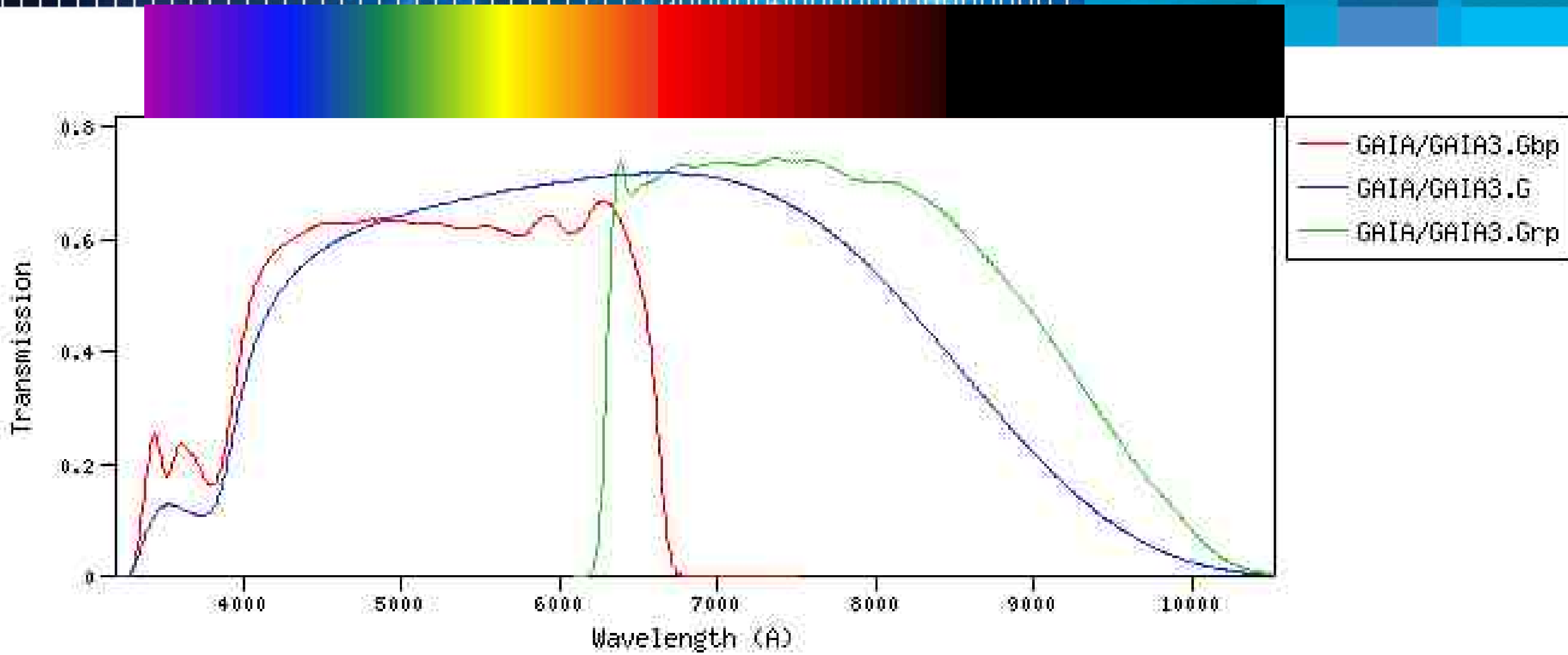


Les filtres GAIA : G, G_BP et G_RP

A more comprehensive description of the photometric and spectral external calibrations will be published in Riello et al. (2020, the paper presenting the EDR3 photometry) and Montegriffo et al. (in preparation, a paper entirely dedicated to the external calibration of the BP/RP spectra). The passbands are shown in the figure above as green, blue, and red solid lines for the G, G_BP, and G_RP bands, respectively. The thin grey lines show the nominal, pre-launch passbands published in Jordi et al. 2010.



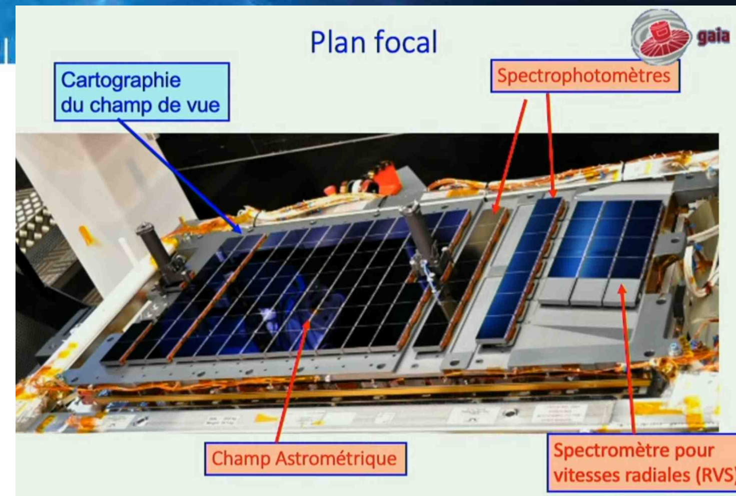
(Crédits ESA/Gaia/DPAC, P.Montegriffo, F. de Angeli, C. Cacciari)

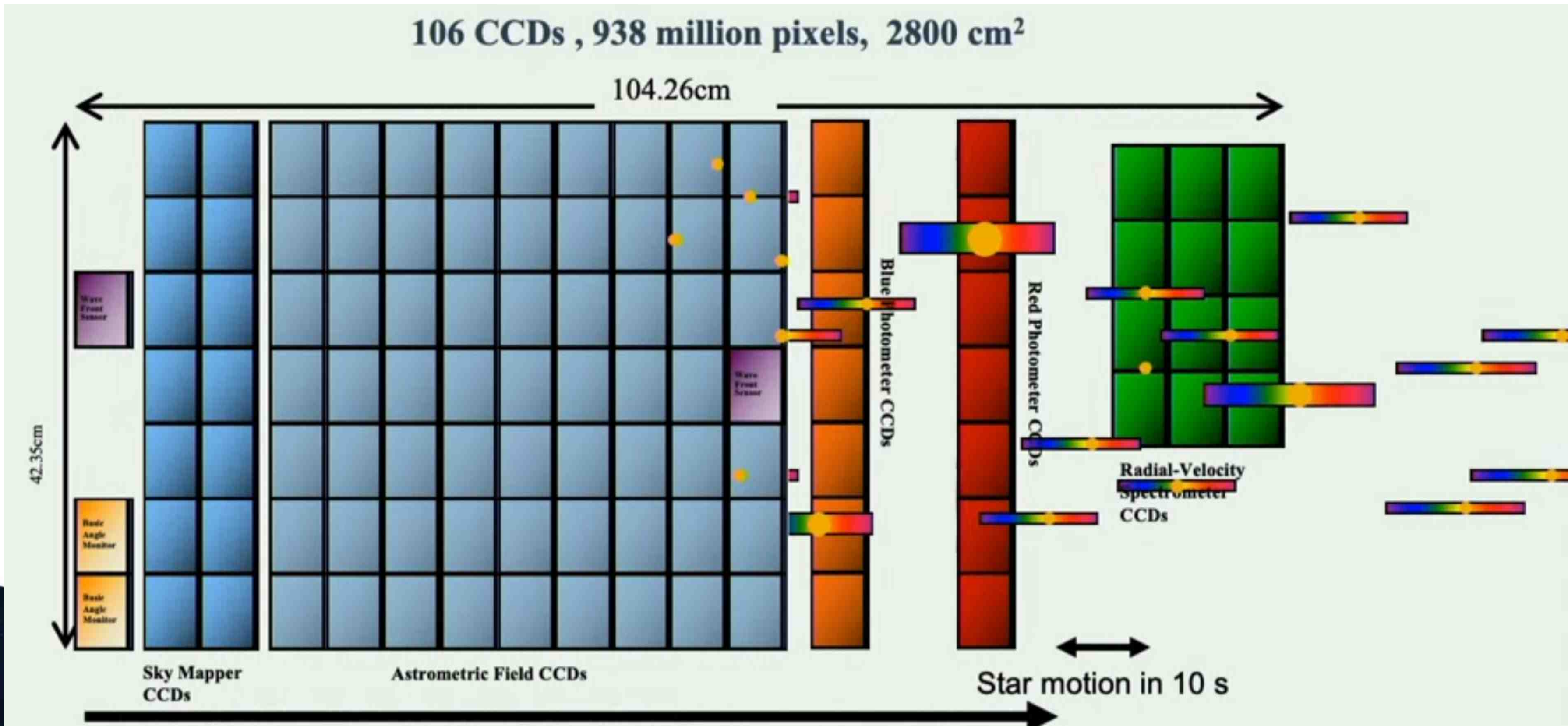


Filter ID	λref	λmean	λeff	λmin	λmax	Weff	ZPν	ZPλ .
GAIA/GAIA3.Gbp DR3	5109.71	5319.87	5035.75	3292.83	6738.11	2157.50	3552.01	4.08e-9
GAIA/GAIA3.G DR3	6217.59	6719.55	5822.39	3294.02	10301.96	4052.97	3228.75	2.5e-9
GAIA/GAIA3.Grp	7769.02	7939.10	7619.96	6196.05	10422.96	2924.44	2554.95	1.27e-9

http://svo2.cab.inta-csic.es/svo/theory/fps3/index.php

Gaia focal plan array





the Gaia photometric catalog

- Gaia DR3 was released on June 13, 2022 - info from : https://www.cosmos.esa.int/web/gaia/data-release-3
- 1,46 E9 sources complete astrometry up to mag G 21
- 1,806 E9 sources with G photometry
- 1,54 et 1,55 E9 sources with GBP and GRP bands.

cross reference with other catalogues :

- Hipparcos-2, Tycho-2 + TDSC merged,
- 2MASS PSC (2MASS XSC merged),
- **SDSS DR13**,
- Pan-STARRS1 DR1, SkyMapper DR2, GSC 2.3, APASS DR9, RAVE DR5, allWISE, URAT-1, et RAVE DR6

- Marc Serrau will release Grappa version of Gaia DR3 as Gaia EDR3 ready to be plug in Prismv11, CDC, ...

Gaia DR3 catalog accy

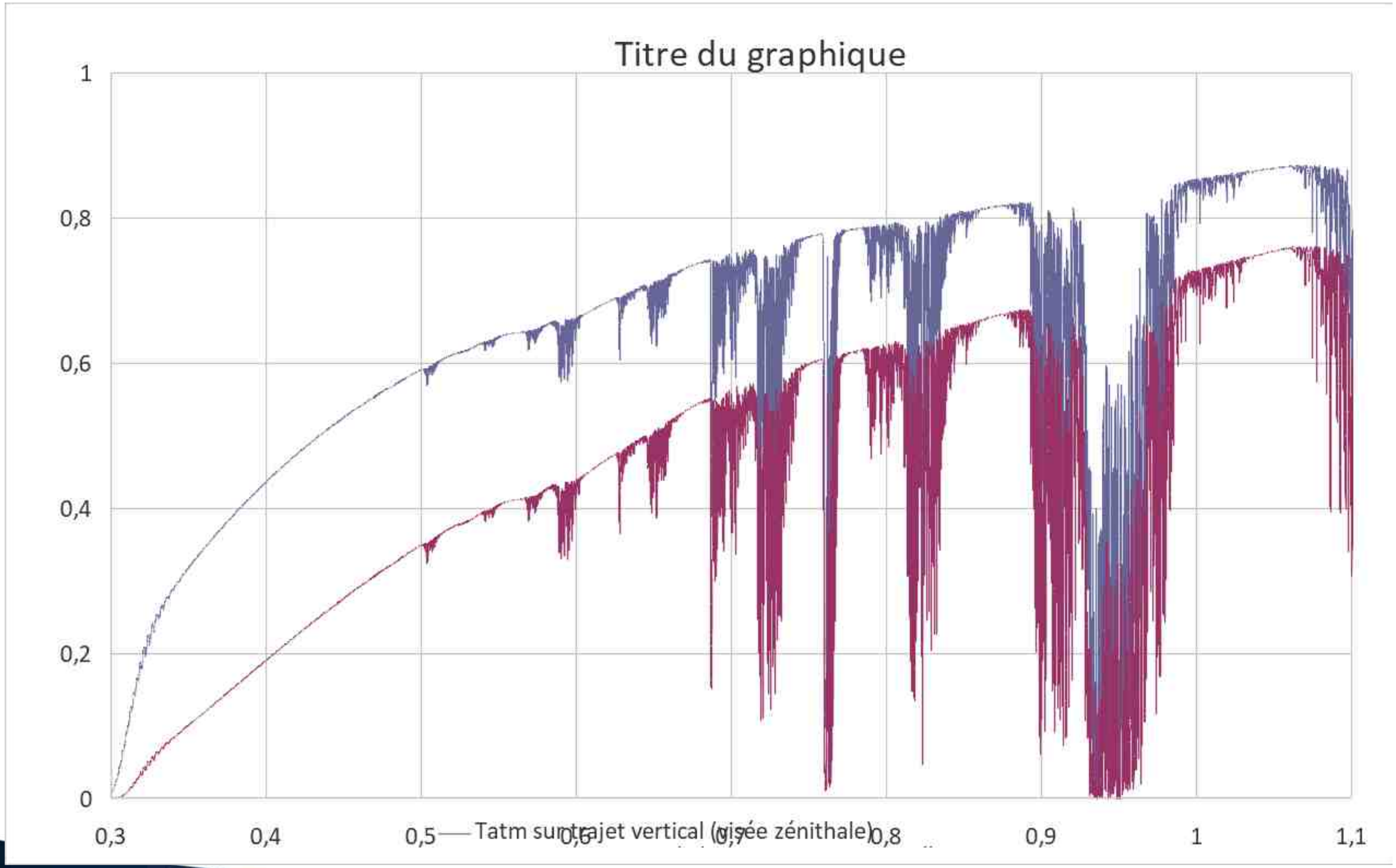
- Photometry (G, GBP, and GRP published as part of Gaia EDR3, OTHER DATA ARE NEW IN GAIA DR3)

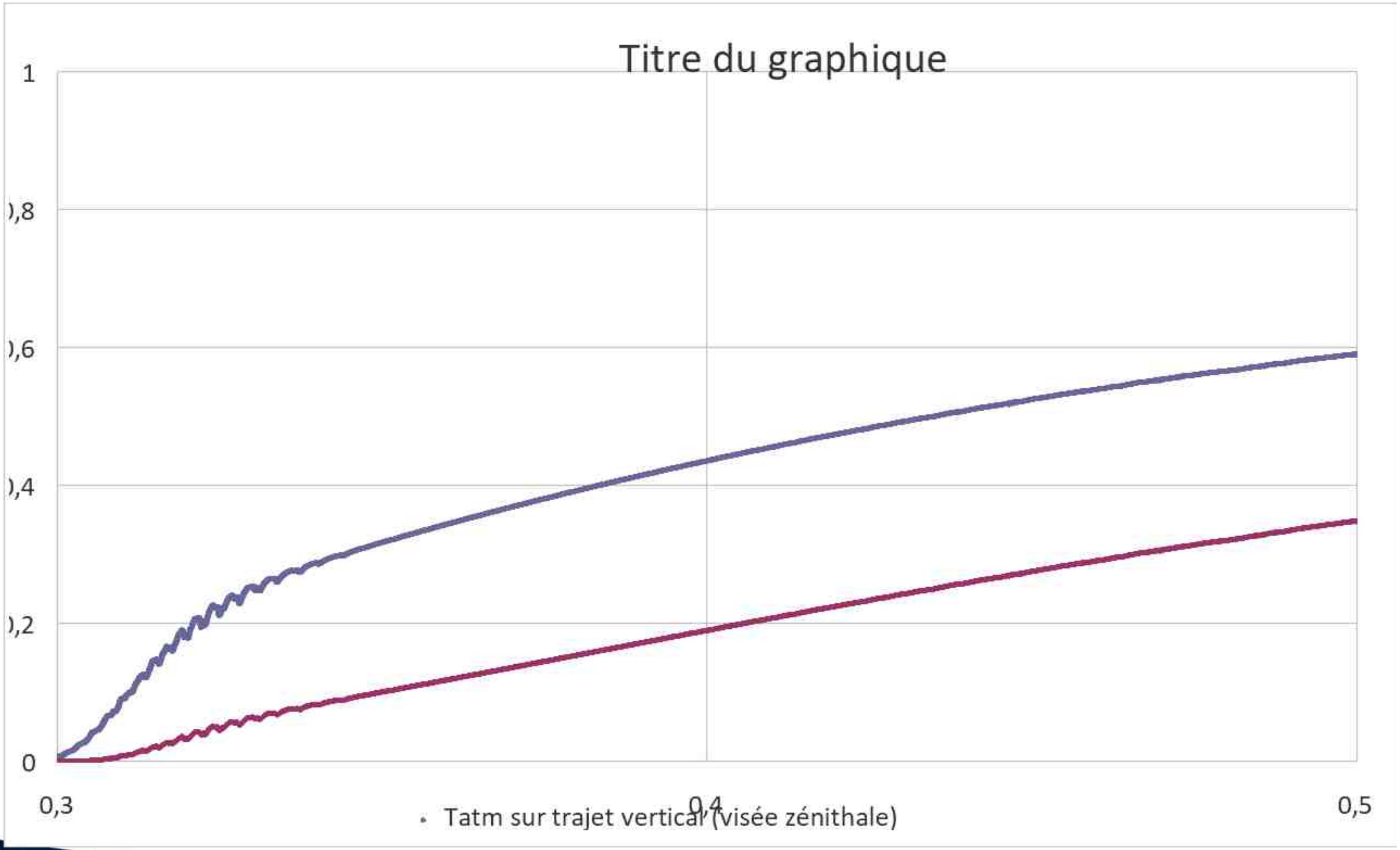
- The G-band photometric uncertainties are ~0.3 mmag for G<13, 1 mmag at G=17, and 6 mmag at G=20 mag.
- The GBP-band photometric uncertainties are ~0.9 mmag for G<13, 12 mmag at G=17, and 108 mmag at G=20 mag.
- The GRP-band photometric uncertainties are ~0.6 mmag for G<13, 6 mmag at G=17, and 52 mmag at G=20 mag.
- More information on the properties and limitations of the BP/RP spectra will be published closer to the release of Gaia DR3.

defining RAPAS filters specs

- Gaia bands are defined outside atmosphere
- Therefore we have to adapt the filter spectral bands to be less sensitive to air mass
- Limit the effect of near infrared QE discrepencies between CCD and CMOS, front ill or back ill, Si thickness

Atmospheric transmission 1 and 2 air mass





Titre du graphique
1
),8
),6
),4
),2
0
0,3
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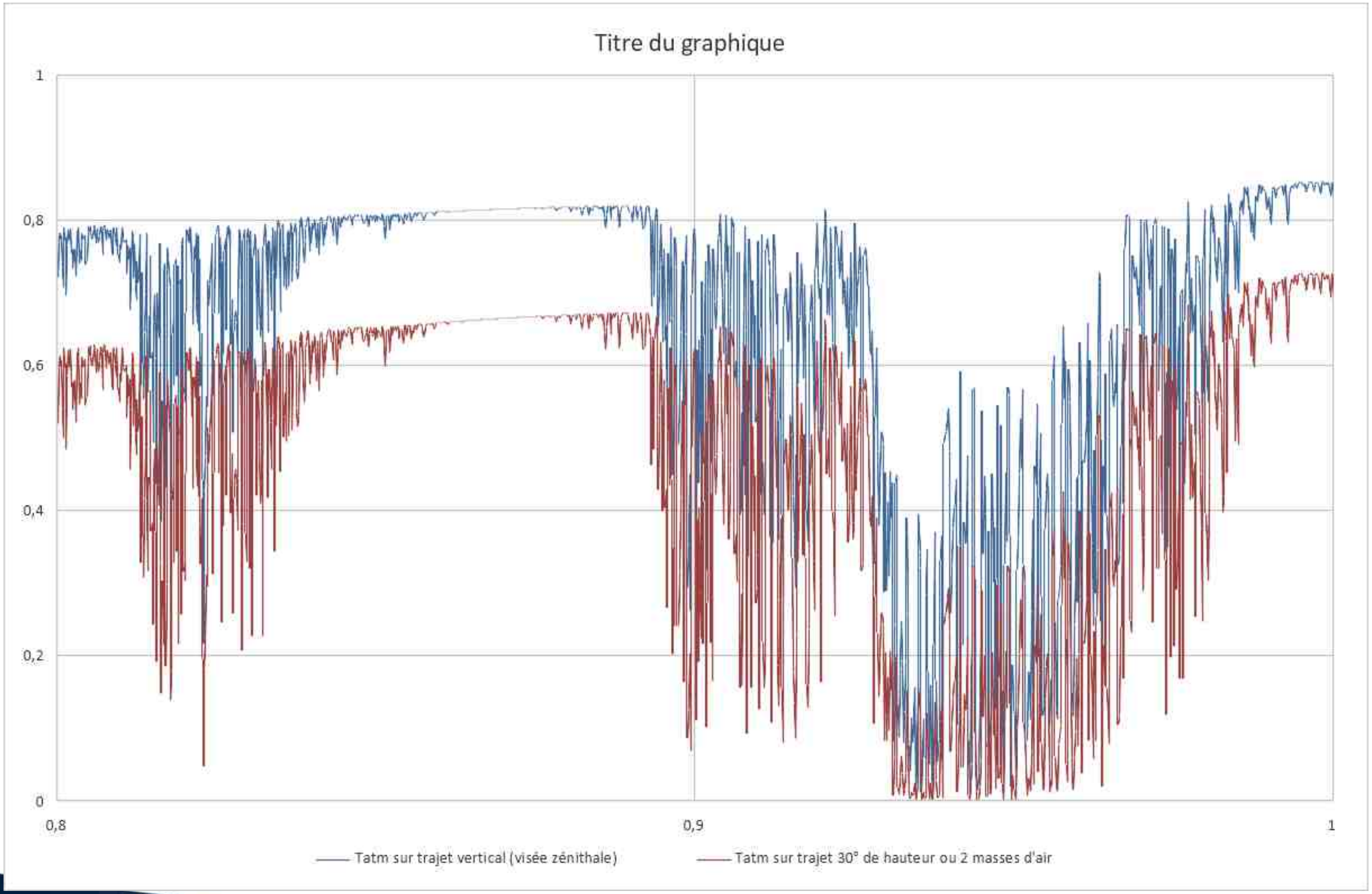
0,5
Tatm sur trajet vertical (visée zénithale)



Titre du graphique
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0,8
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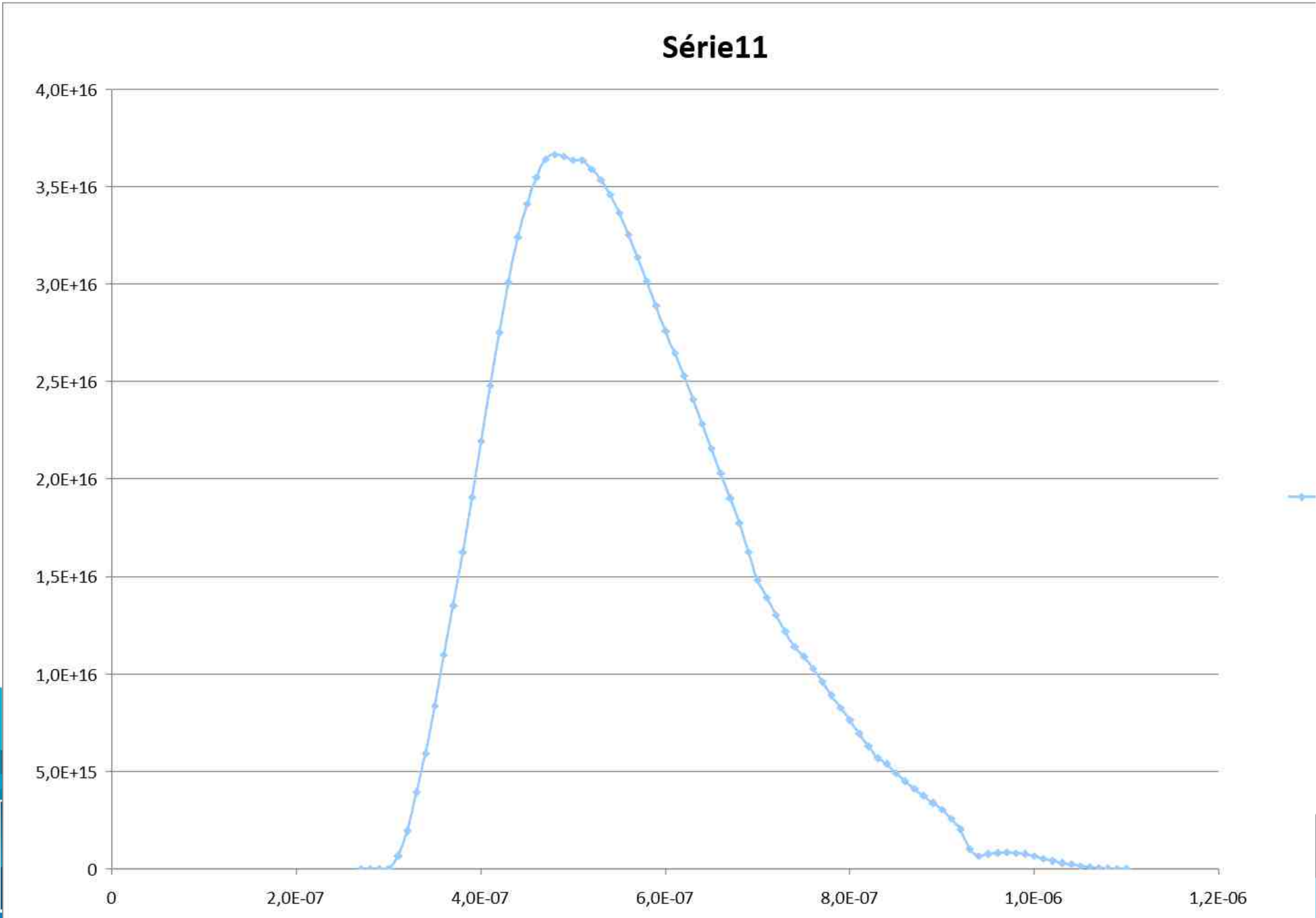
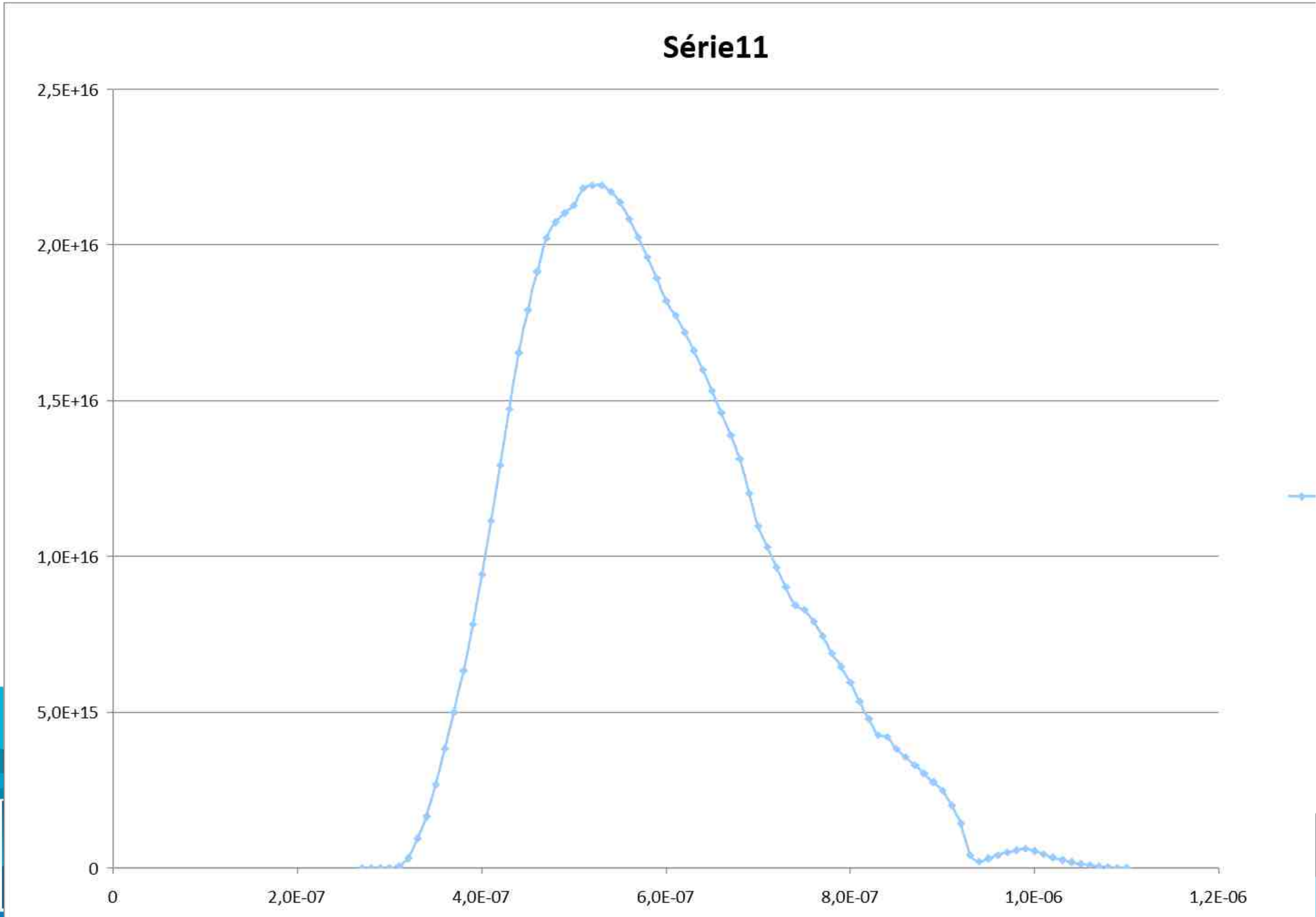
1
Tatm sur trajet vertical (visée zénithale)
Tatm sur trajet 30° de hauteur ou 2 masses d'air


Série11
4,0E+16
3,5E+16
3,0E+16
2,5E+16
2,0E+16
1,5E+16
1,0E+16
5,0E+15
0
0
2,0E-07
4,0E-07
6,0E-07
8,0E-07
1,0E-06
1,2E-06


Série11
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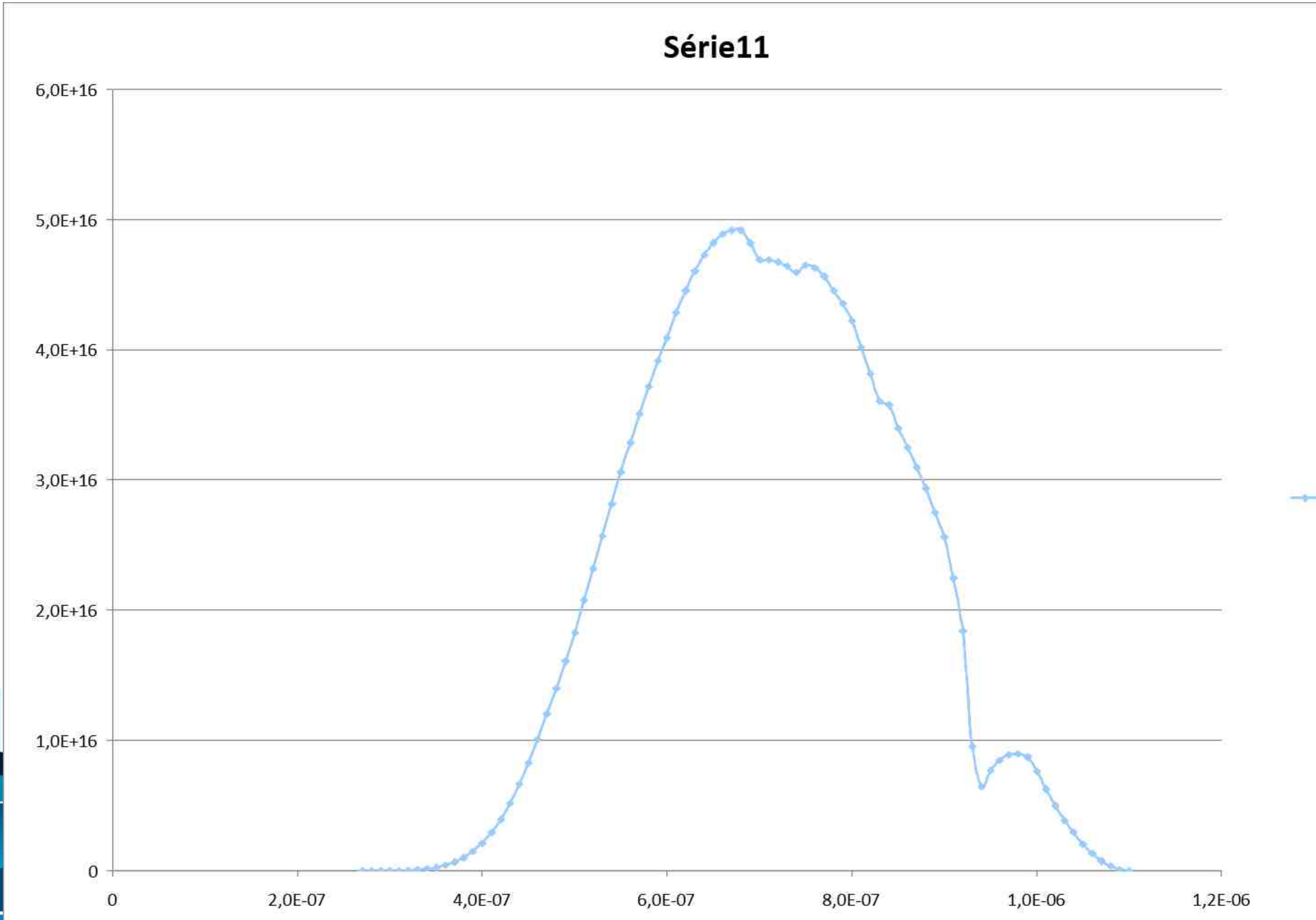
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4,0E+16
3,0E+16
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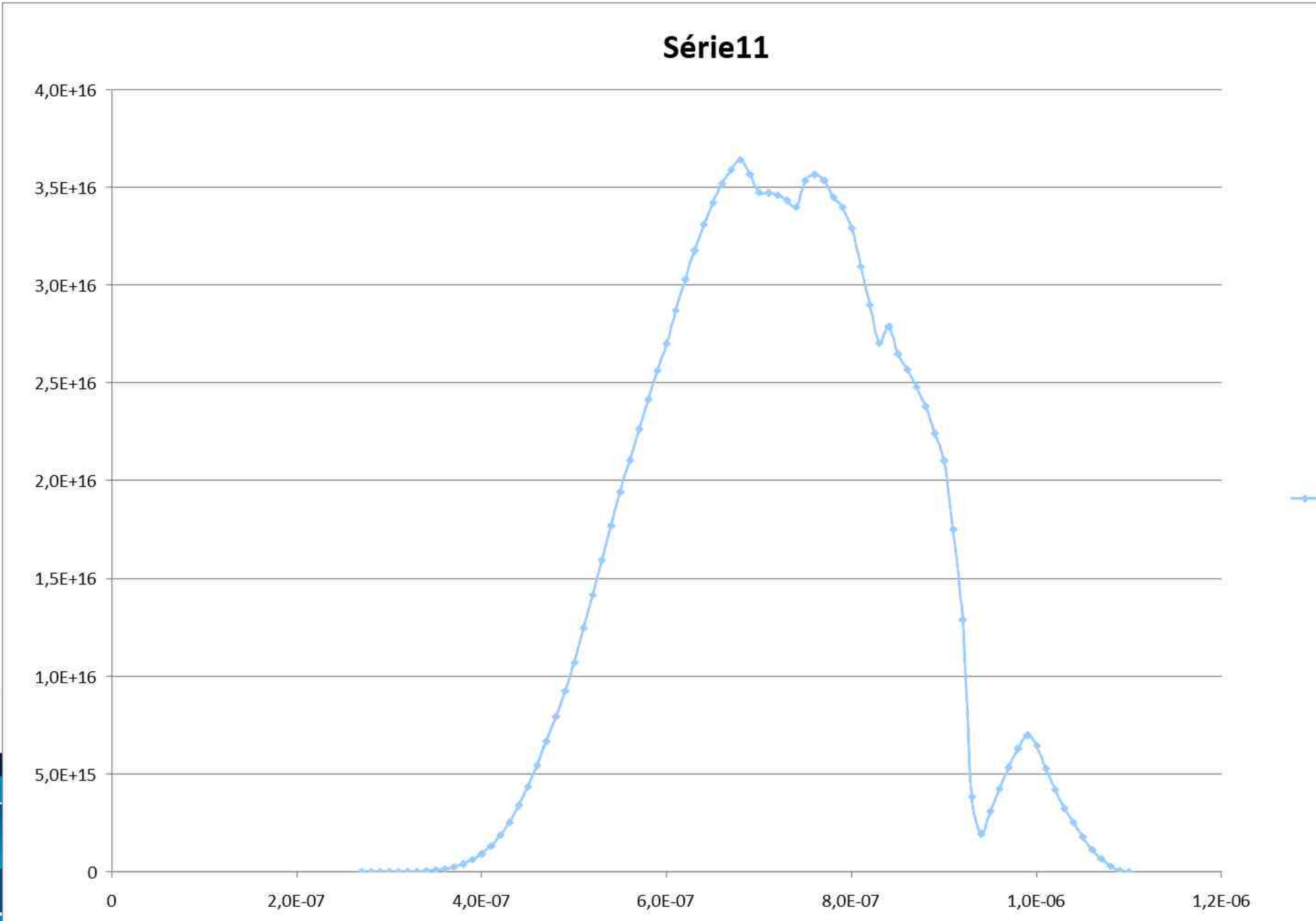
1,0E-06
1,2E-06


Série11
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1,5E+16
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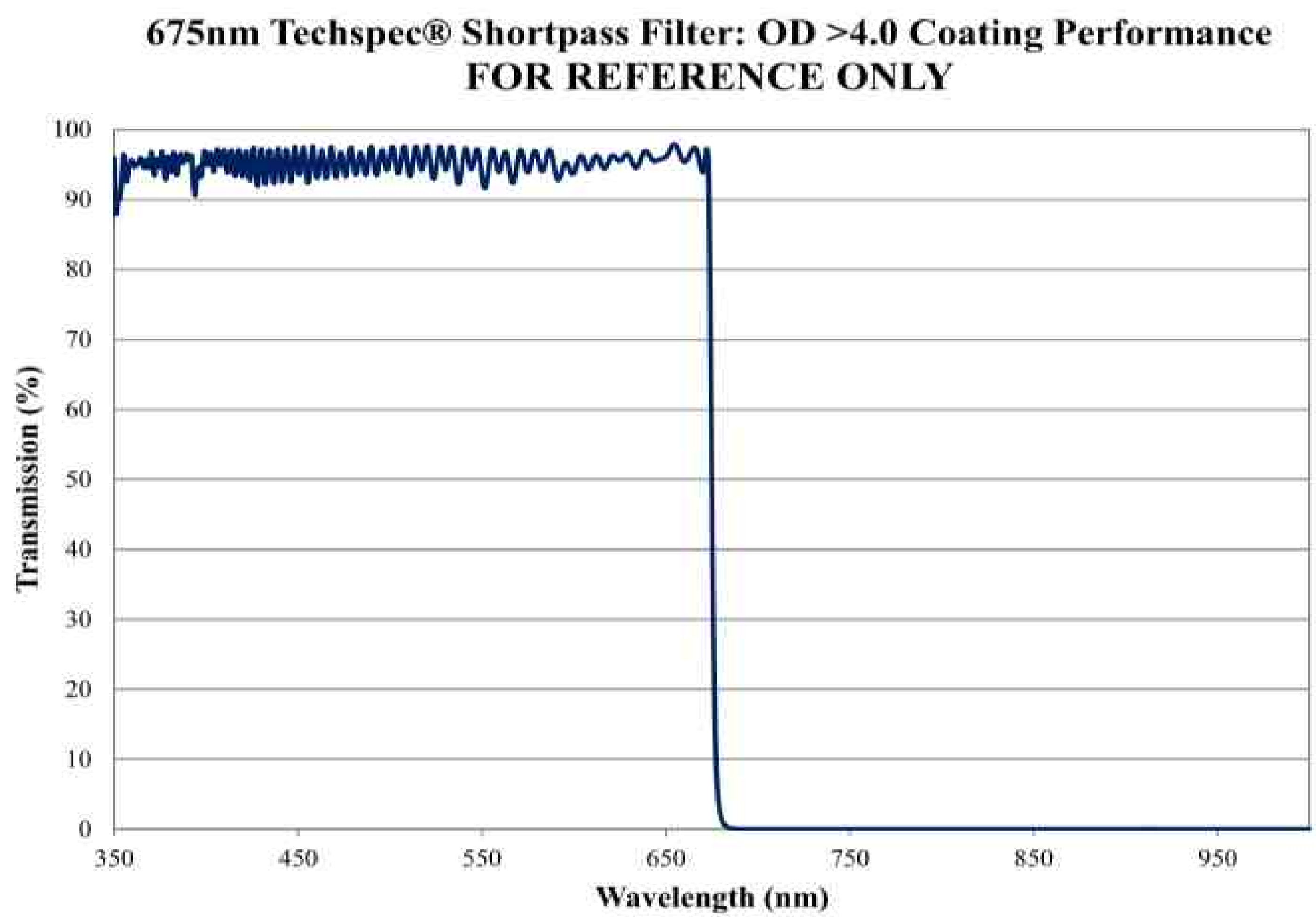
5,0E+15
0
0
2,0E-07
4,0E-07
6,0E-07
8,0E-07
1,0E-06
1,2E-06

Coating Curve

Edmund Optics Inc.
USA | Asia | Europe

COATING CURVE



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Coating Curve

Edmund Optics Inc.
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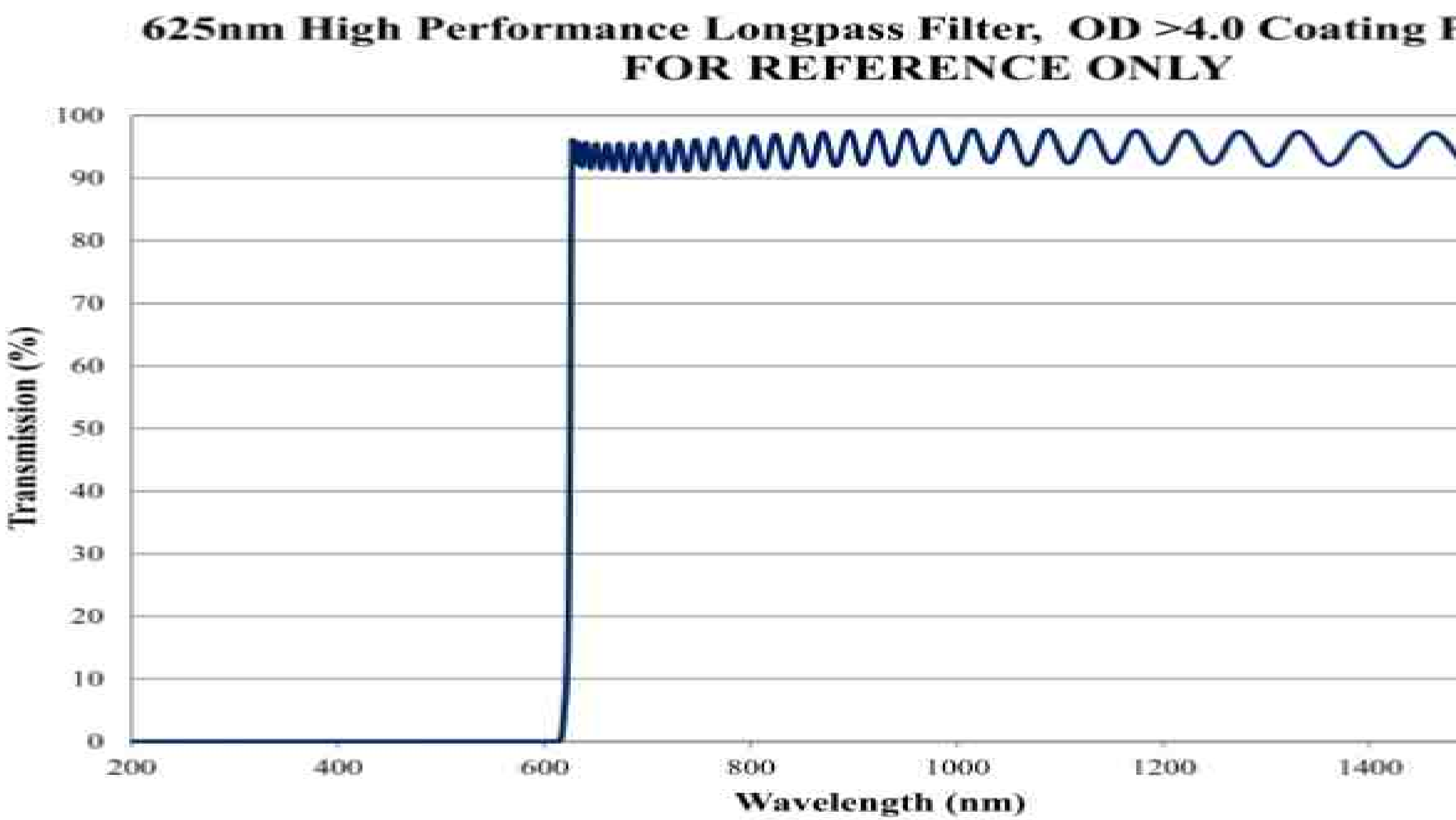
COATING CURVE

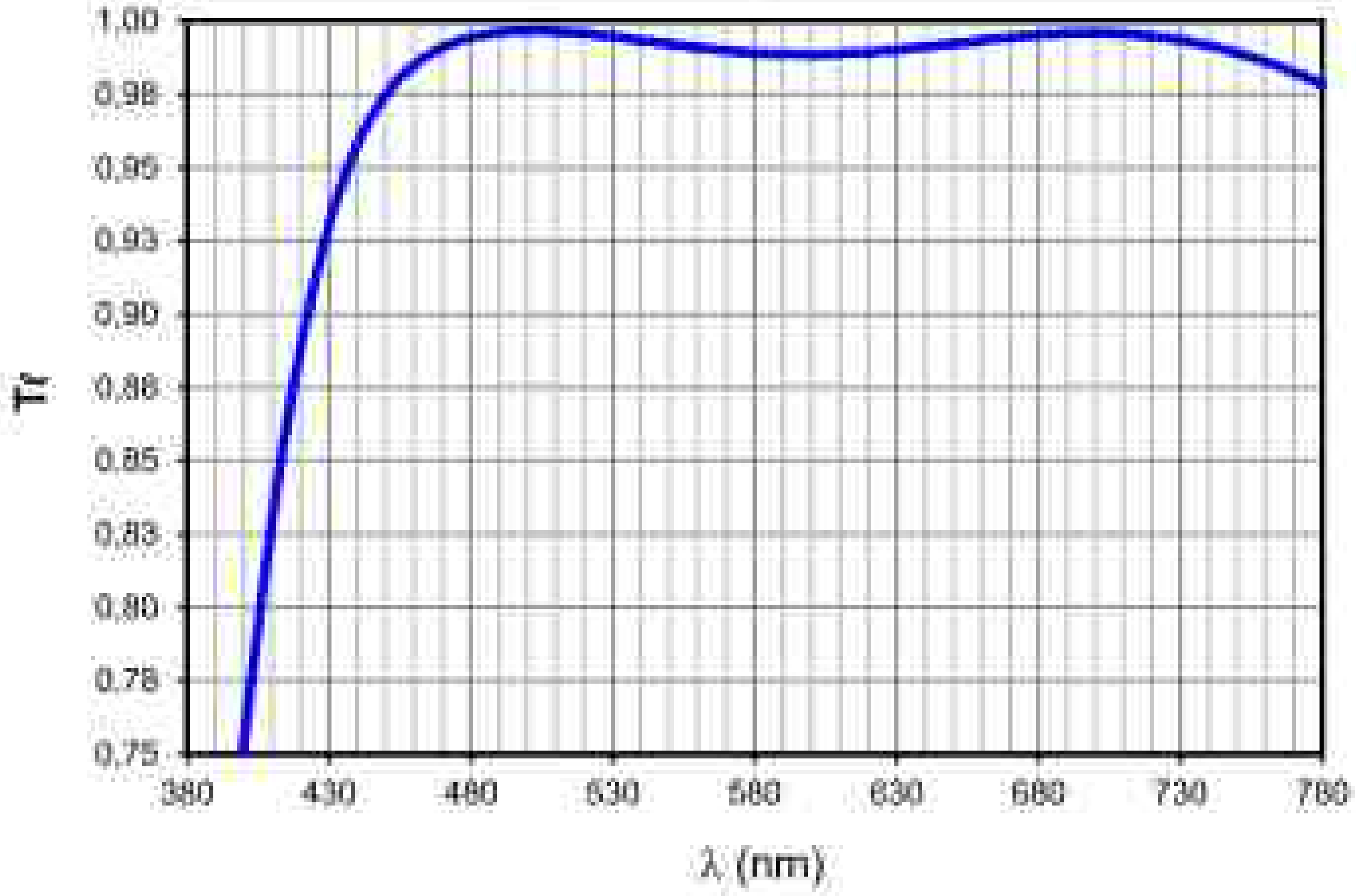


Ec
opt
www.edm

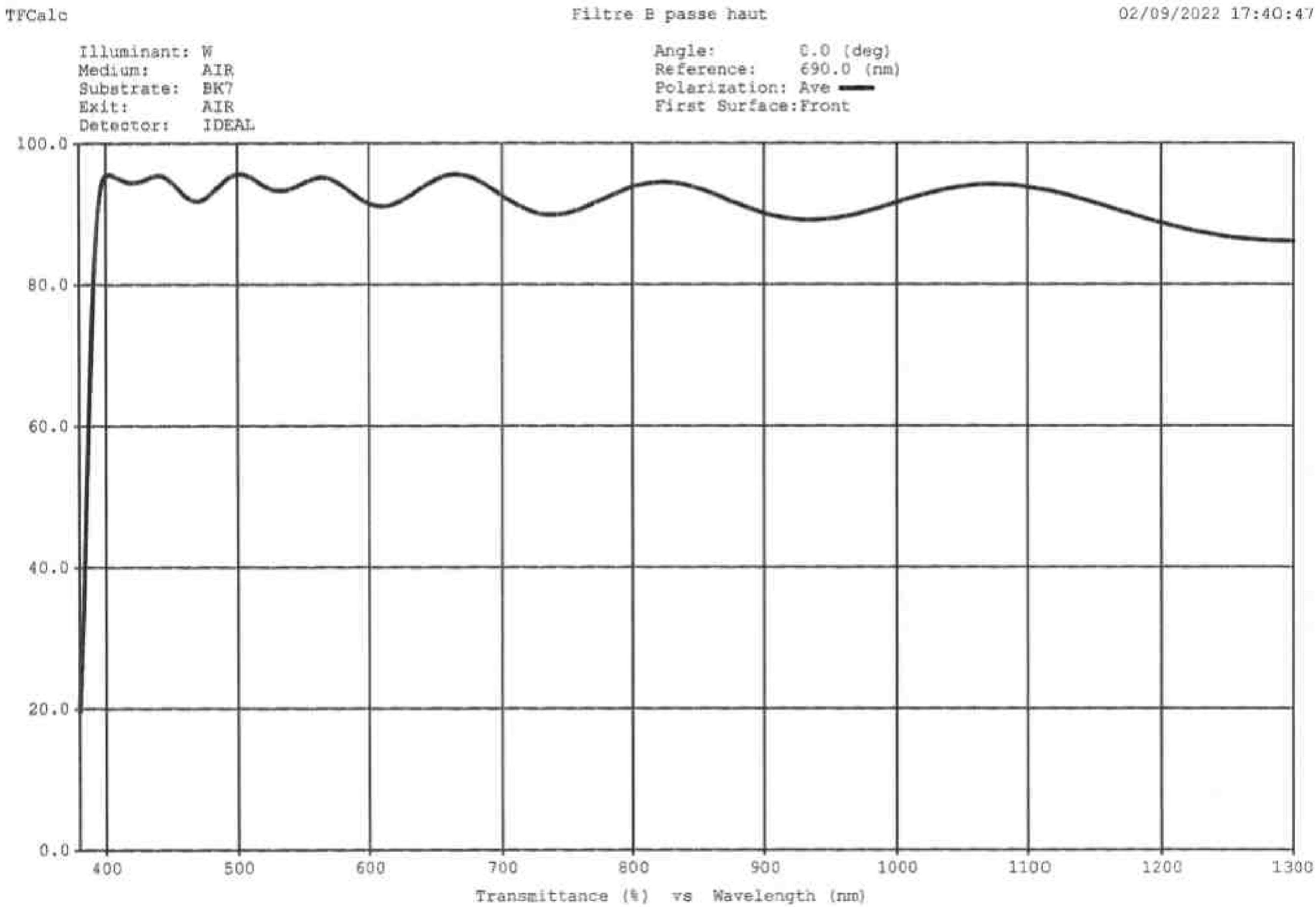
Lignes directrices de la spécification des filtres

- Harmonisation des trois filtres avec les filtres Gaia
- Limiter dans le violet la bande pour limiter la sensibilité à la masse d'air traversée des effets de la diffusion de Rayleigh (hauteur et altitude)
- Limiter dans le proche IR la bande pour limiter la sensibilité à la masse d'air et des bandes d'absorption intenses de l'atmosphere et la dispersion des rendements quantiques des détecteurs CCD ou CMOS
- placer la raie Halpha du coté de la bande GRP et la rejecter du coté GBP
- Maximiser les bandes passantes
- Filtres de même épaisseur optique

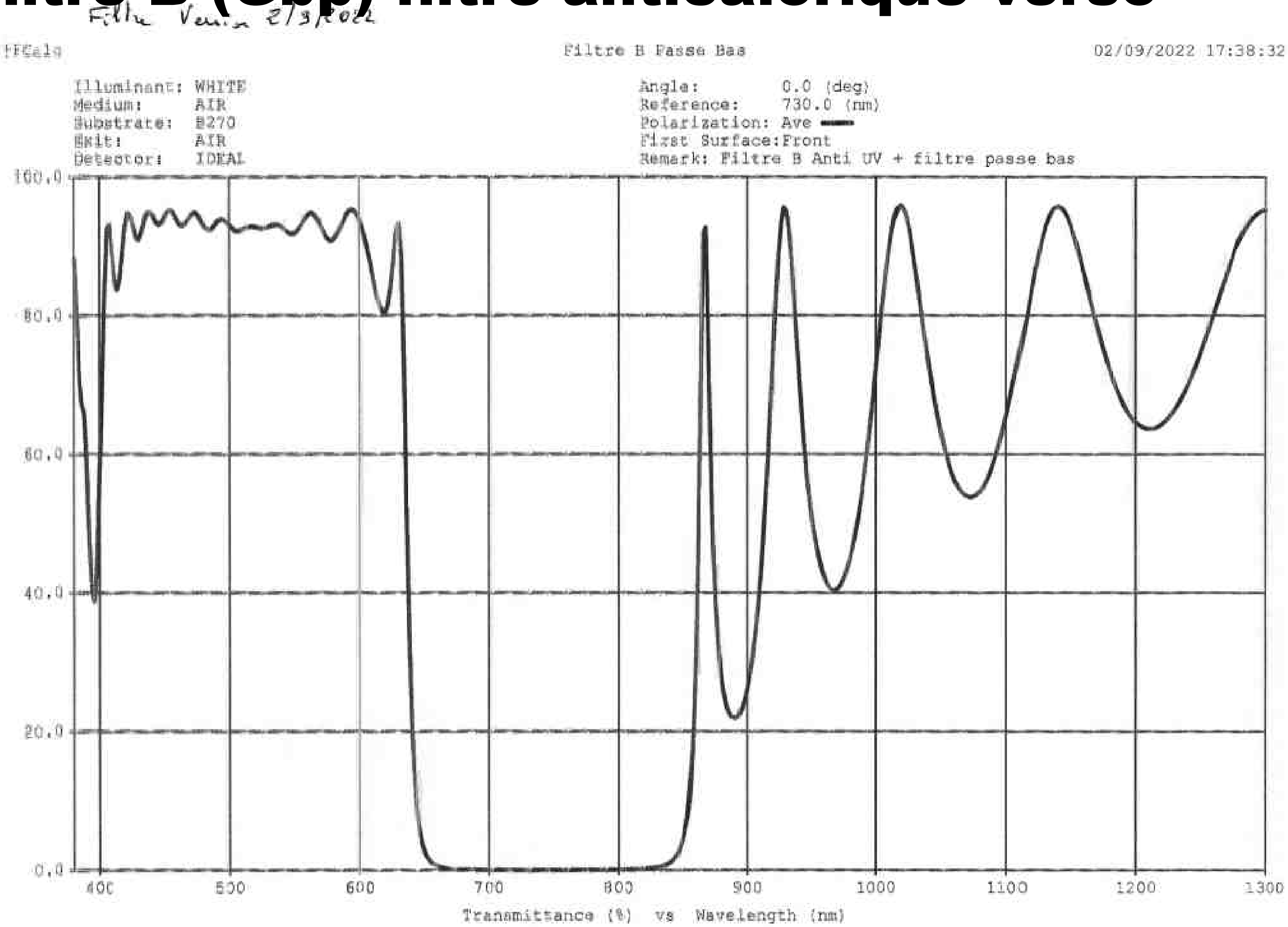
Filtre A (G) N-BK7 AR AR 400-700nm



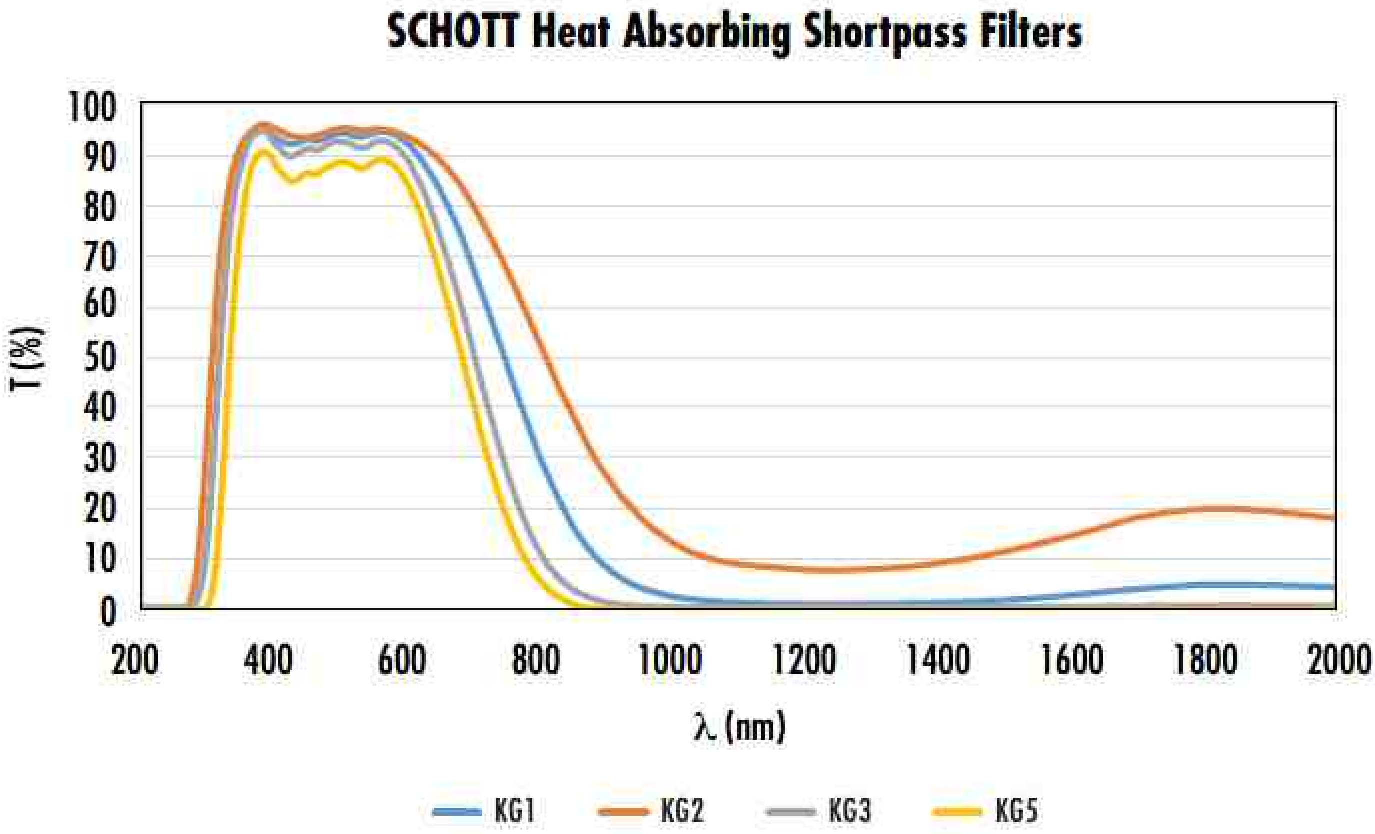
Filtre B (Gbp) passe bas recto



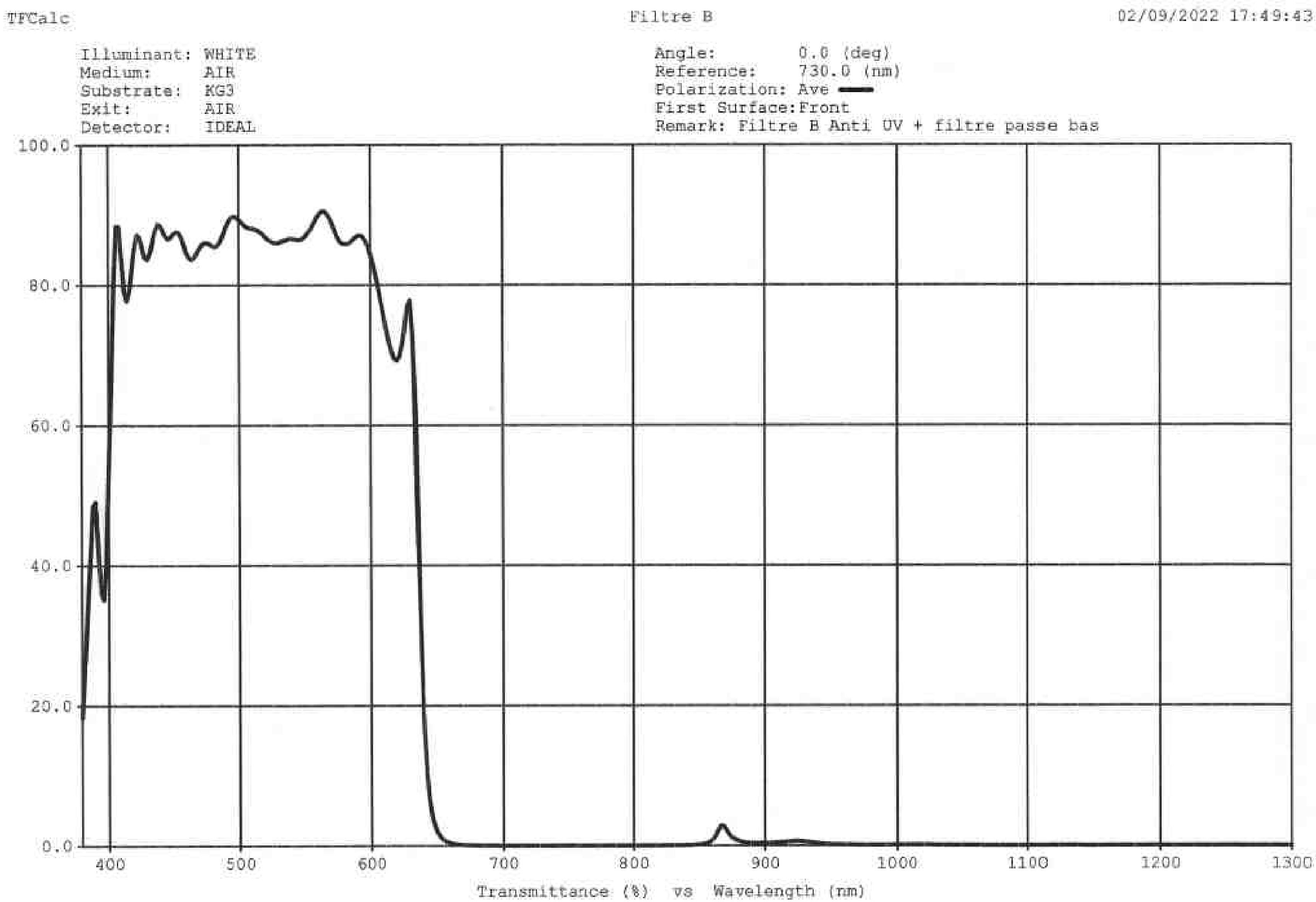
Filtre B (Gbp) filtre anticalorique verso



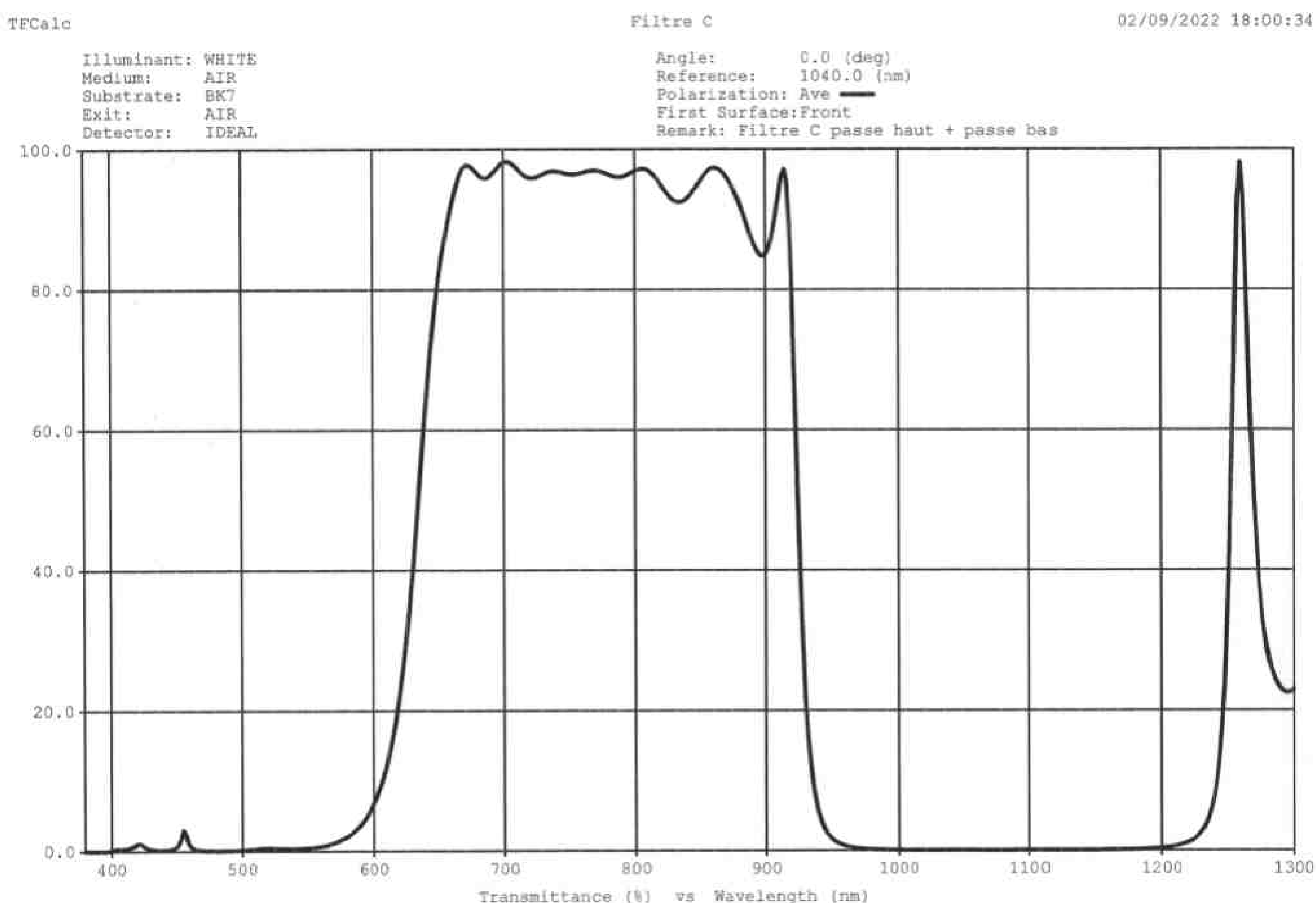
Substrat KG3



Filtre B (Gbp) transmission globale



Filtre C (Grp) transmission globale



Selected areas to assess magnitude upper limit

Edgar Everhart Sky&Telescope Jan 1984

Finding Your Telescope's Magnitude Limit

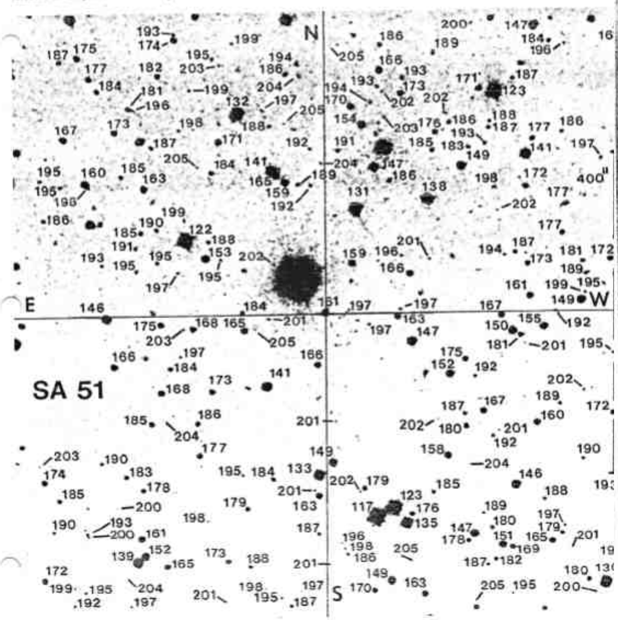
EDGAR EVERHART, *Chamberlin Observatory, University of Denver*

HOW FAINT will it reach? This is a question that often comes to mind when considering a telescope or camera to be turned toward the heavens. While there are numerous tables that cite the limiting stellar magnitude for a given telescope aperture (see, for example, page 193 of the March, 1980, issue), in practice this limit is affected by many factors.

The condition and number of optical surfaces in a system will affect performance, as will light pollution and other atmospheric effects. For the observer, the physical condition of the eye is important, while photographers must consider such factors as film, filters, exposure times, and developing methods.

Therefore, in order to determine the limiting magnitude of a particular instrument, it is best to observe or photograph the sky directly. This calls for some type of star atlas or chart showing the magnitudes of selected stars. But herein lie[s a] problem: Even binoculars and short exp[o]sures with small cameras will reveal st[ars] fainter than those plotted in Wil Tirio[n's] *Sky Atlas 2000.0* (limiting magnitude 8[…]) or *The AAVSO Variable Star Atlas* (li[…] about 9.0).

For fainter magnitudes there are [the] Vehrenberg *Atlas of the Selected Ar[eas]* and charts for certain variable stars p[re]pared by the American Association of V[ariable] Star Observers. Both include stars to about 16th magnitude — adequate for visual observers working with instruments up to nearly 30-inch aperture. But photographers can reach even fainter stars with surprisingly modest equipment.



Sixty years ago, the famous 16-inch (0.4-meter) Metcalf camera at Harvard Observatory was recording stars to magnitude 16. Today, however, advances in emulsions and hypersensitizing techniques make it possible for the same size telescope to photograph stars of 21st magnitude. Smaller telescopes can easily reach beyond the 16th-magnitude limit of the charts mentioned above.

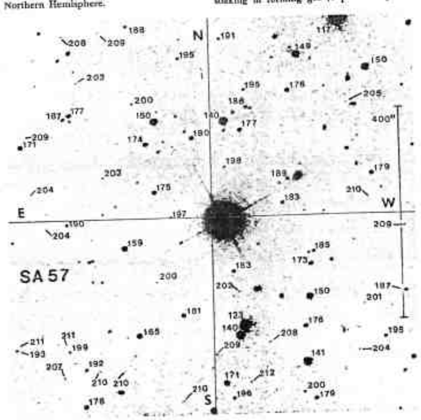
Large observatories have special methods for calibrating photographic plates and determining the magnitudes of faint stars on them. The photographs described and reproduced here will be useful for smaller [ob]servatories and advanced amateurs, as [the]y contain accurate star brightnesses down to 21st magnitude.

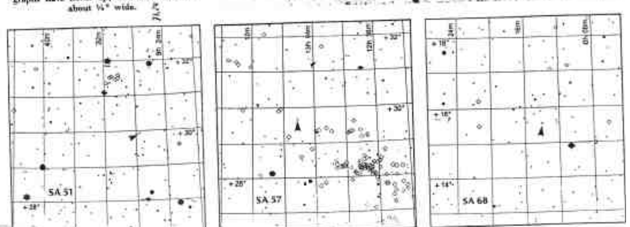
The magnitudes marked on the photographs are from a paper by L.-T. G. Chiu published in the *Astrophysical Journal Supplement* for September, 1980. Chiu was studying the structure of our galaxy as determined by proper motions of stars. For this work he used numerous photographs made in blue, yellow, and red light with the giant reflectors at Lick, Kitt Peak, and Palomar observatories. Chiu credits I. R. King and co-workers at the University of California, Berkeley, for the photovisual magnitudes of the stars. They used an iris photometer calibrated with photoelectric sequences. Photovisual magnitudes do not correspond exactly with what the eye sees but are reasonably close.

Chiu studied stars in Selected Areas (SA) 51, 57, and 68, each nearly centered on an 8th- or 9th-magnitude star listed in the Smithsonian Astrophysical Observatory *Star Catalog*. These areas are fairly well distributed in right ascension, and at least one field is accessible on most nights in the Northern Hemisphere.

Although the magnitudes listed in Chiu's tables are quite accurate, he did not include charts. I remedied this by photographing all three areas with the 16-inch f/5.5 astrographic reflector at Chamberlin Observatory's Dick Mountain Field Station near Bailey, Colorado. The exposures, made between December, 1980, and July, 1981, were 75 to 100 minutes in duration on nights of good seeing. I used Kodak's Technical Pan Film 2415, which was hypersensitized before exposure by soaking in forming gas (8 percent hydrogen, 92 percent nitrogen) at atmospheric pressure for five hours at 60° C. The 4 x 5 film sheets were processed in D-19 developer for five minutes at 21° C.

The photographic charts with this article were prepared by the author and are more fully described in the text. Each is nearly centered on a bright star listed in the table on page 30, while finder charts for the fields are below. Photovisual magnitudes are shown for selected stars with decimal points omitted (for example, 184 indicates a star of magnitude 18.4). All photographs have north up, and each field is about ¼° wide.





These finder charts for the three Selected Areas described in the text are adapted from a star atlas published by the Smithsonian Astrophysical Observatory. North is up, and each field is 5° square. Arrows denote the bright star near the center of each of the author's photographs. The finder chart for SA 51 contains Gemini's bright stars Castor at top center and Pollux at lower left. The brightest star in the SA 57 finder is 4th-magnitude Beta Comae Berenices at lower left. SA 68 is located just northeast of 3rd-magnitude Gamma ~~Persei~~ Pegasi.

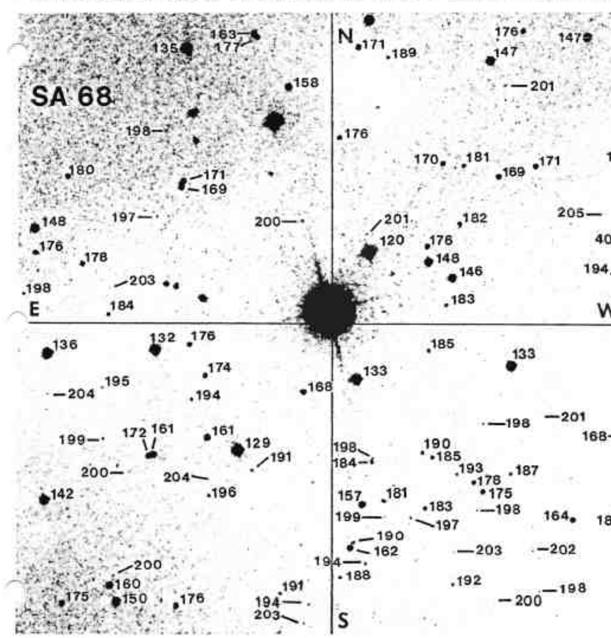
PRIMARY STAR IN EACH SELECTED AREA

Area	Star	Mag.	1950.0	2000.0
SA 51	SAO 79445	9.1	7h 27.5m, +29° 56'	7h 30.6m, +29° 50'
SA 57	SAO 82672	8.1	13h 6.3m, +29° 39'	13h 8.6m, +29° 23'
SA 68	SAO 91810	8.2	0h 14.0m, +15° 34'	0h 16.6m, +15° 50'

My negatives were enlarged 24 times and made into reverse prints (black stars on a white background). The exact scale as reproduced here can be found from the line 400 arc seconds long on the right side of each print.

Within the borders of the photograph of SA 51, Chiu's list contains 235 stars to photovisual magnitude 20.5. Of these, seven stars are covered by the image of a brighter one. Six of magnitude 20.5 are shown on the photograph, but another of the same brightness is not.

For the photograph of SA 57, Chiu's list contains 65 stars. Of these, two were covered by other images and three were not found. Among the 60 stars marked are five with magnitudes from 21.0 to 21.2 (the basis for my earlier statement [that to]day a 16-inch telescope can rea[ch 21st-]magnitude stars). The photograp[h of SA] 68 should contain 89 stars from Ch[iu's list,] but one was not found. The remai[ning stars,] some as faint as magnitude 20.5, [are] visible.

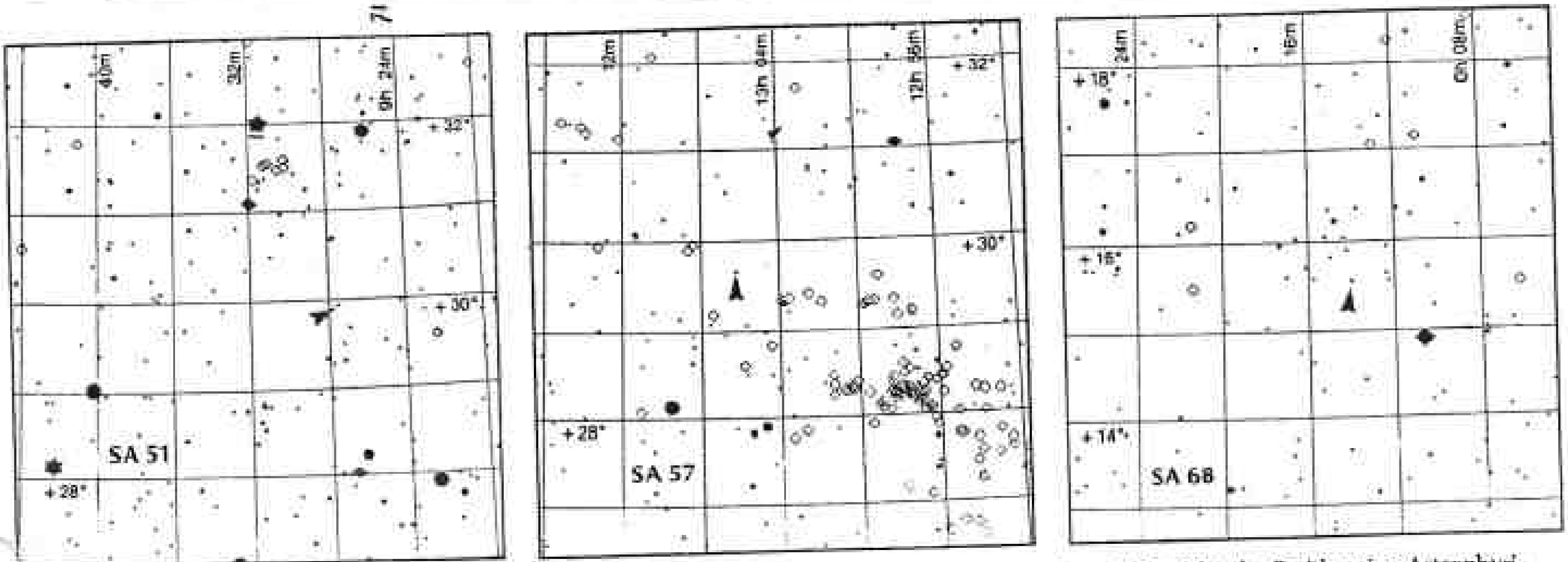


I wish to thank Elizabeth Roem[er of the] University of Arizona for calling m[y atten]tion to Chiu's original paper, and [Arthur] Hoag at Lowell Observatory for hi[s comments] and suggestions while I was work[ing] on this project.

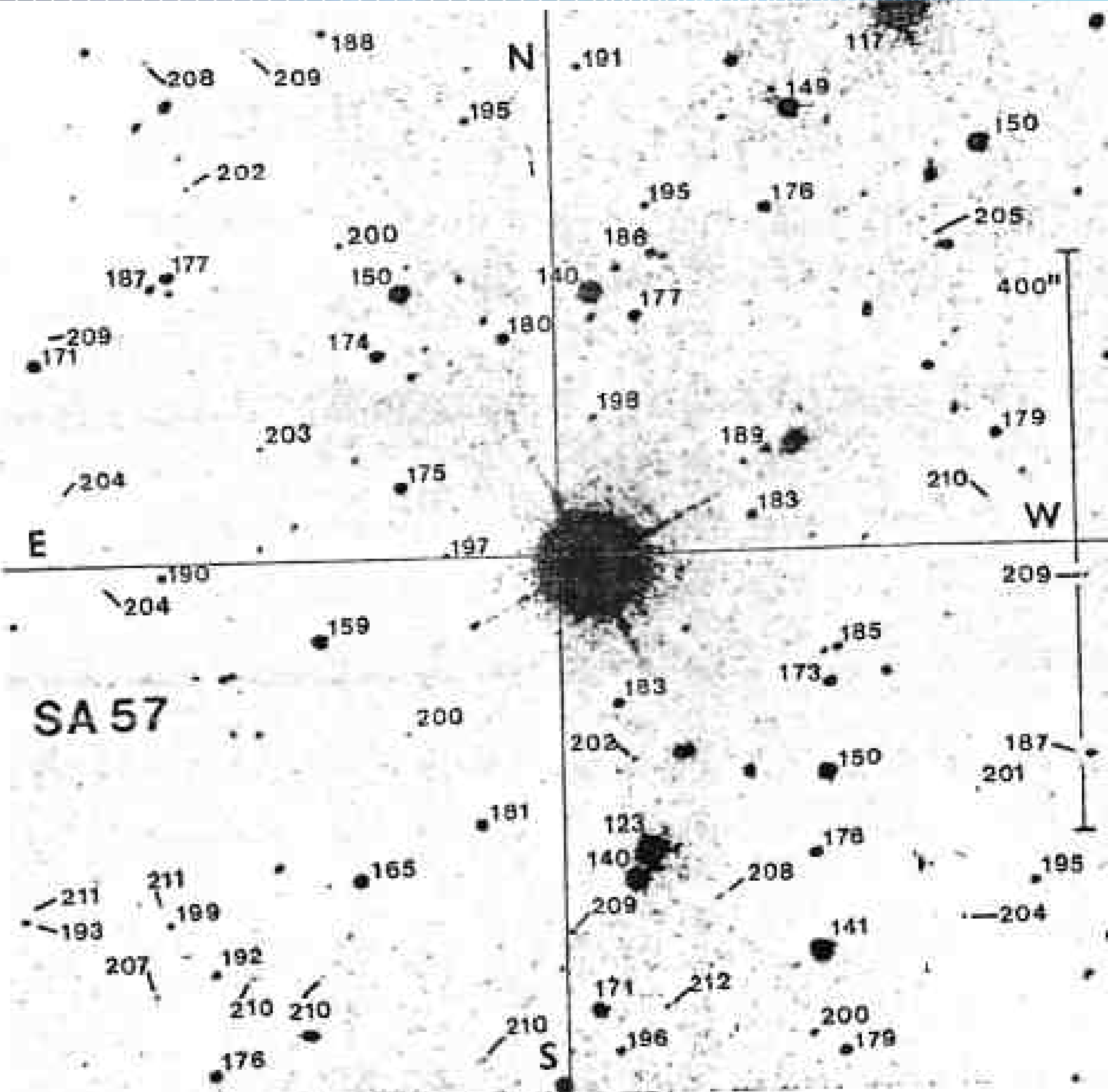
Edgar Everhart is the director of C[hamber]lin Observatory at the University of [Denver,] where he teaches physics and astronom[y …] currently active in astrometry, partic[ularly the] determination of accurate positions of [...]

PRIMARY STAR IN EACH SELECTED AREA

Area	*Star*	*Mag.*	*1950.0*	*2000.0*
SA 51	SAO 79445	9.1	7h 27.5m, +29° 56′	7h 30.6m, +29° 50′
SA 57	SAO 82672	8.1	13h 6.3m, +29° 39′	13h 8.6m, +29° 23′
SA 68	SAO 91810	8.2	0h 14.0m, +15° 34′	0h 16.6m, +15° 50′



These finder charts for the three Selected Areas described in the text are adapted from a star atlas published by the Smithsonian Astrophysical Observatory. North is up, and each field is 5° square. Arrows denote the bright star near the center of each of the author's photographs. The finder chart for SA 51 contains Gemini's bright stars Castor at top center and Pollux at lower left. The brightest star in the SA 57 finder is 4th-magnitude Beta Comae Berenices at lower left. SA 68 is located just northeast of 3rd-magnitude Gamma ~~Persei~~ Pegase.


N
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W
SA 57
400"
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191
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187
177
150
140
177
180
400"
209
171
174
198
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183
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173
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181
123
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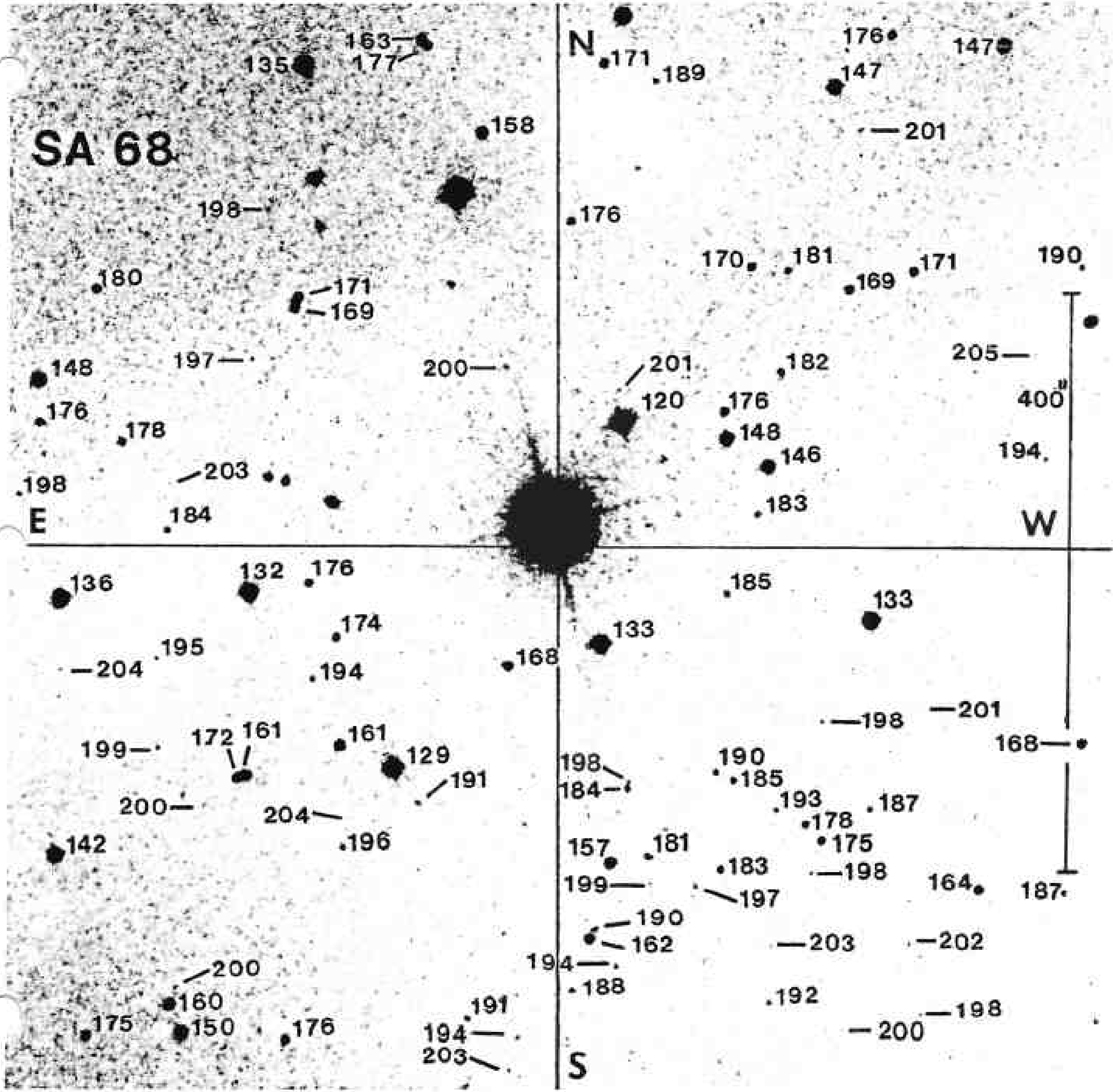
SA 68
N
S
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W
400"
163
177
135
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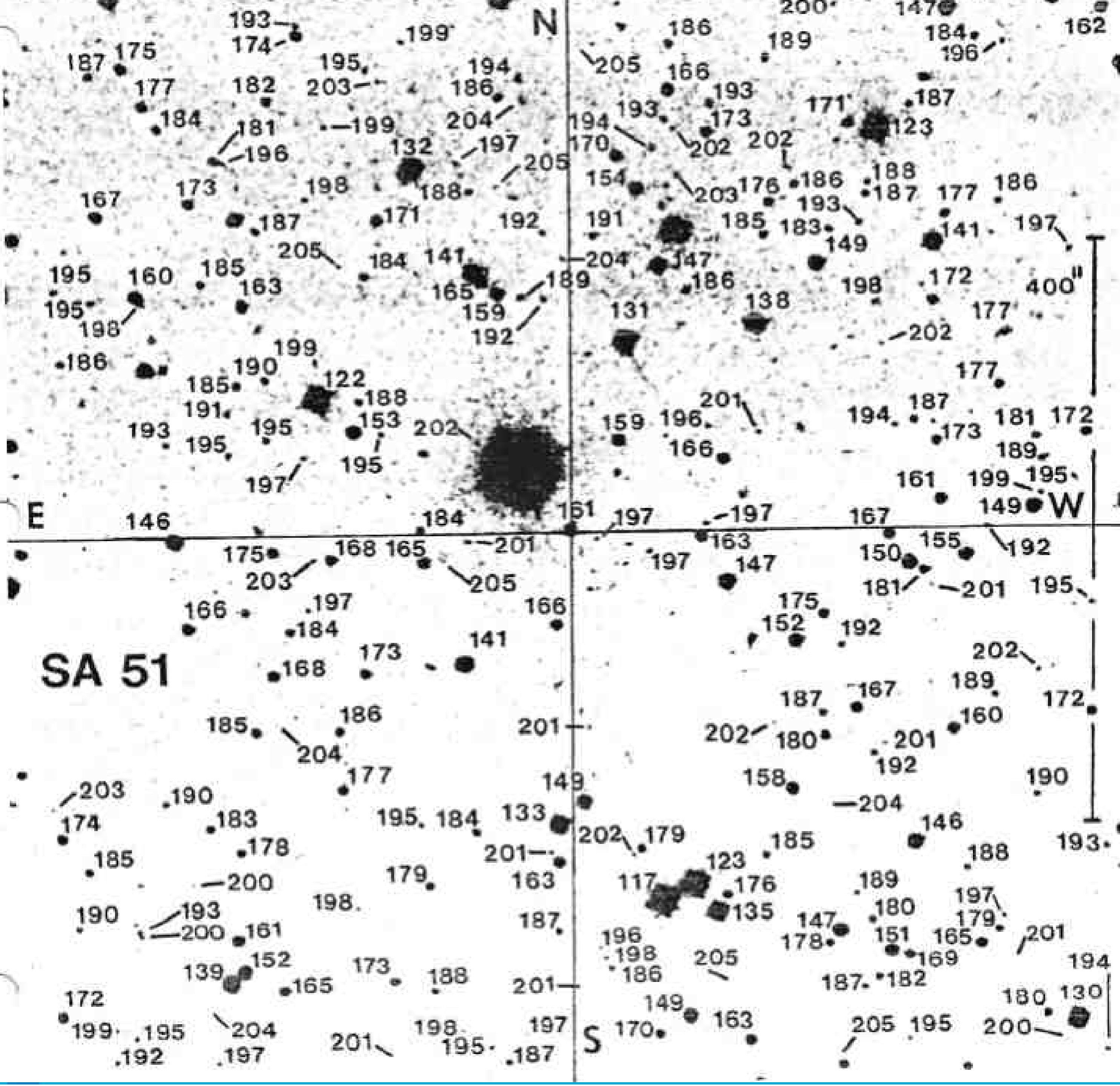
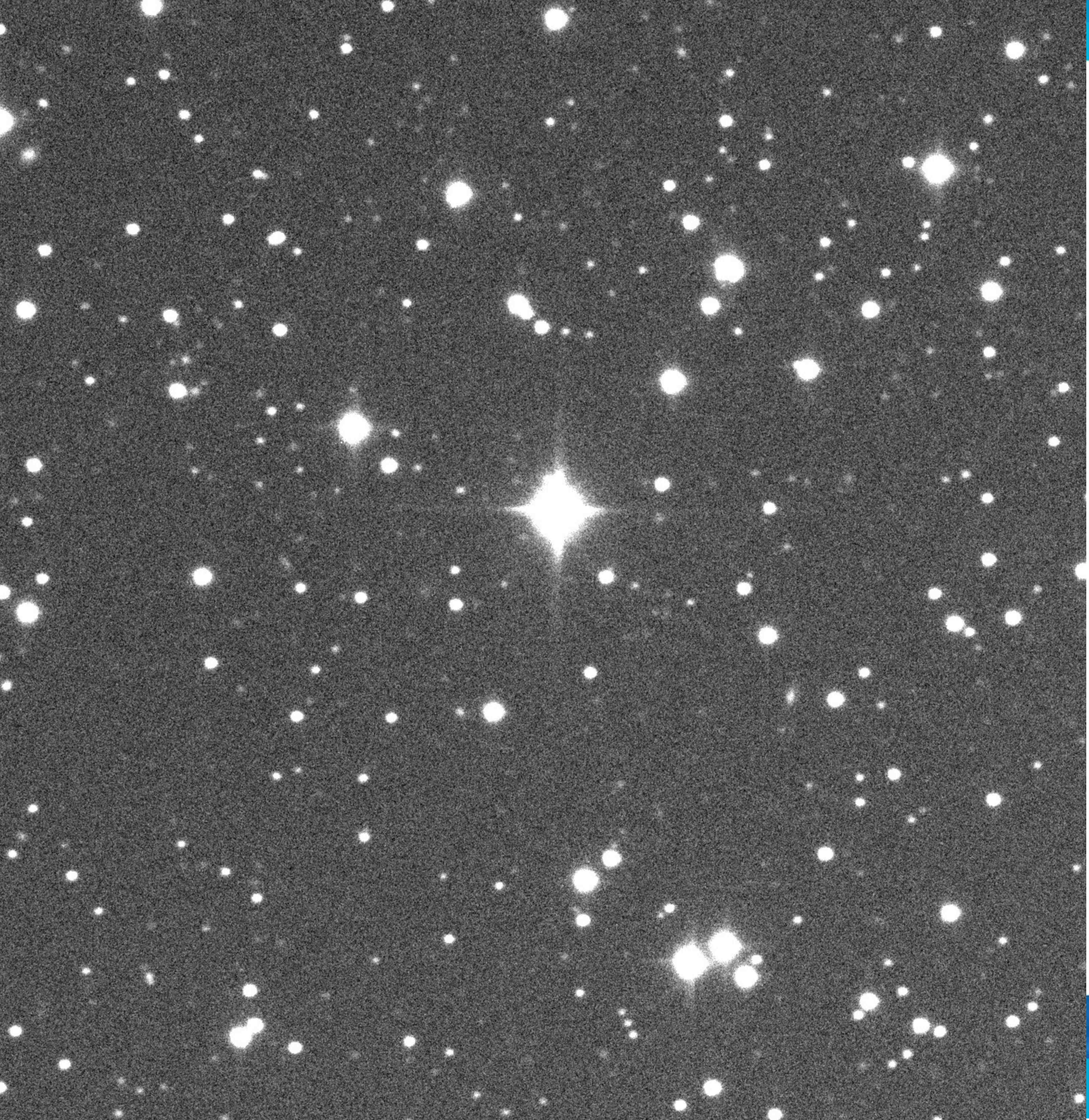


N
E
W
S
SA 51
400"



5 stacked 60s exposures
500 mm aperture
1400 mm focal length
IMX455 CMOS detector
less than 1,5e rms noise

FOM = 30
1,5 x 1°²
20
1min

Thierry Midavaine

RAPAS 2023 - 2024 on the way

- Qualify the photometric accy of the network
- Perform search and photometric data deliveries to prgm alerts

- Study enhanced filter set grade 2
- Production of filters set 2nd batch

- Study high efficiency low dispersion spectroscopic device