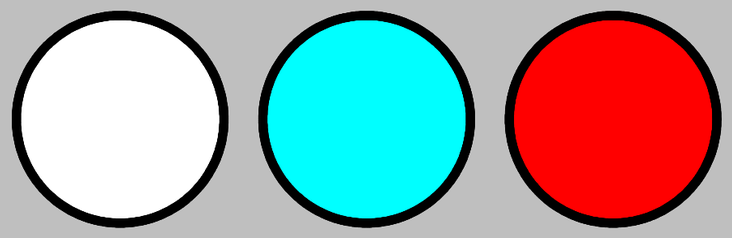

RAPAS
Atelier RAPAS 8-9 octobre 2022
Observatoire de Paris

RAPAS
Spécifications, conceptions et réalisations des filtres



Thierry Midavaine[1]
William Thuillot[2], Michel Dennefeld[3], Christian Buil[4], Stephane Neveu[1]

[1] Société astronomique de France
[2] Observatoire de Paris IMCCE
[3] IAP
[4] ARAS

Atelier de lancement 8-9 octobre 2022

RAPAS

Réseau Amateurs Professionnels pour les Alertes Scientifiques

1. Besoins, la FOM des instruments
2. Gaia, l’idée induite
3. Les systèmes de filtres et de catalogues
4. Les bandes de Gaia et son catalogue
5. Définir les spécifications des filtres
6. Lignes directrices de la spécification des filtres
7. Les courbes de transmission des filtres A, B et C
8. 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 then 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...

er Letter	Effective Wavelength Midpoint λ_{eff} For Standard Filter[2]	Full Width Half Maximum[2] (Bandwidth Δλ)	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

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

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

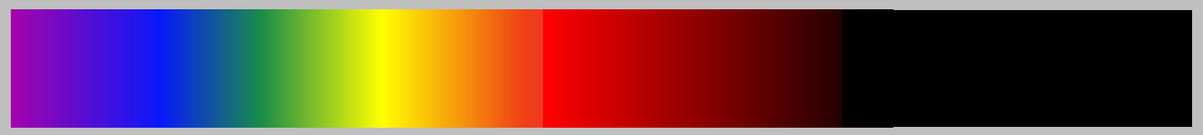
Combinaisons de filtres alternatifs

- Johnson Cousins : UBVRI
- Bessell,
- Sloan Digital Sky Survey (SDSS) : ugriz de 14.5 à 19.5
- u’g’r’i’z’
- [redacted]
- [redacted]

Les filtres GAIA : G GBP et GRP

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	ZPv	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 will be 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

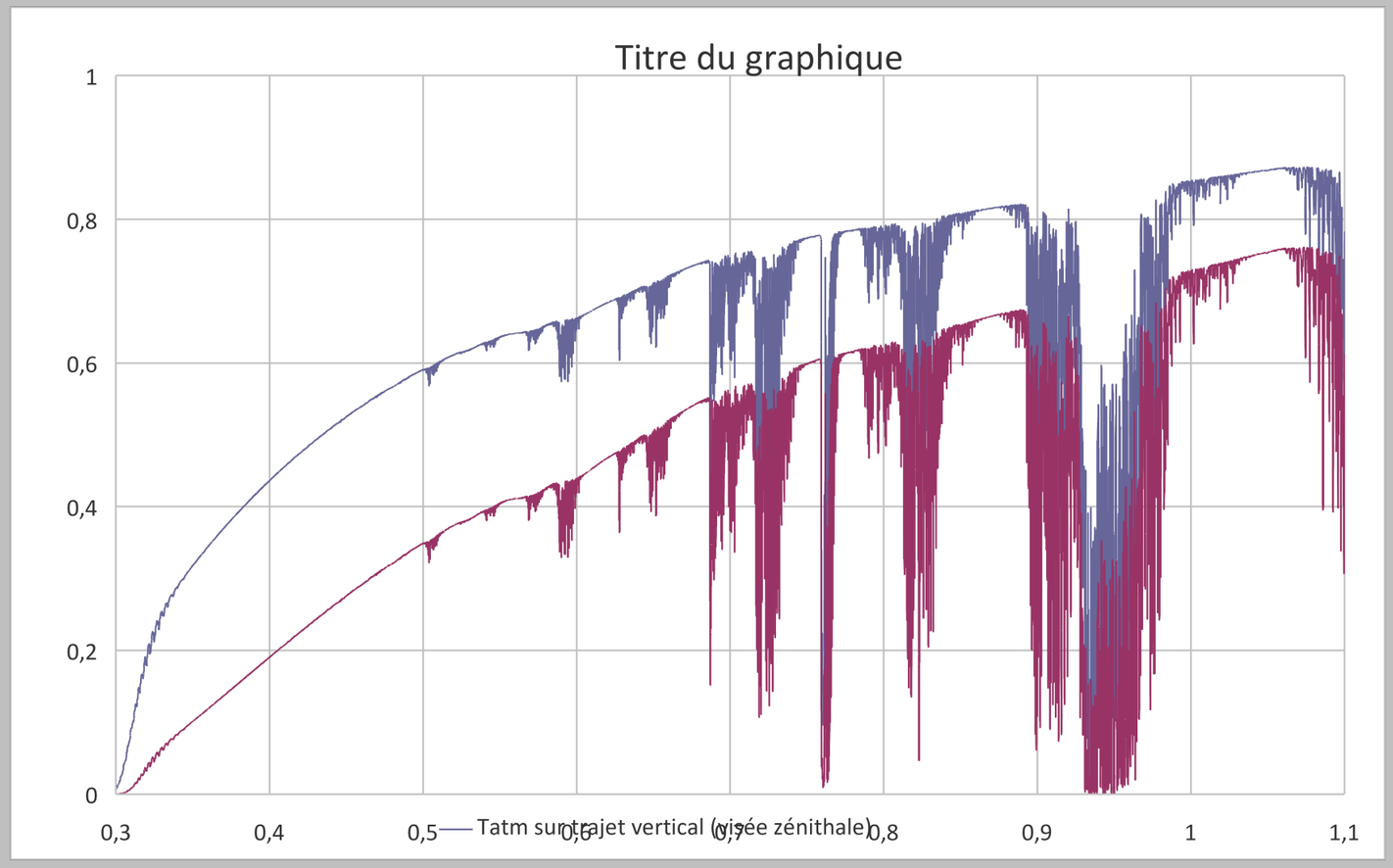
- Photometry (G, GBP, and GRP published as part of Gaia EDR3, OTHER DATA ARE NEW IN GAIA DR3)

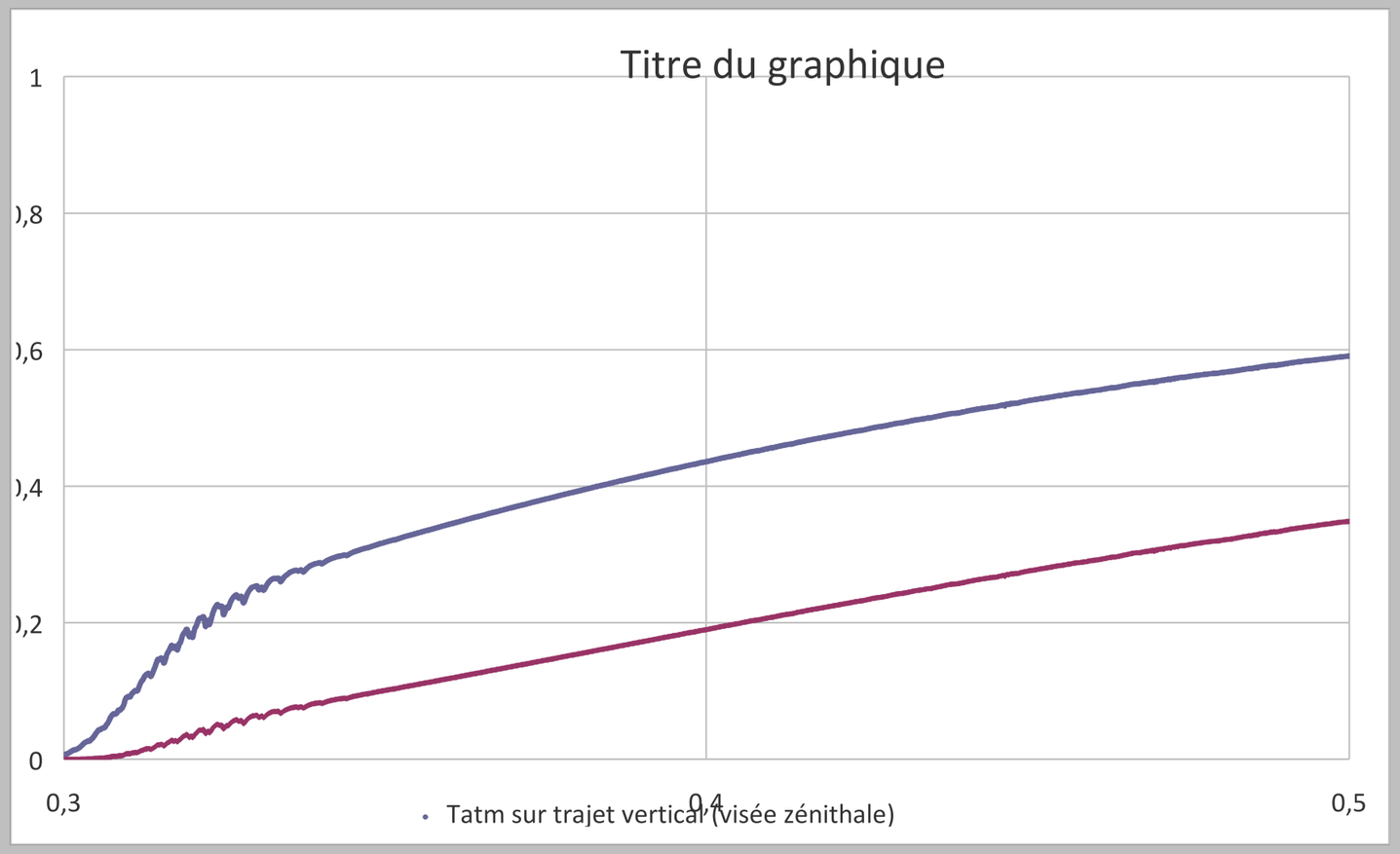
- The G-band photometric uncertainties are ~0.3 mmag for G<13, 1 mmag at G=17, and 6 mmag at G=20 mag.
- The GBP-band photometric uncertainties are ~0.9 mmag for G<13, 12 mmag at G=17, and 108 mmag at G=20 mag.
- The GRP-band photometric uncertainties are ~0.6 mmag for G<13, 6 mmag at G=17, and 52 mmag 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.

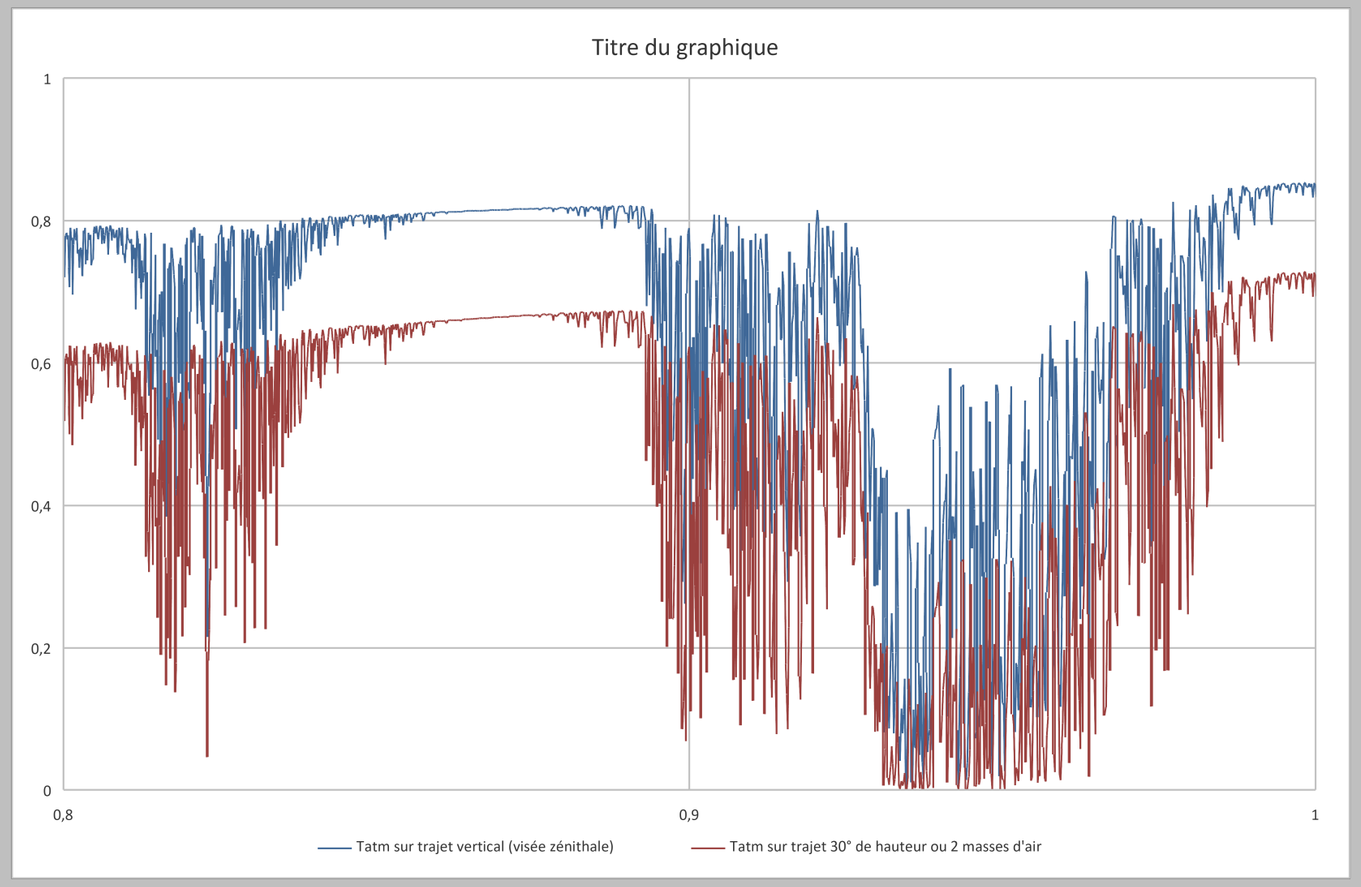
defining RAPAS filters specs

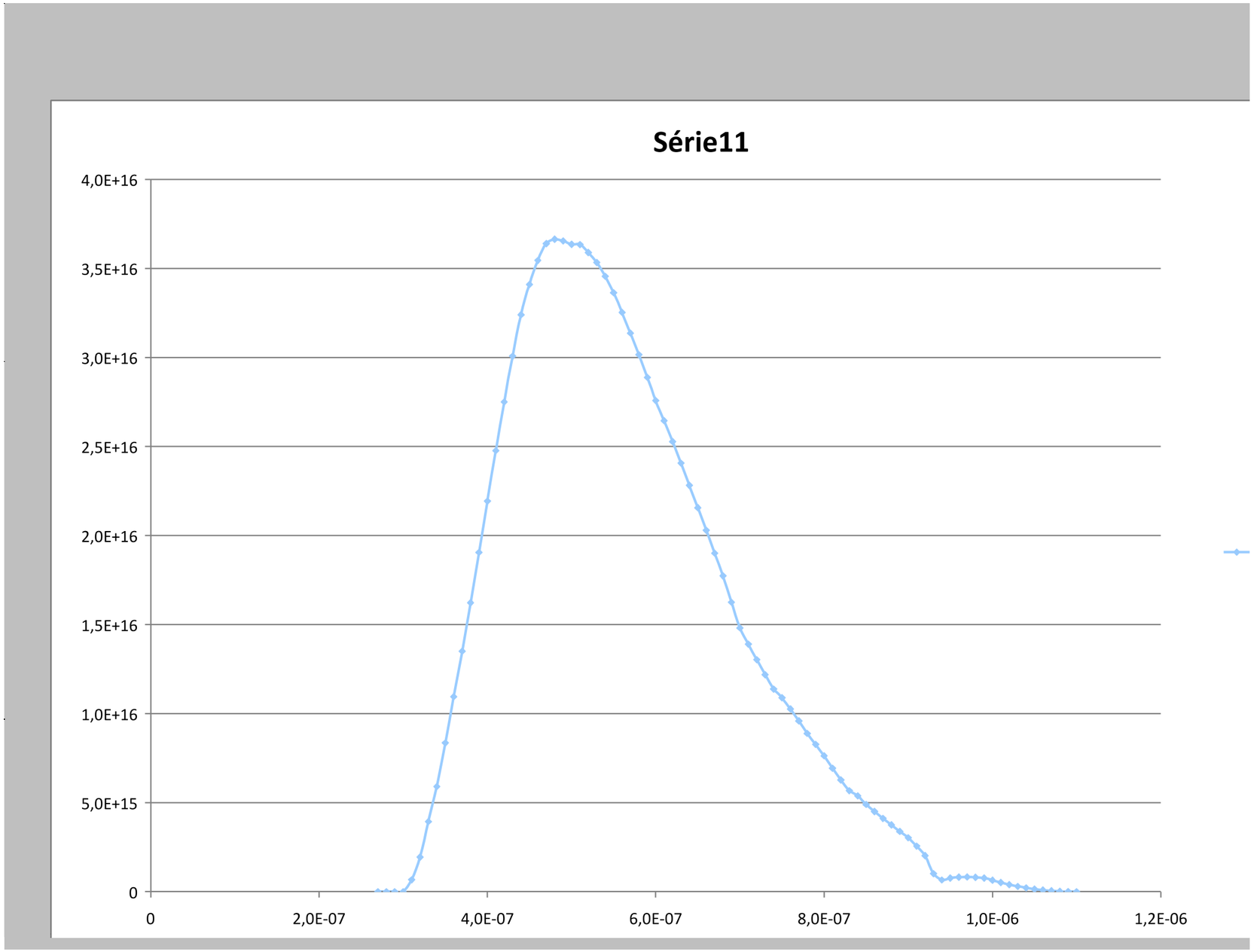
- Gaia bands are defined outside atmosphere
- Therefore we have to adapt the filter spectral bands to be less sensitive to air mass
- Limit the effect of near infrared QE discrepencies between CCD and CMOS, front ill or back ill, Si thickness

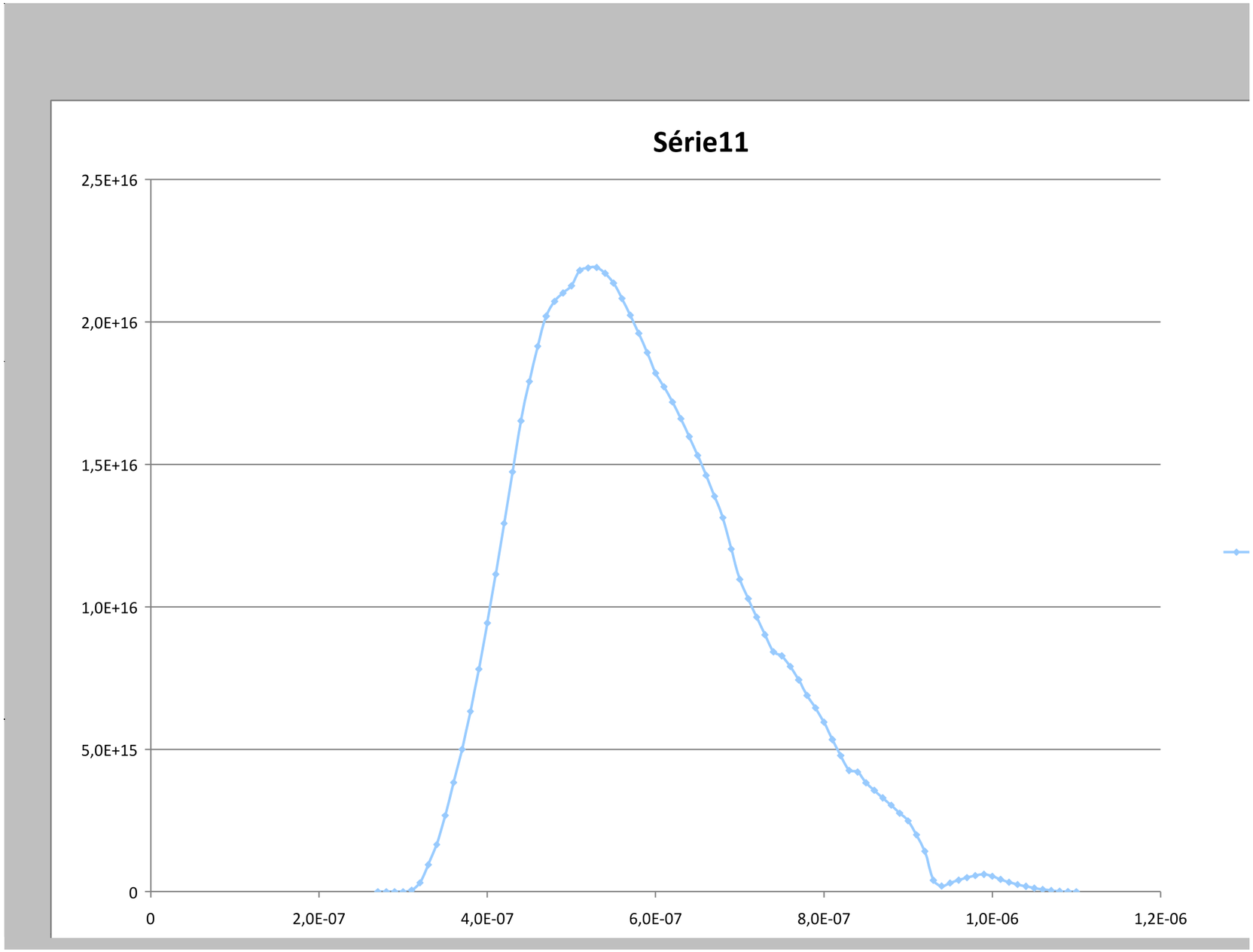
Atmospheric transmission 1 and 2 air mass

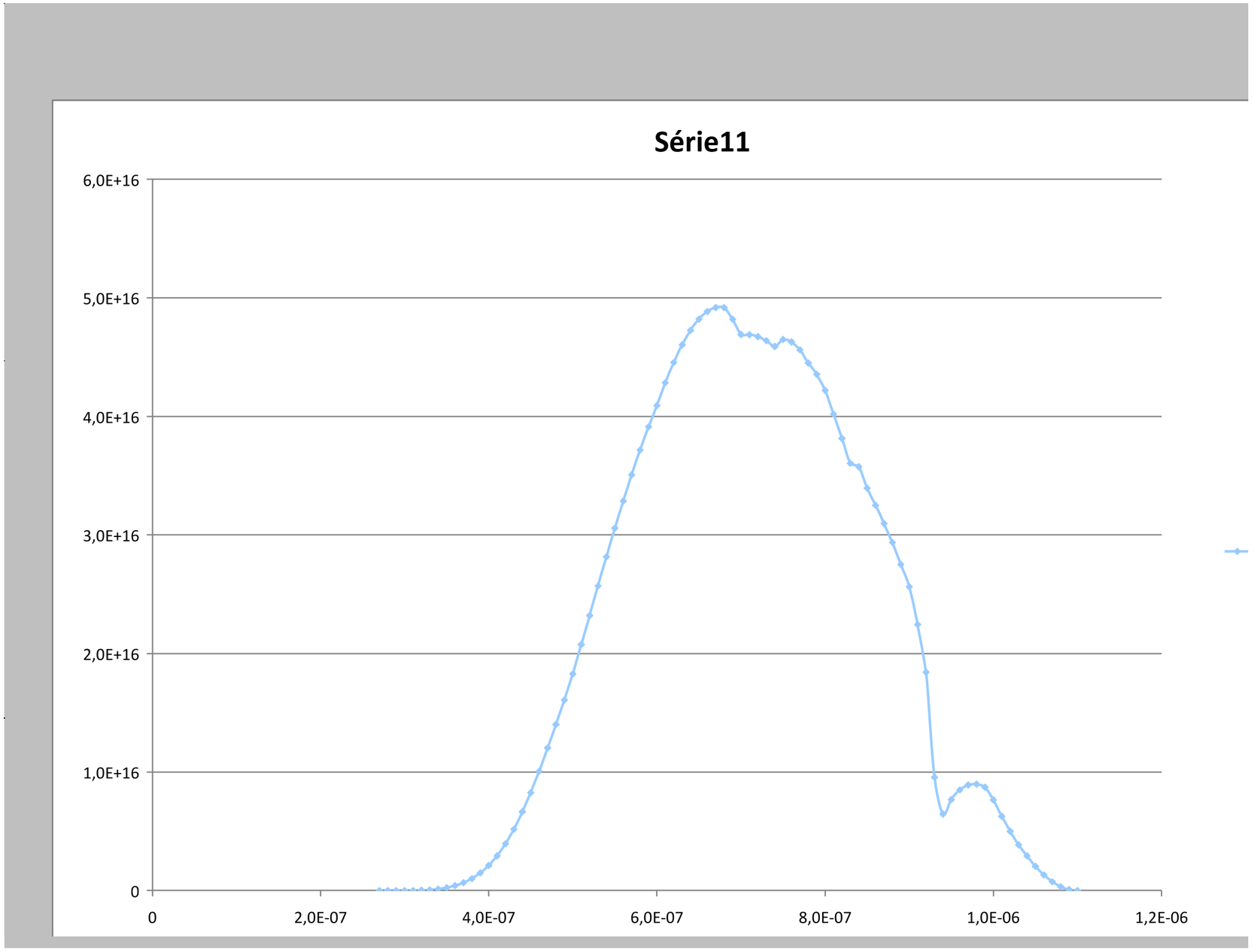


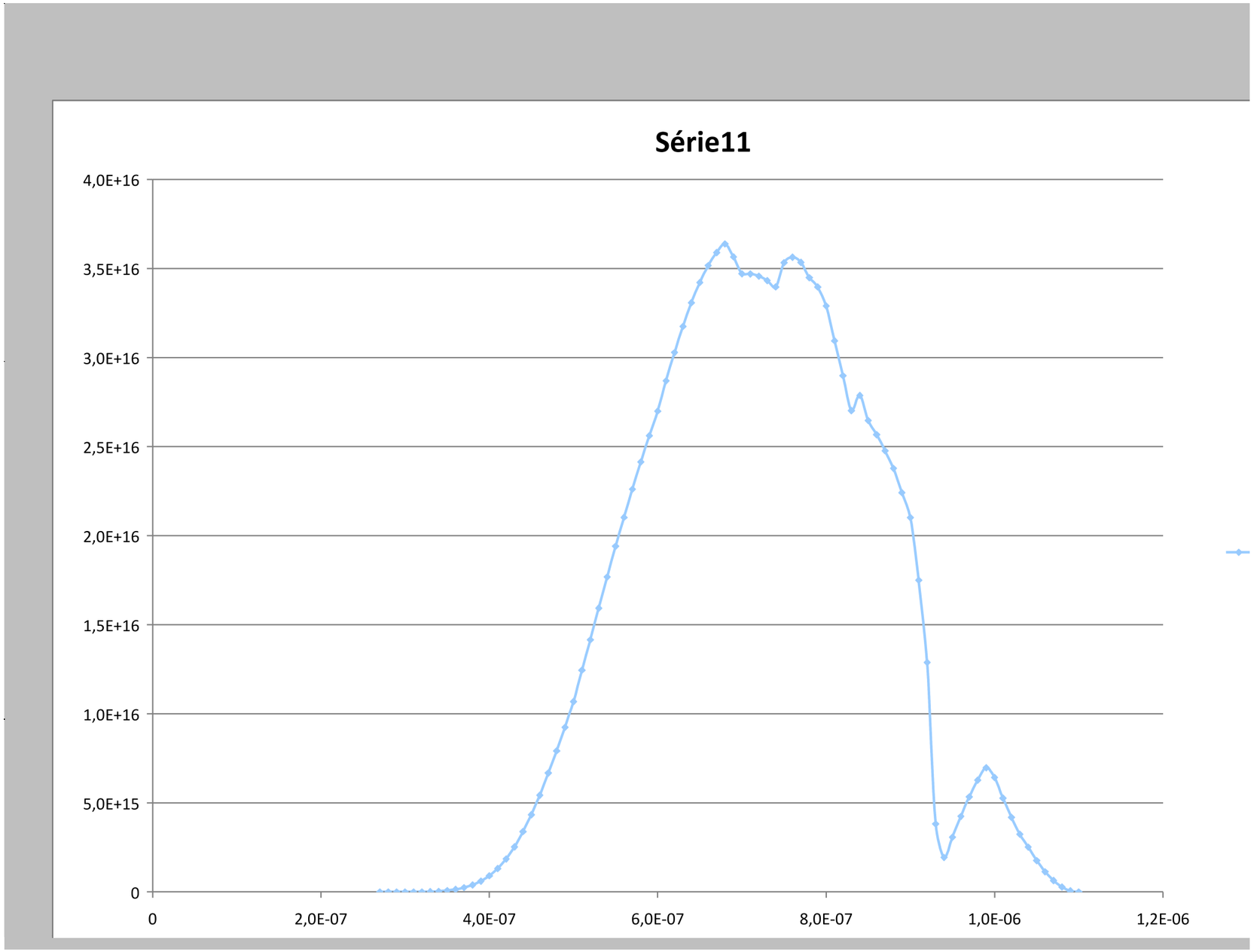

Titre du graphique
1
),8
),6
),4
),2
0
0,3
0,4
0,5
Tatm sur trajet vertical (visée zénithale)

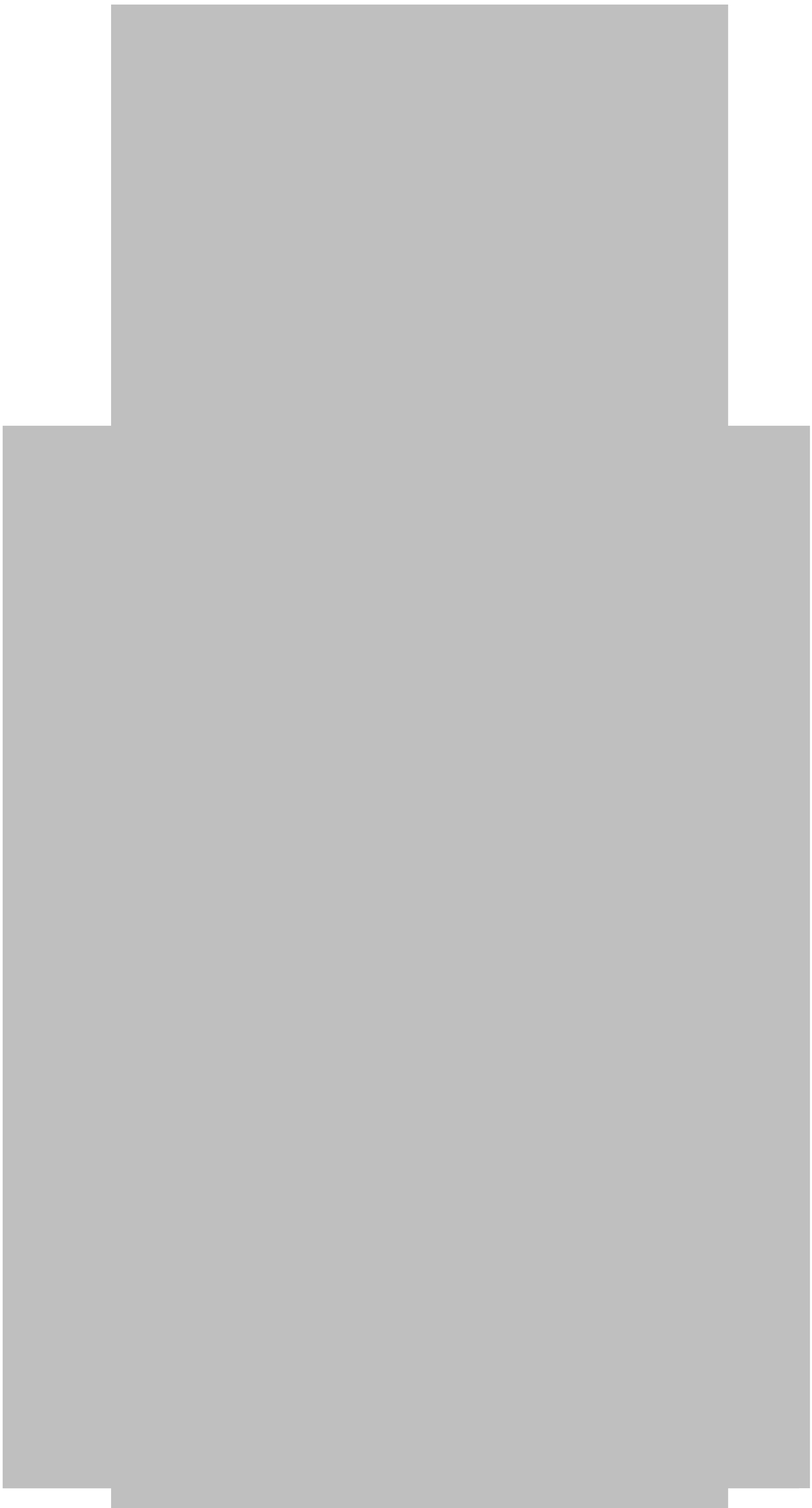

Titre du graphique
1
0,8
0,6
0,4
0,2
0
0,8
0,9
1
Tatm sur trajet vertical (visée zénithale)
Tatm sur trajet 30° de hauteur ou 2 masses d'air


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


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



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

5 stacked 60s exposures
500 mm aperture
1400 mm focal length
IMX455 CMOS detector
less than 1,5^{e} 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