

Precisiones en astrometría, fotometría y espectroscopía

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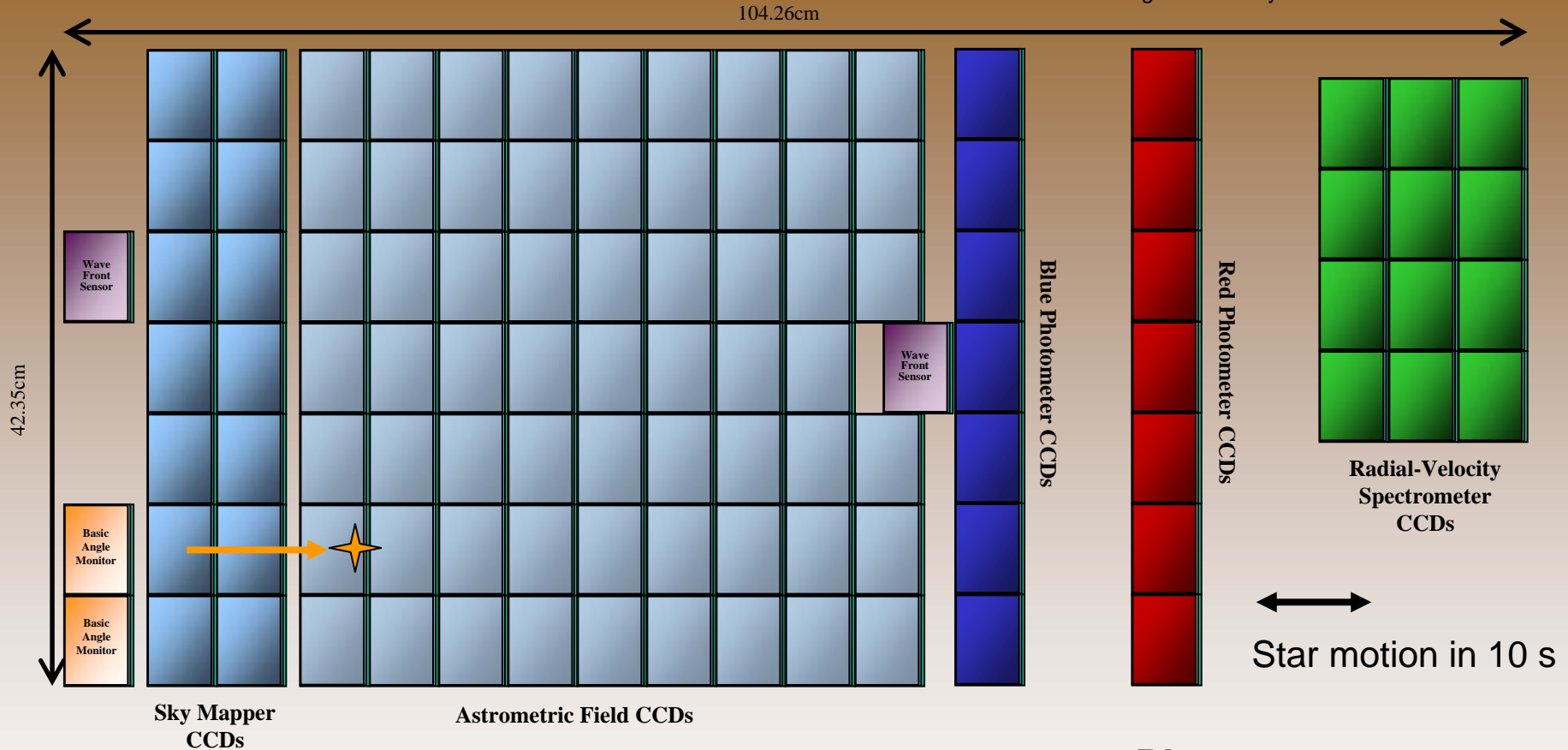


Gaia: Design Considerations

- Astrometry ($V < 20$):
 - completeness to 20 mag (on-board detection) $\Rightarrow 10^9$ stars
 - accuracy: 10–25 μ arcsec at 15 mag
 - scanning satellite, two viewing directions
 - \Rightarrow global accuracy, with optimal use of observing time
 - principles: global astrometric reduction
- Photometry ($V < 20$):
 - astrophysical diagnostics (low-dispersion photometry) + chromaticity
- Radial velocity ($V < 16$ –17):
 - application:
 - third component of space motion, perspective acceleration
 - dynamics, population studies, binaries
 - spectra: chemistry, rotation
 - principles: slitless spectroscopy using Ca triplet (847–874 nm)



Astrometría

**Total field:**

- active area: 0.75 deg^2
- CCDs: $14 + 62 + 14 + 12$
- 4500×1966 pixels (TDI)
- pixel size = $10 \mu\text{m} \times 30 \mu\text{m}$
= $59 \text{ mas} \times 177 \text{ mas}$

Sky mapper:

- detects all objects to 20 mag
- rejects cosmic-ray events
- FoV discrimination

Astrometry:

- total detection noise: $\sim 6 e^-$

Photometry:

- spectro-photometer
- blue and red CCDs

Spectroscopy:

- high-resolution spectra
- red CCDs

Astrometric requirements

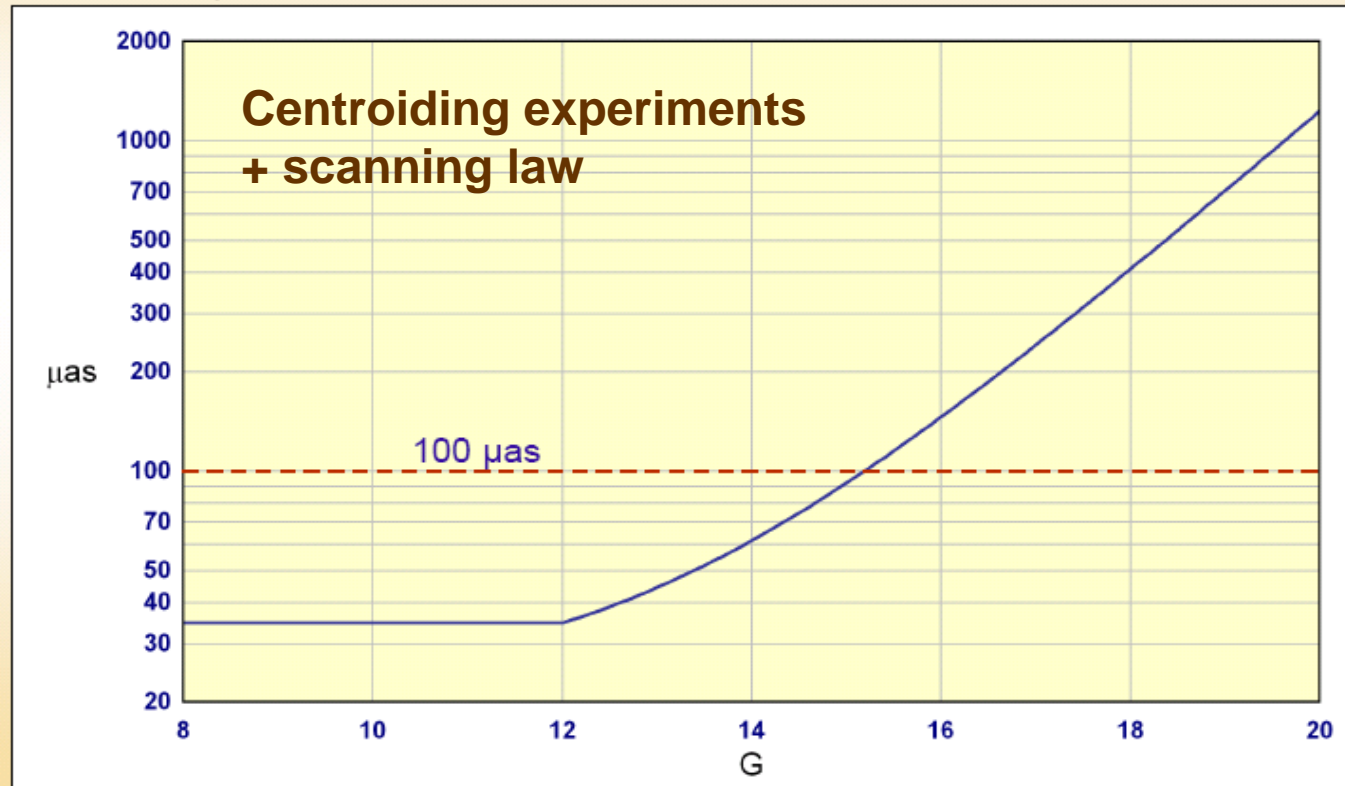
The end-of-mission parallax standard errors (averaged over the sky) for unreddened B1V, G2V, and M6V stars shall be:

	B1V	G2V	M6V
$V < 10$	$< 7 \mu\text{as}$	$< 7 \mu\text{as}$	$< 7 \mu\text{as}$
$V = 15$	$< 25 \mu\text{as}$	$< 24 \mu\text{as}$	$< 12 \mu\text{as}$
$V = 20$	$< 300 \mu\text{as}$	$< 300 \mu\text{as}$	$< 100 \mu\text{as}$

The end-of mission systematic parallax errors for unreddened B1V, G2V, and M6V stars shall be lower than $1 \mu\text{as}$

- Integration over 9 AF CCDs - 40 s
- 1D (AL) astrometry

Single transit



Gaia Astrometric Accuracy Tool (courtesy J. de Bruijne, ESA)

For sky-averaged position and proper-motion errors, σ_0 and σ_μ , the following relations can be used, based on scanning-law simulations:

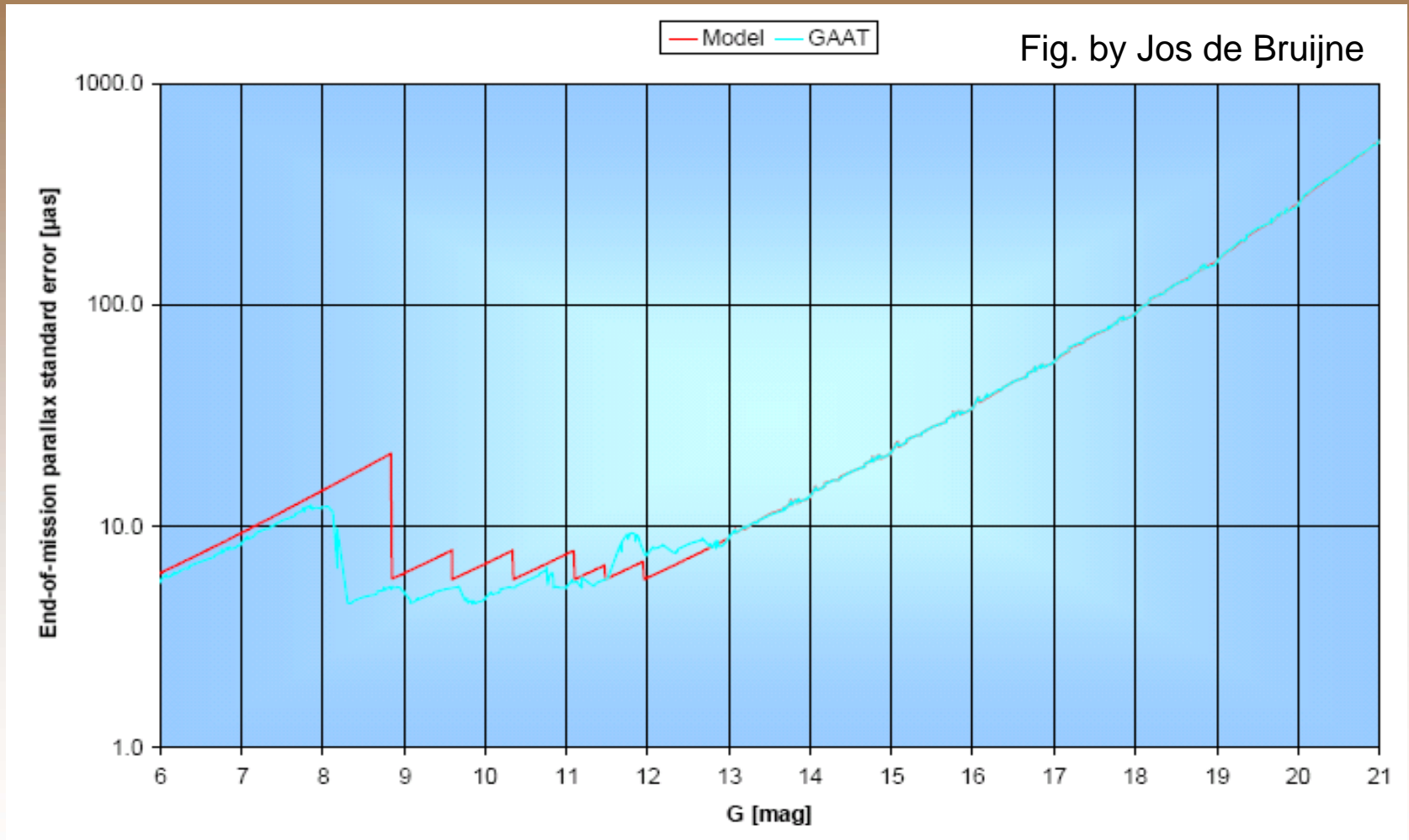
$$\begin{aligned}\sigma_0 &= 0.743 \cdot \sigma_\varpi \\ \sigma_{\alpha^*} &= 0.787 \cdot \sigma_\varpi \\ \sigma_\delta &= 0.699 \cdot \sigma_\varpi \\ \sigma_\mu &= 0.526 \cdot \sigma_\varpi \\ \sigma_{\mu\alpha^*} &= 0.556 \cdot \sigma_\varpi \\ \sigma_{\mu\delta} &= 0.496 \cdot \sigma_\varpi\end{aligned}$$

where the asterisk denotes true arcs on the sky ($\sigma_{\alpha^*} = \sigma_\alpha \cdot \cos \delta$, etc.)

The following table summarises Gaia's performance as function of G:

	G<13	G=13	G=14	G=15	G=16	G=17	G=18	G=19	G=20	G=21
σ_0 [μas]	5.22	6.54	10.17	16.04	25.56	41.35	68.56	117.92	214.20	413.28
σ_ϖ [μas]	7.02	8.81	13.68	21.58	34.41	55.65	92.28	158.70	288.28	556.24
σ_μ [$\mu\text{as yr}^{-1}$]	3.69	4.63	7.20	11.35	18.10	29.27	48.54	83.48	151.64	292.58

Gaia Astrometric Accuracy Tool (courtesy J. de Bruijne, ESA)



Number of transits

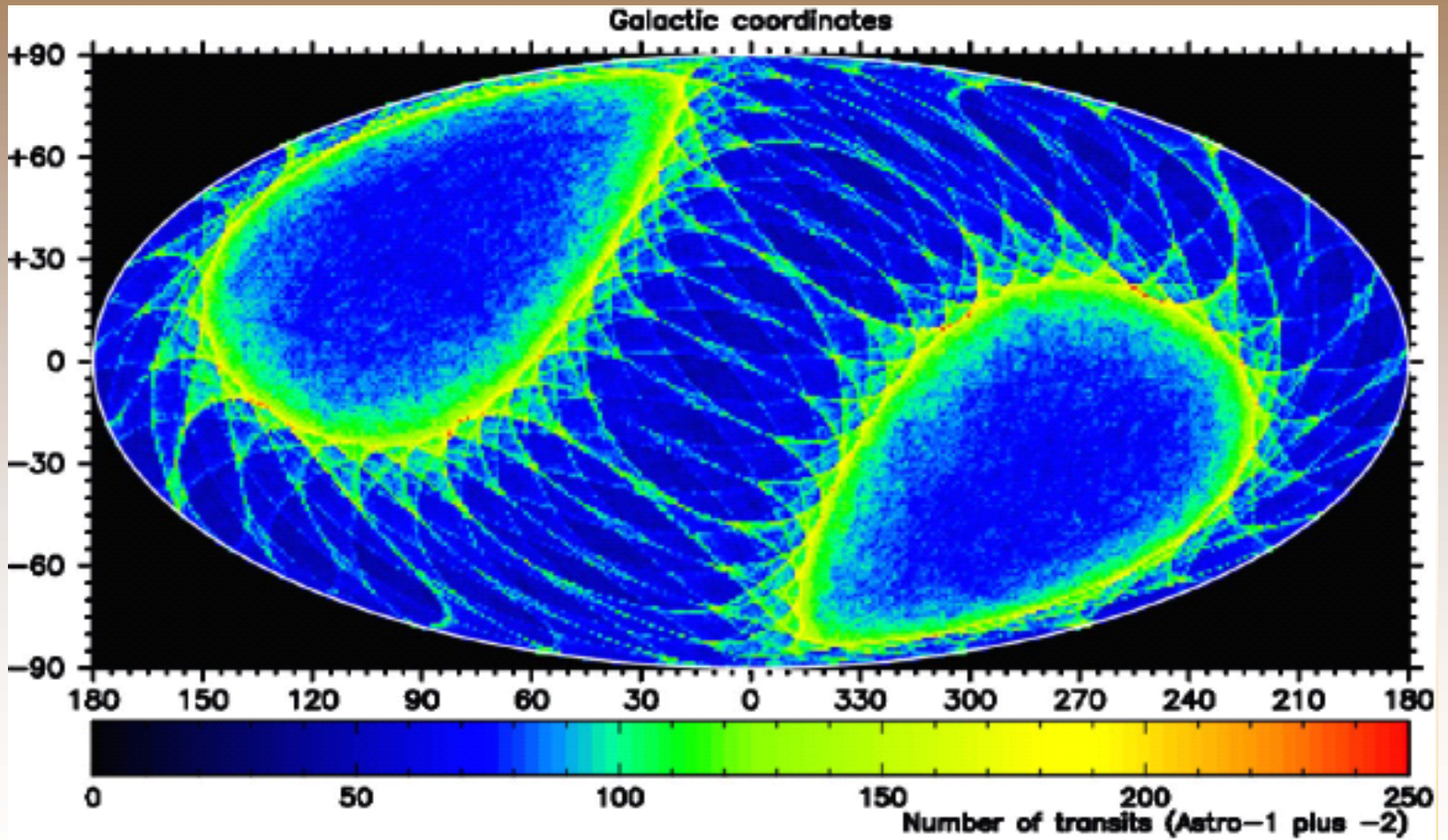
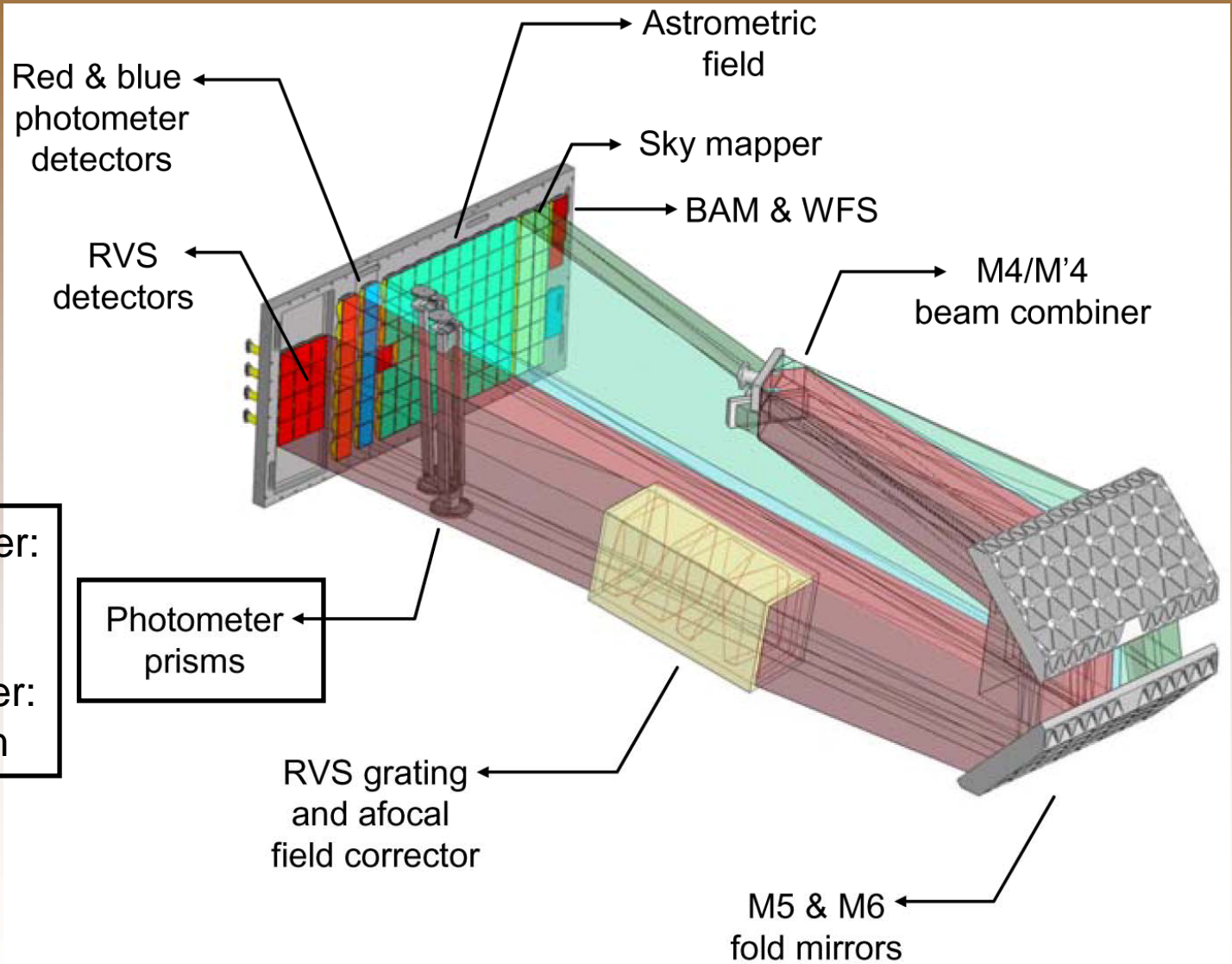


Table 5. Distances for which the relative parallax error is $\sim 10\%$: d_o is the value of this distance for zero interstellar extinction and d_{abs} is the value for an average Galactic plane interstellar extinction of 0.7 mag kpc^{-1} . $V(d_o)$ and $V(d_{\text{abs}})$ are the corresponding apparent V magnitudes. Parallax accuracies are from Table 8.4 in ESA (2000)

SP	M_V	$d_o(\text{pc})$	$V(d_o)$	$d_{\text{abs}}(\text{pc})$	$V(d_{\text{abs}})$	SP	M_V	$d_o(\text{pc})$	$V(d_o)$	$d_{\text{abs}}(\text{pc})$	$V(d_{\text{abs}})$
B1 V	-3.2	20 000	13.2	7000	15.7	G8 III	0.8	9000	15.6	4400	17.1
A0 V	0.65	8500	15.2	4500	16.8	K3 III	0.3	10 000	15.3	4800	17.1
A3 V	1.5	7000	15.7	3800	17.1	M0 III	-0.4	13 000	15.2	5500	17.2
A5 V	1.95	6500	16.0	3500	17.3	M7 III	-0.3	17 000	15.9	6300	18.1
F2 V	3.6	4500	16.7	2700	17.8						
F8 V	4.0	4000	17.0	2500	18.1	B0 Ib	-6.1	33 000	11.5	9500	15.4
G2 V	4.7	3500	17.2	2200	18.2						
K3 V	6.65	2400	18.4	1700	19.1	WD	8.0	1500	18.9	1200	19.2
M0 V	8.8	1500	19.7	1200	20.0						
M8 V	13.5	500	21.8	450	22.1						



Fotometría

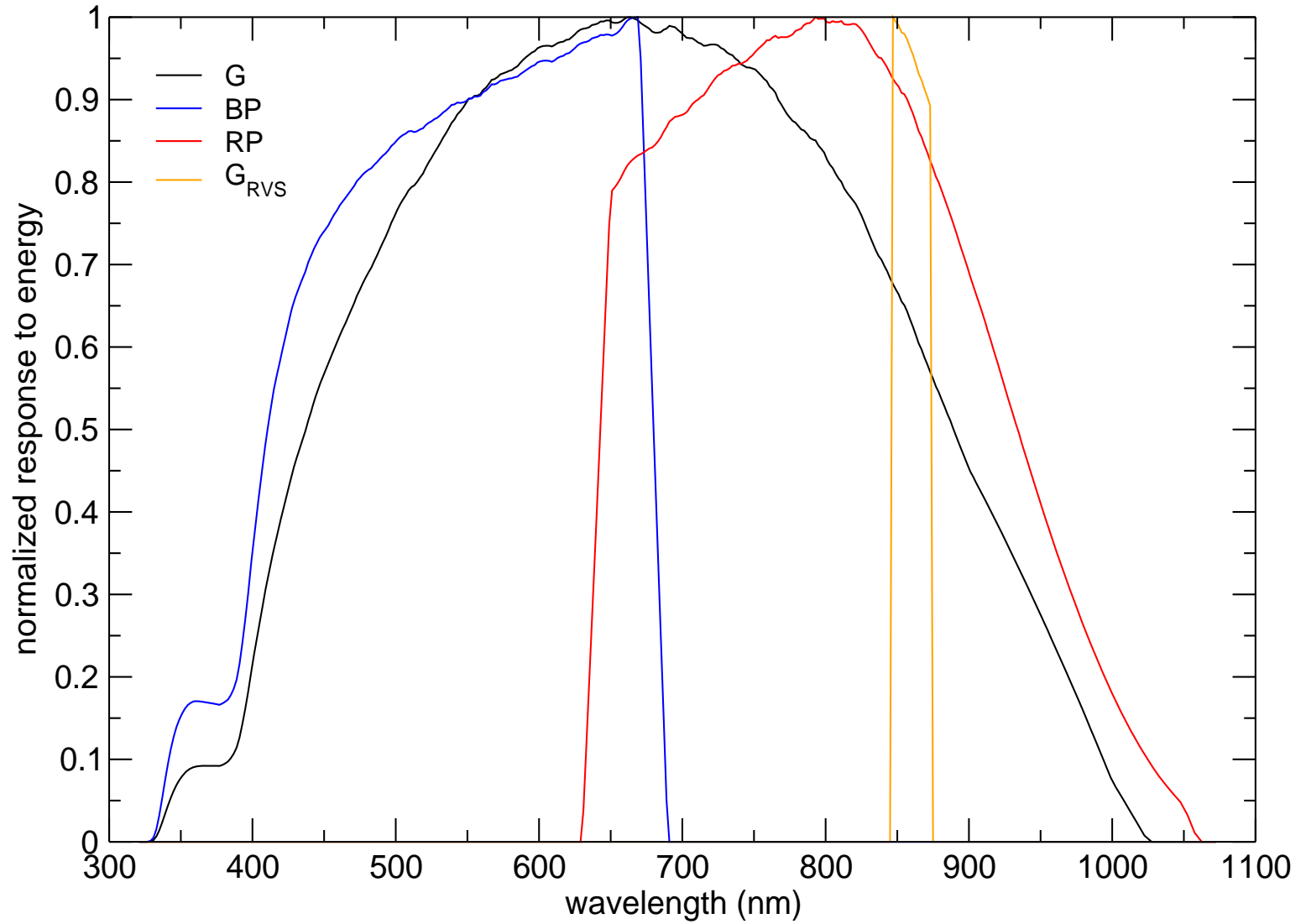


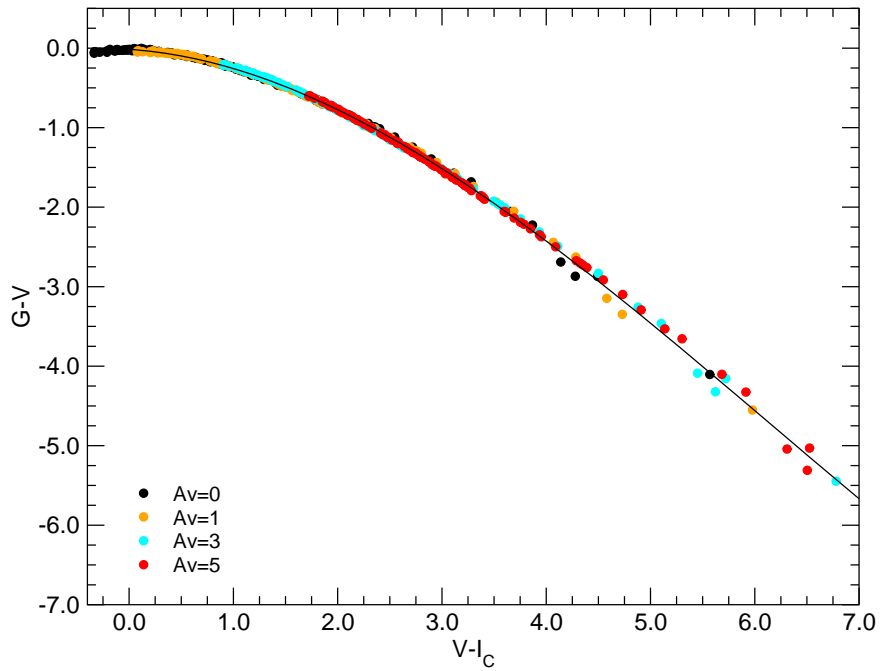
Blue photometer:
330–680 nm

Red photometer:
640–1000 nm

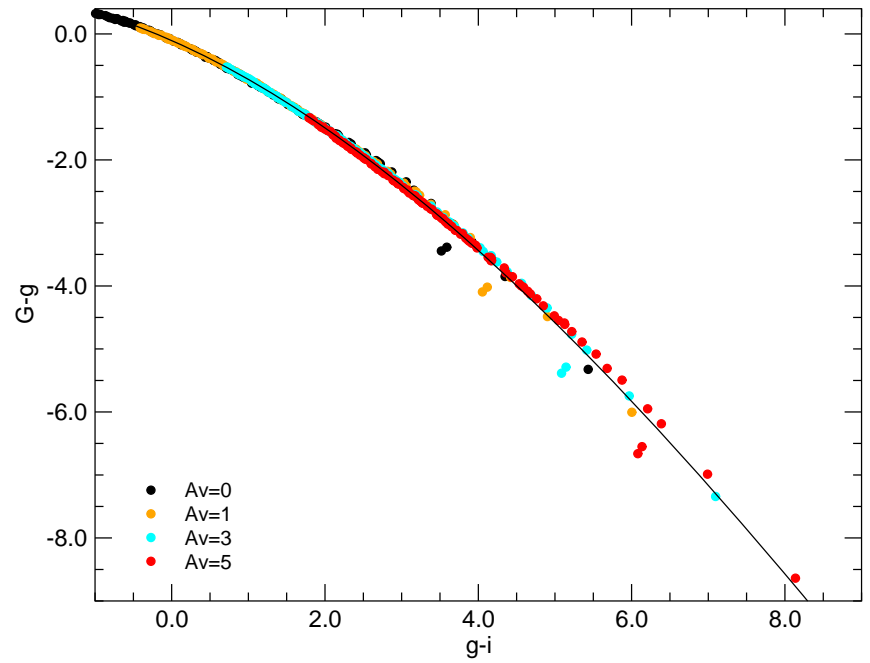


G magnitude (white light)

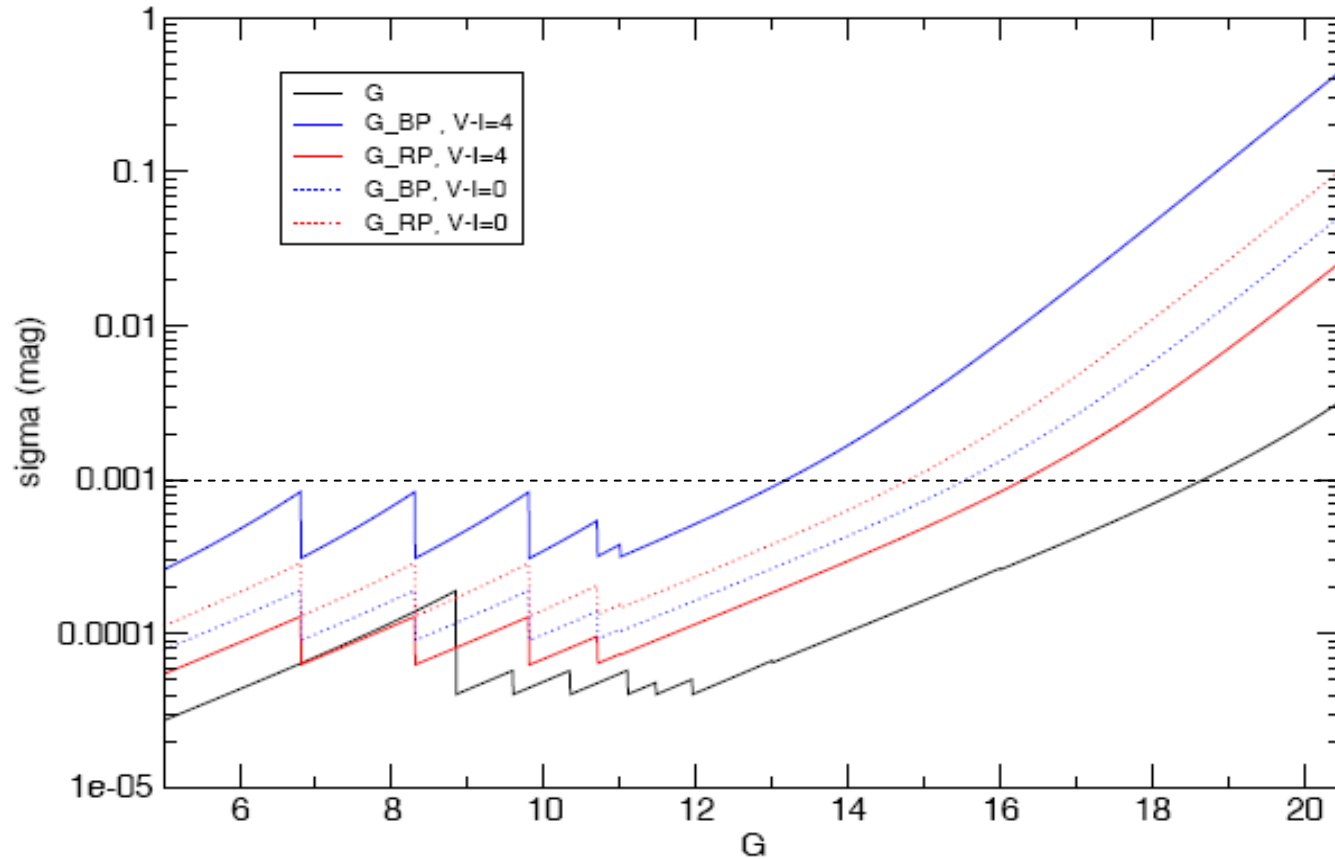




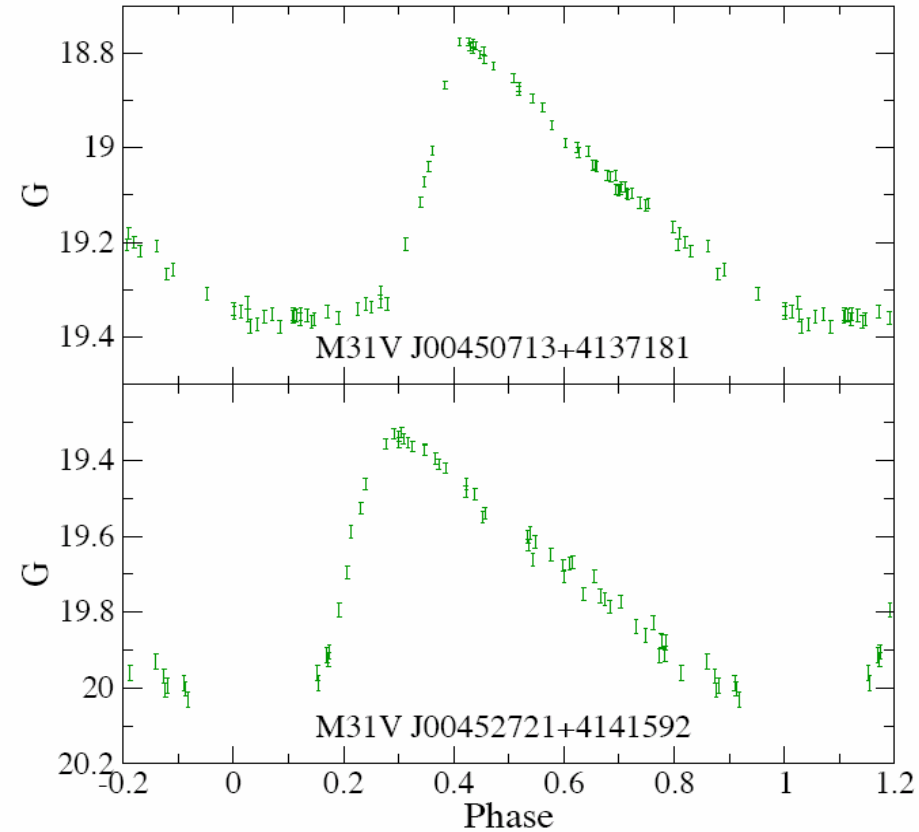
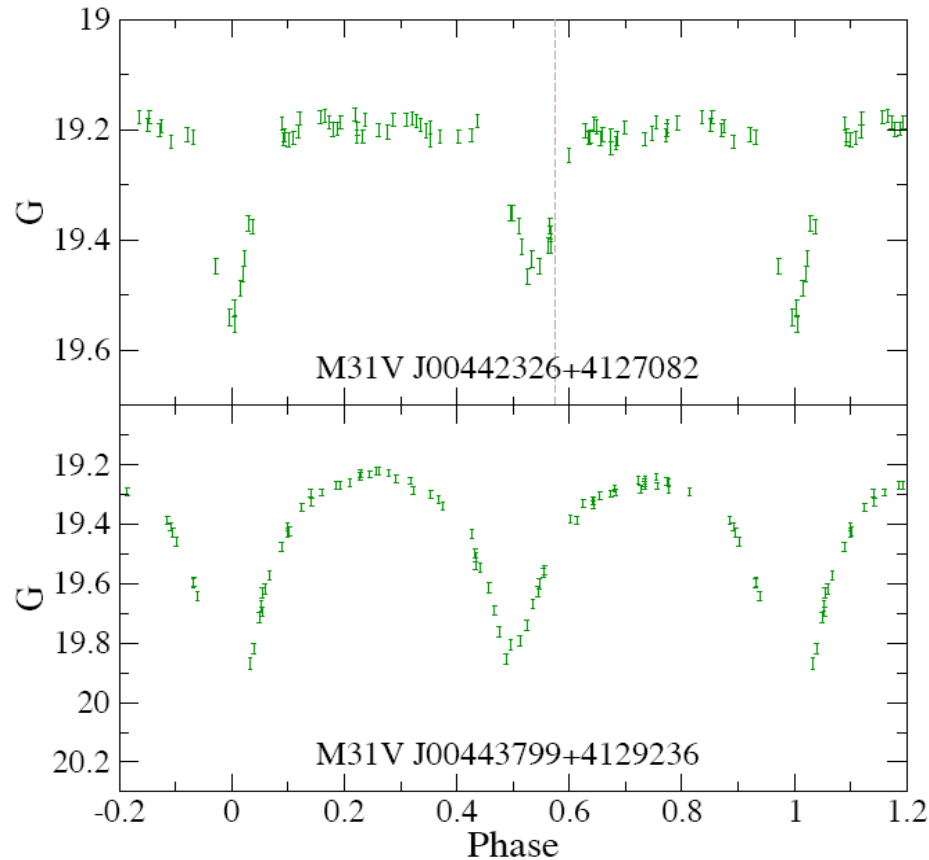
131 spectra in Pickles (1998, PSAP 110,863)



σ_G end-of-mission, sky-averaged

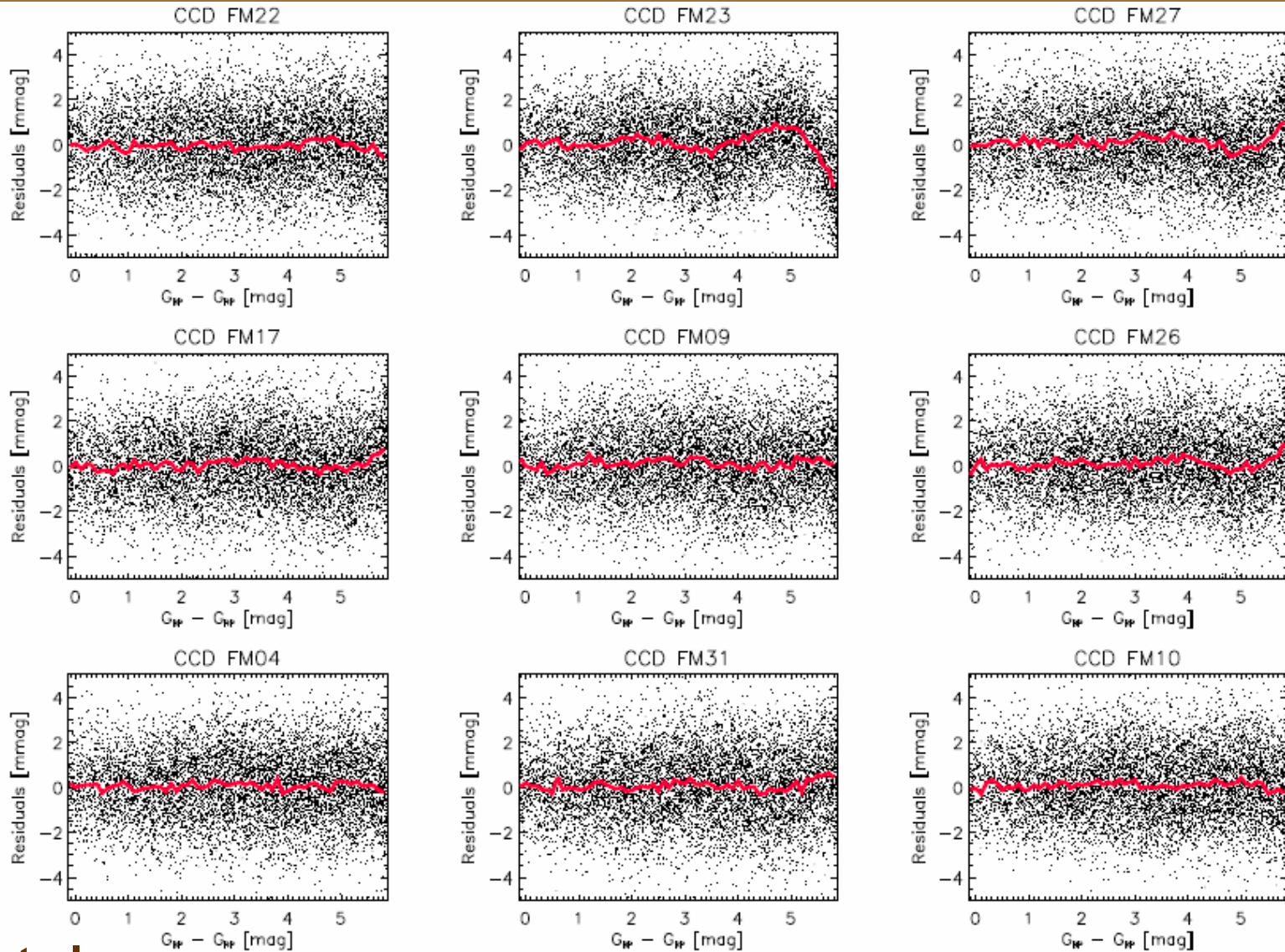


apperture photometry approach

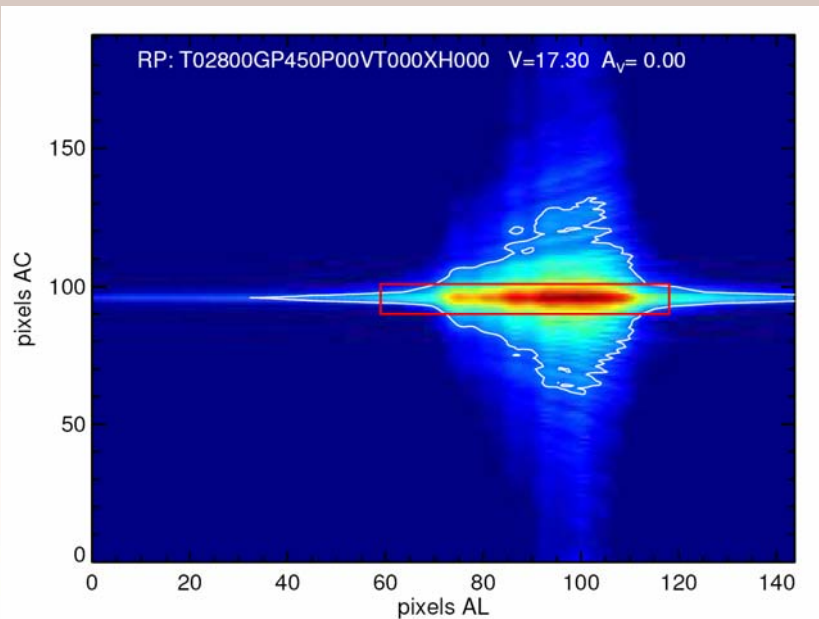
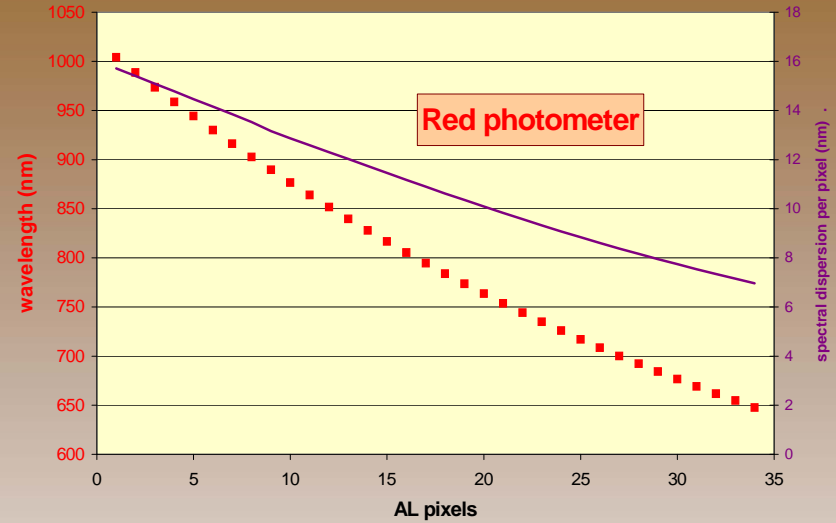
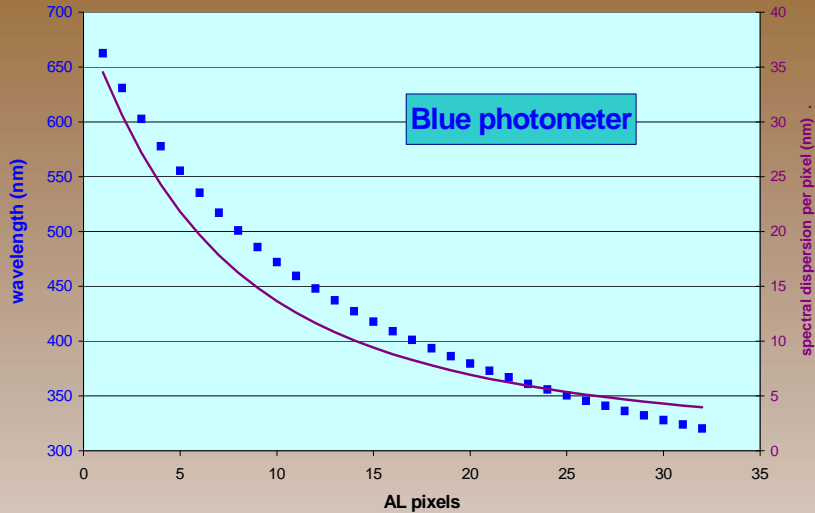


Light curves of stars in M31

Vilardell et al



Voss et al

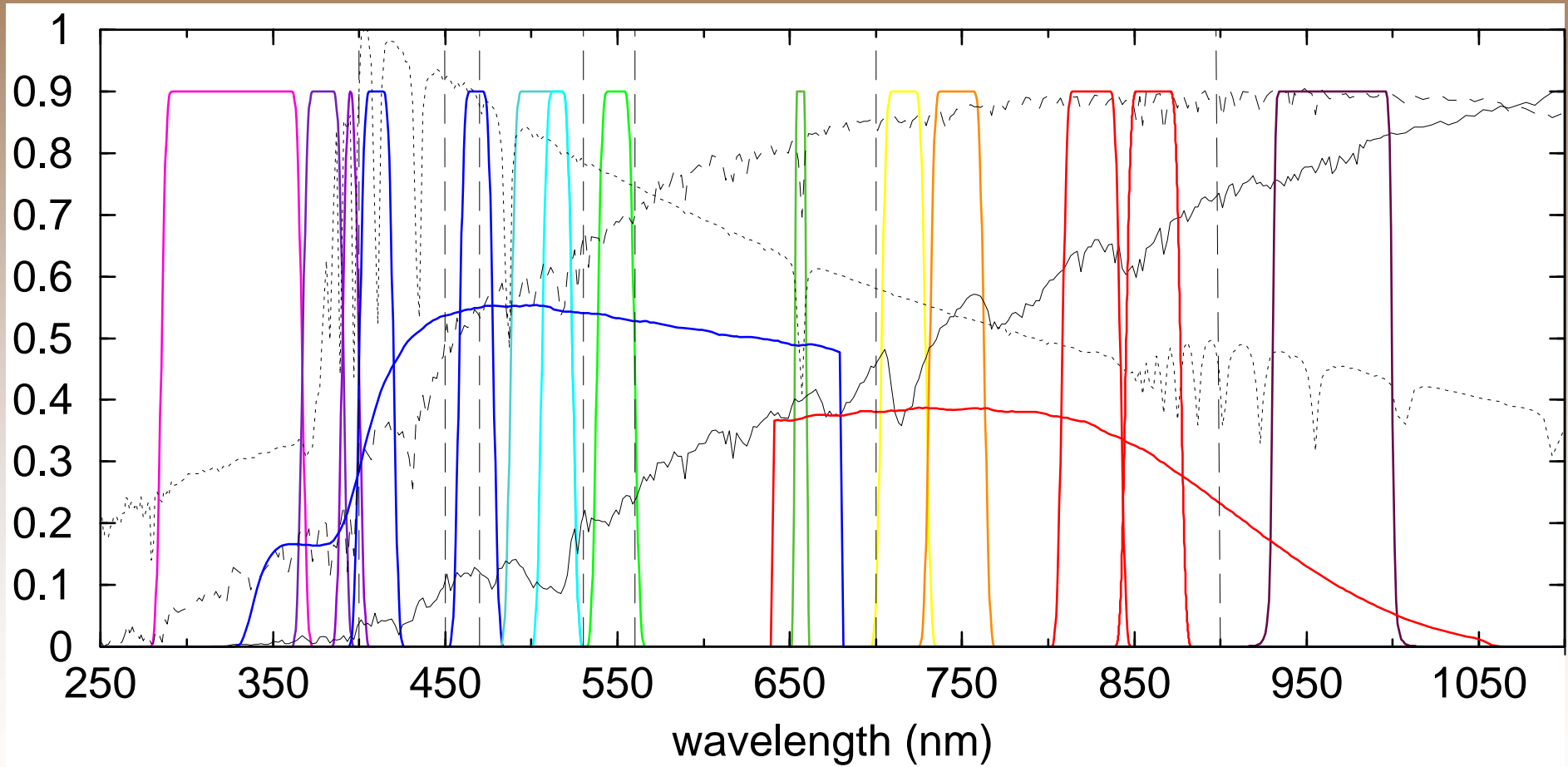


RP spectrum of M dwarf (V=17.3)
 Red box: data sent to ground
 White contour: sky-background level
 Colour coding: signal intensity

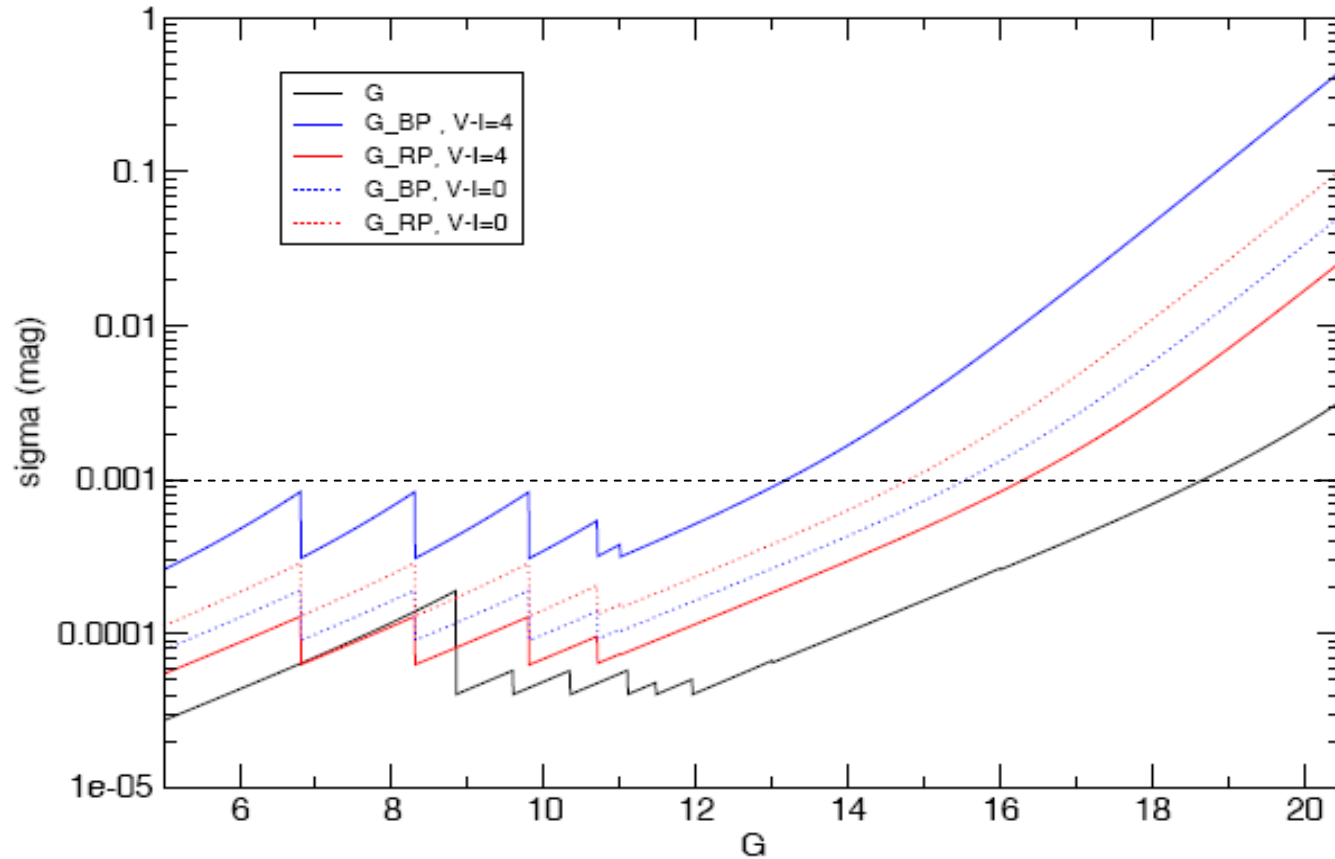


Medium band photometry

Jordi et al (2006)



σ_G end-of-mission, sky-averaged

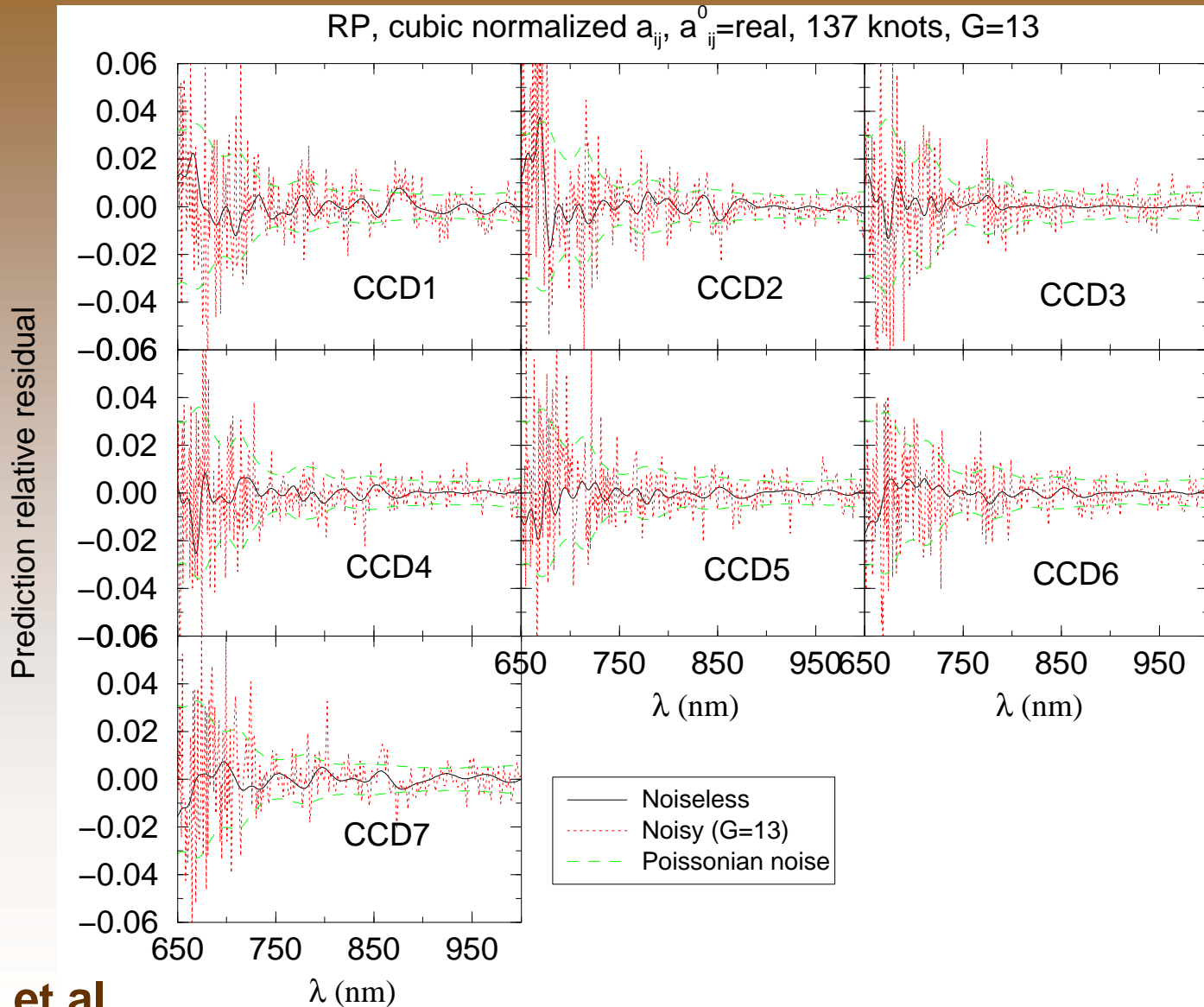


apperture photometry approach



Precisions de Gaia

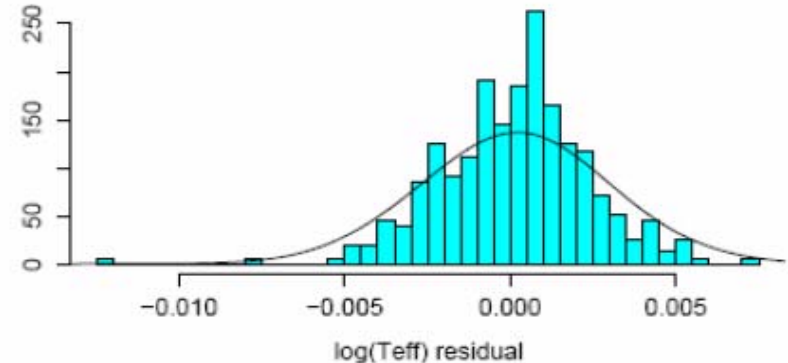
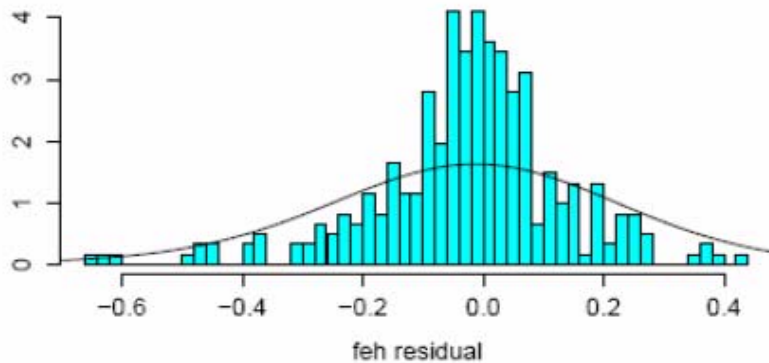
$T=2950K$, $\log g=0.7$, 56 obs, $\lambda_{src} = \lambda_{CCD3}$



Carrasco et al

	T_{eff}	A_v	$\log g$	$[M/H]$	$[\alpha/Fe]$
$G < 16$	$< 5\%$	0.05-0.2	0.2-0.3	0.2-0.4	0.2
$G = 18$	5-15%	0.05-0.3	0.2-0.5	0.5-0.7	?

- Ranges in errors reflect the influence of the spectral type, metallicity



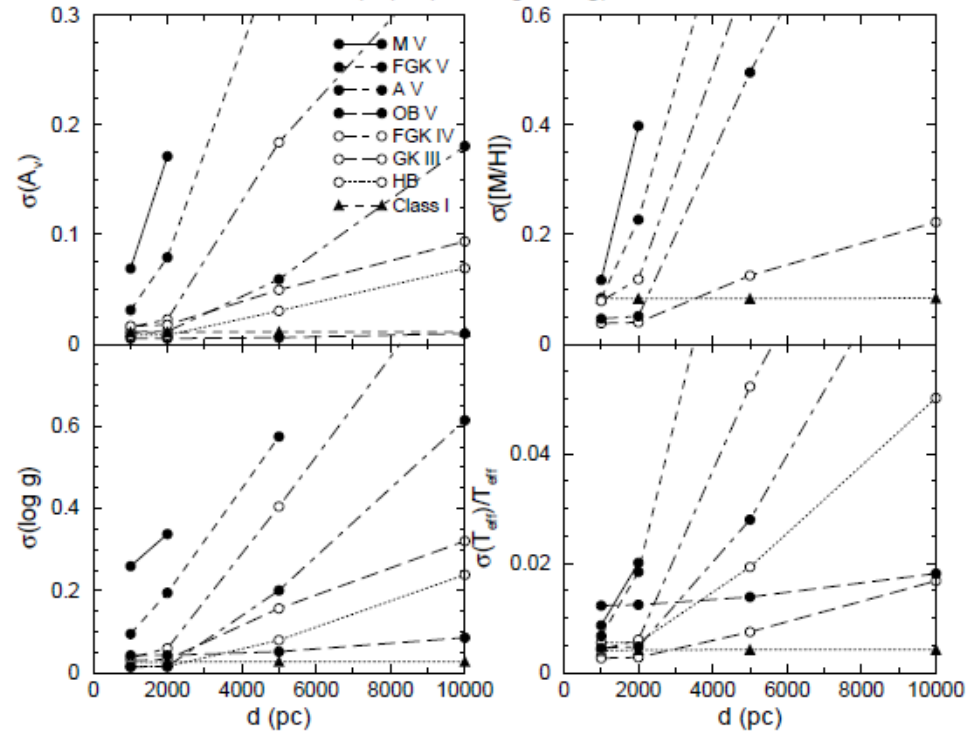
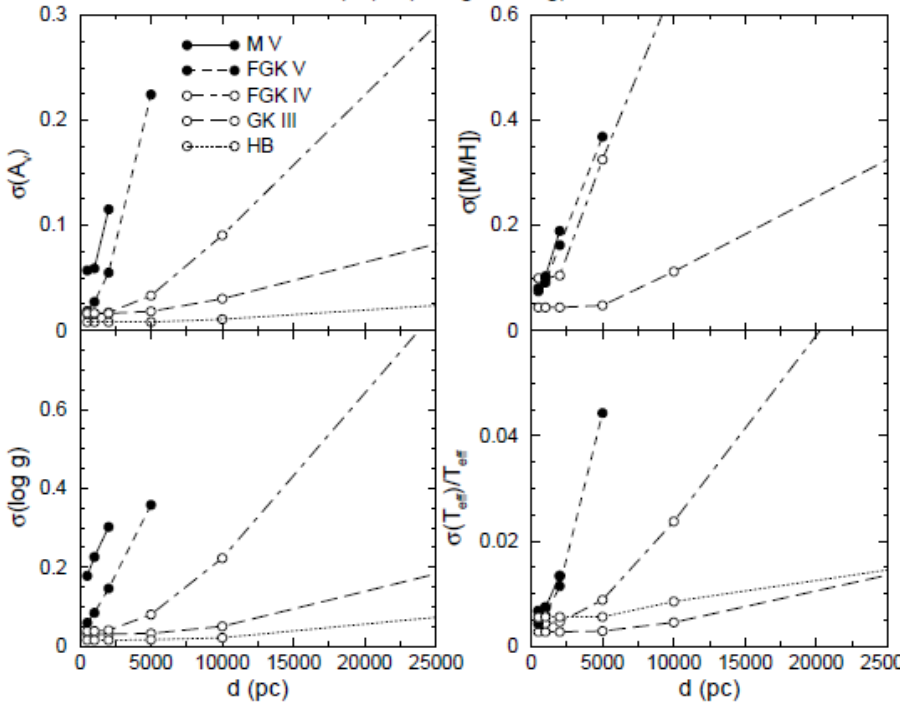
dwarfs, $G = 15$, $T < 7000 \text{ K}$, $[Fe/H] > -2$

C. Bailer-Jones, GAIA-C8-TN-MPIA-CBJ-043



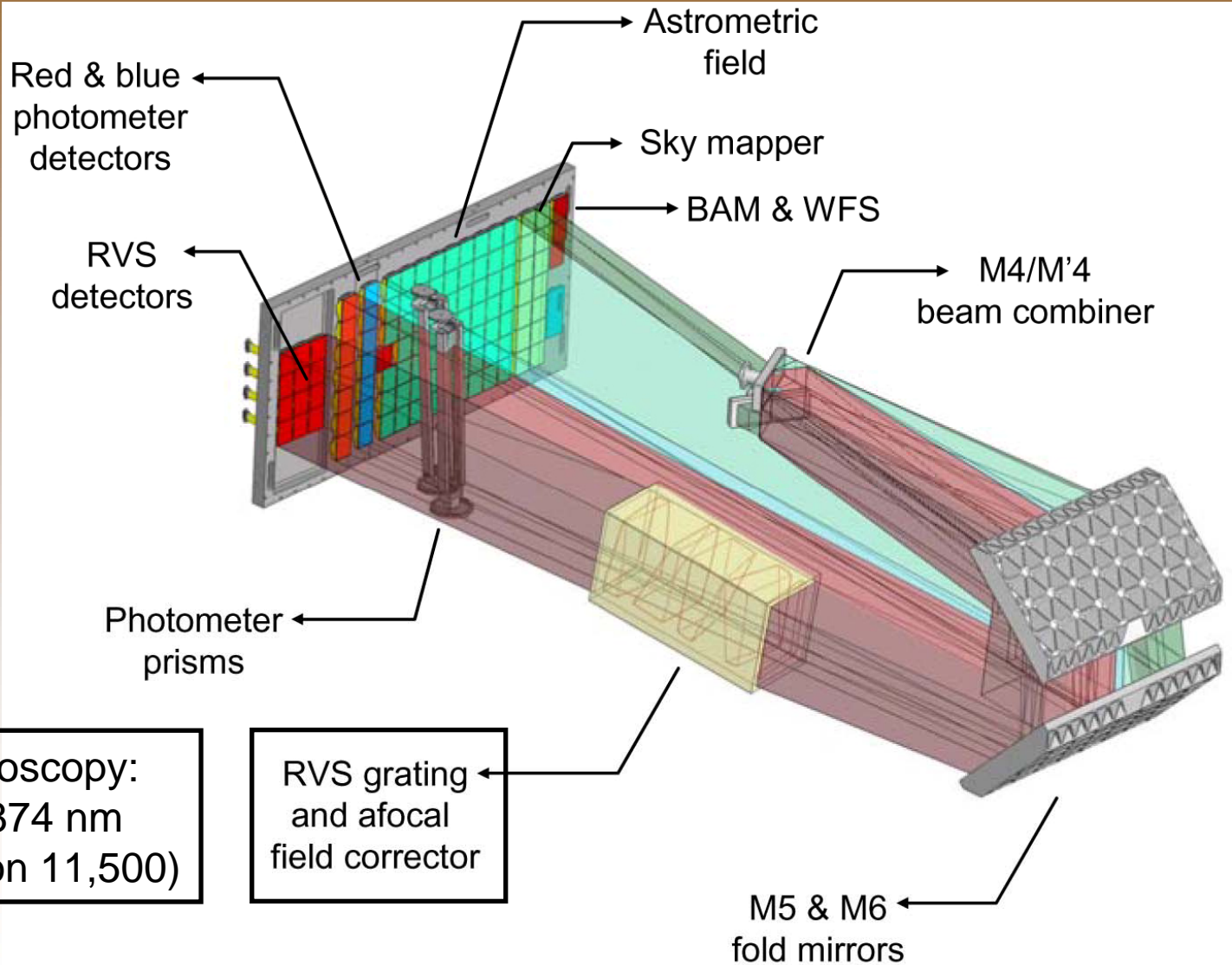
(l,b) = (0 deg, 90 deg)

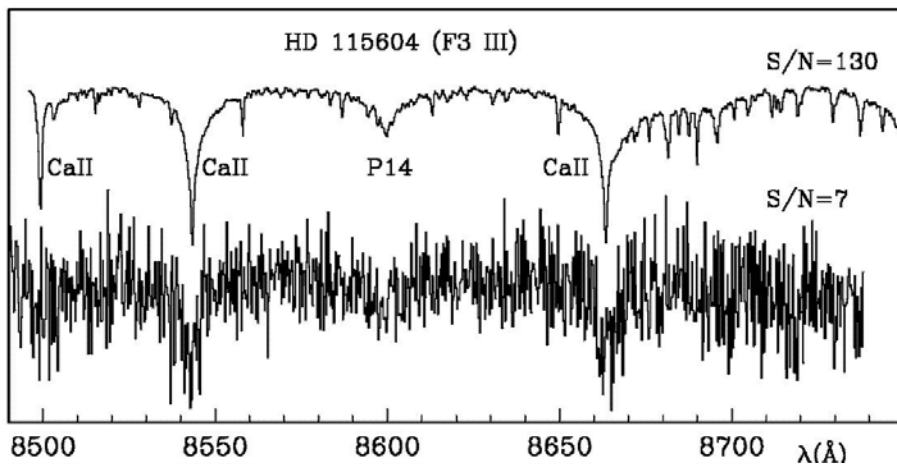
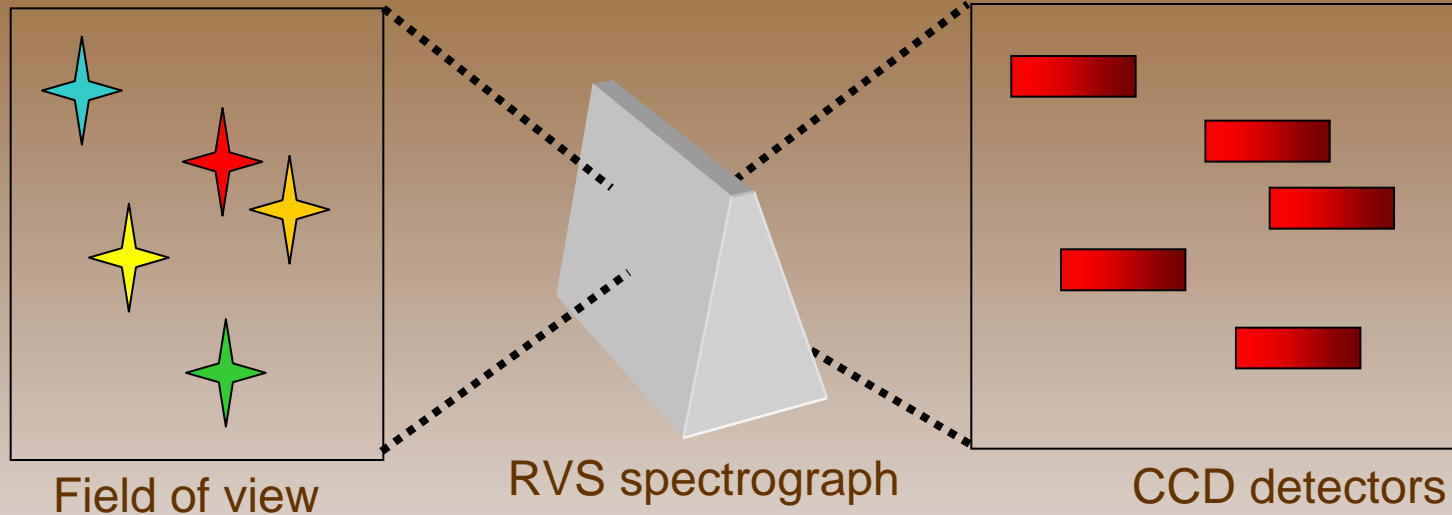
(l,b) = (180 deg, 0 deg)





Espectroscopía





RVS spectra of F3 giant ($V=16$ mag)
S/N = 7 (single measurement)
S/N = 130 (summed over mission)

Spectroscopic requirements

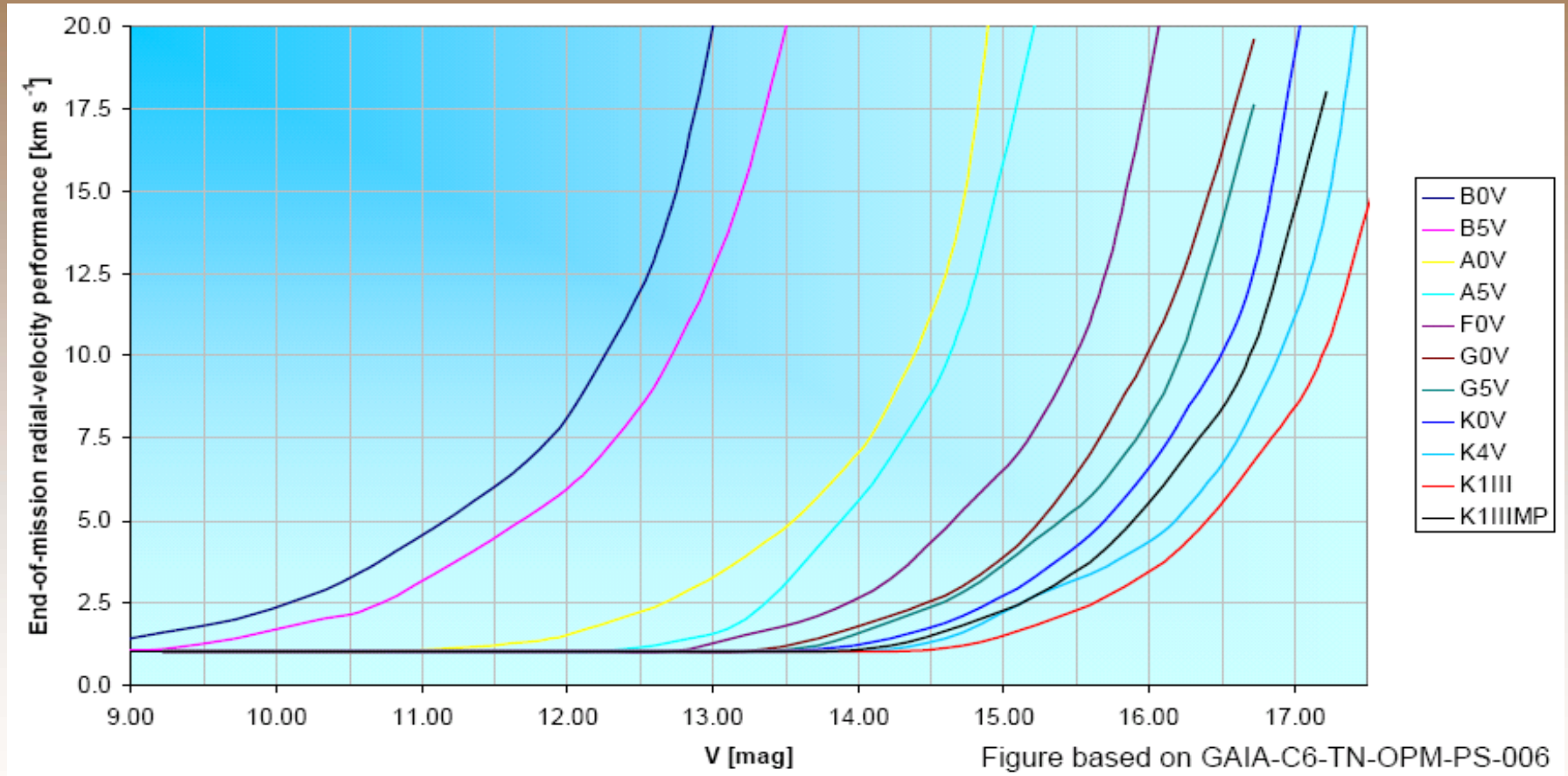
The following end-of-mission radial velocity performance shall be met:

Stellar type	V (mag)	Performance (km s ⁻¹)
B1V	7.0	1
G2V	13.0	1
K1IIIIMP	13.5	1
B1V	12.0	15
G2V	16.5	15
K1IIIIMP	17.0	15

The maximum instrumental systematic radial-velocity error after calibration shall be smaller than 300 m s⁻¹



Precisions de Gaia





Main caveats

1. Radiation damage (shape deformation AL)
astrometry: flux loss included
residual bias-calibration errors not included
photometry & RVS: not included
2. Serial register charge loss (shape deformation AC)
consolidated information is lacking
3. Offset non-uniformity
residual errors or calibration errors not included
(preliminary indications yield errors < 3 e-
astrometric degradations < 1%)

Current estimations include a 20% margin
is it enough ? threshold needed ?

PLM CDR (March 2010) and s/c CDR (Summer 2010)