



Gaia

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Science Capabilities

- Astrometry
 - absolute μ arcsec accuracy only achievable from space
- Photometry
 - required for astrometric colour correction and provides science
- Spectroscopy
 - the lesson learnt from Hipparcos: get the radial velocities too



Science Topics

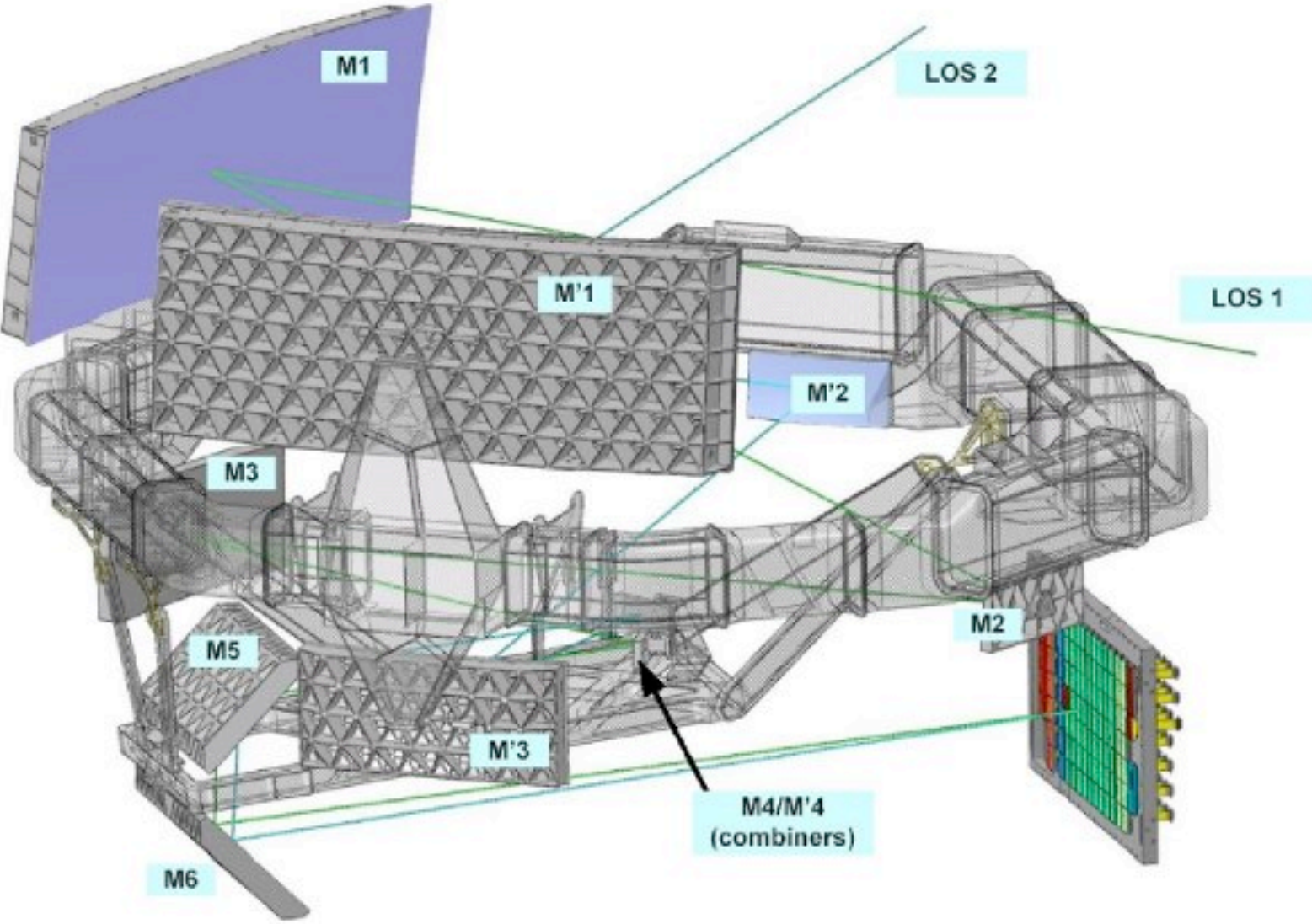
- Structure and dynamics of the Galaxy
- The star formation history of the Galaxy
- Stellar astrophysics
- Binaries and multiple stars
- Brown dwarfs and planetary systems
- Solar system
- Galaxies, Quasars and the Reference Frame
- Fundamental physics: General relativity



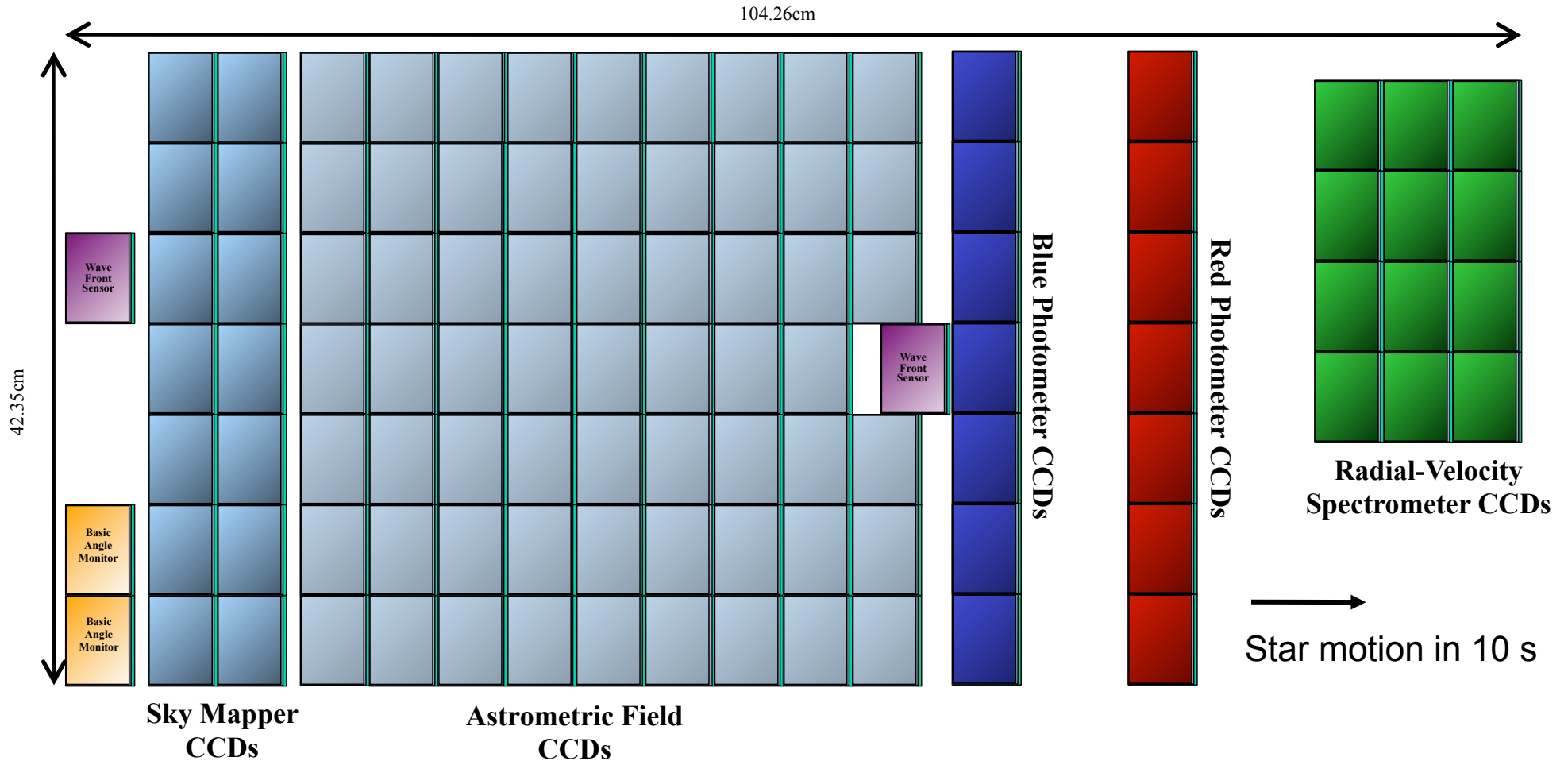
Gaia: Complete, Faint, Accurate

	Hipparcos	Gaia
Magnitude limit	12 mag	20 mag
Completeness	7.3 – 9.0 mag	20 mag
Bright limit	0 mag	6 mag
Number of objects	120,000	26 million to $V = 15$ 250 million to $V = 18$ 1000 million to $V = 20$
Effective distance	1 kpc	50 kpc
Quasars	1 (3C 273)	500,000
Galaxies	None	1,000,000
Accuracy	1 milliarcsec	7 μ arcsec at $V = 10$ 10 – 25 μ arcsec at $V = 15$ 300 μ arcsec at $V = 20$
Photometry	2-colour (B and V)	Low-res. spectra to $V = 20$
Radial velocity	None	15 km s ⁻¹ to $V = 17$
Observing	Pre-selected	Complete and unbiased

Payload and Telescope



Focal Plane



Total field:

- active area: 0.75 deg^2
- CCDs: $14 + 62 + 14 + 12 (+ 4)$
- 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
- field-of-view discrimination

Astrometry:

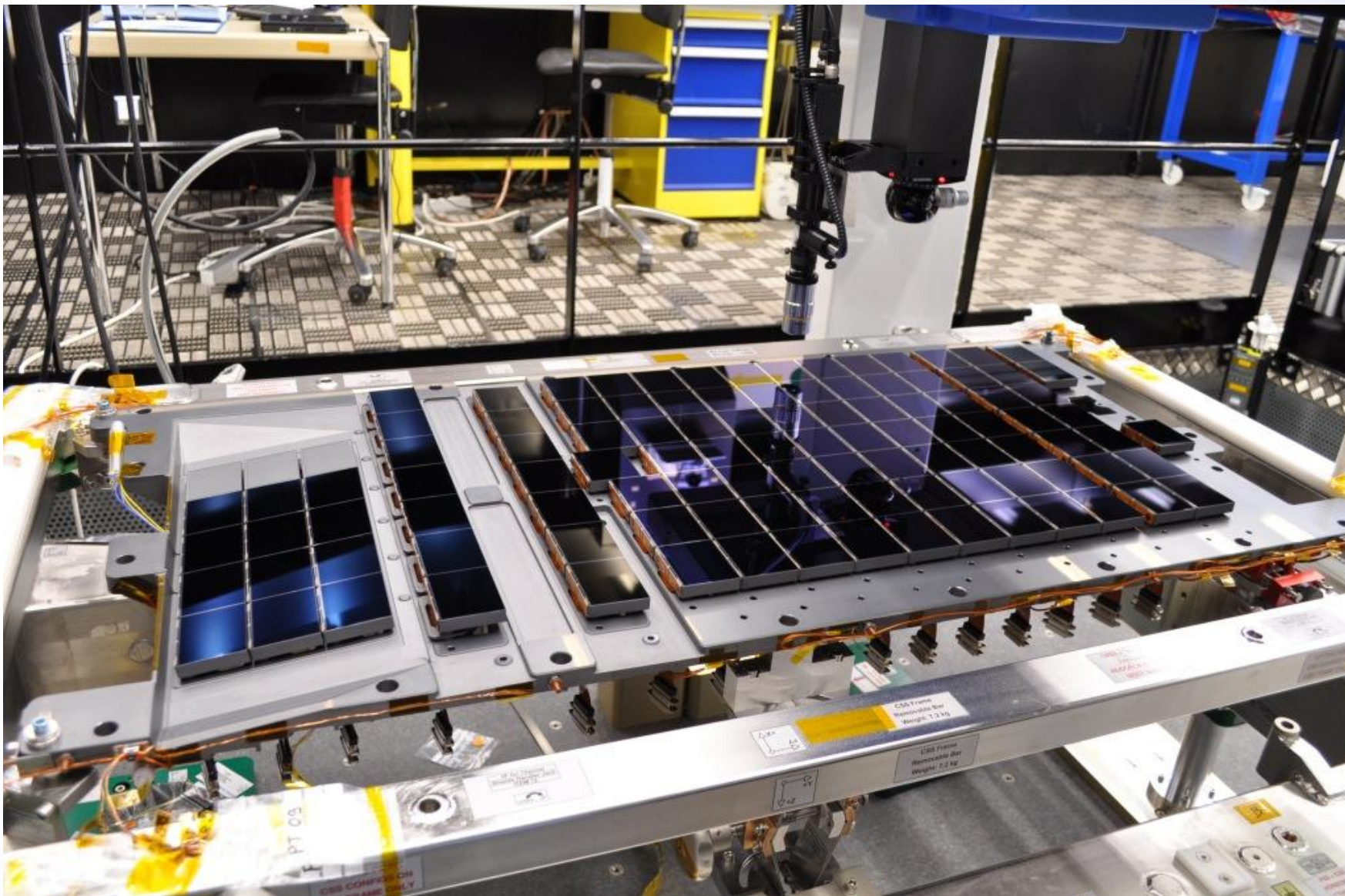
- total detection noise $\sim 6 e^-$

Photometry:

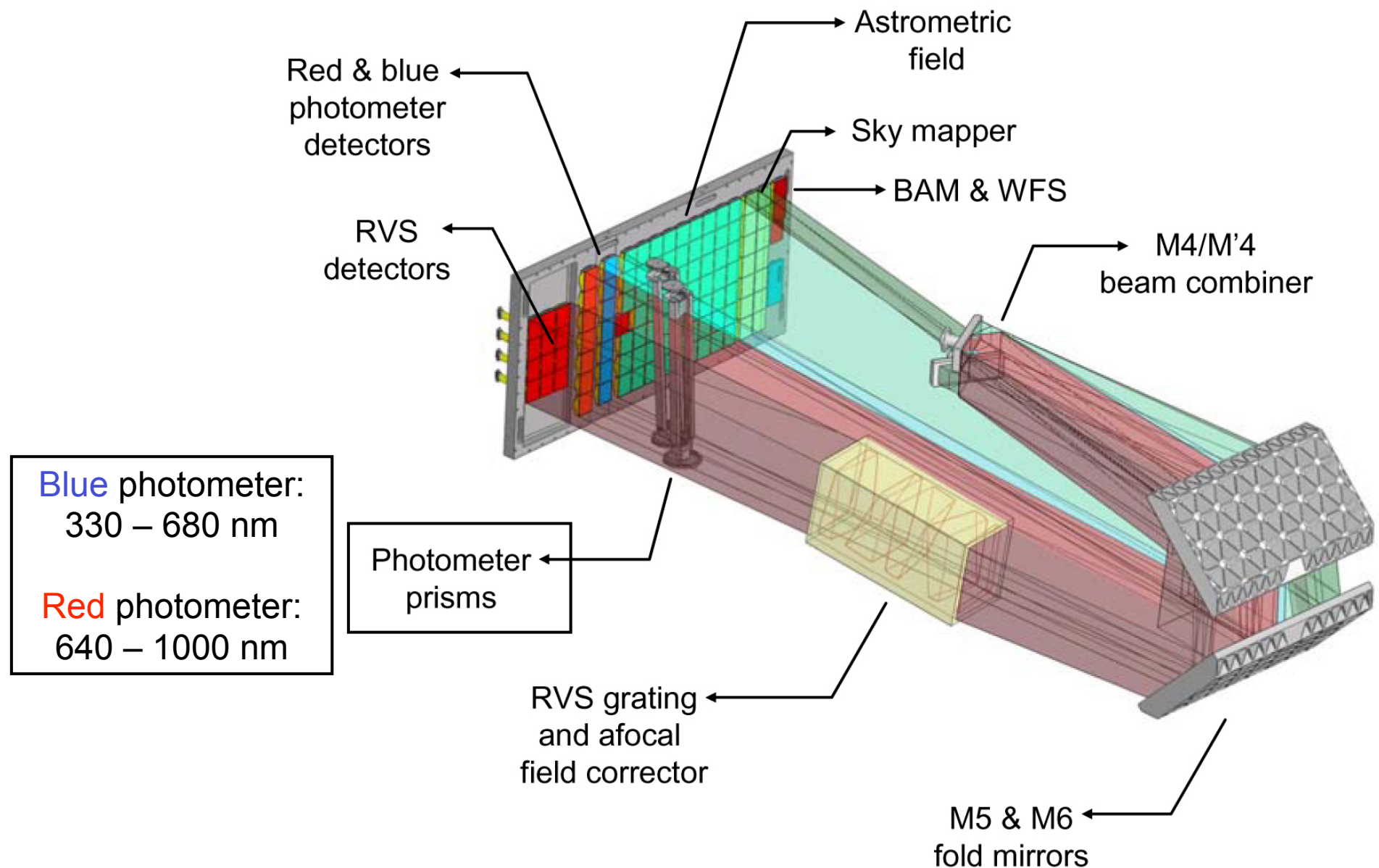
- spectro-photometer
- blue and red CCDs

Spectroscopy:

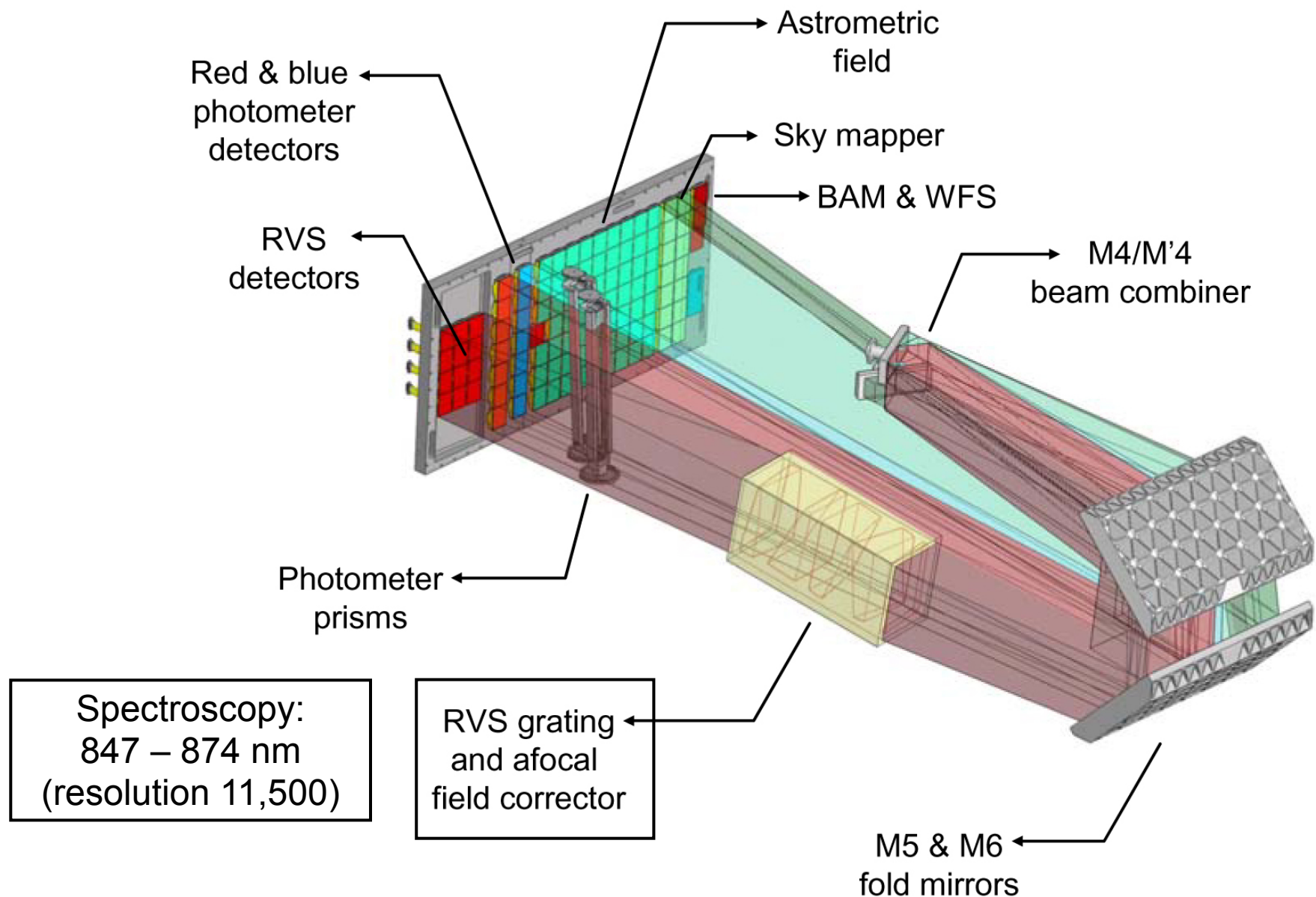
- high-resolution spectra
- red CCDs



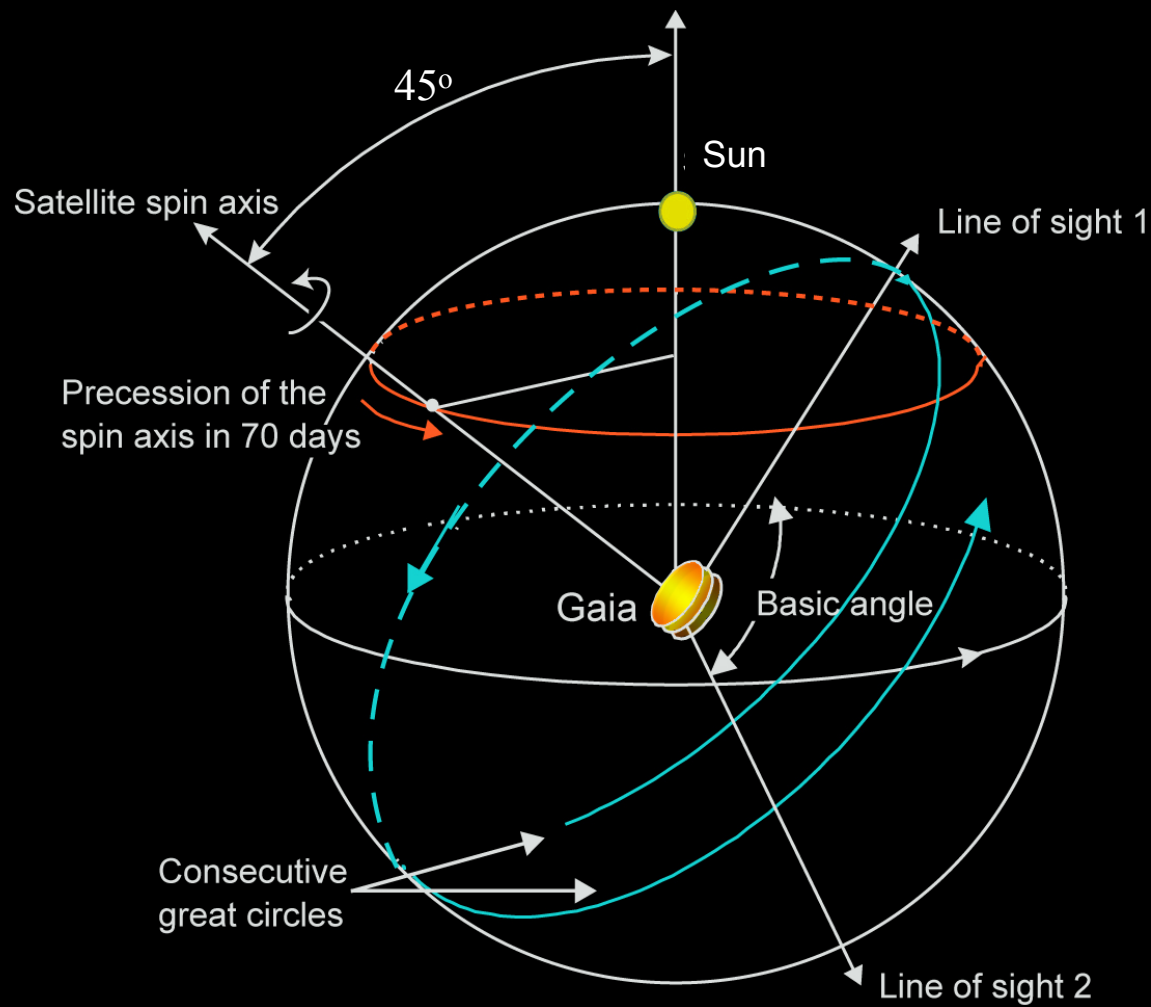
Photometry Measurement Concept



Radial-Velocity Measurement Concept

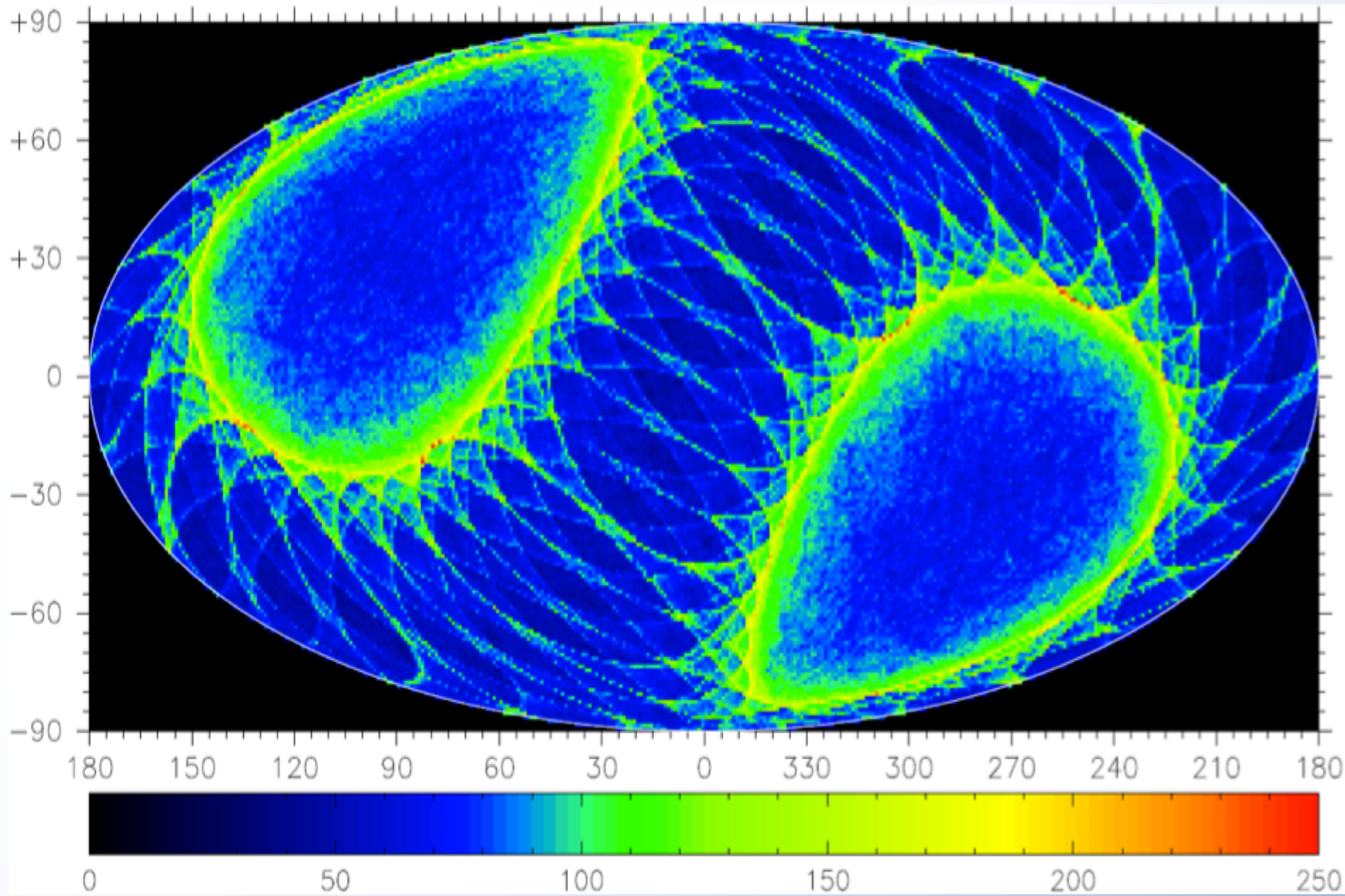


Sky-Scanning Principle



Spin axis	45° to Sun
Scan rate:	60 arcsec s ⁻¹
Spin period:	6 hours

Number of focal-plane observations in Galactic coordinates

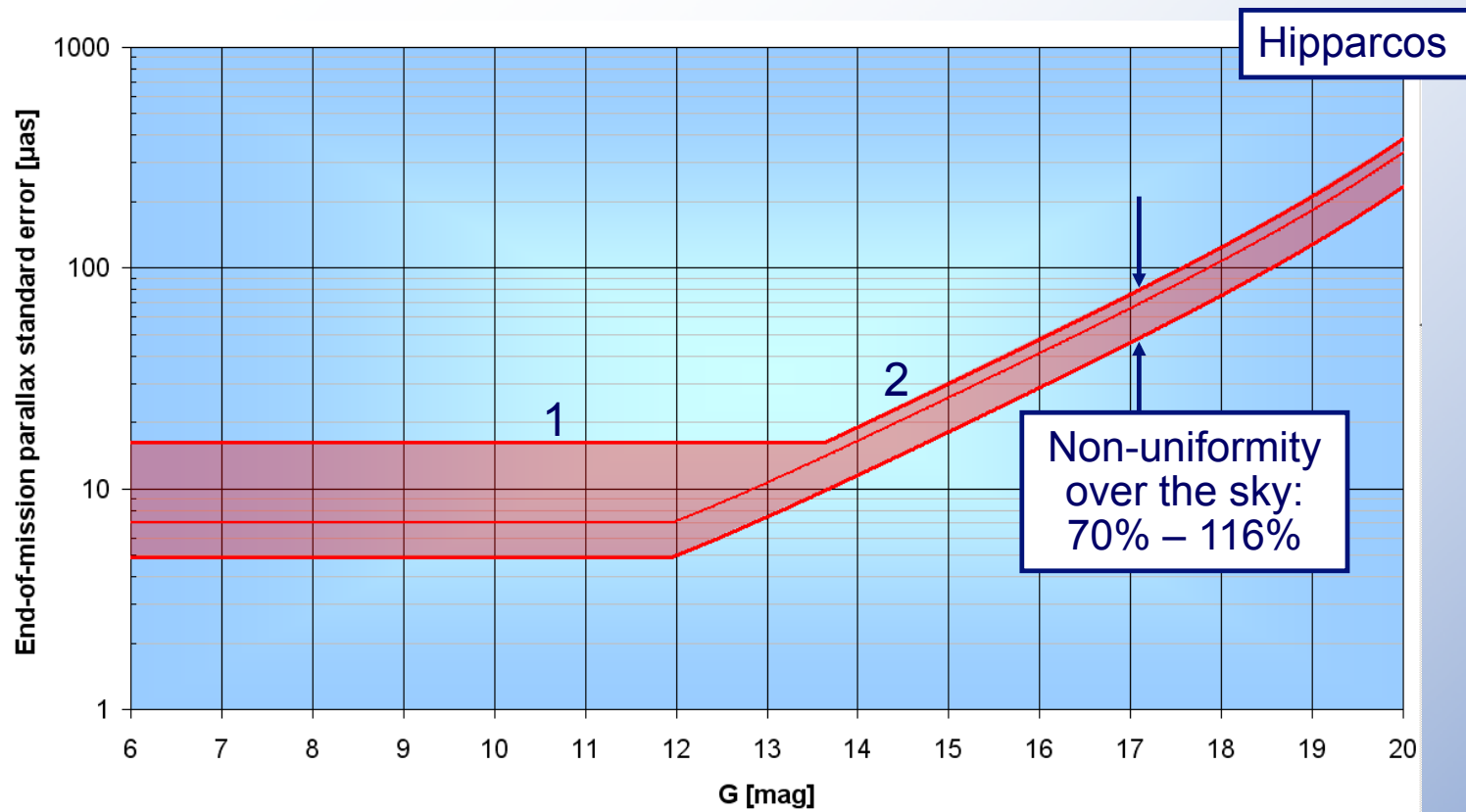


Science Volume

- Astrometry & Photometry for at least one billion stars (1% of the stars in the Milky Way)
- One billion objects observed on the average 70 times over 5 year mission is 40 million stars a day (and more than 400 million measurements a day)
- Spectroscopy of 150 million stars i.e. 10 million spectra a day of 3.3 million stars



Astrometry



1. $6 < G < 12$: bright-star regime (calibration errors, CCD saturation)
2. $12 < G < 20$: photon-noise regime, with sky-background noise and electronic noise setting in around $G \sim 20$ mag



Parallax horizon for G0V stars (no extinction)

10 kpc



Parallax horizon for G0V stars

10 kpc

$A_V = 0$

$A_V = 5 \text{ mag}$

20%

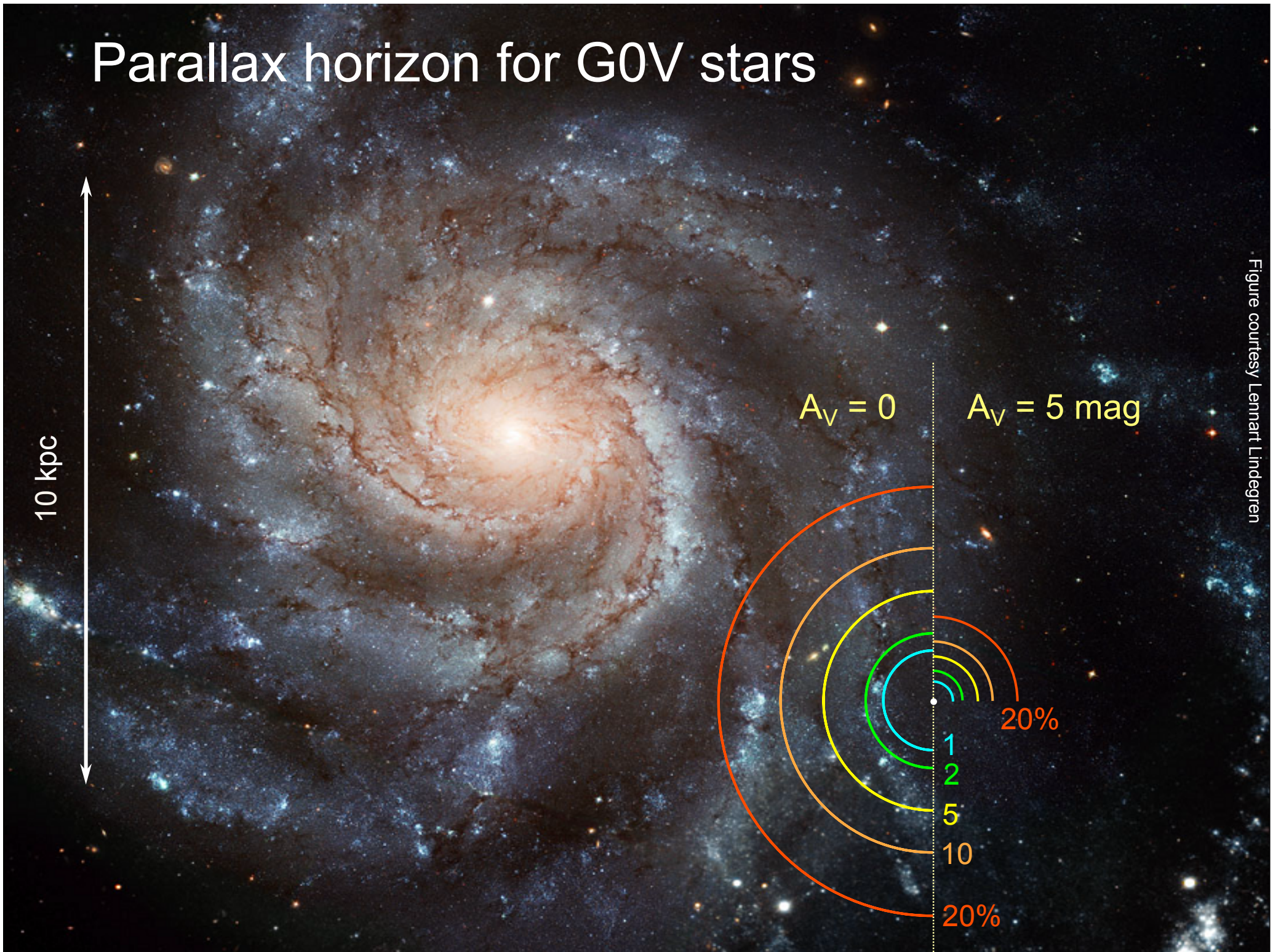
1

2

5

10

20%



Parallax horizon for K5III stars

10 kpc

$A_V = 0$

$A_V = 5 \text{ mag}$

10

1

2

5

1

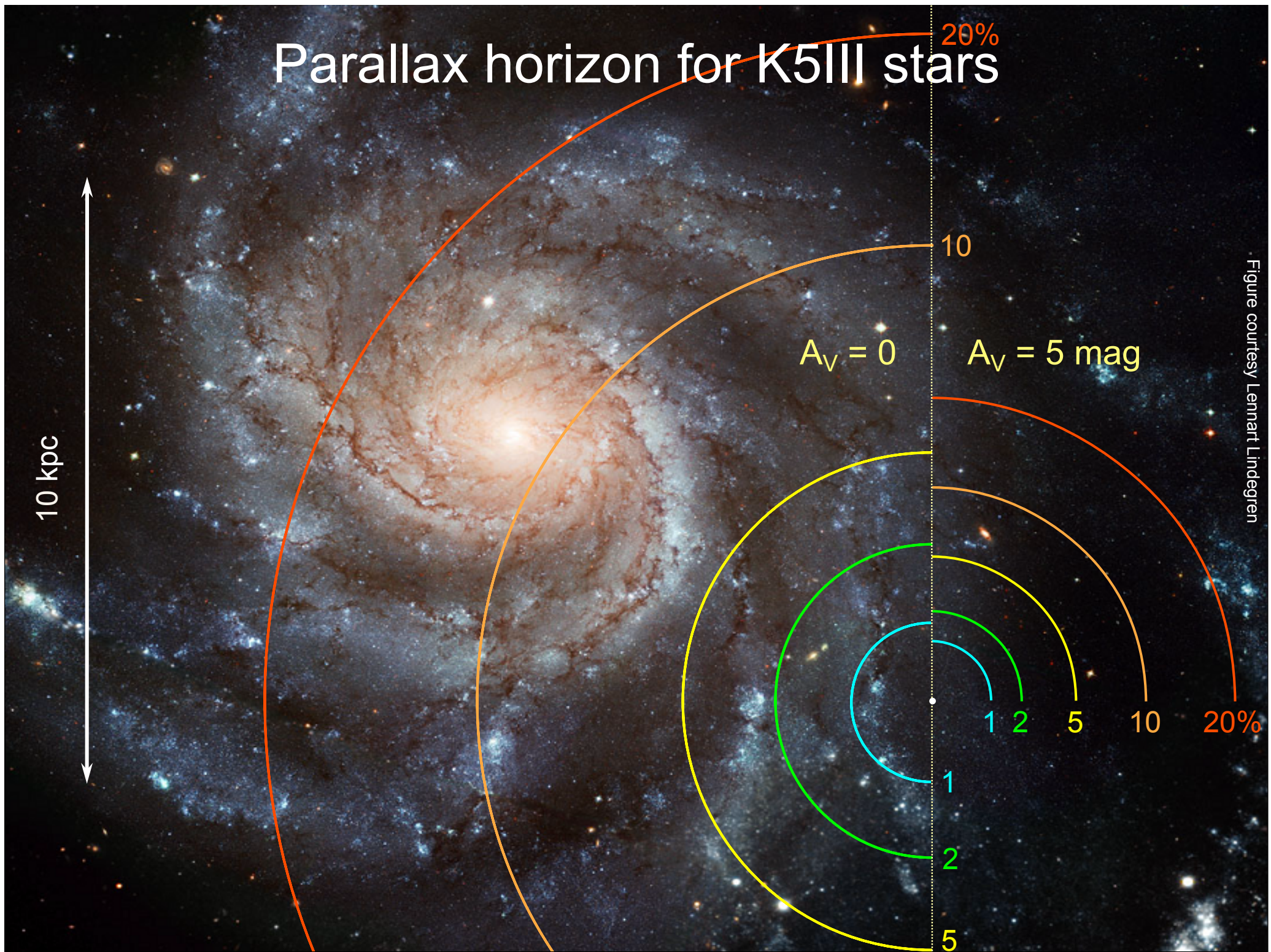
2

5

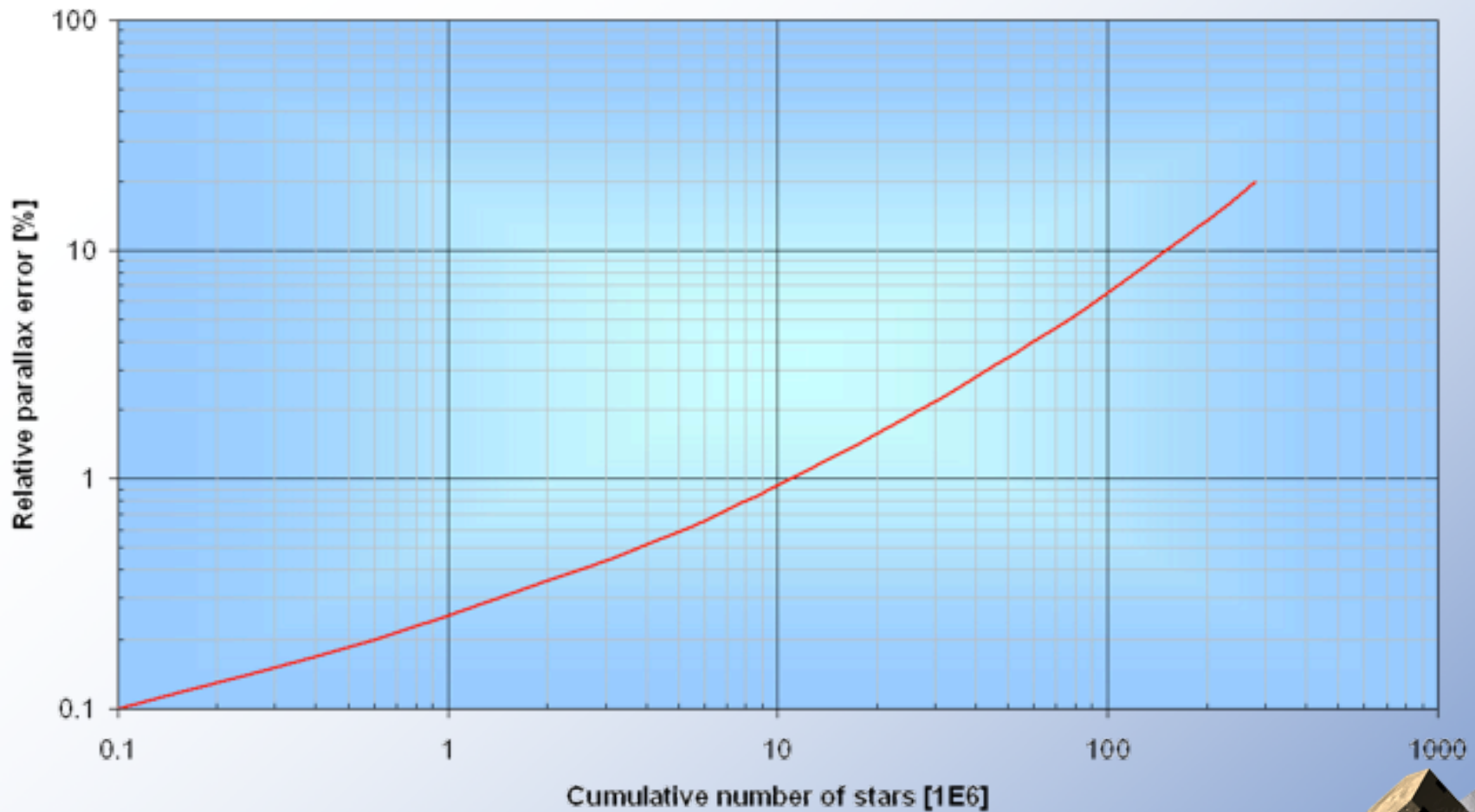
10

20%

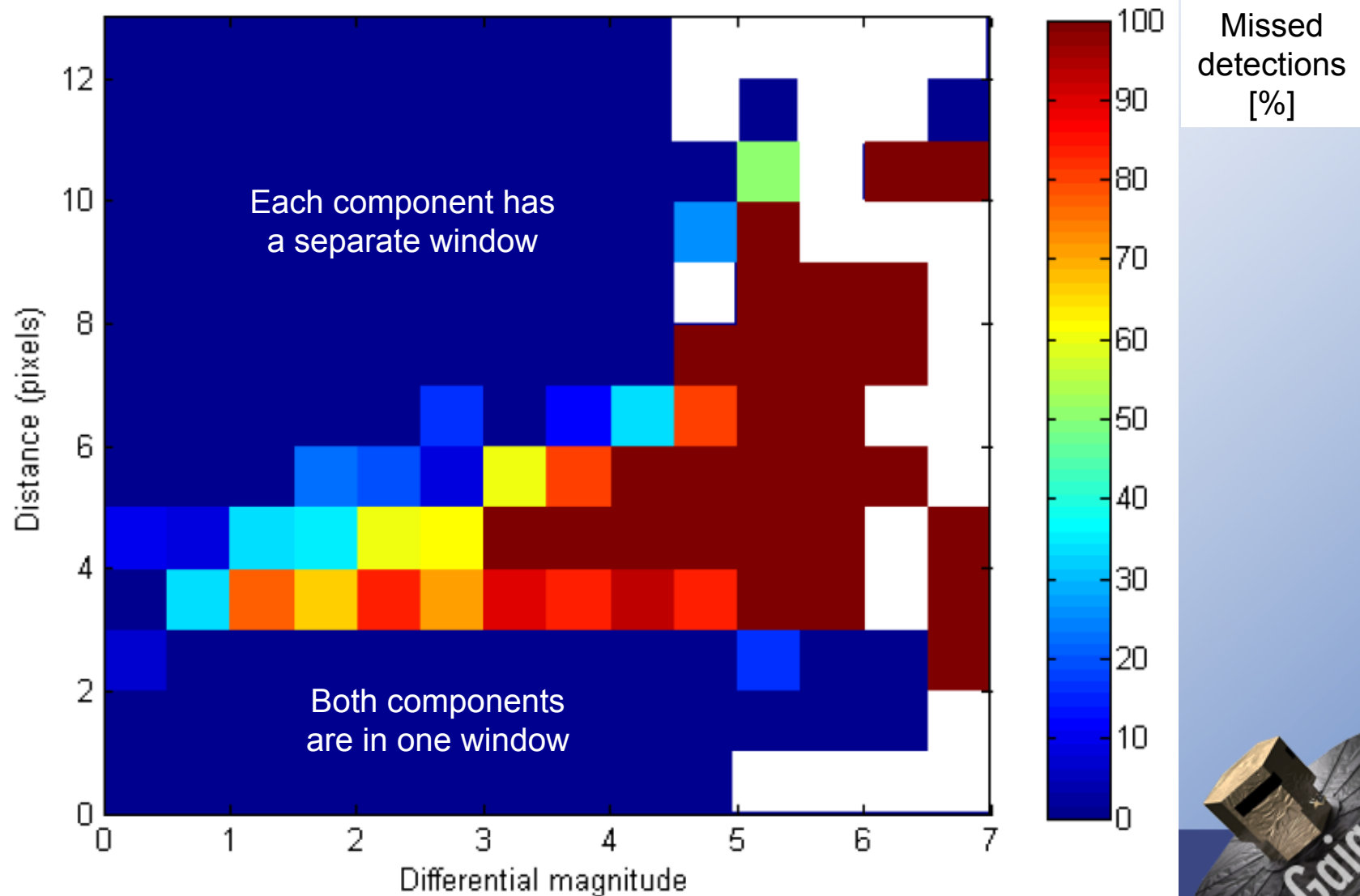
Figure courtesy Lennart Lindgren

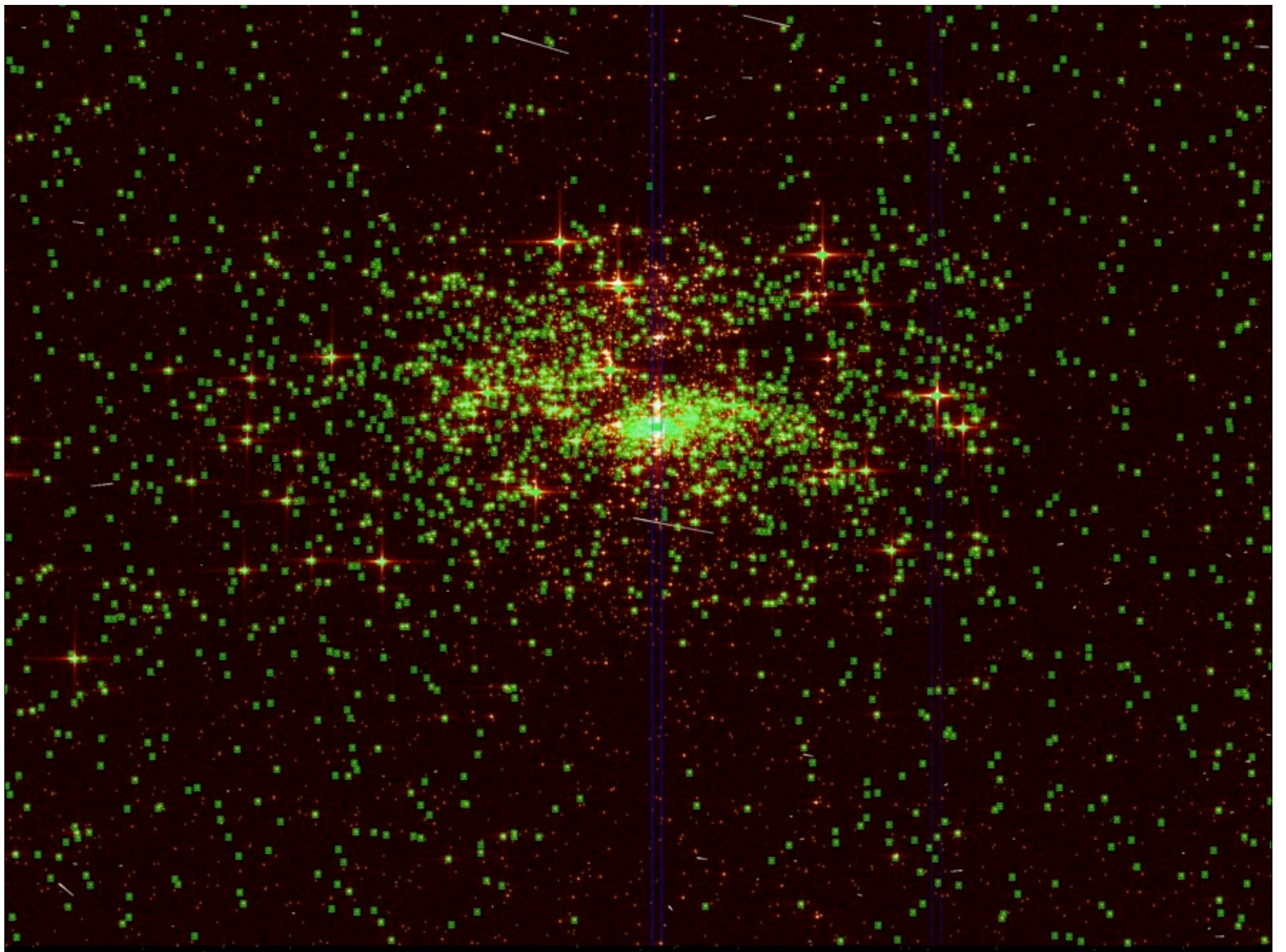


Parallax statistics

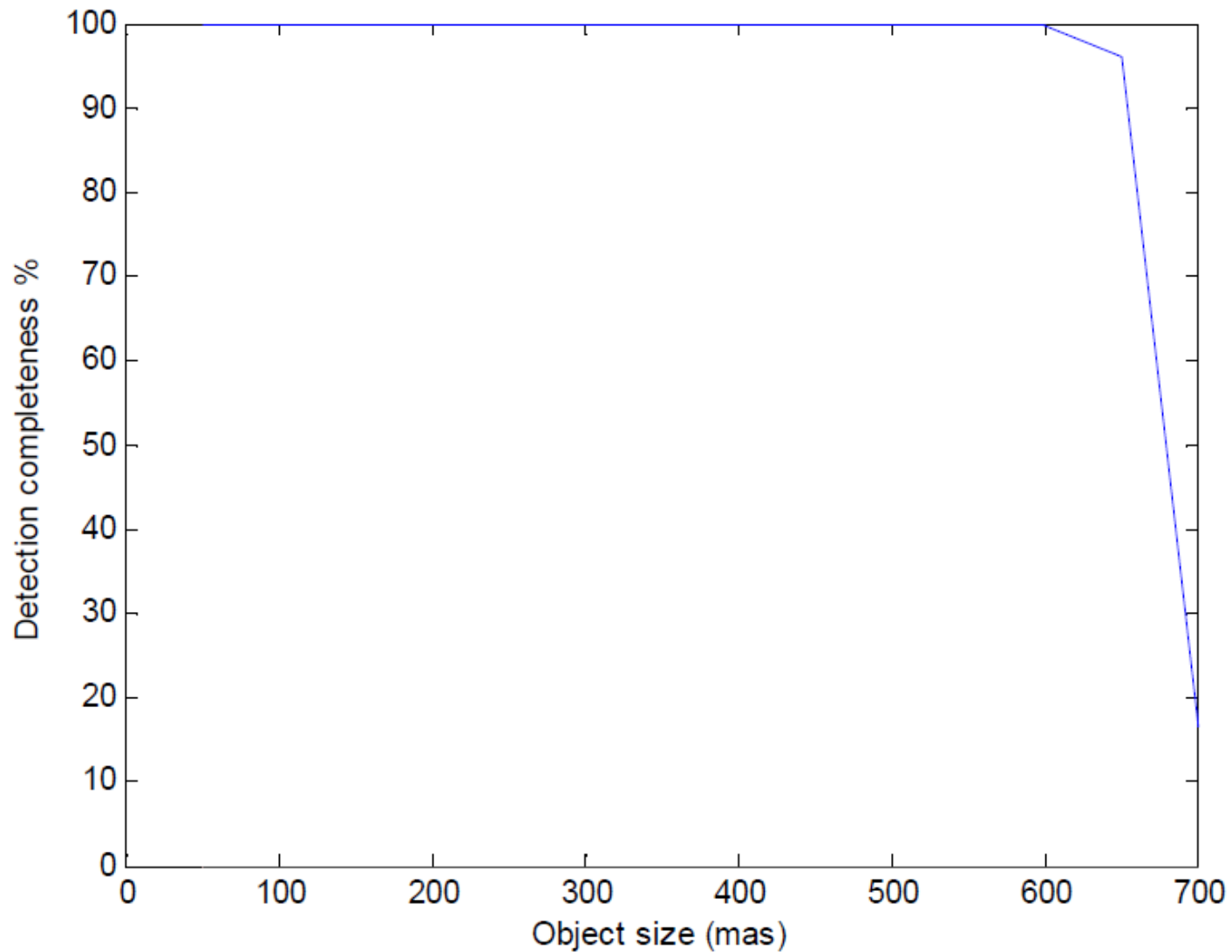


Detection in crowded regions

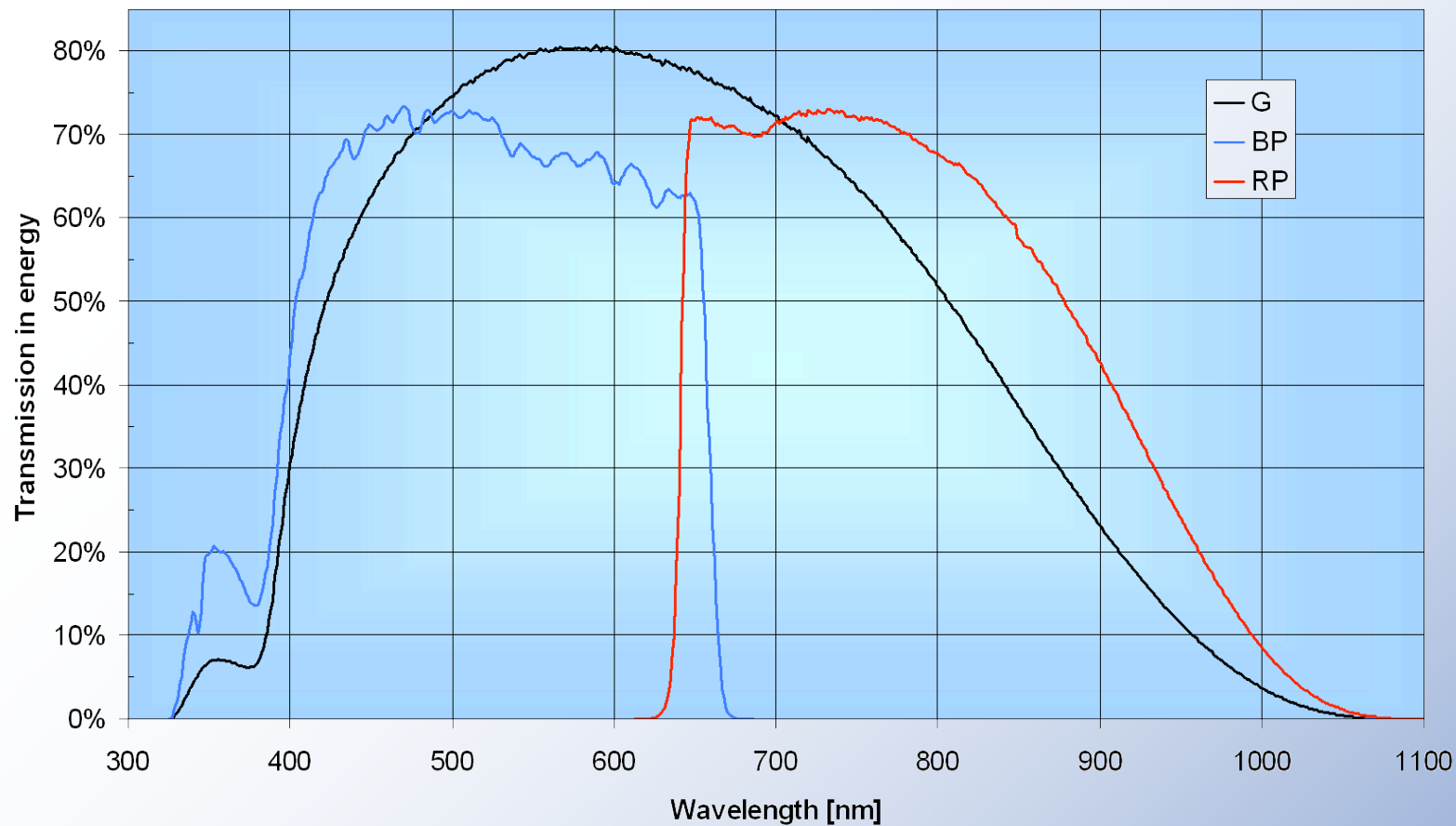




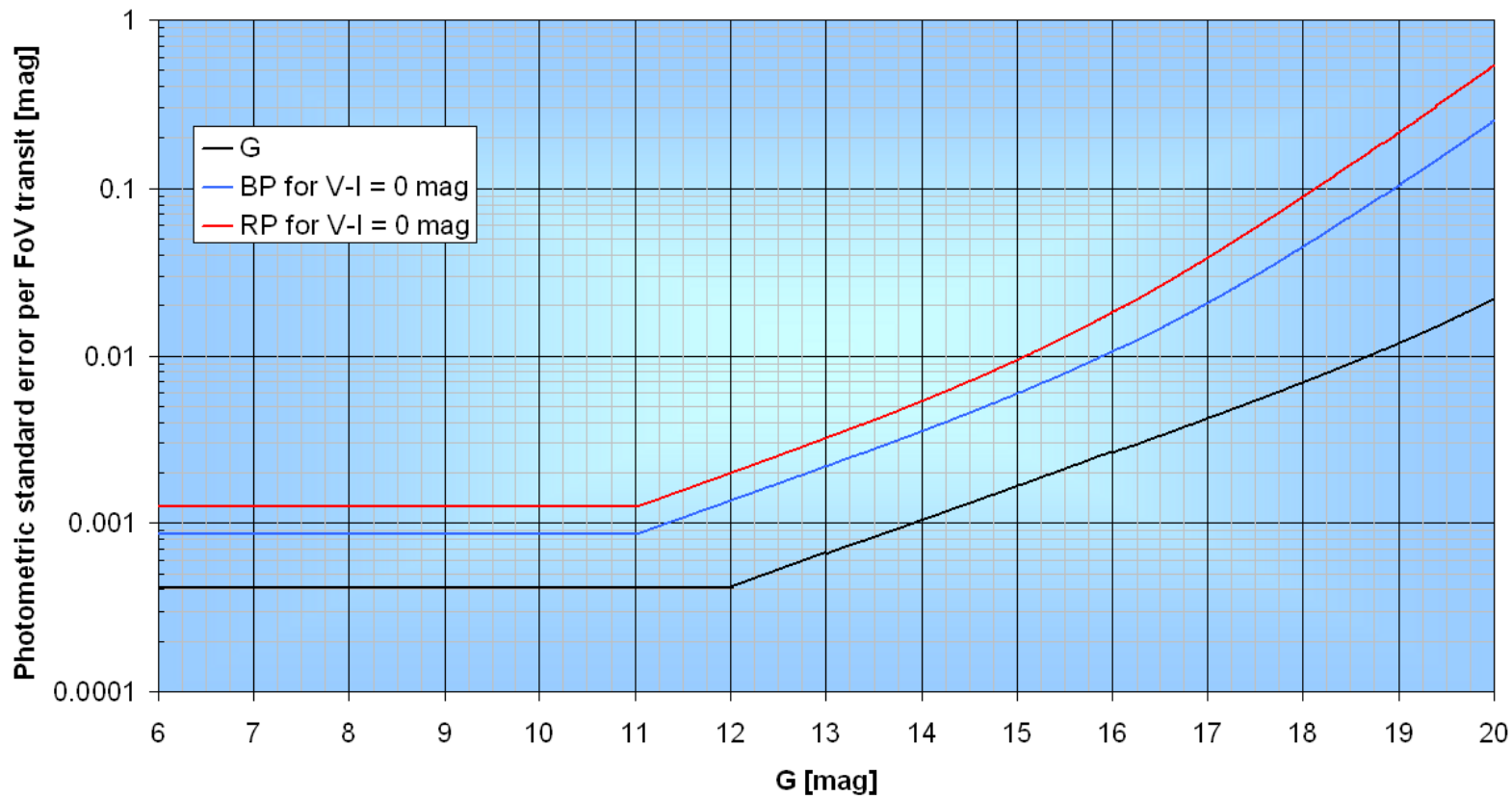
Extended sources



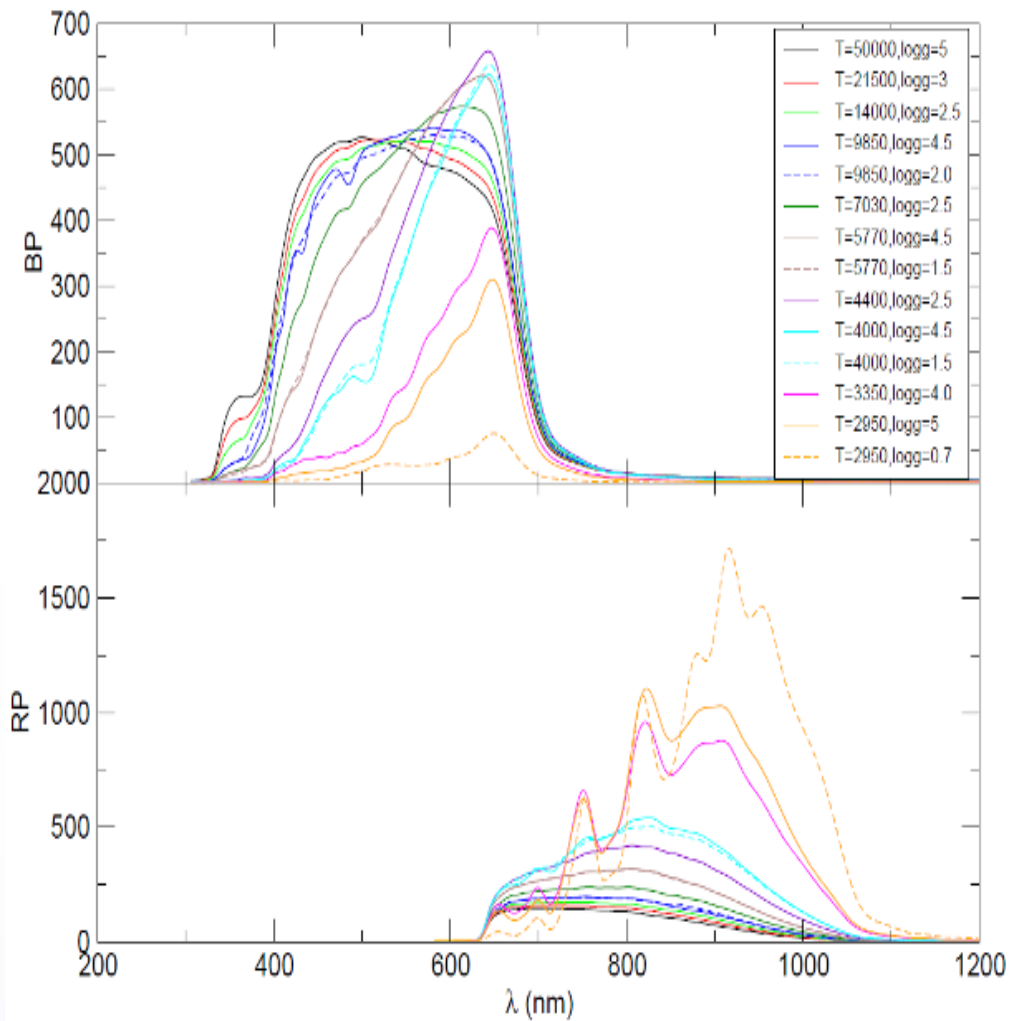
Photometry



Transit level integrated photometry



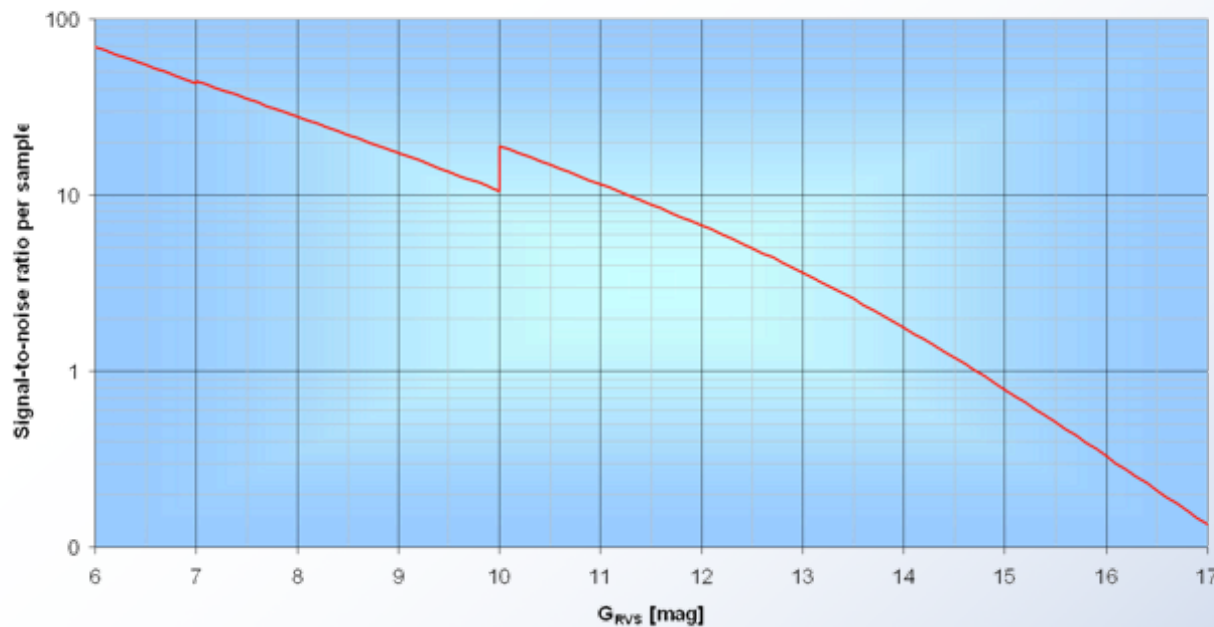
Spectro-photometry



- Illustrative spectra for G=15mag stars (Jordi et al. 2010)
- Goals at G=15mag e.g. extinction within 0.1mag, surface gravity 0.2dex, metallicity 0.2dex and effective temperature within 200K (Bailer-Jones 2010)



Spectroscopy

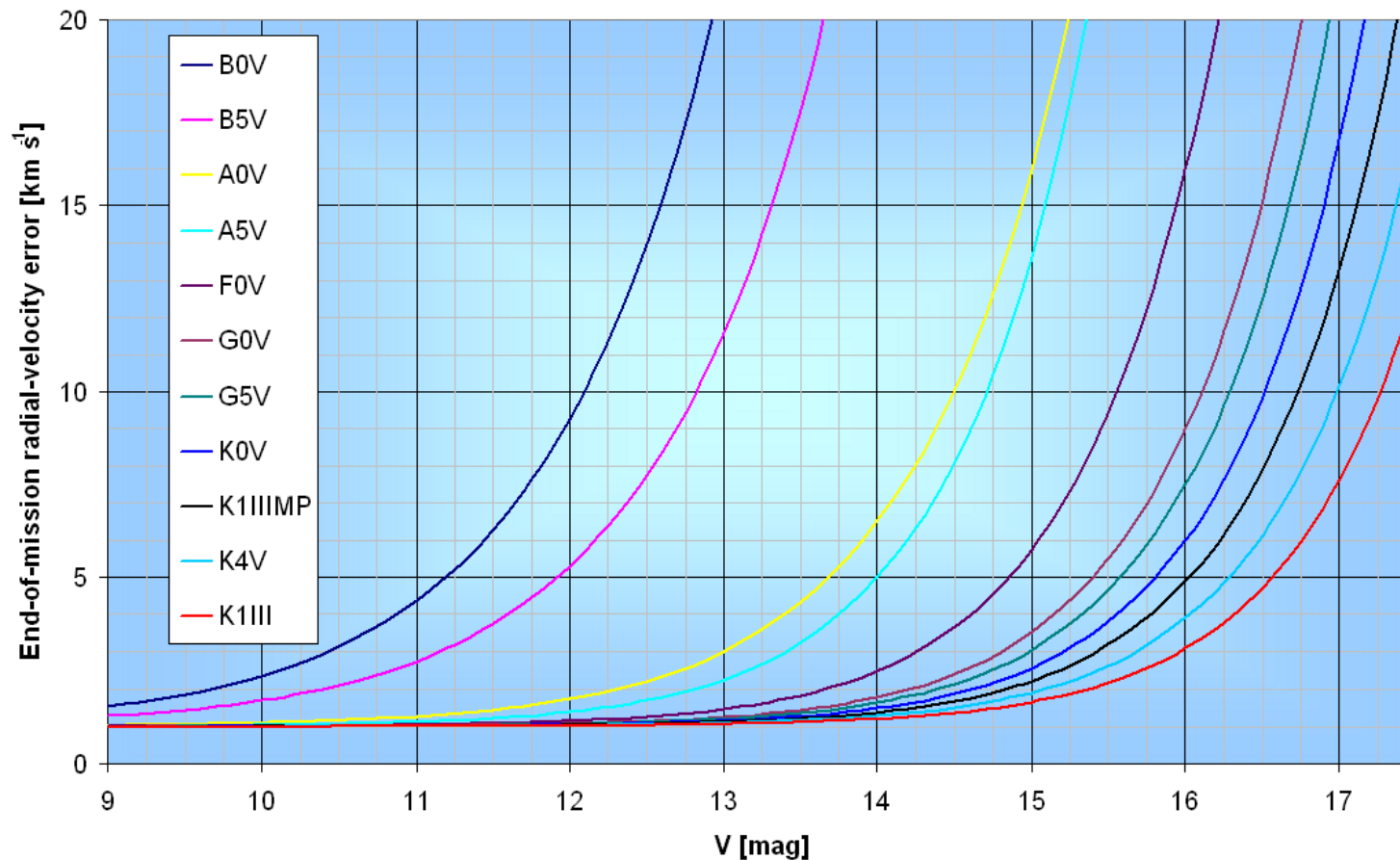


Single CCD S/N estimate

- Interstellar reddening, atmospheric parameters, and rotational velocities, for stars brighter than $G_{RVS} \approx 12$ mag (~ 5 million stars)
- provide element abundances for stars brighter than $G_{RVS} \approx 11$ mag (~ 2 million stars)



End-of-life Radial Velocity Errors



Concluding remarks

- Schedule: launch June 2013
- Data releases: as soon as possible, but self-calibration and astrometry require time
- Gaia is on track to be a scientific giant

...Feeding the Giants

