GAIA: STELLAR PHYSICS AND CHARACTERIZATION OF HOST STARS

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SF2A, BORDEAUX, 6 JUILLET 2018

GAIA: STELLAR PHYSICS AND CHARACTERIZATION OF HOST STARS

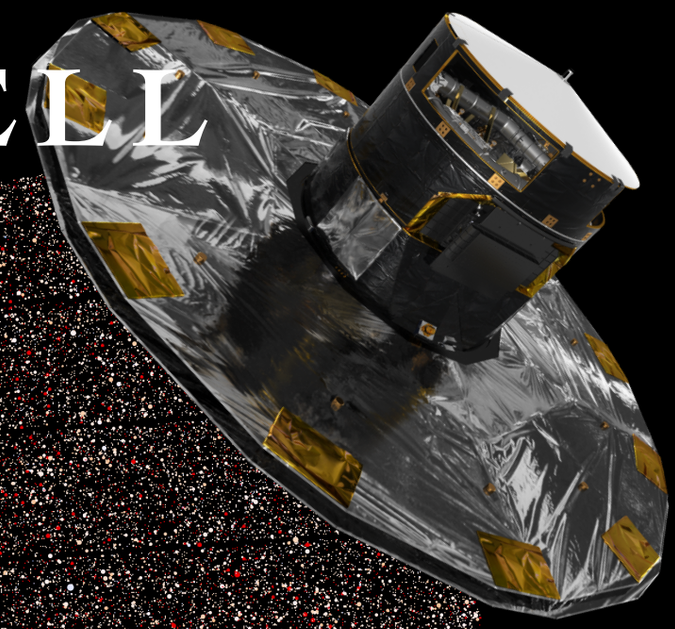
- Gaia overview and status
- Gaia and stellar physics
- Gaia and exoplanets

SF2A, BORDEAUX, 6 JUILLET 2018

Institut UTINAM

OSU THETA

GAIA IN A NUTSHELL



- All sky survey
- Astrometry and photometry to G=20 (V≃20-22)
- Spectroscopy to G=17
- ~70 observations per source during 5 years, with a quasi regular time sampling
- Angular resolution comparable to HST

GAIA IN A NUTSHELL

- >10^9 stars: distances, motions, physical properties

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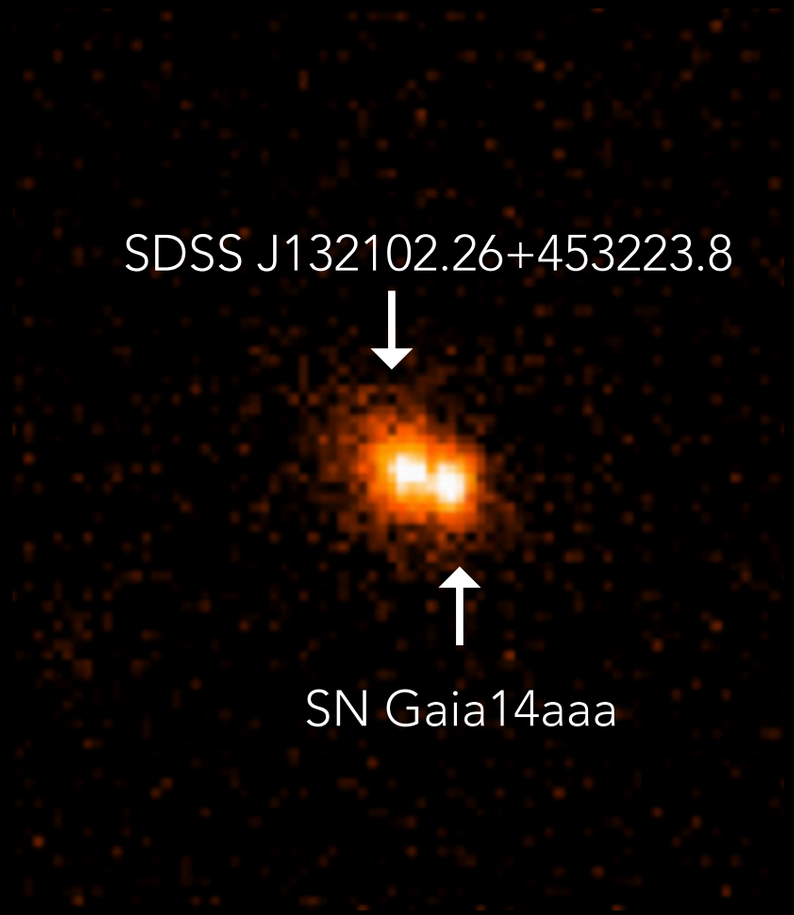
- 10^6 galaxies, 500 000 quasars

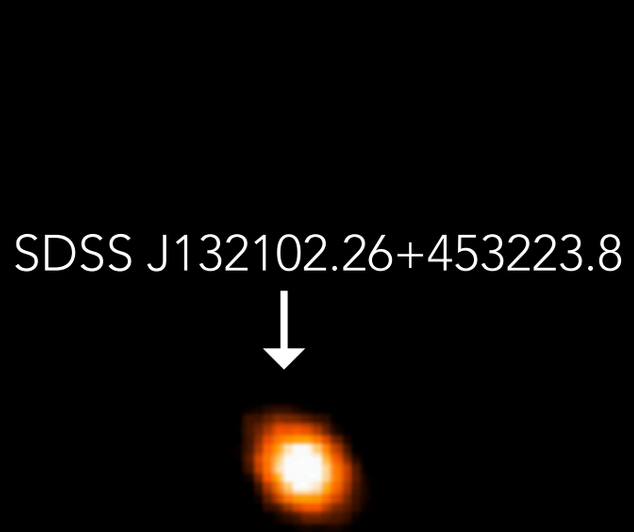
GAIA IN A NUTSHELL

- >10^9 stars: distances, motions, physical properties
- 10^6 galaxies, 500 000 quasars
- Supernovae

Supernova Gaia14aaa and its host galaxy.

Credit: M. Fraser/ S. Hodgkin/ L. Wyrzykowski/ H. Campbell/ N. Blagorodnova/ Z. Kostrzewa-Rutkowska/ Liverpool Telescope/ SDSS



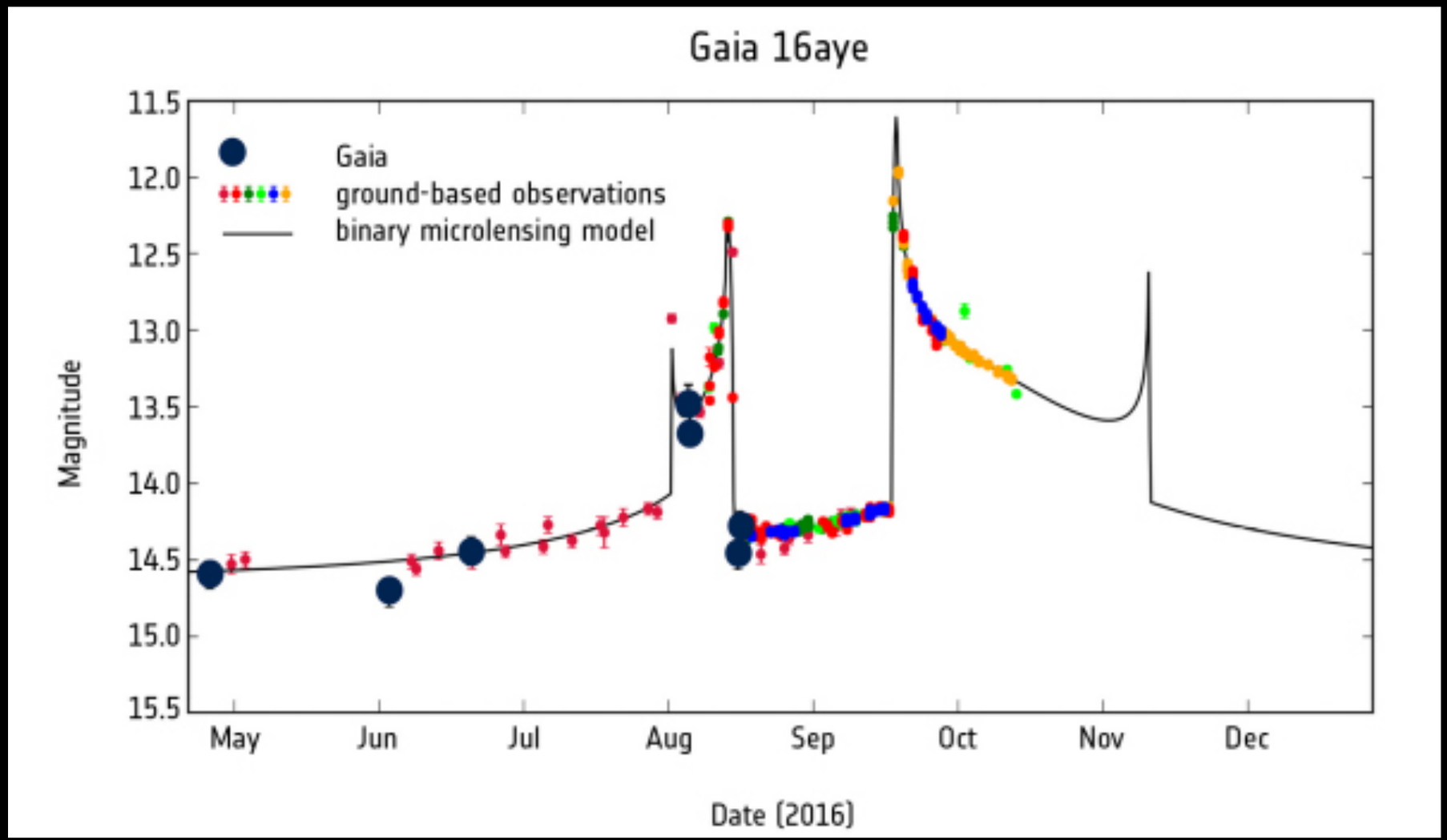


GAIA IN A NUTSHELL

- >10^9 stars: distances, motions, physical properties
- 10^6 galaxies, 500 000 quasars
- Supernovae, gravitational lenses

Light curve of binary microlensing event.

Credit: ESA/Gaia/DPAC, P. Mroz, L. Wyrzykowski, K.A. Rybicki



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- 10 000s exoplanets, up to 500 pc

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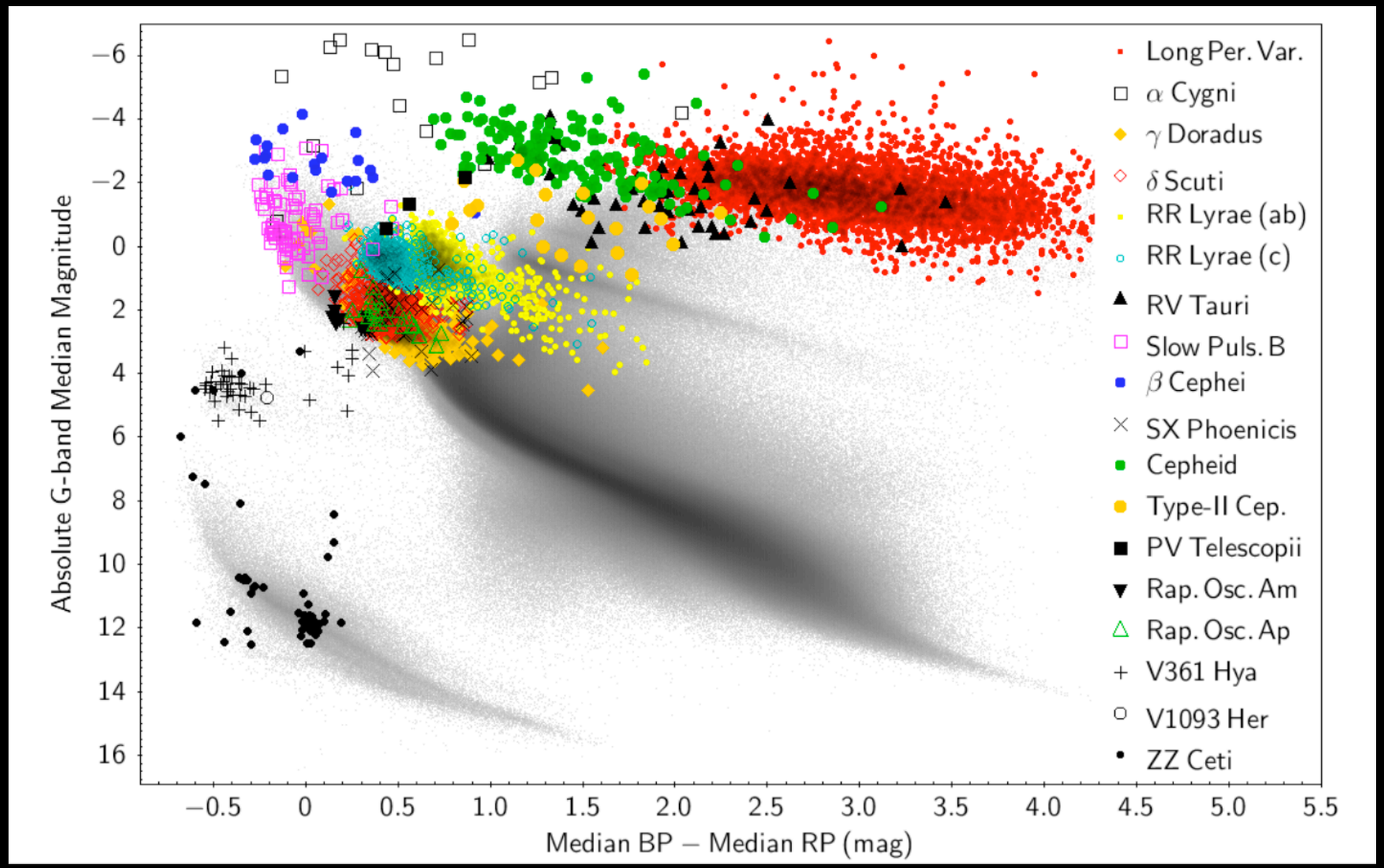
- Supernovae, gravitational lenses
- 10 000s exoplanets, up to 500 pc
- 10^5 new Solar System objects

Animated view of 14 099 asteroids and orbits of the 200 brightest, from Gaia DR2.

Crédit: Gaia DPAC CU4, P. Tanga, Gaia Sky, S. Jordan

GAIA IN A NUTSHELL

- Alerts on transient phenomena
- Variable sky survey



Eyer et al 2018

GAIA IN A NUTSHELL

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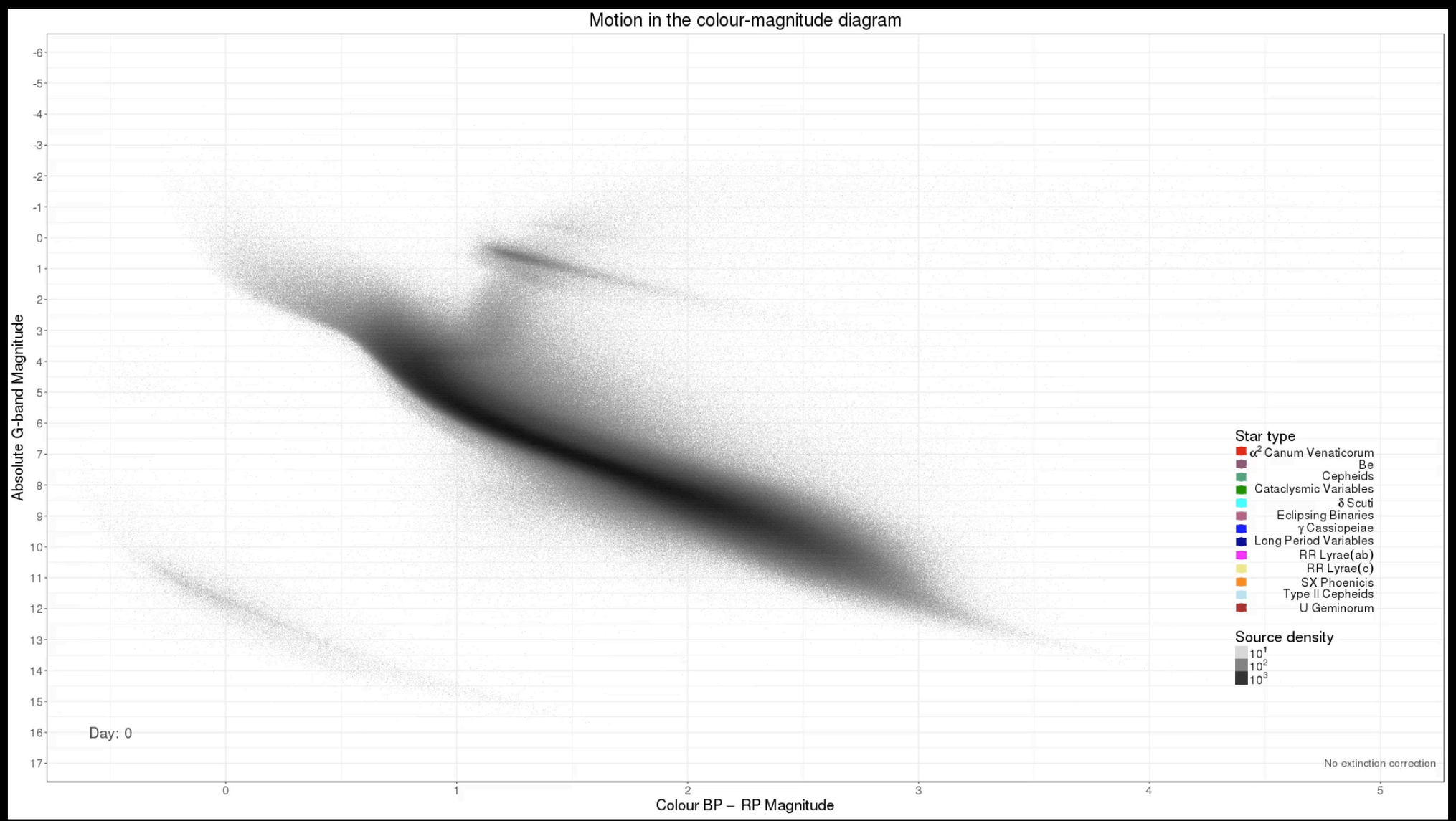
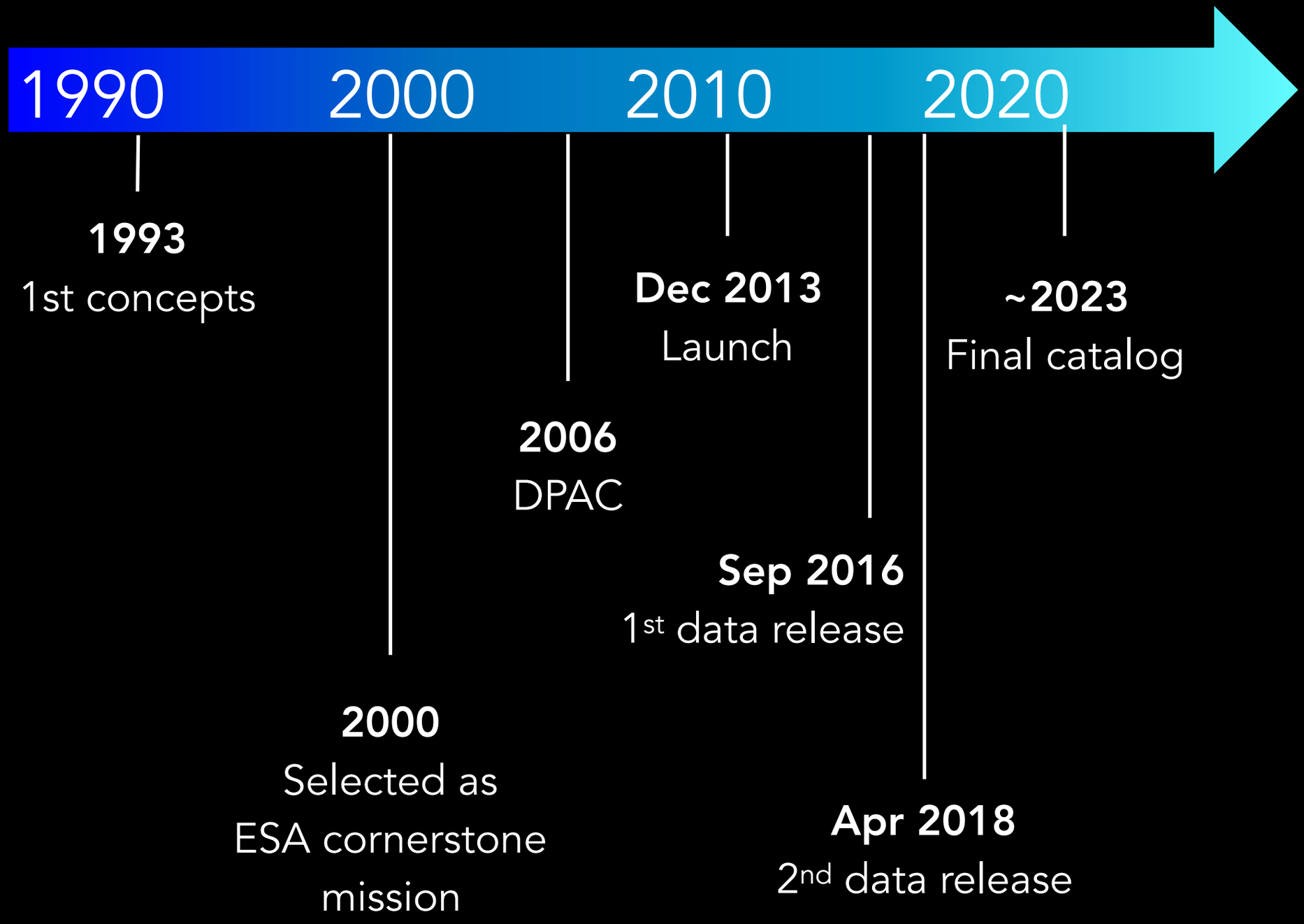


TOWARDS THE FINAL GAIA CATALOGUE



GAIA DATA RELEASE 2

GAIA DATA RELEASE 2

	DR1	DR2
• Data processed	14 months	22 months
• Positions	1.1 10^9	1.7 10^9
• Parallaxes	2 10^6	**1.3 10^9**
• Proper-motions	2 10^6	**1.3 10^9**
• Solar system objects	—	14 000
• G mag	1.1 10^9	1.7 10^9
• Bp, Rp mag	—	**1.4 10^9**
• Variable stars	3 10^3	**551 10^3**
• Physical parameters	—	**77 - 161 10^6**
• Radial velocities	—	**7.2 10^6**

GAIA DATA RELEASE 2

→ HOW MANY STARS WILL THERE BE IN THE SECOND GAIA DATA RELEASE?

esa

position & brightness on the sky

1 692 919 135

surface temperature

161 497 595

red colour

1 383 551 713

blue colour

1 381 964 755

parallax and proper motion

1 331 909 727

radius & luminosity

76 956 778

amount of dust along the line of sight

87 733 672

radial velocity

7 224 631

14 099
Solar System objects

550 737
variable sources

www.esa.int

The second data release of ESA's Gaia mission is scheduled for publication on 25 April 2018.

European Space Agency

BASIC CATALOGUE CONTENT

- Astrometry

α, δ, π, μ_α, μ_δ, binaries with orbital solutions when possible

- Photometry

multi-epoch G, G_{BP}, G_{RP}, G_{RVS}

A_V, T_{eff}, log g, [M/H], and [α/H] for brighter stars

luminosity, mass, age

BASIC CATALOGUE CONTENT

- Spectroscopy

radial velocities to G<17 (~150 million stars)
rotational velocities, atmospheric parameters, interstellar reddening (G<12, ~5 million stars))
abundances (G<11, ~2 million stars)

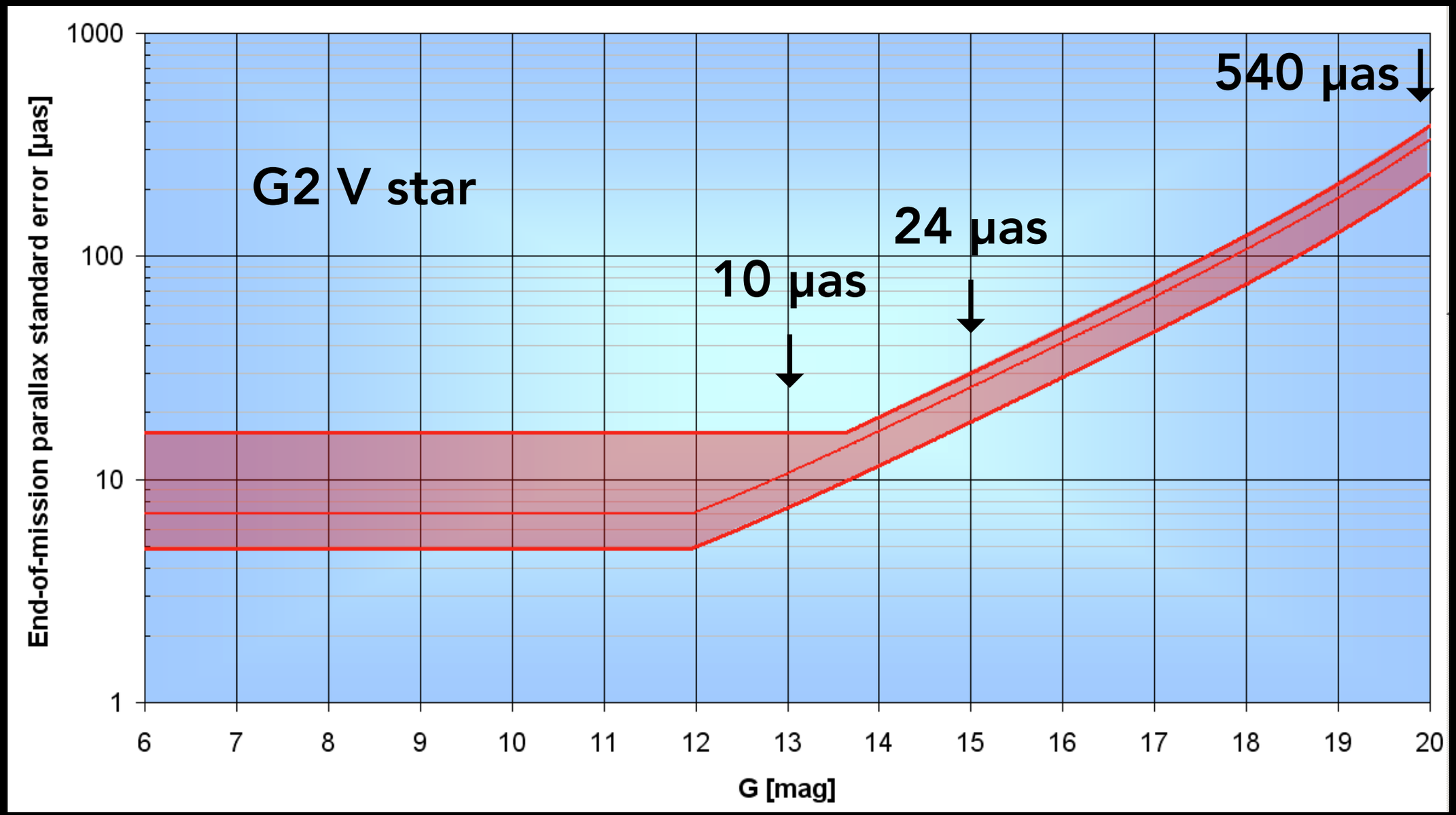
- Also

object classification
variable star classification + period
classification of extended objects
…

- ….

PERFORMANCES

- Astrometric



De Bruijne 2012

PERFORMANCES

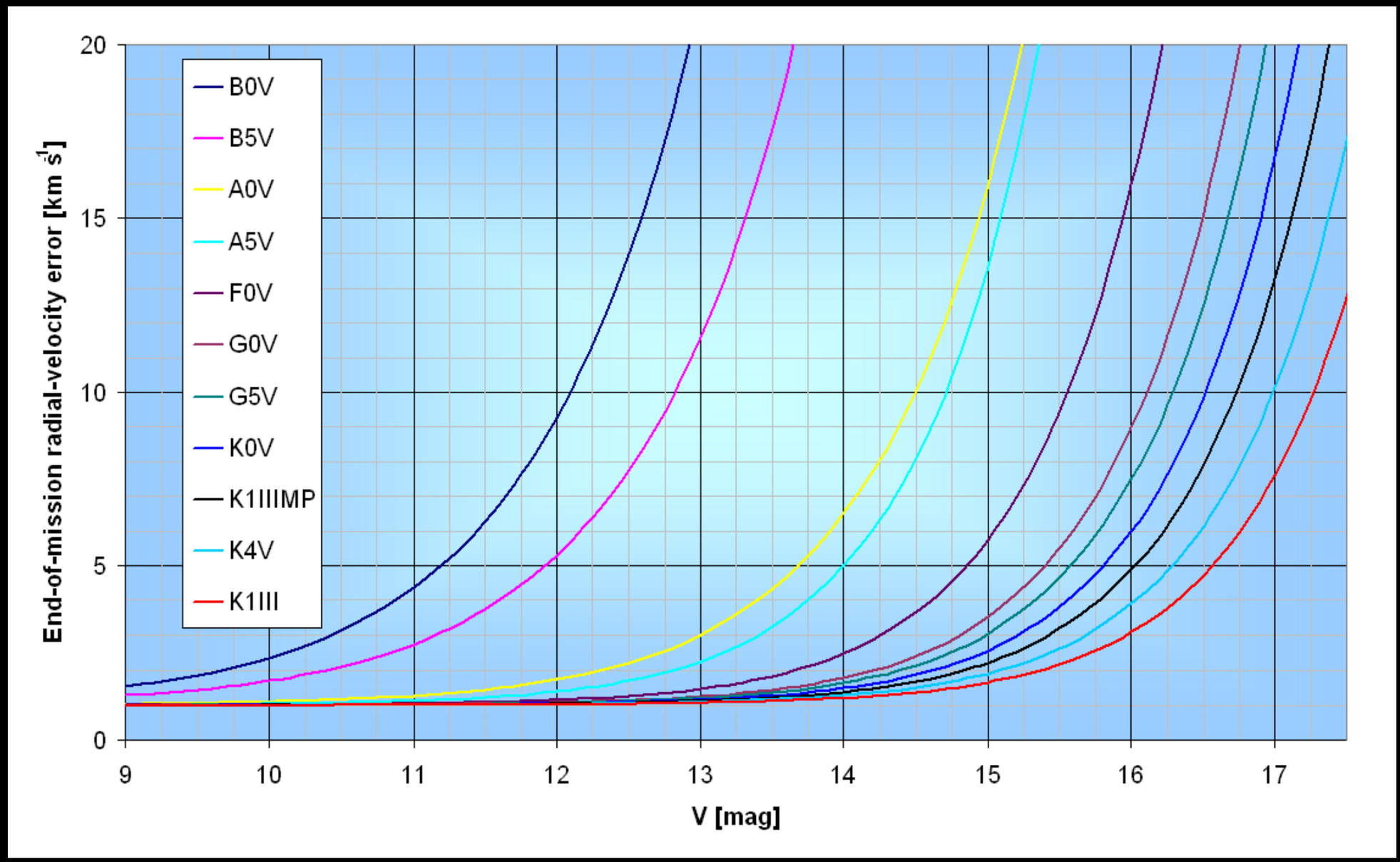
- Photometric

	B1V			G2V			M6V		
G [mag]	**G**	**BP**	**RP**	**G**	**BP**	**RP**	**G**	**BP**	**RP**
3 - 13	0.2	1	1	0.2	1	1	0.2	1	1
14	0.2	1	1	0.2	1	1	0.2	2	1
15	0.2	1	2	0.2	1	1	0.2	5	1
16	0.4	2	3	0.4	2	2	0.4	10	1
17	0.6	3	6	0.6	4	4	0.6	25	2
18	0.9	6	15	0.9	9	8	0.9	63	4
19	1.8	15	37	1.8	23	20	1.8	157	8
20	3.7	37	91	3.7	56	48	3.7	395	20

unit is mmag

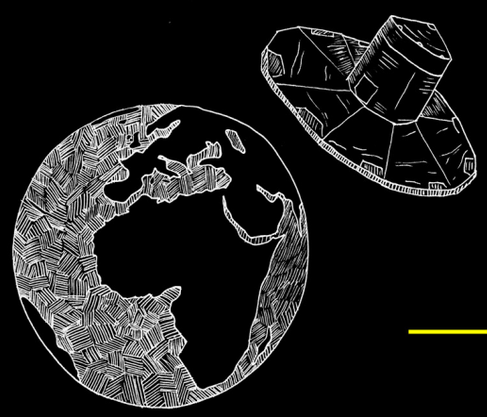
PERFORMANCES

- Spectroscopic RVS : R = 11500, 845–872 nm

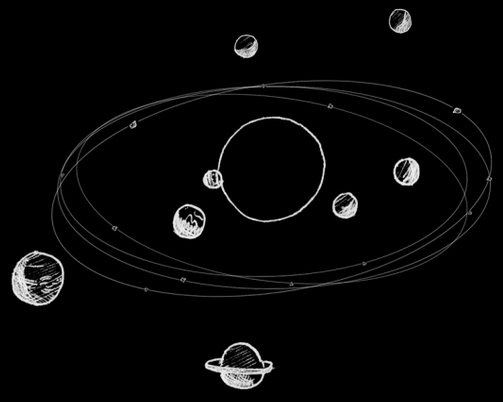


De Bruijne 2012

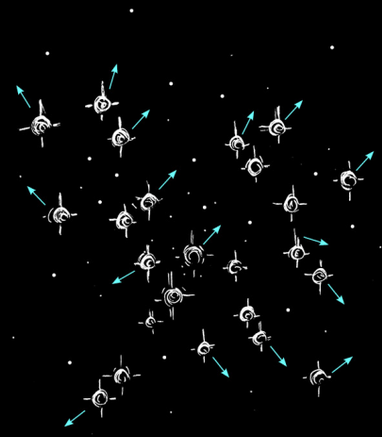
SCIENCE PERFORMANCES



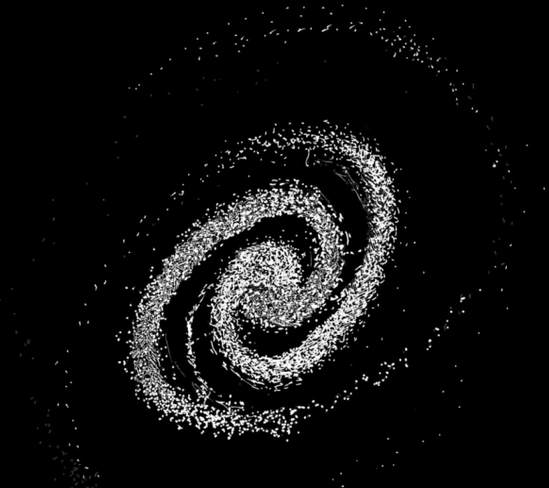
Earth & Gaia



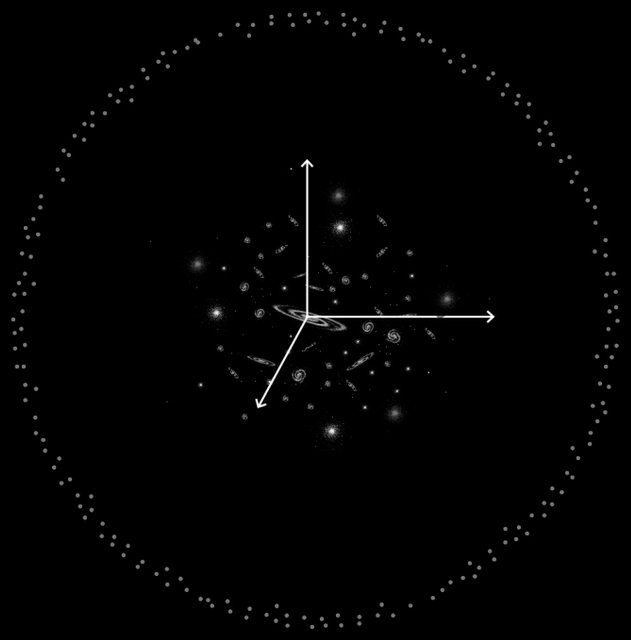
Solar System objects



Stars near the Sun



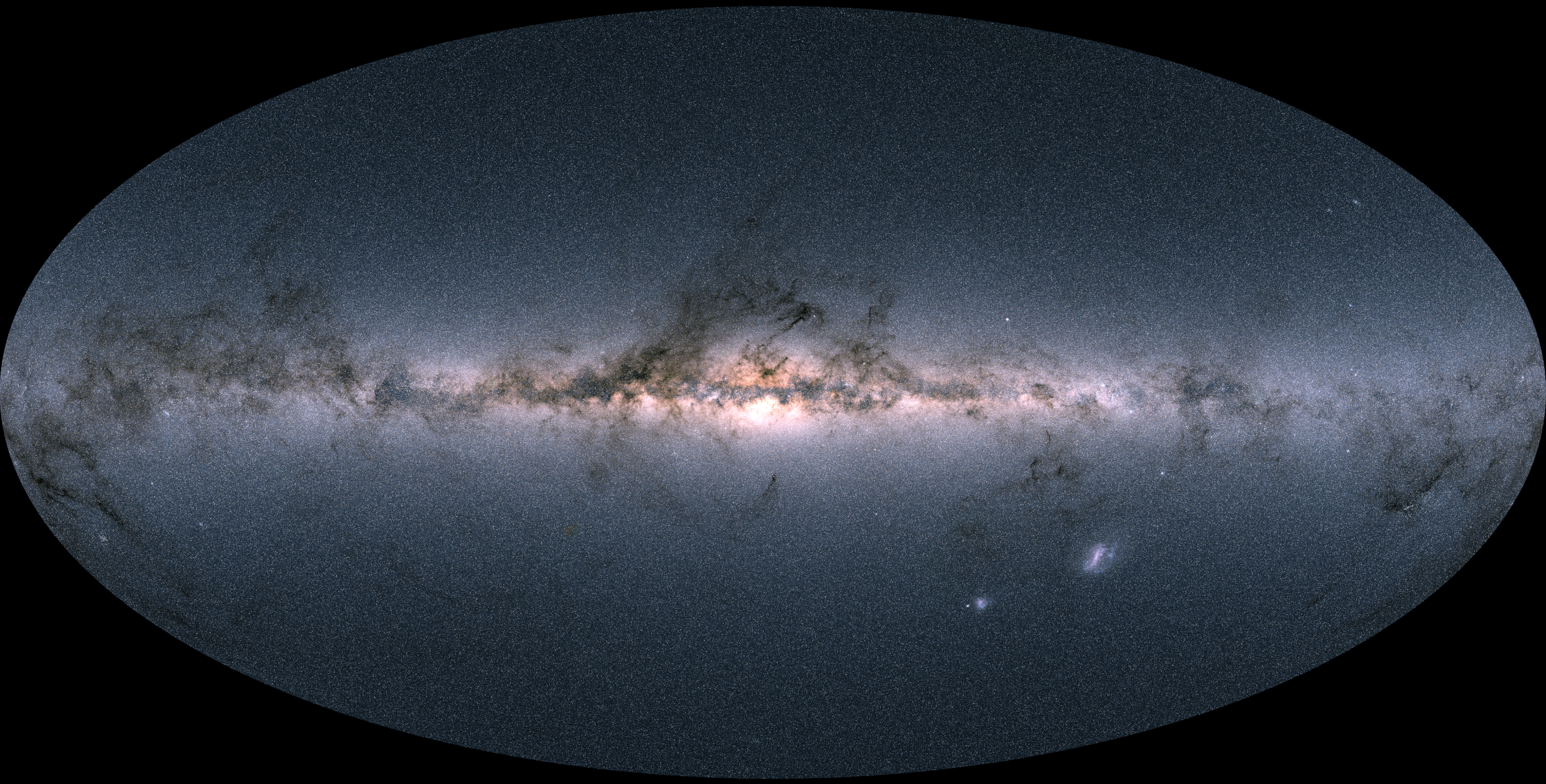
Milky Way: disc and bulge

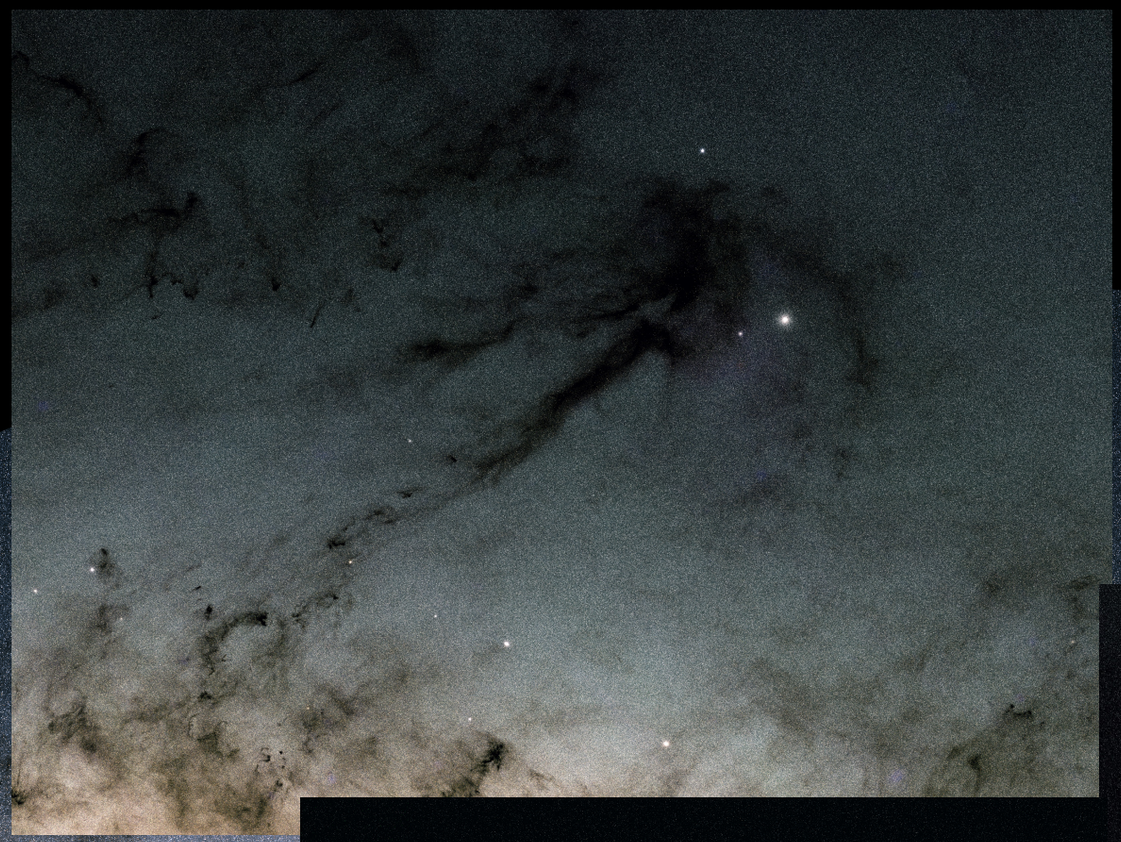


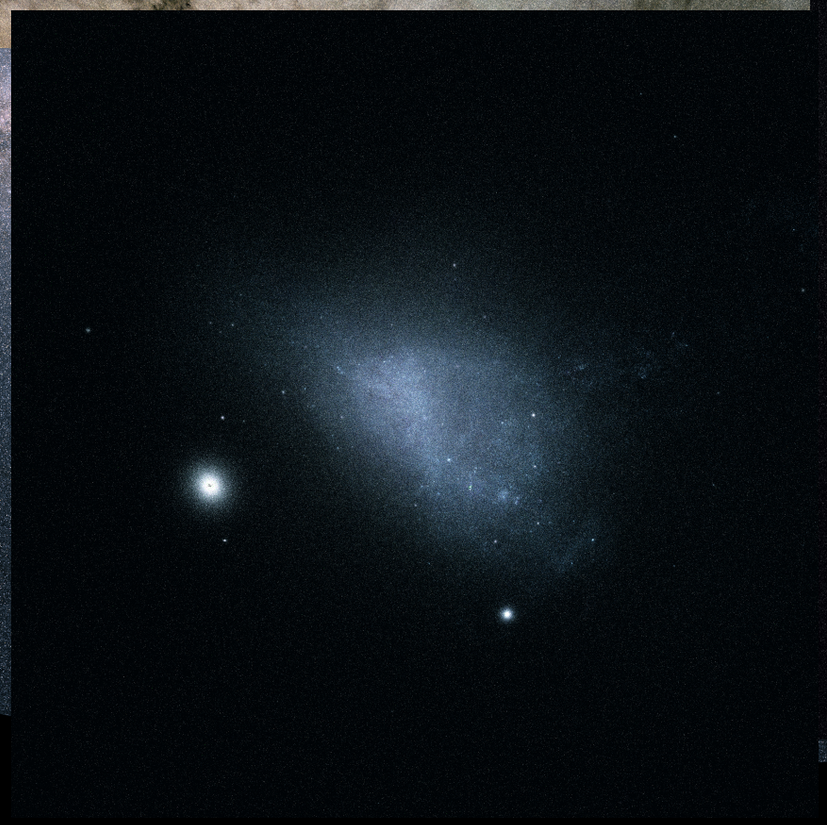
Celestial reference frame: distant quasars

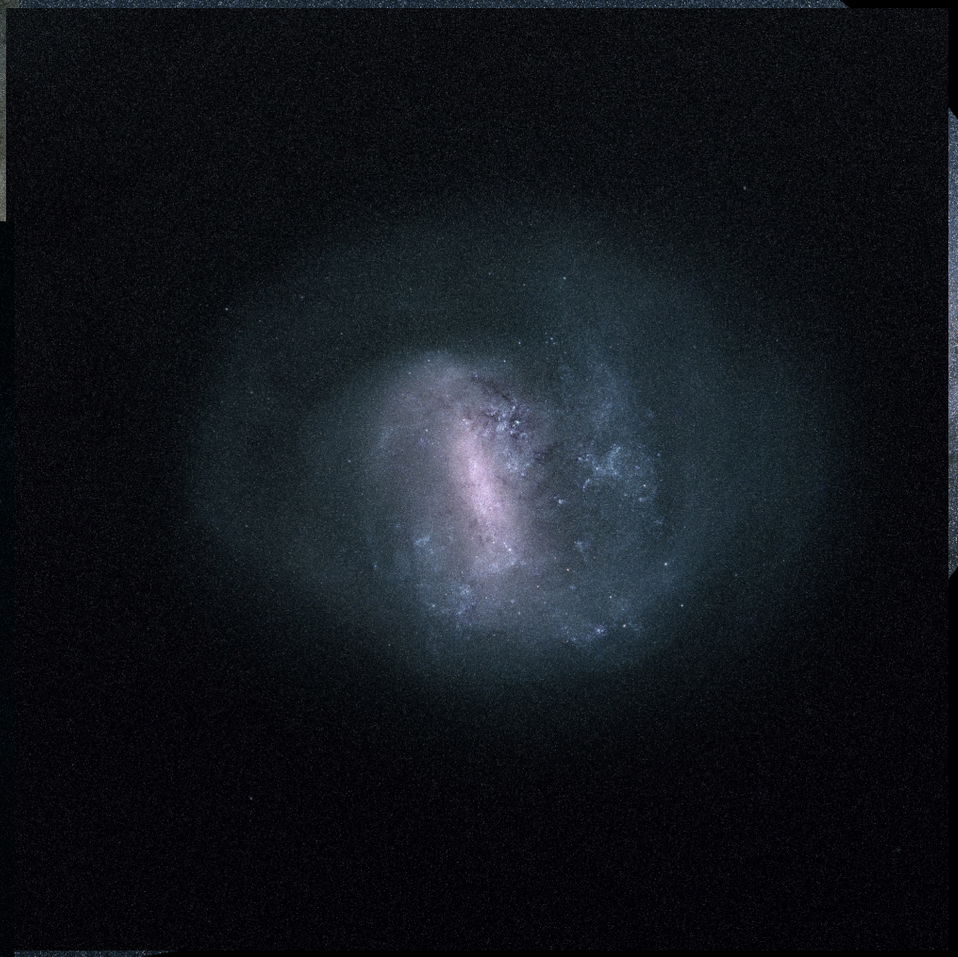
Nearby galaxies

Milky Way: halo and globular clusters









GAIA AND STELLAR PHYSICS

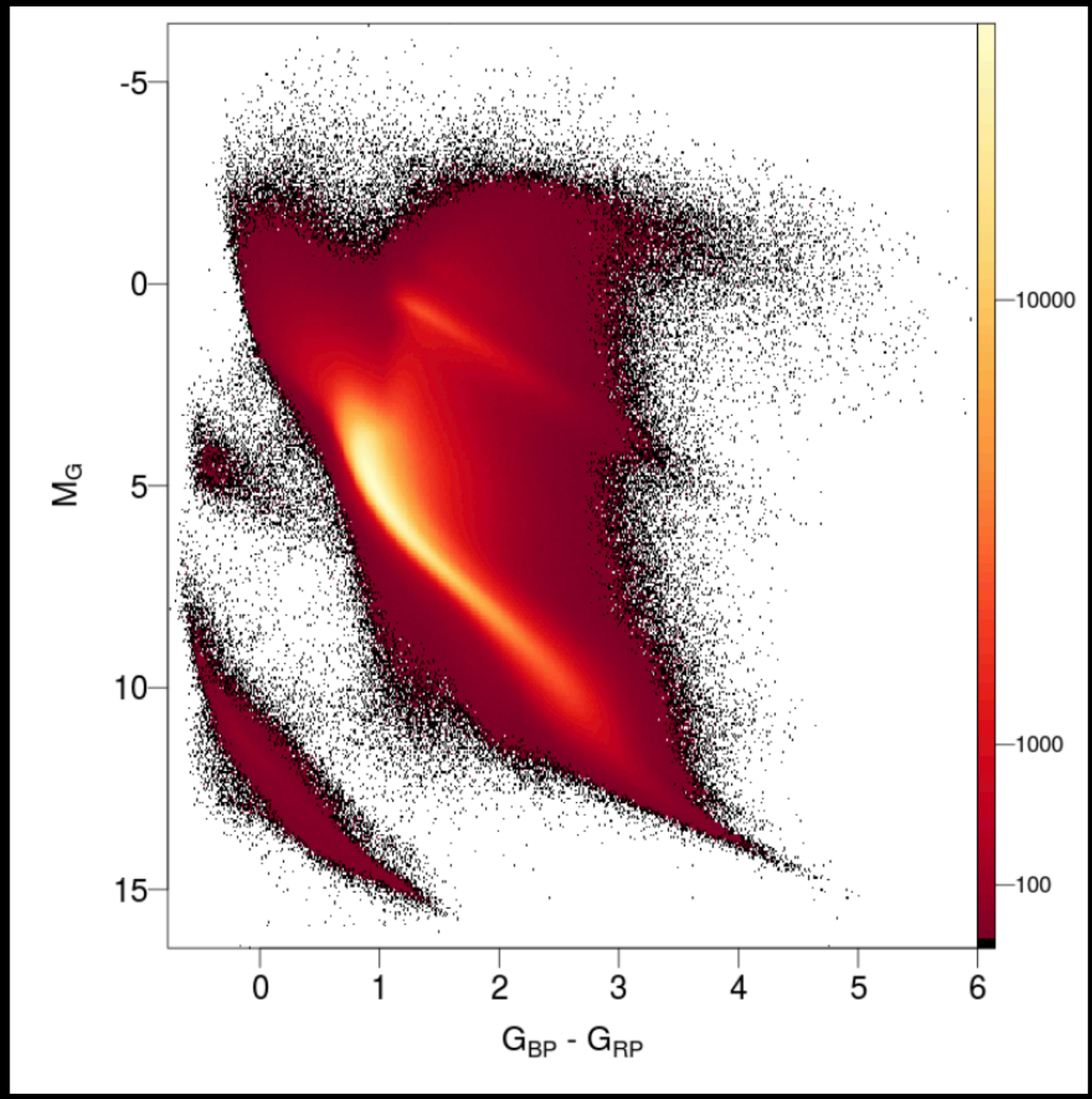
distances at 1% for ~10^6 stars up to 2.5 kpc
distances at 10% for ~10.10^6 stars up to 25 kpc

GAIA AND STELLAR PHYSICS

- Paramètres fondamentaux types d'étoiles rares, phases d'évolution rapide
  - Tests modèles stellaires …
- Etoiles variables (~70 observations sur 5 ans, précision mmag)
  - 20 x 106 variables
  - 1-5 x 106 binaires à éclipse
  - RVS : ~106 SB ~105 à eclipse (~25% SB 2 → masses)
  - ~5000 Cepheids, 70 000 RR Lyrae (75 kpc)

HR DIAGRAM

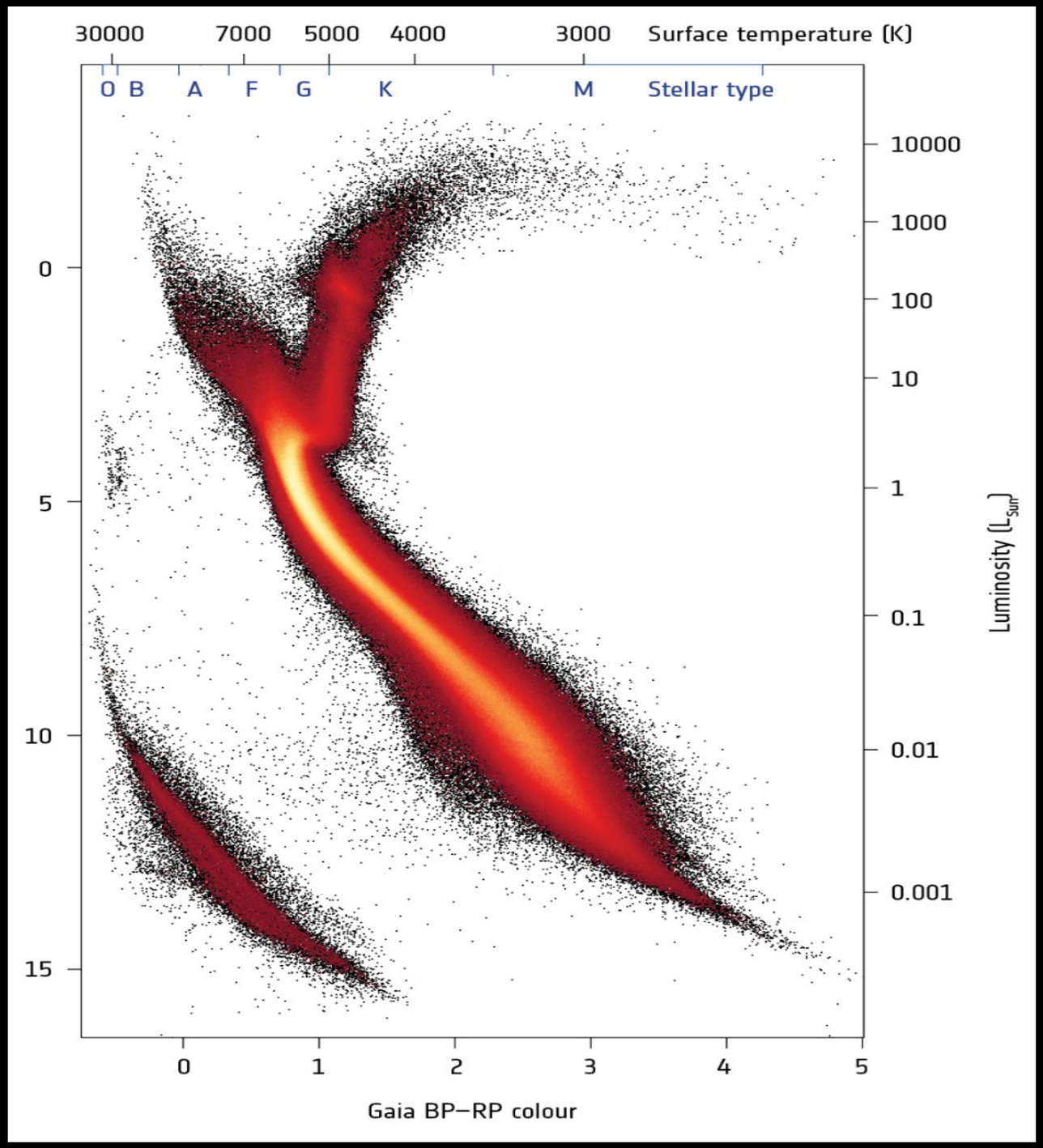
65 921 112 stars
parallax error<10%



Gaia collaboration, Babusiaux et al, 2018

HR DIAGRAM

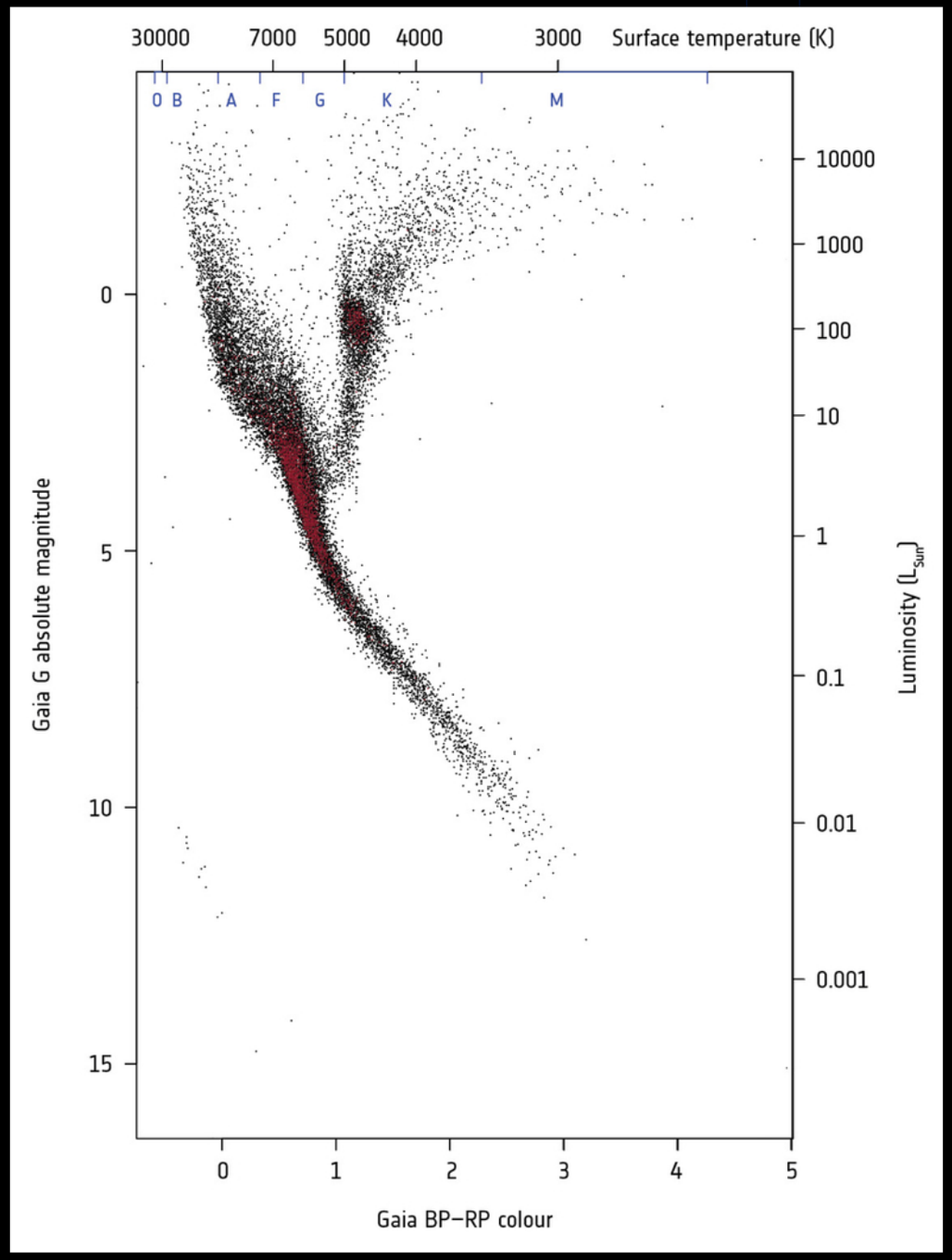
4 276 690 stars
parallax error<10%
E(B-V)<0.015

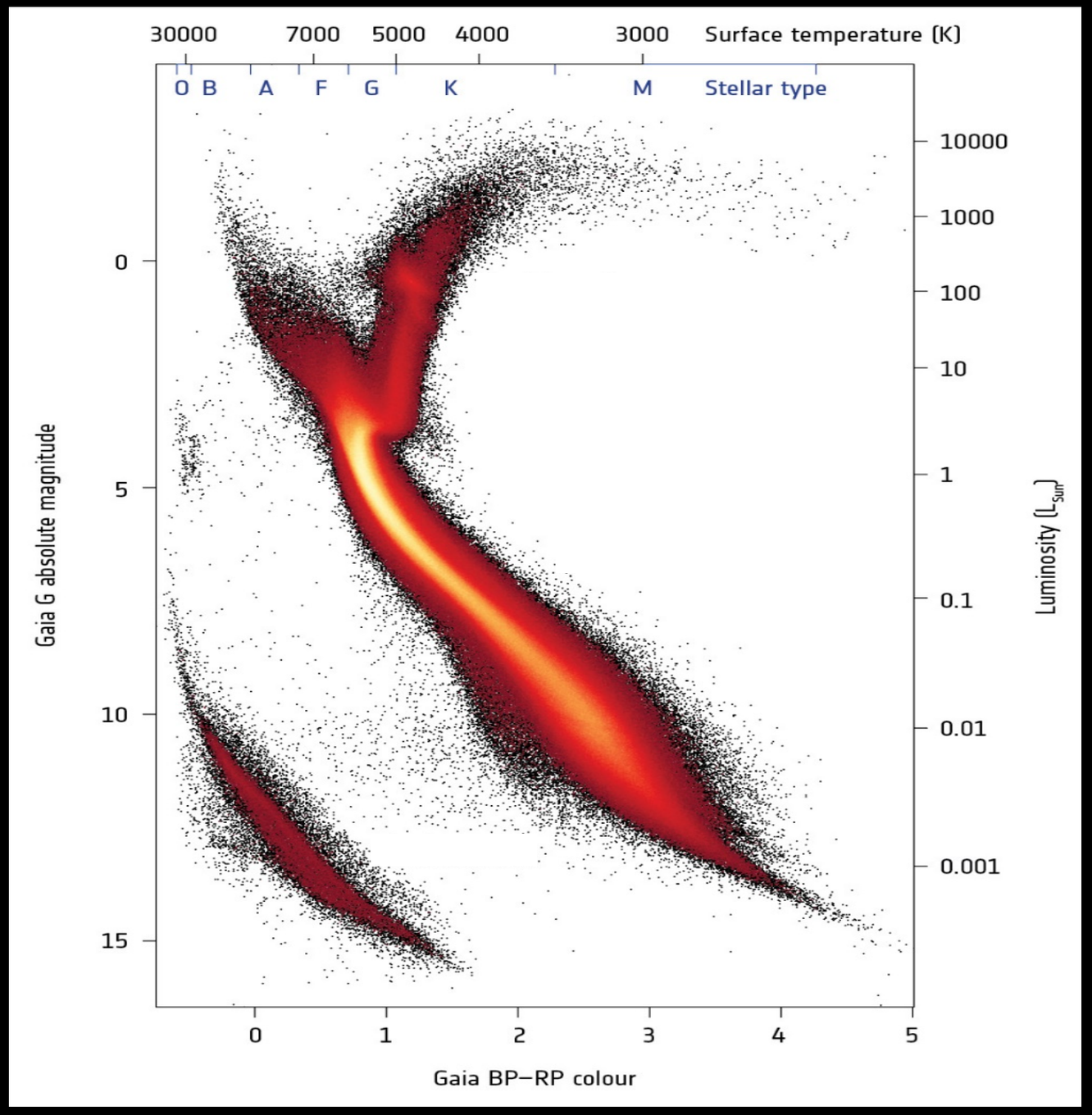


Gaia collaboration, Babusiaux et al, 2018

HR DIAGRAM

Hipparcos, 41 453 stars





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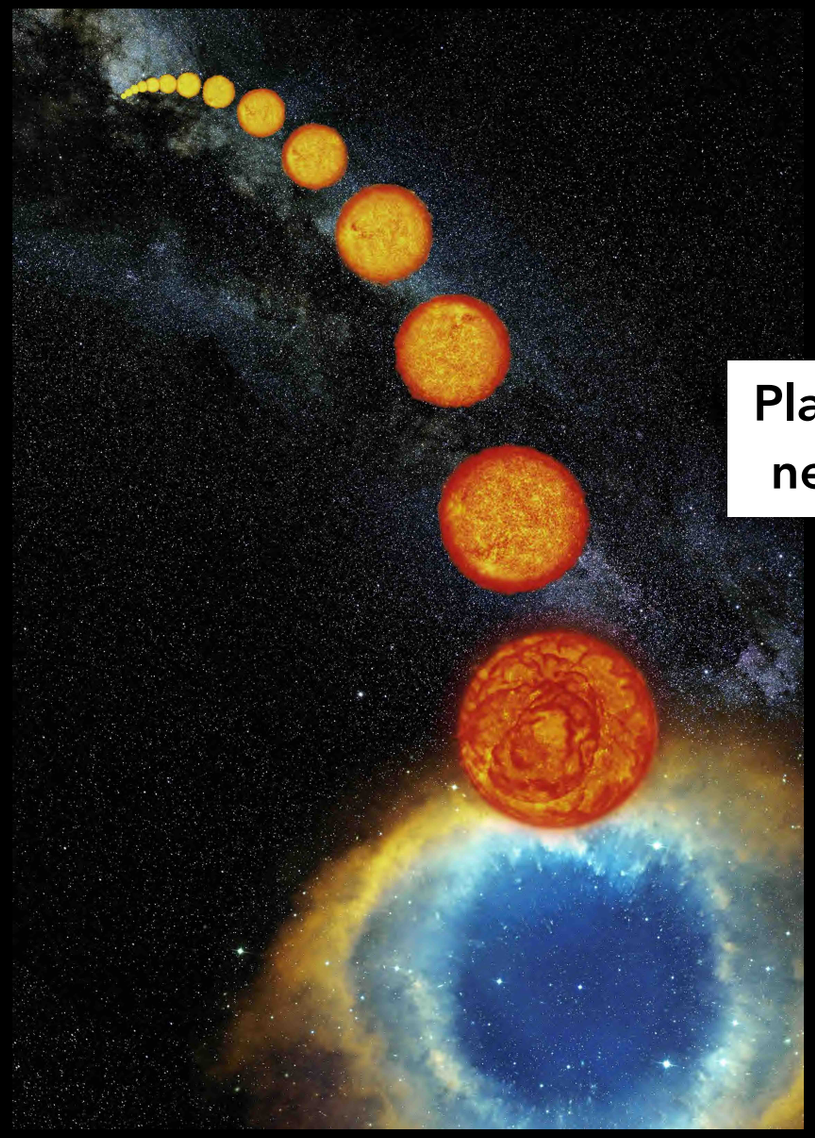
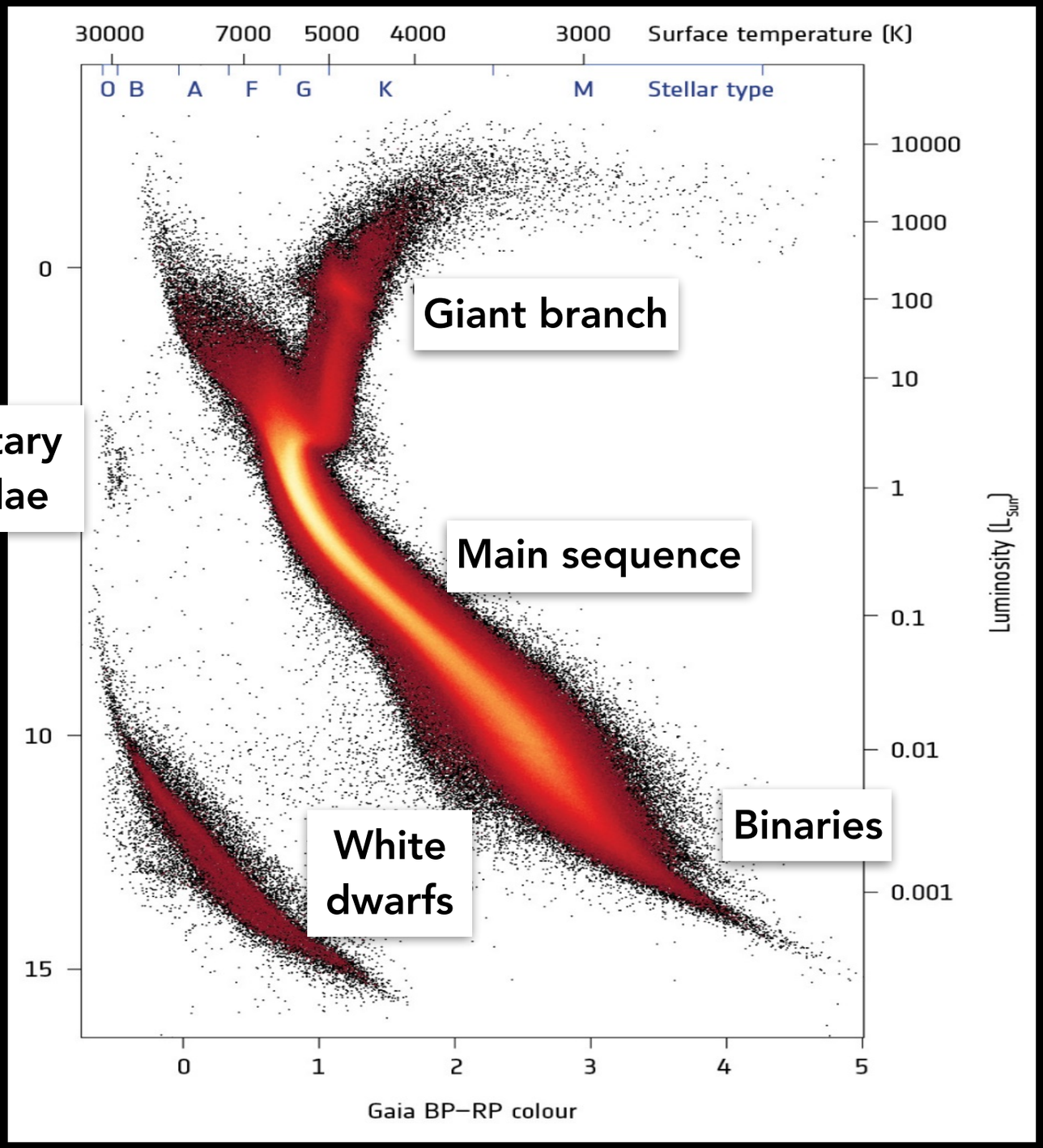


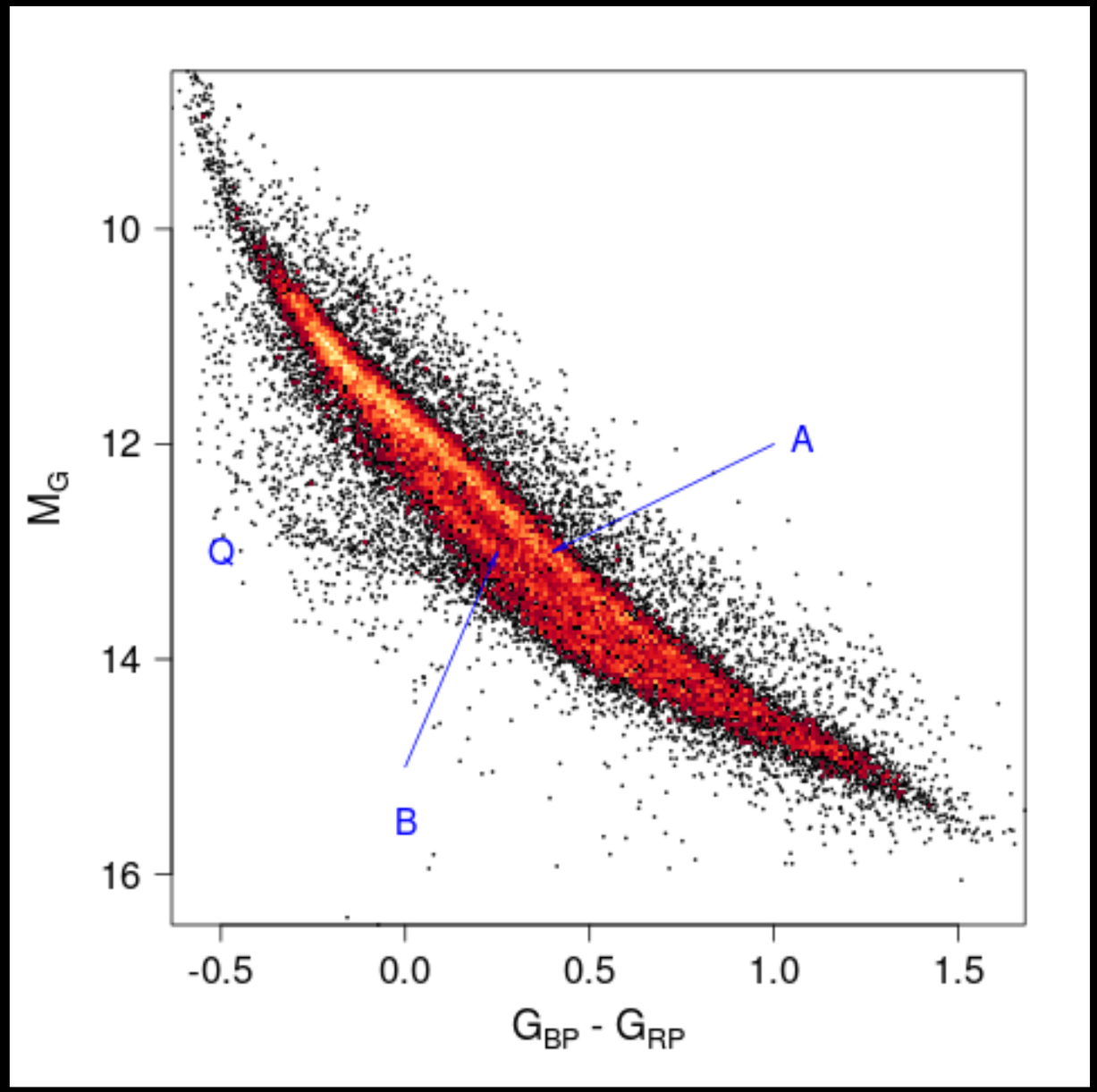
Planetary nebulae



Gaia collaboration, Babusiaux et al, 2018

HR DIAGRAM

White dwarfs
26 264 stars

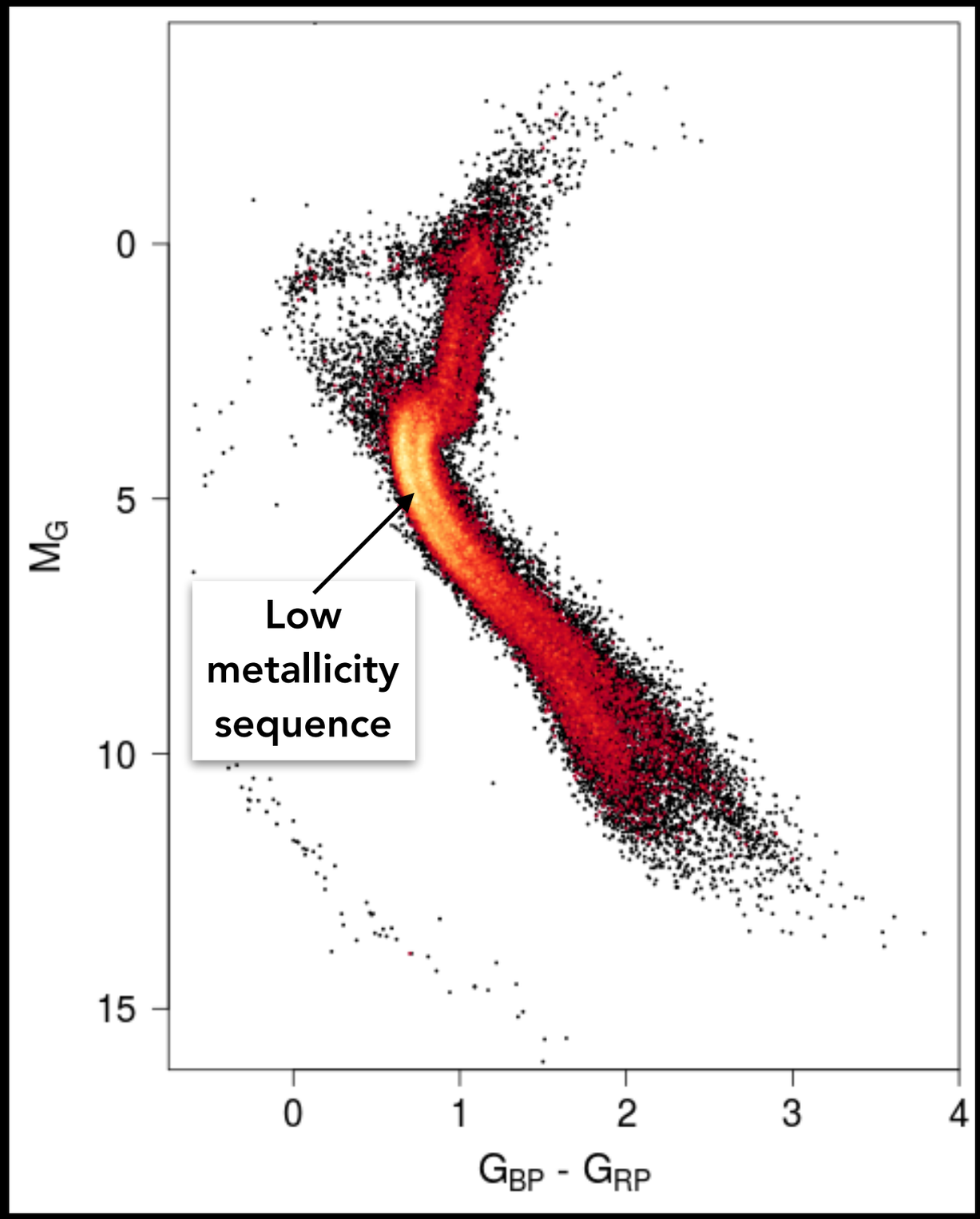


Gaia collaboration, Babusiaux et al, 2018

HR DIAGRAM

$V_{transverse}$>200 km s^{-1}

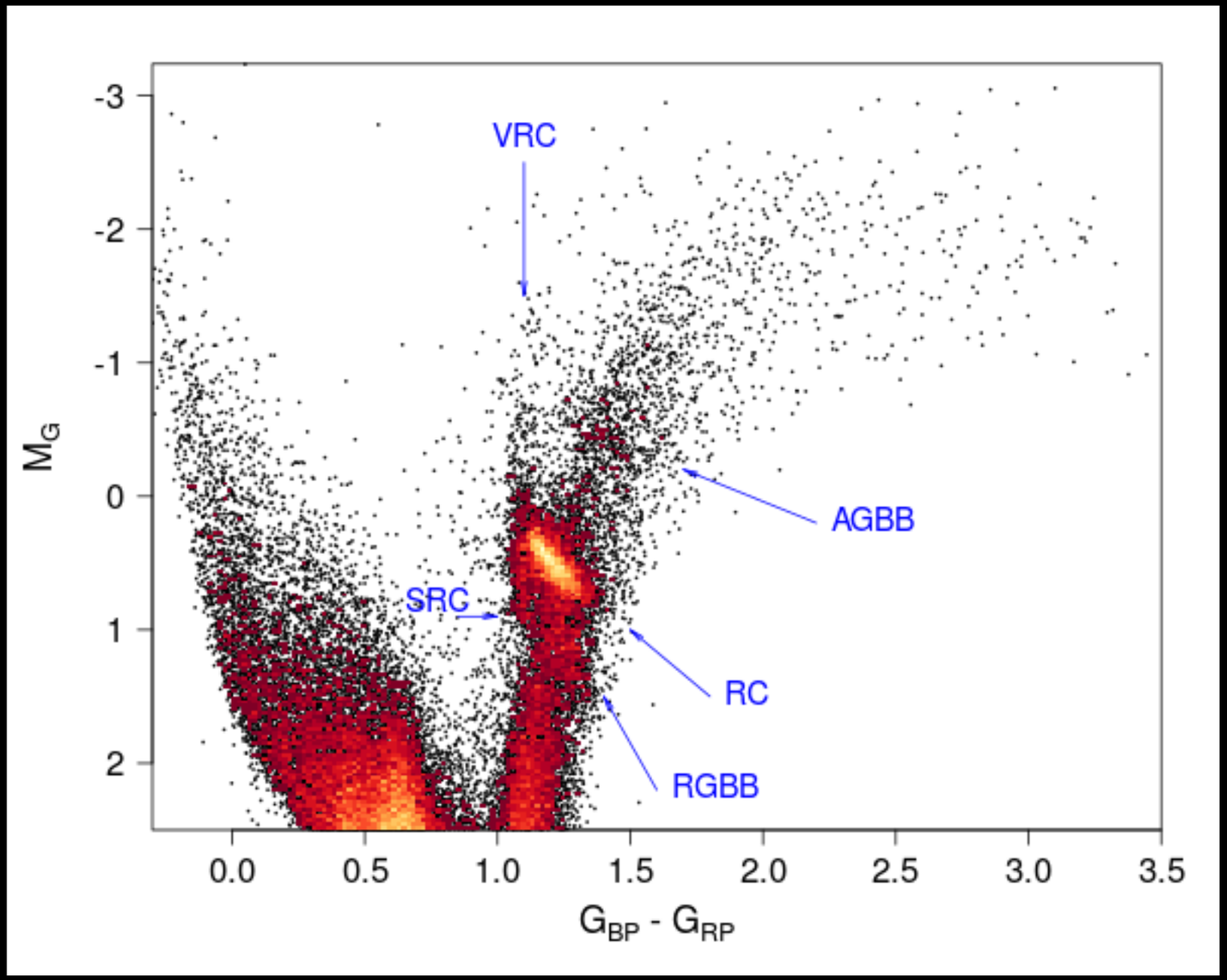
64 727 stars



Gaia collaboration, Babusiaux et al, 2018

HR DIAGRAM

Giants
d<500 pc
29 288 stars



Gaia collaboration, Babusiaux et al, 2018

HR DIAGRAM

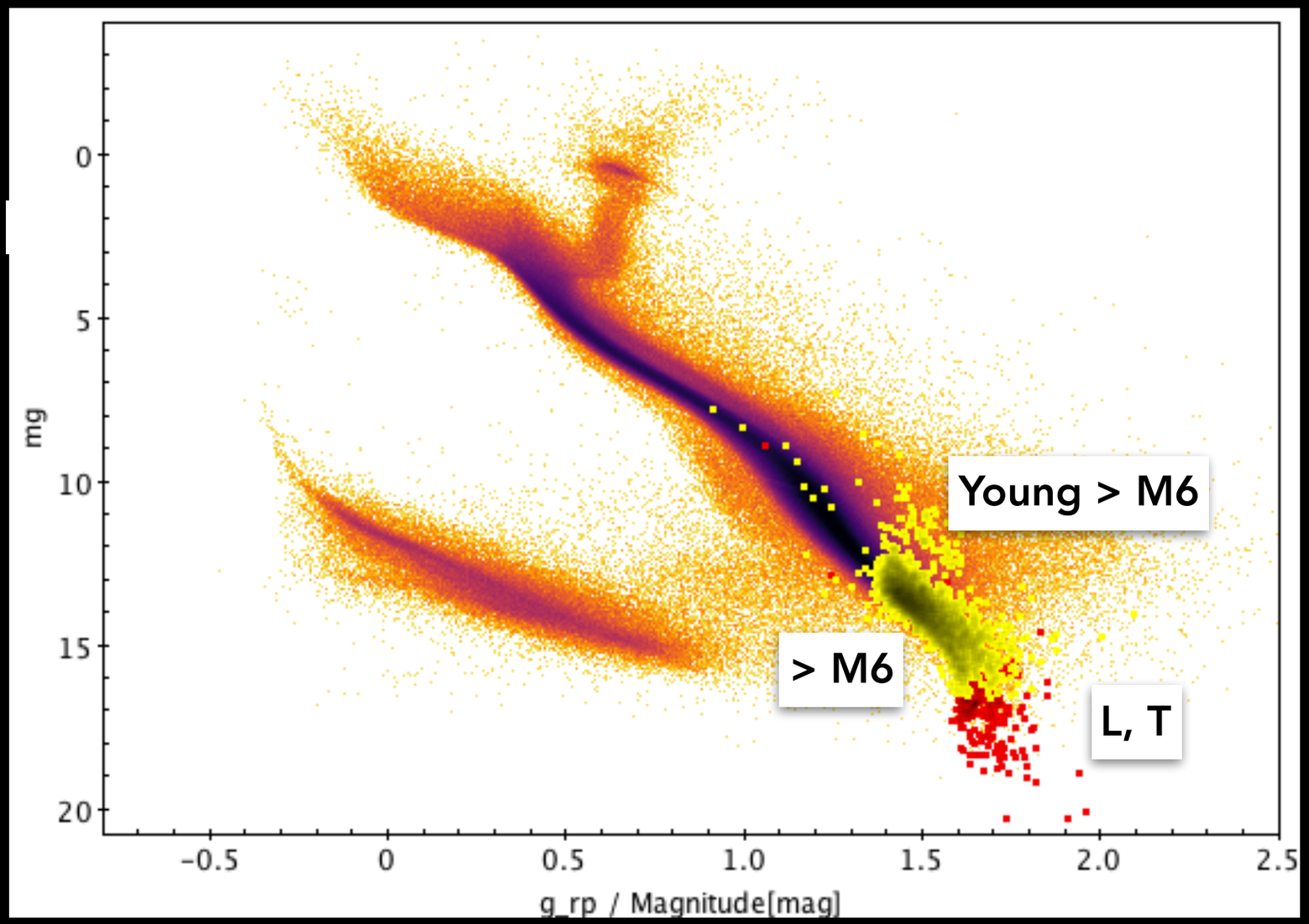
Low mass stars and brown dwarfs

d < 200 pc

~113 400 >M6

~2000 very young

~600 L,T



GAIA AND STELLAR PHYSICS

- Luminosity calibration, cosmic candles
- Fundamental parameters of rare stars (eg rapidly evolving stage)
- Variability of stars (~70 observations over 5 years, precision mmag)
- Accurate luminosity + effective temperature provides radius of stars in the whole HR diagram
- Test stellar models (evolution, interior)

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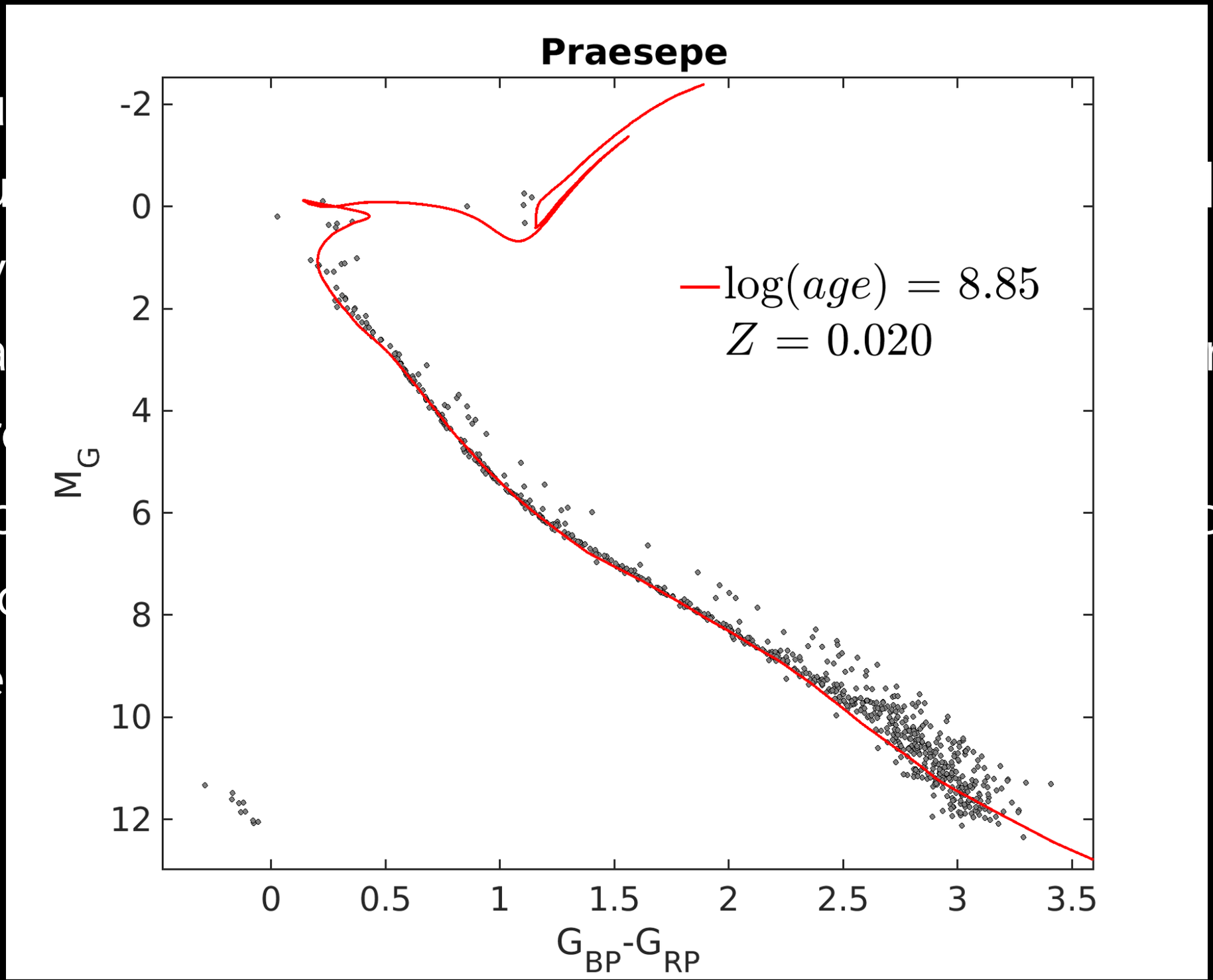
GAIA AND STELLAR PHYSICS

- Lu
- Fu ly
  ev
- Va rs,
  pr
- Ac ovides
  rac
- Te



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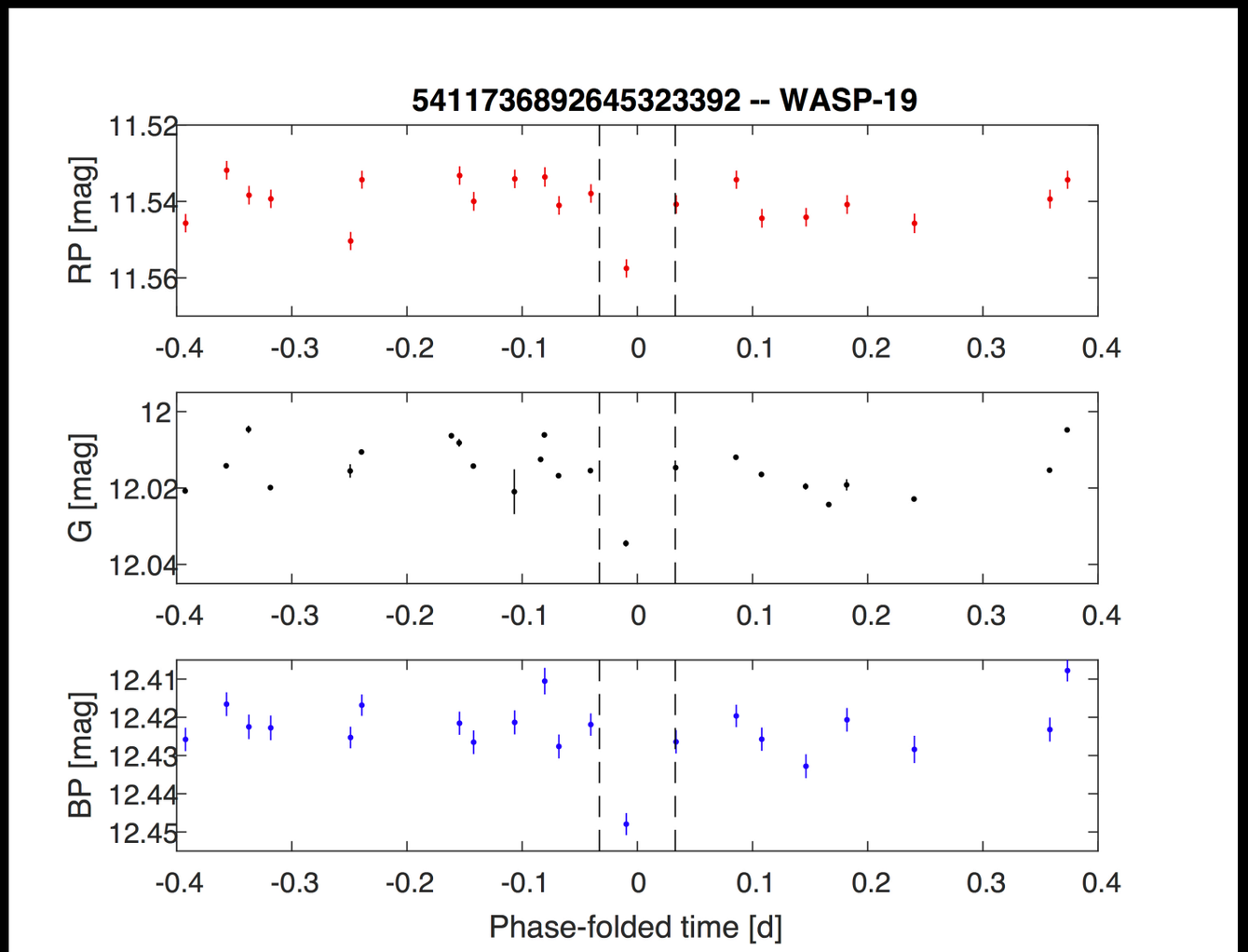
GAIA AND EXOPLANETS

- ~10 000s (1-15 M_{Jup}) long-period planets, up to 500 pc, by measuring the wobble they cause in the path followed by their parent stars on the sky.

GAIA AND EXOPLANETS

- Transiting exoplanets

Gaia might also serve as an all-sky survey for transiting exoplanets.



Light-curve of WASP-19b in the bands RP, G and BP. The vertical dashed lines mark the times of transit

Credit: ESA/Gaia/DPAC/CU7

GAIA AND EXOPLANETS

- use the astrometry and photometry to get stellar radii and thereby get better estimates of planet radii for the Kepler planets.
- use Gaia-based stellar age estimates to compare planetary systems around stars of different ages
- compare ages for planetary systems of different architectures
- eccentricities with stellar ages
- Gaia could detect signatures of stars that have recently accreted their planets? Different signatures on different time-scales?