Gaia — counting down to launch

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- Gaia spacecraft status
- Summary of the Gaia sky survey
- Science performance
- Launch and commissioning
- Data processing
- Catalogue and archive access

gaia

Universiteit Leiden

- ESA Cornerstone mission within Horizon 2000+ programme
- Create large and highly accurate stereoscopic map of the Galaxy
- Global astrometry concept successfully demonstrated by Hipparcos

Gaia DPAC

gaia

- Launch in 2013 with Soyuz-Fregat from Kourou
- Orbit: vicinity of L2
- Mission duration 5 (+1) years

Image credit: Lund Observatory

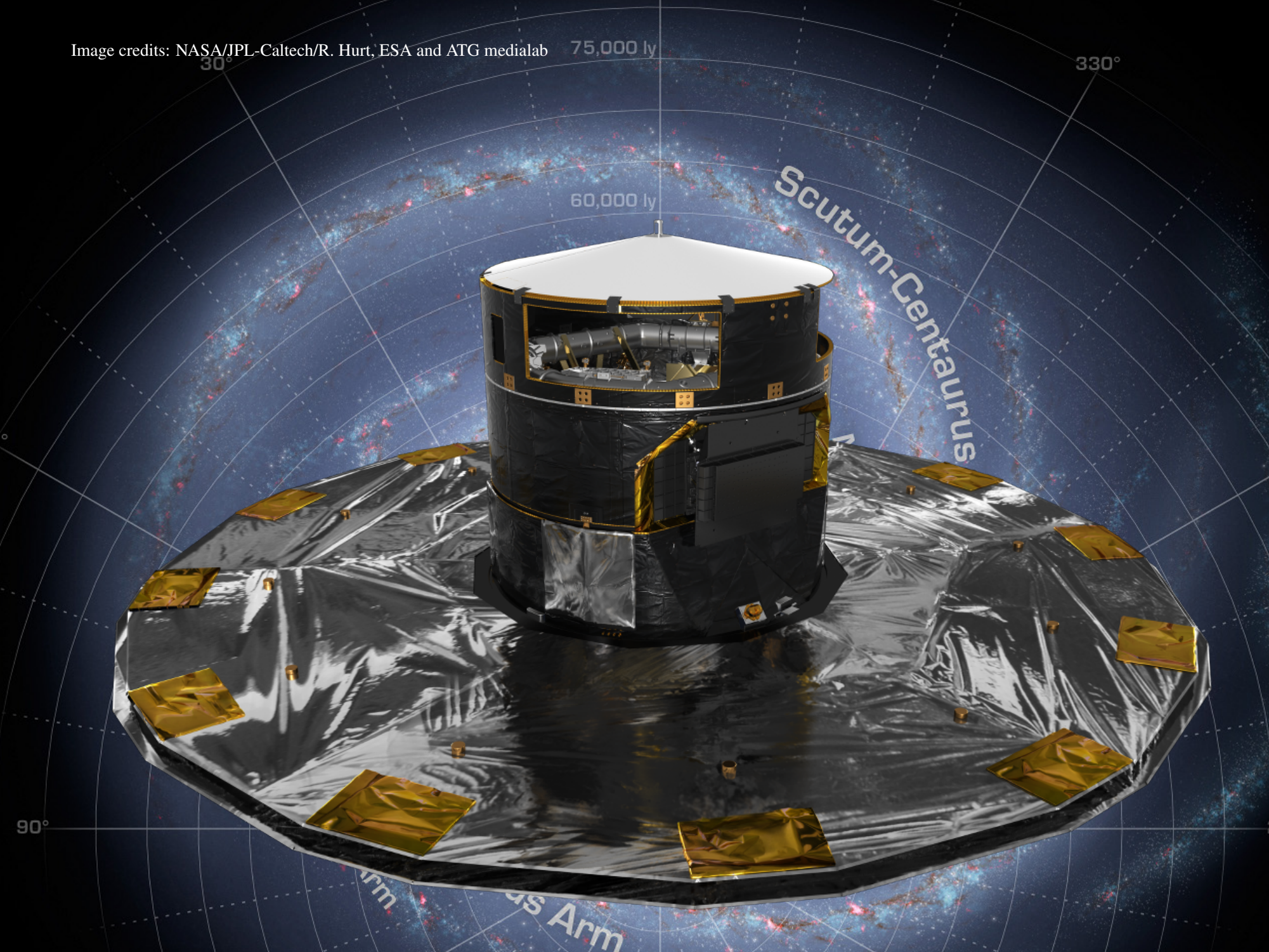
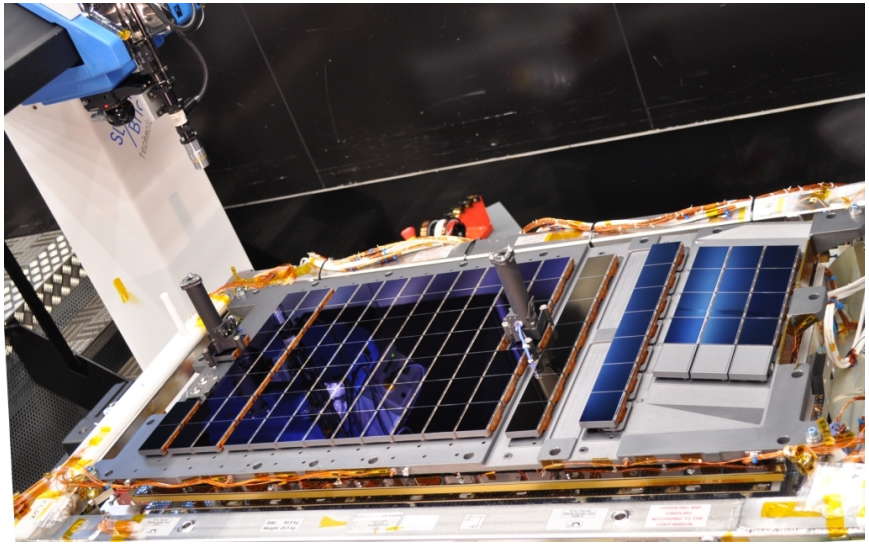
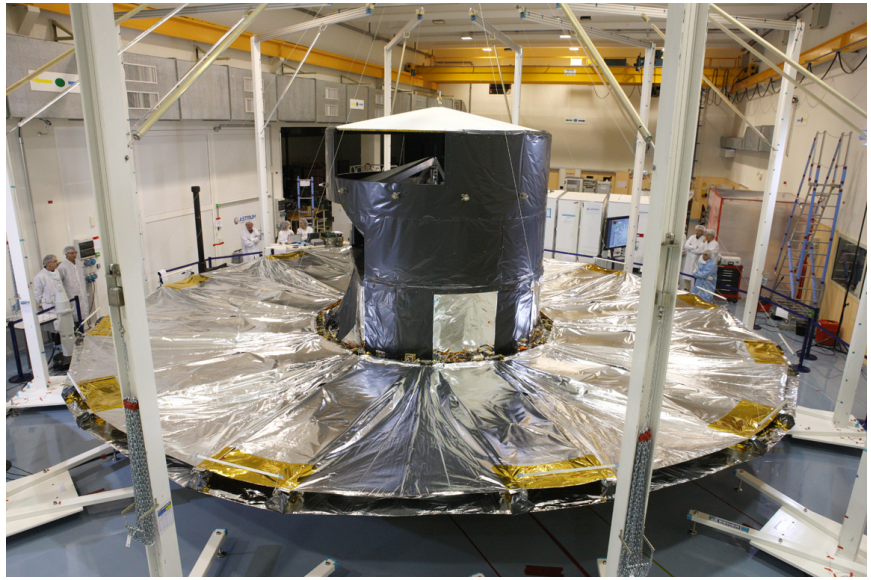


Image credits: NASA/JPL-Caltech/R. Hurt, ESA and ATG medialab
75,000 ly
30°
330°
60,000 ly
Scutum-Centaurus
90°

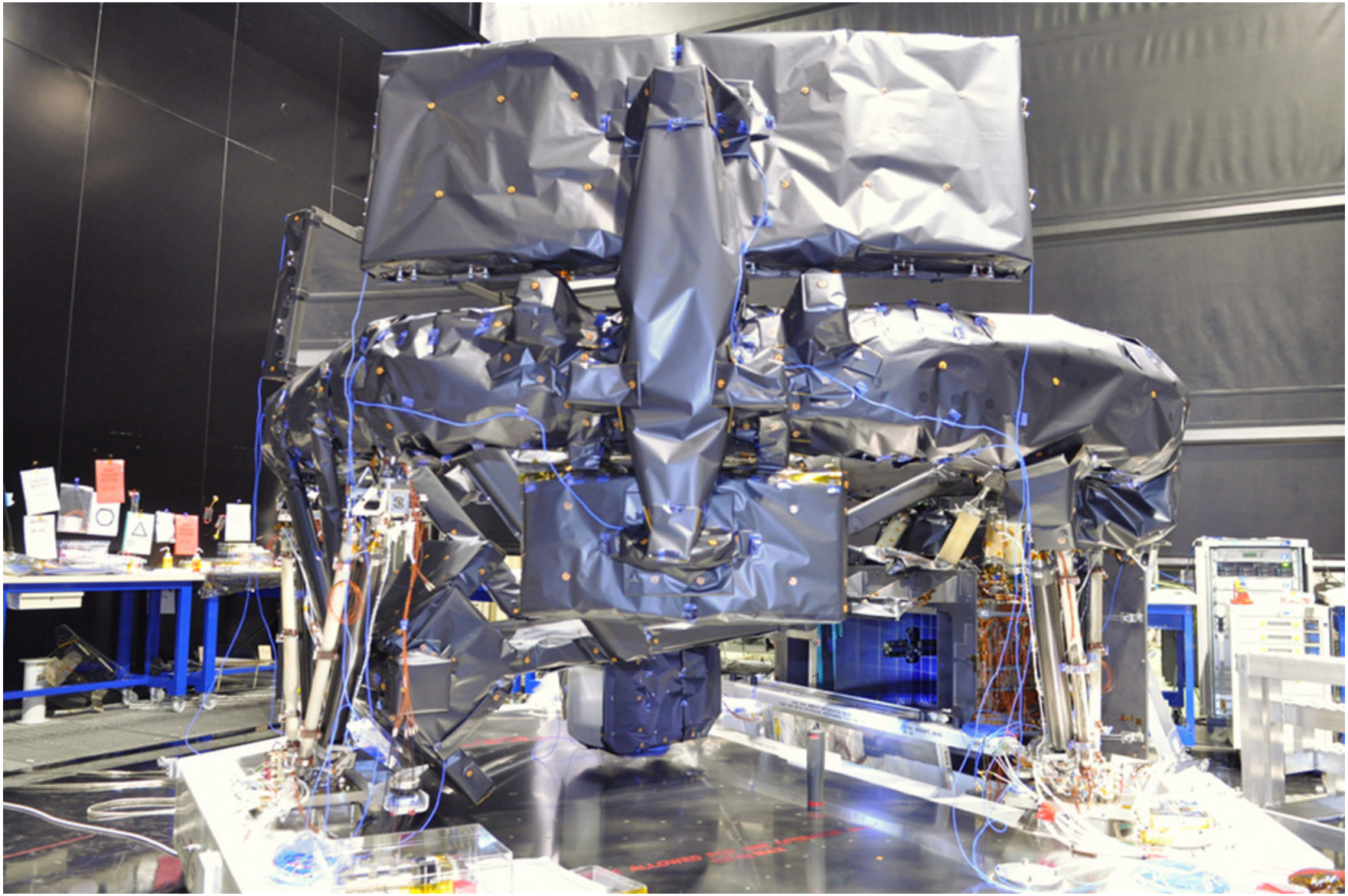
Launch November 2013





Images courtesy EADS-Astrium and ESA

Launch November 2013



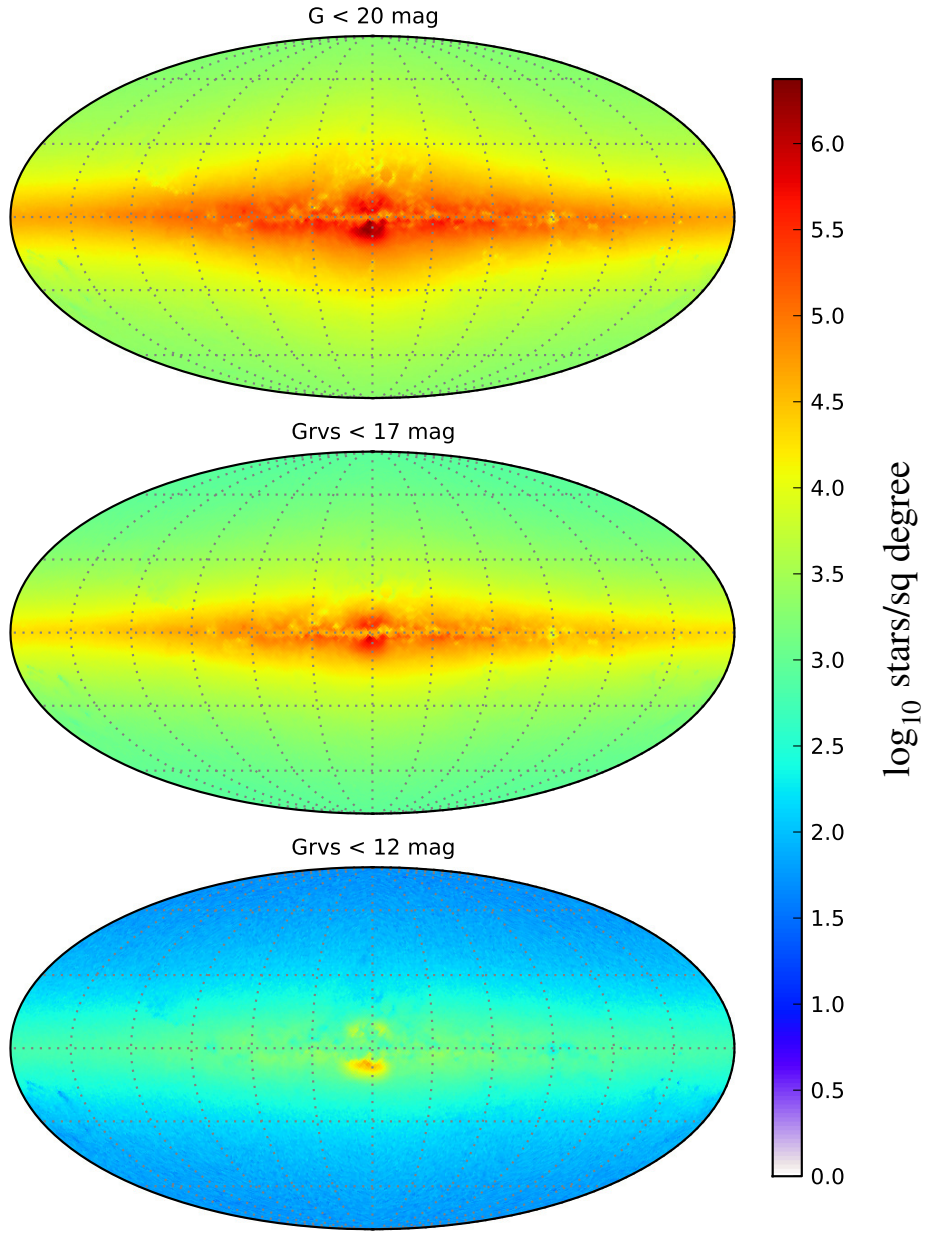
Survey capabilities

- Three simultaneous observing modes
- Complete to $G = 20$ ($V = 20$–22)
- Observing programme: autonomous on-board detection and unbiased
- Quasi-regular time-sampling over 5 years ($\sim$ 70 observations)
- Angular resolution comparable to HST

Number of objects

- 1 billion stars to $G = 20$
- 10^6–10^7 galaxies
- 500 000 quasars
- 3×10^5 solar system bodies
- tens of thousands of exoplanets

Simulated Gaia sky — Robin et al., arXiv:1202.0132



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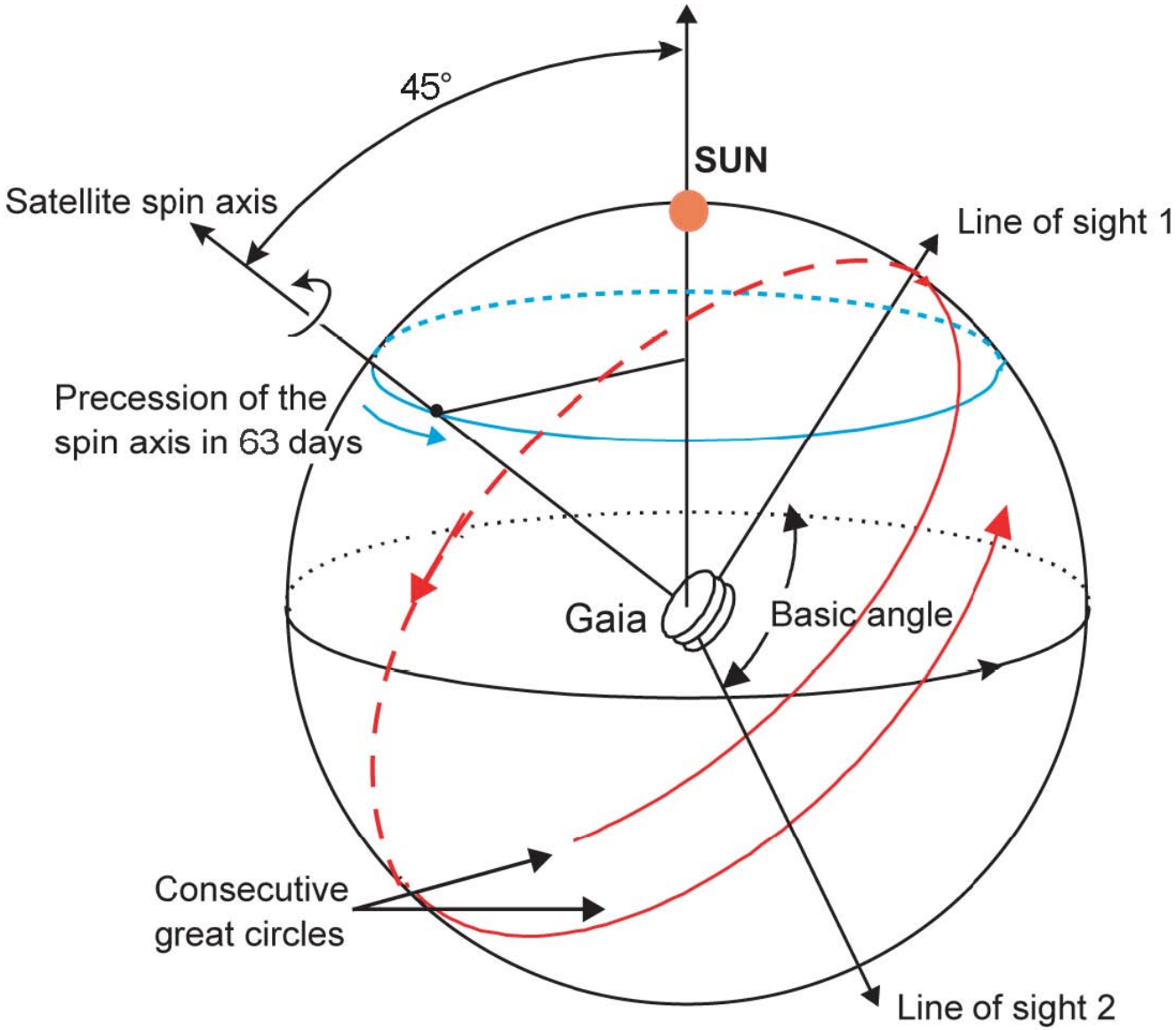
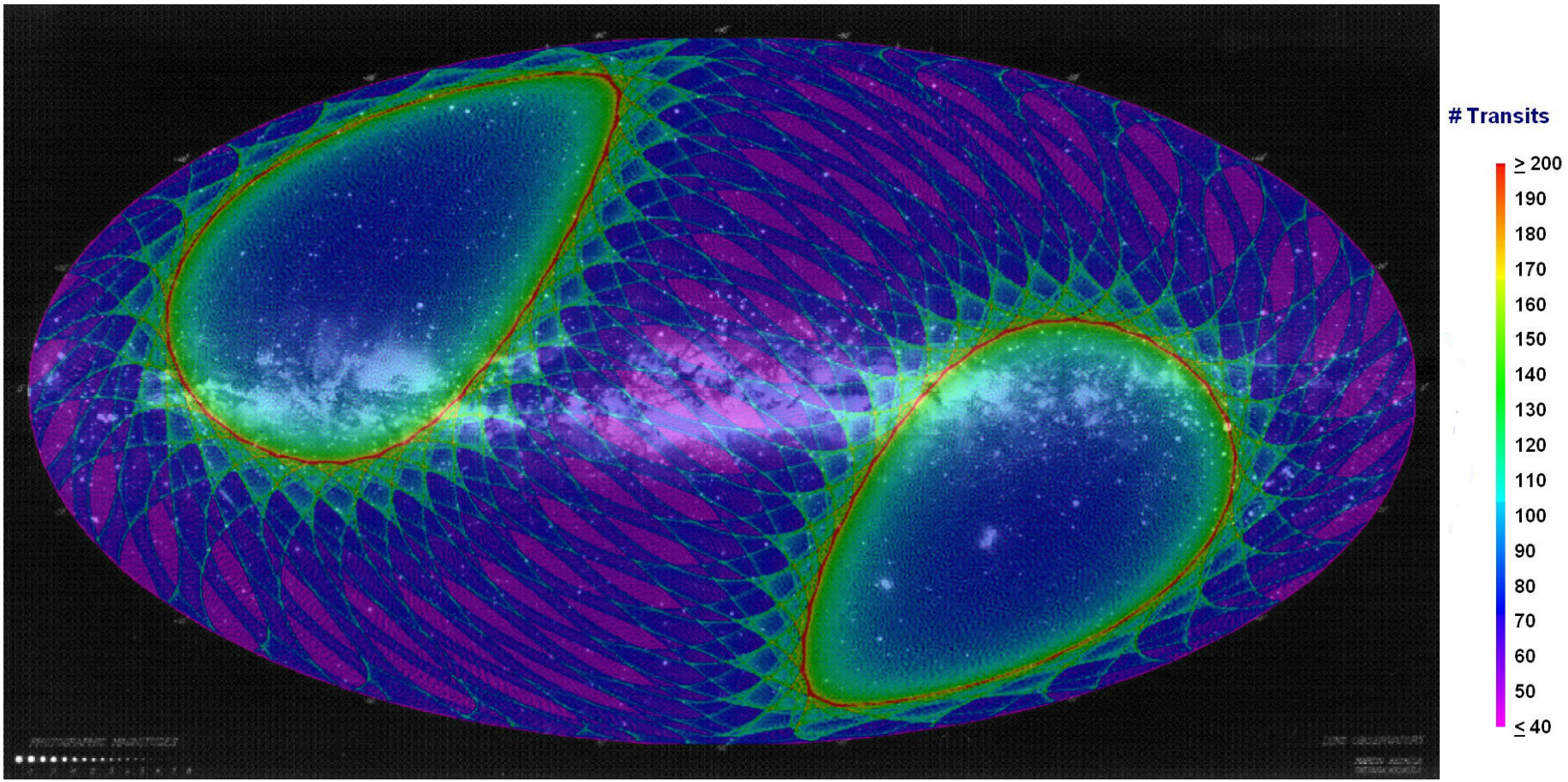


Number of field of view transits



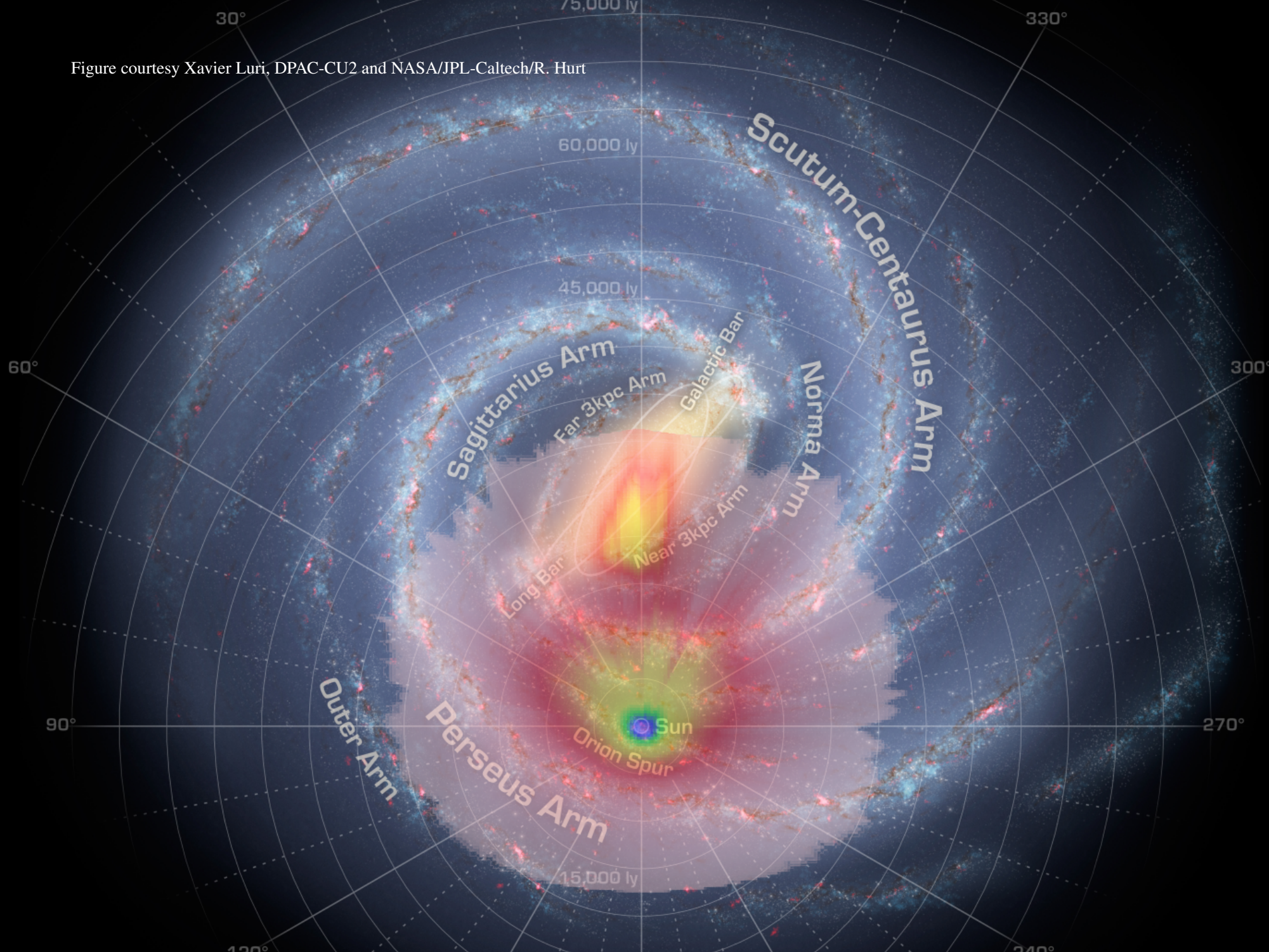


Figure courtesy Xavier Luri, DPAC-CU2 and NASA/JPL-Caltech/R. Hurt
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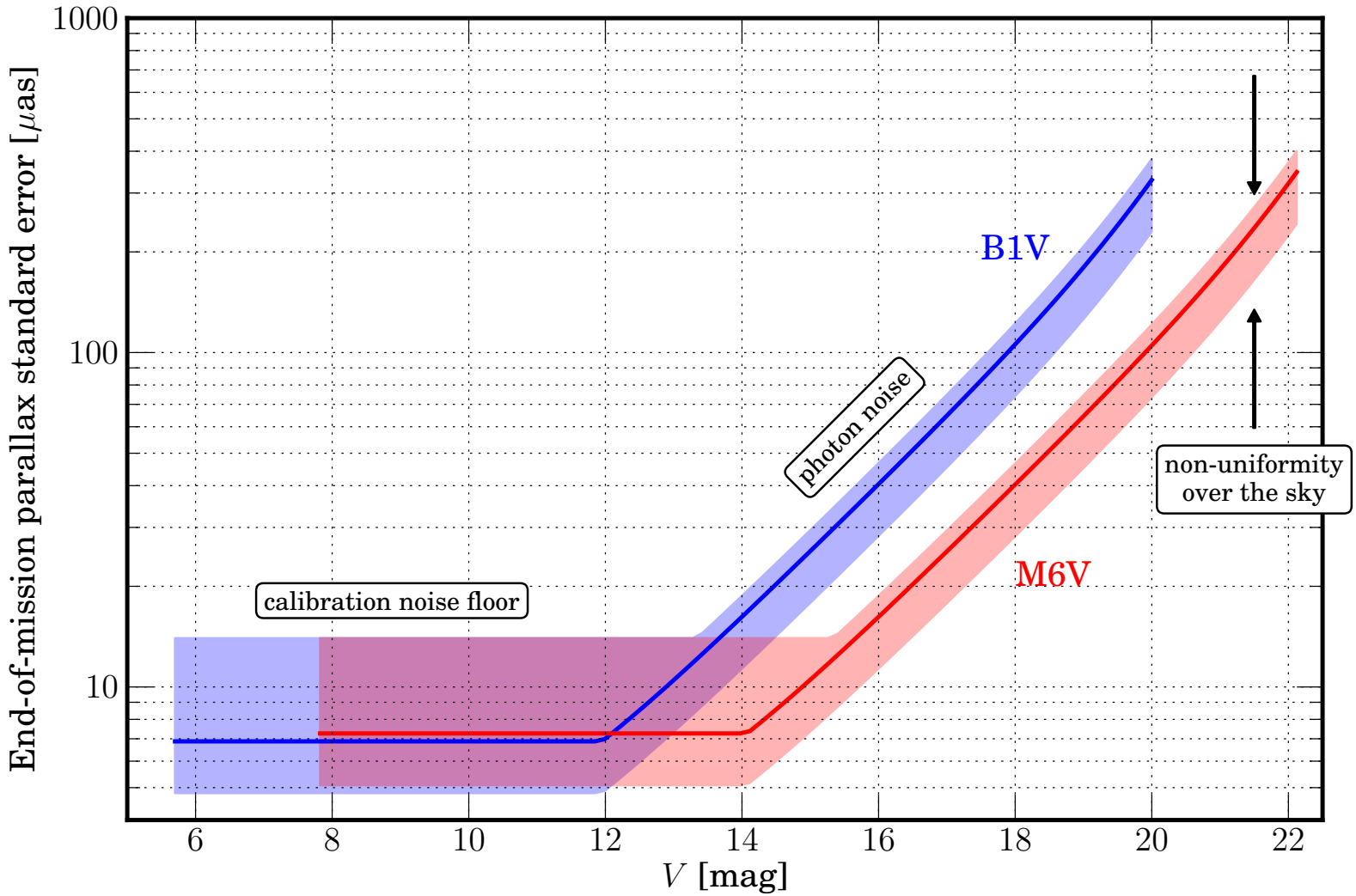
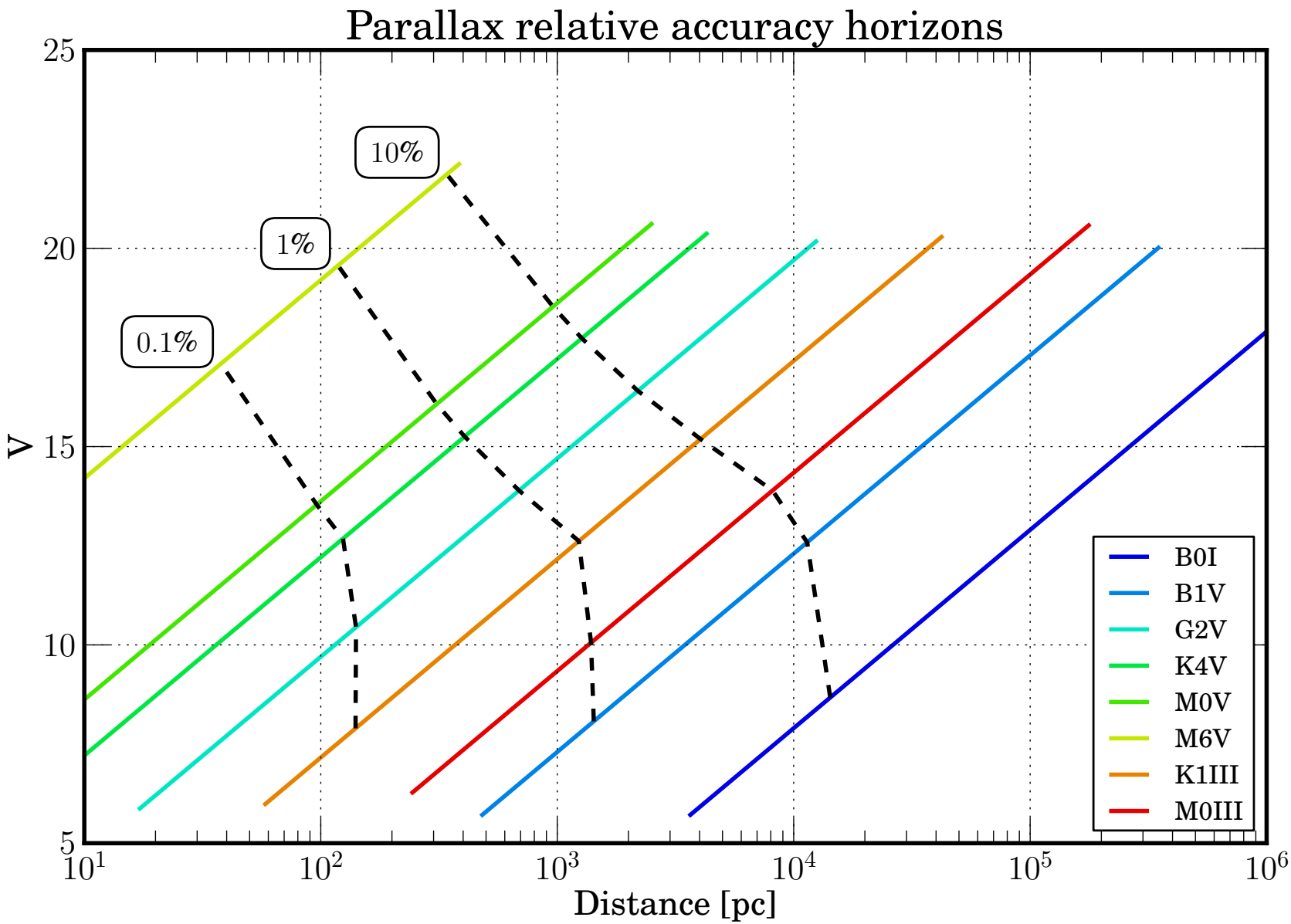
60,000 ly
45,000 ly
15,000 ly
30°
330°
60°
300°
90°
270°
Scutum-Centaurus Arm
Sagittarius Arm
Far 3kpc Arm
Galactic Bar
Norma Arm
Near 3kpc Arm
Long Bar
Outer Arm
Perseus Arm
Sun
Orion Spur



Apply factors ~ 0.5 and ~ 0.7 for positions and proper motions


Parallax relative accuracy horizons
10%
1%
0.1%
V
Distance [pc]
B0I
B1V
G2V
K4V
M0V
M6V
K1III
M0III

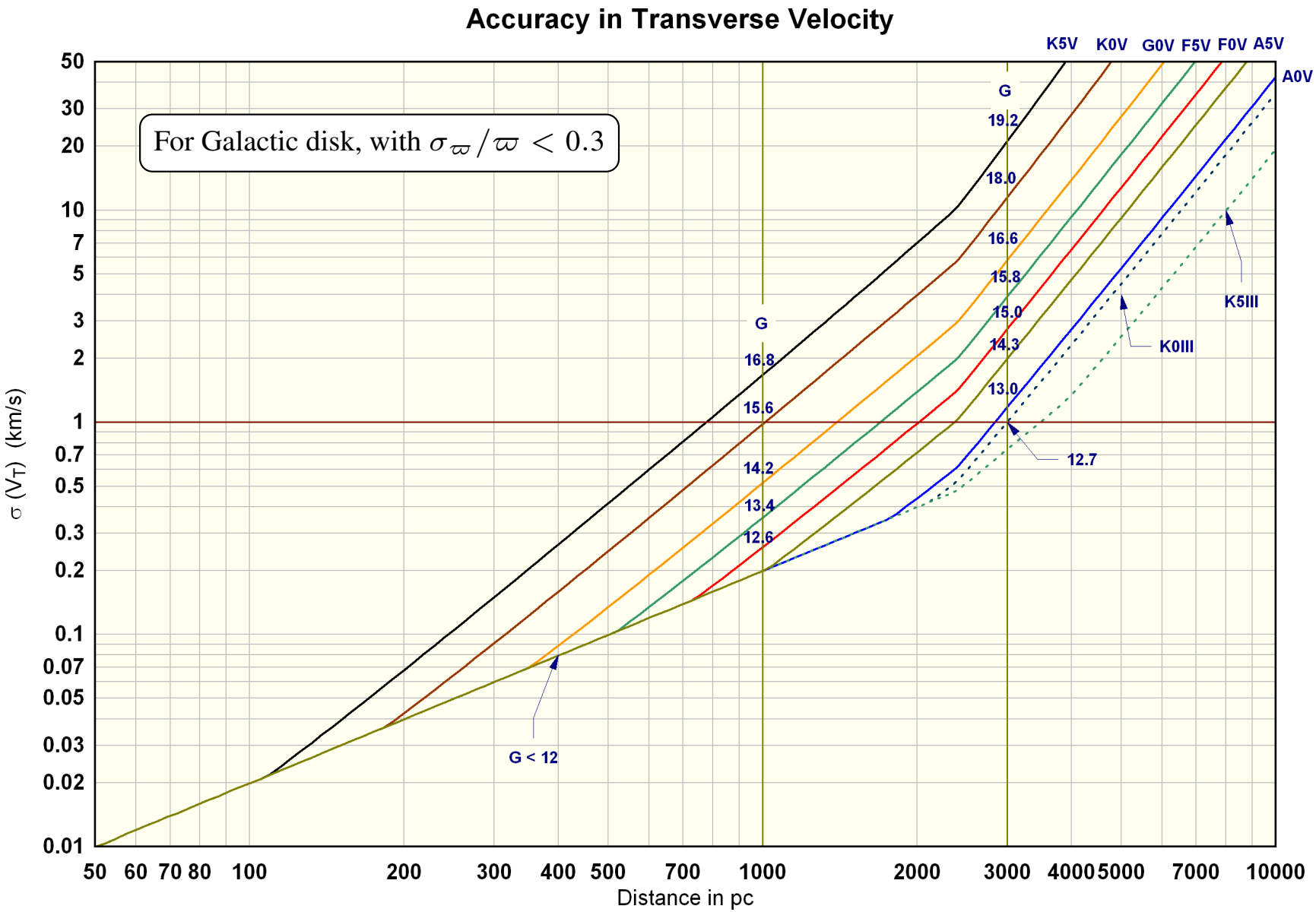
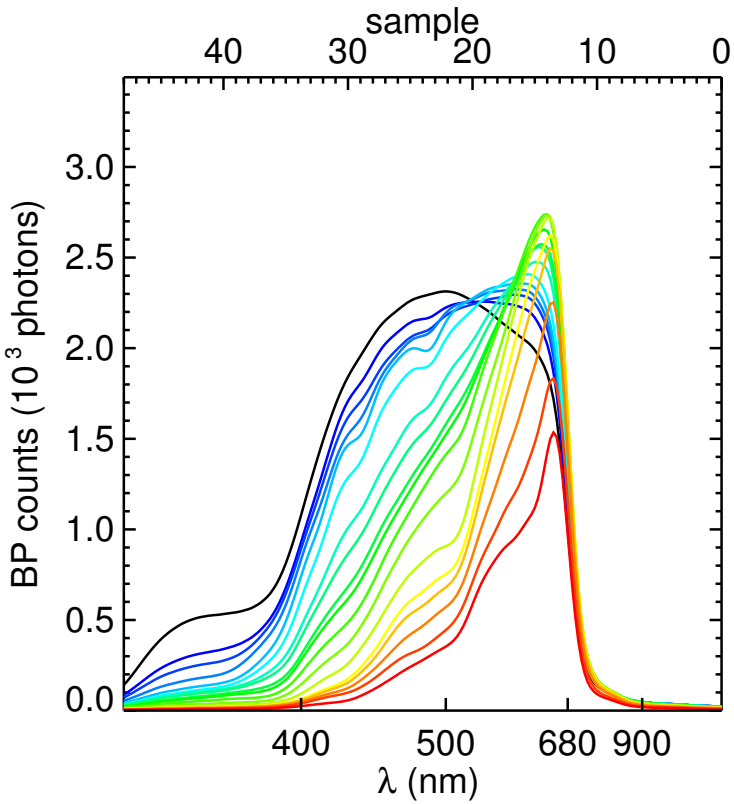


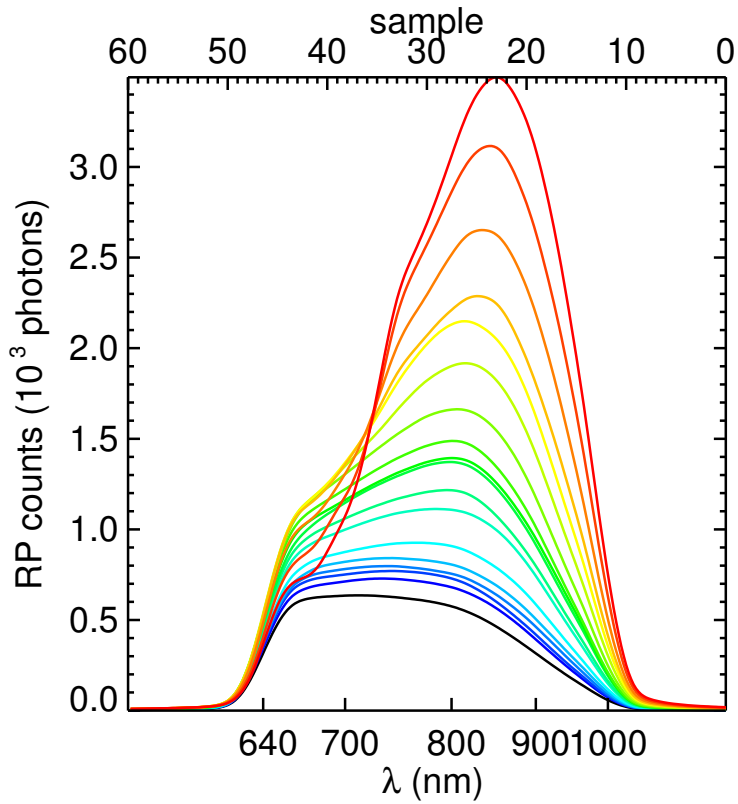
Figure courtesy François Mignard

Gaia spectrophotometry

Photometer

- Two channels: 330–680 nm (BP), 640–1000 nm (RP)
- Low resolution ($\sim$ 3–30 nm/pixel) prism spectra
- Allows derivation of A_V, $T_{\rm eff}$, $\log g$, [M/H], and [α/H] for brighter stars





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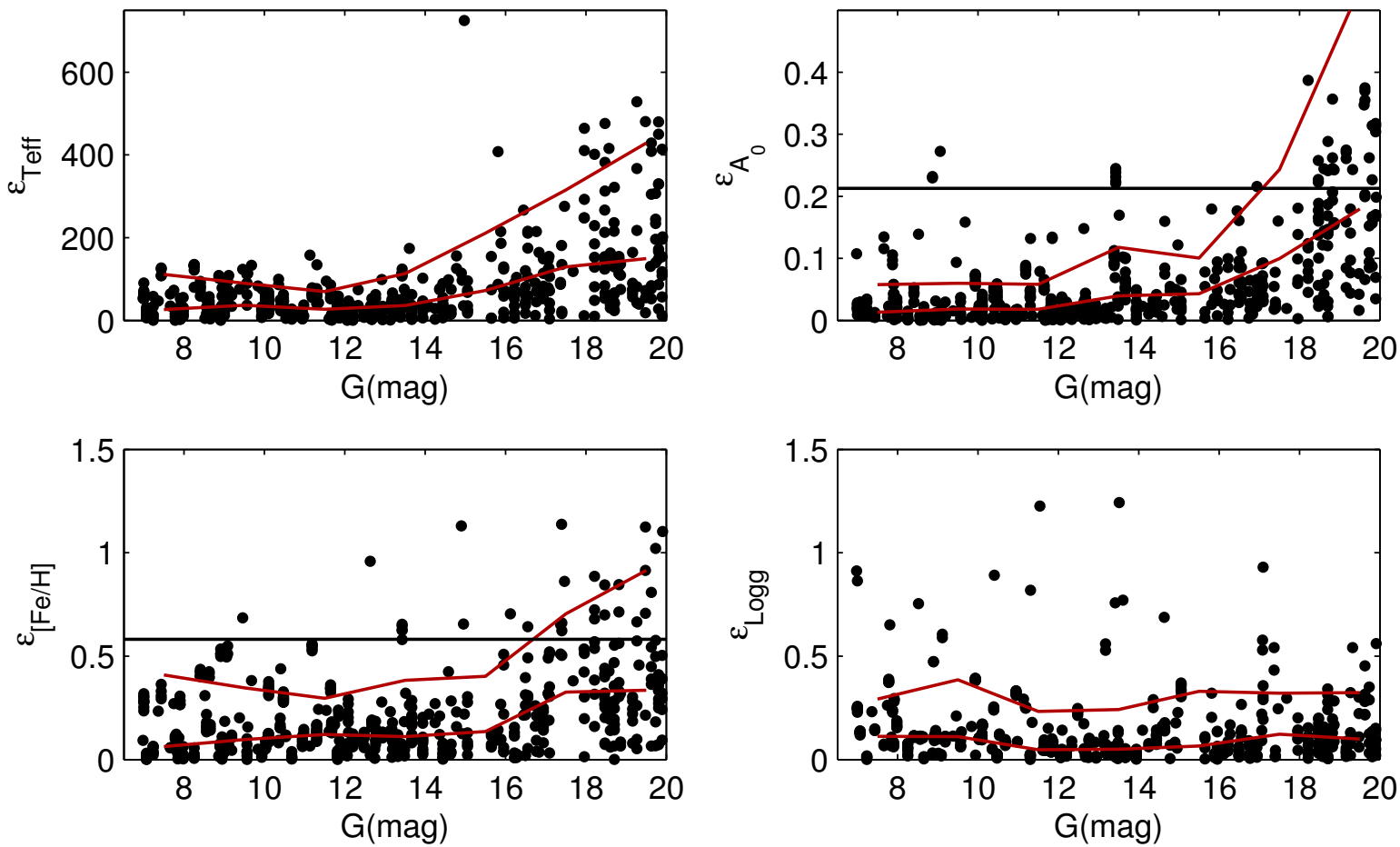
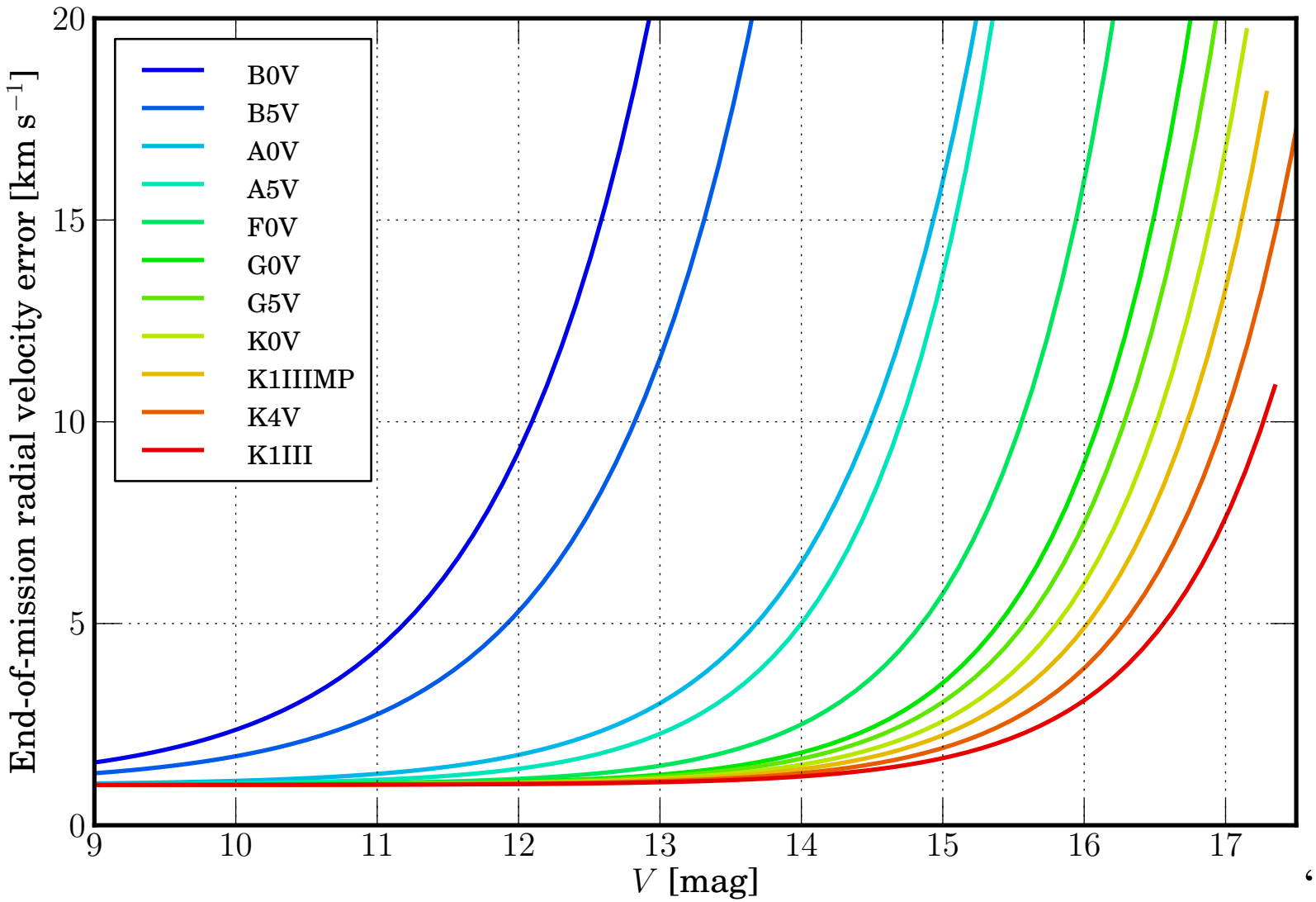


Example of stellar parametrization performance (in this case with SVM).
From Liu et al., 2012, MNRAS 426, 2463

Gaia spectroscopy

- Slitless spectroscopy in Ca triplet region (847–874 nm)
- $\lambda/\Delta\lambda \sim 11\,000$



Stellar and interstellar parameters (conservative estimates)

◆ Radial velocities	$V \leq 17$	$\sim 150 \times 10^6$ stars
◆ Rotational velocities	$V \leq 13$	$\sim 5 \times 10^6$
◆ Atmospheric parameters	$V \leq 13$	$\sim 5 \times 10^6$
◆ Abundances	$V \leq 12$	$\sim 2 \times 10^6$
◆ Interstellar reddening	$V \leq 13$	$\sim 5 \times 10^6$

Diagnostics

- Binarity/multiplicity, variability
- $\sim 10^6$ spectroscopic binaries
- $\sim 10^5$ eclipsing binaries ($\sim 25\%$ SB2 $\rightarrow$ masses)
- Long period classical Cepheids $\sigma_{v_r} < 7$ km/s $\rightarrow$ 20–30 kpc

Simulate your own

What

- Background information on instruments and error modelling
- Interpolation tables and formulae
- Error variations on sky
- Transformations from Johnson, Sloan systems to Gaia photometric system
- Will be updated with more information on astrophysical parameter performances, other products from photometry and spectroscopy
- Simulated Gaia catalogues (billion objects) will be made available through CDS

Where

- Go to: www.rssd.esa.int/gaia, look for 'Science Performance' button
  - (or google for 'Gaia science performance')
- Python implementation at: pypi.python.org/pypi/PyGaia

Launch and commissioning

- Sunshield deployment within hours after launch
- Travel to L2 takes up to $\sim$ 30 days
- First data received after about 40 days
- Total commissioning phase 4–6 months
  - repeatedly scanning over well characterized ecliptic pole fields
  - detailed instrument check out and performance verification

Expect first Gaia publications in 2014

- Description of Gaia 'as built'
- Detailed performance assessment
  - early indication of what can really be expected from Gaia

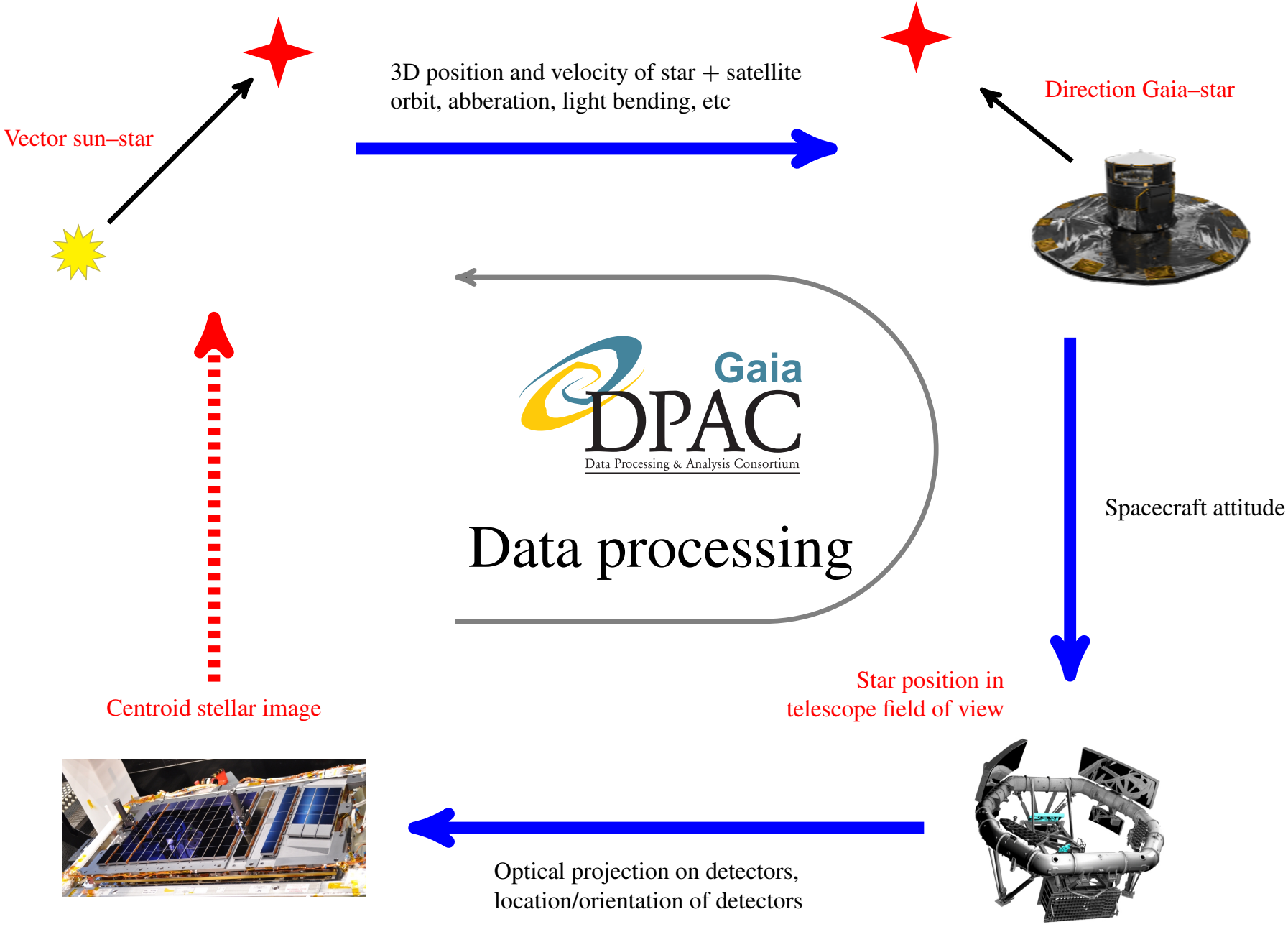
Image credit: Holger Voss

Gaia DPAC
Data Processing & Analysis Consortium

- Gaia data processing is a Pan-European cooperation
  - Over 1000 staff years effort since 2006
  - Processing power spread over 6 centres
  - Supported through national funding
  - Additional support from EC Marie Curie and ESF

DPAC membership
January 2013
432 total

BR: 5
CA: 1
CL: 1
ESA: 28
IL: 1
US: 2


Vector sun–star
3D position and velocity of star + satellite orbit, abberation, light bending, etc
Direction Gaia–star
Gaia
DPAC
Data Processing & Analysis Consortium
Data processing
Spacecraft attitude
Star position in telescope field of view
Optical projection on detectors, location/orientation of detectors
Centroid stellar image

Data release scenario

Release

L + 22m

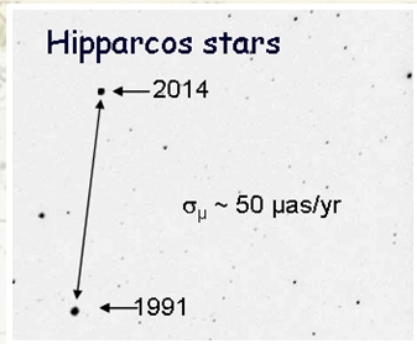
L + 28m

L + 40m

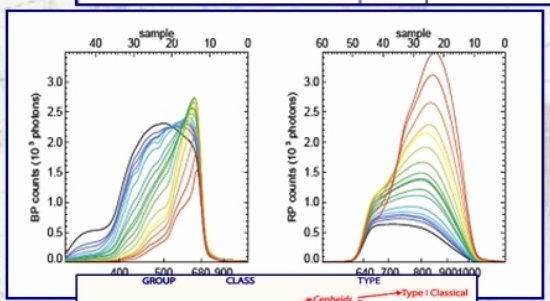
L + 65m

α deg 8	δ deg 9
4.18700521	41.06905721
57.84982093	−25.93298679
87.24506095	63.69702032

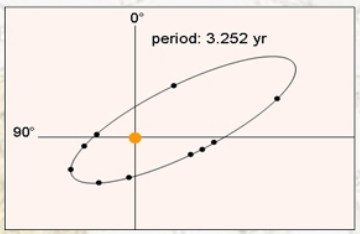
α deg 8	δ deg 9	π mas 11	$\mu_{\alpha*}$ mas/yr 12	μ_δ 13
4.18700521	41.06905721	18.92	190.14	27.75
57.84982093	−25.93298679	21.42	273.72	167.93
87.24506095	63.69702032	4.12	5.07	−98.19
97.98452970	−27.72950422	17.95	21.31	217.87
106.43757563	26.14031575	21.74	18.58	−10.54
109.41026120	−29.01434479	7.92	−4.53	−7.01

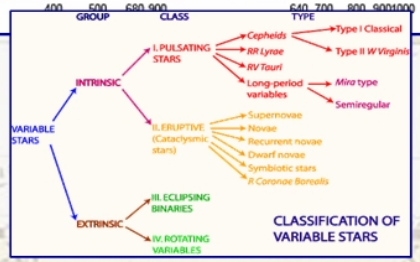


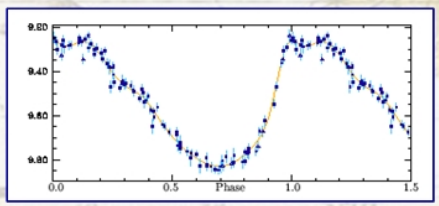
G G_{BP} G_{RP}



⟨Vr⟩







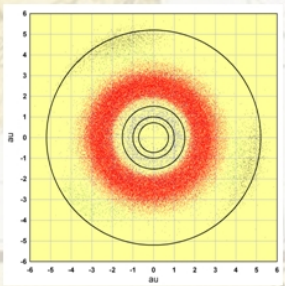


Figure by François Mignard

Data release scenario

- Assumes smooth operations!
- Each release updates the previous and contains significant new additions

October 2013 launch

L+22M Positions + G magnitude ($\sim$ all sky, single stars)
- Includes more often scanned Ecliptic pole regions
- Hundred Thousand Proper Motions (Hipparcos-Gaia, ~ 50 μas/yr)

L+28M radial velocities for bright stars, two-band photometry, and full astrometry (α, δ, ϖ, $\mu_{\alpha*}$, μ_δ) where available.

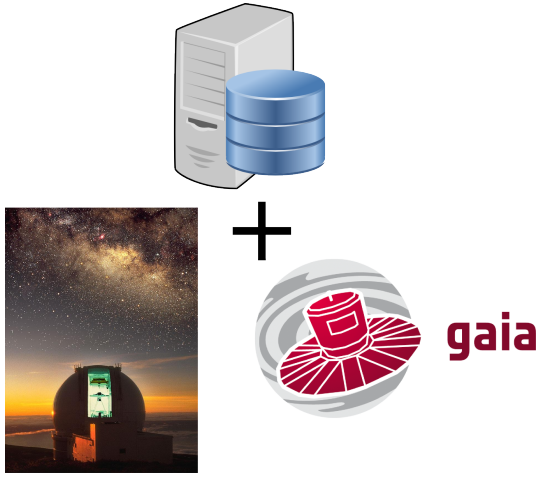
L+40M full astrometry, orbital solutions for short period binaries, $(G_{\rm BP} - G_{\rm RP})$, BP/RP Spectrophotometry and astrophysical parameters , radial velocities, RVS spectra

L+65M Updates on previous release — including more sources, source classifications, multiple astrophysical parameters, variable star solutions and epoch photometry for them, solar system results

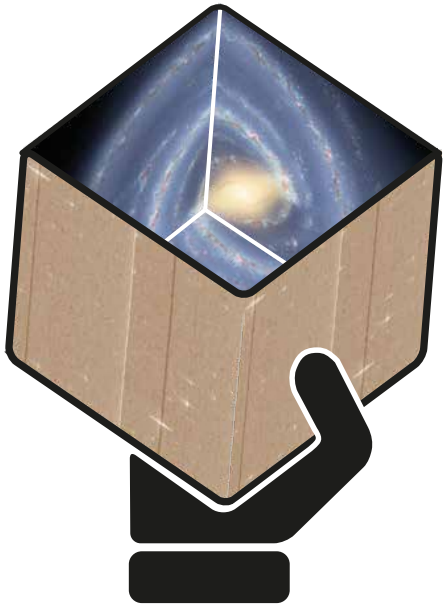
End+3yr Everything

Efficient access to a billion source catalogue

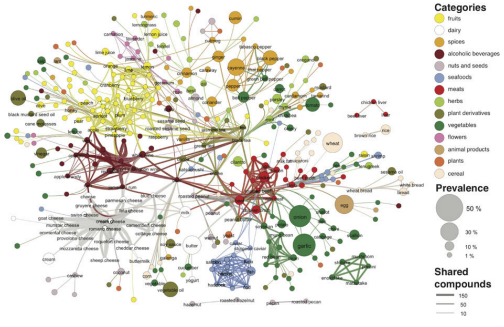
Reaching out to the general public



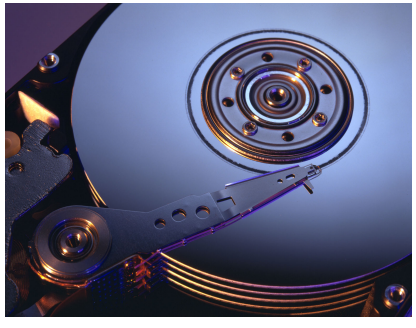
Seamless inter-operation with other missions and surveys



Delivering the Promise of Gaia



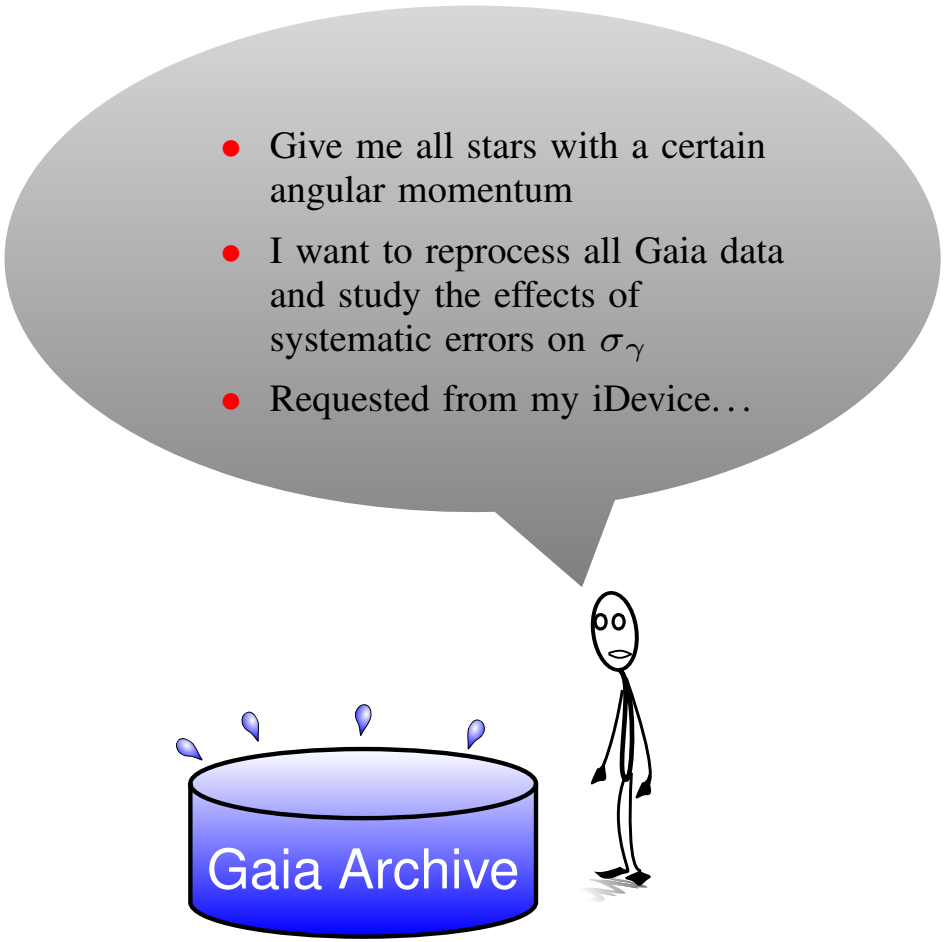
Visualization to aid the discovery process



Long term archive preservation in the context of data re-use

Your ideas here

- DPAC-CU9 has started work on the Gaia catalogue and archive
- Maximizing science depends on archive that can *deliver what you want*
  - tell us how you want to access and use the Gaia data
  - feel free to go crazy...
  - think about possibilities in 2020!



Gaia data access use cases

- Provide your ideas through GREAT wiki pages
  - `http://great.ast.cam.ac.uk/Greatwiki/GaiaDataAccess`
- Many ideas collected already
- Reviewed and ranked according to
  - Urgency, generality, science impact, scale, expected frequency
  - ranking will be used to prioritize CU9 efforts
- All of this is summarized in a publicly available document
  - `http://www.rssd.esa.int/SA/GAIA/docs/library/AB-026.htm`

Please read this document and provide feedback
(and keep ideas on use cases coming)!

Gaia's 'limitations'

- Sky-coverage non-uniformity
  - Average $\sim$ 70 observations over 5 years ($\sim$ 20% dead time)
  - Varies over the sky between $\sim$ 50 and $\sim$ 130 ($\sim$ 20% dead time)

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  - Astrometric limit is $\sim 1\,000\,000$ stars deg^{-2} (without bright stars)
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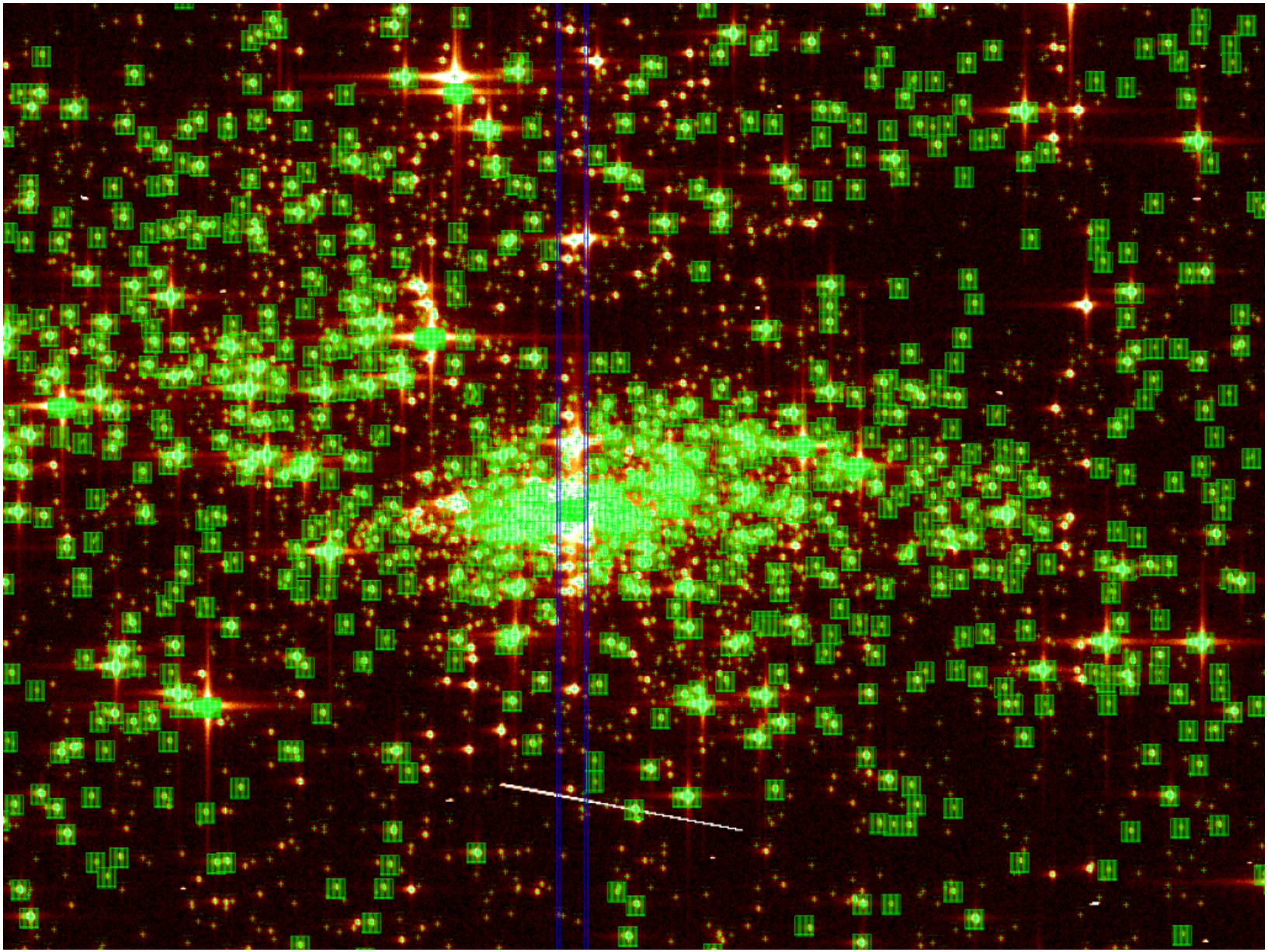

Gaia's view of R136, image courtesy Jos de Bruijne and Guido de Marchi

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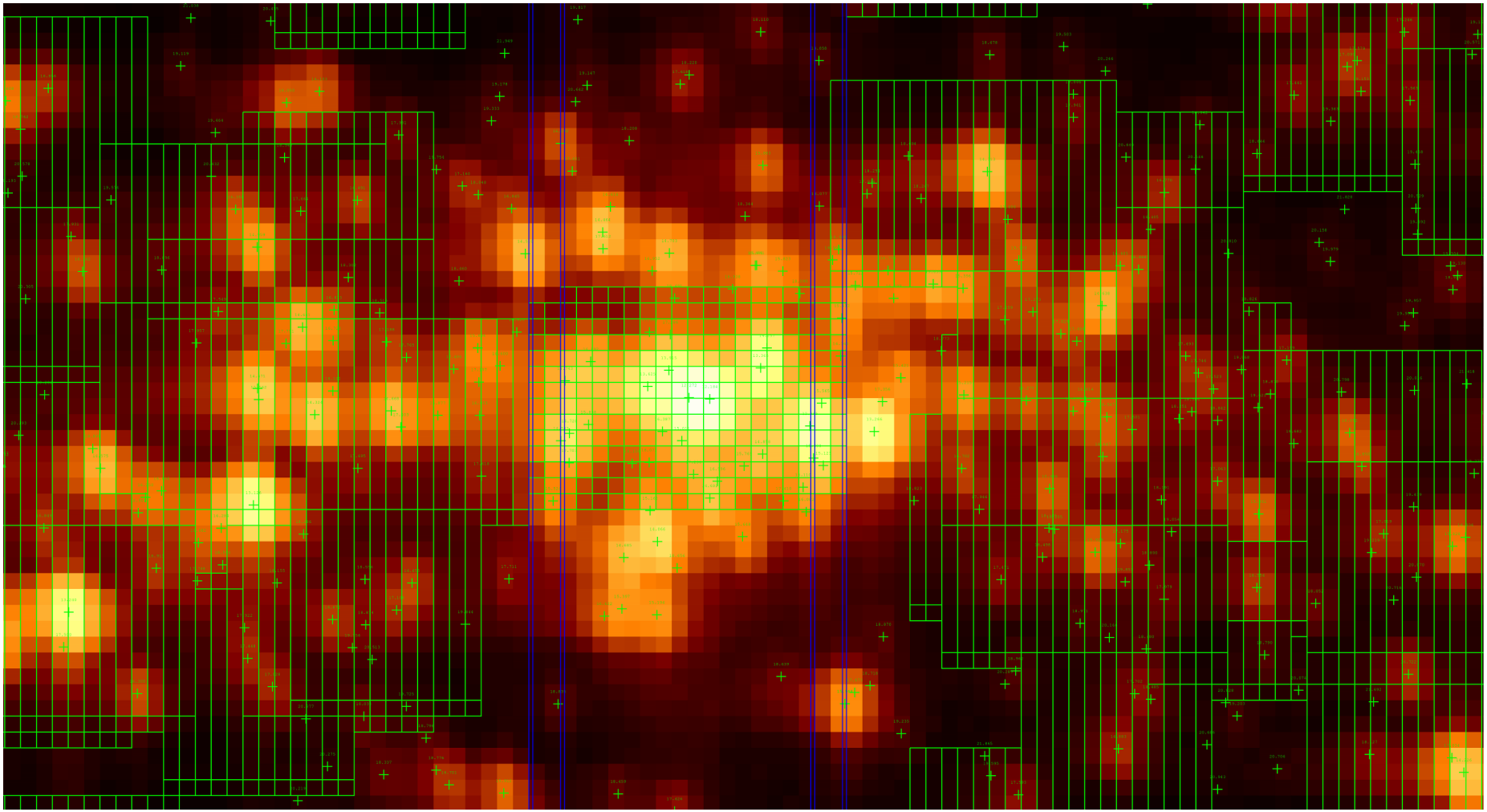

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  - In reality, extended objects up to 700 mas are detected

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  - In reality, extended objects up to 700 mas are detected
- Dynamic range: existence of a bright limit
  - The paper limit is $G = 5.7$ mag ($V = 6$ mag is normally quoted)
  - The real limit is a bit better (and varies from CCD row to row)
  - Investigations are ongoing to extend to $G \sim 1.5$

Gaia's 'limitations'