

Gaia Data Releases

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Gaia and the Vera Rubin Observatory

Gaia astrometry underpins Rubin Observatory survey calibration

Gaia (spectro) photometry for flux calibration

Gaia key input for many SMWL/ TVS/ Solar System Rubin Observatory survey science cases

Gaia in-flight operations likely overlaps Rubin Observatory operations for H2/2023 to H1/2025



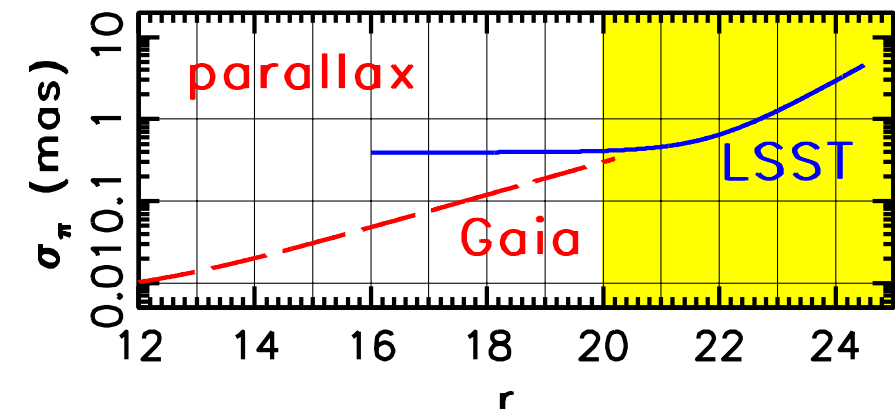
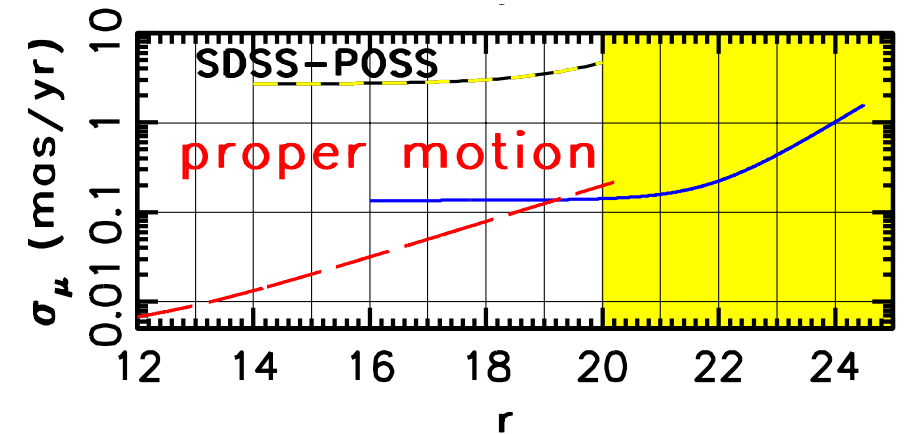
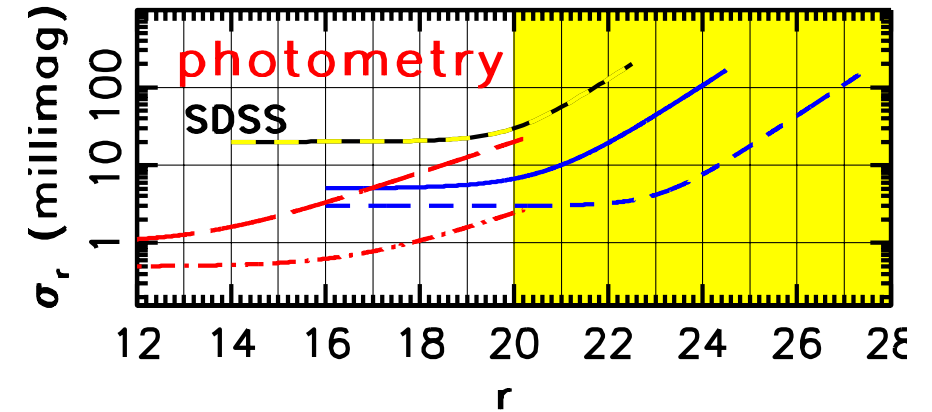
The Gaia-LSST Connection

Table 6.6: Adopted Gaia and LSST Performance

Quantity	Gaia	LSST
Sky Coverage	whole sky	half sky
Mean number of epochs	70 over 5 yrs	1000 over 10 yrs
Mean number of observations	320 ^a over 5 yrs	1000 ^b over 10 yrs
Wavelength Coverage	320–1050 nm	<i>ugrizy</i>
Depth per visit (5σ , <i>r</i> band)	20	24.5; 27.5 ^c
Bright limit (<i>r</i> band)	6	16-17
Point Spread Function (arcsec)	0.14×0.4	0.70 FWHM
Pixel count (Gigapix)	1.0	3.2
Syst. Photometric Err. (mag)	0.001, 0.0005 ^d	0.005, 0.003 ^e
Syst. Parallax Err. (mas)	0.007 ^f	0.40 ^f
Syst. Prop. Mot. Err. (mas/yr)	0.004	0.14

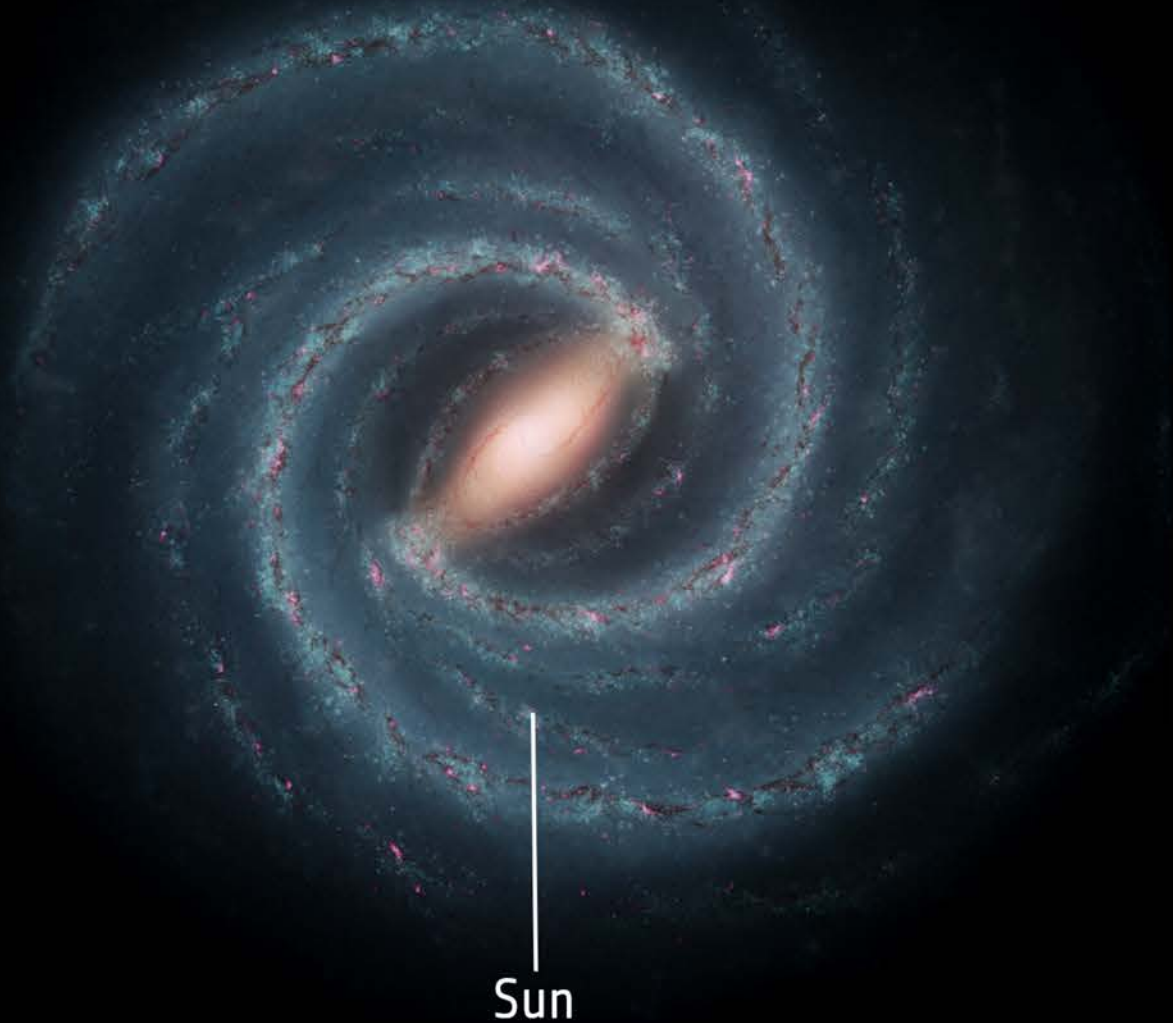
Tables with design parameters pre-launch/
credit Ivevic+ 2012

- In general terms the LSST survey extends Gaia from $\sim r = 20$
- Gaia's domain is the inner Milky Way and Disk (and it is whole sky!)
- The LSST probes the Halo and faint

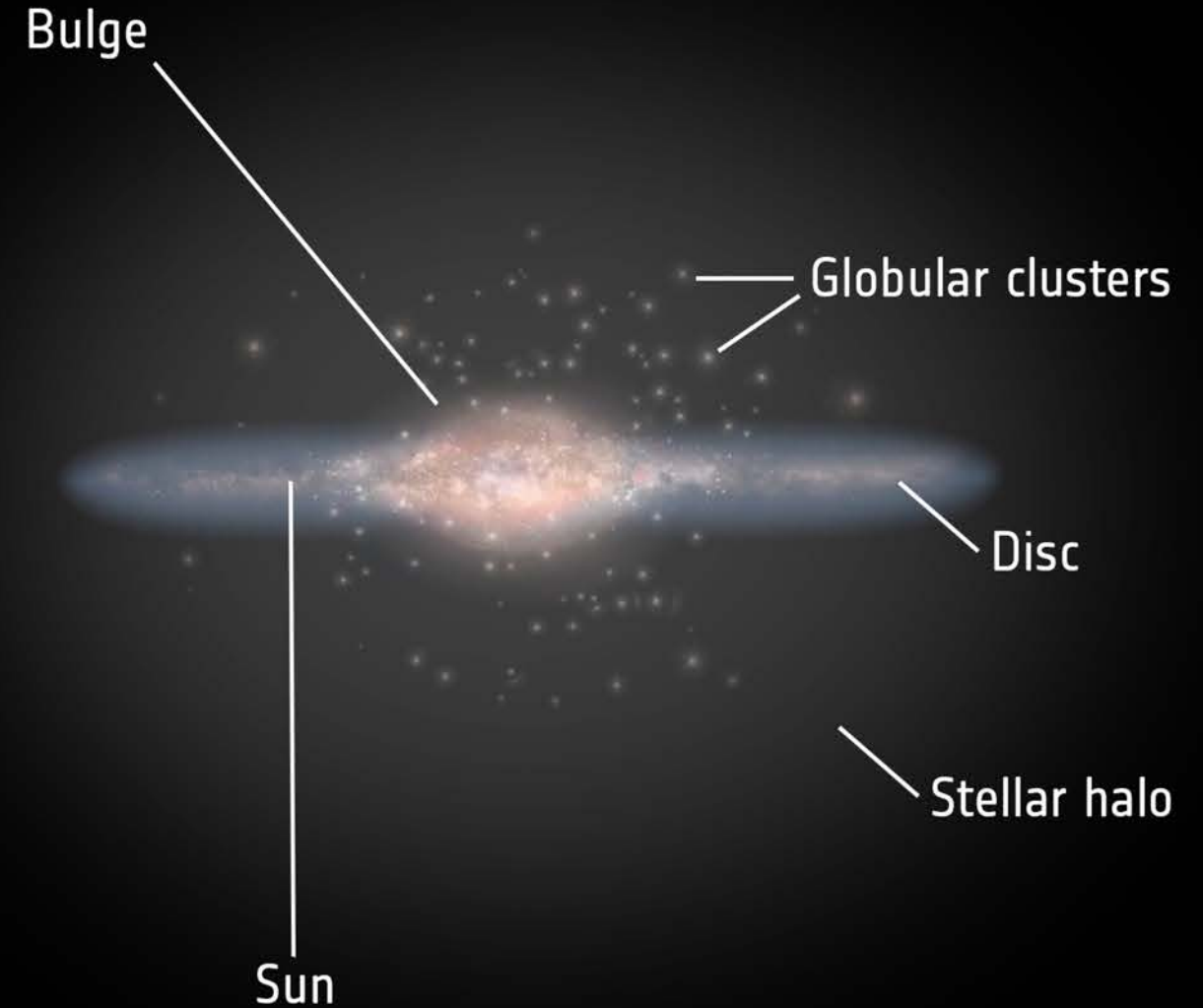


Gaia: star map for the Milky Way

→ ANATOMY OF THE MILKY WAY



Sun



Bulge

Globular clusters

Disc

Stellar halo

Sun

Gaia: a Big Science, Big Data Challenge

Gaia data leads to insight across astronomy



Gaia EDR3: with larger to come

1 811 709 771
stellar positions

1 806 254 432
brightness
in white light

1 542 033 472
brightness
in blue light

1 540 770 489
colour

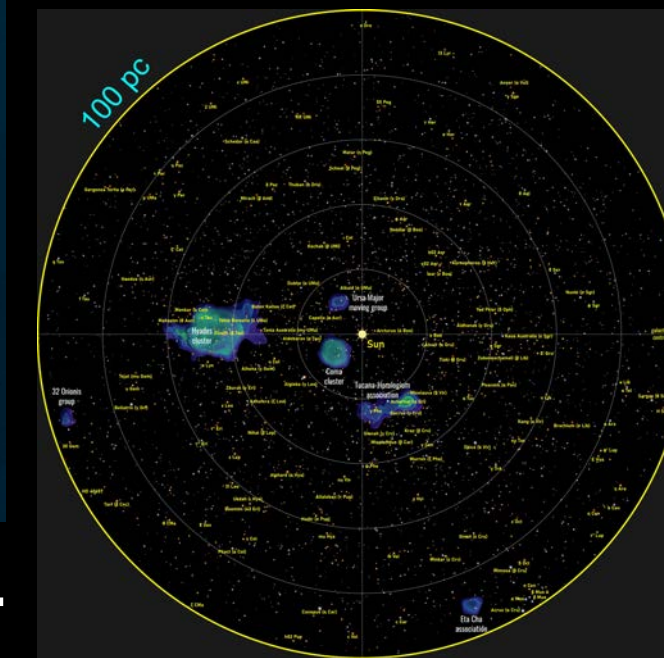
1 467 744 818
parallax and
proper motions

1 614 173
extragalactic
sources

1 554 997 939
brightness
in red light



Credit: ESA/
Gaia/ DPAC



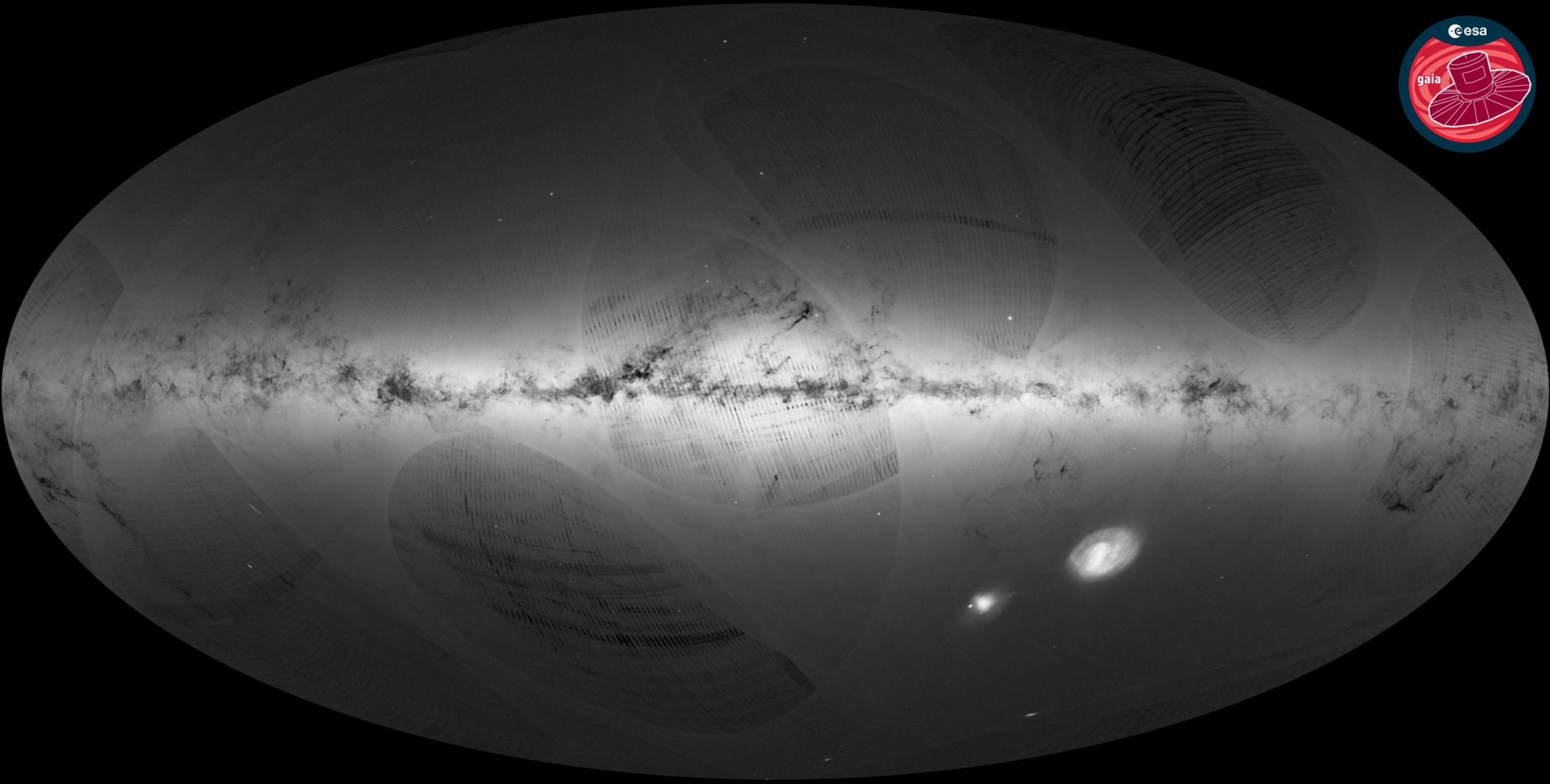
Mapping
star
density out
to 100pc

Credit: ESA/
Gaia/ LMC and
SMCDPAC

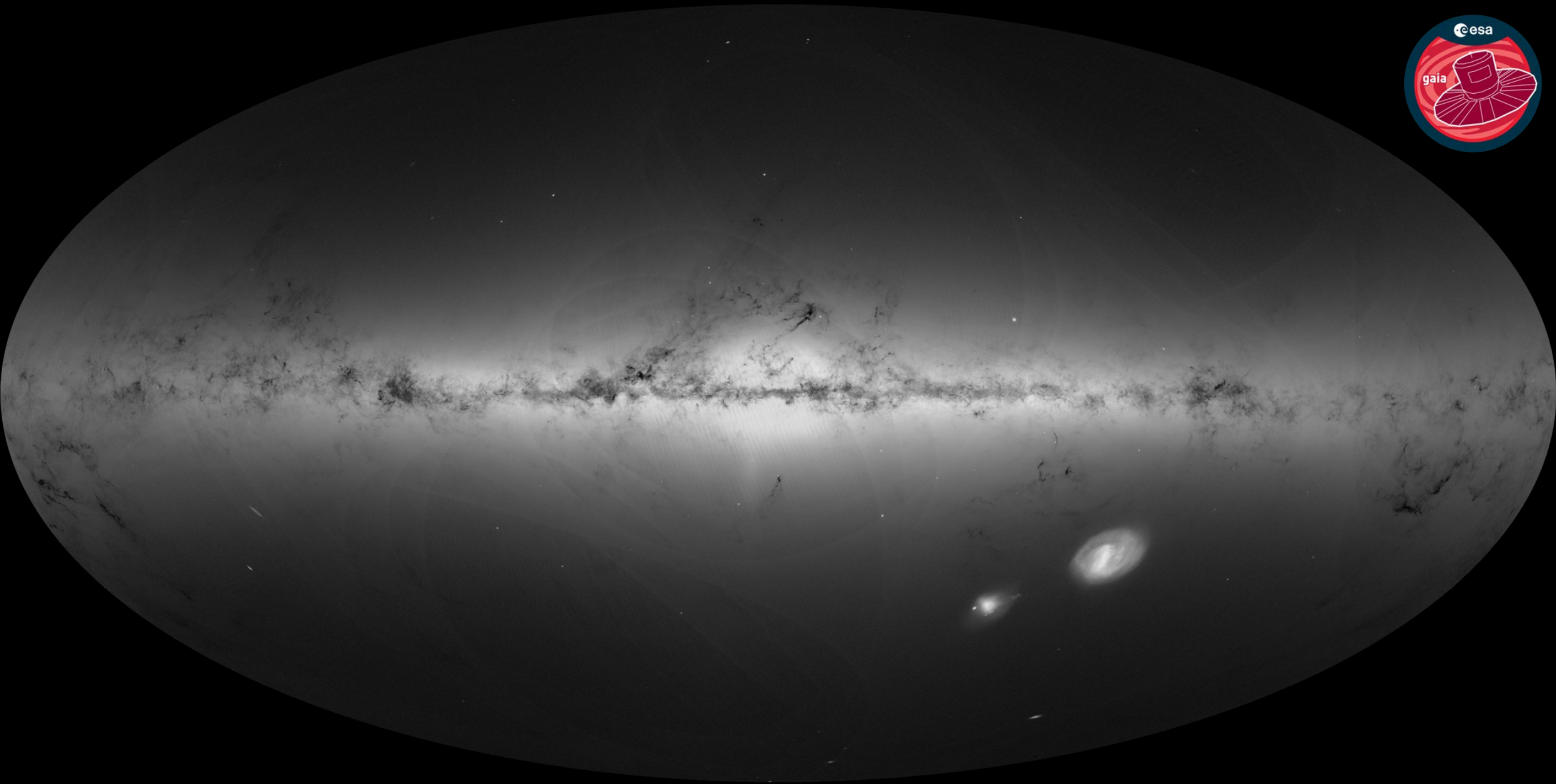


The LMC and
SMC

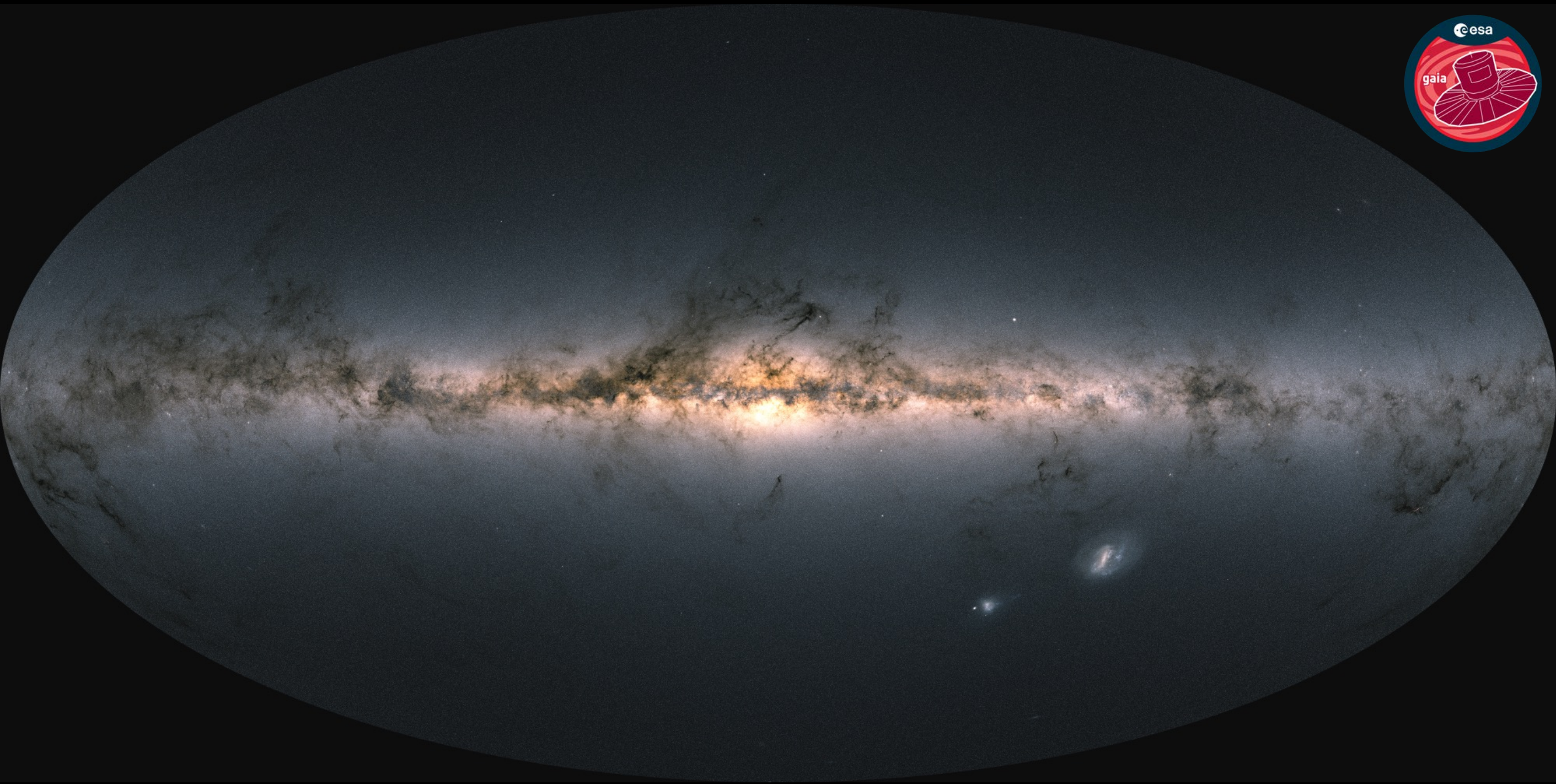
Over 1.7 Trillion observations, and counting ...



Gaia DR1 source counts /Credit ESA/Gaia/DPAC

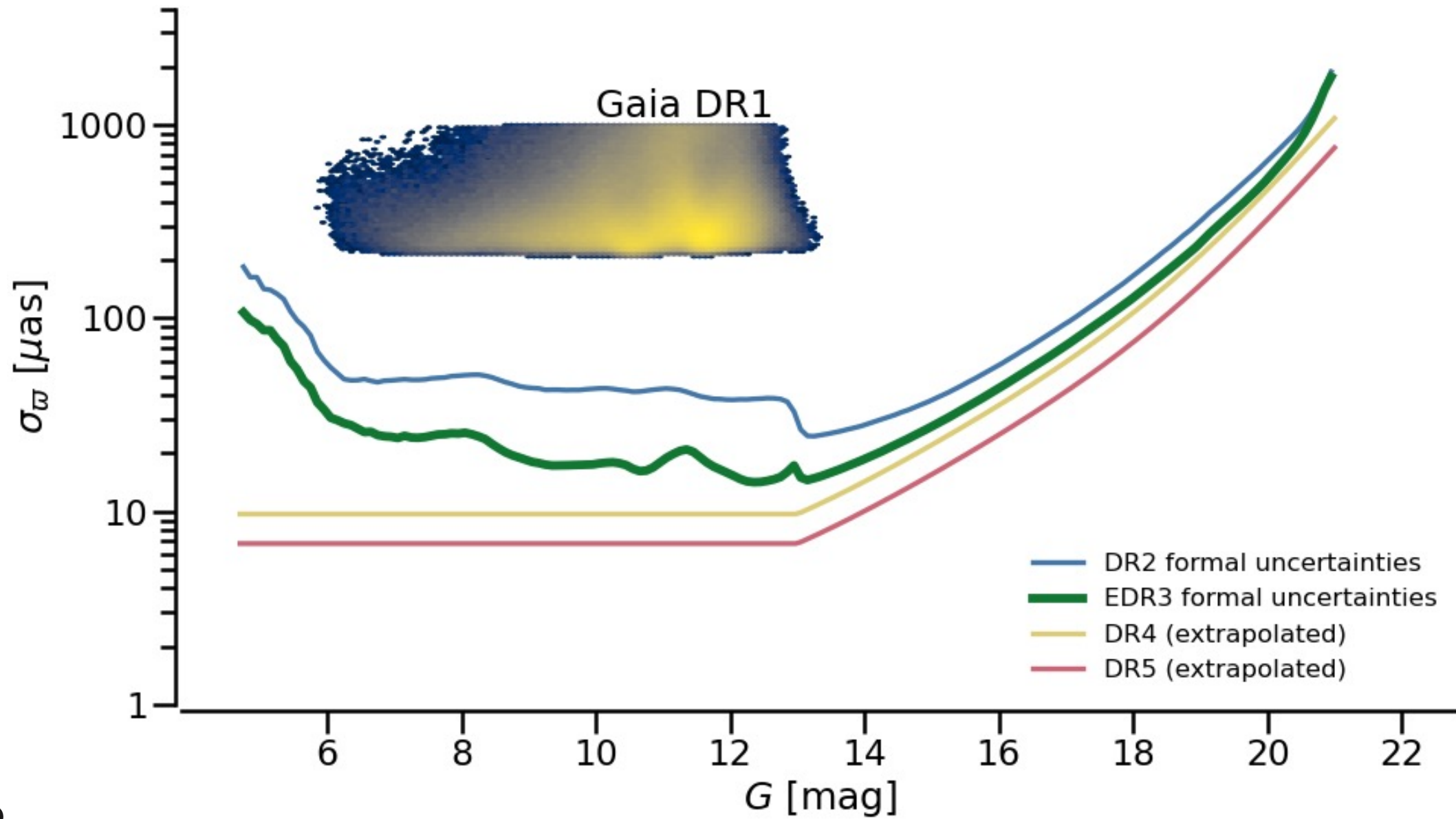


Gaia DR2 source counts /Credit ESA/Gaia/DPAC



Gaia EDR3 flux colour (~1.5 Billion sources /Credit ESA/Gaia/DPAC

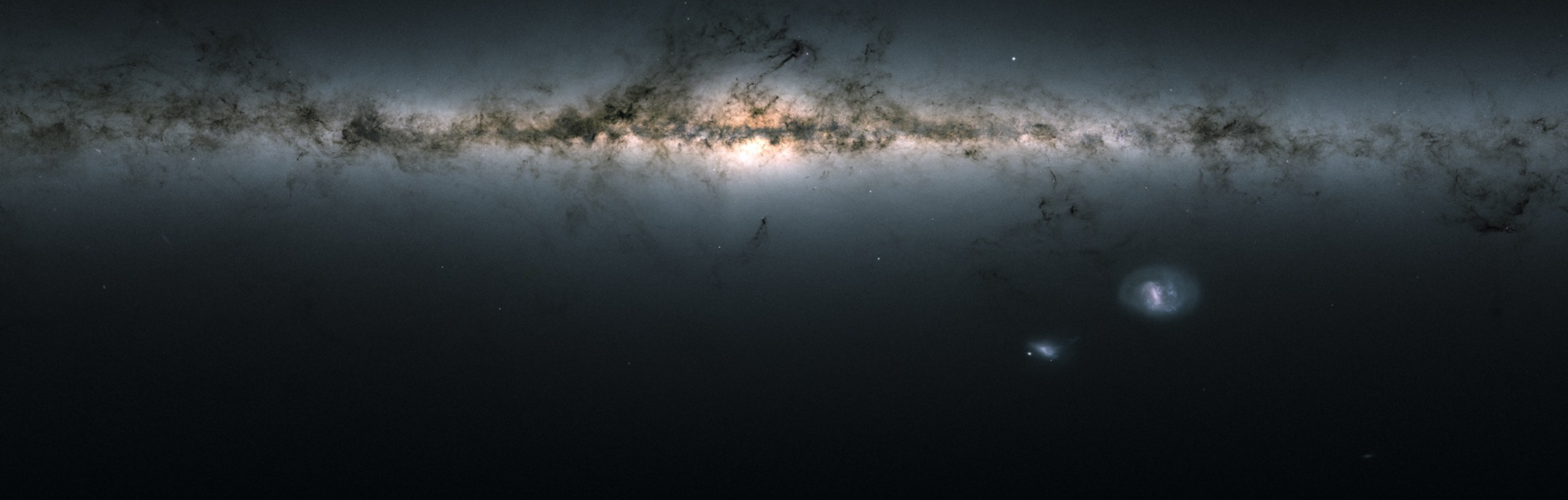
Latest (Gaia EDR3) Astrometric contents





Gaia EDR Science Examples

see <https://www.cosmos.esa.int/web/gaia/edr3-papers>



GAI



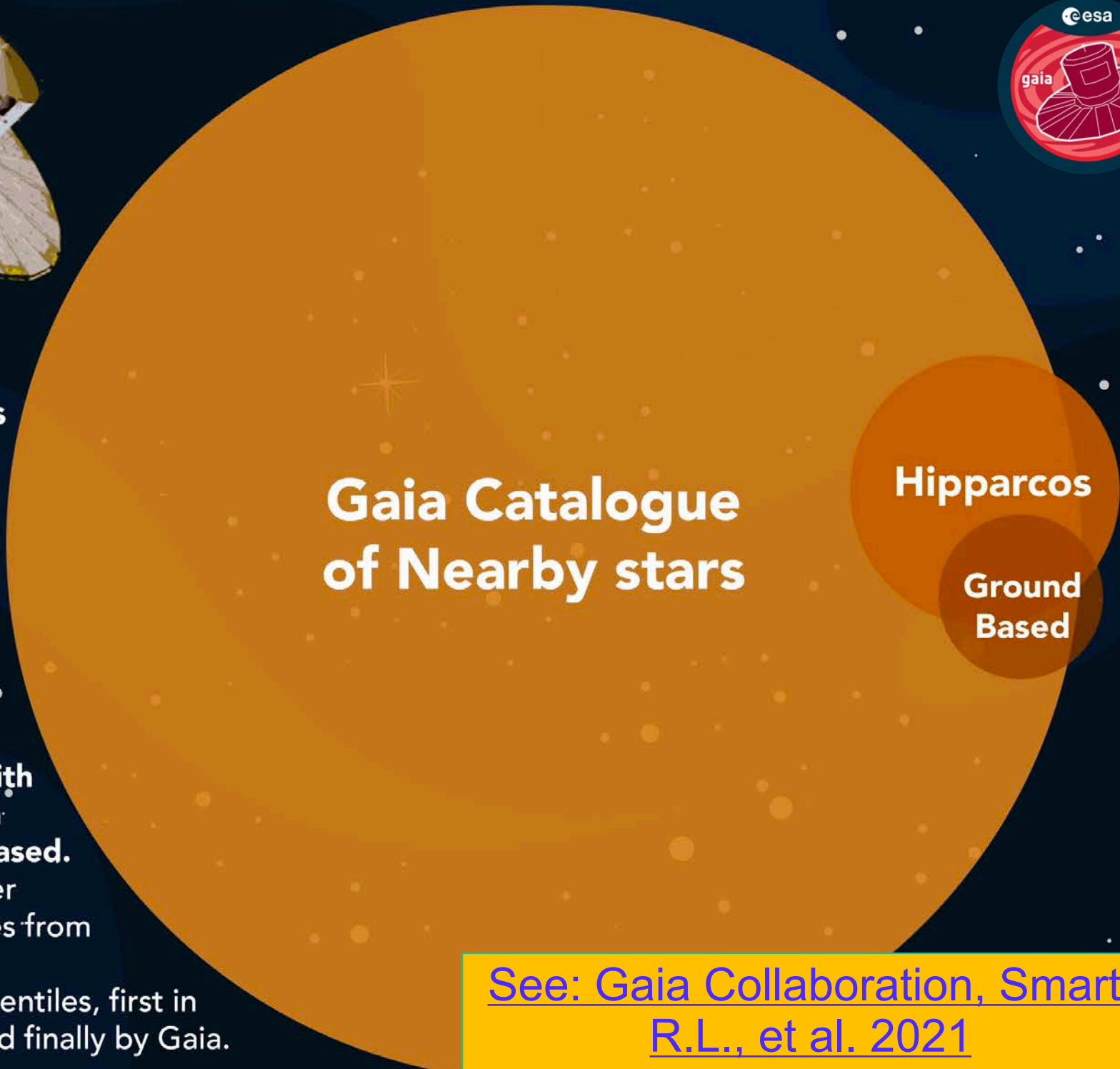
Number of stars with trigonometric parallaxes



Number of stars within 10 pc, 25 pc, and 100 pc, with parallaxes in the Gaia Catalogue of Nearby Stars, in Hipparcos, and in other programs, mainly ground-based.

The surface of the circles is proportional to the number of stars. The circles intersect when stars have distances from several programs.

The histogram represents the number of stars, in percentiles, first in ground-based programs, completed by Hipparcos, and finally by Gaia.



[See: Gaia Collaboration, Smart, R.L., et al. 2021](#)

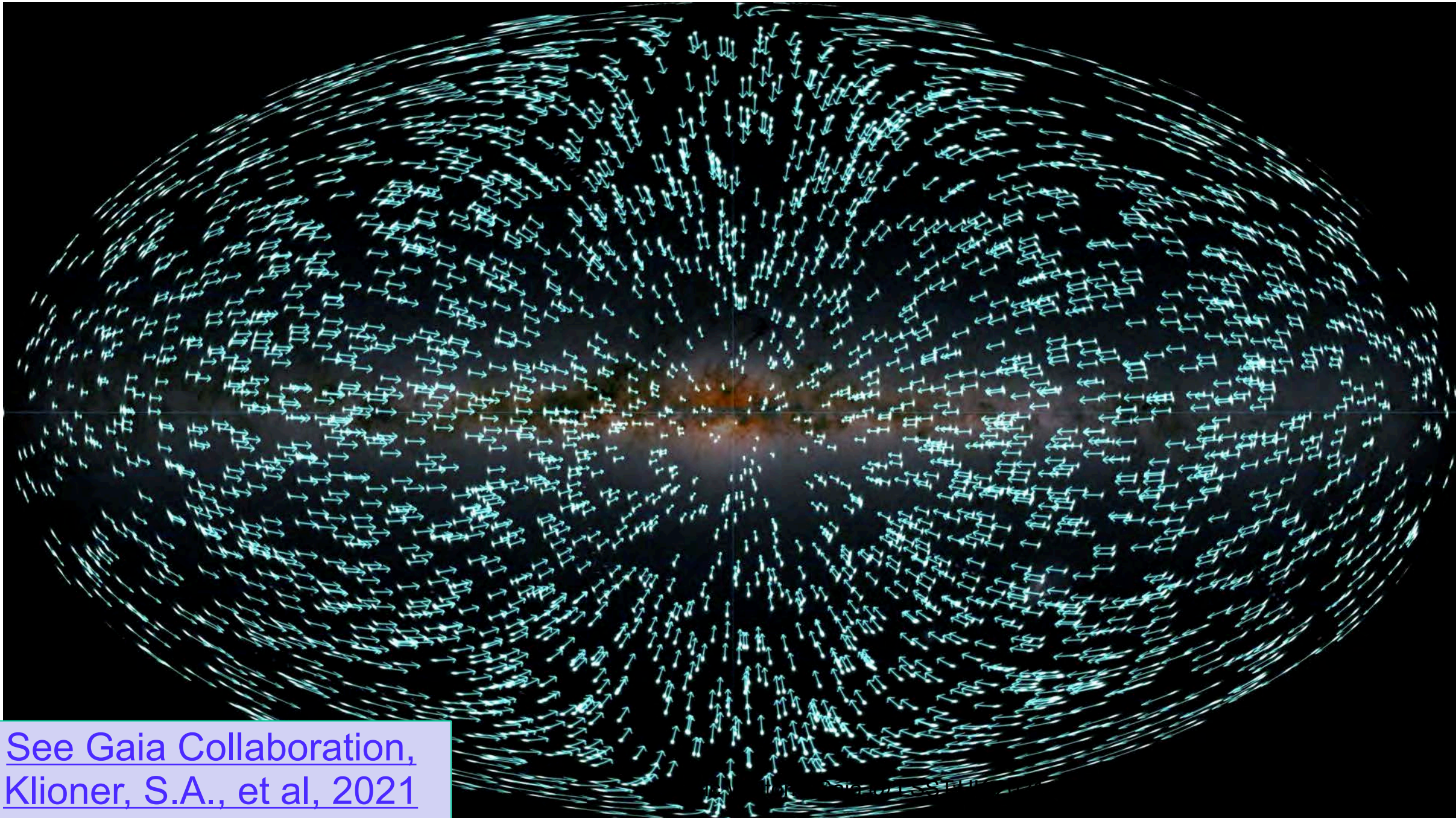


000.0 Myr

Image credit: ESA/Gaia/DPAC

Stars within 100 parsecs (326 light years) of the Sun are shown in a dot compared to the whole Milky Way Galaxy (100,000 light years).

A systematic pattern in the proper motions of the QSO's (extragalactic sources) detected by Gaia



[See Gaia Collaboration, Klioner, S.A., et al, 2021](#)

The acceleration of the Solar System



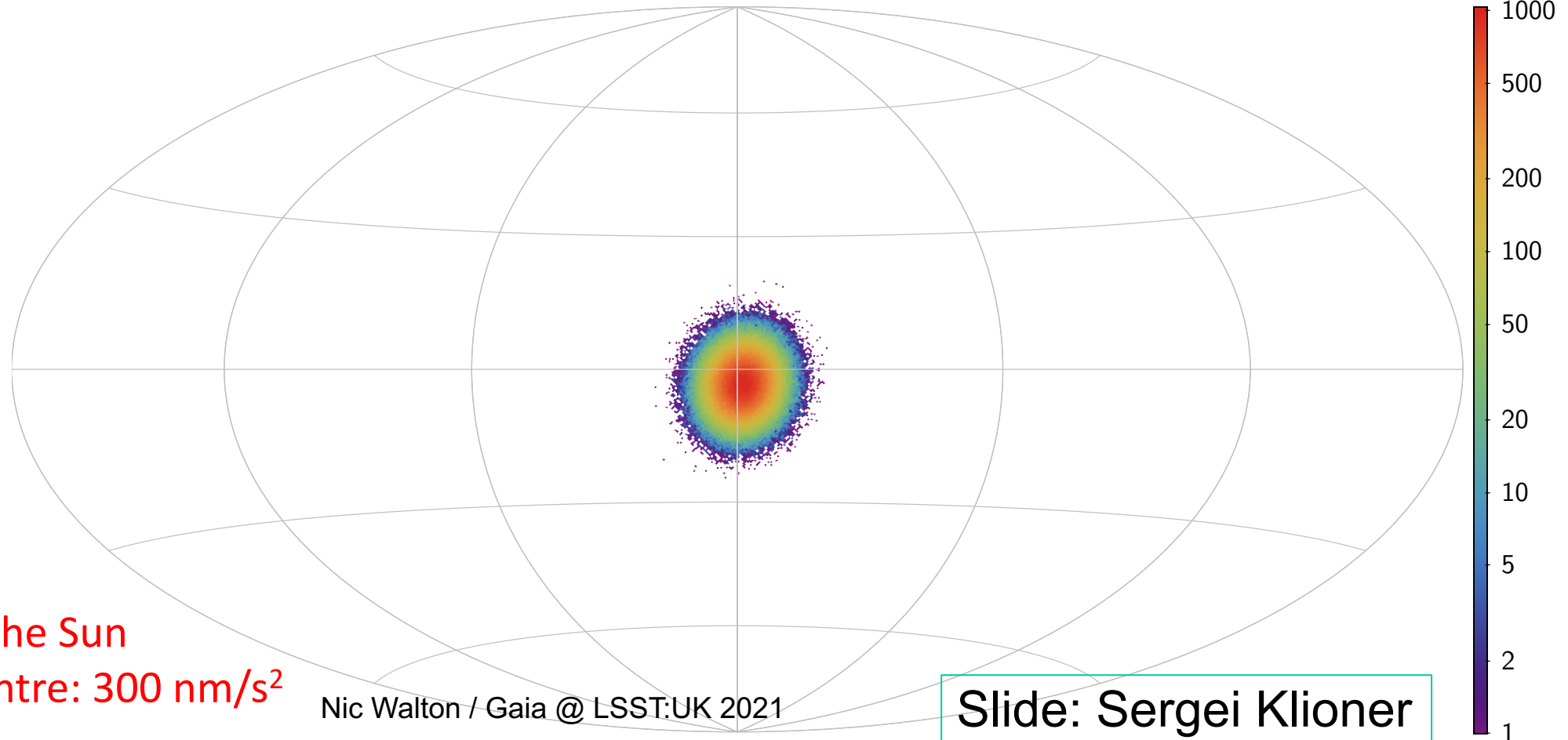
- The measurement results in an ***astronomically small number***:

$$(0.232 \pm 0.016) \text{ nm/s}^2 \text{ towards } \alpha = 269.1^\circ \pm 5.4^\circ, \delta = -31.6^\circ \pm 4.1^\circ$$

or $(7.33 \pm 0.51) \text{ km/s Myr}^{-1}$ or a proper motion amplitude of $5.05 \pm 0.35 \text{ microarcsecond/yr}$

→ This is close to the expected centripetal acceleration of the Solar System in its motion in the Galaxy!

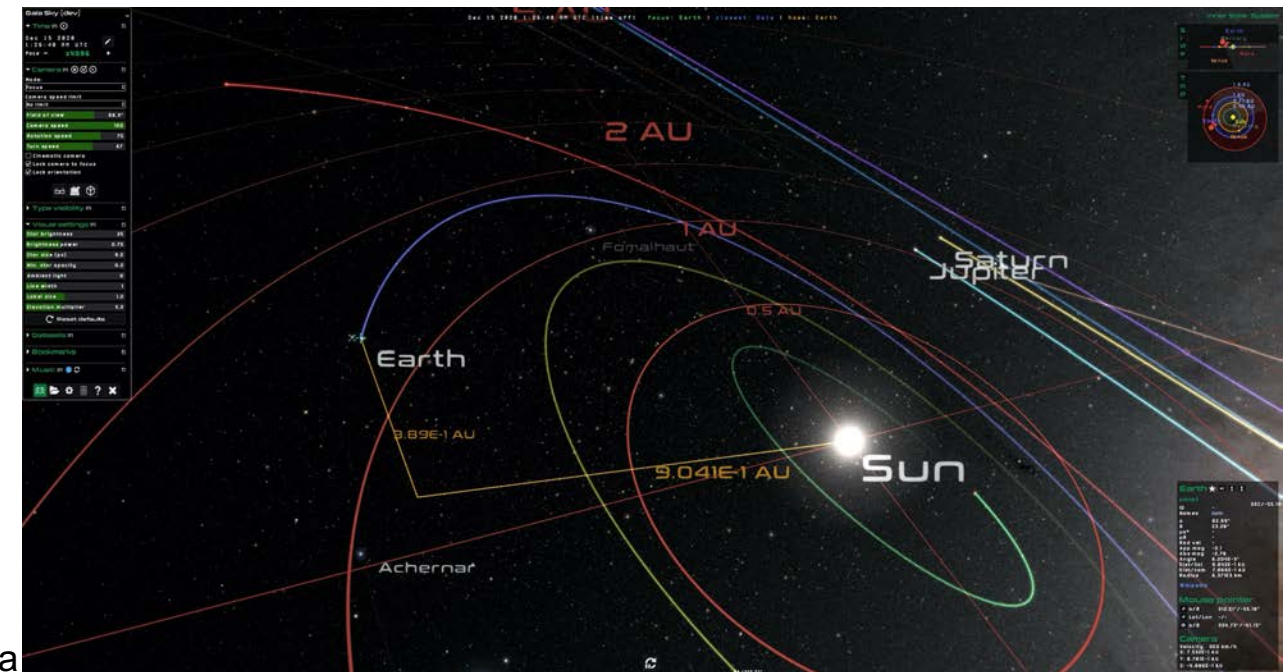
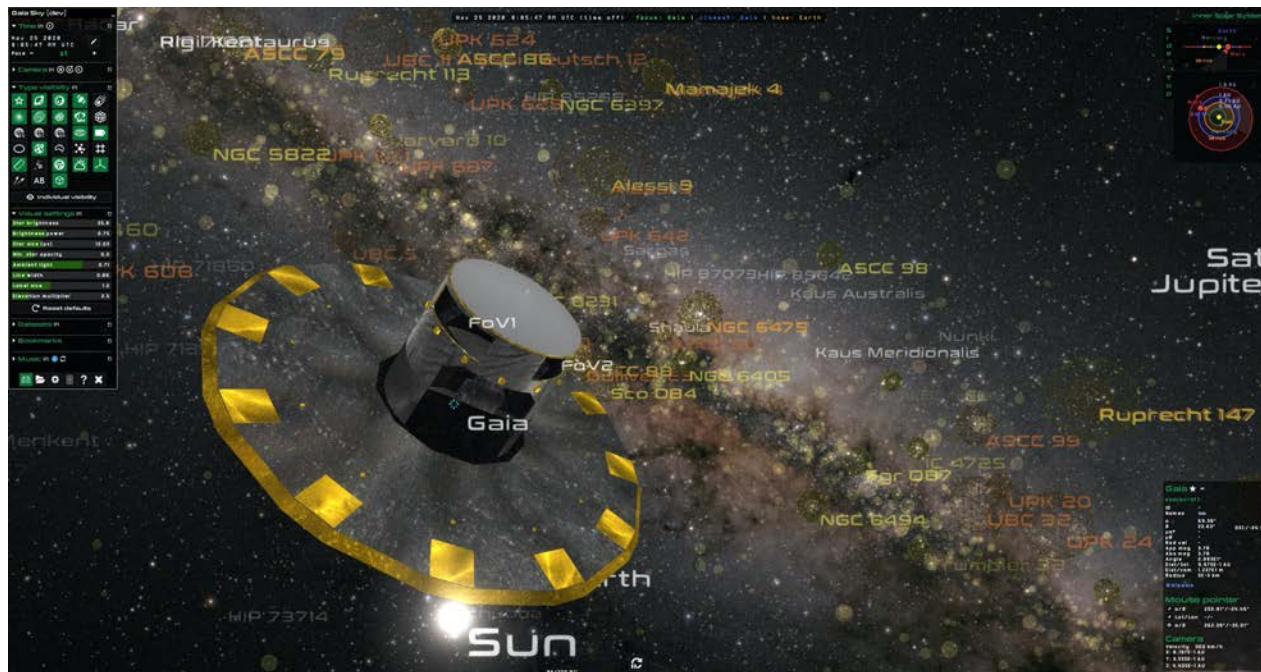
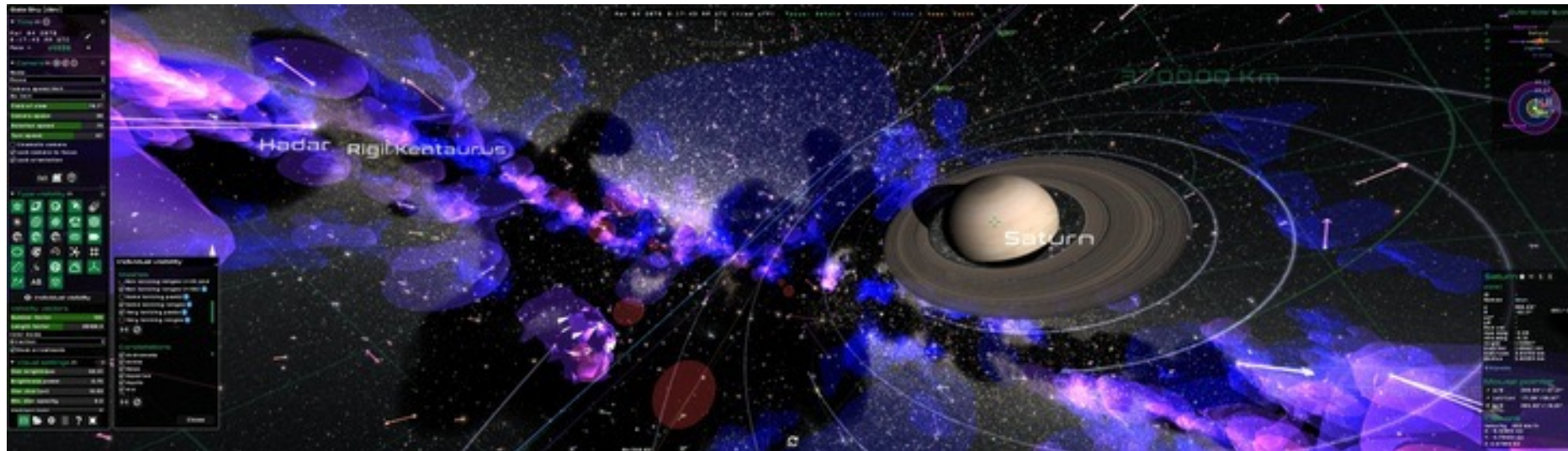
This measurement based on the observations of 1.6M QSO's



NB: maximal acceleration of the Sun w.r.t. the solar system barycentre: 300 nm/s^2

Visualising the Gaia Sky

<https://zah.uni-heidelberg.de/gaia/outreach/gaiasky/>



Find Out More:

<https://www.cosmos.esa.int/web/gaia/early-data-release-3>



GAIA EDR3 INFO

Information on Gaia Early Data Release 3 contents, completeness and limitations.

GAIA EDR3 PAPERS

Find [here](#) the titles of the expected papers describing the data processing and demonstrating the science potential of Gaia Early Data Release 3, including [Python code](#) accompanying the papers.

GAIA EDR3 DOCUMENTATION

The data release documentation for Gaia Early Data Release 3, describing the processing of the data from raw to Gaia EDR3 will appear both on webpages and through a downloadable PDF-file.

GAIA EDR3 DATA RELEASE EVENTS

Overview of the Gaia EDR3 release events. Some events were recorded and are available from this page, as well as some of the slides presented.

GAIA EDR3 DATA MODEL

The [Gaia EDR3 data model](#) explains in further details the tables and columns providing the Gaia data

GAIA EDR3 KNOWN ISSUES

Find [here](#) the issues found with Gaia EDR3 data after the release / [data release documentation](#) got

GAIA EDR3 PASSBANDS

Find [here](#) a description of the Gaia EDR3 passbands.

GAIA EDR3 DATA

Gaia Early Data Release 3 data is now available from the Gaia Archive and its partner data centres.



Contents of Gaia DR3



ready for the start of Rubin Observatory operations

Data Product	No. of sources	Comments
Astrometry	1.8 billion	Same as Gaia EDR3
G/BP/RP photometry	1.8 billion	Same as Gaia EDR3
Radial velocities	~30 million	$G_{RVS} \lesssim 14$
Photometric variability: classification, characterization, light curves	7+ million	Includes eclipsing, (MS) pulsating, transients, spotted, flaring, evolved pulsators, and quasars
Source Classification and astrophysical parameters	$\gtrsim 300$ million	based on the BP/RP/RVS spectra, magnitude limit TBD
<i>Mean</i> BP/RP/RVS spectra	TBD subset	

numbers as presented at Gaia EDR3 release



Contents of Gaia DR3



Data Product	No. of sources	Comments
Solar system objects epoch astrometry/photometry	$\gtrsim 100,000$	including orbit solutions
Solar system objects mean BP/RP reflectance spectra	~ 5000	
Catalogue of astrometric, spectroscopic, eclipsing non-single stars	TBD	Combined solutions where possible
QSO host and galaxy morphological characterization	TBD	Based on input list
G/BP/RP photometry light curves for all sources in 5.5° radius field centred on M31	~ 1.1 million	Includes variable and non-variable sources



Contents of Gaia DR3



■ Astrometric non-single star solution types

- acceleration, 7 and 9 parameters
- orbital solutions, 12 parameters
- stochastic solutions
 - single star source model or basic binary star model does not fit
- NOTE: no epoch astrometry or epoch radial velocities will be released as part of Gaia DR3

■ Astrophysical parameters based on BP/RP/RVS spectra

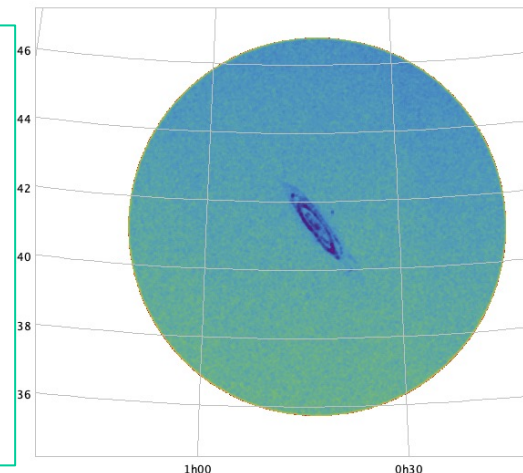
- T_{eff} , $\log g$, A_G , $E(G_{BP} - G_{RP})$, metallicity, abundances, distances, radii, masses, activity index
 - solutions from multiple algorithms will be provided
 - rotational velocity for bright subset of stars (TBC)
- Extinction map
- Source classification (star, binary, galaxy, . . .)

■ Mean BP/RP/RVS spectra

- For subset of sources only
- Tool to handle BP/RP spectra will be provided
- Solar system objects
 - Orbits
 - Reflectance spectra
- QSO hosts and galaxies
 - Morphological characterization
- Light curves for field around M31
 - Preview of Gaia DR4 epoch photometry

A 'pencil beam survey' (GAPS) will be released together with Gaia DR3

- all integrated photometry time series for ~1.1 million sources (variables and non-variables)
- 5.5 degree radius field centred on M31





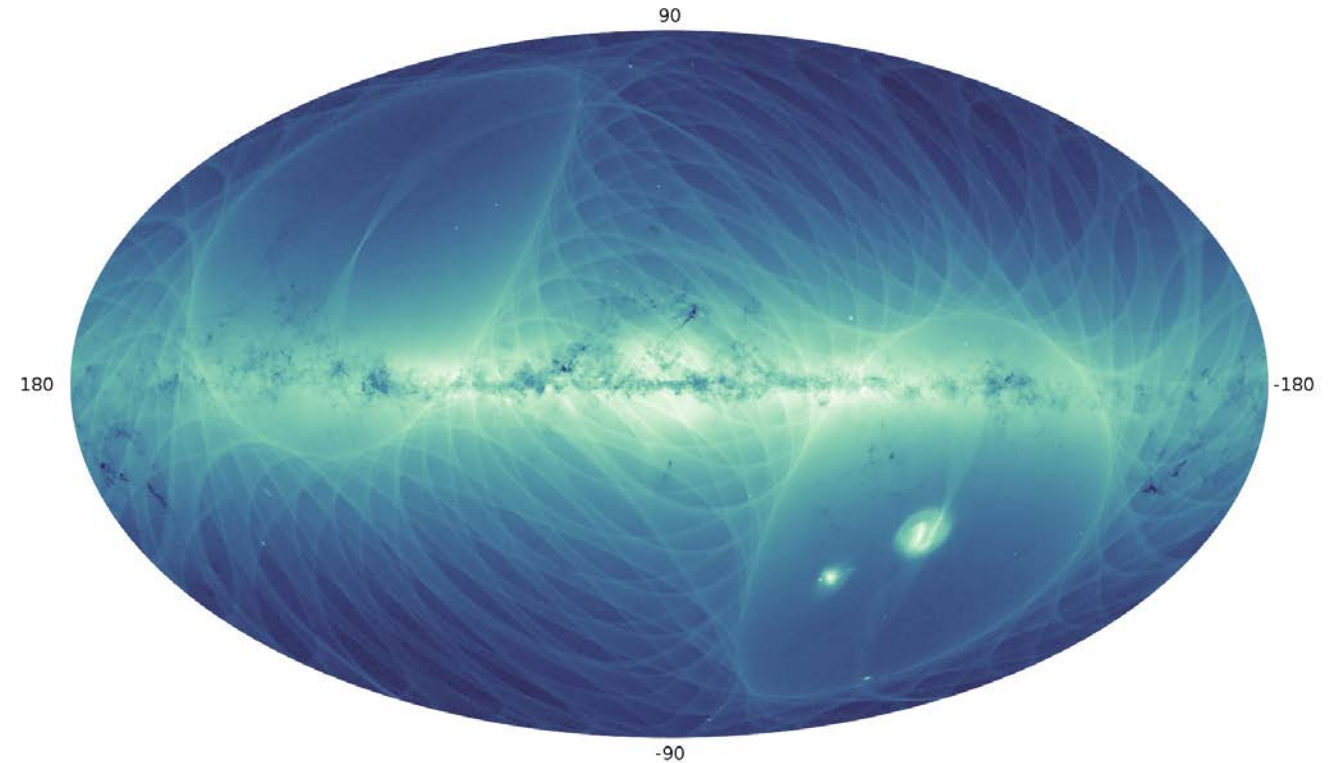
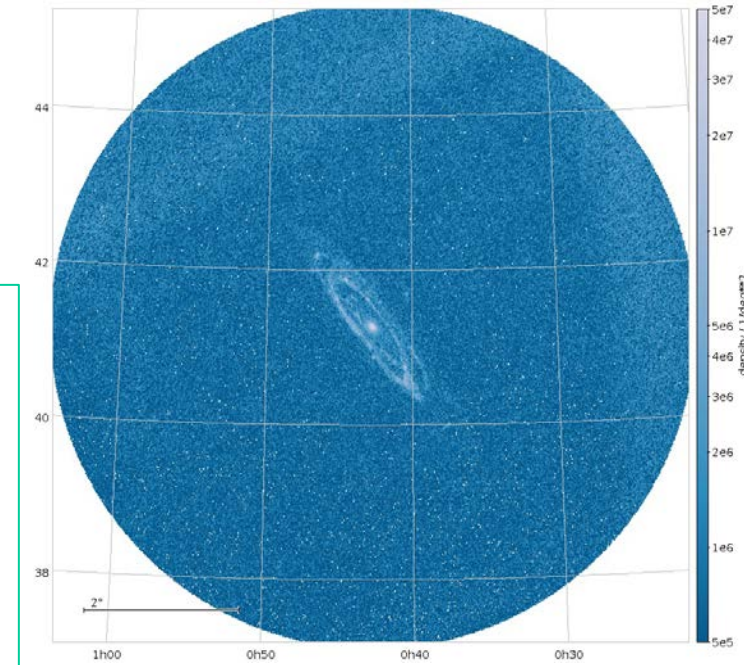
Gaia DR4 and Beyond

<https://www.cosmos.esa.int/web/gaia/release>

- Full astrometric, photometric, and radial-velocity catalogues.
- All available variable-star and non-single-star solutions.
- Source classifications (probabilities) plus multiple astrophysical parameters (derived from BP/RP, RVS, and astrometry) for stars, unresolved binaries, galaxies, and quasars. Some parameters may not be available for faint(er) stars.
- An exo-planet list.
- All epoch and transit (reduced) data for all sources.

DR5 release will include mission extension data

Map shows early DR4 cross match run - 142 billion detections processed – 750K CPU hours on MareNostrum
Insert shows zoom in on M31
Credits: ESA/Gaia/DPAC, F. Torra, J. Portell, J. Castañeda, M. Bernet, S. Bartolomé and CU3-IDU/DPCB team



Gaia/MW-Gaia Plenary 14 @ EAS 2021:
=> register for Gaia Symposium S15 at
<https://eas.unige.ch/EAS2021/registration.jsp>

Credit: E

Symp15: <https://eas.unige.ch/EAS2021/session.jsp?id=S15>

