

The ESA Gaia mission and its promise for cool giant planets

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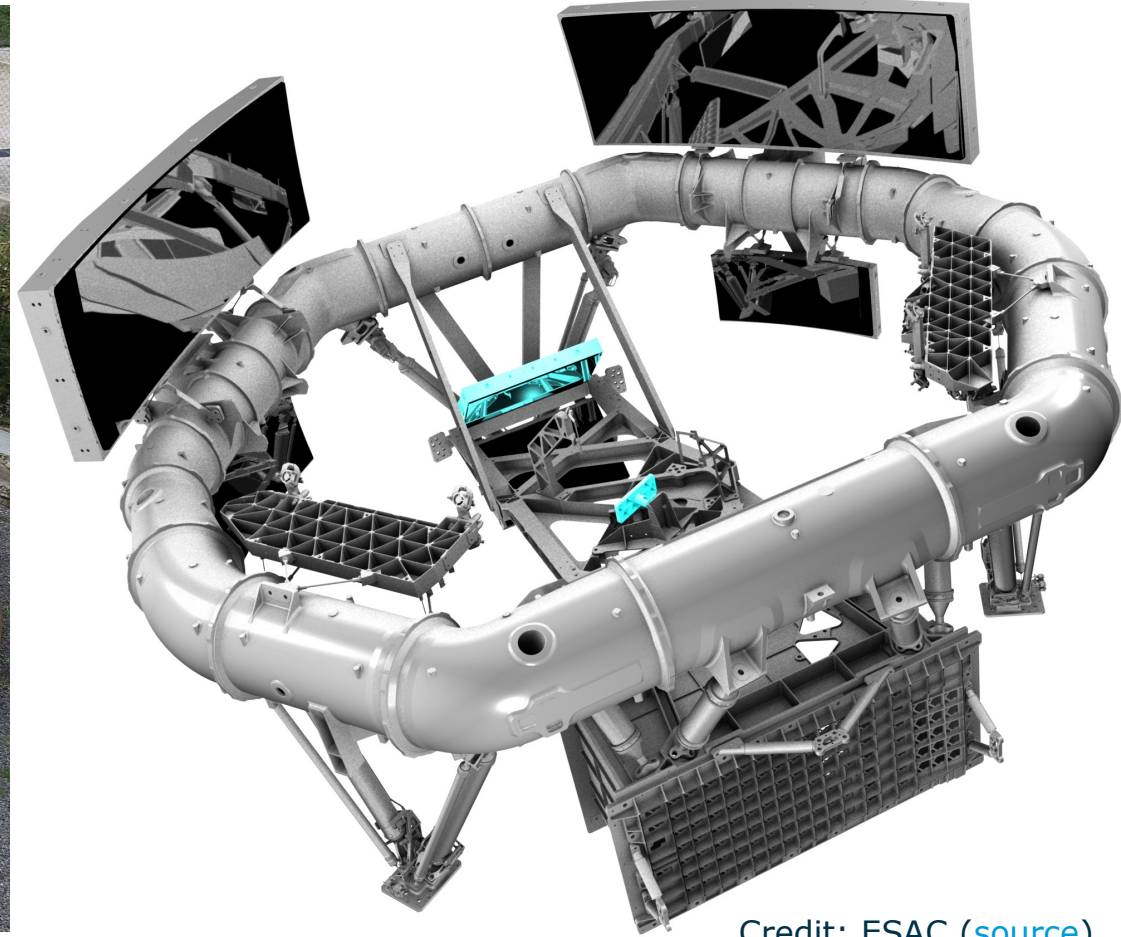
7/10/2025

Gaia reveals the origin and evolution of the Milky Way

- Stellar positions and distances
 - ➡ Galactic structure
- Stellar motions
 - ➡ Galactic kinematics
- Stellar parameters, compositions, ages
 - ➡ Galactic evolution
- Optical all-sky survey with 3 instruments:
Astrometry, Photometry, Spectroscopy
- Gaia observes ~1% of the stars in the Galaxy
- Gaia survey enables rich complementary science



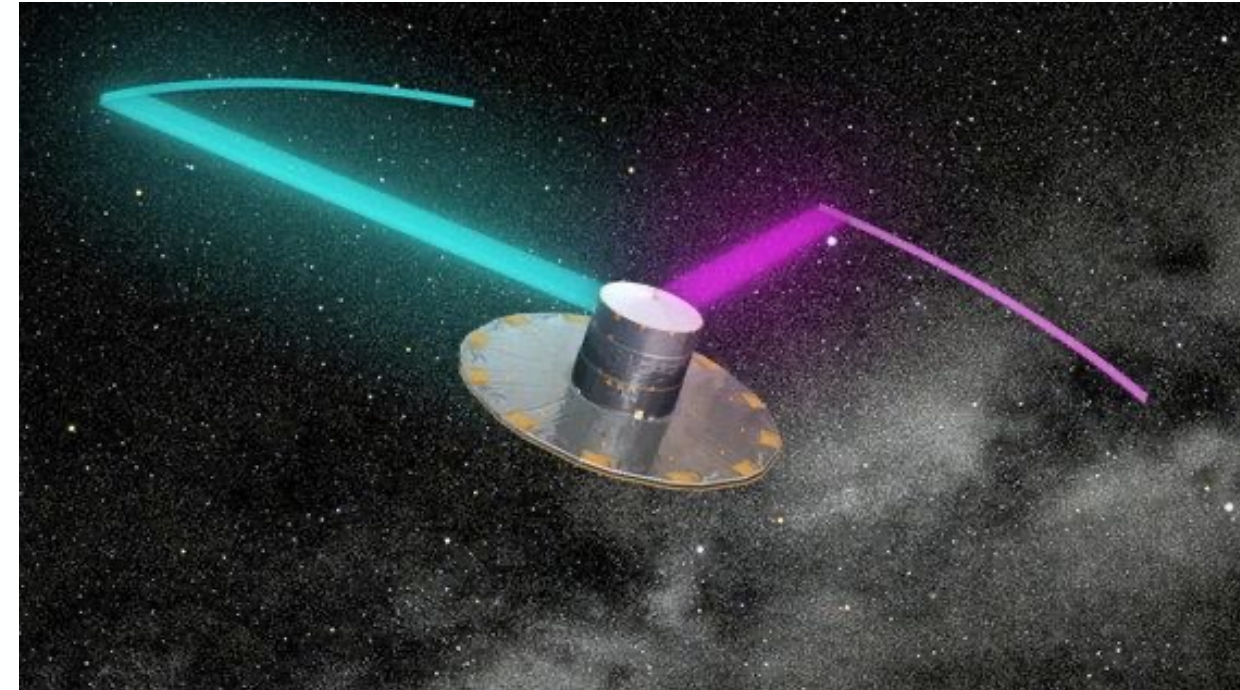
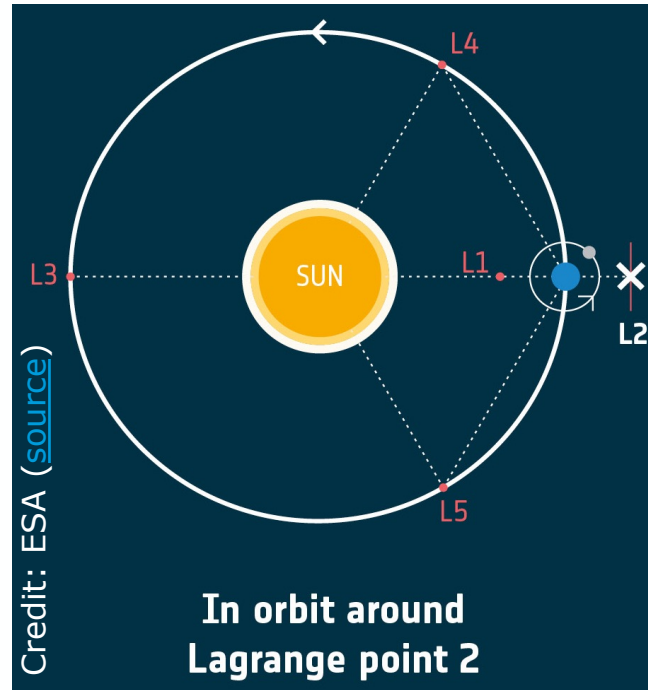
The Gaia spacecraft is 10 m wide and has 2 telescopes



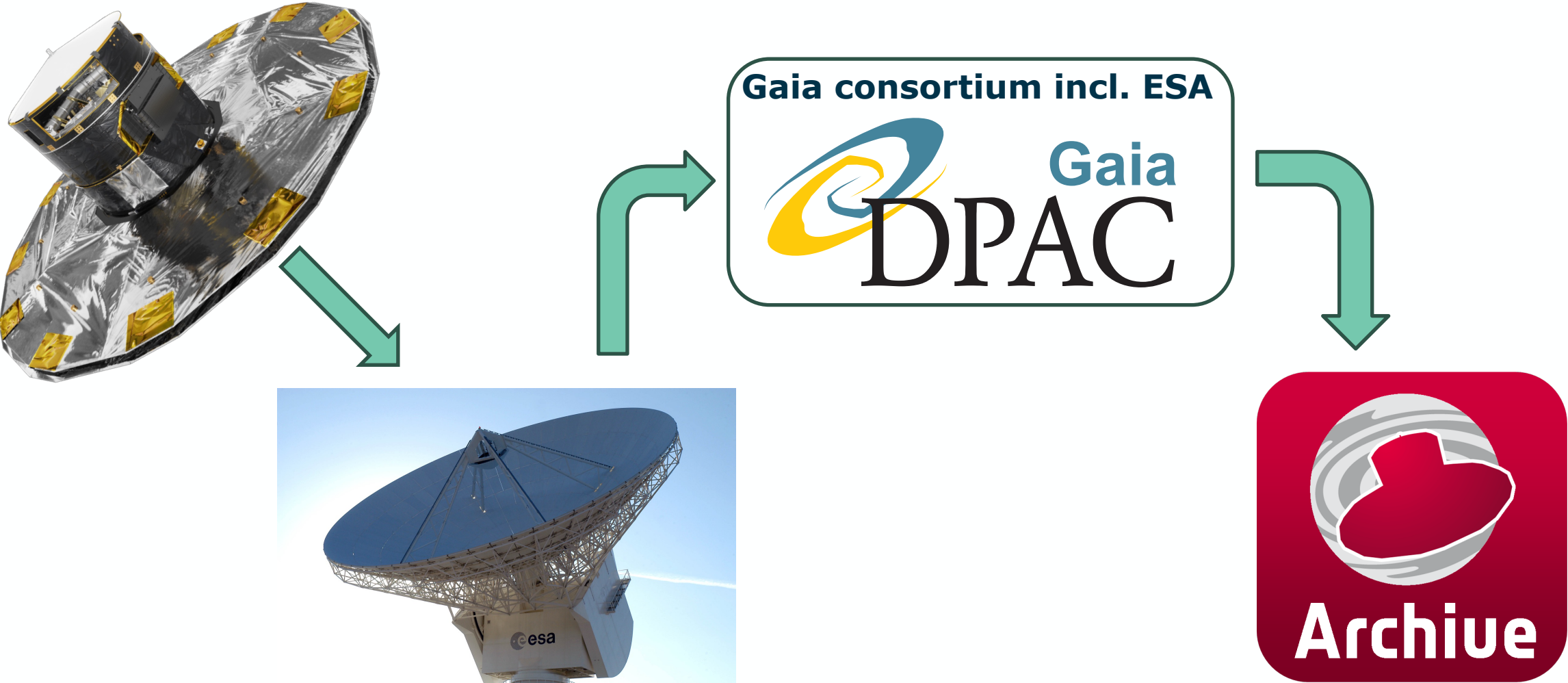
Credit: ESAC ([source](#))

Gaia was launched to L2 in December 2013

- 10.5 years of science observations from July 2014 to January 2025
- Gaia was constantly spinning and scanning the sky
- Surveying star-like sources, e.g. stars, galaxies, quasars, asteroids, ...
- Magnitudes range $G \approx 3-21$



Gaia data flow from the spacecraft to the ESA archive



Credit: ESA/ATG medialab ([source](#))

Credit: ESA ([source](#))

There were 3 intermediate Gaia data releases so far

- Iterative process of incremental data releases
- There is no proprietary period on science data for the Gaia collaboration

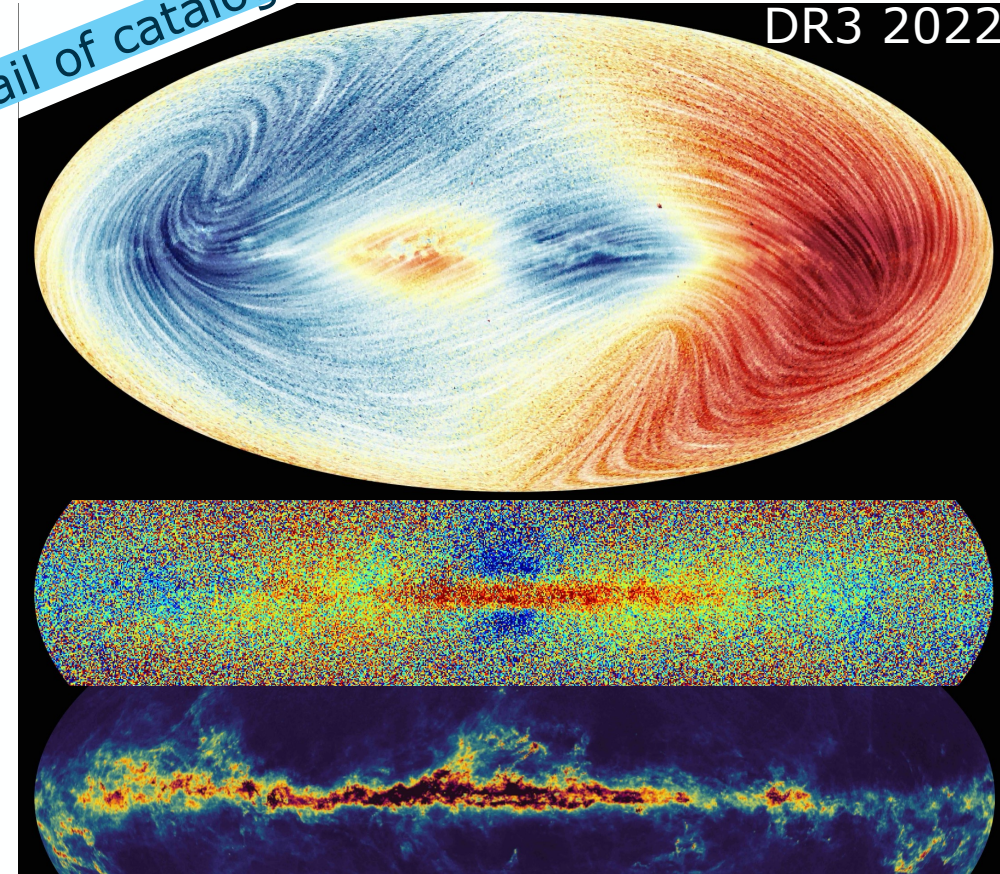
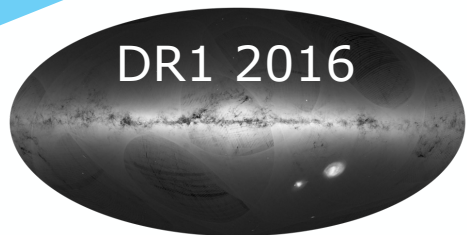
- <https://www.cosmos.esa.int/web/gaia/data>

- Early DR3 (2020)
- Focused Product Release (5 products, 2023)

Data timespan; Data quality; Data volume; Number and detail of catalogues

Gaia
DPAC

DR3 2022



[source](#)

SKY-SCANNING COMPLETE FOR ESA'S MILKY WAY MAPPER GAIA

From 24 July 2014 to 15 January 2025, Gaia made more than three trillion observations of two billion stars and other objects, which revolutionised the view of our home galaxy and cosmic neighbourhood.



3 TRILLION
Observations

2 BILLION
Stars & other objects observed

938 MILLION
Camera pixels on board

15 300
Spacecraft 'pirouettes'

55 KG
Cold nitrogen gas consumed

3827
Days in science operations

50 000 HOURS
Ground station time used

580 MILLION
Accesses of Gaia catalogue so far

13 000
Refereed scientific publications so far

2.8 MILLION
Commands sent to spacecraft

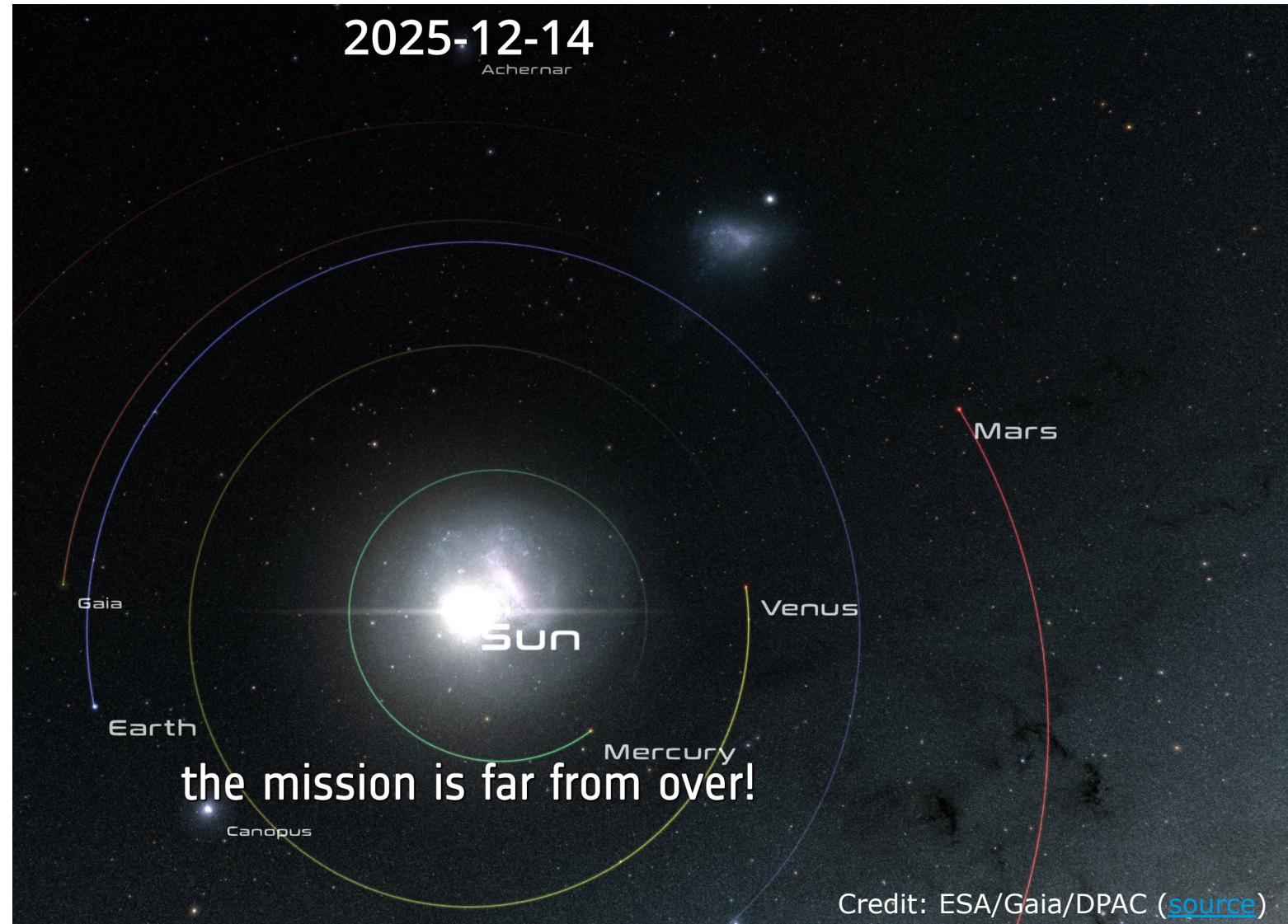
142 TB
Downlinked data (compressed)

500 TB
Volume of data release 4
(5.5 years of observations)

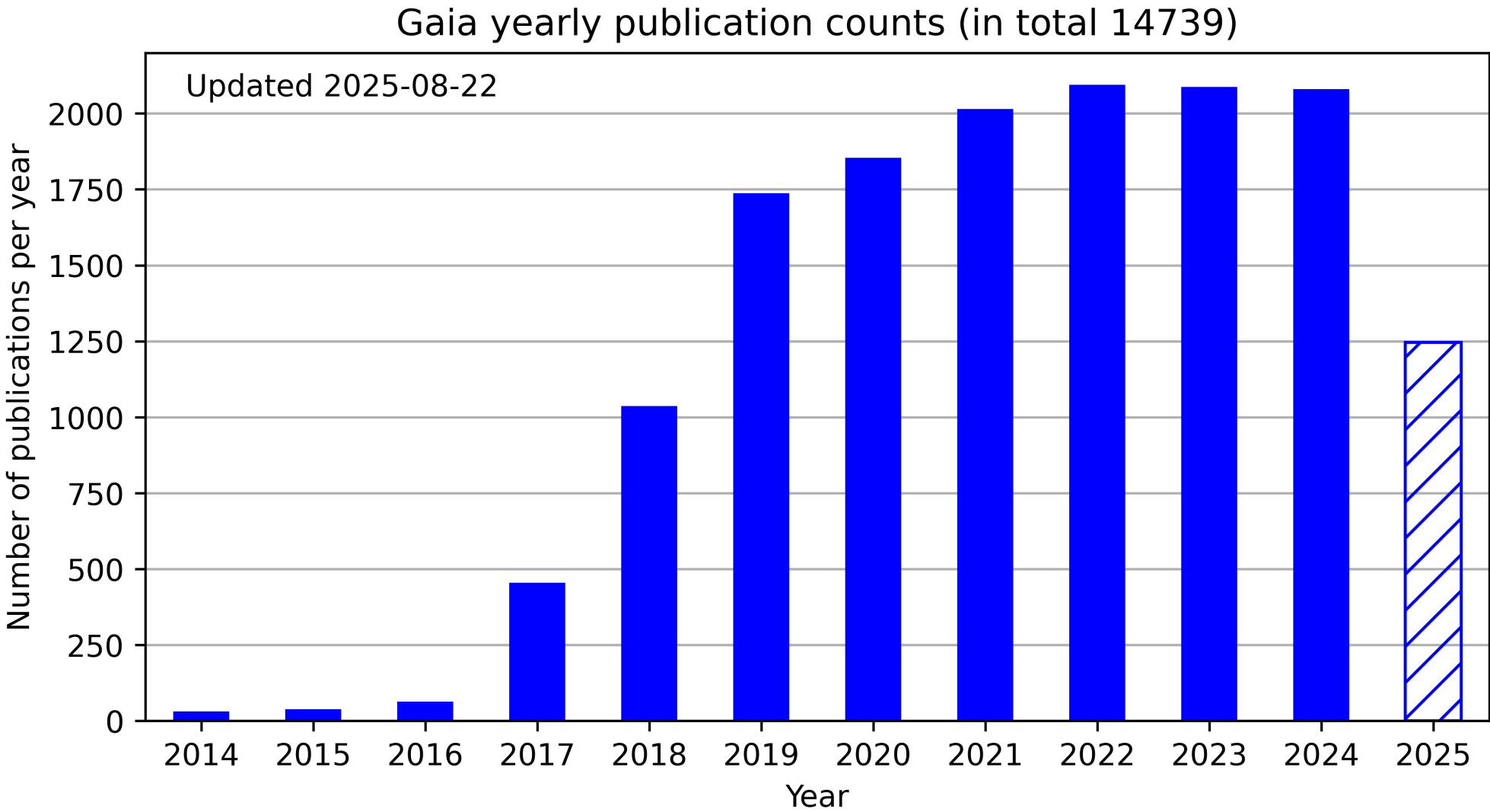


Gaia spacecraft was passivated on 27 March 2025

- Gaia exhausted its cold gas and stopped science observations on 15 January 2025
- Gaia was put in a heliocentric orbit and permanently switched off
- ESA news release:
[https://www.esa.int/Enabling_Support/Operations/Farewell_Gaia! Spacecraft operations come to an end](https://www.esa.int/Enabling_Support/Operations/Farewell_Gaia!_Spacecraft_operations_come_to_an_end)
- Additional information:
https://www.cosmos.esa.int/web/gaia/iow_20250327
https://www.cosmos.esa.int/web/gaia/iow_20250929
- This is not the end of the mission



Gaia is a very productive science mission



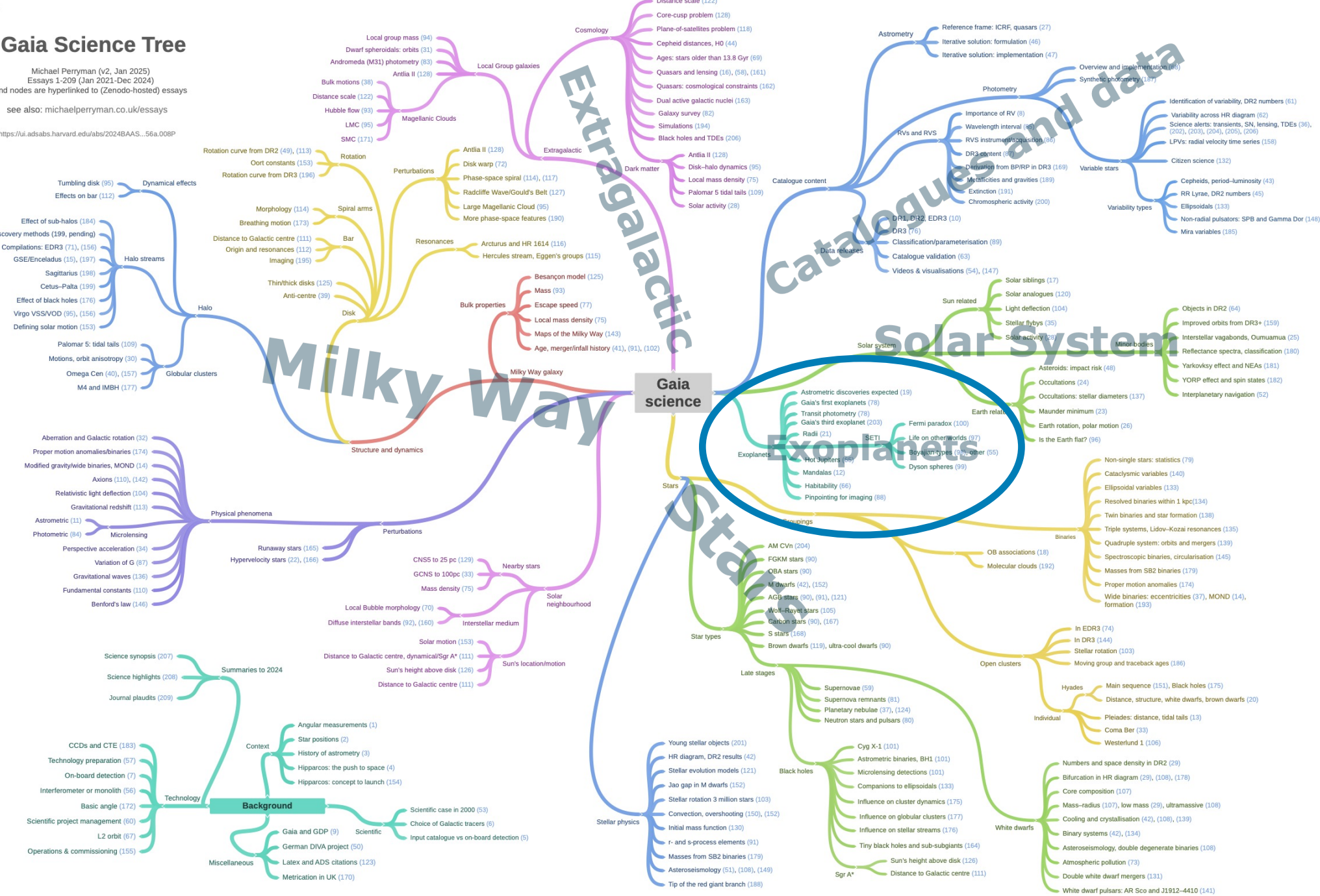
Credit: ESA/Gaia/DPAC ([source](#)) 9

Gaia Science Tree

Michael Perryman (v2, Jan 2025)
Essays 1-209 (Jan 2021-Dec 2024)
end nodes are hyperlinked to (Zenodo-hosted) essays

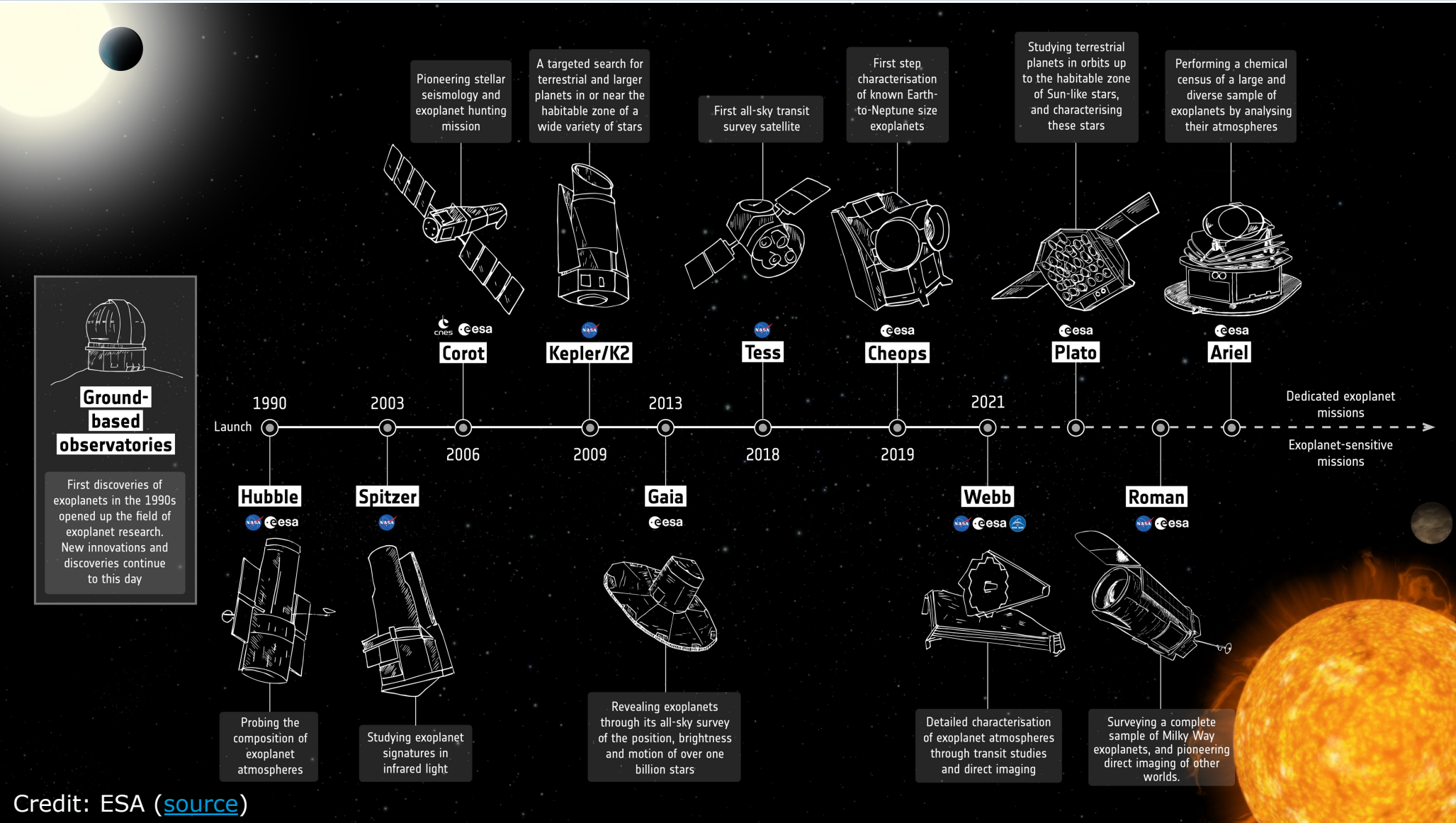
see also: michaelperryman.co.uk/essays

<https://ui.adsabs.harvard.edu/abs/2024BAAS...56a.008P>



Credit:
Michael Perryman
([source](#))

Gaia was not designed as an exoplanet mission



Credit: ESA ([source](#))

- ## Contribution by Lammers

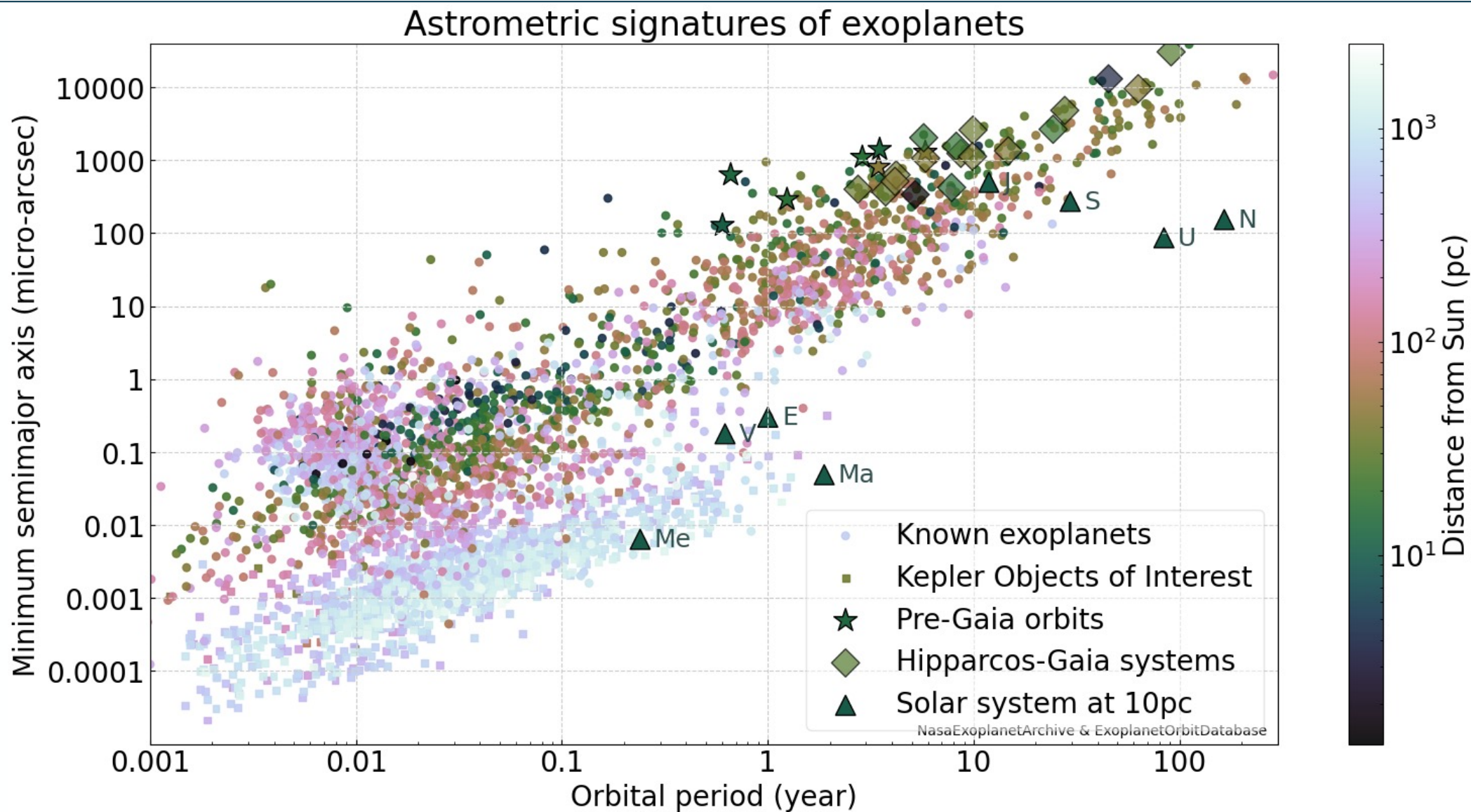


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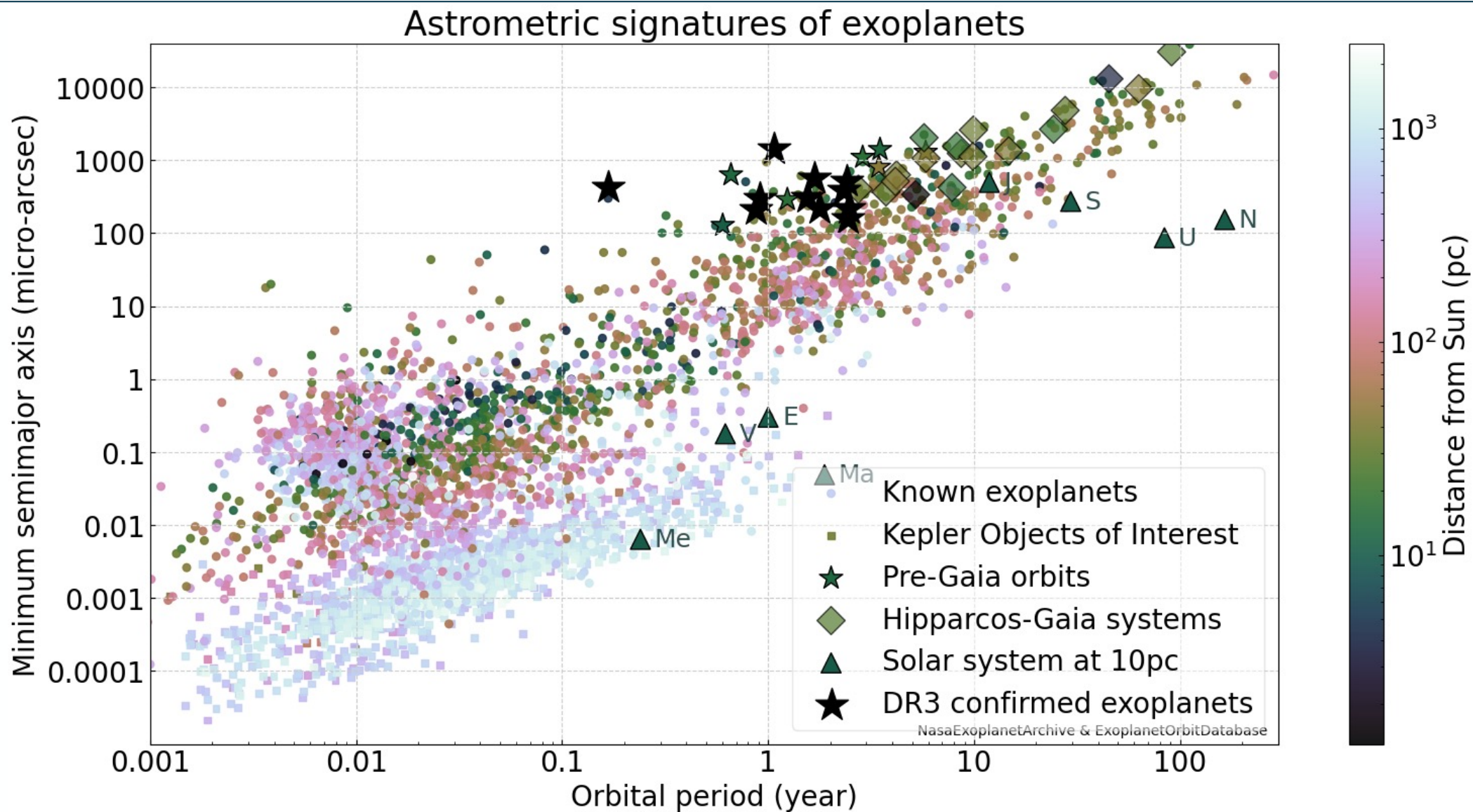
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Gaia astrometry opens up a new exoplanet window



Gaia astrometry opens up a new exoplanet window



The Gaia collaboration is preparing Gaia Data Release 4

- **High quality data releases:** science-ready, calibrated, and validated data products; extensive documentation



Gaia DR4

(planned December 2026)

- 5.5 years of data ; ~500 TB
 - New data products
- Timeseries for all sources / instruments
- Previews, content, and more
- **New Science!**

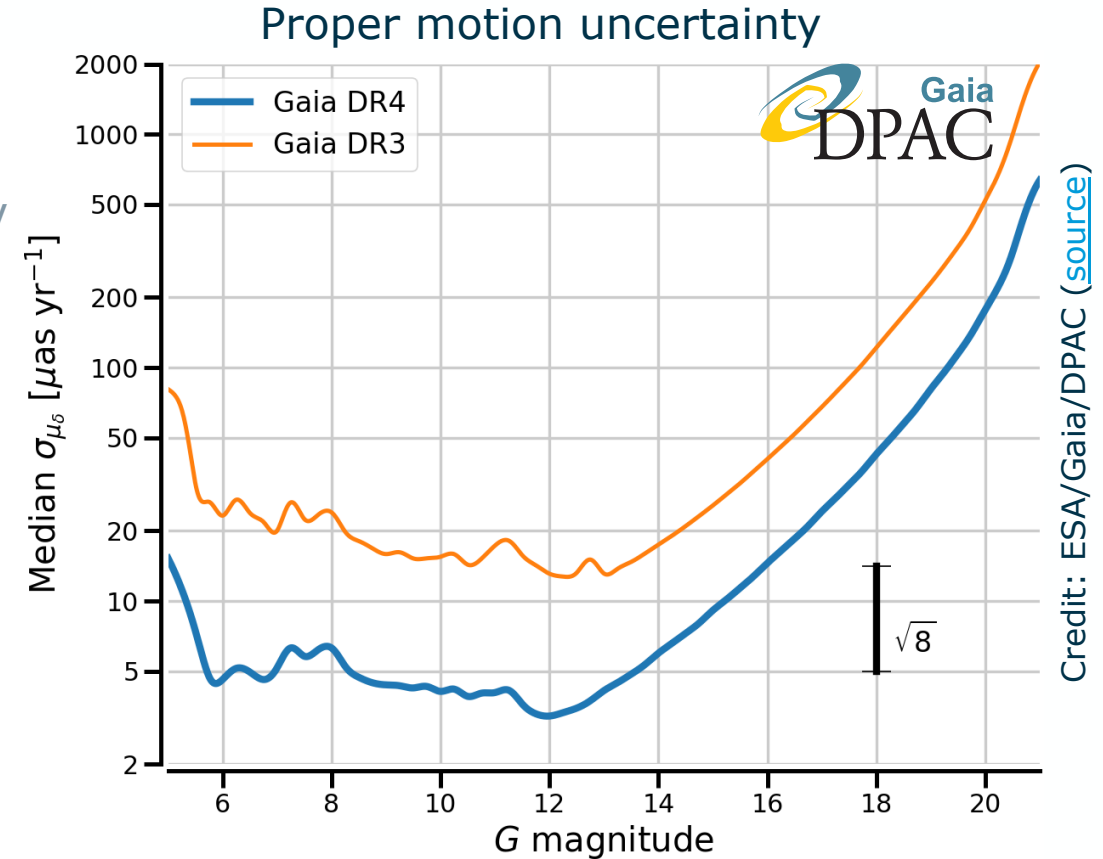
DR1 2016

DR2 2018

DR3 2022

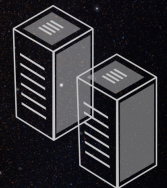
Upcoming Gaia DR4 is the “nominal mission” data release

- Gaia DR4 covers 5.5 years (2014-2020) of Gaia data
- More data, longer timespan, better precision, higher accuracy
- >2 billion sources
- More and new data products, including lower-level data:
 - [Time series of astrometric data](#) + CCD images
 - Lightcurves: time series of photometric data
 - Radial velocity time series
 - Time series of low- and high-resolution spectra
 - New non-single-source classes, source environment information, crowded field images, and much more
- Gaia DR4 will lead to another flurry of discoveries



500 TB

Volume of data release 4 (5.5 years of observations)



Overview of Gaia DR4 and its content is public



- Landing page: <https://www.cosmos.esa.int/web/gaia/data-release-4>
- Content page: <https://www.cosmos.esa.int/web/gaia/dr4>
- Currently incomplete list of >100 data tables and release items. Updates will be made gradually.

Export

Search:

AA Case Insensitive

Id	Data Model Chapter	Gaia Archive Table Name	Description	Category	New in DR4	Data level	Label
01.01	Main source catalogues	gaia_source	Sources considered to have both high quality astrometry and photometry. In contrast to previous data releases, the parameters in this table are consolidated from several different processing modules.	Main		DL3	General
01.02	Main source catalogues	gaia_source_environment	Astrometry, photometry, and related information for sources detected by the SEAPipe processing in the surrounding of sources in the main Gaia source catalogue.	Main	NEW	DL3	General
01.03	Main source catalogues	all_source_astrometry	Astrometric parameters obtained for all sources (except those in crowded_field_source and gaia_source_environment).	Main	NEW	DL3	Astrometry

GAIA: BLACK HOLES

Preliminary astrometric timeseries of Gaia BH3 and an orbit-fitting notebook are public:

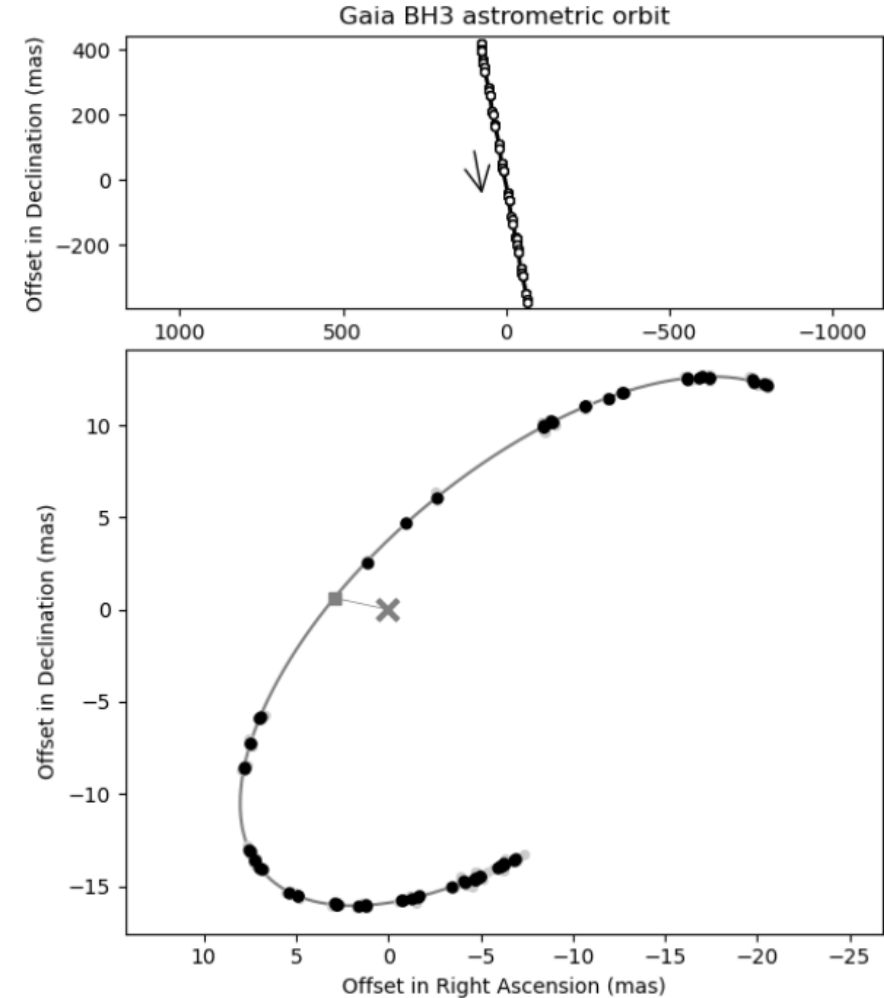
<https://github.com/esa/gaia-bhthree>



Gaia splinter session
(Ségransan & Delisle)

https://www.cosmos.esa.int/web/gaia/iow_20240416

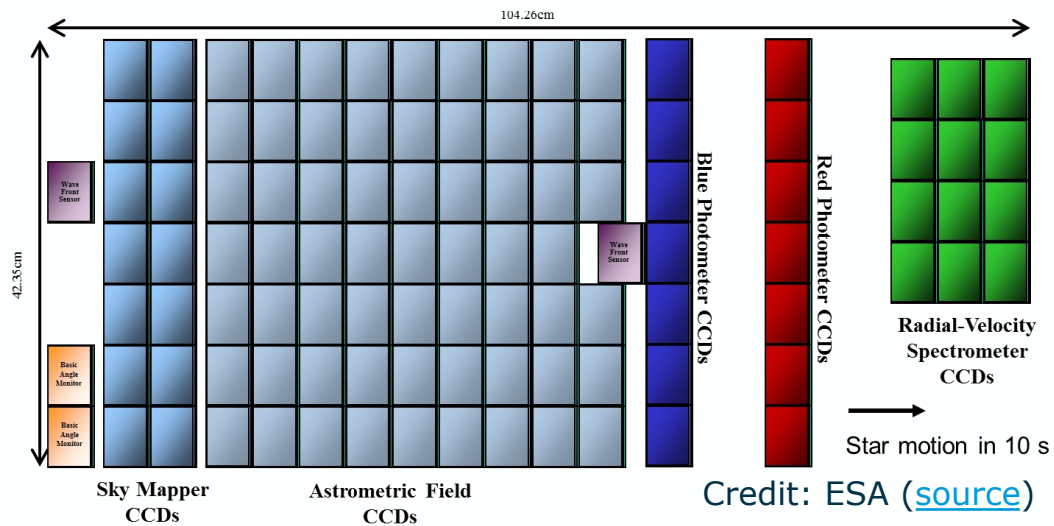
https://www.esa.int/Science_Exploration/Space_Science/Gaia/Sleeping_giant_surprises_Gaia_scientists



Gaia DR4 astrometric timeseries are accurate enough for exoplanet detection

Gaia DR4 astrometric timeseries “epoch_astrometry” will contain all individual CCD measurements (cf. gaiadr3.sso_observation).

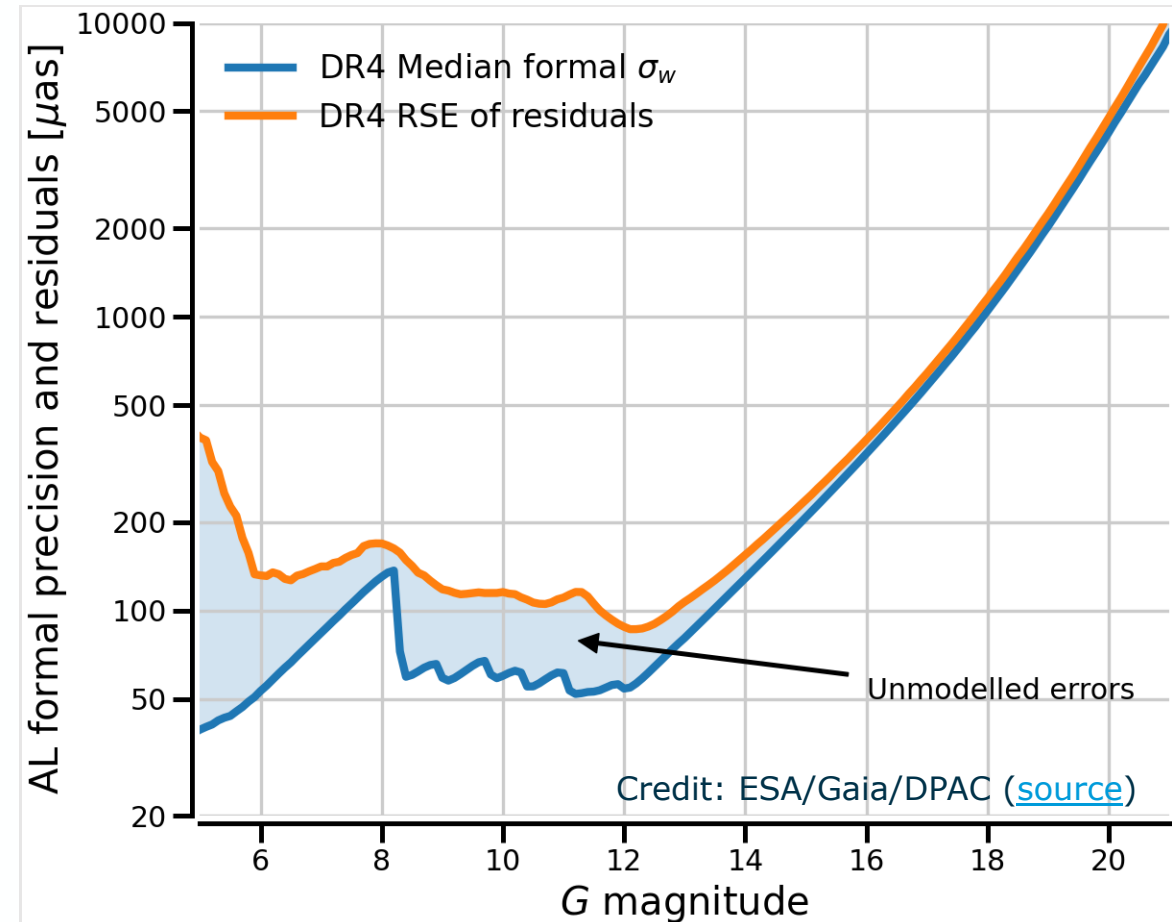
CCD-level accuracy limited by calibration errors to $\geq 80\text{--}150\ \mu\text{as}$ at bright end.



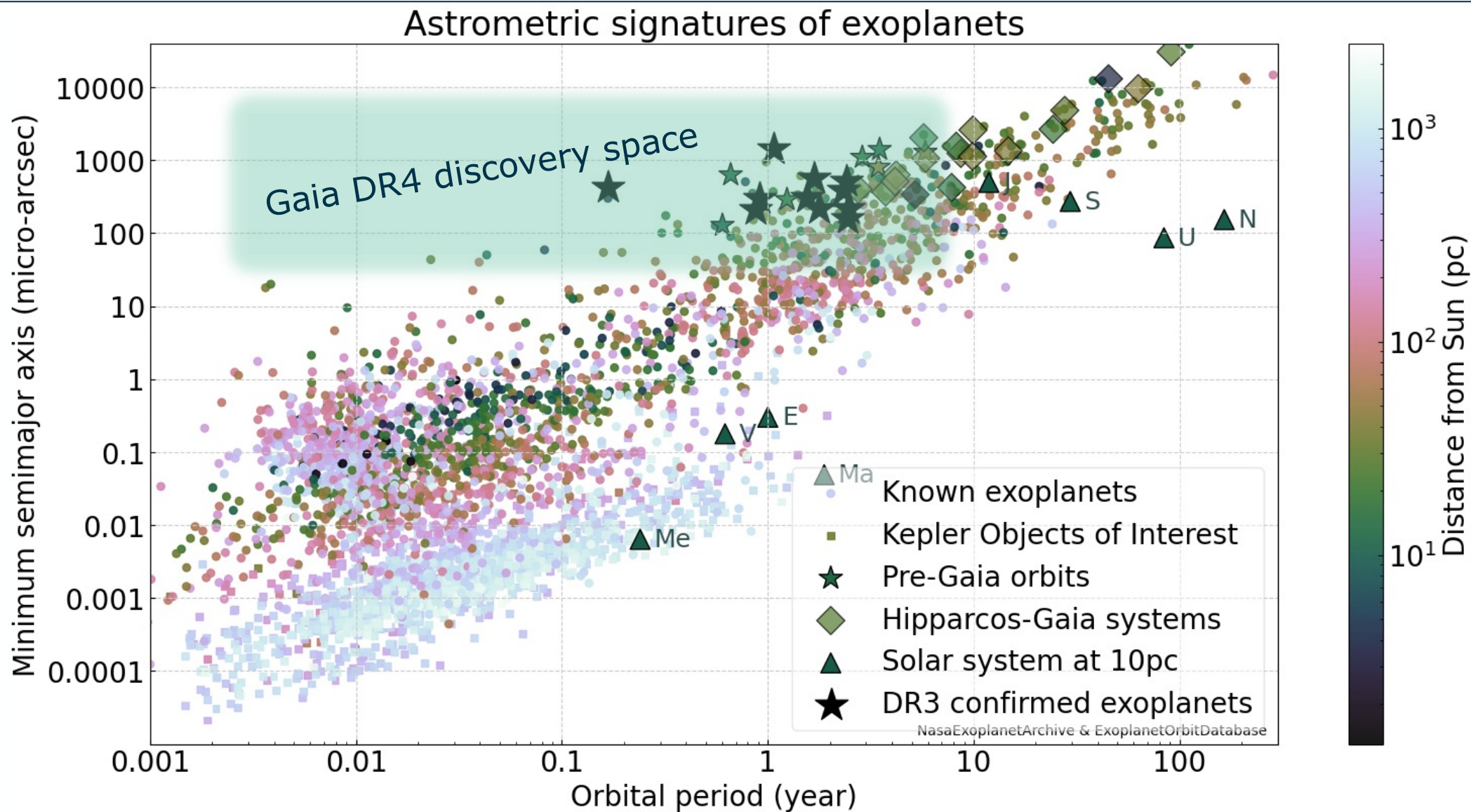
Combination of 9 CCD measurements limited to $\geq 30\text{--}50\ \mu\text{as}$ per Gaia Field-of-View transit.

Perryman+14 assumed $34\ \mu\text{as}$ for $G < 13$ stars.

Astrometric precision and accuracy for individual CCD measurements



Gaia astrometry opens up a new exoplanet window



Gaia DR4 will contain an astrometric exoplanet candidate catalog

How many exoplanets will Gaia DR4 reveal?

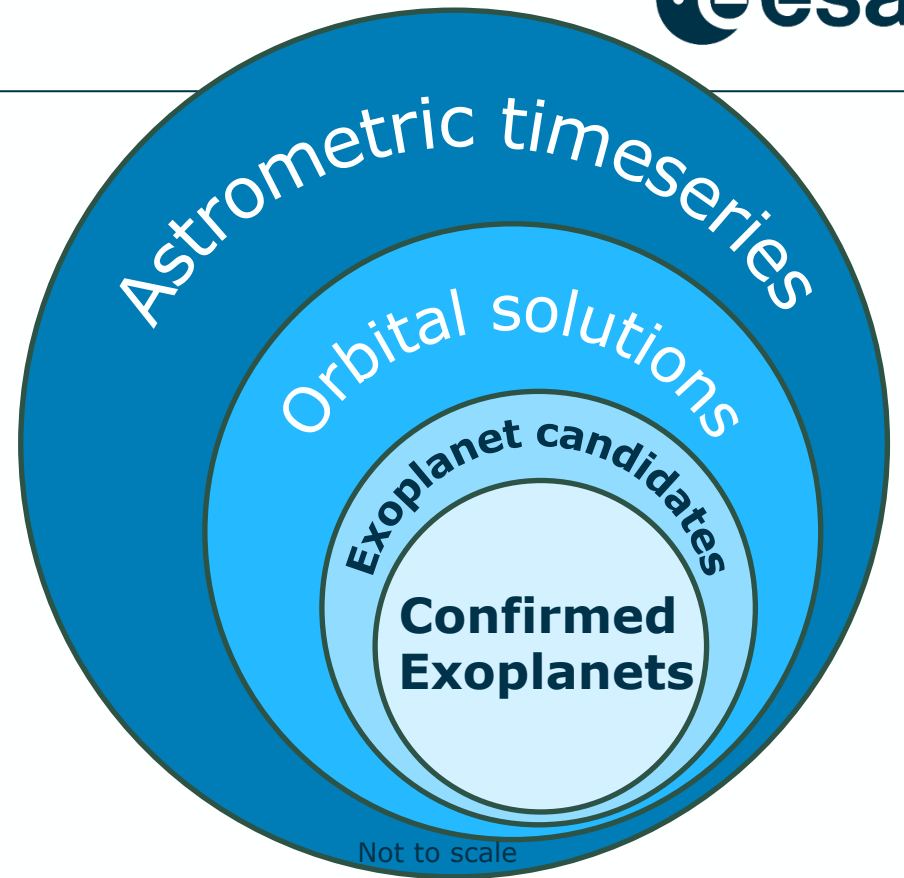
- Number detected by the DPAC pipelines?
- Number detectable in Gaia DR4 epoch astrometry?
- Mass and period range?
- Completeness or purity?

Twin binary stars can be astrophysical false positives. Mitigated by e.g.

- Colour-magnitude modelling (Gaia Collab., Arenou+23)
- Observations (e.g. Marcussen & Albrecht 23, Stefánsson+25)
- Ensemble analysis (e.g. Sahlmann & Gómez 25)

Most of the science will be done by the community

- Gaia DR4 astrometric timeseries are a gamechanger
- Astrometric accelerations of long-period systems
- Combination with other techniques is very powerful



**Contributions by Bouchy, Greenfield, Handley, Nowak, Parc, Van Zandt, Schlaufman, and others.
Gaia splinter session**

- 
- Gaia
DPAC

- **New Science!**

- **New Science!**

DR3 2022

Gaia and ESA resources at your fingertips



- Gaia general information and news releases: https://www.esa.int/Science_Exploration/Space_Science/Gaia
- Information for Gaia scientific community: <https://www.cosmos.esa.int/web/gaia>
- Receive Gaia data user notifications by signing up for the Gaia Bulletin emailing list: <https://www.cosmos.esa.int/web/gaia/bulletin>
- Interested in boosting the visibility of your Gaia-related research with an ESA news release? See <https://www.cosmos.esa.int/web/gaia/communicating-your-results>
- Please acknowledge the use of Gaia data in your research: <https://www.cosmos.esa.int/web/gaia-users/credits>
- Information on **ESA Archival Research Visitor Programme**: <https://www.cosmos.esa.int/web/esdc/visitor-programme> (next deadline 10 November 2025)
- Information on **ESA Research Fellowships in Space Science**: <https://www.cosmos.esa.int/web/space-science-faculty/opportunities/research-fellowships> (next call expected in the third quarter of 2026)

Conclusions

- Gaia delivered on the promise to revolutionise our understanding of the Milky Way and became a new backbone of modern astronomy and astrophysics.
- We wave goodbye to the Gaia spacecraft, but the Gaia mission continues strong.
- Gaia DR4 will be fantastic for giant exoplanet science!
- Gaia Data Release 4 is planned for December 2026.
- Gaia Data Releases 4 (and 5) will unleash the full scientific power of the Gaia survey. The best from Gaia is ahead of us.



Credit: ESA ([source](#))

ESA is celebrating its 50th anniversary

