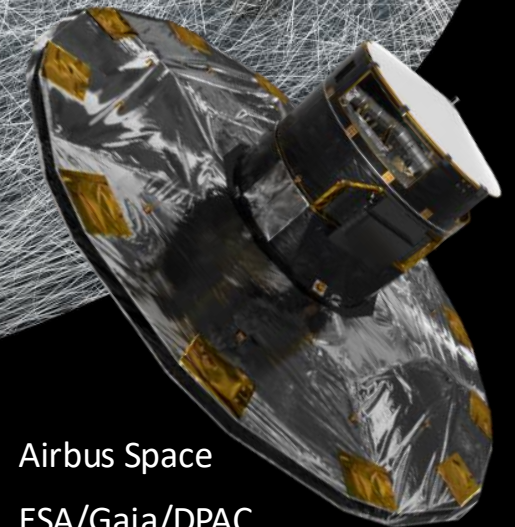




# Gaia Futures: Towards DR4, DR5 and GaiaNIR

Nicholas Walton

Institute of Astronomy, University of Cambridge  
(Member of the ESA Gaia Science Team)



Airbus Space  
ESA/Gaia/DPAC



# Gaia Science

from launch to May 2025 **14,000** peer reviewed papers from the world-wide community, now the most scientifically productive\* ESA science mission

Gaia science spans most of Astrophysics from studies of nearby solar system asteroids, to the structure of stars, to formation of the Milky Way, revealing dark matter, to fundamental physics

Science highlights: <https://www.cosmos.esa.int/web/gaia/highlights-of-gaia-dr3>



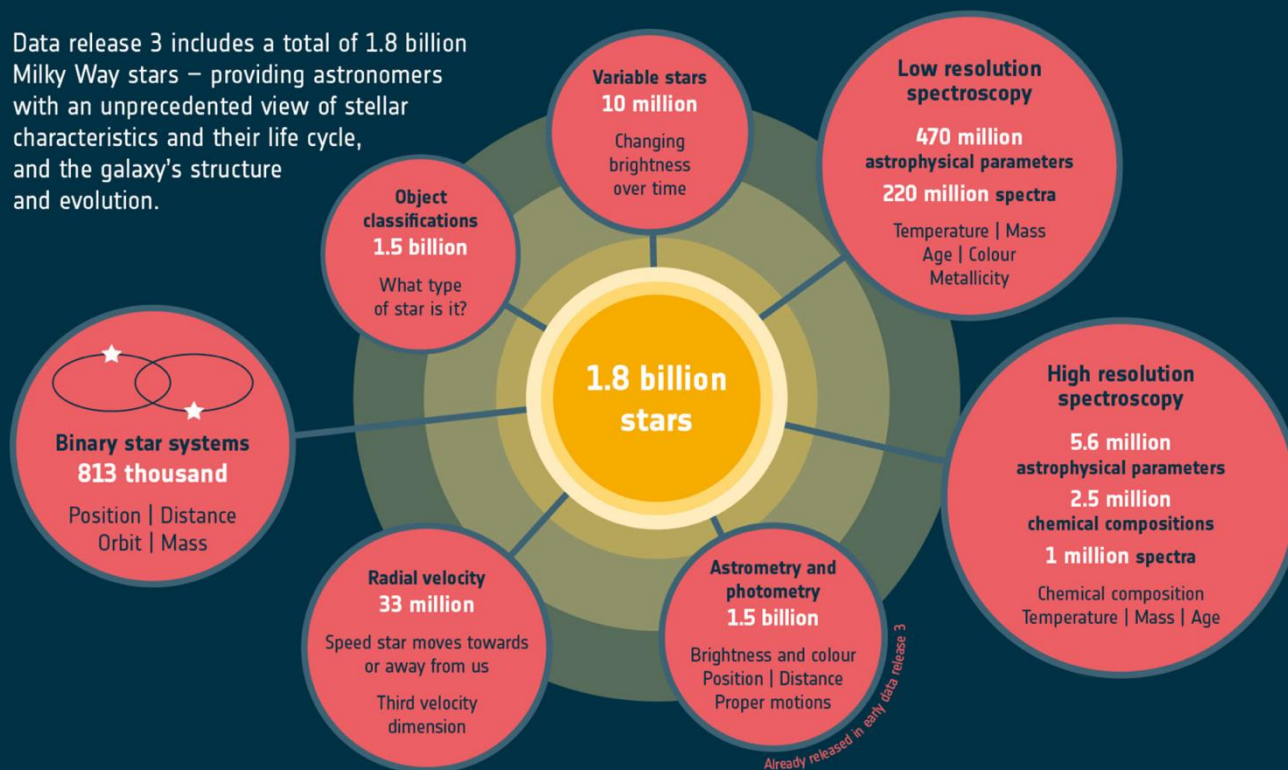
# Gaia: Currently at Release Gaia DR3

Gaia data leads to insight across astronomy

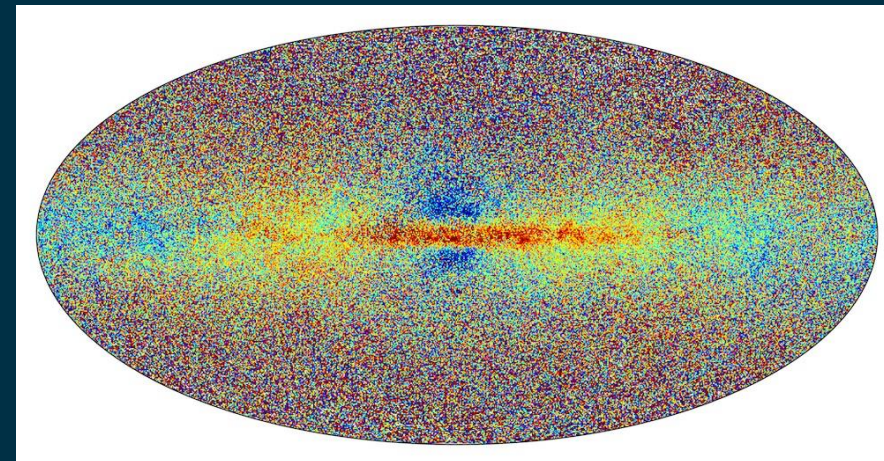


## MILKY WAY STARS

Data release 3 includes a total of 1.8 billion Milky Way stars – providing astronomers with an unprecedented view of stellar characteristics and their life cycle, and the galaxy's structure and evolution.

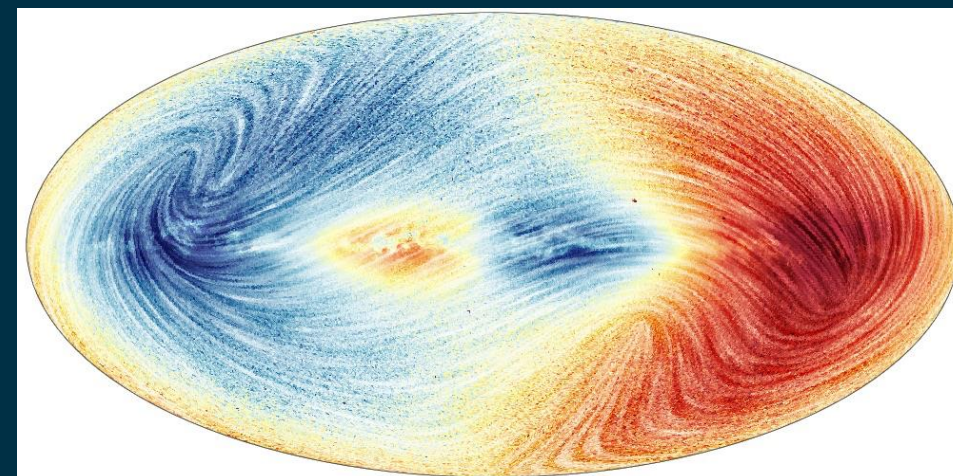


Gaia EDR3/ DR3: with larger to come



Credit: ESA/ Gaia/ DPAC

Stellar abundances

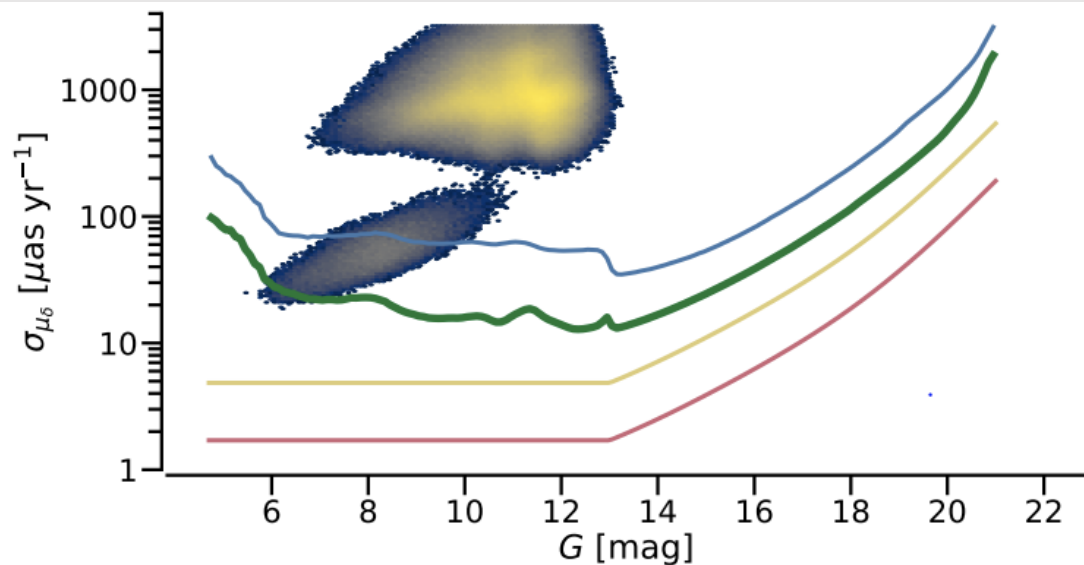
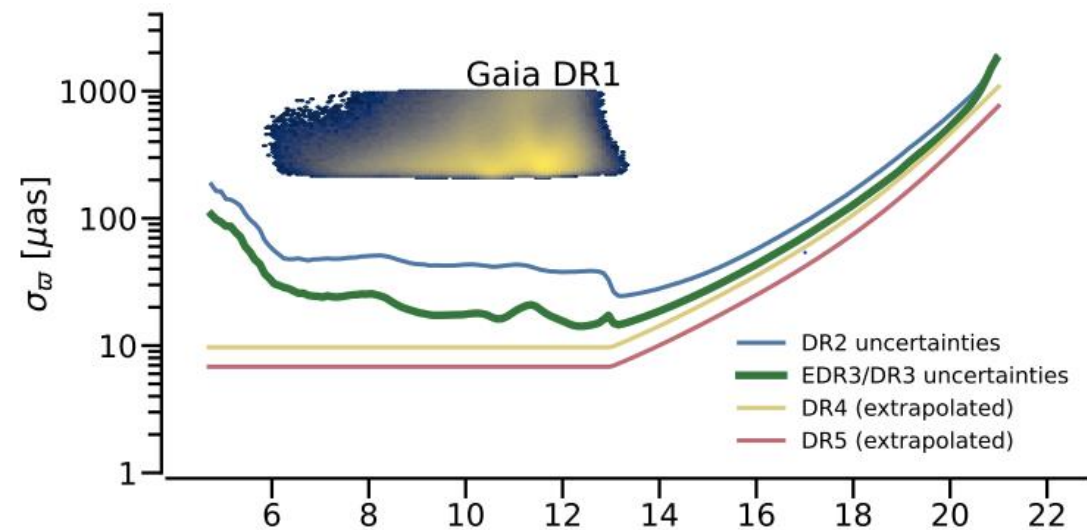


Stellar velocities ...

Credit: ESA/  
Gaia/ DPAC

Over 2.5 Trillion observations, and counting ...

# Gaia Performance from DR1 to DR5



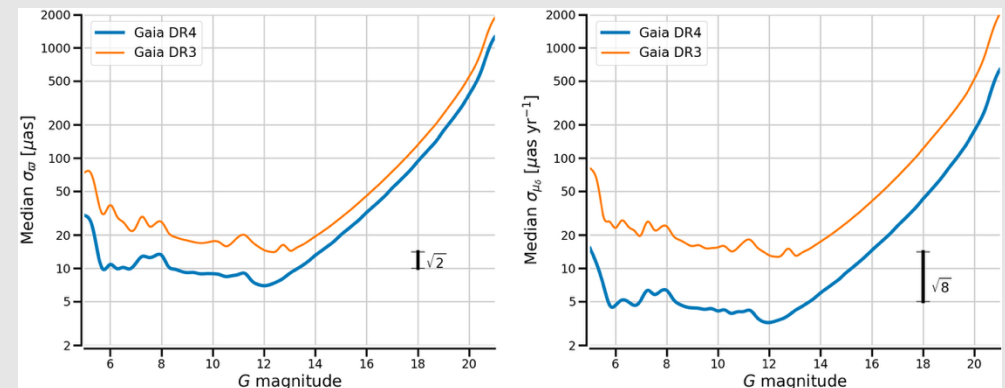
● Basic mission results improve as  $t^{-0.5}$

▶ Positions, parallaxes, photometry and radial velocities  $\rightarrow$  factor 1.4 (DR4), 1.9 (DR5)

● Proper motion improves as  $t^{-1.5}$

▶ Rapidly increasing gain in kinematics and dynamics  $\rightarrow$  factor 2.7 (DR4), 6.6 (DR5)

● Higher order terms scale more! e.g. improvement in unambiguous determination of orbital period, mass and distance of a perturbing body scales as  $t^{-4.5}$



# Towards Gaia DR4:

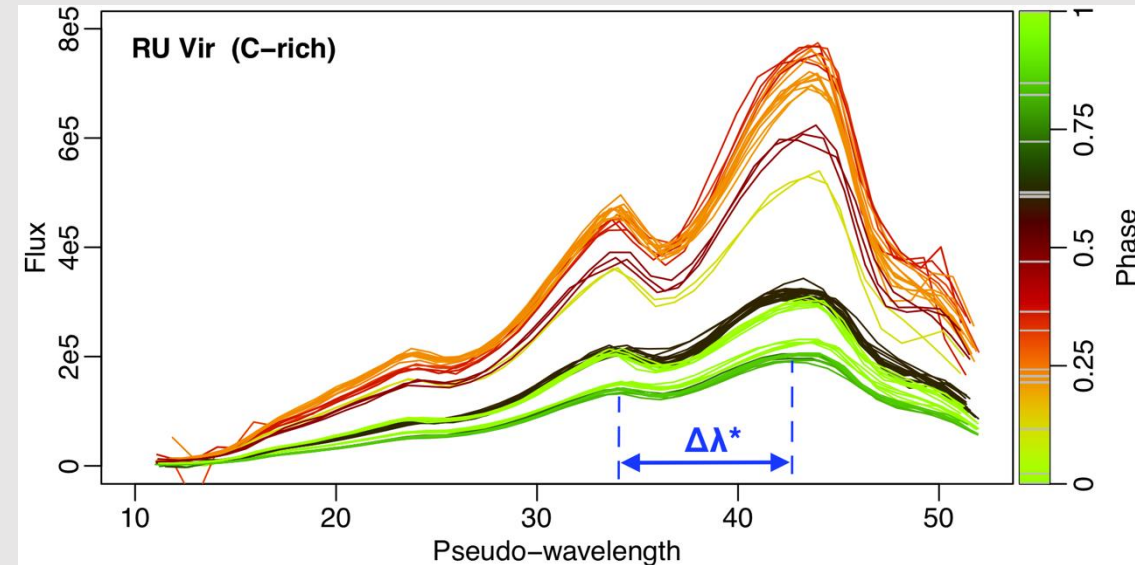
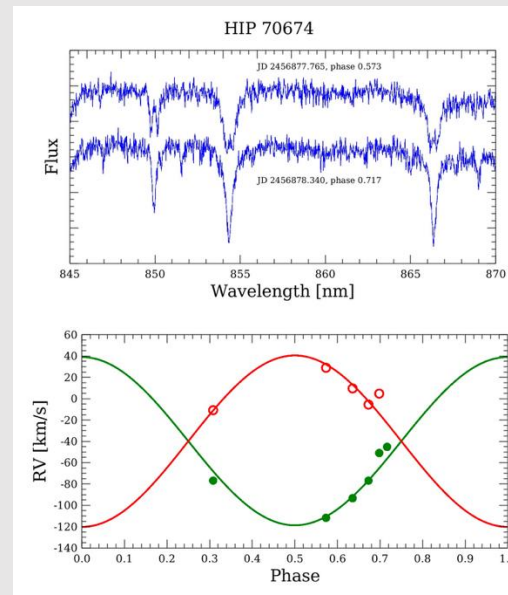
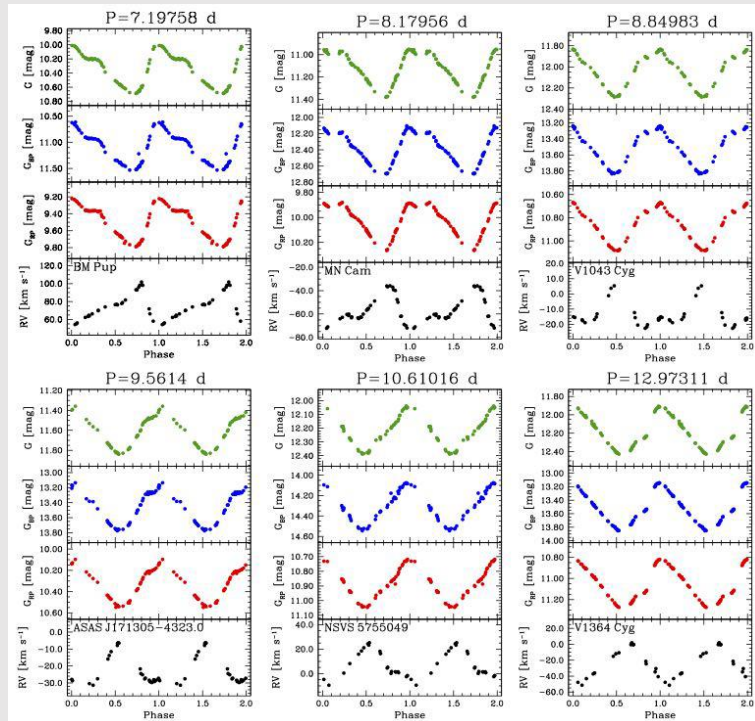
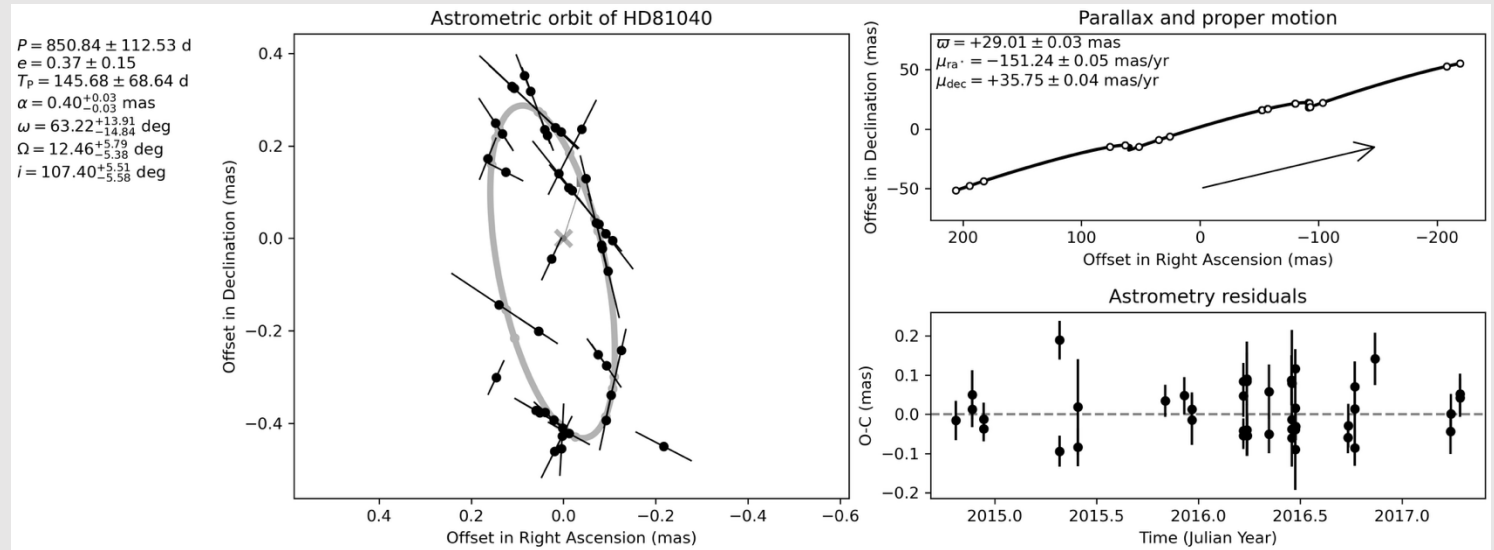
Full discussion of Gaia and Gaia DR4 tomorrow  
in the Gaia #94 session TLC101 @ 09.00

- Gaia in-flight operations completed Jan 2025 (no more cold gas propellant)
  - ▶ Nominal mission ended in 2019
  - ▶ Post operations phase until the release of Gaia DR5.
- Gaia DR4 : December 2026
- Gaia DR4 is the final release for the nominal mission, 66 months of data
  - ▶ Including a 6 months period of reverse direction of the satellite precession (mitigates degeneracy between AC stellar motion and parallax)
  - ▶ Full Epoch data: epoch astrometry, broad band photometry, radial velocity, BPRP, RVS,
  - ▶ Full astrometric, photometric, and radial-velocity catalogues, variable-stars and non-single-star solutions, classification, exoplanet list, RB/RP and RVS spectra
- Gaia DR5 : will include the extended mission data.



# Gaia DR4: Epoch data for 2.5 Billion Sources

- Epoch astrometry
- Epoch light curves
- Rad vel time series
- XP spectra time series
- RVS spectra time series



# Gaia Future and Next Data Releases: to DR5

- Gaia DR5 targeted not before the end of 2030
- Final release of the mission 10+ years of data
- Full astrometric, photometric, and radial-velocity catalogues, variable- star and non-single-star solutions, classification, exoplanet list, epoch and transit data, RB/RP and RVS spectra, epoch data
  - ▶ Gaia DR5 fulfils the extended mission science with an increased focus on topics such exoplanets and structure and evolution of the Milky Way and Local Group Galaxies (e.g. reaching brightest stellar populations in dwarf galaxies at 100kpc with a full 10 year Gaia survey)
- Legacy Archive

# What follows? Into the centre of the Milky Way GaiaNIR & ESA Voyage 2050

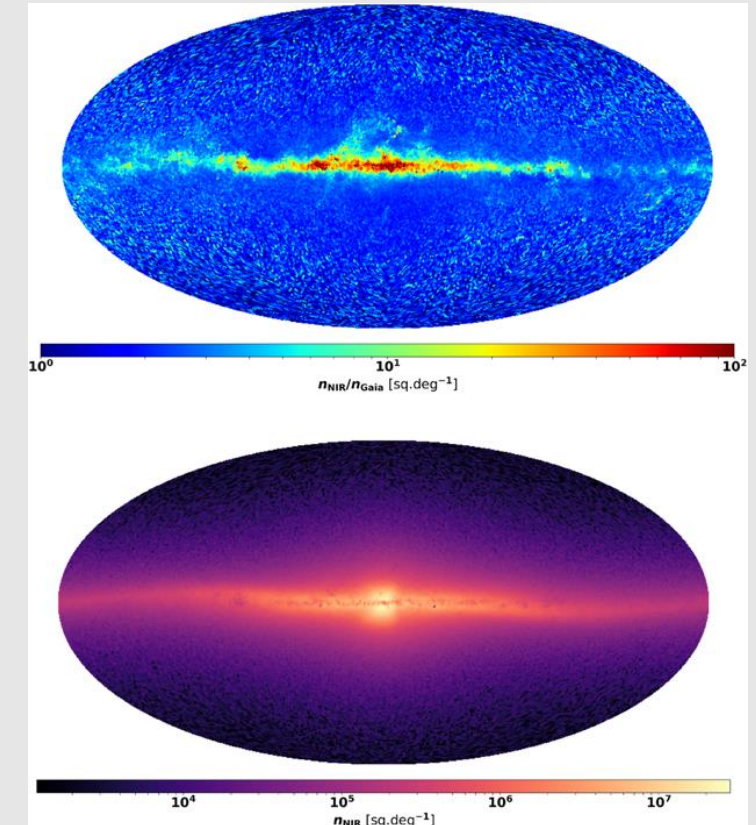
- Gaia like mission extending to the near infrared – probes x20 Gaia sources – implies > **50 Billion** sources
- Three key science goals:
  - ▶ Penetrate dust obscured of the Milky Way to reveal the Bulge and Disk to disentangle the formation history of our Galaxy
  - ▶ Combine with Gaia data to increase the proper motion baseline to probe the outer regions of our galaxy
  - ▶ Maintain the Celestial Reference Frame and explore the fundamental physics of gravitational waves
- Key technical challenges include the development of InfraRed detectors

**A transformational L-class ESA Space mission**

See David Hobb's talk earlier in this session

## Voyage 2050

Final recommendations from the Voyage 2050 Senior Committee



Credit: Hobbs et al 2020

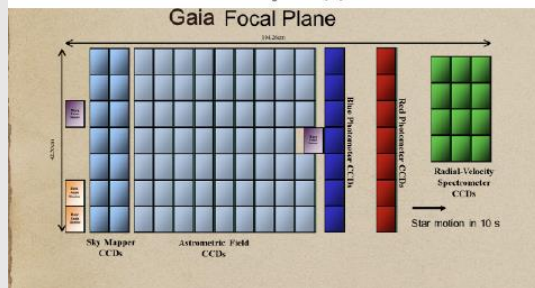
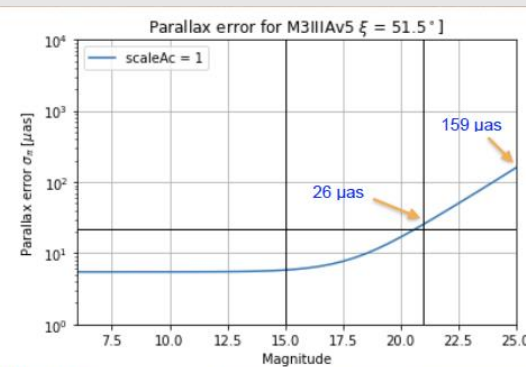
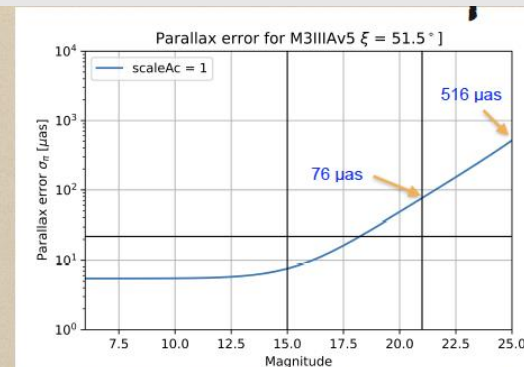
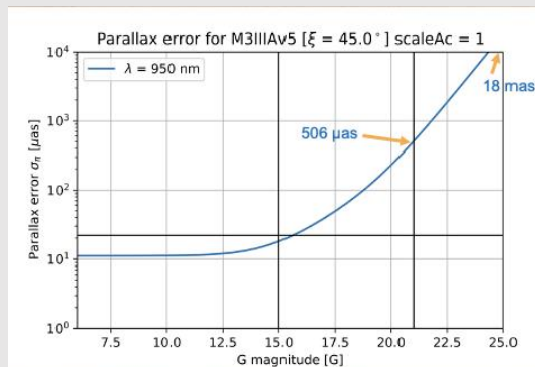


Gaia observes the visible sky in the optical, but to see through the dust to where the bulk of the stars are, we need the near IR!

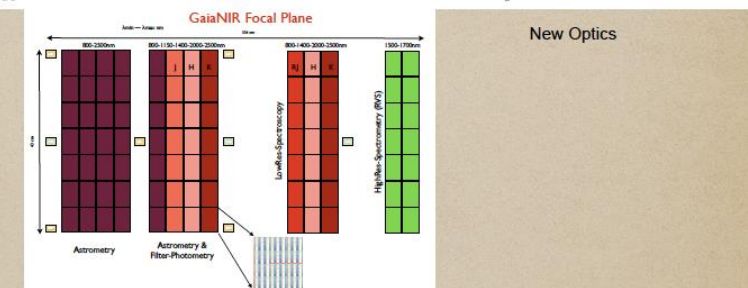


# GaiaNIR Detector Studies in the UK

- Use of Linear Mode Avalanche Photon Detectors (APD) as the IR detector operating in a 'TDI' like mode now being studied (Leonardo, Cambridge, et al)
- Initial paper study (UKSA NSTP funded) in 2021-2022 demonstrated the viability of APDs
- ESA CTP funded study (2024-2025) now underway to carry out evaluation of physical devices
- Initial results (e.g. readnoise) indicate performance suitable for GaiaNIR



CDF Optics



New Optics

Identical runs for a M3 III red giant:  
APD error scales linearly with magnitude (c.f. exponential increase in CCDs)



# Getting involved in Gaia and GaiaNIR

## networking across the UK and Europe

# GREAT Plenaries

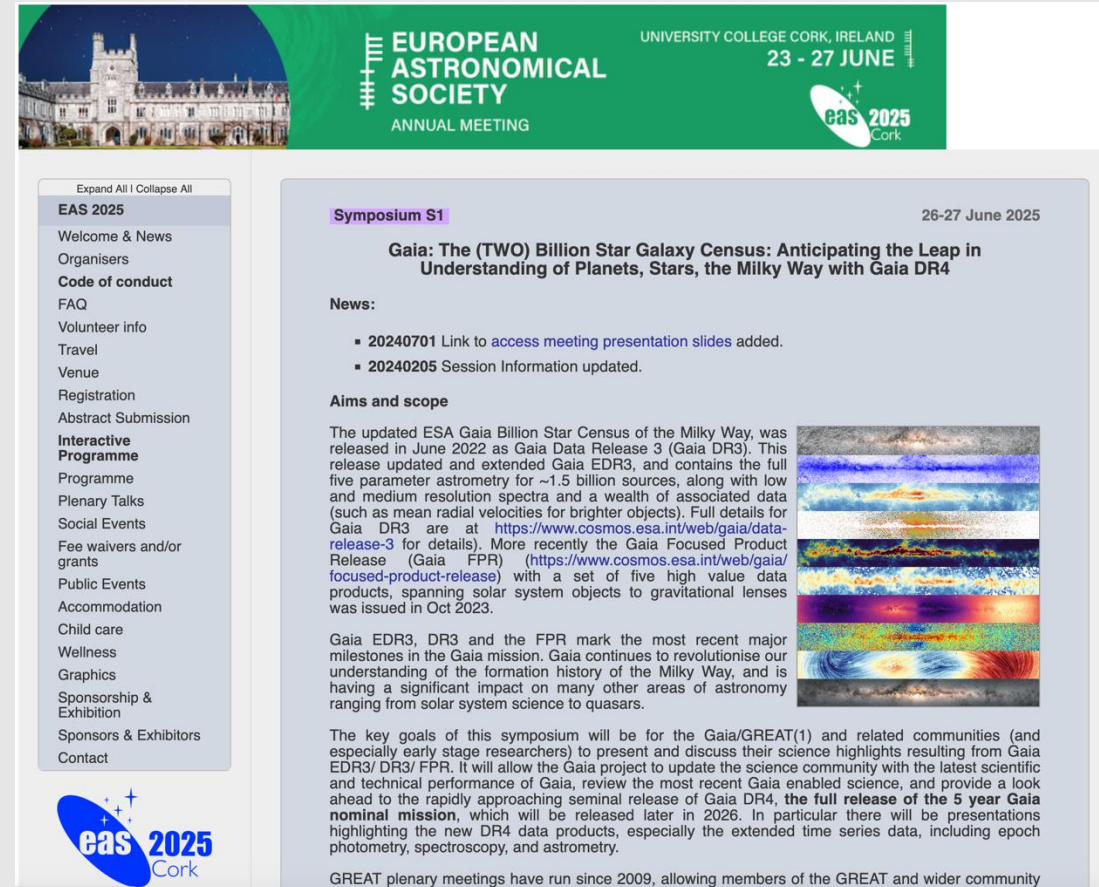
slides on-line at: <http://great.ast.cam.ac.uk/Greatwiki/GreatMeet-PM18>

Last GREAT plenary was held at the EAS Annual Meeting 2025 in Cork as Symp S1 (26-27 Jun 2025)

<https://eas.unige.ch/EAS2025/session.jsp?id=S1>

## Programme

- Gaia DR3: Highlight Science including a review of recent major science highlights from Gaia DR3, Gaia FPR and science discovery enabled by Gaia, with attention to the potential of Gaia DR4.
- Gaia / GREAT/MW-Gaia / Gaia Unlimited Status
- Gaia EDR3/DR3/FPR: Highlight Science (The Milky Way as a Galaxy)
- Gaia EDR3/DR3/FPR: Highlight Science (The Birth, Life and Death of Stars)
- Gaia EDR3/DR3/FPR: Highlight Science (from Solar system to reference frames)
- Gaia networking and ground based synergies with Gaia
- Lunch session with an update on the Gaia Archive, and update on the ESA Voyage 2050 L mission concept (GaiaNIR), and also an opportunity for poster presenters to deliver a 'lightening' talk of their (e-)poster.



The screenshot shows the EAS 2025 website. The header features a green banner with the text "EUROPEAN ASTRONOMICAL SOCIETY ANNUAL MEETING" and "UNIVERSITY COLLEGE CORK, IRELAND 23 - 27 JUNE". Below the banner is a sidebar with a menu for "EAS 2025" including links for Welcome & News, Organisers, Code of conduct, FAQ, Volunteer info, Travel, Venue, Registration, Abstract Submission, Interactive Programme, Programme, Plenary Talks, Social Events, Fee waivers and/or grants, Public Events, Accommodation, Child care, Wellness, Graphics, Sponsorship & Exhibition, Sponsors & Exhibitors, and Contact. The main content area is titled "Symposium S1" and "26-27 June 2025". It features the title "Gaia: The (TWO) Billion Star Galaxy Census: Anticipating the Leap in Understanding of Planets, Stars, the Milky Way with Gaia DR4". Under "News", it lists two items: "20240701 Link to access meeting presentation slides added." and "20240205 Session Information updated." The "Aims and scope" section describes the updated ESA Gaia Billion Star Census of the Milky Way, released in June 2022 as Gaia Data Release 3 (Gaia DR3). It mentions that this release updated and extended Gaia EDR3, containing full five parameter astrometry for ~1.5 billion sources, along with low and medium resolution spectra and a wealth of associated data. It also mentions the Gaia Focused Product Release (Gaia FPR) and the Gaia DR4 data products. A vertical strip of astronomical images is shown on the right. The footer mentions "GREAT plenary meetings have run since 2009, allowing members of the GREAT and wider community".



# MW-Gaia: <http://www.mw-gaia.org>

March 2019 to September 2023

see also COST page at <https://www.cost.eu/actions/CA18104/>

**MW-GAIA**

Home News Themes > Participate > Collaborate > About >

## Welcome to MW-Gaia

MW-GAIA will provide European leadership in understanding the Galaxy, its stars and planets, enhance the potential of the community in its scientific exploitation of the observations of more than a billion stars with the European Space Agency's Gaia satellite, and enhance the development of the next steps in astrometry and space astrometry missions.

The Action brings together key stakeholders from across Europe, to leverage expertise, and develop new techniques to fully maximise the scientific returns from Gaia's rich and complex data.

Five key challenges are addressed: The Milky Way as a Galaxy, The Life and Death of Stars; Planetary Systems Near and Far; Gaia Fundamentals: Space and Time; and Astrometry Innovation Challenge – towards sub- $\mu$ s astrometry. COST enables the vital Action activities, supporting exchanges, training and meetings.

The Action will have a significant legacy, creating a dynamic and vibrant network of researchers with expertise in the study of the Milky Way, its constituents and the art of Astrometry. Participation is inclusive, with researchers accessing the Network from across Europe, irrespective of their gender or location.

This COST Action commenced 14 Mar 2019 and will complete 13 Sep 2023.

participate



### Final Conference: The Milky Way Revealed by Gaia: The Next Frontier [↗](#)

01.05.2023 Filed in: [Participate](#)

The Action COST MWGaia invites you to participate in the Final Conference "The Milky Way Revealed by Gaia: The Next Frontier" that will take place in Barcelona, ES from 5 to 7 September 2023.

### Social Media



### Post Index

Select specific posts by **Category** or by **Month Posted**

### Categories

[News](#)  
[Outreach](#)  
[Participate](#)

### Tags

- [Brexit](#)
- [Conferences](#)
- [covid-19](#)
- [GP4](#)
- [ITC](#)
- [Outreach](#)
- [Schools](#)
- [STSM](#)
- [UK](#)
- [VM Grants](#)
- [WG1](#)
- [WG2](#)
- [WG3](#)
- [WG4](#)
- [WG5](#)

- The MW-Gaia COST Action had participants from 30 COST countries across Europe
- Networked a significant proportion of the science community leading studies of the Milky Way
- [New proposal to be submitted Oct 2025 to cover Gaia science development for Gaia DR5 and GaiaNIR](#)
  - [Will run Nov/26 to Oct/30 if approved!](#)



# MW-Gaia: <http://www.mw-gaia.org>

March 2019 to September 2023

MW-Gaia Outcomes

17 Workshops (~1000 attendees) over the Action lifetime

4 Schools over the Action lifetime

~50 STSM and ITC grants



About

Organizing Committees

Registration

Scientific Program

Call for Abstracts

Contribution List

Participants

Timetable

Venue and Accommodation

Social Dinner

How to reach the ICCUB

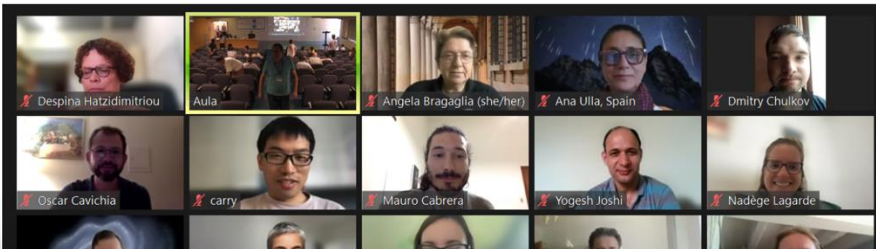
Useful information

Photography and Filming Consent

Code of Conduct



Year 2: Sep 2021,  
WG3 Workshop,  
Helsinki



Year 3: Sep 2022, WG5 Workshop, Santiago de Compostela



10/07/2025

Nic Walton - Gaia DR4/5 & GaiaNIR @ NAM 2025, Durham



# MWGaia Doctoral Network

<https://www.mwgaiaadn.eu>

- EU Horizon Europe MWGaia Doctoral Network (2023-2027)

12 PhD projects based at 10 EU Institutes + 2 UK Institutes and 13 Associate industry partners

- Range of workshops now underway (open to the MWGaia community) – Cambridge (7/25) and Dresden (9/25) meetings coming up
- Keep the date: 11-15/1/27 in Athens. Focus on Gaia DR4, DR5 and GaiaNIR

10/07/2025

Nic Walton - Gaia DR4/5 & GaiaNIR @ NAM 2025, Durham

**MWGaiaDN**  
Revealing the Milky Way with Gaia

*This project is a Horizon Europe Marie Skłodowska-Curie Actions Doctoral Network funded under grant agreement no. 101072454.*

**Overview**

This doctoral network features PhD projects focused on the science that can be extracted from Gaia DR3 and Gaia DR4 but also projects that look forward towards the potential follow-up to the Gaia mission, GaiaNIR, investigating the technical challenges that will have to be overcome. With an eye on the even longer term the Gaia celestial reference frame will be investigated in detail and the challenges of sub-microarcsecond astrometry will be researched aiming at relativistic astrometric models at the 10 nanoarcsec level.

Funded by the European Union

UK Research and Innovation

## Network events

Workshops, conferences, and meetings organized by MWGaiaDN will be listed here.

### Meetings

Meeting	Dates	Location	Links
Kick-off	March 22–23 2023	Leiden	<a href="#">Meeting page</a>
Training programme kick-off workshop	September 7–8 2023	Barcelona	<a href="#">Meeting page</a>

### Schools and Workshops

School/Workshop	ECTS	Dates	Location	Links
ESR induction school + Diversity, public engagement and communication	1.5	January 29–February 2 2024	Leiden	<a href="#">Meeting page</a>
The Art of Astrometry and Computation	0.5	June 24–28 2024	Lund	<a href="#">Meeting page</a>
ESR school: Introduction to Astro-statistics and data visualisation	1	September 9–13 2024	Coimbra	<a href="#">Meeting page</a>
PhD School Frontiers of stellar physics	0.5	October 15–17 2024	Padova	<a href="#">Meeting page</a>
Galaxy modelling + galactic centre workshop	1	December 9–13 2024	Guildford	<a href="#">Meeting page</a>
ESR School on transferable skills: managing, entrepreneurial and IPR	1	June 2–6 2025	Barcelona	<a href="#">Meeting page</a>
Roadmap: Technical Challenges workshop	0.5	July 15–16 2025	Cambridge	<a href="#">Meeting page</a>
MWGaiaDN School “Gravitation and astrometry”	0.5	September 8–12 2025	Dresden	<a href="#">Meeting page</a>

### Conferences

Conference	ECTS	Dates	Location	Links
The Milky Way revealed with Gaia; on to the hidden regions with GaiaNIR	1	January 11–15 2027	Athens	<a href="#">Meeting page</a>

# GaiaNIR: UK – The Science Network

- A significant range of UK involvement in the various Gaia networking activities since 2009
  - ▶ GREAT ESF: ESF research network programme 2010-2015
  - ▶ GREAT ITN: EU ITN PhD training network 2011-2015
  - ▶ MW-Gaia: EU COST Action 2019-2023
  - ▶ MWGaiaDN: EU Doctoral Network 2023-2027
  - ▶ GREAT Plenaries: Science Symposium @ EAS Annual meetings since 2012
- New activity in support of GaiaNIR science and mission development
  - ▶ **GaiaNIR:UK** – currently with involvement from groups in Cambridge, UCL, Durham, Bath, Edinburgh, Exeter, LivJM, Oxford, Surrey, UCLan ...
  - ▶ GaiaNIR:UK focus community meeting: March 2026
  - ▶ Find out more: signup to the [ast-gaianir-uk](mailto:ast-gaianir-uk) mailing list or see the GaiaNIR pages at <https://www.gaia.ac.uk> or email me!



# ***For now ... Gaia DR3: the current data release and Gaia DR4, the upcoming release***

## ***Gaia Data Release 3 Information:***

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

## ***Gaia Data Release 4 Information:***

<https://www.cosmos.esa.int/web/gaia/data-release-4>

## ***Gaia DPAC***

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

## ***Gaia and GaiaNIR in The UK***

<https://www.gaia.ac.uk/>

Cite the data release and data processing papers

<https://gea.esac.esa.int/archive/documentation/credits.html>