Gaia Futures:
Towards DR4, DR5 and GaiaNIR

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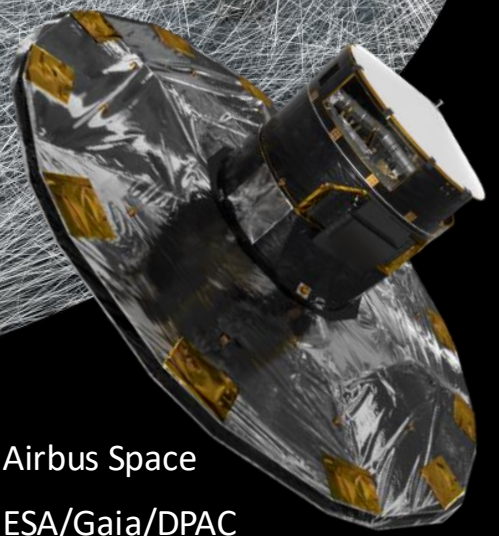
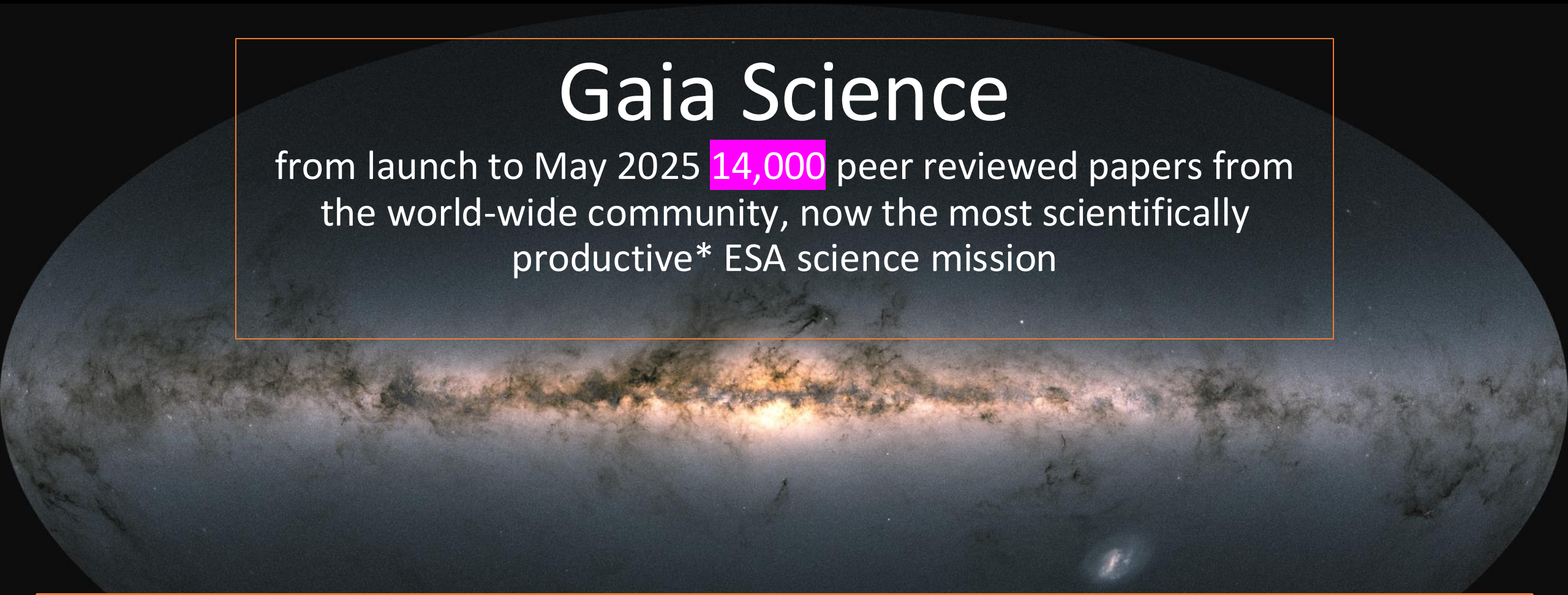


Airbus Space

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



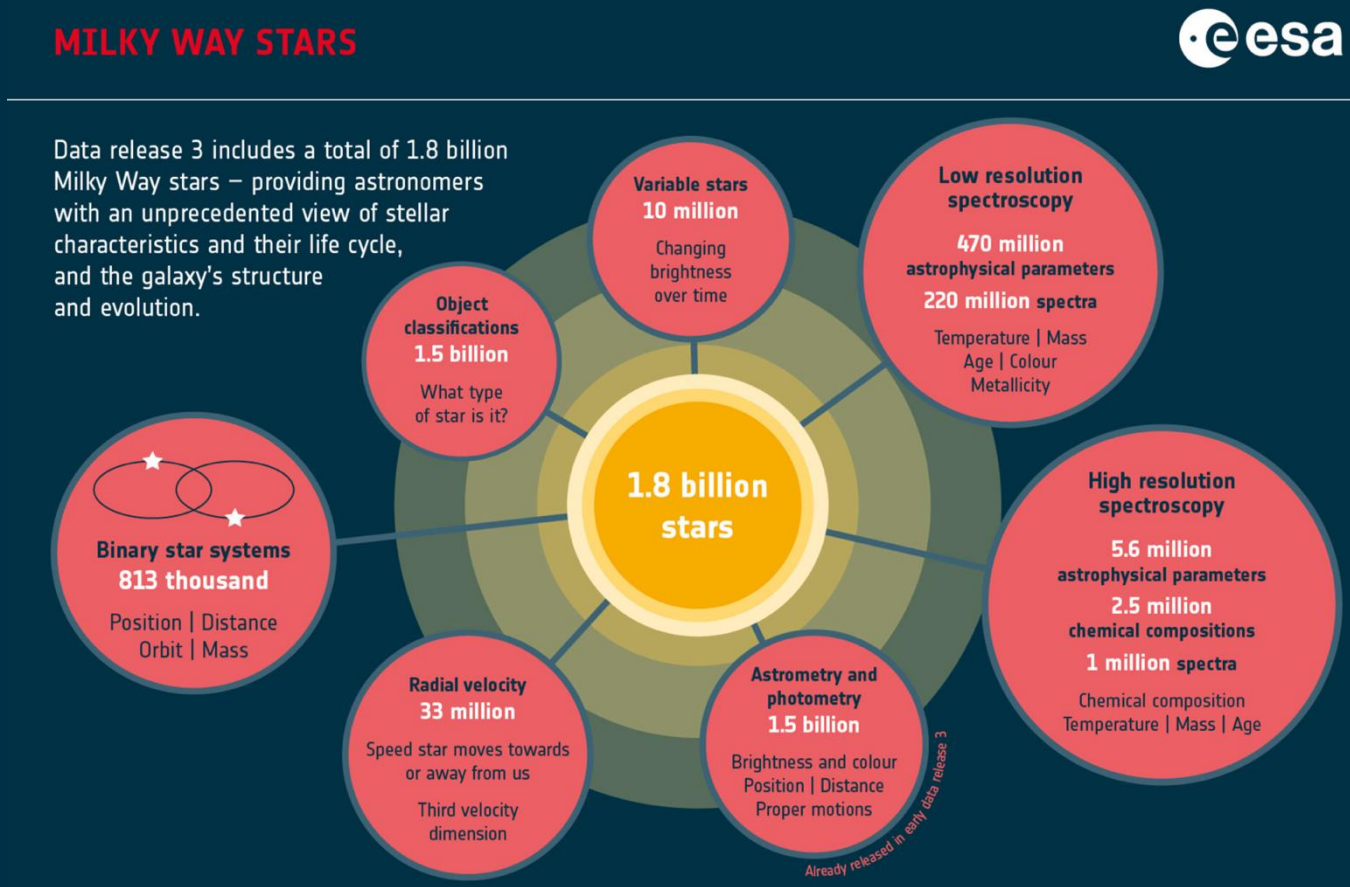
Gaia science spans most of Astrophysics from
studies of nearby solar system asteroids, to the structure of stars, to formation of the Milky Way, revealing dark matter, to fundamental physics
Science highlights: https://www.cosmos.esa.int/web/gaia/highlights-of-gaia-dr3

Credit ESA/Gaia/DPAC

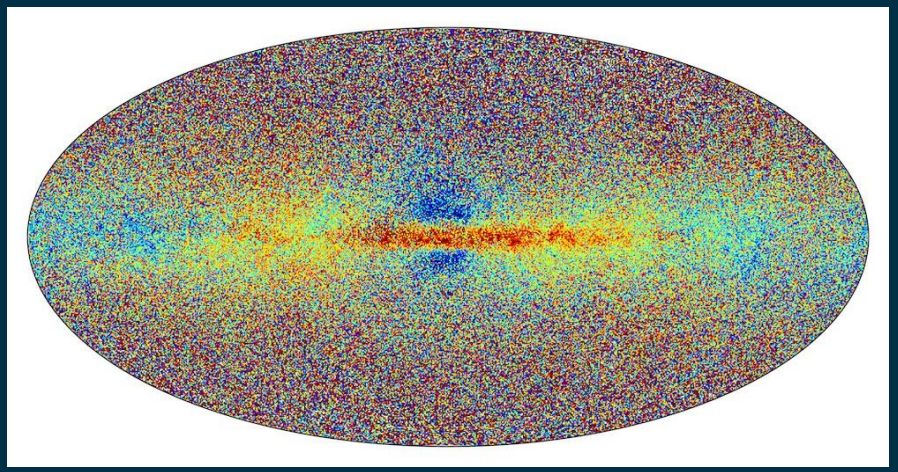
* (papers/yr)

Gaia: Currently at Release Gaia DR3

Gaia data leads to insight across astronomy

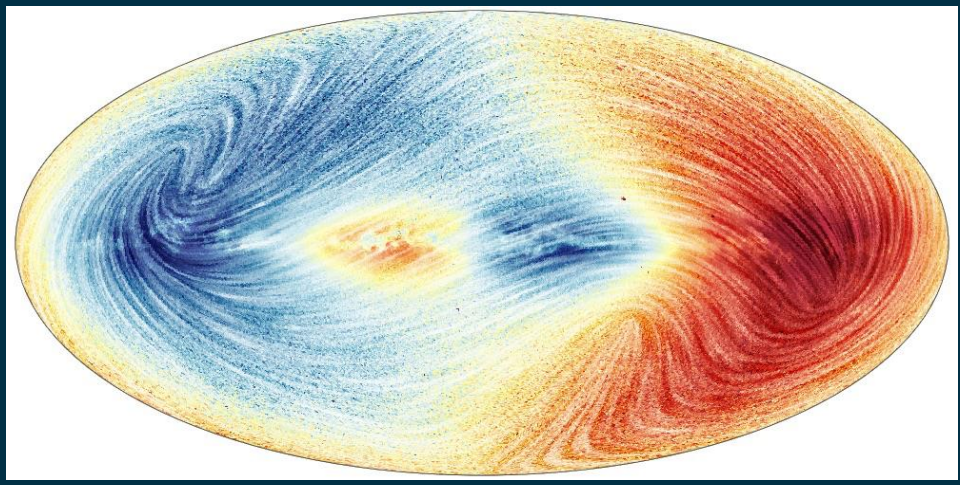


Gaia EDR3/ DR3: with larger to come



Credit: ESA/ Gaia/ DPAC

Stellar abundances

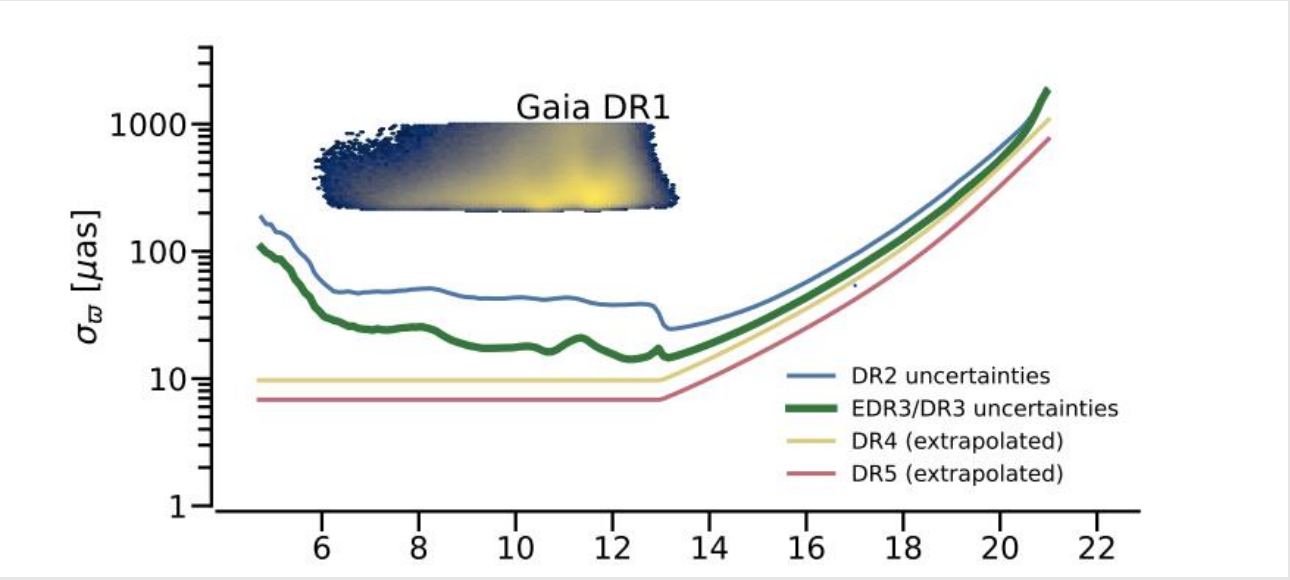


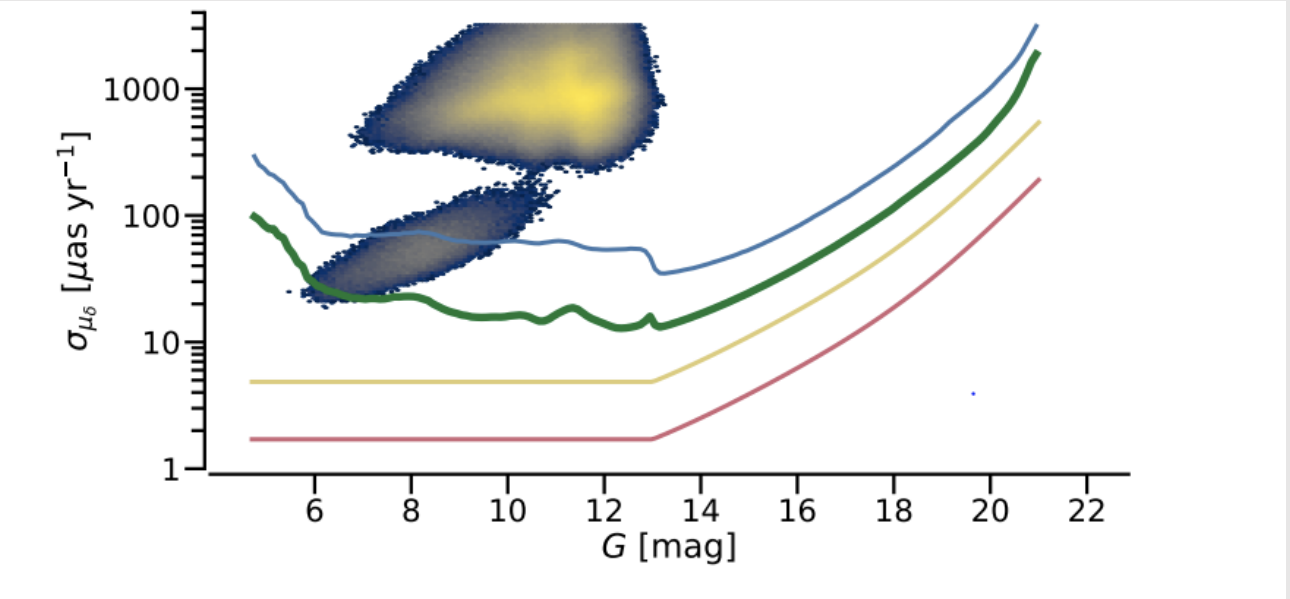
Stellar velocities …

Credit: ESA/ Gaia/ DPAC

Over 2.5 Trillion observations, and counting …

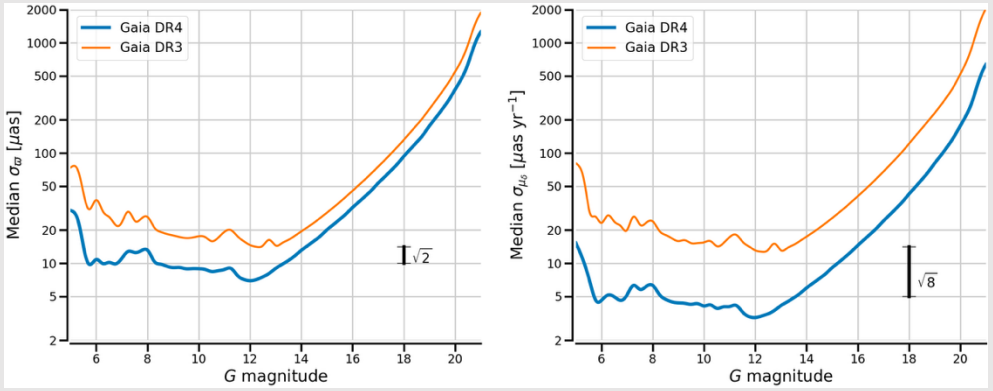
Gaia Performance from DR1 to DR5





Gaia Collab, Vallenari et al (2022)

- Basic mission results improve as $t^{-0.5}$
  - Positions, parallaxes, photometry and radial velocities → factor 1.4 (DR4), 1.9(DR5)
- Proper motion improves as $t^{-1.5}$
  - Rapidly increasing gain in kinematics and dynamics → 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 $t^{-4.5}$



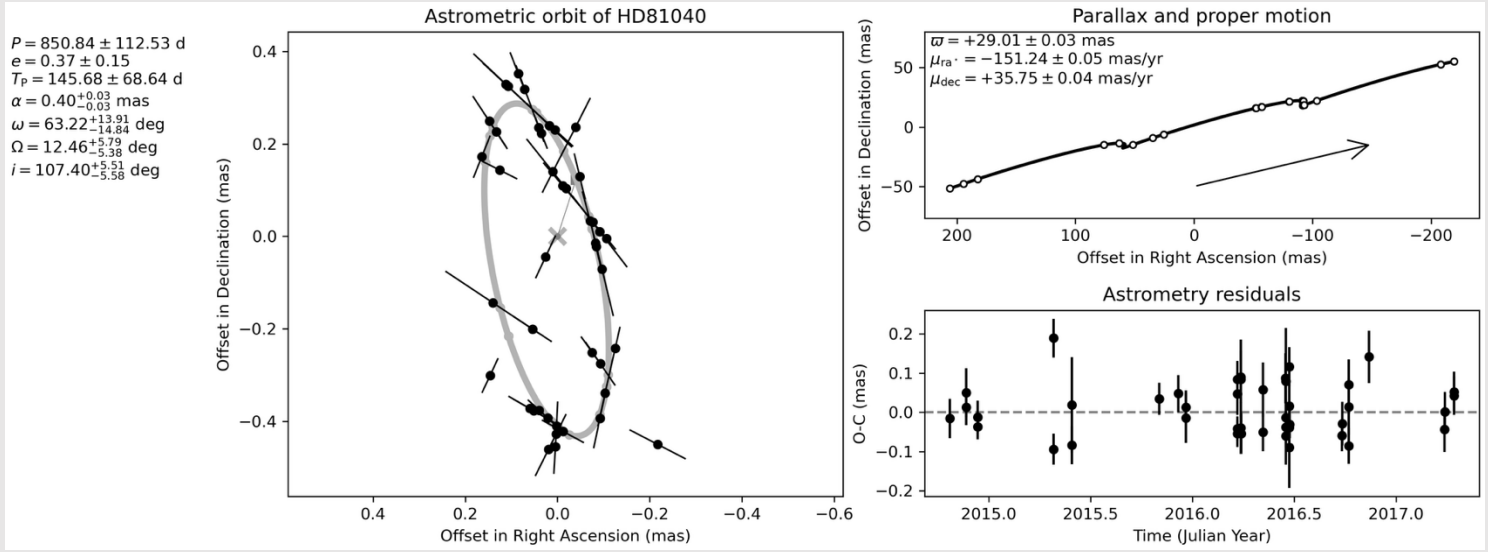
Towards Gaia DR4:

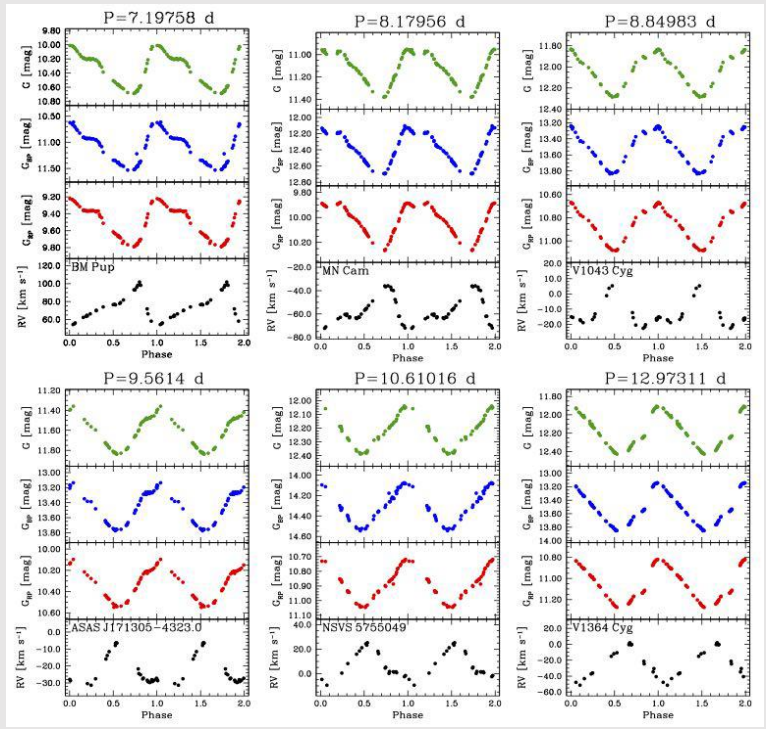
Full discussion of Gaia and Gaia DR4 tomorrow in the Gaia #94 session TLC101 @ 09.00

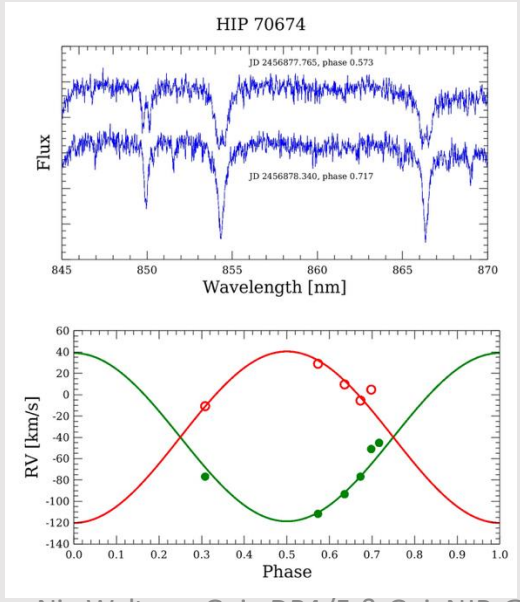
- Gaia in-flight operations completed Jan 2025 (no more cold gas propellant)
  - Nominal mission ended in 2019
  - Post operations phase until the release of Gaia DR5.
- Gaia DR4 : December 2026
- Gaia DR4 is the final release for the nominal mission, 66 months of data
  - Including a 6 months period 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.

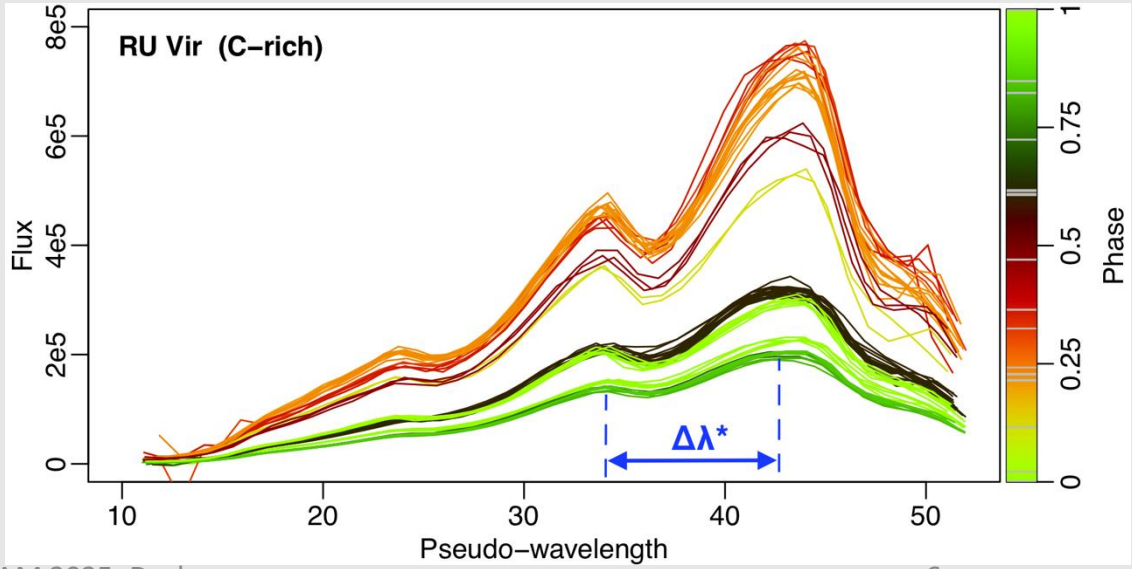
Gaia DR4: Epoch data for 2.5 Billion Sources

- 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

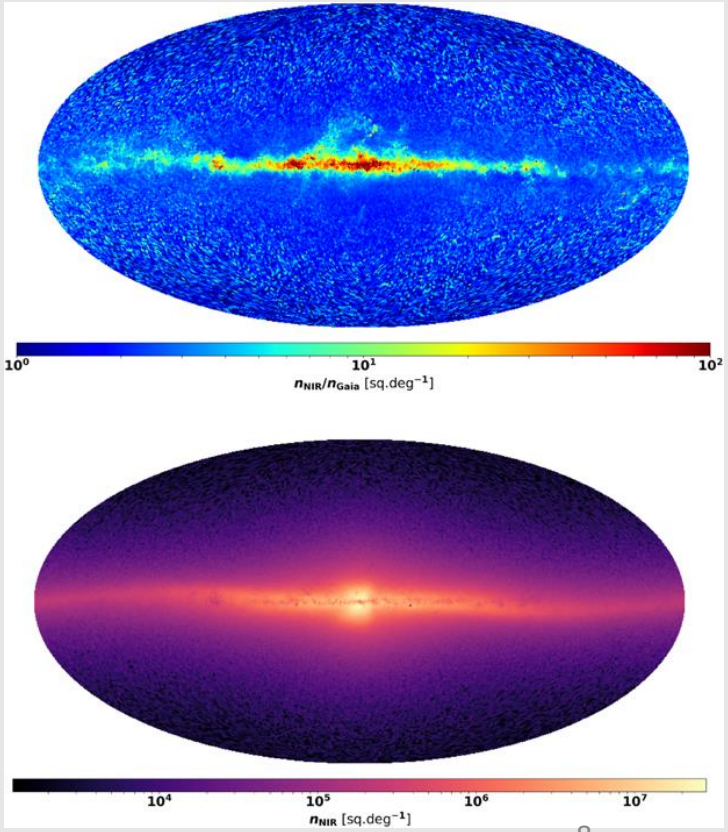
- Gaia DR5 targeted not before the end of 2030
- Final release of the mission 10+ years of data
- Full astrometric, photometric, and radial-velocity catalogues, variable- star and non-single-star solutions, classification, exoplanet list, epoch and transit data, RB/RP and RVS spectra, epoch data
  - 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 WayGaiaNIR & ESA Voyage 2050

See David Hobb's talk earlier in this session

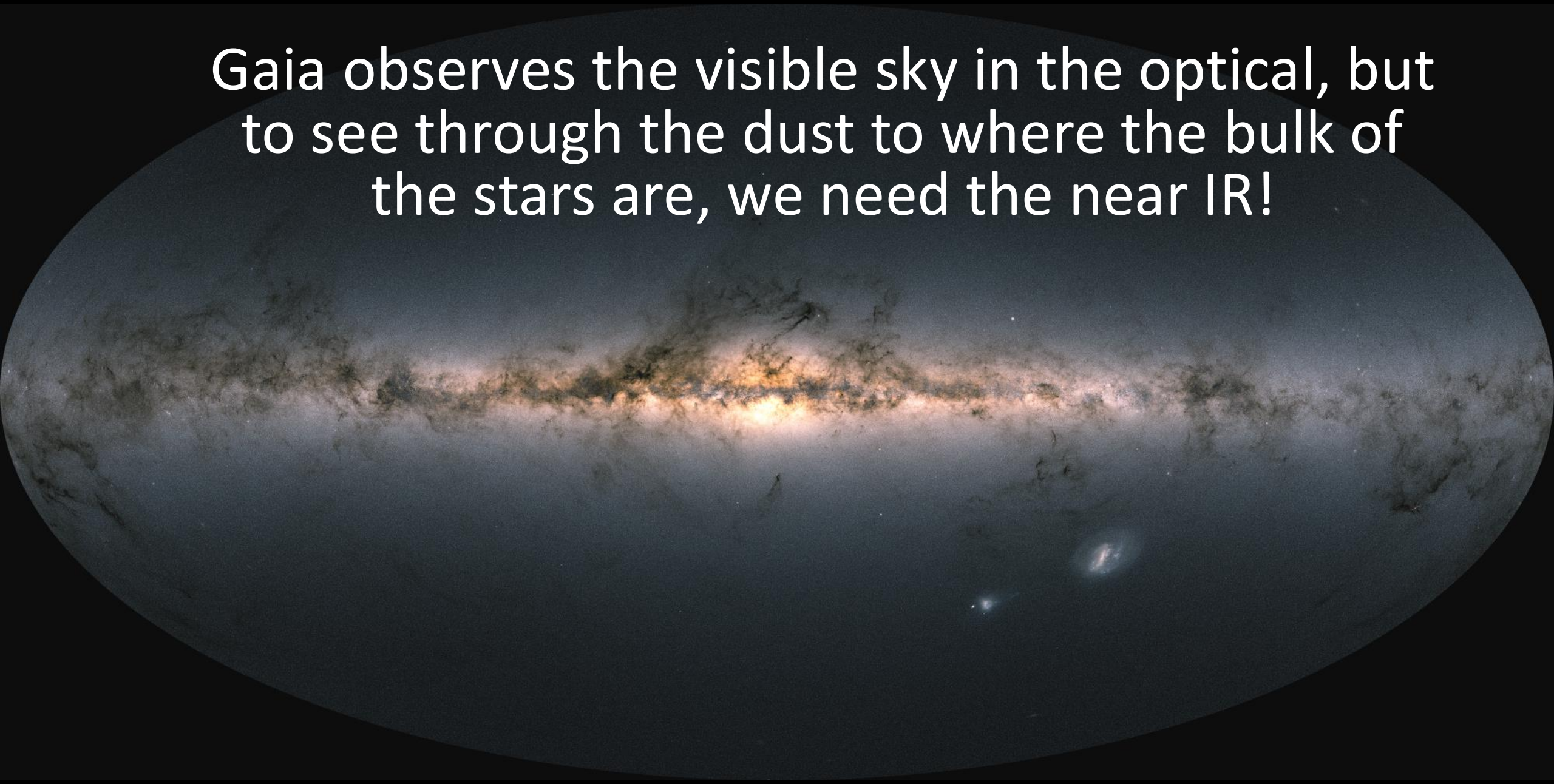
- Gaia like mission extending to the near infrared – probes x20 Gaia sources – implies > **50 Billion** sources
- Three key science goals:
  - Penetrate dust obscured of the Milky Way to reveal the Bulge and Disk to disentangle the formation history of our Galaxy
  - Combine with Gaia data to increase 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



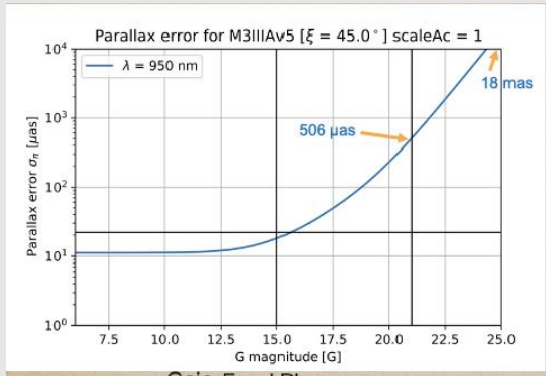
Credit: Hobbs et al 2020

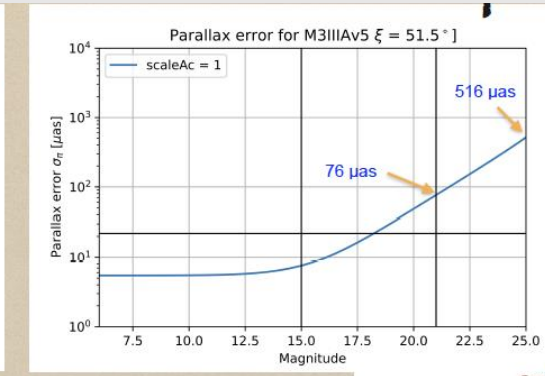
Gaia observes the visible sky in the optical, but to see through the dust to where the bulk of the stars are, we need the near IR!

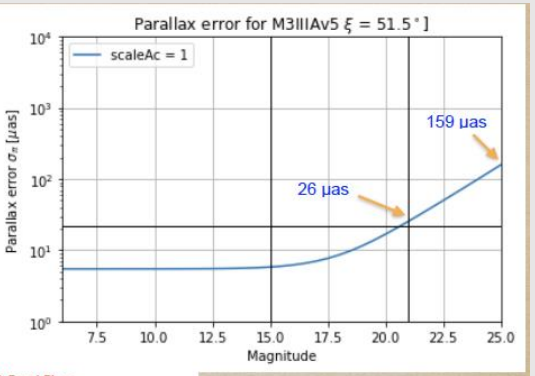


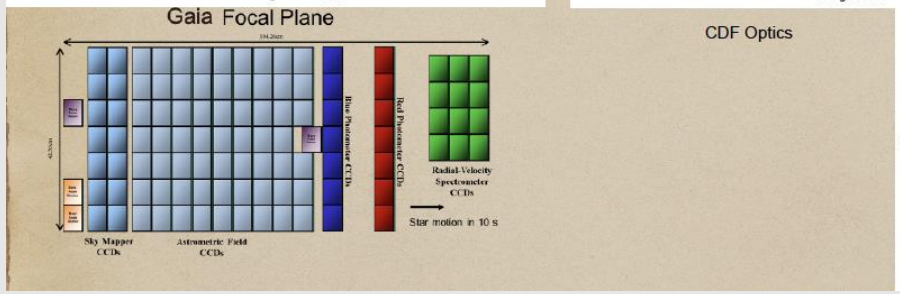
GaiaNIR Detector Studies in the UK

- 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

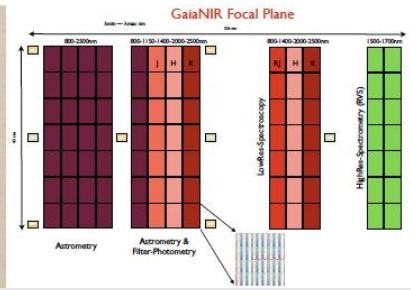








CDF Optics



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.

MW-Gaia: http://www.mw-gaia.org

March 2019 to September 2023

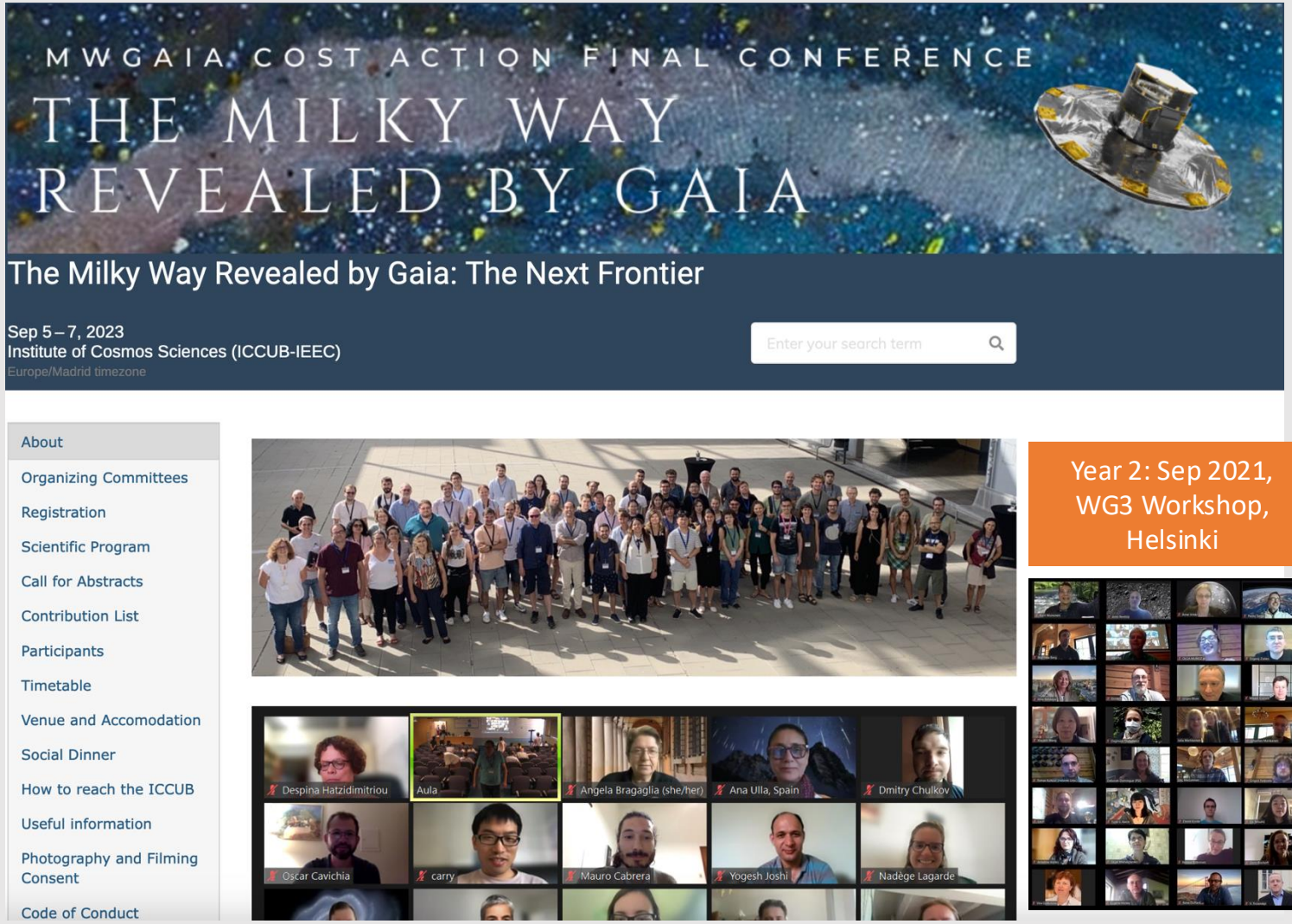
see also COST page at https://www.cost.eu/actions/CA18104/

- 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



Year 2: Sep 2021, WG3 Workshop, Helsinki

17 Workshops (~1000 attendees) over the Action lifetime

4 Schools over the Action lifetime

~50 STSM and ITC grants

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

MWGaia Doctoral Network

https://www.mwgaiadn.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

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	Meeting page
Training programme kick-off workshop	September 7–8 2023	Barcelona	Meeting page

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	Meeting page
The Art of Astrometry and Computation	0.5	June 24–28 2024	Lund	Meeting page
ESR school: Introduction to Astro-statistics and data visualisation	1	September 9–13 2024	Coimbra	Meeting page
PhD School Frontiers of stellar physics	0.5	October 15–17 2024	Padova	Meeting page
Galaxy modelling + galactic centre workshop	1	December 9–13 2024	Guildford	Meeting page
ESR School on transferable skills: managing, entrepreneurial and IPR	1	June 2–6 2025	Barcelona	Meeting page
Roadmap: Technical Challenges workshop	0.5	July 15–16 2025	Cambridge	Meeting page
MWGaiaDN School “Gravitation and astrometry”	0.5	September 8–12 2025	Dresden	Meeting page

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	Meeting page

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 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