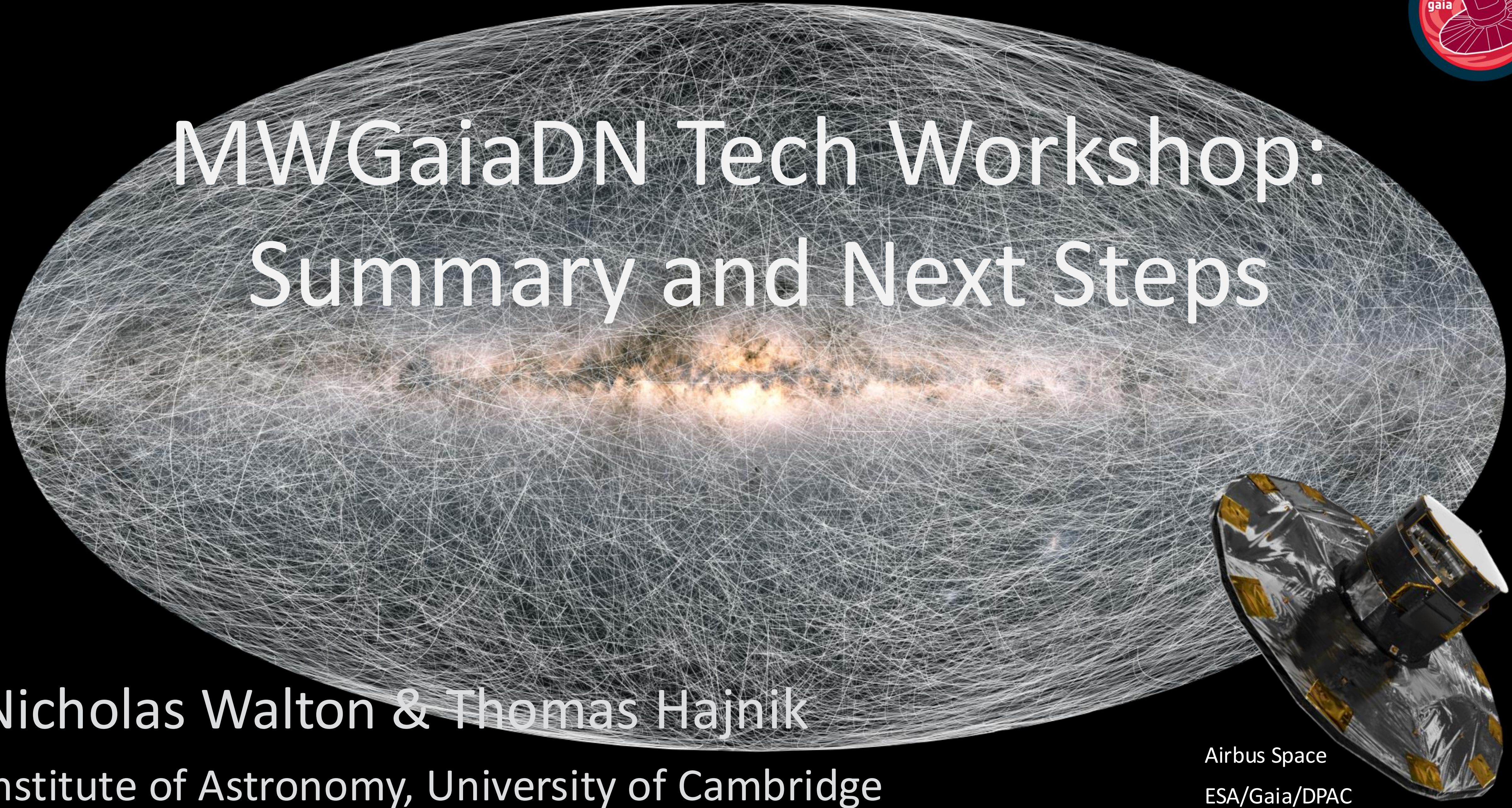
MWGaiaDN Tech Workshop: Summary and Next Steps



Nicholas Walton & Thomas Hajnik

Institute of Astronomy, University of Cambridge

Airbus Space

ESA/Gaia/DPAC

Block 1: MWGaia Doctoral Network: Status and Updates

Anthony Brown

- Network approx. at half-way point in terms of funding
- MWGaiaDN focused on Gaia Science and technical challenges for Gaia NIR
- Projects: MW (Mass-loss rates for RGB stars, kinematics, stell. characterisation, Exoplanet populations, Extinction Maps, L/SMG), extra-gal (Binary SMBH detection, Astrometric Quality of DR3 Quasars), Investigation of rel. effects on high accuracy astrometry

Antonella Vallenari

- Publication/Outreach: Network presented at EAS 2024 & 2025
  - Science talks by multiple PhD candidates within MWGaiaDN

Despina Hatzidimitriou

- Outreach Event planned close to Gaia DR4 release (schools across Europe)

Action: Incorporate GaiaNIR concept in to plans for 'Gaia Map' event planning

Block 2: GaiaNIR: Overview and Status / Other existing and upcoming astrometry missions

David Hobbs

- **Science Case Gaia NIR:**
  - Probe hidden regions. Up to 75% of MW stars could be mapped
  - More precise proper motions by combining with Gaia precison ~ nas/yr
  - Resetting the Gaia optical Reference Frame
  - Low res. Dispersion spectra for most of the stars
  - RV spectrograph for maybe 1 billion objects
  - Exoplanets with periods up to 40 yrs
  - Read-noise key in determining if GaiaNIR can outperform Gaia

Ryouhei Kano

- **JASMINE**:
  - Astrometry in gal. Nuclear region (1 kpc form centre / within 4kpc) --> 10^4 stars
  - Transit obs. Around mid M type stars (aiming for earth-analogues)
  - MDR passed in 2024/07 -> planned launch 2032
  - Building interactions with the European community (Science, Data, Downlink).

Block 2: GaiaNIR: Overview and Status / Other existing and upcoming astrometry missions

Action: Messaging: GaiaNIR gives the map of every component of the MW

Anthony Brown

Gaia's key impacts:

- **High-precision sky atlas**
  - Enables detailed maps, including Kuiper Belt object outlines via occultation.
- **Accessible, vast dataset**
  - Provides the community with easy access to an extensive and rich dataset.
- **Dense astrophysical sampling**
  - Offers detailed CMD and phase space coverage (e.g., WD crystallization, Gaia-Enceladus merger, disc perturbations).
- **Stellar and Galactic insights**
  - Delivers astrophysical parameters for many sources, informing studies of the Milky Way's oldest populations and disc dynamics.
- **Survey calibration and time series**
  - Calibrates past/future surveys with a precise stellar reference frame; DR4 will include time series of astrometry, photometry, and spectra.

Block 3: MWGaiaDN/ Industry Forum and Discussion

Luis Venancio

Gaizka Murga Llano

Joan-Manel Casalta

- **Strong mission requirements**
  - Ensure requirements are valid, clear, consistent, traceable, and realistically achievable.
- **Science–industry collaboration**
  - Establish common requirement definitions and maintain good communication between scientists and industry.
- **Lessons from past missions**
  - Learn from cases like Euclid where insufficient requirements led to issues (e.g., stray light, sunshield x-rays, focal plane size).

Rob Wilson

- **Detector challenges for GaiaNIR**
  - Minimize noise at high NIR gains, balance sensitivity with array size and TDI length, and keep design margins.

Action: Inform/ engage with industry. Aim at TechWS#2 late 2026

- **Plan for evolution and risk**
  - GaiaNIR should not simply copy Gaia; allow for system evolution, mature key elements early, and have backups for high-risk components.

Block 4: Science Requirement Input to Next Generation Astrometry Missions

David Hobbs

- **Major technical challenges**
  - Address crowding, high telemetry loads, detector performance (800–2300 nm), and read-noise constraints.

Action: link with tools being developed in the MWGaiaDN

- **Spectral and RV improvements**
  - Justify low-dispersion spectra, improve resolution, and plan for 1 billion radial velocities with slower scans, wider detectors, and lower noise.
- **Ambition for GaiaNIR**
  - Aim for a large-scale GaiaNIR mission to extend capabilities, especially in near-infrared.

Marie Schölch

- **Mock Catalogues**
  - Will help uncertainty estimates using modelling of 3D extinction, G mag etc., resulting in mock Gaia observations

Alejandro Martín Escabia

- **Advance extinction studies**
  - Use GaiaNIR to probe obscured regions and combine with optical data for more accurate extinction and 3D R(V) maps.

Block 4: Science Requirement Input to Next Generation Astrometry Missions

Action: review how lessons from Gaia might alter how re specifiy key requirements from GaiaNIR (e.g. BAV)

Robin Geyer

Ed Serpell

Lessons from Gaia:

- **Precise spacecraft tracking and synchronization**
  - Ensure accurate determination of spacecraft orbit, velocity, and use of good clocks.
- **Advanced calibration capability**
  - Design systems to support complex calibration procedures and handle technical byproducts from solutions.
- **Prepare for surprises**
  - Maintain flexibility and readiness to address unexpected issues during the mission.
- **Avoid disruptive mode changes**
  - Minimize spacecraft mode switches (e.g., instruments, transmitters) to maintain stability.
- **Design and testing insights**
  - Understand and measure basic angle variations (BAV), isolate the launch adaptor, and account for multi-layer insulation (MLI) rigidity effects.

Block 5: Near-IR astrometry missions: Current and Future technical studies

Action: detector study outputs early 2026 → update GaiaNIR models

Nicholas Walton

- **Detector Tests**
  - Mid-term study review Aug 2025. Currently Leonardo APDs looking very promising

Fabien Malbet

- **Metrology lessons from Theia/HWO**
  - CMOS 46MP Gigapyx viable for high-precision astrometry
  - Lab tests approaching spec; test bench operational
  - Fringes & modulation measured; pixel calibration pending
  - Optical correction ~10^{-2} pixel level, aiming for 10^{-4}
  - GaiaNIR similar process, different detector materials

Block 5: Near-IR astrometry missions: Current and Future technical studies

- **RV's for GaiaNIR:**

Action: define RV window(s) and abundances/ based on updated requirements → WG activity

Szabolcs Mészáros

  - Synthetic tests: 20,000 spectra with random Teff, log g, [M/H], vrad, SNR
  - Optimal wavelength: 1910–2010 nm (strong Fe, Ca lines across parameter space)
  - Backup options: 1430–1530 nm; other candidates between 1200–1600 nm
  - Further analysis: 1 nm step, finer spectral sampling from 1200–2100 nm
  - Additional potential: evaluate Teff, log g, [M/H], abundances in optimal range
- **Deutsches Zentrum für Astrophysik**

Martin Roth

  - Large new lab for detector development
  - Provide significant know-how for next generation ground/space based telescopes

Block 6: Roadmap for Next Generation Astrometry

Action: preparation for early proposal for mission selection

- **Voyage 2050 timeline**

  Nic Walton

  - L4 mission/concept CDF likely 2026 -> launch 2043
  - L5 science & mission development to commence 2027
    -> mission selection 2028/2029
  - We need to ramp up communication efforts!
- **Building the GaiaNIR community** (www.gaianir.org)

  David Hobbs

  - GaiaNIR working groups need to be established/enlarged
  - Consortium needs to be in place next year
  - Co-I's must actively engage with the funding agencies and SPC representatives
  - Codebase needs to be accessible and allow for development flexibility as well as adhering to ESA standards (learn from Vera Rubin etc.)
  - Bluesky handle secured (gaianir.bsky.social) for the cost of one beer, thanks to Paul!

Action: website and communications campaign from q4/25

Next Steps

- Workshop brief report with list of actions
- Thanks to all for their input and contributions!