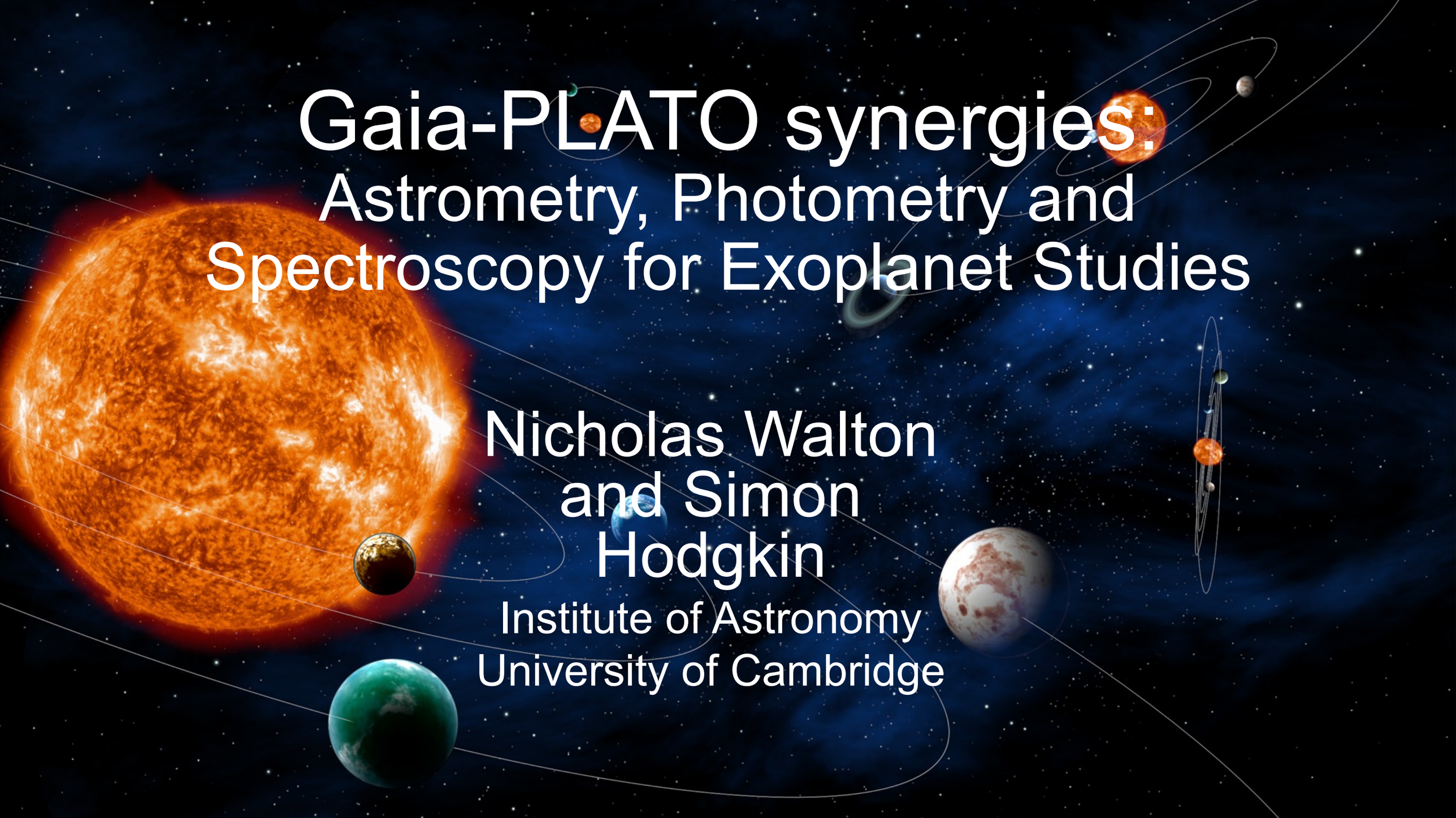

Gaia-PLATO synergies:
Astrometry, Photometry and Spectroscopy for Exoplanet Studies

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Gaia – PLATO
characterising exo-planets systems

- **Gaia** released its first all sky data (**Gaia DR1**) Sep 2016
- The first all sky astrometric catalogues (**Gaia DR2**) April 2018
- Major new astrometric release (**Gaia EDR3**) Dec 2020
- Astrophysical parameters release (**Gaia DR3**) June 2022
- **PLATO** begins its exoplanet hunt end **2026**
- **Gaia** releases large release of new exoplanets (**Gaia DR4**) (not before end **2025**)
- Finding and characterising extra solar planets requires a detailed knowledge of the host stars
  - And it helps to know your target stars before you observe them
  - Gaia both finds exoplanets and characterises host stars

PLATO (ESA M3)

http://sci.esa.int/plato

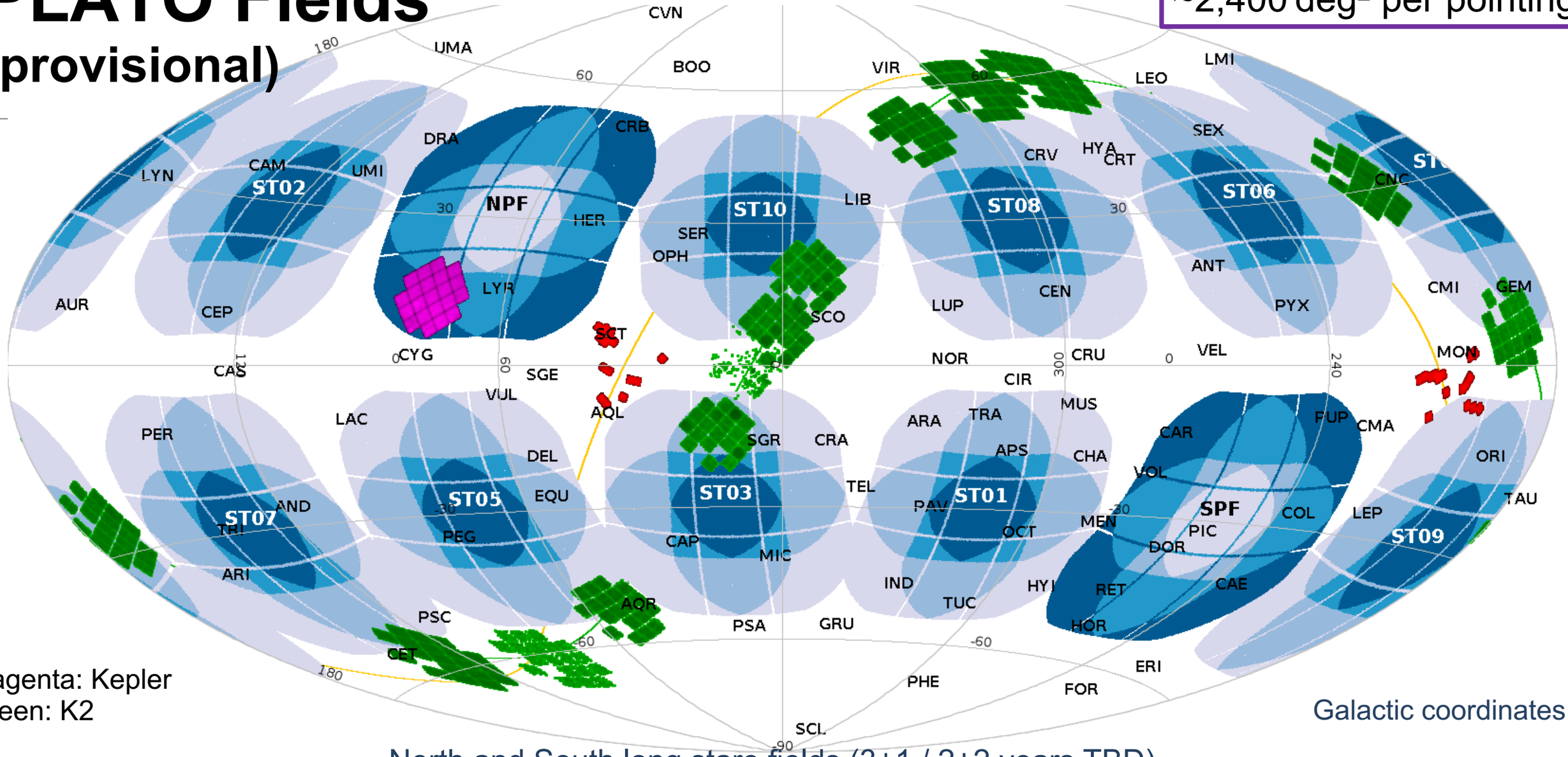
key facts at https://sci.esa.int/web/plato/-/42276-summary

Launch 2026.
4 to 8 years
operations plus
post operations

PLATO Fields (provisional)

WEAVE can observe northern fields

~2,400 deg^2 per pointing



Magenta: Kepler
Green: K2

Galactic coordinates.

North and South long stare fields (3+1 / 2+2 years TBD)
Step and Stare fields (~few months each) (TBD)

PLATO Samples

long pointings	step & stare	mag	Noise in central field	spectral type
P1: 20 000 stars	P1: 66000 stars	V<11	34 ppm	F5/K7
P2: 1 000 stars	P3: 3 000 stars	V<8	34 ppm	F5/K7
P4: 5 000 stars V<16	5000 stars V<15	V<15 V<16	800 ppm	M
P5*: 245 000 stars	P1: 881000 stars	V<13		F5/K7

No requirements; adding these leads to ~1,000,000 lightcurves total

P1+P2+P3: Exoplanet characterization and asteroseismology

P4: M dwarf host star sample

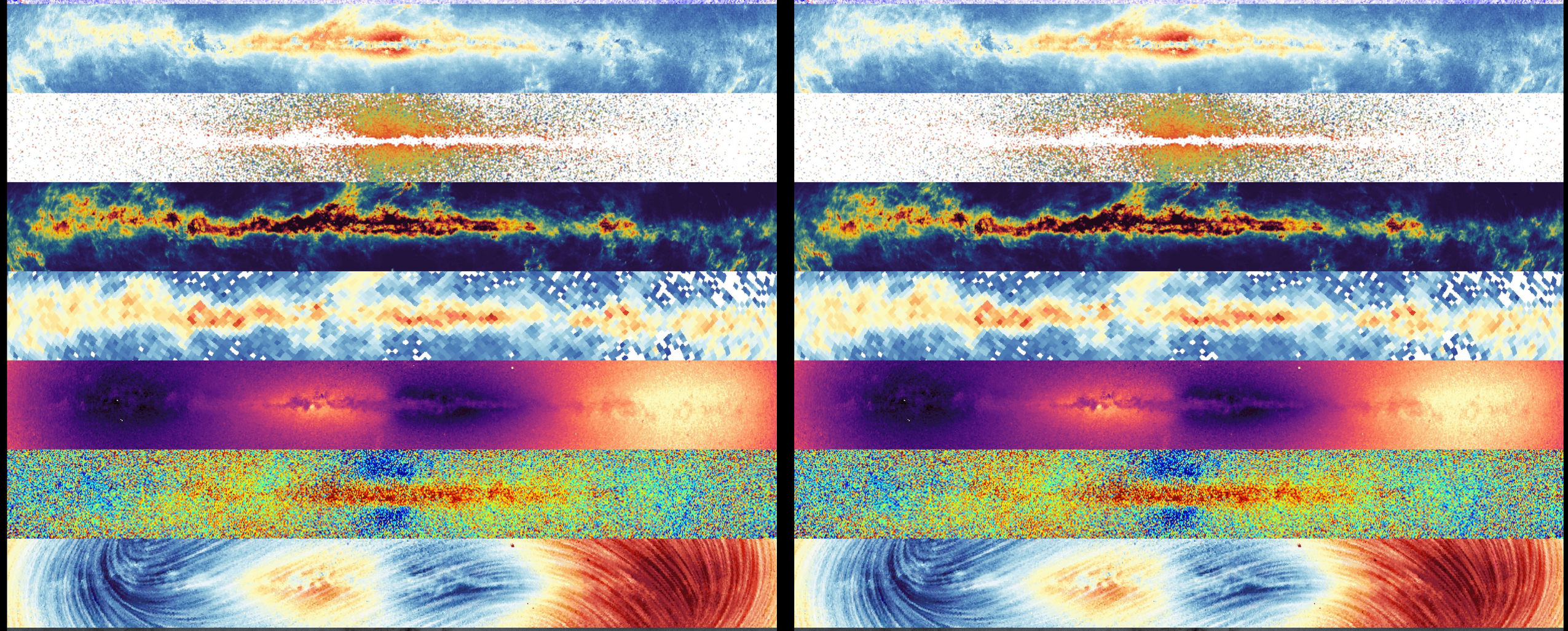
P5: Exoplanet statistics and stellar science

Exact sample sizes TBD

★ P5 for long and step/stare phases:
~ 1 Million light curves at <13 mag

Gaia DR3:

https://www.cosmos.esa.int/web/gaia/dr3



The Gaia DR3 Sky

Credit: ESA/Gaia/DPAC

Gaia as a PLATO helper

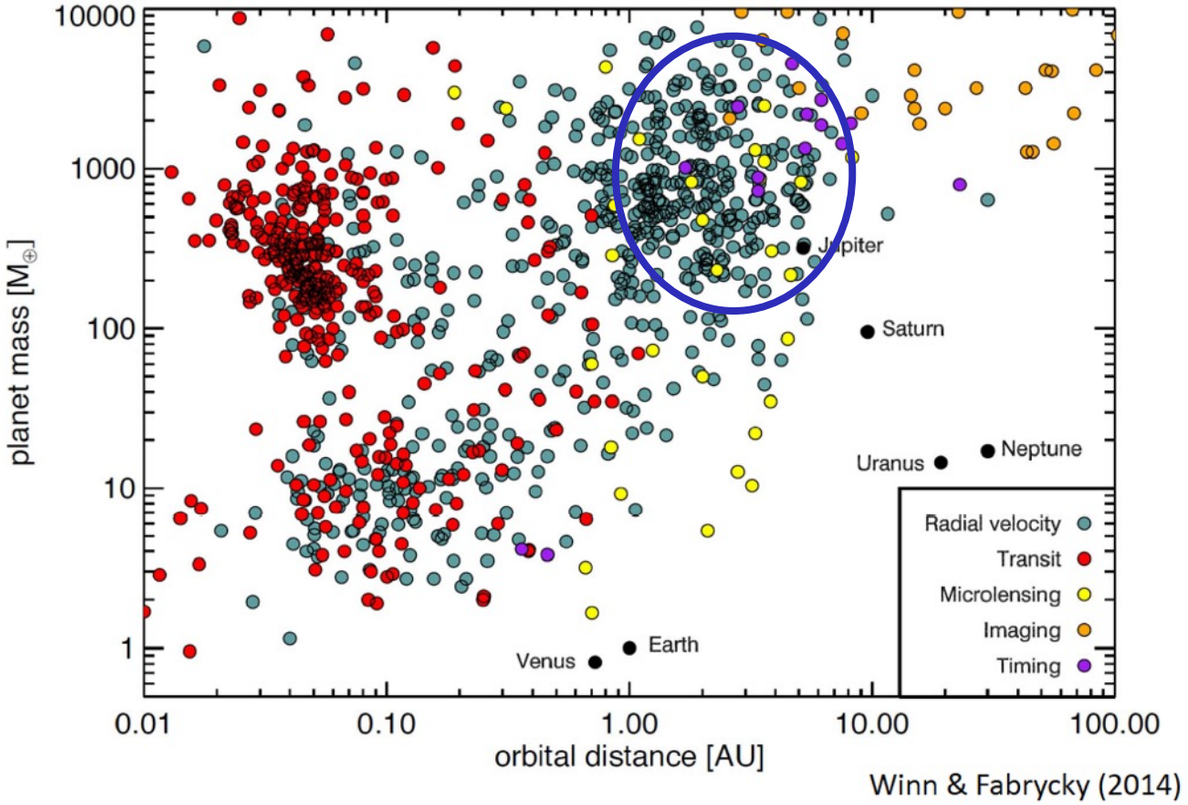
- Gaia provides detailed properties for all PLATO host stars (distances, T_{eff}, radius, log g, [Fe/H], A_v, etc)
- Gaia enables the selection of PLATO target stars – ability to type all input stars (e.g. select dwarfs, careful selection of activity type)
- Gaia astrometry will allow for detection of more massive planets in PLATO target systems
- Gaia will allow characterisation of the PLATO target fields – also at the pixel level (one PLATO pixel = over 20,000 Gaia pixels!!)

(most) Gaia data required by PIC will be public in advance of PLATO launch

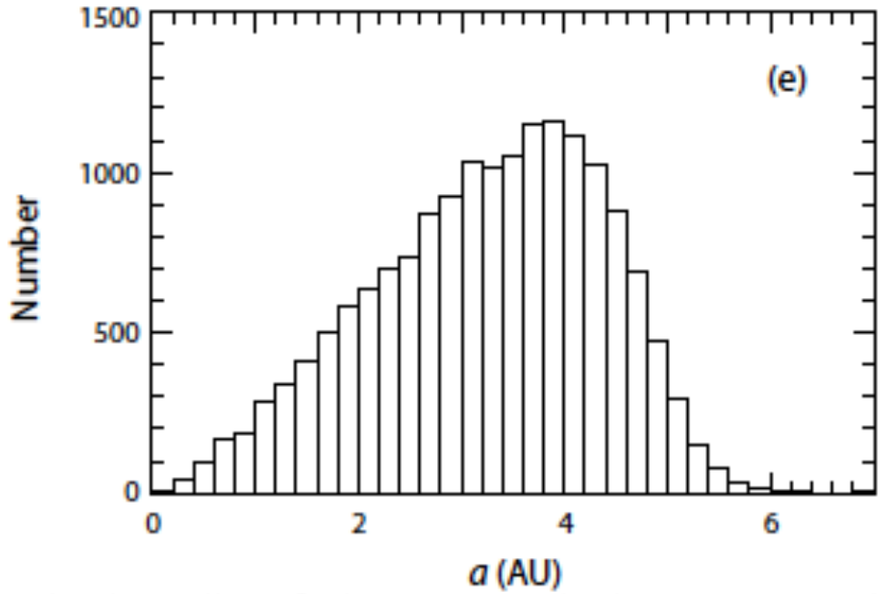
Gaia as a Planet Finder

GAIA Astrometric Planets:

typical discovery space indicated



Perryman et al, 2014, Sozzetti et al 2014
Circumbinary planets: Sahlmann et al 2015



For the baseline Gaia 5 year mission expect >20,000 high mass 1-15 M_J planets out to distances of 500 pc (1000+ planets in M dwarfs to ~100pc)

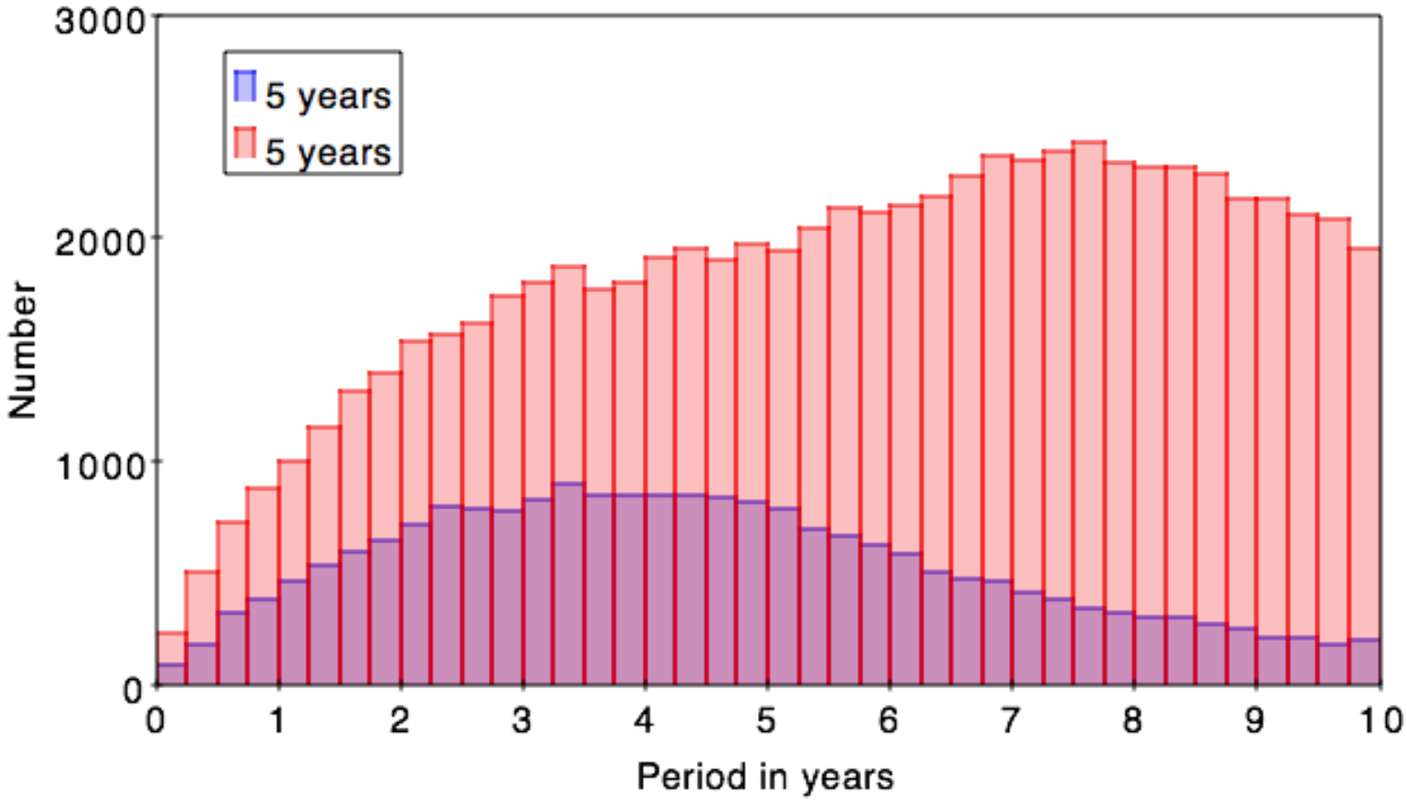
Gaia will also find 100's of close in hot Jupiters via transits (Dzigan & Zucker 2012)

Gaia Mission Extension: Exoplanet

nominal mission 7/2014 to 6/2019 | extension 7/2019 to ~H1/ 2025

- Gaia's strength is Neptune-Jupiter mass planets around stars
- Mission extension reveals population of giant planets above several AU distances from the parent star
  - giant planets before migration, systems with giant planets 'guarding' habitable zone
- Basic mission results scale as $t^{-0.5}$
  - Proper motions scale as $t^{-1.5}$
  - High order orbital motions scale as $t^{-4.5}$

Calculations: Lindegren (priv comm, based on Perryman et al, 2014)



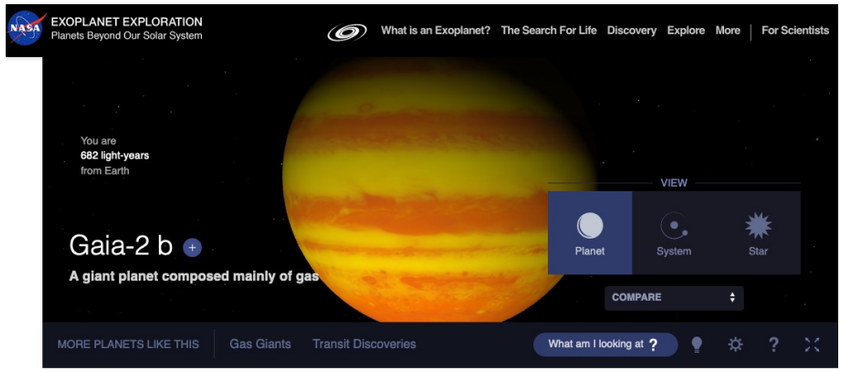
Gaia Exoplanets from Gaia DR3

- Gaia (Candidate) Exoplanet List published with Gaia DR3
  - https://www.cosmos.esa.int/web/gaia/exoplanets
- Gaia DPAC detections via three methods (# as of DR3)
  - Astrometrically, by observing the wobble of the host star's position on the sky caused by the exoplanet: Gaia-ASOI-# (73 candidates)
  - Photometrically, by observing the photometric transit of the exoplanet in front of its host star: Gaia-TROI-# (214 candidates)
  - Spectroscopically, by observing the variation in the radial velocity of the host star caused by the exoplanet: Gaia-RVOI-# (10 candidates)
- Gaia confirmed exoplanets: Gaia-#-b etc (Gaia 1-b Panahi et al, 2022)
- Gaia also supports direct imaging discoveries
  - e.g. HD 206893c identified from Gaia astrometry and then VLTI/ Gravity imaging (Hinckley et al, 2023)

Gaia exoplanet candidate confirmations

Gaia-2 b

Transit detection



Gaia-2 b is a gas giant exoplanet that orbits a G-type star. Its mass is 0.817 Jupiters, it takes 3.7 days to complete one orbit of its star, and is 0.0467 AU from its star. Its discovery was announced in 2022.

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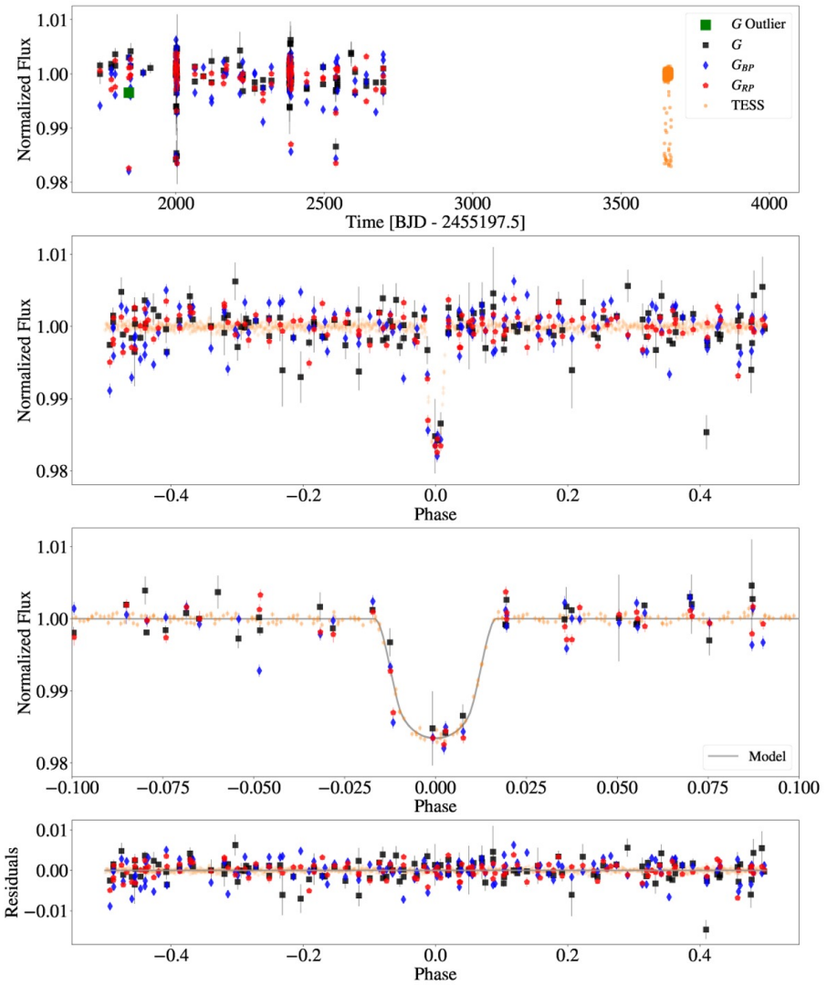
PLANET TYPE Gas Giant	DISCOVERY DATE 2022
MASS 0.817 Jupiters	PLANET RADIUS 1.322 x Jupiter
ORBITAL RADIUS 0.0467 AU	ORBITAL PERIOD 3.7 days
ECCENTRICITY 0.0	DETECTION METHOD Transit



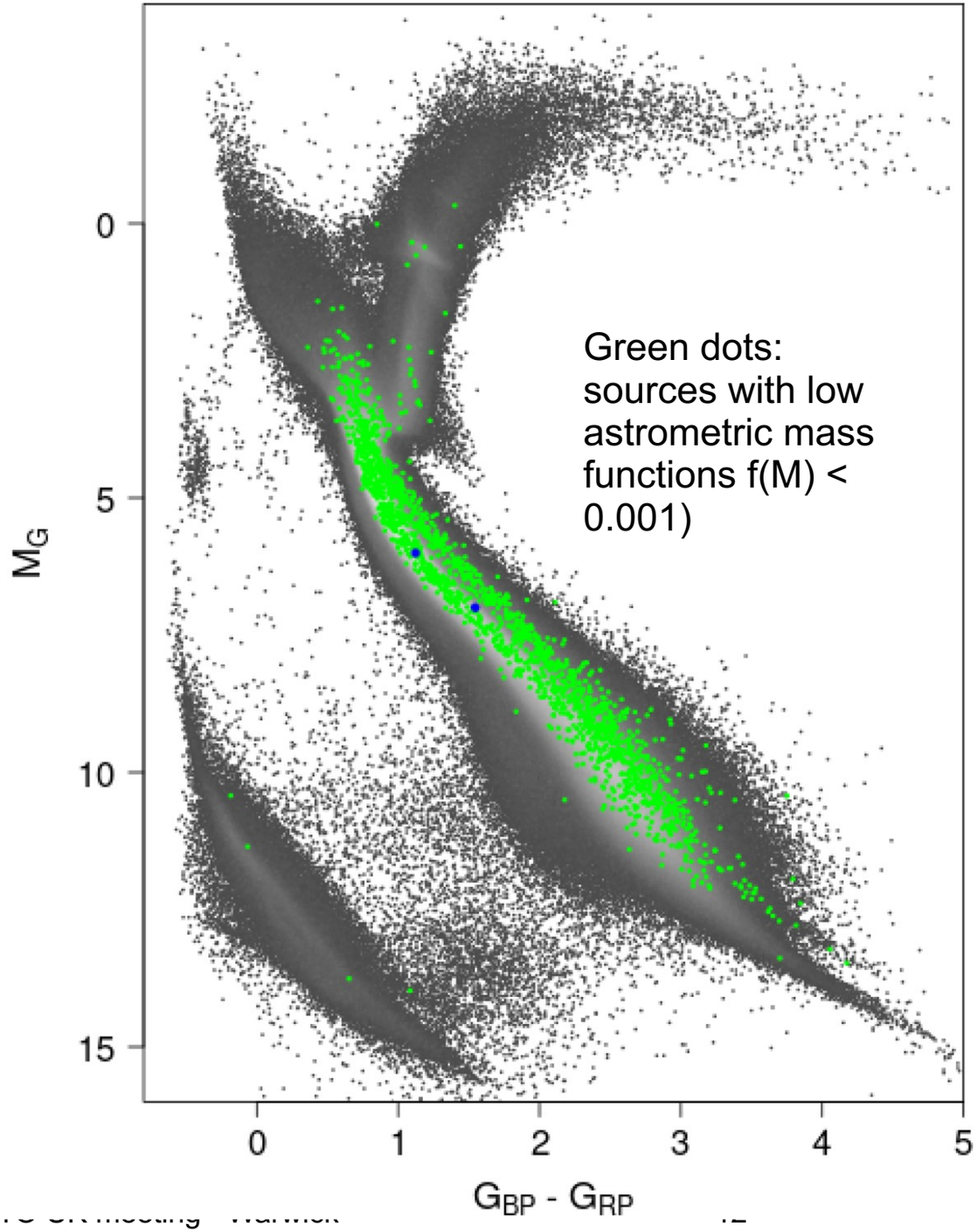
Panahi et al, 2022

Gaia exoplanet candidate non-confirmations

Astrometric detection method described in Gaia Collaboration, Arenou et al, 2023, A&A 674, A34

- many of the sources with low astrometric mass functions are not stars with low mass companions, rather binaries (M1 ~ M2 **and** F1 ~ F2)

- Marcussen & Albrecht 2023 analysed 6 of the Gaia astrometric candidates: 4 of these were false positives with F1 ~ F2.
  - High res spectra required to flag EB false positives.



Gaia DR4

Gaia DR4 (based on 66 months of data) not before the end of 2025

- 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.
- All epoch and transit data for all sources.
- **An exo-planet list.**

GaiaDR4 will provide 1,000's of long period massive planets and much information concerning the host star environment