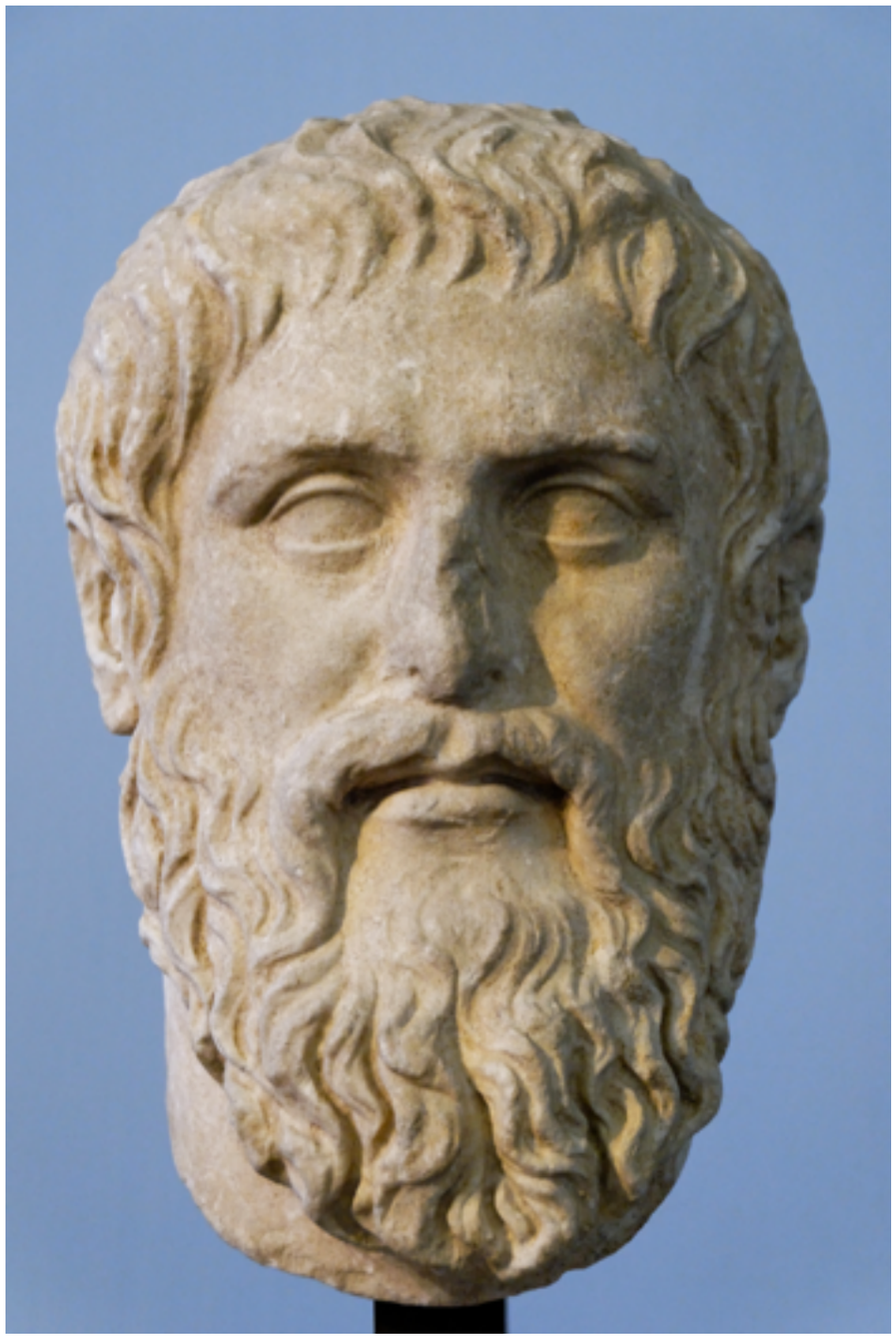
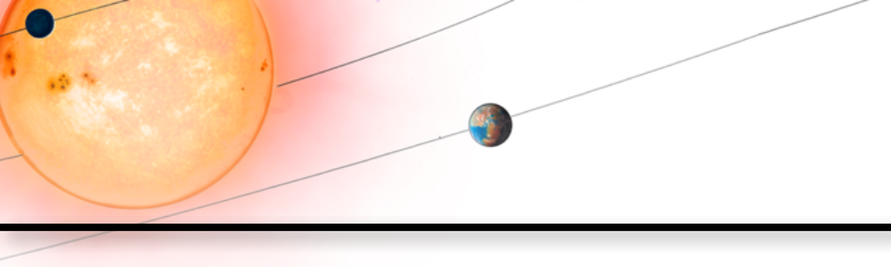

# Current Status and UK Contributions

David Brown
(@DBrown_astro)

# PLAnetary Transits and Oscillations of stars





# What is PLATO?

## PLAnetary Transits and Oscillations of stars

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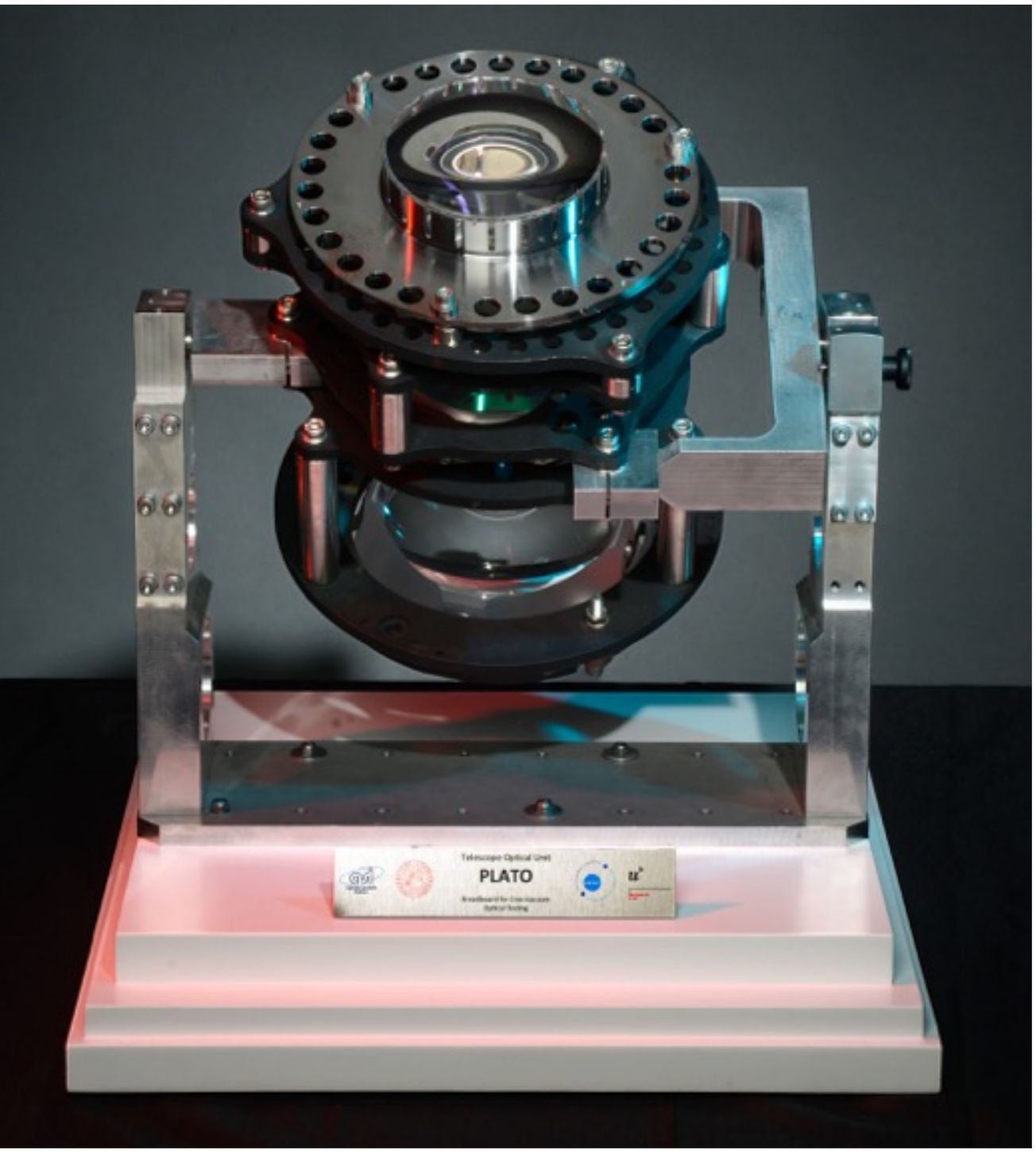
# PLAnetary Transits and Oscillations of stars

- ESA's M3 mission
  - ➡ Due to launch Q4 2026
  - ➡ Positioned at L2

- "The habitable zone explorer"
  - ➡ Will search for Earth-sized planets
  - ➡ Around Sun-like stars
  - ➡ At orbital distances up to and including the 'habitable zone' of Sun-like stars

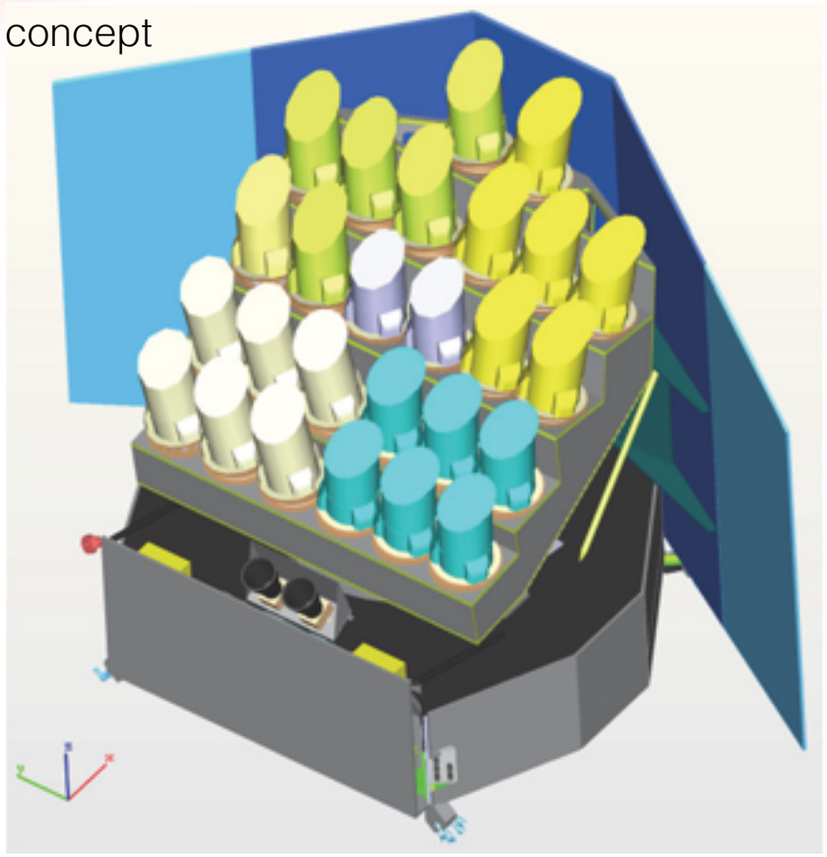
# PLATO satellite

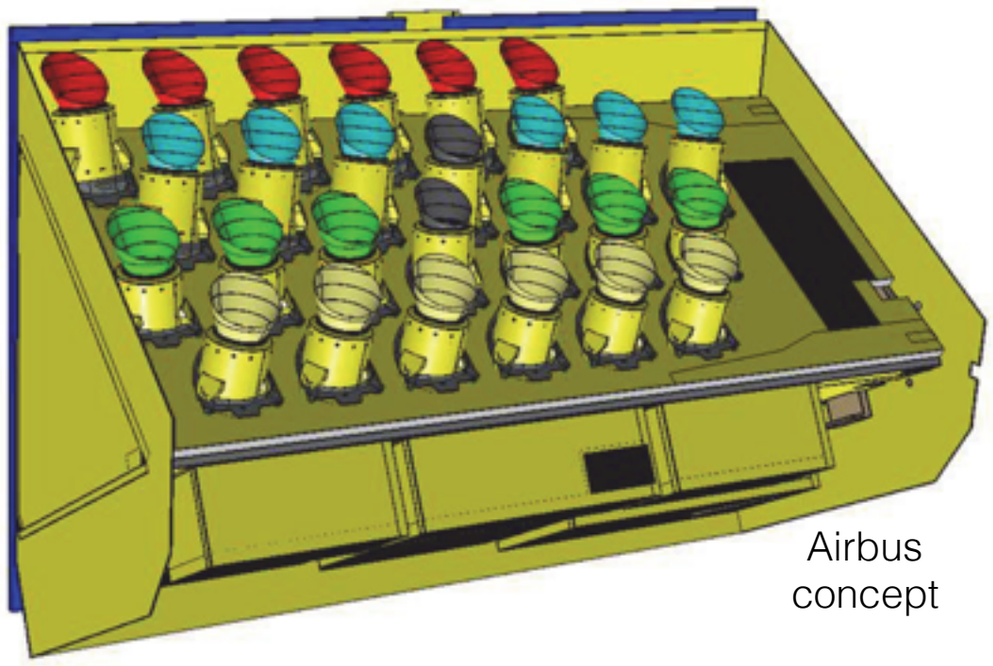



- 24 telescopes
  - ➡ 12cm aperture
  - ➡ 25s cadence
  - ➡ White light (500 - 1000nm)
  - ➡ Four groups of 6
  - ➡ FoV 1037 deg$^2$
  - ➡ Combined FoV 2232 deg$^2$
- 2 additional ‘fast’ telescopes
  - ➡ 2.5s cadence
  - ➡ One ‘red’, one ‘blue’
  - ➡ FoV 619 deg$^2$
- $4 \leq m_V \leq 16$

# PLATO satellite

OHB concept





Airbus concept

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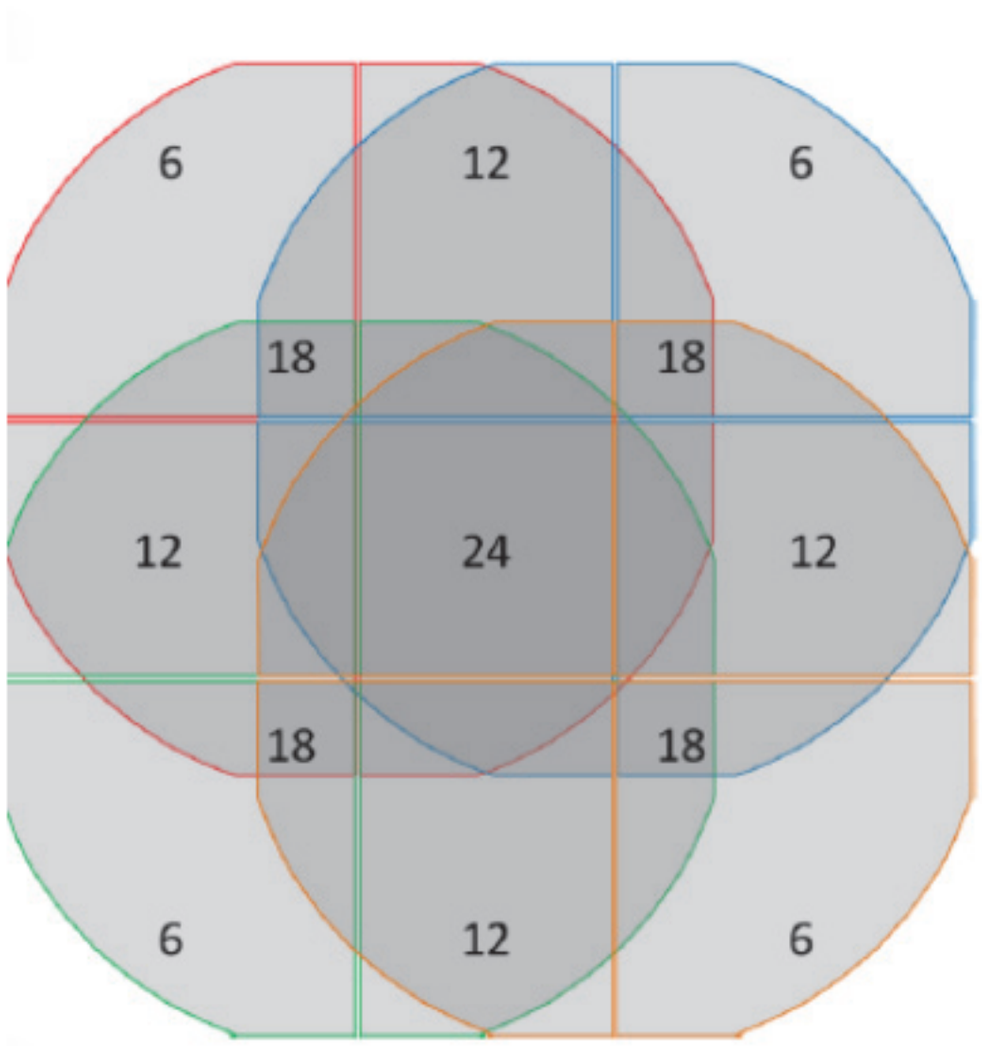


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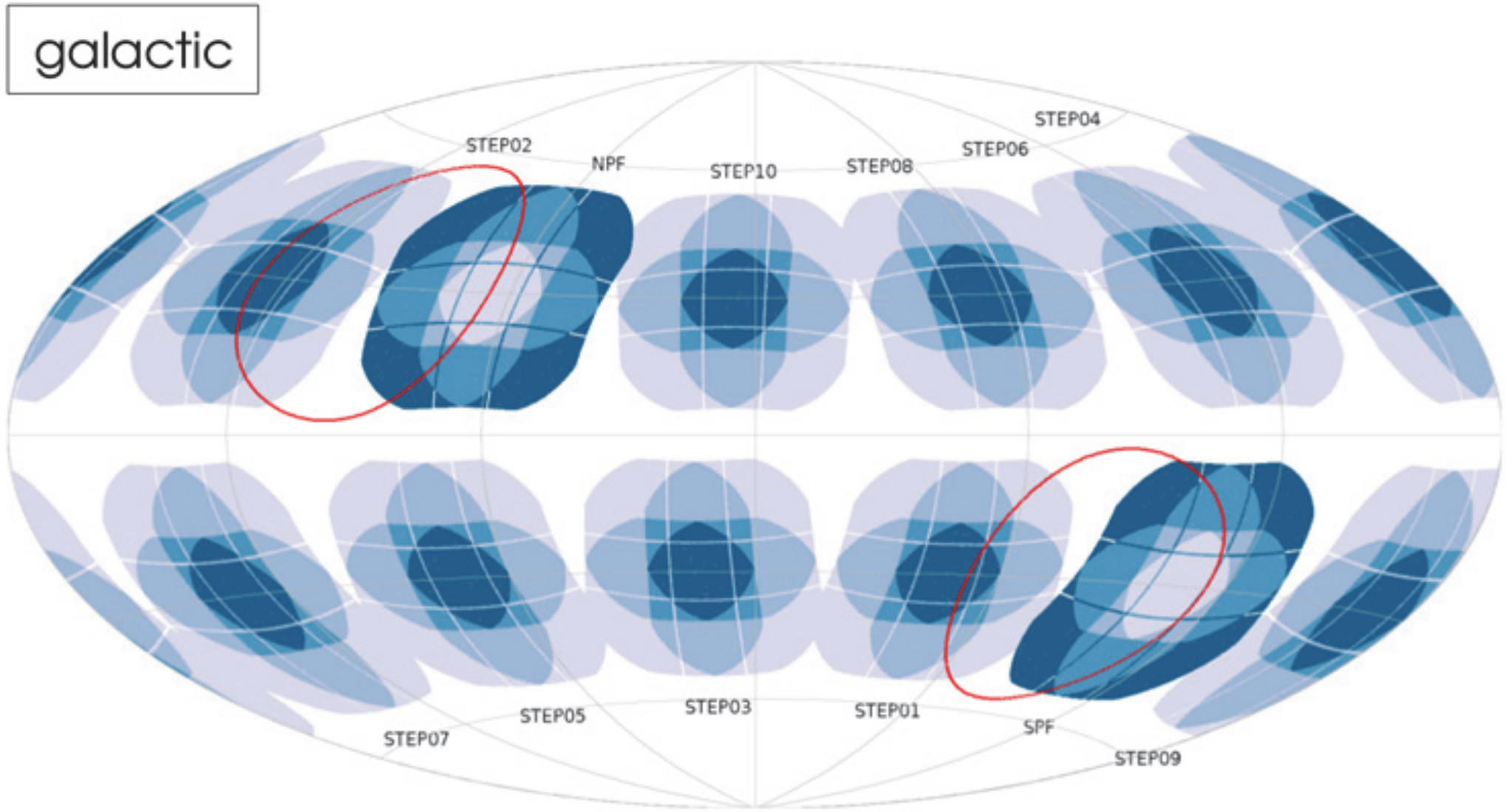
# Observing strategy




- Baseline observing strategy of two, 2-year stares
- Fields constrained to “allowed regions” at ecliptic latitude >63$^{o}$

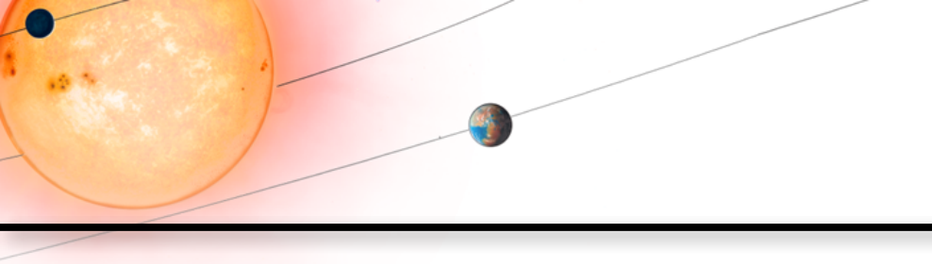
# PLATO targets

- PLATO Input Catalogue (PIC)
  - ➡ Preliminary, internal versions being worked on now
  - ➡ Uses data from Gaia, Hipparcos, UCAC5, Tycho, APASS, Galex, 2MASS, ALLWISE, sdss, *Kepler*, K2, etc.
  - ➡ Contaminant information
  - ➡ Major stellar parameters

- Gaia DR2 will provide a big step forwards

# PLATO targets

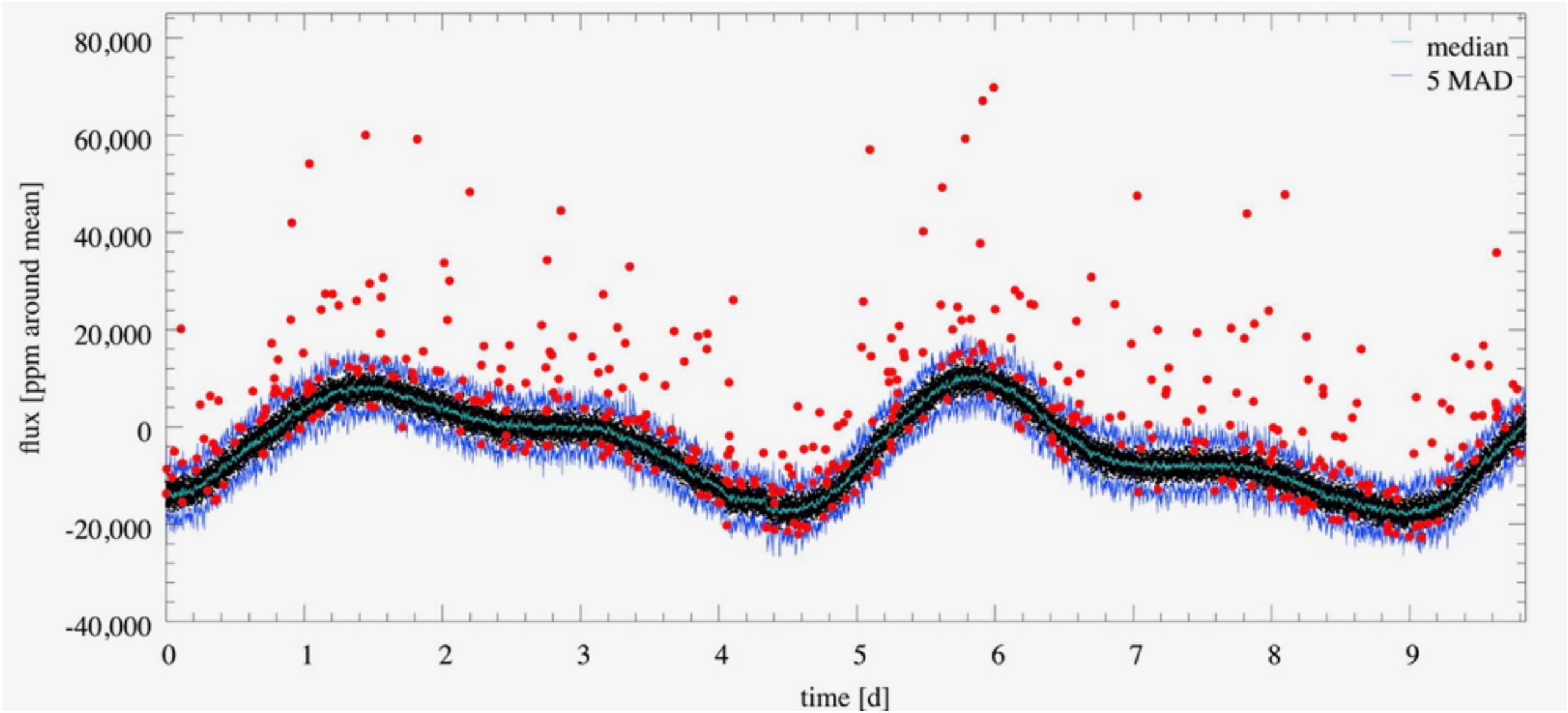
| | Sample 1 | Sample 2 | Sample 4 | Sample 5 |
|---|---|---|---|---|
| No. stars | ≥15,000 | ≥1,000 | ≥5,000 | ≥245,000 |
| Type | Dwarf & sub-giant F5 - K7 | Dwarf & sub-giant F5 - K7 | M-dwarf | Dwarf & sub-giant F5 - K7 |
| V magnitude | ≤11 | ≤8.2 | ≤16 | ≤13 |
| Random noise (ppm in 1hr) | ≤34 | ≤34 | ≤800 | - |
| Wavelength | 500-1000nm | 500-1000nm 300 stars with colour information | 500-1000nm | 500-1000nm |
| *Sampling times (s)* | | | | |
| Lightcurve | - | - | - | ≤600 |
| Centroid curve | - | - | - | ≤50 for 5% of targets |
| Transit oversampling | - | - | - | ≤50 for 10% of targets |
| Imagettes (6x6 postage stamps) | 25 | 2.5 | 25 | 25 for >9000 targets |



# Testing

# Testing

- Onboard processing for sample 5
  - ➡ Photometric masks; centroid & lightcurve calculation; outlier detection; time averaging; PSF inversion



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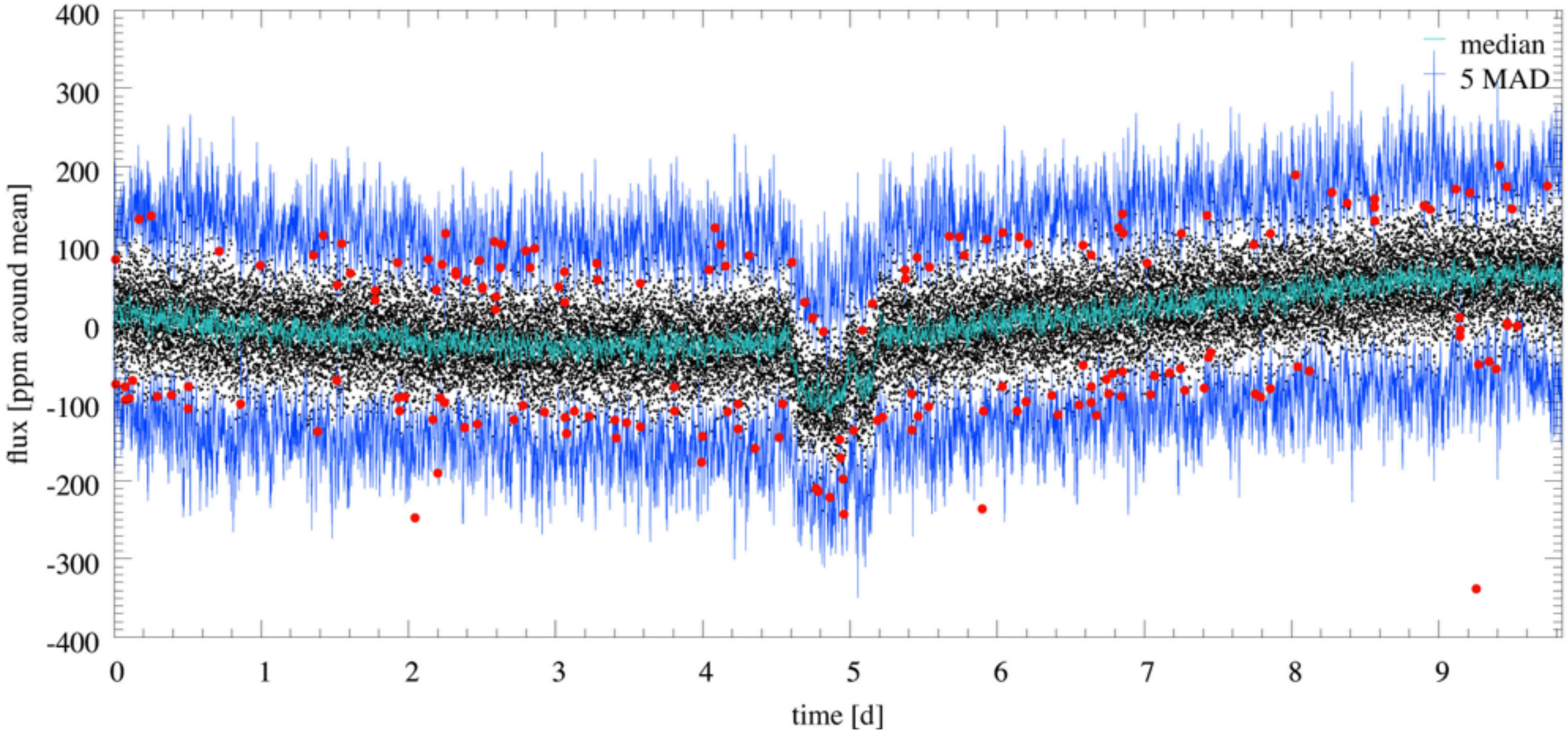

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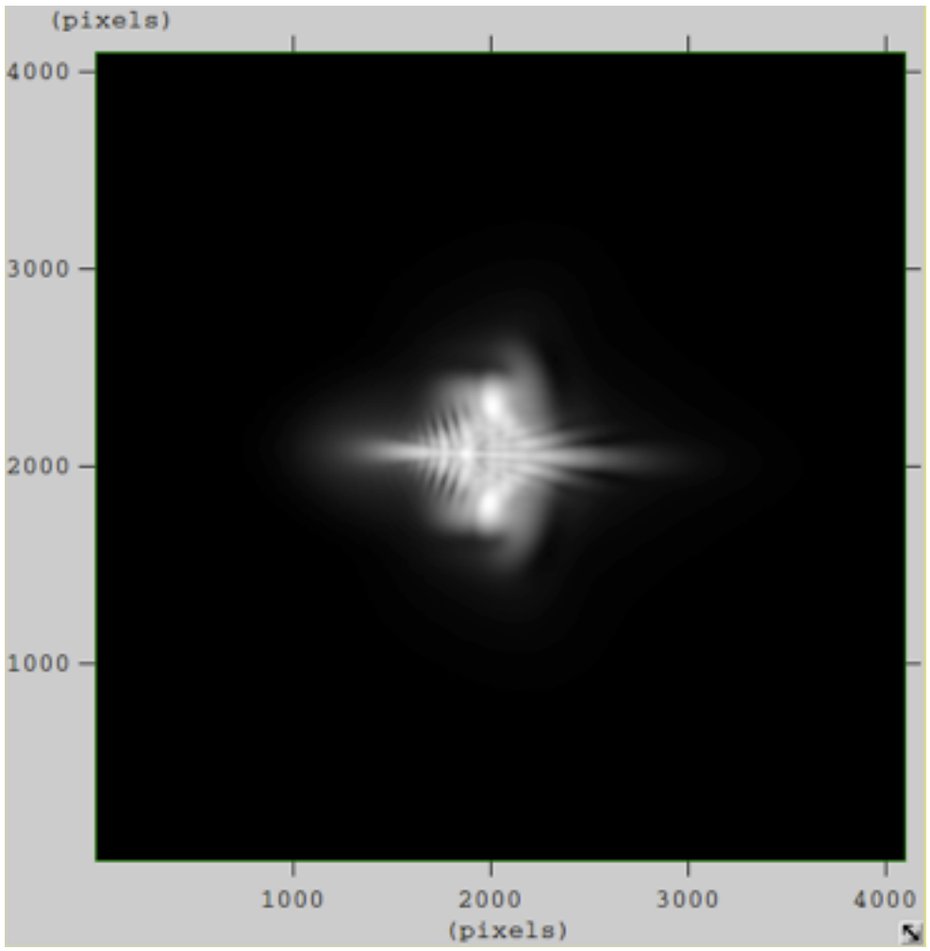
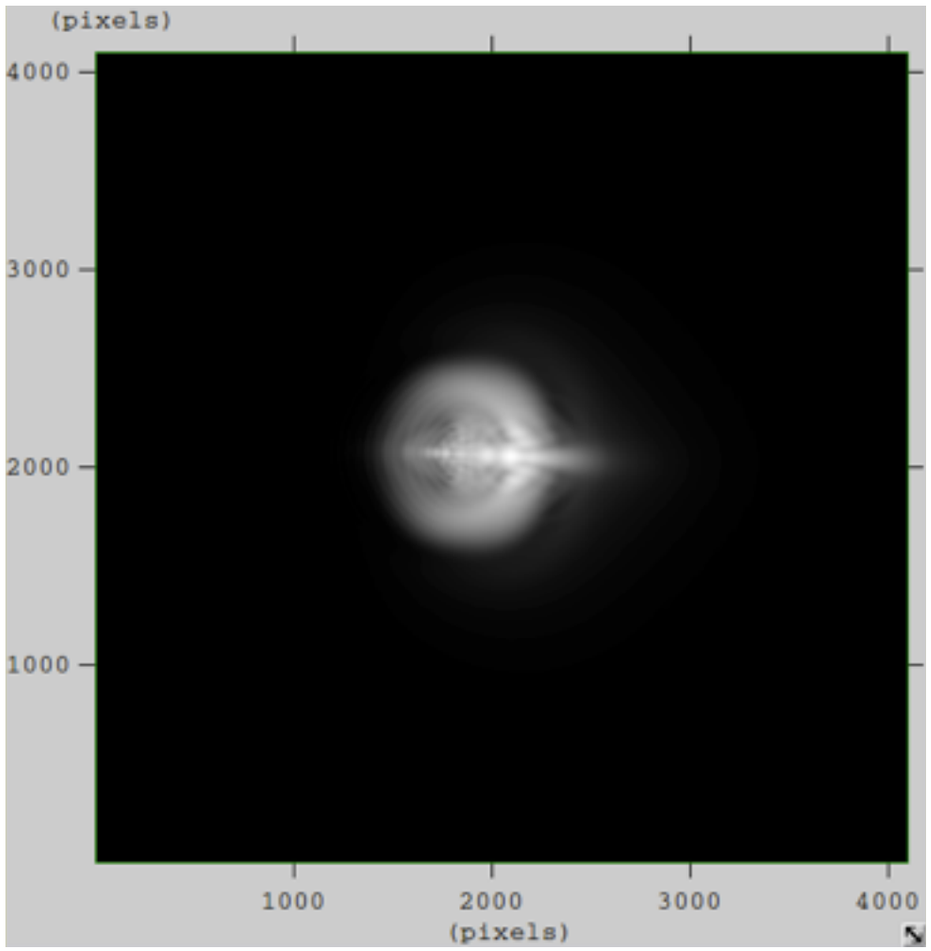
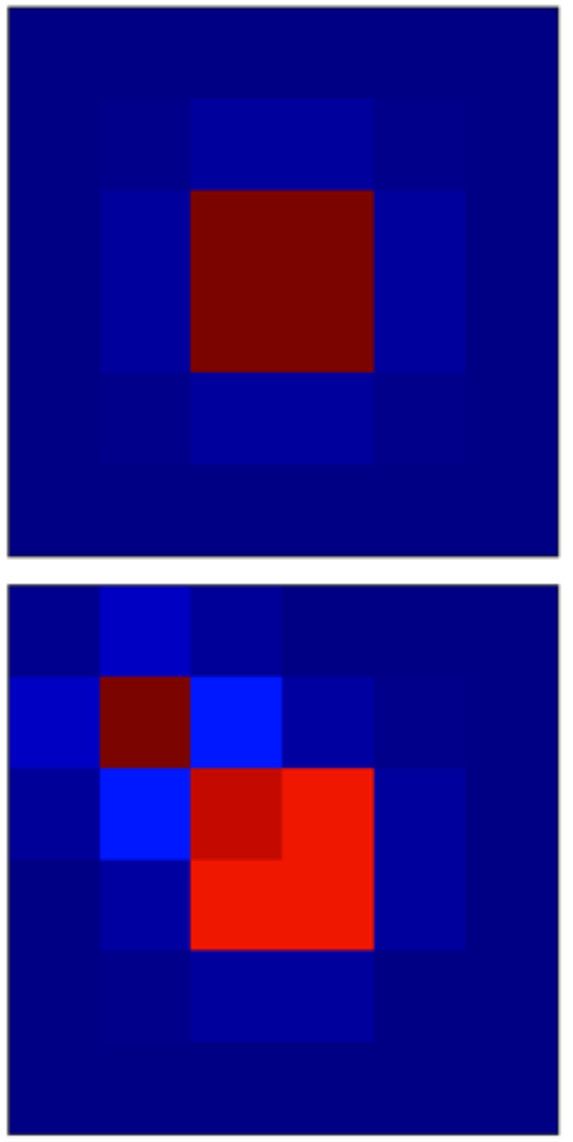


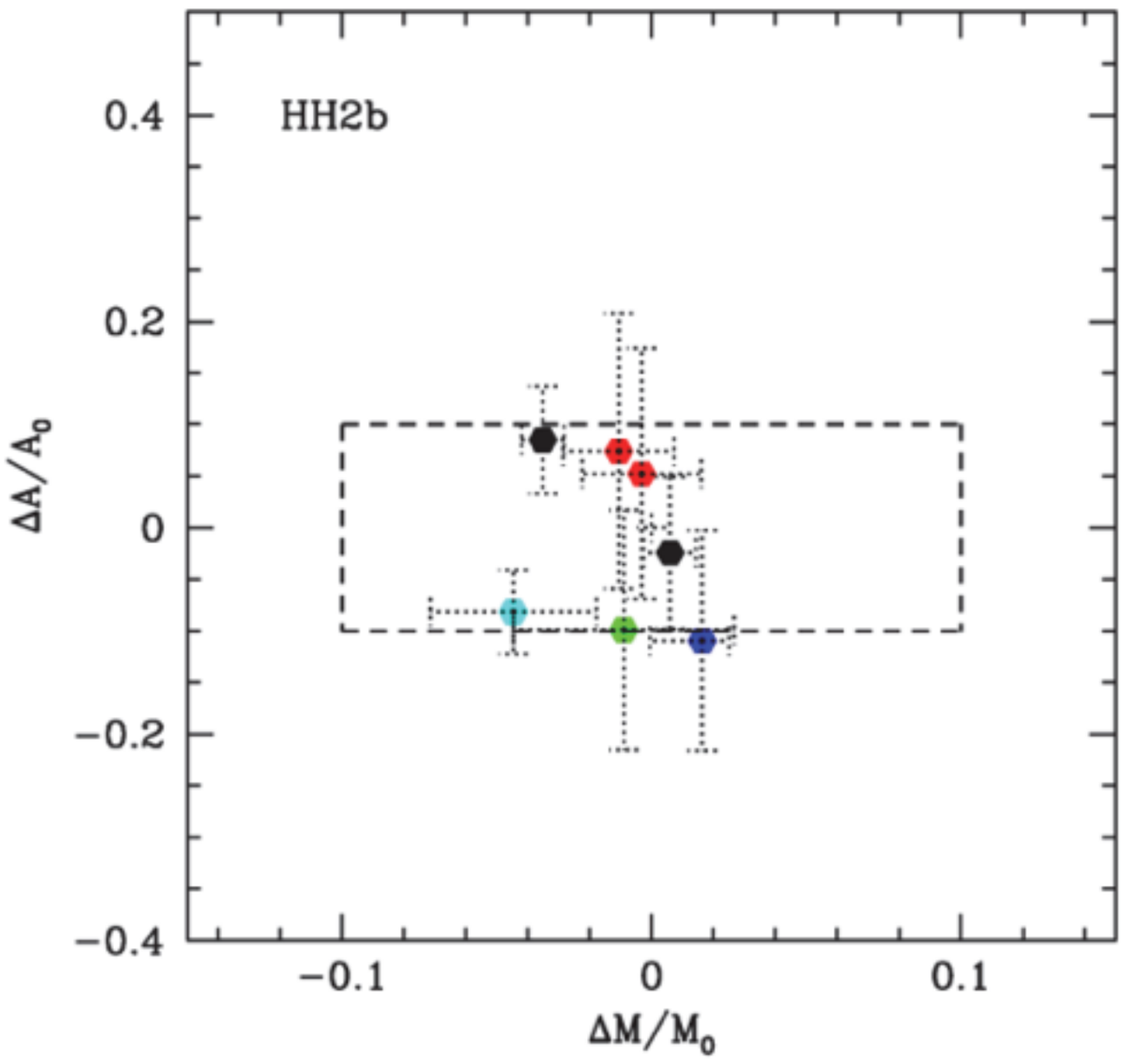
# PLATO outputs

- Level 1:
  - ➡ Calibrated lightcurves, postage stamps, and centroid curves
- Level 2:
  - ➡ Planetary candidates with transit parameters
  - ➡ Asteroseismic mode parameters
  - ➡ Stellar rotation periods
  - ➡ Stellar radii, masses, and ages
  - ➡ Living catalogue of confirmed planetary systems from TTVs, with parameters
- Level 3:
  - ➡ Living catalogue of confirmed planetary systems from PLATO and follow-up, with parameters

# Stellar science

- Asteroseismic analysis for thousands of stars
- Bulk characterisation of hundreds of PLATO planet hosts

➡ Will determine stellar | mass to 10%
radius to 2%
age to 10%



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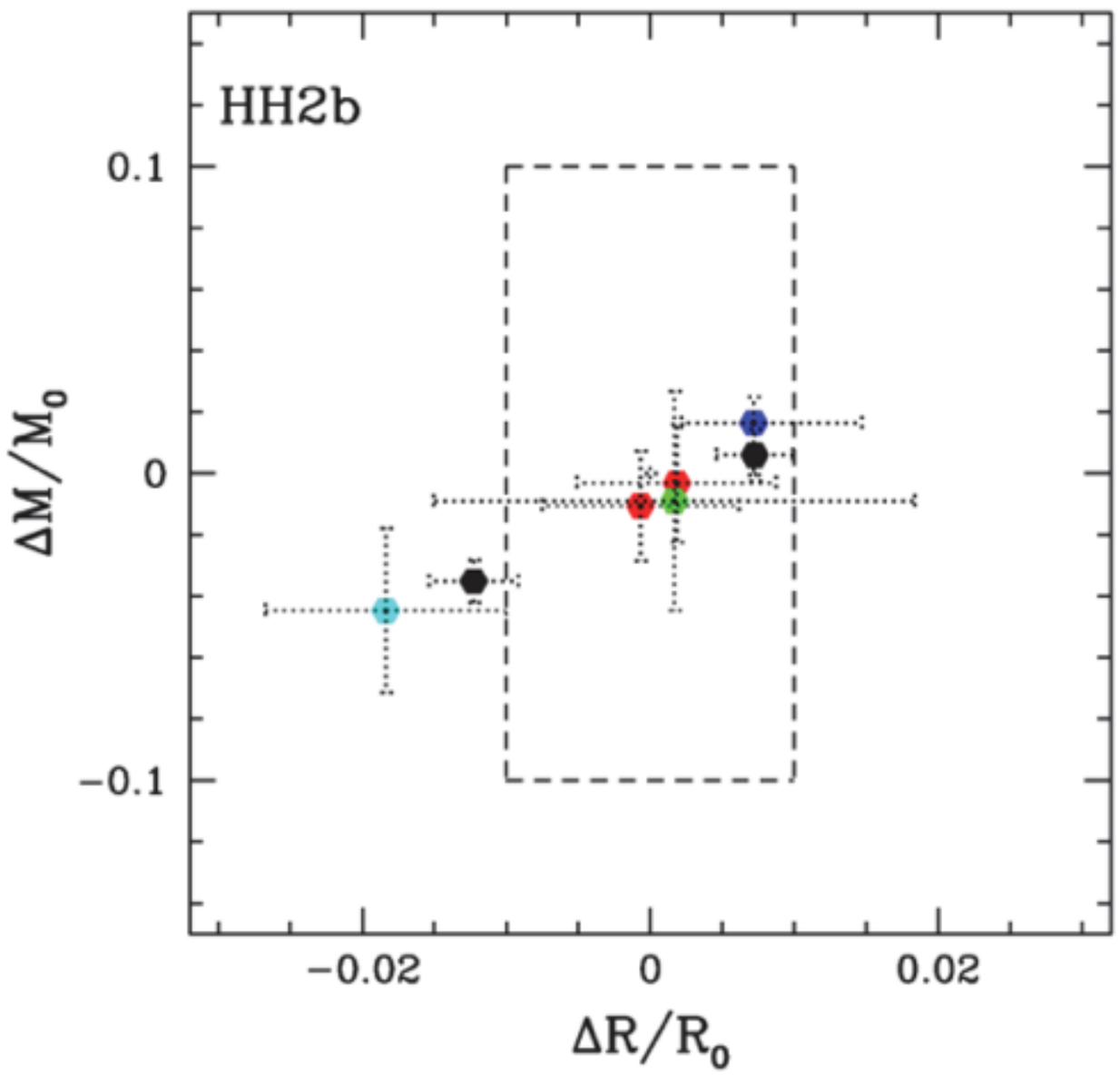


# Exoplanet science

- Wide-angle, multiple telescope, transiting exoplanet survey

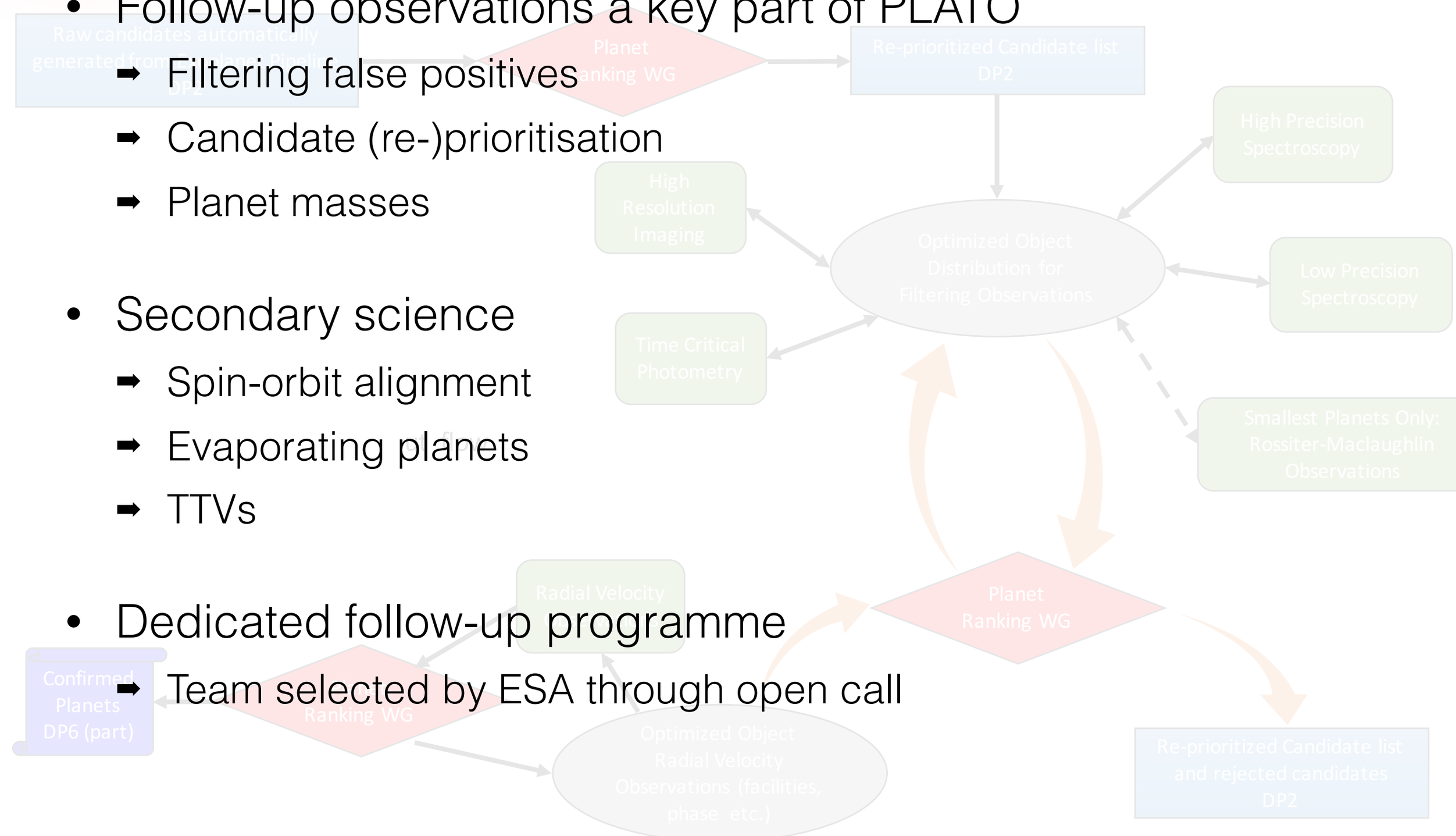
- Multitude of science cases:
  - ➡ Transit detection (inc. multi-planet systems, circumbinary planets, single transits, planets around post-MS stars, moons, rings, etc.)
  - ➡ Bulk properties (inc. correlations with stellar parameters)
  - ➡ High-accuracy planet classification
  - ➡ Constraints on core mass for gas / ice giants
  - ➡ Distance dependence for planetary inflation
  - ➡ Exploring the evaporation valley
  - ➡ Statistical constraints on planet formation
  - ➡ Evolution of planetary systems

# Follow-Up

- Follow-up observations a key part of PLATO
  - ➡ Filtering false positives
  - ➡ Candidate (re-)prioritisation
  - ➡ Planet masses

- Secondary science
  - ➡ Spin-orbit alignment
  - ➡ Evaporating planets
  - ➡ TTVs

- Dedicated follow-up programme
  - ➡ Team selected by ESA through open call



# Planet yield

| | Host stars | Yield |
|---|---|---|
| All planets, all orbital periods | Sun-like stars, V≤13 | ~4600 |
| All planets, all orbital periods | Sun-like, bright stars, V≤11 | ~1200 |
| Small planets (R<2RE), all orbital periods | Sun-like, bright stars, V≤11 | ~770 |
| Small planets (R<2RE), in HZ | Sun-like, bright stars, V≤11 | 6 - 280 |

Non-HZ occurrence rates from Fressin et al. (2013), ApJ 766, 81

In HZ, use range of eta-Earth values to constrain yield

Large uncertainties on these estimates.

# Uncertainties

- eta-Earth is not well known

| **Reference** | **Planet Frequency** | **Host stellar type** |
|---|---|---|
| Catanzarite & Shao (2011), ApJ 738, 151 | 1% - 3% | Sun-like stars |
| Traub (2012), ApJ 745, 20 | 20% - 58% (34%) | FGK |
| Gaidos (2013), ApJ 770, 90 | 31% - 64% (46%) | dwarf stars |
| Bonfils et al. (2013), A&A 549, A109 | 38% - 95% (41%) | M dwarfs |
| Dressing & Charbonneau (2013), ApJ 767, 95 | 9% - 28% (15%) | M dwarfs |
| Kopparapu (2013), ApJ 767, 8 | 24% - 60% | M dwarfs |
| Petigura, Howard, & Marcy (2013), PNAS 110, 19273 | 14% - 30% (22%) | Sun-like stars |
| Batalha et al. (2014), PNAS 111, 12647 | 4% - 30% | Sun-like stars |
| Silbert, Gaidos, & Wu (2015), ApJ 799, 180 | 5.3% - 9.8% (6.4%) | Sun-like stars |

See also:

Dressing & Charbonneau (2015), ApJ 807, 45

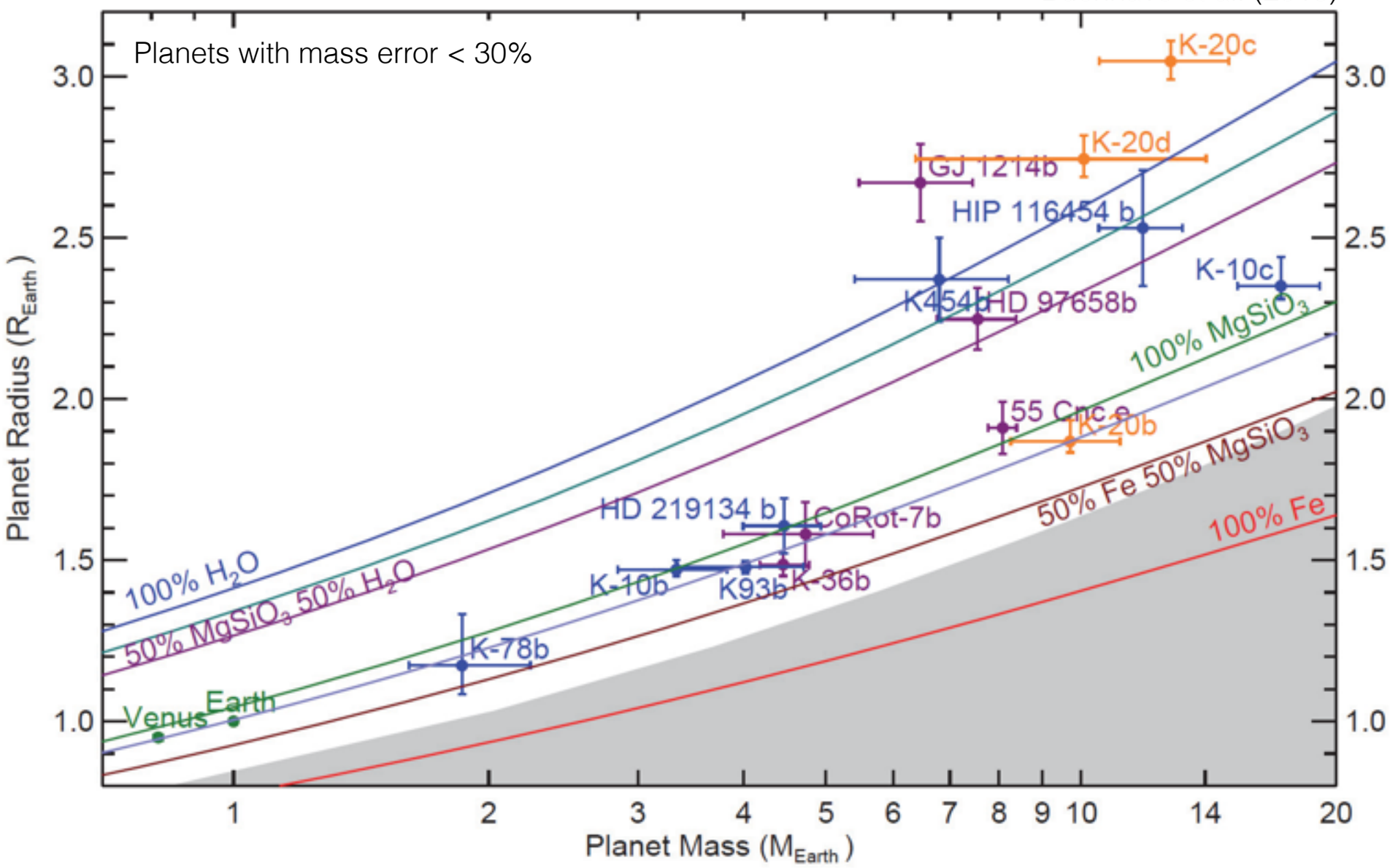
Burke et al. (2015), ApJ, 809, 8

Traub (2016), arXiv:1605.02255

# Small planets

- Limited number of small, terrestrial planets with precise masses and radii

Buchhave et al. (2016)



# PLATO Mission Consortium

**PLATO Office**

Performance

Science

Data Processing

Payload

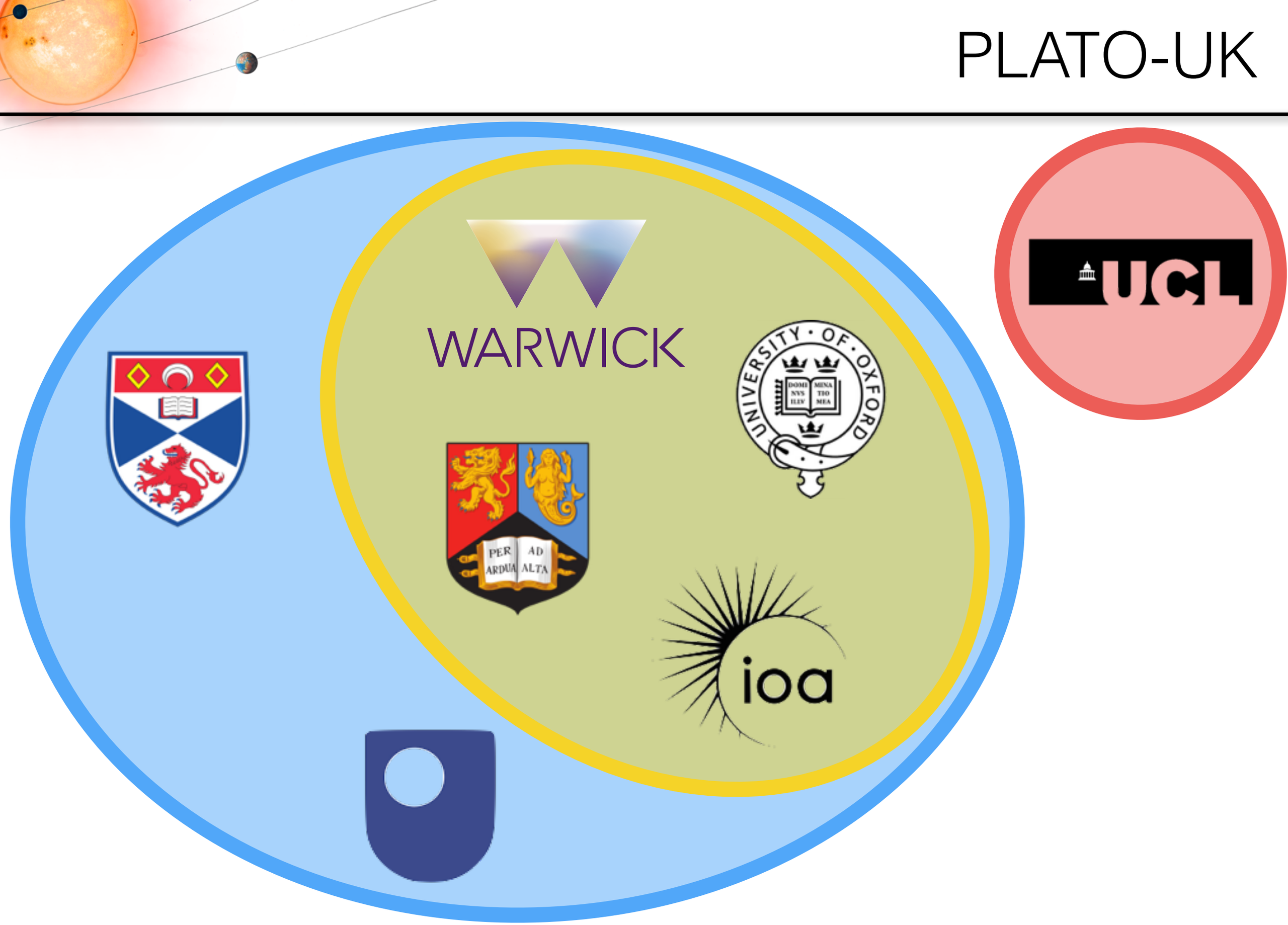
# PLATO-UK

- PSM lead and coordination
- Coordinates scientific work on exoplanet data analysis

- Development and implementation of exoplanet data processing and analysis

- Development and build of electronics that operate the ‘normal’ cameras

# PLATO-UK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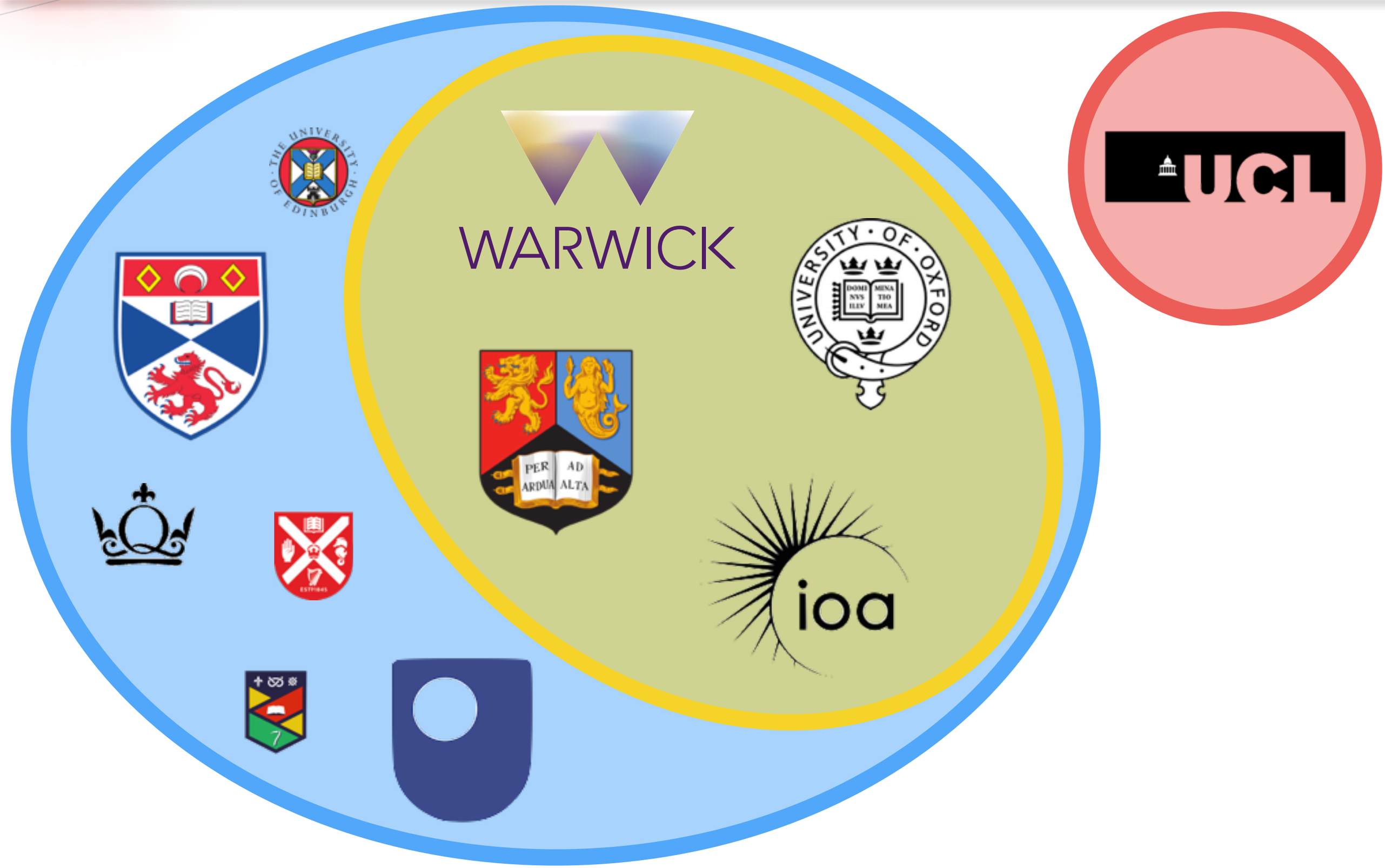
# PLATO-UK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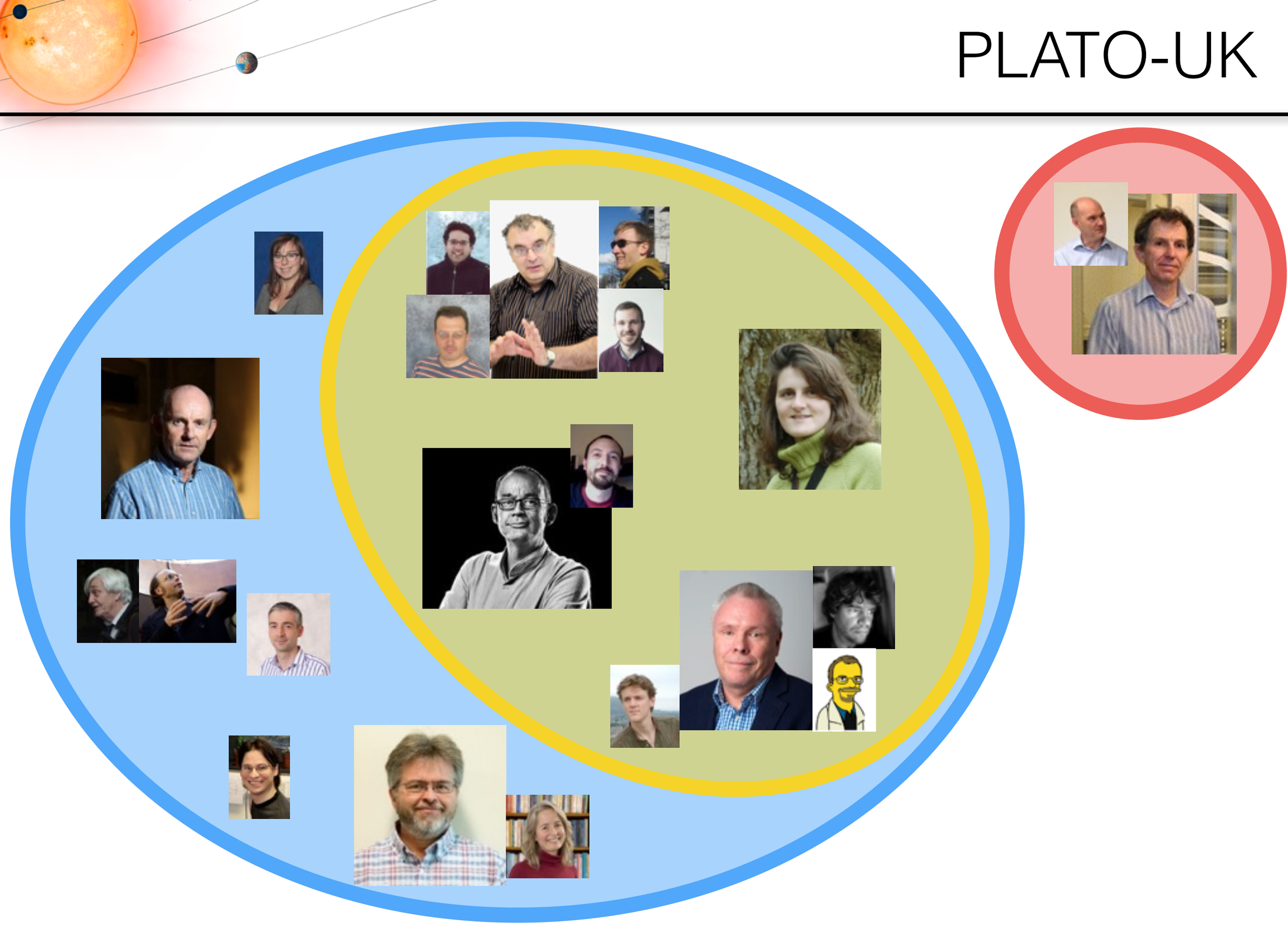


# PLATO-UK

WARWICK

- Lightcurve filtering for residual noise and long-term effects
- Detection of single and unusual transits
- M-dwarfs as planet hosts
- Follow-up strategy

- Lightcurve filtering for stellar noise
- Simulated lightcurves for pipeline development

- Scaling laws
- Seismology of evolved stars
- Power spectrum fitting for solar-type stars, inc. multiple systems (inc mode fitting)

- Analysis and modelling of contaminants using Gaia data
- False positive abundances
- Transits of close-in objects

- Candidate ranking
- False positive identification

- QUB: astrophysical noise and impact on RV
- QMUL: planetary formation and orbital evolution (inc. in binary systems); forward approaches to stellar parameter determination
- IoA: PMS evolution; use of Gaia photometry for target selection
- Edinburgh: candidate classification using high angular resolution imaging

# Mission timeline

| | |
|---|---|
| 2014 | Mission selection |
| 2015 | |
| 2016 | |
| 2017 | Mission adoption<br>Mission conference |
| 2018 | Selection of spacecraft manufacturer |
| 2019 | |
| 2020 | |
| 2021 | Critical review |
| 2022 | |
| 2023 | |
| 2024 | |
| 2025 | |
| 2026 (Q4) | Launch |
| 2030 | End of nominal operations |
| 2033 | End of (possible) extended operations |

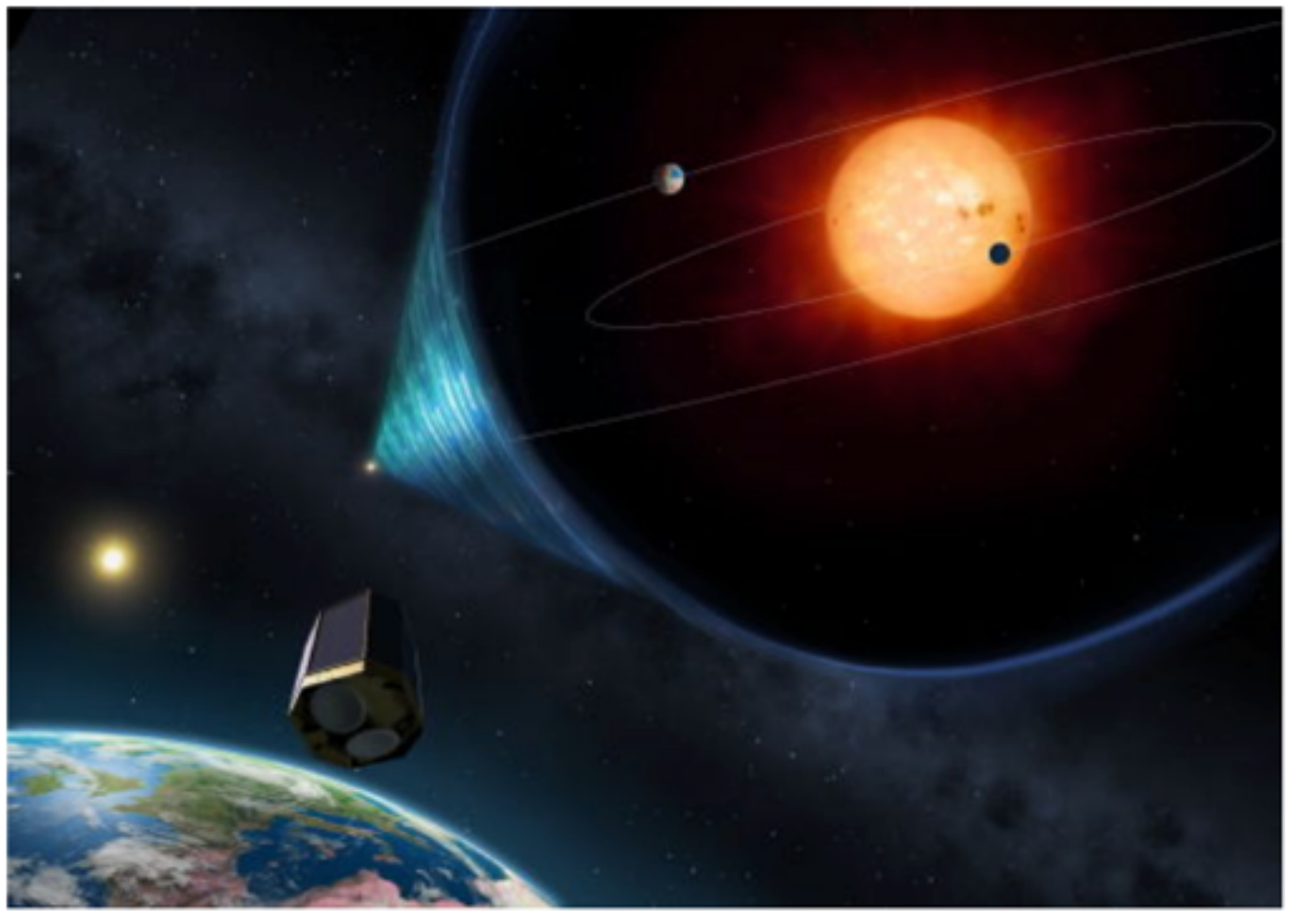
# Want to get involved?

warwick.ac.uk/plato-science

WARWICK

PLATO Science Management

About the PSM | Pre-launch Work | Research | People | Resources | Meetings | Telecons | News & Events



About PLATO

Research Topics

Countdown to launch

Resources

## Welcome to the PSM website

PLATO (PLAnetary Transits and Oscillations of stars) is the European Space Agency's M3 mission. It is designed to search for small, rocky exoplanets in the habitable zone of stars like the Sun, and will do so using the transit method. By staring at a large area of sky,

## News

Fri 10 Nov '17

ATBD review ongoing

The PSM review of the onboard data processing algorithms continues.

Following the delivery of the final reports to the PDC Office and the Performance Team, the PSM Office have been working with these

## PLATO Events

### Upcoming events

**Wed 21 Mar '18**

9am: UK Exoplanet Meeting 2018

**Fri 23 Mar '18**

Closing date for PSM Office job applications

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- Guest Observer programme
  - ➡ Call for proposals to cover Complementary Science
  - ➡ Up to 8% of observations
  - ➡ Number of objects depends on requested cadence and data product
  - ➡ No repointing!

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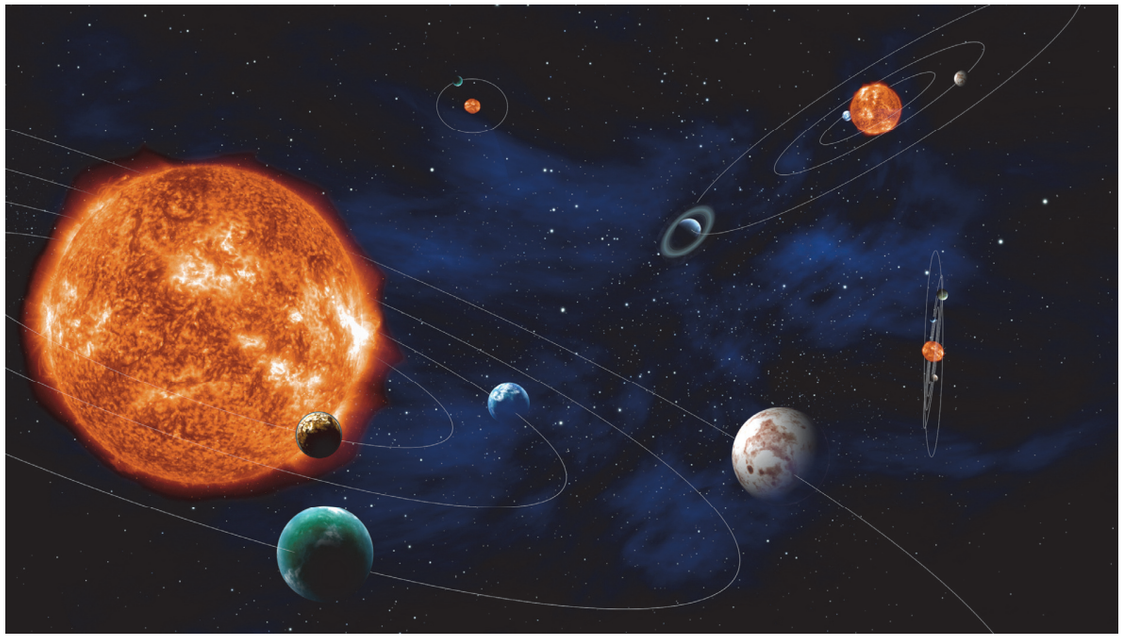
ESA-SCI(2017)1
April 2017

# PLATO

## Revealing habitable worlds around solar-like stars



**Definition Study Report**

# Job advert

## Exoplanet Discovery & Characterisation from Transit Surveys

## PDRA at the University of Warwick

Available for an initial 2 year period.

Please contact Peter Wheatley (P.J.Wheatley@warwick.ac.uk) or Don Pollacco (D.Pollacco@warwick.ac.uk) if you are interested

# Thank you

@PLATOMissionCon
@PLATOSatellite

# Data policy

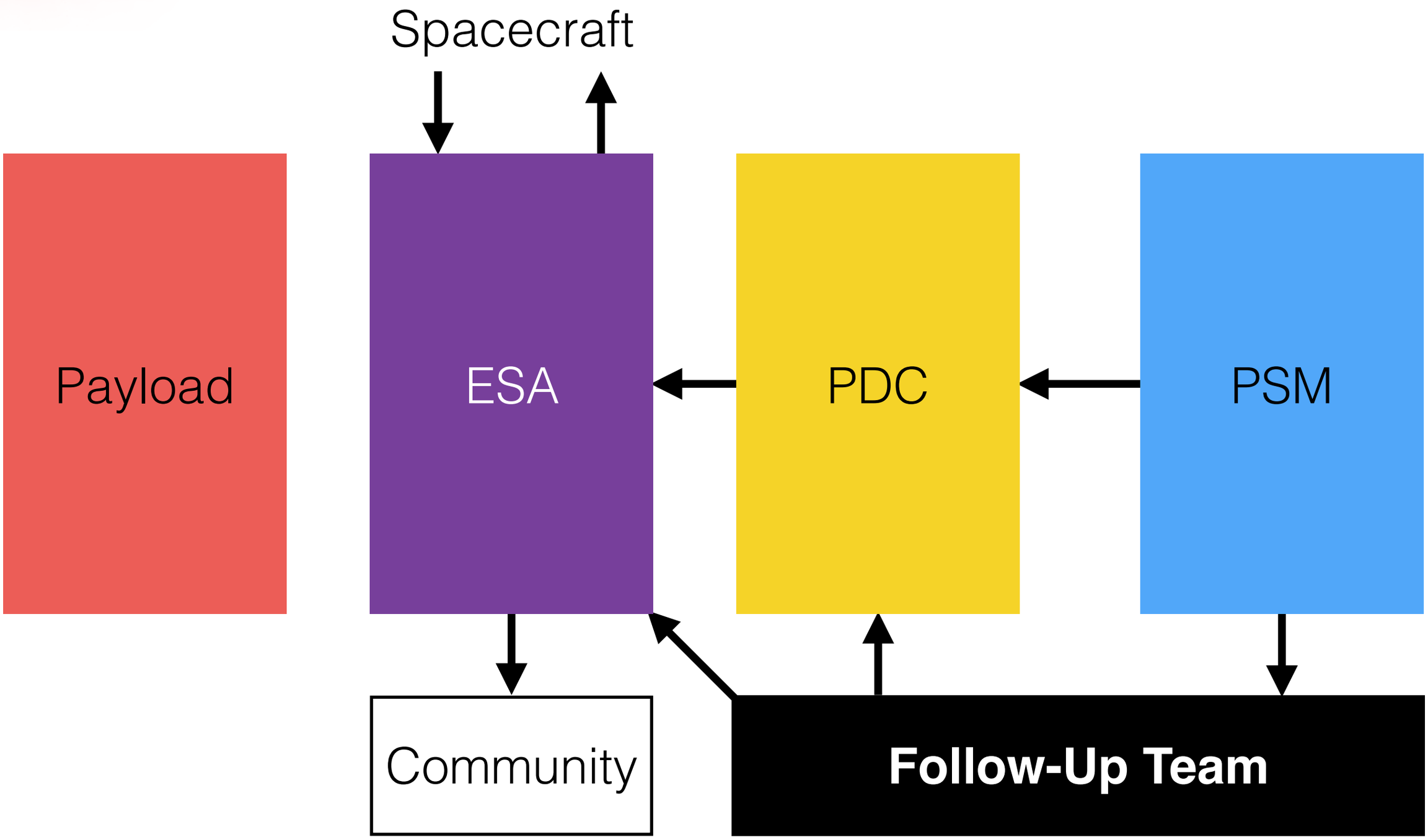
- Public release of data products up to L2 will be asap, ≤ 1 year after validation

- ≤ 2000 targets over both fields will be proprietary to PMC
  - ➡ Selected using first 3 months of observations for a field
  - ➡ Approved by ESA
  - ➡ Become public 6 months after completion of follow-up and planet characterisation

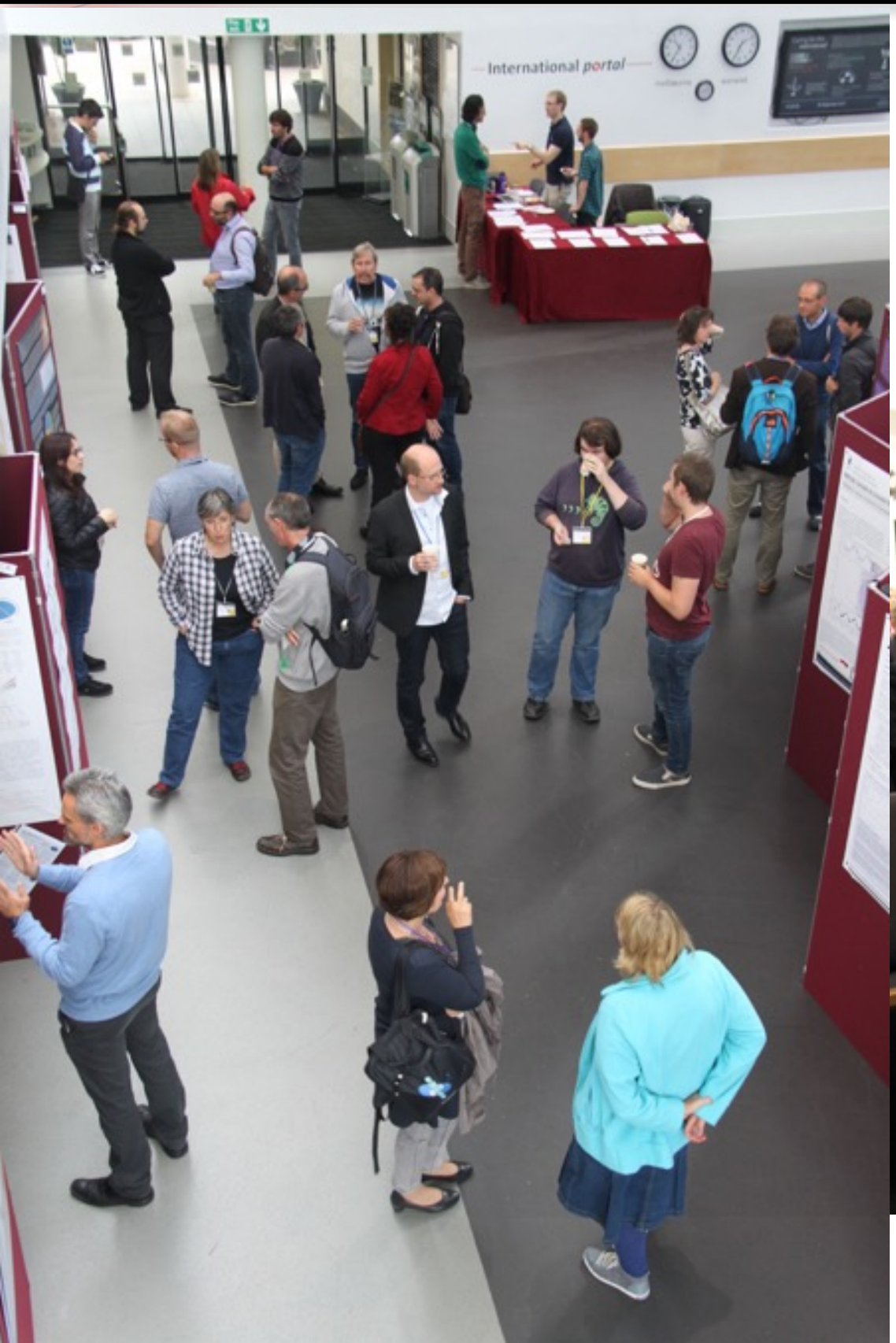
- Public release of L3 data products will be
  - ➡ immediately after publication, or
  - ➡ asap and ≤ 6 months after completion of ground-based follow-up

- Guest Observer targets will be proprietary for 1 year after delivery of last L1 data
  - ➡ data delivery every 3 months

# How it all fits together



# PLATO Mission Conference 2017




Covered full range of science enabled by PLATO

PLATO & PLATO-UK

# PLATO Mission Conference 2017