PLATO – ESP2025
Planets throughout the Habitable Zone
Marseille 23–25 June 2025

PLATO Mission Performance

search for Earth-like planets in the habitable zone
23 - 25 June 2025

DLR KU LEUVEN l'Observatoire de Paris LESIA Università degli Studi di Padova INAF Istituto Nazionale di Astrofisica FREIE UNIVERSITÄT Planetenforschung WARWICK The University of Warwick esa

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Juan Cabrera, Heike Rauer, Sami-Matias Niemi, Reza Samadi, Claas Ziemke, Ulrike Witteck, Dave Walton, Peter Verhoeve, Bart Vandenbussche, Alan Smith, Gabriel Schwarzkopf, Francesco Santoli, Pierre Royer, Sara Regibo, Roberto Ragazzoni, Giampaolo Piotto, Martin Pertenais, Carsten Paproth, Gianalfredo Nicolini, Valerio Nascimbeni, Marco Montalto, Francesca Molendini, Paola Marrese, Silvia Marinoni, Demetrio Magrin, Alexander Koncz, Peter Klagyivik, Nicholas Jannsen, Sascha Grziwa, Valentina Granata, Marijo Goupil, Nicolas Gorius, Denis Grießbach, Yoshi Eschen, Giacomo Dinuzzi, Joris De Ridder, Cilia Damiani, Anders Erikson, Philipp Eigmüller, Szilárd Csizmadia, Francesco Borsa, Anko Börner, Aaron Birch, Claudio Arena, Thierry Appourchaux, Jose Lorenzo Alvarez, Isabella Pagano, J. Miguel Mas-Hesse.

Payload design drivers

planet detection
(up to HZ solar-like stars)

- 80 ppm 1h → (planet yield)
- **long baseline (>2yr)**
- 600s sampling
- 25s sampling

→ telemetry and data processing requirements

stellar characterization
(up to 10% age for Sun-like star)

- noise requirements in the Fourier domain → requirements on the residuals of systematic noise

planet characterization
(down to 3% uncertainty in radius for Earth-Sun analogs)

- 34 ppm in 1h (3% Rp; 10% age)
- **50 ppm in 1h (5% Rp; 20% age)**

→ random noise requirements

- **V<11 (radial velocity)** → P1 sample requirements

→ pointing requirements

→ FOV requirements

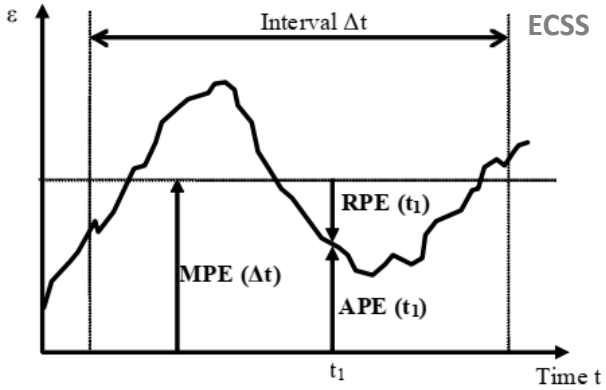


Figure A-1: Example showing the APE, MPE and RPE error indices

APE: Absolute Performance Error of the pointing.
PDE: Performance Drift Error of the pointing.
MPE: Mean Performance Error of the pointing.
PRE: Performance Repeatability Error of the pointing.
RPE: Relative Performance Error of the pointing

signal and noise

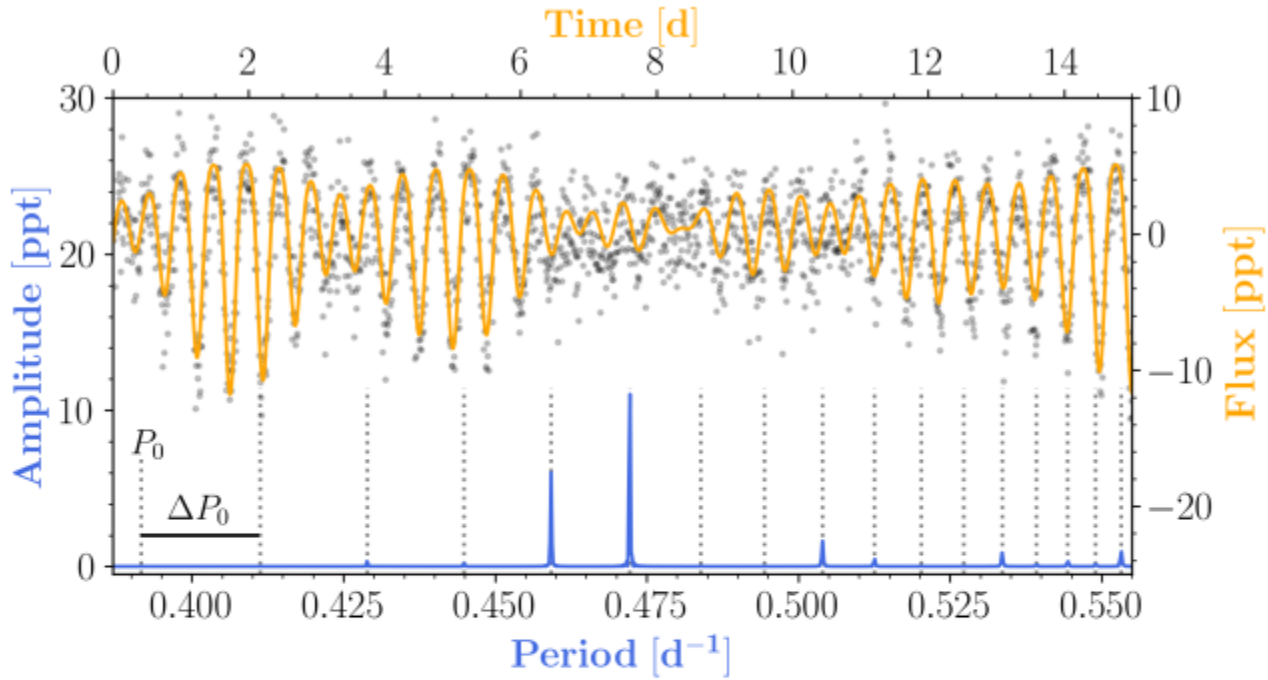


Fig. 5. Example of a simulated SPB star. The lower/left axes belong to the amplitude spectrum (blue line), where we have highlighted the mode frequencies (dotted lines), the first mode period (P_0), and the first period spacing (ΔP_0). The upper/right axes belong to the corresponding light curve (shown for the first 15 days) in its noise-less form (orange line) and simulated form (black points, representing a $\mathcal{P} \approx 10.3$ star observed with $n_{\rm CAM} = 6$).

Jannsen et al. (2025)

signal and noise

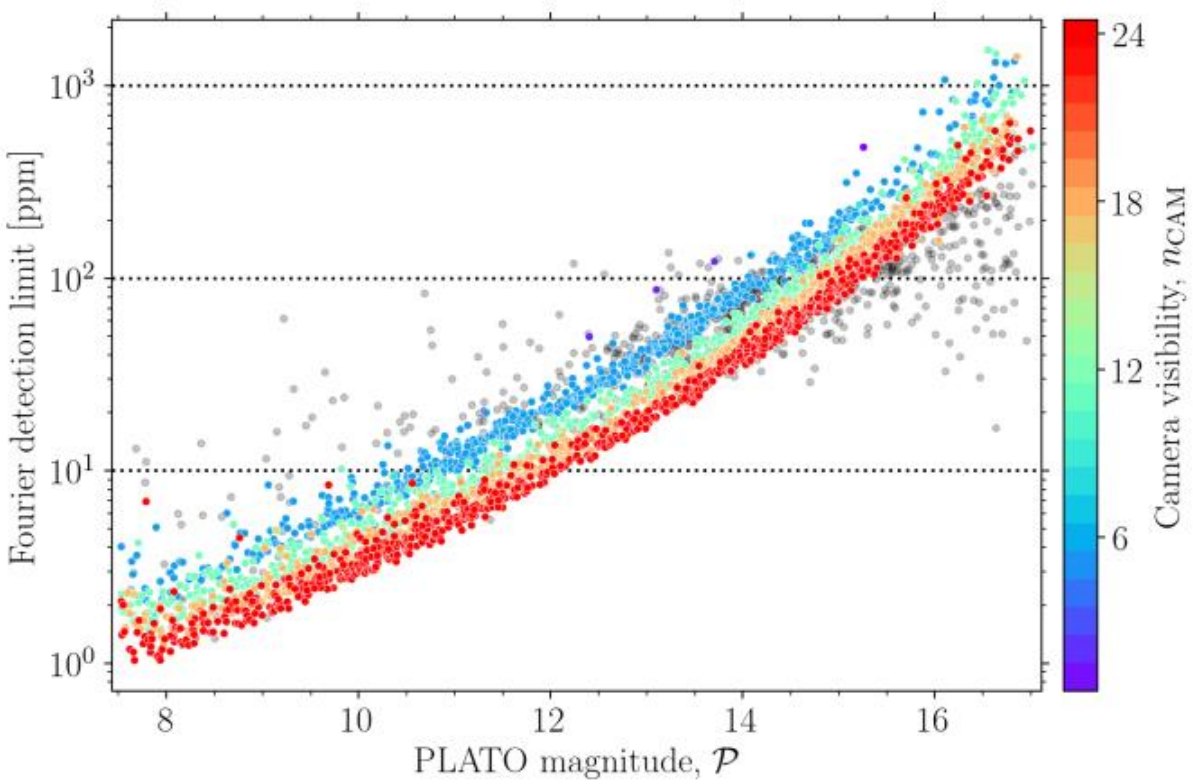
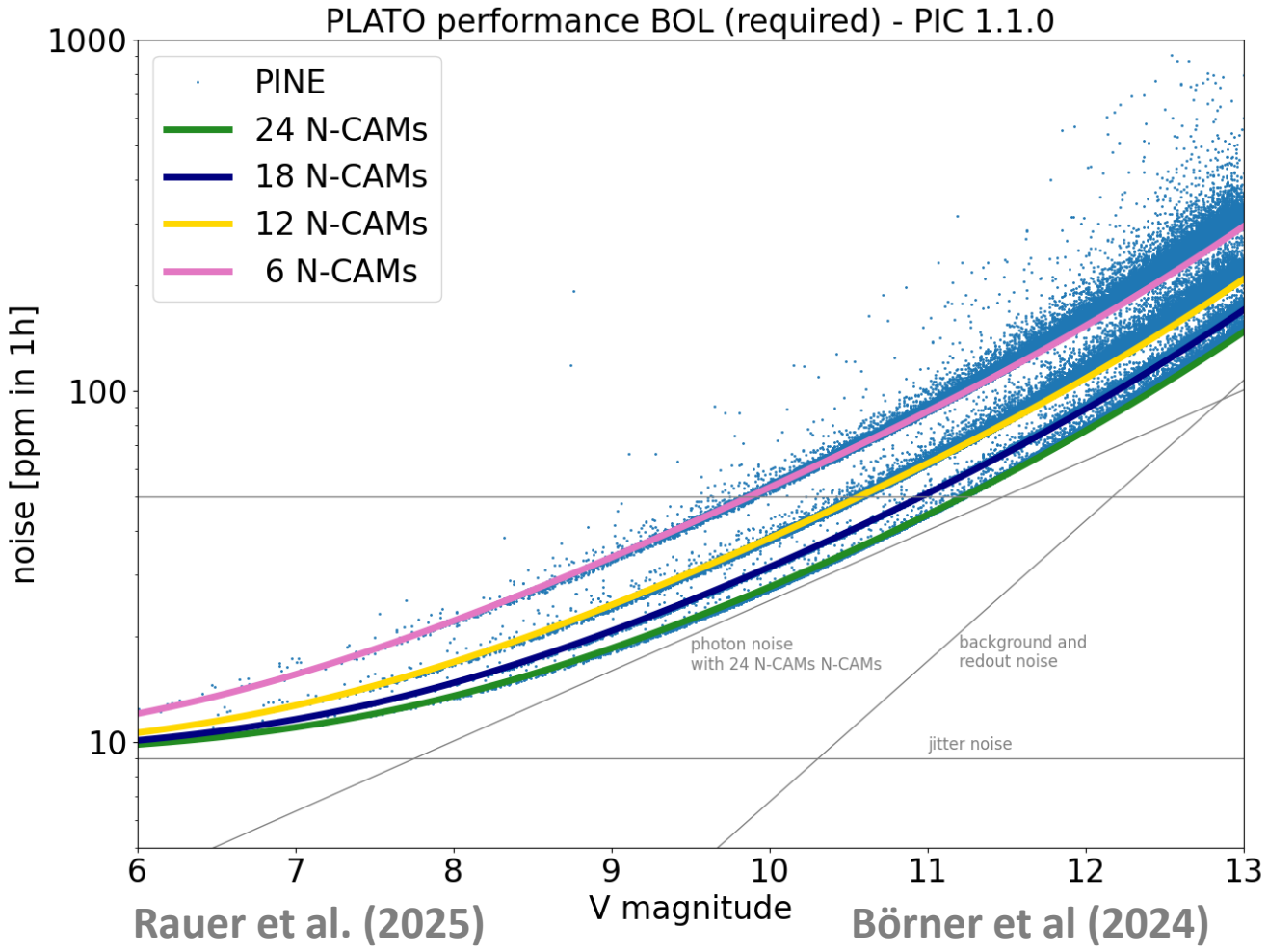


Fig. 13. Amplitude detection limit from a prewhitening strategy using the S/N stopping criterion and a high amplitude version of the AFFOGATO SPB sample (cf. Sect. 6.2). This plot illustrates the general noise budget in the frequency domain enforced by random and systematic noise sources. Like in the time domain (see Fig. C.1), the detection limit at mission level is a clear function of the camera observability (colour scale). The dark grey data points are stars with a SPR value larger than 6% (a critical threshold explained in Sect. 6.5). The dotted horizontal lines are reference limits. We highlight that multiple stars have a camera visibility different from $n_{\rm CAM} \in \{6, 12, 18, 24\}$ due to the usage of pointing error sources in our simulations (cf. Sect. 5.1). The same is true for Figs. 14 and 15. While we illustrate the star count histogram (versus $n_{\rm CAM}$) of this figure in Fig. C.4, the effect in this plot is most noticeable from the four (upper-most) purple/blue data points with $n_{\rm CAM} \in \{1, 2\}$.

Jannsen et al. (2025)

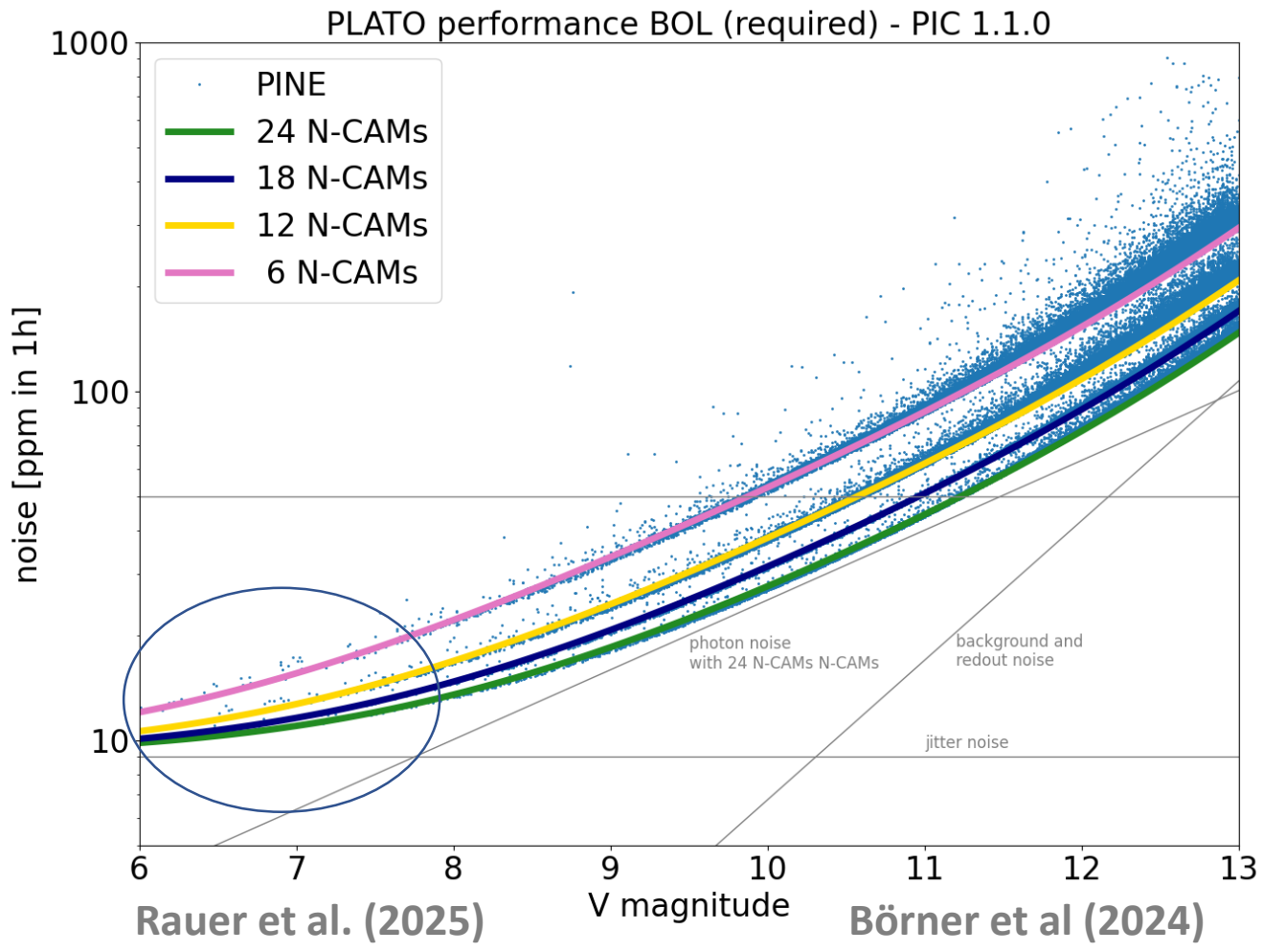
signal and noise



- Uninterrupted observations for ≥**2 years**
- Duty cycle >93% in-flight
  (Kepler ~88%, see Burke et al. 2015)

in this presentation, ppm in 1h should be understood as ppm/sqrt(1h) in the Fourier domain

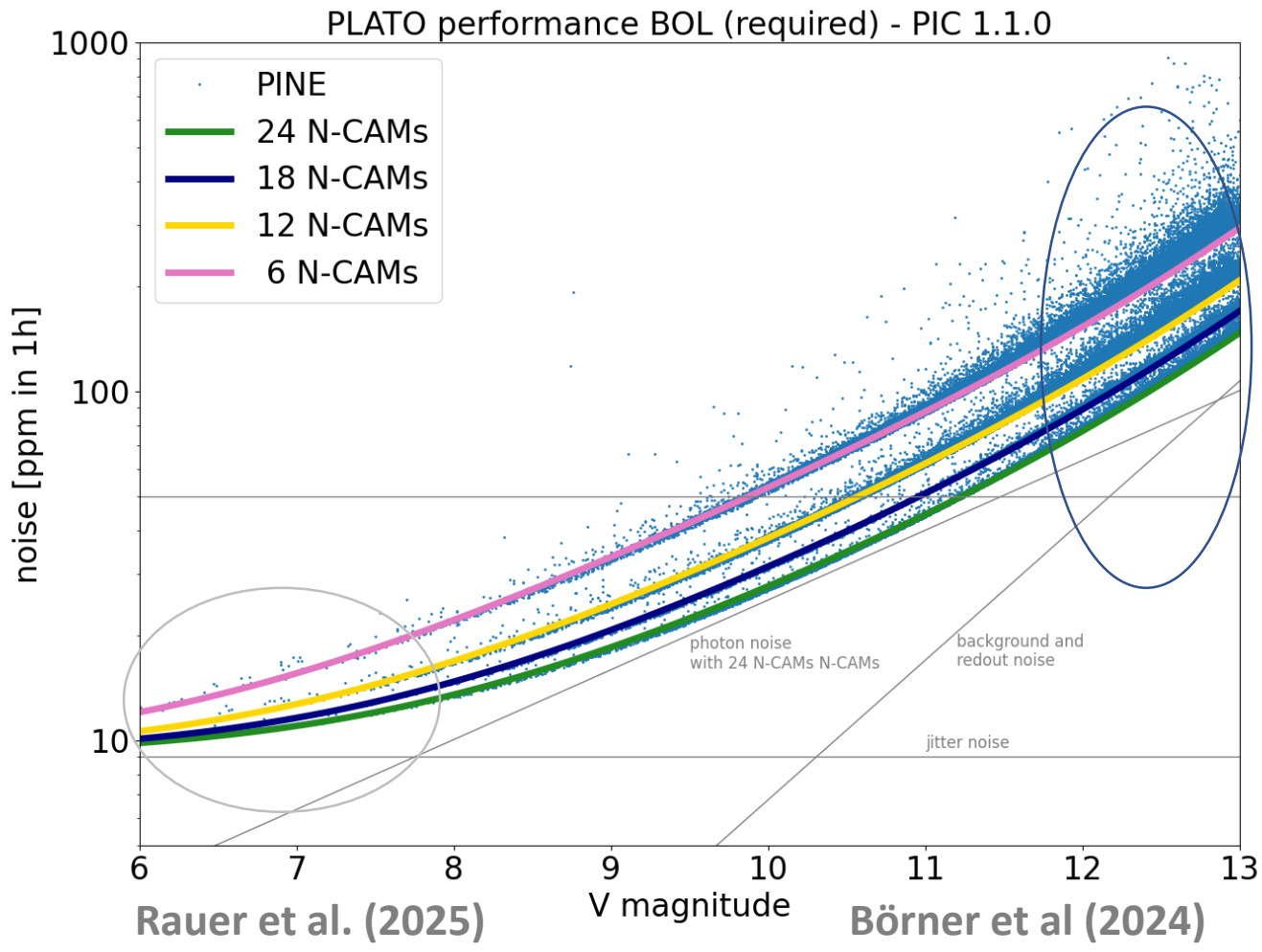
signal and noise



- Uninterrupted observations for ≥**2 years**
- Duty cycle >93% in-flight
  (Kepler ~88%, see Burke et al. 2015)
- Noise budget dominated by:
  - **jitter** in the bright end

in this presentation, ppm in 1h should be understood as ppm/sqrt(1h) in the Fourier domain

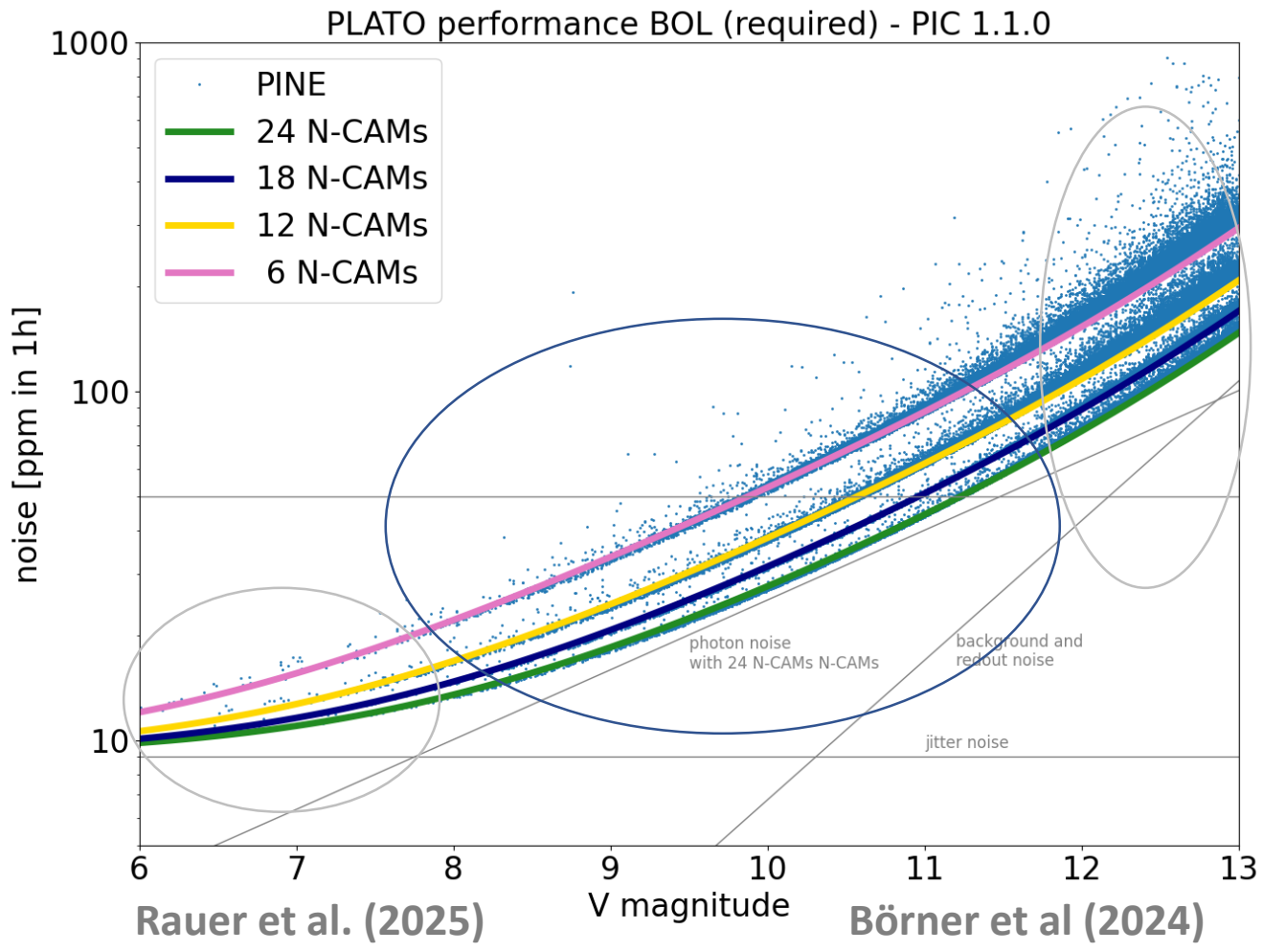
signal and noise



- Uninterrupted observations for ≥**2 years**
- Duty cycle >93% in-flight
  (Kepler ~88%, see Burke et al. 2015)
- Noise budget dominated by:
  - **jitter** in the bright end
  - **background** and **readout** noise in the faint end

in this presentation, ppm in 1h should be understood as ppm/sqrt(1h) in the Fourier domain

signal and noise

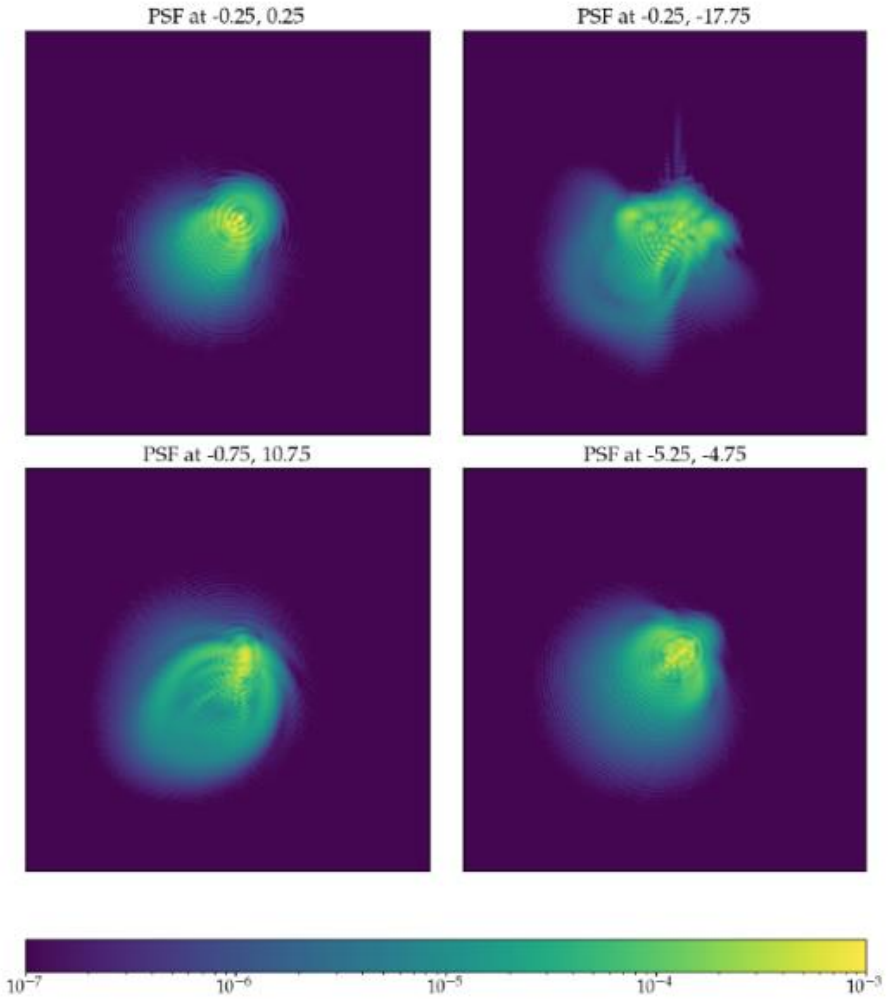


- Uninterrupted observations for ≥**2 years**
- Duty cycle >93% in-flight
  (Kepler ~88%, see Burke et al. 2015)
- Noise budget dominated by:
  - **jitter** in the bright end
  - **background** and **readout** noise in the faint end
  - **photon shot noise** everywhere else

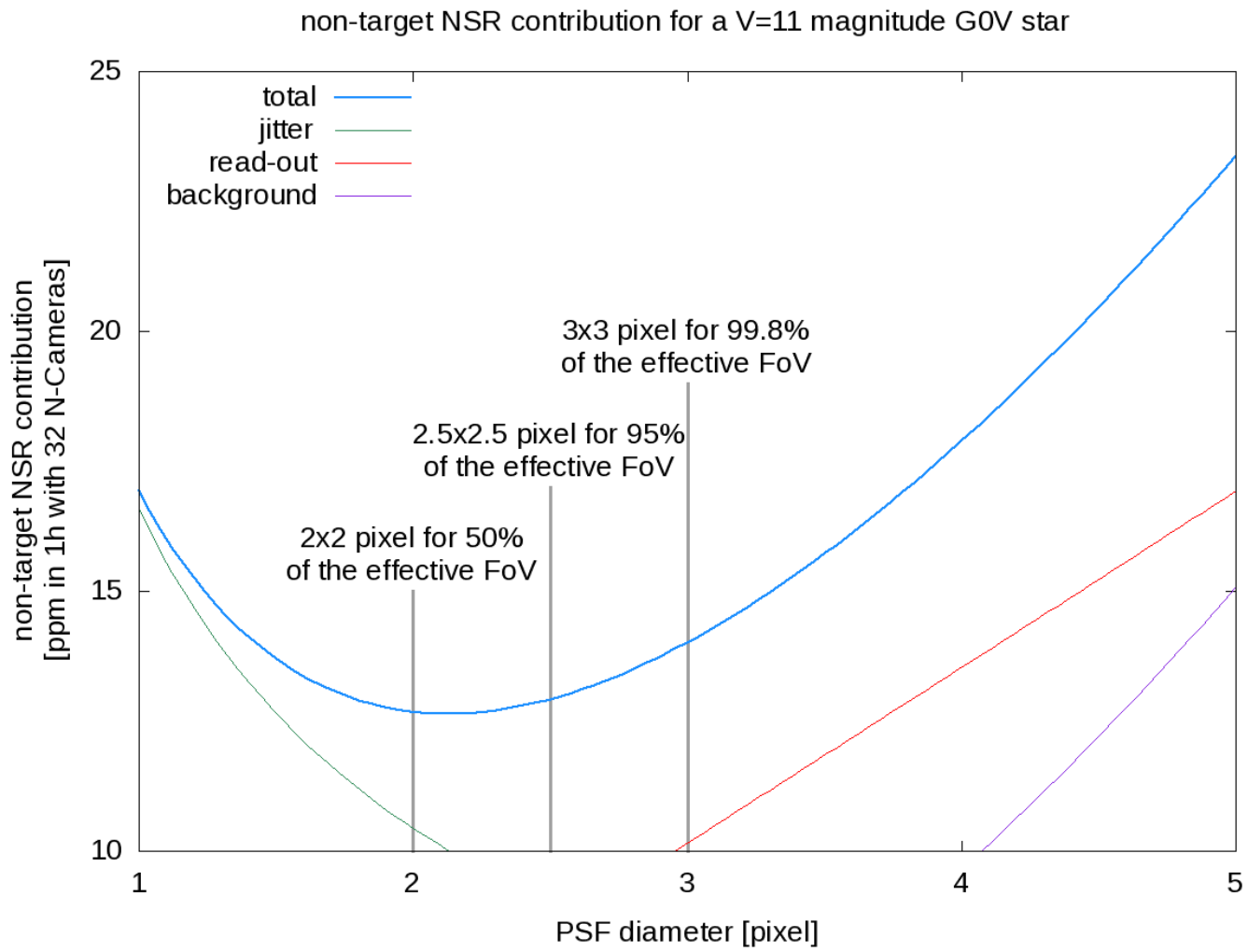
But note the particular architecture of the FOV.

in this presentation, ppm in 1h should be understood as ppm/sqrt(1h) in the Fourier domain

signal and noise

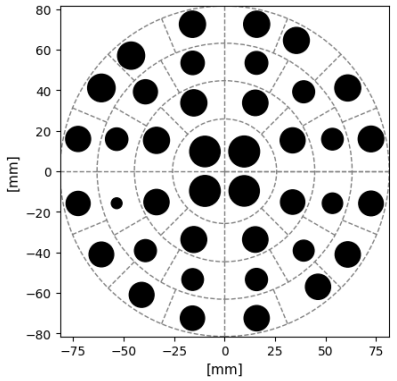
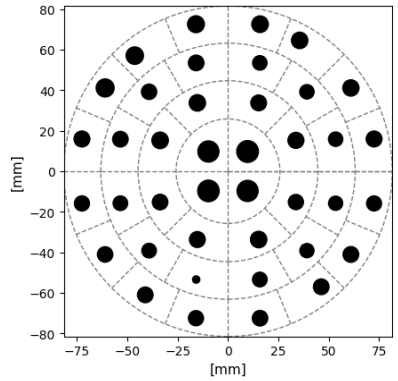
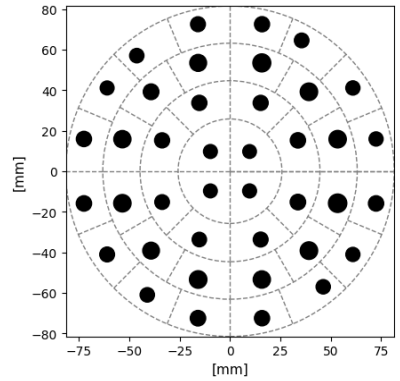
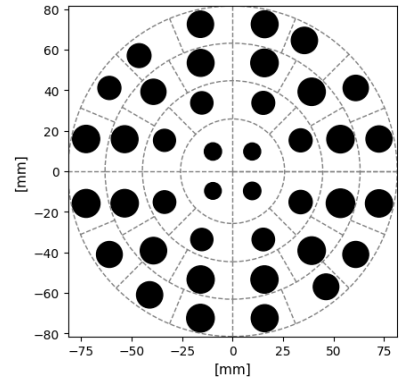
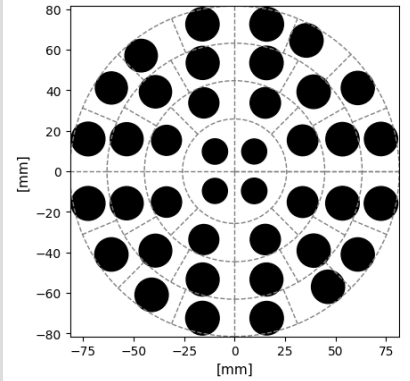
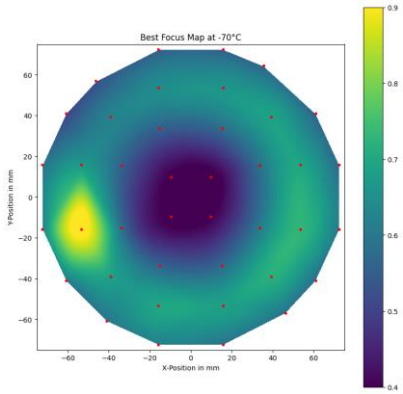
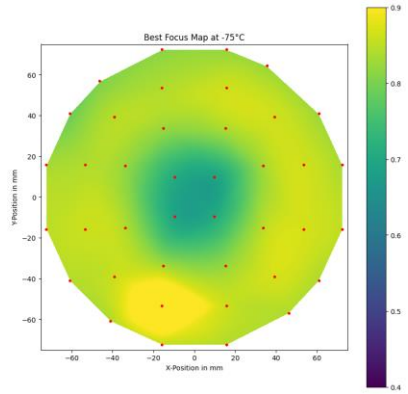
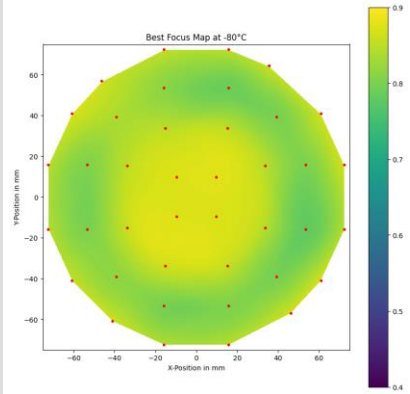
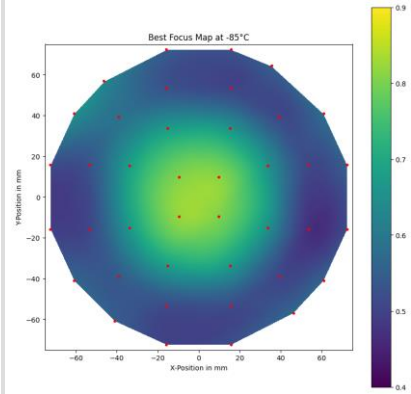
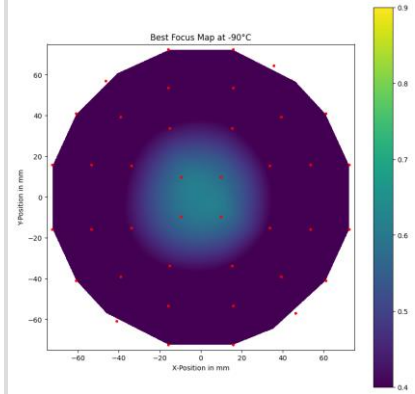


PSF of the blue F-CAM



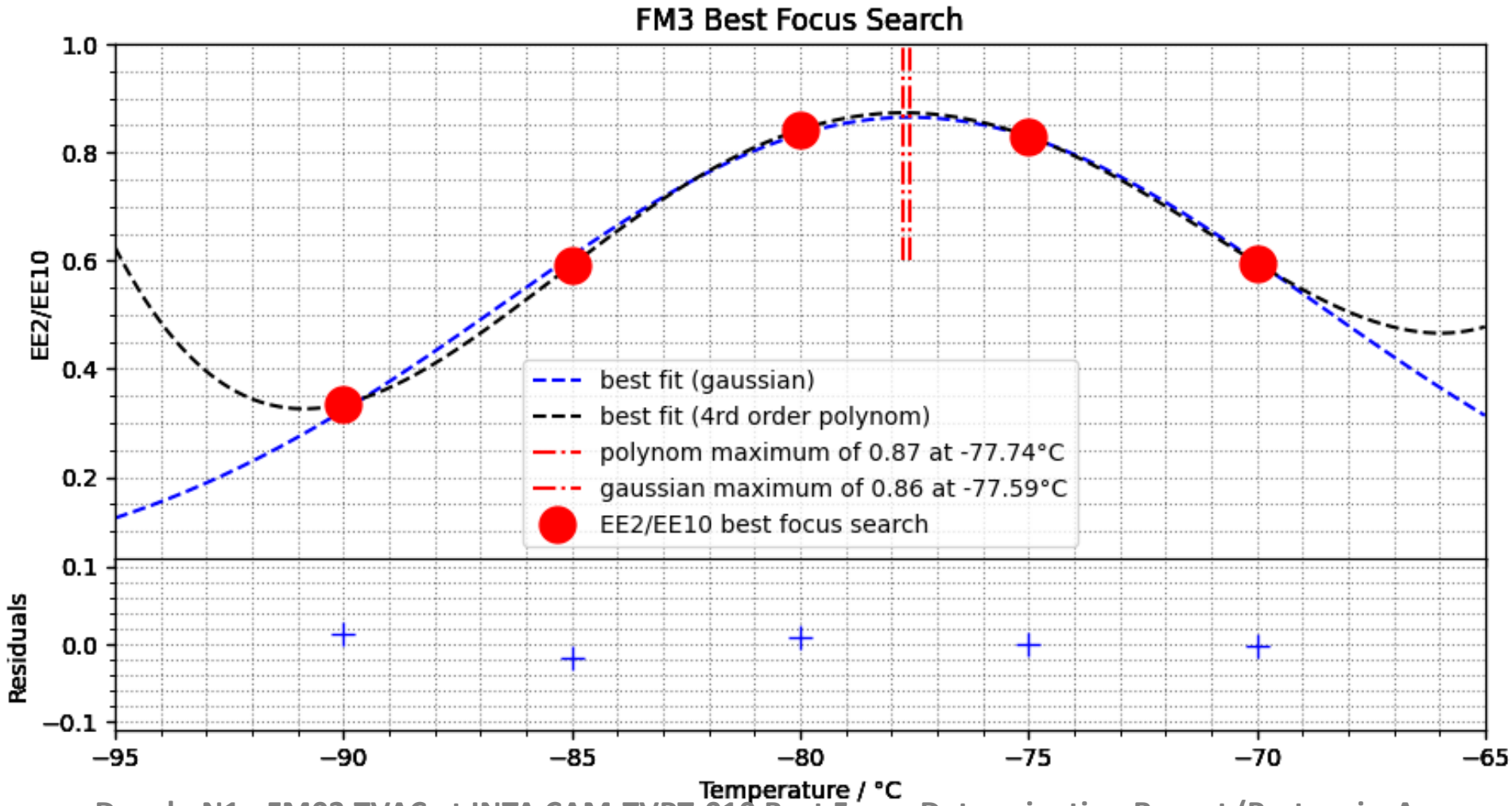
signal and noise

FM03 at INTA

-70°C	-75°C	-80°C	-85°C	-90°C
				
				

signal and noise

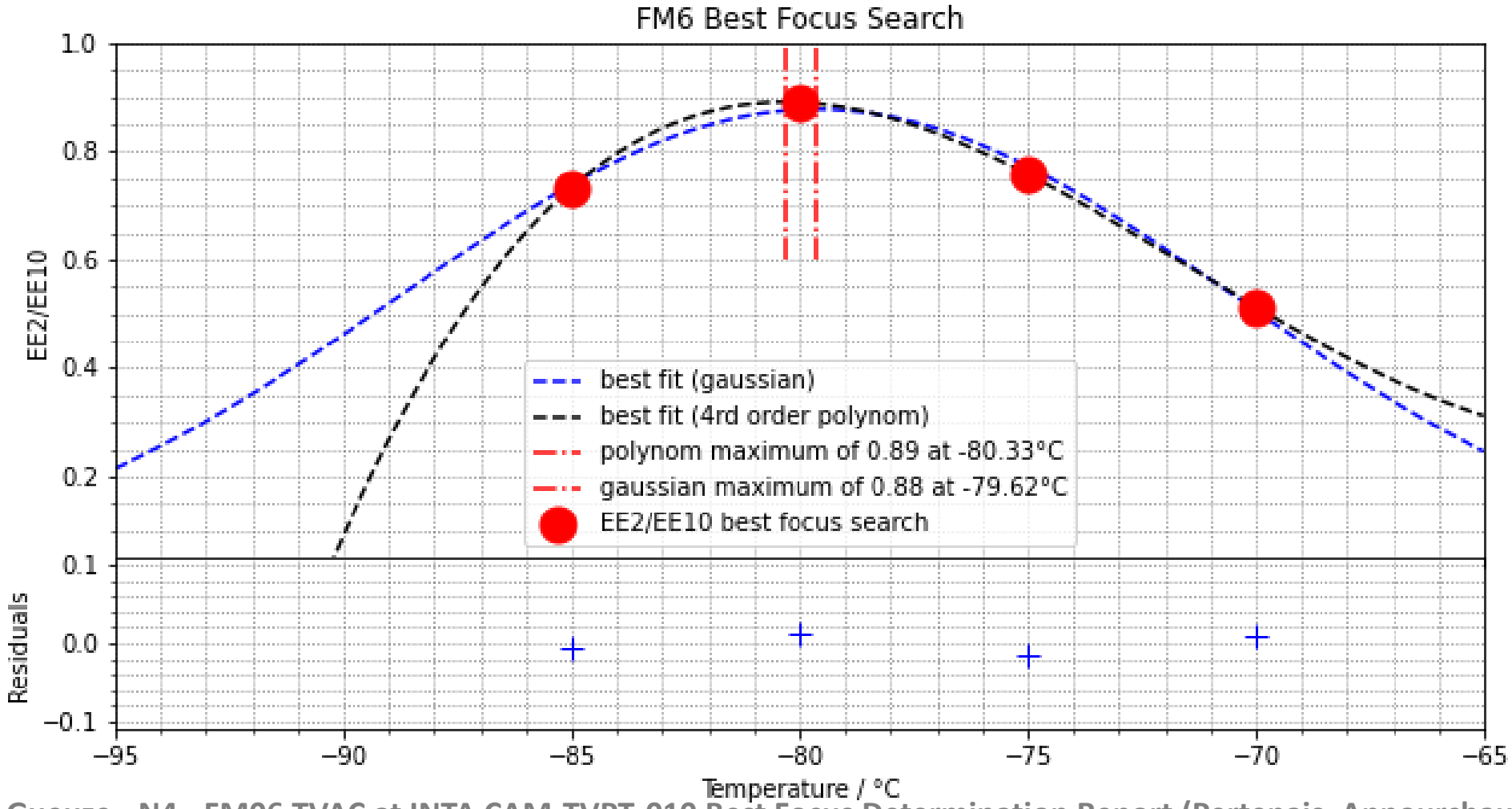
FM03 at INTA



PLATO BengtStromgren - Duvel - N1 - FM03 TVAC at INTA CAM-TVPT-010 Best Focus Determination Report (Pertenais, Appourchaux, Eigmüller)

signal and noise

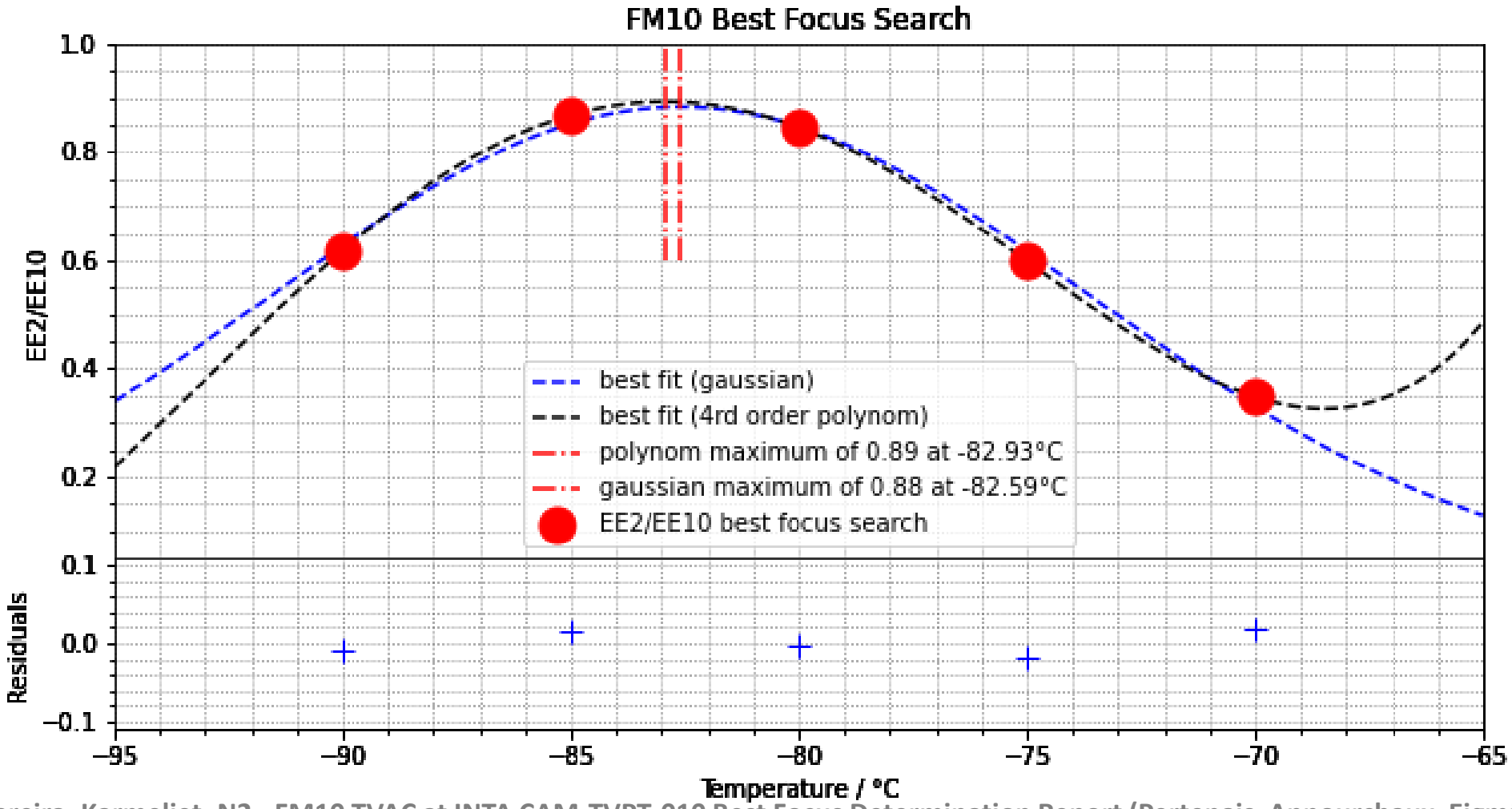
FM06 at INTA



PLATO FPraderie - Gueuze - N4 - FM06 TVAC at INTA CAM-TVPT-010 Best Focus Determination Report (Pertenais, Appourchaux, Eigmüller)

signal and noise

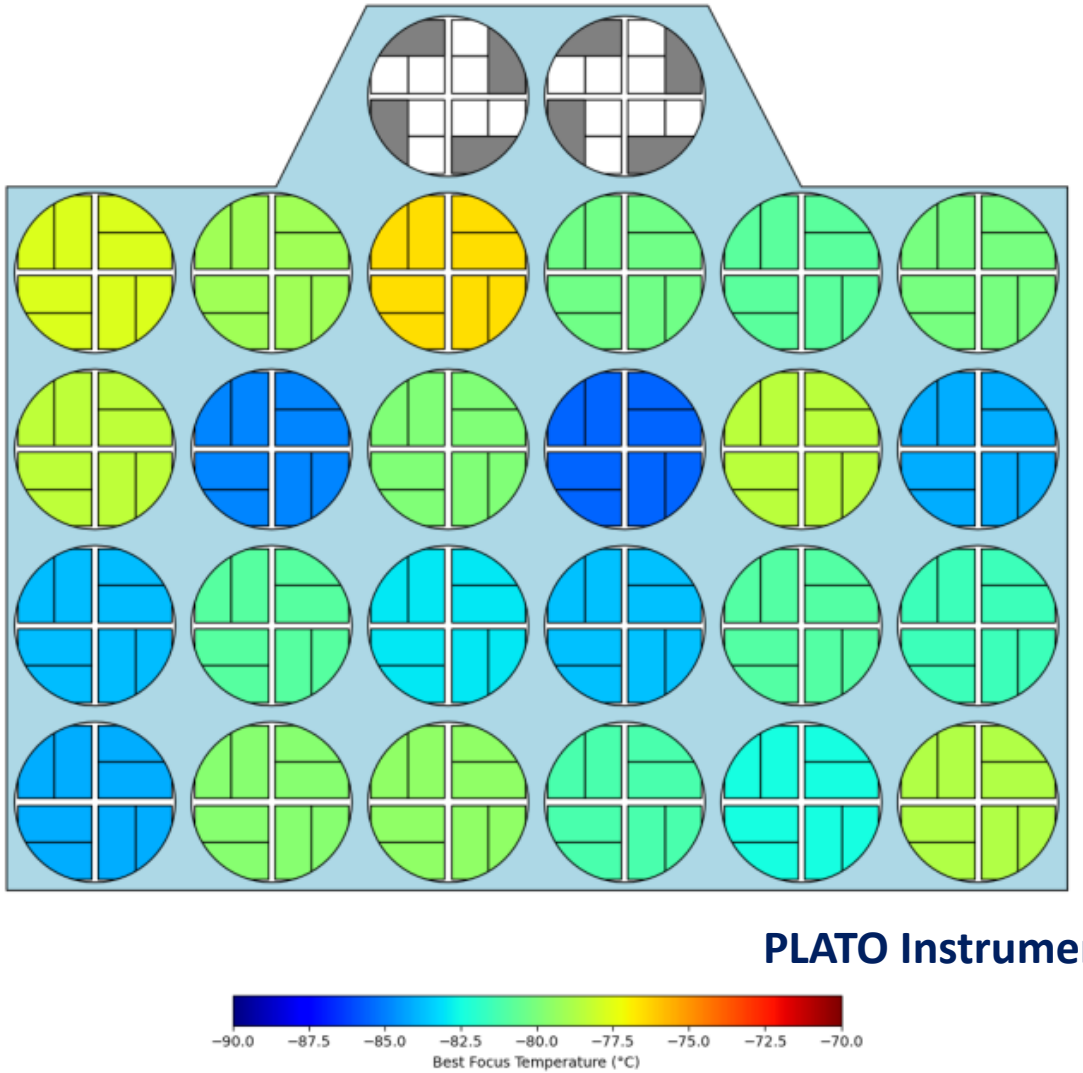
FM10 at INTA



PLATO YVFerrazPereira- Karmeliet- N2 - FM10 TVAC at INTA CAM-TVPT-010 Best Focus Determination Report (Pertenais, Appourchaux, Eigmüller)

signal and noise

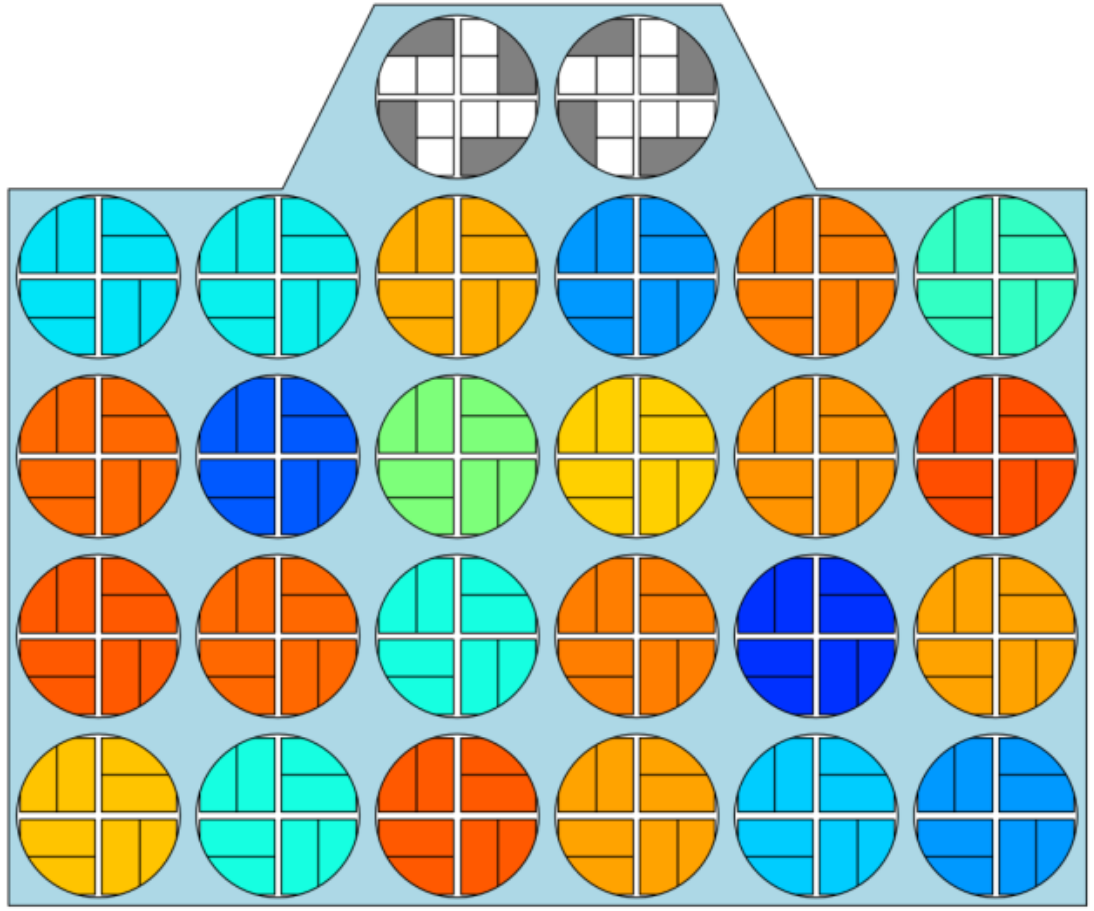
best focus temperature



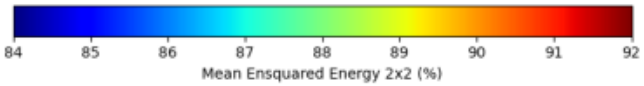
PLATO Instrument Performance Report (S. Niemi)

signal and noise

enclosed energy in 2x2 pixels



PLATO Instrument Performance Report (S. Niemi)



signal and noise

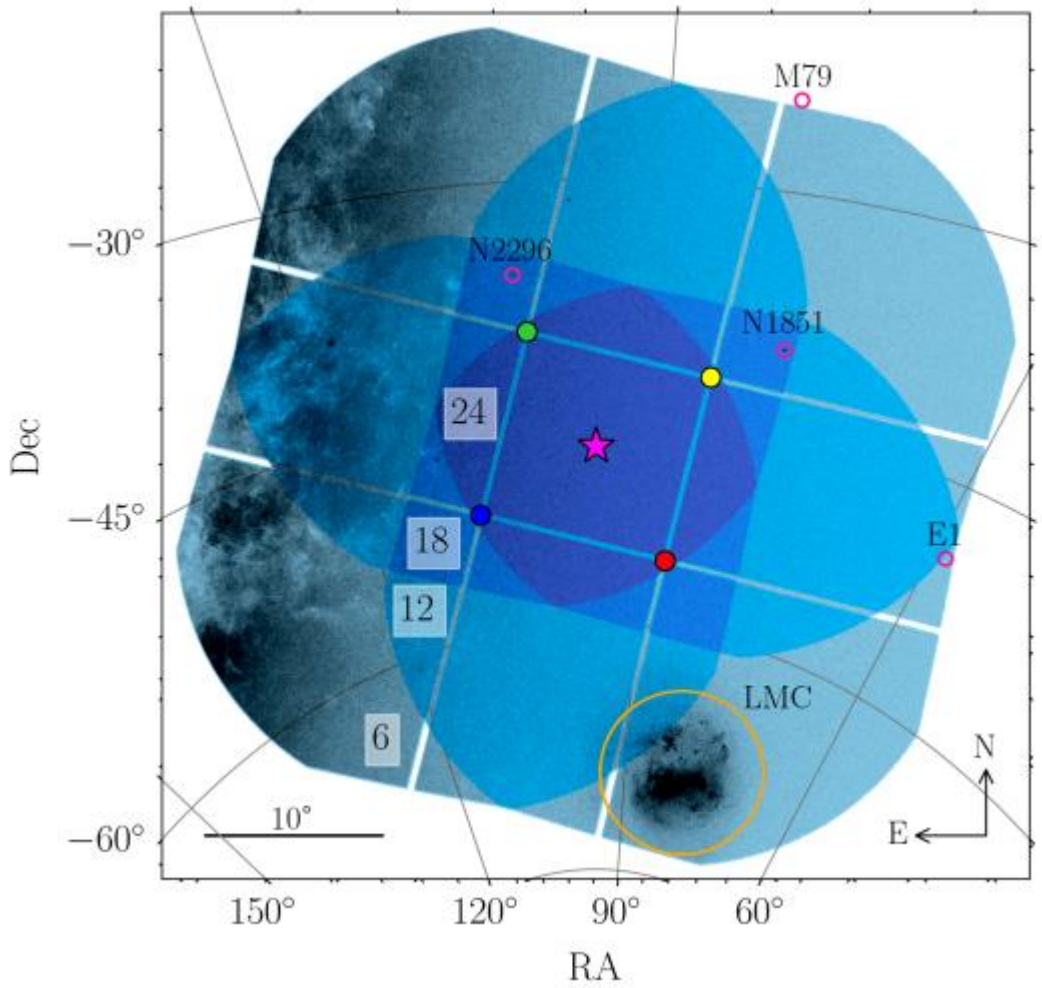
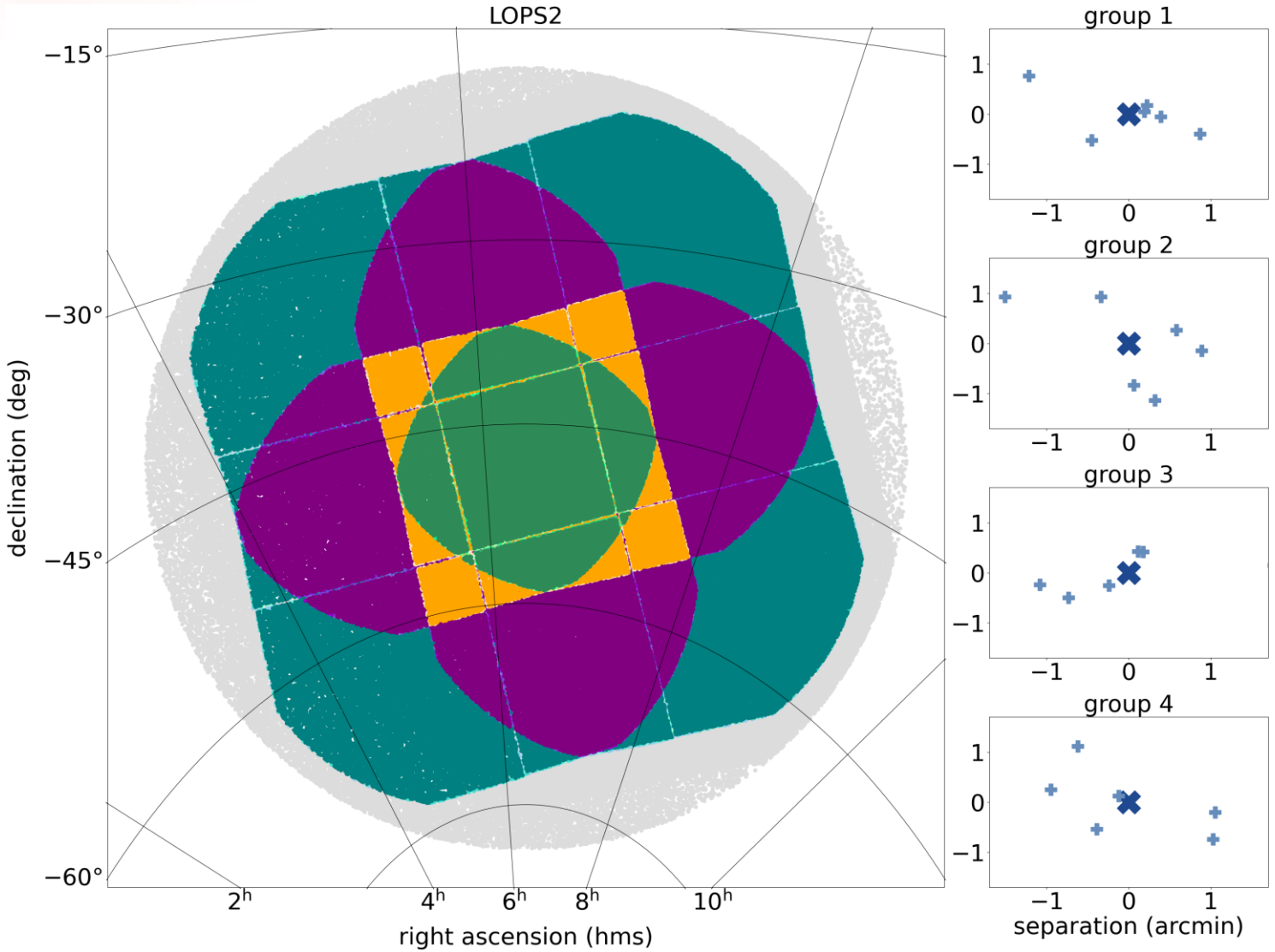


Fig. 1. Illustration of the first PLATO pointing field called LOPS2. The platform pointing (being parallel to the pointing of the two F-CAMs; see magenta star) is centred at the equatorial coordinate $(\alpha, \delta) = (95.310\,43°, -47.886\,93°)$, with zero rotation with respect to the Galactic equator. The N-CAM overlap of $n_{\mathrm{CAM}} \in \{6, 12, 18, 24\}$ is illustrated with an increasing darker shade of blue (also indicated in the white boxes), and the blue, green, yellow, and red dot show the pointing of N-CAM group one, two, three, and four, respectively. The black transparent map highlights dense sky regions such as the location of the Milky Way plane, the Large Magellanic Cloud (LMC, encircled in orange), and a few globular clusters (pink circles, from Harris 1996).

Jannsen et al. (2025)

signal and noise

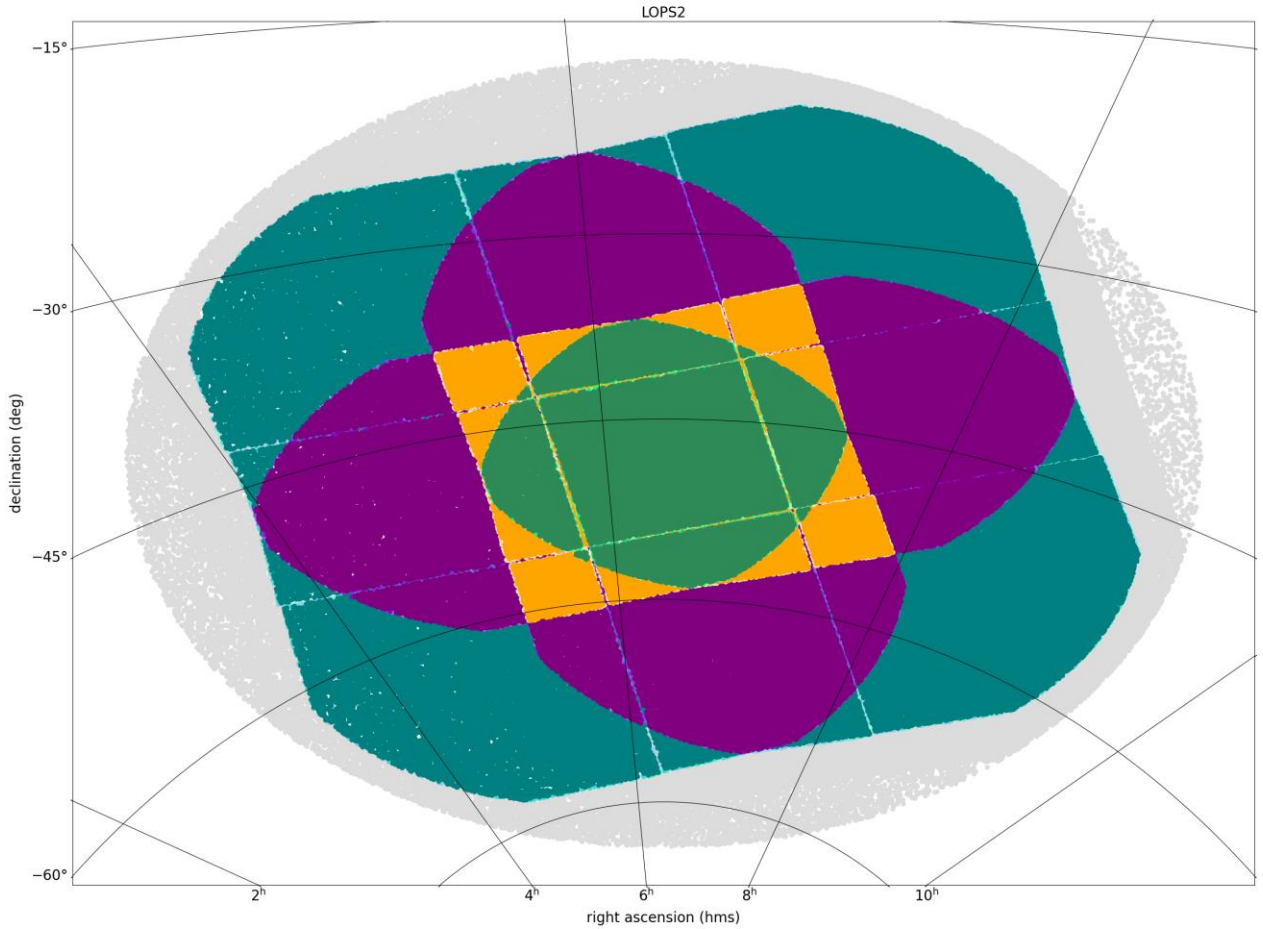


Left: Distribution of stars in PIC 2.1 overlaid with the number of cameras observing each star.

Right: misalignment of the individual camera boresight reference frame of each normal camera on the sky, as measured by the Prime on the optical bench.

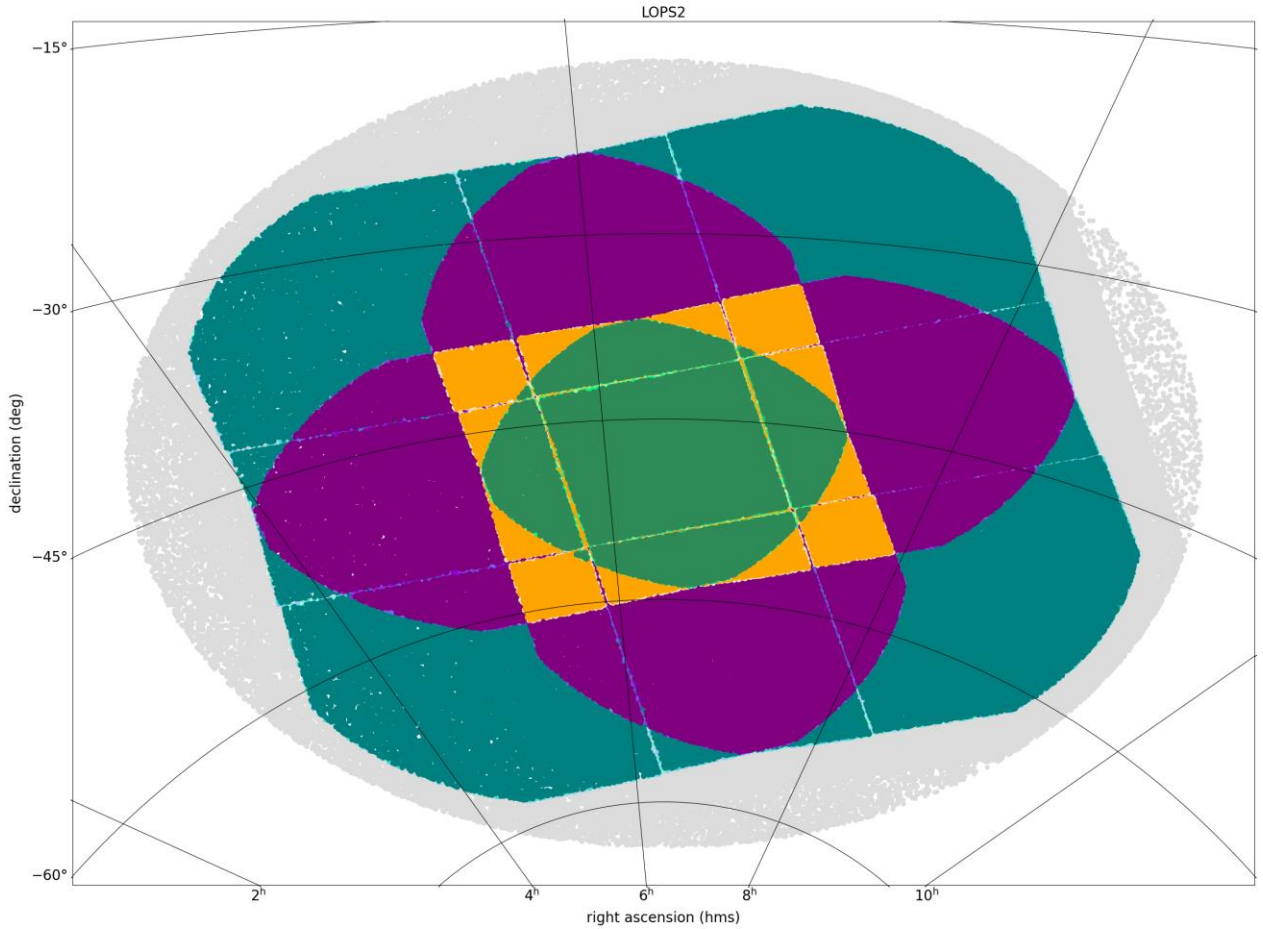
signal and noise

Q1
Feb.-April 2027 (TBC)



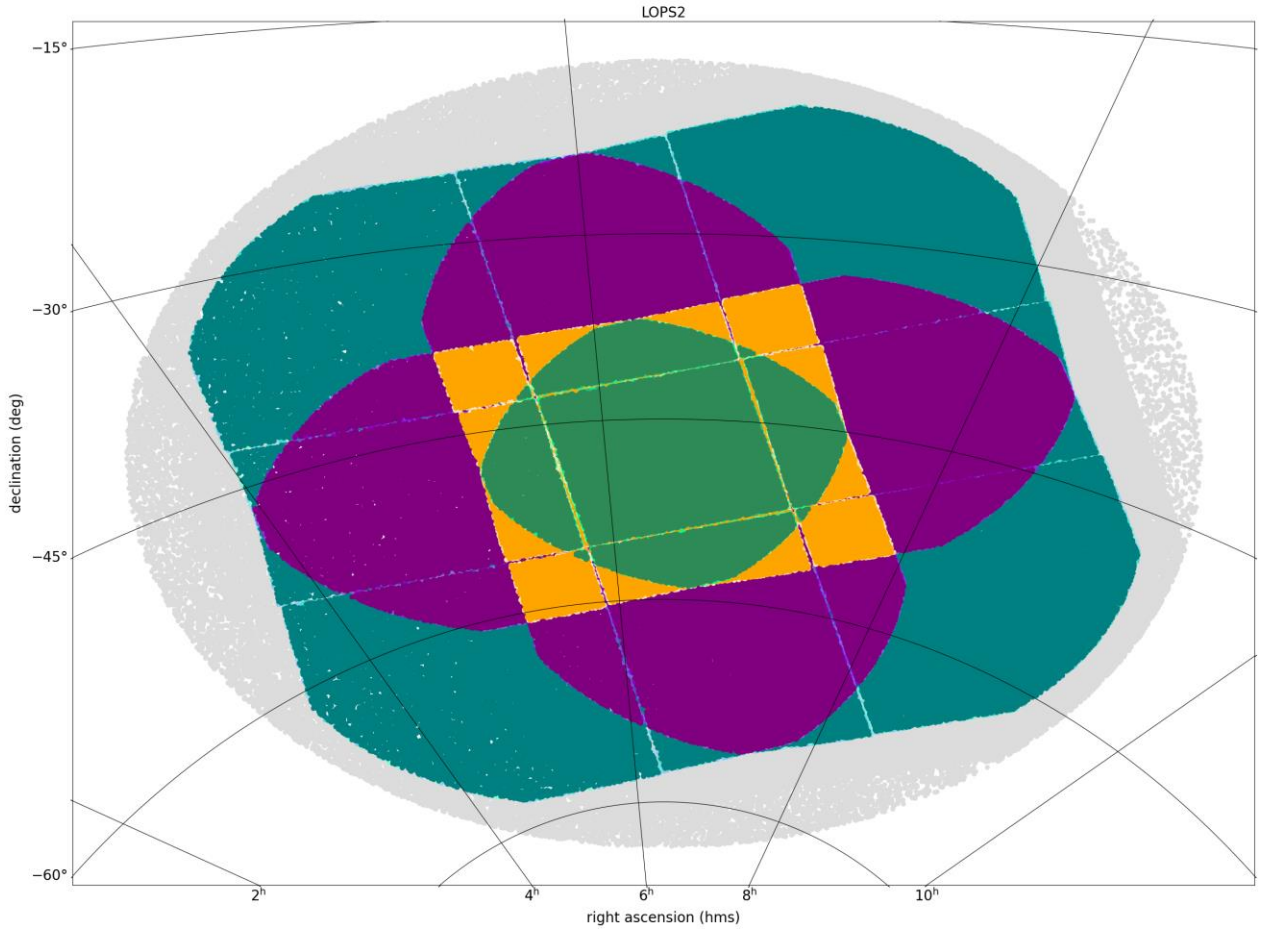
signal and noise

Q2
May.-July 2027 (TBC)



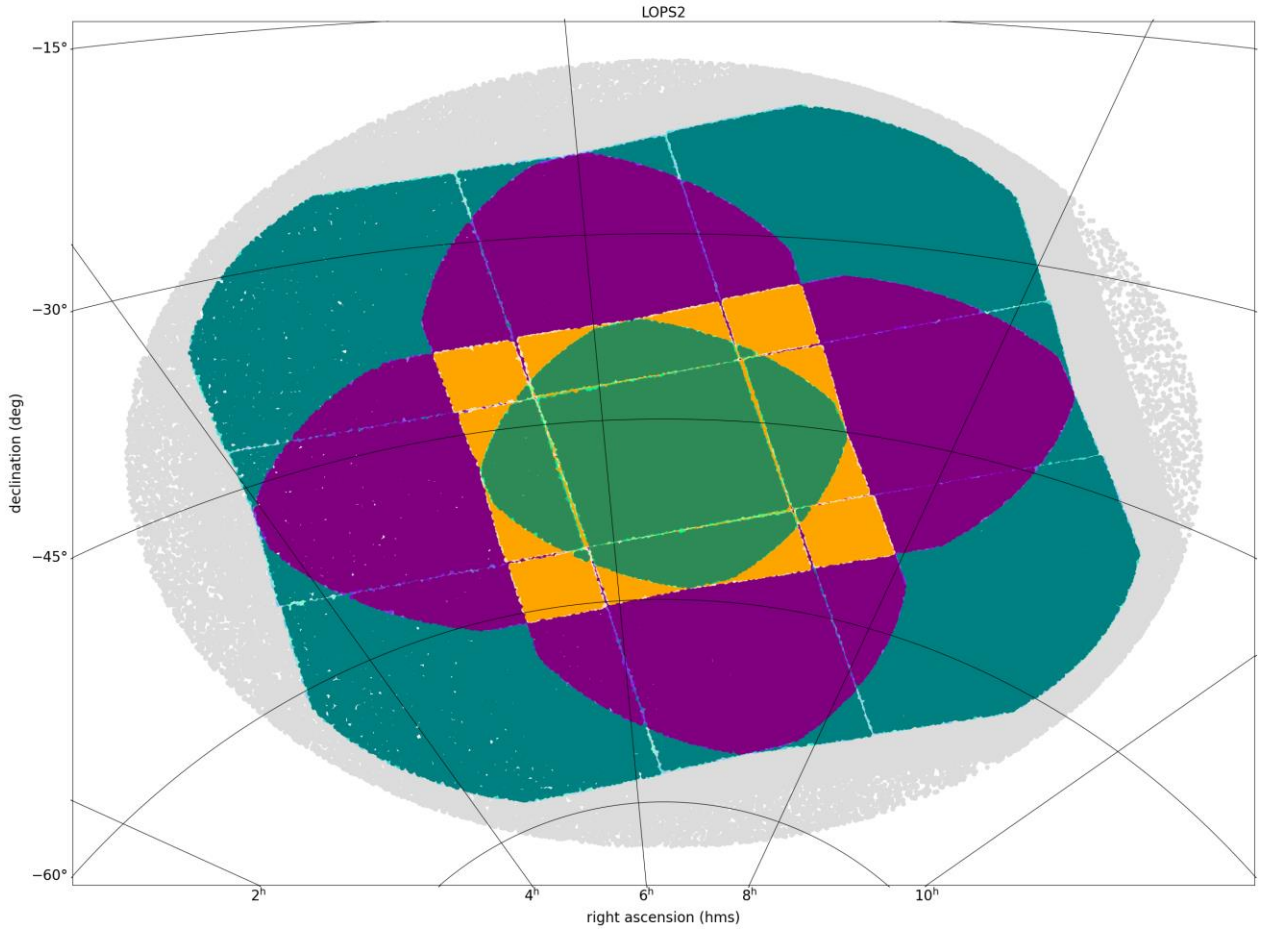
signal and noise

Q3
Aug.-Oct 2027 (TBC)



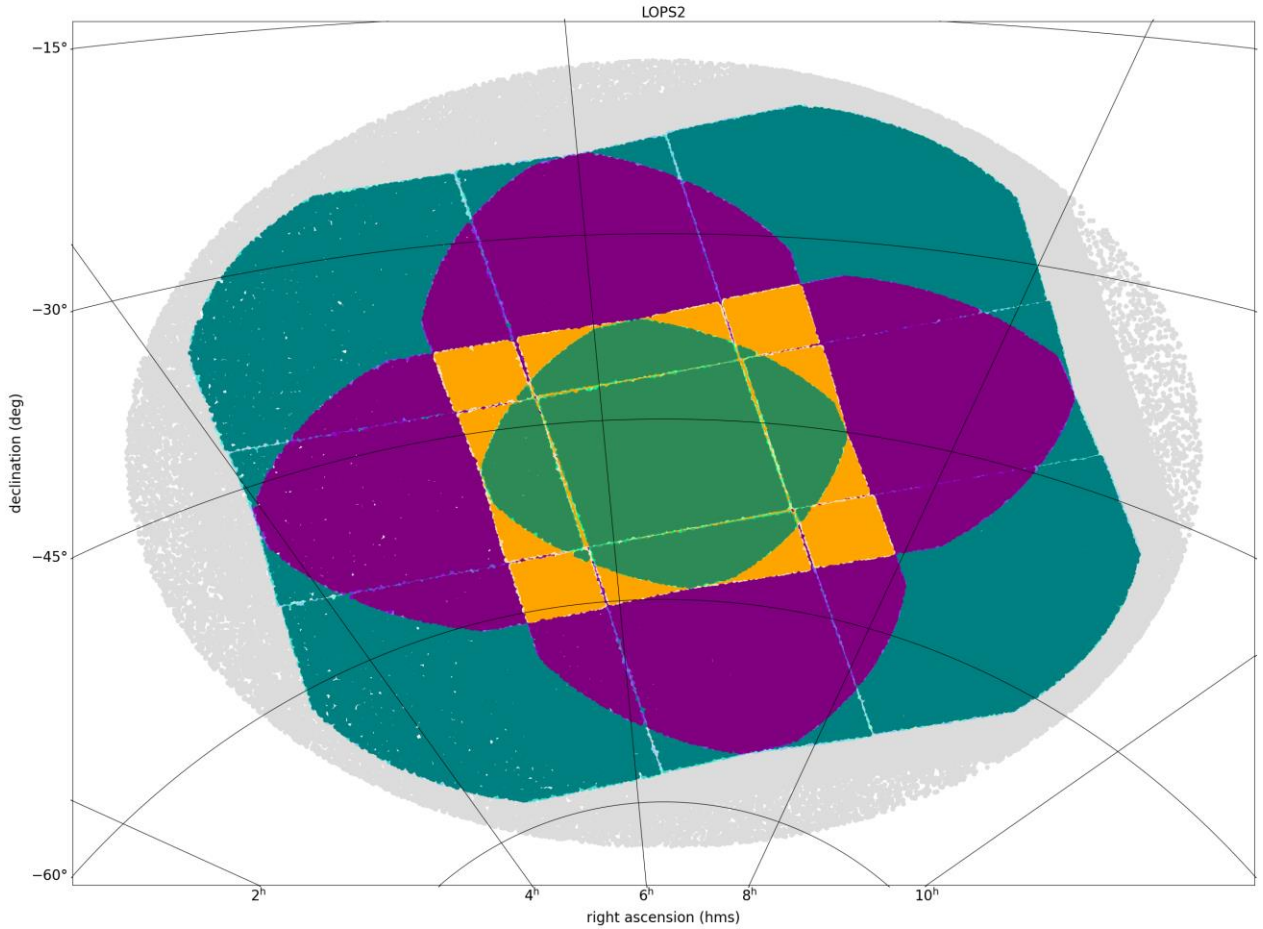
signal and noise

Q4
Nov. 2027-Jan 2028 (TBC)



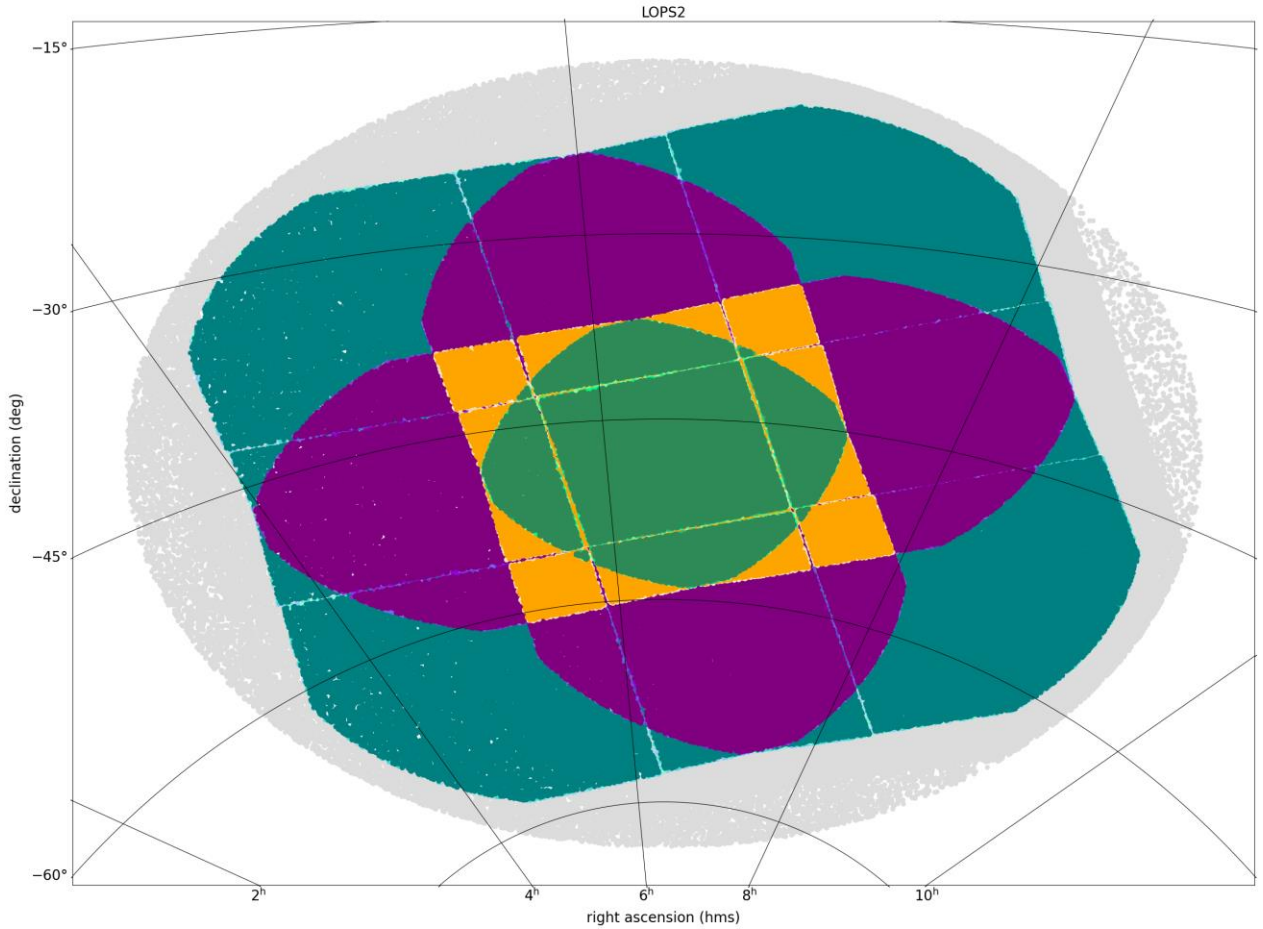
signal and noise

Q5
Feb.-April 2028 (TBC)



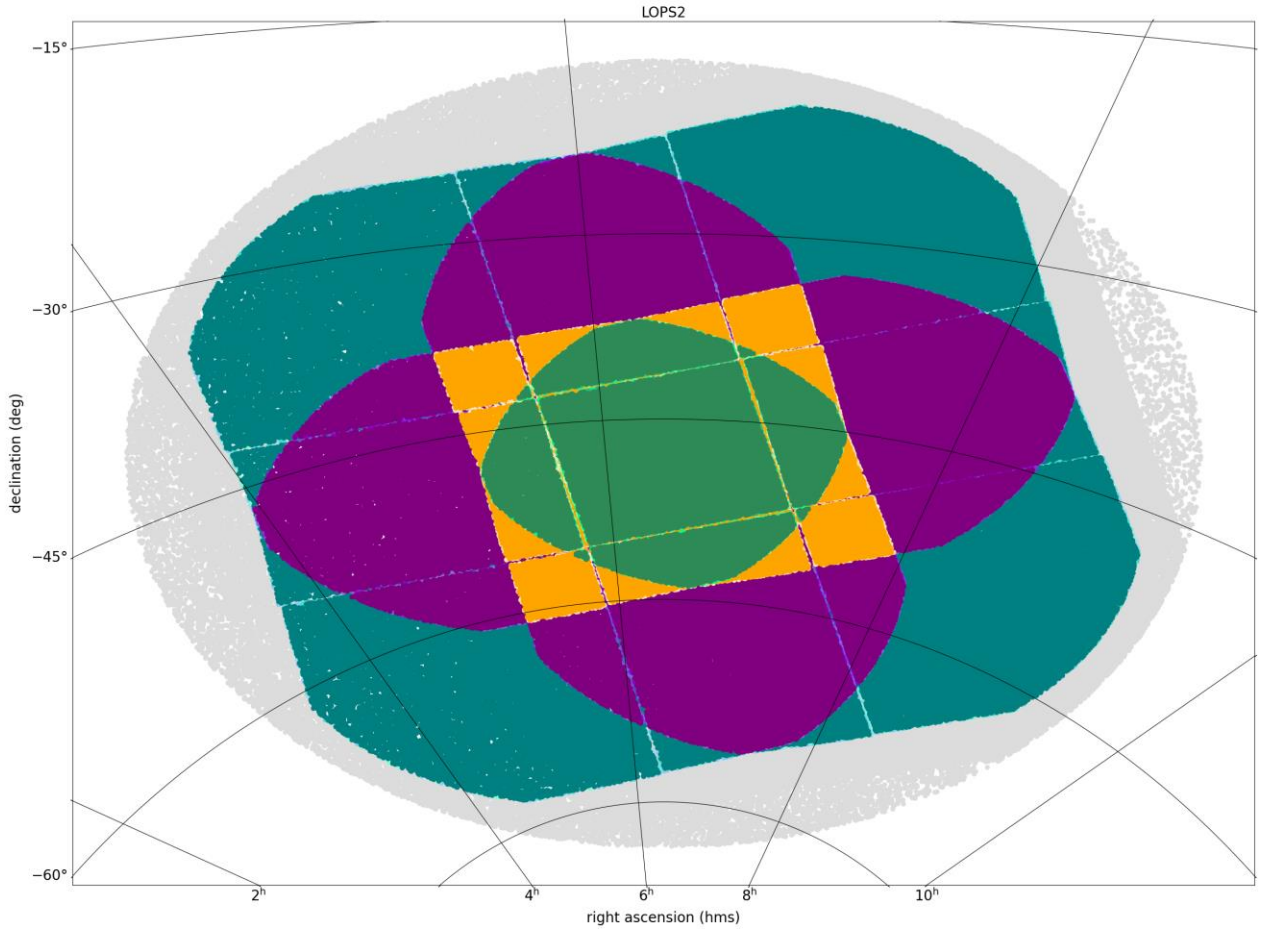
signal and noise

Q6
May.-July 2028 (TBC)



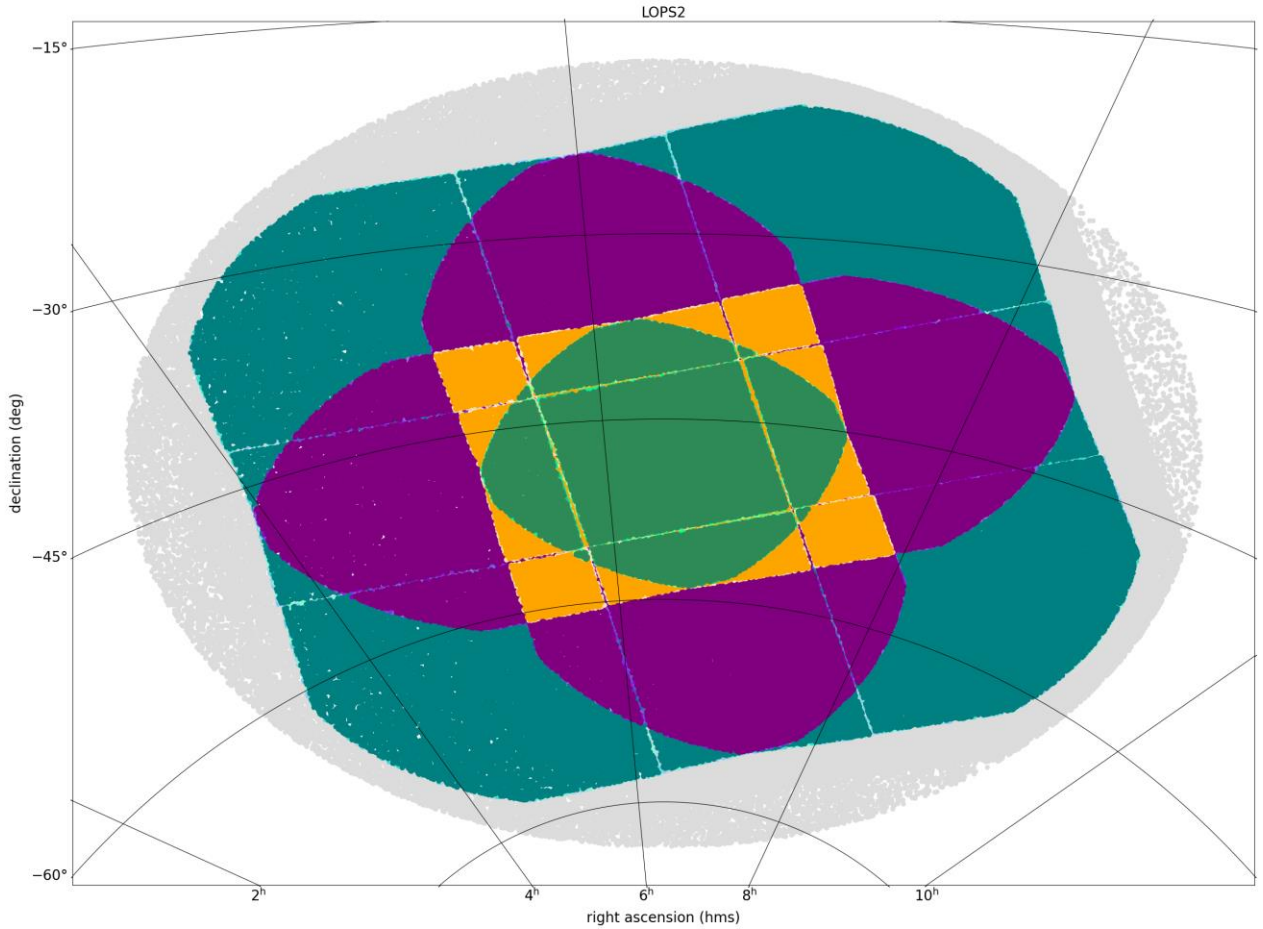
signal and noise

Q7
Aug.-Oct. 2028 (TBC)



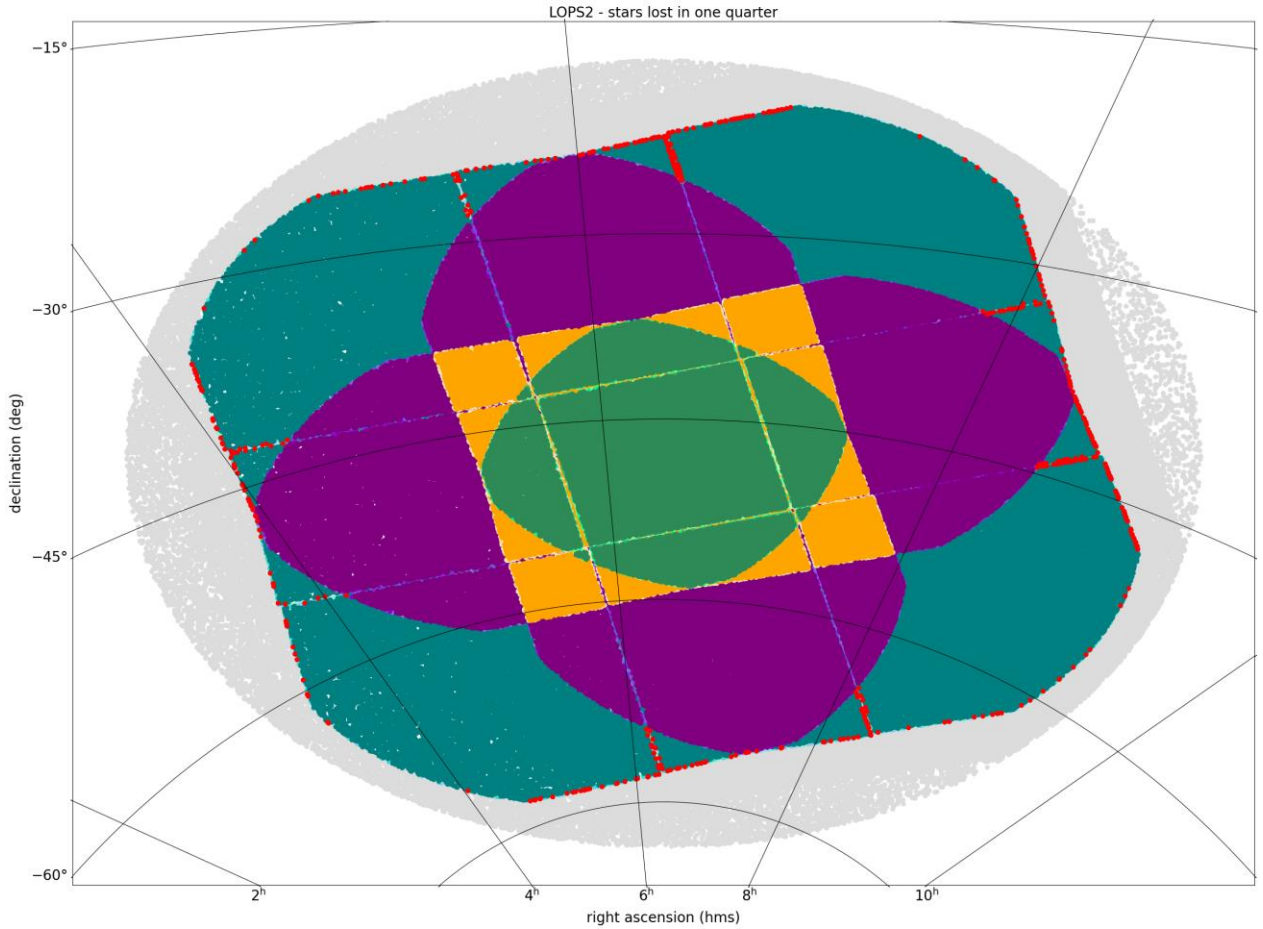
signal and noise

Q8
Nov.-Jan 2028 (TBC)



signal and noise

stars whose light curve would be interrupted by the misalignment of the cameras during at least one quarter (<1%).

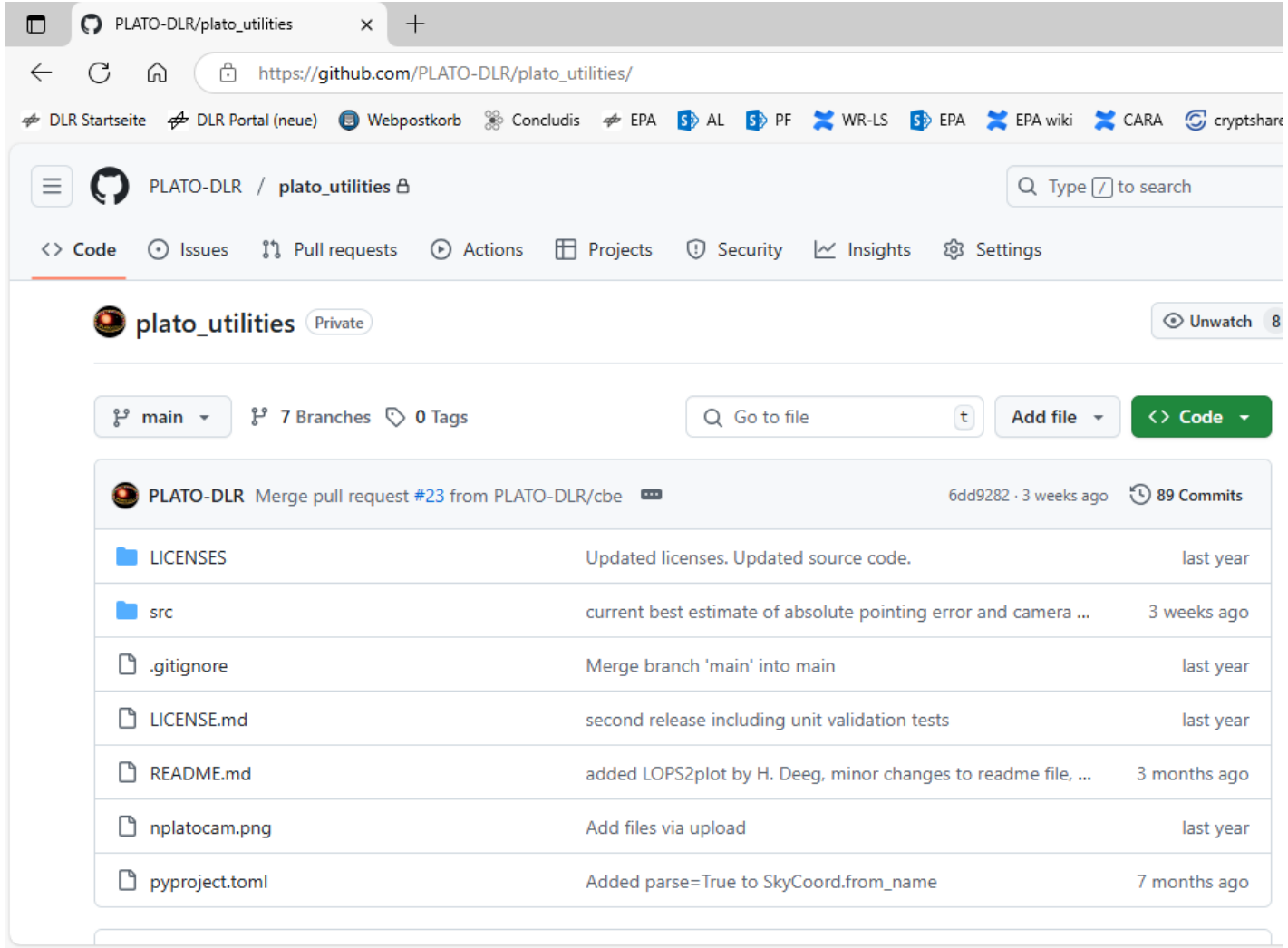


github repository

We make available to PLATO Mission Consortium members tools developed by the PLATO Performance Team:

- To compute how targets fall on the FoV.
- To compute instrument response.
- To interface the PIC.
- Etc.

contact:
`simulations-helpdesk@dlr.de`



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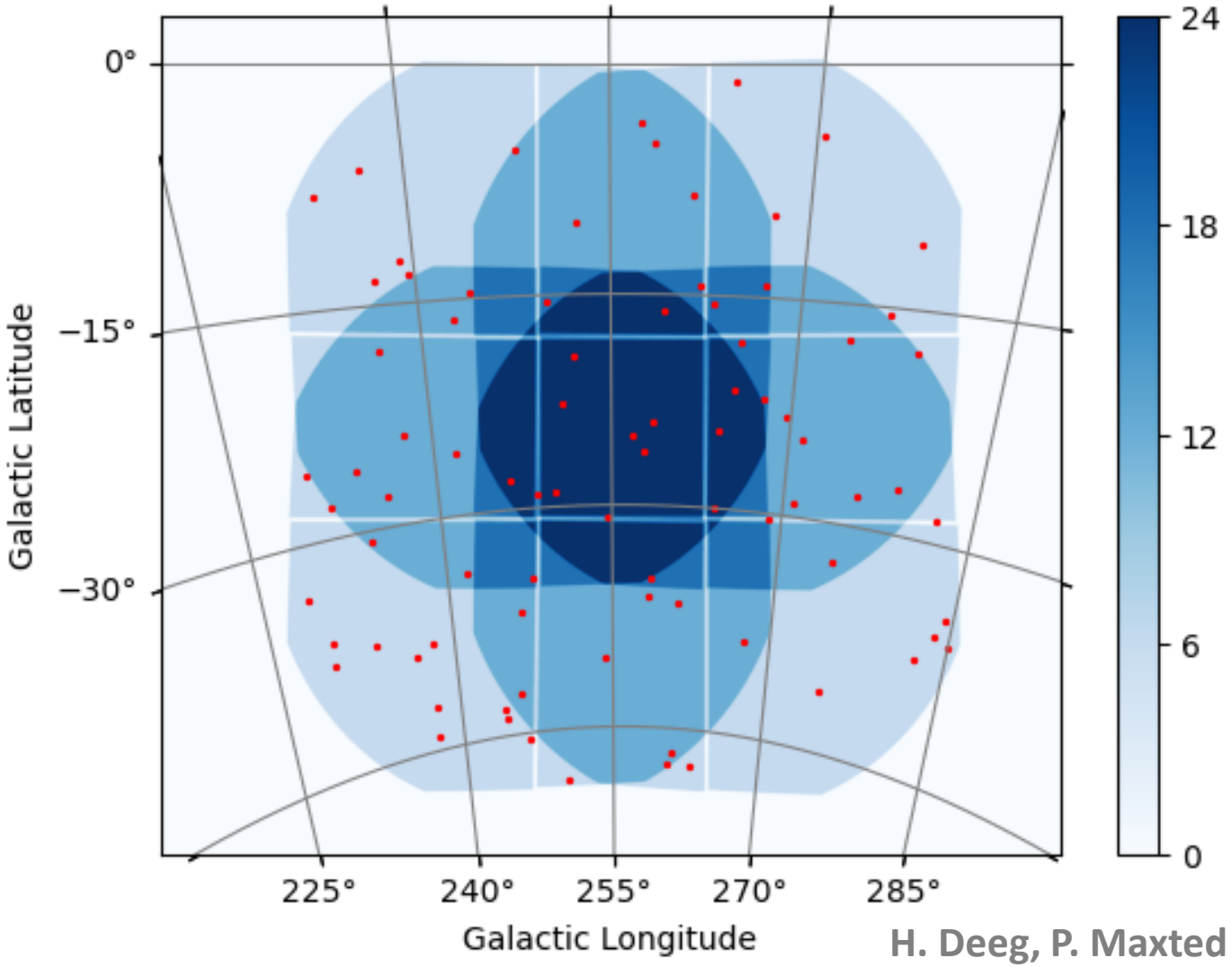
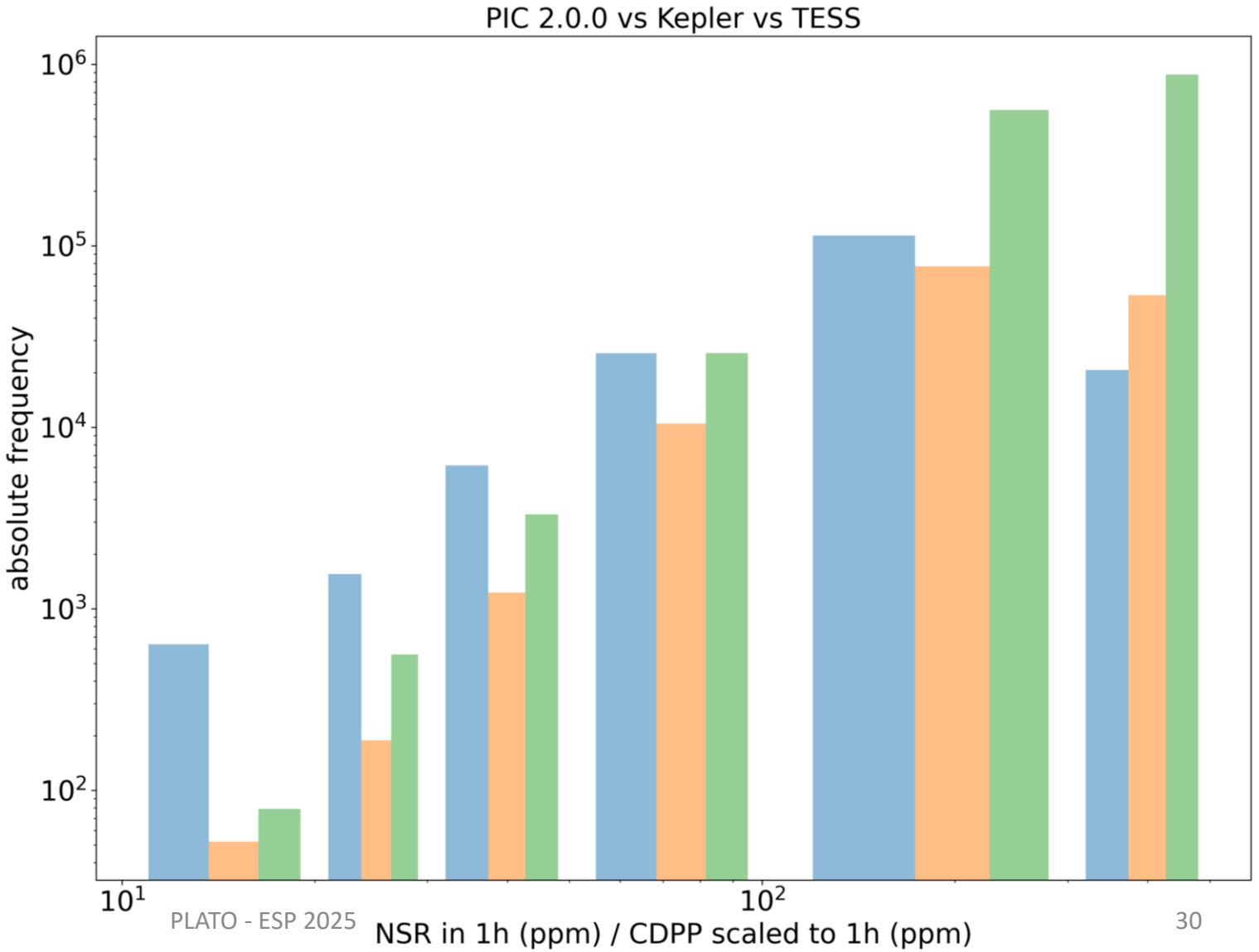


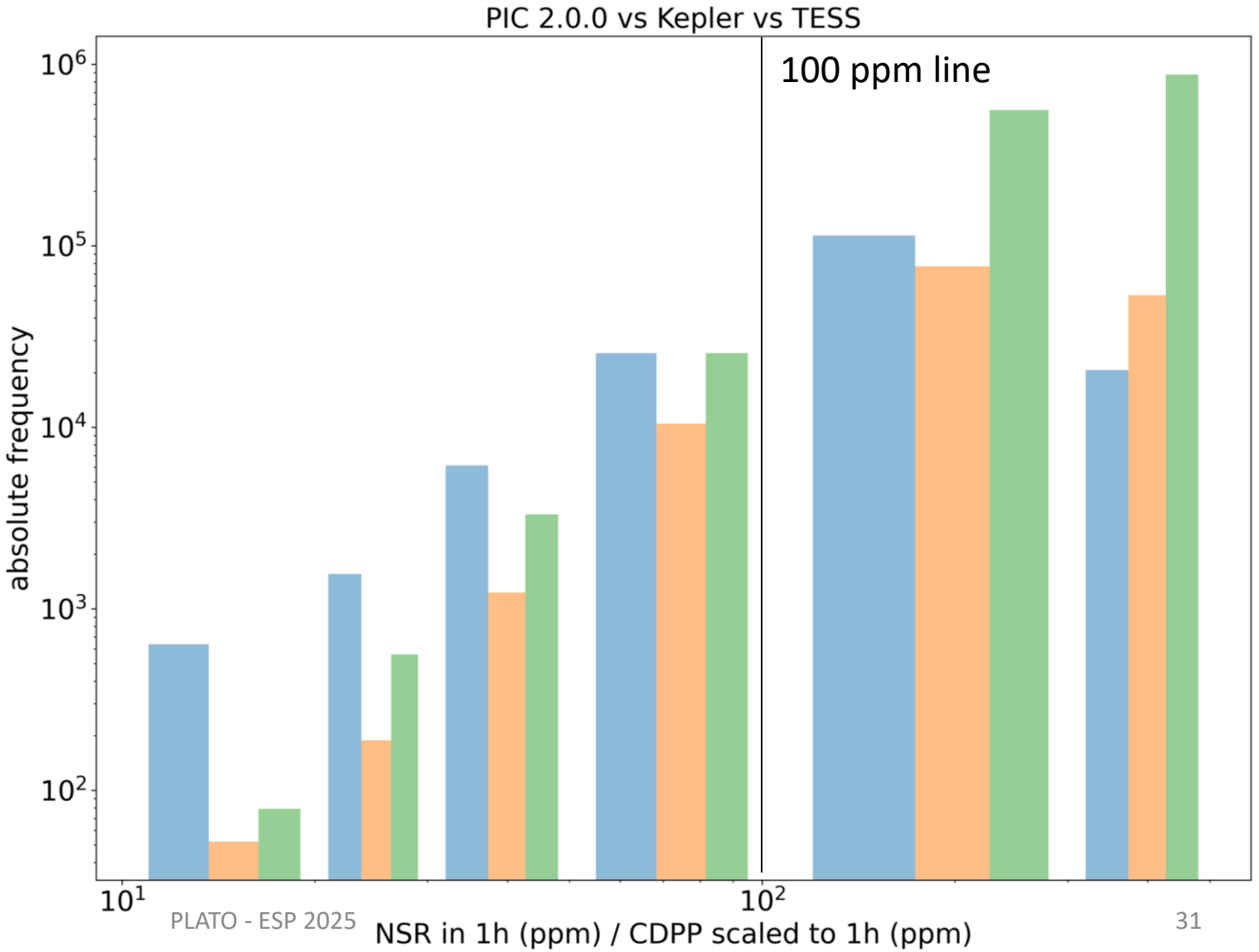
H. Deeg, P. Maxted

signal and noise budget



in this presentation, ppm in 1h should be understood as ppm/sqrt(1h) in the Fourier domain

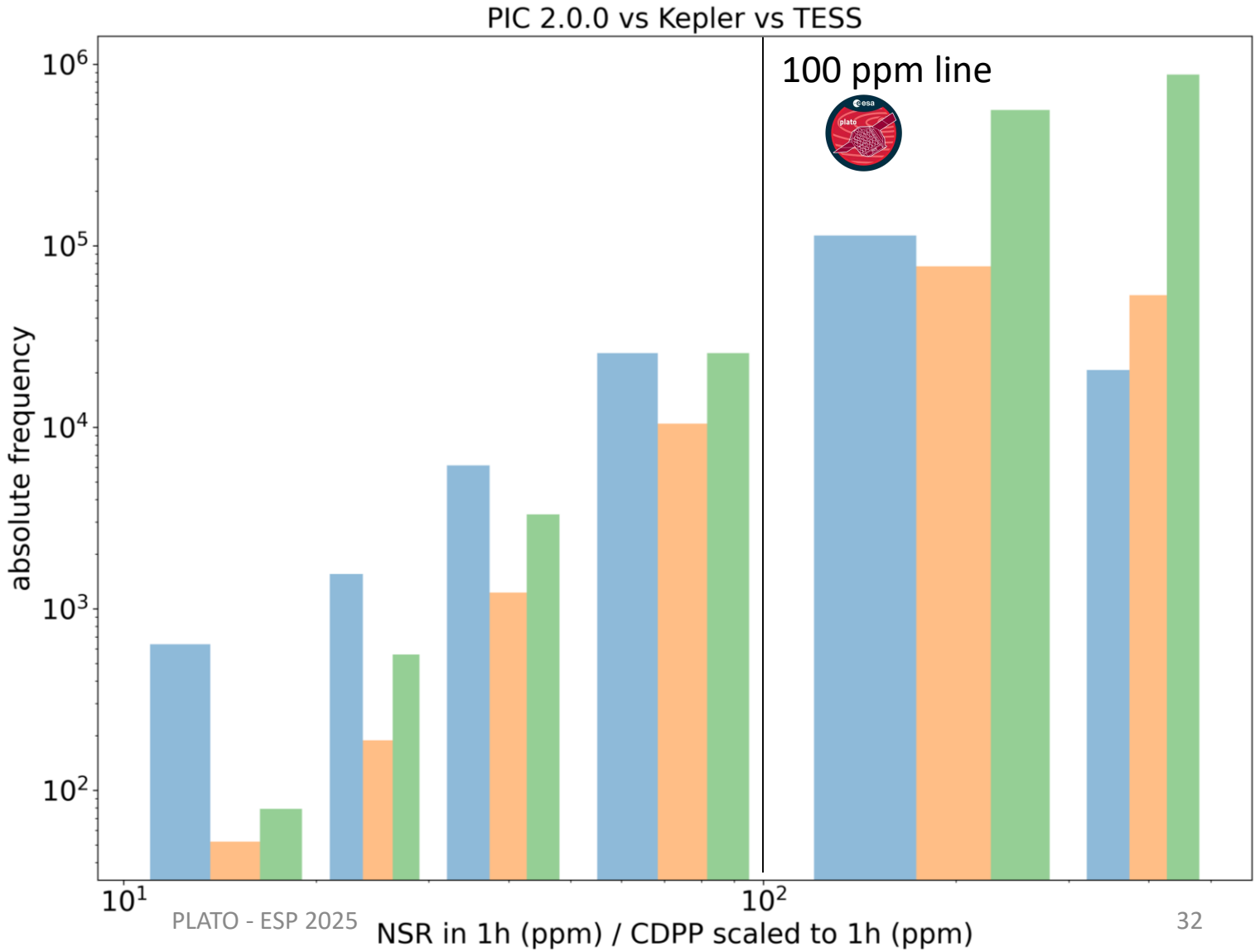
signal and noise budget



in this presentation, ppm in 1h should be understood as ppm/sqrt(1h) in the Fourier domain

signal and noise budget

tPIC 2.0.0

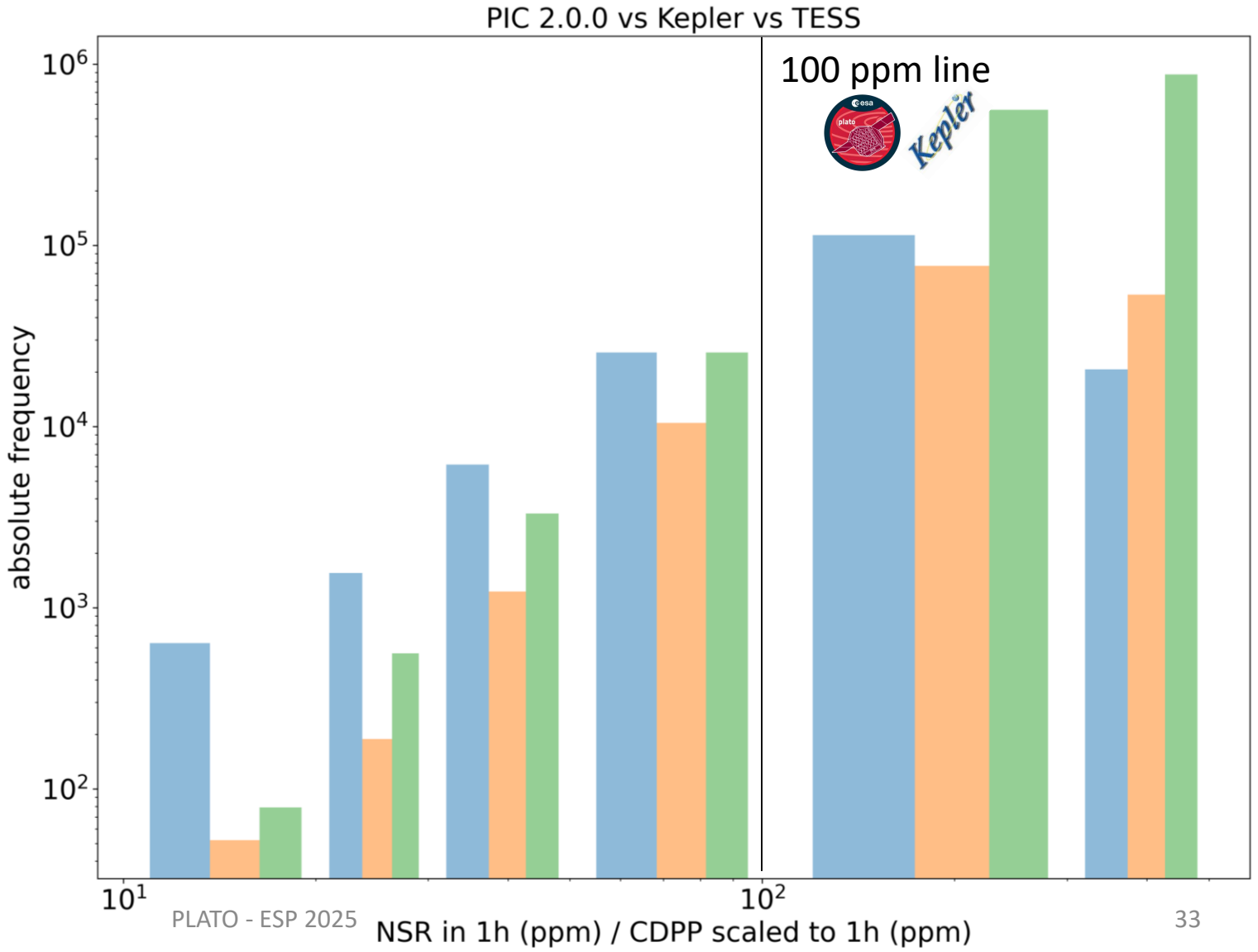


in this presentation, ppm in 1h should be understood as ppm/sqrt(1h) in the Fourier domain

signal and noise budget

tPIC 2.0.0

CDPP from Q3
(Christiansen et al. 2012)



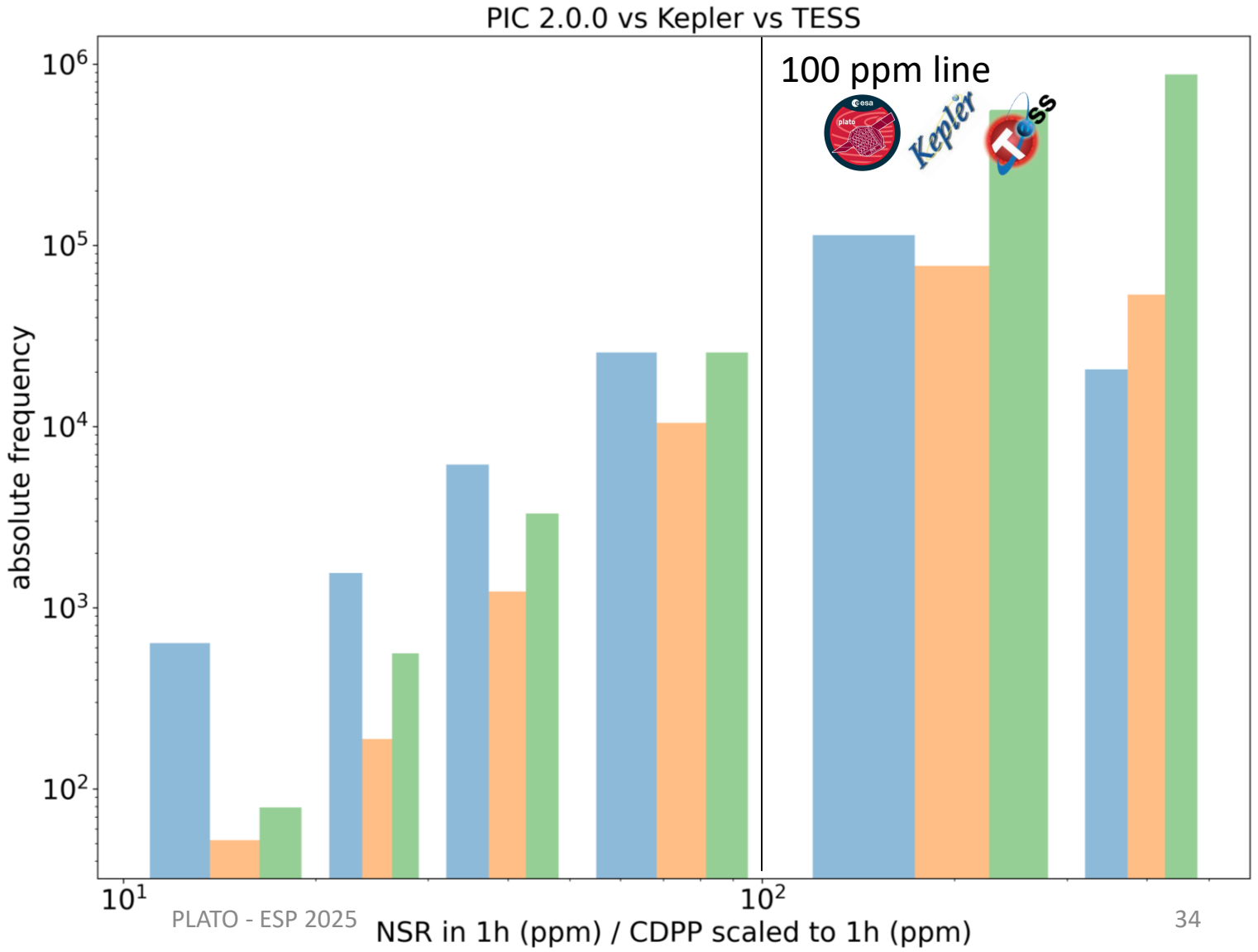
in this presentation, ppm in 1h should be understood as ppm/sqrt(1h) in the Fourier domain

signal and noise budget

tPIC 2.0.0

CDPP from Q3
(Christiansen et al. 2012)

SPOC CDPP
Sectors 1 to 28



in this presentation, ppm in 1h should be understood as ppm/sqrt(1h) in the Fourier domain

signal and noise budget

tPIC 2.0.0

CDPP from Q3
(Christiansen et al. 2012)

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(ice)giant planet population studies

seismology of giant stars

longer baseline than TESS!

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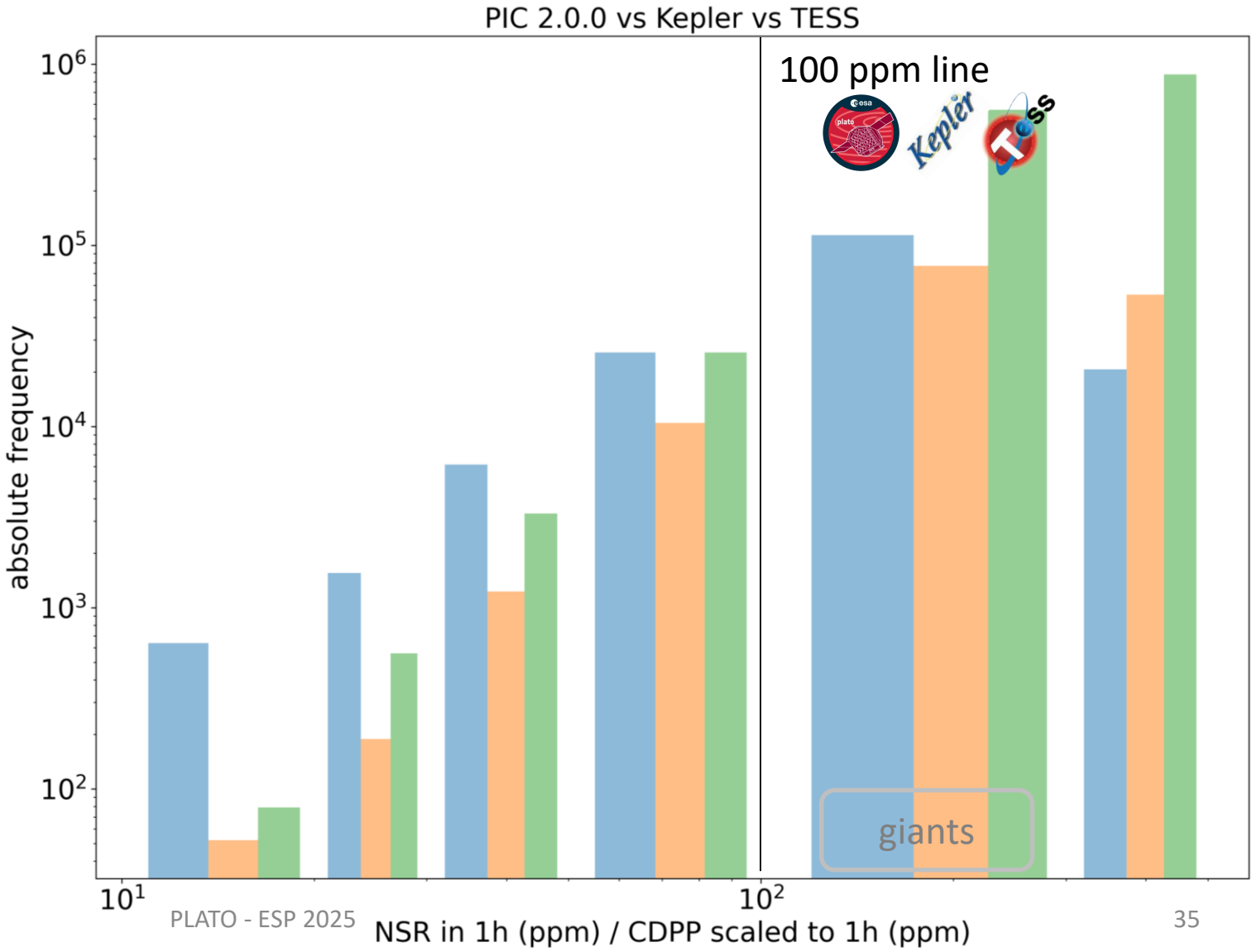

signal and noise budget

tPIC 2.0.0

CDPP from Q3
(Christiansen et al. 2012)

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Sectors 1 to 28

small planet population studies

seismology of evolved stars

longer baseline than TESS!

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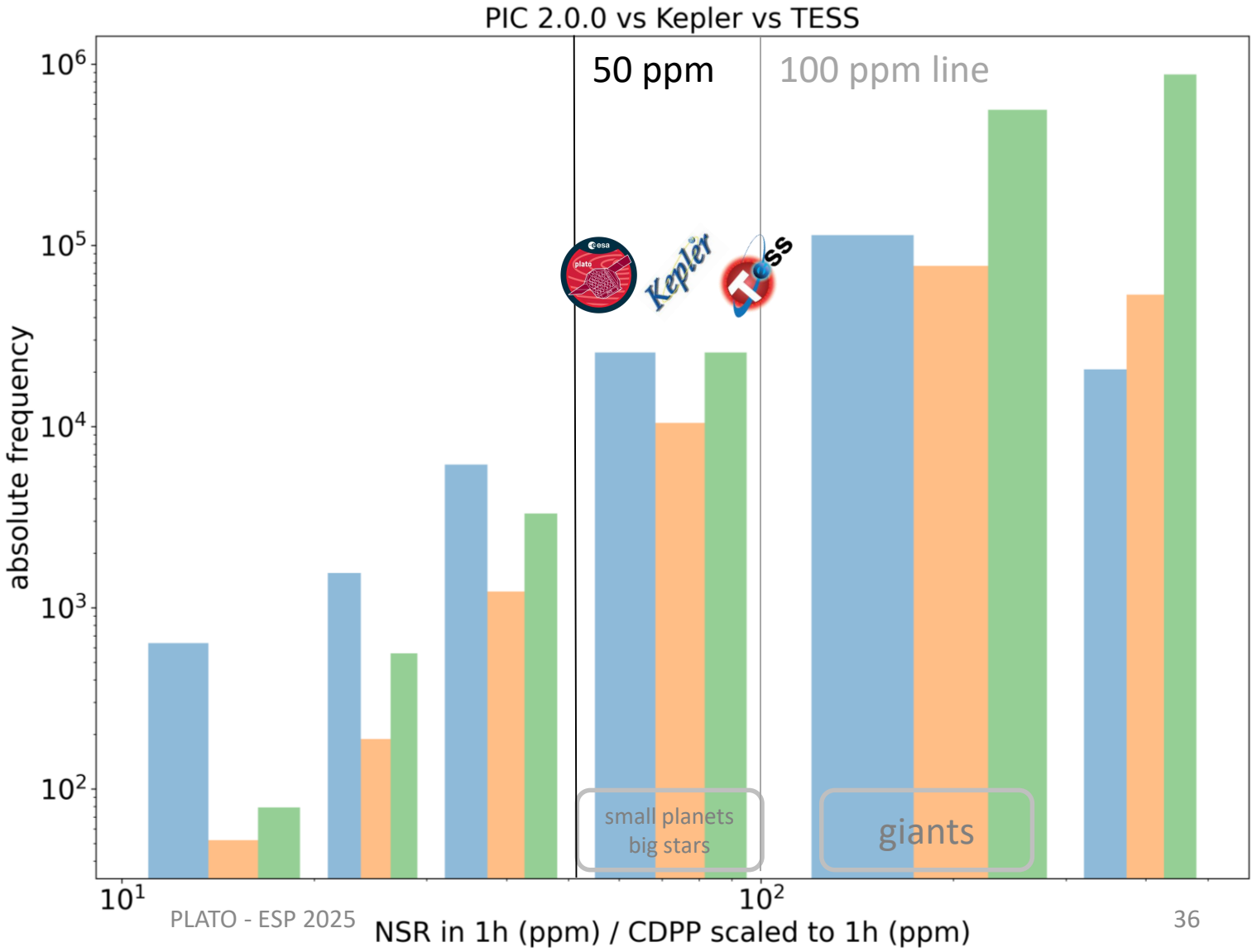

signal and noise budget

tPIC 2.0.0

CDPP from Q3
(Christiansen et al. 2012)

SPOC CDPP
Sectors 1 to 28

Earth around the Sun

seismology of Sun-like stars

longer baseline than TESS!

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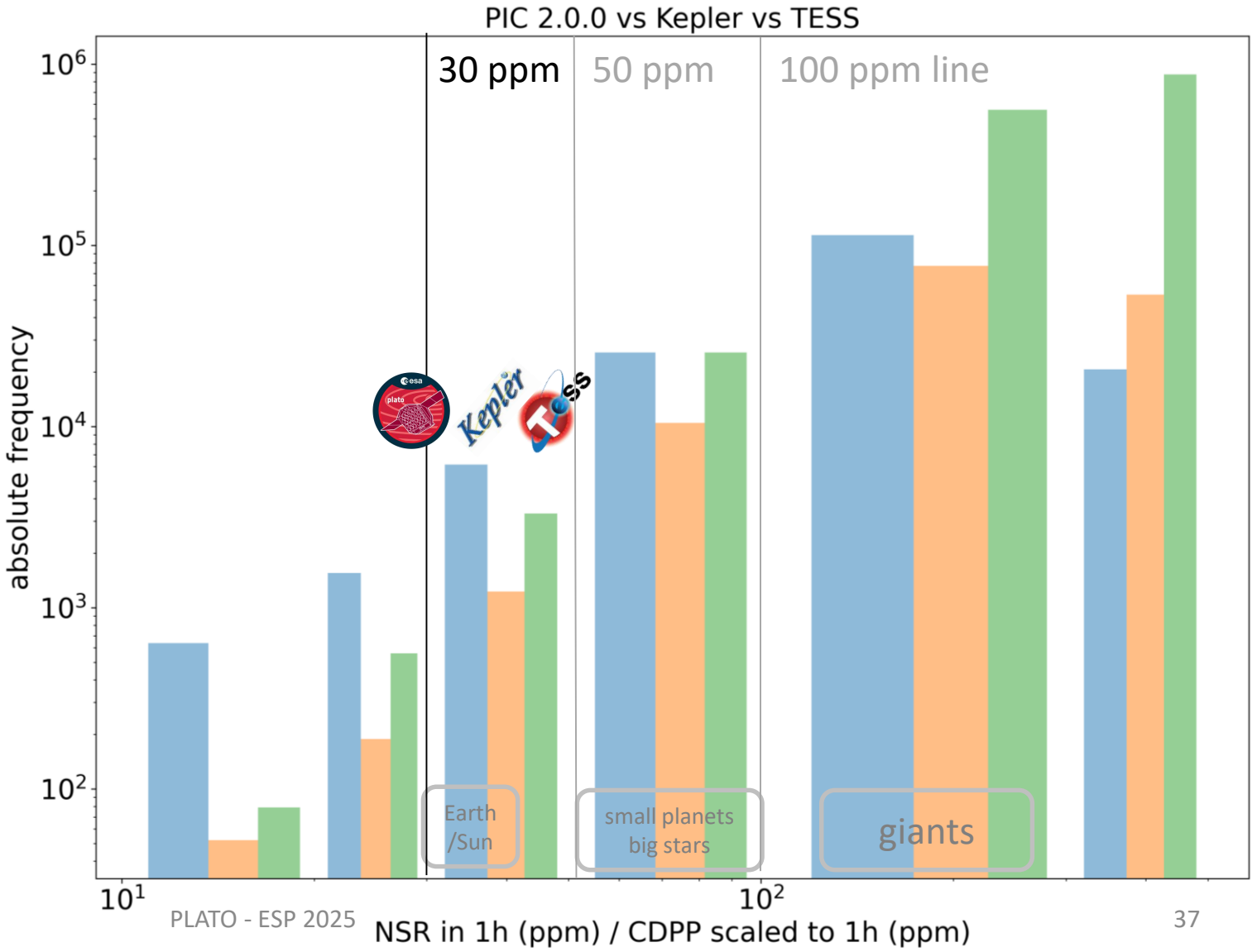

signal and noise budget

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CDPP from Q3
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SPOC CDPP
Sectors 1 to 28

new

new

unprecedented photometric precision

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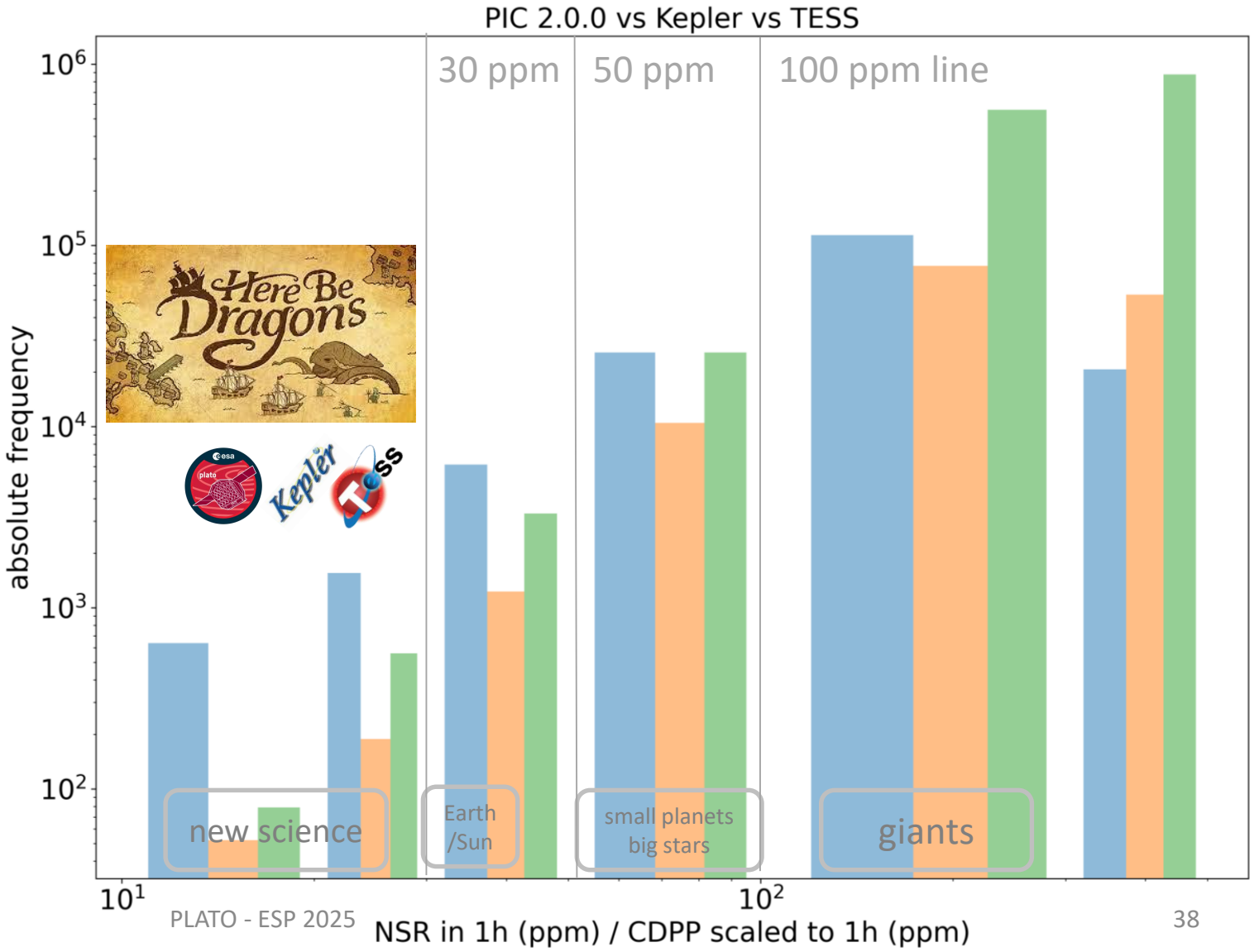

signal and noise budget

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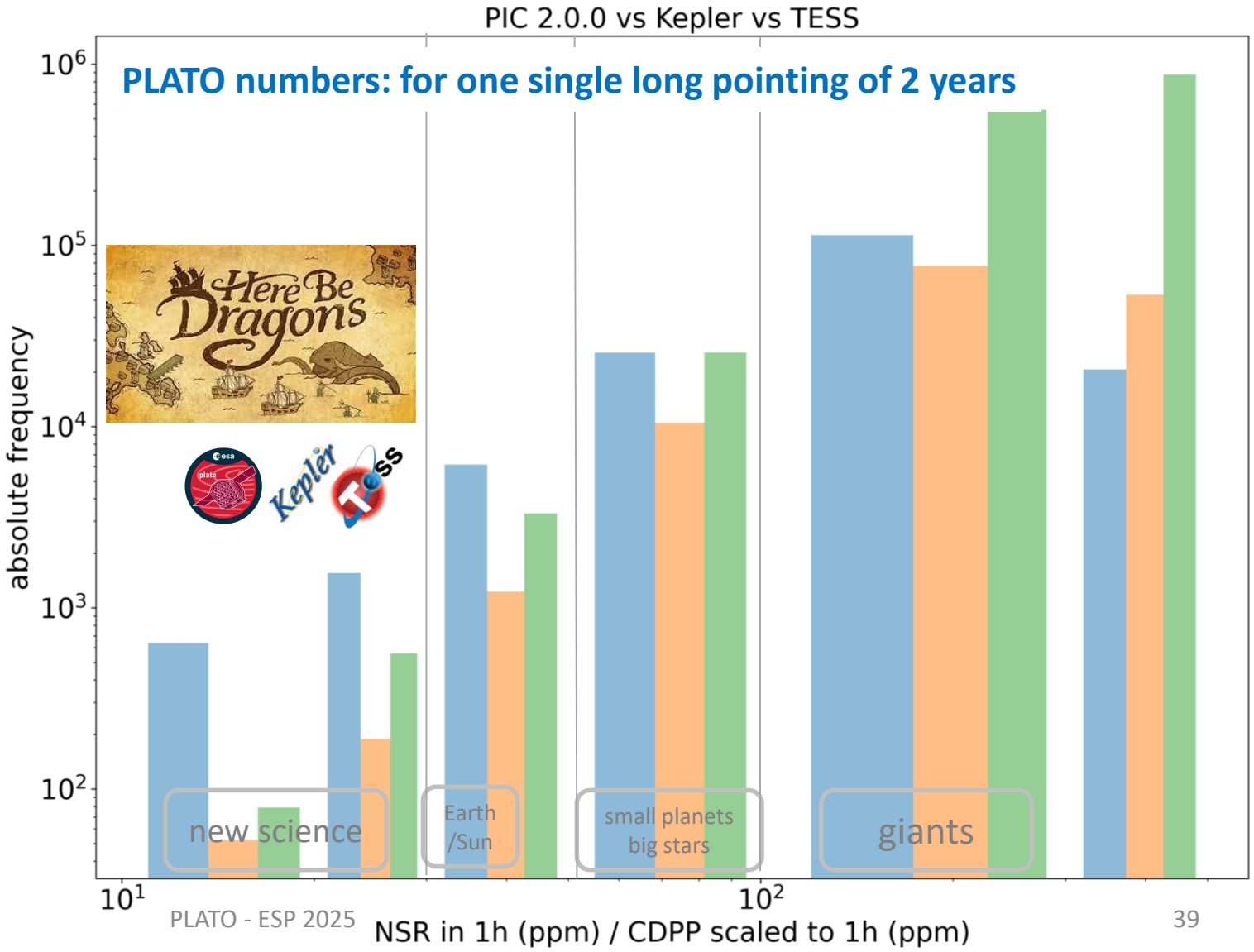

summary: 553

- The PLATO Consortium has **designed**, **integrated**, **tested**, and **delivered** all the cameras that will fly in 2026
- The Prime has completed the integration of the cameras on the **optical bench** of the spacecraft.
- All cameras tested so far are **compliant** with the strict noise **requirements** at mission level.
  - In particular, we shall be able to **focus** the cameras and optimize the PSF size for the **photometry**.
- The results from the test campaign increase our confidence on the performance simulations carried out in the past:
  - With the information today, **PLATO shall be able to meet its science goals for planet and star characterization**.
- The bulk of the consortium activities in the next **one and a half years** will be on the ground segment implementation and validation.

a big thank you to the formidable team supporting the PLATO mission