

PLATO+CHEOPS synergy

David Ehrenreich

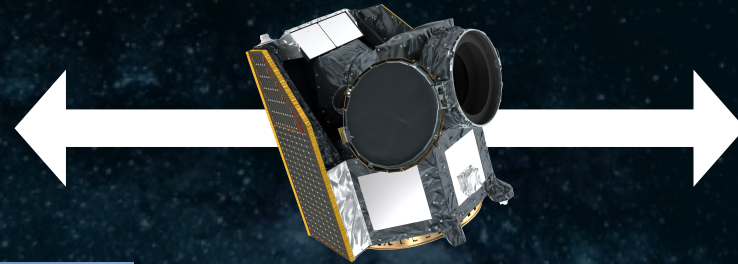
PLATO GOP meeting, Genève • 19 October 2022



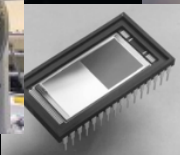
CHEOPS: First “S”-class mission

- Ultrahigh-precision photometer for exoplanet science
- Partnership

- Launching state
- Mission architect
- Launch services
- Platform procurement
- CCD procurement
- Space debris service
- Guest Observers Programme



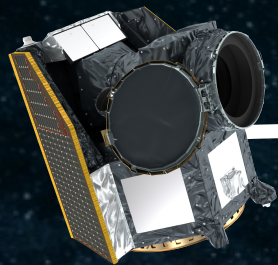
- Mission concept
- Instrument design, manufacture, calibration
- Spacecraft operations
- Science operations
- Guaranteed Time Observations



→ THE EUROPEAN SPACE AGENCY

CHEOPS operations

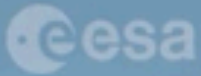
From Mission Operations Centre...



CHEOPS operations

...to Science Operations Centre





- Data Processing
- Archiving & community access to data
- Scheduling all observations
- Creating activity plans for MOC

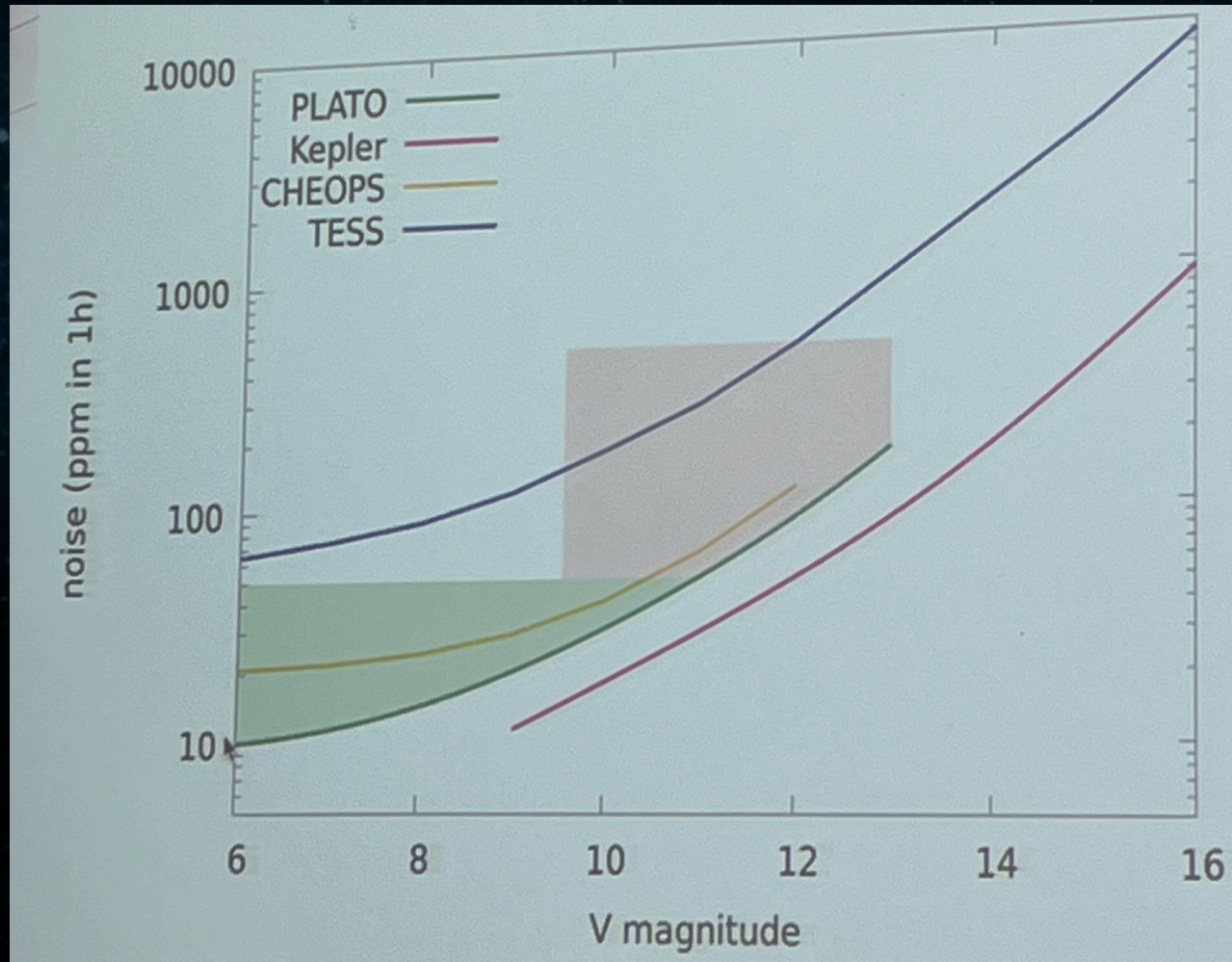


CHEOPS is in optimal shape

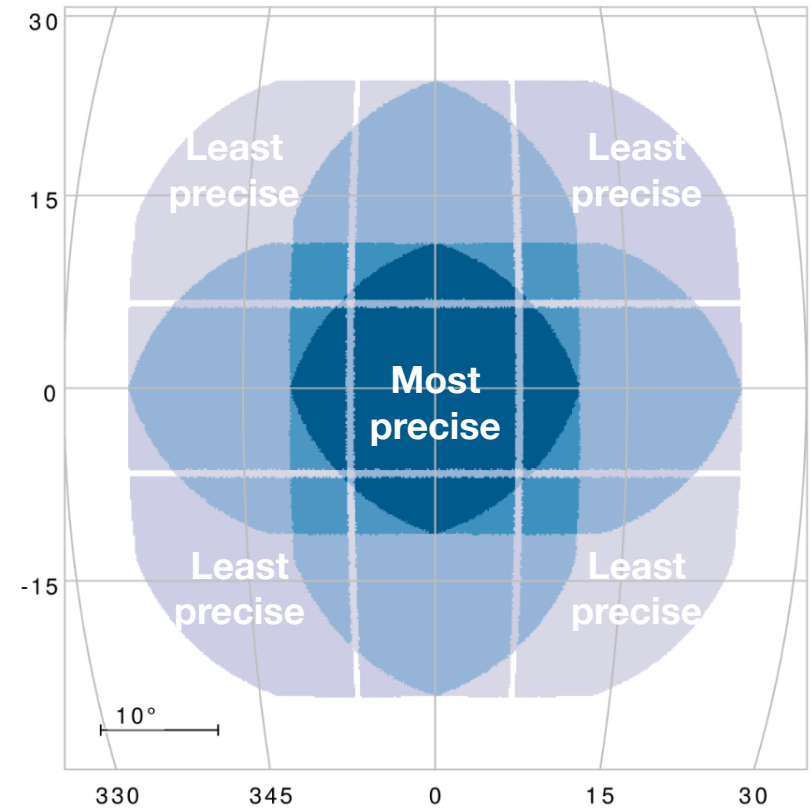
- Mission & science operations are nominal
- Space & ground segments are in excellent shape + at full redundancy
- Operational performances are excellent
- Science performances are excellent and will remain so for the foreseeable future



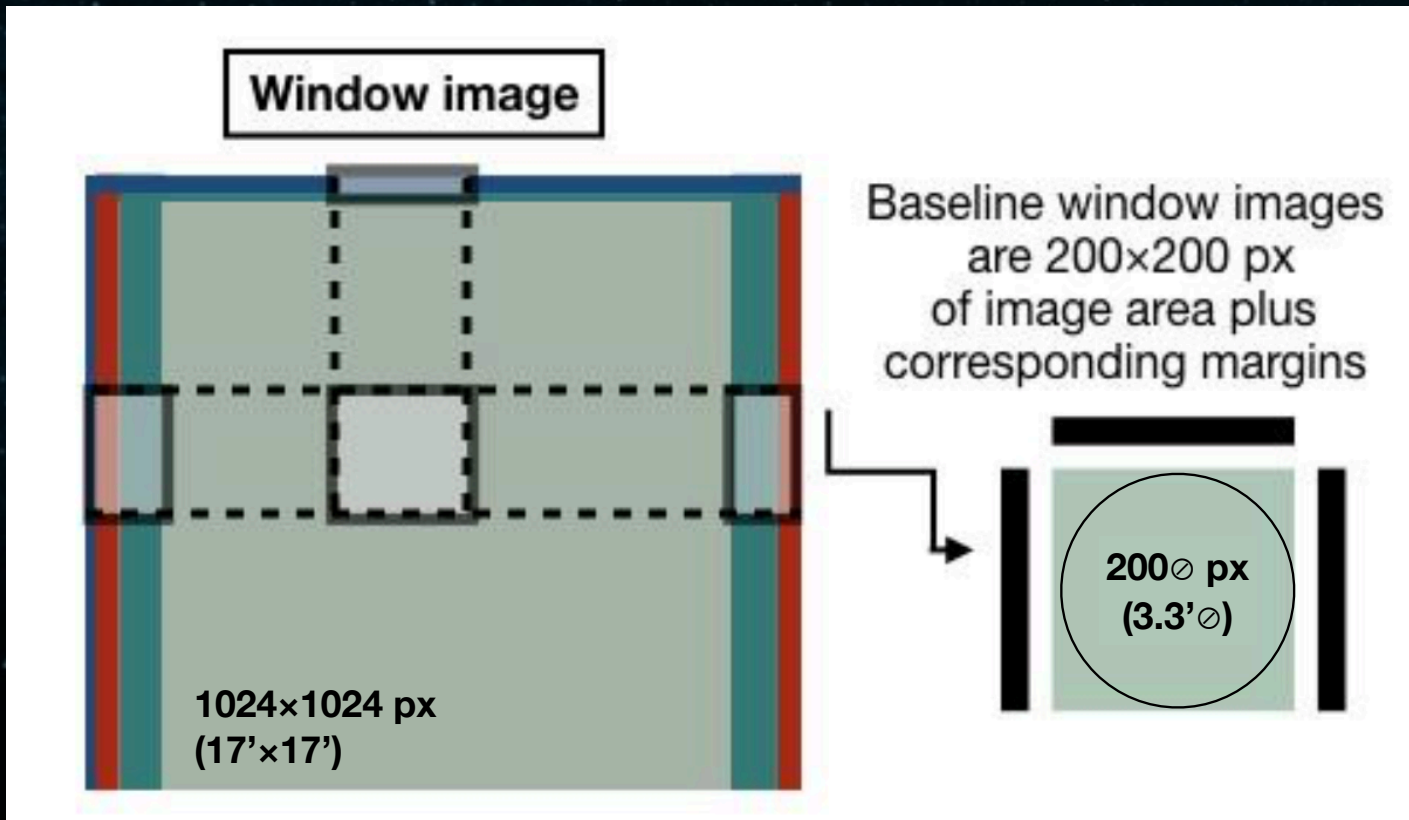
Photometric performance



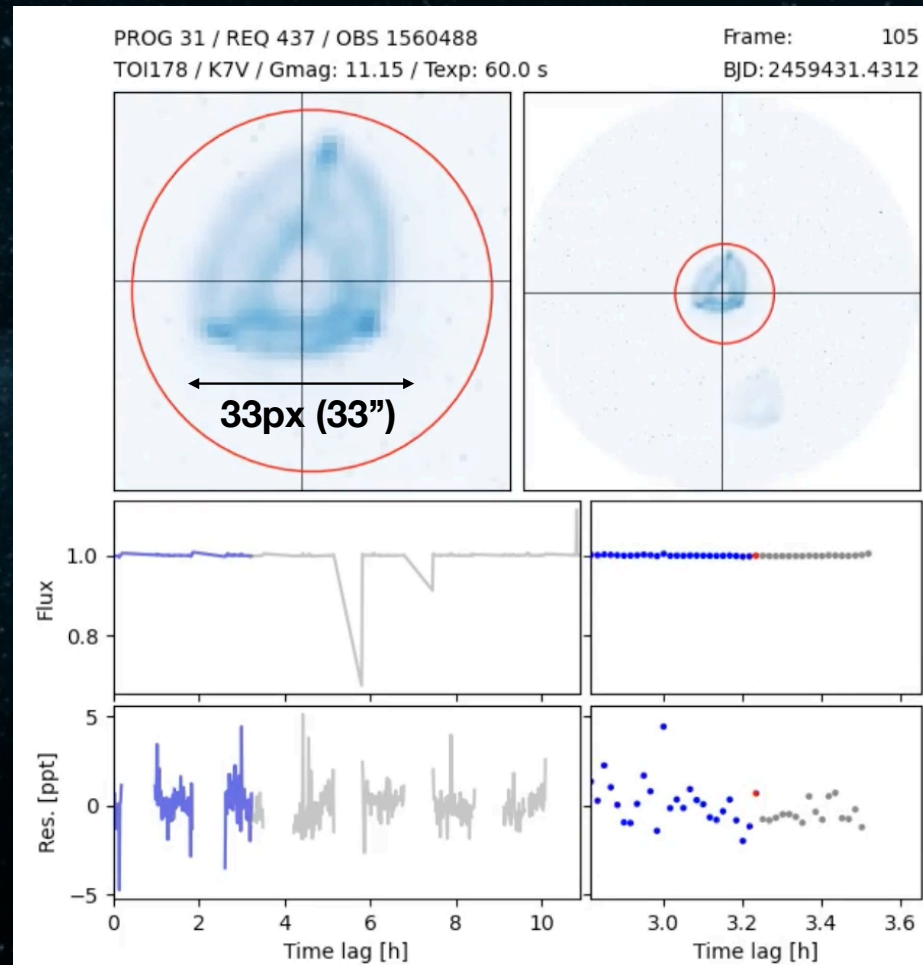
Captured from Heike Rauer's talk



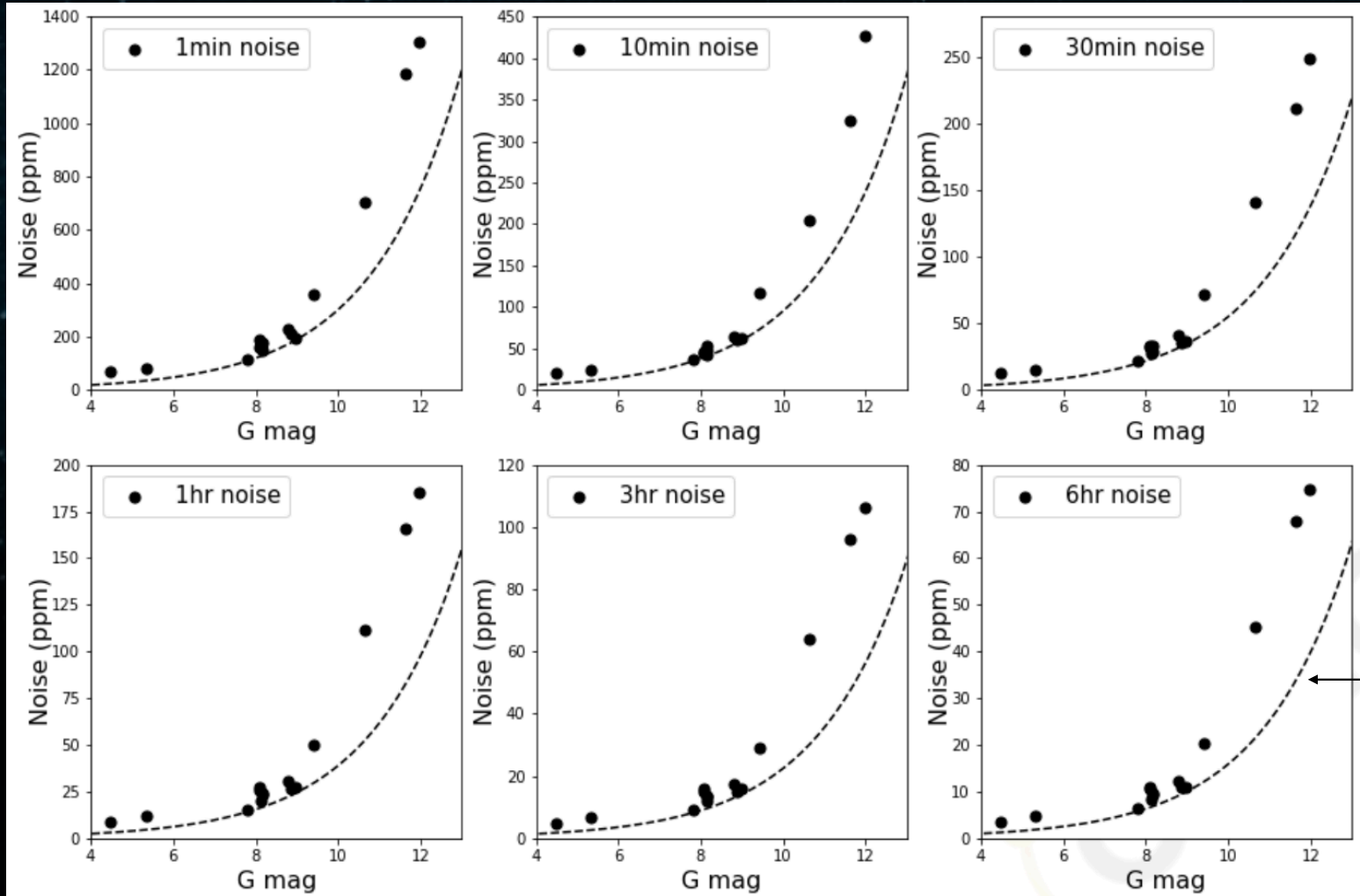
Photometric performance



Photometric performance



Photometric performance



- Results obtained w/ `pycheops` v1 <https://github.com/pmaxted/pycheops>
- Light curves extracted w/ `DRP` v13
- Default aperture of 25 px

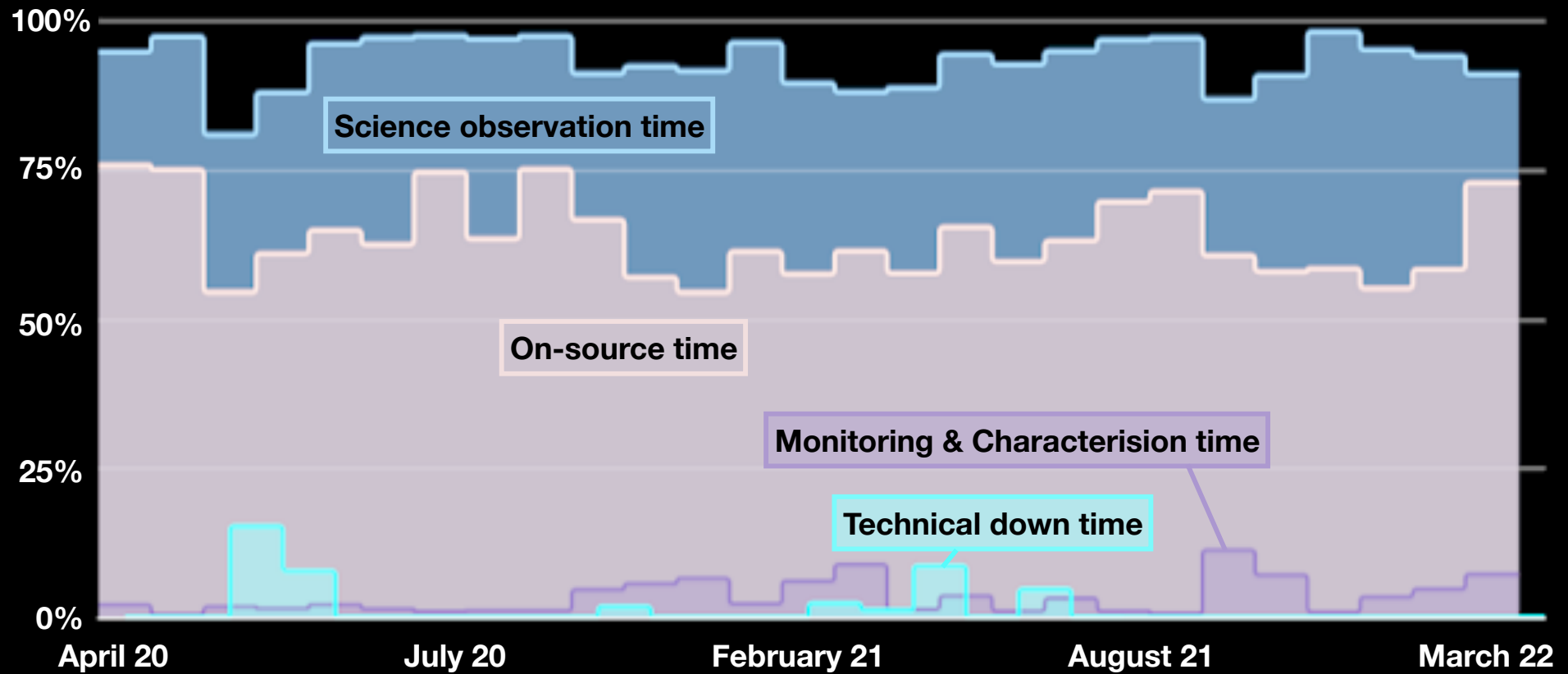
Photon noise

CHEOPS
MISSION CONSORTIUM

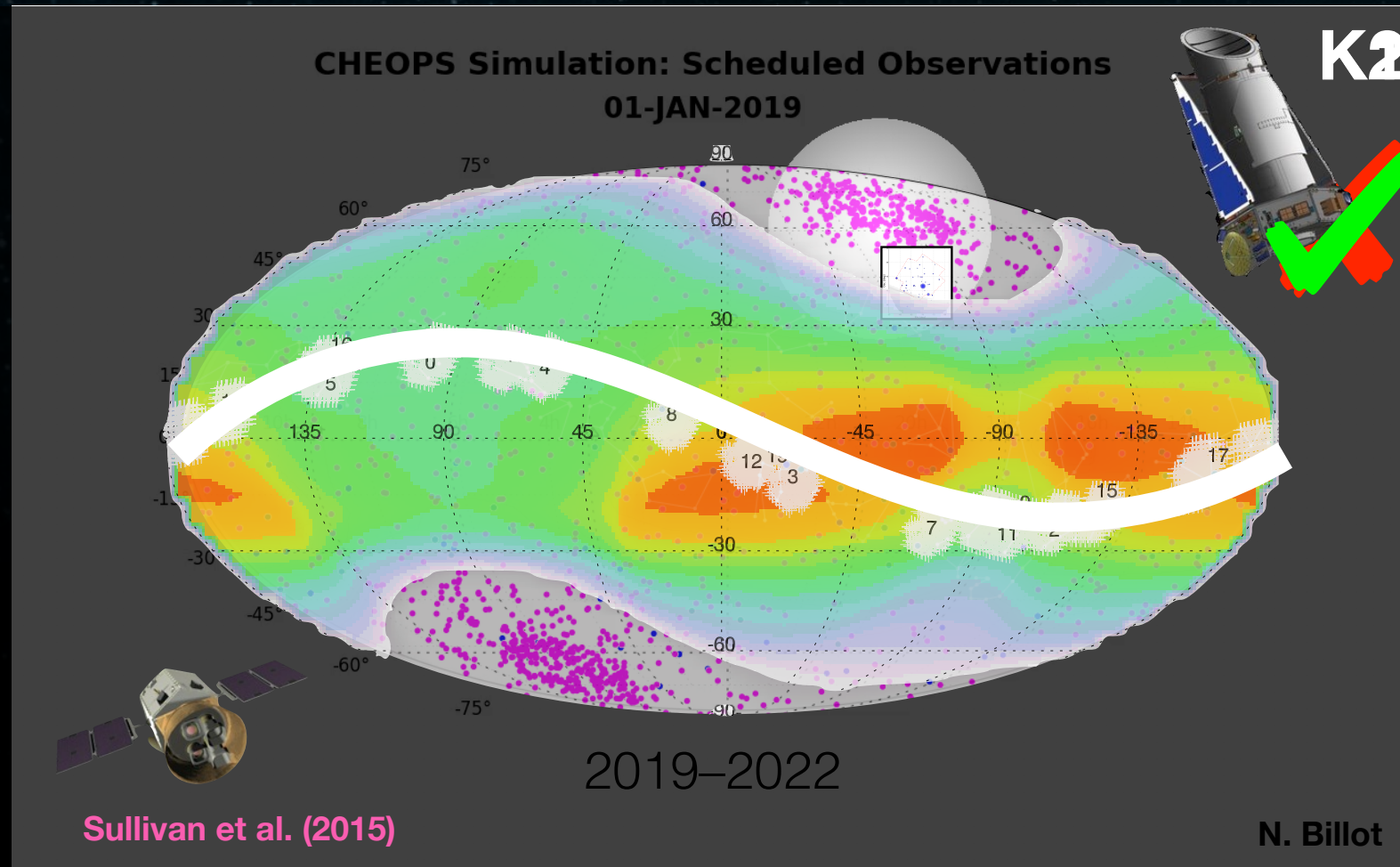


Andrea Fortier & CHEOPS Monitoring & Characterisation Working Group

CHEOPS on the sky



Photometric performance



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Revisiting planetary systems

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MISSION CONSORTIUM



●
Earth



d?



c



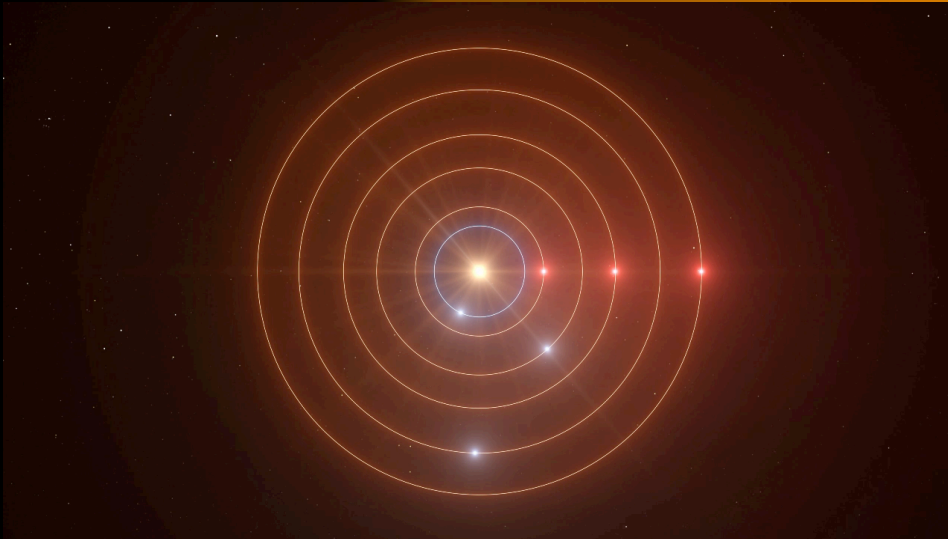
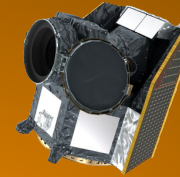
b



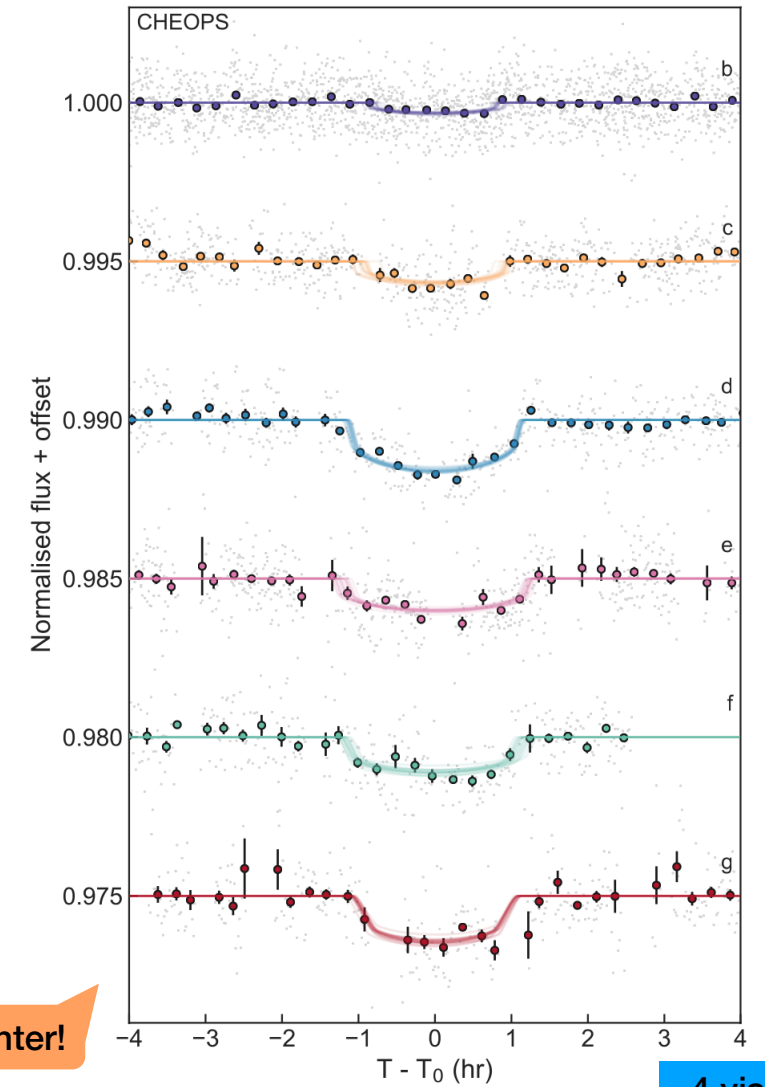
●
Earth

g ●
f ●

e ●
d ●
c ●
b ●



akin to TRAPPIST-1 but brighter!

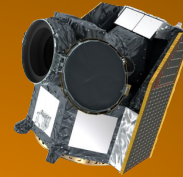


4 visits
171 orbits

●
Earth

g ●
f ●

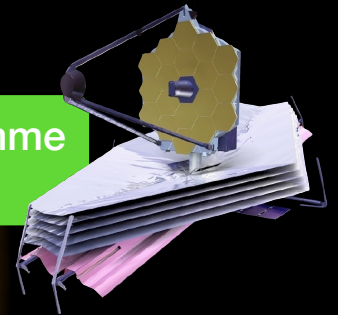
e ●
d ●
c ●
b ●



Improving planet parameters
leads to reassess
the whole system

“Complete” systems are critical
tests of planet formation theories

Follow-up programme
on *JWST*



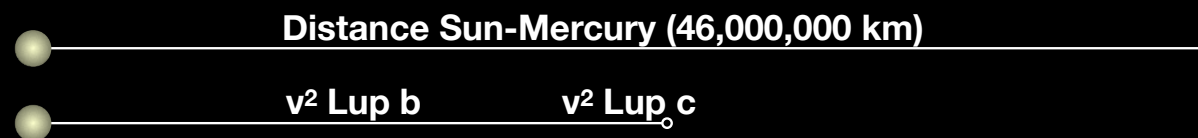
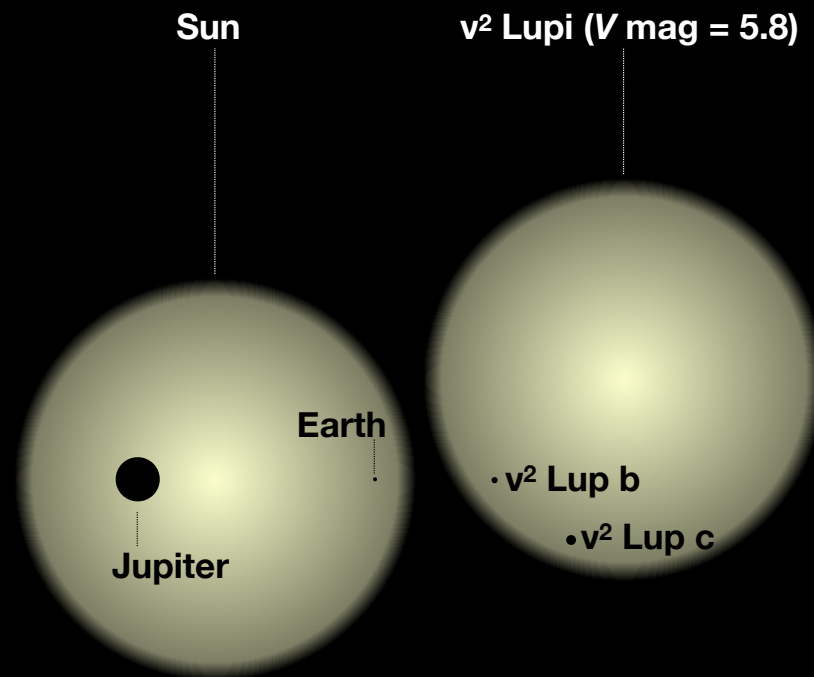
Planetary structure & system architecture

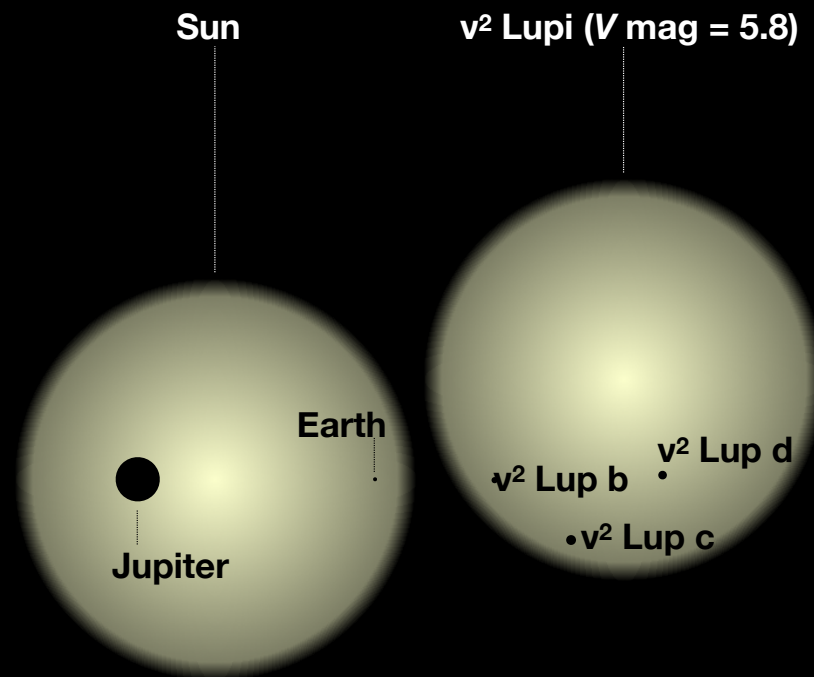
- Explore compact multi-planet systems
- Achieve complete demographics by sustained observations
- Each new such system is a breakthrough!

Finding **golden** targets

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Transit detection of the long-period volatile-rich super-Earth ν^2 Lupi d with CHEOPS

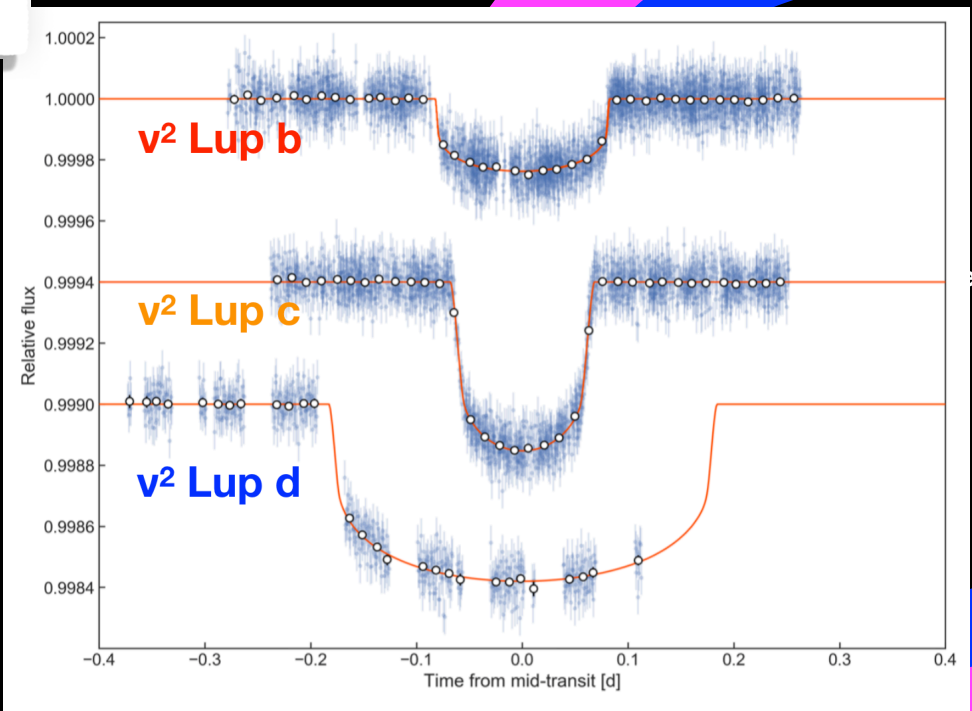
Laetitia Delrez^{1,2,3}✉, David Ehrenreich³, Yann Alibert⁴, Andrea Bonfanti⁵, Luca Borsato⁶, Luca Fossati⁵, Matthew J. Hooton⁴, Sergio Hoyer⁷, Francisco J. Pozuelos^{1,2},

ν^2 Lup b

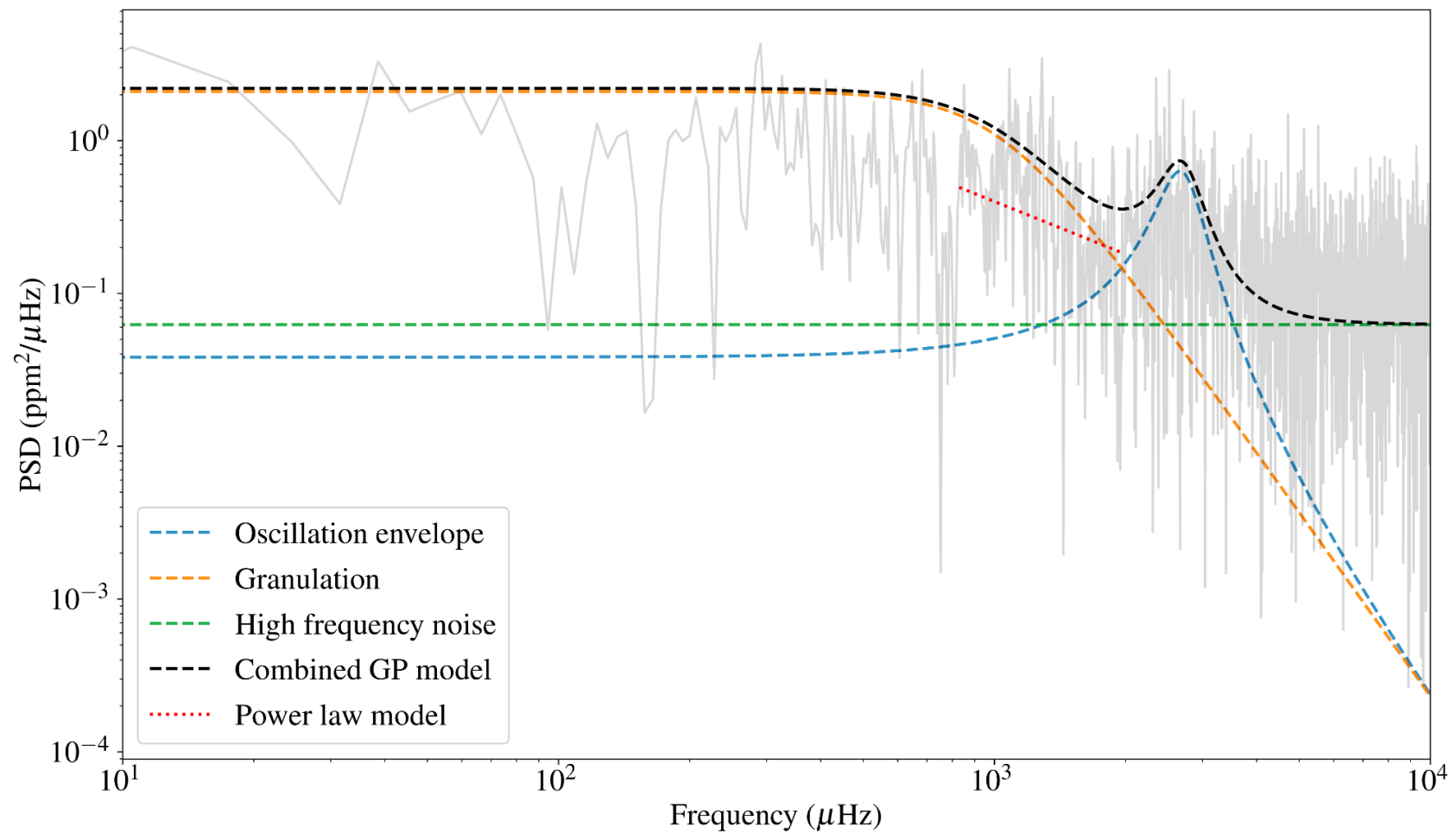
ν^2 Lup c

ν^2 Lup d

- hydrogen/helium envelope
- thin atmosphere
- ice mantle/volatile envelope
- solid core (rocks+metals)



Delrez et al. (2021)



Delrez et al. (2021)

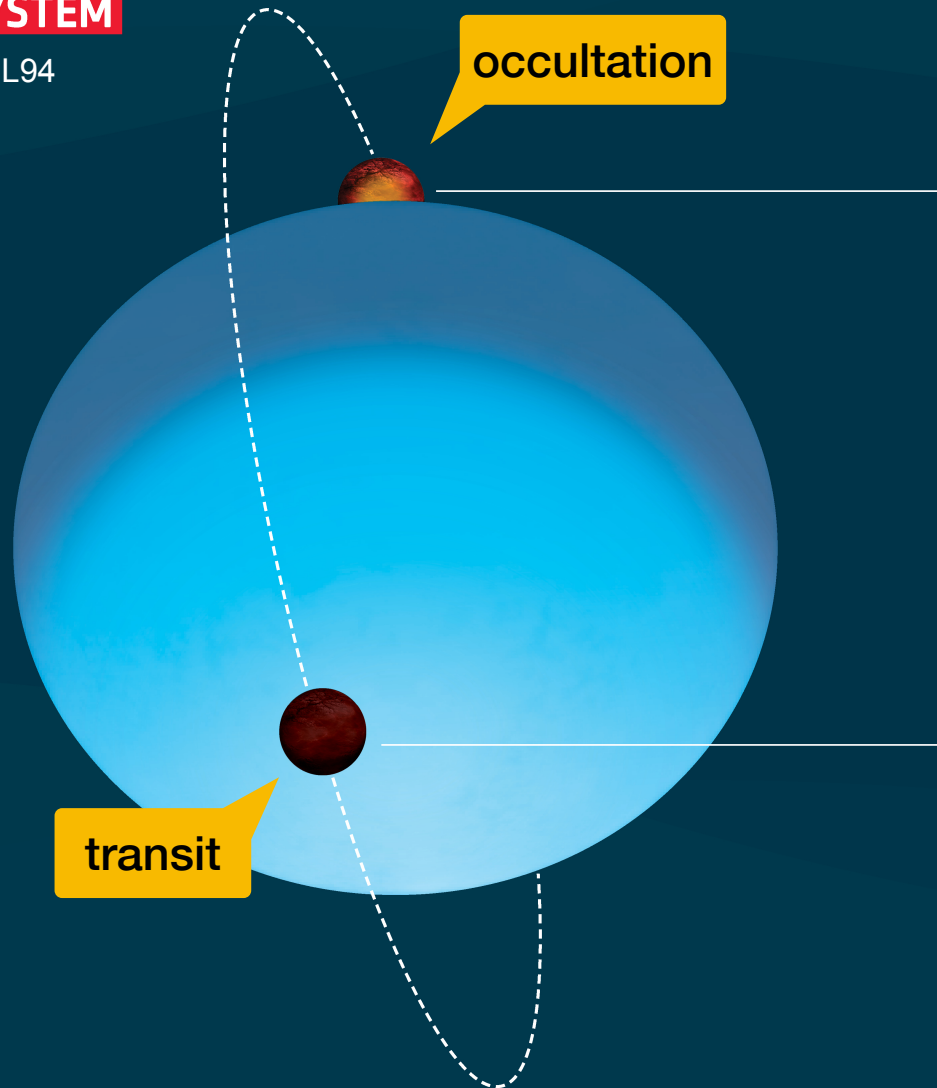
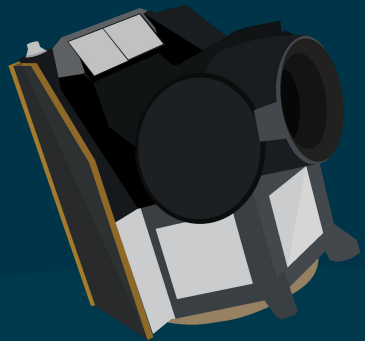
Characterising atmospheres

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CHEOPS WASP 189 SYSTEM

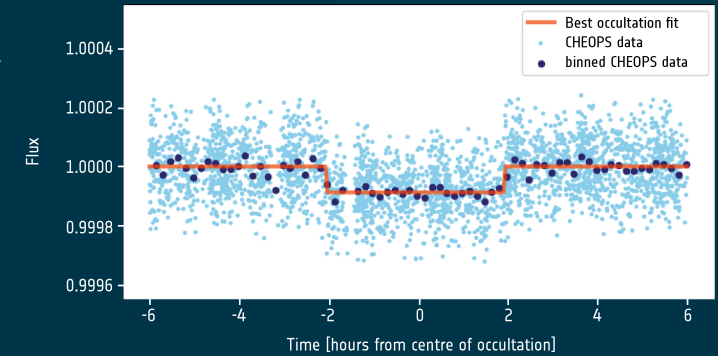
Lendl et al. (2020), A&A 643, L94



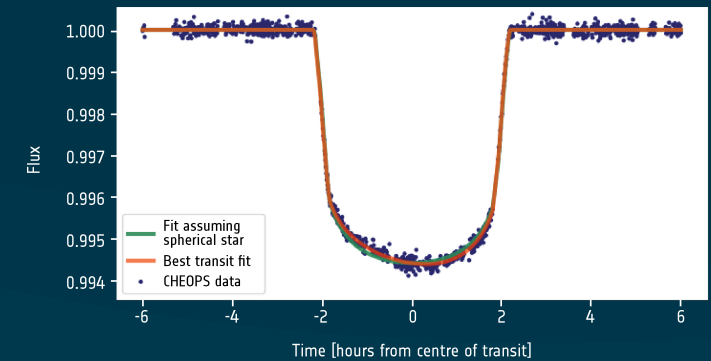
occultation

transit

Occultation light curve of WASP-189 b



Transit light curve of WASP-189 b



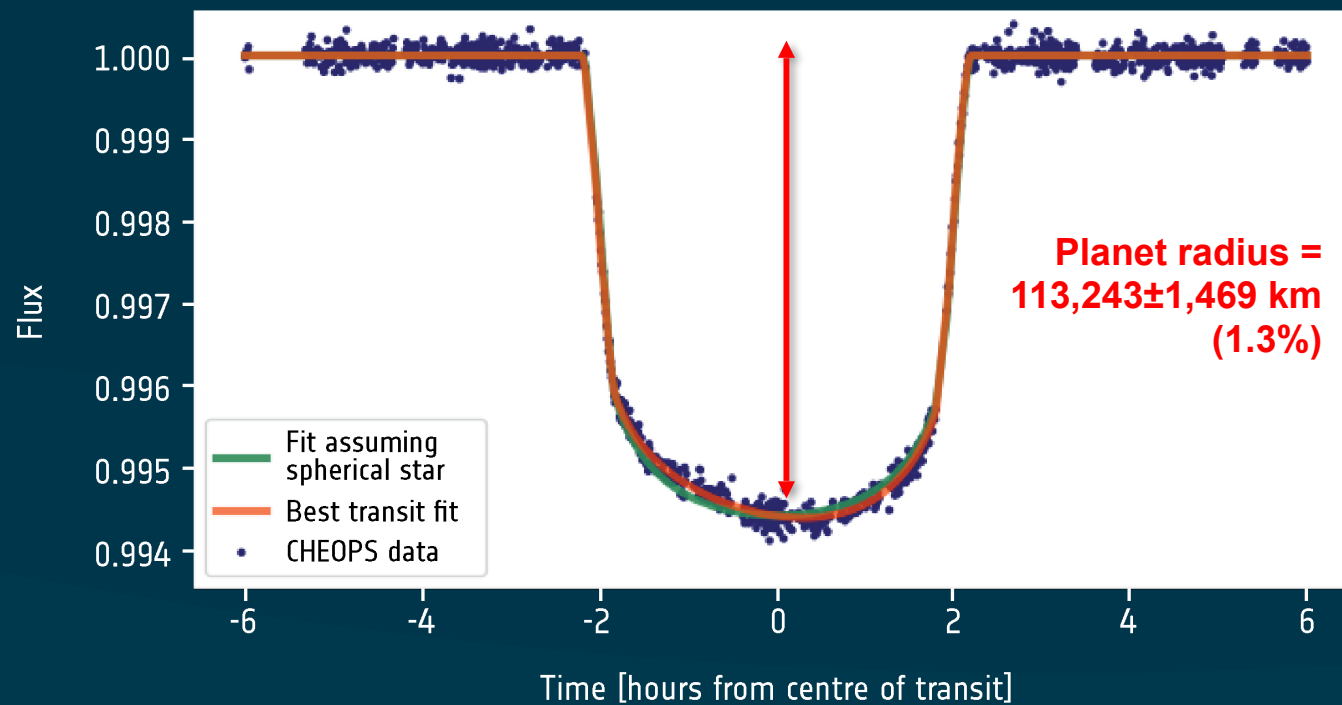
#cheops

Data: CHEOPS Mission Consortium

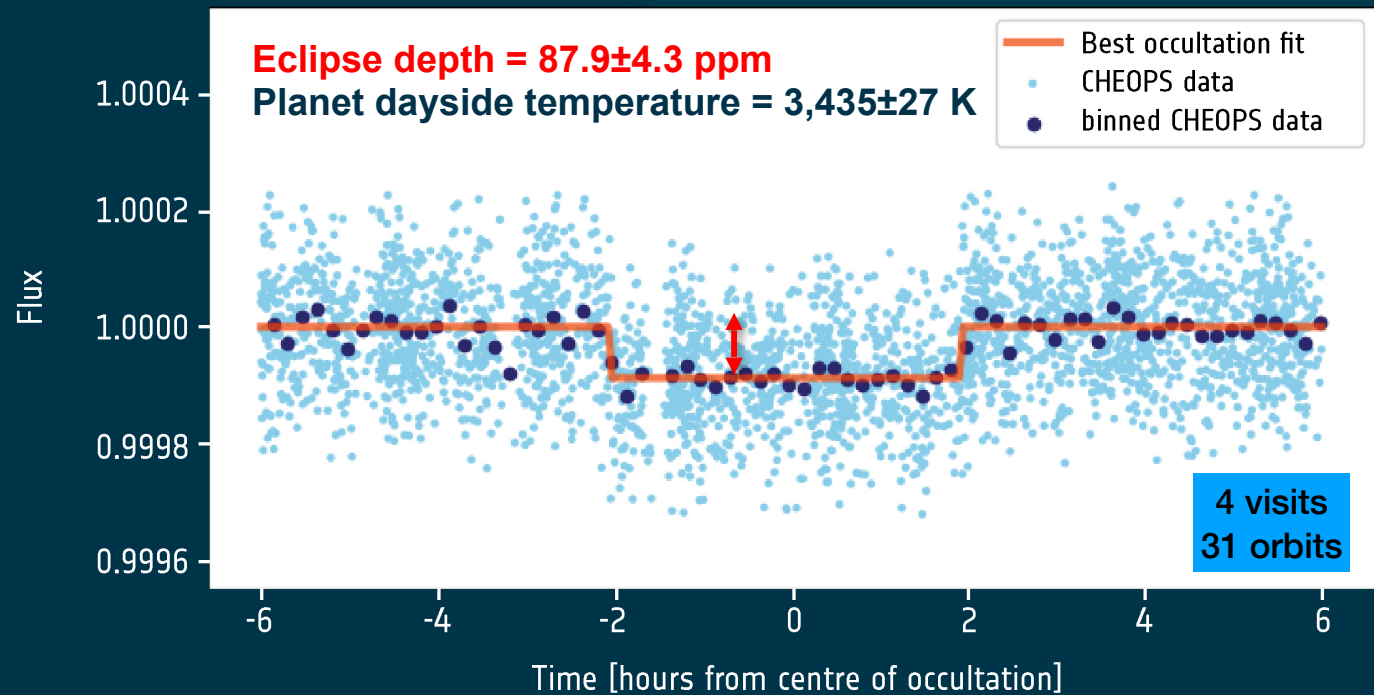
CHEOPS
MISSION CONSORTIUM



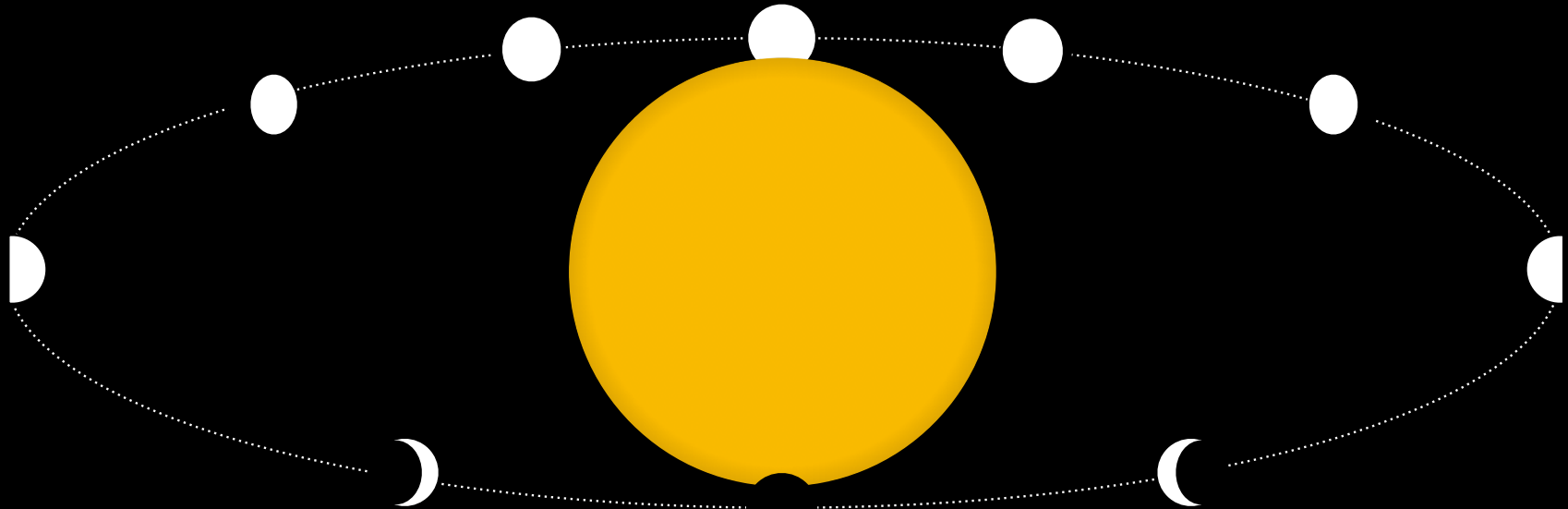
Transit light curve of WASP-189 b



Occultation light curve of WASP-189 b



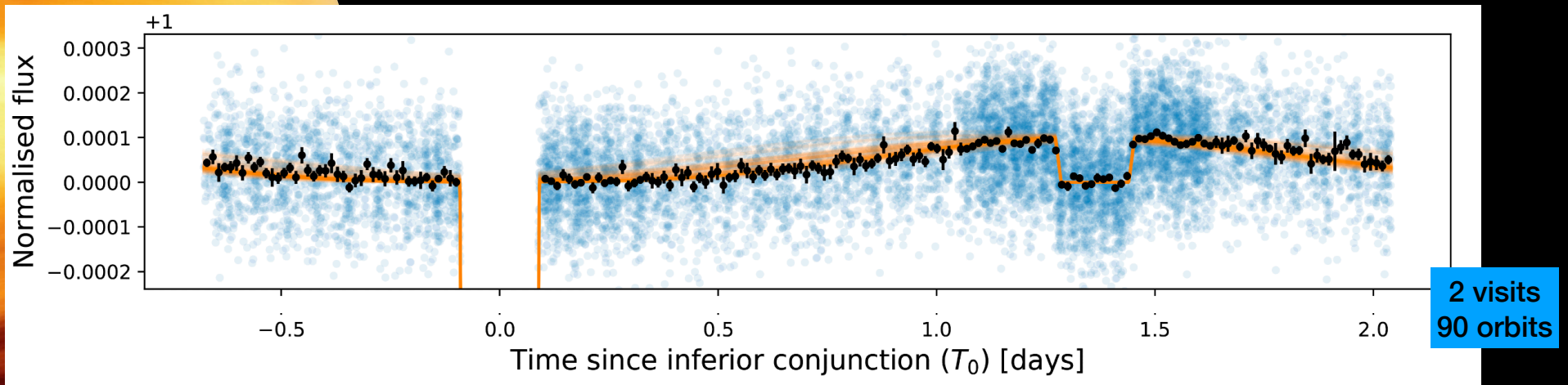
Optical phase curves?



Optical phase curves? Yes!

Ultrahot gas giant
WASP-189b

Deline et al. (2021)



Timescales



2022
today!

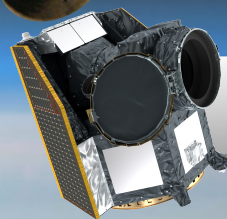
September 2022



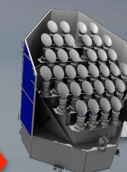
TESS

Ext#1

September 2023



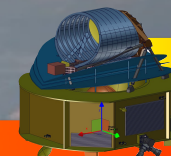
CHEOPS



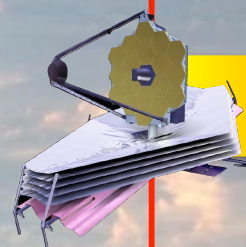
PLATO



Hubble Space Telescope



ARIEL



JWST

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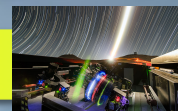
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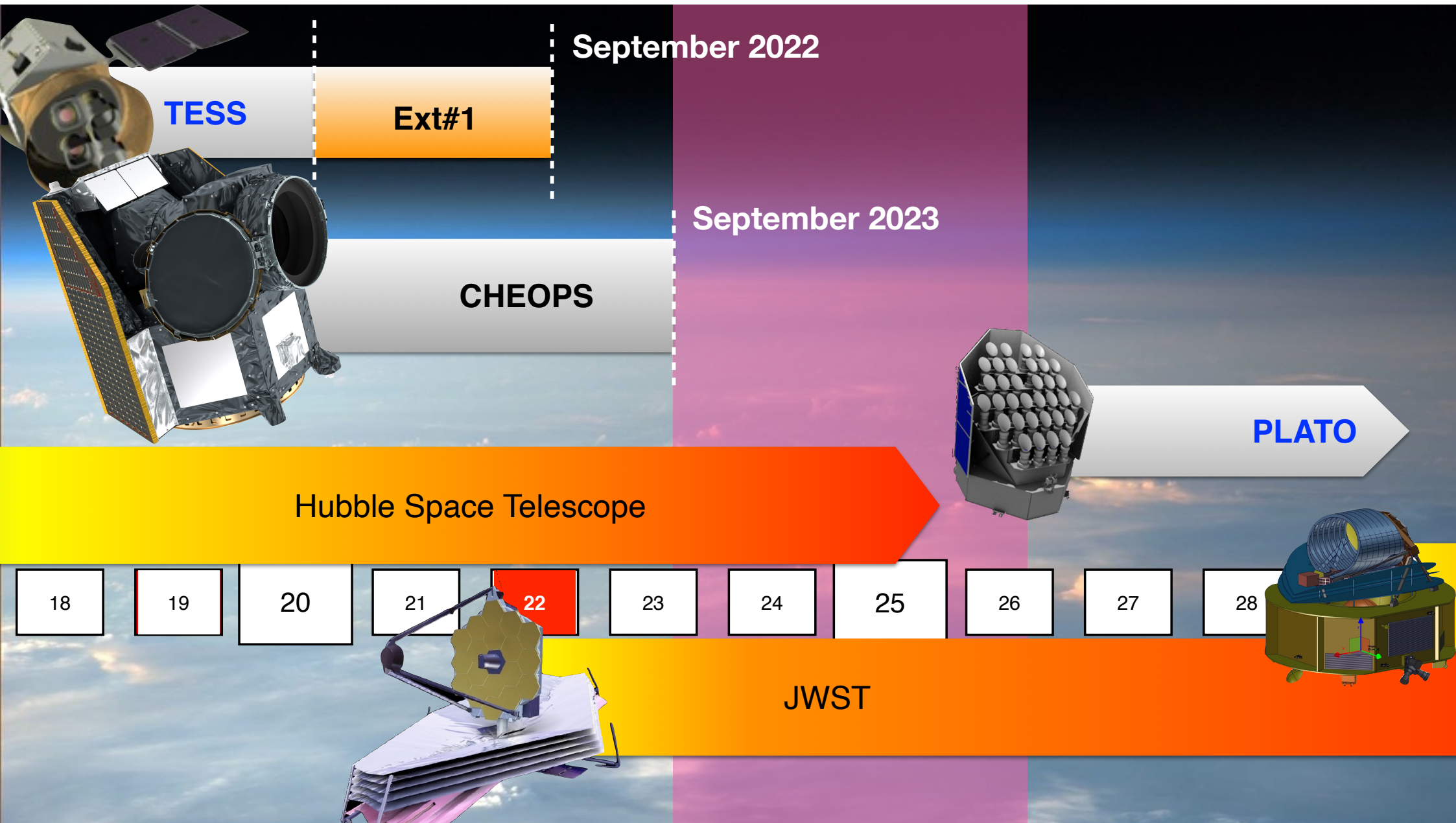
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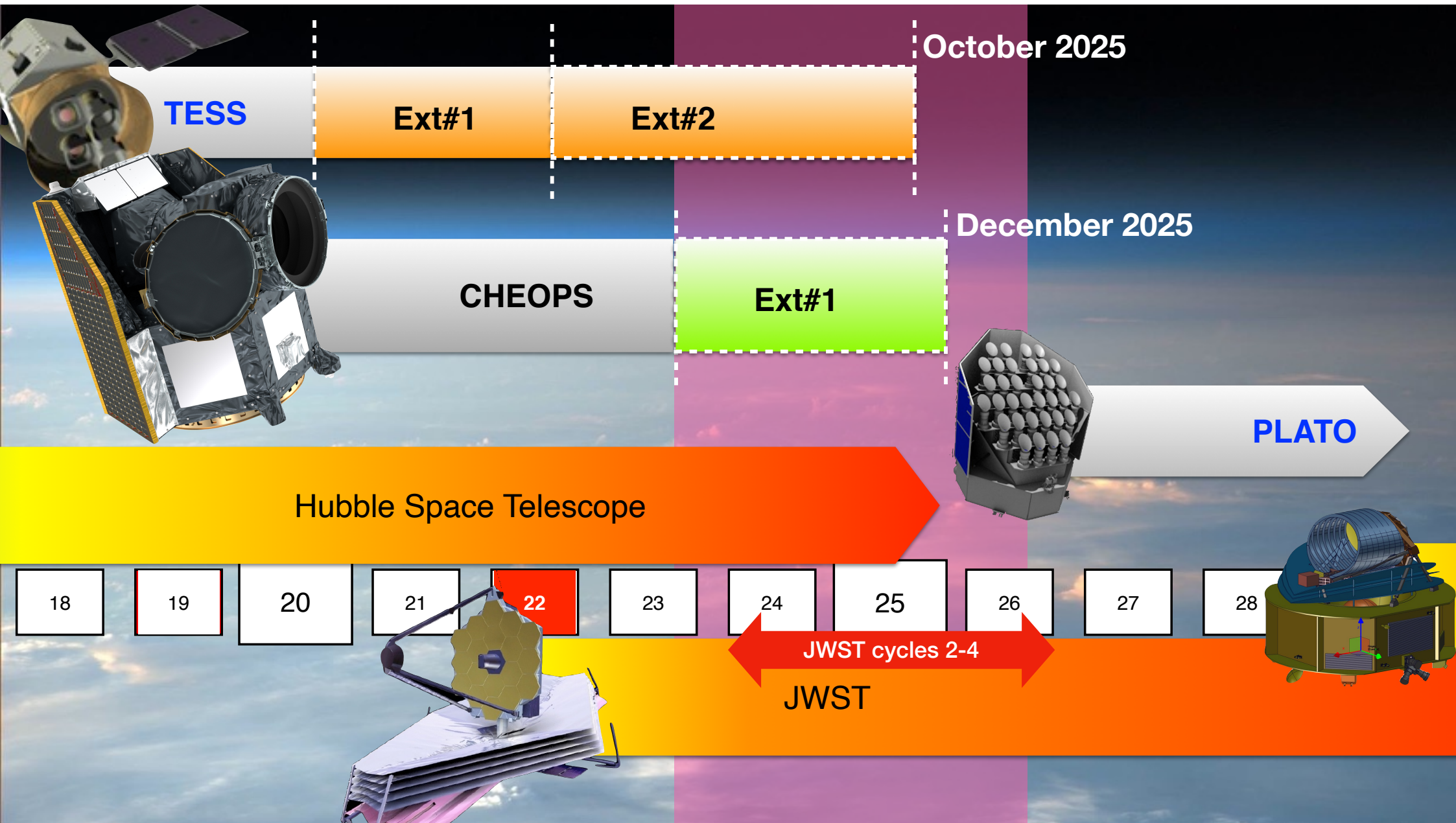
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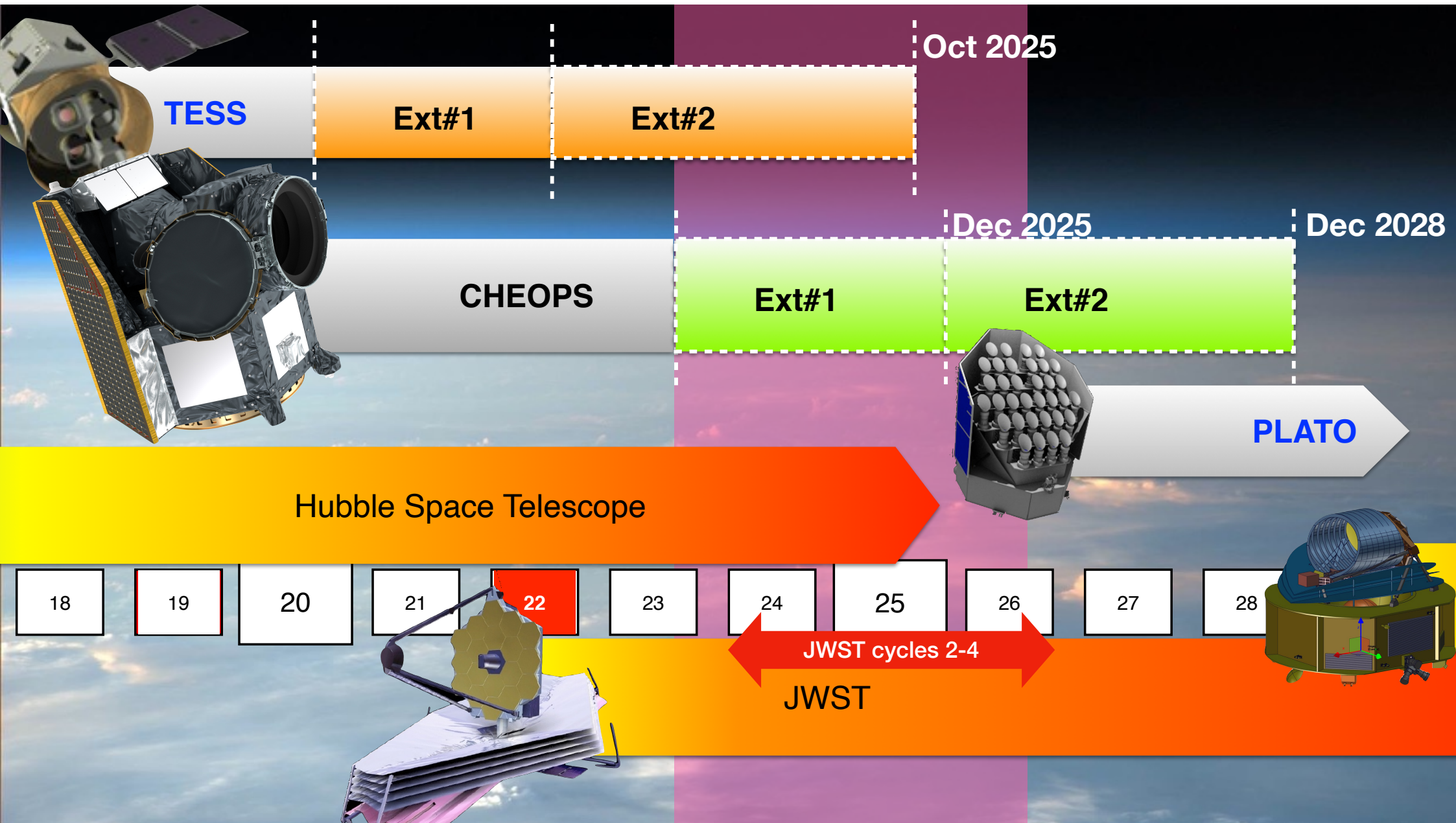
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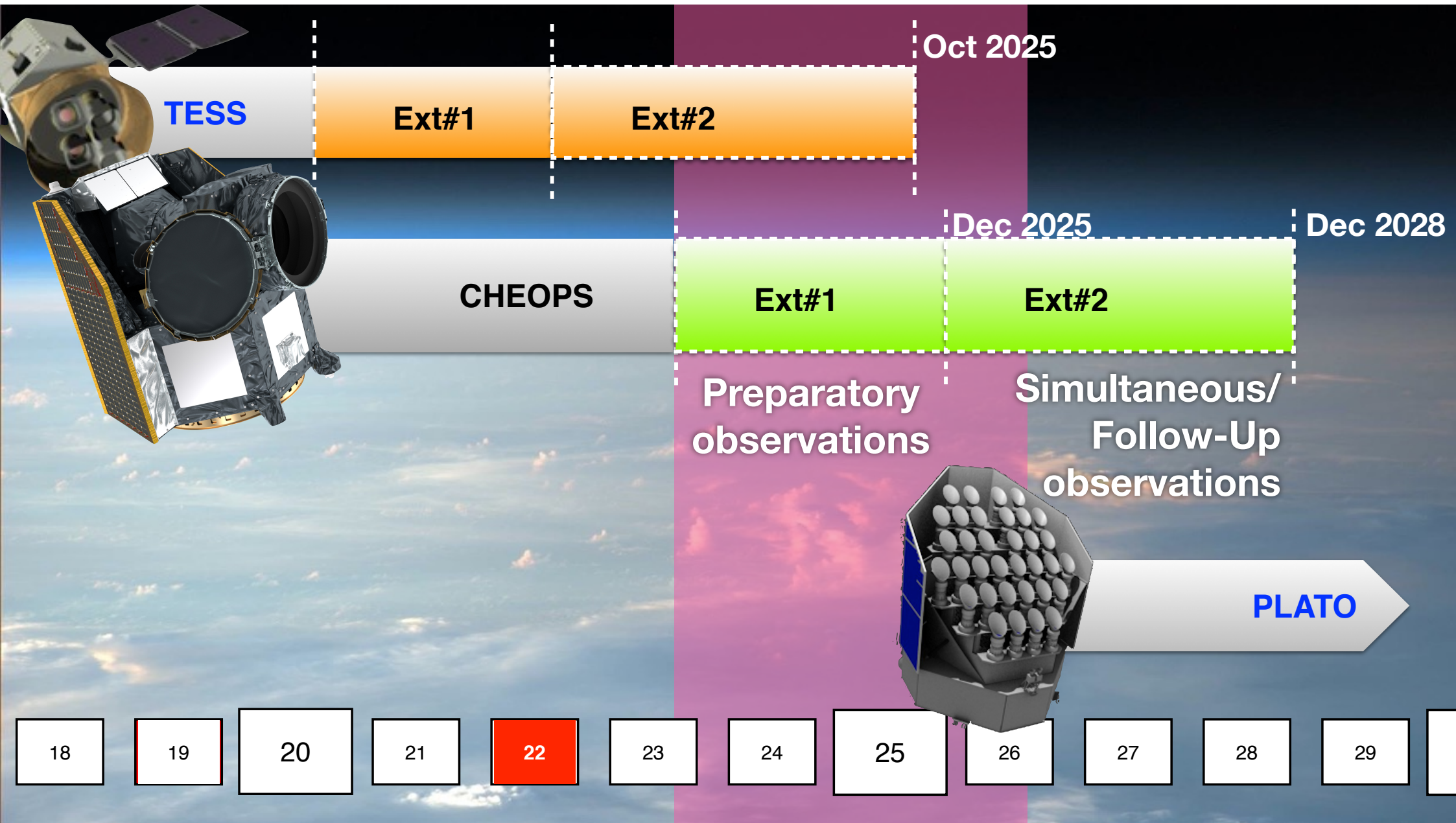
Ground-based radial velocity surveys, ground-based transit surveys







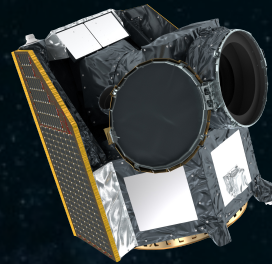




CHEOPS & the Community



- Unique position: discovery



characterisation



- Help maximise the scientific output of future missions!



CHEOPS & the Community

- **ESA's Guest Observers Programme**
 - More time available (up to 30%)
 - More targets available (GTO can only reserve 50)
- **Consortium's Synergies with Other Missions**



Synergies with Other Missions

- Service to the Community (up to 15% of GTO)
- Observations enabling
• Rescuing lost planets
• Validating TFOP candidates
• Preparing/complementing PLATO observations

NOMINAL MISSION

Run by
CMC

GTO
80%

unlimited
reserved target list
(currently 186)

CONSORTIUM
SCIENCE

Run by
ESA

GO
20%

COMMUNITY
SCIENCE

NOMINAL MISSION

GTO
80%

unlimited
reserved target list
(currently 186)

GO
20%

Run by
CMC

Run by
ESA

EXTENDED MISSION

GTO
down to 70%

reserved target list
limited to 50

Synergies 12%

GO
up to 30%

CONSORTIUM
SCIENCE

COMMUNITY
SCIENCE

How much time is this?

- Extension #1 is Sep 2023-Dec 2025 (≈ 27 months)
- Minimum of $\approx 1,500$ orbits
(1 orbit = 100 min)

EXTENDED MISSION

GTO
down to 70%

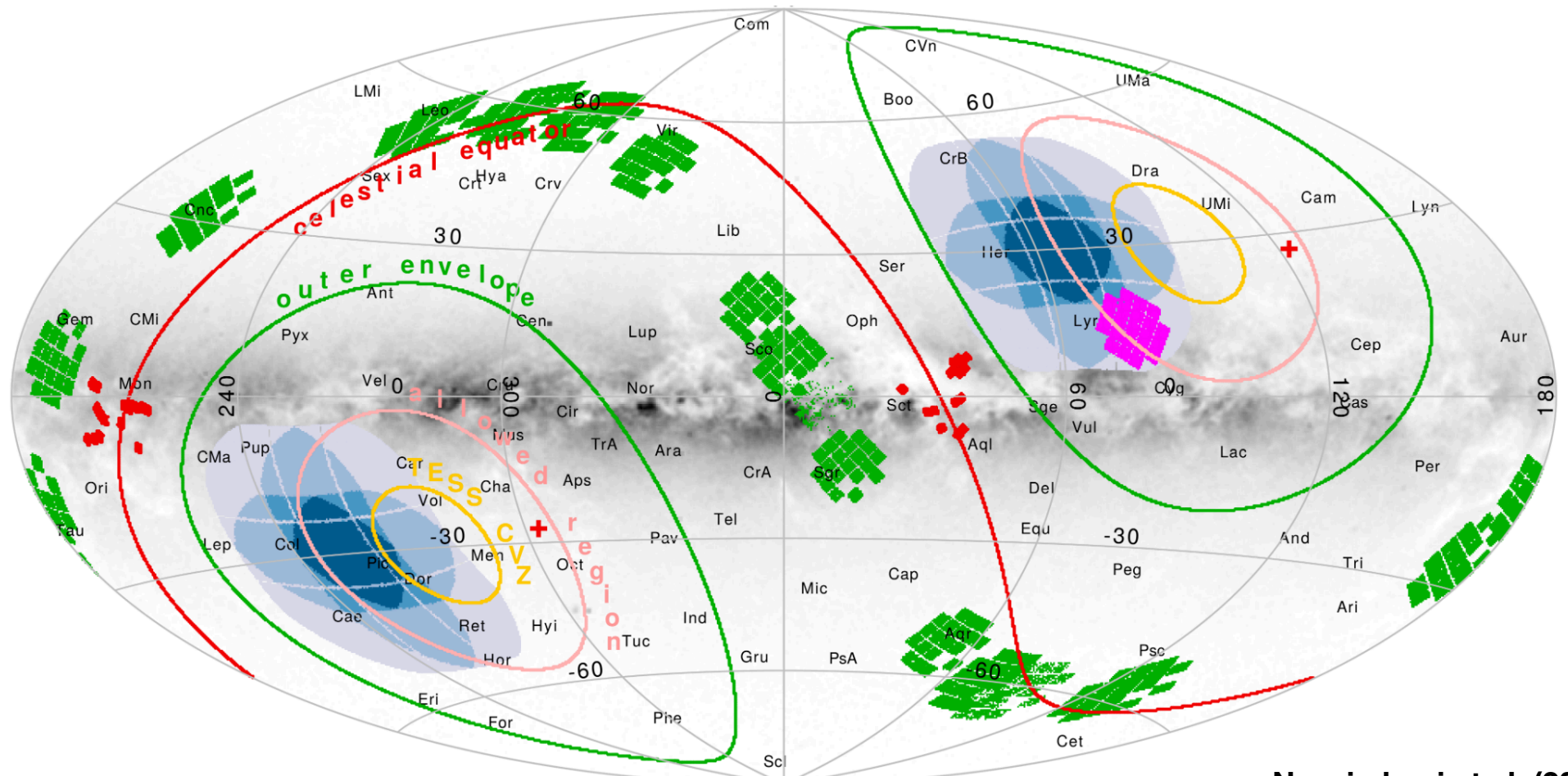
reserved target list
limited to 50

Synergies 12%

GO
up to 30%

CONSORTIUM
SCIENCE

What is the target overlap?



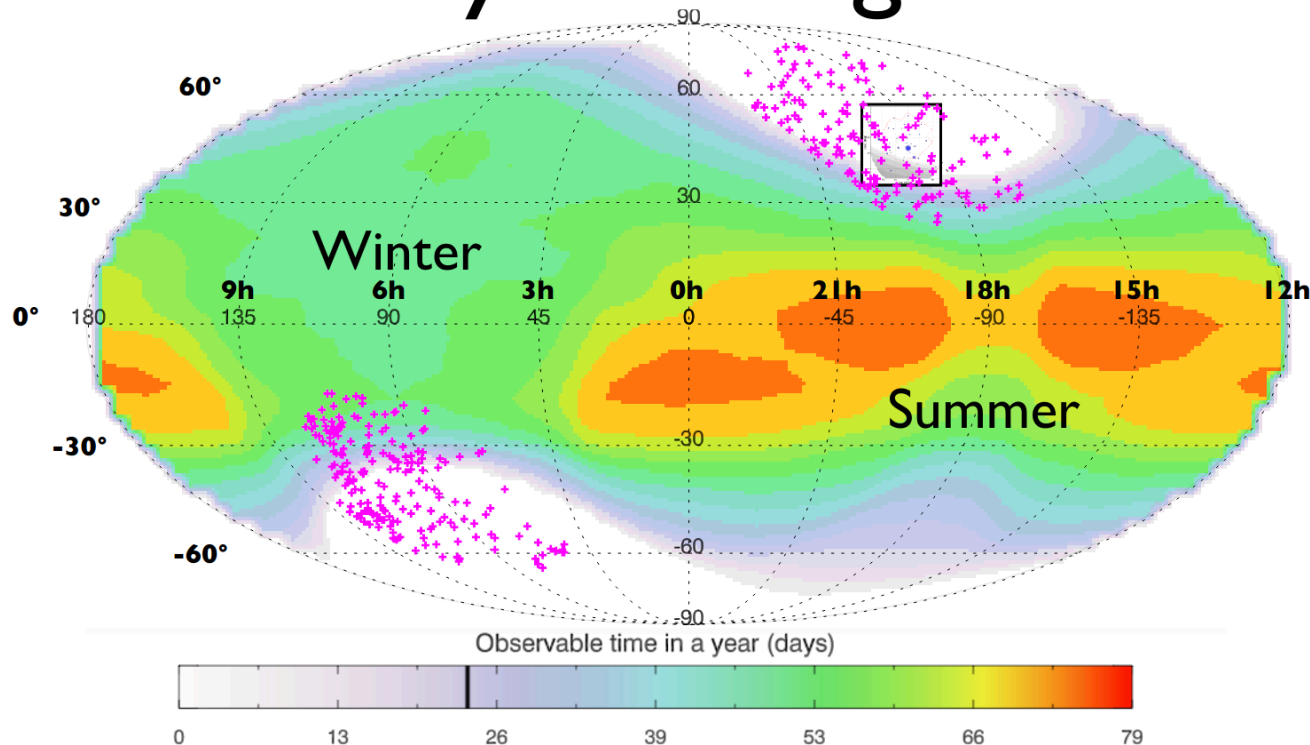
Nascimbeni et al. (2022)

What is the target overlap?

CHEOPS



Sky coverage (50% interruptions of light curves)



David Ehrenreich



cheops

CHEOPS Open Time Workshop: 26-27th July, Schloß Seggau

10

Valerio Nascimbeni:

“I just did a **quick calculation** to get some numbers as a starting point. The Bright Star Catalogue (CDS V/50/catalog) is supposed to be complete at $V < 6$. If I match the BSC with the PLATO long-pointing fields LOPN1 and LOPS1 (Nascimbeni+ 2022) I get, respectively, **316 and 236 $V < 6$ stars**, with no further selection on spectral types or anything else. Of course most of them are at high declinations and ecliptic latitudes (in modulus).”

I superimposed those 552 targets on a standard CHEOPS visibility map (attached; magenta crosses) and, not surprisingly, **only a small subset (~50?) can be monitored with a reasonable efficiency, mostly in the LOPS1 field.**

It is also worth checking how many of these 552 have been already observed in short cadence by TESS in at least one sector: 355, or about 64%.”

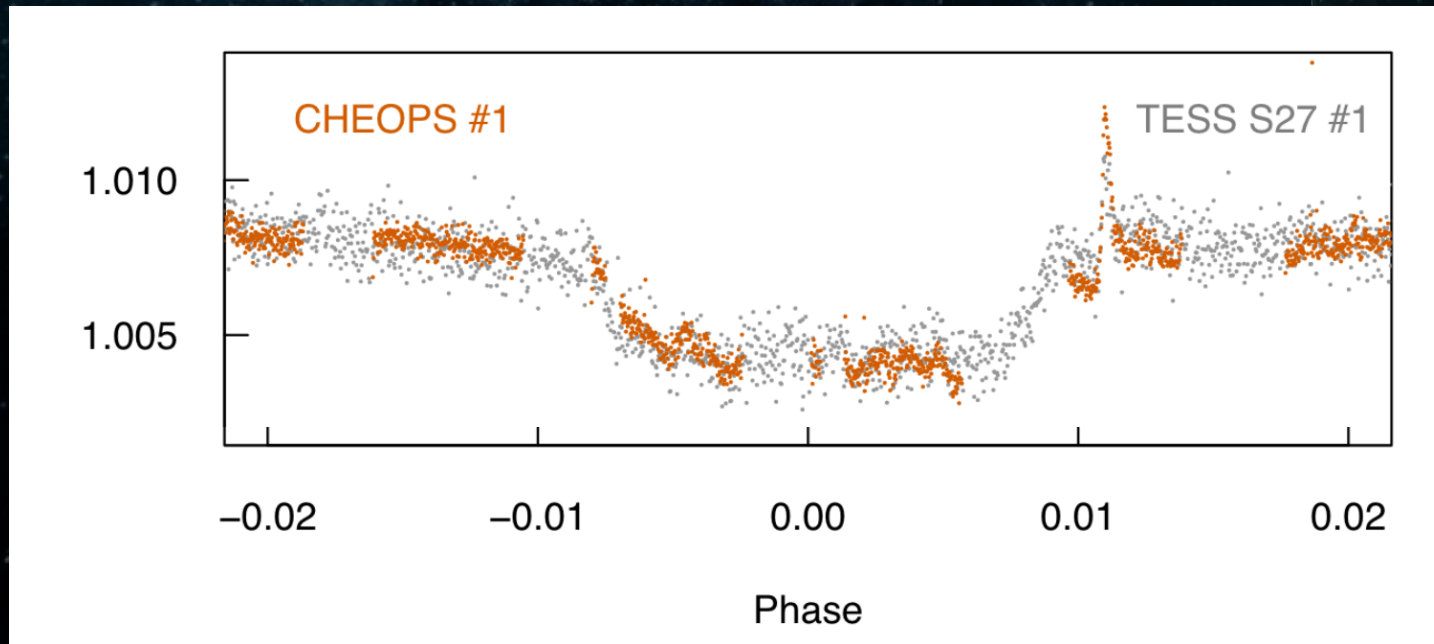
Nascimbeni et al. (2022)

Preparatory observations

- Could start Oct 2023 (better defined by Spring 23)
- Useful for in-flight commissioning of PLATO?
 - ➔ on a few selected targets available to both missions
- Provide long temporal basis for TTVs of PLATO targets
- ?

Simultaneous observations?

- Possibly during CHEOPS Extension #2 (2026-28)
- Useful for in-flight commissioning of PLATO?
 - ➔ on a few selected targets available to both missions



AU Mic
Szabó et al. (2021)

Follow-Up observations??

- Possibly at the end of CHEOPS Extension #2
- Targets from LOPS fields hard to reach for CHEOPS
- Preparation of SOPS fields?

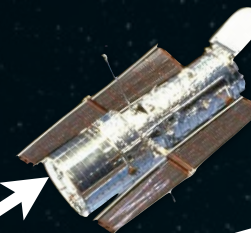
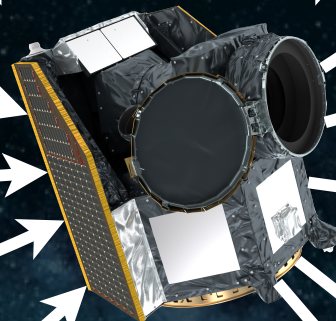


Characterisation of exoplanets

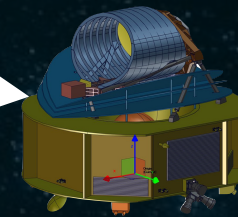
Detection of exoplanets



New synergies



New science
w/ other missions



New GTO science axes



New GO science

- Outstanding performances & achieving its goals
- Stepping stone between detection & characterisation
- Enable new science & new synergies
- With increased community participation