CHEOPS in brief

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with inputs from the CHEOPS Mission Consortium

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Questions? Email cheops-support@cosmos.esa.int

The CHEOPS mission

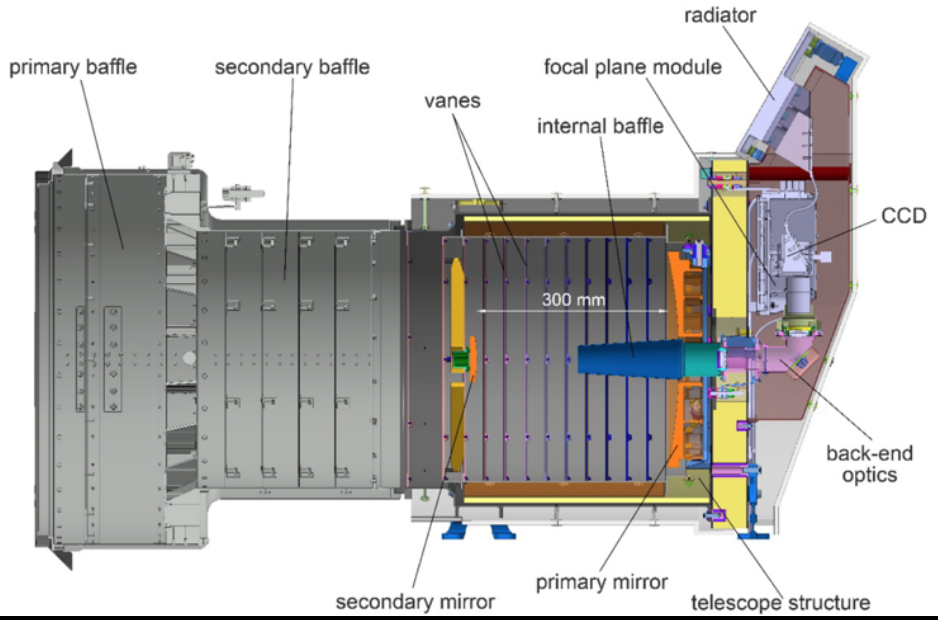
- Follow-up mission to study the transits of known exoplanets orbiting bright stars using high precision, single band photometry
- Satellite launched on 18 December 2019 from ESA's spaceport in Kourou, French Guiana
- In a Sun-synchronous, dawn-dusk near-polar orbit (orbital period ~99 minutes), altitude 700 km
- Nominal mission duration of 3.5 years, starting March 2020 (ending September 2023). Extension to end 2025 and beyond is under discussion
- Mission operations under the responsibility of the CHEOPS Mission Consortium (PI: Willy Benz)
  - Mission Operations Centre at INTA, Torrejón near Madrid, Spain
  - Science Operations Centre at Geneva Observatory near Geneva, Switzerland
    - Observing scheduling, Data Reduction Pipeline and mission archive

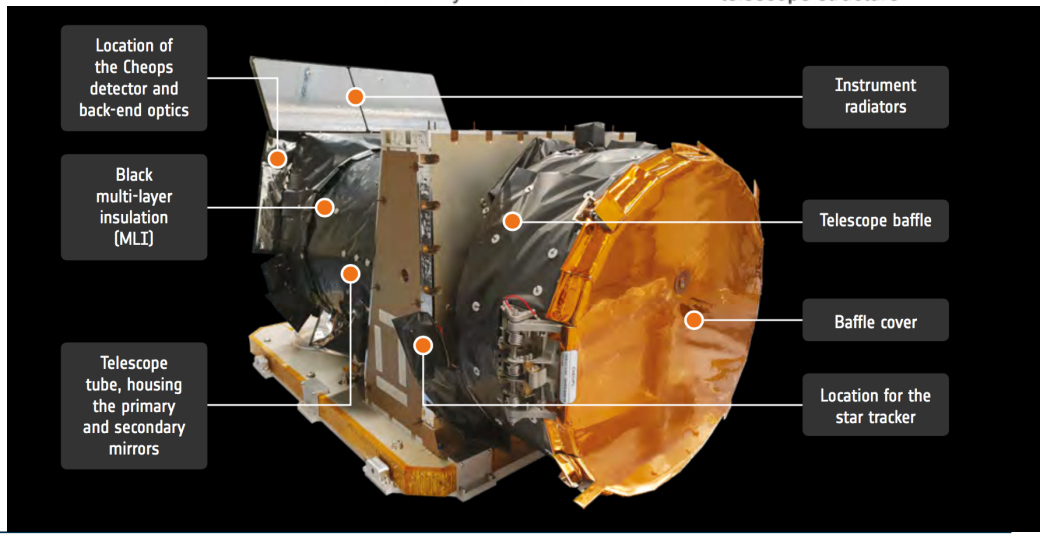
The CHEOPS payload

Single, high precision photometer comprising:

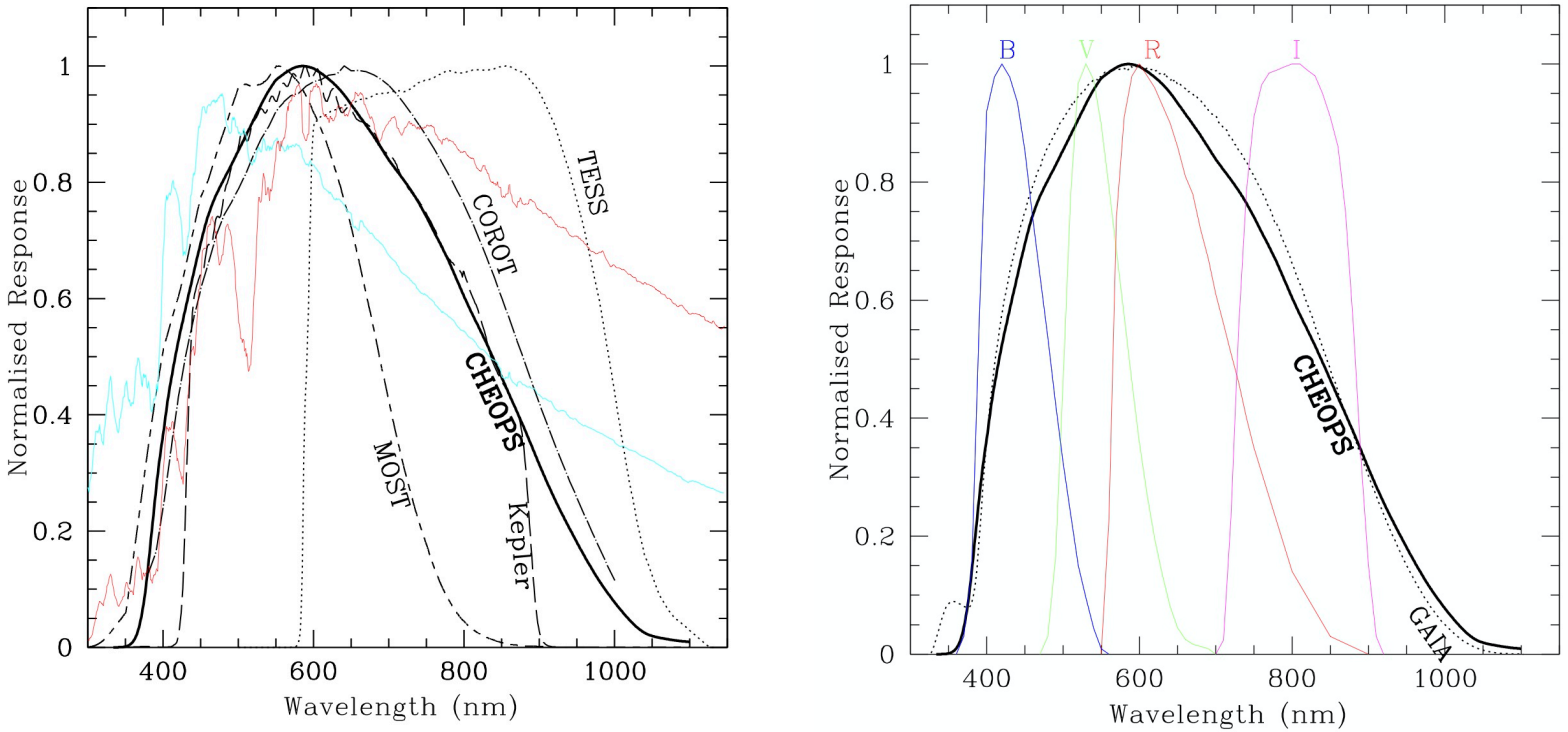
- A compact Ritchey-Chretien telescope
  - effective diameter of 300mm
  - Defocused point spread function (90% encircled energy radius ~ 16.5 pixels (“))
  - Baffling to minimise the impact of straylight
  - Plate scale ~1”/pixel

- Single E2V AIMO 4720 CCD cooled to - 45º C
  - 1024 x 1024 pixels, back-illuminated, frame-transfer
  - 330 – 1100 nm bandpass (single band, no filter)
  - 13 micron pitch pixels





The CHEOPS bandpass



CHEOPS bandpass normalised to its peak value as a function of wavelength: overplotted are the equivalent curves for other exoplanet missions together with the spectral energy distributions (SED) of a T_{eff}~5500K and T_{eff}~4500K dwarf star (left panel), and bandpasses of the BVRI filter set together with GAIA (right panel). Note the similarity between the GAIA and CHEOPS passbands

The CHEOPS PSF

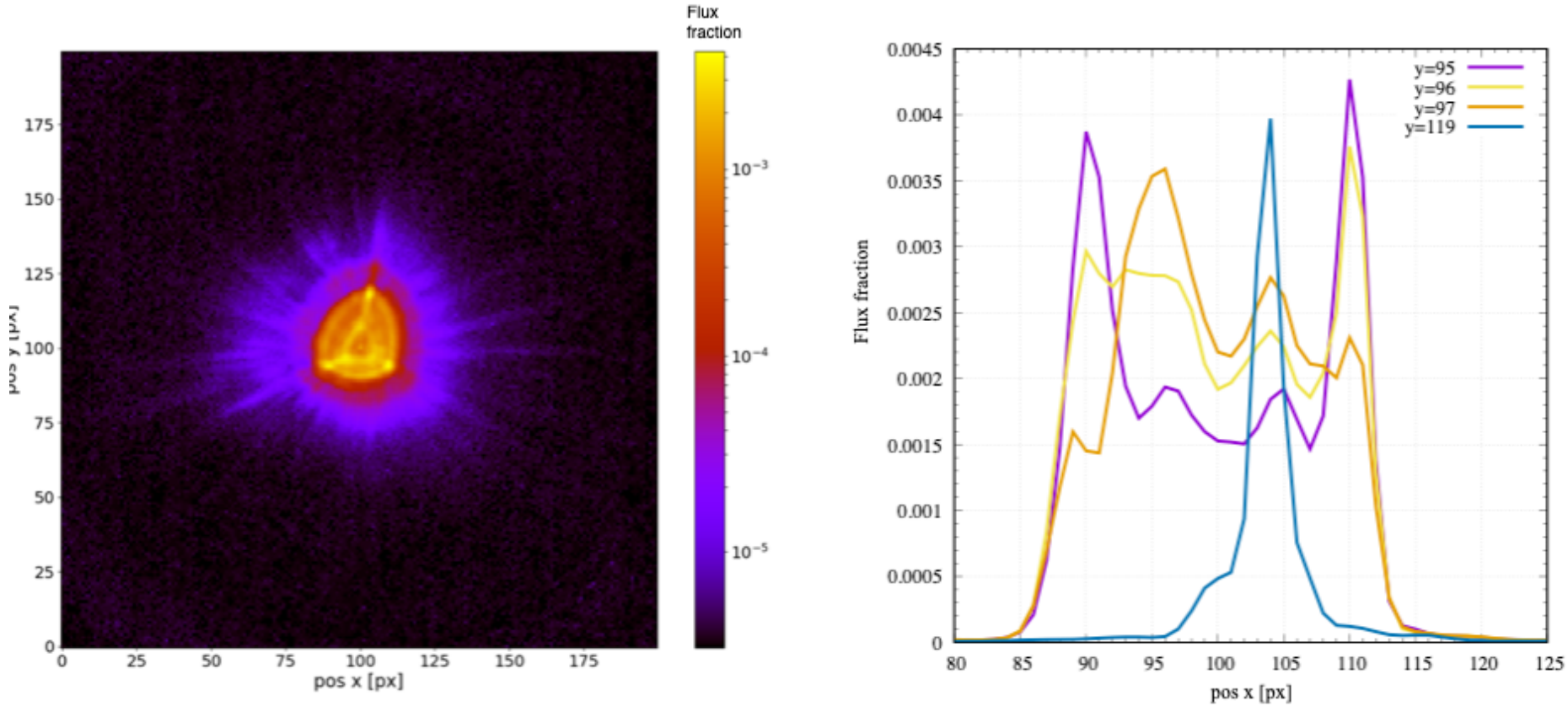
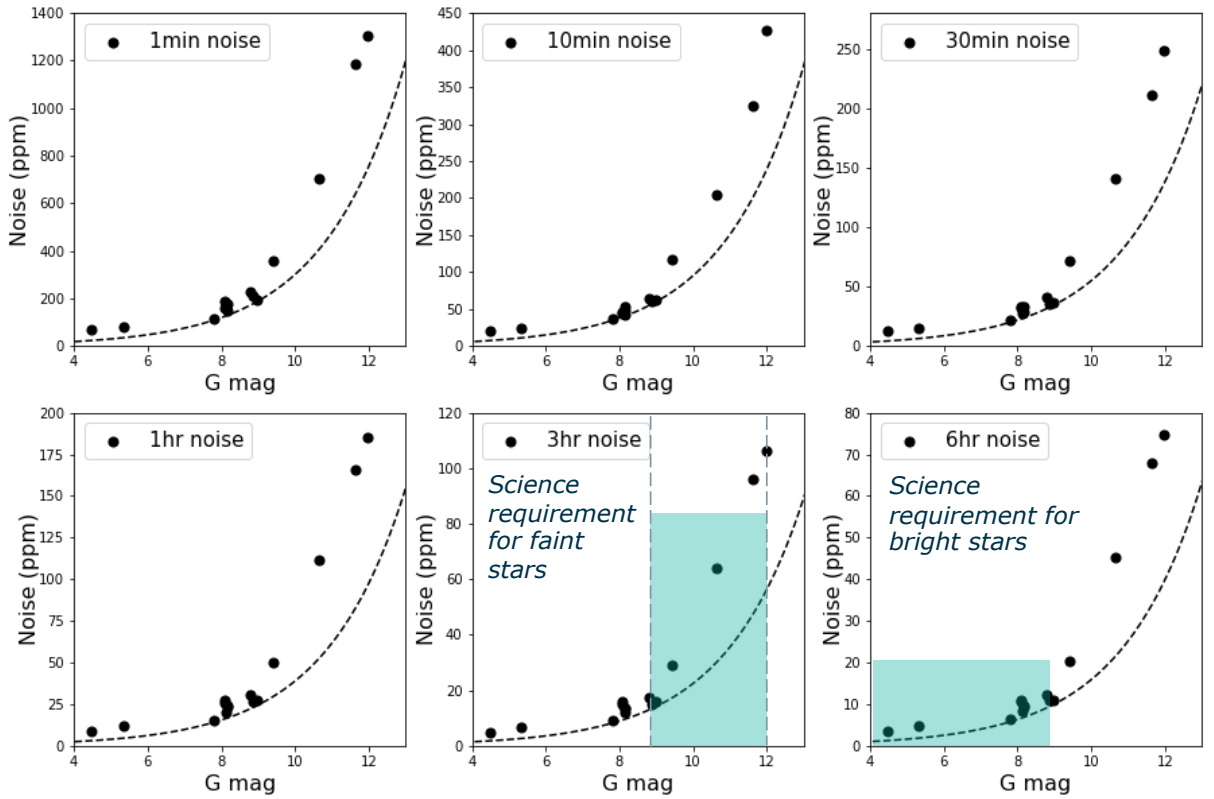


Image of the point spread function (PSF) measured during in-orbit commissioning. Left: flux distribution, x and y axis in pixels. Right: PSF profiles along the y axis for different horizontal cuts. The y values chosen for the figure contain the pixels with the highest flux of the PSF.

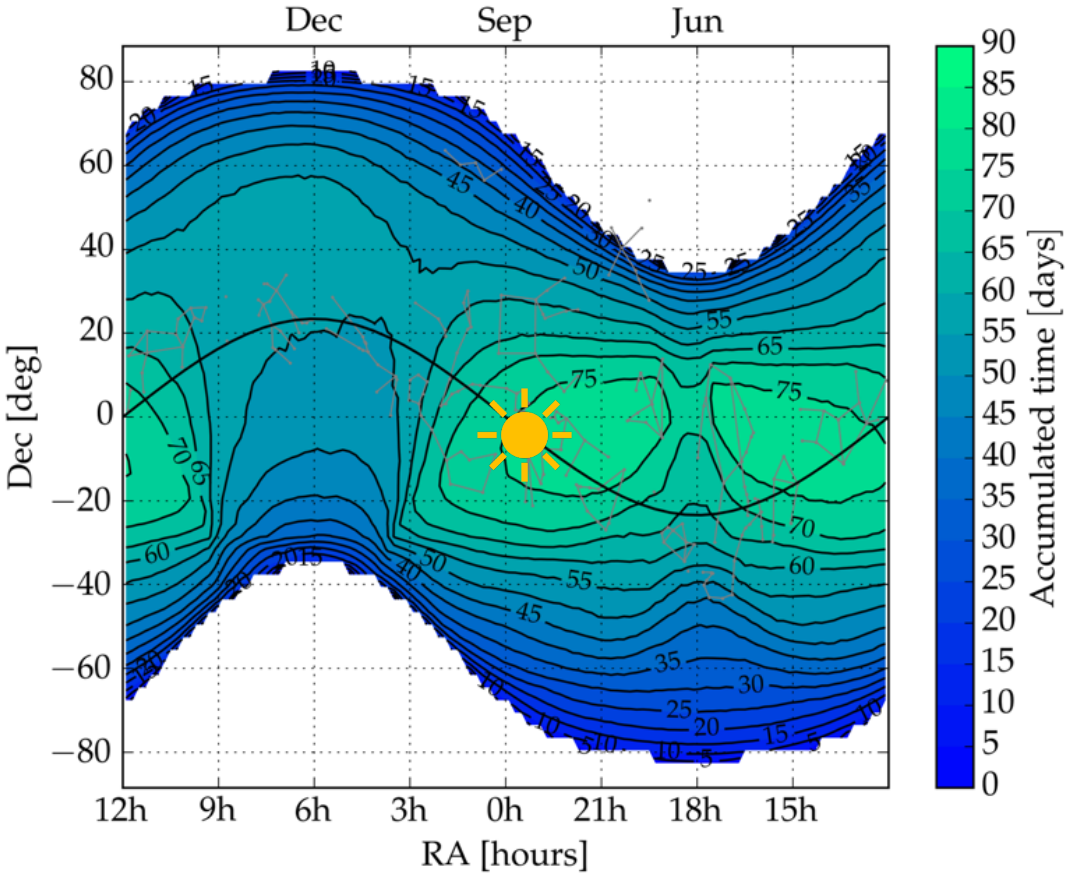
CHEOPS photometric precision

- Measured photometric precision/ noise as a function of stellar G magnitude for different integration times
- In each panel the dashed curve represents photon noise
- Results obtained with PYCHEOPS (v1.0.0) for light curves extracted using DRP v13 and a photometric aperture of radius = 25 pixels
- Precision maintained for periods of 48 hrs and longer



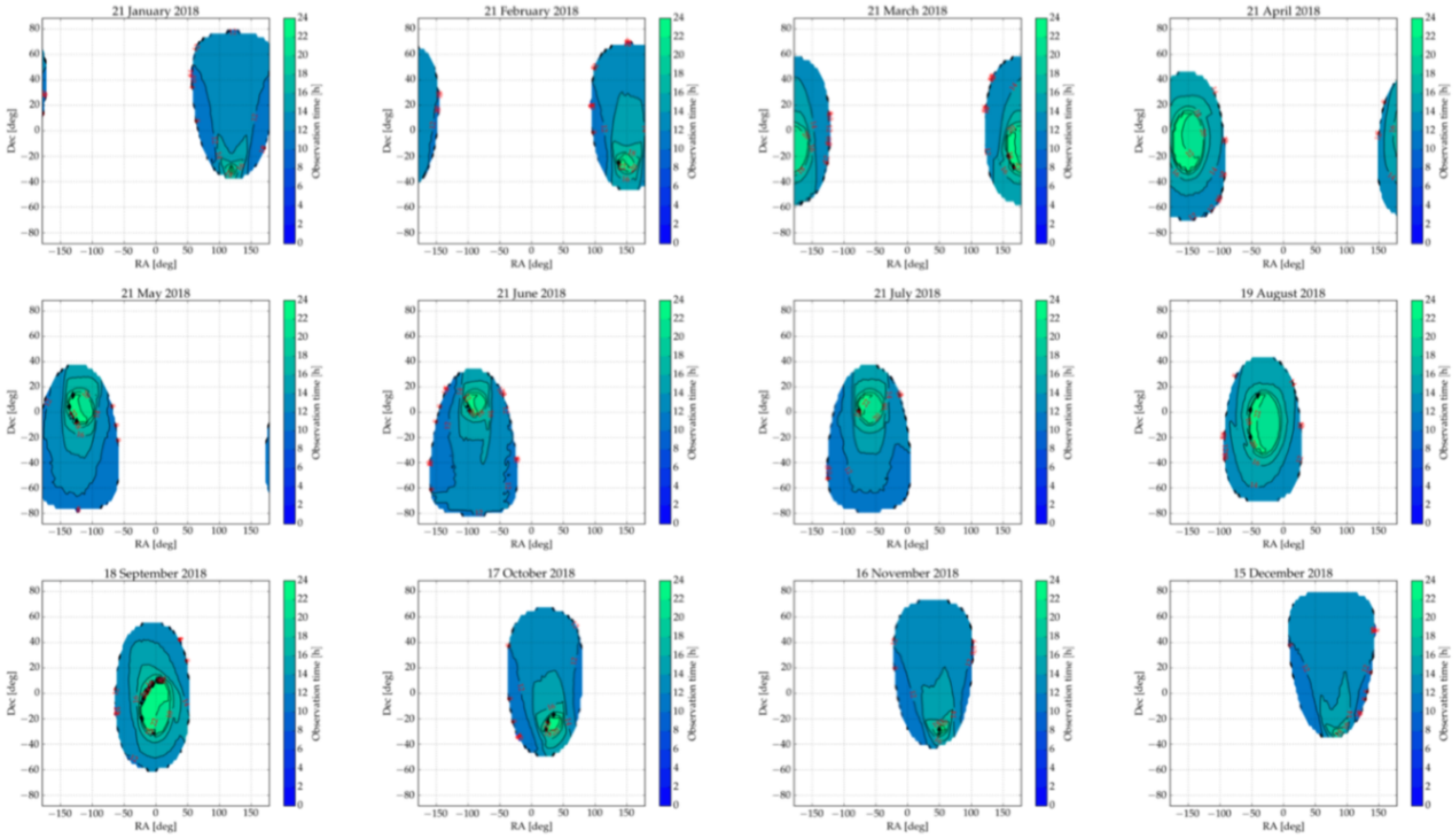
The CHEOPS Sky

- Annual sky visibility map illustrating the number of days a given position in the sky can be observed over one year, allowing for up to 50% orbital interruptions
- Interruptions due to Earth occultations and passage through the South Atlantic Anomaly
- Visibility best around the ecliptic plane (black line) - regions in white including ecliptic poles are not accessible
- More detailed checks of a target's visibility with CHEOPS can be made using the Scheduling Feasibility Checker:



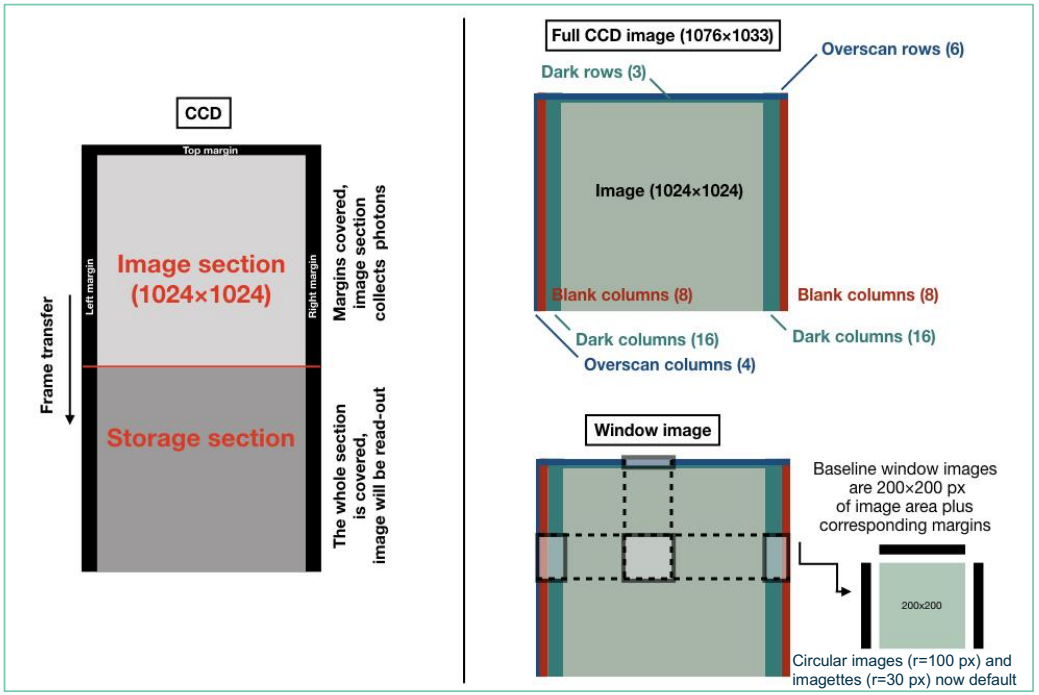
https://www.cosmos.esa.int/web/cheops-guest-observers-programme/scheduling-feasibility-checker/

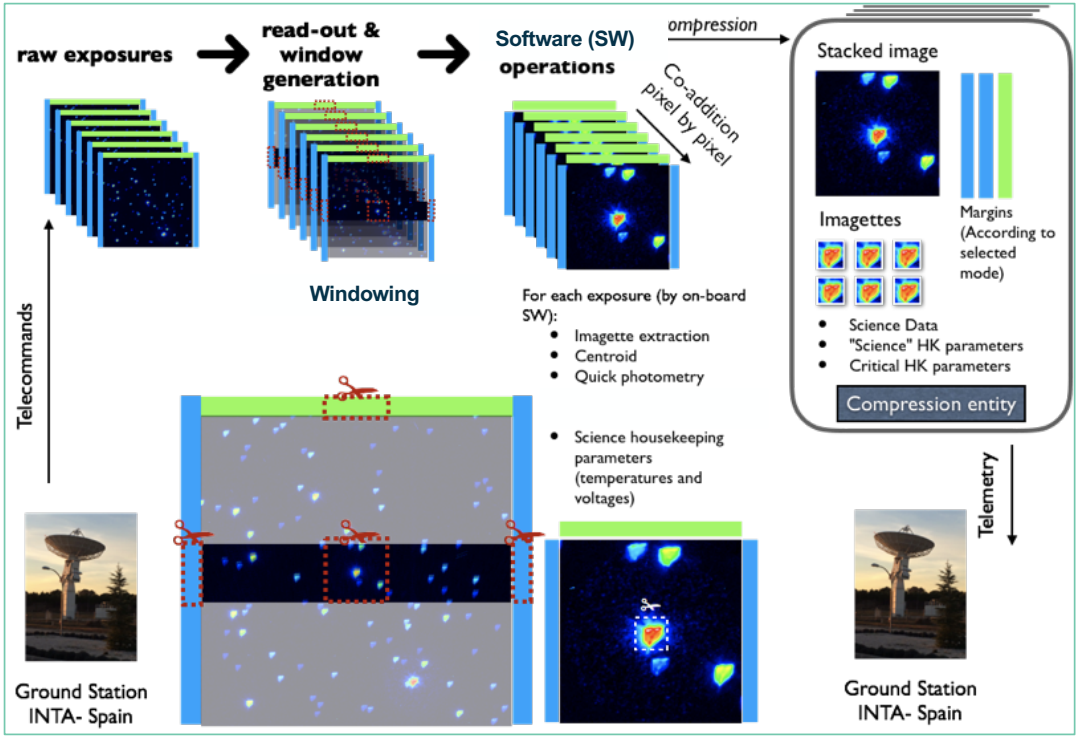
CHEOPS monthly instantaneous visibility



Number of hrs that a point in the sky can be observed with up to 50% interruptions on different days of the year

Observing with CHEOPS





CHEOPS full-frame CCD images are typically “windowed” (circular) to reduce the data volume which is constrained by the satellite downlink budget. Window images are also stacked for exposures shorter than 23 s. Imagettes (circular) are not stacked thus the exposure cadence is maintained.

CHEOPS observing constraints

Parameter	Comments
Duration of a single observation (1 orbit ~ 99 minutes)	Min: 5 orbits to enable efficient detrending of lightcurves Max: 100 orbits/ ~1 week). Longer possible by concatenation.
Total time requested in a single proposal	No limit on the maximum number of orbits that can be requested.
Solar System objects	CHEOPS does not support nonsidereal tracking. It is possible to use static coordinates (RA, Dec), however observations become highly time-critical/very challenging to schedule.
Simultaneous observations with other facilities	Challenging due to planning constraints, however can be considered in exceptional cases.
Targets on the reserved target list	Currently may not be included in proposals.
Targets for which data exists in the mission archive	Contact cheops-support@cosmos.esa.int to request further information on what has been done.

CHEOPS data products

Data products include:

- Level 0: Telemetry packets as received from the Mission Operations Centre (science+ housekeeping)
- Level 0.5: Unpacked data (FITS) sorted by visits. Time-tagged in UTC/MJD. Housekeeping data is in physical units
- Level 1: Calibrated and corrected science images – full array as well as window images and imagettes. Time-tagged in UTC, MJD and BJD
- Level 2: Light curves

+ calibration/reference data from the on-ground calibration campaign + in-orbit Monitoring & Calibration Programme

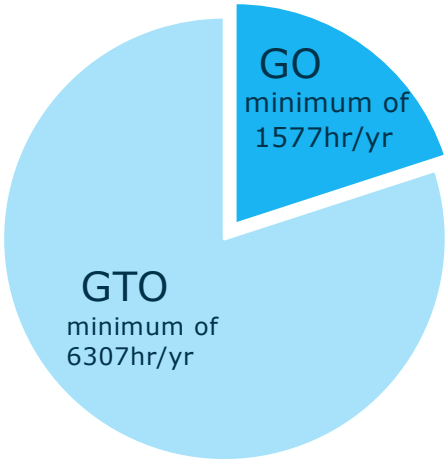
- All data – public and proprietary science data as well as calibration/reference files available from the CHEOPS Mission Archive

  https://cheops.unige.ch/archive_browser/

- Proprietary period of 1 year after last visit, and no longer than 18 months after the first

Observing time on CHEOPS

- 20% of the observing time on CHEOPS is available to the Community through ESA's Guest Observers (GO) Programme, remainder available to the CHEOPS Mission Consortium (Guaranteed Time Observing Programme – GTO)
- The majority of the time is available through annual calls (AOs), open to all. There is also a Discretionary Programme that is available throughout the year
- The third and final AO for the nominal mission – AO-3 – for proposals will come out on 15 February 2022, closing 4 weeks later on 15 March 2022 at midday (GMT)



CHEOPS in context

Parameter	CHEOPS	TESS
Pointing strategy	Pointed observations of ndividual targets	Survey
Cadence	At least 1 window frame per minute, higher cadence for imagettes	20 seconds (astroseismology – sample of very brightest stars); 2 minutes (core planet search); 30 minutes (all pixels)
PSF	Defocused – radius (90% encircled energy) ~ 16.5 “	https://heasarc.gsfc.nasa.gov/docs/tess/observing-technical.html/
Photometric Precision (representative)	See slide #6	https://heasarc.gsfc.nasa.gov/docs/tess/observing-technical.html/
Bandpass	See slide #4	See slide #4 and https://heasarc.gsfc.nasa.gov/docs/tess/the-tess-space-telescope.html/
Visibility/sky coverage	See slides #7 and #8	https://heasarc.gsfc.nasa.gov/docs/tess/primary-science.html/
Time stamp accuracy/precision	Accuracy and precision of better than 1s and 0.3s respectively	See eg. https://arxiv.org/abs/2005.07203/

Useful webpages

Webpages:

- CHEOPS for scientists – ESA website
  https://cosmos.esa.int/web/cheops/
- CHEOPS Mission Consortium website
  https://cheops.unibe.ch/
- CHEOPS mission archive
  https://cheops.unige.ch/archive_browser/
- CHEOPS in the Literature
  https://www.cosmos.esa.int/web/cheops/cheops-in-the-literature/
- CHEOPS data
  https://www.cosmos.esa.int/web/cheops-guest-observers-programme/cheops-data/
- CHEOPS Guest Observers Programme
  https://www.cosmos.esa.int/web/cheops-guest-observers-programme/
- CHEOPS AO-3
  https://www.cosmos.esa.int/web/cheops-guest-observers-programme/ao-3/
- CHEOPS Discretionary Programme
  https://www.cosmos.esa.int/web/cheops-guest-observers-programme/discretionary-programme/

Useful tools/manuals

Tools/manuals:

- CHEOPS Observers Manual

  https://www.cosmos.esa.int/web/cheops-guest-observers-programme/cheops-observers-manual/

- Reserved target list checker

  https://cheops.unige.ch/pht2/search-reserved-targets/

- Exposure Time Calculator (ETC)

  https://cheops.unige.ch/pht2/exposure-time-calculator/

- Scheduling Feasibility Checker

  https://www.cosmos.esa.int/web/cheops-guest-observers-programme/scheduling-feasibility-checker/

User-contributed tools/aids ("as-is"/no support):

- PYCHEOPS - python package for analysis of CHEOPS light curves

  https://pypi.org/project/pycheops/

- CHEOPSim (CHEOPS simulator)
  - Detailed in a paper by Futyan et al. https://doi.org/10.1051/0004-6361/201936616/
  - Source code, installation instructions and documentation: https://github.com/davefutyan/CHEOPSim/

- Linea – linear detrending package (python) for analysing CHEOPS observations

  https://linea.readthedocs.io/en/latest/