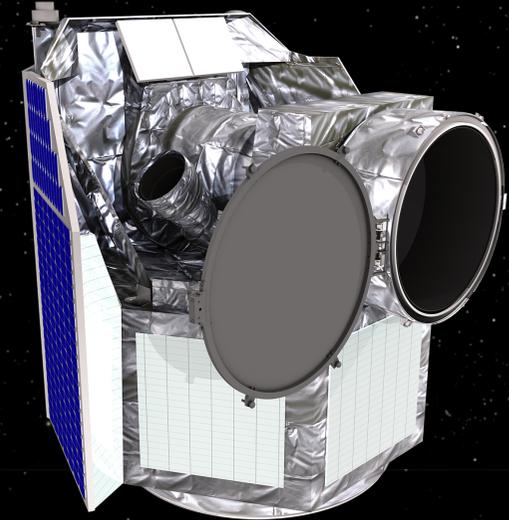


CHEOPS



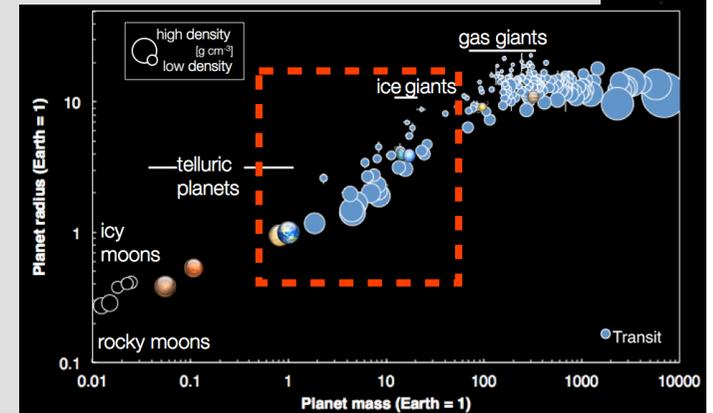
CHEOPS: **Characterising ExOPlanet Satellite**

Kate Isaak (ESA project scientist)

on behalf of ESA CHEOPS Project Team and the
CHEOPS Mission Consortium

What is CHEOPS?

- Mission dedicated to the search for exoplanet transits of local, bright stars already known to host exoplanets:
 - Detection and first-step characterisation of transiting exoplanets smaller than Saturn ($P < 50$ days) through high-precision, wideband transit photometry
 - Follow-up, pointed observations of individual stars:
 - Know where and when to point \rightarrow efficient way to measure shallow transits
 - Bright host stars ($V < 12$) \rightarrow detailed knowledge of star, also accurate mass measurements (RV)
- Accurate measure of mass + radius \rightarrow robust estimates of bulk density \rightarrow ...

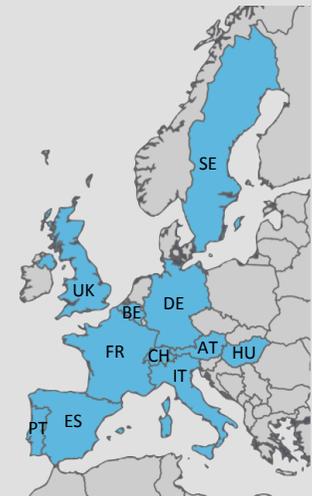


CHEOPS science objectives

- Measurement of bulk density in a large sample of Super-Earths and Neptunes
 - Insight into physics and formation of planets
 - Identification of planets with atmospheres → critical core mass, atmospheric loss
 - Constraints on planet migration
- Identification of golden targets
 - Thin atmospheres → targets for spectroscopic follow-up
- Probing atmospheres of hot-Jupiters using phase curve measurements
 - Albedos and occurrence of clouds
 - Study of physical mechanisms and efficiency of energy transport from day -> night side

CHEOPS: an S-class mission

- First small (S)-class mission in the ESA Science Programme
- Boundary conditions:
 - High technology readiness levels for platform and payload
 - Total cost ESA: $\leq 50\text{M€}$ (2012 econ.cond), $\leq 150\text{M€}$ (ESA + MS)
 - Development time no more than 3.5 – 4 years
- Implemented in partnership with Switzerland, with a consortium comprising 10 other ESA member states (MS) - PI Willy Benz (CH)
- Division of responsibilities very different from other, larger ESA science missions:
 - ESA: Mission architect, spacecraft (ADS), launcher (shared), LEOPS, IOC
 - CMC: Science Team+chair, CHEOPS payload, Mission and Science Operations Centres, science performance monitoring&evaluation
- Selected December 2012, adopted Feb 2014, launch-ready end of 2018



→ Test case for the S-class concept ←

Top level science requirements

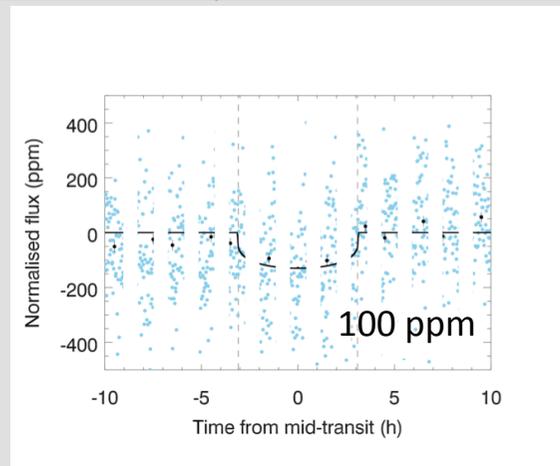
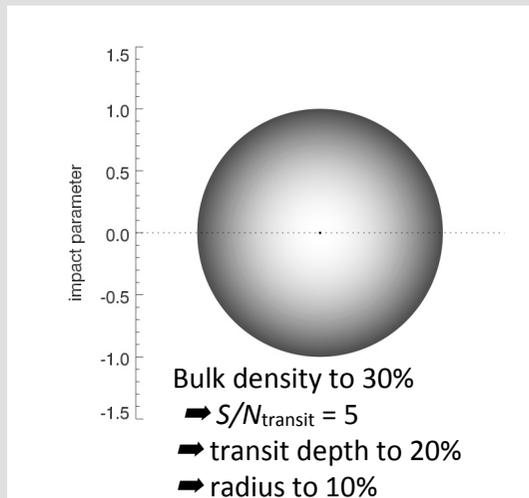
- Photometric precision → high-precision light curves → accurate radii.
- Sky coverage → accessibility of targets, repeated obs.
- Temporal resolution and uncertainty → sampling ingress/egress + TTV.
- Mission lifetime of 3.5 years (goal 5 years).

Detailed description at:

<https://www.cosmos.esa.int/web/cheops/science-requirements>

Requirements on photometric performance

Detection of Super-Earths transiting bright stars ($6 < V < 9$)

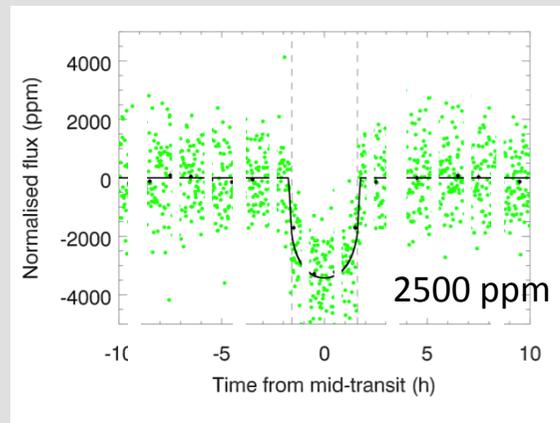
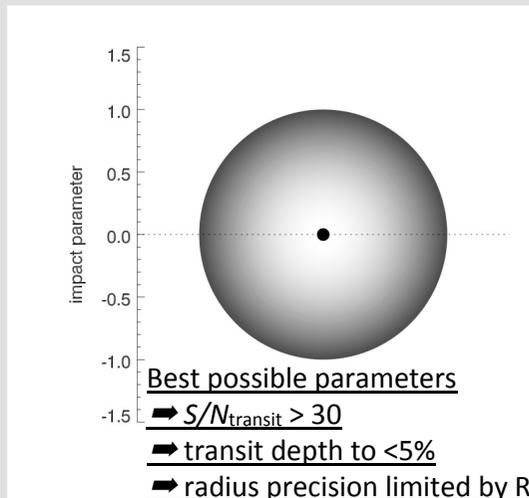


20ppm in 6 hrs for G5V star

($T_{\text{eff}}=5500\text{K}$) $V=9$

(tolerating up to 50% interruptions ie. SAA, earth occultations)

Characterisation of Neptune transit light curves ($9 < V < 12$)



85ppm in 3 hrs for K-type stars

with $V < 12$

(tolerating up to 20% interruptions)

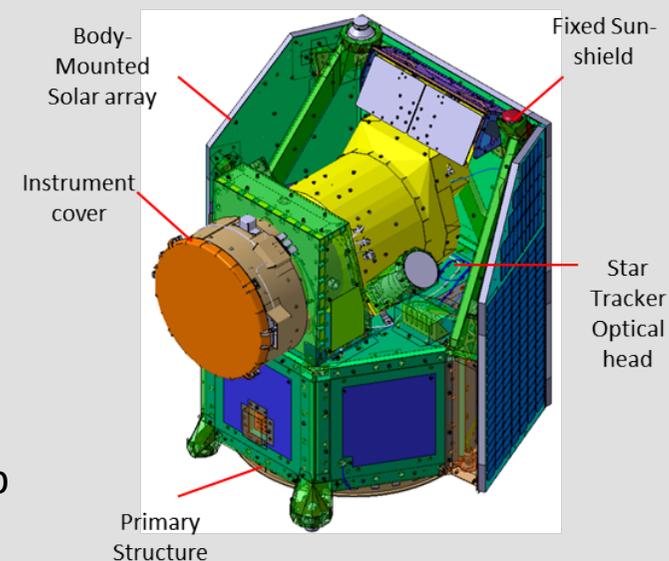
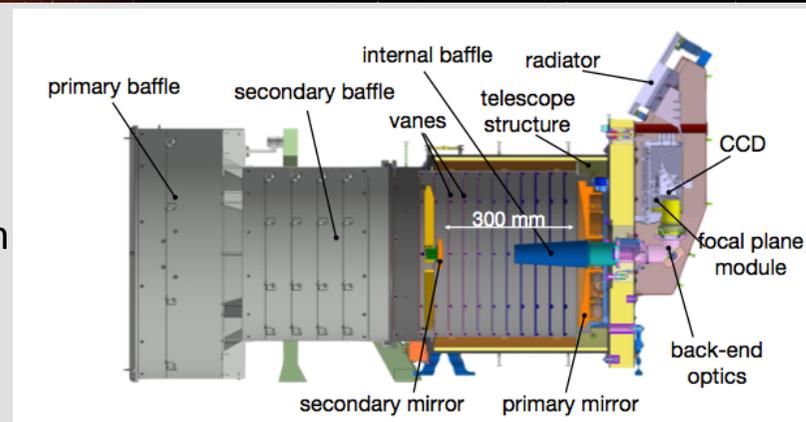
CHEOPS in a nutshell: payload and platform

Payload:

- Single-band ultra high-precision photometer (0.33-1.1 μ m).
- Single CCD, 1k x 1k pixels (+ frame store), 13 μ m pitch ($\sim 1''$ /pix):
 - Op temp -40 deg C, stabilised to 10 mK.
- Compact Ritchey-Chrétien telescope, effective \varnothing dia.=300 mm:
 - Entrance baffle provides high stray-light rejection.
- Defocussed PSF to reduce impact of spacecraft jitter.
- 60 kg / 60 W / 1Gbit downlink budget per day.

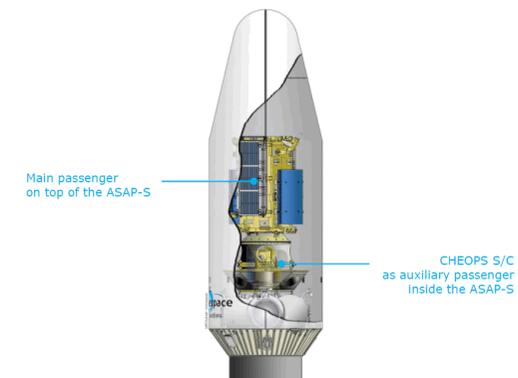
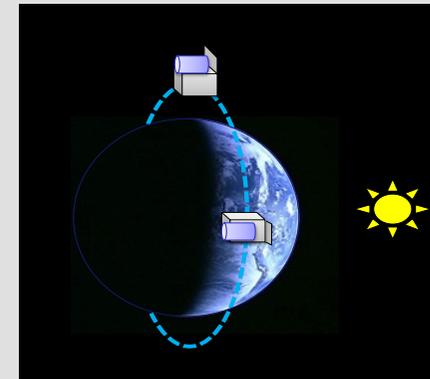
Platform:

- ~ 1.6 (h) x 1.5 x 1.5 m, ~ 280 kg.
- Pointing accuracy < 4 arcsec (rms), payload in the loop to centroid, roll around Line of Sight.



CHEOPS in a nutshell: launch, orbit and operations

- Shared launch:
 - Co-passenger on-board Soyuz, launching from Kourou.
 - Launch-ready end 2018
- Low-earth orbit:
 - Sun-synchronous, dawn-dusk, local time of ascending Node (LTAN) 6AM, 700 km altitude.
- Mission Operations (Centre MOC):
 - Developed by GMV; MOC operated by INTA from Torreón
 - Ground stations at Villa Franca and Torreón
- Science Operations (Centre SOC):
 - Developed by team led by UGE, including CH, FR, IT, PT, SE, UK; SOC run from Geneva Observatory.

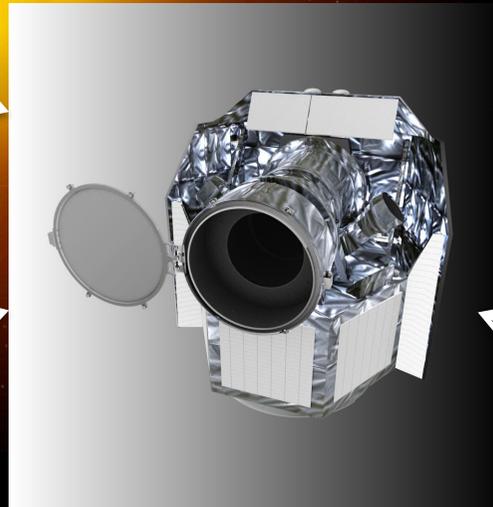


CHEOPS Targets

Ground-based transit surveys
eg. NGTS



Ground-based RV surveys
Eg. HARPS, HARPS-N, HIRES, SOPHIE
(on-going) ESPRESSO (2017)



TESS



Kepler/K2 survey



Open-time proposals (20%)



3.5 yrs baseline (5 yrs goal)

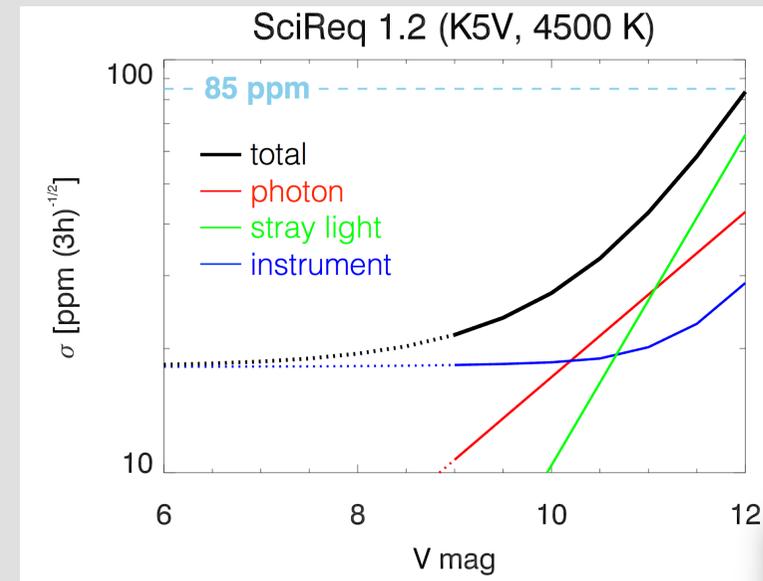
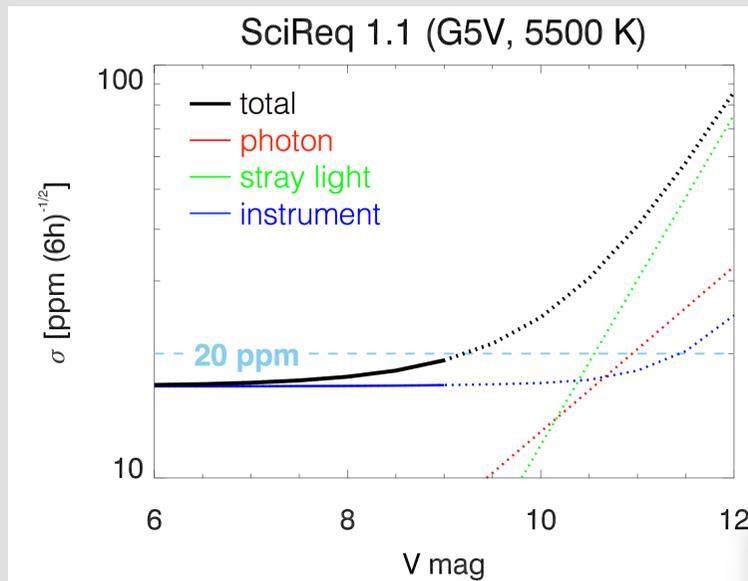
Adapted from CHEOPS Consortium slide

Observing with CHEOPS

- 80% : 20% split between CHEOPS Mission Consortium (GTO) and Guest Observers' (GO) Programme.
- ESA manages the GO programme:
 - Time allocated competitively by ESA-appointed TAC, based on annual AOs, first 6 months before launch.
 - Reserved target list for GTO , first frozen 6 months before launch (updated during mission), can be queried.
 - Up to 25% of GO time available as Director's Discretionary Time (DDT) to enable quick turn-around on new targets between calls
- Proprietary time on a target-by-target basis: 1 year after last observation (1.5 years after first) → same for GTO and GO observations, up to for DDT.
- All data reduced by common DR pipeline at SOC
 - End product fully-calibrated light curve
 - Available through CHEOPS archive, subject to proprietary status

More details on GO Programme on poster S1.5, also at the CHEOPS Open Time Workshop on 26/27th June and on ESA webpages (eg. <https://www.cosmos.esa.int/web/cheops/observing-with-cheops1>)

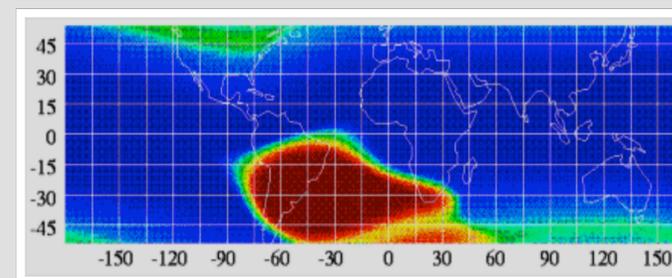
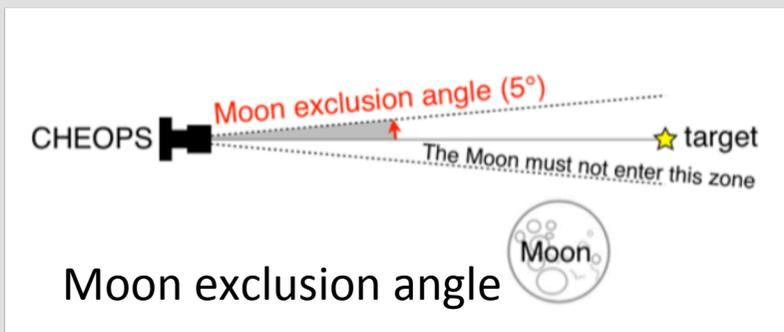
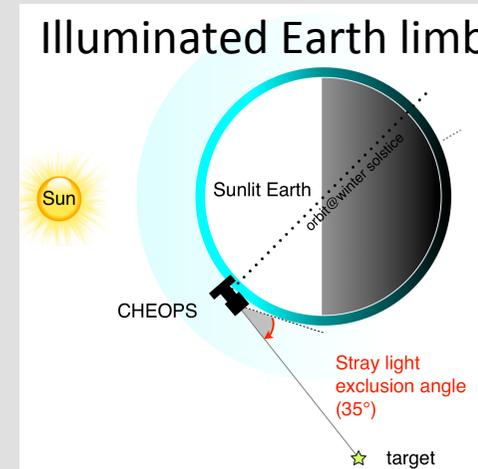
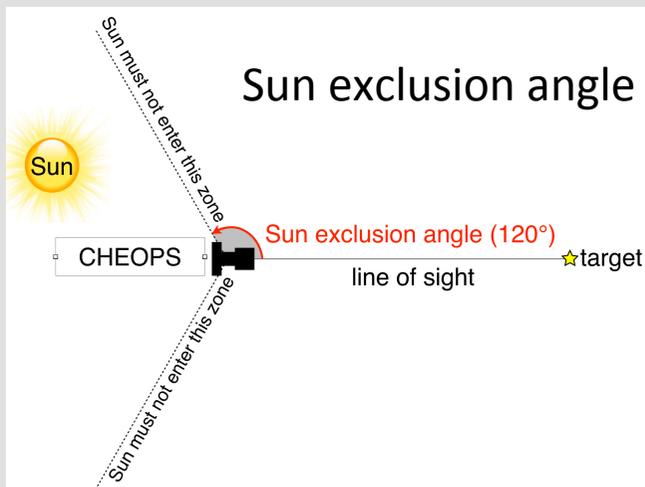
CHEOPS Performances: photometric precision



Performance maintained over 48 hrs

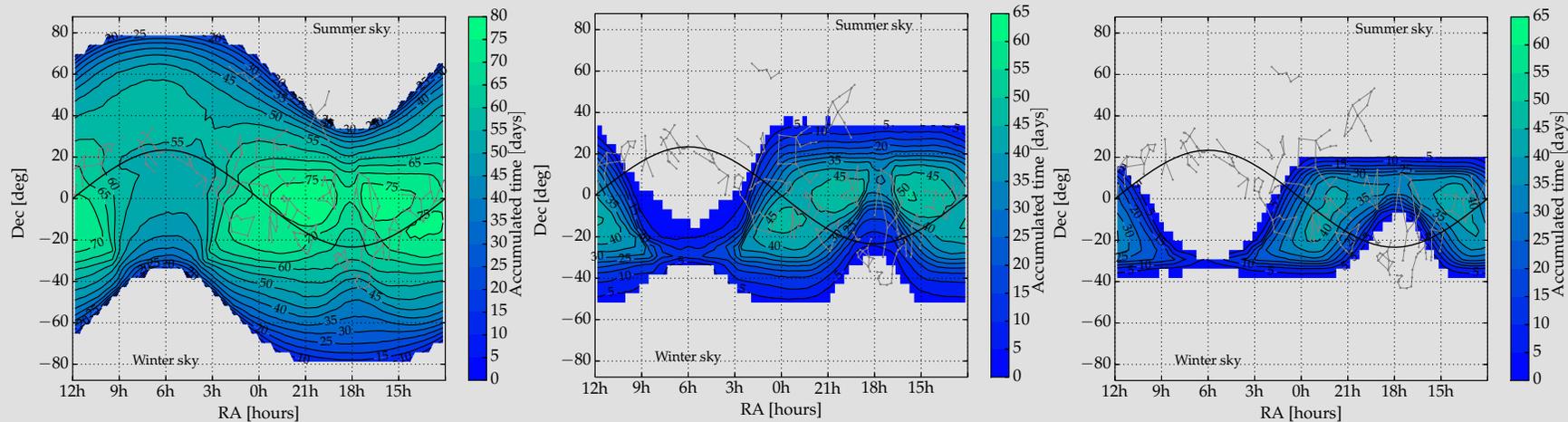
CHEOPS Instrument Performance v1.0 - CHEOPS Mission Consortium

CHEOPS Performances: pointing constraints



South Atlantic Anomaly (SAA)

CHEOPS Performances: sky coverage



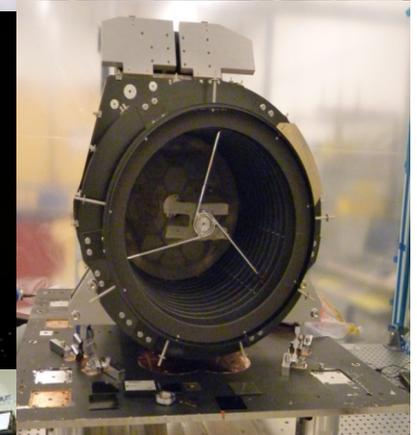
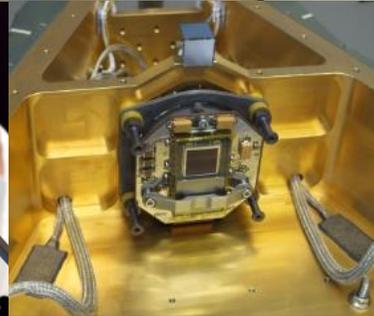
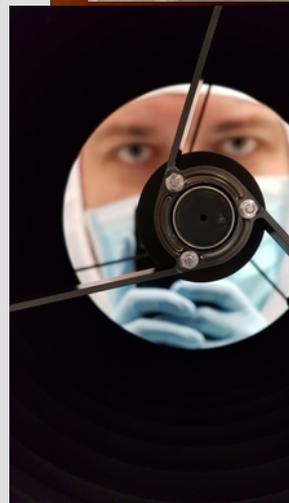
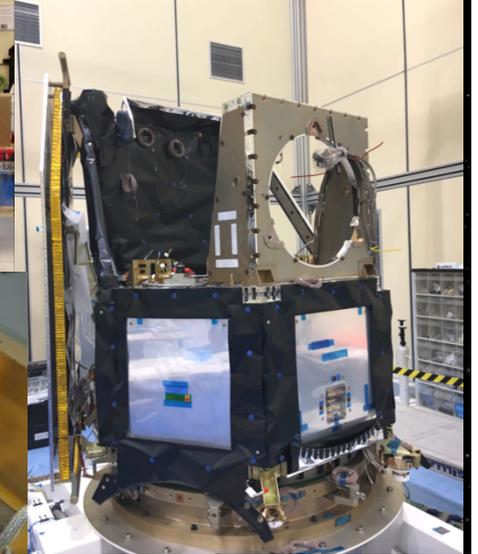
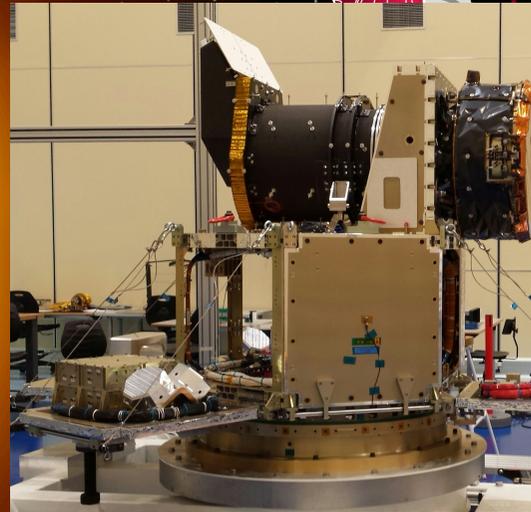
No: days/yr for which one can observe with $\leq 50\%/30\%/20\%$ interruptions/orbit, straylight threshold 5ppm for a G5V/ $m_v=9$ star (6hrs) (equiv 70 ppm for K5V/ $m_v=12$ star (3hrs))

- Detecting Super Earth transits: $>50\%$ of sky, $\leq 50\%$ interruptions, 50 days/yr
- Characterising Neptune light curves: $\sim 25\%$ of sky ($2/3^{\text{rd}}$ in south), $\leq 20\%$ interruptions, 13 days/yr

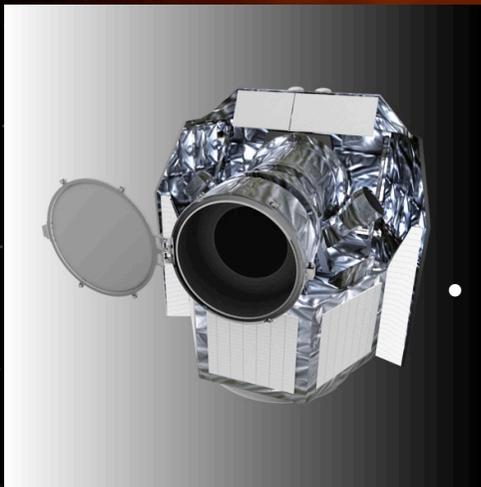
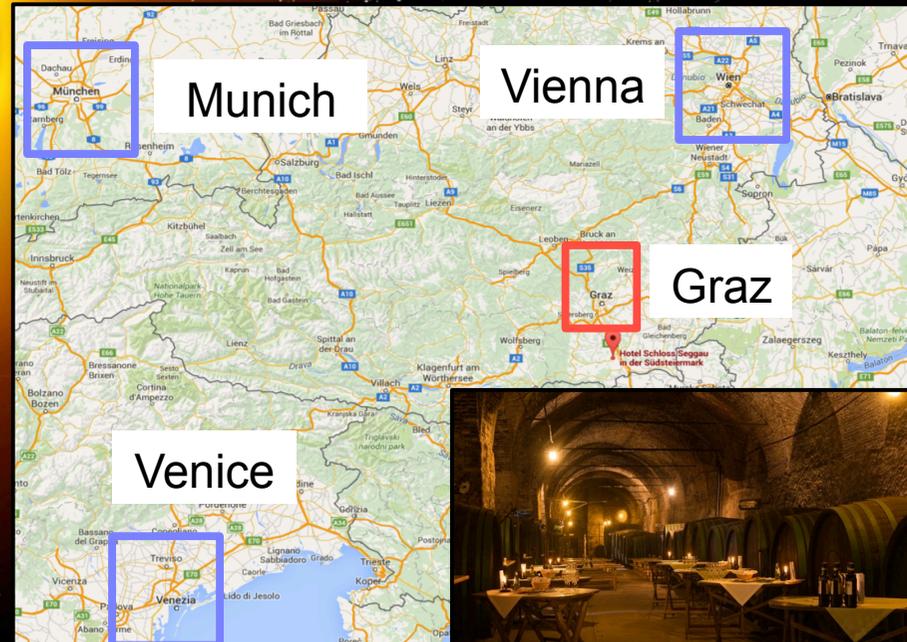
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CHEOPS status

- Assembly of Instrument Flight Model ongoing
- Platform assembly and integration completed end May
- On-ground payload calibration campaign to start in November
- Instrument integration into platform Spring 2018
- Satellite environmental testing
- Launch ready end 2018



CHEOPS Workshops - 24 – 27th July 2017 Schloss Seggau (nr Graz , Austria)



- 5th Annual CHEOPS Science Workshop 24-26th July:
<http://geco.oew.ac.at/cheops-workshop-05.html>
- CHEOPS Open Time Workshop 26-27th July:
<https://www.cosmos.esa.int/web/cheops-open-time-workshop-2017/>

CHEOPS



Thank you for your attention