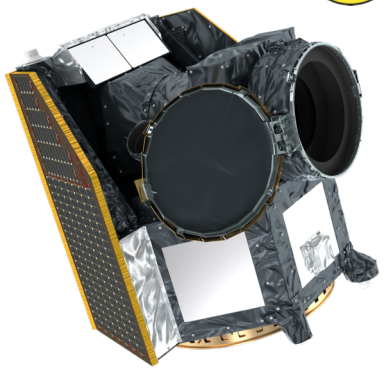
Observing outside the nominal magnitude range



Observing outside the nominal magnitude range

- CHEOPS was designed to observe stars in the magnitude range $6 \leq G \leq 12$
- Main limitations for observing fainter stars:
  - background contamination (**straylight**, stars in the FoV)
  - bad pixels, esp. hot pixels
  - cosmic rays

  Note that a 1-m ground-based telescope will perform photometrically better than CHEOPS for stars fainter than G ~ 13. Therefore, the reason to use CHEOPS in these cases should be well justified (e.g. long, uninterrupted observations needed).

- Main limitations for observing very bright stars (much brighter than G = 6):
  - should avoid saturation (i.e. very short exposure time, large image stacking order)
  - strong self-smearing trails (manual reduction of the images required –not provided by the consortium)

Main noise sources for stars fainter than G ≃ 12

- Although CHEOPS rejection of Earth straylight works as expected, faint targets are much more sensitive to this spurious contamination, which can become the dominating noise source. Note that, unlike the zodiacal light, the Earth straylight varies with the periodicity of the CHEOPS orbit.

- An unexpected source of straylight has been detected in flight: the atmospheric airglow. When the Line of Sight to the target is close to the Earth limb (up to ~ 8 deg.) images show signs of straylight, even if flying over a night region. It was concluded that the most likely source for this is the atmospheric airglow. This event is unpredictable, as it depends on the state of the atmosphere and can degrade the signal of several images in a visit.

Main noise sources for stars fainter than G ≃ 12 (cont.)

- Due to the large size of the PSF (90% of encircled energy within r ~ 16.5 px), the fainter the target is, the more likely that background stars (of similar magnitude) will significantly contaminate the photometry, either by overlapping with the target's PSF and/or by coming in and out of the photometric aperture over the period of a CHEOPS orbit.
- The number of hot pixels in the CCD is increasing daily (~100/day). Due to the large size of the PSF, there will invariable be hot pixels within the location of the PSF and inside the photometric aperture. While for the moment we have not seen any impact on the photometry (the observation window is always placed in a region of the CCD with a low density of hot pixels), the fainter the star is, the more affected it will be by their presence. Even if hot pixels are stable (and many are not), they could, for example, affect the estimated transit depth.
- Cosmic rays also have more effect on the photometric precision of fainter stars. Although cosmic rays are easily detected for these targets, and are corrected by the data reduction pipeline, the noise that this introduces is proportionally greater for fainter stars than it is for bright stars.

In spite of all the caveats mentioned in the previous slides, it should be noted that CHEOPS is performing as predicted by the ETC, even for very faint stars (G > 12).
On-going studies show that for "ideal targets" (ie. isolated, "quiet" stars), the photometric noise estimated by the ETC is in good agreement with the measured noise for stars as faint as G = 14.
We, however, discourage observations of such faint targets as it is very unlikley that they are "ideal" and there are other facilities better suited for the study of these stars.

Main noise sources for very bright stars

CHEOPS is well suited for the observation of bright stars. However, when the stars are very bright CHEOPS performance is not optimal.

- Short exposure times to avoid saturation: the observation of very bright stars require an exposure time, t_{exp}, of well below 1 s. For example, a G = 2.5 star would require a t_{exp} ~ 0.1 s. The observer will receive one stacked image per minute that corresponds to the on-board stacking of 39 individual exposures. Imagettes will also be stacked in sets of 3. While there is nothing intrinsically wrong with this, the maximum duty cycle of this observation can be only 65%. Such short exposure times therefore translate into inefficient use of CHEOPS time.

- Images of very bright stars show a strong self-smearing trail (see image on the right). Although the DRP can handle smearing trails within the nominal magnitude range, for very bright stars these are too strong and need a “personalized” treatment with a dedicated tool (not provided by the consortium).