

#### **CHEOPS T&S WORKING GROUP 2 – DATA ANALYSIS**

# CHEOPS AO-3

### Top tips for applicants



# How many orbits do I need?

- CHEOPS is in a nadir-locked 100-min orbit:
  - Hence the field of view rotates.
- CHEOPS photometry contains orbitally-modulated systematics:
  - Contamination by other stars
  - Thermally-driven changes in PSF shape.
- These are easily decorrelated
  - ... given enough out-of-transit data.
- Recommendation: 5 contiguous orbits out-of-transit (OOT)
  - 3 OOT orbits before ingress AND
  - 2 OOT orbits after egress



Example: Field contamination and flux modulation with roll angle in HD108236 (Bonfanti et al 2021A&A...646A.157B)

### Visit efficiency (EFF) and duration



#### Aim for EFF > 60%, bare minimum 50%

visit\_duration = MAX( 3 \* transit\_duration, transit\_duration + N \* cheops\_orbit) + /

where N = number of cheops\_orbit of out-of-transit. Recommend 3 before and 2 after for ramp and roll-angle decorrelation,

And *I* = Latest\_Observation\_Start - Earliest\_Observation\_Start

*I* is needed to increase flexibility in the scheduling process. It assures that the observation covers the right amount of time before and after the transit.

The EFF changes with different  $\phi_{\text{start}} \Rightarrow$  run the FC with three trial scenarios:

- Earliest\_Observation\_Start == Latest\_Observation\_Start = starting phase ( $\phi_{start}$ )
- Earliest\_Observation\_Start == Latest\_Observation\_Start = earliest starting phase ( $\phi_{early start}$ )
- Earliest\_Observation\_Start == Latest\_Observation\_Start = latest starting phase ( $\phi_{\text{late start}}$ )

Check the behaviour of the EFF returned by the FC  $\Rightarrow$  get an idea of the EFF behaviour (indicative!)



# Example: HD106315

Maxted et al (2021)



In this illustration [transit\_duration + 5\*CHEOPS\_orbit +  $P_{planet}$ \*( $\phi_{late} - \phi_{early}$ )] > [3\*transit\_duration].



# How can I observe both ingress and egress?

- Target visibility is subject to interruptions:
  - When the target passes behind the Earth
  - When CHEOPS crosses the South Atlantic Anomaly
- Use the Feasibility Checker to set efficiency.
- You should define two important things:
  - Overall efficiency (previous slide)
  - Efficiency in Critical Phase Ranges (i.e. ingress, egress)
- Every target requires a different compromise:
  - Higher efficiency => fewer feasible visits
  - Lower efficiency => risk of missing ingress and/or egress



### Critical phases ranges (CPR)

#### e.g. ingress and/or egress tips:

Run the FC with:

- Fulfil\_all\_Phase\_Ranges == false (e.g. condition on ingress or egress, not exclusive)
- Minimum\_Phase\_Duration == 30% (minimum value allowed in the FC)
- Minimum\_Effective\_Duration (EFF) == 50%

#### CPR efficiency **does not change** with different $\phi_{\mathsf{start}}$

Test different CPR values, e.g.:

- based on full ingress/egress time ( $\tau$ ) taking into account parameter errors
- based on  $\tau$  without errors on the parameters
- based on half  $\tau$  centered on the ingress/egress (so-called T<sub>1.5</sub> and T<sub>3.5</sub>)

If the timing is the objective, prepare the ObsReq taking into account:

- high EFF on the centered ingress/egress provides strong constraints on transit time
- to increase the schedulability it is better to require one CPR with minimum value of 50%
- remember that requiring both CPR will reduce drastically the chance to be scheduled
- FC provides general information on the visibility and qualitative information on the EFF of the CPR.

### CHEOPS (SCIENCE TEAM Statistics about ingress/egress sampling

- Ingress  $\phi_{12}$  and egress  $\phi_{34}$  are delicate phases to constrain:
  - the impact parameter b and
  - the time  $T_0$  of mid-transit.
- Gaps in the Cheops LCs may prevent a proper sampling either of  $\phi_{12}$  or  $\phi_{34}$ .
- The (worst) case of TOI-1233 (3 visits, no constraints specified:)
  - Efficiency of the three scheduled visits: 55-60% • Number of transits:  $5 \rightarrow 5 \phi_{12} + 5 \phi_{34} = 10 \phi$
- - Over 10 φ: • 3 we're fully missed
    - 3 were fully covered
    - 4 were partially covered

| gap <sub>12</sub><br>[%] | gap <sub>34</sub><br>[%] |
|--------------------------|--------------------------|
| 47                       | 0                        |
| 0                        | 100                      |
| 100                      | 56                       |
| 94                       | 0                        |
| 16                       | 100                      |
|                          |                          |

Percentage duration of gaps:  $100\% \rightarrow$  Phase fully missed  $0\% \rightarrow$  Phase fully covered From Bonfanti+ (2021)

- Take-home message: wise use of the FC will improve your results while ensuring schedulability.
  Some targets will be easy to cover adequately in one visit; others may need multiple visits.
  In addition you need to consider how many visits are needed to achieve required SNR (use the ETC).