

### **MISSION PLANNING** AND THE FEASIBILITY CHECKER

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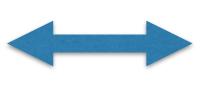
CHEOPS Open Time Workshop: 26-27th July, Schloss Seggau





## Mission Planning Overview





#### Scheduling of spacecraft activities (mostly science observations) that satisfy various constraints

Of relevance to CHEOPS observers:

- Observing constraints (physical constraints) See D. Ehrenreich's presentation
- Scheduling constraints (competition with other observations)









- Low Earth orbit
  - Frequent crossing of the South Atlantic Anomaly (strong radiation zone)

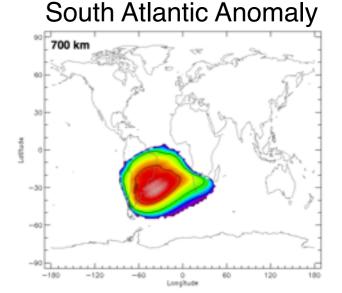
# South Atlantic Anomaly



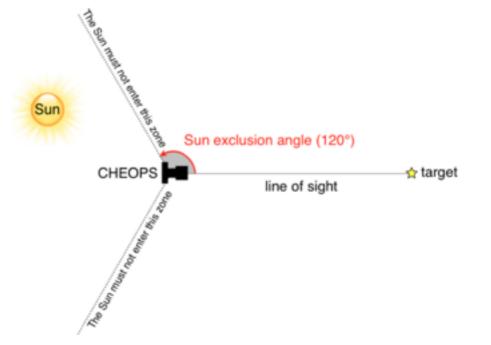




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- Low level of stray light required for precision photometry:
  - Sun avoidance angle = 120 degrees



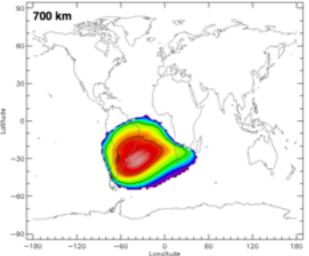




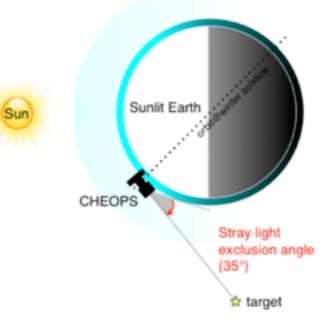


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#### South Atlantic Anomaly



- Low level of stray light required for precision photometry:
  - Sun avoidance angle = 120 degrees
  - Earth illuminated limb exclusion angle = 35 degrees

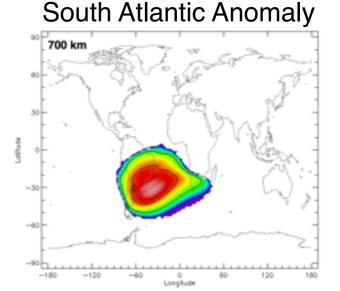




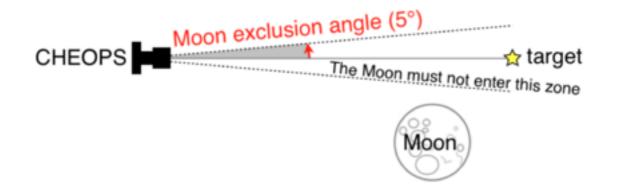




- Low Earth orbit
  - Frequent crossing of the South Atlantic Anomaly (strong radiation zone)



- Low level of stray light required for precision photometry:
  - Sun avoidance angle = 120 degrees
  - Earth illuminated limb exclusion angle = 35 degrees
  - Moon exclusion angle = 5 degrees









# Scheduling Constraints

- Competition with other science observations
  - Time-constraints associated with transiting planets
  - Science priority (see next slide)
  - GTO/GO/DDT balance (see K. Isaak's presentation)
  - Over-subscription (required for higher scheduling efficiency)







# Scheduling Constraints

- Competition with other science observations
  - Time-constraints associated with transiting planets
  - Science priority (see next slide)
  - GTO/GO/DDT balance (see K. Isaak's presentation)
  - Over-subscription (required for higher scheduling efficiency)
- Accommodate for non-science activities
  - Monitoring & Characterisation (see A. Deline's + R. Alonso's presentation)
  - Platform requests (spacecraft maintenance, expected to be rare)
  - Collision Avoidance manoeuvres (spacecraft orbit adjustment, expected to be rare)







### Science Priorities

#### **Three-level priority scheme:**

#### A : high priority science (high profile / urgent)

Undersubscription to limit scheduling conflicts / visits overlaps => expected high completion rate (tentatively above 80%)

#### **B** : Main science observations

Expected completion rate above 50% (depending on oversubscription)

#### **C** : Filler observations

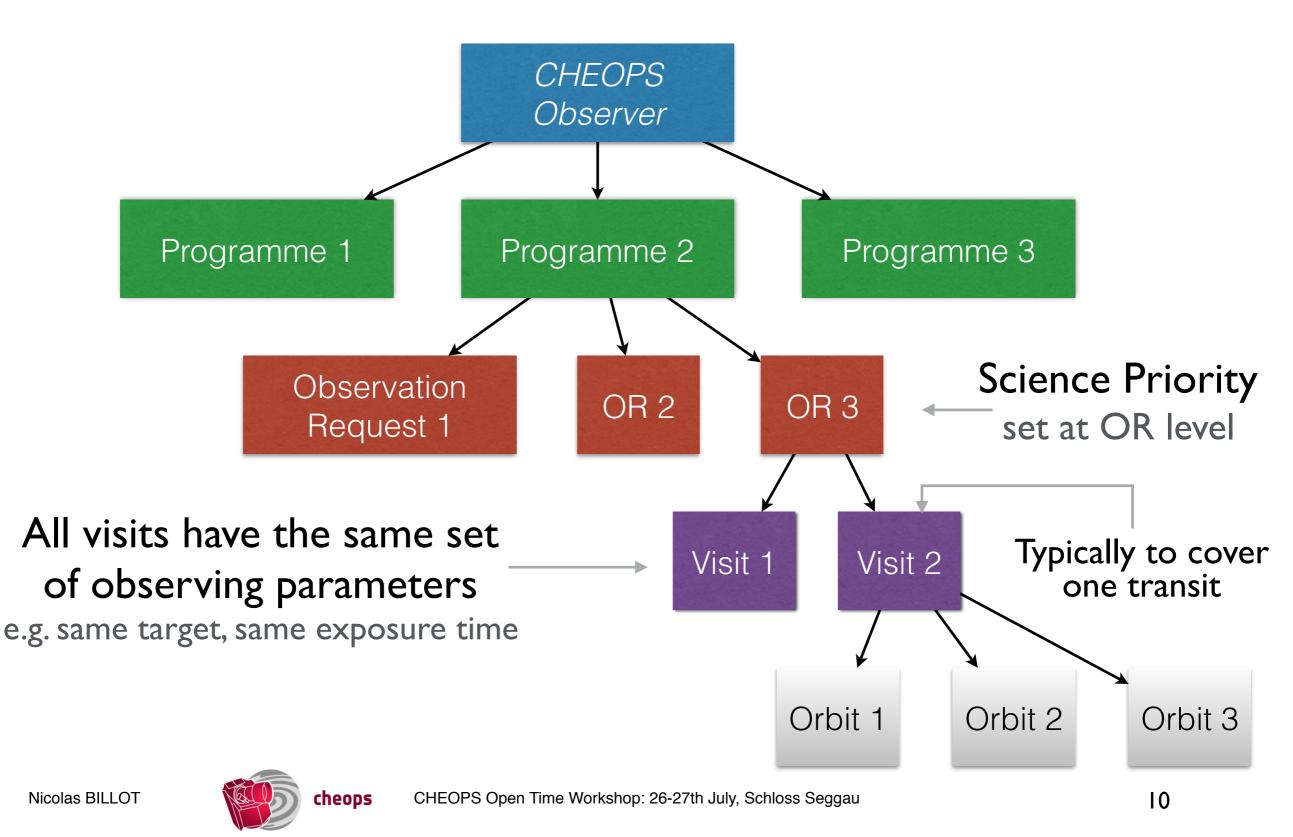
Mostly non-time-constrained **short** observations Expected low completion rate (below 30%, depending on oversubscription)







### Programme - Observations Hierarchy







# Schedule Optimisation

The observing schedule will be generated to maximise:

### • Science return

- Schedule as many visits as possible (satisfying observers' constraints)
- Ensure timely completion of high priority observations

### • Telescope time

- Promote observations with highest observing efficiencies
- Filler observations

A so-called *merit function* is defined in that sense, and it will be optimised with "smart" (genetic) algorithms.

Merit function computation includes:

- Science Priority
- GO/DDT-to-GTO ratio
- Overall timeline filling factor
- Observing efficiency of individual visits
- Completion of individual observation requests



cheops





# Mission Planning Simulations

### Mission Planning prototype developed for test purposes

Relevant parameters were explored for their impact on scheduling performances



Relevant at individual visit level



Relevant for competition during schedule optimisation

- Number of visits
- Observing efficiency
- Critical phase ranges
- Visit duration
- Start-phase slack
- GO/GTO
- Relative fraction of A-to-B observations (aiming at 80+% completion rate for A-grades)
- Oversubscription of A+B
- Number/duration of filler observations





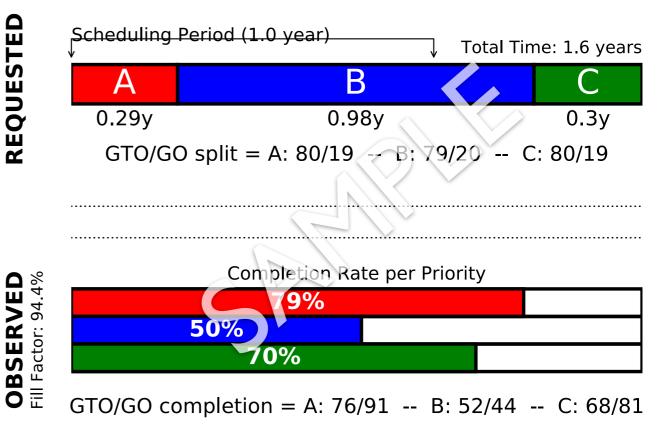


# Mission Planning Simulations

#### Test dataset:

I.6 years of synthetic observationrequests with realistic priority and GO/GTO distributions.

Generate a 1-year optimised schedule with the Mission Planning prototype



GTO: 80.0% -- GO: 20.0%

### Mission Planning prototype performs as expected:

- High filling factors achieved
- High completion rate for A-rated observations
- GTO-to-GO ratio is respected





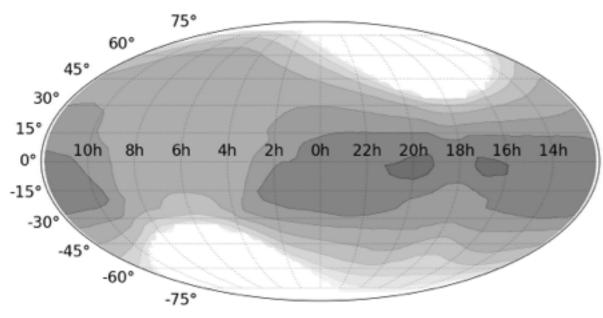


### Mission Planning for Observers

### Before applying for CHEOPS time:

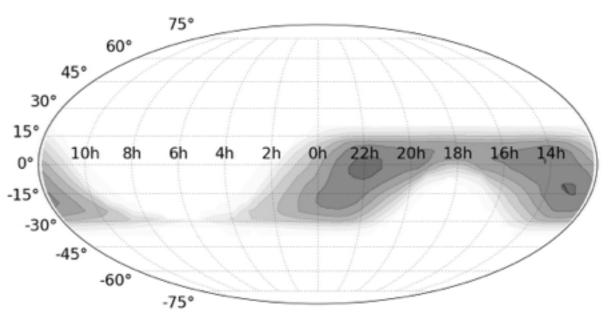
Is the target visible at all?

Check out the CHEOPS visibility maps



#### Most unconstrained / favourable case

Allows for high levels of stray light (adequate for bright stars) Over 50% of uninterrupted observation per orbit



#### Most restrictive / unfavourable case

Allows for lower levels of stray light (required for faint stars) Over 80% of uninterrupted observation per orbit



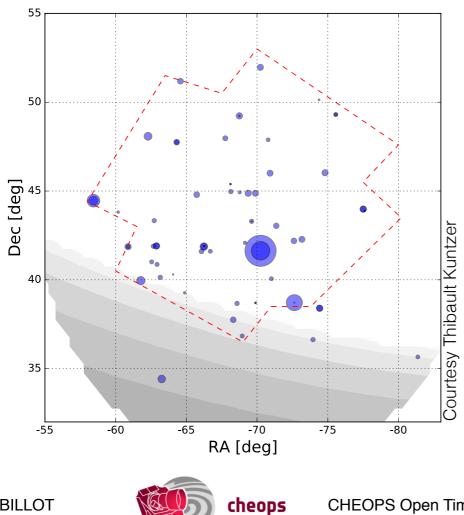




### Mission Planning for Observers

### Before applying for CHEOPS time:

- Is the target visible at all?
  - Check out the CHEOPS visibility maps



**Kepler Field Visibility** 

Most targets from the Kepler field are **not** visible by CHEOPS due to the Sun exclusion angle

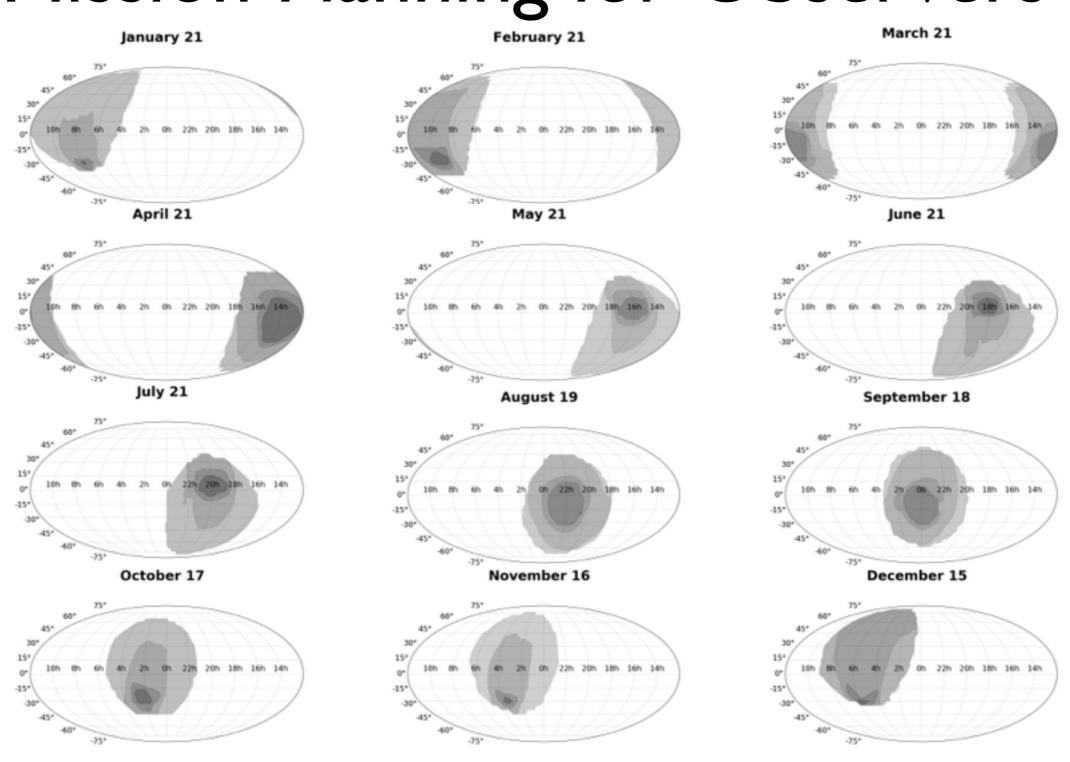






### Mission Planning for Observers

Monthly sky visibility maps When can my source be observed by CHEOPS?









#### Tool to generate possible visits satisfying user-defined constraints

- Most functionalities already implemented
- Available to the community from 1st Announcement of Opportunity on
- FC used to check if an observation is feasible (≠ will be scheduled)
- FC results should be considered as indicative only (not binding)
- FC provides clues to evaluate if an observation is easy to schedule
  - Two major observation constraints can be checked with the FC:
    - visibility windows
    - "reasonable" observing efficiency (on-source time, excluding interruptions)

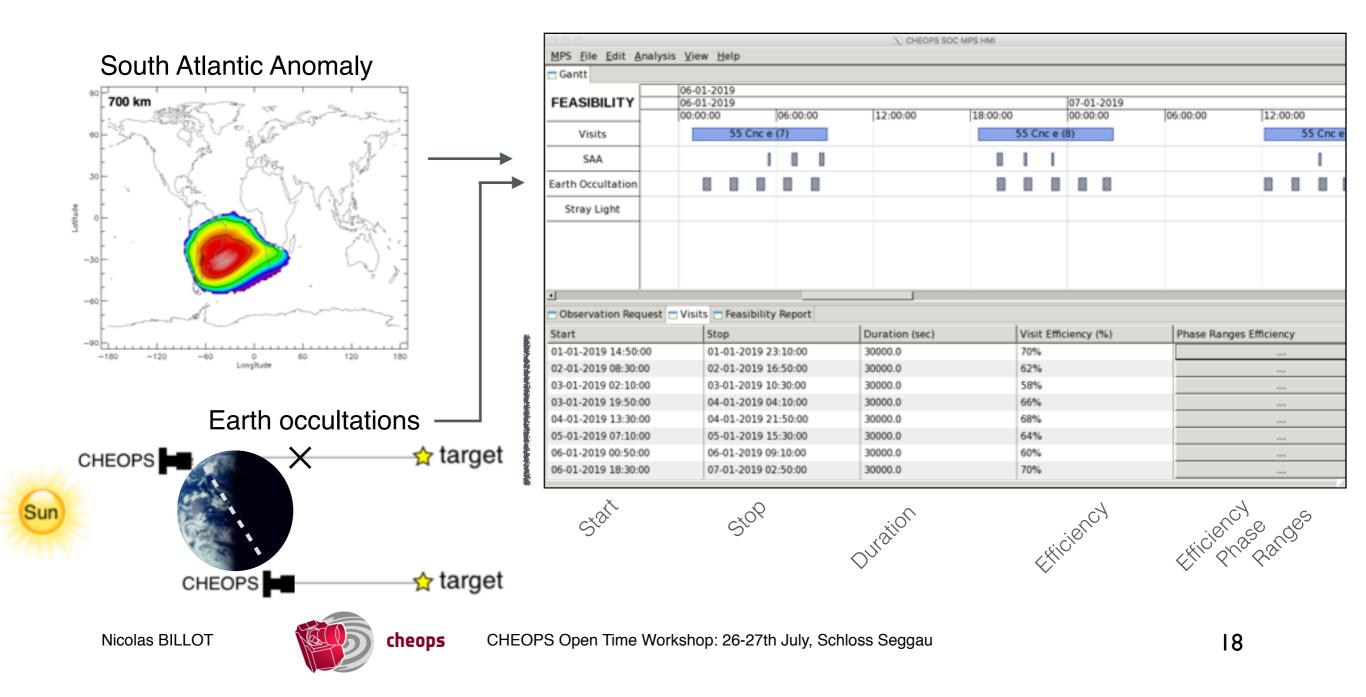






#### The Feasibility Checker is a powerful tool

• Born as a by-product of the Mission Planning System used for operations

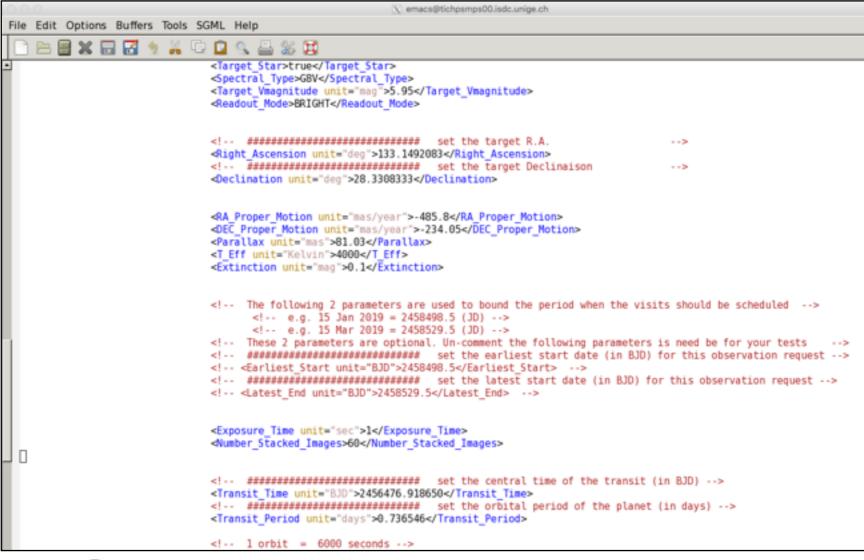






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- Born as a by-product of the Mission Planning System used for operations
- But... it inherited the rigidity of a mission-critical system...









### Test Case on 55 Cnc:

- Short visit around transit of 55 Cnc e
- Any time in January 2019
- Requested visit duration of 4 orbits
- Requested min. efficiency of 75%

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- Short visit around transit of 55 Cnc e
- Any time in January 2019
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- Requested min. efficiency of 75%
  - => 40 possible visits in January

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CHEOPS

- Requested visit duration of 4 orbits
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=> 40 possible visits in January

Explore the result

Efficiencies in the range 55 - 75% => Only I visit is valid

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### Likelihood of scheduling 1 visit $\propto$ Number of possible visits







### Lessons learned with the FC:

- Observing efficiency is a critical parameter
  - Too restrictive = no data
  - Too loose = incomplete data
- Summer targets (R.A. ~ I3-23h) allow for higher observing efficiencies (fewer/shorter interruptions from Earth illuminated limb constraints)
- High-declination targets suffer from frequent Earth occultations and shorter visibility windows
- Check how many visits are possible yearly (estimate ease of scheduling)

### More for you to learn on the FC at the hands-on session Tomorrow (July 27th) 8:45 — 9:30

