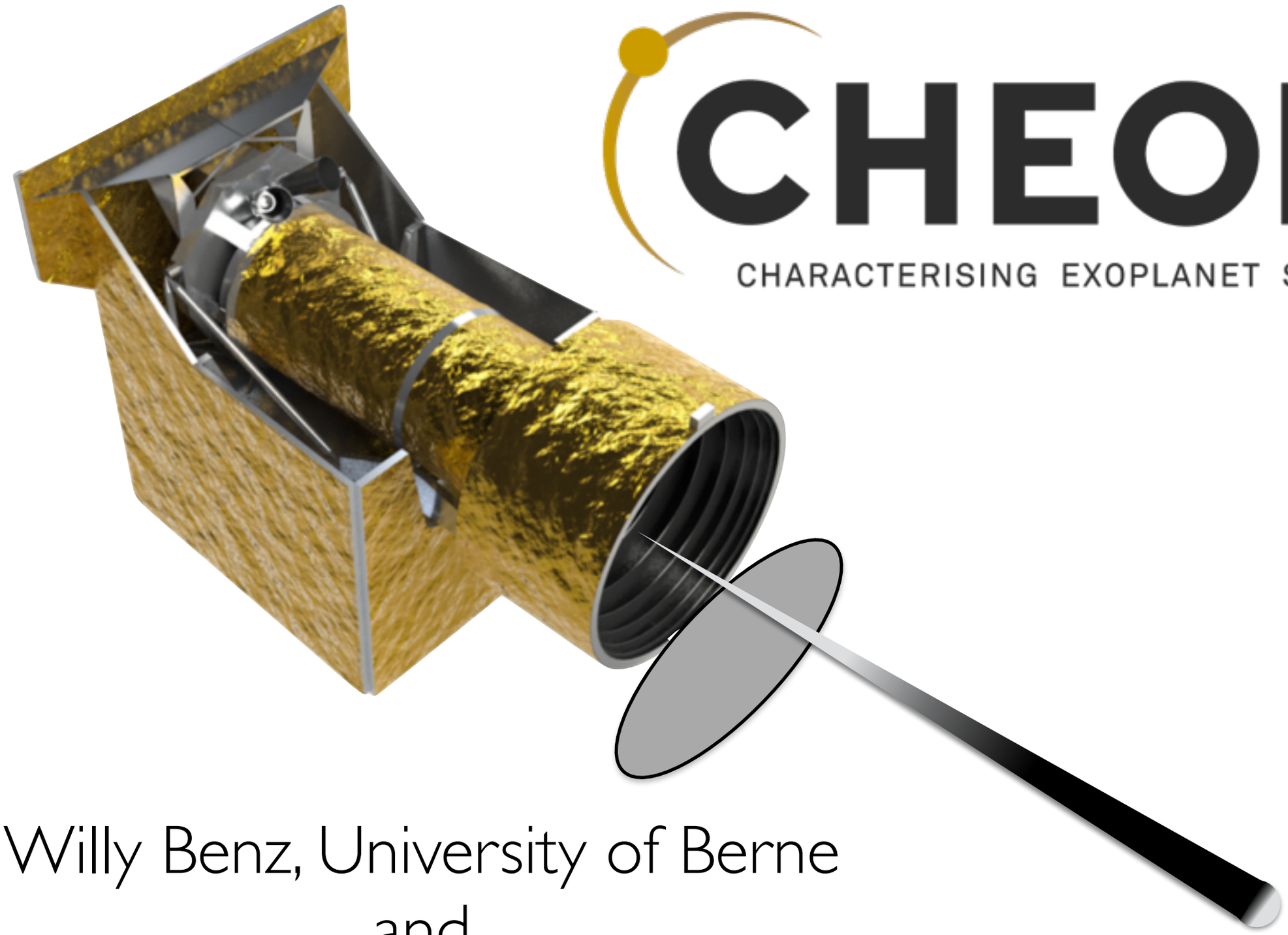

CHEOPS

CHARACTERISING EXOPLANET SATELLITE

Willy Benz, University of Berne
and
the CHEOPS team

ESA missions

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- **L-missions**

  Cost to ESA: 1 b€

  Examples: XMM-Newton, Rosetta, Herschel, Juice

- **M-missions**

  Cost to ESA: 0.5 b€

  Examples: Integral, Huygens, Solar Orbiter, Euclid

- **S-missions**

  Cost to ESA: 0.05 b€

  Example: CHEOPS

ESA mission selection

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- **Open call**
- **Down selection → competitive studies: 3 missions**
    - Scientifically: Advisory structure
    - Technically: ESA
- **Mission selection → detailed studies: 1 mission**
    - Scientifically: Advisory structure
    - Technically: ESA
    - Voted by Science Programme Committee (SPC)
- **Mission adoption**
    - Scientifically: Advisory structure
    - Technically: ESA
    - Voted by Science Programme Committee (SPC)

ESA S-missions

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- **Science**
  - top rated in any area of space science
- **Budget**
  - total cost of the mission < 150 M€
  - total cost to ESA < 150 M€ (incl. launch)
- **Schedule: Developed and launched within 4 years**

call issued	March 3, 2012
proposal due	June 15, 2012
mission selection	October 19, 2012
mission adoption	February 2014
launch	end 2017

CHEOPS history

- **2008:**
  - CHEOPS conceived as a Swiss small mission with possibly 1-2 partners (not as an ESA mission)
  - Study submitted in response to a call issued by SNSF for National Centers (NCCR) to be established in Switzerland
  - *proposal not successful.*

- **2011:**
  - Study funded by the Swiss federal government (Secretary for Education and Research) and private industry (Ruag Space)

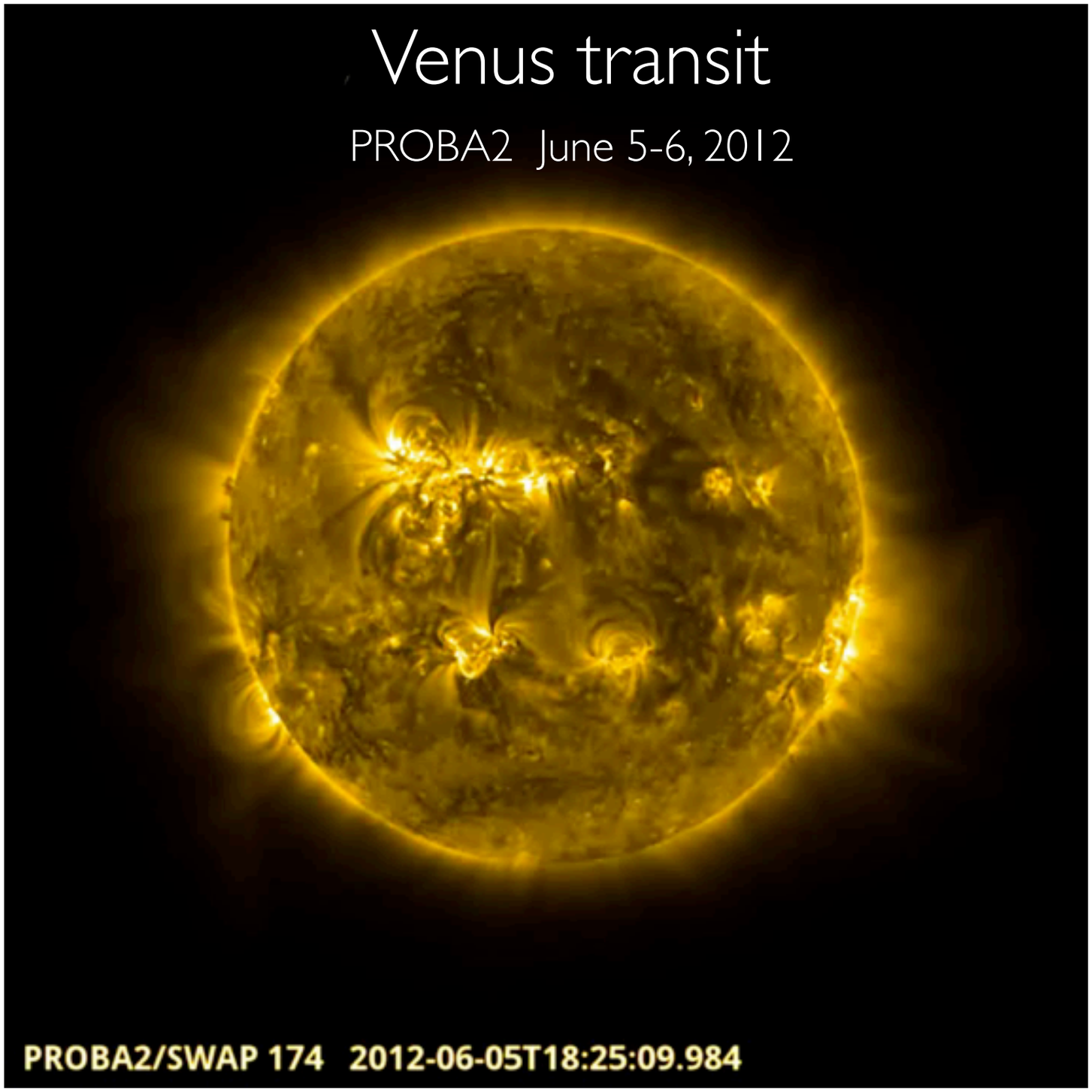
CHEOPS history

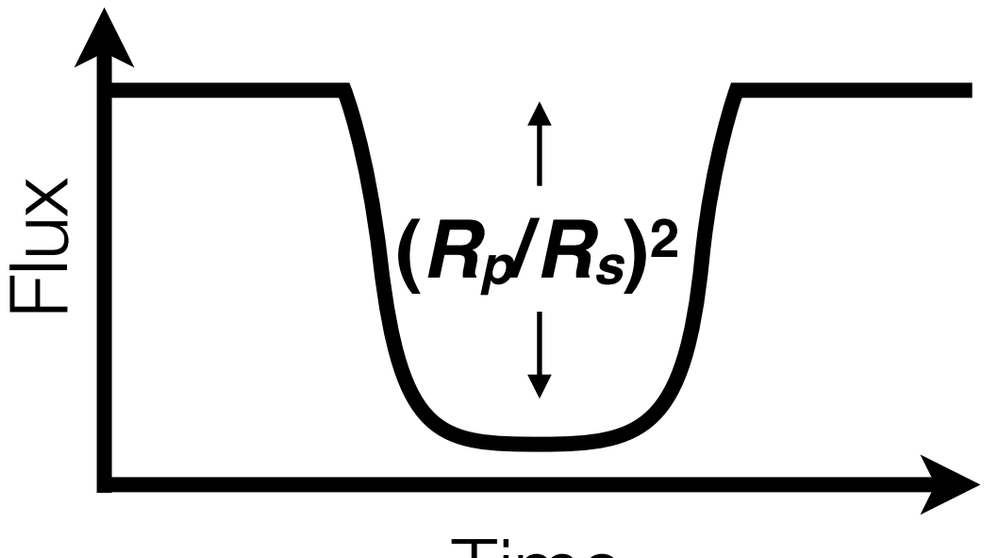
- **2012 (March):**
  - ESA issued a call for small missions

- **2012 (June):**
  - CHEOPS submitted in response to the call

- **2012 (October):**
  - CHEOPS is **selected** as ESA's first S-mission out of 26 proposals

Photometric accuracy





CHEOPS photometric accuracy:

- 20 ppm over 6 hours for G-type stars with $m_V < 9$
  → ***Earth-like planets***
- 85 ppm over 3 hours for K-type stars with $m_V < 12$
  → ***Neptune-like planets***

Previous transit missions

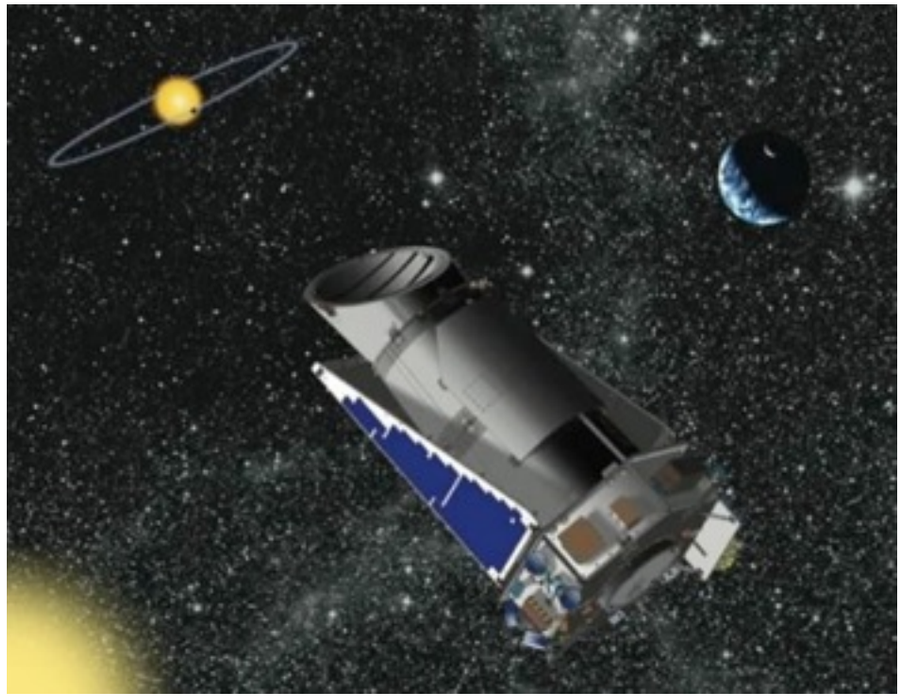
CHEOPS
CHARACTERISING EXOPLANET SATELLITE

CoRoT

27 cm telescope
First exoplanet mission

Kepler (2009-2013)

95 cm telescope
More than 2700 candidate planets detected



Discovery missions:

- Looking at > 100'000 stars in fixed regions of the sky

Previous transit missions

CHEOPS
CHARACTERISING EXOPLANET SATELLITE

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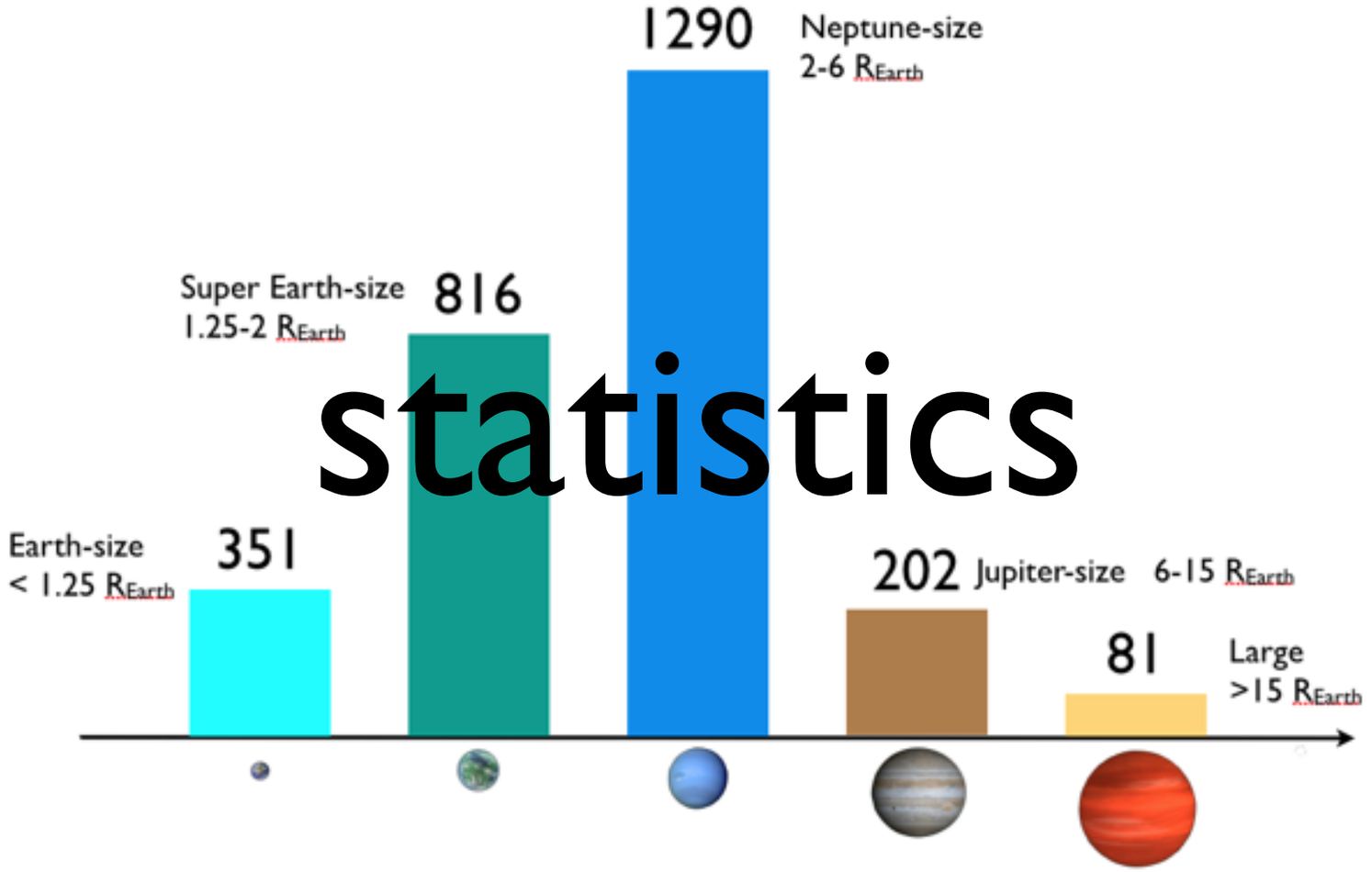
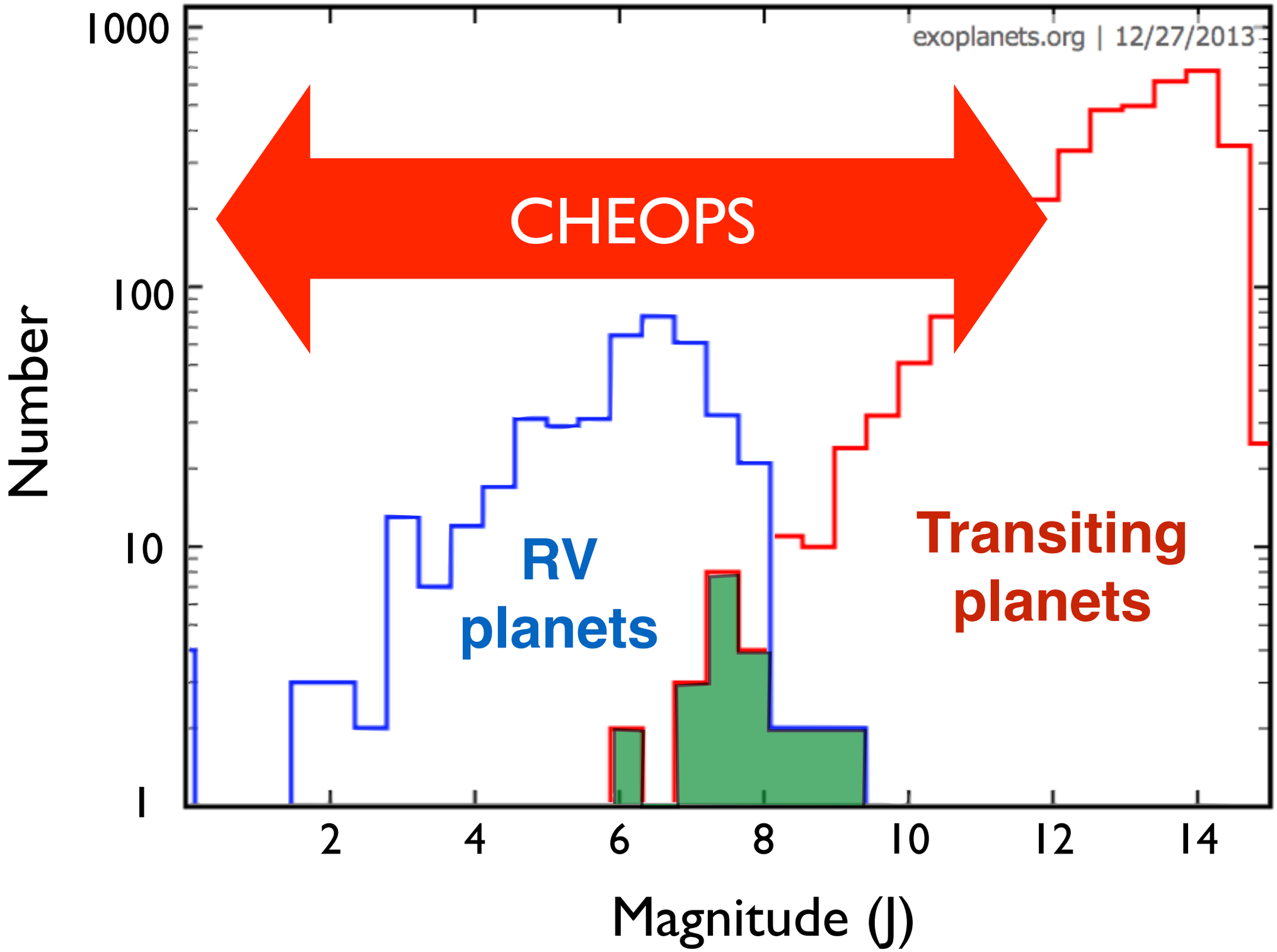


Adapted from NASA/Kepler mission (as of 7.1.2013)

Discovery missions:

- Looking at > 100'000 stars in fixed regions of the sky

Targets


exoplanets.org | 12/27/2013
CHEOPS
RV
planets
Transiting
planets
Number
1000
100
10
1
2
4
6
8
10
12
14
Magnitude (J)

Mission objectives

- Search for transits on bright stars already known to host planets

  → *CHEOPS is a **follow-up mission** looking at one star at a time*

- Measure accurate radii for planets ranging between Neptune- and Earth-size

  → *CHEOPS will achieve **similar photometric precision as Kepler** but on bright stars ($m_V < 9.0$)*

Science objectives

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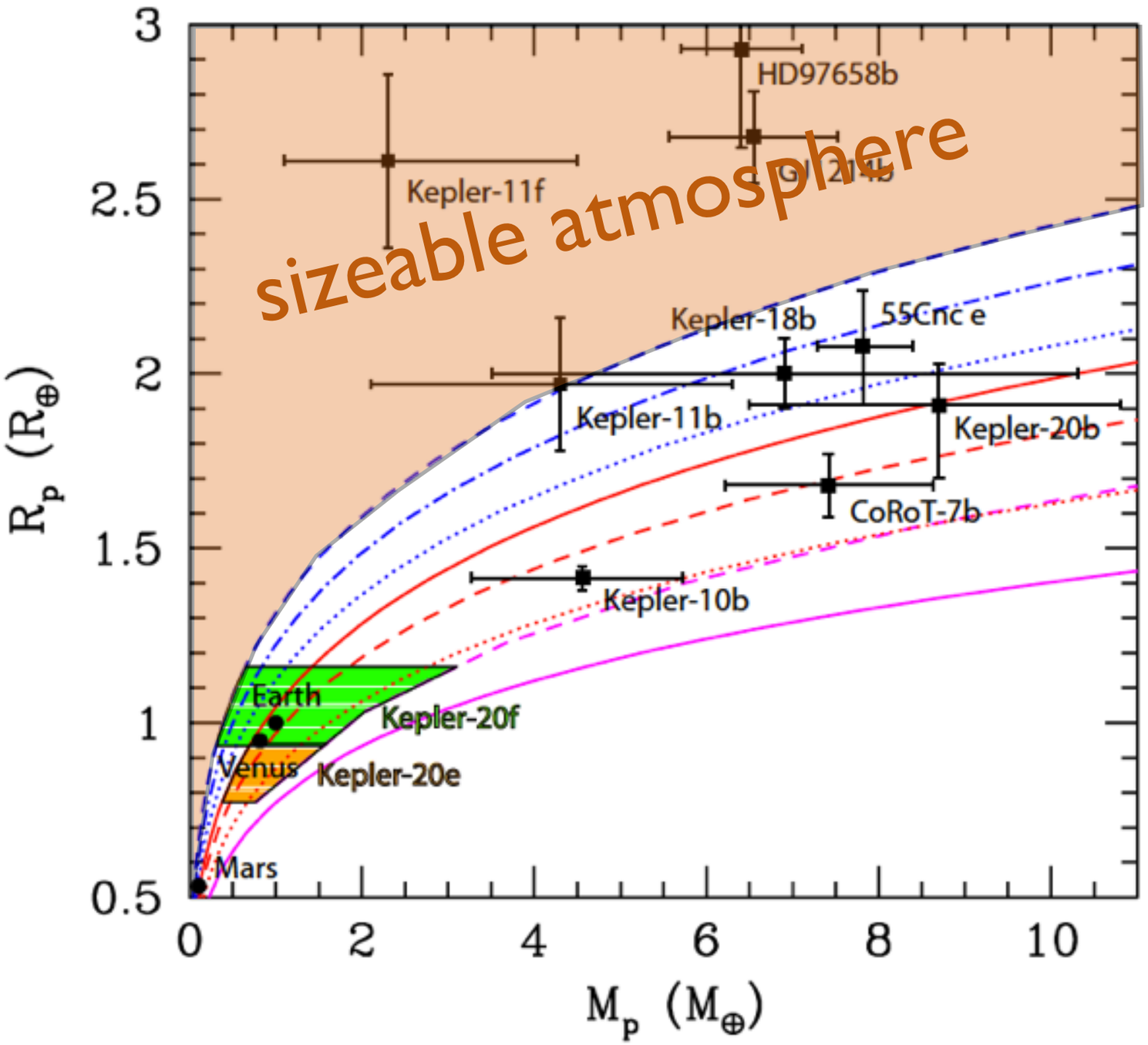
1. Mass-radius relation
2. Identification of planets with atmospheres
3. Constraints on planet migration paths
4. Energy transport in hot-Jupiter atmospheres
5. Targets for future spectroscopic facilities
6. 20% open time (selection through ESA)

Mass radius relation



pure water ice

pure silicate

pure iron

Diversity!

Atmospheres

- *origin*
- *retention*
- *composition*

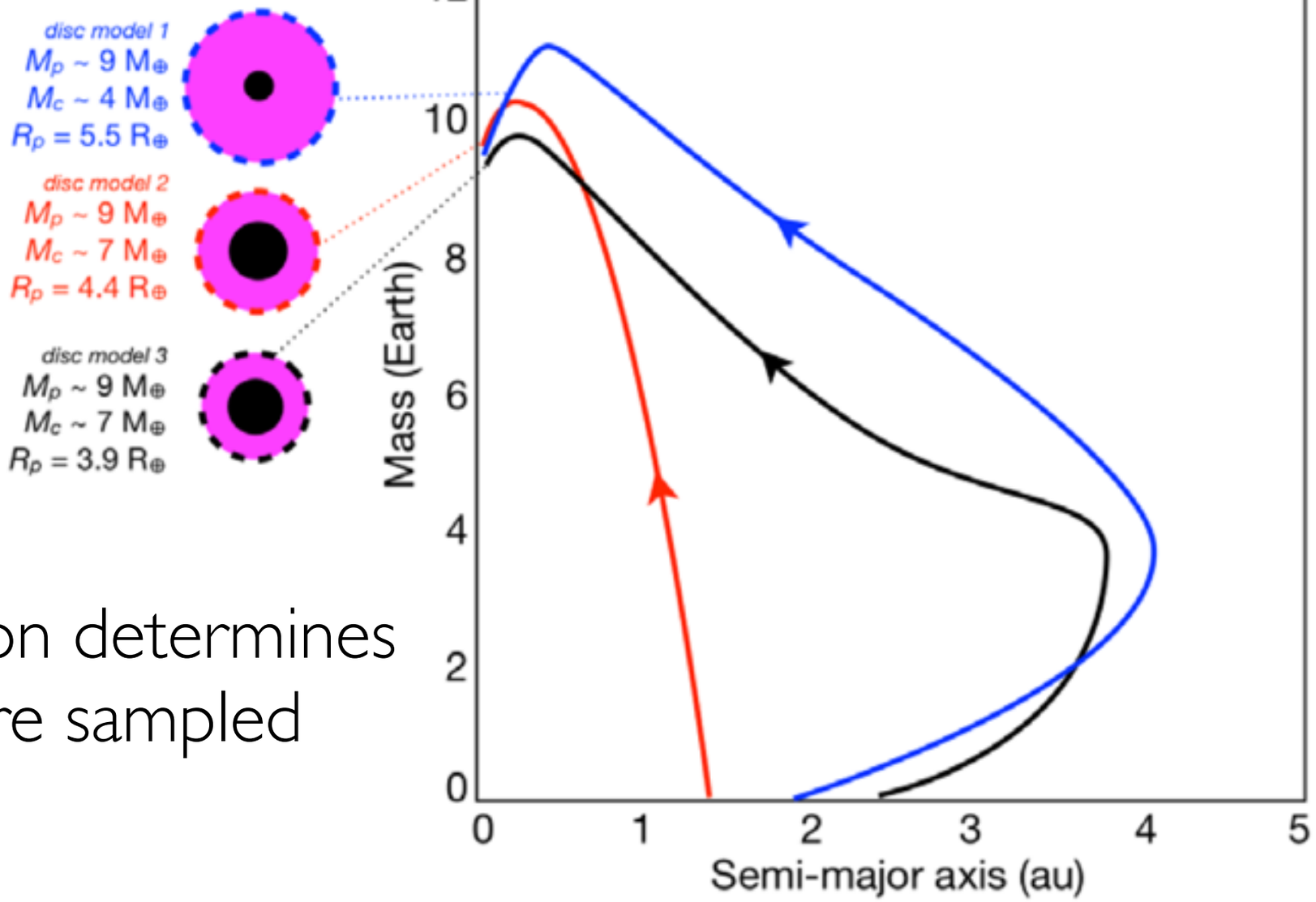
Formation tracks

mean density

0.30 g/cm^3

0.58 g/cm^3

0.83 g/cm^3



Migration during formation determines which area of the discs are sampled

⇓

Structure and thermodynamics of the disc matters

Target providers

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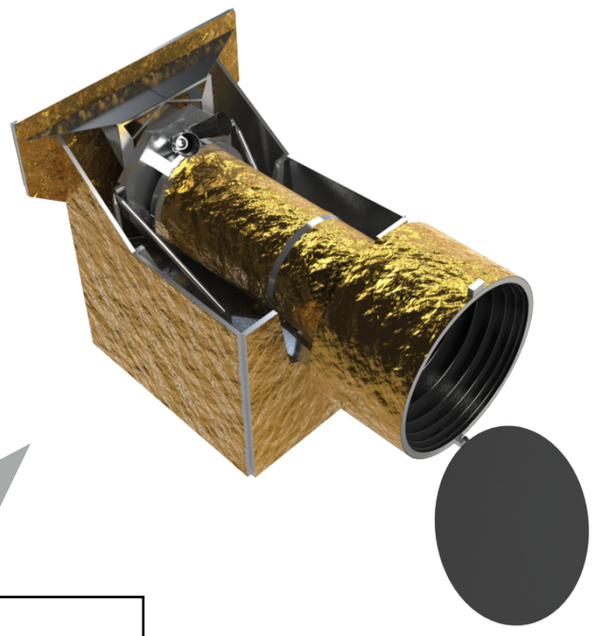
Ground-based transit surveys
NGTS ***(2014)***

TESS
(2017)

Measure accurate light curves for Neptunes

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

Detect the transit of known super-Earths



20% open time
(3.5-yr mission)

National Center

The Swiss Federal Government establishes Centers of Competence in Research (NCCR). Funded for 4 years (~20 MCHF) renewable up to two times.

Newly established Center (17.12.2013): **PlanetS**

Dedicated to

The origin, evolution and characterisation of planets inside and outside the solar system

Leading houses:

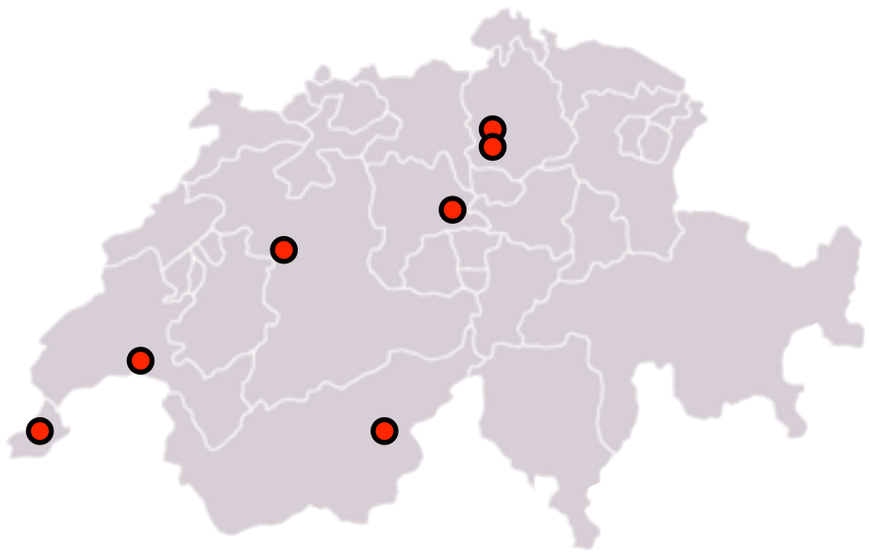
University of Berne

University of Geneva

Academic members:

ETH-Z

University of Zürich



Other partners:

Swiss Space Center

Verkehrshaus Luzern,

Burgergemeinde Zermatt

CHEOPS consortium

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10 countries

Switzerland
Mission Lead
Instrument Team
Science Operations Center

SOC

Sweden
Data simulator

UK
Mission Operations Center

France
Data Reduction Software

Portugal
Mission Planning, Archive, &
Data Reduction Software

Payload

Germany
Focal Plane
Assembly

Belgium
Baffle

Italy
Optics

Austria
Digital
Processing Unit

Hungary
Radiators

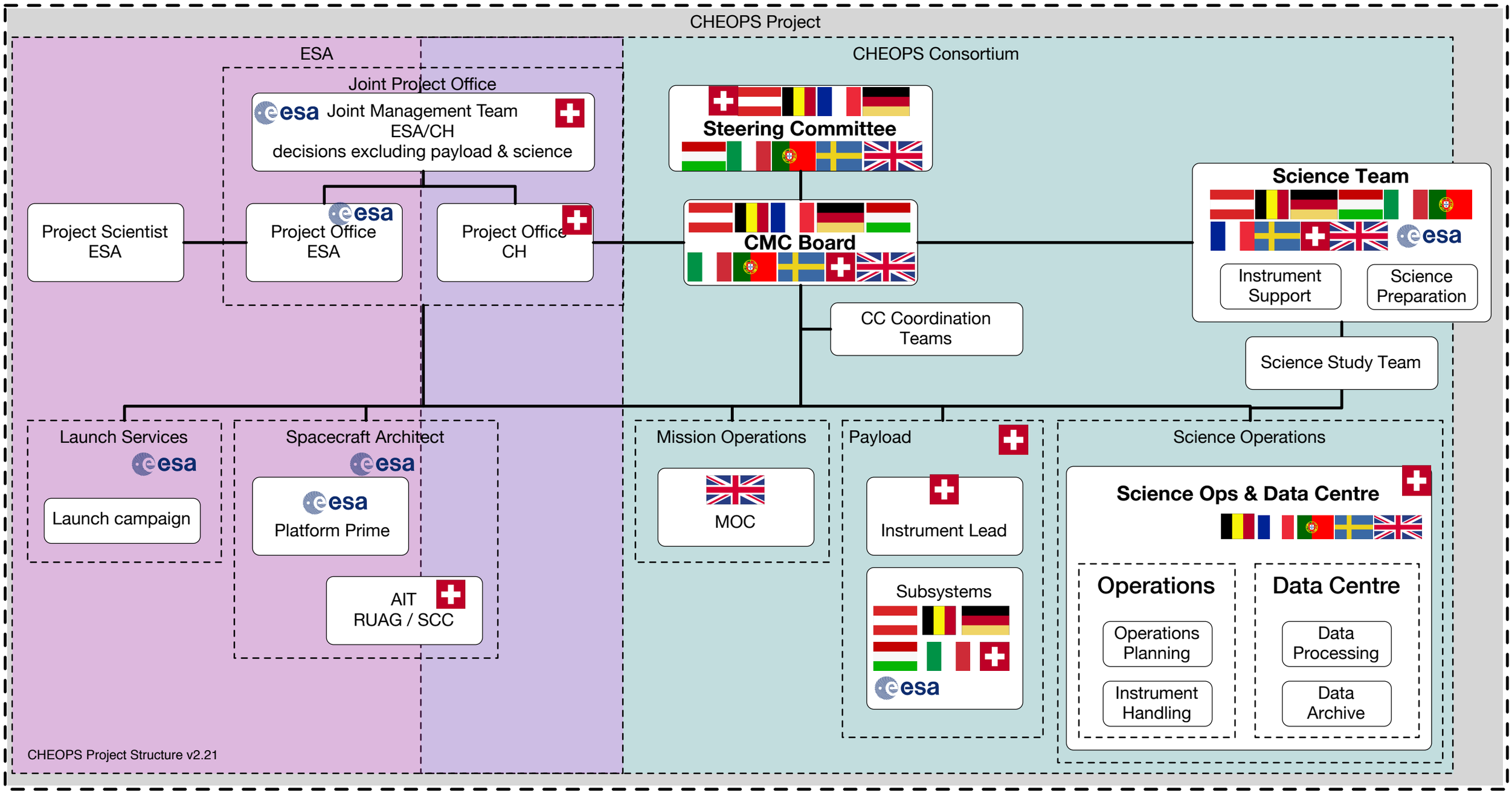
CHEOPS consortium

CHEOPS
CHARACTERISING EXOPLANET SATELLITE

Switzerland	University of Berne (project lead) University of Geneva Swiss Space Center ETH-Zürich
Austria	Institut für Weltraumforschung, Graz
Belgium	Centre Spatial de Liège Université de Liège
France	Laboratoire d'astrophysique de Marseille
Germany	DLR Institute for Planetary Research
Hungary	Konkoly Observatory
Italy	Osservatorio Astrofisico di Catania – INAF Osservatorio Astronomico di Padova – INAF Università di Padova
Portugal	Centro de Astrofisica da Universidade do Porto Deimos Engenharia
Sweden	Onsala Space Observatory, Chalmers University University of Stockholm
UK	University of Warwick

Organisation

CHEOPS
CHARACTERISING EXOPLANET SATELLITE



Payload block diagram

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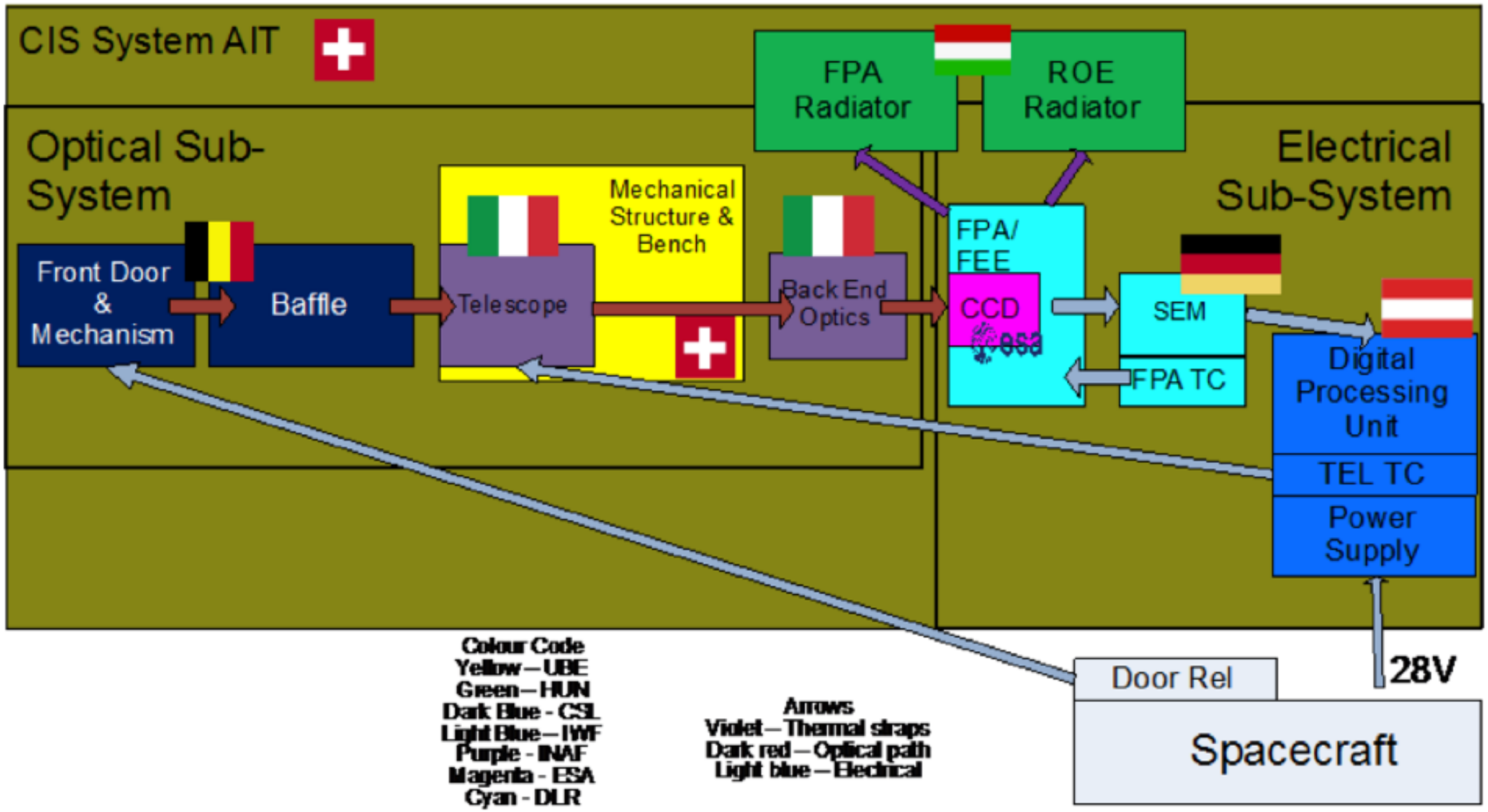

Telescope

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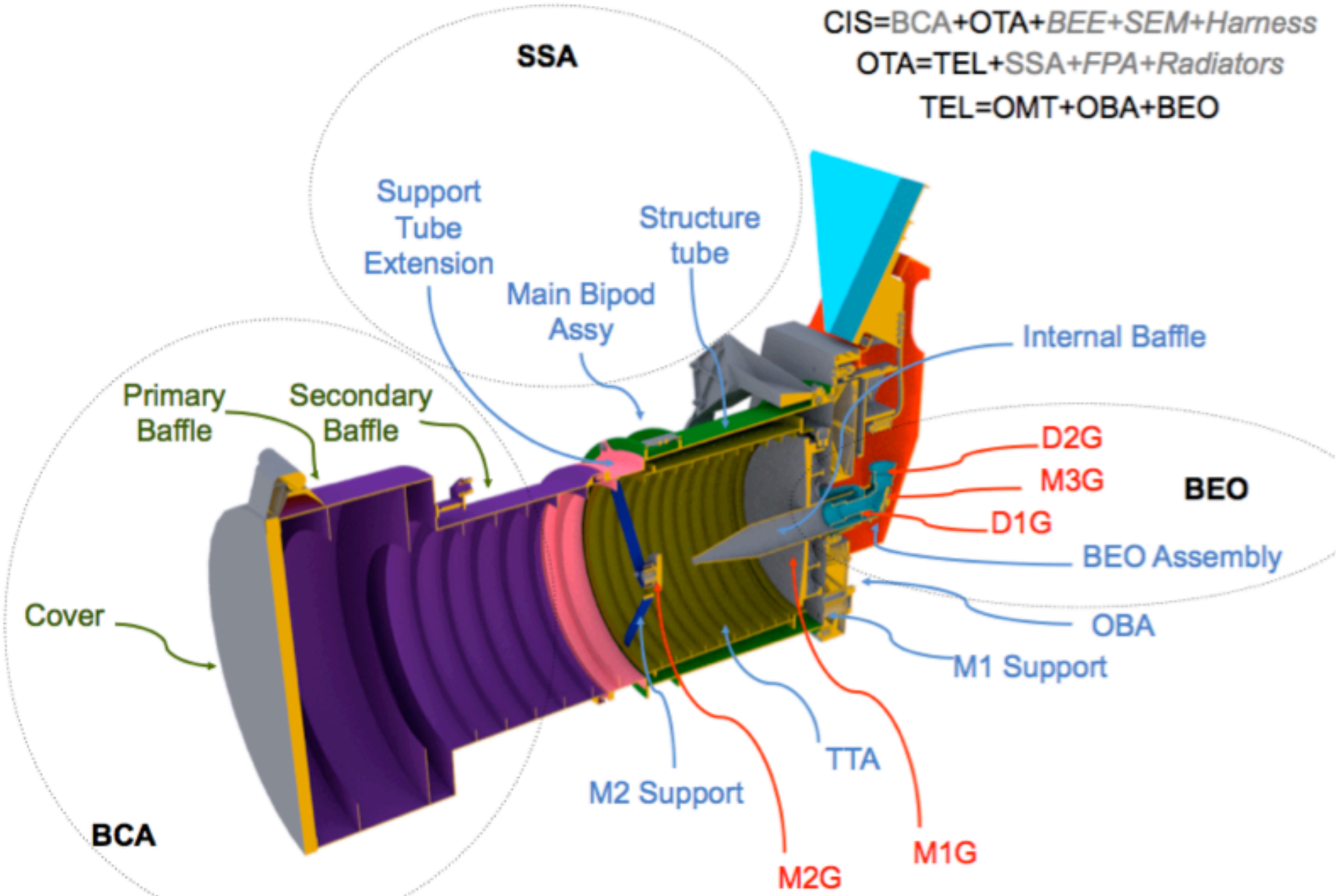
Belgium

Italy

Switzerland



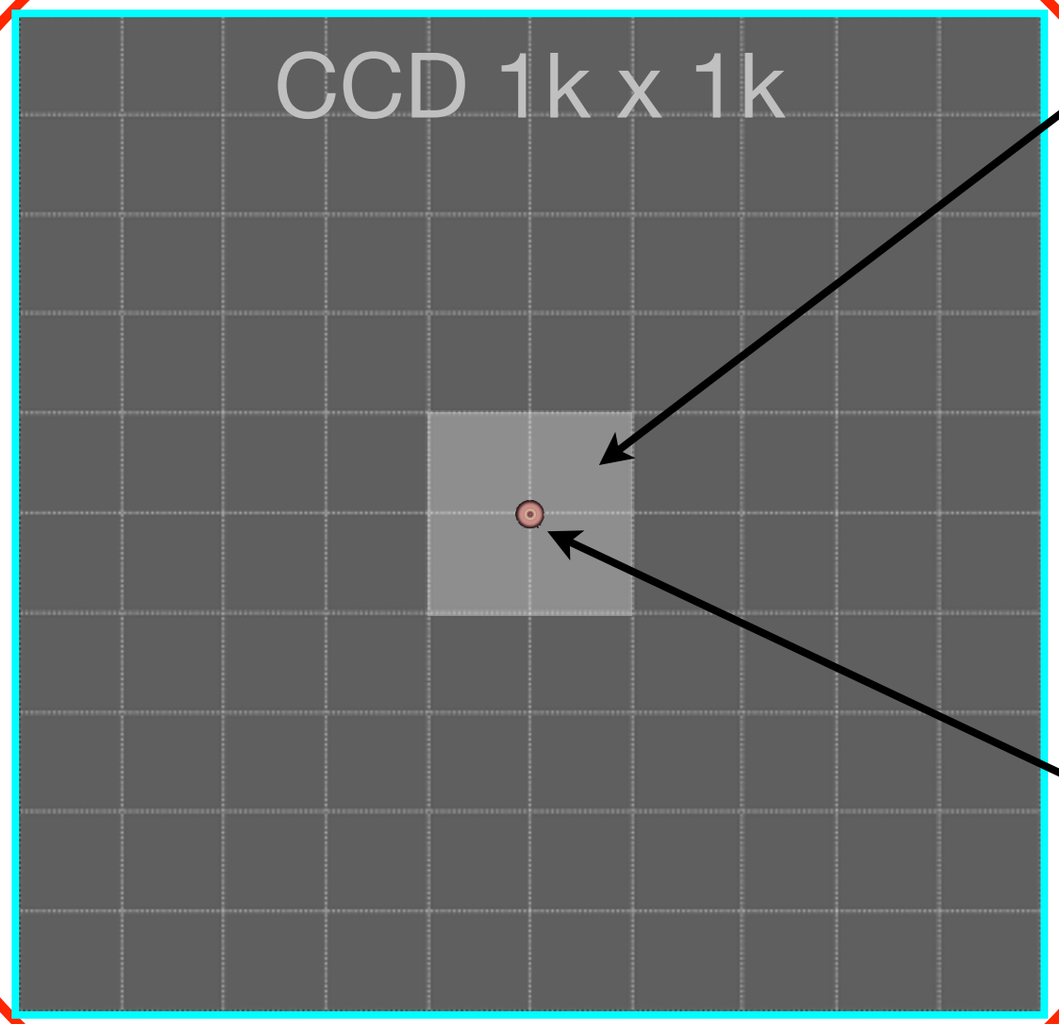
- **OMT (Opto Mechanical Tube)**
  - TTA=Telescope Tube Assembly=internal tube + vanes + M1 Support + M1 Interface + M2 Support+ M2 Interface
  - M1G= M1 Group=M1 + M1 Mount
  - M2G= M2 Group=M2 + M2 Mount
- **OBA (Optical Bench Assembly)**
  - Rear Bipod
  - Optical Cube

- **BEO (Back End Optics)**
  - D1G= D1 Group=D1 + D1 Mount
  - M3G= M3 Group=M3 + M3 Mount
  - D2G= D2 Group=D2 + D2 Mount
  - BEO Assembly=Housing + Tripod + Internal Baffle

telescope: 33 cm
weight: 60 kg

Data acquisition

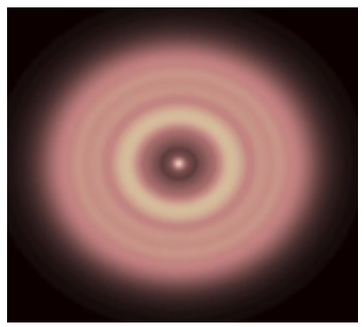
telescope
FoV: 20’



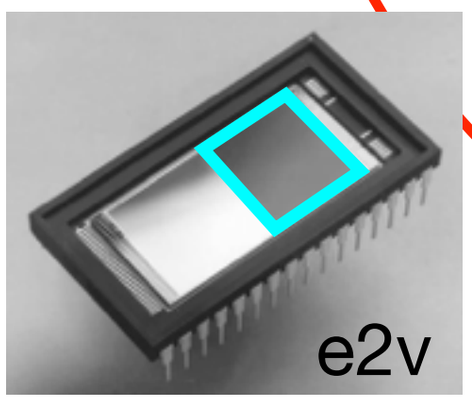
subarray image
200×200 pixels
(4 arcmin^2)

stacked &
downloaded
to the ground
1 min^{-1}

30 pixels (30”)



defocused PSF



pointing stability requirement < 8” rms

Spacecraft design

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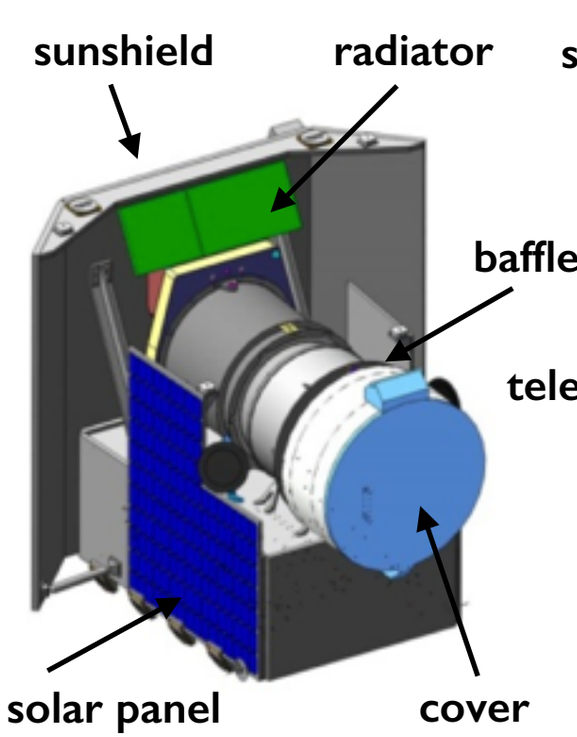
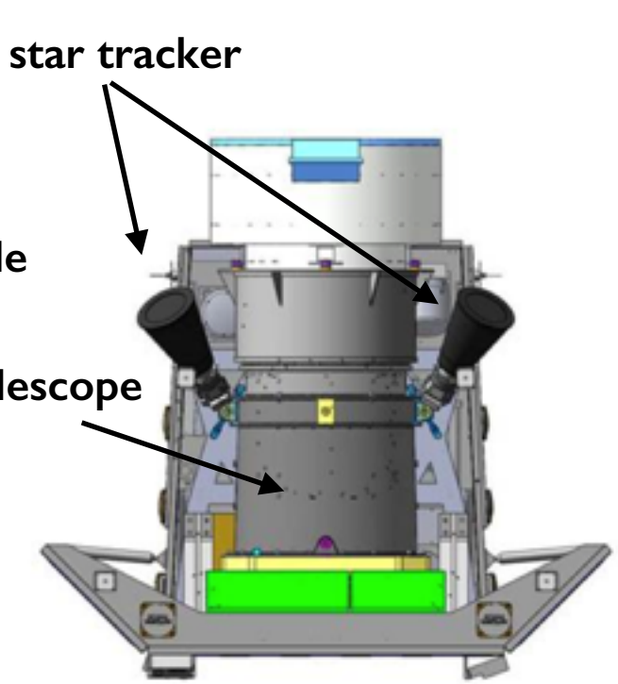
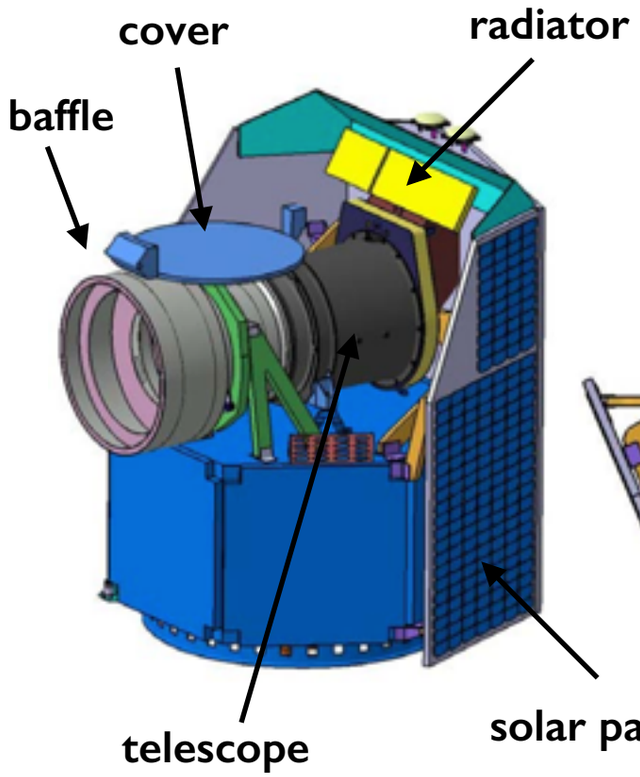
2 competitive design:

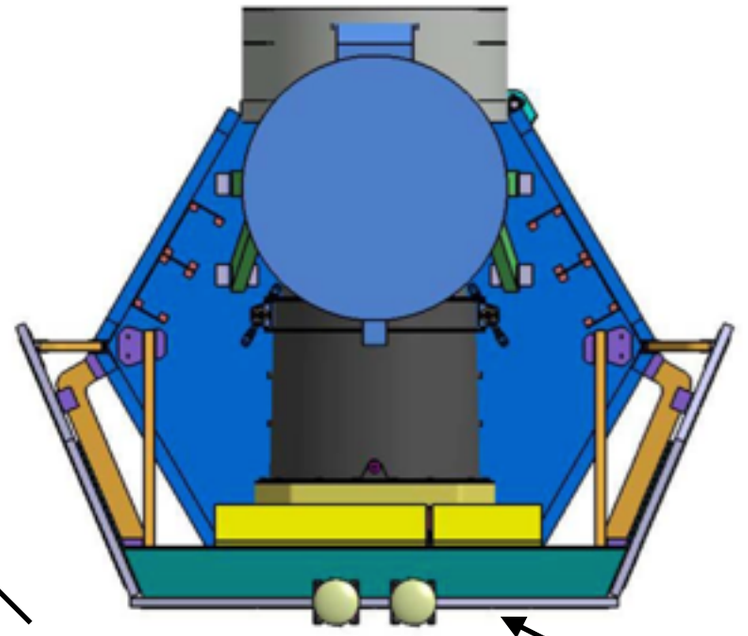




Surrey Satellite Technology Ltd. (UK)

Total weight: 235 kg
Total power: 160W





EADS Casa Espacio (Spain)

Total weight: 255 kg
Total power: 210W

selection of platform: March 2014

Orbit

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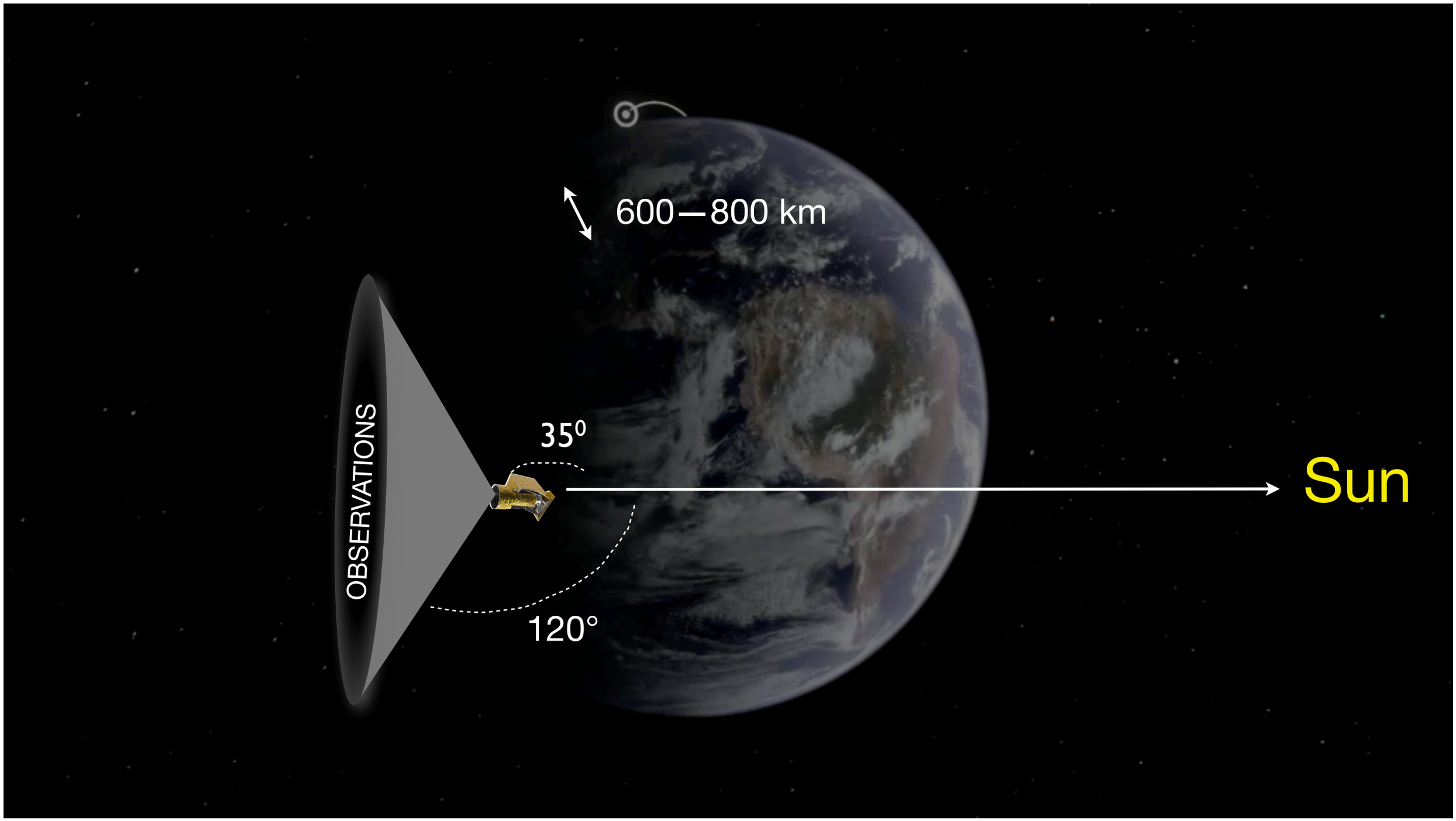

The CHEOPS sky

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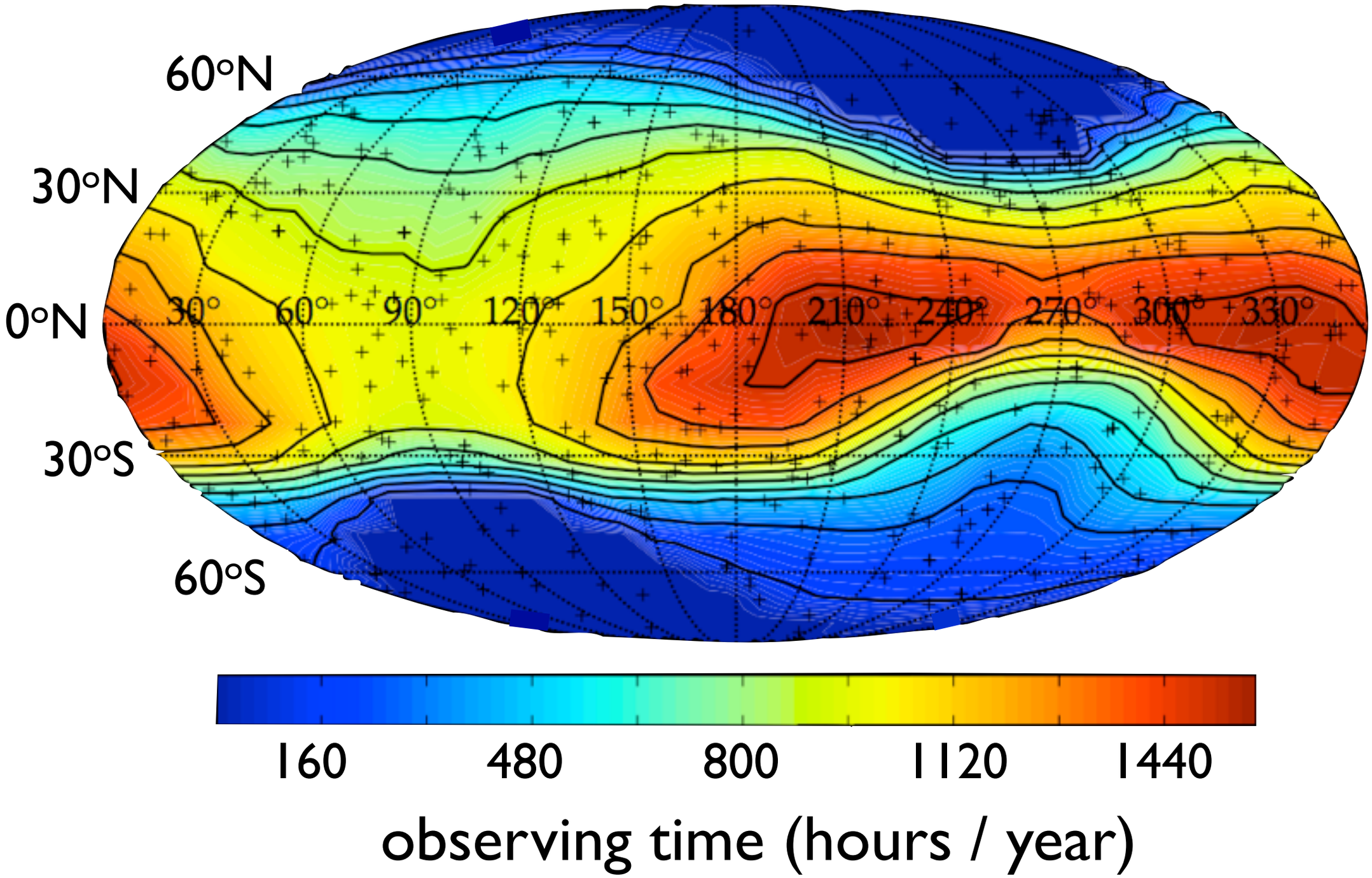

Summary

- CHEOPS is the first S-mission selected in ESA's Science Programme

- CHEOPS is a small mission!
    - there are limits to what one can do within the available budget!

- CHEOPS is a follow-up mission
    - different from all other transit missions
    - allows to choose specific targets
        → *pick the most interesting objects*