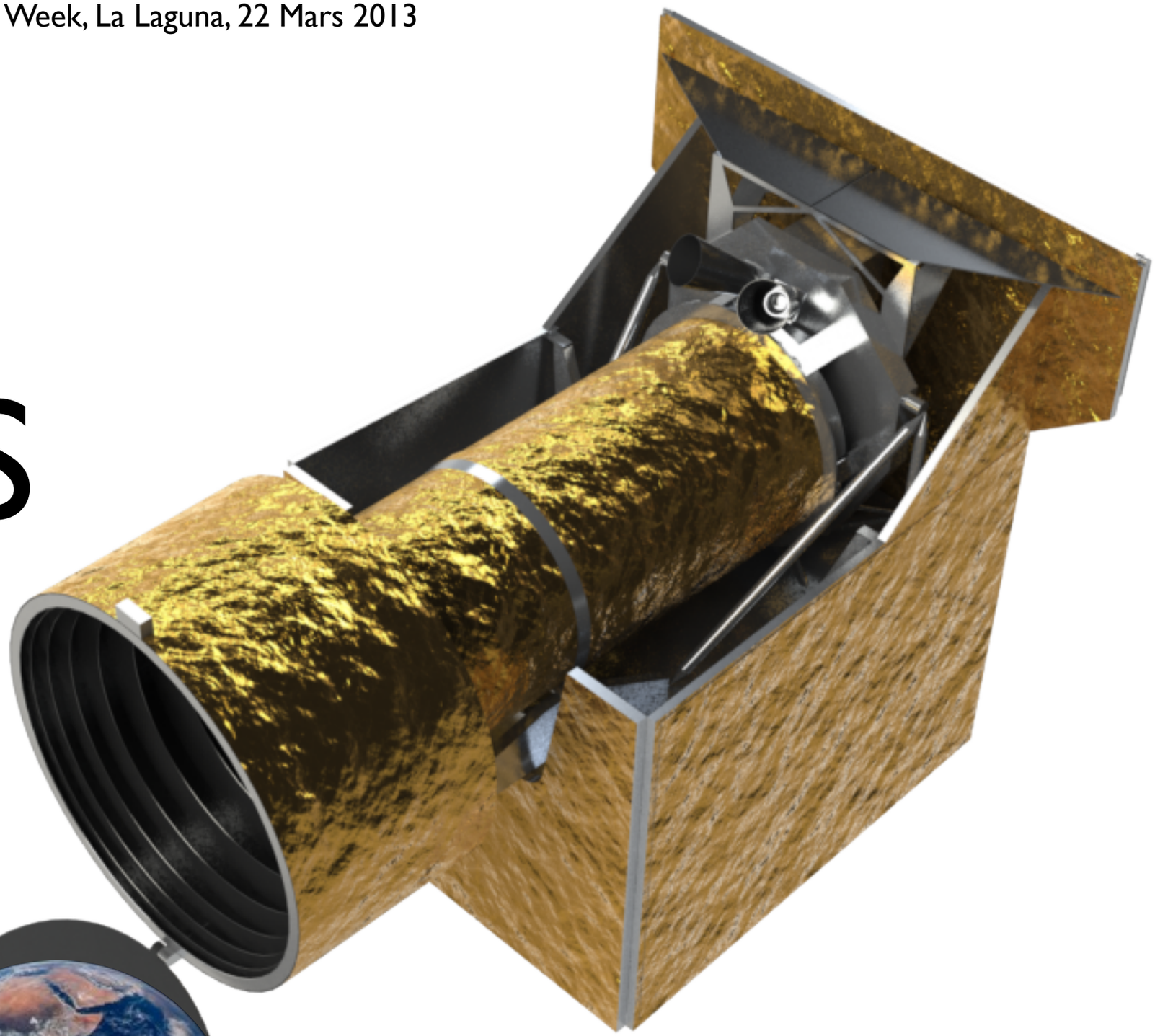
The CHEOPS Mission



Università degli Studi di Padova
INAF Istituto Nazionale di Astrofisica National Institute for Astrophysics
LAM Laboratoire d'Astrophysique de Marseille
ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich
CSL Centre Spatial de Liège
Université de Liège
Université de Berne
Observatoire de Genève Fondé en 1772
The University of Warwick
Université de Genève Faculté des Sciences
swiss space center
IWF
Konkoly
Stockholm University
DLR Institut für Planetenforschung
ÖAW

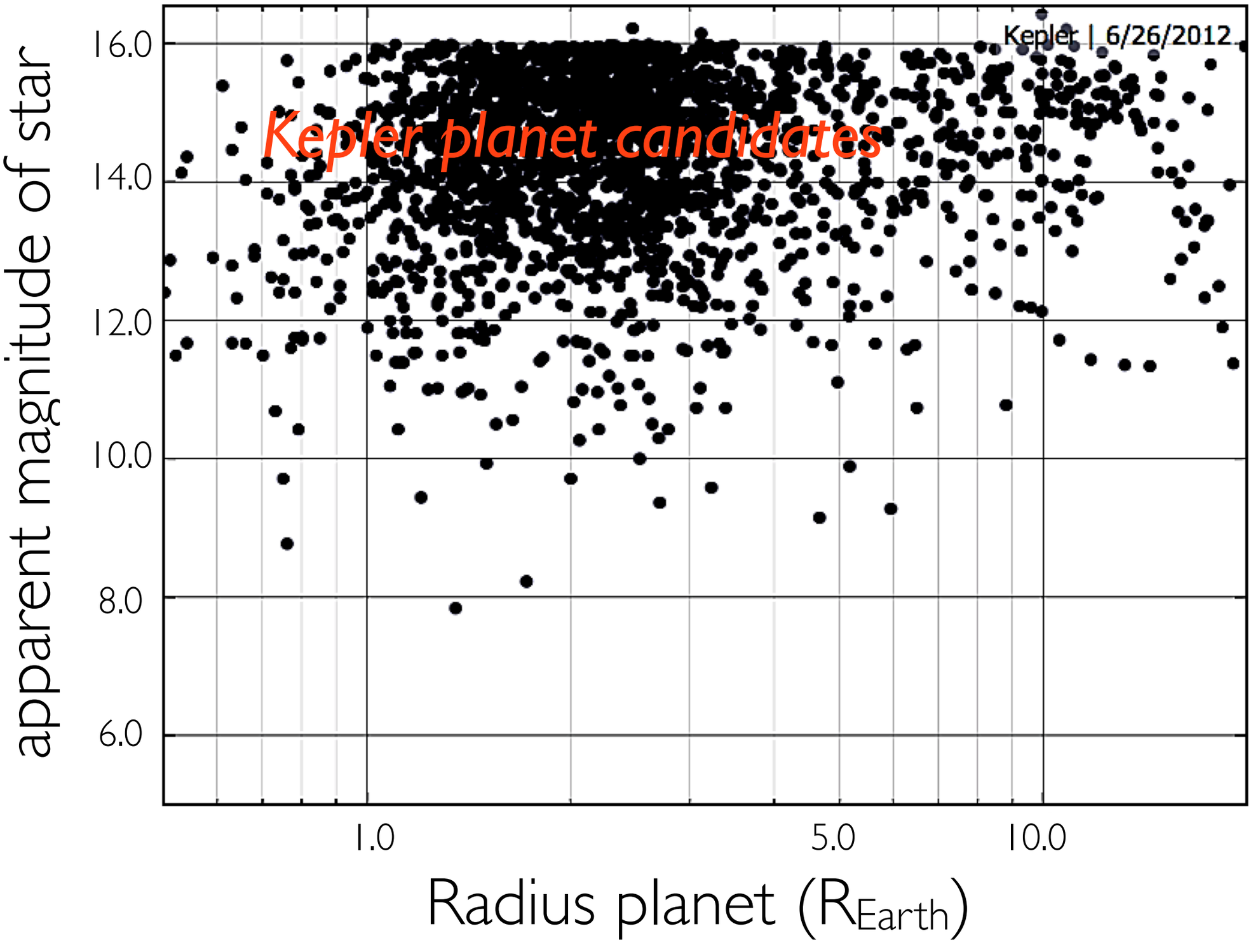
ESA small missions requirements

- Science
  - top rated science in any area of space science
- Cost
  - total cost < 150 M€
  - cost to ESA: not to exceed 50 M€
- Schedule
  - developed and launched within 4 years

call issued	March 3, 2012
proposal due	June 15, 2012
mission selection	October 19, 2012
mission adoption	Nov 2013/ Feb 2014
launch	2017

Country	Institutes	Contacts
CH	University of Bern (project lead) University of Geneva Swiss Space Center (EPFL) ETH-Z	Willy Benz, Nicolas Thomas Didier Queloz Anton Ivanov Michael Meyer
Austria	Institut für Weltraumforschung, Graz	Wolfgang Baumjohann
Belgium	Centre Spatial de Liège Université de Liège	Etienne Renotte Michaël Gillon
France	Laboratoire d'astrophysique de Marseille	Magali Deleuil
Germany	DLR Institute for Planetary Research	Tilman Spohn
Hungary	Konkoly Observatory	Laszlo Kiss
Italy	Osservatorio Astrofisico di Catania – INAF Osservatorio Astronomico di Padova - INAF Università di Padova	Isabella Pagano Roberto Ragazzoni Giampaolo Piotto
Portugal	Centro de Astrofisica da Universidade do Porto	Nuno C. Santos
Sweden	Onsala Space Observatory, Chalmers University University of Stockholm	R. Liseau G. Olofsson
UK	University of Warwick	Don Pollaco

Targets: Bright stars



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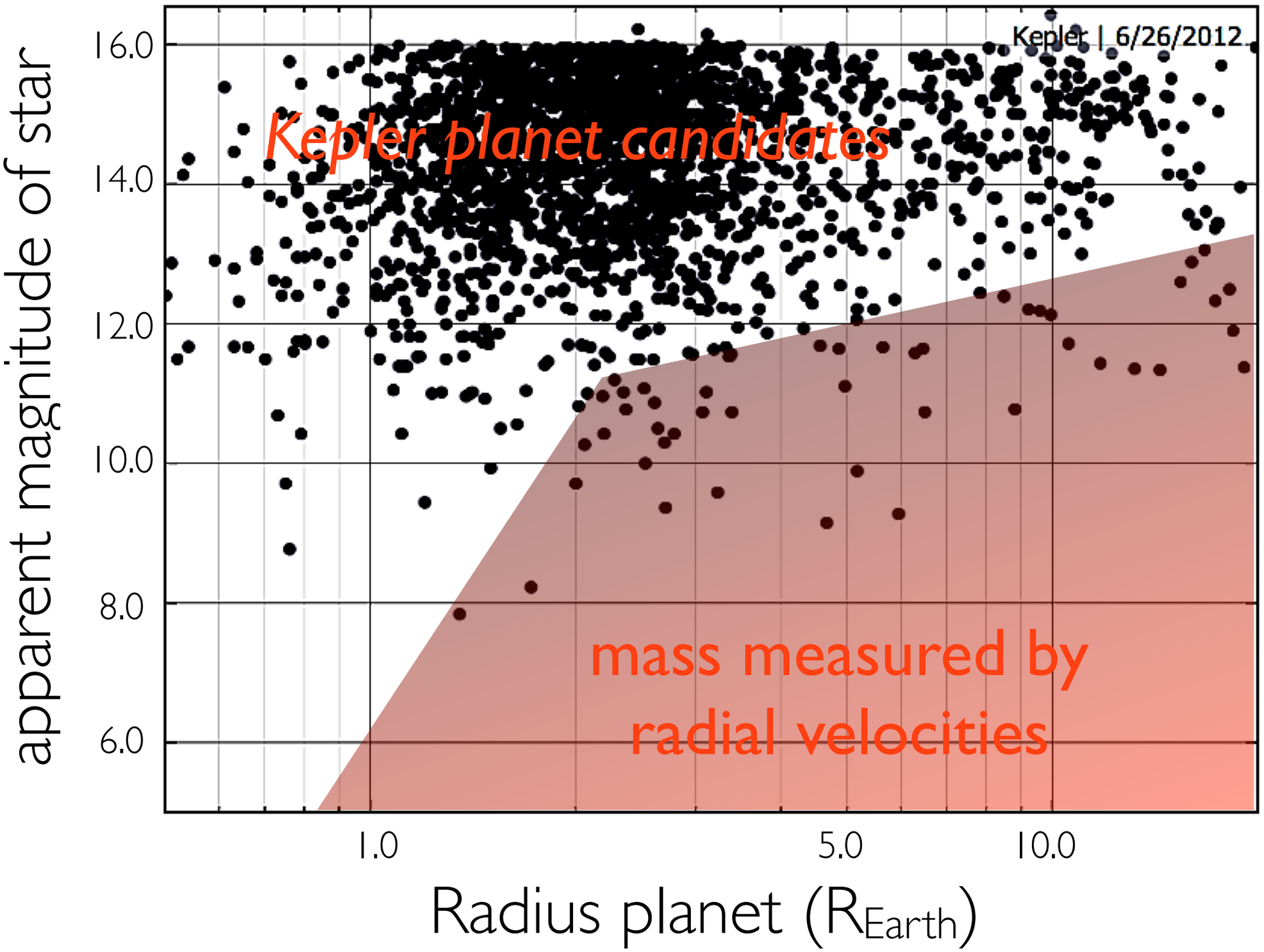

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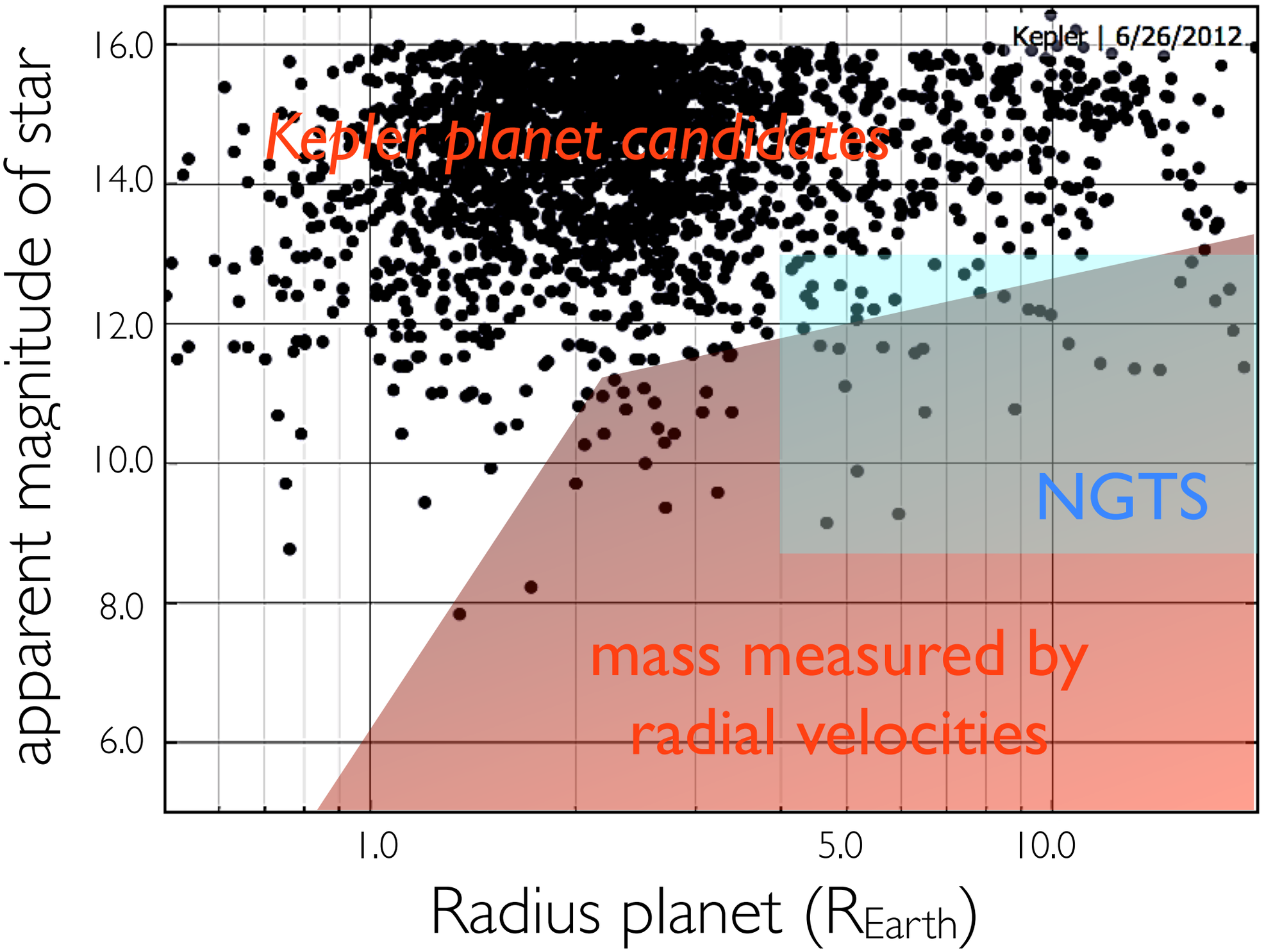

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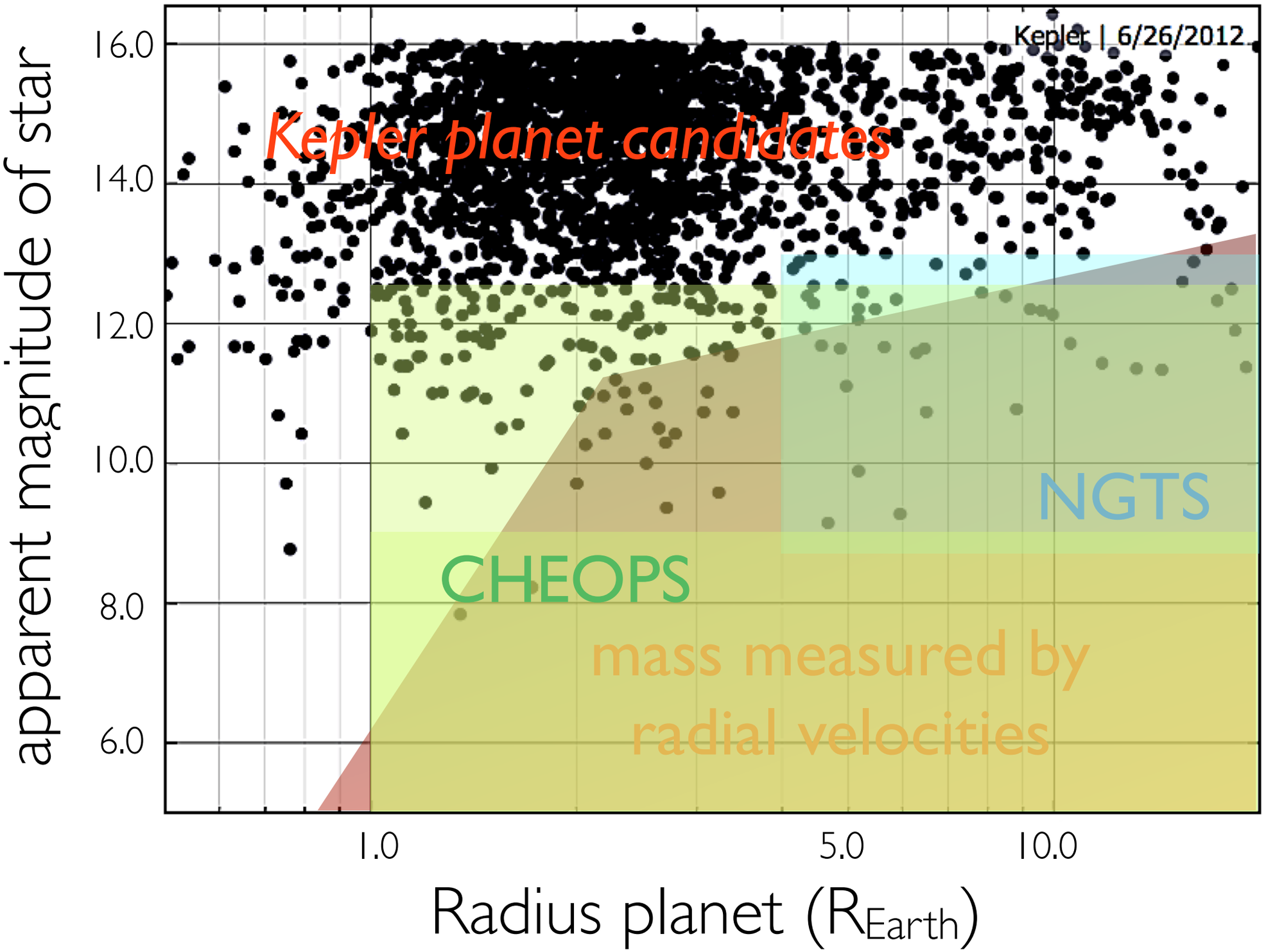
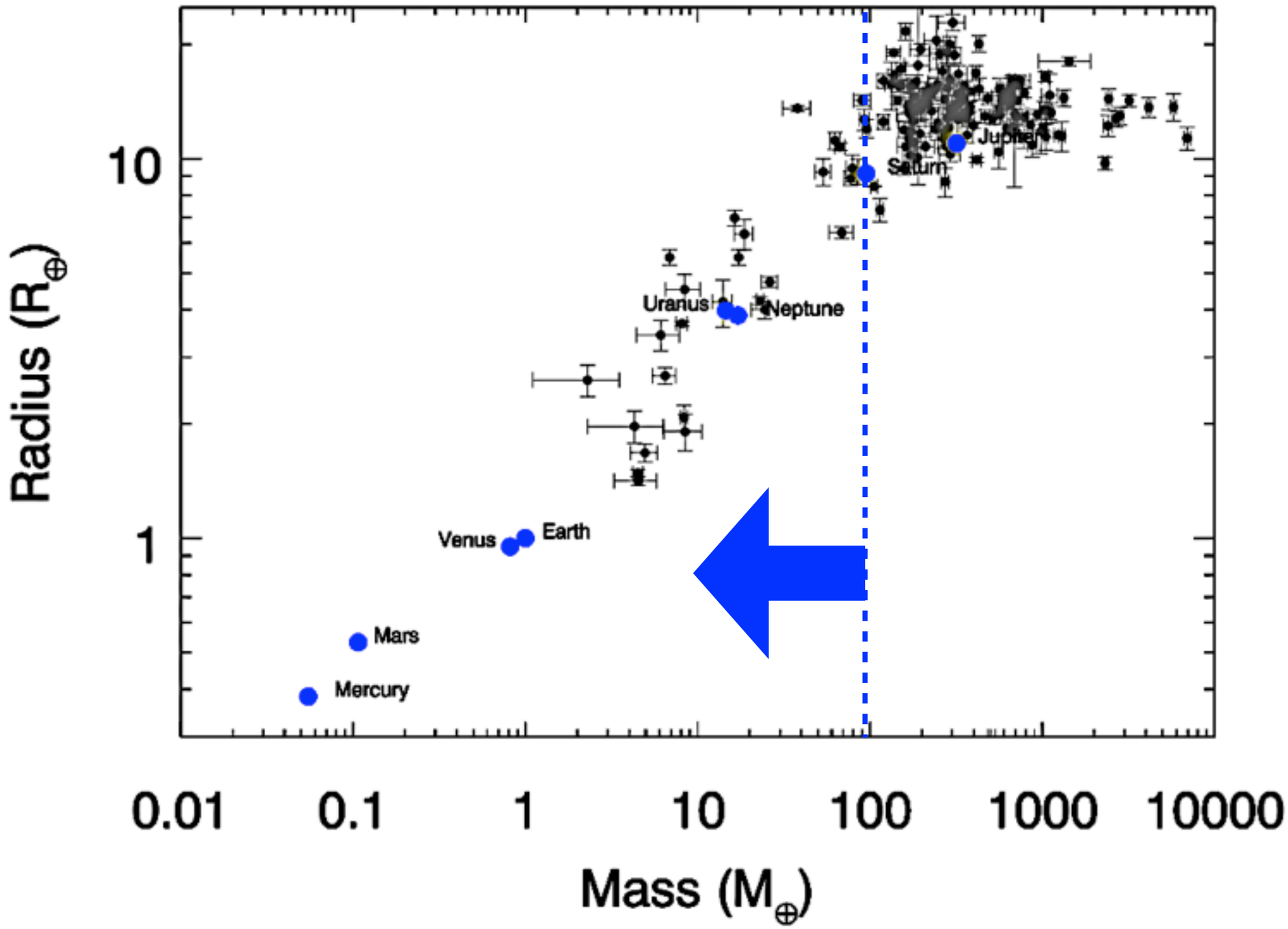


Science objectives

- Mass-radius relation for planets below the mass of Saturn
- Constraints on planet migration paths
- Identification of planets w/ atmospheres in the 1–10 M_{Earth} regime
- Energy transport in hot Jupiter atmospheres
- New targets for future characterization facilities with spectroscopic capabilities

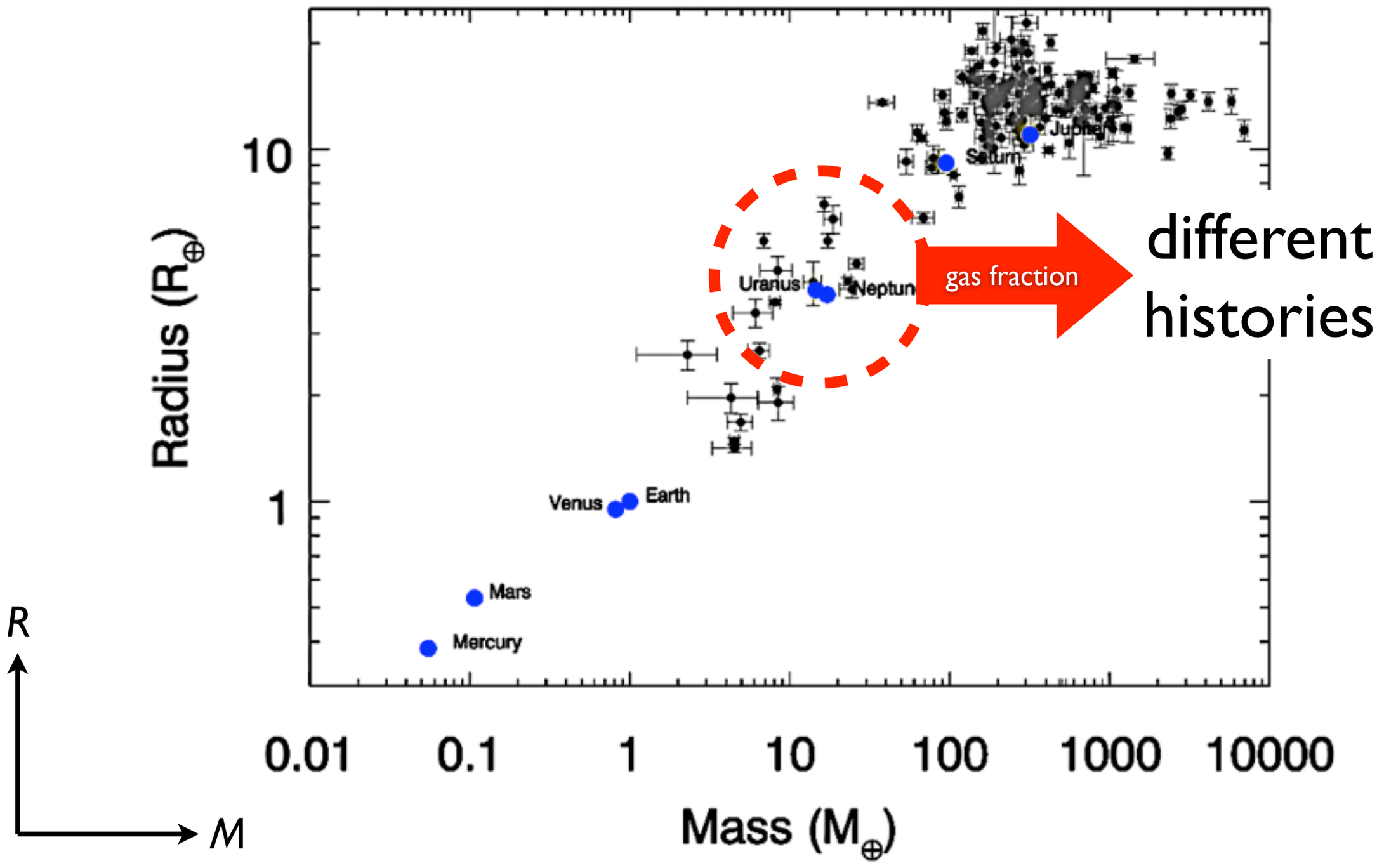
Science objectives

- Mass-radius relation for planets below the mass of Saturn



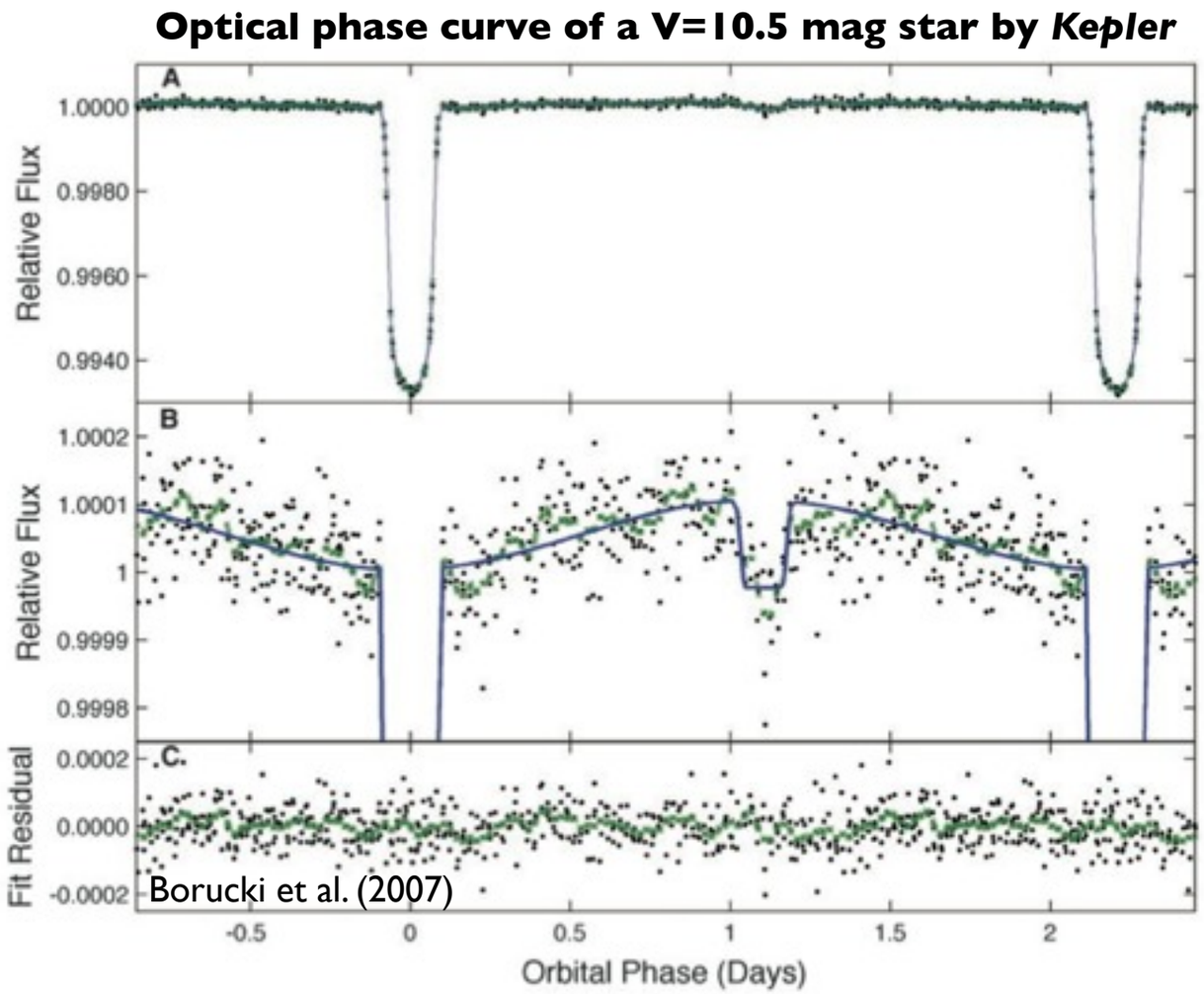
Science objectives

- Constraints on planet migration paths



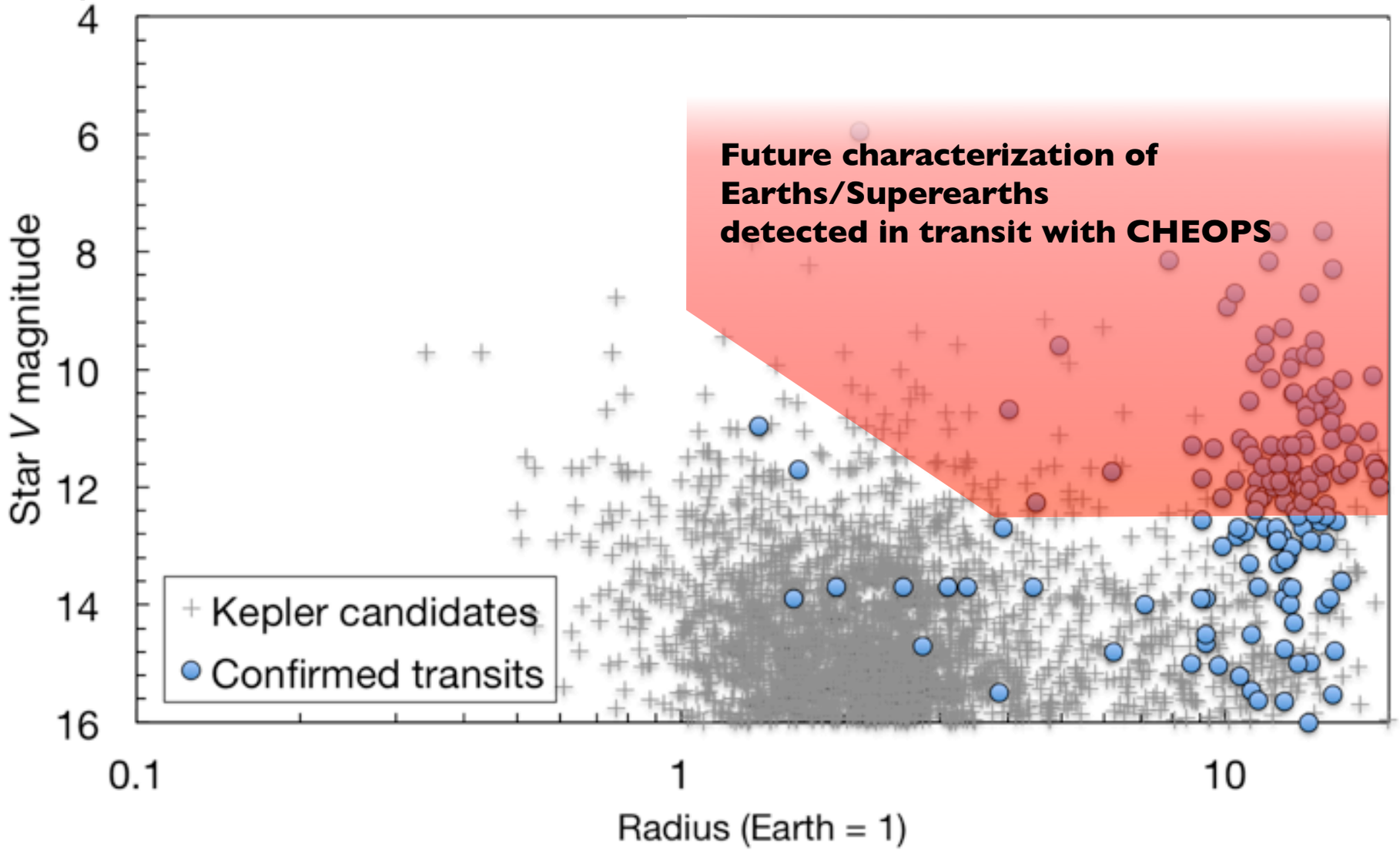
Science objectives

- Energy transport in hot Jupiter atmospheres



Science objectives

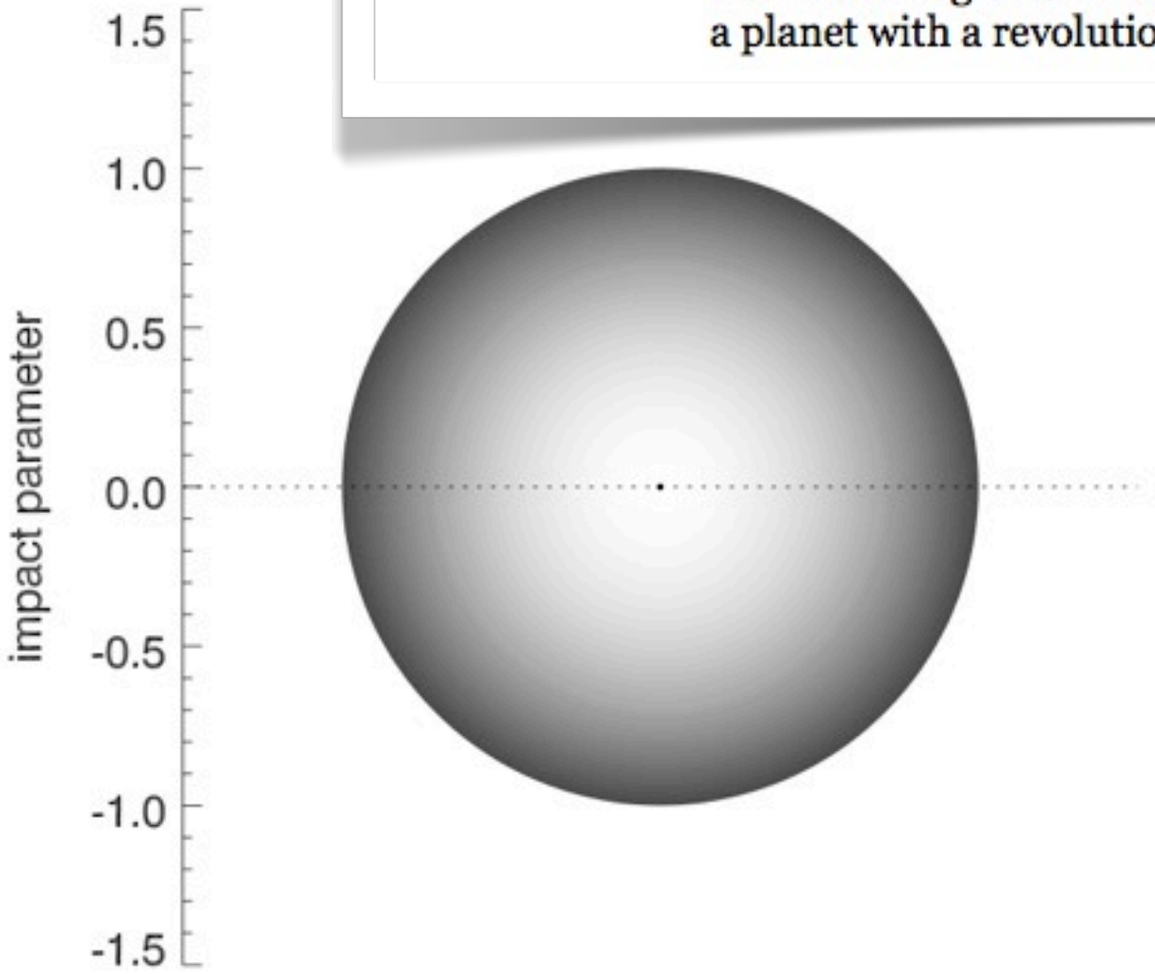
- New targets for future characterization facilities with spectroscopic capabilities

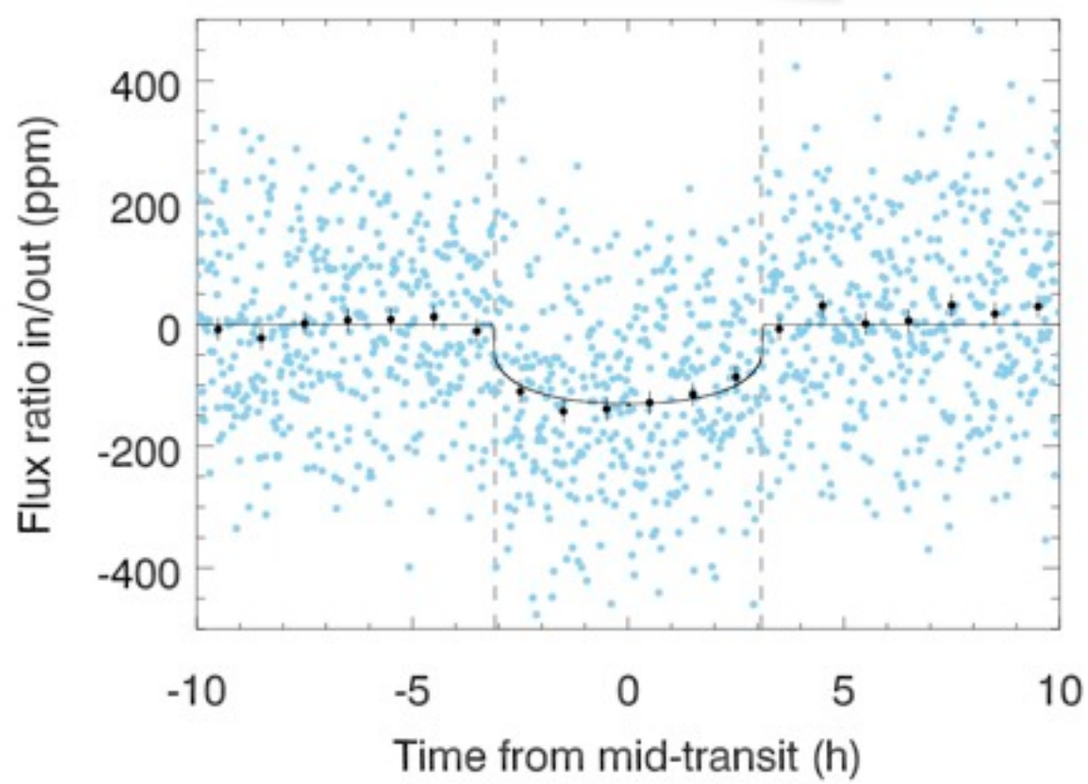


High-level Sci Reqs.

Photometric accuracy

SciReq 1.1 **Photometric precision for transit detection**
CHEOPS shall be able to detect an Earth-size planet transiting a G5 dwarf star (0.9 $R_\odot$) of the 9th magnitude in the *V* band, **with a signal-to-noise ratio of 10.** Since the depth of such a transit is 100 parts-per-million (ppm), this requires achieving a photometric precision of 10 ppm in 6 hours of integration time. This time corresponds to the transit duration of a planet with a revolution period of 50 days.

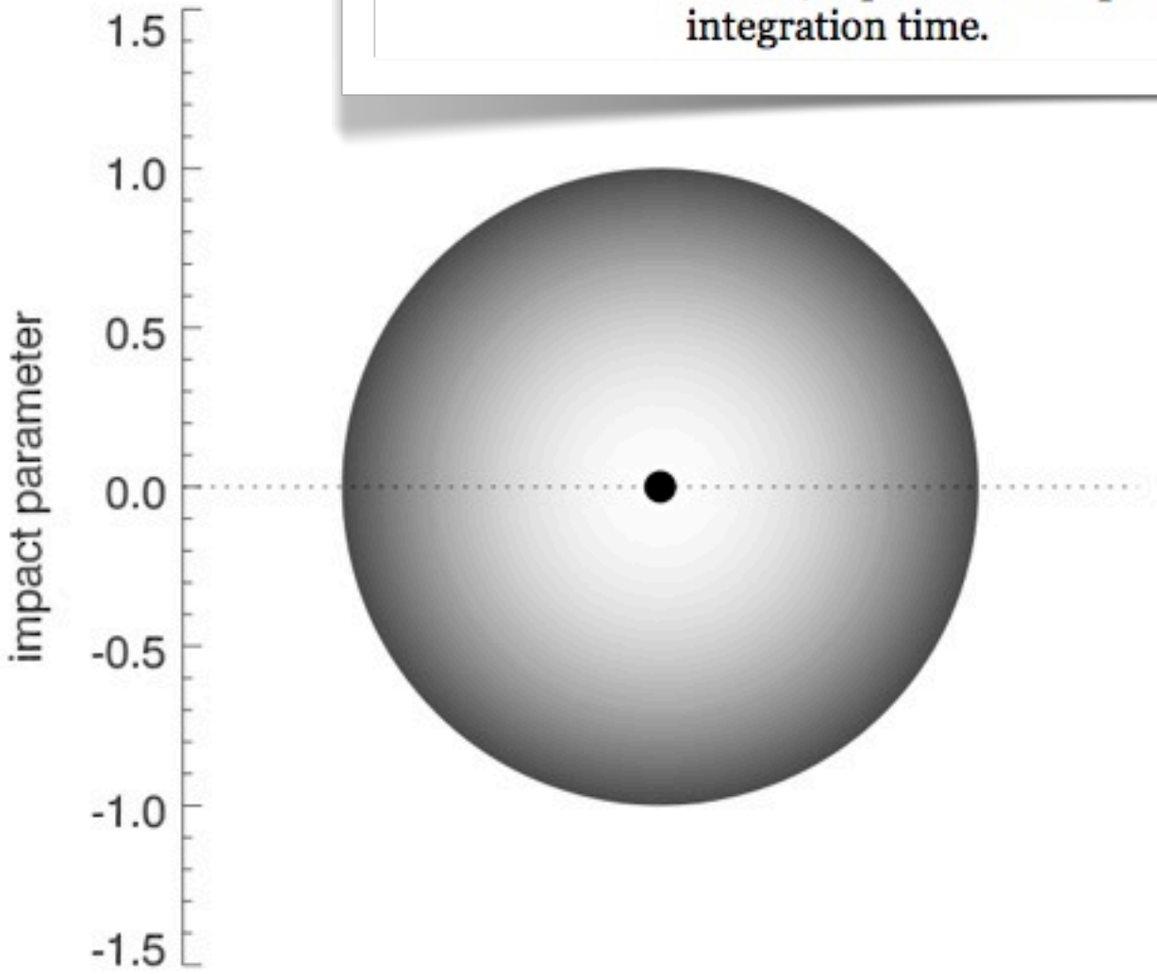


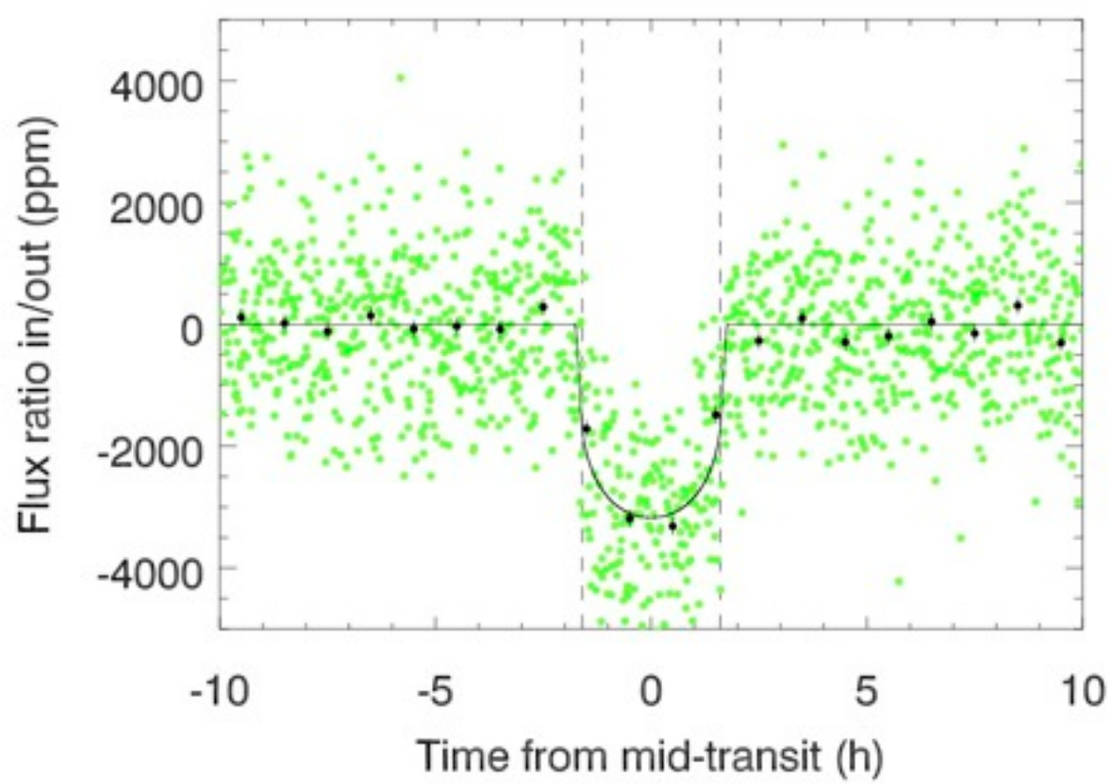


High-level Sci Reqs.

Photometric accuracy

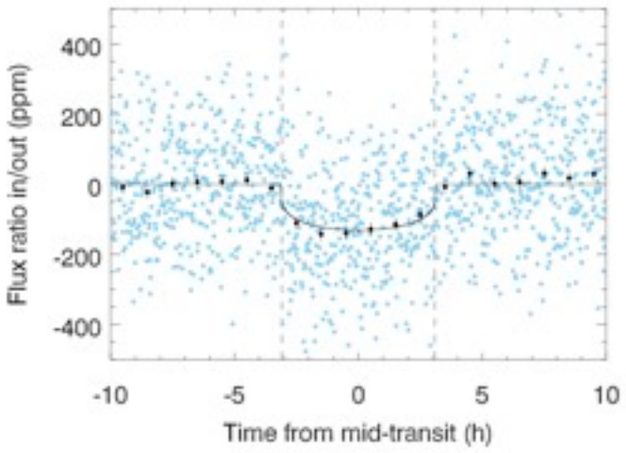
SciReq 1.2 **Photometric precision for transit characterization**
CHEOPS shall be able to detect a Neptune-size planet transiting a K-type dwarf (0.7 $R_\odot$) star of the 12.5th magnitude in the *V* band (goal: *V*=13) **with a signal-to-noise ratio of 30**. Such a transit has a depth of 2500 ppm and last for nearly 3 hours for planets with a revolution period of 13 days. Hence, a photometric precision of 85 ppm is to be obtained in 3 hours of integration time.



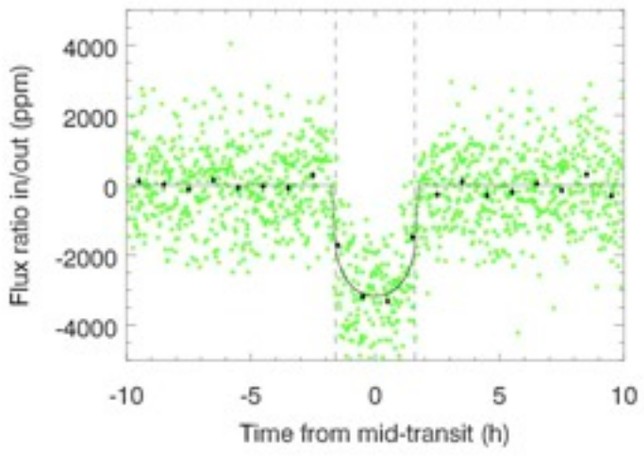


High-level Sci Reqs.

Sky coverage



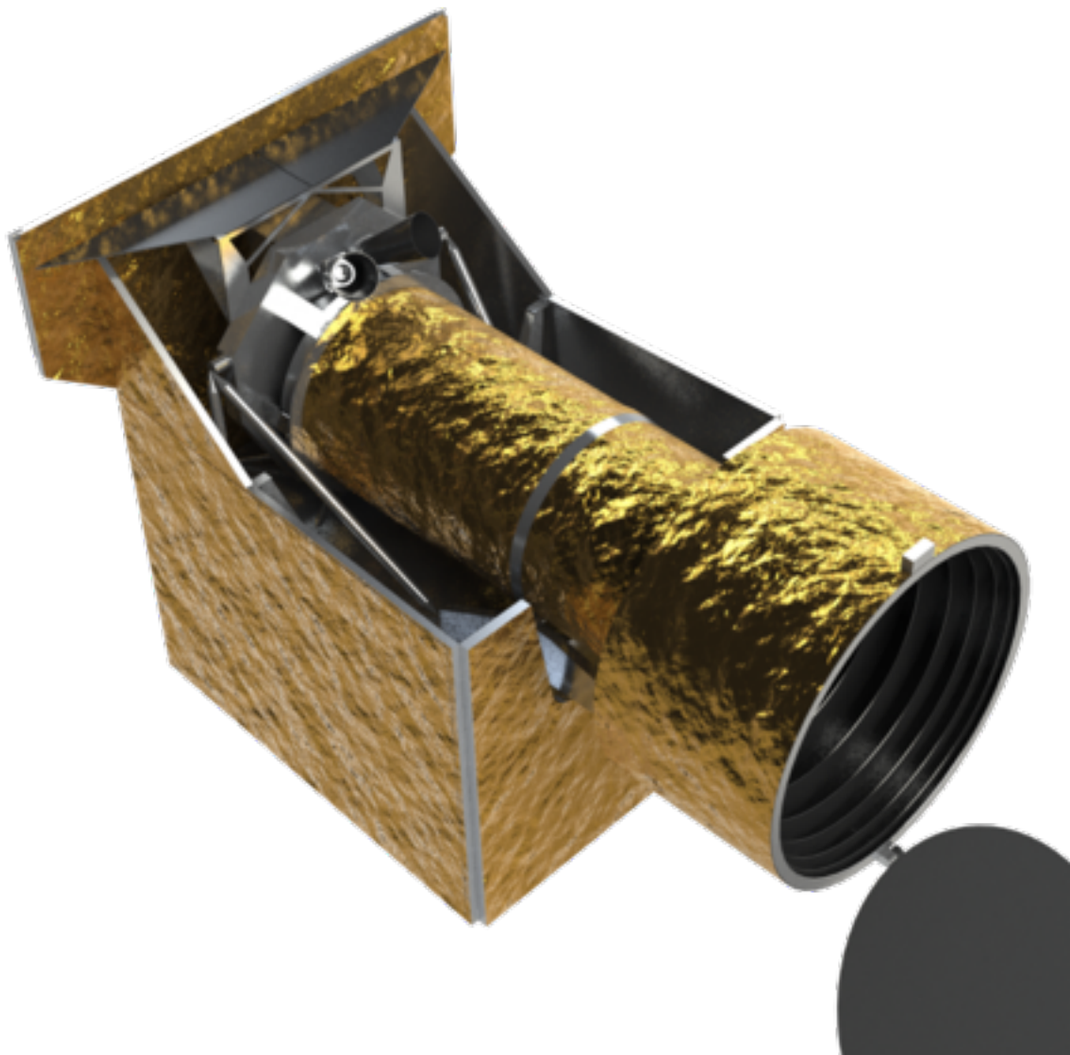
SciReq 2.1 **Stars with planets detected via Doppler velocimetry**
50% of the whole sky should be accessible for 50 days of observations (consecutive; goal: 60 days) per year and per target with observation duration longer than 50% of the spacecraft orbit duration (>50 min for 100-min spacecraft orbital period).



SciReq 2.2 **Stars with planets detected via ground-based transit surveys**
25% of the whole sky, with 2/3 in the southern hemisphere, should be accessible for 13 days (cumulative; goal: 15 days) per year and per target, with observation duration longer than 80% of the spacecraft orbit duration (>80 min for 100-min spacecraft orbit).

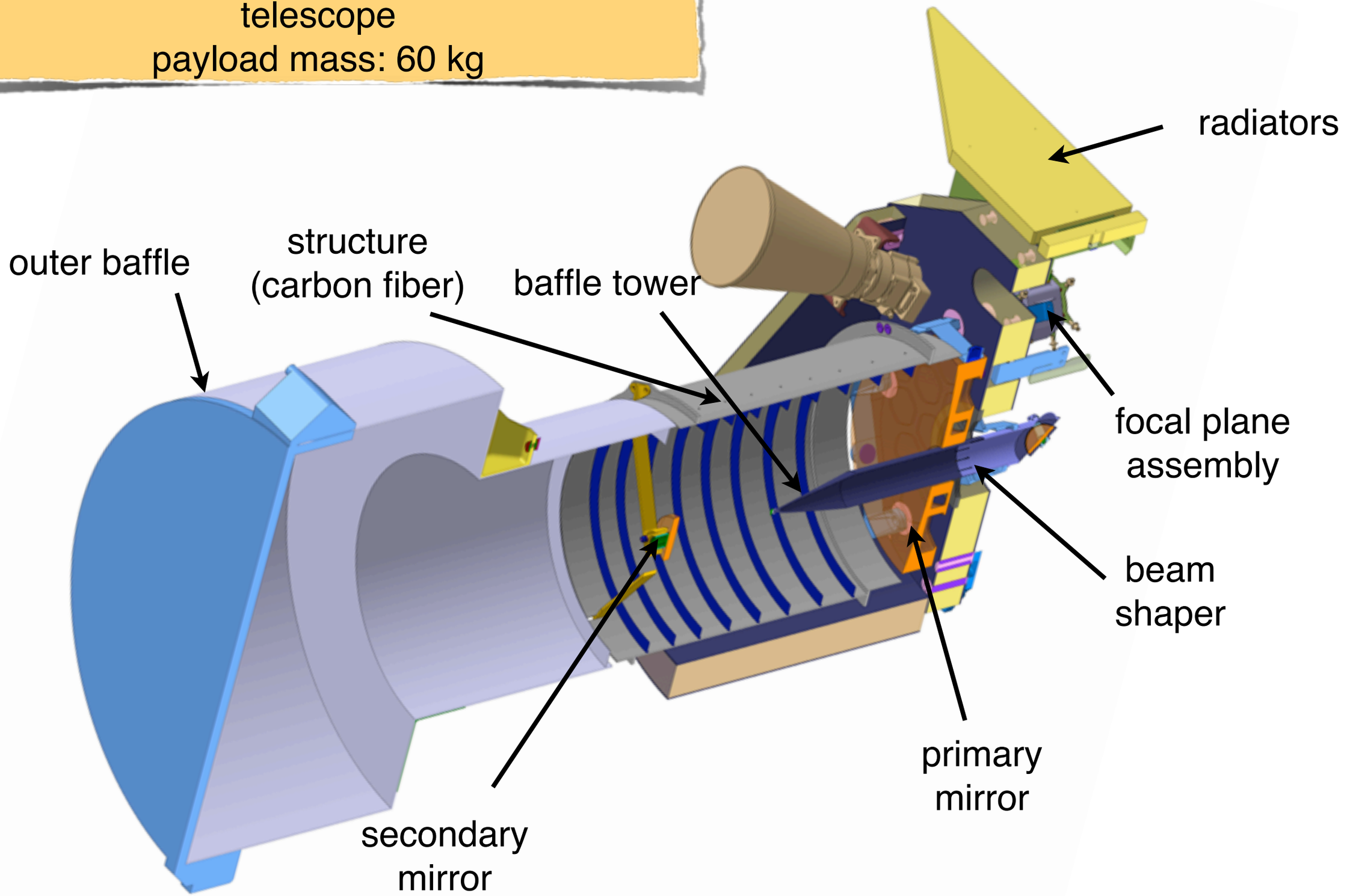
Platform

- Attitude Control
  - 3-axis stabilized S/C - one side facing Earth
  - pointing accuracy < 8 arc sec rms for 10h
- Instrument Power
  - 50 W continuous power,
  - 70 W peak
- Data rate
  - 1 Gbit/day downlink
- Total mass with payload
  - 200 kg

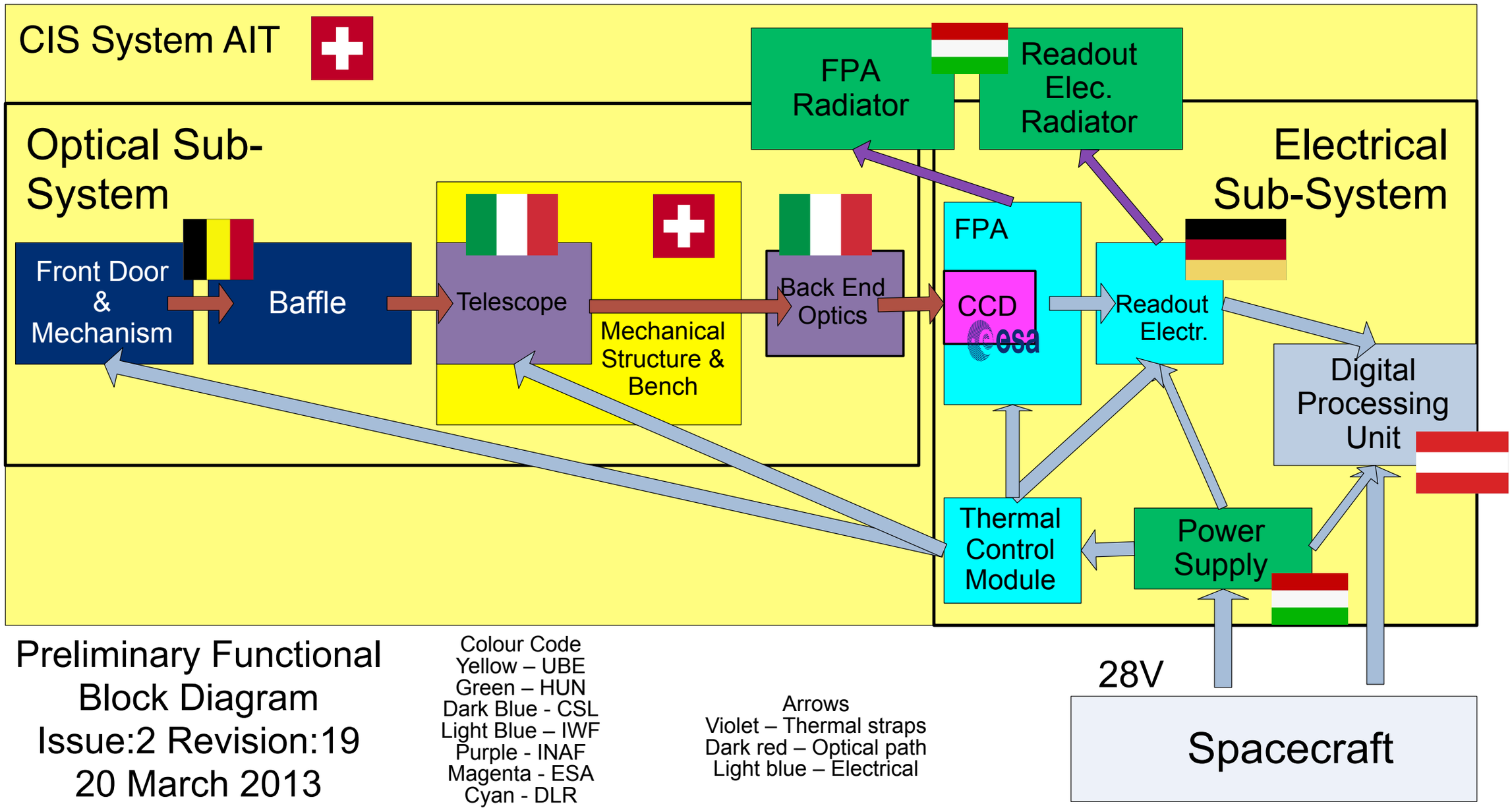


Payload

F/8 ~30 cm effective diameter on-axis telescope
payload mass: 60 kg



CHEOPS Payload FBD



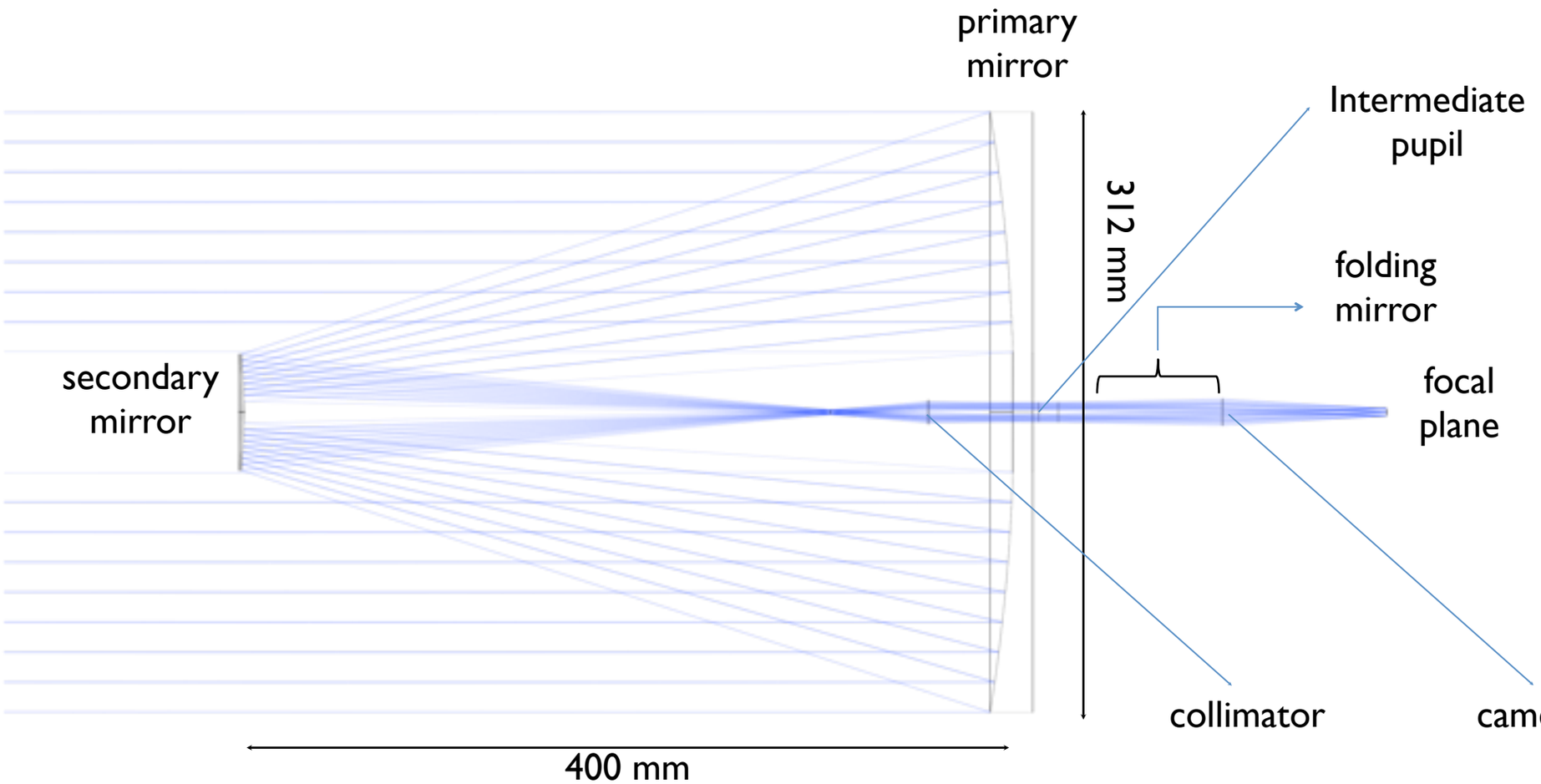
Preliminary Functional Block Diagram
Issue:2 Revision:19
20 March 2013

Colour Code
Yellow – UBE
Green – HUN
Dark Blue - CSL
Light Blue – IWF
Purple - INAF
Magenta - ESA
Cyan - DLR

Arrows
Violet – Thermal straps
Dark red – Optical path
Light blue – Electrical

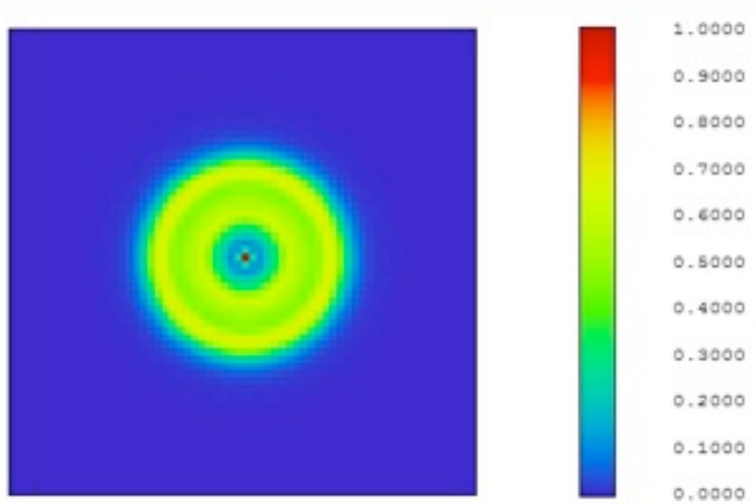
Optical Design

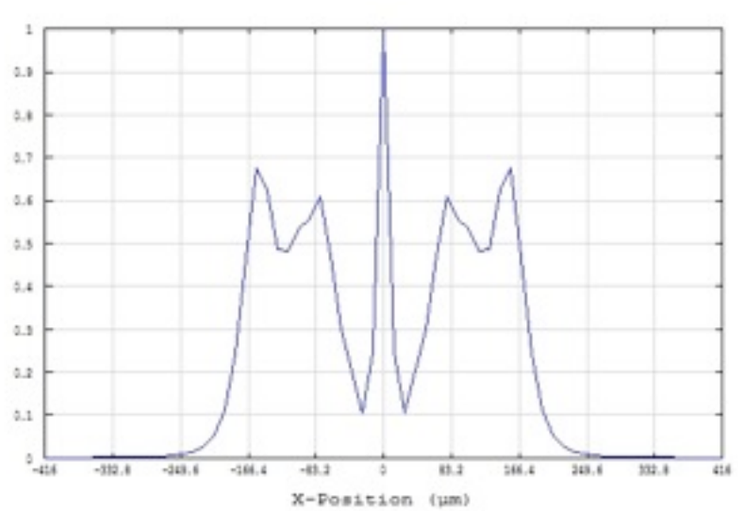
F/5.13 Ritchey-Chretien Telescope (0.2 central obstruction) + collimator-camera re-imaging system



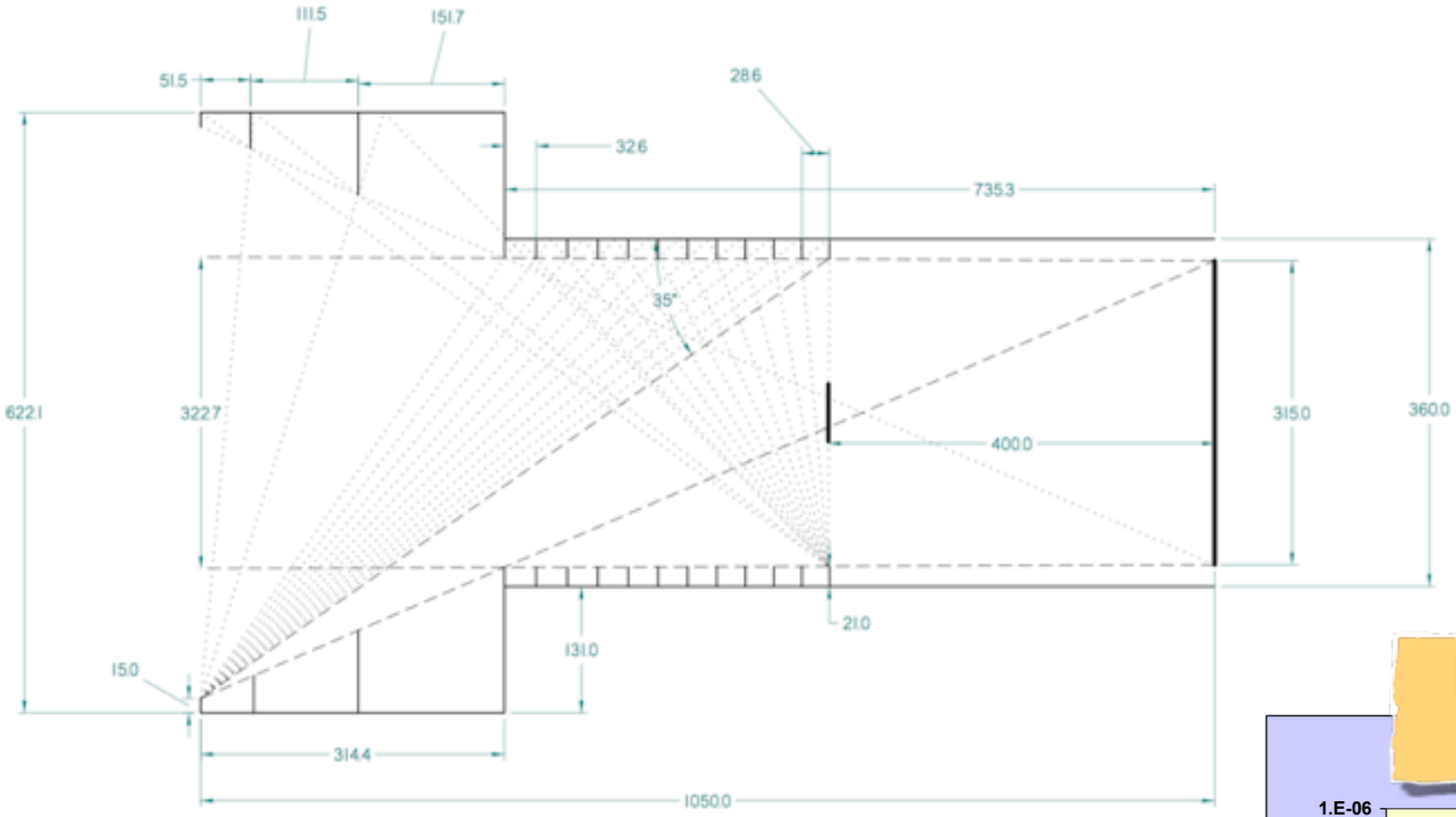
EPD 312 mm
efl 2676 mm
F/# 8.6
Plate scale 1 arcsec/pixel

Polychromatic defocused PSF with 30 pixel diameter





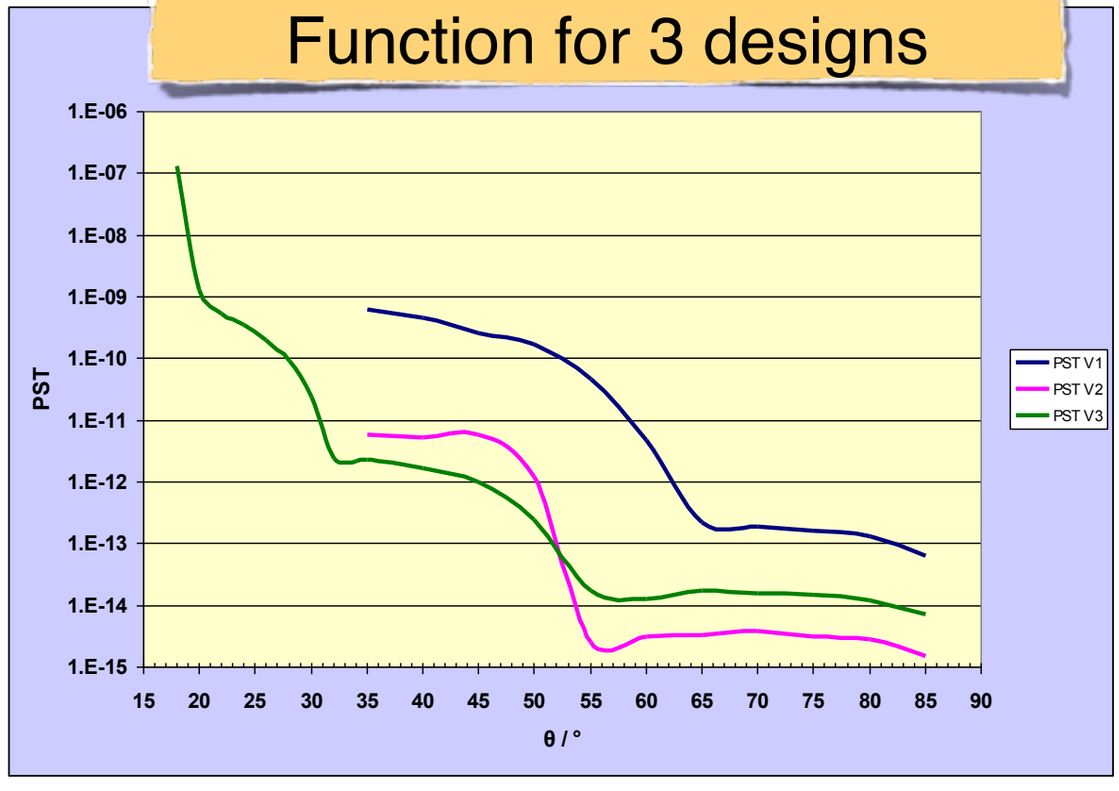
Optical design and stray light performance



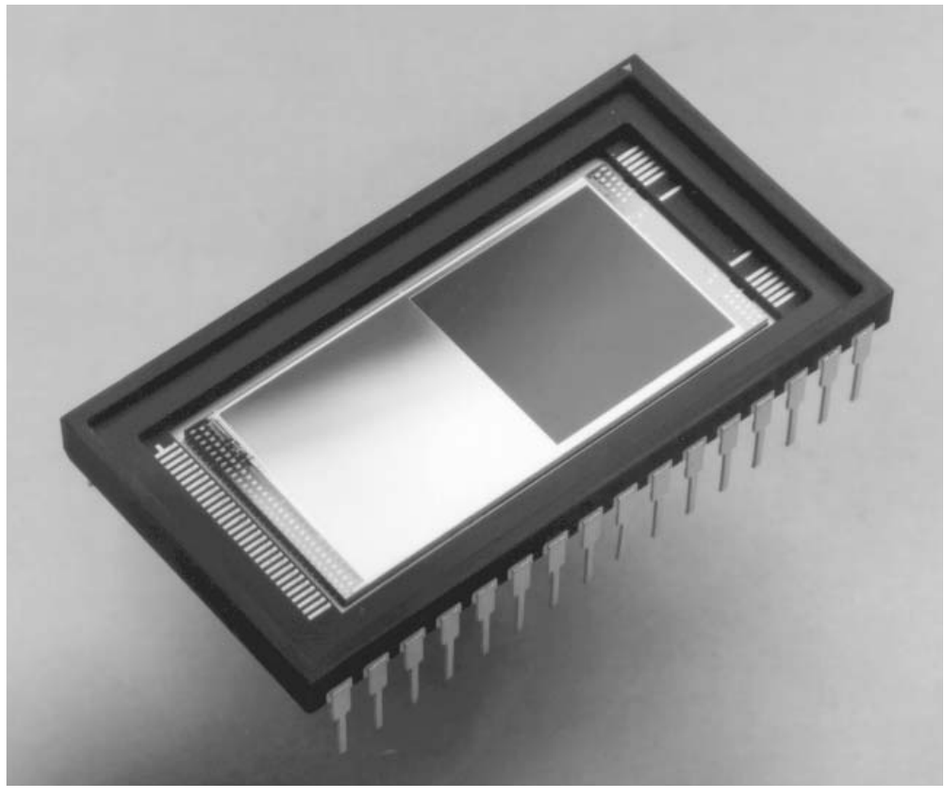
Baffle Layout

- Baffle designed for 35 degree exclusion angle

Point Source Transmission Function for 3 designs



e2V CCD47-20 Detector



Characteristic	Value
Effective wavelength range	0.4 – 1.1 nm
Size	1024x1024 px
Operating temperature range	-60 .. -40 C
Temperature stability requirement	< 10 mK
Angular scale	approx. 1.2 “/px
Full well capacity	80,000 e-
Read Noise	4 e/px
Dark Current	negligible
Readout frequency	5 MHz
Pixel size	13 um
Manufacturer	e2V

Mission summary

Name	CHEOPS (CHaracterizing ExOPlanet Satellite)
Primary science goal	Measure the radius of planets transiting bright stars to 10% accuracy
Targets	Known exoplanet host stars with a V-magnitude < 12.5 anywhere on the sky
Wavelength	Visible range : 400 to 1100 nm
Telescope	707 cm^2 effective aperture reflective on-axis telescope
Orbit	LEO sun-synchronous, LTAN 6am, 620-800 km
Lifetime	3.5 years
Type	s-class