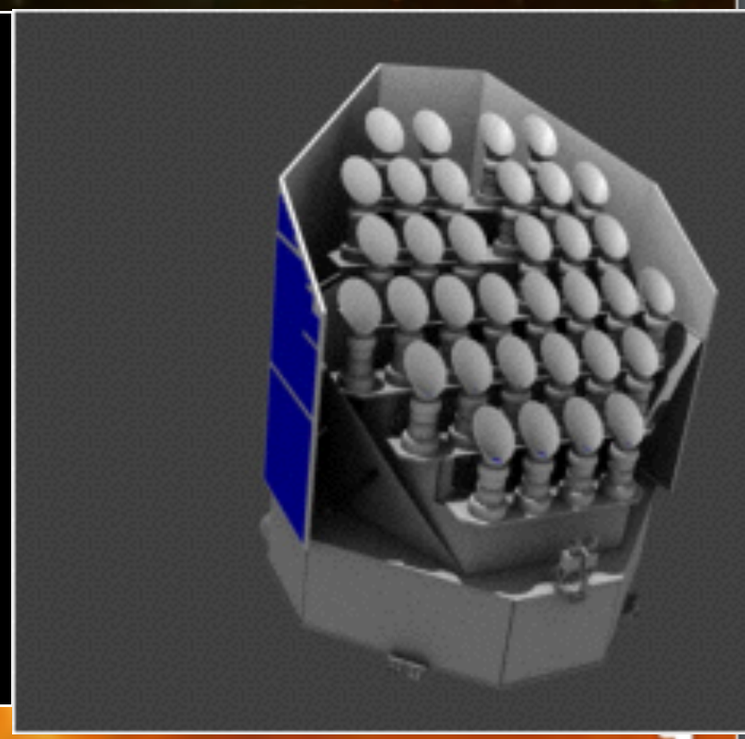
Űrfotometriai lehetőségek magyar hozzájárulással: a CHEOPS és a PLATO programok

Kiss László, Szabó Róbert, Szabó M. Gyula

MTA CSFK KTM CSI, ELTE GAO

Magyar Űrkutatási Fórum
Sopron, 2015. május 7-9.



Exobolygók: 51 Pegasi (1995)

A Jupiter-mass companion to a solar-type star

Michel Mayor & Didier Queloz

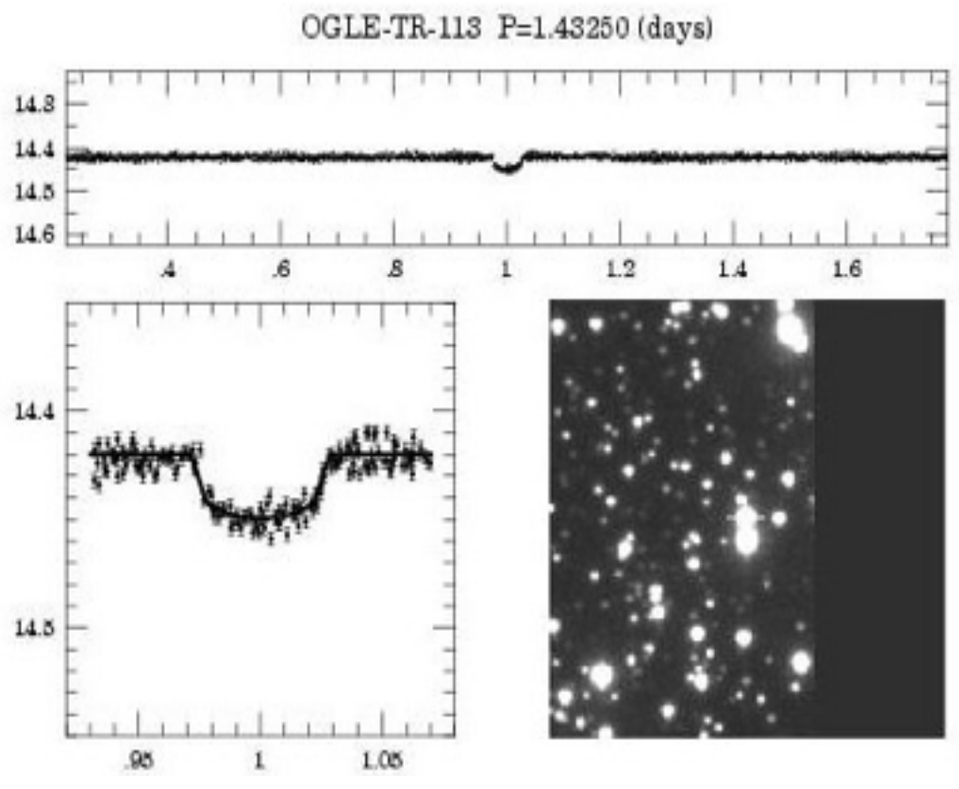
Geneva Observatory, 51 Chemin des Maillettes, CH-1290 Sauverny, Switzerland

The presence of a Jupiter-mass companion to the star 51 Pegasi is inferred from observations of periodic variations in the star's radial velocity. The companion lies only about eight million kilometres from the star, which would be well inside the orbit of Mercury in our Solar System. This object might be a gas-giant planet that has migrated to this location through orbital evolution, or from the radiative stripping of a brown dwarf.

Más csillagok napfogyatkozásai

Fedési exobolygók: a bolygó elhalad a csillag előtt, és kitakarja. Ebből megállapítható, kiszámítható, detektálható:

- a valós méret (a csillagsugár arányában)
- a sűrűség
- a bolygó szerkezete!
- a bolygólégkör színképe
- a visszavert fény
- a bolygólégkör szerkezete
- a csillag légkörének szerkezete



Űrfotometria: mire jó az?

Nagyságrendi ugrások a fényességmérés *relatív pontosságában*

- Új fizika!
- 100%: Mirák, (szuper)nóvák
- 1–10%: Geometriai és fizikai (pulzáló, eruptív és kataklizmikus) változócsillagok
- 0,1%: Fedési exobolygók – forró jupiterek
- 0,0001–0,01%: Nap típusú csillagrezgések, exoholdak, exoföldek, ???

Űrfotometria: mire jó az?

Az űrbéli mérések célja

- A földi légkör zavaró hatásaitól mentes adatgyűjtés
- A nappalok és éjszakák váltakozásaitól mentes mérések
- Fotonzaj-limitált adatok (0,1% – 1 millió foton)
- Kis távcső – fényes csillag!

Kepler-űrtávcső

A Kepler célja Föld típusú, lakható bolygók felfedezése a fedési módszerrel

Szimultán észlelt több mint 150 ezer csillagot

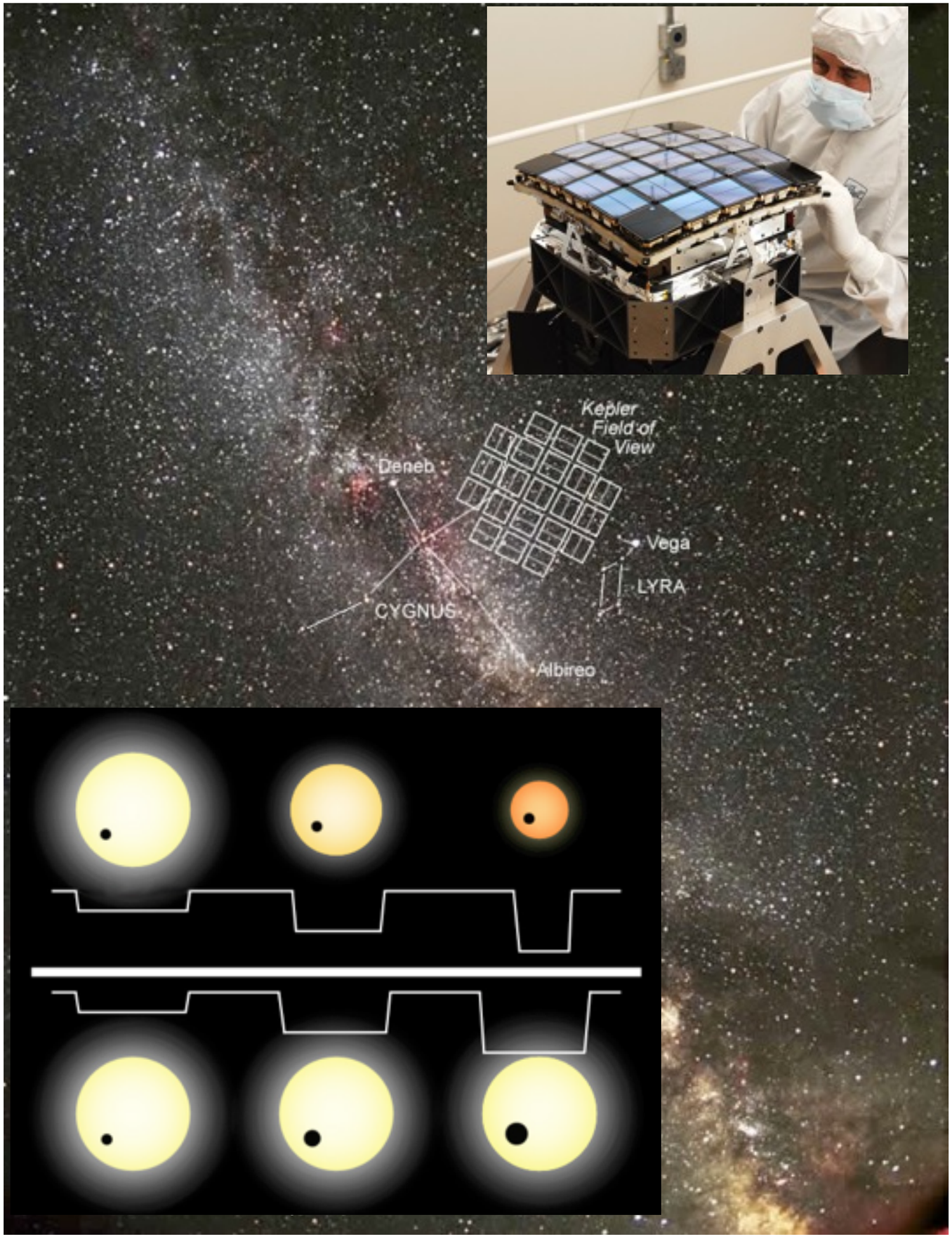
95 cm-es belépő nyílású Schmidt-távcső, látómezeje mintegy 100 négyzetfok, 42 CCD-ből álló mozaikkal

Fotometriai pontosság:

A zaj < 20 ppm 6,5 órányi mérés után egy 12 magn. Nap típusú csillagra

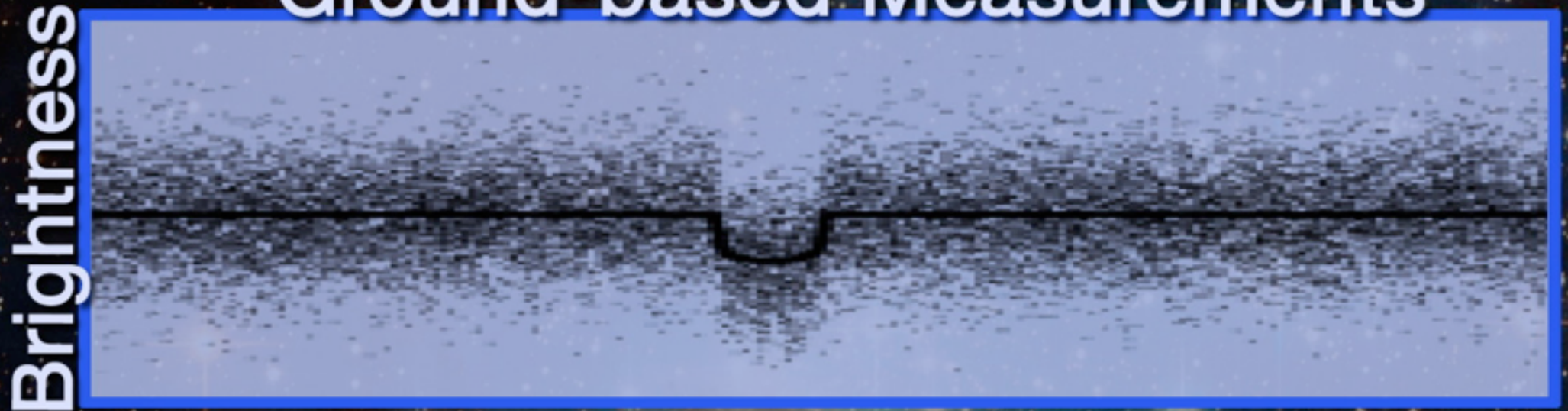
=> 4-szigma detektálás egy exoföld tranzitja esetén.

Heliocentrikus pálya, 2009-2013

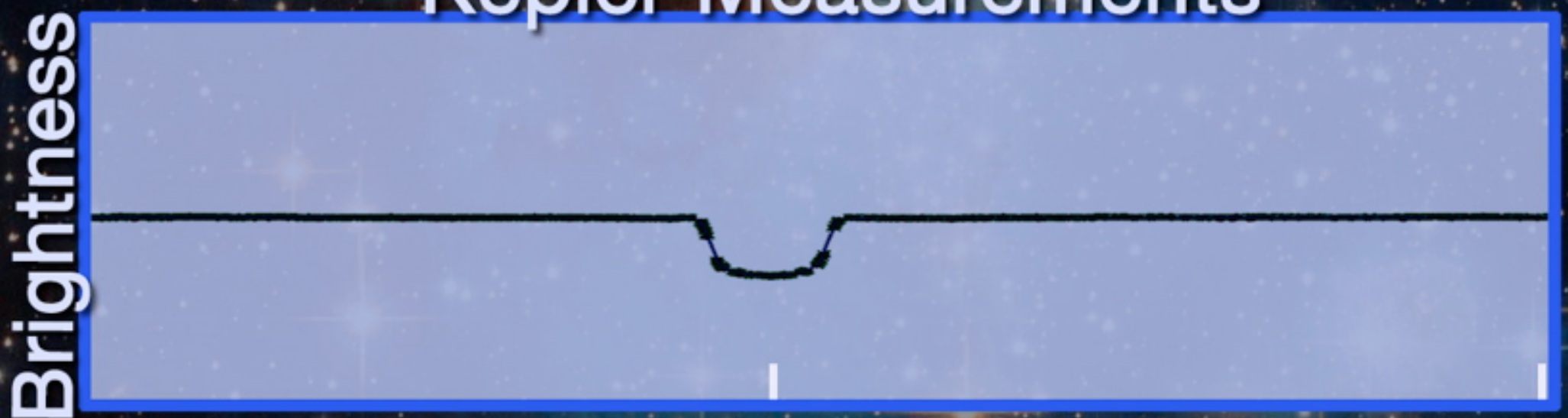


HAT-P-7 Light Curves

Ground-based Measurements



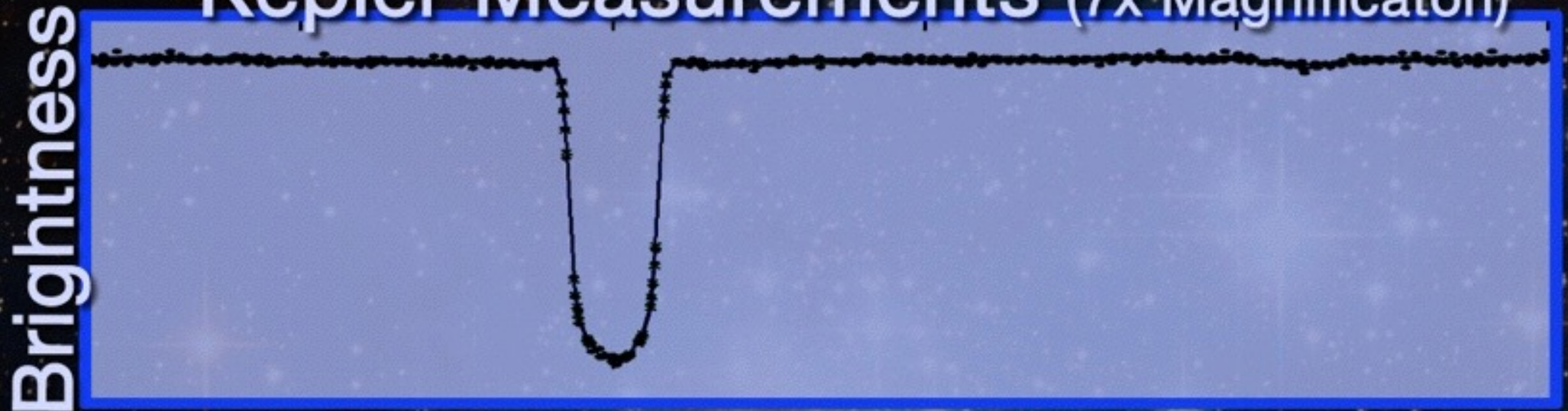
Kepler Measurements



Borucki et al. (2009)

HAT-P-7 Light Curves

Kepler Measurements (7x Magnificaton)



Kepler Measurements (100x Magnification)

Borucki et al. (2009)

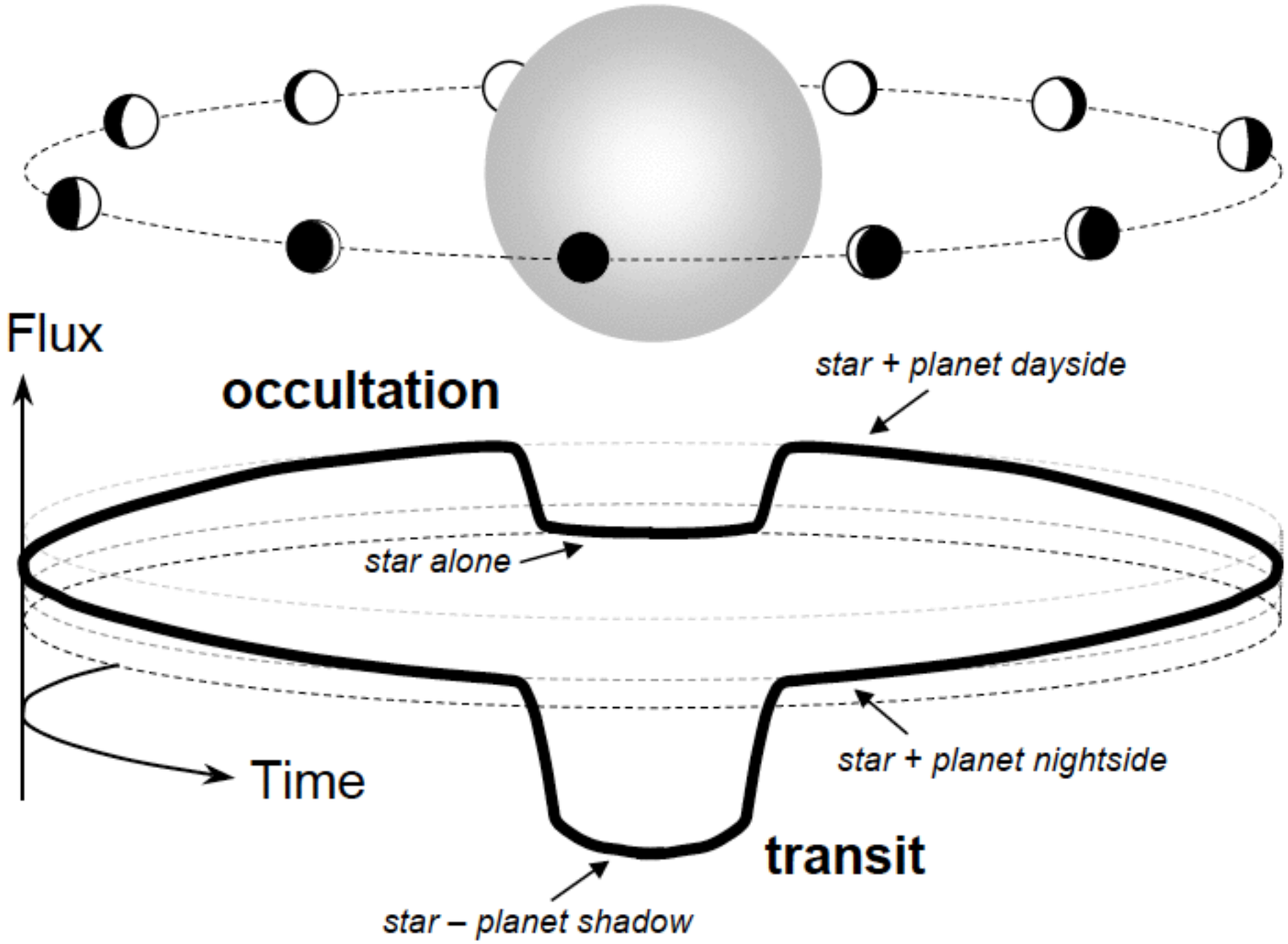
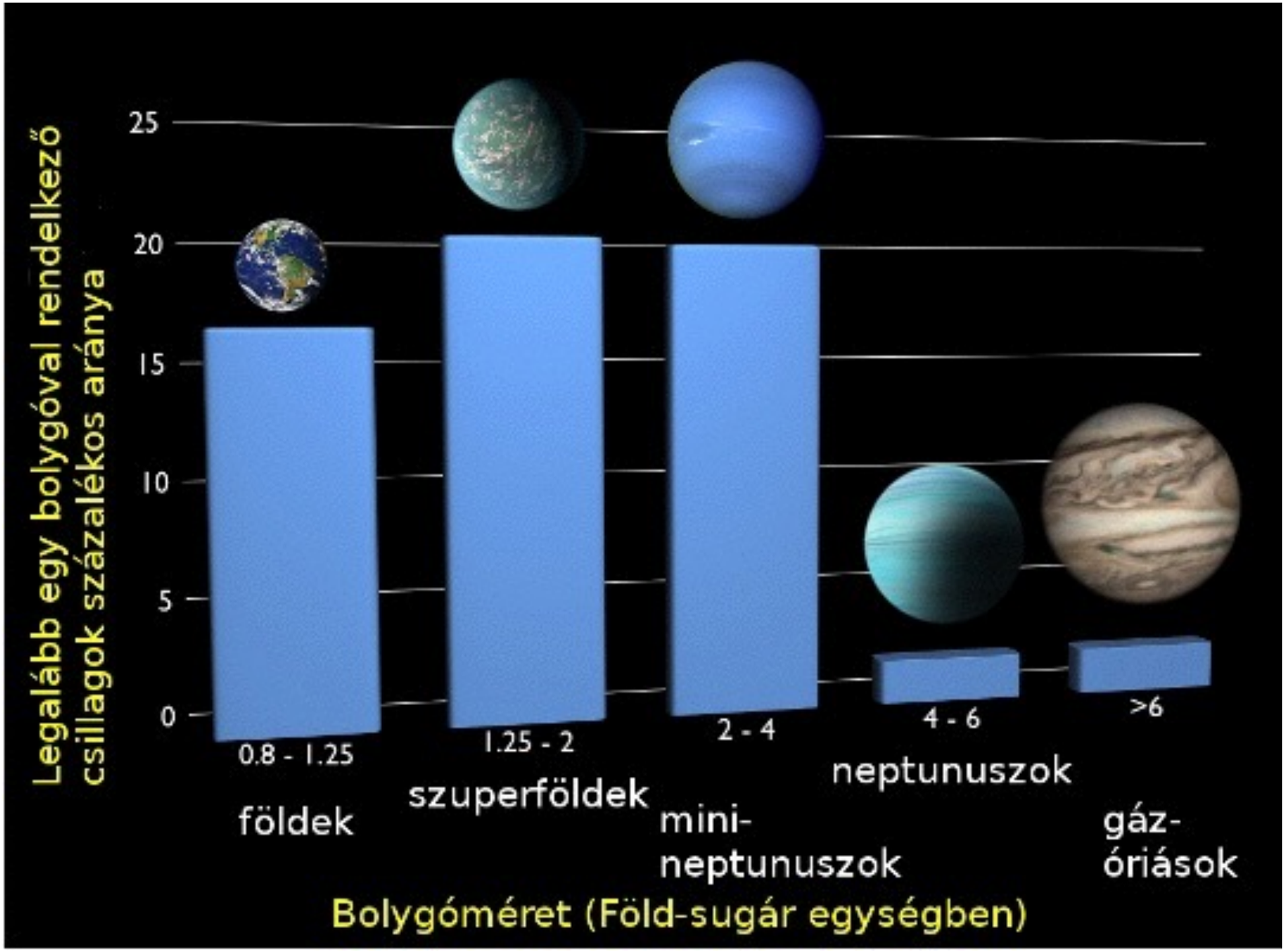
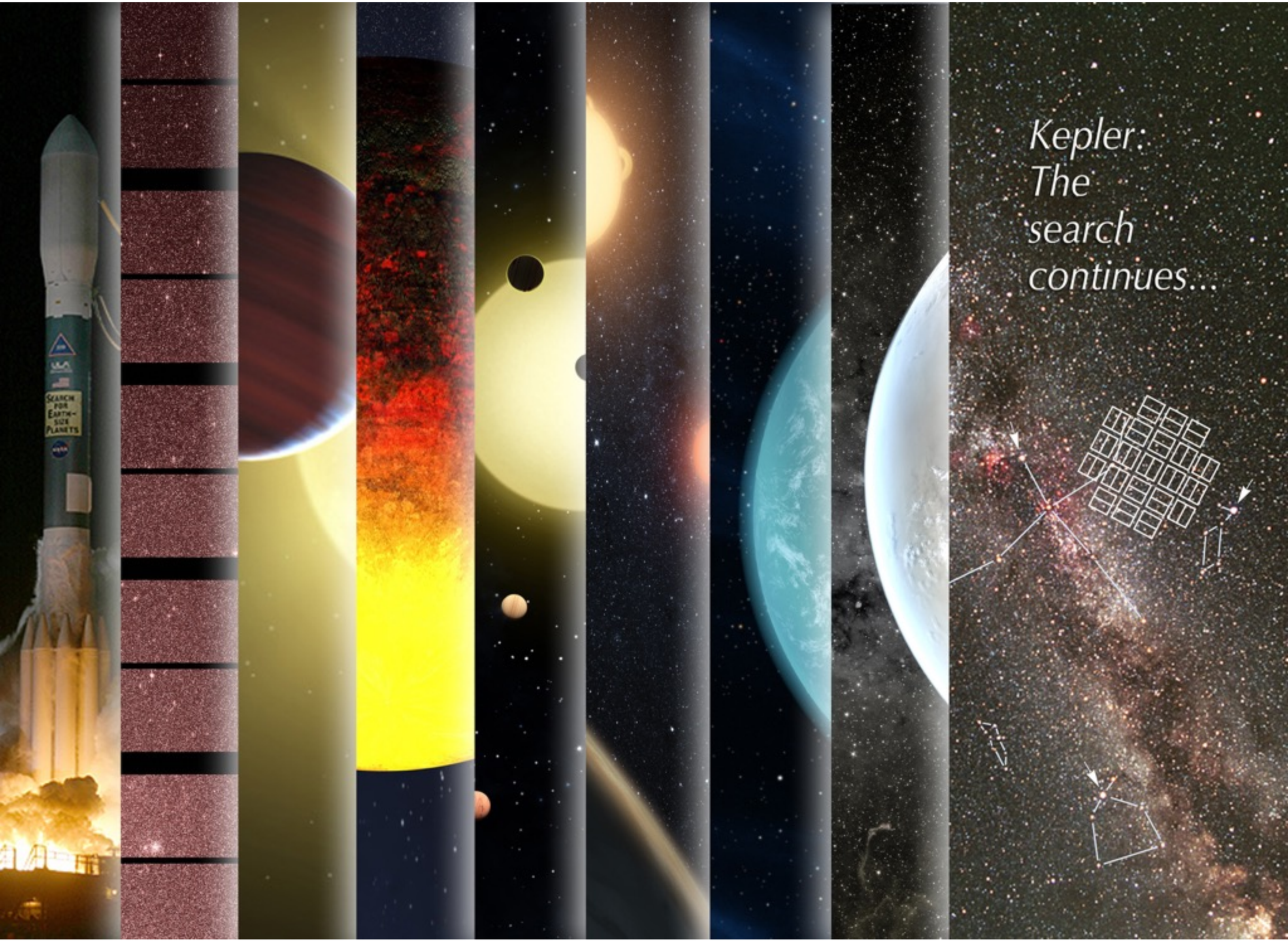
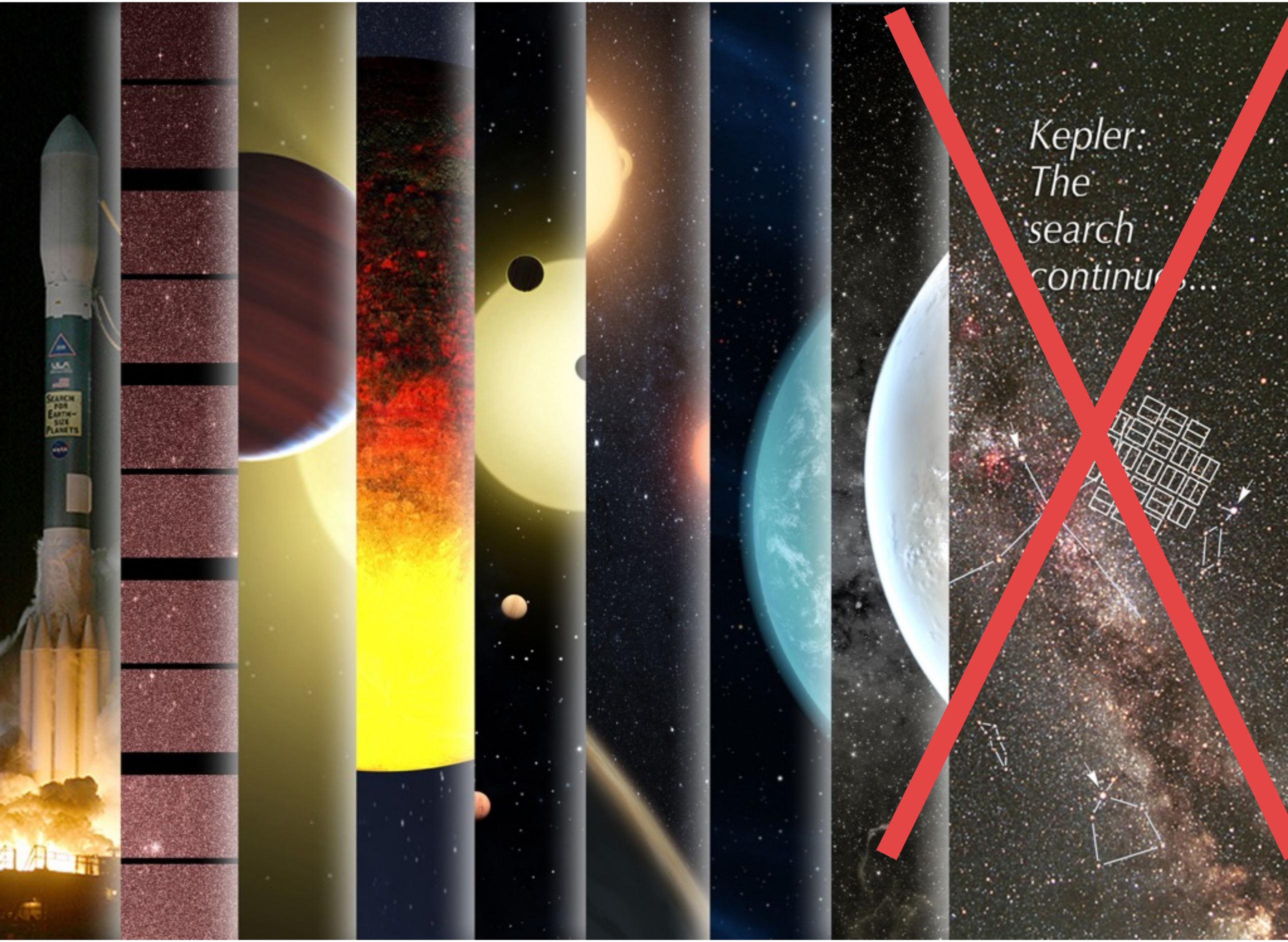


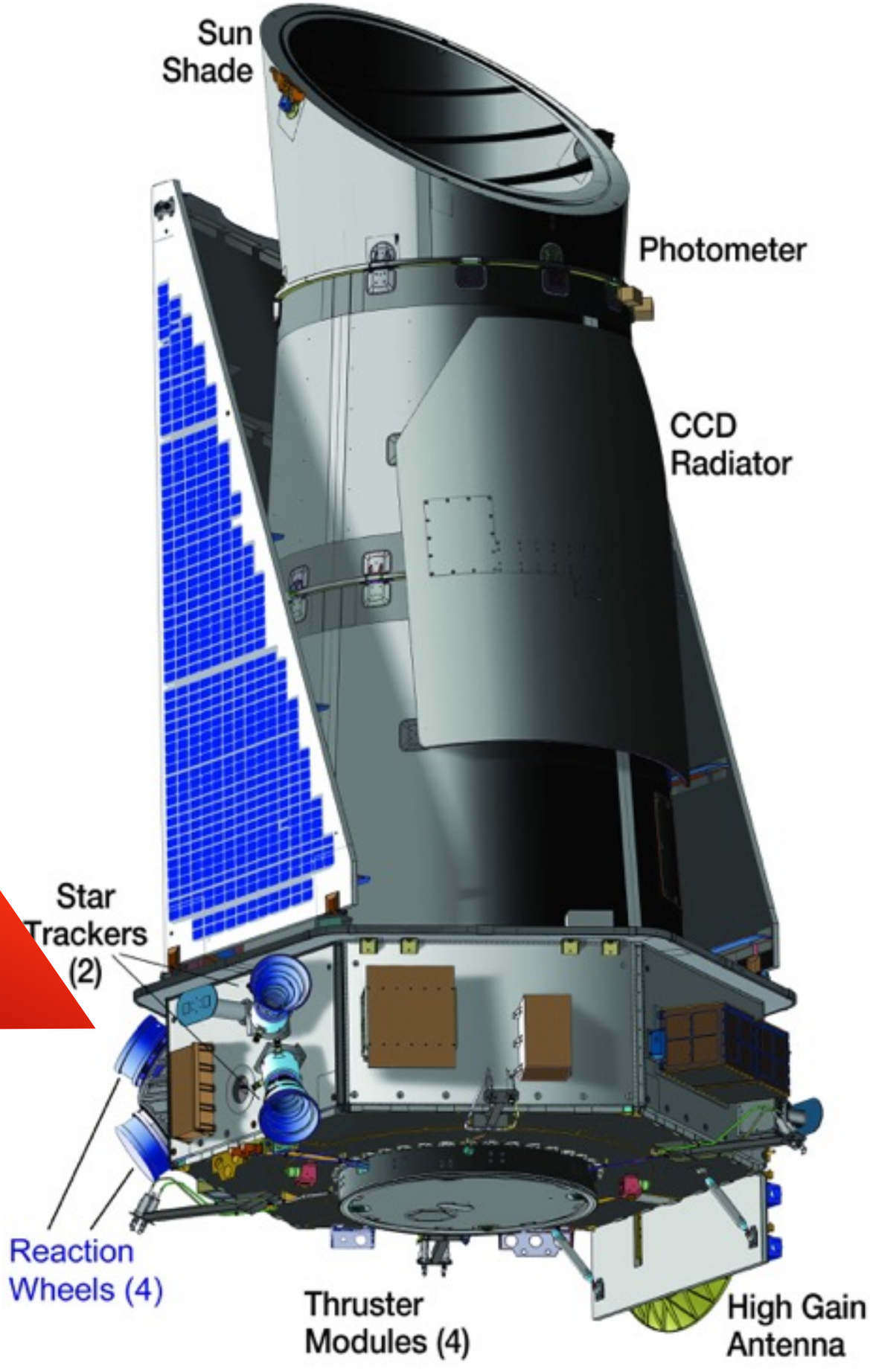
Fig. 1.— Illustration of transits and occultations. Only the combined flux of the star and planet is observed. During a transit, the flux drops because the planet blocks a fraction of the starlight. Then the flux rises as the planet's dayside comes into view. The flux drops again when the planet is occulted by the star.

Rövidperiódusú bolygók gyakorisága

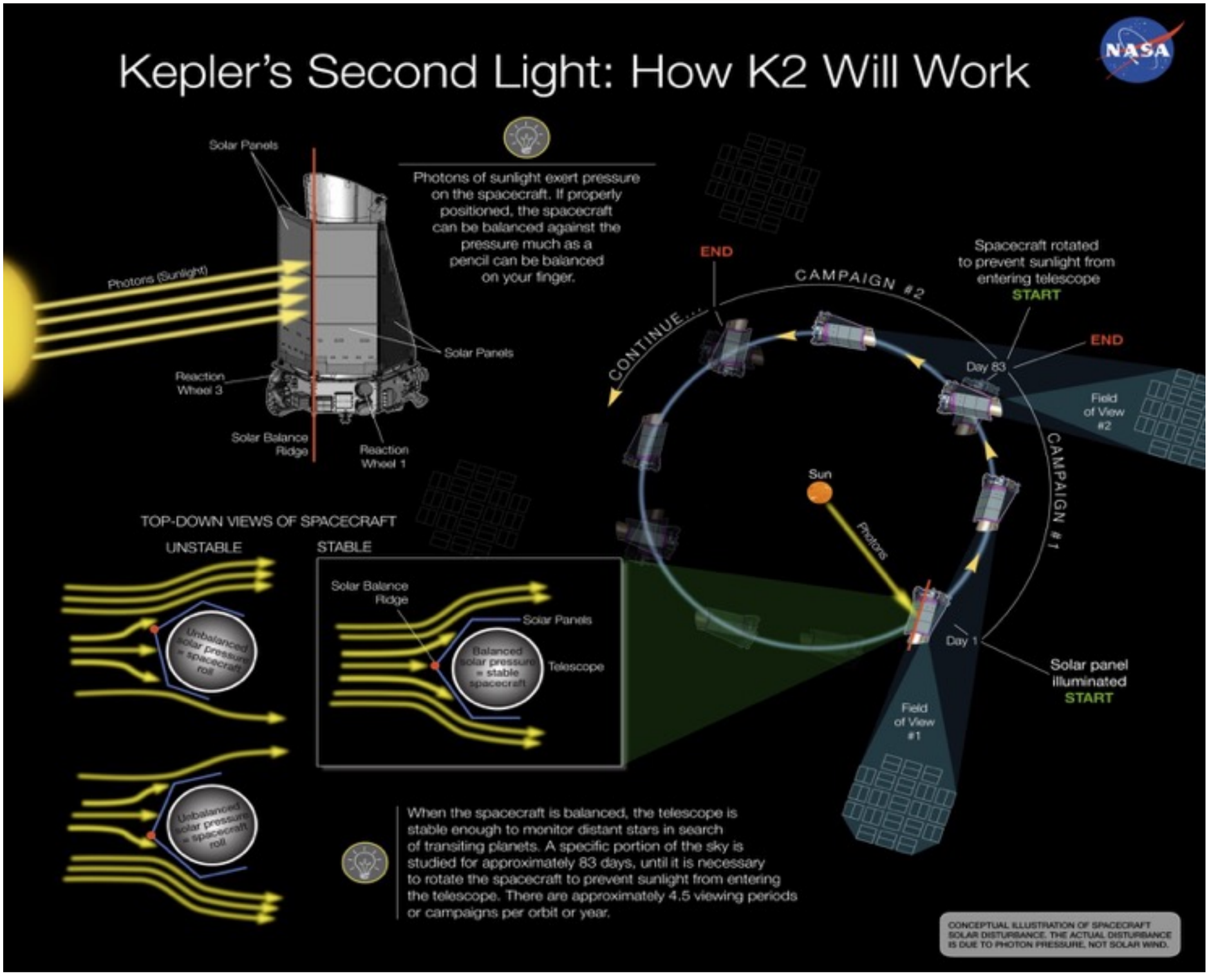



SEARCH FOR EARTH-SIZE PLANETS
Kepler:
The
search
continues...


SEARCH FOR EARTH-SIZE PLANETS
Kepler:
The
search
continues...

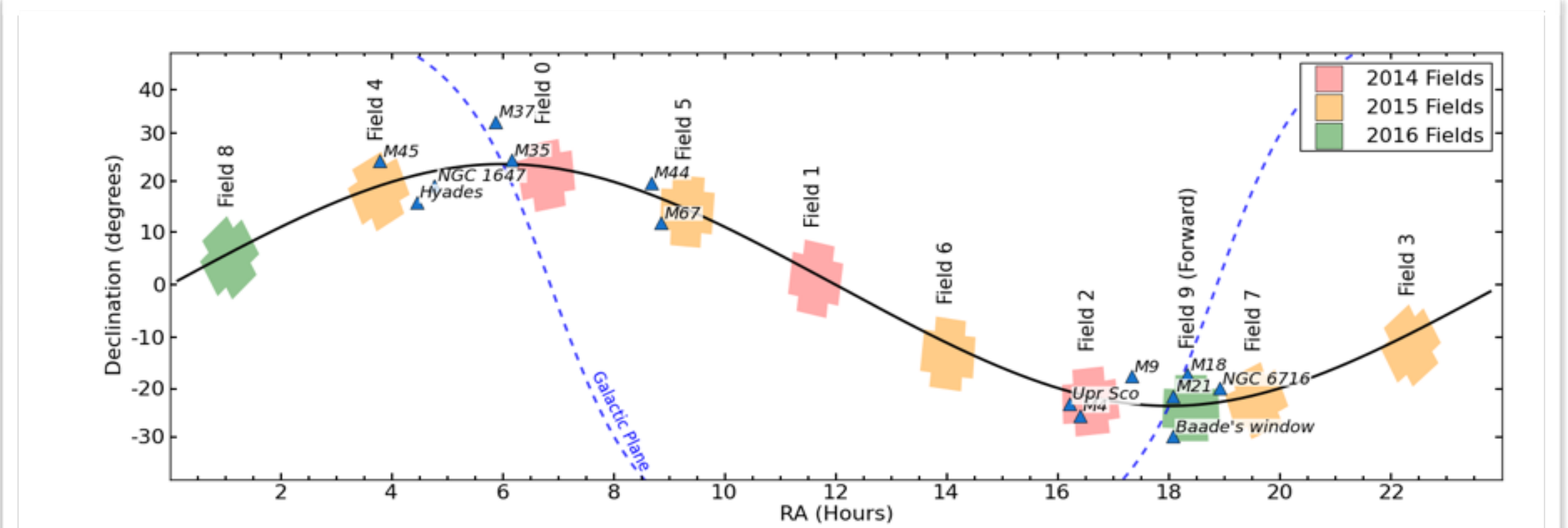

Sun
Shade
Photometer
CCD
Radiator
Star
Trackers
(2)
Reaction
Wheels (4)
Thruster
Modules (4)
High Gain
Antenna

A K2-misszió

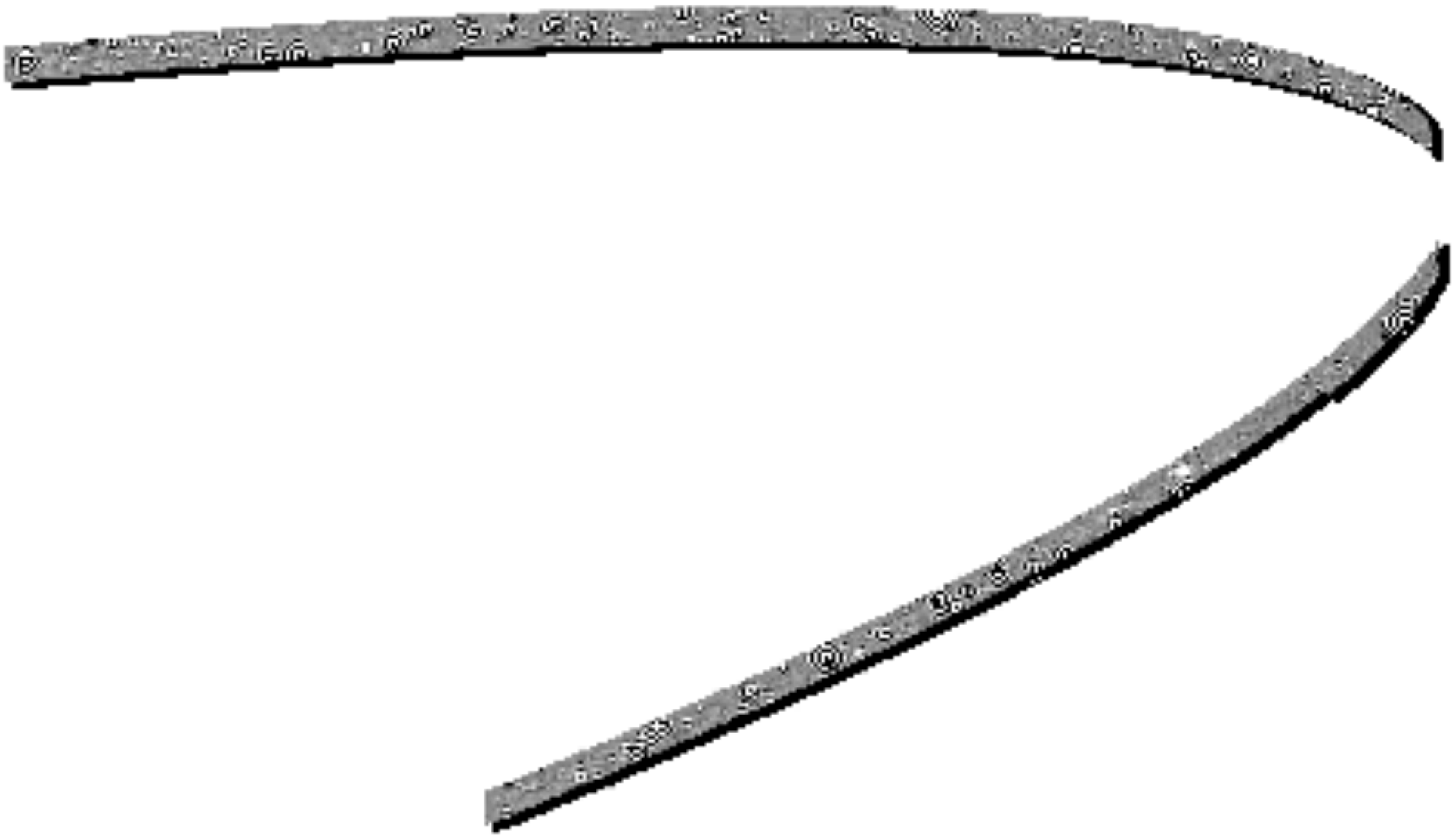

Kepler's Second Light: How K2 Will Work
NASA
Solar Panels
Photons (Sunlight)
Reaction Wheel 3
Solar Panels
Solar Balance Ridge
Reaction Wheel 1
Photons of sunlight exert pressure on the spacecraft. If properly positioned, the spacecraft can be balanced against the pressure much as a pencil can be balanced on your finger.
TOP-DOWN VIEWS OF SPACECRAFT
UNSTABLE
STABLE
Unbalanced solar pressure = spacecraft roll
Solar Balance Ridge
Solar Panels
Balanced solar pressure = stable spacecraft
Telescope
Unbalanced solar pressure = spacecraft roll
When the spacecraft is balanced, the telescope is stable enough to monitor distant stars in search of transiting planets. A specific portion of the sky is studied for approximately 83 days, until it is necessary to rotate the spacecraft to prevent sunlight from entering the telescope. There are approximately 4.5 viewing periods or campaigns per orbit or year.
END
CAMPAIGN #2
CONTINUE...
Spacecraft rotated to prevent sunlight from entering telescope
START
END
Day 83
Field of View #2
CAMPAIGN #1
Sun
Photons
Day 1
Solar panel illuminated
START
Field of View #1
CONCEPTUAL ILLUSTRATION OF SPACECRAFT SOLAR DISTURBANCE. THE ACTUAL DISTURBANCE IS DUE TO PHOTON PRESSURE, NOT SOLAR WIND.

A K2-misszió


K2
Extending Kepler's Power to the Ecliptic


2014 Fields
2015 Fields
2016 Fields
Field 8
Field 4
Field 0
Field 5
Field 1
Field 6
Field 2
Field 9 (Forward)
Field 7
Field 3
M37
M45
M35
NGC 1647
Hyades
M44
M67
M9
M18
M21
NGC 6716
Upr Sco
Baade's window
Galactic Plane
Declination (degrees)
RA (Hours)

2007 JJ43: Neptunuszon túli kisbolygó a Keplerrel!

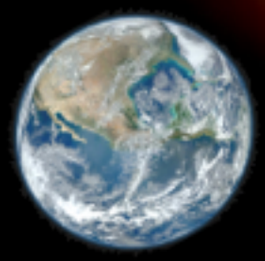


MOST

Canada's first space telescope

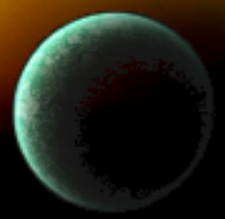
Microvariability & Oscillations of Stars Microvariabilité et Oscillations

Peering into the hidden hearts of stars
Finding and exploring exoplanets
Reading stellar life stories

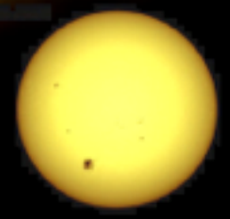


HOME

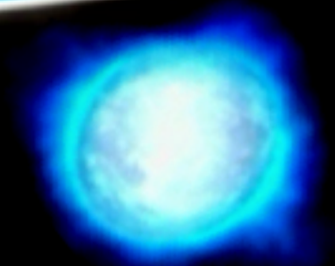
MISSION AT A GLANCE



NEWS



SCIENCE



GALLERY

LINKS

Scientific Goals (in astro-jargon)

- Asteroseismology of acoustic and gravity-mode oscillations in Sun-like stars, magnetic (rapidly oscillating Ap or roAp) stars, cool giants, pre-main-sequence delta Scuti pulsating stars, massive O and B stars, and other stellar classes, to probe uniquely their internal structures and evolutionary states
- Analyses of the transits and eclipses of exoplanets around Sun-like stars and red dwarf stars, to reveal their sizes, atmospheric compositions, magnetic fields and other properties
- Measurement of the turbulent variations in massive evolved (Wolf-Rayet) stars to understand

MOST: max. 60 napos folyamatos mérés, 15 cm-es távcső, 65 x 65 x 30 cm, 54 kg, 2003 óta

BRITE: max. 180-200 napos folyamatos mérés, 3 cm-es távcső, 20 x 20 x 20 cm, <8 kg, 2013 óta

CHEOPS

CHARACTERIZING EXOPLANET SATELLITE

esa

100% vapor

CHEOPS (2017 – 2020)

Mission Status & Summary

Mission Status

CHEOPS has been proposed as an S-class mission in response to the call for Proposals issued by ESA in March 2012.

On 19 October 2012 it was selected for study for the first S-class mission.

On 19 February 2014 CHEOPS was adopted by SPC.

Mission Summary:

The following table summarizes the mission.

Name	CHEOPS, CHaracterizing ExOPlanet Satellite
Primary Goal	Characterize transiting exoplanets on known bright and nearby host stars
Targets	Known exoplanet host stars with a V-magnitude < 12.5 (goal: 13) anywhere on the sky
Wavelength	Visible range : 400 to 1100 nm
Telescope	33 cm reflective an-axis telescope
Orbit	Sun-synchronous Low Earth Orbit, LTAN 6am, altitude 620-800 km
Lifetime	3.5 years
Type	S-class mission

(last update Feb 2014)

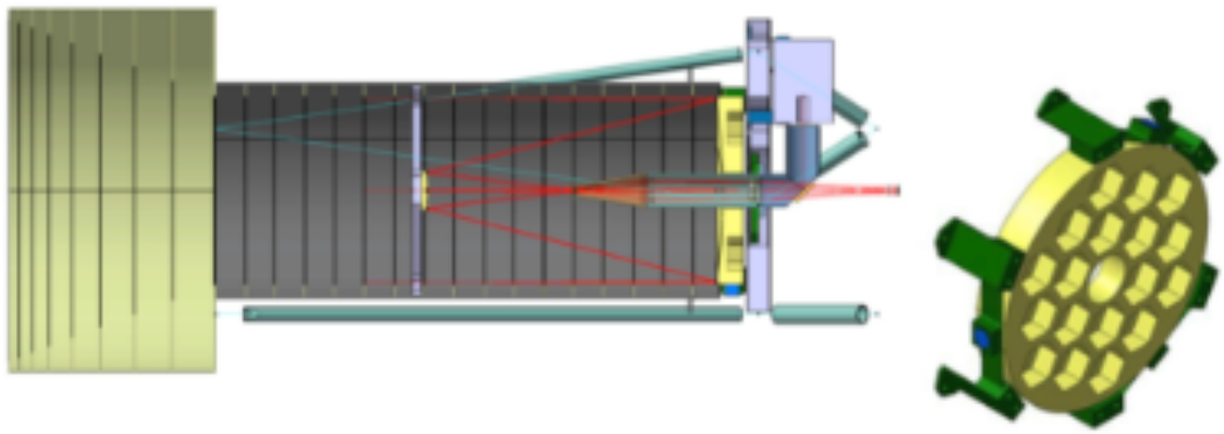


Fig. 2: Initial mechanical concept for the telescope and the lightweighted primary mirror

	Mass (kg, No Margin)	Mass (kg, incl.20% Margin)
Telescope Structure	14.6	17.5
Optical Bench	2.5	3.0
Focal Plane Assembly	2.0	2.4
Lens Assembly	2.0	2.4
Readout Electronics	5.0	6.0
Electronics Box (PCM, DPM, TCM)	5.6	6.7
Radiator	1.0	1.2
Outer Baffle Assembly	11.0	13.2
Total	46.1	55.3
Gyro Assembly	4.5	5.4
Star Tracker Assembly	1.1	1.3
Total (incl. PRS components)	48.3	58.0

Table 1: Current payload mass breakdown

Board Members:

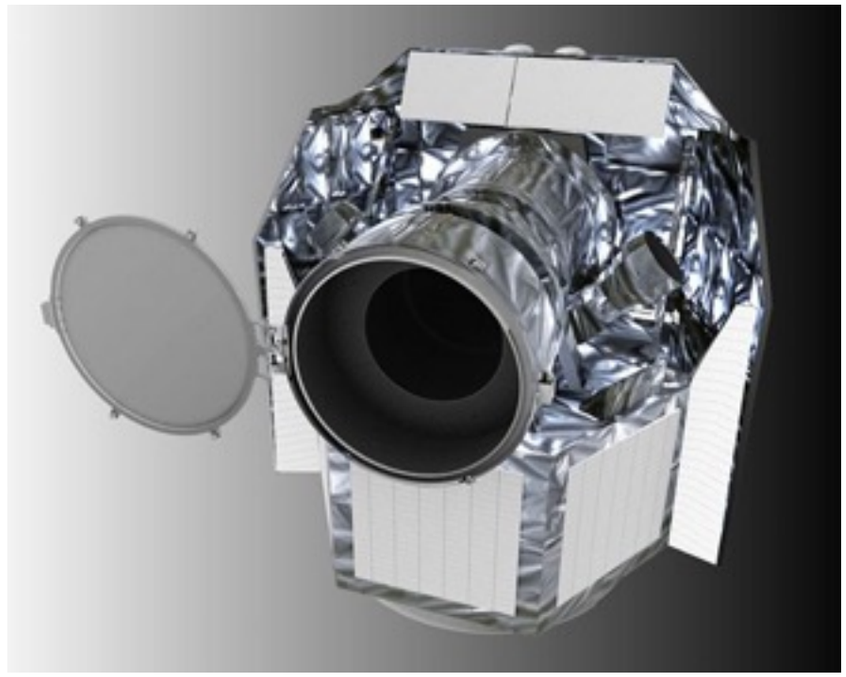
Country	Institute	Name
A	Institut für Weltraumforschung, Graz	Baumjohann Wolfgang
A	Institut für Weltraumforschung, Graz	Steller Manfred
B	University of Liège	Gillon Michaël
B	Centre Spatial de Liège	Renotte Etienne
CH	Universität Bern	Benz Willy
CH	Universität Bern	Thomas Nicolas
CH	Observatory of the University of Geneva	Udry Stéphane
F	Laboratoire d'astrophysique de Marseille	Deleuil Magali
F	Institut d'astrophysique de Paris	Lecavelier des Etangs Alain
GER	DLR Institute of Planetary Research	Spohn Tilman
HU	Admatis	Barczy Tamas
HU	Konkoly Observatory	Kiss Laszlo
I	Università di Padova	Piotto Giampaolo
I	Osservatorio Astronomico di Padova - INAF	Ragazzoni Roberto
P	Deimos	Gutierrez Antonio
P	Centro de Astrofisica da Universidade do Porto	Santos Nuno C.
S	Onsala Space Observatory, Chalmers Univ. of Technology	Liseau René
S	Stockholm University, Stockholm	Olofsson Göran
UK	University of Warwick	Pollacco Don

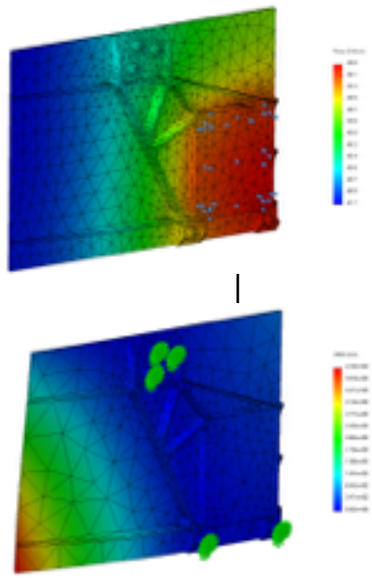
CHEOPS

Admatis
Advanced Materials in Space

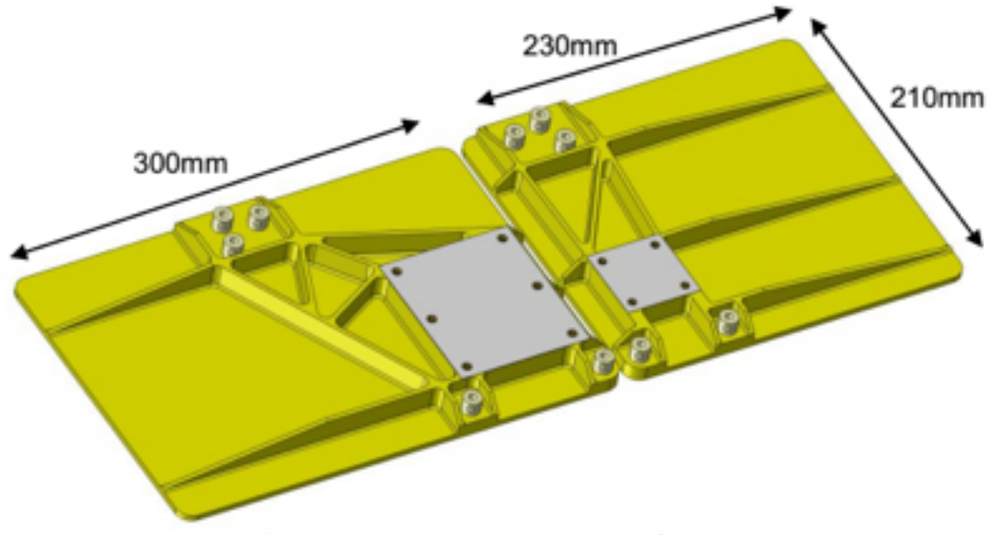
A konzorcium vezetője:
University of Bern, Svájc
Partnerek:
Olasz, svájci, osztrák, svéd, brit, német, belga intézetek, cégek,

Kelet-Európából egyedül:
Admatis Kft. és MTA CSFK



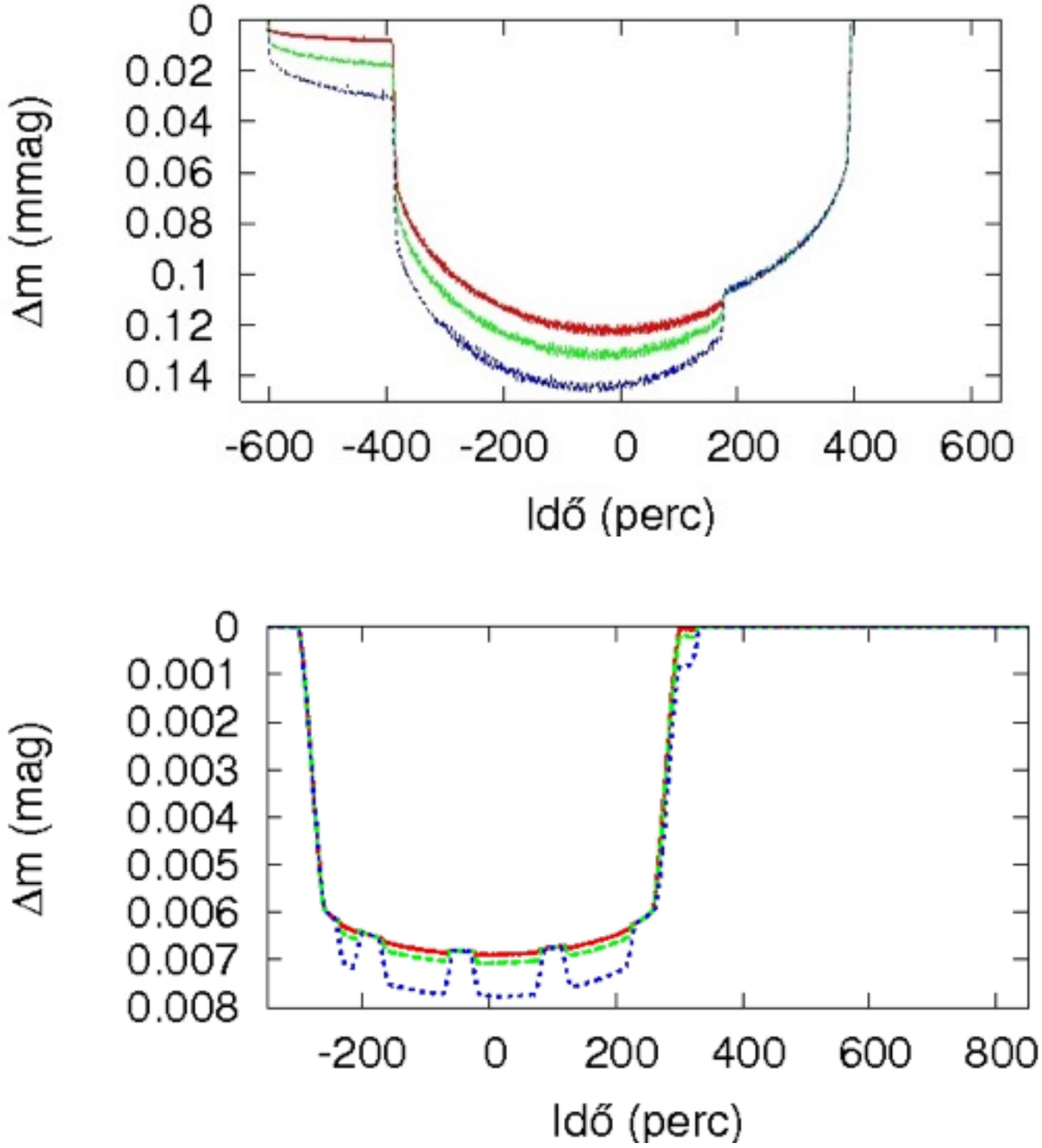


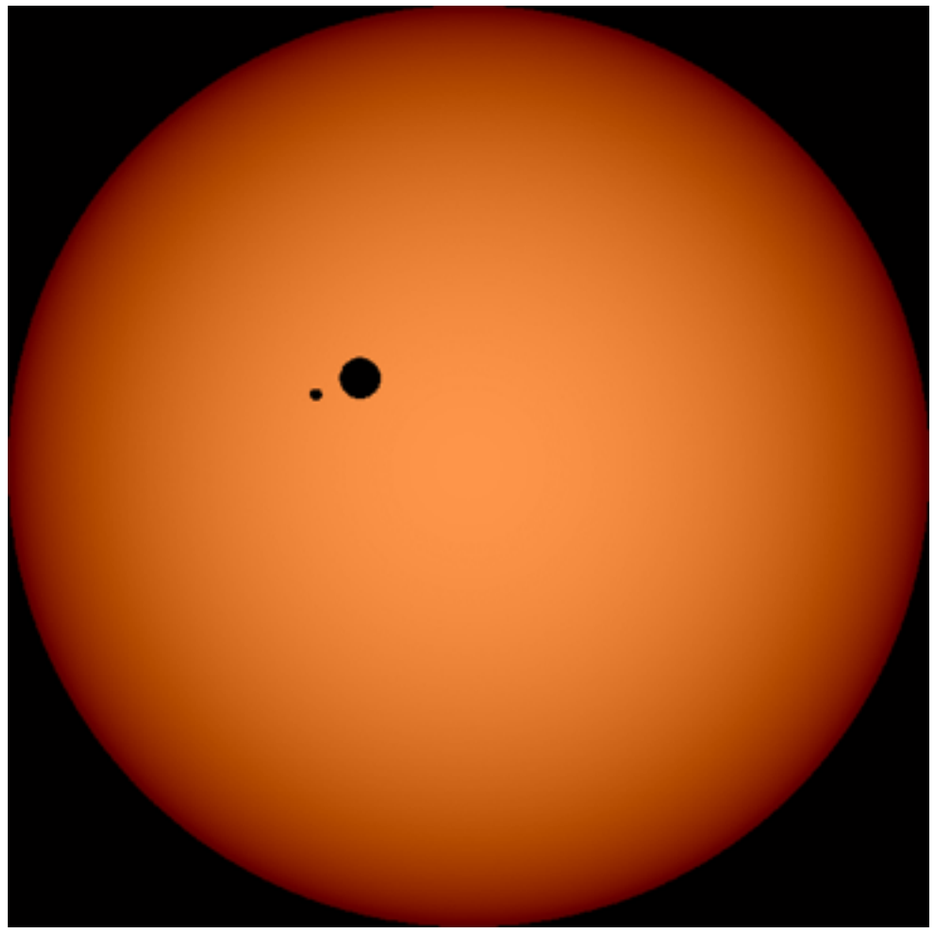
Az Admatis feladatai:
Hűtő radiátorok tervezése és kivitelezése.
Az MTA CSFK feladatai:
Exoholdak



Preliminary design of radiators

Exoholdak: tranzitos exobolygók holddal





Simon Attila és mtsai.

Horizon 2020

Search Topics

Calls

Call Updates

Other EU Programmes 2014-2020

Research Fund for Coal & Steel

COSME

3rd Health Programme

Consumer Programme

FP7 & CIP Programmes 2007-2013

Calls

H2020-LEIT-Space-Competitivenessof the European Space Sector-2015

H2020-COMPET-2015

Publication date	2013-12-11	**Deadline Date**	2014-11-27 17:00:00 (Brussels local time)
Total Call Budget	€36,500,000	**Main Pillar**	Industrial Leadership
Status	Open	**OJ reference**	OJ C 361 of 11.12.2013

Topic: Scientific exploitation of astrophysics, comets, and planetary data **COMPET-05-2015**

Topic Description | Topic Conditions & Documents | Submission Service

Specific Challenge: Three specific areas of space science where there is a significant underinvestment when compared to the potential scientific return for Europe are the exploitation of astrophysics, comets, and planetary data.

Europe has an impressive track record in space astrophysics, comets and planetary research. Astrophysics missions such as XMM-Newton, Herschel or Planck, and in coming years Gaia, JUICE, EUCLID, CHEOPS or the James Webb Space Telescope are an opportunity for European researchers. The challenge will however be to allow the European astrophysics community to make the best possible use of those missions by supporting

NASA gives planet-hunting TESS space telescope go-ahead for 2017 launch

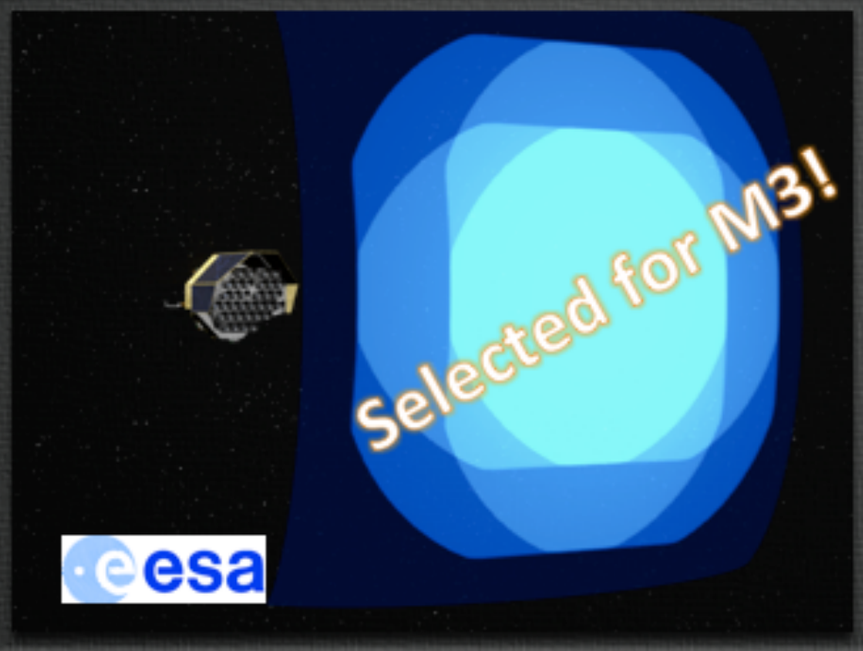
By **Donald Melanson** posted Apr 9th, 2013 at 3:01 PM

17

NASA's Kepler space telescope hasn't exactly been a slouch when it comes to planet

PLATO 2.0

An European Space Agency (ESA) Cosmic Vision 2015-2025 Project



ESA/SRE(2013)5 - The YellowBook

ESRE-F/2013.075 - Preliminary Requirement Review

PLATO 2.0 (PLAnetary Transits and Oscillations of stars) is a medium class (M class) mission studied in the framework of the ESA Cosmic Vision 2015-2025 program.

Project Status

On February 19th 2014 PLATO has been selected by the ESA SPC for the M3 slot, according to the proposal made by he ESA executive that followed the recommendation by the ESA Space Science Advisory Committee.

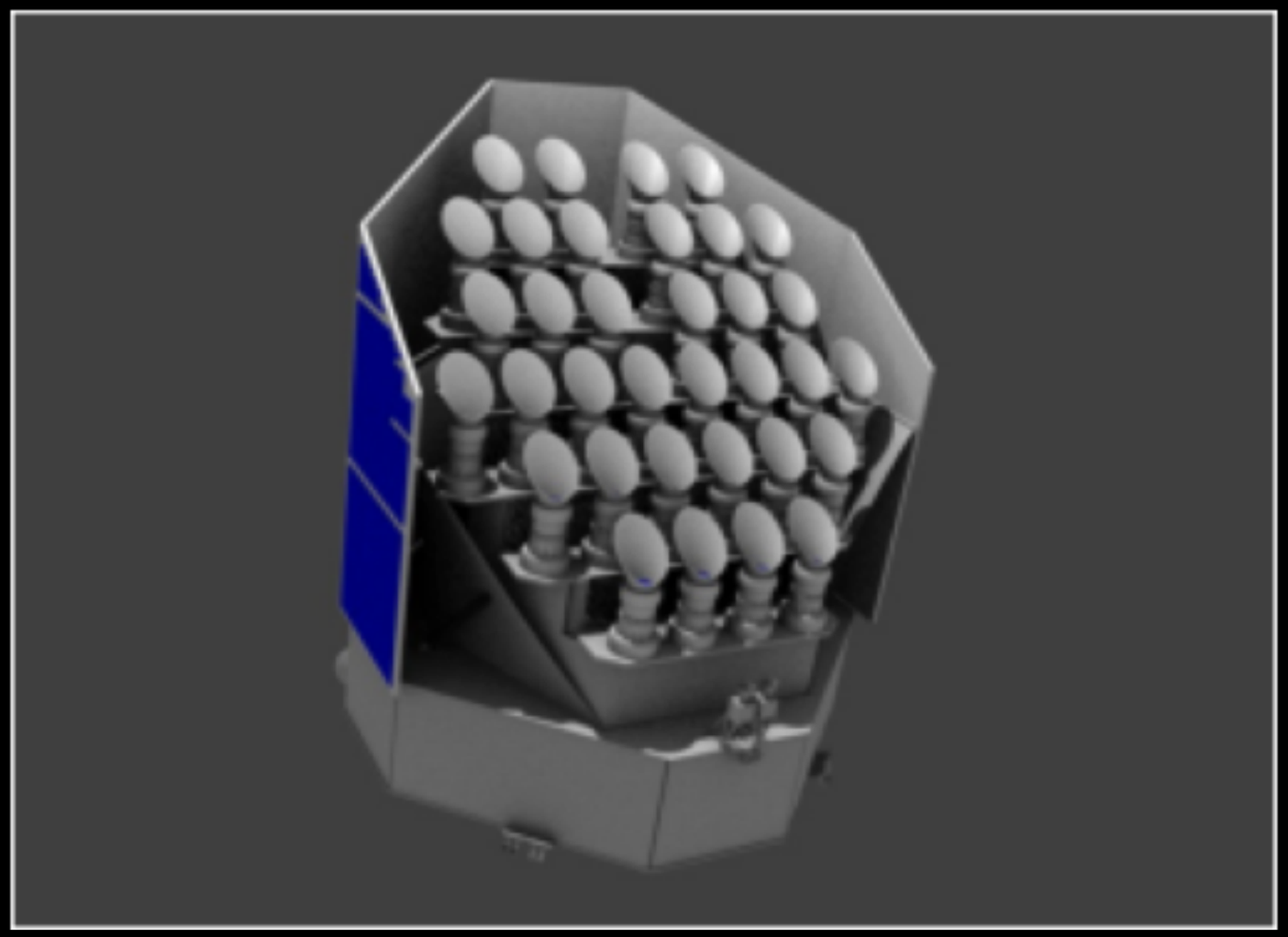
Tweets Follow

A jövő űrfotometriai missziói

TESS 2017-
NASA

CHEOPS 2017-
ESA S-misszió

PLATO 2024-
ESA M-misszió



esa

PLATO 2.0

Planetary Transits and Oscillation of Stars