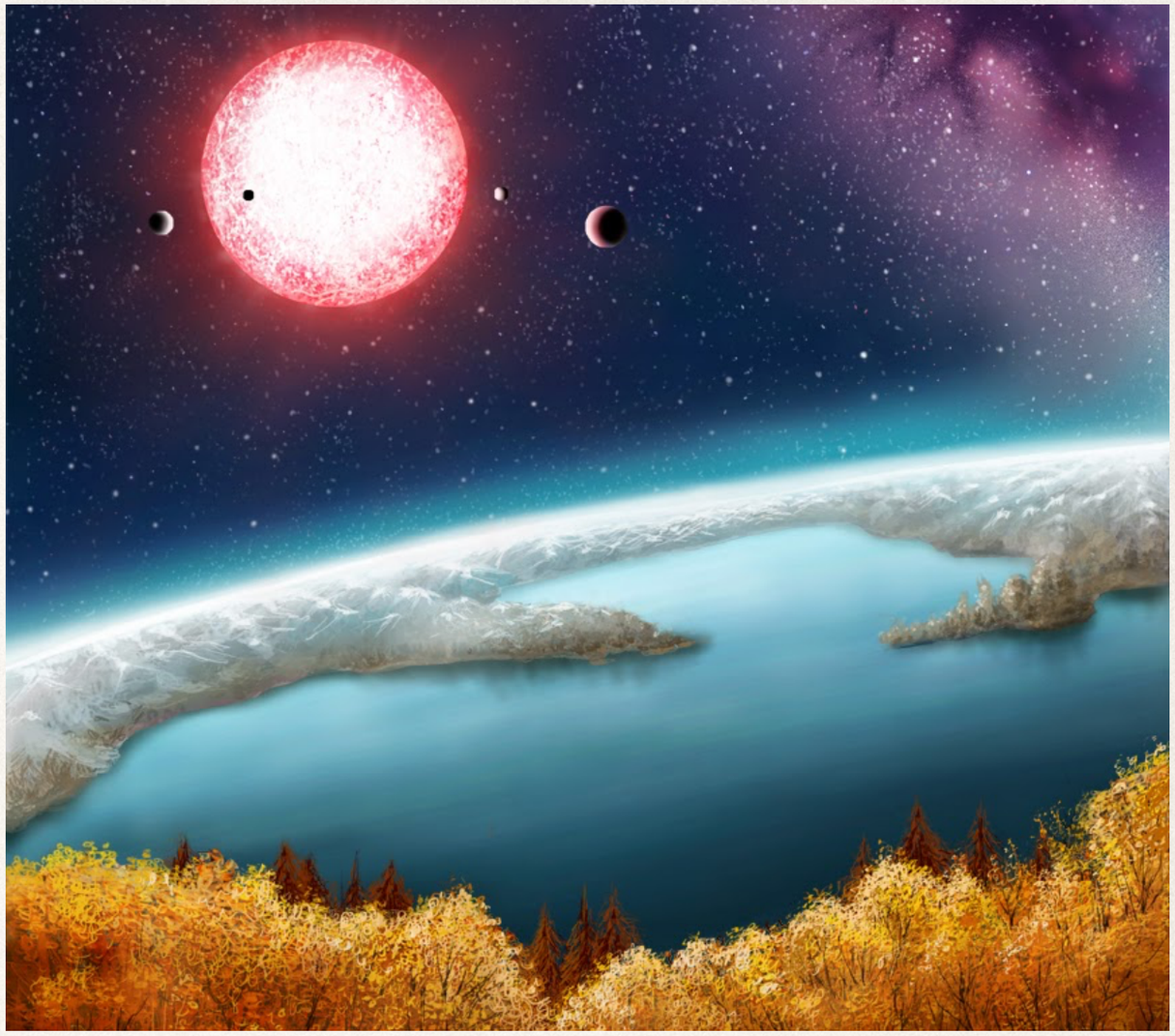
UNIVERSITÉ BISHOP'S UNIVERSITY

CSA ASC

Canadian Space Agency | Agence spatiale canadienne



Western UNIVERSITY · CANADA

Photometric Observations of Extrasolar Planets

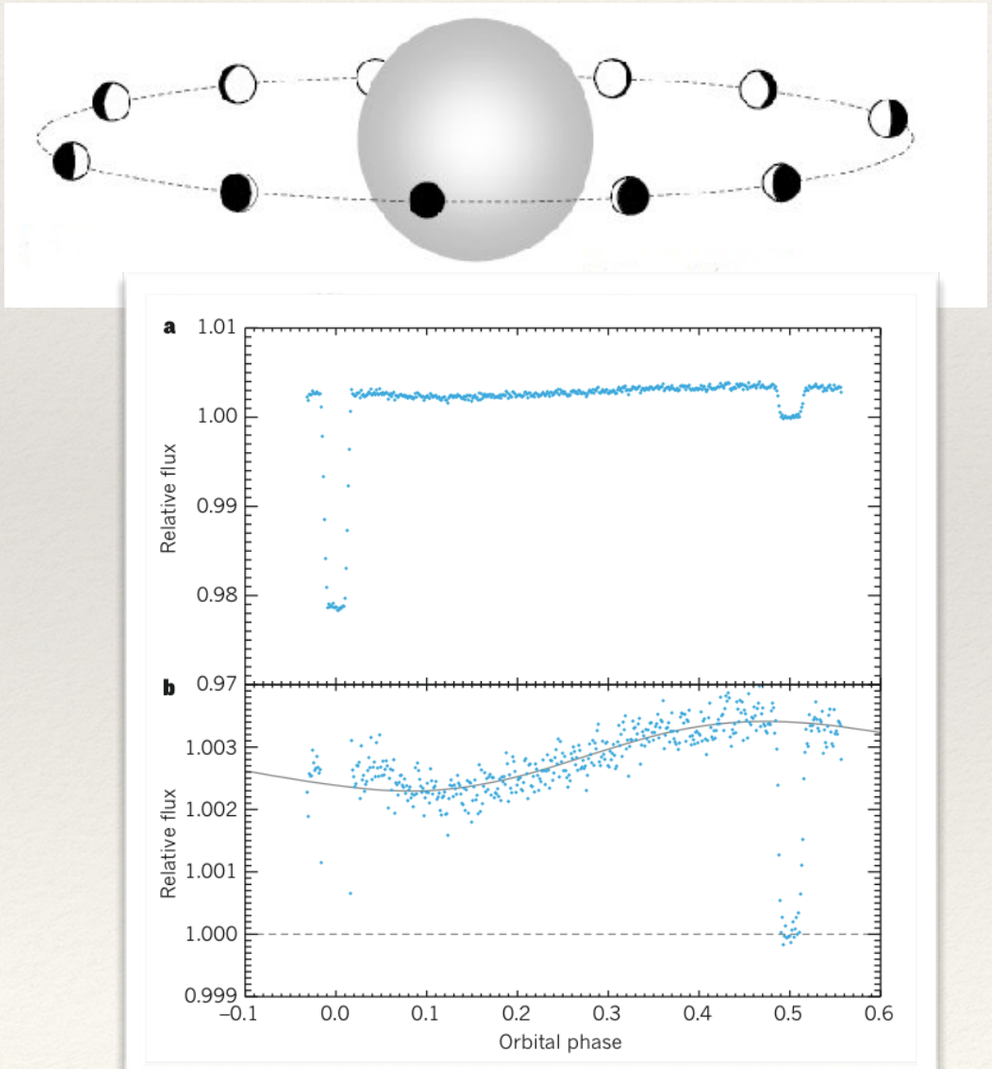
Nov 7, 2018

Our Team

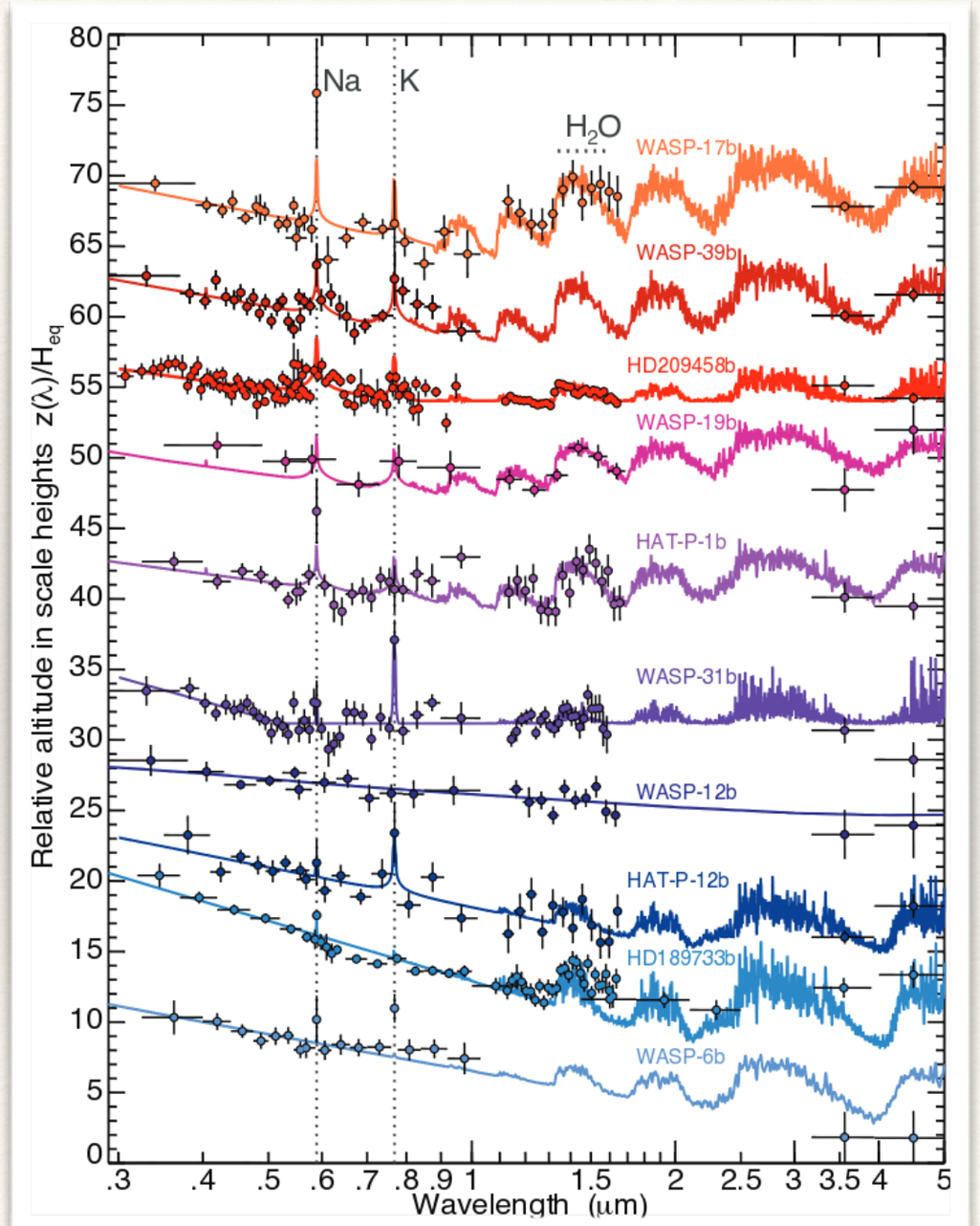
- Bishops :
  - Kelsey Hoffman, Lorne Nelson, Jason Rowe
  - Miles Turnbull, Sylvie Coté (University Support)
- Western :
  - Stan Metchev, Paulo Miles-Paez
- CSA :
  - James Doherty, Denis Laurin, Jean Dupuis, Alexander Koujelev, Alfred Ng
- Ursa Major :
  - Frederic Pelletier, Narendra Gollu, Jean-Claude Leclerc
- UVic & NRC:
  - Colin Goldblatt, JJ Kavelaars

Detecting the Atmosphere of an Extrasolar planet

- Transit Spectroscopy
- Phase curves

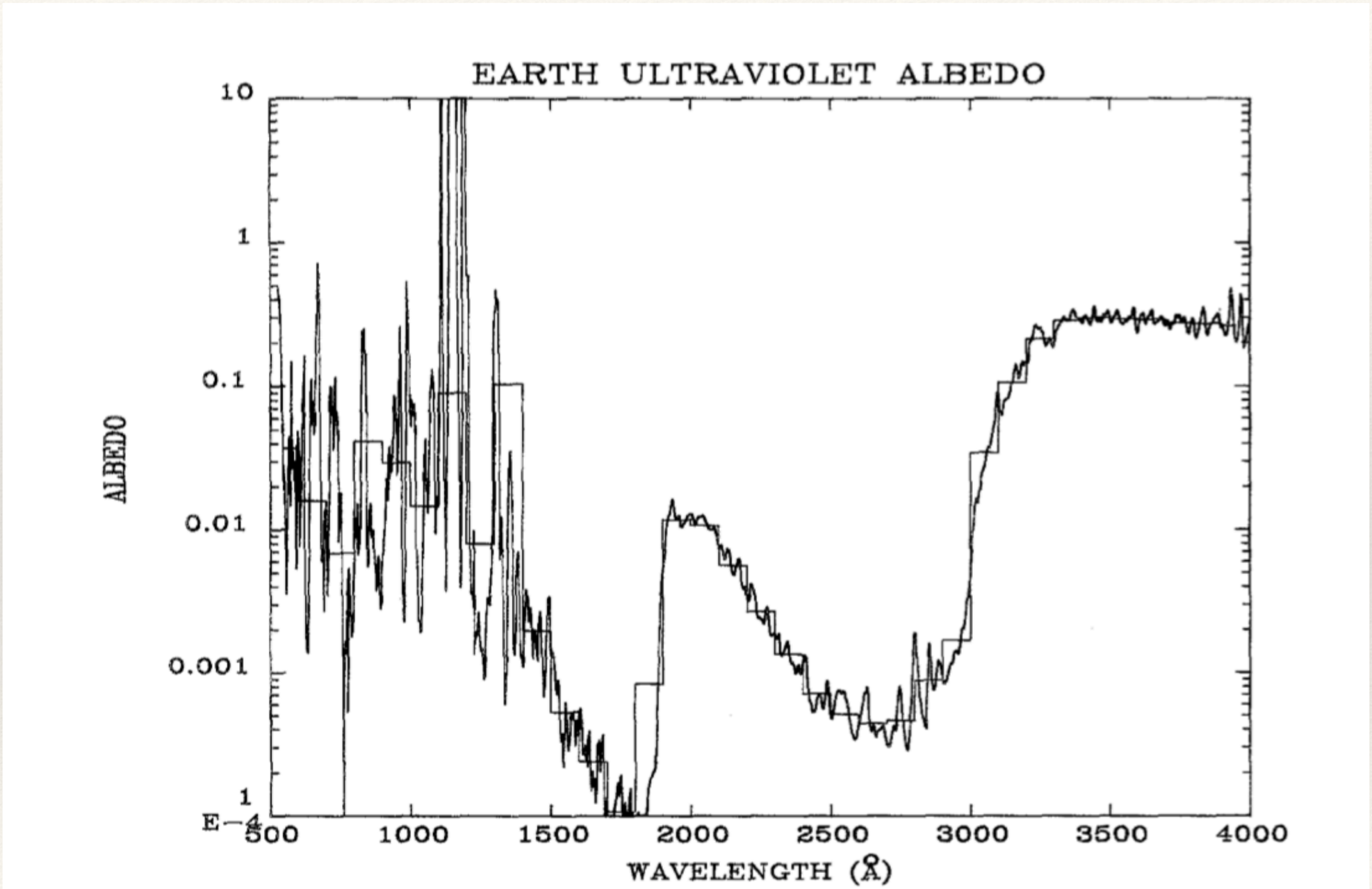


Knutson et al.

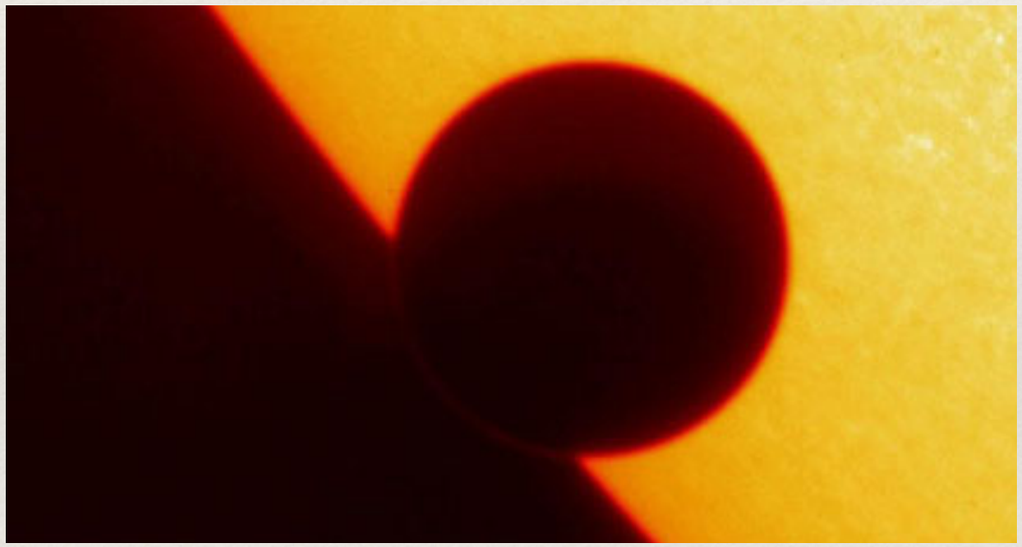


Sing et al. 2017

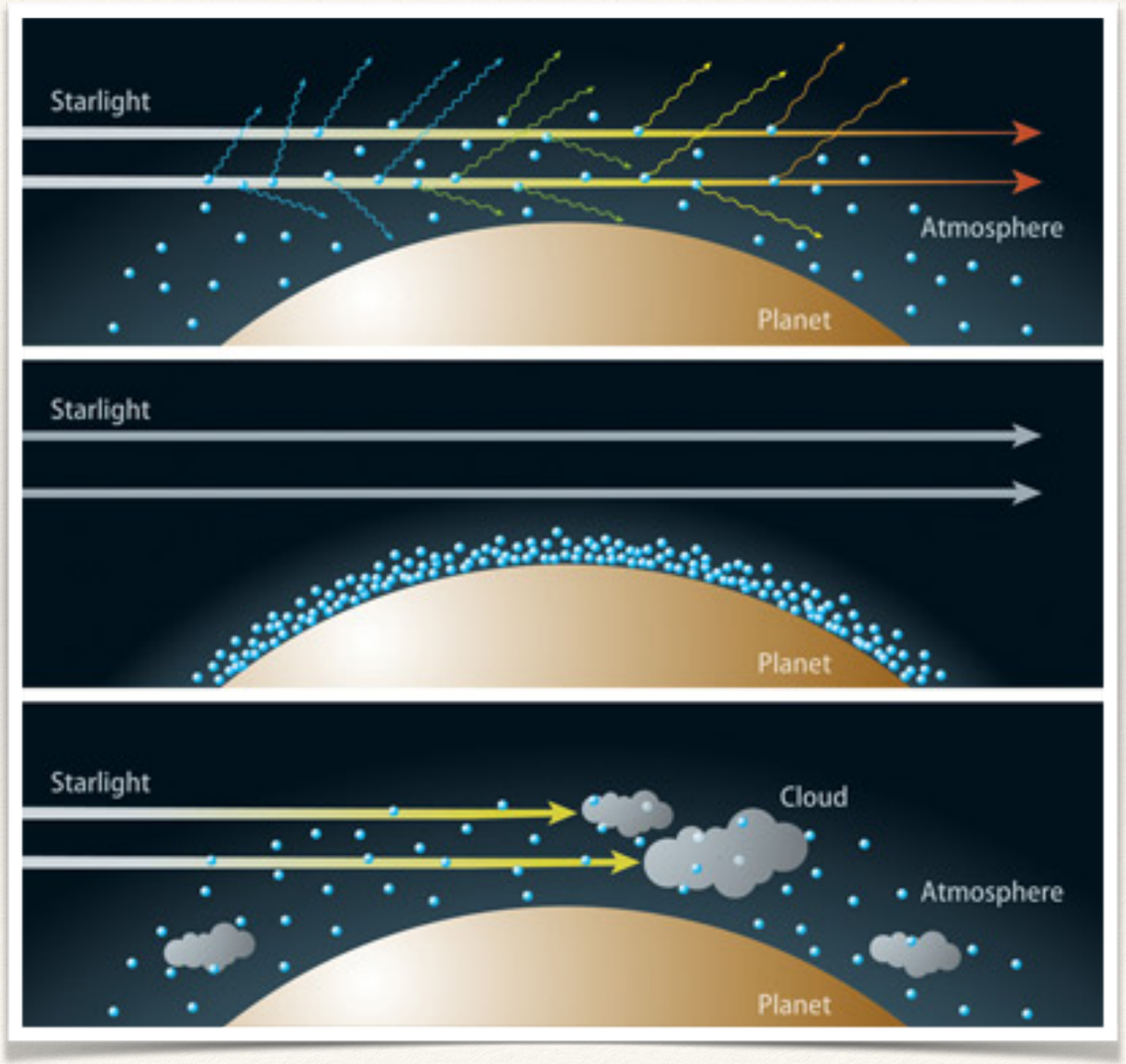
Albedo of Earth



Detecting the Atmosphere of an Exoplanet

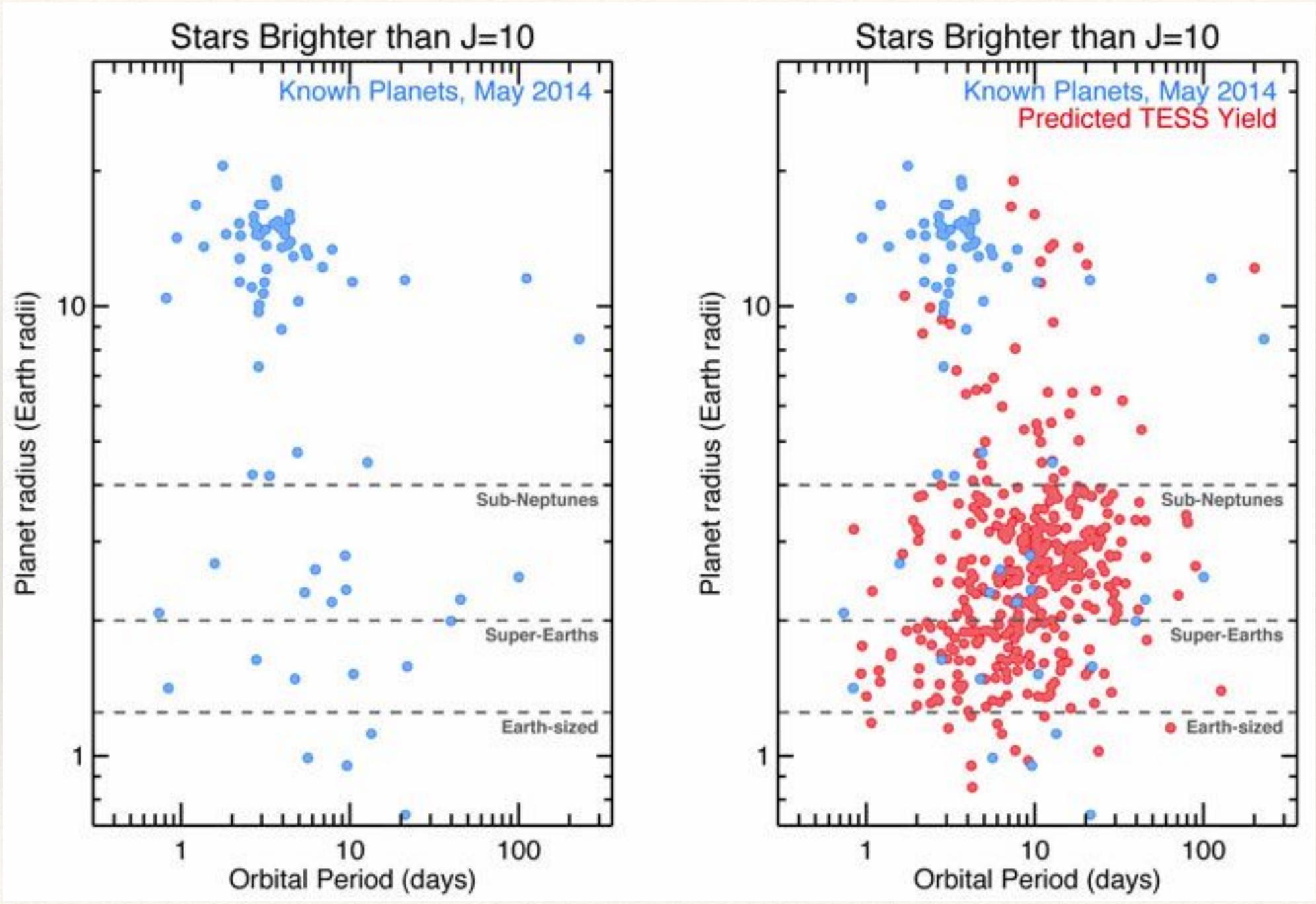


Venus Transiting the Sun

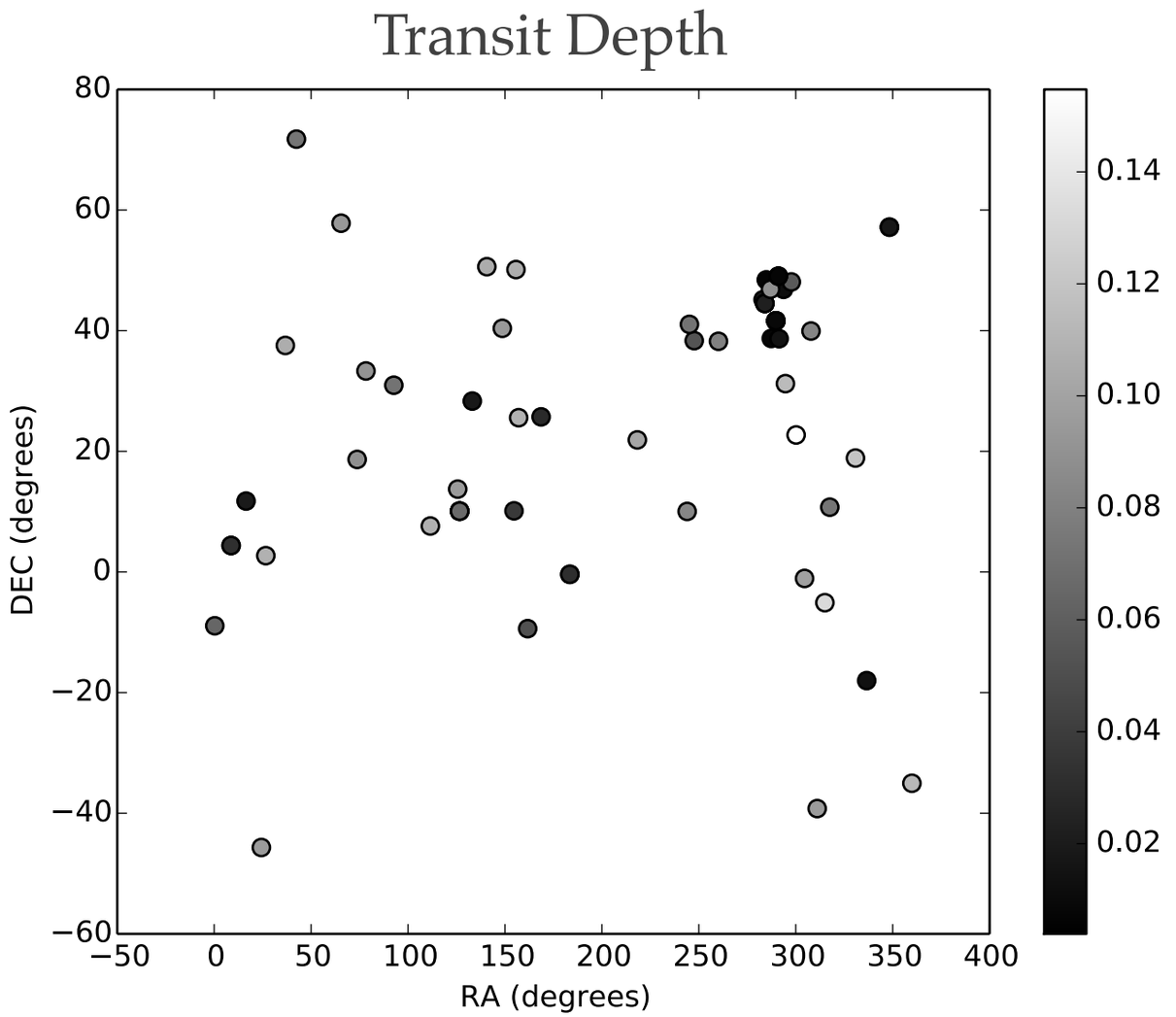


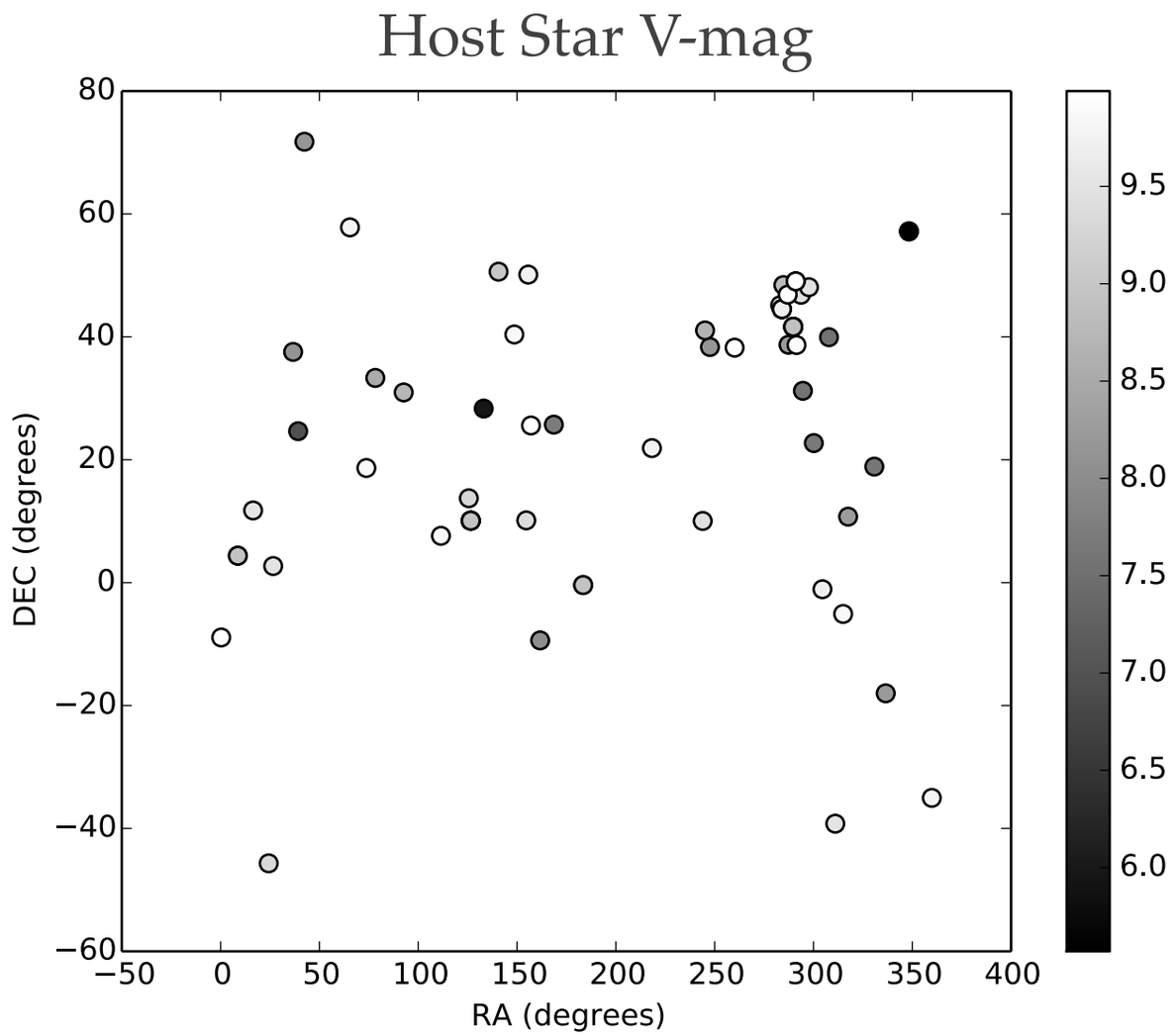
Credit: NAOJ

Nearby and Bright



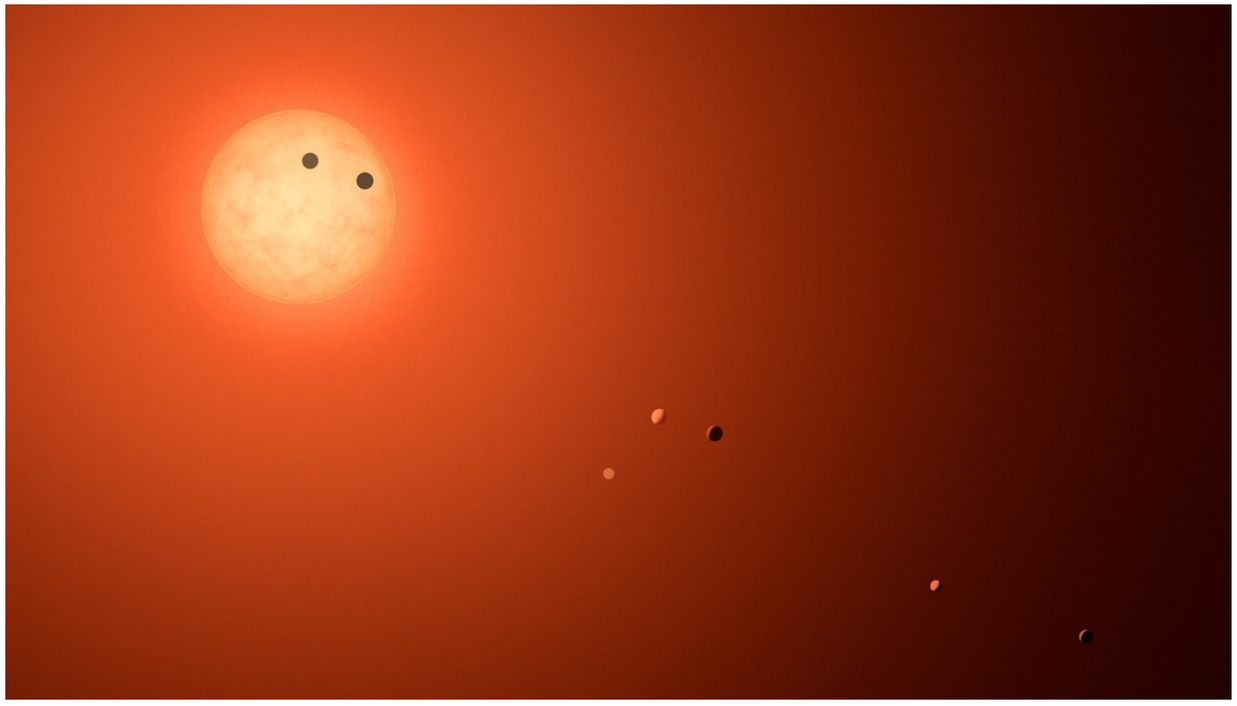
Potential Targets





Primary Goal B:
Discovery of rocky planets around very low-mass stars and brown dwarfs

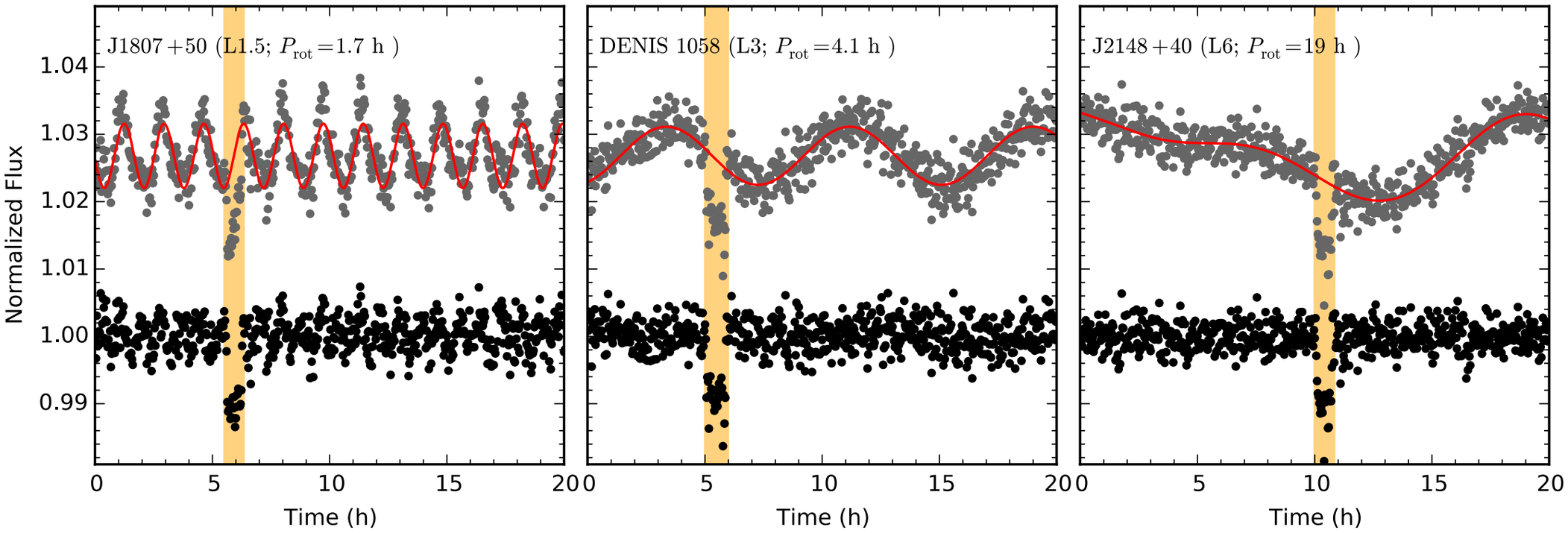
- Discovery and characterization of habitable exo-Earths is a top priority for Canadian Space Astronomy:
  - CASCA 2010–2020 Long Range Plan
  - CSEW 2016 “Space Astronomy – Origins” Topical Team report
  - CSEW 2016 “Planetary Systems – Astrobiology” Topical Team Report



Artist’s rendition of the Trappist-1 seven-rocky-planet system. Credit: NASA/JPL

- *Kepler* photometry has shown that low-mass stars tend to harbour multiple rocky planets:
  - Trappist-1 has 7 Earth-sized planets; other rocky-planet low-mass hosts: GJ 1132, LHS 1140, Proxima Centauri
- High rocky planet frequency is expected even around lower-mass hosts: <0.08 solar-mass brown dwarfs
- Brown dwarf hosts offer best chance to detect biosignature gasses on exoplanets via transit spectroscopy

Primary Goal B:
Space photometry offers unique advantages in precision and cadence



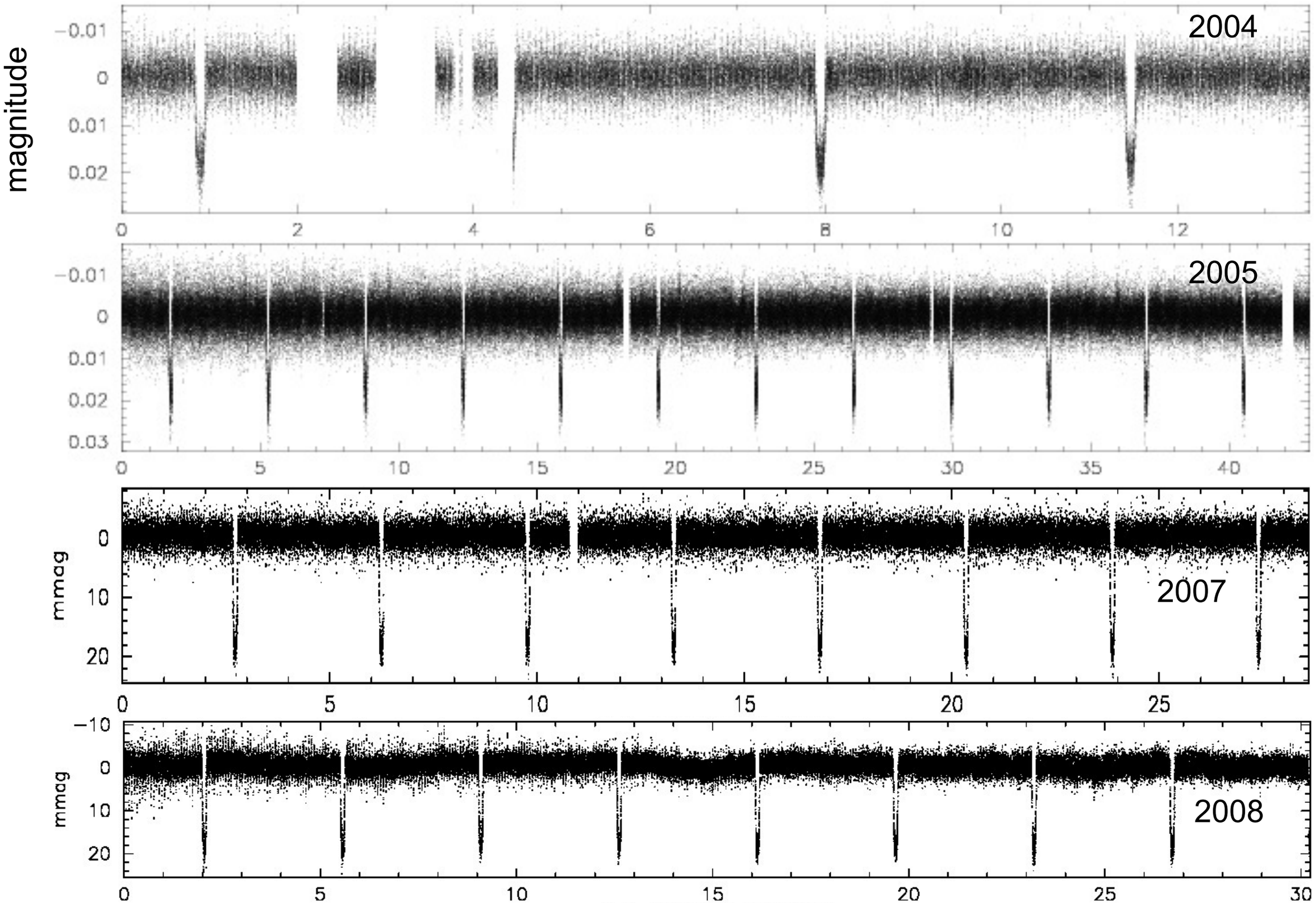
Simulated transits (orange bands) of a 1 Earth-radius planet in the habitable zones of three brown dwarfs observed with the Spitzer Space Telescope. Gray data points show the actual Spitzer data, which includes variability instrinsic to the brown dwarf. We can successfully remove the intrinsic variability with Fourier fiting (red lines) to obtain variability-free residuals (black data points), in which the transits are easily detectable.

- Our infrared observations with the *Spitzer Space Telescope* have demonstratred unprecedented sensitivity to photometric variations in brown dwarfs (Metchev et al. 2015)
- Simulated transist of 1 Earth-radius planets can be easily detected in the *Spitzer data.*
- For the current SMS we will assess the detectability of exo-Earths with a range of possible micro-sat concepts using similar simulation techniques

MOST Mission

- launched June 30, 2003
  - 800 km polar orbit
  - 15 cm broadband, optical telescope
- low albedo of HD209458
- transit of 55 Cnc e

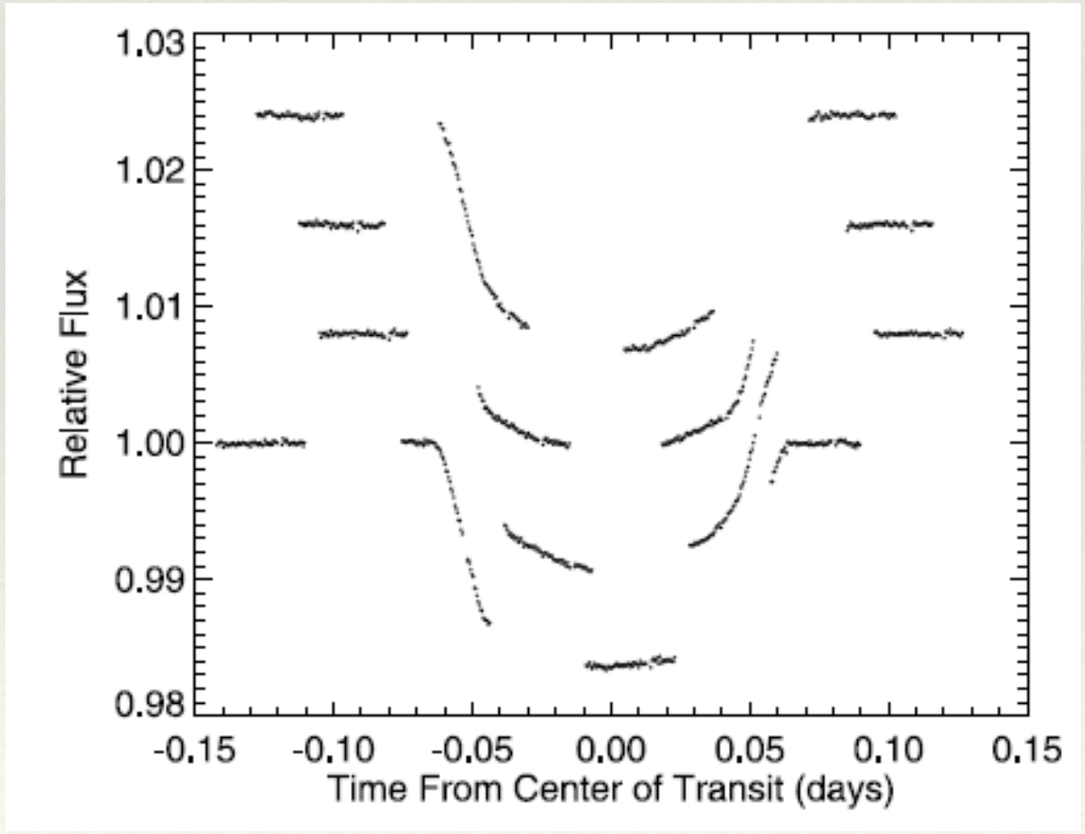
MOST Observations



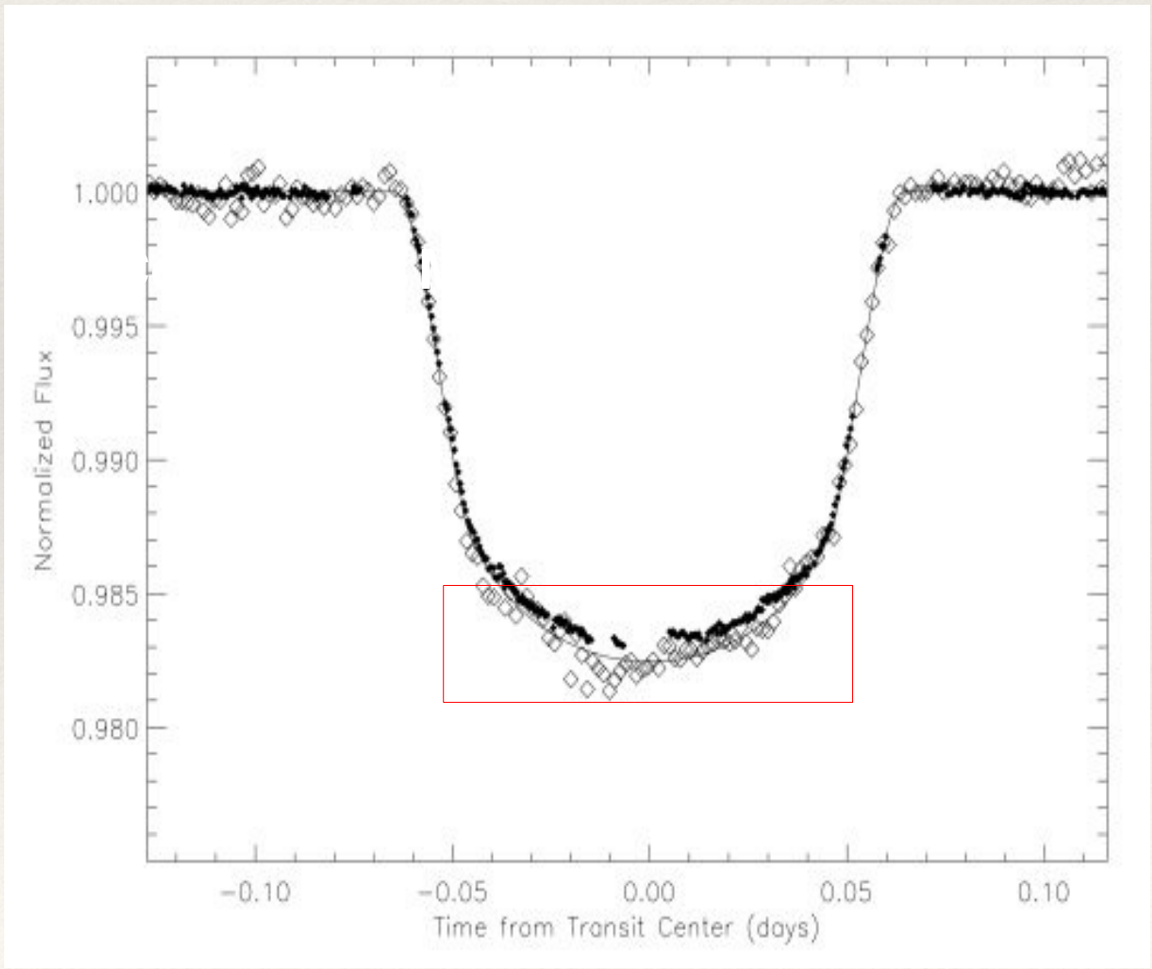
641 692 measurements!

MOST-HST Comparison

- HST data not continuous and has to be corrected for offsets

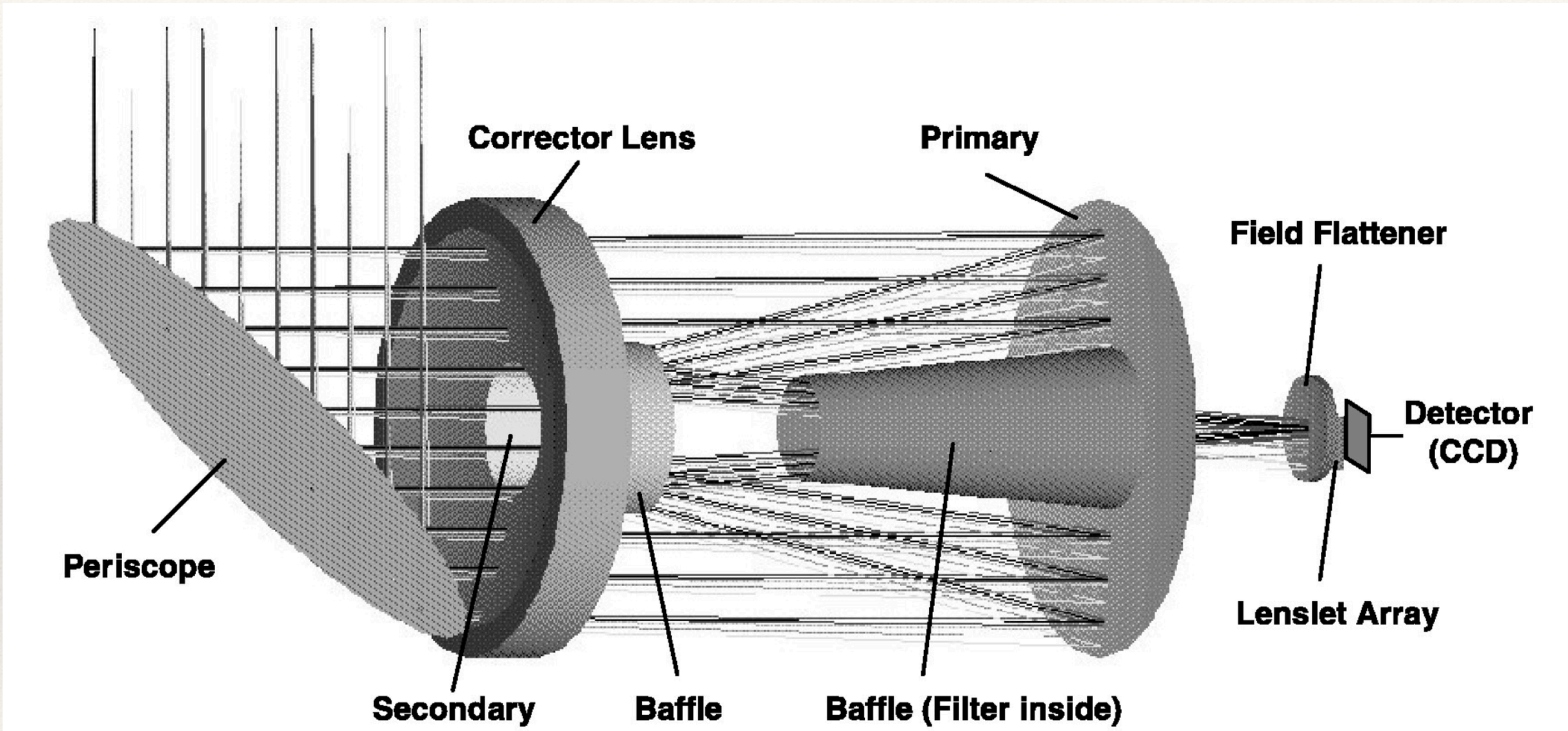


HST STIS photometry convolved to MOST bandpass



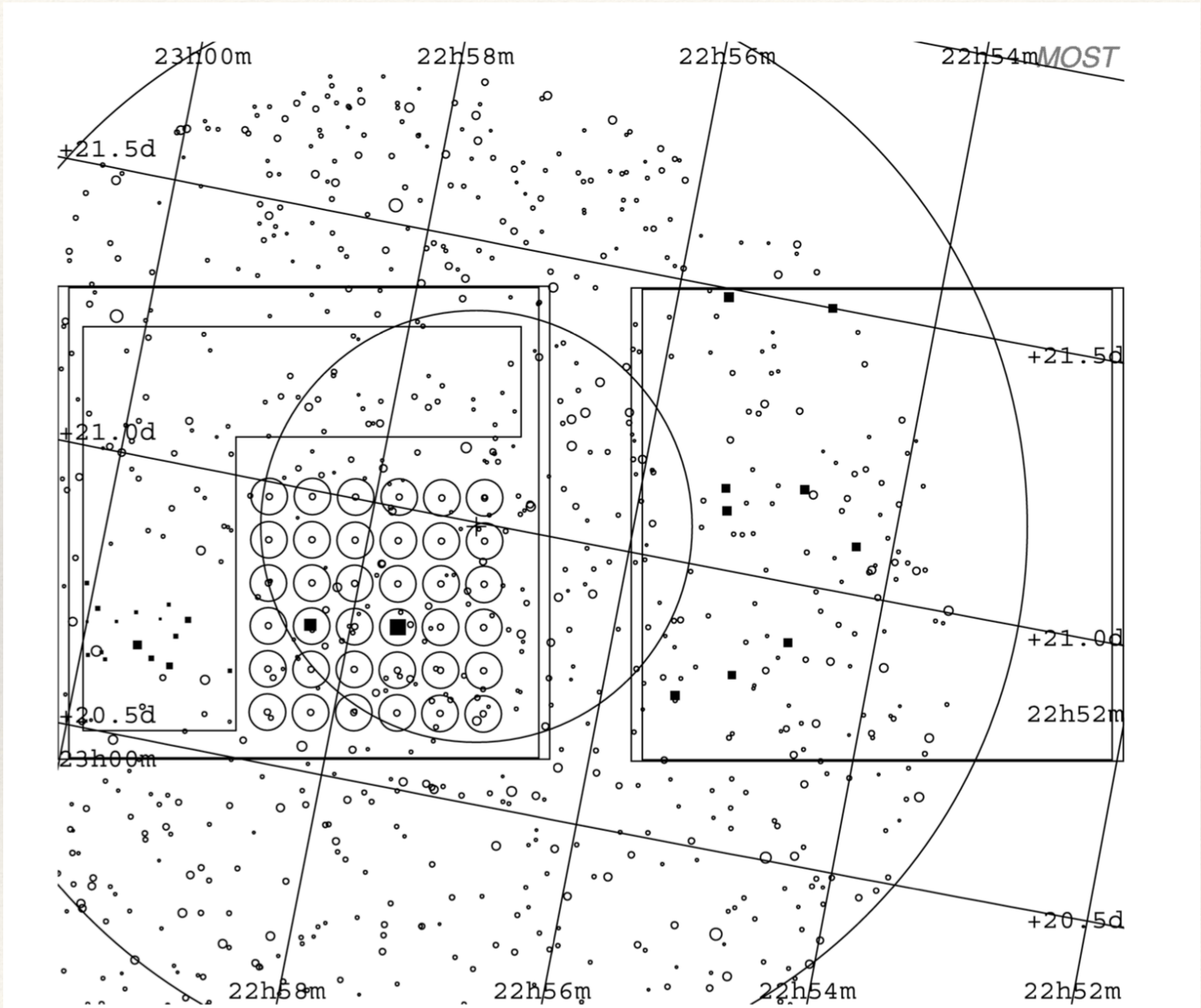
Days

MOST Concept



Focal Plane

- UV ~ 200-300 nm
- NIR ~ 1150 - 1350 nm
- Defocused imaging
  - 3” / pixel
  - FWHM 2-3 pixels
- Pointing stability based on MOST
  - 0.4 pixels RMS



Science Maturation Study

- Primary efforts are to create realistic end-to-end simulations
  - Inform : Detectors, optics, bandpasses
    - Cost
- Goals
  - Exoplanet Discovery and Characterization
- Build upon legacy of MOST hardware design.