TRANSIT PHOTOMETRY & THE *KEPLER* MISSION

A Search for Habitable Planets

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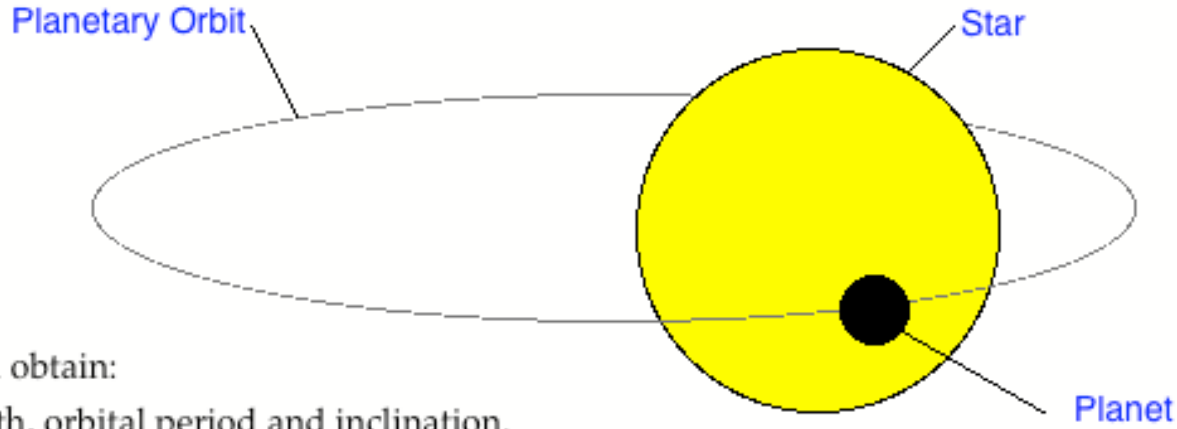
STScI

Information Obtained from Planetary Transits

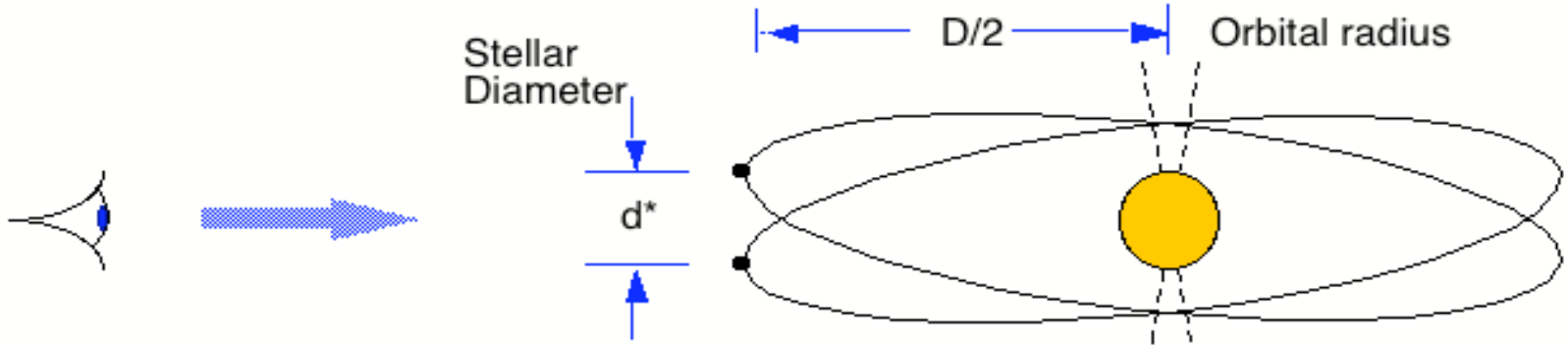


From transit data obtain:

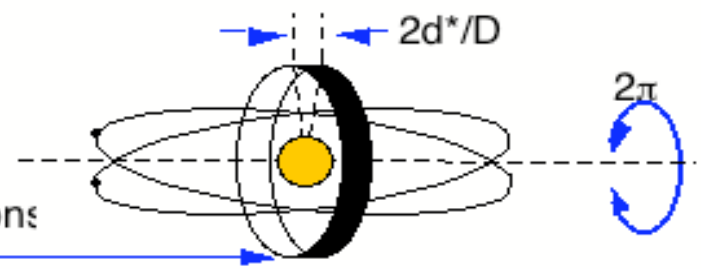
Duration, depth, orbital period and inclination.

Derive planet sizes and orbital radii (when combine with stellar information)

Geometry for Transit Probability



1) Range of Pole Positions = $\frac{d^*}{D/2}$



2) Solid angle of $4\pi d^*/D$
for all possible pole positions
for any given LOS

3) Geometric Transit Probability = d*/D

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TRANSIT PROPERTIES

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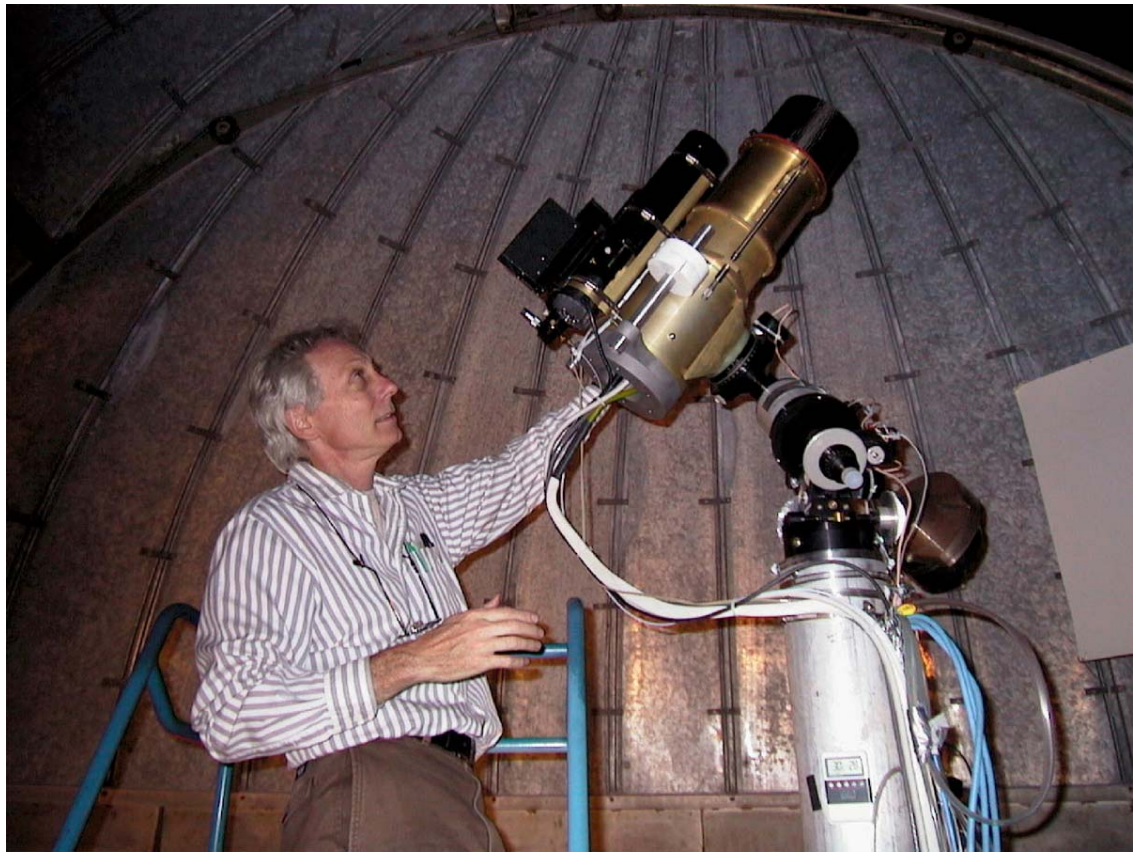
Planet	Orbital Period P (yrs)	Semi-Major Axis R (A.U .)	Transit Duration (hours)	Transit Depth (%)	Geometric Probability (%)	Inclination Invariant Pl ϕ (deg)	Prob Sec Det (%)
Mercury	0.241	0.39	8.1	0.0012	1.19	6.33	15
Venus	0.615	0.72	11.0	0.0076	0.65	2.16	23
Earth	1.00	1.00	13.	0.0084	0.47	1.65	22
Mars	1.88	1.52	16	0.0024	0.31	1.71	14
Jupiter	11.86	5.2	30	1.01	0.089	0.39	18
Saturn	29.5	9.5	40	0.75	0.049	0.87	4
Uranus	84.0	19.2	57	0.135	0.024	1.09	2
Neptune	164.8	30.1	71	0.127	0.015	0.72	2

VULCAN: GROUND-BASED SEARCH FOR GIANT PLANETS

A Search for Habitable Planets

Vulcan transit search of 10,000 stars for extrasolar planets

- **OBJECTIVES:**
- Monitor 10,000 stars "continuously" for periods of at least 6 weeks
- Detect jovian-size planets in short period orbits
- Use Doppler-velocity measurements to determine mass and density
- **TELESCOPE:**
- Aperture: 10 cm
- Focal length: 30 cm
- Field of View: 7x 7 degrees
- Detector: 4096x4096 CCD with 9 μ pixels



GIANT PLANET SEARCHES WITH SMALL TELESCOPES

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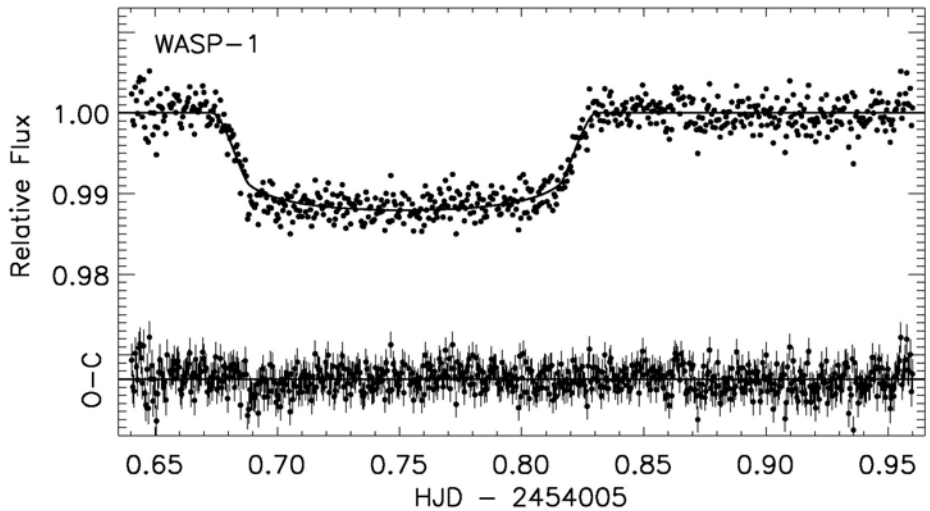
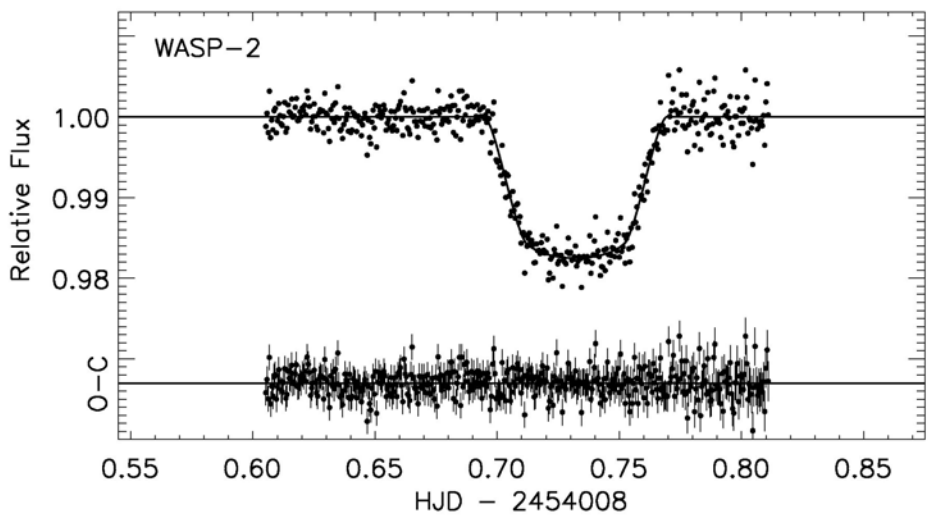
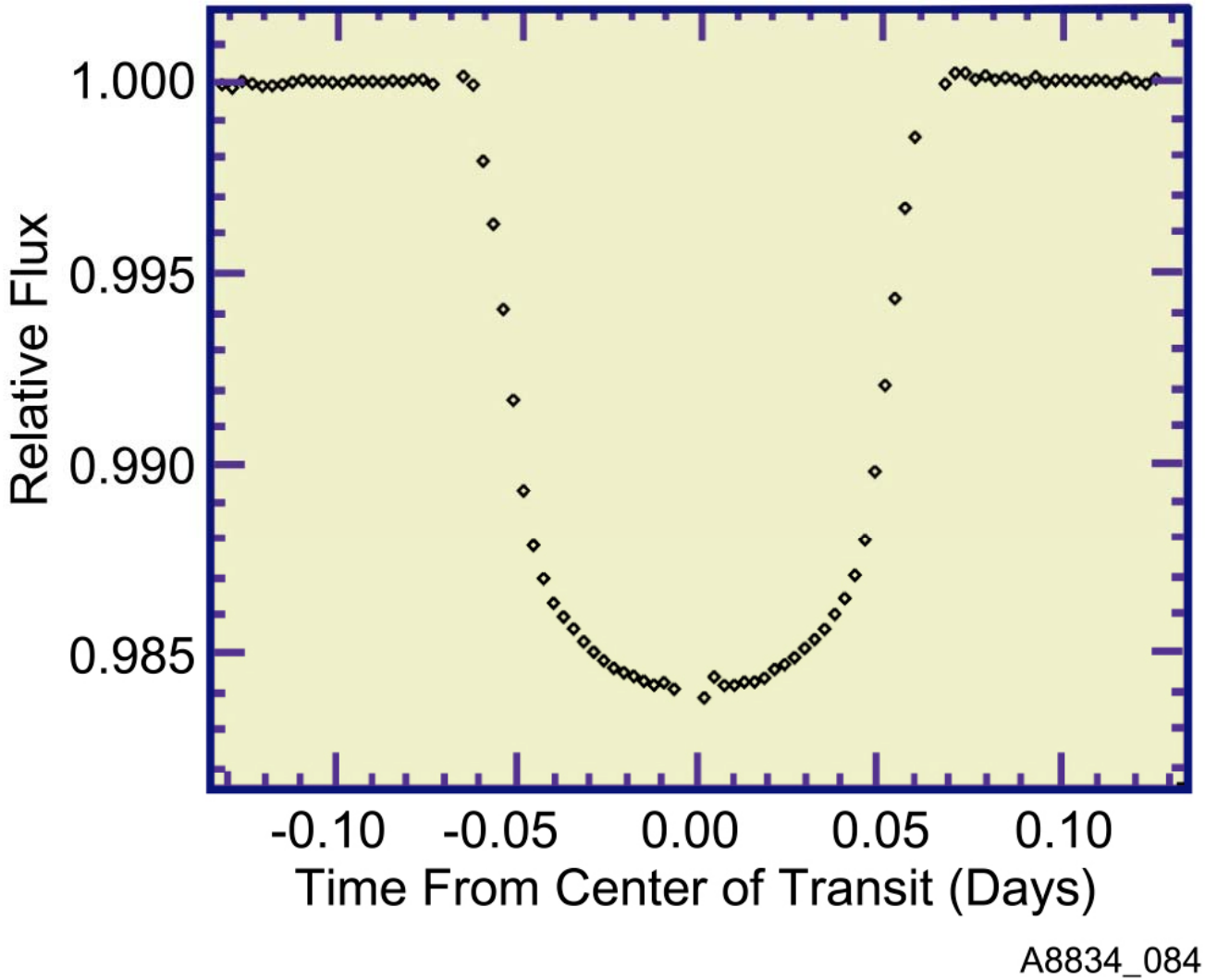


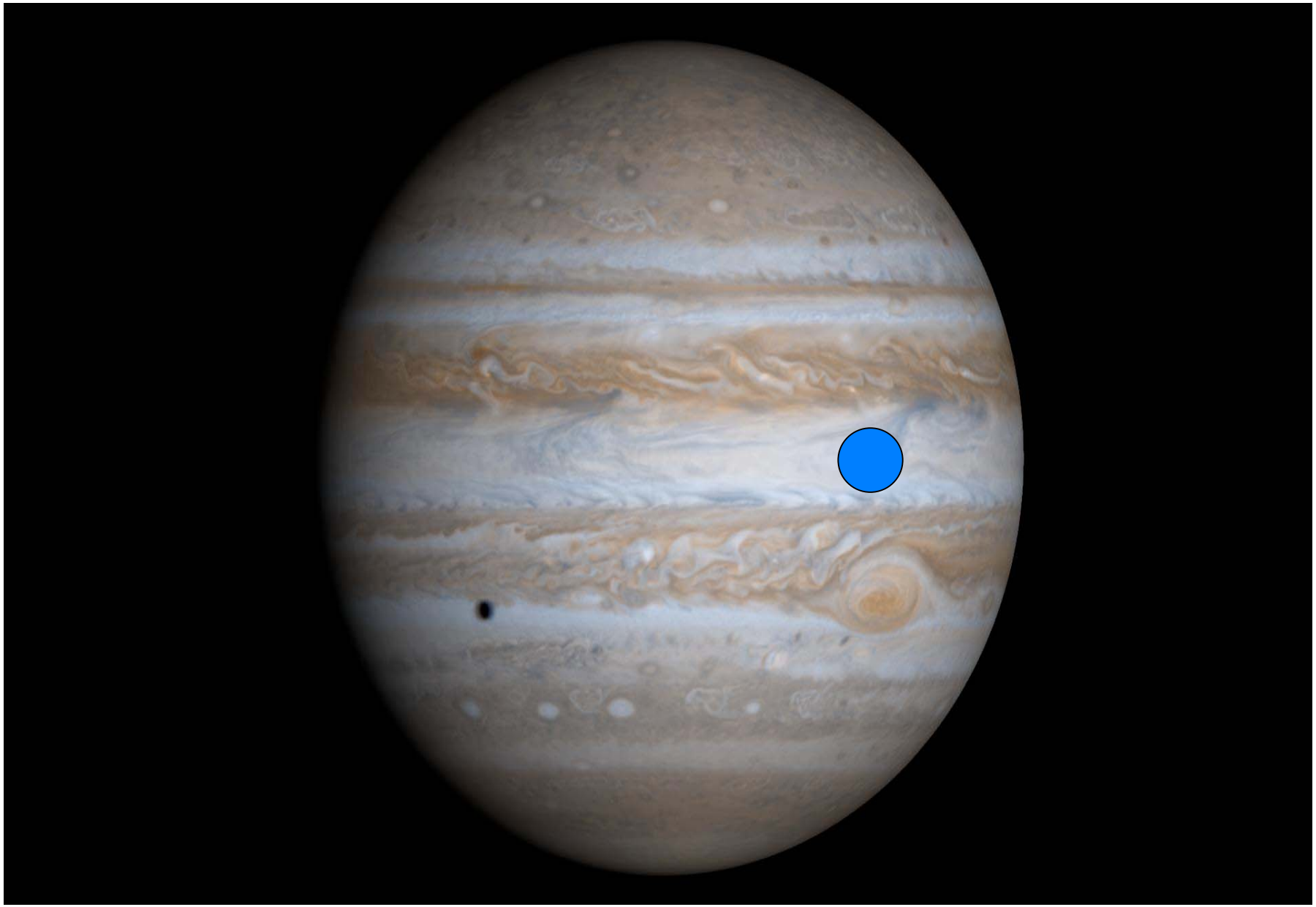


HST observation of a jovian-size planet orbiting the star HD209458



Ten-minute to ten-minute binned data from several orbits have a precision of 60 ppm (Brown et al. 2001).

EARTH COMPARED TO JUPITER



ULTRAVIOLET IMAGE OF THE SUN

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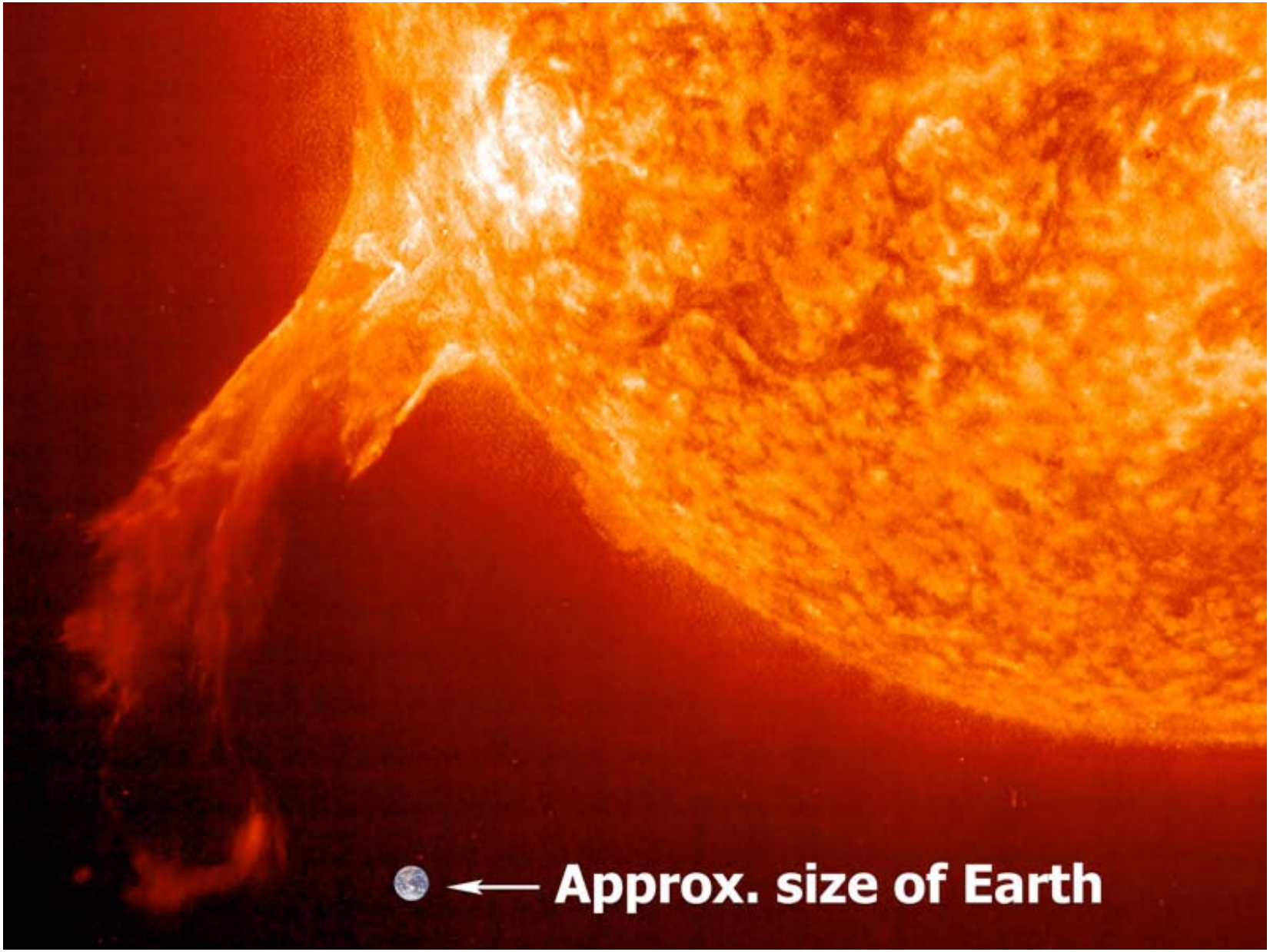

THE SUN IN VISIBLE LIGHT

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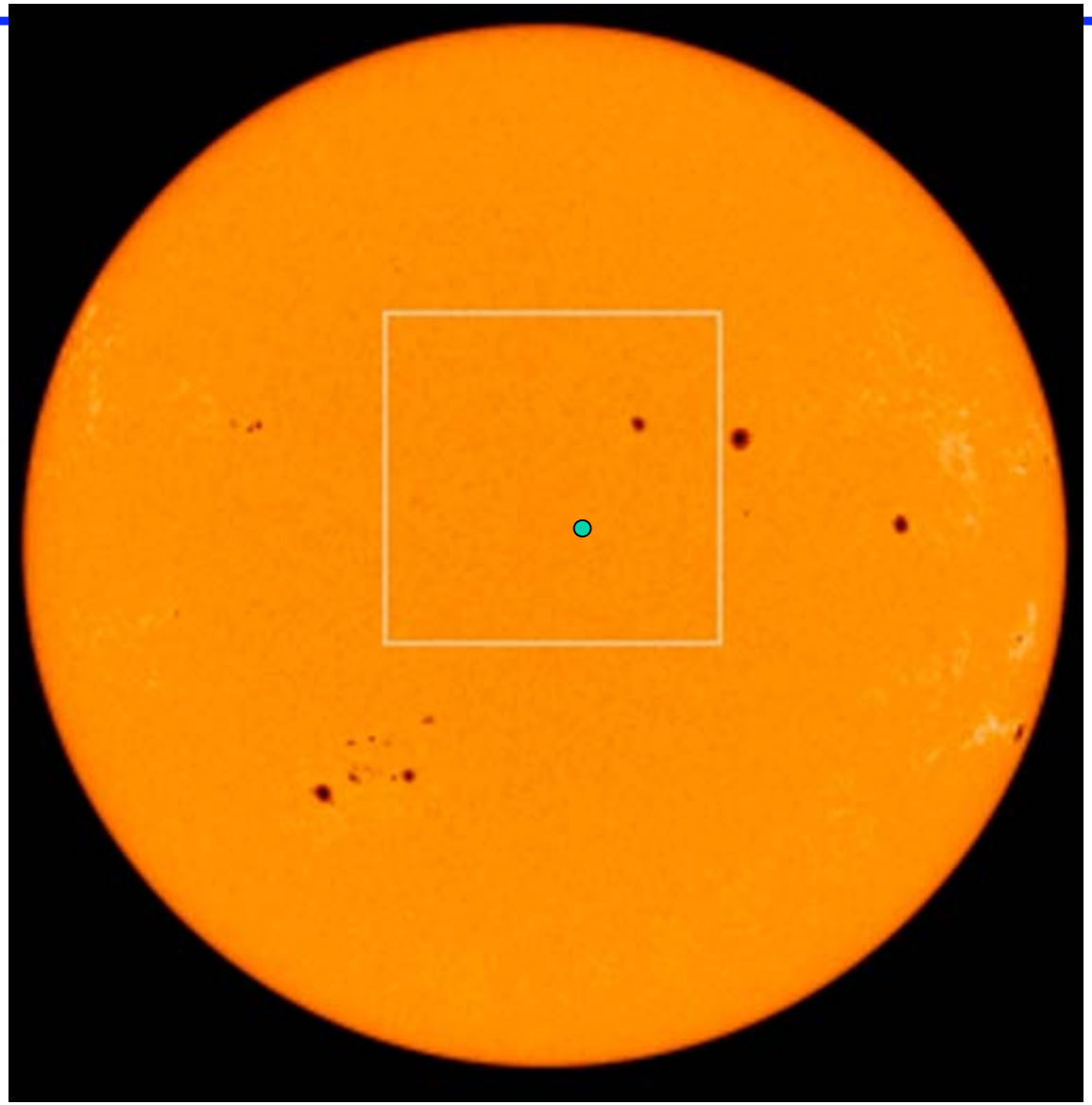

Comparison of an Earth-size planet with star spots and plages.

SOLAR POWER SPECTRUM

Kepler
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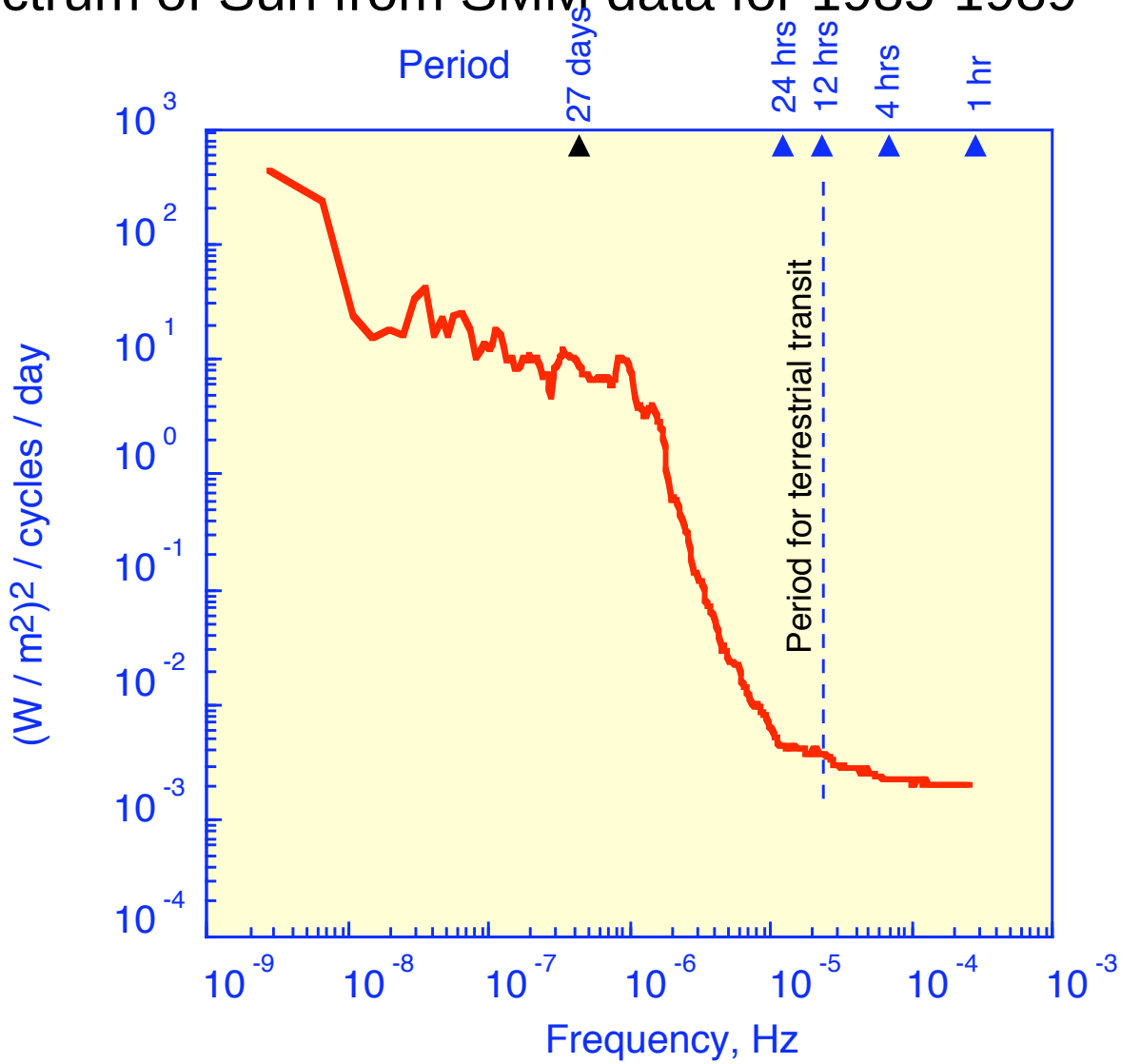
Power spectrum of Sun from SMM data for 1985-1989



The power spectrum of the Sun is very low at the periods of interest for planetary transits

CRITICAL QUESTIONS:

A Search for Habitable Planets

- Are terrestrial planets common or rare?
- What are their sizes & distances?
- How often are they in the habitable zone?
- What is their dependence on stellar properties?

MISSION APPROACH

Kepler
A Search for Habitable Planets

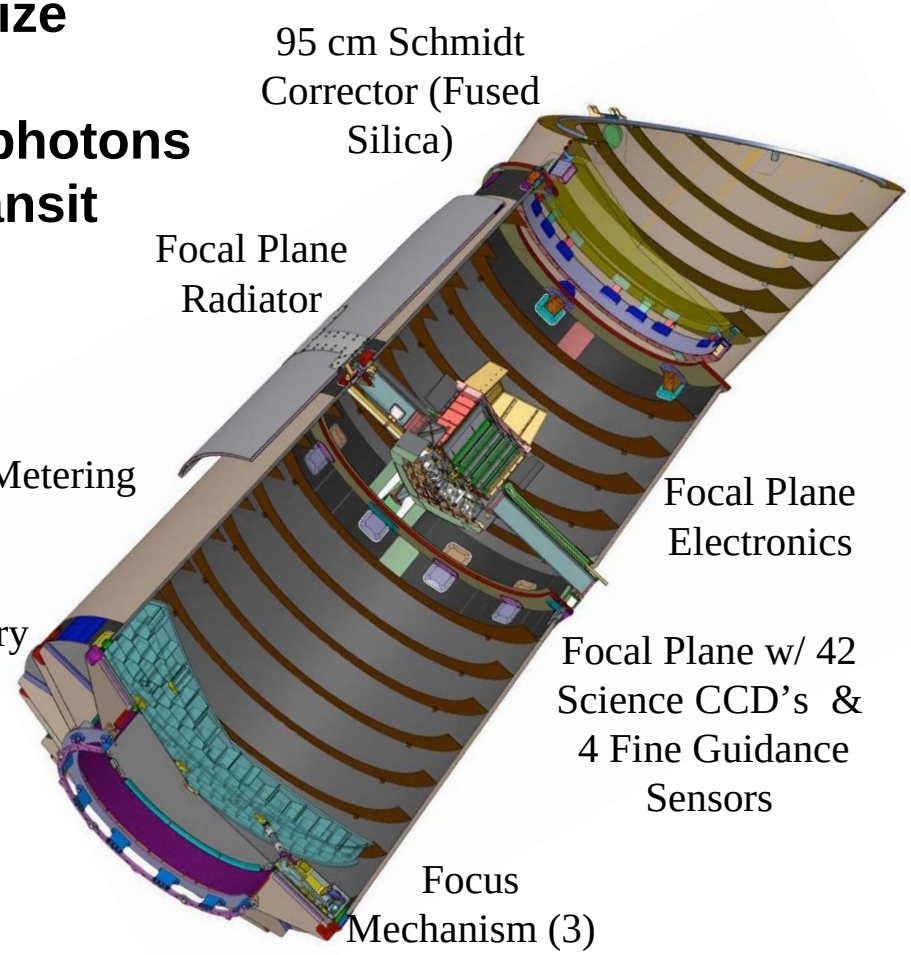
***KEPLER*: A Wide FOV Photometer that Monitors 100,000 Stars for 4 years with Enough Precision to Find Earth-size Planets in the HZ**

Use transit photometry to detect Earth-size planets

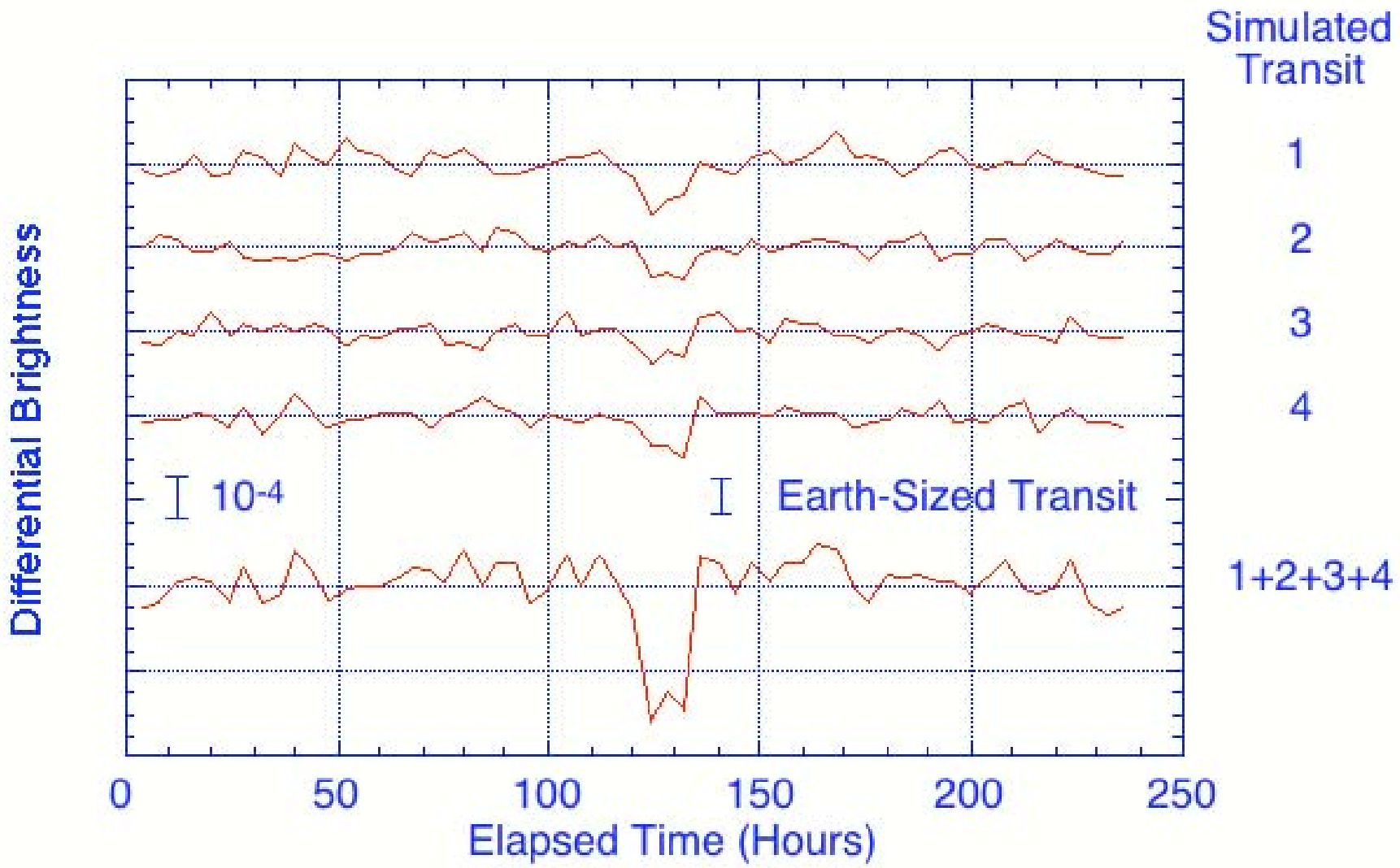
- **0.95 meter aperture provides enough photons**
- **Observe for several years to detect transit patterns**
- **Monitor a single FOV continuously to avoid missing transits**
- **Use heliocentric orbit**

Get statistically valid results by monitoring 100,000 stars

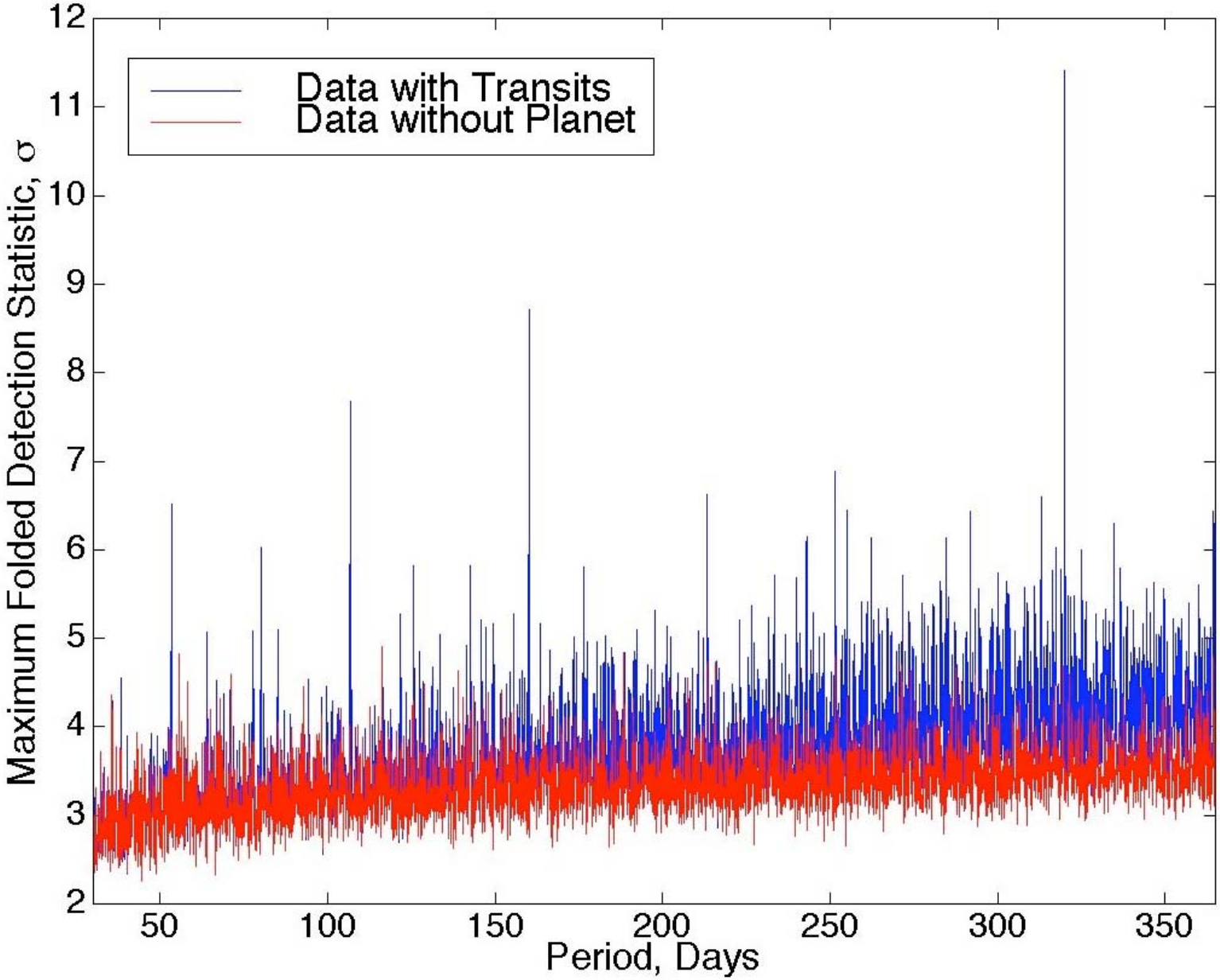
- **Wide FOV telescope**
- **Large array of CCD detectors**



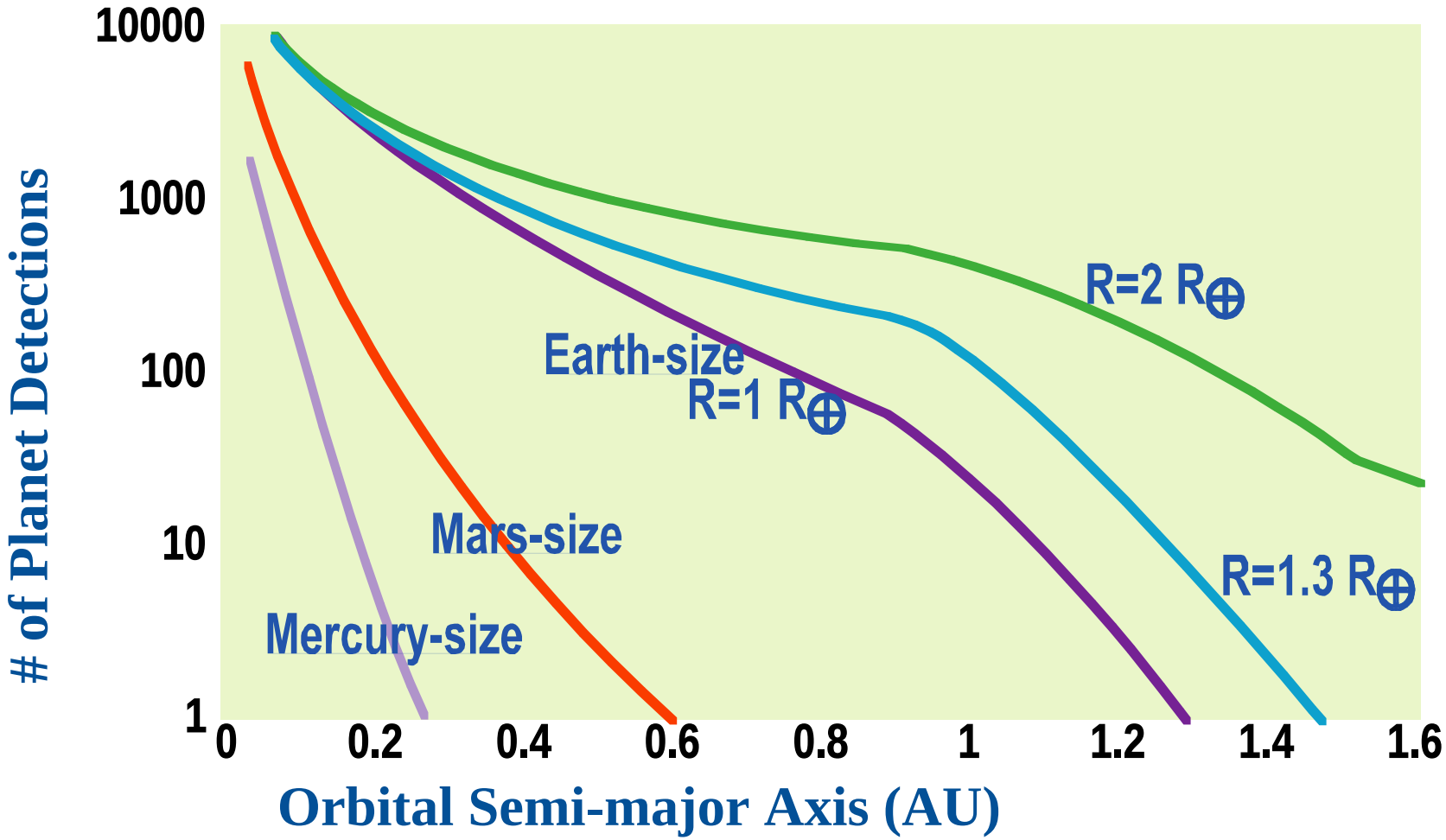
SIMULATION OF FOUR EARTH-SIZED TRANSITS



AUTOMATED DETECTION



DETECTIONS VS. PLANET SIZE AND ORBIT



Expected # of planets found, assuming one planet of a given size & semi-major axis per star and random orientation of orbital planes.

DISTINGUISHING IRON, ROCKY, & WATER PLANETS

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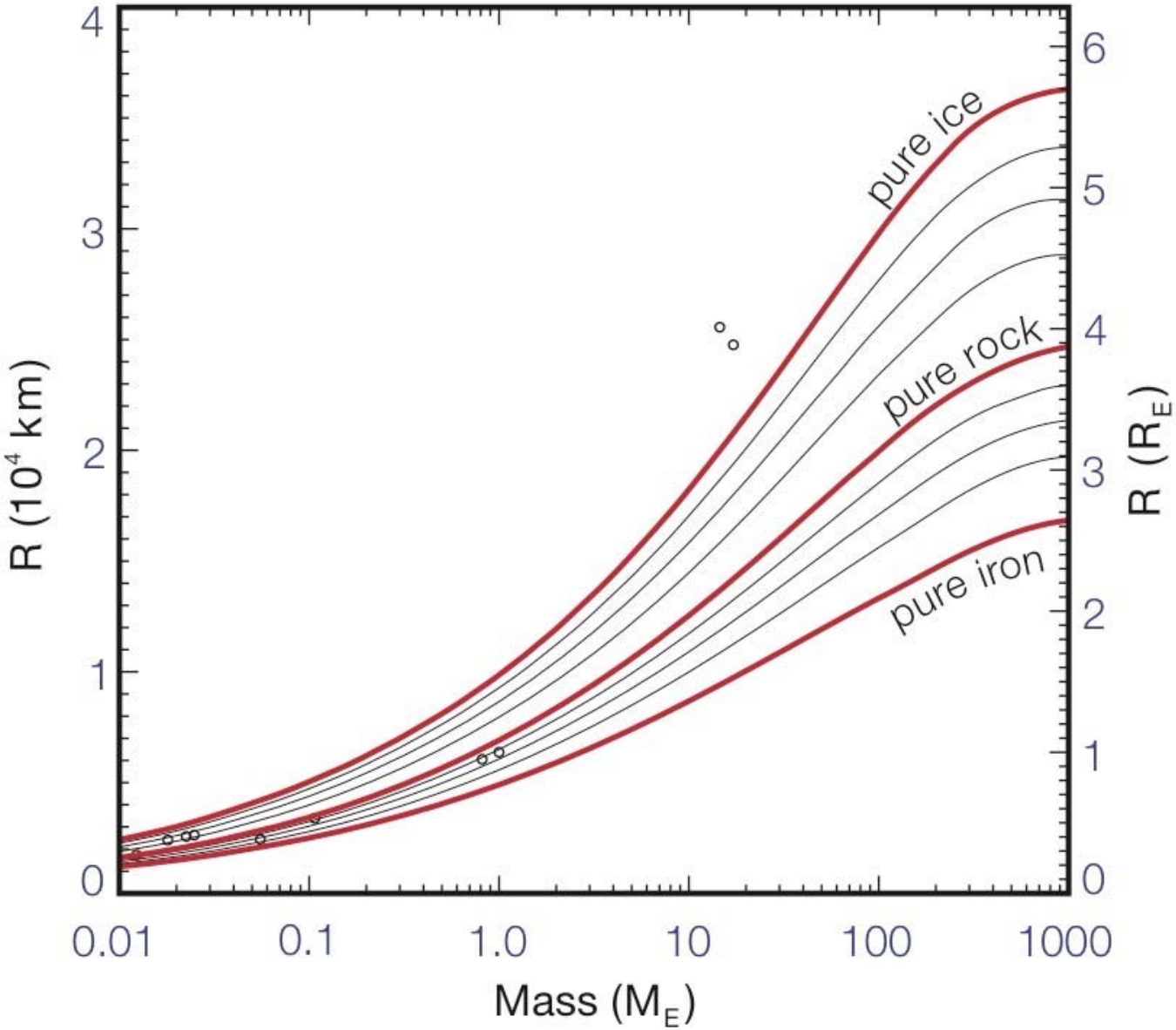

Fortney et al, submitted 2006

CANADIAN AND EUROPEAN PHOTOMETRIC INVESTIGATIONS

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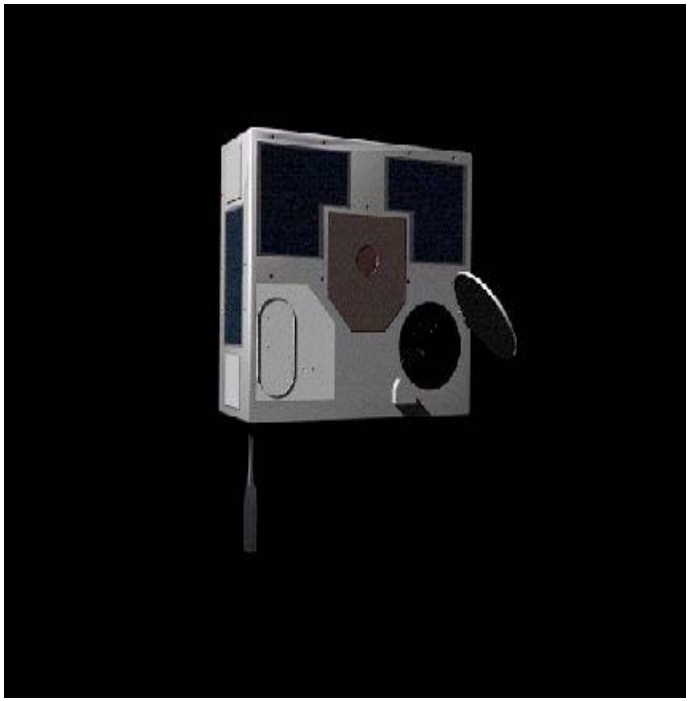

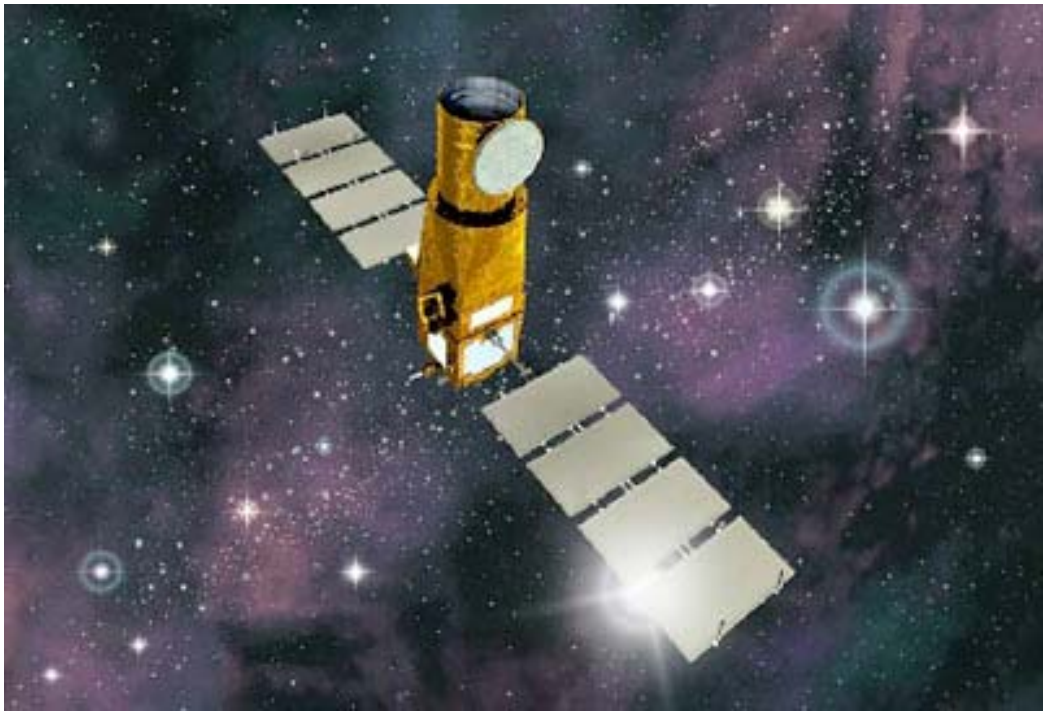

MOST; 10 cm Aperture
Launch: on orbit
Capability: few giants in short period orbits

COROT: 30 cm Aperture
Launched; 12/27/2006
Capability: few terrestrial planets in short period orbits