NASA's *Kepler* Mission

Jonathan Fortney, Jack Lissauer and the *Kepler* Team

Sagan Workshop, July 23


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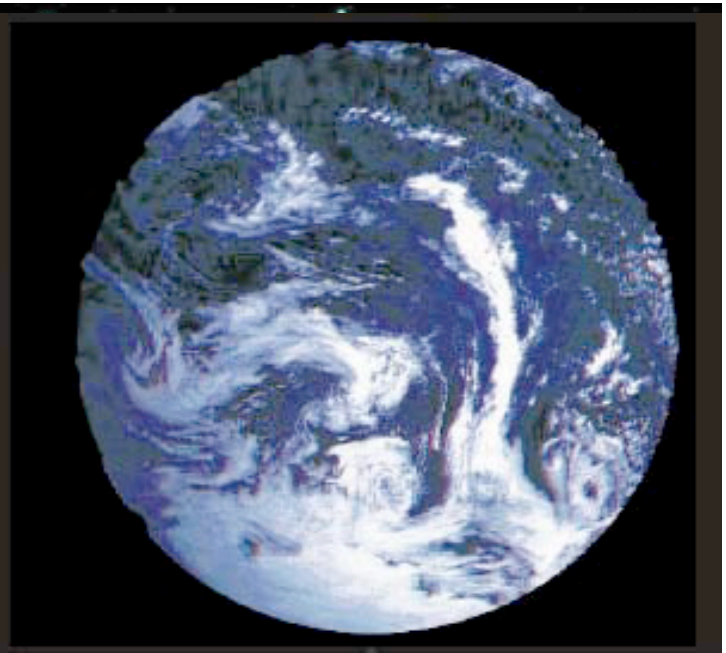
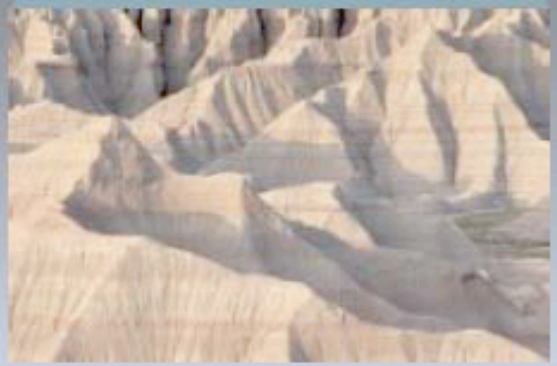
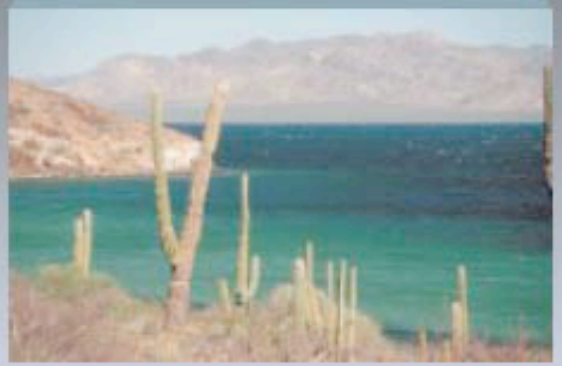
Small, dry planet



Ocean-covered world

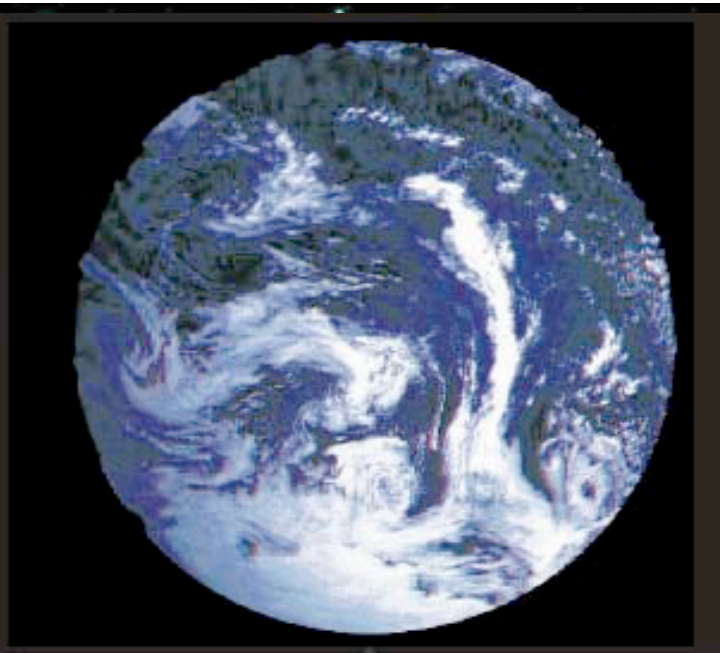
High-Resolution Images of First Three Planets Discovered by *Kepler*





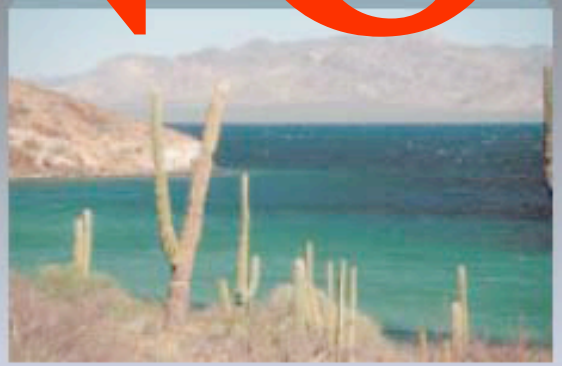
Small, dry planet

Earth



Ocean-covered world

Not



Lissauer 1999

What to Expect

(By far) the best data yet on abundances of planets in our region of the galaxy, including an estimate of η_{Earth} (encompassing **true Earth analogs**, not just hot large rocks).

What ***Not*** to Expect

Images of planets

Major results in 2009

η_{Earth} prior to ~ 2013

Kepler Timeline

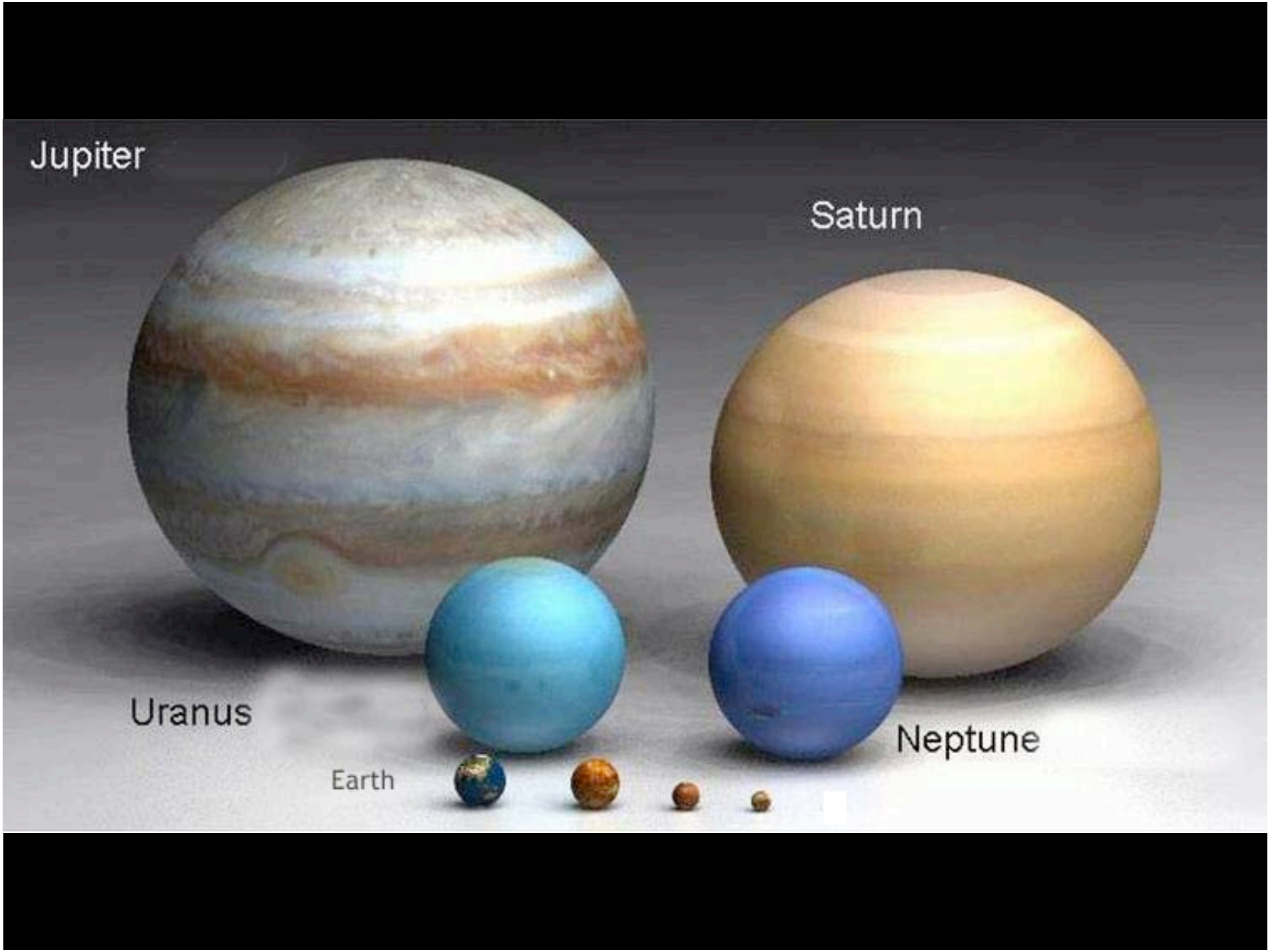
2001 December: Selection as Discovery Mission #10

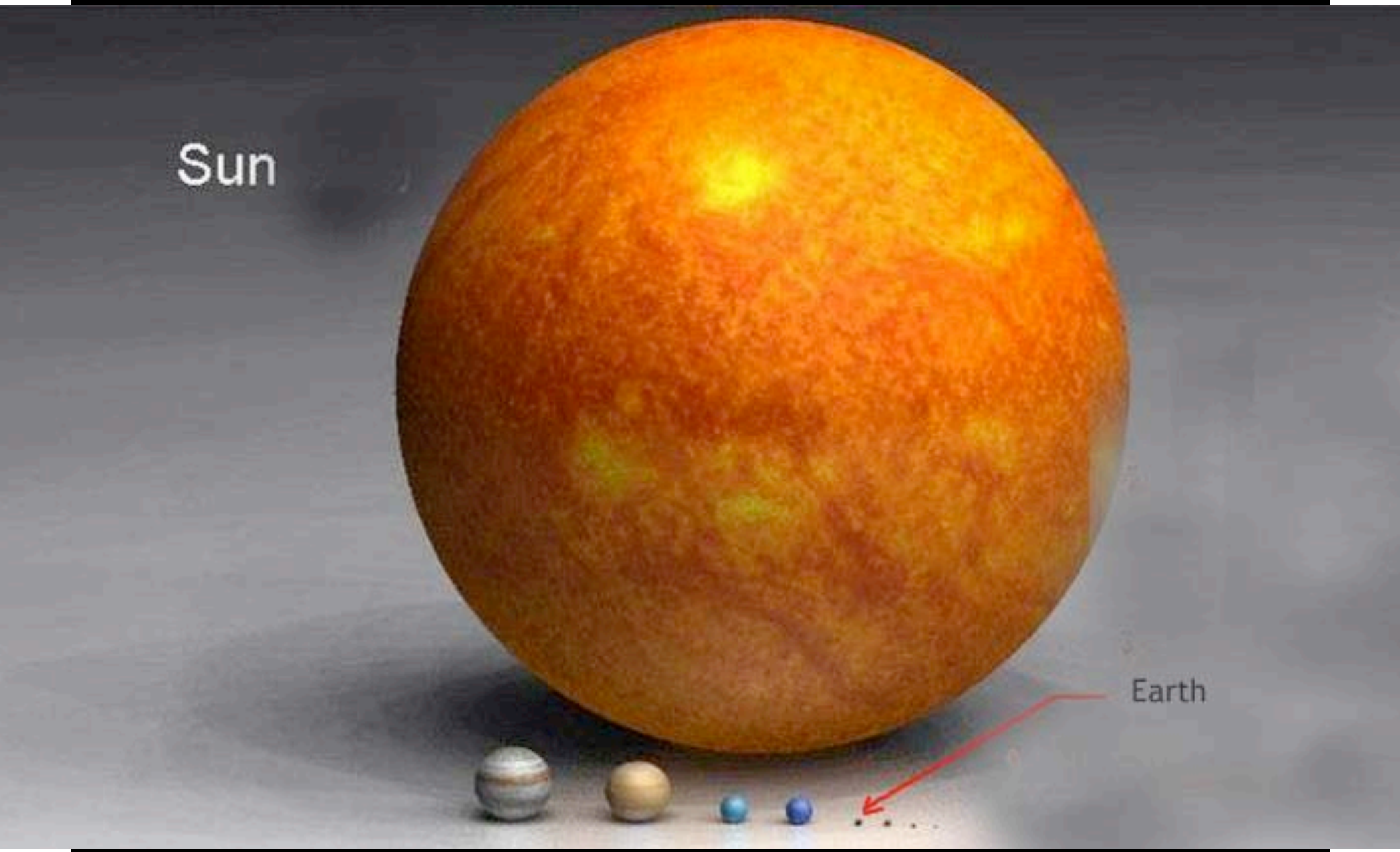
2009 March 6: Launch

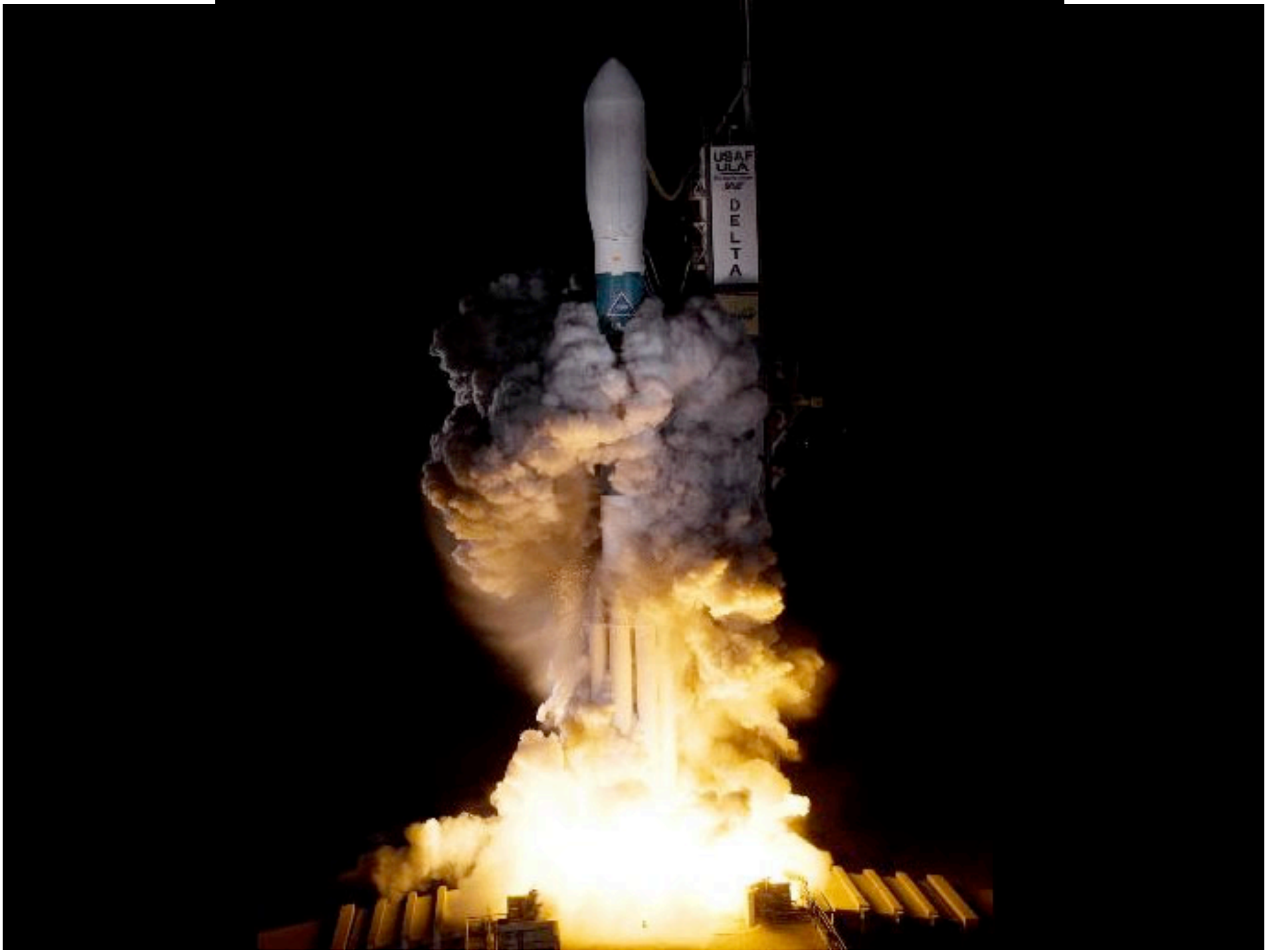
2009 April 7: Dust cover ejected

2009 May: Science observations began

2012 November: Observations finished (baseline mission)


Jupiter
Saturn
Uranus
Neptune
Earth


Sun
Earth


USAF
ULA
DELTA

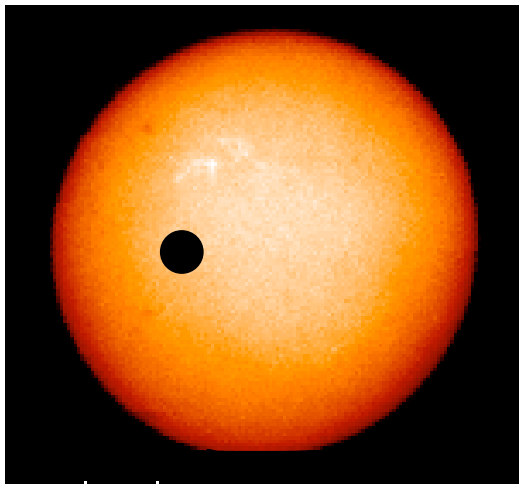

Kepler Launch
Time lapse image
Ben Cooper

Kepler Launch

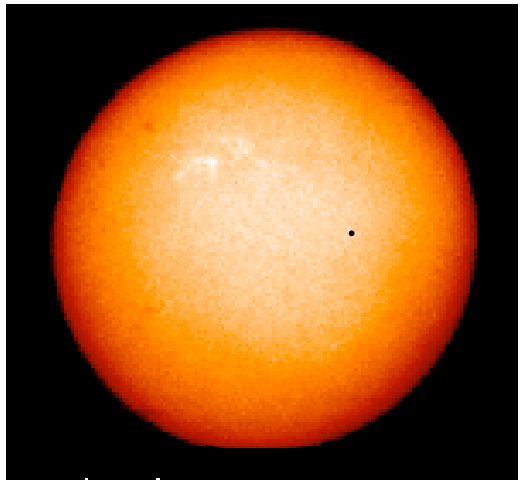
- Mosaic of 6 images by Jacques Amable

DETECTING EARTH-SIZE PLANETS

- Relative change in brightness equals relative areas (A_{planet}/ A_{star})



Jupiter:
1% area of the Sun (1/100)



Earth or Venus
0.01% area of the Sun (1/10,000)

- To measure 0.01% must get above the Earth's atmosphere

Kepler

A Search for Terrestrial Planets

- *Kepler Mission* is optimized for finding habitable planets (0.5 to 5 $M_{\oplus}$) in HZ (near 1 AU) of Sun-like stars

- Continuously monitor 100,000 stars for 3.5 years using 1 meter telescope

Kepler

Single science instrument:

Photometer: 0.95m aperture, 42 CCDs, 420-890nm, passive cooling, focusable primary

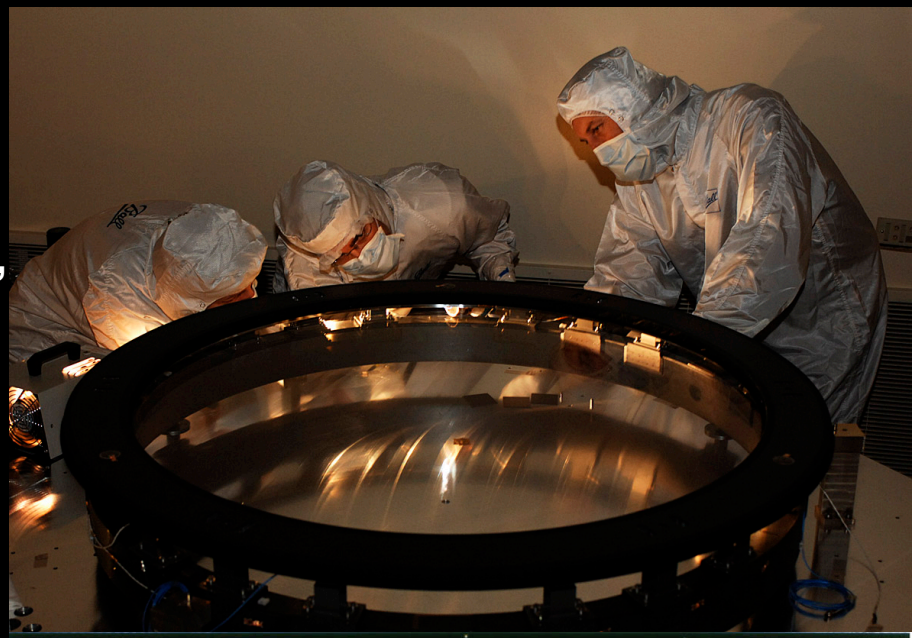
FOV: 100 sq deg. centered & fixed at 19h22m40s, 44º 30'

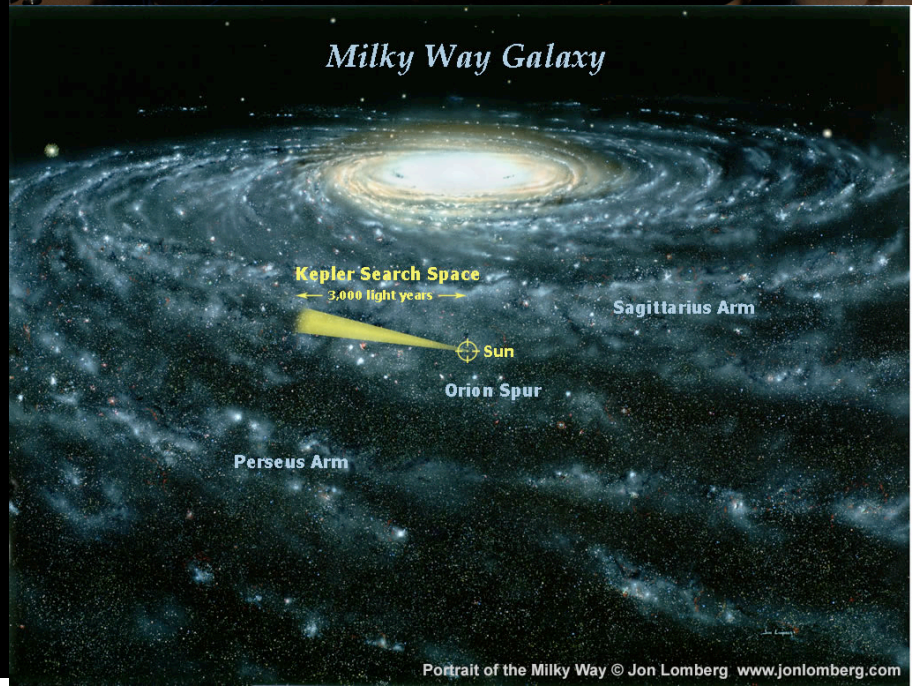
Spacecraft provides power, guidance, telecommunications, and fault protection.

Launch Vehicle: Delta 2925-10L

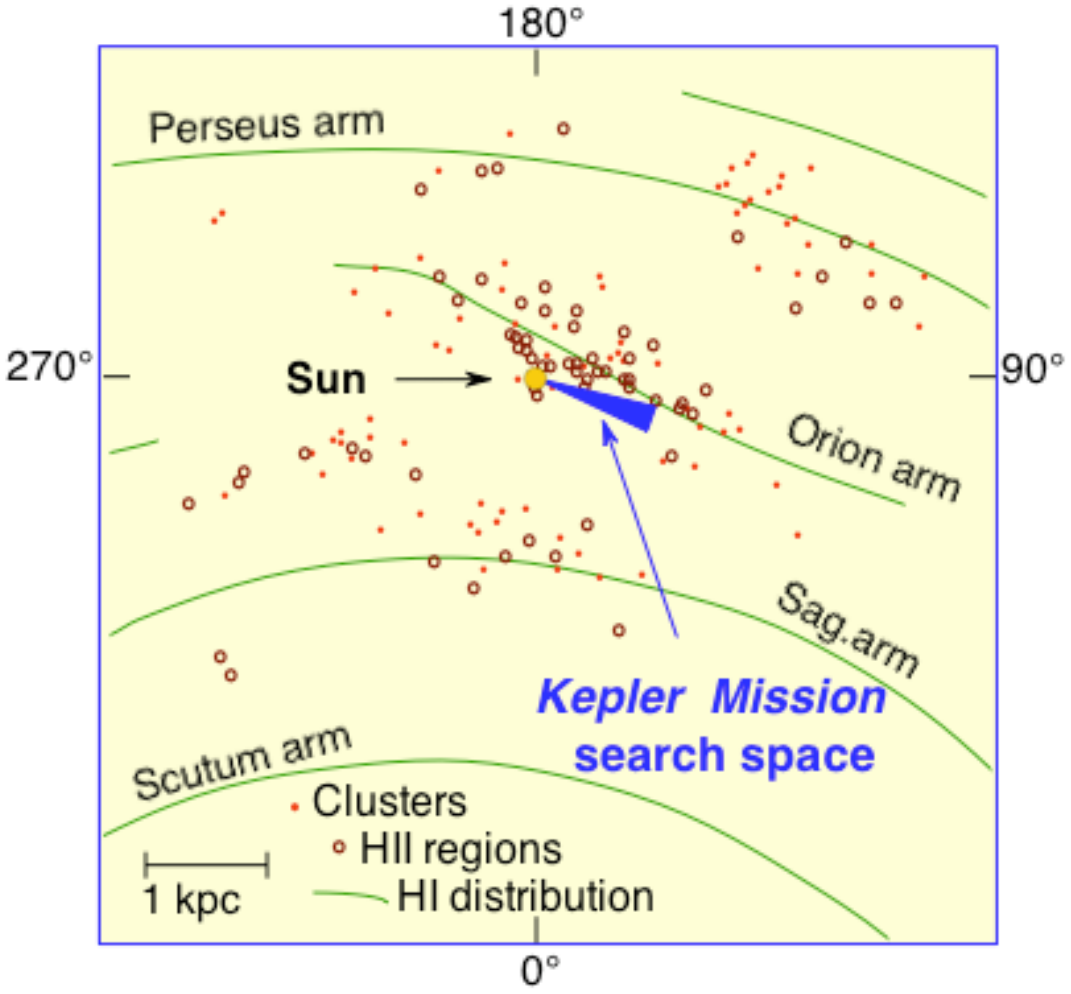
Launch date: 6 March 2009

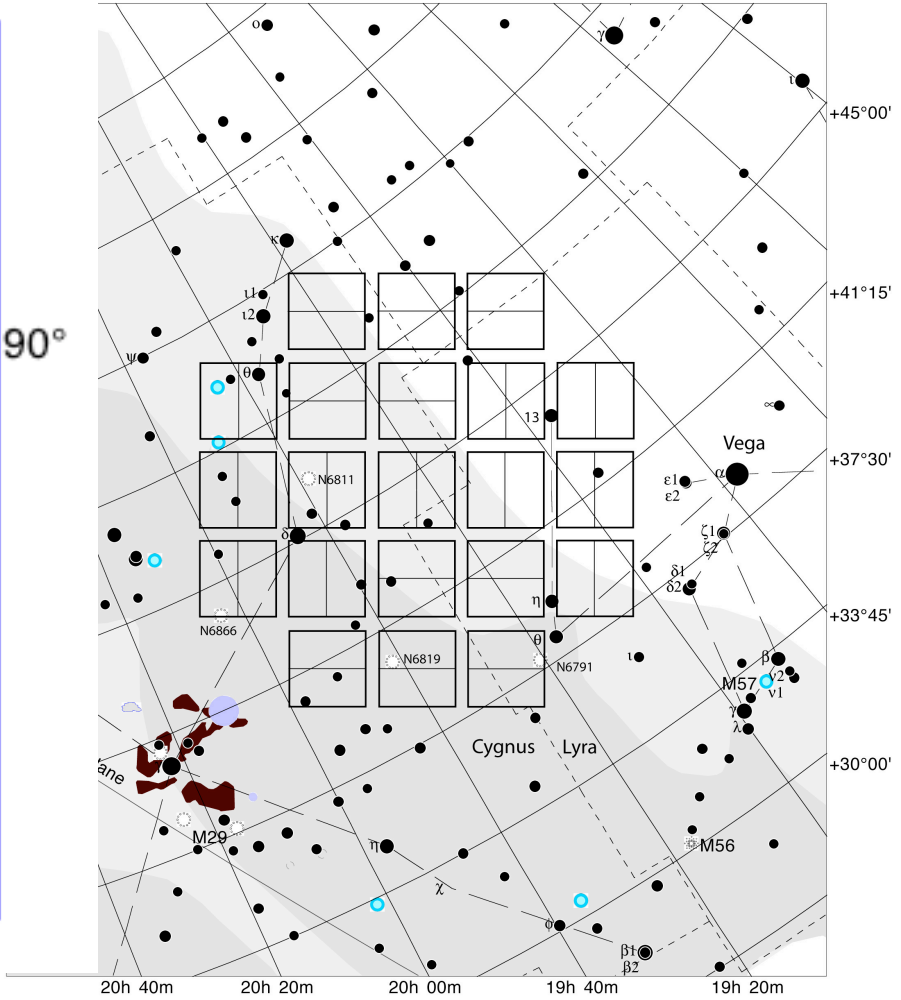
Operational life: 3.5 years with expendables for 6 years





FIELD OF VIEW IN CYGNUS

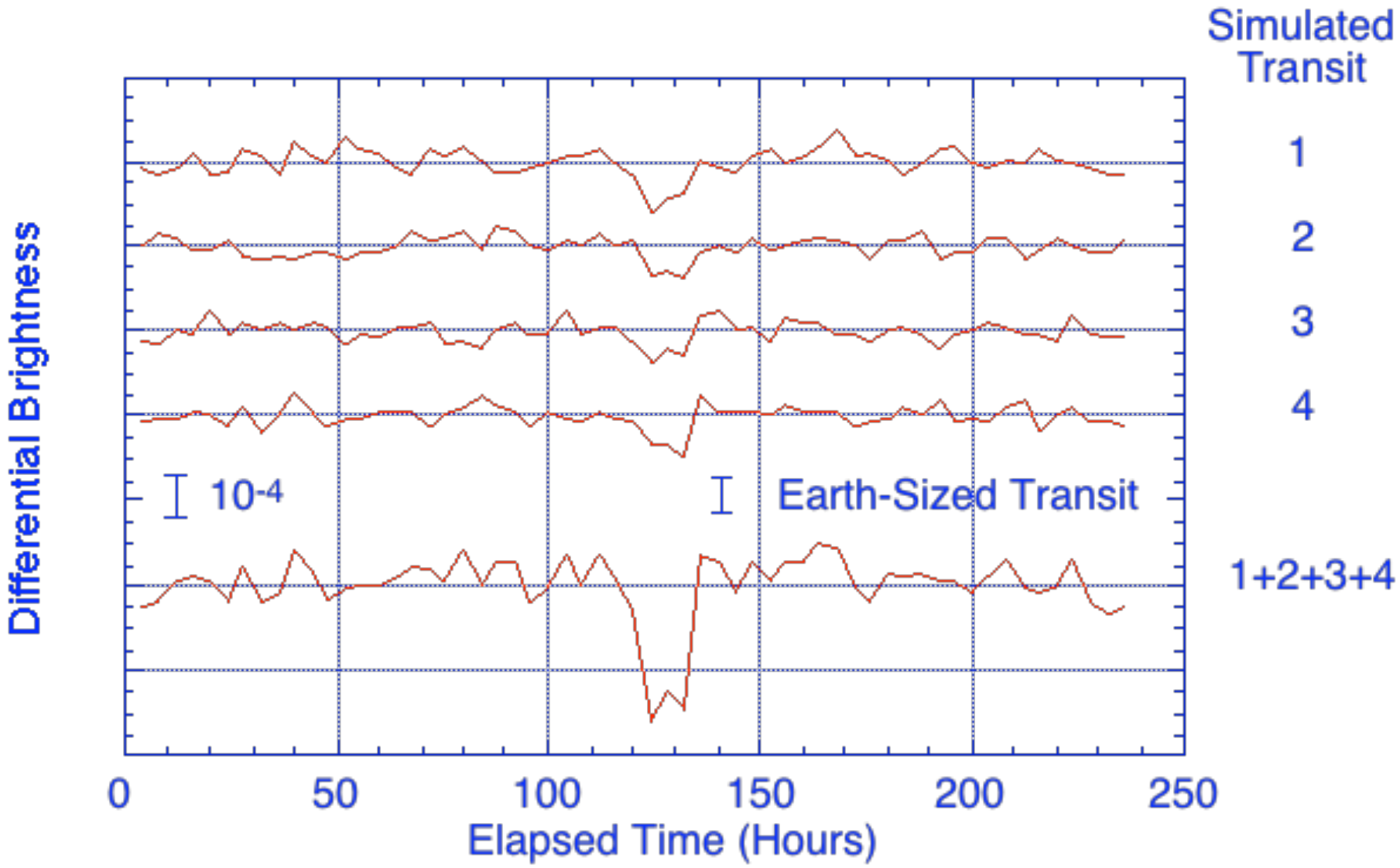




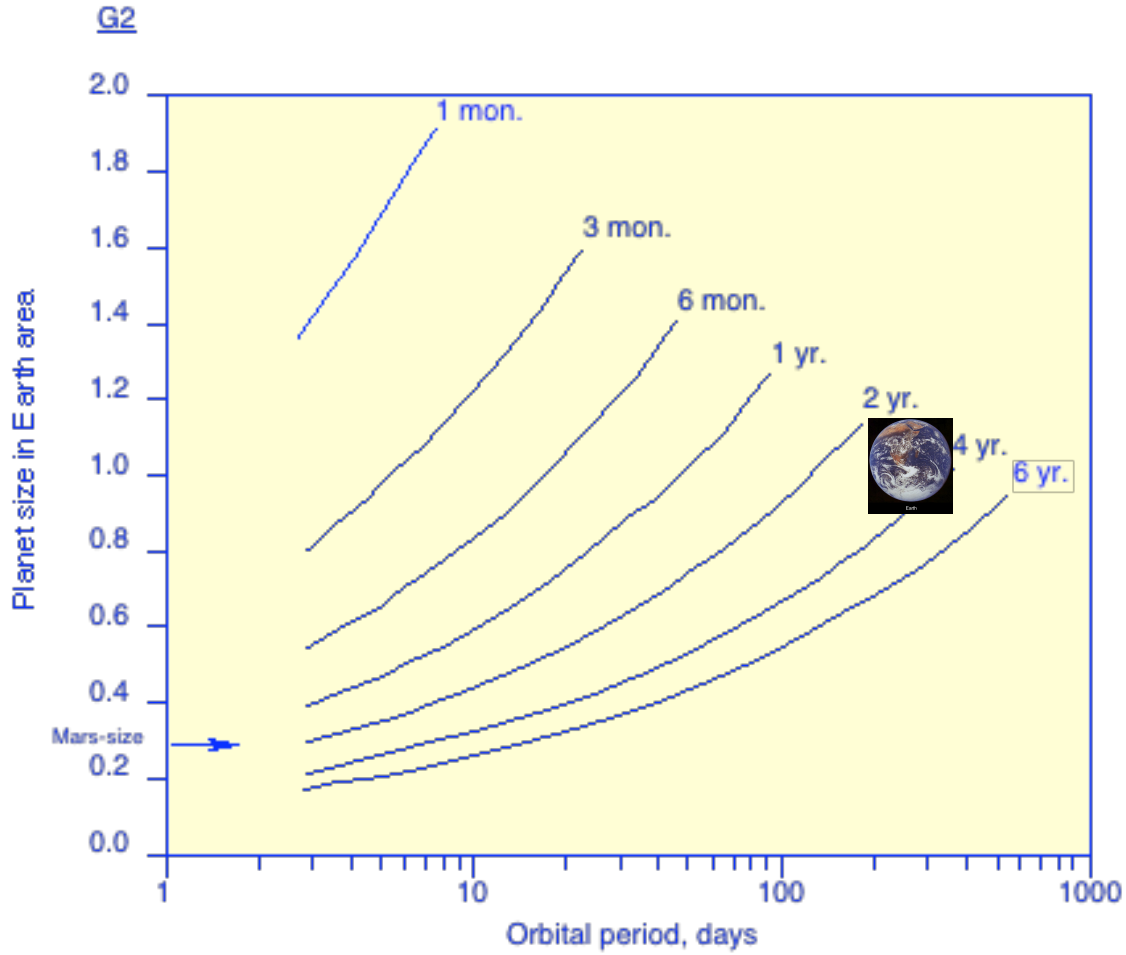
Each CCD module covers 5 square degrees

Region of the extended solar neighborhood in Cygnus-Lyra regions, along the Orion arm of our galaxy.

SIMULATION OF FOUR EARTH-SIZED TRANSITS



KEPLER CAPABILITIES

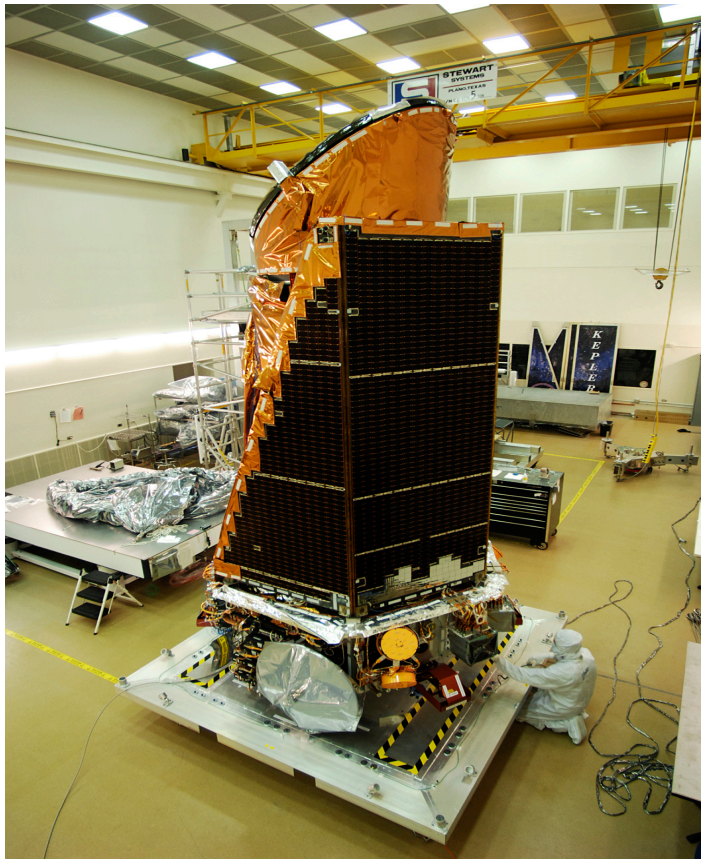


The minimum detectable planet size versus planetary orbital period for a 12th magnitude solar-like star (G2), a CDPP of 20 ppm and $\geq$4 half-maximum transits.

PHOTOMETER MATED TO SPACECRAFT

TELESCOPE/PHOTOMETER READY FOR TESTING

SOLAR PANEL INTEGRATED WITH SPACECRAFT & INSTRUMEENT

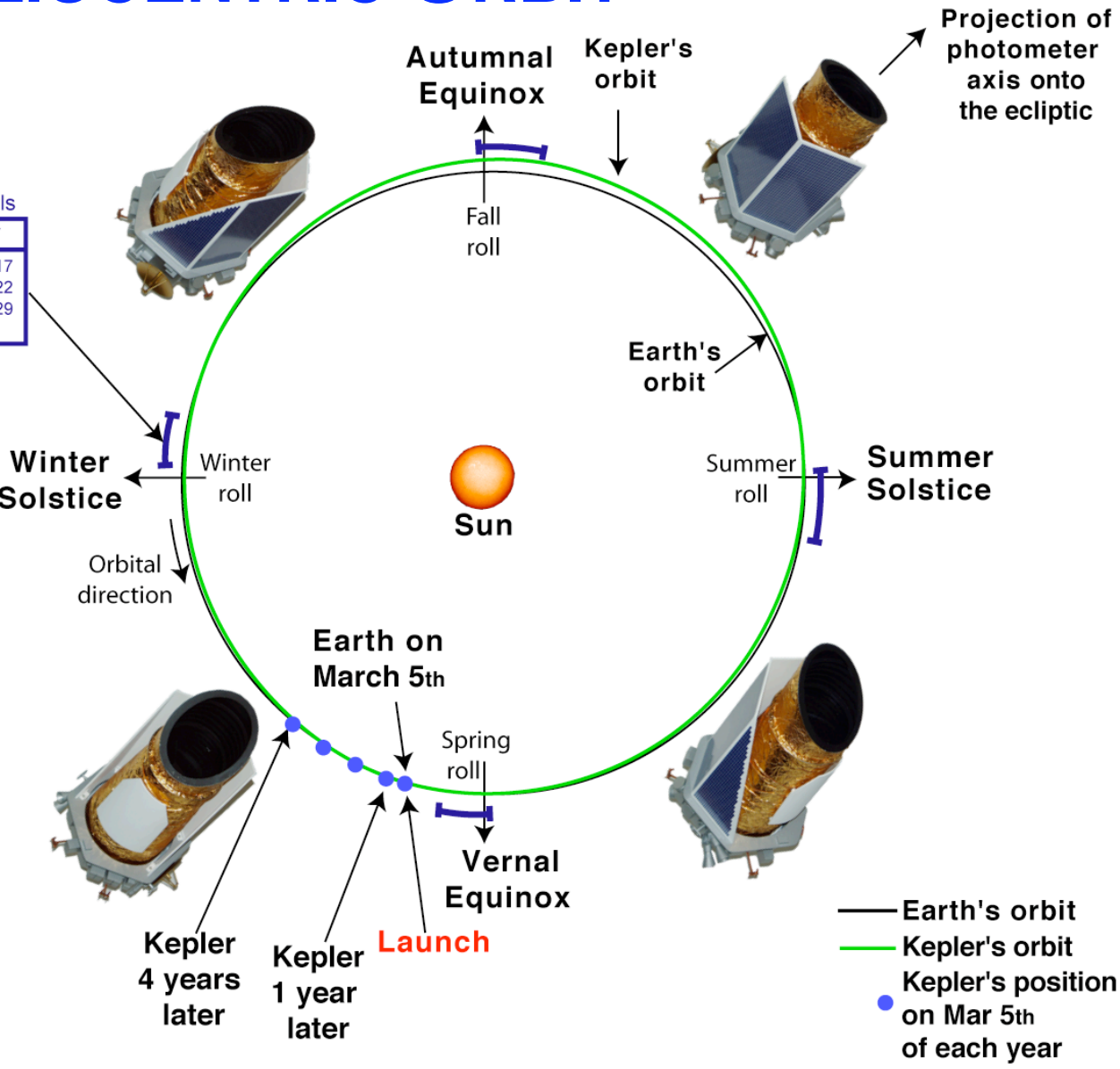


EARTH-TRAILING HELIOCENTRIC ORBIT

Delta II 2925-10L

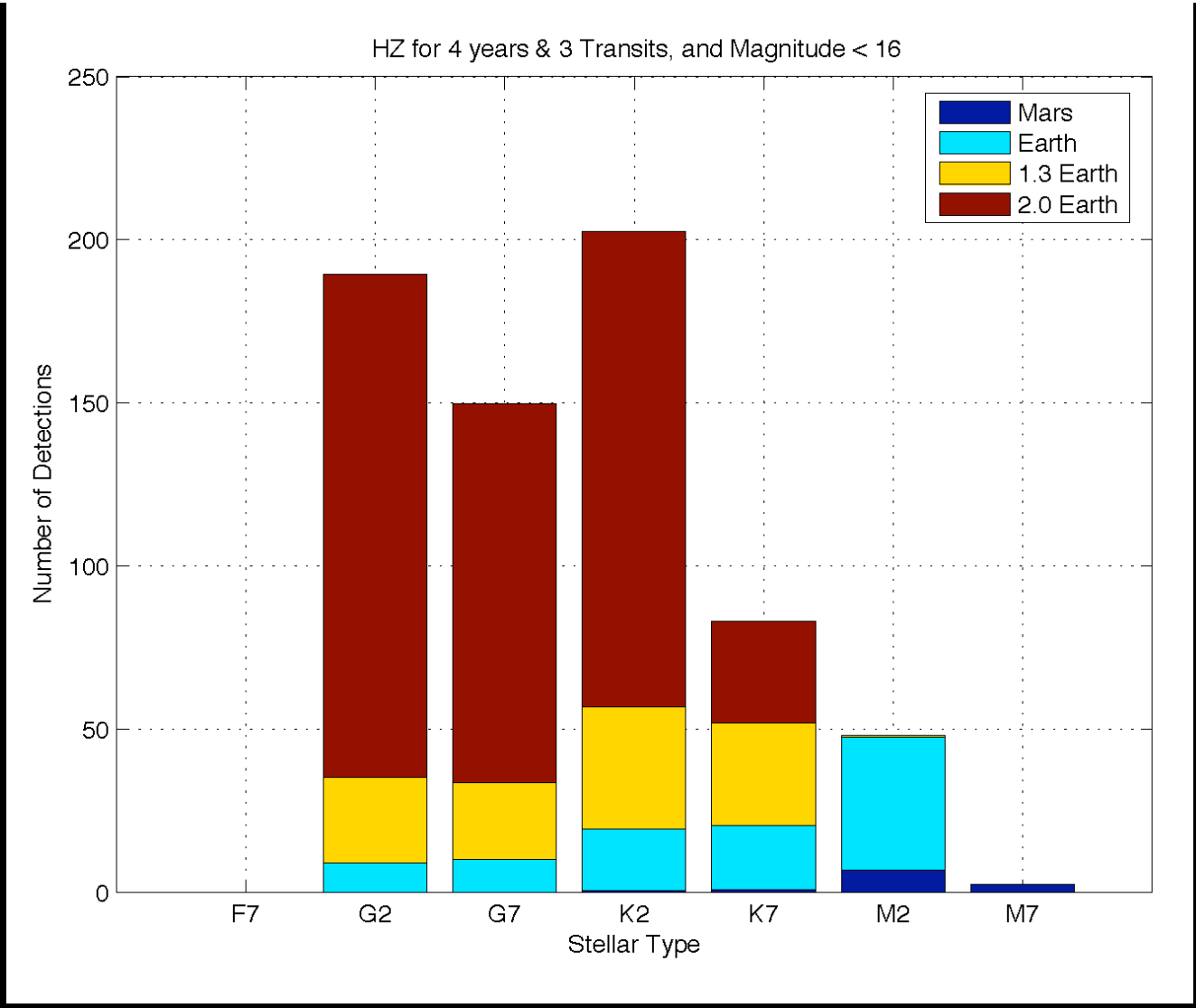
Planned Dates for Quarterly Rolls

Year	Sp	Su	Fall	W
2009	3/17	6/18	9/17	12/17
2010	3/22	6/24	9/23	12/22
2011	3/28	6/27	9/29	12/29
2012	4/2	6/28	-	-

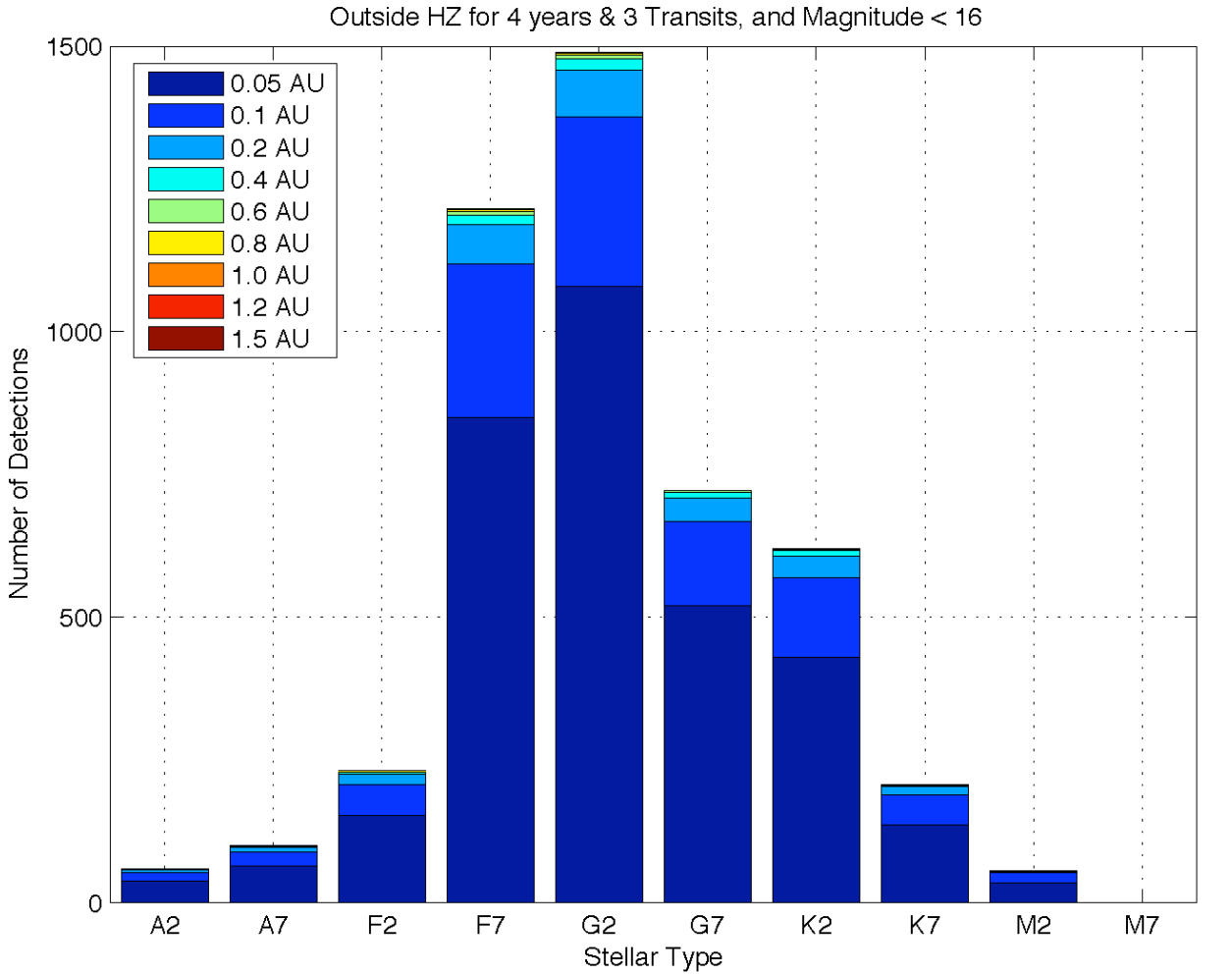


View from the ecliptic North Pole

DGK 11/08



•Several hundred terrestrial planets are expected in the HZ if they are common. A null result would mean Earths in the HZ are rare in our galaxy.



- Several thousand Earth-size (1 R_{Earth}) planets should be detected if such planets are common close to stars.

TABLE 2

EXPECTED NUMBER OF CLOSE-IN EXTRASOLAR GIANT PLANETS IN *Kepler*'S FIELD OF VIEW

	SPECTRAL TYPE						
m_R	B5	A5	F5	G5	K5	M5	All
9.5.....	1	3	2	1	0	0	7
10.5.....	4	7	6	3	1	0	22
11.5.....	9	19	20	11	2	0	61
12.5.....	16	44	62	37	9	0	167
13.5.....	27	90	173	117	29	1	437
14.5.....	39	159	447	368	96	5	1114
Total	96	321	709	537	136	7	1807

Jenkins & Doyle (2003)

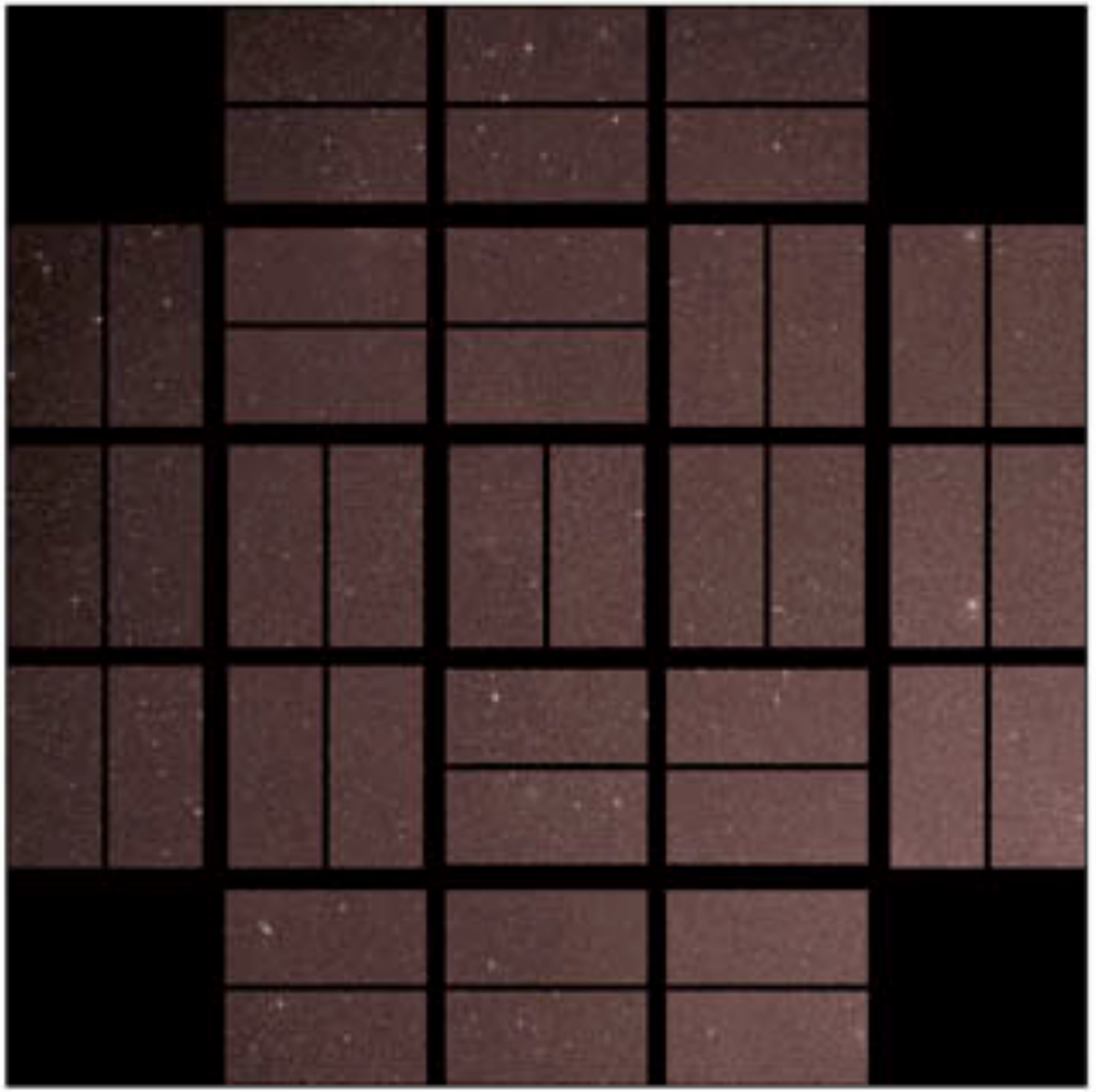
TABLE 3

EXPECTED TRANSITING CLOSE-IN EXTRASOLAR GIANT PLANETS IN *Kepler*'S FIELD OF VIEW

	SPECTRAL TYPE						
m_R	B5	A5	F5	G5	K5	M5	All
9.5.....	0	0	0	0	0	0	1
10.5.....	0	1	1	0	0	0	2
11.5.....	1	2	2	1	0	0	6
12.5.....	2	4	6	4	1	0	17
13.5.....	3	9	17	12	3	0	44
14.5.....	4	16	45	37	10	1	111
Total	10	32	71	54	14	1	181

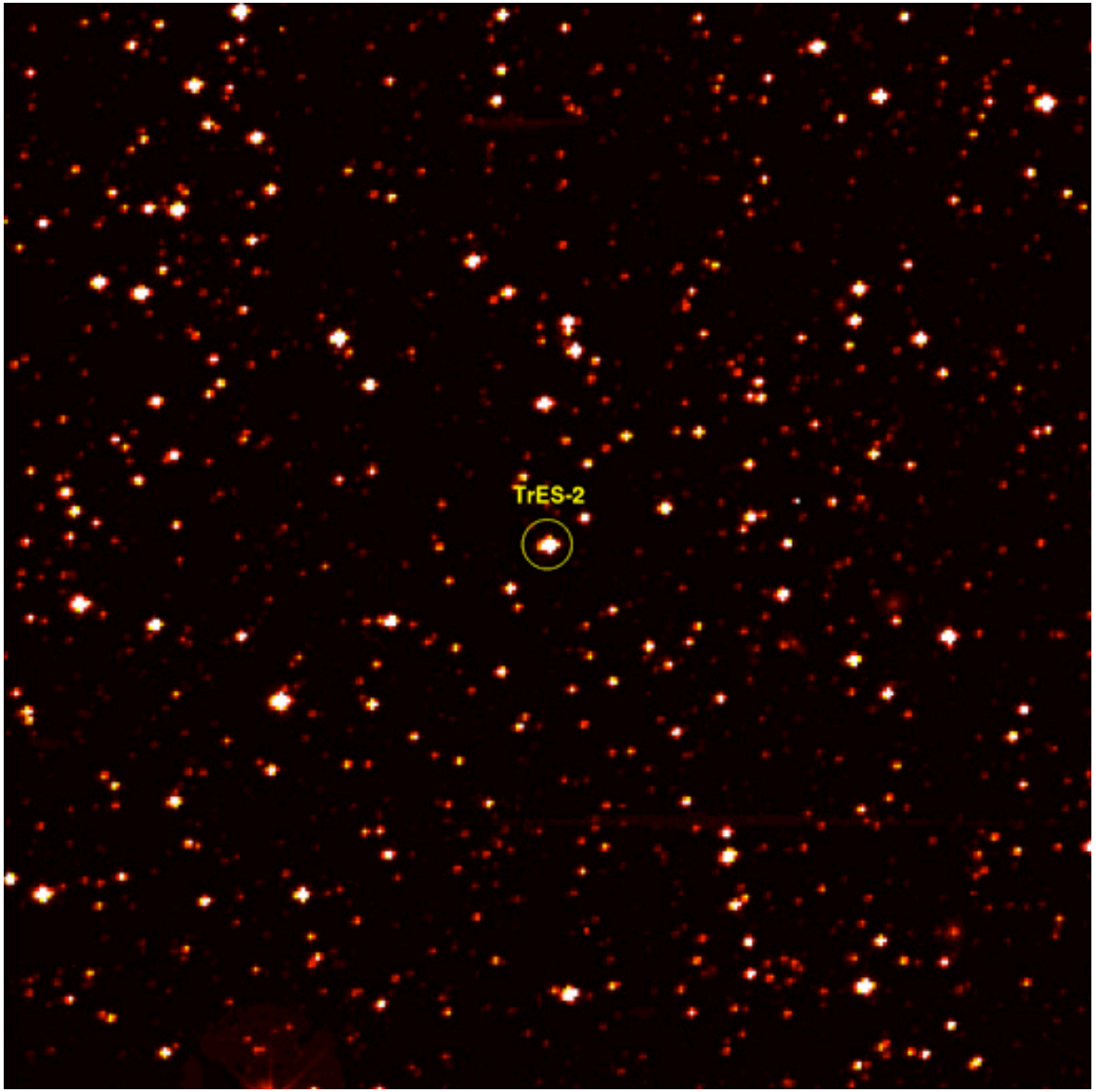
Kepler Full Frame Image

- 60 sec. exposure, 2009 April 8
- Color coded: bright stars white, faint stars red



Known Exoplanet Host
in *Kepler* Full Frame Image

- Close-up
- 0.2% *Kepler* FOV



SUMMARY

The *Kepler Mission* will:

Observe more than 100,000 dwarf stars
continuously for 3.5 to 6+ years
with a precision capable of detecting Earths in the habitable zone

The *Kepler Mission* can discover:

Planet sizes from that of Mars to greater than Jupiter
Orbital periods from days up to two years
About 50 1-Earth-mass planets orbiting in HZ
Far more terrestrial planetary systems if
they are larger or closer
About 50 inner-orbit giant planets based on
already known frequency
A NULL result would also be very significant ! ! !

More info at http://www.Kepler.NASA.gov