The NASA Exoplanet Exploration Program

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The NASA Exoplanet Exploration Program (ExEP) is chartered to implement the NASA space science goals of detecting and characterizing exoplanets and to search for signs of life. The ExEP manages space missions, future studies, technology investments, and ground-based science that either enables future missions or completes mission science. The exoplanet science community is engaged by the Program through Science Definition Teams and through the Exoplanet Program Analysis Group. The ExEP includes the space science missions of Kepler, K2, and the proposed WFIRST-AFTA that includes dark energy science, a widefield infrared survey, a microlensing survey for outer-exoplanet demographics, and a coronagraph for direct imaging of cool outer gas- and ice-giants around nearby stars. Studies of probe-scale (medium class) missions for a coronagraph (internal occulter) and starshade (external occulter) explore the trades of cost and science and provide motivation for a technology investment program to enable consideration of missions at the next decadal survey for NASA Astrophysics. Program elements include follow-up observations using the Keck Observatory which contribute to the science yield of Kepler and K2, and include mid-infrared observations of exo-zodiacal dust by the Large Binocular Telescope Interferometer which provide parameters critical to the design and predicted science yield of the next generation of direct imaging missions. ExEP includes the NASA Exoplanet Science Institute which provides archives, tools, and professional education for the exoplanet community. Each of these program elements contribute to the goal of detecting and characterizing earth-like planets orbiting other stars, and seeks to respond to rapid evolution in this discovery-driven field and to ongoing programmatic challenges through engagement of the scientific and technical communities.

ExEP is a program office managed by the NASA Jet Propulsion Laboratory for the NASA Astrophysics Division, within the NASA Science Mission Directorate.

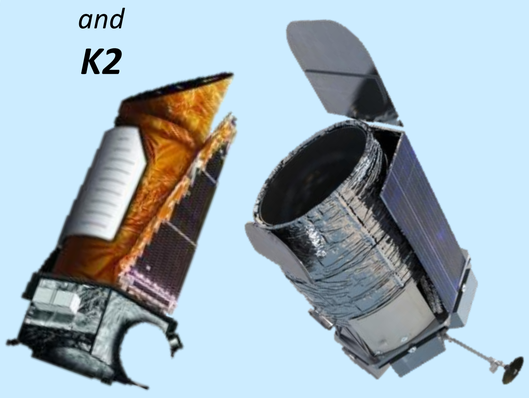
Program Office is assisted technically by:
- **SDT:** Science Definition Teams
- **STDT:** Science and Technology Definition Teams
- **ExoTAC:** Technology Assessment Committee
- **ExoPAG:** Program Analysis Group

ExEP

http://exep.jpl.nasa.gov
http://planetquest.jpl.nasa.gov

Space Missions and Mission Studies

Kepler* and *K2



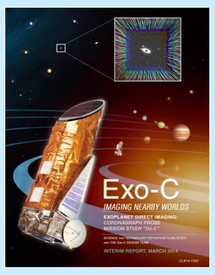
WFIRST-AFTA[1]

Probe-Scale Studies

External Occulter (Starshade)

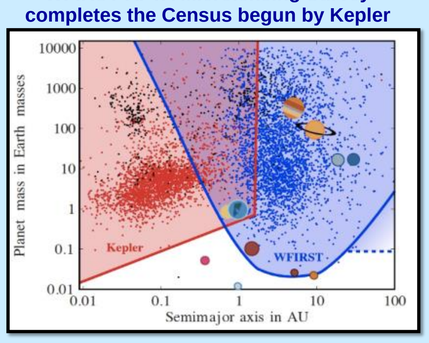
1.1m aperture, 30m diameter starshade

Internal Occulter (Coronagraph)



1.4 m aperture

WFIRST-AFTA Microlensing Survey completes the Census begun by Kepler



No Mask | **With Mask** | **With Mask and Deformable Mirrors**

- **Kepler Closeout will process 4 years of collected data by FY17**
- **K2 observes fields in ecliptic in two-wheel mode augmented by solar torque**
- **WFIRST/AFTA includes an exoplanet microlensing survey and a coronagraph for direct imaging of gas and ice giants**
- **Probe studies explore the science possible for a $1B lifecycle cost**

[1] Wide Field Infrared Survey Telescope - Astrophysics Focused Telescope Asset 2.4 meter aperture on-axis

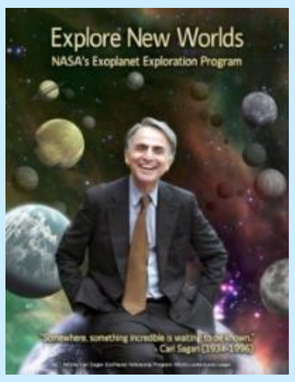
Public Engagement

NASA Exoplanet Science Institute (NExScI)

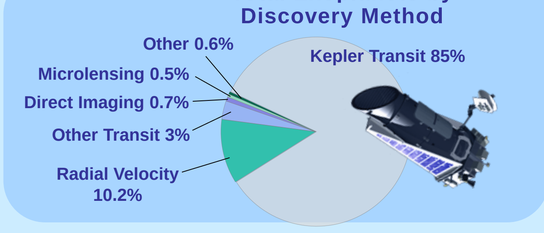
California Institute of Technology

Archives, Tools & Professional Education

Sagan Workshops and Fellows



Total Exoplanets by Discovery Method



Ref: http://exoplanetarchive.ipac.caltech.edu/docs/counts_detail.html

Total Exoplanets (9/9/2014): 5036

Confirmed: 35%
Candidate: 65%

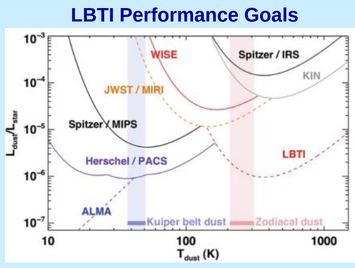
Kepler Total in the Habitable Zone: 304
Total Earth-size in the HZ: 1

Supporting Research & Technology

Key Sustaining Research

Large Binocular Telescope Interferometer

LBTI Performance Goals



Roberge et al. PASP, 2012

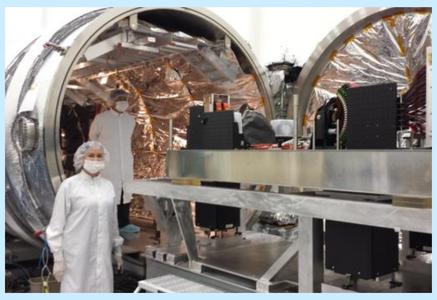
Keck Observatory Single Aperture Imaging and Radial Velocity

- **LBTI will characterize the exo-zodiacal dust emissions of 50 target stars to a level of 3 zodi (one sigma)**
- **A fraction of the 8-m Keck Observatory time is awarded to radial velocity follow-up of priority Kepler candidates**

Technology Development

High Contrast Imaging

Hybrid Lyot in High Contrast Imaging Testbed



Ultra-Low-Noise Visible Detectors

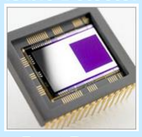
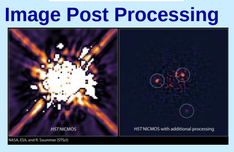
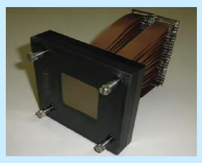


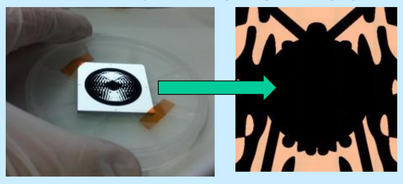
Image Post Processing



Deformable Mirrors



Occulting Masks (Shaped Pupil)



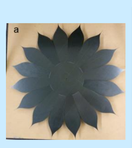
- **Technology Development competed through SAT/ ROSES/ TDEM**
- **Goal: <10^{-9} raw contrast (10^{-10} post processing) at >10% optical bandwidth**

Deployable Starshades

Petal Fabrication

Starshade Deployment Test

Subscale Contrast Tests in Desert, 1km baseline



Exoplanet Missions and Investigations – underway and planned – promise a future abundant with exoplanet discoveries. Progress in direct imaging technologies and high-contrast demonstrations on the ground and on-orbit enable and enhance the prospects for a New Worlds Telescope (coronagraph, starshade or both) that will be considered by the 2020 Astrophysics Decadal Survey.