THEIA: Telescope for Habitable Earths and Interstellar /Intergalactic Astronomy

David Spergel for the THEIA team

Princeton

THEIA Team (XPC+UVS+SFC)

- **Industry Partners: Lockheed Martin, ITT, Ball Aerospace, Goodrich, ATK**
- **NASA Centers: JPL, GSFC, Ames, Marshall**
- **University Partners: Arizona State, Caltech, Carnegie, Case Western, Colorado, JHU, Massachusetts, Michigan, MIT, Penn State, Princeton, STScI, UCSB, UCB, Virginia, Wisconsin, Yale**
- **Team Members:** Paul Atcheson, Matt Beasley, Rus Belikov, Morley Blouke, Eric Cady, Daniela Calzetti, Craig Copi, Steve Desch, Alan Dressler, Dennis Ebbets, Rob Egerman, Alex Fullerton, Jay Gallagher, Jim Green, Olivier Guyon, Sally Heap, Rolf Jansen, Ed Jenkins, Jeremy Kasdin, Jim Kasting, Ritva Keski-Kuha, Marc Kuchner, Roger Lee, Don J. Lindler, Roger Linfield, Doug Lisman, Rick Lyon, John MacKenty, Sangeeta Malhotra, Mark McCaughrean, Gary Mathews, Matt Mountain, Shouleh Nikzad, Bob O'Connell, William Oegerle, Sally Oey, Debbie Padgett, Behzad A Parvin, Xavier Prochaska, I. Neill Reid, James Rhoads, Aki Roberge, Babak Saif, Dmitry Savransky, Paul Scowen, Sara Seager, Bernie Seery, Kenneth Sembach, Stuart Shaklan, Mike Shull, Oswald Siegmund, Nathan Smith, Remi Soummer, David Spergel, Phil Stahl, Glenn Starkman, Daniel K Stern, Dominick Tenerelli, Wesley A Traub, John Trauger, Todd Tripp, Jason Tumlinson, Ed Turner, Bob Vanderbei, Rogier Windhorst, Bruce Woodgate, Bob Woodruff

What is THEIA?

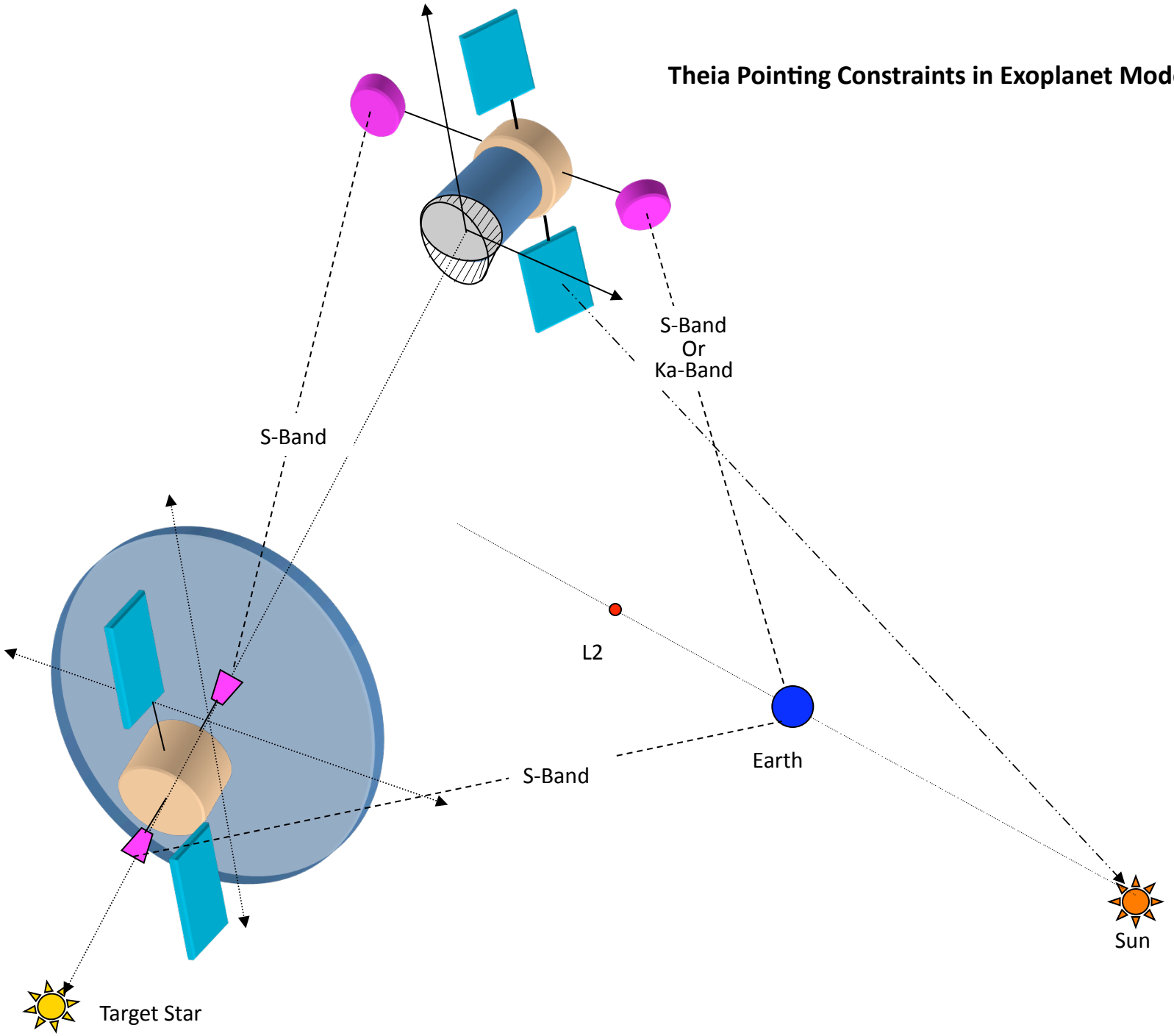
THEIA is a concept for a powerful 4-meter telescope capable of detecting and characterizing Earth-like planets around nearby stars. With its powerful instrument suite, THEIA is also capable of conducting a broad program of astronomical observation and having a major impact on our understanding of star formation, galaxy evolution and the intergalactic medium.

THEIA is the combination of 3 NASA mission concept studies:

- XPC: the eXtrasolar Planet Characterizer
- SFC: Star Formation Camera, a wide field near-IR/optical/UV camera optimized to study star formation and galaxy evolution
- UVS: an ultraviolet spectrum designed to study the intergalactic medium and probe the chemical evolution of the universe

THEIA is an occulter/telescope system. When the occulter is "on target", it searches for and characterizing planets around nearby stars. While the occulter is moving (>75% of the time), it carries out a program of general astrophysics.

In Greek mythology, Theia is the Titan goddess of sight (thea), is also called the "far-seeing one". She is the mother of the Sun, the Moon and Dawn.


Theia Pointing Constraints in Exoplanet Mode
S-Band
Or
Ka-Band
S-Band
L2
S-Band
Earth
Sun
Target Star

eXtrasolar Planet Characterizer (XPC)

- The XPC baseline instruments are three narrow-field cameras for the UV (250-400 nm), blue (400-700 nm), and red (700-1100 microns) with filters, and an integral field spectrograph (IFS) operating in the red with spectral resolution R~70. All three instruments can be operated simultaneously
- The IR occulter camera monitors the position of the occulter by observing it in the mid-IR.

What do we measure?

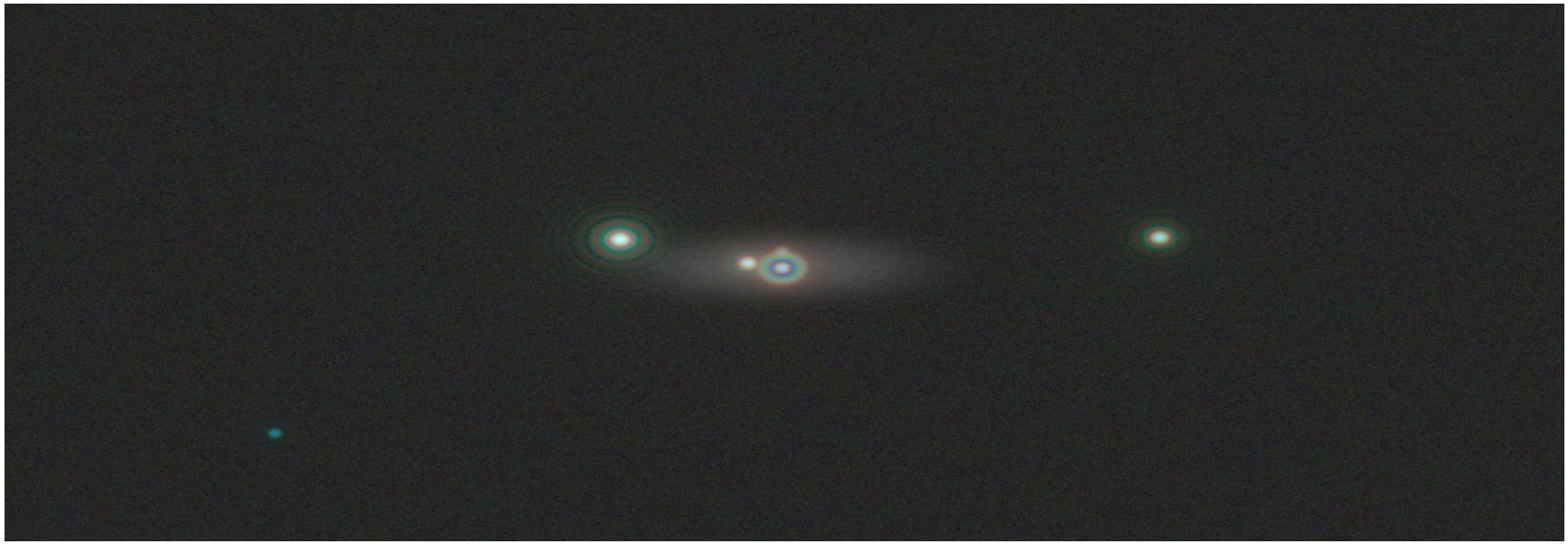
THEIA will carry out an extensive program of extrasolar planet science:

- Surveying 130 nearby stars for planets in the habitable zone
- Return to detected planets and characterize their orbits by multiple visits (10% measurement of period– 5 detection). [detection and orbit characterization is best in the blue]
- Study diurnal variations during several week long observations and annual variations during revisits.

THEIA's spectroscopic capabilities will enable the detection of ozone, oxygen, water and carbon dioxide. With its ability to study the planets' atmosphere from the near IR (1 micron) to UV (3000 A), THEIA will be able to search for the signatures of habitability

XPC is searching for O_2 absorption; on Earth O_2 is produced in large quantities only by life. At UV wavelengths XPC is looking for the sharp cutoff indicating the presence of O_3; O_3 is a photolytic byproduct of O_2. All life on Earth requires liquid water. XPC is looking for water vapor absorption that is indicative of liquid water oceans.

Planet Detection



A very high S/N characterization image of the solar system by THEIA as viewed from the distance of Fomalhaut (7.7 pc). Earth is in the center of the image, Jupiter to the left of center and Saturn to the right of center (courtesy R. Vanderbei).

Do we need an astrometric precursor for TPF-C or TPF-O (and their variants)?

- No!
- By moving the occulter out to double the distance and operating in the blue, planet searches can be done efficiently.
- Simulations show that identifying planets in advance leads to only a modest increase in efficiency. Program is limited by system IWA
- Measurements of planetary atmosphere and colors will yield novel insights
- If we know the target stars and devote significant amount of integration time to the target (and know its period), radial velocity searches will be able to measure masses with higher sensitivity than a blind search. (What do we need to eliminate Uranus-masses?)