Jet Propulsion Laboratory
California Institute of Technology

EXOPLANET EXPLORATION PROGRAM ANALYSIS GROUP #11,
Seattle, WA

Exoplanet Exploration Program Update

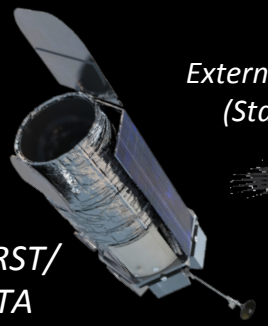
Gary Blackwood, Exoplanet Exploration Program Manager
Jet Propulsion Laboratory, California Institute of Technology

January 3, 2015

The Exoplanet Exploration Program

Space Missions and Mission Studies

Kepler, K2



WFIRST/ AFTA

Probe-Scale:
External Occulter (Starshade)

Coronagraph

Public Engagement

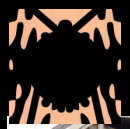
Supporting Research & Technology

Key Sustaining Research

Large Binocular Telescope Interferometer

Keck Single Aperture Imaging and RV

Technology Development



Coronagraph Masks

High Contrast Imaging

Deployable Star Shades

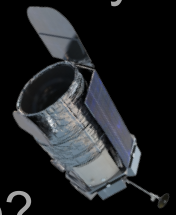
NASA Exoplanet Science Institute

The Program Address the Key Questions

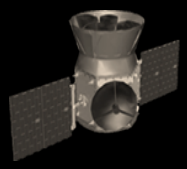
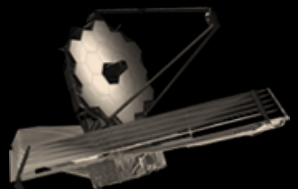
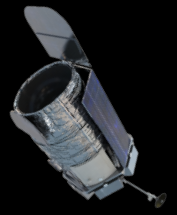
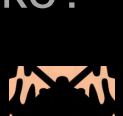
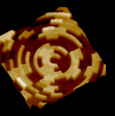
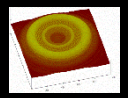
Through Science, Advanced Studies, and Technology Development

1. Discovering Planets: How abundant are exoplanets in our Galaxy?
   - Radial Velocity
   - Transit Photometry

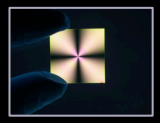
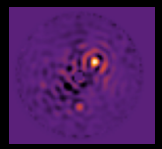


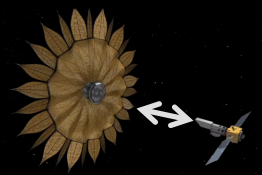
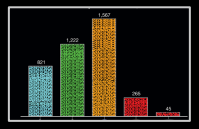



2. Characterizing Planets: What are the (large) exoplanets like?
   - Transit Spectroscopy
   - Direct Imaging

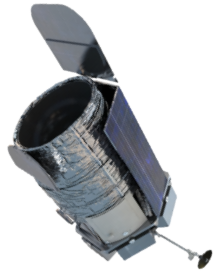
3. "Pale Blue Dots": Are the planets habitable? Are there signs of life?
   - Transit Spectroscopy
   - Direct Imaging
     - High Contrast
     - Small Inner Working Angle
     - Spectroscopy
     - η_Earth
     - Exozodiacal Dust
     - Yield

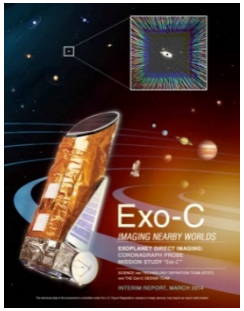



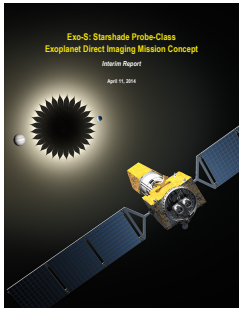





Accomplishment Highlights since last ExoPAG

- **Program Management**
  - Funded and completed RV completeness study, and 3 supporting science studies
- **Kepler**
  - Closeout: completed Q1-12 and Q1-16 activity tables (release notes to NExScI). Reviews held for schedule baseline and occurrence rates
  - K2: Completed Science Campaigns 1 and 2
- **WFIRST-AFTA**
  - Completed 5 technology milestones (3 coronagraph, 2 IR detector)
  - Significant progress on Mission/WFI/CGI design towards final report and CATE
- **Probe Studies**
  - Significant progress on mission design towards final report and CATE
- **Technology**
  - Delivered Hybrid Lyot Coronagraph testbed readiness to WFIRST
  - Starshade: Completed construction of 60%-scale deployable inner disk
  - TDEM-13 selection
- **NExScI**
  - Successful Sagan workshop “Imaging Planets and Disks”. Ongoing data ingestion to KOA
- **LBTI**:
  - Rebaseline review/recommendation delivered to HQs: 4/16/15 ORR. Reached 24 zodi performance level during November run







Kepler Closeout

Harvesting the exoplanet yield from the mission

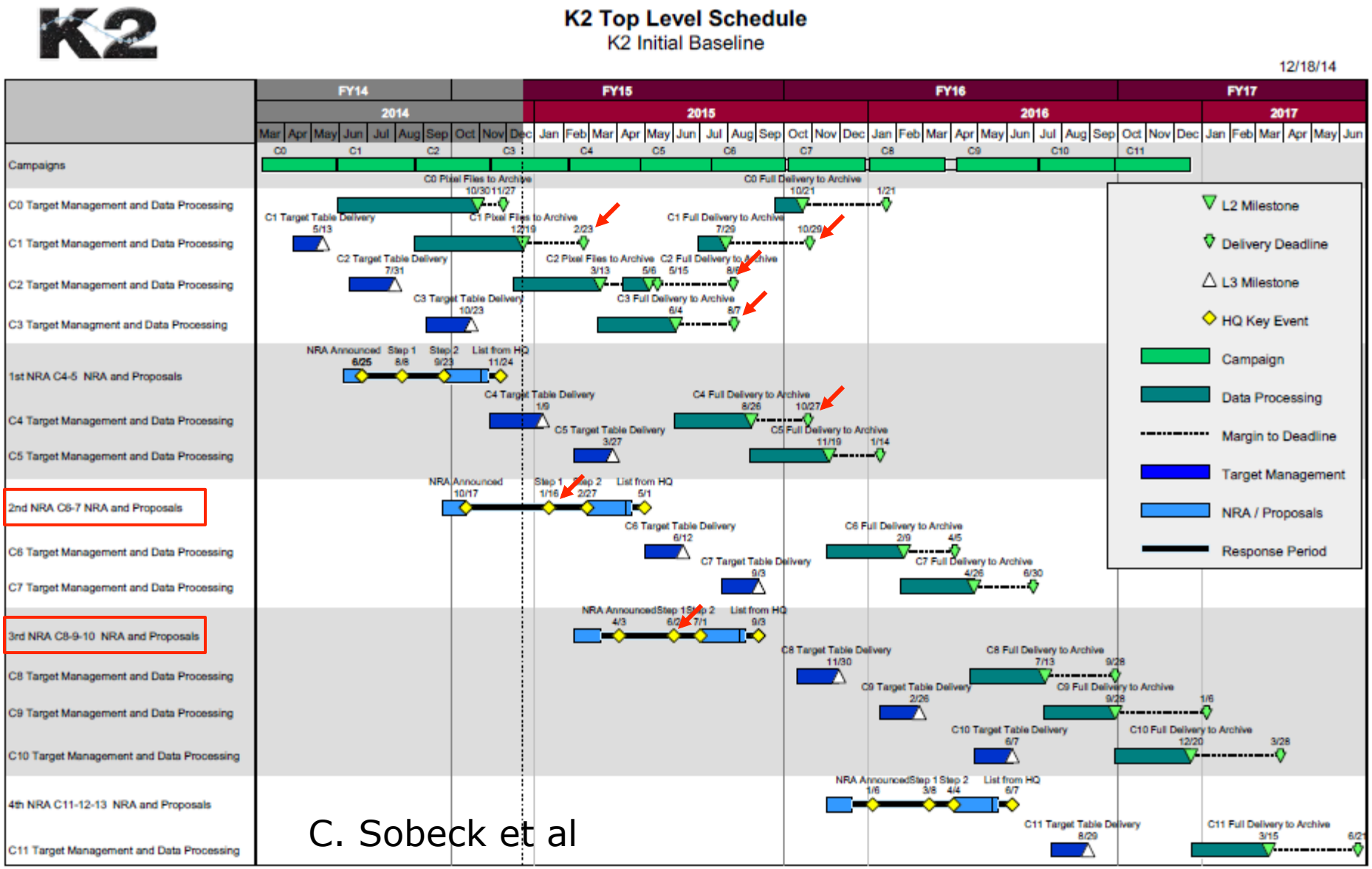
- Already available to Community: Q0-Q16

Pending HQs confirmation of baseline:

- Uniform Processing: Q0-Q17 (9.2)
  - Long cadence light curves — Dec 2014
  - Short cadence light curves — Apr 2015
  - KOI Catalog — Oct 2015
  - “Hack Week” — Oct 2015

- Final Data processing: Q0-Q17 (9.3)
  - Light curves — Feb 2016
  - KOI Catalog — Nov 2016

K2 NRAs and Light Curve Deliveries to Archive (baseline pending HQs approval)



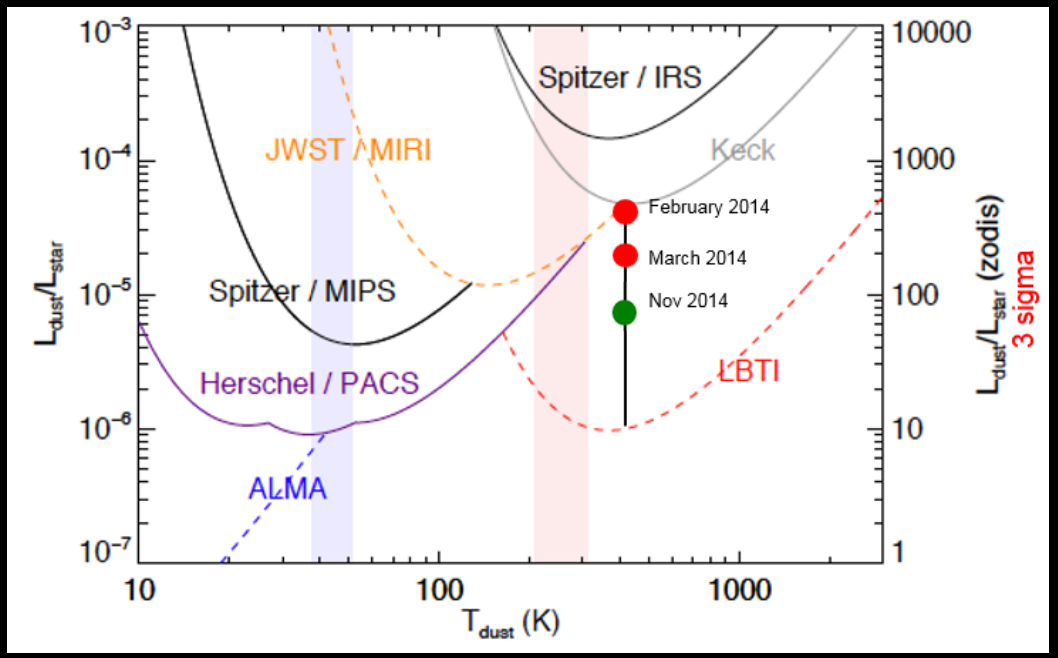
C. Sobeck et al

Large Binocular Telescope Interferometer

Measures exozodiacal dust in habitable zones

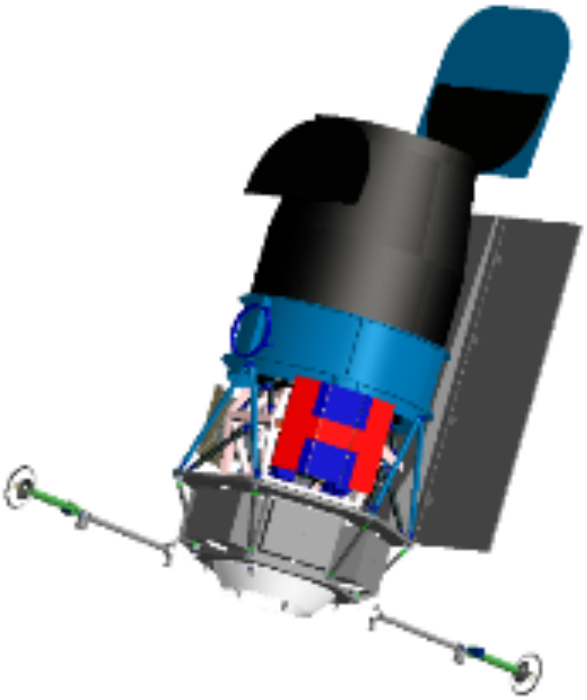
University of Arizona
P. Hinz, PI

LBTI Performance



- 24 zodi (one sigma) achieved during November 2014 run
- LBTI will characterize the exo-zodiacal dust emissions of 50 target stars in mid-IR to a level of 3 - 6 zodi (one sigma)

WFIRST/AFTA Status



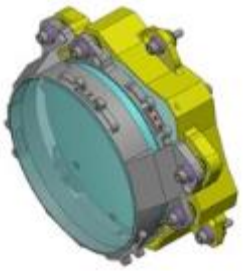
- L2 vs Geo trade underway
- Baseline plan completed for optical verification testing
- WFI design models being updated and preliminary assessments have begun.
- Element wheel / F2 actuated mount risk reduction effort underway
- Nearing completion of final report (1/31) and inputs to Aerospace CATE
- Completed technology milestones: 3 coronagraph, 2 infrared detector

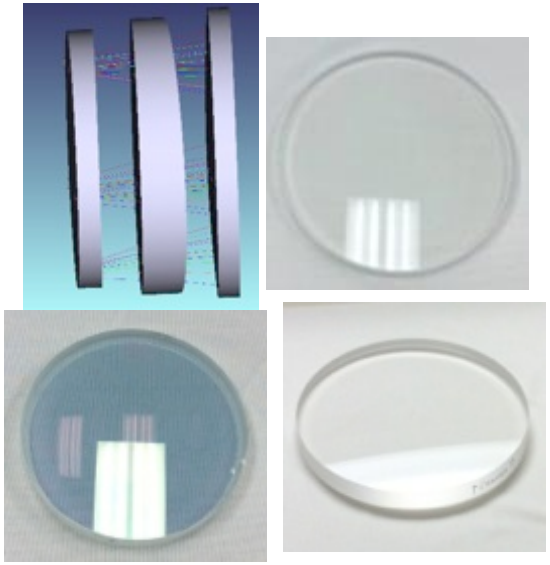
C. Peddie

WFIRST WFI Status

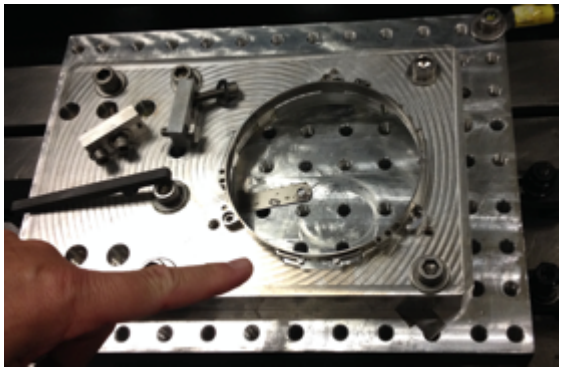
STATUS AS OF: 12-8-14

- WFI design models being updated and preliminary assessments have begun
- Optics - New Optics lead on board, welcome Cathy Marx
  - Stray light and thermal emission analysis report issued
  - Completed opto-mechanical layout including IFU
  - Band pass filters – received substrates, characterization to begin imminently
  - Grism – test grating samples demonstrated 90-94% at 630nm (desired efficiency 90% at 630nm)



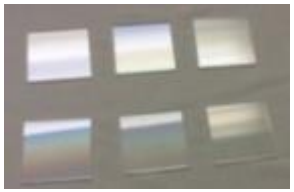


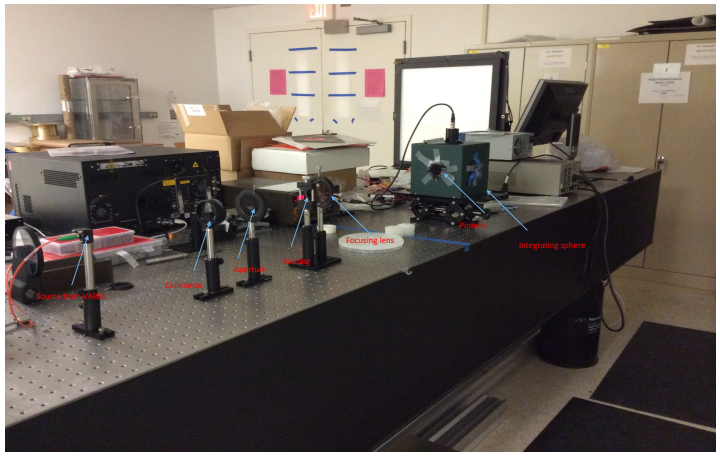
Grism layout and procured substrates



Grism mechanical design
&mounting ring in fabrication

Grating samples





Grating samples testing in
GSFC Bldg 5

C. Peddie

WFIRST-AFTA Detector Technology Milestones

MS #	Milestone	Milestone Date
✓ 1	Produce, test, and analyze **2 candidate passivation techniques** (PV1 and PV2) in **banded arrays** to document baseline performance, inter-pixel capacitance, and shall meet the following derived requirements: dark current less than 0.1 e-/pixel/sec, CDS noise less than 20 e-, and QE greater than 60% (over the bandpass of the WFI channel) at nominal operating temperature.	7/31/14
✓ 2 *	Produce, test, and analyze **1 additional candidate passivation technique** (PV3) in **banded arrays** to document baseline performance, inter-pixel capacitance, and shall meet the following derived requirements: dark current less than 0.1 e-/pixel/sec, CDS noise less than 20 e-, and QE greater than 60% (over the bandpass of the WFI channel) at nominal operating temperature.	12/30/14
3	Produce, test, and analyze **full arrays with operability > 95%** and shall meet the following derived requirements: dark current less than 0.1 e-/pixel/sec, CDS noise less than 20 e-, QE greater than 60% (over the bandpass of the WFI channel) , inter-pixel capacitance ≤3% in nearest-neighbor pixels at nominal operating temperature.	9/15/15
4	Produce, test, and analyze final selected recipe in **full arrays demonstrating a yield of > 20%** with operability > 95% and shall meet the following derived requirements: dark current less than 0.1 e-/pixel/sec, CDS noise less than 20 e-, QE greater than 60% (over the bandpass of the WFI channel) , inter-pixel capacitance ≤3% in nearest-neighbor pixels, persistence less than 0.1% of full well illumination after 150 sec at nominal operating temperature.	9/15/16
5	Complete environmental testing (vibration, radiation, thermal cycling) of one SCA sample part, as per NASA test standards.	12/1/16

*pending HQs acceptance of TAC recommendation

MS #	Milestone	Milestone Date
✓ 2 *	Produce, test, and analyze **1 additional candidate passivation technique** (PV3) in **banded arrays** to document baseline performance, inter-pixel capacitance, and shall meet the following derived requirements: dark current less than 0.1 e-/pixel/sec, CDS noise less than 20 e-, and QE greater than 60% (over the bandpass of the WFI channel) at nominal operating temperature.	12/30/14

The Band 1 pixel design exhibits the best performance across the 4 PV3 SCAs tested in the DCL and exceeds the milestone requirements by a significant margin.

- Other bands (3, 4) also show good performance; preliminary recommendation of band 1 folds in yield considerations as well as performance
- PV3 shows significant improvement in persistence (roughly 0.1% after 180sec vs 0.3% for PV2a)

	Milestone value	PV3 result
Median Dark Current (e-/pix/sec)	<0.1	0.007
Median CDS Noise (e- rms)	<20	17
Median QE (%)	>60	>90

*pending HQs acceptance of TAC recommendation

C. Peddie

WFIRST Coronagraph Progress

- Excellent progress on technology milestones
  - Three completed ahead of schedule
  - Progress underway on next three
- Coronagraph flight design
  - Satisfies current mission resource constraints
  - Not driving the mission design
- Physics-based models are predicting compelling science
- SDT actively engaged with coronagraph engineers through several workshops to address complexity, risk, performance

Coronagraph Key Milestones

MS #	Milestone	Date
✓ 1	First-generation reflective Shaped Pupil apodizing mask has been fabricated with black silicon specular reflectivity of less than 10^{-3} and 20 μm pixel size.	7/21/14
✓ 2	Shaped Pupil Coronagraph in the High Contrast Imaging Testbed demonstrates 10^{-8} raw contrast with narrowband light at 550 nm in a static environment.	9/30/14
✓ 3 *	First-generation PIAACMC focal plane phase mask with at least 12 concentric rings has been fabricated and characterized; results are consistent with model predictions of 10^{-8} raw contrast with 10% broadband light centered at 550 nm.	12/15/14
4	Hybrid Lyot Coronagraph in the High Contrast Imaging Testbed demonstrates 10^{-8} raw contrast with narrowband light at 550 nm in a static environment.	2/28/15
5	Occulting Mask Coronagraph in the High Contrast Imaging Testbed demonstrates 10^{-8} raw contrast with 10% broadband light centered at 550 nm in a static environment.	9/15/15
6	Low Order Wavefront Sensing and Control subsystem provides pointing jitter sensing better than 0.4 mas and meets pointing and low order wavefront drift control requirements.	9/30/15
7	Spectrograph detector and read-out electronics are demonstrated to have dark current less than 0.001 e/pix/s and read noise less than 1 e/pix/frame.	8/25/16
8	PIAACMC coronagraph in the High Contrast Imaging Testbed demonstrates 10^{-8} raw contrast with 10% broadband light centered at 550 nm in a static environment; contrast sensitivity to pointing and focus is characterized.	9/30/16
9	Occulting Mask Coronagraph in the High Contrast Imaging Testbed demonstrates 10^{-8} raw contrast with 10% broadband light centered at 550 nm in a simulated dynamic environment.	9/30/16

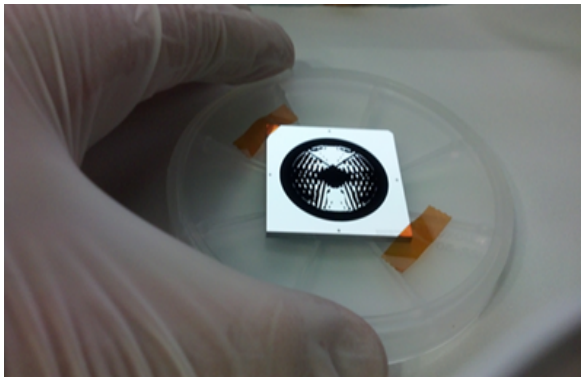
*pending HQs acceptance of TAC recommendation

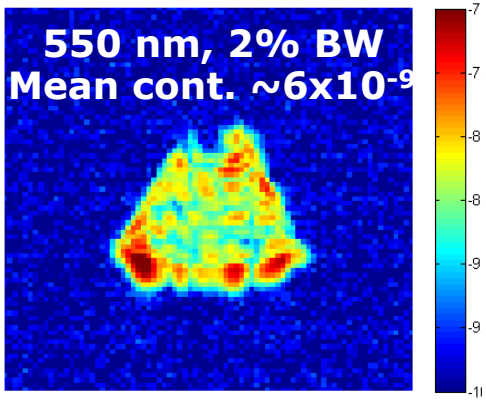
WFIRST Coronagraph: OMC Technology Development

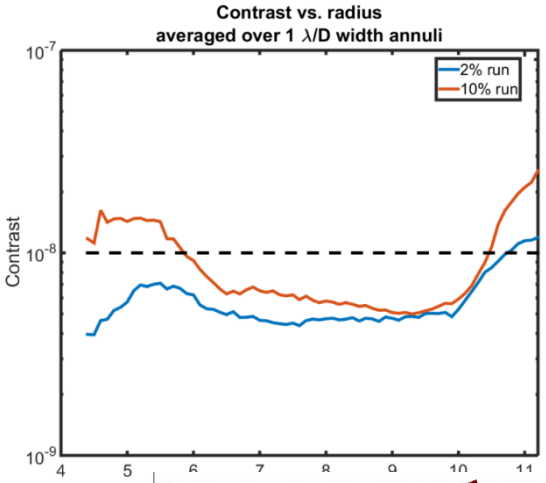
Occulting Mask Coronagraph = Shaped Pupil + Hybrid Lyot

Shaped Pupil Mode

- Reflective pupil mask (Black Si on Al mirror coating) fabricated and characterized: passed Milestone 1
- High contrast demonstrated in SPC testbed: passed Milestone 2

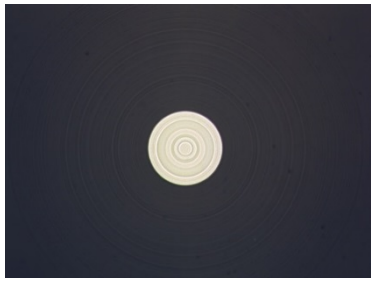


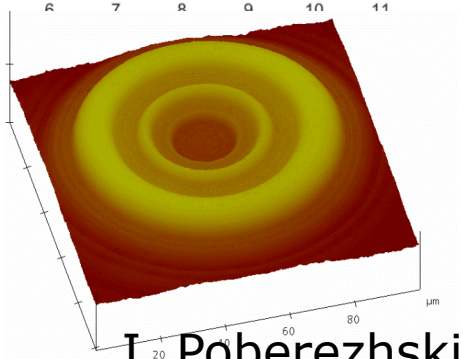




Hybrid Lyot Mode

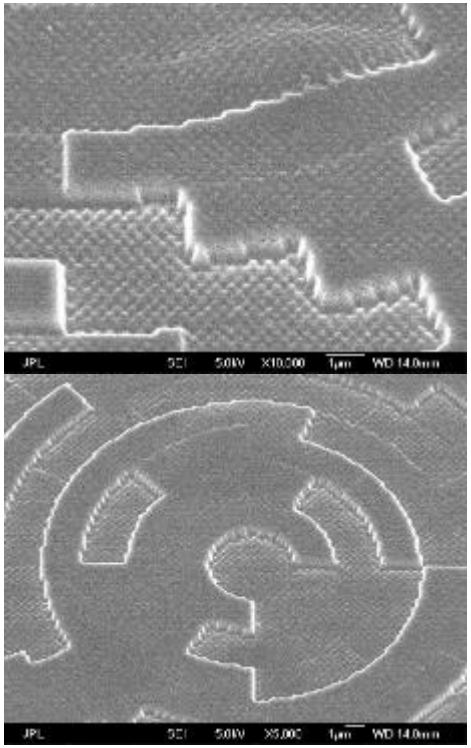
- Circular focal plane occulting mask fabricated and characterized
- HLC testbed commissioned and performing nulling runs toward Milestone 4 due 2/28/2015



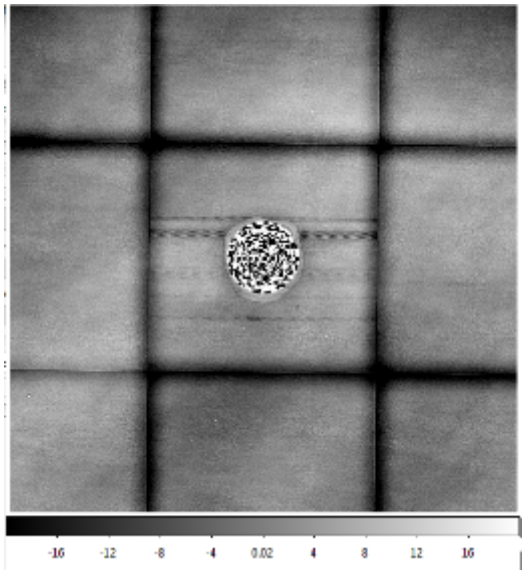


PIAA / CMC: Technology Milestone #3

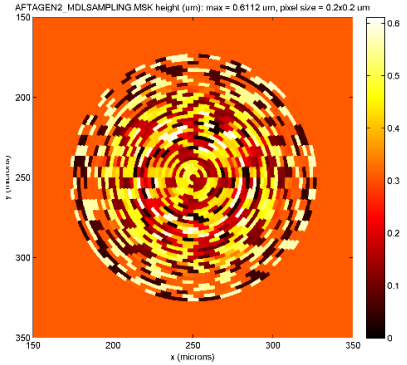
✓	3 *	First-generation PIAACMC focal plane phase mask with at least 12 concentric rings has been fabricated and characterized; results are consistent with model predictions of 10^{-8} raw contrast with 10% broadband light centered at 550 nm.



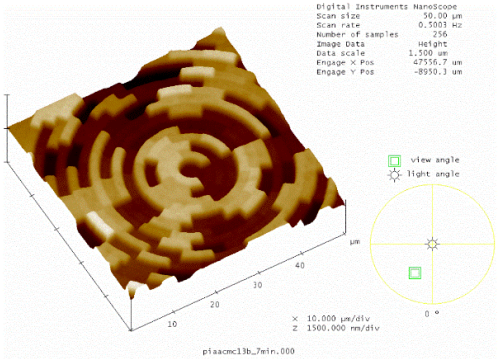
SEM



ZeMapper Profilometer

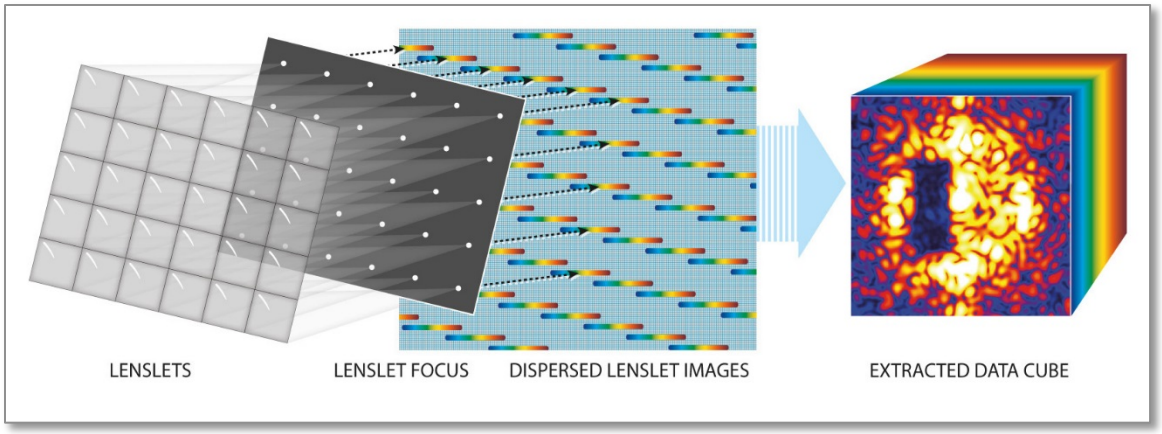


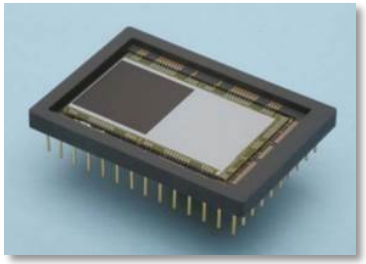
PIAACMC Mask Design



PIAACMC 2nd run measurements

WFIRST/AFTA: Spectrometer For Coronagraph





Test-bed IFS (PISCES) provided by GSFC

1. Will be integrated into High Contrast Imaging Test-bed (JPL) in FY15
2. Detector: 1K×1K format, 13 micron pixels
3. Will be used to demonstrate planet spectroscopy and to develop post processing software

CCD201 can be operated in three modes:

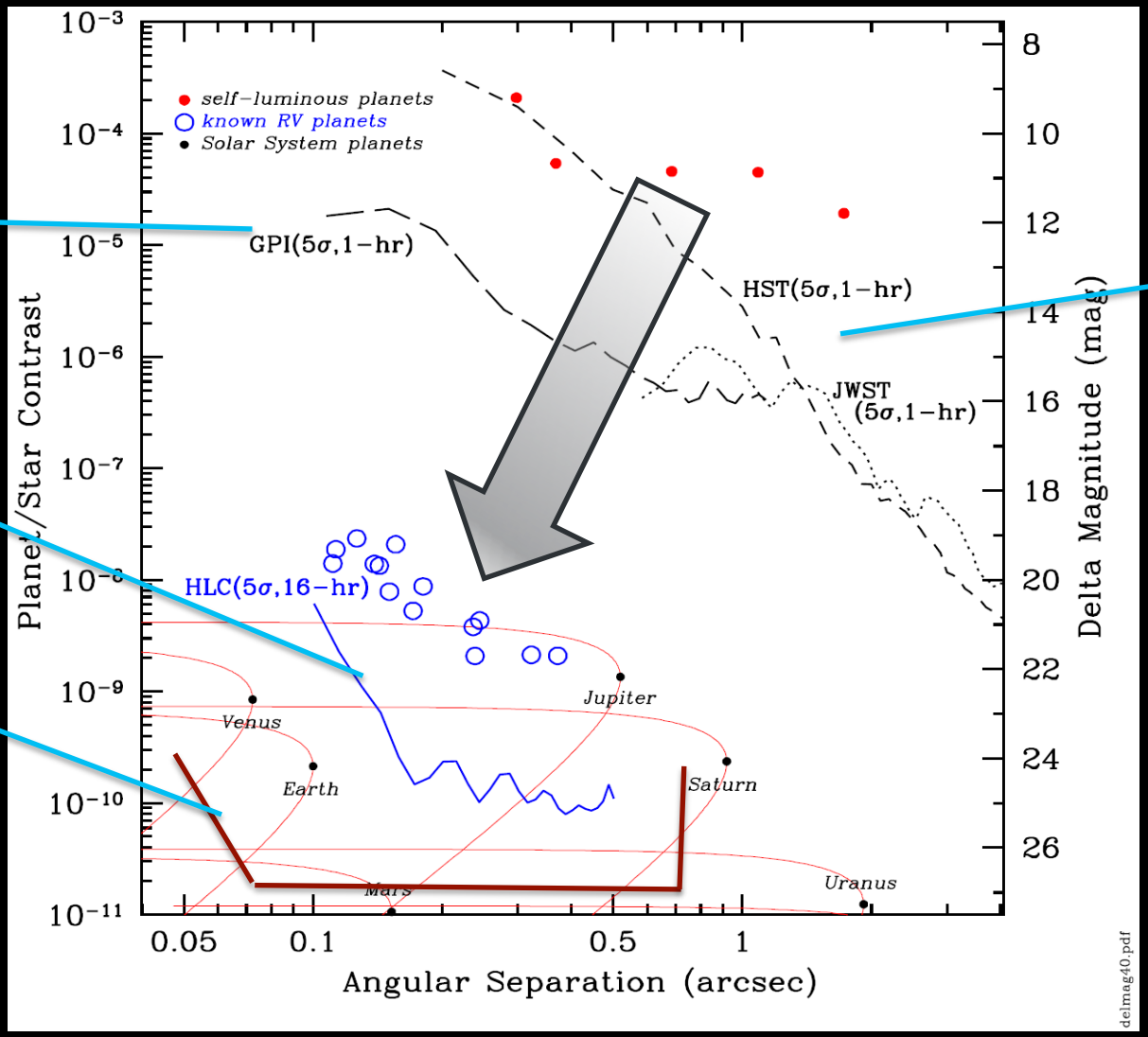
1. Conventional CCD (unity gain)
2. EMCCD (analog gain)
3. EMCCD (photon counting)

Flight Qualification planned:

1. Radiation degradation (DDD & TID)
2. Thermal cycling

M. McElwain, R. Demers

WFIRST Coronagraph images cool gas and ice giants



GPI

WFIRST

New Worlds Telescope

HST

JWST

W. Traub

Program Science: Studies in support of WFIRST/AFTA and Probes

- RV completeness of the likely candidate stars for WFIRST and the Probes. **Andrew Howard** (University of Hawaii)

  http://exep.jpl.nasa.gov/reportsAndDocuments/completenessStudy/

Quick Studies provided to each S(T)DT:

- Detection and Characterization of Circumstellar Material with an AFTA or EXO-C/S CGI. **Glenn Schneider** (UofA)
- A Quick Study of the Characterization of Radial Velocity Giant Planets in Reflected Light by Forward and Inverse Modeling. **Mark Marley** et al (ARC, STScI, UC Santa Cruz)
- Scientific Return of Coronagraphic Exoplanet Imaging and Spectroscopy Using WFIRST. **Adam Burrows** (Princeton University)
- Ammonia, Water Clouds and Methane Abundances of Giant Exoplanets and Opportunities for Super-Earth Exoplanets. **Renyu Hu, (**Hubble Fellow, JPL)

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Technology Needs and Priorities

- Quantified, prioritized technology gaps (needs, capabilities) drive investment solicited through SAT / ROSES / TDEM

Science Goal	Capability	Needed Technologies	Technology Gaps
Detection of life	Spectroscopy of light from direct exo-planet imaging	starlight suppression (internal and external occulters)	Coronagraph Technology Gap List Starshade Technology Gap List

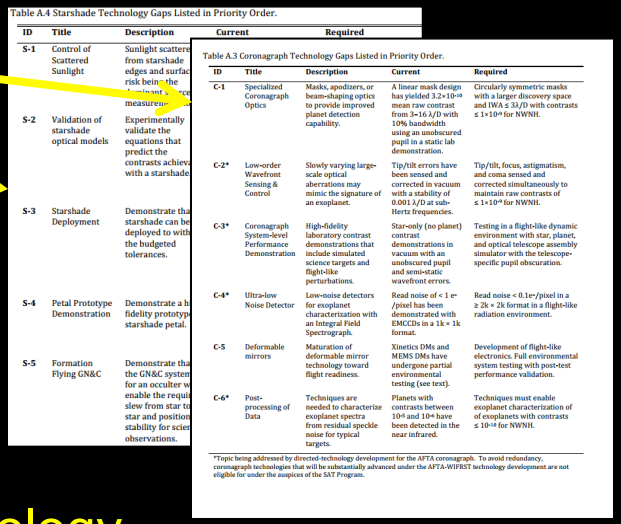


Table A.4 Starshade Technology Gaps Listed in Priority Order.

ID	Title	Description	Current	Required
S-1	Control of Scattered Sunlight	Sunlight scattered from starshade edges and surfac risk being the measureu		
S-2	Validation of starshade optical models	Experimentally validate the equations that predict the contrasts achiev with a starshade		
S-3	Starshade Deployment	Demonstrate tha starshade can be deployed to with the budgeted tolerances.		
S-4	Petal Prototype Demonstration	Demonstrate a h fidelity prototyp starshade petal.		
S-5	Formation Flying GN&C	Demonstrate tha the GN&C syster for an occulter w enable the requi slew from star t star and position stability for scie observations.		

Table A.3 Coronagraph Technology Gaps Listed in Priority Order.

ID	Title	Description	Current	Required
C-1	Specialized Coronagraph Optics	Masks, apodizers, or beam-shaping optics to provide improved planet detection capability.	A linear mask design has yielded 3.2×10^{-10} mean raw contrast from $3-16\,\lambda/D$ with 10% bandwidth using an unobscured pupil in a static lab demonstration.	Circularly symmetric masks with a larger discovery space and IWA ≤ $3\lambda/D$ with contrasts ≤ 1×10^{-8} for NWNH.
C-2*	Low-order Wavefront Sensing & Control	Slowly varying large-scale optical aberrations may mimic the signature of an exoplanet.	Tip/tilt errors have been sensed and corrected in vacuum with a stability of $0.001\,\lambda/D$ at sub-Hertz frequencies.	Tip/tilt, focus, astigmatism, and coma sensed and corrected simultaneously to maintain raw contrasts of ≤ 1×10^{-9} for NWNH.
C-3*	Coronagraph System-level Performance Demonstration	High-fidelity laboratory contrast demonstrations that include simulated science targets and flight-like perturbations.	Star-only (no planet) contrast demonstrations in vacuum with an unobscured pupil and semi-static wavefront errors.	Testing in a flight-like dynamic environment with star, planet, and optical telescope assembly simulator with the telescope-specific pupil obscuration.
C-4*	Ultra-low Noise Detector	Low-noise detectors for exoplanet characterization with an Integral Field Spectrograph.	Read noise of < 1 e^-/pixel has been demonstrated with EMCCDs in a 1k × 1k format.	Read noise < 0.1e^-/pixel in a ≥ 2k × 2k format in a flight-like radiation environment.
C-5	Deformable mirrors	Maturation of deformable mirror technology toward flight readiness.	Xinetics DMs and MEMS DMs have undergone partial environmental testing (see text).	Development of flight-like electronics. Full environmental system testing with post-test performance validation.
C-6*	Post-processing of Data	Techniques are needed to characterize exoplanet spectra from residual speckle noise for typical targets.	Planets with contrasts between 10^{-6} and 10^{-8} have been detected in the near infrared.	Techniques must enable exoplanet characterization of of exoplanets with contrasts ≤ 10^{-10} for NWNH.

*Topic being addressed by directed-technology development for the AFTA coronagraph. To avoid redundancy, coronagraph technologies that will be substantially advanced under the AFTA-WFIRST technology development are not eligible for under the auspices of the SAT Program.

- Read more at http://exep.jpl.nasa.gov/technology

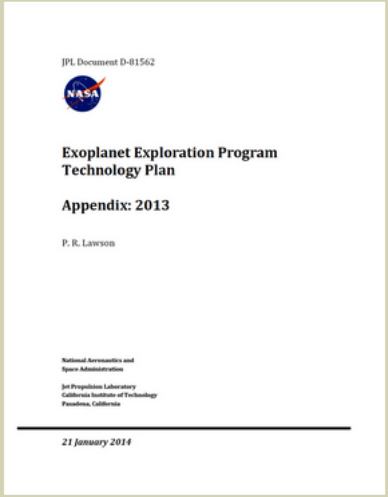
Technology Progress Through TDEM

JPL WBS	PI	NICKNAME
		TDEM 2009
	Martin	Mid-IR Interferometric planet detection, instability noise
09.01.12	Noecker/Kendrick /Shaklan	Speckle measurement algorithms & Pin-Hole Method
09.01.04	Trauger	Hybrid Lyot Masks, broad-band starlight suppression
GSFC/HQ	Guyon	PIAA Low-order WF Sensor
09.01.16	Kasdin	Starshade petal manufacturing
09.01.03	Krist	Efficient Coronagraph Modeling (MS #1)
09.01.03	Krist	Efficient Coronagraph Modeling (MS #2)
GSFC/HQ	Figer	Avalanche Photo-diode arrays, radiation testing
09.01.08	Guyon	PIAA, monochromatic suppression
GSFC	Clampin/Lyon	Visible Nulling Coronagraph
		SAT/TDEM 2010
10.34	Serabyn	Vector Vortex Masks, starlight suppression in HCIT
10.33	Sandhu	Visible Nulling Coronagraph, starlight suppression
non-TDEM	Schneider	EXCEDE (Explorer supported)
10.35	Shaklan	TPF-C MS #3A, Lyot Mask model sensitivity validation
10.31	Kasdin	Starshade deployment demonstration
10.41	Kasdin	2 DMs starlight suppression
HQ	Bierden	MEMS deformable mirrors
HQ	Helmbrecht	Testing of MEMS DMs
10.29	Guyon	PIAA, broadband starlight suppression
GSFC	Lyon	Visible Nulling Coronagraph broadband testing
		SAT/TDEM 2012
HQ	Casement	Starshade edge scattering
HQ	Glassman	Optical Model Validation "Field Test"
	Kasdin	Optical and Mechanical Verification of External Occulter
		SAT/TDEM 2013
		SAT/TDEM 2014

Completed Completed since last ExoPAG
Will complete FY15
Planned complete > FY15

TECHNOLOGY PLAN

Technology Plan Appendix: 2013 (Preliminary)


JPL Document D-81562

Exoplanet Exploration Program
Technology Plan

Appendix: 2013

P. R. Lawson

21 January 2014

TDEM plans and final reports posted at exep.jpl.nasa.gov

ExoTAC

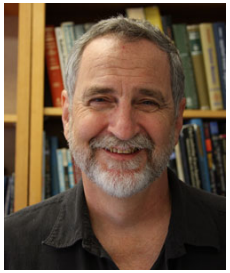
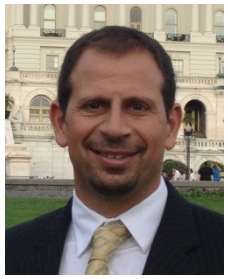
Alan Boss, Carnegie Institute for Science
Rebecca Oppenheimer, American Museum of Natural History
Joe Pitman, Exploration Sciences
Lisa Poyneer, Lawrence Livermore National Laboratory
Stephen Ridgway, National Optical Astronomy Observatory

SAT 2014: amendment released 12/16/14
SAT 2014 solicitation briefing: 1/20/15
Proposals due: 3/20/15

Technology Accomplishments and Status (cont'd)

- **Four TDEM-13 Awardees:**
  - **Rick Lyon** (NASA GSFC): Segmented Aperture Nulling Coronagraphy *(Coronagraph Technology Gap #1)*
  - **Jeremy Kasdin** (Princeton University): Formation Flying for External Occulters *(Starshade Technology Gap #5).*
  - **Webster Cash** (Colorado University): Development of Formation Flying Sensors *(Starshade Technology Gap #5)*
  - **Eduardo Bendek** (NASA Ames): Enhanced Direct Imaging Exoplanet Detection with Astrometric Mass Determination.



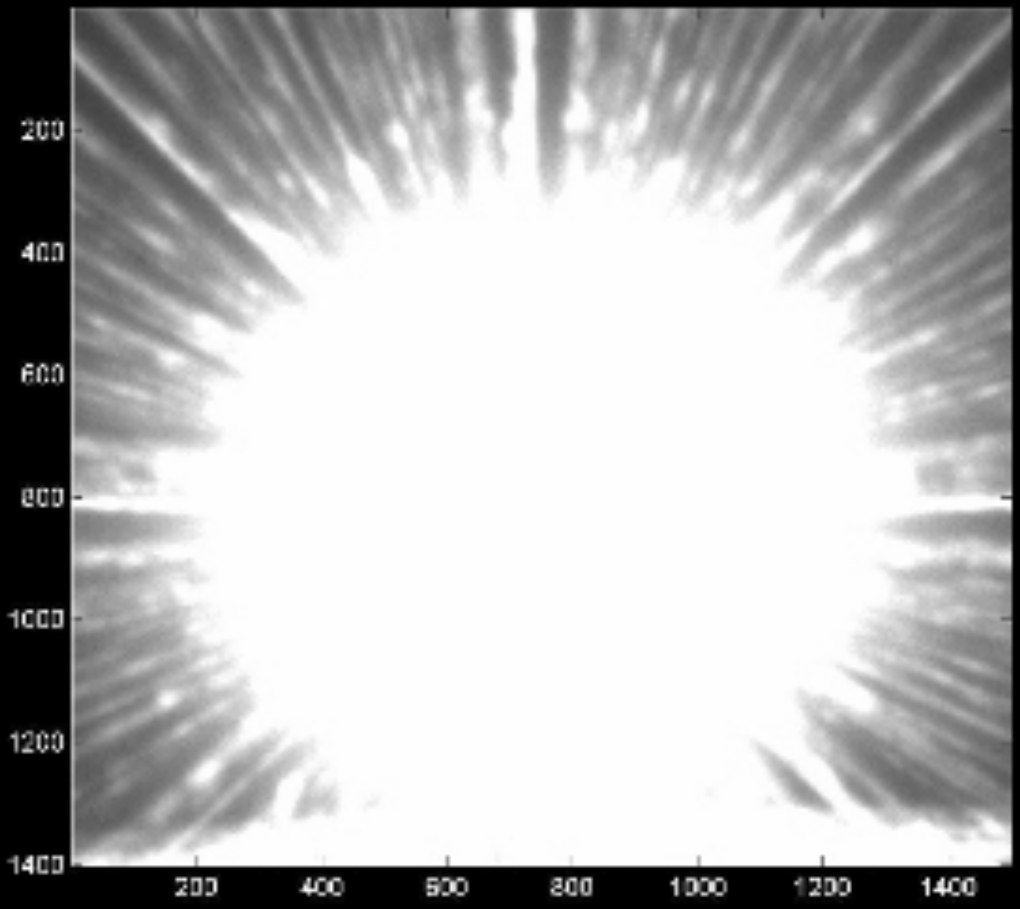
- **Suzi Casement's TDEM-12 (Starshade Edge Scattering) Milestone Definition Report was approved by the Exo-TAC.** *(Starshade Technology Gap #1)*
- **Preliminary designs, model predictions, and error budgets have been completed for the HCIT Modelable Coronagraph Bench.** *(Coronagraph Technology Gap #3)*

Technology Accomplishments and Status (cont'd)

- **Starshade demonstrations by NGAS (TDEM-12 PI Glassman) concluded their second testing campaign in the Nevada desert.** *(Starshade Technology Gap #2)*
  - Several sets of 58 cm starshades (each with intentional defects added for model validation studies) were tested.
  - Results are being analyzed and will be compared to model predictions.

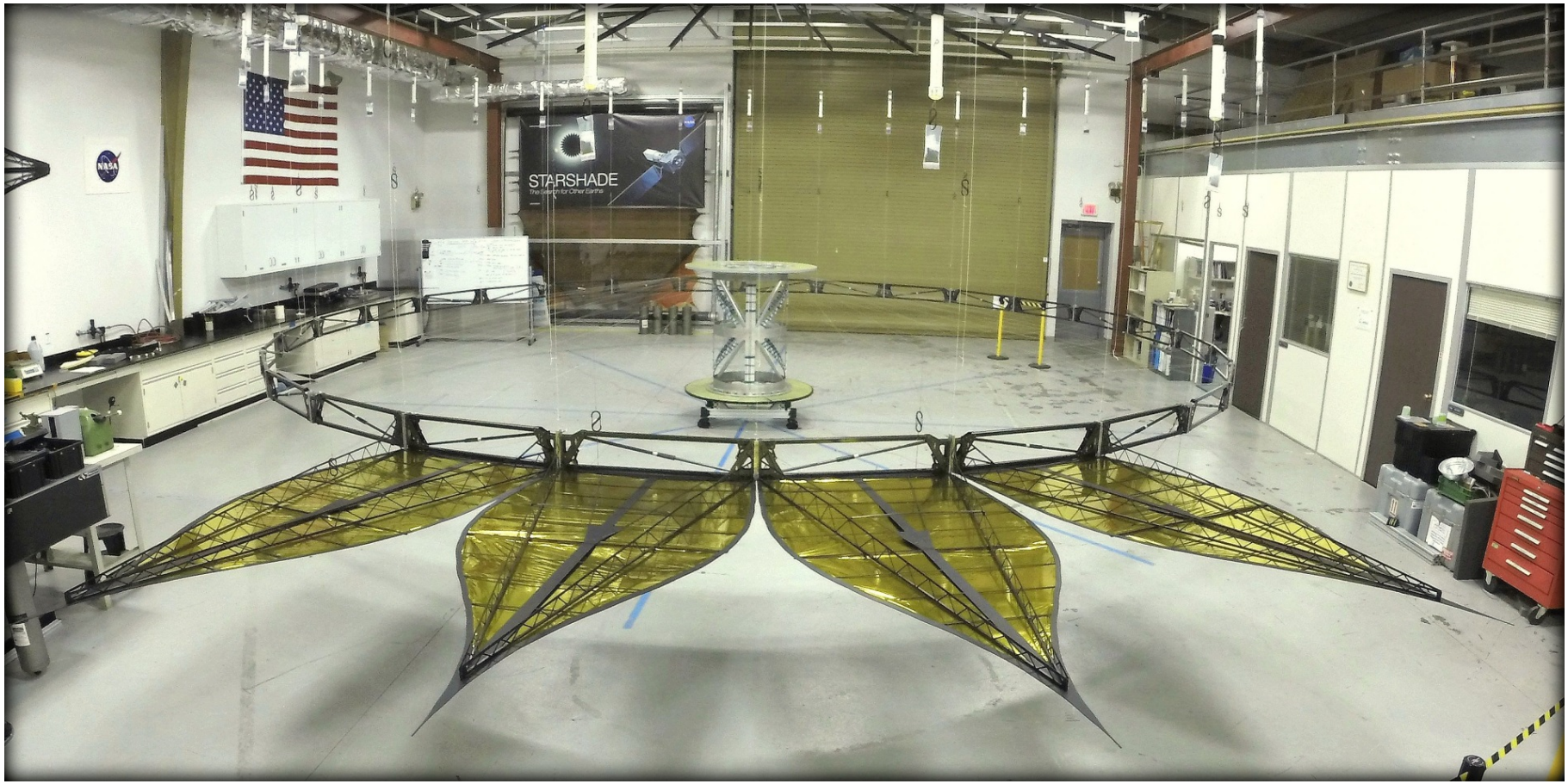
Credit: NGAS

Desert Testing of Starshades



S. Warwick, Northrop Grumman

Starshade Deployment Testbed

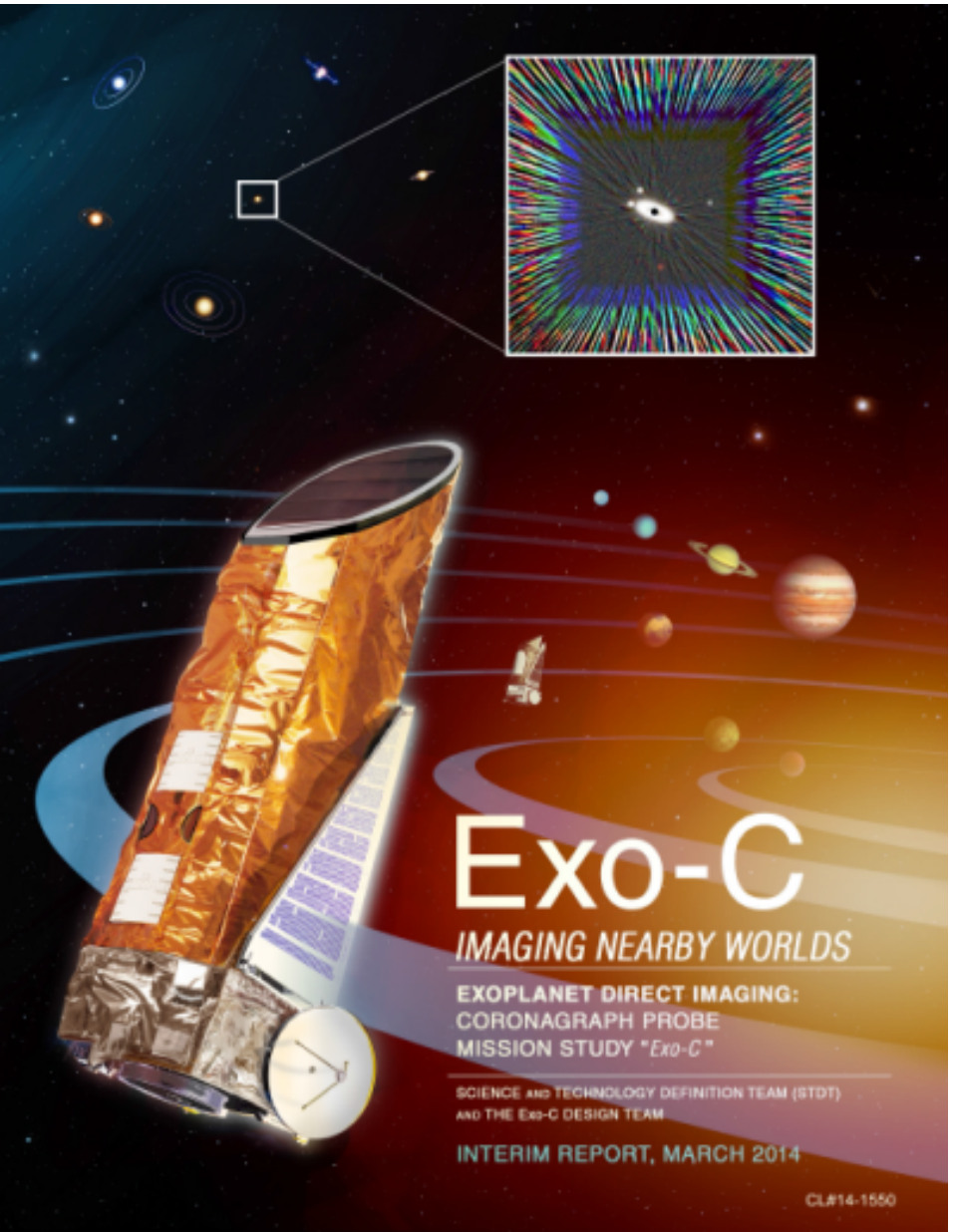


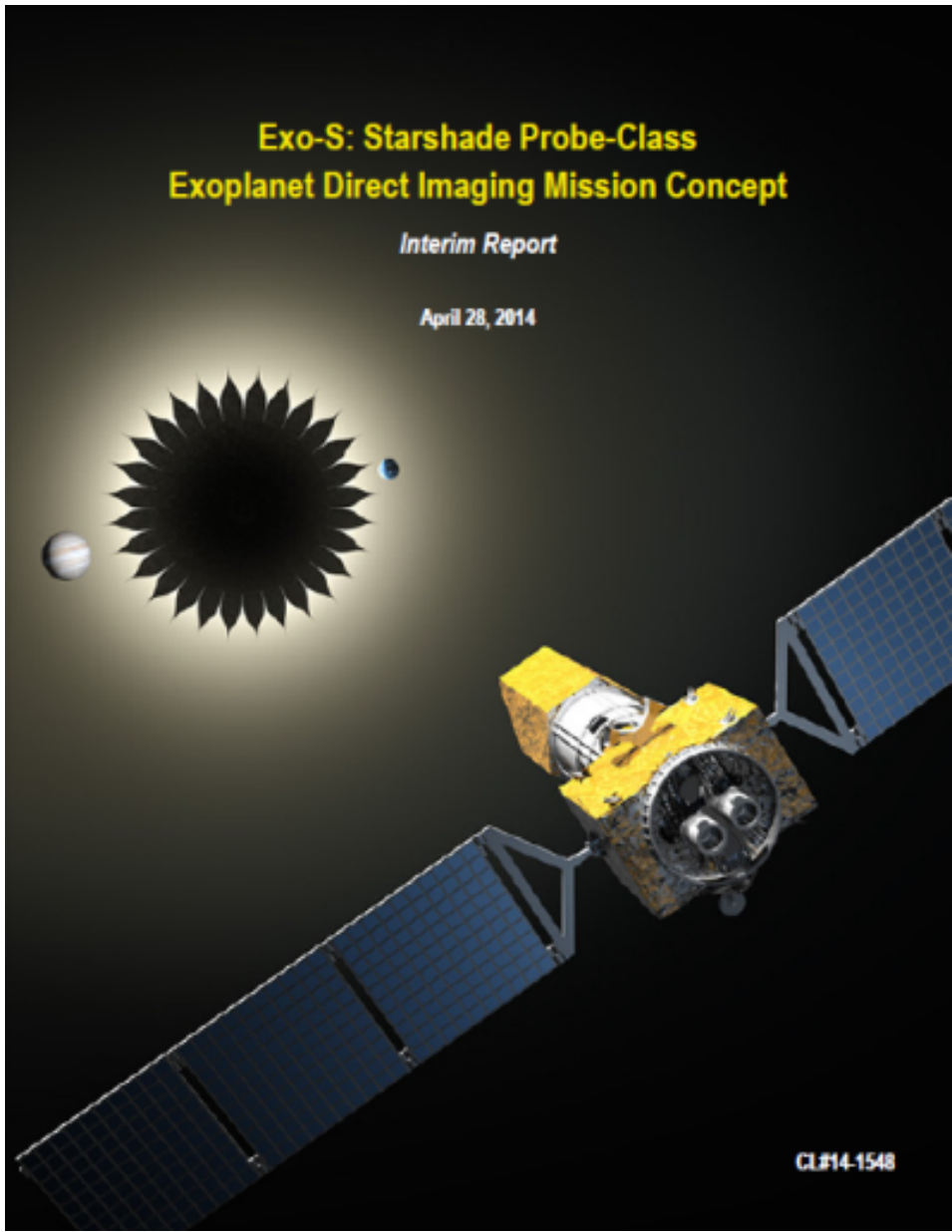
- **The 10m half-scale inner disk is shown in full deployment in Bldg 299 at JPL along with its gravity compensation fixtures. The petals are only for physical demonstration.** *(Starshade Technology Gap #3)*
- **This facility is now available for technology demonstrations by all selected PI's in behalf of the Exoplanet Program (ExEP).**

N. Siegler

Early Starshade Deployment Trial at JPL (Front View)

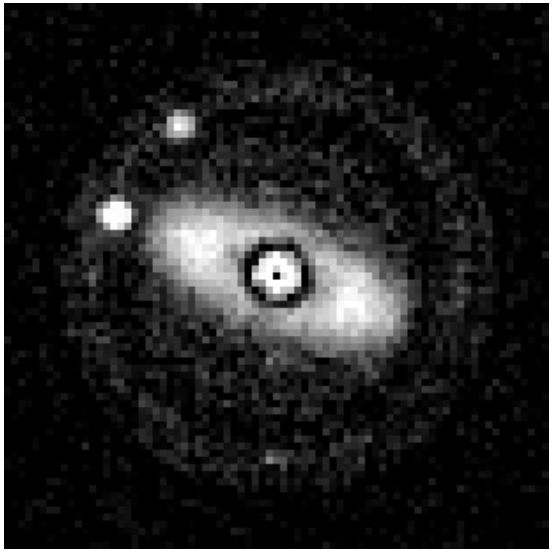
Probe Studies



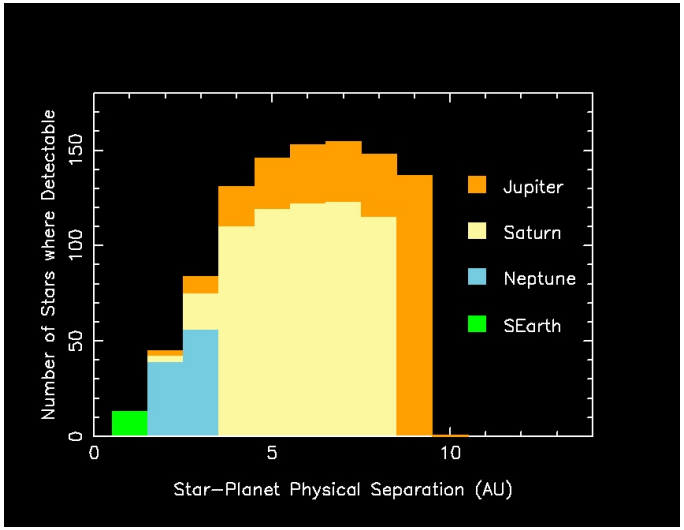


Exo-C: Probe Coronagraph

Simulated 6-hr exposure of Altair: Jupiter analogs at 5 and 10 AU are readily detected, along with a 1 zodi dust belt between 2-4 AU.

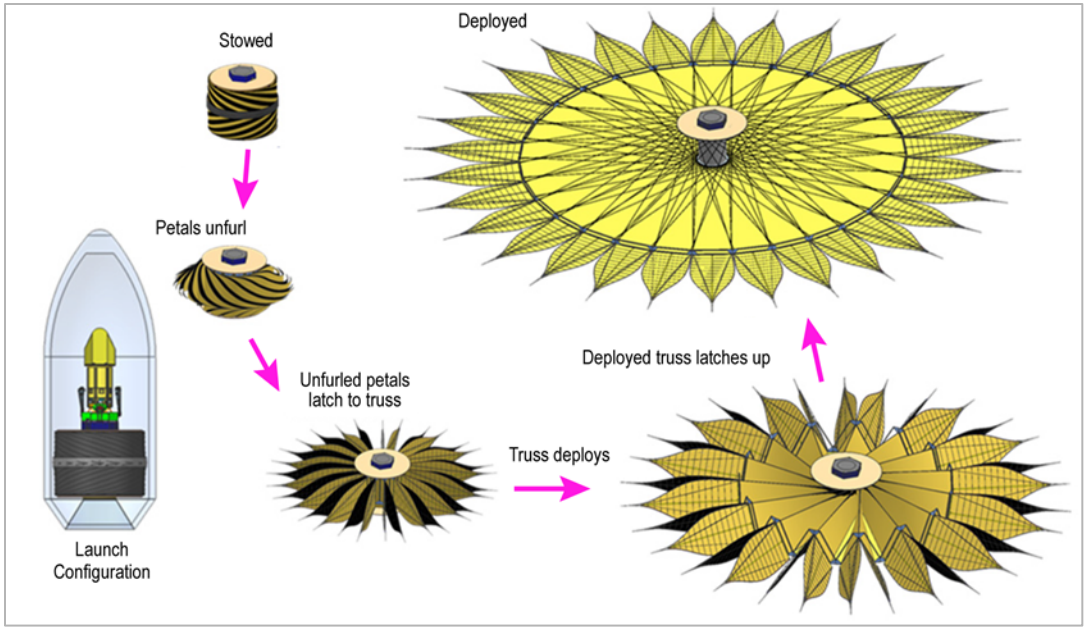


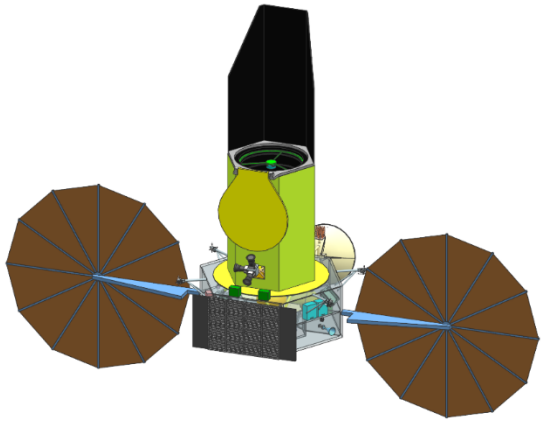
Exoplanet search space for Exo-C with the Hybrid Lyot Coronagraph.

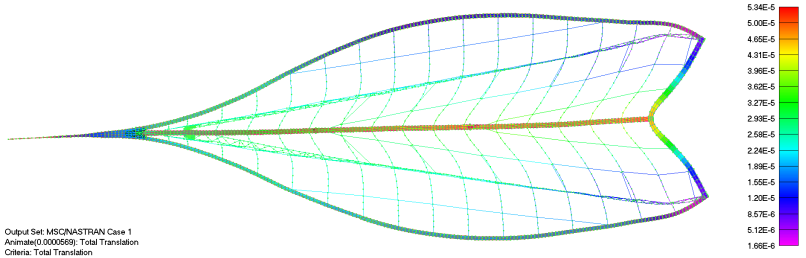


K. Stapelfeldt et al

Exo-S: Probe Starshade

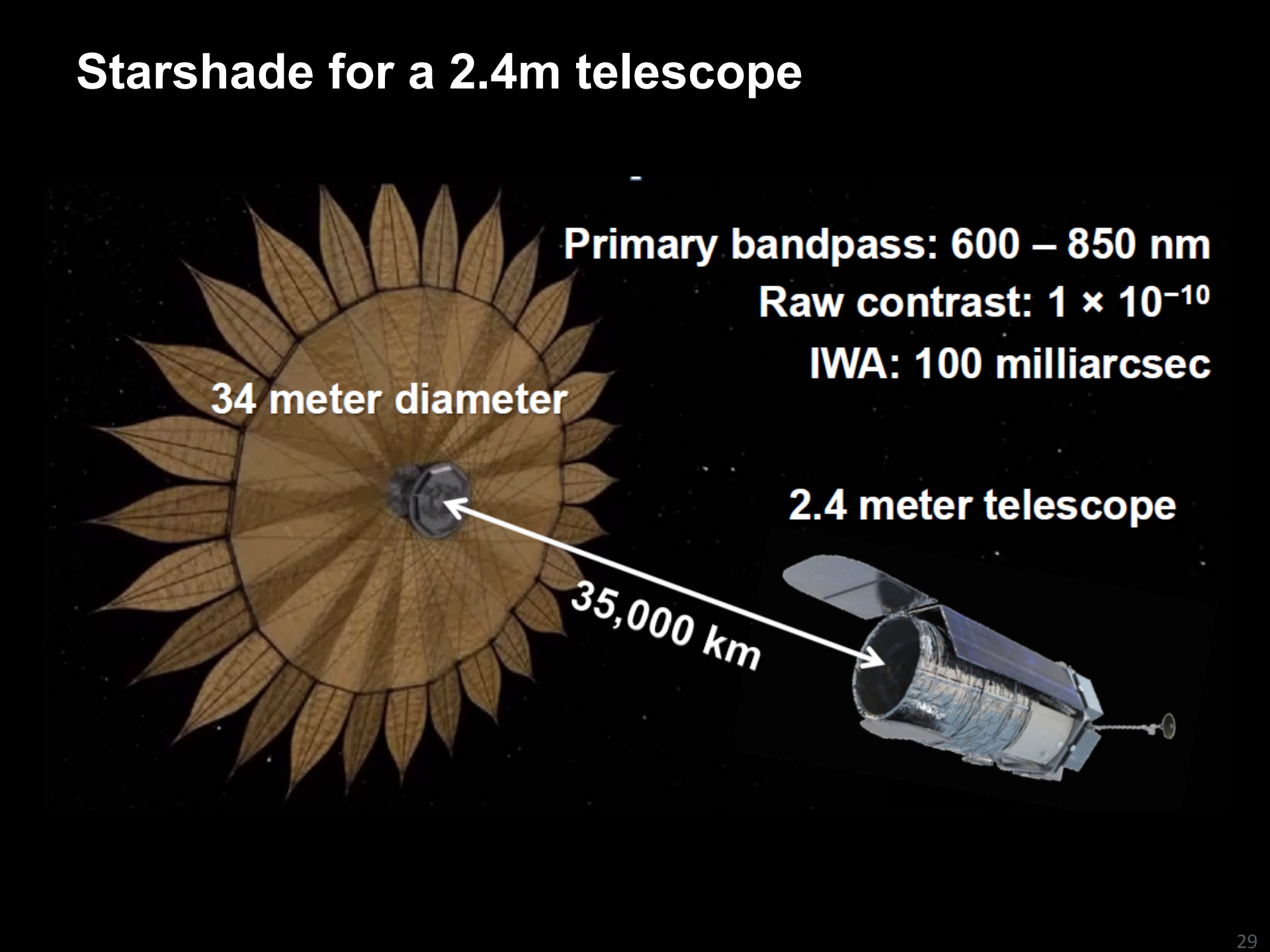






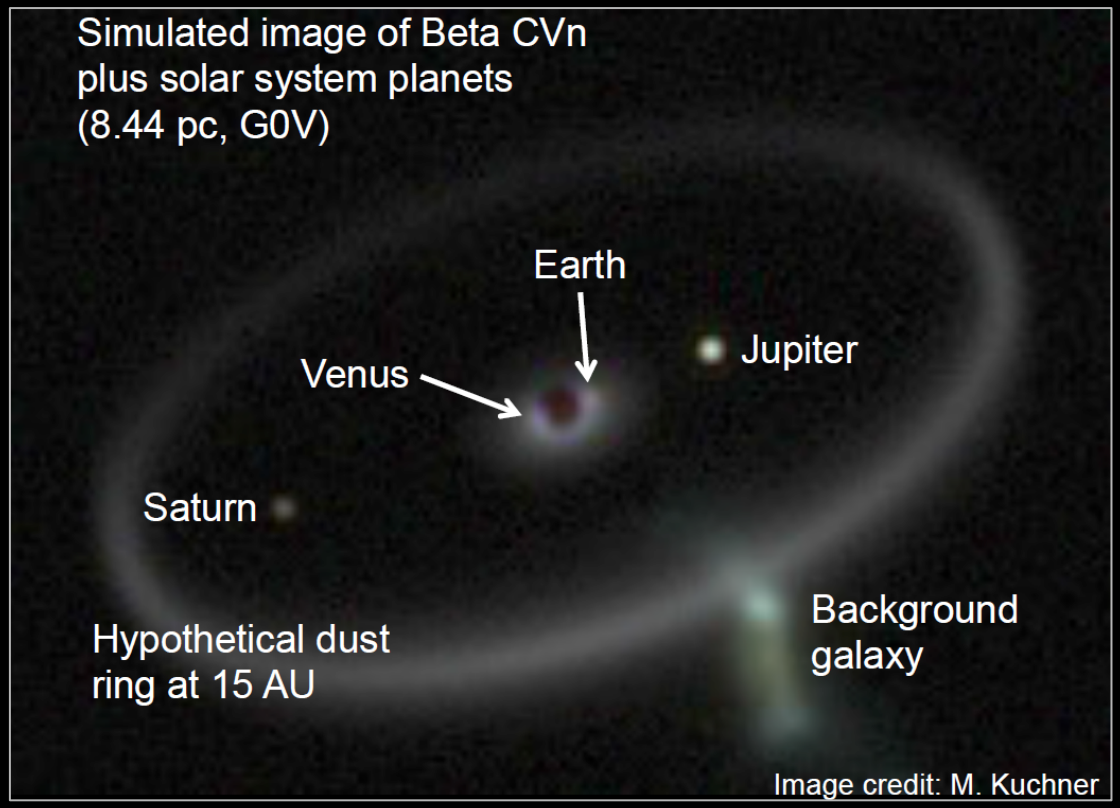
S. Seager et al

Starshade for a 2.4m telescope



Example of Science from Starshade with 2.4m telescope

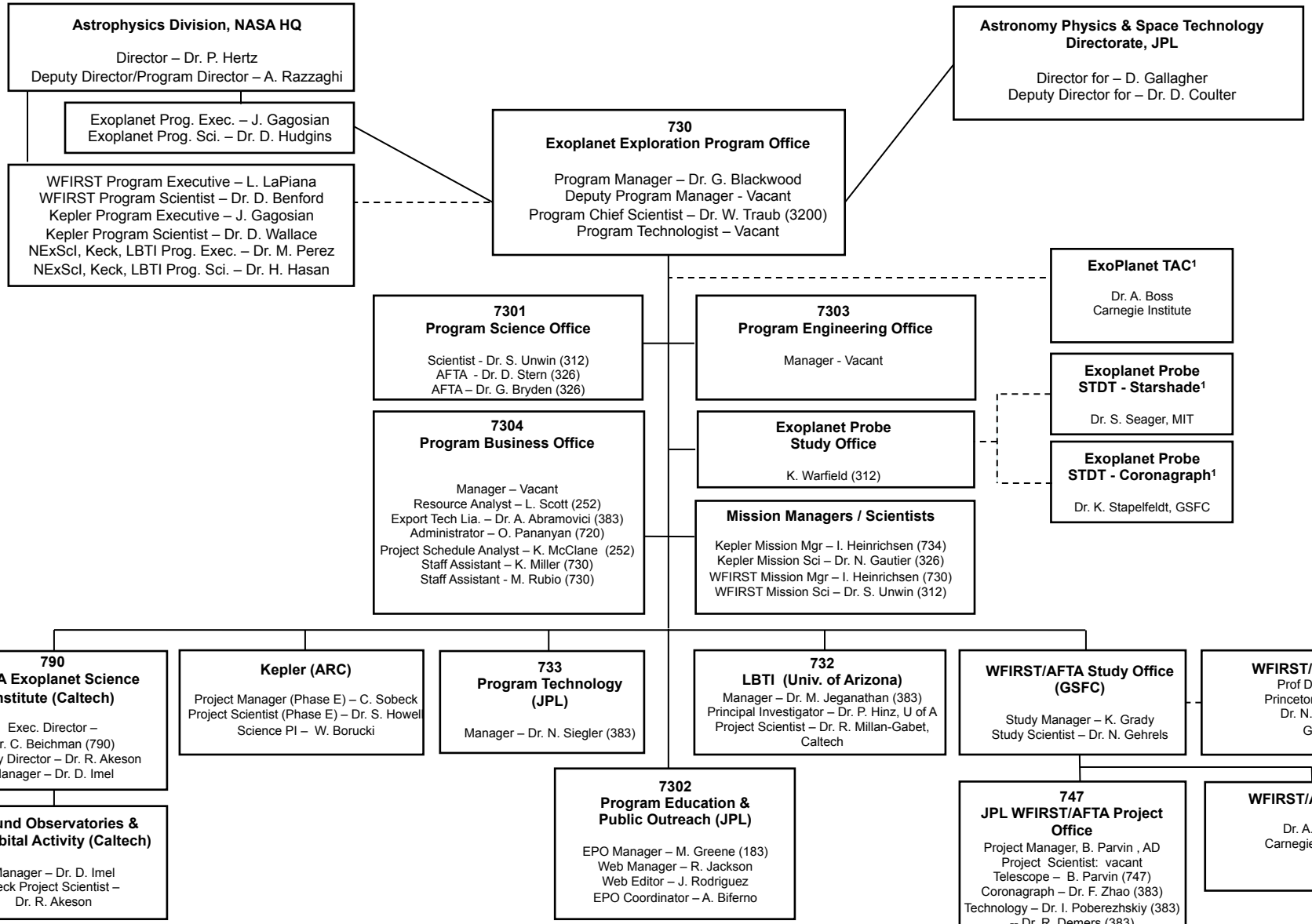
- Observe 52 stars in 2 years
- 13 known exoplanets
- 19 HZ targets. Expect ~ 2 Earths or Super-Earths
- Can detect sub-Neptunes to Jupiters around all HZ targets and 20 additional stars



Probe Follow-On Studies

- Explore variations in parameter space (science, cost, TRL) beginning with perturbations to the Probe design and cost points
- Will help inform potential decadal study concept studies on the critical **design** and **science** sensitivities for starshade and coronagraph concepts
- Maintain two existing STDTs and a small study team
- Will review priorities with STDTs and APD during PPBE process, after final reports are briefed to national committees in April

Exoplanet Exploration Program Organization Chart



[1]Reports to HQs APD

ExEP Program Chief Scientist: Job Opening

- Wes Traub appointed by JPL as the JPL WFIRST/AFTA Project Scientist
- ExEP PCS position is at JPL, Pasadena CA, for the NASA Astrophysics Division
- Job responsibilities include:
  - Scientific oversight of the various projects within ExEP;
  - Support of NASA HQ in programmatic and scientific matters within ExEP;
  - Reporting to NASA science advisory bodies and science communities;
  - Support of the NASA HQ Lead Program Scientist in liaison activities with the science community;
  - Open and frequent communications with the scientists at NExScI, JPL, and the national and international science community

- If you are interested in making a difference in exoplanet science and missions at the program level, please see Gary Blackwood (Program Manager) or Doug Hudgins (Program Scientist)
- Information available at http://exep.jpl.nasa.gov.

Looking Ahead

- Jan 31, 2015 WFIRST/AFTA SDT Final Report
  Probe Studies Final Reports
- Feb 26, 2015 Aerospace CATE on WFRIST/AFTA and Probes
- Feb 12-13 LOWFSC & Point-Spread Function Meeting (JPL)
- Summer 2015 Sagan Workshop: "Exoplanetary System Demographics"
- CY15: Planning for placement of Eyes on Exoplanets at the National Air & Space Museum in Washington DC.
- April 16 2015: LBTI Operational Readiness Review
- CY15: Continuation of two probes STDTs and small study team.
- Autumn 2015: Engage Industry and Academia further in exoplanet technology: an Exoplanet Technology Group (ExoTech), possibly as a session within existing Mirror Days.

At this AAS:

- Poster sessions on WFIRST Technology, Probe Studies, LUVOIR
- Many Oral presentations

Acknowledgements

- This was carried out at the Jet Propulsion Laboratory, California Institute of Technology under a contract with the National Aeronautics and Space Administration. © 2015. All rights reserved.
- Work also carried out by
  - NASA Goddard Space Flight Center
  - NASA Ames Research Center
- Work also carried out by University of Arizona under a contract with the Jet Propulsion Laboratory.
- Work also carried out by Princeton University, University of Arizona and Northrop Grumman Aerospace Systems under contracts with the National Aeronautics and Space Administration.
- Contributions gratefully acknowledged from Karl Stapelfeldt and the Exo-C STDT, and by Sara Seager and the Exo-S STDT, Wes Traub,, Nick Siegler, Feng Zhao, Steve Unwin, Kevin Grady, Cathy Peddie, and Kelly McClane.

BACKUP

NASA/NSF Partnership for Exoplanet Research

Extreme Precision Doppler Spectrometer

- Scope:
  - Exoplanet-targeted Guest Observer program with existing instrumentation on WIYN using NOAO share (40%) of telescope time
  - Solicitation for facility-class extreme precision radial velocity spectrometer for WIYN telescope (commissioning goal: 2018)
- Motivation
  - Follow-up of current missions (K2, TESS, JWST)
  - Pathfinder observations inform design/operation of future missions
- Anticipated Timeline:
  - Early Dec 2014: community announcement
  - Jan 2015: amendment to ROSES 2014 NRA

3.5m WIYN Telescope
Kitt Peak National Observatory
Arizona

Extreme Precision Doppler Spectrometer

Information / FAQs: http://exep.jpl.nasa.gov/epds

Extreme Precision Doppler Spectrometer

Community Announcement of Intent to release an Extreme Precision Doppler Spectrometer Call for Proposals

Summary of Announcement: This notice is to announce the upcoming release by NASA of an amendment to the ROSES-2014 NASA Research Announcement (NRA) soliciting proposals for development of an Extreme Precision Doppler Spectrometer for the Wisconsin, Indiana, Yale and NOAO (WIYN) 3.5-m telescope at Kitt Peak.

Background and Details: In its report, "New Worlds, New Horizons," the Astro2010 Decadal Survey challenged NASA and the National Science Foundation (NSF) to "support an aggressive program of ground-based high-precision radial velocity surveys of nearby stars in order to validate and characterize exoplanet candidates." In response to that challenge, the two agencies recently announced the establishment of a new partnership for exoplanet research. This NASA-NSF Exoplanet Observational Research (NN-EXPLORE) partnership will take advantage of the National Optical Astronomy Observatory (NOAO) share of the 3.5-m WIYN telescope at Kitt Peak National Observatory to provide the community with telescope access and tools to conduct ground based observations that advance exoplanet science. The NN-EXPLORE partnership will particularly emphasize research to validate space-based transit observations (e.g. K2, The Transiting Exoplanet Survey Satellite) or to inform the exoplanet observations of future NASA missions (e.g. James Webb Space Telescope and Wide Field Infrared Survey Telescope/Astrophysics Focused Telescope Assets .

In accordance with Astro2010, the cornerstone of the NN-EXPLORE partnership will be a new, NASA-funded Extreme Precision Doppler Spectrometer (EPDS) installed as a facility instrument on the WIYN telescope. NASA will require that the EPDS be capable of delivering a radial velocity precision of less than 50 cm/s, with a goal of ~10 cm/s. The goal is for the EPDS to be available for use in facility mode as early as FY 2018. To this end, NASA has identified a funding profile totaling $7M over the period FY 2015 – FY 2018, although the final budget and funding profile will be determined after review of the proposed instruments.

This community announcement is issued to provide the scientific community with advance notice that NASA plans to release a solicitation in the near future for the purposes of procuring the above EPDS. The solicitation will be released as an amendment to the ROSES-2014 NRA, and is expected to be issued in early January 2015. The due date for proposals will be not less than 90 days after the **release of the solicitation**.

NASA Point of Contact:
Dr. Douglas M. Hudgins
Program Scientist,
NASA Exoplanet Exploration Program
Telephone: 202-358-0988
E-mail: **Douglas.M.Hudgins@nasa.gov**

UPDATE

Exoplanet Exploration: A Decade Horizon

NASA and ESA efforts

ExoPlanet Exploration Program