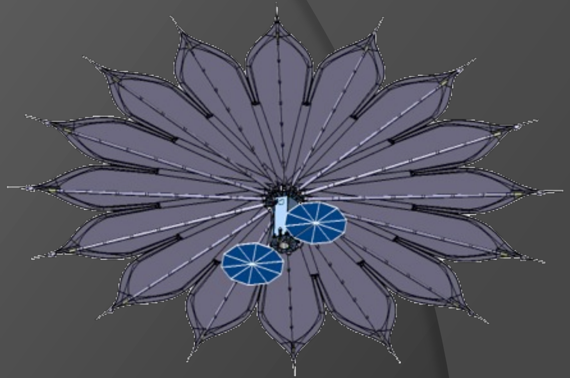
EXOPLANET PROBE – STARSHADE STUDY UPDATE



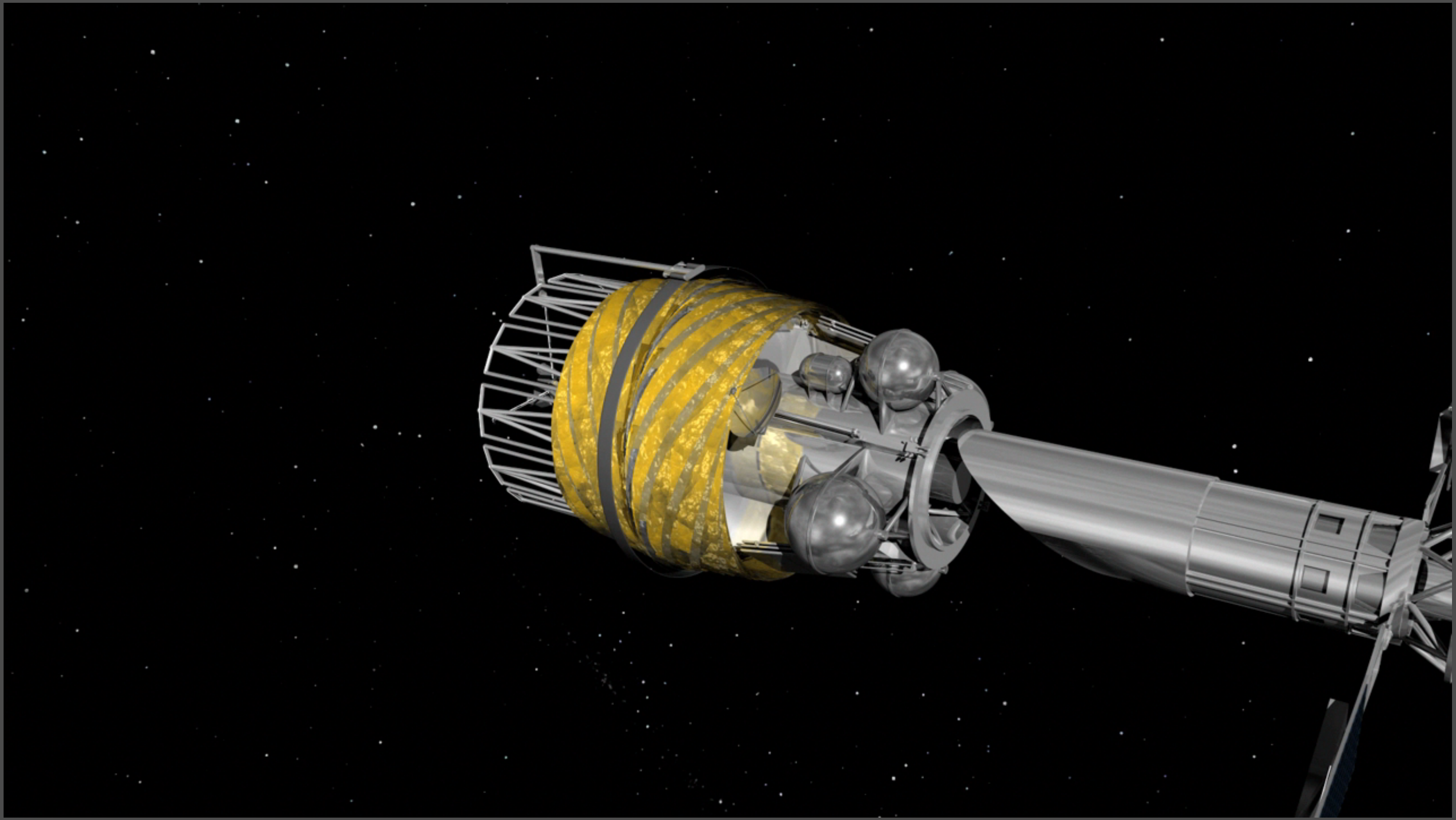
Aki Roberge (NASA GSFC)

on behalf of the Exoplanet Probe – Starshade STDT and Design Team

STDT: S. Seager (MIT), W. Cash (Colorado), S. Domagal-Goldman (NASA GSFC), N. J. Kasdin (Princeton), M. Kuchner (NASA GSFC), A. Roberge (NASA GSFC), S. Shaklan (NASA JPL), W. Sparks (STScI), M. Thomson (NASA JPL), M. Turnbull (GSI)

Design Team: D. Lisman, E. Cady, S. Martin, D. Webb, … (NASA JPL)

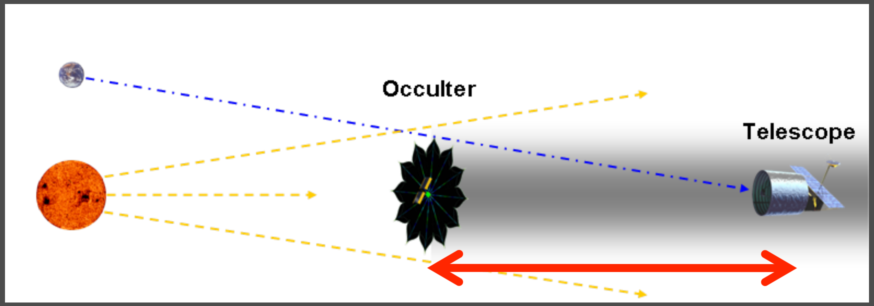
Starshade primer



http://planetquest.jpl.nasa.gov/video/15

Starshade strengths

- Contrast and inner working angle decoupled from telescope size



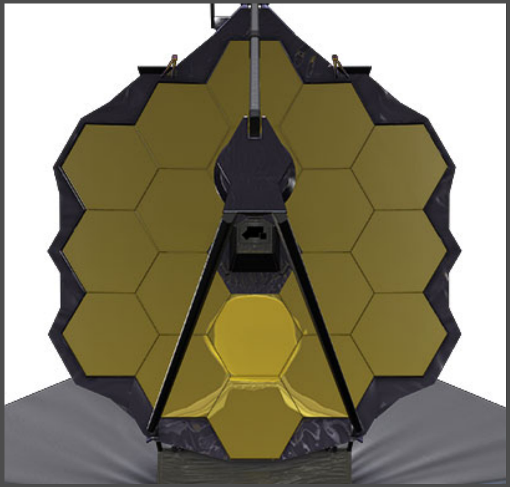
- Inner working angles can be changed by altering telescope/occulter separation

W. Cash (Colorado)

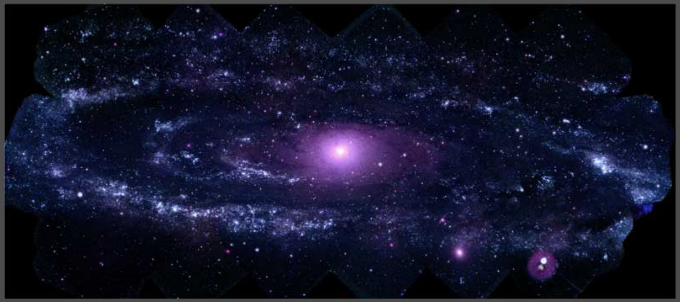
- No outer working angle
- 360 degree suppressed field of view

Starshade strengths

- High quality telescope not required
  - Segments & obstructions not a problem
  - Wavefront correction not needed
- Broad bandpass, high total throughput
- No constraints on other astronomical instruments



NASA / STScI



NASA / Swift

Starshade drawbacks

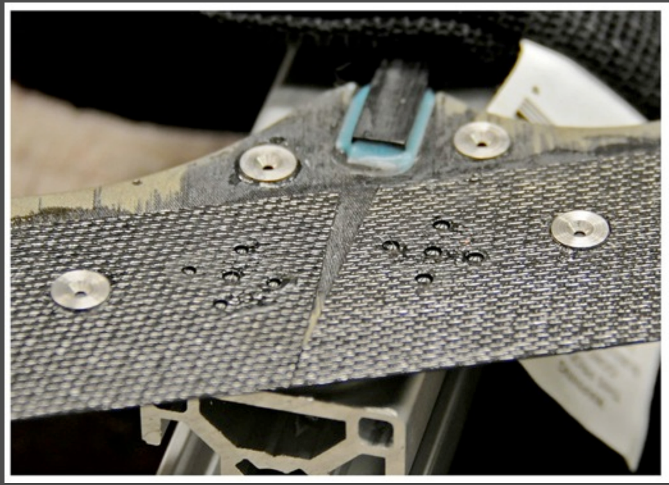
- Full-scale end-to-end system test on the ground not possible
  - Sub-scale lab and field tests possible (more later)

T. Glassman / NGAS

- Long times between observations while moving starshade
  - But can do other astronomy in the intervals
- Limited number of starshade movements

Technical challenges

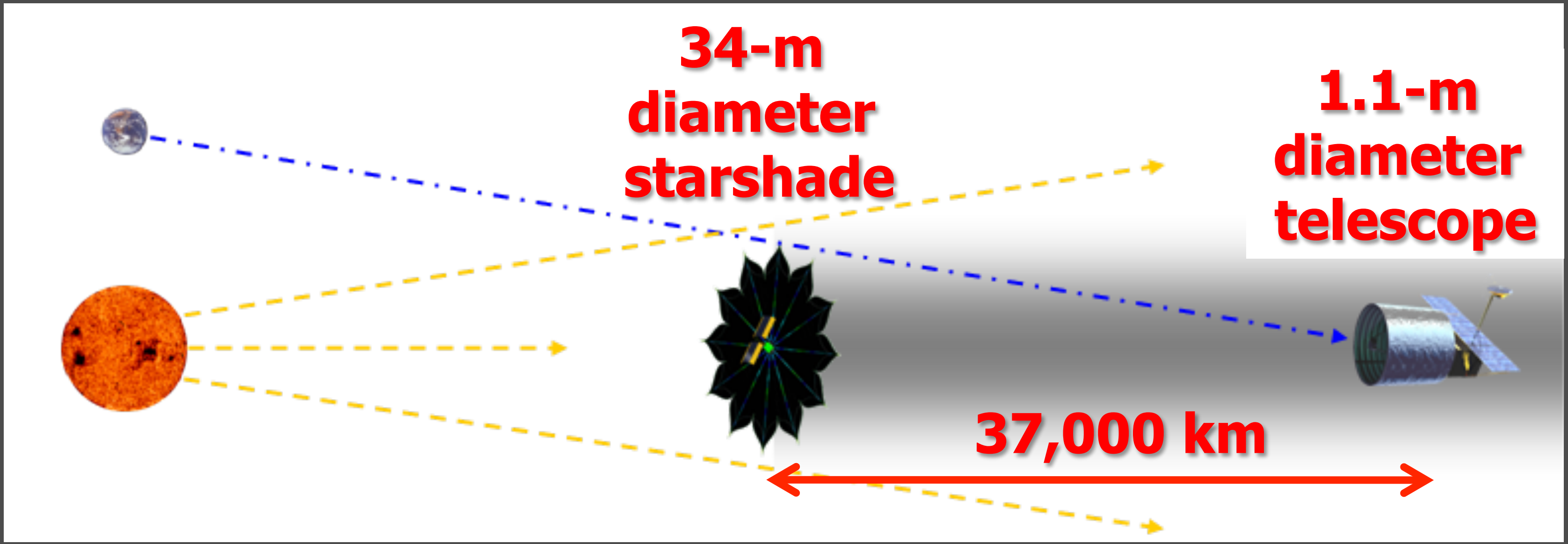
- Precise edge profile (~ 50 µm tolerance) required over large structure



NASA / JPL / Princeton

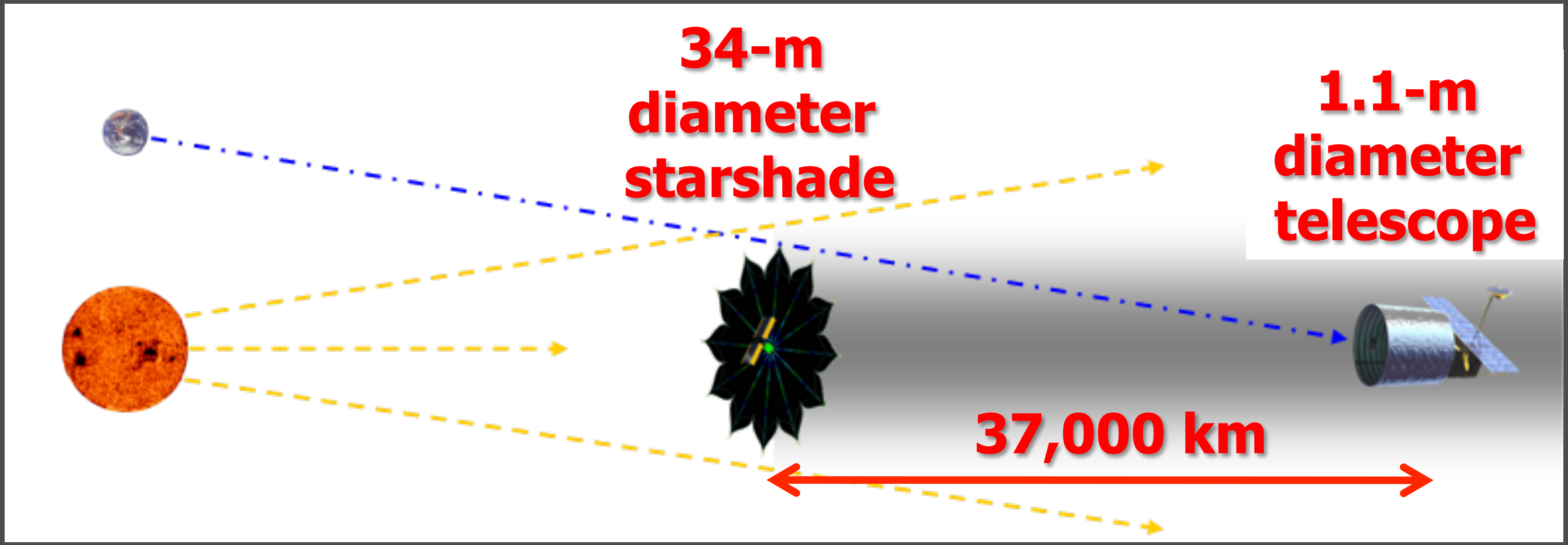
- On-orbit deployment of large structure
- Precise alignment between starshade and telescope needed (± 1 meter tolerance)
- Cost models not fully developed

Probe baseline design specs



- Off-the-shelf on-axis optical telescope
- Earth-leading orbit
- Imager and low resolution spectrograph
- Slewing telescope, not starshade

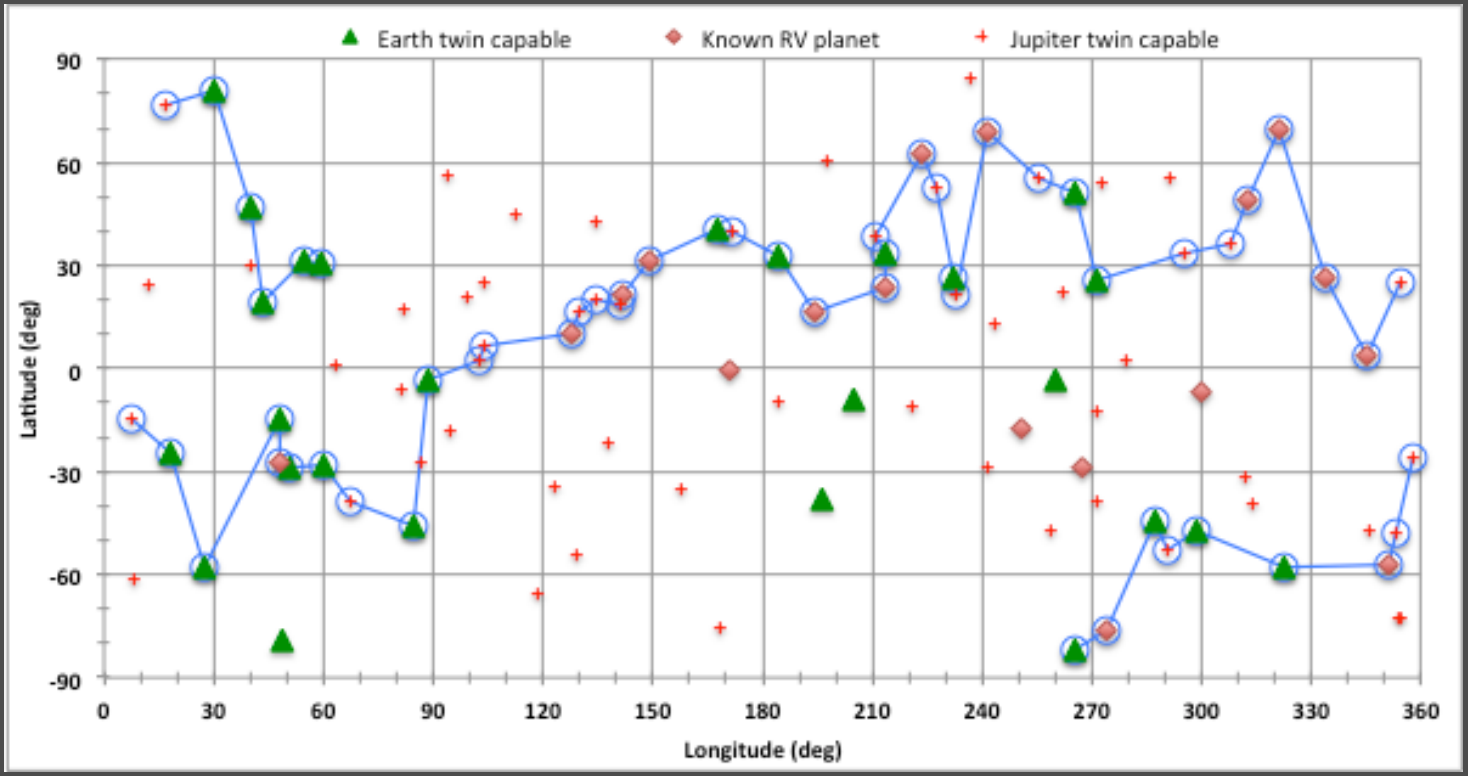
Probe baseline design specs



- Primary operating mode
  - 500 – 850 nm bandpass
  - 95 milli-arcsecond inner working angle
  - Limiting fractional planet brightness ~ 9×10^{-11}
- Other bands with different IWAs for follow-up

Preliminary observing strategy

- First 18 months in "reconnaissance mode"
  - Multi-color imaging only to find candidates
- Second 18 months for revisits and spectroscopy

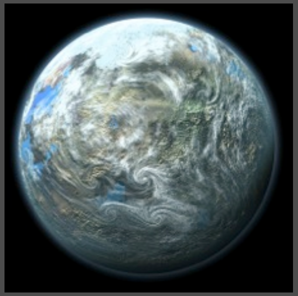


D. Lisman (NASA JPL)

Preliminary science yield predictions

- In 18 months, observe 55 stars
  - Assuming 1 zodi of exozodi dust …
  - Can detect Jupiter-twins around all stars
  - 14 stars with detectable known giant planets from radial velocity surveys
  - Possibility of detecting Earth-analog exoplanets around 22 stars

NASA



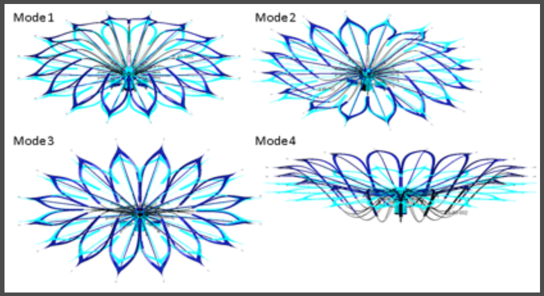
L. Cook

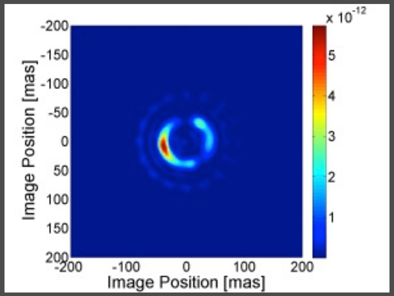
- Remainder of mission for revisits, follow-up spectroscopy, maybe disk observations

Technology demonstrations

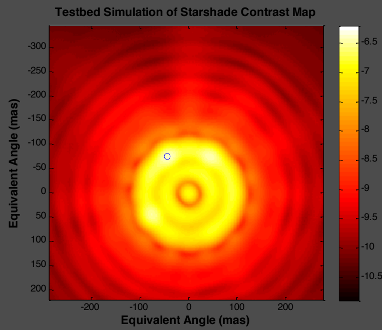
Performance Modeling and Testing

Optical models with distortions



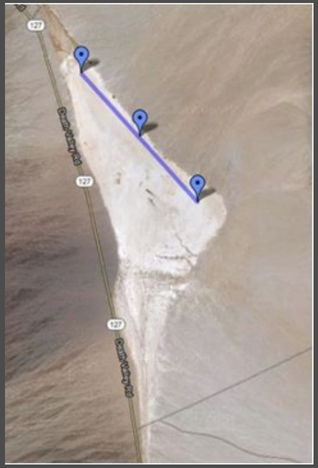


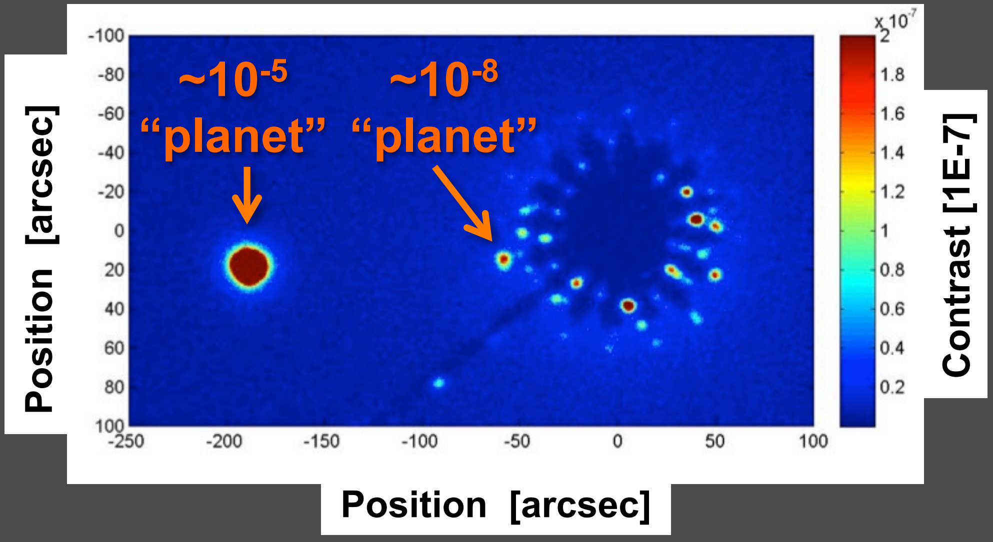
0.1% scale lab testing



~ 1% scale field testing

T. Glassman / NGAS



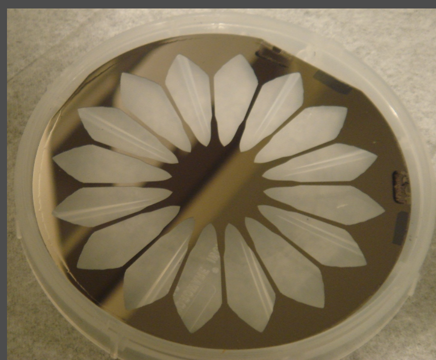


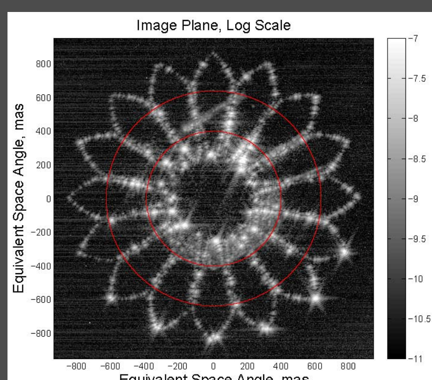
Technology demonstrations

Precision petal manufacturing

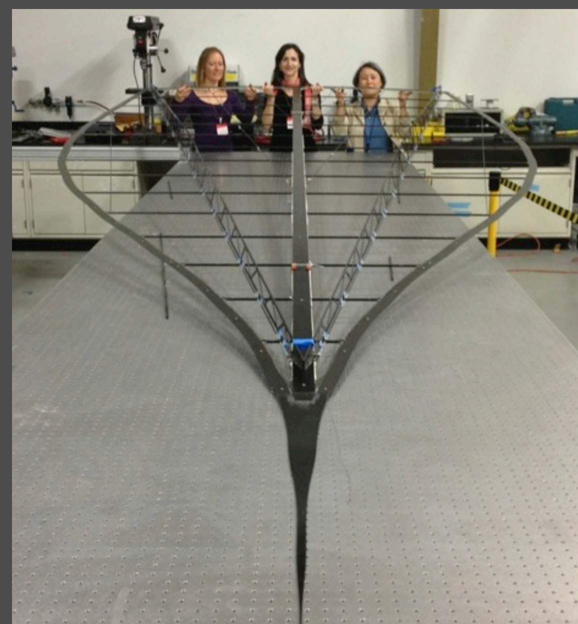
Sub-scale full starshade

Sirbu, Kasdin, & Vanderbei 2013





Full-scale petal with required edge profile

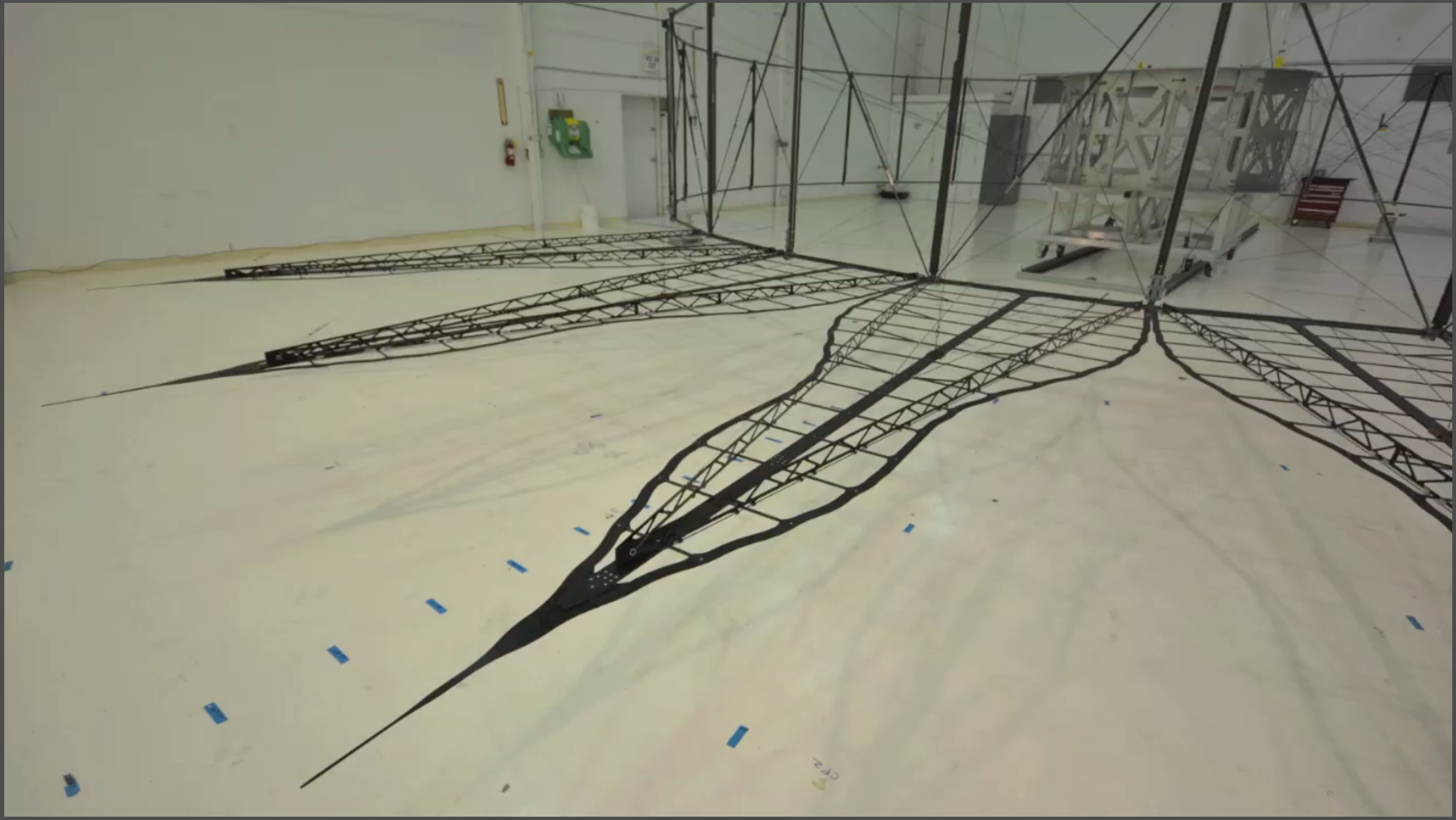


D. Lisman

- Development of knife-edge to control edge scatter underway

Technology demonstrations

Starshade stowage and deployment



http://www.youtube.com/watch?v=G68sqgRhP2E

Next steps

- Refine baseline mission design and science yield simulations
- Continued technology development
  - Through competed NASA technology programs; some STDT members participating
- Work on cost modeling with Aerospace Corp.
- Consider general astrophysics science cases
- Make design for starshade with NRO telescope