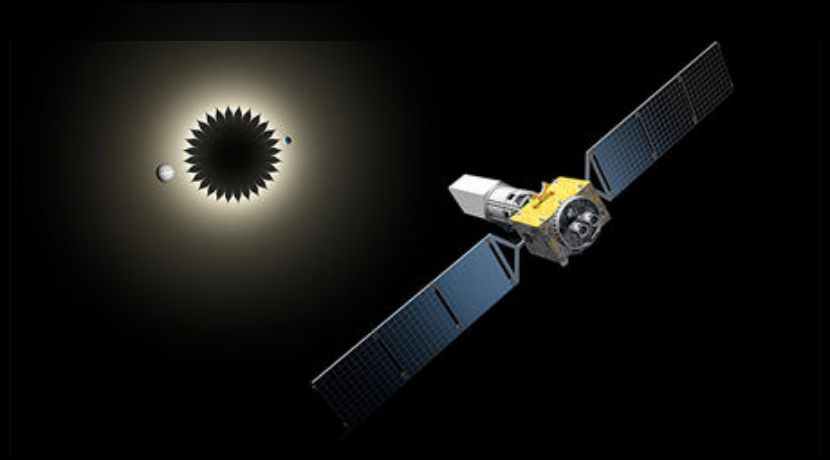
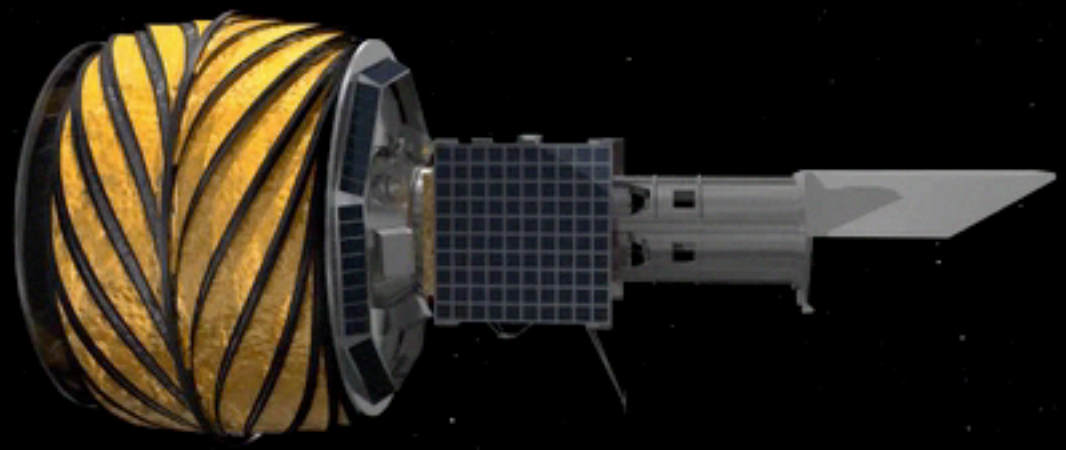
WFIRST CGI DATA CHALLENGE
Starshade

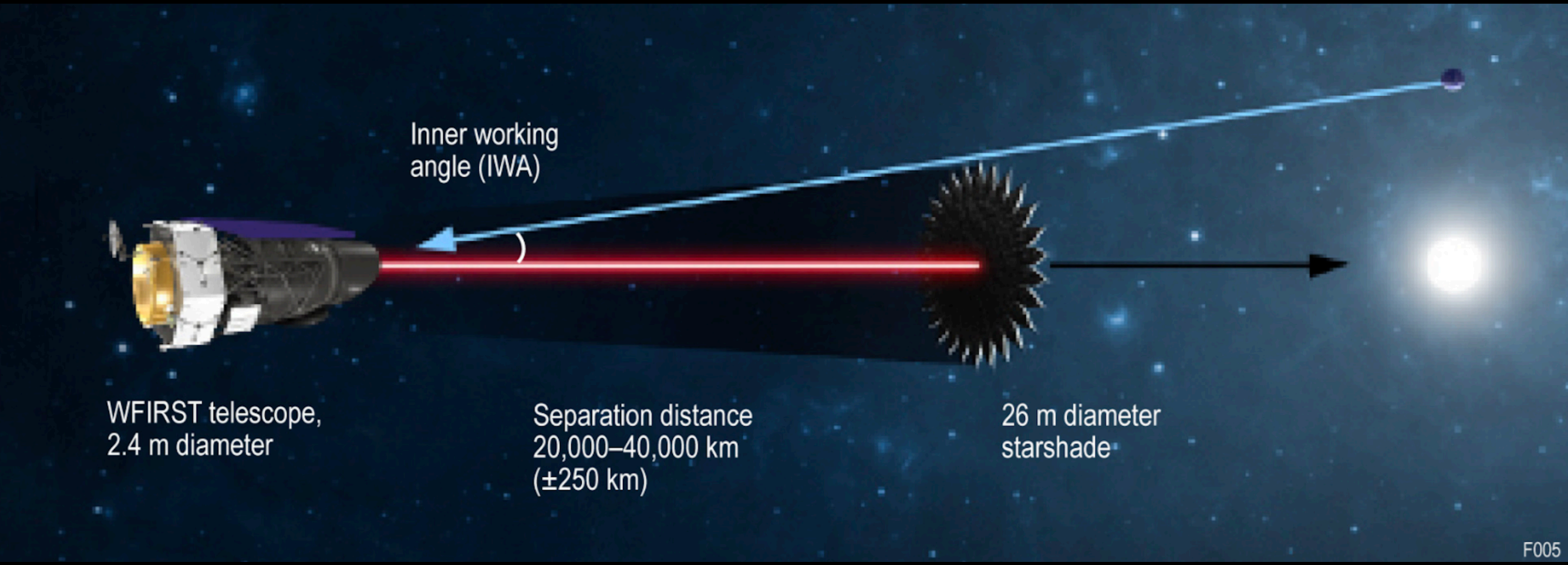


Sergi R. Hildebrandt, JPL/Caltech

Starshade in a movie



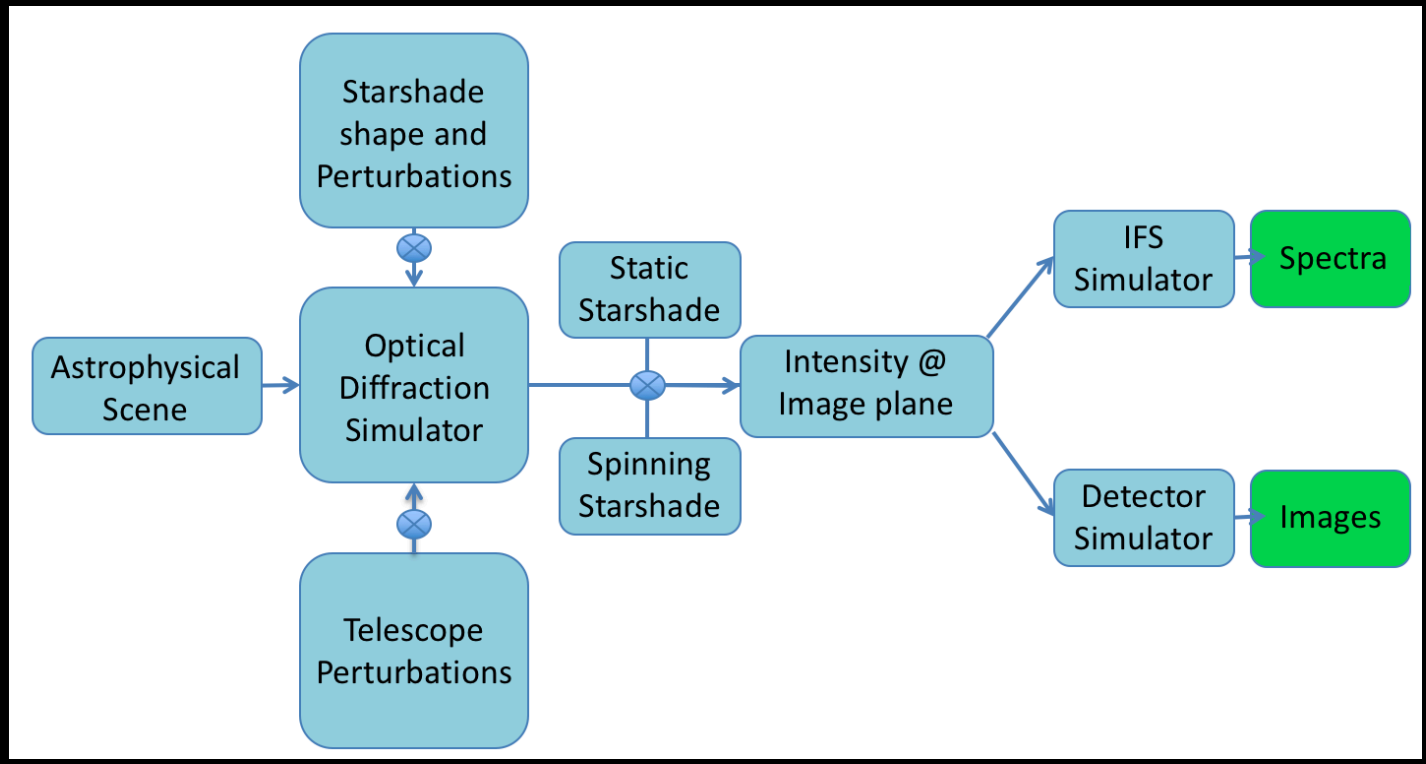
Starshade geometry



Starshade geometric IWA in the 425-552 nm band is **72** mas.
Same angular size as **1 AU** at **45.4** light years (**13.9** pc).

SISTER

SISTER (Starshade Imaging Simulation Toolkit for Exoplanet Reconnaissance) is a versatile tool designed to provide enough accuracy and variety for starshade astrophysical simulations.*
SISTER is a Matlab, open source project: sister.caltech.edu



(*) **S.R. Hildebrandt**[1] **S.B. Shaklan**[1], **E.J. Cady**[1], and **M.C. Turnbull**[2,1]. (1) Jet Propulsion Laboratory, California Institute of Technology (2) SETI Institute, Carl Sagan Center for Life in the Universe

sister.caltech.edu

Starshade Imaging Simulation Toolkit for Exoplanet Reconnaissance (SISTER)

Sergi R. Hildebrandt [1,a], Stuart B. Shaklan [1,b], Eric J. Cady [1,c], and Margaret C. Turnbull [2,1,d]

1: Jet Propulsion Laboratory/California Institute of Technology. **2**: SETI Institute, Carl Sagan Center for Life in the Universe.

a: srh.jpl.caltech@gmail.com, **b**: stuart.b.shaklan@jpl.nasa.gov, **c**: eric.j.cady@jpl.nasa.gov, **d**: turnbull.maggie@gmail.com

The Starshade Imaging Simulations tool is a versatile tool designed to provide enough accuracy and variety when predicting how an exoplanet system would look like in an instrument that utilizes an Starshade to block the light from the host star: AAS233 Poster

The tool allows for controlling a set of parameters of the whole instrument that have to do with: (1) the Starshade design, (2) the exoplanetary system, (3) the optical system (telescope) and (4) the detector (camera). There is a built-in plotting software added, but the simulations may be stored on disk and be plotted with any other software.

The optical response of a starshade design is computed making use of the boundary diffraction wave method developed by Eric Cady (JPL/Caltech): SPIE, PDF

Sign-up SISTER Handbook SISTER Imaging Basis GitHub

SISTER Examples

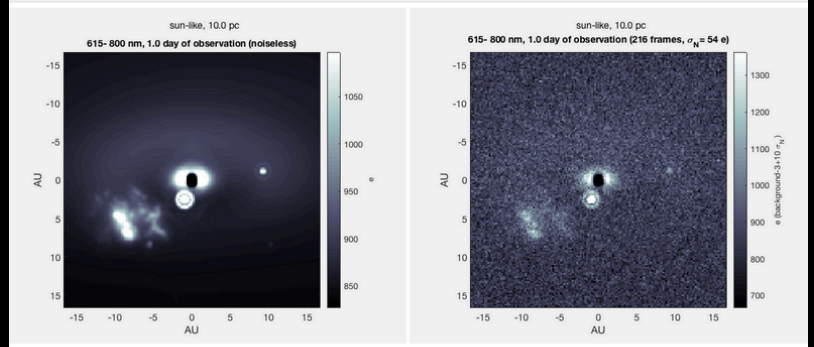


Figure 3.1: WFIRST RENDEZVOUS MISSION (GREEN BAND): Left: Noiseless simulation with SISTER of the solar system with some background objects at 10 pc and with an inclination of 60 degrees (Data from the Haystacks Project with local zodiacal light added). Right: Same as left, but including detector noise (standard CCD, not EMCCD) and shot noise. (see scene_5 in SISTER

SISTER Handbook

Prepared by Sergi R. Hildebrandt[1] and Stuart B. Shaklan[2], JPL/Caltech

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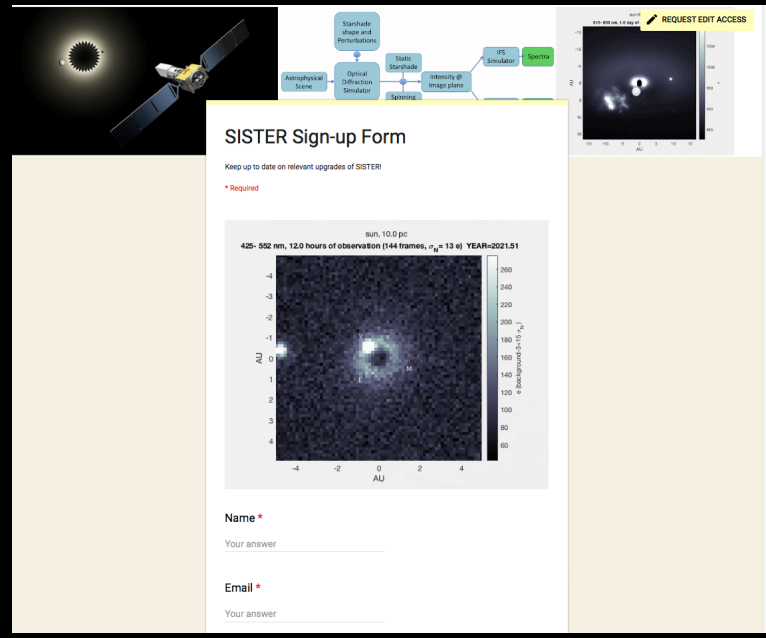
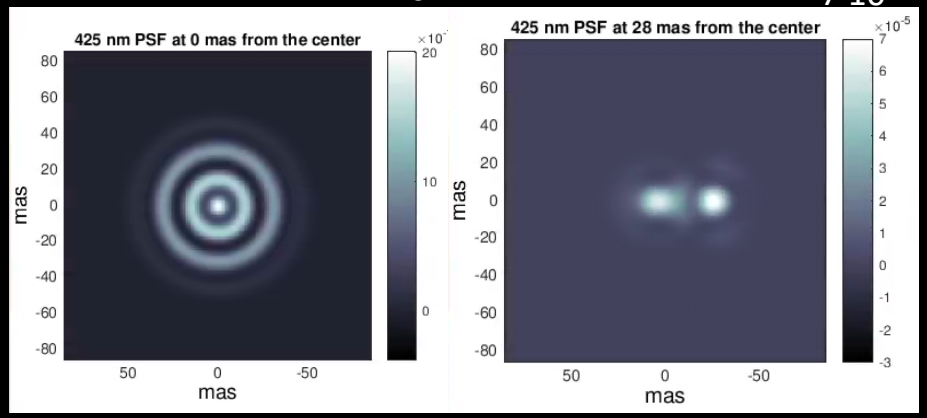
[2] stuart.b.shaklan@jpl.nasa.gov



Starshade Optical Response

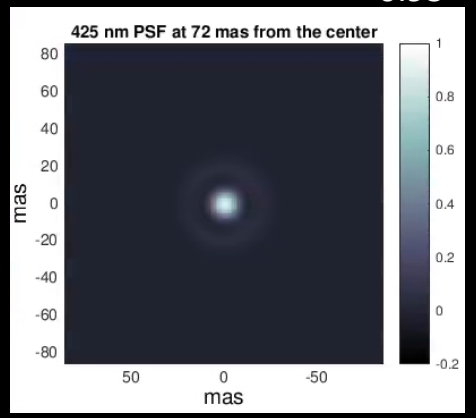
Point Spread Function (telescope response to a point-like source) at different distances from the center of the Starshade: 425-552 nm. Starshade-WFIRST distance of 37,200 km. Spinning starshade. Diameter of 26 meters, 24 petals.

2 10^{-11} 7 10^{-5}



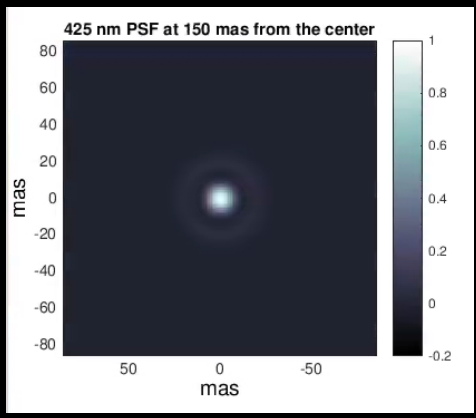
0 m, 0 mas 5 m, 27.7 mas

0.93



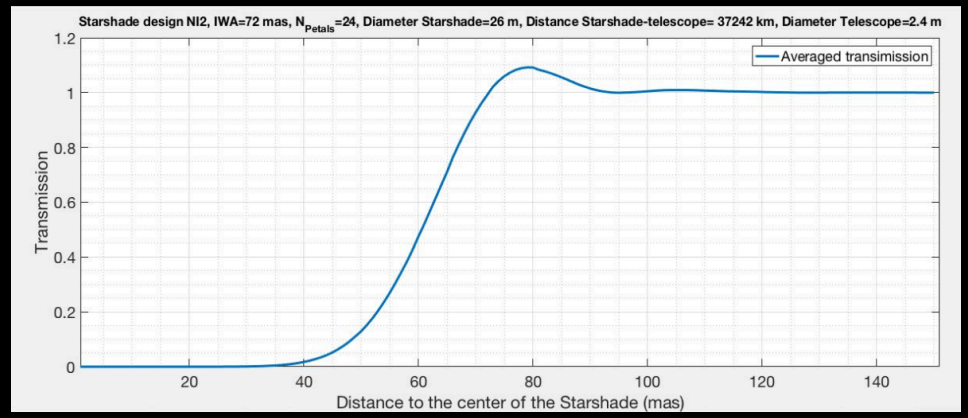
13 m, IWA 72.0 mas

1.0



>= 150.0 mas

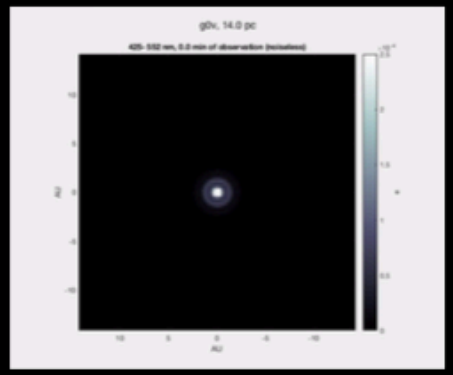
WFIRST SS Petal



Starshade Images

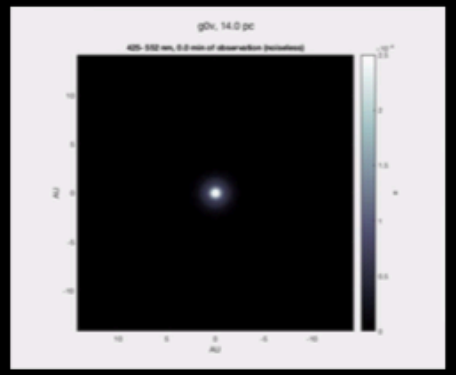
The WFIRST Exoplanet Imaging Data Challenge simulations steps by step

47 Uma star blocked by the SS (G0V, 14pc, V5)



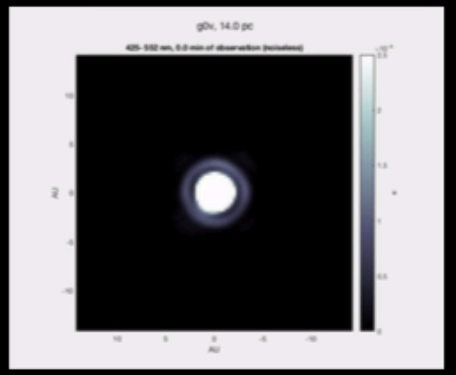
Suppression[1]: 8 10^{-11}

+ Telescope pointing jitter (20 mas)



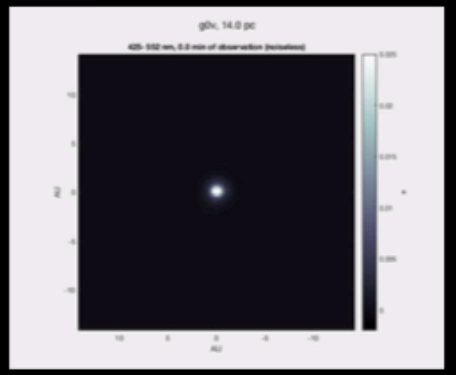
Suppression: 8 10^{-11}

+ Non-ideal SS (maximum distortion within specs)



Suppression: 5 10^{-9}

Same image as before Color scale / 100



Suppression: 5 10^{-9}

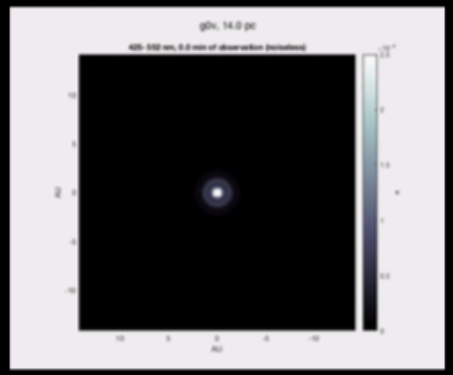
2''

Suppression: here is defined as the ratio between the total counts of the image shown and the total counts of the telescope PSF. under the same configuration. If the PSF core were to be used (half energy), multiply the contrast by 2.

Starshade Images

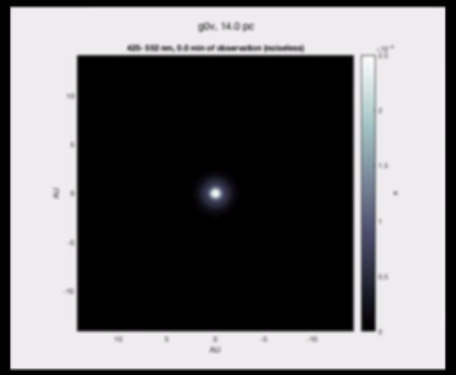
The WFIRST Exoplanet Imaging Data Challenge sims steps by step

47 Uma star blocked by the SS (G0V, 14pc, V5)

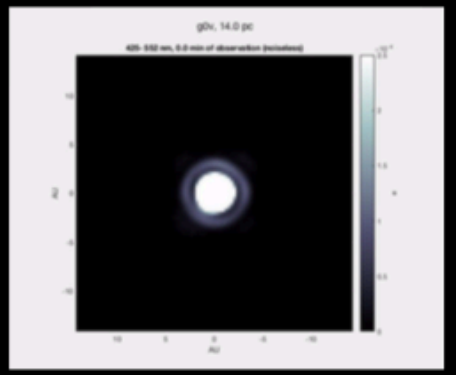


2''

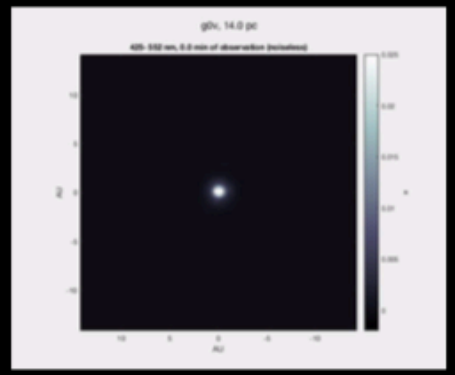
+ Telescope pointing jitter (20 mas)



+ Non-ideal SS (maximum distortion within specs)

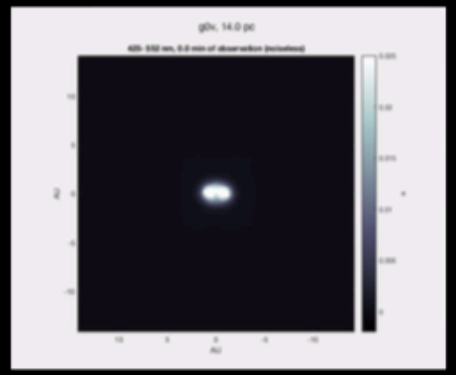


Same as before stretch / 100



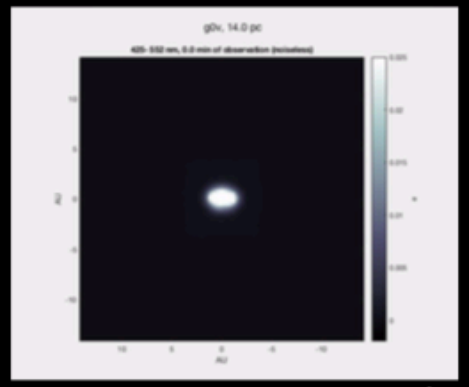
Suppression: 5 10^{-9}

Solar glint and jitter (no starlight)



Suppression: 2 10^{-8}

All: non-ideal SS, solar glint, and jitter



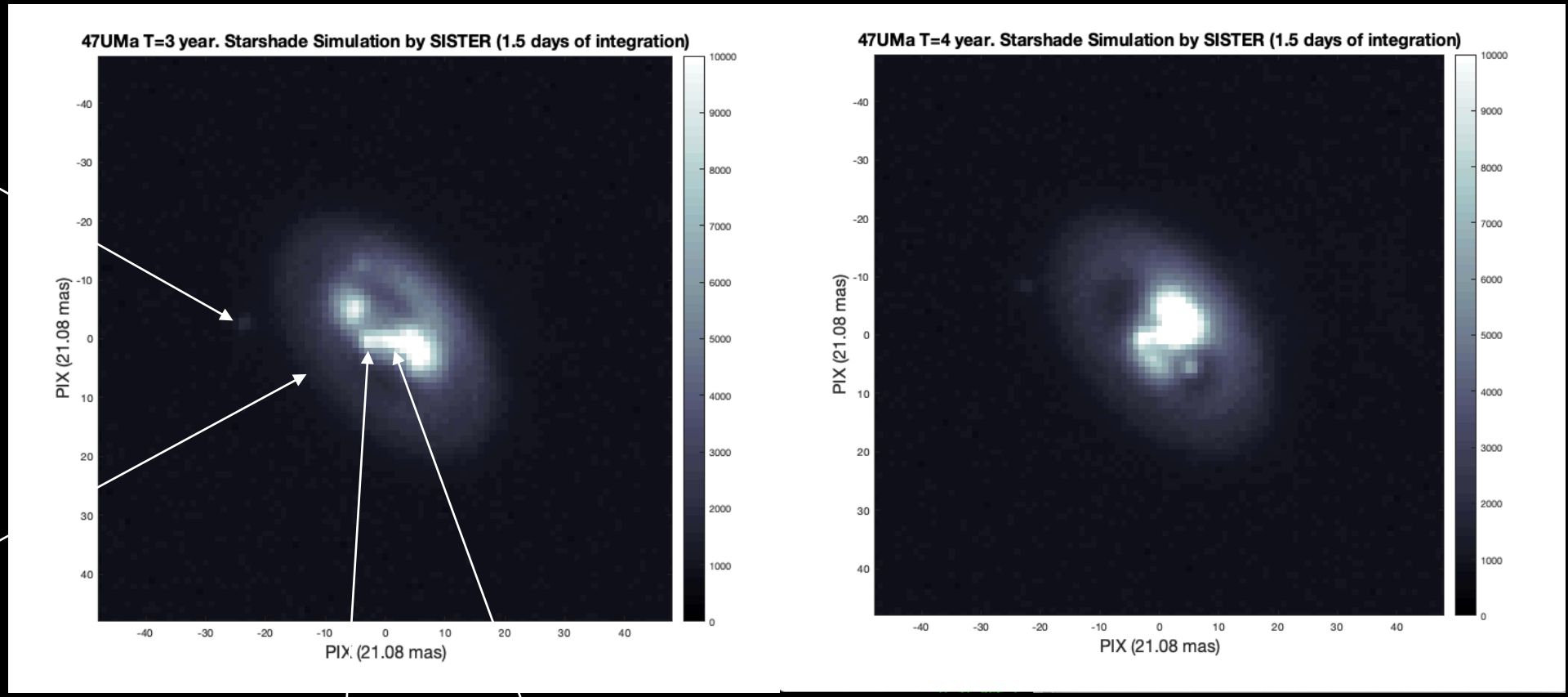
Suppression: 2.5 10^{-8}

This pattern is expected to be measured relatively well during the mission.

Next … adding planets and background field ...

… including exozodiacal light and noise …

Starshade Epochs in the Data Challenge



Exoplanet?

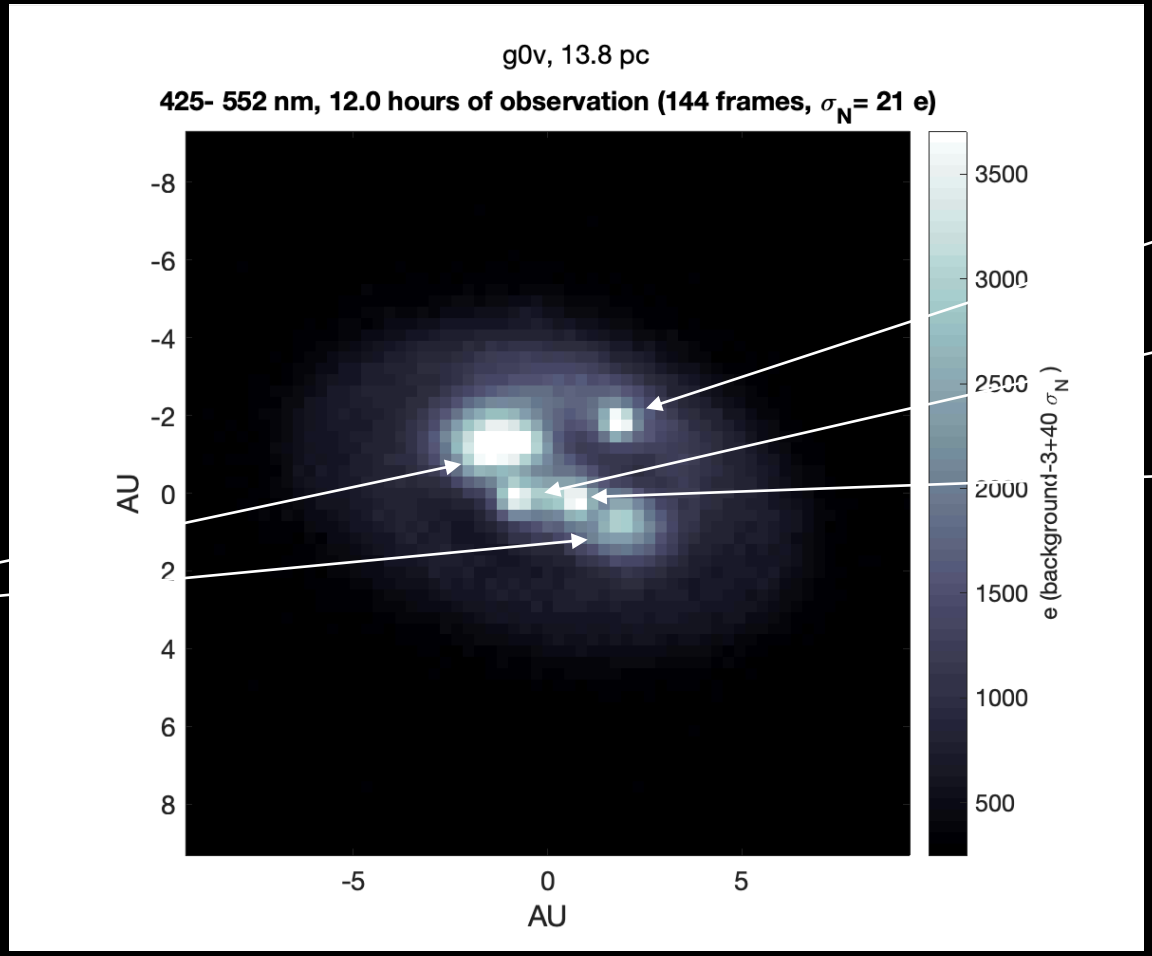
Exozodiacal light

Remaining Starlight

Solar Glint

Starshade Data: astrometry

(Different planetary system than in the challenge)

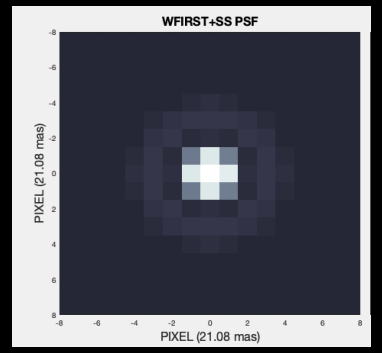


Exoplanets

Remaining Starlight

Solar Glint

Exozodiacal light

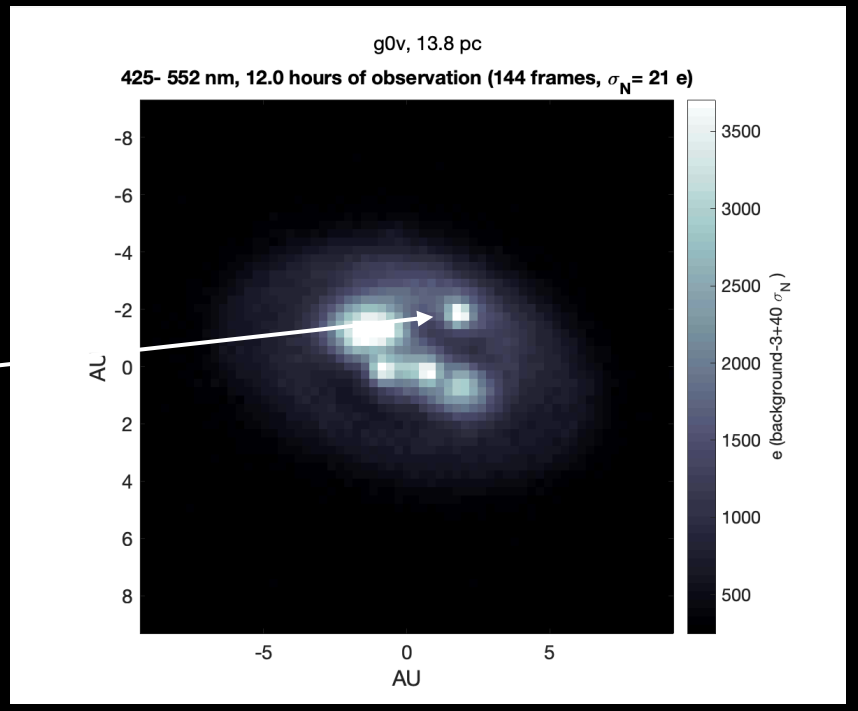


Starshade Data: astrometry

(Different planetary system than in the challenge)

One can use any software package with the provided PSF or code up any estimator. For instance, the table below shows the astrometry for three different estimations in milli arcsec (mas), including the relative error with respect the true position of the planet (129.58,-128.13) mas.

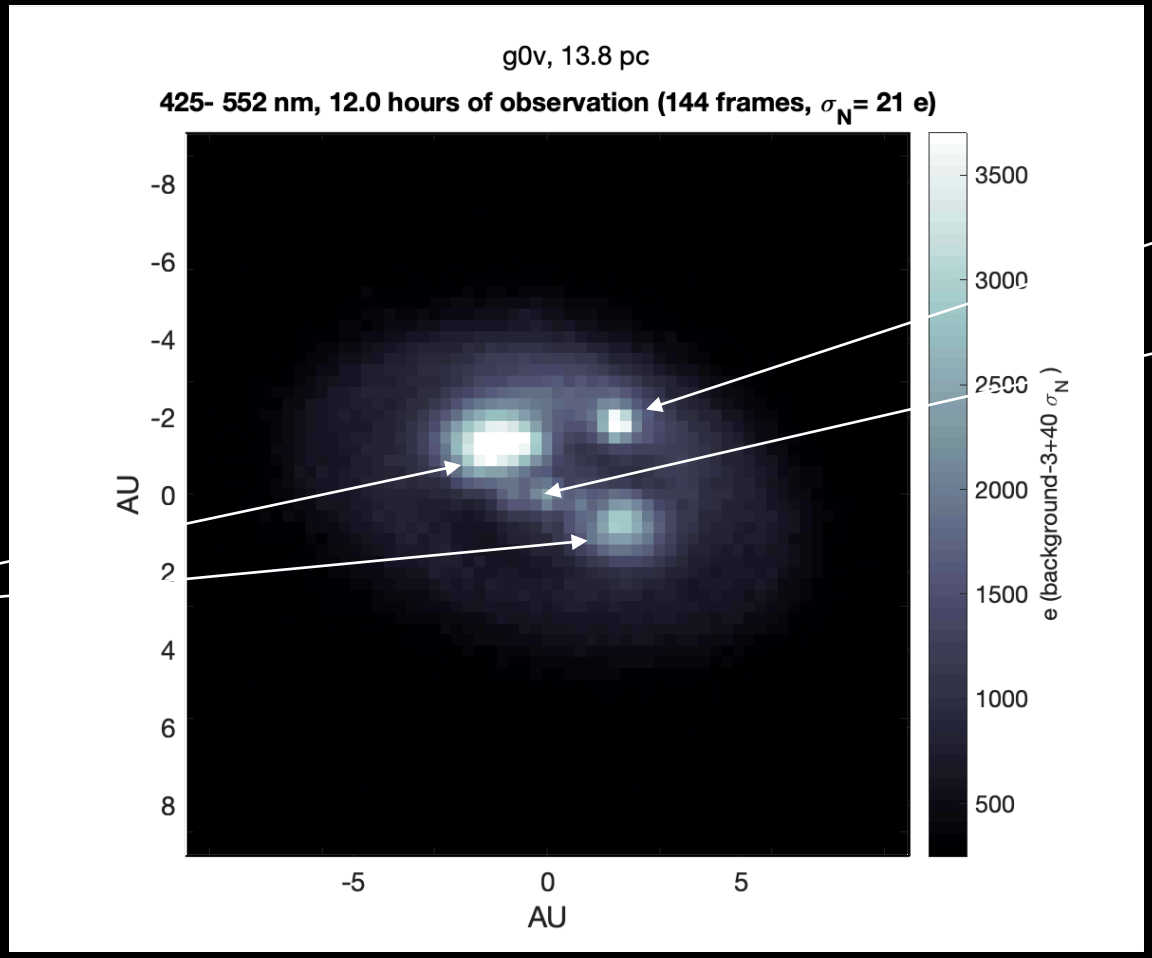
Maximum Pixel	Centroid	Optimal Shifted PSF (FFT)
(126.48,-126.48) mas	(144.66,-105.33) mas	(122.27,-122.27) mas
The error is (-0.147,0.078) pixels	The error is (0.715,1.082) pixels	The error is (-0.347,0.278) pixels



The maximum pixel just got ‘lucky’ in this case. There’s noise and background confusion. The centroid got affected by some background gradient. Finally, the shifted PSF got the right result within 1/3 pix which is good. However, in practice if the background and/or noise are quite relevant, additional care is needed.

Starshade Data

Optional: for interior planets, you may remove solar glint with the template provided (scaled to the same integration time)



Exoplanets

Remaining Starlight

Exozodiacal light

Starshade Epochs

Thank you!
Let us know what you find!