STARSHADE DATA CHALLENGE

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High-Level Objectives

- **Independently validate and review the WFIRST Starshade error budget**
  - Is the current error budget sufficient to achieve the science goals?
  - Are we able to loosen the tolerances in the current error budget?

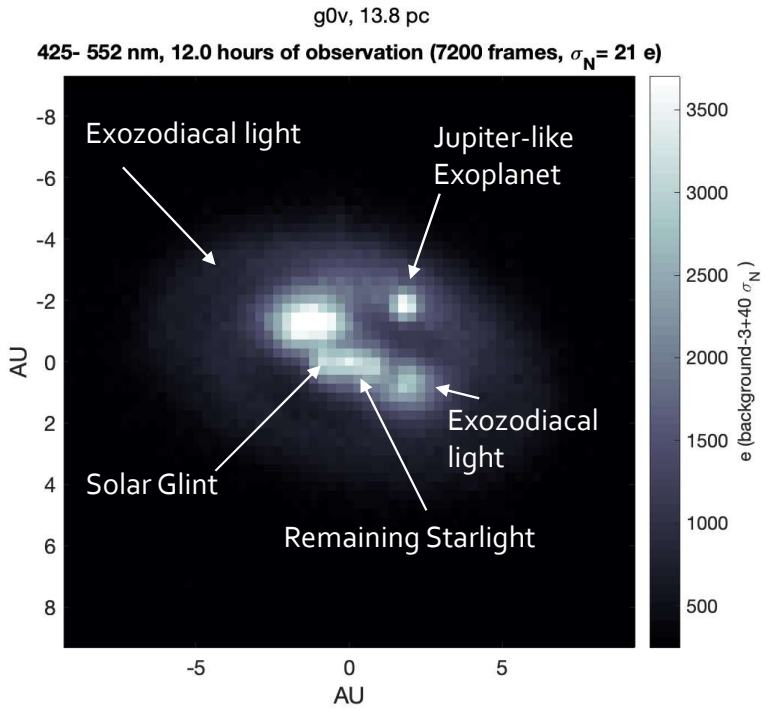
- **Development and comparison of algorithms for Starshade image processing and science recovery**
  - What's the state-of-the-art in the algorithms for Starshade image processing?
  - To what extent can algorithms overcome technology limitations?

Detailed Objectives

- **The data challenge will ask to retrieve *X*, including e.g.**
  - Detection
  - Relative astrometry
  - Absolute photometry (4 color filters)
  - Including confidence levels
- ***X* is extracted from a comprehensive image dataset (>10k) generated**
  - Using the expected starshade performance by the current error budget
  - Increasing dedicated errors and their combinations such as
    - Solar glint
    - Formation-flying
    - Local defects (broken petal tip)
    - Global defects (thermal expansion)

Image Generation (1)

- SISTER software (http://sister.caltech.edu/) can be used to generate images
- Several starshade shapes can be generated to include different errors from the budget based on their magnitude
- Images are labelled with ground-truth data ***X*** which describe the simulated scene, type and magnitudes of errors



Stuart Shaklan and Sergi Hildebrandt (JPL)

Image Generation (2)

- **Does SISTER include all the capabilities we need? Such as**
  - accurate solar glint calculation (time-varying dependency on sun angle)
  - time-varying formation flying dynamics
  - starshade rotation
- **Has SISTER been verified? Such as through comparison with**
  - Princeton hardware-in-the-loop testbed
  - Recovery of ground-truth through image processing
  - Other tools?

Scoring

- Scores are used to rank submissions
- Scores capture the relative deviation of the submission $\boldsymbol{X}_{est}$ from the ground-truth data $\boldsymbol{X}$ for each image and for each parameter
- Consolidated scores for each parameter can be computed by averaging across images or groups of images
- A global score can be computed by a weighted average across parameters using normalization weights which take into account units of measure
- Robustness to perturbations can be scored by the ratio between the perturbation magnitude (truth) and the estimation error (computed above)

Implementation

- **The competition is hosted by a web server which provides access to**
  - The challenge: competition in a nutshell, credits
  - Image datasets: for training (labelled), for competition (not labelled), scripts
  - Scoring: formulas and rationale
  - Rules: eligibility, winner, license, honor code, etc.
  - Leaderboard: dynamic table with columns for rank, name, scores
  - Final results: final leaderboard evaluated on complete dataset
  - Discussion blog: Q&A
- **There are websites that can host competitions for free, such as CodaLab** (https://codalab.org/)
- **Or we can collaborate with ESA as for other competitions** (https://kelvins.esa.int/satellite-pose-estimation-challenge/)

Deployment

- **The competition is deployed through the following tentative milestones for a total timeframe of 15 months since start**

• Drafting:	2 months	Internal process
• Internal review:	1 month	
• Finalization:	1 month	
• Public with nominal errors:	5 months	**Low barrier to entry**
• Public with increased errors:	5 months	**Experts**
• Analysis and dissemination:	1 month	**Deliverable to S5**

Tasks and Resources

- The data challenge project entails the following tasks and full-time-equivalent-hours (*fteh*)
  - Overall technical and scientific management: 250 *fteh*
  - IT/Website/Scripts (if the website is not outsourced): 200 *fteh*
  - **Dataset generation and testing: 300 *fteh***
  - PR/reach out: 200 *fteh*
  - Dissemination: 250 *fteh*
- S5 has indicated that $150k total is reasonable (= 1200 *fteh?*)
- S5 has indicated that the work should be done in tight coordination and oversight by JPL

Rewards

- **How do we engage the community to participate?**
  - Participants are given access to a more complete dataset
  - Participants are invited to publish with JPL hosts of competition
  - Winners are given award at JPL event
  - Winning researchers are offered internships opportunities at JPL
  - Potential of direct involvement and contribution to first Starshade mission

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SISTER Simulated Image for SRM

- 47 Uma
- 12 hour observation
- 425-552 nm
- Optical Throughput 0.434
- EMCCD 221, QE = 0.76
  - Simple noise model with equivalent noise
  - 7 s frames, EM Gain = 4000
  - CIC = 0.01
  - End-of-mission dark current
  - No cosmic rays, no hot pix.
- Exozodi = 5x Zodi, dynamical
- Local Zodi included
- Extra-galactic background
- 10^{-10} starshade (non-ideal)
- 15 mas telescope jitter
- 1 planet visible in this image