Starshade Design Considerations for HabEx

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Agenda

Key features of JPL's mechanical architecture

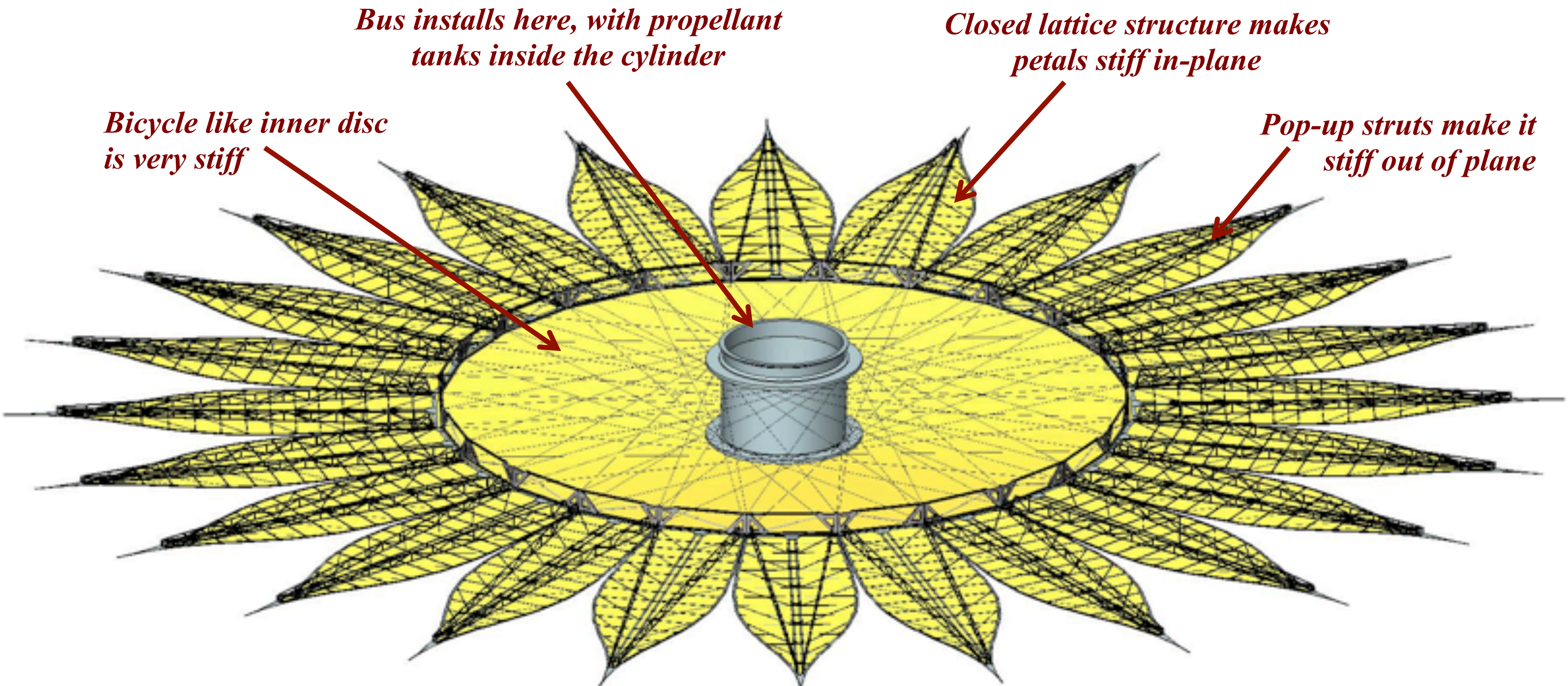
Retarget propulsion optimization

SEP power generation

Solar edge scatter

Stiff Deployed Structure

HabEx *preliminary* baseline is a 48-m dia. starshade (28-m disc, 10-m petals) for 40 mas IWA.
WFIRST baseline is 26-m starshade (10-m disc, 8-m petals) for 72 mas IWA.
Configuration shown is for a 10-m disc and 6-m petals.



High deployed stiffness is key for precise deployments and ground testability, with gravity compensation fixtures of manageable complexity.

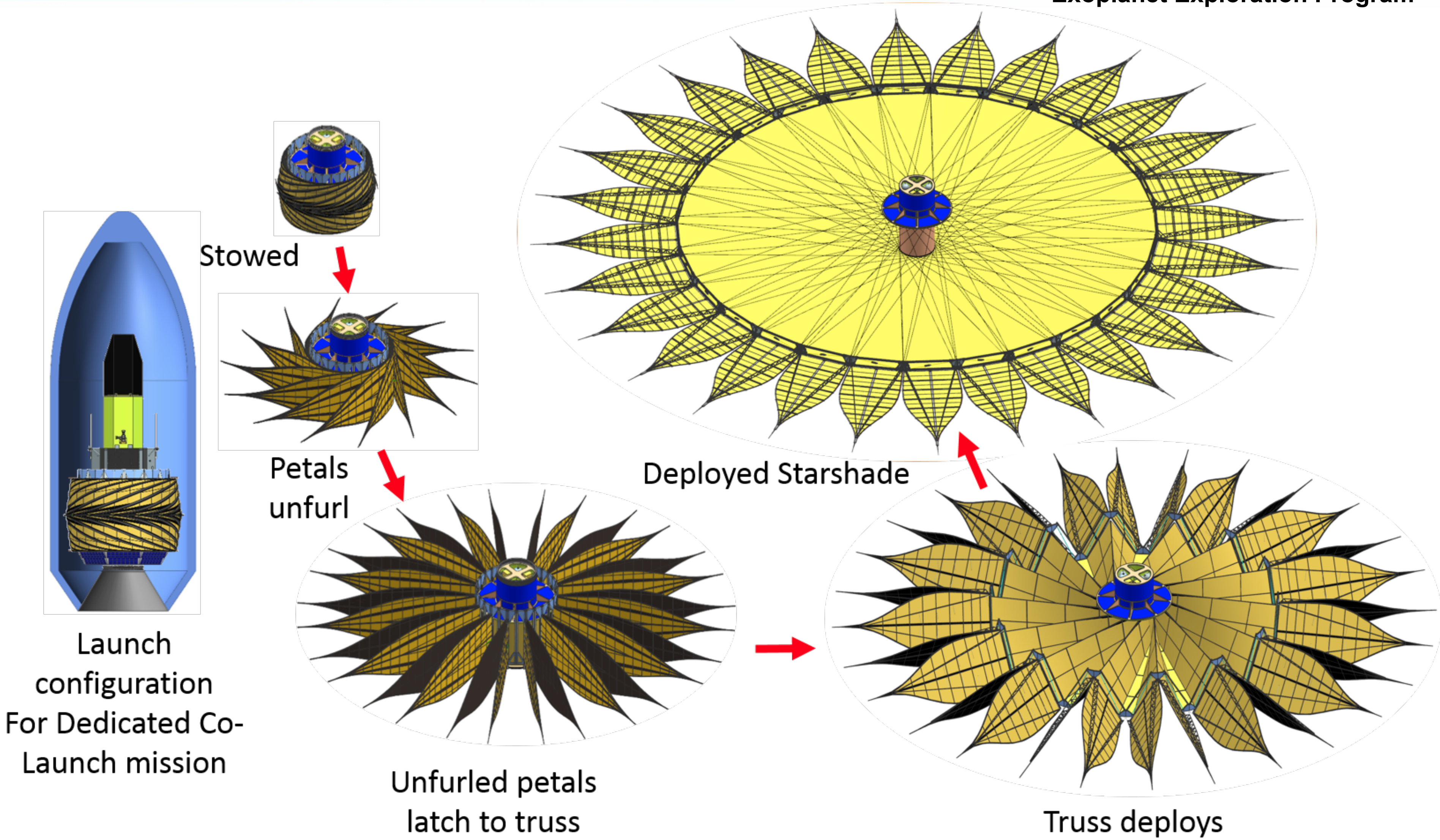
Secondary Payload Launch Opportunity and Scaling

A secondary payload can be stacked on top the compactly stowed starshade.
It could be an unrelated telescope or a 2nd starshade.

Currently available Falcon-9 5-m fairing is short relative to Atlas-V and Delta-IV fairings. Taller Falcon-9 fairings options are planned.

The radial fit in the fairing limits starshade size to about 50-m dia., maybe 60-m.

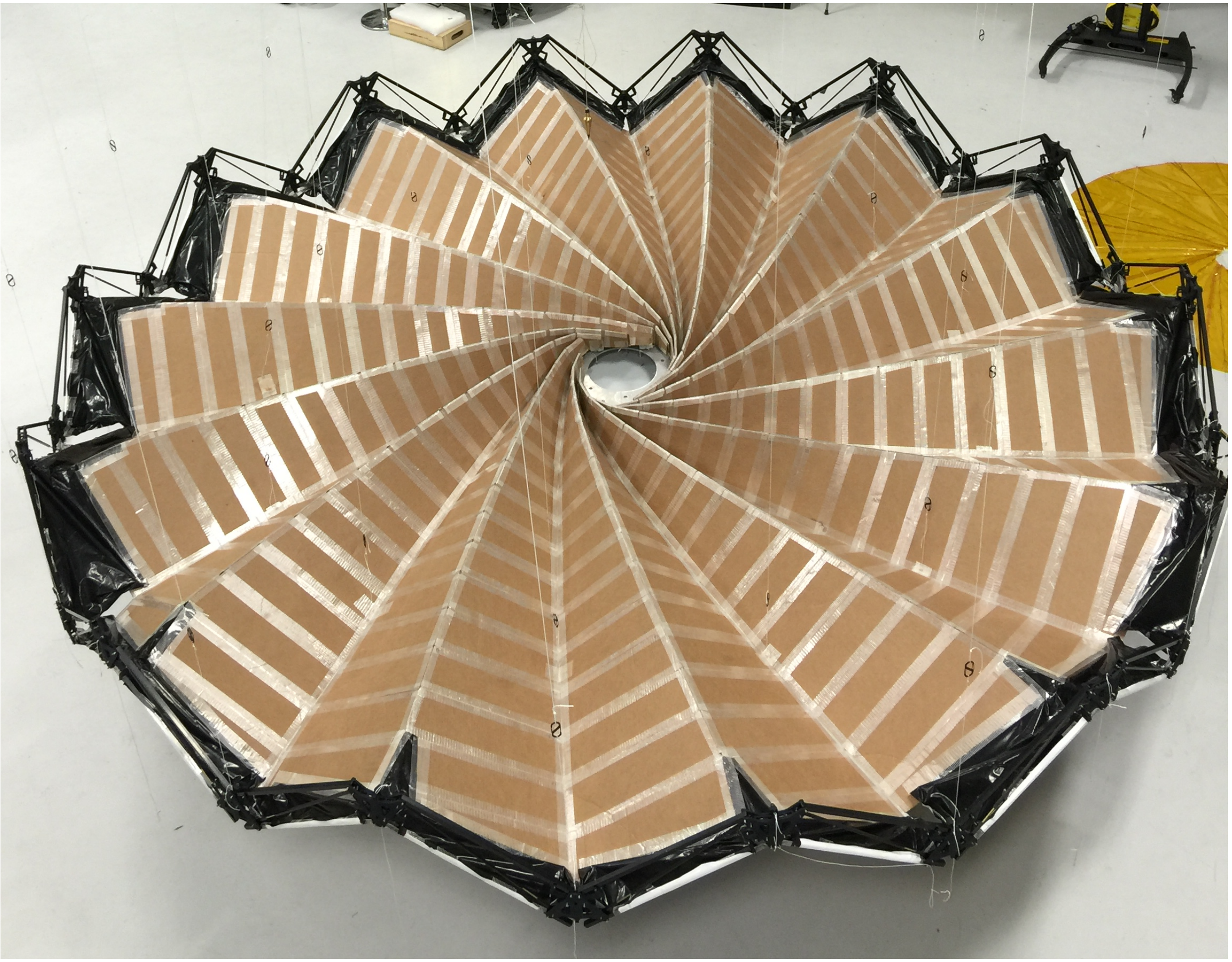
Two-Step Deployment and Early Shape Verification



Deployed petals and disc are stiff by themselves to enable early verification of shape.

Inner Disc Optical Shield Deployment

Inner Disc Optical Shield deploys as an origami structure, along with the perimeter truss.
Gores will be of Kapton & Foam sandwich construction and semi-stiff to make stowing and deploying kinematically repeatable.



Launch Restraint and Petal Unfurler

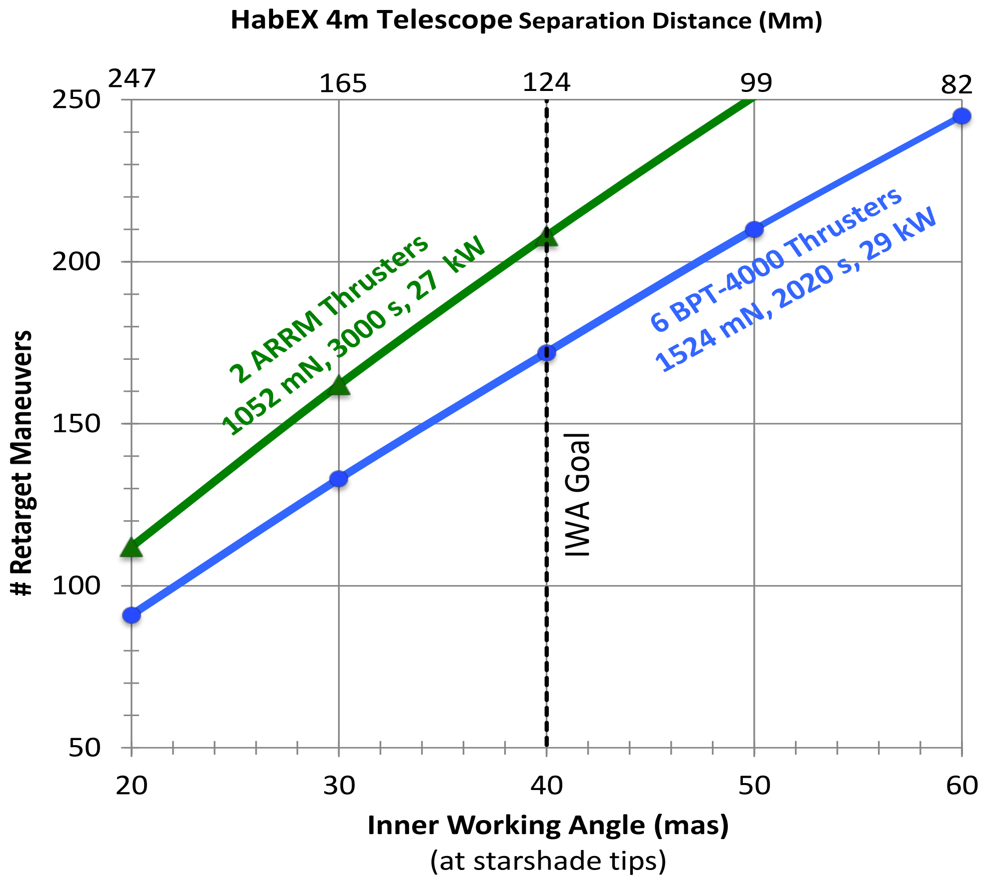
Internal launch restraint (e.g., radially inward tensioned cords) is deemed too complex and we now adopt a relatively heavy, but much simpler external design.

Sorry, I have not cleared these images for ITAR

Mass impact is mitigated by jettisoning the module after petals unfurl (no added fuel).

Retarget Propulsion Optimization

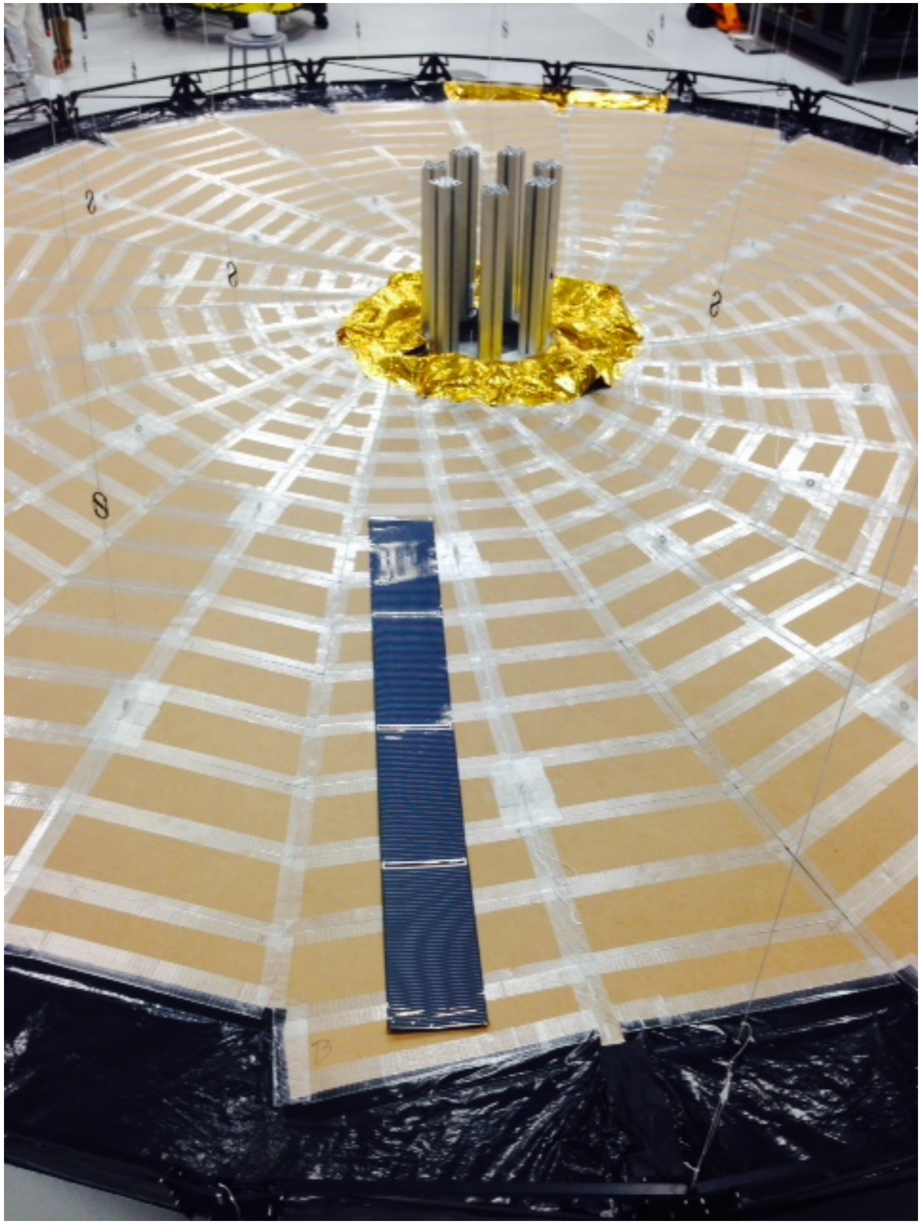
- **Solar Electric Propulsion (SEP) is critical for HabEx's large mass and separation distance**
- **Observation performance is limited by the volume available for propellant (Xenon) inside the central cylinder (2500 kg is a preliminary estimate, <u>but not max possible</u>)**
- **Observation performance (# targets) is optimal with the right combination of thrust, specific impulse and propulsion dry mass**



Ion thrusters, with higher Isp but lower thrust and higher mass/power, are not advantageous but should be represented on this plot

SEP Power Generation

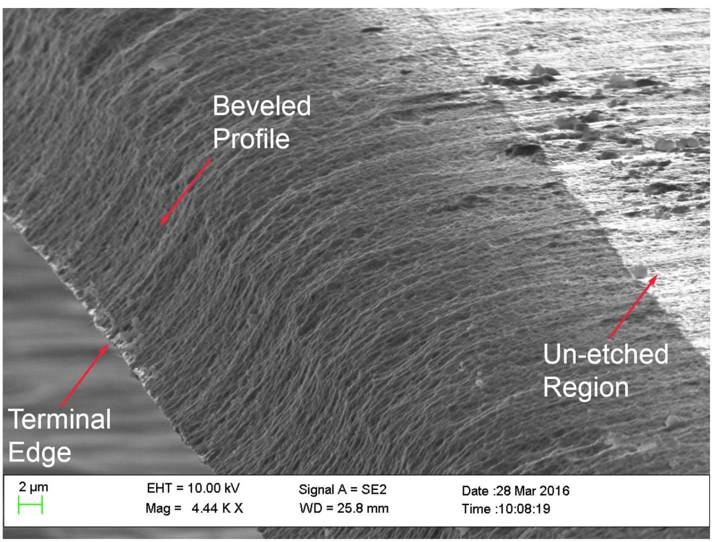
- A large solar array will cast shadows and thermally deform the starshade.
- An alternative is to integrate thin-film solar cells with the inner disc optical shield.
  - The large area available accommodates the relatively low efficiency of thin-film cells
  - The thin cells (few microns on 25 µm substrate) should not interfere with deployment kinematics
- A 5-m dia. proof of concept model is now in development with the required areal coverage
  - Commercially available, but not space qualified CIGS cells (Copper Indium Gallium di-Selenide)
  - OS will be Kapton & Foam sandwich construction
  - 1 of 4 strings is shown to right on old OS model



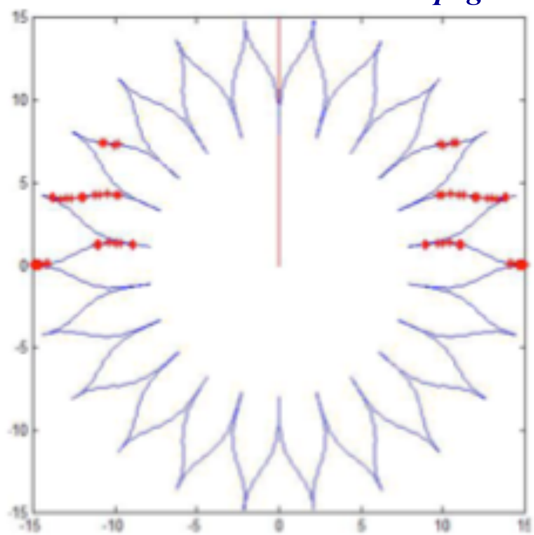
Limiting Solar Glint

- Sharp (< 1μm radius) and dark edges can limit solar glint to less than exo-zodiacal dust
- Flux entering the telescope is dominated by edge segments oriented broadside to Sun
- Stealth edges (high frequency waveform added) reduce flux by ~50X, but require 3-axis pointing
  - 3-axis control is practical for small starshades but much harder for large starshades (need HabEx study)
  - Also need trade study to consider lost benefit of spinning to remove errors that move with the starshade
- Another trade study is to consider diffuse vs. specular surfaces

Optical edge chemically etched in amorphous metal

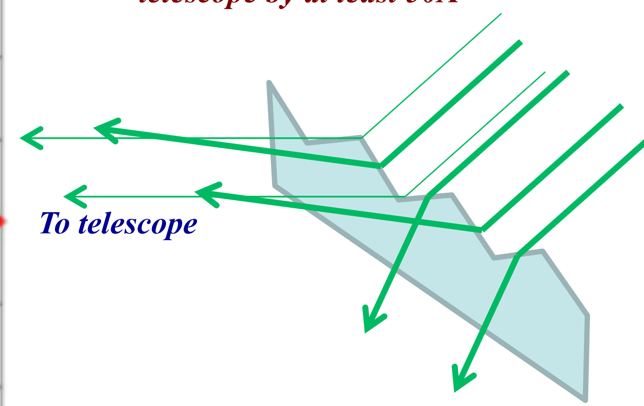


Sun is above and into the page



Solar flux scattered to telescope is mostly broadside to Sun

Stealth edges can reduce flux to telescope by at least 50X



But, requires 3-axis pointing, which may not be practical for HabEx due to large inertia