# Starshade Design Considerations for HabEx

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# Agenda

**Key features of JPL's mechanical architecture**

**Retarget propulsion optimization**

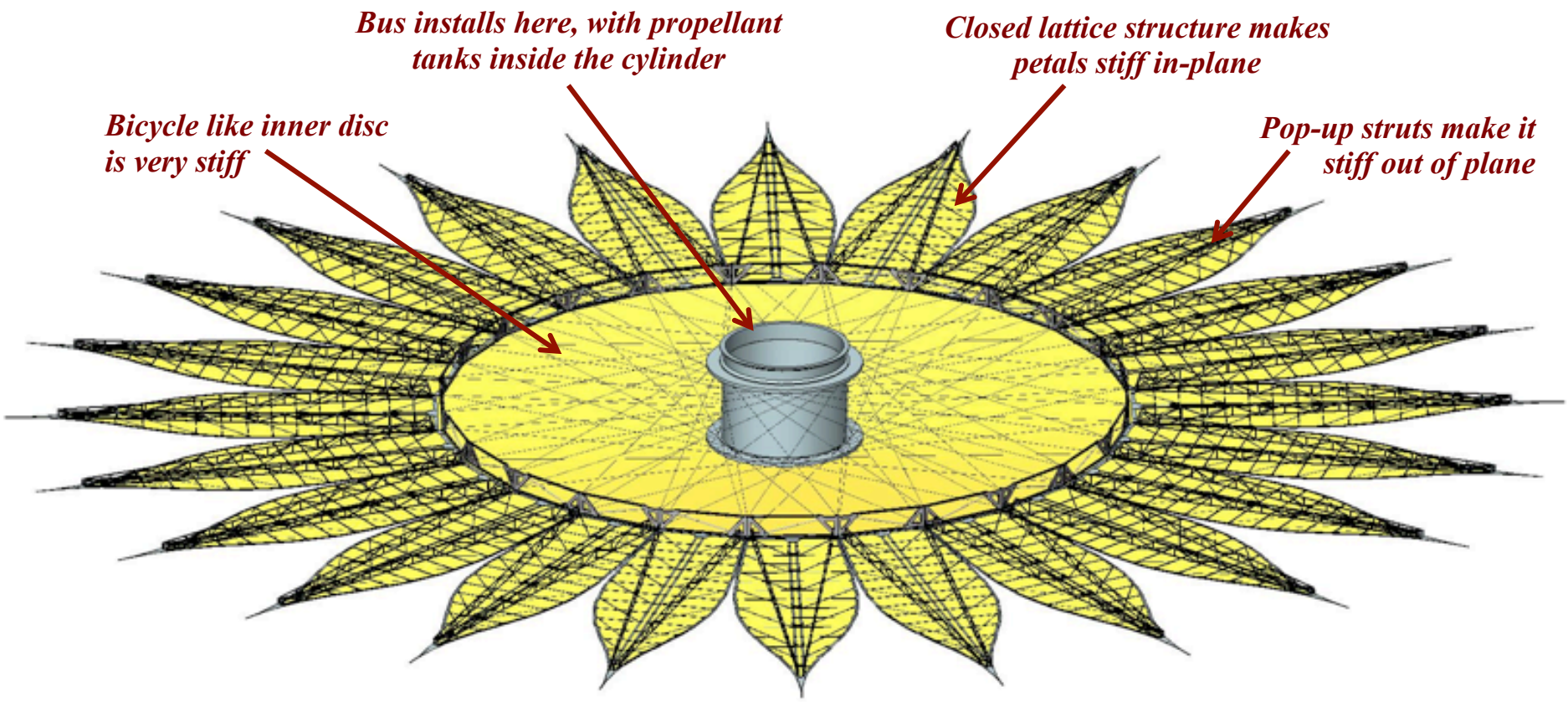
**SEP power generation**

**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



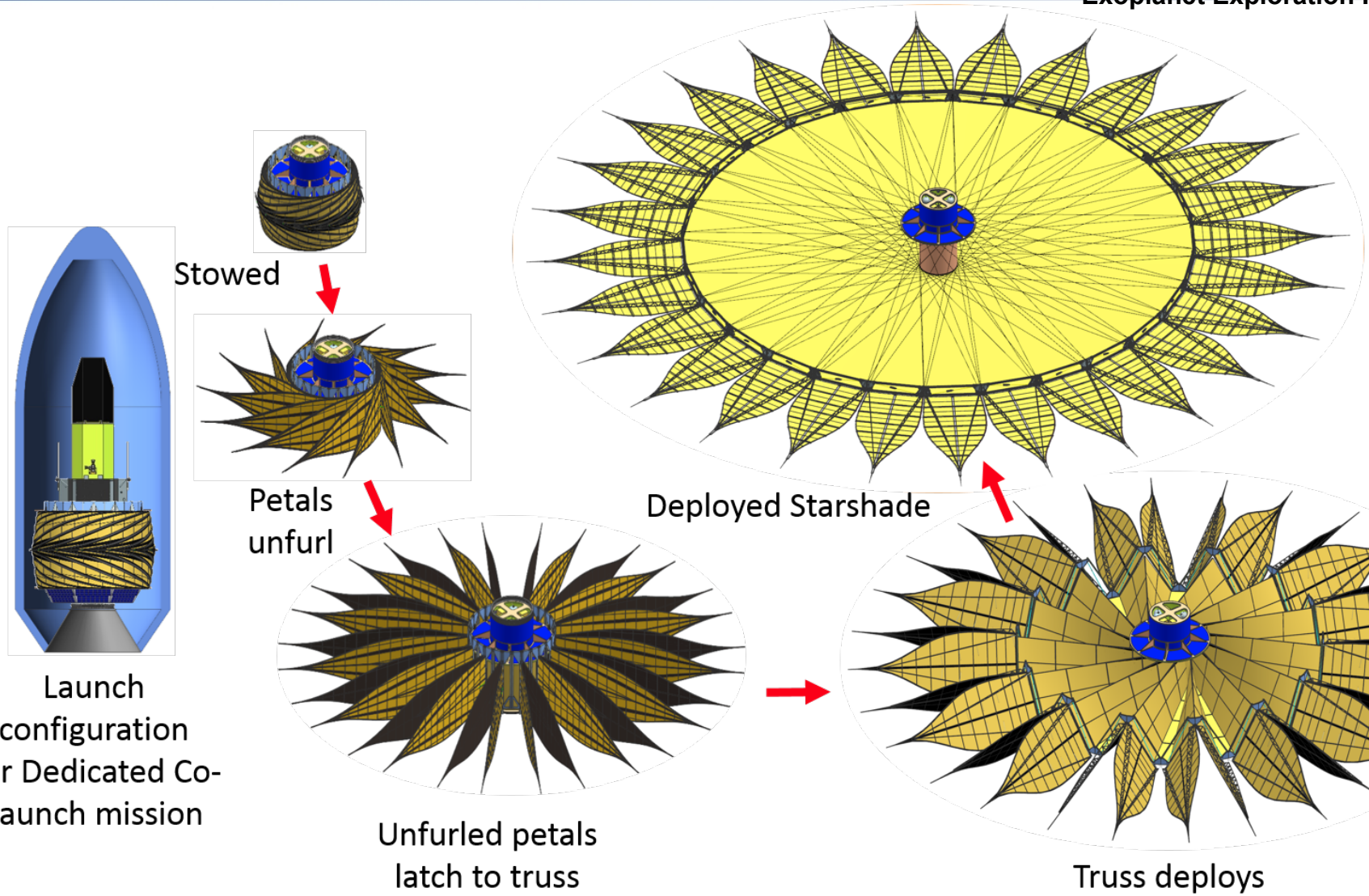
**A secondary payload can be stacked on top the compactly stowed starshade. It could be an unrelated telescope or a 2nd starshade.**

*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



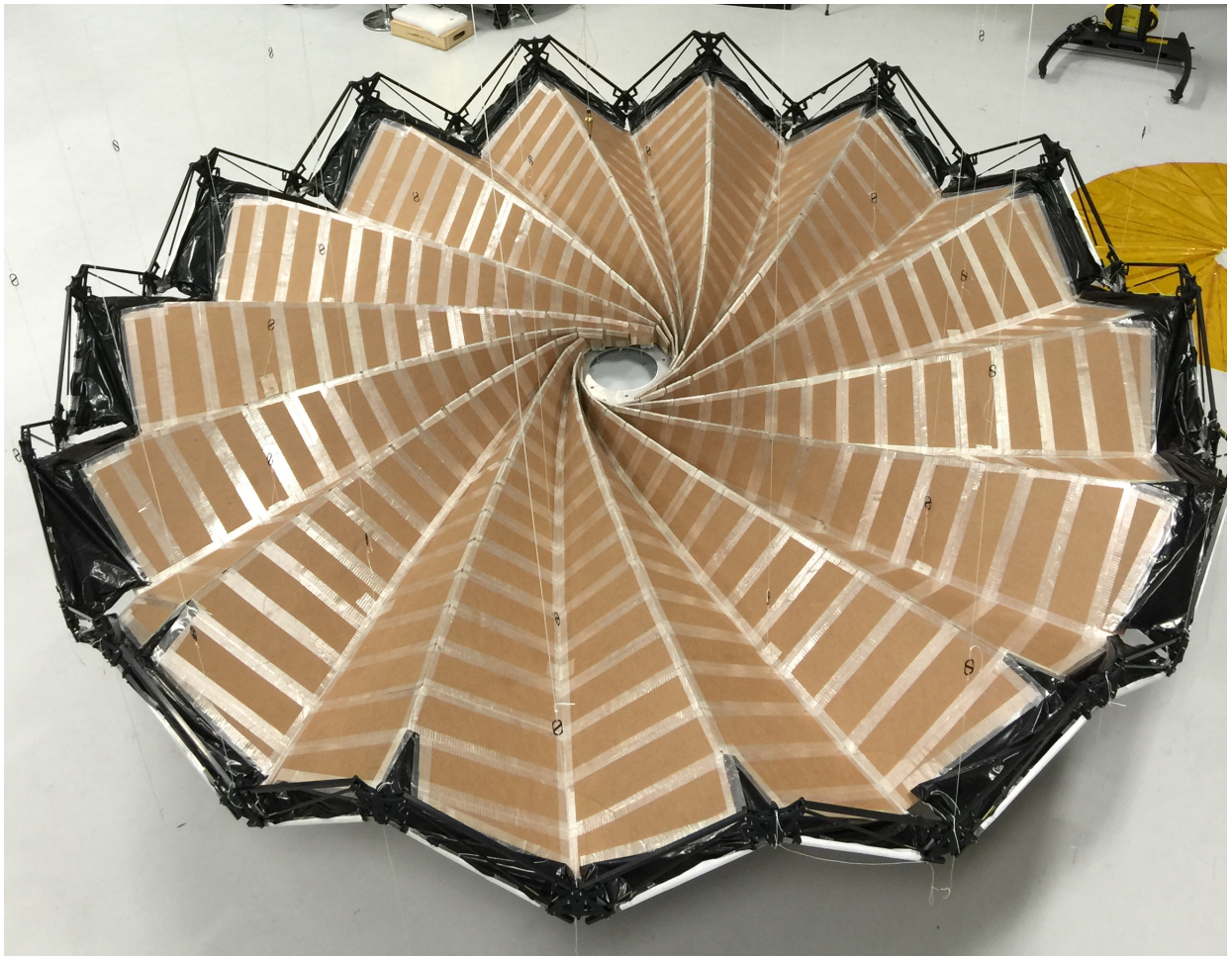



**Deployed petals and disc are stiff by themselves to enable early verification of shape.**

# 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.**

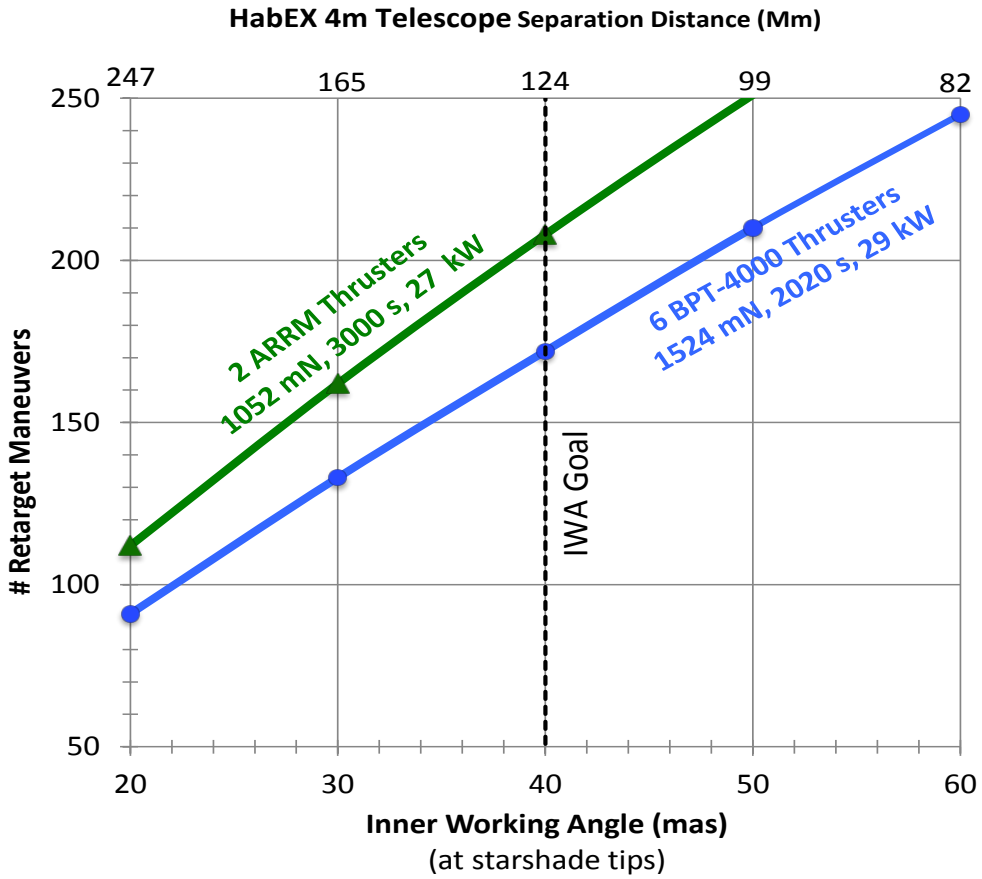
Sorry, I have not cleared these images for ITAR

**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, but not max possible)**
- **Observation performance (# targets) is optimal with the right combination of thrust, specific impulse and propulsion dry mass**

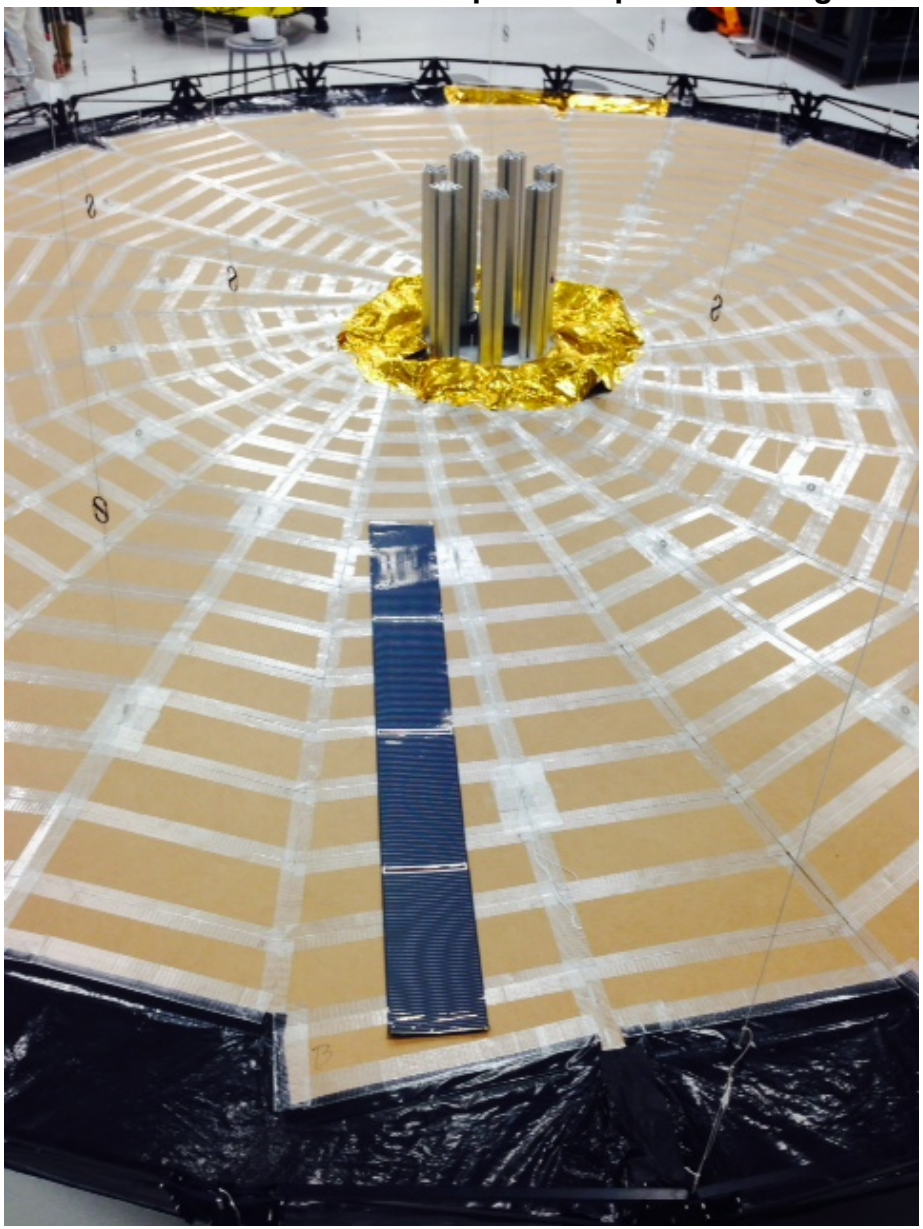



*Ion thrusters, with higher Isp but lower thrust and higher mass/power, are not advantageous but should be represented on this plot*

# SEP Power Generation



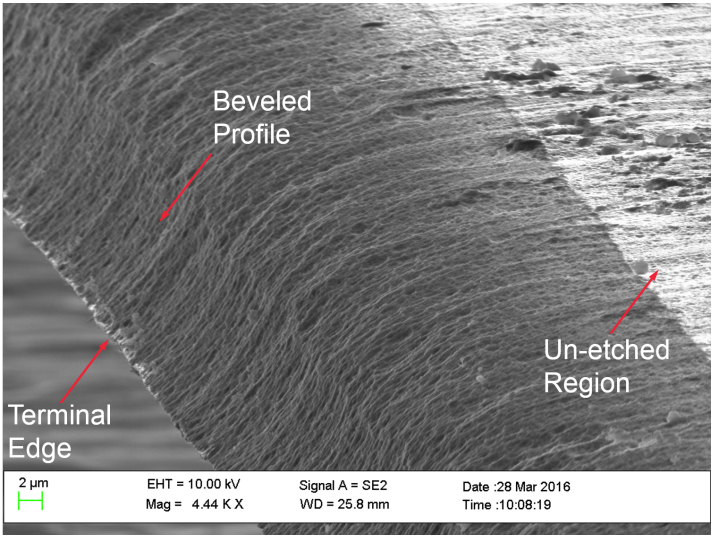
- A large solar array will cast shadows and thermally deform the starshade.
- An alternative is to integrate thin-film solar cells with the inner disc optical shield.
  - The large area available accommodates the relatively low efficiency of thin-film cells
  - The thin cells (few microns on 25 µm substrate) 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



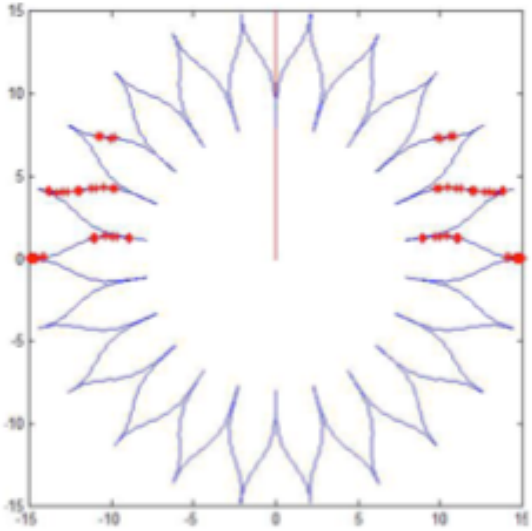
# Limiting Solar Glint

- 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***

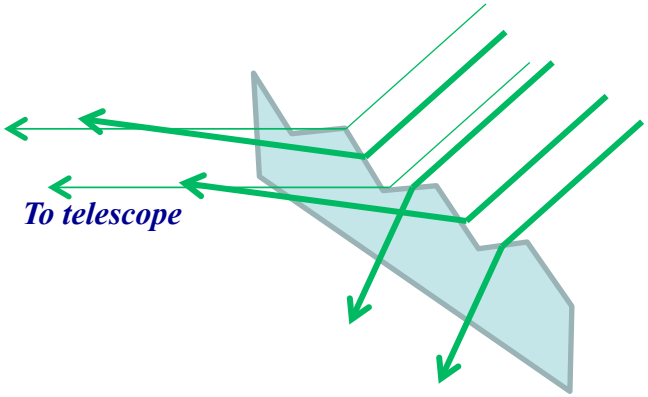



***Sun is above and into the page***



***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***