Starshade Exoplanet Mission Options
WFIRS Conference

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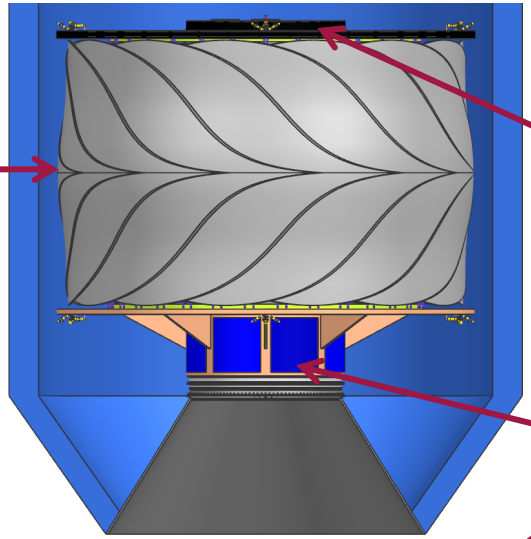
Starshade Spacecraft Architecture

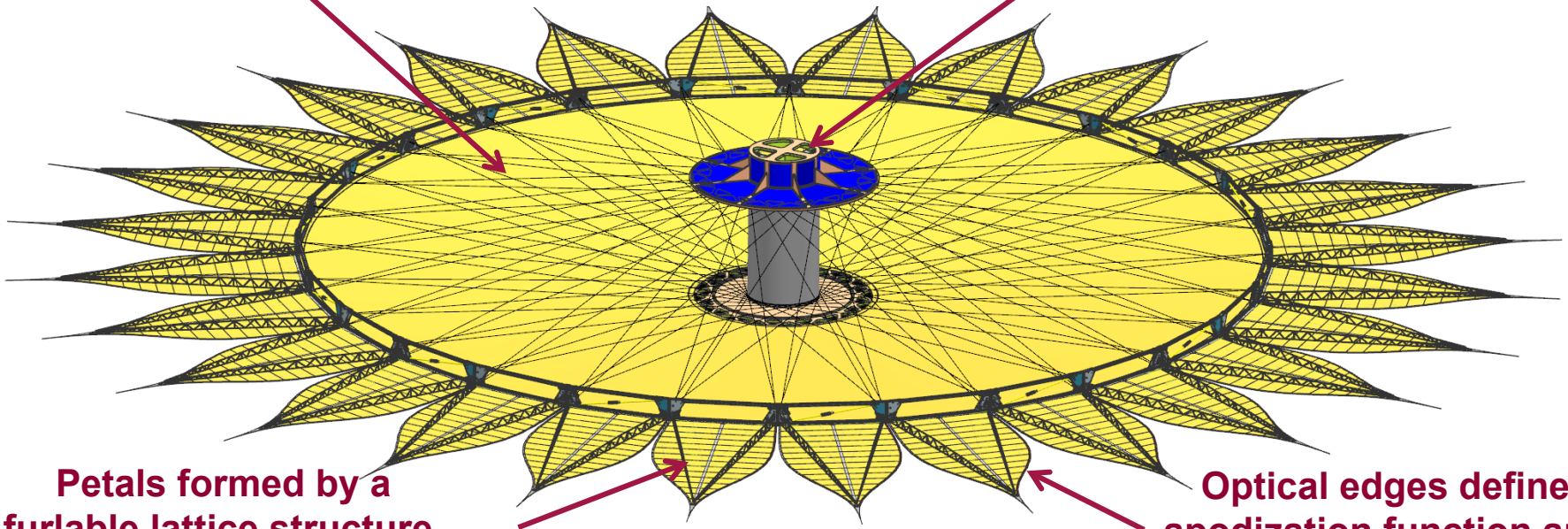


Compact stowed volume fits in 5m fairing

Another spacecraft (e.g., telescope) can stack on top

Inner Disk formed by a perimeter truss, wire spokes, optical shield and central hub

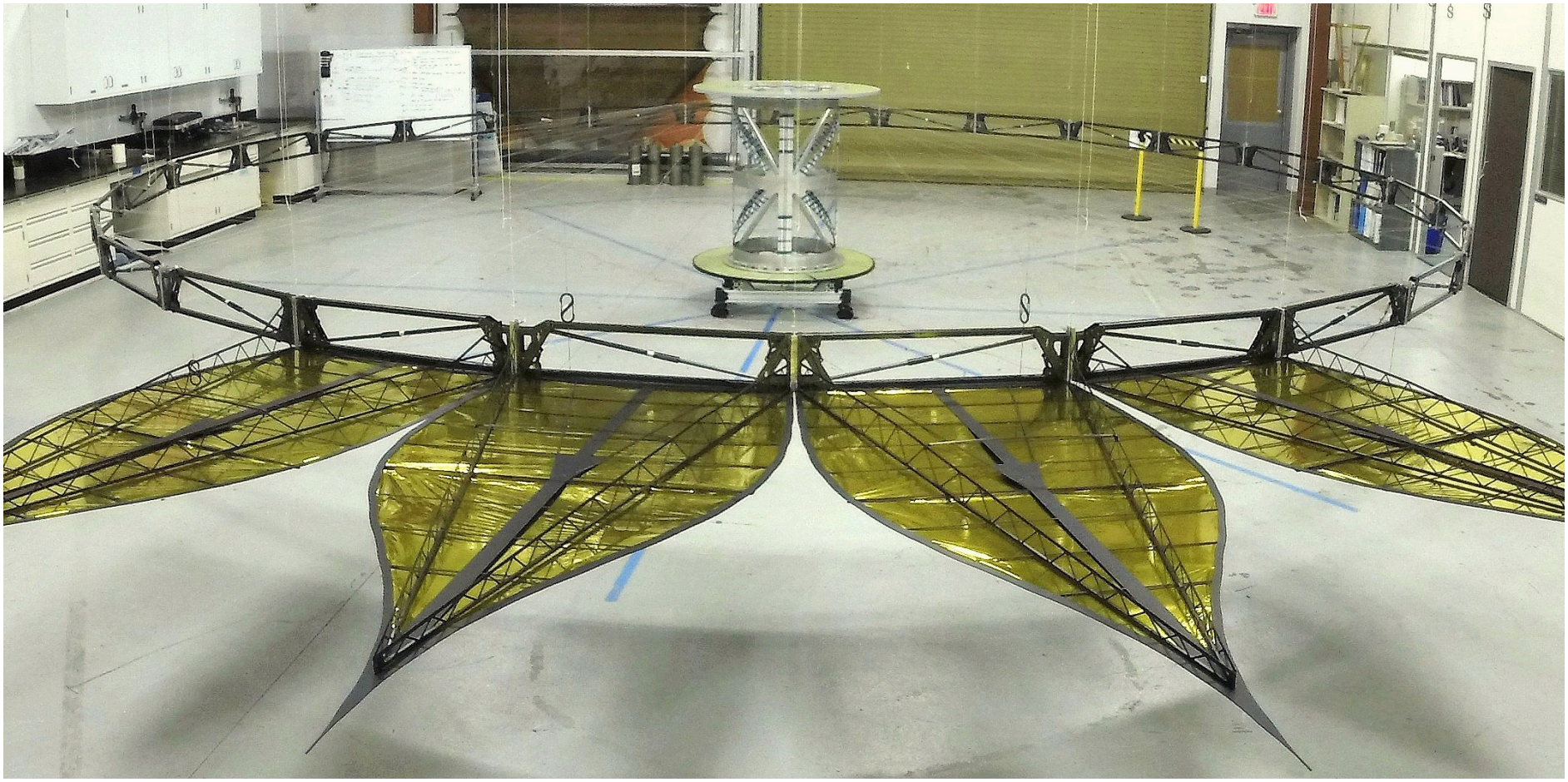
Bus system mounts to central hub with optional propellant tanks in center



Petals formed by a furlable lattice structure, optical shields and pop-up ribs

Optical edges define apodization function and control solar glint

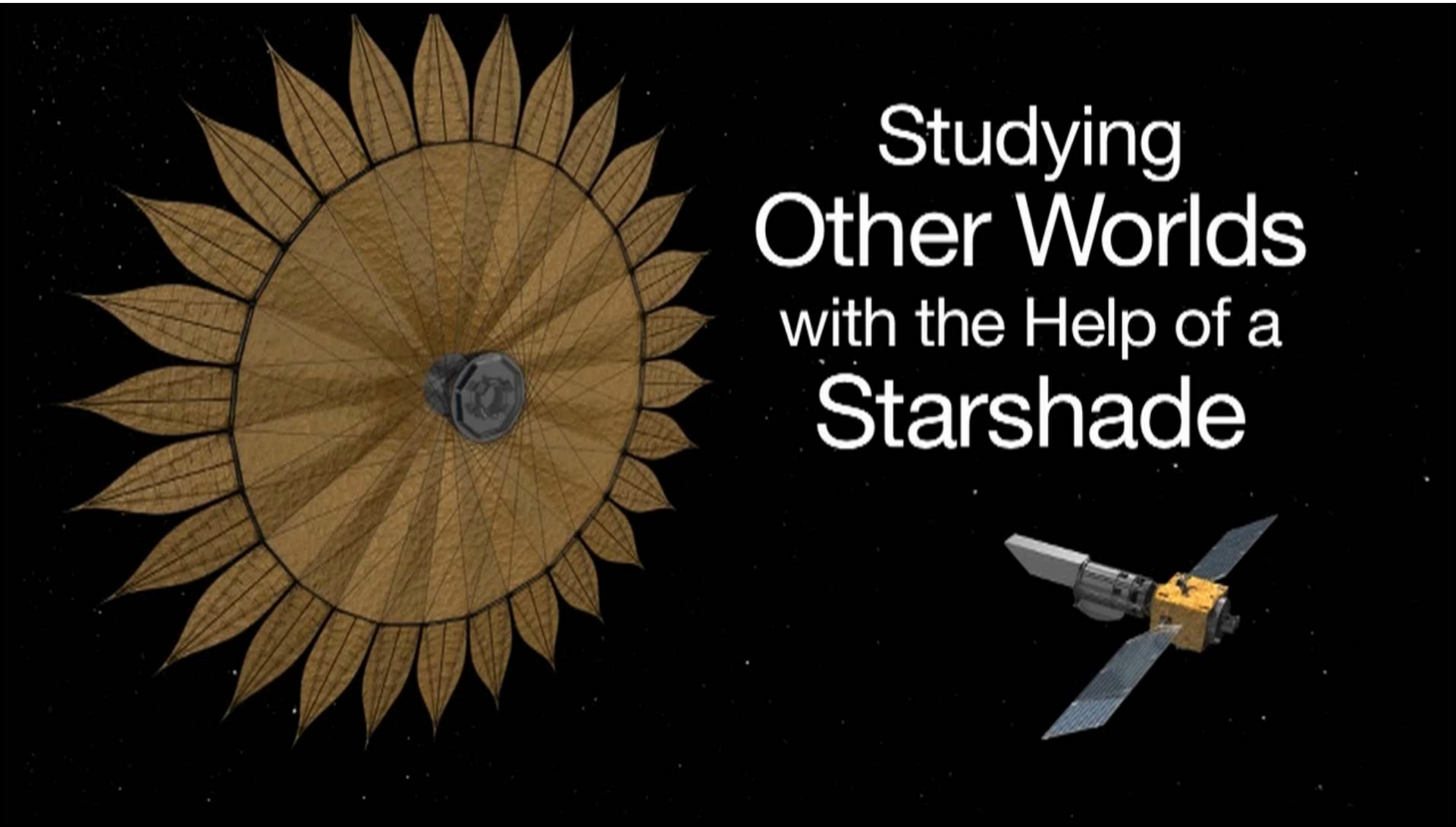
Starshade Deployment Testbed at JPL



10m diameter inner disk and 3.5m long petals assembled by undergraduate students in summer of 2014

Deployment Tolerance Demo

Deployment tolerances were successfully demonstrated with this earlier prototype with 20 deployment cycles



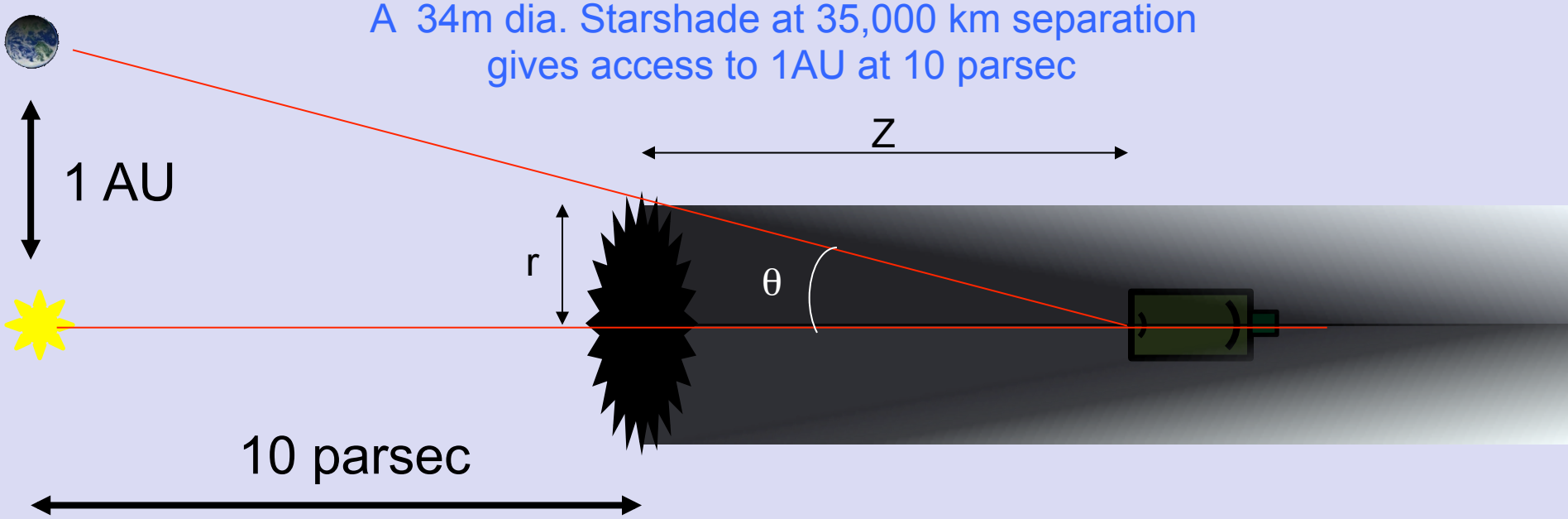
Starshade Basics

- Starlight is suppressed before entering the telescope, so wavefront does not require correction and no stringent requirements are levied on the telescope
- No outer working angle
- Contrast and inner working angle are largely independent of the telescope
- Lateral formation control band is created by making the shadow larger than aperture

IWA = θ = angle to tip of starshade

$\theta = r/Z$

A 34m dia. Starshade at 35,000 km separation gives access to 1AU at 10 parsec

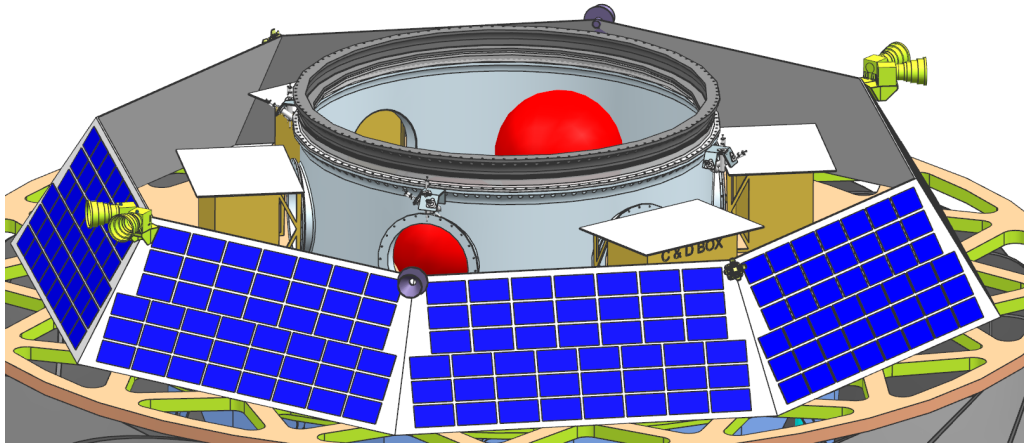


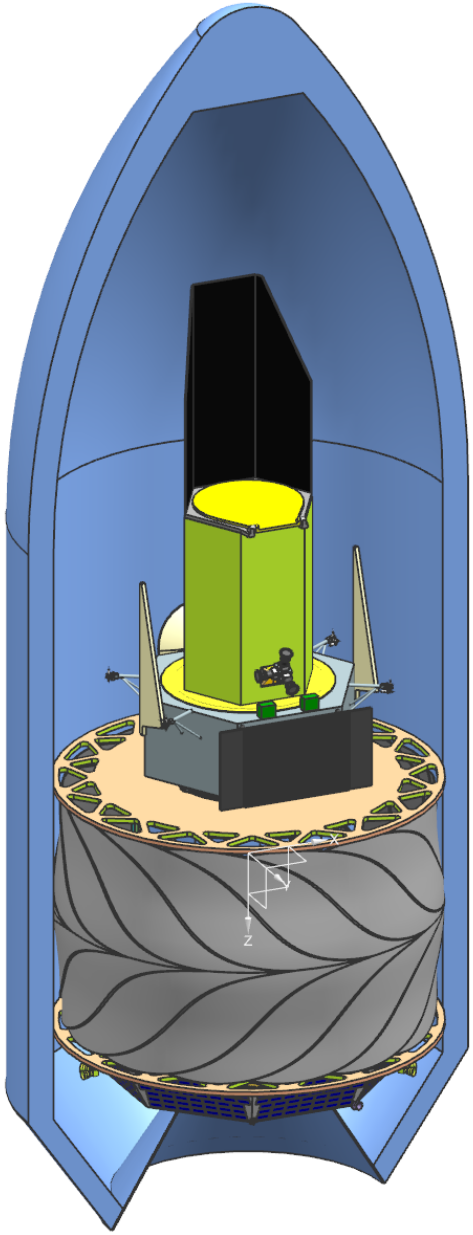
Mission Options

- Exo-S STDT is studying two mission scenarios:
  - Small dedicated telescope co-launched with starshade
  - Larger multi-purpose telescope launched separate from starshade
- Remainder of presentation details the two options the STDT plans to detail in their report

Small Dedicated Telescope Case Study

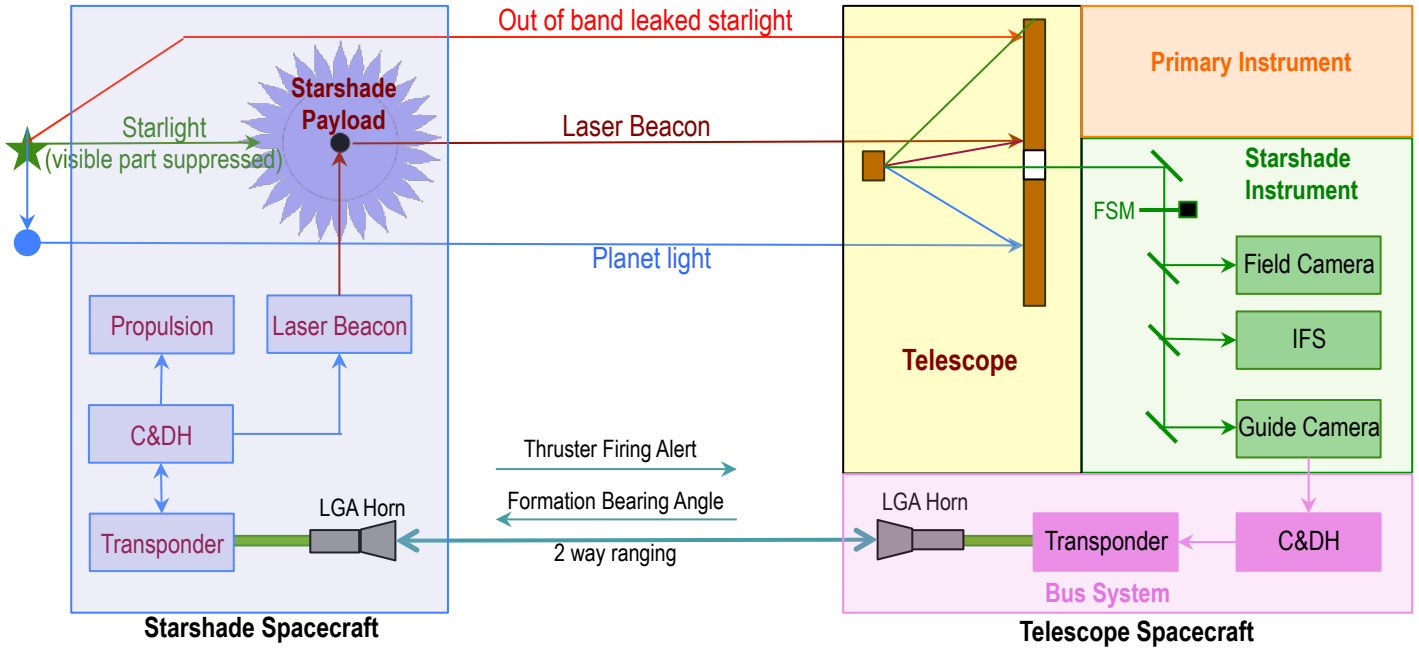
- 1.1 m telescope stacks on-top starshade at launch
- Falcon-9 launch vehicle with 5 m fairing
- Earth Drift Away orbit for simple navigation and benign environment for formation control
- Telescope provides propulsion for retargeting and formation control
- Telescope carries instrumentation for starshade:
  - Field camera, guide camera and IFS with 3” FOV
- 30 m starshade operates 34,000 km from telescope for primary band of 515-825 nm





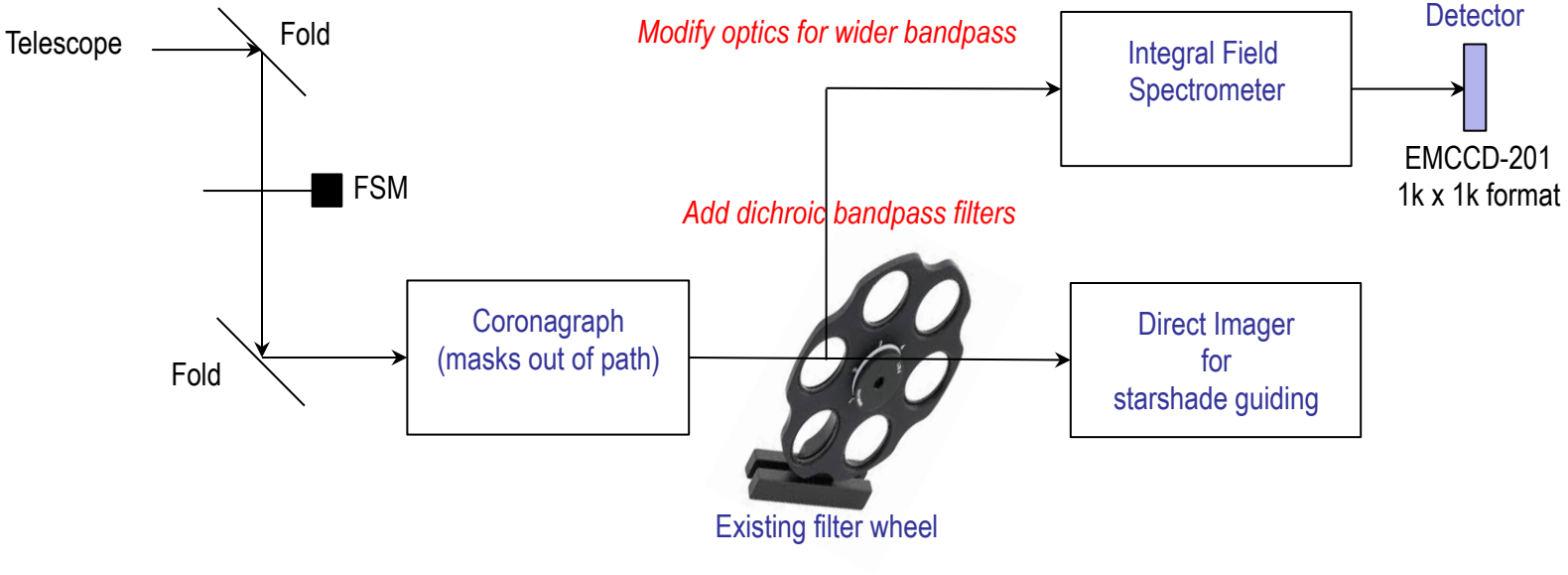
Multi-Purpose Telescope Missions in General

- Starshade based exoplanet science is a secondary mission objective
- Telescope launches with a “starshade ready package”:
  - Proximity radio for inter-spacecraft communication and range measurement
  - Guide camera for sensing starshade lateral position
  - IFS for science and optional field camera
- Telescope operates at Earth-Sun L2 to enable rendezvous
- Starshade launches later to start observing after primary mission objectives are met
- Starshade provides propulsion for retargeting and formation control



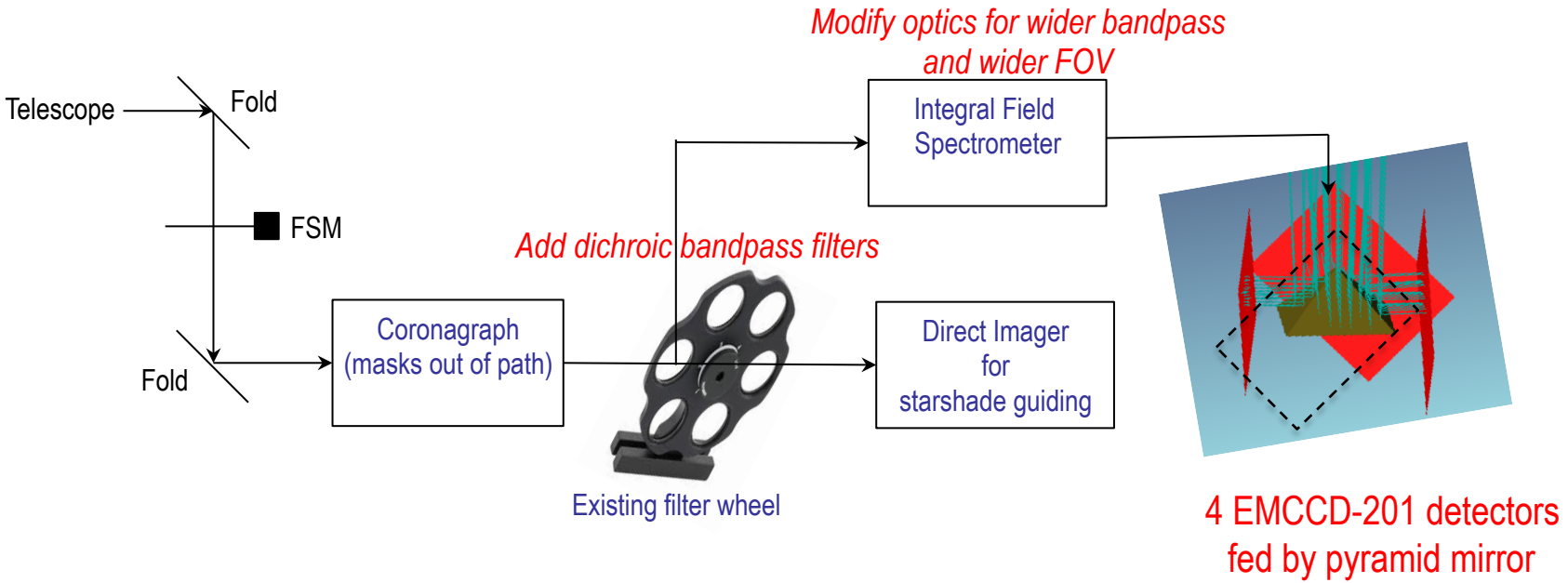
WFIRST/AFTA Case Study

- Study assumes that WFIRST/AFTA operates at Earth-Sun L2
- Spacecraft bus provides proximity communications (transponder and LGA)
- Coronagraph provides starshade instrumentation with no added focal planes
  - Direct Imager for starshade guiding, IFS for science and no field camera (optional)
  - Dichroic bandpass filters added and IFS optics modified for wider bandpass
- Starshade FOV is limited to 0.75” by IFS detector size and coronagraph optimized pixel scale and spacing between spectrums
- 34 m starshade operates 35 Mm from telescope for primary band of 600-850 nm



FOV Enhancement Option

- FOV increase to 1.1” requires adding detector area
- Low noise detector required for coronagraph is only available in 1k x 1k format
- This concept spreads spectrums over 4 baseline detectors fed by a pyramid mirror



Starshade Spacecraft for WFIRST/AFTA case study

- Falcon-9 launch vehicle with 5m fairing
- Simple spin-stabilized spacecraft (1/3 rpm), with loose pointing requirements (1 deg)
- Chemical propulsion with commercial tanks sized to fit in existing 1.6 m dia. Hub
- Propellant capacity is sufficient for > 3 years of operation, with large mass margins
  - Excess capacity could be used to deliver a separate payload to L2
- Future studies will consider SEP with solar cells embedded in optical shield