Australian National University

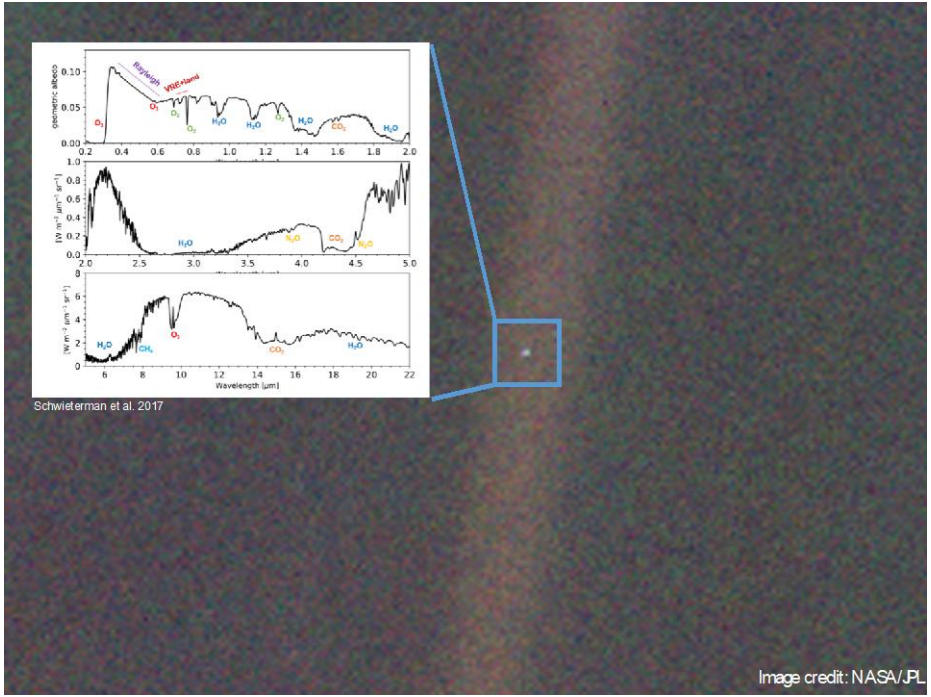
An Australian CubeSat mission for Formation Flying Space Interferometry

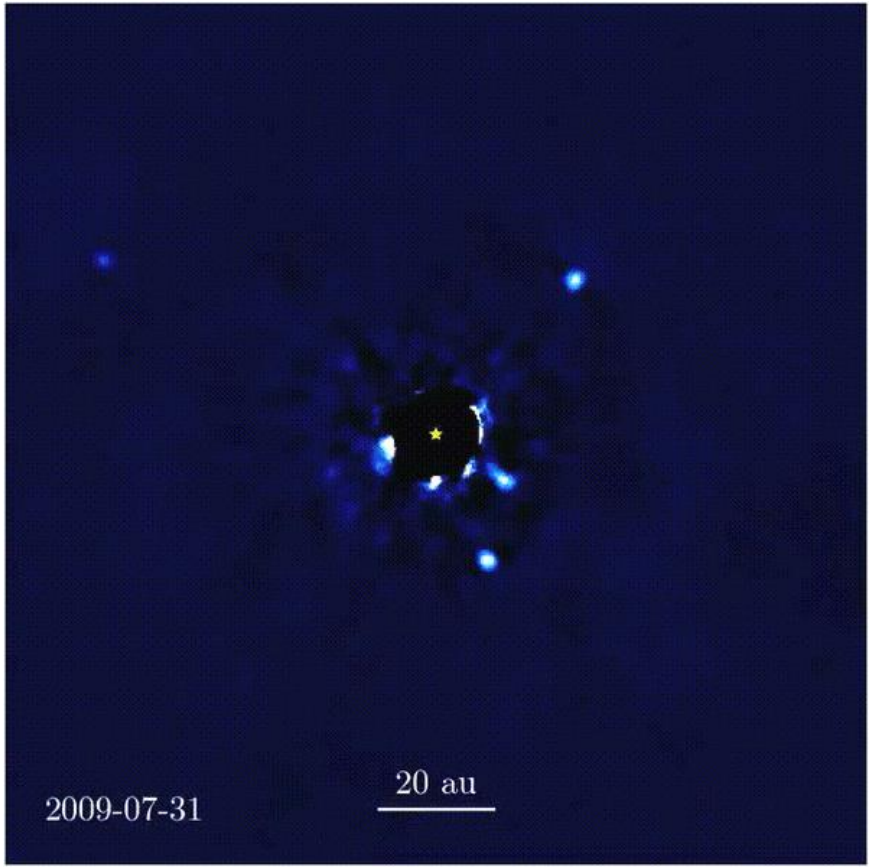
Jonah Hansen and Michael Ireland

Directly Imaging Earth-like Exoplanets

Goals

- Determining the atmospheric composition of a planet
- Seeing a planet in the process of formation

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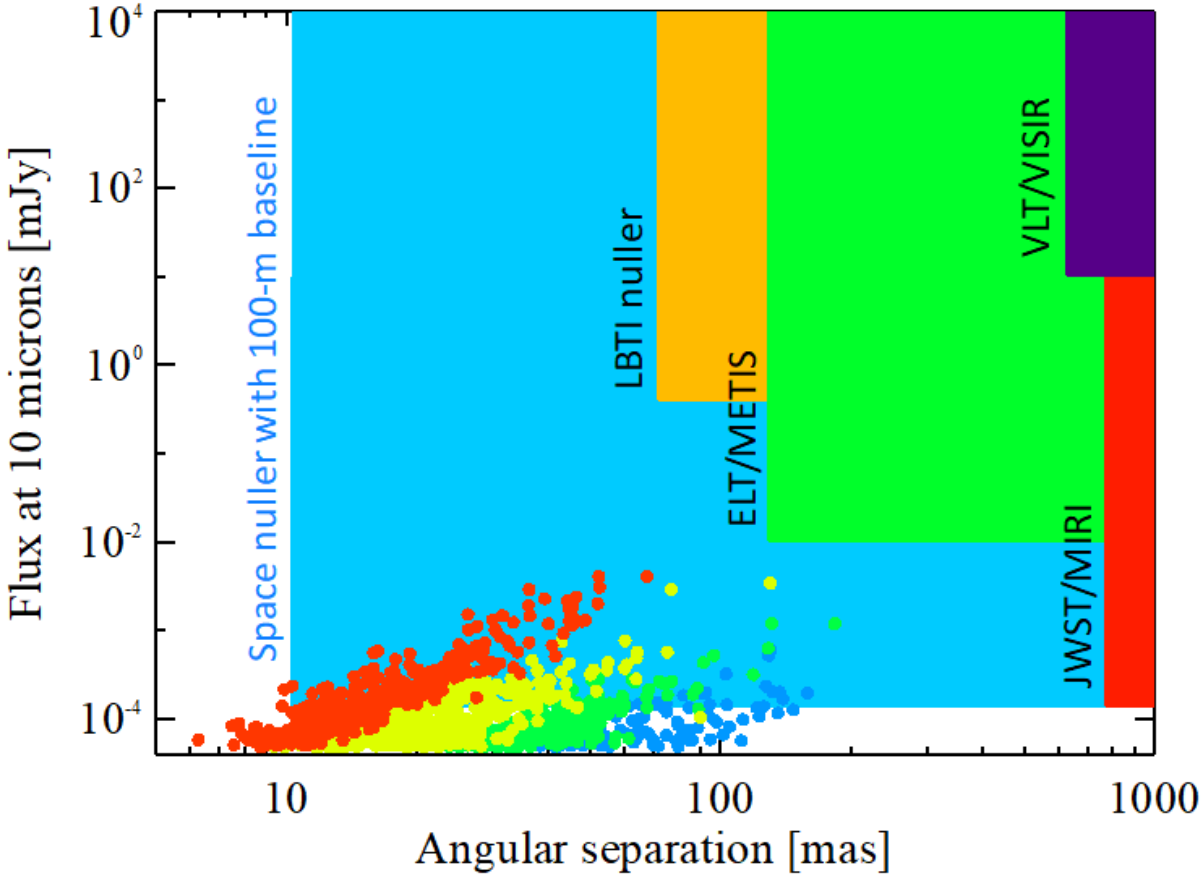
But Houston, we have (many) problems

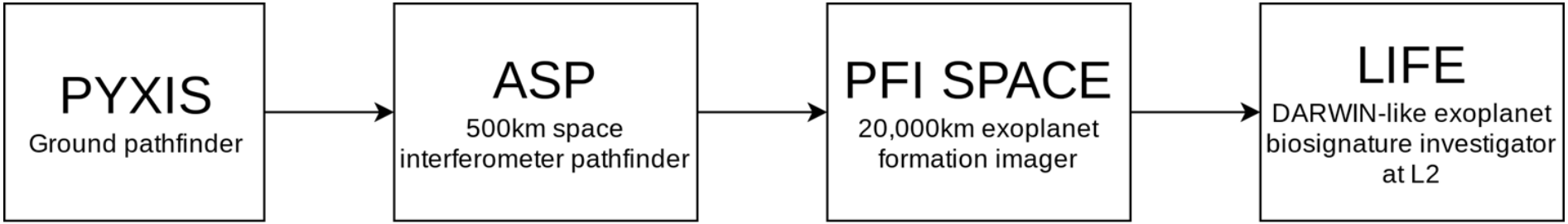
- Contrast and sensitivity
  - To achieve peak contrast, we need to look in the infrared
  - Limited by telescope and atmosphere emission
- Angular separation
  - For the closest systems around F type stars, we require a >25m telescope (100mas)
  - Anything further away or around a dimmer star requires a larger telescope


Flux at 10 microns [mJy]
10^4
10^2
10^0
10^{-2}
10^{-4}
10
100
1000
Angular separation [mas]
Space nuller with 100-m baseline
LBTI nuller
ELT/METIS
VLT/VISIR
JWST/MIRI

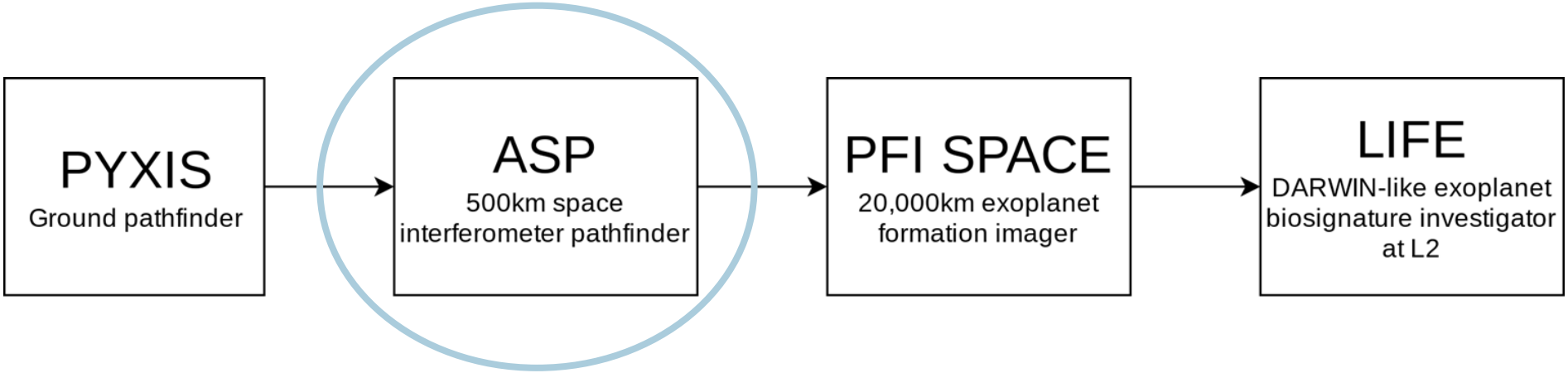
Current state of space interferometry

- Large number of ESA studies in the 1980s and 1990s
- Flagship missions of DARWIN and TPF-I
- All missions were cancelled due to budget constraints in the late 2000s
- LISA for gravitational waves

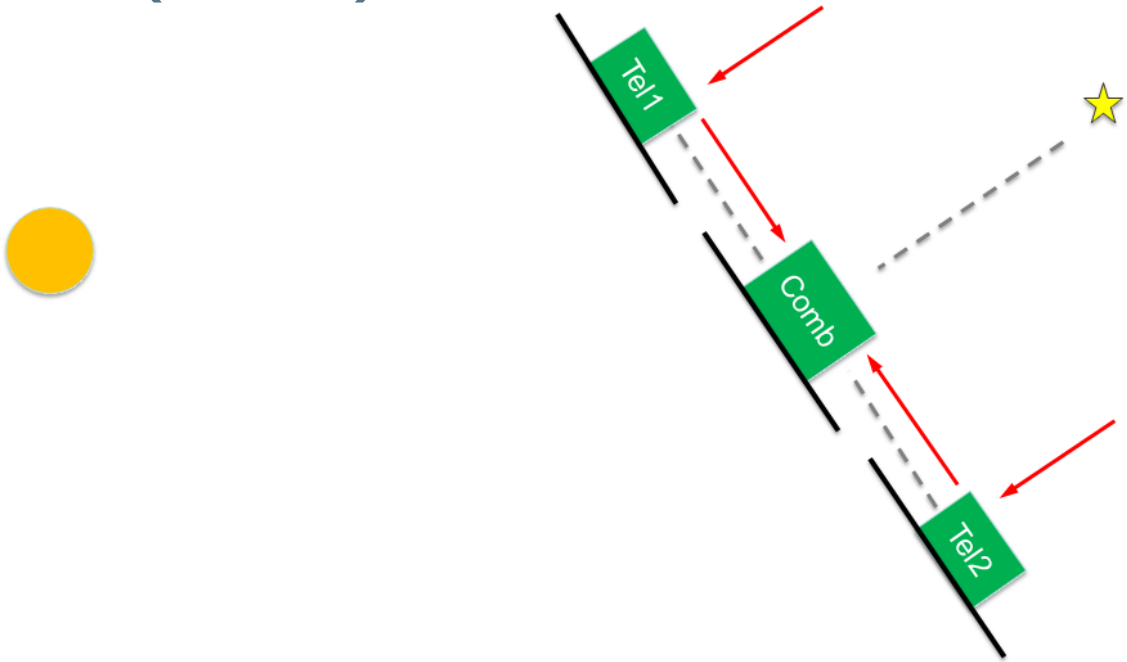
Our proposed pathway



Our proposed pathway



The Astrophysical Space-interferometry Pathfinder (ASP)



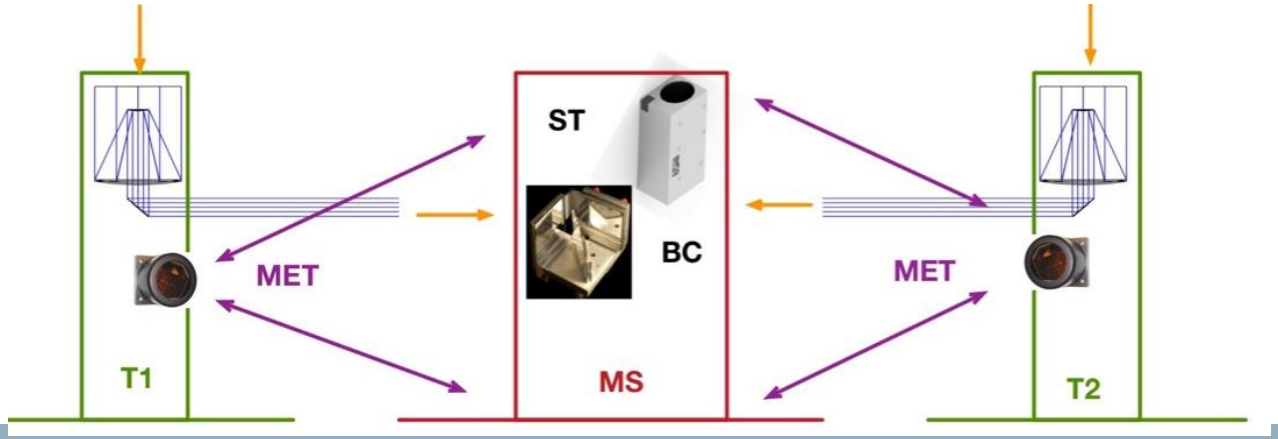
The optical pathlength offset

$$\Delta = |\mathbf{b_1}| - \mathbf{b_1} \cdot \hat{\mathbf{s}} - |\mathbf{b_2}| + \mathbf{b_2} \cdot \hat{\mathbf{s}}$$

- The key is to control this parameter to within the coherence length of the interferometer - approximately 0.1-1mm
- Also can’t have a velocity more than 10nm/s (assuming 10s integrations

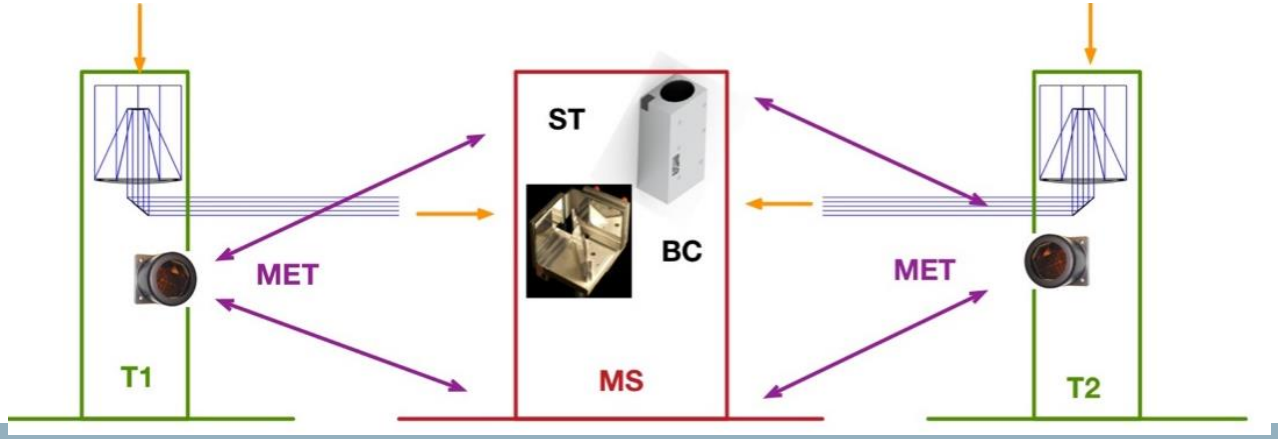
Required Metrology

- Camera/LED and time of flight system coarse metrology for angles and positions



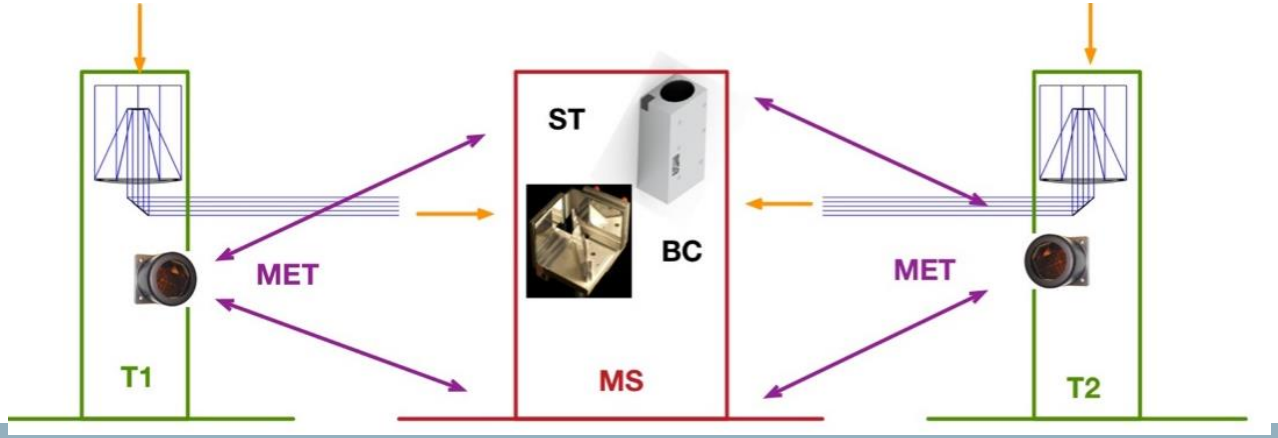
Required Metrology

- Precise and accurate star trackers at the level of 0.2 arcsec demonstrated on JPL's Asteria CubeSat



Required Metrology

- Fine velocity/position measurement with broad band interferometry and spectrograph or multiple lasers

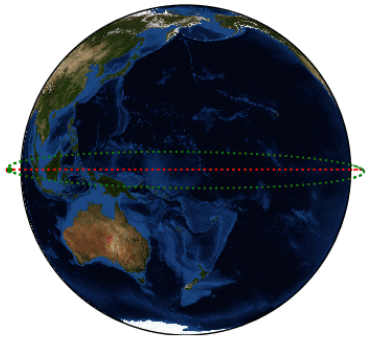


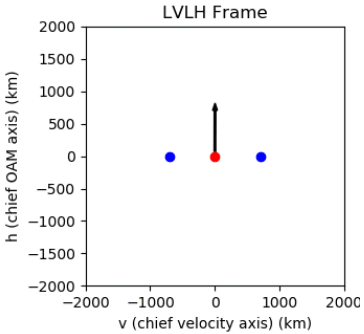
Required Metrology

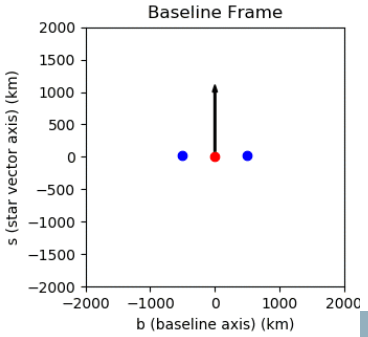
- Positioning will come from a few micro-thrusters (two on the two deputy satellites and up to two on the main beam combiner) and a moving mirror for fine optical path adjustments

Orbital Dynamics

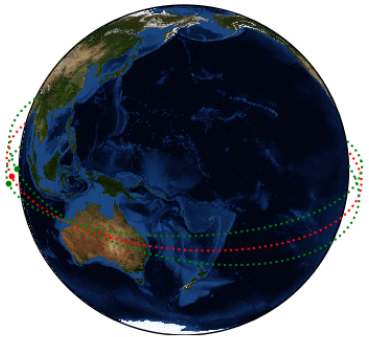
$i = 0°$ $\alpha = 0°$
$\Omega = 0°$ $\delta = 45°$

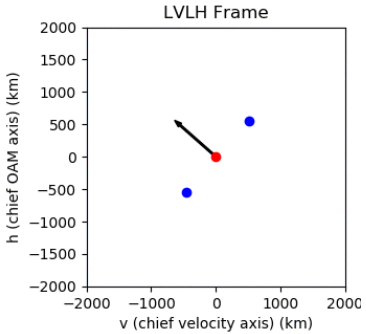


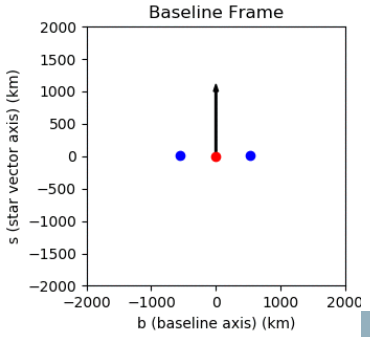




$i = 27°$ $\alpha = 36°$
$\Omega = 10°$ $\delta = 45°$

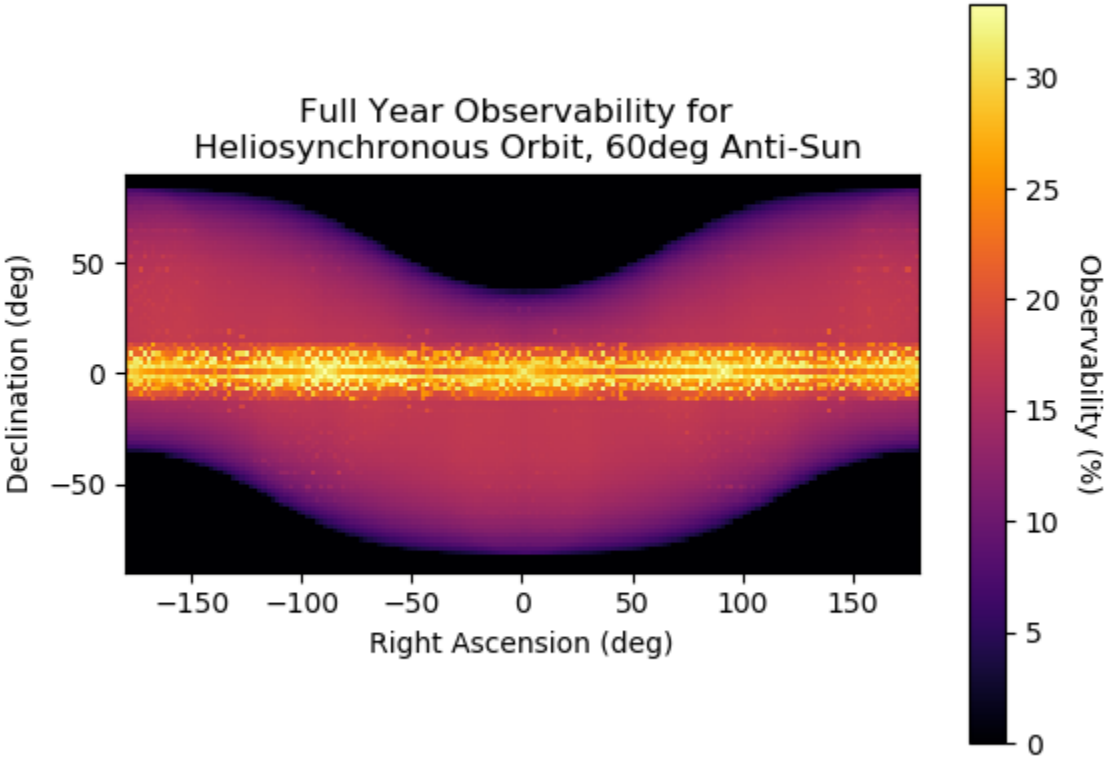


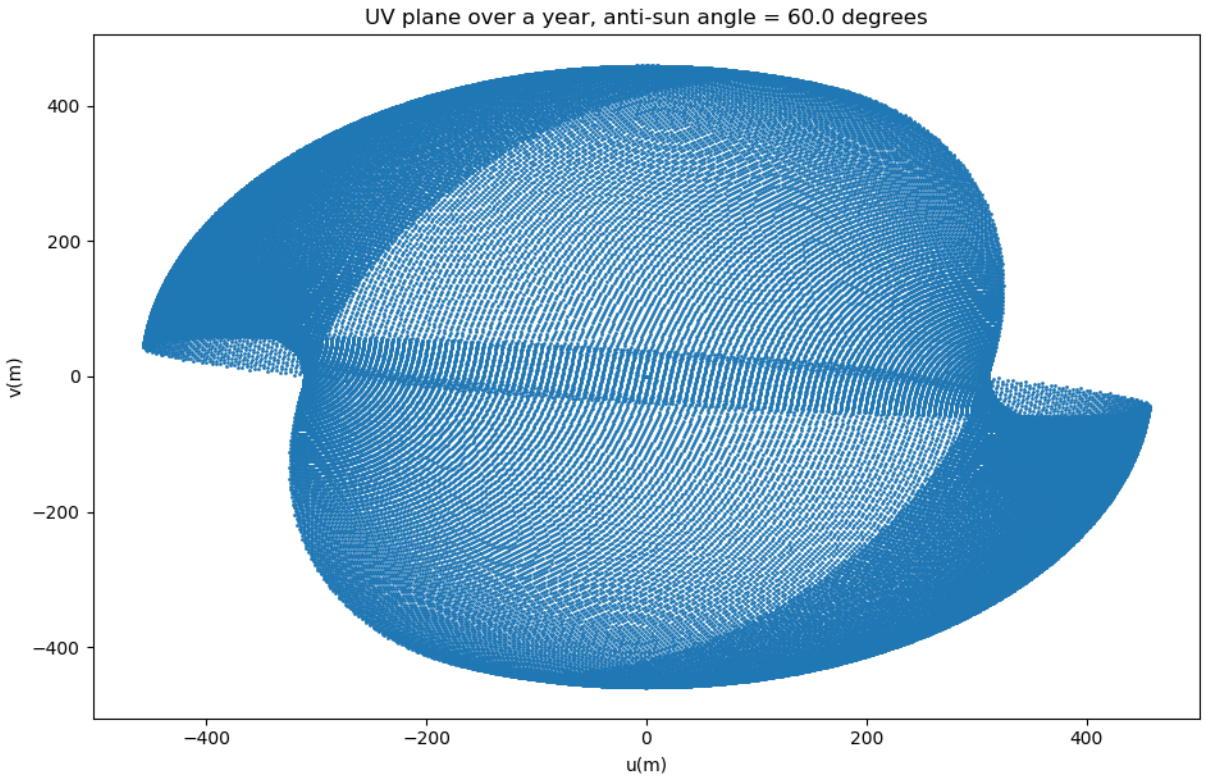




Future Goals

- A full orbit simulation with thruster burns
- Identifying what proportion of stars are available to observe over a given length of time
- Realistic science targets for this pathfinder (eg. binaries, young accreting stars, quasars)


Full Year Observability for
Heliosynchronous Orbit, 60deg Anti-Sun
Declination (deg)
50
0
−50
−150
−100
−50
0
50
100
150
Right Ascension (deg)
30
25
20
15
10
5
0
Observability (%)


UV plane over a year, anti-sun angle = 60.0 degrees
400
200
0
−200
−400
v(m)
−400
−200
0
200
400
u(m)