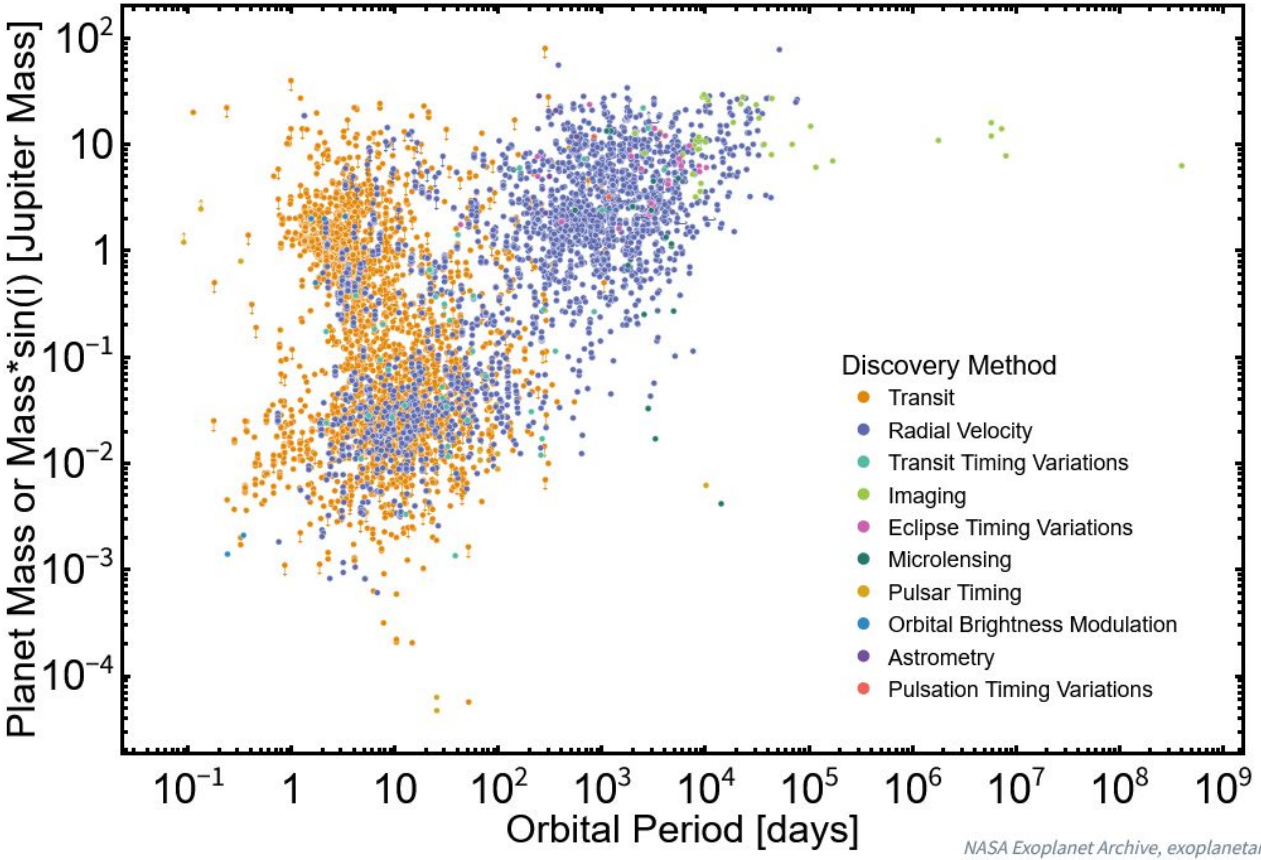
Orbit-Fitting Methodology for the Searching for Habitable Exoplanets with Relative Astrometry (SHERA) SMEx Mission Concept

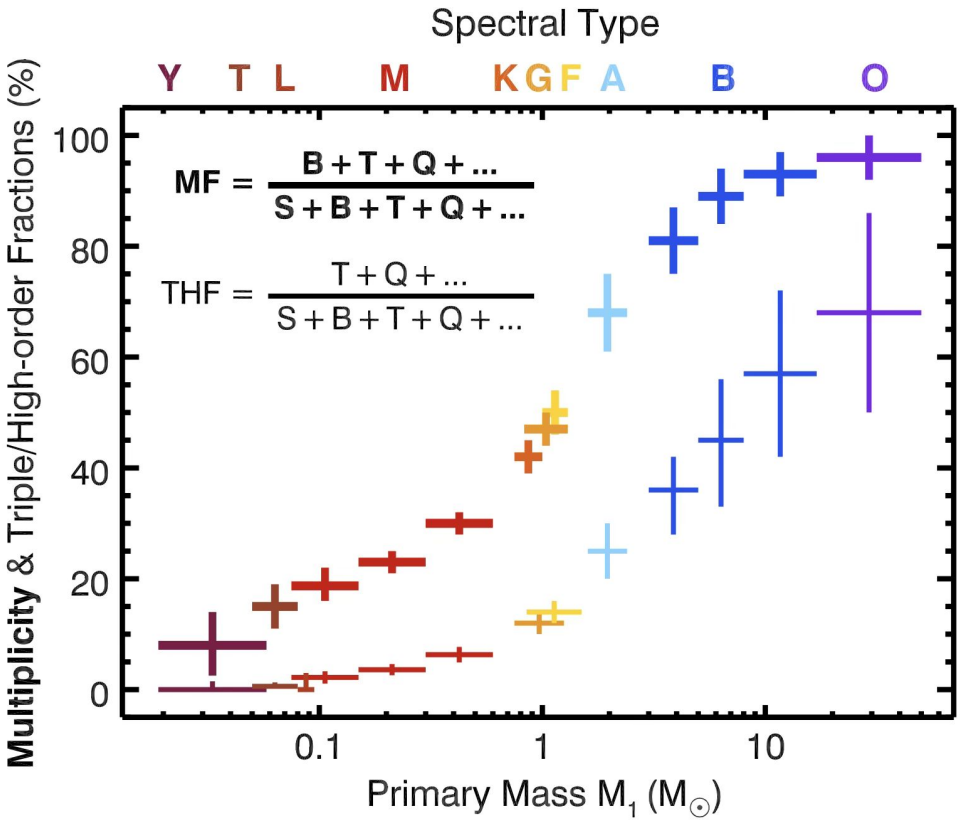
William Roberson

SHERA: Motivation



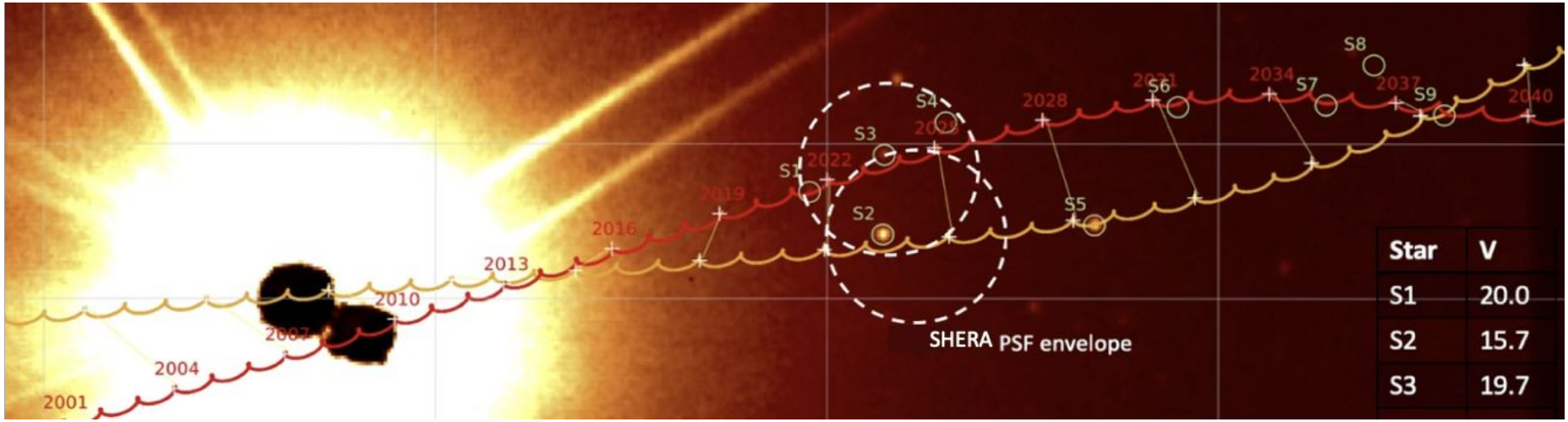
NASA Exoplanet Archive, exoplanetarchive.ipac.caltech.edu, 2025-12-31 12:48:34

SHERA: Motivation



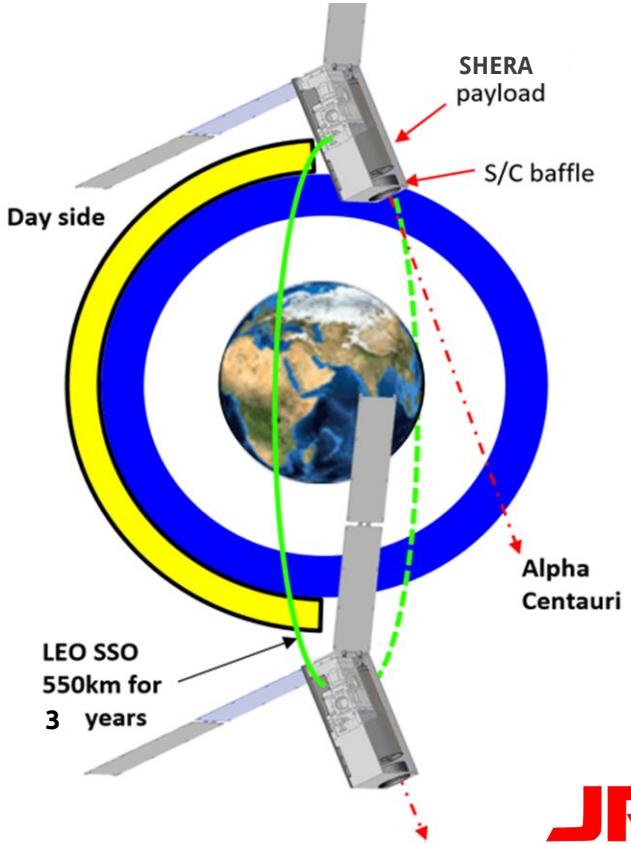
Offner et al. 2023

SHERA: Motivation



SHERA SMEx Mission Concept

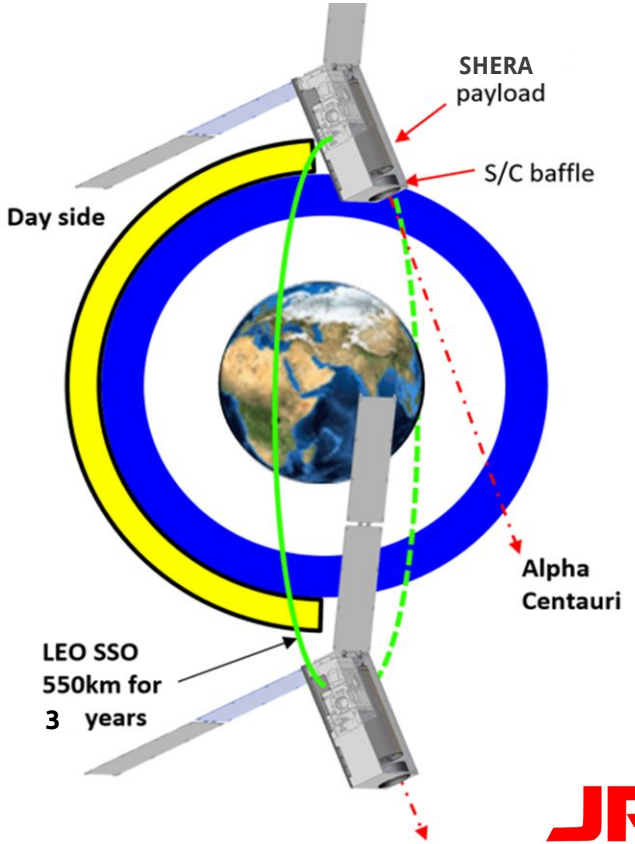
- PI: Jessie Christiansen
- Will search nearby binaries for S-type habitable zone planets
- Will be able to detect Earth-analogs with microarcsecond astrometry
- Modified diffractive pupil allows for microarcsecond precision astrometry
- Preparation for HWO



Tuthill et al. 2018

SHERA Science Goals

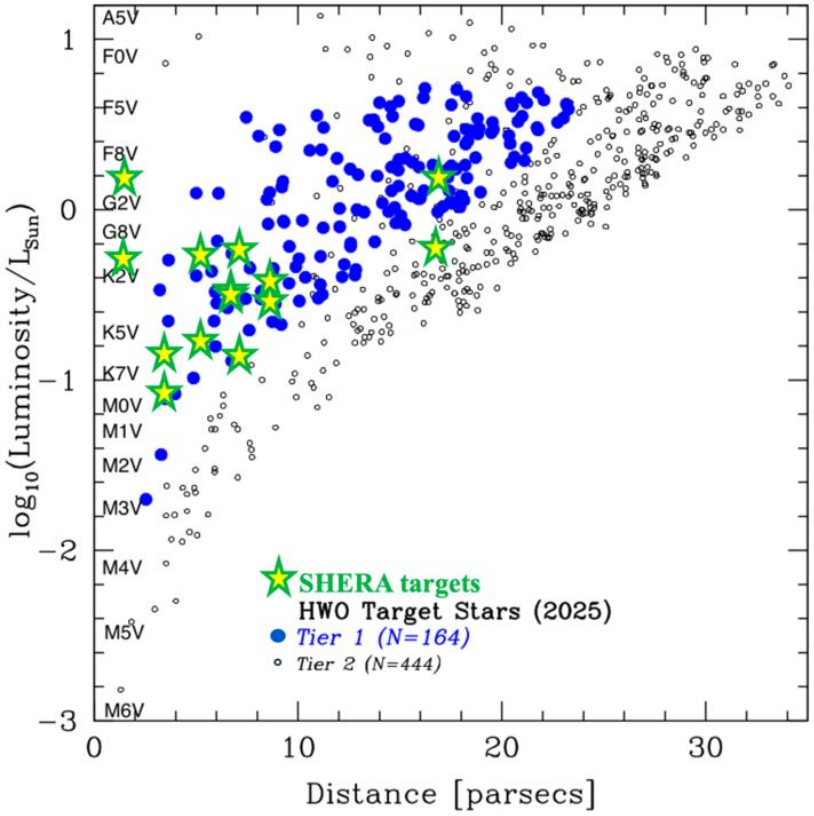
- Search nearby binaries for Earth-analog exoplanets
- Measure suppression of occurrence rate for Earth-analogs around binaries
- Inform HWO observation strategies for SHERA targets



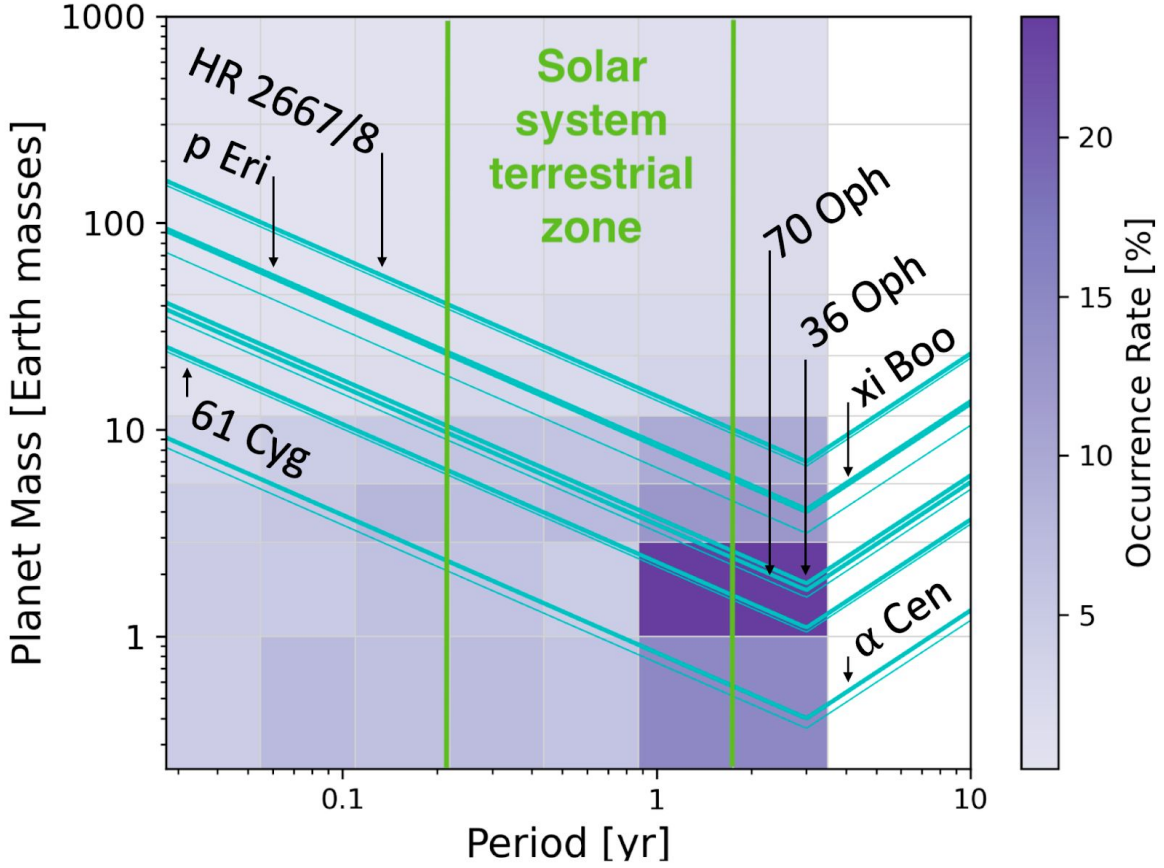
JPL

Tuthill et al. 2018

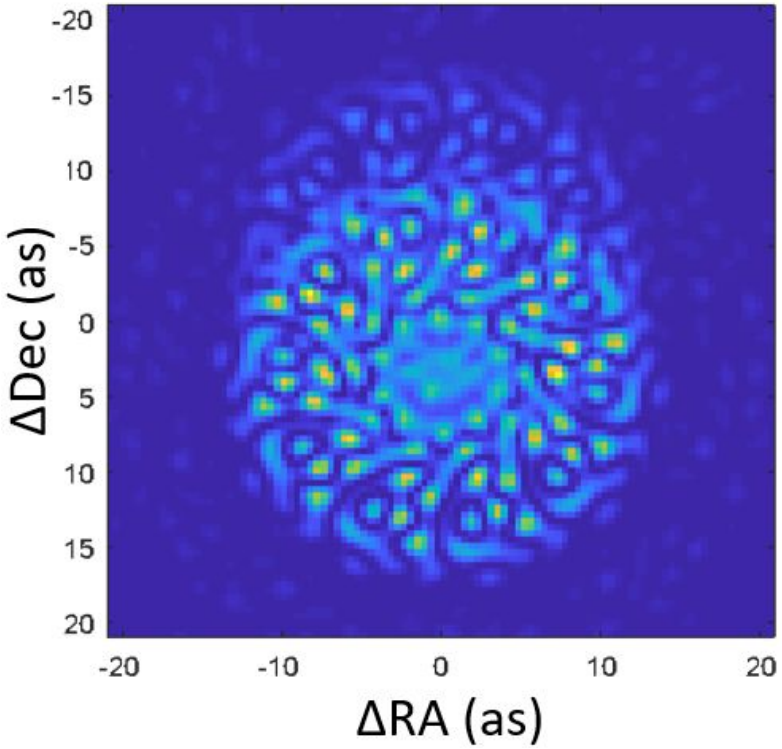
SHERA Targets

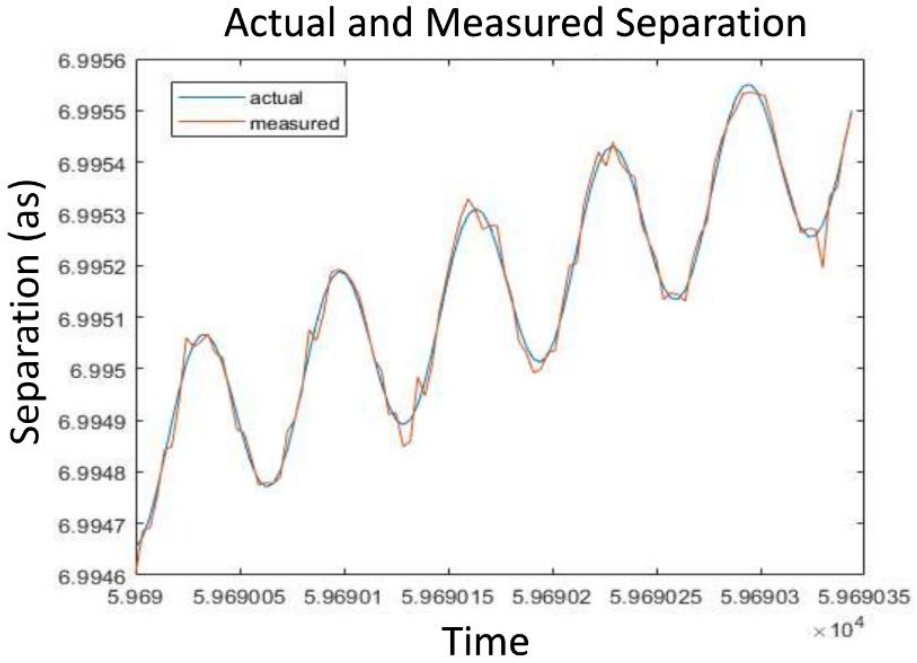


SHERA Sensitivity

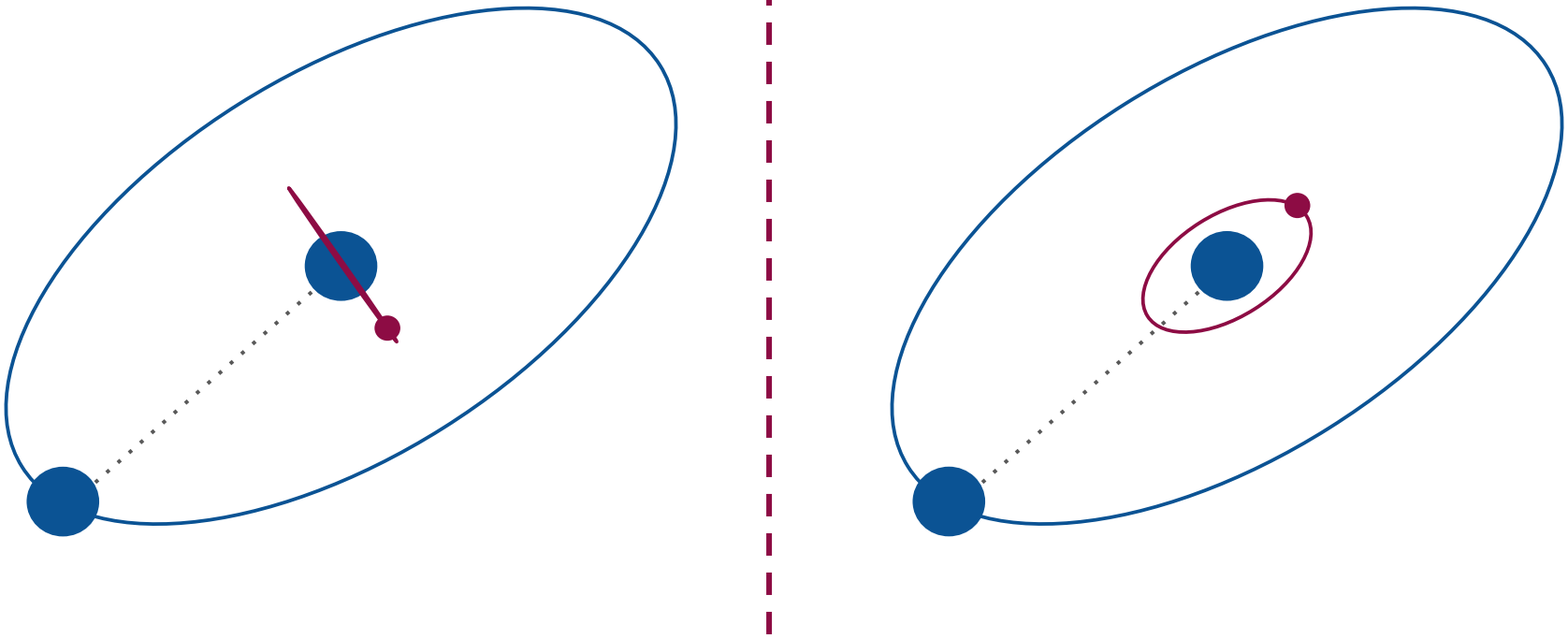


1D High Precision Astrometry

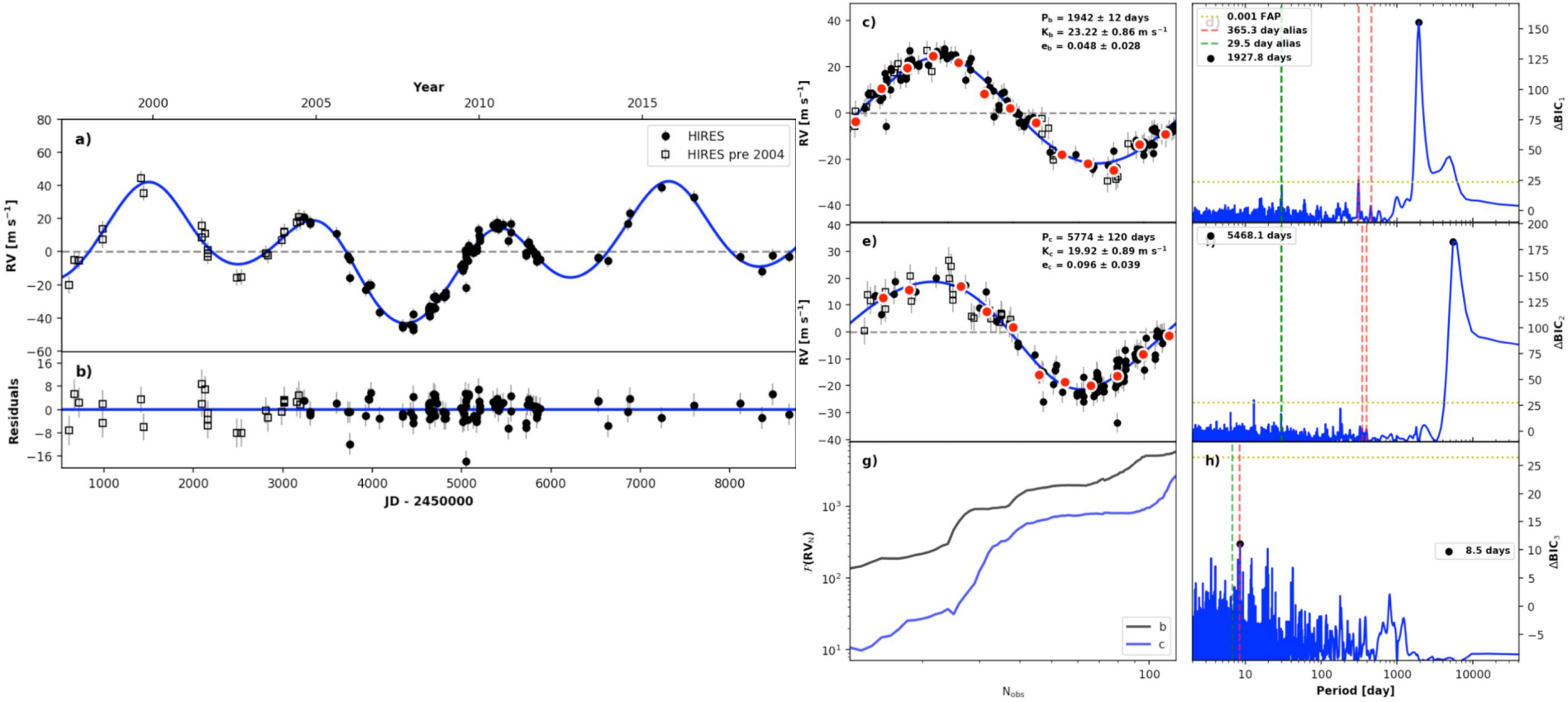




Assuming Coplanarity

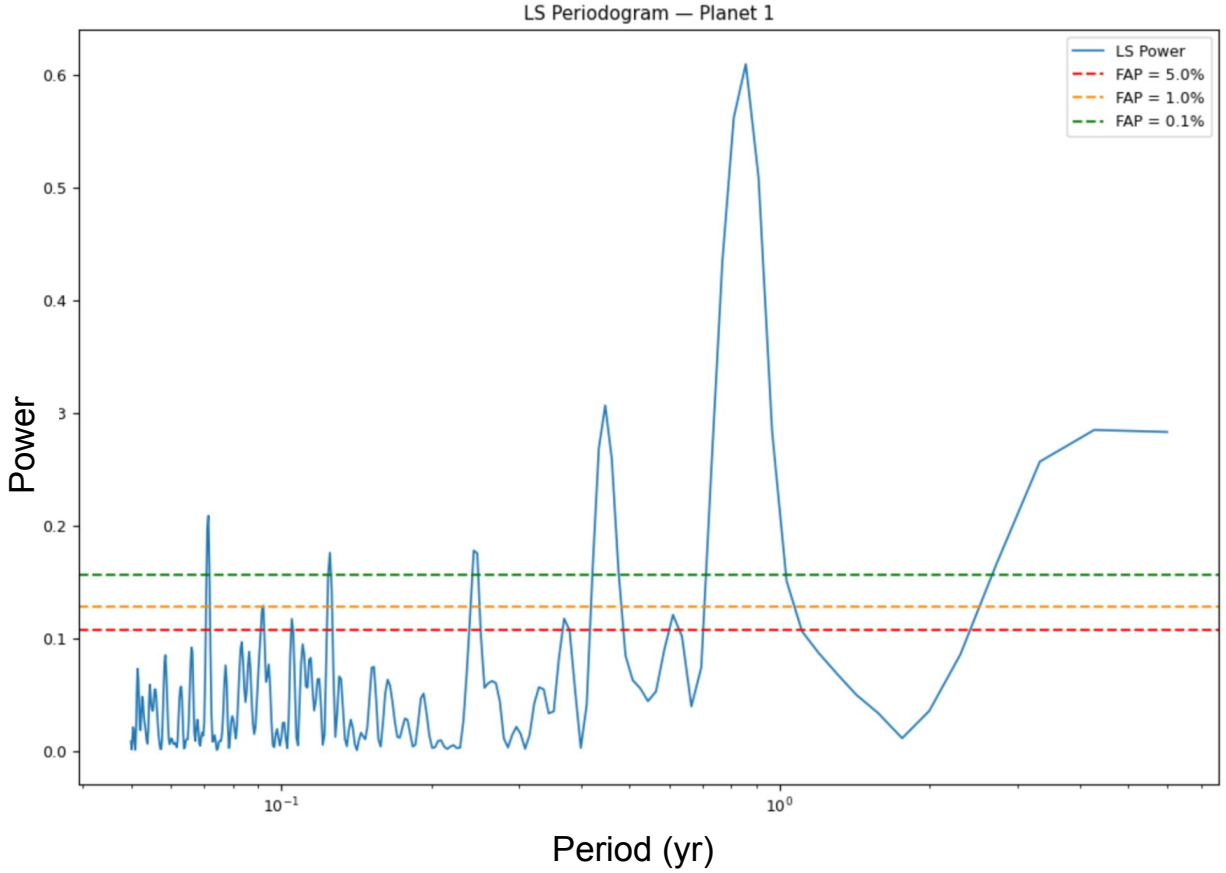


Planet Detection: Adapting RVsearch

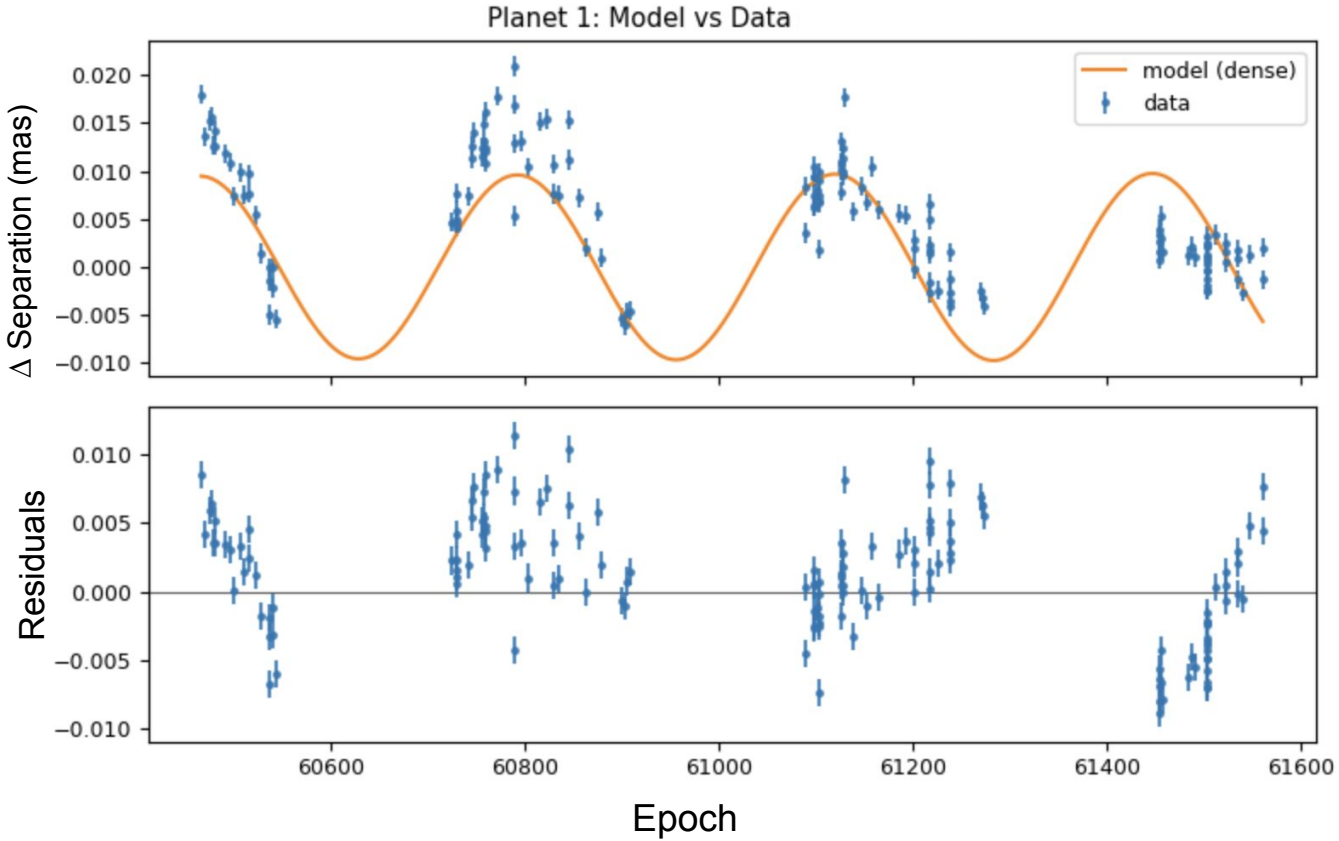


Rosenthal et al. 2021

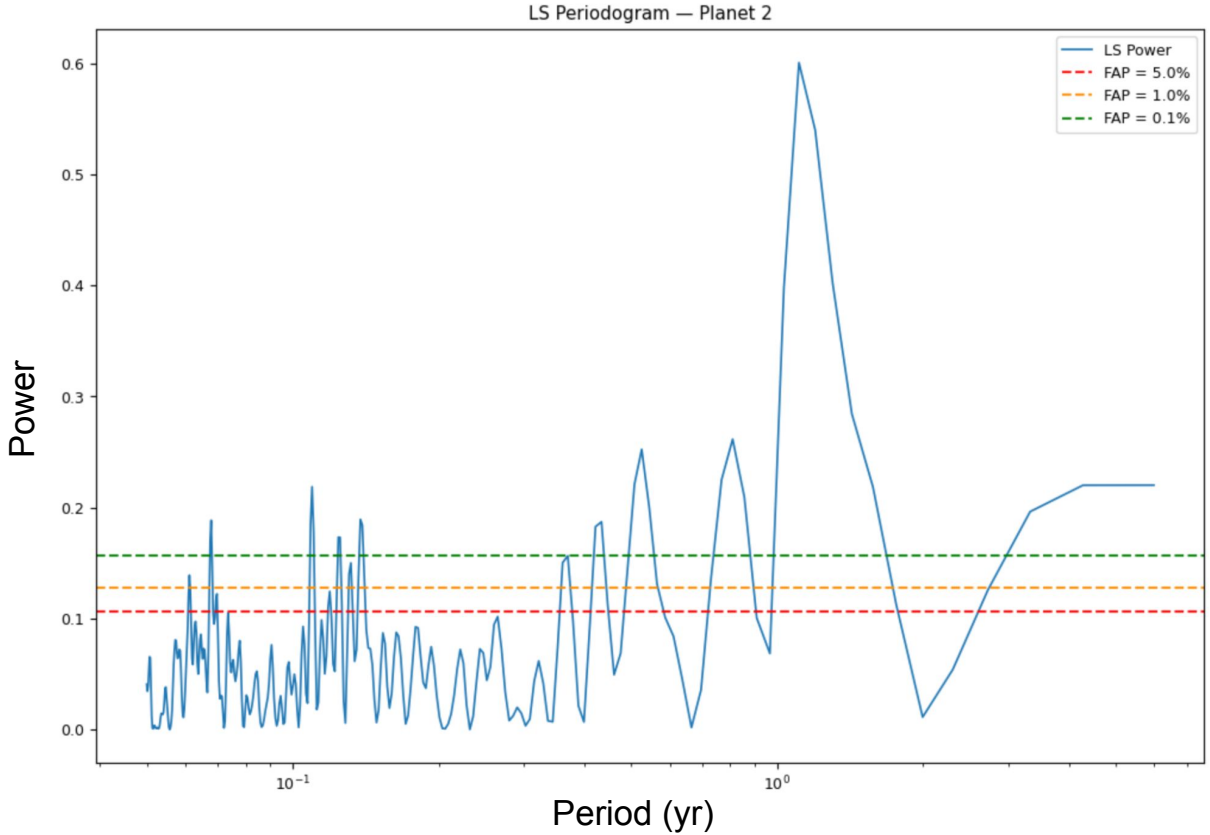
Planet Detection: Periodograms



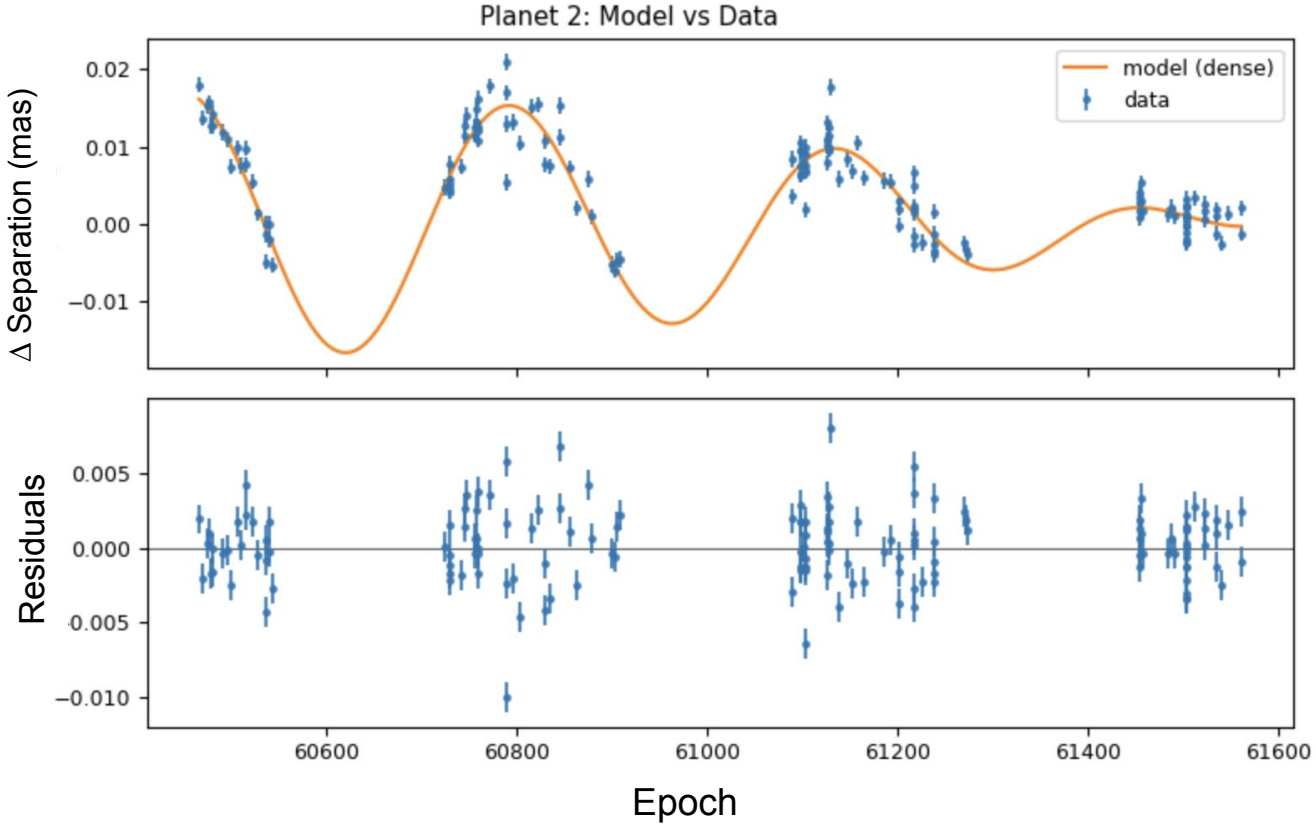
Planet Detection: MAP Fitting



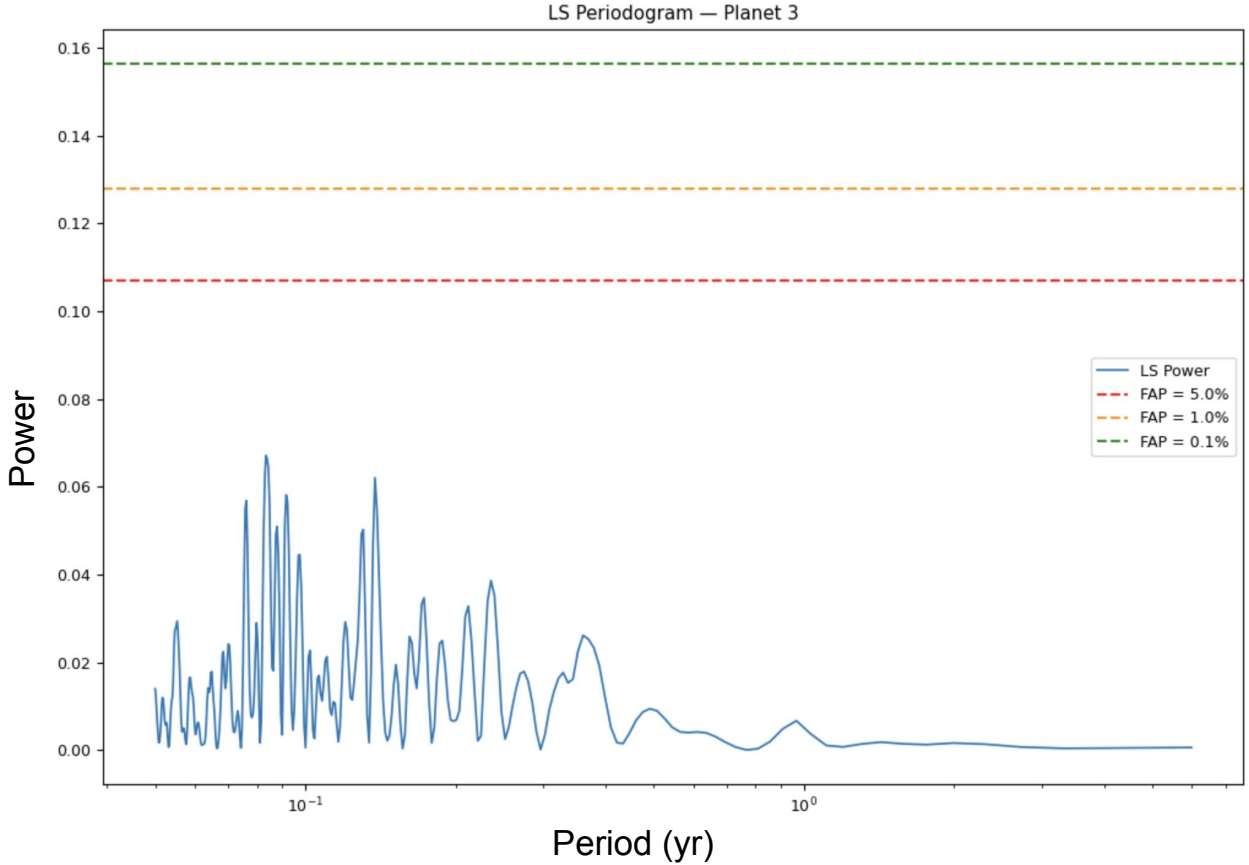
Planet Detection: Iterating



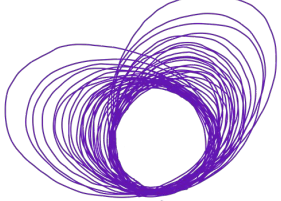
Planet Detection: Iterating

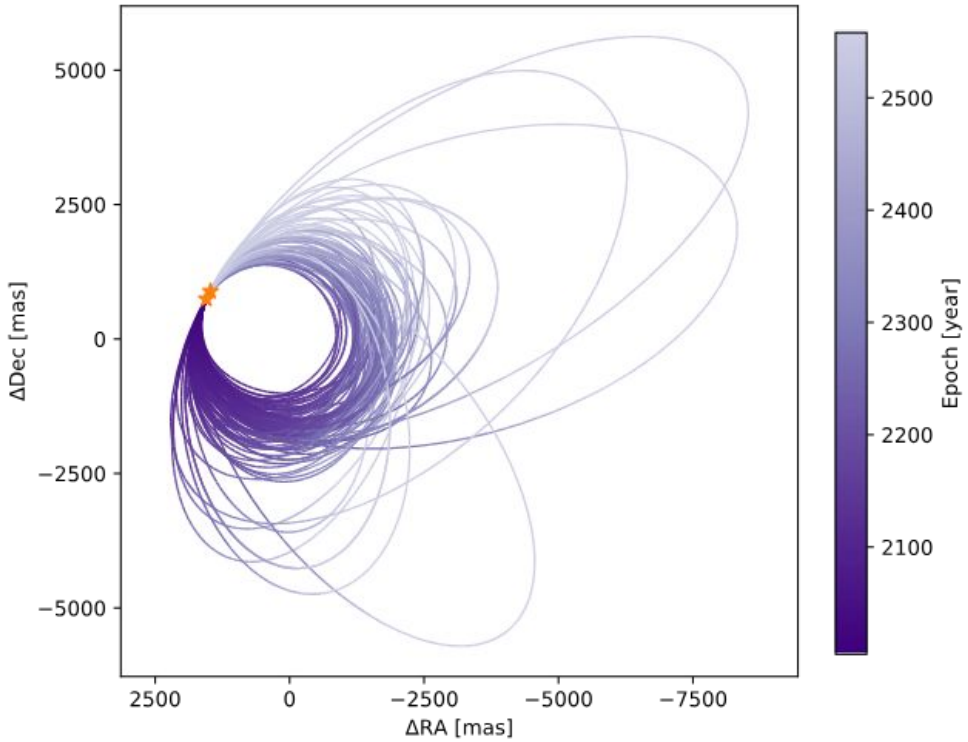


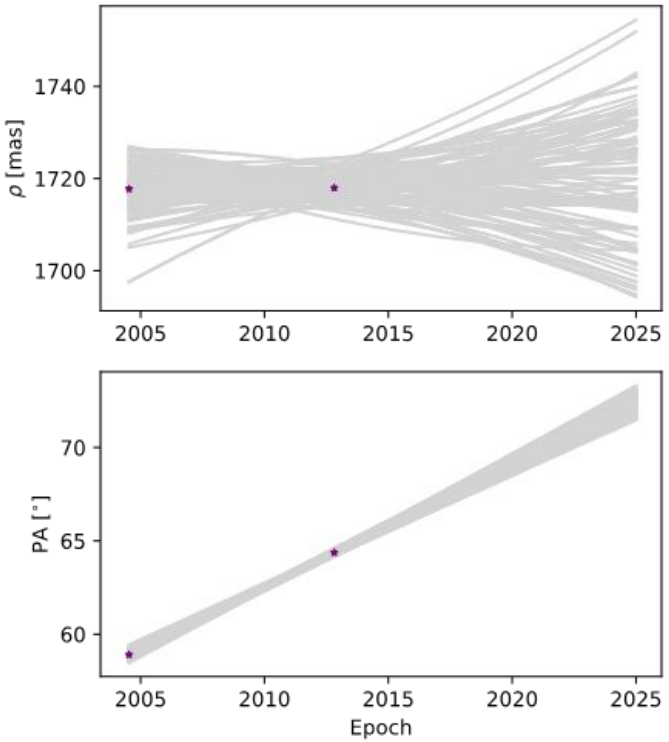
Planet Detection: Iterating



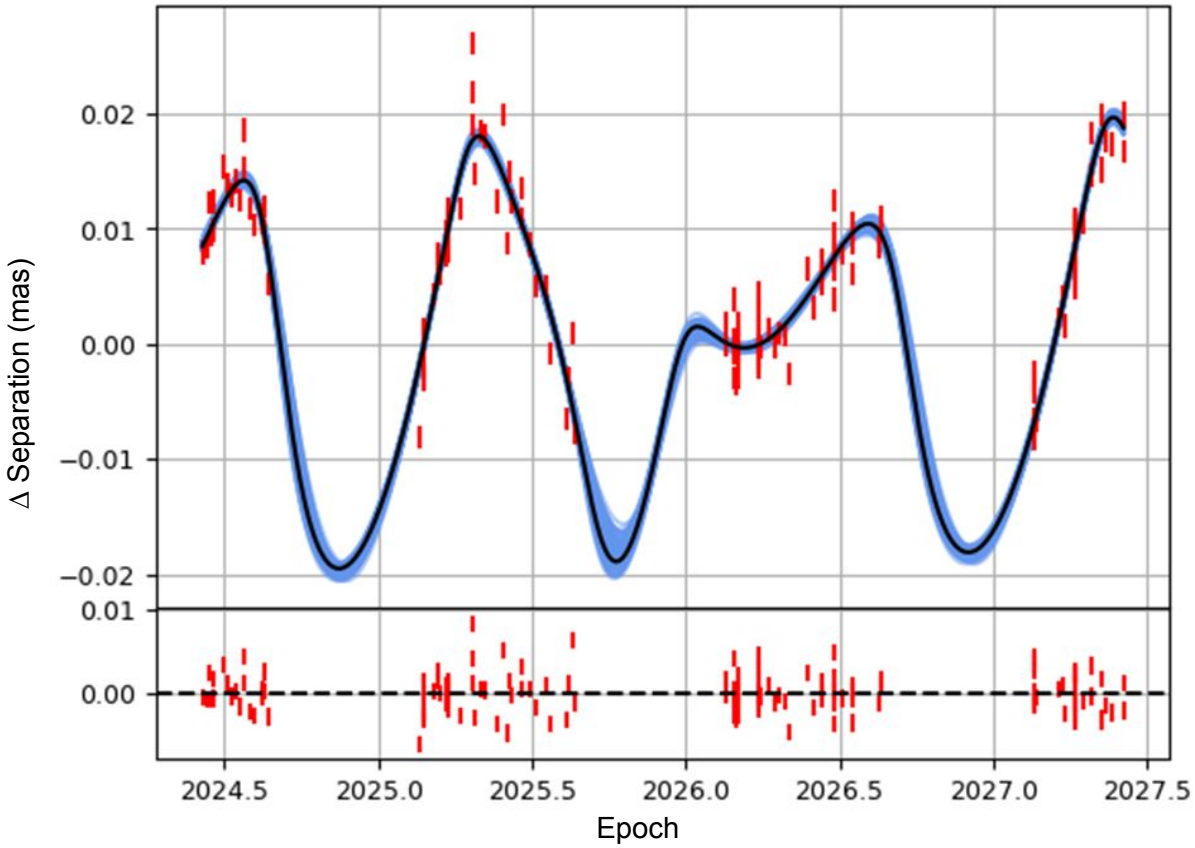
Planet Characterization: Adapting *orbitize!*



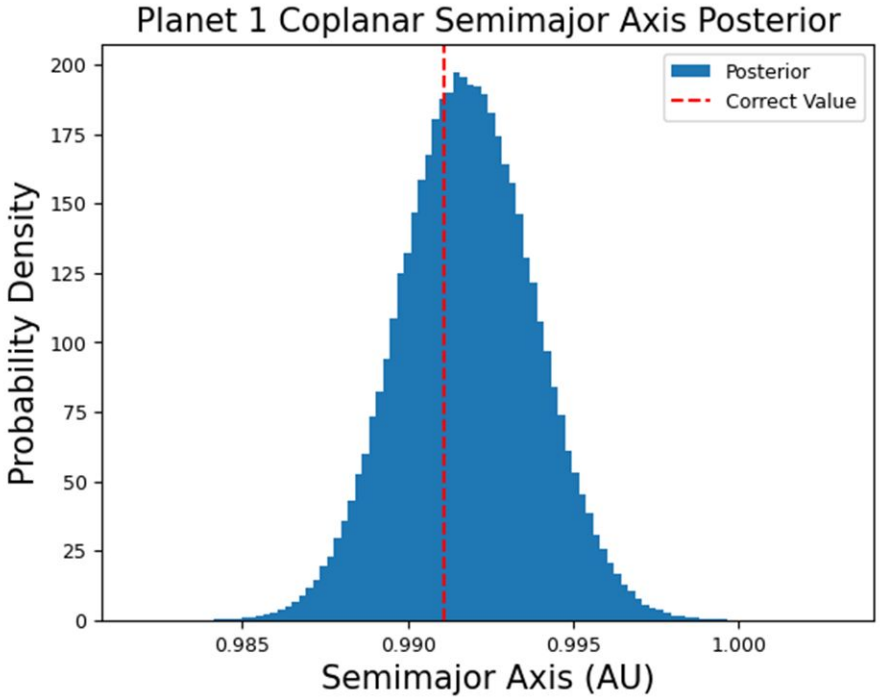


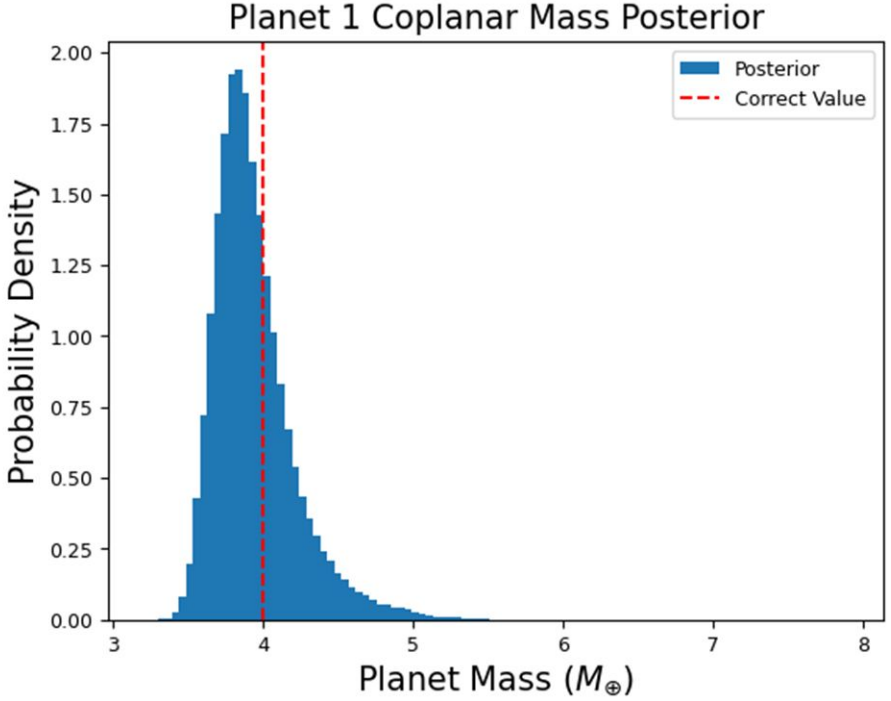


Planet Characterization: MCMC

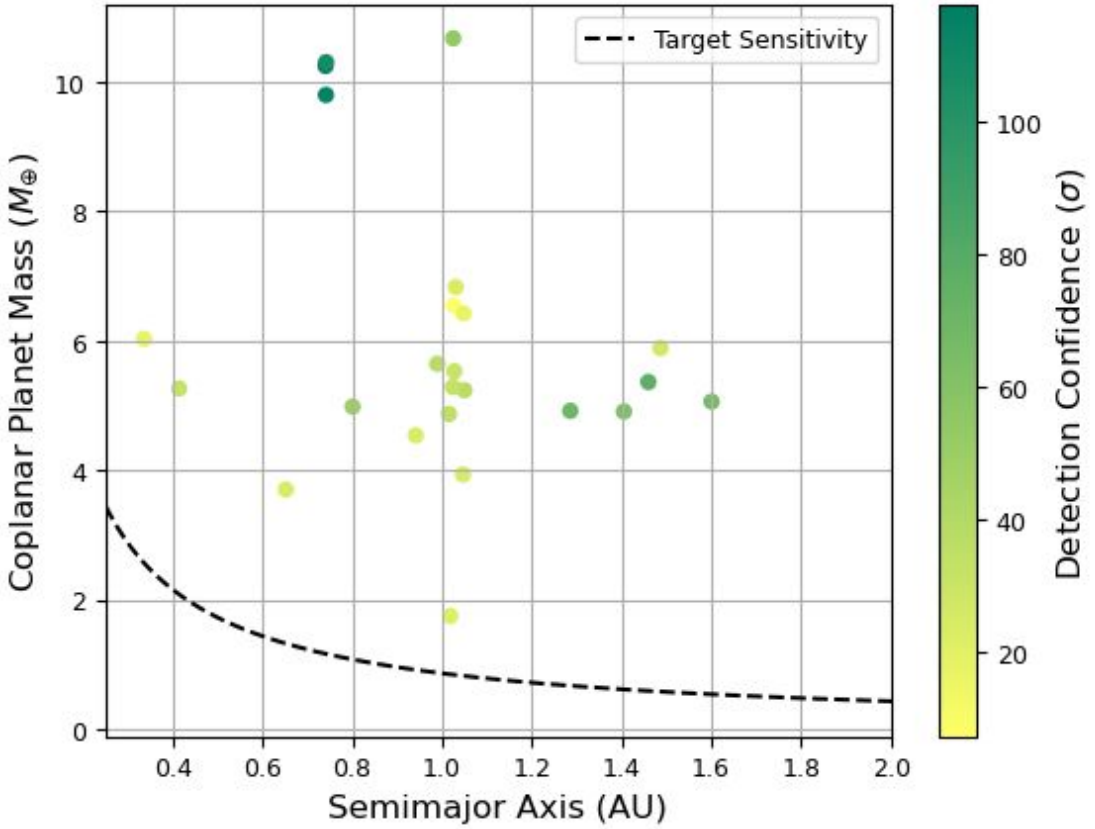


Results

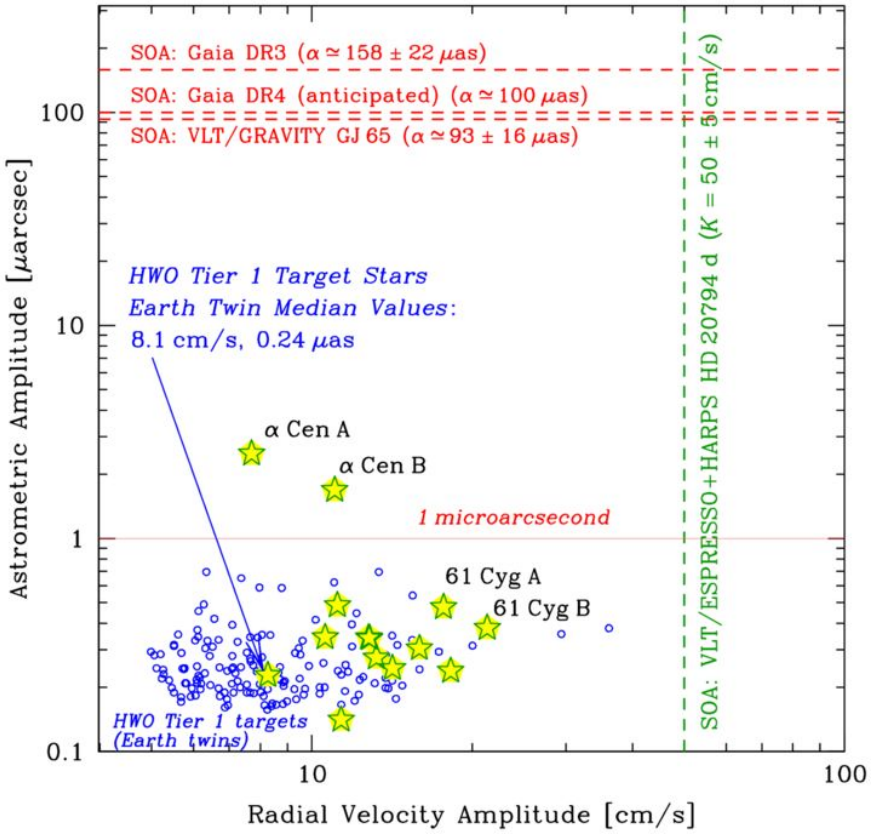

Planet 1 Coplanar Semimajor Axis Posterior
Posterior
Correct Value
Probability Density
0
25
50
75
100
125
150
175
200
0.985
0.990
0.995
1.000
Semimajor Axis (AU)


Planet 1 Coplanar Mass Posterior
Posterior
Correct Value
Probability Density
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
3
4
5
6
7
8
Planet Mass ($M_\oplus$)

Results

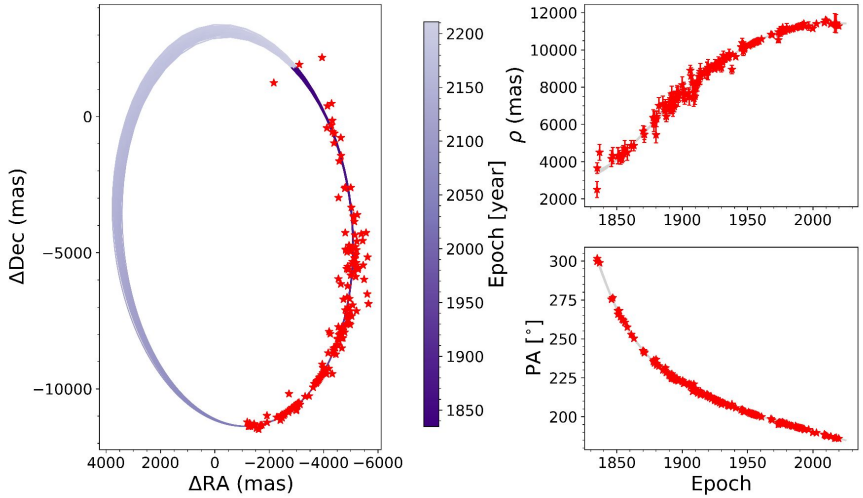

Target Sensitivity
Coplanar Planet Mass ($M_\oplus$)
Semimajor Axis (AU)
Detection Confidence (σ)
0
2
4
6
8
10
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
20
40
60
80
100

Preparation for HWO



Future Work

- Simulating and fitting planets on the edge of SHERA sensitivity
- Testing planet detection algorithm on more complex system architectures
- Improving orbits of SHERA binaries



Summary

- We can detect planets down to ~1 Earth mass with simulated SHERA data
- We can disentangle multiple planets from a single data set
- We measure coplanar mass to ~10% precision and semimajor axis to ~1% precision