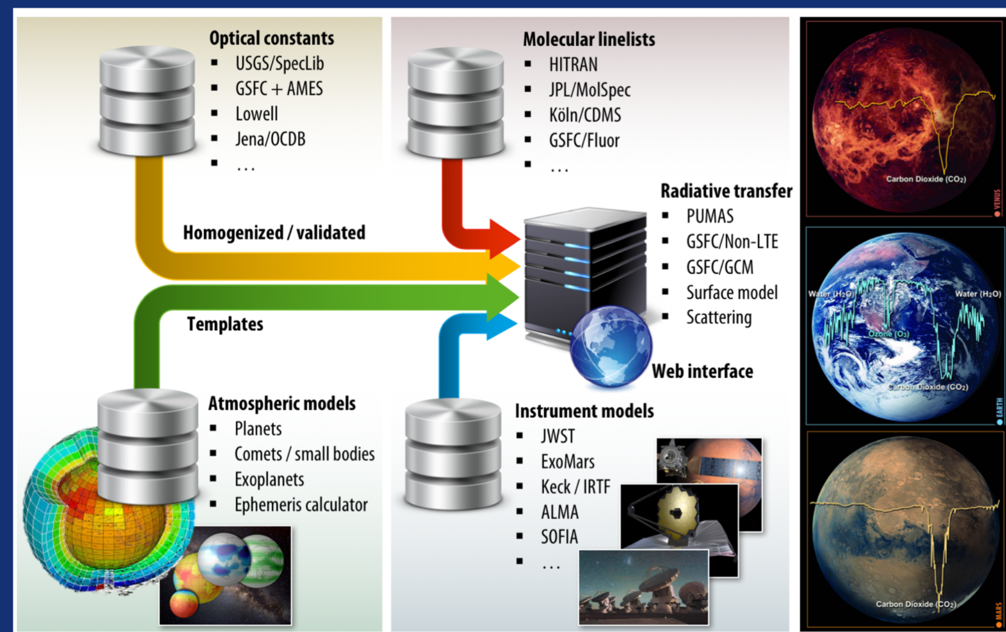
Exploring Potential Targets for the Roman Coronagraph: Some Deeper Dives

Team Members: **Prabal Saxena**, Geronimo L. Villanueva, Neil Zimmerman, Avi Mandell, Margaret Turnbull, Julien Girard, Sergi Hildebrandt, Ell Bogat and Adam J. R. W. Smith

Supported by Roman Turnbull SIT, Sellers Exoplanet Collaboration, CRESST II

Simulating Reflected Light Spectra with the Planetary Spectrum Generator



Flexible radiative transfer suite that allows the public to implement targeted observing scenarios – see Villanueva et al. (2018)

Simulating Reflected Light Spectra with the Planetary Spectrum Generator

Ups And d as a Direct Imaging Target

WFIRST-AFTA

Planet name	Planet SMA (AU)	Planet mass (MJ)	Separation (arcsec)	Contrast (rel to star)	Integration time (days)
HD62509b	1.69	2.9	0.1558	2.08E-08	0.0007
HR8974b	2.05	1.85	0.1389	1.39E-08	0.0128
Ups And d	2.55	10.19	0.1805	8.74E-09	0.0298
47 Uma b	2.1	2.53	0.1427	1.34E-08	0.1093
Ups And e	5.25	1.059	0.3717	2.09E-09	0.1995
HD192310c	1.18	0.075	0.1265	2.35E-08	0.2092
47 Uma c	3.6	0.54	0.2446	4.32E-09	0.2353
HD176051b	1.76	1.5	0.113	1.88E-08	0.4871

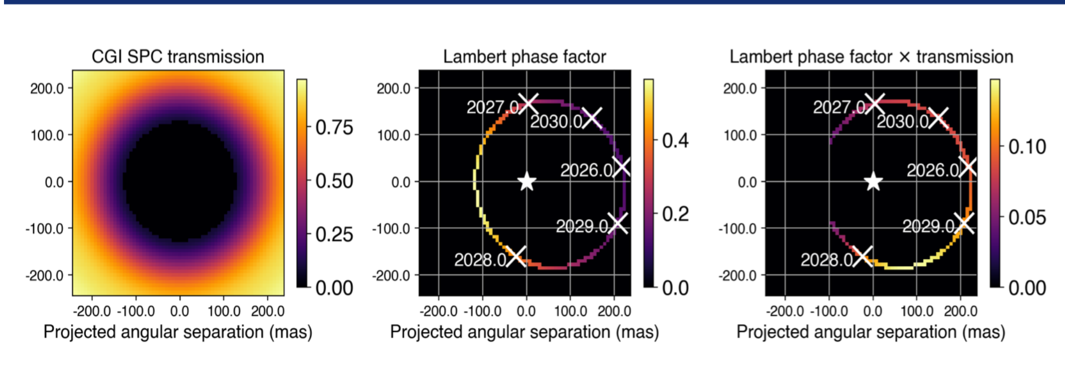
Recognized as a potentially interesting high contrast target in the 2015 SDT report – but appeared to pose IWA concerns. However, based on system parameter fitting by McArthur et al. (2010) and Deitrick et al. (2015), Ups And d is likely at sufficient separation at least at apastron.

Models w/different metallicity suggest a significant range of T/P + cloud structure over orbit!

Ups And D Parameters
Observation Derived
Planetary Mass - $10.25^{+0.7}_{-3.3}$ $M_{Jupiter}$
Planetary Radius - 1.02 $R_{Jupiter}$
Semi-major Axis - 2.53 au
Orbital Eccentricity - 0.316
Orbital Inclination - 23.758°
Model Parameters
T_{eff} (max, min, mean) - 260, 188, 215 K
Planetary Gravity (g) - 244.23 m/s^2
Metallicity ($[Fe/H]_{star} = 0.131$) = 1/3/5/10x

Config files + more info at Saxena *et al* 2021 *AJ* **162** 30

Saxena *et al* 2021 *AJ* **162** 30



Simulating Reflected Light Spectra of the Promising Direct Imaging Target, ups And d, using the Planetary Spectrum Generator

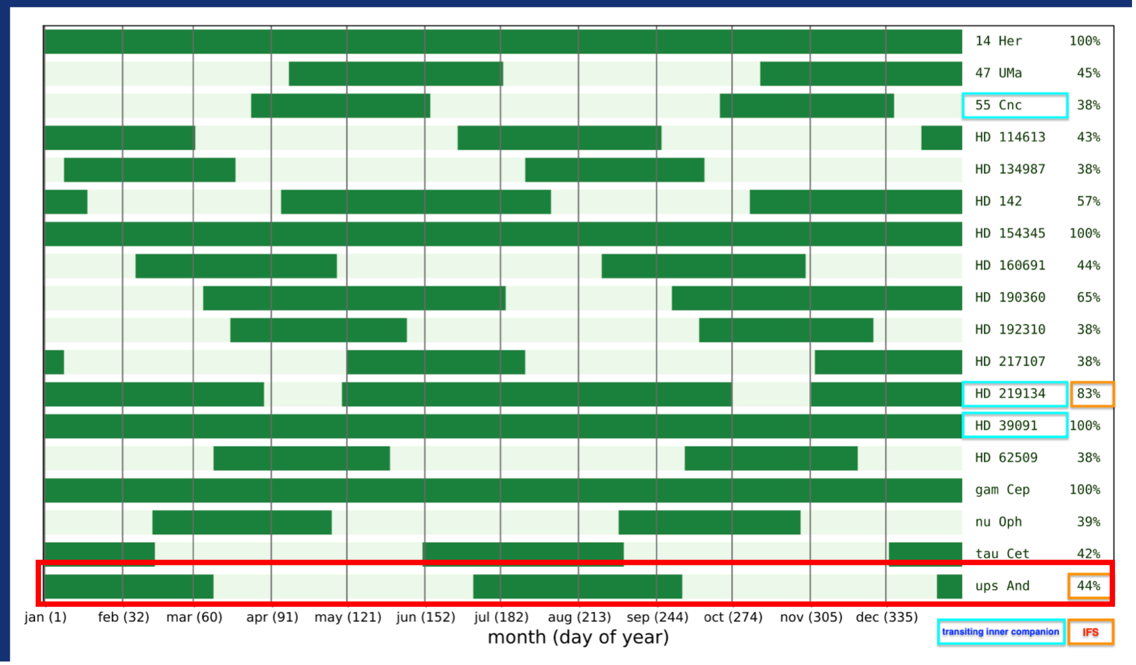
Ups And d is a nearby gas giant in its system's habitable zone. Its orbital parameters have been constrained using RV + Astrometry, and its eccentric orbit may portend significant seasonal atmospheric variations

Using Roman simulator to examine ups And d orbit, planet is observable for most of orbit except near periastron

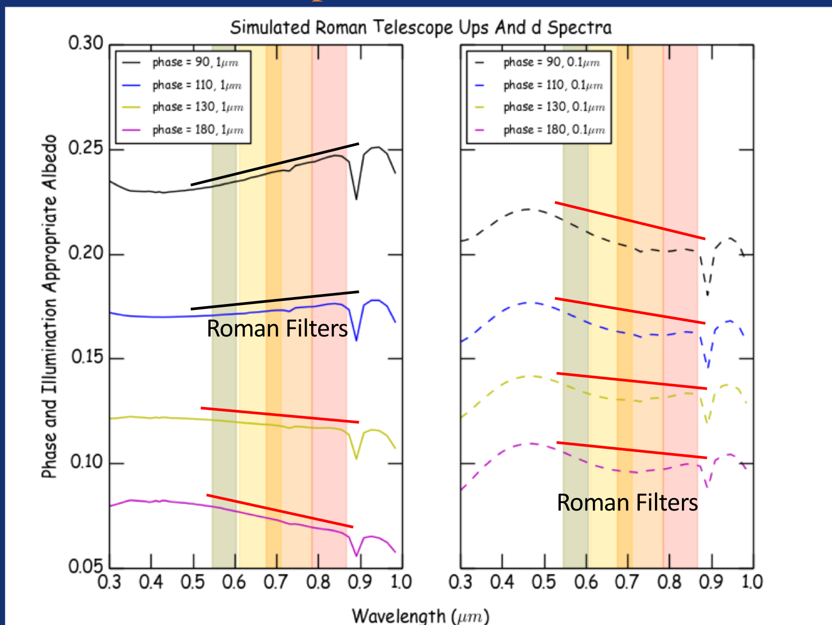
Simulated phase and illumination appropriate spectra using orbital constraints

Viability of Roman Observations of ups And d

Multiple observing windows in complementary time periods to other potential high priority targets



Filter color-color ratio flips depending on cloud particle size!



System and Bulk Properties Using RV + Astrometry

\+

Atmospheric Temperature and Pressure Profile

\+

Atmospheric Composition/ Vertical Mixing Ratios

\+

Clouds and Hazes

\+

Radiative Transfer

Butler et al. (1999), McArthur et al. (2010), Deitrick et al. (2015)

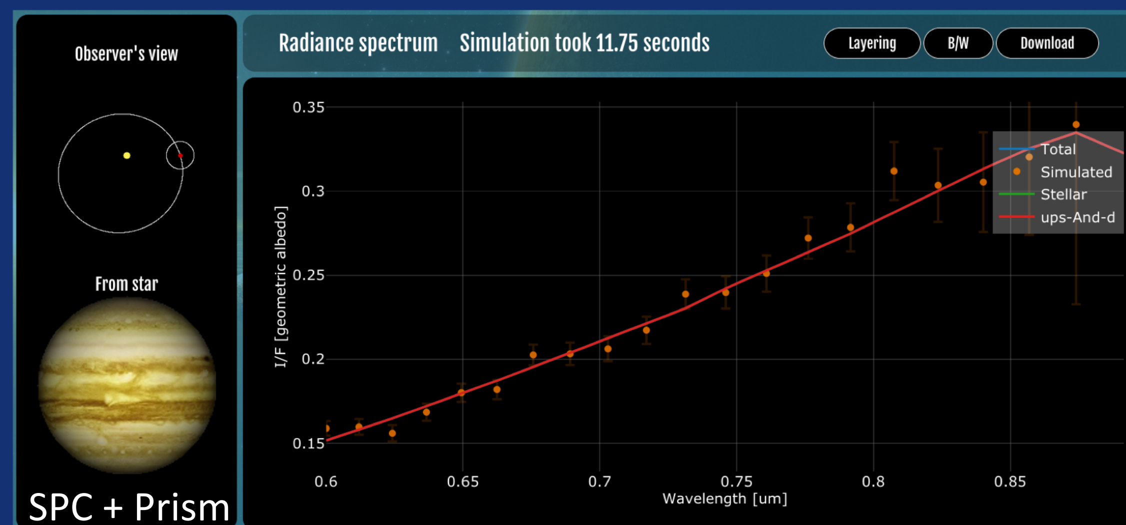
Fits from MacDonald et al. (2018) from Fortney et al. (2008)

Equilibrium Chemistry using GGchem code (Woitke et al. 2018)

Cloud Morphology + Abundances based on condensation curves and mass conservation, Ersatz Hazes

Planetary Spectrum Generator (Villanueva et al. 2018)

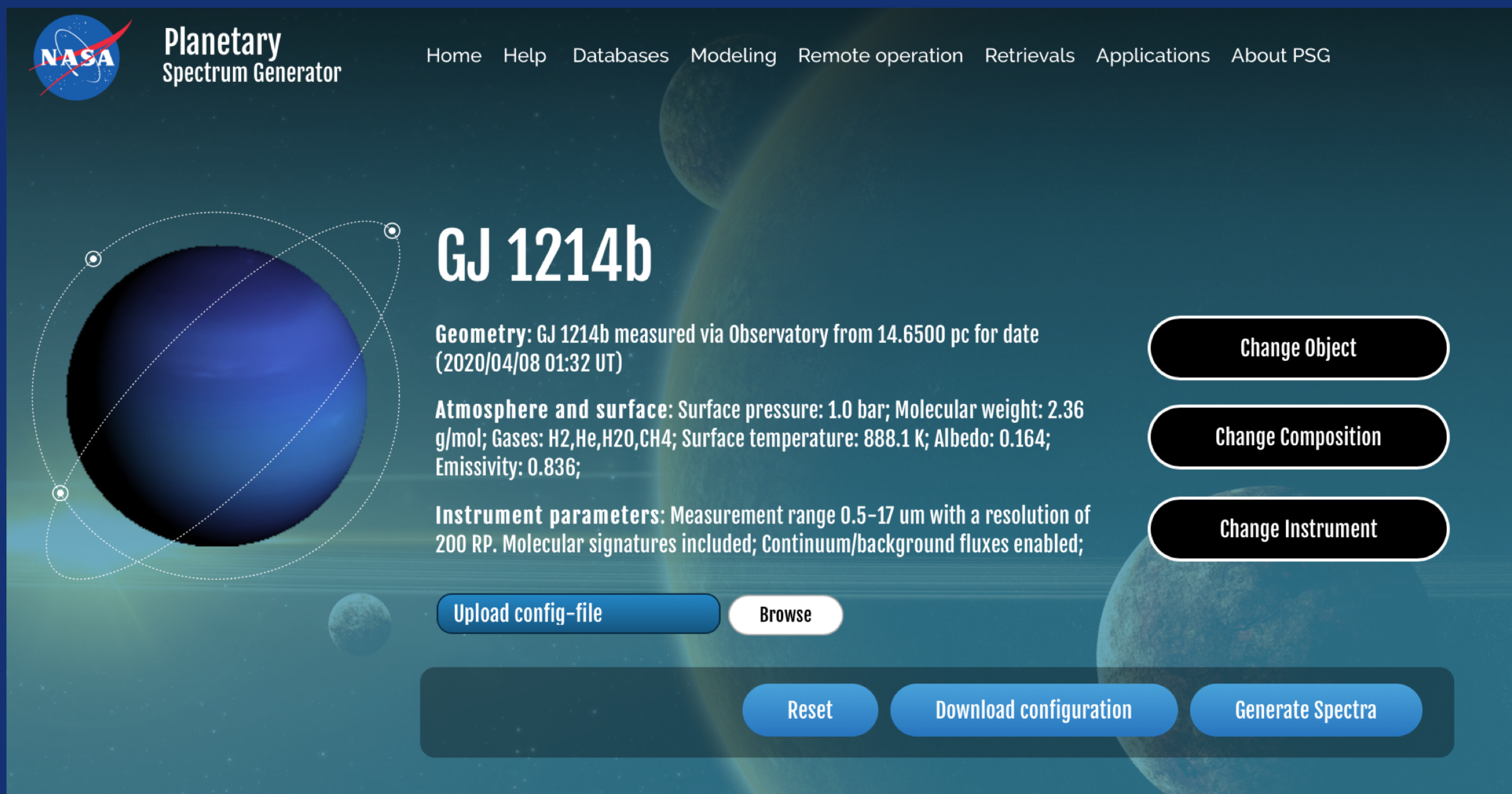
Preliminary results: →



At 90 degrees from periastron, SNR=10 in 400h, with speckles and jitter in 675 – 785 nm band (SPC) – peak contrast of 3.5E-9, also a promising target for HLC

Noise characteristics taken from https://roman.ipac.caltech.edu/sims/Param_db.html

Using PSG and the Coronagraph Template

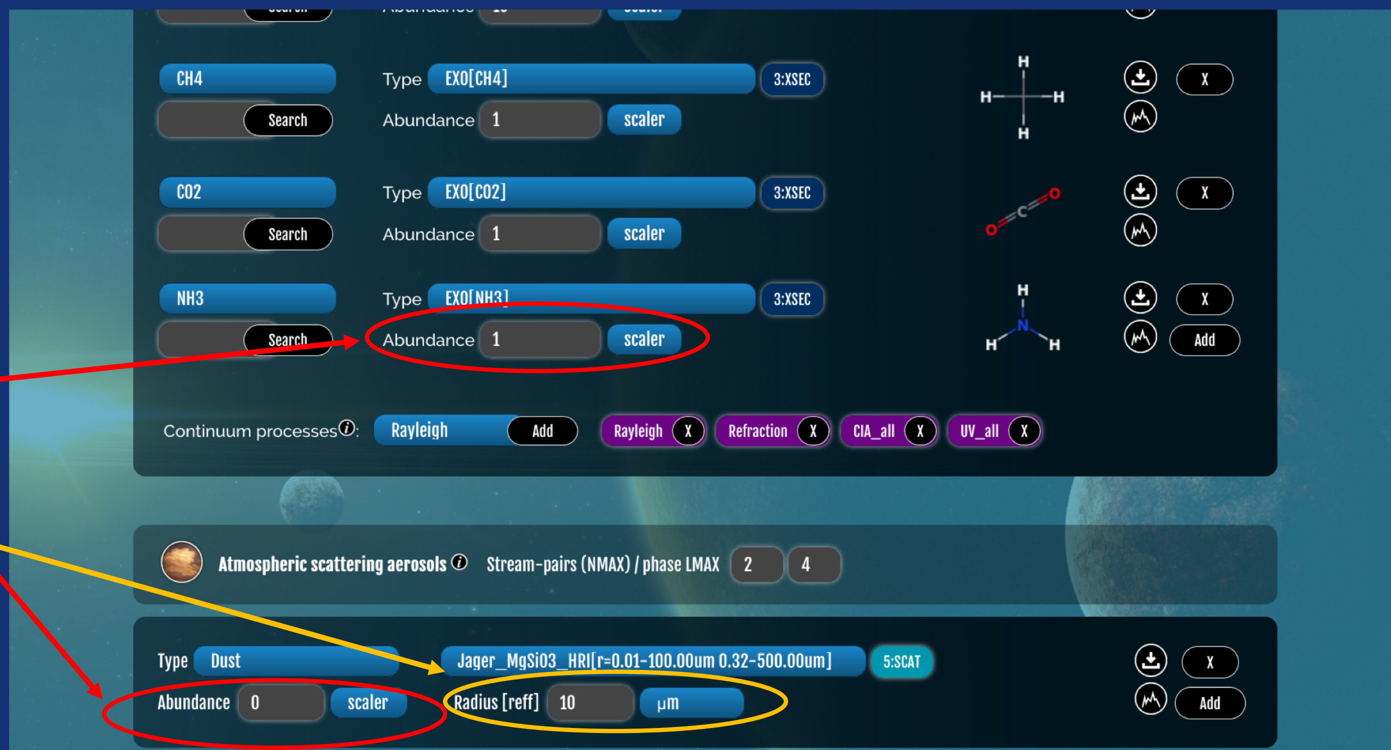


psg.gsfc.nasa.gov/

Atmosphere Properties that can be changed

Abundances

Particle Size



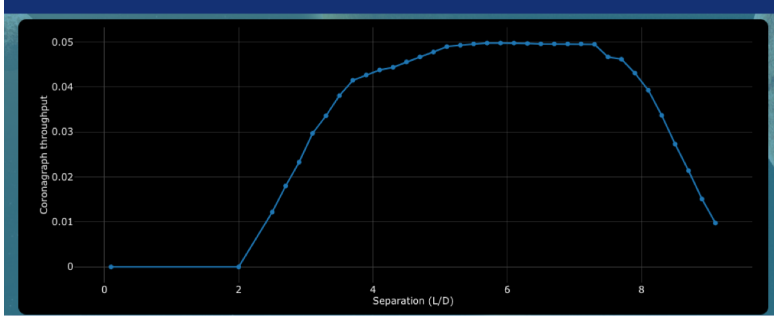
psg.gsfc.nasa.gov/

psg.gsfc.nasa.gov/

Instrument Properties that can be changed

Exozodi

Assuming a 10 hr integration – exposure time/# exposures

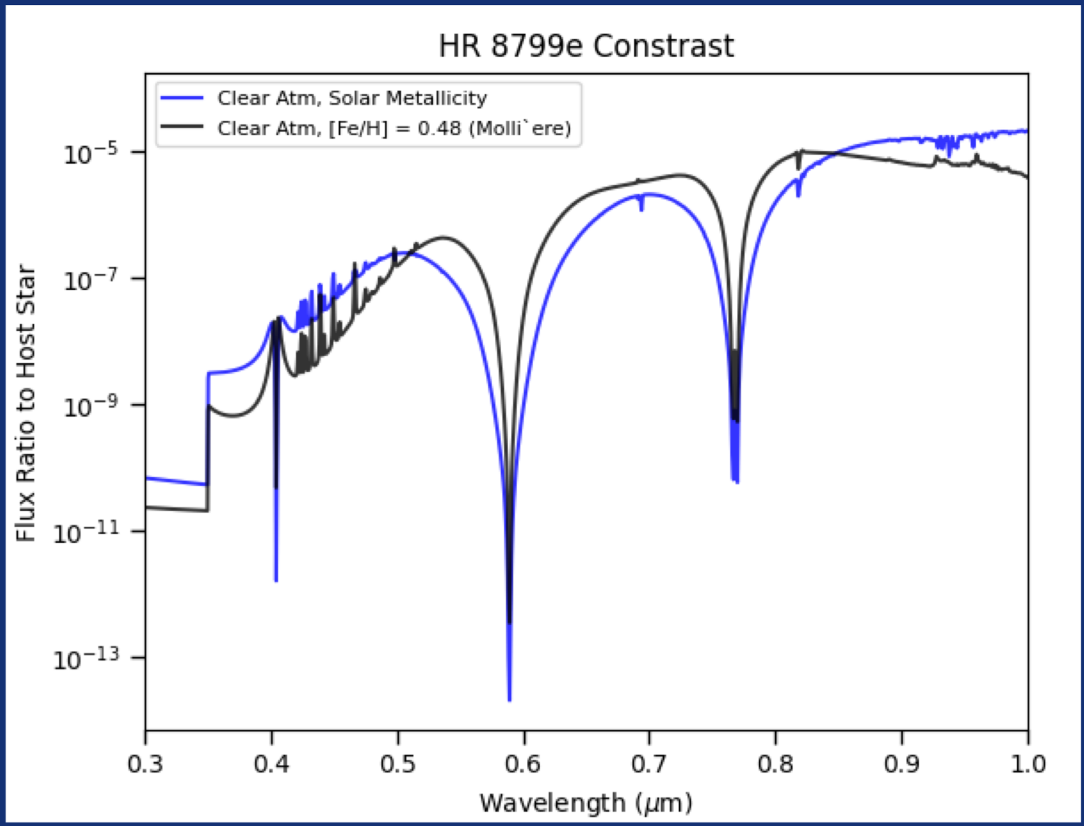


Separation Dependent Throughput

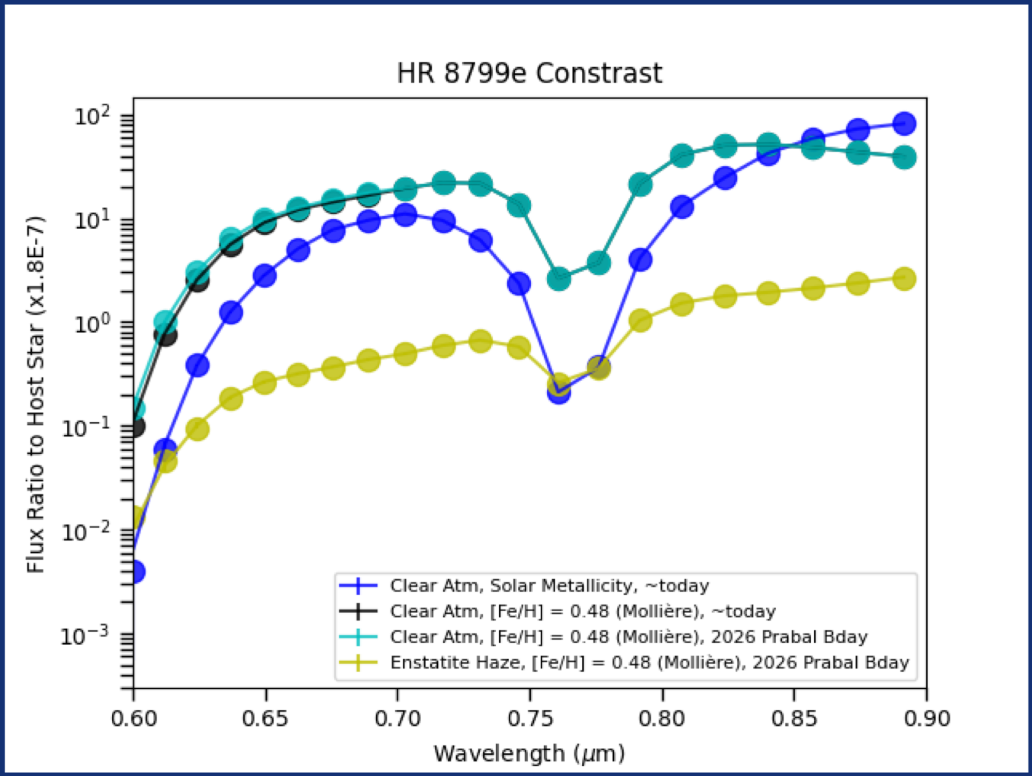
HR 8799e: Solar Metallicity vs super-Solar

- P-T profile and basic cloud profile from Mollière et al (2020). Using atmospheric retrieval on GPI, SPHERE and GRAVITY data

- Abundances using GGchem. Note Ruffio et al. (2021) find solar metallicity seem to fit for b, c + d, A0V star, working on template for star



HR 8799e: Exploring Phase Appropriate Spectra (Birthday Observations)



Assuming a 20 hr observation using Roman CGI SPC template we find:

- Phase driven differences from current to 2026 observations are minimal (may be different in 2030 though!)

- Solar vs [Fe/H] = 0.48 may be somewhat distinguishable using K line

- An enstatite haze (from Mollière et al (2020)) is likely distinguishable

More to come!