



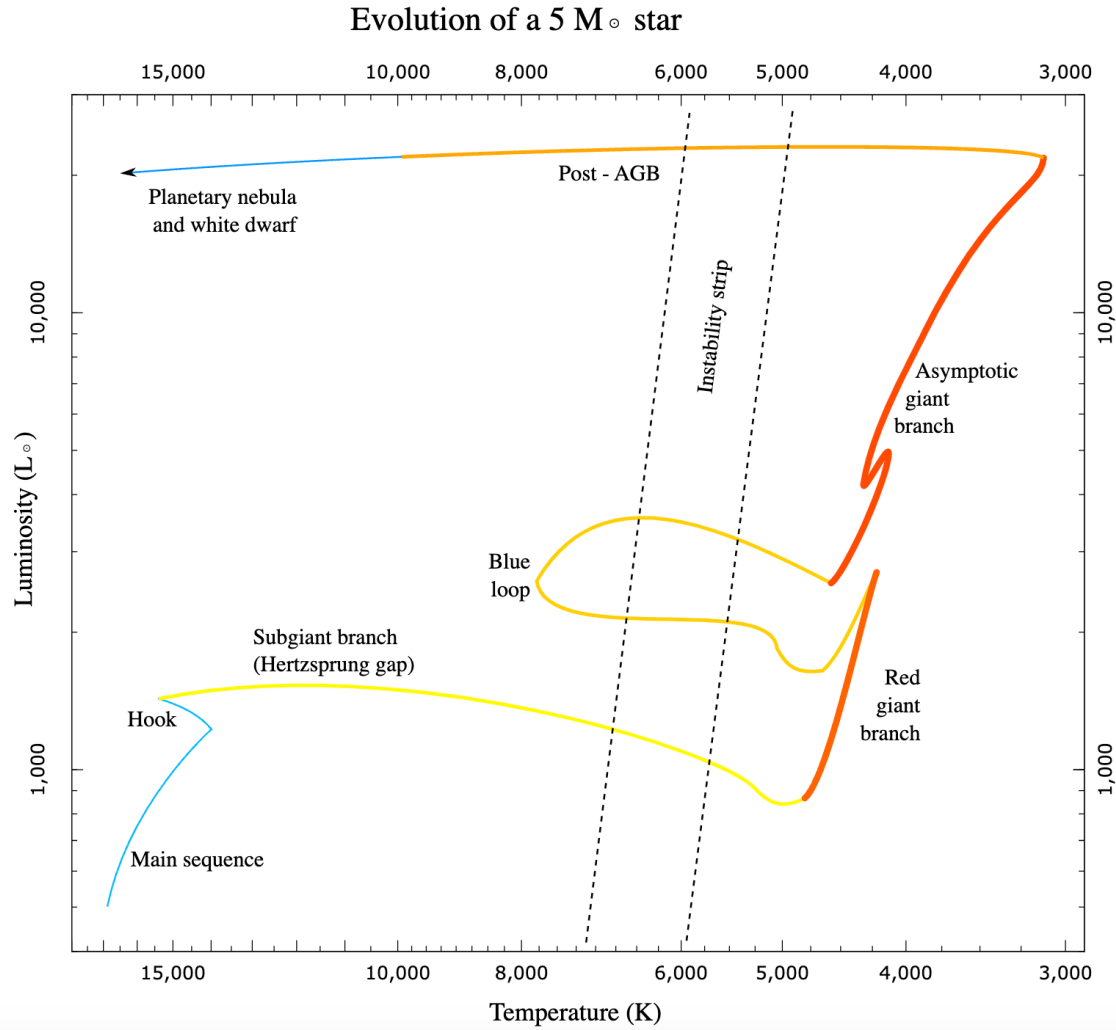
Circumbinary disks around evolved stars seen with the CHARA Array

Narsireddy Anugu
CHARA Array, GSU

John Monnier, Gail Schaefer, Tyler Gardner, Stefan Kraus ..
Jacques Kluska, Hans Van Winckel ..



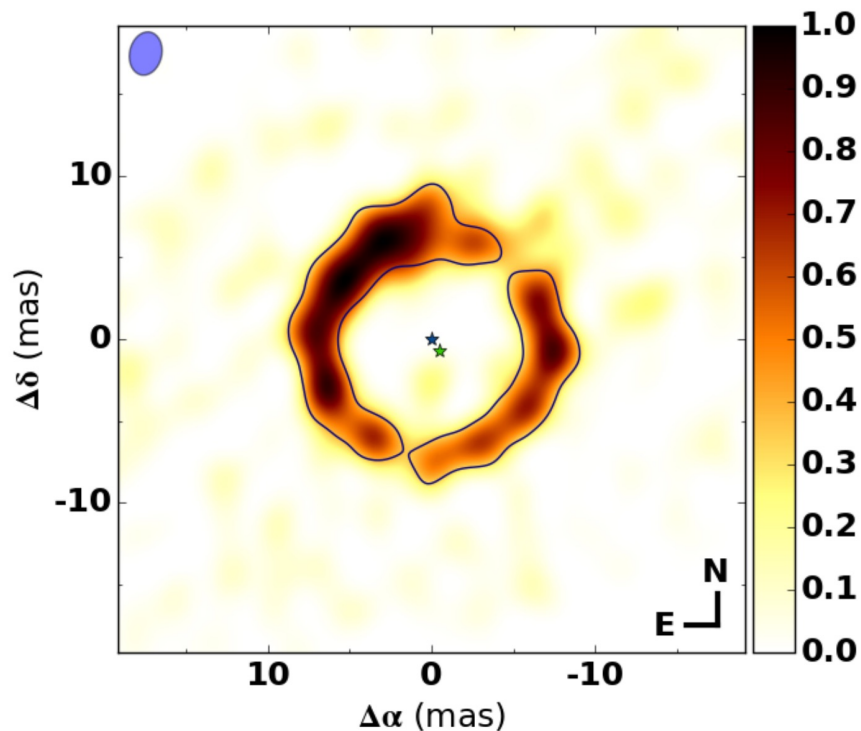
Post-AGB binary



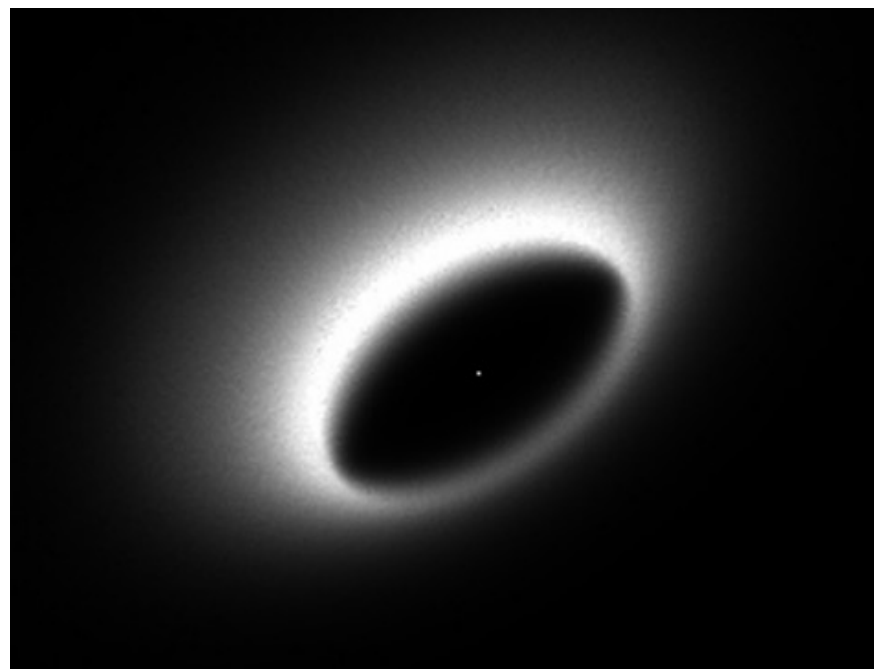
(credit D. Bollen)



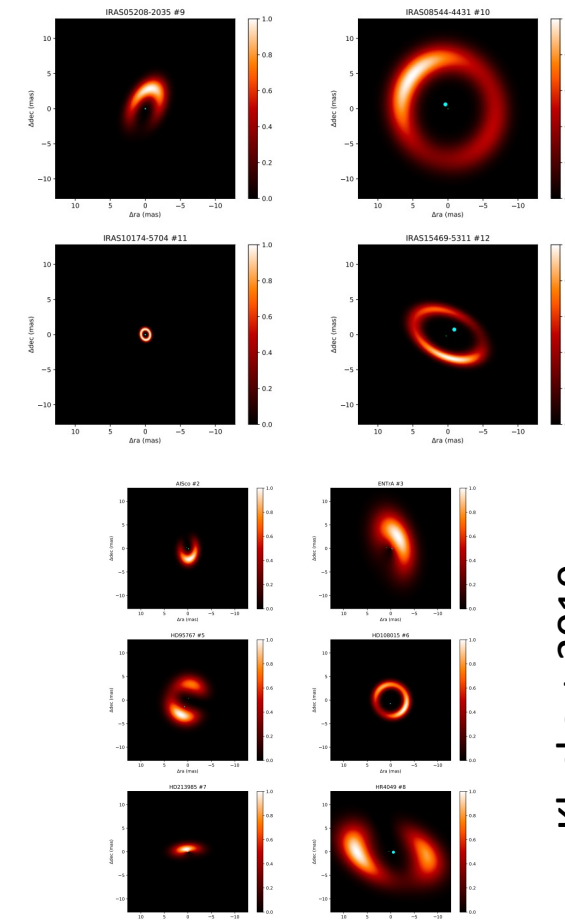
Post-AGB circumbinary disks are resolved from VLT/PIONIER and MIDI



IRAS08544-4431
Hillen + 2016, Kluska + 2018



AC Her
Hillen + 2015



Kluska + 2019

Why post-AGB binaries are great targets for CHARA?

- They have disks similar to young stars
- So we ask if they host exoplanets
- They are so far $\sim 1\text{kpc}$, $\sim 1\text{ms}$, need high-angular resolutions
- The visual binaries and accretion disks around companion are not resolved



CHARA observations

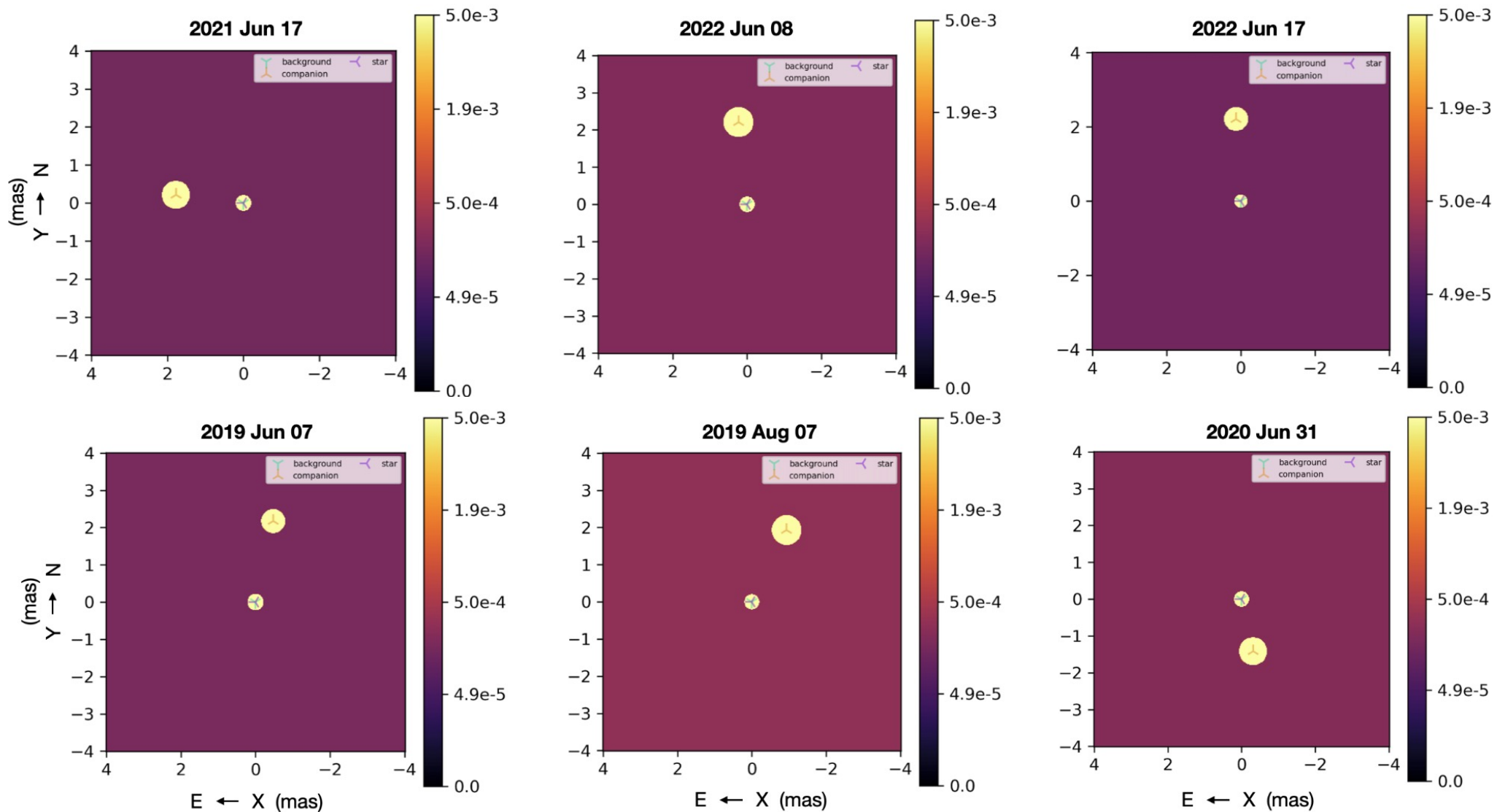
- Observed a total of 17 targets with MIRC-X
- 76% binaries are resolved of observing sample
- Made orbits for 4 targets

- AC Her 10 epochs (2017-2022)
U Mon 35-epochs (2015-2022)

- 1-paper submitted
- 2nd-paper is in prep submit in next month(s)

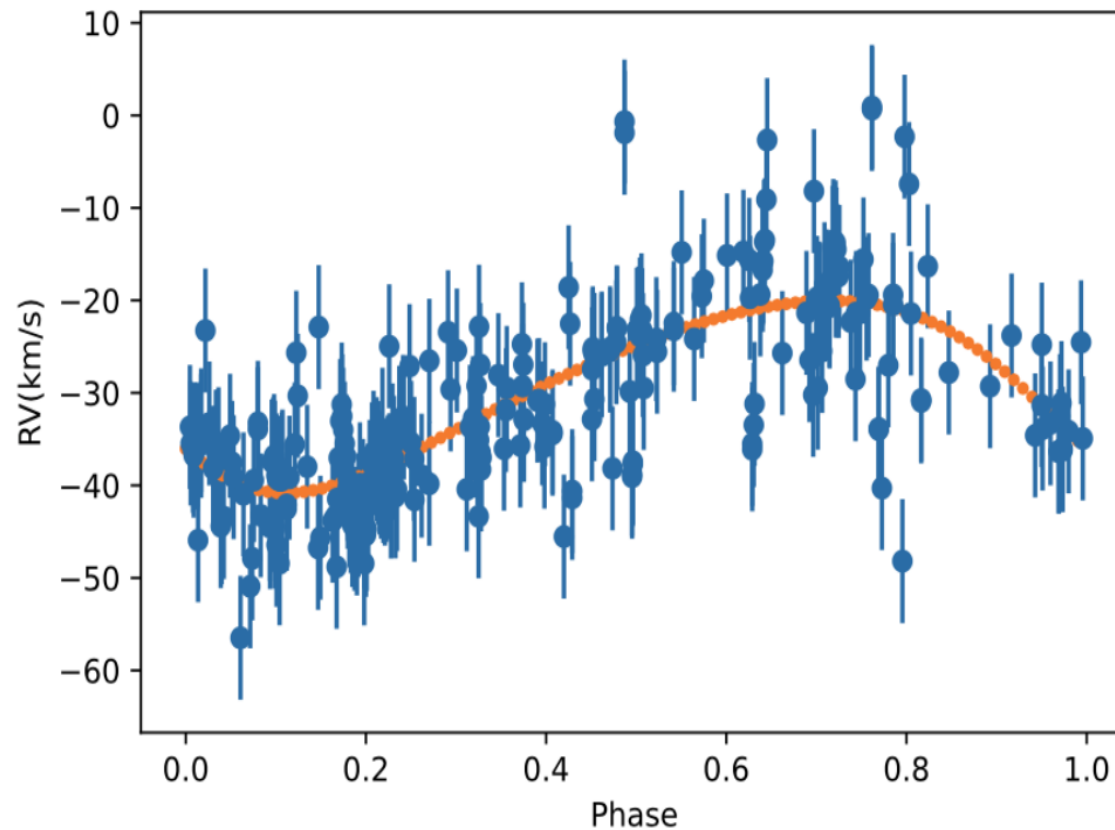
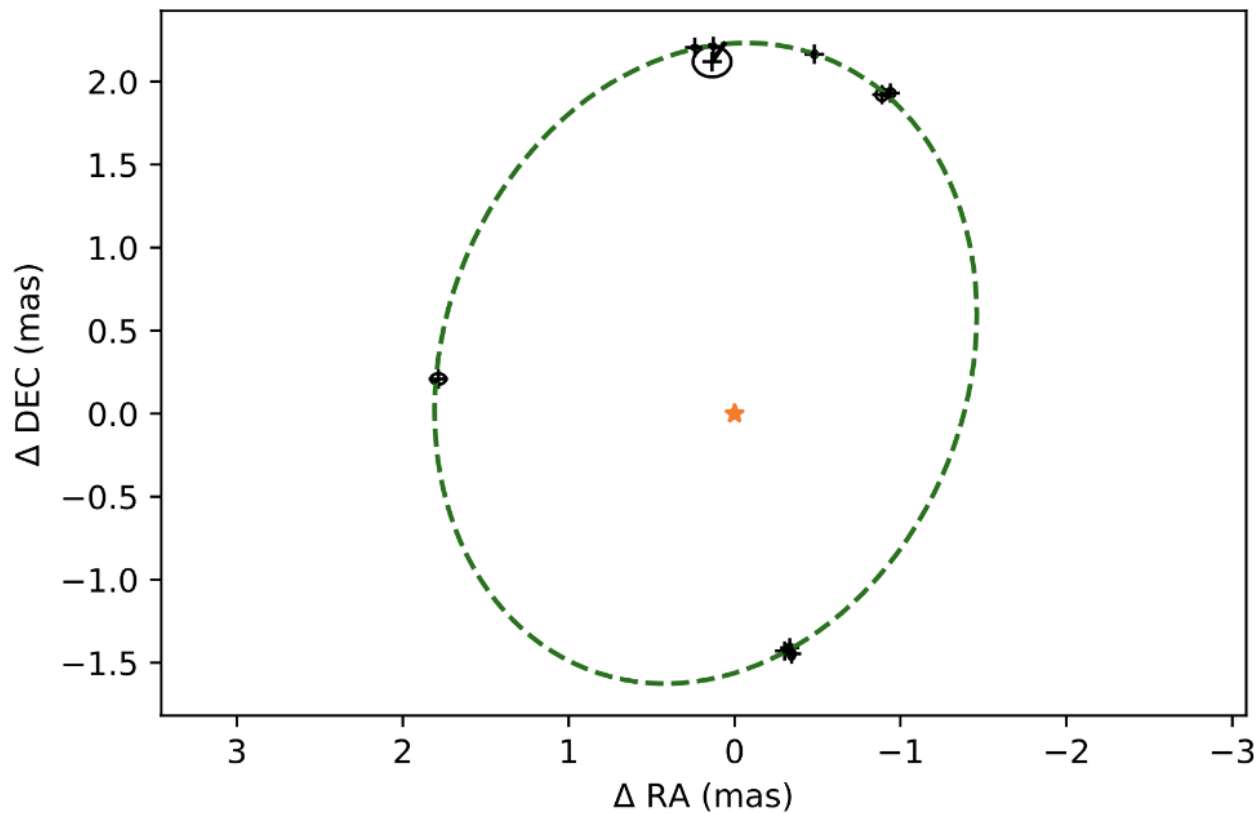


AC Her, MIRC-X (H-band), a few epochs



PMOIRD

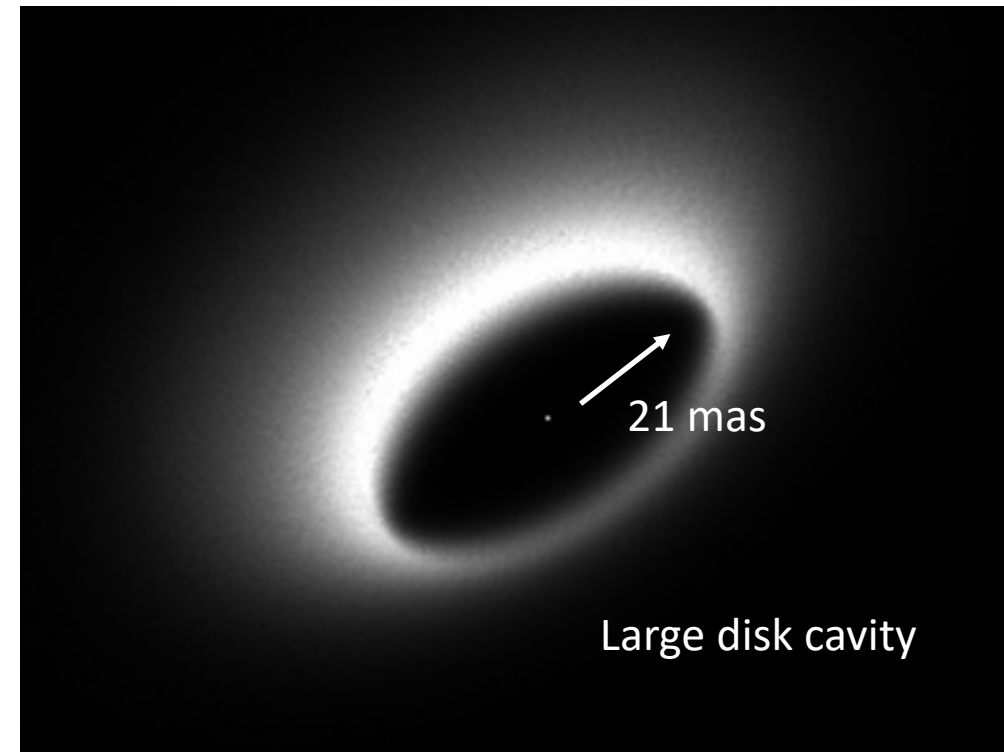
AC Her binary orbit (first visual orbit for a post-agb)



Thanks to Tyler, Gail for the orbital fit

AC Her orbital parameters

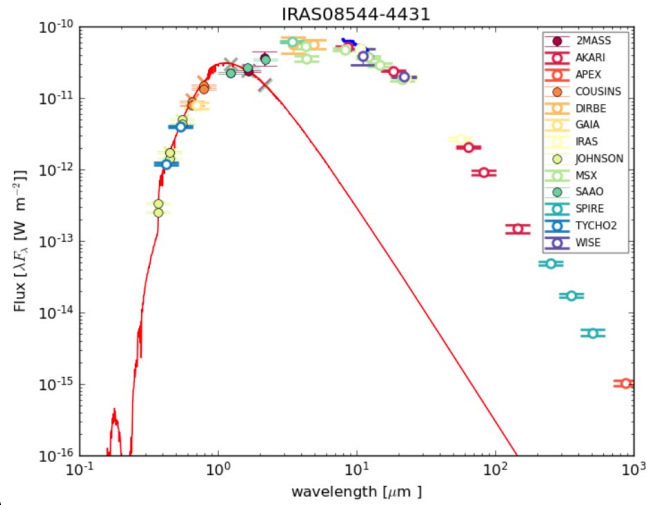
Orbital element	This work (Astrometry+RV)	Oomen et al. 2018 (RV)
Semi-major axis, a (mas)	2.01 ± 0.01	-
Inclination, i ($^\circ$)	142.9 ± 1.1	-
Ω ($^\circ$)	155.1 ± 1.8	-
ω_1 ($^\circ$)	118.6 ± 2.0	-
T_0 (MJD)	59023.1 ± 2.2	-
eccentricity, e	0.206 ± 0.004	0.0 ± 0.05
Orbital period, P (days)	1187.7 ± 0.7	1188.9 ± 1.2
M_{total} (M_\odot)	2.13 ± 0.19	0.75 ± 0.03
M_1 (M_\odot)	0.73 ± 0.13	0.6 (fixed)
M_2 (M_\odot)	1.40 ± 0.12	0.15 ± 0.03
K_1 (km/s)	10.5 ± 0.5	10.8 ± 0.7
γ (km/s)	-29.3 ± 0.4	-27.0 ± 0.2



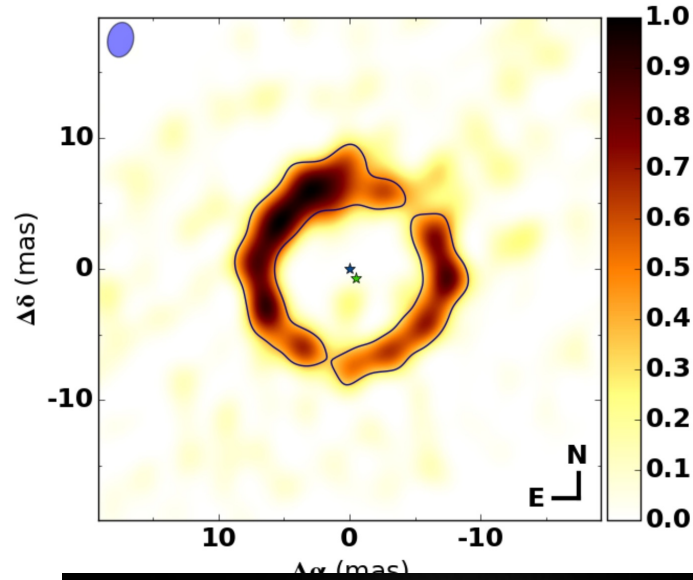


Full disk vs transition (cavity) disk

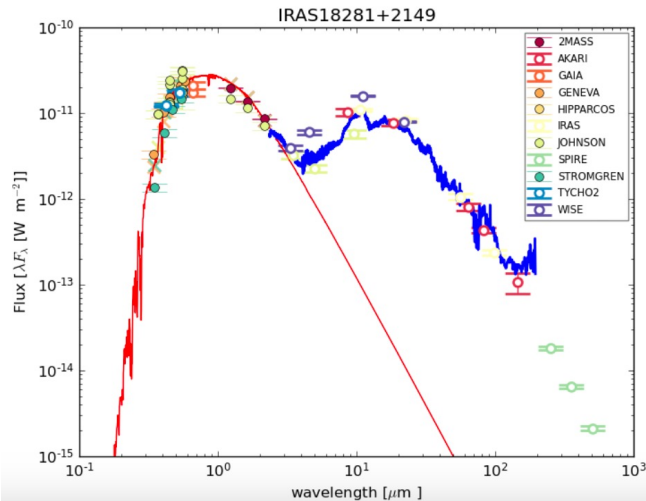
SED



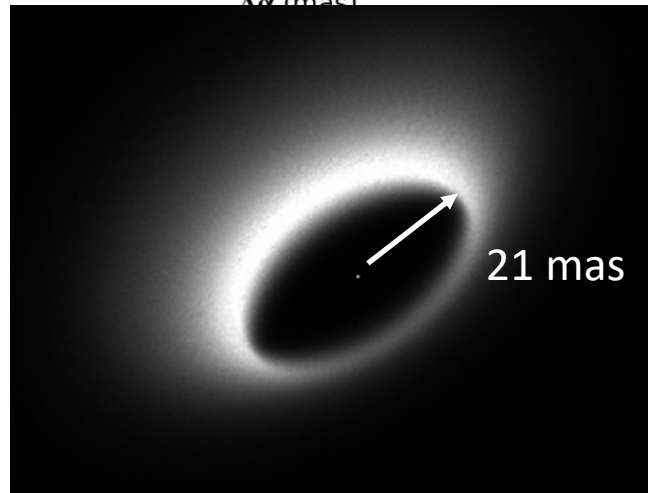
Full disk



IRAS08544-4431
(Hillen + 2016, Kluska + 2018)



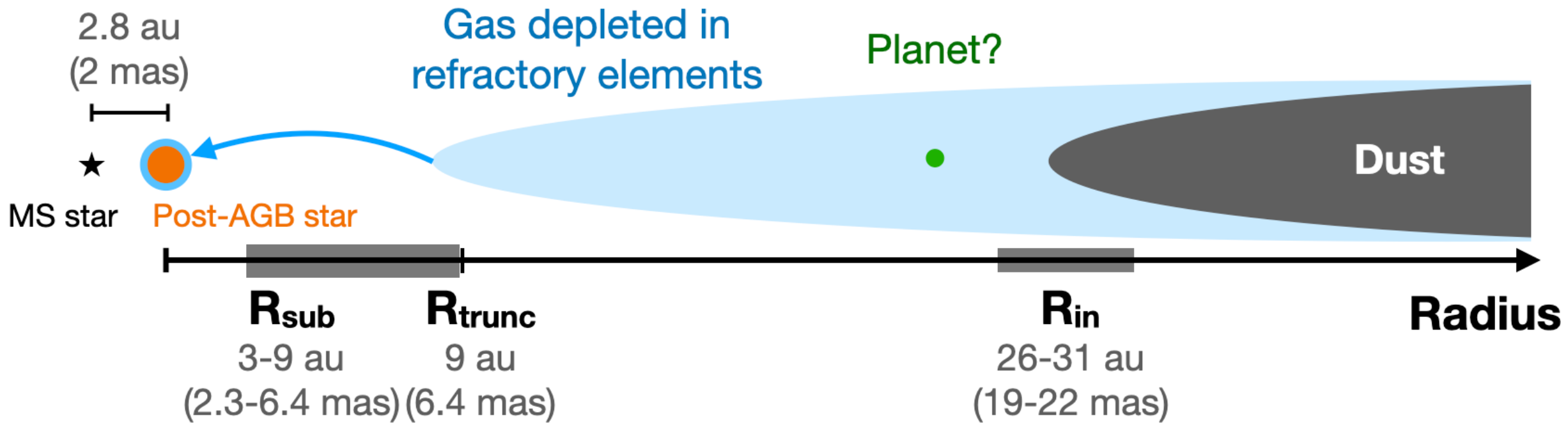
Cavity disk



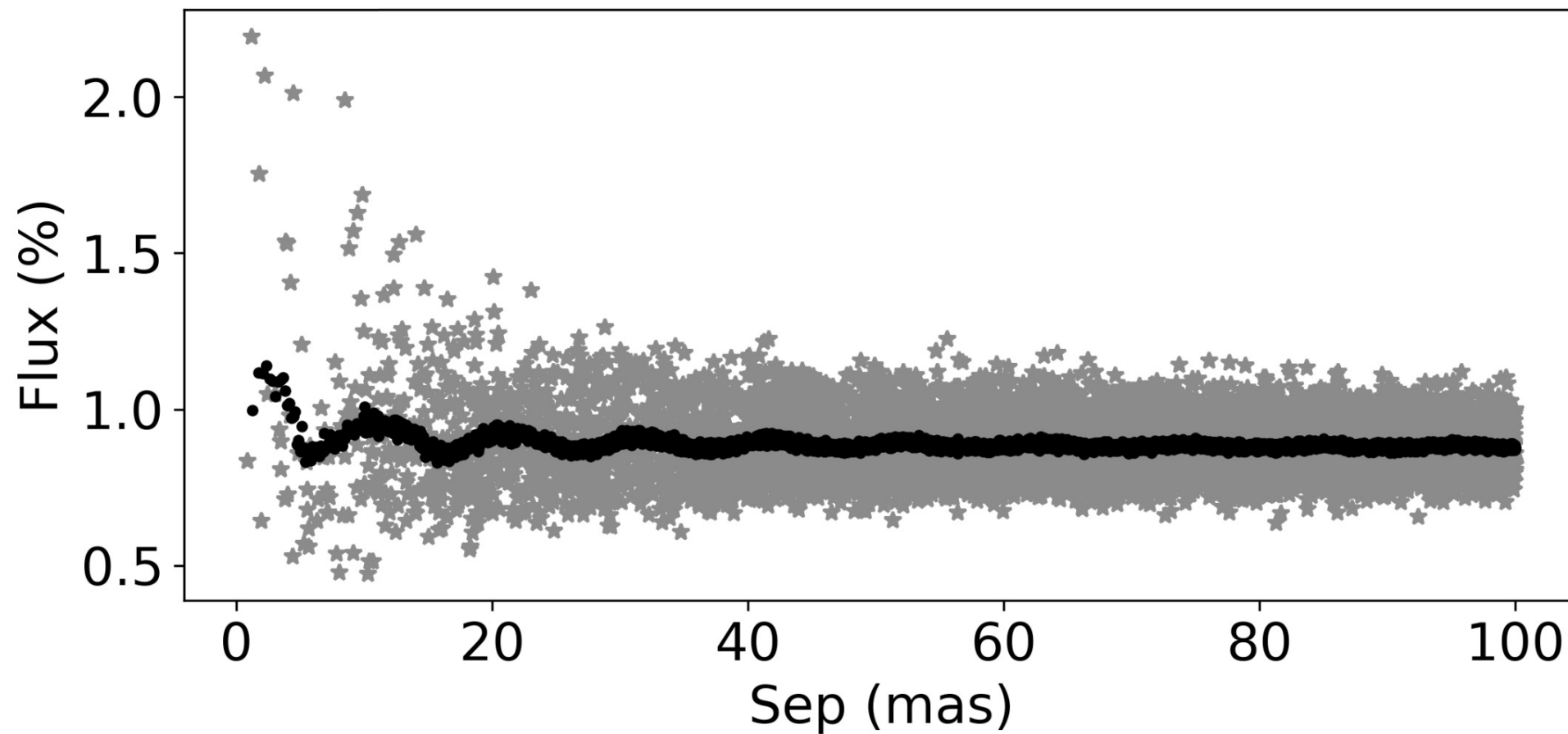
AC Her
(Hillen+ 2015)



Disk cavity is created by planet?

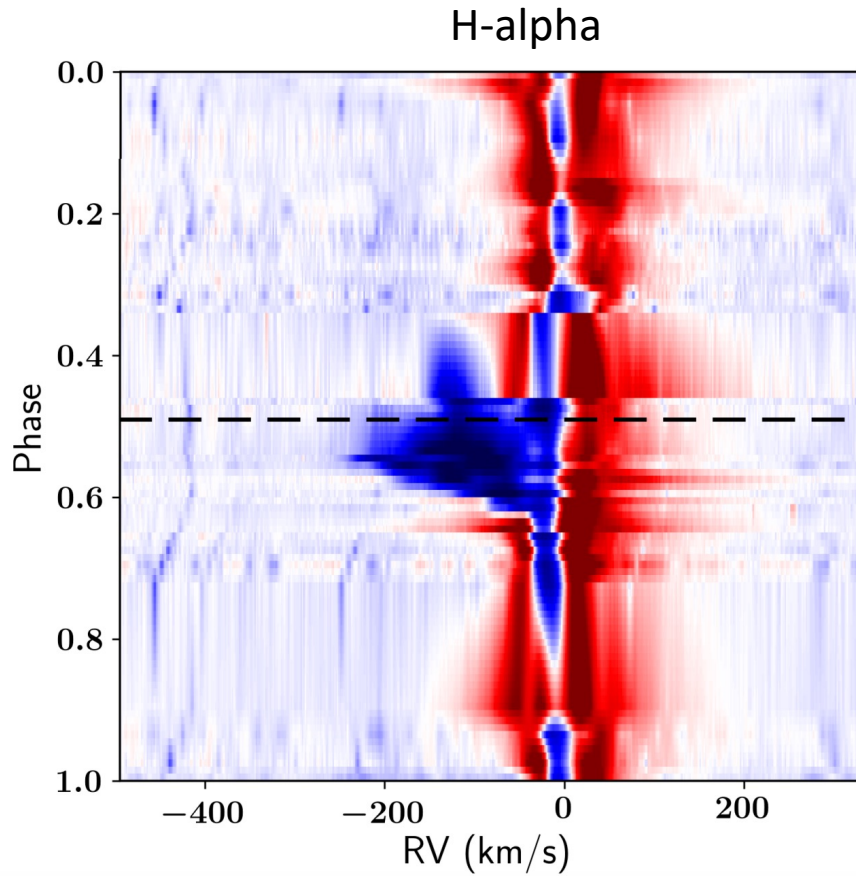


No tertiary was found $> 1\%$





Jets in AC Her

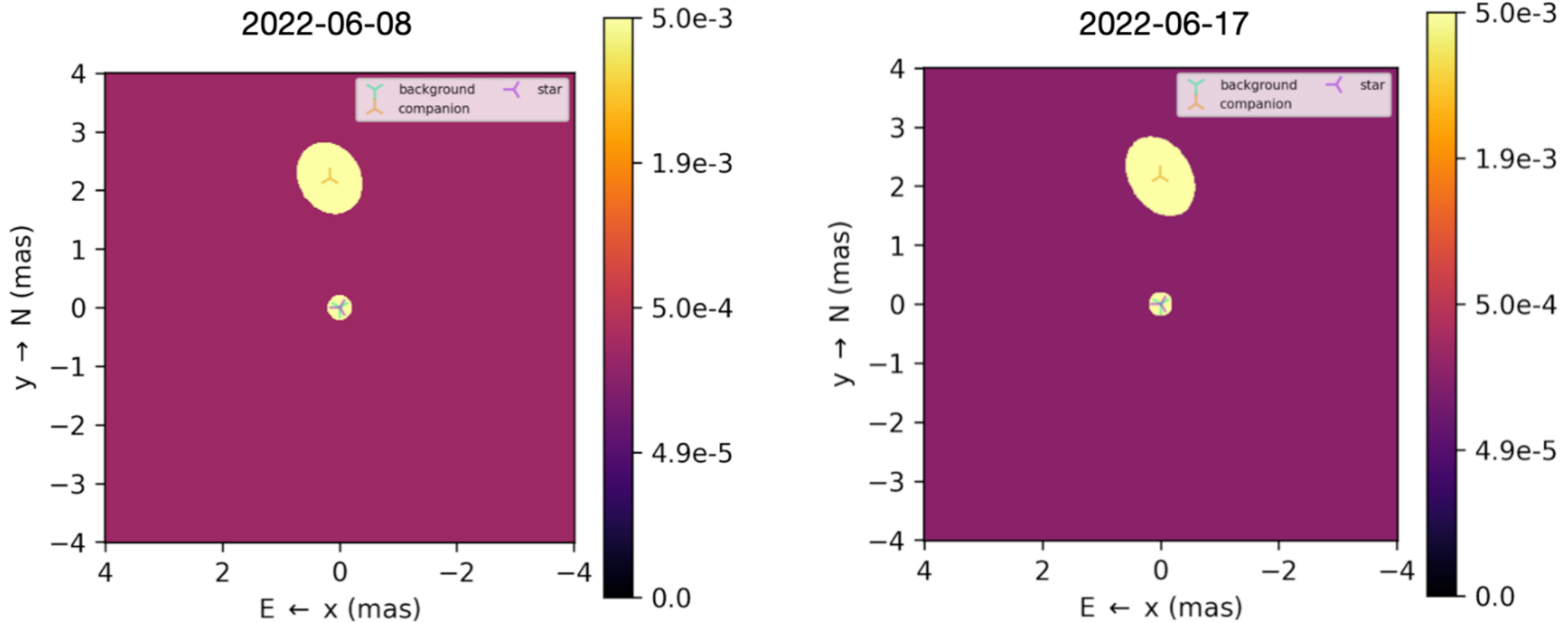


Bollen + 2022



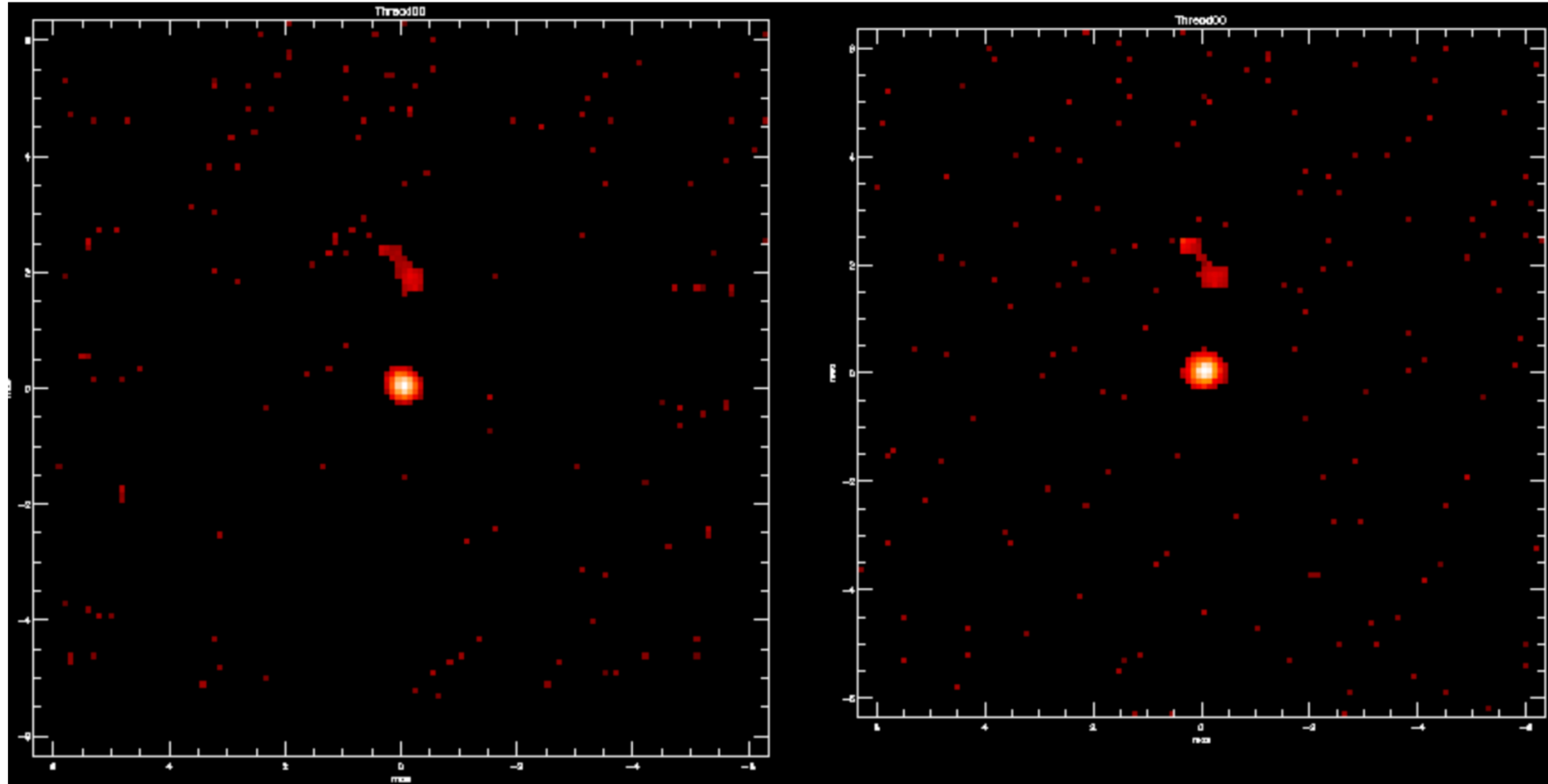
(credit D. Bollen)

AC Her: MYSTIC (K-band) sees extended flux around companion





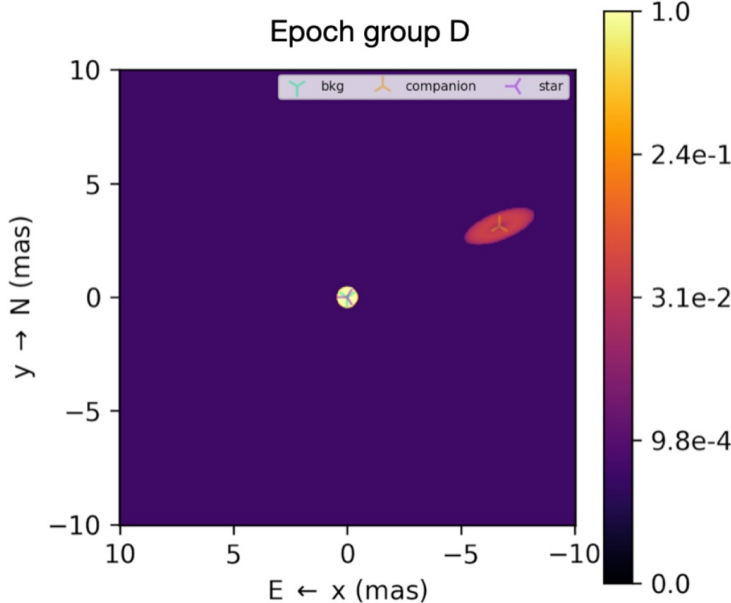
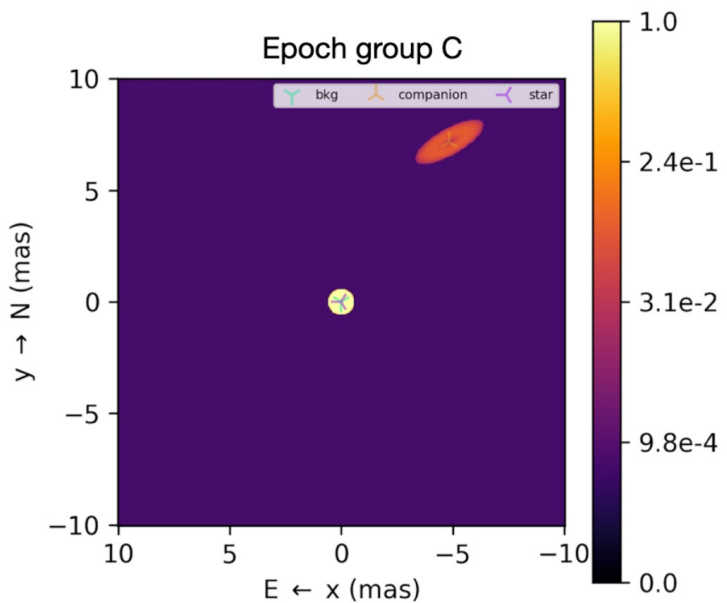
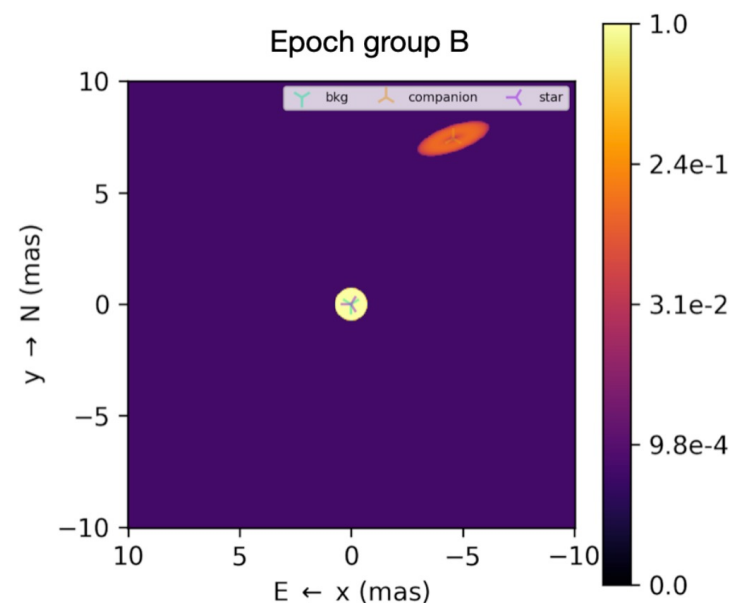
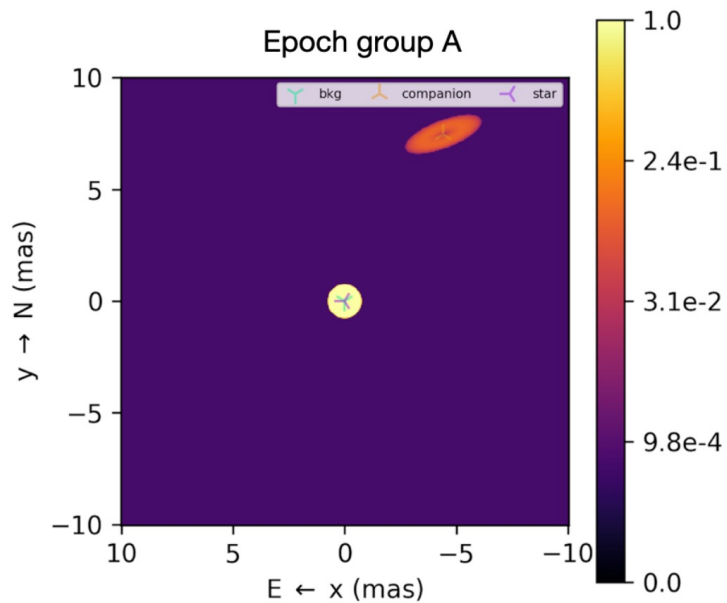
AC Her, MYSTIC, Image reconstruction



Thanks to John Monnier

Disk around companion?

	H-band	K-band
Size	0.73 ± 0.20 mas 1.1 au	1.25 ± 0.13 mas 1.7 au
Flux (%)	5.1 ± 0.2	10.0 ± 0.1
Temp (K)	3350 ± 1200	2403 ± 170

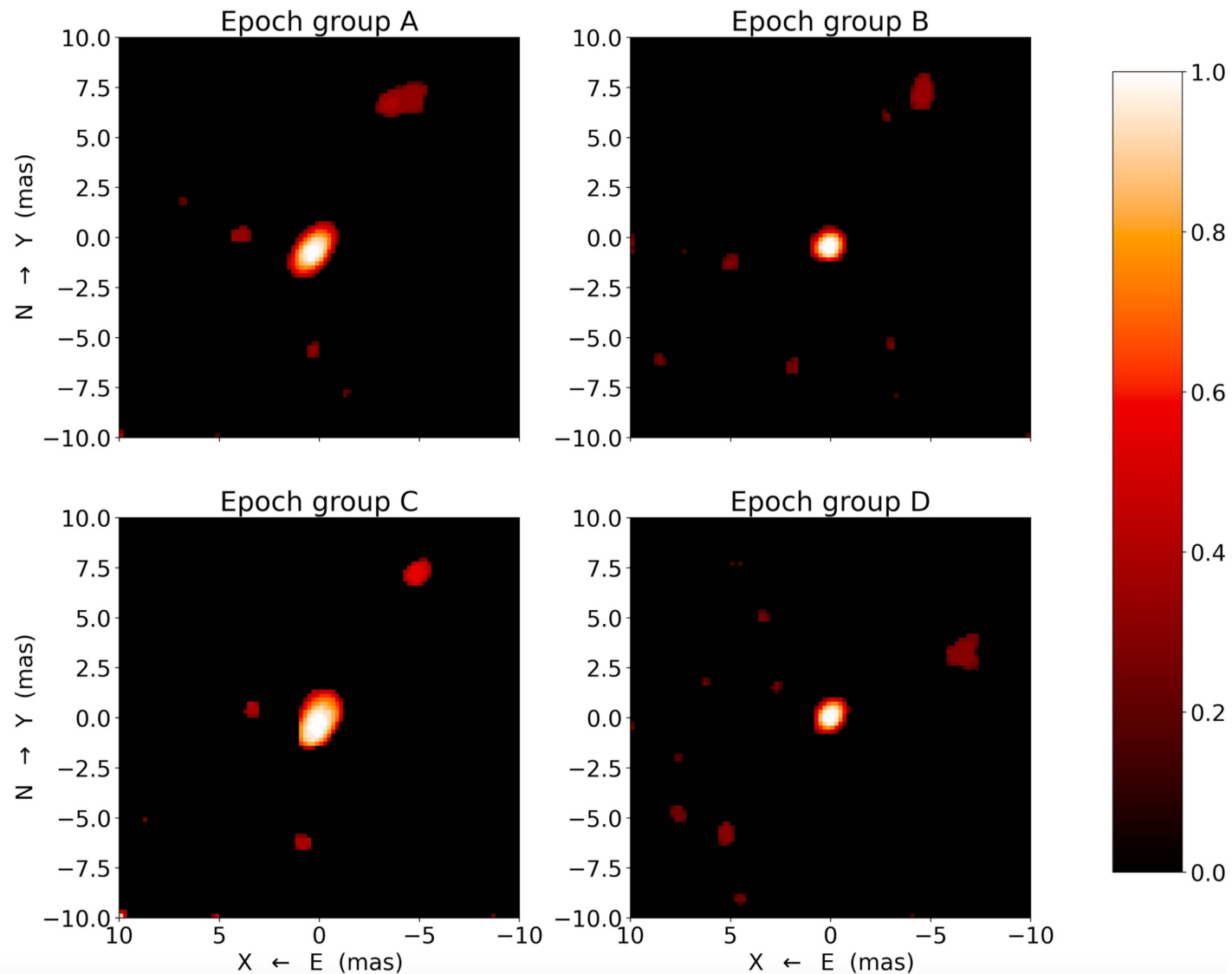


2. U Mon

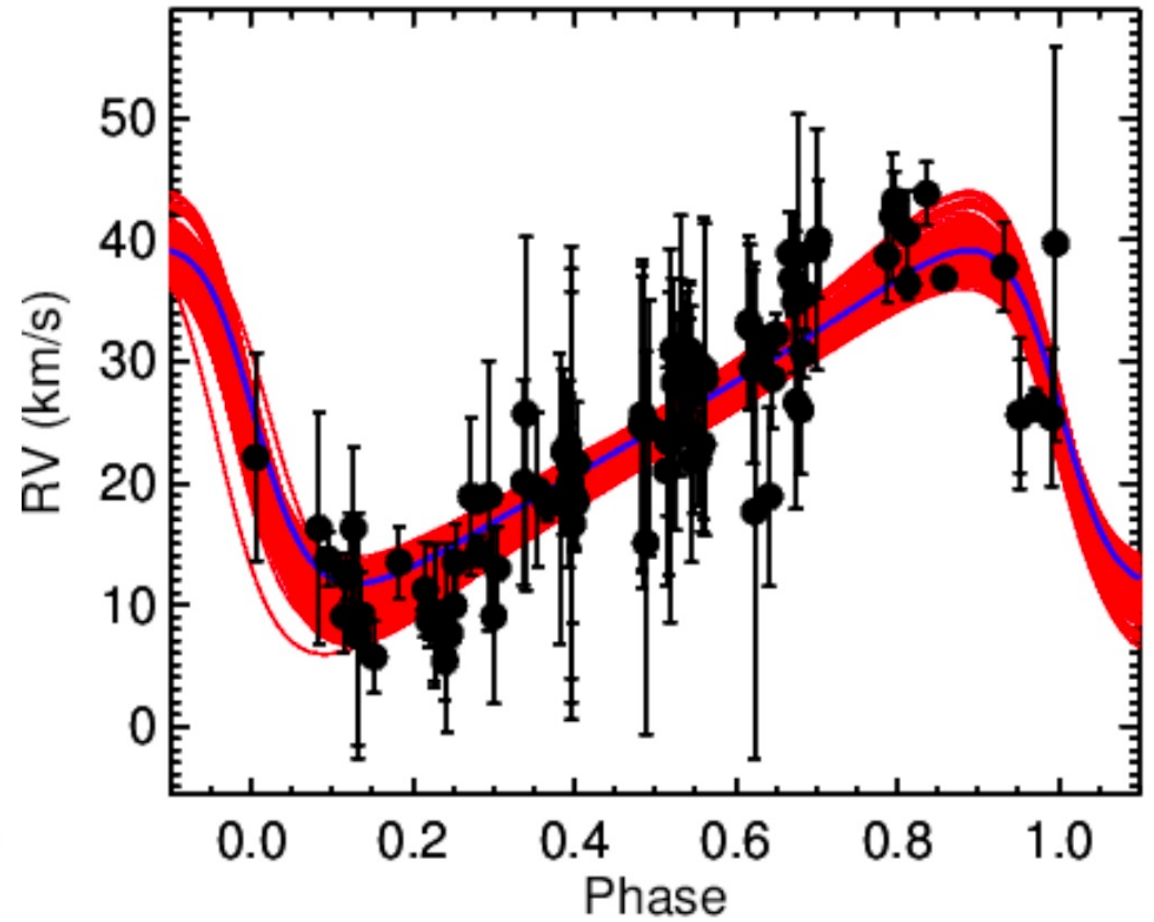
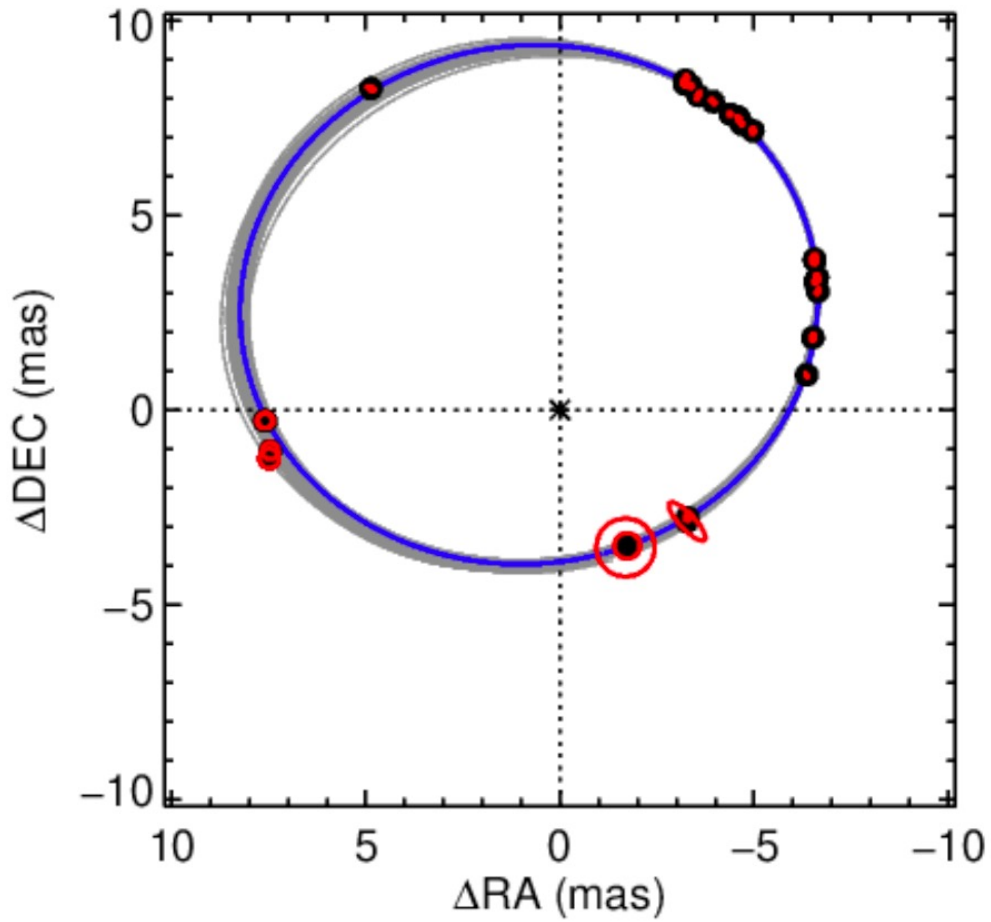
MIRC-X MYSTIC PIONIER



U Mon, SQUEEZE image reconstruction



U Mon binary orbit



Thanks to Gail and Tyler

U Mon binary orbit and dynamical masses

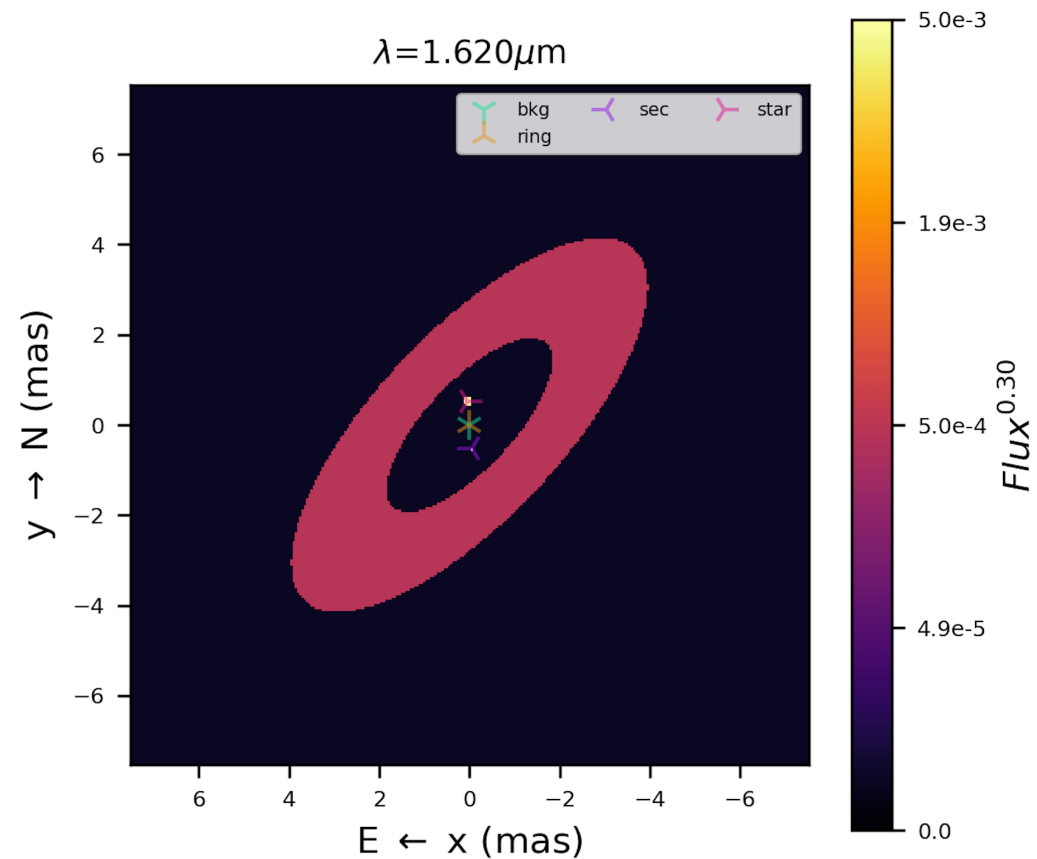
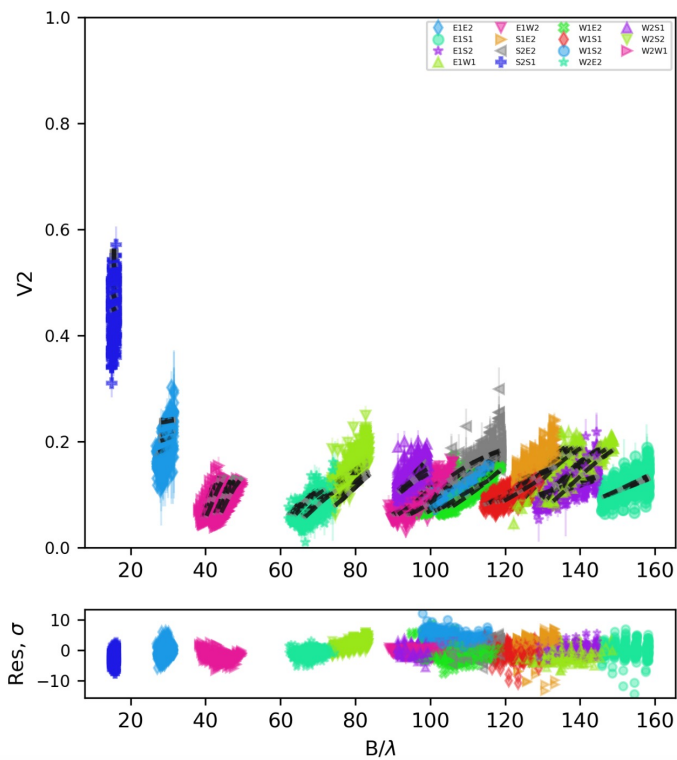
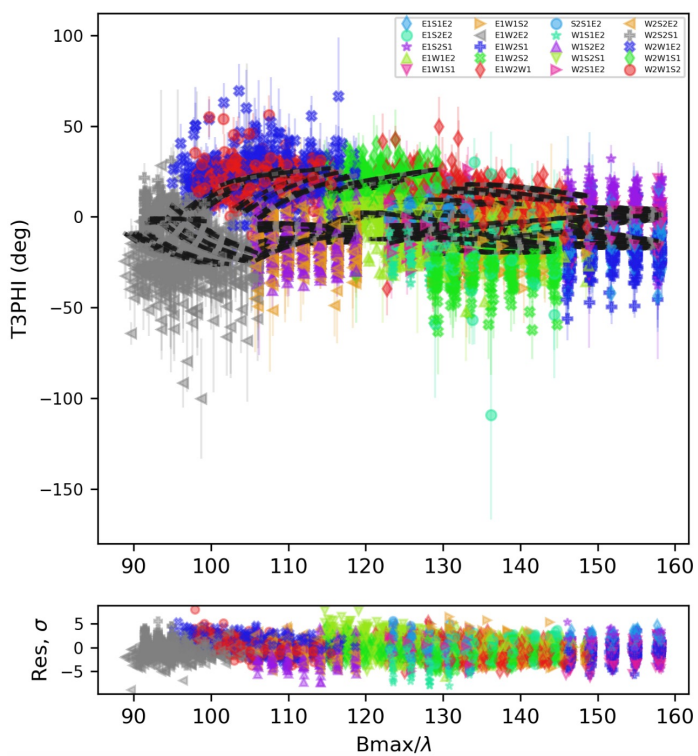
Orbital element	This work
Semi-major axis, a (mas)	8.21 ± 0.030
Inclination, $i(^{\circ})$	144.22 ± 0.47
$\Omega(^{\circ})$	101.92 ± 0.58
Orbital period, P	2444.31 ± 2.46
Eccentricity, e	0.421 ± 0.003
$\omega_A(^{\circ})$	86.35 ± 0.48
T_0 (BJD)	2507119.00 ± 2.53
K_A (km/s)	13.77 ± 0.34
γ (km/s)	24.40 ± 0.25

Table 5. U Mon dynamical masses for all reported distances

Source	Distance [pc]	$M_{\text{total}} [M_{\odot}]$	$M_1 [M_{\odot}]$	$M_2 [M_{\odot}]$
Gaia DR2 (1)	1067 ± 109	15.0 ± 5.0	6.8 ± 3.2	8.2 ± 2.0
Gaia DR3 Geometry (2)	800 ± 102	6.3 ± 2.4	1.7 ± 1.4	4.6 ± 1.3
Gaia DR3 Phot (2)	773 ± 64	5.7 ± 1.4	1.4 ± 0.9	4.3 ± 0.9
Gaia DR3 gspphot (3)	620 ± 13	3.0 ± 0.2	0.2 ± 0.4	2.8 ± 0.4

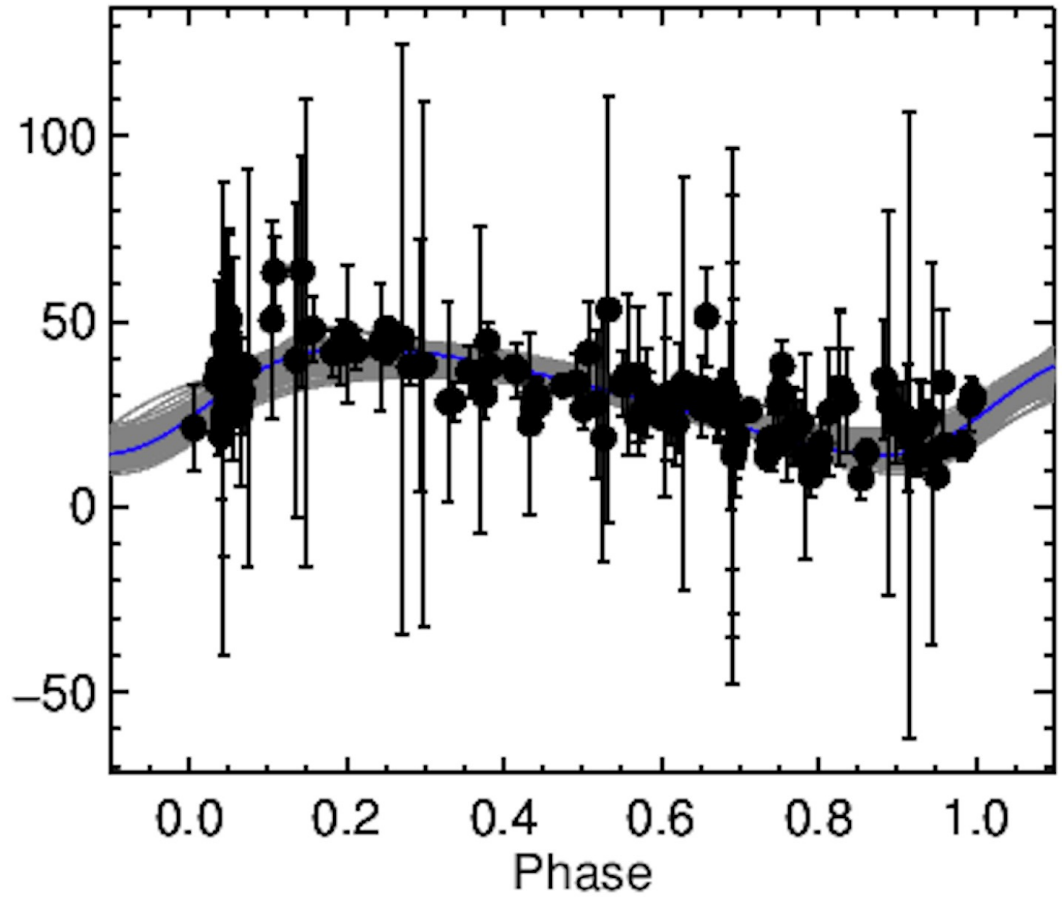
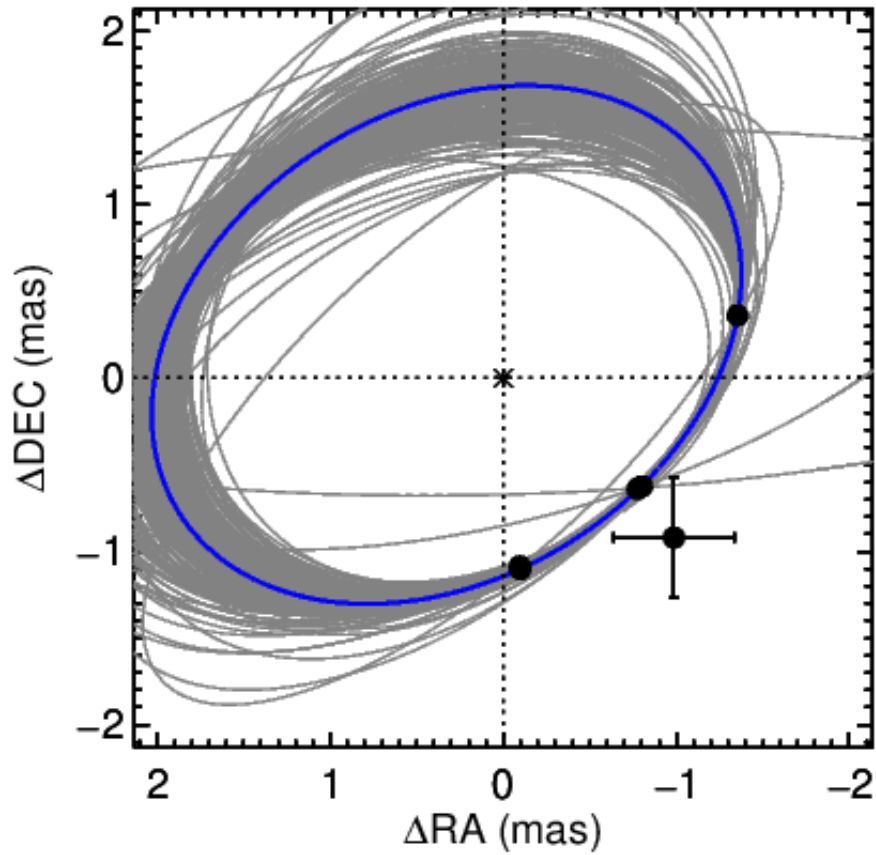


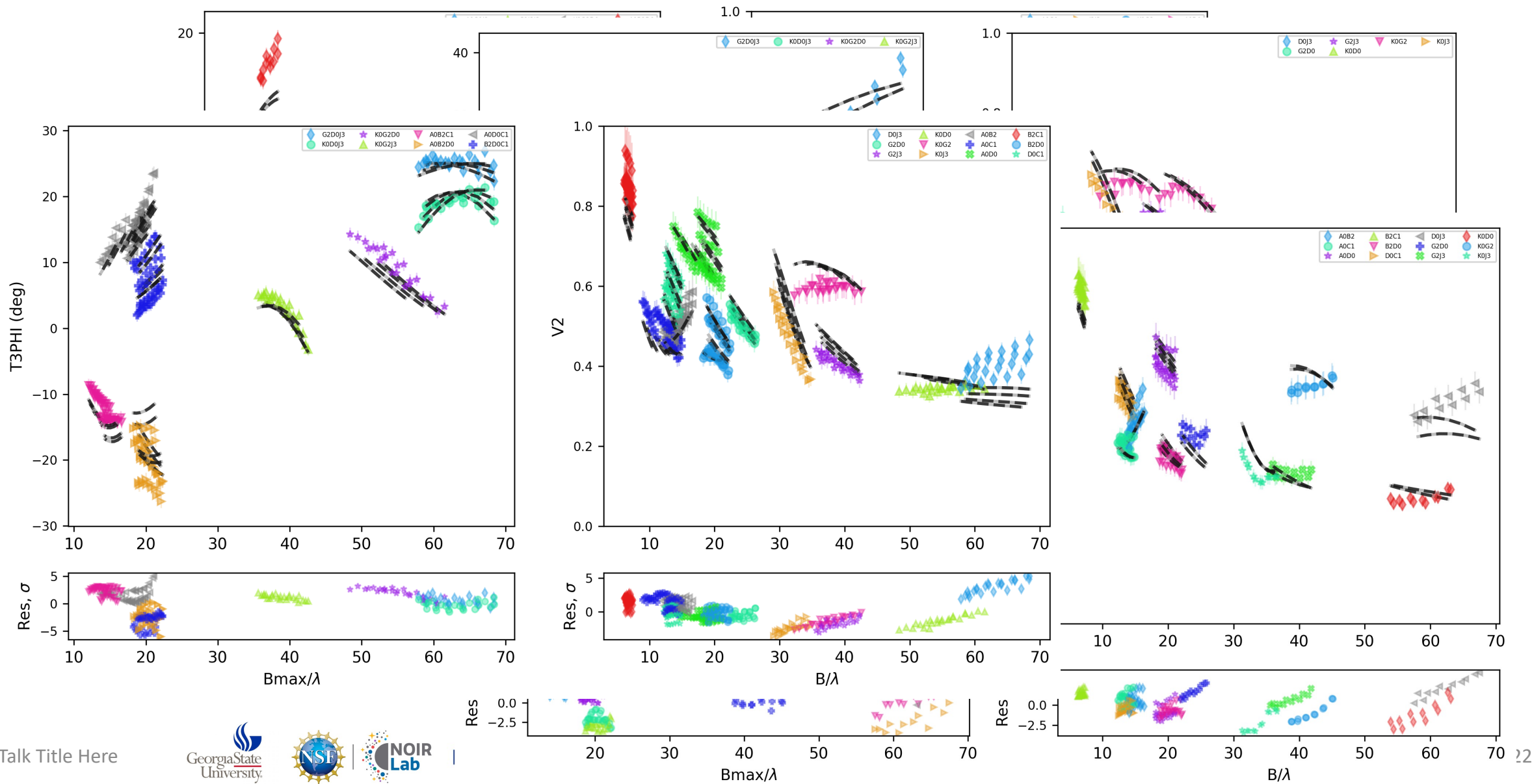
RV Tau

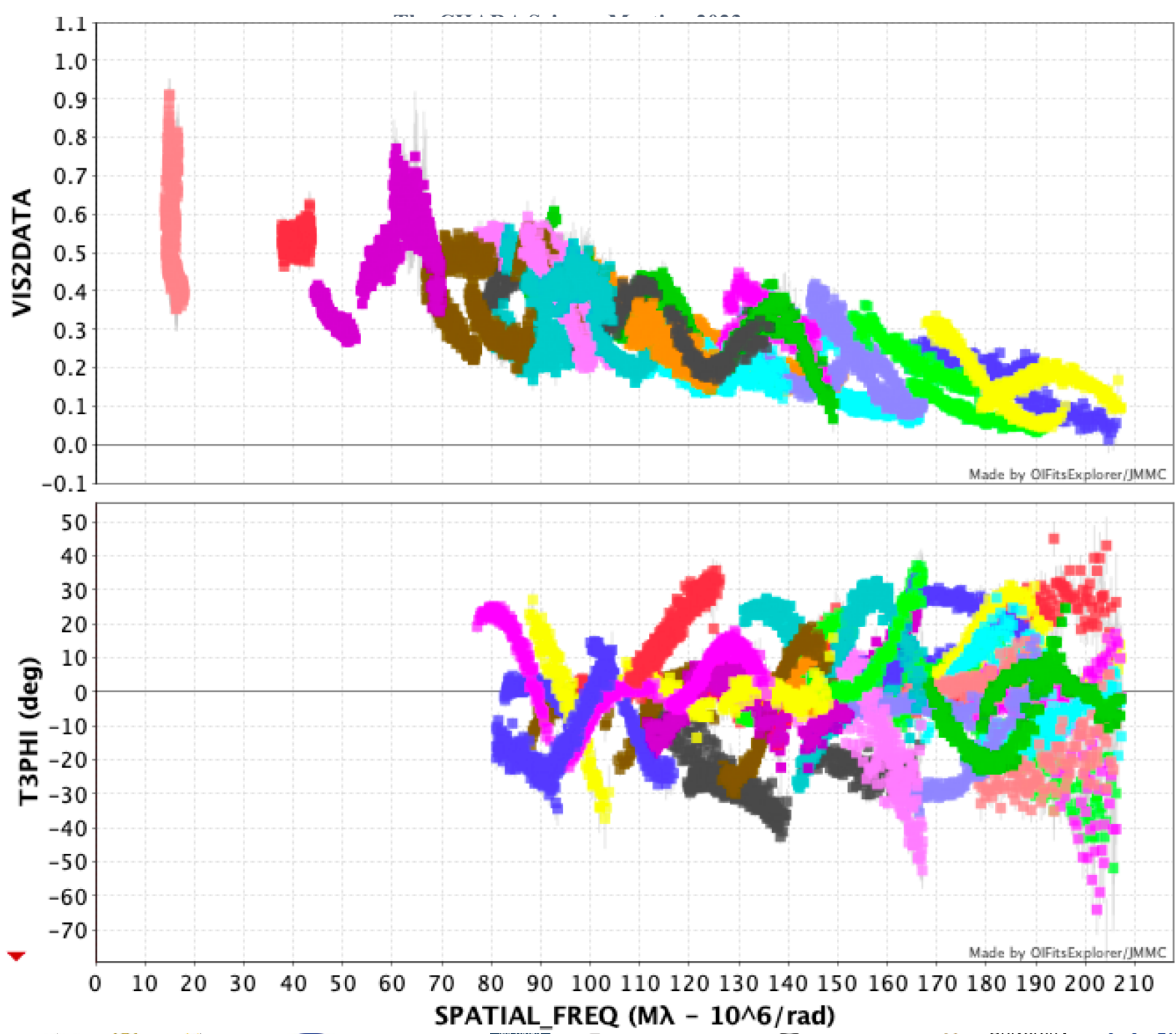


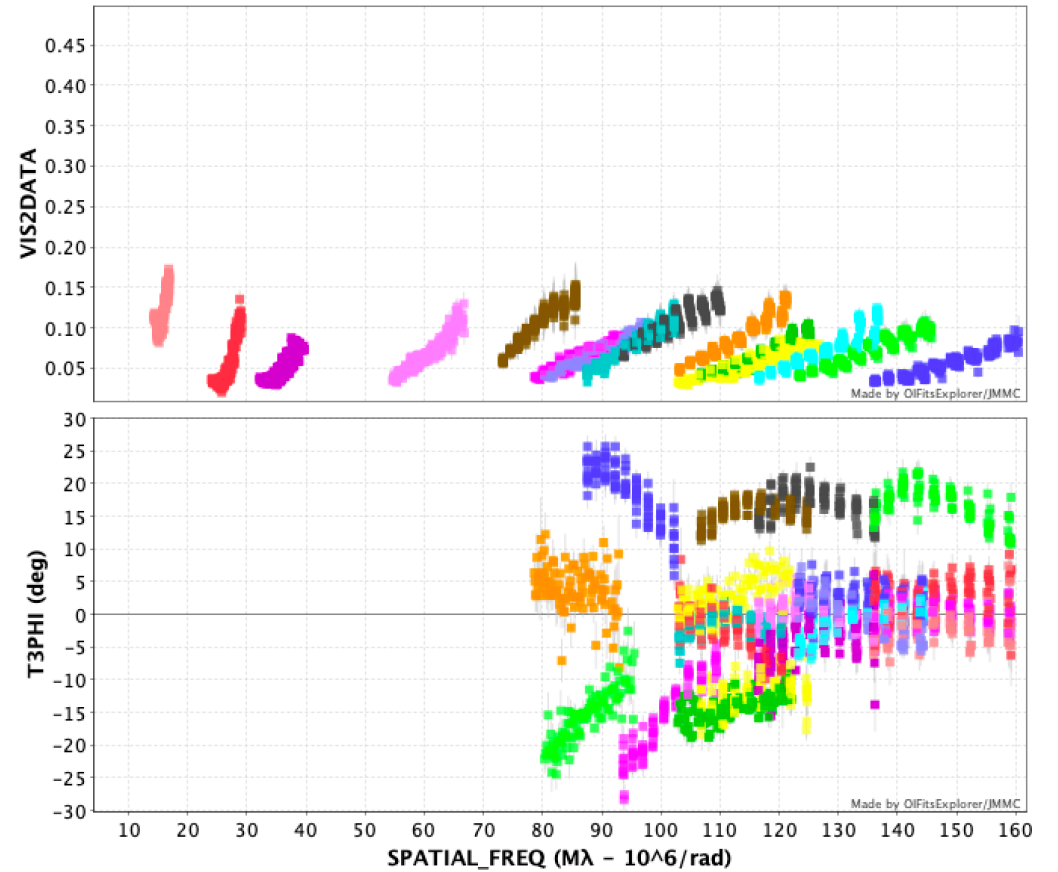
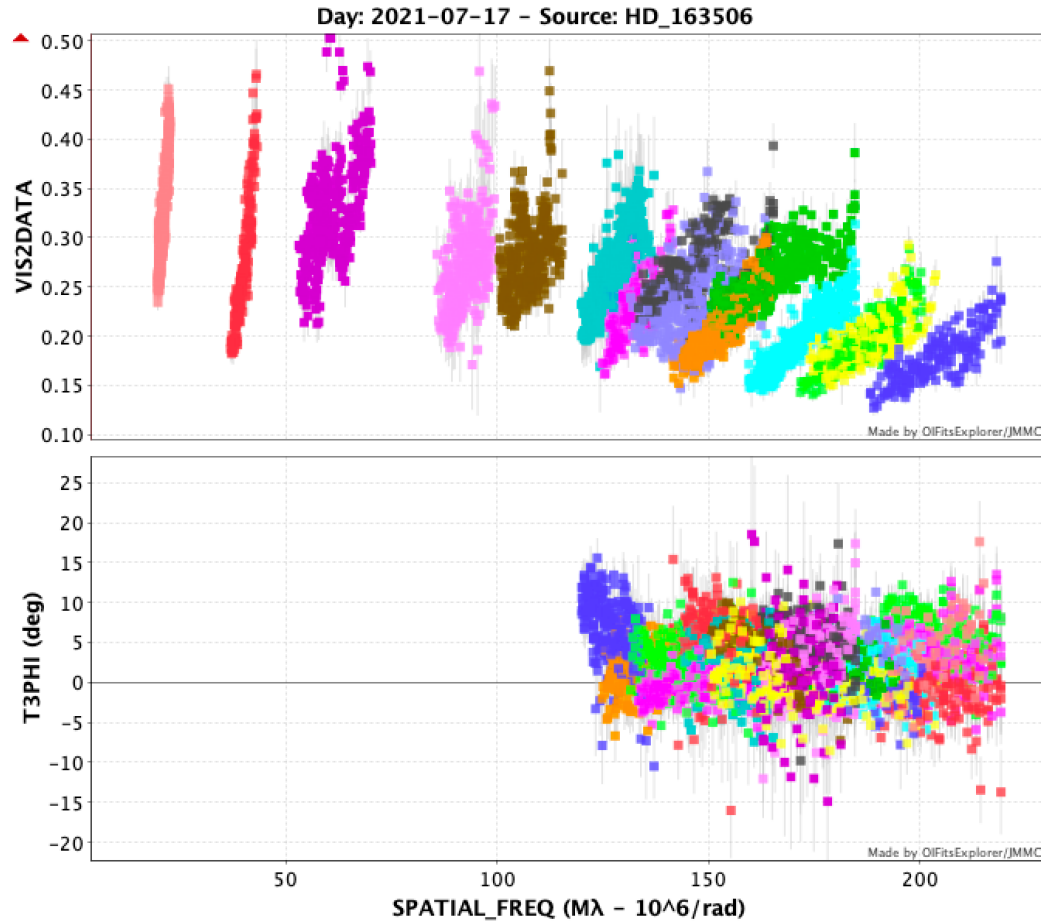


RV Tau binary orbit



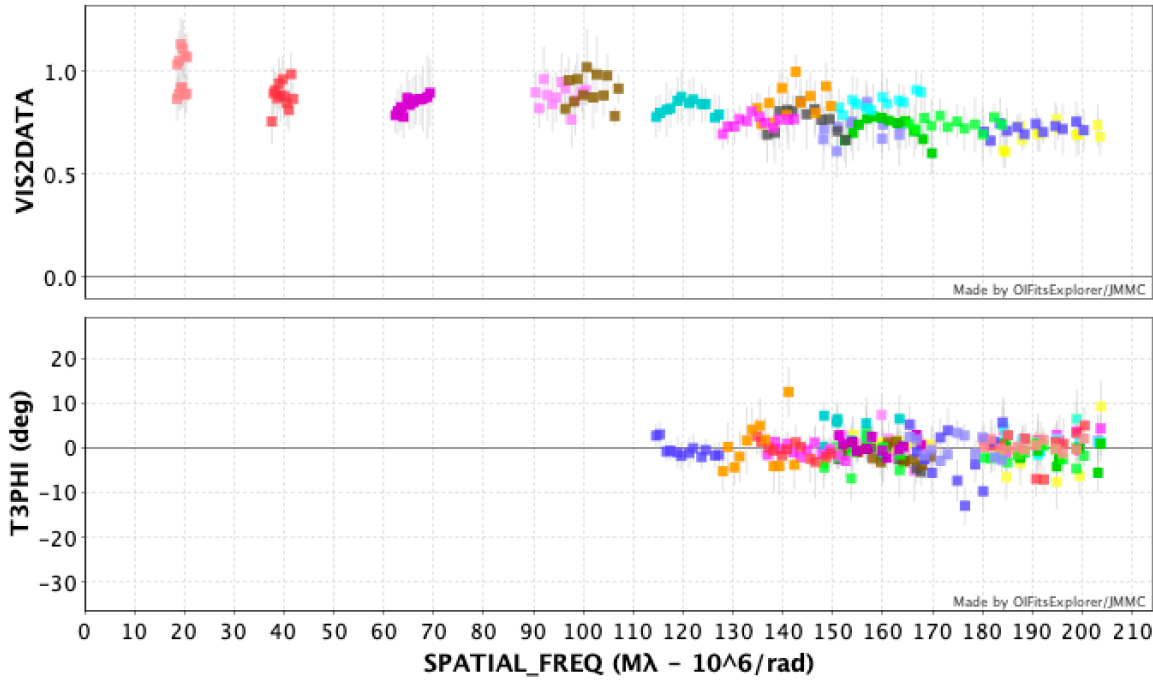








CHARA - MIRCX [1.5367 μm - 1.6946 μm] - S1-S2-E1-E2-W1-W2
Day: 2022-12-23 - Source: PS Gem



CHARA - MIRCX [2.0511 μm - 2.342 μm] - S1-S2-E1-E2-W1-W2
Day: 2022-12-23 - Source: PS Gem

