

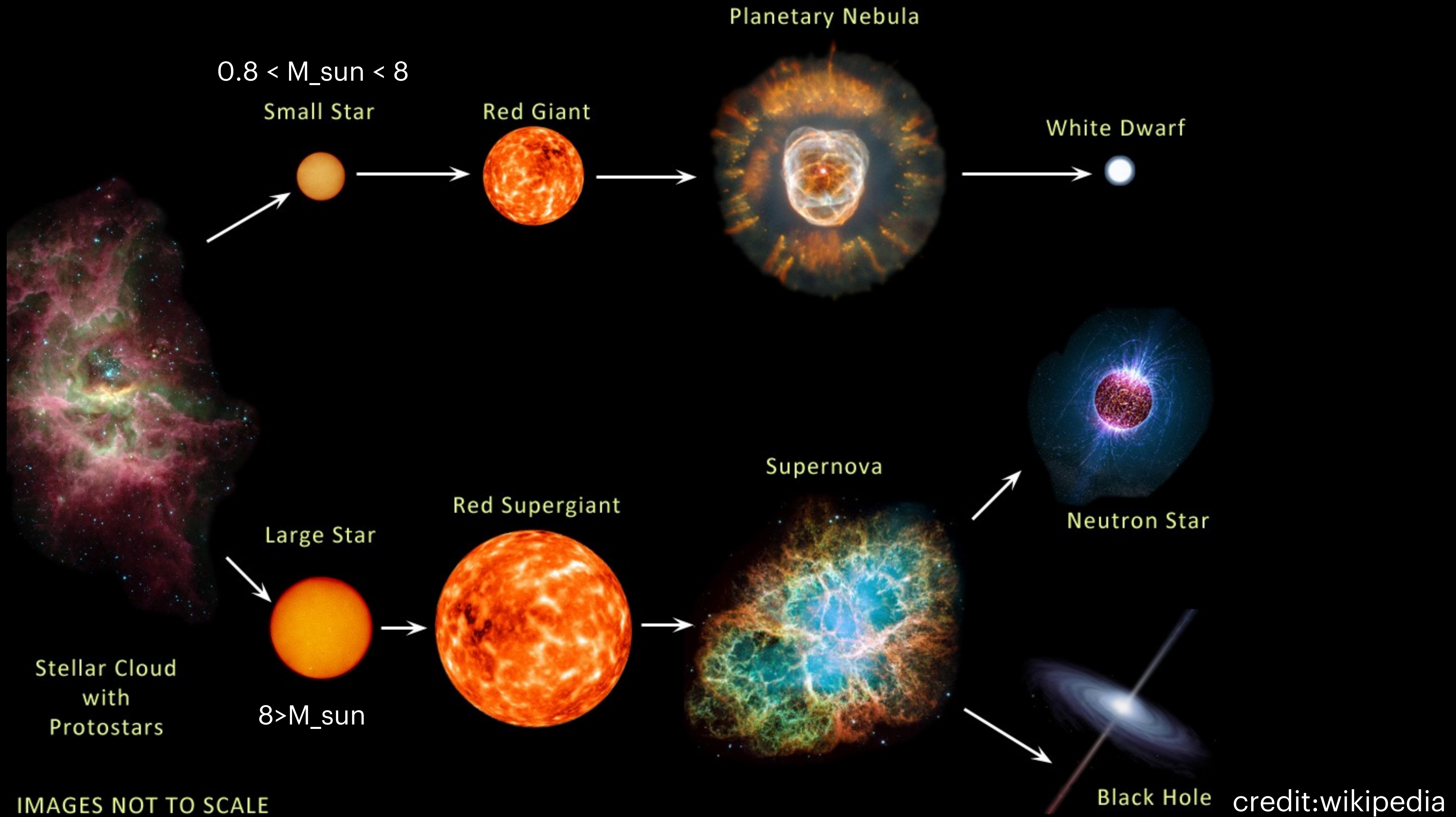
The CHARA Array Imaging of Evolved Stars

Narsireddy Anugu

CHARA Collaboration

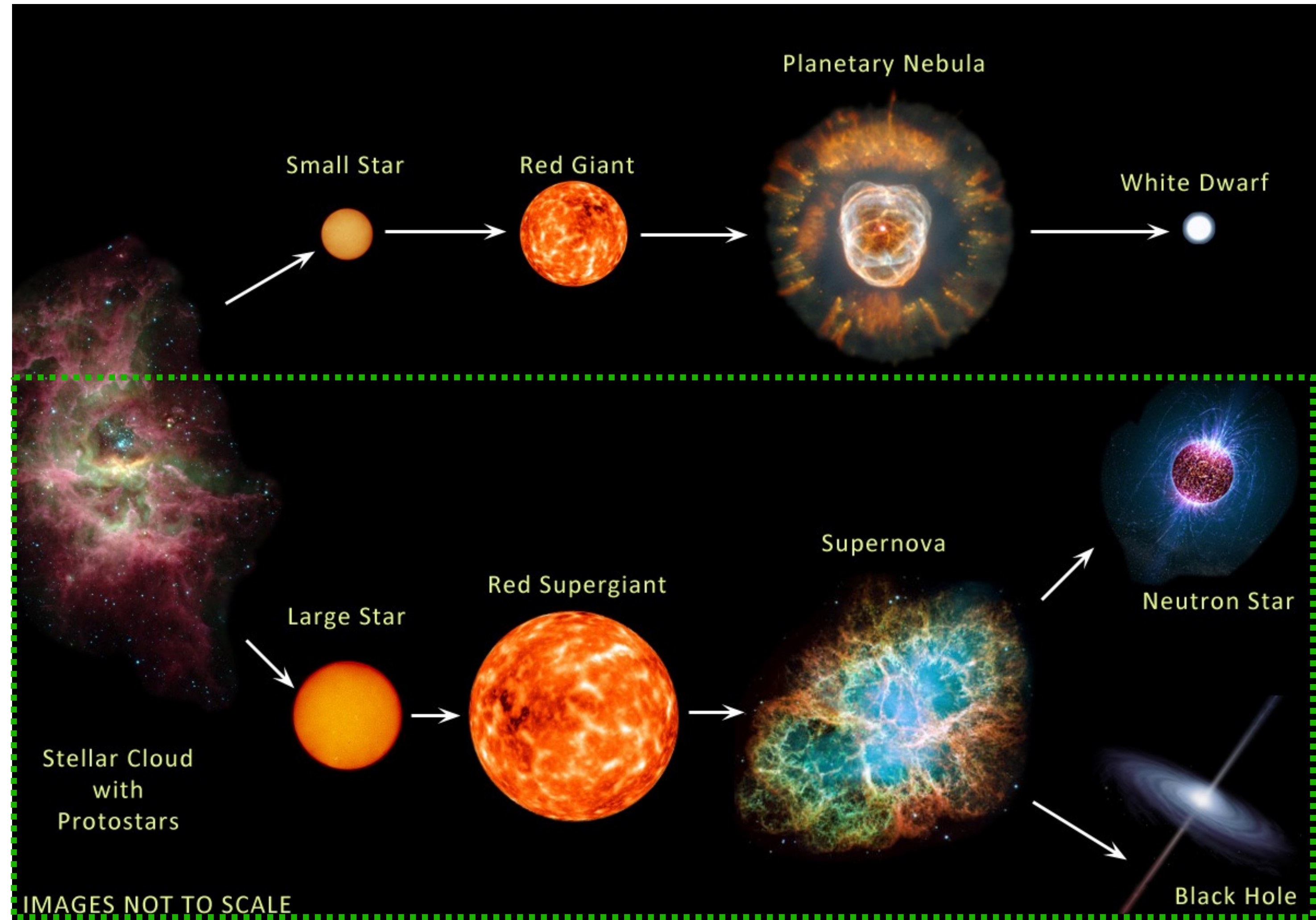
2024 Mar 12

What stars I study?



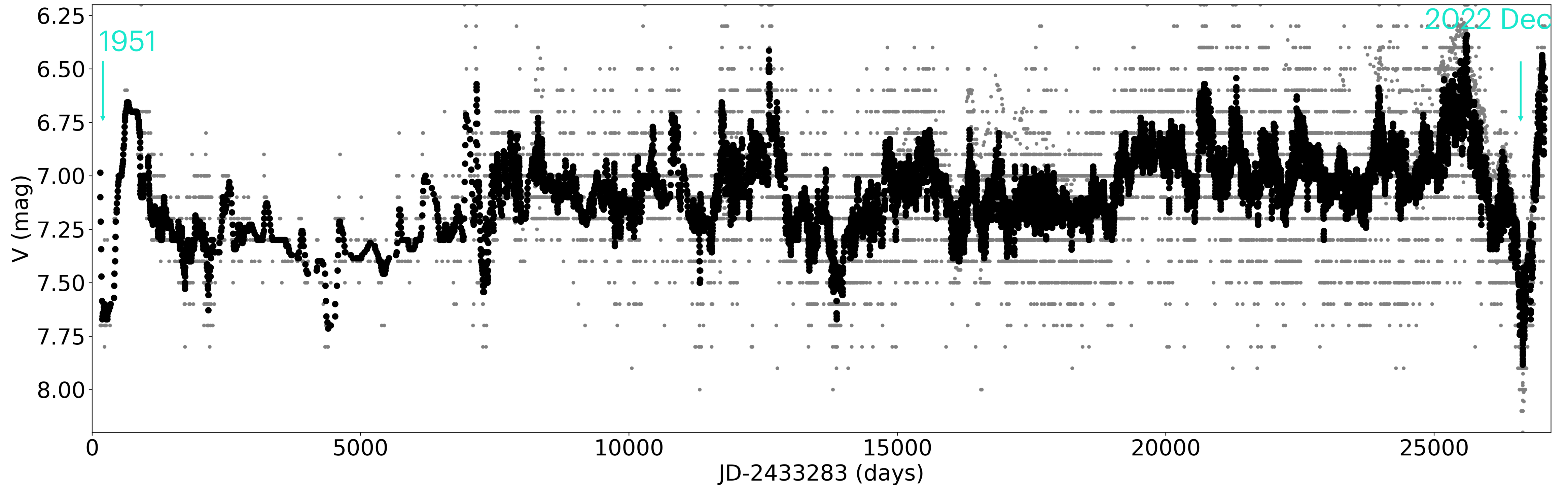
1. Red supergiants or hypergiants

- Active research in studying mass-loss mechanisms
- What happens between red supergiant to supernovae phase?
- How they impact the fate of the star become black hole or neutron star?



Cool hypergaint: RW Cep

Target of opportunity (TOO)

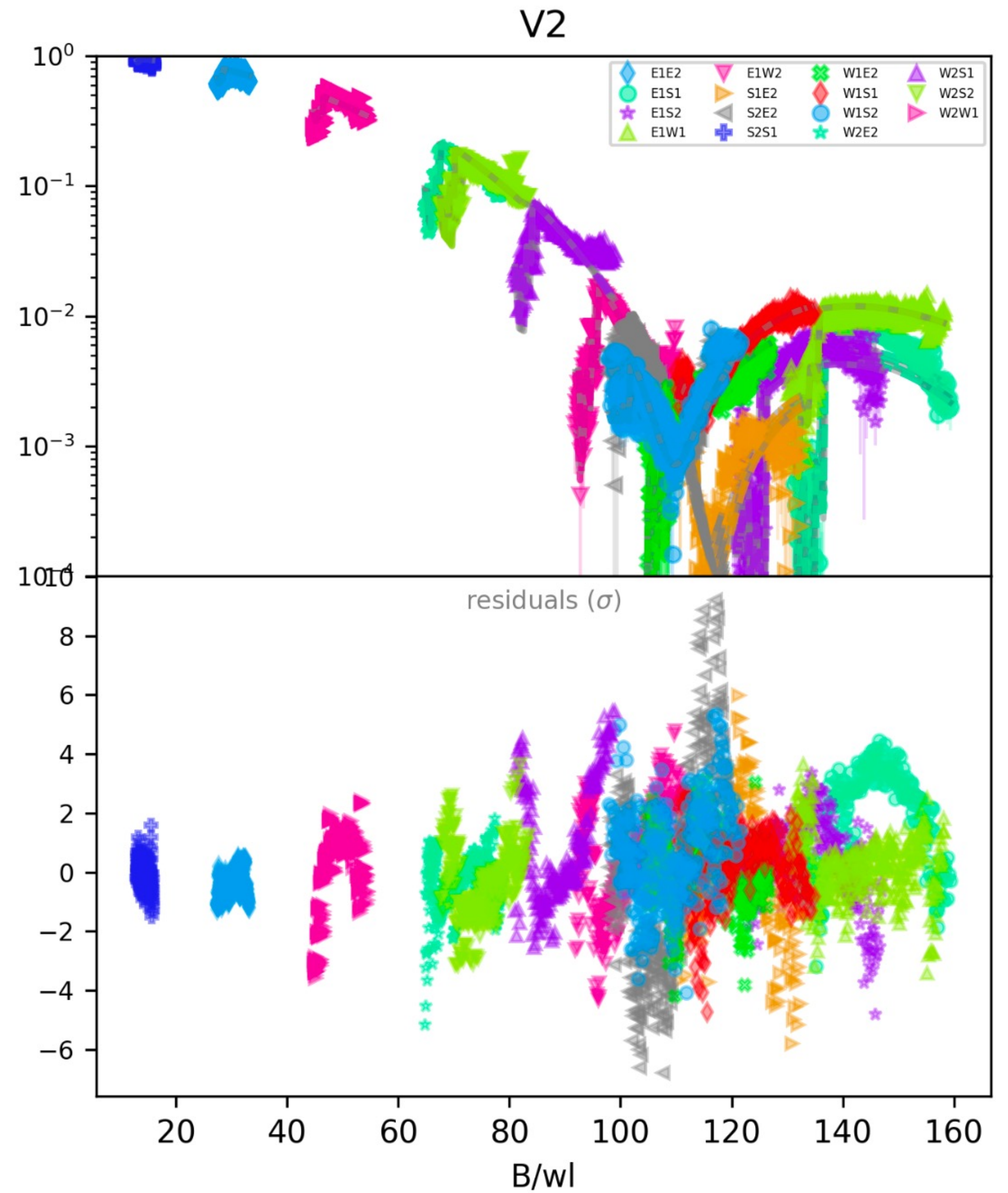
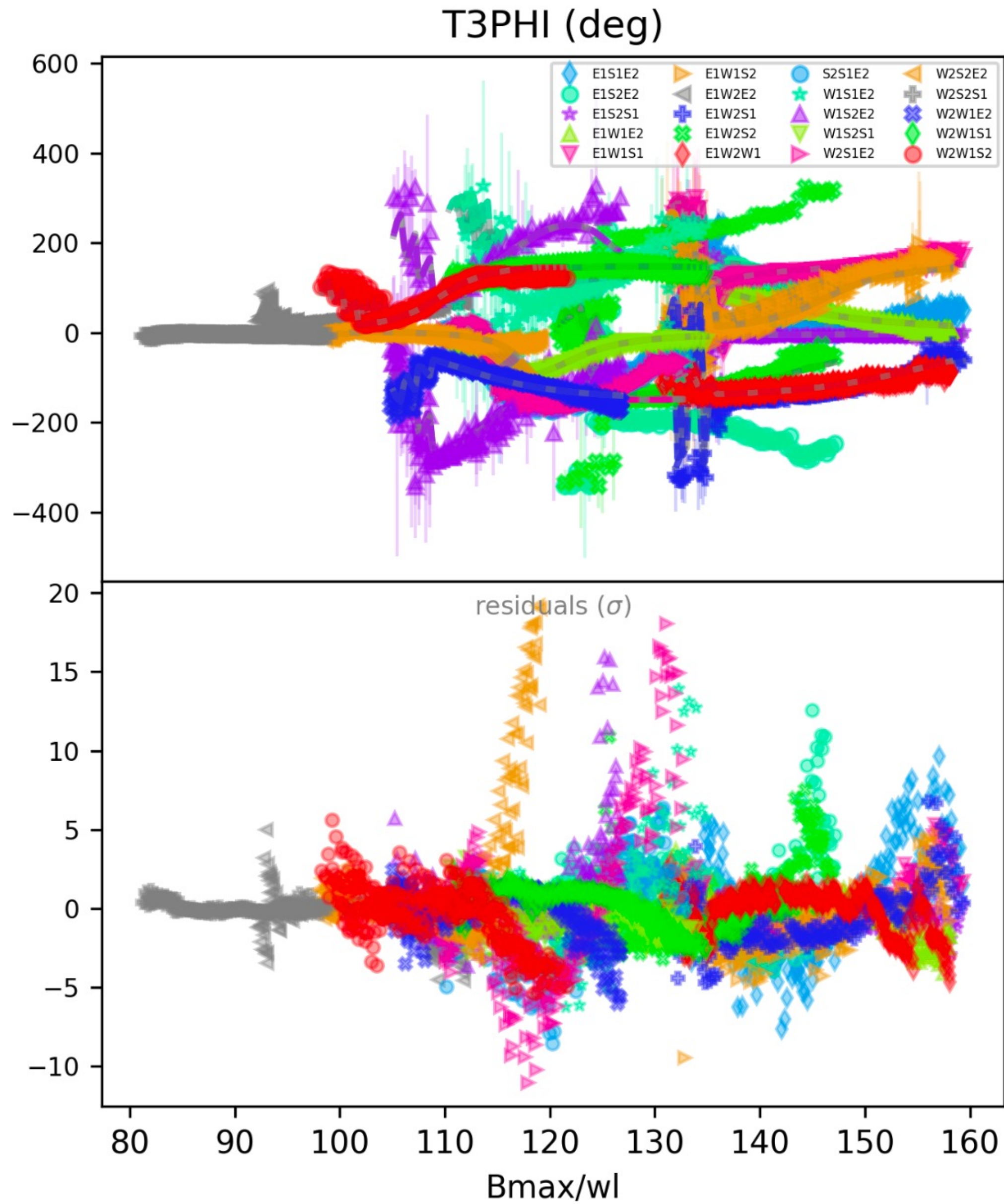


RW Cep light curve from AAVSO data

Cool hypergaint: RW Cep

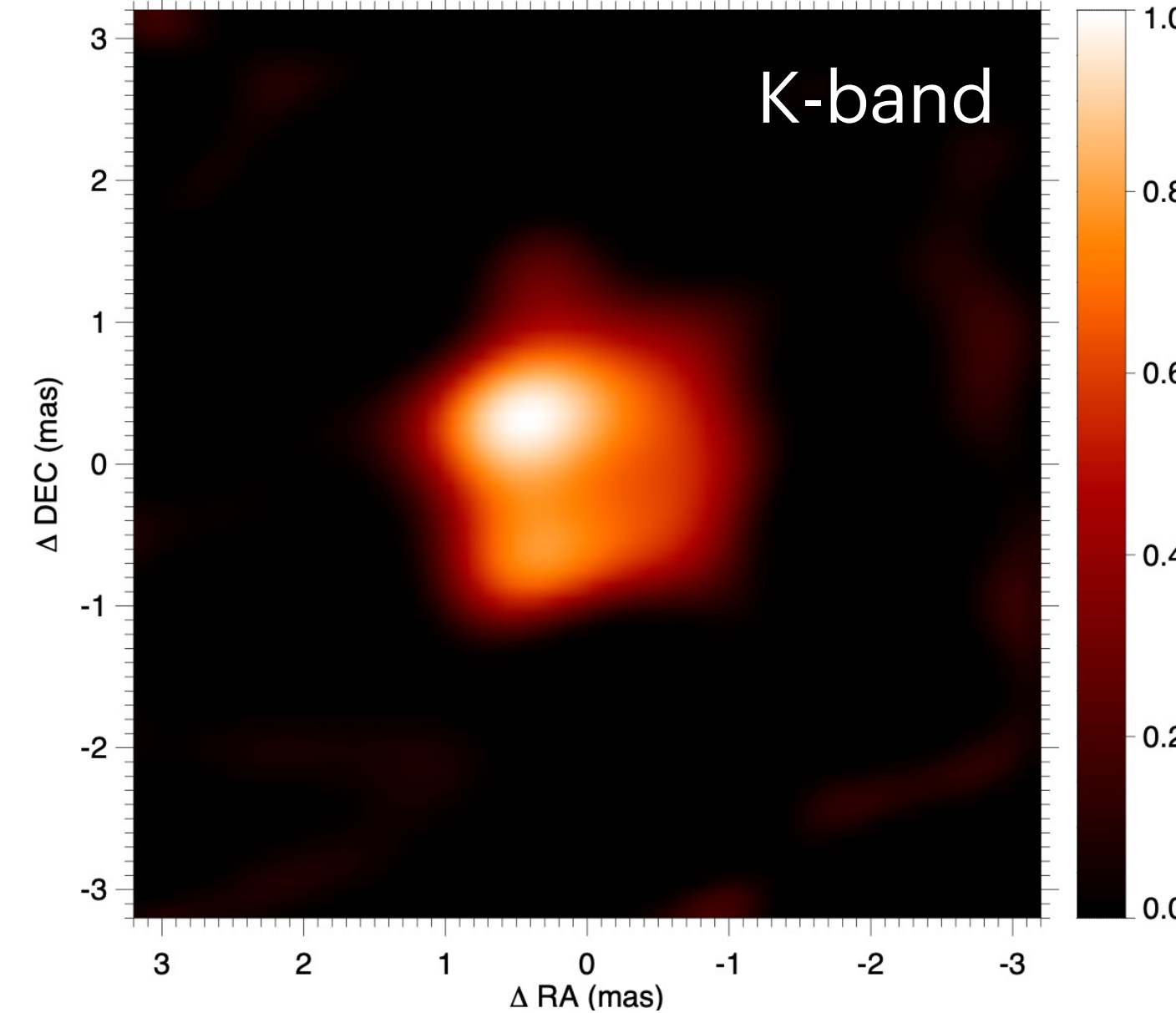
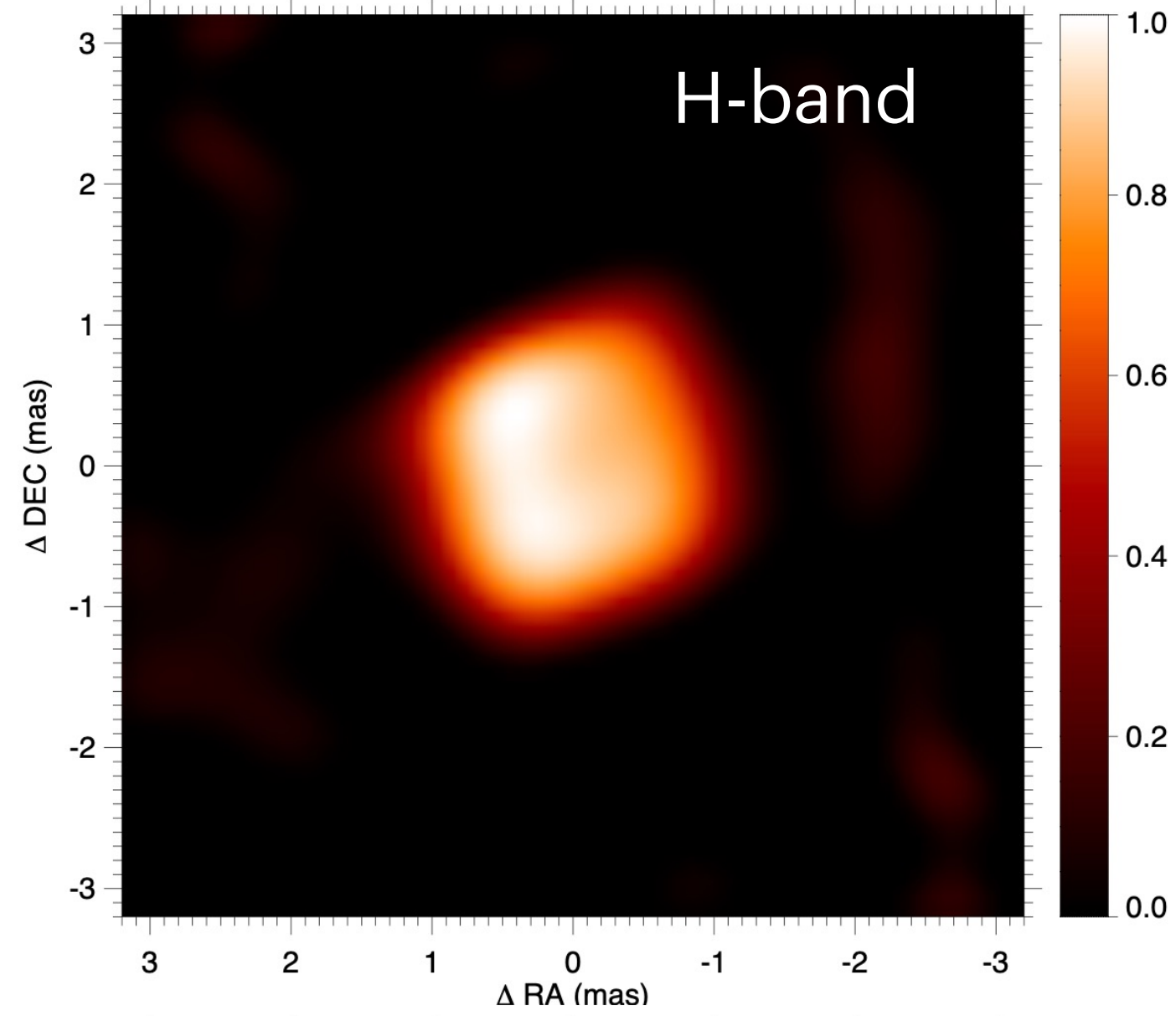


RW Cep observations

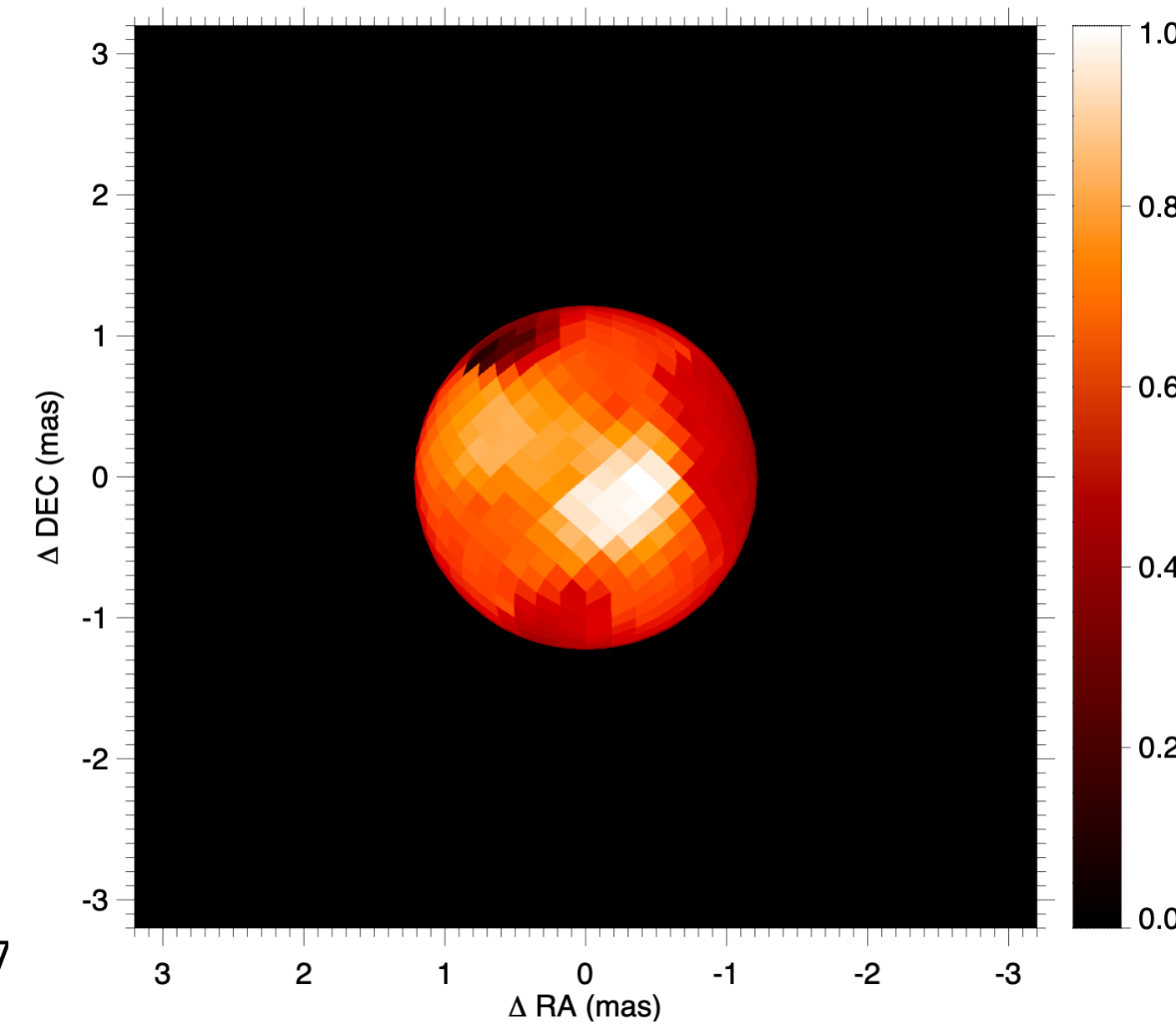
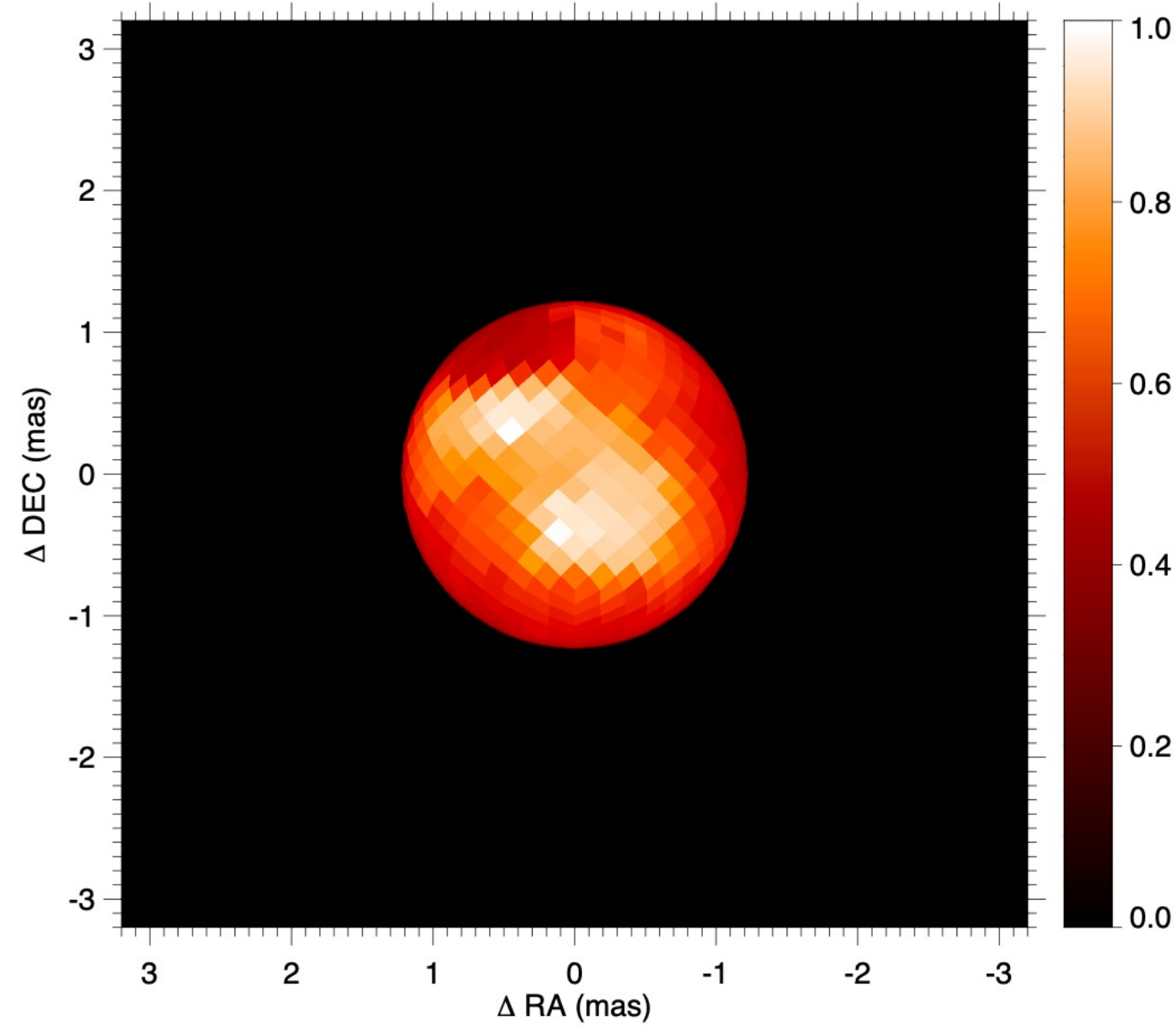


Images of RW Cep 2022 Dec

SQUEEZEE/
OITOLS



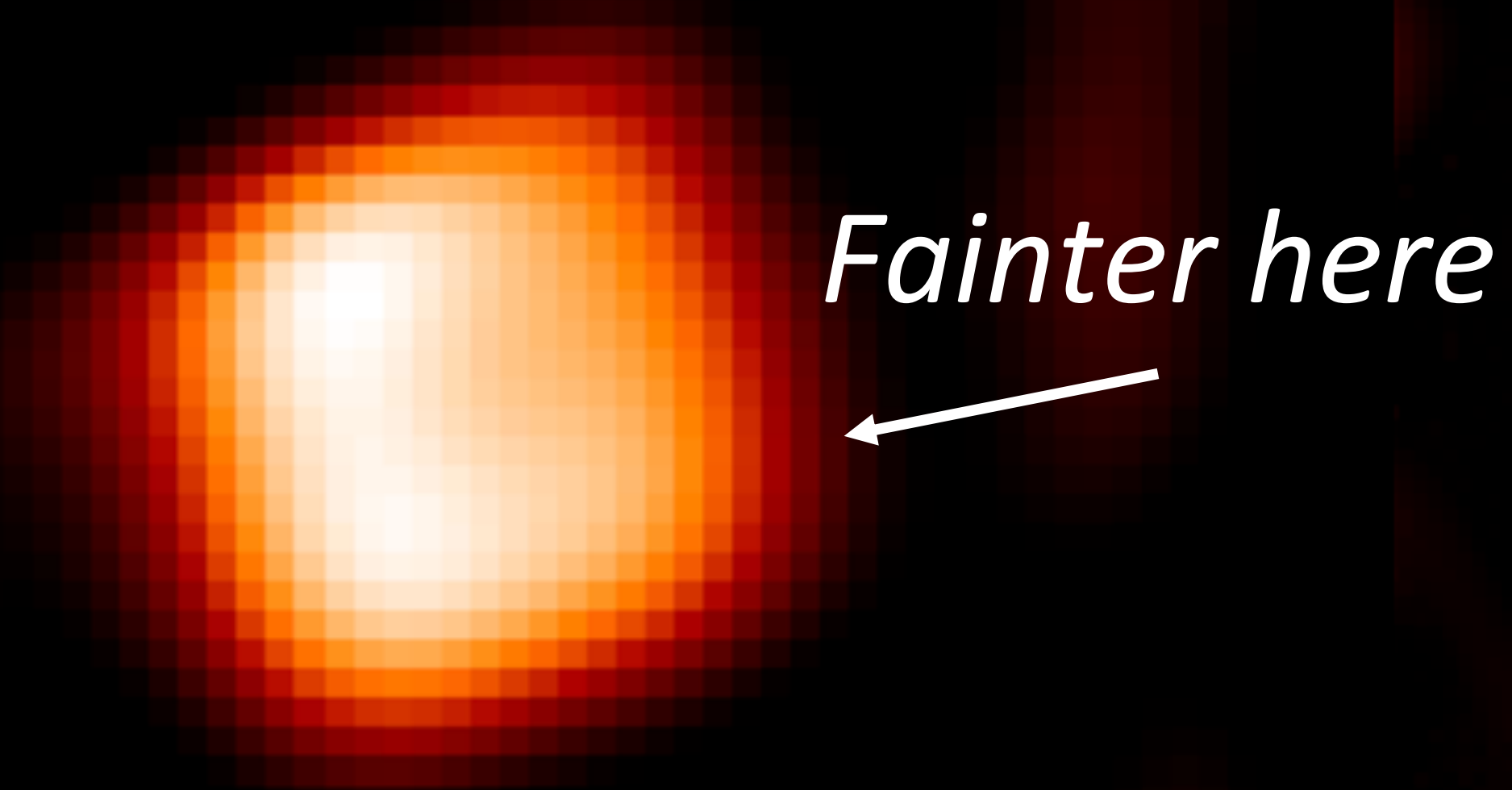
SURFING



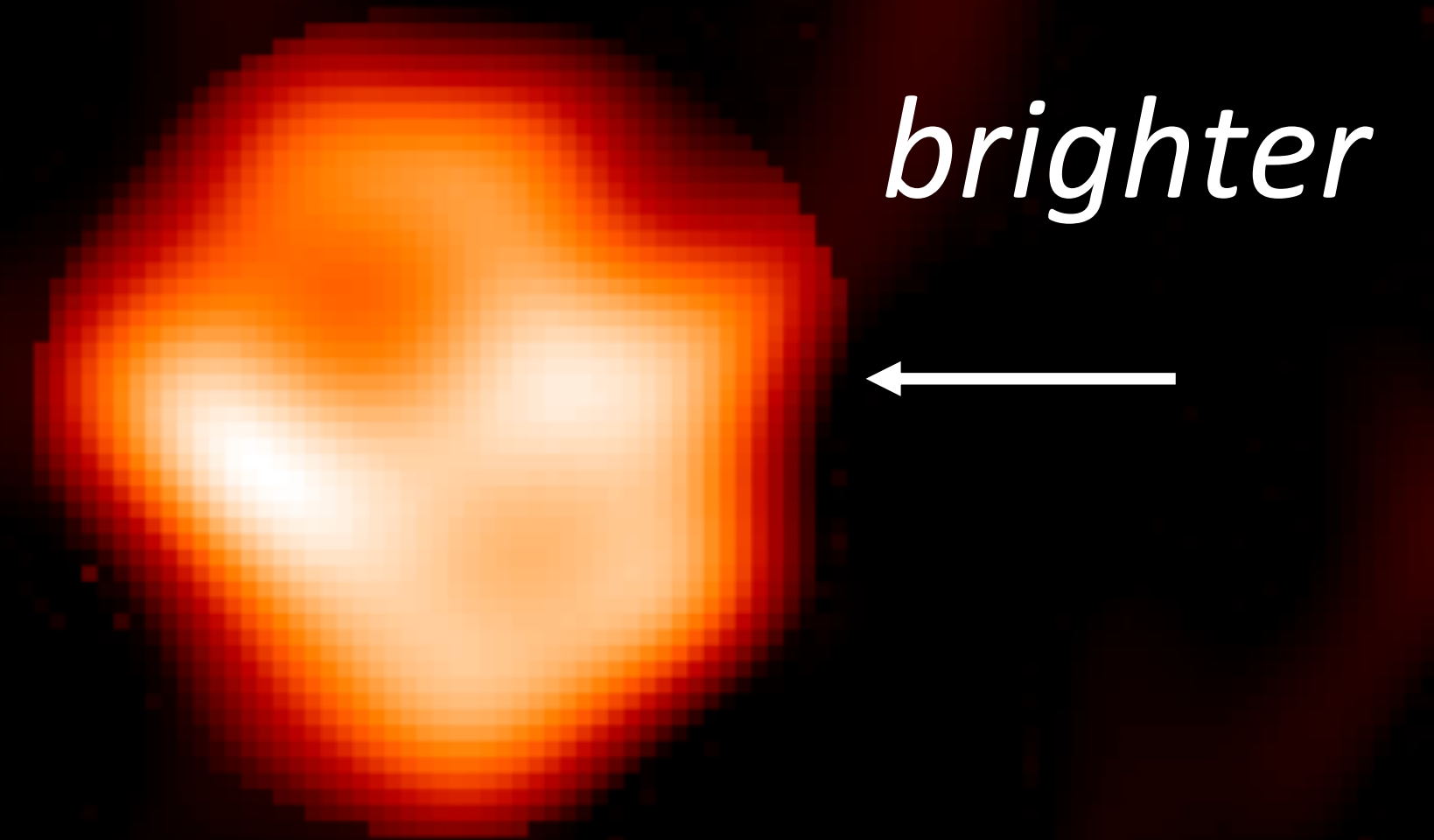
Anugu et al. 2023

CHARA images of RW Cep

H-band



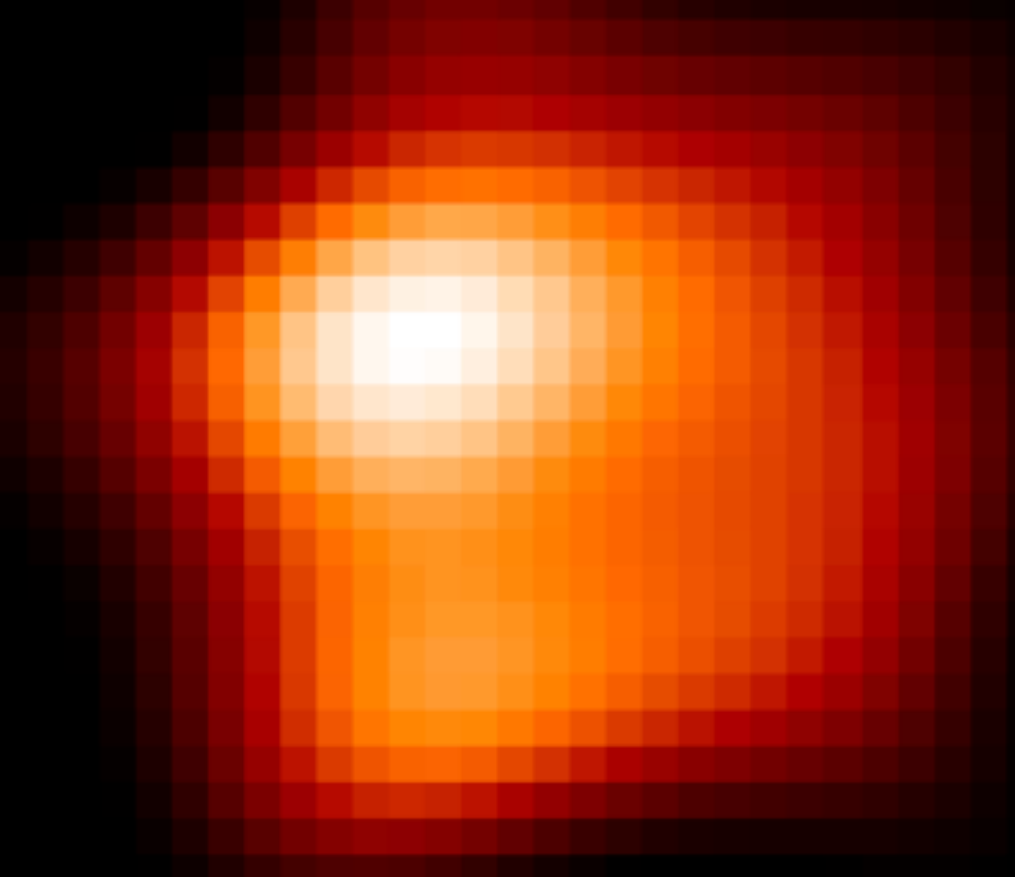
2022 December
faintest



2023 July
brightening

CHARA images of RW Cep

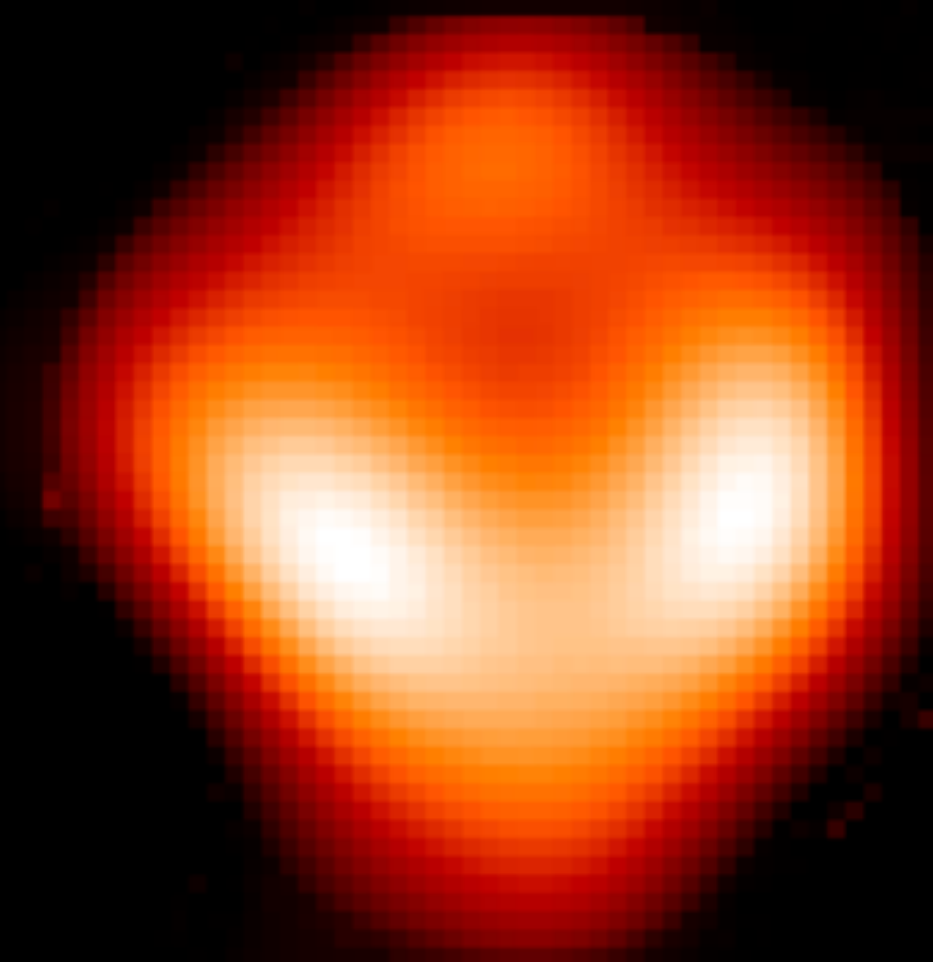
K-band



Fainter here



2022 December
faintest



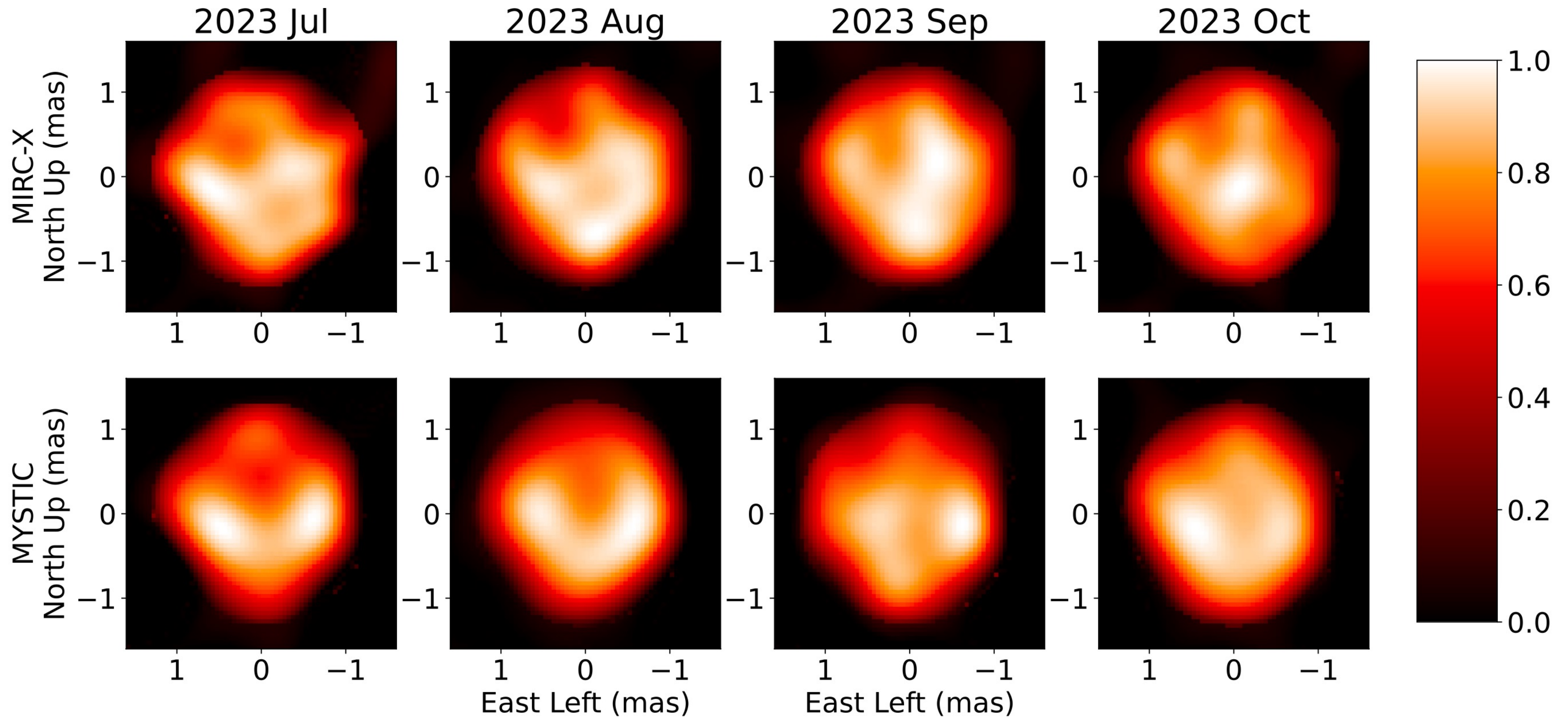
brighter



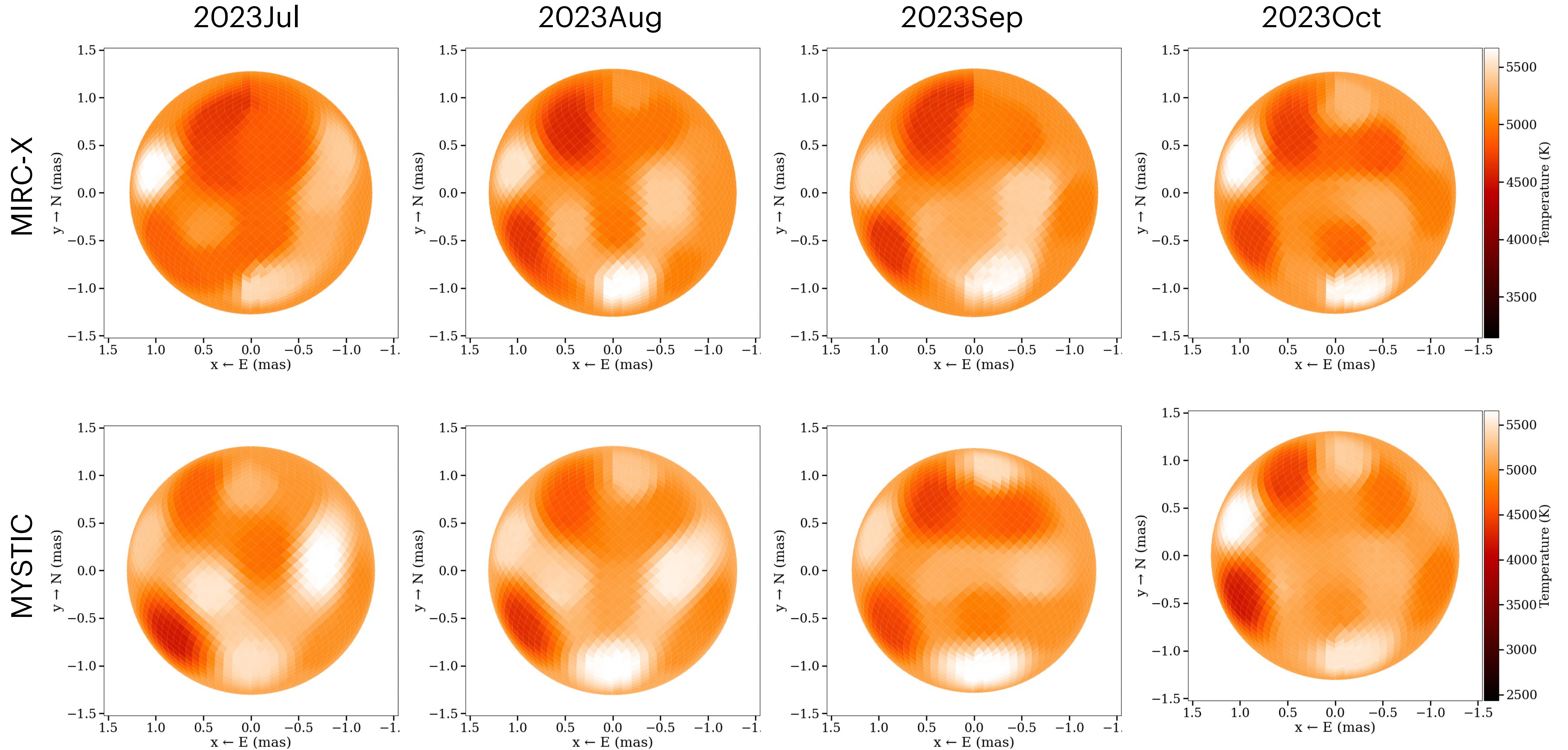
2023 July
brightening

RW Cep: OITOOOLS

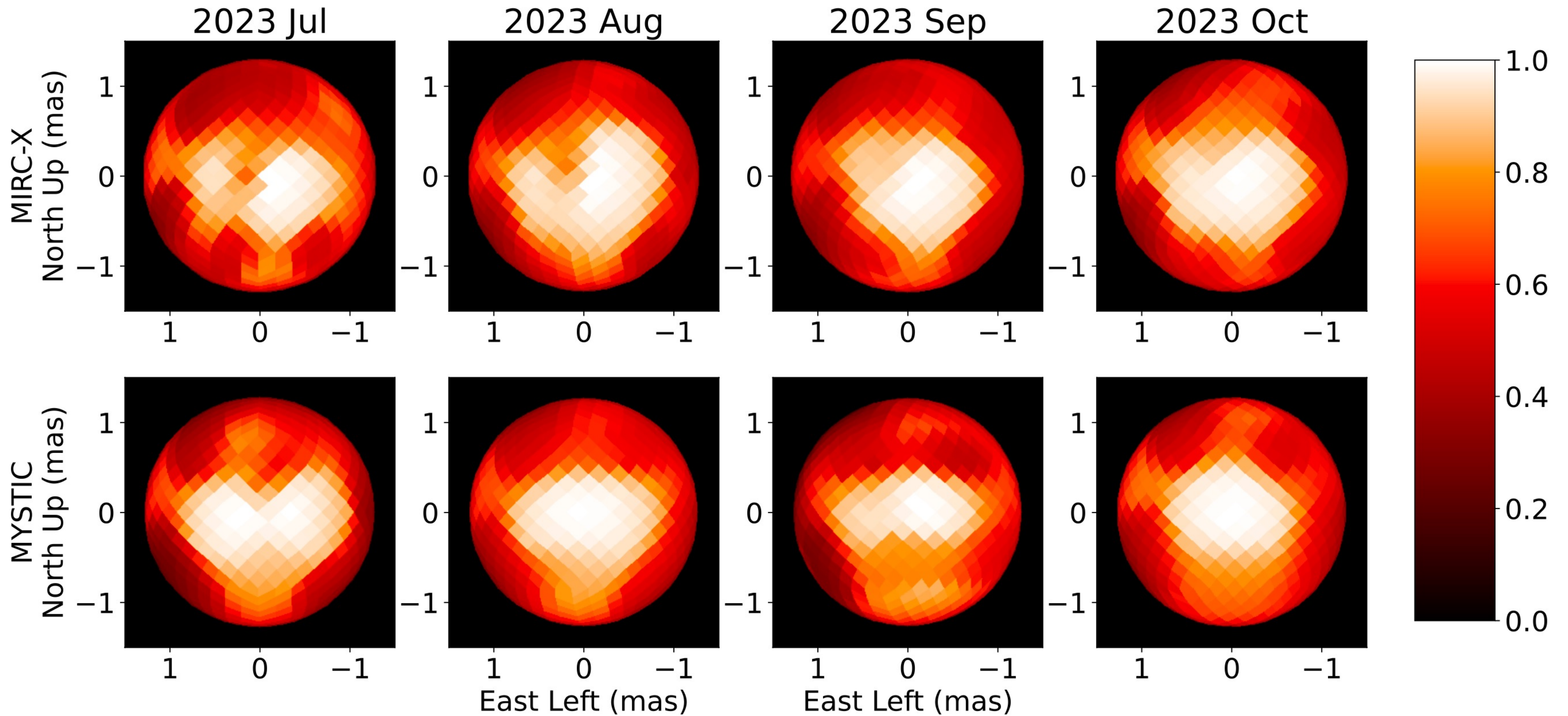
Do we see time varying dust evolution?



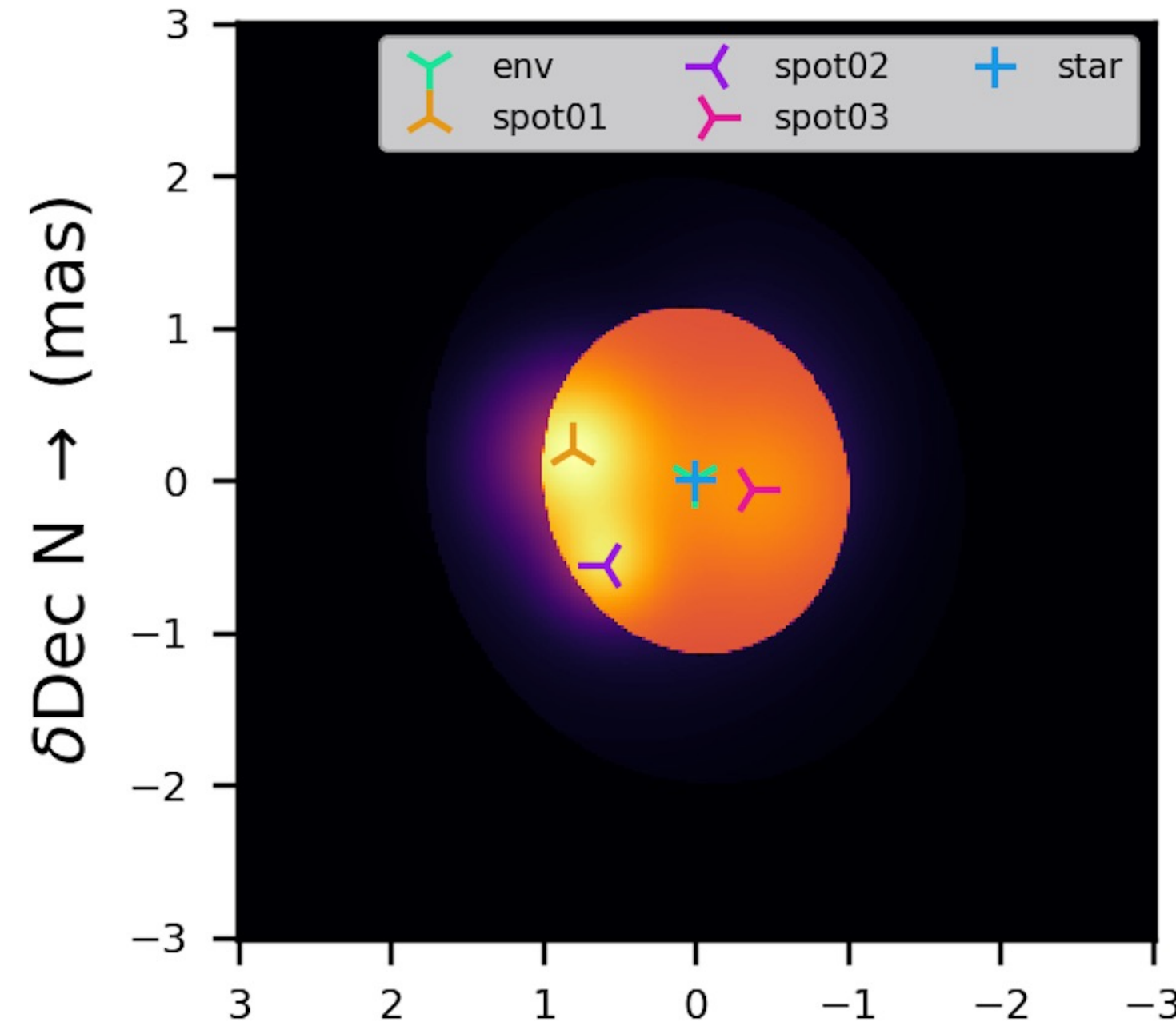
RW Cep: ROTIR



RW Cep: SURFING

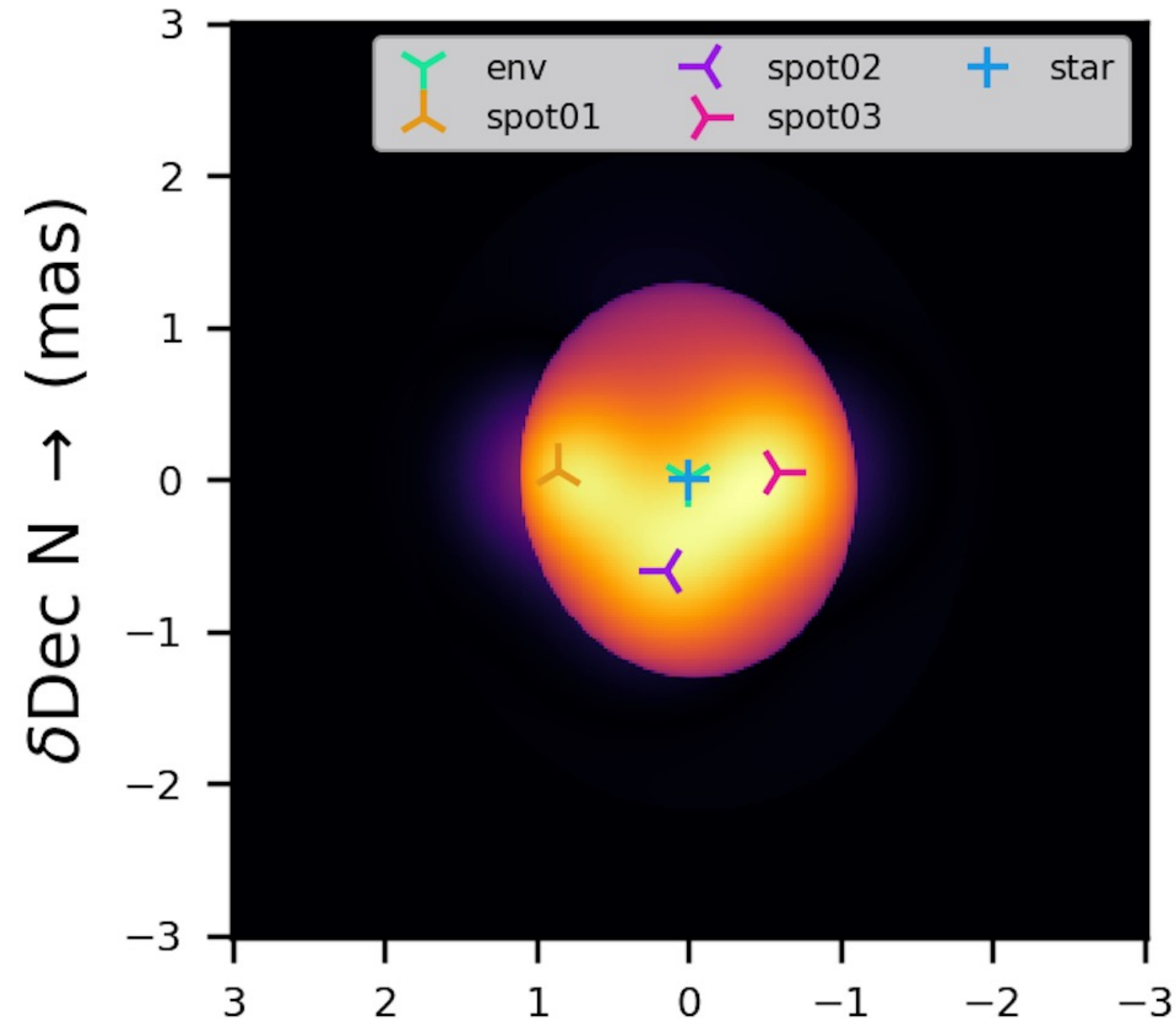


2022 Dec

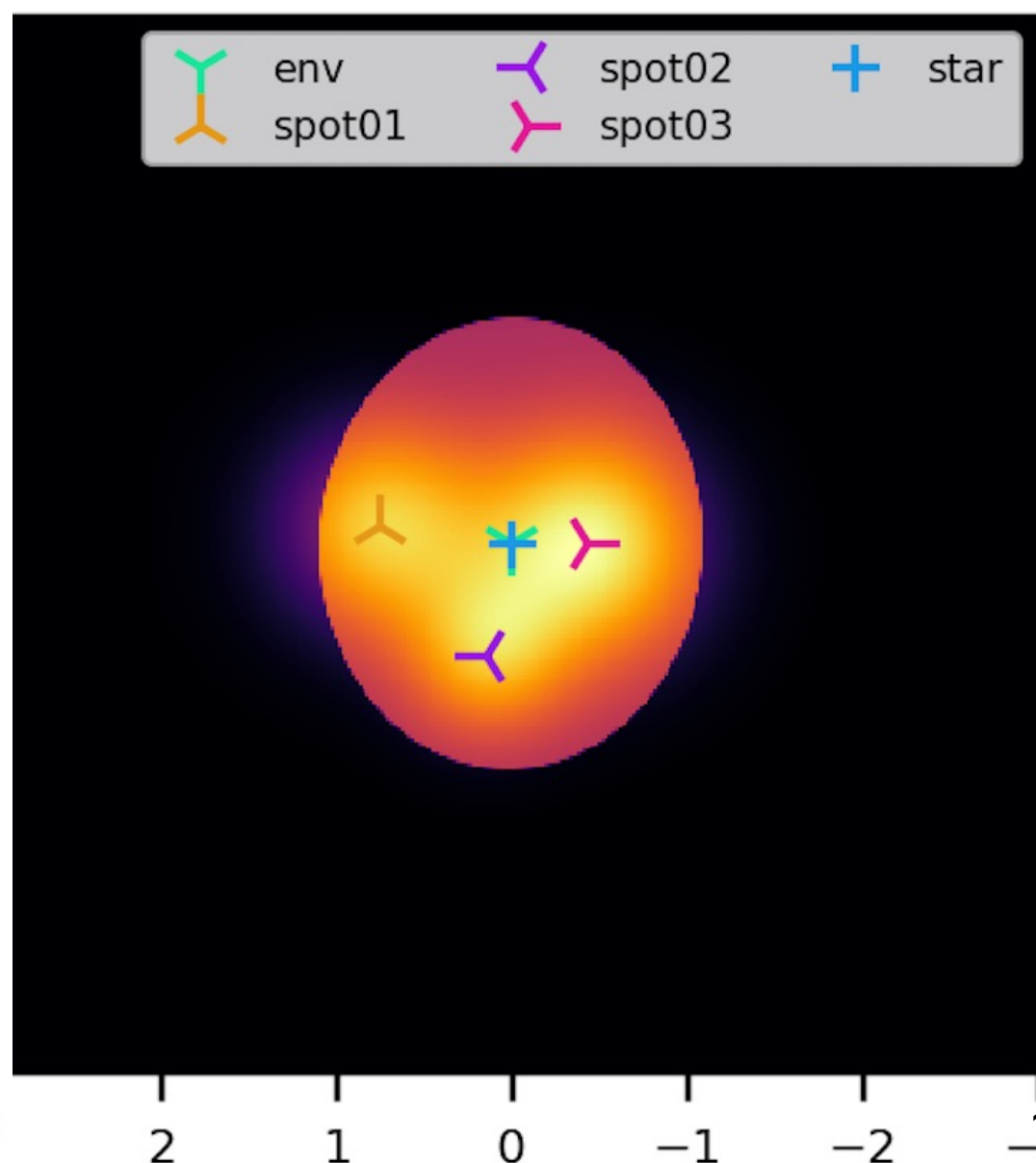


PMOIRE
model fitting

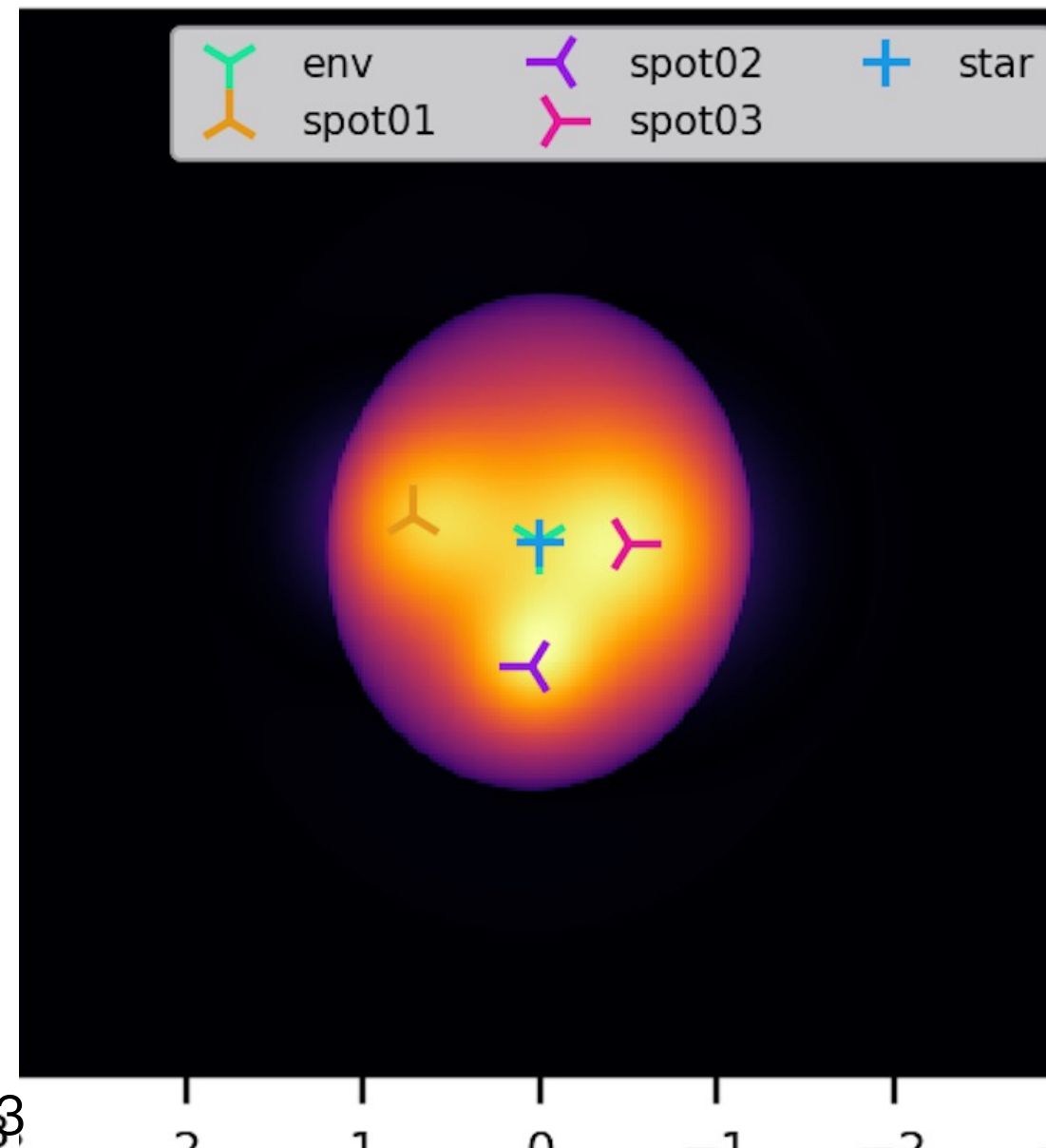
2023 Jul



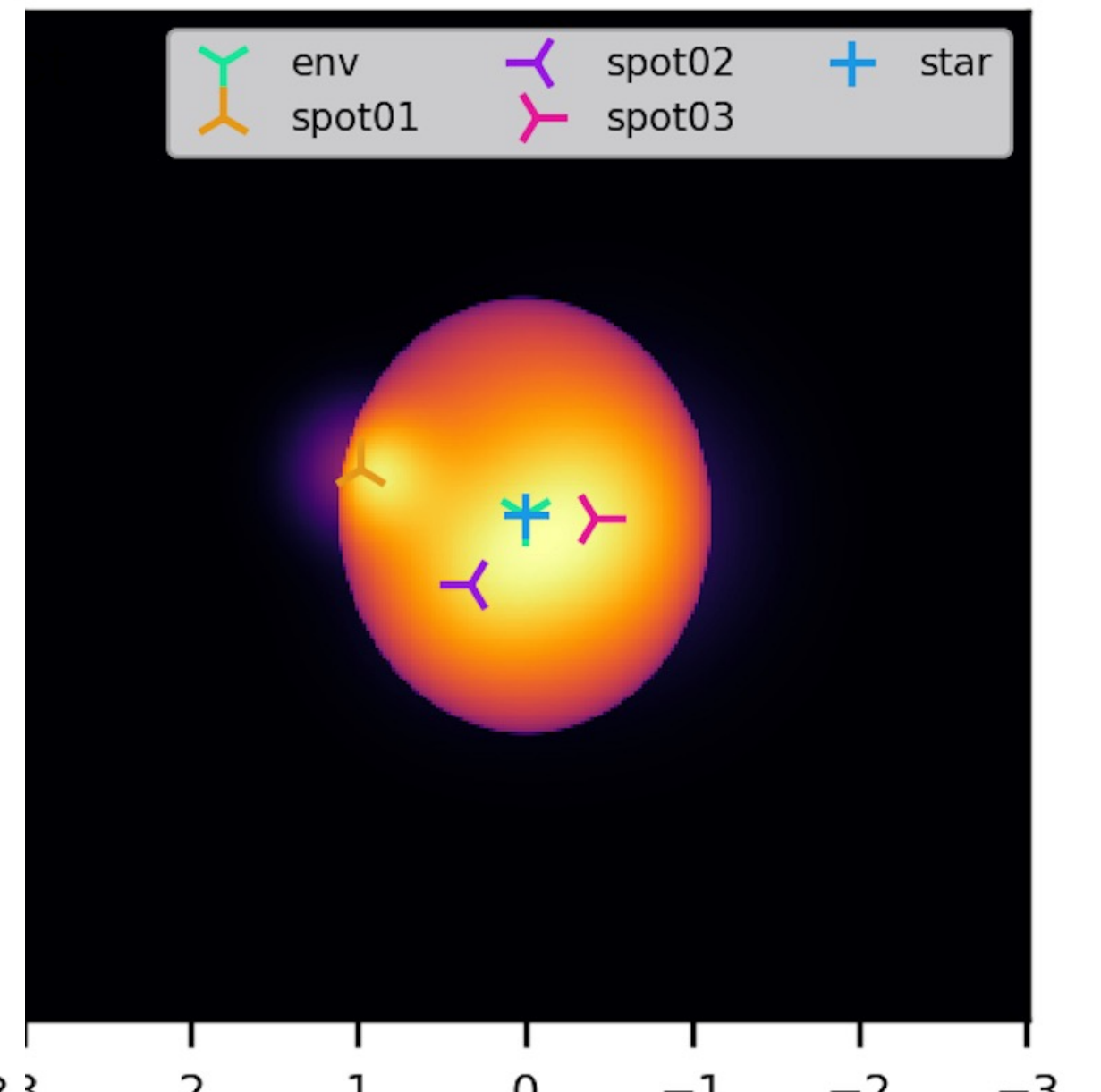
2023 Aug



2023 Sep

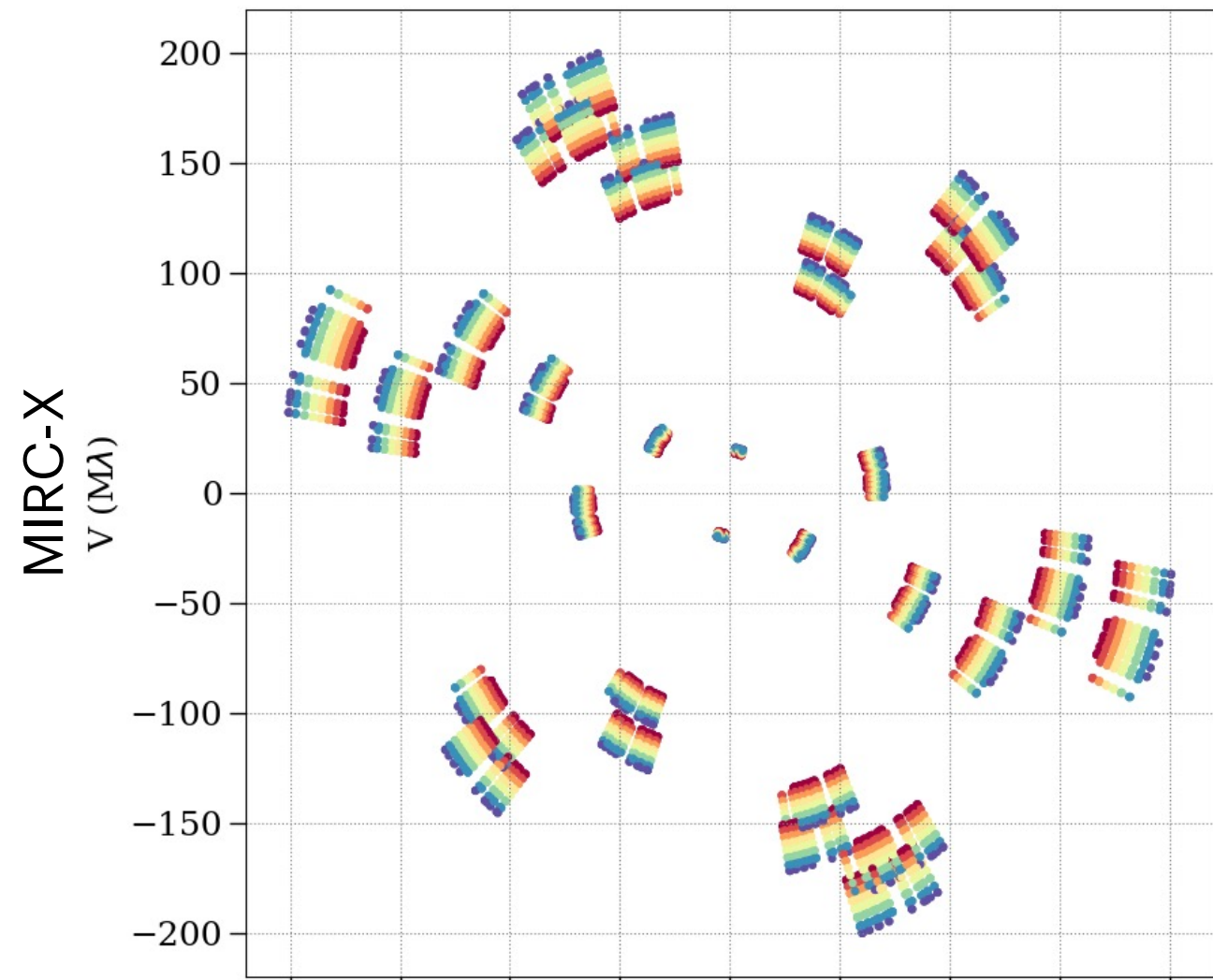


2023 Oct

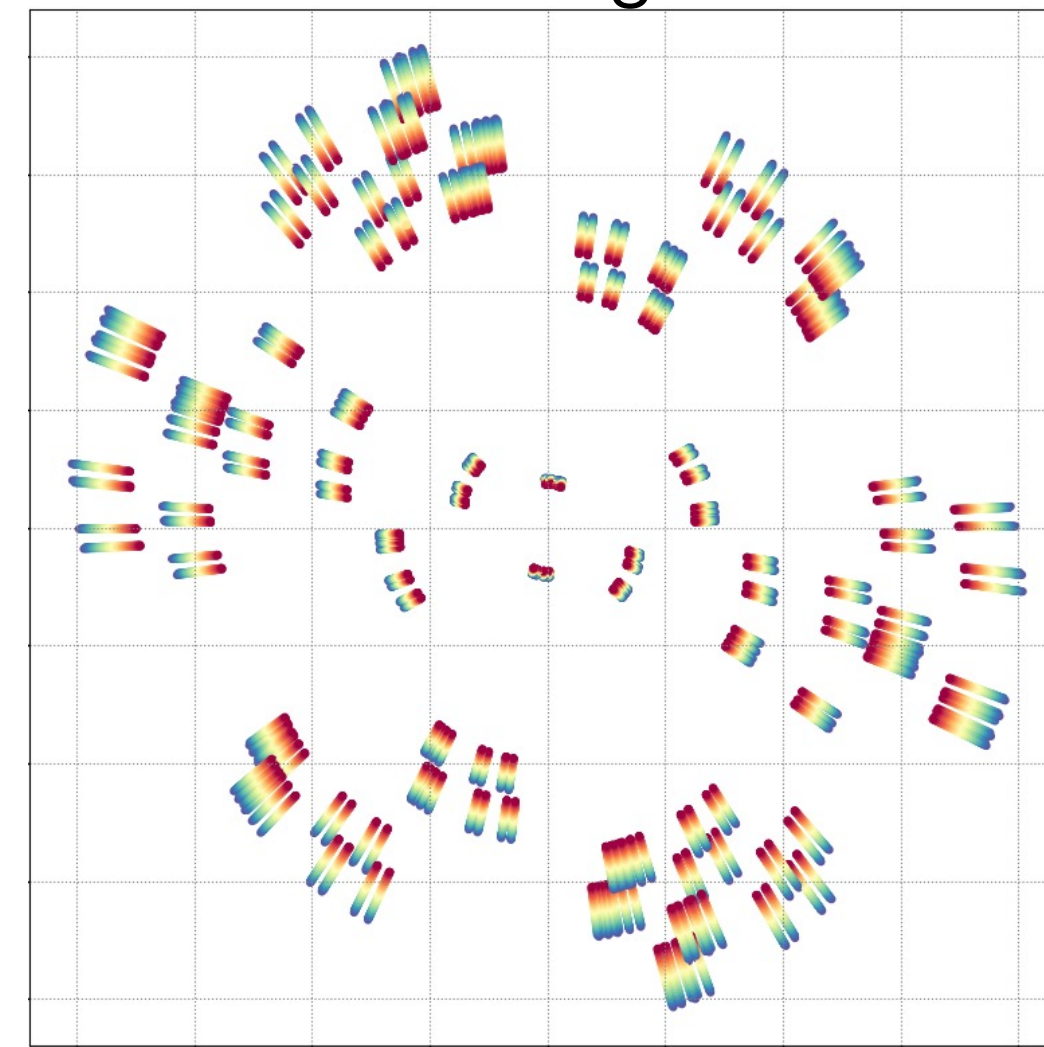


(U, V)-coverage

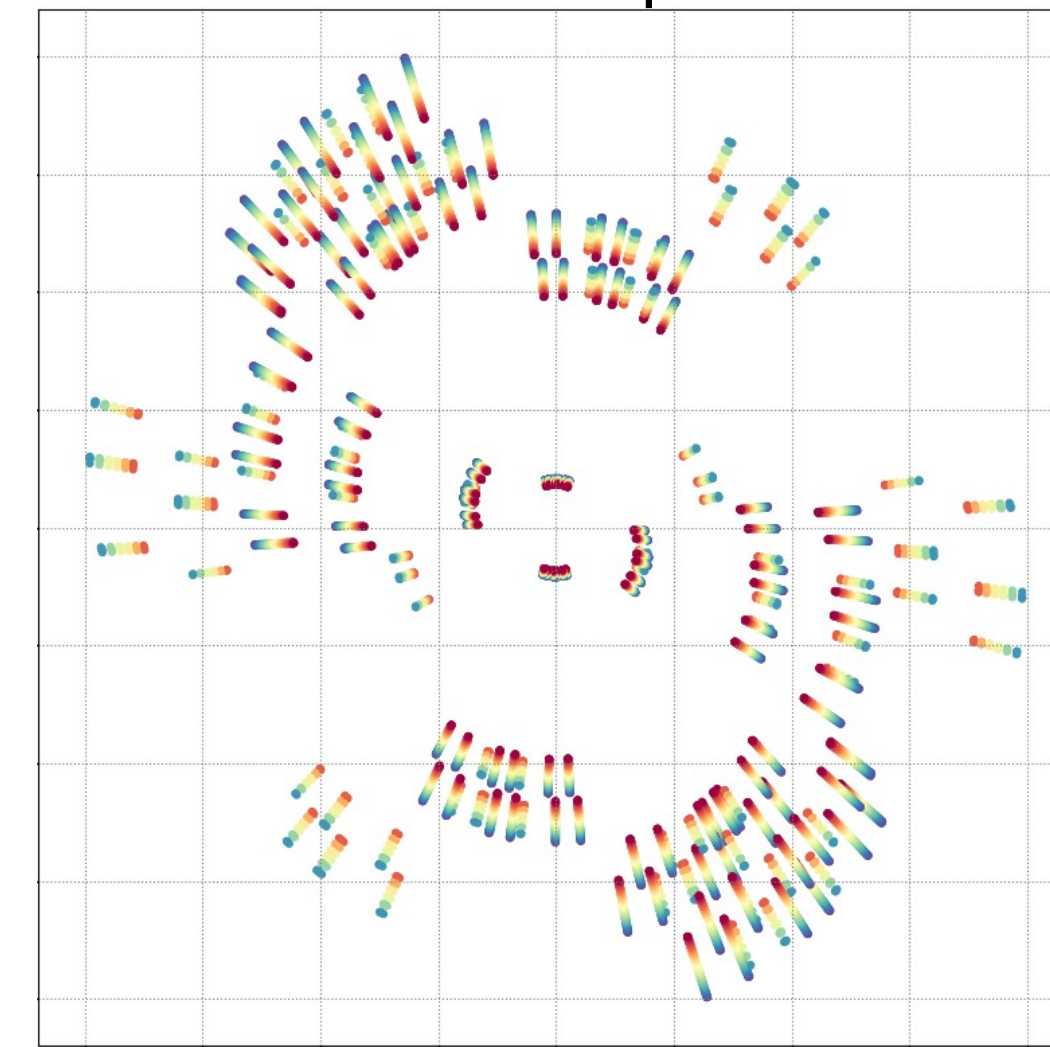
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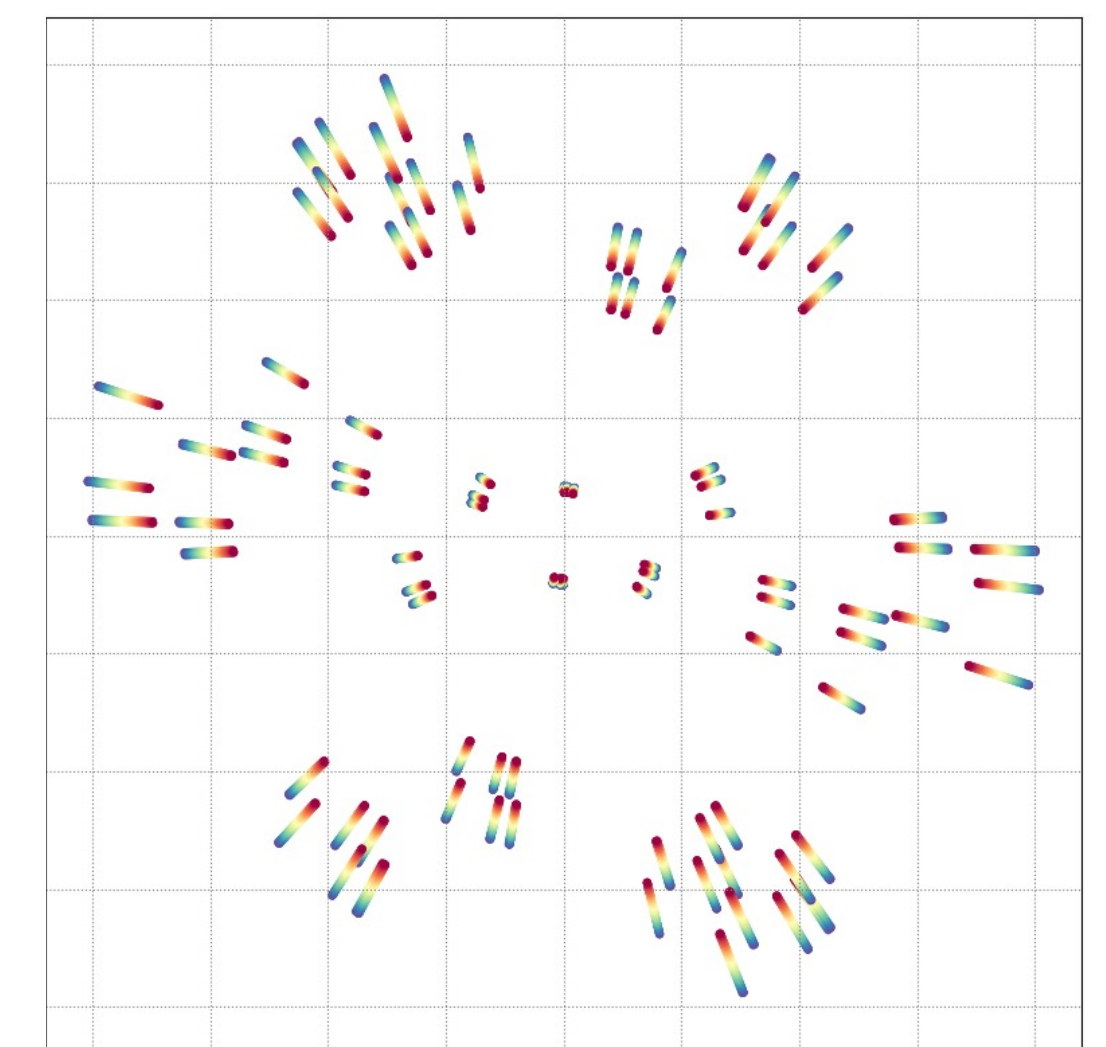
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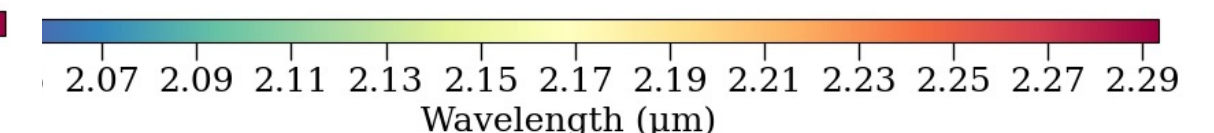
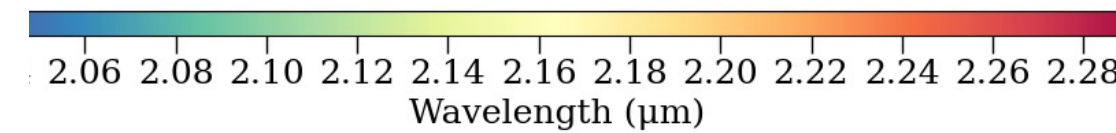
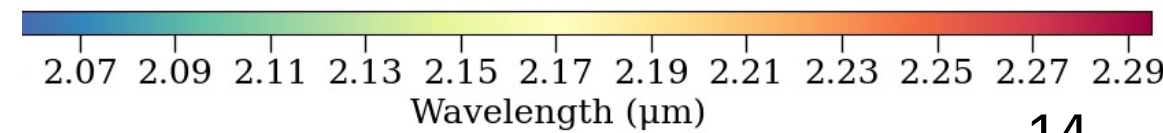
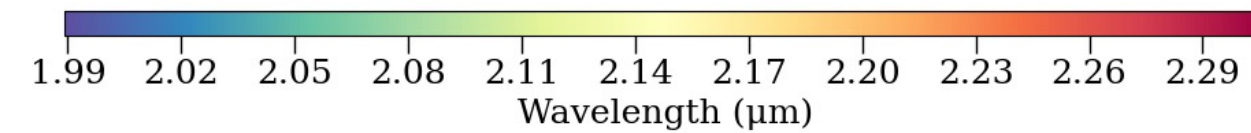
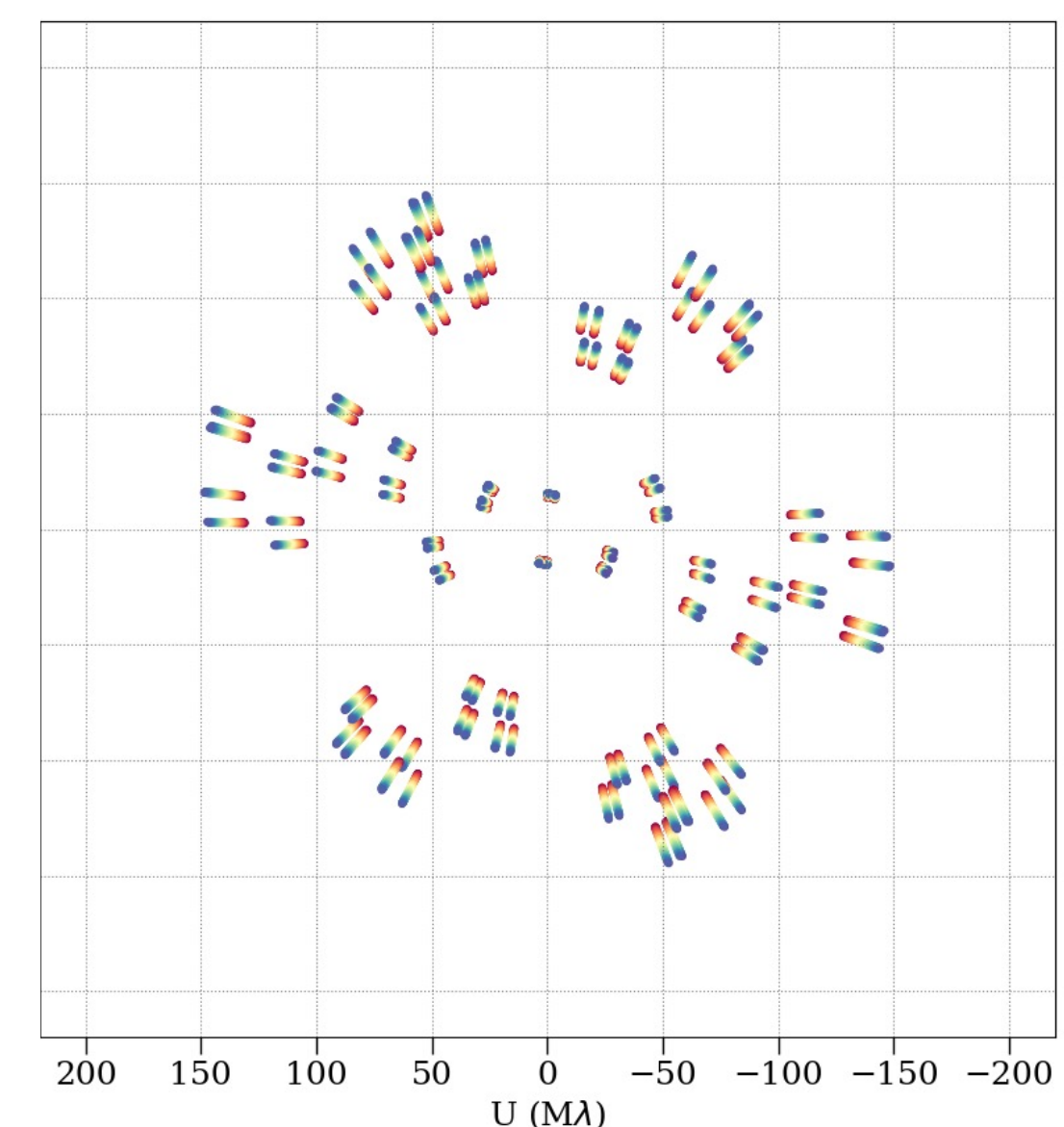
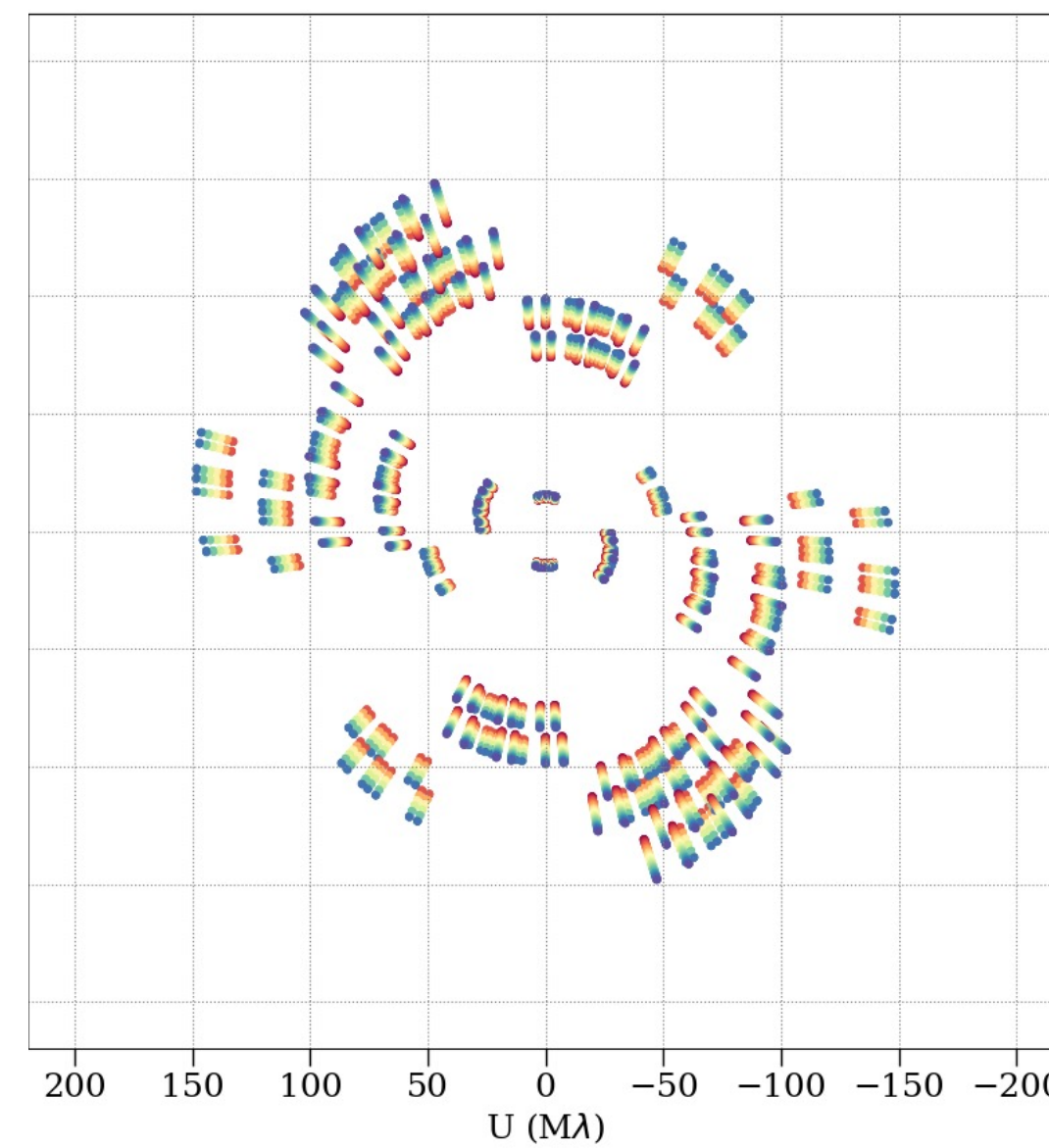
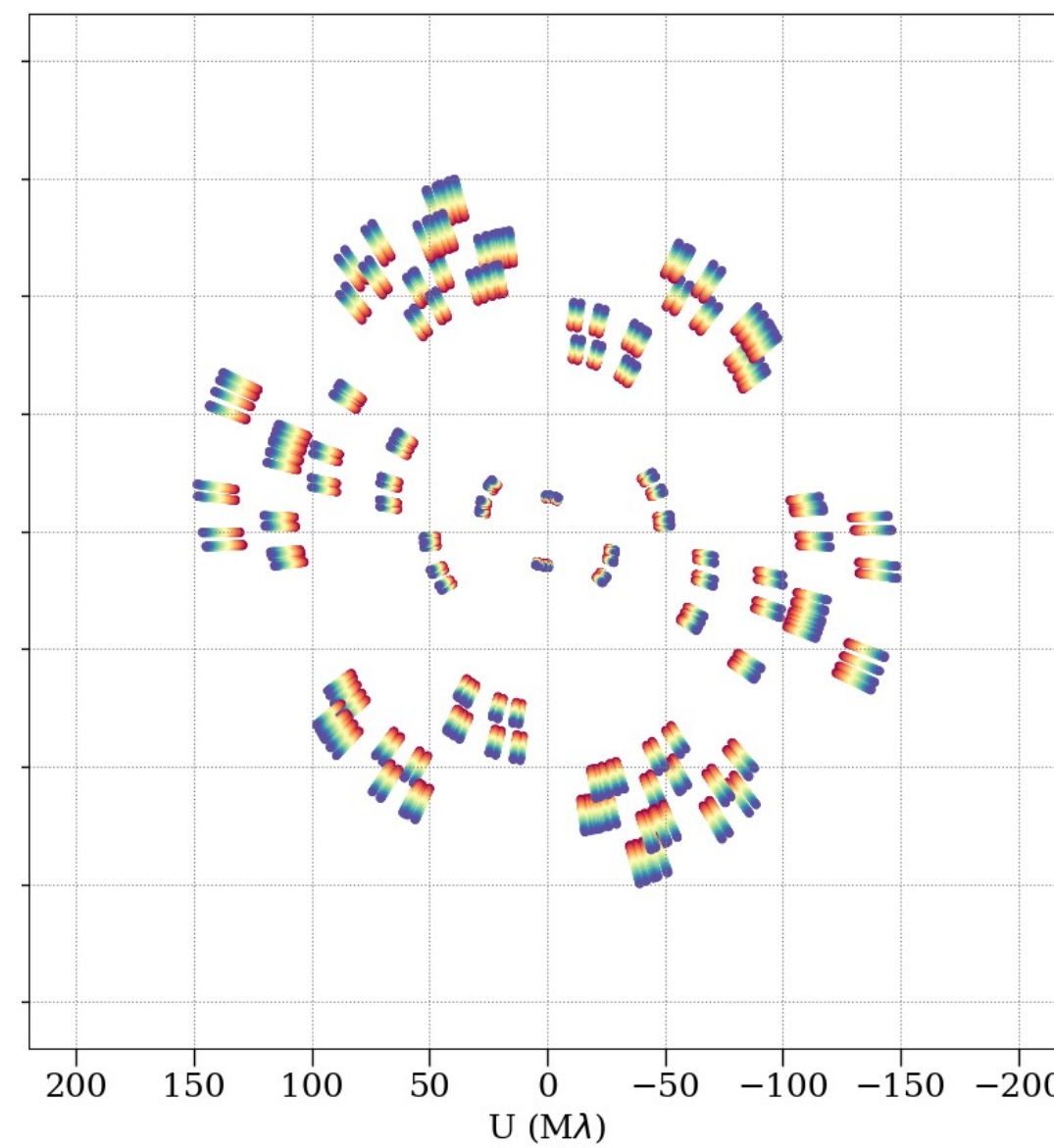
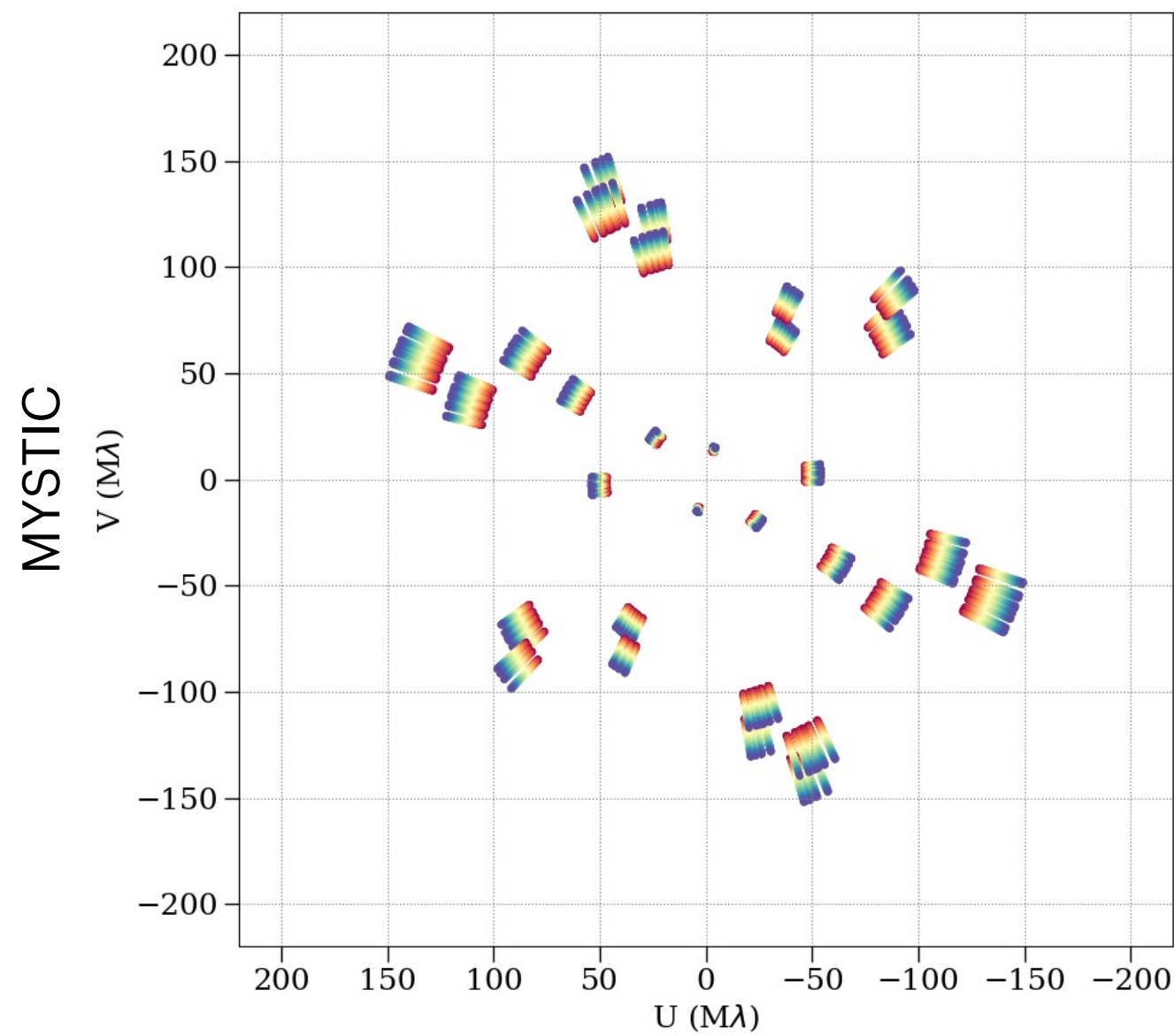
2023 Sep

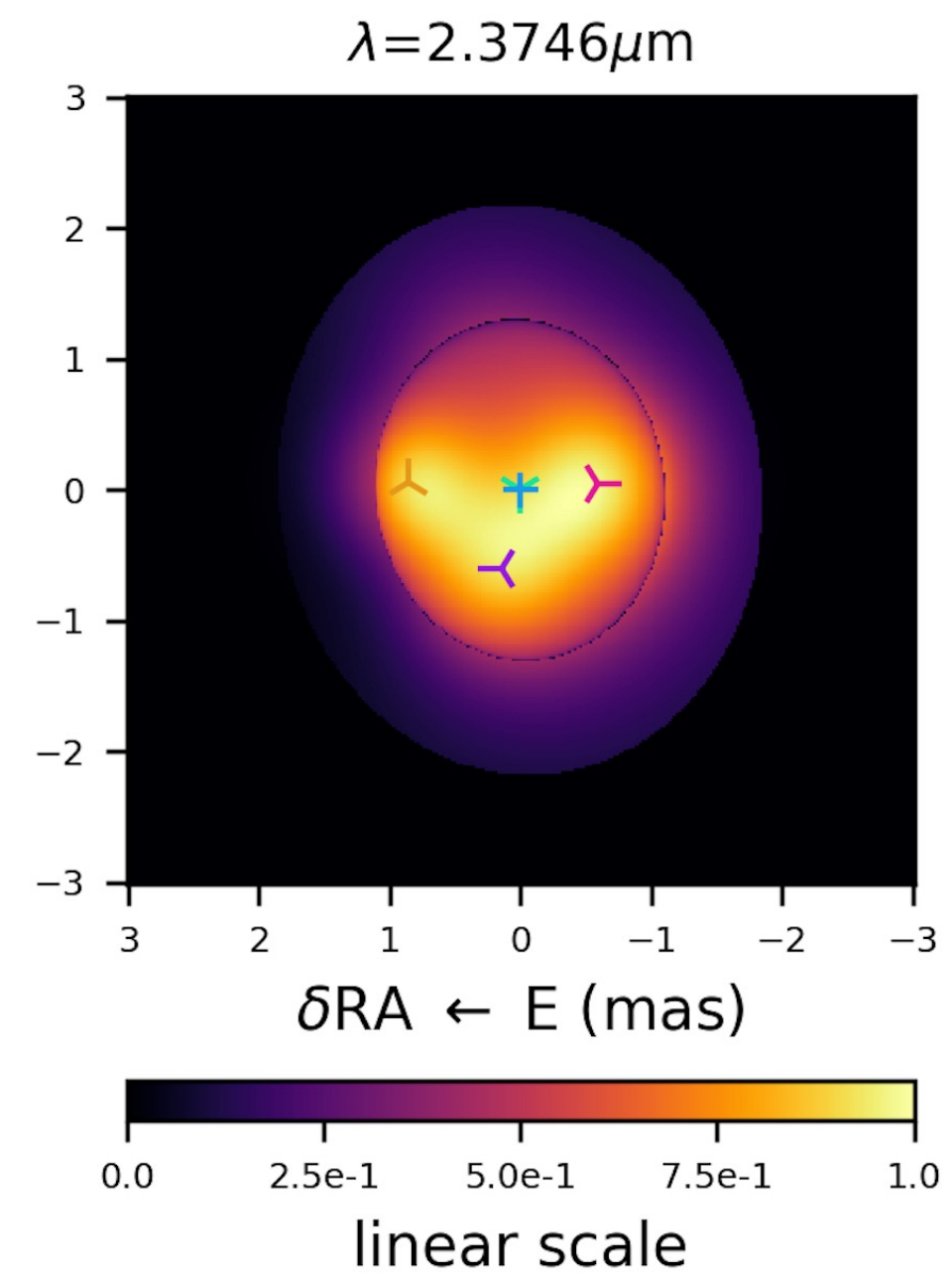
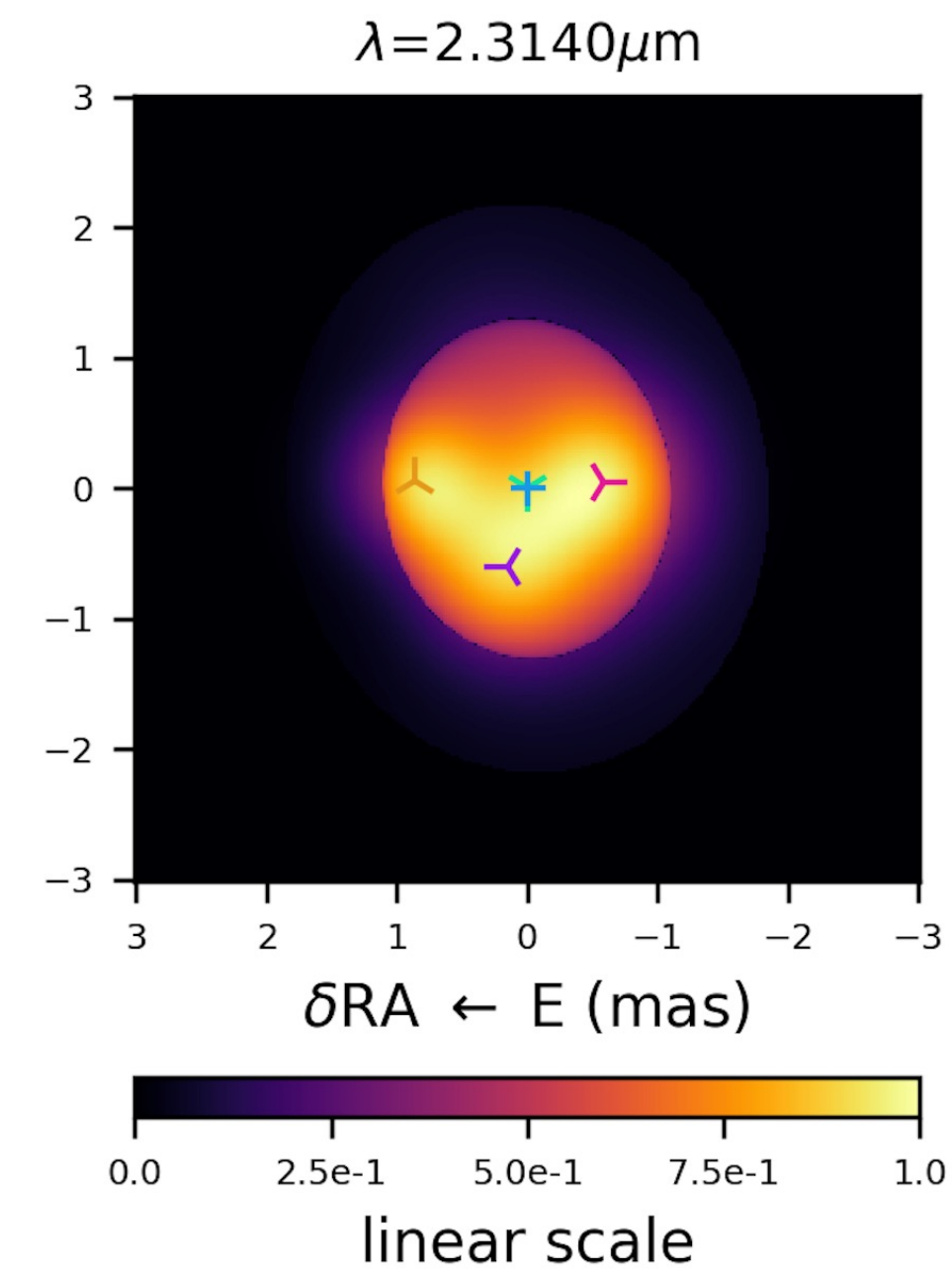
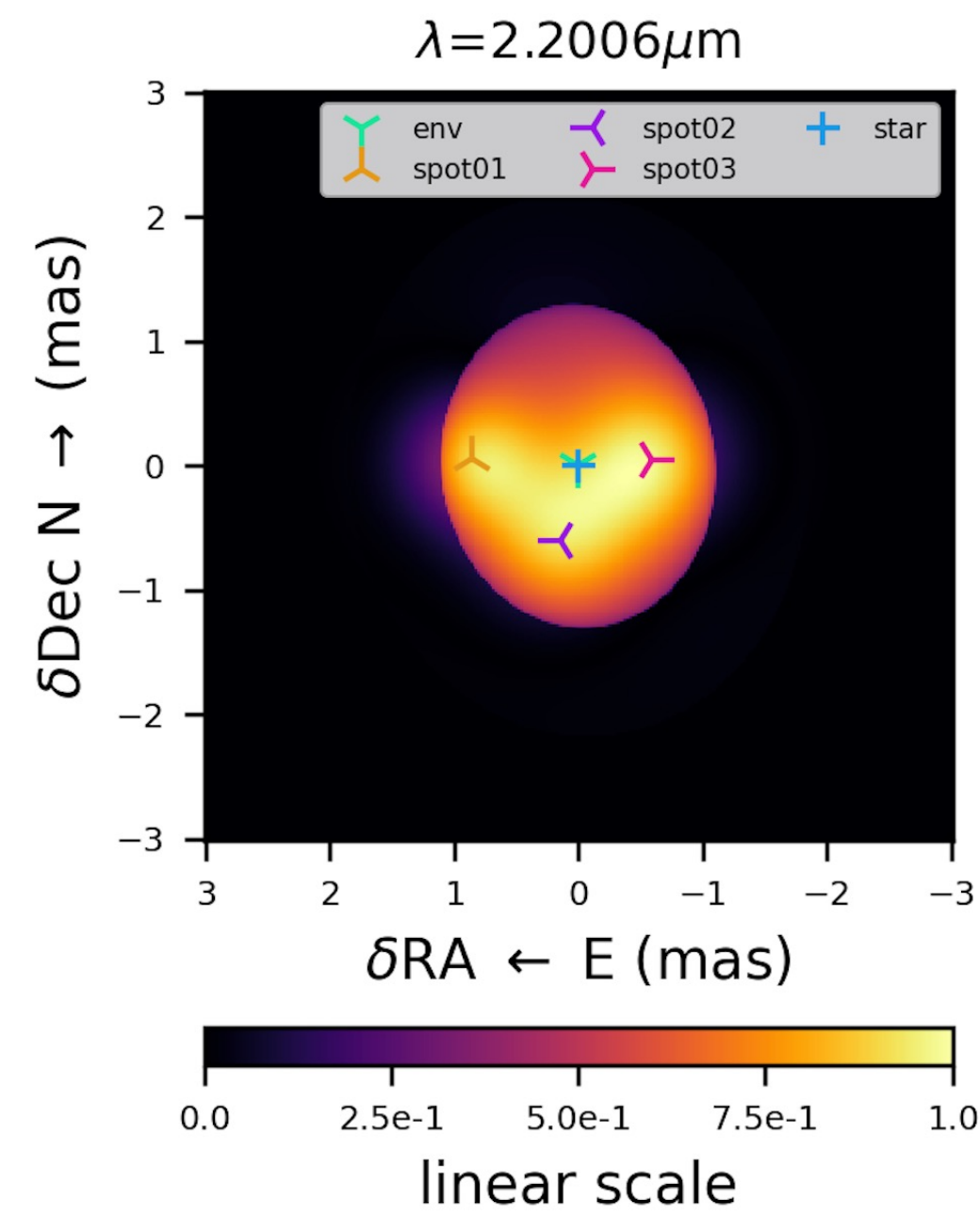
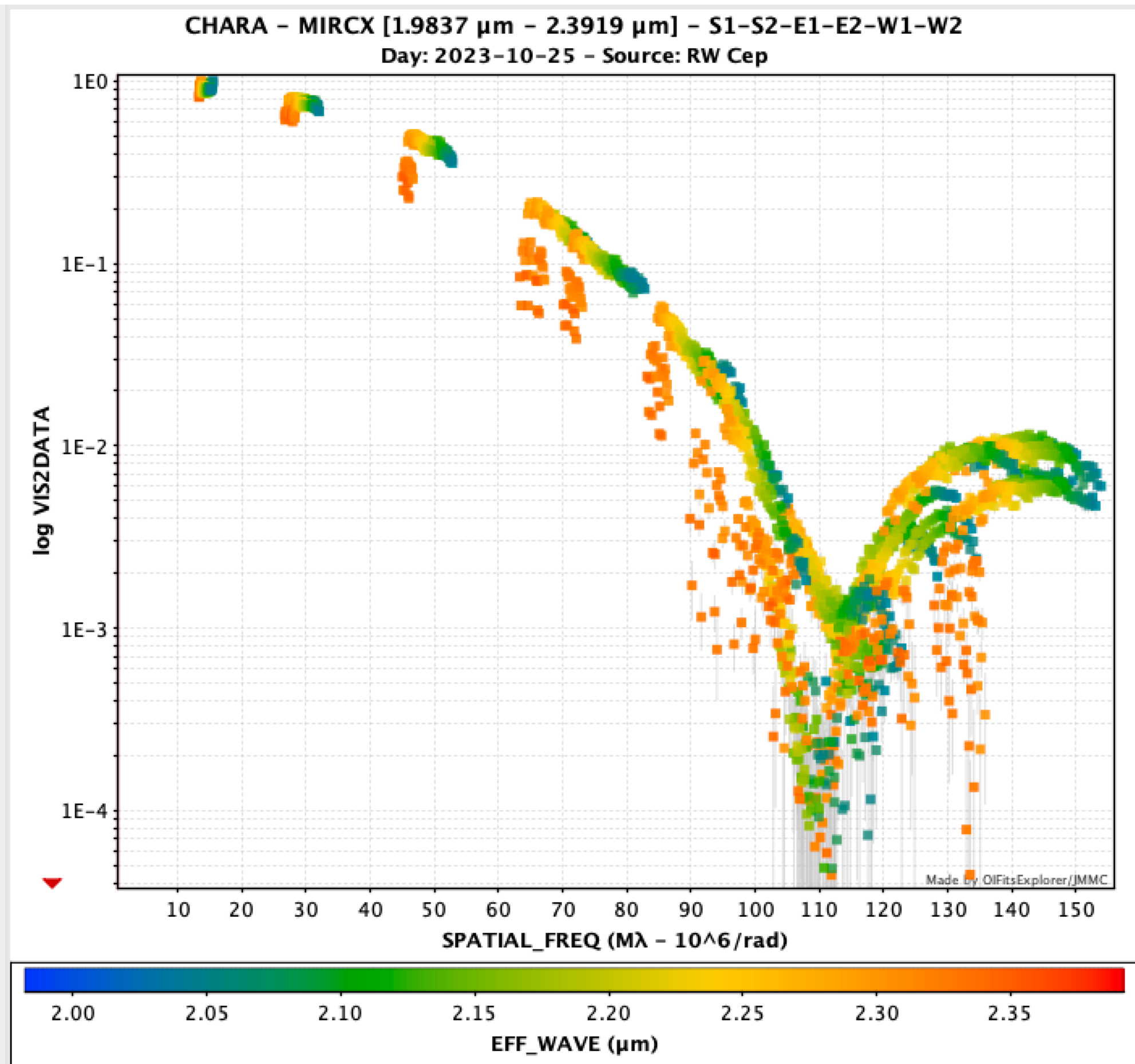


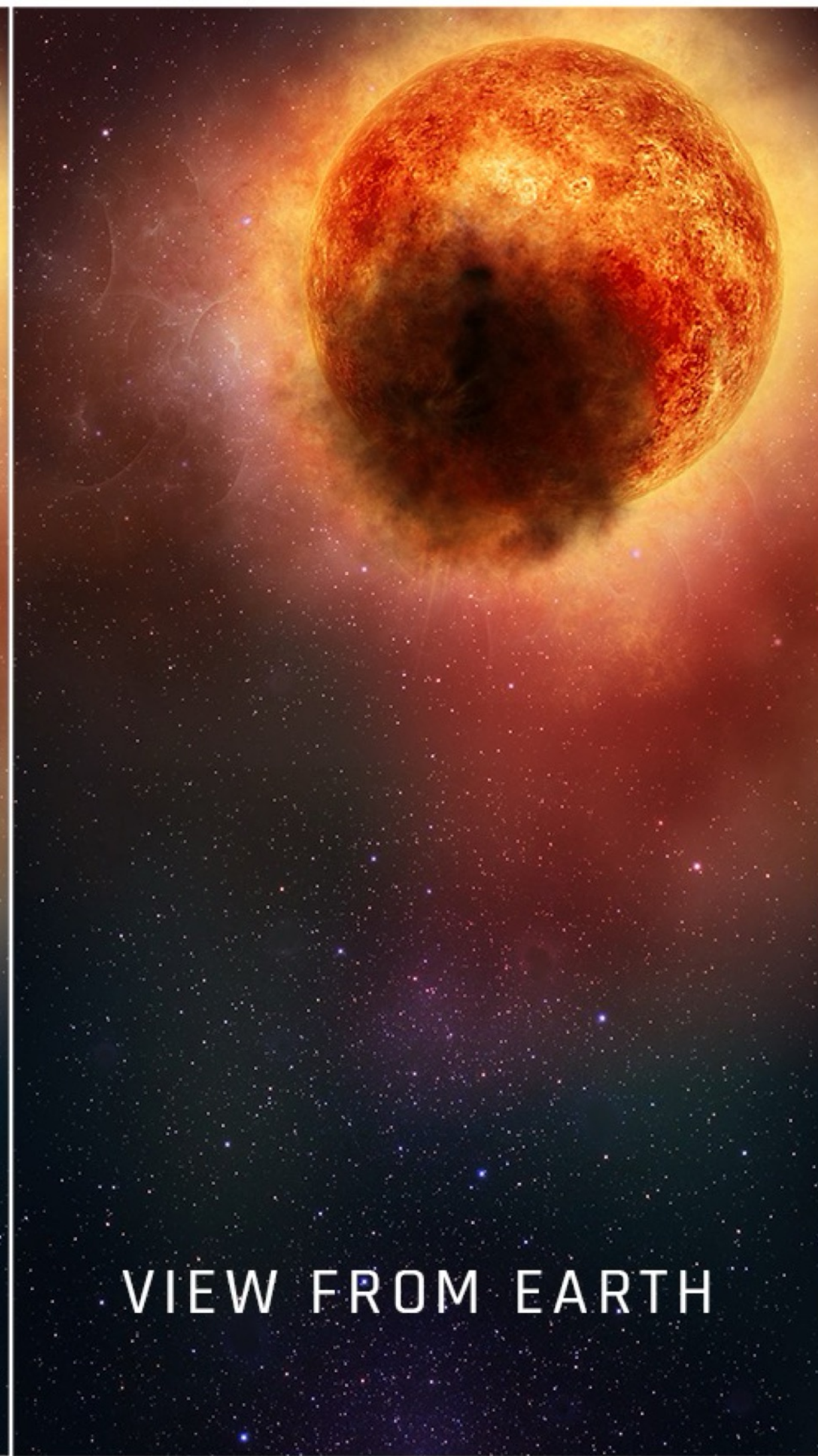
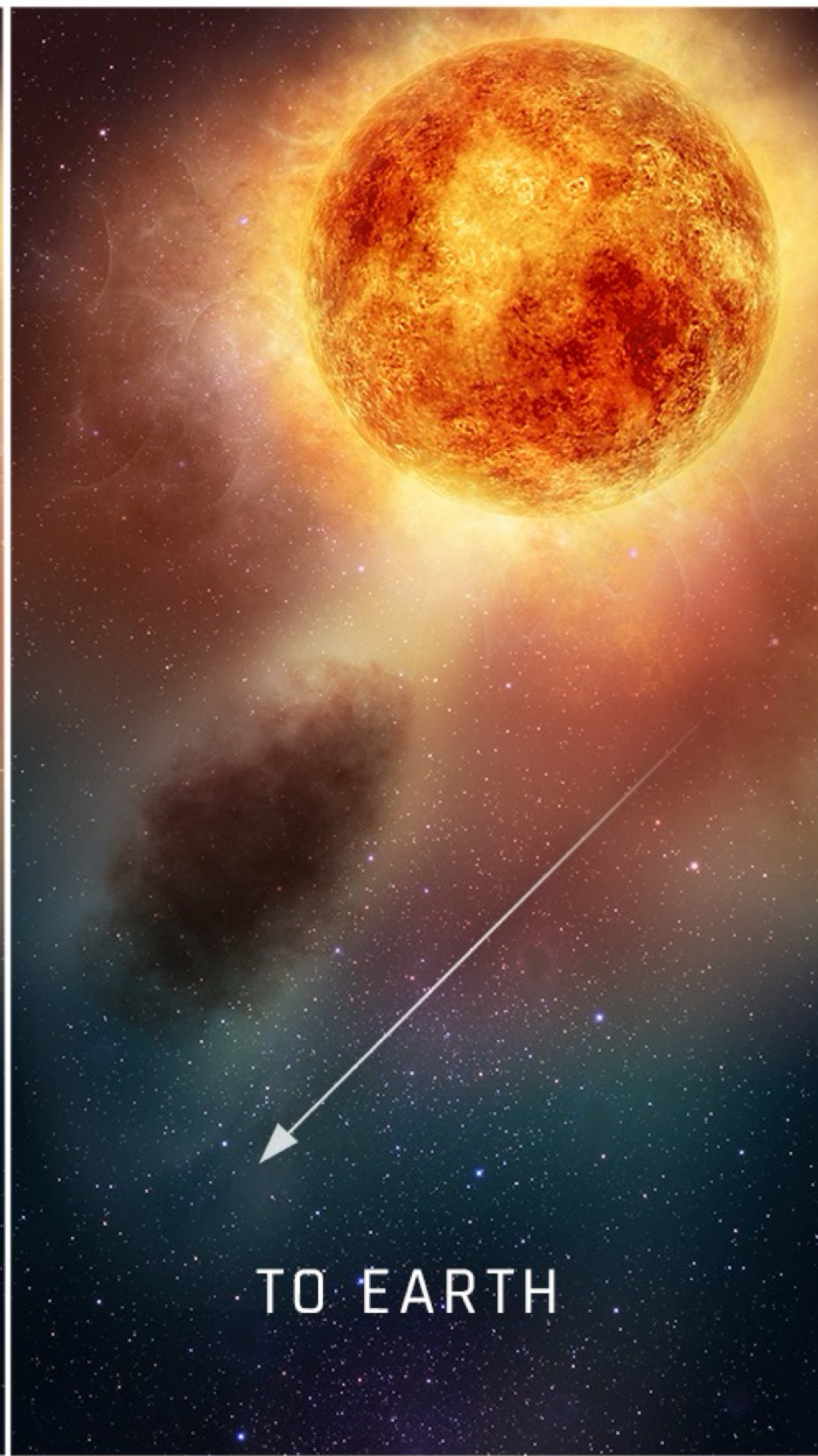
2023 Oct



MYSTIC







- Vast gas cloud ejection
- Cloud cools and forms dust
- dust blocks starlight

TO EARTH

VIEW FROM EARTH

• *Similar to Betelgeuse*

Illustration credit: NASA, ESA, and E. Wheatley (STScI)
Montarg`es et al. 2021, Dupree et al. 2022

Presented at AAS meeting

Covered by more than 20 websites



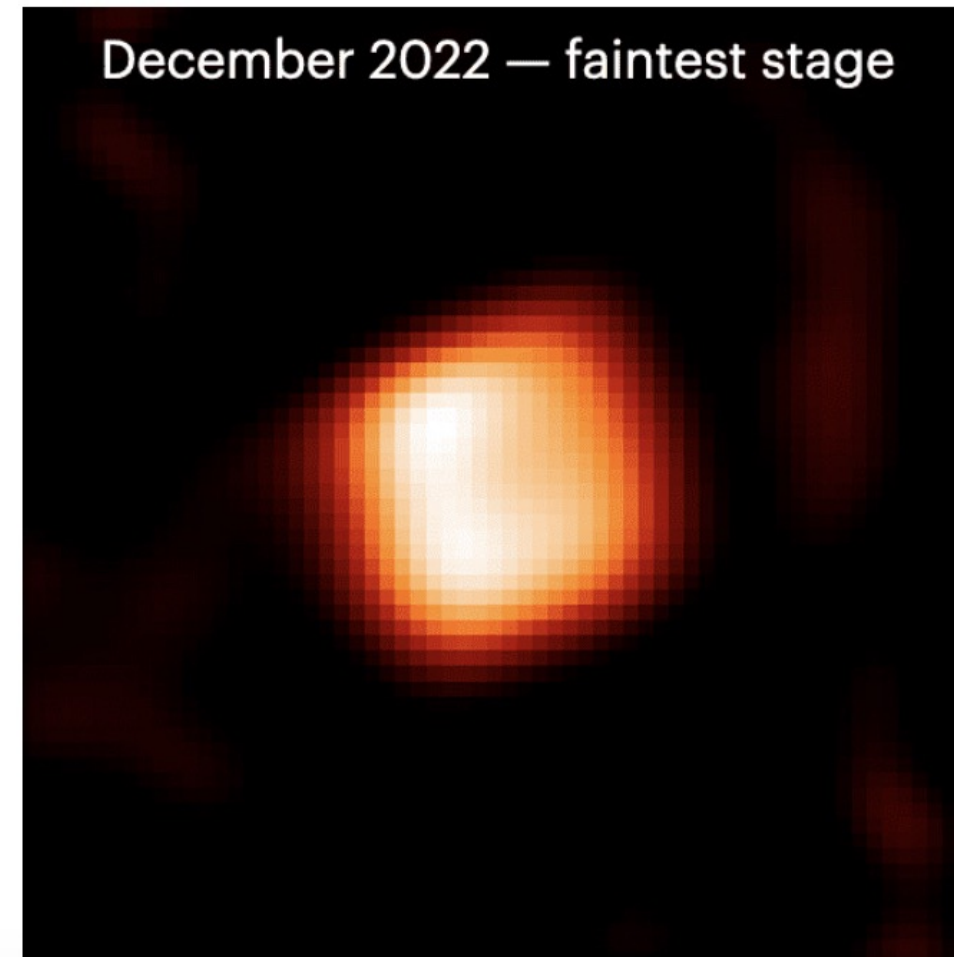
STELLAR SCIENCE

ASTRONOMERS WATCH ANOTHER GIANT STAR DIM

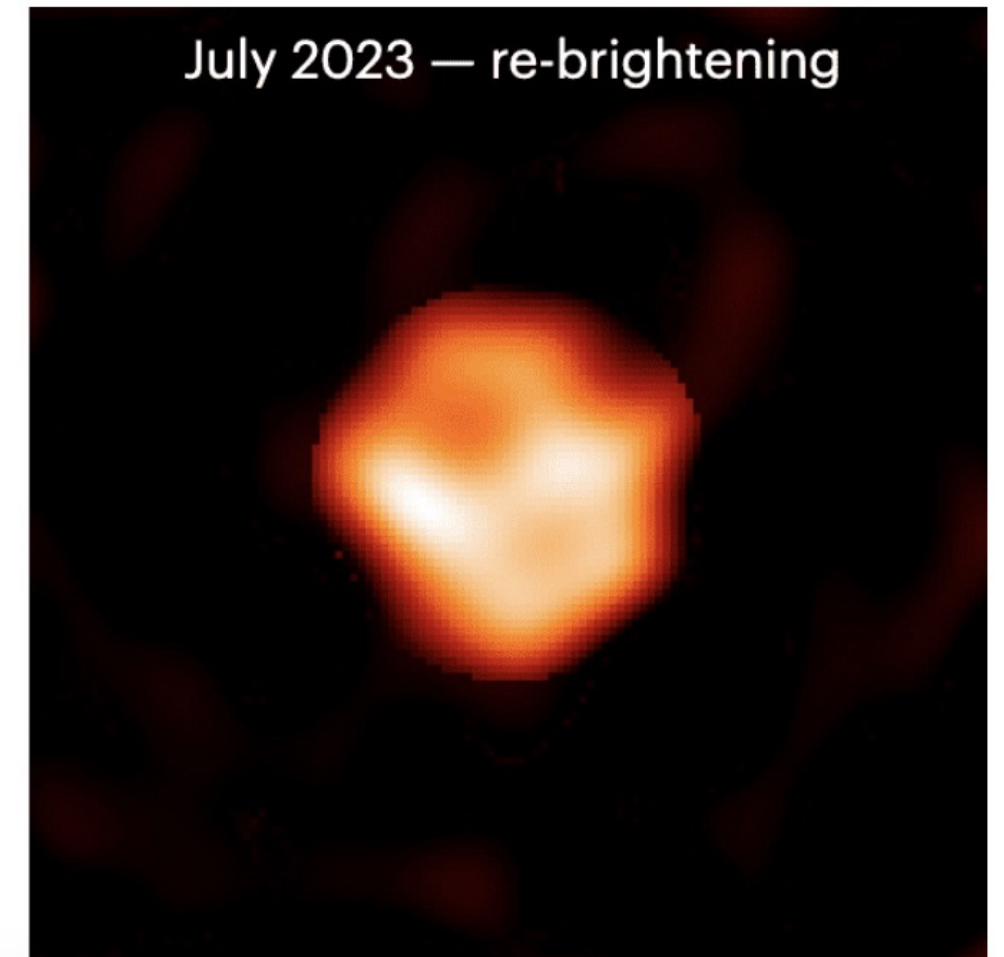
BY: GOVERT SCHILLING | JANUARY 9, 2024 | 3

Betelgeuse isn't the only giant star to undergo a "Great Dimming."

December 2022 — faintest stage



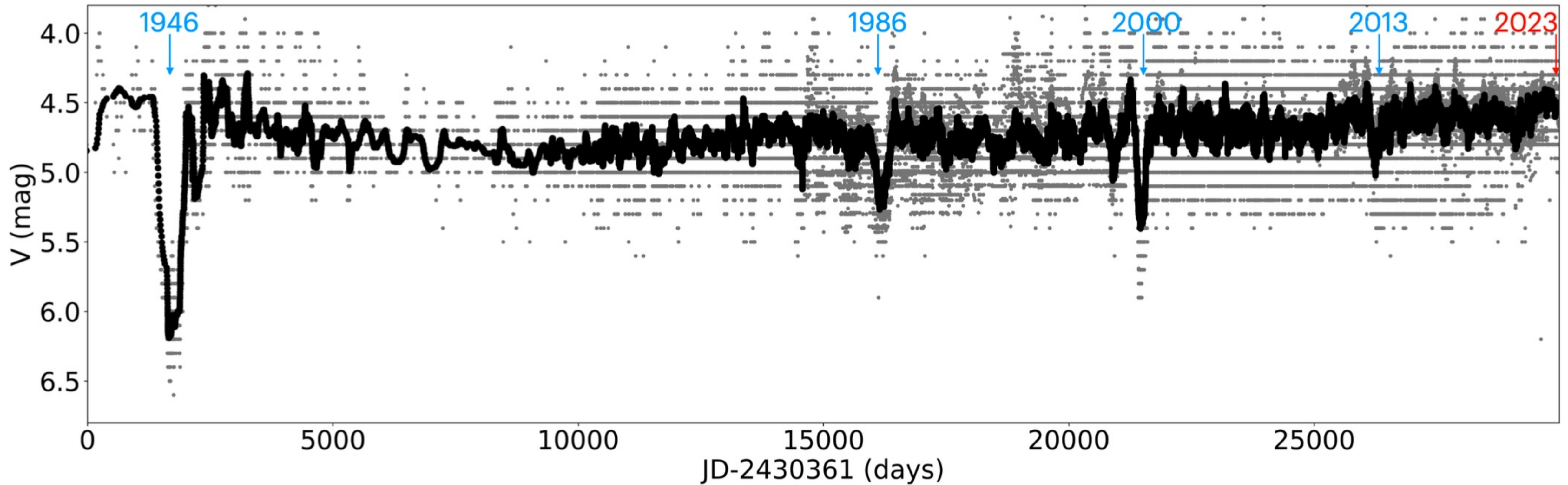
July 2023 — re-brightening



**With that motivation
studied another target:
rho Cas**

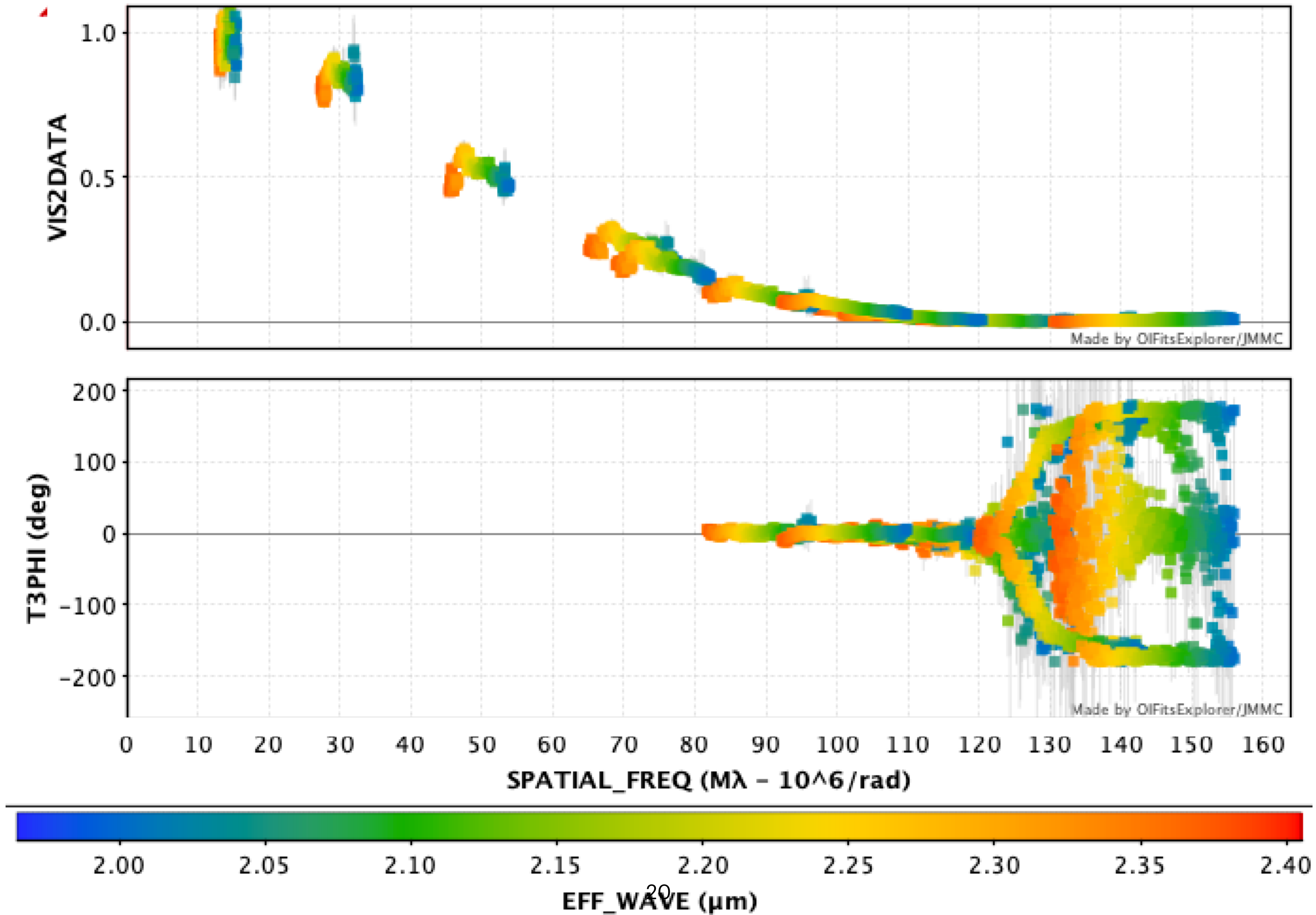
rho Cas light curve from AAVSO

- Yellow hypergiant, known for episodic outbursts

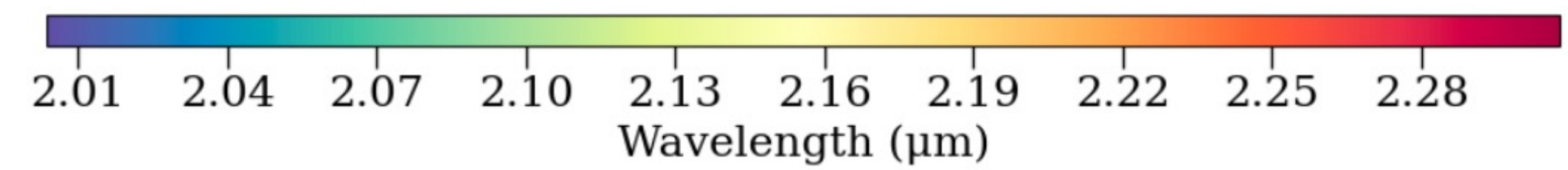
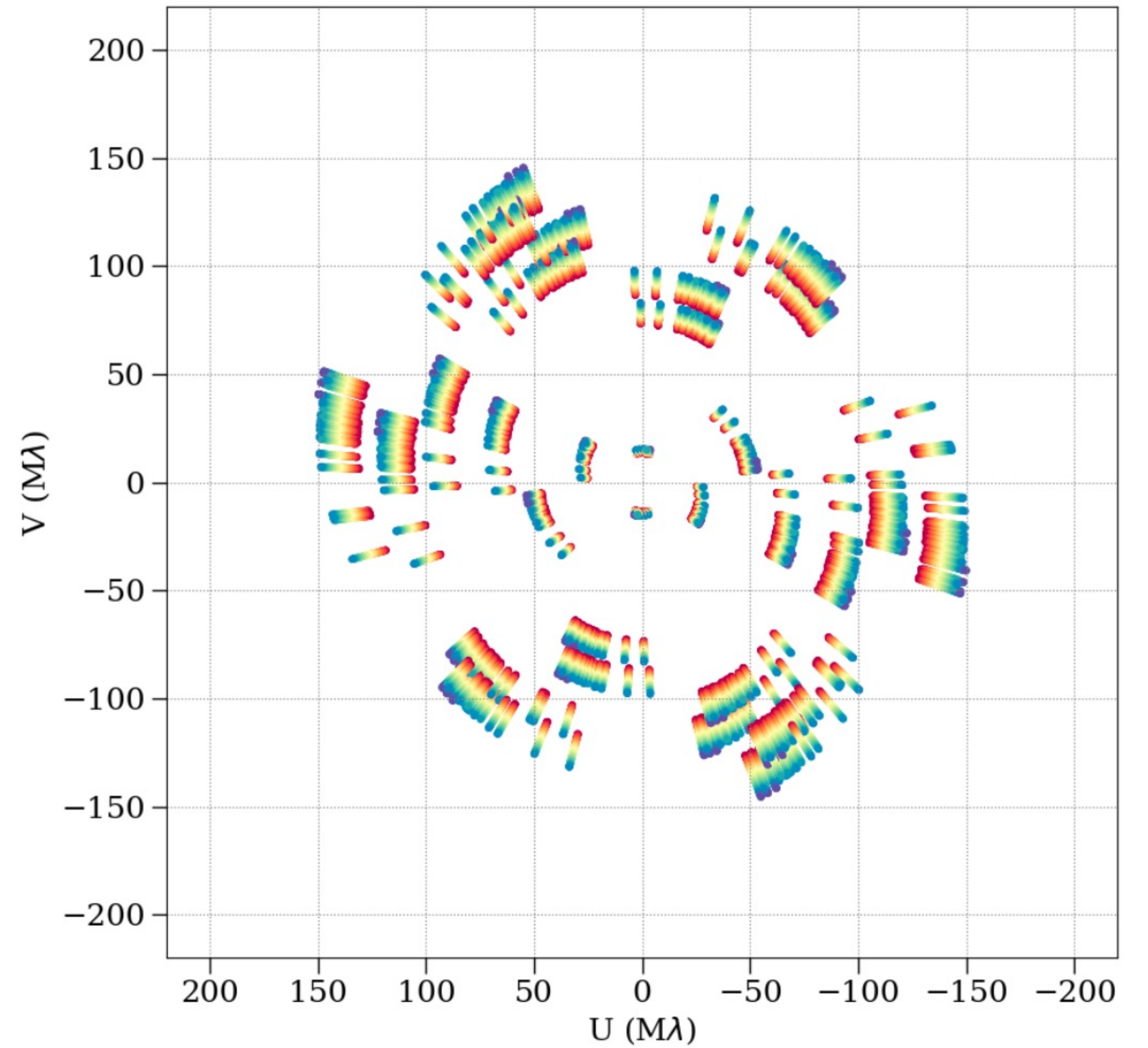
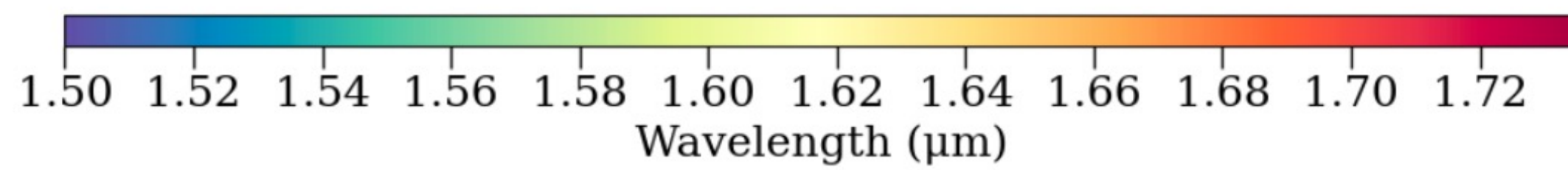
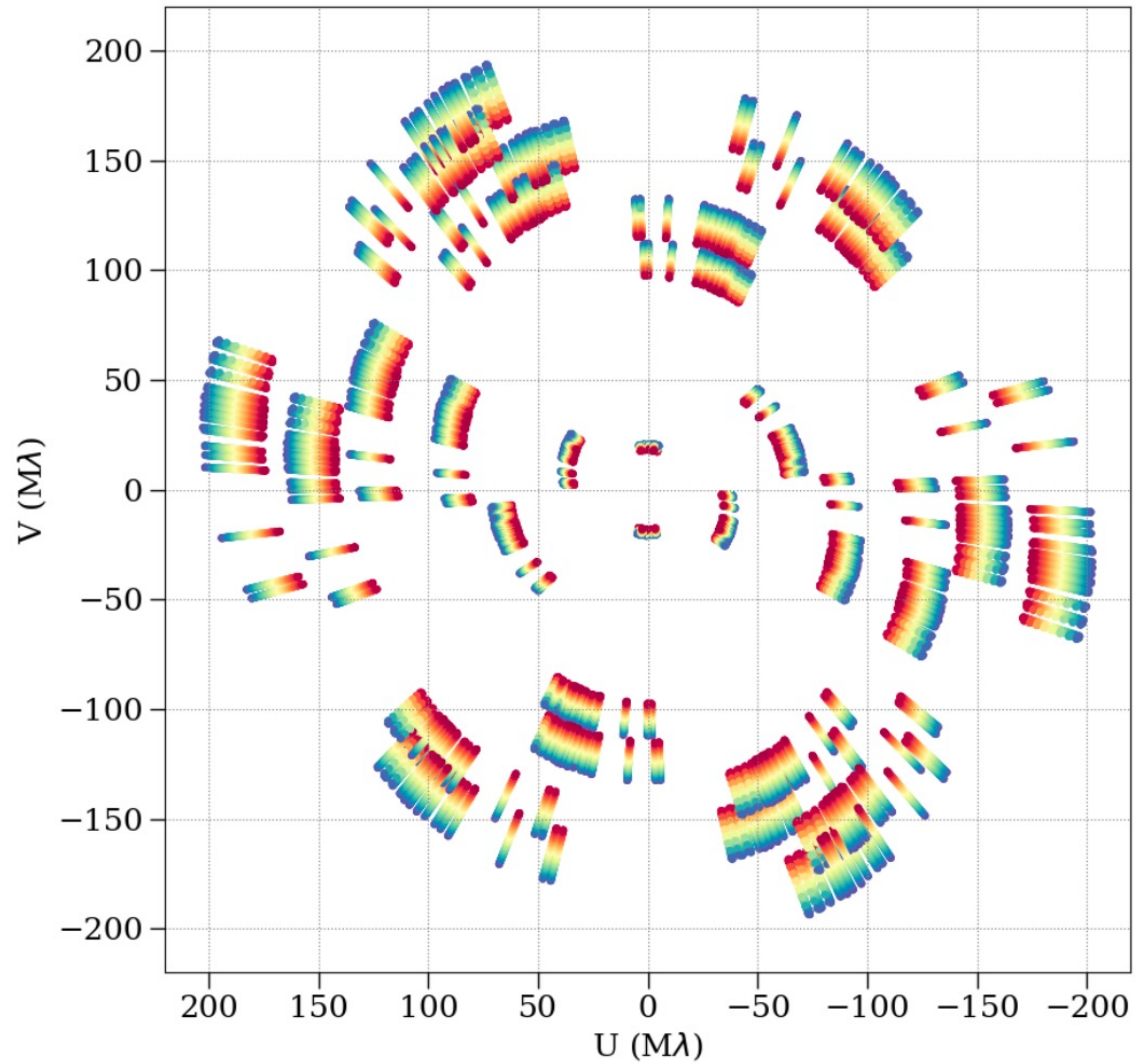


Anugu et al. submitted

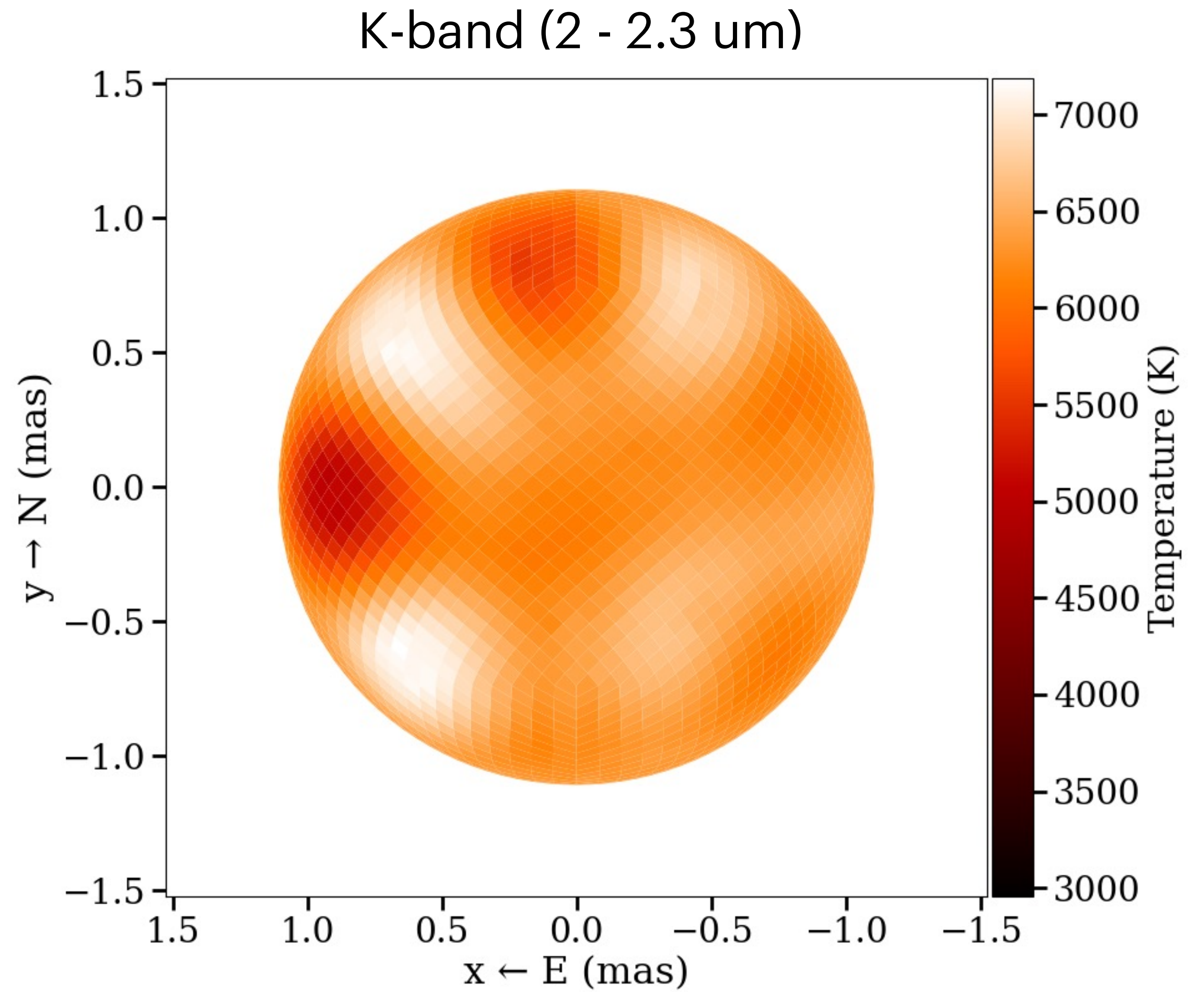
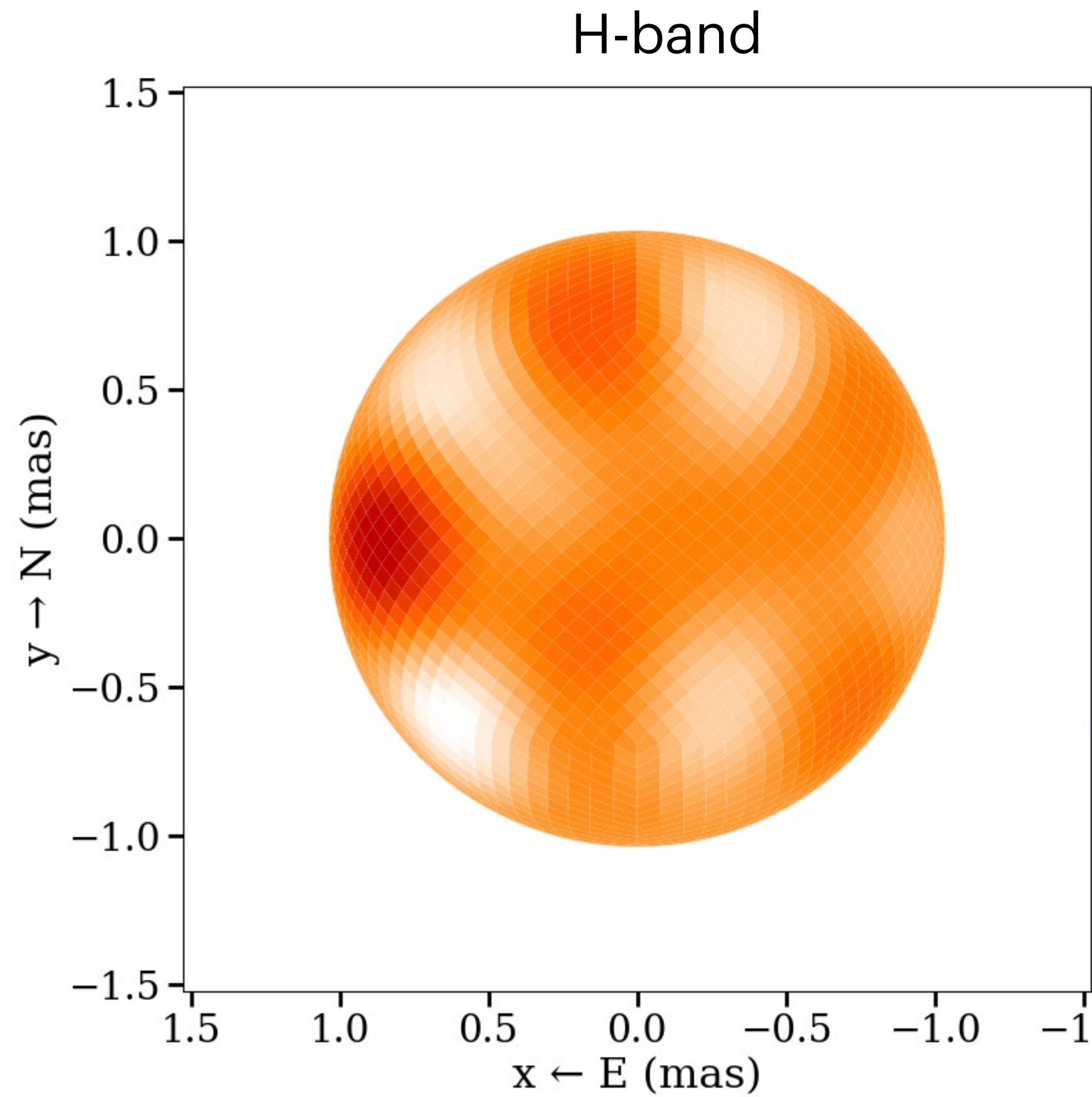
rho Cas observations



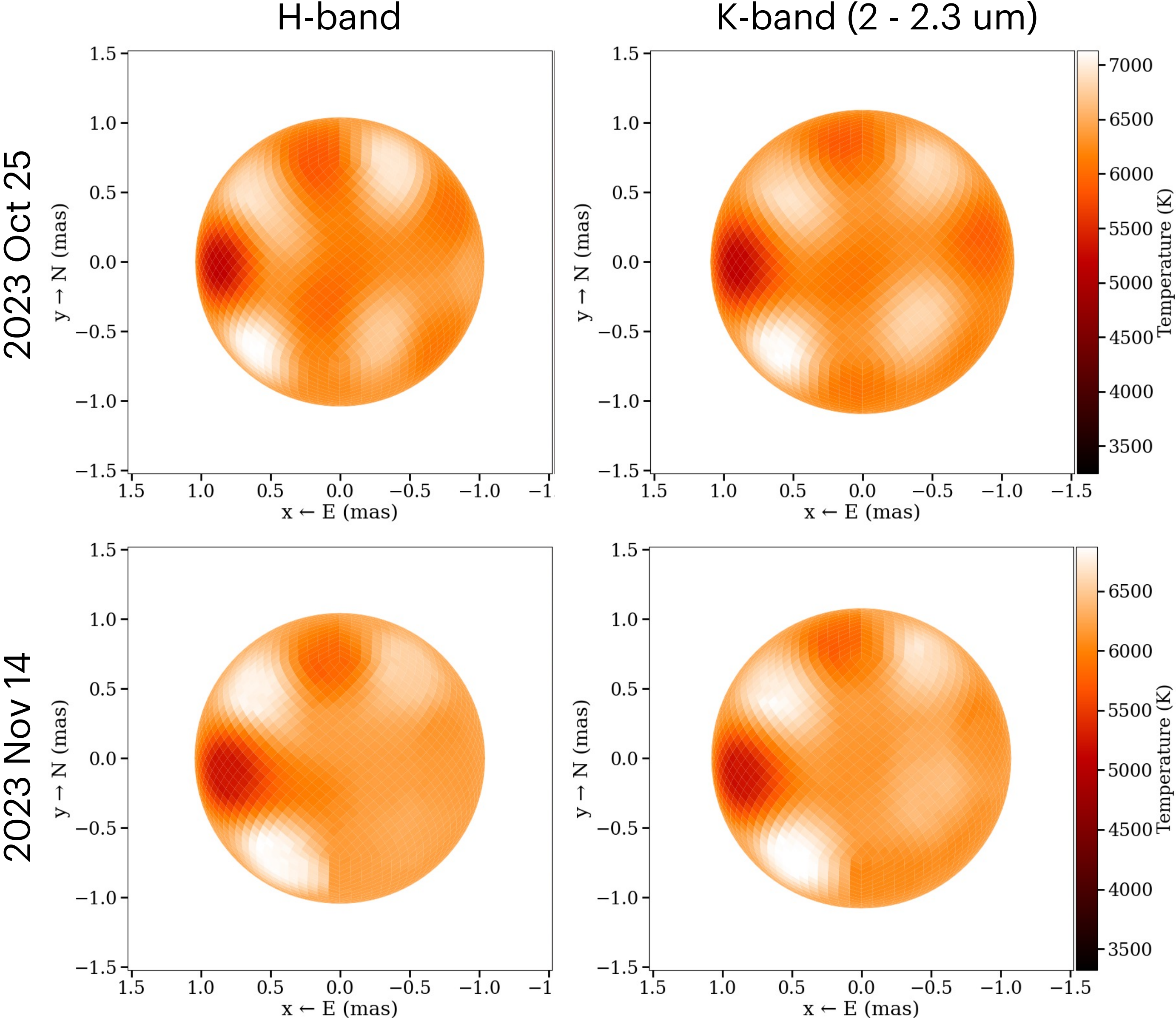
rho observations



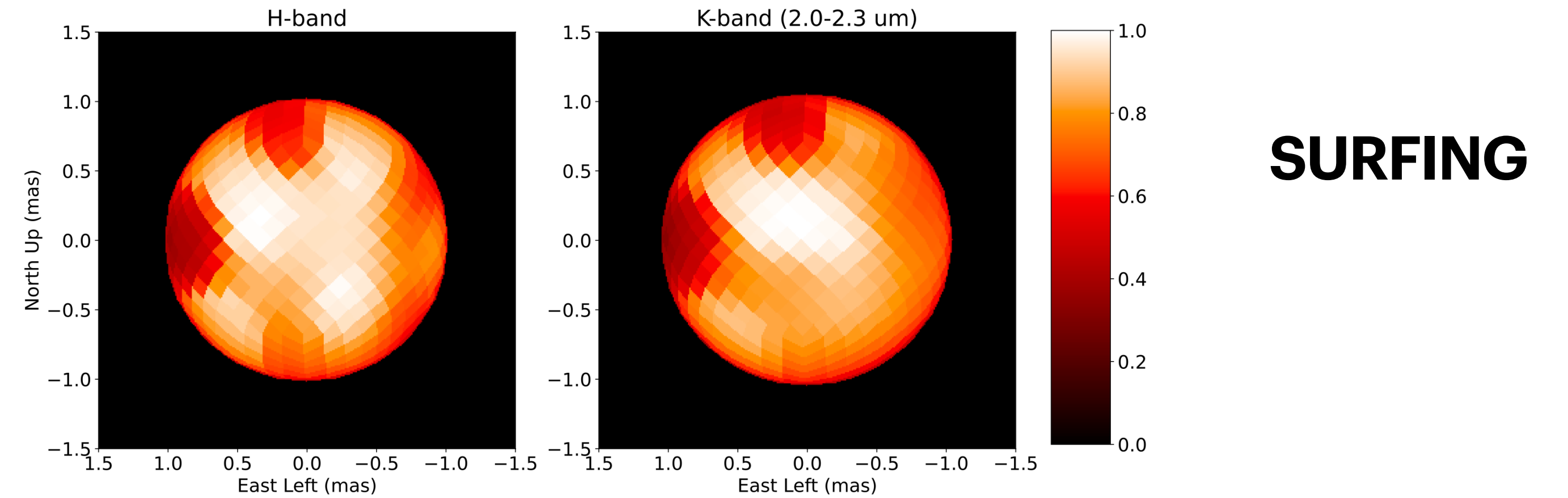
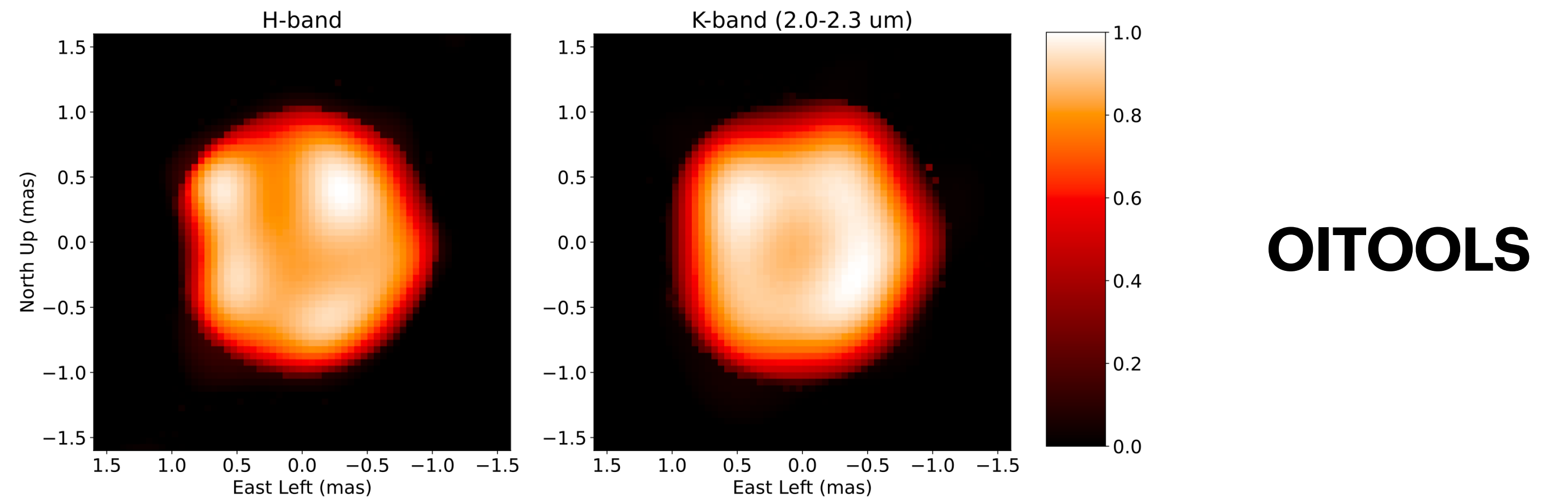
CHARA images (combined epochs)



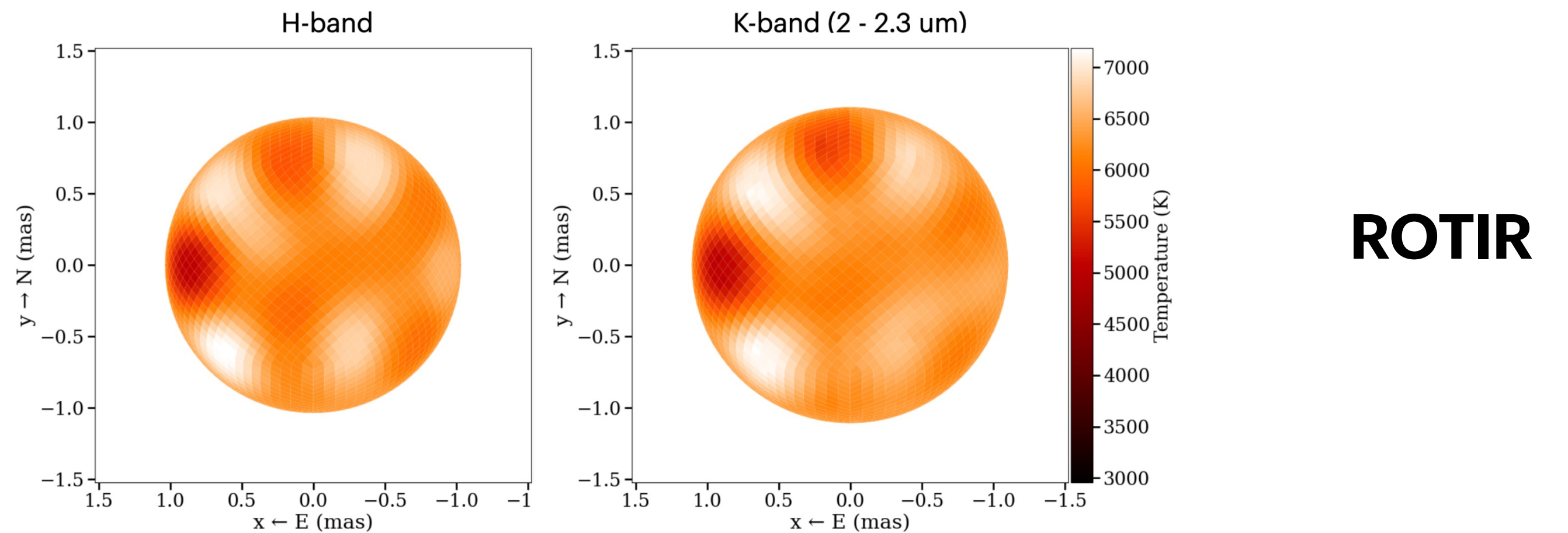
CHARA images (individual epochs)



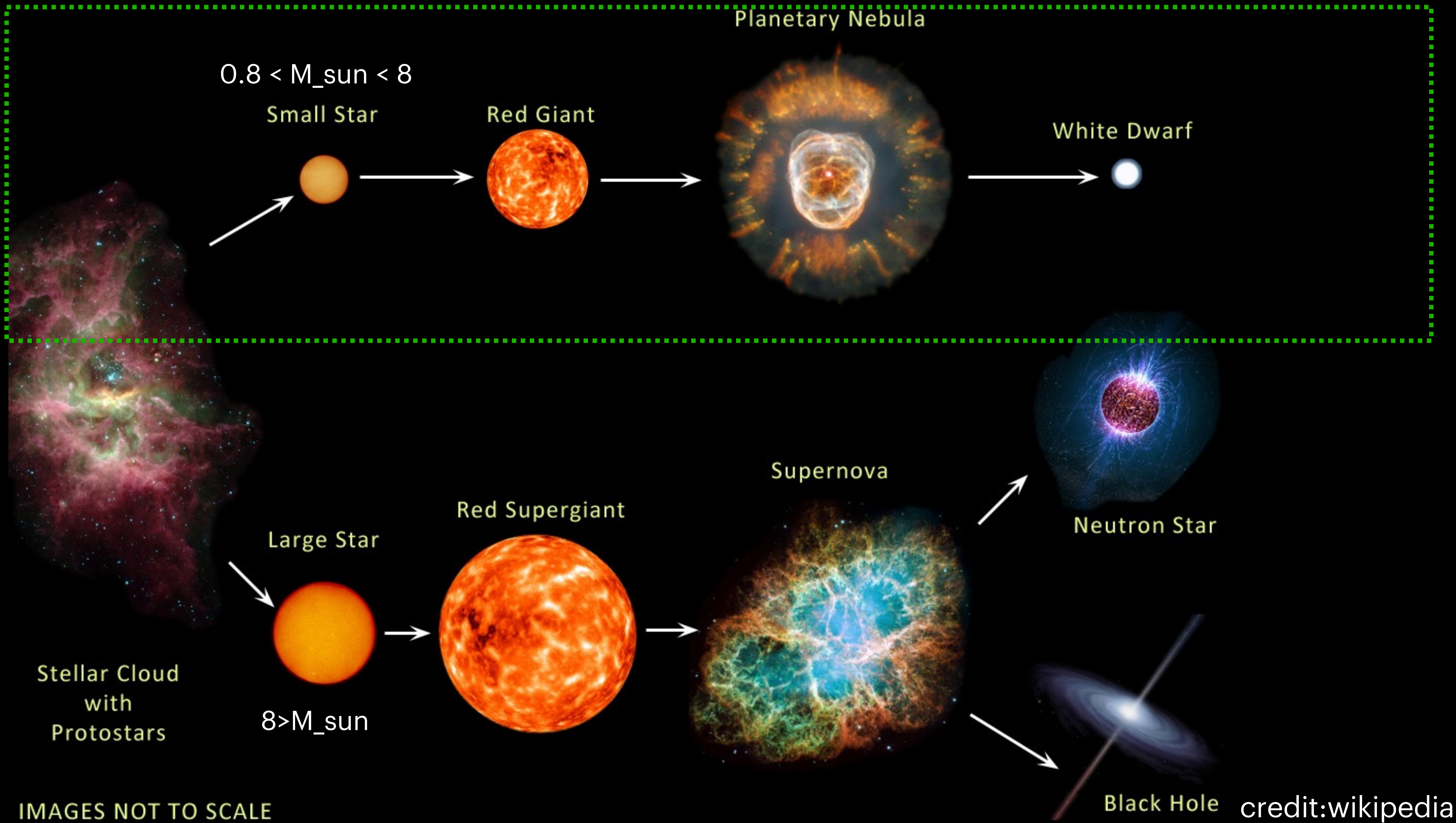
Images from different software well agree



Anugu et al. submitted

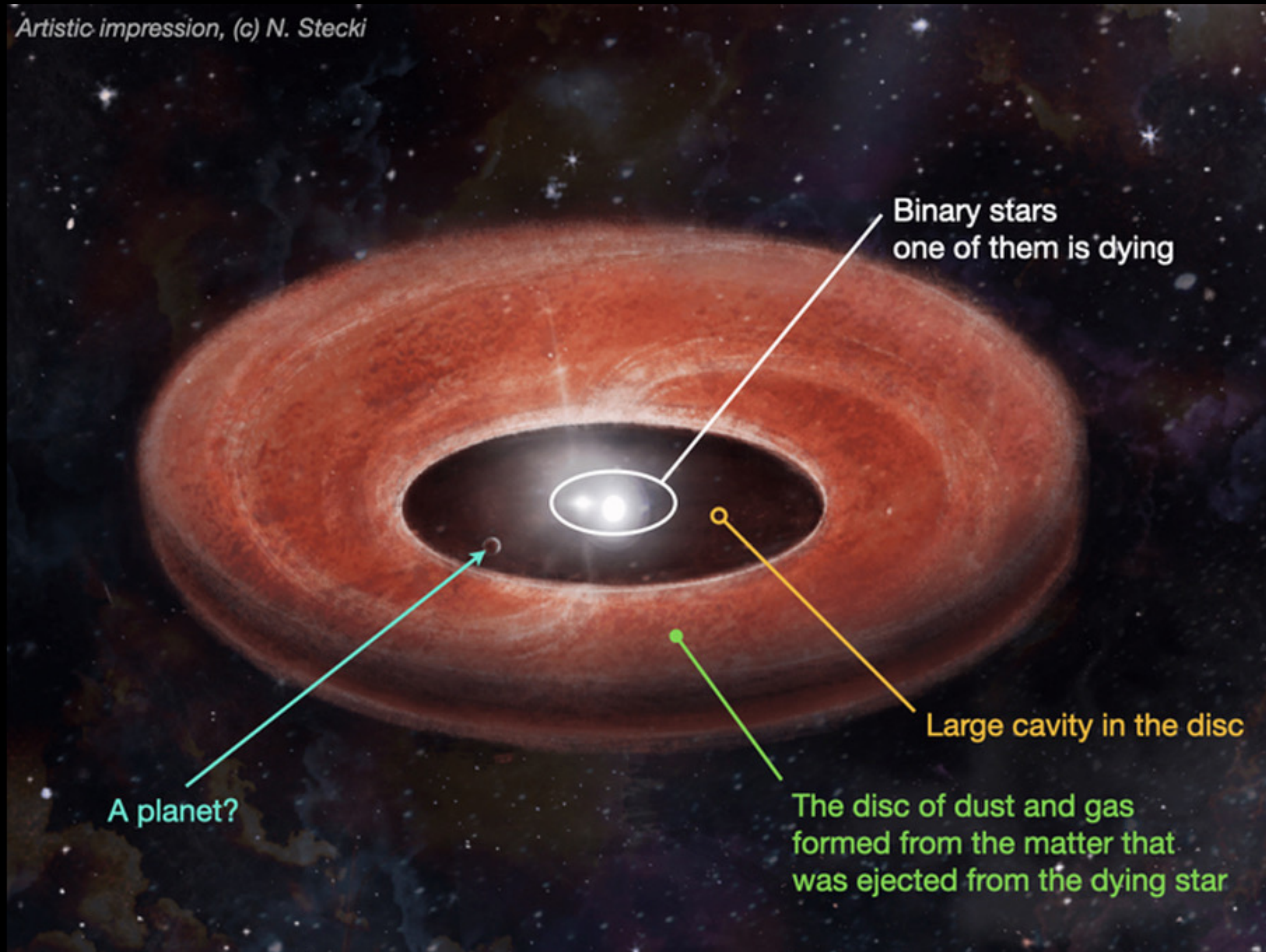


2. Post-AGBs



Planets form in evolved stars?

Artistic impression, (c) N. Stecki



Post-AGB binaries

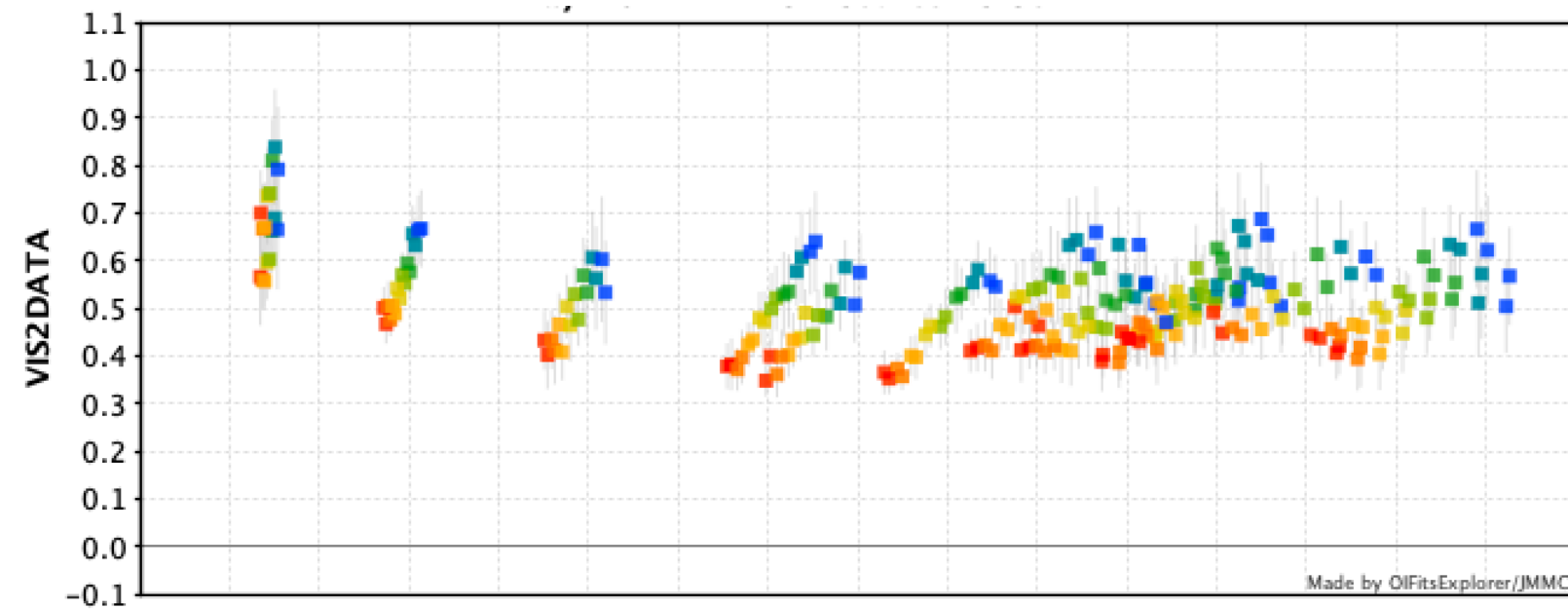
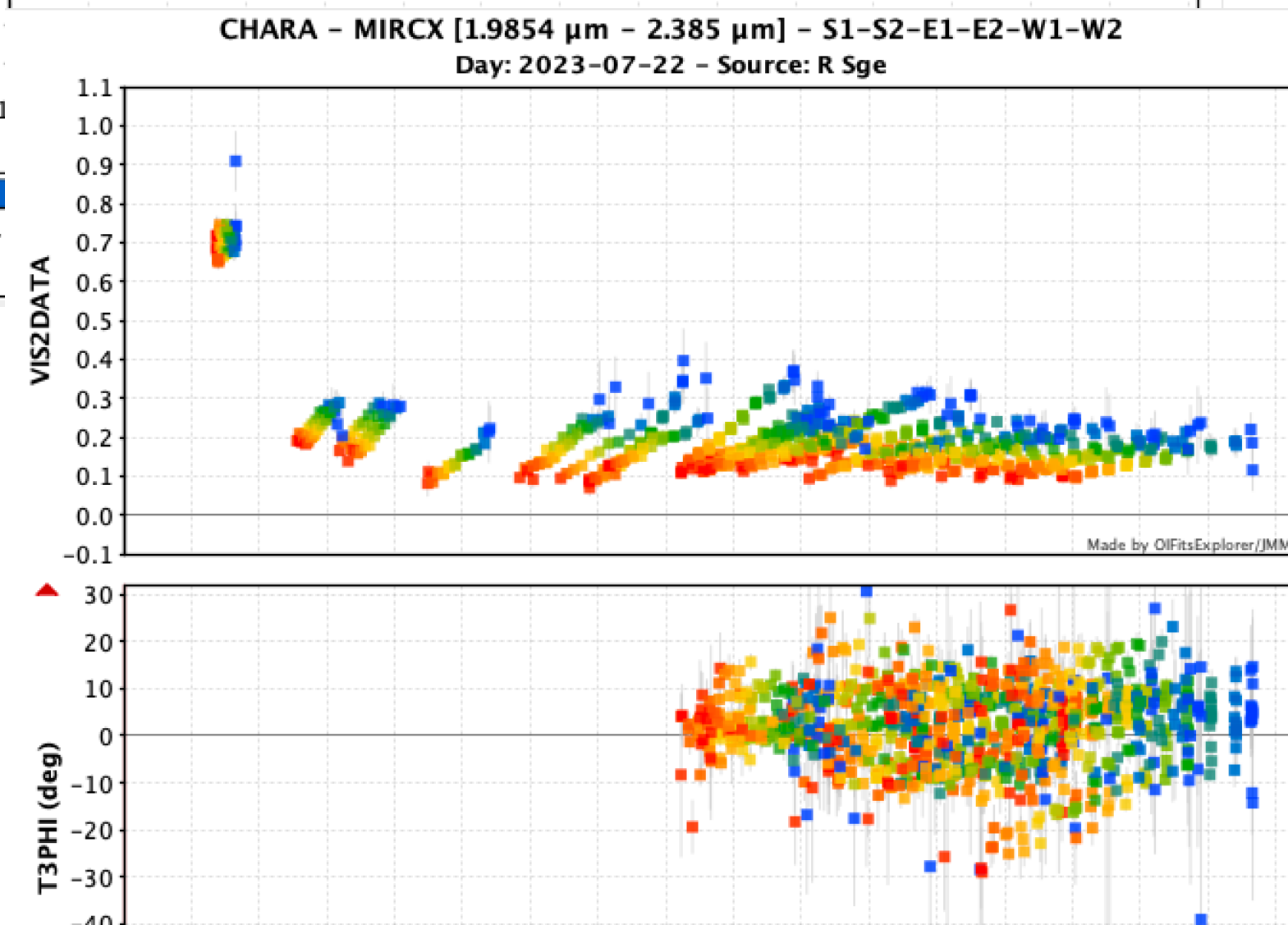
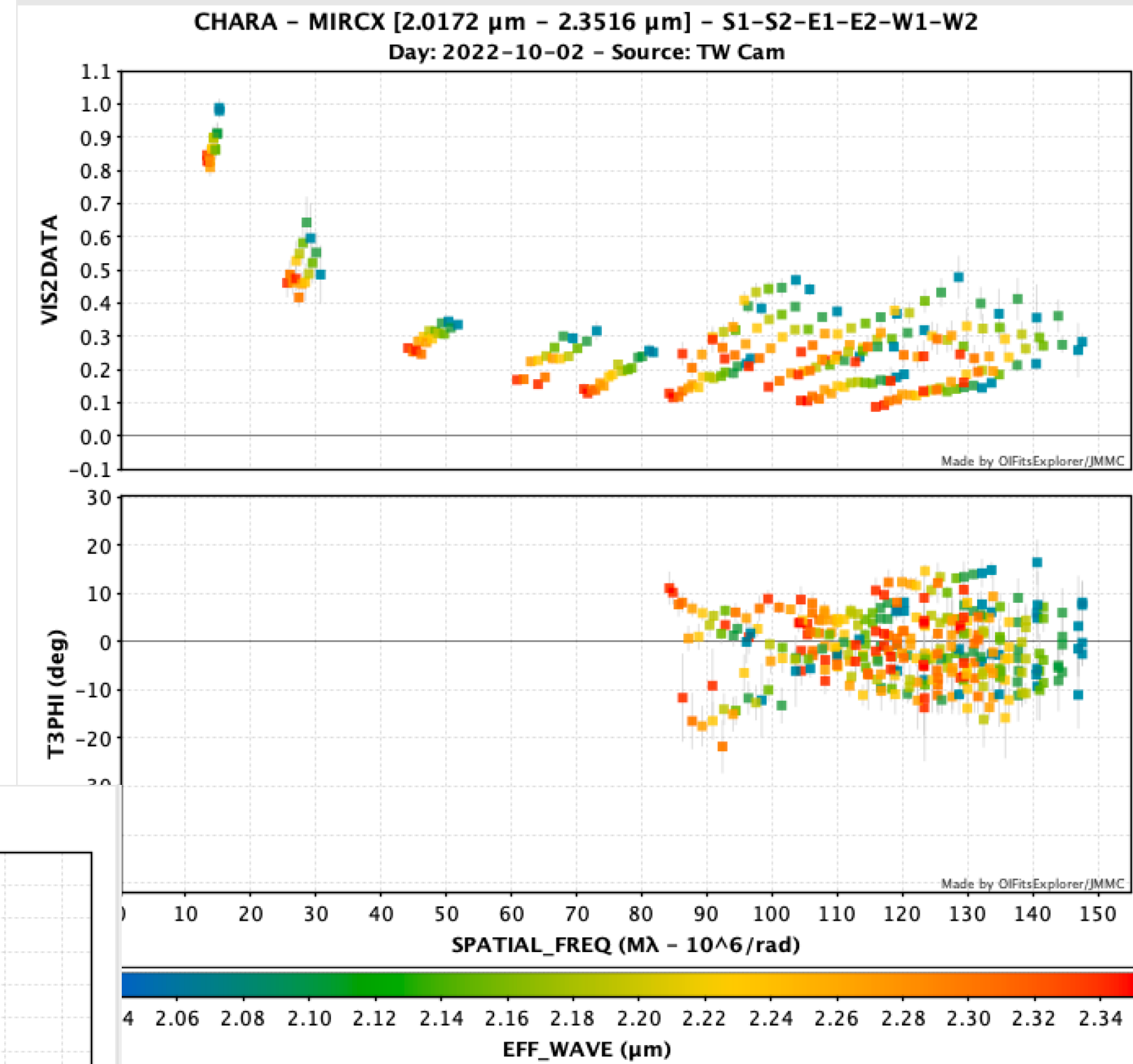
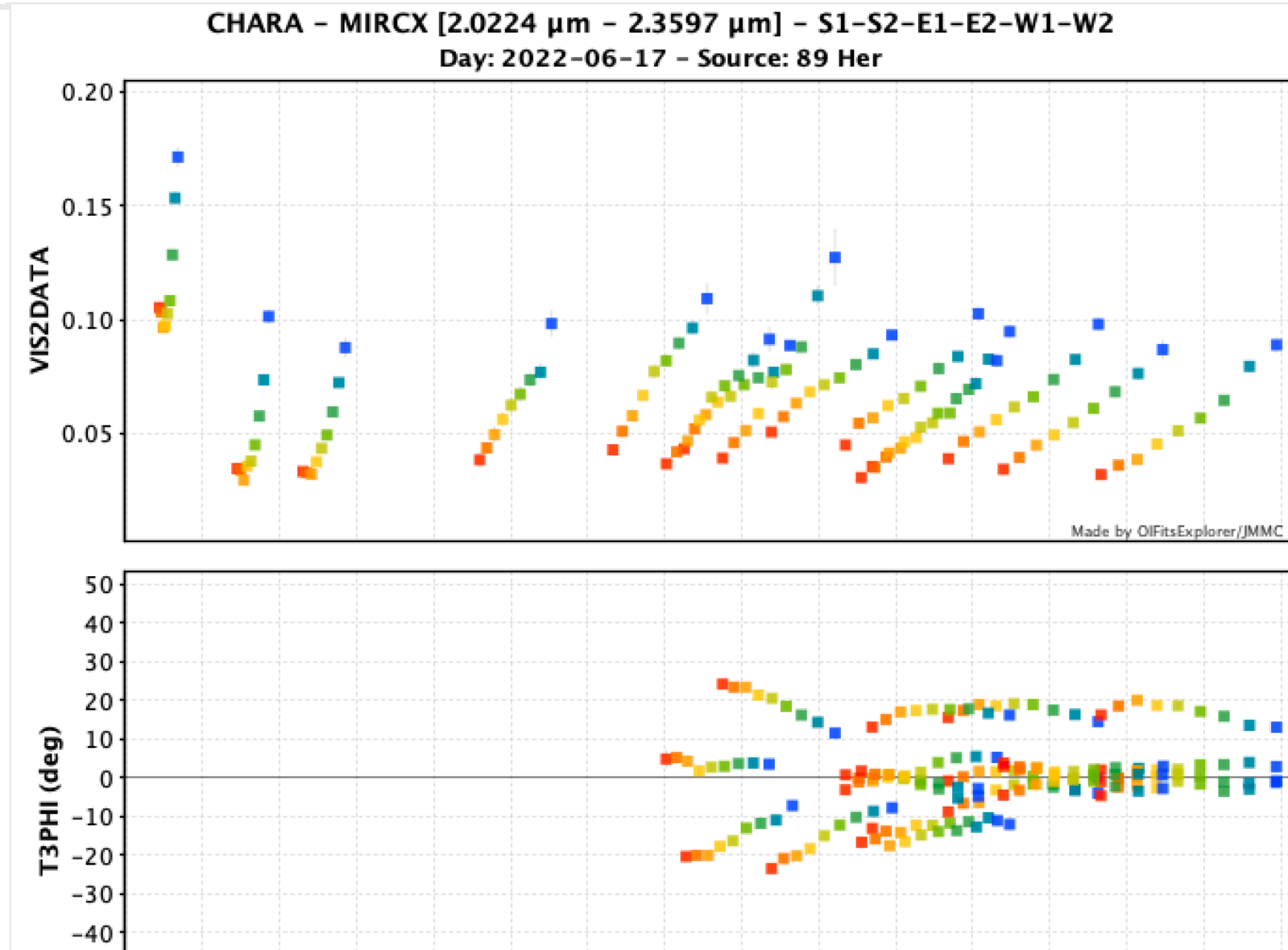
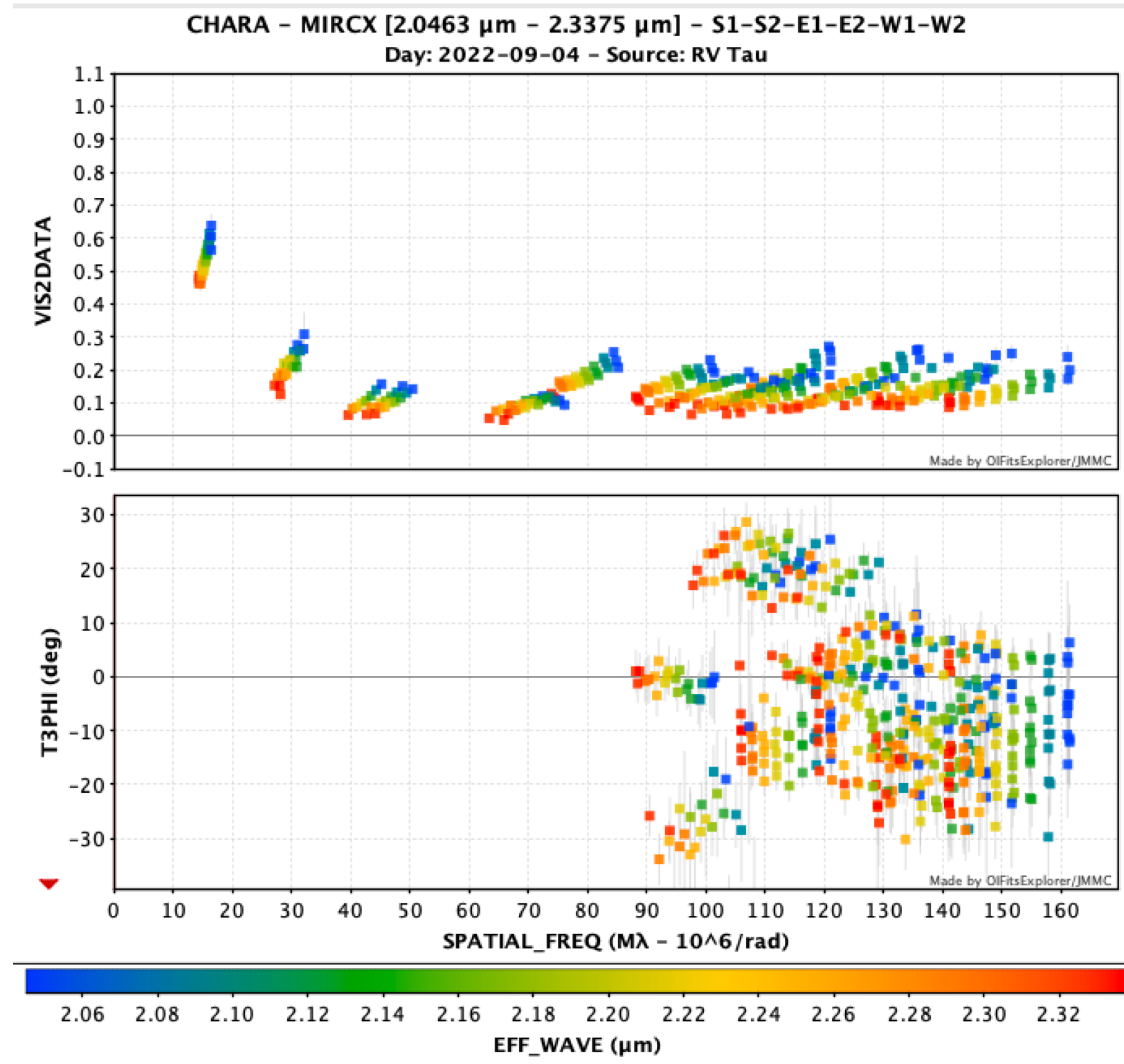
Do they form exoplanets in their disks?

With collaboration with Jacques Kluska and H van Winckel group

Backup science:

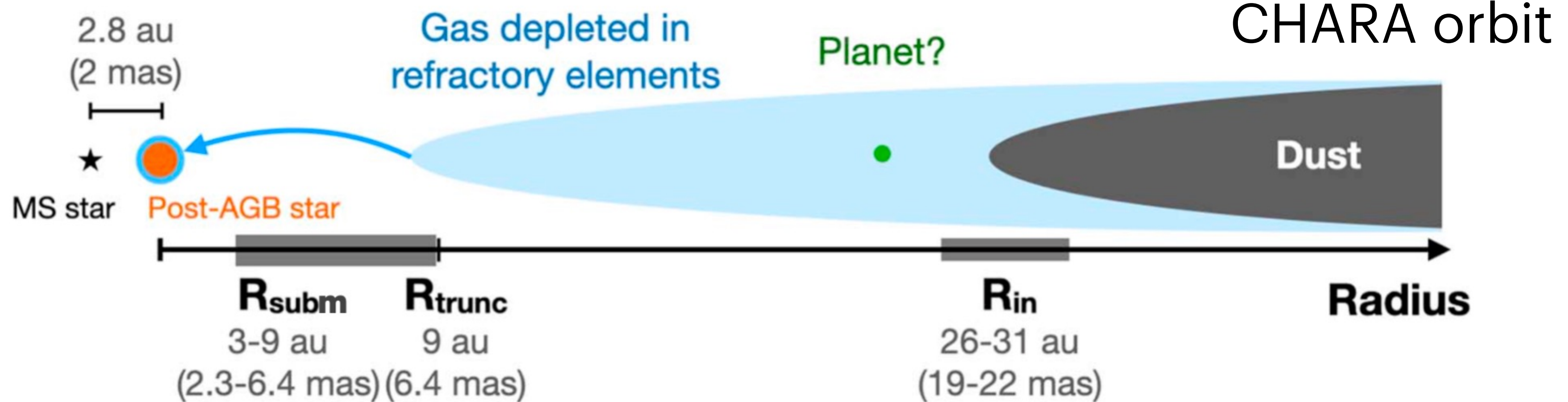
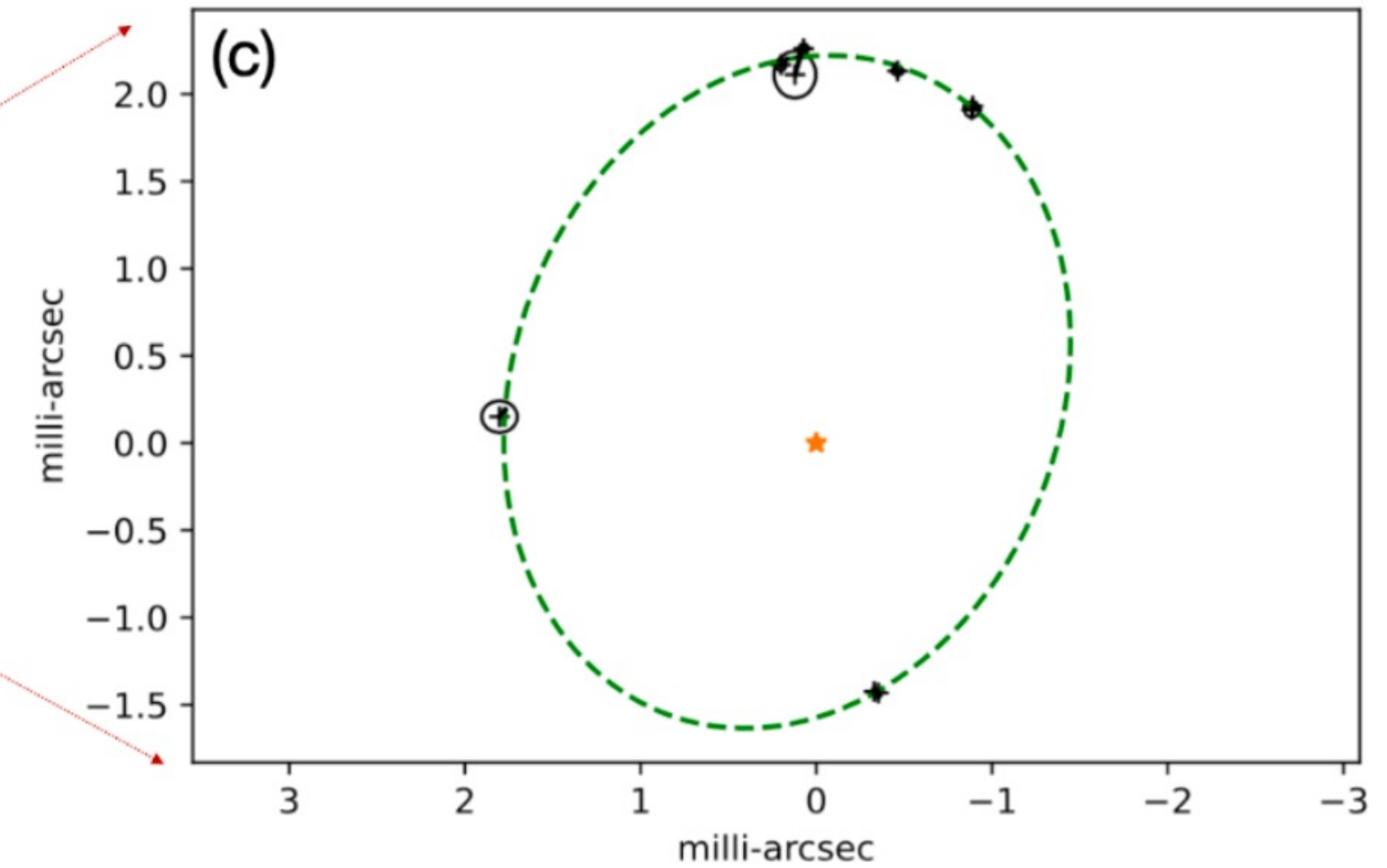
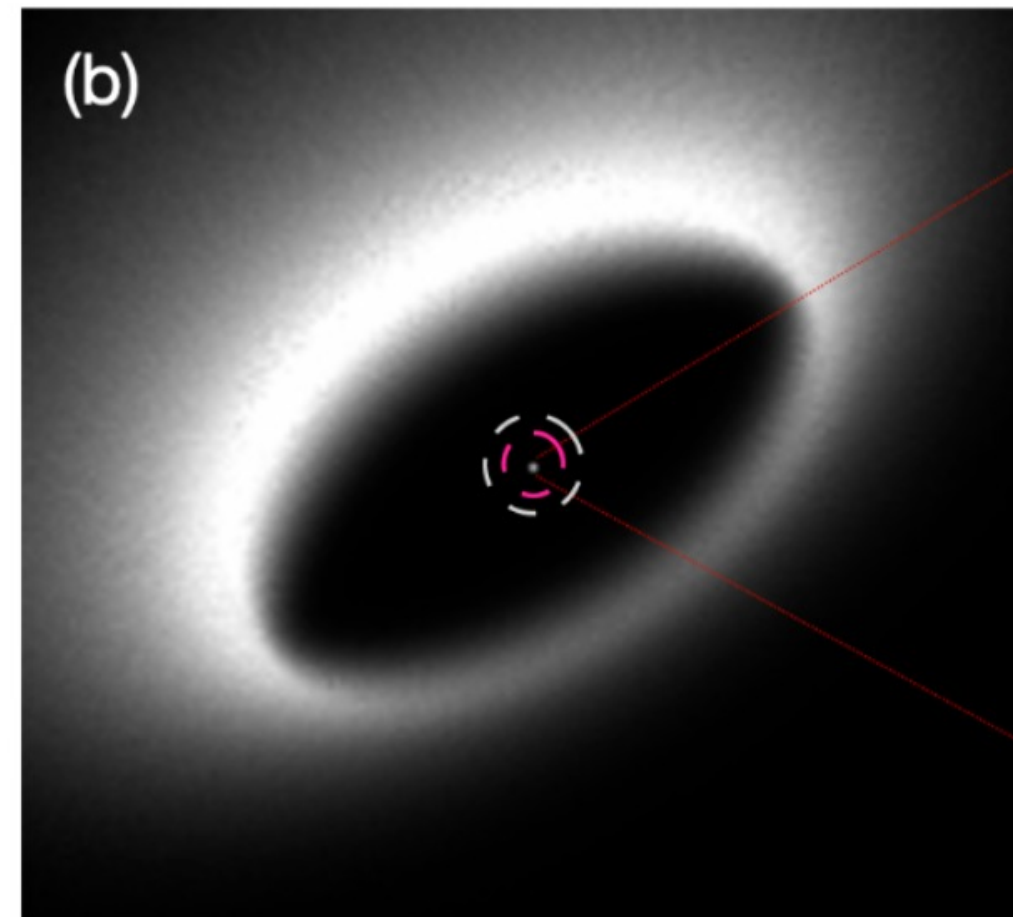
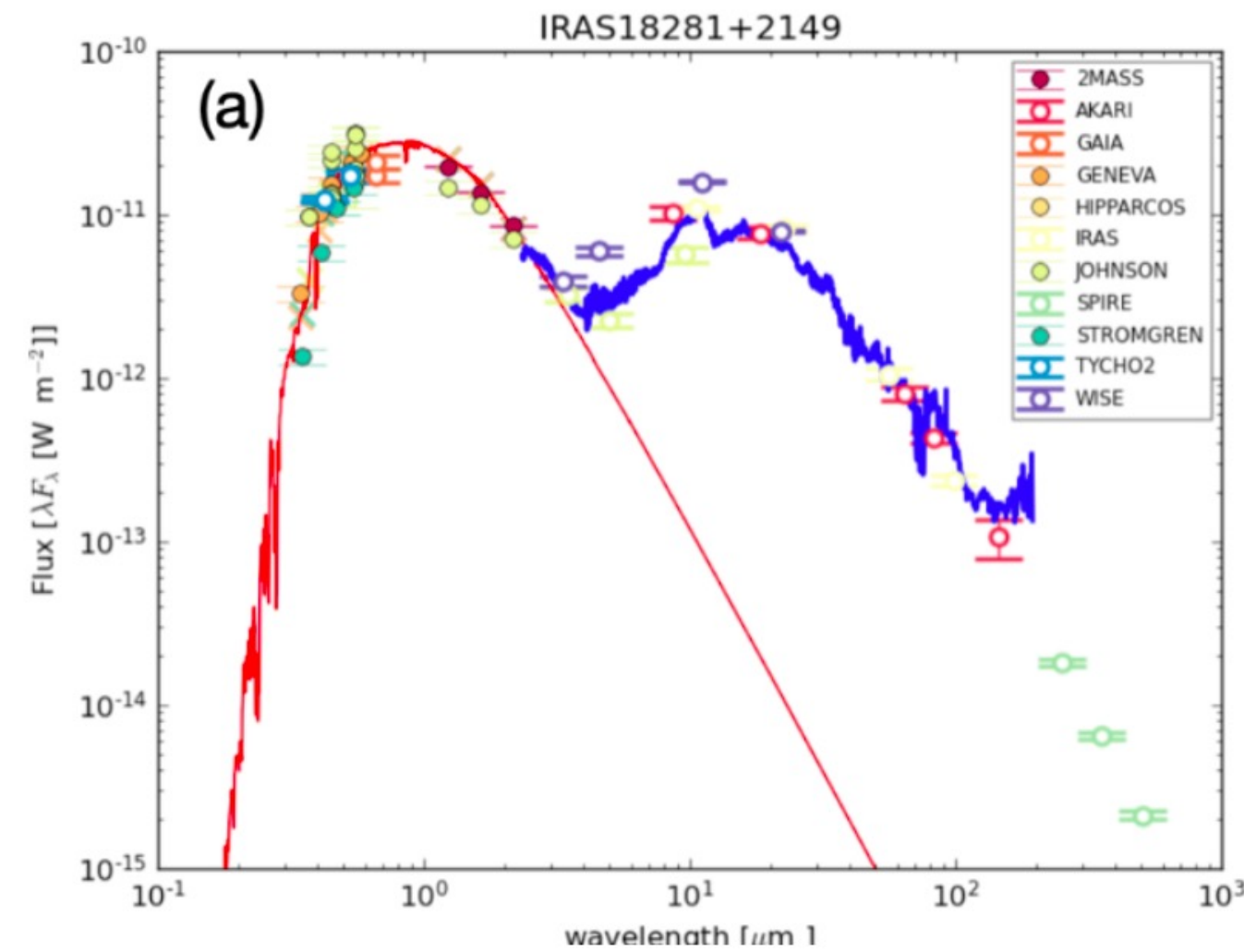
- How the circumbinary disks align with binary orbits?
- Can we image jet forming disk around the secondary?
- How to explain the long period variability (RVb phenomenon)?

How the data look



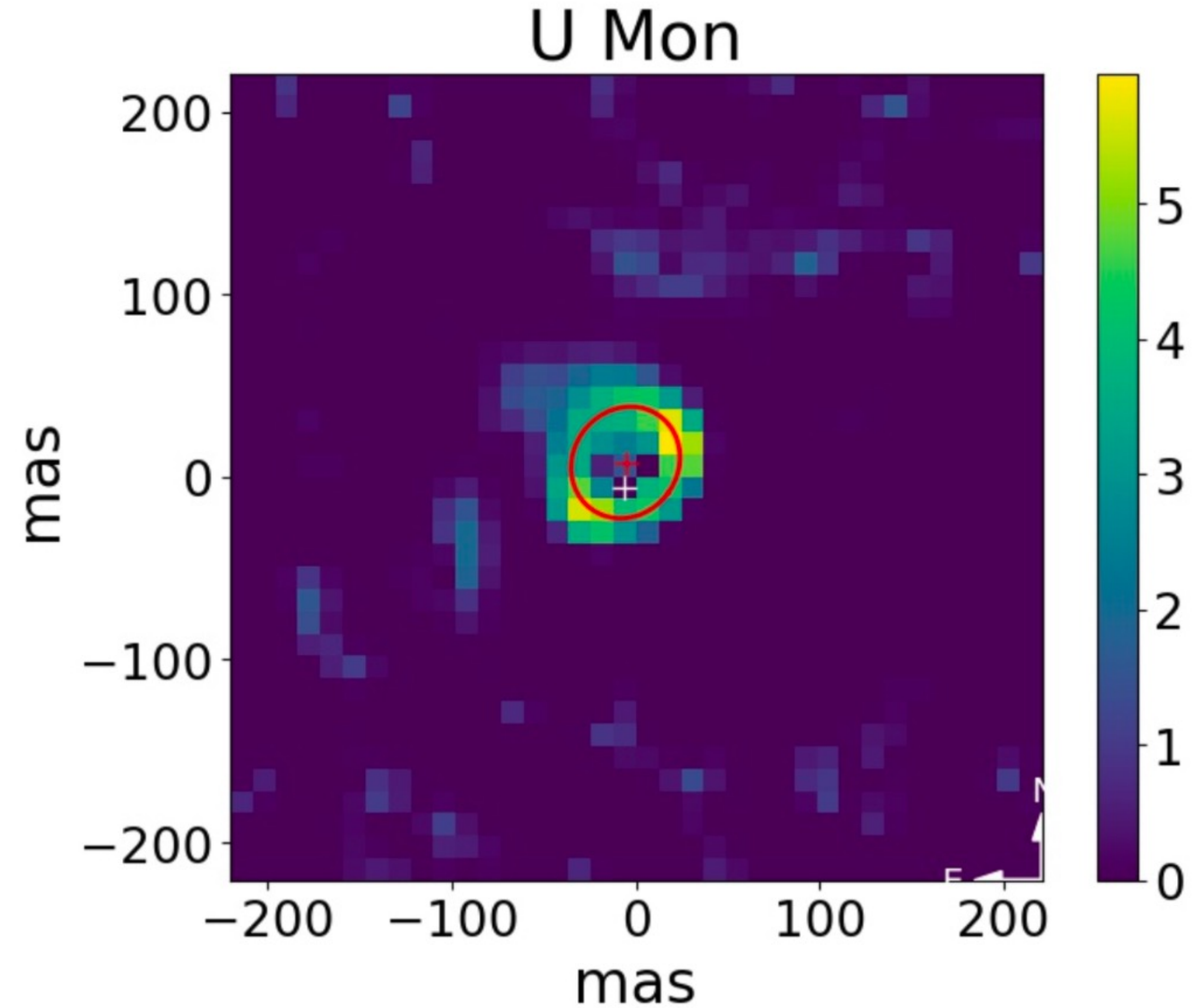
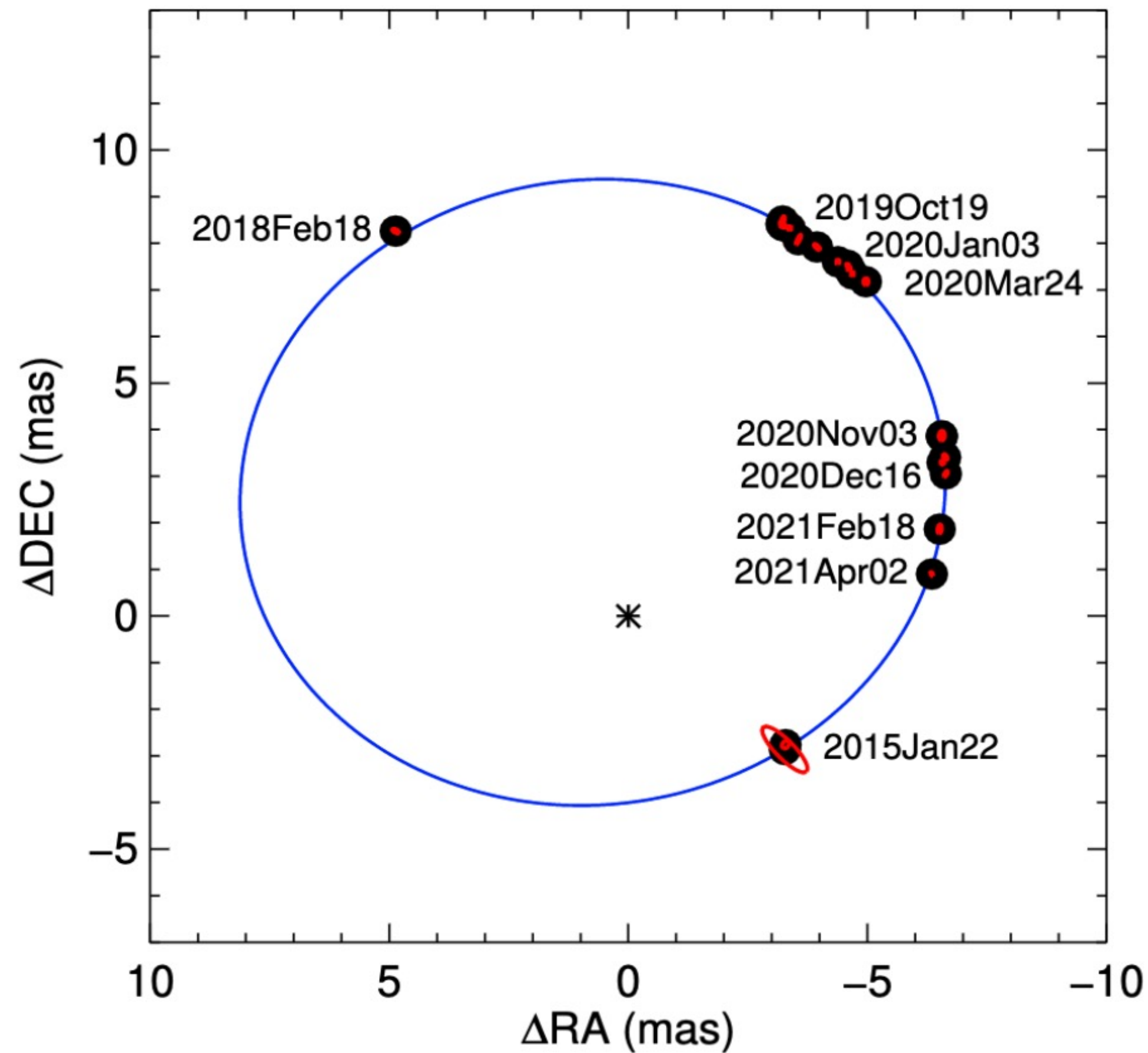
Do they form exoplanets in their disks?

Example: AC Her (Anugu et al. 2023)



The disk gap created by an unseen companion or planet

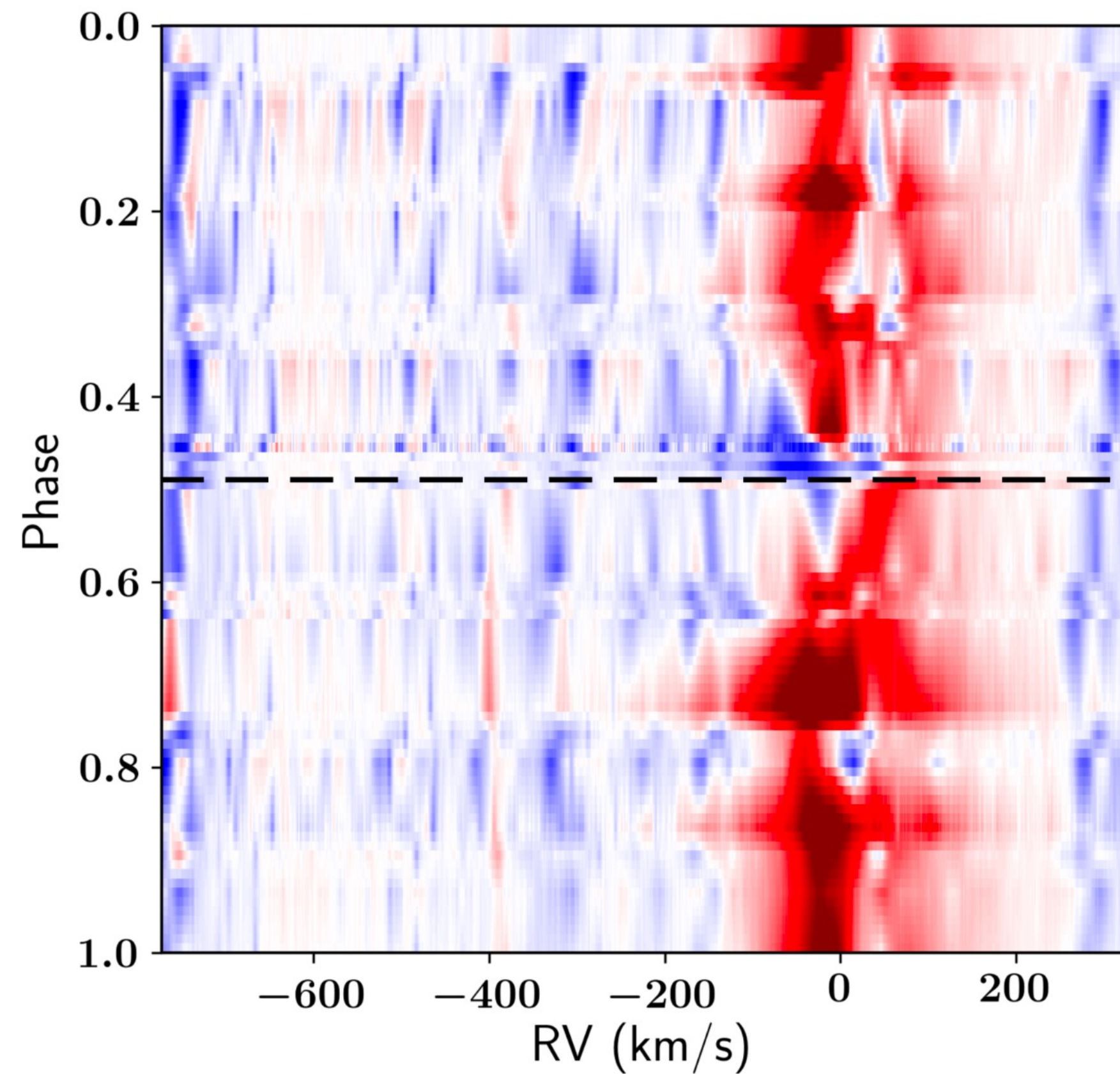
No Evidence of Planet in U Mon system



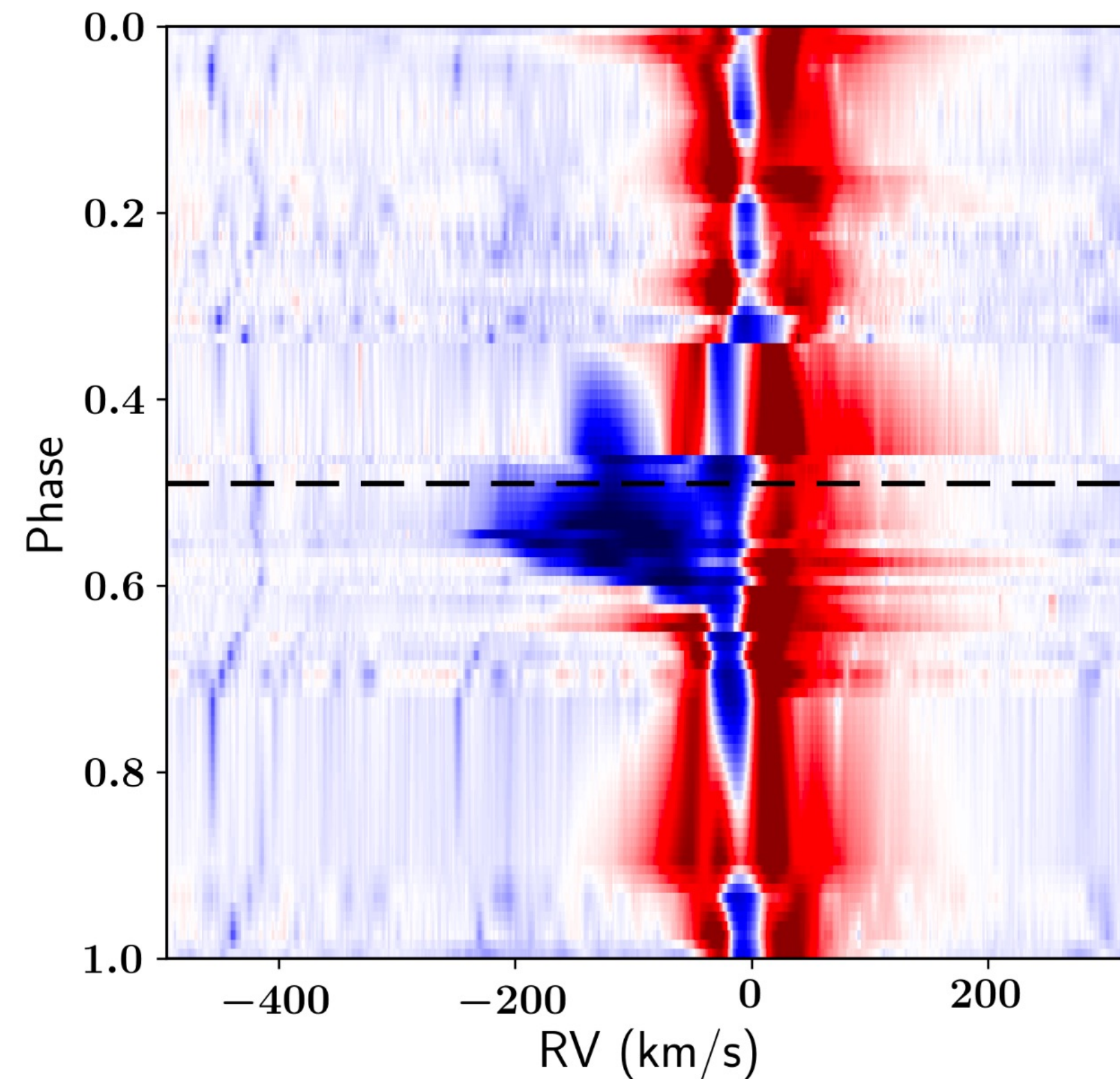
The disk gap created by inner binary not by a planet

Jets in post-AGB binaries

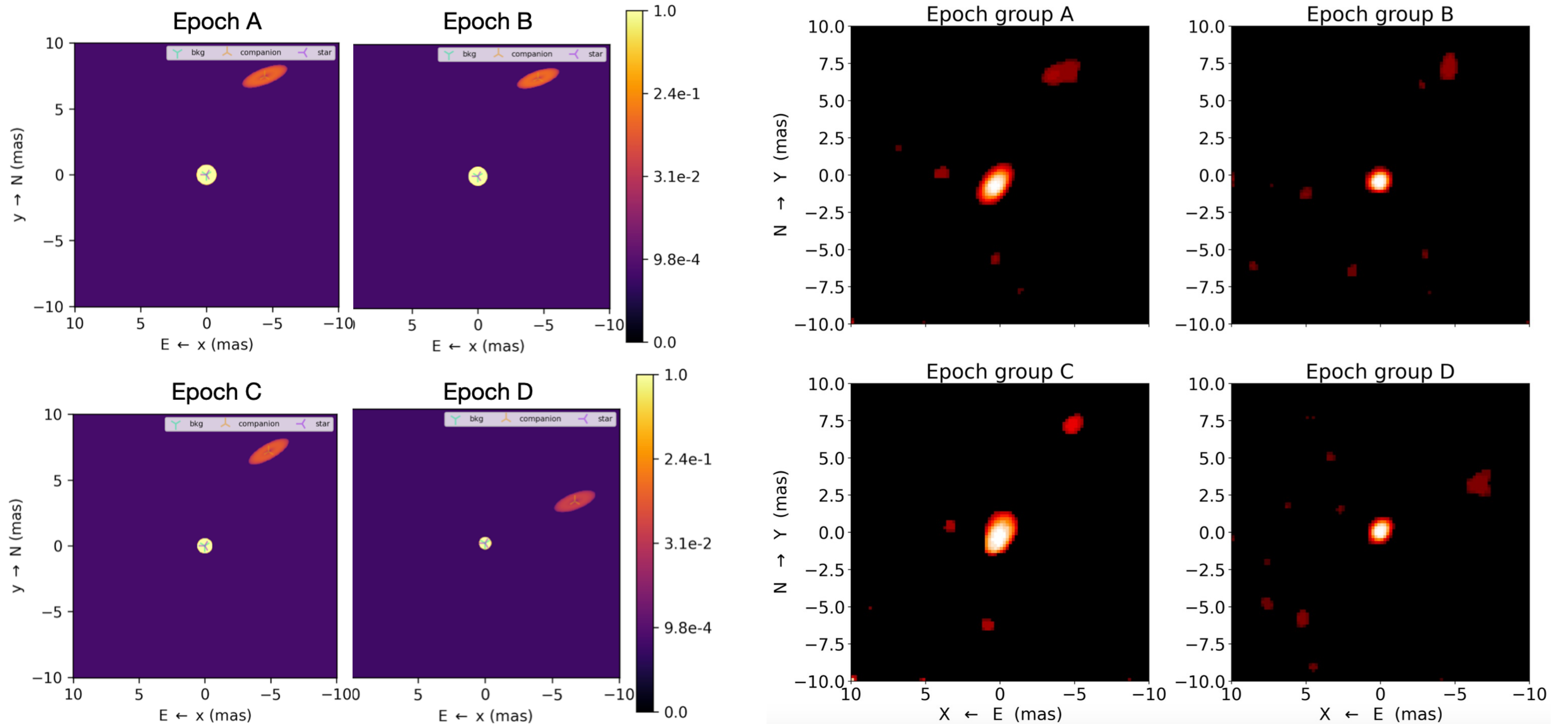
U Mon (Bollen et al. 2022)



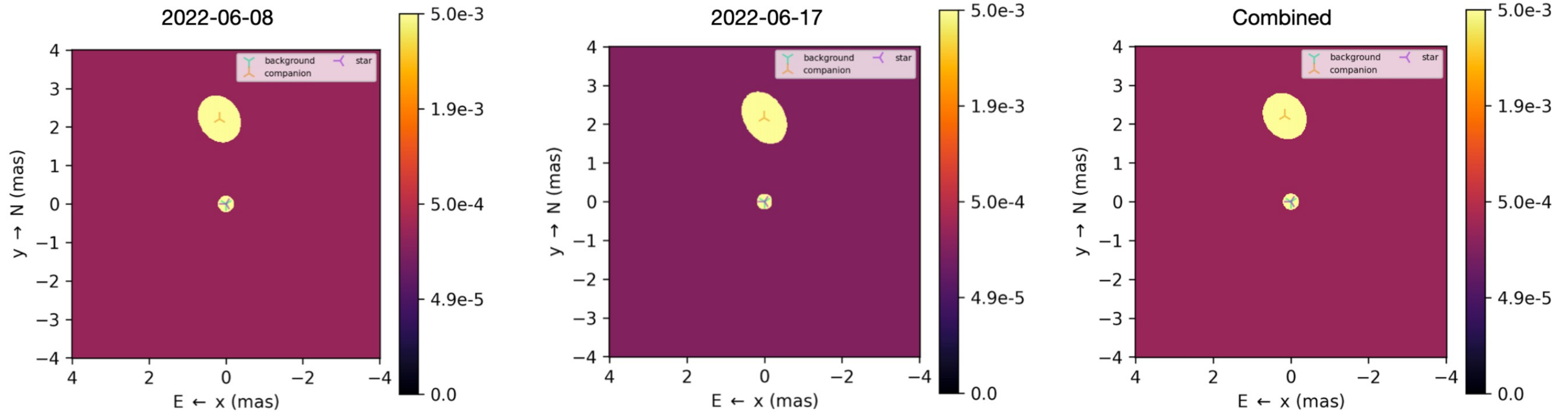
AC Her (Bollen et al. 2022)



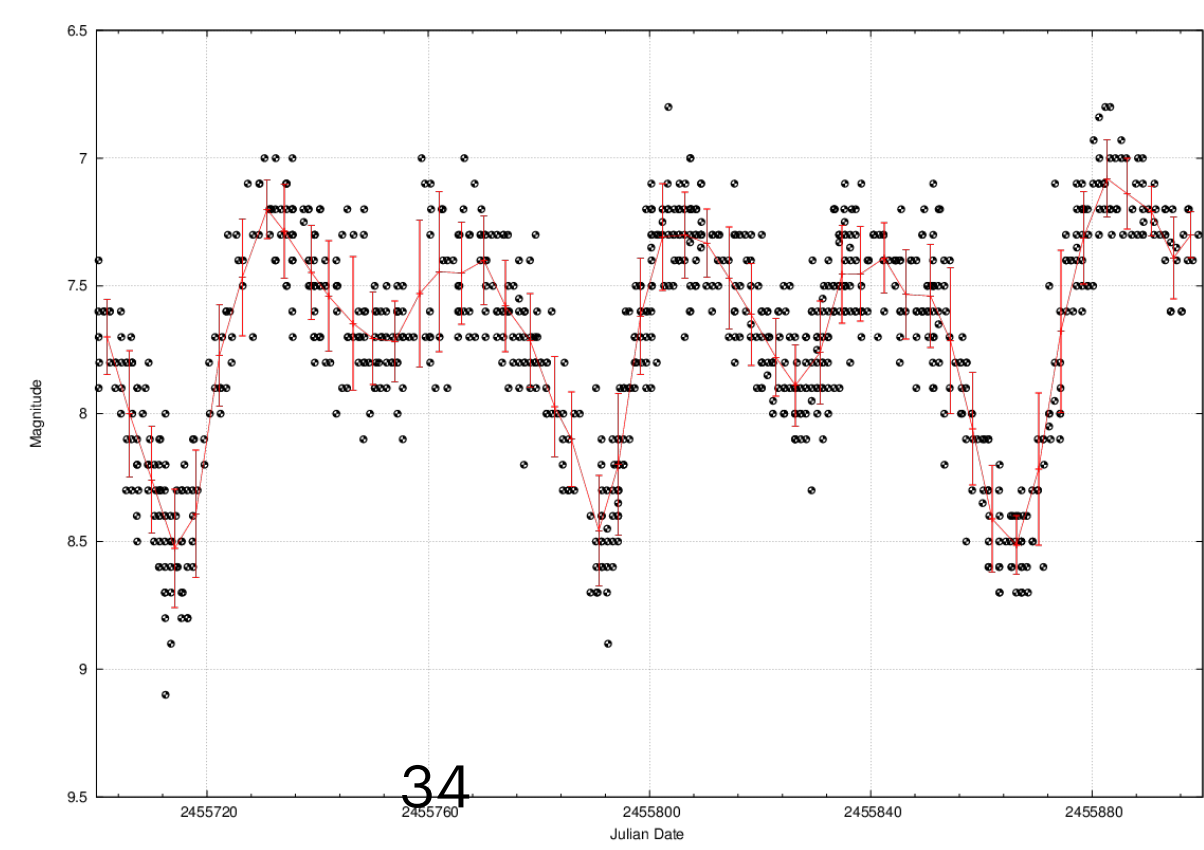
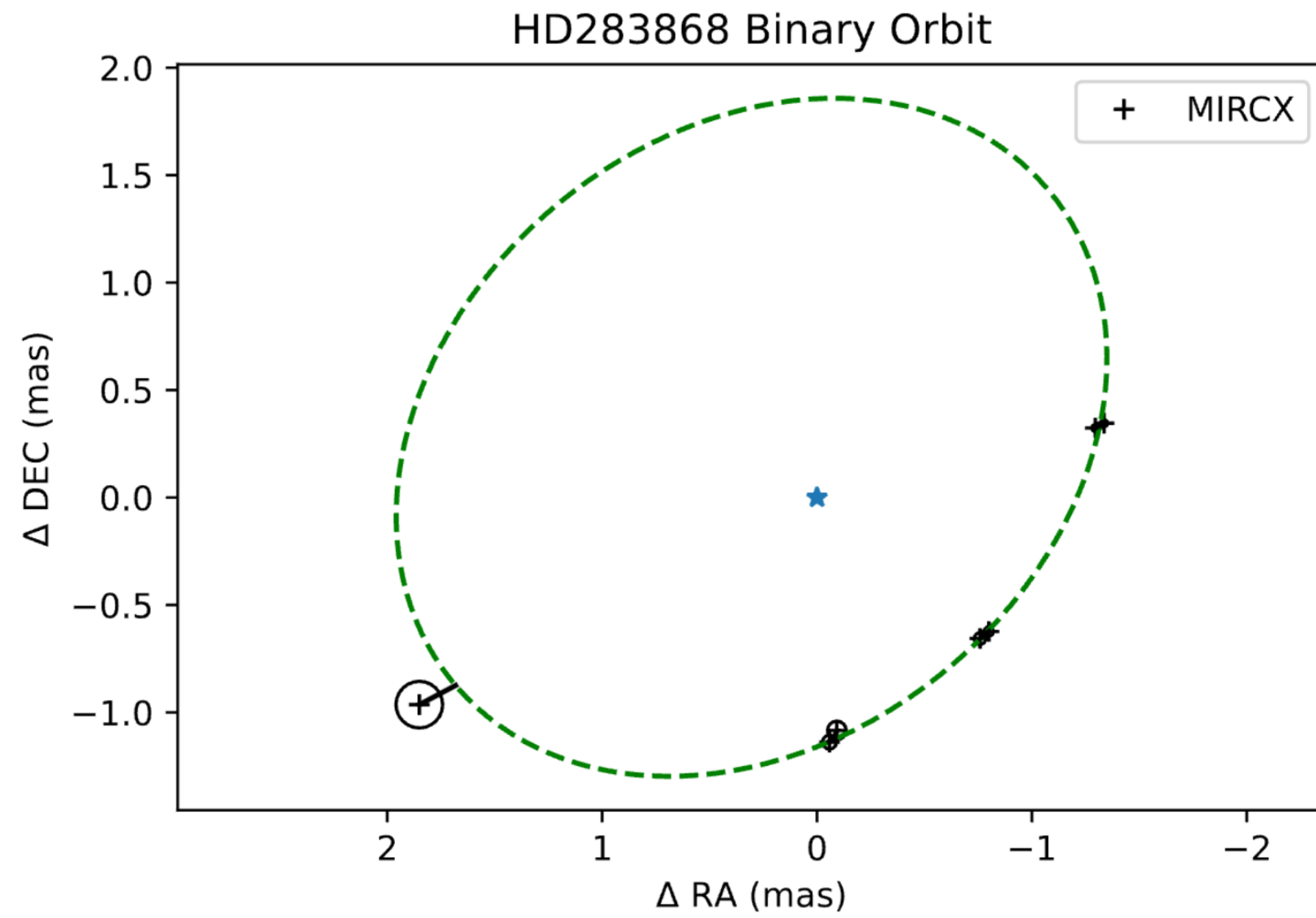
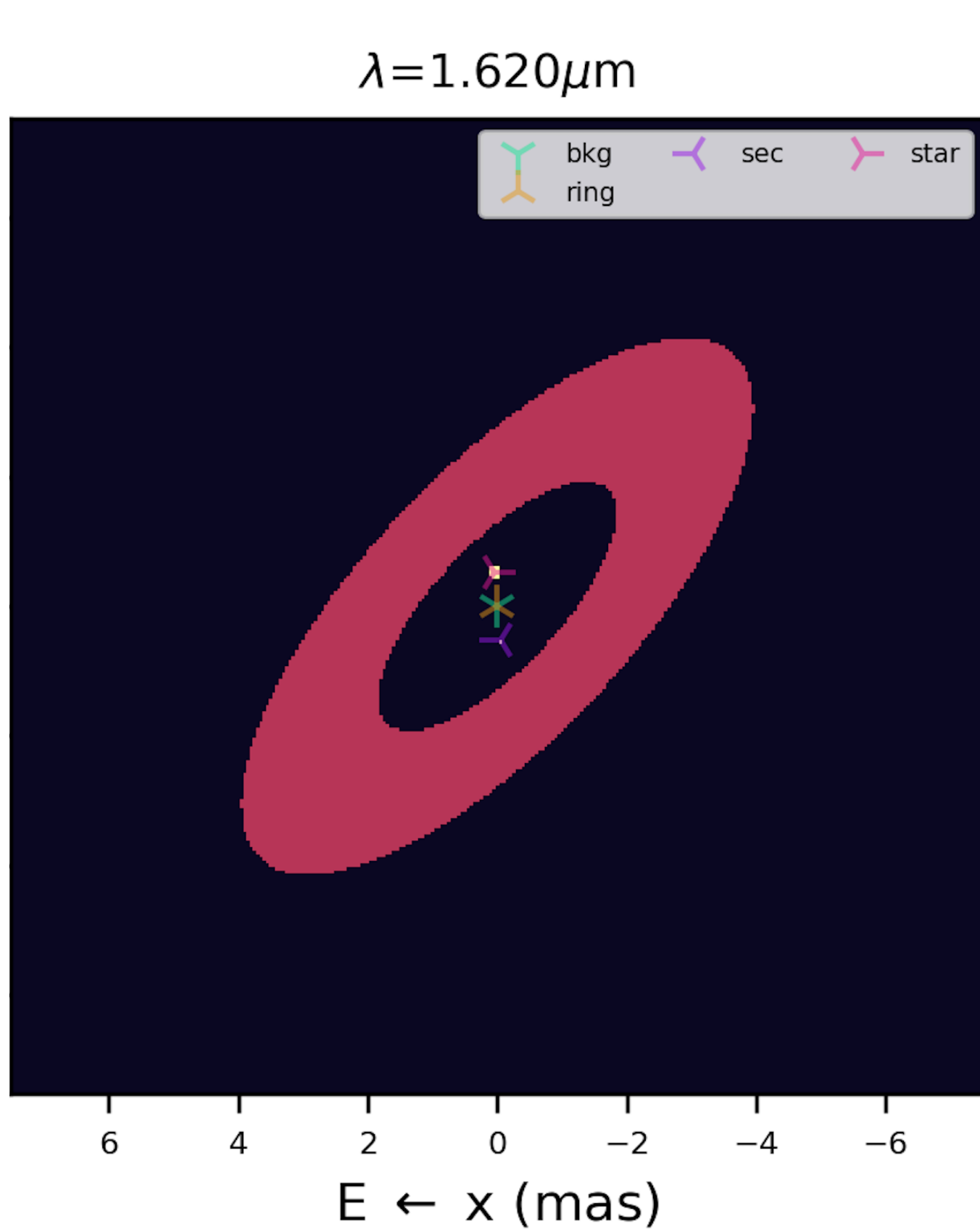
U Mon circumsecondary disk



AC Her circumsecondary disk

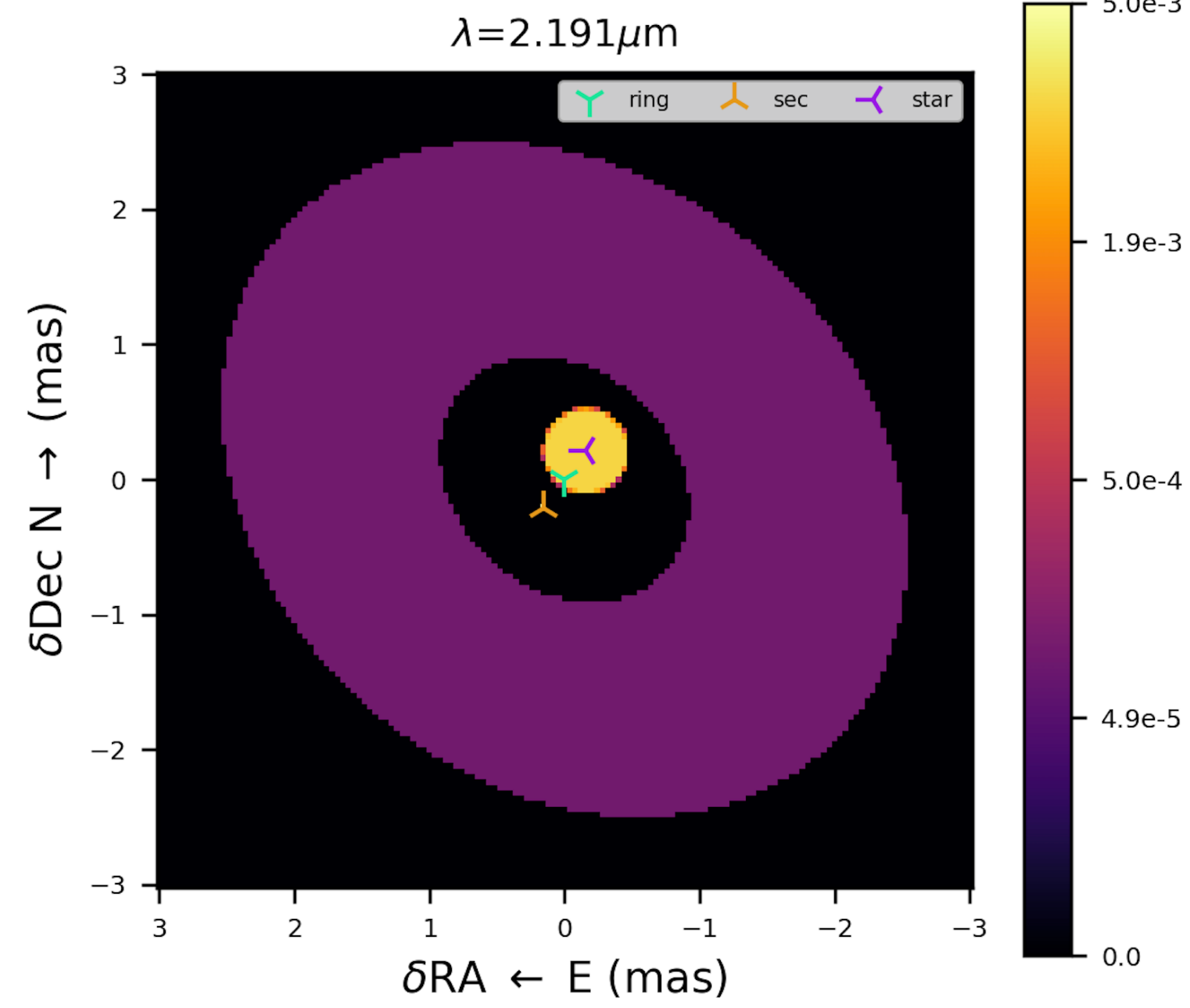


RVb phenomenon

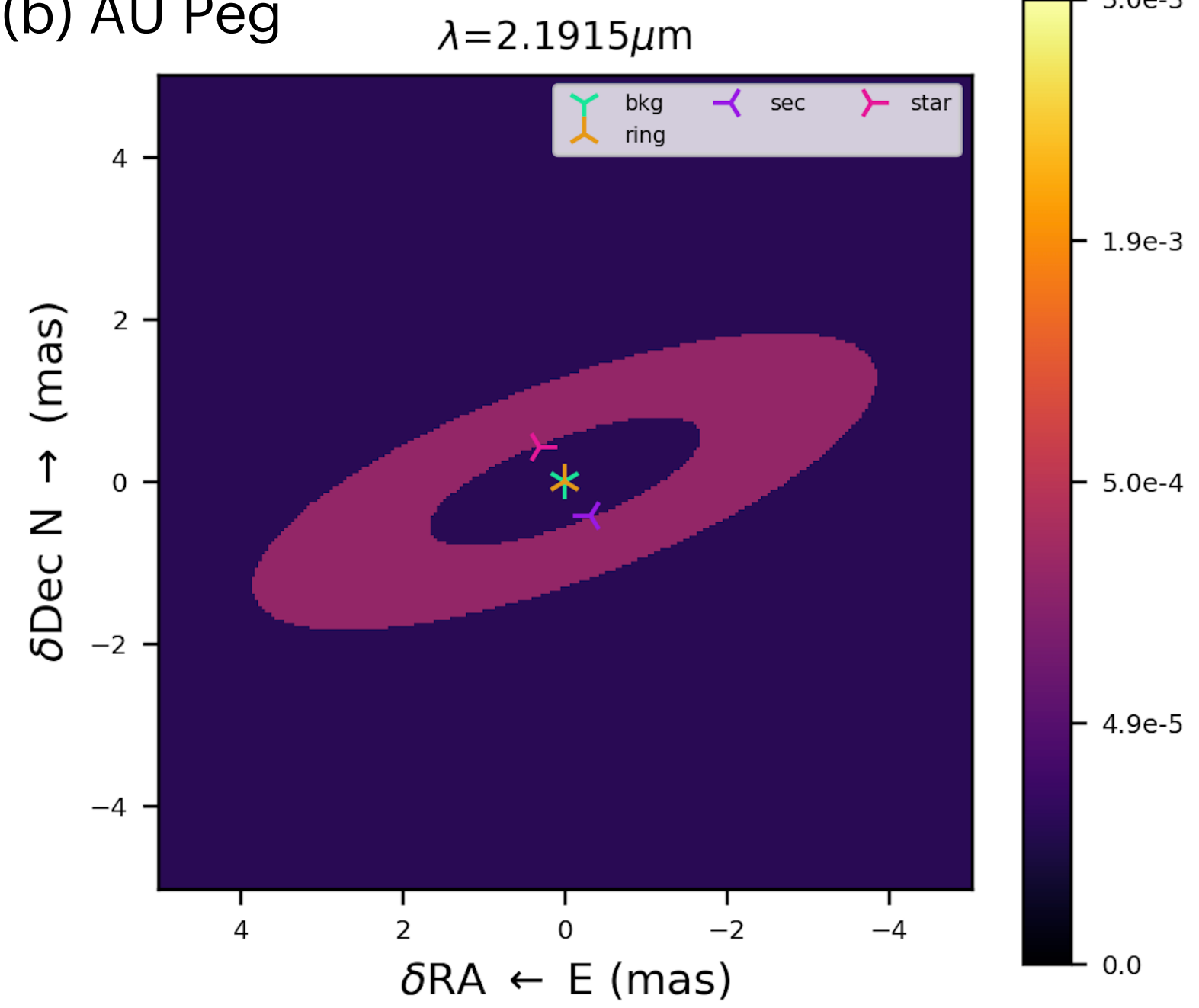


Disk-binary obscuration
in our line of sight

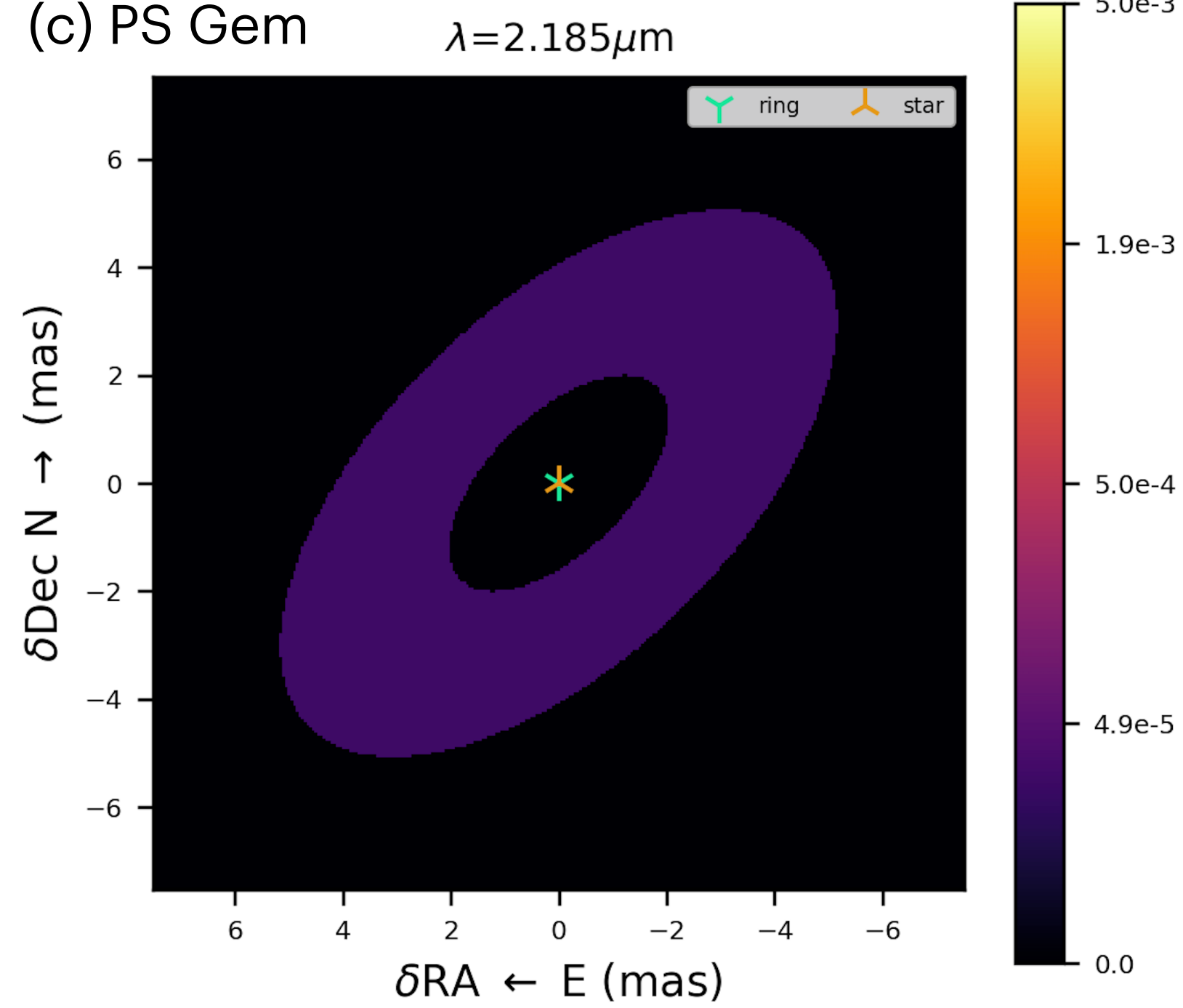
(a) TW Cam



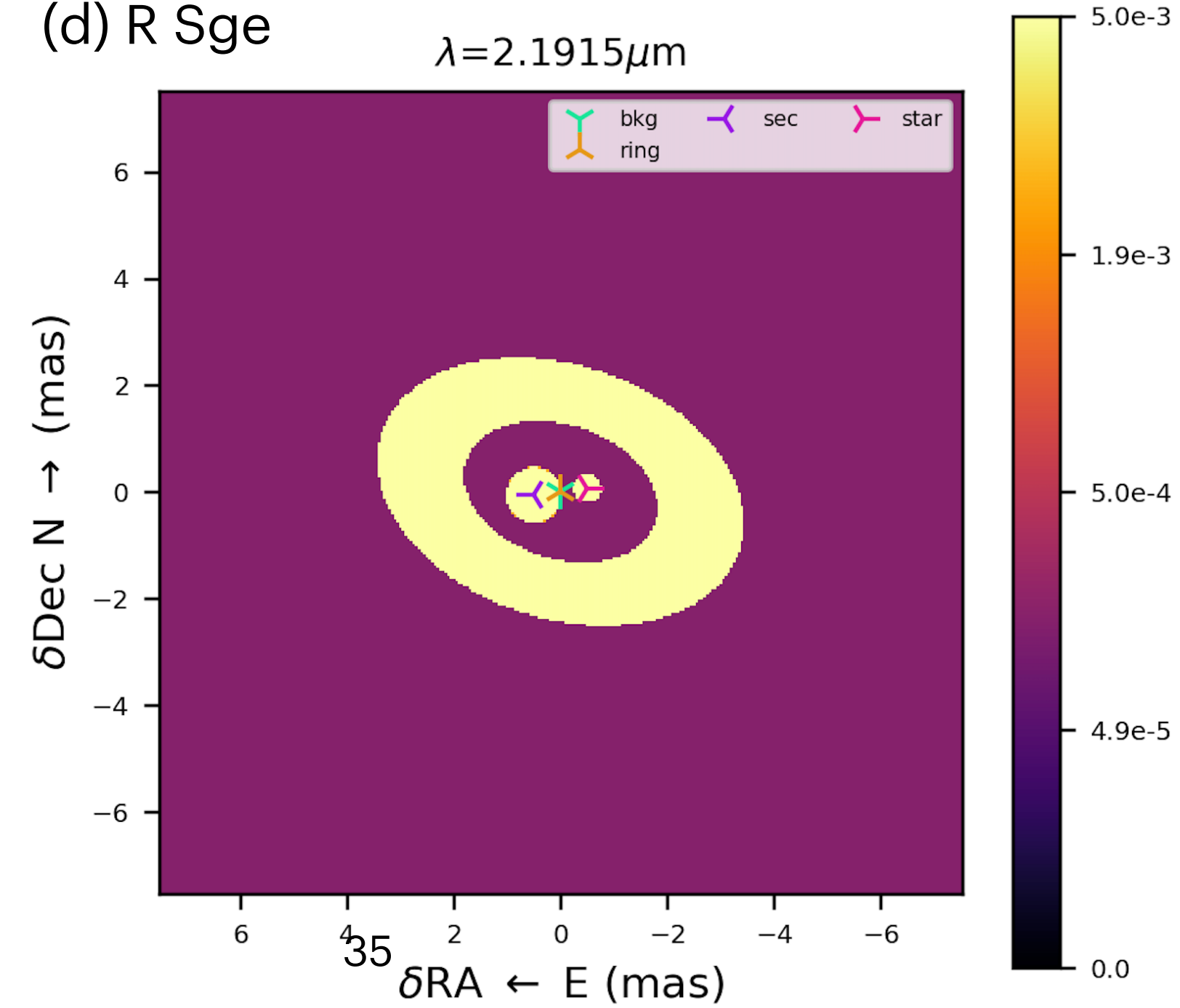
(b) AU Peg



(c) PS Gem

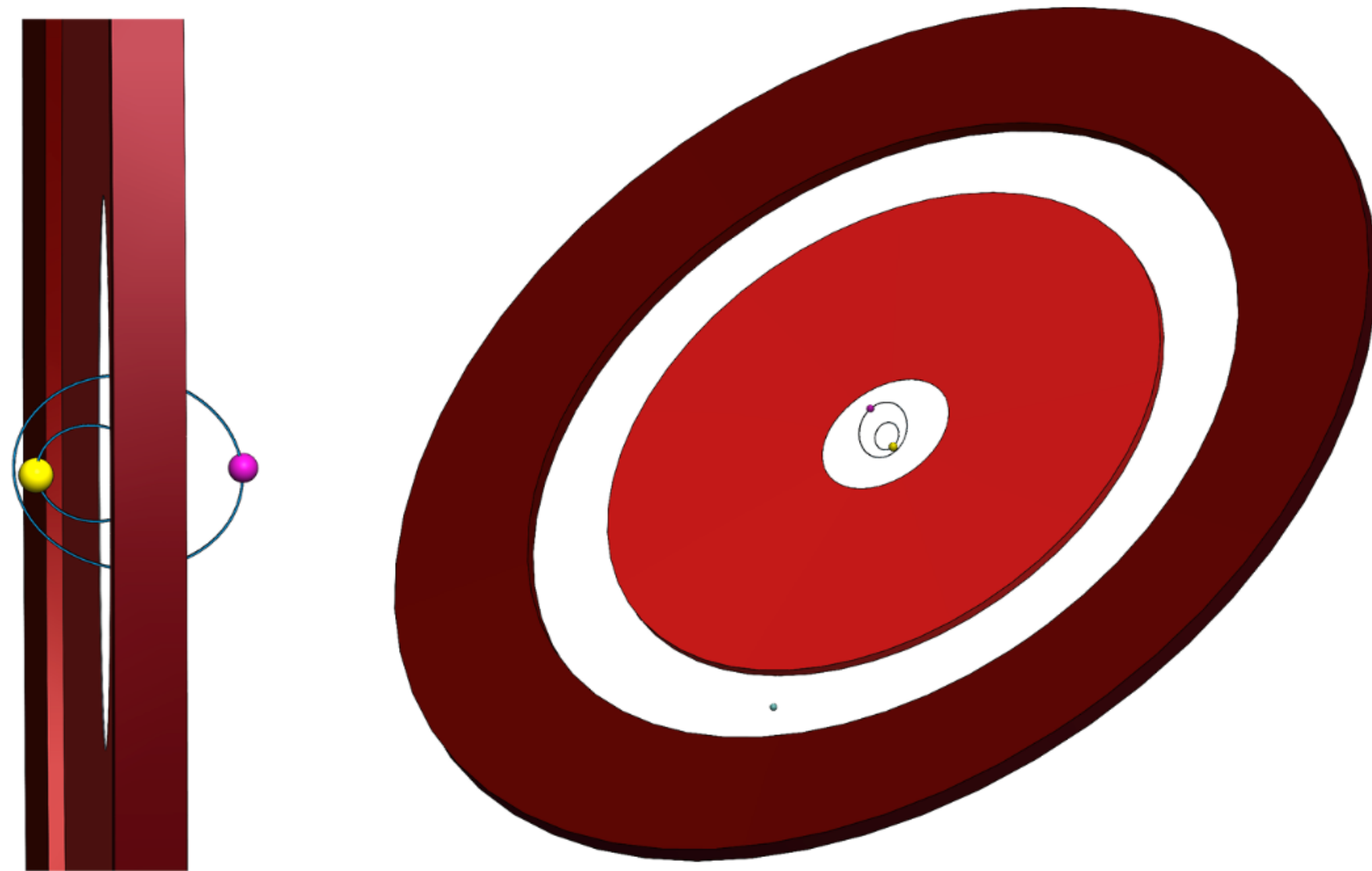


(d) R Sge



Circumbinary disks

Circumbinary disk misalignments



Made three binary orbits, found all of them misaligned:

U Mon

RV Tau

V Vul

AC Her polar circumbinary disk

Martin et al. 2023