



MACQUARIE  
University

Research Centre for  
Astronomy, Astrophysics &  
Astrophotonics

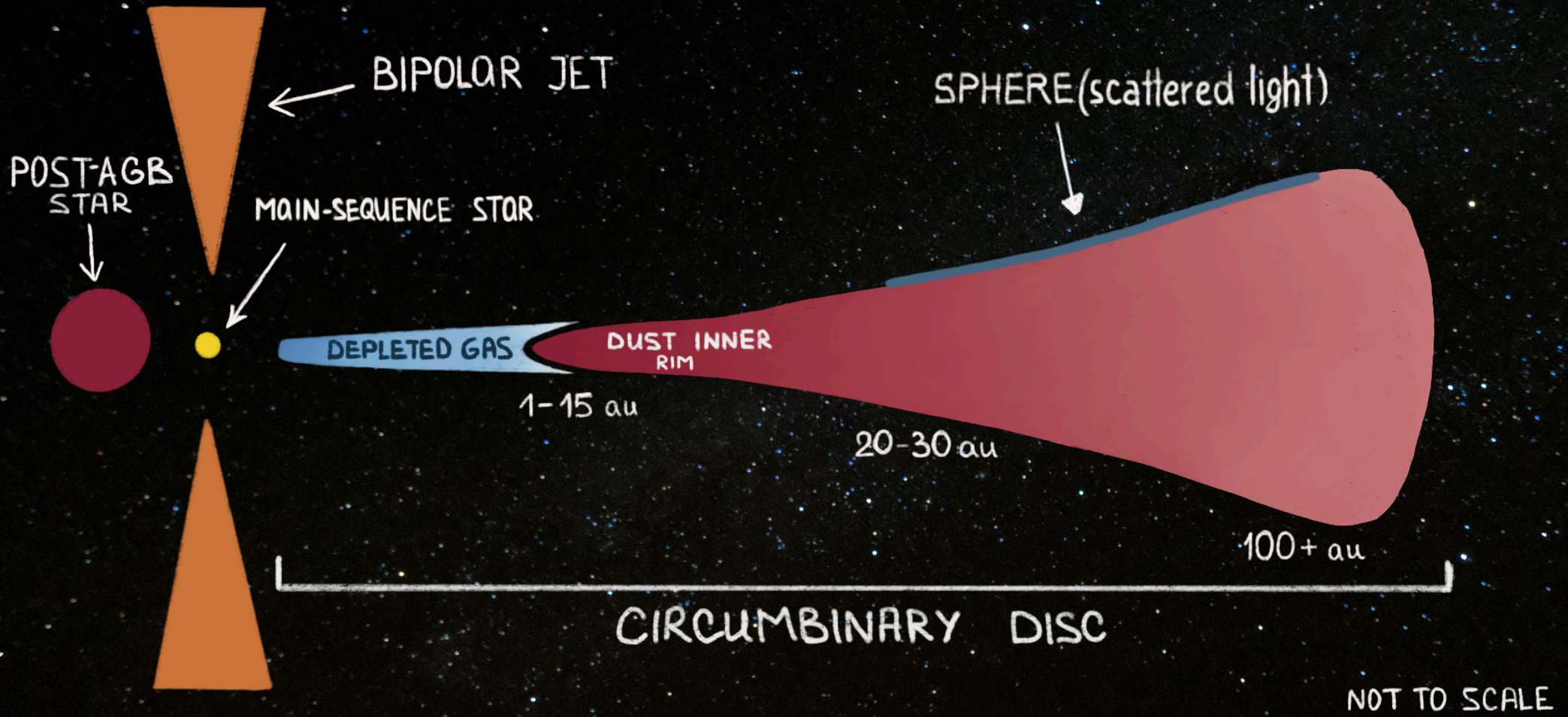
# MULTIWAVELENGTH STUDY OF CIRCUMBINARY DISKS AROUND EVOLVED BINARY STARS WITH

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**K. Andrych**, D. Kamath, H. Van Winckel, J. Kluska,  
A. Corporaal, H.M. Schmid

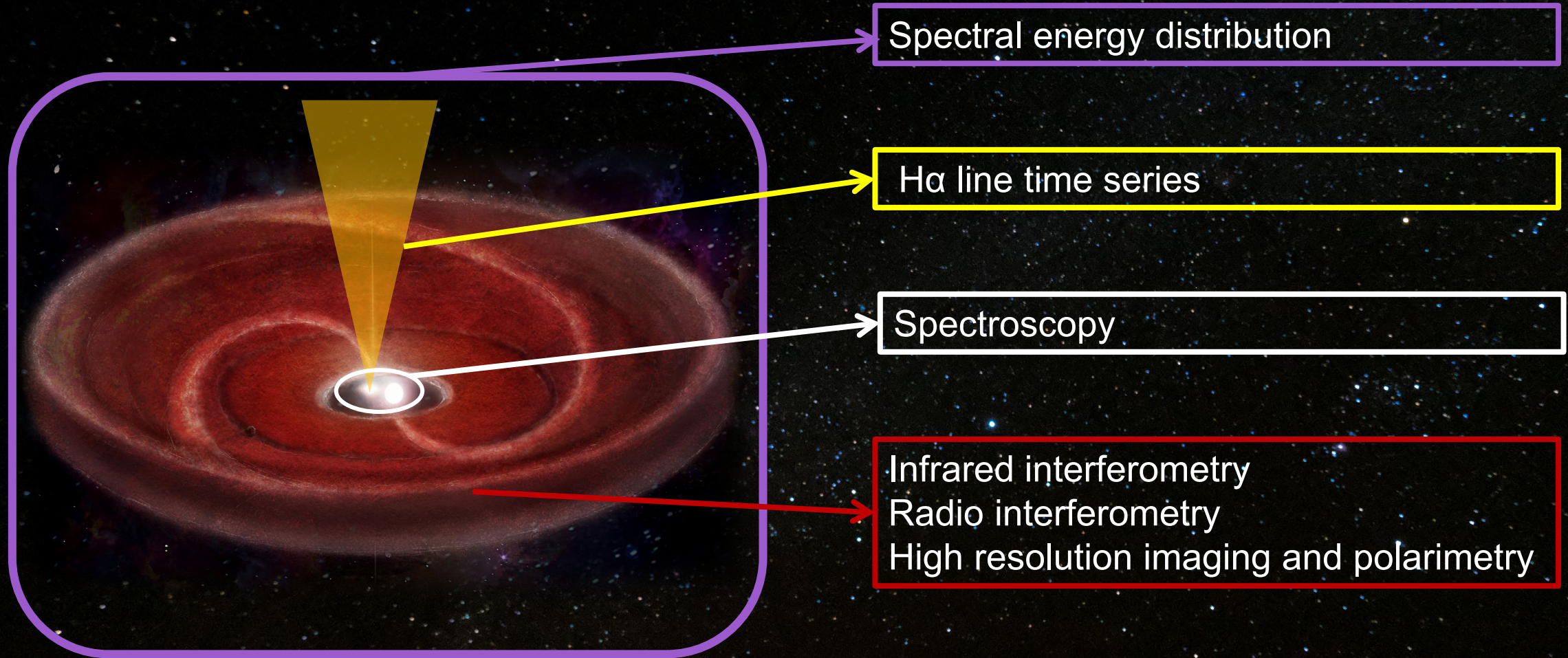


# The post-AGB binary system



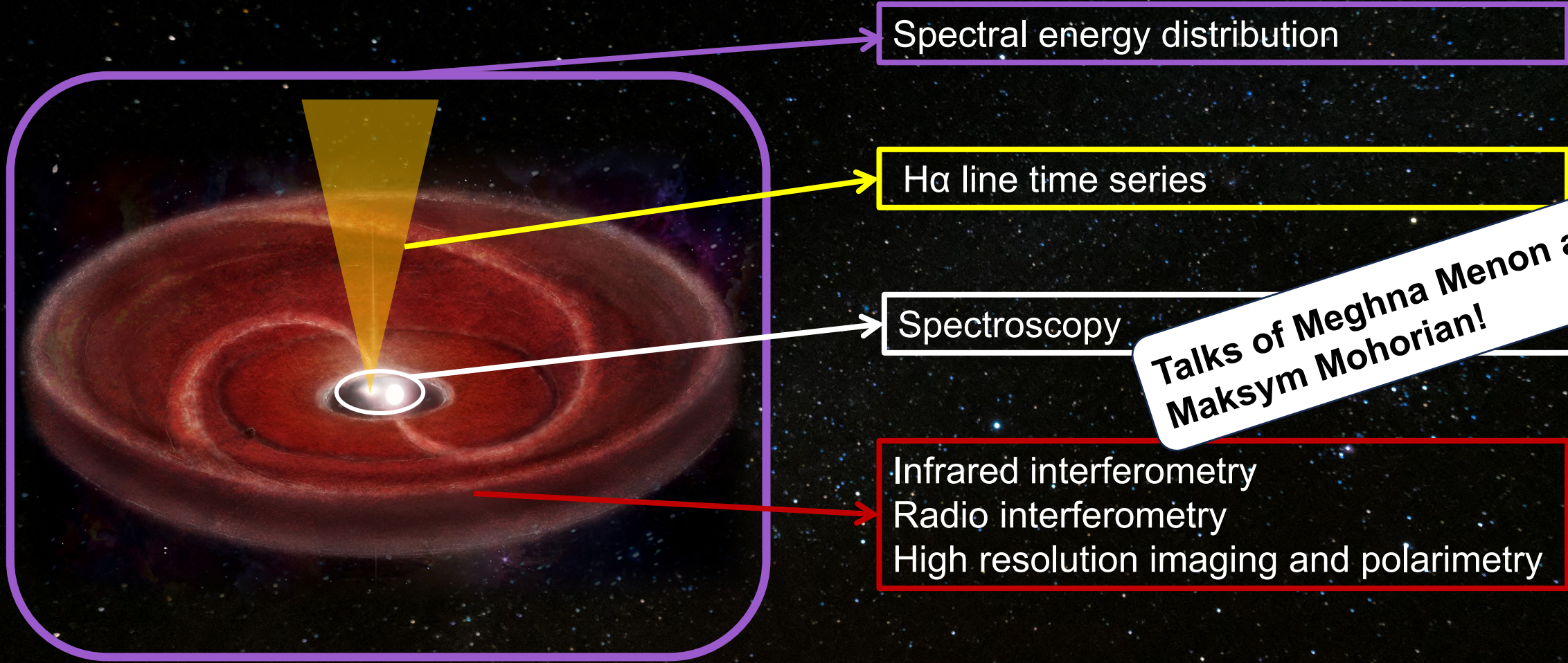


# Comprehensive study of the post-AGB binary systems





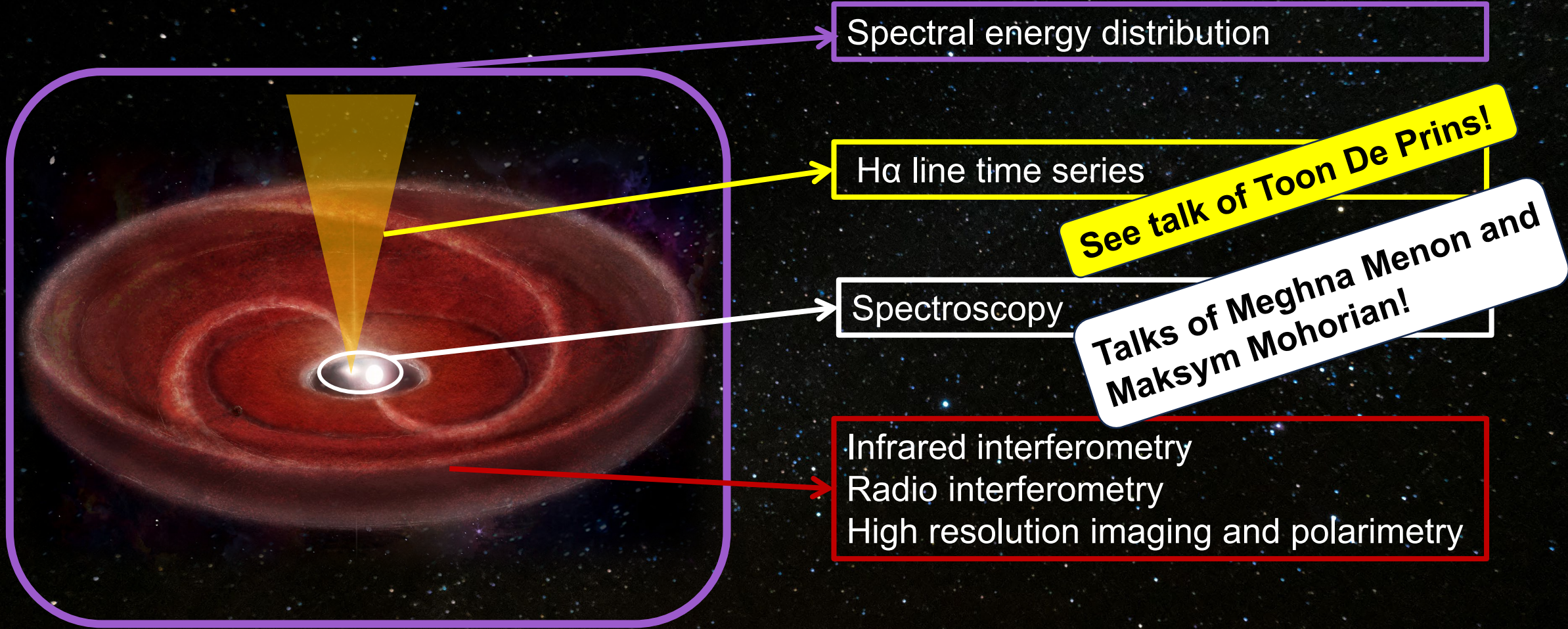
# Comprehensive study of the post-AGB binary systems



**Talks of Meghna Menon and Maksym Mohorian!**

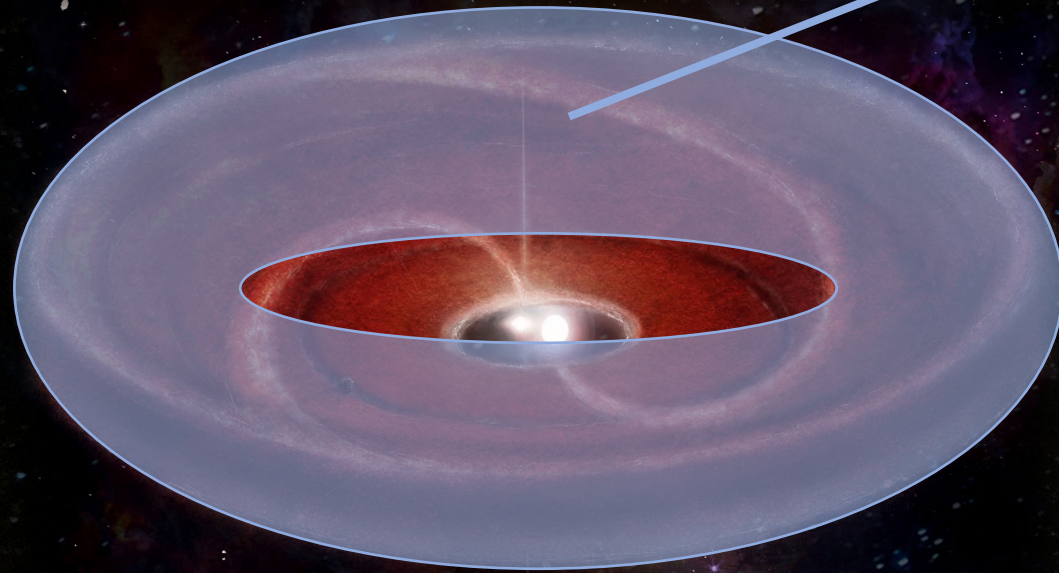


# Comprehensive study of the post-AGB binary systems



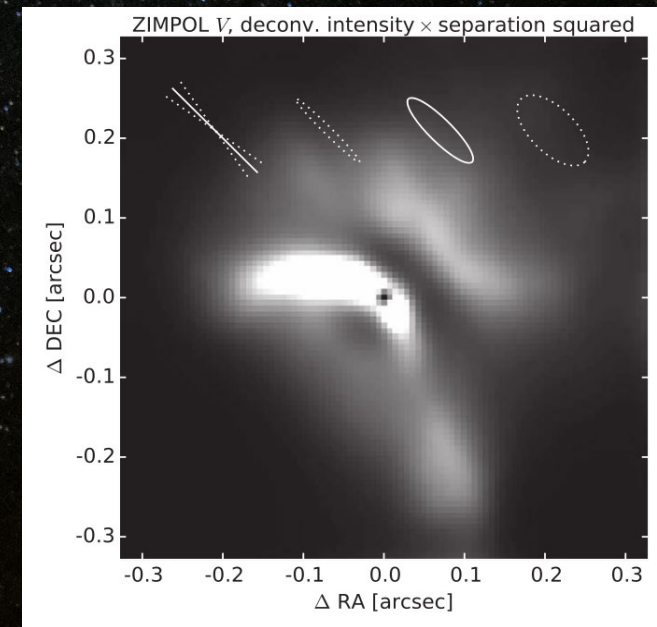


# Comprehensive study of the post-AGB binary systems



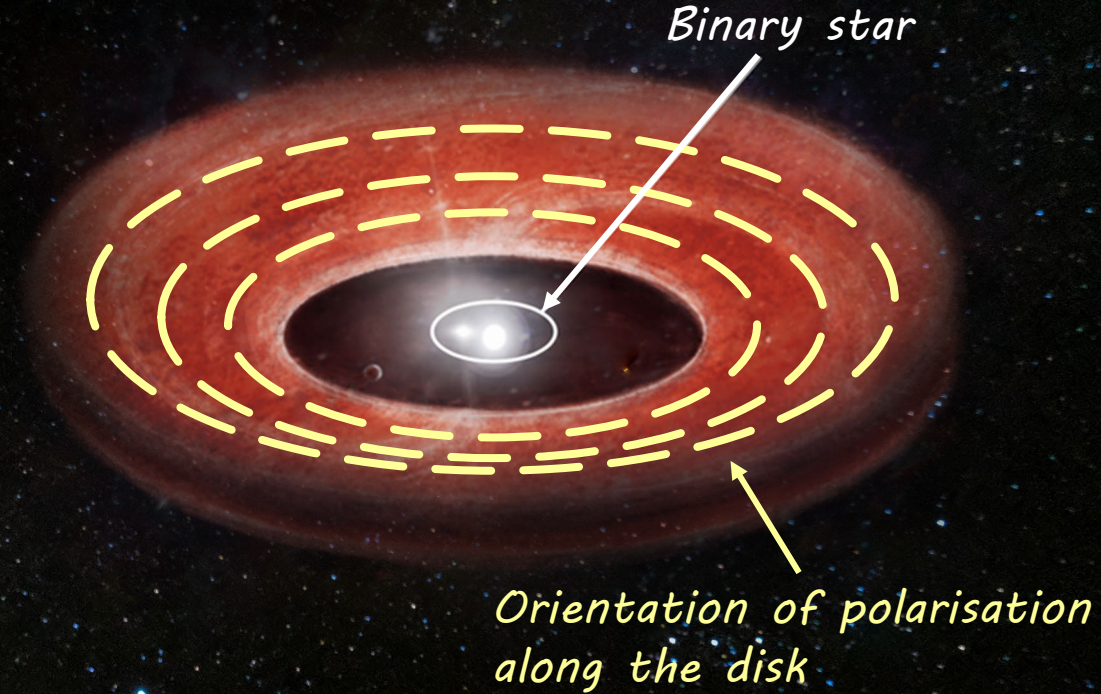
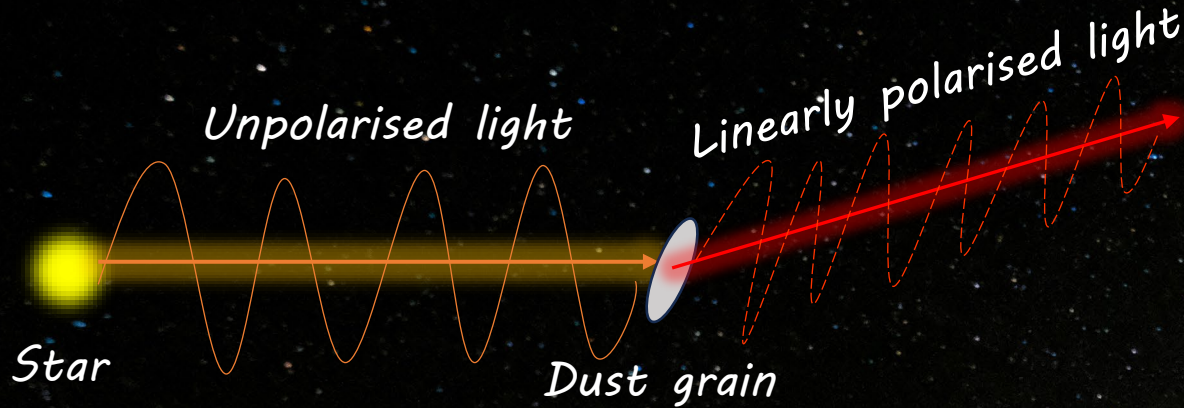
## High resolution imaging and polarimetry

- Morphology of the extended disk
- Dust grain sizes and properties



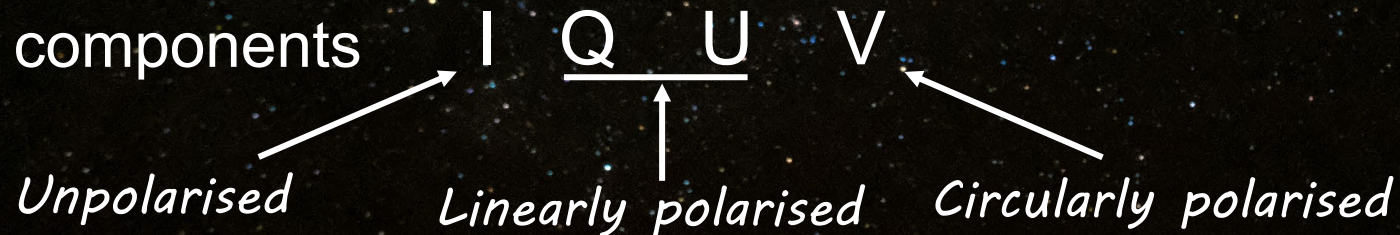


# Polarisation of the stellar light



Observational data:

Stokes components





# Observations and sample of objects



SPHERE

ZIMPOL: V (554 nm) and I (817.3 nm) bands

IRDIS: H (1625 nm) band



11 representative post-AGB stars

- 5 with IRDIS and ZIMPOL

- 4 with IRDIS

- 2 with ZIMPOL

- Temperature range: 4250-7250 K
- Orbital period range: 300-2500 days
- Inclination range: 20-80°
- Range of chemical composition and SED



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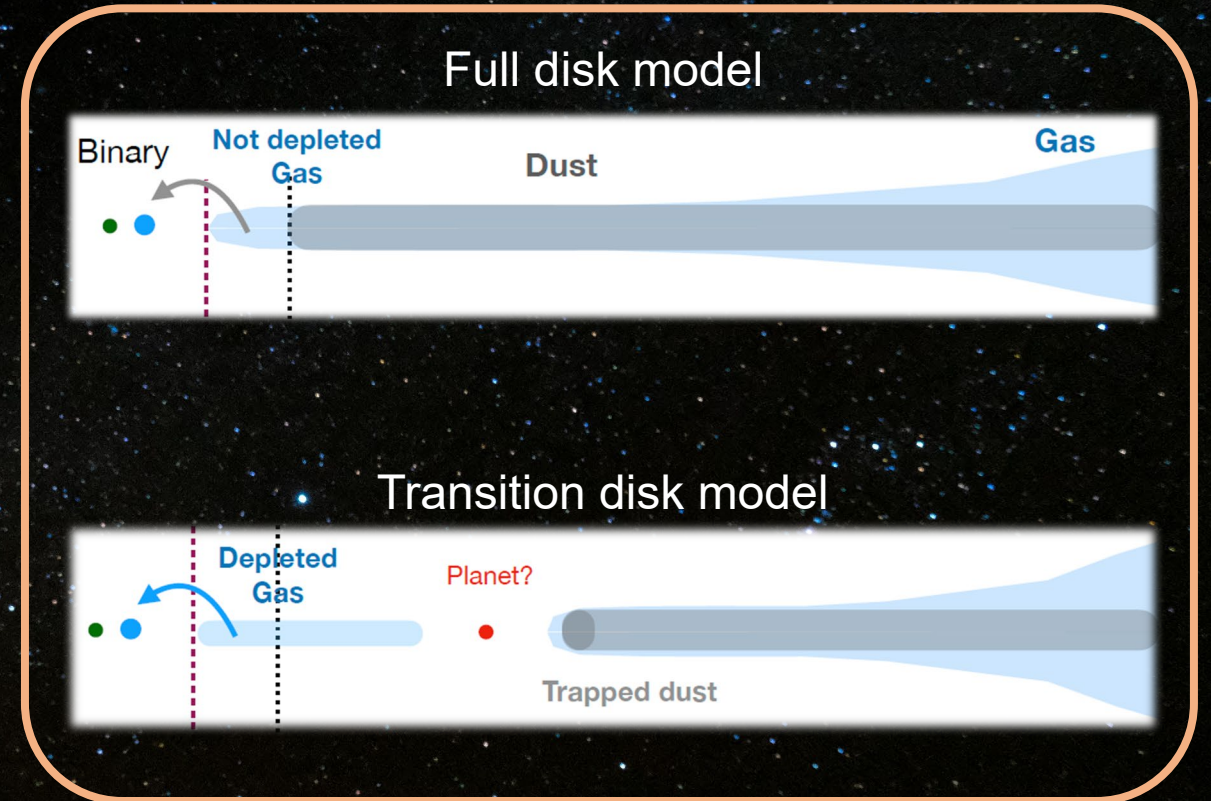
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Kluska et. al. 2022, Corporaal et al., 2023



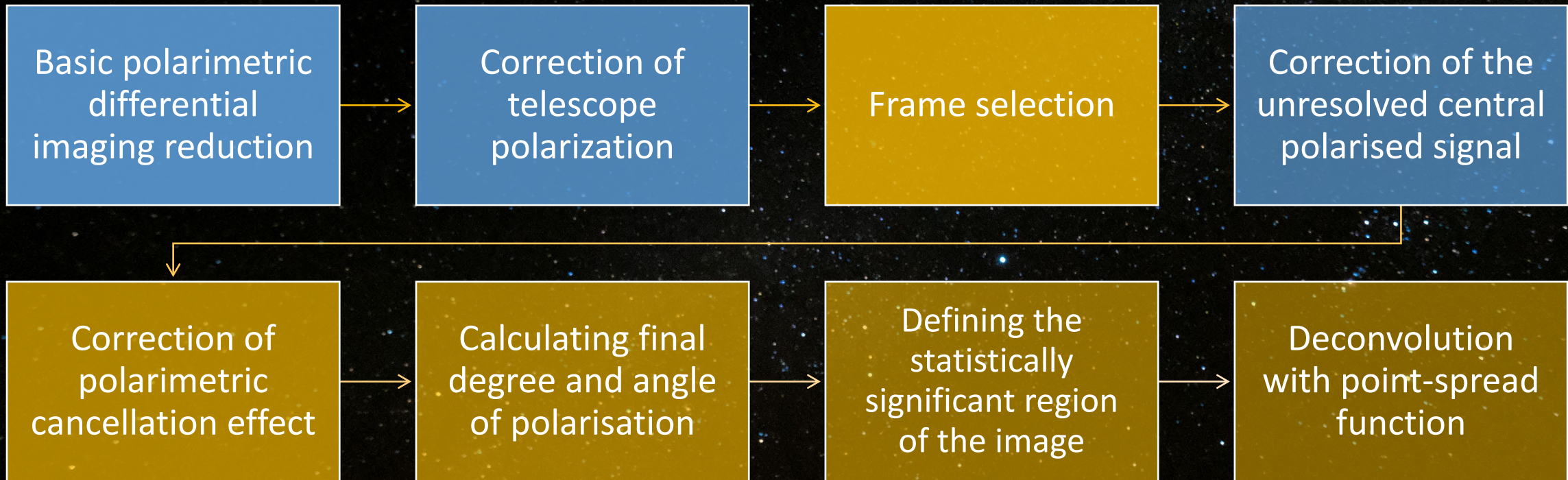
# Data reduction for polarimetric observations

IRDIS camera:

- IRDAP (van Holstein et al. 2020)

ZIMPOL camera:

- SPHERE-DC (Delorme et al. 2017)
- SZ software (Schmid et al. 2018)

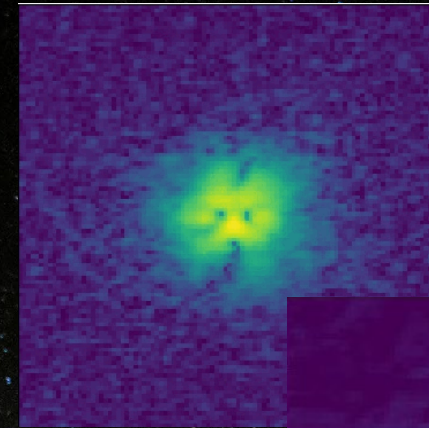
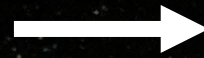




# Data reduction for polarimetric observations

*An example object IRAS08544-4431, I band*

Basic reduction



Correction for unresolved polarisation

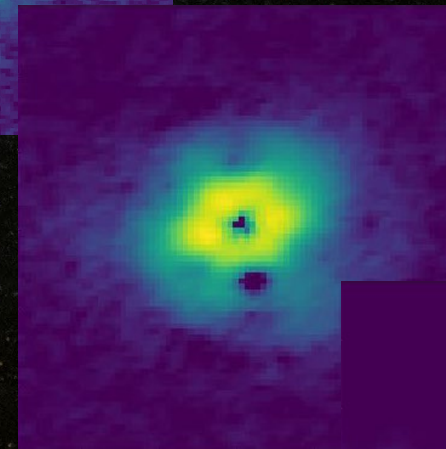
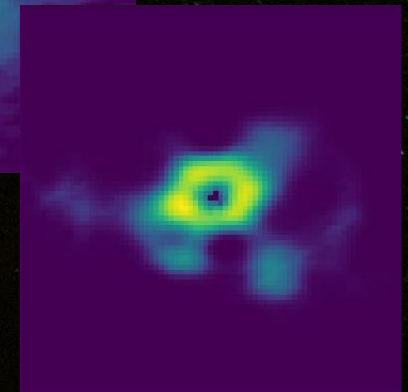
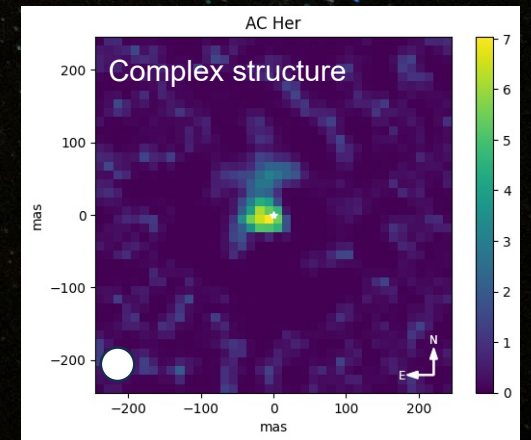
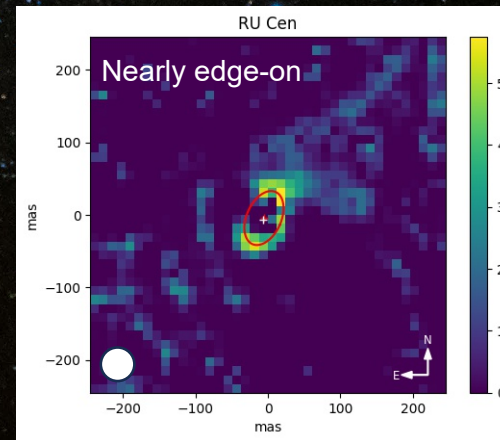
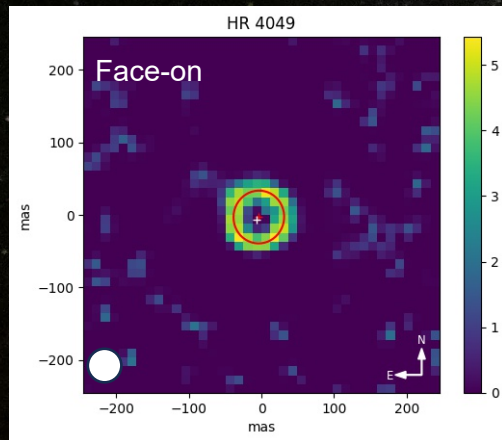
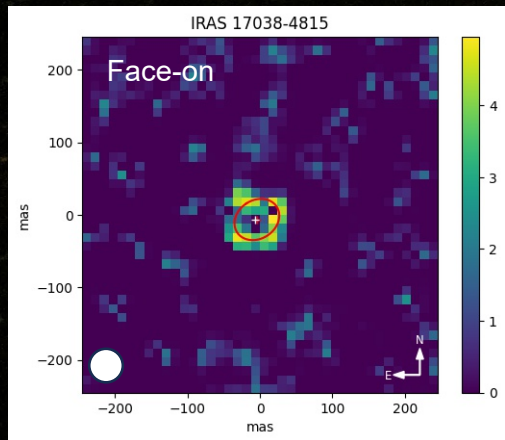
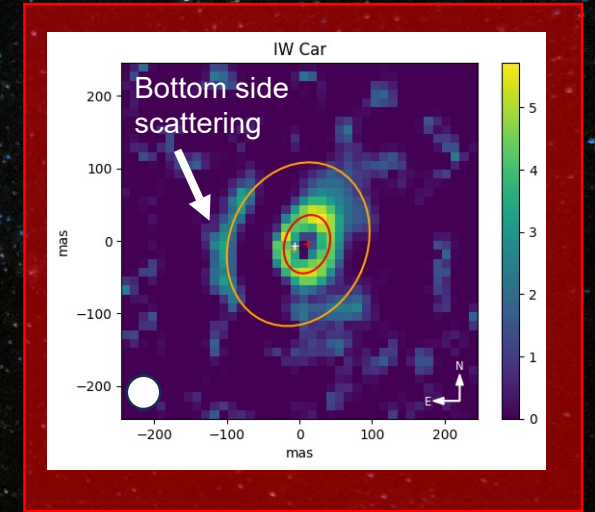
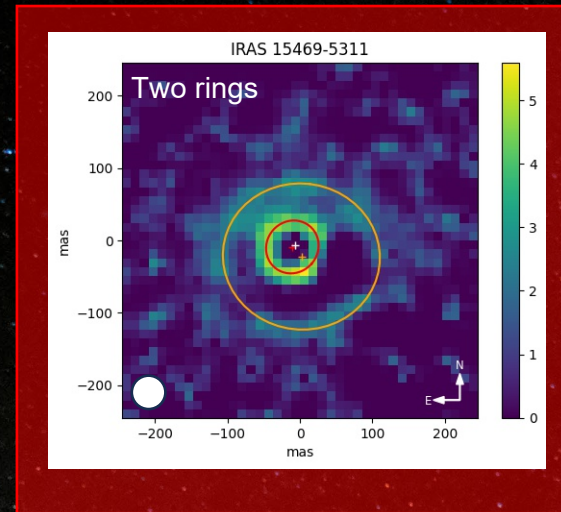
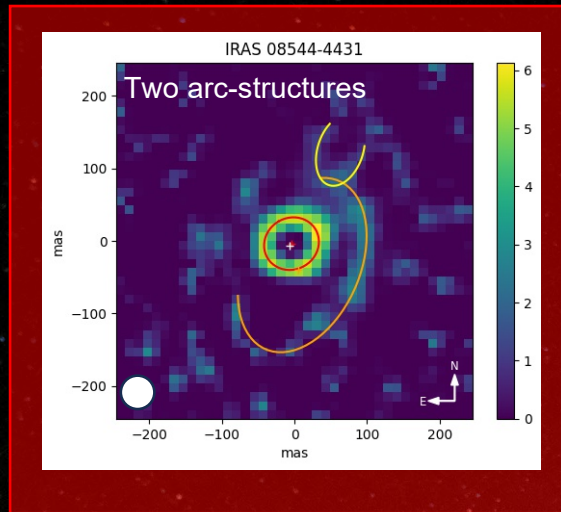
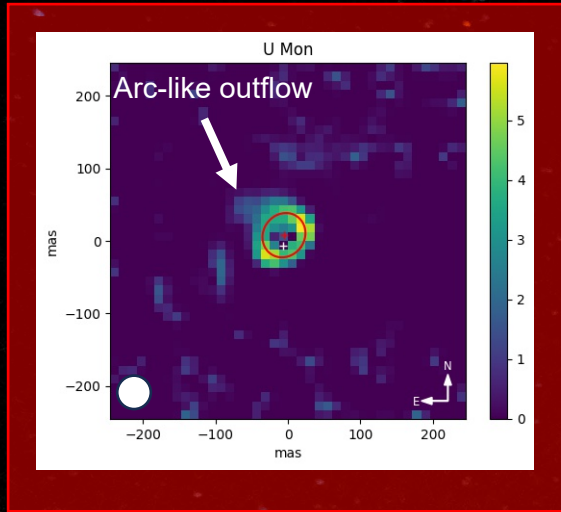


Image after deconvolution  
*Richardson-Lucy algorithm*



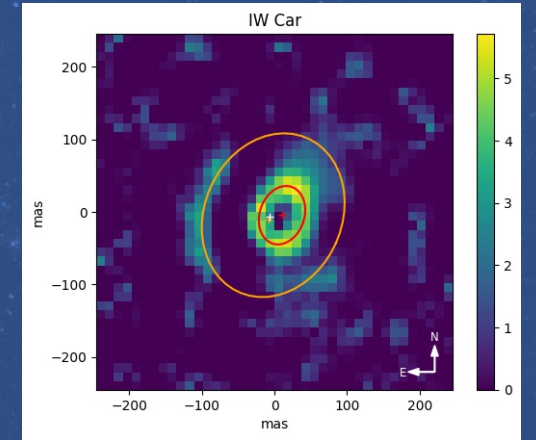
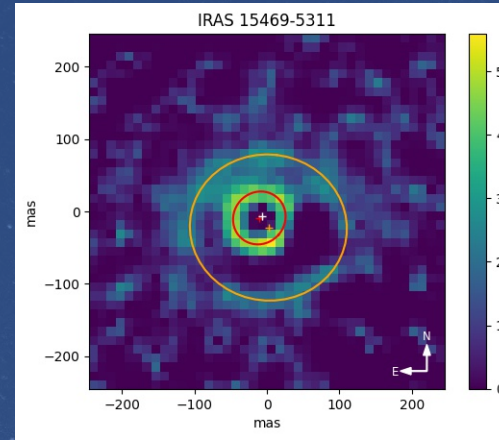
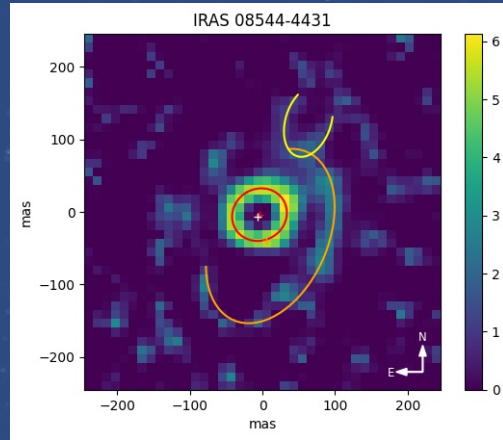
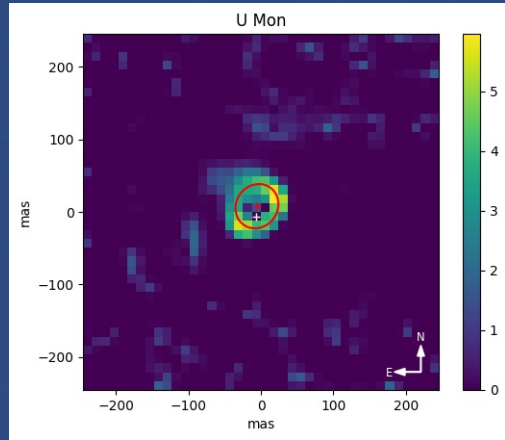


# Result: variety of complex structures

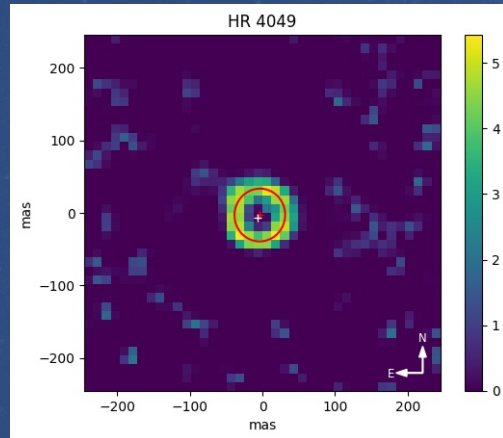
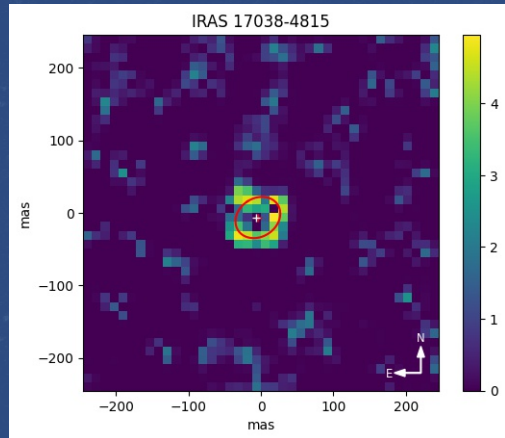




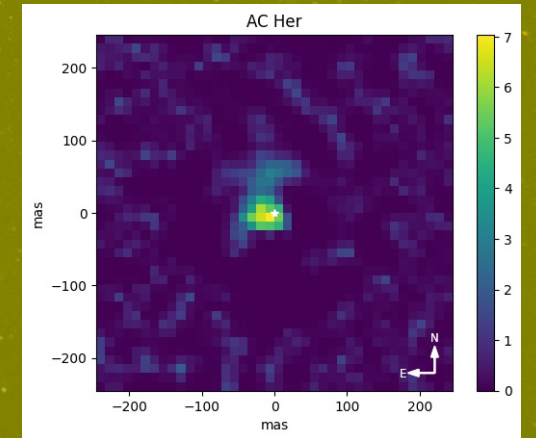
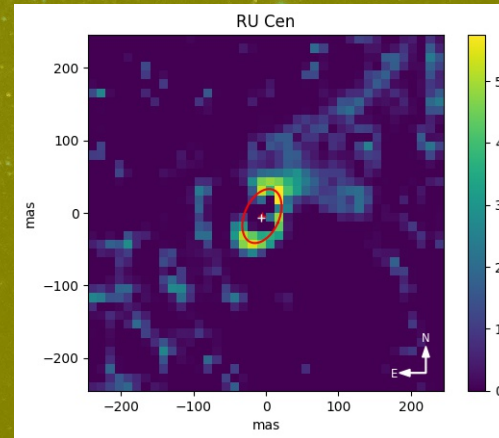
# Results: only full discs show clear elliptical disc surface



Full disks

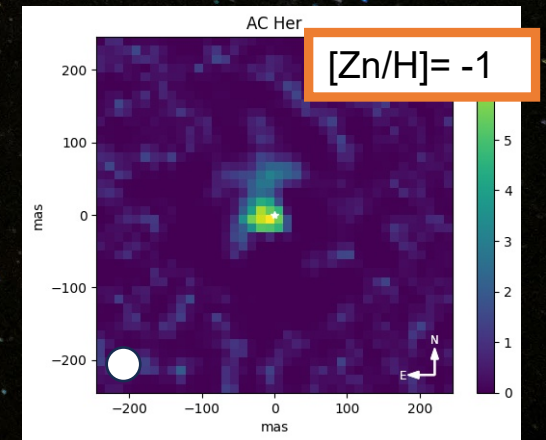
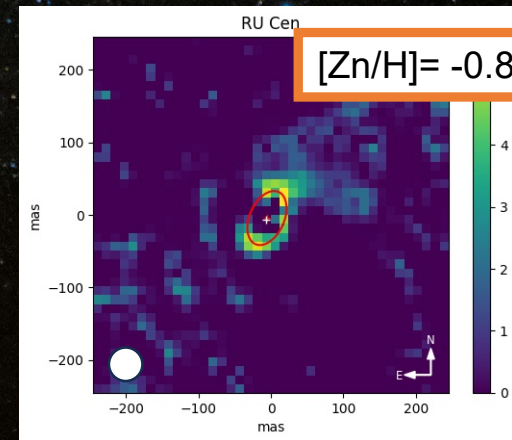
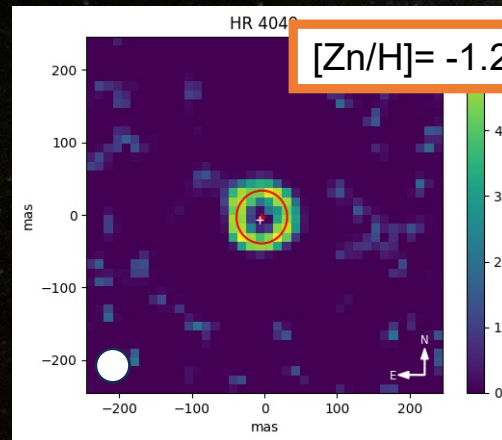
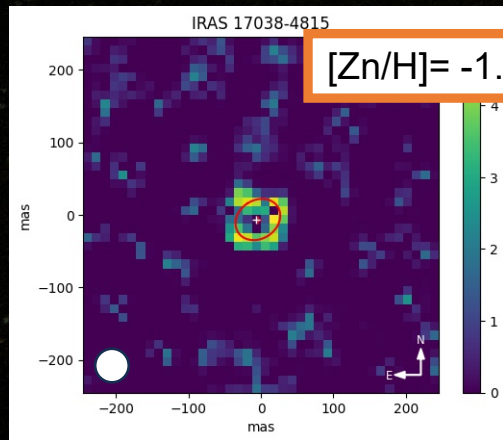
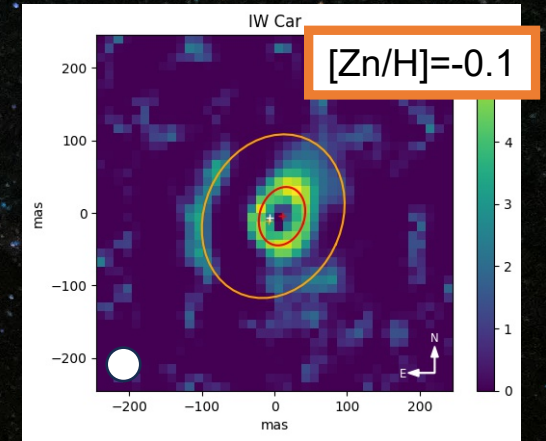
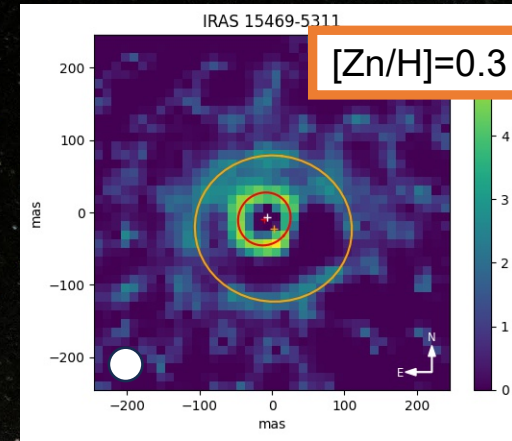
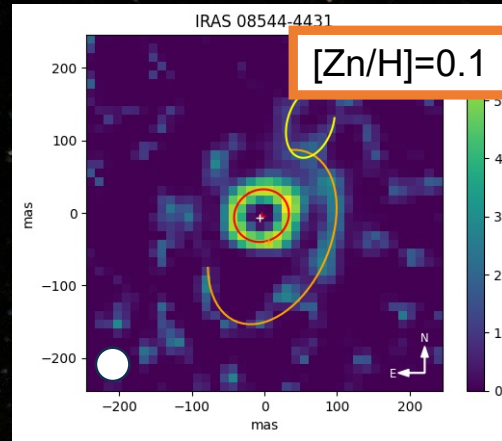
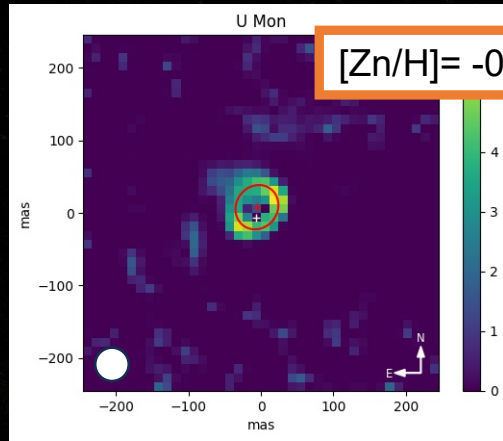


Transition disks



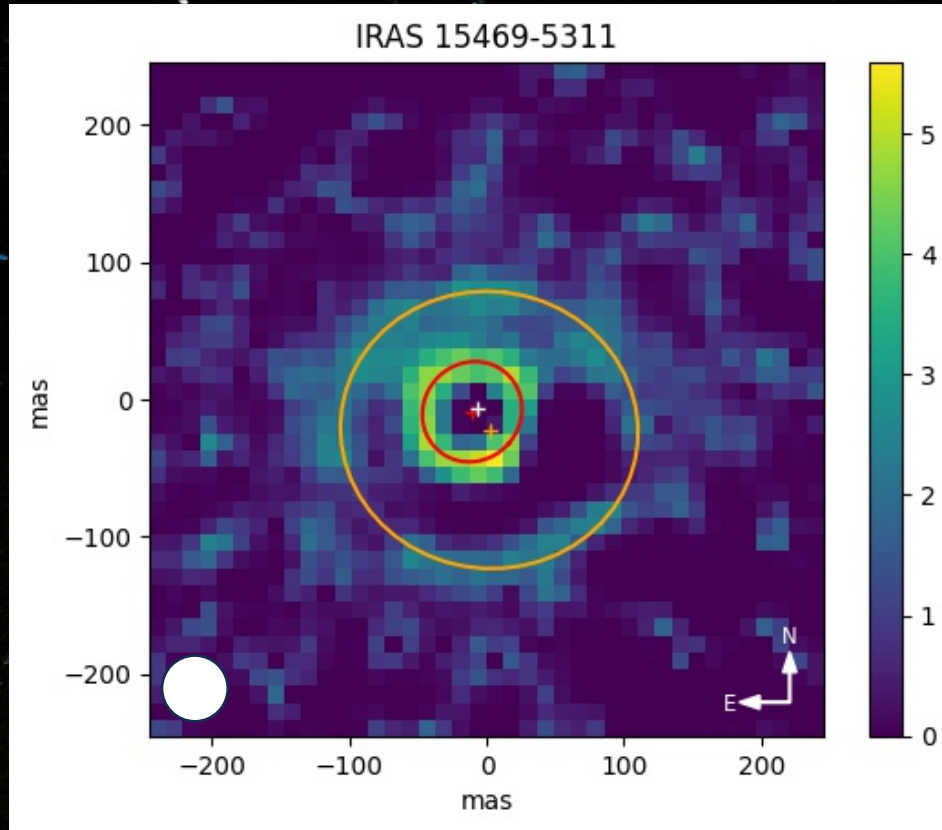


# Results: dust-metallicity dependence

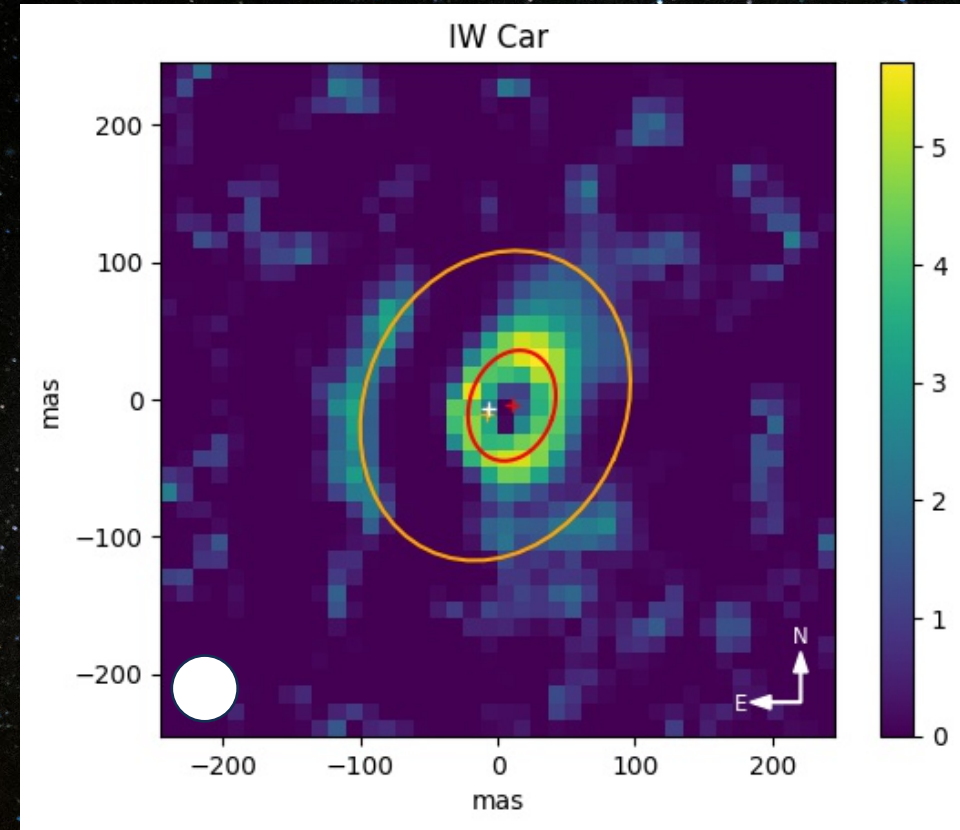




# Results: first direct measurement of the post-AGB disk scale-height



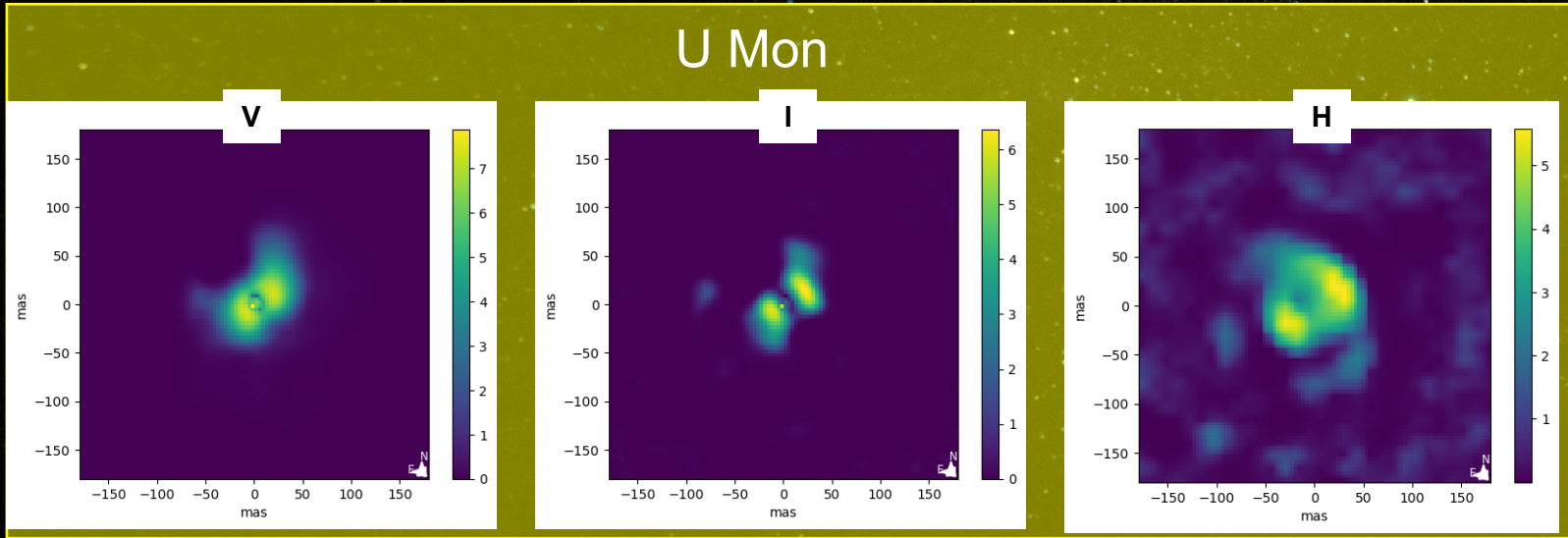
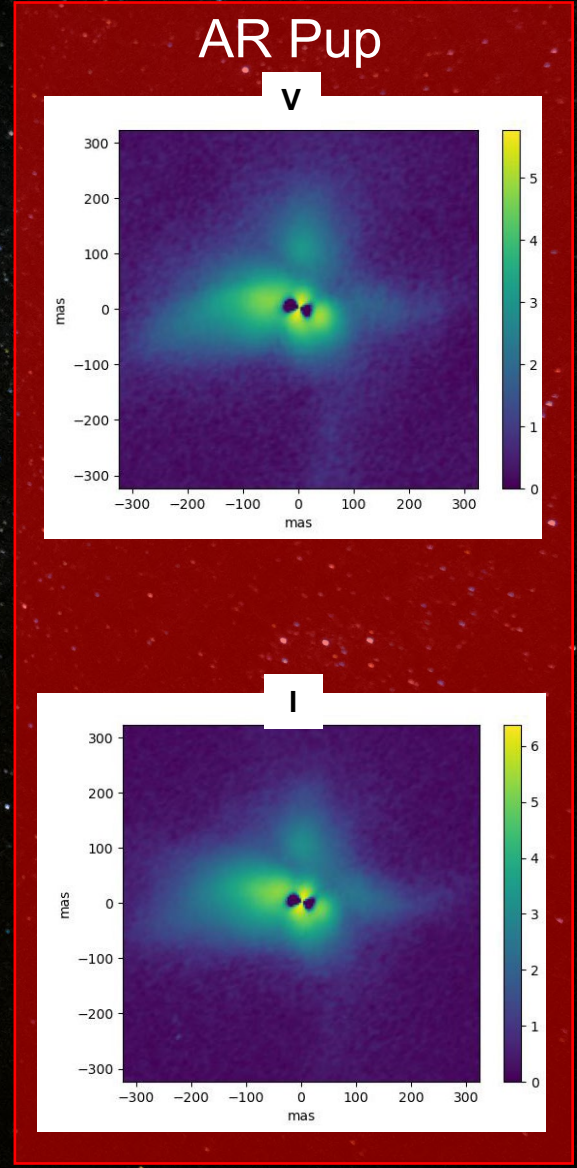
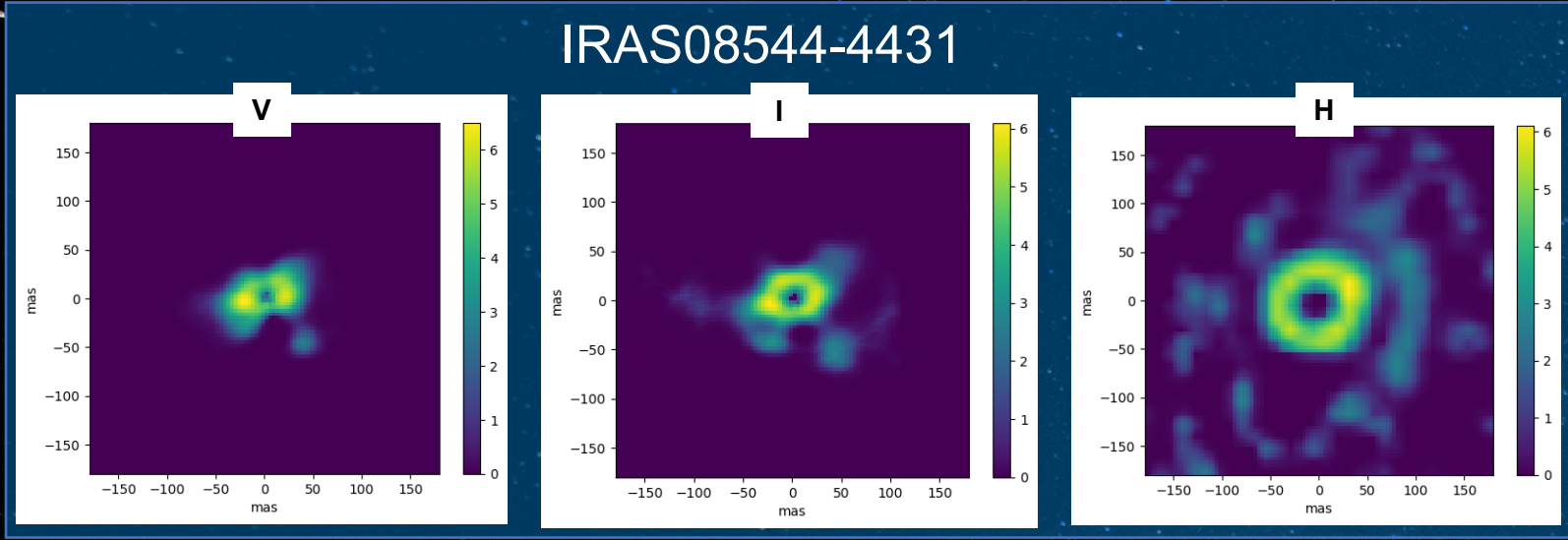
height above the mid-plane  $\sim 190$  AU for the separation from the central binary of  $\sim 1100$  AU



total height of the disc  $\sim 90$  AU  
detected scattered emission to  $\sim 250$  AU



# Preliminary results: ZIMPOL vs IRDIS



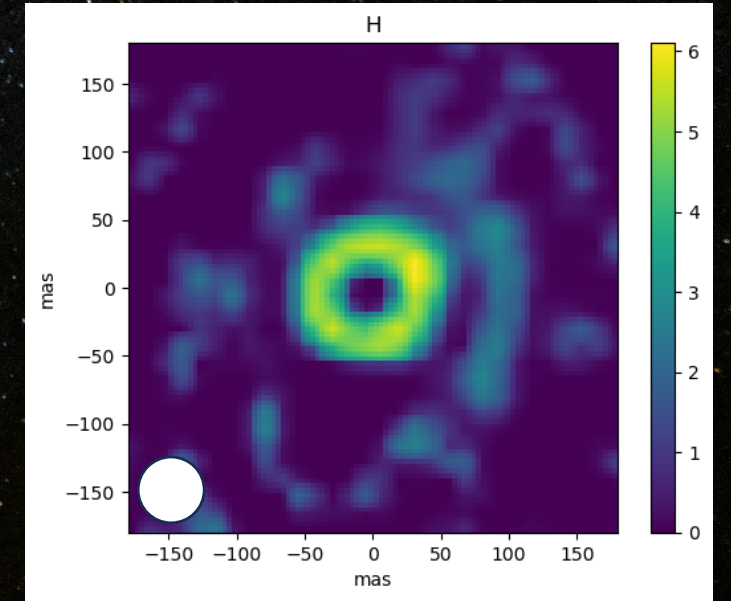
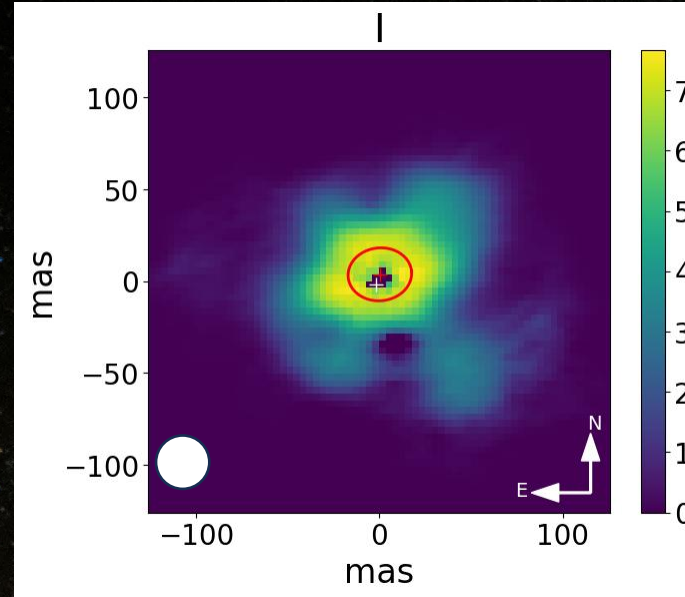
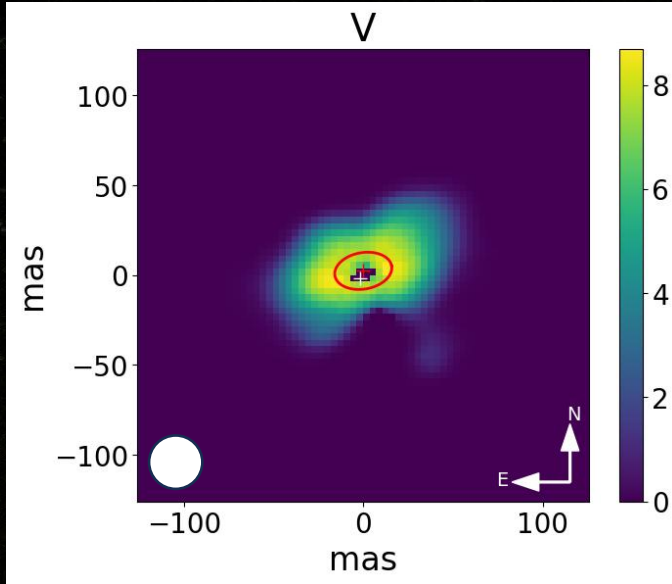


## Multiwavelength case study of IRAS 08544-4431



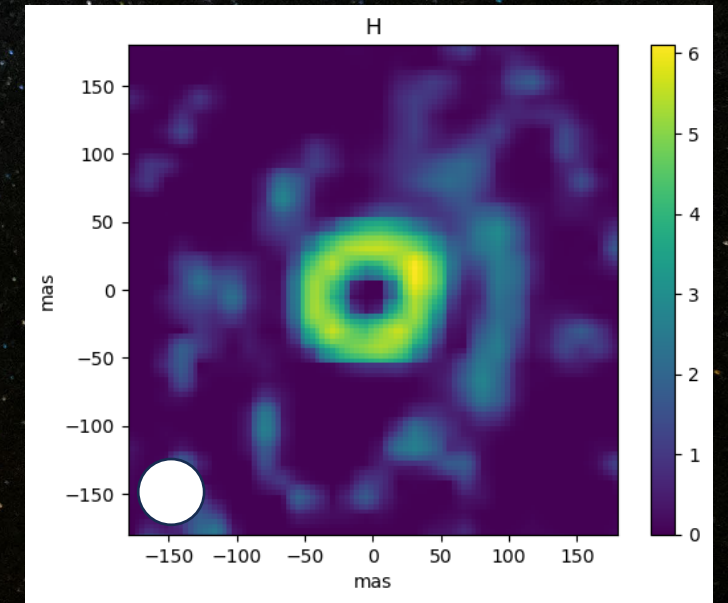
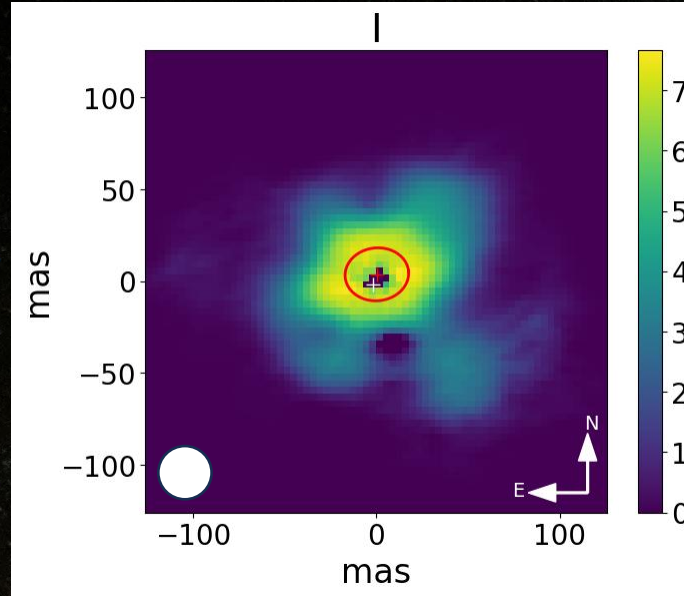
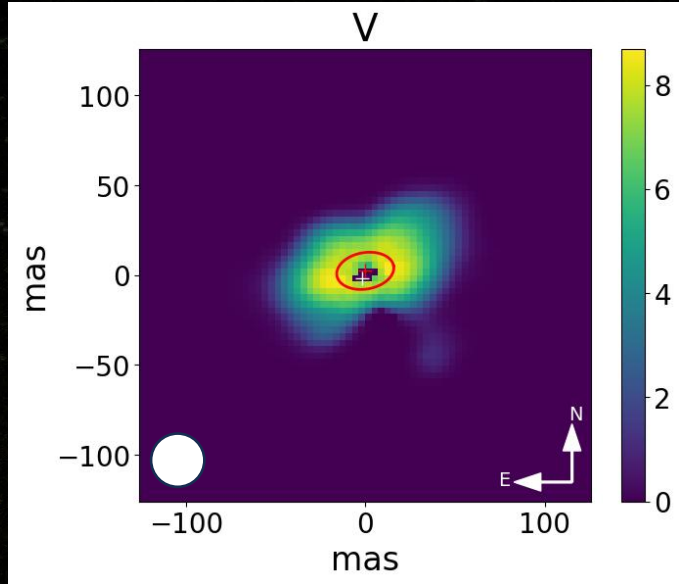
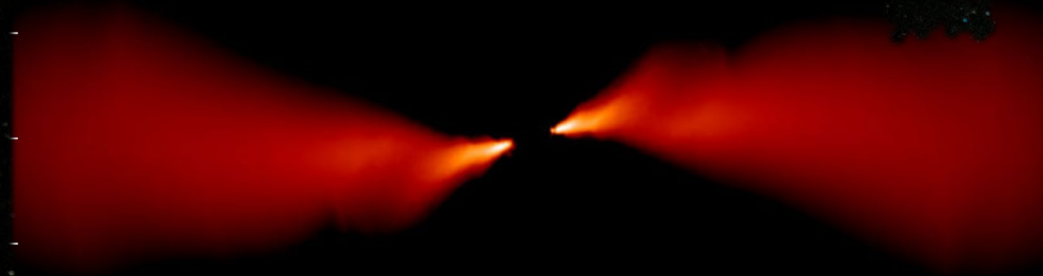
# Multiwavelength results: IRAS 08544-4431

band	$a$ [mas]	$b$ [mas]	$i$ [ $^{\circ}$ ]	$PA$ [ $^{\circ}$ ]	$e$
V	$22.2^{+4}_{-3}$	$13^{+2}_{-2}$	$55^{+10}_{-12}$	$102^{+10}_{-10}$	0.82
I	$23^{+1}_{-1}$	$18^{+1}_{-1}$	$40^{+5}_{-6}$	$102^{+8}_{-8}$	0.65
H	$38.6^{+1.2}_{-1.2}$	$35.5^{+1.5}_{-1.4}$	$23^{+7}_{-15}$	$121^{+27}_{-30}$	0.39





# Multiwavelength results: IRAS 08544-4431

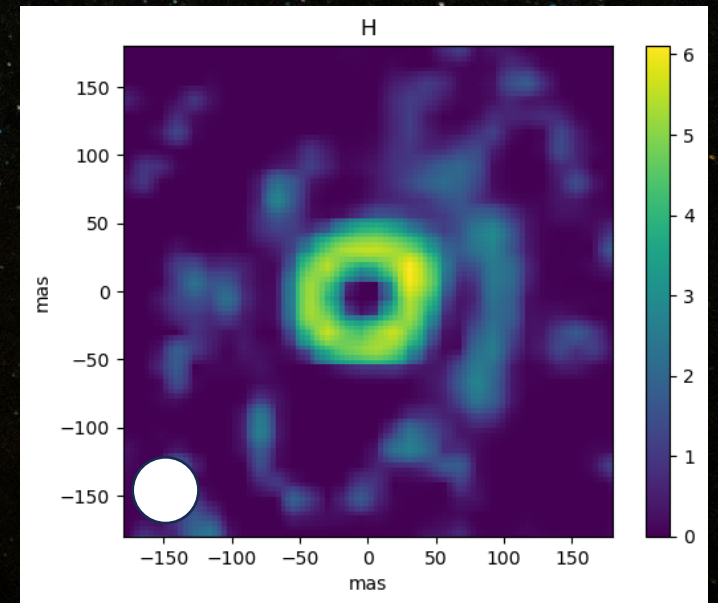
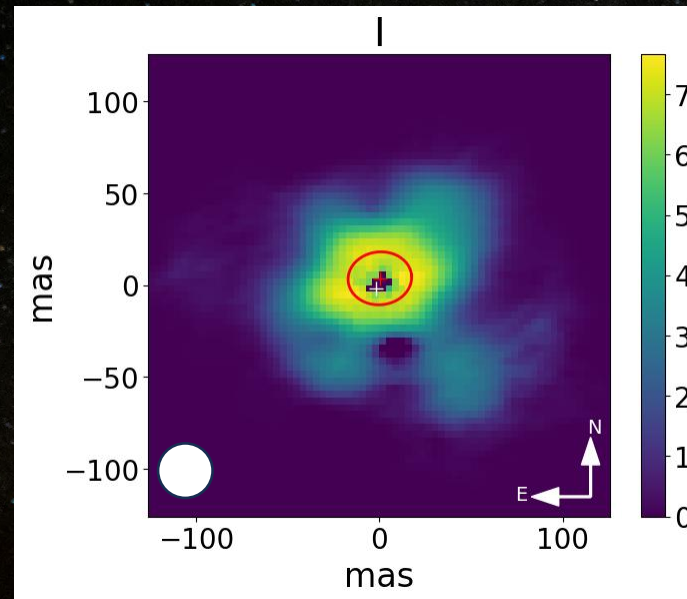
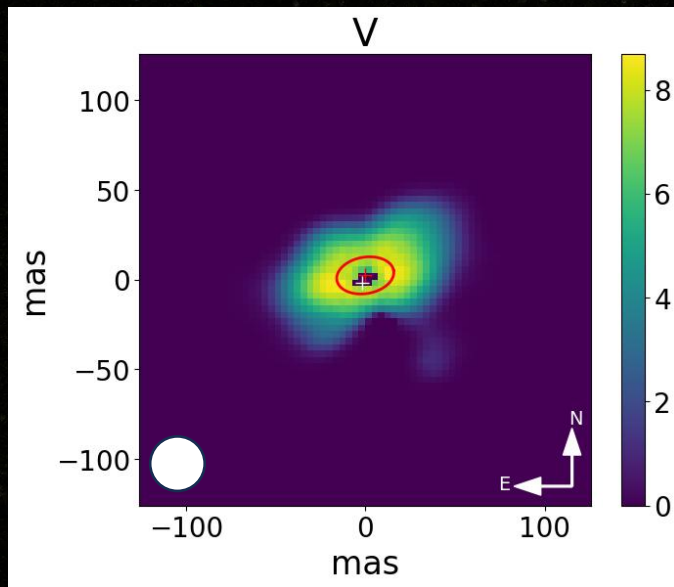
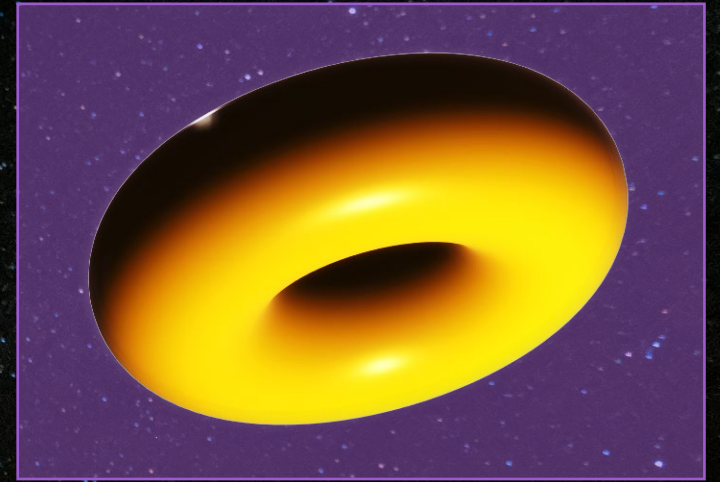


Higher inclination and lower extension of the disk with shorter wavelength  $\rightarrow$  warp in the disk?



# Multiwavelength results: IRAS 08544-4431

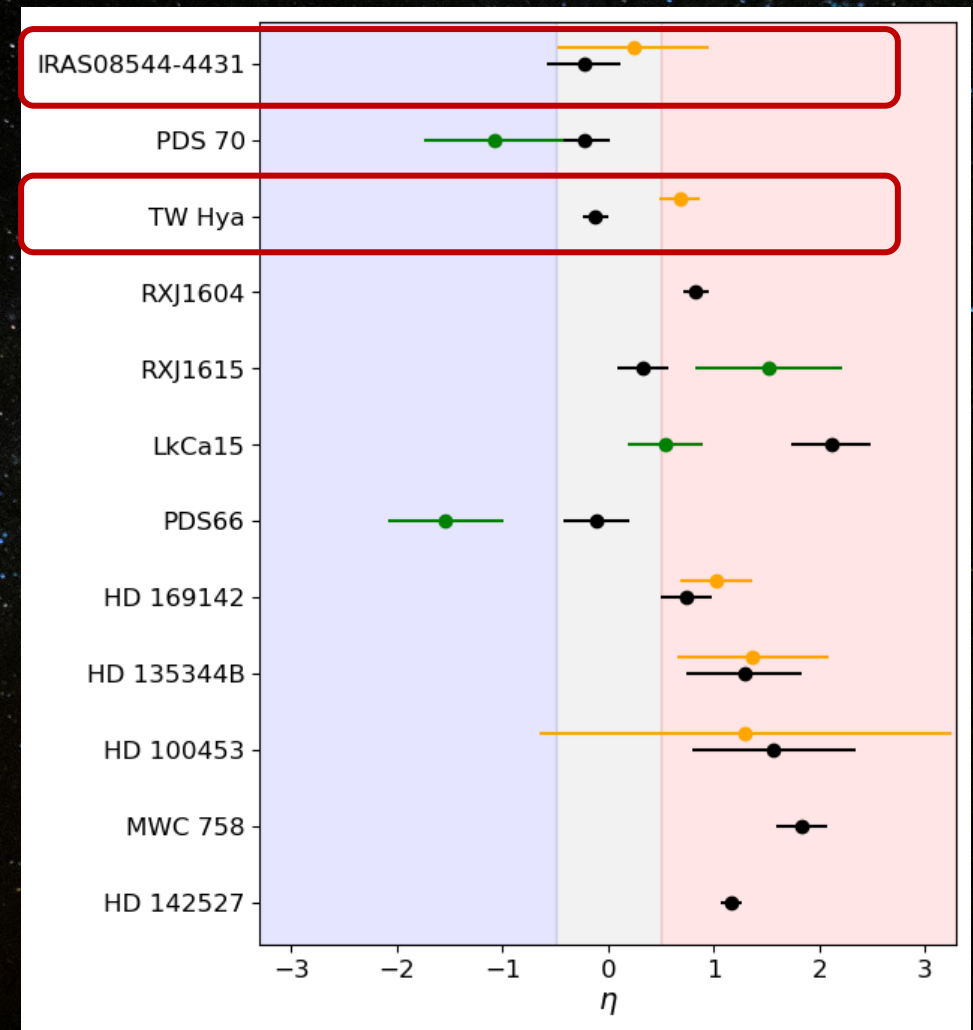
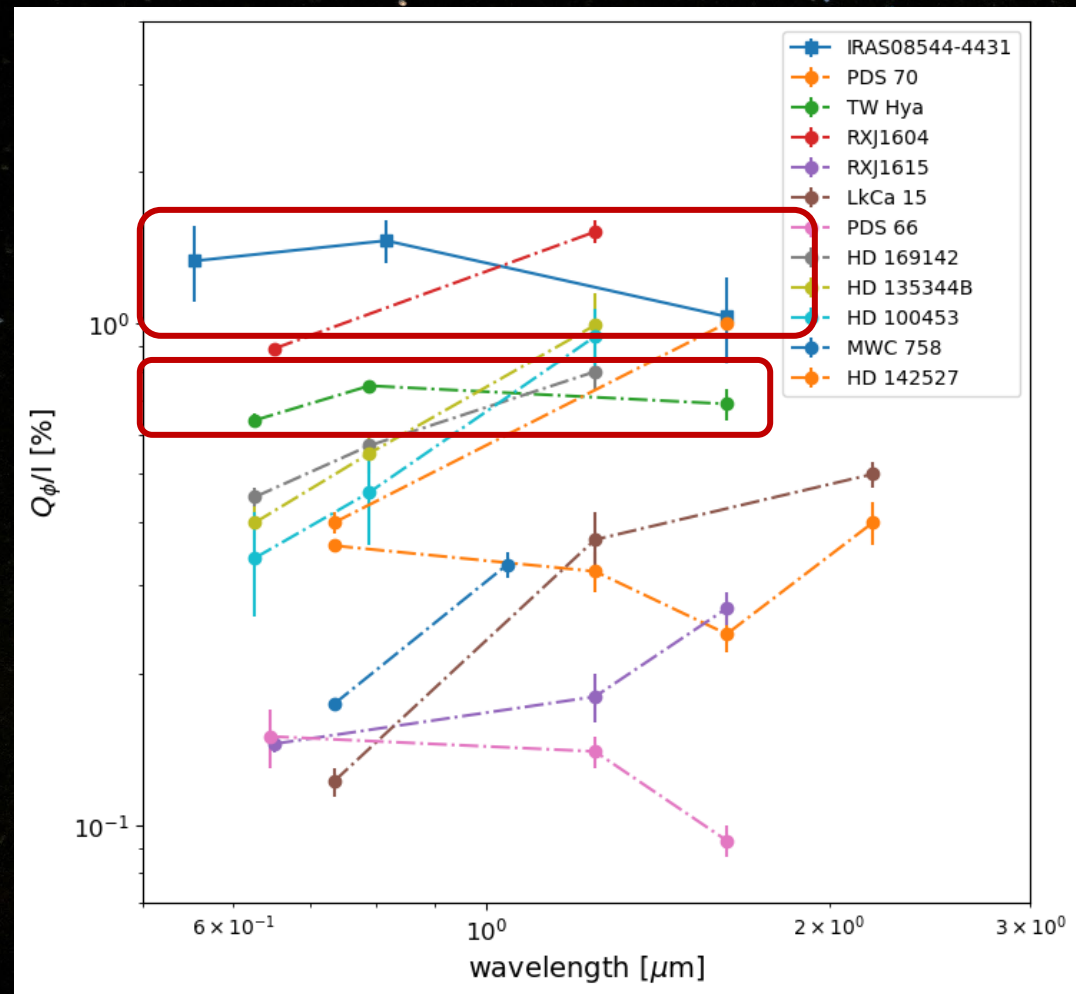
Presence of forward scattering peak is consistent with the porous dust aggregates of  $\sim 1\mu\text{m}$  size and suggest the northern part of the disk being closer to the observer!





Post-AGB system shows relative polarized brightness similar to the brightest PPDs!

Grey polarized disc color is consistent with dust aggregates instead of single monomers!





- Disks around post-AGB binaries are quite similar to protoplanetary disks
- Post-AGB binaries can bring important constraints on disk-binary interaction and disk evolution processes (including potential planet formation)
- Polarimetric observations show:
  - ✓ Complex morphology of the second-generation circumbinary disks.
  - ✓ Polarimetric efficiency of the post-AGB disk similar or higher than of protoplanetary disks
  - ✓ Lack of scattered light for some systems could be caused by lower level of dust production during the AGB/RGB phase
  - ✓ Wavelength dependence of the polarimetric disc brightness suggests porous dust aggregates of  $>1\mu\text{m}$  size
  - ✓ Signs of warping in the disk
- Combining multi-technique observational data and modelling efforts is essential to build a comprehensive image of these systems!

