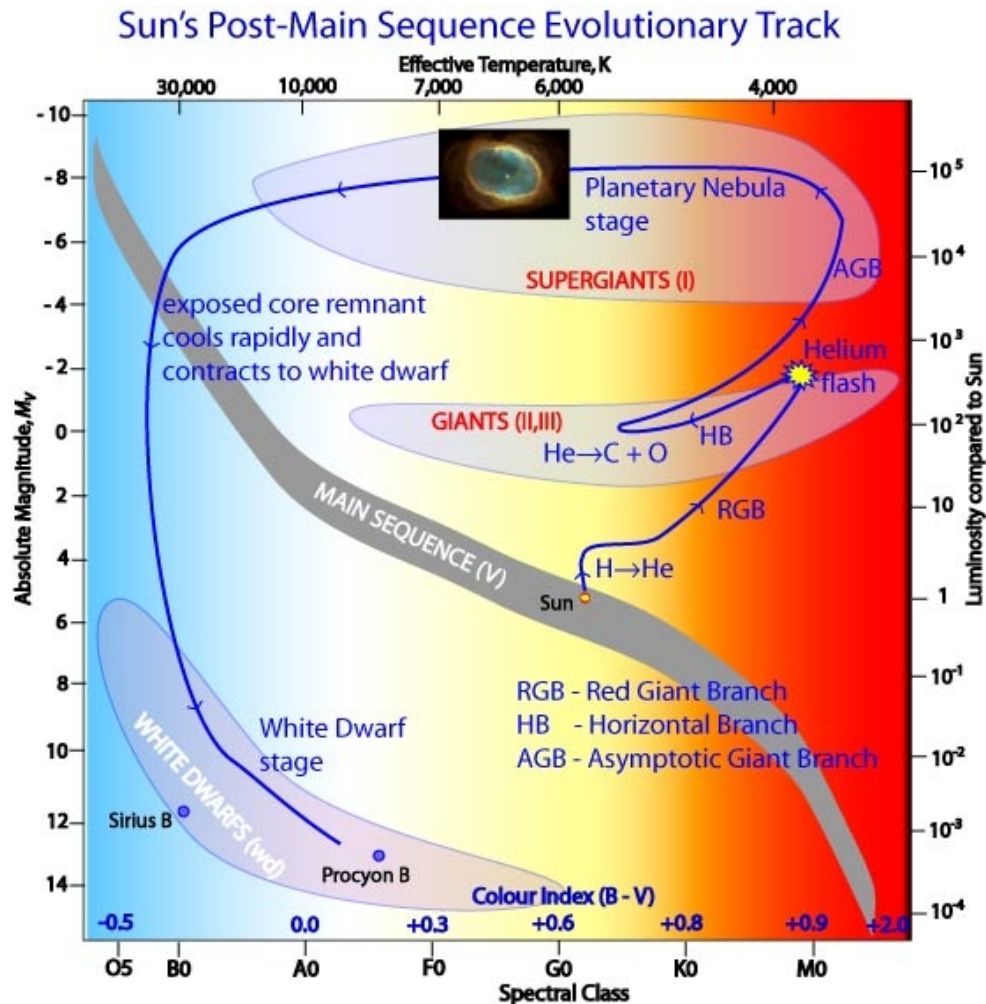


# Dissection of Post-AGB binaries



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Belgium

Jacques Kluska; Devika Kamath; Akke Corporaal; Dylan Bollen; Glenn-Michael Oomen; Olivier Verhamme; Kateryna Andrich, Valentin Bujarrabal; Orsola De Marco; Jonathan Ferreira



# Outline:

- Conclusion
- Dissecting Post-AGB Binaries:
  - SED
  - Circumbinary Disc
  - Inner Rim Circumbinary Disc
  - Central Binary
  - Circum-companion Jet
  - Central Star(s)
- Why would be bother?



# Conclusion



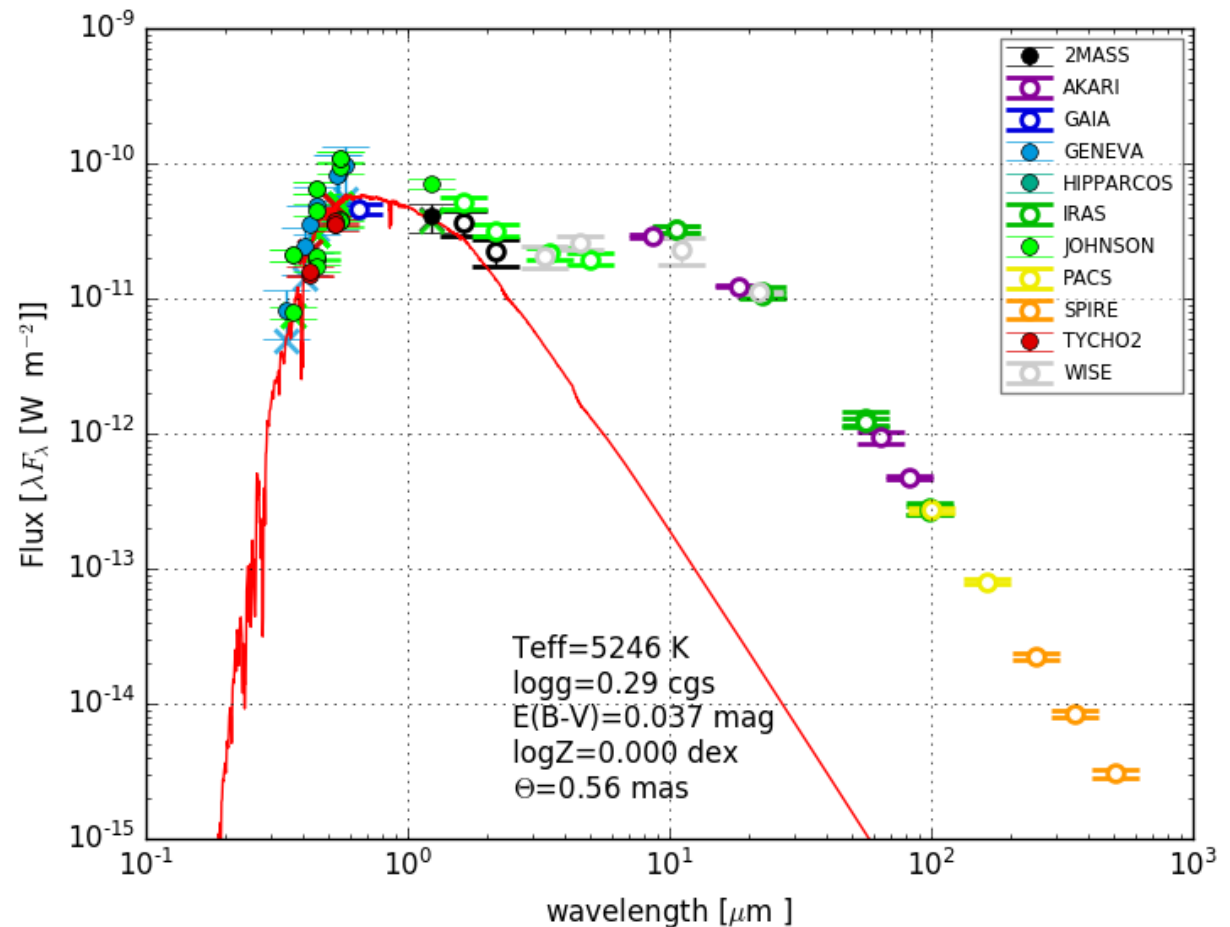
# SED of a post-AGB binary: disc sources

Central star is  
typically F-K star

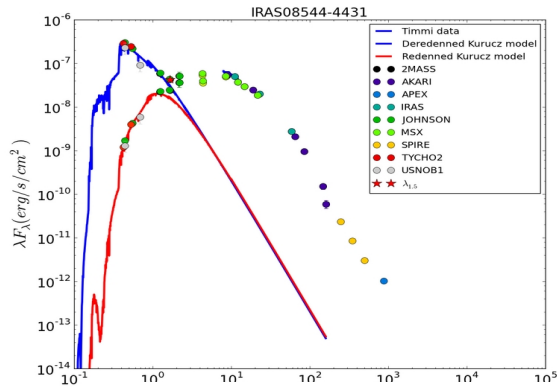
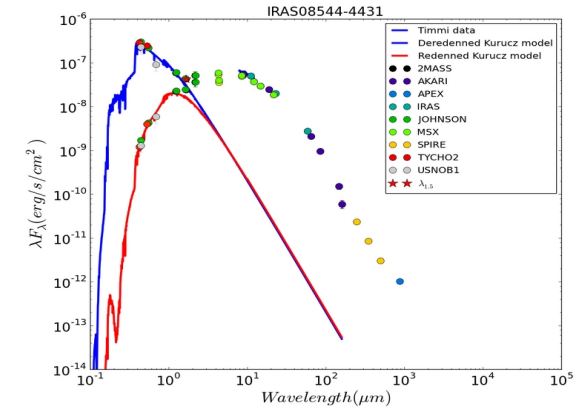
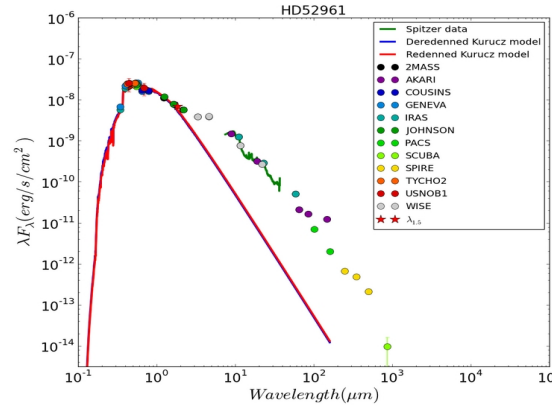
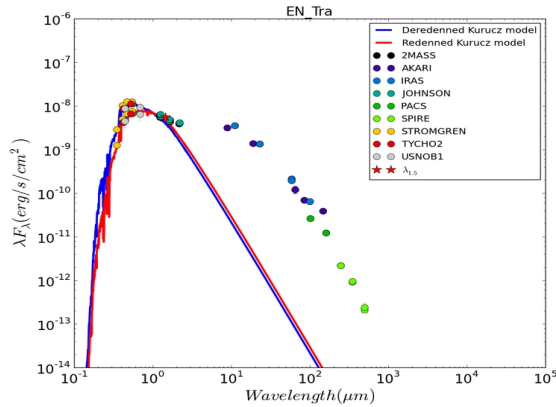
No current  
dust production

Hot dust component  
is indicative of  
Keplerian disc

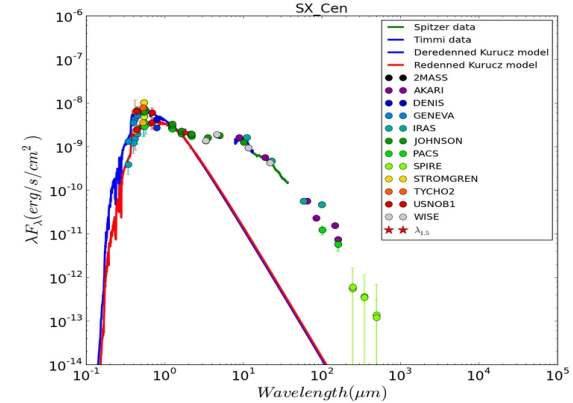
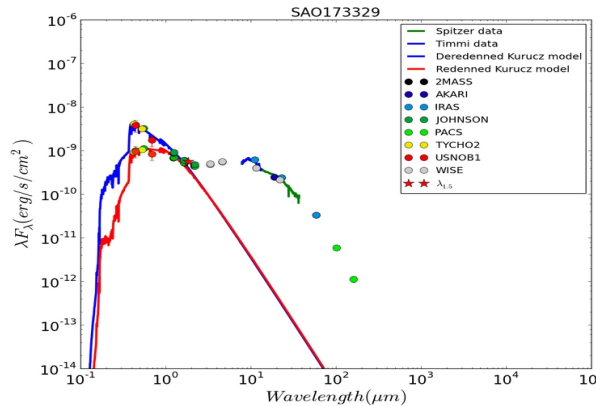
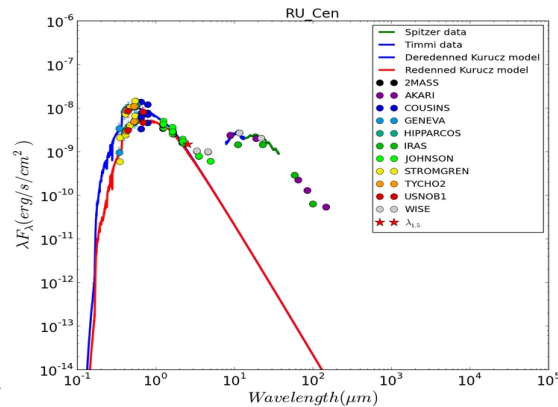
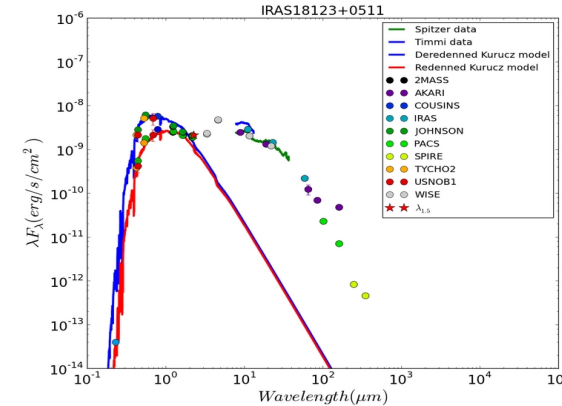
Long wavelength  
spectral index: large  
grains.



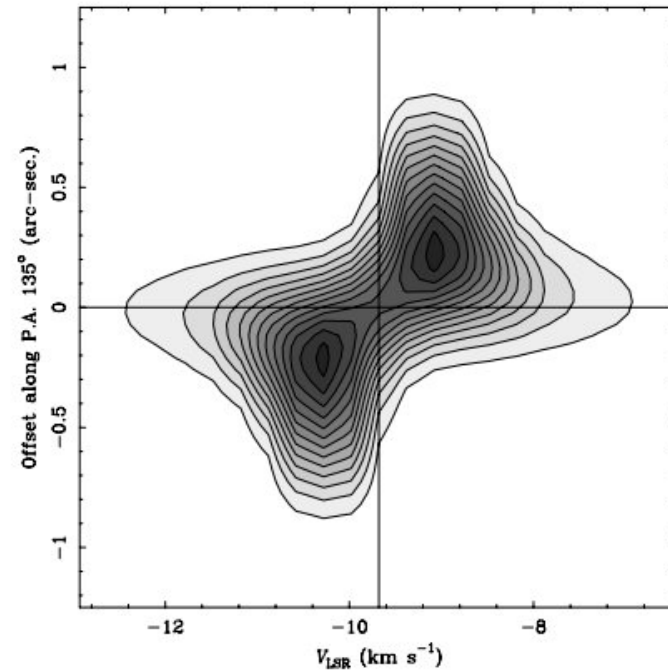
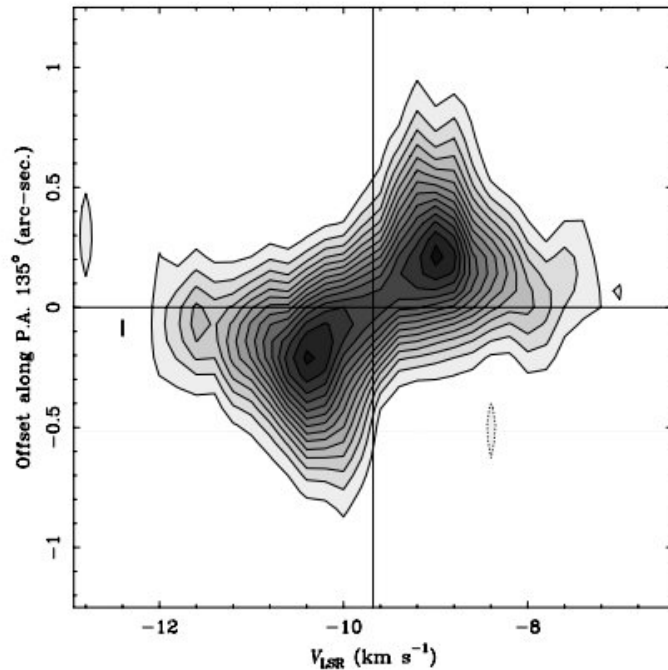
# SED : commonly observed



**SED very similar :**  
**Dust excess stars near sublimation T**  
**No present dusty mass loss**  
**Galactic sample: +/- 90 sources**  
**LMC and SMC sample is large !**



# ALMA-PdB: rotation resolved

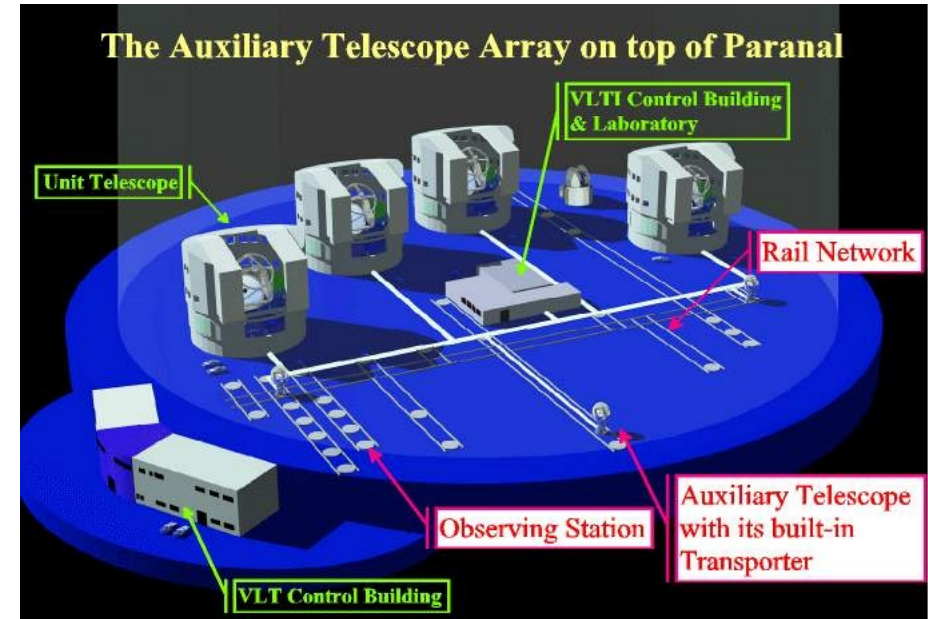
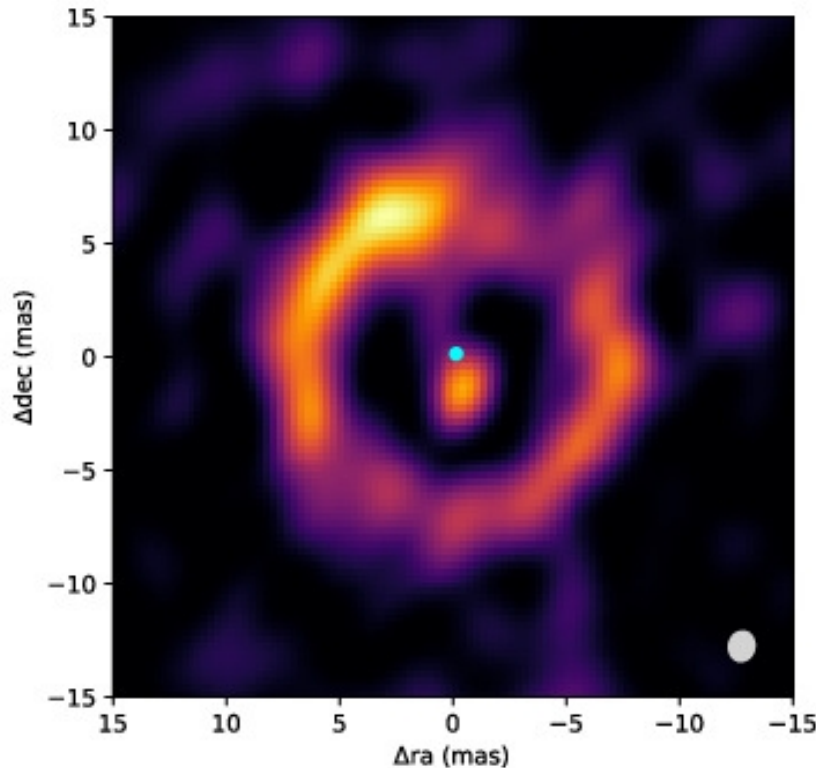


**Single dish: narrow CO profiles omnipresent**

**Interferometric CO: Keplerian rotation is resolved**



# CB-discs: Near & Mid-IR interferometry



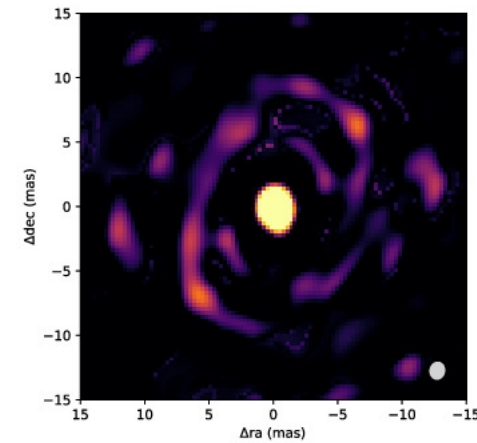
- Interferometric Image Reconstruction: 1mas resolution!
- Hot inner rim at sublimation radius
- Main star is removed from image
- Secondary is resolved: circum-companion disk



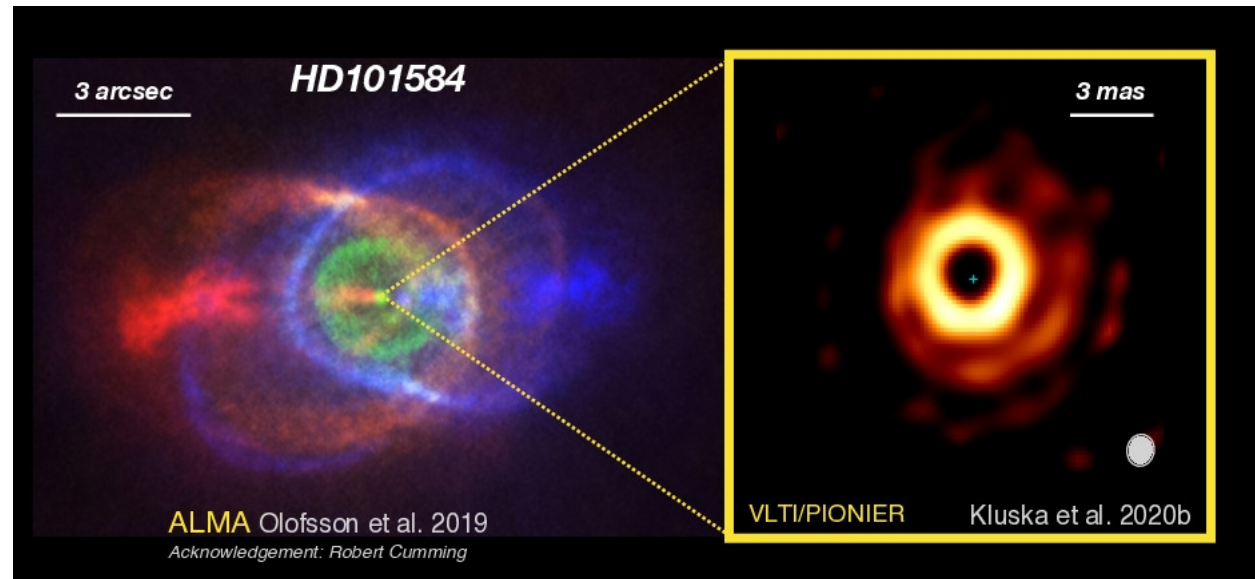
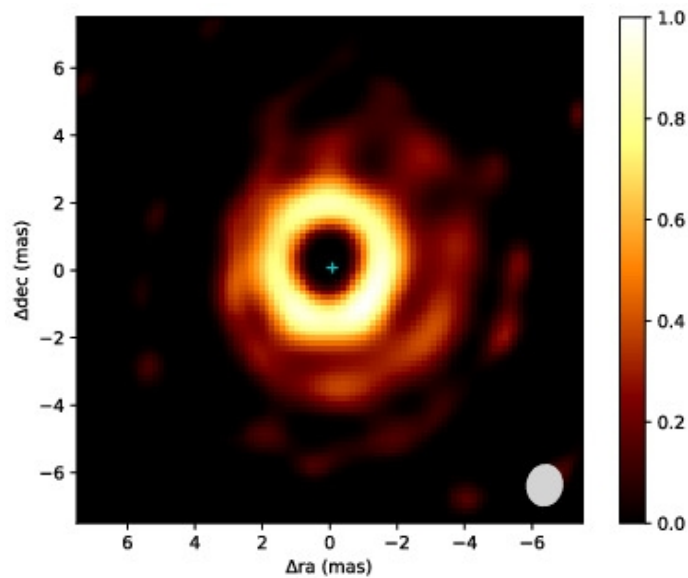
# CB-discs: Near & Mid-IR interferometry



ESO large programme at VLT  
PI: Jacques Kluska



Resolving the inner rim !

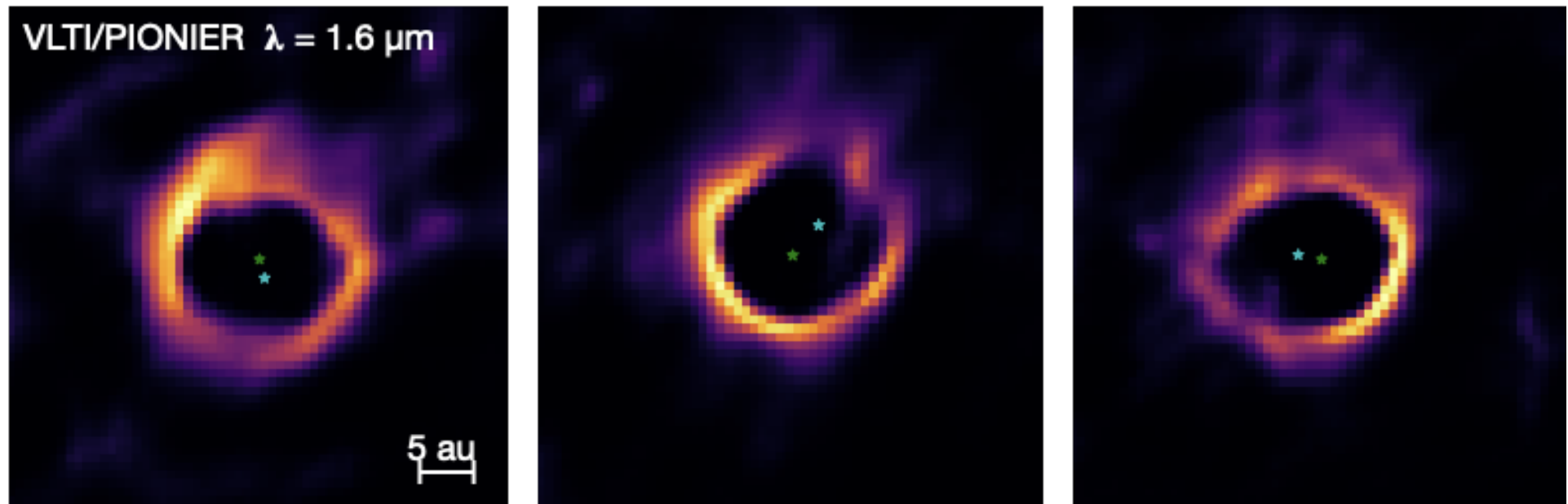


Kluska et al., 2020, 2021, 2022 in prep

Busso's Perugia party 2022



# CB-discs: time resolved interferometry



Time

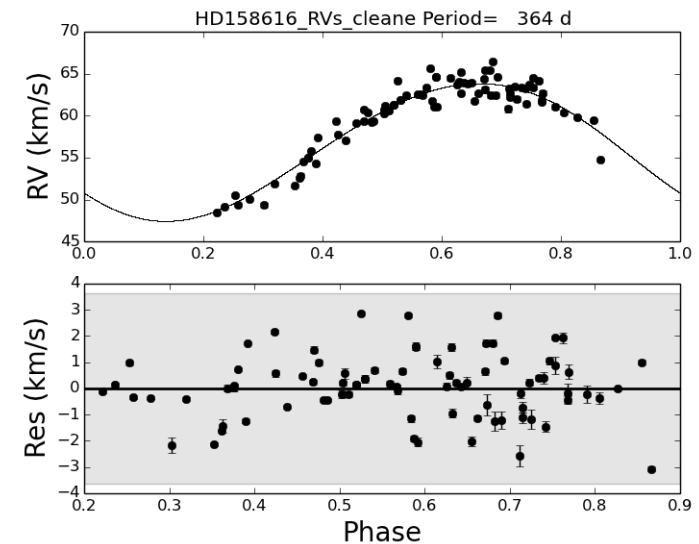
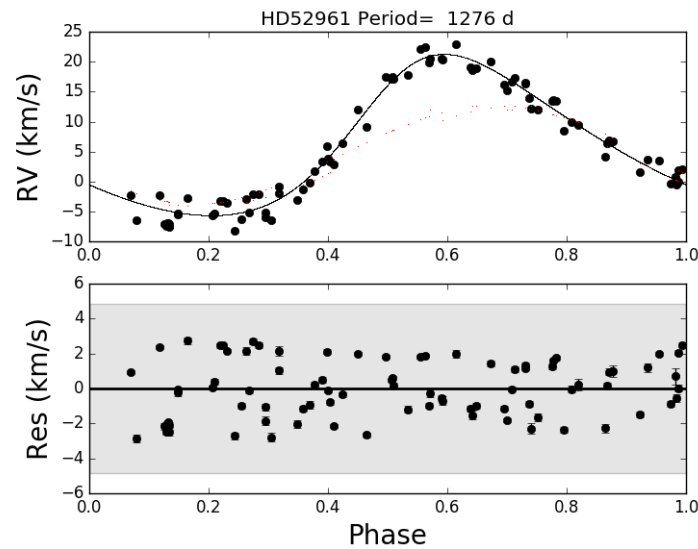
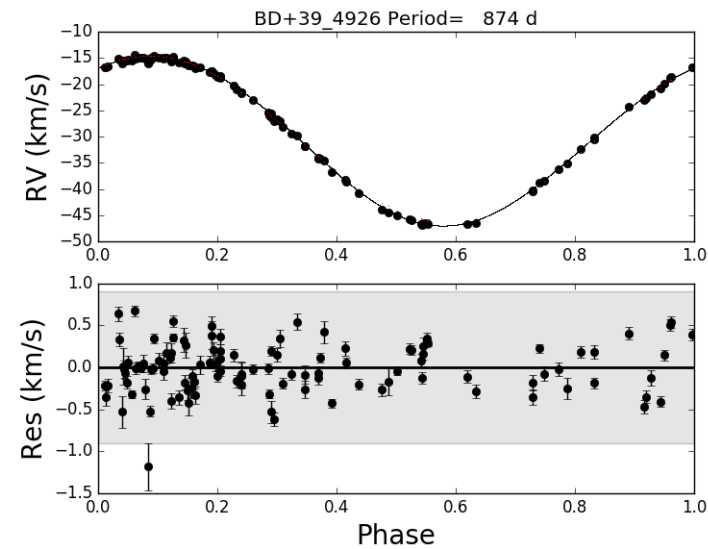
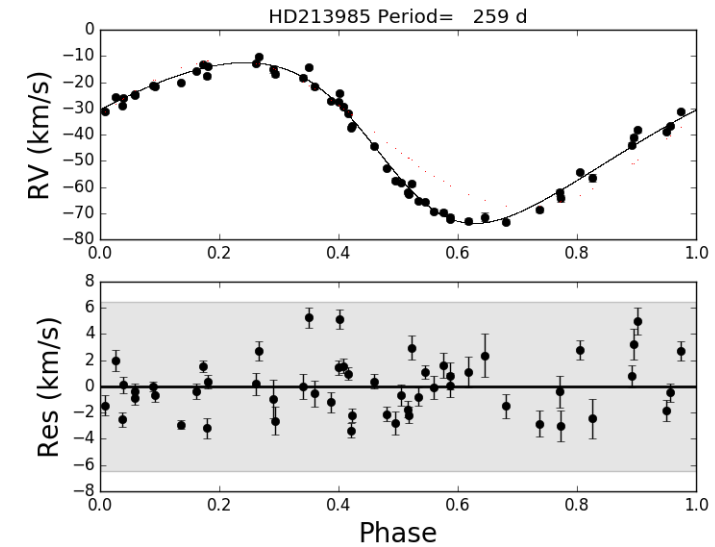
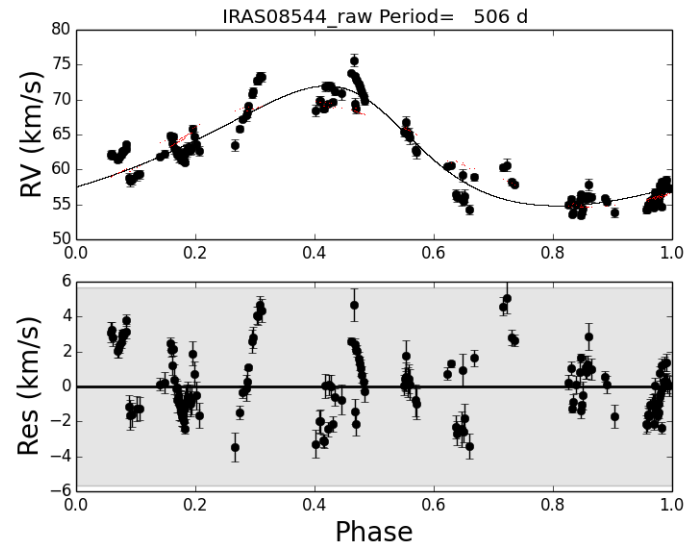
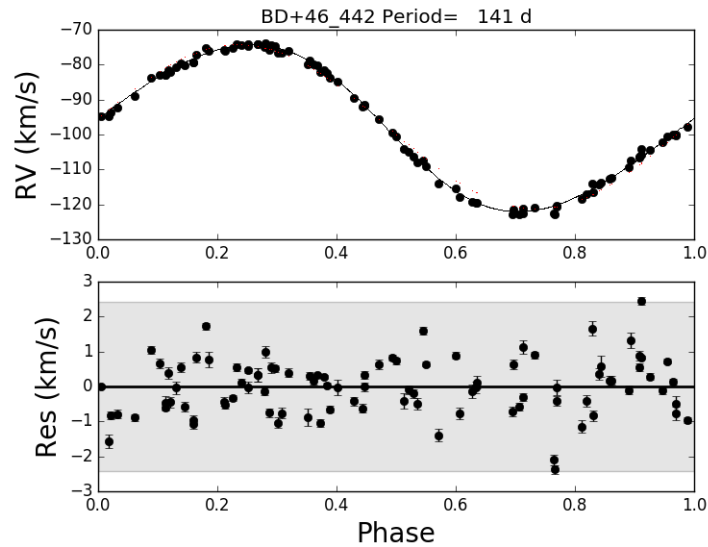


Kluska et al., 2022 in prep

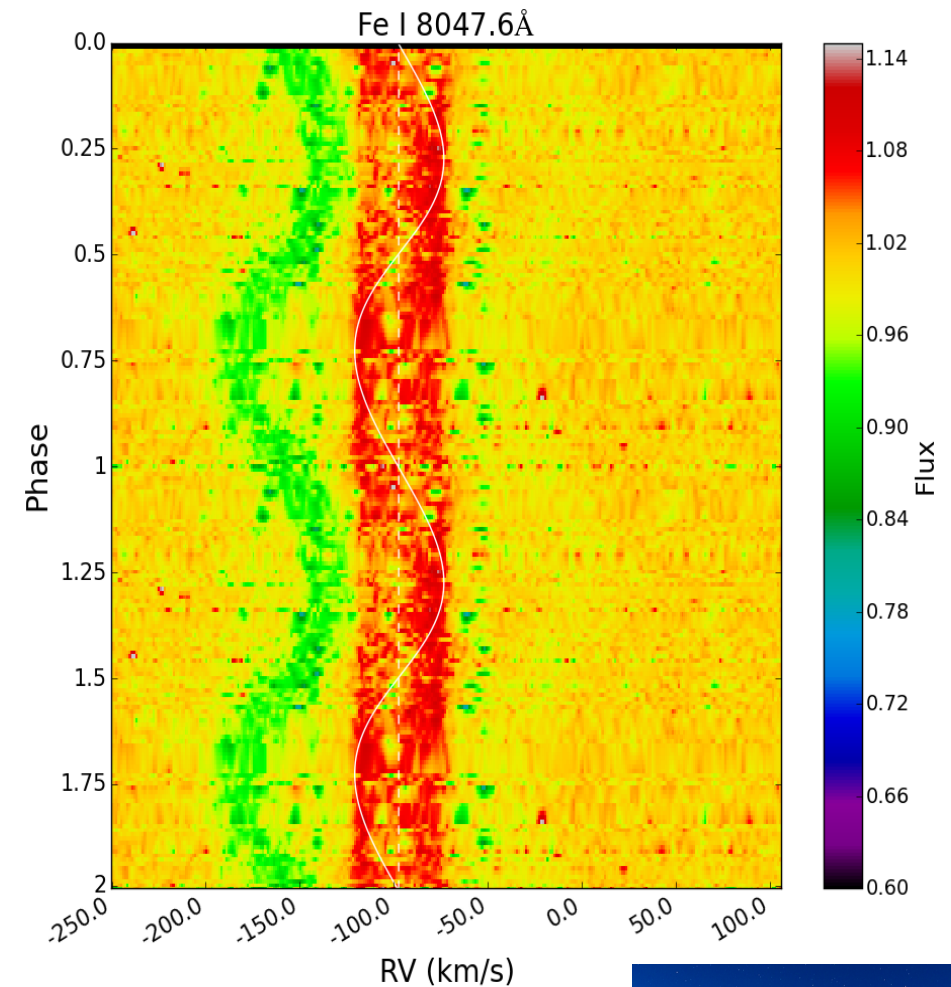
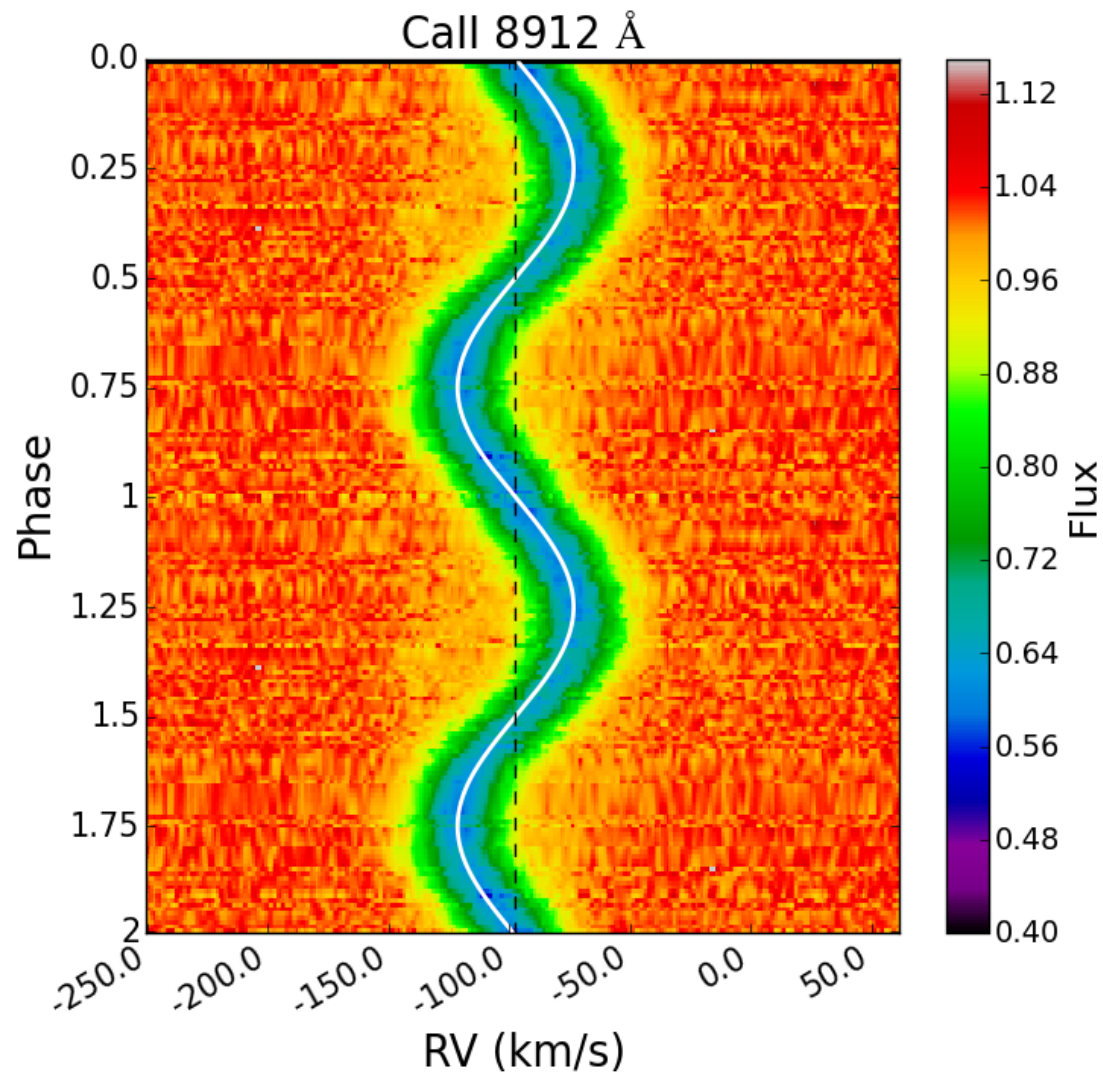


Busso's Perugia party 2022

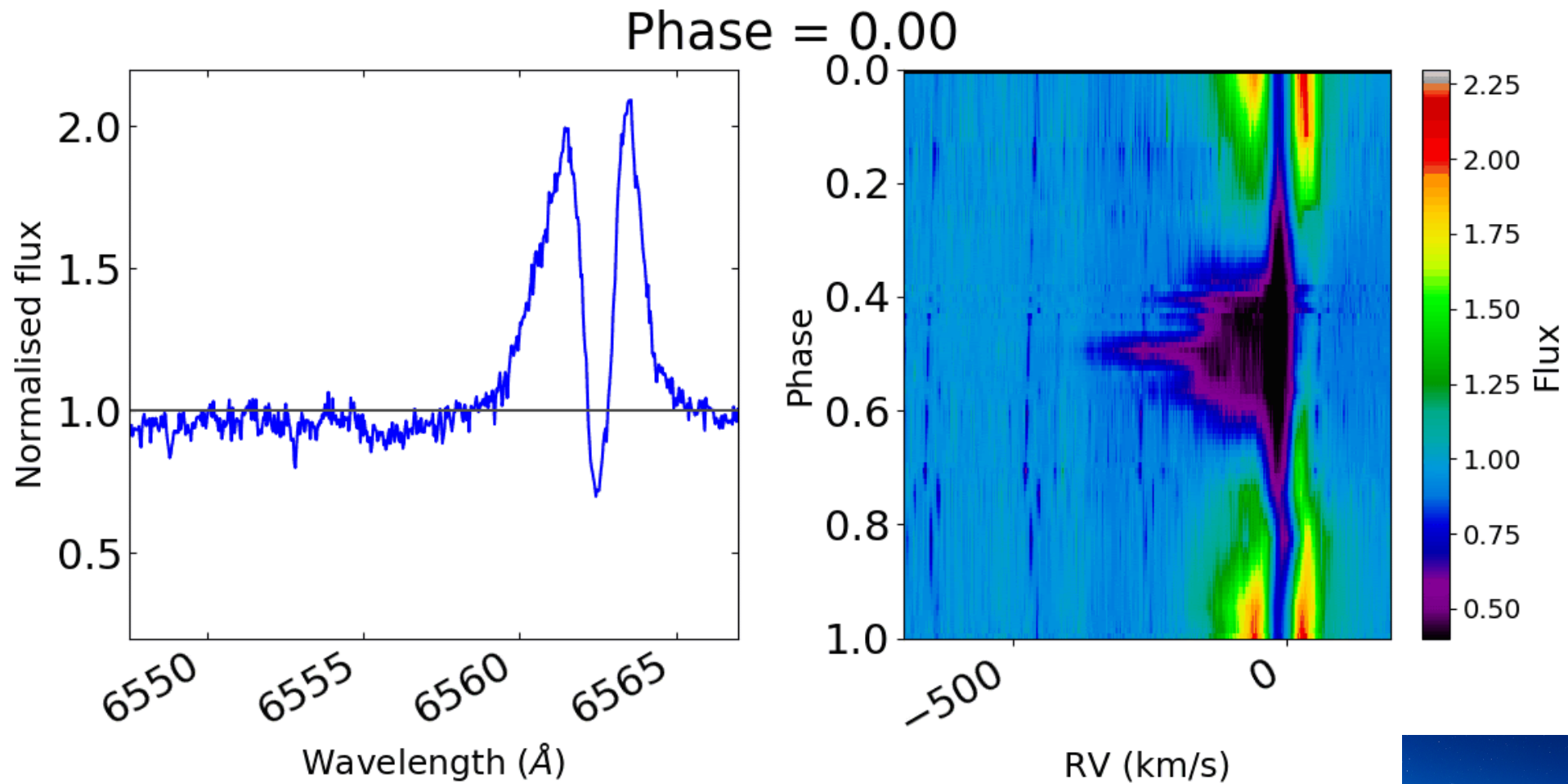
# Binaries: ranges in P and e



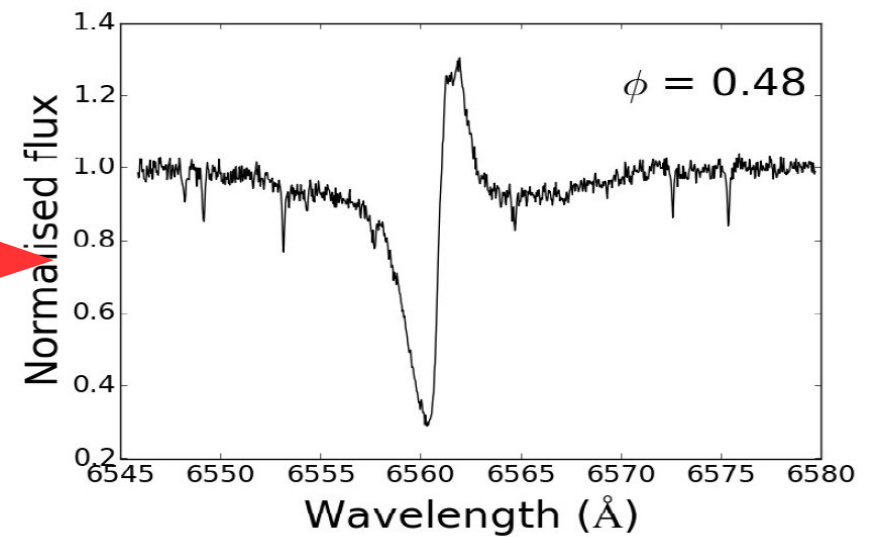
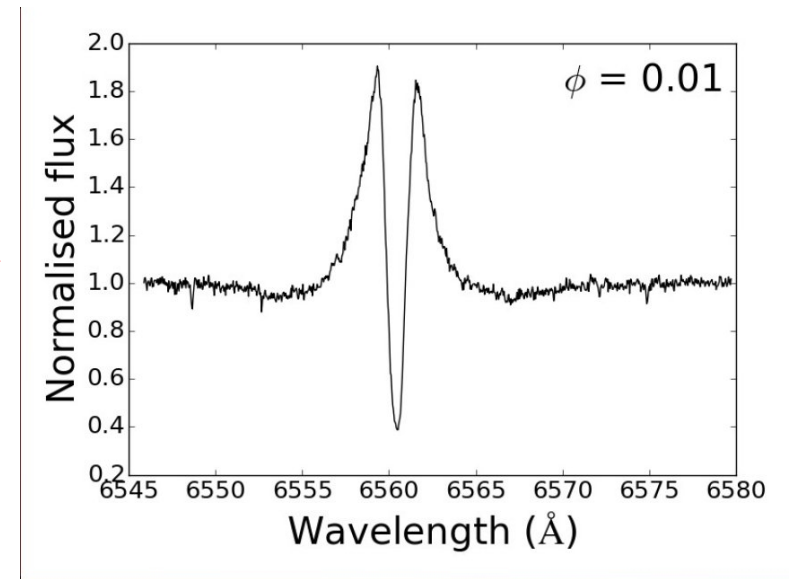
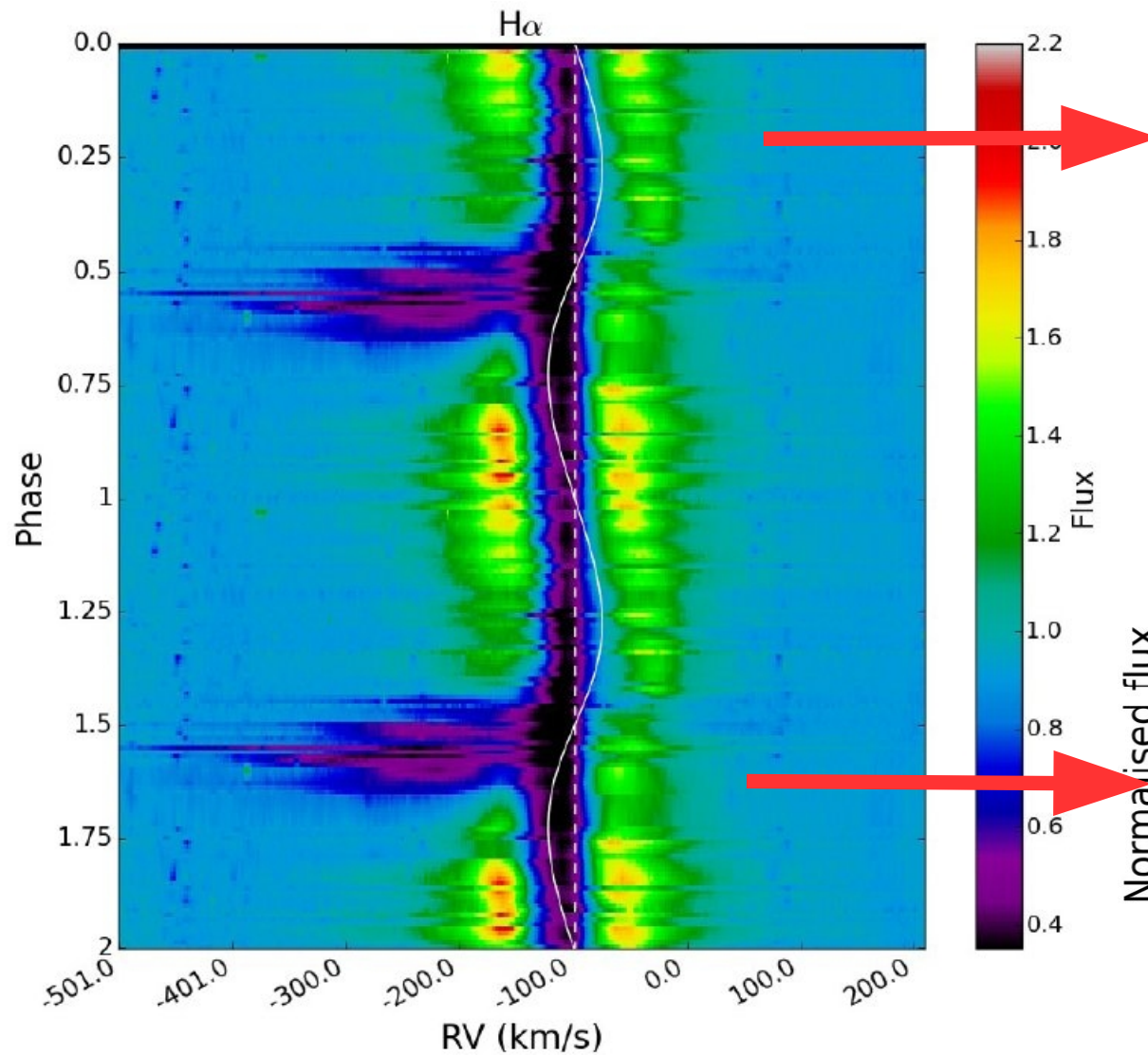
# Dynamic Spectra: time resolved spectroscopy



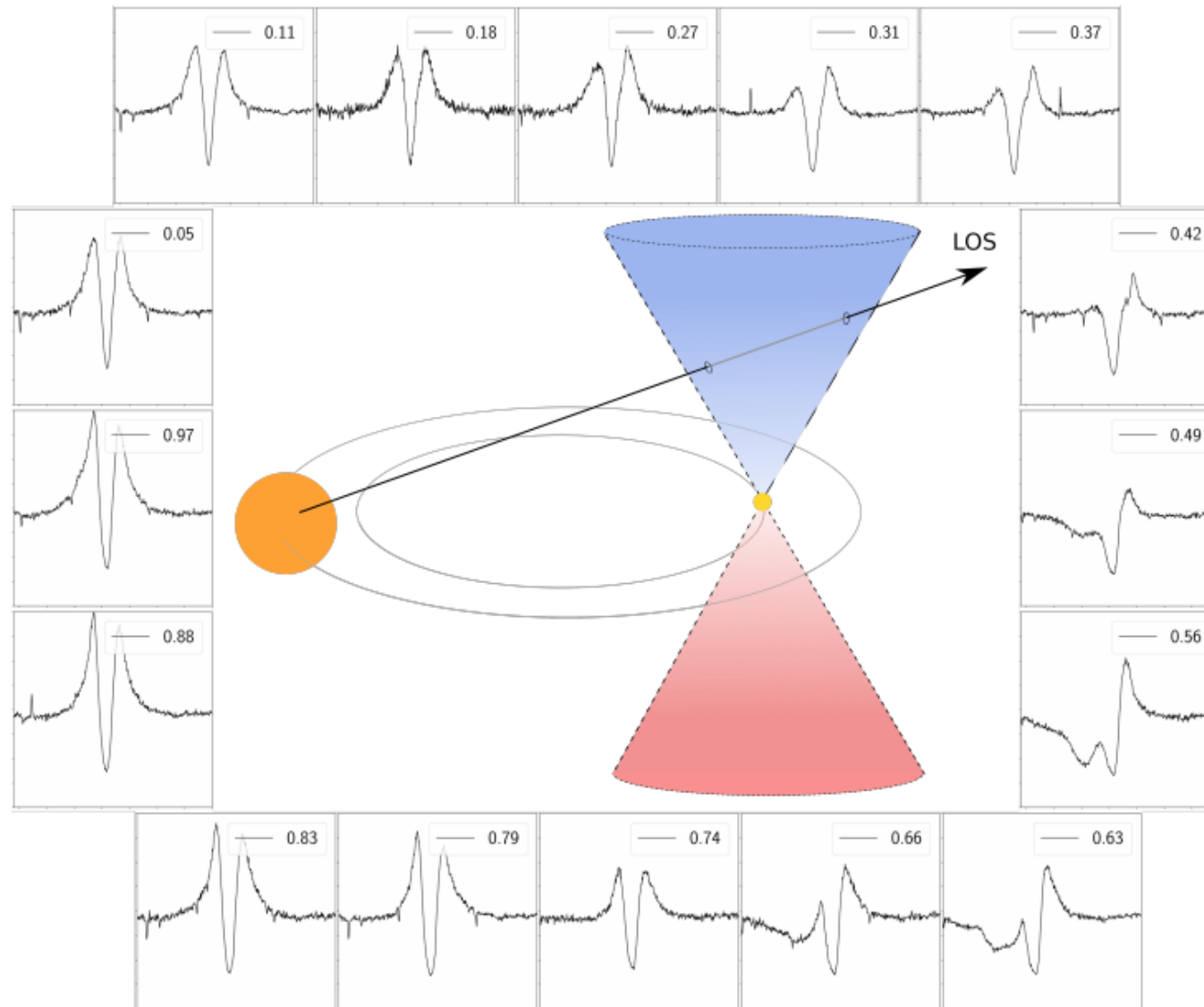
# Dynamic Spectra



# Dynamic Spectra



# Jet configuration

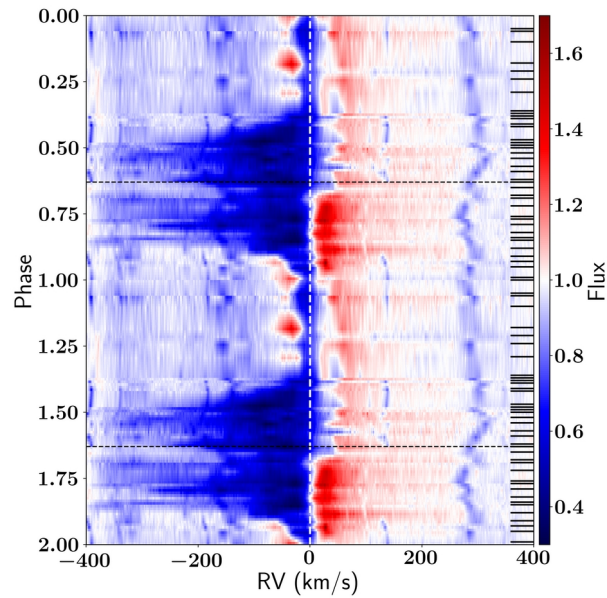


Bollen et al., 2016

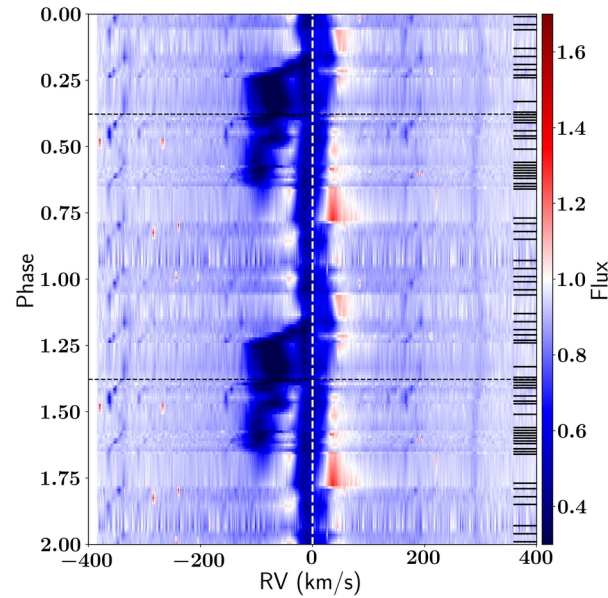
Busso's Perugia party 2022

# Commonly Observed

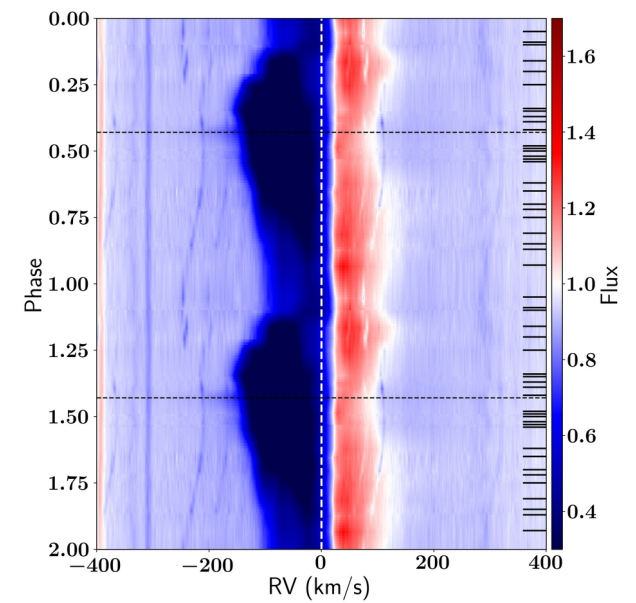
IW Car



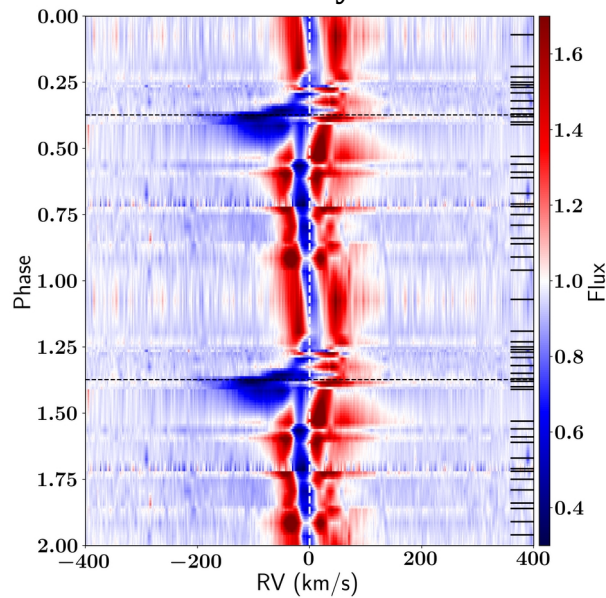
HP Lyr



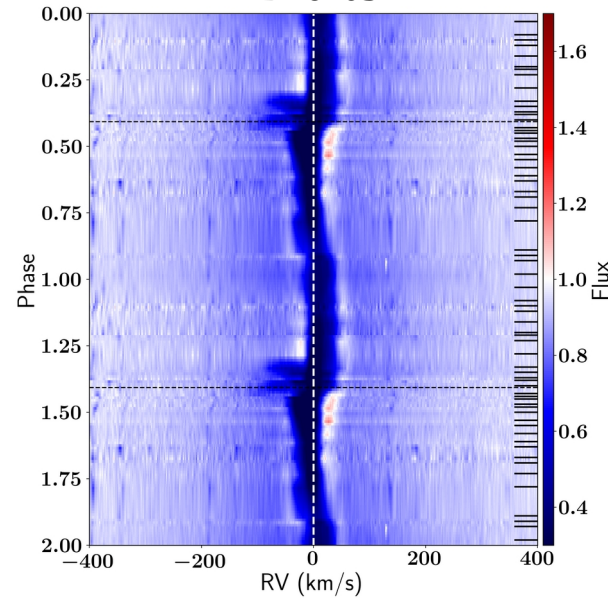
89 Her



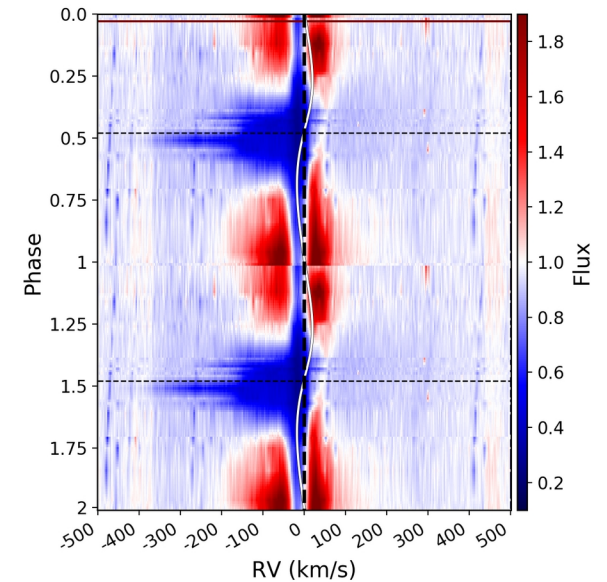
EP Lyr



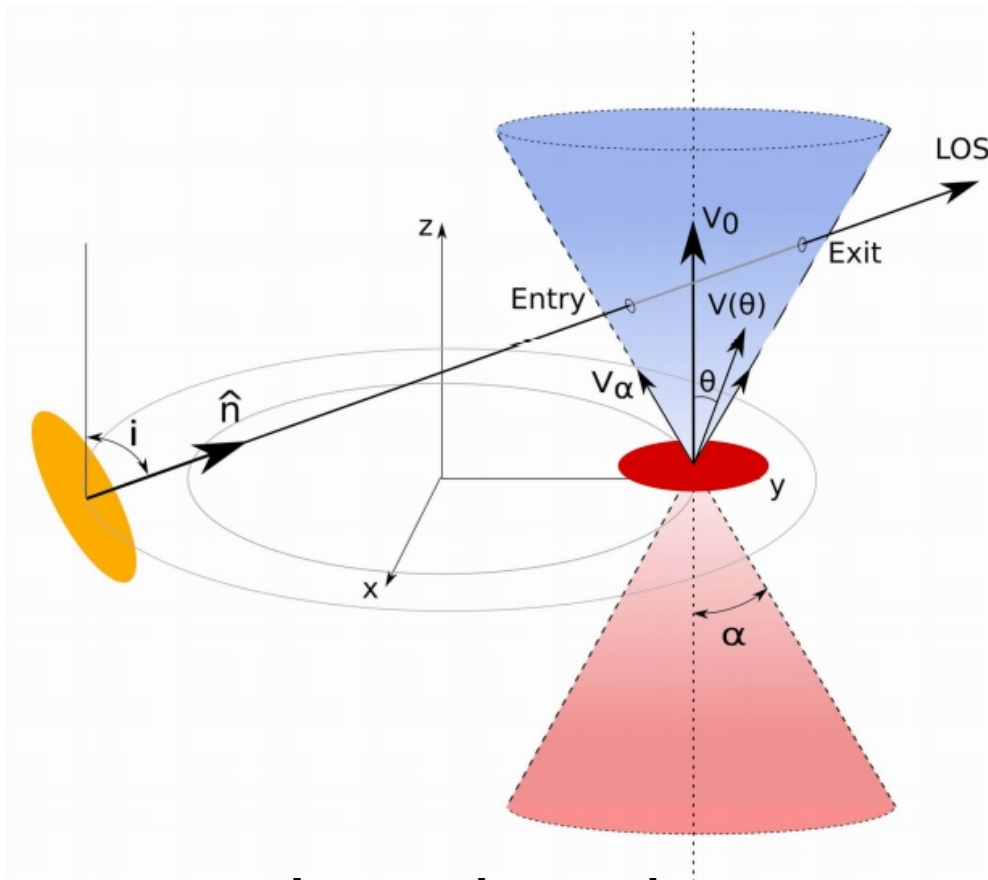
HD46703



IRAS19135



# Modeling in several steps



- Jet opening angle
- Jet tilt
- Angular Velocity structure
- Density structure
- Binary (radius components, orbit)

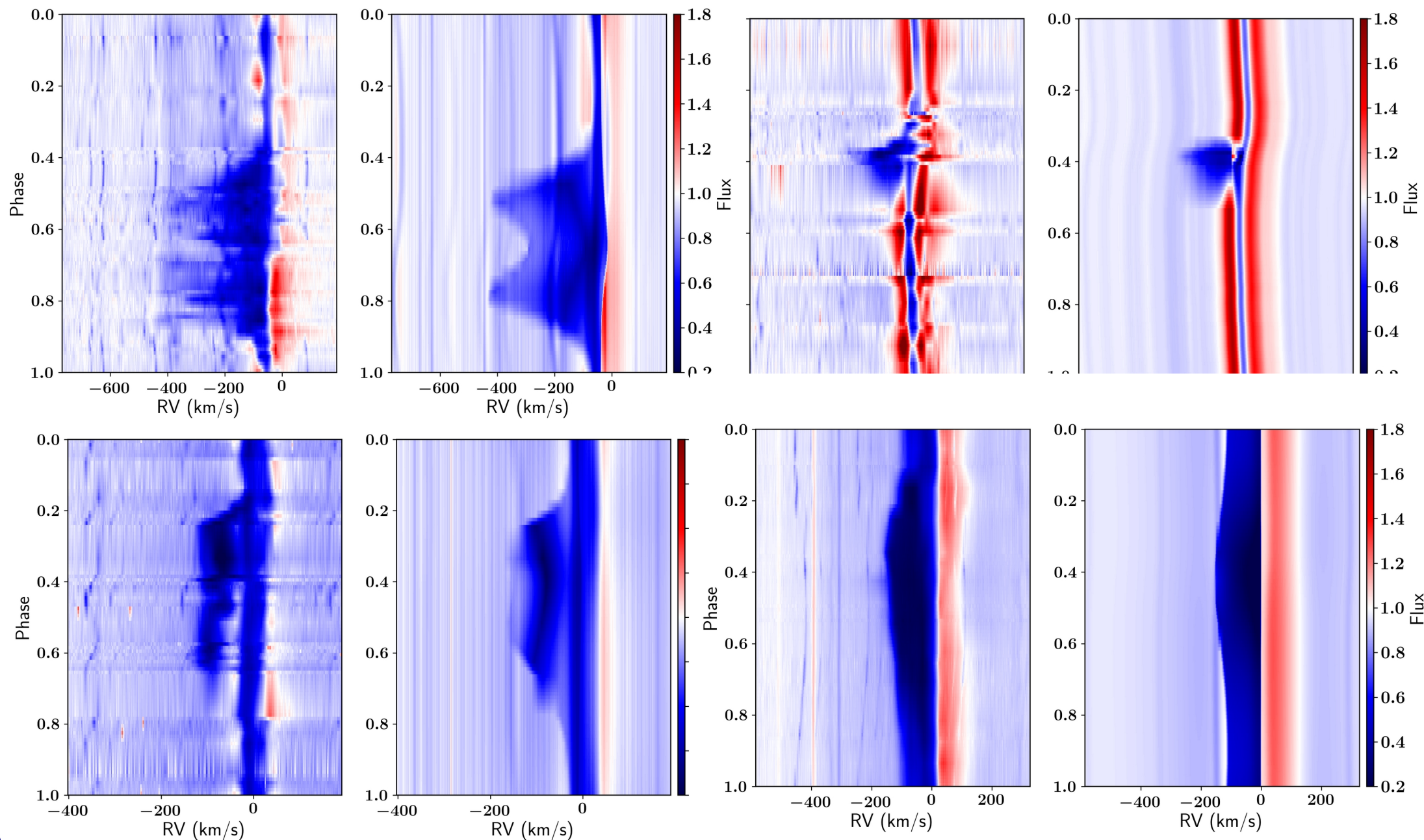
## Time-resolved spectroscopy:

- spatio-kinematic (geometric modelling)
- RT (constraints are the Balmer lines)
- testing with self-similar jet models from YSOs

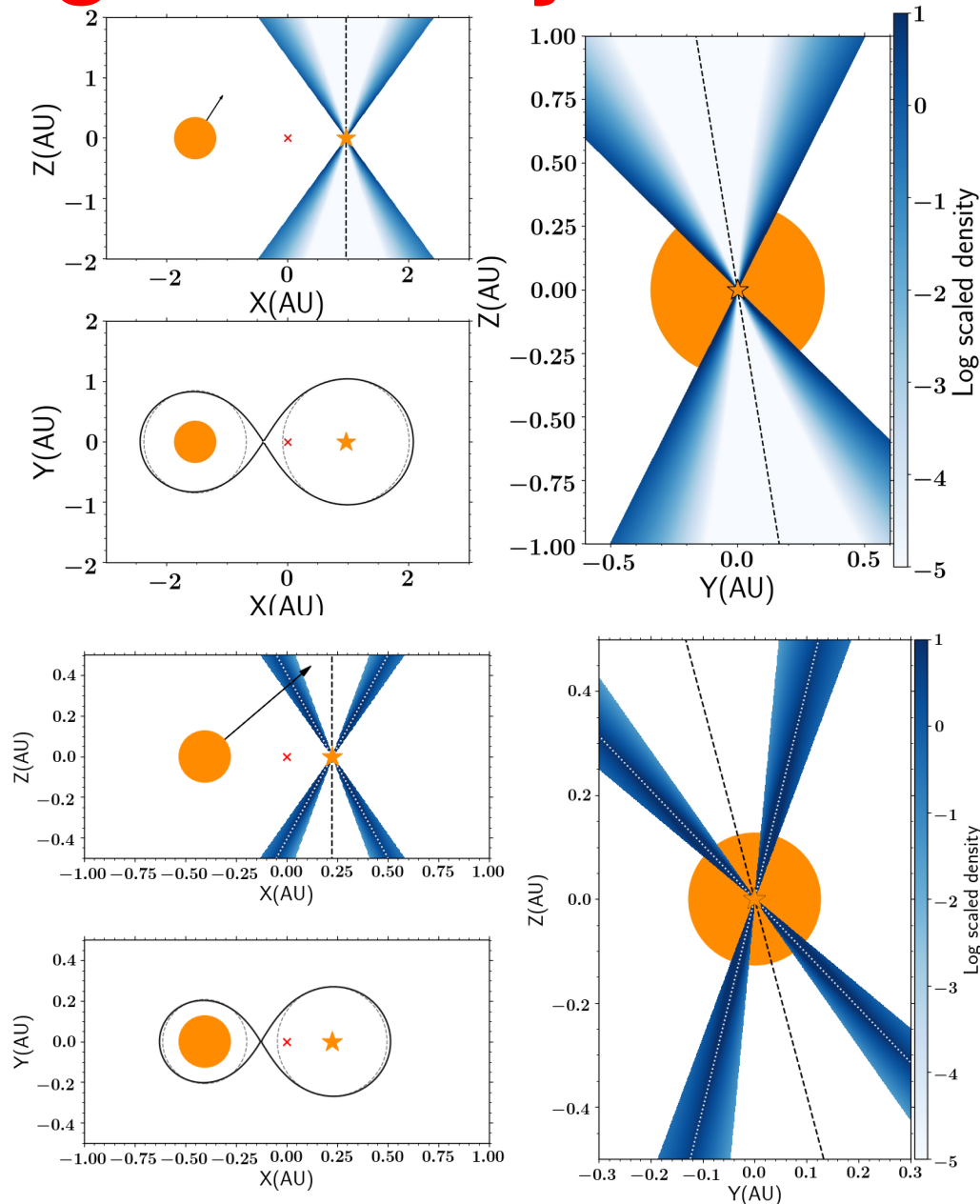


# Geometric model fits

Bollen et al., 2019; 2020; 2021



# High velocity outflow: geometric model



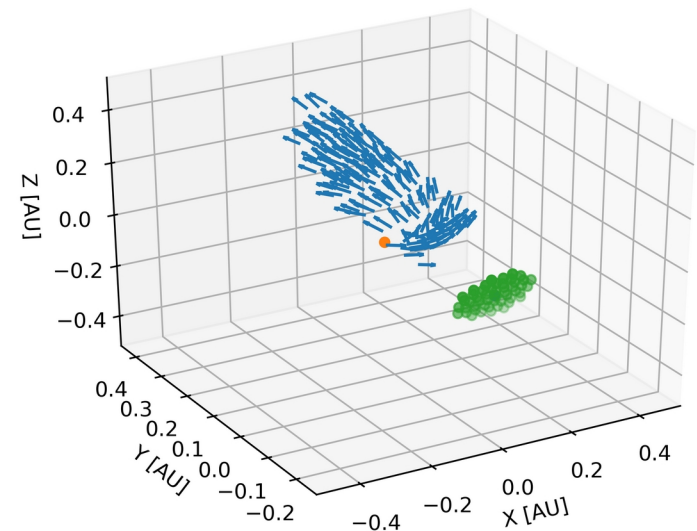
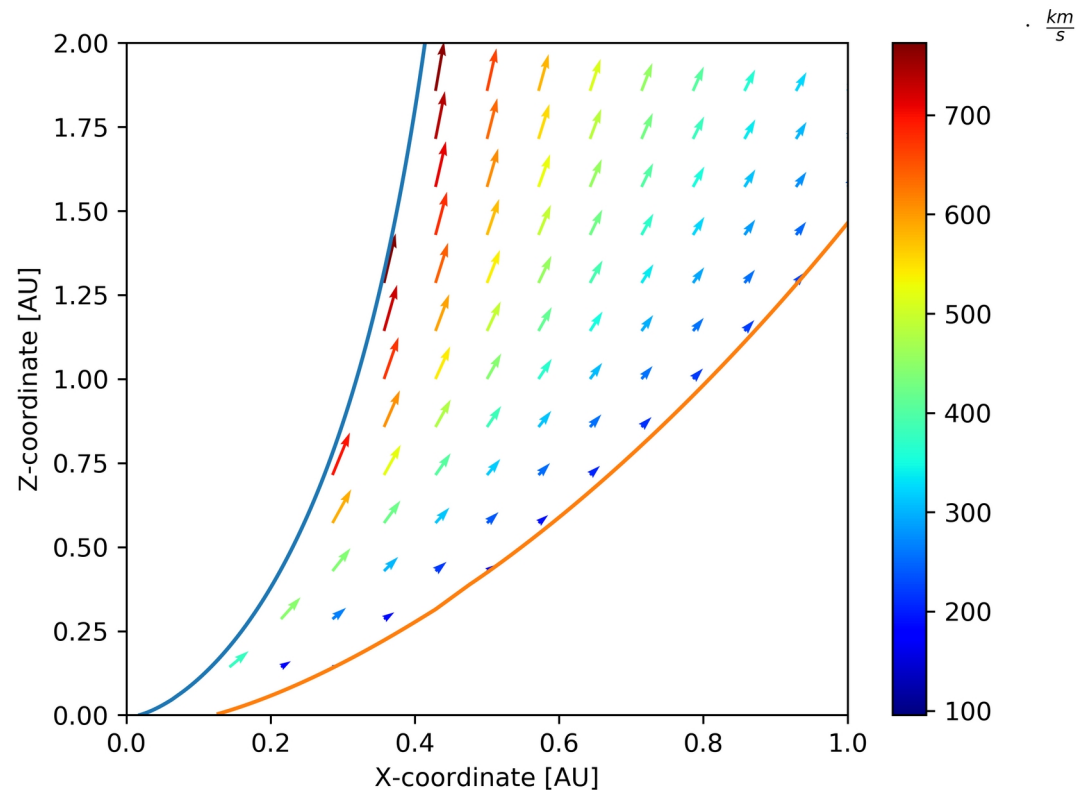
- Wide opening angle
- inclination dependent
- angle dependent velocity law in cone
- deprojected outflow velocity escape velocity of MS not WD

Bollen et al., 2017; 2019; 2020; 2021, 2022 (sub)



# MHD self-similar models

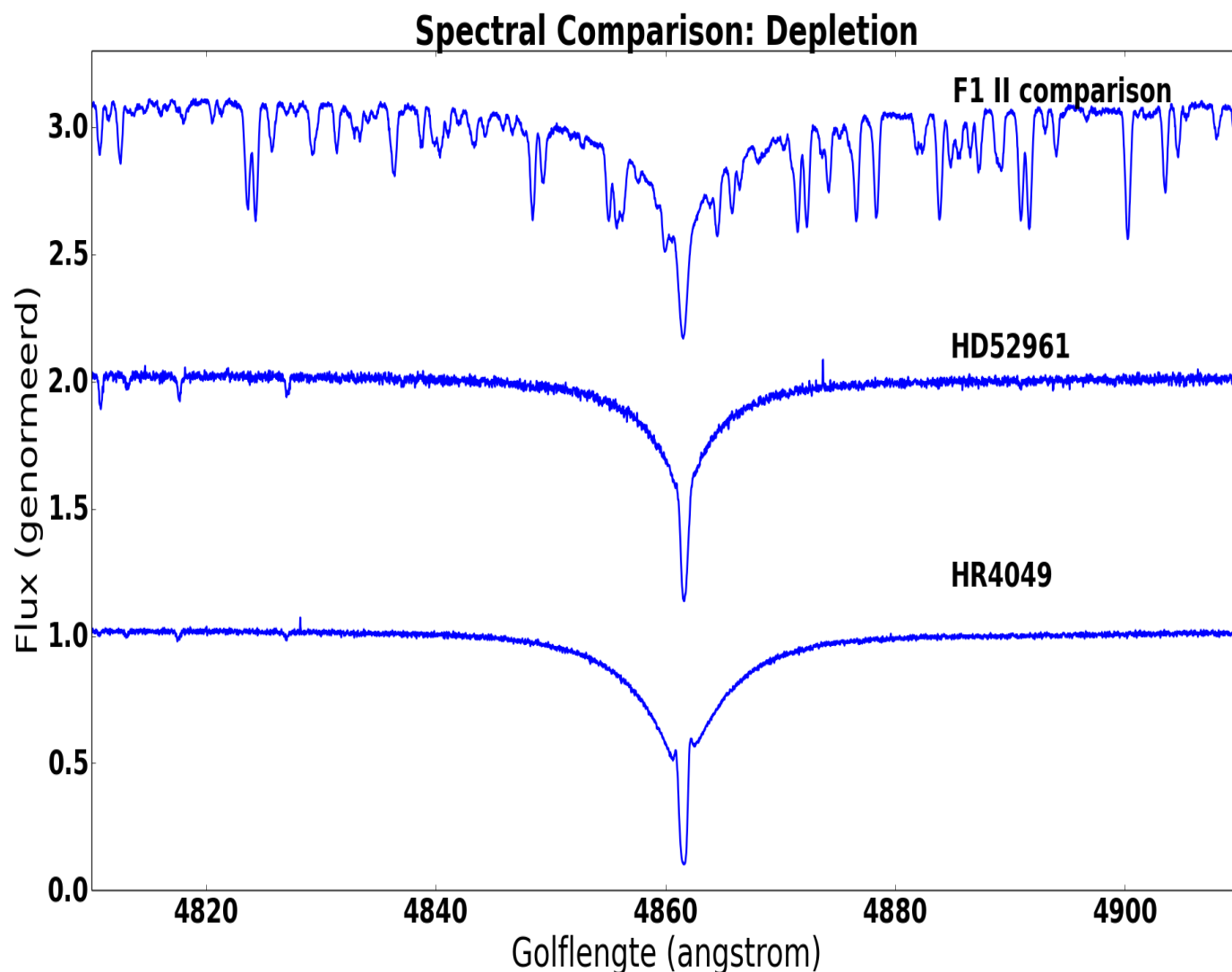
models turning into observables



Verhamme et al., in prep

Busso's Perugia party 2022

# Photospheres: special chemical anomaly

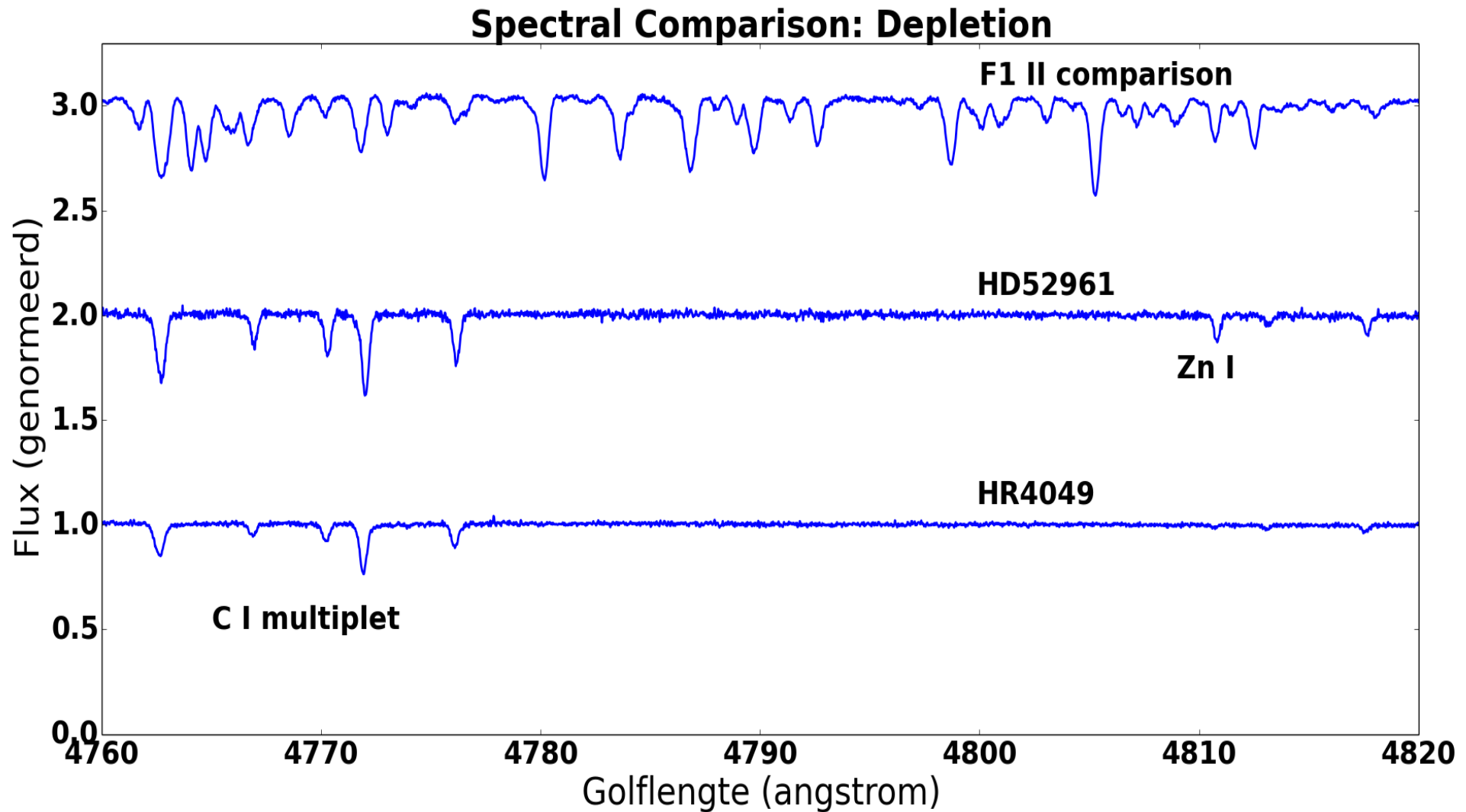


**Almost no Fe  
nor other elements  
down to  
 $[\text{Fe}/\text{H}] = -4.8$  !!**

**Rich in  
CNO, S, Zn...**



# Photospheres: special chemical anomaly



# Photospheric Depletion: Feedback from disc

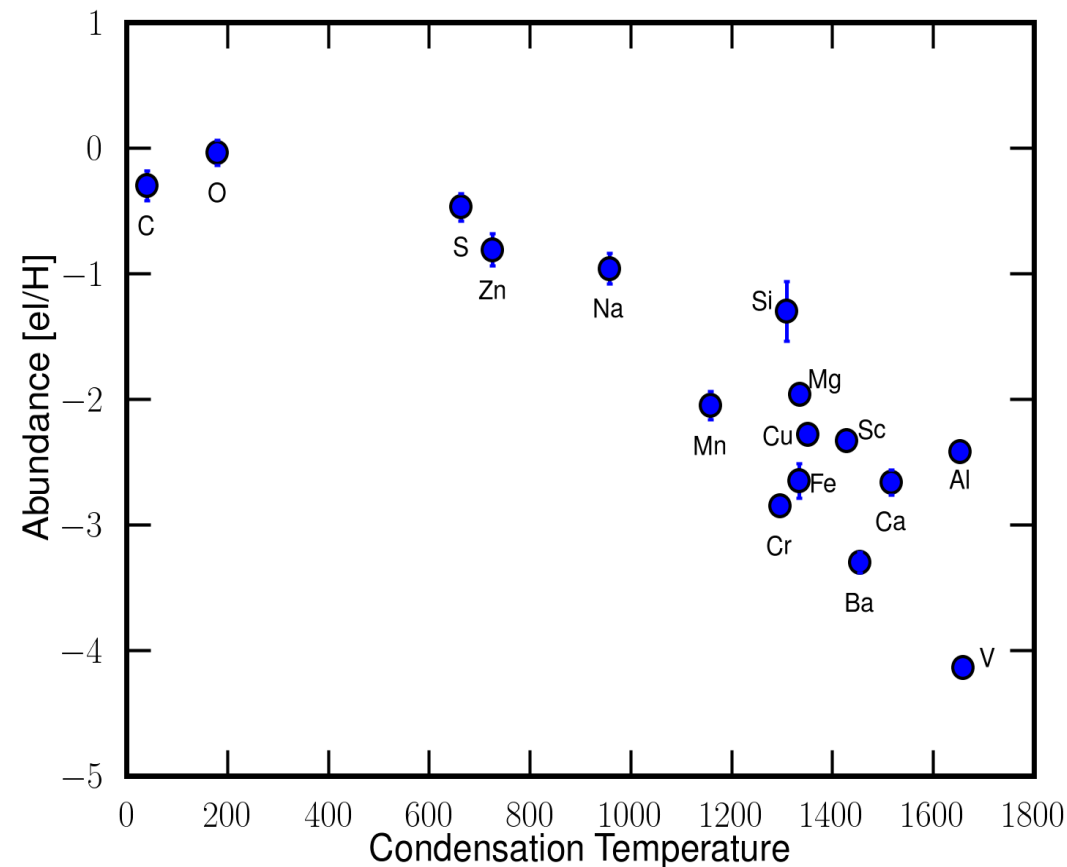
Abundance patterns ~  
gas phase abundance of ISM

You **lose the nucleosynthetic history**

Can be very efficient  
(down to  $[\text{Fe}/\text{H}] = -4.8$ )

**Accretion** of circumstellar gas hence  
**you slow down the evolution**

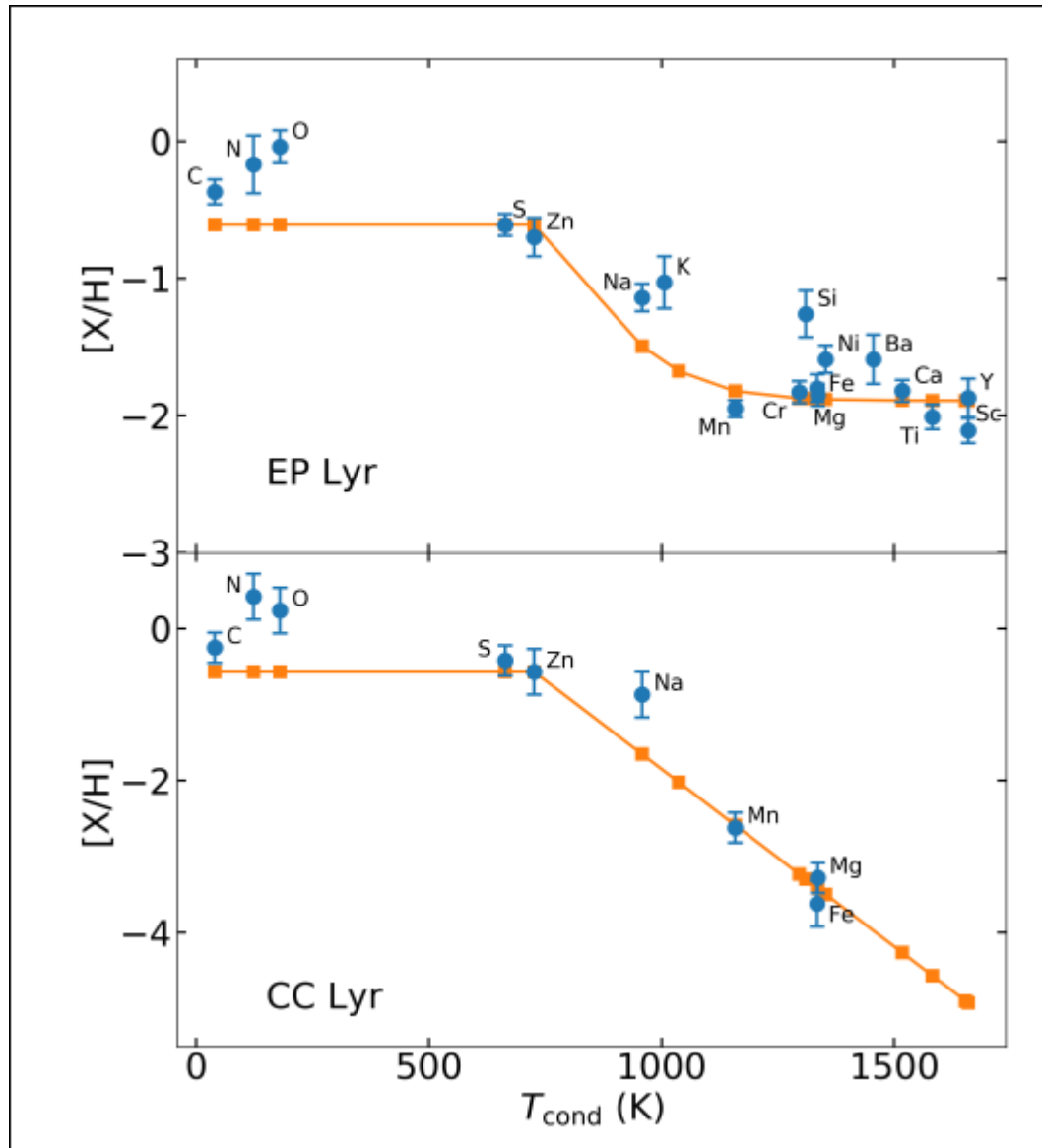
Disc is needed to guarantee low  
density and long timescale.



Waters et al., 1992; Van Winckel et al., 1992, 2003 ; Giridhar et al., 2005; Gielen et al., 2009, Rao 2013  
Gezer et al. 2015; Van Winckel 2018; Kamath 2019



# Photospheric Depletion: Feedback from disc



- Modelling + stellar evolution
- Many saturated profiles
- Impact on evolutionary time in some cases

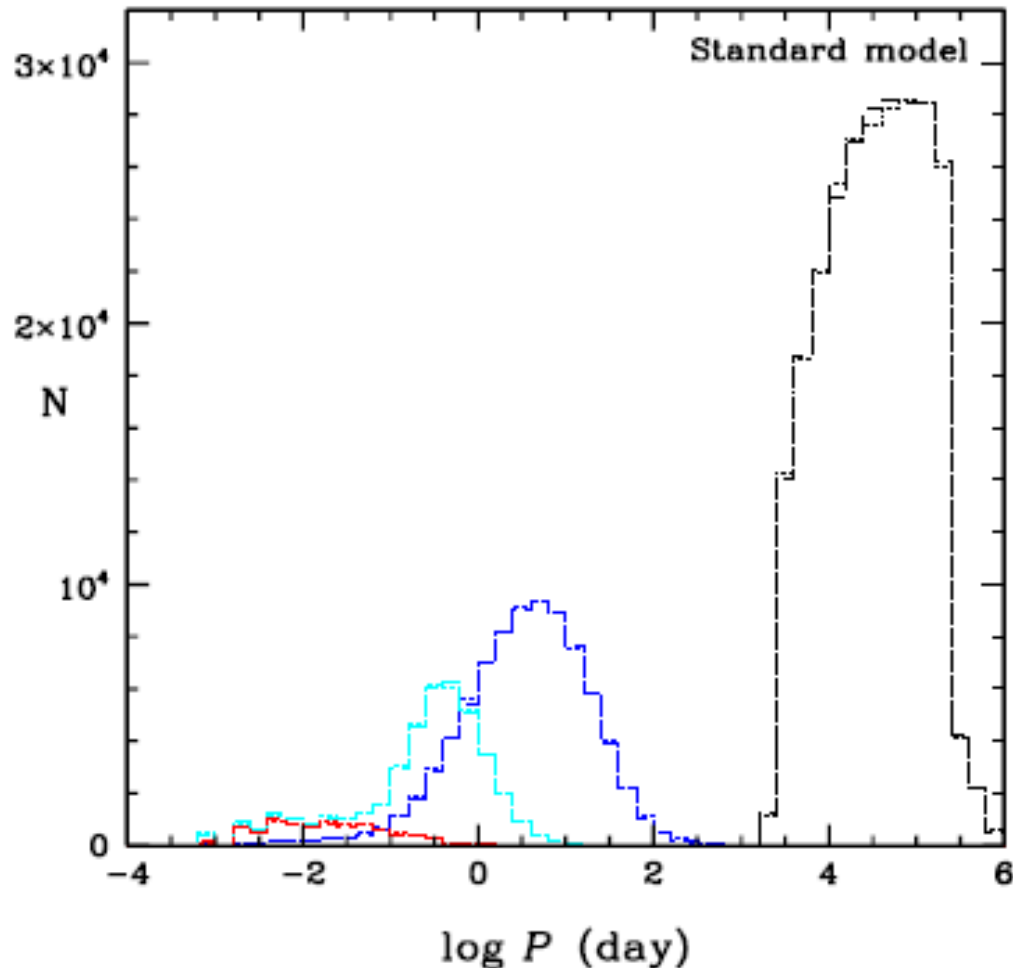
Oomen et al., 2019; 2020



# Conclusion



# Why bother?



**Population Synthesis of binaries**

**Prediction: bimodal distribution**

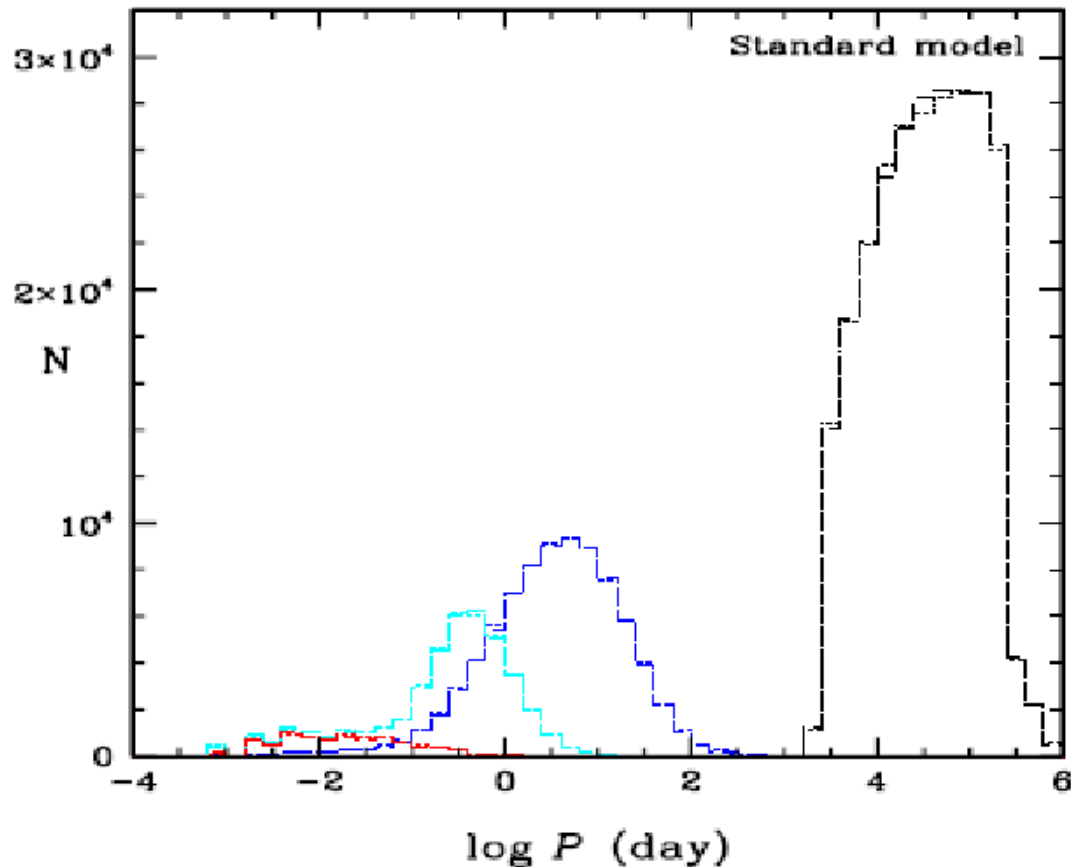
**Common Envelope Results:  
inspiring**

**Wind transfer**

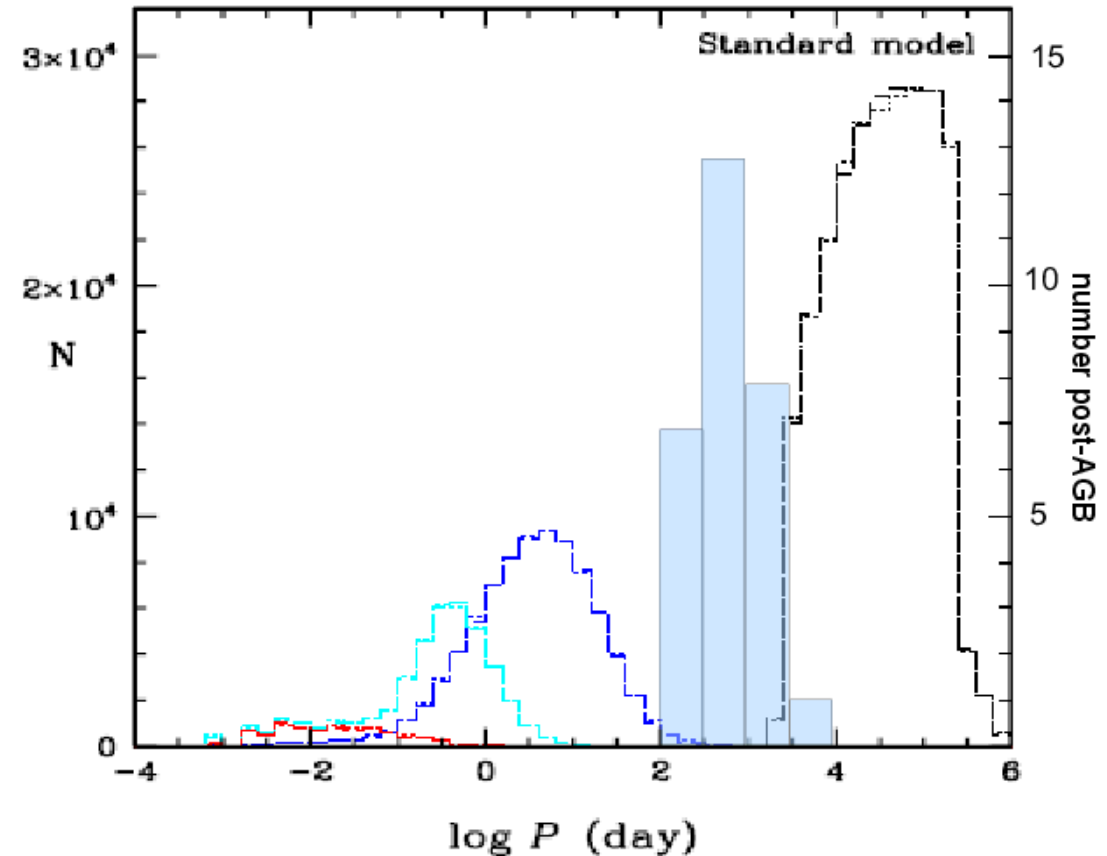


**Nie et al., 2012;**

# Why bother ?



Pop. synthesis Nie et al., 2012



What we observe



# Why bother?: holistic approach

