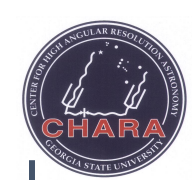


# CHARA/VEGA focus on classical Be stars and hot supergiants

R. Klement, T. Rivinius, D. Mourard, A. Carciofi, A. Meilland



# ABOUT ME

## PRE-CHARA RESULTS

## CHARA/VEGA NEW DATA





# ABOUT ME



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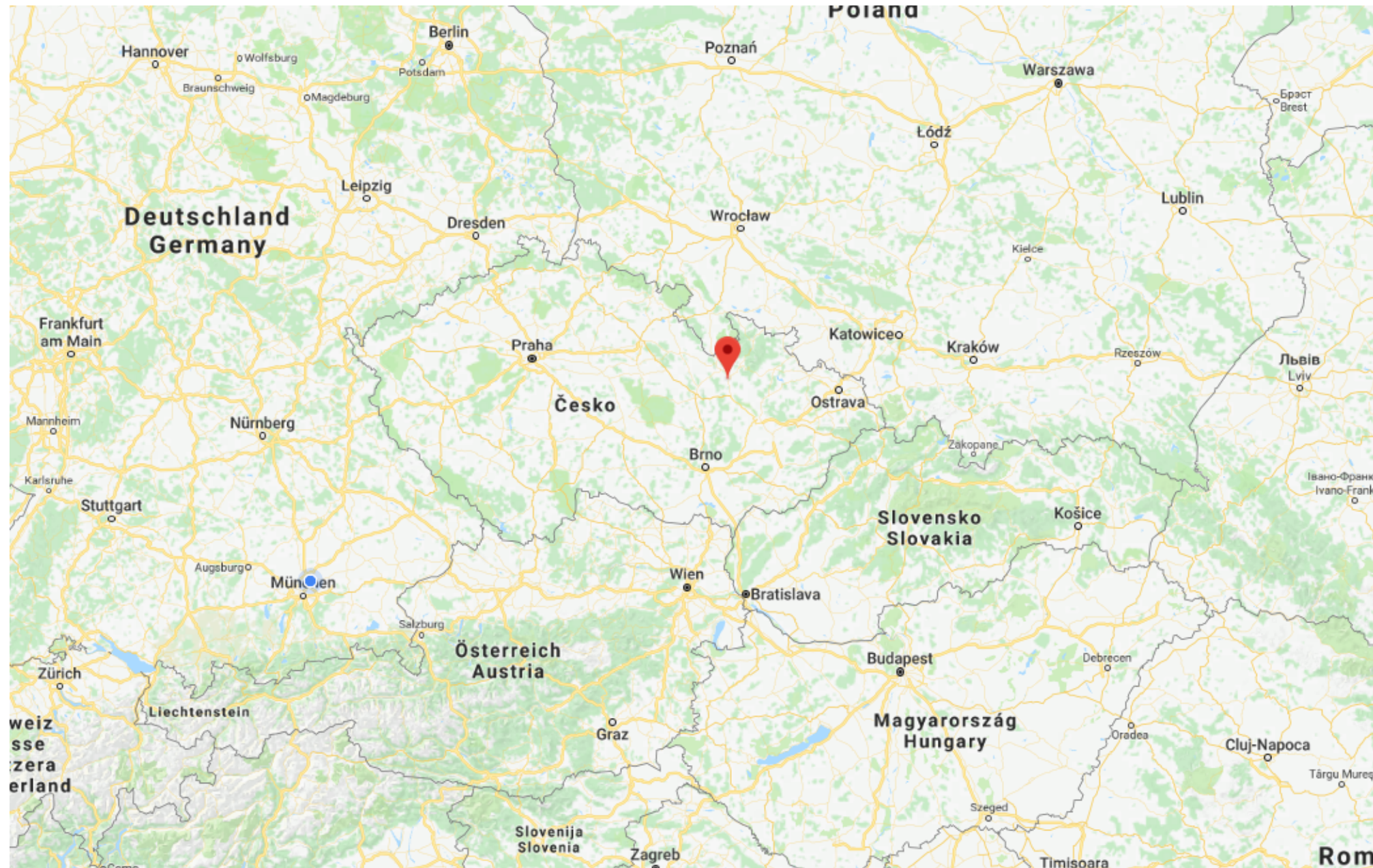


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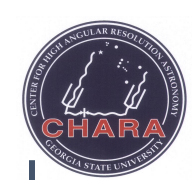


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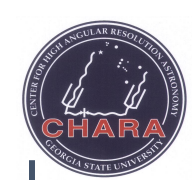






- **Brno** – Institute of Theoretical Physics and Astrophysics
- J. Krtička – hydrodynamics of circumstellar disks

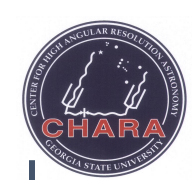




- **Prague** - Astronomical Institute of the Charles University
- S. Štefl - VLT/ALMA
- A.C. Carciofi - radiative transfer, code HDUST, Be stars

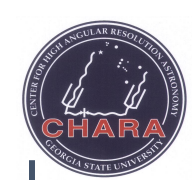






- Santiago - **ESO Chile**
- S. Štefl - VLT/ALMA
- T. Rivinius - spectroscopy, VLT, Be stars





# PRE-CHARA RESULTS



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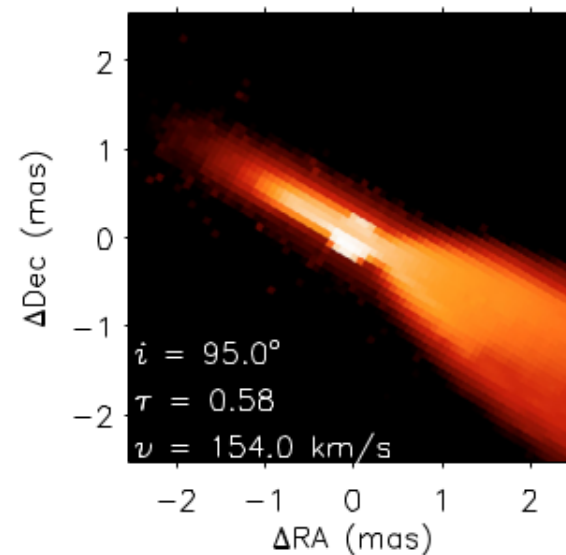
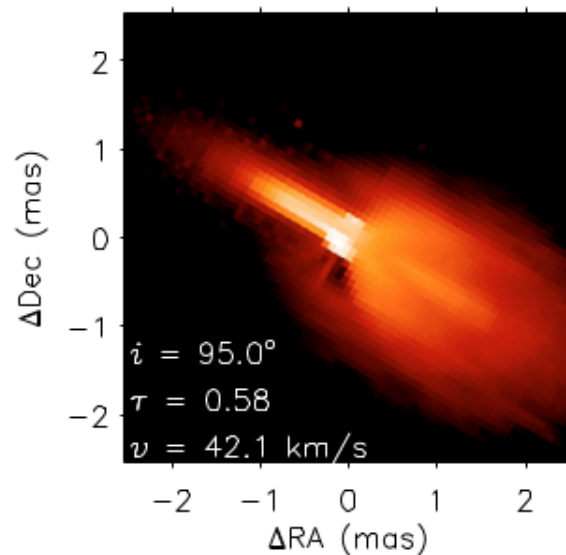
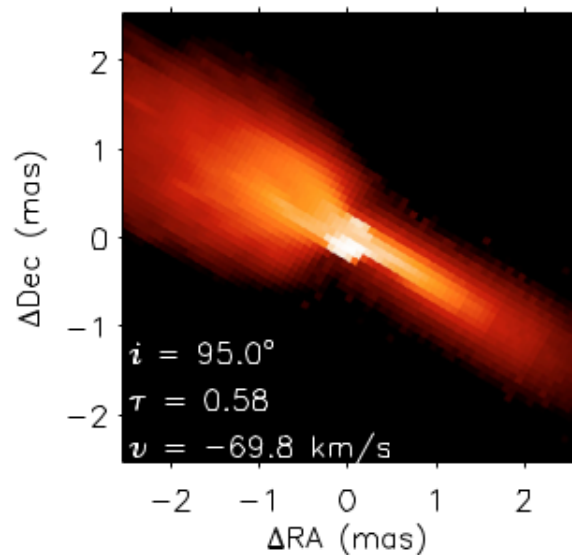
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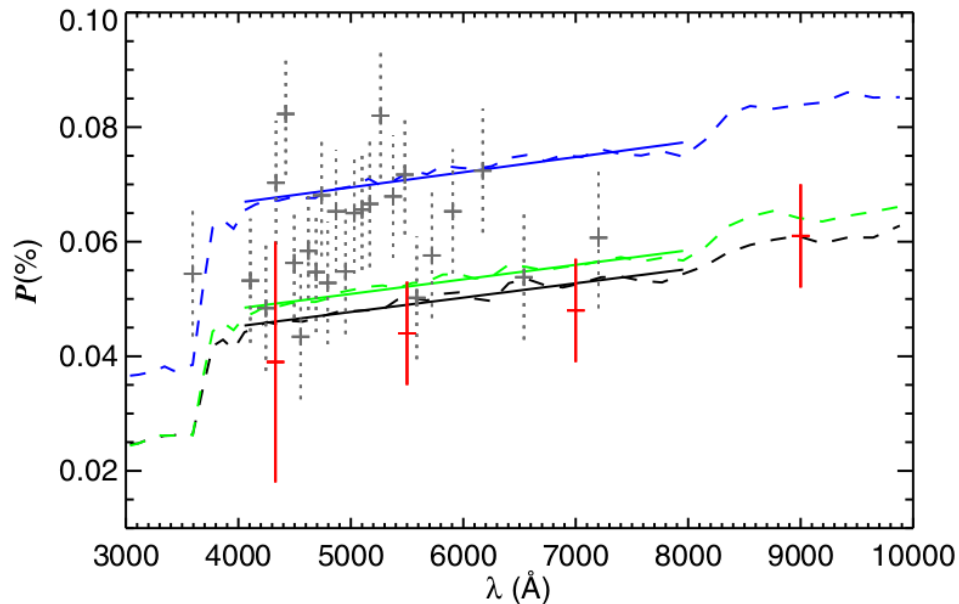
- Multi-technique study of the classical Be star  $\beta$  CMi
  - Classical Be stars - rapid rotators with outflowing Keplerian disks  $\rightarrow$  viscous decretion disk (VDD)
  - Follow up (sort of) on  $\zeta$  Tau study (Carciofi+2009)



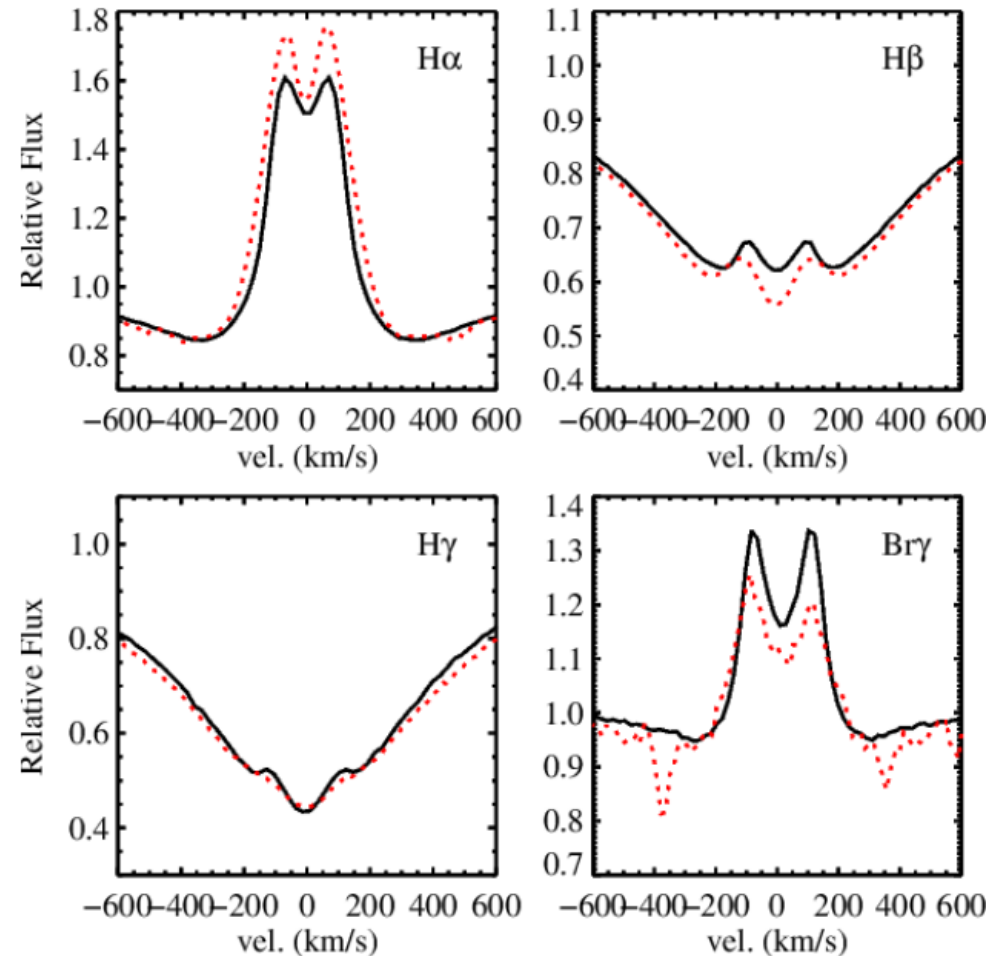


# • Multi-technique study of the classical Be star $\beta$ CMi

- SED from UV to radio
- Spectroscopy
- Polarimetry

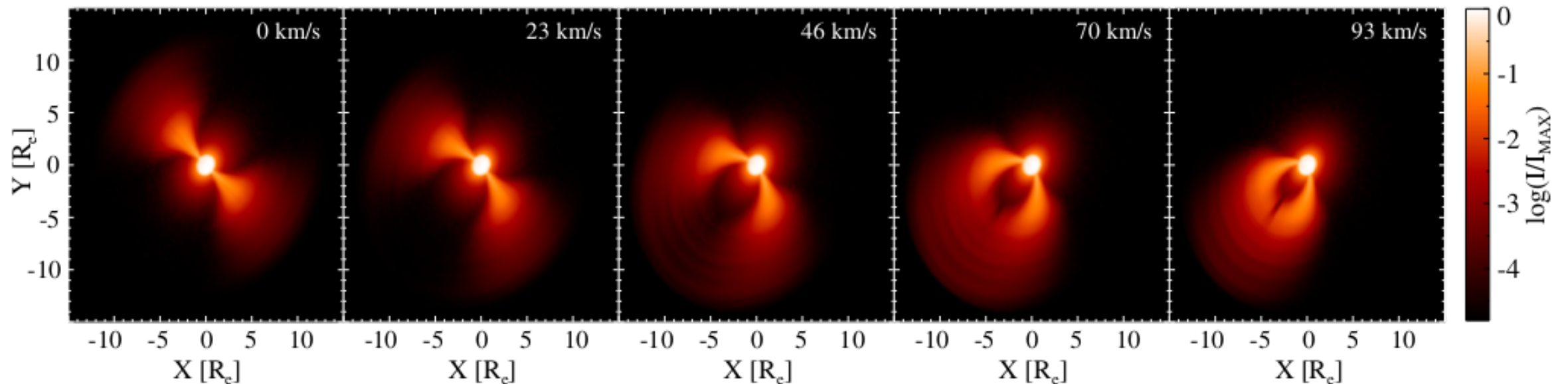


Klement+2015





- Multi-technique study of the classical Be star  $\beta$  CMi
  - Interferometry - VLTI, CHARA, NPOI

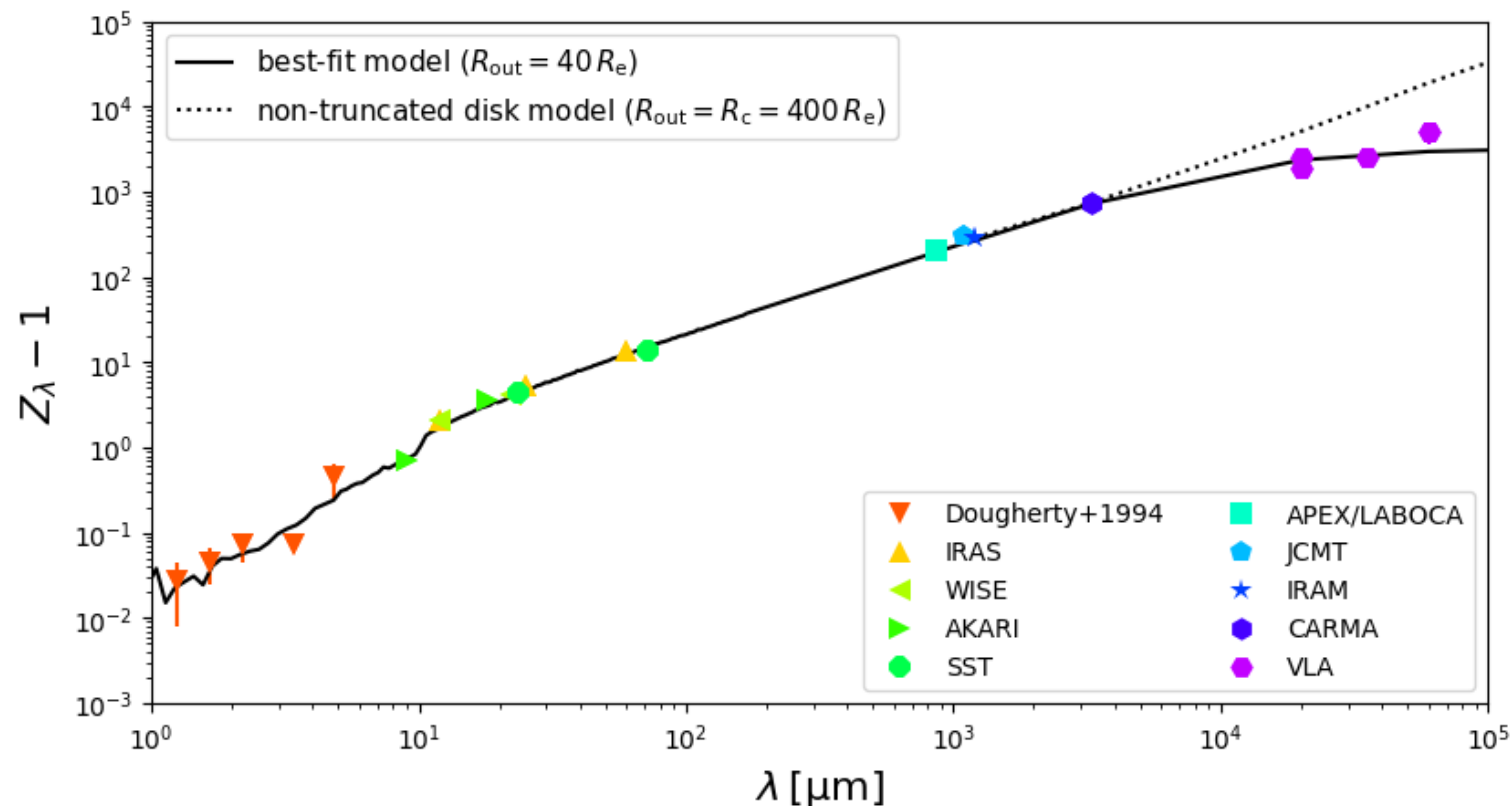






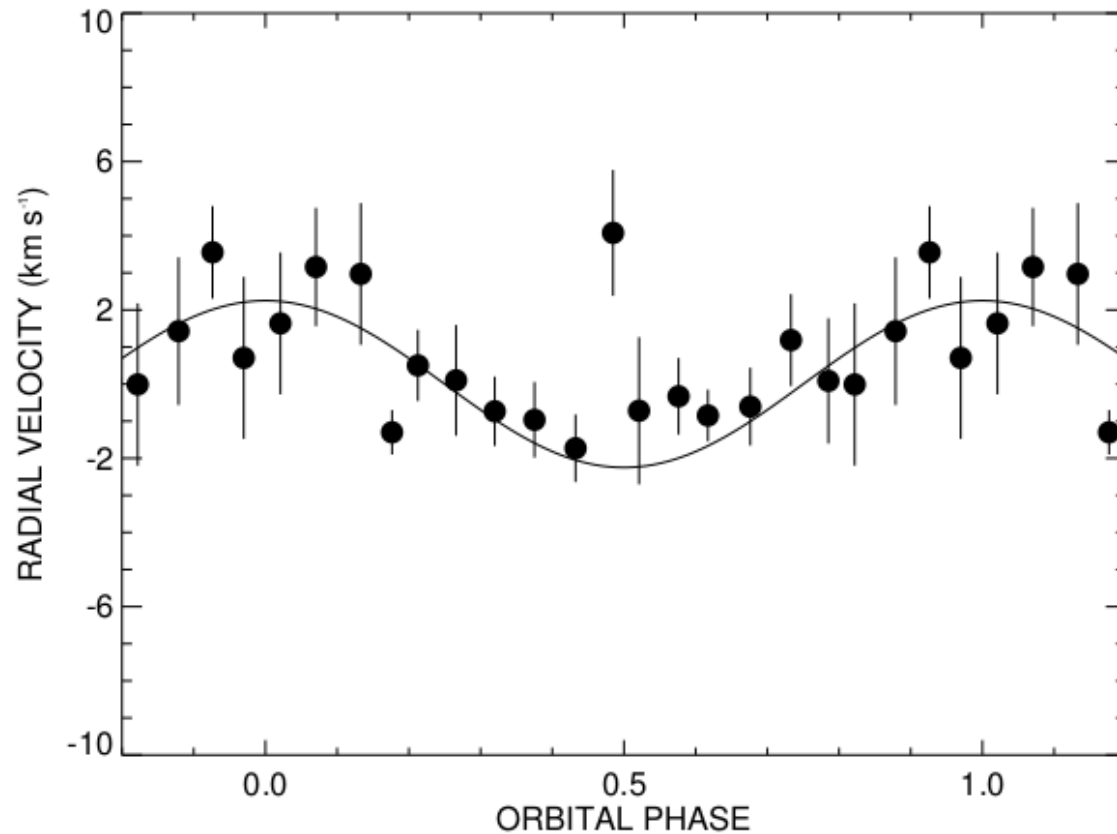
- Multi-technique study of the classical Be star  $\beta$  CMi
  - VDD model **simultaneously** reproduces almost the whole dataset
  - Radio (cm) part of the SED indicates **disk truncation**

$$Z_{\lambda} = F_{\lambda, \text{obs}} / F_{\lambda, \text{phot}}$$

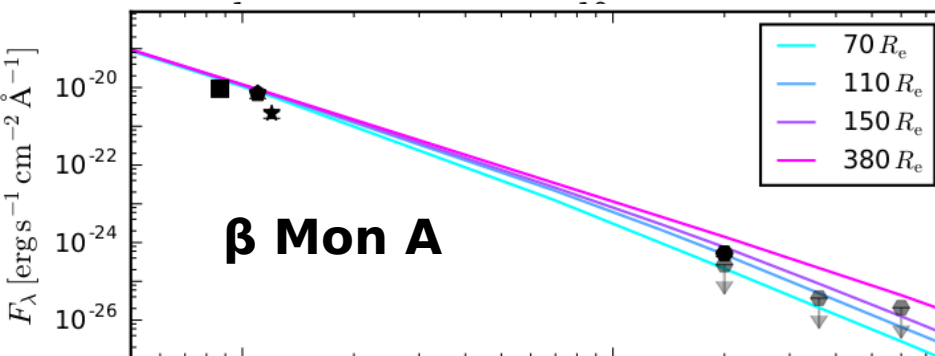
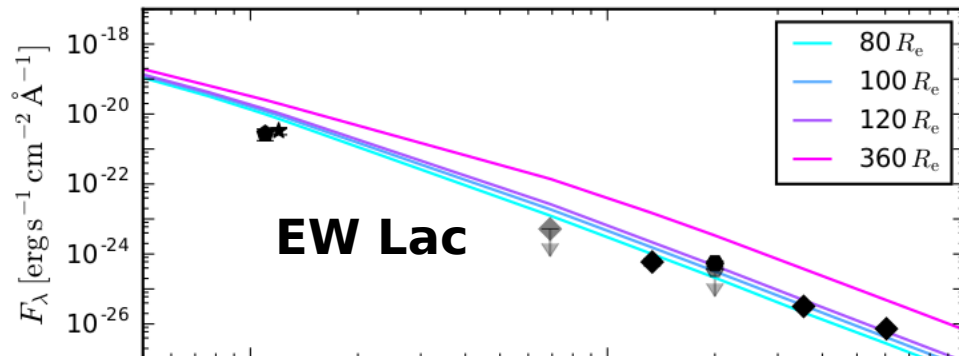
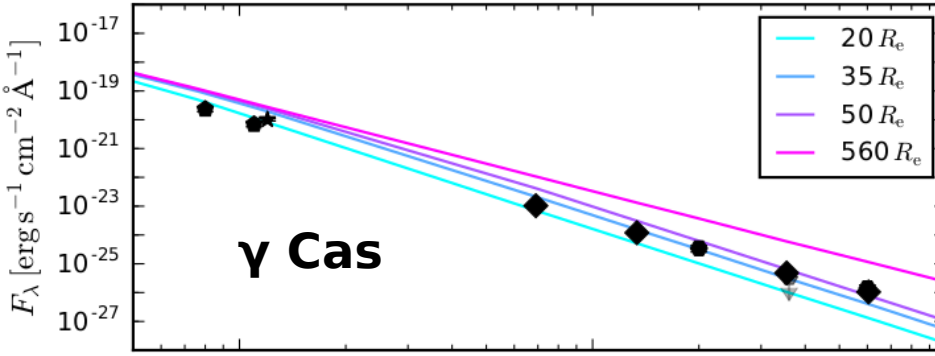
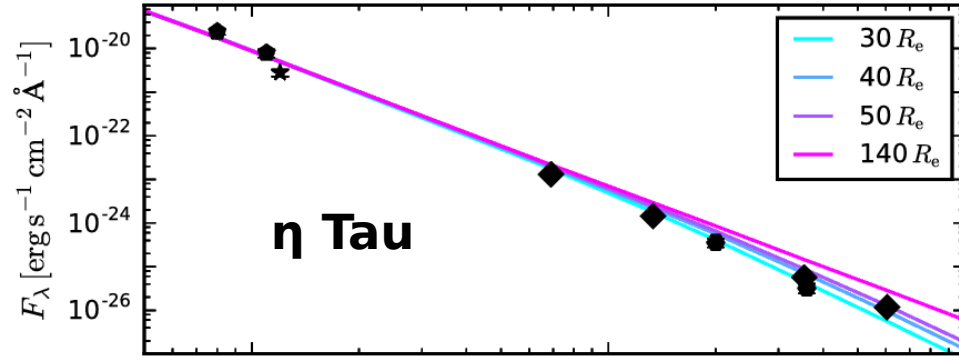
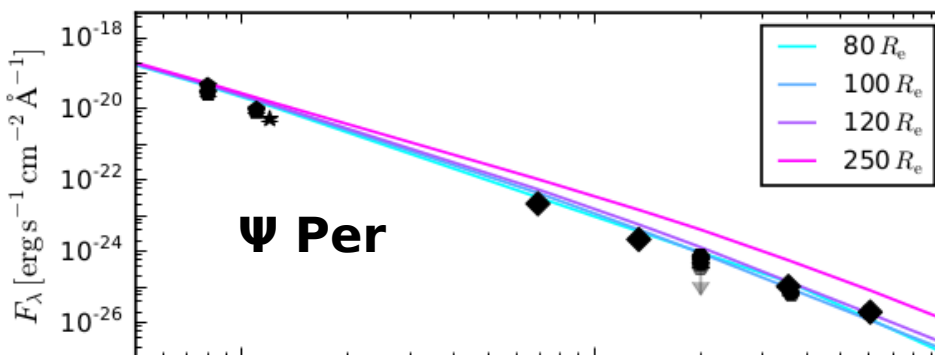
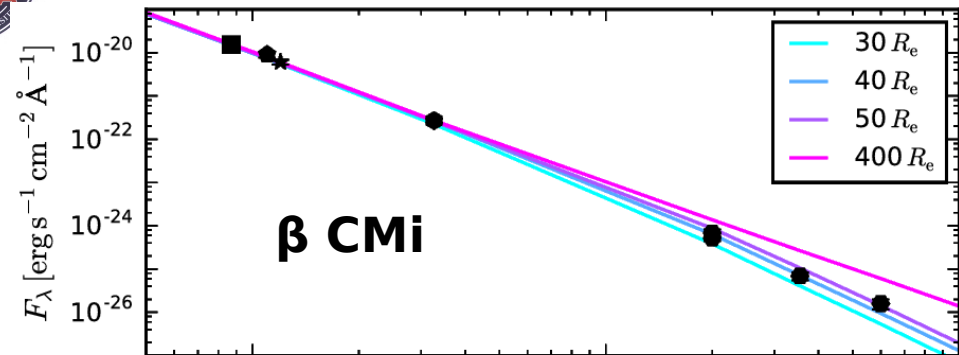




- Multi-technique study of the classical Be star  $\beta$  CMi
  - Follow-up: **binary companion detected** in H $\alpha$  RVs



Dulaney+2017



- Radio
- APEX - sub-mm
- VLA - cm

• Are all Be stars binaries?

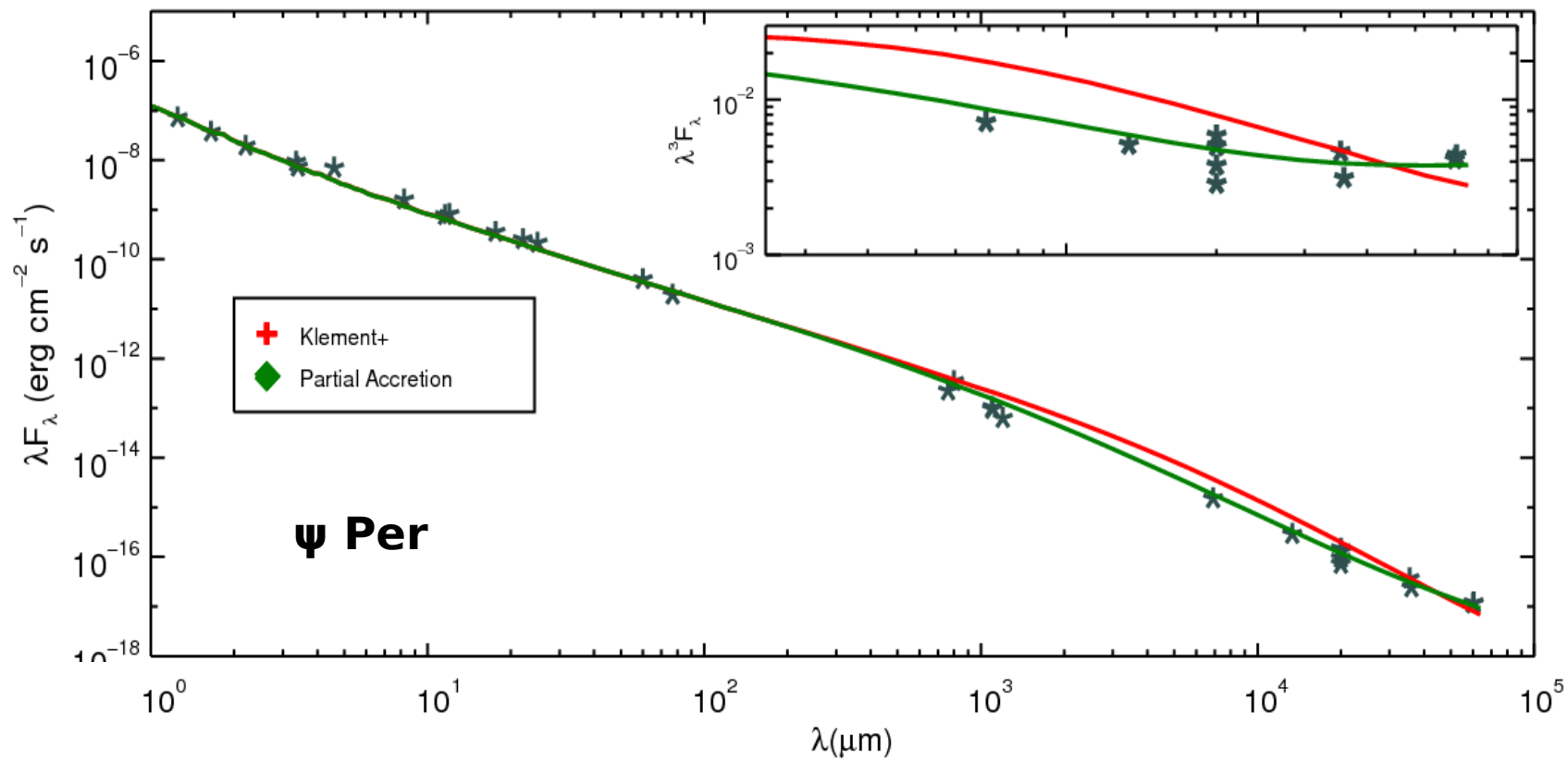
$\lambda$  [mm]

Klement+2017

$\lambda$  [mm]

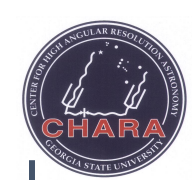






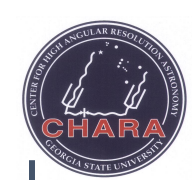
Bratcher+ in prep.

**Truncated disk vs. Circumbinary disk** (partial accretion on the companion)



# HOT SUPERGIANTS WITH VEGA

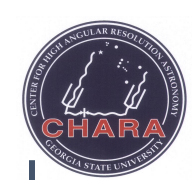




## • BA Supergiants

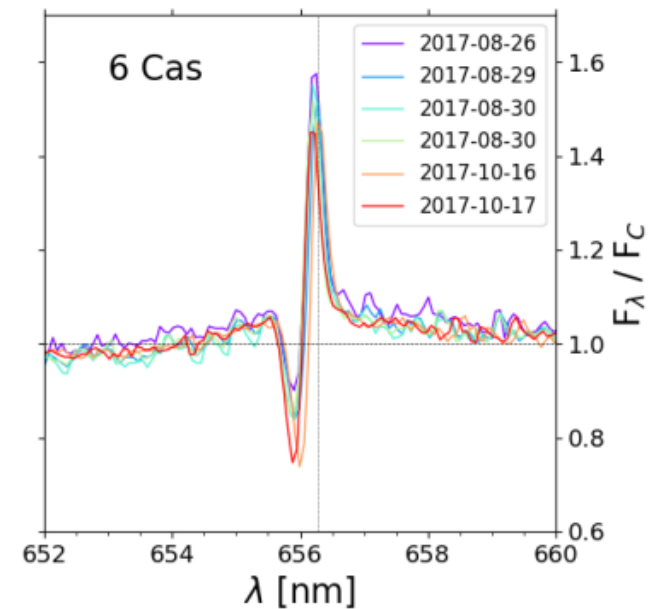
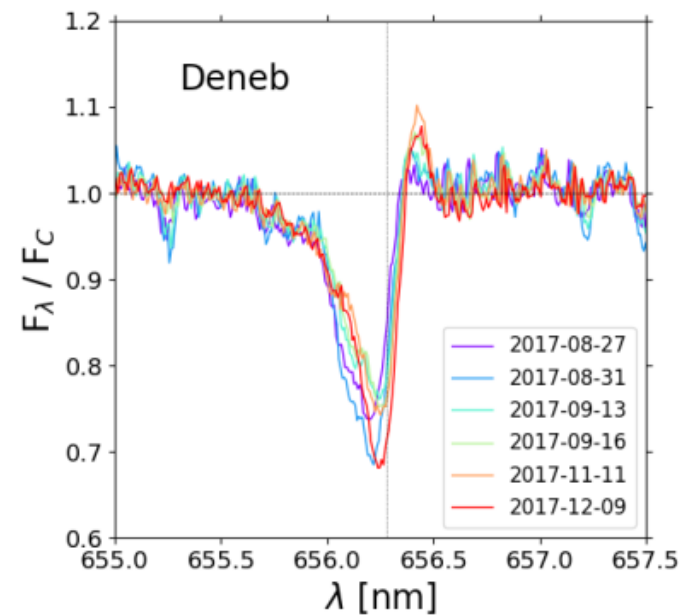
- Massive stars evolving from MS to RSG and possibly after RSG, dubbed luminous blue variables (LBVs) if outbursting
- Line-driven winds
  - variable, **asymmetric**
  - bright spots/non-radial pulsations → localized time-dependent mass ejections → hints of corotating interaction regions (Chesneau+2010,2014)
- P Cygni line profiles – strongest emission in **H $\alpha$**  → high resolution spectro-interferometry
- **Rigel** (B8Iae), **Deneb** (A2Ia), **P Cygni** (B1-2Ia)



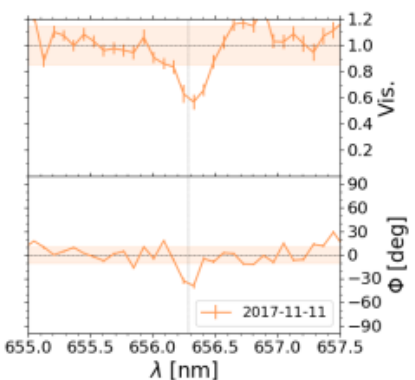
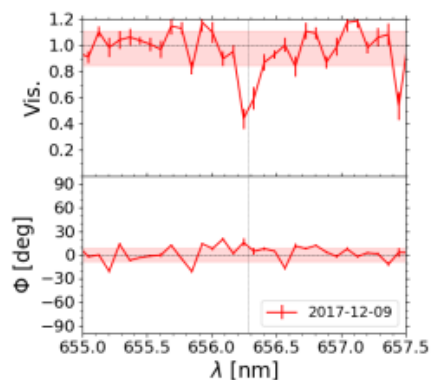
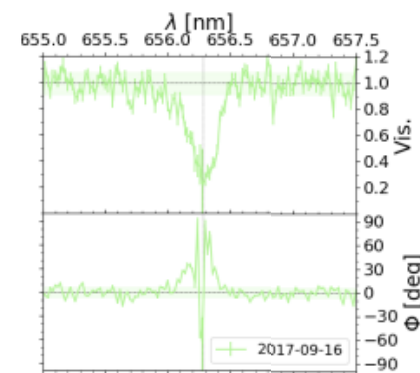
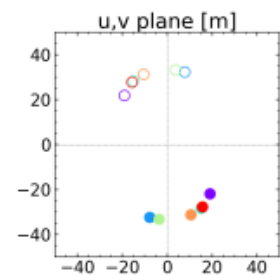
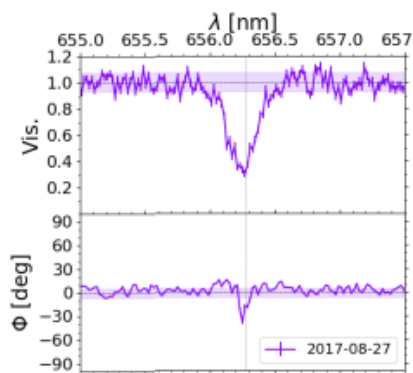
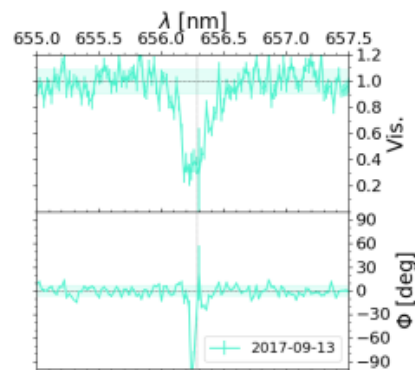
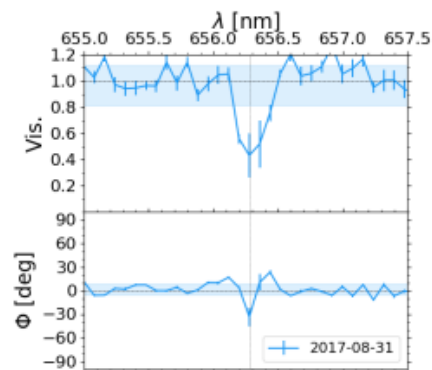
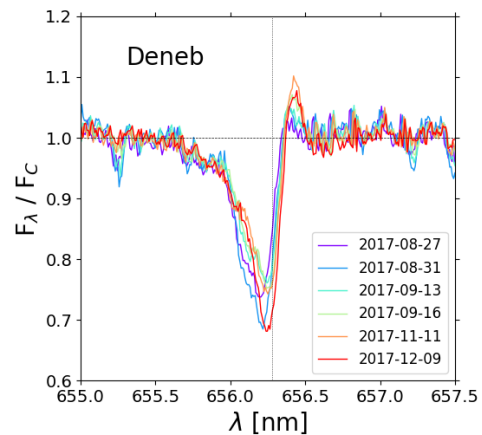


## • BA Supergiants

- CHARA/VEGA – find suitable targets for detailed study
- Image the strongest winds across H $\alpha$
- Compare with radiative transfer models – 3D structure of the stellar wind with HDUST (Carciofi & Bjorkman 2006)

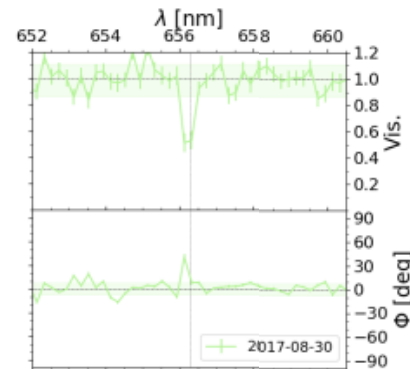
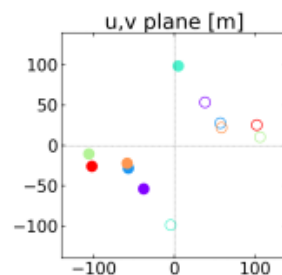
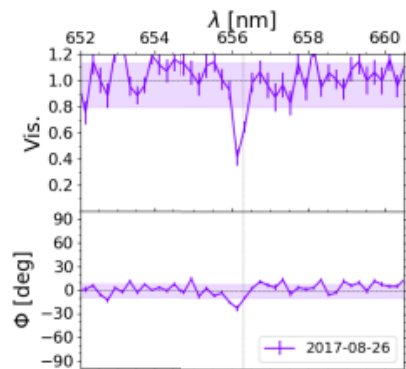
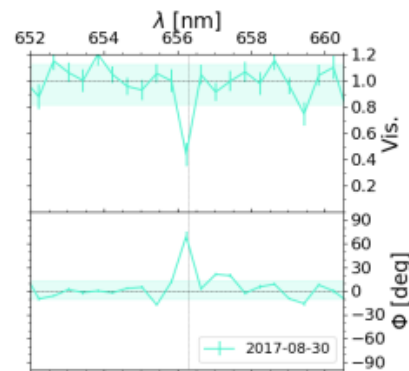
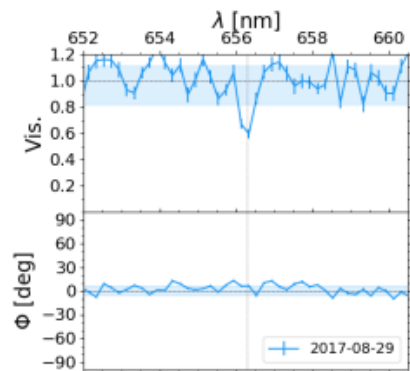
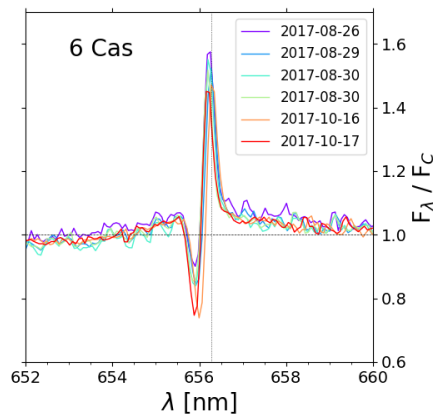


Deneb:  $R = 1.14$



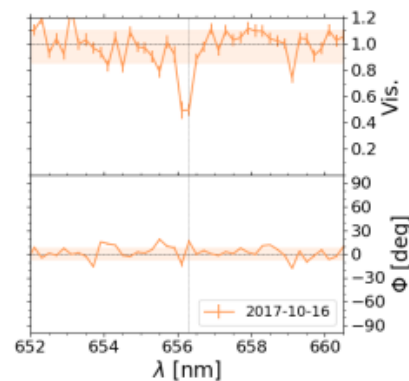
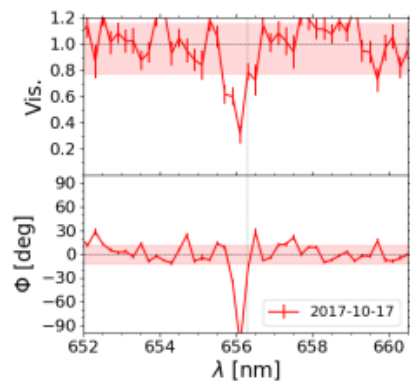


6 Cas:  $V = 5.43$

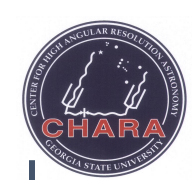


6 more objects observed

More to be observed soon if weather allows







# CLASSICAL BE STARS WITH VEGA



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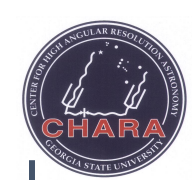


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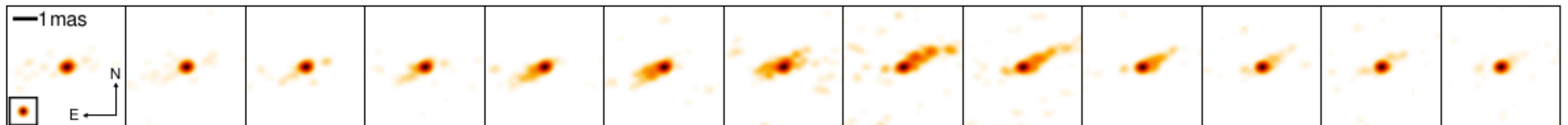
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## • Classical Be stars

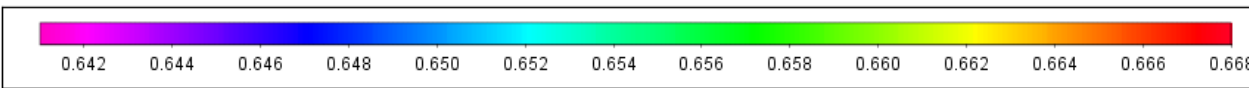
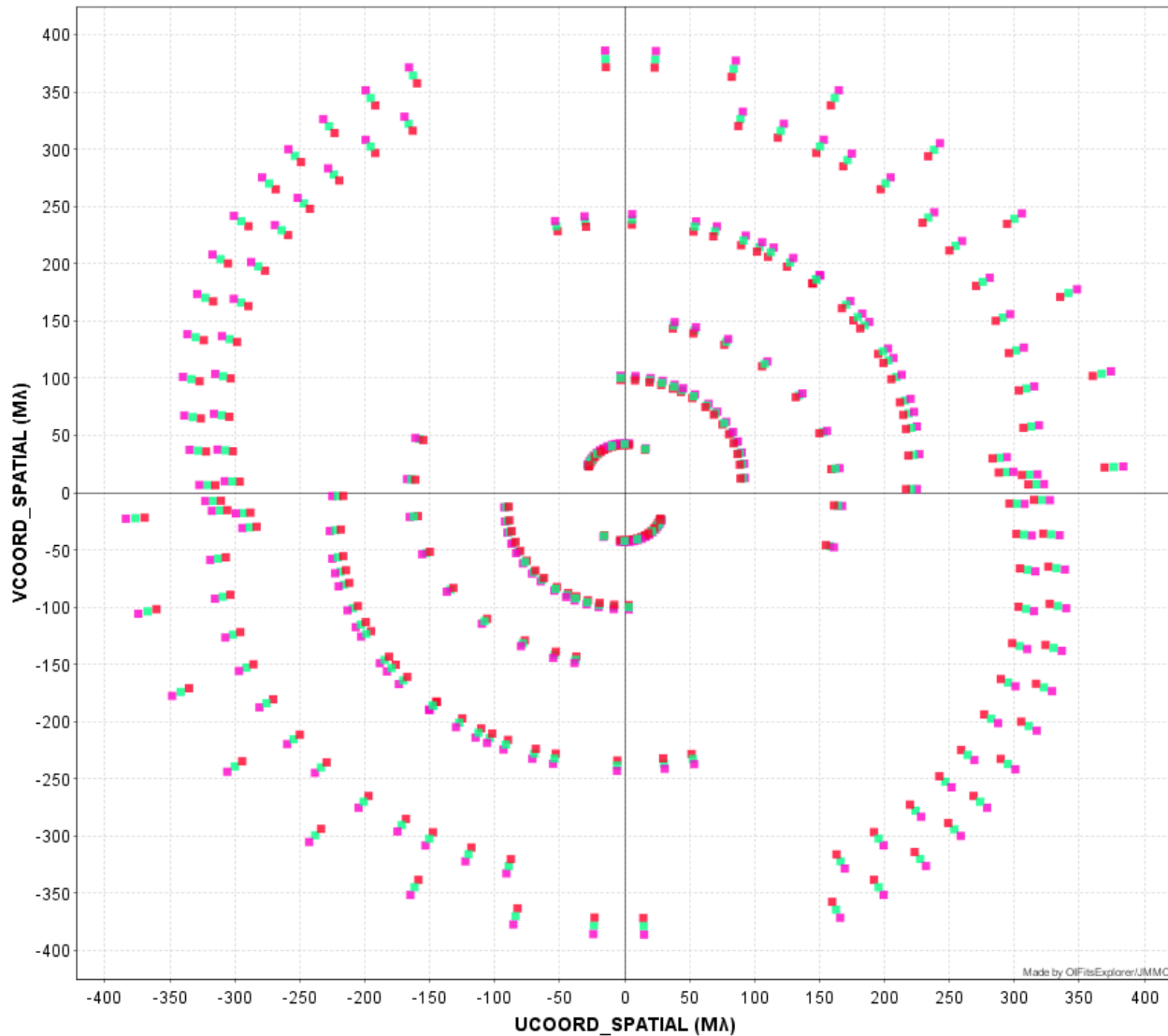
- CHARA/VEGA Be star survey (PI: Meilland) - ~25 stars observed at short baselines
- $\gamma$  Cas – 4T program in 2016,  $\alpha$  Aqr (E. Almeida), Pleione + Alcyone
- **Image across H $\alpha$** 
  - $\phi$  Per – Mourard+2015
  - $\kappa$  Dra (F. Millour, A. Soulain) – 3T imaging project in 2014-2016 - data collected and reduced
  - $\beta$  CMi (A. Meilland, Klement) – Winter 2017 – part of data collected, need more in 2018



CHARA - VEGA [0.655  $\mu\text{m}$  - 0.655  $\mu\text{m}$ ] / [0.6675  $\mu\text{m}$  - 0.6675  $\mu\text{m}$ ] / [0.6425  $\mu\text{m}$  - 0.6425  $\mu\text{m}$ ] - MULTI CONFIGURATION

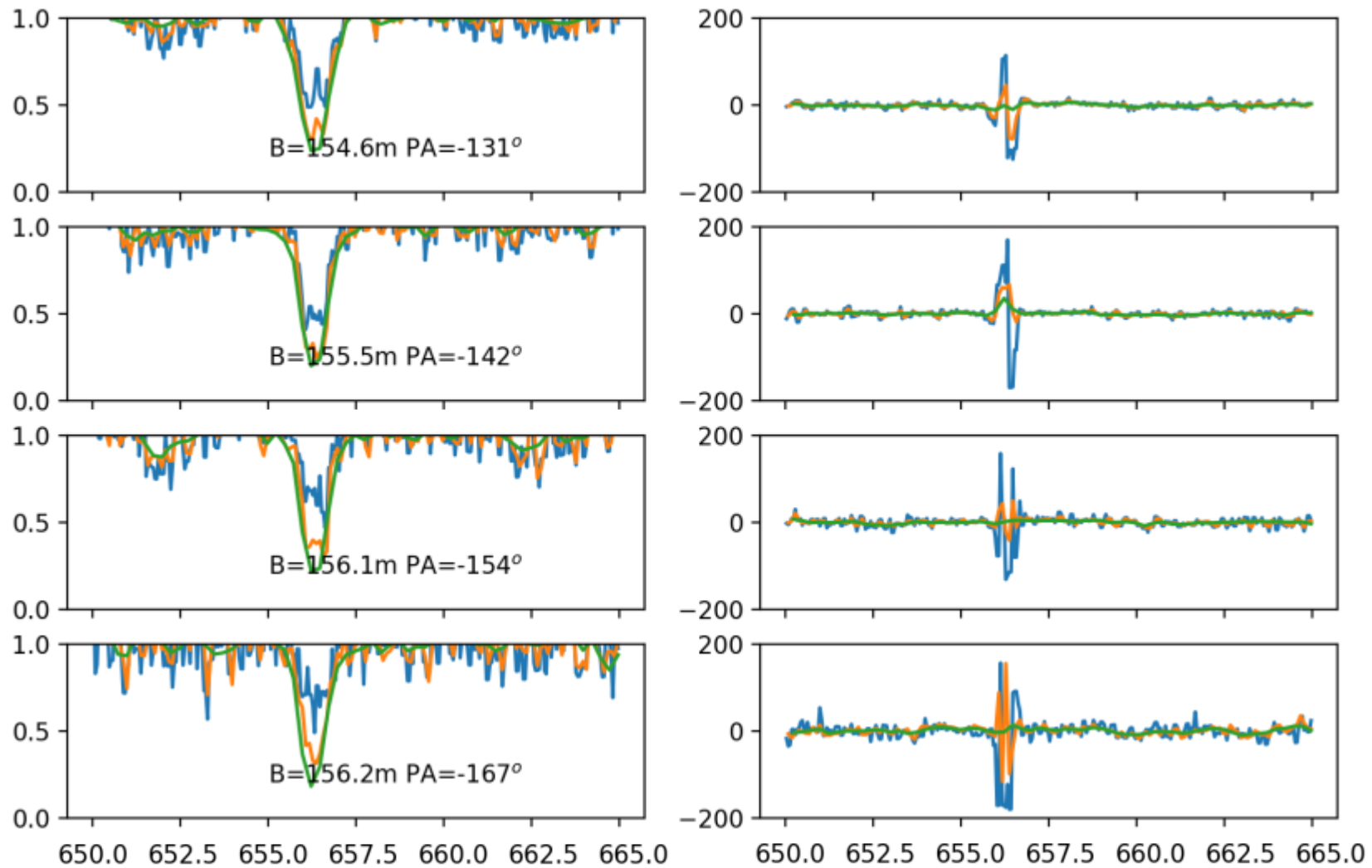
Day: MULTI DATE - Source: HD109387

- $\kappa$  Dra





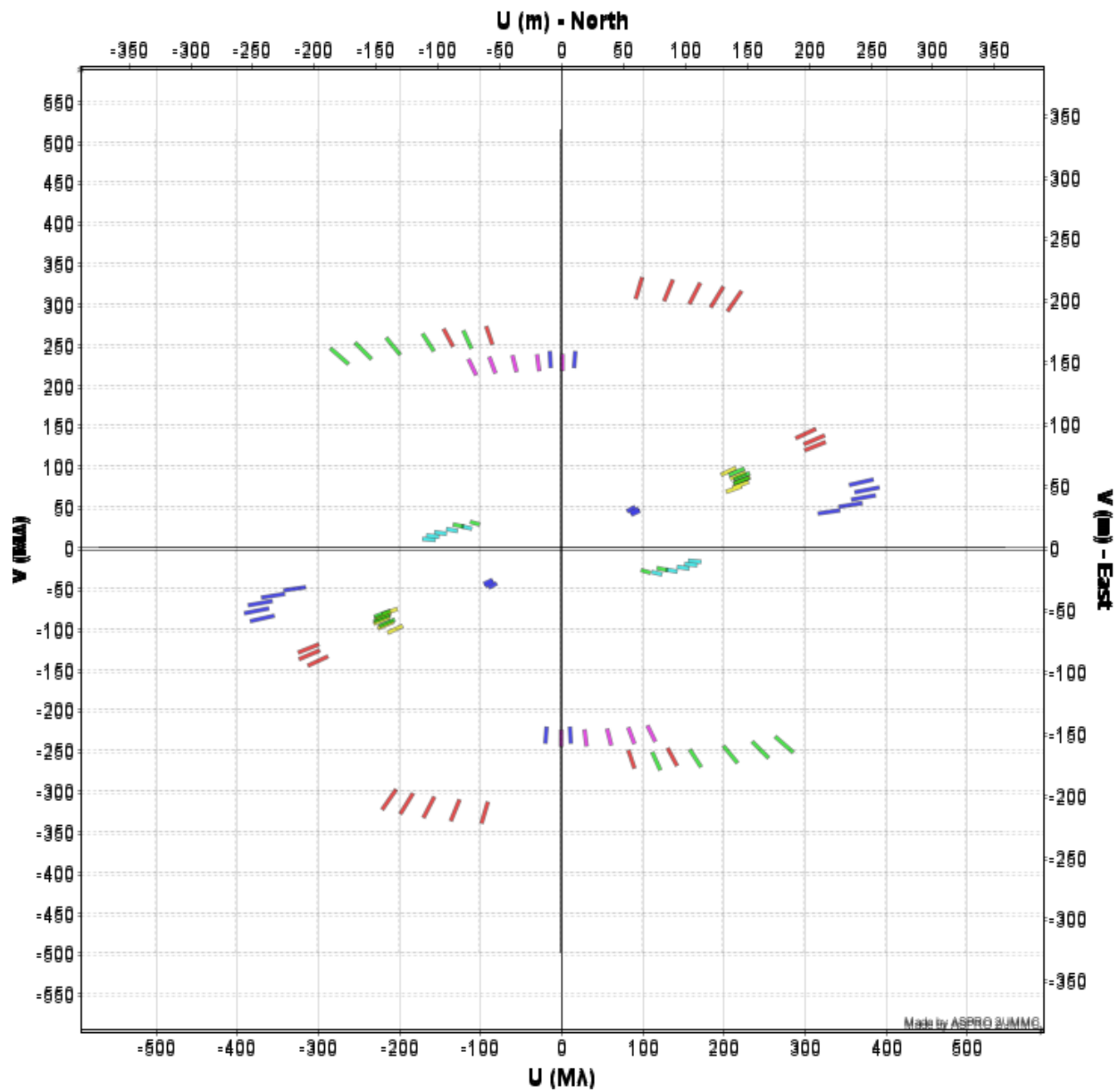
- κ Dra







- $\beta$  CMi





# THANK YOU



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