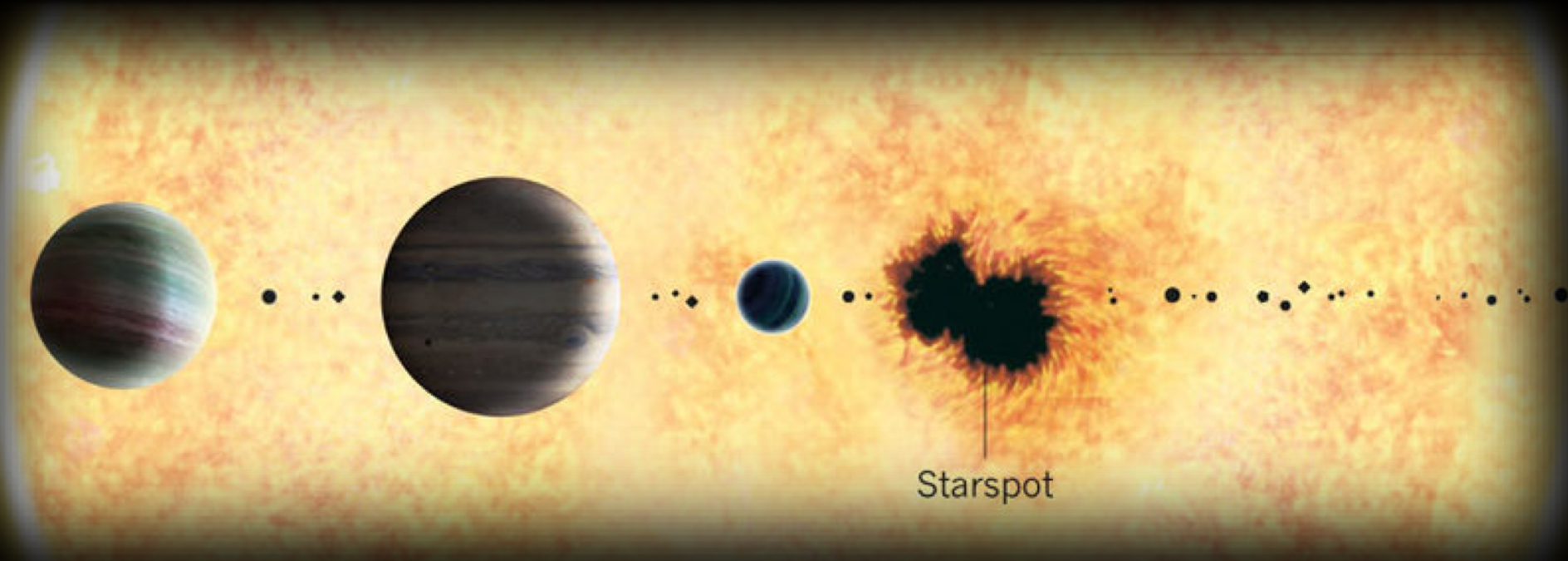


# Studying Radial-velocity variations of active stars in the CARMENES Survey for Exoplanets



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(Landessternwarte / MPIA, Heidelberg)

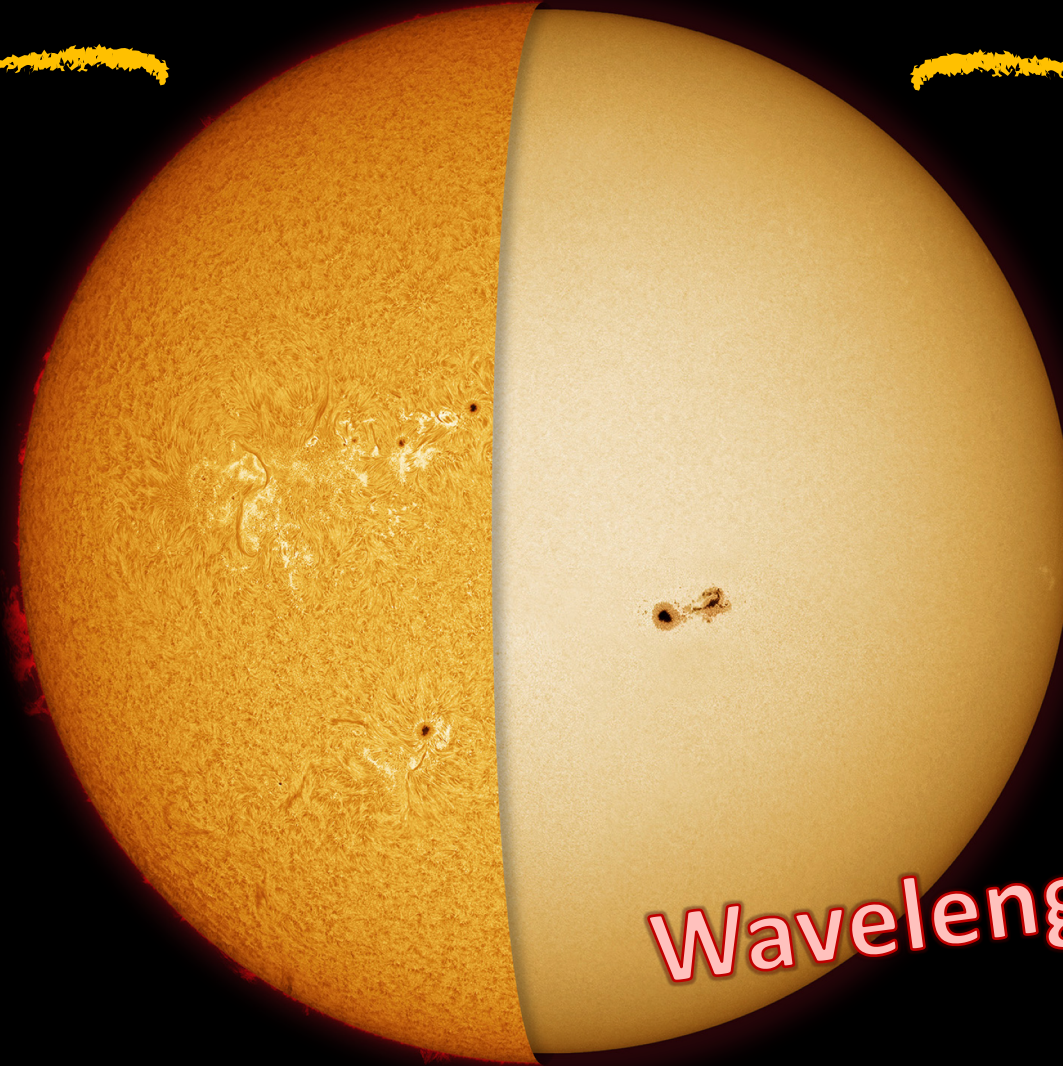
Collaborators: S. Reffert, A. Quirrenbach, M. Kürster, L. Tal-Or, D. Kossakowski, M. Zechmeister, A. Reiners, M. Lafarga & CARMENES Consortium

## Chromospheric activity

- **Plages**
- **Filaments**



Cause variation in  
Ca II H&K and H $\alpha$   
emission lines



## Photospheric activity

- **Spot**
- **Faculae**



Distort shape of  
the spectral lines

**Wavelength dependant!**

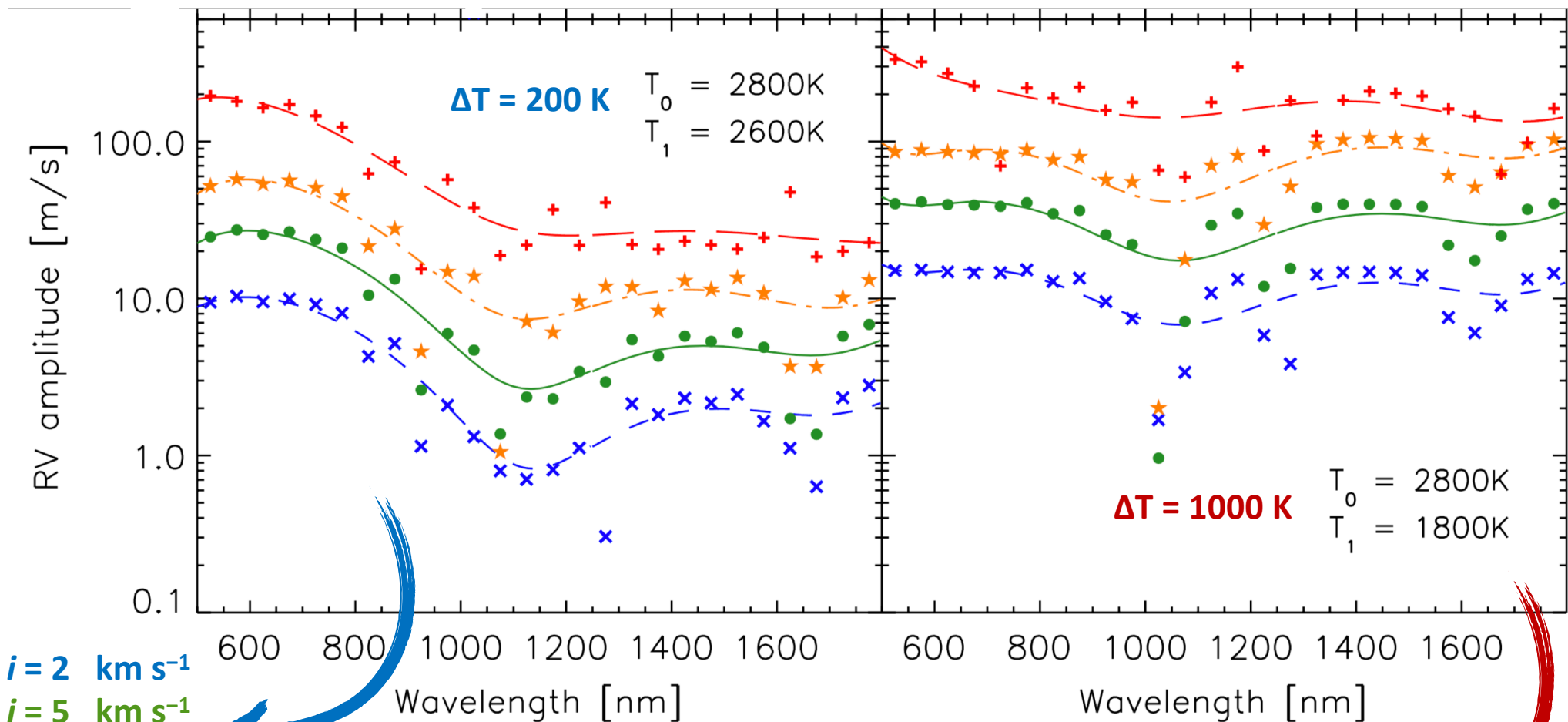
# Forward Modelling



RV amplitude depends on:

- **Spot-coverage Fraction**
- **$v \sin i$**
- **$SpT$**
- **Spot-to-photosphere temperature contrast.**

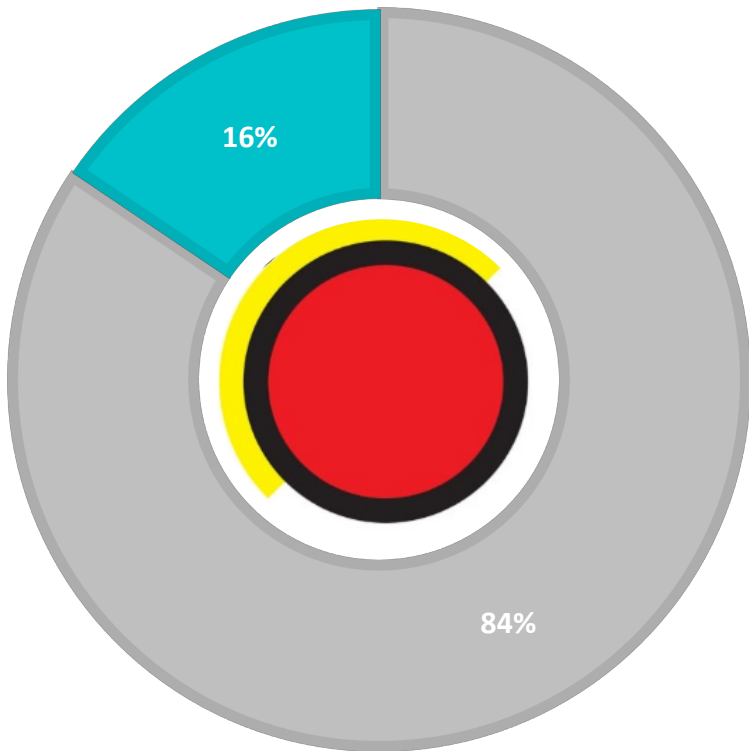
- $v \sin i = 2 \text{ km s}^{-1}$
- $v \sin i = 5 \text{ km s}^{-1}$
- $v \sin i = 10 \text{ km s}^{-1}$
- $v \sin i = 30 \text{ km s}^{-1}$



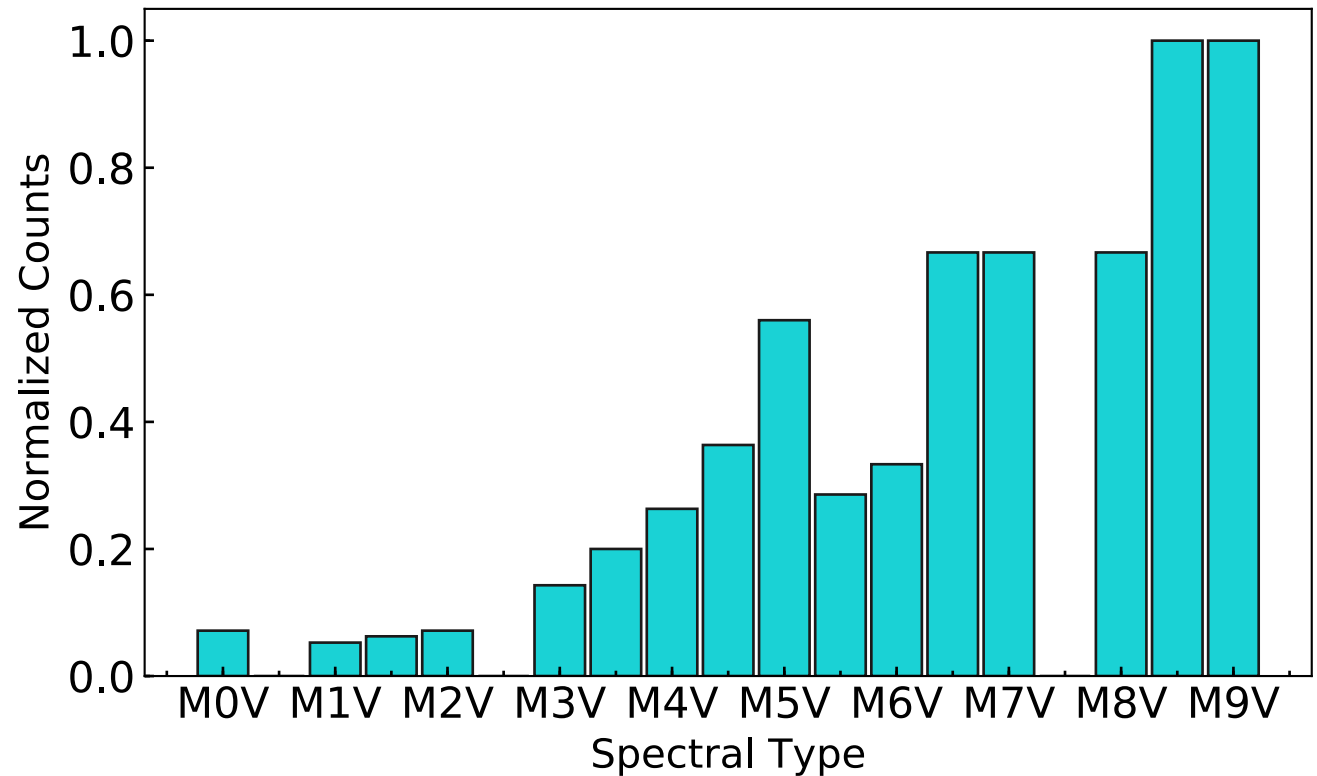
Different temperature combinations

## 53 Active RV-loud Sample\*

- Std (RV) > 10 m/s
- $v \sin i > 2 \text{ km s}^{-1}$
- Number of RVs > 10
- No known or suspected companions

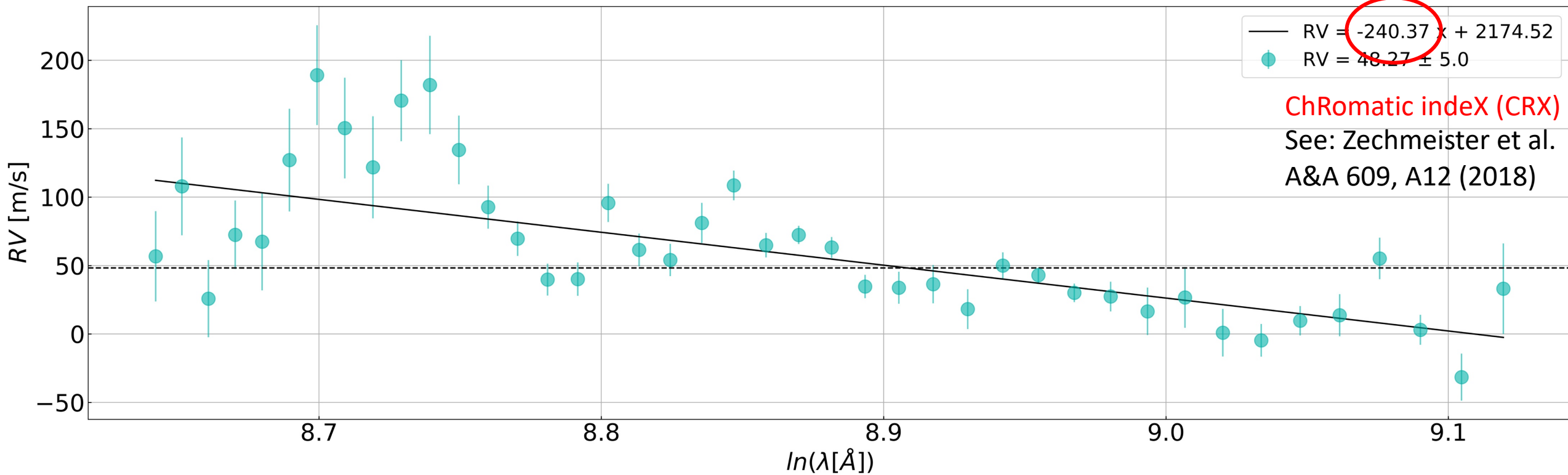
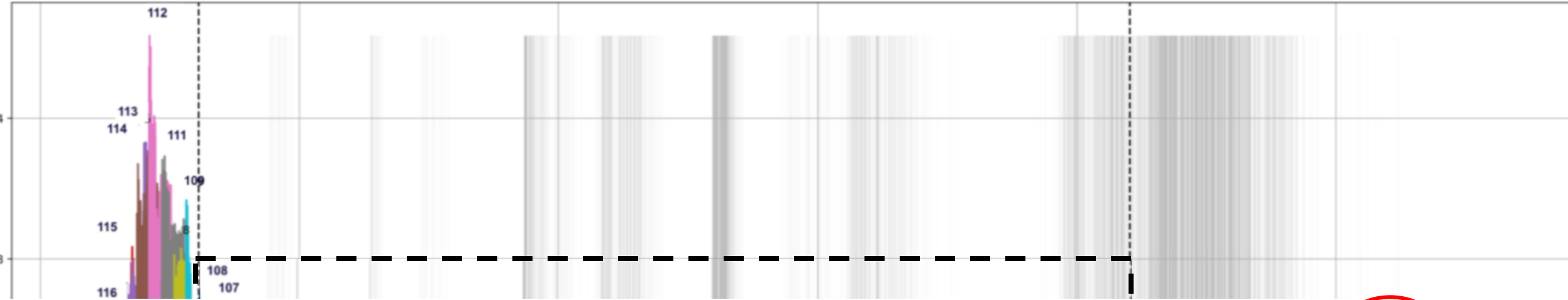


**341 M dwarfs in CARMENES**

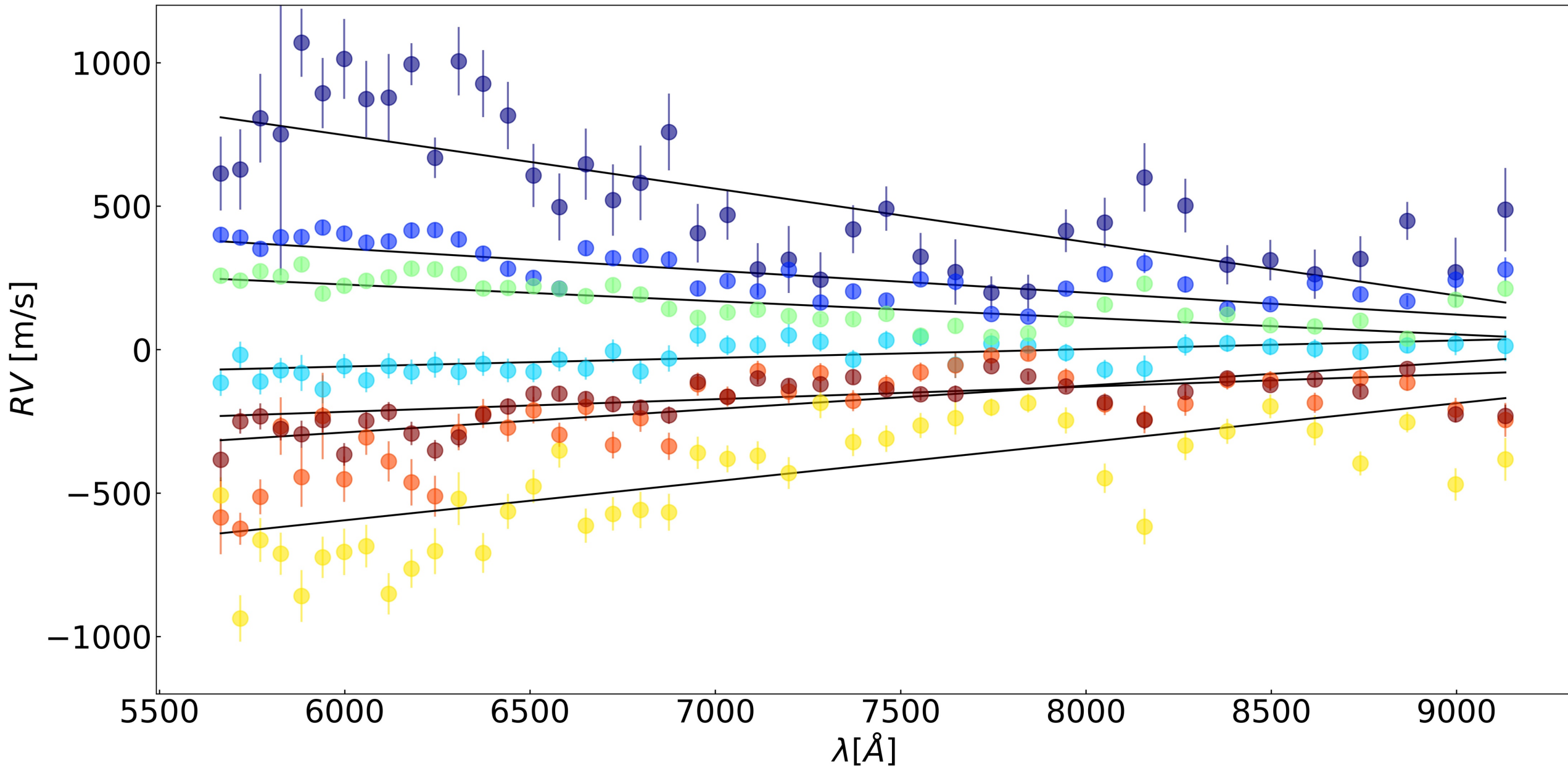


\* Criteria by Tal-Or.

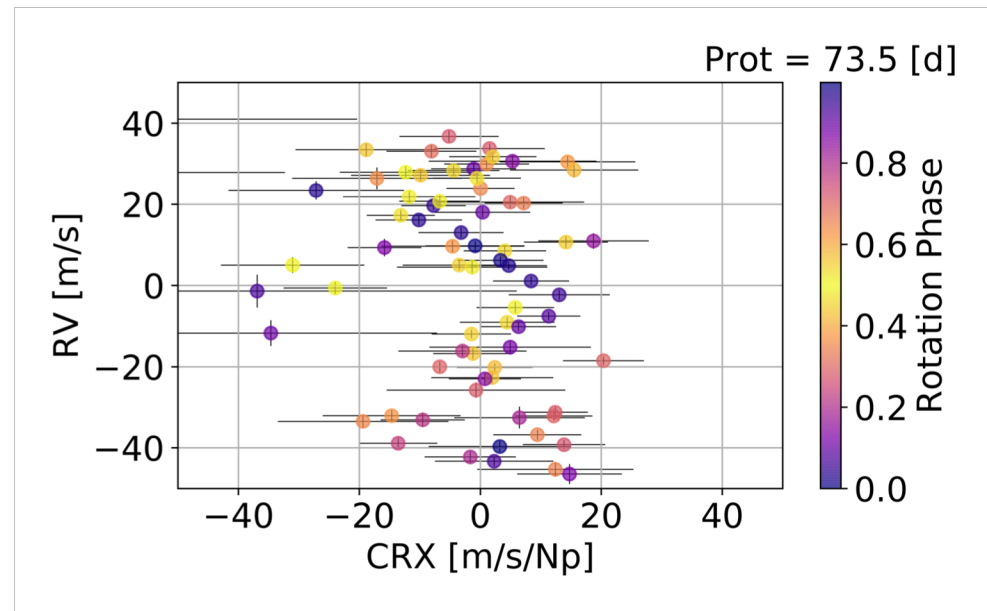
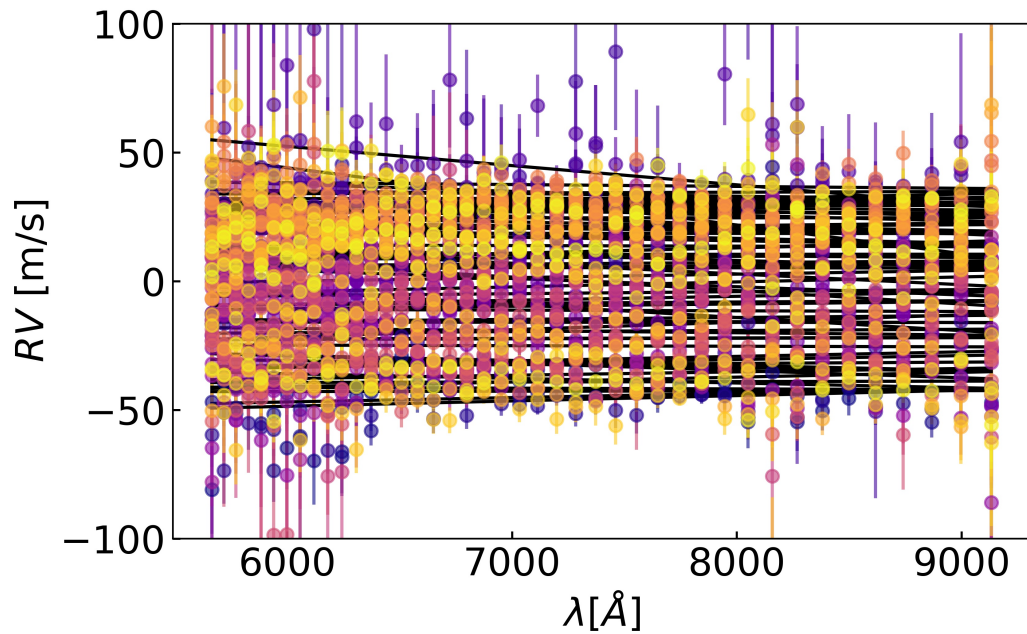
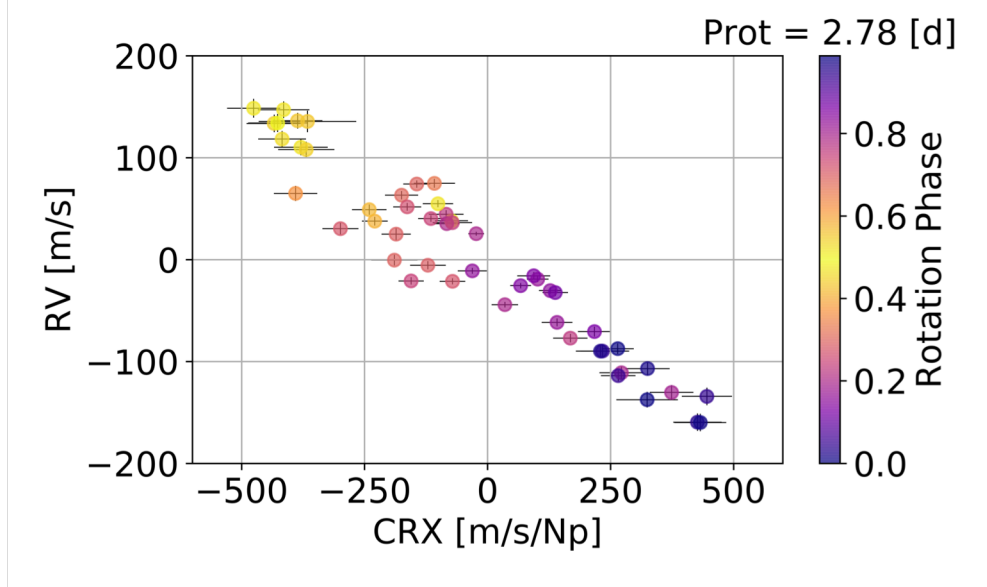
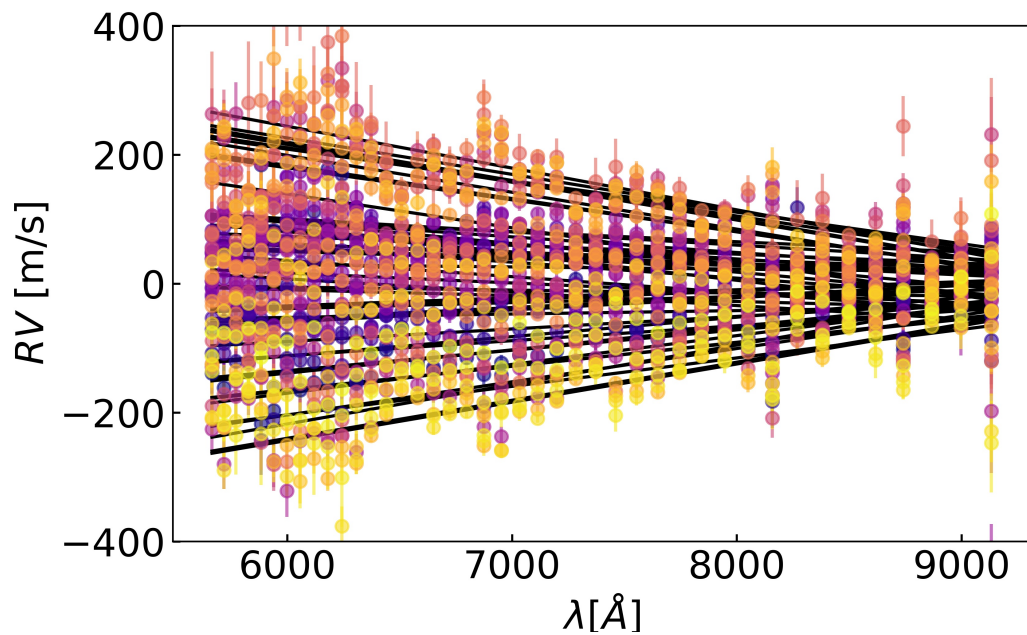
# CARMENES wide spectral range



# Spot effect on RVs

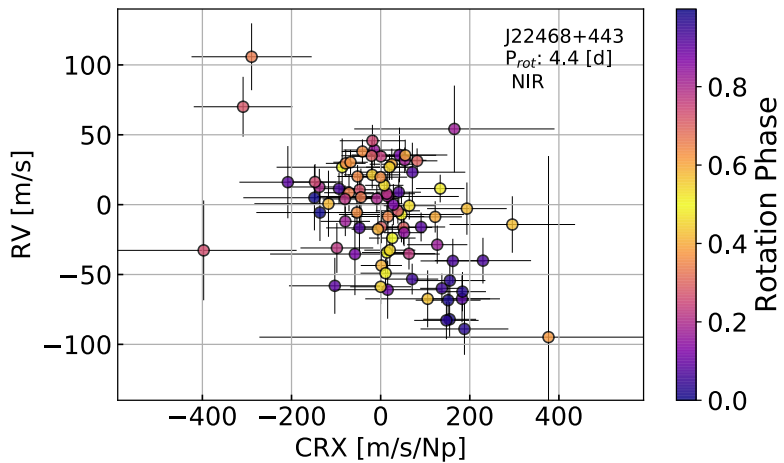
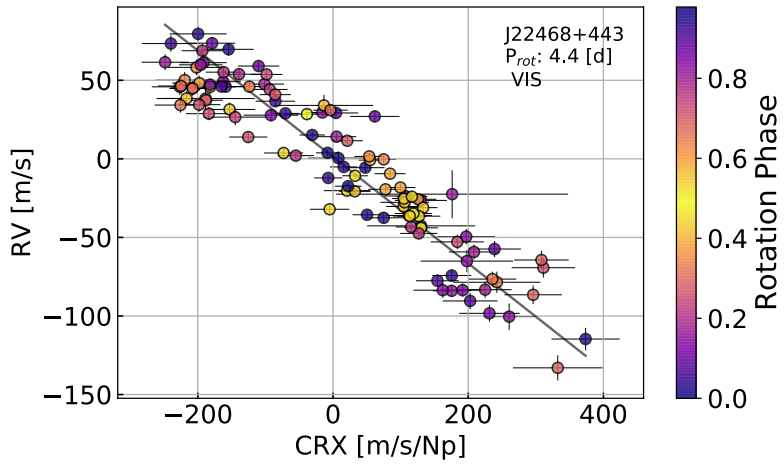


# Spot or Planet



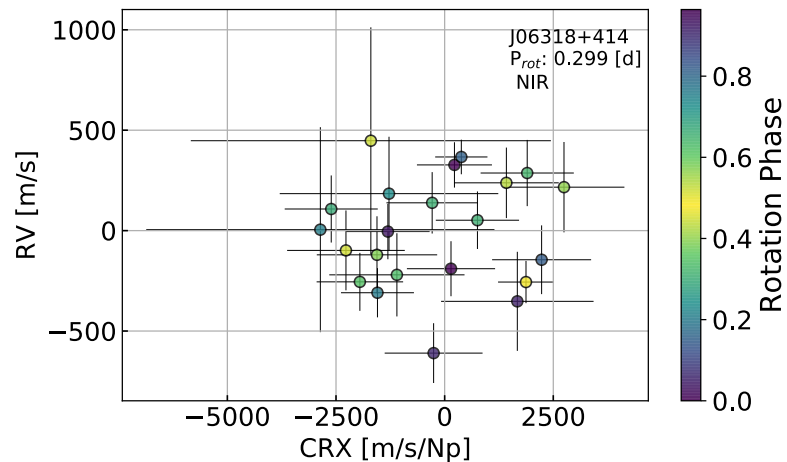
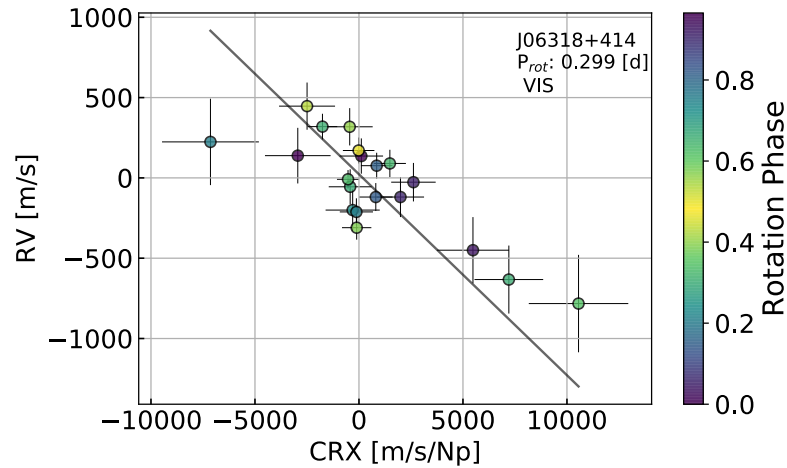
## Chromatic

p-value < 0.005



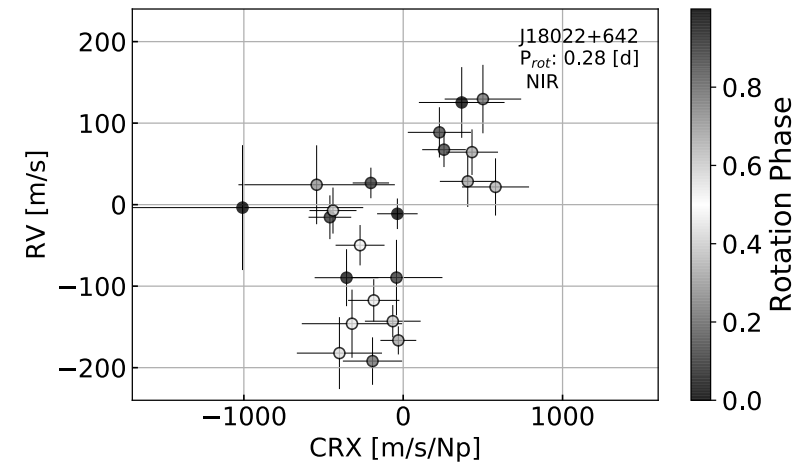
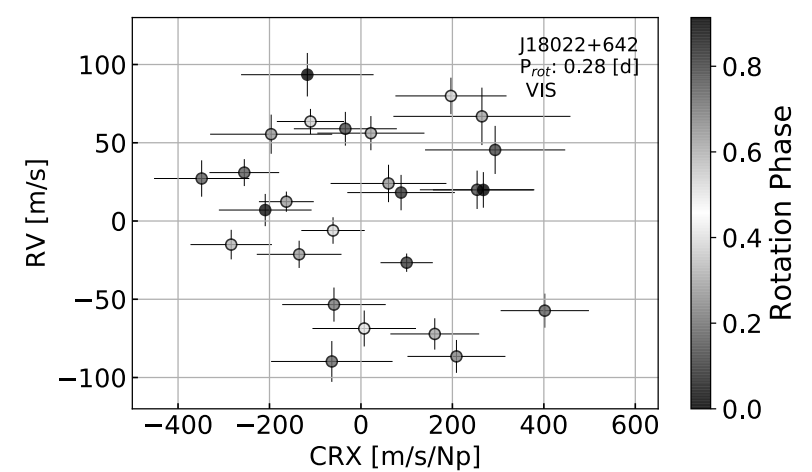
## Suggestive

0.005 < p-value < 0.05



## Non-chromatic

p-value > 0.05

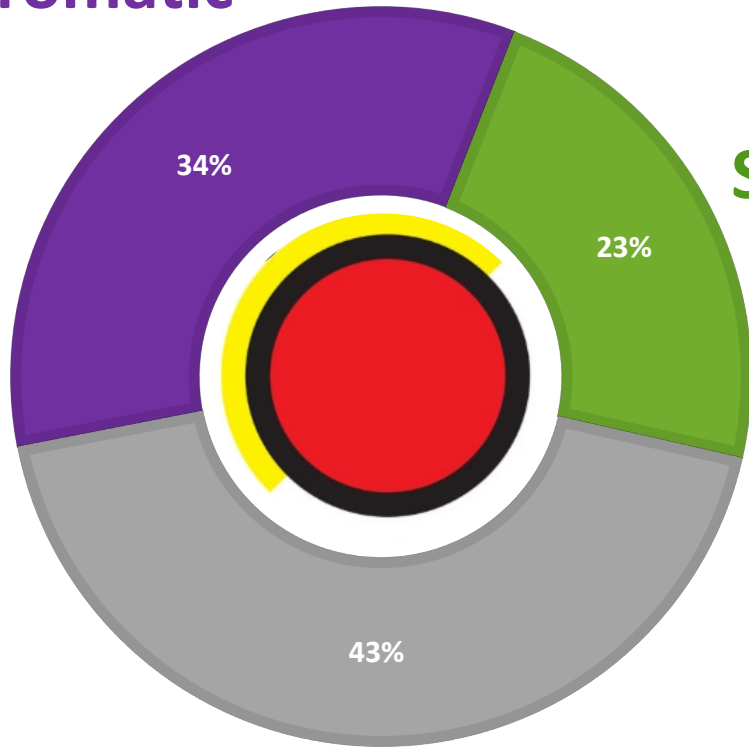




# Distribution over Spectral type



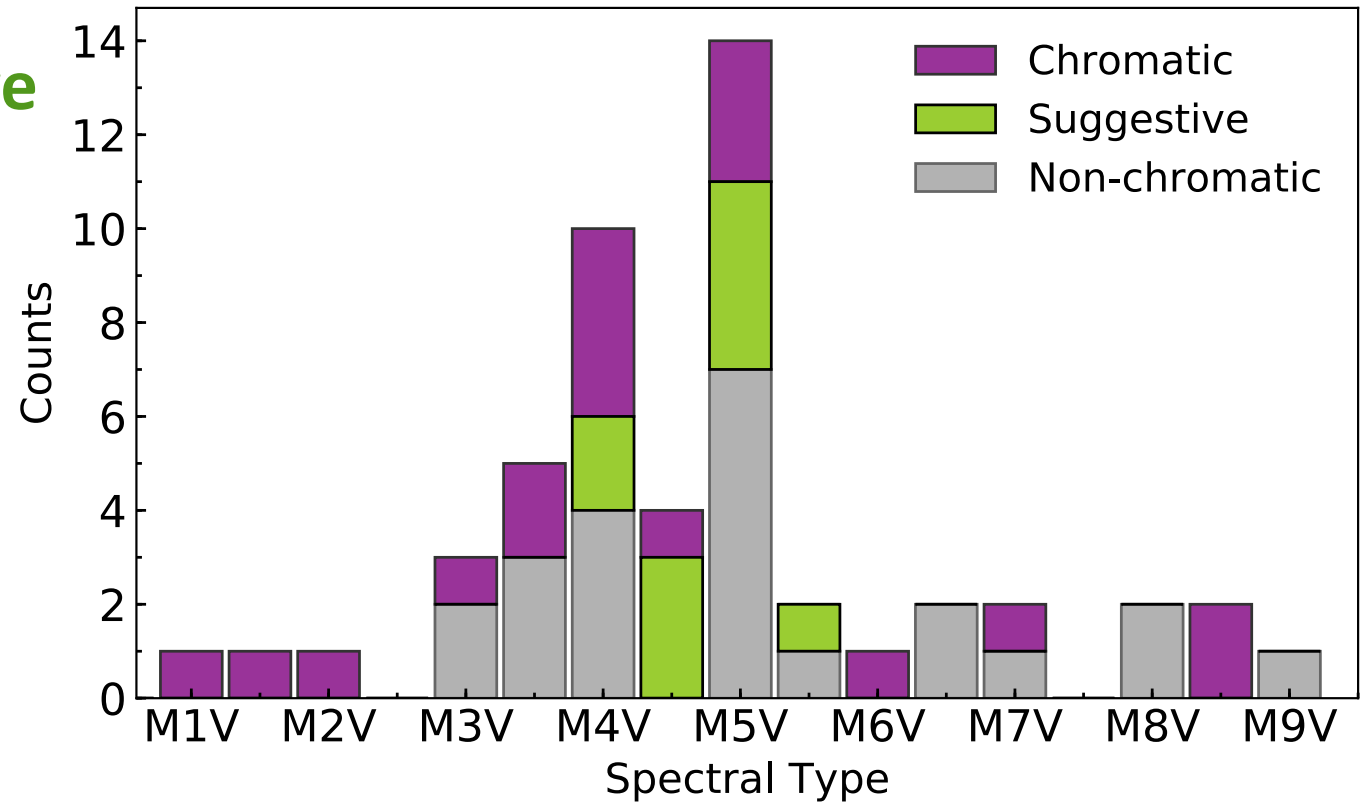
Chromatic



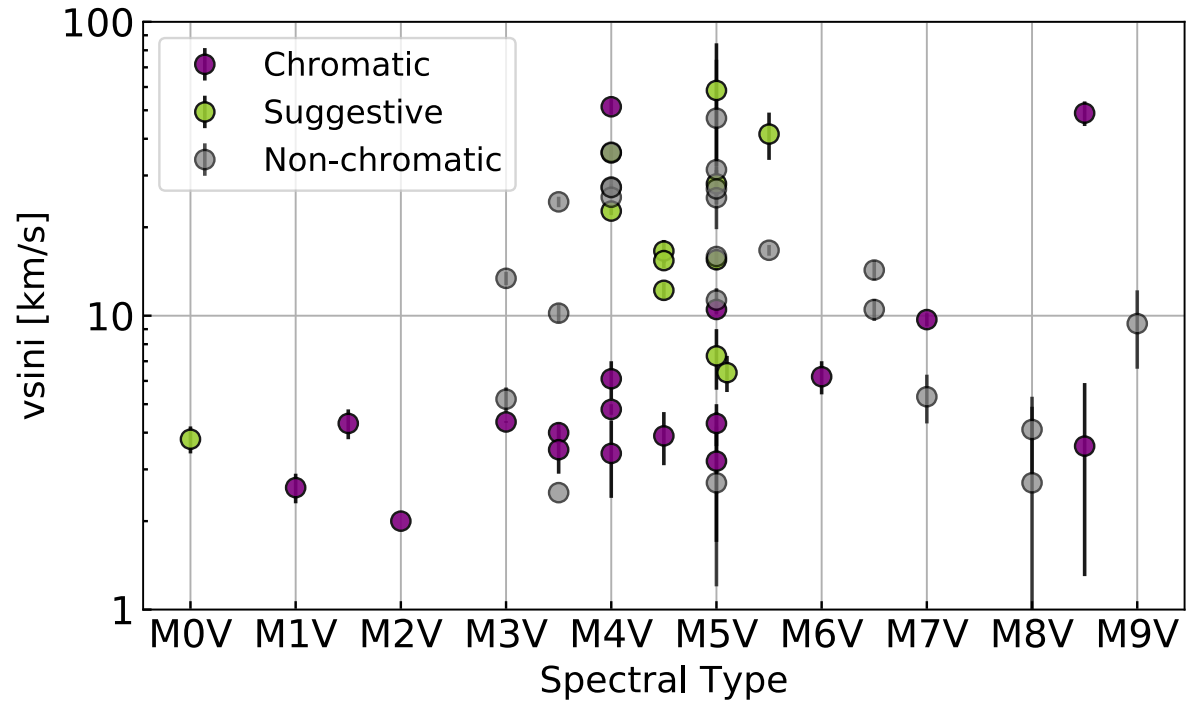
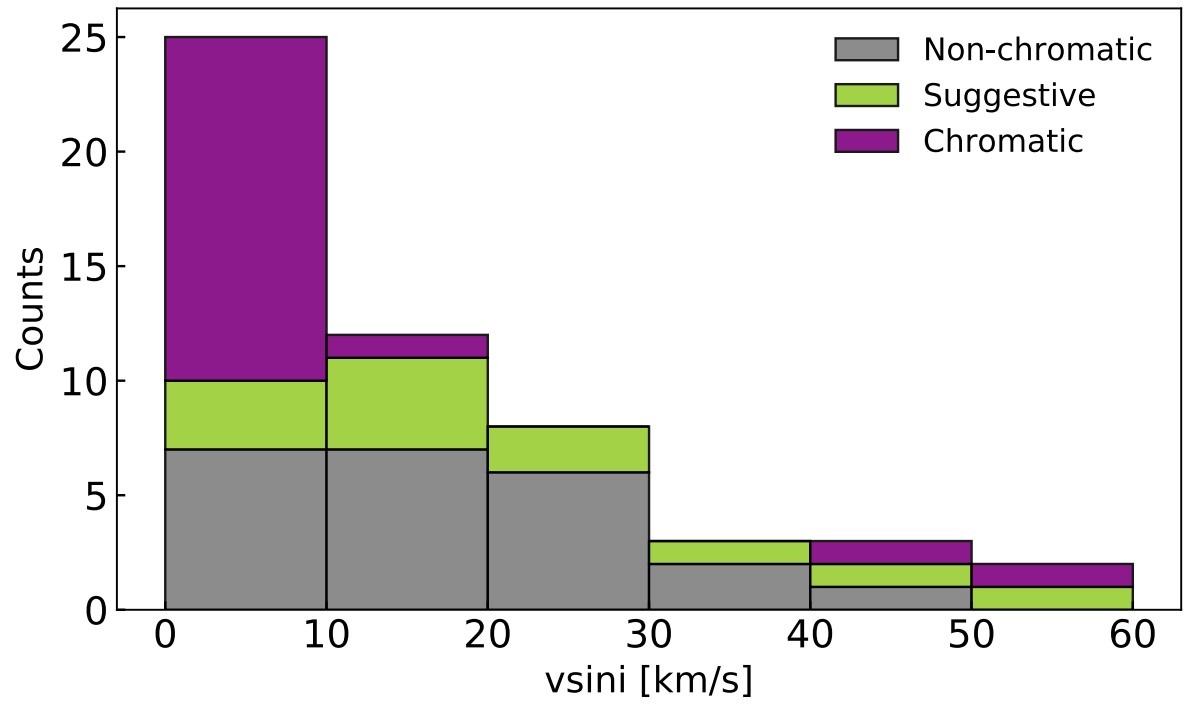
Suggestive

Non-chromatic

53 Active RV-loud Sample

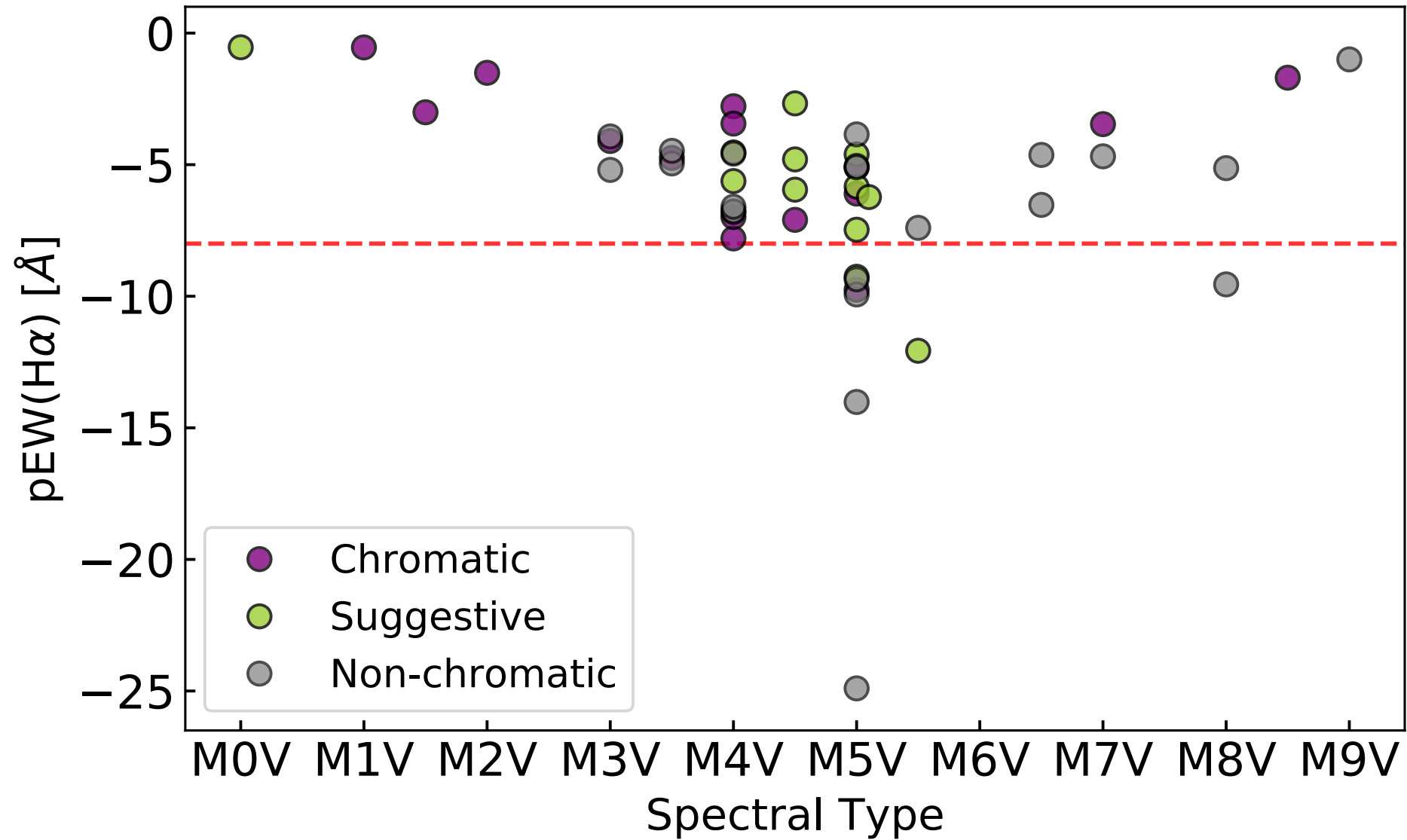


# Distribution over $v \sin i$

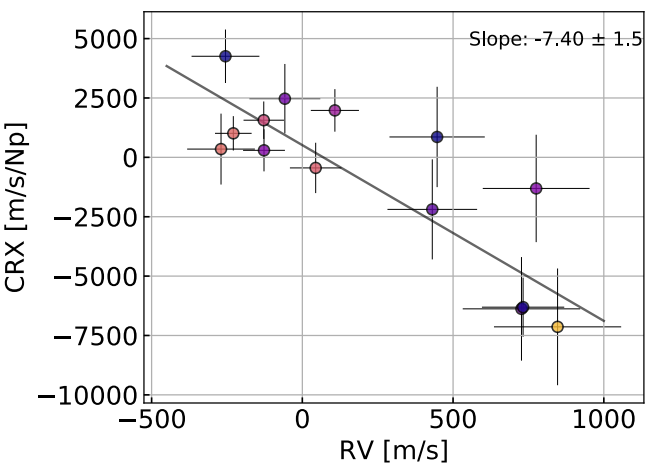
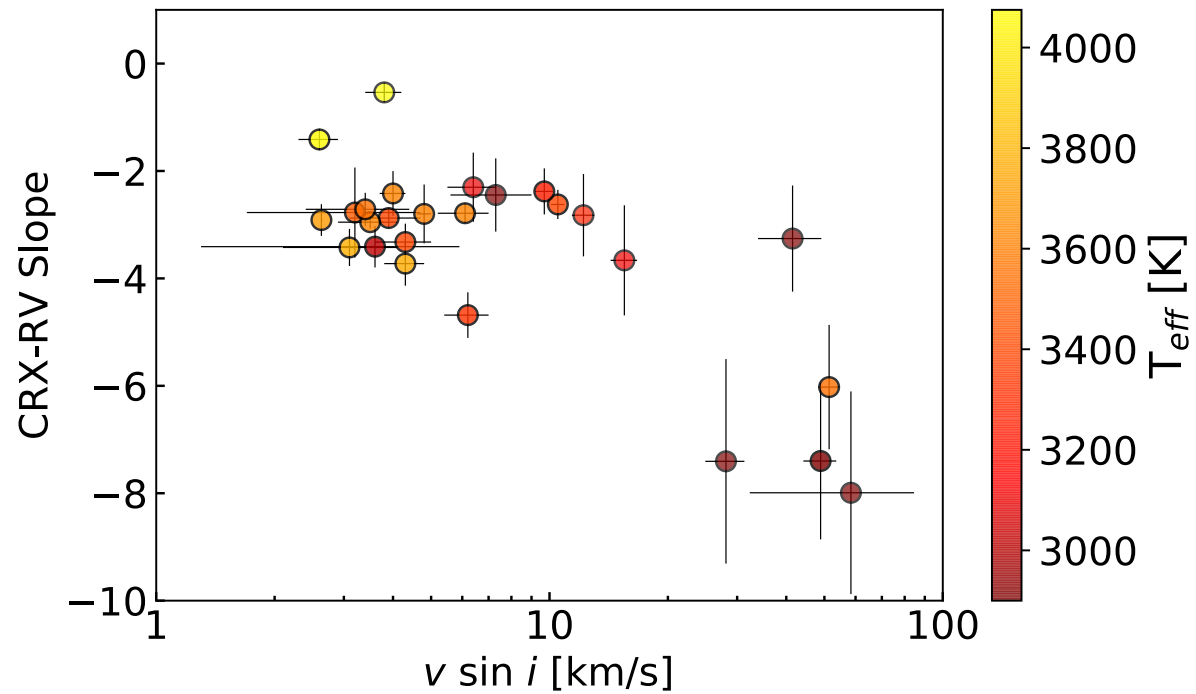
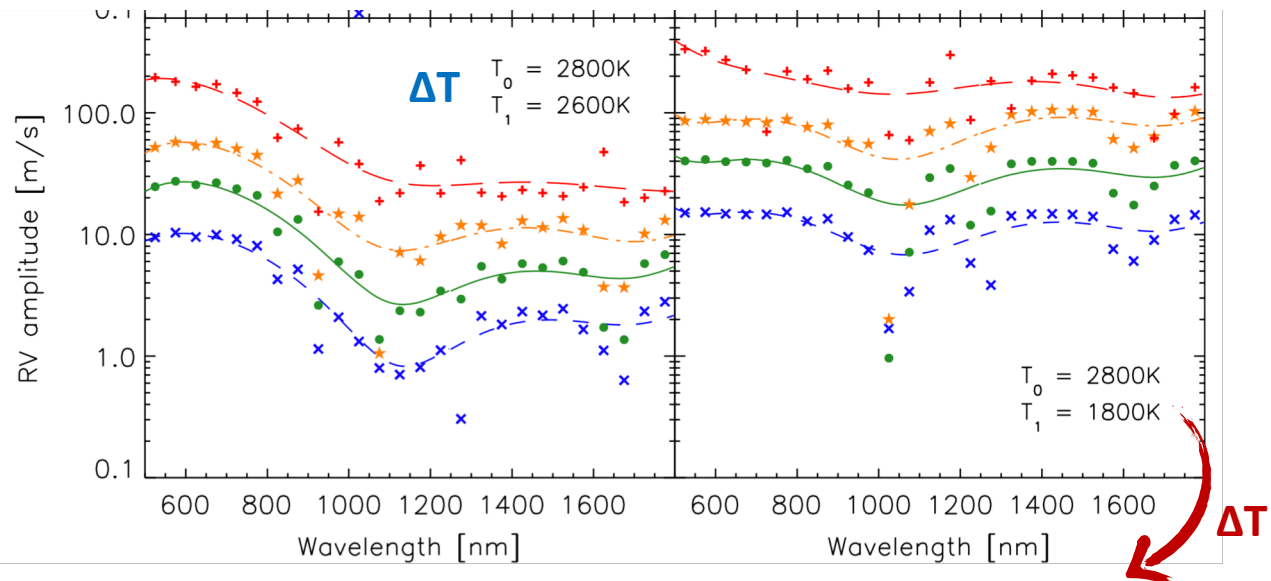


Most of the chromatic targets have  $v \sin i < 10$  km/s

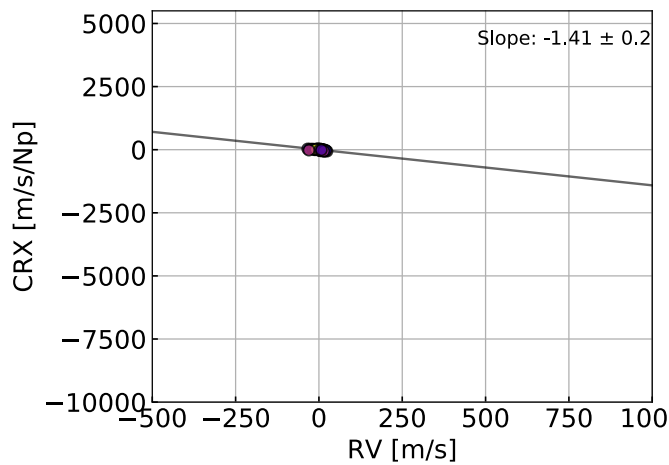
# Chromospheric Level



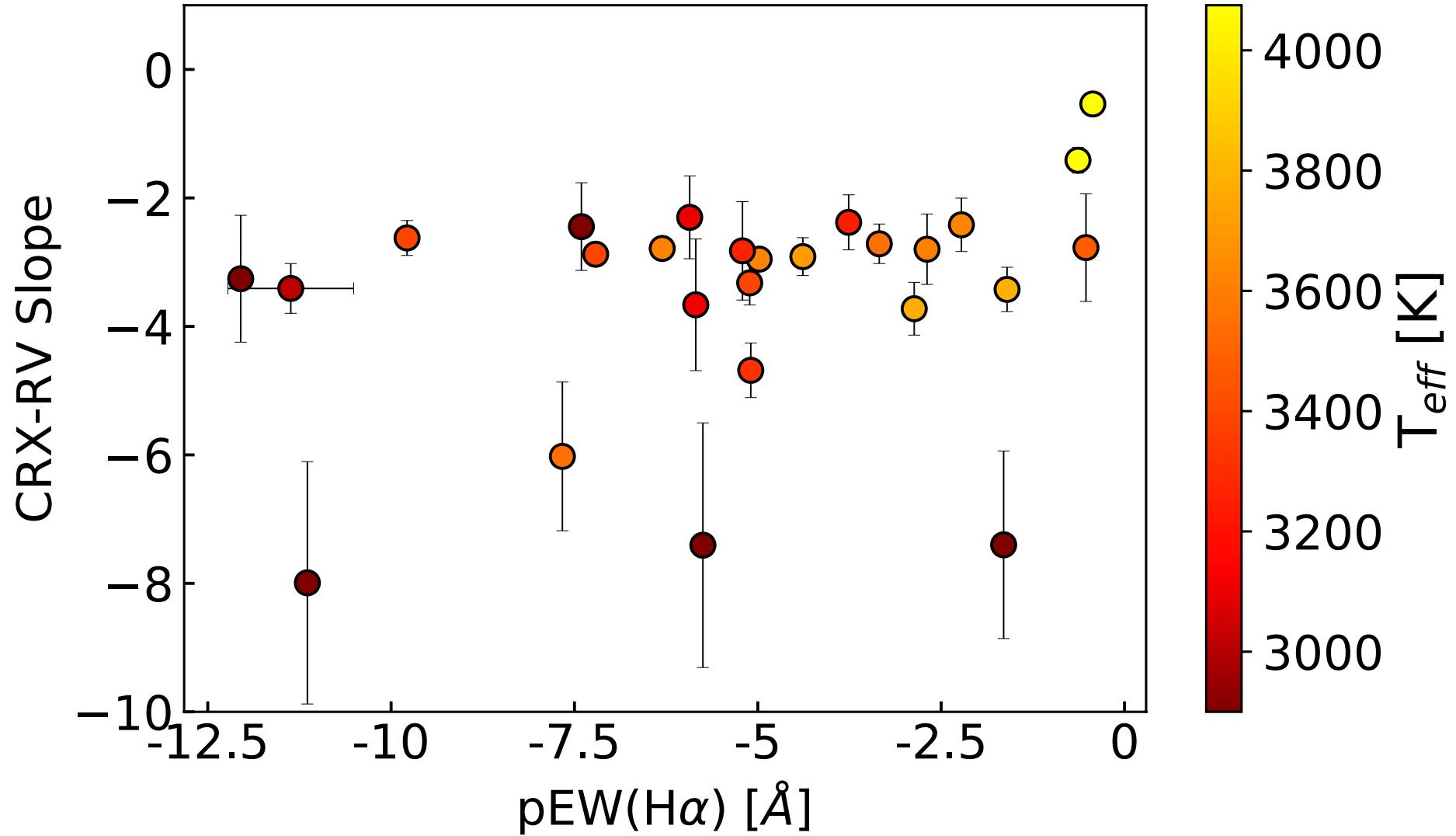
# Temperature Contrast



$v \sin i = 48.9 \pm 4.7 \text{ km s}^{-1}$



$v \sin i = 2.6 \pm 0.3 \text{ km s}^{-1}$



# Summary

- ✦ Fraction of active stars **increases with SpT**
- ✦ The lack of RV chromaticity for 43% of our sample can be explained by **complex spot patterns**
- ✦ No correlation with chromospheric components sensitive to activity
- ✦ We do not have a direct measure of spot-coverage fraction
- ✦ **CRX-RV slope** measures *spot-to-photosphere temperature contrast* and shows correlation with  $v \sin i$  and Effective temperature

Thank you for your attention!