Disentangling planetary RV signals and stellar activity

1st ITA - MPIA/Heidelberg - IPAG Colloquium, Grenoble
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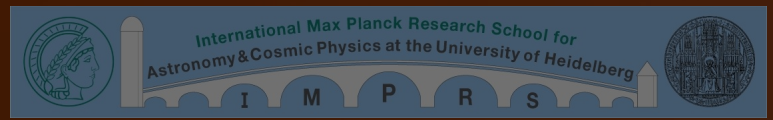
Maren Mohler-Fischer

Max-Planck-Institute for Astronomy
Heidelberg, Germany



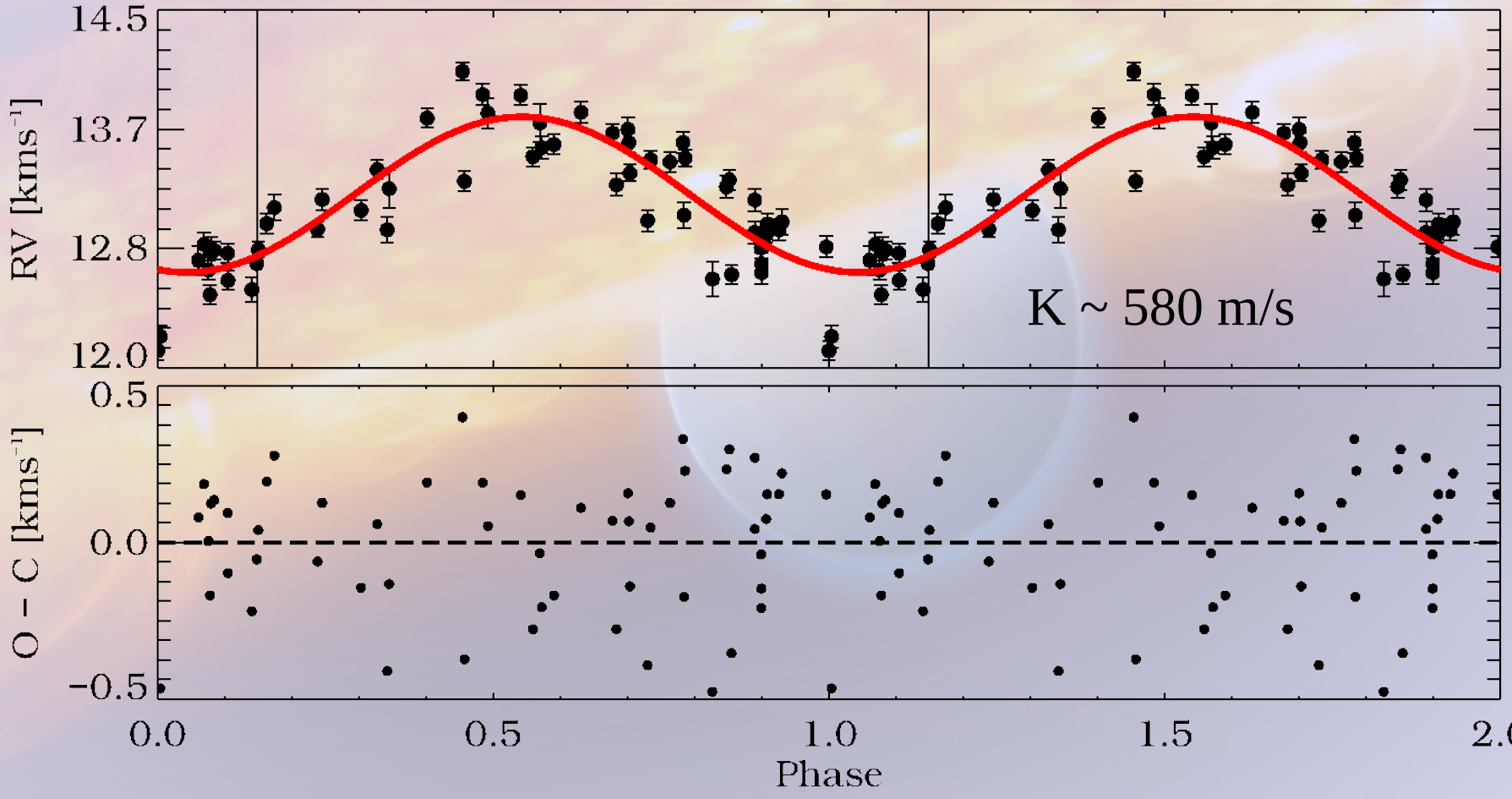
My project

- PhD student at MPIA, Heidelberg
- Looking for planets around young stars (< 600 Myr) with the radial velocity (RV) method
- Working together with
  - Thomas Henning (MPIA)
  - Ralf Launhardt (MPIA)
  - André Müller (ESO Chile)
  - Eike Guenther (LSW Tautenburg)

Example star

- Spectral type: G9
- T_{eff} = (5235 ± 125) K
- log g = 3.9 ± 0.3
- v sini = (20.8 ± 0.4) km/s
- Age:
  - (9 ± 3) Myr - Lithium equivalent width
  - (16 ± 3) Myr - activity index, Ca II K emission line
- Observations: 57 spectra with FEROS at the MPG/ESO 2.2m telescope @ La Silla, Chile (between Jan 2010 and Jun 2012)

The radial velocity signal



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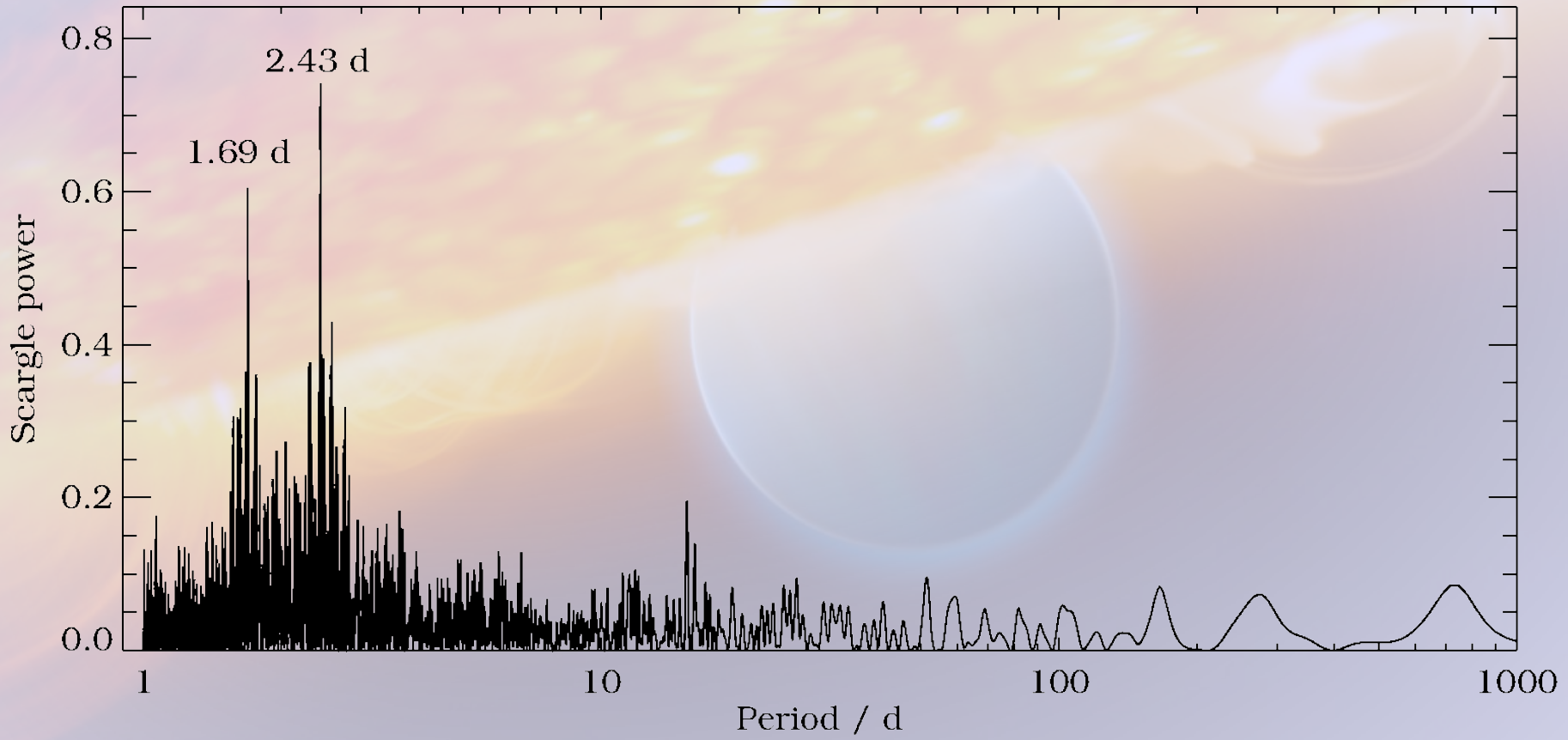
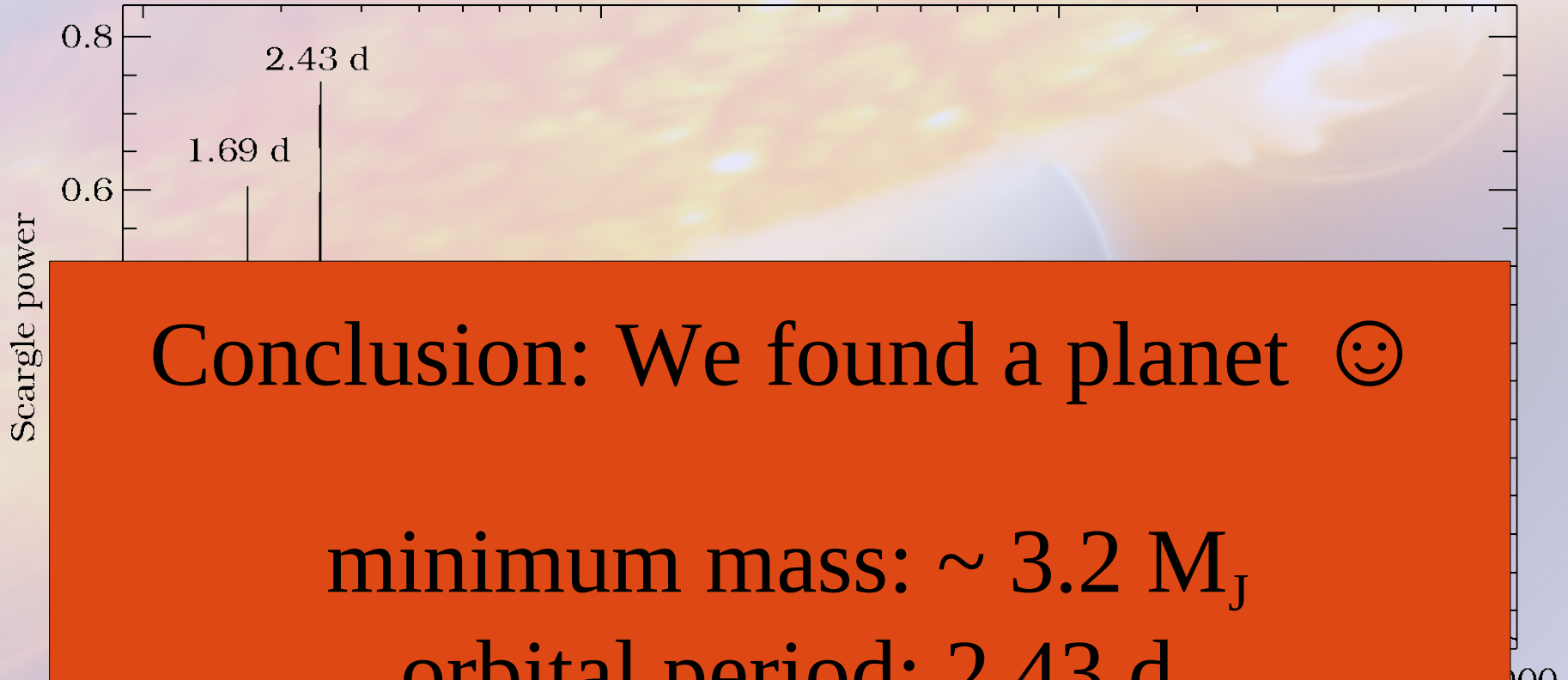


The radial velocity signal



Conclusion: We found a planet ☺

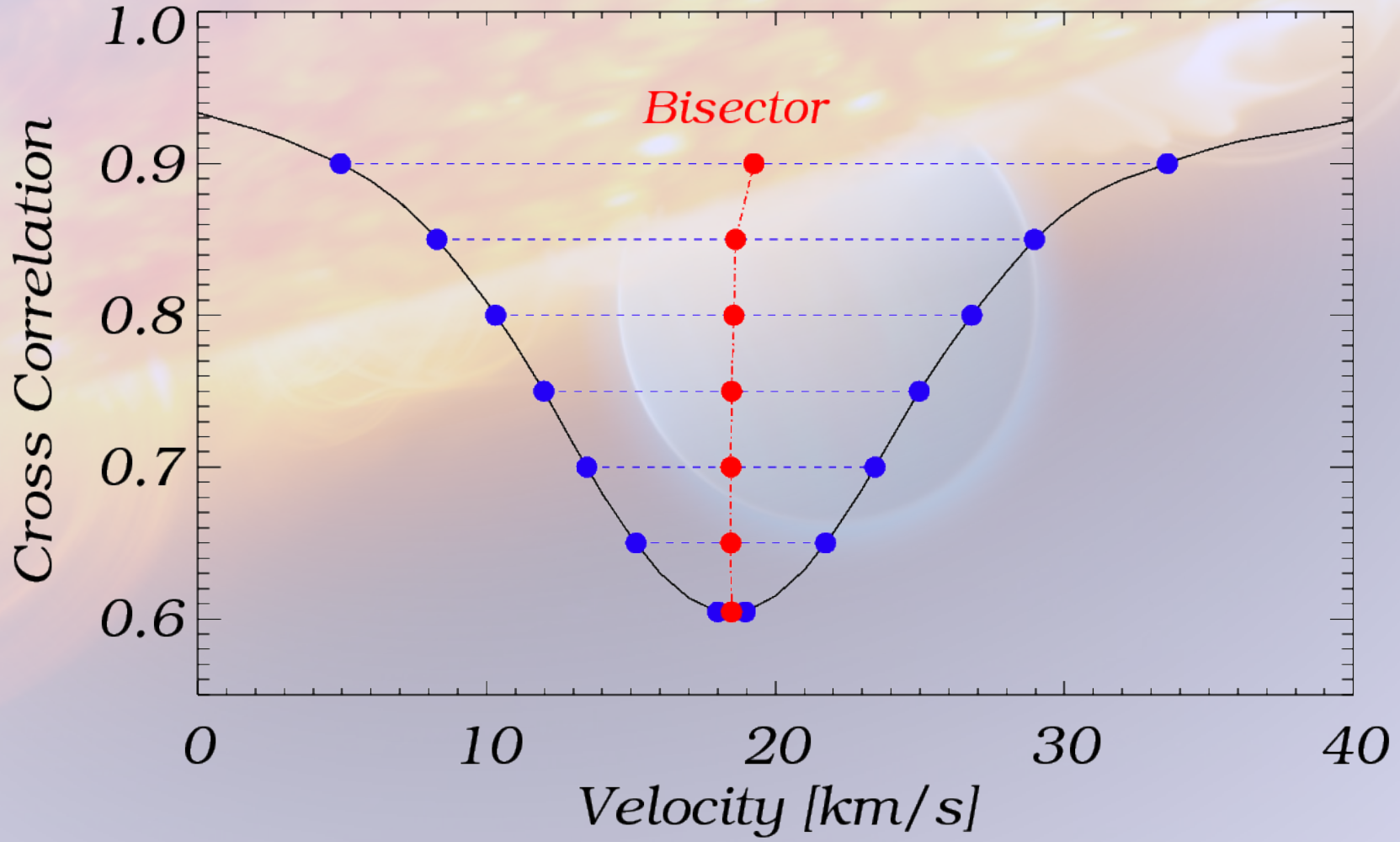
minimum mass: ~ 3.2 M_J

orbital period: 2.43 d

semi-major axis ~ 0.04 AU

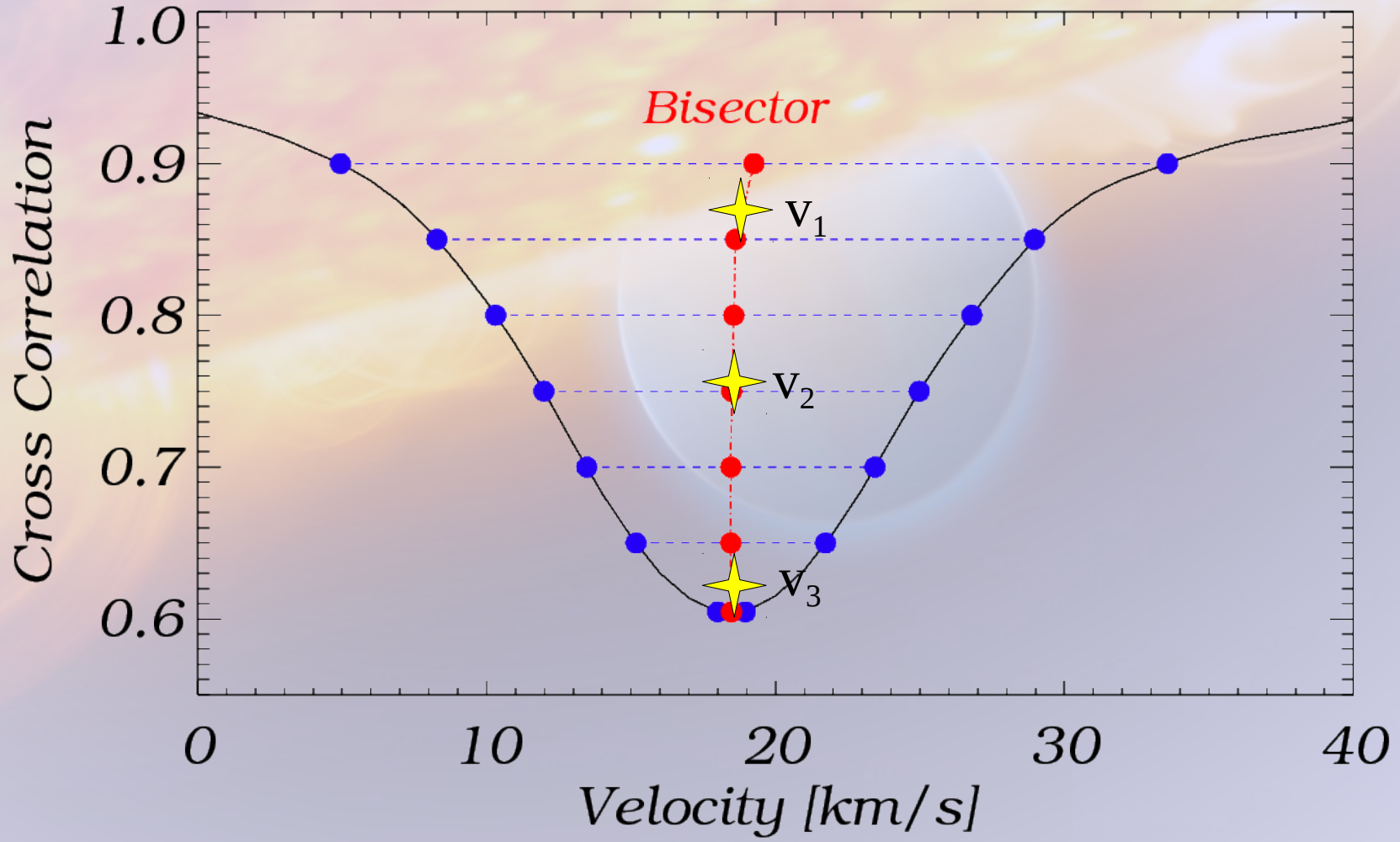
Activity indicators

- Bisector of the CCF



Activity indicators

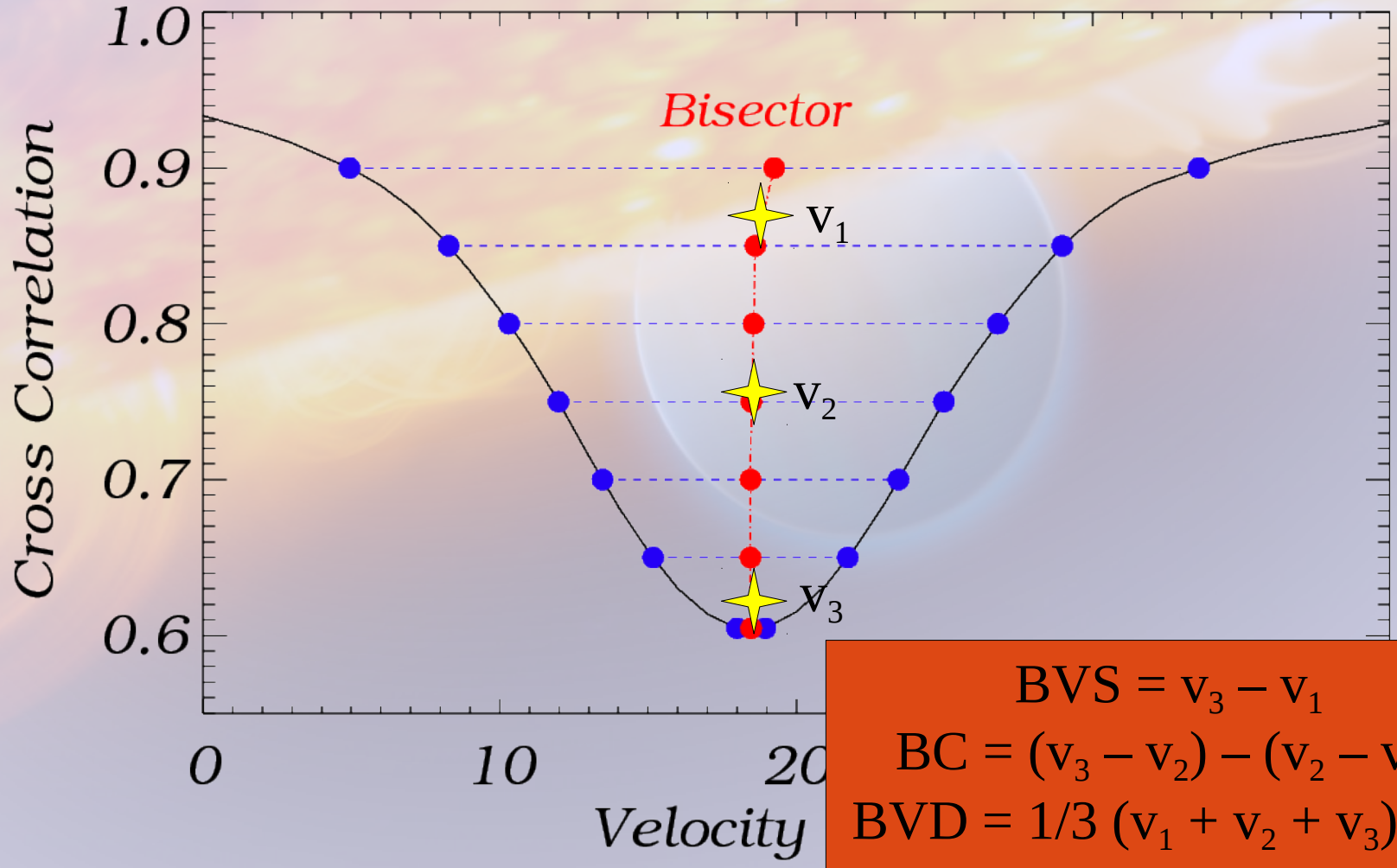
- Bisector of the CCF



Location of v_1, v_2, v_3 Povich et al., 2001

Activity indicators

- Bisector of the CCF



$$BVS = v_3 - v_1$$

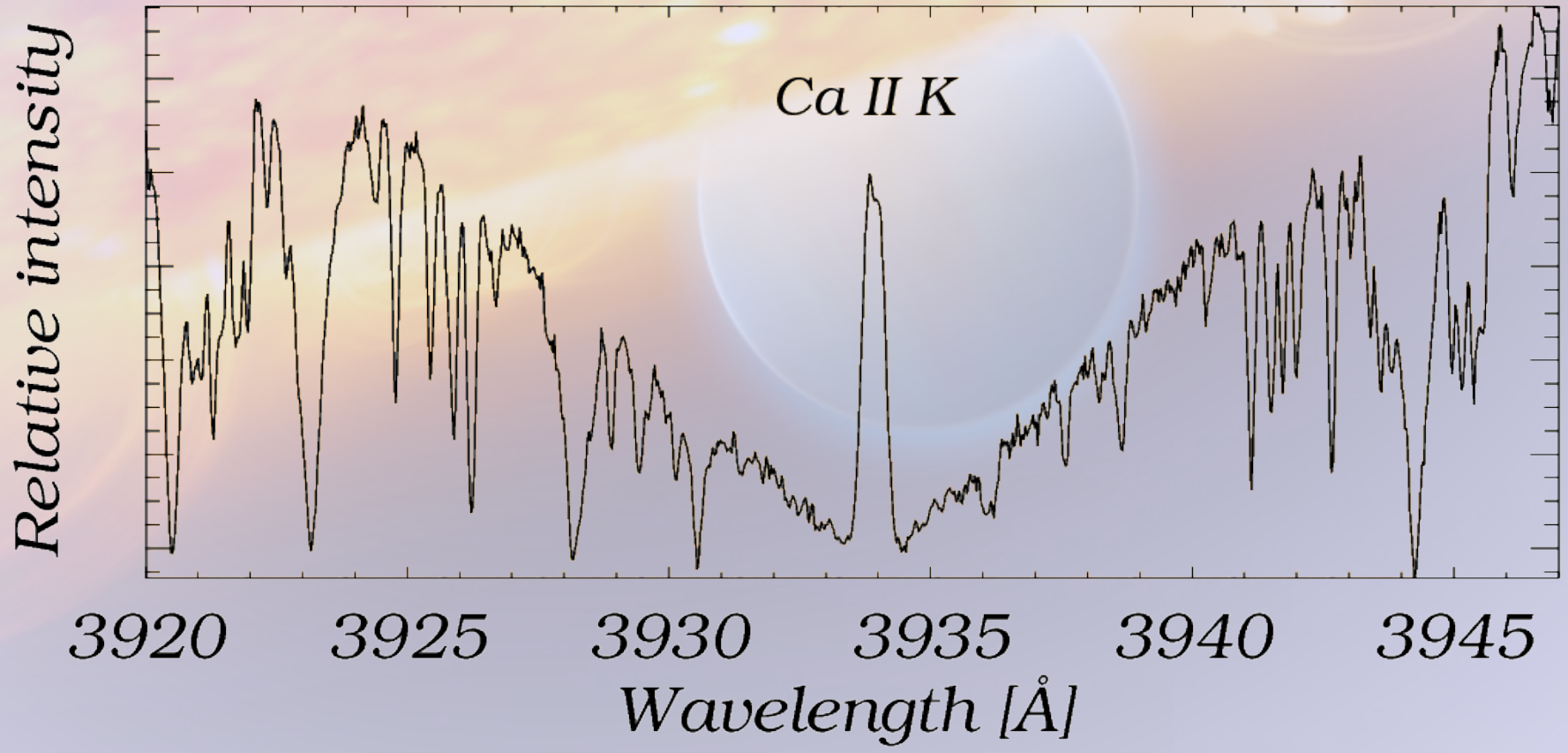
$$BC = (v_3 - v_2) - (v_2 - v_1)$$

$$BVD = 1/3\,(v_1 + v_2 + v_3) - \lambda_c$$

Location of v_1, v_2, v_3 Povich et al., 2001

Activity indicators

- Activity index S_{FEROS}
- Ca II K asymmetry

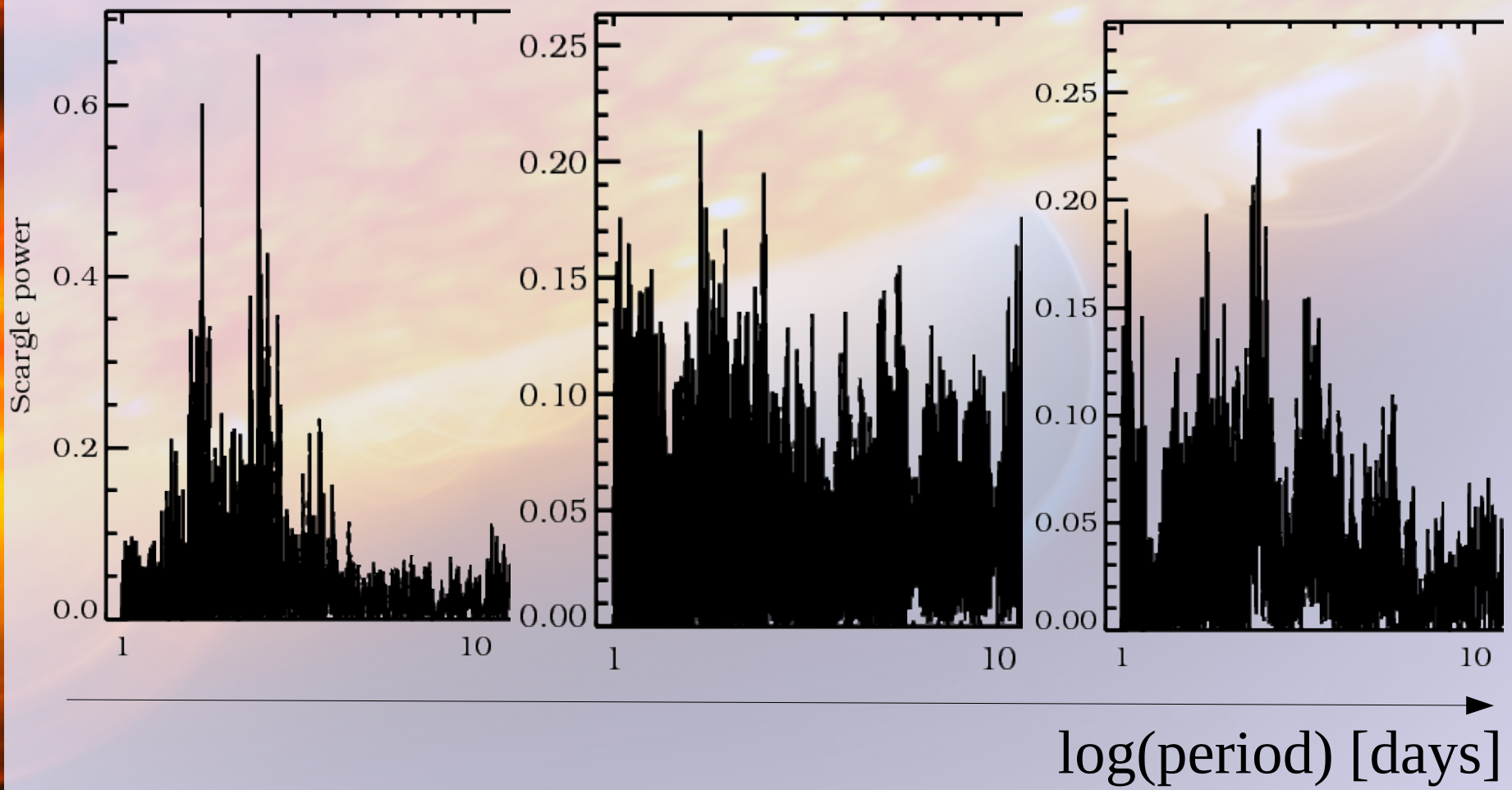


Activity indicators

- Activity index S_{FEROS}
- Ca II K asymmetry
- Ca EW @ 8662 Å
- CCF asymmetry
- Line depth ratios (e.g. V I / Fe I @ 6252 & 6253 Å)

  → temperature changes, Catalano et al., 2002
- TiO bandstrength, Reid et al., 1995
- H_α index → tracer for accretion, flares etc.
- Photometry (so far: if available)

Activity indicators - Results



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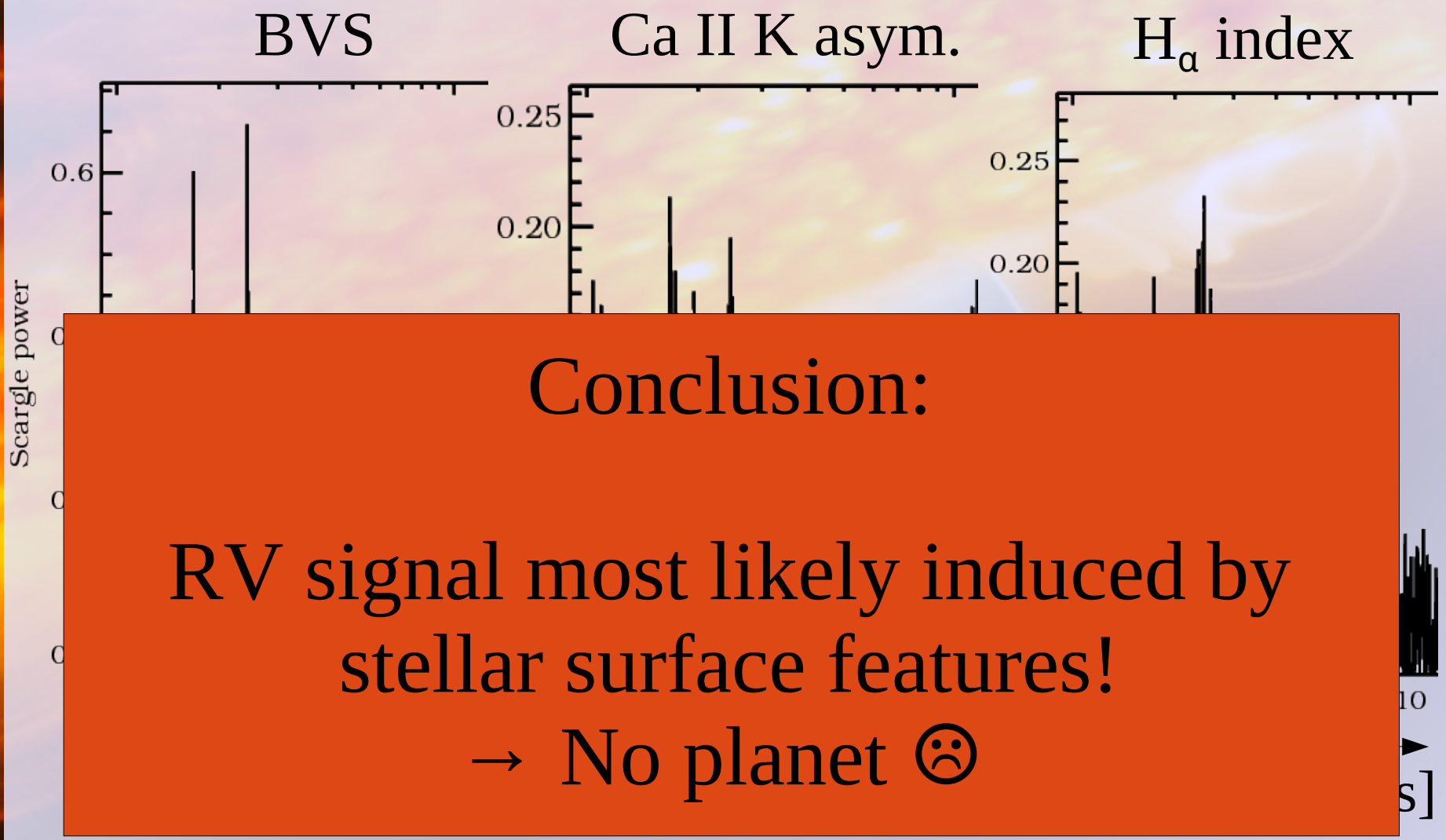
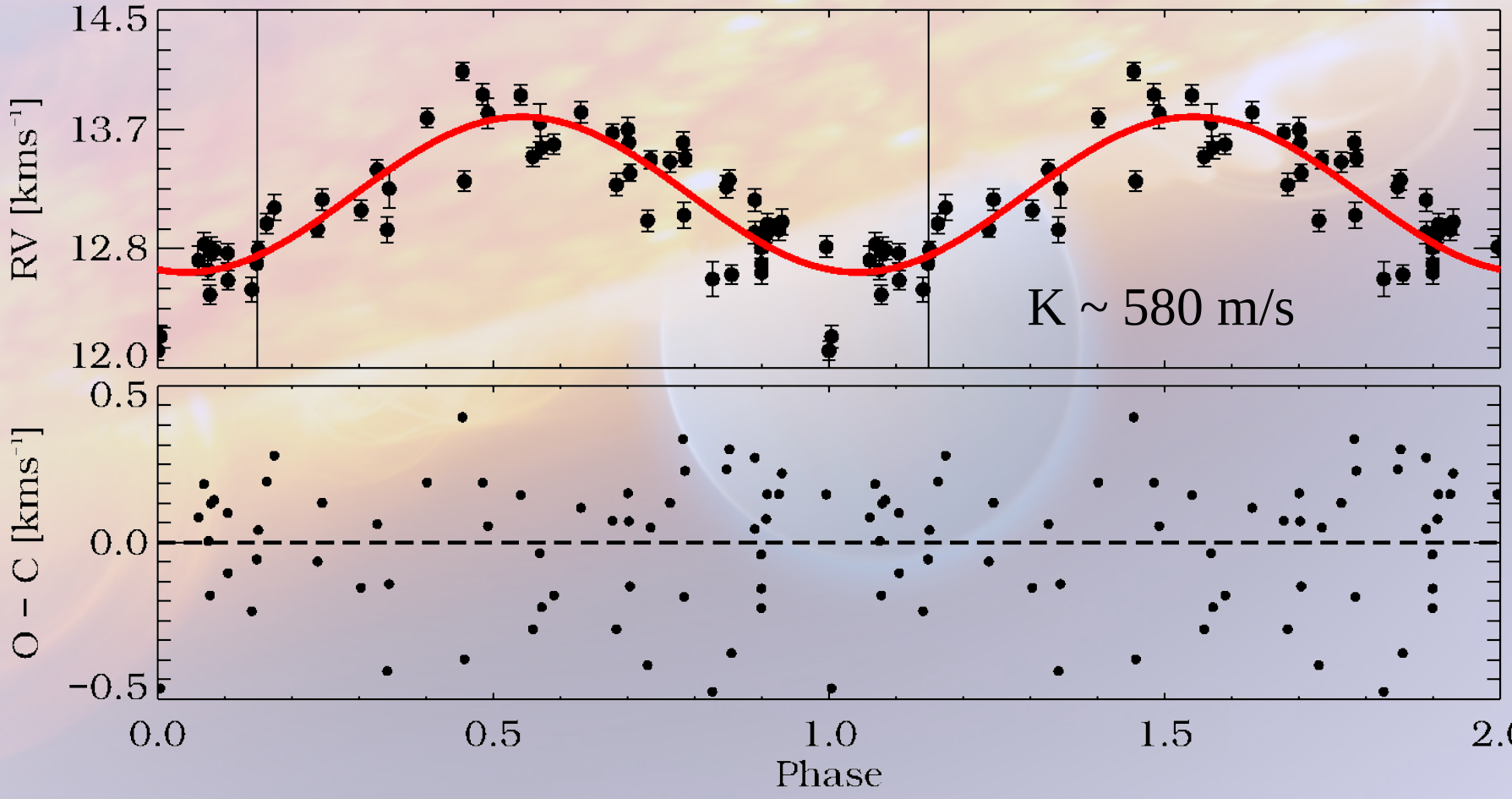


Conclusion:

RV signal most likely induced by stellar surface features!

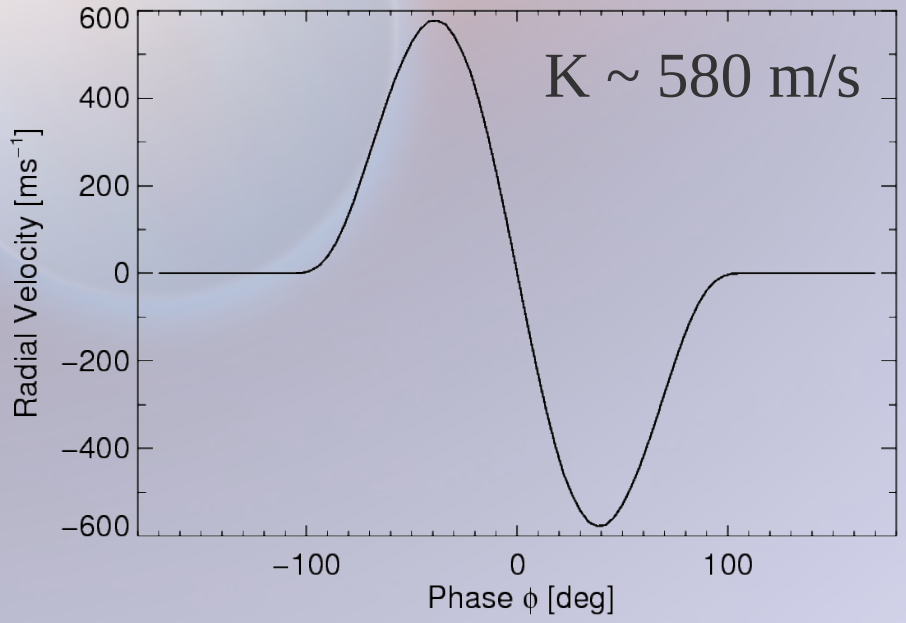
→ No planet ☹

Star spots – the explanation?



Star spots – the explanation?

- Simulated grid of dark, cool stellar surface spots
- Different spot sizes, temperatures, latitude and system inclinations
- RESULT: Dark, cool spot of
  - 3200 K (Δ T ~ 2000 K)
  - Covering 6 % of stellar surface
  - Latitude ~ 10°
  - System inclination ~ 5°



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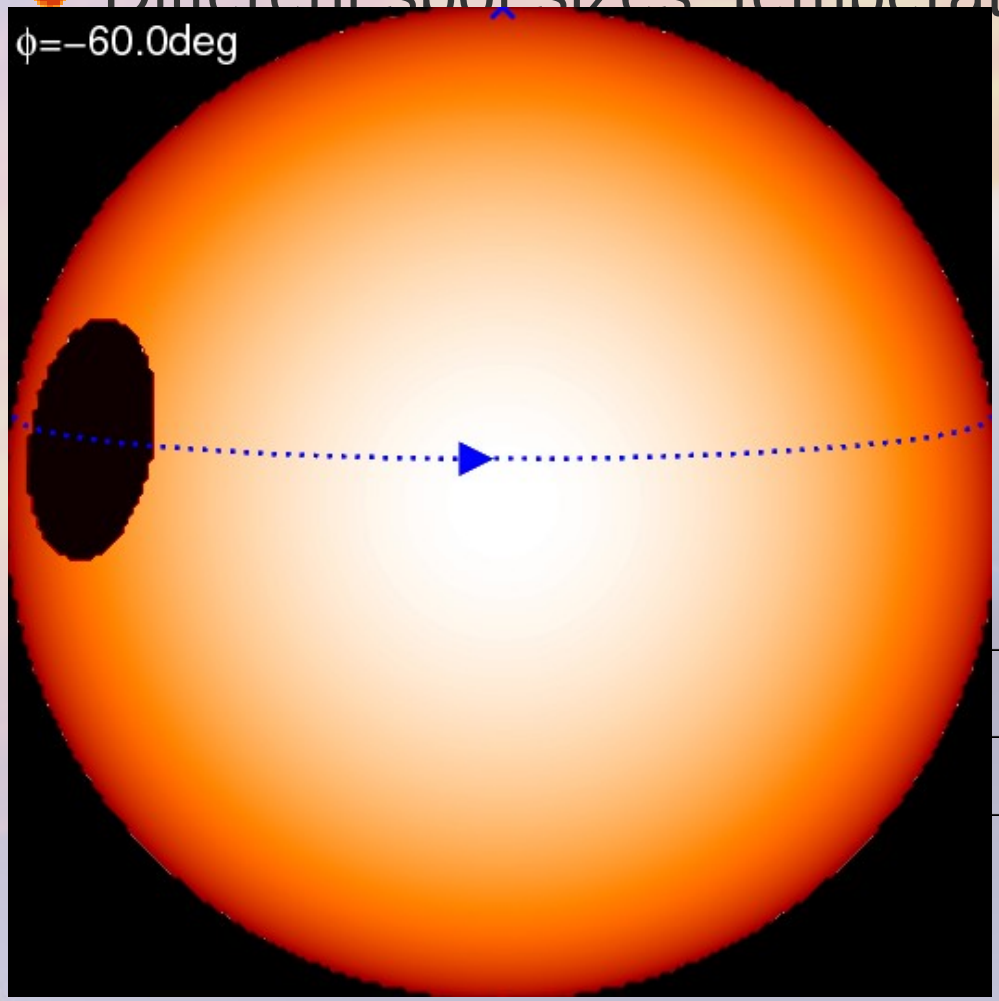
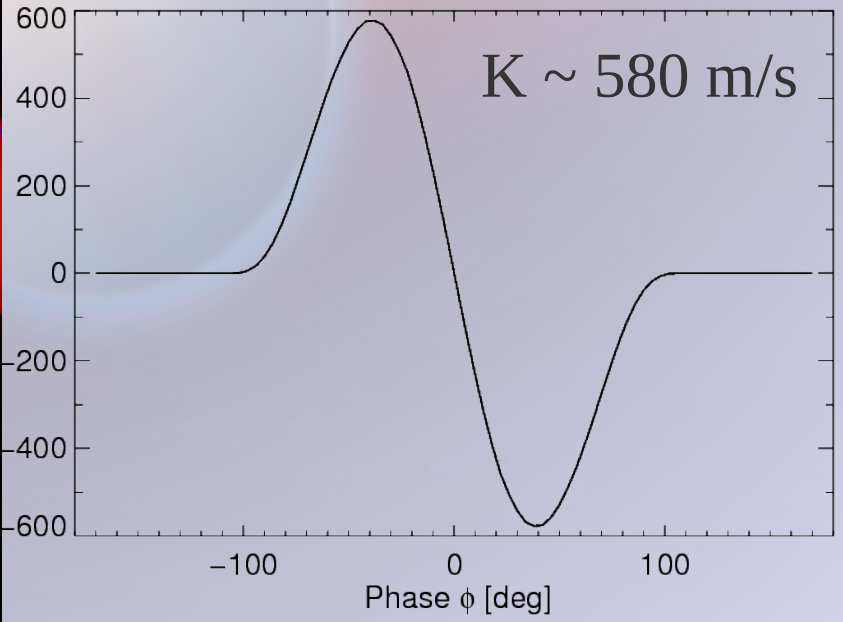


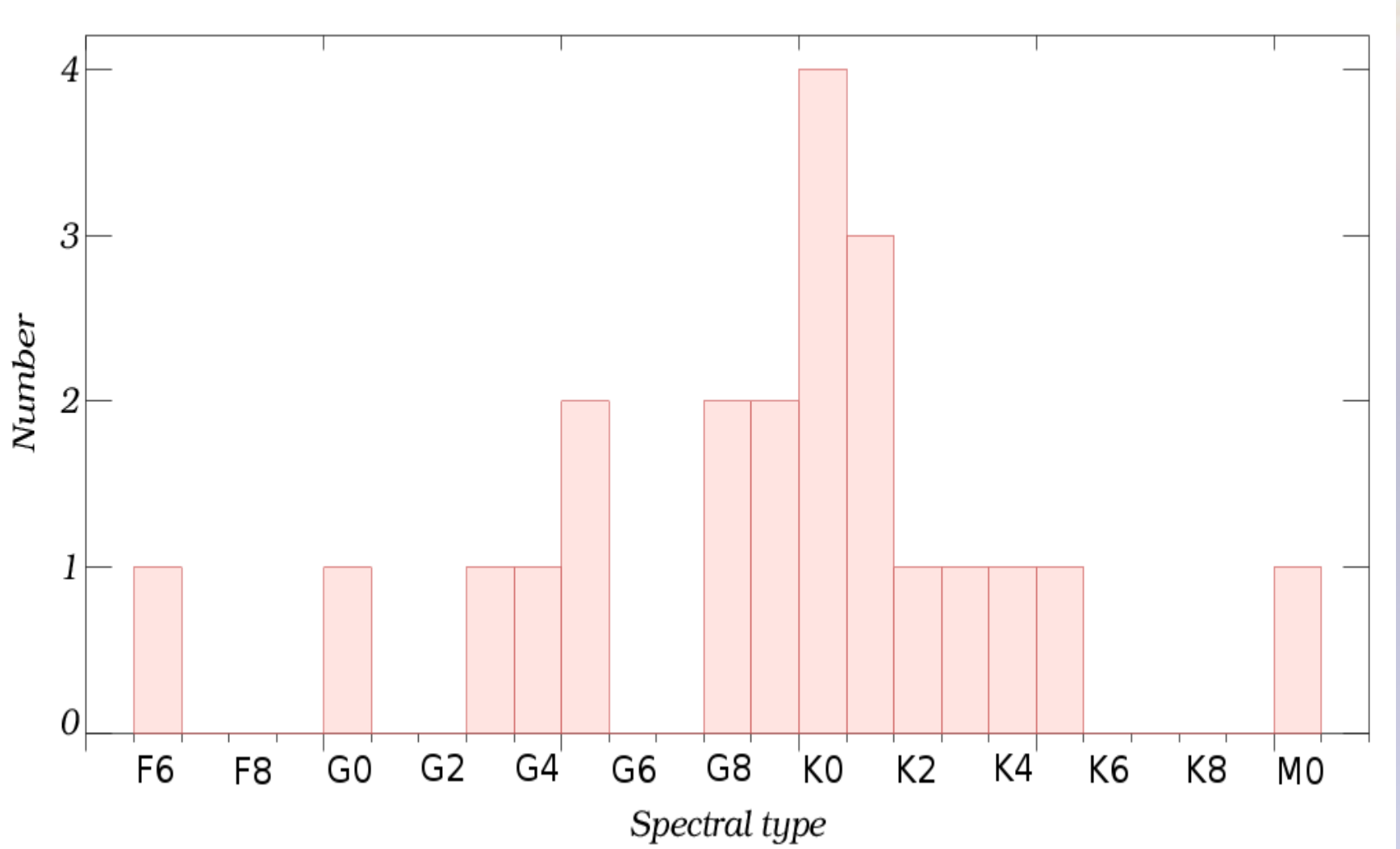


Summary and Outlook

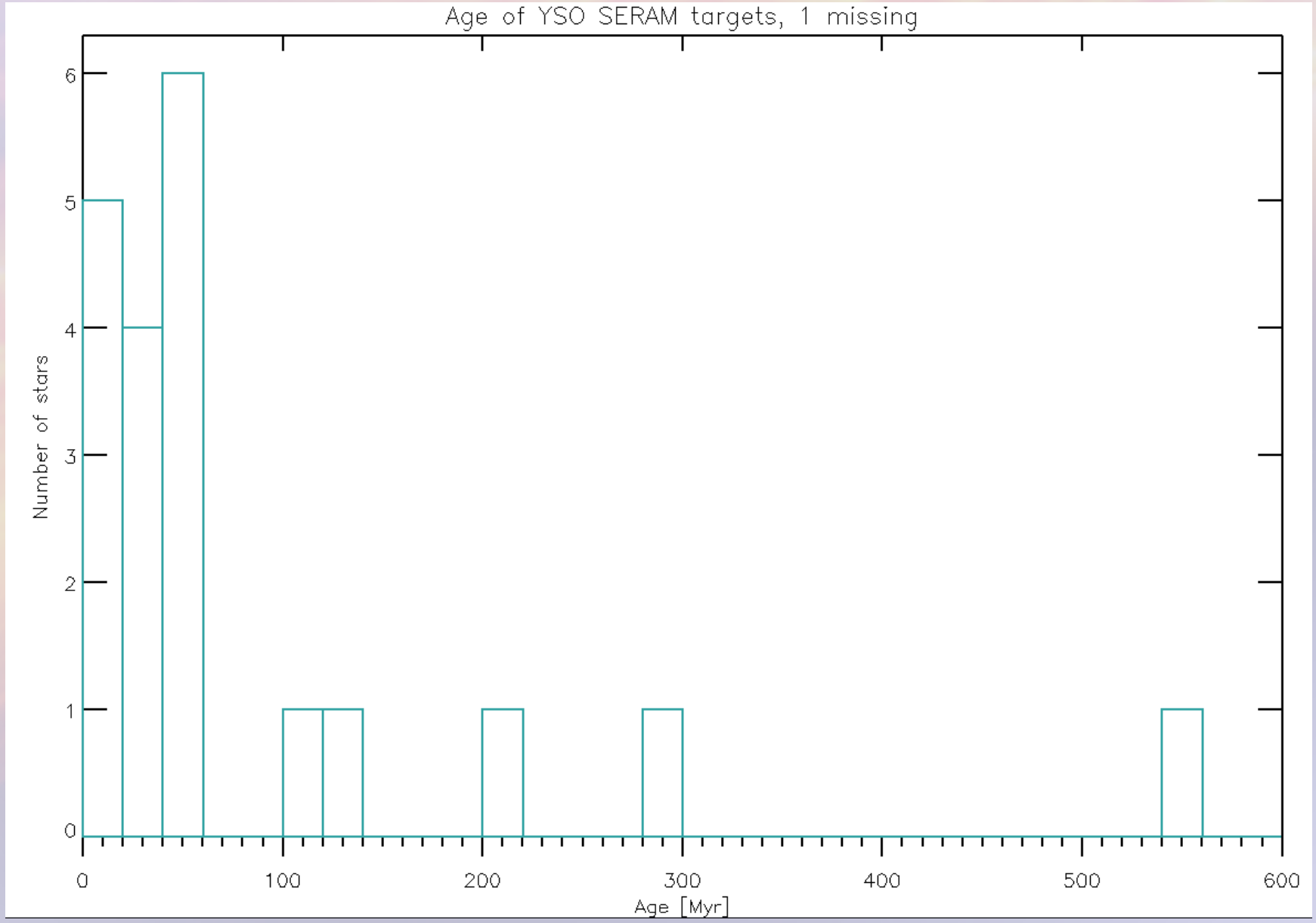
- **Stellar surface features** of young stellar objects can **mimic** radial velocity signals of potential **planetary companions**.
- A detailed analysis of **stellar activity indicators** is essential to disentangle planet signals and activity.

- Ongoing: Modify spot program in terms of:
  - → use in a whole spectrum for star & spot
  - → proper limb-darkening (λ dependent)

The target sample - Spectraltype



The target sample - Age



The target sample – v sin i