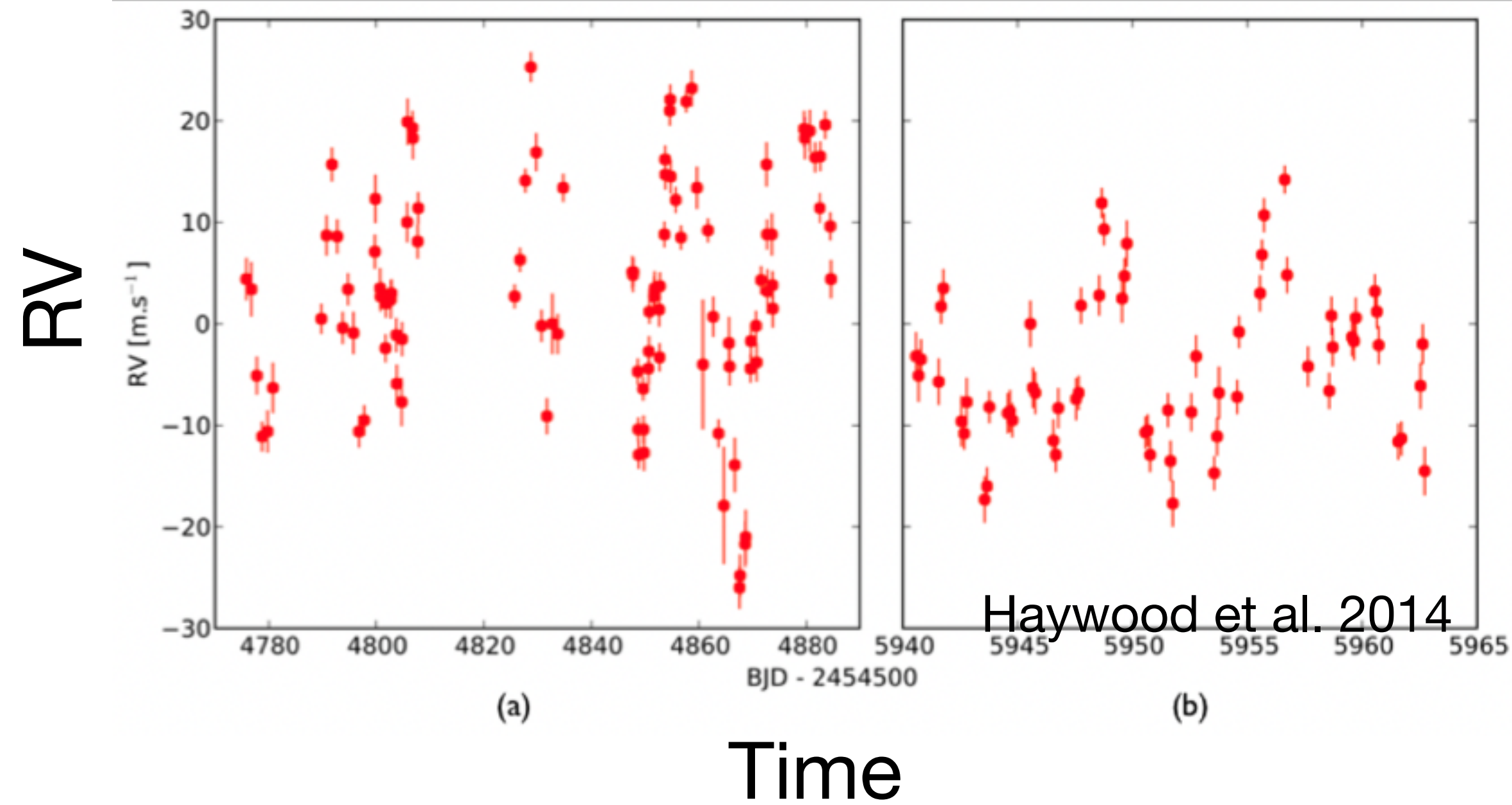
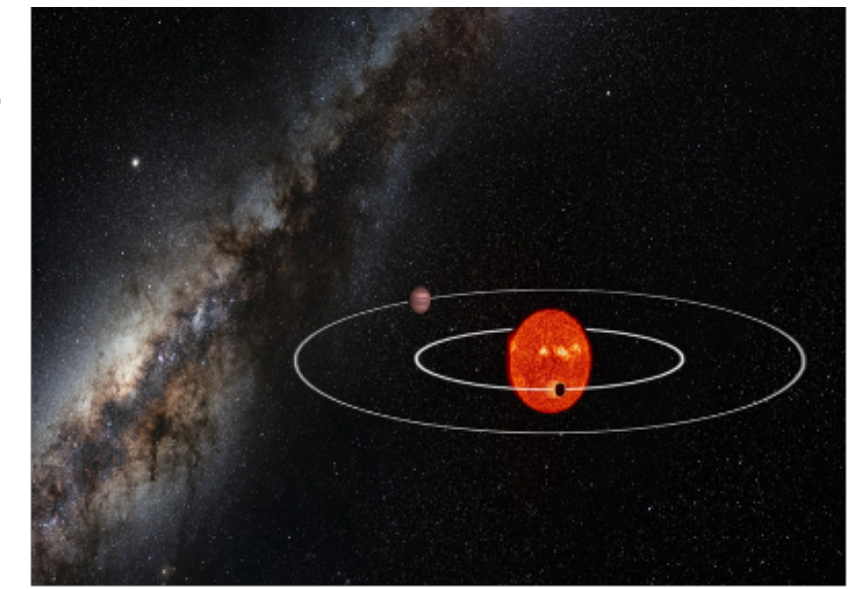


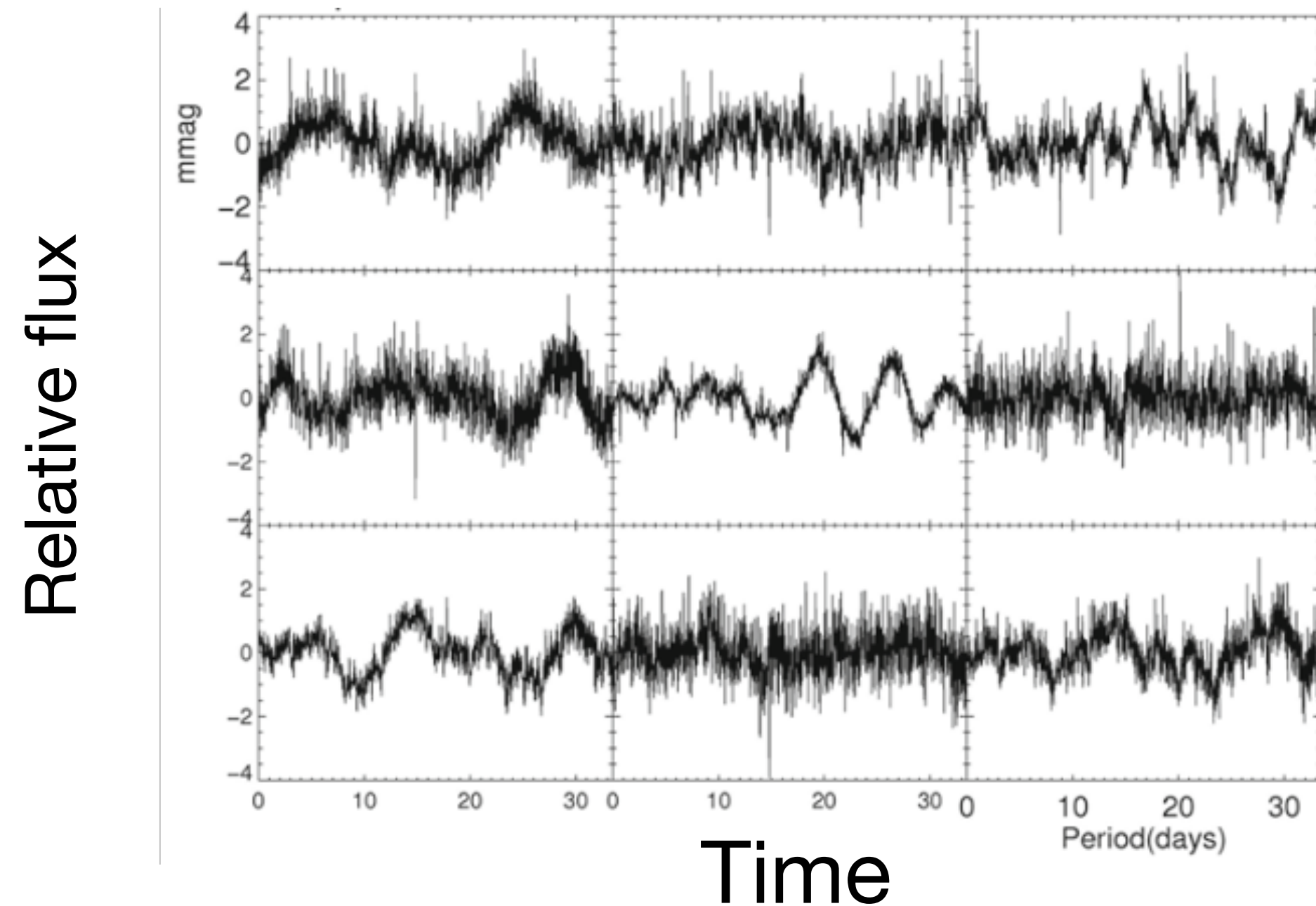
Reconstructing Intrinsic Stellar Noise with Stellar Chromospheric Activity

**Jinghua Zhang, Maosheng Xiang, Jie Yu, et al.
2024.05.10**

negative influences of activity in exploration of exoplanets

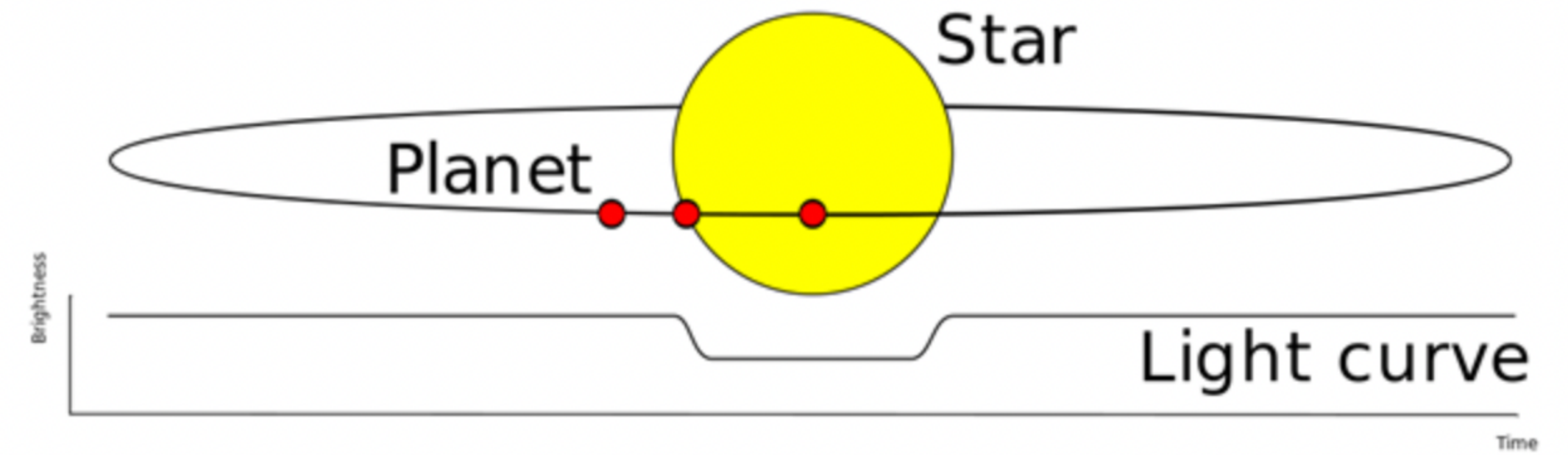
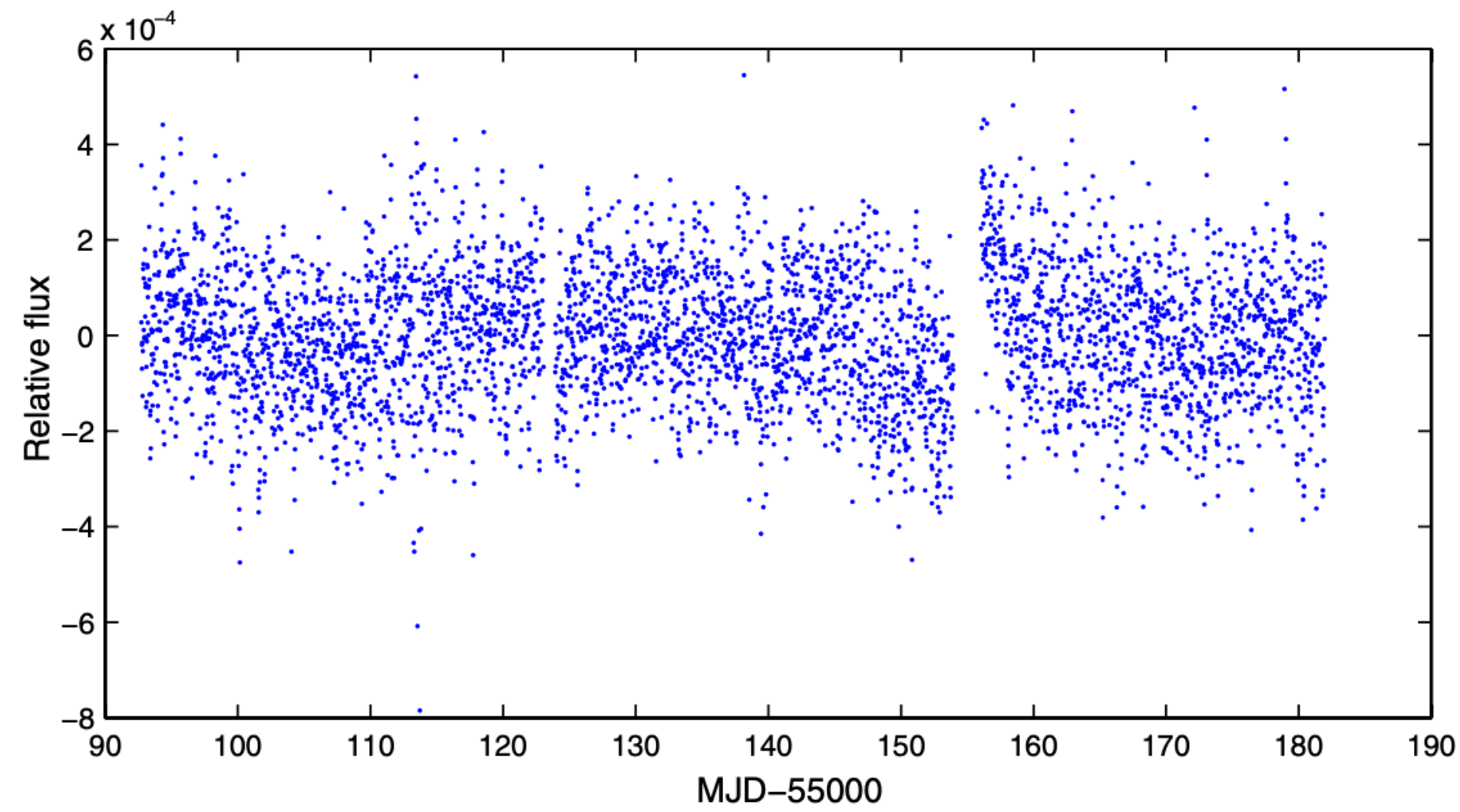


- Activity-induced RV variation can mimic the Doppler signatures of orbiting planets.
- Stellar activities is one of the sources in the higher than expected noise of the Kepler photometric time series.



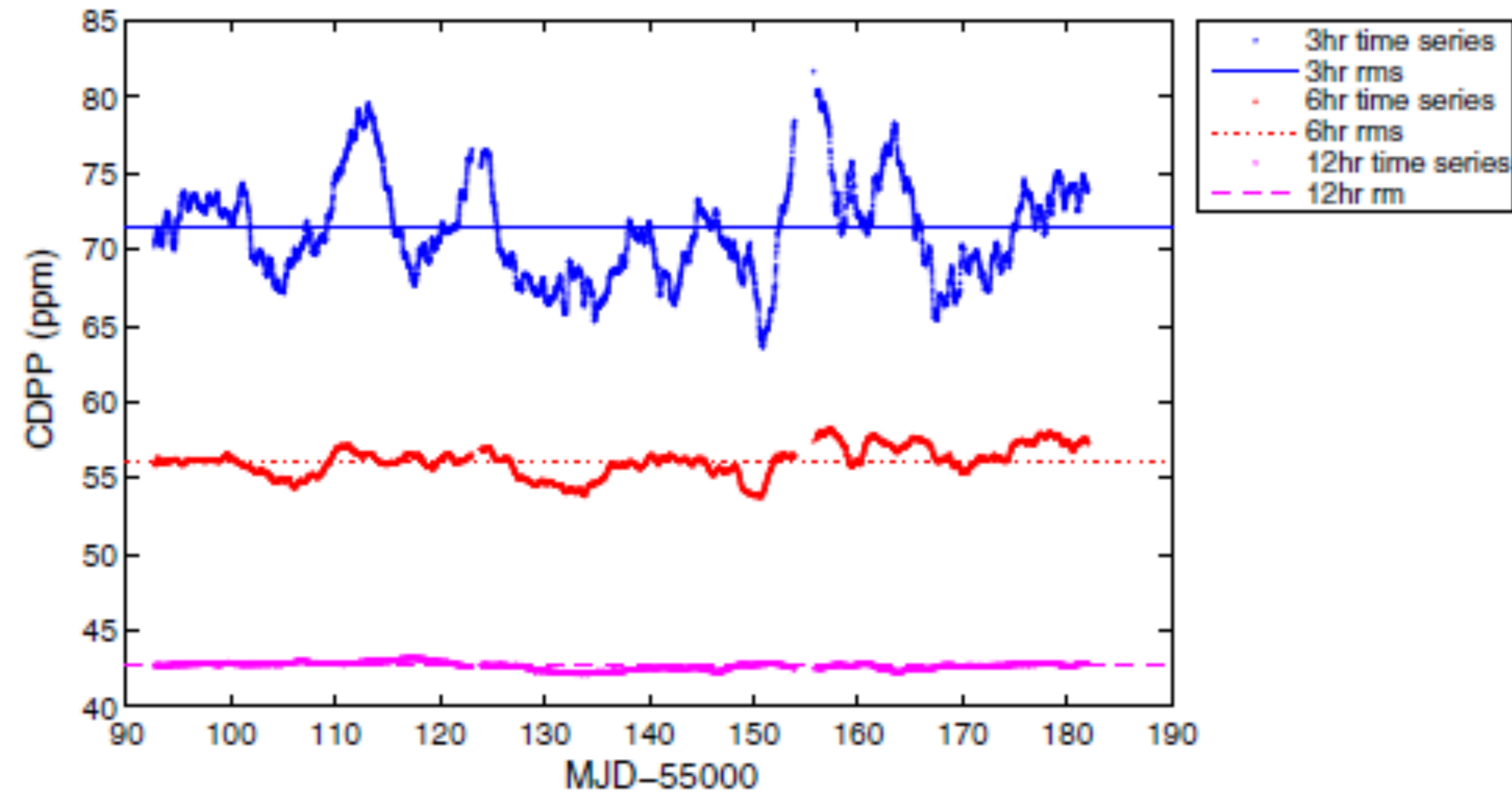
Basri et al. 2011

Kepler noise metric



- Noise metric for *Kepler* targets: **CDPP** (Combined Differential Photometric Precision)
- A time series of the effective white noise as seen by a specific transit duration for each target star.

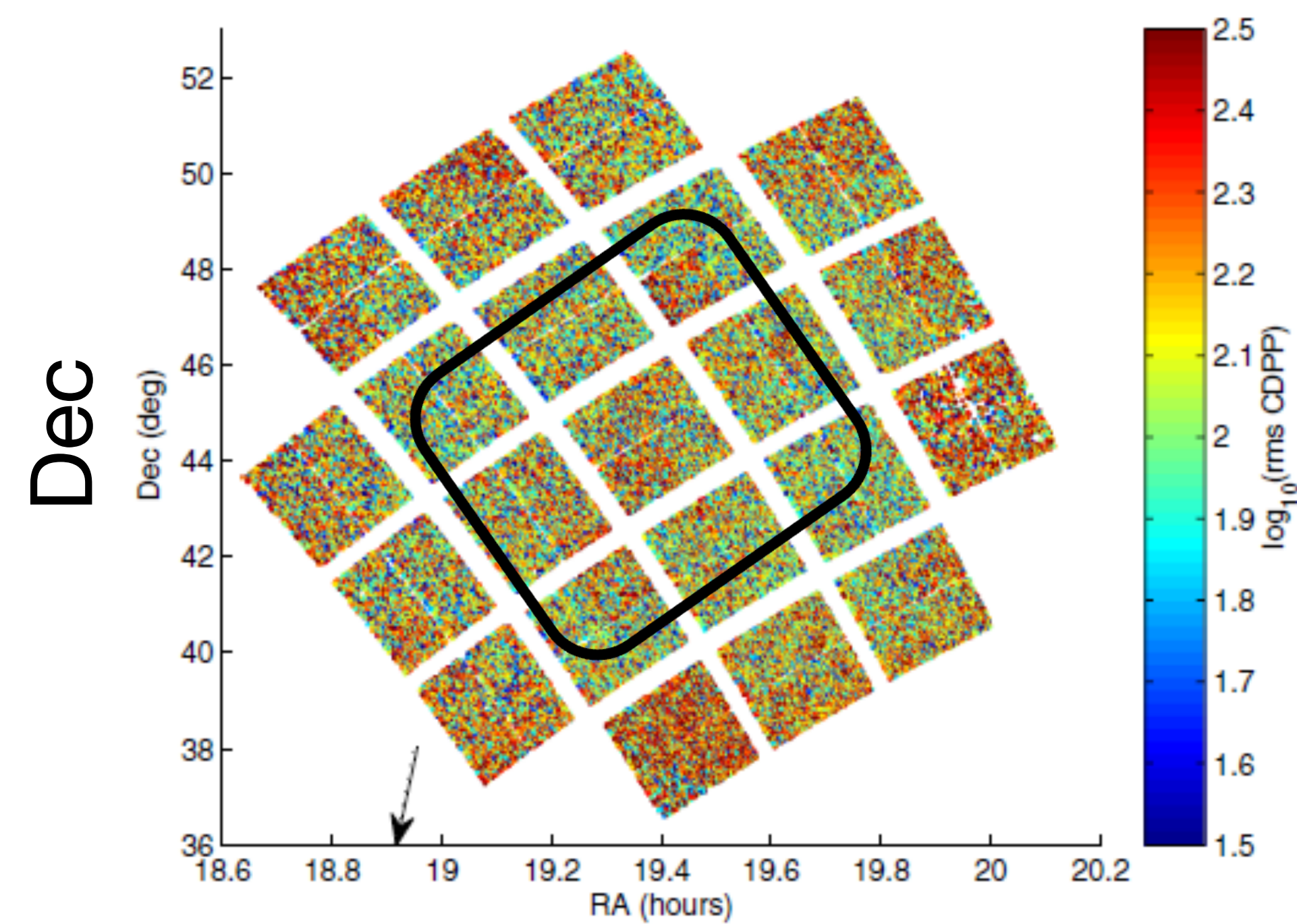
CDPP



MJD - 55000

Christiansen et al. 2012

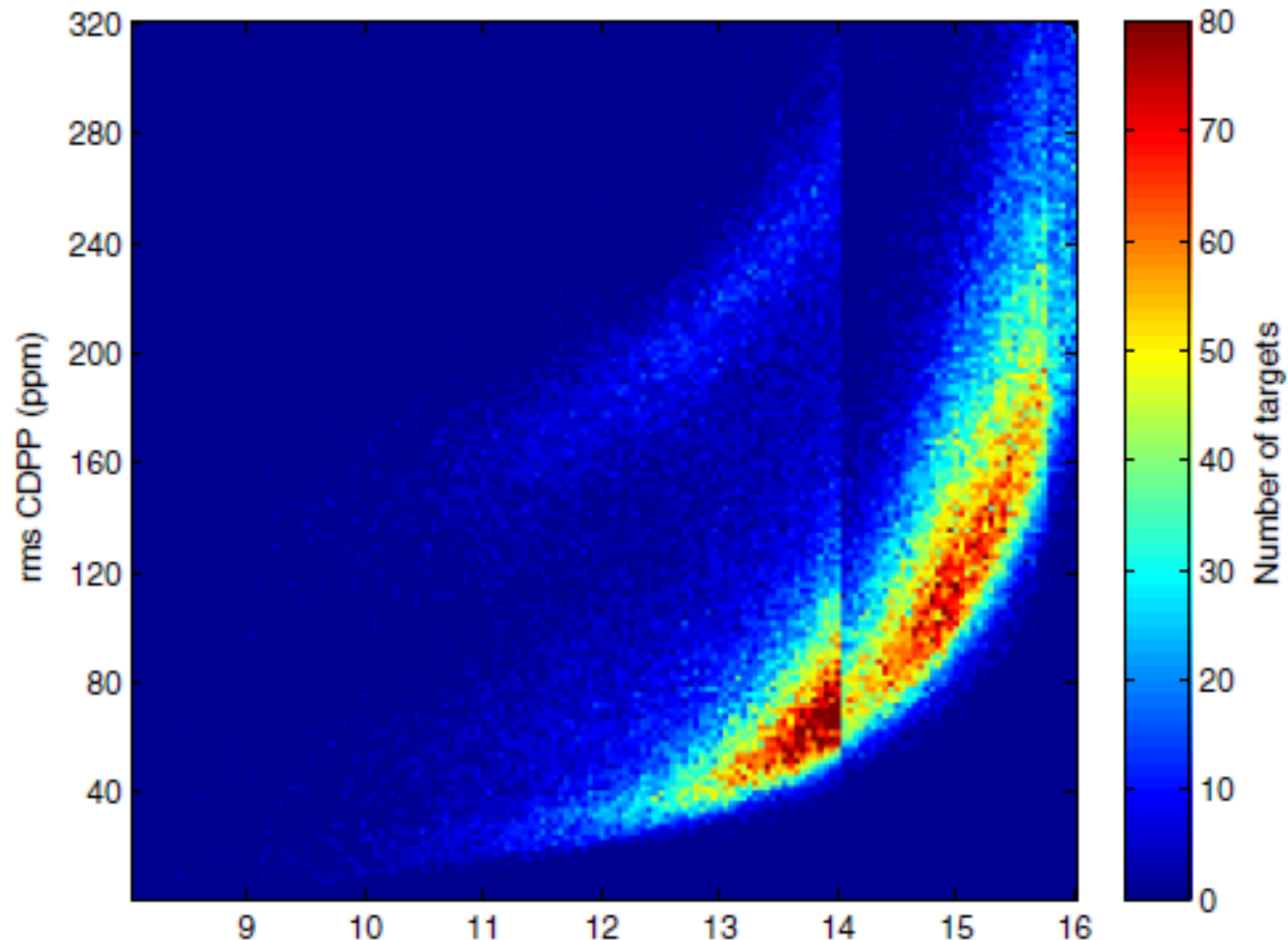
CDPP distributions of *Kepler* targets



RA

Christiansen et al. 2012

rms CDPP

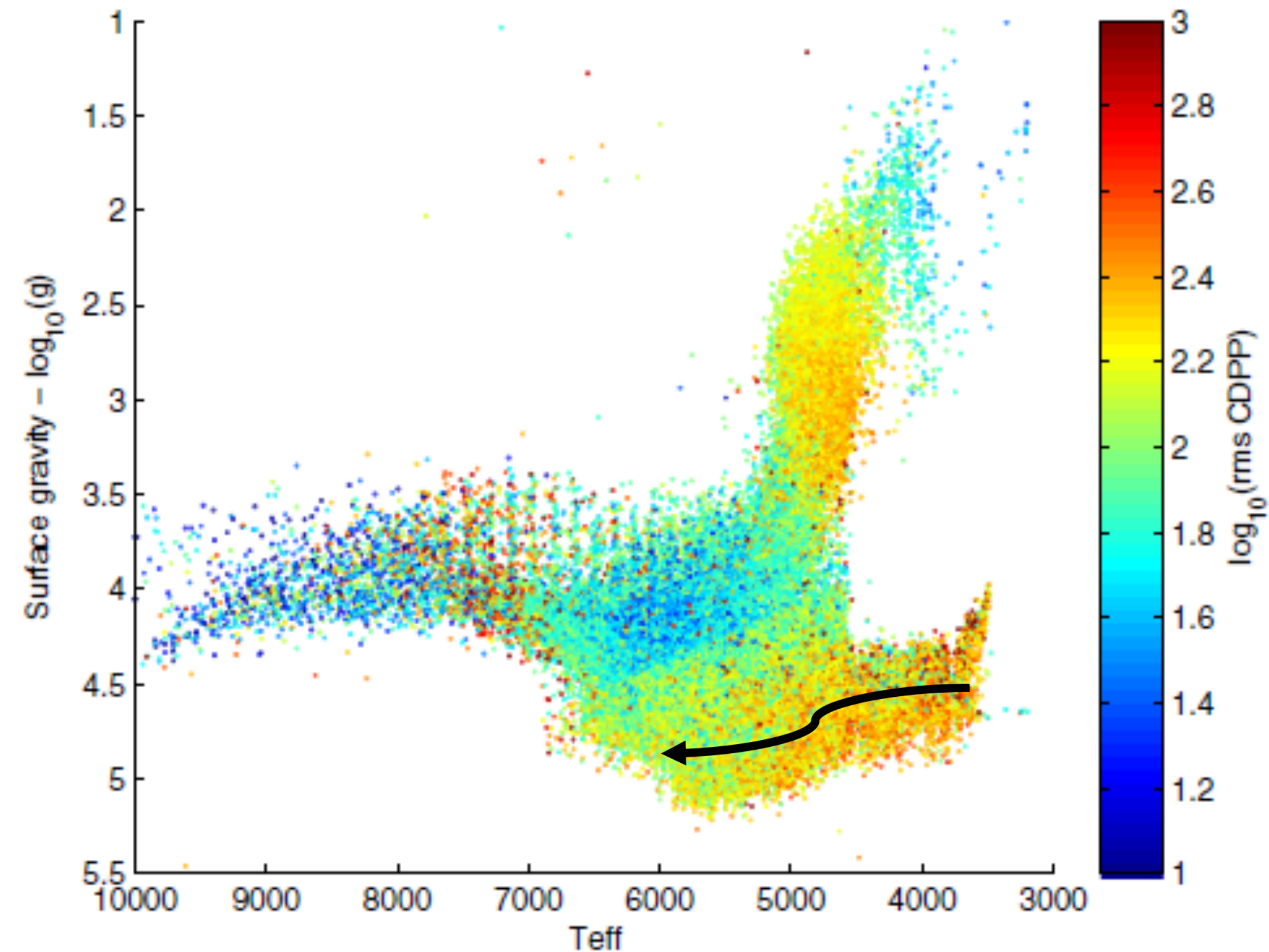


Kp mag

Intrinsic detector noise

Poisson + read noise

CDPP distributions of *Kepler* targets



Christiansen et al. 2012

Intrinsic stellar noise

- A correlation between CDPP and stellar parameters.

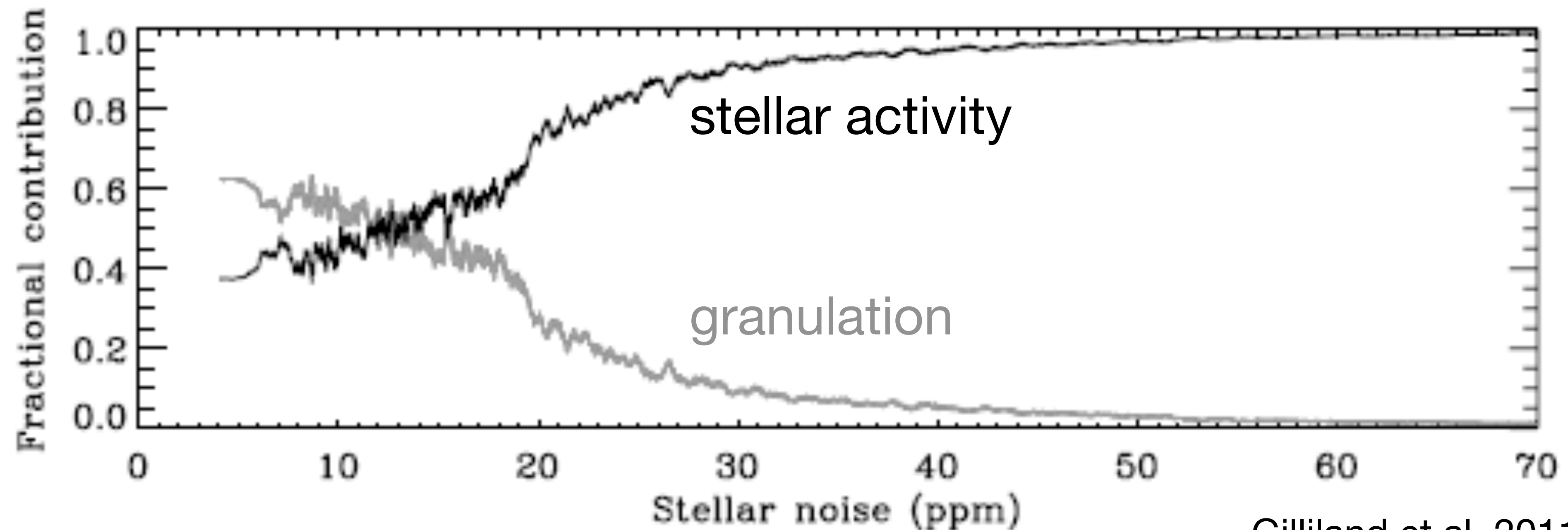
Global Roll Up of Noise Terms

Component	Variance (ppm ²)	Noise (ppm)	Baseline Noise (ppm)
Intrinsic stellar	380.5	19.5	10.0
Poisson + readout	283.0	16.8	14.1
Intrinsic detector	116.2	10.8	10.0
Quarter dependent	60.1	7.8	...
Total	839.8	29.0	20.0

Gilliland et al. 2011

- The **largest factor** in the modestly higher than anticipated noise follows from **intrinsic stellar noise**.

Intrinsic stellar noise : stellar activity vs. granulation

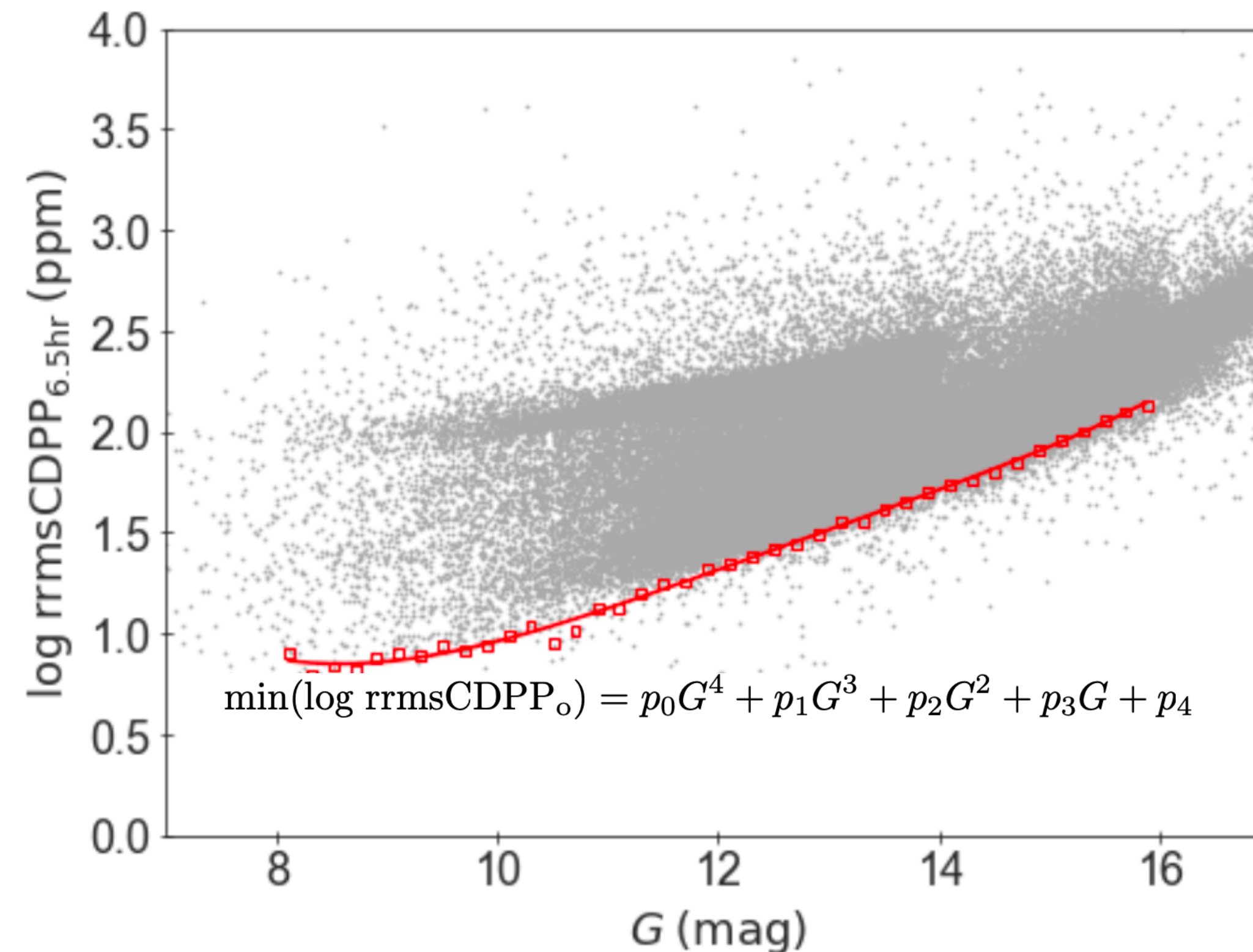


Gilliland et al. 2011

- The respective fractional contributions are quite similar at low stellar noise.
- **The stellar activity dominates at high noise.**

Dependence of intrinsic noise on stellar activity

- Subtracting Poisson noise & Instrumental noise



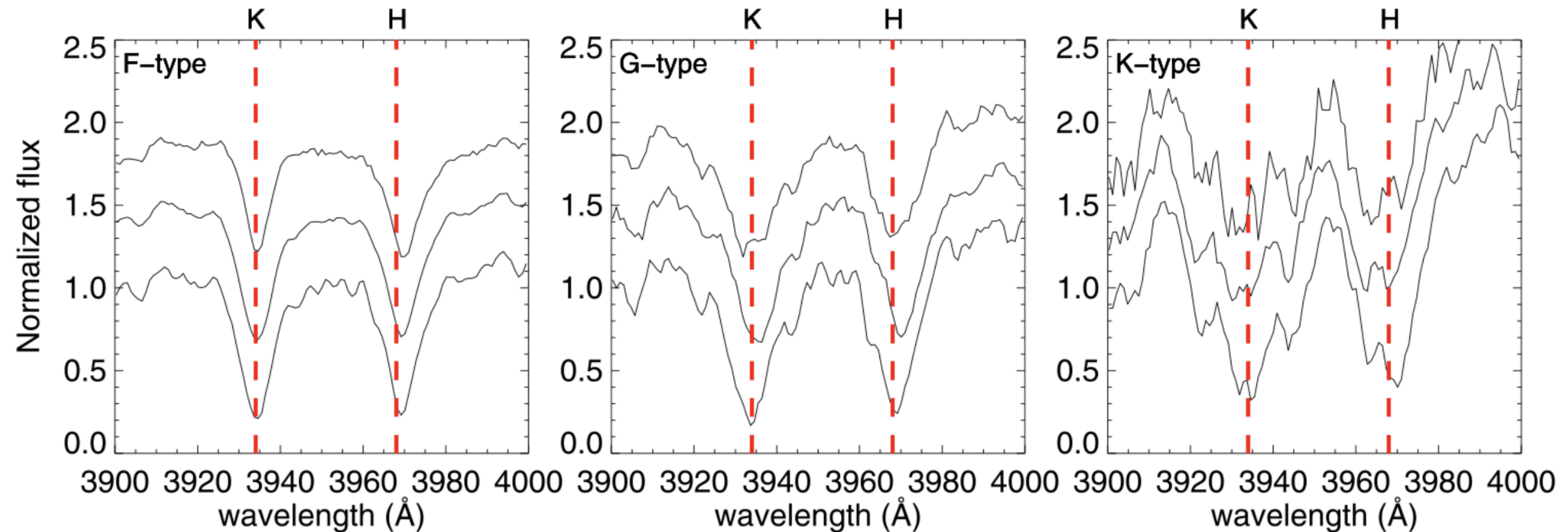
Zhang et al. 2024

$$\text{rrmsCDPP}_i^2 = \text{rrmsCDPP}_o^2 - (10^{\min(\log \text{rrmsCDPP}_o)})^2 - 0.13 \text{rrmsCDPP}_o^2$$

Intrinsic noise Overall noise Photo noise Instrumental noise

Dependence of intrinsic noise on stellar activity

► Measuring activity level



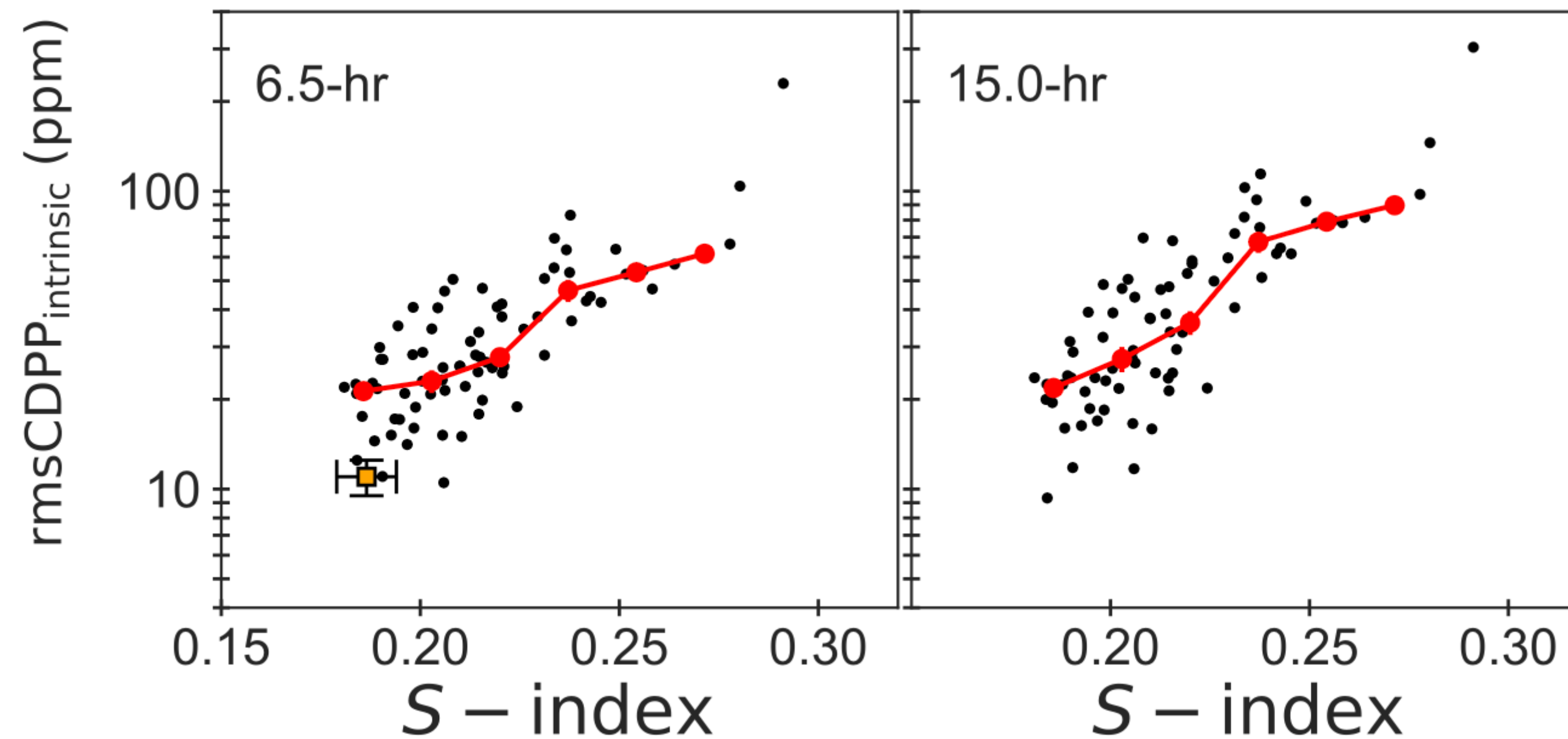
Zhang et al. 2020

$$S_{\text{LAMOST}} = \alpha \cdot \frac{H + K}{R + V}$$

Dependence of intrinsic noise on stellar activity

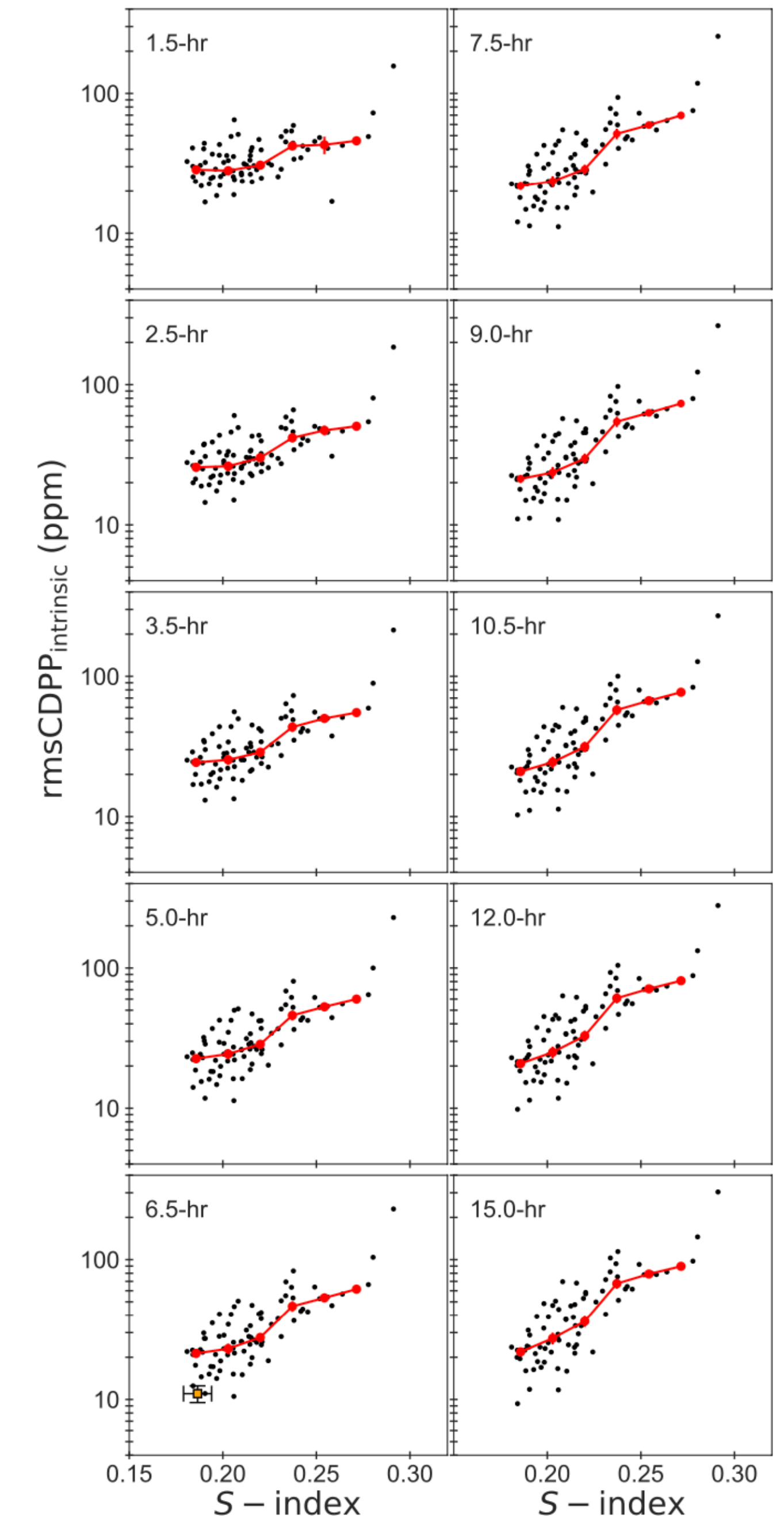
$5677 < T_{\text{eff}} < 5877$ K; $4.34 < \log g < 4.54$ dex; $-0.1 < [\text{Fe}/\text{H}] < 0.1$ dex;

$11.5 < K_p \text{ mag} < 12.5$

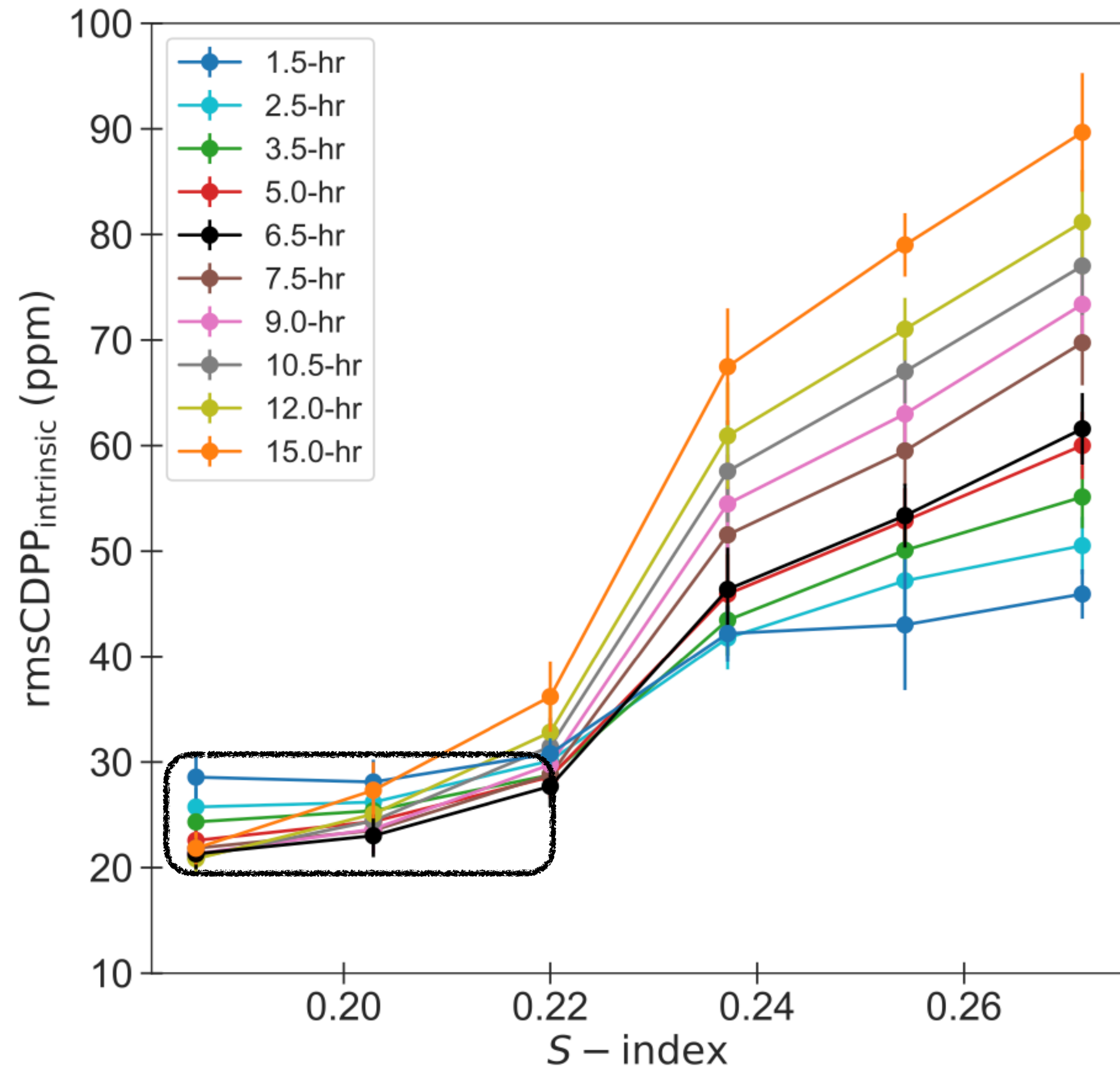


Zhang et al. 2024

- A correlation between CDPP and S-index.
- The correlations are more significant for longer integration duration.



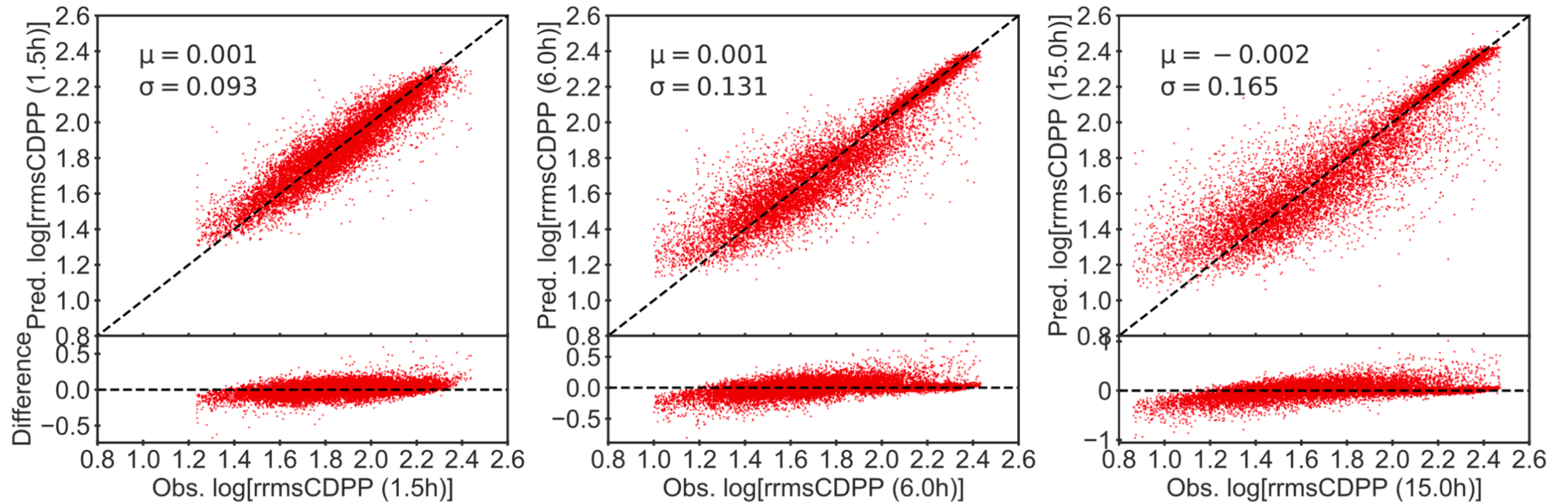
Dependence of intrinsic noise on stellar activity



Zhang et al. 2024

- The median intrinsic rms CDPP on all timescales distribute mainly in the range of 20–30 ppm at the low-activity end.
- The inactive stars with **S-index < 0.22** would be favourable for selecting targets in future Earth2.0 search missions.

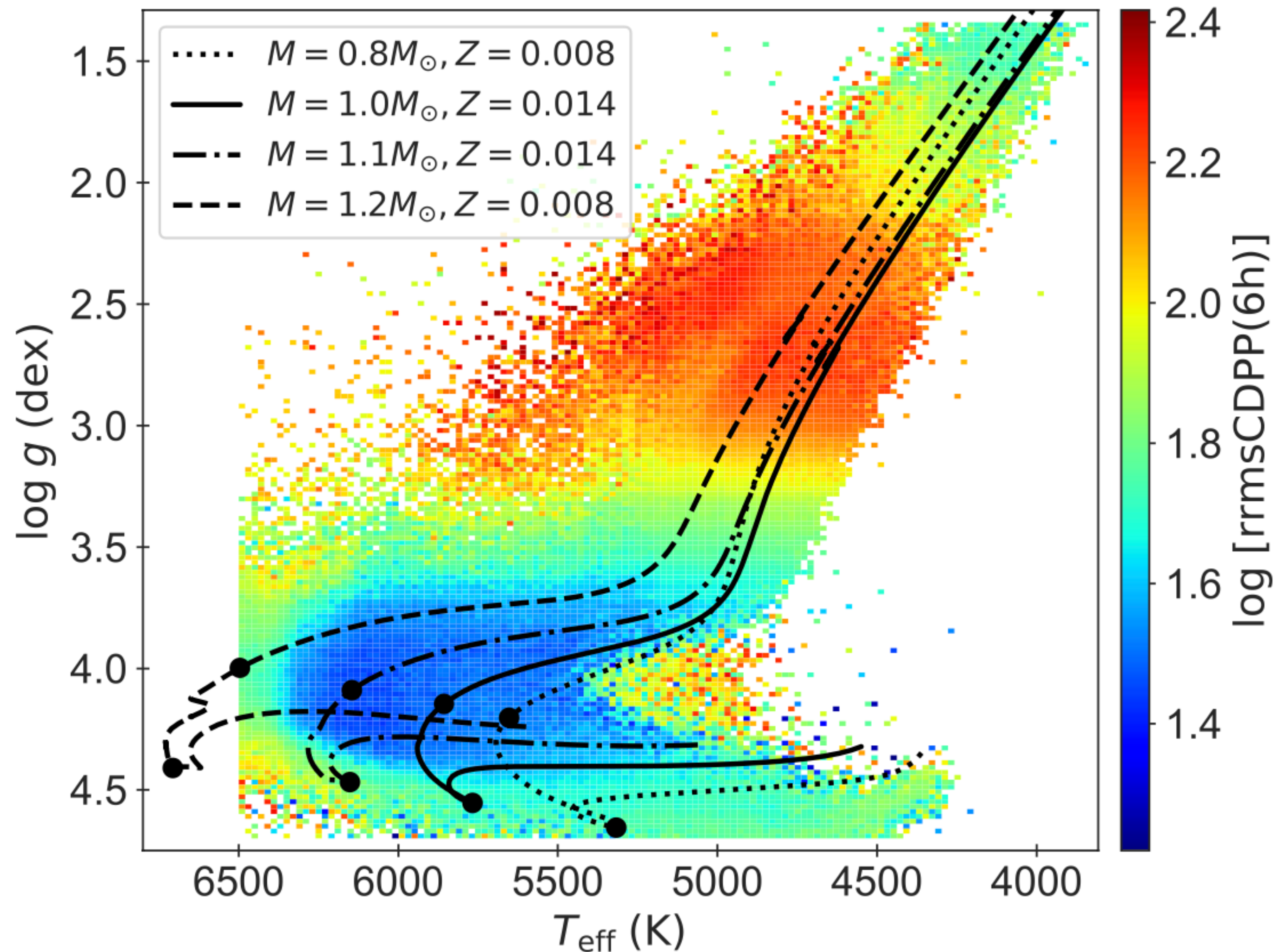
Fitting relations: $\text{rrmsCDPP}_{\text{intrinsic}} = f(\text{s-index}, T_{\text{eff}}, \log g, [\text{Fe}/\text{H}], G)$



Zhang et al. 2024

- The models are around 81%(15h)—85%(1.5h) accurate on average.

Predicting intrinsic stellar noise for the LAMOST targets



- The noise levels tend to drop off over time for MS stars.
- Some stars with relatively low noise levels have entered sub-giant phase.
- The bulk of less-luminous red giants are generally the noisiest.
- Resultant noise catalog with stellar parameters will be invaluable for optimizing target selection for Earth2.0 search missions.

Summary

- Stellar activity has significant impact on photometric observations for exoplanet search.
- There is a strong correlation between intrinsic stellar noise and stellar activity level.
- The inactive host stars with S-index < 0.22 would be favourable for selecting targets in Earth2.0 search missions.
- The intrinsic stellar noise can be predicted with stellar activity level as well as stellar parameters, which is important for Earth2.0 search missions.

Thank !