Properties of the SB1 sample detected in the Gaia-ESO Survey

Submitted to A&A

2019-06-25

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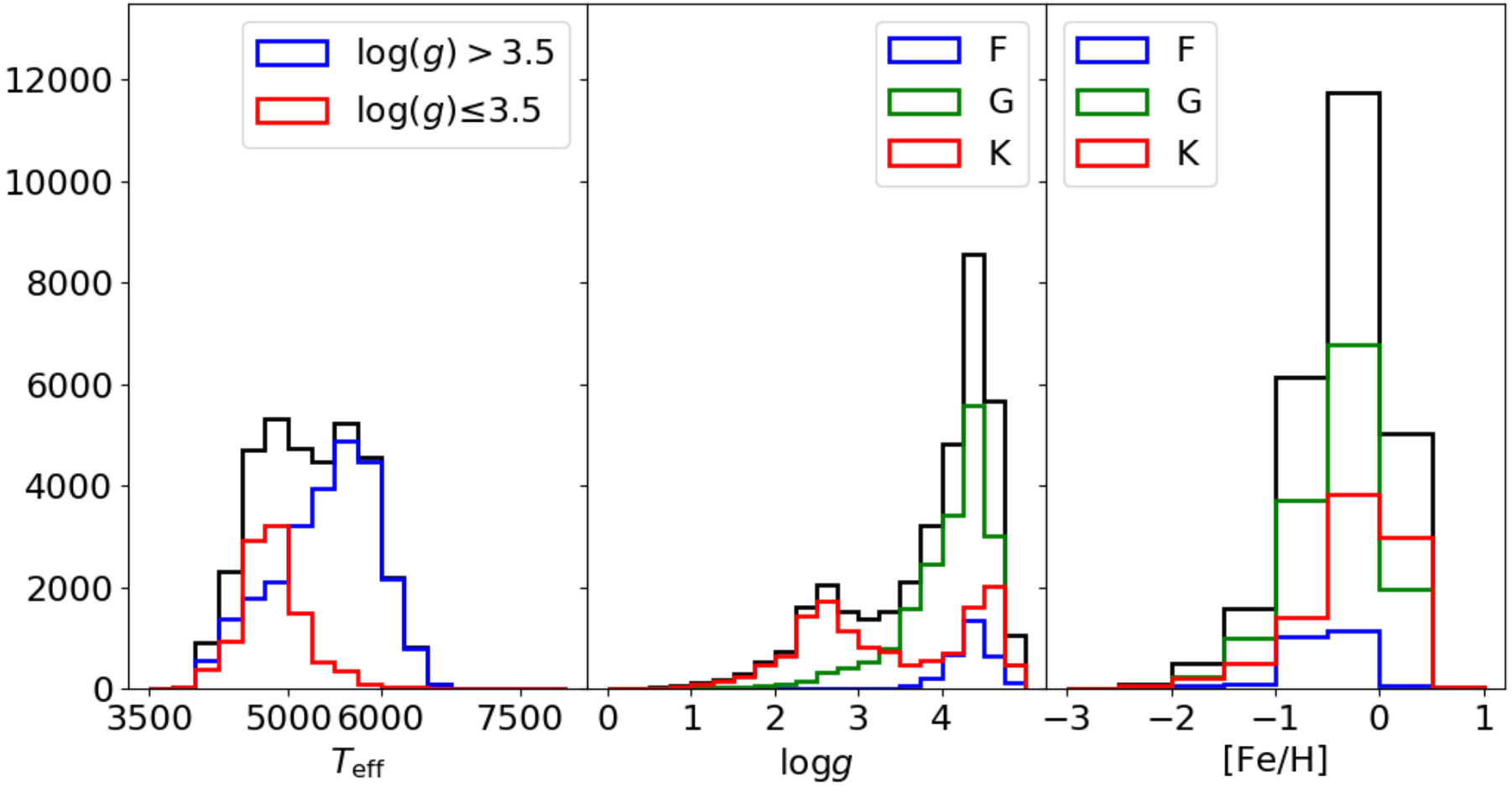
EWASS 2019 – SS 22
Stellar multiplicity in the Gaia era: where do we stand?

What is the Gaia-ESO Survey (GES)?

Study of the formation history of stellar populations of the Milky-Way:
100 000 FGK stars in bulge, discs, halo and stellar clusters

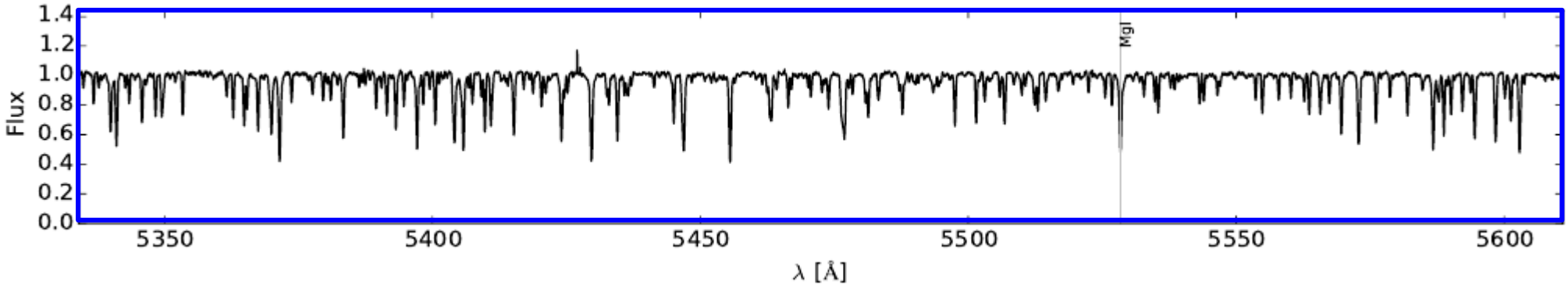
The GES was **not designed** as a monitoring survey!

What are the properties of the observed stars in the GES?

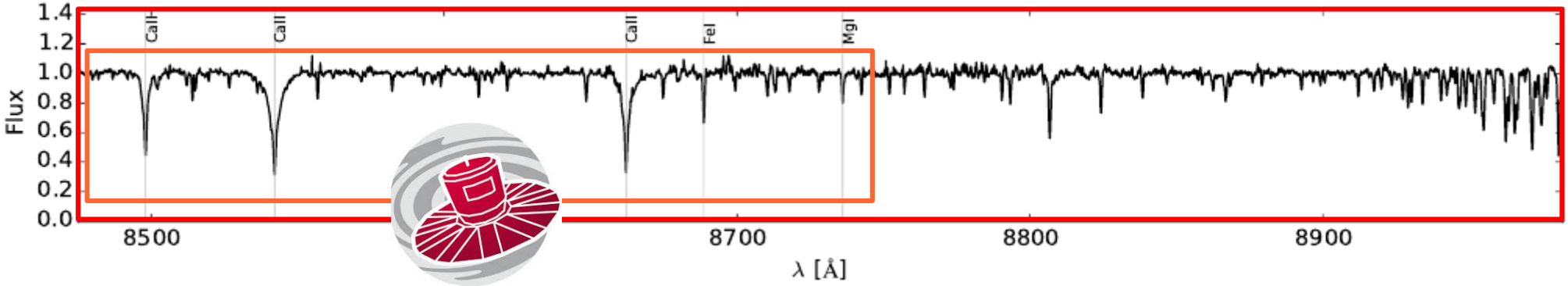


What are the observational characteristics?

GIRAFFE HR10, R~20000



GIRAFFE HR21, R~18000



How do we efficiently detect RV variables?

(RV = radial velocity)

- Selection of a GES stellar sample with:
  - At least **2 observations**
  - Signal to noise ratio: **S/N ≥ 3**
  - Outlier rejection criterion: $\mathbf{d}v_{max}/\mathbf{d}t \leq 62.5$ **km/s/h**

  ➞ **43400 stars**

- **χ² statistical test**:

$$\chi^2_{N-1} = \sum_{i=1}^{N} \left(\frac{v_i - \bar{v}}{e_i} \right)^2$$

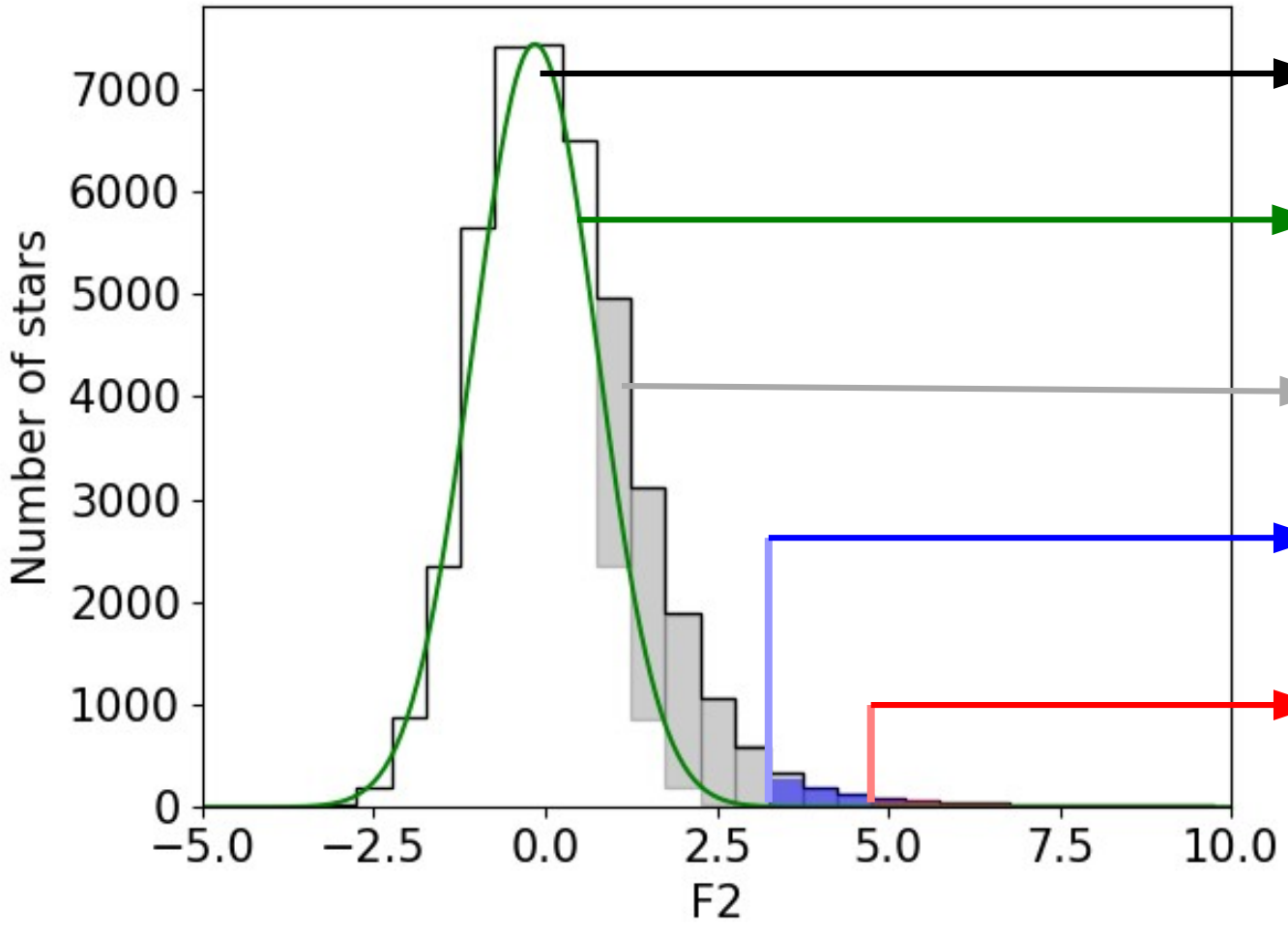
  - N ~ 4 RV measurements per star
  - RV uncertainties are quadratic sum of:
    Gaussian fit + physical + spectrograph configuration uncertainties

- **F2 statistics** (Wilson&Hilferty 1931): $F2(\chi^2, N) = \sqrt{\frac{9(N-1)}{2}} \left[\left(\frac{\chi^2}{N-1} \right)^{1/3} + \frac{2}{9(N-1)} - 1 \right]$

χ^2_{N-1} → **F2**: $\mathcal{N}$**(0,1)** independent of ***N***

How do we efficiently detect RV variables?

(RV = radial velocity)



43400 GES stars

Standard normal distribution

1.5σ 9600 RV variables

3σ (set 2)
1400 RV variables

5σ (set 1)
770 RV variables

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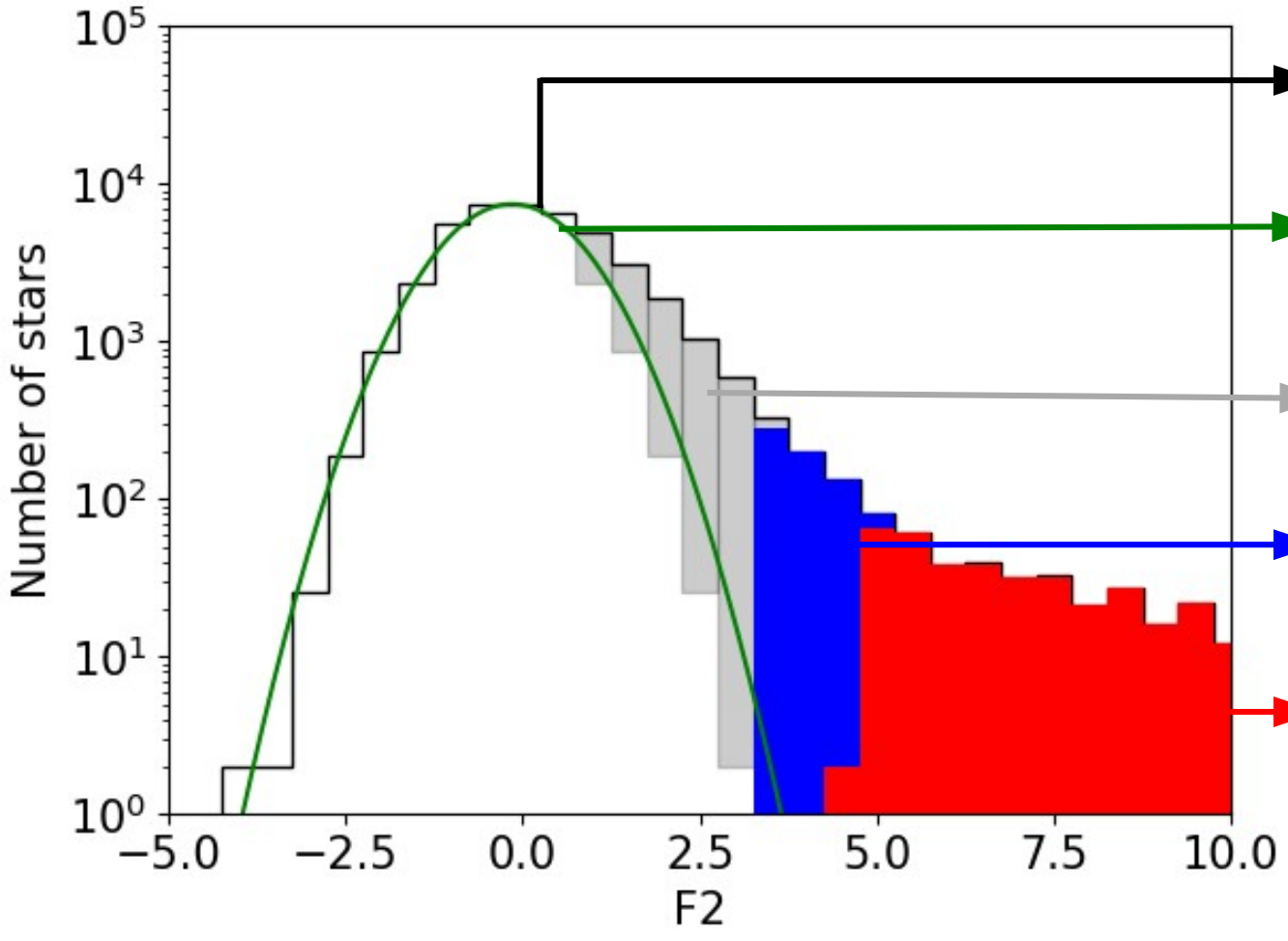
(RV = radial velocity)



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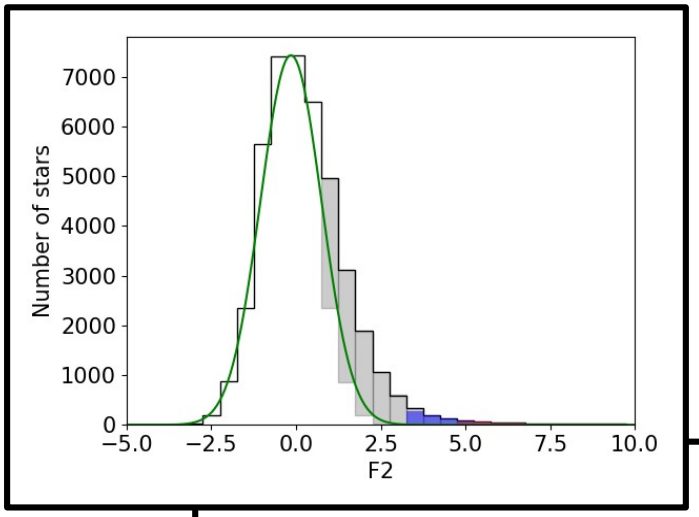
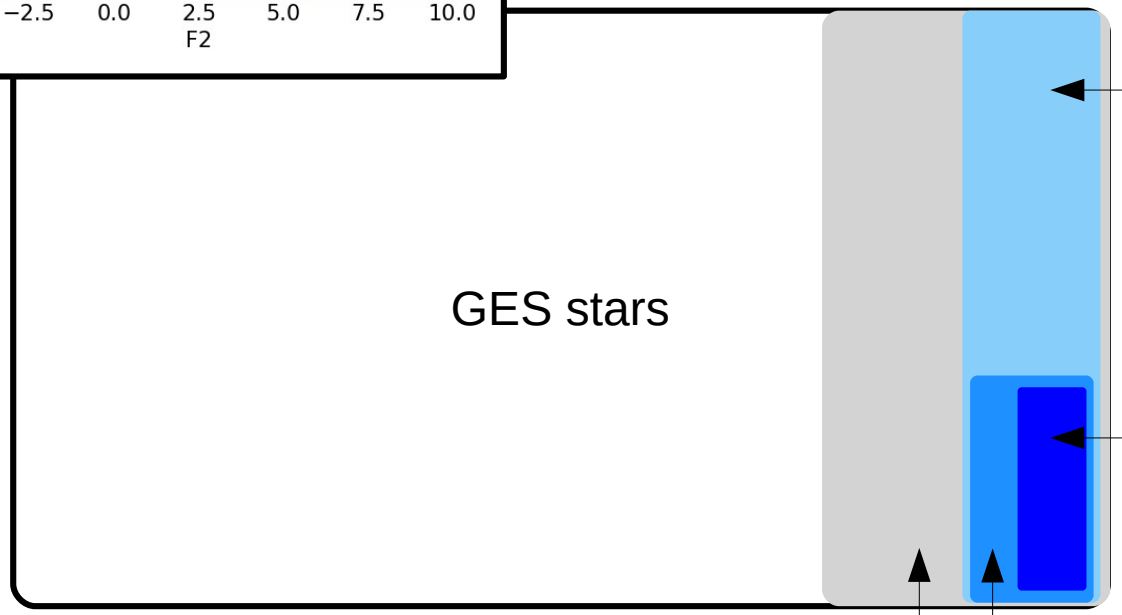
What is the corrected SB1 fraction in GES?



- RV variables can include single stars that show jitter/ spots/pulsations in their atmospheres
- Detection efficiency estimated using the SB9 catalogue (Pourbaix+ 2004)



10% of corrected SB1 (conservative)

Detection efficiency

2% of raw SB1

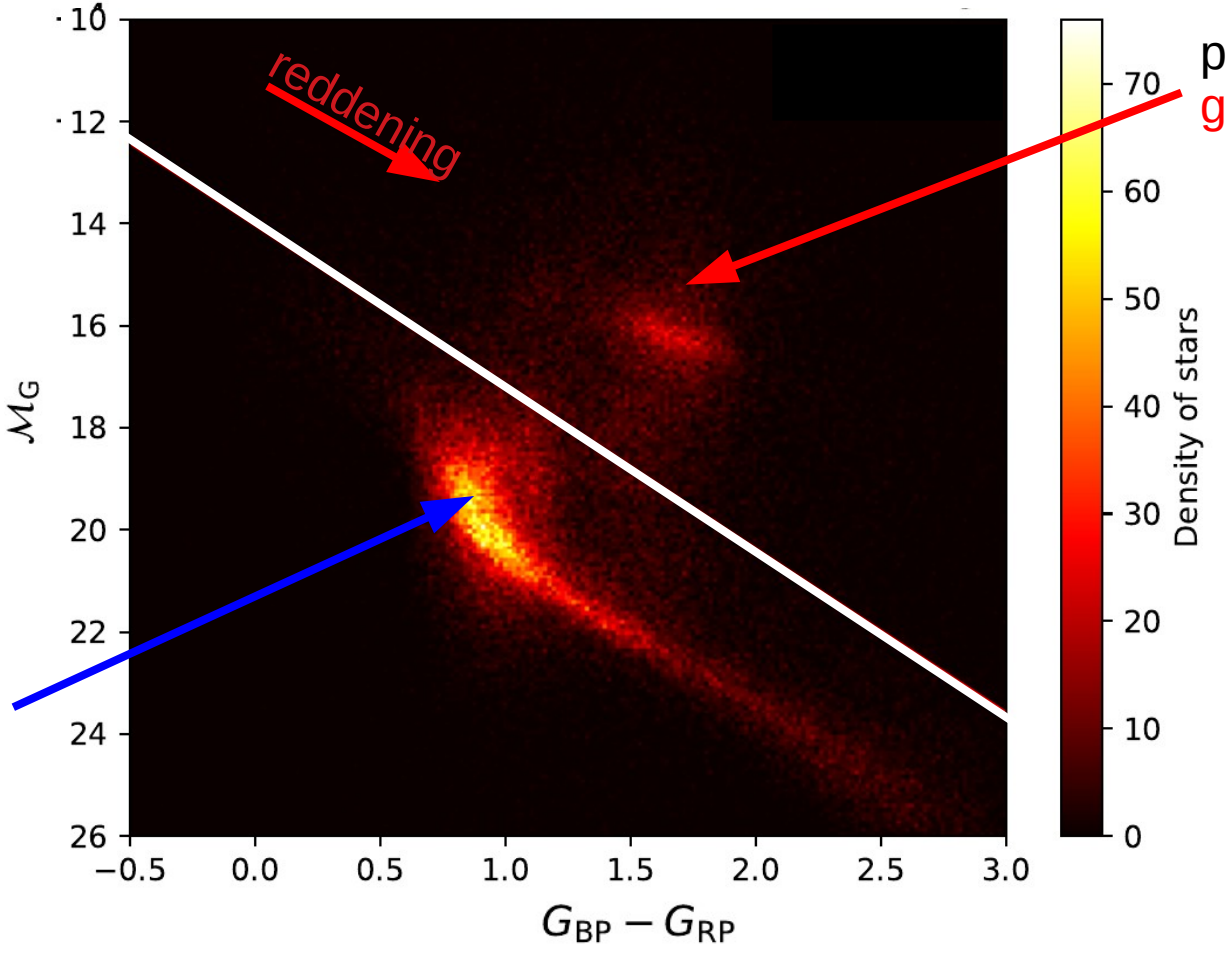
Removal of photometric variables

3% of RV variables at 3σ (set 2)

22% of RV variables

How do we select SB1 from RV variables?

By filtering photometric variables due to pulsation/jitter using Gaia DR2



pulsations/jitter in giant RV variables

δ Sct, jitter/spot in dwarf RV variables

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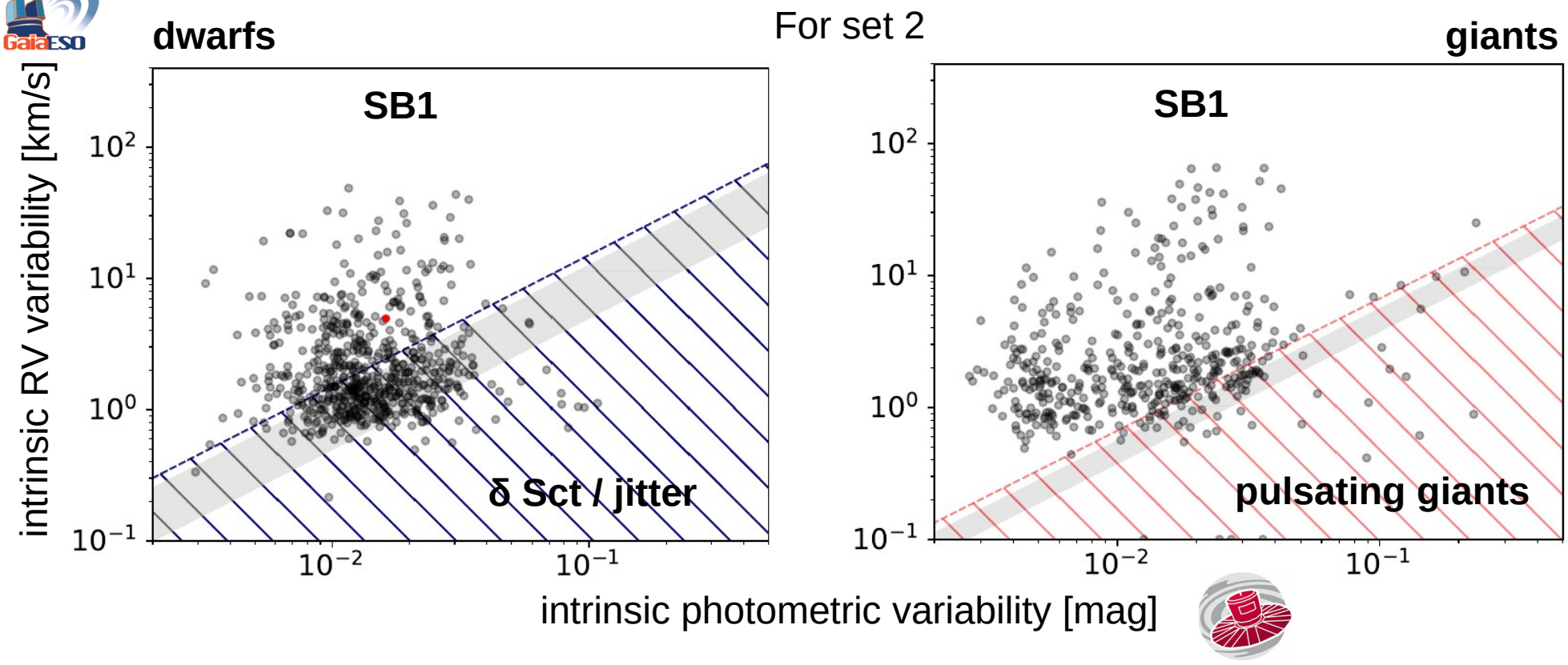

After cleaning:

- **Set 1 (5σ):** ~460 SB1 dwarfs, ~140 SB1 giants, ~30 without classification
- **Set 2 (3σ):** ~520 SB1 dwarfs, ~200 SB1 giants, ~90 without classification

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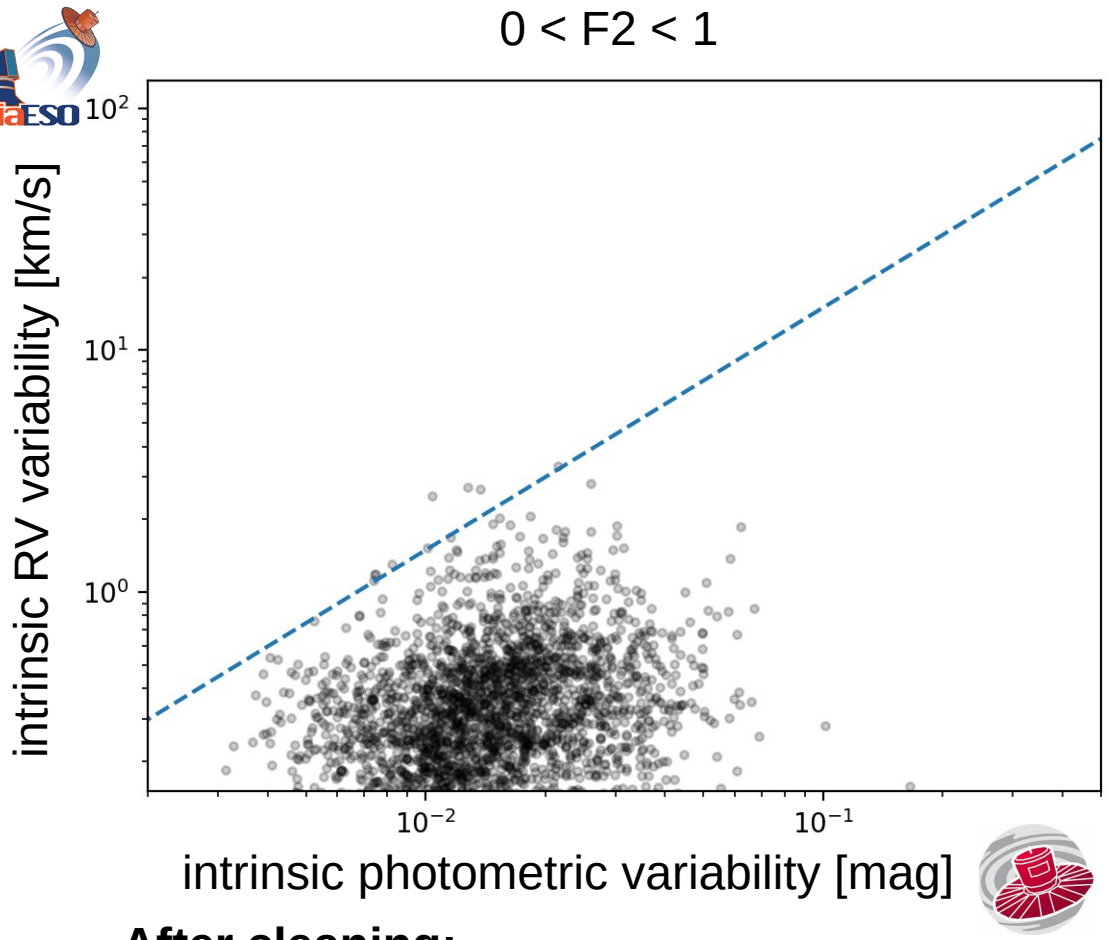

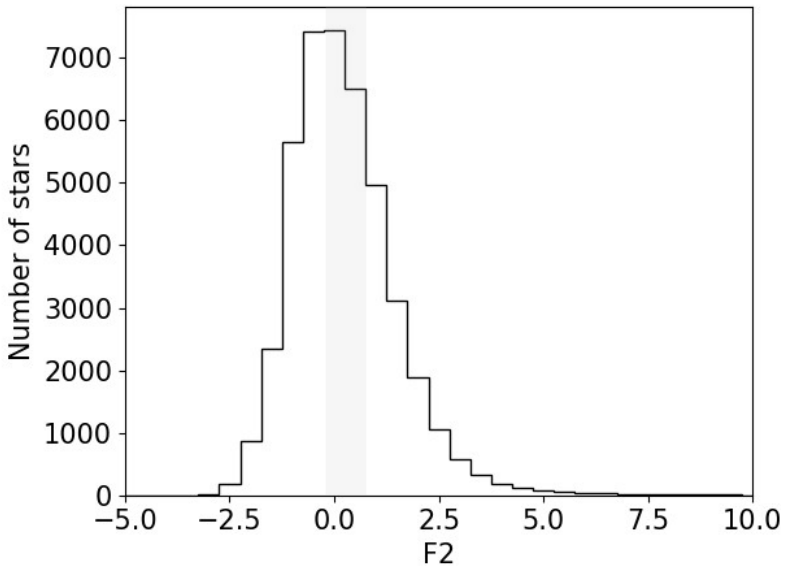

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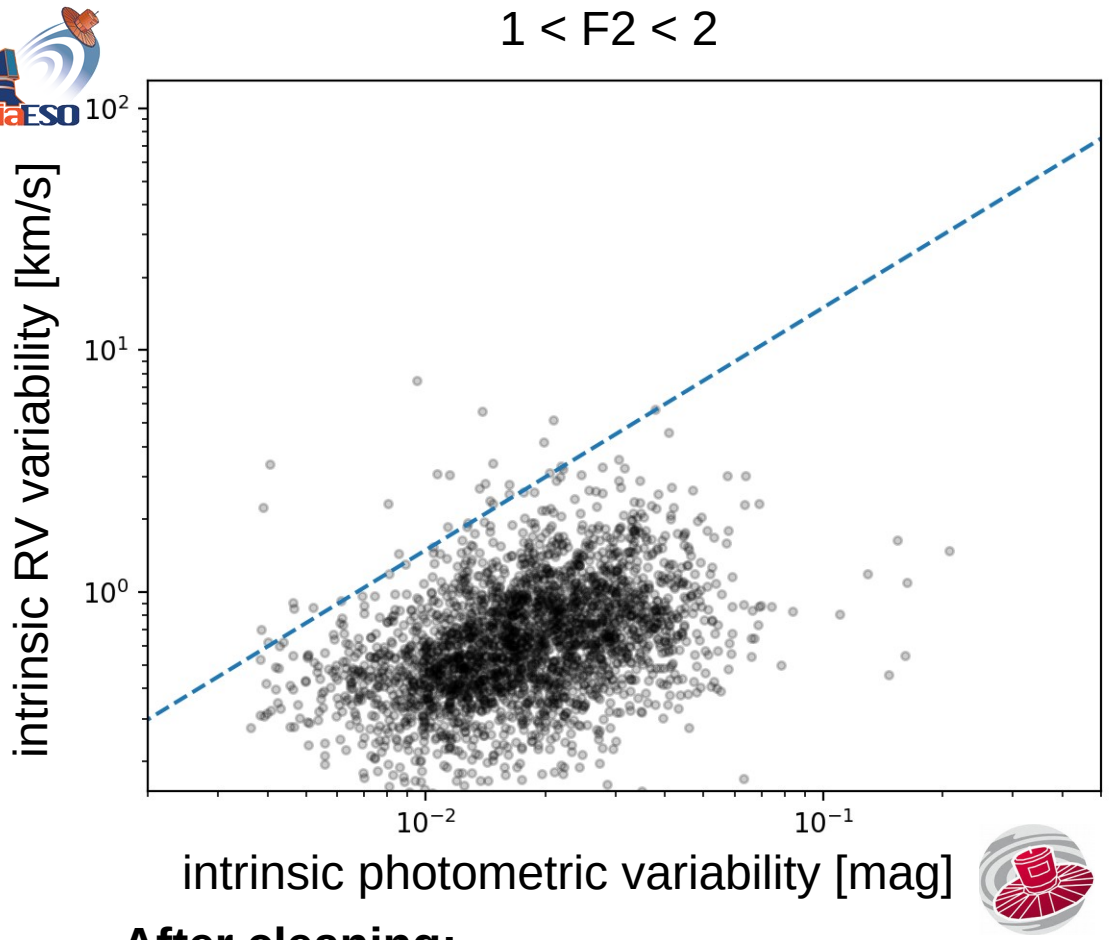

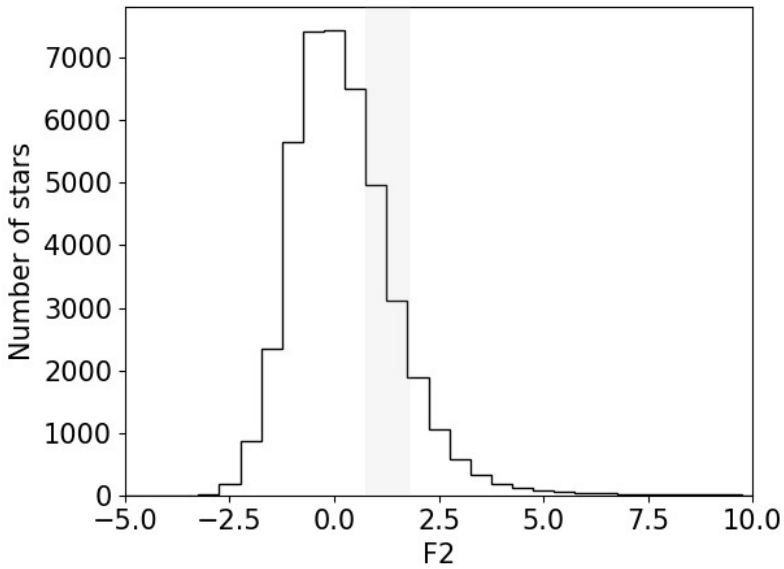

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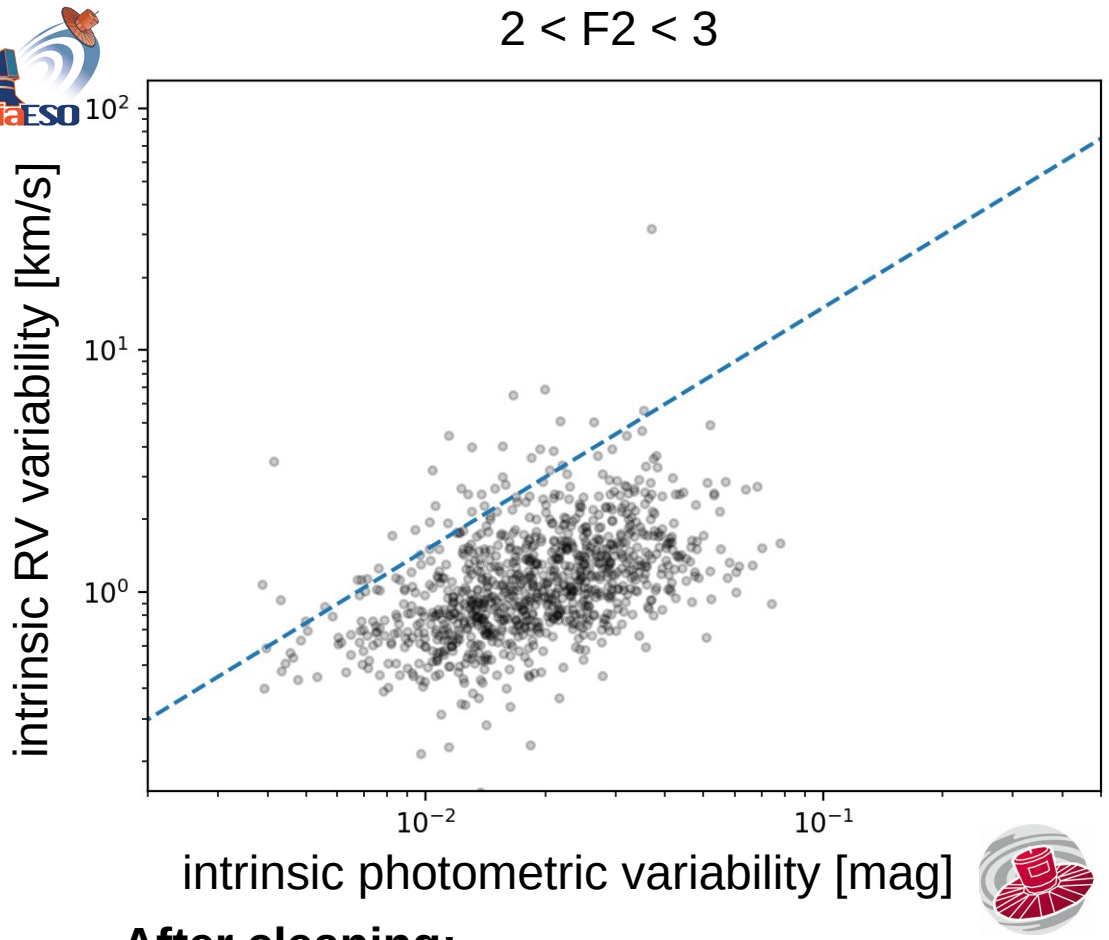

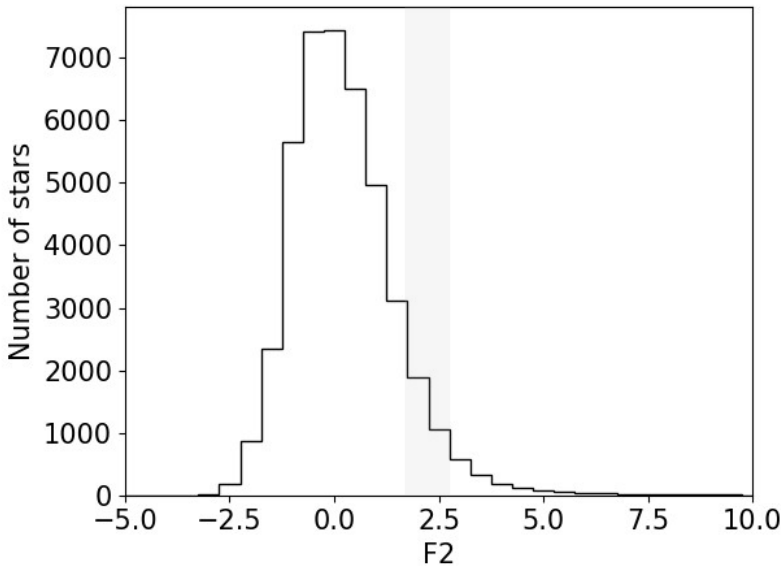

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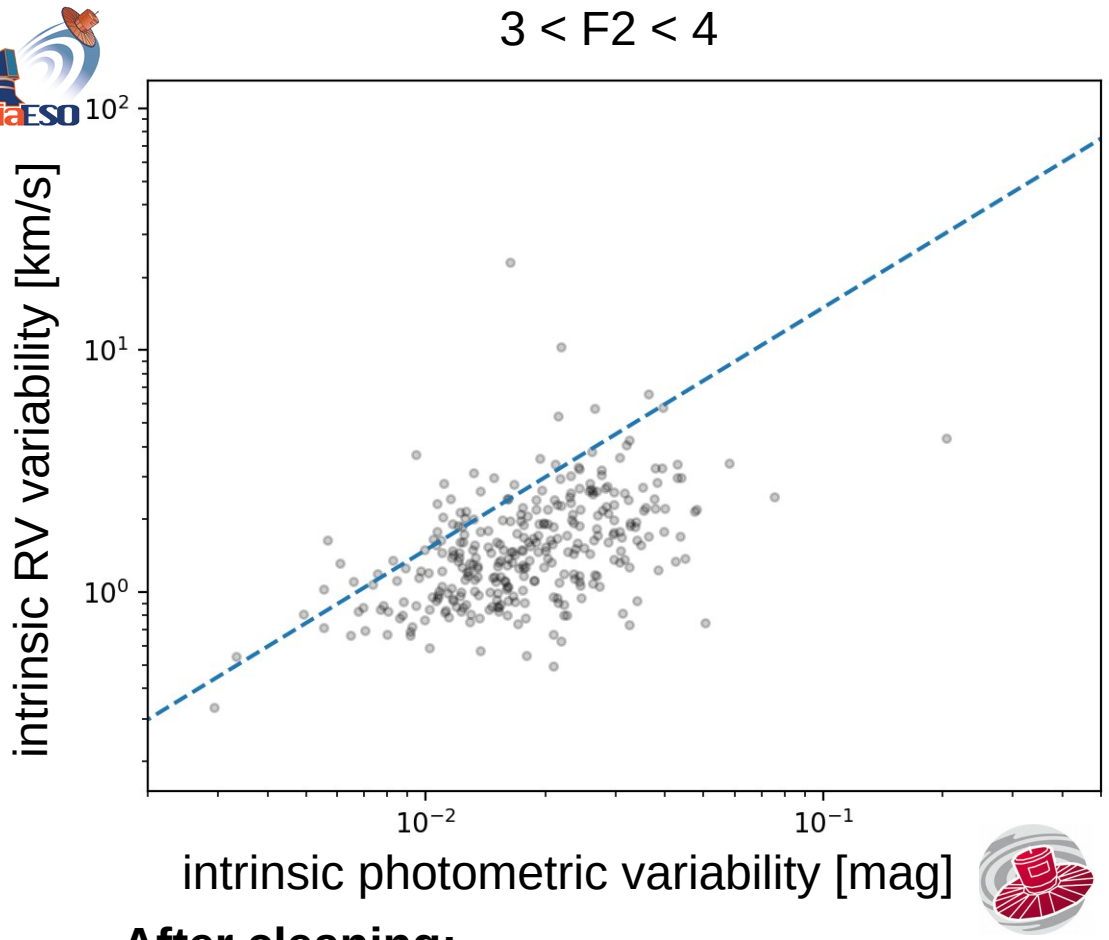

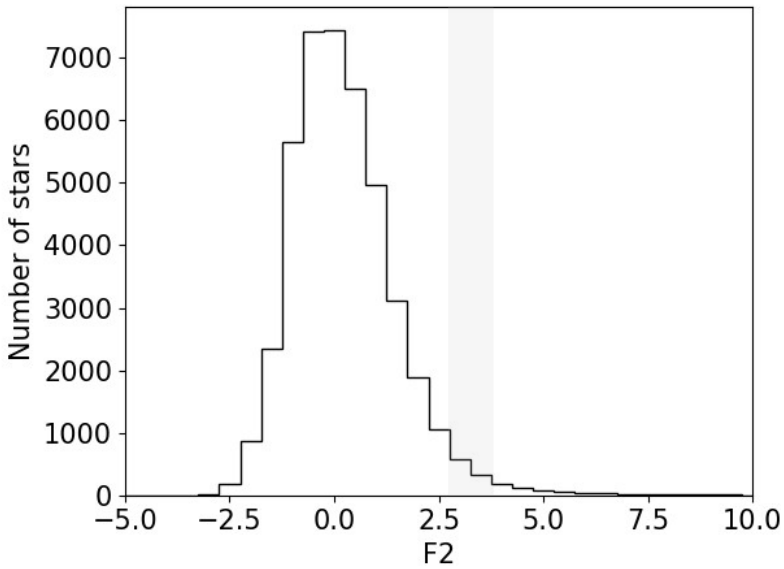

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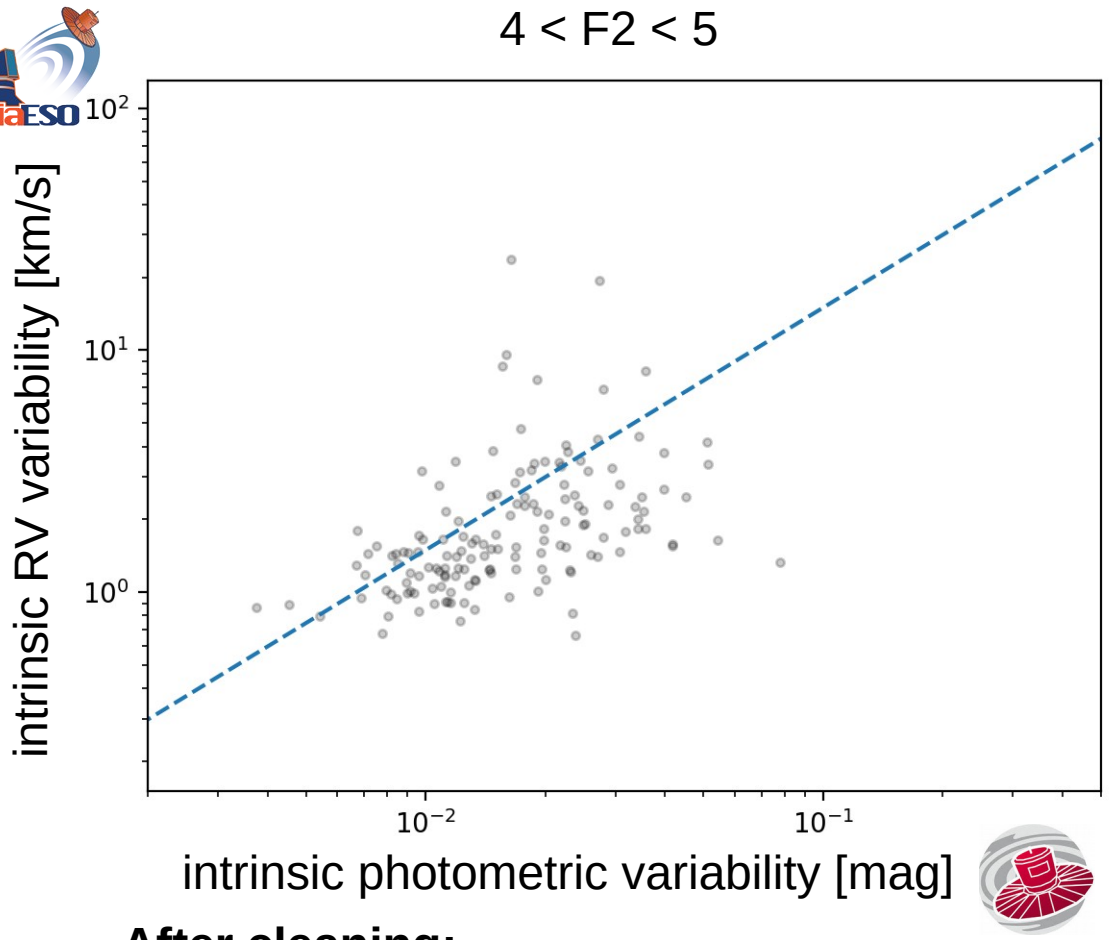

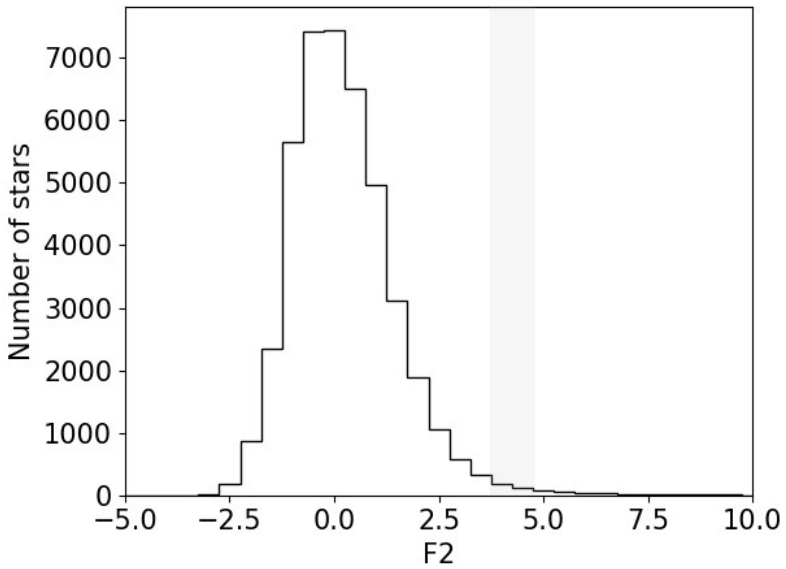

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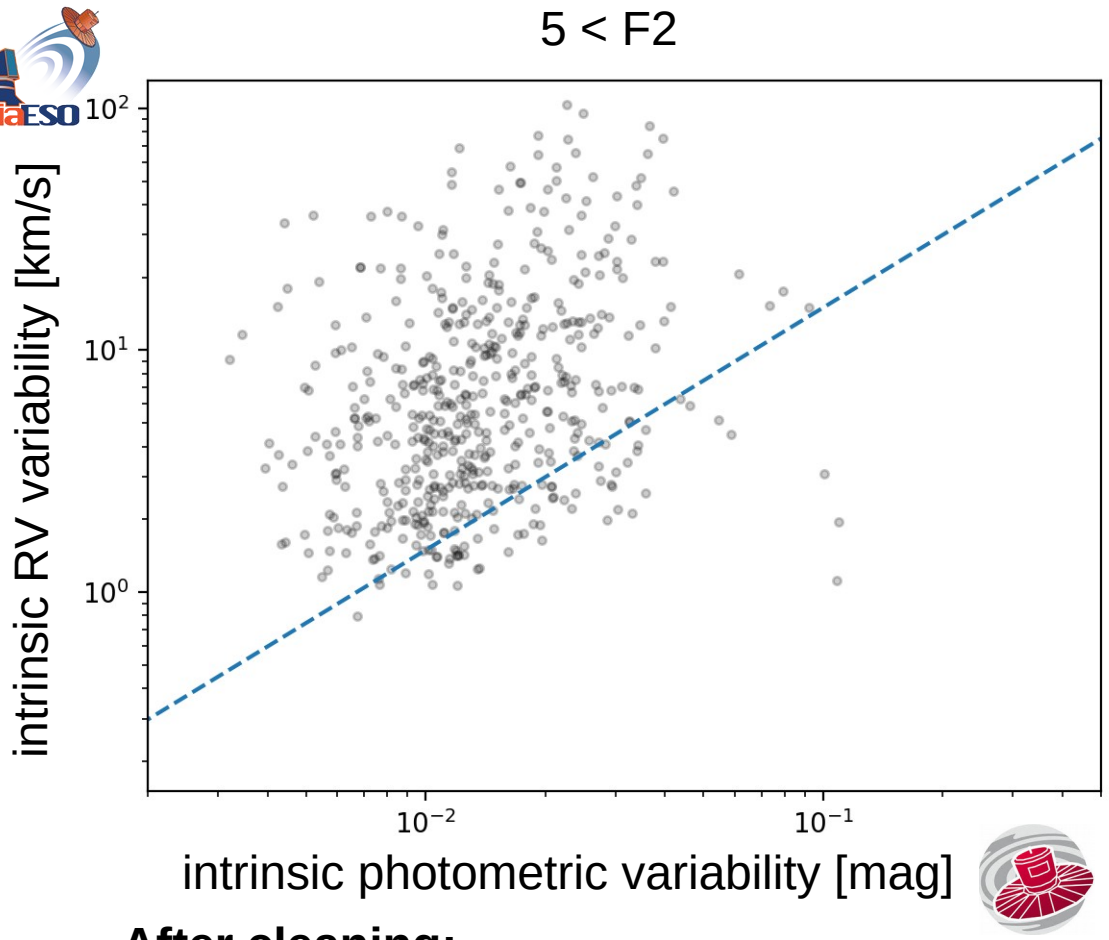

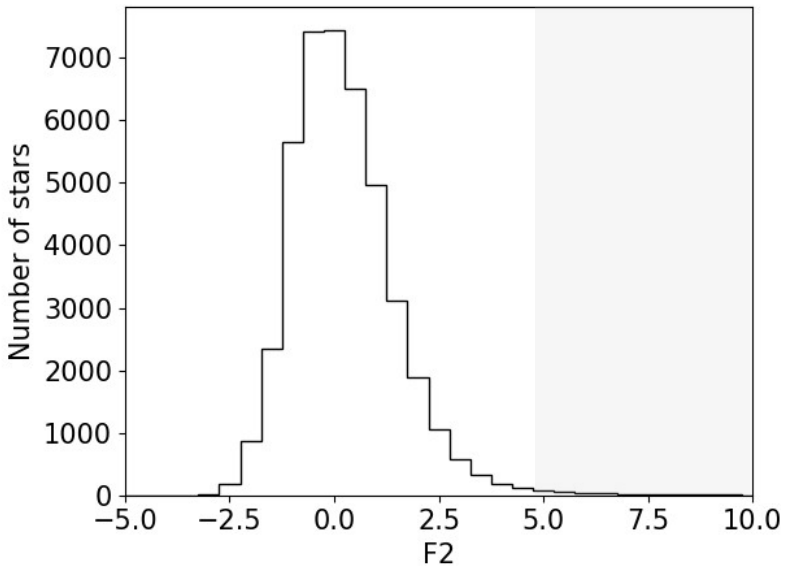

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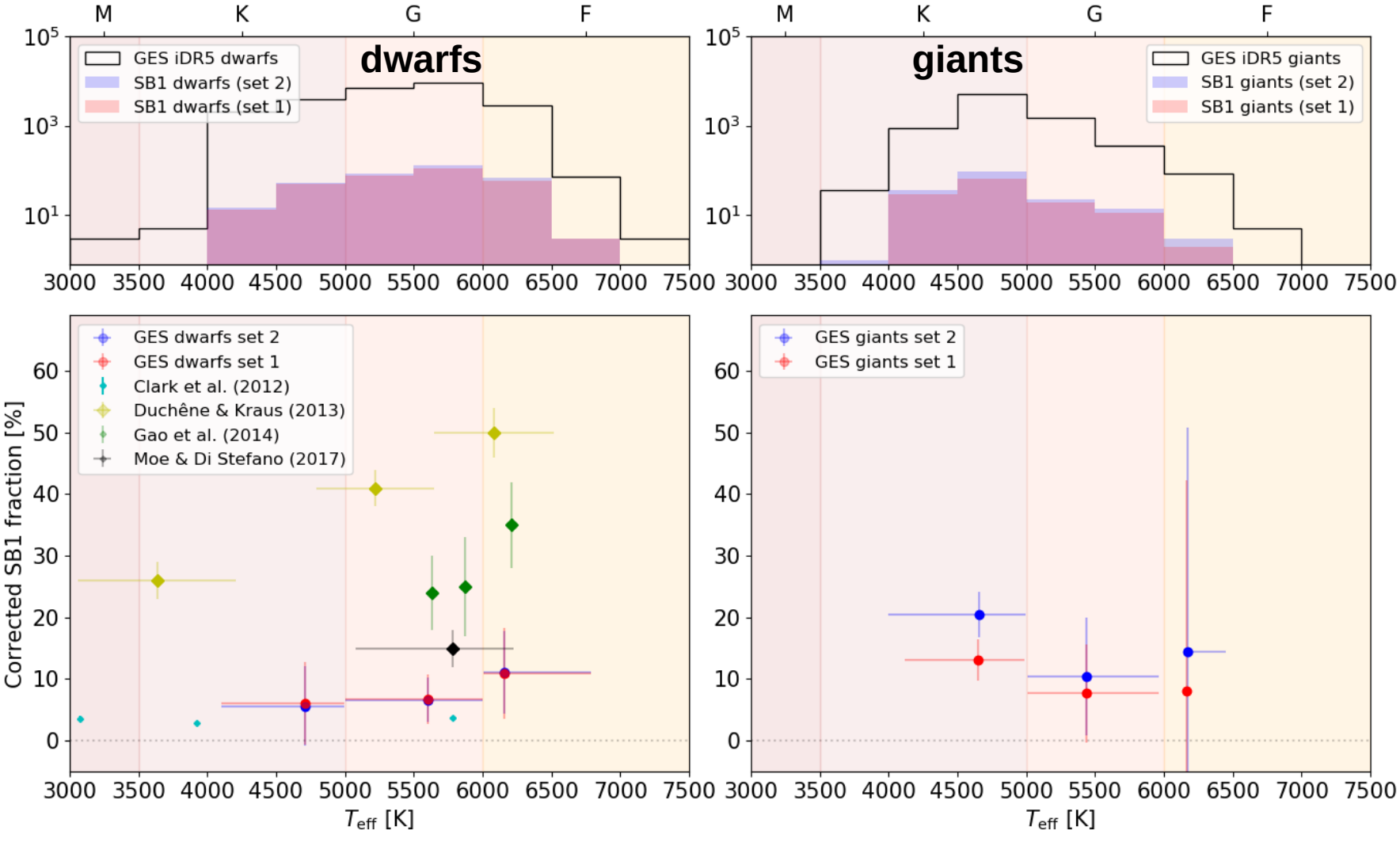
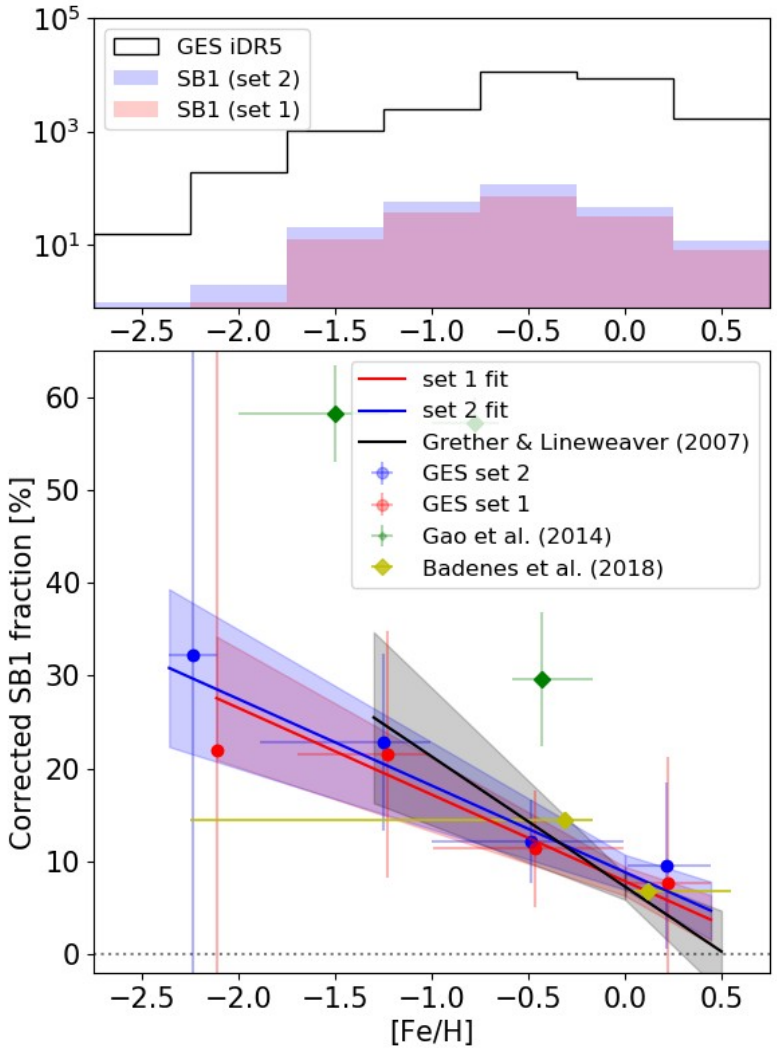
What is the SB1 distribution and fraction with T_{eff}?



What is the SB1 distribution and fraction with [Fe/H]?



- 25000 stars with Teff and [Fe/H]
- 166 SB1 candidates in set 1
- 256 SB1 candidates in set 2

Anticorrelation with metallicity at the 2σ level:

- Slope: –9 ± 3% dex^{-1}
- Y-intercept: 8-10 ± 2%

Comparison with literature:

- Grether & Lineweaver (2007)
- Gao et al. (2014)
- Badenes et al. (2018)

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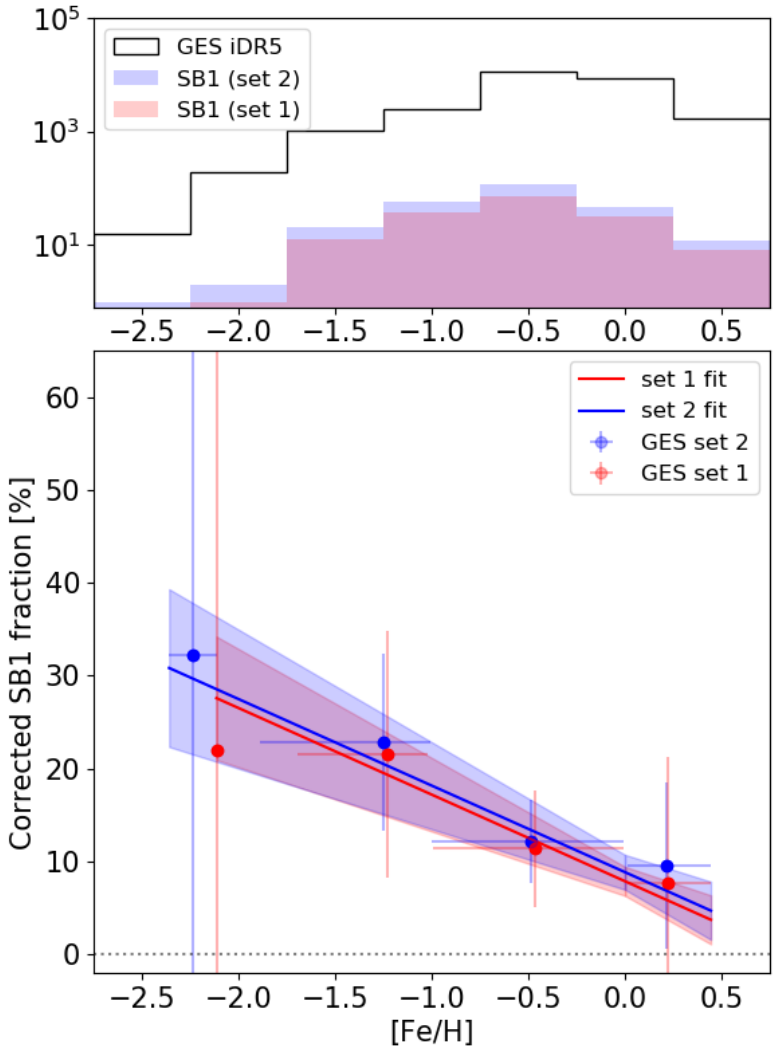
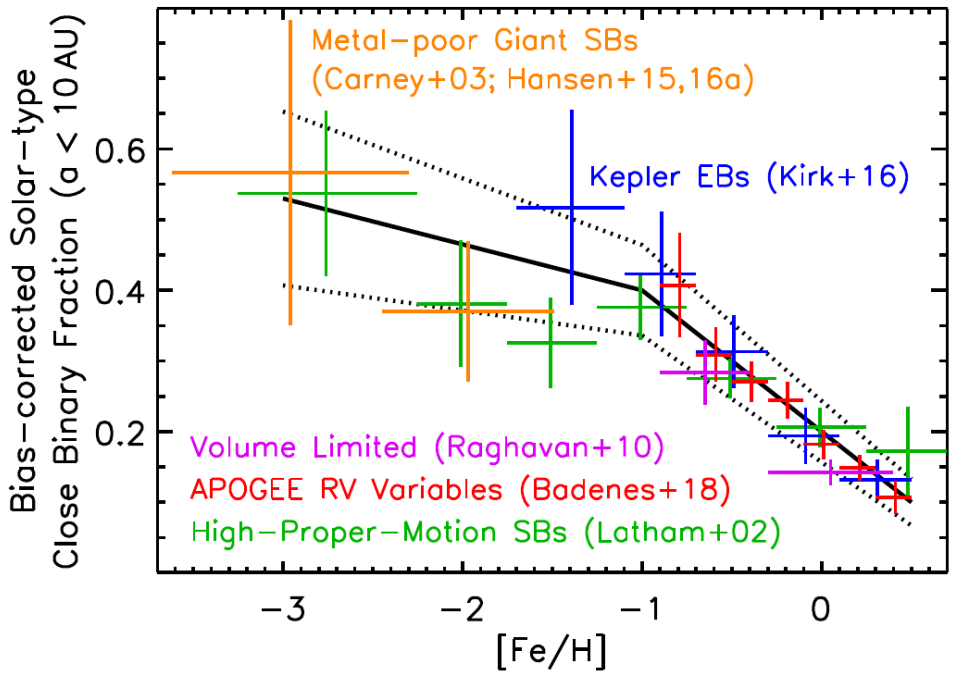


Merle et al. (submitted)

Moe et al. (2019)



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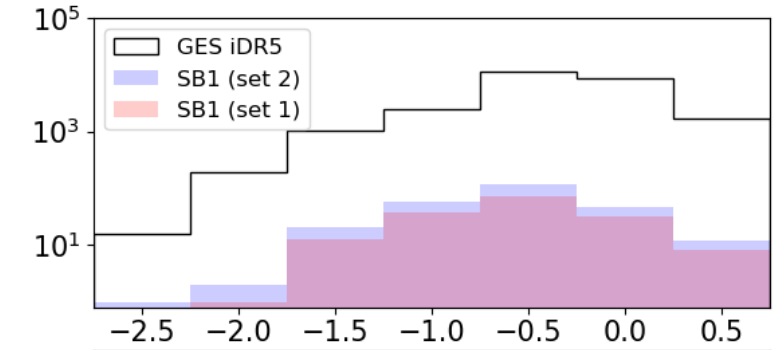

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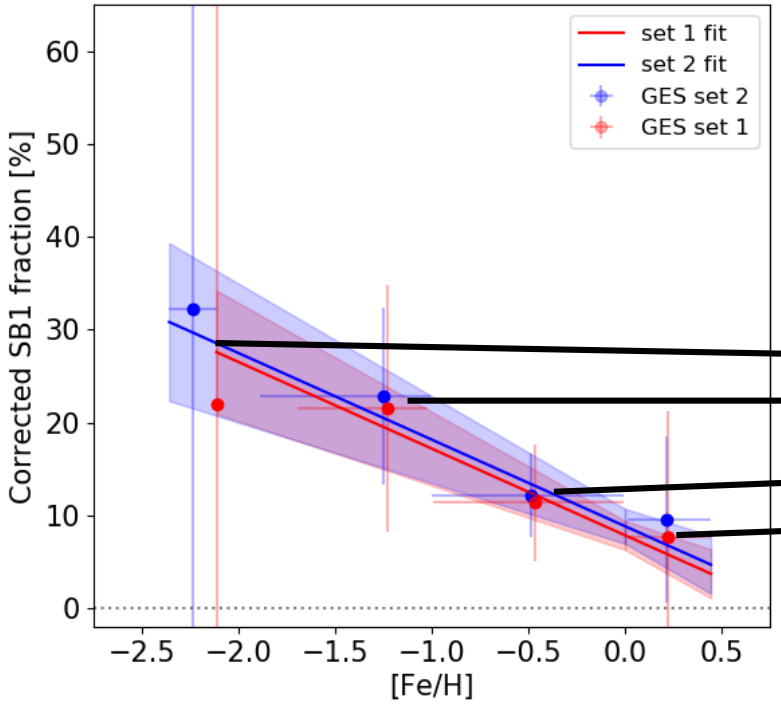

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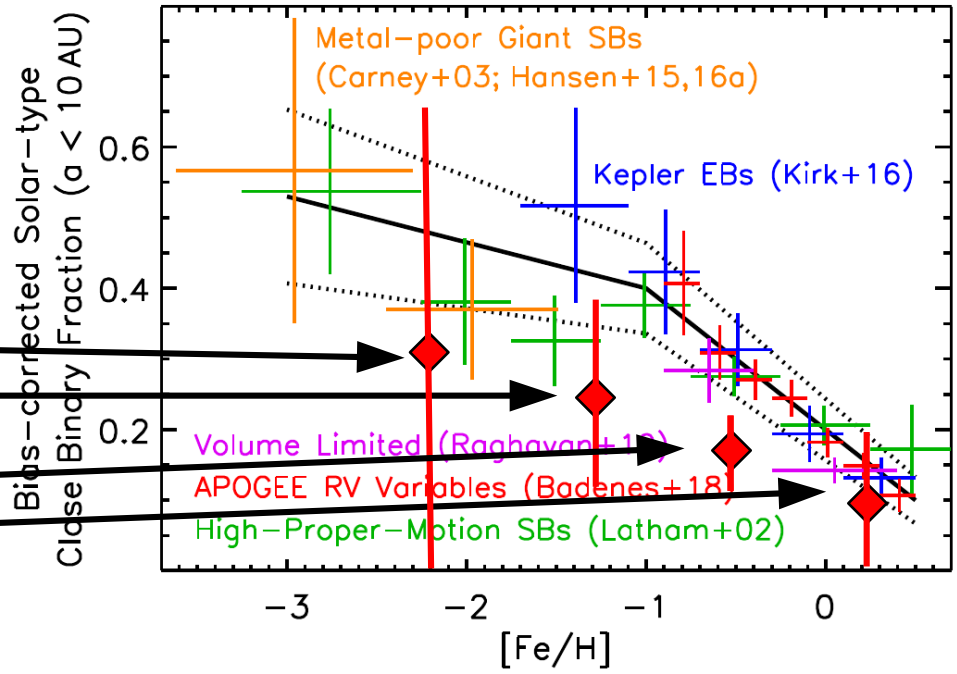
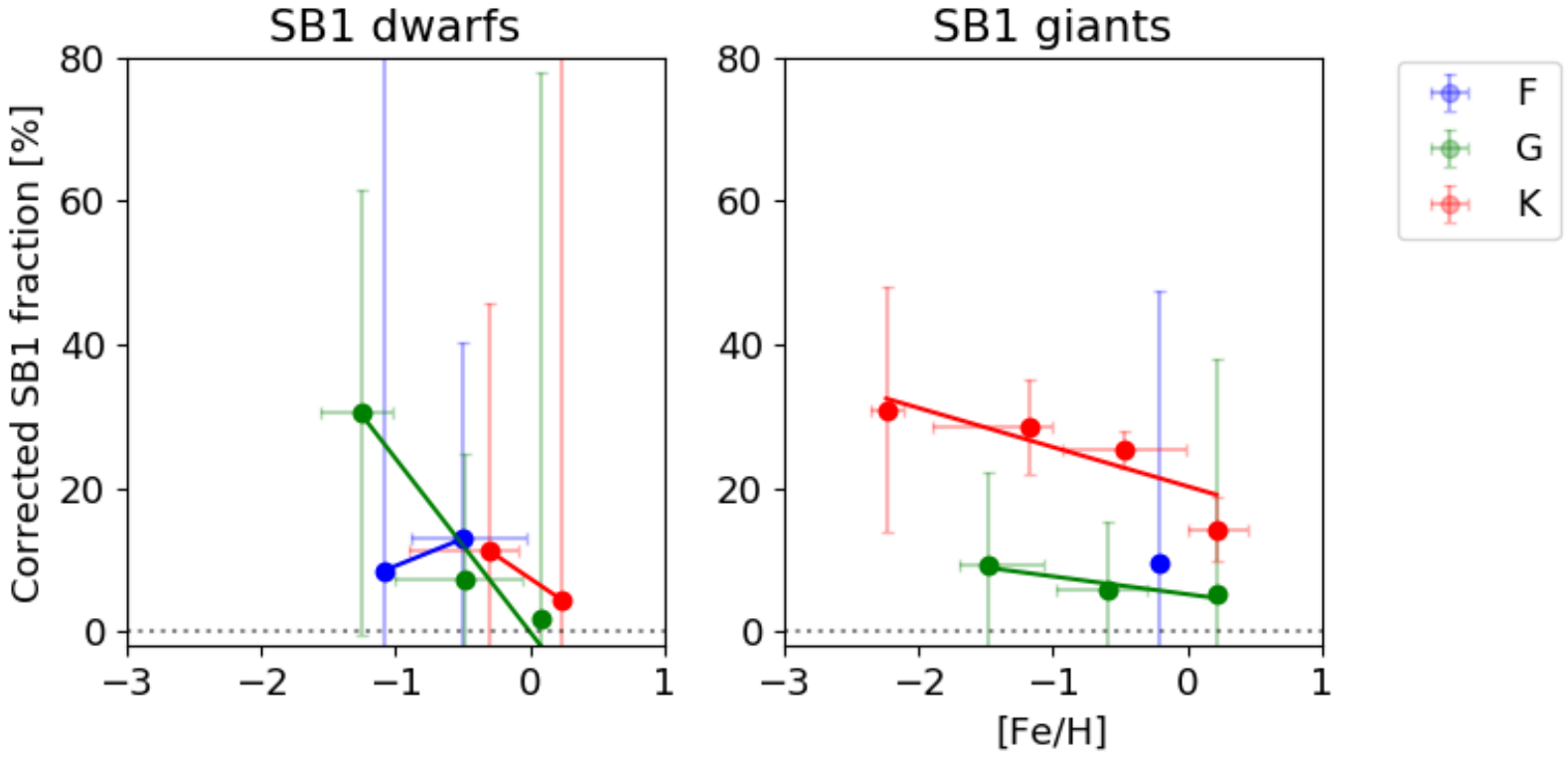


And finally, the SB1 fraction with [Fe/H] per spectral type and evolutionary stage?



Summary

Detection & characterization study of the FGK GES SB1 sample submitted to A&A

- Detection of **640 SB1** candidates at **5σ** that increases to **800 at 3σ** confidence level among **43400 stars** with S/N ≥ 3, at least 2 exposures and d*v*/d*t* ≥ 62.5 (km s $^{-1}$)/h
- **Global GES SB1 fraction** before and after removal of **photometric variables** and correction of **detection efficiency**:
  3% ➞ 2% ➞ **10%**
- GES SB1 fraction **increases with effective temperature** on MS, unclear for RGB
- GES SB1 fraction **increases with decreasing metallicity** at a rate of **–9 ± 3% dex^{-1}** for **-2.5 < [Fe/H] < +0.5**
- This increase seems **independent** of the **spectral type** and the **evolutionary stage** within the errorbars