

CHARACTERIZING STELLAR FLARES IN THE ARIEL TARGETS: ACTIVITY ANALYSIS AND TRANSIT PROBABILITIES

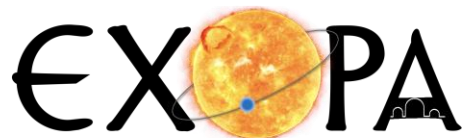
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OUTLINE



Introduction to flare and light curve analysis



Methods

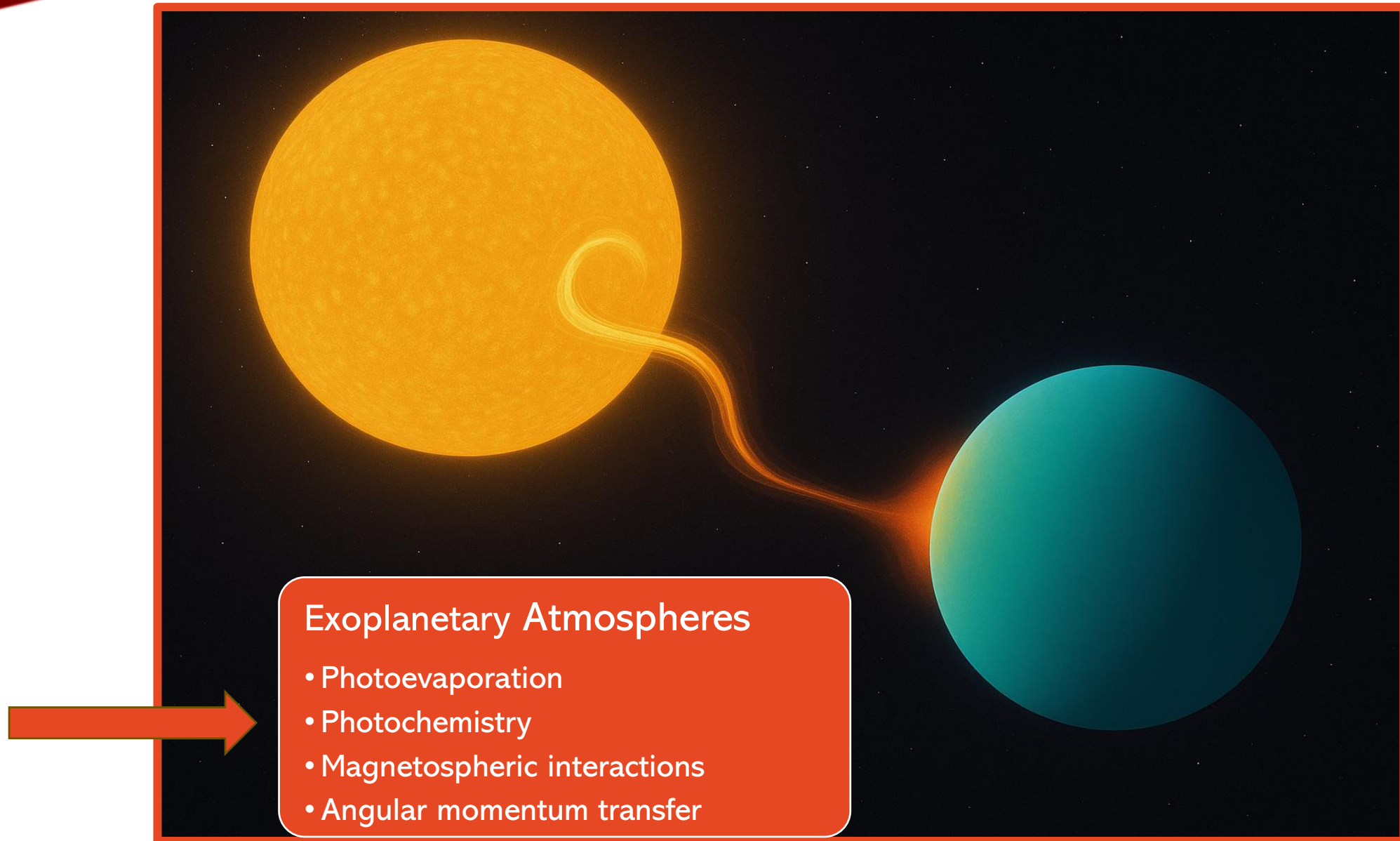
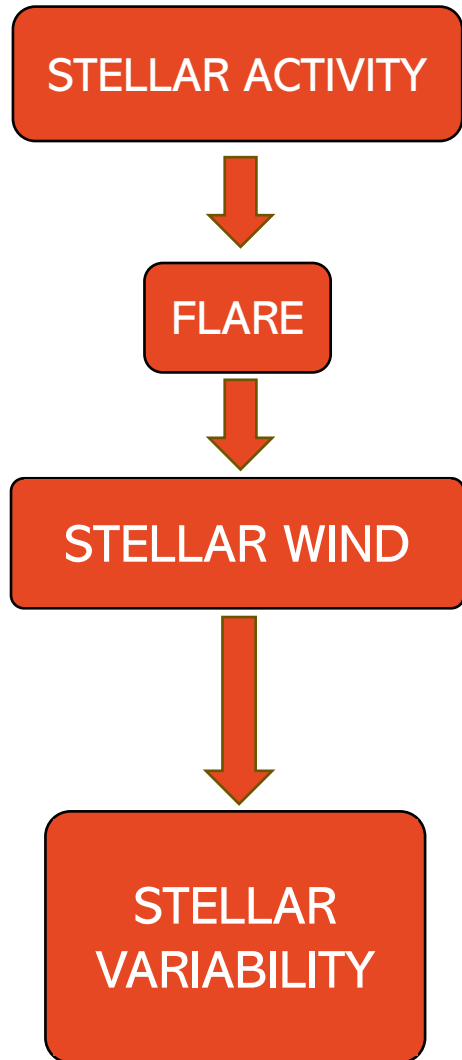


Results

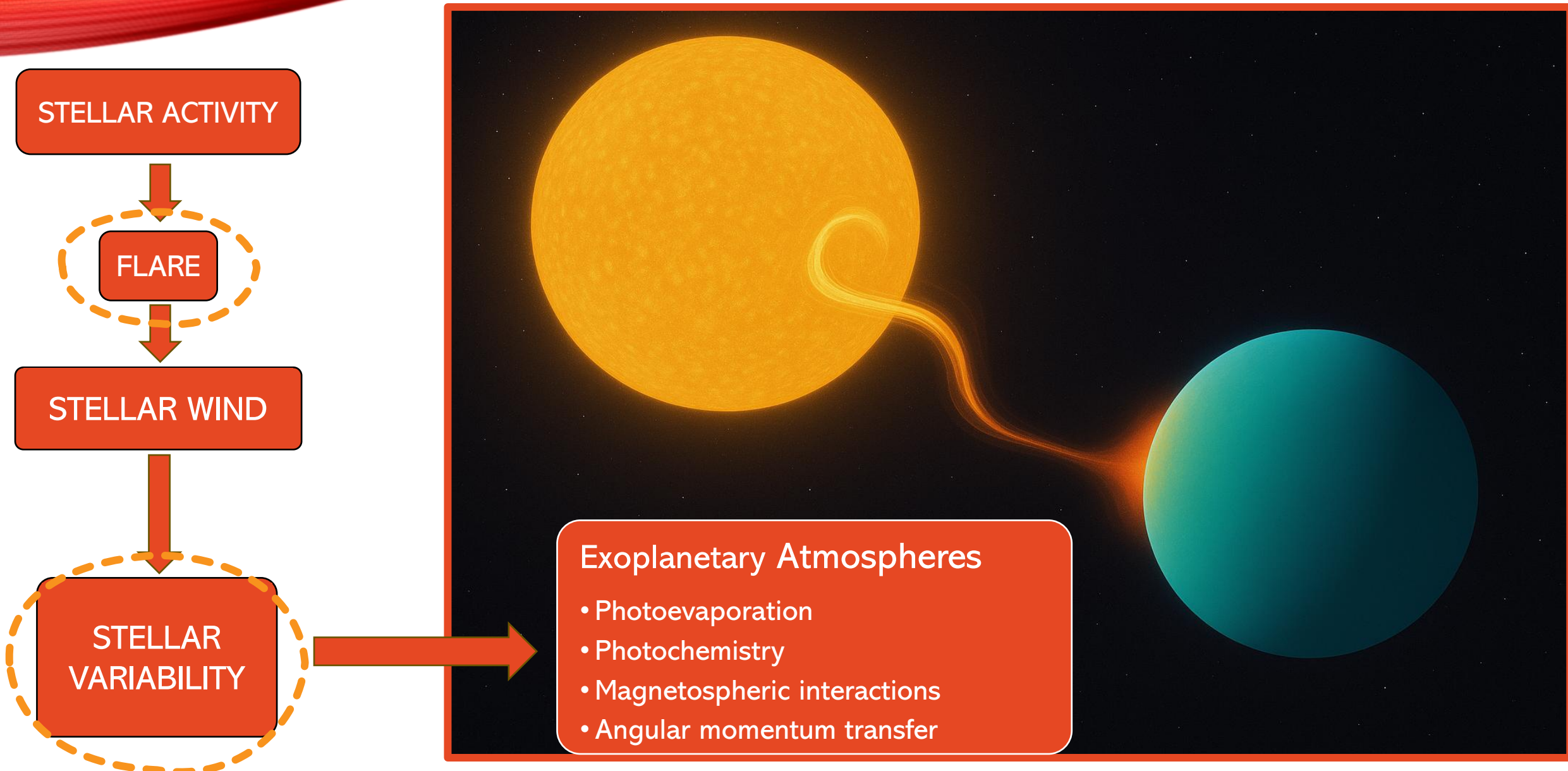


Conclusion and future works

INTRODUCTION



INTRODUCTION



INTRODUCTION - FLARE



Flares are sudden, violent bursts of energy that occur on stars.



Caused by magnetic reconnections, when the star's magnetic field and coronal plasma interact.



Observable in a variety of wavelengths, from X-rays to optical radiation and radio.

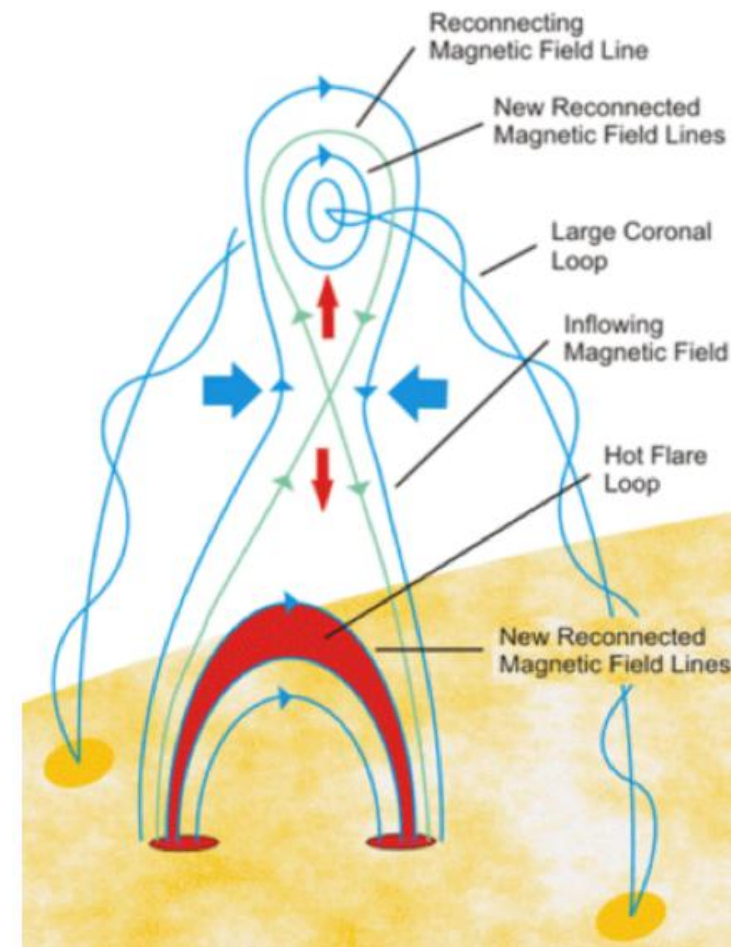


Diagram of a stellar flare

INTRODUCTION - FLARE



Optical Band

Source: Stellar photosphere.

Mechanism: Brightness increase due to magnetic reconnection and electron acceleration.



X-Ray Band

Source: Stellar corona (hottest outer layer).

Mechanism: Plasma heated to millions of degrees by magnetic reconnection.



Radio Band

Source: Non-thermal emissions (e.g., synchrotron radiation).

Mechanism: Particle acceleration in shocks and plasma waves.

INTRODUCTION - WHY FLARES?

1. Magnetic Dynamo:

- Underlying stellar dynamo mechanisms responsible for generating and sustaining magnetic fields.

2. Impacts on Planetary Atmospheres:

- Flares emit high-energy particles and radiation, affecting the chemical composition and stability of nearby planetary atmospheres.
- Intense radiation can strip away atmospheres over time.
- UV radiation from flares can alter atmospheric chemistry.

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OBJECTIVES

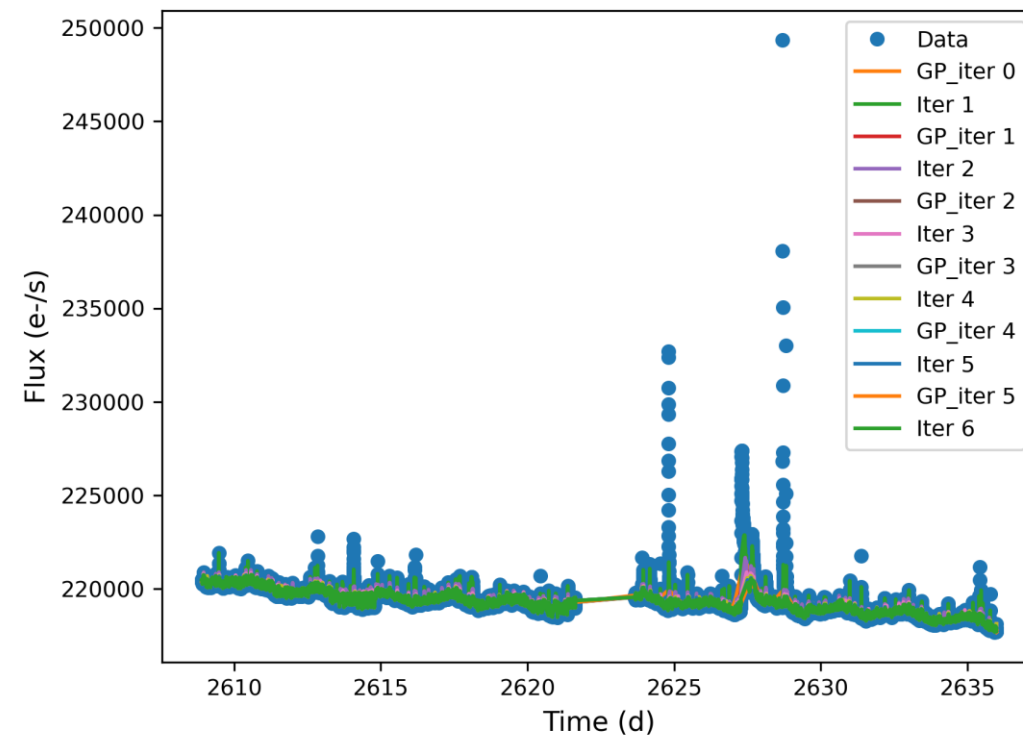
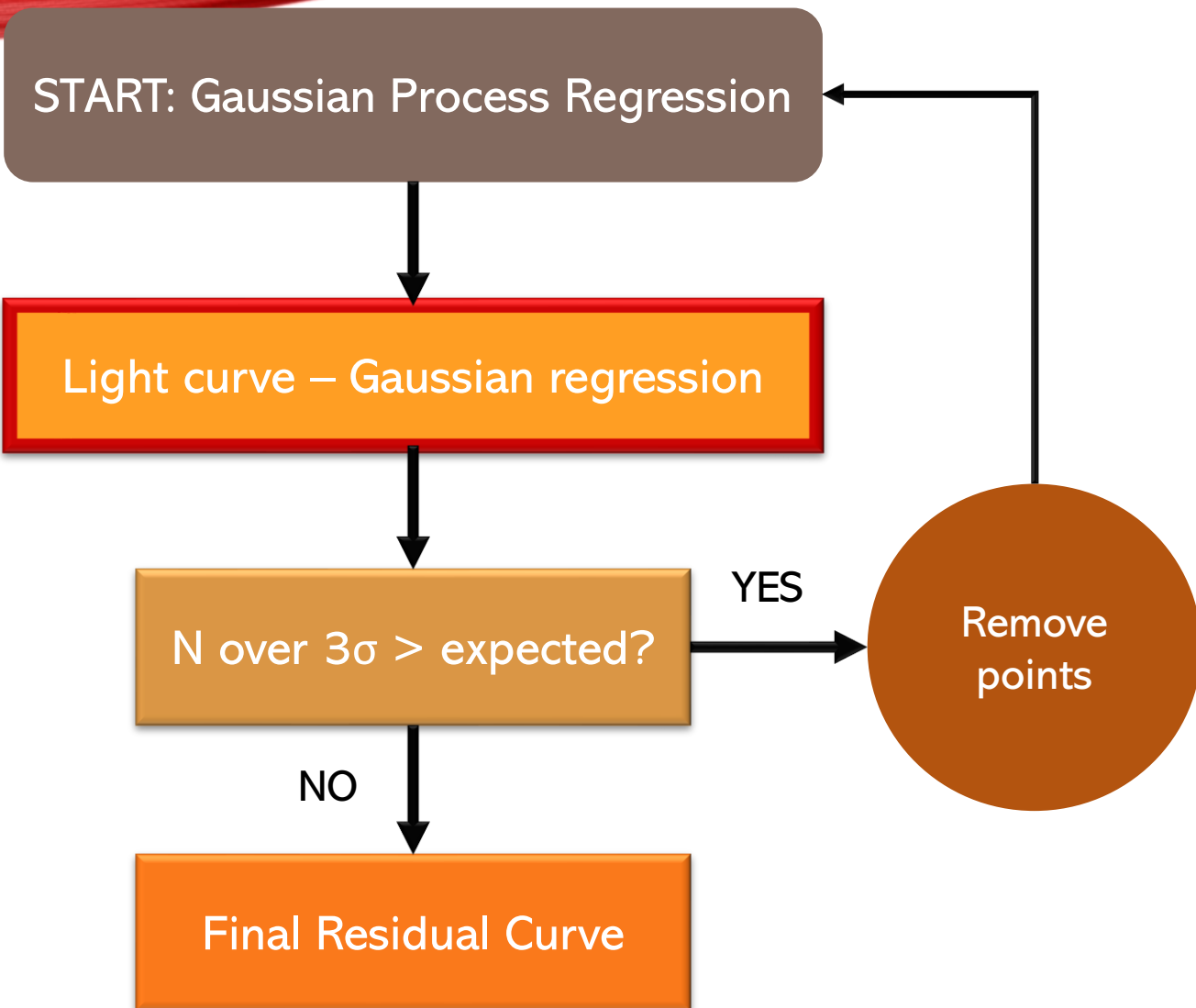


Identifying impulsive events in TESS light curves building on the methodology developed by Colombo et al. (2022) and Galletta et al. (2025).

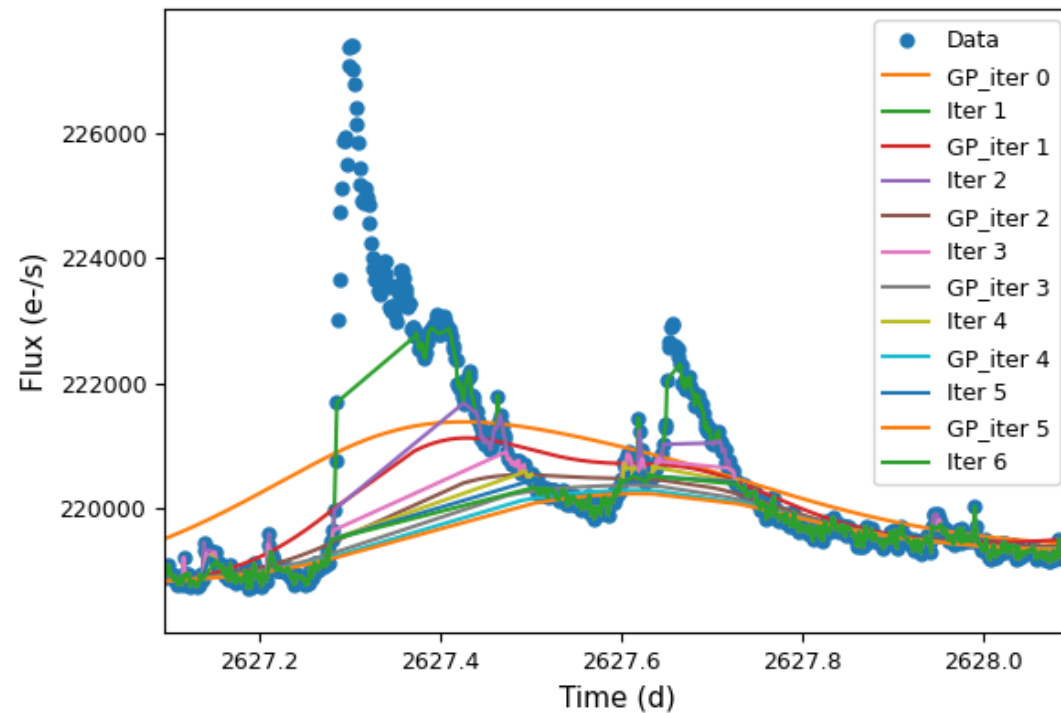
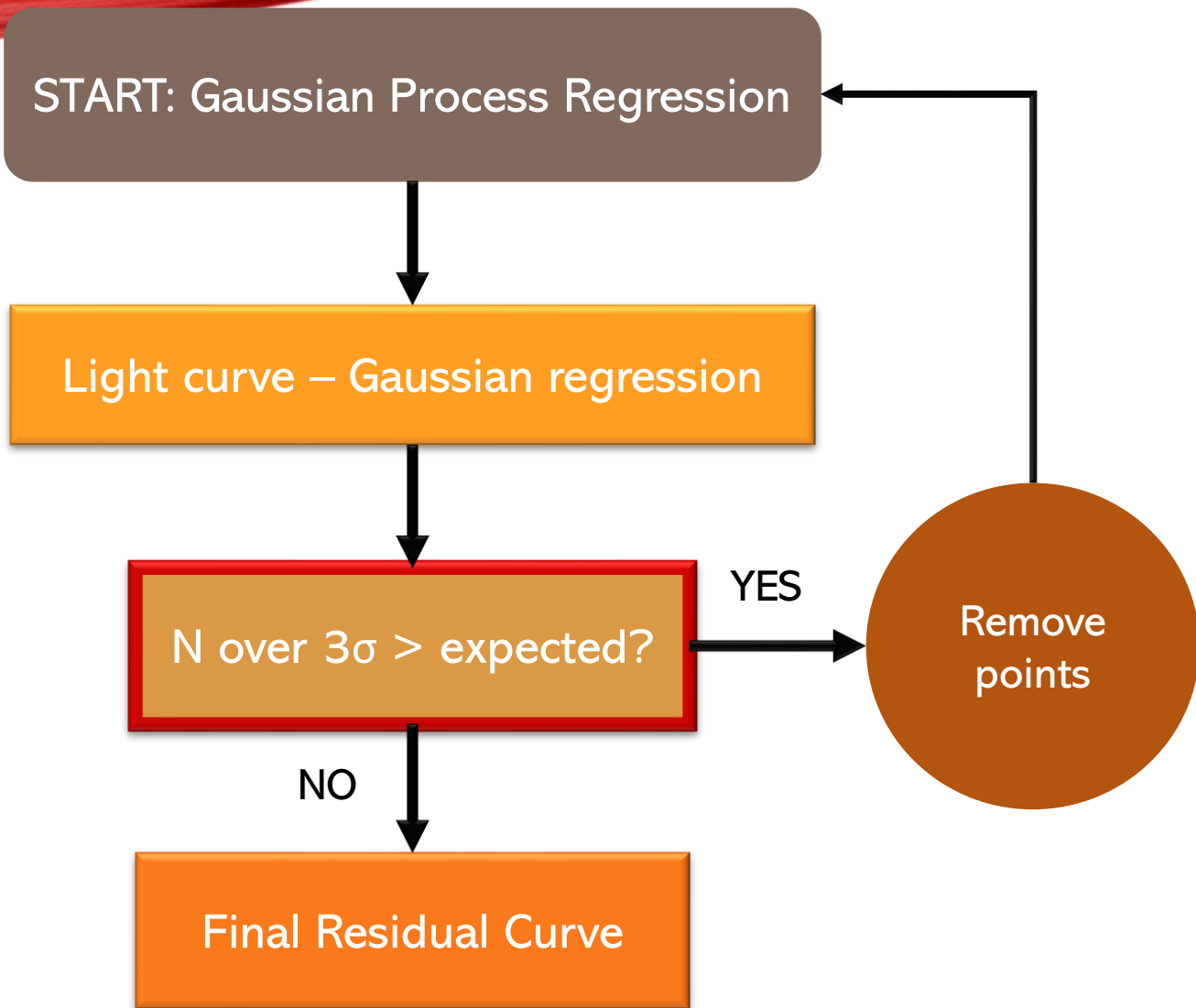


Determine flare frequency and energy distribution for different stars

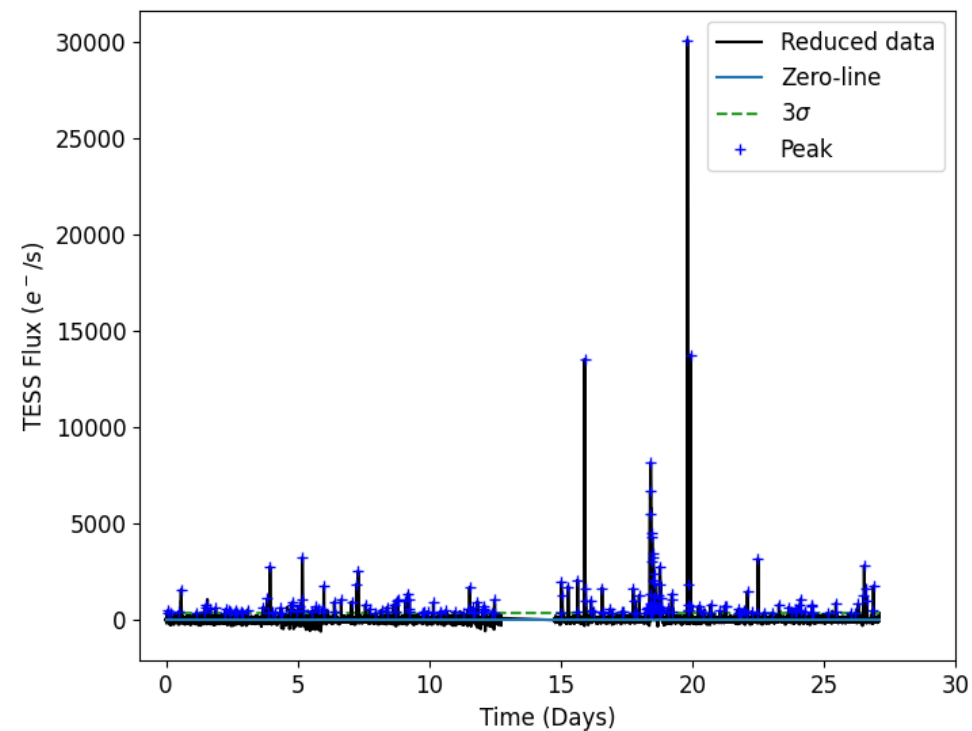
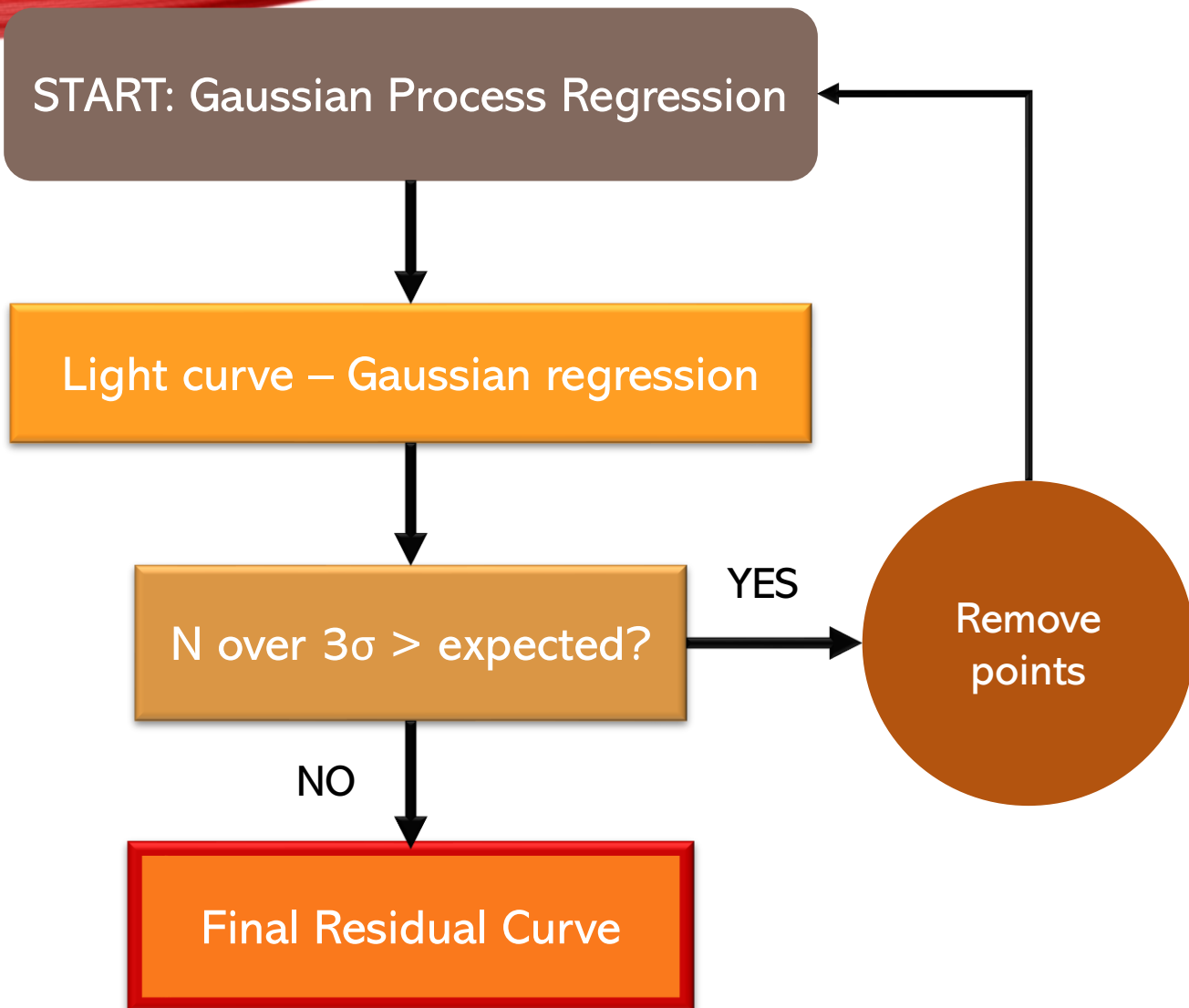
METHODS



METHODS



METHODS



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$$F(t) = H(t_0 - t) \cdot A e^{\frac{t-t_0}{t_r}} + H(t - t_0) \cdot A e^{\frac{t_0-t}{t_d}}$$

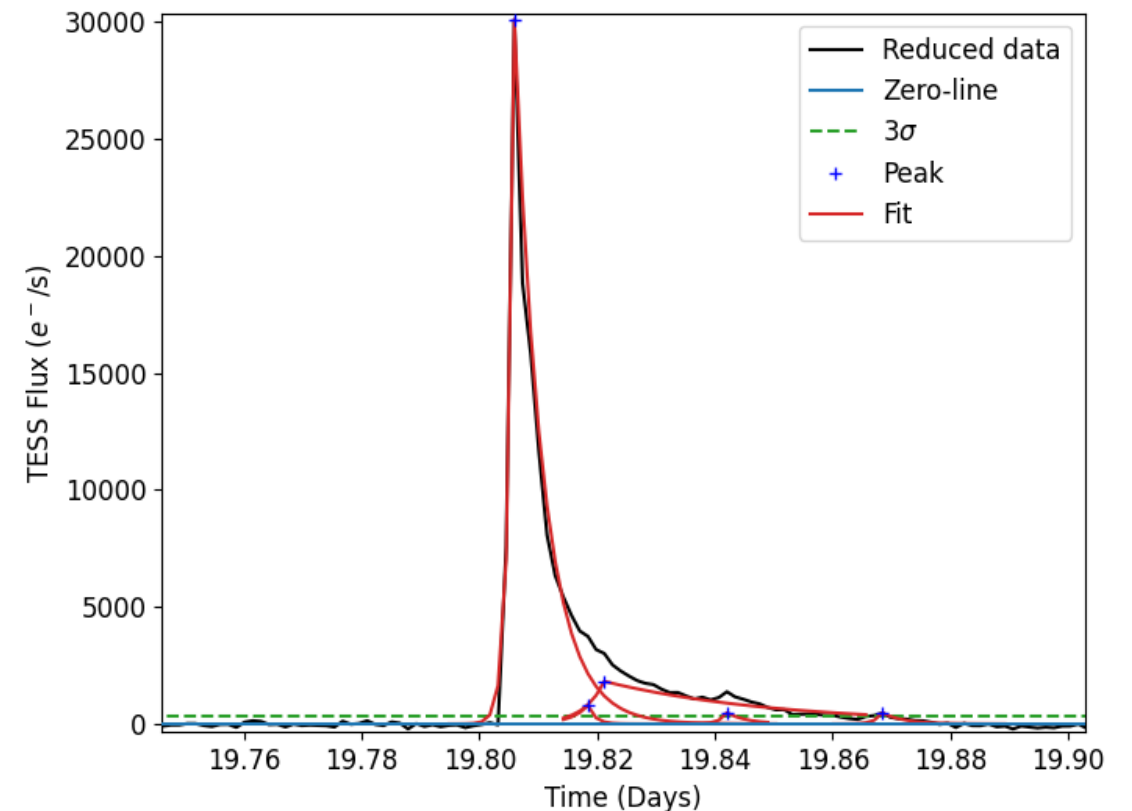
- $H(t_0 - t)$: The Heaviside function used to transition from the rising part to the decaying part of the function.
- A : The peak of the event.
- t_r : The rise time.
- t_d : The decay time.

Energy Estimation for Each Event:

$$E = (A \cdot t_r + A \cdot t_d) \frac{L_{bol}}{L_{TESS}}$$

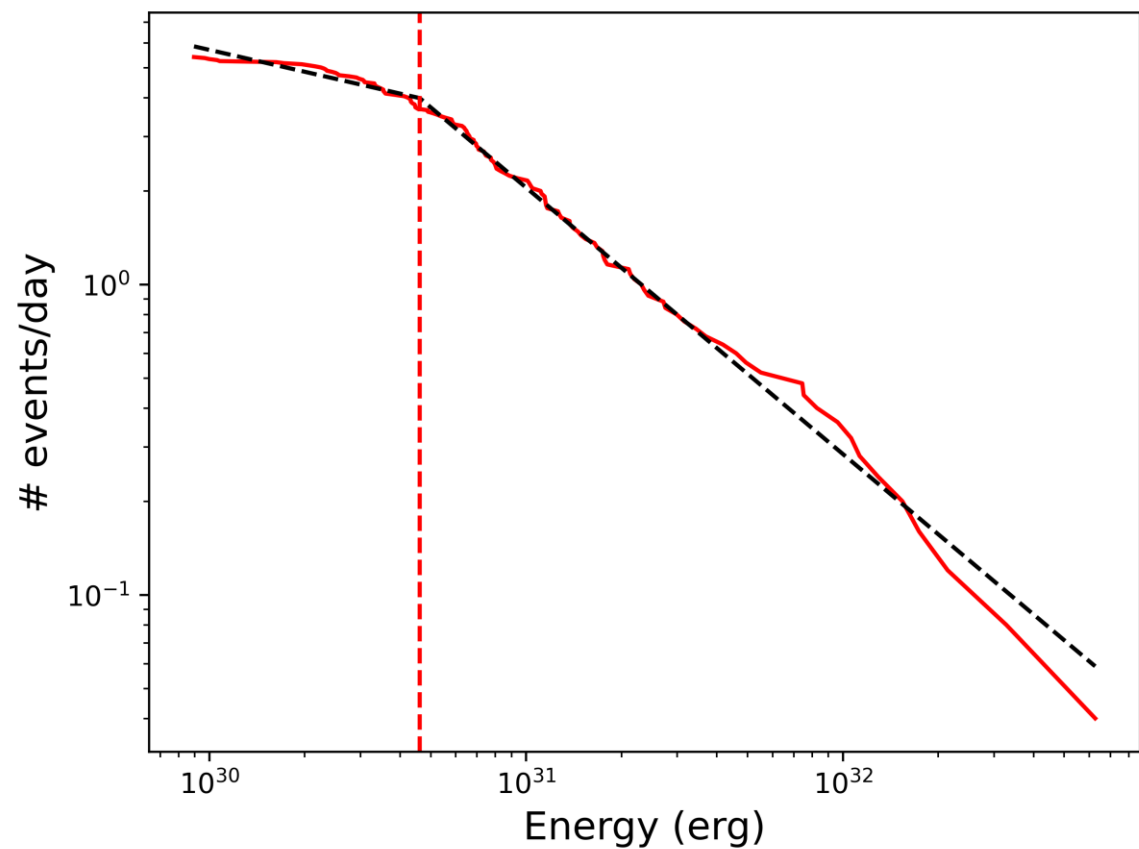
L_{bol} is the bolometric luminosity for each star.

- Amplitude
- Position in time
- t_r and t_d
- Energy

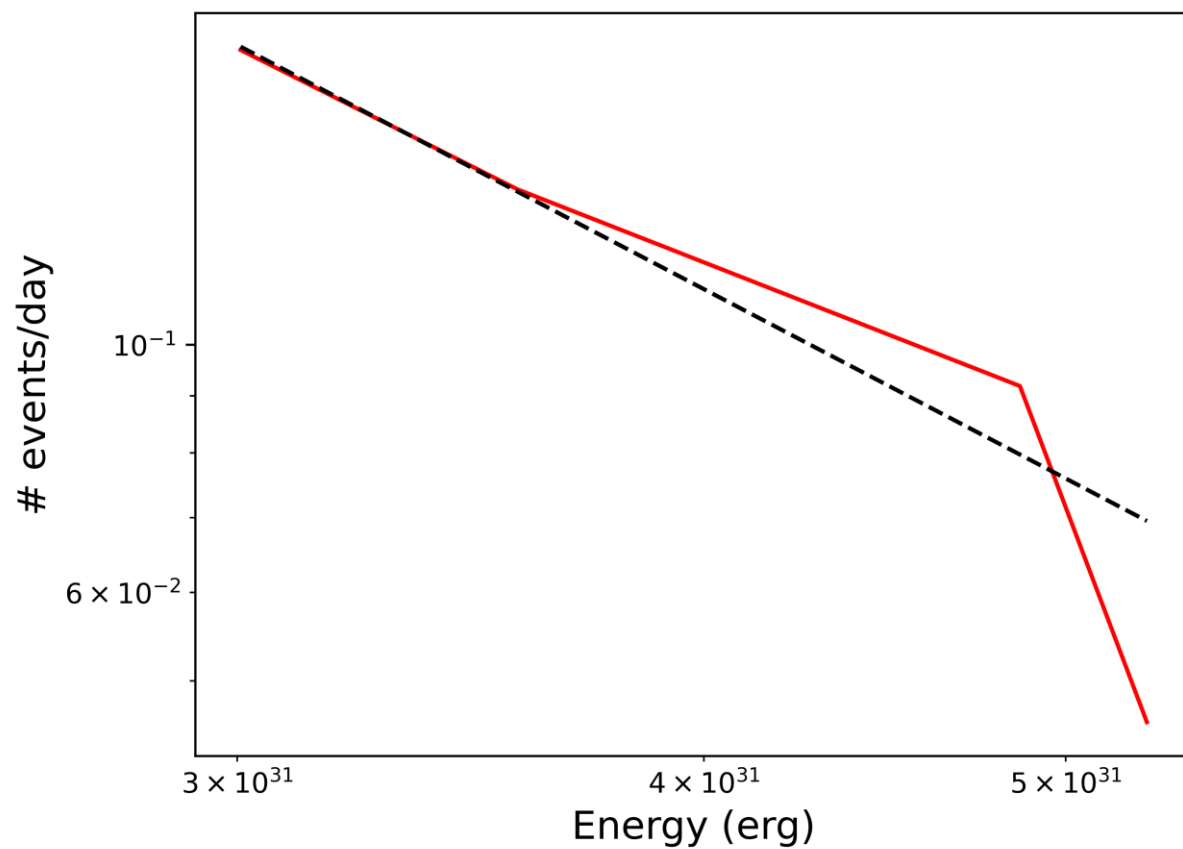


METHODS – SLOPE AND ENERGY BREAK CALCULATIONS

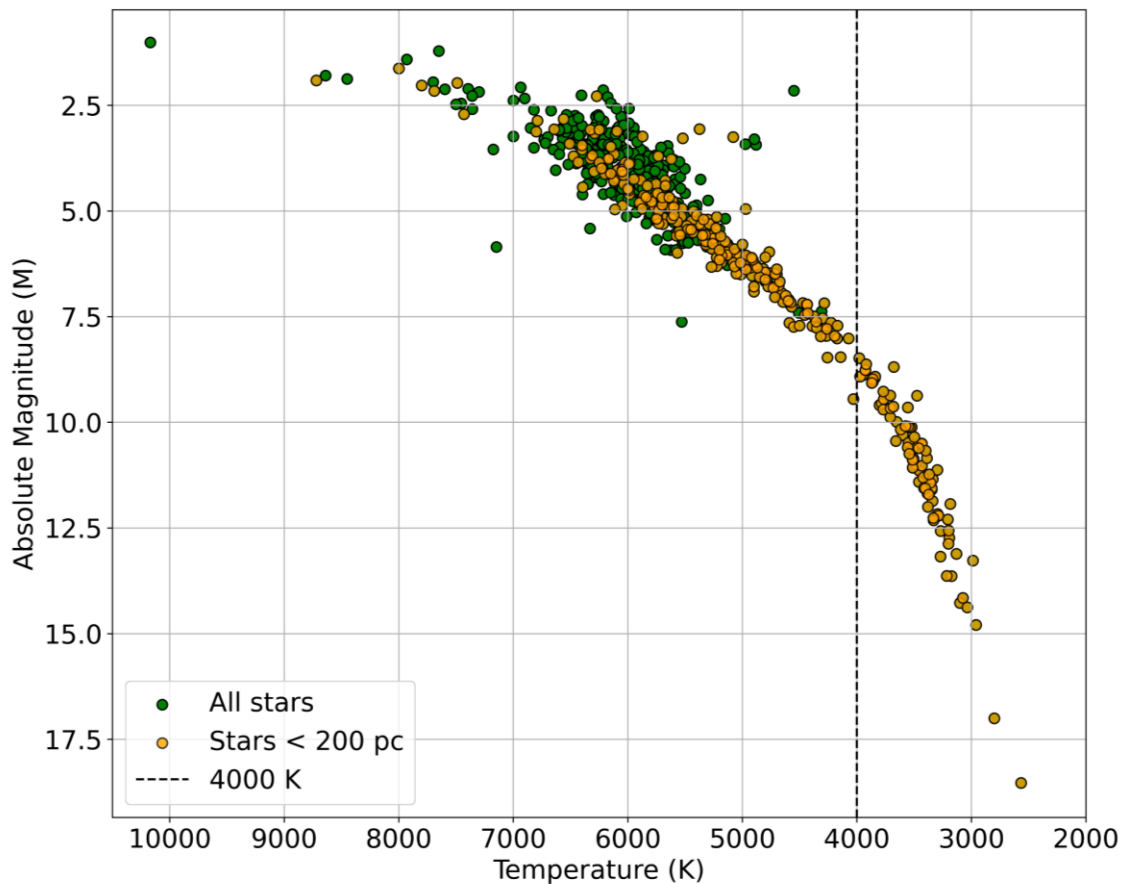
Two-Segment fit



One-Segment fit

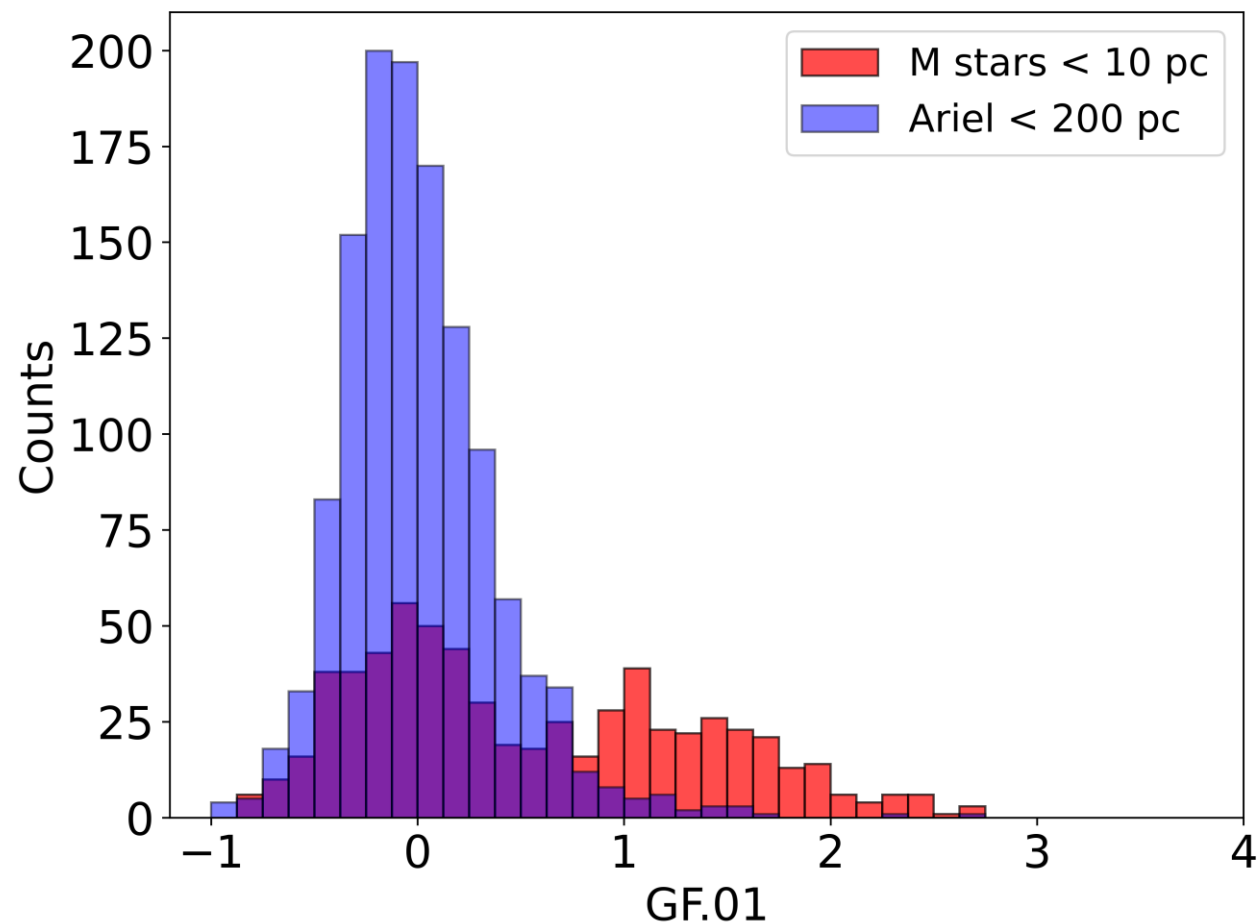


RESULTS – ARIEL SAMPLE



- We analyzed 290 stars within 200 parsecs in Ariel catalog
- A total of 1638 TESS sectors
- The mean slope is -1.87 ± 1.55

RESULTS – GF.01



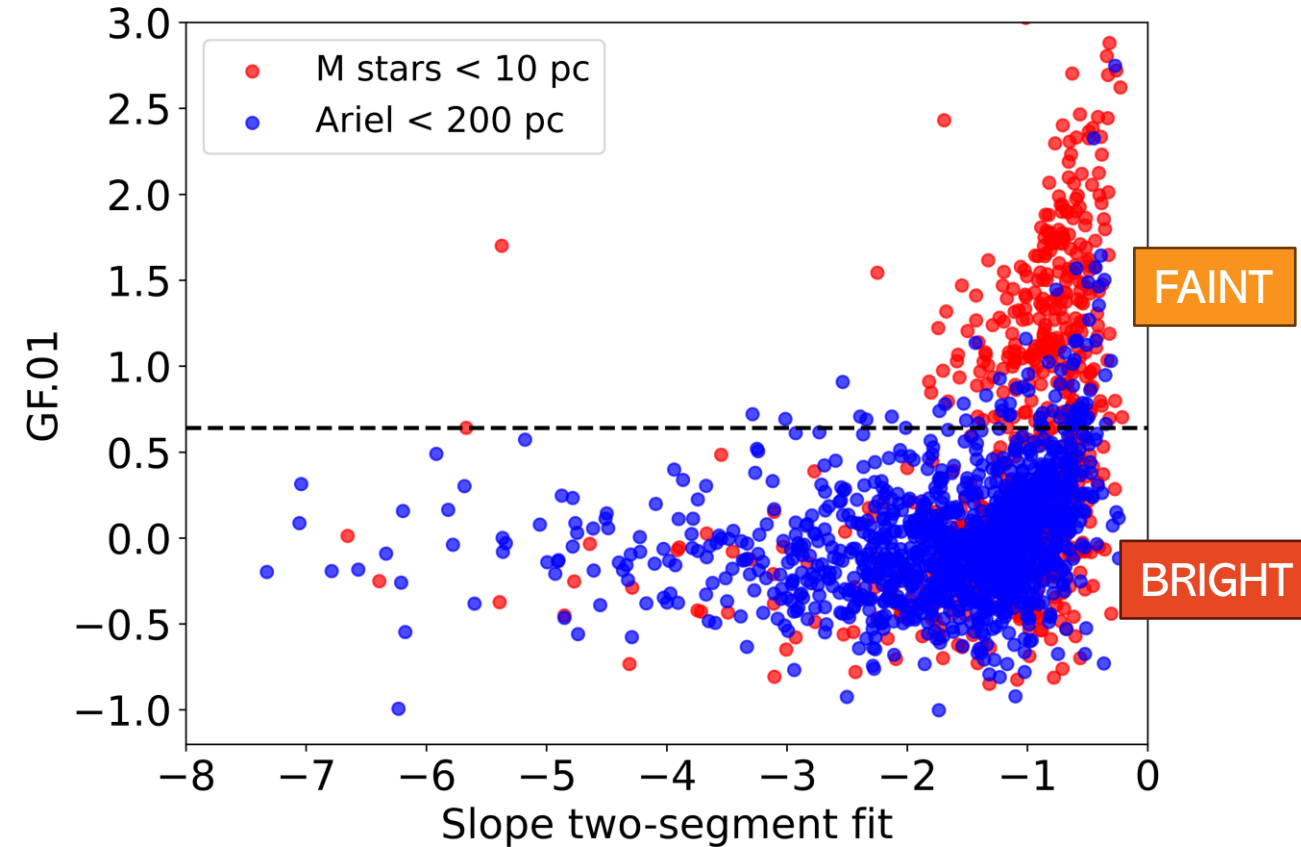
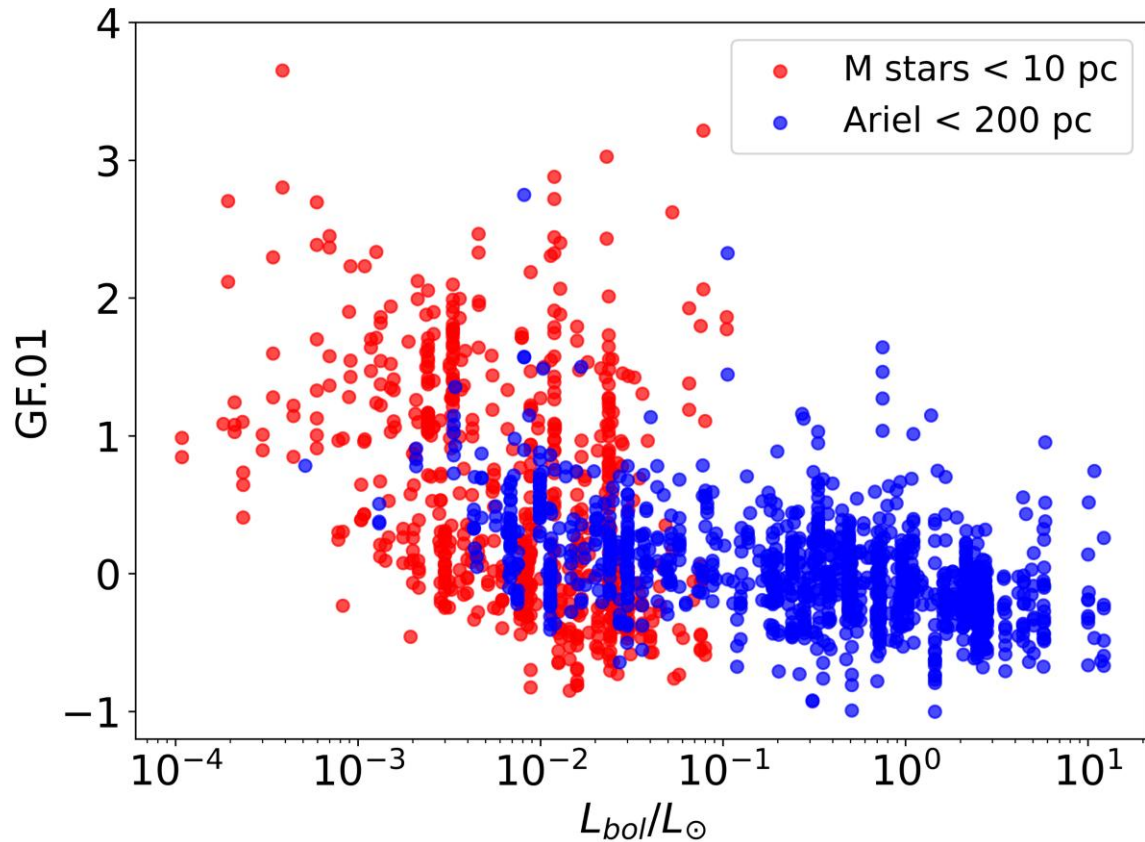
To quantify the activity we introduce GF.01:

$$GF.01 = \frac{0.1 - q}{m} / L_{bol}$$

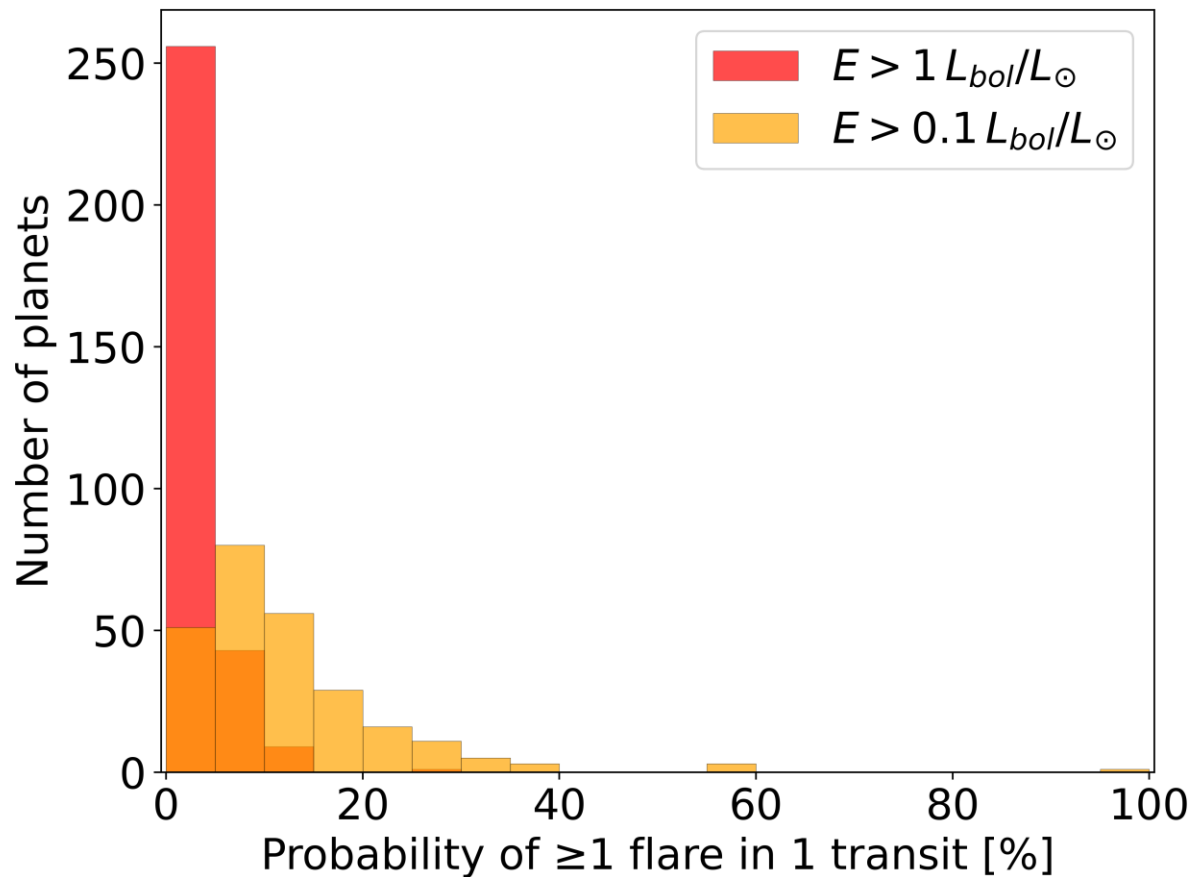
97% of the sample moderate flare activity
($GF.01 \leq 1$)

RESULTS – GF.01

Flatter Slope > -1 \rightarrow Faint star \rightarrow High-energy flare dominated
Steeper Slope ≤ -1 \rightarrow Bright star \rightarrow Low-energy flare dominated



RESULTS – CONTAMINATION PROBABILITY



Using the Poisson formalism:

$$\lambda = rate \times t_{window}$$

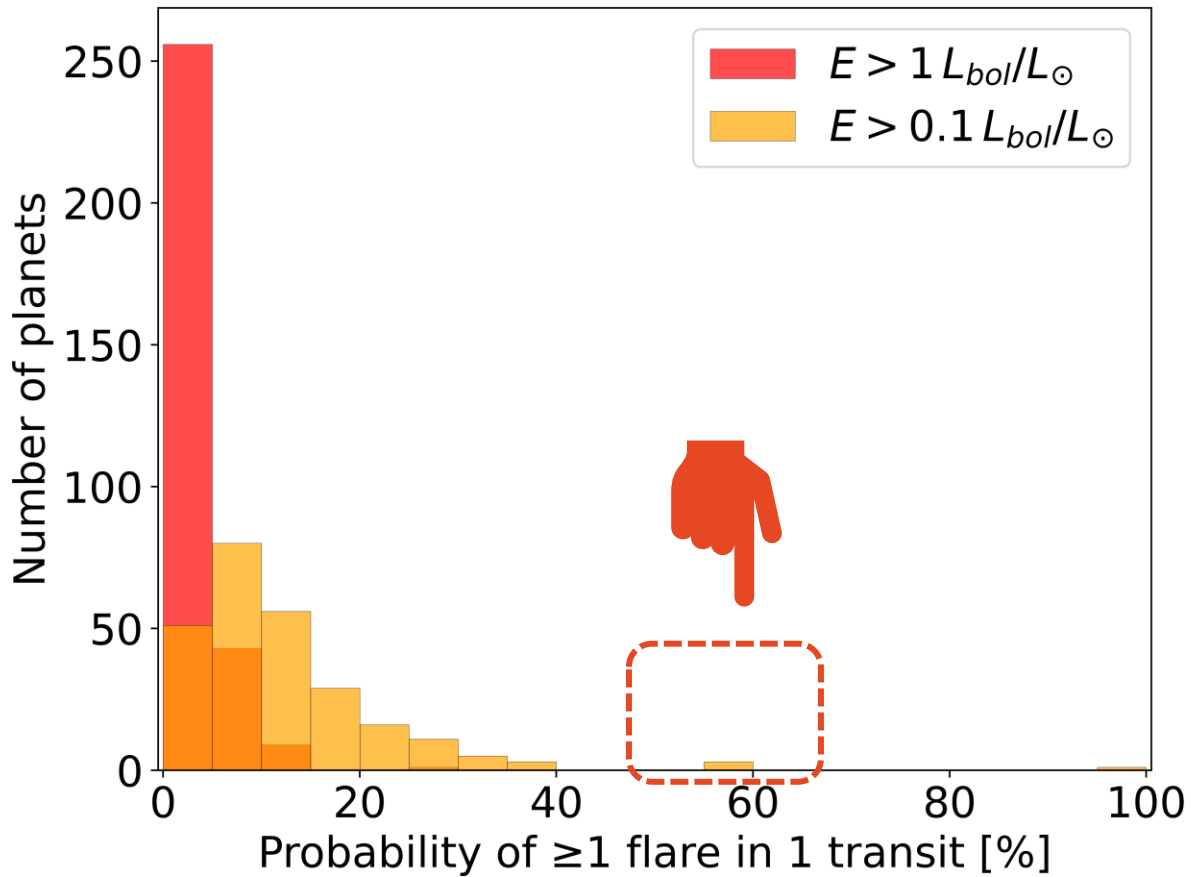
Where:

$$t_{window} = 2 \times transit\ duration$$

Probability of observing at least one flare during a single transit visit:

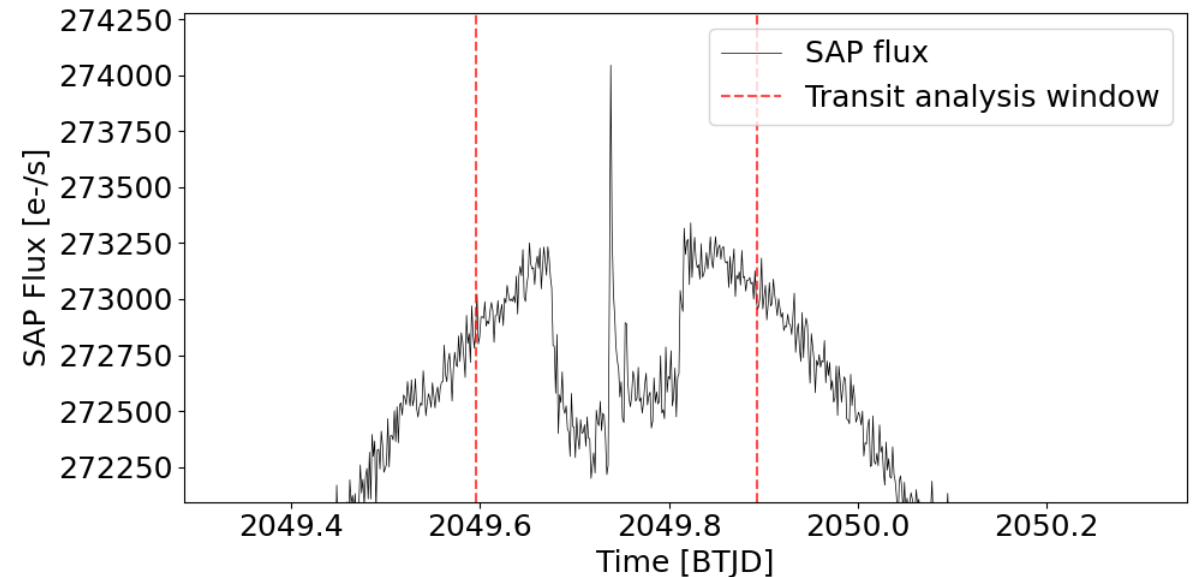
$$P_{flare} = (1 - e^{-\lambda}) \times 100$$

RESULTS – CONTAMINATION PROBABILITY

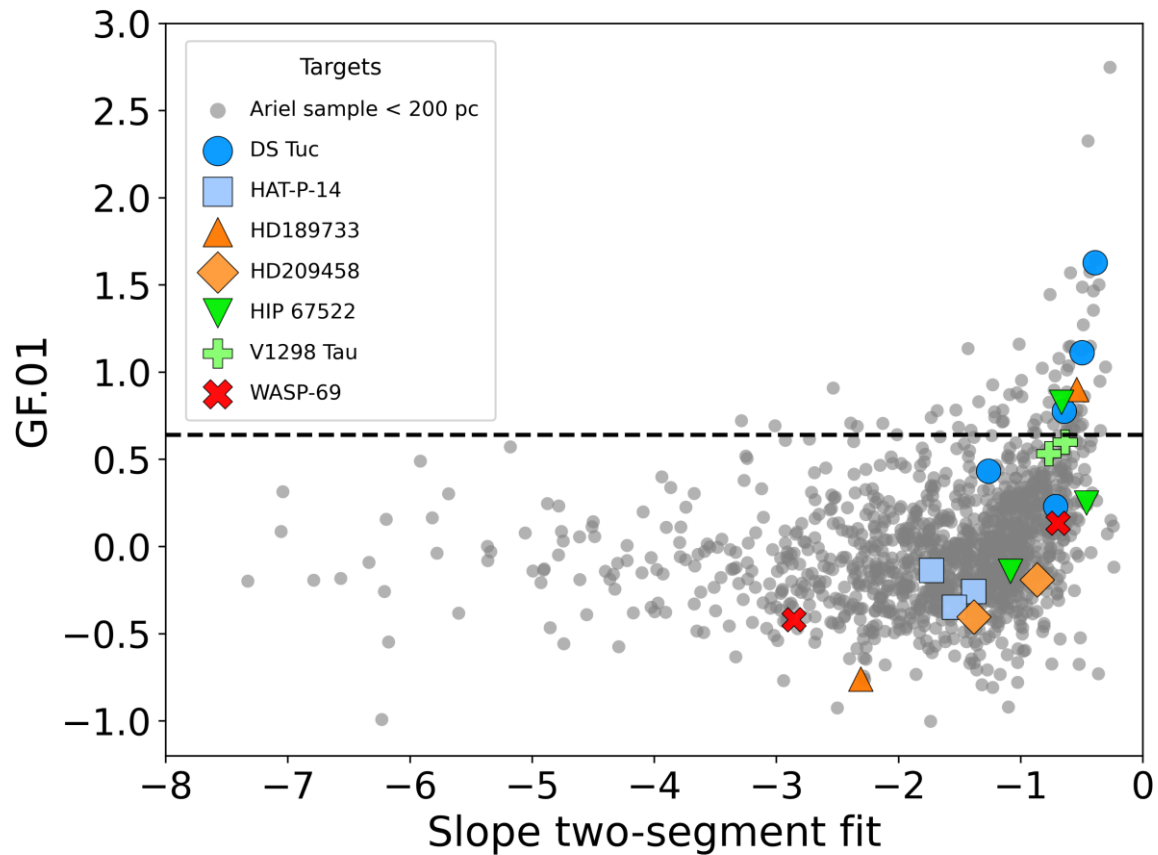


Most active stars with most probability:

- AU Mic b \rightarrow 57%
- HD28109 c \rightarrow 57.4%
- HD28109 d \rightarrow 59.1%



RESULTS – ARIEL DRY RUN'S TARGET



Planet	Prob 100% L_{bol} (%)	Prob 10% L_{bol} (%)
DS Tuc b	9.3	25.2
HAT-P-14 b	0.7	4.8
HD 189733 b	4.5	12.2
HD 209458 b	1.5	12.4
HIP 67522 b	12.9	31.7
HIP 67522 c	14.9	35.9
V1298 Tau b	12.7	30.3
V1298 Tau c	9.4	23.1
V1298 Tau d	11.2	26.9
WASP-69 b	2.1	6.7

CONCLUSIONS



97% of the sample moderate flare activity
($GF.01 \leq 1$)



AU Mic and HD 28109, shows a high probability of flare contamination



DS Tuc, HIP 67522, and V1298 Tau are the most active stars in the Dry run's sample



Ariel Dry run's sample is a good representation of Ariel MCS



THANKS FOR THE ATTENTION!