# Exoplanets Around Flare Stars

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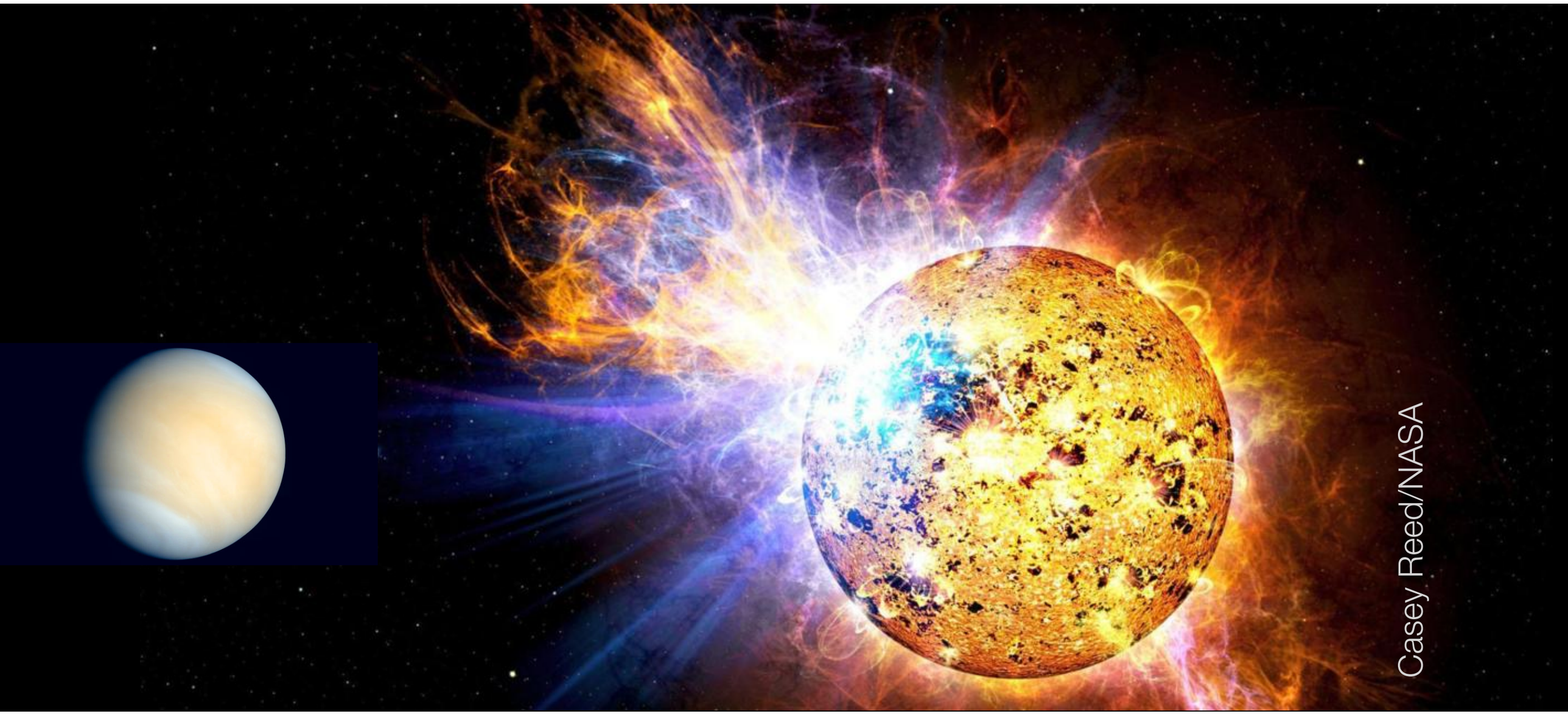
# Exoplanets Around Flare Stars

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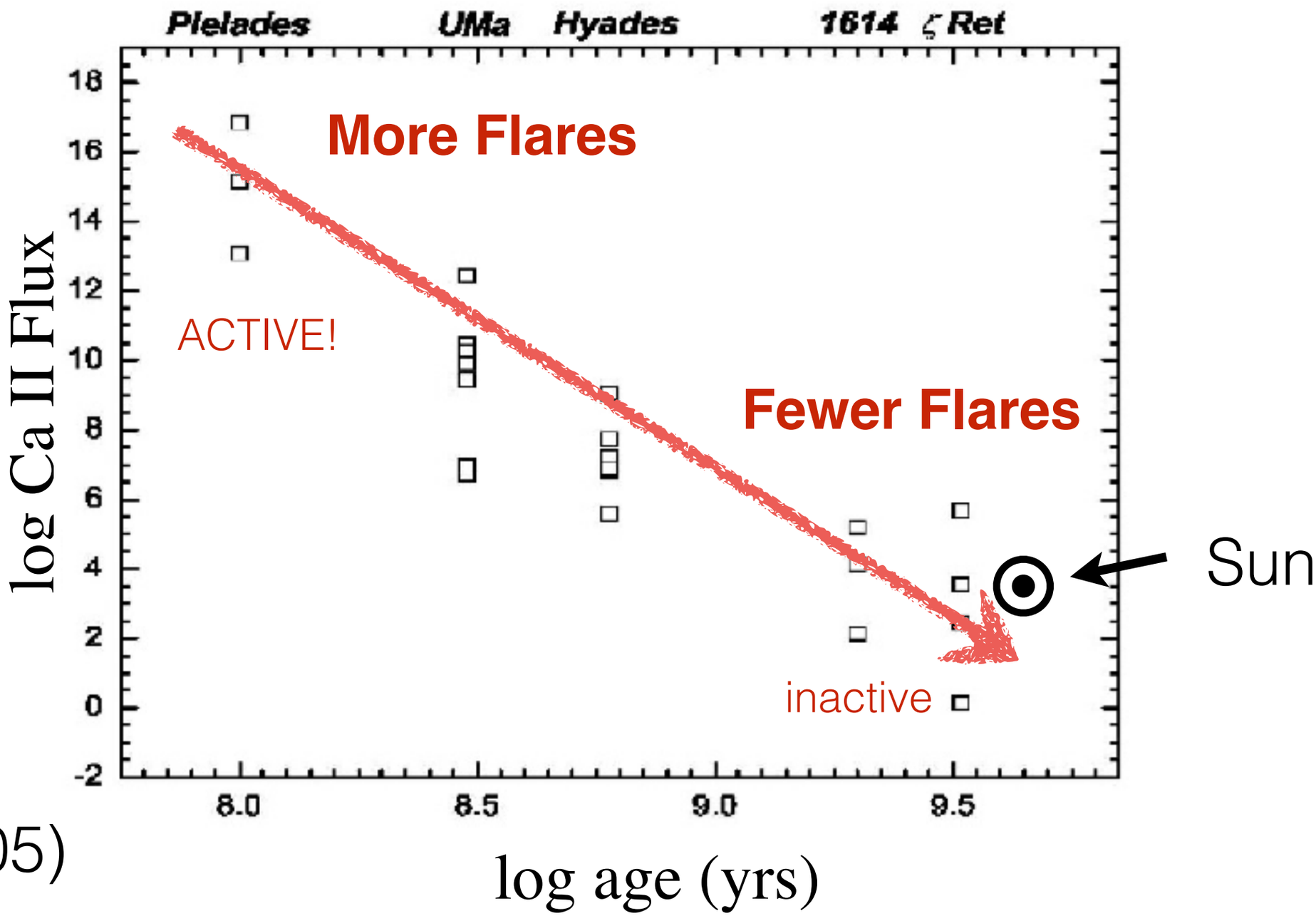
# Age vs. Activity




Lyra (2005)

See poster Adam Schneider:
The UV Evolution of Mid-Type M Dwarfs with GALEX

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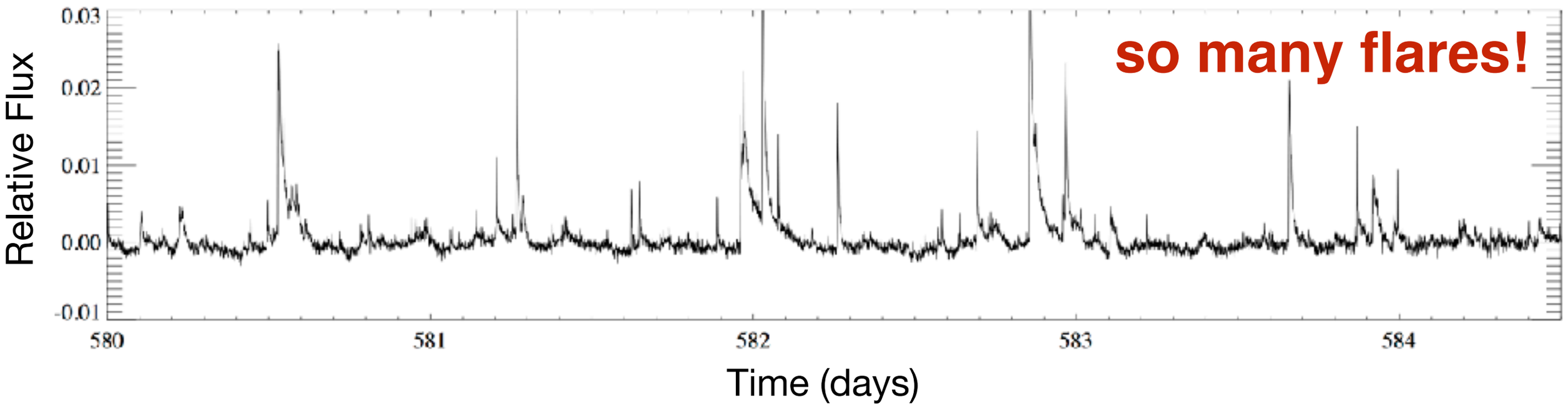
# some Kepler data




GJ 1243, M4

300 days of 1-min data

$P_{rot}$ = 0.59 days

**+6100 flares!**

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# find every flare in Kepler: **appaloosa**

http://github.com/jradavenport/appaloosa

*why “appaloosa”? Ask me later

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# find every flare in Kepler: **appaloosa**

## 3 steps to find flares in Kepler:

1. Detrend – iterative removal of “noise”
2. Detect – find “significant” peaks
3. Distrust – artificial flare injection and recovery

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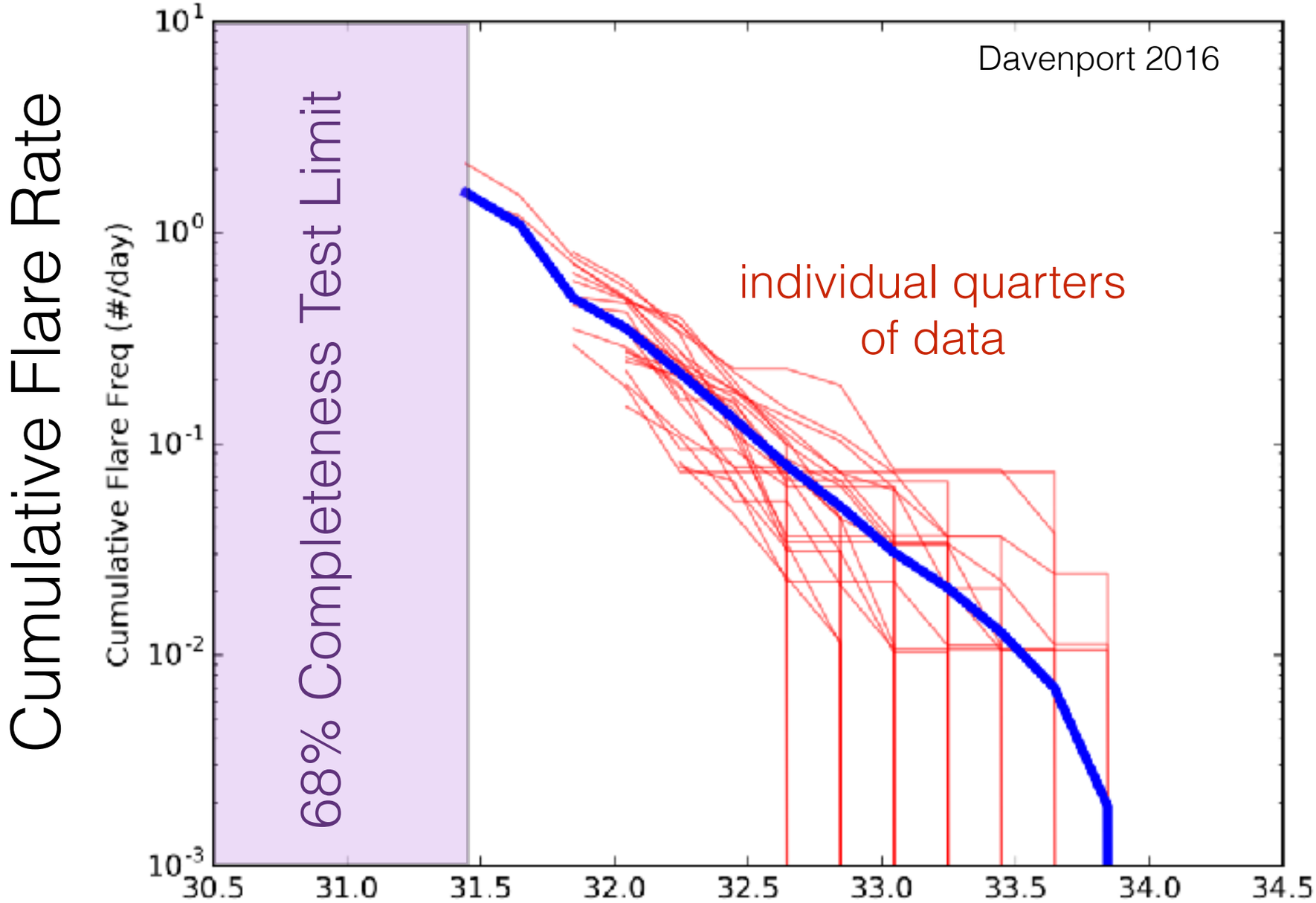
# Flare Frequency Distribution (for 1 star)

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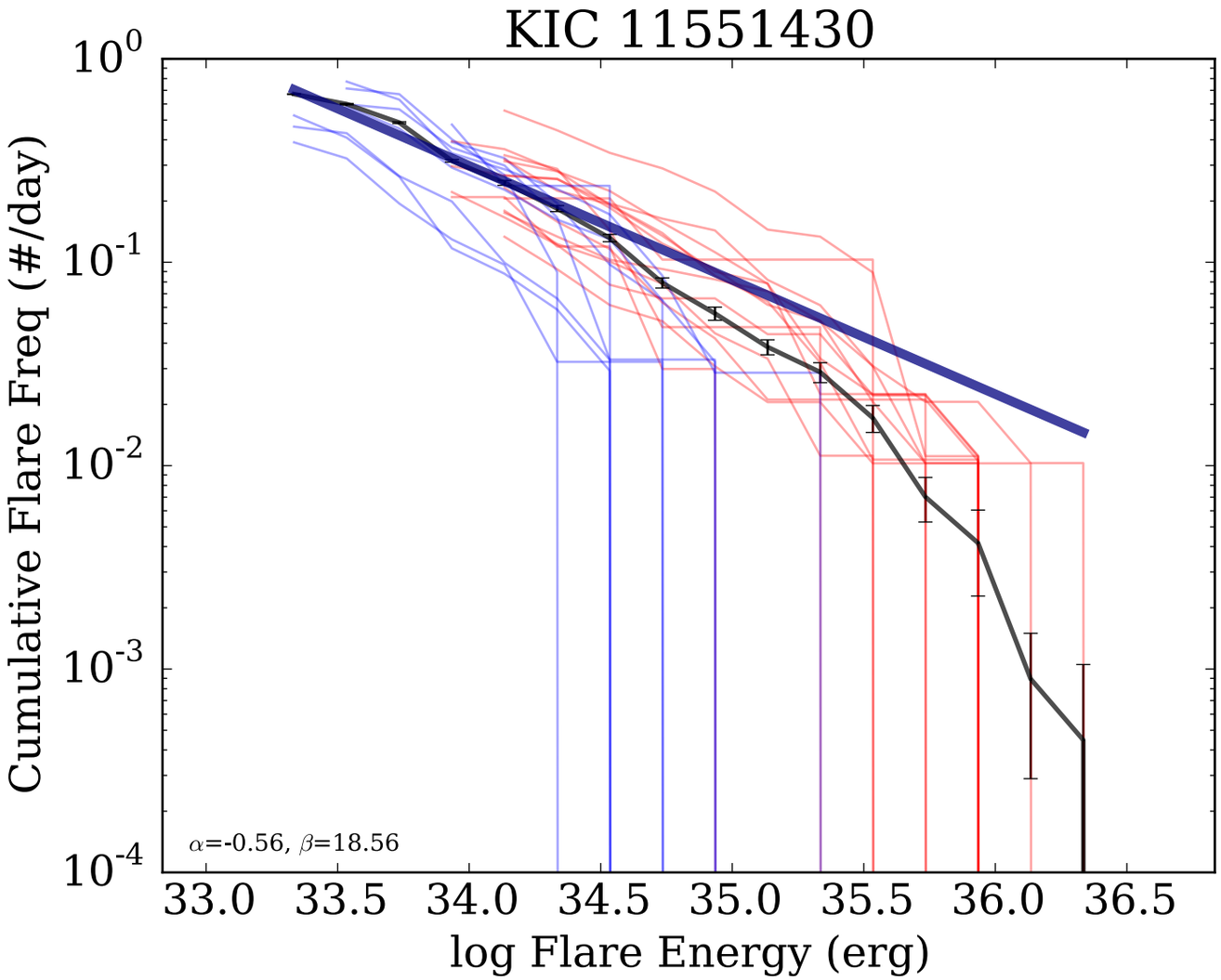
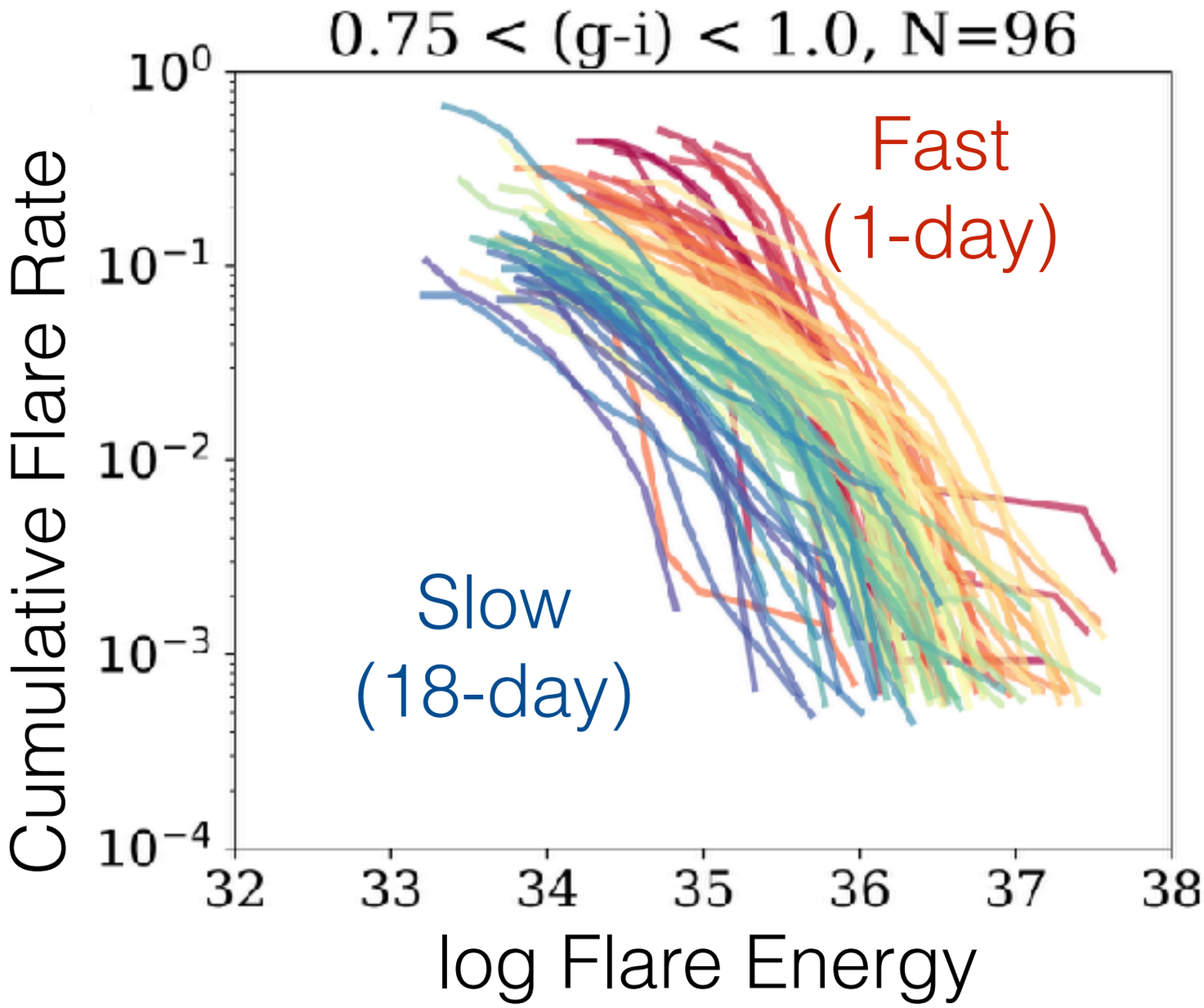
# A break in the powerlaw?
# (talk with Dave Soderblom)



# Flare Frequency vs. Rotation

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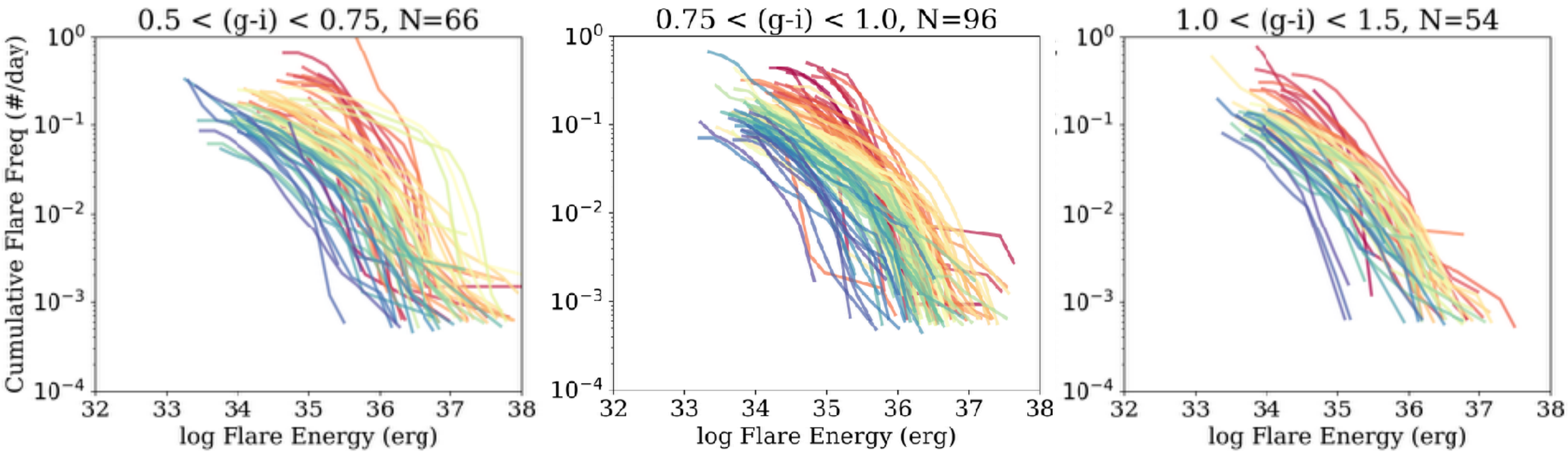
# Flare Frequency vs. Rotation

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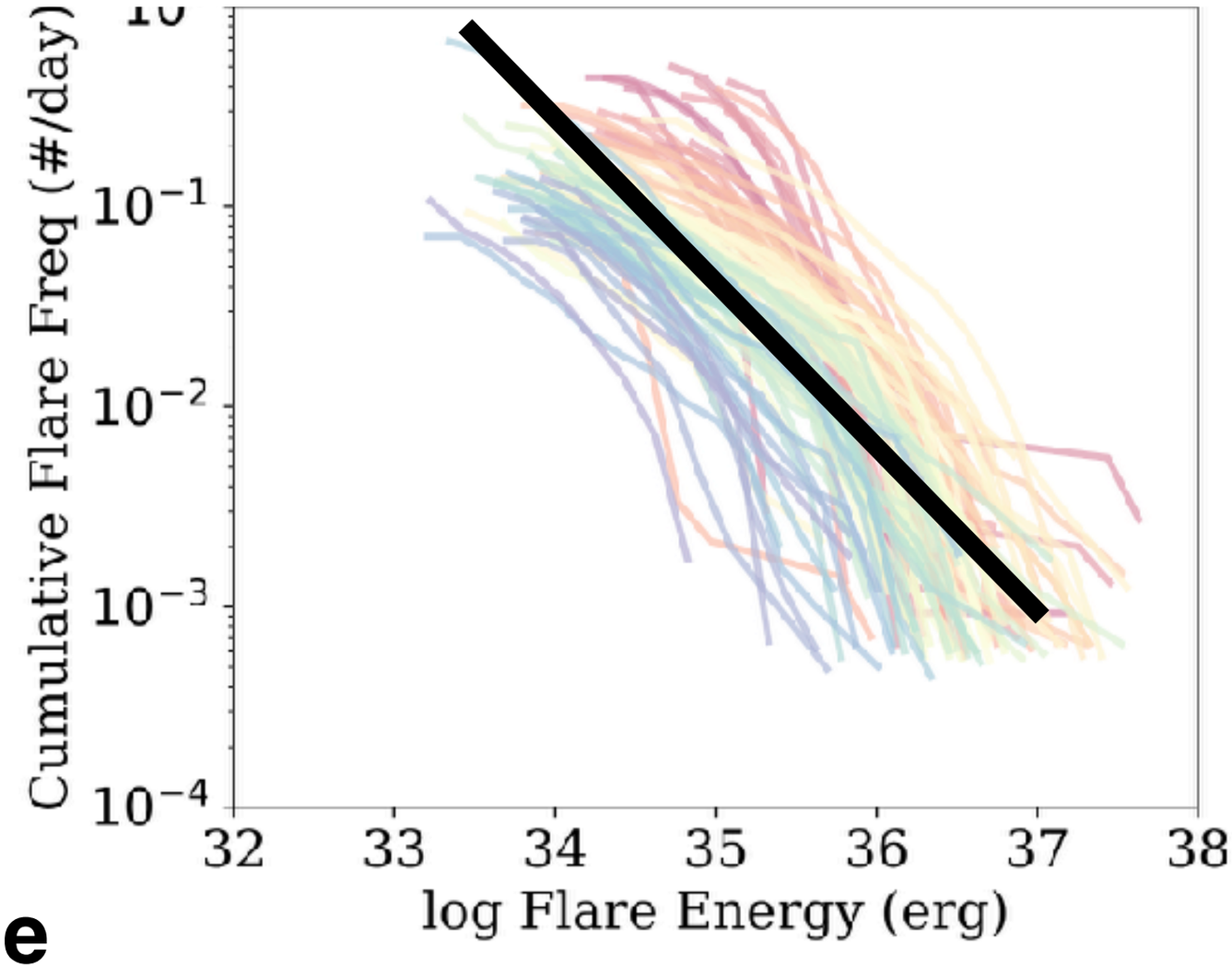
# Fit with powerlaw

$$\log \nu = a \log \varepsilon + b$$

flare rate slope

specific flare rate




Add terms for **mass** and **age**

$$a = a_1 \log t + a_2 m + a_3$$

$$b = b_1 \log t + b_2 m + b_3$$

*Age from gyrochronology model

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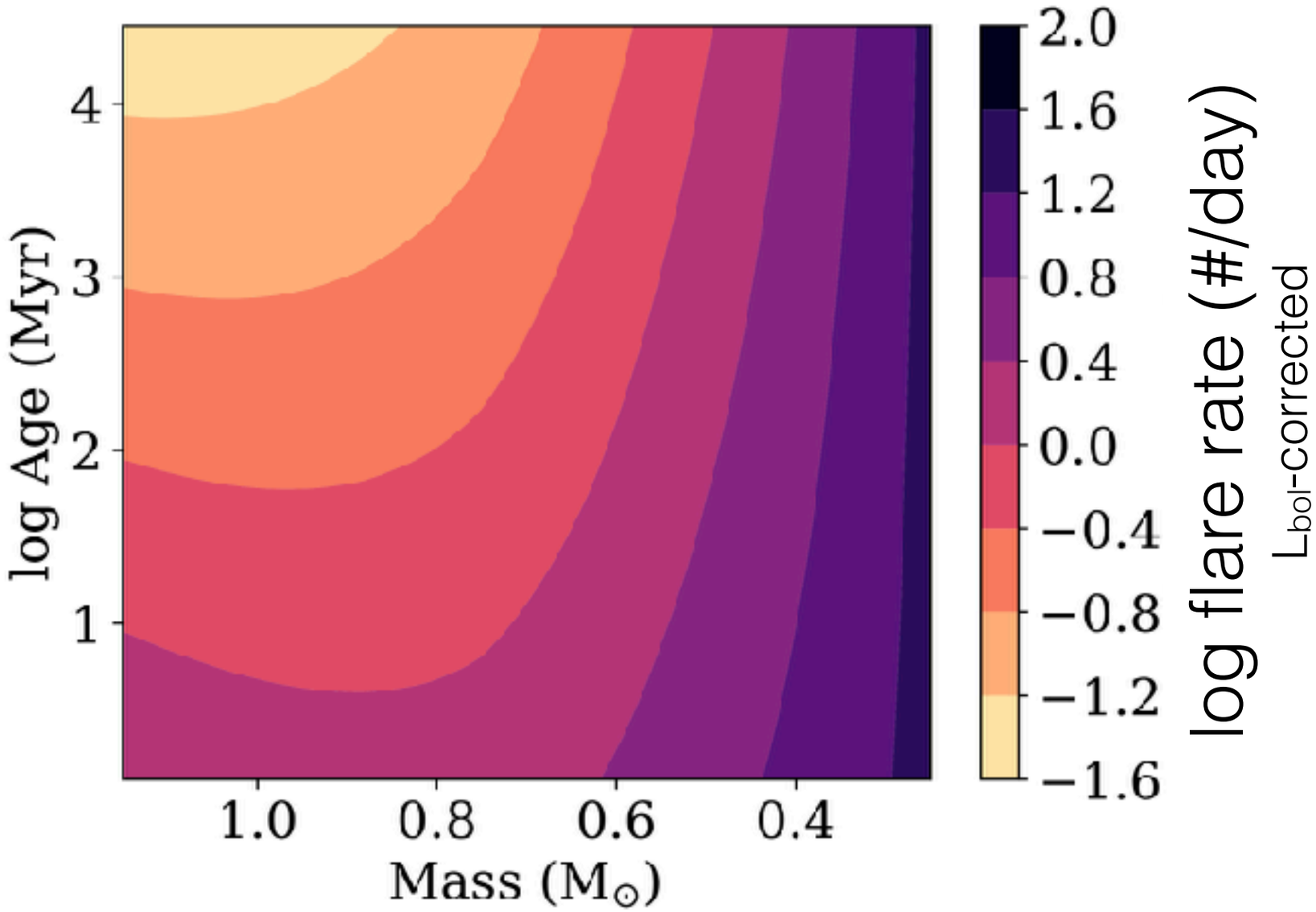
# Flare Rate vs. (Mass, Age)




Davenport et al. (2017 in prep)

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P = 11.186 days
m sin i = 1.27 $M_\oplus$
habitable zone!

**transit?**

Alpha Cen A&B

Proxima

Proxima b

ESO

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Alpha Cen A&B

Proxima

Proxima b

ESO/M. Kornmesser

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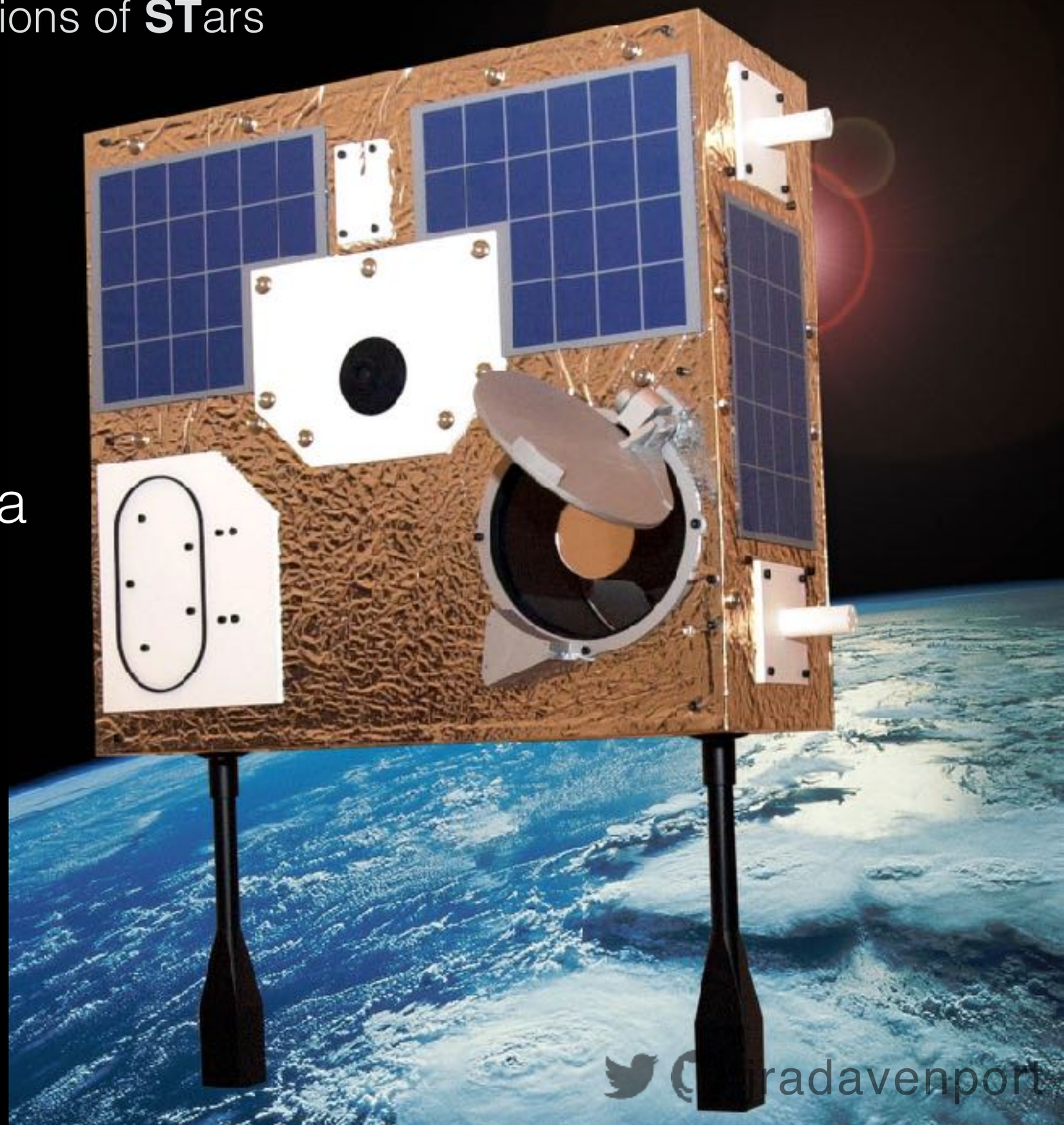
# MOST

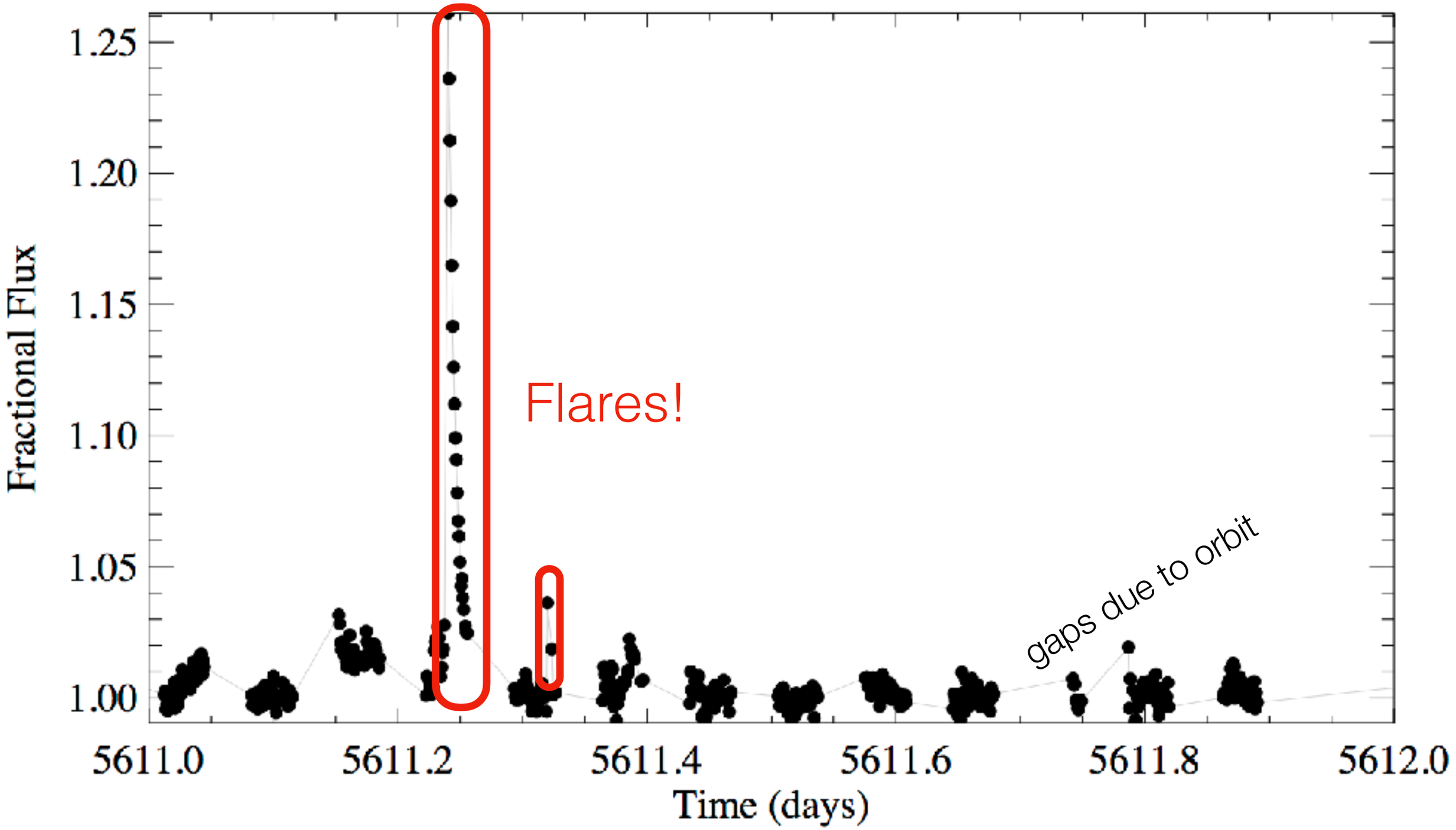
**M**icrovariability and **O**scillations of **ST**ars

2014 & 2015
37.6 days on Proxima
~1min cadence



# Proxima Cen

Over 60 flares found

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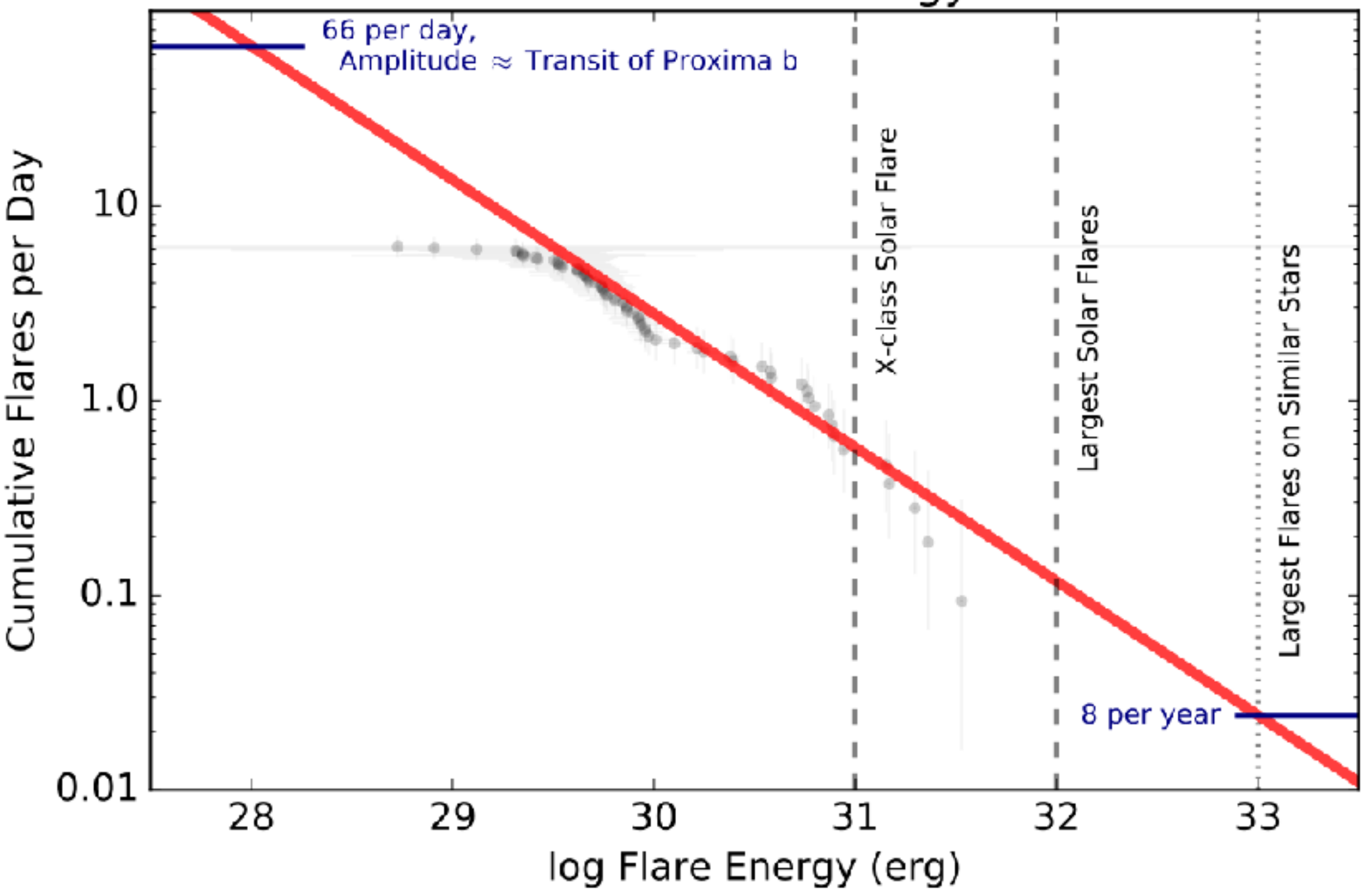


See poster: Ward Howard
Stellar Activity for Every TESS Star in the Southern Sky

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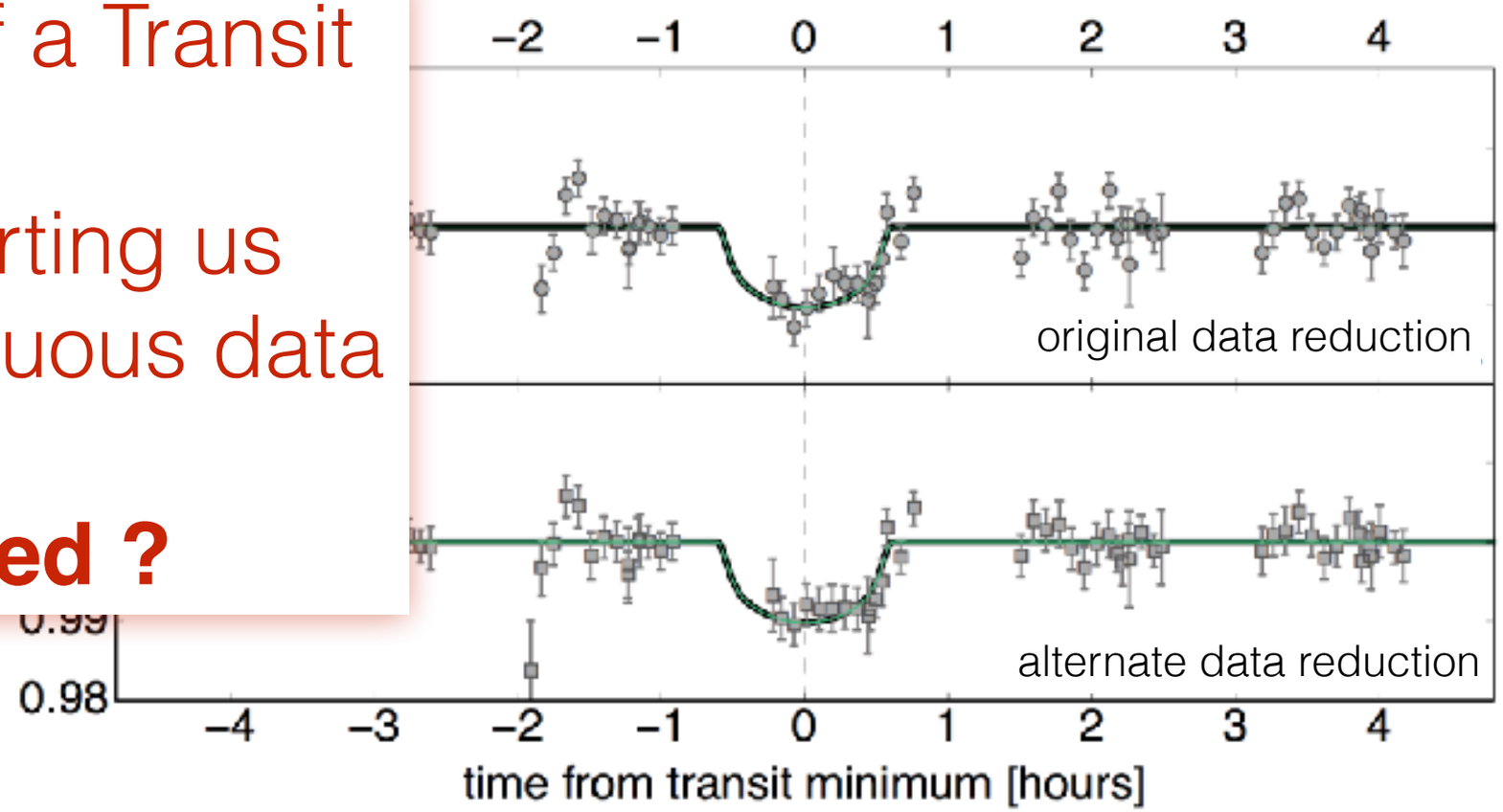
# No conclusive evidence for a transit from MOST data

~1.5% chance of a Transit

Flares really hurting us
Need more continuous data

**Go to infrared ?**




Kipping+2016

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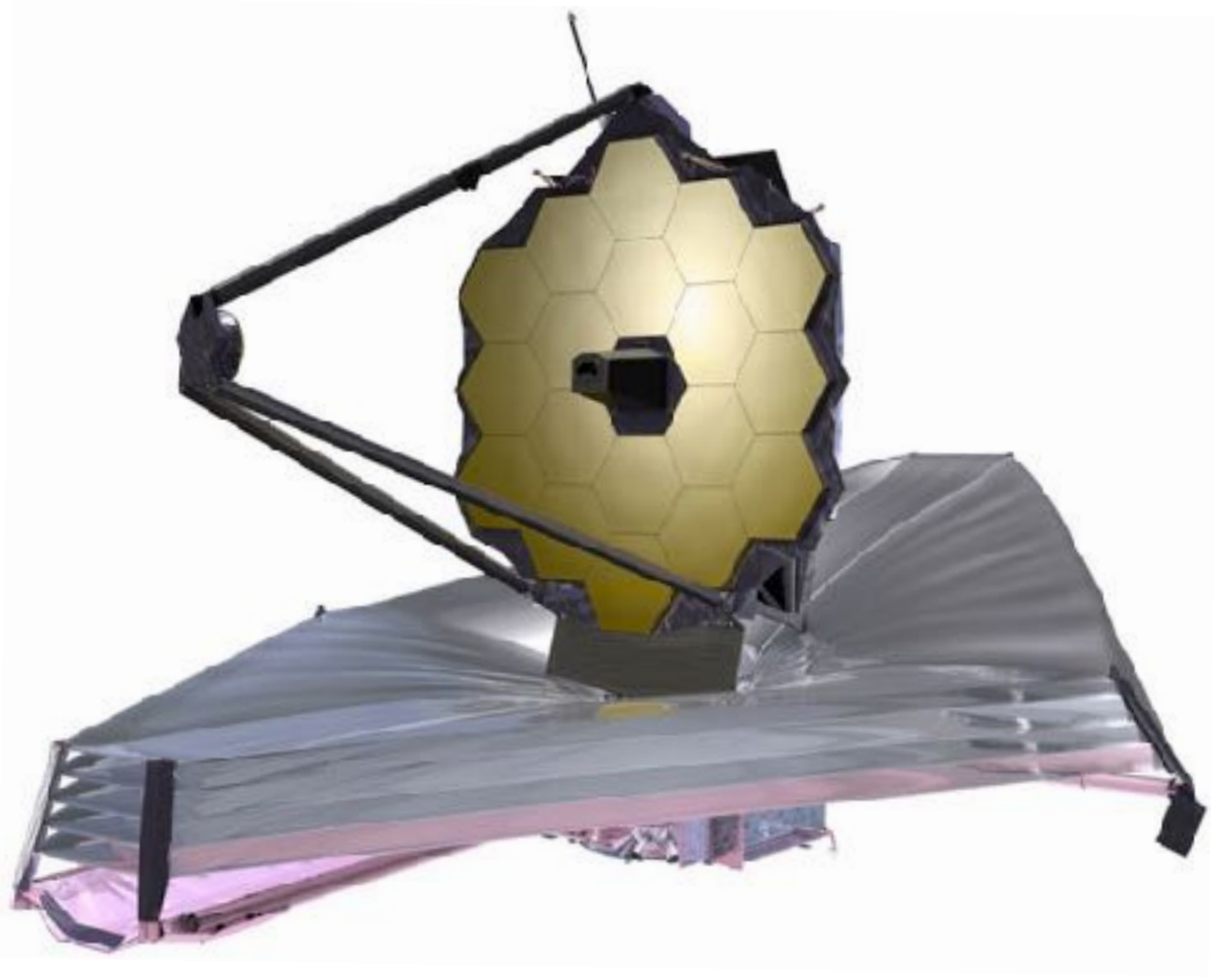
# Flares in the Optical & IR



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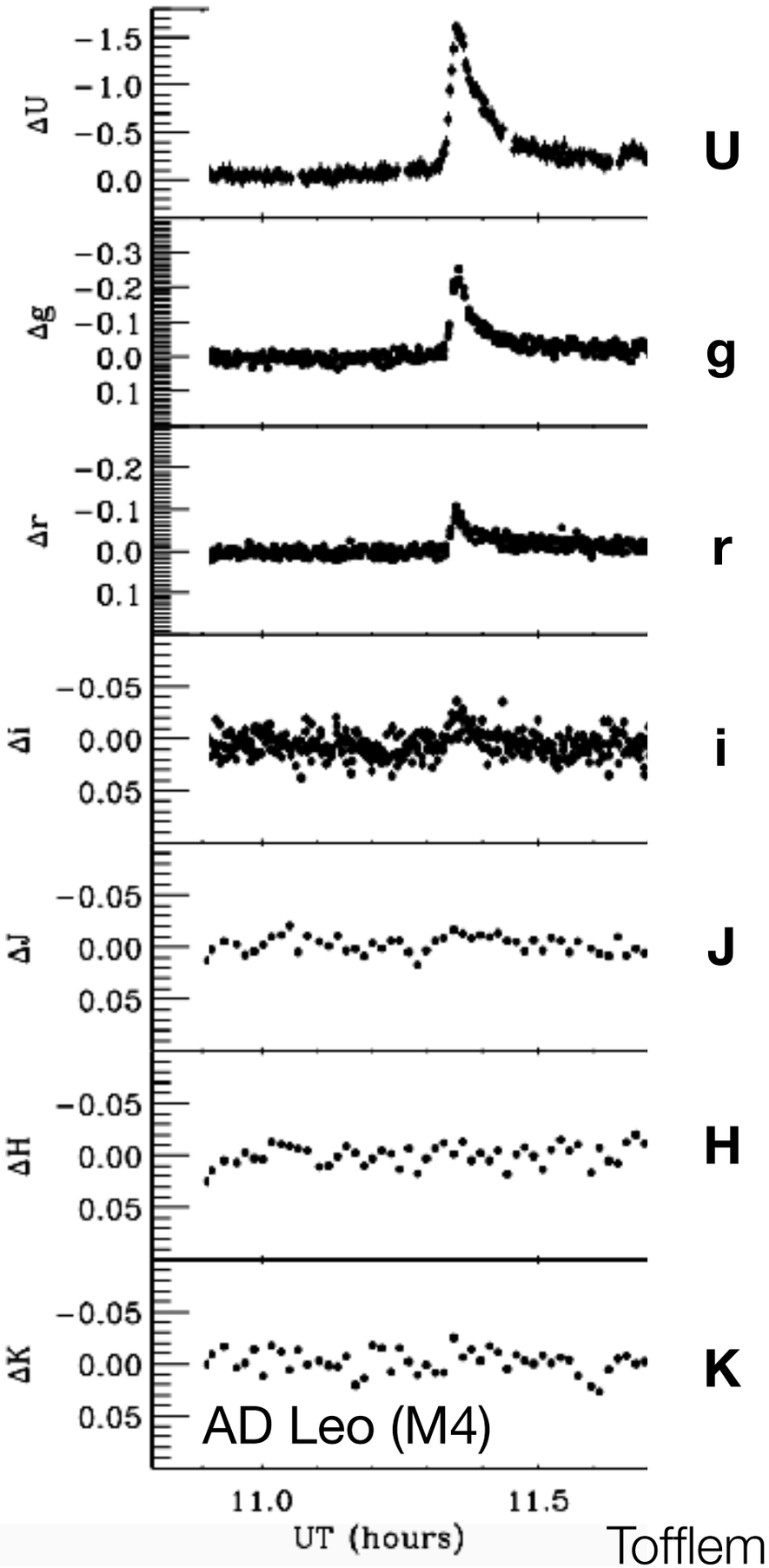
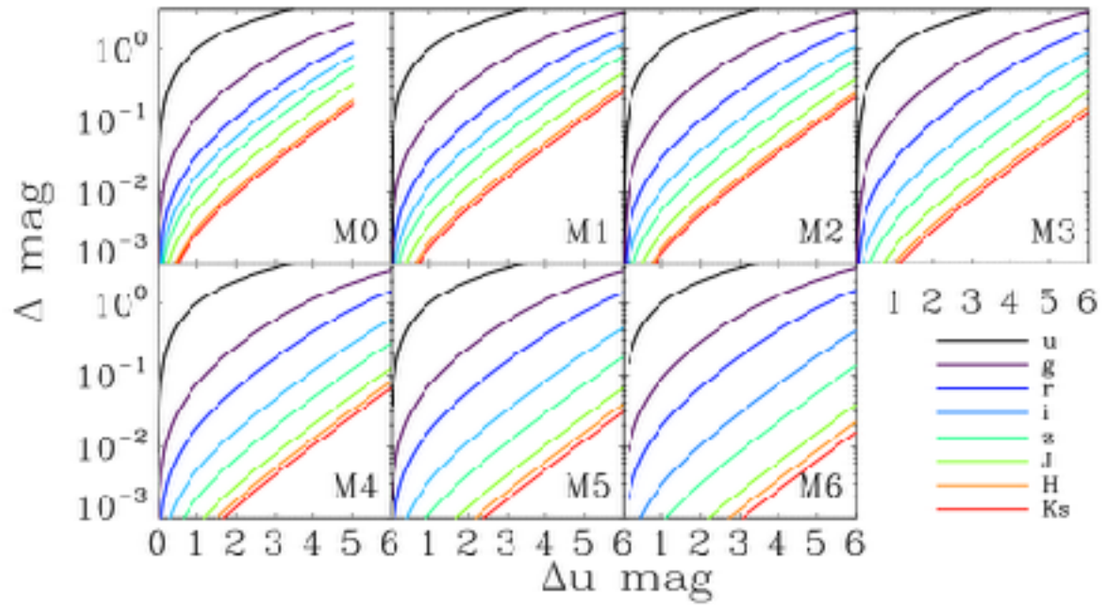
# Flares in the Optical & IR

## Observations




Tofflemire et al. (2012)

## Models




Davenport et al. (2012)

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# TRAPPIST–1

b

c

d

e

f

g

h

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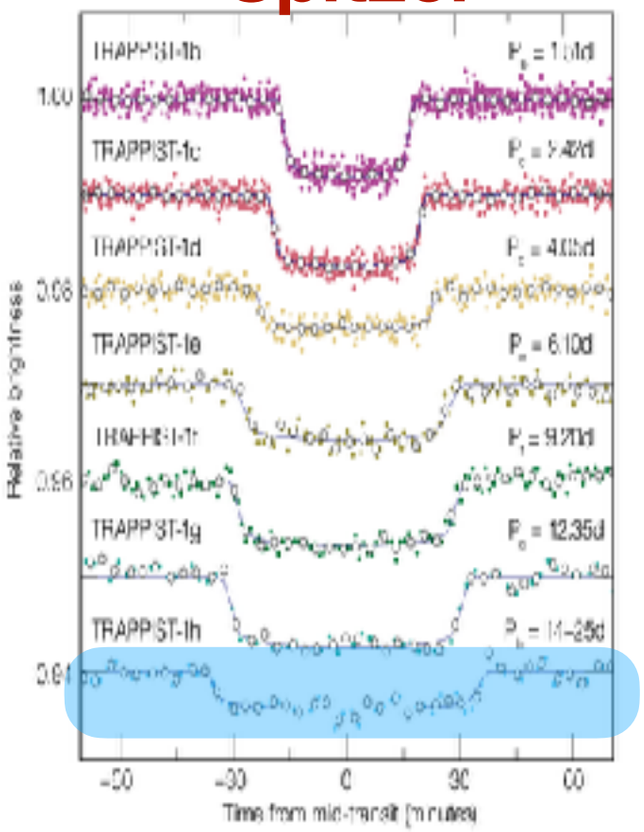
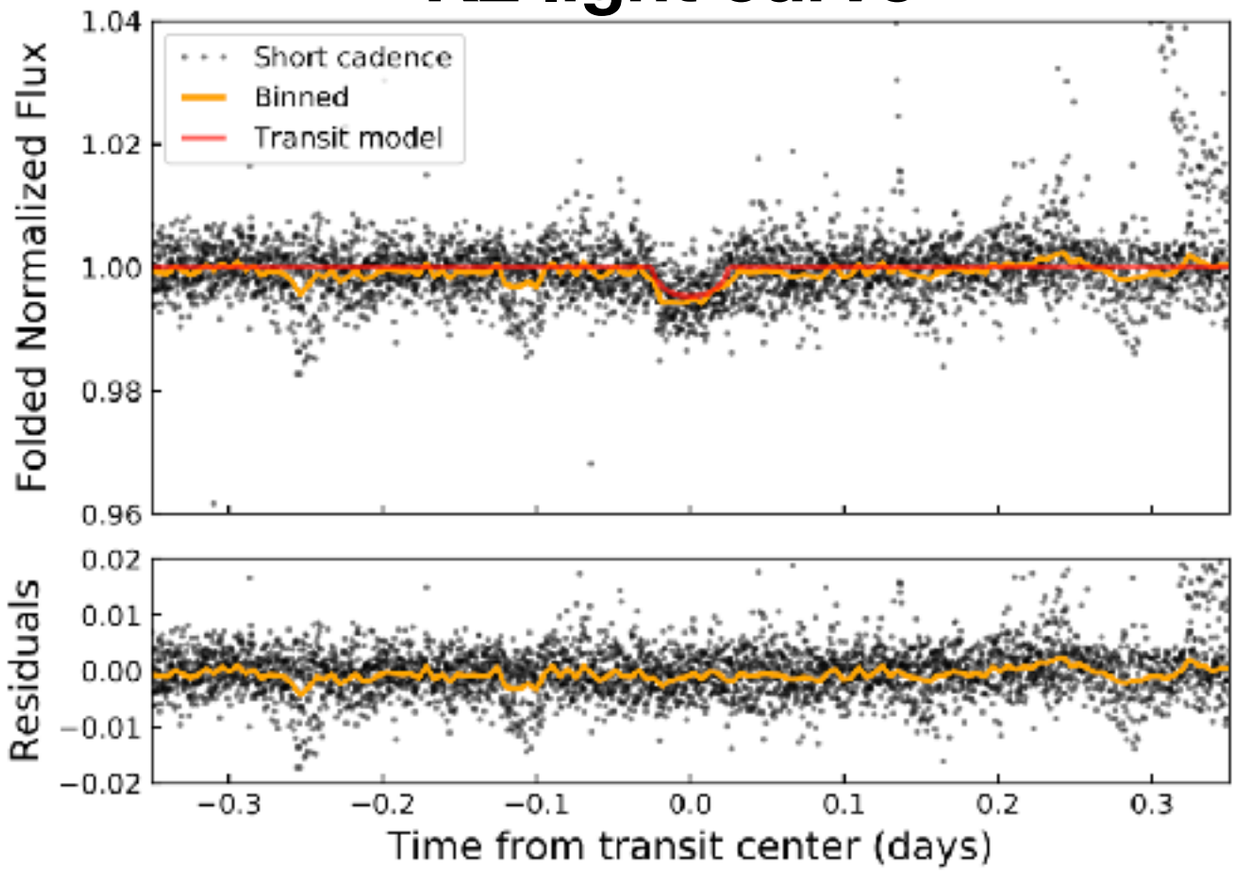
# TRAPPIST–1

## Spitzer




## K2 light curve




Gillon et al. (2017)

~20 days

Luger+2017

~79 days

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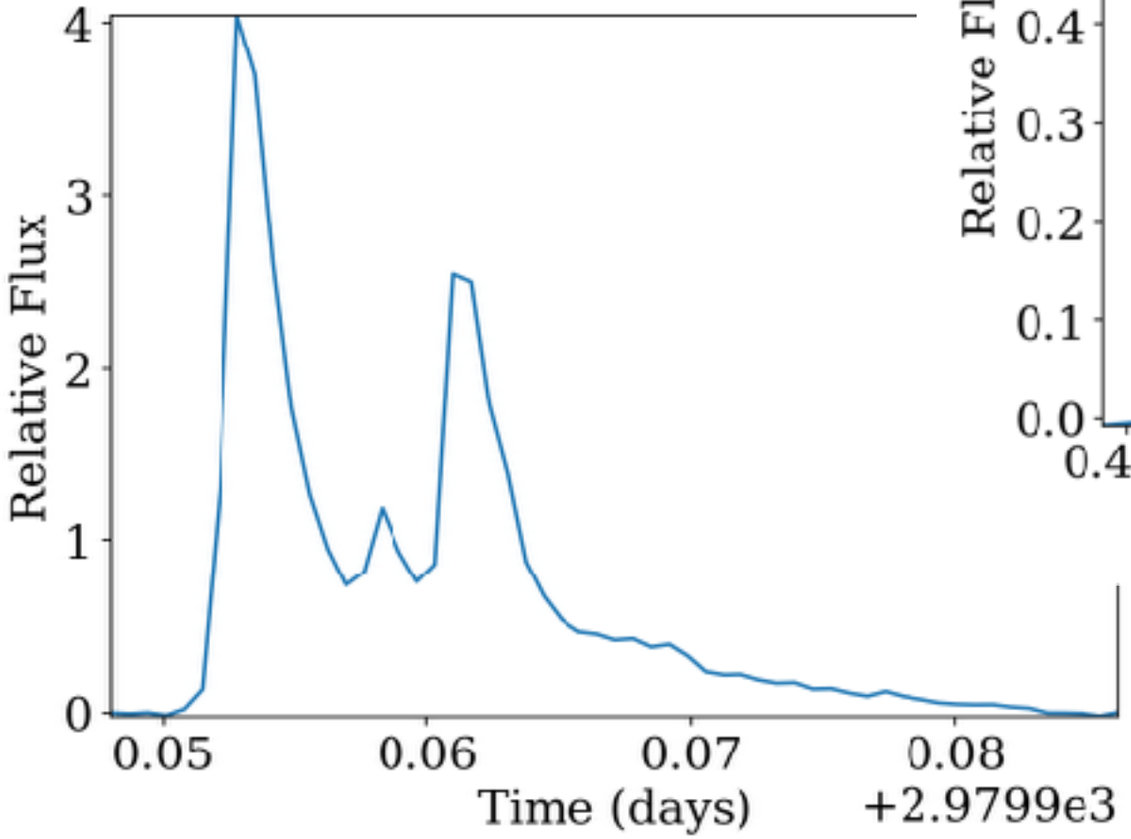
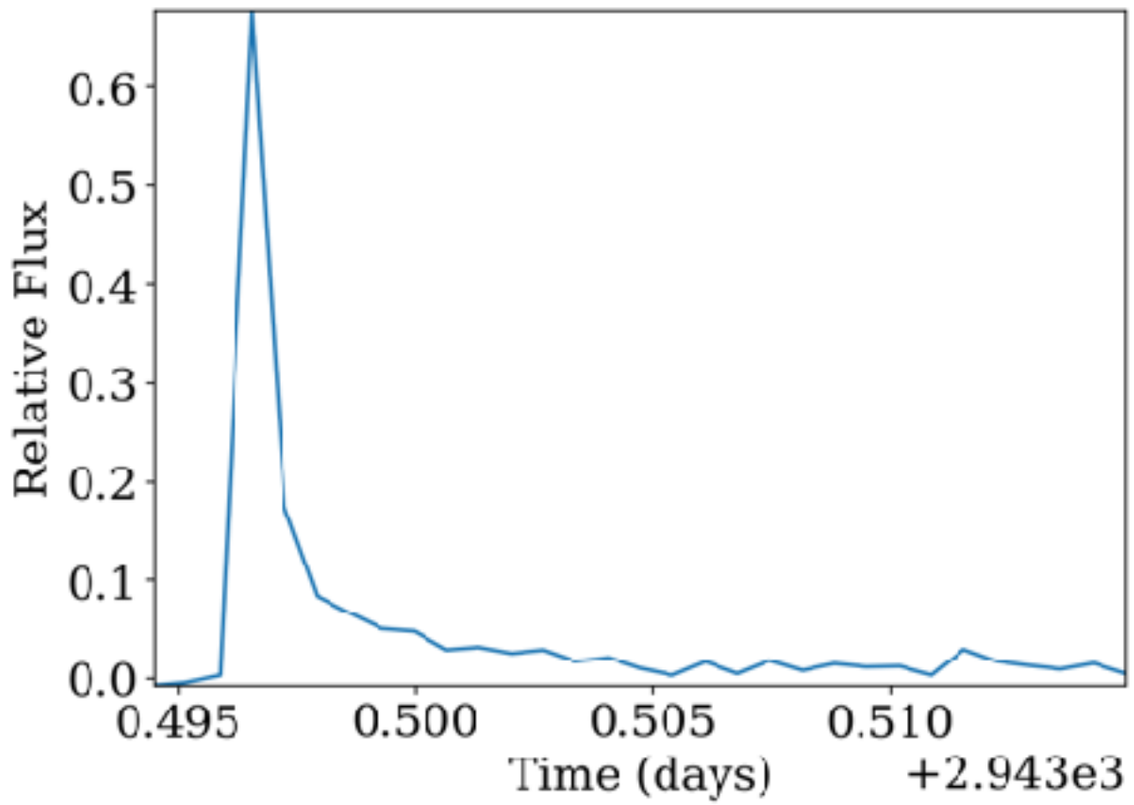
# TRAPPIST–1

BIG flare(s)




**K2 light curve**

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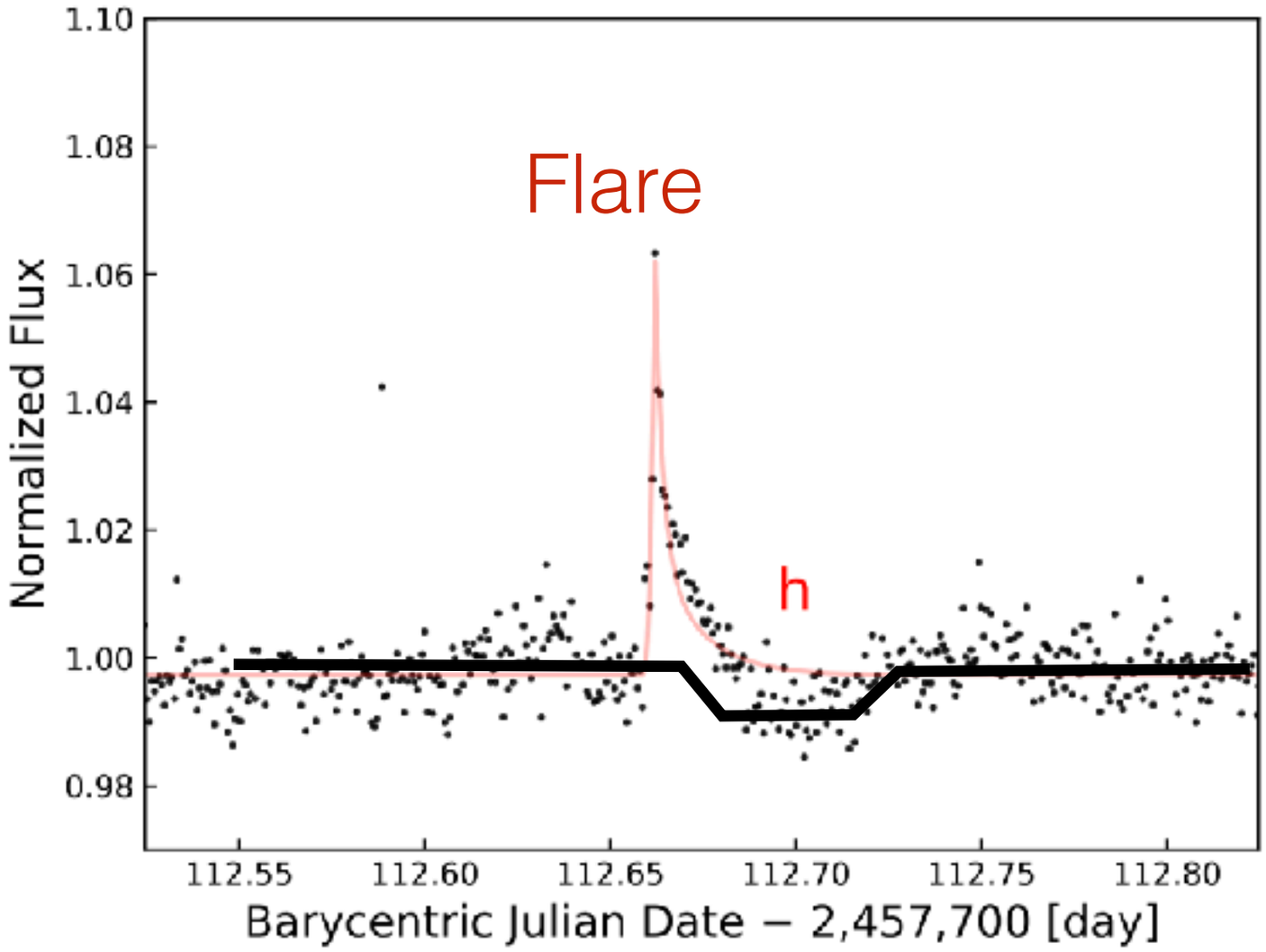
# TRAPPIST–1

**K2 light curve**




Luger+2017

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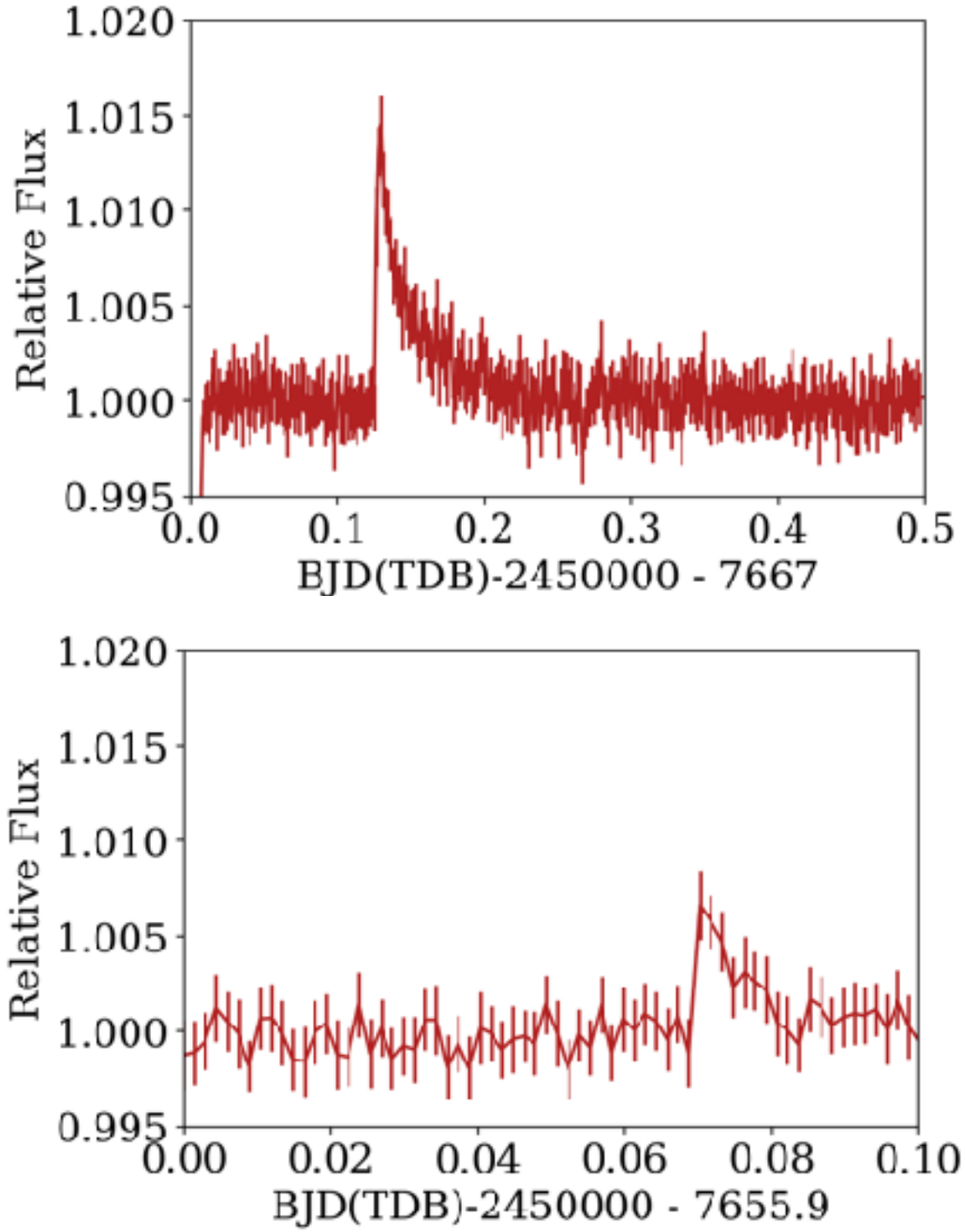
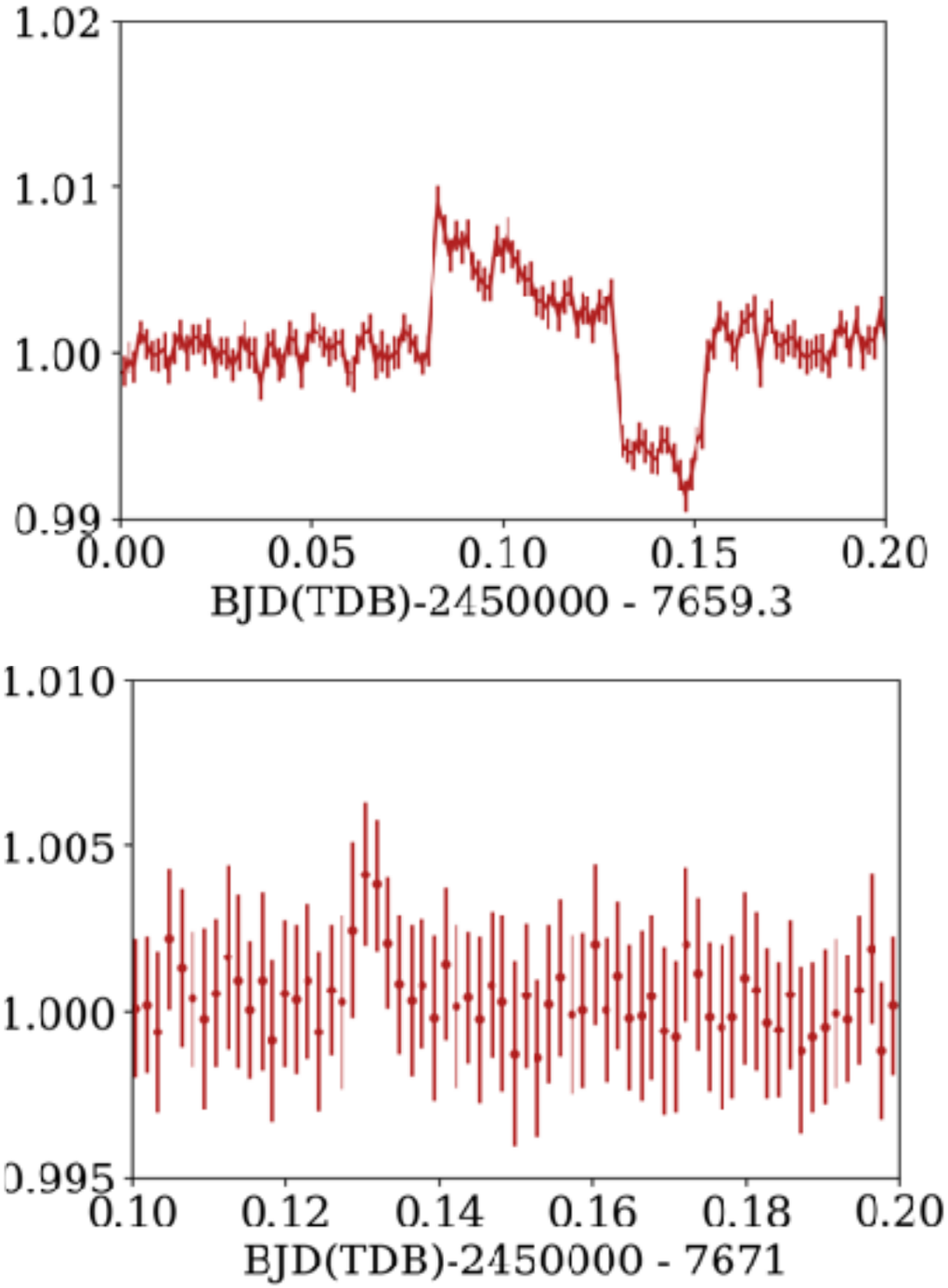
# Flares from Spitzer

# TRAPPIST–1







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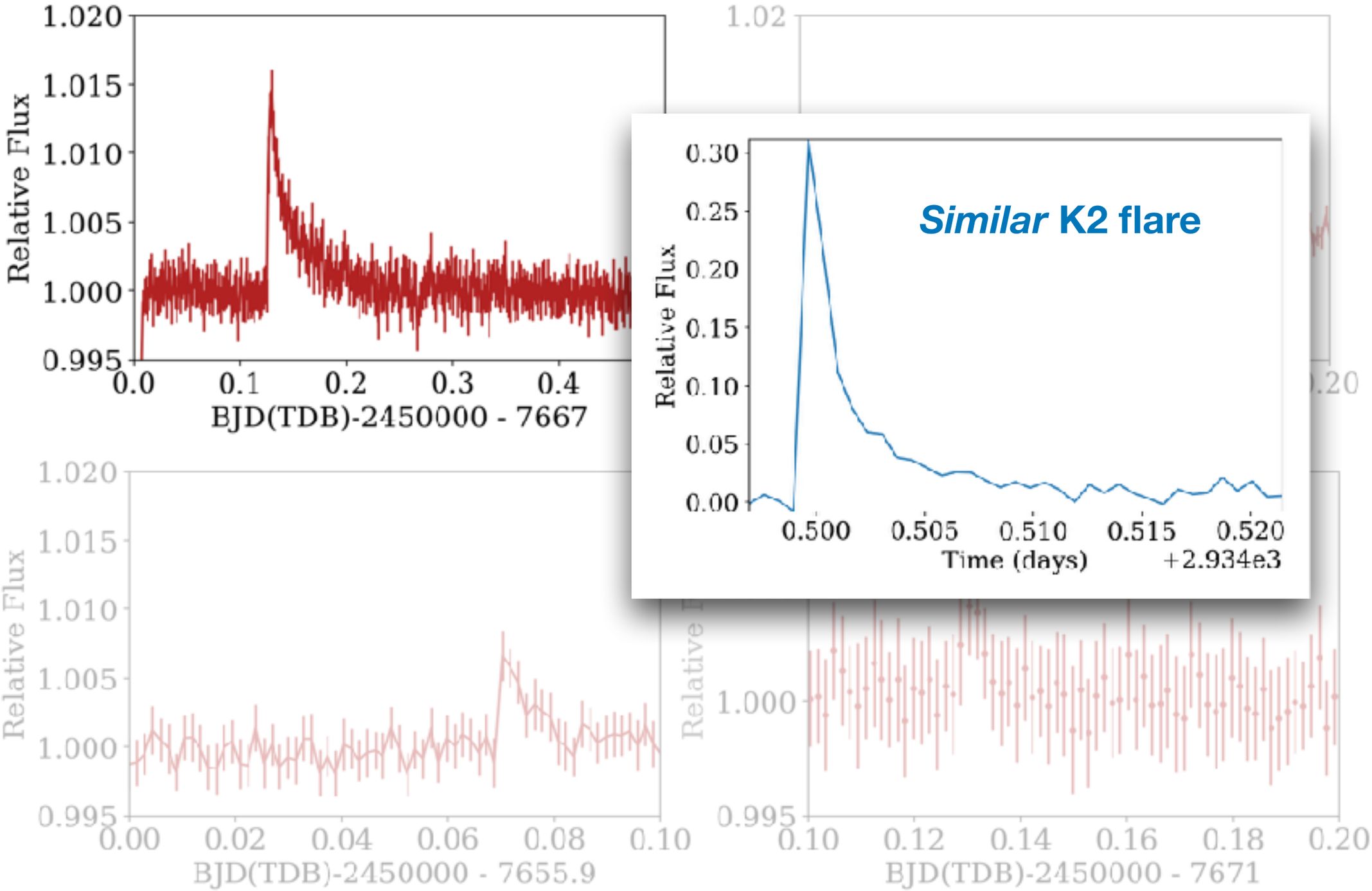
# Flares from Spitzer

# TRAPPIST–1

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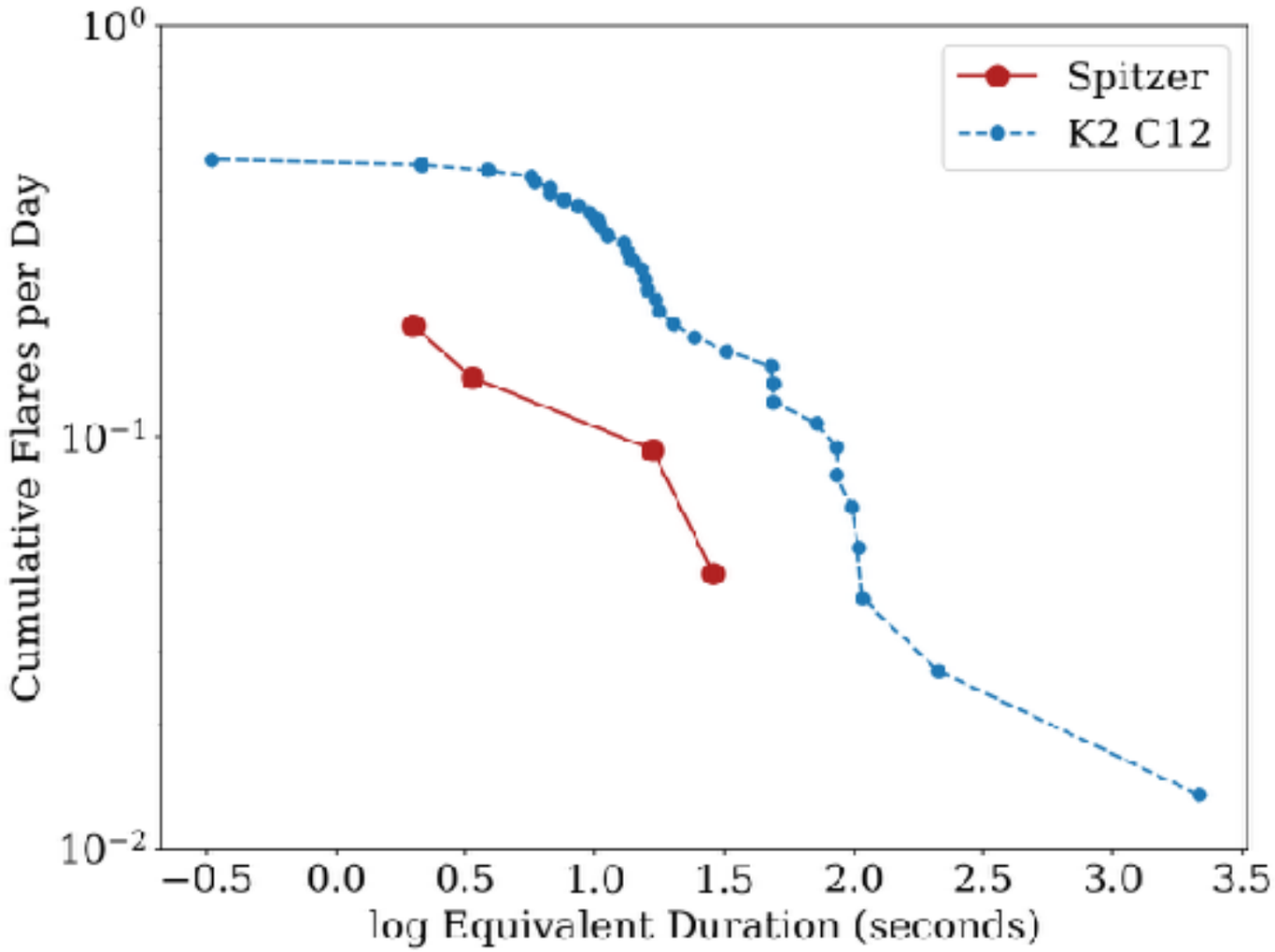
# TRAPPIST–1

Comparable rates between optical & IR

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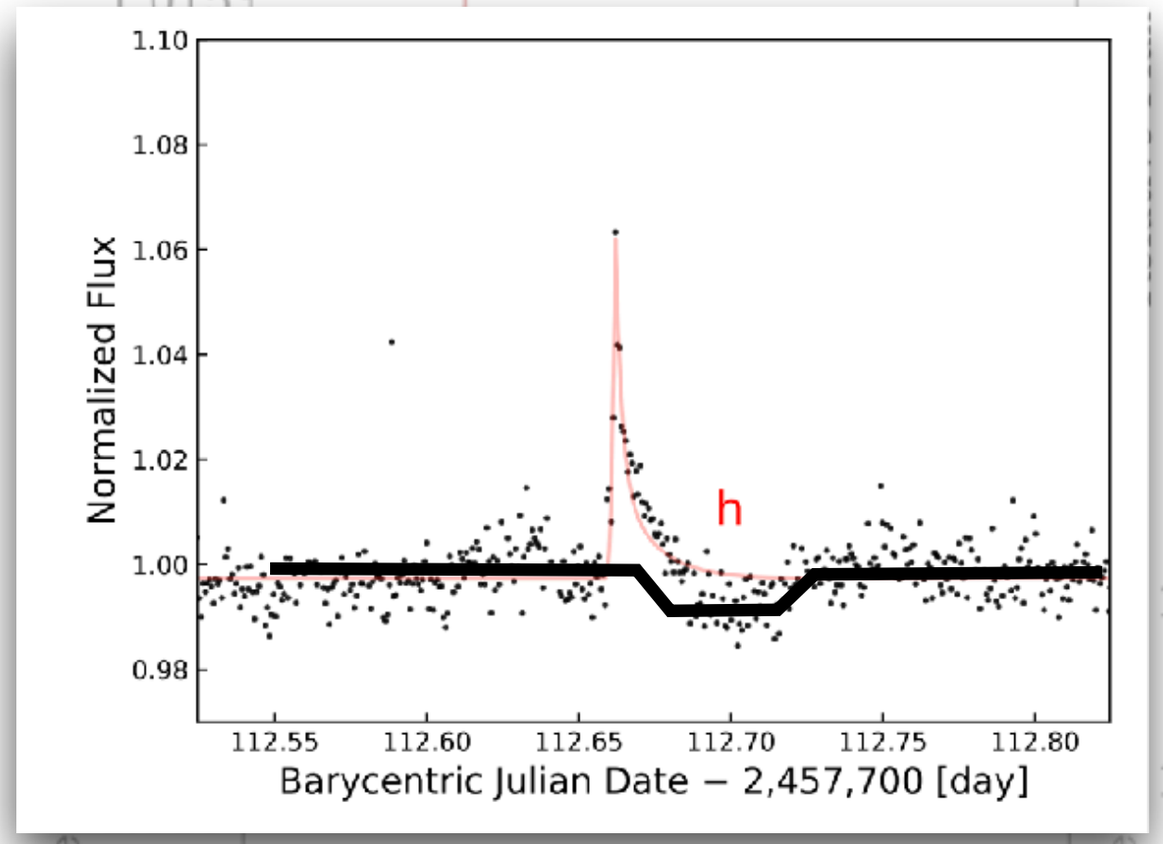
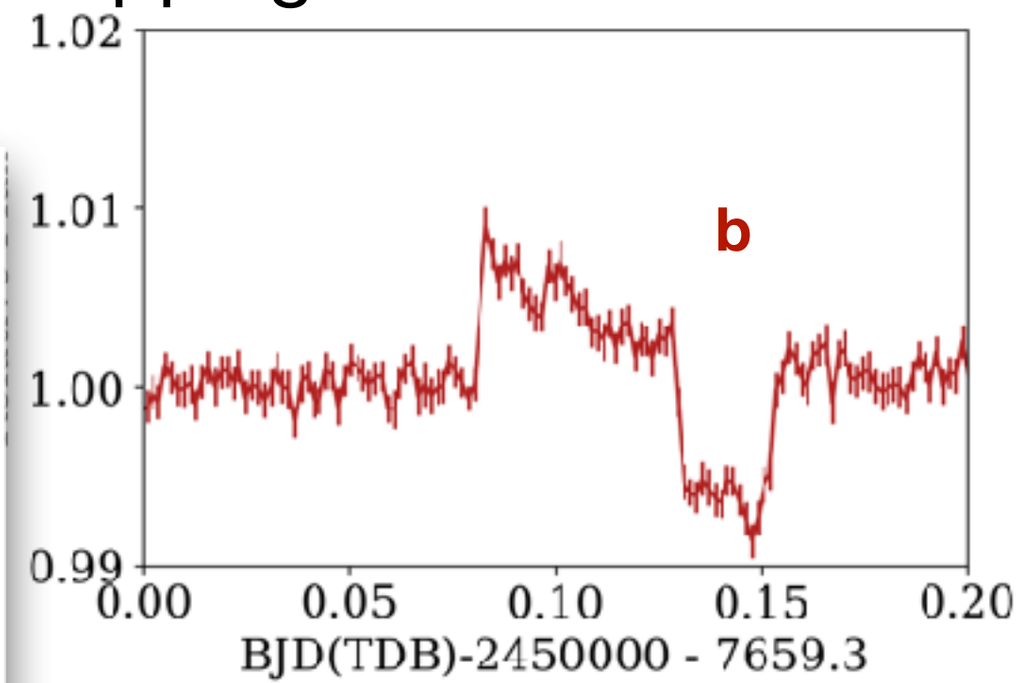
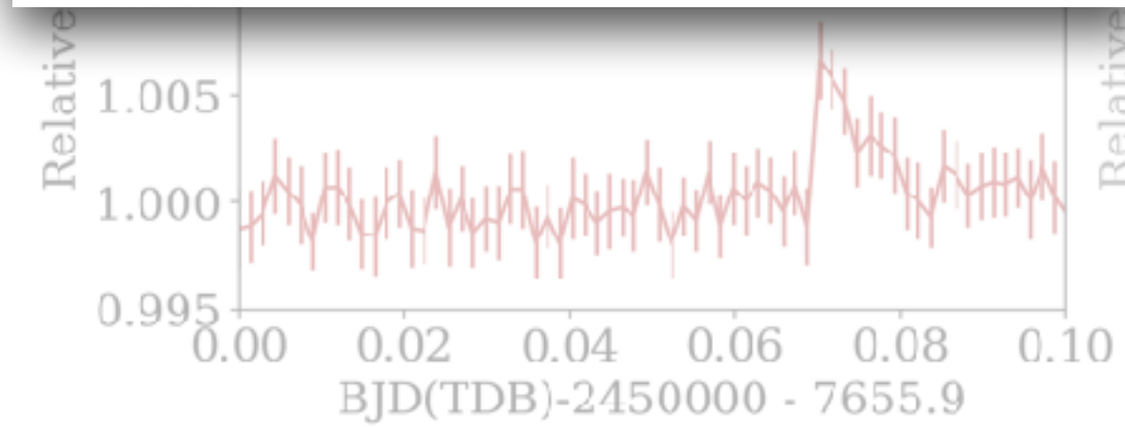
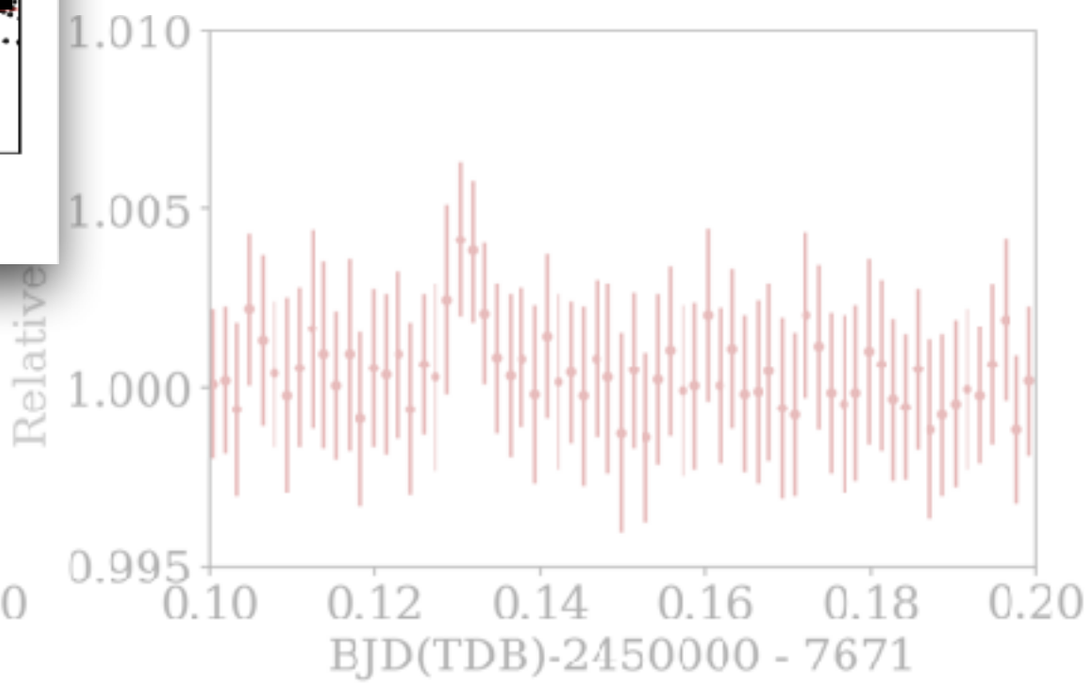
# TRAPPIST–1

Incredible - flares overlapping 2 transits!

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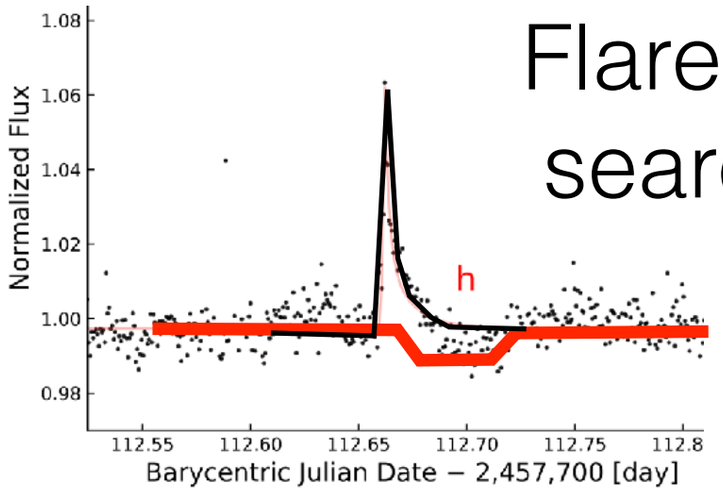
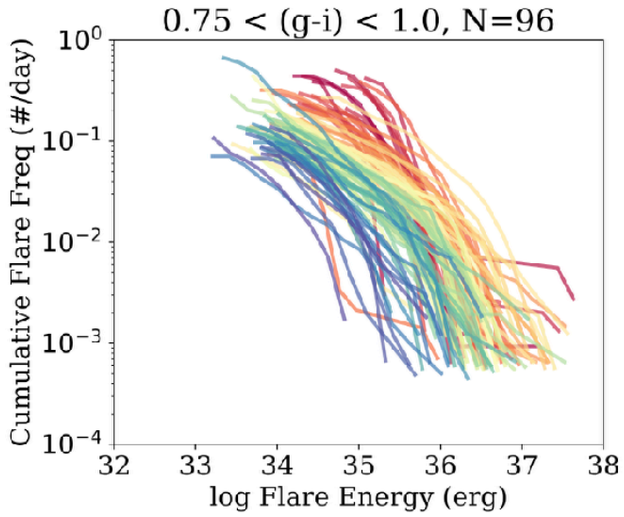
# Summary

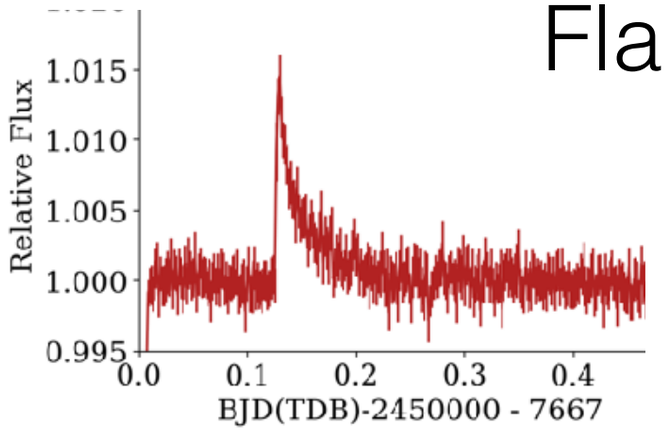
Flares *may* be bad for habitability!




Flares make transit searches hard(er)




Flare rates change with stellar age!




Flares are visible in the IR!