CENTER FOR ASTROPHYSICS
HARVARD & SMITHSONIAN

FLARE STATISTICS AND HIGH-RESOLUTION SPECTROSCOPY OF A VOLUME COMPLETE SAMPLE OF MID-TO-LATE M DWARFS WITHIN 15 PARSECS

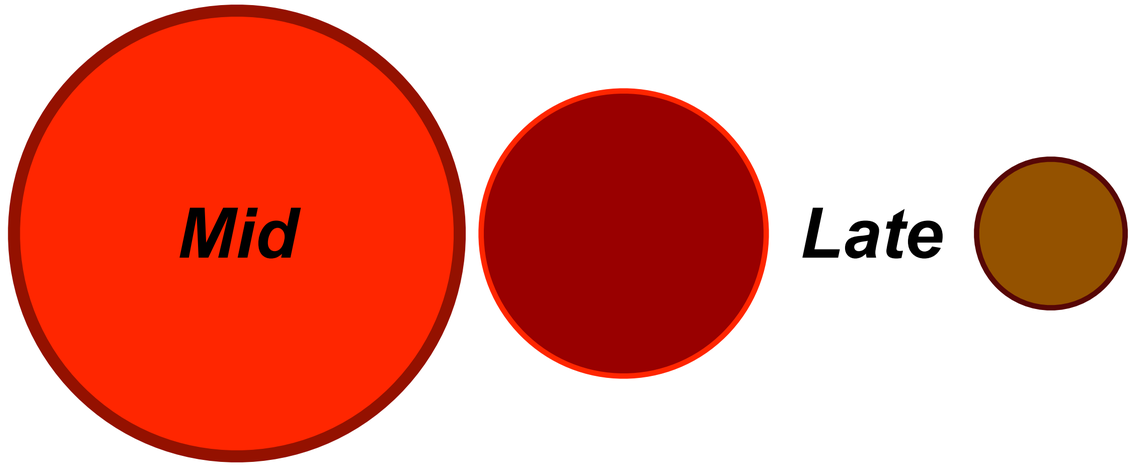
Amber Medina, David Charbonneau, Jennifer Winters, Jonathan Irwin

the David & Lucile Packard FOUNDATION
JOHN TEMPLETON FOUNDATION
NSF
NASA

MID-TO-LATE M DWARFS

$0.1\ M_{Sun} < M < 0.3\ M_{Sun}$

- Are fully convective
- Lack a tachocline
- Have magnetic activity
- Magnetic field generation may be different in low-mass stars



M4V	**M6V**	**M8V**
$M = 0.25\ M_{sun}$	$M = 0.15\ M_{sun}$	$M = 0.1\ M_{sun}$
$R = 0.25\ R_{sun}$	$R = 0.15\ R_{sun}$	$R = 0.1\ R_{sun}$
$T = 3100$ K	$T = 2800$ K	$T = 2600$ K

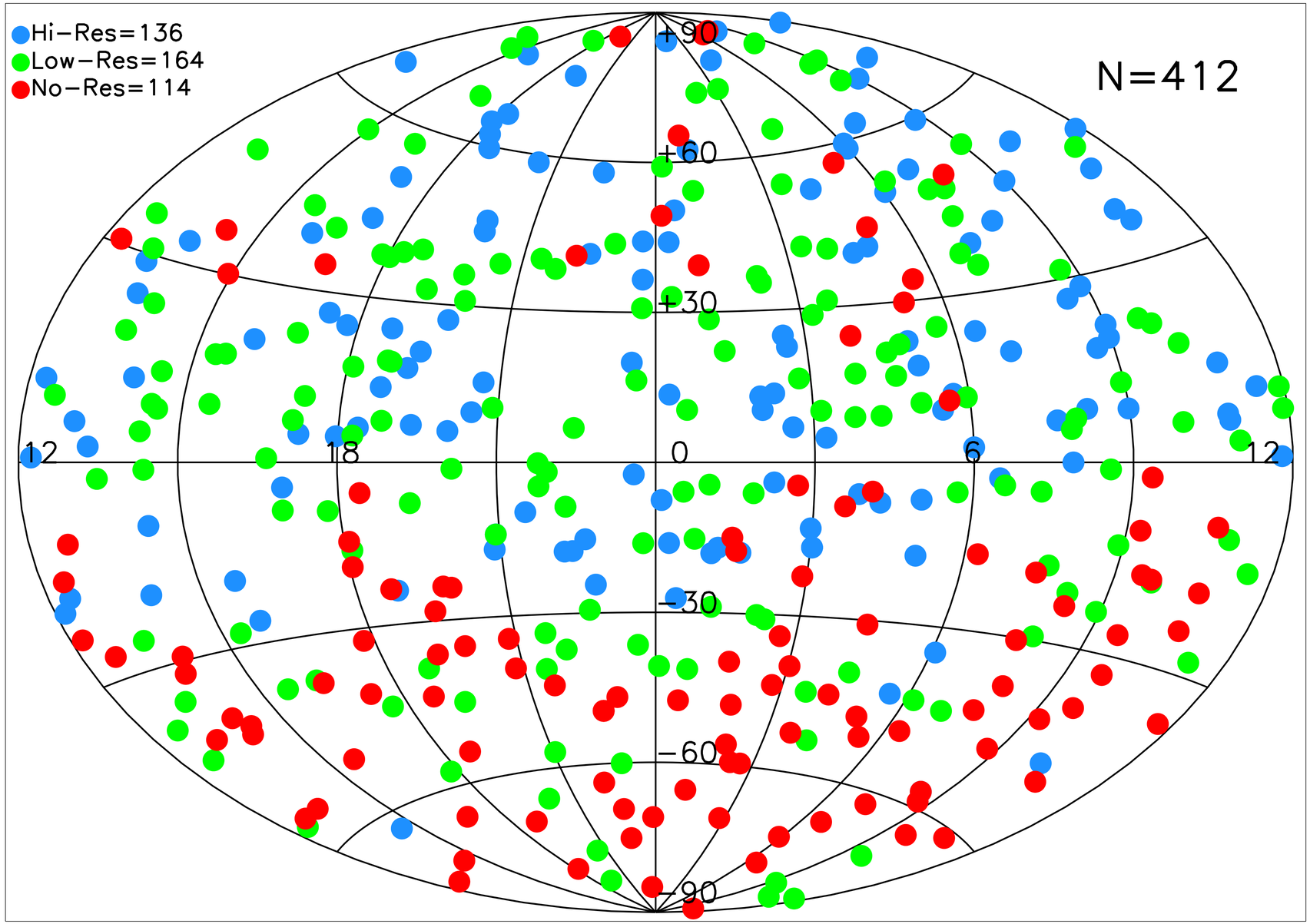
HOW DOES THE RATE OF LARGER, ENERGETIC FLARES RELATE TO STELLAR ROTATION AND ACTIVITY?

VOLUME COMPLETE SAMPLE OF MID-TO-LATE M DWARFS WITHIN 15 PARSECS

- We are gathering multi-epoch high-resolution spectra of each star.
- In the south, we use the CHIRON Spectrograph located on the SMARTS 1.5 meter telescope at Cerro Tololo Inter-American Observatory, Chile.
- In the north, we use the TRES Spectrograph located on the 60 inch telescope at Fred Lawrence Whipple Observatory on Mt. Hopkins, Arizona.

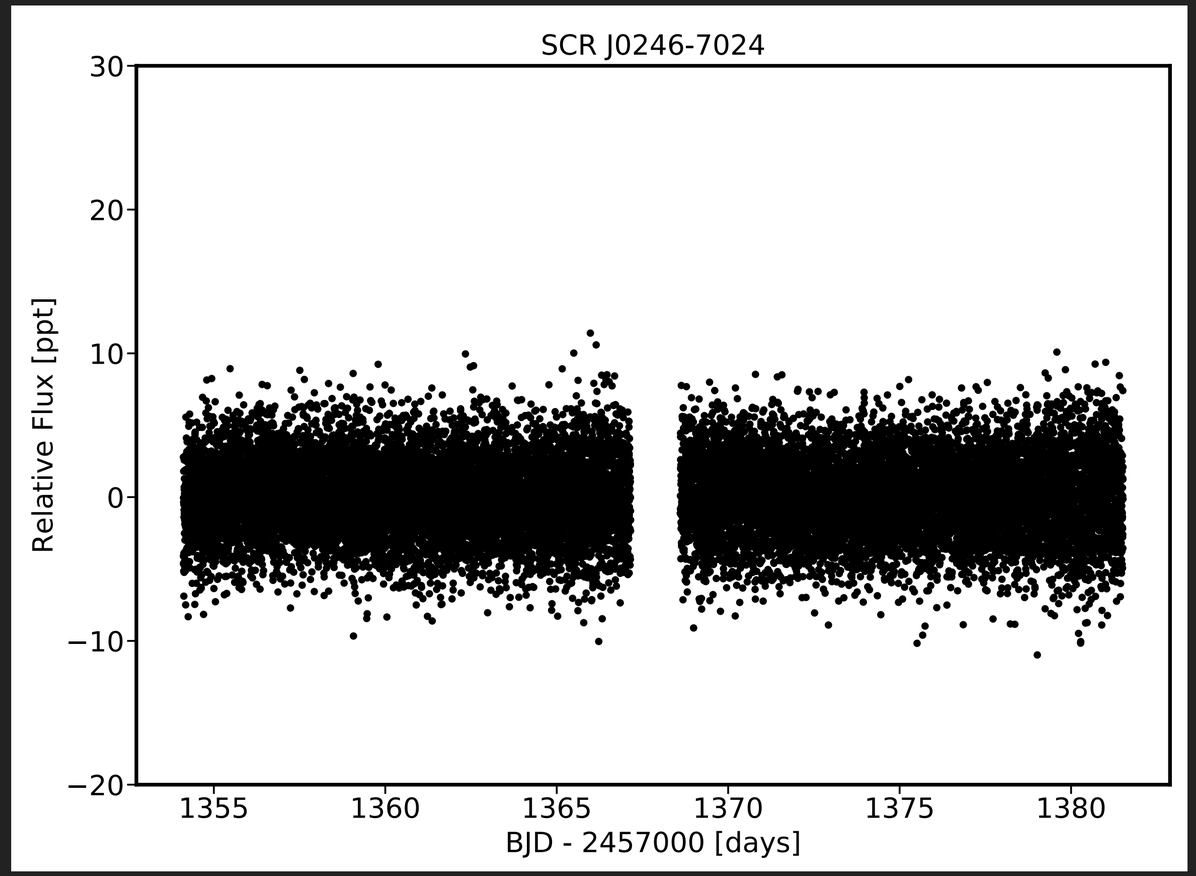
VOLUME COMPLETE SAMPLE OF MIR TO LATE M DWARFS WITHIN

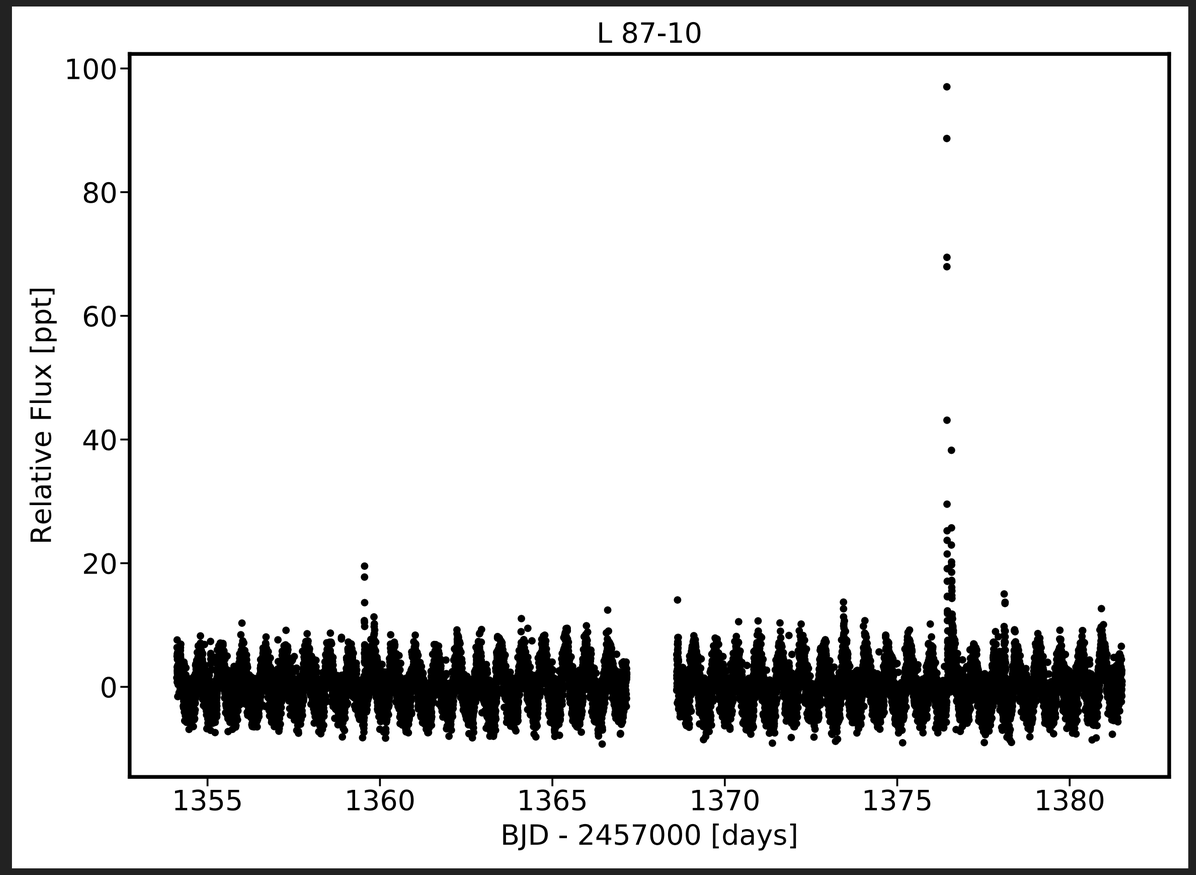
- We ar… …ar.
- In the … …SMARTS 1.5 m… …, Chile.
- In the … …nch telesc… …ns, Arizon…



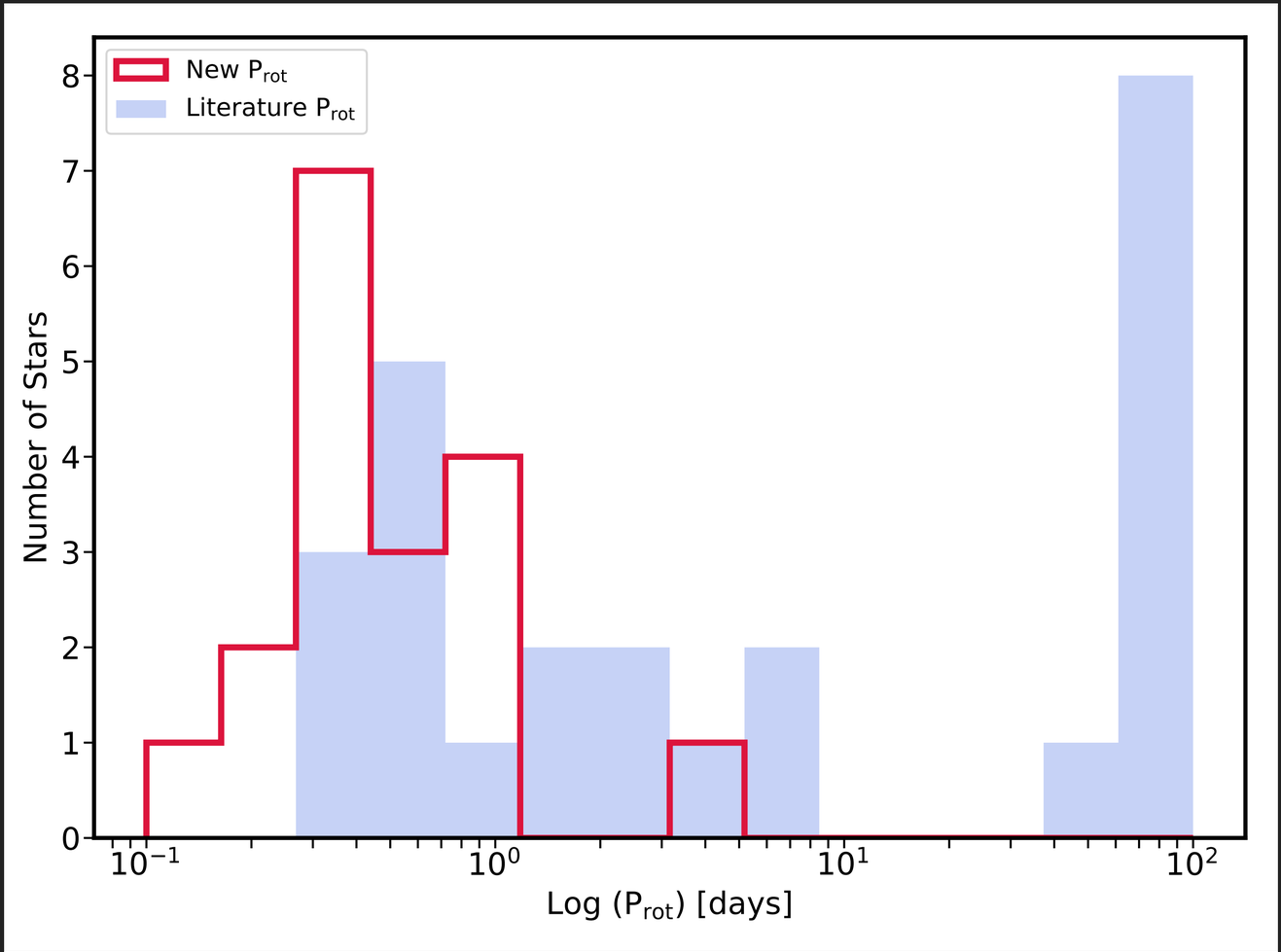
TESS DATA OF NEARBY MID-TO-LATE M DWARFS!

2 minute cadence TESS data off mid-to-late M dwarfs within 15 parsecs! *TESS GI Proposals: G011231, G022076 | PI Jennifer Winters*





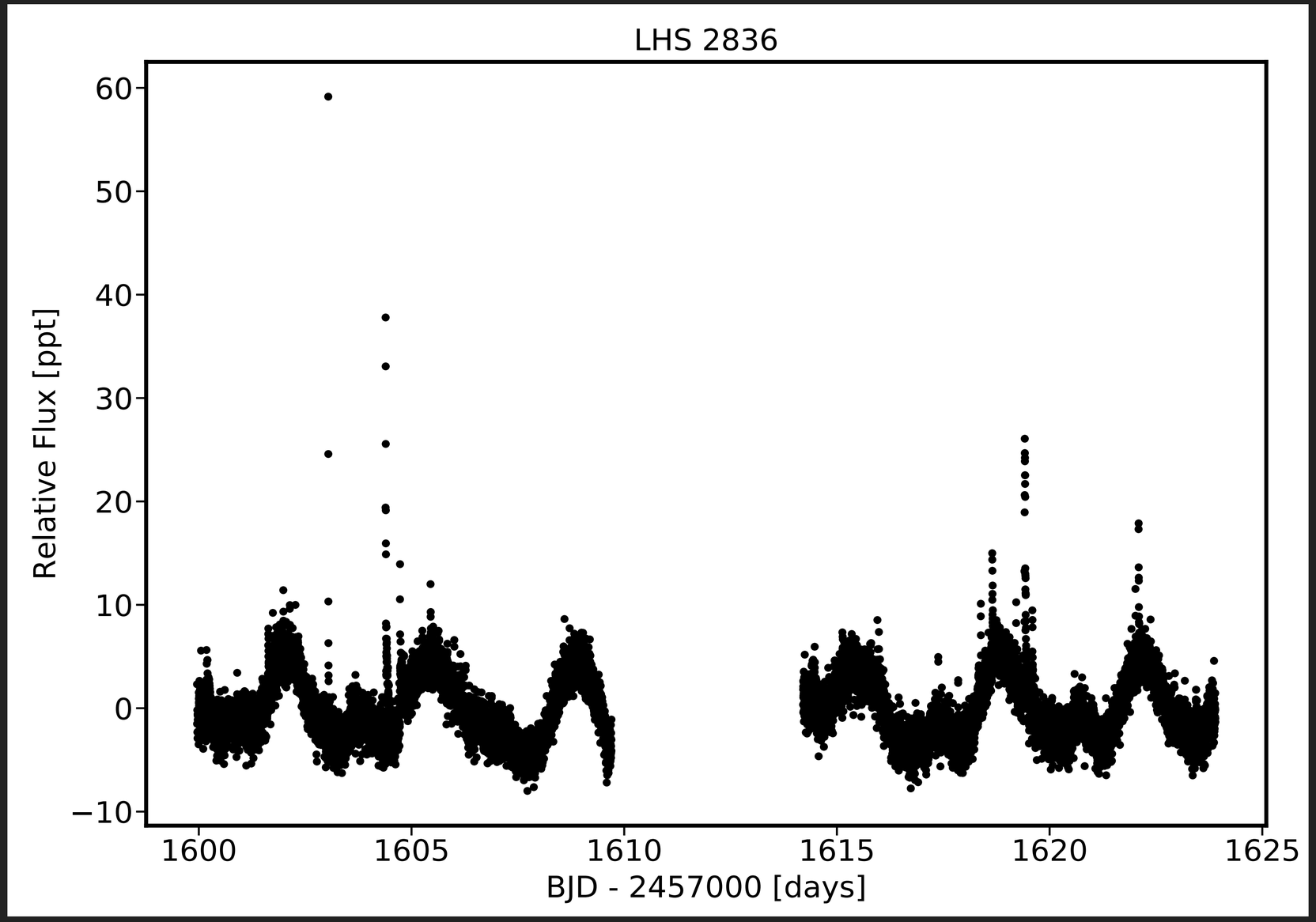
NEARBY MID-TO-LATE M DWARFS PROVIDE A RICH HUNTING GROUND FOR FLARES WITH TESS!



- **154** stars have been observed in sectors 1-12.
- **116** are single stars.
- **36** stars have a previously published rotation period.
- We measured **17** new rotation periods with TESS.

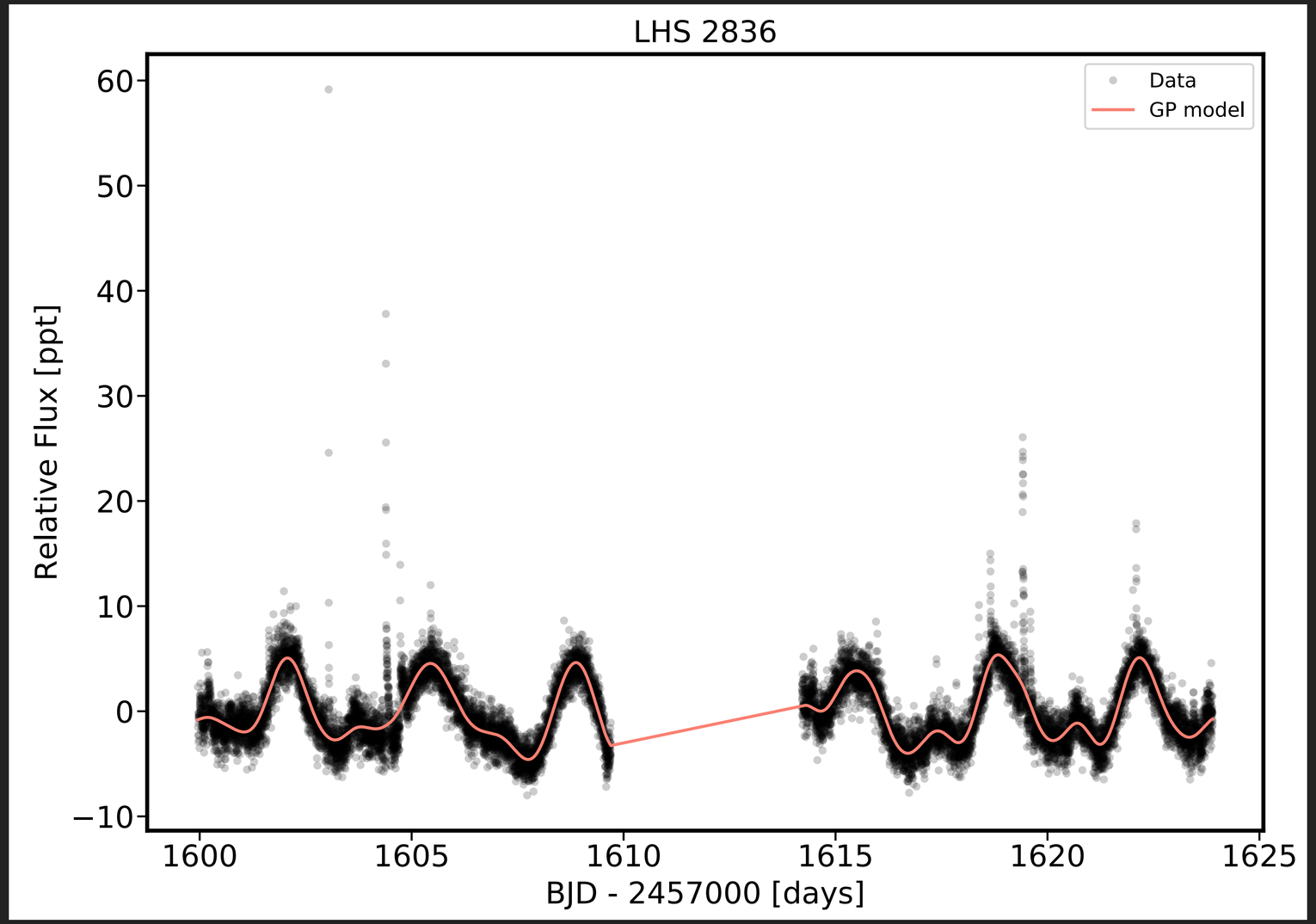
FINDING FLARES IN TESS DATA

- We use PDC TESS light curve



FINDING FLARES IN TESS DATA

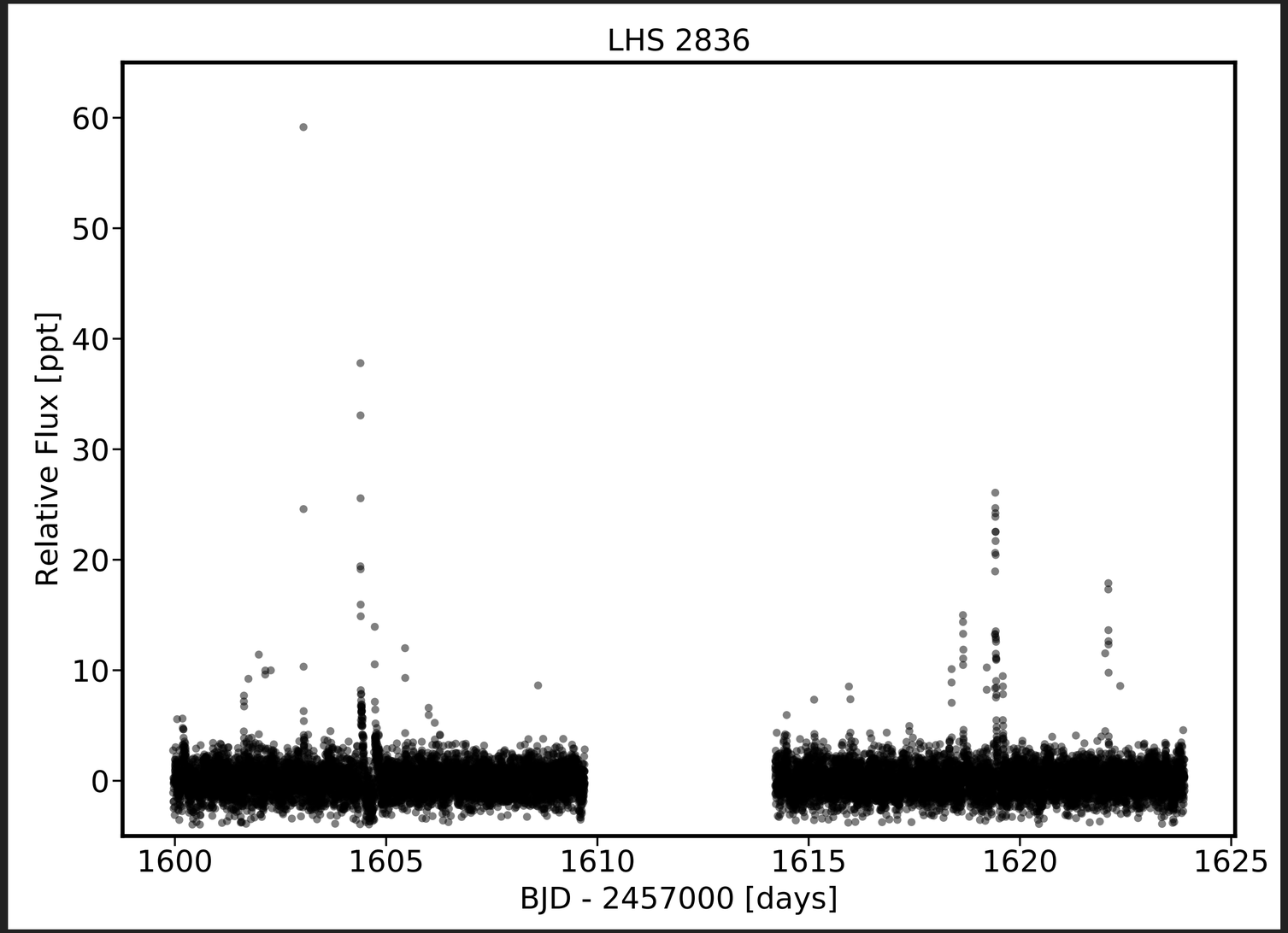
- We use a Gaussian Process model to de-trend the data.



FINDING FLARES IN TESS DATA

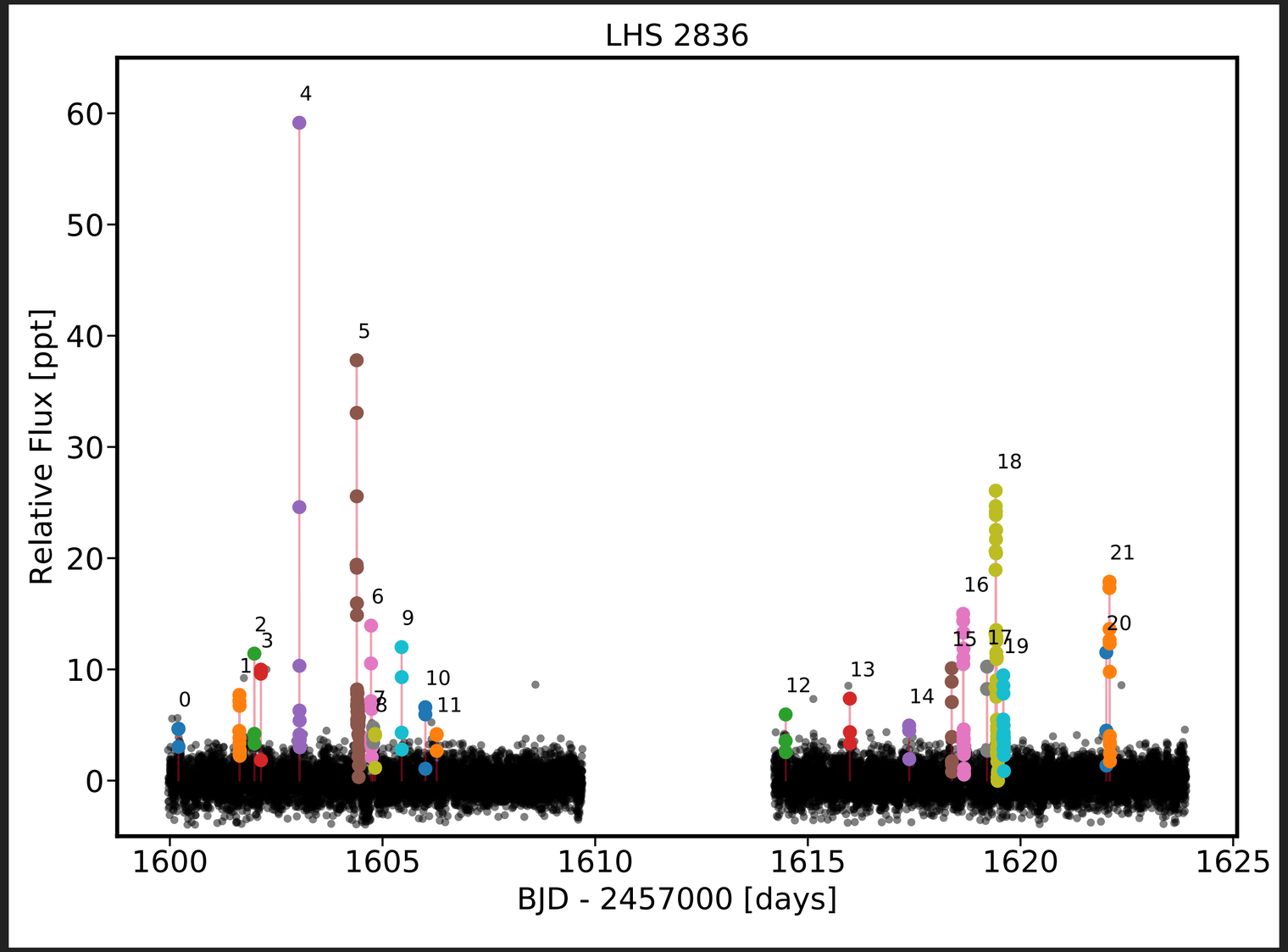
- We search for flares using the de-trended light curves.

- The flares are detected using the criteria from Chang et al. (2015)

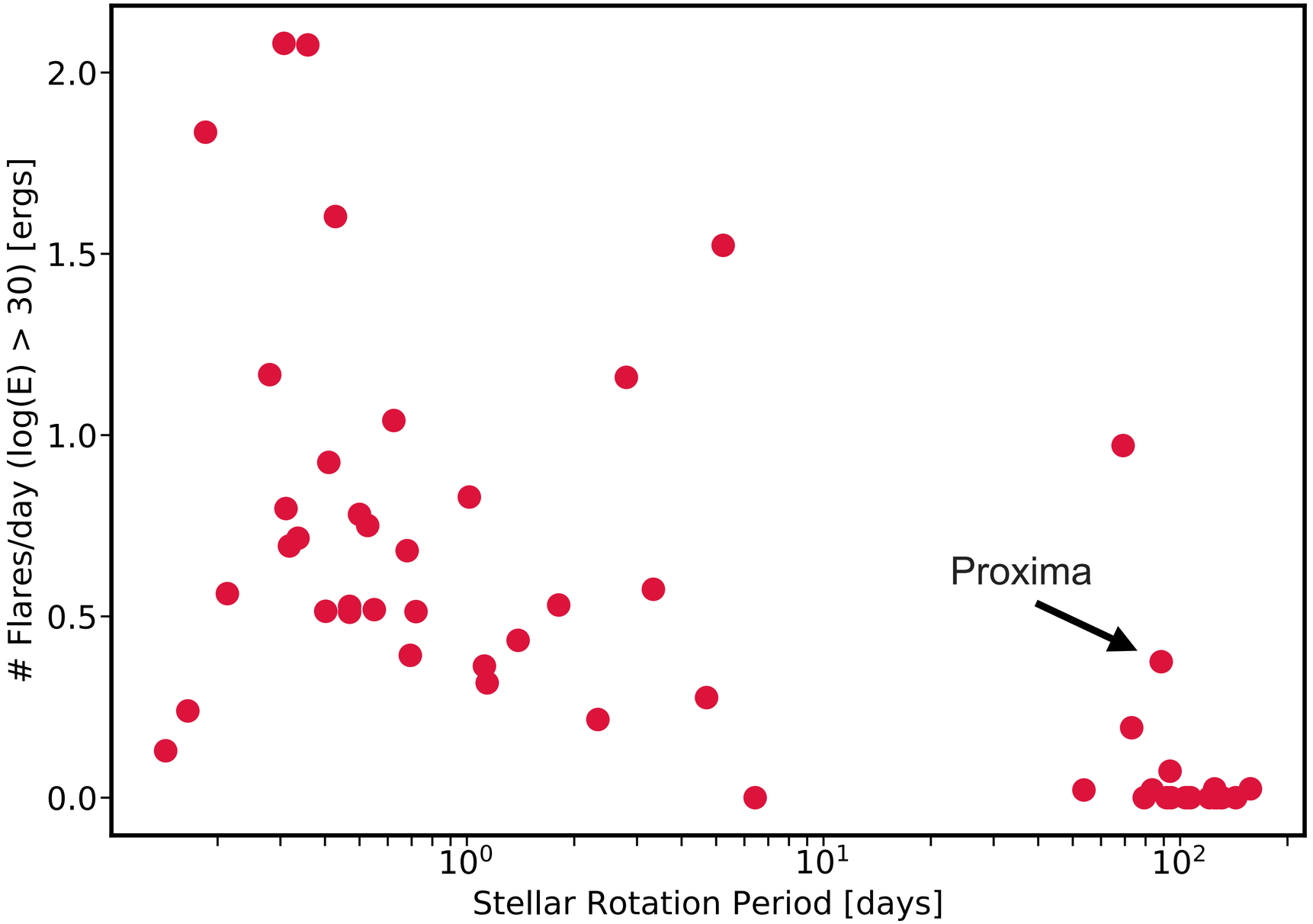


FINDING FLARES IN TESS DATA

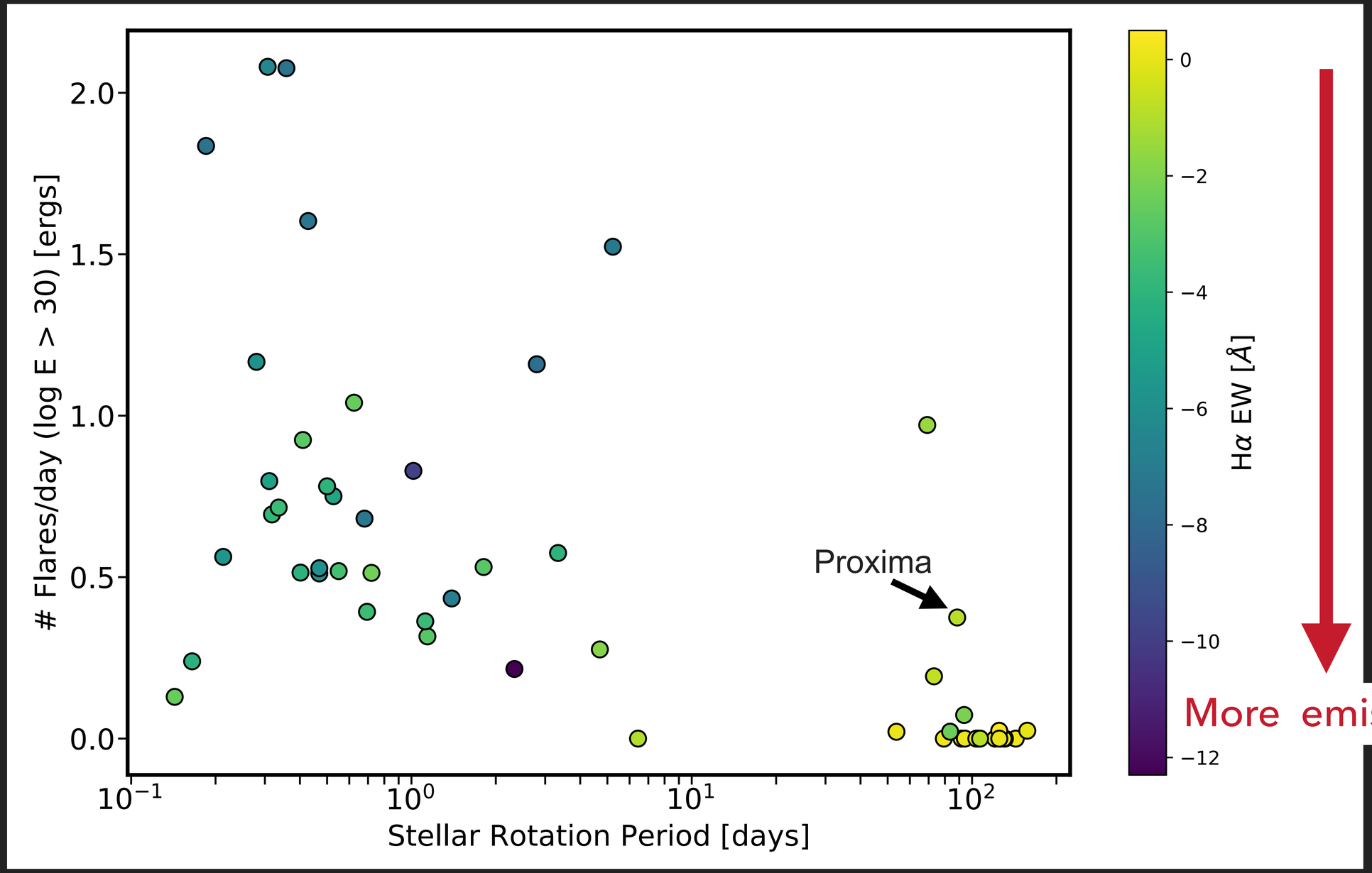
- We search for flares using the de-trended light curves.



FLARE RATES OF MID-TO-LATE M DWARFS



FLARE RATES OF MID-TO-LATE M DWARFS



SUMMARY

- We are measuring flare rates of all (0.1 - 0.3) M_{Sun} mid-to-late M dwarfs within 15 parsecs observed by TESS.
  - In sectors 1-12, 36 stars have published rotation periods.
  - We measure 17 new rotation periods.
- Stars with P_{rot} < 85 days show Hα in emission and a high rate of energetic flares. This rate does not correlate with rotation period.
- Stars with P_{rot} > 100 days show no Hα in emission and little to no energetic flares.
- More to come with continuing analysis of sectors 13-26!