

Identification of Tidal Disruption Events from the Zwicky Transient Facility

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Background

- Tidal Disruption Events (TDEs) occur when a **star passes** within the tidal radius of a **black hole and is torn apart**.
- About half of the **stellar debris** forms an accretion disk; the **rest is ejected into space**.
- TDEs typically occur **near galactic centers** containing **supermassive black holes (SMBHs)**.
- Although rare, TDEs show identifiable traits: **distinctive light-curve shapes** and **characteristic decay rates ($\sim t^{-5/3}$)**.
- Their emission is bright enough to be detected as transients by surveys such as the **Zwicky Transient Facility (ZTF)**.

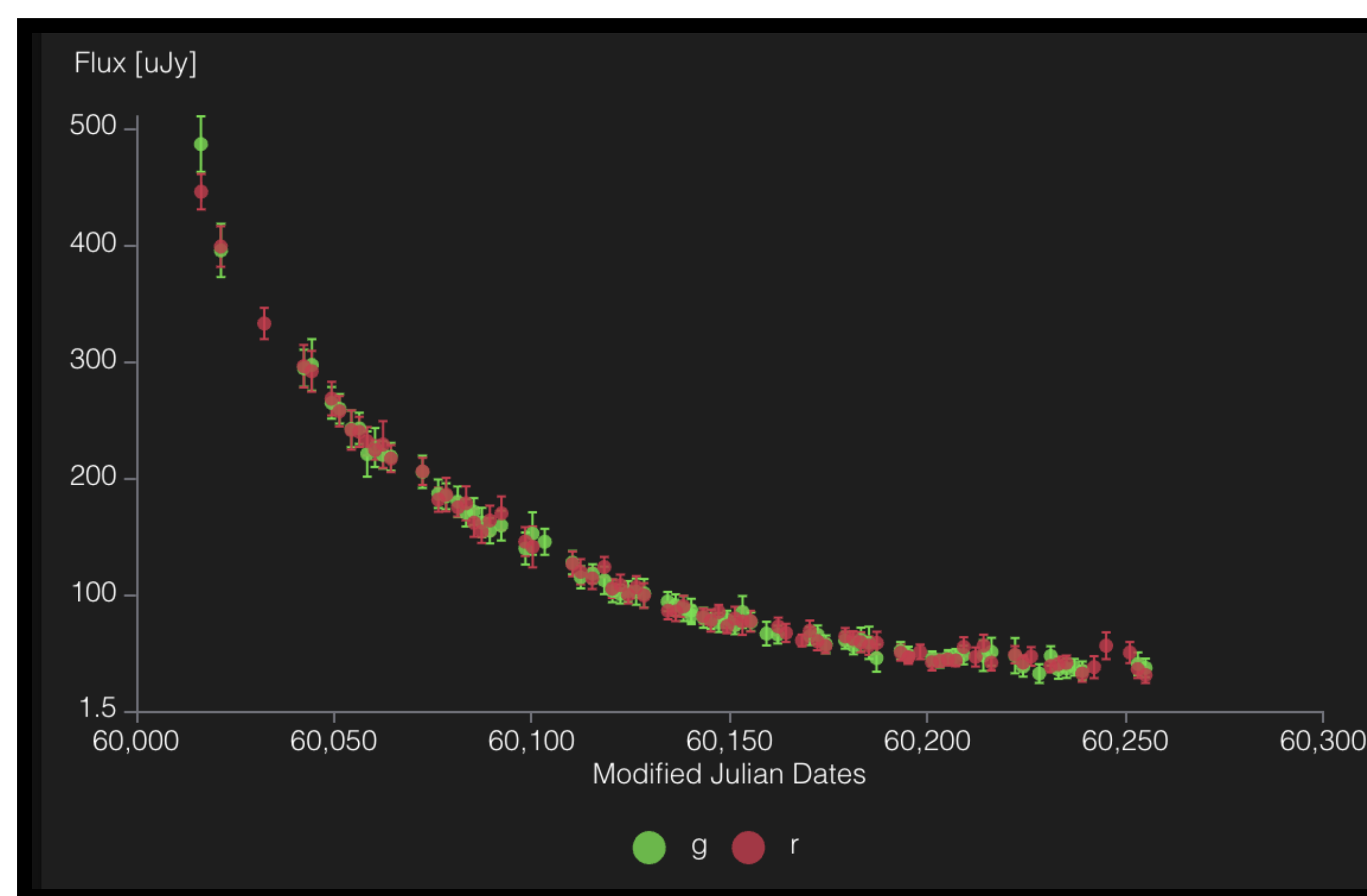


Figure 1. Identified TDE: ZTF23aadcbay

Purpose

- Develop a **filtering algorithm** to identify ZTF-recorded transients that are likely TDEs.
- Leverage **ALeRCE** and **ANTARES** brokers to obtain photometry, metadata, and classifications for each transient.
- Implement a **Scikit-learn anomaly-detection model** to score objects based on deviation from typical non-TDE behavior.
- Apply **multiple filters (light-curve quality, redshift, galactic-center offset, etc.)** to refine the candidate list.
- Test the pipeline on hundreds of ZTF objects to evaluate the effectiveness of the **combined ML + manual approach**.
- Flag a **prioritized list of candidates** suitable for further astrophysical follow-up.

Methodology

Used the following criteria to filter out our objects:

1. Number of Data points
2. Peak luminosity
3. Dates (MJD)
4. Light Curve (Best Fit)
5. Offset to Galactic Center
6. ML Model

Post-Filtering:

1. Scored the transient's performance against **filters** with **machine learning model**.
2. Looked through a select number of candidates that best fit the $t^{-5/3}$ **declination** and read through their **classifications** on **ALeRCE**
3. The ML Model uses scikit-learn and TensorFlow to run a anomaly detection model trained on 2500 "normal" events to detect TDEs as anomalies
4. We used the DELIGHT framework(see GitHub in references) to run a Computer Vision Host Galaxy classification and an **offset(in arcsec)** calculation.
5. We used the **Alerce catsHTM** cross matching to obtain redshift values to calculate Peak luminosity using the **Distance Modulus relation**. Note: redshift is only available rarely(**10% of times**) due to added step of **spectroscopy** that needs to be conducted on an event.

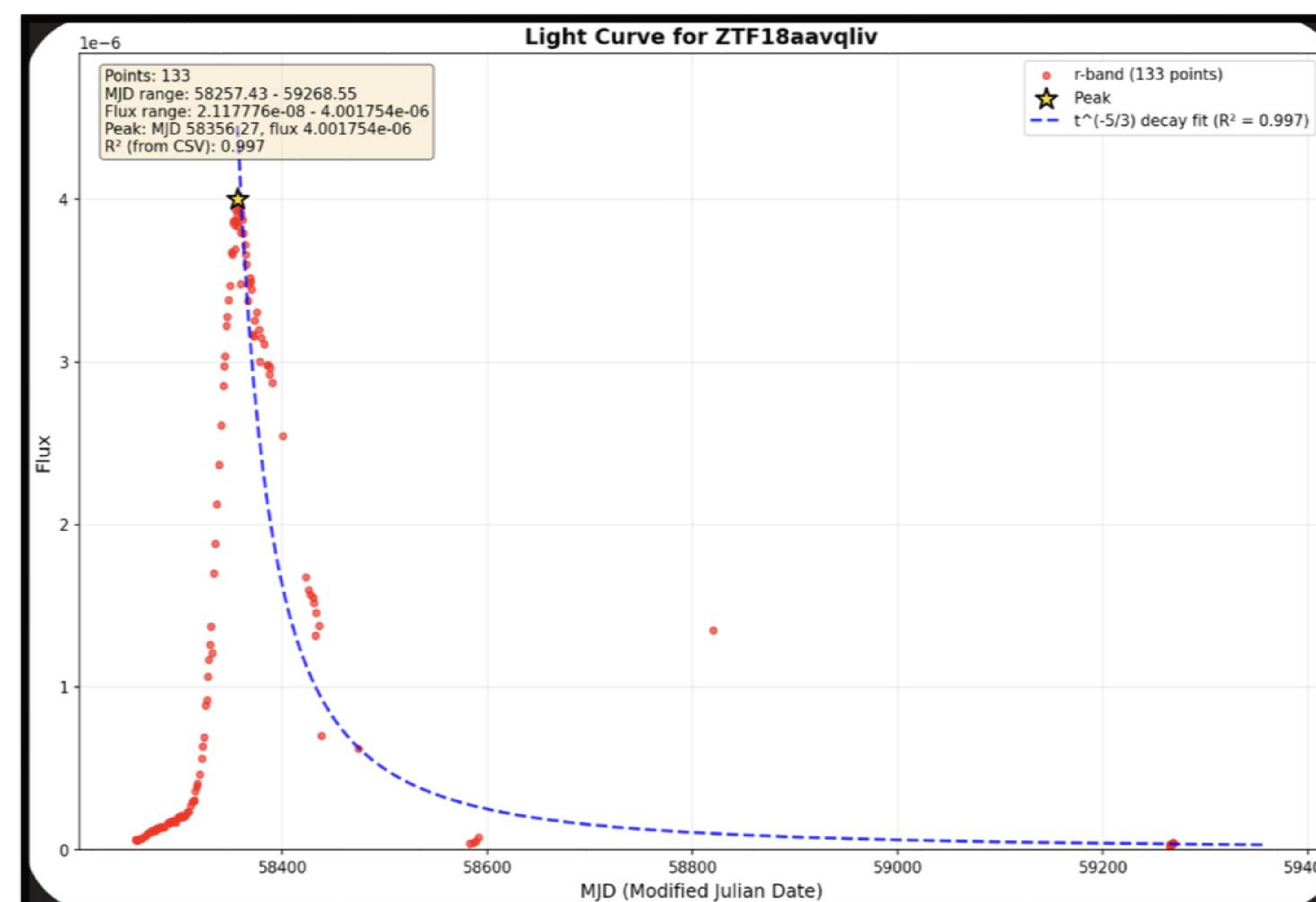


Figure 2. Light Curve for ZTF18aavqliv with a peak and fall off

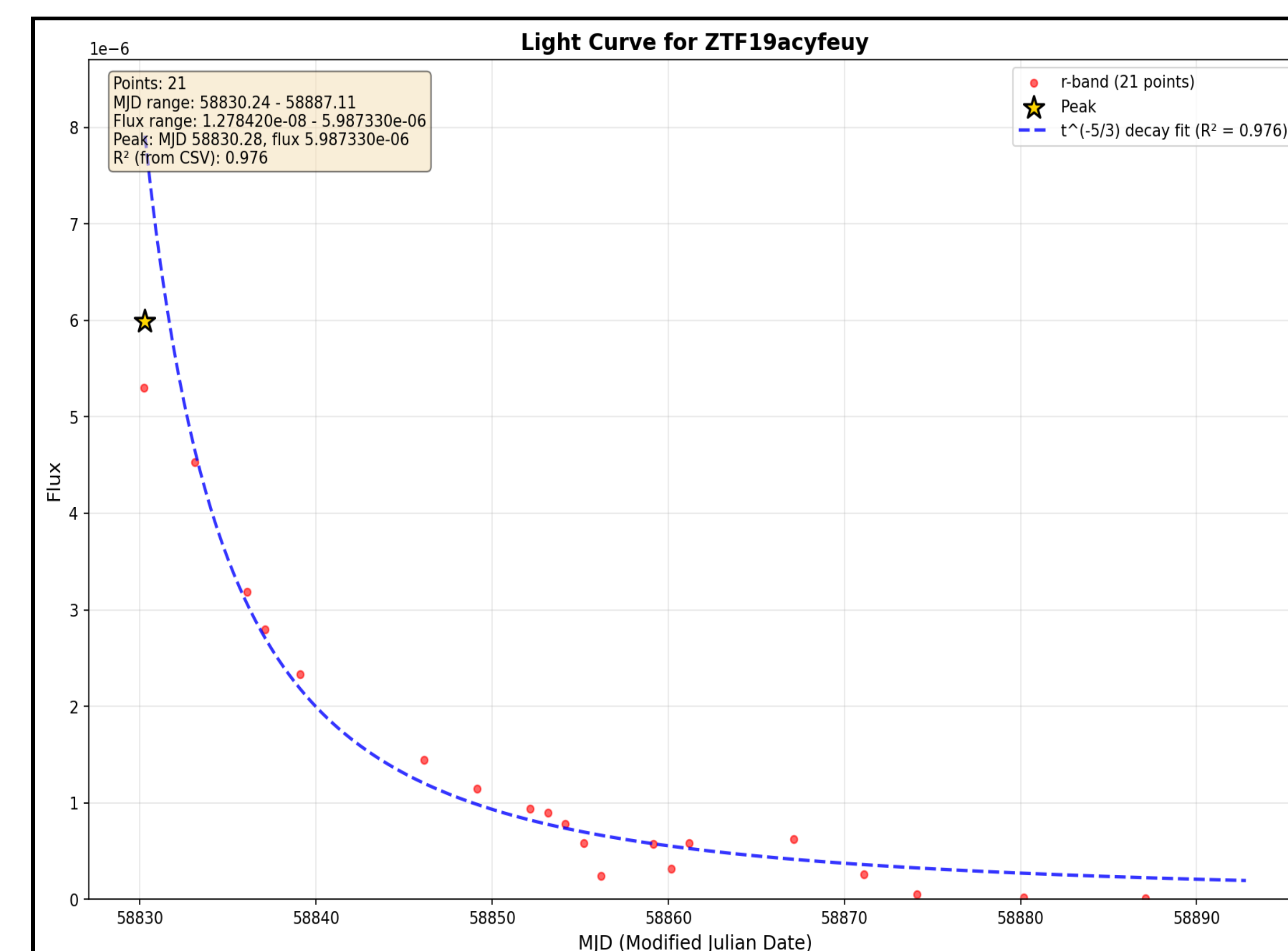


Figure 3. Light Curve for ZTF19acyfeuy following the $t^{-5/3}$ decay fit

Results and Further improvements

- Filtering algorithm successfully **identified 24 transients** showing **TDE-like characteristics**.
- Most promising candidates: **ZTF19acyfeuy, ZTF17aaadasj, ZTF19abydbvw, ZTF18aaqxfg, ZTF18aavqliv**
- Current approach **reduced noise** and improved **candidate selection effectiveness**.
- Future improvements:
 - Apply more **restrictive filters** to reduce false positives, particularly with variable stars.
 - Use **AI-driven noise reduction** to support classical regression models.
 - **Expand dataset** and **refine anomaly-detection thresholds** for higher accuracy.
 - **Filtering for variable stars**, using noise reduction and using "fluctuation detection" models.
- After further investigation through online databases, we unfortunately found that **none of our candidates were actual classified TDEs**. Our most promising candidate, ZTF18aavqliv, ended up being a variable star. However, this candidate did follow the $t^{-5/3}$ falloff rate that TDEs do, with an R^2 of 0.997, which shows promise that even **this filtering algorithm is indeed capable of detecting actual TDEs**.

References

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