

The background of the slide is a dynamic, abstract painting. It features a central, dark, circular void, reminiscent of a black hole or a deep well. This center is surrounded by concentric, swirling bands of color. The innermost rings are bright yellow and orange, transitioning through green and cyan to deep, rich blues as they move outwards. The brushstrokes are visible and energetic, creating a sense of movement and depth. The overall effect is that of a cosmic vortex or a nebula captured in a moment of intense energy.

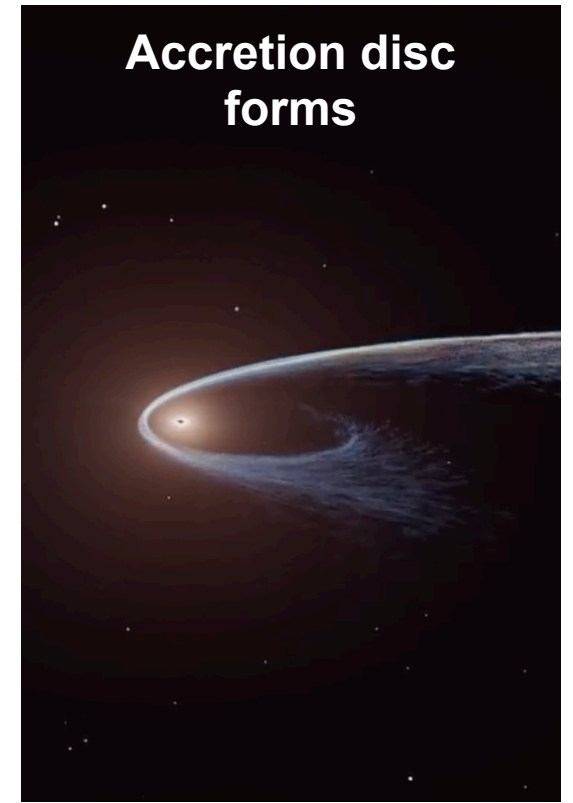
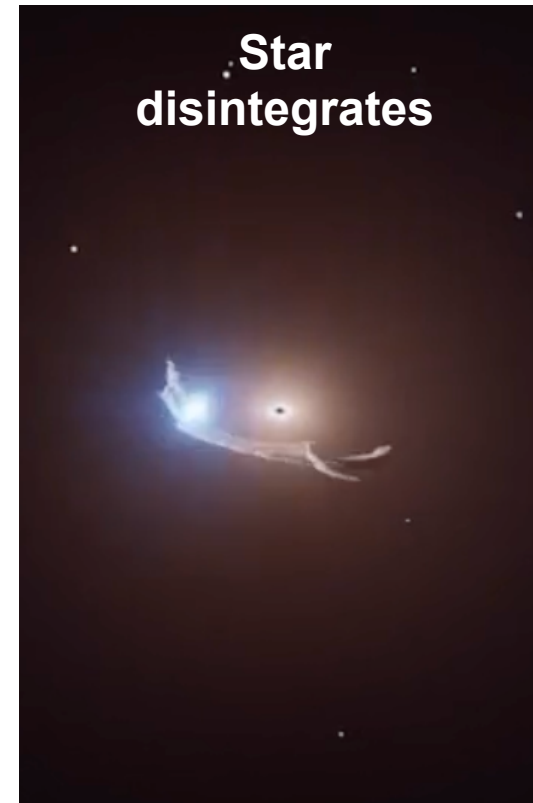
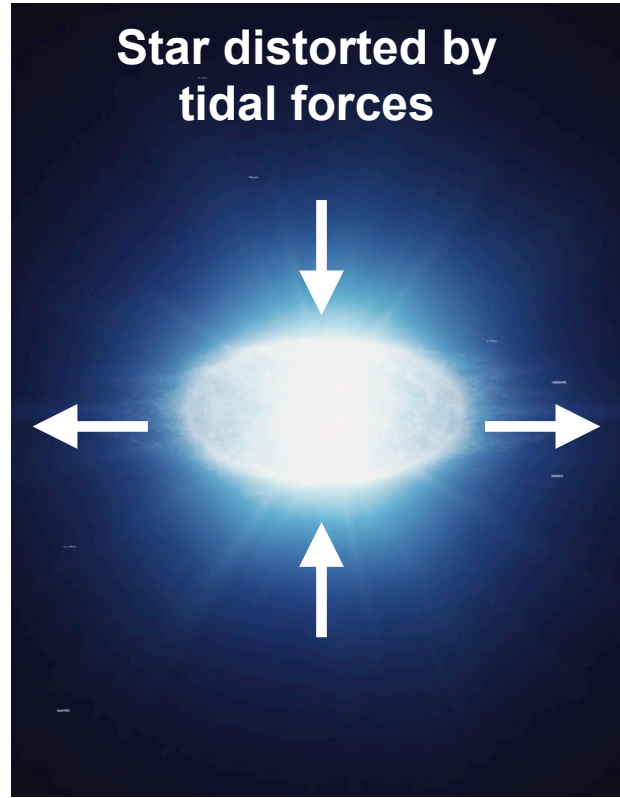
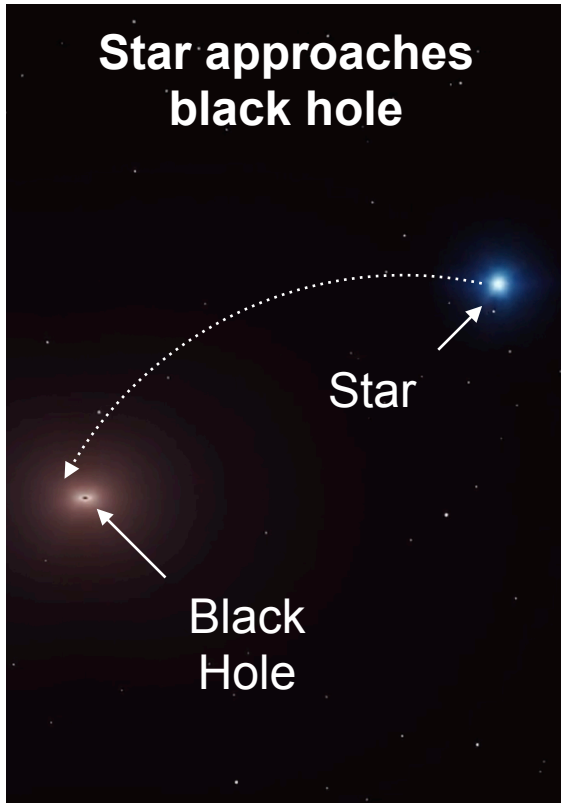
tdescore

Robert Stein
Transient and Variable Universe
June 21st, 2023

Image credit: Dall-e

A brief introduction to TDEs

What are TDEs?



1

2

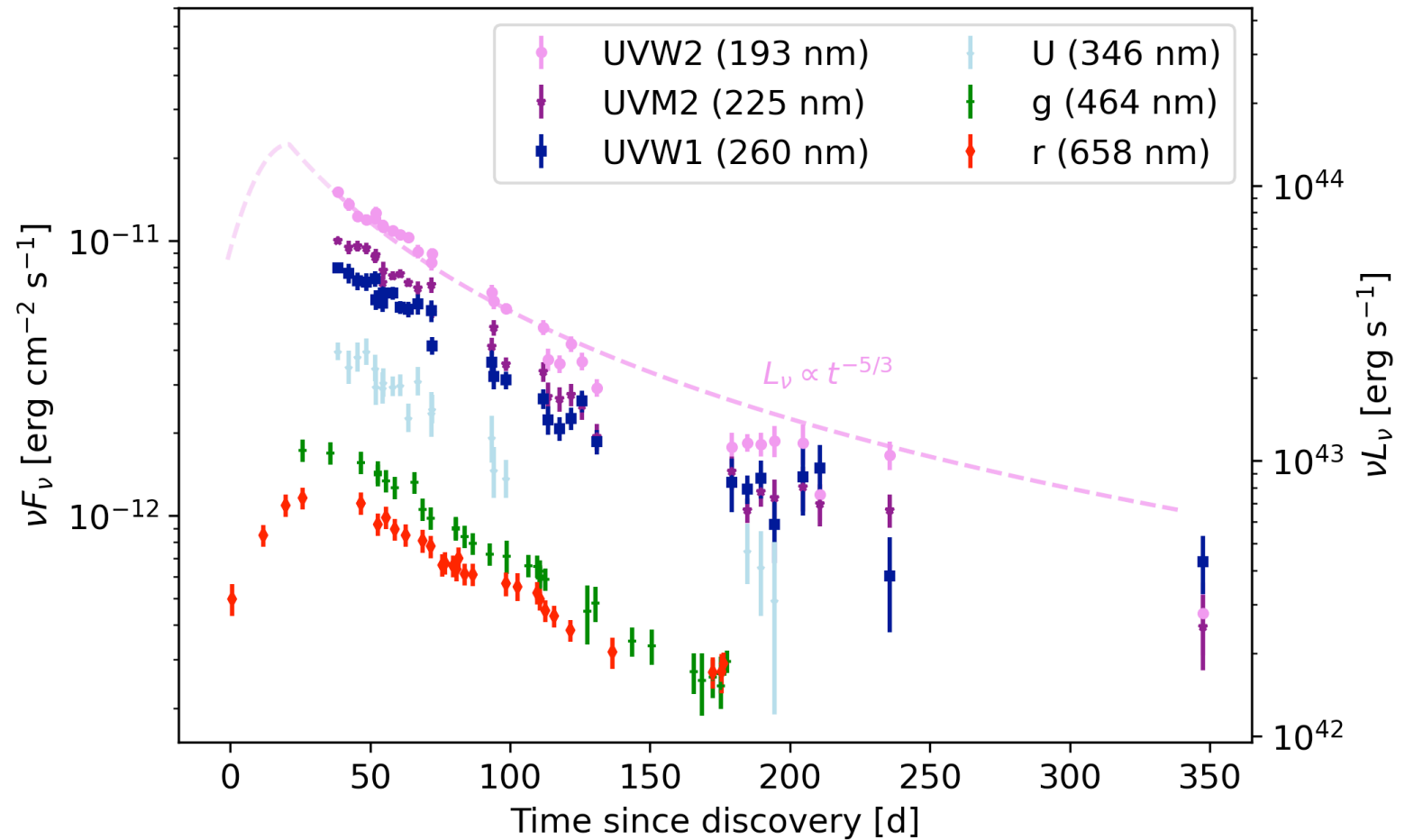
3

4

What are TDEs? - An empirical definition

TDEs are (to first order):

- nuclear flares
- Intrinsically hot/blue
- rise over a period of ~weeks
- and then fade over months
- with little apparent cooling



The TDE Explosion



1 TDE
per month

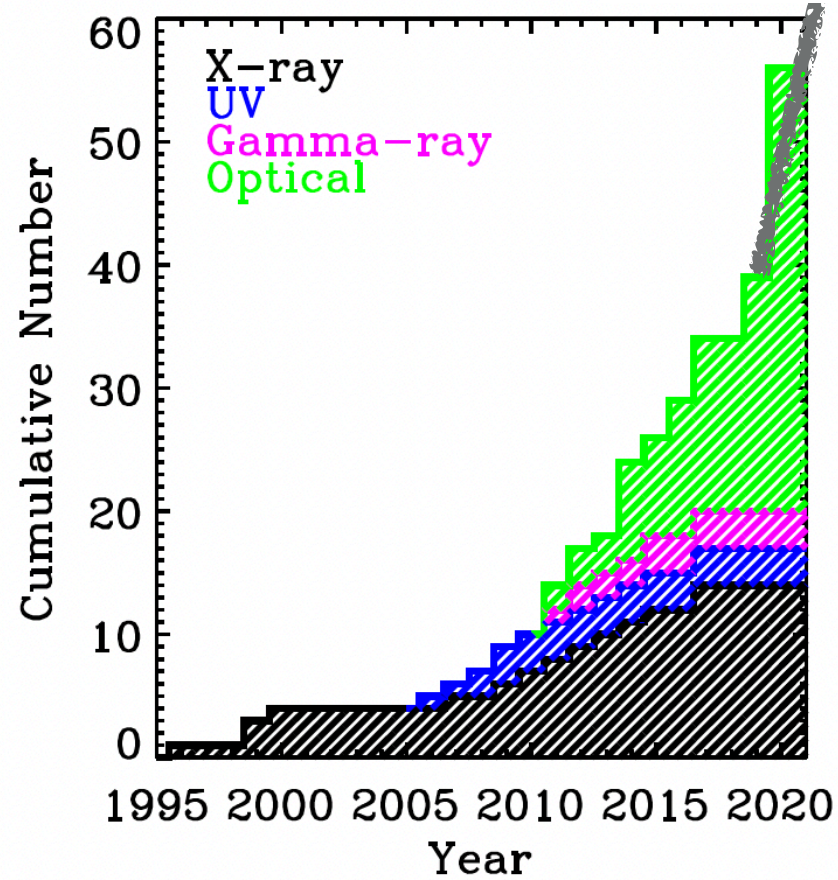
ATLAS

Pan-STARRS

ZTF

ASAS-SN

Gaia



Gezari (2021)

<https://doi.org/10.1146/annurev-astro-111720-030029>

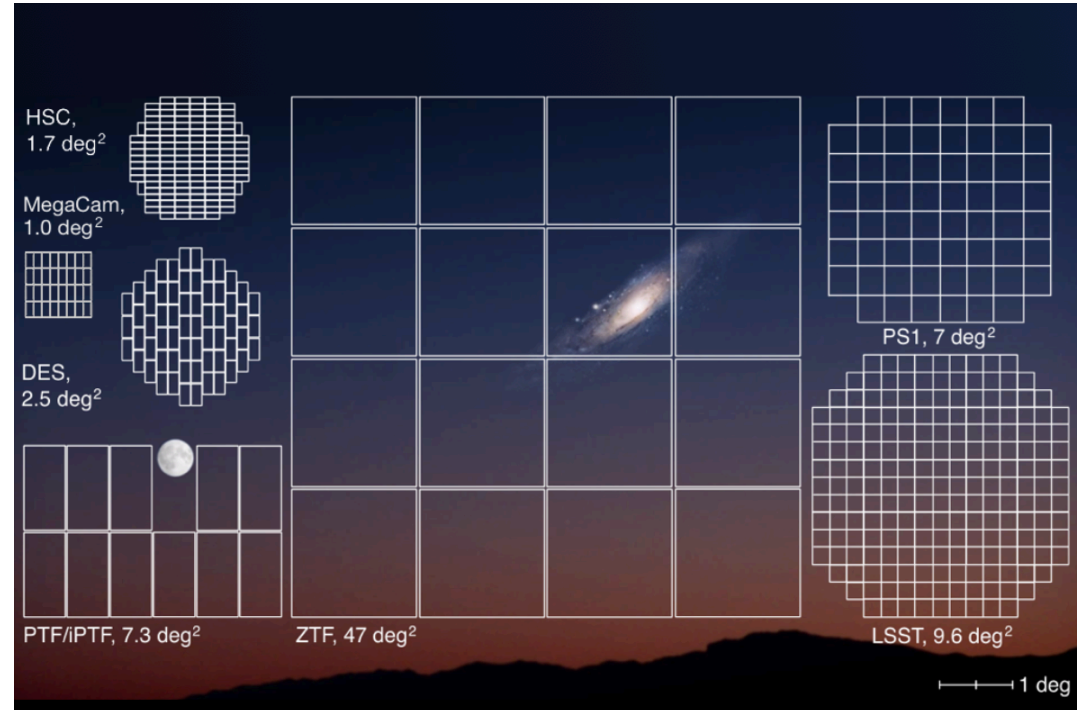
The ZTF TDE Program

Introducing the Zwicky Transient Facility (ZTF)

Credit: Iair Arcavi



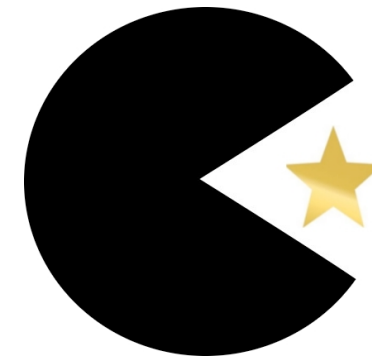
Credit: Joel Johansson



ZTF is an optical telescope with a 47 sq. deg. field of view

ZTF surveys the entire northern sky every 2 nights, in g+r, as part of a public survey

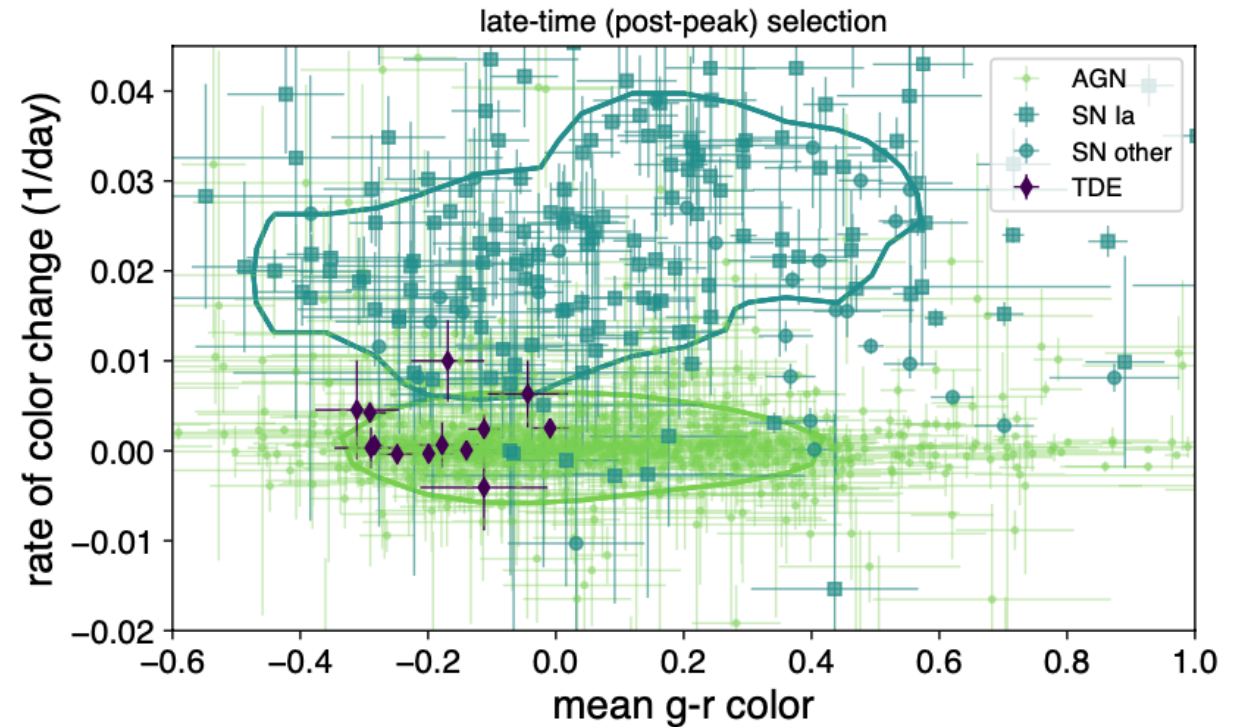
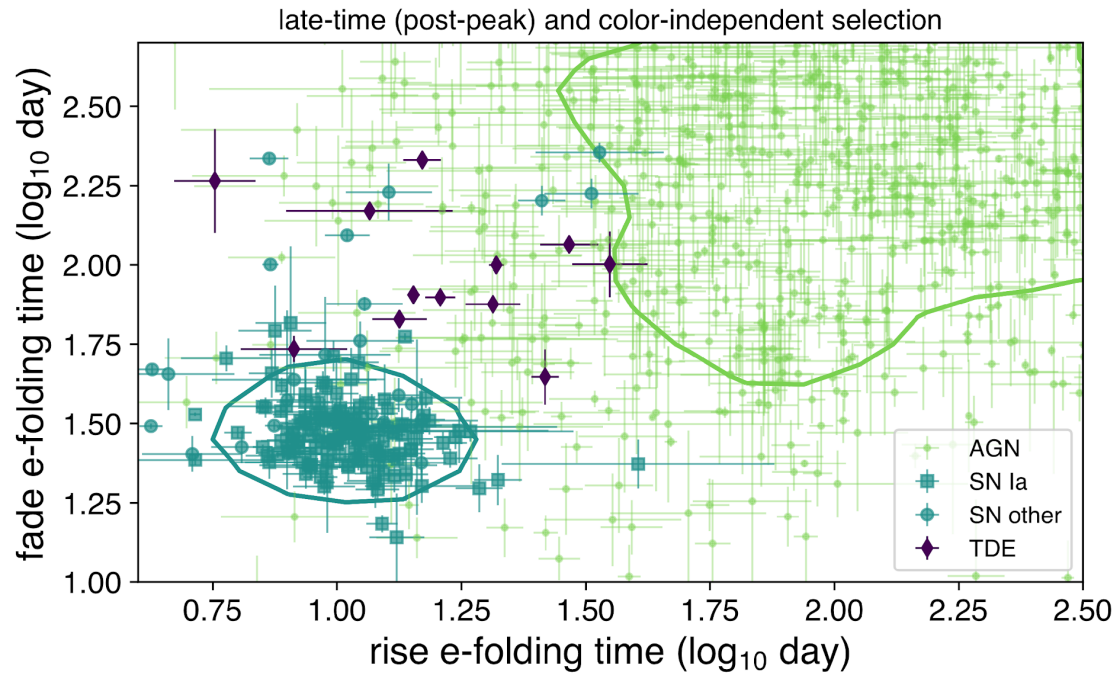
The ZTF TDE program



“No TDE left behind”
- since 2018

The ZTF TDE program

van Velzen et al. 21



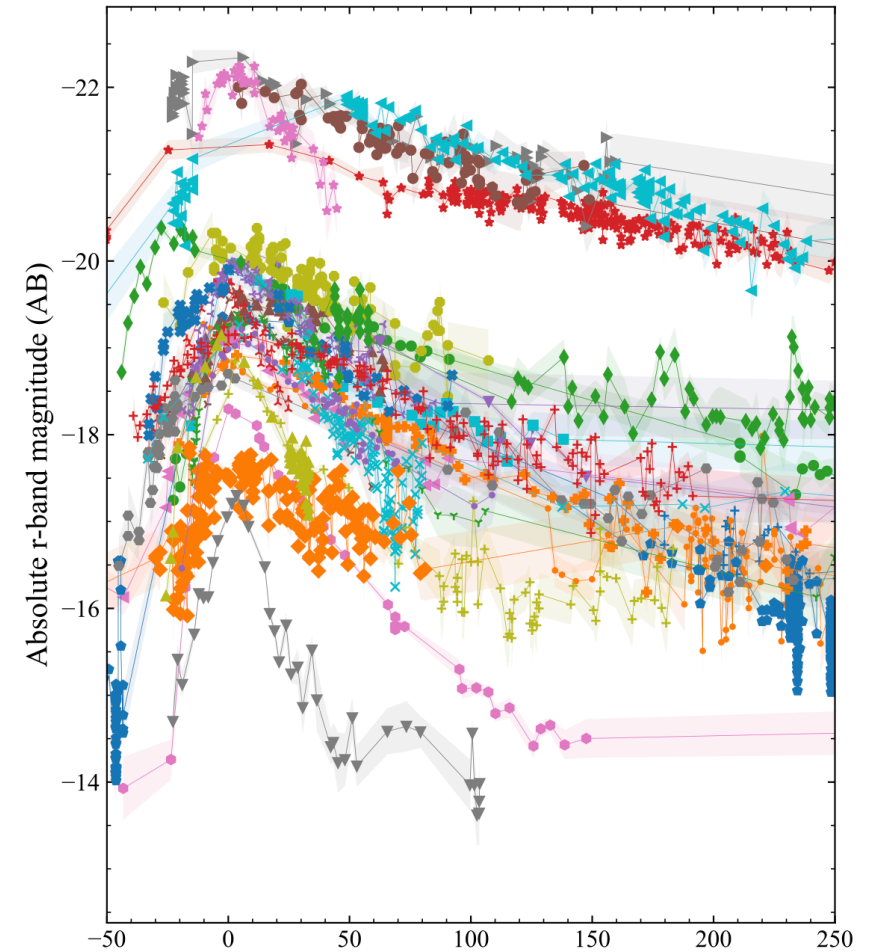
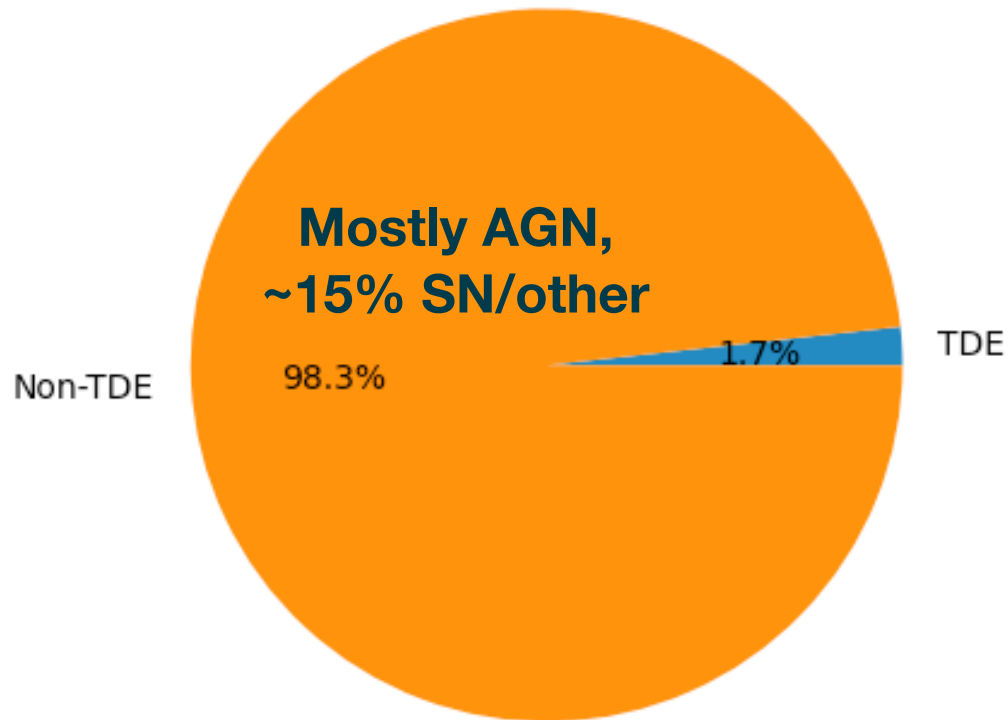
ZTF has a systematic program to identify and classify nuclear transients

~11000 sources passed latest iteration of filter (Reusch et al. in prep), after which we do mag-based census

The ZTF Nuclear Sample

Hammerstein et al. 23

ZTF Nuclear Transients



ZTF has high-cadence two-band coverage of ~80 TDEs

Also have an extensive sample of TDE imposters, among ~5000 classified sources

TDEs with Rubin: from dozens to thousands?

With multi-colour light curves and exquisite depth with TDE-appropriate cadence, Rubin should soon start detecting thousands of TDEs

However, mass spectroscopic classification programs will not be feasible



Credit: Gianluca Lombardi

The solution?

Tinkering With ChatGPT, Workers Wonder: Will This Take My Job?

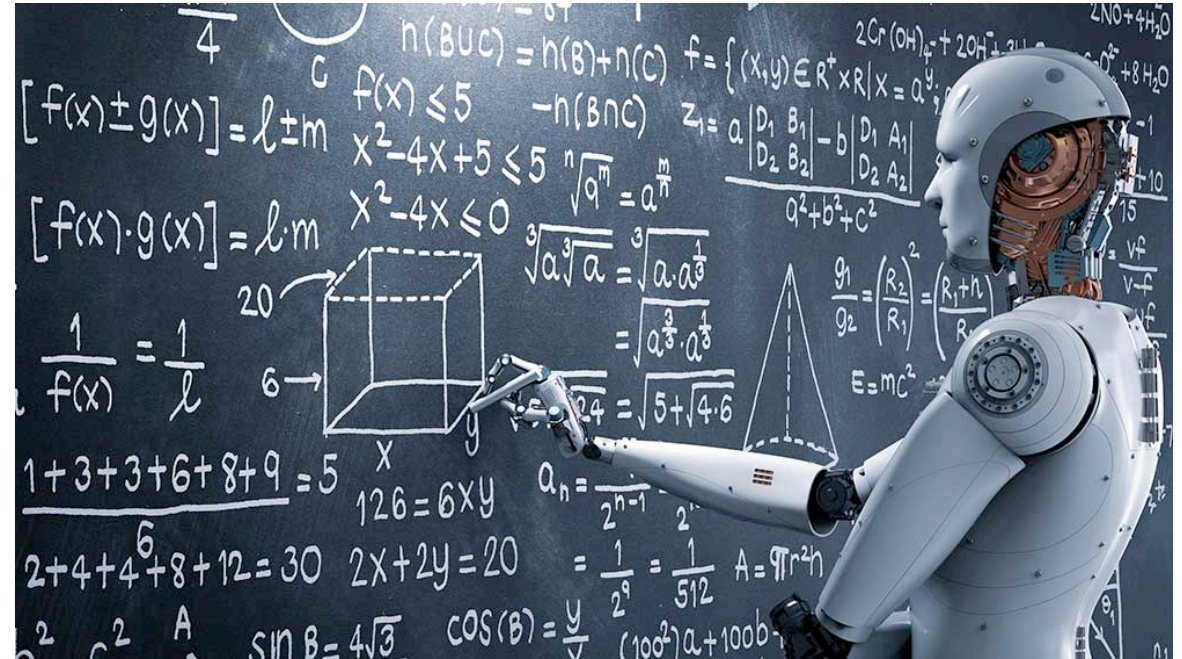
Artificial intelligence is confronting white-collar professionals more directly than ever. It could make them more productive — or obsolete.

NYT, March 28, 2023

Automating astronomy

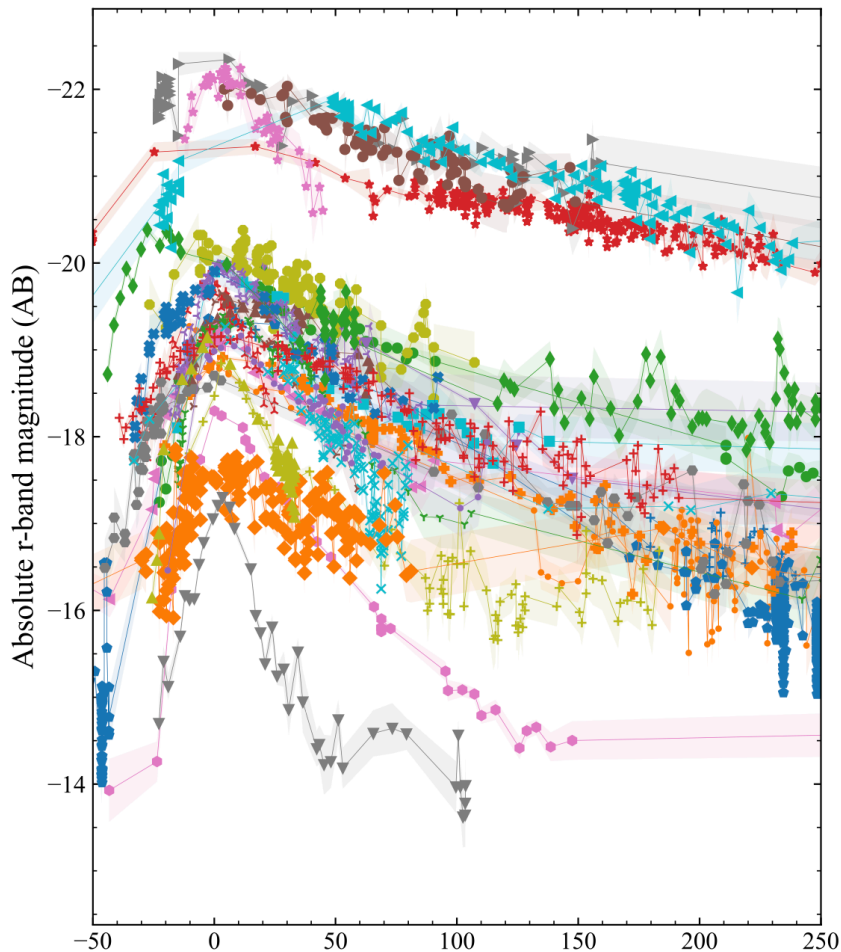
Replacing astronomers with AI: a three step guide

1. Make problem “machine-readable”
2. Develop ML model tailored to problem
3. Train, test, deploy



Step 1: Make the ZTF data “machine-readable”

Hammerstein et al. 23

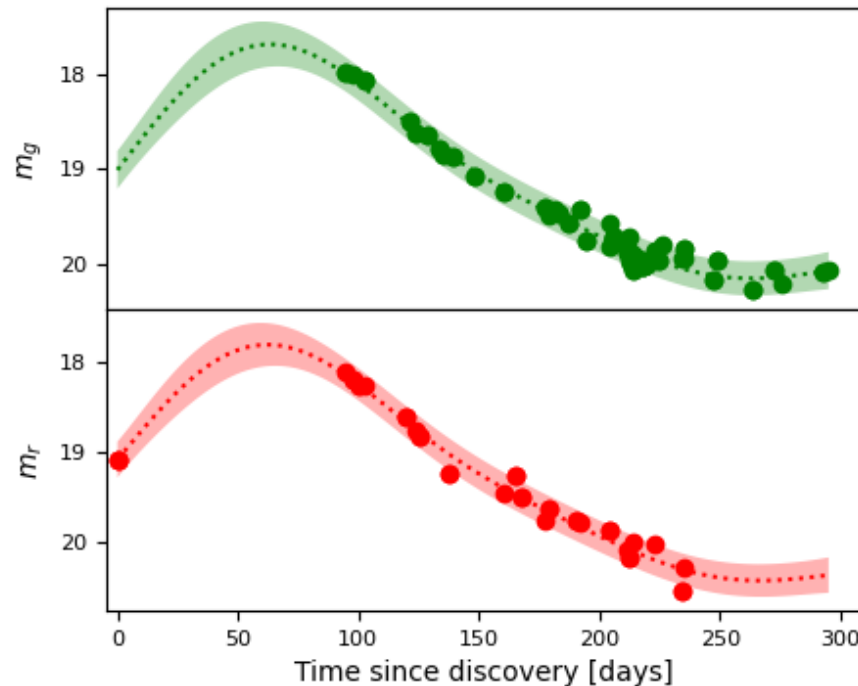


~5000 classified nuclear sources from ZTF



Use Gaussian Process with linear colour evolution

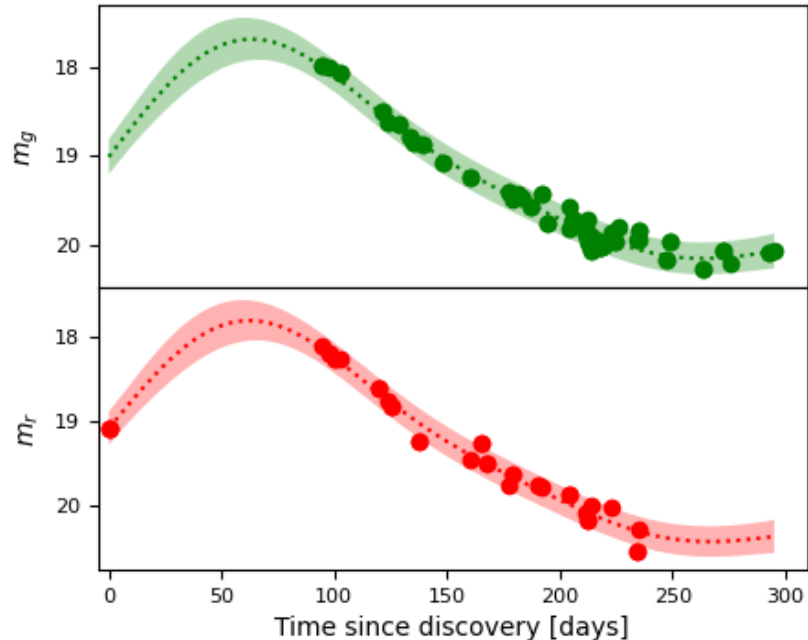
ZTF20achpcvt (Tidal Disruption Event)



Interpolated light curves for thousands of sources

Step 1: Make the ZTF data “machine-readable”

ZTF20achpcvt (Tidal Disruption Event)

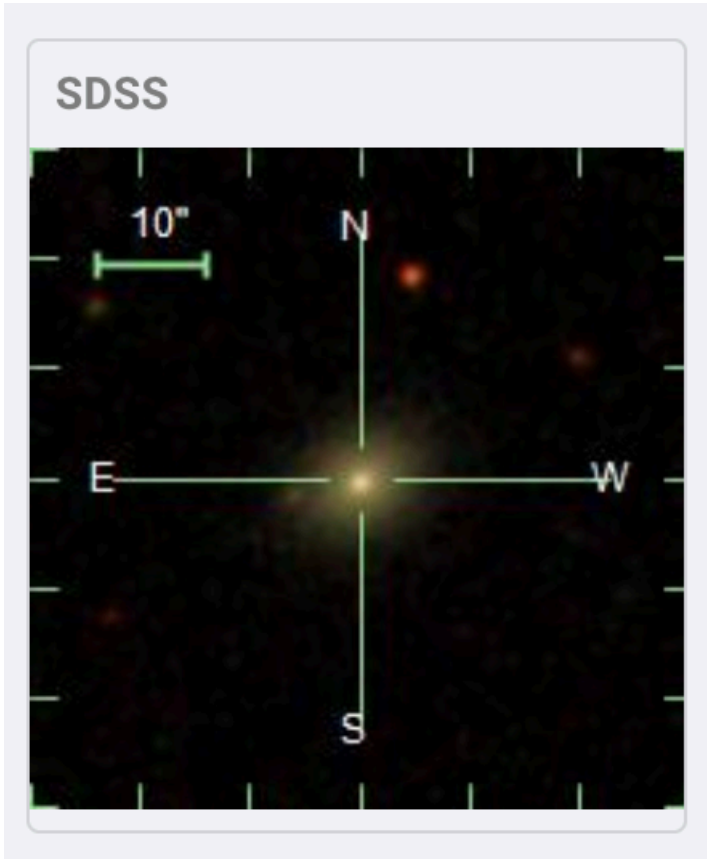


Score: 0.98, Length Scale: 72.62 days, Y Scale: 1.80
pre-peak lightcurve has 0 inflection points, rise = 36.6 d
post-peak lightcurve has 1 inflection points, fade = 41.4 d
Color at peak: -0.12 mag, color grad: -0.75 milli-mag/day
n_det: 117, density = 2.52 days between detections

- With the gaussian process fits:
 - Extract peak
 - Extract rise time/fade time (peak-0.5 mag)
 - Extract peak colour, and colour gradient
 - Count inflection points (pre, post) - AGN are bumpy
 - Score - How well the model can capture data
 - Y scale/amplitude increase

For fun:
SNcosmo fit as a proxy for Ia-ness

Step 1: Make the ZTF data “machine-readable”



- **Data from crossmatch:**
 - **WISE host colours**
 - **PS1 host colours**
 - **Milliquas**
- **Info from the ZTF alerts themselves:**
 - **star galaxy score,**
 - **Distance to host**
 - **fraction of positive detections**

Ultimately have ~50 TDEs with well-sampled rise/fade/colour and all relevant crossmatches, alongside ~2500 other nuclear transients

Step 2: Tailor ML solution to specific problem

The problem:

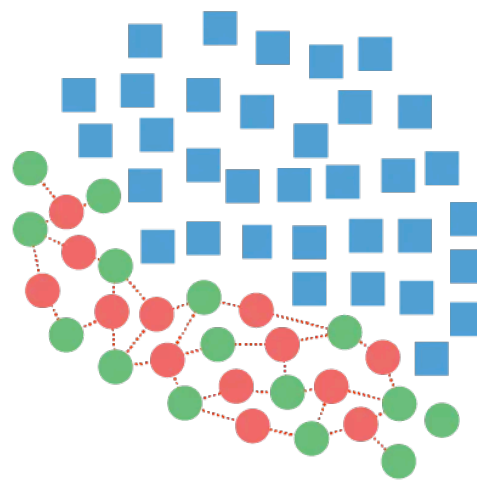
$f(x) = \text{"Not TDE"}$ -> Will be ~98.5% accurate

The solution:

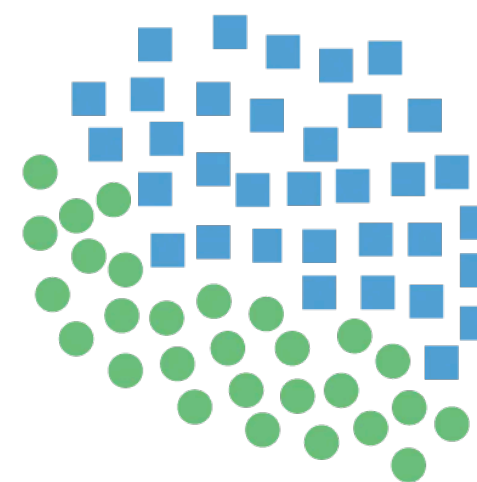
Synthetic Minority Oversampling Technique



Original Dataset



Generating Samples



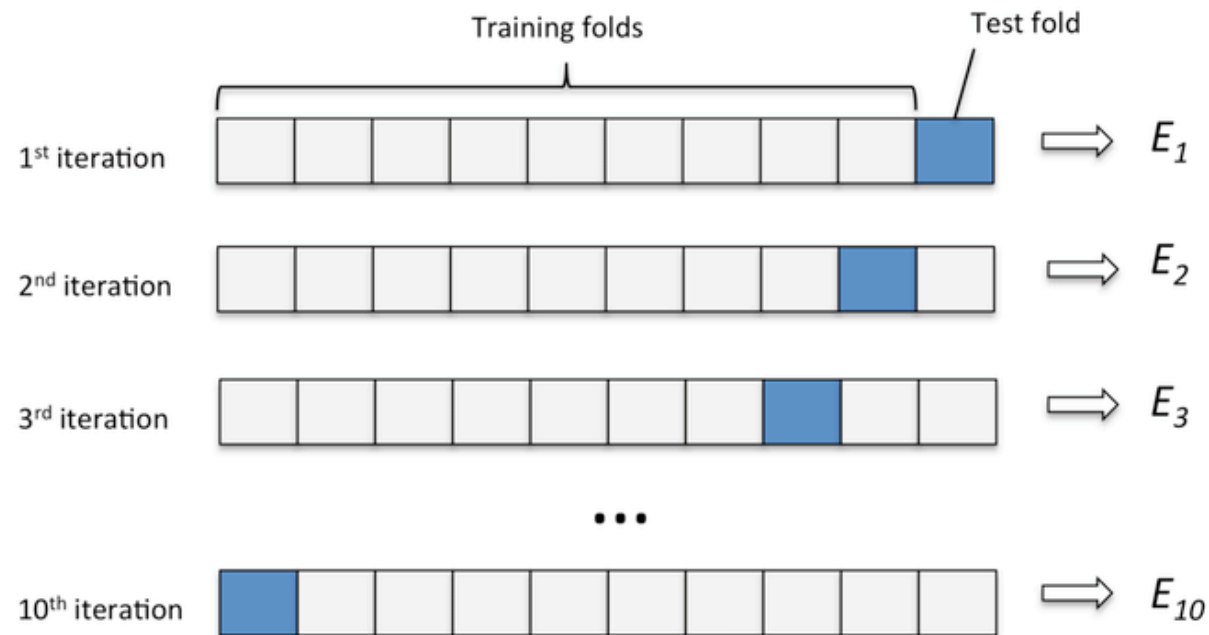
Resampled Dataset

Credit: Y Charfaoui

“tdescore”

Step 3: An ML architecture for photometric classifier

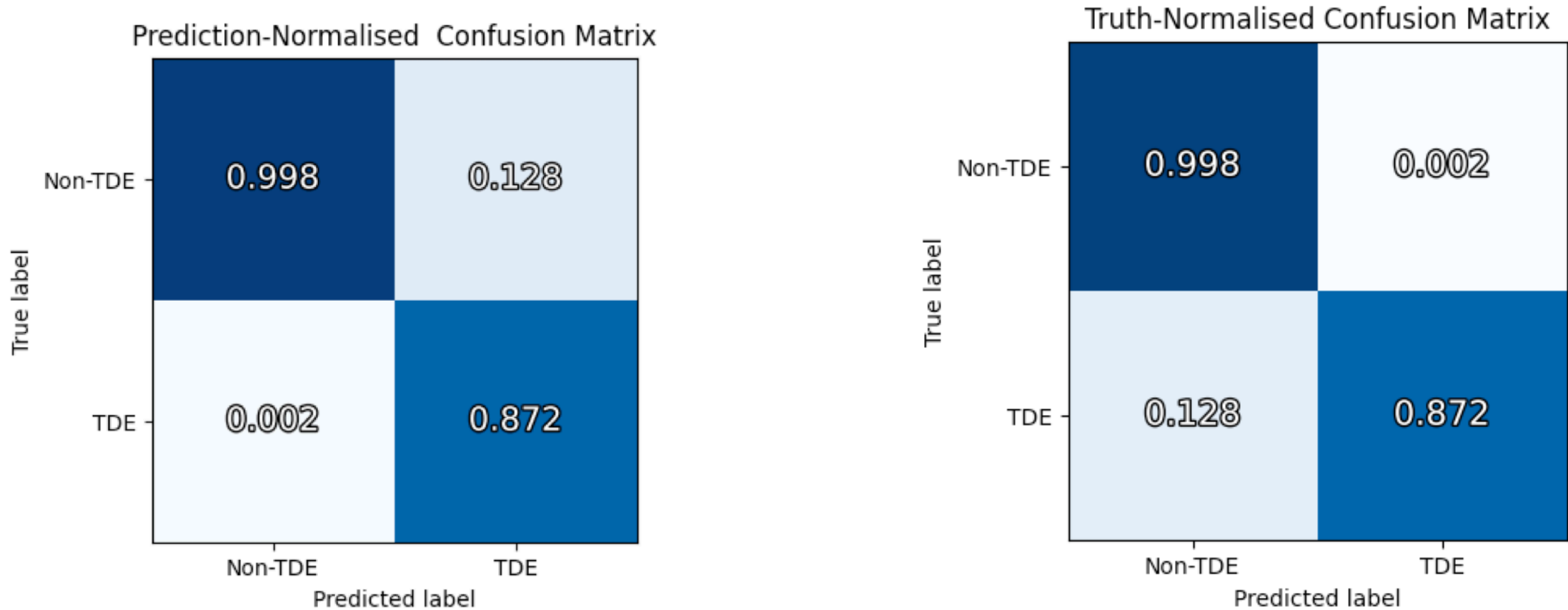
- Our problem is not particularly complicated
 - Use a simple “XGBoost” classifier
- Only a handful of TDEs in total, and no reliable simulation method for lightcurves
 - Use k-fold cross validation to measure performance (“leave one out method”)
- Small dataset (5000 sources)
 - Do not heavily optimise hyper parameters to avoid overtraining



See <https://github.com/robertdstein/tDESCORE>

Credit: K Rosaen

The result: an accurate photometric classifier



Rejects non-TDEs with 99.8% efficiency

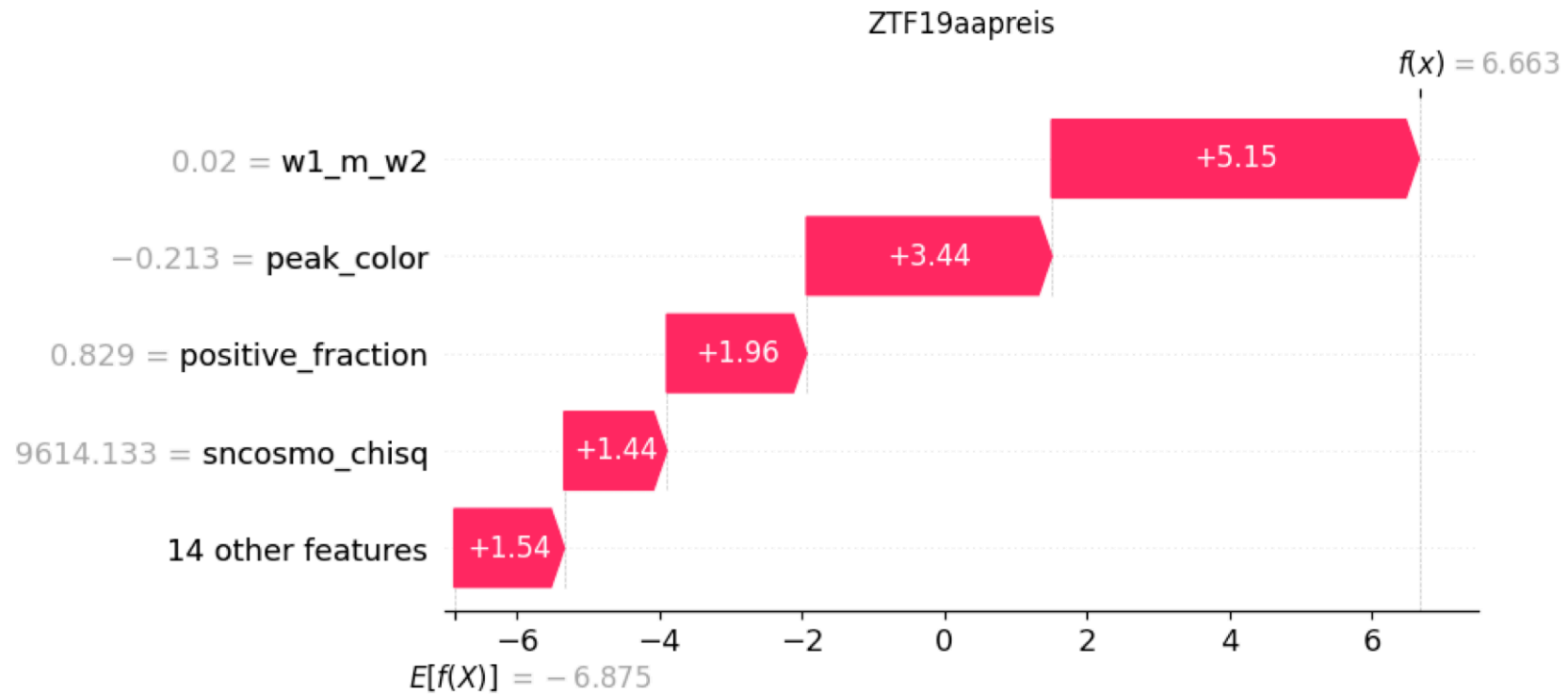
Yields very pure (>80%) sample of TDEs

Explainable AI

Which you can argue with!

Real TDE gets high score

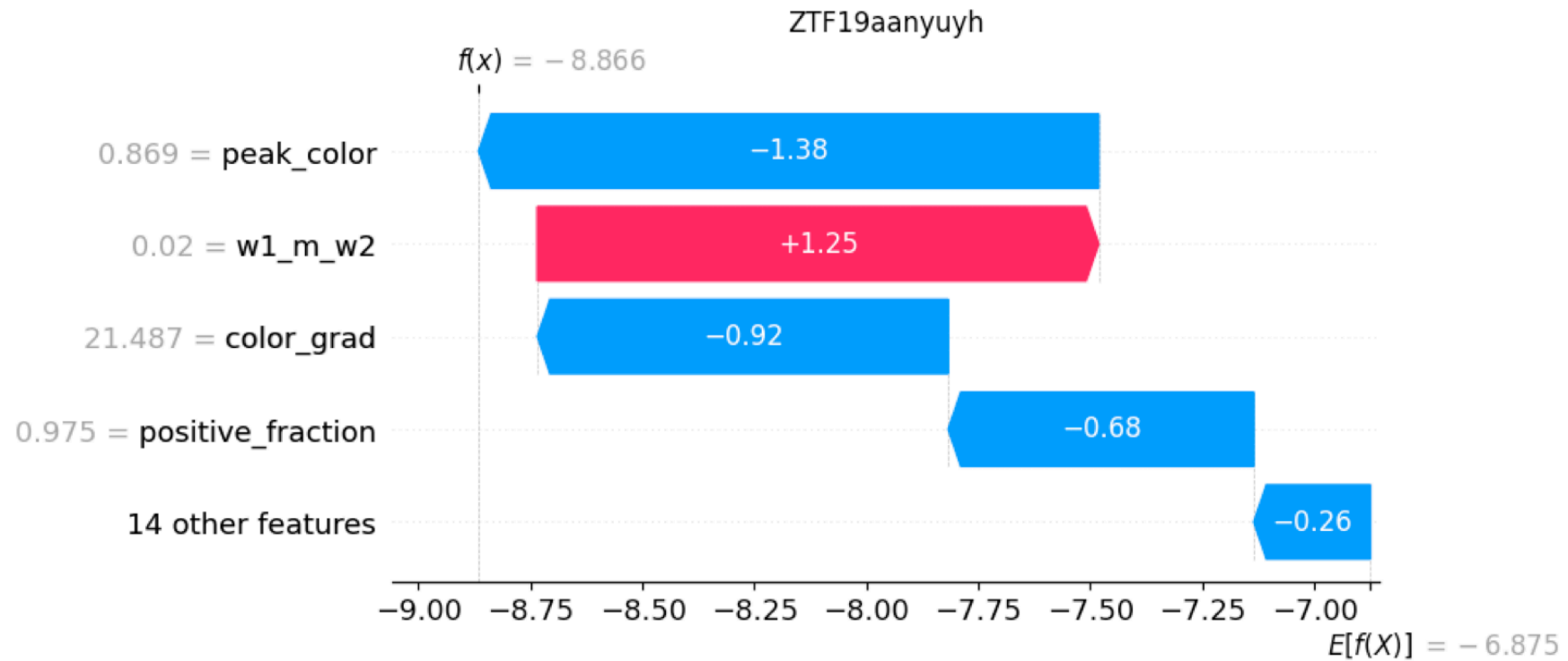
(Due to e.g non-AGN WISE colour, peak colour...)



Which you can argue with!

Real SNIa gets low score

(due to colour at peak, cooling ..., and despite non-AGN WISE colour)



Summary

Summary

- ZTF has a systematic program of TDEs with high-cadence light curves. Unprecedented sample of TDEs, but also of TDE imposters!
- Using XGBoost random forest and the ZTF nuclear sample, I extracted parameters for ~5000 sources and trained a photometric classifier, **tdescore**
- **tdescore** was able to reject non-TDEs with 99.8% accuracy, leaving pure sample of mostly (>80%) TDEs
- Explainable AI method helps us to understand/evaluate classifier reasoning.
- Expect to see the paper on arXiv in July!



Credit: Dall-e