



BlackGEM

Jan van Roestel
Institute for Science and Technology Austria (ISTA)
& **BlackGEM** project scientist and guest at the University of Amsterdam

Stellar Alerts

Galactic science with ZTF alerts

Jan van Roestel

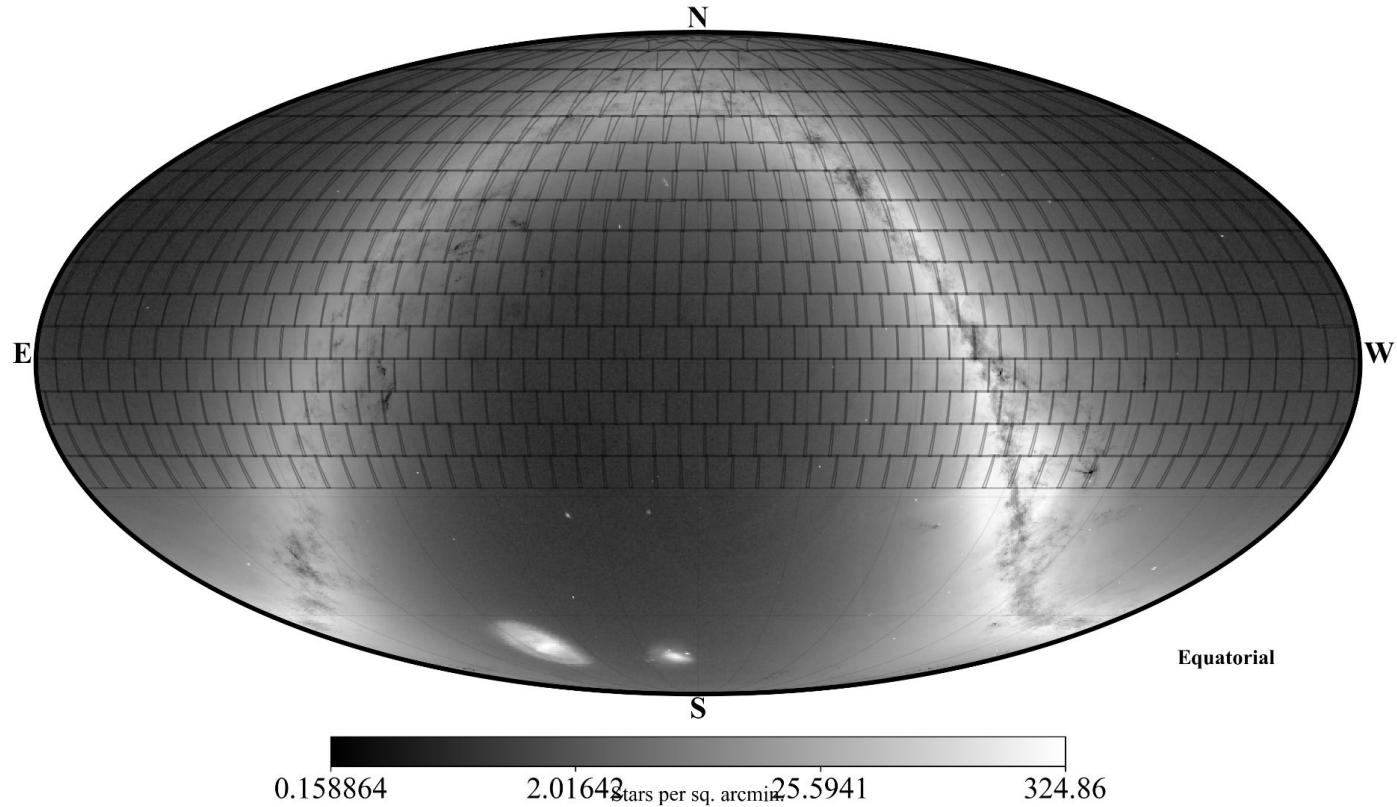
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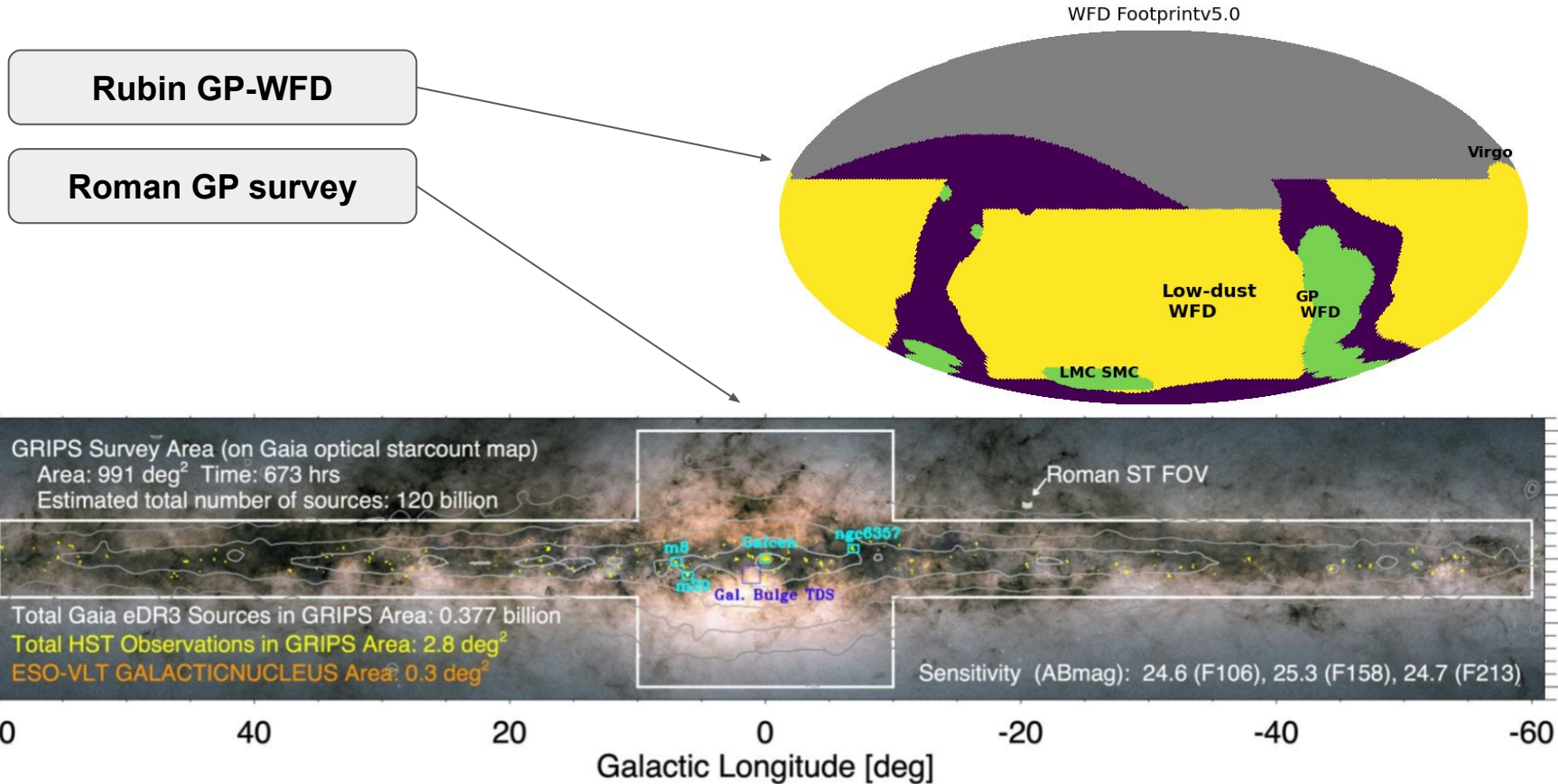
Outline

- What data products do we use to study stars?
- Galactic science with ZTF alerts
- What can we do with negative alerts?
- Lessons, questions and open issues

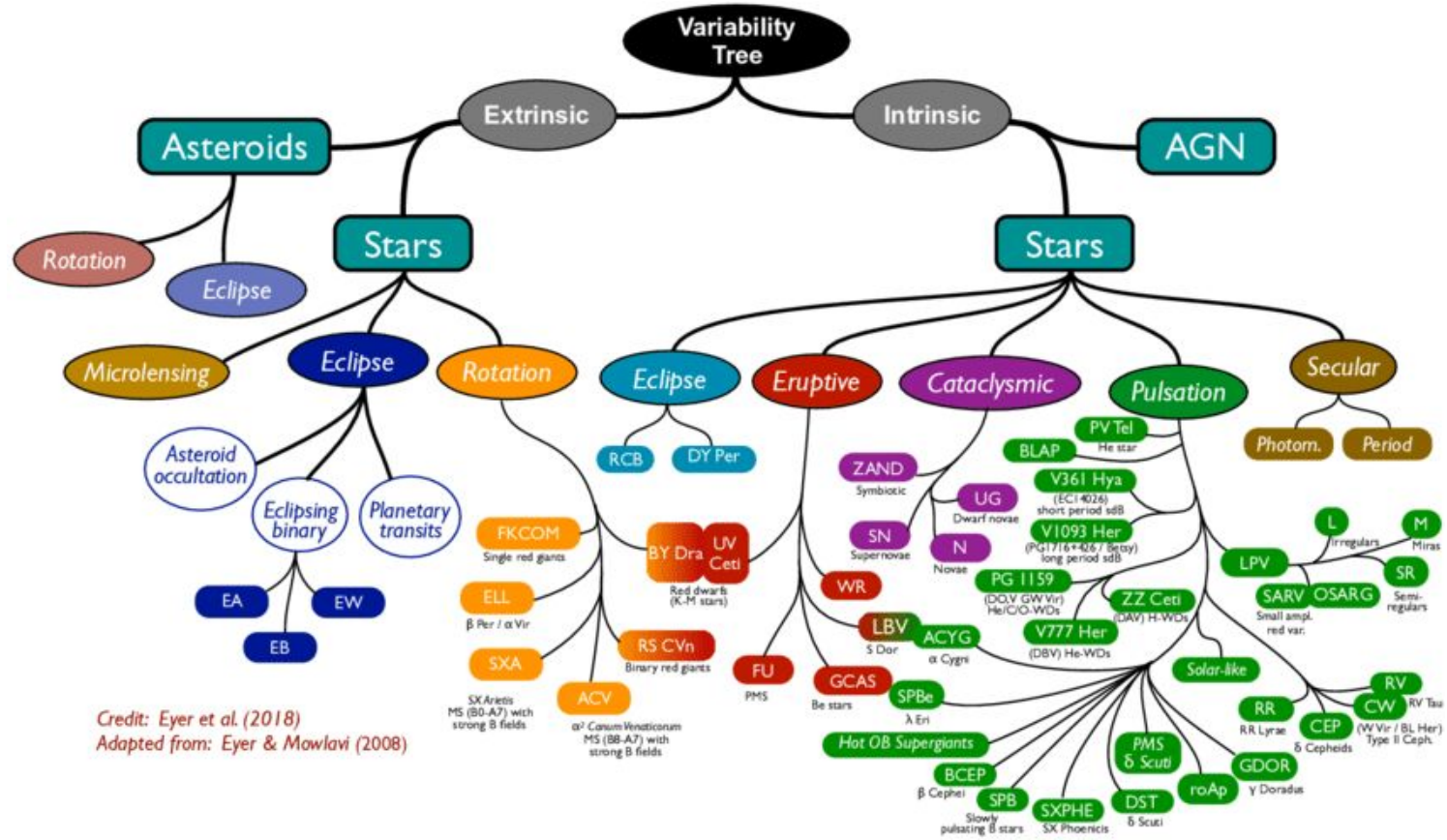
Time domain surveys detect many stars in our Galaxy



Future surveys will detect many stars in the Galaxy



What changes in the night sky?



Credit: Eyer et al. (2018)

Adapted from: Eyer & Mowlavi (2008)

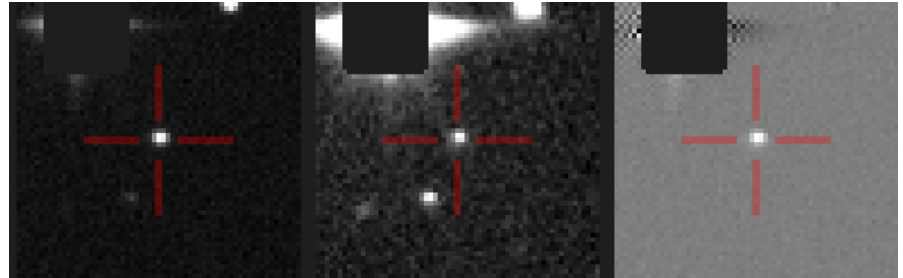
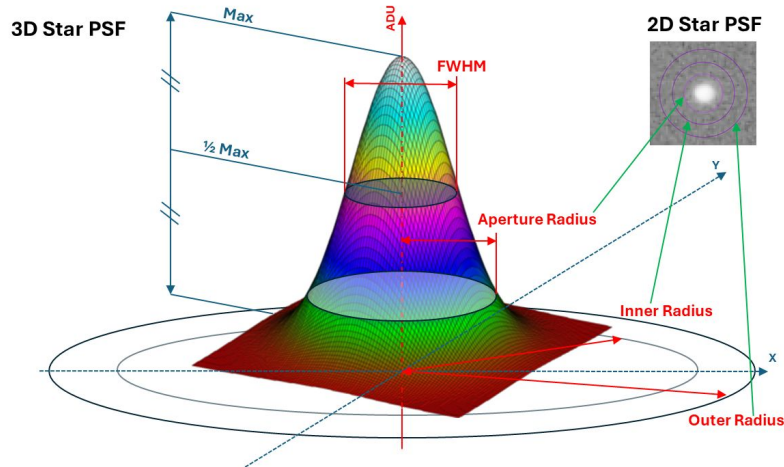
What data products are best suited to study stars?

Forced PSF-photometry

- Science or difference images
- Known sky-location
- Typically high-latency

Image differencing Alerts

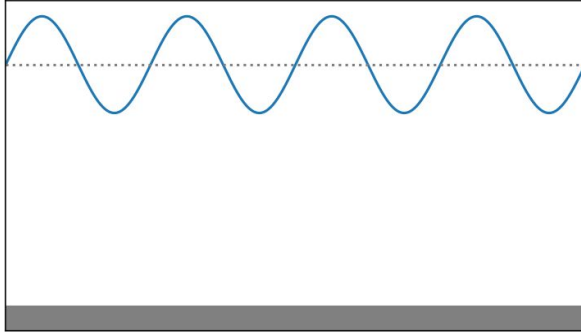
- Difference images
- Unknown sky-location
- Low latency



What type of dataproduct to use?

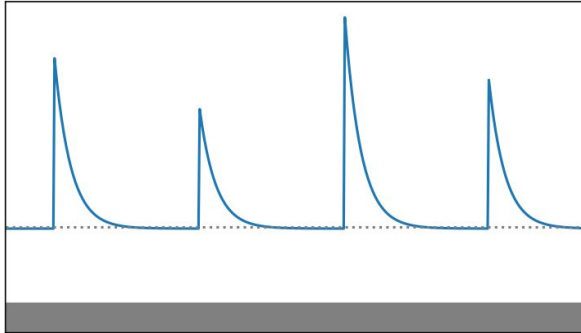
Is the sky-position known a-priori? How fast do you need to respond?
How crowded is the region on the sky?

Forced phot. and
frequency space
analysis

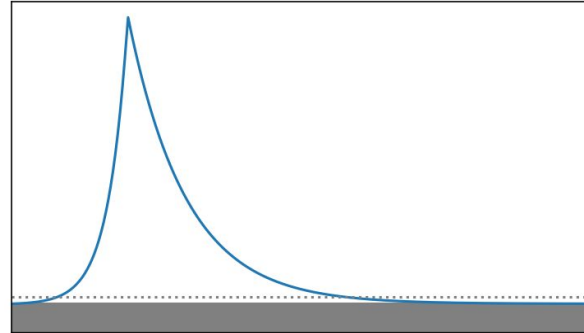
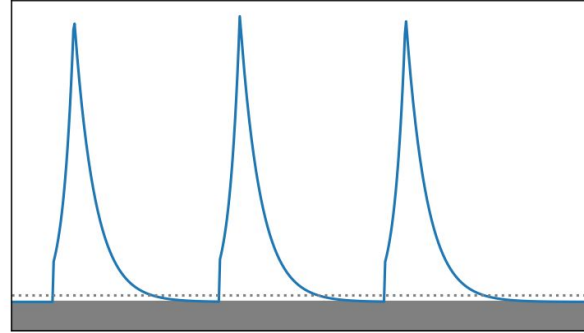


**Alerts &
Forced Phot.**

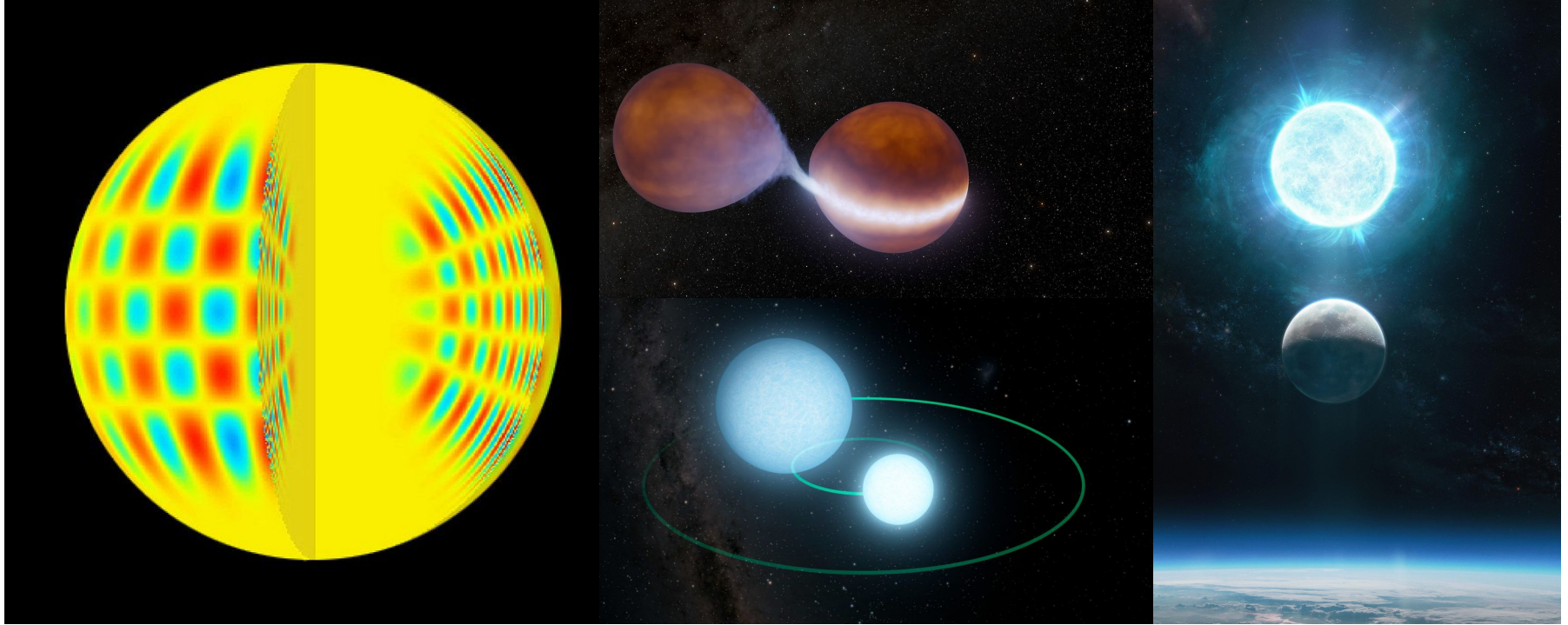
Forced phot. &
alerts



Alerts



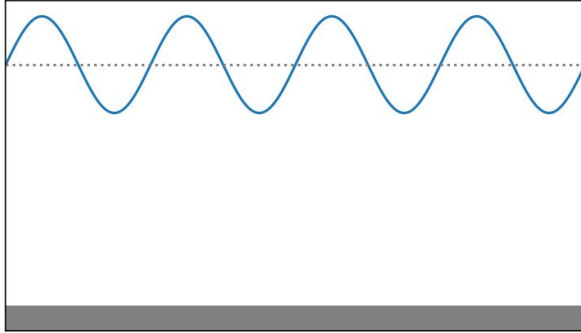
Periodic variable stars from ZTF



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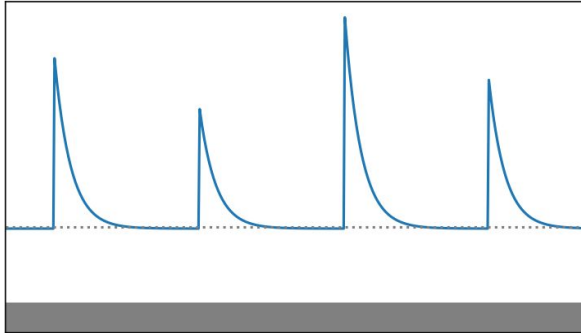
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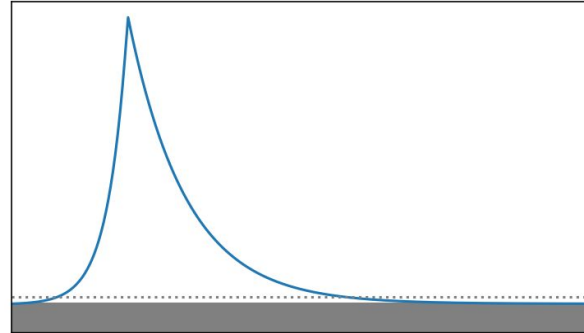
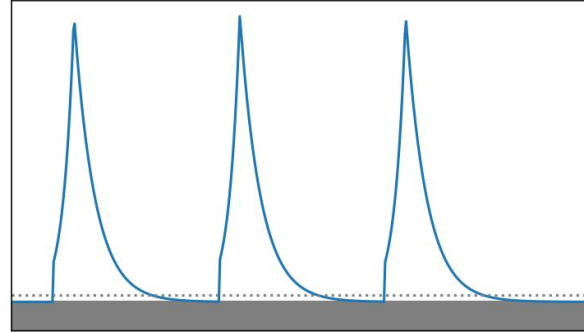


**Alerts &
Forced Phot.**

Forced phot. &
alerts



Alerts



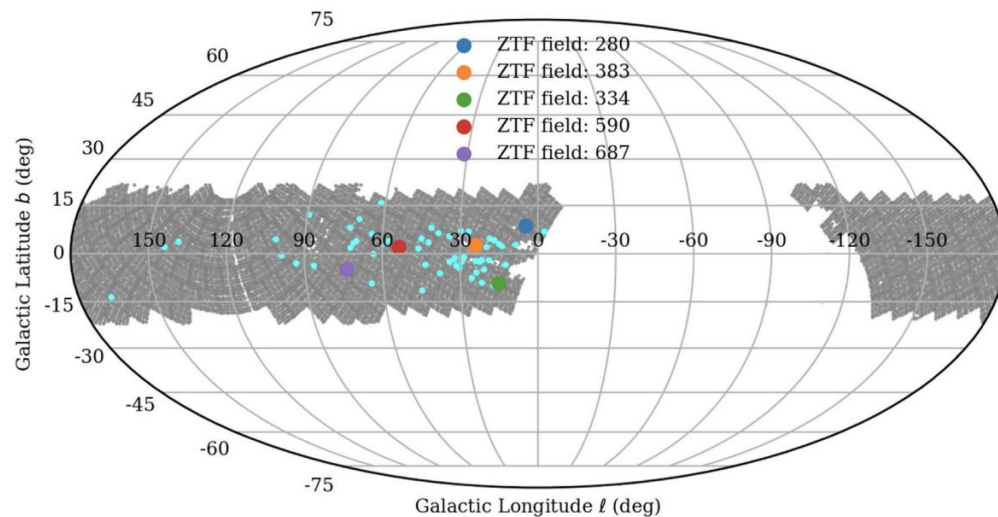
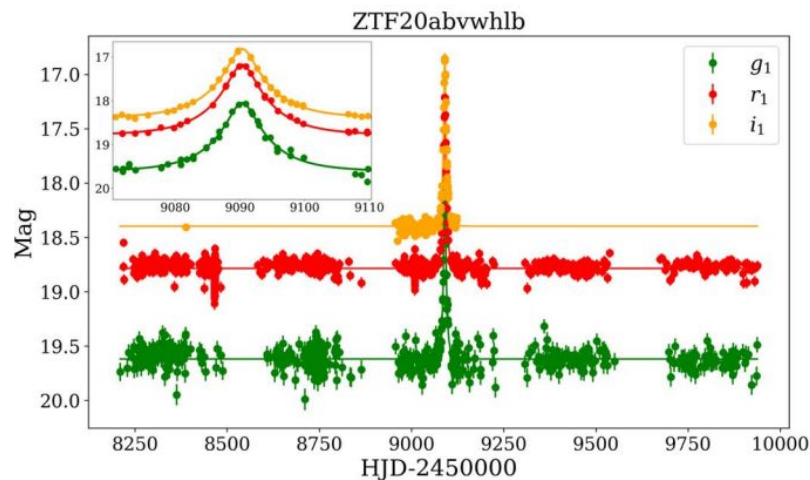
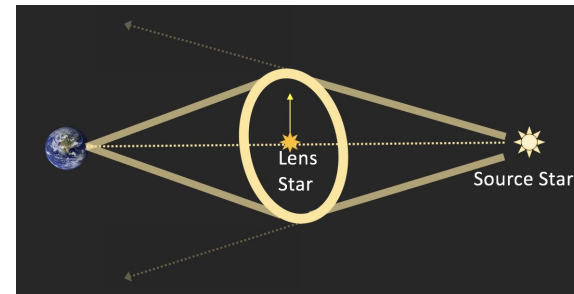
Galactic/Stellar science with ZTF-alerts



Galactic/Stellar science with ZTF-alerts

Microlensing events

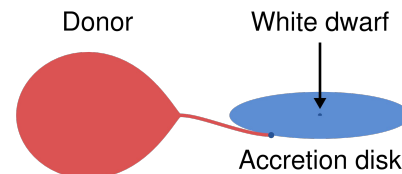
Detect faint, invisible, or distant objects—such as exoplanets or stellar mass black holes



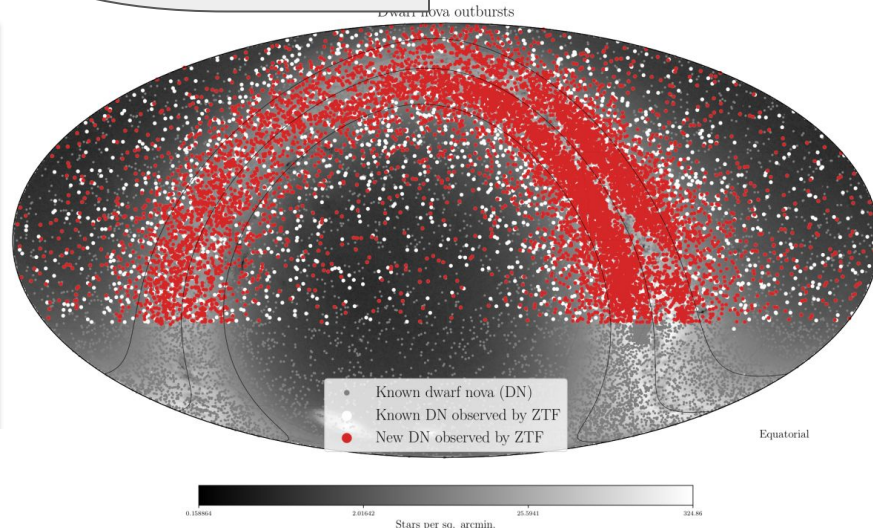
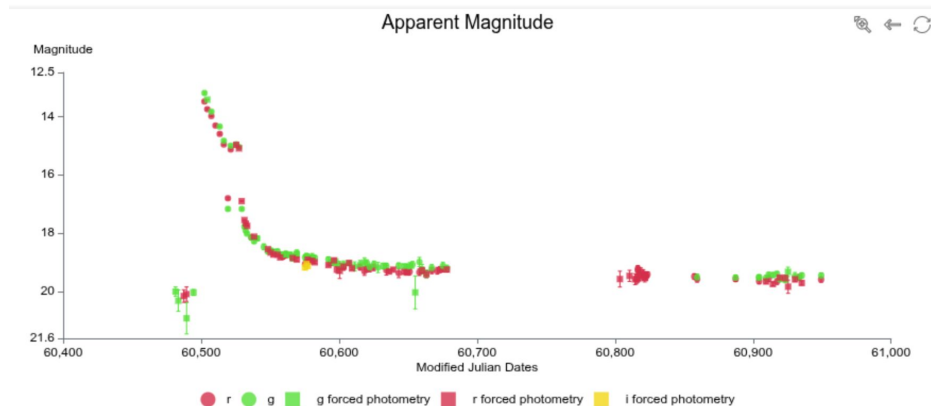
Galactic/Stellar science with ZTF-alerts

Dwarf Novae

Used to study accretion physics, binary evolution physics, and LISA GW sources



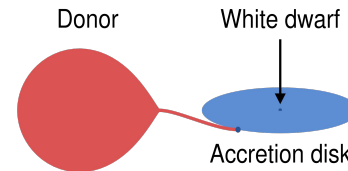
10.000+
dwarf novae!



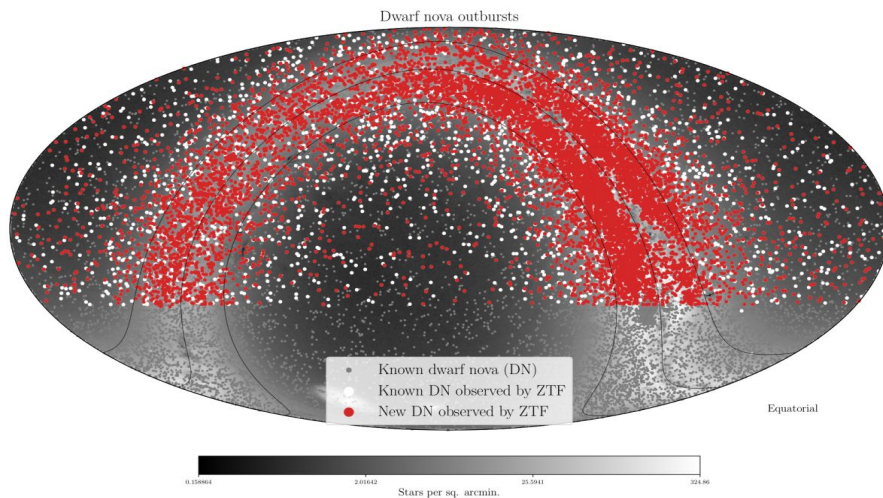
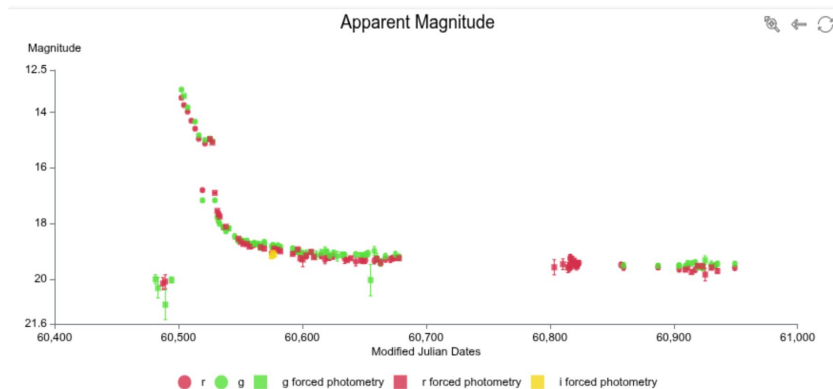
Galactic/Stellar science with ZTF-alerts

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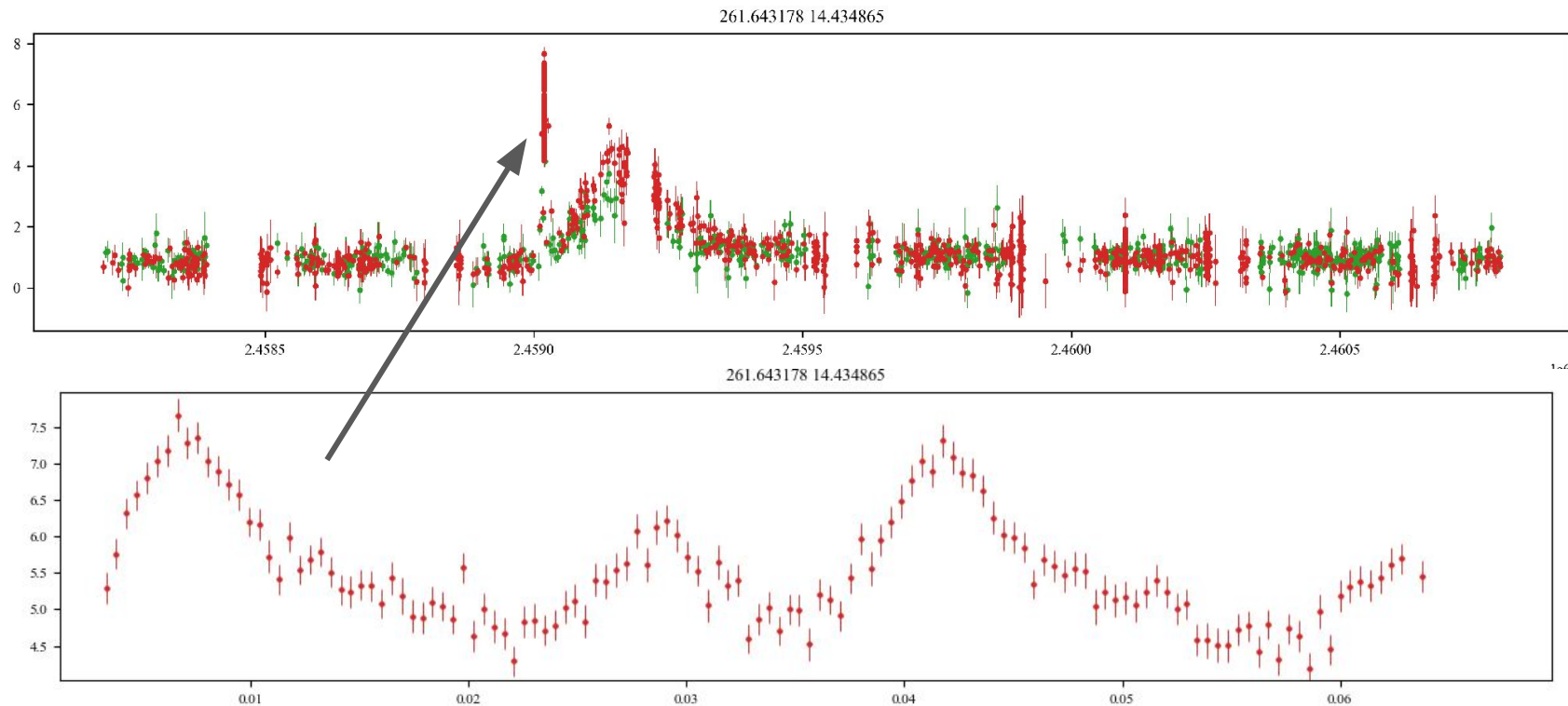
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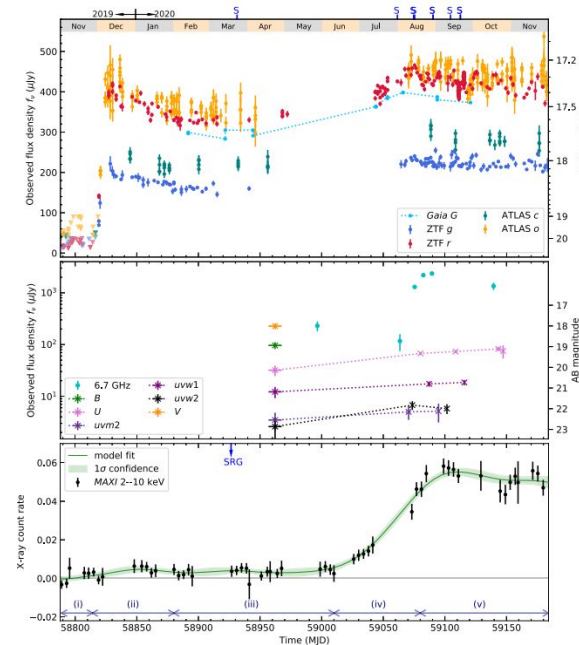
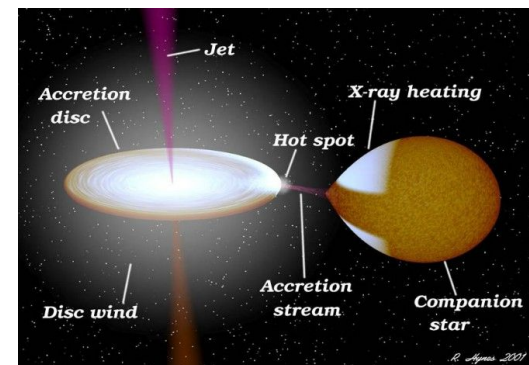
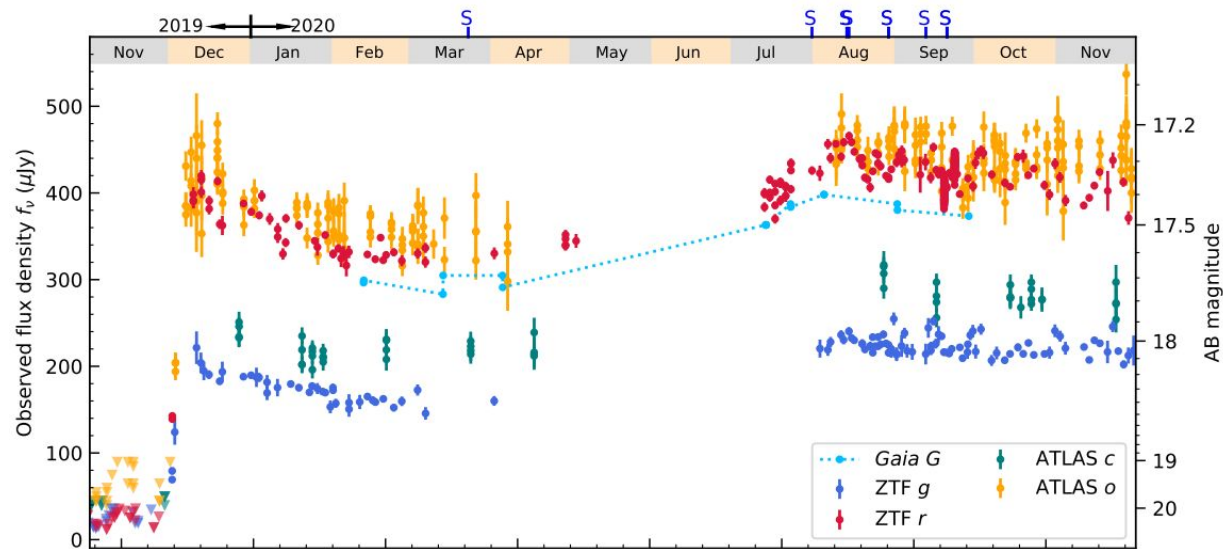
Galactic/Stellar science with ZTF-alerts

Dwarf Novae – unexpected long outbursts



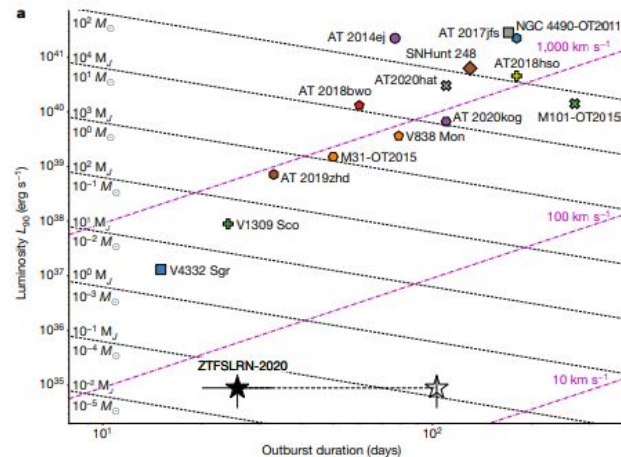
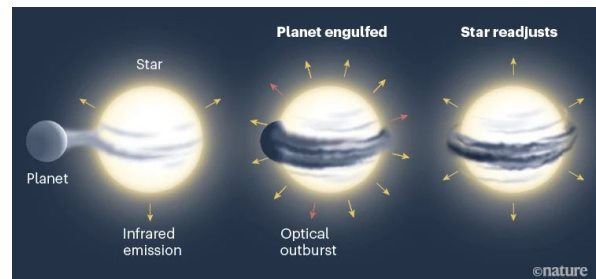
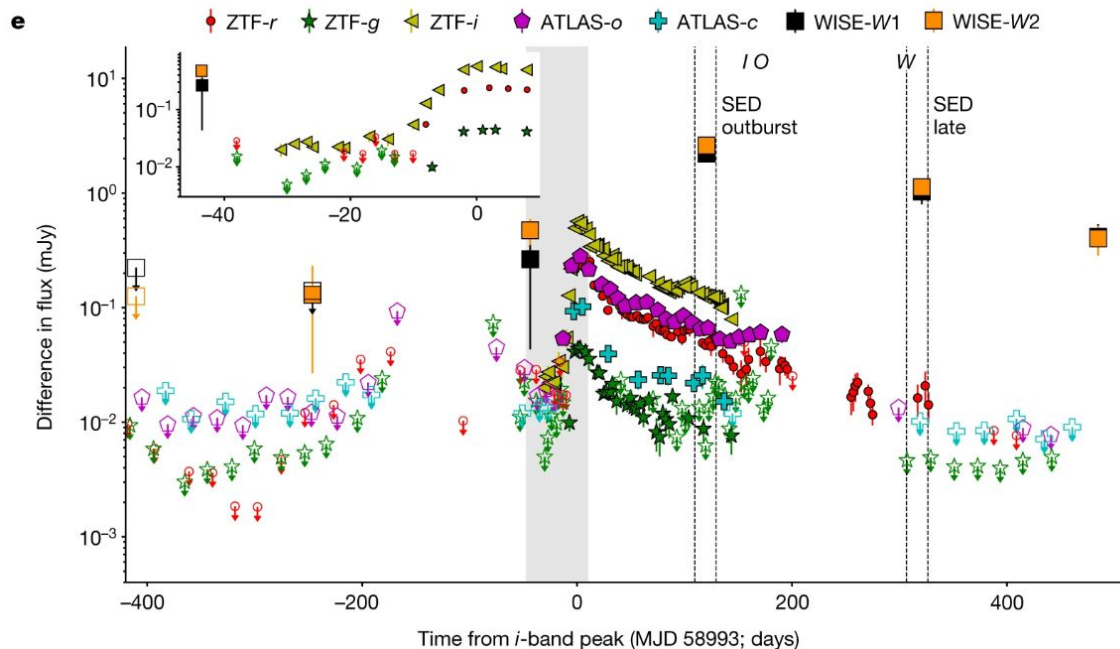
Galactic/Stellar science with ZTF-alerts

X-ray binaries



Galactic/Stellar science with ZTF-alerts

Stellar mergers - SLRN-2020



Science with negative ZTF alerts – dipping stars



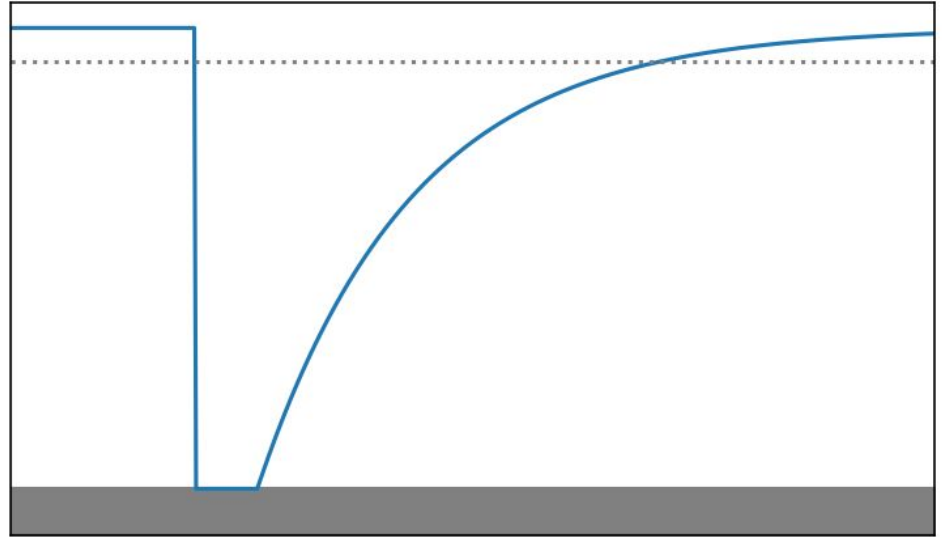
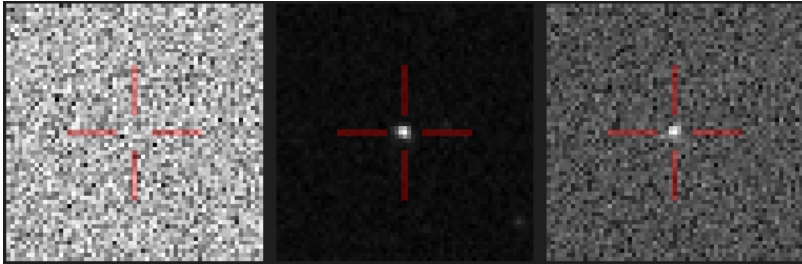
Science with negative ZTF alerts – dipping stars



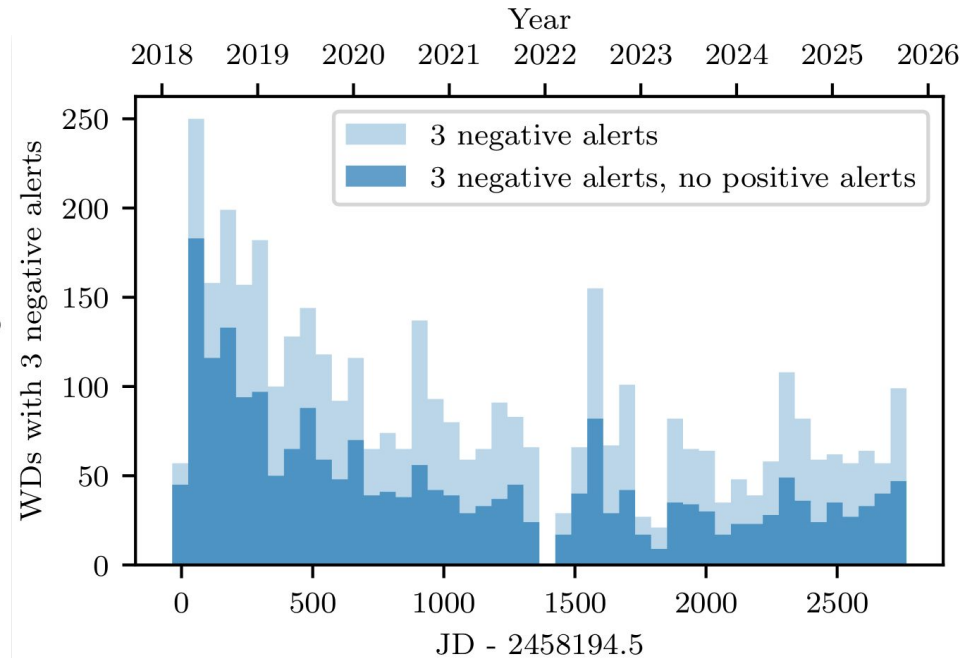
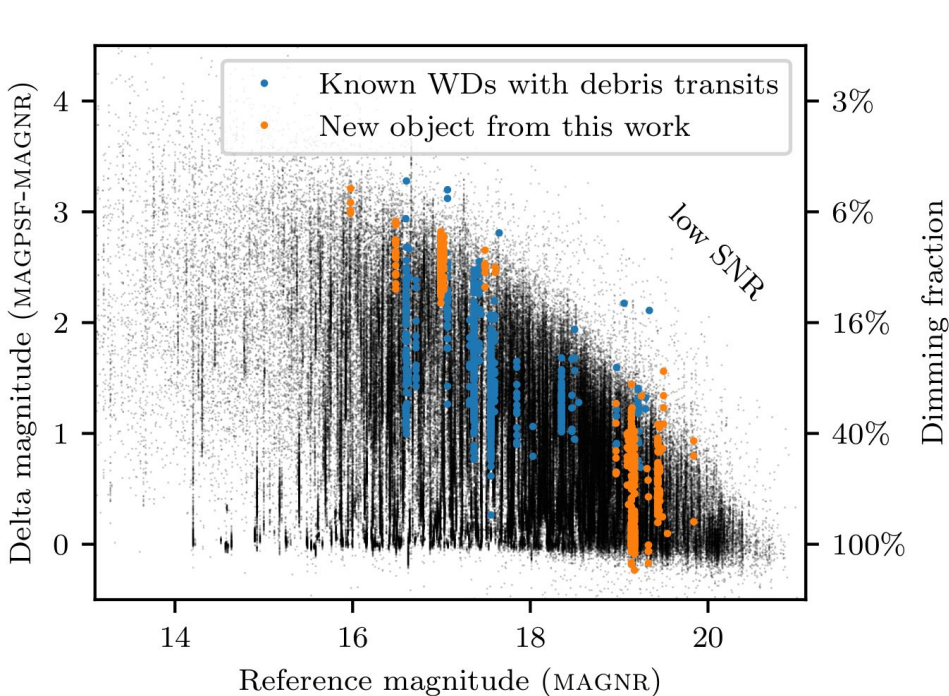
Science with negative ZTF alerts – dipping stars

- Diffmagpos == False
- Dstrnr < 3 arcsec

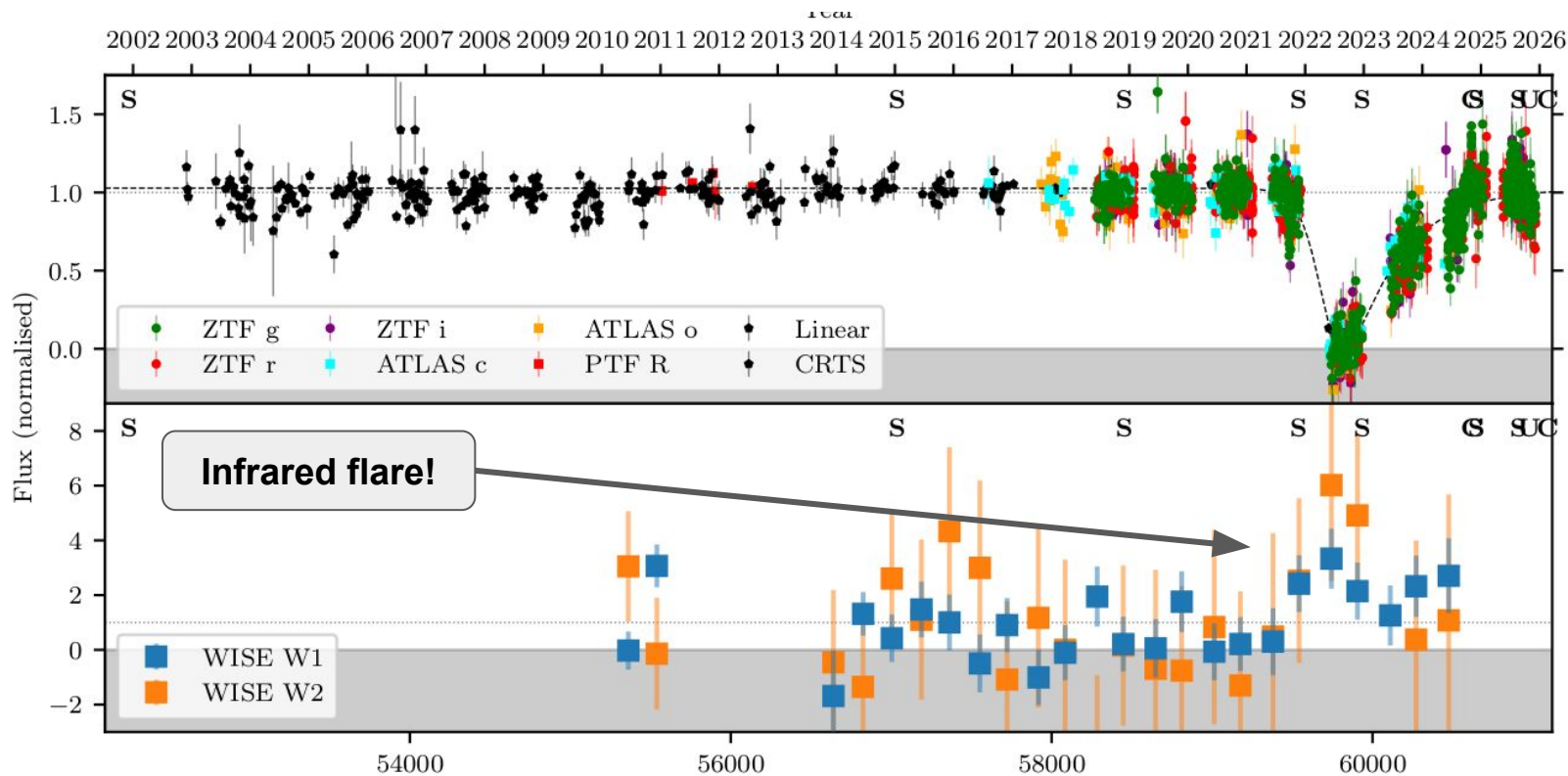
Translation: there is a source in the reference/template image and the difference is negative



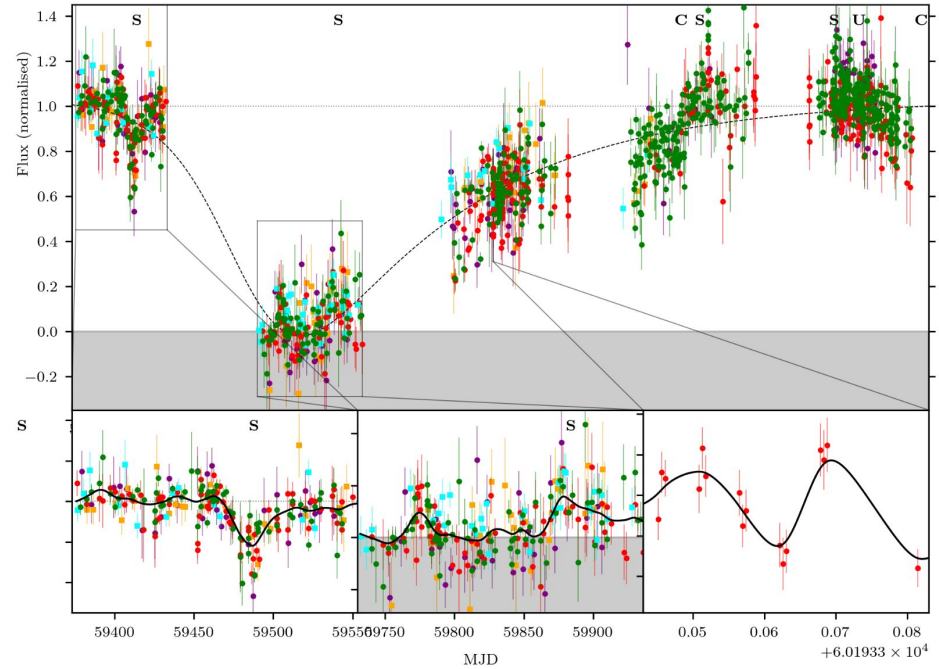
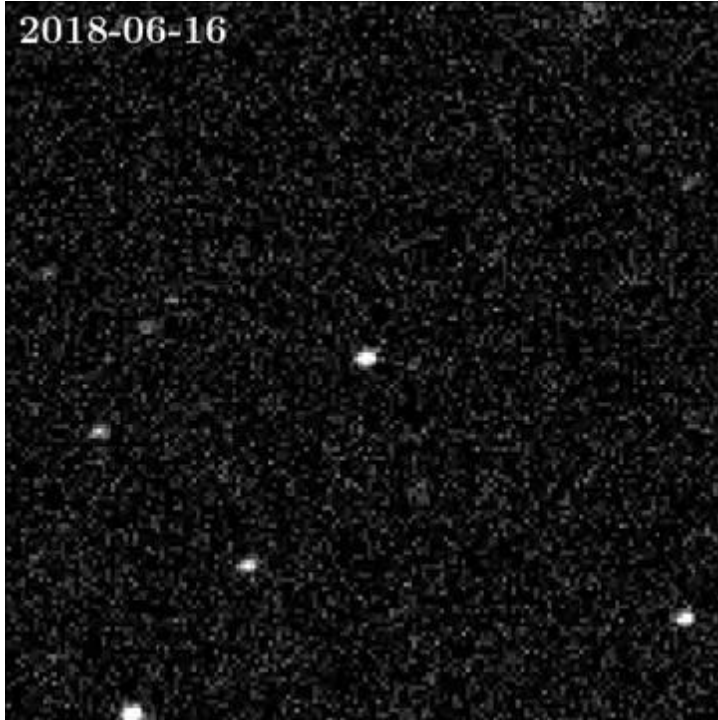
Pilot: negative alerts associated with white dwarfs



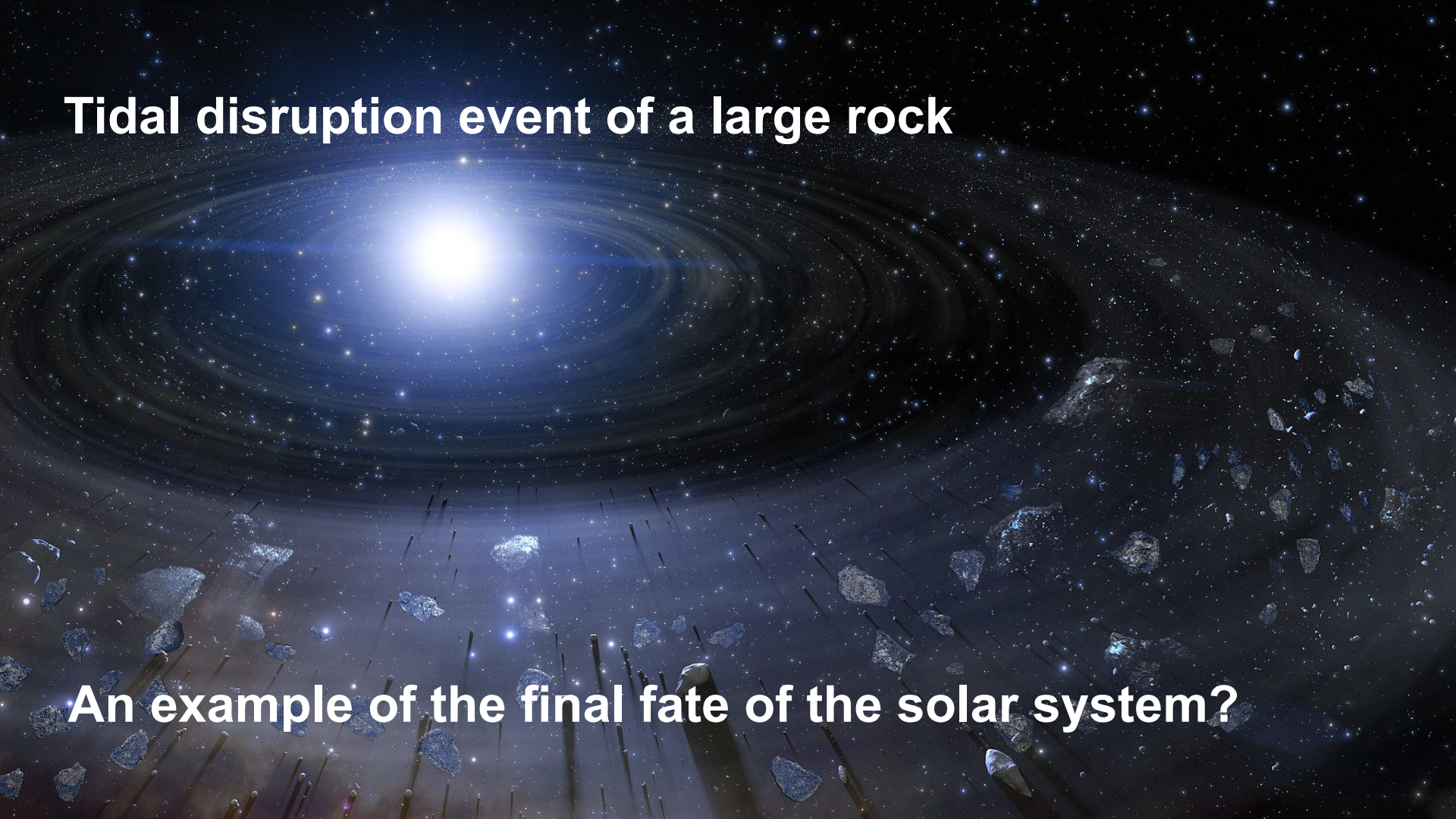
A white dwarf that disappeared for a year



A white dwarf that disappeared for a year



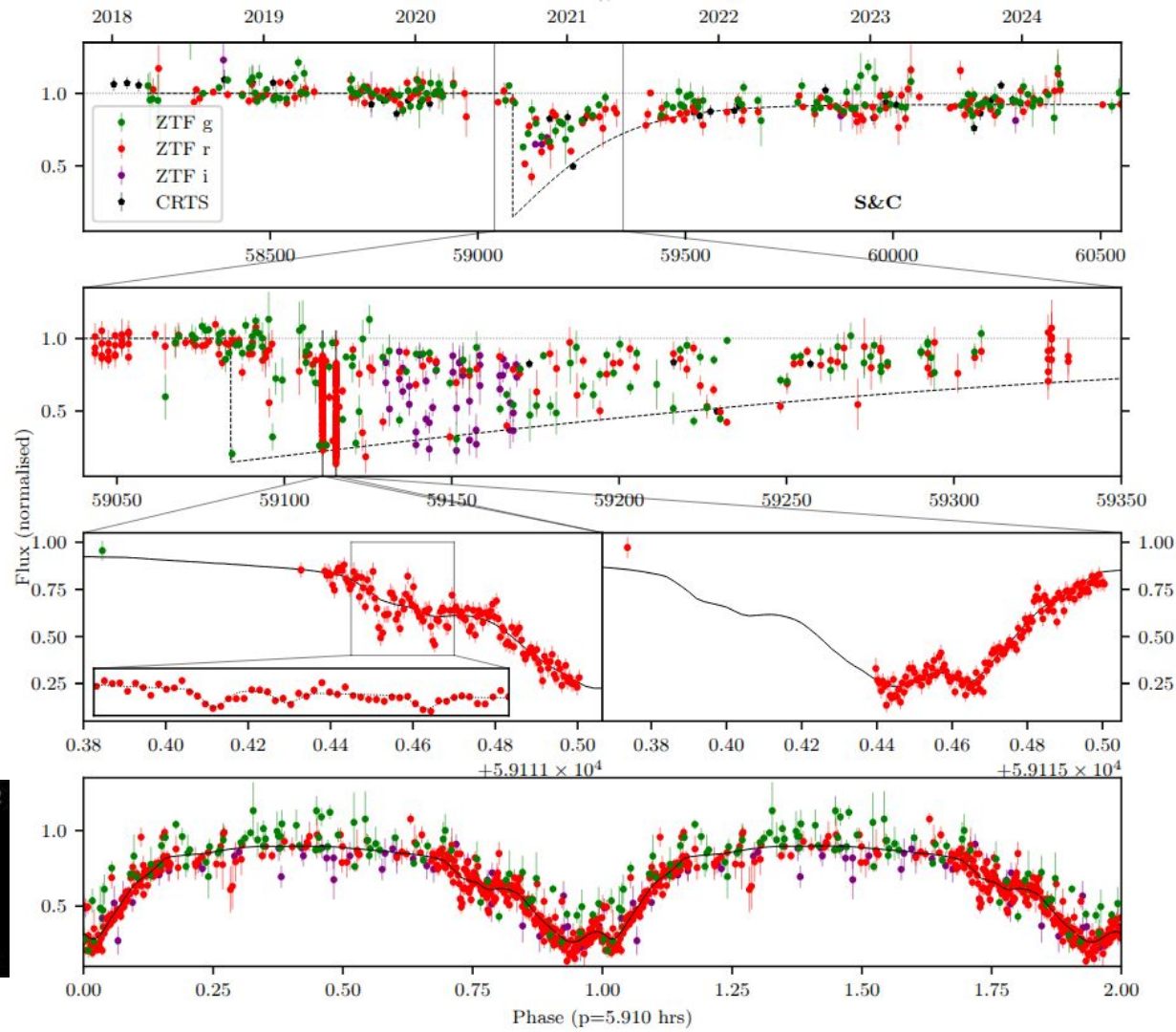
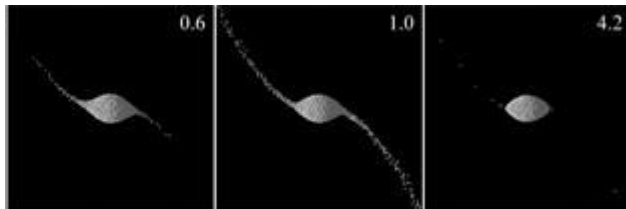
Tidal disruption event of a large rock



An example of the final fate of the solar system?

A transient periodic signal!

- Appearance of a 5.9h periodic signal
- A slowly disintegrating rock
- Average density is planet-like ($\sim 5 \text{ g/cm}^3$)



Lessons, questions and open issues

- **Time domain surveys keep finding interesting objects in our Galaxy!**
- Different science cases benefit from different data products
- How do we identify the stars that are *astrophysically* interesting?
Humans are still better at finding *interesting* anomalies
- Historical data and multi-wavelength data is important;
How do we effectively do a combined search?
- Large samples of objects are useful for population studies
How to make complete samples with well-understood biases?

Cataclysmic variables: Szkody, Mistry, van Roestel, Rivera Sandoval

Xray binaries: David Wang, Kishalay De, Yuhang Yao (AT2019wey)

Micro-lensing: Mroz Medford, Rodriguez, Möller et al. 2021

YSO; Hillenbrandt, Kuhn, Fang 2022

Techno signatures: Gallay 2025

Nova: De et al. 2020

Mflares: Alishov et al. (2024)

Other: Sánchez-Sáez et al. (2021): "The ALERCE Light Curve Classifier." Tachibana et al. (2020):

Galactic/Stellar science with ZTF-alerts

Young Stellar Objects (YSO)

Pre

