Fast transient identification in optical survey data

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Rubin PCW 2023

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Let's discuss

What do you think are the minimum ingredients to make a good real time classification based on your experience?

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Let's get on the same page:

- ❖ The answer is highly dependent on the science case

- ❖ The more information the better but it can be expensive (time, resources)

Electromagnetic counterparts to Gravitational Waves (GWs)

Short hard GRB
(w/ **afterglow**)

Kilonova
(optical/IR)
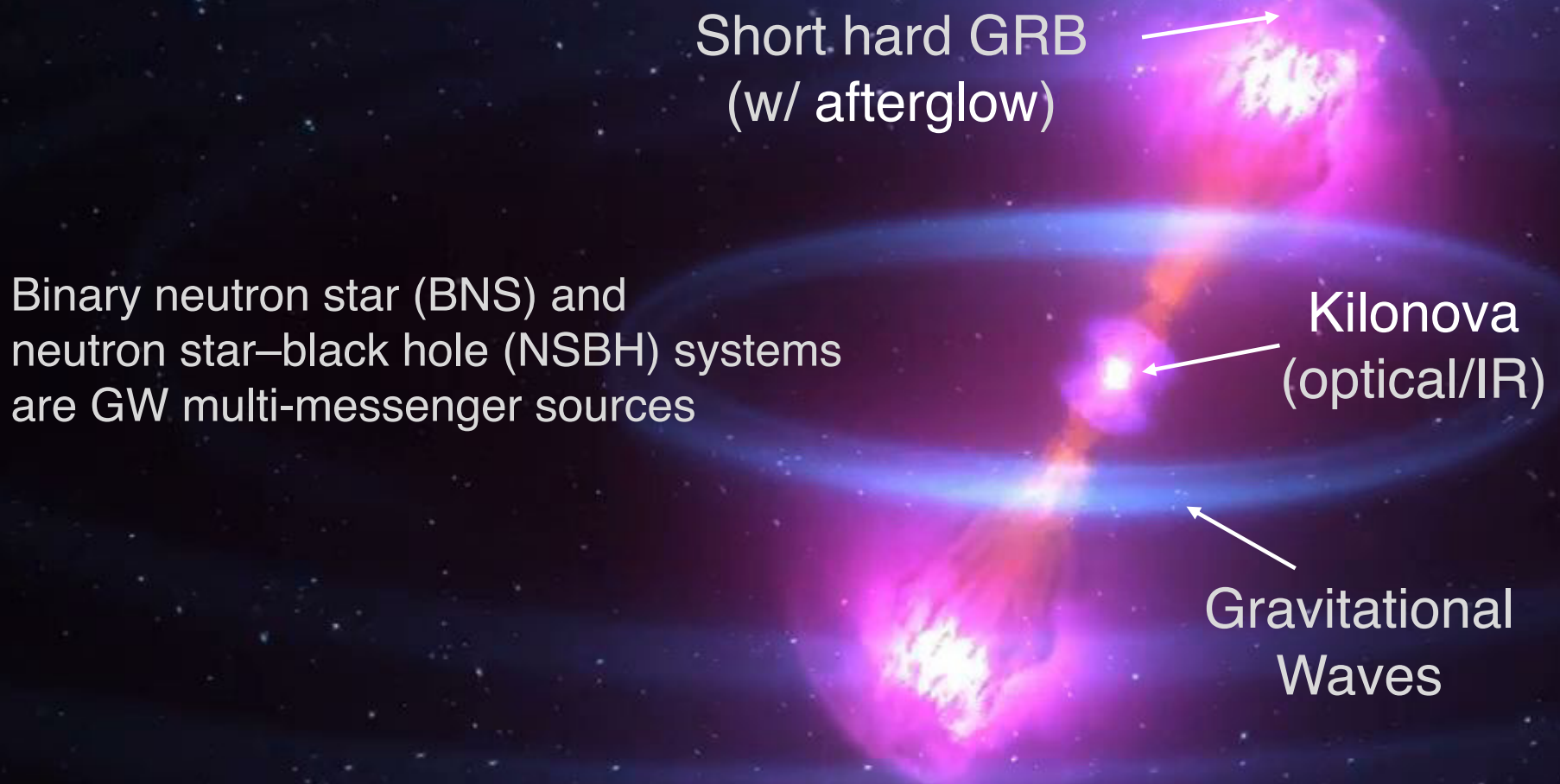
Binary neutron star (BNS) and
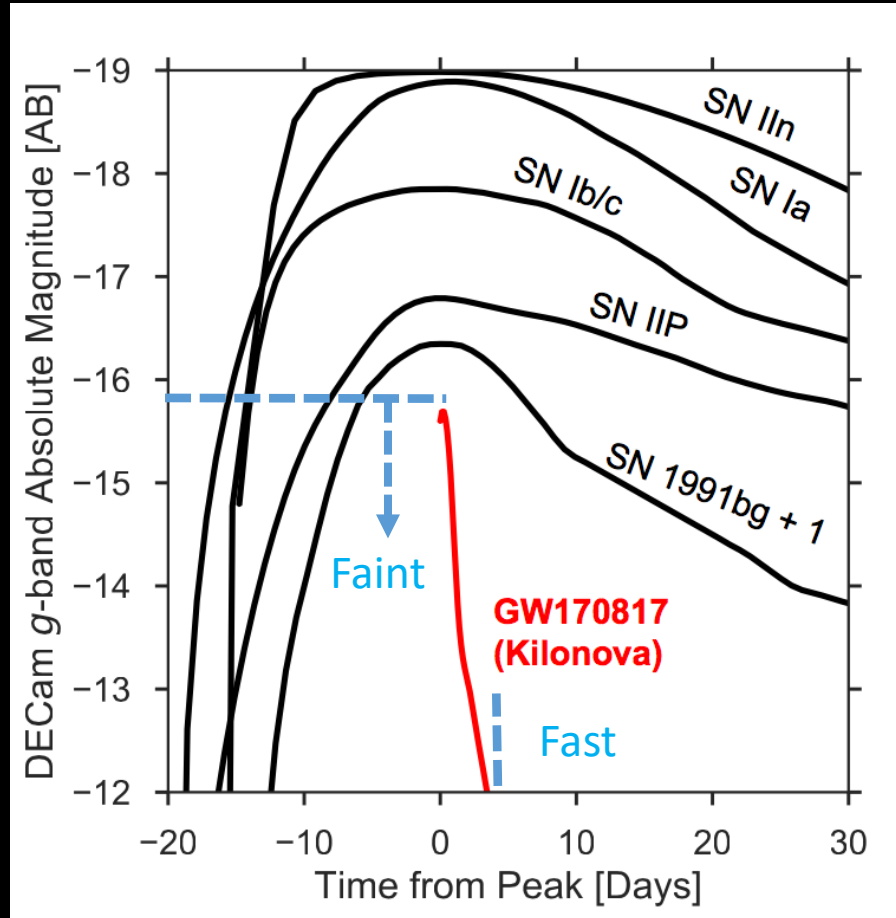neutron star–black hole (NSBH) systems
are GW multi-messenger sources

Gravitational
Waves

The focus will be on optical transient counterparts

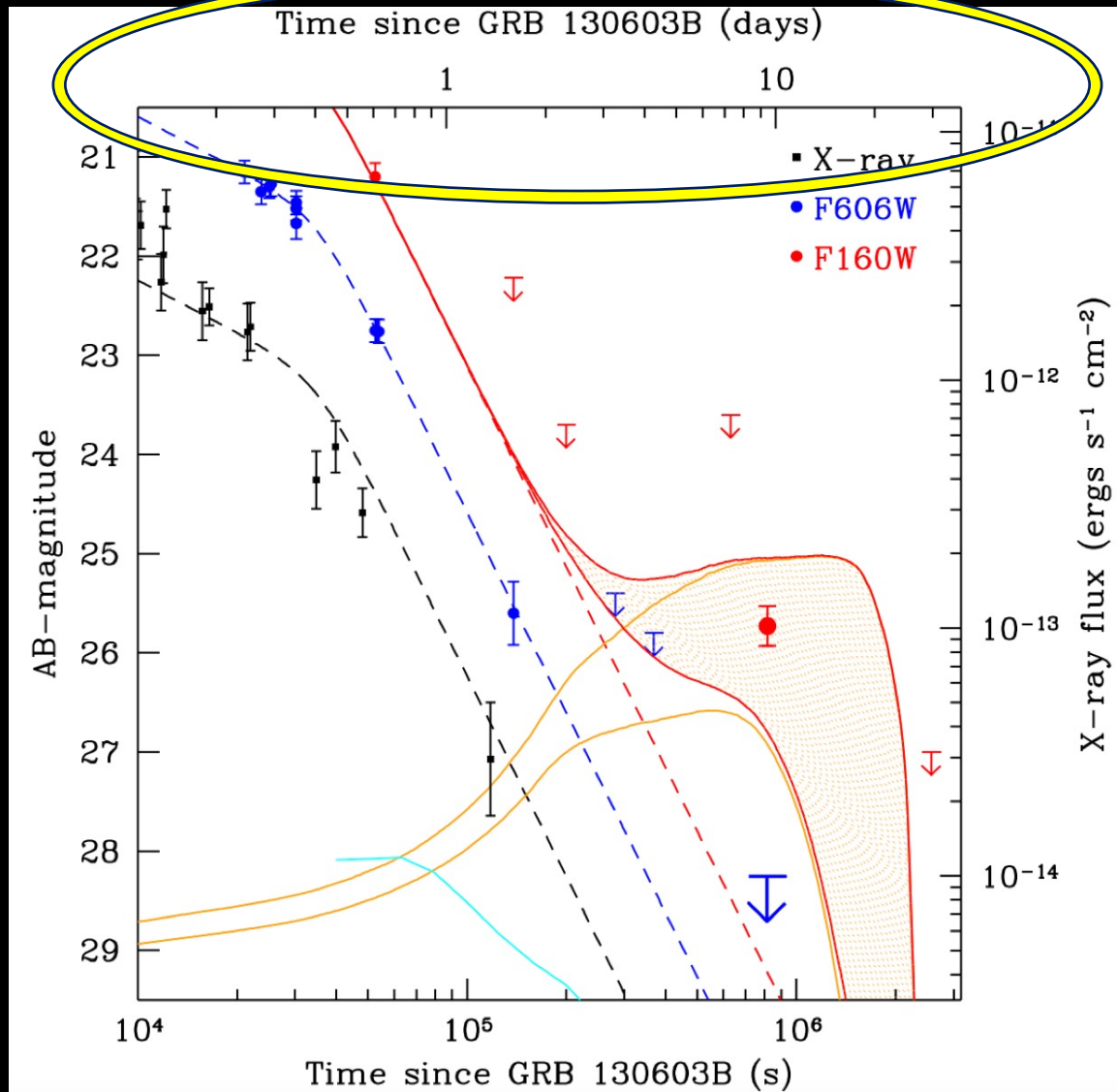Image credit: NASA

Kilonova:
faster & fainter than supernovae

modified from
Andreoni+2018

Magnitude = $-2.5 * \log_{10}$(flux) + Constant

Faint + Fast = hard to catch!

Kilonova + GRB afterglow

Tanvir+2013

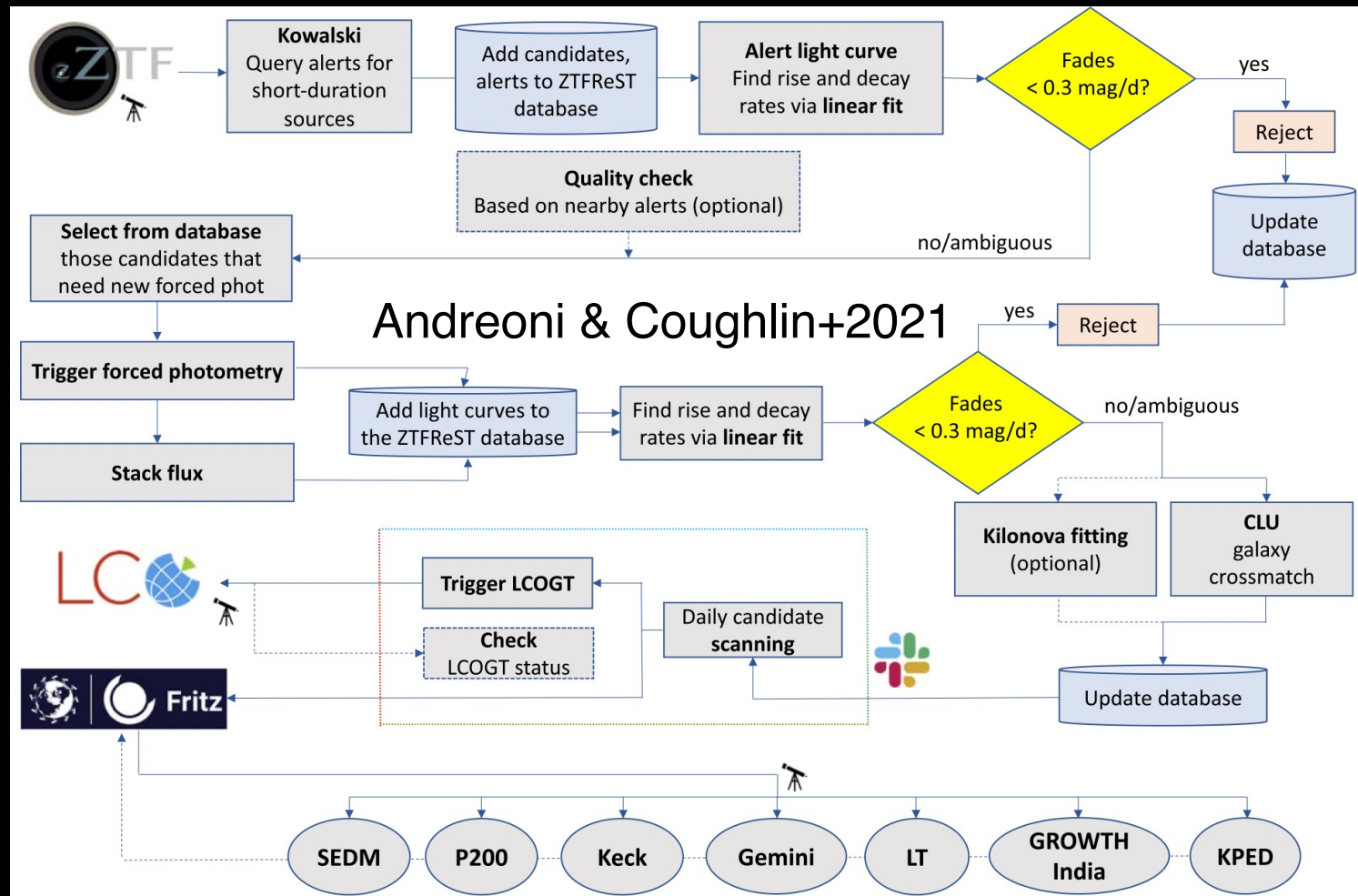# ZTFReST for fast transient discovery

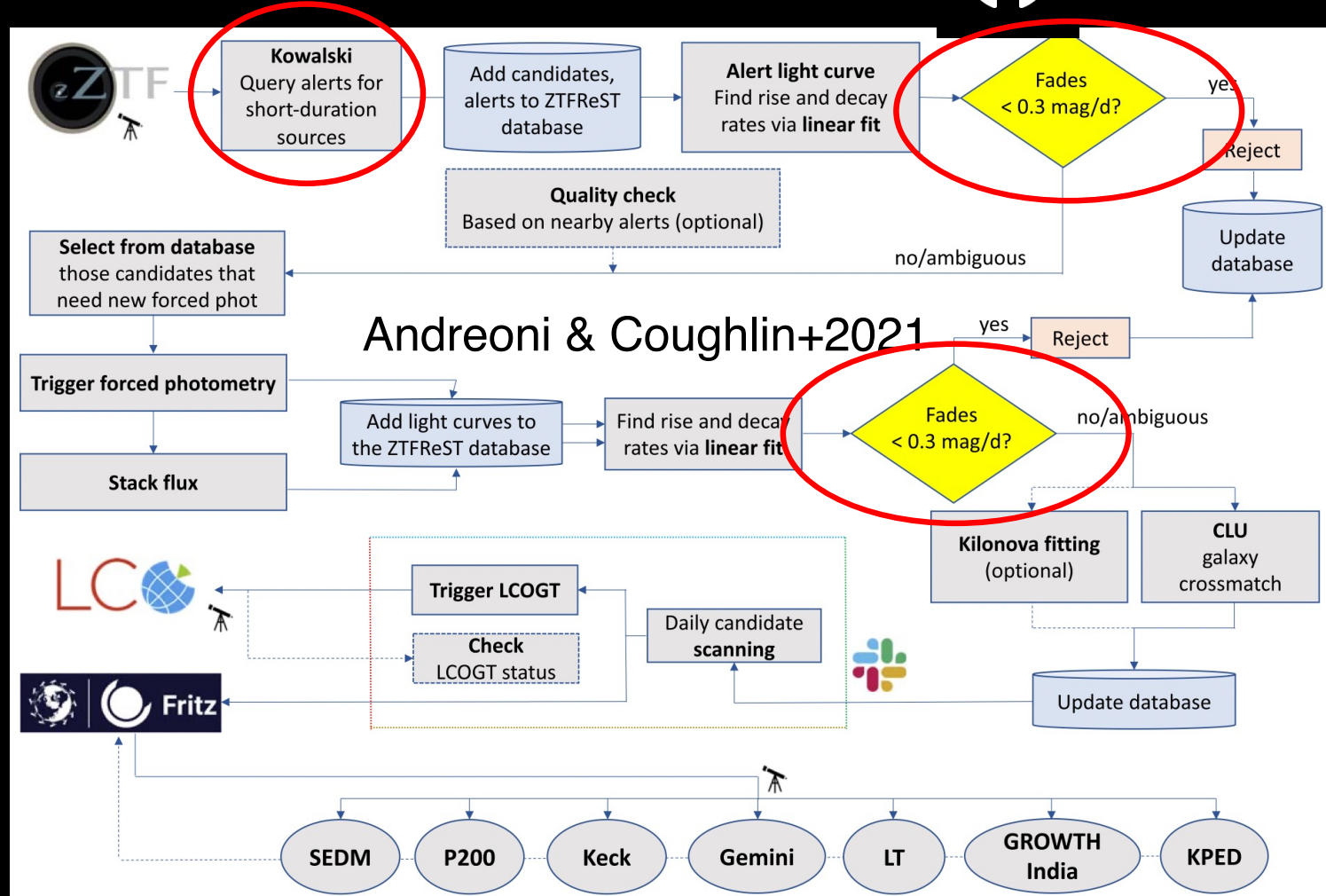## ZTF Realtime Searching and Triggering   growth-astro/ztfrest

Andreoni & Coughlin+2021

ZTFReST for fast transient discovery

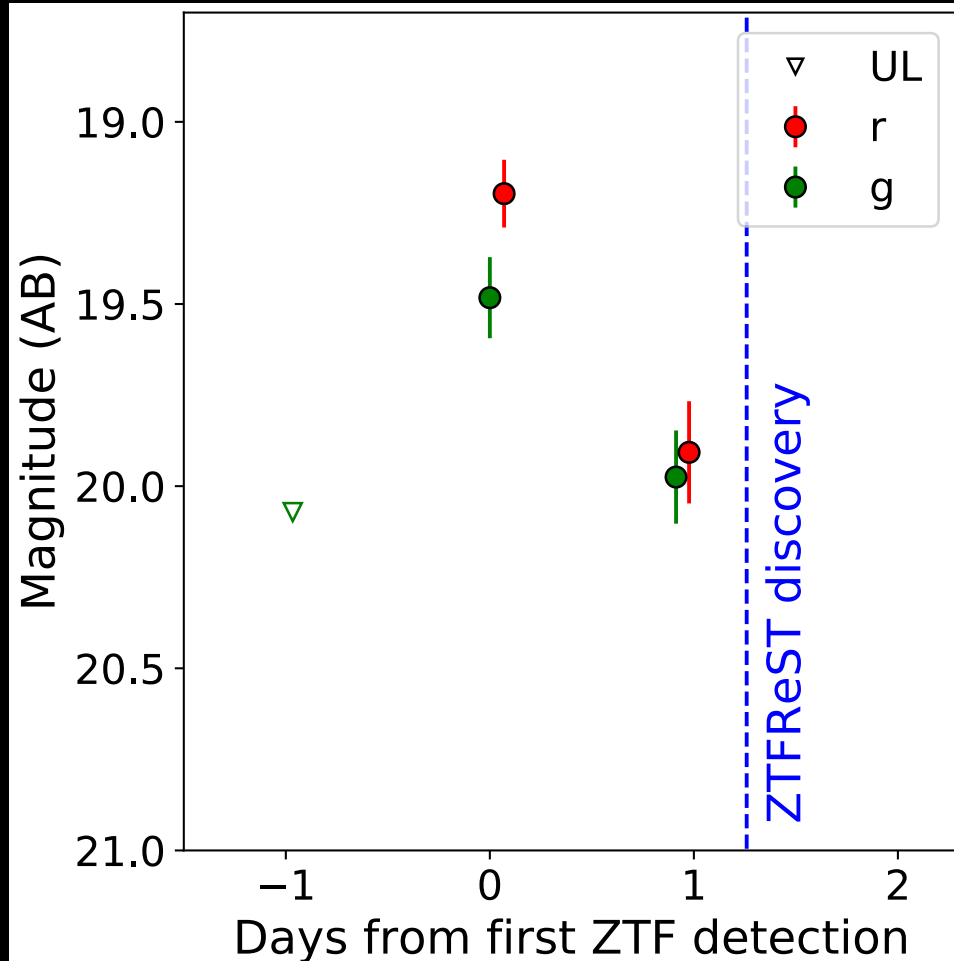ZTF Realtime Searching and Triggering   growth-astro/ztfrest

Andreoni & Coughlin+2021

ZTFReST Results

Michael Coughlin

Andreoni & Coughlin et al. (2021), ApJ, 918, 2, 63

Near real-time implementation of the search methods used in Andreoni et al. (2020d)

Supernova shock cooling
~ a dozen

Serendipitous GRB afterglows
- 5 with GRB association (long)
- four confirmed, un-triggered afterglows w/o GRB association
see also Ho+2020,2021,2022; Andreoni+2020d

Kilonovae
Still waiting…

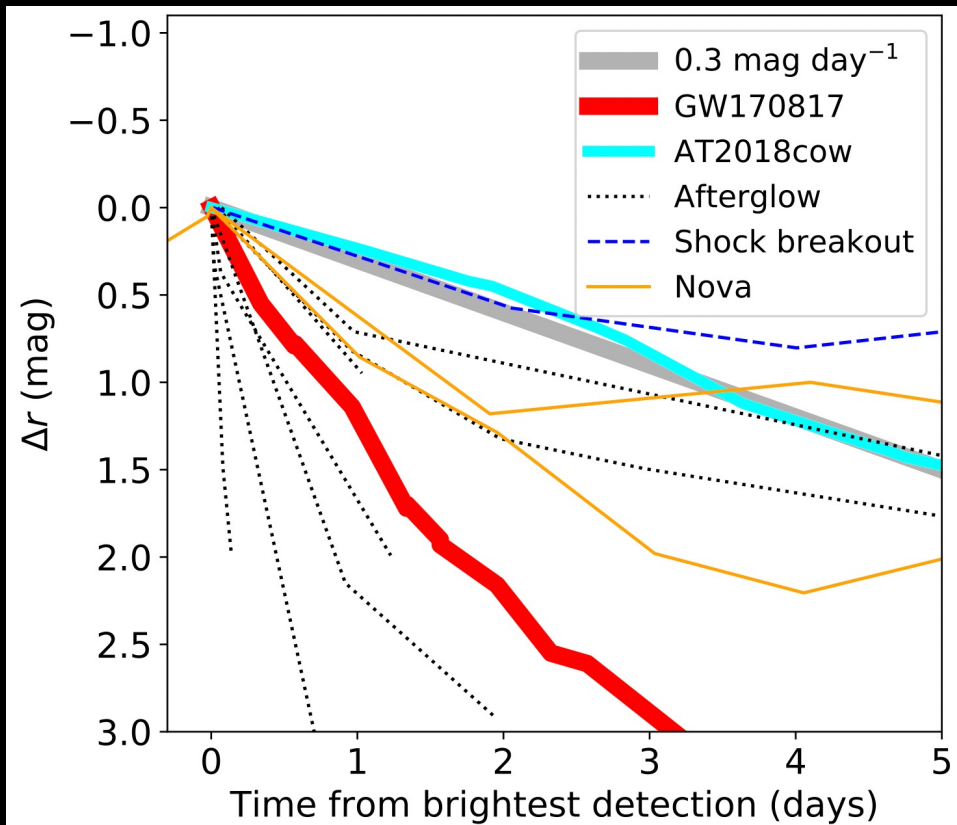AT2022cmc
a jetted TDE!

ZTFReST Results

Andreoni & Coughlin et al. (2021), ApJ, 918, 2, 63

Michael Coughlin

Near real-time implementation of the search methods used in Andreoni et al. (2020d)

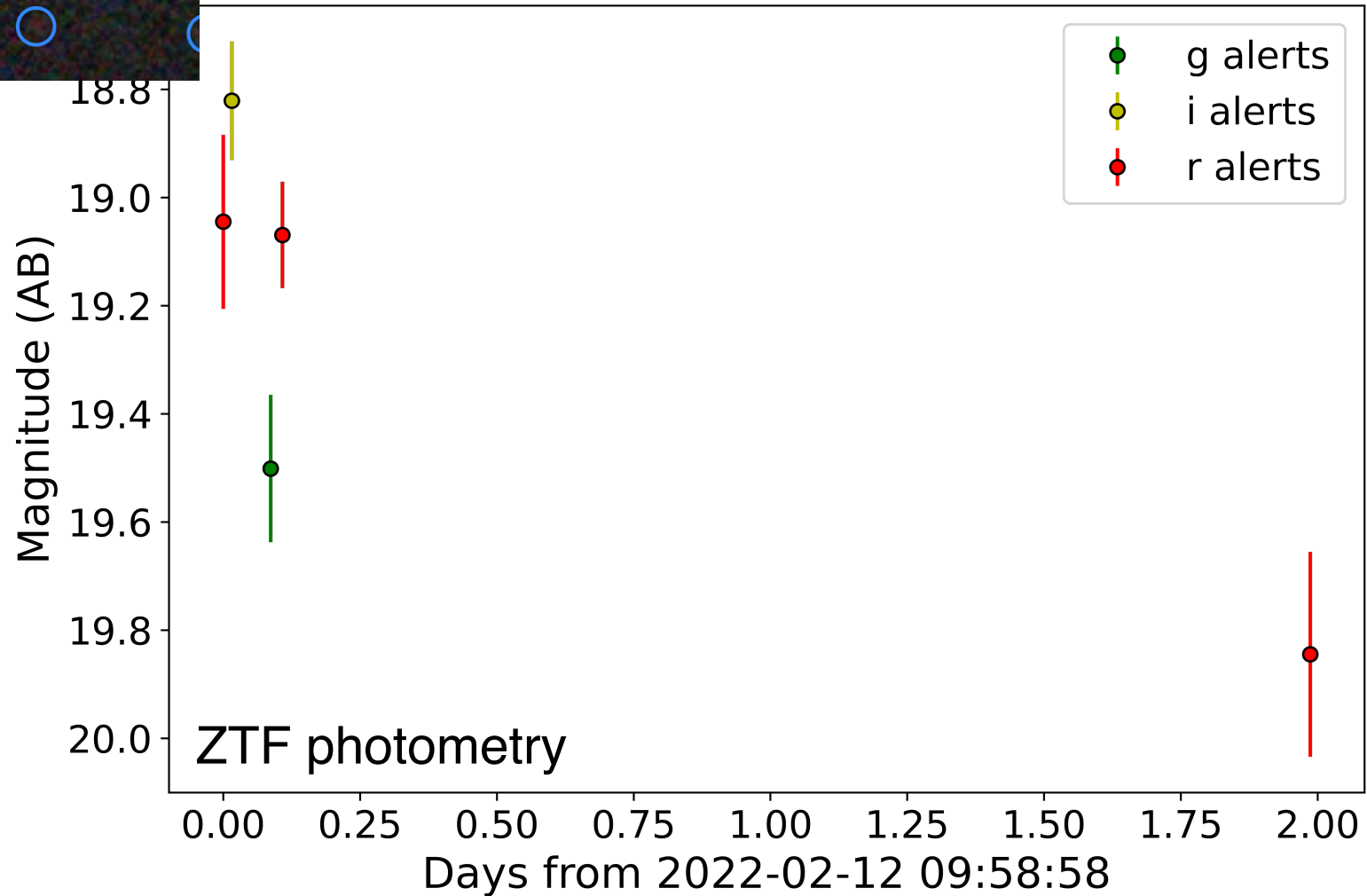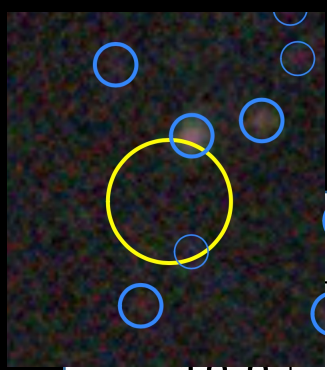Supernova shock cooling
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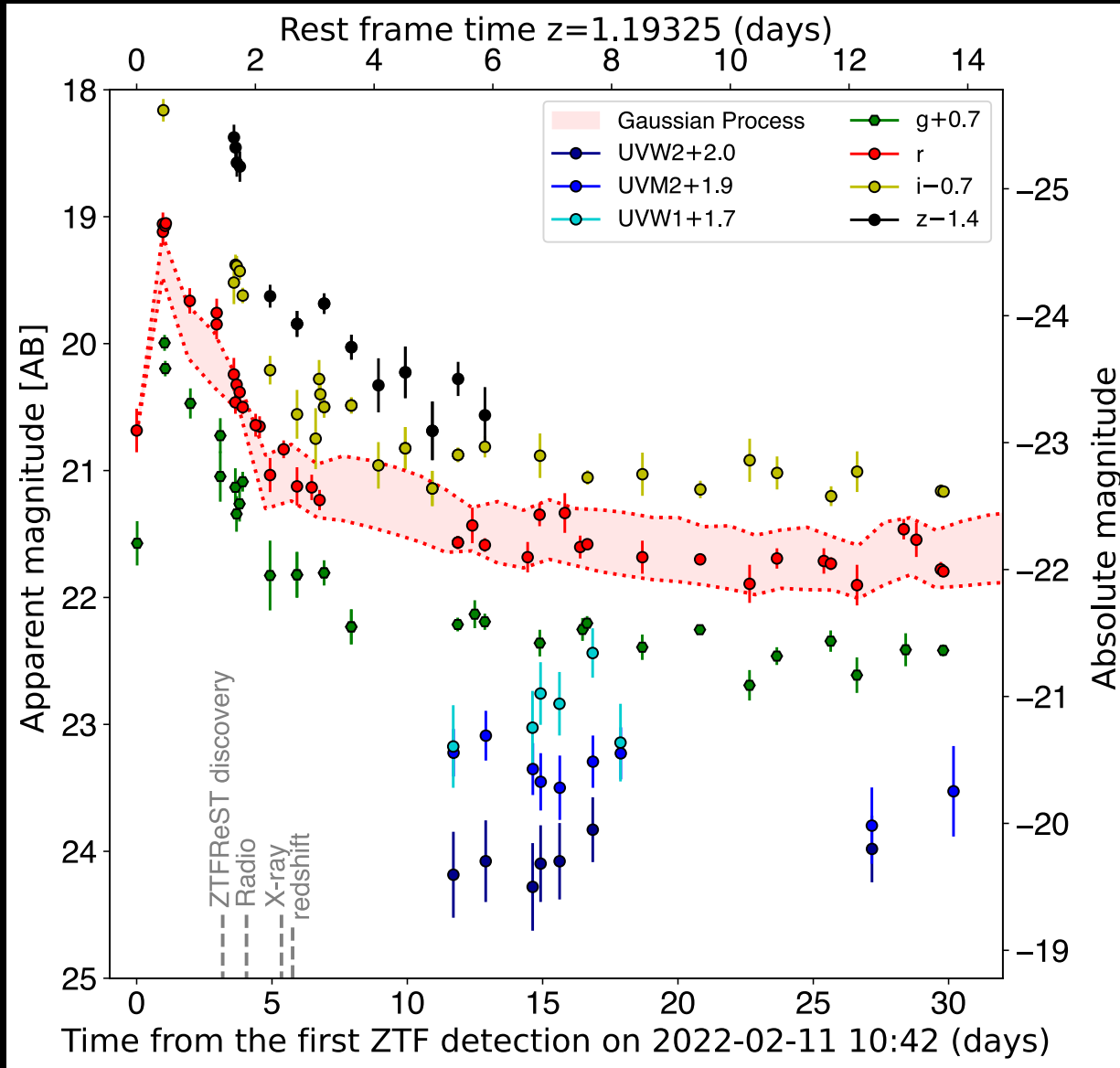Kilonovae   AT2022cmc
Still waiting…   a jetted TDE!

AT2022cmc: Discovery

AT2022cmc: a relativistic TDE

A couple of fun facts:
- ❖ **First** relativistic TDE identified in near real time by an optical survey

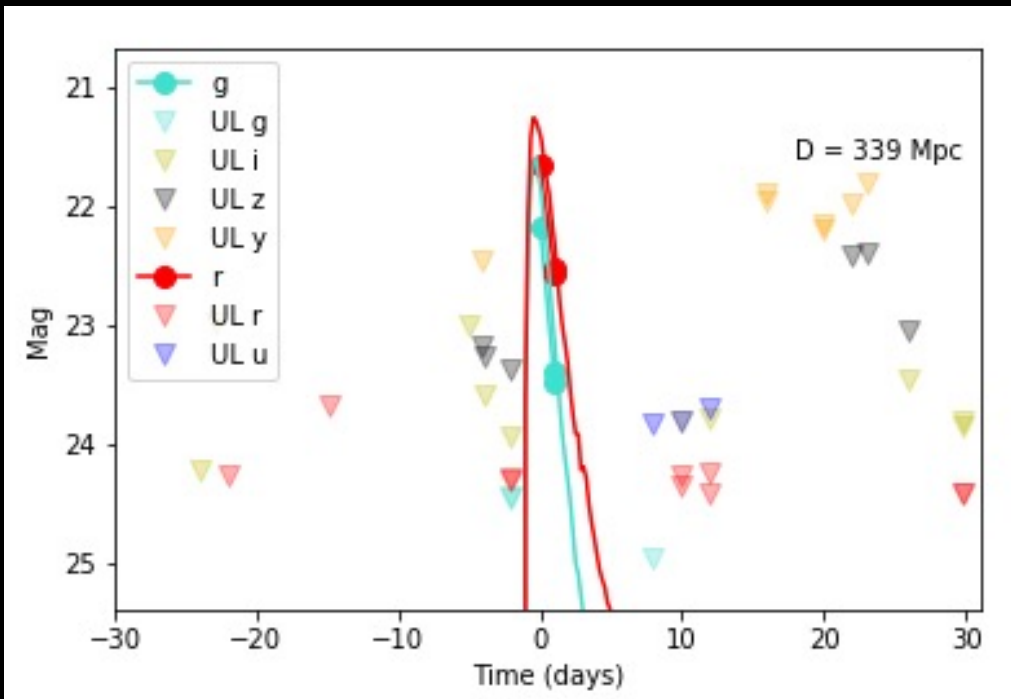- ❖ **Furthest** TDE ever found

Credit: ESO/Kornmesser

Andreoni & Coughlin et al. (2022), Nature, 612, 7940

Kilonova discovery with Rubin Observatory

Serendipitous discovery during the survey

Assuming a rate of 800 Gpc^{-3}y^{-1} and a uniform luminosity function, ~350 GW170817-like kilonovae are expected to be present in Rubin data, but only 3-32 might be discovered

Andreoni+2022a, ApJS, 258, 1, 5

Reality check
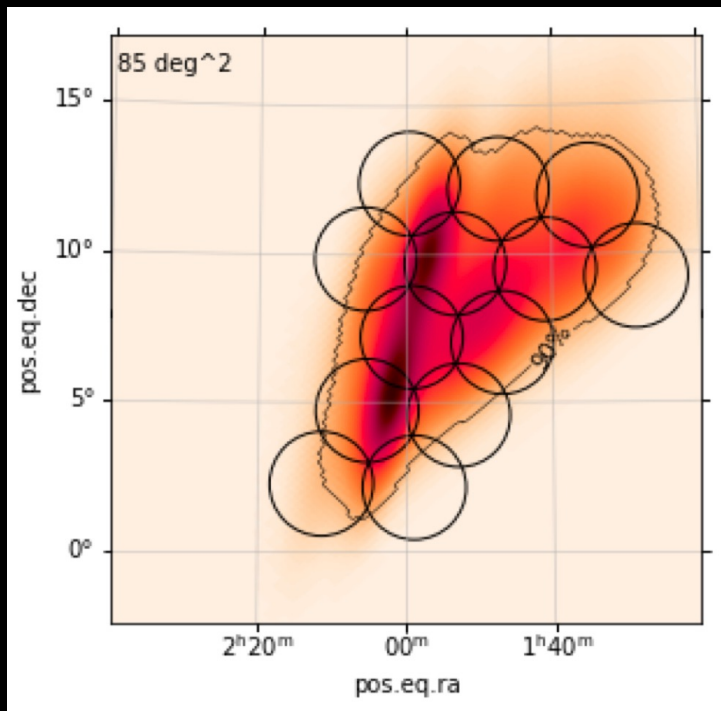we cannot take > ~few spectra per night

JSI NASA

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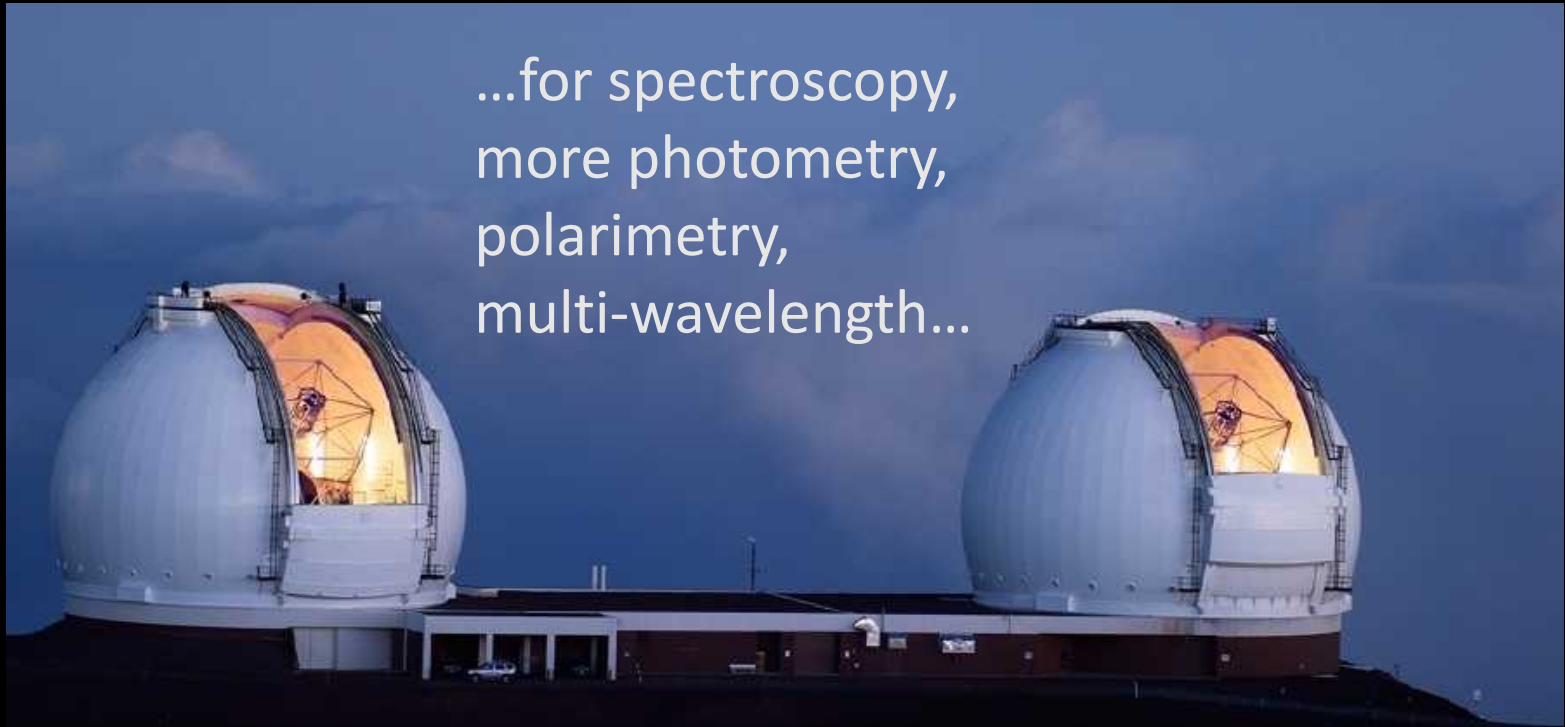we cannot take > ~few spectra per night

For ToO observations see:
Margutti+2018 (white paper)
Andreoni+2022b, ApJS, 260, 1, 18

Minimum ingredients of choice

...for spectroscopy,
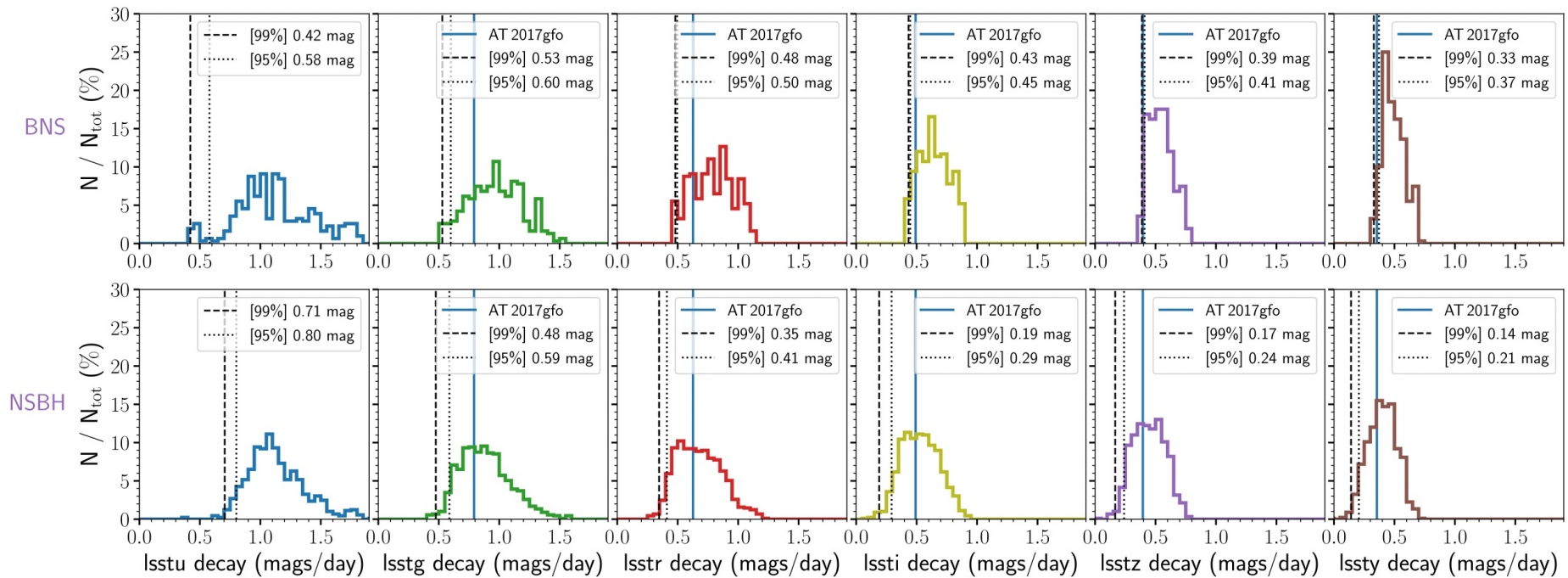more photometry,
polarimetry,
multi-wavelength...

❖ Transient being real
❖ Extragalactic: high b_{Gal} + deep archival images + star/galaxy separ.
❖ Fade rate ($\Delta m/\Delta t$) ➡ importance of the cadence choice

Always welcome: same-night color, history, proximity to a galaxy, photoz

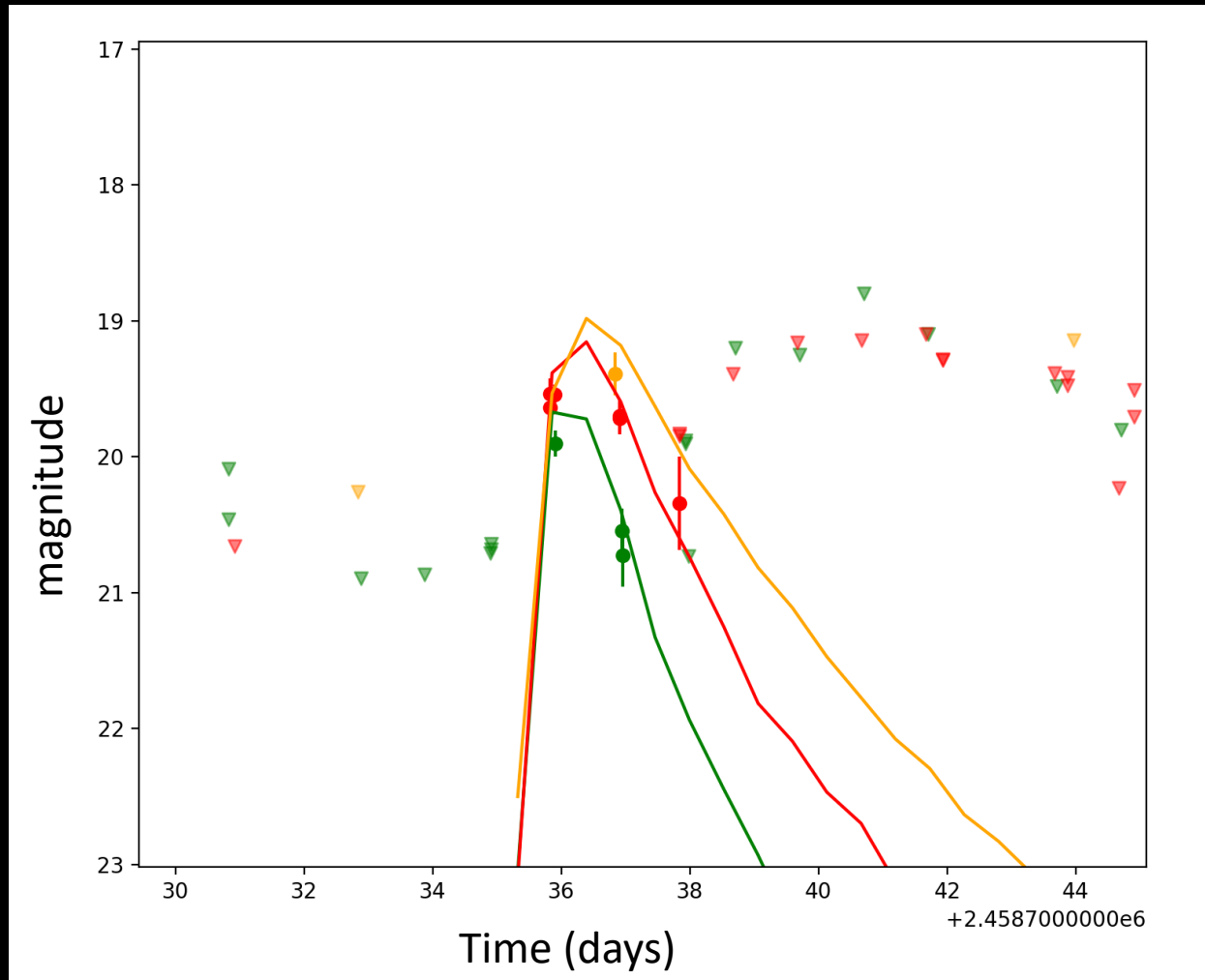# Kilonova model grid: decay rates

Andreoni et al.

Untriggered kilonova searches

Simulated distant kilonova in ZTF data (plot by: Segues-Carracedo)