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Lost and Found — A gallery of overlooked optical nuclear transients from the ZTF archive

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ABSTRACT

Context. Tidal disruption events (TDEs) correspond to the destruction of a star by the tidal forces around a black hole, leading to outbursts which can last from months to years. These transients are rare, and increasing the current sample is paramount to understand them. As part of the Fink alert broker, we have developed an early detection system for TDEs for the Zwicky Transient Facility (ZTF) data.

Aims. In this paper, we report on the optical transients we found either during the development of this tool, or when applying the classifier to the existing archive. We use this sample to anticipate what improvements to the TDE detection systems will need to be implemented for future surveys.

Methods. For all the transients, we present optical and infrared archival photometry from ZTF, WISE, and Catalina, and assess the previous nuclear activity of the host. We fit the ZTF lightcurves with both a phenomenological and a physically-motivated model.

Results. We report on a total of 19 optical nuclear transients, out of which nine are in passive galaxies, eight in active galaxies, and two for which the activity of the host is uncertain. Two transients are newly discovered repeated TDE candidates, and we compare them to the current sample of repeated optical nuclear transients. One transient is exceptionally long-lived (>5 years), in an until-now passive galaxy. Three of the TDE-like flares in active galaxies have absolute $g-$band magnitudes brighter than -24, making them new Extreme Nuclear Transient (ENT) candidates. One seemingly repeated object was revealed to be two independent supernovae in the same galaxy.

Conclusions. This sample shows both the potential of our detection system for future discovery, and the relevance of archival searches to reveal overlooked transients. It also raises several points of concern and avenues of improvement for current and future classifiers.

Key words. Methods: observational, data analysis – Black hole physics – Surveys

. Introduction

Due to the advent of large scale surveys, the diversity of transient astrophysical sources has increased significantly in the last few decades. Successive observatories and surveys, and increasingly more intricate detection and classification schemes, have allowed to paint a diverse picture of the transient sky, covering orders of magnitude in terms of luminosity and timescale. In particular, as the samples grow and outliers are discovered, the boundaries between different classes can be challenged – and so can be our understanding of these objects (e.g. Zabludoff et al. 2021). In this work, we focus in particular on optical nuclear transients, i.e. objects lying in the nucleus of their host galaxy that show an episode of dramatic variability, way beyond their usual behavior. A schematic representation of a selection of these transients can be seen in Fig. 1, where the overlap between the classes is clearly visible. In this work, our goal is to show the value of using archival datasets in discovering optical nuclear transients, especially outliers which might have been rejected by already-existing classifiers.

As the galactic nuclei have a dense stellar population, one can expect to observe nuclear supernovae (SNe – nuclear here indicating their location within the galaxy, not their triggering mechanism), which typically last a few weeks, showing slightly different behaviors depending on their type, but consistently displaying a fast cooling in their decay phase. SNe also have a slower and brighter cousin, aptly named superluminous supernovae (SLSNe, e.g. Moriya et al. 2018), which can last for several months. Another category of transients which is yet to receive a definitive interpretation are the Fast Blue Optical Transients (FBOTs, e.g. Ho et al. 2023), which can reach luminosities similar to those of SLSNe but on timescales comparable to typical, faster SNe. One category of nuclear transients that is the subject of significant effort from the community at the moment are Tidal Disruption Events (TDEs, e.g. Gezari 2021). These correspond to the outburst resulting from the destruction of an inbound star by the tidal forces around the central supermassive black hole (SMBH) of a galaxy. They can be seen in various wavelengths, typically lasting a few months, and with optical brightness at the frontier between SNe and SLSNe. While most of the ~150 known TDEs happened in passive galaxies (i.e. where the central SMBH was not accreting matter before the stellar disruption), in theory, they can also happen in comparable rates in Active Galactic Nuclei (AGNs) as well (e.g. Chan et al. 2019). Recently, a number of nuclear transient events have been suggested to be linked to such TDEs in AGNs. The first, quite broad, category are Ambiguous Nuclear Transients (ANTs, e.g. Kankare et al. 2017; Wiseman et al. 2025), and correspond to bursts that photometrically roughly look like TDEs (with a smooth rise and slower decay), but for which the spectra do not match expected TDE emission. The exact mechanism behind these objects is still to be understood. The most luminous of them (absolute magnitudes above -24) are called Extreme Nuclear Transients, with only a handful of instances (ENTs, e.g. Hinkle et al. 2024; Russeil & Quintin 2025; Graham et al. 2025). Somewhat perhaps linked to ANTs and TDEs are the so-called Bowen Fluorescence Flares (BFFs, e.g. Trakhtenbrot et al. 2019b) and the Extreme Coronal Line Emitters (ECLEs, e.g. Komossa et al. 2008), which are both characterized by smooth, long TDE-like lightcurves and optical spectra showing specific transient emission line features. For BFFs and ECLEs, the exact triggering mechanism is unclear, and they could arise from flares in AGN accretion flow or from TDEs alike. A final type of nuclear optical transient are the Changing Look Active Galactic Nuclei (CL-AGNs, e.g. Trakhtenbrot et al. 2019a; Ricci & Trakhtenbrot 2023). These correspond to AGNs where the optical classification as type 1 or 2 changes over time – this is usually associated with flaring behaviour in the optical, and sometimes a dip in the X-ray lightcurve. Such a change should not be possible in the unified AGN model, where the type is a function of the inclination angle only (e.g. Antonucci 1993). Several scenarios can be invoked to explain these transients, including intrinsic changes in the accretion flow due to a TDE embedded within the AGN (e.g. Merloni et al. 2015).

One final note on the zoo of optical nuclear transients is that some of them have been shown to repeat. These repeated bursts can take the form of rebrightening during an otherwise smooth decay, or a fully fledged second peak at later times. For some objects, this peculiar behavior can put constraints on the corresponding models. For instance, a repeated TDE can indicate that the inbound star survived the initial encounter, with a disruption that was partial only. However, in order to survive a significant number of such partial TDEs, a main sequence star requires strong fine-tuning of the parameters of the problem (e.g. Payne et al. 2021). If this fine-tuning becomes too constraining, it might indicate issues in the models. As such, collecting repeated transients and assessing their fraction within the overall population is of particular interest to constrain the models and their limits.

For all those events, the current sample is limited and prevents us from strongly constraining the existing models. As such, any new detection should ideally lead to a multi-wavelength photometric and spectroscopic monitoring. But the first step is to ensure a timely detection of these events. This was the idea behind the development of an early TDE detection system (Llamas Lanza et al. 2025) in the Zwicky Transient Facility (ZTF, Bellm 2014) data, for the Fink broker (Möller et al. 2021). We purposely built it for high completeness rather than high purity, in order to detect the outlier events that will push the existing models of each class. While developing this tool, we have encountered several objects of interest. These objects were either picked up directly by the TDE detection system itself, or found serendipitously in the archive during its development. The goal of this paper is to present these objects in a single place, and put them into perspective in order to anticipate the efforts that should be done for future, larger transient surveys such as LSST (Ivezić et al. 2019).

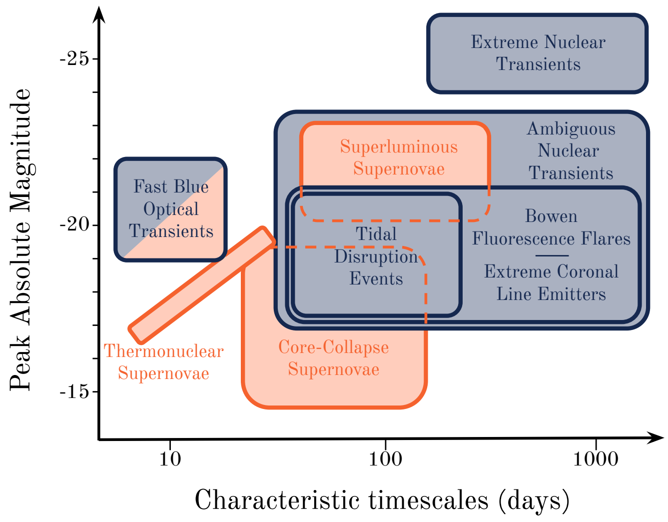

Fig. 1. Representation of the timescale and peak absolute magnitude of the various optical transients considered in this paper. The exact borders of each category are generally not well-defined – in particular, there might be a continuum between ANTs and ENTs, the latter being for now crudely defined as brighter than absolute magnitude -24. The orange boxes correspond to supernovae events, and the blue ones to accretion-powered events (the interpretation of FBOTs is still open). The clear overlaps between categories indicate the difficulty of classifying these events based on photometric data only. This figure is inspired from Fig. 4 of Hinkle et al. (2024).

Section 2 gives a general idea of the methods which lead to the identification of this sample, and how we analysed them to reveal their nature. Section 3 presents detailed information about the sample and highlights a few candidates of particular interest. Finally, we discuss the broader impact of these findings in Section 4, especially from the point of view of automatic classifiers, and present our conclusions in Section 5.

2. Methods

2.1. Finding the candidates

As a part of the Fink alert broker (Möller et al. 2021) we created a dedicated science module aimed at detecting TDEs during their initial rising phase (Llamas Lanza et al. 2025). It is based on applying a physically-motivated parametric fit (the Rainbow model, Russeil et al. 2023) to the rising parts of the lightcurves, as a feature-extraction step, followed by a machine learning classifier applied on these features, without relying on additional external information. The module's design choices, which prioritize completeness over purity and result in a relatively low precision but a recall as high as 76%, make it particularly well suited for identifying off-nuclear TDE-like events and those superimposed on AGN-like variability, alongside standard nuclear TDEs.

We extracted and analyzed the data for all ZTF observed objects having significant rising parts in their lightcurves between late 2019 and mid 2025, and applied different versions of the classifier to them. Visual inspection of the objects flagged as prominent TDE candidates but lacking proper classification in Transient Name Server[1] (TNS) revealed 89 objects of interest – out of those, about 40 were interpreted as AGNs, about 40 as SNe, and the remaining dozen objects were interesting TDE/ANT sources, that are presented below. We additionally found serendipitously a number of transients of interest, which were added to the sample presented here, leading to the total of 19 optical nuclear transients. It is important to note that the selection biases of our sample are thus relatively unknown, due to the diverse ways in which these transients were found.

2.2. Analysing the candidates

2.2.1. Photometric data

This study made use of various archival data for each object. Once the candidates were found in alert photometry, we retrieved the detailed ZTF lightcurves through the forced photometry pipeline (Masci et al. 2018, 2023), making use of the g, r and i bands. Where needed, we converted these differential fluxes into apparent magnitudes following the standard instructions in Masci et al. (2023).

We also collected any available V-band data from the Catalina Real-time Transient Survey (CRTS, Drake et al. 2009). Infrared photometric data is obtained from the NeoWISE catalog data (Mainzer et al. 2011), in order to reveal reprocessing of the light from the nuclear transient by dust in the form a delayed infrared echo (e.g. Masterson et al. 2024). We use both the $W1$ and $W2$ data, with a 30 days binning. When it was available, we retrieved the Swift/XRT 0.3-10 keV detections and 3σ upper limits using the online products (Evans et al. 2023).

2.3. Discriminating between active and passive host galaxies

Before studying the burst in each of the objects presented here, we try to determine whether the host galaxy was previously active (in the sense of having an active galactic nucleus) or passive. This allows to separate the transients between candidate TDEs (in passive galaxies) and candidate ANTs (in active galaxies). We emphasize that this is here mostly a phenomenological consideration, and we make this distinction mostly to support the point that known AGN hosts should not be blindly excluded from transient search algorithms. This classification is ideally performed using spectroscopic data, for instance through the use of BPT diagrams (Baldwin et al. 1981). Whenever such a spectroscopic classification is available (e.g. for objects with SDSS or DESI archival spectra, York et al. 2000; Collaboration et al. 2025), we use it.

[1] `https://www.wis-tns.org/`

In the absence of previous spectroscopic classification, the task of discriminating between active and passive galaxies is more difficult. We make use of Gaia DR3 photometric classification when available (Gaia Collaboration et al. 2023). We assess the presence of significant AGN-like archival variability in the optical and infrared lightcurves, as an indication of the presence of an AGN. In the absence of any of this information, we use the infrared color criterion $W1 - W2 > 0.8$ (Stern et al. 2012) to assess the presence of an AGN.

We take this opportunity to raise the caveat that, in the context of variability studies, the definition of AGN might be somewhat ambiguous. Indeed, an AGN diagnostics based on the relative amplitudes of narrow lines might indicate that the SMBH has been accreting in a relatively recent past, leading to non-stellar ionization of a narrow line region (and thus be typically identified as Type 2 AGN). However, it does not necessarily indicate that the SMBH is currently accreting – which is the most important question in our context, both to exclude standard AGN flaring variability, and differentiate between TDEs in vacuum or embedded withing an accretion disk. Fortunately, these concerns should be lifted in the presence of broad emission lines or photometric variability, which require current accretion.

2.4. Phenomenological fitting

In order to obtain quantified estimates of the various timing parameters of the TDE candidates we present here, we fitted their $g-$band flux lightcurve with a standard phenomenological model to describe TDE evolution, a Gaussian rise followed by a power-law decay (e.g. van Velzen et al. 2021):

$$F_g(t) = F_g^{\rm host} + F_g^{\rm peak} \times \begin{cases} e^{-(t-t_{peak})^2/2\tau_{rise}^2} & \text{if } t \leq t_{peak} \\ ((t - t_{peak} + \tau_{decay})/\tau_{decay})^p & \text{if } t > t_{peak} \end{cases} \quad (1)$$

The free parameters are thus six: $F_g^{\rm host}$ and $F_g^{\rm peak}$ the g-band fluxes of the host and the (host-subtracted) transient at the peak, t_{peak} the time of the peak, τ_{rise} the rising timescale, τ_{decay} the decay timescale, and p the decay power-law index, which we fix at $p = -5/3$. A late-time (> one year) plateau is known to sometimes happen in TDEs, at least in optical and ultraviolet wavelengths (e.g. van Velzen et al. 2019). This is not accounted for in this model, and for some of our objects this plateau is detected as an excess from the model.

In practice, the fit is performed on the ZTF g-band lightcurve, using the function `curve_fit` from the `scipy` Python package. Where needed, a late-time component was added (either a late-time plateau emission, or a negative component arising from a quiescent emission lower after the transient compared to before it). In these cases, the components are simply added to the 'if $t > t_{peak}$' part of the equation.

2.5. Physically-motivated fitting

The selection in the Fink early TDE module is based on Rainbow (Russeil et al. 2023), a phenomenological model well suited to describe the evolution of the lightcurve. However, such approach is not enough to constrain the physics and build a finer understanding of the event. In order to obtain physically informative parameters, we turn to analytical models. For this purpose, we use the Redback python package v.1.0.31 (Sarin et al. 2024; Ashton et al. 2019) that provides a collection of models able to fit transients of various natures. It uses Bayesian inference to build a full posterior distribution of the physical parameters, offering highly informative fits. Note that although the parameters carry valuable information regarding the physics of the event, fitting semi-analytical models to every lightcurve is computationally impossible. Indeed, a single lightcurve fit typically takes hours to tens of hours to converge, and therefore can only be applied to carefully selected objects of particular interest.

We use the `tde_fallback` model, which is a direct adaptation of the model proposed by Mockler et al. (2019). In the latter, the bolometric flux of the TDE is powered by the fallback rate of the matter coming from the disrupted star onto the black hole, given an efficiency parameter. It also assumes a photosphere around the black hole, allowing the reprocessing of high energy electromagnetic radiations to visible/UV emissions. Within Redback, the model consists of 9 parameters: z the redshift, M_{BH} the mass of the black hole, M_{star} the mass of the star, t_{visc} the time delay due to viscosity effects (which comprise circularization and accretion processes), β^* a proxy for the impact parameter, η the efficiency of the conversion of the fallback rate of material into electromagnetic emissions, R_{ph-0} a normalizing parameter for the radius of the photosphere, L^*_{photo} the exponent in the power-law describing the dependence of the radius of the photosphere to the luminosity, and t_0 the time of the TDE start. The priors for the parameters were chosen following the analysis of Nicholl et al. (2022), that provides a systematic modeling of a sample of TDE lightcurves[2]. Only the prior on the mass of the star differs. In our case, it was approximated by a gaussian truncated between 0.01 and 100 $M_\odot$, with $\mu = 0.01$ and $\sigma = 0.5$. The Markov chain Monte Carlo (MCMC) is performed using the dynesty sampler (Speagle 2020), a robust and standard nested sampling method. We set the number of live points to 1000.

3. Results

We present here a sample of 23 optical transients of interest that were found in the ZTF archive. Out of those, 9 are TDE-like flares in galaxies that were previously passive, and as such are good TDE candidates. This includes one very long-duration burst, and one repeated TDE candidate. 8 flares are TDE-like in galaxies that were previously active, and so are ANT candidates. For 2 other transients, the diagnostic methods to assess the host activity were not decisive. Finally, we present 4 supernova candidates, including a seemingly repeated event which is in fact two different SNe in the same galaxy, a few years apart.

A summary of the sources can be found in Table 1, with their respective properties and an assessment of their state of activity at the time of writing, to motivate follow-up studies where relevant. For more details, the properties of the bursts are shown in Tab. A.1 for the phenomenological fit, and Tab. A.2 for the physically motivated fit. Fig. B.1 provides an optical sky view of the host of the transients, Fig. B.2 and Fig. B.3 provide a detailed view of their ZTF lightcurves, and Fig. B.4 and Fig. B.5 gives the broader multi-wavelength, multi-epoch context, by showing their CRTS and WISE lightcurves as well.

[2] Given the extreme behavior of AT2020ukj (see Section 3.1), the t_{visc} prior upper bound for this particular event was increased by one order of magnitude

3.1. TDE candidates in passive galaxies

3.1.1. AT2020ukj: A long-lived optical nuclear transient

Because of the selection biases of our early detection system, aiming specifically at slow and hot nuclear transients to distinguish SNe candidates from TDEs, we tend to select objects with long rising timescales. AT2020ukj was selected because of this, but its decay timescale is even more outstanding. Its host is WISEA J073134.20+571628.9, a galaxy with a photo-z=0.089 ± 0.016 (Duncan 2022), which is likely passive (no sign of variability in the past ZTF, CRTS or WISE lightcurves, WISE color W1-W2∼0, and classified as passive galaxy by Gaia DR3, Gaia Collaboration et al. 2022). Between June and December 2020, it underwent a slow blue brightening (rise timescale of 68.5 ± 8.8 days, peak difference color of $g - r \sim -0.3$), peaking at differences magnitudes of 19.0 (19.2), or absolute magnitudes of -19.0 (-18.8). It then started an exceptionally slow decay, at constant color, with a decay timescale of 4984.9 ± 497.2 days – since its peak in December 2020, it has not yet reached the quiescent level.

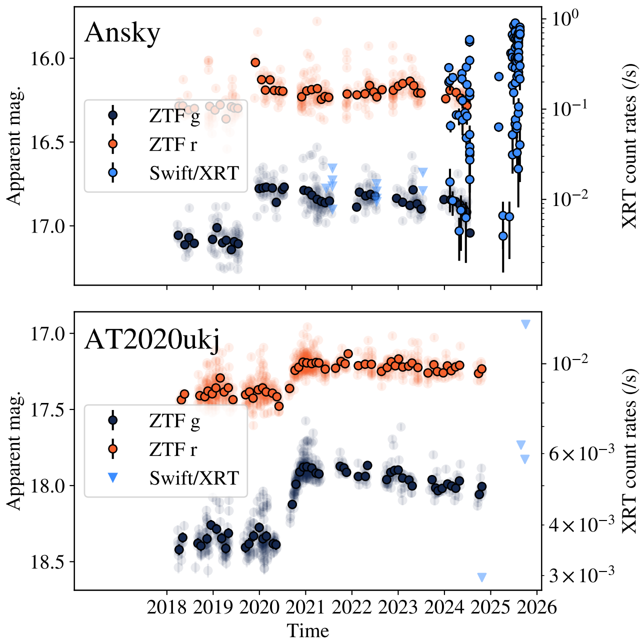

Fig. 2. Comparison of the behaviors of ZTF19acnskyy ("Ansky", top panel) and AT2020ukj (bottom panel), showing their ZTF r and g bands (orange and dark blue), and the Swift/XRT detections and upper limits (light blue circles and downwards triangles). This shows their similarities in terms of long decay timescales, as well as the complex late-time X-ray behavior of Ansky.

Such long timescales exclude SNe contaminants. In fact, this source shows striking similarities with ZTF19acnskyy (hereafter Ansky, Sánchez-Sáez et al. 2024) in terms of timescales, as can be seen in Fig. 2. Ansky has a comparable decay timescale of 6600.5 ± 1484.6 days, which is very large compared for instance to that of the slowest TDE in the ZTF sample from Hammerstein et al. (2022), AT2018iih, which is about 200 days. In particular, one way to obtain such long bursts in a standard TDE model is through a combination of high viscosity and low efficiency of the accretion flow, which is confirmed by the `tde_fallback` fit, showing AT2020ukj as an outlier in both parameters (respec-

Name	RA	Dec	Redshift	$M_{\rm abs,g}^{\rm peak}$ [mag]	IR echo	Comments	Still active
Candidates TDE							
AT2020ukj / ZTF20accxwrk	07:31:34.20	+57:16:29.04	0.089 ± 0.016 (P)	−19.0 ± 0.2	No	Very slow flare in passive galaxy	Yes
AT2023adr / ZTF22abzajwl	14:36:19.83	+32:23:16.46	0.131 (S)	-20.7±0.1/-19.3±0.1	Hints	Repeated flares in passive galaxy	Maybe
AT2023npi / ZTF18acfhomp	00:12:15.73	+22:19:18.34	0.0256 (S)	−16.8 ± 0.1	Yes	Very faint flare	No
AT2020pno / ZTF20abjwqqq	16:46:37.04	+55:36:26.81	0.279 (S)	−21.5 ± 0.1	Yes	Hints of late-time plateau	No
AT2020aexc / ZTF21aabgjcz	12:07:13.45	+44:10:15.60	0.43 ± 0.03 (P)	−22.6 ± 0.3	Hints		No
ZTF20aatpzog	11:18:54.34	+21:49:42.44	0.38 ± 0.06 (P)	−21.8 ± 0.5	Yes		No
AT2020afap / ZTF18aasvknh	11:36:33.82	+61:43:39.00	0.099 (S)	−18.5 ± 0.1	Yes		No
AT2023jag / ZTF23aajsmul	16:09:12.09	+46:33:42.4	0.13 ± 0.05 (P)	−19.2 ± 0.1	No		No
AT2021ovg / ZTF21aazenvp	17:48:05.01	+40:14:17.42	0.24 ± 0.06 (P)	−20.4 ± 0.1	No		No
Candidates ANT							
ZTF23abjvojy	02:34:39.04	+01:07:40.14	0.27 (S)	−21.2 ± 0.1	Yes	Repeated flares in active galaxy	Unclear
AT2022yhf / ZTF19aayijkh	21:46:06.85	-11:58:01.02	0.56 ± 0.03 (P)	−24.2 ± 0.2	Yes	ENT candidate	Yes
AT2024nxp / ZTF24aamfius	17:31:27.23	+57:36:58.09	1.7 ± 0.8 (P)	-25.5±1.5	No	ENT candidate – Rebrightening?	Yes
AT2023rav / ZTF23aaxaehw	23:51:14.69	+25:41:50.65	0.504 (S)	−24.2 ± 0.05	Yes	ENT candidate	Below quiescence
AT2020actc / ZTF20acxtaau	10:03:16.37	+21:05:45.85	0.145 (S)	−20.2 ± 0.1	Yes		No
AT2021wxd / ZTF21abvydim	15:58:19.21	+07:28:24.59	0.231 (S)	−21.0 ± 0.3	No		No
AT2024hhj / ZTF24aaimfrw	08:48:37.12	+33:50:15.01	0.217 (S)	−21.5 ± 0.5	No		No
AT2024gzn / ZTF24aafvgzk	17:55:16.11	+38:58:41.44	0.23 ± 0.03 (P)	−20.5 ± 0.2	No	Likely AGN burst	Rebrightening?
Ambiguous							
AT2023zaj / ZTF23abowyjf	00:37:34.44	-13:33:51.5	0.4 ± 0.1 (P)	-22.5±0.6	Yes	ANT or TDE	Yes
AT2023szj / ZTF23aajnfna	14:46:28.16	+08:41:36.7	0.57 ± 0.16 (P)	-23±0.75	Yes	Likely AGN burst	Rebrightening?
Candidates SNe							
AT2021lnu / ZTF21aazrgtw	15:32:18.68	-00:00:00.74	0.15 ± 0.07 (P)	-20.2±1.2	No	SLSN candidate	No
AT2020mvg / ZTF20aazyvre	12:05:26.53	+28:54:34.36	0.31 ± 0.11 (P)	-22.4±0.9	Unclear	SLSN candidate	No
AT2019agc / ZTF19aafmytc	14:06:45.32	+13:55:04.7	0.15 ± 0.05 (P)	-19.7±0.7/-19.7±0.7	No	Multiple SNe	No
AT2024ljd / ZTF20aacedmi	21:13:39.44	+02:29:36.59	0.046 (S)	−19 ± 0.05	No	Confirmed SN Ia	No

Table 1. Summary information about the various transient objects present11ed here. The table is divided in four sections, corresponding to flares in passive galaxies (secure TDE candidates), flares in active galaxies (TDE or flaring AGN candidates), ambiguous sources where classification is uncertain, and the most interesting SN candidates. For the redshift, we indicate with (S) those for which it is spectroscopic, and with (P) when it is photometric. The absolute magnitude, given for the g band, comes from the fitted phenomenological burst profile and takes into account the redshift uncertainties.

tively $\log(t_{\rm visc}) = 3.21^{+0.02}_{-0.02}$ and $\log(\eta) = -3.98^{+0.03}_{-0.01}$). We fitted the same TDE model to Ansky's ZTF data, leading to similar very low viscosity ($\log(t_{\rm visc}) = 3.28 \pm 0.01$), although the lower absolute magnitude led to the other parameters being different between the objects.

As a consequence of their similarity, AT2020ukj and Ansky have the same possible interpretations: either an extreme long-duration TDE, a TDE in an AGN with a low inclination angle, or an AGN in the process of activation. The main difference between these models would be the physical origin of the materials being accreted, either a tidally disrupted star (likely very massive, e.g. Zhu et al. 2025), or a gas overdensity. However, compared to Ansky, AT2020ukj is significantly brighter (absolute g-band magnitudes of -19 for AT2020ukj compared to -16.5 for Ansky). Such a brightness over such timescales leads to a massive energy budget, which could be too important for the disruption of a single star, and the interpretation of a starting AGN would seem to be favored here. A smoking gun evidence of this interpretation would be the late-time appearance of typical AGN observables, such as emission lines. We have obtained two spectra from the Caucasian Mountain Observatory (CMO, Russia), taken on December 14$^{\rm th}$, 2024 and January 26$^{\rm th}$, 2025, which showed no sign of clear emission feature, although the signal to noise ratio was too low to perform any definitive conclusion (Russeil et al. 2024). As such, we have requested an optical spectral monitoring of this source, and will report on its evolution. Ansky is also interesting for its multi-wavelength behaviour, through the late-time appearance of X-ray Quasi-Periodic Eruptions (QPEs) in its decay (Hernández-García et al. 2025a), which are rare repeated bursts of thermal X-rays, with a dozen known sources to this date. The QPEs in Ansky are also the first one to show an evolution of their periodicity (Hernández-García et al. 2025b). We have thus requested an X-ray monitoring of this source, in order to constrain the late-time X-ray behaviour of this peculiar object.

3.1.2. AT2023adr: a repeated pTDE candidate

Our pipeline detected two transient objects displaying repeated flares: AT2018mac/TDE2022dbl and AT2023adr. The former has been reported recently (e.g. Chen et al. 2024; Lin et al. 2024; Liu et al. 2025; Makrygianni et al. 2025); however the rebrightening of the latter had gone unnoticed until we detected it (Llamas Lanza et al. 2024).

AT2023adr was first detected in early 2023. Its host is a bright relatively red galaxy ($g - r \simeq 19.6 - 18.8 = 0.8$) at a spectroscopic redshift $z = 0.131$, that displayed no variability before the first peak in either ZTF, WISE or CRTS data. Moreover, its WISE color is $W1 - W2 \sim 0.1$. As such, the host can be safely classified as passive. In January 2023, it underwent a slow (rise time of 25.5 ± 0.9 days and decay of 64.3 ± 1.6 days) and blue (difference color of $g - r \sim -0.2$, constant during decay) brightening, peaking at difference magnitudes 18.15 ± 0.1 (18.0 ± 0.1) and absolute magnitudes -20.7 ± 0.1 (-20.9 ± 0.1) in the ZTF g-band (r-band respectively). This is too bright for standard supernovae – without a spectral follow-up, this object could be either a TDE or SLSN candidate, with the constant temper-

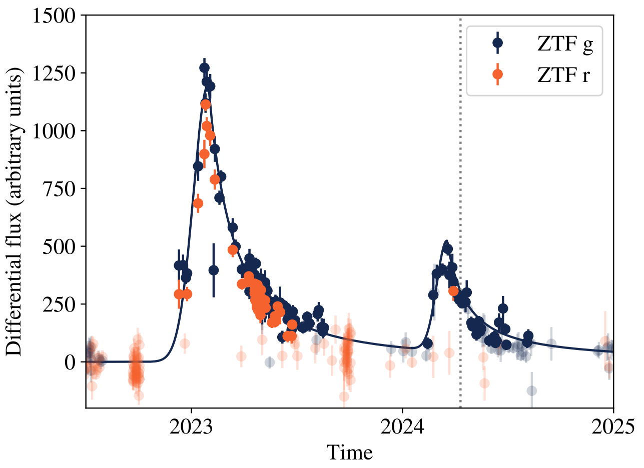

Fig. 3. ZTF forced photometry lightcurve of AT2023adr, a candidate repeated TDE. Points with a signal to noise ratio below 3 have been plotted in transparence. The full line corresponds to a double TDE profile (gaussian rise, $\propto t^{-5/3}$ decay) fitted to the g-band lightcurve. The dotted vertical line shows the timing of the ePESSTO+ optical spectrum, during the second peak.

ature being indicative of TDE. Over the course of 2023, it then dropped back down to the quiescence level (with a 3σ upper limit of the absolute g-band magnitude around -18).

However, about a year after the first peak, the source underwent a strong rebrightening (see Fig. 3). This second peak had relatively faster timing properties (rise of 16.6 ± 1.5 days and decay of 40.5 ± 3.7 days). It was mostly covered by the ZTF g-band only, with a single good detection in the ZTF r-band, so no color evolution can be strongly inferred from the photometric data, although this single point indicates similar color and thus temperature as the first peak. It peaked about one magnitude fainter than the first event, at difference magnitude of 18.8, and absolute magnitude of -19.3 in the g-band (consistent with either SN or TDE). The separation between the peaks and the return to quiescence are not consistent with a single, not-smoothly-evolving SLSN. Additonnally, a follow-up optical spectrum was obtained during the decay of the second peak by the ePESSTO+ collaboration (Dalen et al. 2024, see vertical dotted line in Fig. 3). This spectrum, while having a relatively low signal to noise ratio, does not display any line expected from SN decay. It shows [O II] and [O III] emission lines, and an emission feature around 4610Å which could be ascribed to blueshifted N III 4640 or He II 4686, which would be consistent with a TDE. Additionally, hints of an infrared echo can be found in the NeoWISE lightcurve of the object, with a slight increase by 0.3 magnitudes of the W2 band only.

As such, the lack of cooling during the first peak, and the lack of typical SN decay-related emission features in the second peak, lead us to the conclusion that a repeated TDE would be a strong interpretation of this event. By fitting the two distinct peaks with Redback separately, we obtained different physical parameters for the two events - in particular, the mass of the disrupted star is lower in the second peak ($0.76^{+0.14}_{-0.14} M_\odot$ compared to $0.32^{+0.23}_{-0.12} M_\odot$), which is physically consistent if the first disruption is only partial. However there are a handful of caveats, the main one being that the Redback model `tde_fallback` was built for full disruptions, and might as such not provide proper estimates for partial disruptions. Moreover, the inferred mass of the central black hole is not consistent between the two peaks ($\log(M_{SMBH}/M_\odot) = 6.79^{+0.06}_{-0.08}$ compared to $5.84^{+0.32}_{-0.31}$) – this could be explained if the two disruptions happened for one star in a relatively asymmetric binary SMBH system (as has been suggested for instance for AT2018fyk, a similar repeated event, with similarly asymmetric SMBH mass estimates, Wen et al. 2024). This inconsistency could also arise from `tde_fallback`'s assumption of full disruption, which would not be respected here, or from the absence of r-band detections in the second peak preventing a proper fit.

3.1.3. AT2023npi: an extremely faint TDE candidate

The host of AT2023npi is UGC 113, a nearby galaxy at a spectroscopic redshift of $z = 0.0256$. It is not bright in radio or X-rays despite being very close, its UV emission is not peaked at the nucleus, and its infrared color is $W1 - W2 \sim 0$. As such, it is likely a passive galaxy.

In 2023, its nucleus underwent an outburst, rising with a timescale of 46.6 ± 6.6 days. It peaked at difference magnitudes of ~ 18.5 in both r and g bands, corresponding to absolute magnitudes of ~ -16.8. The outburst was quite blue, with difference color $g - r \sim 0$. It then decayed very slowly, with a timescale of 246.5 ± 13.0 days, with no clear cooling in the decay, and some hints of structure in the lightcurve. It showed one of the most significant infrared echo of our sample (owing to the nearby nature of the host), with a brightening of the $W1$ and $W2$ bands by 0.4 and 0.7 respectively, associated with a significant change in the infrared color of the galaxy (shifting from $W1 - W2 = -0.05$ to $W1 - W2 = 0.25$).

Such an absolute magnitude excludes SLSN, which should be at least three magnitudes brighter. Additionally, the very long timescales (active emission during more than 2 years) exclude standard supernovae. As such, AT2023npi is an excellent faint, nearby TDE candidate. The physical fit provides us with extreme parameters to account for the faintness of the transient, seemingly favoring a very low mass star (the fit hits the border of the prior, at a stellar mass of $0.01 M_\odot$) and a small photosphere radius $\log(R_{ph-0}) = 0.03^{+0.05}_{-0.09}$. This would make this source one of the faintest optical TDE candidate to date, along with for instance AT2020wey, Ansky or J0744, all peaking around absolute magnitude -17 (Yao et al. 2023; Sánchez-Sáez et al. 2024; Malyali et al. 2023). A part of this faintness could be due to absorption by a particularly dusty galactic nucleus (which could also account for the bright infrared echo) – optical spectra of the transient while it was active would have been needed to confirm this hypothesis, and estimate clearly the intrinsic brightness of the transient.

3.1.4. AT2020pno: hints of late-time plateau

The host of AT2020pno is WISE J120713.44+441015.6, a red galaxy at a spectroscopic redshift of $z = 0.279$, that showed no variability in the historical CRTS, ZTF or WISE data, with infrared color $W1 - W2 \sim 0.1$, and no UV counterpart in GALEX. As such it is likely a passive galaxy.

In 2020 it displayed a strong blue brightening, with a rise timescale of 19.0 ± 0.7 days, and a peak difference color of $g - r \sim -0.2$. The peak reached difference magnitudes of about 19.2, corresponding to absolute magnitudes of -21.5 in both bands. A spectrum was obtained during the burst from the Keck observatory (Pessi et al. 2024), showing among other things a

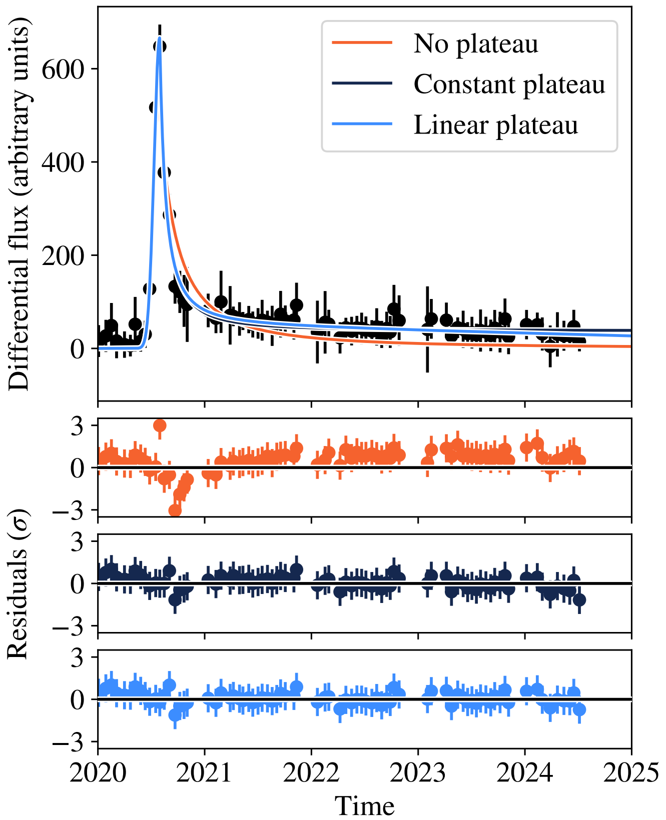

Fig. 4. Evidence for late-time plateau in AT2020pno, with the data and the fitted models in the top panel, and the corresponding residuals in the bottom three panels. Here three models are compared: a simple $\propto t^{-5/3}$ decay (orange, significant negative then positive residuals), a constant plateau (dark blue, slight negative then positive residuals), and a linearly decreasing plateau (light blue, no strong residuals). Data here is shown in bins of 15 days.

broad emission complex around 4600Å. This could correspond to blueshifted HeII, which is a common feature in TDEs. It then decayed with a typical timescale of 50.5 ± 1.9 days. However, using a simple $\propto t^{-5/3}$ decay leads to significant late-time residuals. This can be interpreted as a late-time plateau emission, which is a typical TDE behaviour (e.g. Mummery et al. 2024). In particular, by fitting models to the photometric data, the absence of plateau is significantly worse than a constant plateau, which is marginally worse than a linearly decreasing plateau (Reduced χ^2 of 0.48, 0.24 and 0.19 respectively, see residuals in Fig. 4). Finally, in late 2024, this source showed a significant infrared echo, with an increase of NeoWISE magnitudes by 0.6 and 0.4 for the W1 and W2 bands respectively.

This source has been noticed in Pessi et al. (2025) and Pavez-Herrera et al. (2025) as an ambiguous transient event. The broad He II emission complex, the lack of significant color evolution during the decay, and the late-time plateau and infrared echo, all lead us to classify this source as a strong TDE candidate. We obtained a monitoring of this source by Swift, which did not lead to any X-ray or UV detection.

3.1.5. AT2023jag

The host of AT2023jag is SDSS J160912.07+463342.4, which has a photo-z of 0.13±0.05. This galaxy has no detected infrared counterpart or radio counterpart, did not show any significant variability in CRTS, and is classified as passive by Gaia – as such, it is likely a passive galaxy.

In early 2023, it underwent a blue brightening, with rise timescale of 28.1 ± 1.8 days and decay timescale of 89.8 ± 7.8, and a peak difference color of $g - r \sim 0$. It peaked at difference magnitudes of 19.75 in both bands, corresponding to absolute magnitudes of -19.15. The decay showed constant temperatures. All those properties strongly favor the TDE interpretation.

3.1.6. AT2020aexc

The host of AT2020aexc is SDSS J120713.45+441015.5, with a SDSS photo-z of 0.43 ± 0.03. It is a relatively red galaxy with no UV counterpart in GALEX, whose infrared color is W1-W2∼ 0.1, and that showed no significant variability in the ZTF and CRTS data – as such, it is likely a passive galaxy.

In the beginning of 2021, it showed a slow and blue brightening, with rise timescale of 38.2 ± 2.8 days and peak difference color of $g - r \sim -0.5$. It peaked at difference magnitudes of about 19.25 (19.75), corresponding to absolute magnitudes of -22.6 (-22.1). Such luminosities could only correspond to a SLSN or a (quite bright) TDE. It then decayed slowly, following a timescale of 198.1 ± 11.0 days, with no signs of cooling during the decay. In 2023, the NeoWISE lightcurve showed hints of brightening, especially in the W1 band, by ∼ 0.25 magnitudes, although it is not extremely significant (see Fig. B.4).

AT2020aexc was noticed by another detection tool, FLEET (Gomez & Gezari 2023), with a 58% chance of being a TDE, and flagged as a potential lensed supernova in Magee et al. (2023). The long timescales, large amplitude, blue color, and constant temperature over the decay make this source a solid TDE candidate.

3.1.7. AT2020afap

The host of AT2020afap is SDSS J113633.84+614338.9, a spectrally confirmed passive galaxy at a redshift of $z = 0.099$. In the end of 2018, it showed a blue outburst, rising with a timescale of 59.2 ± 5.0 days, and reaching at the peak difference magnitudes of 19.75, corresponding to absolute magnitudes of -18.5. Its apparent color shifted from $g - r \sim 0.9$ to $g - r \sim 0.6$. It then decayed following a timescale of 92.2 ± 10.6 days, with no clear color evolution. Its NeoWISE lightcurve showed a clear infrared echo in both bands, with the $W1$ and $W2$ bands brightening by 0.25 and 0.5 magnitudes respectively.

The timescales are too long for standard supernovae, while the absolute magnitude is too low for a SLSN. Moreover, the amplitude, timescale, and color evolution all fit what would be expected from a TDE. As such, AT2020afap is a good TDE candidate. It was picked up as such in Gomez & Gezari (2023).

3.1.8. ZTF20aatpzog

The host of ZTF20aatpzog is SDSS J111854.33+214942.4, a faint galaxy with a photometric redshift of $z = 0.38 \pm 0.06$. It showed no strong variability in historical CRTS, ZTF or WISE data, and has an infrared color of $W1 - W2 \sim 0.2$, making it a likely passive galaxy.

In early 2020 it showed a strong brightening, with a typical rise time of 27.9 ± 1.8 days, and peak difference colors of $g - r \sim 0$. It peaked at difference magnitudes of about 19.75 in both bands, corresponding to absolute magnitudes of -21.8 ± 0.4

in both bands. It then decayed relatively quickly, following a typical timescale of 31.7 ± 5.5 days, with a constant color during the decay. The NeoWISE lightcurve of the host showed signs of an infrared echo in late 2020 and early 2021, with a brightening in both $W1$ and $W2$ bands by about 0.25 magnitudes.

The timing and amplitude of the burst point at either the TDE or SLSN interpretation, and the constant color in the decay tends to favor the former. As such, we conclude that ZTF20aatpzog is a good TDE candidate.

3.1.9. AT2021ovg

The host of AT2021ovg is SDSS J174805.00+401417.4, a faint, red galaxy at a SDSS photometric redshift of $z = 0.24 \pm 0.06$. It is undetected in UV and radio, its CRTS, ZTF and NeoWISE historical lightcurves show no significant variability, and the WISE infrared color is $W1 - W2 \sim 0.2$. As such, it is likely a passive galaxy.

In 2021, it underwent a blue outburst, following a timescale of 36.9 ± 2.2 days. It reached difference magnitudes of about 20, or absolute magnitudes of -20.4 in both bands. It also became significantly bluer, with the apparent color shifting from $g-r \sim 1$ to $g - r \sim 0.25$. It then slowly decayed, following a timescale of 59.5 ± 5.7 days, with no significant color change in the decay. Its infrared lightcurve showed no significant echo. While the peak absolute magnitude is consistent with either the TDE or SLSN interpretation, the lack of cooling in the decay allows to conclude that AT2021ovg is a good TDE candidate.

3.2. Flaring events in active galaxies

3.2.1. ZTF23abjvojy

The host of ZTF23abjvojy is SDSS J023439.04+010740.1, a spectrally-confirmed Narrow-Line Seyfert 1 (NLSy1, e.g. Paliya et al. 2024) at z=0.27. As an active galaxy, the quiescent ZTF level showed hints of variability (e.g. in early 2022 by 0.25 mag) – however, the transient in late 2023 is in clear excess of this expected AGN-induced variability level.

The source rose relatively quickly, with a typical timescale of 25.5 ± 2.8 days, up to difference magnitudes of about 19.5 in both bands, corresponding to absolute magnitudes of -21.2. It became significantly bluer, with the apparent color shifting from $g - r \sim 0.6$ in quiescence to $g - r \sim 0.2$ at the peak. It then decayed slowly, following a timescale of 186.1 ± 24.4 days, with no significant color change in the decay. The NeoWISE lightcurve shows a clear echo to this 2023 transient, with a brightening of both the $W1$ and $W2$ bands by 0.6 magnitudes each.

Interestingly, it was not the first time this galaxy displayed such a dramatic brightening: in January 2008, an even brighter event was detected by CRTS, where the source rose quickly (timescale of 16.1 ± 8.4 days) from a V-band apparent magnitude of ~ 20 up to ~ 18.25, corresponding to absolute magnitude of -22.5. It was then followed by a very slow decay over several years (decay timescale 523.5 ± 58.2 days).

Both events are consistent in terms of timing and amplitude properties with a TDE or an AGN flare. However, the shape of the peaks (in particular their noticeable asymmetry) is not consistent with standard AGN red-noise variability. Unfortunately, it is not possible to conclude on the exact cause of the outburts in the absence of spectral data. This source is a good candidate to join the small group of repeated TDE-like flares in AGN, along with AT2019aalc (Milán Veres et al. 2024), AT2021aeuk (Sun et al. 2025), and IRAS F01004-2237 (Sun et al. 2024). The timing properties of the individual flares are roughly consistent between these sources, and they all showed infrared echoes. For AT2019aalc and AT2021aeuk, the time between flares was 3-4 years (which can be understood as a selection bias, as both flares had to be seen by ZTF over a baseline of seven years). However, ZTF23abjvojy repeats on a much longer timescale, with a time between peaks of 5785 ± 10 days, i.e. almost 16 years apart (see Fig. 5) – such a long baseline was made possible by the use of CRTS data. In that sense it is most similar to IRAS F01004-2237, which was revealed as well through a combined use of CRTS and ZTF (time between peaks of 4175 ± 100 days). Interestingly, this source is a NLSy1, which is a class of AGN that has been shown to be associated with similar flaring events (e.g. Frederick et al. 2021)

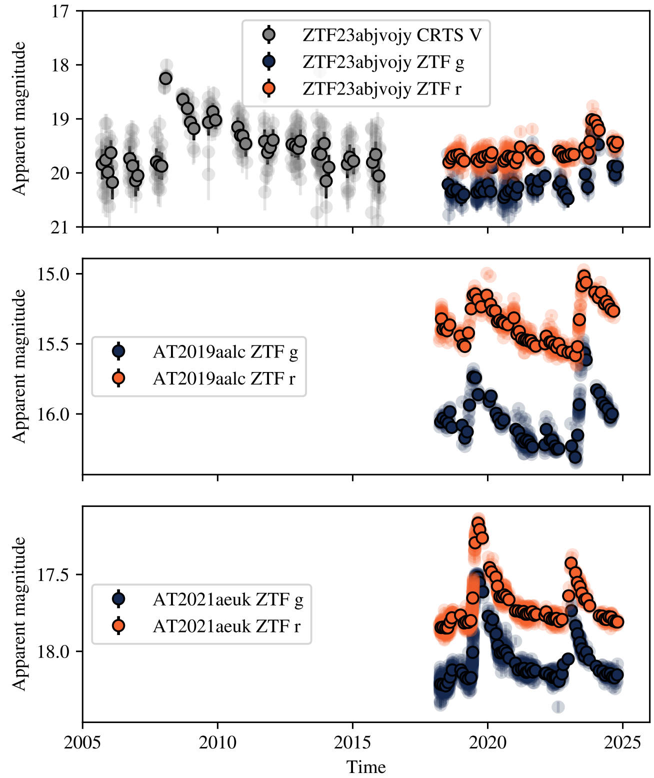

Fig. 5. Evidence for two TDE-like flares 16 years apart in ZTF23abjvojy. Its lightcurve (top panel) is shown for both CRTS V-band (light blue) and ZTF g-band (dark blue) and r-band (orange) data. We also provide comparison with two other known repeated AGN flares: AT2019aalc (middle panel) and AT2021aeuk (botton panel). The transparent points correspond to unbinned data, and the opaque points to data binned in bins of 15 days. We draw attention to the fact that the bands for CRTS and ZTF here are not the same and not cross-calibrated, so their respective magnitudes should not be directly compared.

3.2.2. AT2022yhf

The host of AT2022yhf is WISEA J214606.86-115801.1, which is a blue galaxy with two different photo-z estimates, 0.56 ± 0.03 or 0.769 (Gaia Collaboration et al. 2023; Fu et al. 2024). The quiescent state, as seen by ZTF and CRTS, shows variations on timescales of ~ 6 months that are consistent with nuclear activity - it is also classified as QSO by Gaia DR3. It is thus likely an active galaxy.

On top of the expected AGN-like variability, a significant brightening happened in September 2022, way beyond the amplitudes previously seen. The source slowly rose with a timescale of 64.0 ± 2.0 days, reaching its peak four month later in December 2022, at apparent magnitudes around 18.25 (18.5) in the g-band (r-band), corresponding to absolute magnitudes of -24.3 (-24.0) for the first redshift estimate, -25.1 (-24.8) for the second. It also became significantly bluer ($g-r$ decreasing from ∼0.1 in quiescence to ∼-0.2 at the peak). Since then, it has decayed slowly and steadily, with a typical decay time of 668.2 ± 34.3 days, although some gaps in exposures prevent a consistent sampling of the decay. The color has not reddened noticeably. It is still yet to reach its quiescent state, after more than three years. The NeoWISE lightcurve shows very clear signs of an infrared echo to the transient event, with a brightening of both $W1$ and $W2$ by almost one magnitude. All those properties make this object a good ANT, and perhaps ENT, candidate (depending on the actual redshift of the host).

3.2.3. AT2023rav

This source is a known broad-line QSO, SDSS J235114.69+254150.6, at z=0.504. It is radio and ultraviolet bright (NVSS J235114+254152 and GALEXASC J235114.69+254151.1, Condon et al. 1998; Bianchi et al. 2017), further confirming the AGN nature of the object. It was seen by CRTS, showing long-term variability roughly consistent with AGN behavior.

The source underwent a fast brightening by about one magnitude over August 2023, reaching peak difference magnitudes of around 18 in both bands. This corresponds to a peak absolute difference magnitude of ~ -24.2 in both bands, which would make it an ENT candidate. The transient has a significantly larger amplitude than any previous variability, which tends to exclude standard AGN variability as an explanation. The transient is bluer than the host during its rise, however cools down during the ∼ 6 months of decay. There are hints of a slight infrared echo, especially in the W1 band (by ∼ 0.25 mag).

One of the most striking features of this object is its post-peak behaviour: indeed, once the source reached a new steady state in late 2024, this new quiescence level was about 0.4 (0.3 respectively) magnitudes lower than it was before the transient for the g-band (r-band respectively). This could be indicative that the ENT, whatever its exact physical cause might be, depleted some of the materials from the region directly surrounding the SMBH, and thus slowed down the ulterior standard accretion once the transient is over. This is also supported by the fact that this decreased quiescence is more pronounced in the bluer g-band. This depletion of the accretion flow is akin to what was seen for instance in X-rays in 1ES 1927+654 (Trakhtenbrot et al. 2019a), where the X-ray activity of the source was consistent with an AGN before the transient event and subsequently significantly decreased, indicative of a possible depletion of the accretion flow. In particular, this depletion is expected from a retrograde TDE in an AGN disk (McKernan et al. 2022). One could expect that, as the surroundings of the SMBH recover their previous content, the source should regain its quiescence level over the upcoming months / years - as such, we encourage a further monitoring of this source.

3.2.4. AT2024nxp

The host of AT2024nxp is SDSS J173127.23+573658.1. It is faint ($g \sim 20.7$), blue ($g-r \sim 0.3$), UV-bright (GALEX J173127.2+573658), and its infrared color by NeoWISE ($W_1 - W_2 \sim 0.9$) is consistent with that of an AGN. As such, the host is likely a quasar (e.g. $P_{QSO} = 96\%$ for Gaia DR3 Gaia Collaboration et al. 2023). It has a number of photometric redshift estimates, depending on the method and the wavelengths, ranging from 0.6 to 2.5.

In April 2024, the source underwent a significant brightening by more than two magnitudes, following a rising timescale of 30.4 ± 1.0 days. It became bluer ($g-r \sim 0.1$) and peaked at magnitudes of ∼ 18.75 in both bands, corresponding to absolute magnitudes in the range -24 to -27, depending on the redshift value, qualifying it as an ENT candidate even for the most conservative estimates. It then started to decay at constant color, following a relatively long timescale of 137.1±5.9 days. There is no sign of an infrared counterpart to the optical transient. The decay followed well a $t^{-5/3}$ shape for the first 6 months, after which a slight excess to this shape can be seen (see right panel of Fig. 6, or Fig. B.3). It is unclear whether this corresponds to a change of the power-law index of the decay, or a low-amplitude rebrightening. The current sample of ENTs is currently too limited to assess whether such irregular decay is to be expected. Two other potential ANTs from our sample present similar late rebrightenings, but with higher amplitudes (AT2023szj and AT2024gzn).

3.2.5. AT2024hhj

The host of AT2024hhj is SDSS J084837.11+335014.9, a spectrally confirmed QSO at a redshift of $z = 0.217$. In particular, it is another NLSy1 (Paliya et al. 2024). The CRTS, ZTF and NeoWISE lightcurves show levels of variability consistent with nuclear activity, with around 0.5-1 magnitude amplitude.

However, in 2024 it underwent a significant brightening, rising with a timescale of 18.8 ± 2.6 days, peaking at difference magnitudes of about 18.5, corresponding to absolute magnitudes of -21.5 (although the peak itself was missed due to poor sampling by ZTF). It also became significantly bluer, from apparent color of $g-r \sim 0.5$ to $g-r \sim 0$. It then decayed slowly following a timescale of 82.8 ± 11.1 days, with no significant color change in the decay. There doesn't seem to be an infrared counterpart to the optical transient, beyond some variability with comparable level to what was observed before the optical peak.

3.2.6. AT2021wxd

The host of AT2021wxd is SDSS J155819.21+072824.5, a spectrally confirmed AGN at a redshift of $z = 0.231$. Its CRTS, ZTF and NeoWISE archival lightcurves displayed small-amplitude variability consistent with an AGN.

In late 2021, it underwent a slow blue brightening, with a timescale of 24.8 ± 3.4 days, peaking at difference magnitudes 19.25 or absolute magnitudes of -21. Its color went significantly bluer, from $g-r \sim 0.5$ to $g-r \sim 0$. It then decayed following a timescale of 160.6 ± 16.6 days, with no sign of color change in the decay. The infrared lightcurve shows no sign of variability beyond the historical levels of AGN-induced variability.

3.2.7. AT2020actc

The host of AT2020actc is SDSS J100316.36+210545.8, a spectrally confirmed Seyfert 1 AGN at a redshift of $z = 0.145$. The historical ZTF, CRTS and NeoWISE lightcurves showed very slight levels of variability (around 0.1 magnitude), which is consistent with a steady AGN accretion flow.

In late 2020 the source underwent a brightening over a timescale of 29.5 ± 2.8 days, peaking at difference magnitudes of about 19, corresponding to absolute magnitudes of -20.2 in both bands. It then decayed steadily over a timescale of 136.6 ± 15.4 days, with no signs of color change in the decay. The infrared lightcurve showed signs of an echo just after the optical burst, brightening by about 0.2 magnitudes in both $W1$ and $W2$ bands.

3.2.8. AT2024gzn

The host of AT2024gzn is SDSS J175516.11+385841.3, a spectroscopically confirmed QSO at redshift of $z = 0.201$. It showed no variability in historical CRTS or ZTF data. The infrared lightcurve shows hints of a slow and steady increase ($\sim$ 0.25 magnitudes over a decade).

In late 2023, the nucleus displayed a slow blue outburst, with a rise timescale of 64.9 ± 4.9 days and a peak difference color of $g - r \sim 0$. It reached peak difference magnitudes of about 19.75 in both bands, corresponding to absolute magnitudes of -20.5 ± 0.2 (taking into account the redshift uncertainty) - this could be consistent with a bright SN, a faint SLSN, or a TDE/ANT. It then slowly decayed over the course of 2024, with a typical timescale of 91.1 ± 7.8 days. There was no color change in the decay, which would rather be indicative of a TDE. There is no clear infrared counterpart to the optical transient, beyond the aforementioned slow rise. The timescale of this transient thus tends to exclude SNe; the color evolution favors a TDE/ANT rather than a SLSN.

However, around the beginning of 2025, the transient started to rebrighten, showing a significant excess compared to the expected $\propto t^{-5/3}$ decay (see Fig. 6). The main interpretations of the behaviour of AT2024gzn are a low-accretion AGN that underwent an episode of increased accretion, or a peculiar TDE/ANT with a bumpy decay. The former is the most likely interpretation. Additional monitoring of the source is needed to confirm either hypothesis.

3.3. Flares in uncertain hosts

3.3.1. AT2023zaj

The host of AT2023zaj is WISEA J003734.48-133352.0, a relatively faint galaxy with a photometric redshift of $z = 0.4 \pm 0.1$. Its NeoWISE lightcurve showed signs of low-amplitude variability, it is detected but faint in GALEX, and its infrared color is $W1 - W2 \sim 0.8$, meaning that it might be an active galaxy, but we cannot definitely confirm it. This uncertainty is further confirmed by the Gaia classification, which gives $P_{gal} = 0.32$ and $P_{QSO} = 0.2$.

The source brightened in late 2023 up to magnitudes 19, corresponding to absolute magnitudes between -21.9 and -23.2, depending on the redshift value. Its rise was relatively fast, with a typical timescale of 23.1 ± 2.6 days, and the apparent color evolved from $g - r \sim 0.6$ to $g - r \sim 0$. It then decayed very slowly, following a timescale of 887.5 ± 137.0 days. It showed a clear infrared echo to the transient, with a strong brightening of the $W1$ band by 1.5 magnitudes, and of the $W2$ band by 1 magnitude.

The brightness of the objects means that it is either a SLSN or a TDE/ANT candidate (depending on the actual underlying activity of the host). However, the decay timescale is very long, way too long for standard SLSNe, and as such this source is a good candidate ANT.

3.3.2. AT2023szj

The host of AT2023szj is SDSS J144628.14+084136.6, a faint red galaxy with a photometric redshift of $z = 0.57 \pm 0.16$. It is undetected in UV and radio, has an infrared color of $W1 - W2 = 0.67$, so it could be passive - however, its historical ZTF and NeoWISE lightcurves showed hints of low-amplitude variability, hinting at nuclear activity. As such, it is difficult to confirm on the AGN nature of the host – if it is an AGN, its activity level has been relatively low.

In 2023, it underwent a very slow brightening, over a timescale of 162.3 ± 11.5 days, peaking at difference magnitudes of 19.5, corresponding to absolute magnitudes of -23.0 ± 0.75, depending on the redshift estimate. It also became bluer, with the apparent color shifting from $g - r \sim 0.25$ to $g - r \sim -0.2$ at the peak. It then decayed over a long timescale as well, 375.4 ± 50.6 days, with no signs of color change. Its NeoWISE lightcurve showed a clear echo, both the $W1$ and $W2$ brightening by one magnitude.

While the amplitude is consistent with either a SLSN, a TDE, or an ANT, the very long timescales are rather indicative of either an extreme TDE or of an ANT. In 2025, during its decay the source underwent a rebrightening, with a clear excess to the rough $\propto t^{-5/3}$ expected decay (see Fig. 6). There are two main interpretations of this behaviour. First, and most likely, the past slight optical and infrared variability were indicative of a low-accretion AGN, and this outburst is a sudden episode of higher accretion – or, this was a long-duration TDE/ANT with a complex decaying lightcurve (as was seen for instance in AT2022exr, e.g. Langis et al. 2025). Further monitoring of this source's behaviour will allow to discriminate between these interpretations.

3.4. Physical parameters analysis

The results from the Redback bayesian fits are displayed in Fig. 7. They are useful to constrain the physical parameters of each source, assuming the model is suited to describe the events. In particular, the fit of AT2020ukj reveals that its exceptionally slow decay can occur in a TDE scenario given that: a massive star is disrupted, the time delay due to viscosity is high, and the efficiency of the emission is very low. We also compare our global distribution with the large sample presented by Nicholl et al. (2022). It consists of 32 confirmed TDEs, that were modeled using the same physical model and methodology as this work but using the MOSFiT software (Guillochon et al. 2018). We find that the two distributions are highly consistent with each other, supporting the conclusion that our classifier has identified a sample of objects hosting similar events.

We also attempted to distinguish between the TDEs and ANTs within our sample, but did not observe any significant differences between the two distributions. However, given the limited sample size and the unquantified selection biases inherent to our analysis, further investigations will be necessary to better understand their statistical behaviors, by incorporating a larger number of systematically selected TDE and ANT events.

3.5. Supernova candidates

We identified a series of SN candidates while searching for TDEs. Here, we considered as such any lightcurve which visu-

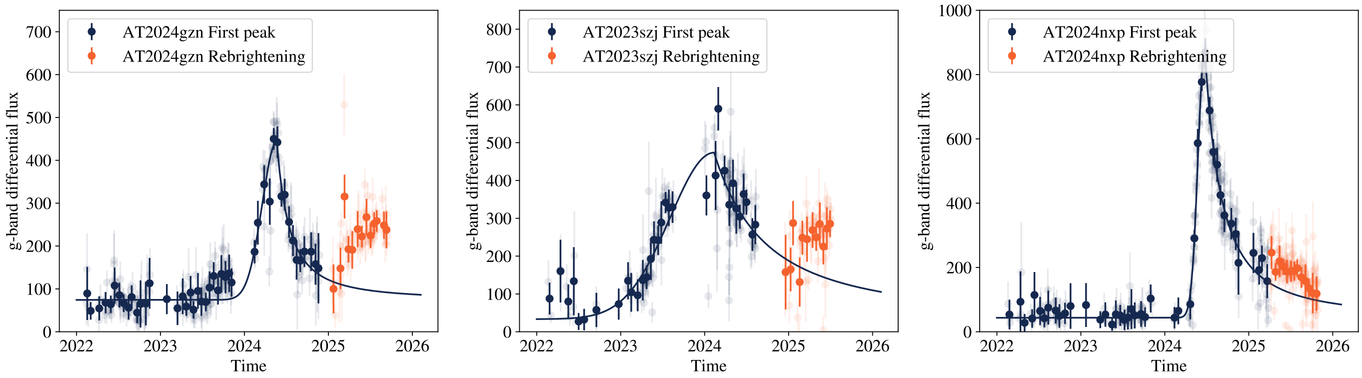

Fig. 6. Evidence for late-time features in AT2024gzn (left), AT2023szj (centre), and AT2024nxp (right). The line displays the best fit phenomenological $t^{-5/3}$ profile to the g-band lightcurve, with the fitting performed on the blue data points (before rebrightening, displayed in orange). Transparent points are unbinned data, opaque points are binned in bins of 15 days.

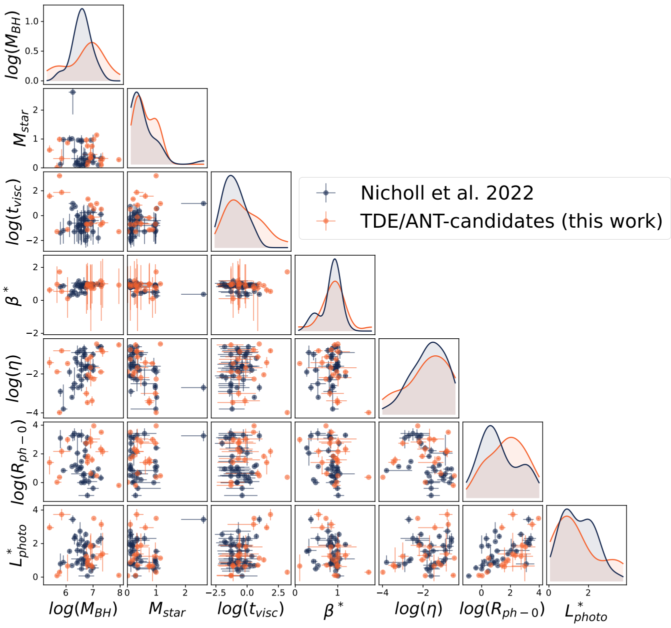

Fig. 7. Distribution of the posterior parameters from the *tde_fallback* Redback model. The values correspond to the median of the posterior distribution. Upper and lower error bars indicate the 84th and 16th percentiles. The orange points are events studied in this work, and blue points are TDE from a similar analysis (Nicholl et al. 2022) performed with the same *tde_fallback* model but using MOSFiT. Exact values are available in Table A.2. Because the fit failed to converge, AT2020actc and AT2023rav are missing from this sample.

ally resembles the expected behavior of a SN (consistent burst with relatively fast rise and different rates of decay). Following Pruzhinskaya et al. (2023), selected sources were fitted with SN templates provided by Peter Nugent[3] and the SALT2 model (the procedure is described in Appendix C). It was not possible to perform a good fit for most of the candidates since many of them had insufficient number of photometric points. From an initial set of 40 objects, 11 were compatible with Type Ia supernova (SALT2, Guy et al. 2007), 8 were better modeled as Type IIP and 7 as Type IIn. We also identified two long-lasting lightcurves which were not compatible with any of the available SN models and which can be better explained as superluminous supernova candidates. We detail the most interesting SN cases below.

[3] https://c3.lbl.gov/nugent/nugent_templates.html

3.5.1. SLSN candidate: AT2021lnu

The host of AT2021lnu is SDSS J153218.78+000000.0, a faint irregular dwarf galaxy at a spectroscopic redshift of $z = 0.15 \pm 0.07$. In 2021, it underwent a fast brightening over a month, up to difference magnitudes of 18.75, corresponding to absolute magnitudes of -20.2 ± 1.2, depending on the redshift estimate. It stayed in a plateau phase about a month, and then decayed over about a month, with no strong sign of cooling. It finally showed a secondary, lower-amplitude peak, with redder colors.

The shape, timescale and amplitude of this outburst all point towards the SLSN interpretation. In particular, its lightcurve shows strong similarities to that of another known SLSN, SN2024afav.

3.5.2. SLSN candidate: AT2020mvg

The host of AT2020mvg is SDSS J120526.52+285434.6, a faint galaxy at a photometric redshift of $z = 0.31 \pm 0.11$. It is blue, UV-bright, and its CRTS lightcurve showed hints of decade-long low-amplitude variability. The NeoWISE data is dominated by the nearby (5") source, WISEA J120526.74+285429.8 - as such, its own infrared emission is difficult to assess. Overall, this source is consistent with being active, although no definitive evidence is available.

In 2020, it underwent a significant relatively fast outburst, with a rise time of 12.9 ± 0.5 days. It reached difference magnitudes of 18.5 ± 0.05 at its peak, corresponding to absolute magnitudes -22.4 ± 0.9 depending on the redshift value. The transient was relatively blue (difference color of $g - r \sim -0.3$ at the peak). It then decayed following a 31.5 ± 2.4 days timescale, with signs of cooling in the decay.

The absolute magnitude, timescale, and color evolution all point towards a good SLSN candidate.

3.5.3. Confirmed SN Ia: AT2024ljd

The host of AT2024ljd is SDSS J211339.40+022937.3, at a redshift of $z = 0.046$. In 2024, its nucleus showed a fast outburst, rising over 15 days and decaying over a month. It reached difference magnitudes of 17.5 ± 0.05, corresponding to absolute magnitude of 19.0 ± 0.05. There is evidence of cooling during the decay, manifest in the color evolution.

We detected this object initially at an early stage of development of our TDE pipeline. We obtained a spectral follow-up by the CMO-2.5m telescope (Shatsky et al. 2020), allowing to classify AT2024ljd as a SN Ia (Quintin et al. 2024a).

3.5.4. Supernova siblings: AT2019agc

The host of AT2019agc is SDSS J140645.34+135505.1, a passive galaxy at a photometric redshift $z = 0.15 \pm 0.05$. It showed a brightening by about 1.5 magnitudes in both ZTF bands in early 2019, and a second one in June 2021. Both peak at around absolute magnitude of -19.7 ± 0.7 (taking into account redshift uncertainties) and cool down during the decay. The two bursts are associated to the same ZTF / TNS object.

Interestingly, by retrieving the positions of each individual detection from the ZTF DR23 data, and plotting them compared to the visual extent of the galaxy, one can see that these objects come from distinct regions (see the g-band points in Fig. 8, where the blue and orange points corresponding to the two peaks display a clear offset). A double-sided KS-test on the right ascension and declination distributions of both bursts lead to p-values of 8.3×10^{-10} and 2.0×10^{-1} respectively for the g-band, and 3.2×10^{-6} and 3.7×10^{-4} for the r-band. These p-values in both bands (especially for right ascension) allow to safely ($> 6\sigma$) exclude the possibility that the two bursts come from the same position. This is further confirmed by the fact that, after averaging the positions of the alerts during the first and then the second peak, the offset between these average positions is about 0.4", which is significantly larger than the typical position accuracy of ZTF (45 to 85 milliarcsec, Masci et al. 2019). It is thus unlikely that they are physically related. However, they are both associated to the same ZTF/TNS object, ZTF19aafmytc/AT2019agc. This highlights one limitation of the current position-based identification scheme for transients. In the current paradigm, the association of a new alert with an existing transient is done individually for each new alert – the individual position error of each alert is quite large, and it would be difficult to separate two spatially close but separate transients this way[4]. However, for this specific object the clearly distinct bursts allowed a temporal clustering, that revealed the two underlying populations in the individual alerts.

Comparing the two bursts individually with the sncosmo built-in supernova models, both were consistent with Type Ia supernova. The 2021 event is in clear agreement with SALT2 model ($x_1 = 0.98 \pm 0.33$, $c = 0.094 \pm 0.033$, $z = 0.149 \pm 0.026$), while the lightcurve format of the event from 2019 does not allow us to reliably discard other supernova types. The study of supernovae siblings (occuring in the same galaxy), has been advocated in the literature as a possible path to further investigate the influence of local environment in supernova properties. A study of spectroscopically confirmed siblings in ZTF (Graham et al. 2022) reported 5 such pairs, highlighting the importance and difficulty in identifying such events. Another study using an active anomaly detection algorithm discovered an additional SN sibling, SN2018fcg (Majumder et al. 2024). A recent work, focusing exclusively in Type Ias for optimizing standardization, found 25 such pairs (Dhawan et al. 2024). The serendipitous discovery of this pair in our analysis points to the potential of ZTF, as well as other large scale sky surveys, in also enabling purely photometric siblings studies, as it was already performed in the Dark Energy Survey (Scolnic et al. 2020). As a final note, we cannot definitely exclude the possibility of contamination by a background galaxy (e.g. two distinct galaxies as hosts for the two peaks, aligned along the line of sight and reasonably close to each other), although the available data shows no clear sign of such a background contribution. This situation would not change our conclusion that the two peaks are physically independent.

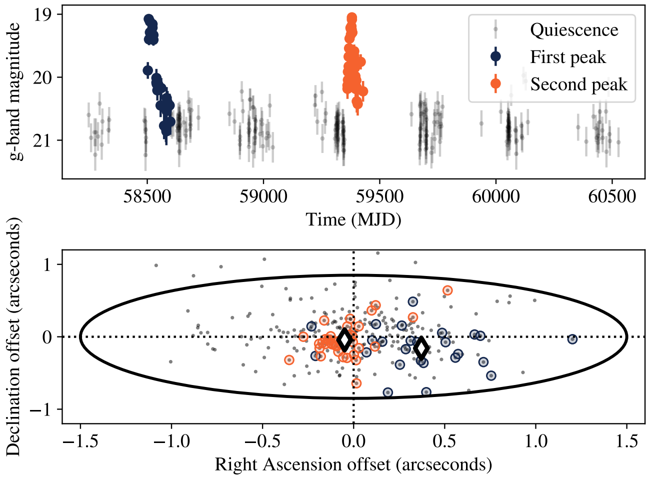

Fig. 8. Comparison of the position of the two bursts associated with AT2019agc, with color-codes corresponding to a temporal clustering of the bursts. *Top panel:* Apparent magnitudes in the g band of the two transients (blue and orange), with black dots for the quiescent emission from the galaxy. *Bottom panel:* positional offset of the corresponding detections from the center of the host galaxy, with the same color code (dark blue for the first burst, orange for the second). The black dotted lines represent the center of the host galaxy, and the black ellipse corresponds to its approximate optical extent. The two black diamonds show the average position of the first (blue) peak and the second (orange) peak. This shows that the transients do not originate from the same position, and neither exactly from the galactic center.

4. Discussion

4.1. Rate considerations

The selections biases of our study are uncertain, as the sample has been built inhomogeneously, not only through the systematic application of the early TDE detection module to the part of the ZTF archive that was not classified in TNS, but also through serendipitous discoveries during the developement of said module. As such, converting the number of TDE or ANT candidates to physical rates (as was done for instance in Yao et al. 2023) is not directly possible. What can be done however is to compare these numbers to those of other studies of a roughly similar sample.

For instance, Yao et al. (2023) presents a sample of 33 spectroscopically-confirmed optical TDEs, obtained by studying 3 years worth of ZTF data. Our sample covers roughly 5 years worth of ZTF data, and presents 9 TDE candidates and 7 ANT candidates. These studies lead to a respective yearly detection rate of 11 TDEs per year compared to 2.2 in our case (or 3.2 if one includes ANT candidates). This indicates that a small,

[4] A simple visual representation would be trying to find two populations in the bottom panel of Fig. 8 if the points were not color-coded.

but not insignificant, number of nuclear transients might still be lying in the archives, and justifies future work to ensure an exhaustive search. In particular, as will be discussed in the later points in more details, such exhaustive searches will require the community to be careful about the assumptions put into the classifiers (e.g. hard cut-off values for some parameters such as the duration or the amplitude, or excluding any host that has sign of prior nuclear activity).

4.2. Insights on repeated nuclear transients

We presented here two newly-revealed repeated nuclear optical transients, one in a passive galaxy (AT2023adr) and one in an active galaxy (ZTF23abjvojy). Additionally, two other objects show hints of late-time rebrightenings during their decay after the initial burst (AT2023szj and AT2024gzn), and AT2024nxp could be a third candidate (although with a much lower amplitude). Conservatively keeping only the first two secure repeated transients, this amounts to 10% of the sample presented in this paper. This is a good opportunity to assess the current state of our knowledge of repeated optical nuclear transients, and what conclusions we might draw from it.

We present in Tab. 2 an up-to-date inventory of the currently known repeated optical nuclear transients. This table was inspired from Tab. 2 of Lin et al. (2024), but we updated it and also added sources that show a strong rebrightening in their decay – for these, it is unclear whether they are repeated or simply show a more complex behaviour than the usual monotonous decay. We also limit this sample to optical transients, otherwise for instance X-ray repeated nuclear transients would include numerous other sources, such as all quasi-periodic eruptions sources (e.g. Miniutti et al. 2019). We include information about the host (whether it contains an AGN or not, i.e. whether the transient is a TDE or an ANT candidate), and information about the flaring pattern (number of flares and approximate interval between them, and the amplitude evolution of the flares). Inspired by a recent discussion about the repeated TDE AT2022dbl at a conference[5], we add a column corresponding to the estimated time of the anticipated next peak, assuming the interval between peaks is constant. While some are in the future, some anticipated third peaks were supposed to have happened in the past. For these, we indicate whether the ZTF photometry covered the expected epoch of the peak or if it fell in a gap, and in the former case whether the lightcurve showed a clear rebrightening or not. Several conclusions can be drawn from this table only.

First, in the last few years the existing sample has grown noticeably, reaching a significant fraction of the total TDE sample. Considering only events with clearly separated peaks, and excluding OJ 287 as it is not TDE-related (Sillanpaa et al. 1988), we are left with 16 sources out of the 25 in the table. These 16 sources amounts to about 10% of the total sample of known optical TDEs (e.g. 134 confirmed optical TDEs in Langis et al. 2025). This fraction is comparable to the one obtained from our sample only, with two clearly repeated events out of 20 nuclear transients. While the poorly constrained biases of our selection process prevent us from drawing any clear conclusion as to the precise rate of repeated TDEs, it appears clear that they represent a non-negligible portion of the total population, and should be accounted for in both the rate estimates and the physical models of (partial) disruption (e.g. see considerations in Makrygianni et al. 2025). This fraction is also bound to increase over time, as the probed temporal baseline increases linearly (e.g. about 20 years now separate the earliest CRTS data and the latest ZTF data). It is however important to note that peaks separated by decades could reasonably arise from independent TDEs instead of repeated partial TDEs of the same initial star, notably in the presence of a locally increase TDE rate (e.g. for a particularly dense nuclear star cluster, see for instance Stone & Metzger 2016). One can also see that among the clearly separated events, there is no strong pattern in the relative amplitudes of the peaks (out of the 15 repeated events, 6 have comparable luminosities between peaks, 7 have a smaller second peak, and 2 have a higher second peak). In order to continue building up this sample, we strongly encourage the community to keep an up-to-date inventory of repeated nuclear transients, similar to that presented in Tab. 2.

Second, a natural approach to confirm the repeated partial TDE nature of a repeated event (as opposed to two independent TDEs) is to assess the presence of a third peak, which would strenghten the former interpretation. This in turn requires to anticipate an observational strategy, and thus the expected timing of the supposed third peak needs to be estimated. The simplest way to do this is to assume that the time between peaks is not modified by the partial disruptions, and extrapolate the date of the third peak from the date of the second peak and the delay between the first and second. This corresponds to the *"Next" Peak* column in Tab. 2. For recent events, this date is in the future, and could be used to design observational strategies. However, one can also look back at objects for which this third peak should have happened in the past. For some, this third peak happened during observational gaps (e.g. AT2023adr), or a faint hint of a peak could perhaps be detected (e.g. AT2019ehz). But for others, a third peak was not detected at all (e.g. AT2019avd). In fact, as of now no known optical TDE has three strong separated peaks in its lightcurve, and only ASASSN-14ko and AT2023uqm show multiple TDE-like peaks. It is unclear whether this means that the second disruption is always total, or that the delay between peaks is modified by the partial disruptions, or even that these events were possibly two independent TDEs – it does warn us though against using this simplified method to anticipate observational strategies.

Third, the impostor repeated event AT2019agc sheds light on some limitations of the current transient identification system. Indeed, while AT2019agc is identified as a singular object showing a rebrightening in both TNS and ZTF catalogs, the study of the position of individual detections we have shown in Sec. 3.5.4, and in Fig. 8 in particular, allows to conclude that the rebrightening is likely to have happened in a distinct location within the galaxy, and as such the two peaks are actually physically independent. More generally, while it could be impossible to distinguish the positions of two independent supernovae arising from the nuclear cluster, objects like AT2019agc where one of the peaks lies in the periphery of the galaxy are bound to happen, and their numbers will increase with the new upcoming surveys and the increasing temporal baseline. This situation indicates that proper systematic checks for positional overlaps should be performed in the case of repeated transients. This is technically different from the standard automatic cross-match of alerts that leads to the existing transient identification, which is performed on a detection-by-detection basis. What we suggest is to (ideally automatically) perform a temporal clustering of the alerts of similar events (repeated transients that are clearly separated in time), and assess whether the alerts from these temporally distinct peaks are spatially consistent or not (e.g. through a simple KS-test on the right ascensions and declinations of the alerts, as

[5] See "Predicting the future" in https://www.cosmos.esa.int/web/x-ray-quasi-periodic-eruptions/programme

we have done here). This should, at a relatively low computational cost, provide an effective solution to filter out most of the impostors repeated events.

4.3. Insights on TDE-like flares in AGNs

Our selection of TDE-like flares in ZTF data lead to a number of transients hosted in previously active galaxies - we classify them as candidates ANTs. We kept only those where the flare itself is clearly in excess to the previous accretion-driven variability witnessed in the host (see their lightcurves in Fig. B.4 and Fig. B.5). Discriminating between fluctuations of accretion in a standard AGN and the flaring pattern of an ANT from photometric data only is a non-trivial problem in general. The selection in our study is mostly qualitative, but one could reasonably design a more quantitative approach (e.g. as was done in Wiseman et al. 2025). For instance, the temporal evolution of photometric properties of standard AGNs is well described by stochastic processes, in particular Damped Random Walks (DRWs). By estimating the parameters of the process in the historical lightcurve, one can then quantify the deviation from this process observed in the flare. Another alternative would be to use anomaly detection methods (e.g. Sánchez-Sáez et al. 2021). Such methods will need to be refined and applied to the upcoming LSST data streams, in order to increase the existing sample of ANTs and e.g. perform population studies. Interestingly, in our sample the number of ANT candidates is very comparable to that of TDE candidates, indicative of the fact that these events might not be exceedingly rare. However, our inhomogeneous selection biases prevent us from definitive rate estimates.

AT2020ukj, along with Ansky, hint at another possibly new class of nuclear transients. These two events show a previously passive galaxy display a TDE-like flare, but on much longer timescales. The main possible interpretations are that, similar to Ansky, AT2020ukj is either a turn-on AGN, a tidal disruption in an AGN with a very low angle, or the tidal disruption of a massive star or massive cloud of gas. We invite further study and monitoring of this object. More generally, the existence of these long-lived objects indicates that we should be careful about including hard cut-offs on the timing properties of the bursts into TDE classifiers, which would lead to rejecting this sort of very long events. In a similar manner, the faintness of AT2023npi despite its long duration indicates that the parameter spaces of different types of optical transients overlap significantly, and hard cut-offs should be avoided if possible, at risk of losing these physically interesting outliers.

Two AGN-related transients in our sample are narrow-line Seyfert 1 sources (ZTF23abjvojy and AT2024hhj). This class has been linked to flaring events in the past (Frederick et al. 2021). While our unquantified selection biases prevent us from definitely confirming whether they are over-represented in our variability-selected sample, it is still of note that this class is clearly present. A pre-existing catalog of NLSy1 could for instance be used as a tool to prioritize early flare detection alerts, in order to organise monitoring campagins of a flaring event.

Finally, AT2023szj and AT2024gzn are both nuclear transients with clear signs of a late-time rebrightening. AT2024gzn is a spectroscopically confirmed QSO, while AT2023szj could be an AGN but the diagnostics methods do not lead to a definitive answer. A likely interpretation of both these events that would account for their observed properties are that they are turn-on AGNs, with very low activity in the past that suddenly increased, leading to the optical burst. It is reasonable to assume that future optical transient surveys will detect more of these objects, which are contaminants for TDE classifiers but could still provide very useful physical insights about the onset of accretion in AGNs.

4.4. Potential of multi-wavelength synergy for transient detection

The main purpose of the real-time early TDE detection tool developed by the Fink collaboration (Llamas Lanza et al. 2025) is to provide early warning on optical nuclear transients matching TDE-expected properties, for the ZTF data stream and for upcoming LSST. The sample presented here is archival in nature, and was obtained as a secondary result of the development of this pipeline. As most of these transients were already over when we found them, it was not possible to obtain spectroscopic follow-ups to confirm their nature. For the few objects that are still active, we requested such follow-ups whenever possible, being often limited by their relative faintness. This however highlights a general difficulty with photometric transient detection, which is the availability of timely spectroscopic follow-ups for classification. Despite significant efforts in upcoming spectroscopic survey capabilities (e.g. the TiDES survey on the 4MOST spectrometer Frohmaier et al. 2025), this issue will be prevalent among LSST transients, due both to the large number of transients and their faintness compared e.g. to ZTF transients, putting them out of reach of the more modest spectrometers.

One solution to help classification in the absence of spectroscopic data is to inform photometric classification methods by using multi-wavelength data. In particular, using variability information and transient alerts from multiple other wavelengths can help discriminate between different classifications. As such, multi-wavelength synergies of transient-detection systems should be encouraged. There are numerous existing transient detection projects in almost all wavelengths: in X-rays (e.g. Evans et al. 2023; Quintin et al. 2024b), ultraviolet (e.g. Modiano et al. 2022), radio (e.g. Murphy et al. 2013), infrared (e.g. Rose et al. 2025), and even other messengers, with neutrinos (e.g. Adrián-Martínez et al. 2016) and of course gravitational waves (e.g. Abbott et al. 2023). Some efforts have been made to centralize alerts from all those channels (e.g. Reichherzer et al. 2021). In the case of nuclear transients, comparing for instance the X-ray, radio and infrared variability to the optical one could in some situations lift uncertainties (e.g. the presence of quiescent X-ray emission, that could perhaps present a dip during the optical burst, is indicative of a pre-existing AGN rather than a simple TDE).

5. Conclusions

In this paper, we presented a sample of optical nuclear transient events that were found during the development of an early TDE detection system for ZTF data, as part of the Fink broker. We report on the discovery of 19 optical nuclear transients, among which 9 in previously passive galaxies:

- **AT2020ukj** is a long-lived transient that has been active for the last 5 years, with a constant blue color, and shows strong similarities to ZTF19acnskyy ("Ansky", Sánchez-Sáez et al. 2024) - it could be an exotic TDE with extreme timescales, or an AGN in the process of turning on;
- **AT2023adr** is a TDE candidate that displayed a clear second peak about 400 days after the first one, with lower amplitude but an optical spectrum consistent with that of a TDE;
- **AT2023npi** is a TDE candidate in a nearby galaxy, and would be the faintest optical TDE to date, despite its very strong infrared echo;

Name	Host	Approx. Interval (d.)	Flares	Peak Evolution	"Next" Peak	Reference
OJ 287	Active	4000	~10	Similar	~2030	Sillanpaa et al. (1988)
IC 3599	Active	~3470?	2/3	Similar	2019 (No)	Campana et al. (2015)
ASASSN-14ko	Active	115.2	~30	Similar	Aug. 2025	Payne et al. (2021)
AT 2019avd	Passive	~500	2	Lower	May 2022 (No)	Malyali et al. (2021)
AT 2019azh	Passive	~4800	2	Similar	2032	Hinkle et al. (2021)
AT 2018fyk	Passive	~1200	2	Lower	Apr. 2025 (No)	Wevers et al. (2022)
†AT 2019baf	Passive	250	2	Lower	Jul. 2020 (No)	Yao et al. (2023)
AT 2019ehz	Passive	~300	2	Lower	Dec. 2020 (Hints)	Yao et al. (2023)
†AT 2020acka	Passive	300	2	Lower	Aug. 2022 (No)	Yao et al. (2023)
†AT 2021uqv	Passive	225	2	Lower	Jan 2023 (Hints)	Yao et al. (2023)
AT 2020vdq	Passive	~870	2	Higher	Oct. 2025	Somalwar et al. (2023)
†AT 2021loi	Active	~400	2	Lower	Aug. 2023 (No)	Makrygianni et al. (2023)
IRAS F01004-2237	Passive	~4175	2	Similar	2032	Makrygianni et al. (2023); Sun et al. (2024)
AT 2022dbl	Passive	~710	2	Lower	Jan. 2026	Lin et al. (2024)
AT 2019aalc	Active	1500	2	Higher	Aug. 2028	Milán Veres et al. (2024)
AT 2024pvu	Passive	~6500	2	Similar	2042	Langis et al. (2025)
†AT 2022exr	Passive	120-50	2/3	Lower	Nov. 2022 (Gap)	Langis et al. (2025)
†AT 2021uvz	Passive	175	2	Lower	Dec. 2021 (Gap)	Langis et al. (2025)
AT 2019teq	Passive	375	2	Similar	Nov. 2020 (No)	Langis et al. (2025)
AT 2021aeuk	Active	1300	2/3	Lower (+precursor)	Oct. 2026	Sun et al. (2025)
AT 2023uqm	Passive	525	5	Higher	Aug. 2026	Wang et al. (2025)
†AT 2024gzn	Active	400	2	Lower	Sep. 2026	This work
†AT 2023szj	Active	600	2	Lower	Feb. 2027	This work
ZTF23abjvojy	Active	~ 5785	2	Lower	2039	This work
AT 2023adr	Passive	400	2	Lower	Apr. 2025 (Gap)	This work

Table 2. Summary of the currently known optical repeated nuclear transient events, sorted by date of reporting. Similar to Tab. 2 from Lin et al. (2024), simplified and updated. Note this only includes optically repeated objects, otherwise X-ray repeated flares would include numerous other objects, including repeated X-ray TDEs but also quasi-periodic eruption sources. Sources marked with the † symbol correspond to a lower amplitude rebrightening during the decay of the first peak, while for the others the peaks are clearly separated in time. For completeness, we included OJ 287, which is interpreted not as a TDE but a binary blazar with periodic increases of accretion rates due to interactions between the disks. We did not include AT 2021mhg (Somalwar et al. 2023), for which the second peak was photometrically identified as likely SN due to its timescale and red color, or AT 2024nxp, as the amplitude of the second peak is so low that it could be a simple flattening of the decay. The 'Next Peak' column corresponds to an estimation of the time of the next peak, assuming the delay between peaks is the same as the last delay. For values that are in the past, we indicated whether this additional peak fell in ZTF observational gaps, whether some hints of such a new peak were seen, or whether it was observed and not seen.

- **AT2020pno** is a TDE candidate that displays a clear optical plateau phase in its decay;
- **AT2020aexc**, **AT2020afap**, **AT2023jag**, **AT2021ovg**, **ZTF20aaptzog** are all TDE candidates, with no particular distinctive features

We also presented 8 in previously active galaxies:

- **ZTF23abjvojy** is a blue flare in a confirmed NLSy1 that had already displayed a similar behaviour almost 16 years before, witnessed at the time by CRTS. It is the repeated ANT with the longest timeline among the limited sample of such objects;
- **AT2022yhf**, **AT2024nxp**, and **AT2023rav** are bright transients in previously active galaxies, that reach absolute magnitudes above -24, classifying them as likely ENTs. AT2024nxp shows hints of late-time rebrightening (or at least flattening of the decay), and AT2023rav shows a lower quiescent flux after the transient, indicative of a possible depletion of the initial AGN-like accretion flow;
- **AT2020actc**, **AT2021wxd**, and **AT2024hhj** are all ANT candidates with no particular distinctive features, apart from the latter one being a NLSy1.
- **AT2024gzn** is a flare in a confirmed QSO, with a late-time rebrightening.

We presented 2 transients in galaxies where we were not able to confirm or infirm previous nuclear activity:

- **AT2023szj** is a bright flare that displays clear late-time rebrightening, which could be turn-on AGN;
- **AT2023zaj** is a slow blue transient with no particular distinctive features

We also have a significant number of supernovae candidates, among which:

- **AT2024ljd** was spectrally confirmed as SN Ia (Quintin et al. 2024a);
- **AT2019agc** is a seemingly repeated optical nuclear transients, but further inspection revealed that it is consistent with two independent supernovae in the same galaxy, two and a half years apart;
- **AT2021lnu** and **AT2020mvg** are both SLSN candidates;

We encourage monitoring of these objects, and spectroscopic confirmation of their redshift when it is only photometric.

All these objects, and the peculiar features some of them display, lead us to a certain number of considerations for future optical transient detection systems, especially with the perspective of upcoming LSST data :

- A significant fraction of the optical nuclear transients we present here (about half of them) happened in a galaxy that showed signs of previous nuclear activity. Future transient detection systems should devise clear methods regarding these nuclear transients in active galaxies (ANTs and ENTs), in particular to discriminate between a simple AGN flare and an exceptional brightening.
- The discovery of AT2020ukj, a long-lived transient in a previously passive host that could be a turn-on AGN, indicates

that ZTF19acnskyy was not the only instance of its class, and upcoming classifiers should keep it in mind (e.g. by not discarding nuclear transients with timescales larger than expected);

– A fraction of the presented nuclear transients are repeated objects (about 10% of them). Even though our selection is biased and as such it is difficult to estimate exact rates, it is clear that repeated events are not exceptionally rare, and as such classifiers should anticipate this situation. This means for instance monitoring previous events, or not excluding events with past variability in TDE classifiers;
– We attempted to create an inventory of the current sample of optical repeated nuclear transients (see Tab. 2). We invite the community to keep it up to date. In particular, this allowed us to assess that one should not use the timing of a two-peaks event to anticipate the date of an hypothetical third peak;
– The discovery of AT2019agc, an impostor repeated event, indicates that we should be mindful of the possibility of independent events being associated with a single object. A systematic check of the consistency of positions between flares could be one way to tackle this issue.

In summary, these results highlight the scientific potential still enclosed in already available data, and demonstrate how the sheer volume of observations being generated by large scale surveys impose a completely different approach to data mining in astronomy. There has been extensive discussion on both sides of this topic: how this change of paradigm impacts research goals focused on well established classes (e.g. SNIa, Ishida 2019), and how it opens the possibility to completely unexpected discoveries using unsupervised anomaly detection (e.g. Volnova et al. 2024).

In this work, we have presented several examples of optical nuclear transients that appear as outliers from the typically expected behaviours (e.g. the long duration of AT2020ukj, the low amplitude of AT2023npi, or the repeated natures of AT2023adr and ZTF23abjvojy). Their peculiar properties make them valuable to constrain models and understand the physics at play, but might also lead to them being excluded by purity-focused classifiers.

Especially in the case of LSST, which will deliver a large number of all possible sources, it is crucial that automatic classifiers and filters are designed for the specific goal of showing to the user a large diversity of examples which could still be generated by the same underlying astrophysical process. While some might argue that the overwhelming number of alerts it will generate can allow us to strive for high purity at the price of low completeness, we argue that doing so would prevent us from detecting the extremely interesting and rare events populating the borders of each classes. This will require adaptation of tools and cultural practices, which are certain to result in the expansion of the current astronomical taxonomy, as hinted by the results presented in this work.

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Appendix A: Fitted properties of the optical transients

Name	t_{peak} (UTC)	τ_{rise} (days)	τ_{decay}(days)
AT2020aexc	2021-02-22 ±2.9d.	38.2 ± 2.8	198.1 ± 11.0
AT2021lnu	2021-06-25 ±1.5d.	34.2 ± 2.3	20.4 ± 4.8
AT2022yhf	2023-01-02 ±3.4d.	64.0 ± 2.0	668.2 ± 34.3
AT2020ukj	2020-12-12 ±7.9d.	68.5 ± 8.8	4984.9 ± 497.2
AT2023adr #1	2023-01-30 ±1d.	25.5 ± 0.9	64.3 ± 1.6
AT2023adr #2	2024-03-19 ±1d.	16.6 ± 1.5	40.5 ± 3.7
AT2024ljd	2024-06-26 ±0.3d.	7.2 ± 0.4	8.3 ± 0.9
AT2023rav	2023-09-02 ±1.1d.	13.6 ± 0.9	45.0 ± 3.0
AT2024nxp	2024-06-23 ±1.1d.	30.4 ± 1.0	137.1 ± 5.9
AT2020mvg	2020-06-12 ±0.6d.	12.9 ± 0.5	31.5 ± 2.4
AT2021ovg	2021-06-19 ±2.1d.	36.9 ± 2.2	59.5 ± 5.7
AT2021wxd	2021-09-16 ±4.8d.	24.8 ± 3.4	160.6 ± 16.6
AT2023jag	2023-06-12 ±1.4d.	28.1 ± 1.8	89.8 ± 7.8
AT2024hhj	2024-05-07 ±4.5d.	18.8 ± 2.6	82.8 ± 11.1
AT2023szj	2024-01-02 ±13.1d.	162.3 ± 11.5	375.4 ± 50.6
ZTF23abjvojy #1	2008-01-22 ±6.3d.	16.1 ± 8.4	523.5 ± 58.2
ZTF23abjvojy #2	2023-11-24 ±3.8d.	25.5 ± 2.8	186.1 ± 24.4
ZTF20aatpzog	2020-04-08 ±2.6d.	27.9 ± 1.8	31.7 ± 5.5
AT2024gzn	2024-06-02 ±5.2d.	138.6 ± 6.4	111.5 ± 15.2
AT2020actc	2021-01-25 ±3.1d.	29.5 ± 2.8	136.6 ± 15.4
AT2020pno	2020-08-01 ±0.6d.	19.0 ± 0.7	50.5 ± 1.9
AT2020afap	2021-03-01 ±3.7d.	59.2 ± 5.0	92.2 ± 10.6
AT2023zaj	2024-10-21 ±9.1d.	168.7 ± 10.1	150.4 ± 33.4

Table A.1. Timing properties of the TDE candidates, as obtained from the simple $g-$band phenomenological fit. Errors are 1σ.

Name	$\log(M_{\rm BH})$	$M_{\rm star}$	$\log(t_{\rm visc})$	β^*	$\log(\eta)$	$\log(R_{ph-0})$	L^*_{photo}	redshift	t_0
Units	*log($M_\odot$)*	$M_\odot$	*log(days)*	–	–	–	–	–	*days*
ZTF23abjvojy	$6.79^{+0.06}_{-0.06}$	$0.10^{+0.01}_{-0.01}$	$-0.71^{+1.13}_{-1.55}$	$0.96^{+0.05}_{-0.07}$	$-1.25^{+0.06}_{-0.07}$	$1.67^{+0.33}_{-0.25}$	$0.89^{+0.23}_{-0.18}$	0.27	$-17.05^{+1.55}_{-2.15}$
AT2023adr (1st peak)	$6.79^{+0.06}_{-0.08}$	$0.76^{+0.14}_{-0.14}$	$-1.15^{+1.28}_{-1.23}$	$1.00^{+0.10}_{-0.12}$	$-3.47^{+0.18}_{-0.25}$	$1.41^{+0.25}_{-0.24}$	$0.71^{+0.13}_{-0.12}$	$0.06^{+0.01}_{-0.01}$	$-8.38^{+1.73}_{-1.68}$
ZTF20aatpzog	$6.75^{+0.10}_{-0.13}$	$0.96^{+0.13}_{-0.50}$	$-0.68^{+1.38}_{-1.62}$	$0.81^{+0.33}_{-0.20}$	$-3.00^{+0.30}_{-0.22}$	$2.74^{+0.83}_{-0.80}$	$1.24^{+0.77}_{-0.75}$	$0.18^{+0.03}_{-0.03}$	$-21.04^{+2.69}_{-3.08}$
AT2020mvg	$6.06^{+0.05}_{-0.05}$	$0.87^{+0.09}_{-0.14}$	$-1.12^{+1.30}_{-1.16}$	$0.10^{+0.04}_{-0.02}$	$-1.46^{+0.19}_{-0.27}$	$2.99^{+0.69}_{-0.91}$	$0.66^{+0.46}_{-0.44}$	$0.06^{+0.00}_{-0.00}$	$-6.39^{+0.76}_{-0.87}$
AT2022yhf	$7.13^{+0.04}_{-0.05}$	$1.14^{+0.07}_{-0.05}$	$0.97^{+0.05}_{-0.05}$	$1.00^{+0.00}_{-0.00}$	$-0.46^{+0.04}_{-0.06}$	$0.47^{+0.02}_{-0.02}$	$1.13^{+0.06}_{-0.06}$	$0.32^{+0.01}_{-0.01}$	$15.92^{+1.35}_{-1.25}$
AT2024gzn	$7.29^{+0.13}_{-0.11}$	$0.24^{+0.15}_{-0.13}$	$-0.74^{+1.20}_{-1.46}$	$1.18^{+0.07}_{-0.06}$	$-1.90^{+0.30}_{-0.39}$	$2.33^{+0.31}_{-0.27}$	$1.29^{+0.34}_{-0.21}$	$0.22^{+0.06}_{-0.05}$	$-39.83^{+4.67}_{-5.15}$
AT2020ukj	$5.75^{+0.08}_{-0.09}$	$0.98^{+0.02}_{-0.04}$	$3.21^{+0.02}_{-0.02}$	$1.72^{+0.06}_{-0.10}$	$-3.98^{+0.03}_{-0.01}$	$0.37^{+0.13}_{-0.12}$	$0.29^{+0.05}_{-0.04}$	$0.01^{+0.00}_{-0.00}$	$-18.4^{+1.8}_{-2.0}$
AT2023npi	$5.66^{+0.16}_{-0.06}$	$0.01^{+0.00}_{-0.00}$	$-1.29^{+1.09}_{-1.13}$	$0.98^{+0.02}_{-0.04}$	$-1.89^{+0.03}_{-0.08}$	$0.03^{+0.05}_{-0.09}$	$0.08^{+0.02}_{-0.02}$	0.03	$-16.30^{+0.96}_{-1.13}$
AT2020afap	$5.39^{+0.16}_{-0.09}$	$0.62^{+0.29}_{-0.20}$	$1.57^{+0.17}_{-0.21}$	$0.63^{+0.29}_{-0.27}$	$-1.42^{+0.43}_{-0.83}$	$1.40^{+0.26}_{-0.13}$	$2.95^{+0.68}_{-0.84}$	0.10	$-31.31^{+8.02}_{-6.23}$
AT2023szj	$7.95^{+0.03}_{-0.06}$	$0.28^{+0.04}_{-0.05}$	$-1.29^{+1.01}_{-1.15}$	$0.93^{+0.14}_{-0.07}$	$-0.51^{+0.08}_{-0.13}$	$-0.19^{+0.08}_{-0.08}$	$0.11^{+0.04}_{-0.04}$	$0.46^{+0.04}_{-0.04}$	$-48.62^{+1.96}_{-1.02}$
AT2020pno	$7.03^{+0.02}_{-0.02}$	$0.99^{+0.01}_{-0.02}$	$0.56^{+0.09}_{-0.11}$	$0.72^{+0.01}_{-0.01}$	$-2.26^{+0.02}_{-0.01}$	$3.95^{+0.04}_{-0.07}$	$3.51^{+0.06}_{-0.06}$	0.28	$-43.59^{+1.58}_{-1.71}$
AT2024hhj	$7.30^{+0.06}_{-0.07}$	$0.10^{+0.01}_{-0.00}$	$0.52^{+0.35}_{-2.08}$	$0.85^{+0.10}_{-0.10}$	$-0.76^{+0.07}_{-0.07}$	$3.51^{+0.28}_{-0.34}$	$3.15^{+0.16}_{-0.17}$	0.22	$-31.13^{+3.57}_{-3.83}$
AT2023zaj	$7.35^{+0.21}_{-0.27}$	$0.33^{+0.24}_{-0.14}$	$-0.58^{+1.52}_{-1.45}$	$1.00^{+0.28}_{-0.26}$	$-0.85^{+0.28}_{-0.33}$	$2.16^{+1.26}_{-1.05}$	$1.38^{+1.31}_{-0.86}$	$0.41^{+0.05}_{-0.06}$	$-44.22^{+6.61}_{-4.03}$
AT2021wxd	$6.90^{+0.35}_{-0.18}$	$0.34^{+0.38}_{-0.17}$	$-0.12^{+1.35}_{-1.32}$	$0.84^{+0.60}_{-0.55}$	$-1.68^{+0.72}_{-0.66}$	$3.04^{+0.70}_{-0.82}$	$1.80^{+0.53}_{-0.52}$	0.23	$-30.89^{+7.18}_{-6.51}$
AT2021ovg	$6.92^{+0.24}_{-0.30}$	$0.46^{+0.29}_{-0.30}$	$-0.64^{+1.13}_{-1.59}$	$1.01^{+0.31}_{-0.45}$	$-2.19^{+0.35}_{-0.42}$	$2.83^{+0.71}_{-0.65}$	$1.90^{+0.66}_{-0.57}$	$0.25^{+0.05}_{-0.05}$	$-26.74^{+8.71}_{-12.83}$
AT2023adr (2nd peak)	$5.84^{+0.32}_{-0.31}$	$0.32^{+0.23}_{-0.12}$	$1.87^{+0.09}_{-0.10}$	$0.55^{+0.10}_{-0.10}$	$-0.81^{+0.26}_{-0.41}$	$2.17^{+0.33}_{-0.35}$	$3.74^{+0.19}_{-0.36}$	$0.14^{+0.05}_{-0.04}$	$-38.29^{+8.14}_{-8.05}$
AT2020act	$6.83^{+0.08}_{-0.09}$	$0.12^{+0.12}_{-0.02}$	$1.35^{+0.04}_{-0.05}$	$0.90^{+0.07}_{-0.07}$	$-1.84^{+0.07}_{-0.28}$	$1.84^{+0.16}_{-0.15}$	$1.02^{+0.12}_{-0.11}$	0.14	$-35.92^{+2.88}_{-2.75}$
AT2023jag	$6.96^{+0.08}_{-0.09}$	$0.75^{+0.19}_{-0.16}$	$-0.17^{+1.20}_{-1.18}$	$0.99^{+0.23}_{-0.26}$	$-3.38^{+0.27}_{-0.22}$	$1.58^{+1.14}_{-0.34}$	$0.63^{+0.62}_{-0.16}$	$0.11^{+0.03}_{-0.03}$	$-24.76^{+2.94}_{-3.38}$
AT2020act	$6.8^{+0.07}_{-0.07}$	$0.20^{+0.09}_{-0.08}$	$1.34^{+0.05}_{-0.05}$	$0.90^{+0.08}_{-0.07}$	$-2.04^{+0.19}_{-0.16}$	$1.83^{+0.15}_{-0.15}$	$1.03^{+0.12}_{-0.11}$	$0.15^{+0.0}_{-0.0}$	$-36.8^{+2.6}_{-2.7}$
AT2020aex	$6.92^{+0.10}_{-0.07}$	$0.35^{+0.17}_{-0.17}$	$0.85^{+0.25}_{-2.60}$	$0.74^{+0.13}_{-0.12}$	$-1.12^{+0.29}_{-0.21}$	$0.63^{+0.09}_{-0.11}$	$0.72^{+0.19}_{-0.16}$	$0.26^{+0.02}_{-0.01}$	$-18.13^{+4.69}_{-3.24}$
Ansky	$6.52^{+0.05}_{-0.05}$	$1.00^{+0.01}_{-0.01}$	$3.28^{+0.01}_{-0.01}$	$0.32^{+0.02}_{-0.01}$	$-1.77^{+0.05}_{-0.07}$	$-0.52^{+0.04}_{0.04}$	$0.007^{+0.01}_{-0.005}$	0.024	$72.67^{+1.63}_{-1.76}$

Table A.2. Fitted parameter values from the *tde_fallback* model using Redback. The central values correspond to the median of the posterior distribution. The upper and lower respectively correspond to the 84th and 16th percentile. Redshift values with no error displayed indicate that they were fixed to their known spectroscopic redshift value. Because the fit failed to converge, AT2023rav is missing from this sample.

Appendix B: Skyview and lightcurves of the optical transients

Fig. B.1. Optical view of the hosts of the optical transients presented in this paper, from PanSTARRS, with a $1' \times 1'$ field of view.

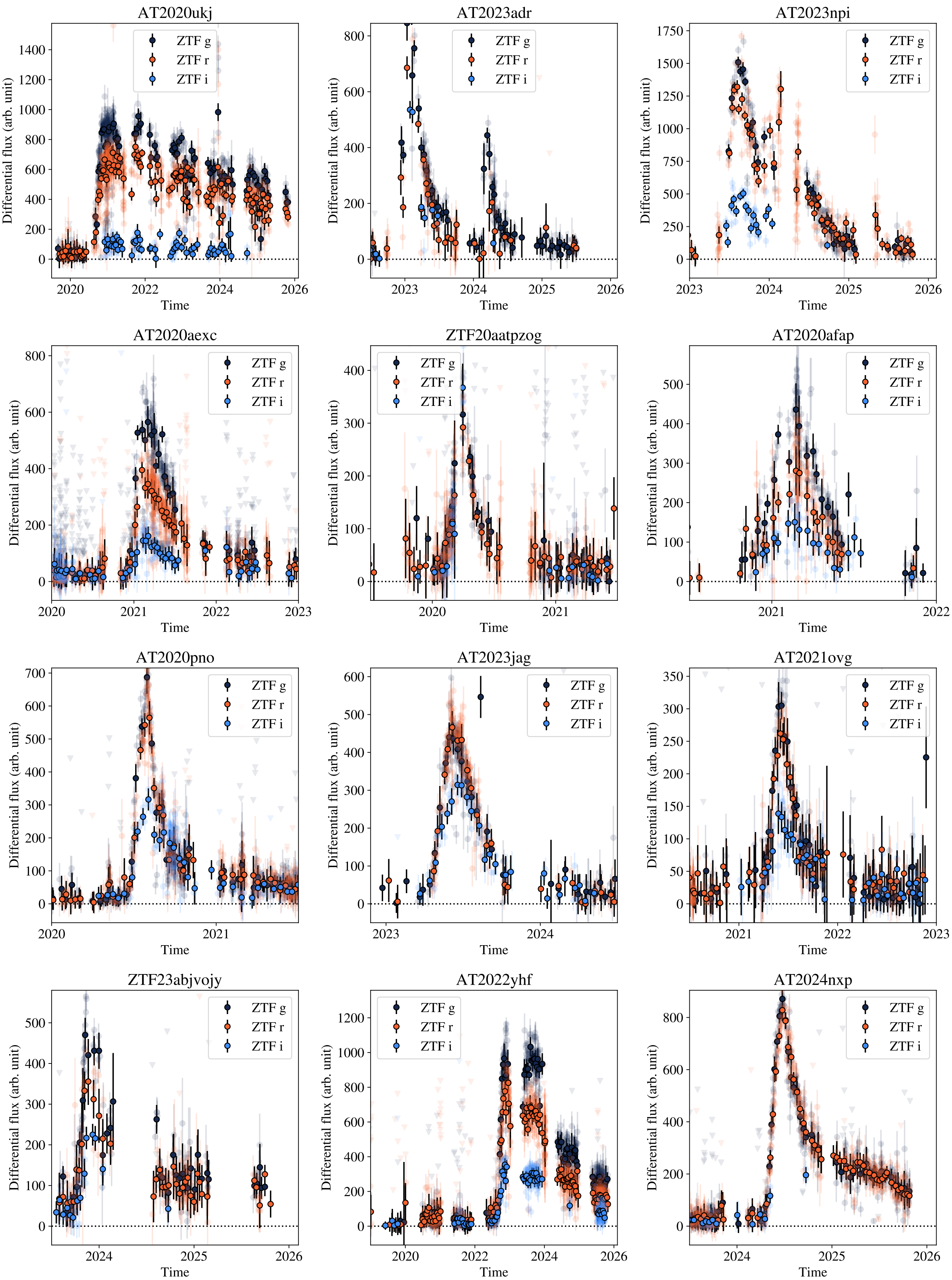

Fig. B.2. ZTF lightcurves of the optical transients in this paper, expressed in the instrumental ZTF units ('Digital Number'), and zoomed in on the transient. The translucent points correspond to the unbinned lightcurve, and the opaque points are binned in bins of 10 days.

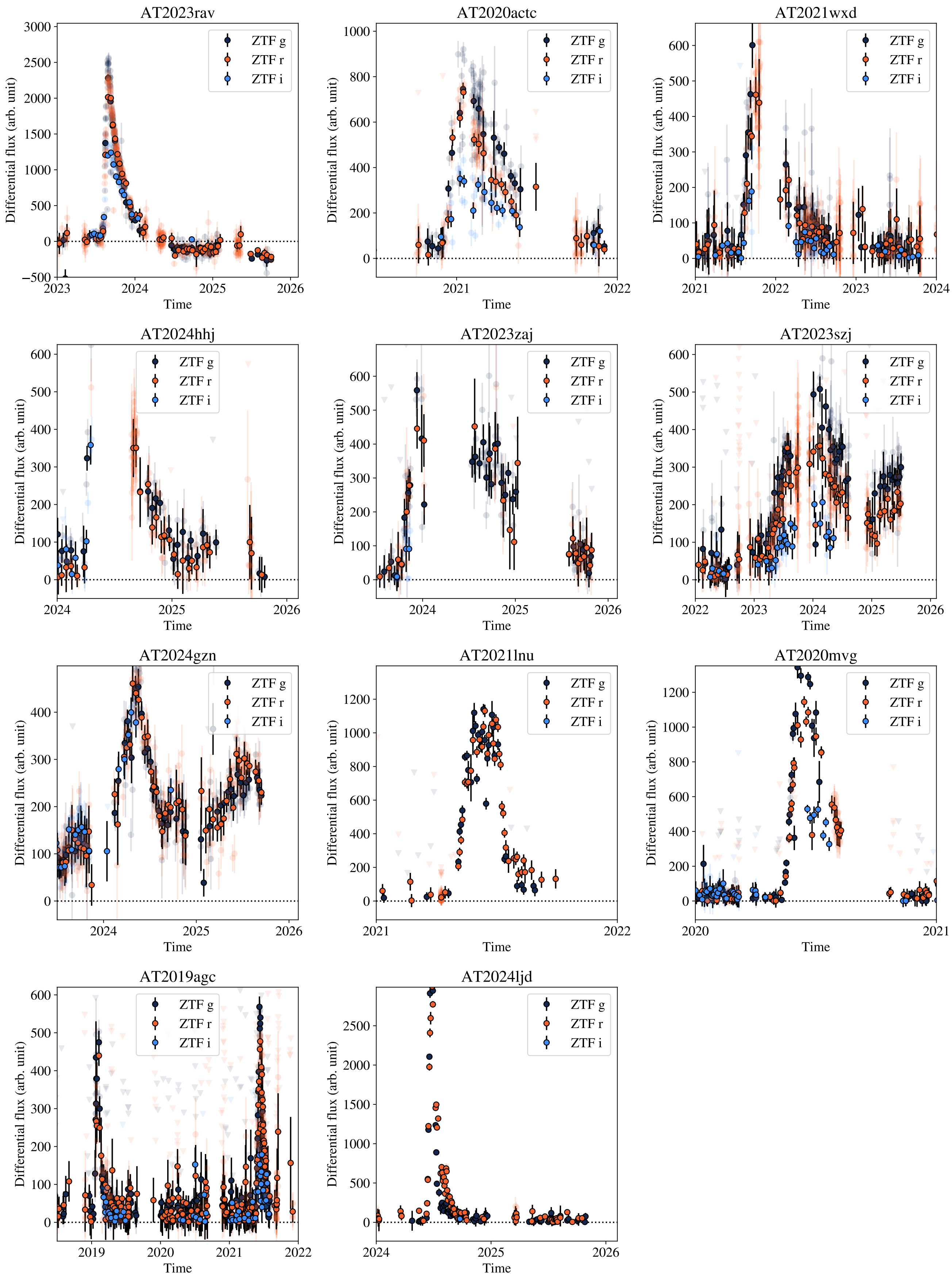

Fig. B.3. Continuation of Fig. B.2, except for the last four objects, which as SNe or SLSNe candidates are plotted in bins of 1 day instead of 10 days.

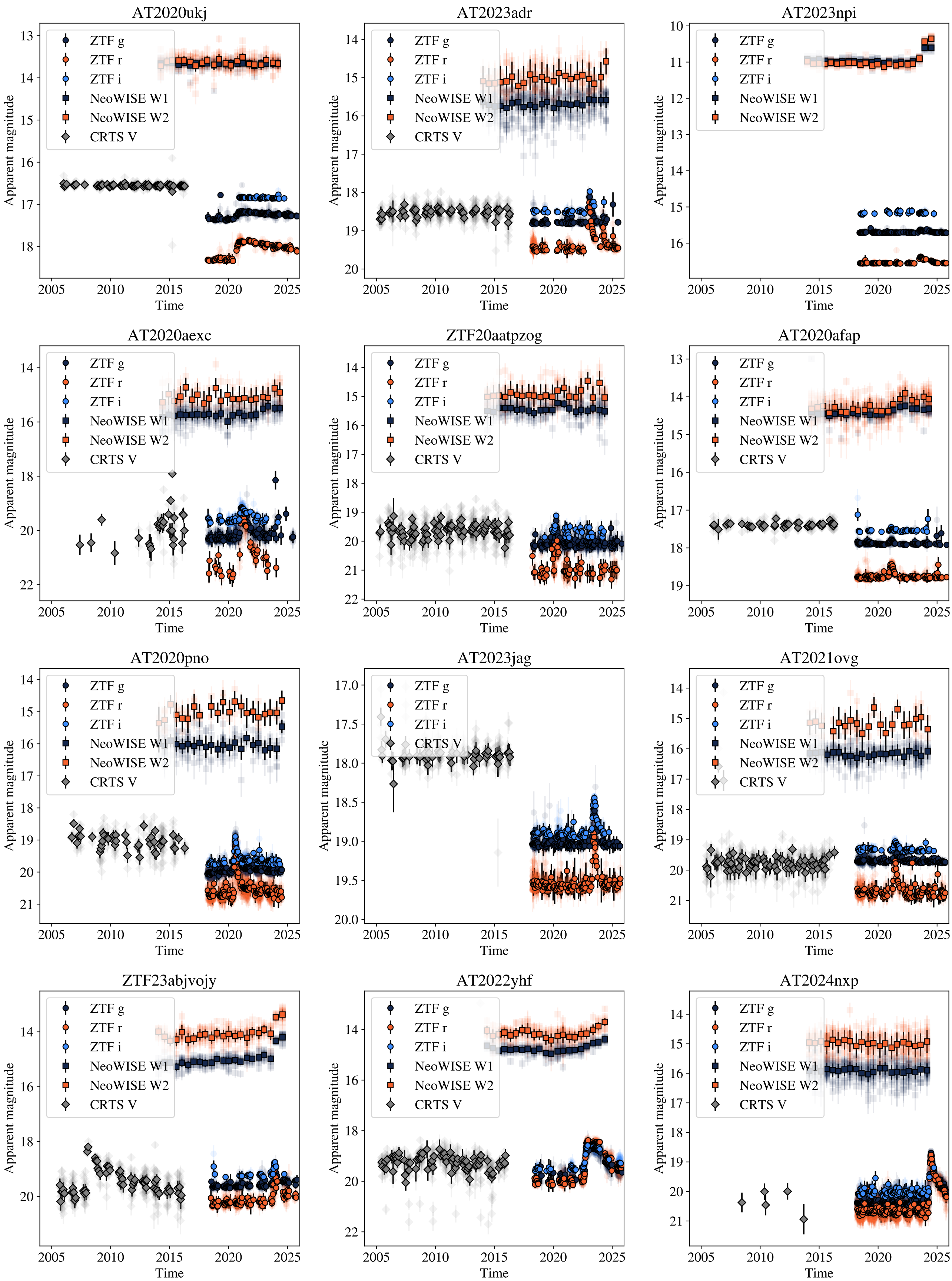

Fig. B.4. Multi-epoch, multi-wavelenght lightcurves of the optical transients in this paper, showing optical (CRTS and ZTF) and infrared (WISE) evolution. The optical points are binned at 15 days. The CRTS counterpart to AT2023jag is a combination of the two central sources, hence the much larger magnitude than ZTF.

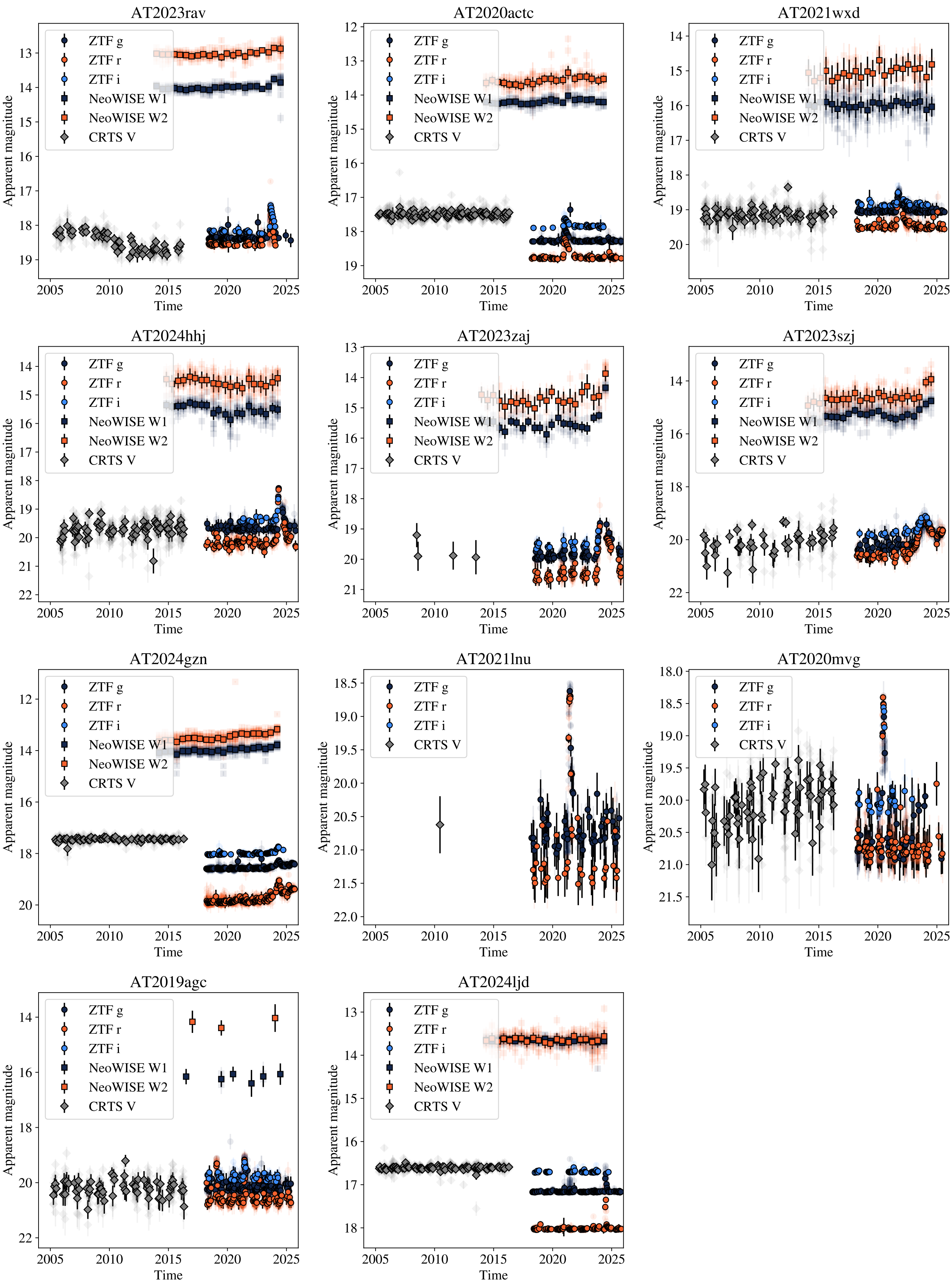

Fig. B.5. Continuation of Fig. B.4

Appendix C: Supernova modeling

We used the Python library sncosmo[6], version 2.12.1 to obtain a preliminary photometric classification for the identified supernovae candidates. Their lightcurves were fitted with Peter Nugent's supernova models[3] which cover the main SN types (Ia, Ib/c, IIP, IIL, IIn) and the SALT2 model (Guy et al. 2007). Nugent's models are simple spectral time series which can be scaled up and down; the model parameters are the redshift z, the observer-frame time corresponding to the source's zero phase, t_0, and the amplitude. In case of SALT2 fit, the free parameters are z, t_0, the normalization of the SED sequence x_0, stretch-factor x_1, and color c.

For this work, we mostly fit the alert data from Fink (consequently, g and r bands), except in a few cases where significantly more photometric points were available in ZTF DR23 (which enabled fit also using the i band). To obtain the transient lightcurve from the DR photometry, we accounted for the host galaxy contribution using the ZTF reference magnitudes. The reference magnitudes were retrieved from the SNAD viewer[7] (Malanchev et al. 2023). We also corrected all lightcurves for a line-of-sight reddening in the Milky Way galaxy using Schlafly & Finkbeiner (2011) estimates. For sources holding spectroscopic redshift of the host galaxy, we fixed the redshift to this value. If this was not available, we adopted $[-15; -22]$ as an acceptable range for the supernova absolute magnitude (Richardson et al. 2014) and then, using the maximum apparent magnitude, roughly transformed it to the corresponding redshift range. We applied a χ^2 criterion to choose the best-fit model for each object.

It should be noted that we did not intend to make a detailed fit, but rather to show that the candidate lightcurves, selected initially by eye, can be satisfactorily fitted by different supernova models. Also, we did not take into account the possible extinction in host galaxies, therefore our fit is less accurate for highly reddened objects. Another potential limitation arises from the fact that the models employed are limited in both wavelength and time range. However, this simple fit is enough to show that a few transients have significant agreement with expected supernova lightcurves, as shown in Section 3.5 and Fig. C.1.

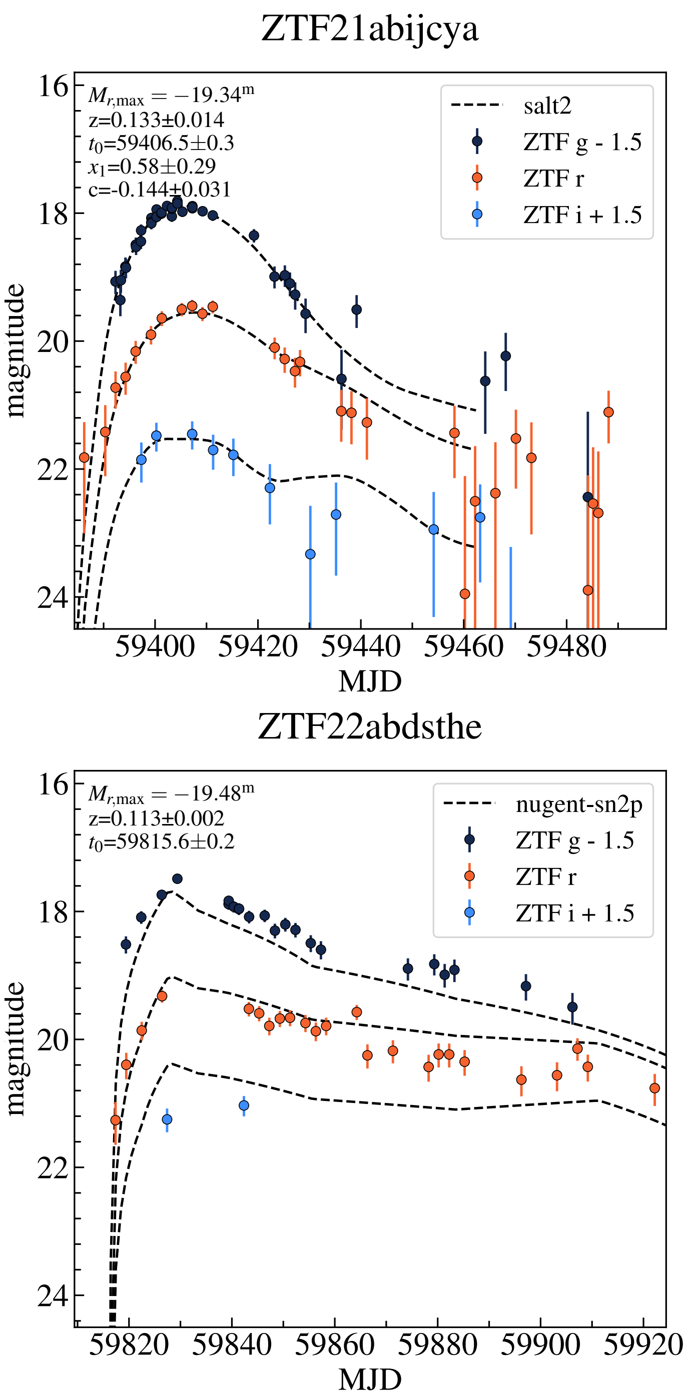

Fig. C.1. Example of best-fitted sncosmo built-in models. Different colors correspond to different ZTF filters. lightcurves in g and i band were shifted by 1.5 mag to improve visualization. The inset shows best-fit parameter values. **Top**: SN Ia candidate. **Bottom**: SN Type IIP candidate.

[6] https://sncosmo.readthedocs.io/
[7] https://ztf.snad.space/