ZTFbh:
Harvesting TDEs: First Crop

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Tiara Hung, UCSC (former grad student)
Sara Frederick, UMd (current grad student)
Scott Anderson UW
Charlotte Ward, UMd (current grad student)
Shri Kulkarni, Caltech
Peter Nugent, LBNL
Tom Barlow, Caltech
Brad Cenko, GSFC
Sjoert van Velzen, UMd/NYU (postdoc)
Lin Yan, Caltech
Po-Chieh Yu, NCU
Zeljko Ivezic, UW
Robert Stein, DESY
David Shupe, Caltech/IPAC
Nathaniel Roth, UMd and GSFC
Daniel Stern, Caltech/JPL

ZTFbh SWG Dinner @ Daisy Mint
March 19, 2018

ZTFbh: AGN and TDE SWG

What are we doing?

We are conducting a systematic study of extragalactic nuclear transients.

What are we interested in?

- variable active galactic nuclei
- changing-look quasars (CLAGN)
- tidal disruption events (TDEs)
- supermassive black holes (binary, recoiling, intermediate-mass)

What tools do we use?

GROWTH
Global Relay of Observatories Watching Transients Happen

PI: Mansi Kaslilwal

AMPEL

(DESY)

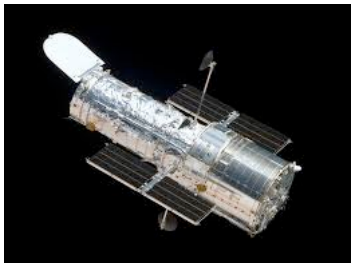
ZTFbh: AGN and TDE SWG

Panchromatic follow-up programs:

SEDm (Partnership Access):

- spectroscopic follow-up of **blue** (g-r < 0) *nuclear* (distnr < 0.5" of galaxy host) **bright** (r < 19 mag) transients
- expect 2 SEDm triggers per week, expect 6 bonafide TDEs per year

HST (PI: Brad Cenko) + DDTs
70 orbits of STIS UV spectroscopy of 5 UV-bright TDEs



XMM (PI: Suvi Gezari)
2x18 ks of XMM X-ray imaging for 6 TDEs discovered pre-peak

VLA (PI: Sjoert van Velzen), AMI (PI: Assaf Horesh)
32 hours of VLA radio follow-up of 7 TDEs

Gemini ToO (PI: Hung)
5 triggers, spectroscopy

Spitzer(PI: Lin Yan)
24 hours of Spitzer MIR follow-up

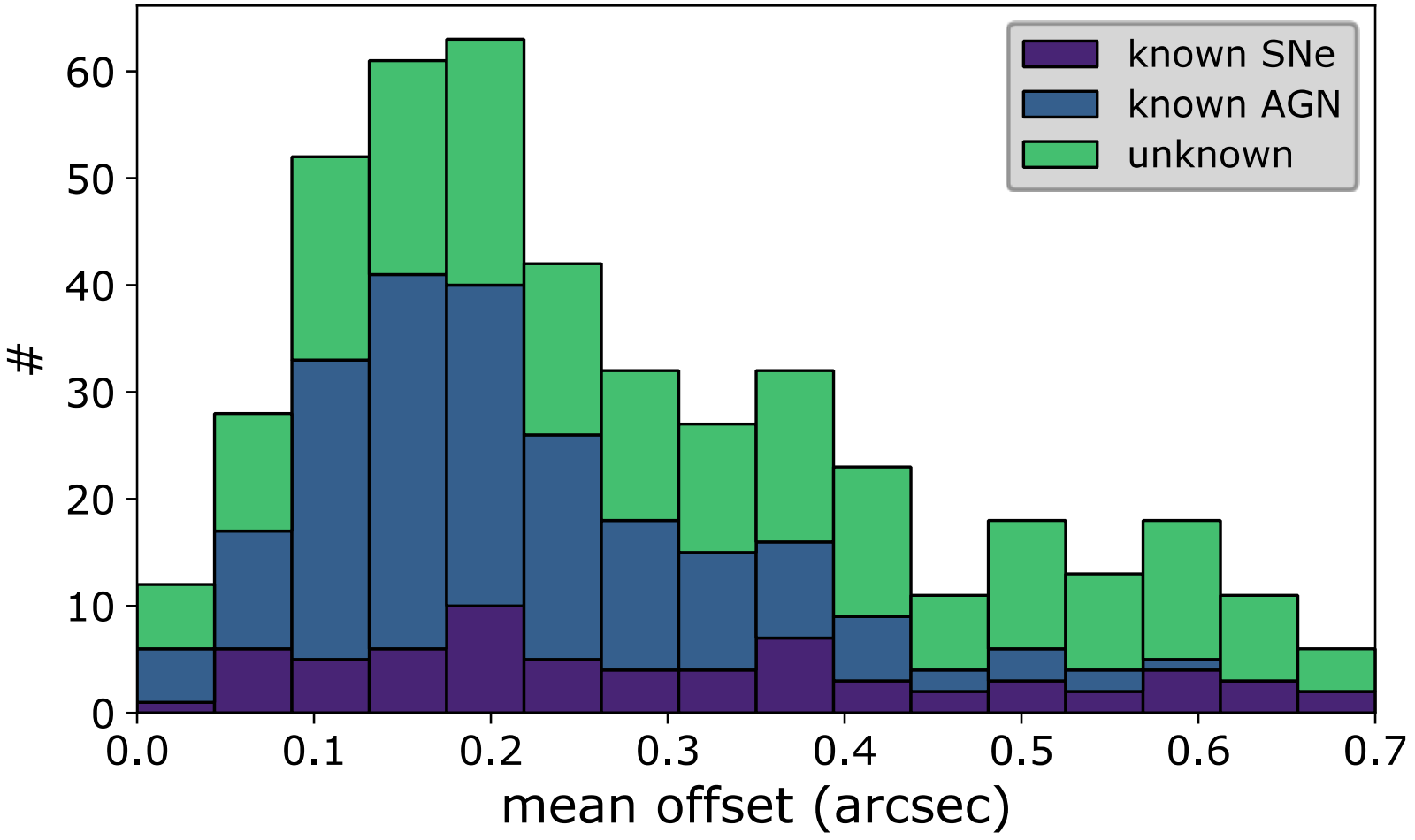
Part one: TDE search

Motivation

- Probe dormant massive black holes
- Accretion/jet physics
- Measure black hole mass (?)

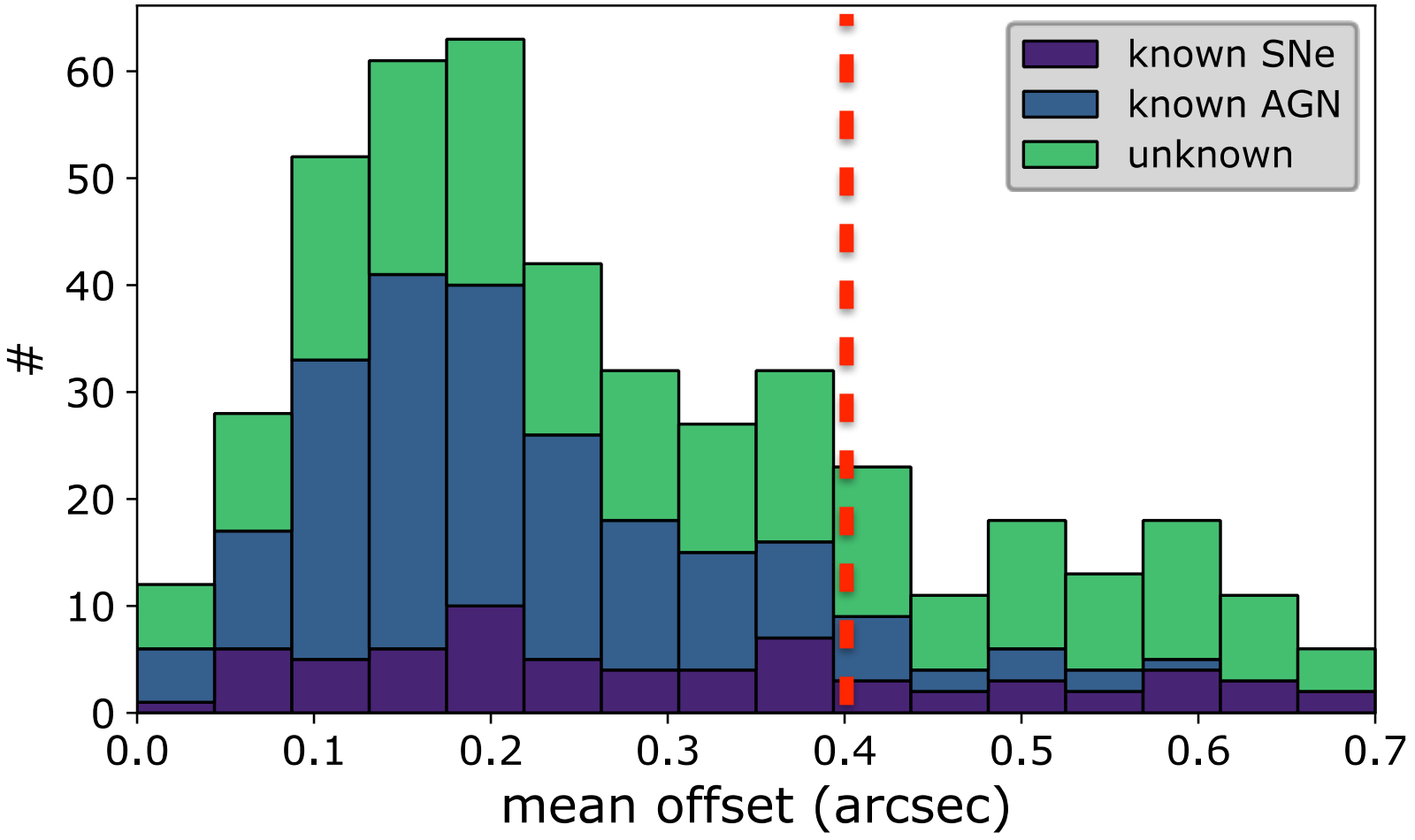
- Rare: One a few dozen know, handful per survey
- ZTF can find large and systematic sample
- Our motto: “no candidate left behind”

Look for nuclear flares



van Velzen, Gezari, et al. 2018

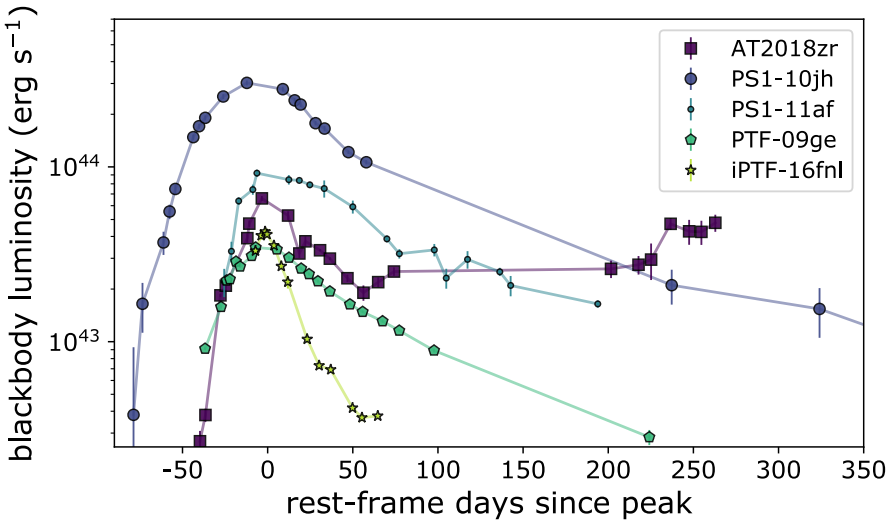
Look for nuclear flares



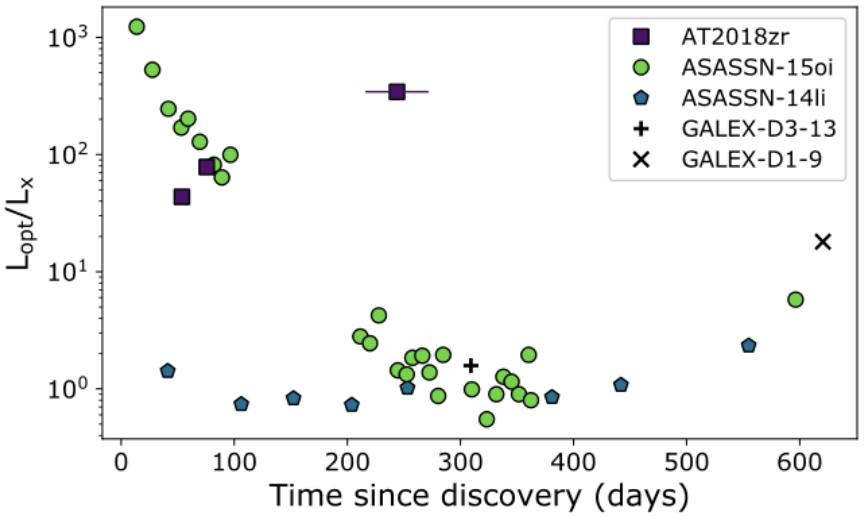
van Velzen, Gezari, et al. 2018

First TDE in ZTF: AT2018zr

TDE caught early on the rise to peak by ZTF



XMM Detected weak soft X-ray component



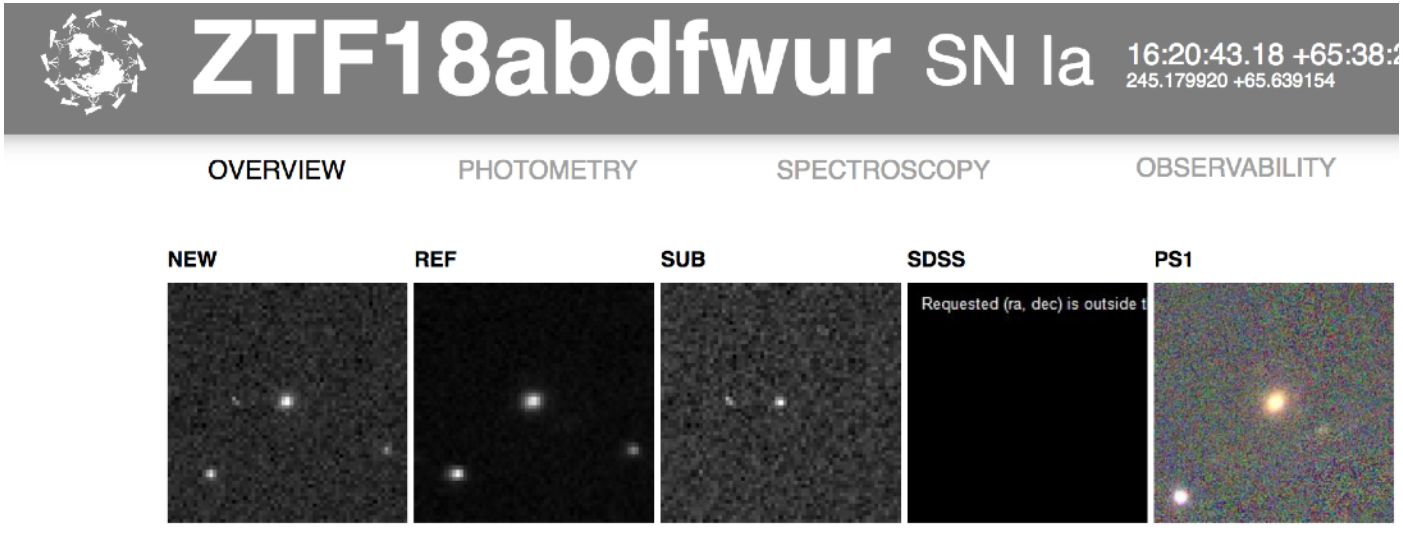
van Velzen, Gezari, et al. 2018

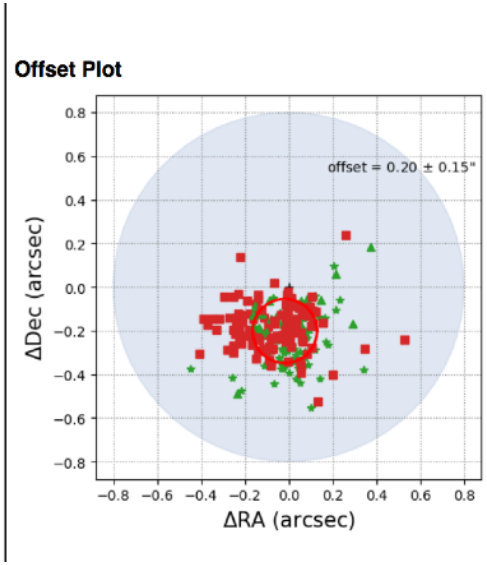
*AT2018zr is one of only 5 TDEs discovered **before** peak!*

*AT2018zr is one of only 5 TDEs with an optical **and** X-ray detection!*

Discovered by Pan-STARRS as PS18kh (Holoien et al. 2018)

Beware of SNe Ia (Joffries)





Beware of AGN (Whitewalkers)

ZTF18aavtklk AGN 16:28:08.11 +63:49:25.5
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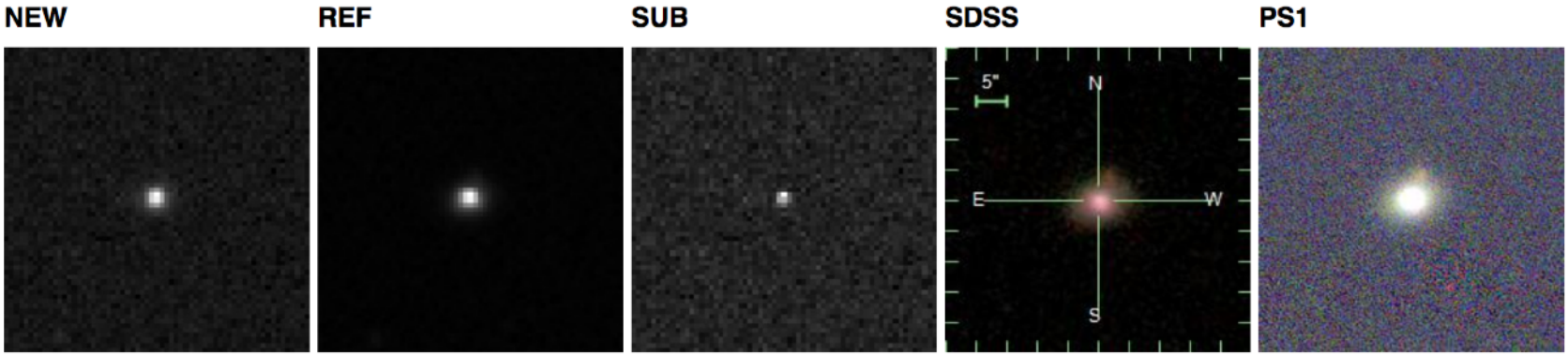
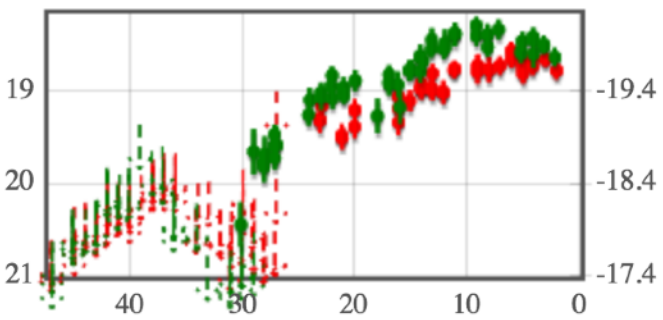
OVERVIEW | PHOTOMETRY | SPECTROSCOPY | OBSERVABILITY





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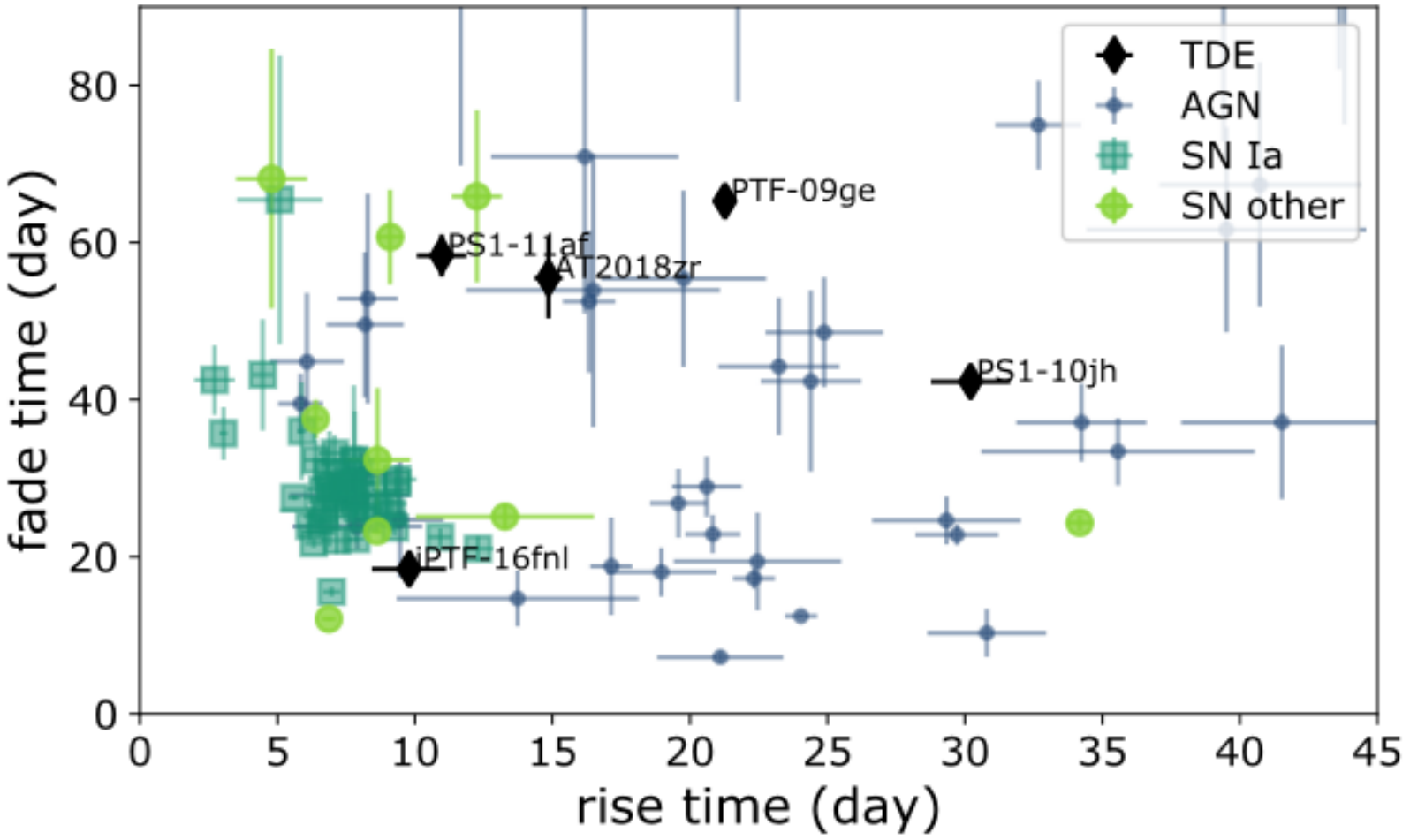
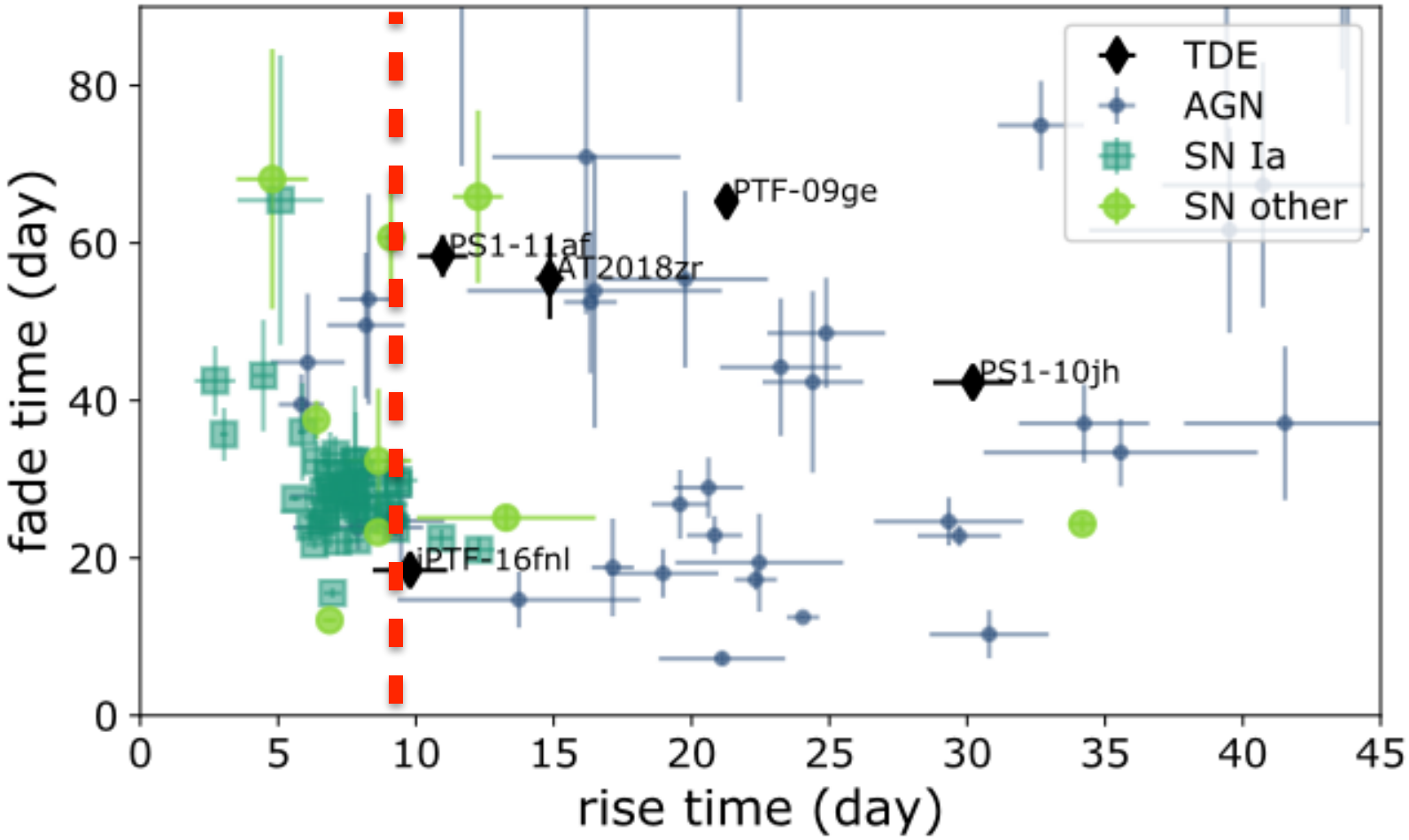
Upload New Spectroscopy
DM (approximate) = 38.40

Filtering Out Pesky SNe



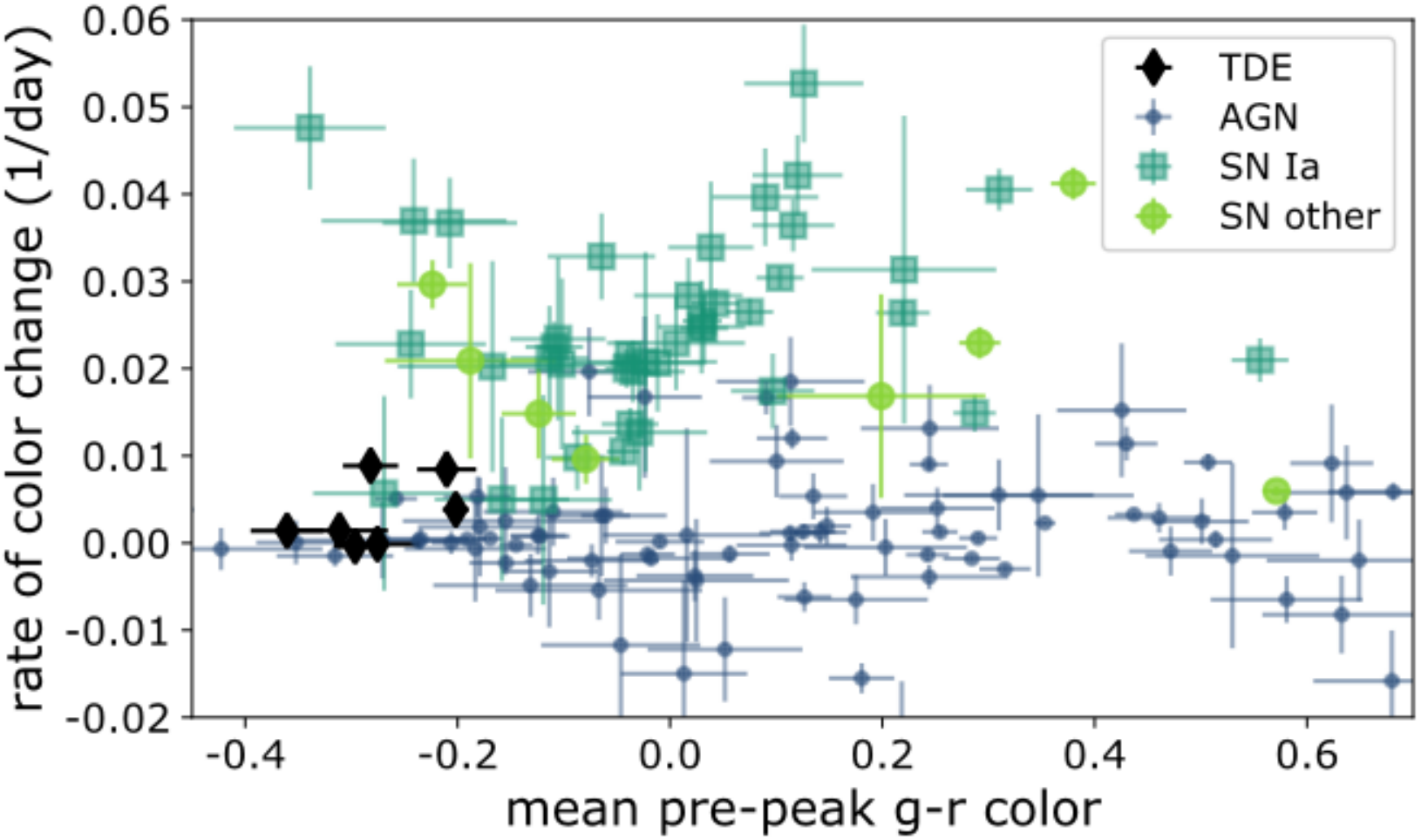
van Velzen, Gezari, et al. 2018

Filtering Out Pesky SNe



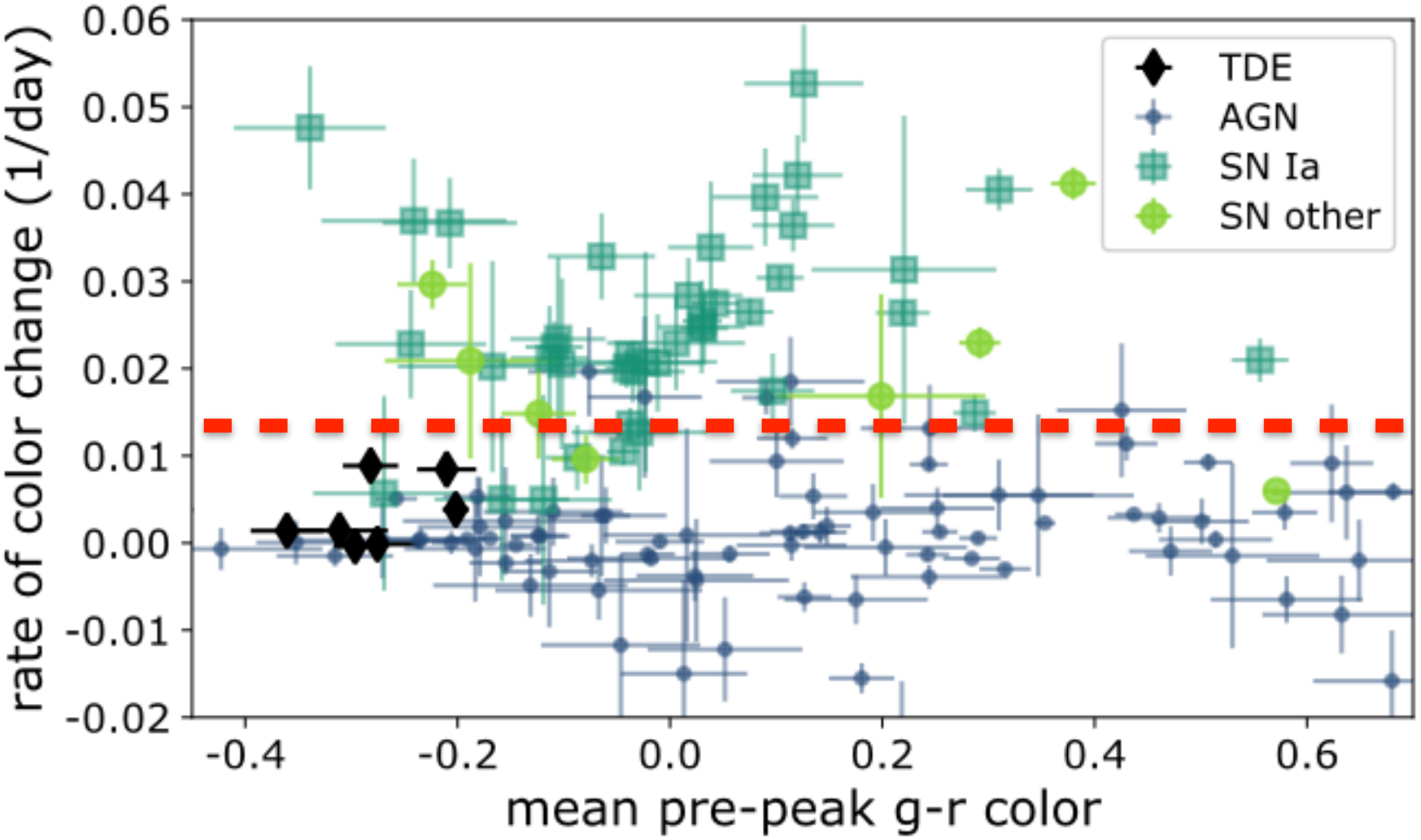
van Velzen, Gezari, et al. 2018

Filtering Out Pesky SNe



van Velzen, Gezari, et al. 2018

Filtering Out Pesky SNe

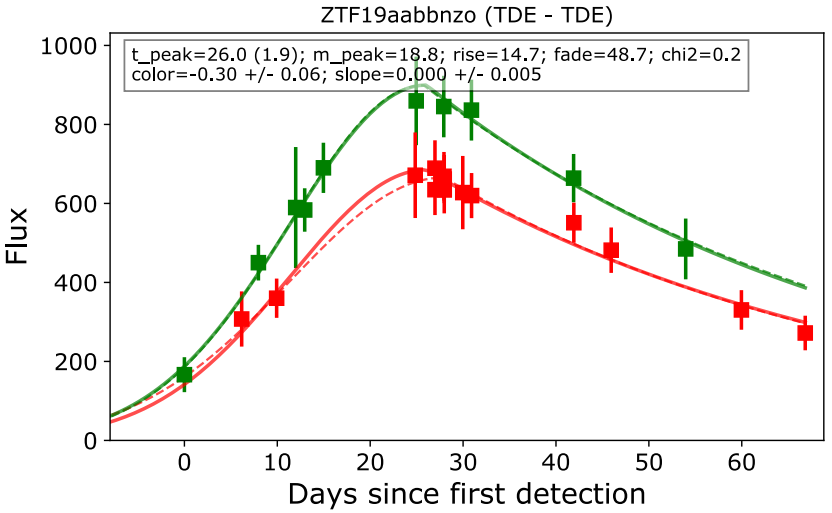


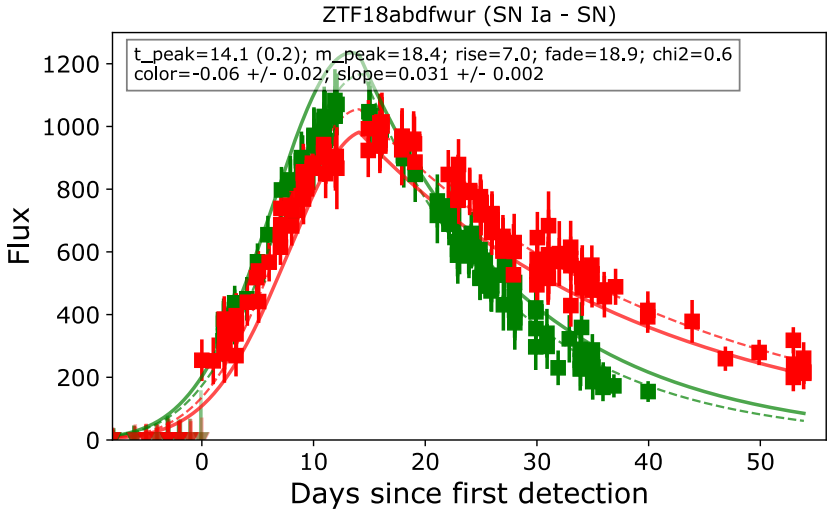
van Velzen, Gezari, et al. 2018

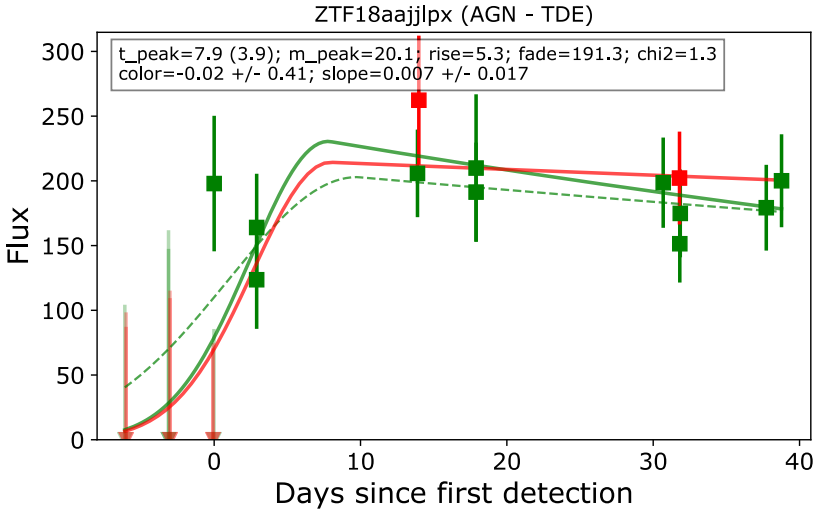
Generic light curve model

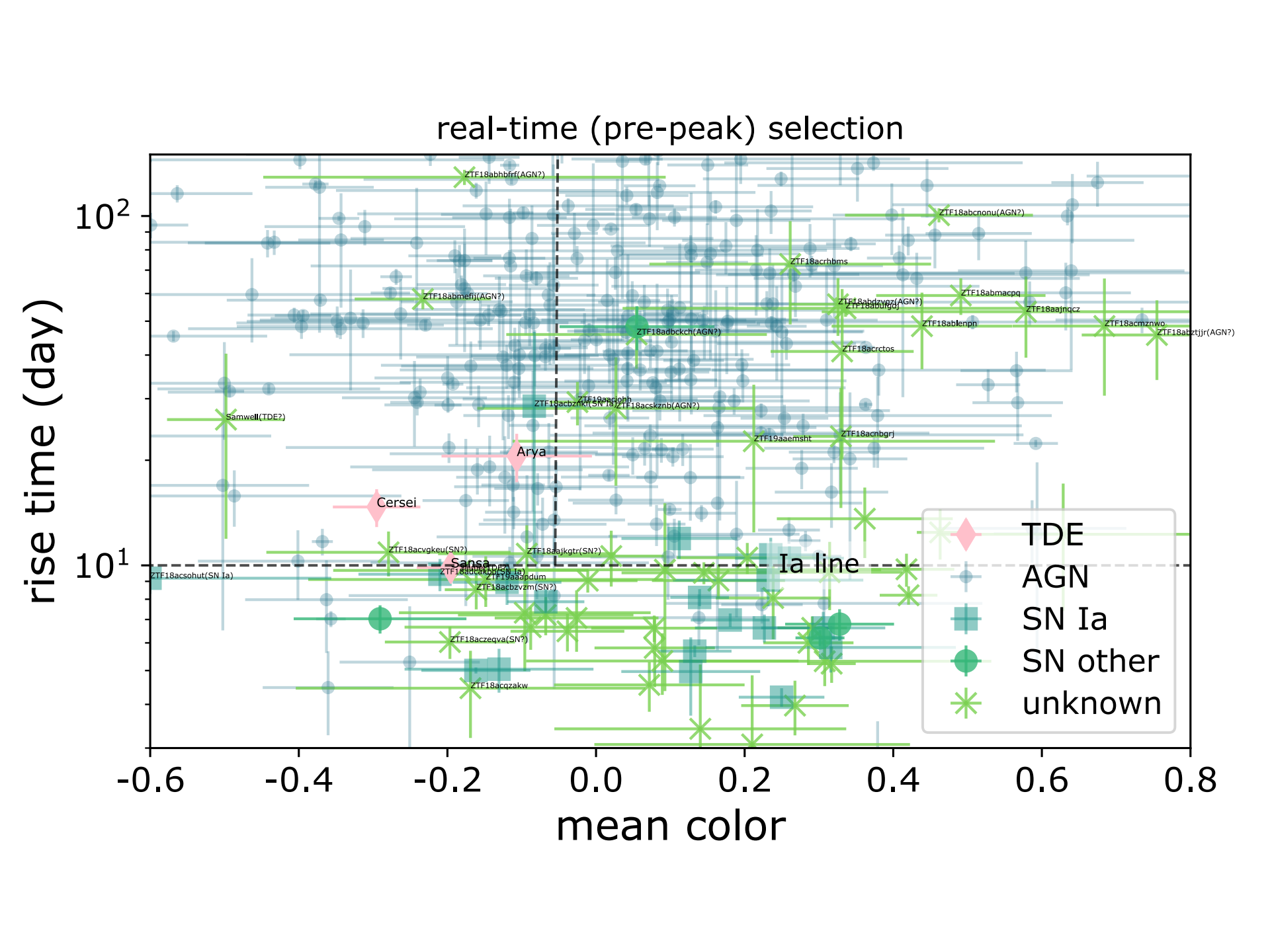
6 free parameters:

- Time of peak
- Flux at peak
- Gaussian rise time
- Exponential decay
- Mean color
- Color change (linear)





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rise time (day)
mean color
10^2
10^1
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
Ia line
TDE
AGN
SN Ia
SN other
unknown
Arya
Cersei
Samwell(TDE?)
ZTF18abhbfrf(AGN?)
ZTF18abmefij(AGN?)
ZTF18adbckch(AGN?)
ZTF18abcnonu(AGN?)
ZTF18acrhbms
ZTF18abmacpq
ZTF18aajnqcz
ZTF18acmznwo
ZTF18abztjjr(AGN?)
ZTF18ablenpn
ZTF18acrctos
ZTF18acnbgrj
ZTF19aaemsht
ZTF18acsohut(SN Ia)
ZTF18acvgkeu(SN?)
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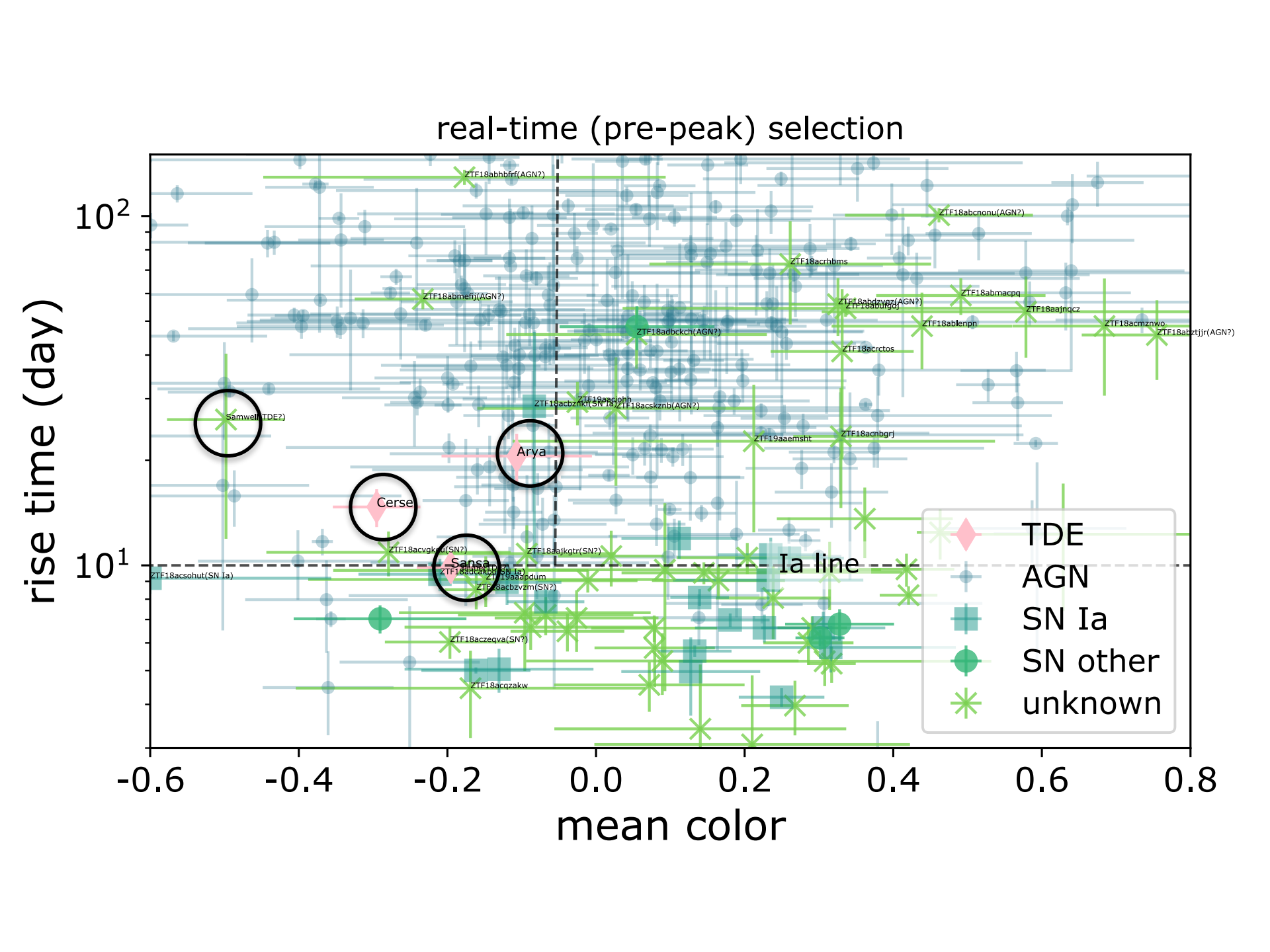
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rise time (day)
10^2
10^1
mean color
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Ia line
Arya
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AGN
SN Ia
SN other
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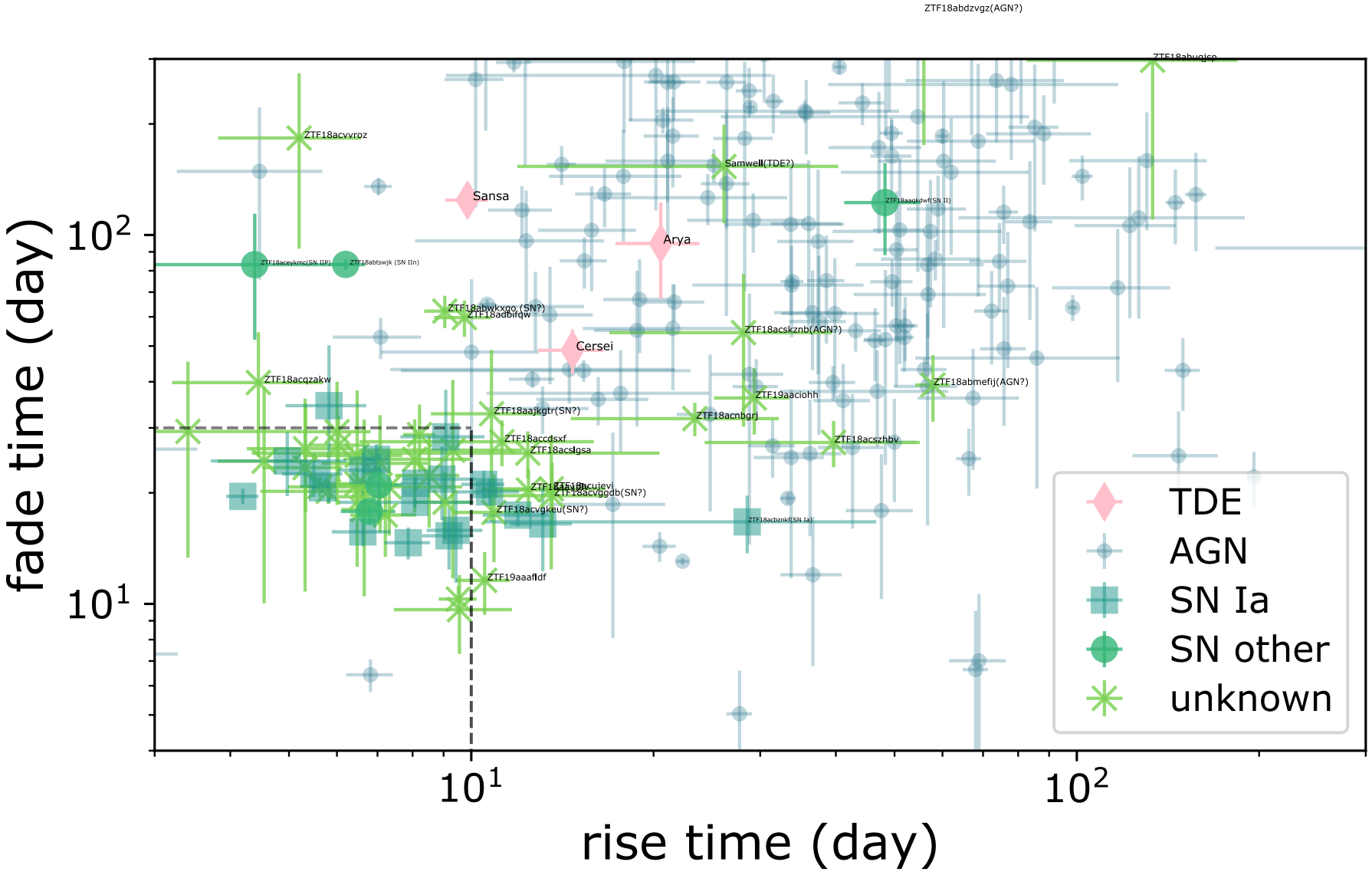
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AGN
SN Ia
SN other
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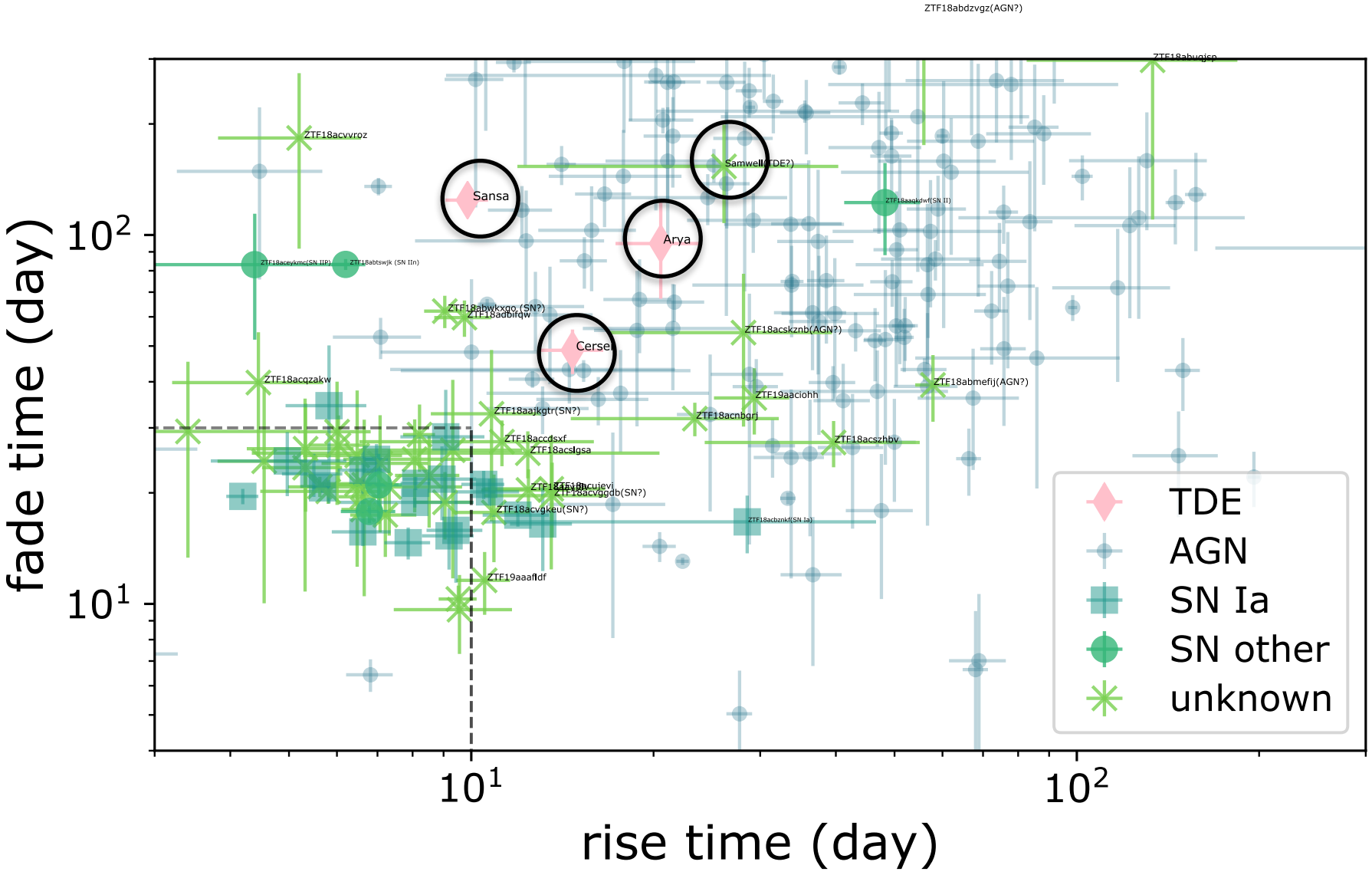
fade time (day)
rise time (day)
10^1
10^2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SN Ia
SN other
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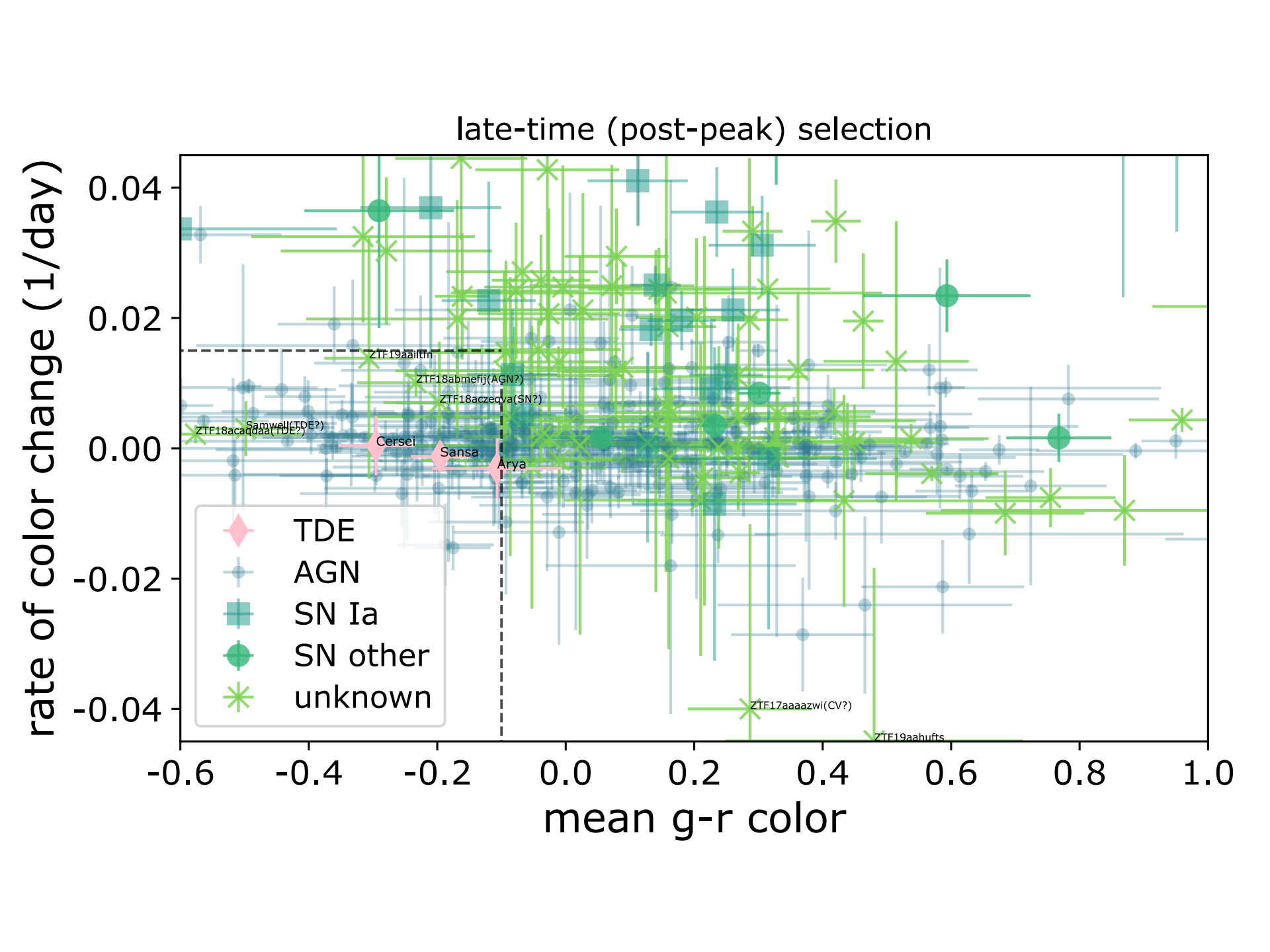
fade time (day)
rise time (day)
10^1
10^2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0.0
0.2
0.4
0.6
0.8
1.0
TDE
AGN
SN Ia
SN other
unknown
Cersei
Sansa
Arya
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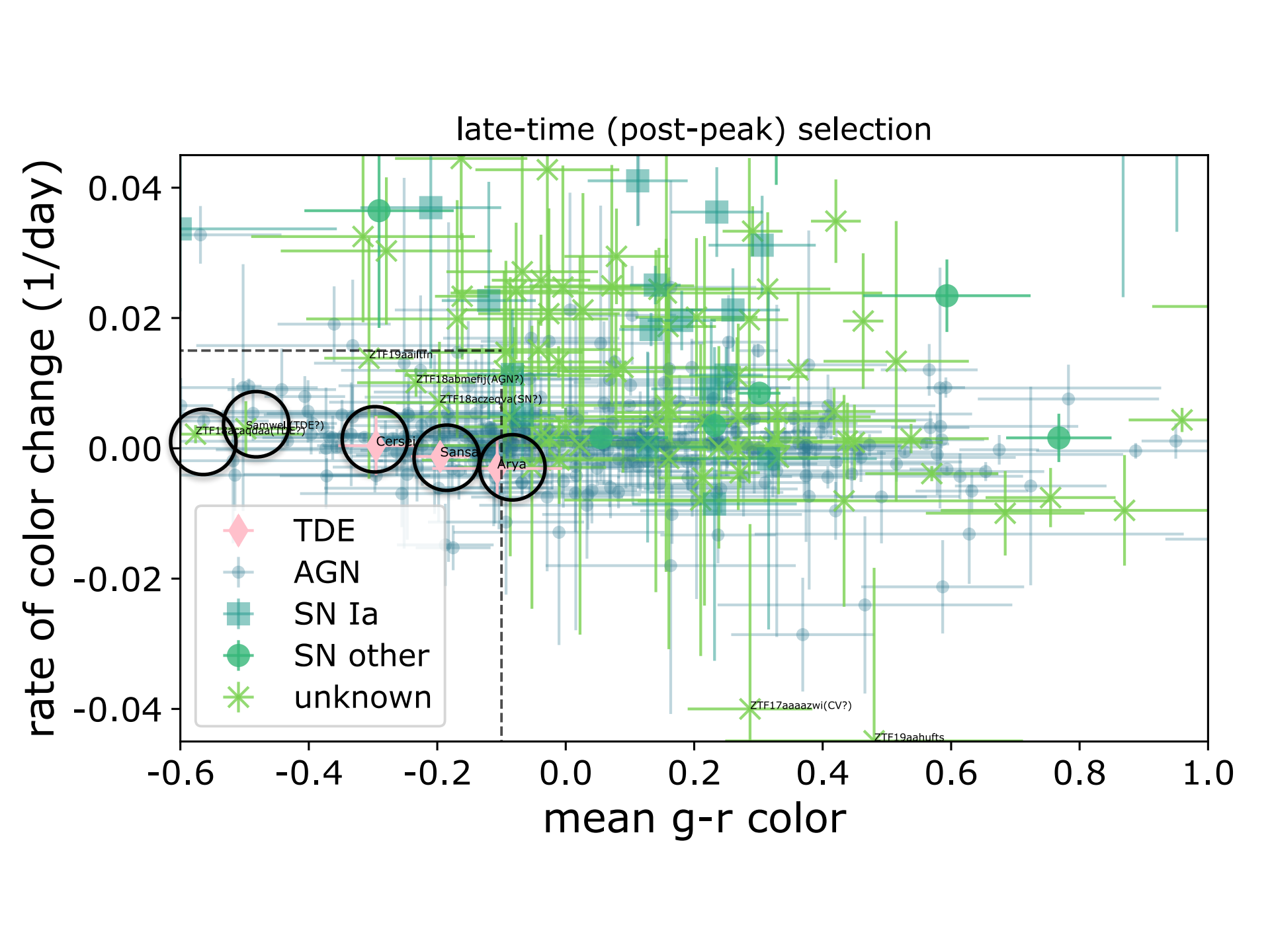
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rate of color change (1/day)
mean g-r color
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0.0
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0.6
0.8
1.0
TDE
AGN
SN Ia
SN other
unknown
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ZTF18abmefij(AGN?)
ZTF18aczeqva(SN?)
Samwell(TDE?)
Cersei
Sansa
Arya
ZTF17aaaazwi(CV?)
ZTF19aahufts

ZTF18abxftqm TDE

01:07:33.61 +23:28:34.
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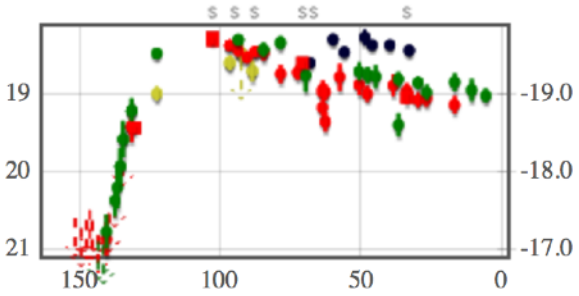
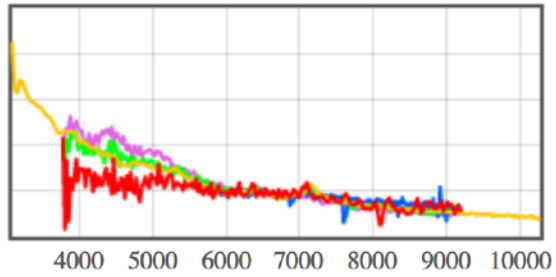
OVERVIEW | PHOTOMETRY | SPECTROSCOPY | OBSERVABILITY | EXAMINE

NEW | REF | SUB | SDSS | PS1





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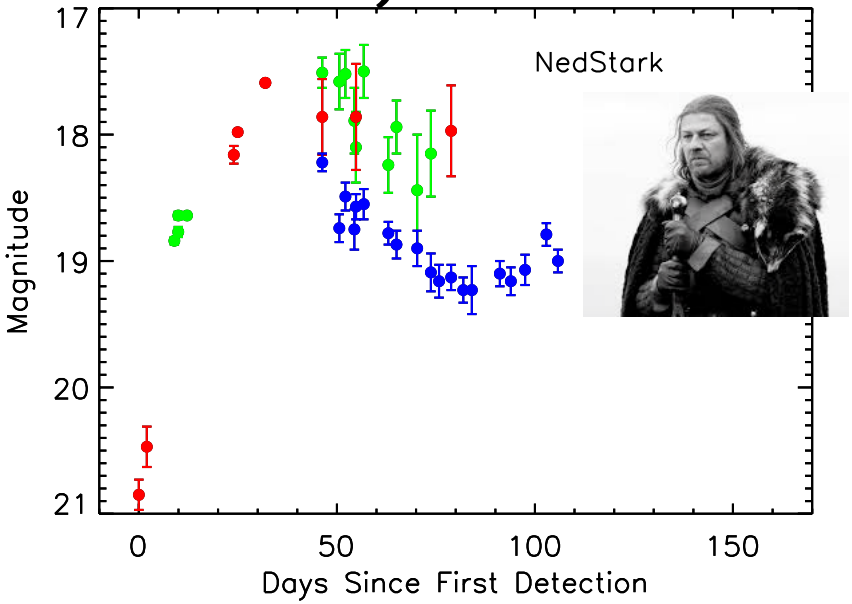
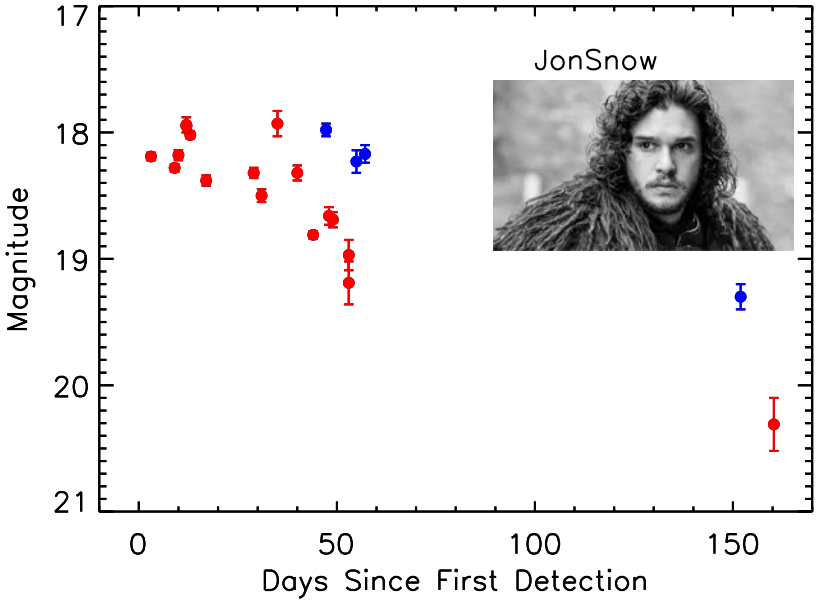
Feb 9, 2018



Apr 9, 2018



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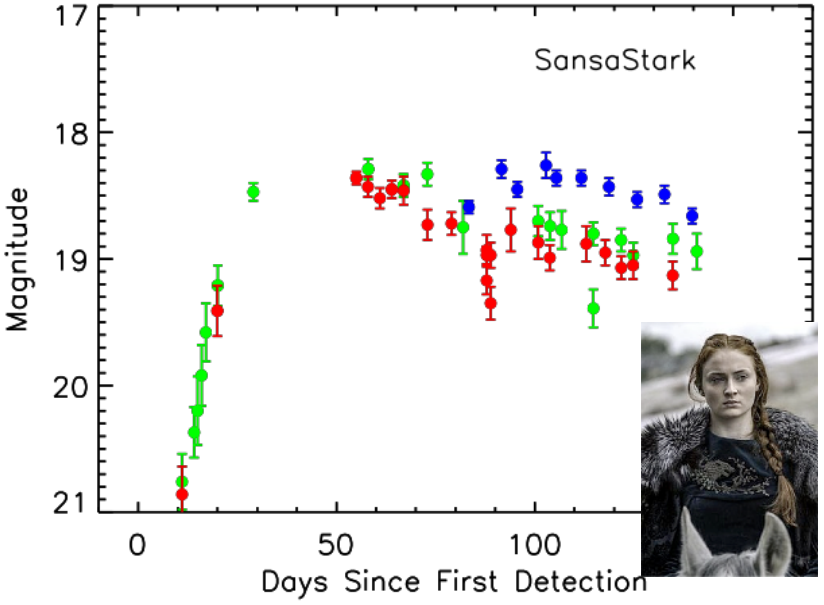

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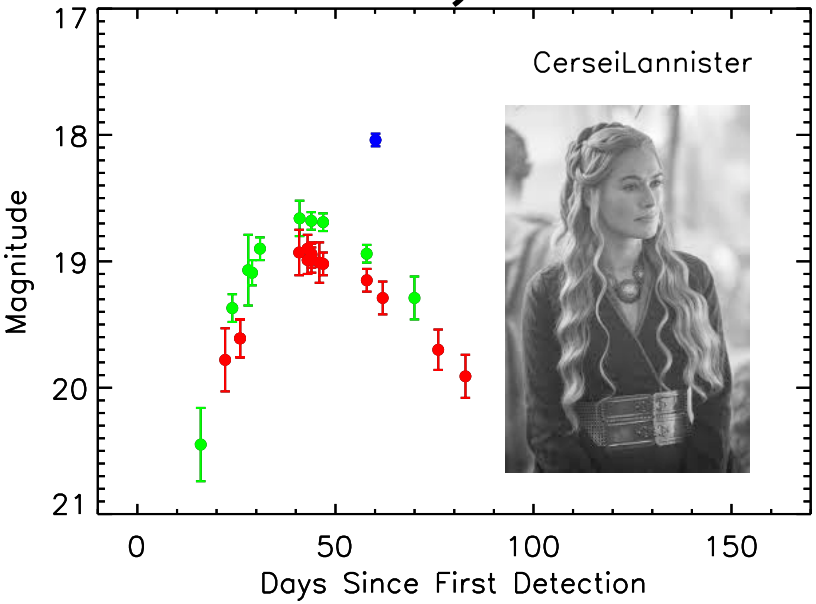

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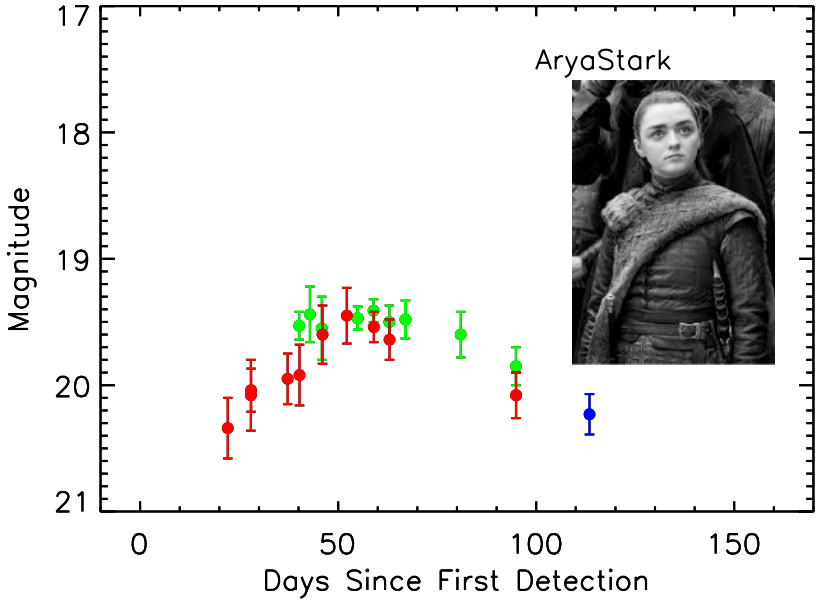

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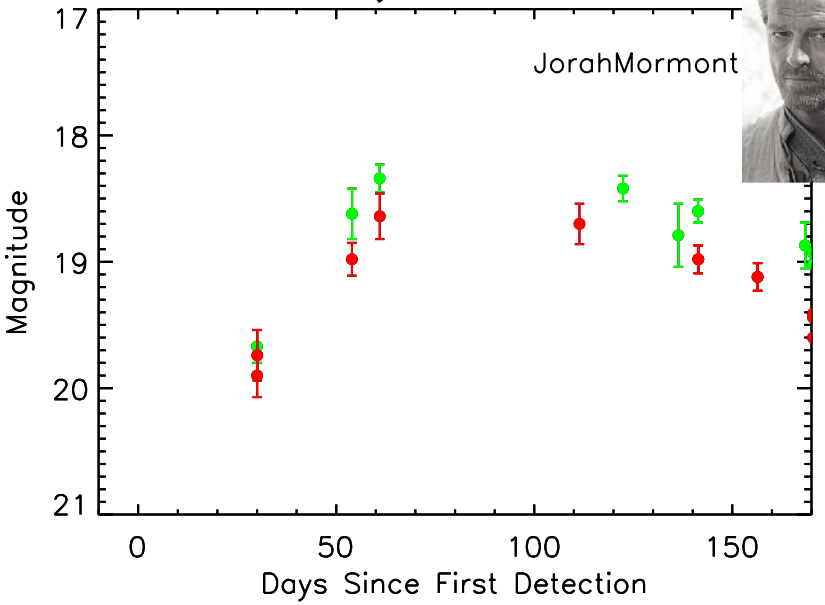

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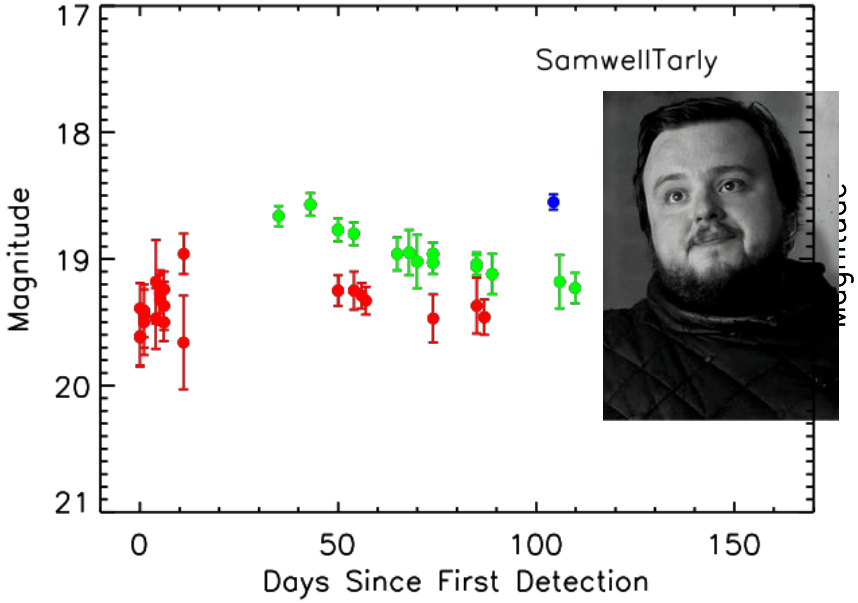

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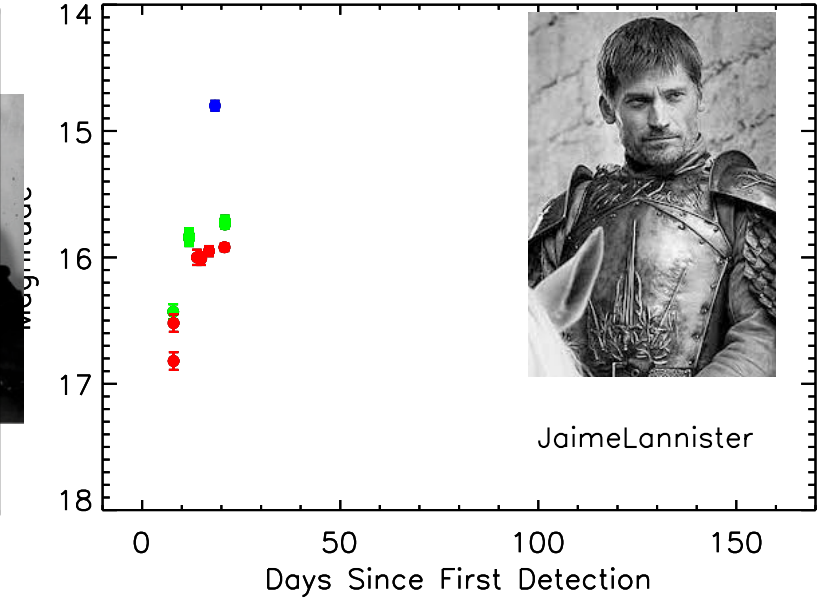
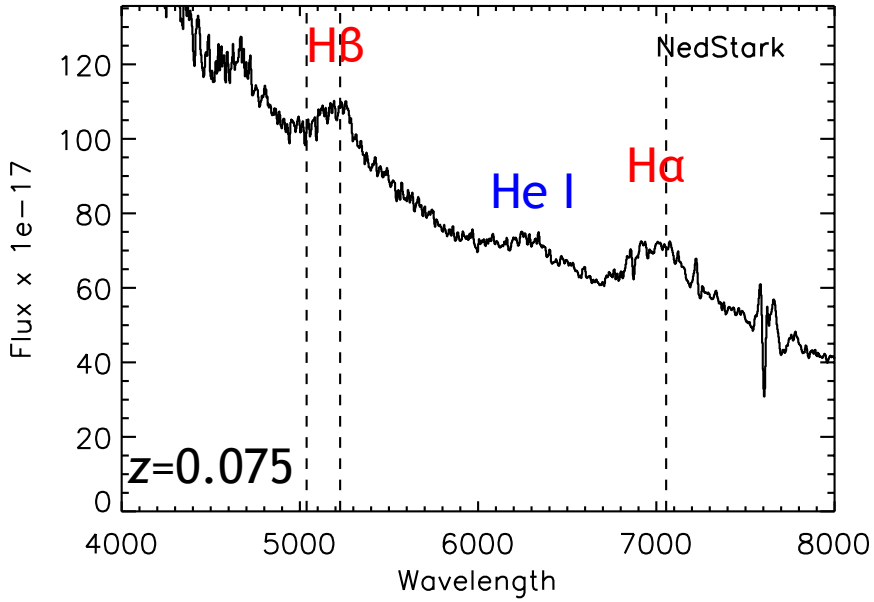
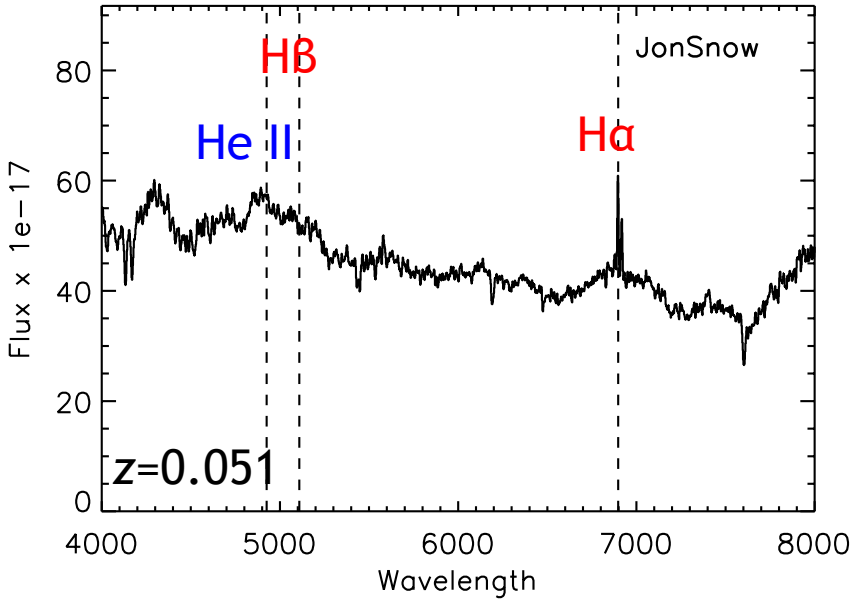
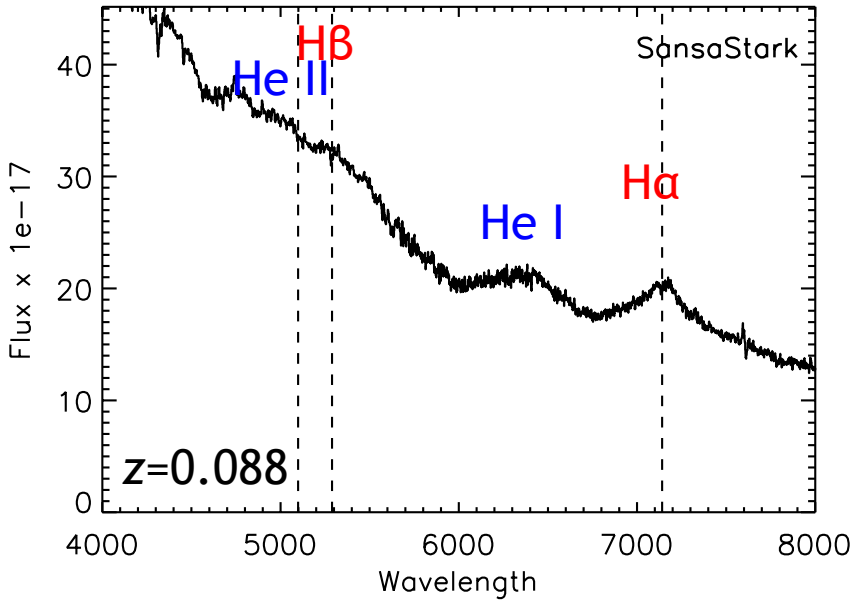
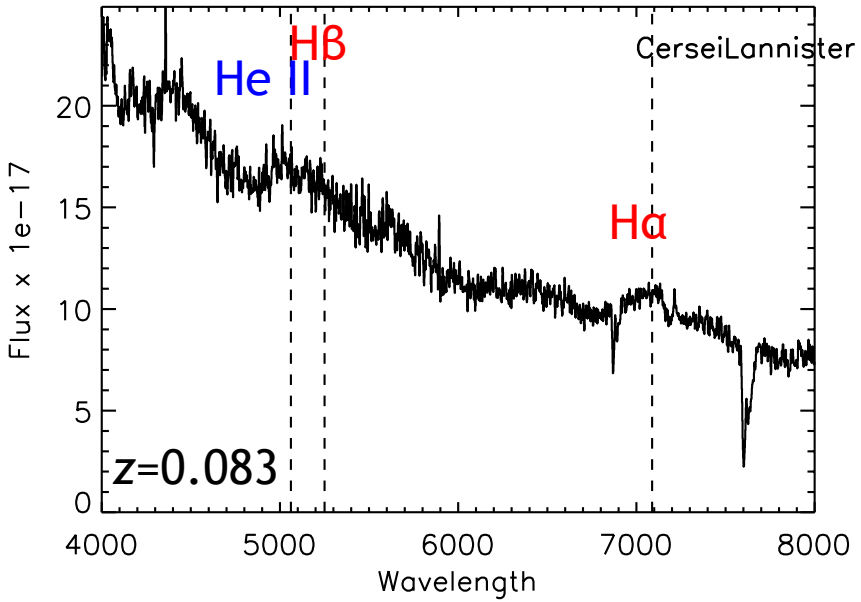


Blue Continuum + Broad H and/or He II

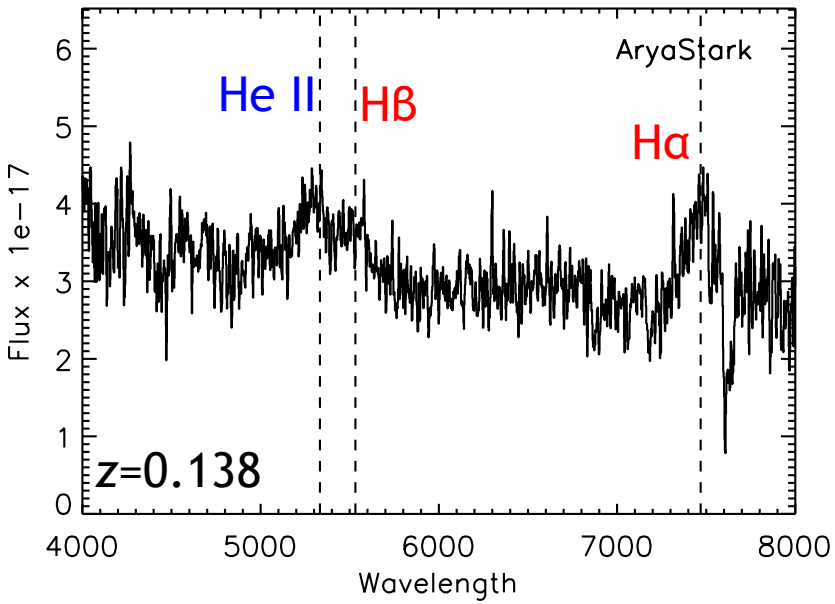


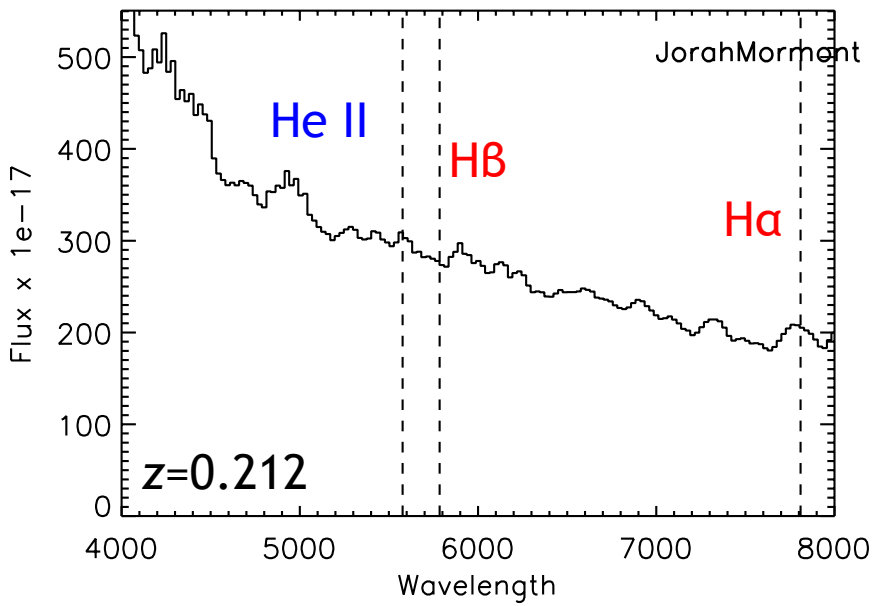


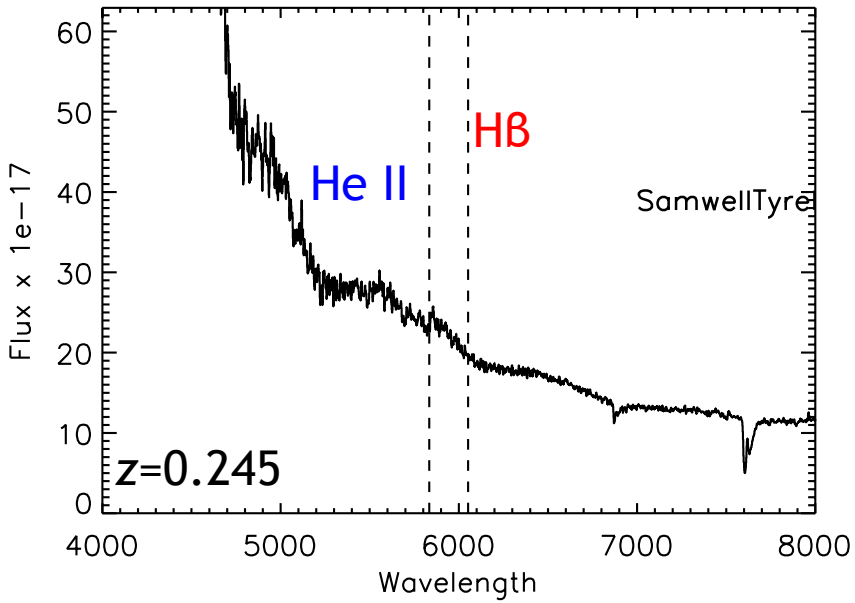


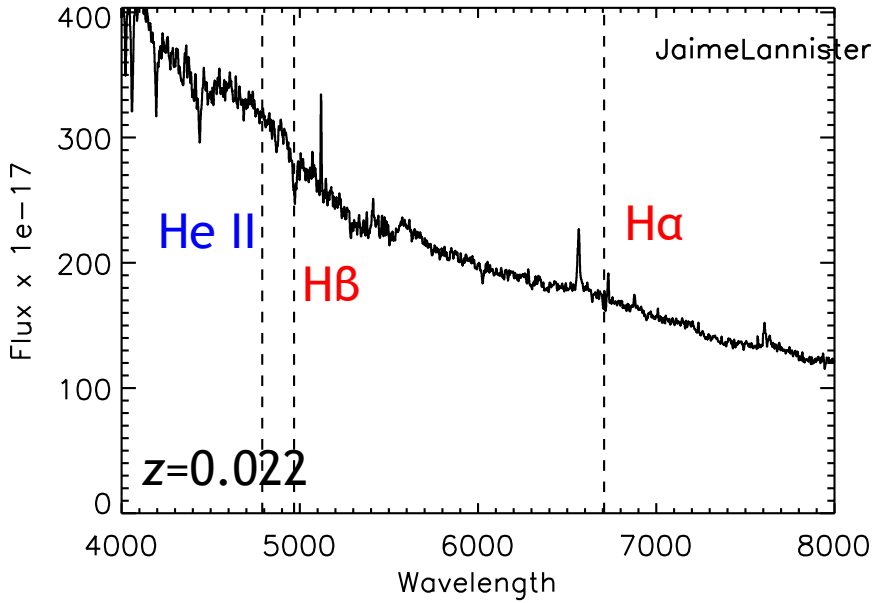


(No?) Broad H and/or He II

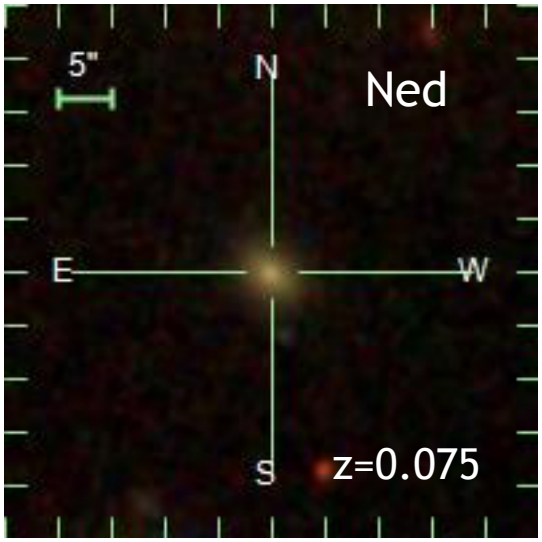


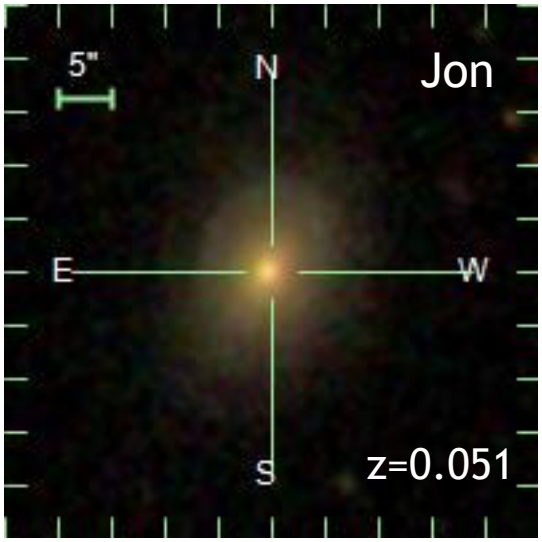


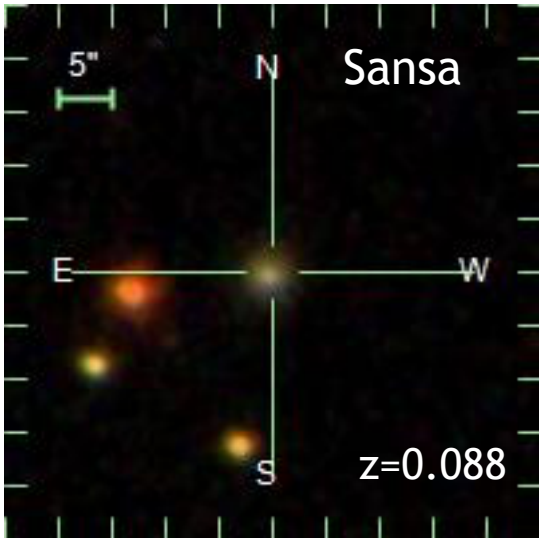


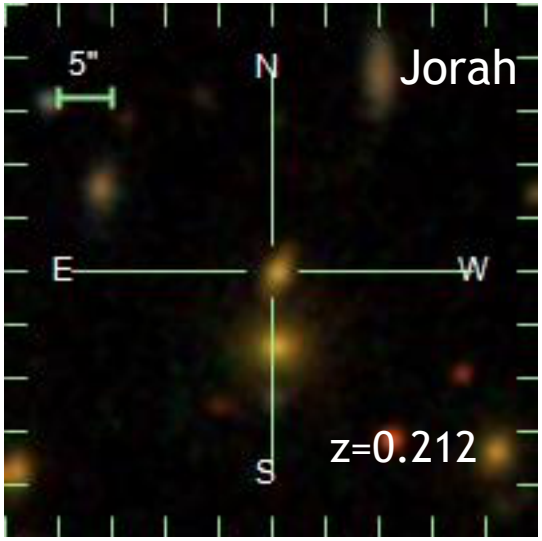


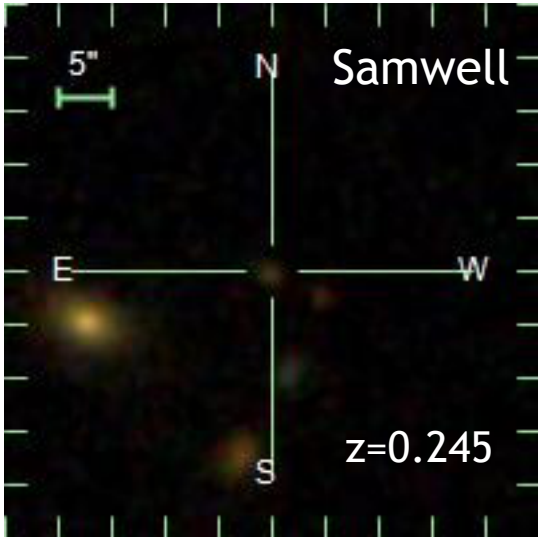
Host galaxies

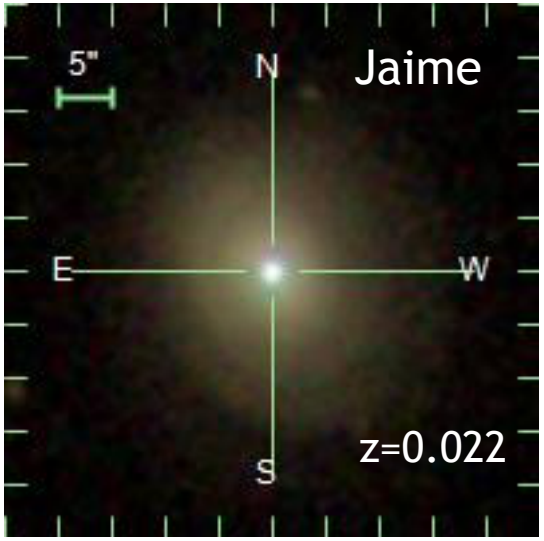




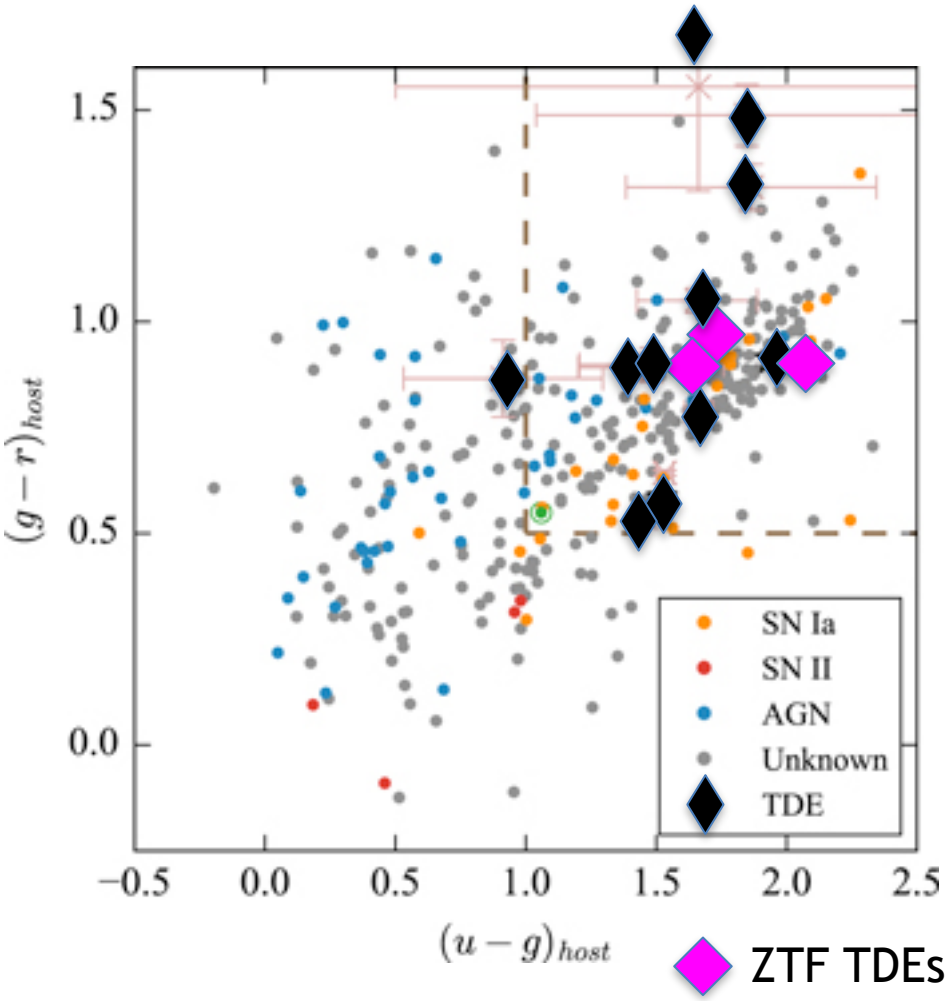








Red Galaxy Hosts



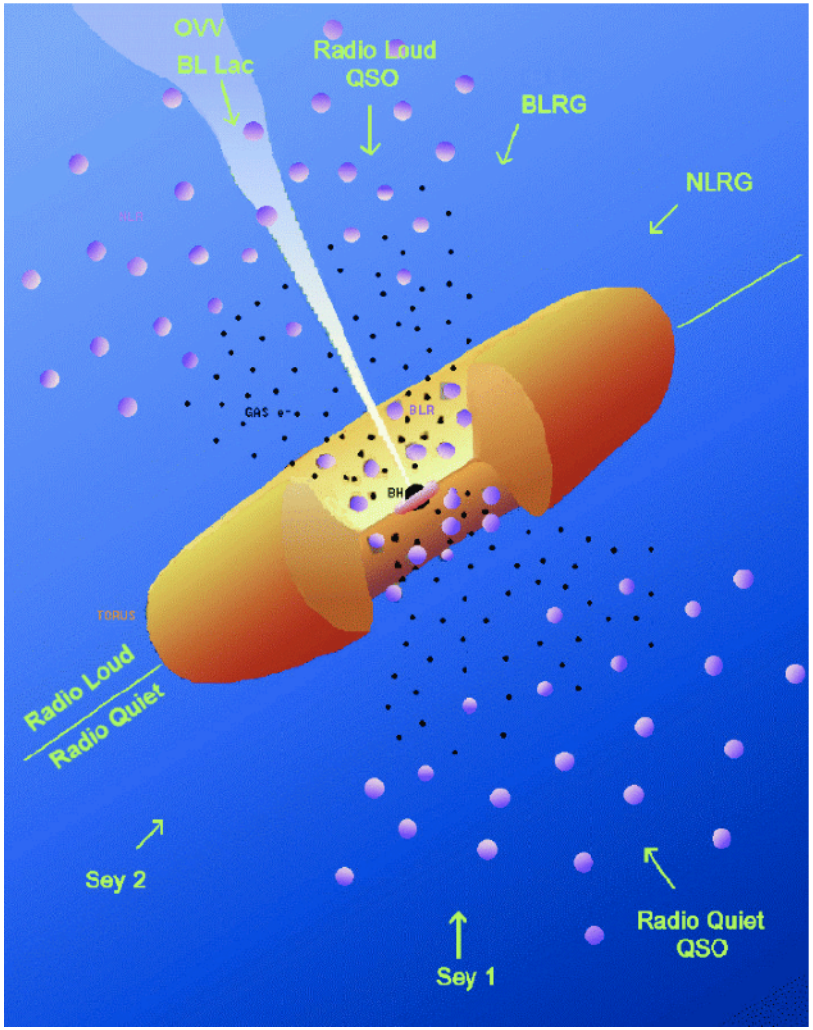
Hung, Gezari+ 2018

Our current workflow

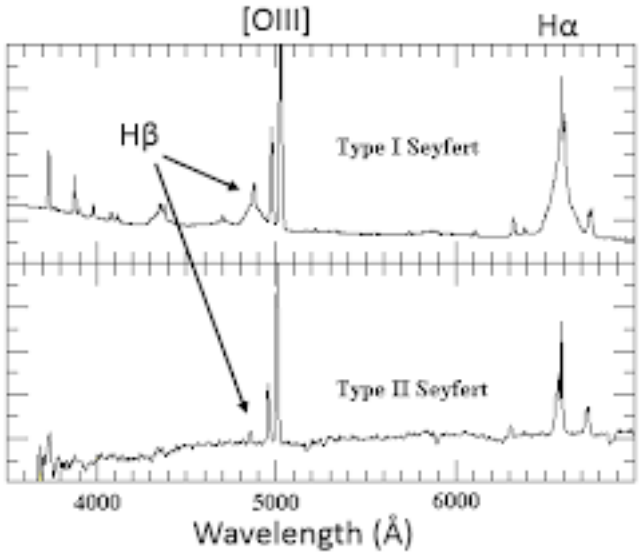
1. Filter stream for nuclear transients using **Ampel**
   - Select on weighted mean offset, flux increase, quality cuts
   - Includes *GaiaVeto*, to improve star-galaxy filtering (sgscore)
2. Autosave Marshal scan candidates (soon: auto-ingest)
3. Pull photometry from Marshal compute light curve metrics (eg, rise time, color, offset, flux increase)
4. Catalog cross matching (remove AGN)
5. Compute ranking based on metrics, produce summary plots
6. Manual allocations of follow-up resources based on ranking (discuss on Slack)

GROWTH
Global Relay of Observatories Watching Transients Happen

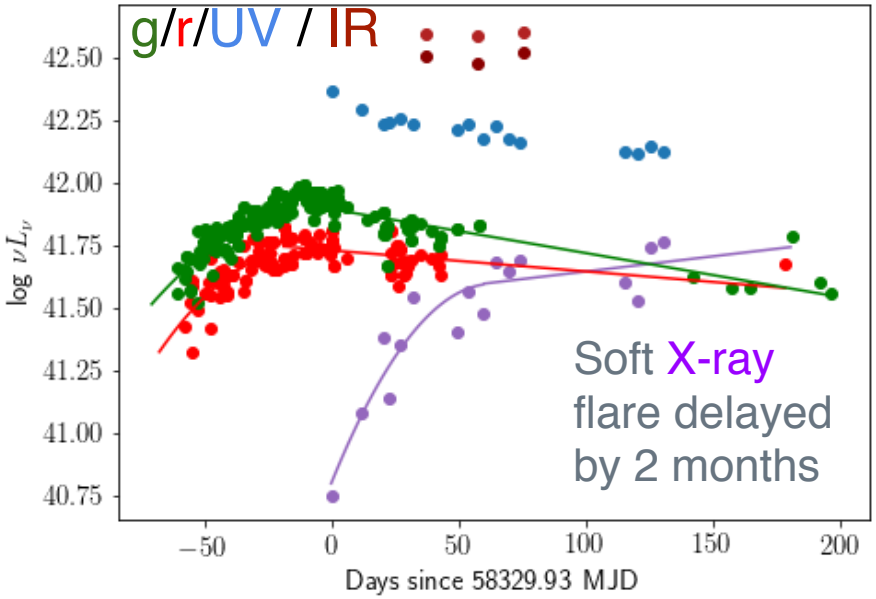
Part 2: Changing Look AGN

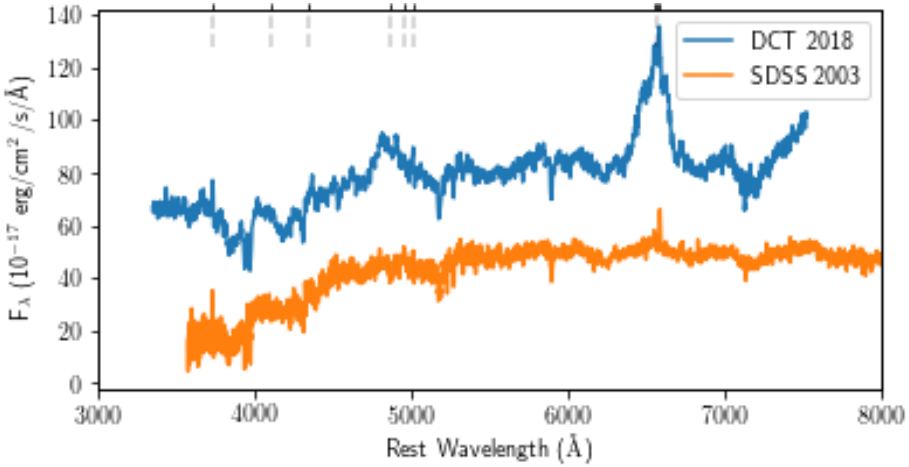


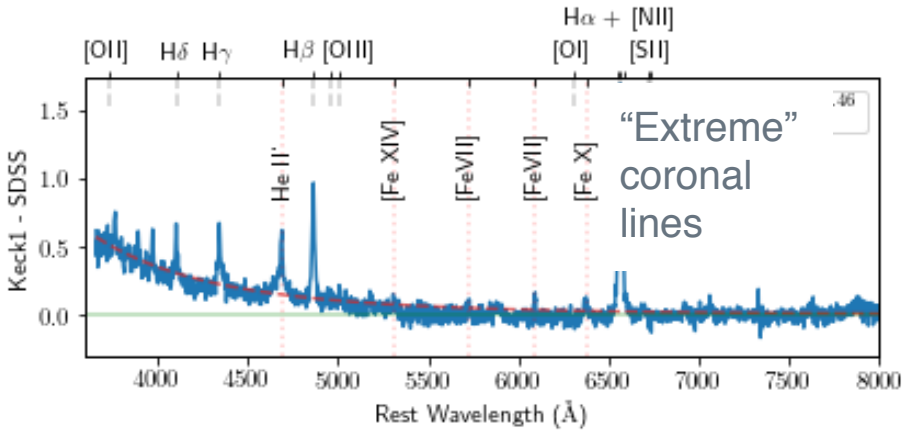
Challenge the classic "AGN" Unification Scheme



“Tyrion Lannister” and a New Class of Changing Look LINERs



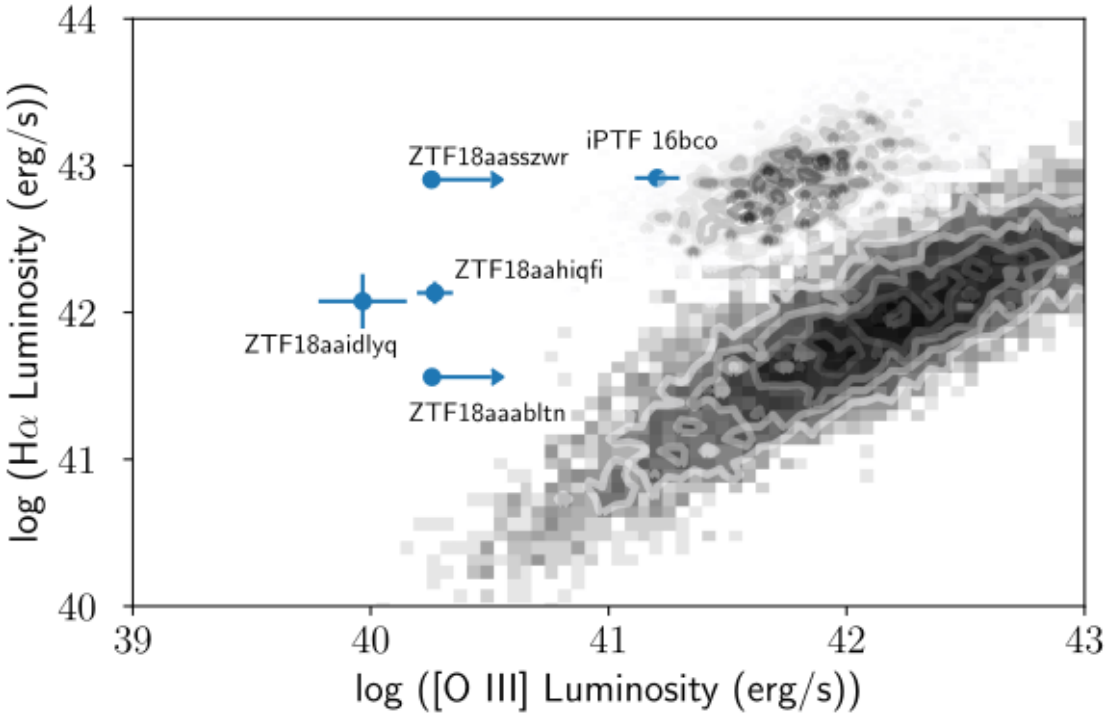




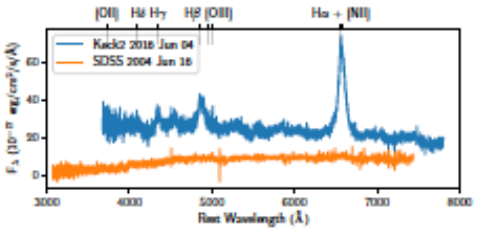
Frederick, Gezari et al. (in prep.)

A New Class of Changing-Look LINERS

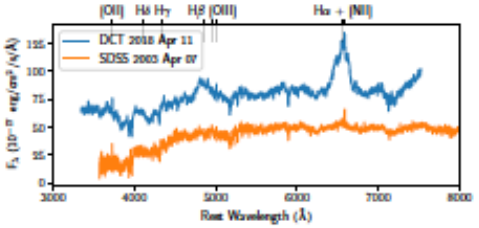
6 new LINERS caught changing look into type 1 AGN by ZTF



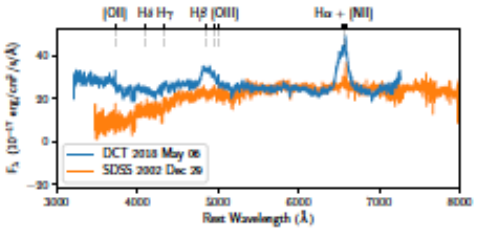
Frederick, Gezari et al. (in prep.)



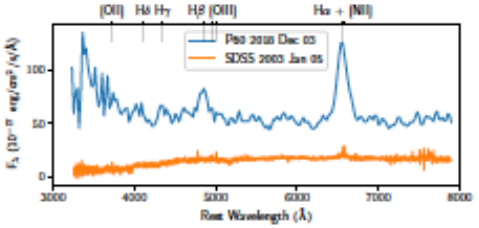
(a) iPTF 16bco



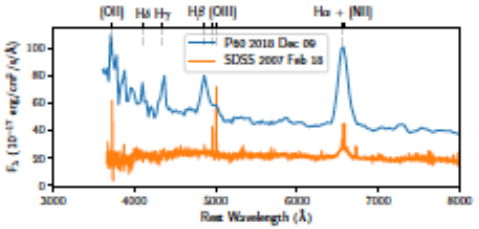
(b) ZTF18aahiqfi



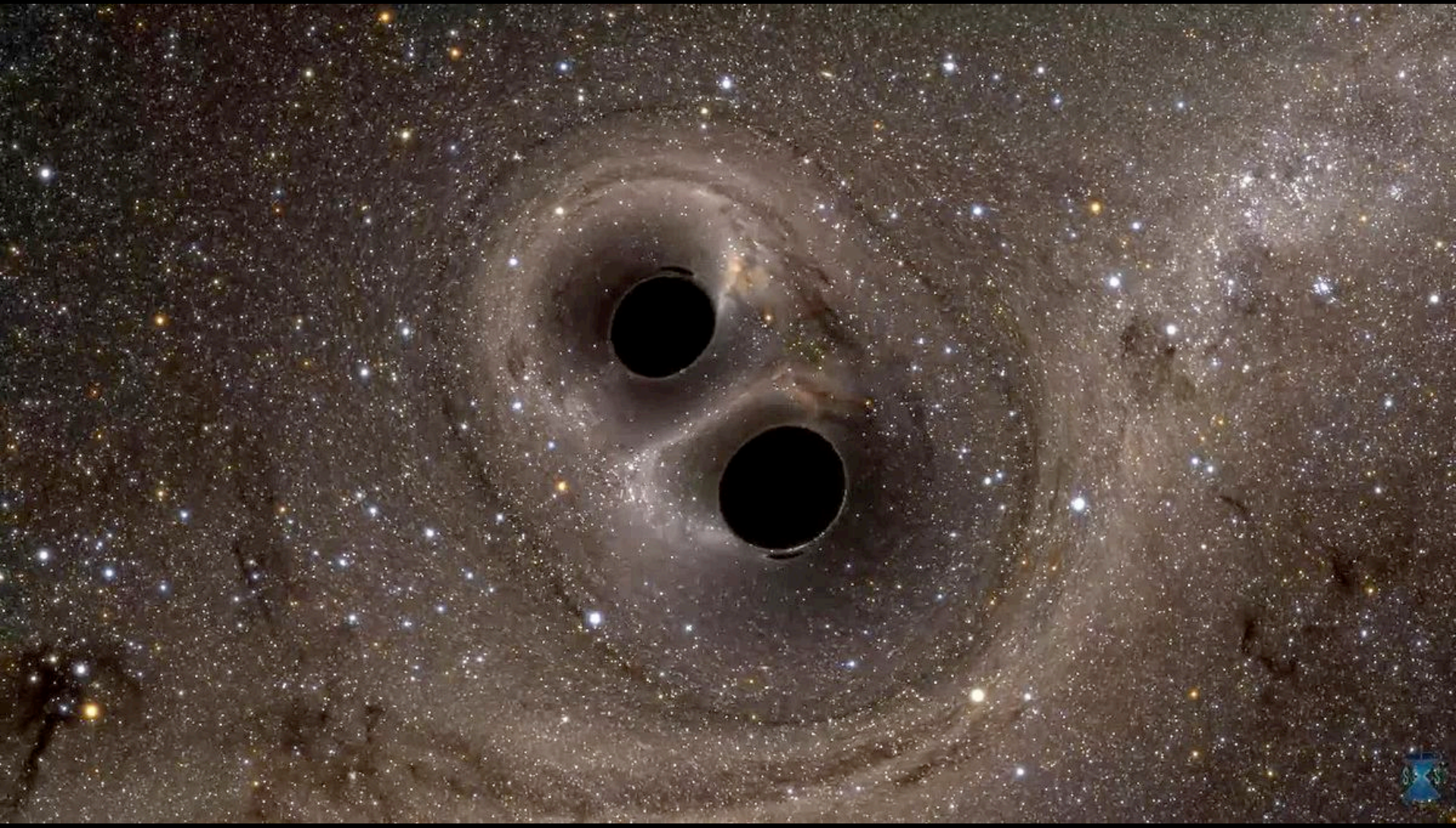
(c) ZTF18aaidlyq



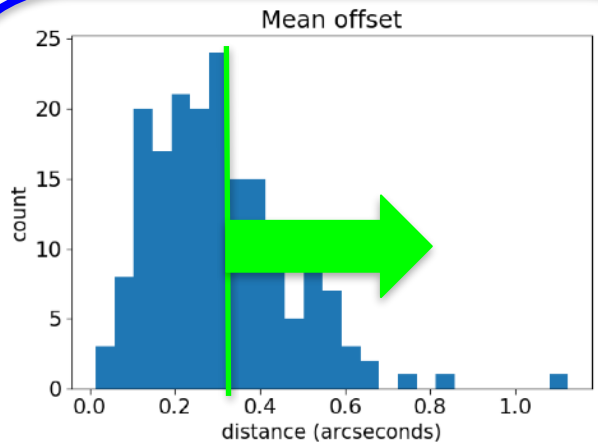
(d) ZTF18aasszwr



Part 3: SMBH Binaries and Recoil

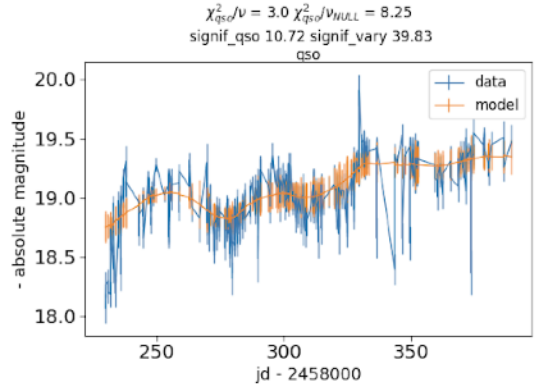


Search for **offset** AGN-like Transients in

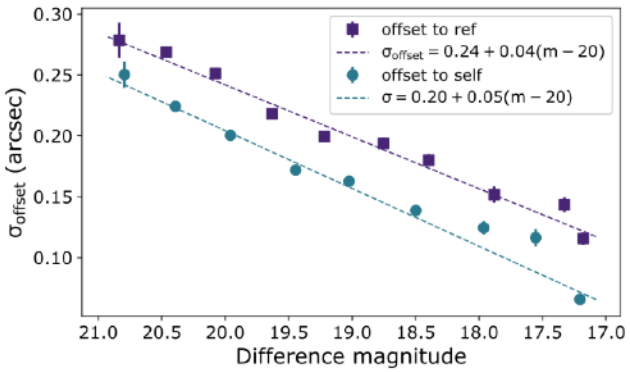


OFFSET FROM GALAXY NUCLEUS

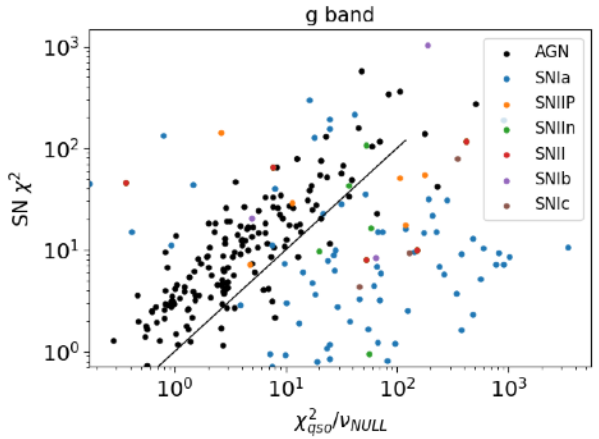
+



known AGN or QSO-LIKE VARIABILITY



van Velzen, Gezari+ 2018

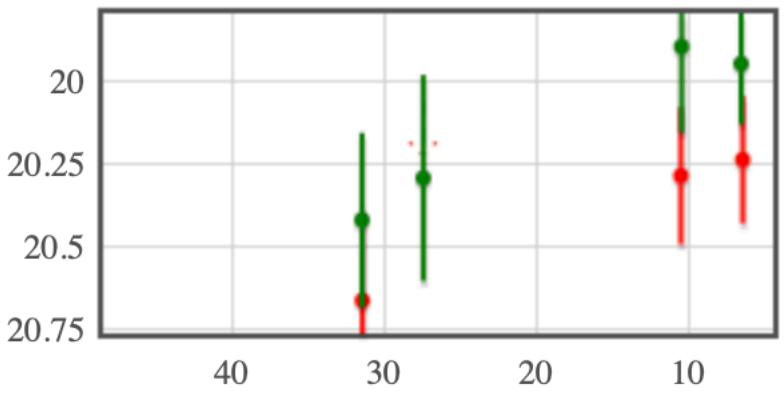


Ward, Gezari+, in prep.

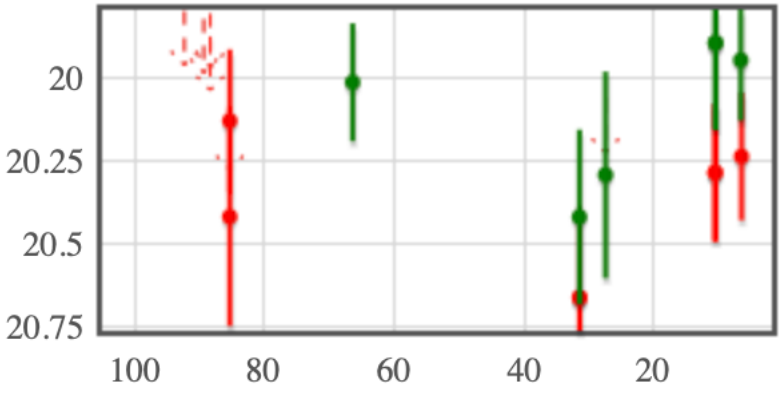
What could be improved?

- Marshal photometry database: duplicates and “Update ZTF data” button

Light curve after saving
(Could be a TDE!)

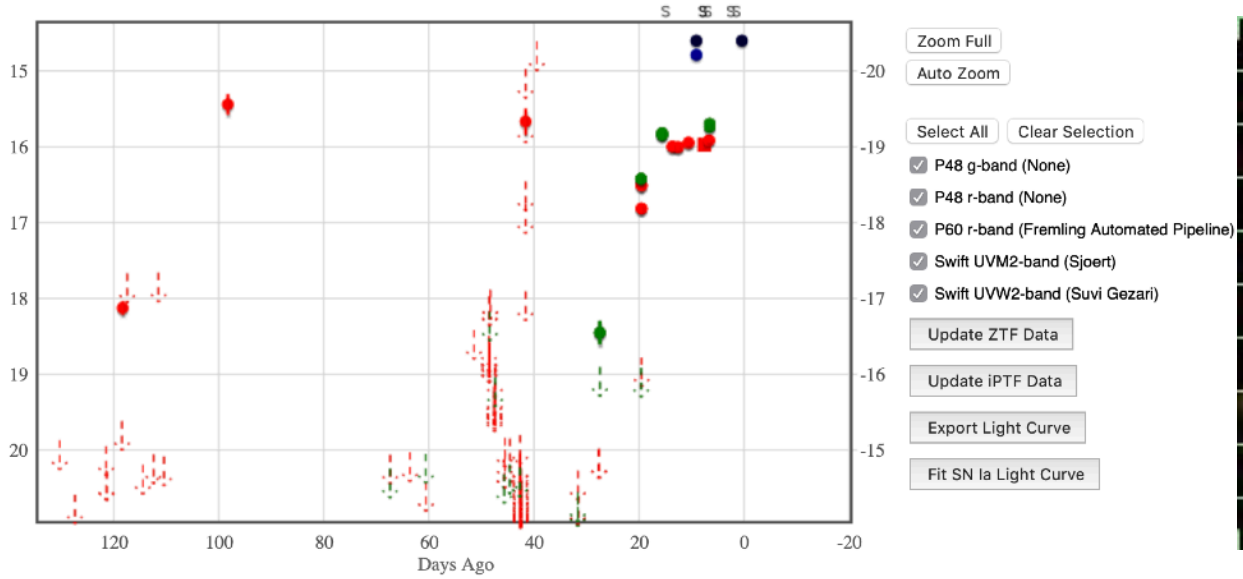


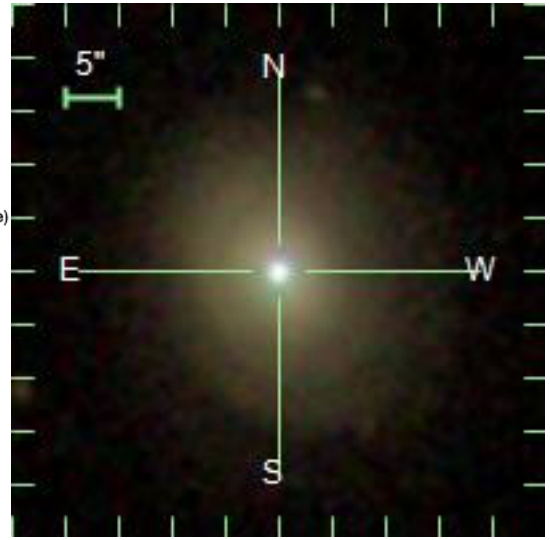
After pressing update
(More likely AGN)



More discussion

- TDEs are slow: we prefer *old* reference images
- ZTF photometry of bright galaxy cores

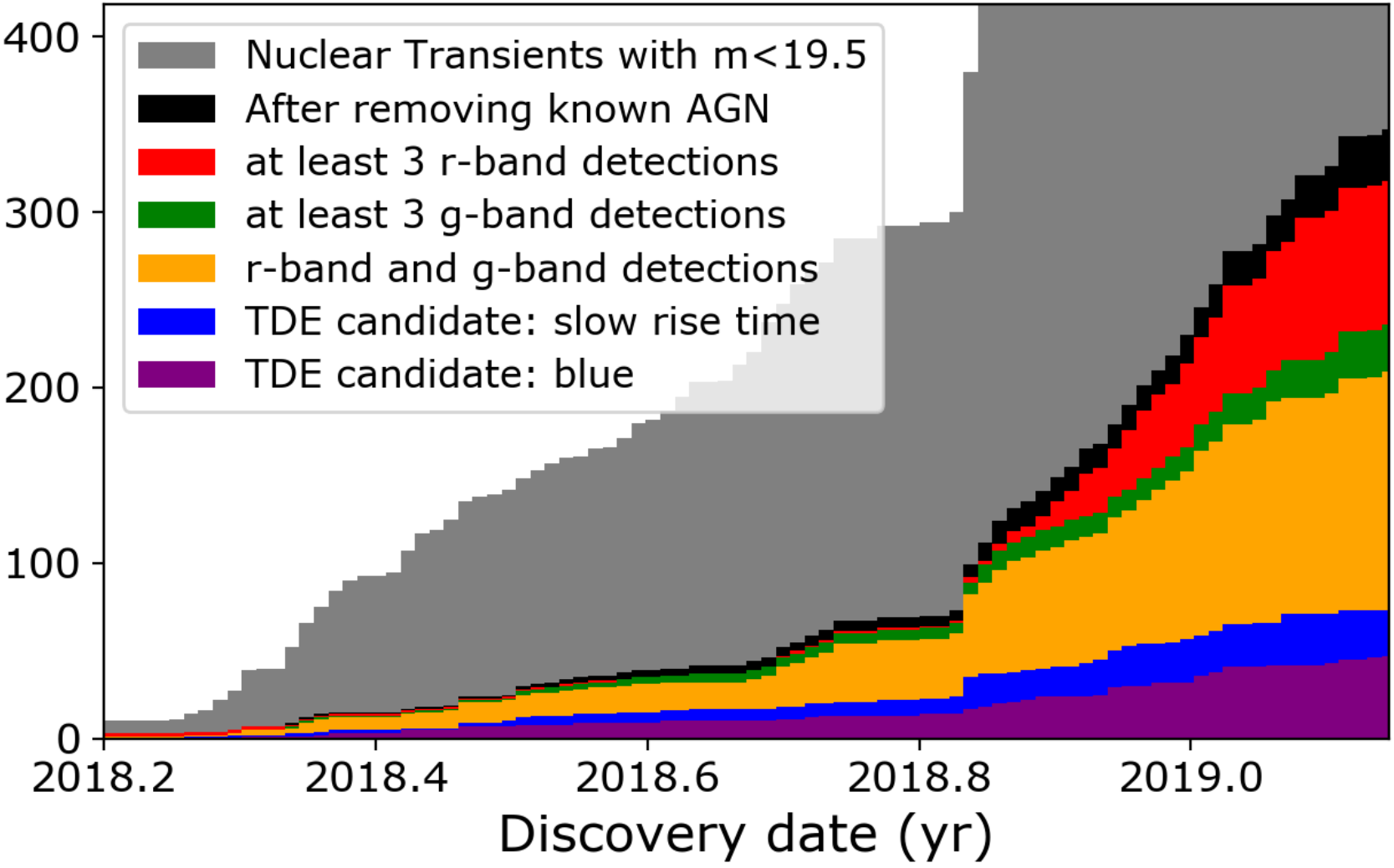




ZTFbh: yield to date

Type	#	Everything	Recent data
AGN	1552	46%	65%
None	1192	36%	21%
Stellar	192	6%	7%
SNe Ia	129	4%	2%
SN (all types)	170	5%	3%
Bogus	47	1.4%	0.3%
CLAGN	**6**	**0.2%**	**0.3%**
TDE	**8**	**0.2%**	**0.3%**

2019 will be very fruitful!



LET’S GET LUNCH