arXiv:2009.01242

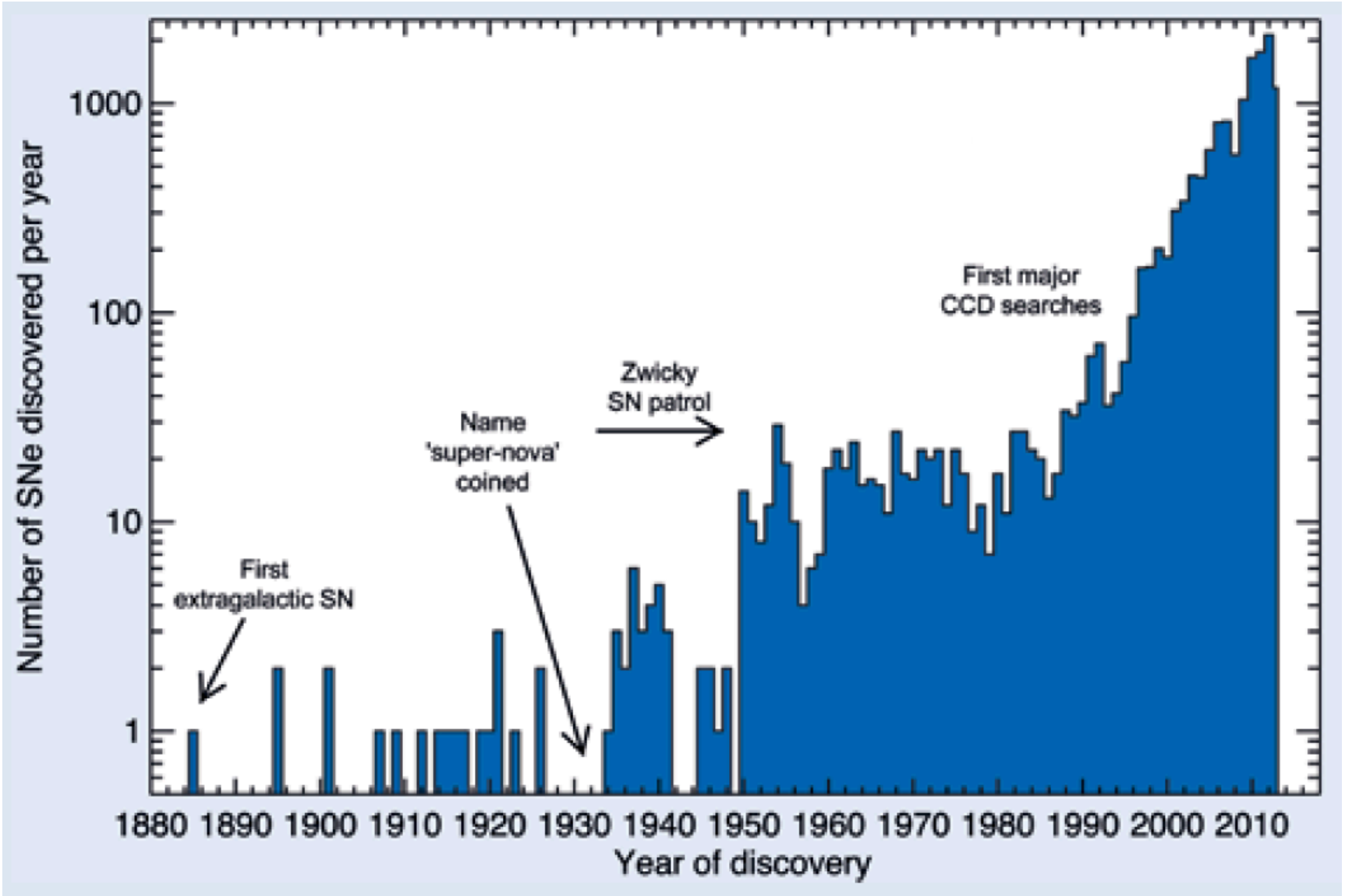
The BTS Statistical Sample

(Or, how to do everything, without doing everything)

Daniel Perley
(Liverpool John Moores University)

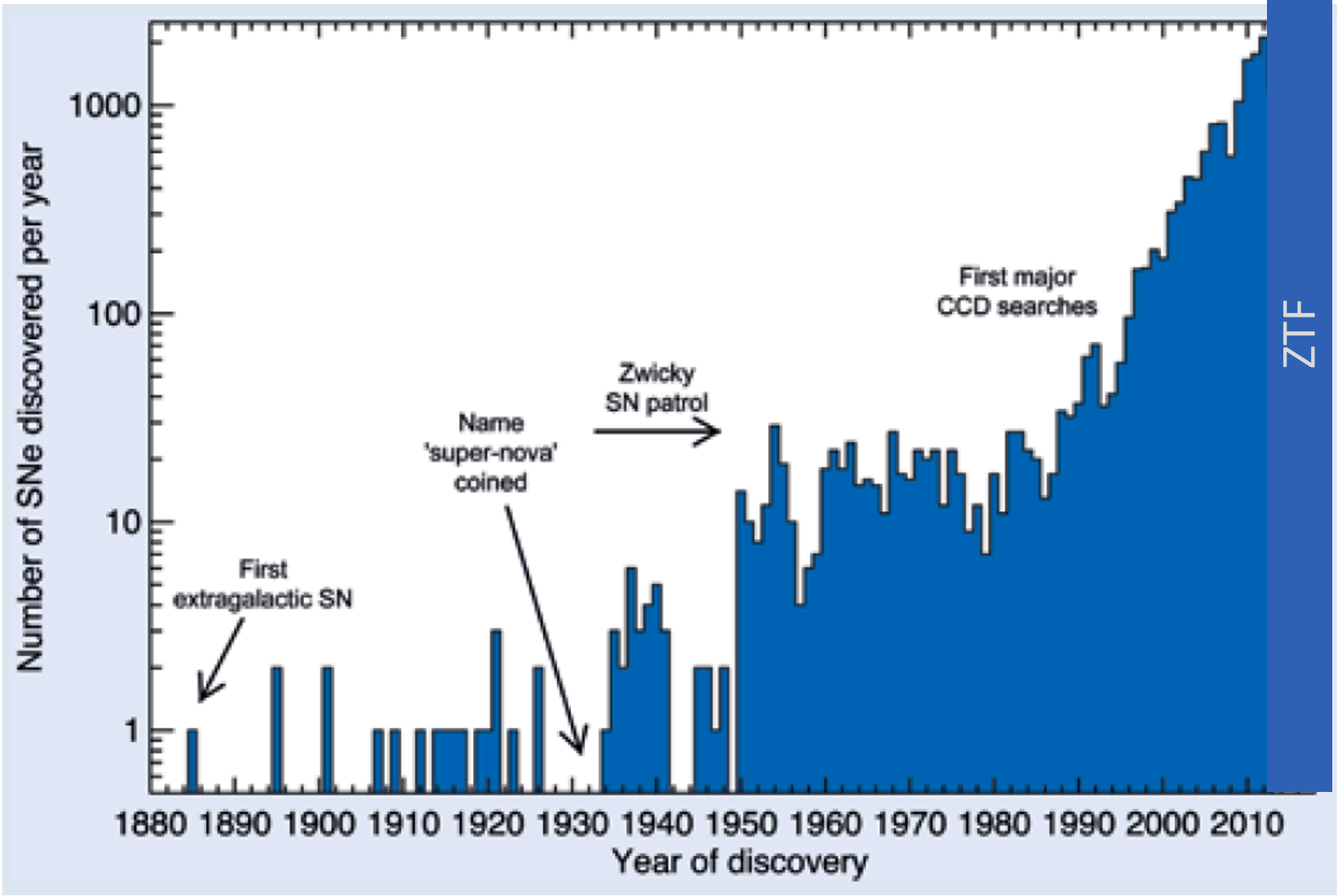
+ Christoffer Fremling,
Jesper Sollerman,
Adam Miller,
Aishwarya Dahiwale,
Yashvi Sharma,
Shri Kulkarni
… and many other of the usual suspects…

Supernova Discoveries By Year



Sullivan 2013

Supernova Discoveries By Ye r



Sullivan 2013

Oh No, Too Many Supernovae

Options for doing science when $n_{classifications} << n_{SNe}$:

- Focus on "interesting" ones
  - Hugely successful when exploring new parameter space or looking for something very specific
  - Not so great for statistics, rates, hosts (the selection function is convolved with your brain)
- Do everything within some limited **unbiased** regime
  - CLU (nearby galaxies), BTS (magnitude limited)

The BTS: a mag-limited transient survey

- **Catalog** "all" ZTF extragalactic transients to **m<19.0**
- **Classify** "all" ZTF extragalactic transients to **m<18.5**

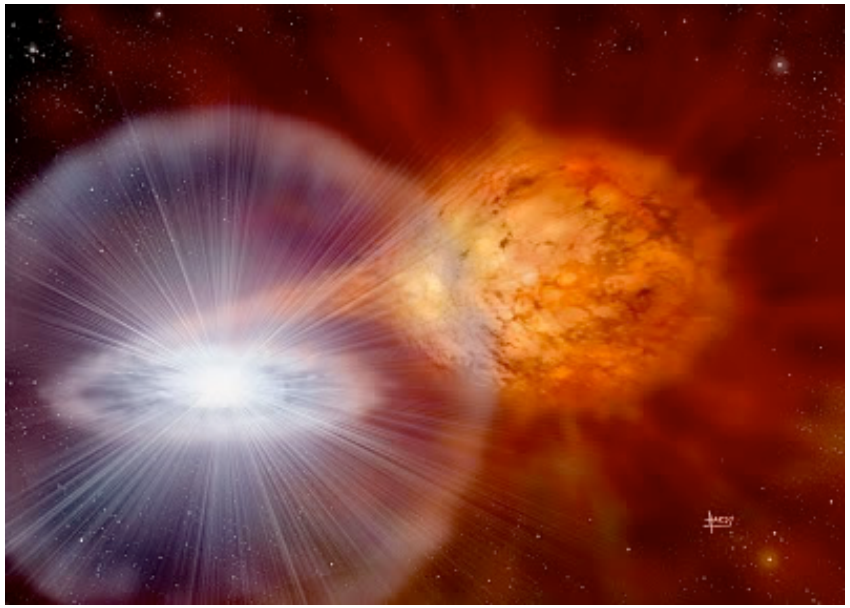
(Sounds simple. But is it really?)

Mag limit	SNe/year
17	155
17.5	300
18	**585**
18.5	**1130**
SEDM limit → **19**	**2220**
19.5	4370
20	8500
20.5	16500

Other Things That Go Bump in the Night

Galactic vermin

(Cataclysmic variables)



5+ per night, many
flaring for the first time

Extragalactic vermin

(AGNs)

1000s all-sky

CVs: Not a good use of SEDM

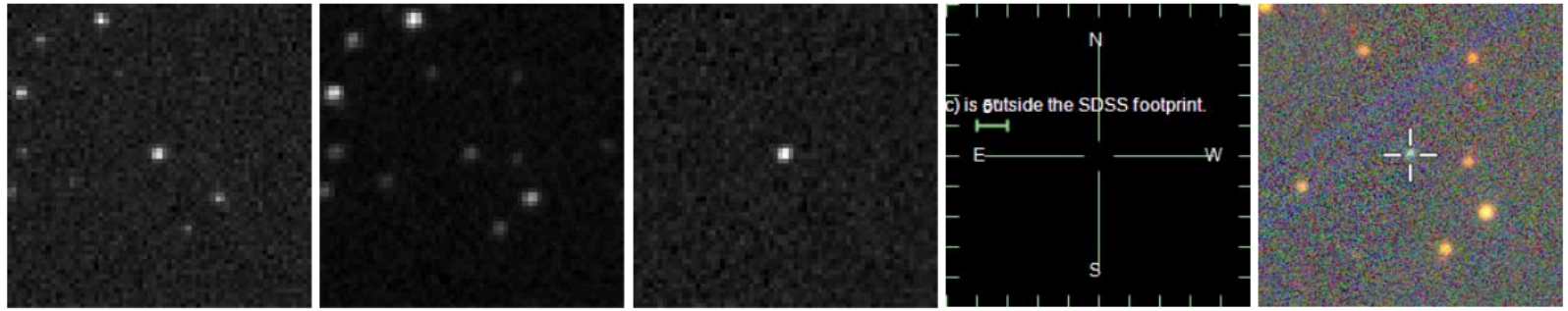
ZTF18abdbgza

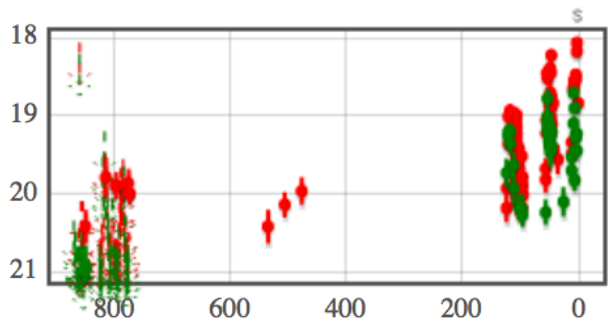
22:21:05.11 +65:40:33.3
335.271280 +65.675919

View another

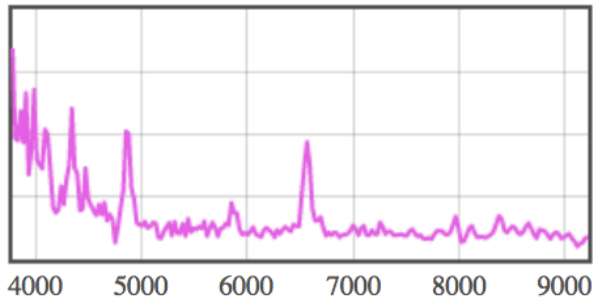
OVERVIEW | PHOTOMETRY | SPECTROSCOPY | OBSERVABILITY | EXAMINE | FINDING CHART

NEW REF SUB SDSS PS1





r = 18.8 (0.9 d) | Upload New Photometry



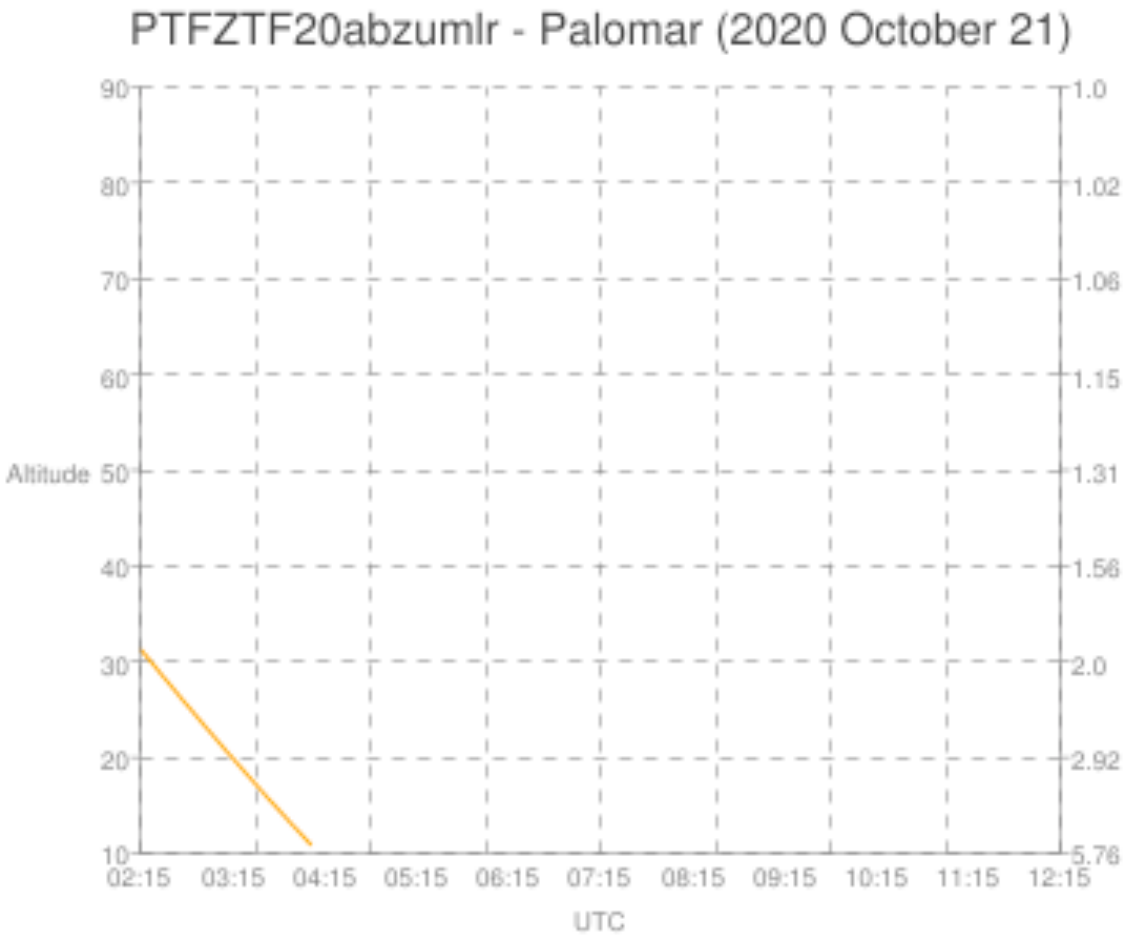
Upload New Spectroscopy

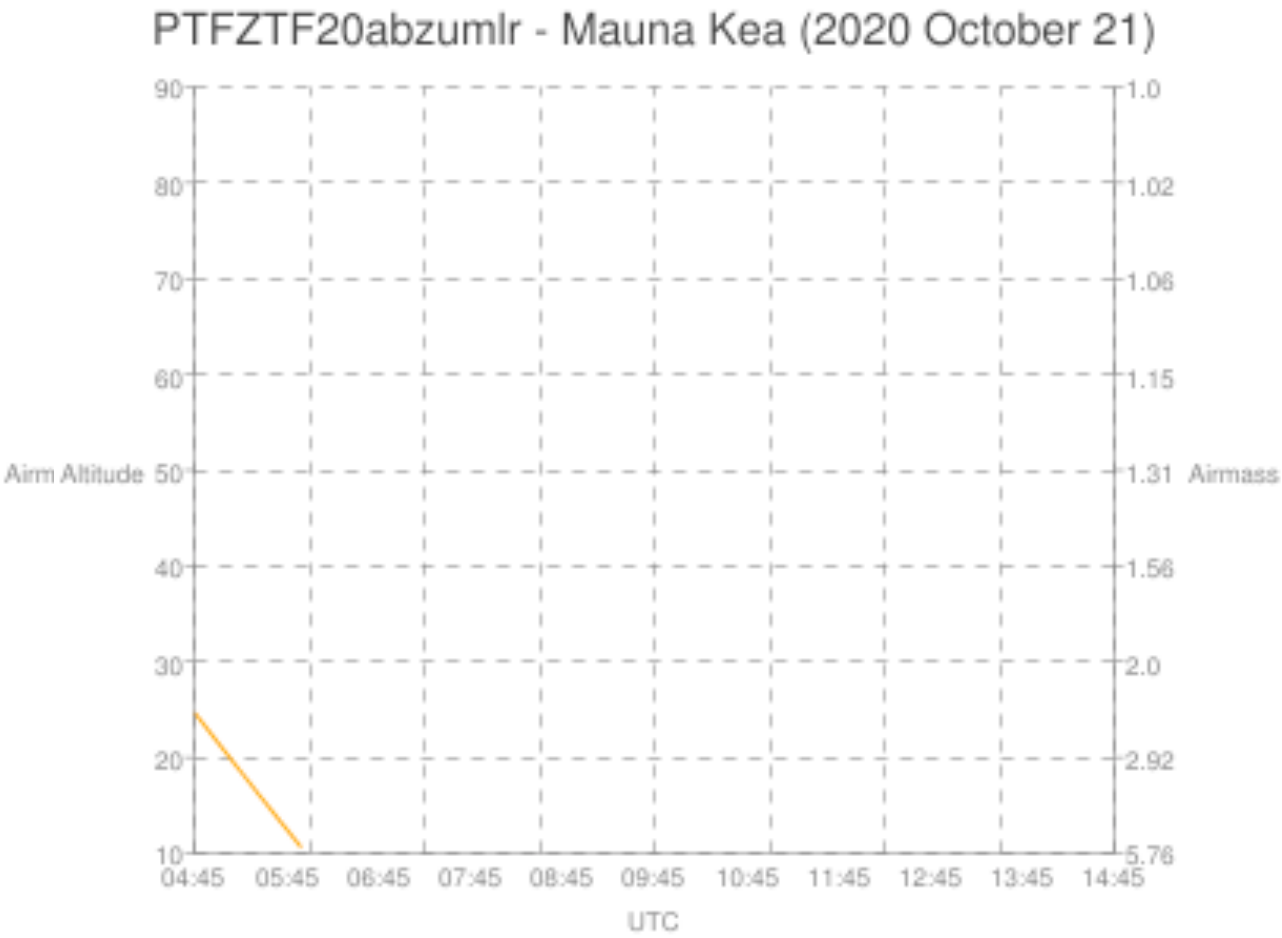
AUTO ANNOTATIONS
2020 Oct 19 rsw [AUTO_SNID_rlap]: 7.74
2020 Oct 19 rsw [AUTO_SNID_redshift]: -0.0004
2020 Oct 19 rsw [AUTO_SNID_match]: LBV
2020 Oct 18 James11222 [passed_filter]: Redshift Completeness Factor
2020 Aug 20 jjencson [Galactic l & b]: 108.263, 7.18189
2019 Jan 25 jjencson [Reference]: 2018-04-09 11:51:59 to 2018-06-13 11:20:41
2018 Aug 22 sfrederick [passed_filter]: Nuclear Transients
2018 Jun 26 jjencson [passed_filter]: Orphan Afterglows Caltech
Auto Annotation Submission Form

COMMENTS
2020 Oct 19 jesper [info]: do not trigger things like this for SEDM RCF
2020 Oct 19 jesper [redshift]: 0.0
2020 Oct 19 rsw [comment]: pysedm_report [view attachment]

Add a Comment:

Also: Earth is round and the Sun exists (and clouds happen)



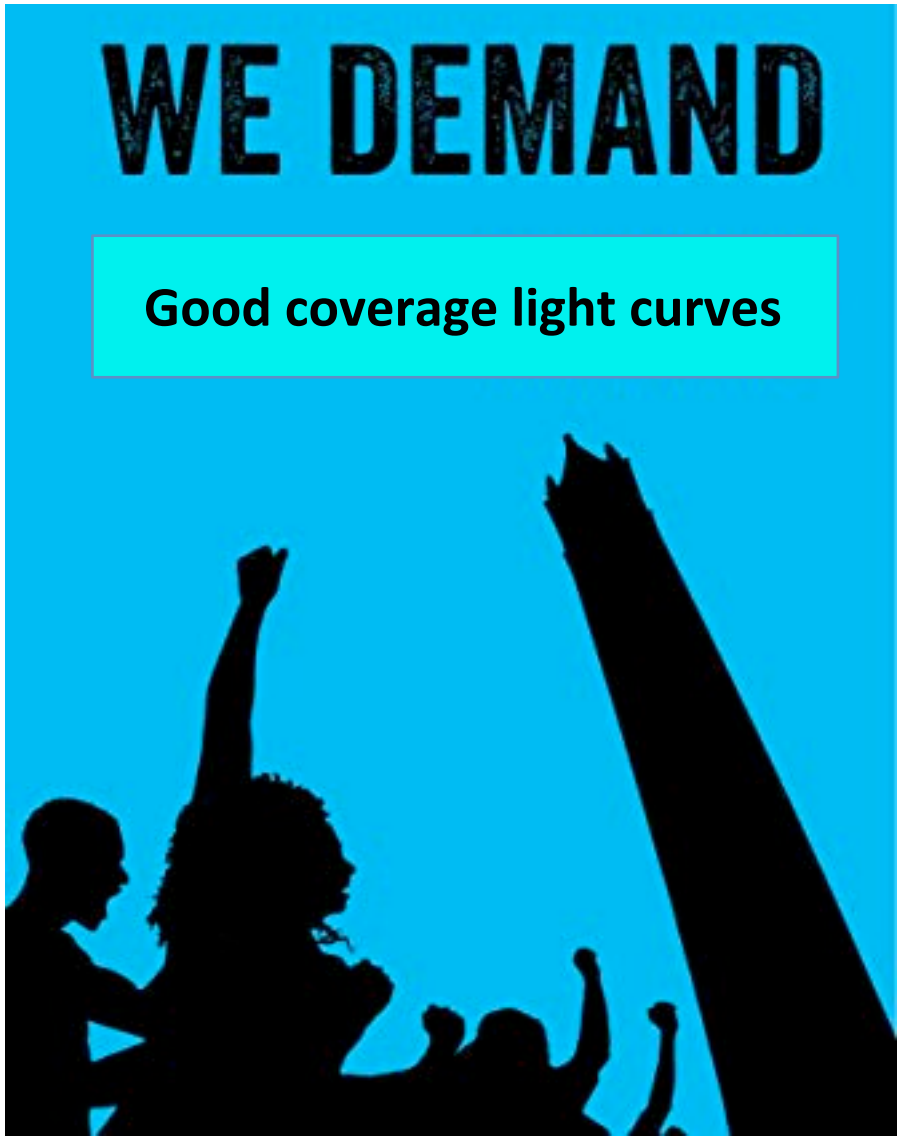


The Challenge

- How do we remove
  the "vermin" without
  removing any useful SNe?

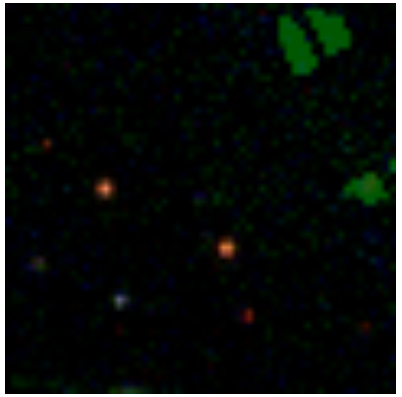
Quality Cut

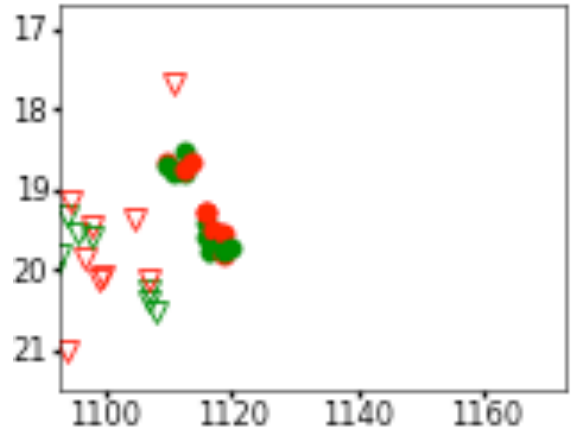
- Require pre-peak and post-peak coverage of the light curve (1 week before, 1 week after)
  - If we don't have this, we can't constrain the timescale and can't say if it's a CV
- Also require that the field is not setting (and some other things, i.e. not <1 month after reference building)

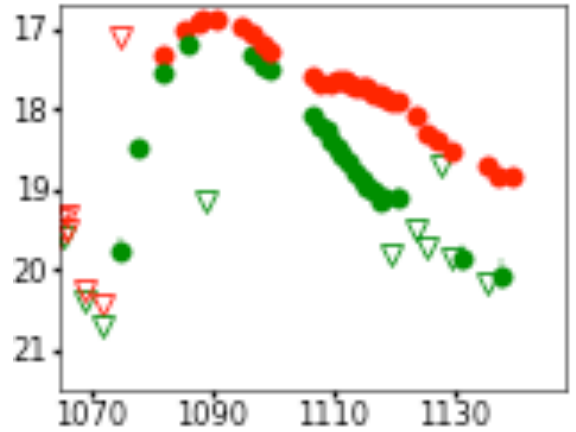


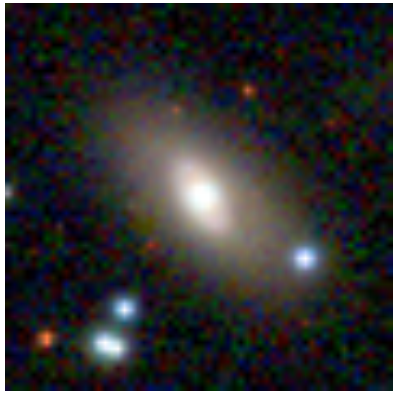
Purity Cut

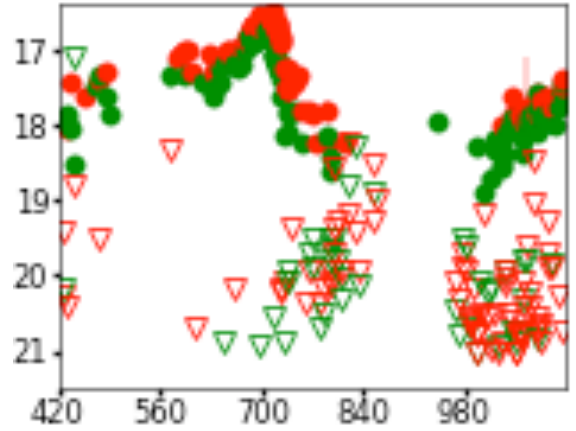
- This allows us to measure characteristic **rise** and **fade** timescales (CVs: fast, SNe: *usually* slow, AGNs: usually really slow)
- We only exclude sources for this reason if they are **not in galaxies,** or are **exactly** coincident with the nucleus.



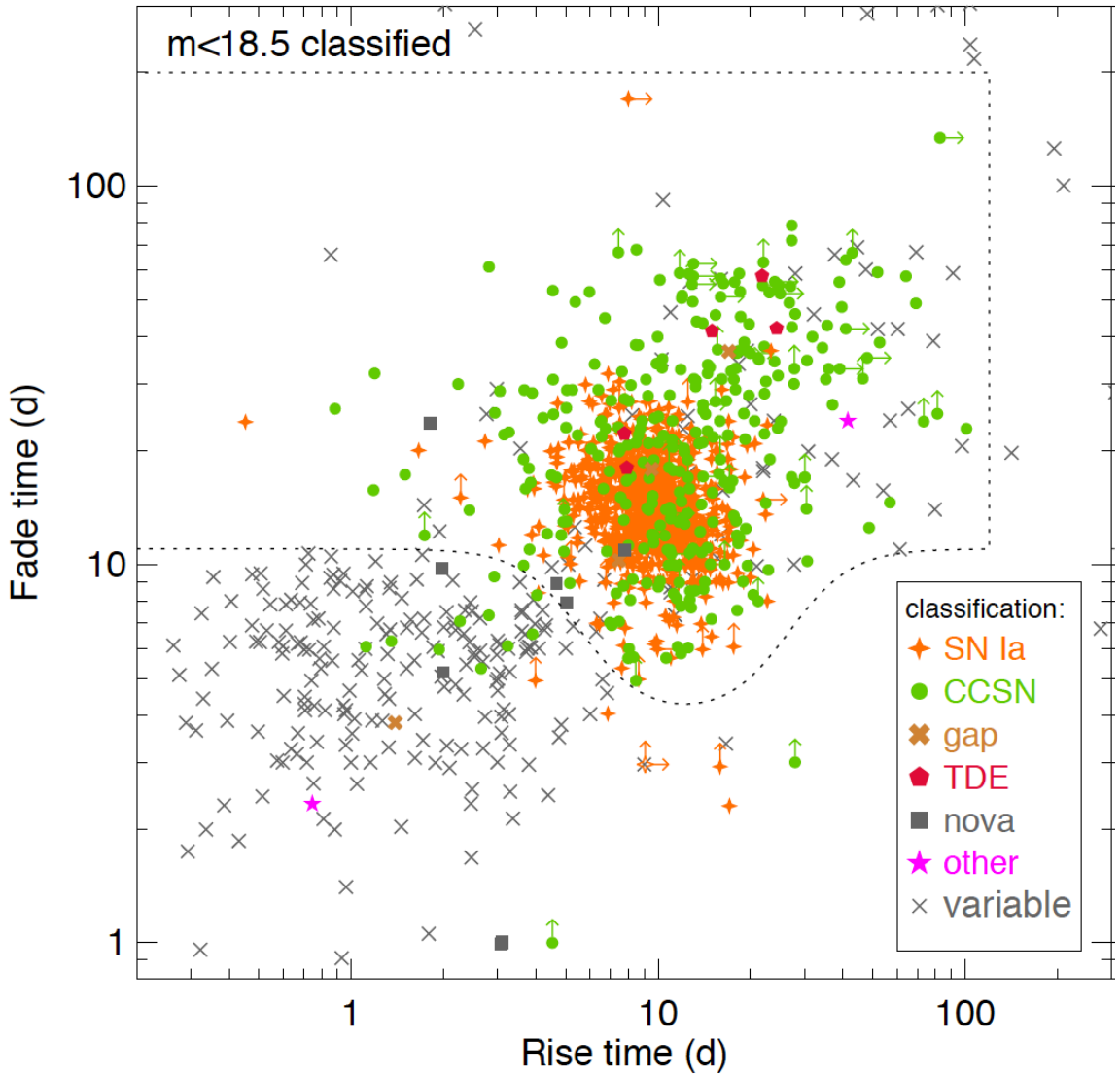


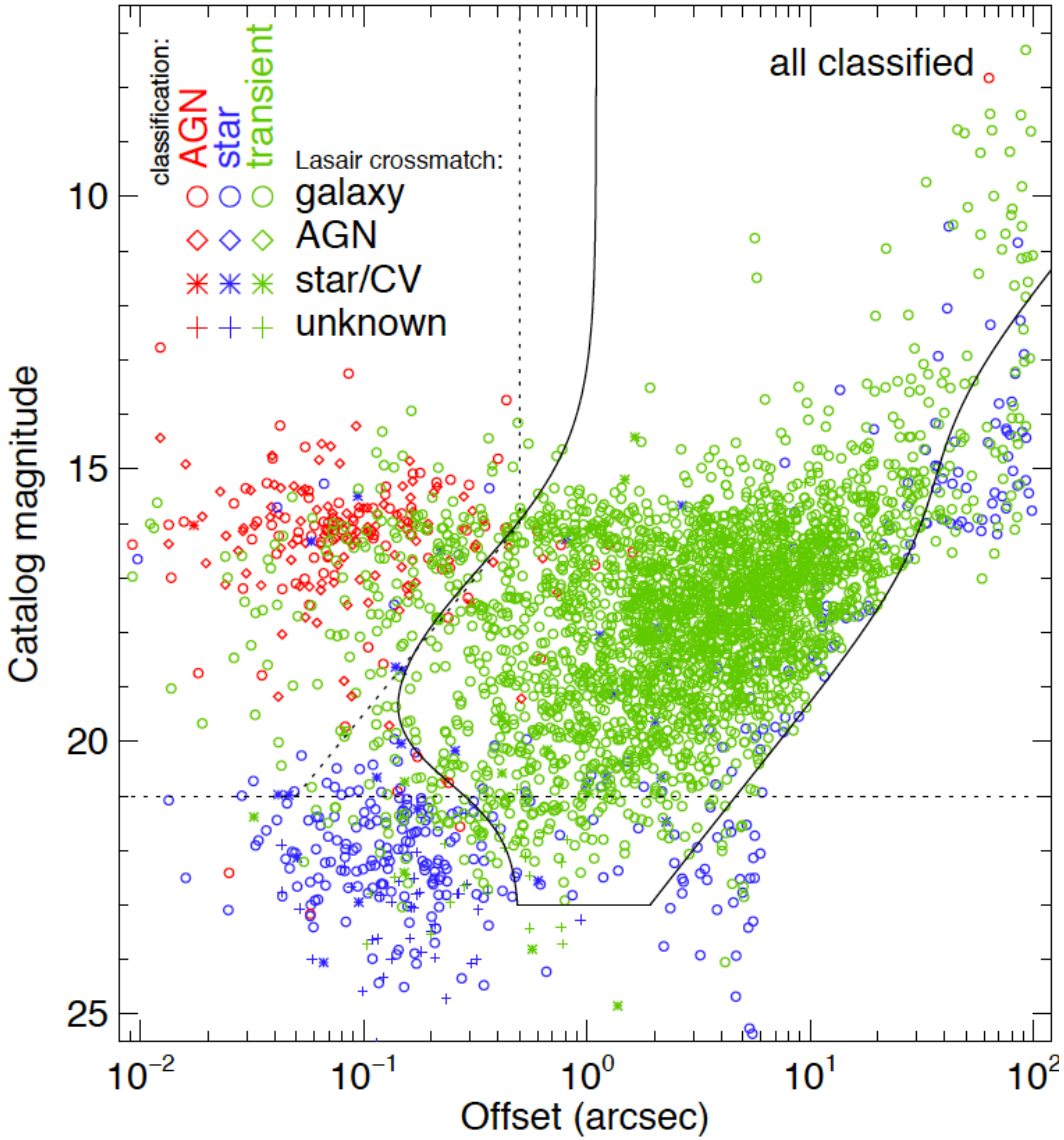






Purity Cut


m<18.5 classified
Fade time (d)
Rise time (d)
100
10
1
1
10
100
classification:
SN Ia
CCSN
gap
TDE
nova
other
variable


all classified
classification:
AGN
star
transient
Lasair crossmatch:
galaxy
AGN
star/CV
unknown
Catalog magnitude
Offset (arcsec)
10
15
20
25
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}

The BTS Statistical Sample

- ZTF difference-image alert stream

  ↓ **BTS alert filter**

- New, PSF-like, non-stellar transients with m<19

  ↓ **BTS quality cut**

- Transients with good coverage that aren't setting

  ↓ **BTS purity cut**

- Transients that act like SNe or are in galaxies

  ↓ $m_{peak} < 18.5$ mag

- **BTS high-value statistical sample**

Classified SN Count (as of Friday)

m < 19 (incomplete)

3609 supernovae

- 2581 Ia
  - incl. 8 Iax, 5 Ia-CSM
- 207 Ib/c
  - incl. 12 Ibn, 31 Ic-BL, 32 SLSN-I
- 747 II
  - incl. 46 IIb, 95 IIn, 22 SLSN-II

+ 16 TDEs, + 13 novae

+ 13 "other" (ILRTs, FBOTs, LBVs)

m < 18.5 passing cuts

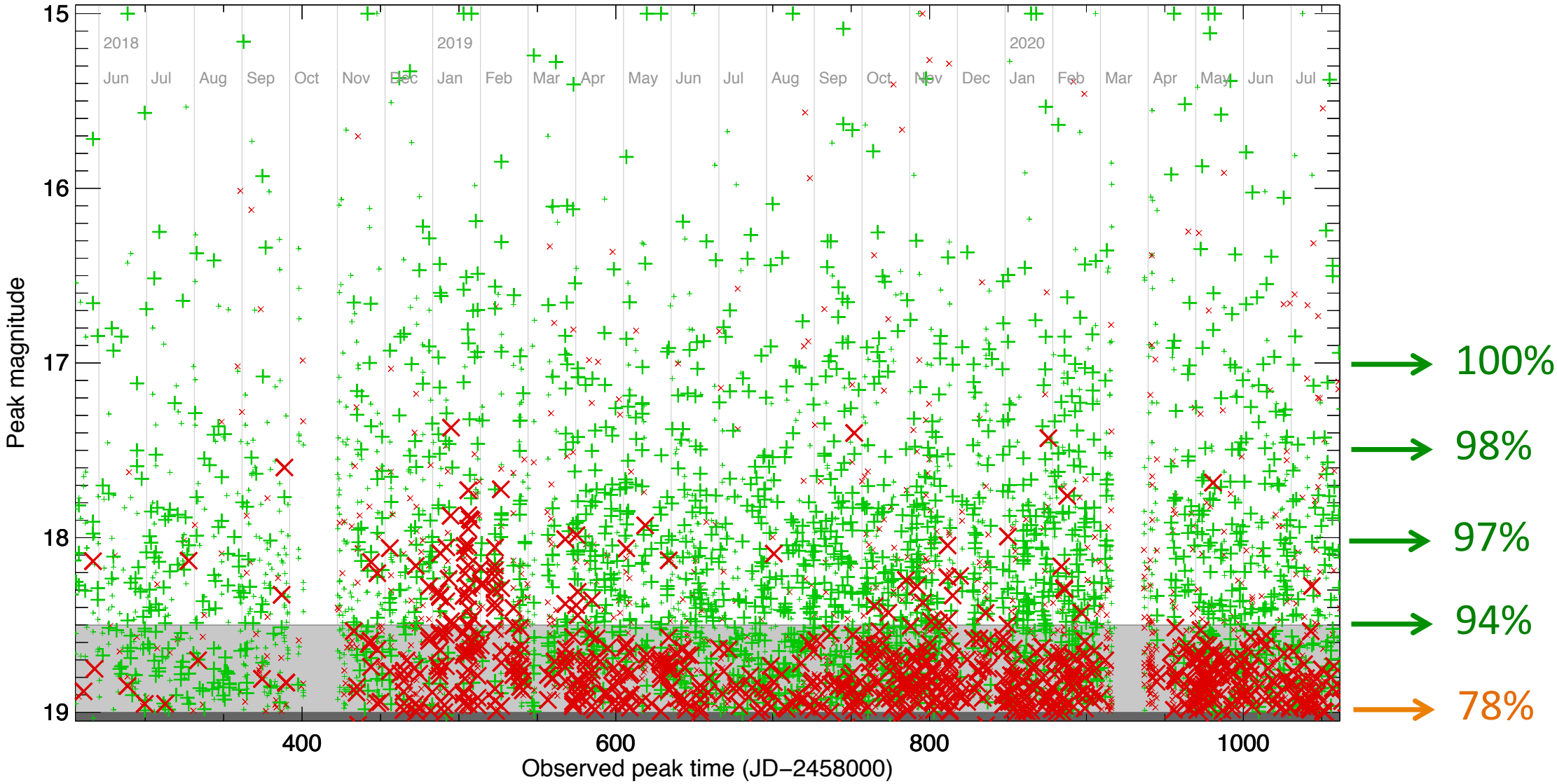
1336 supernovae

- 995 Ia
  - incl. 6 Iax
- 84 Ib/c
  - incl. 10 Ibn, 22 Ic-BL, 16 SLSN-I
- 246 II
  - incl. 28 IIb, 53 IIn, 15 SLSN-II

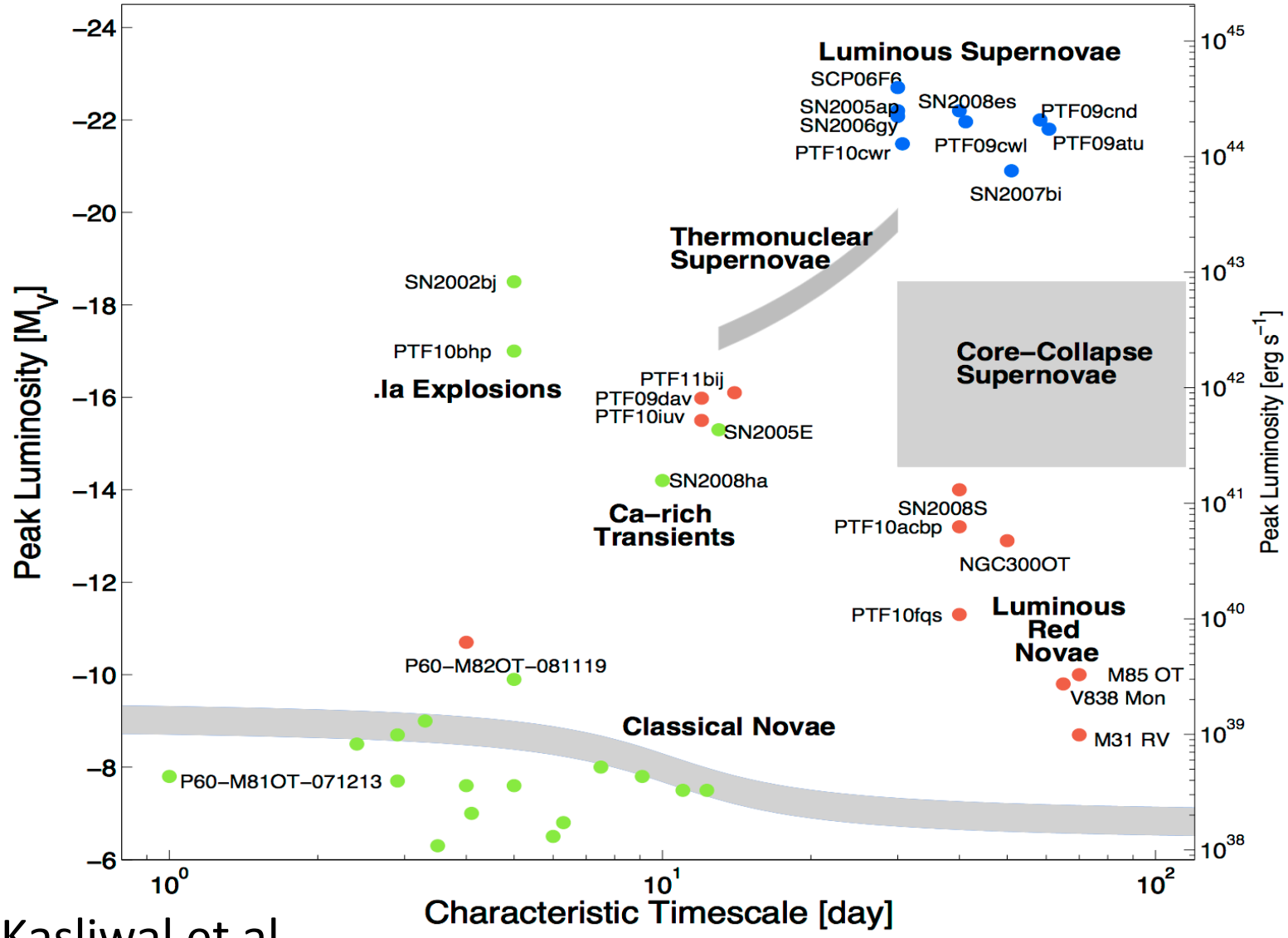
+ 6 TDEs, + 9 novae

+ 6 "other"

SN Classification Completeness

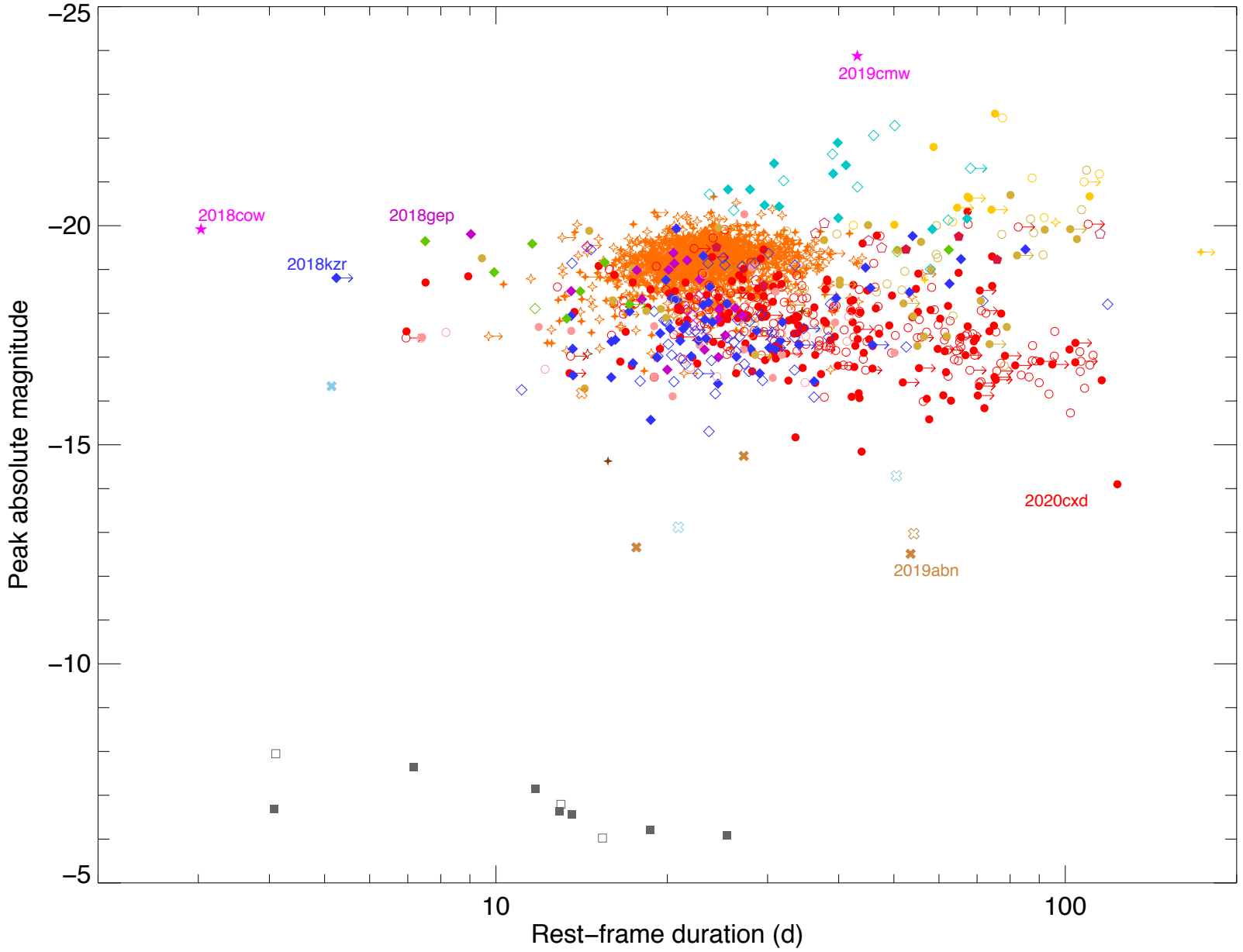


Transient Parameter Space

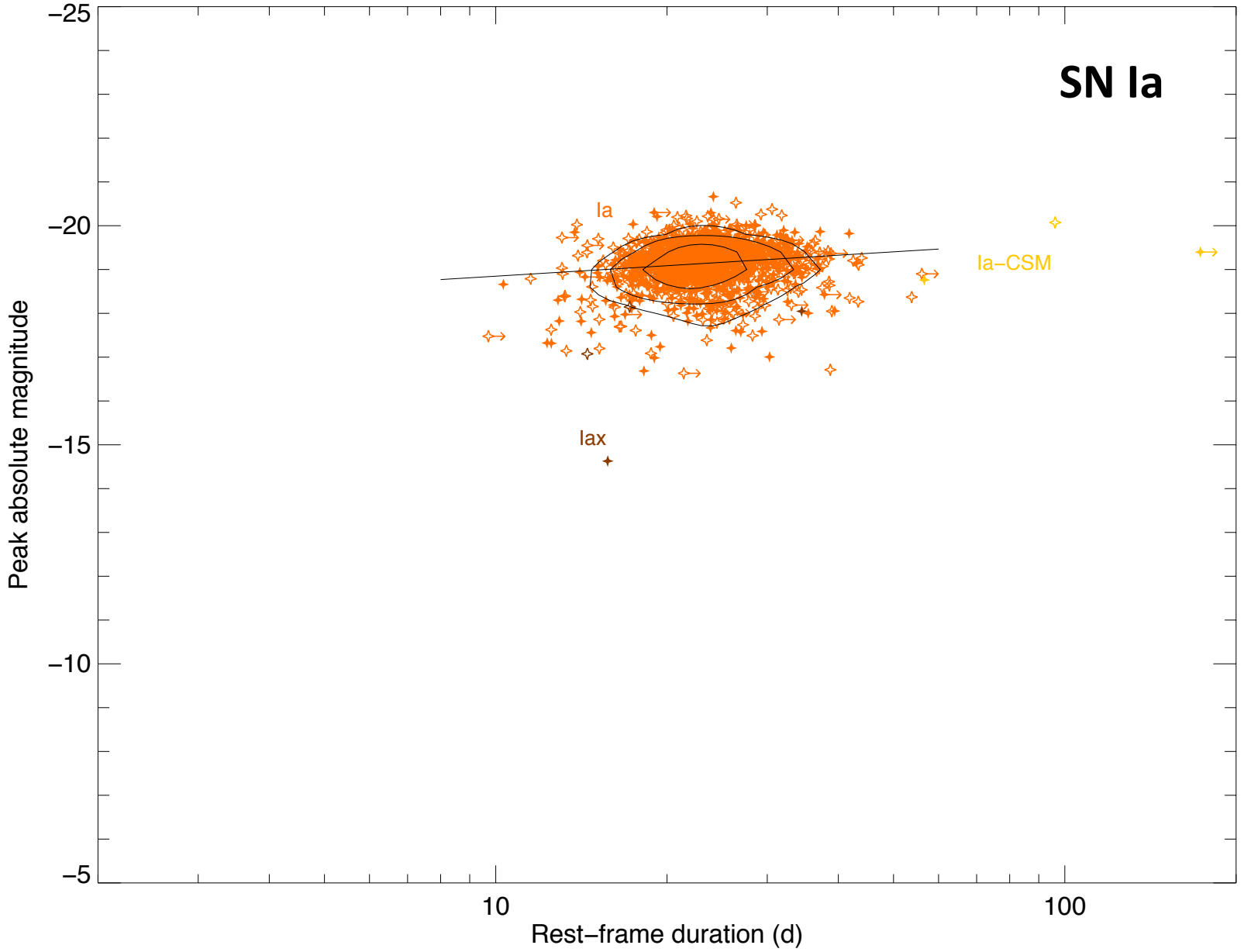


Kasliwal et al.

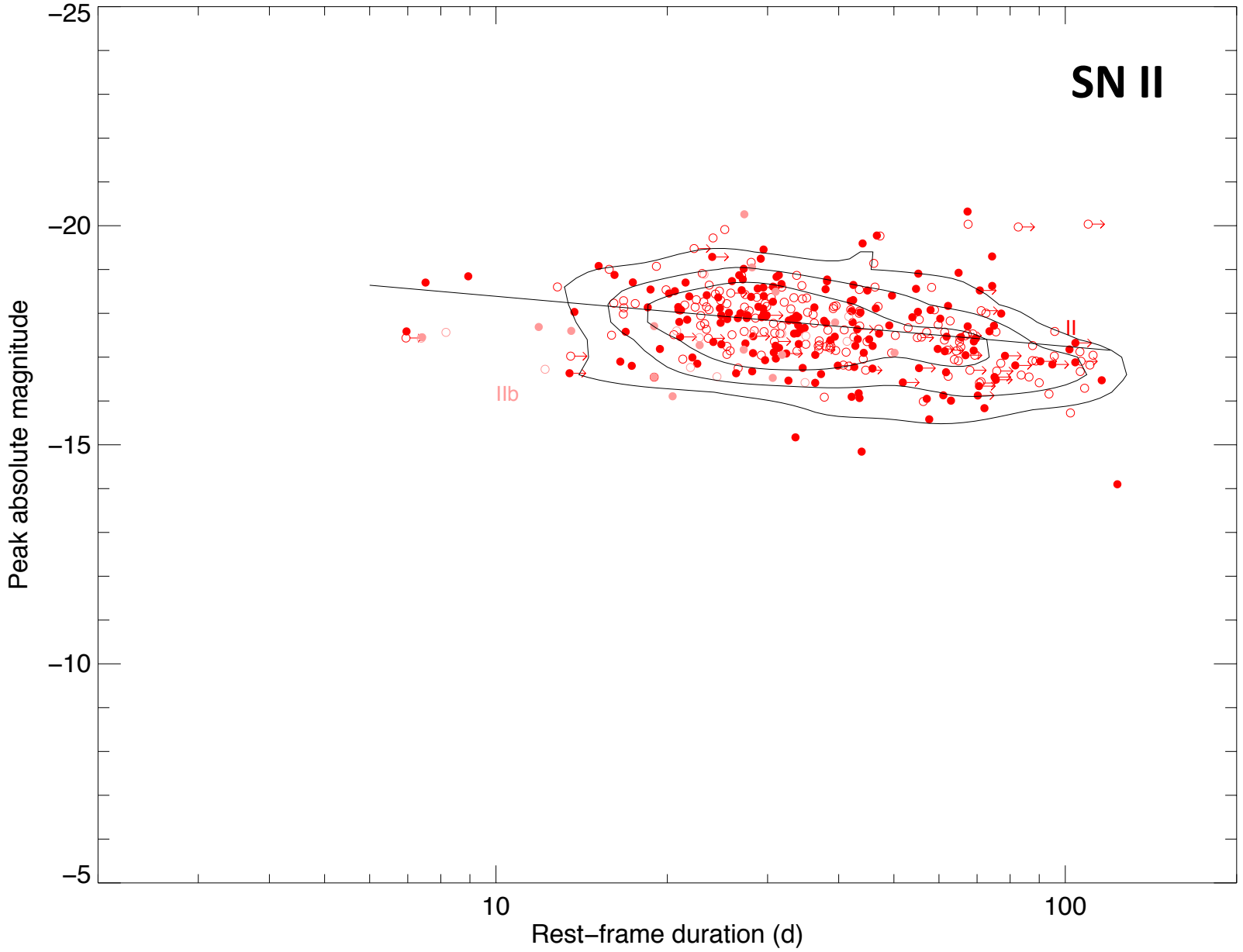
Transient Parameter Space



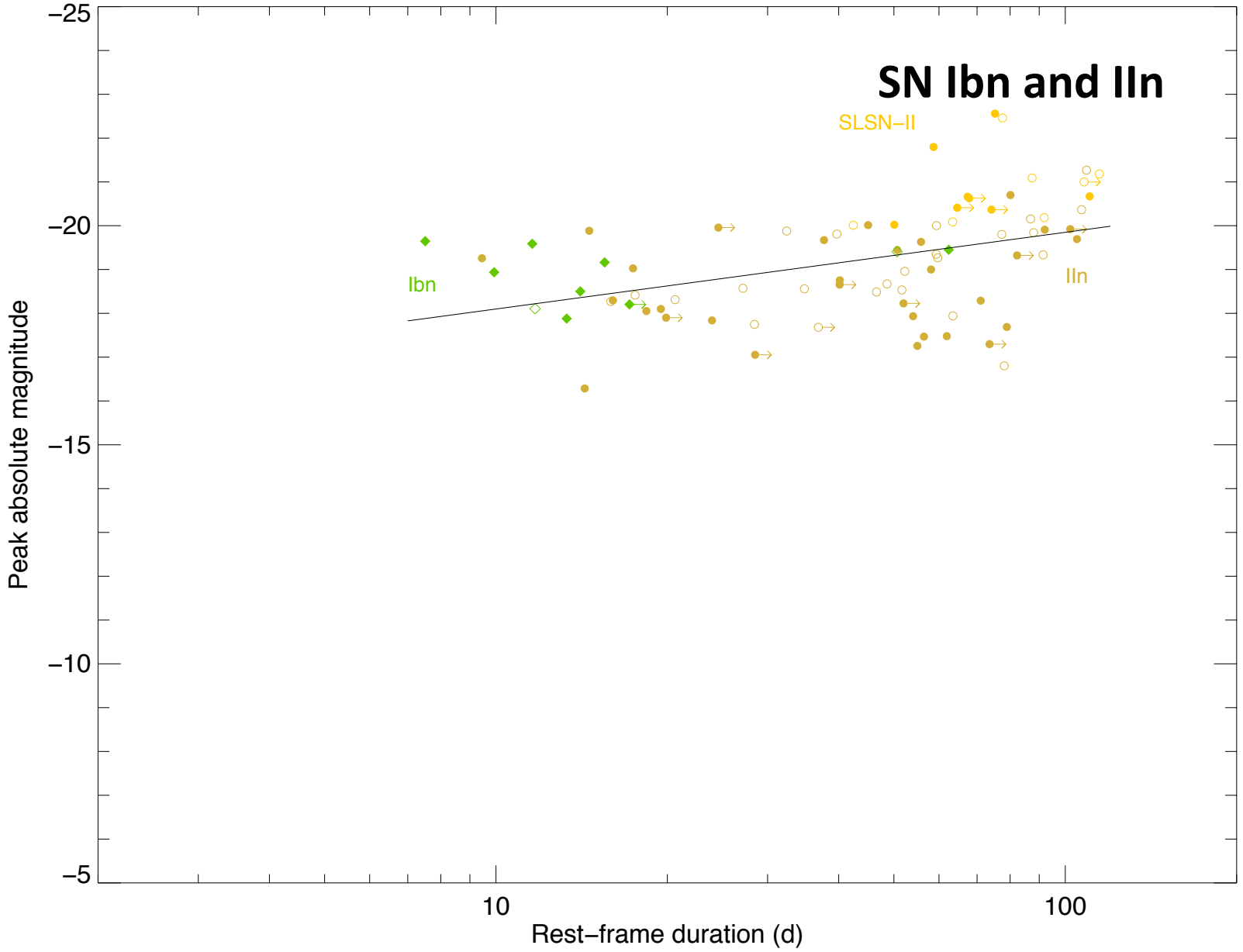
Transient Parameter Space



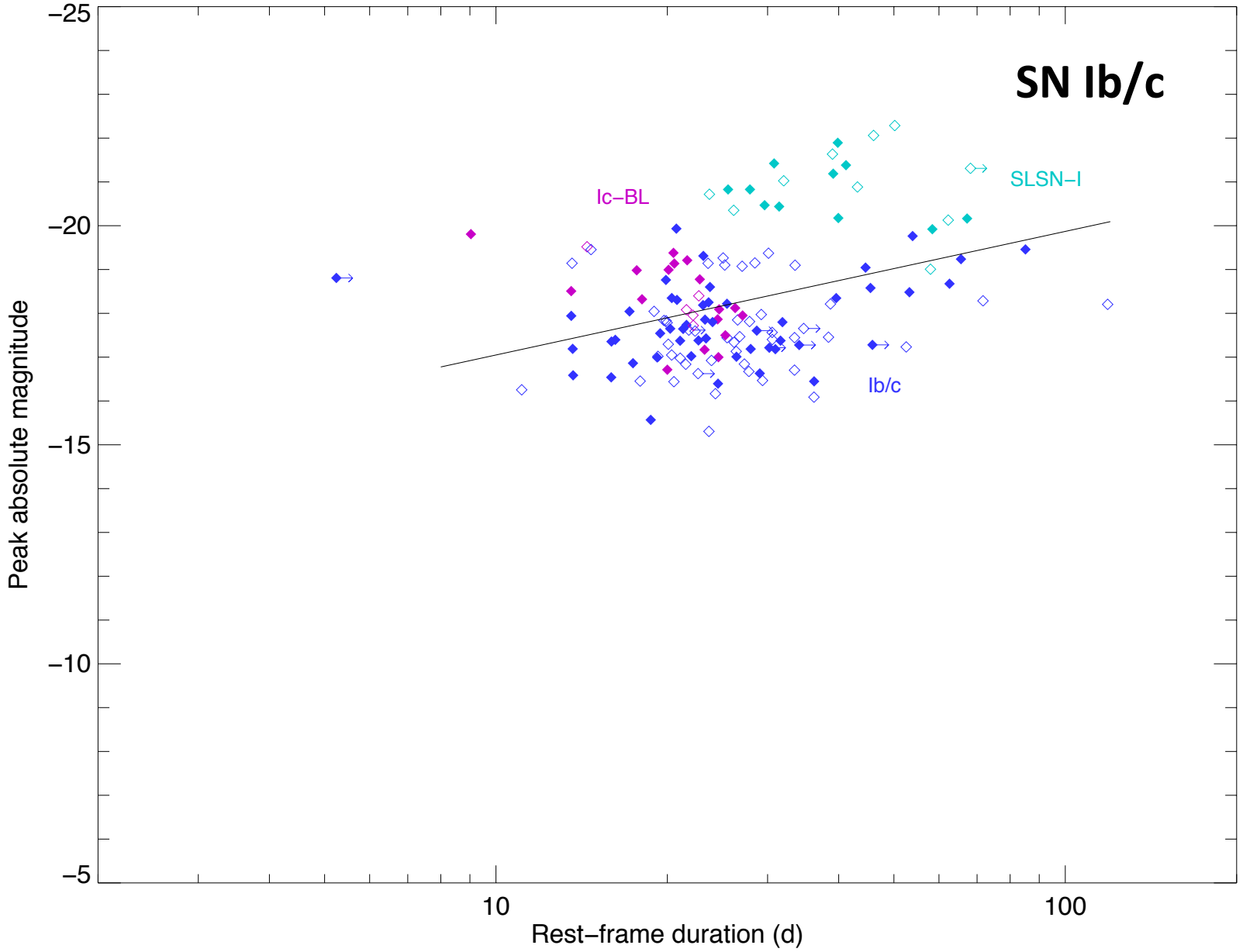
Transient Parameter Space



Transient Parameter Space



Transient Parameter Space



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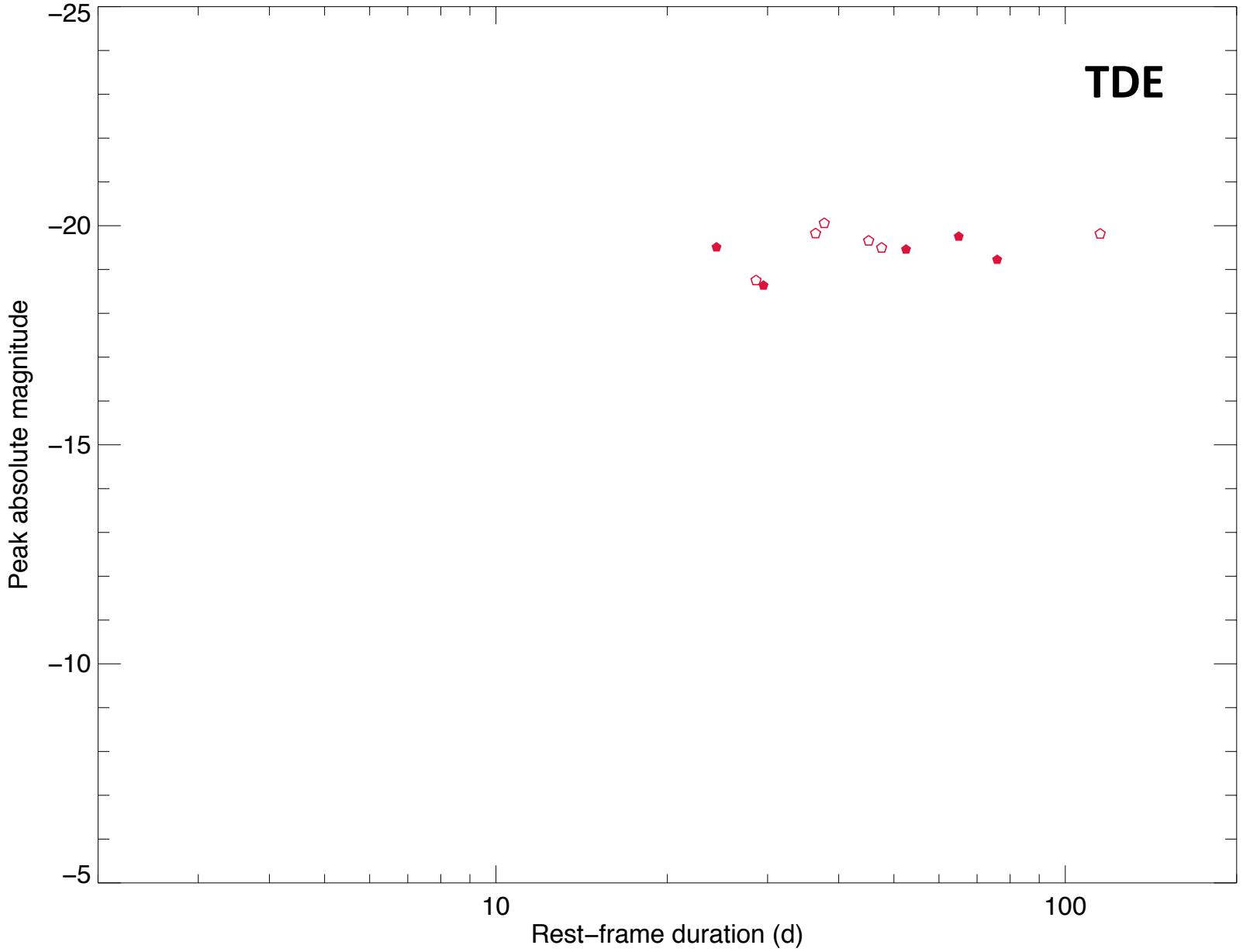
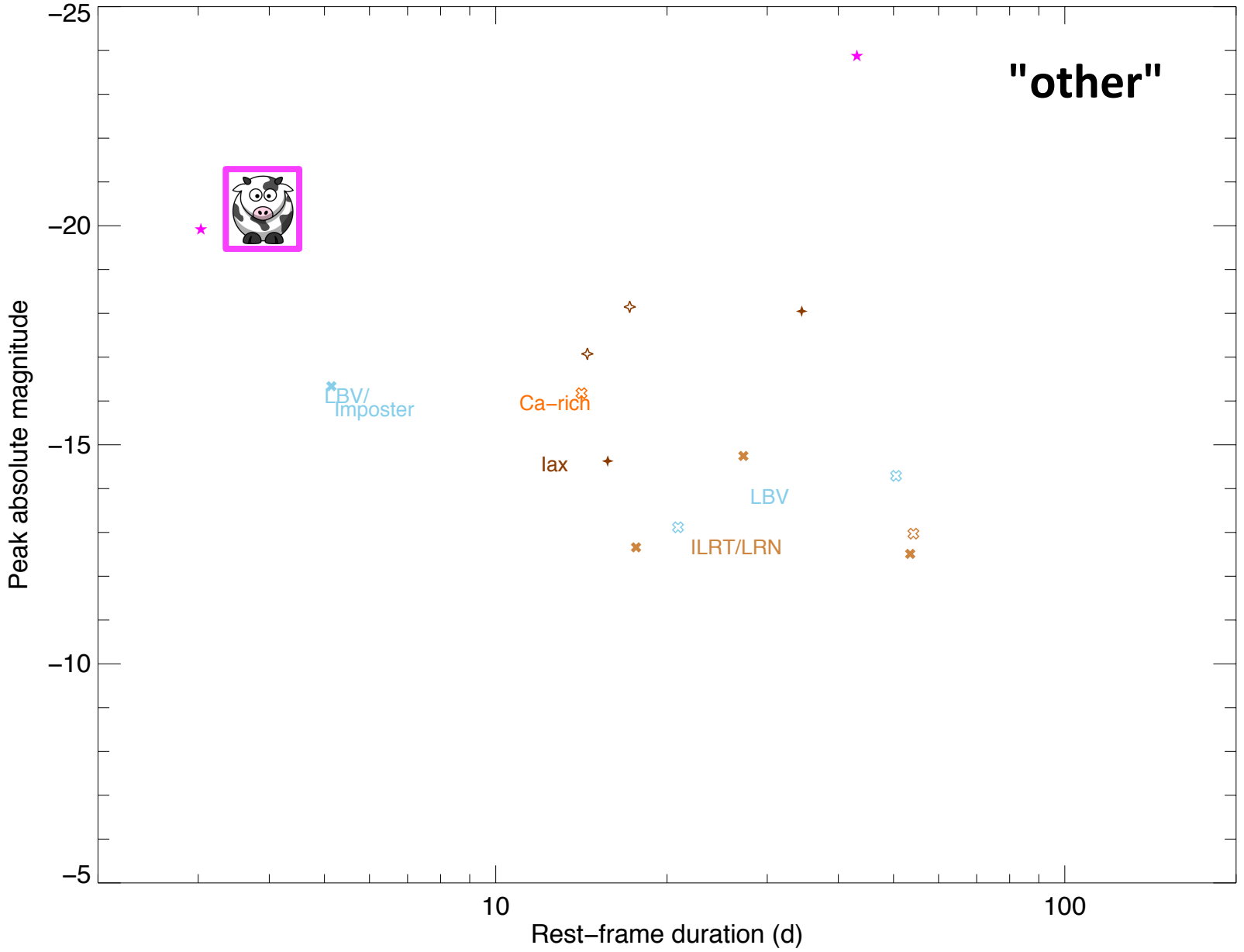
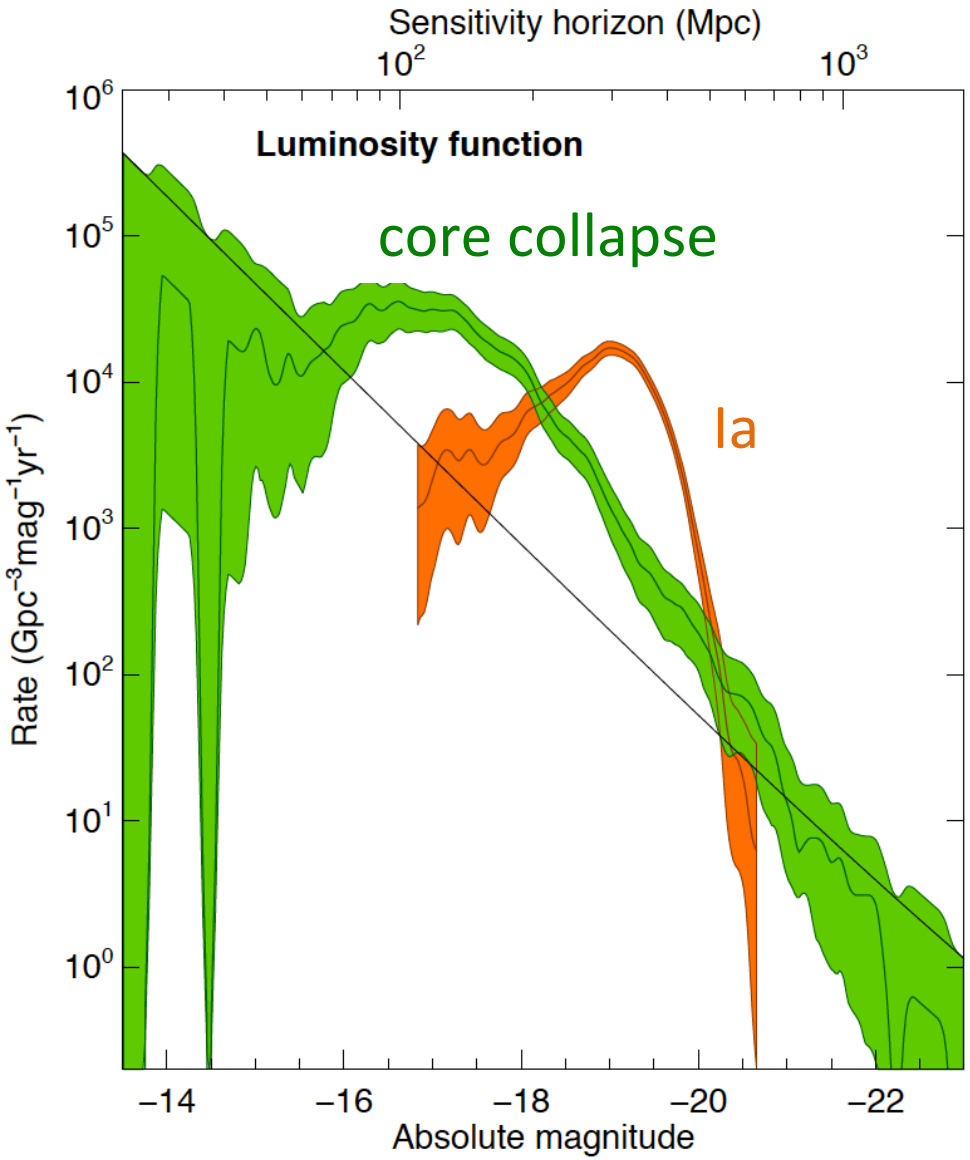


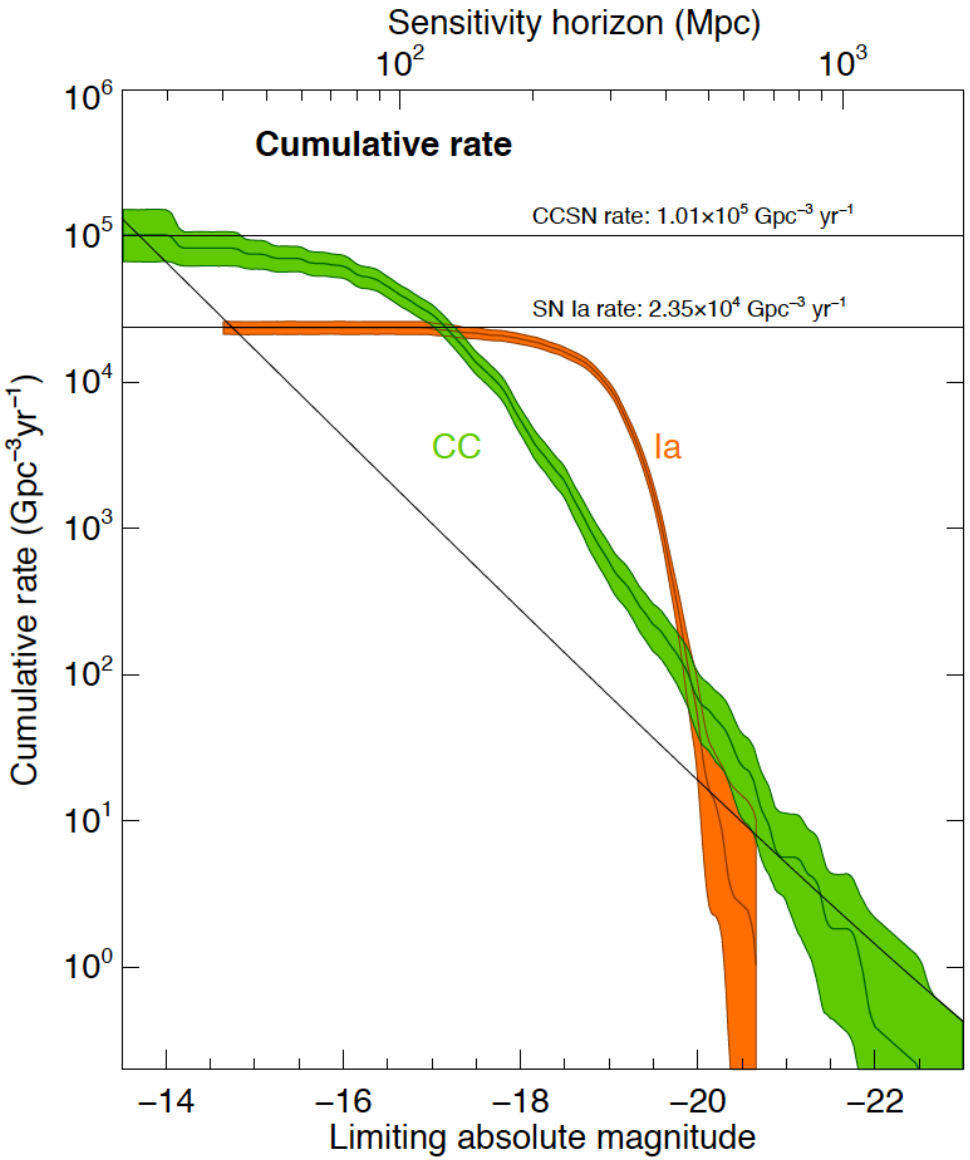
Transient Parameter Space

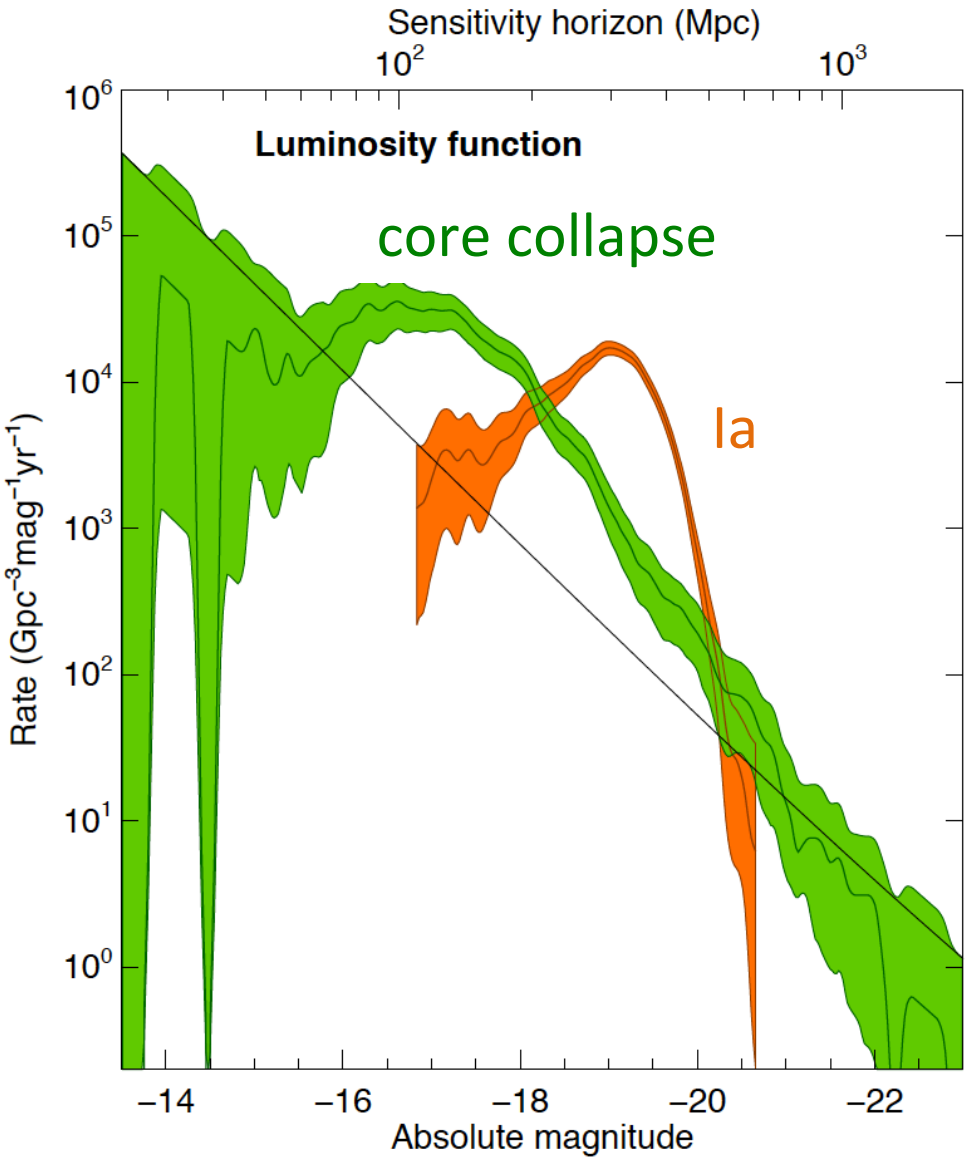


Supernova Rates and Luminosities



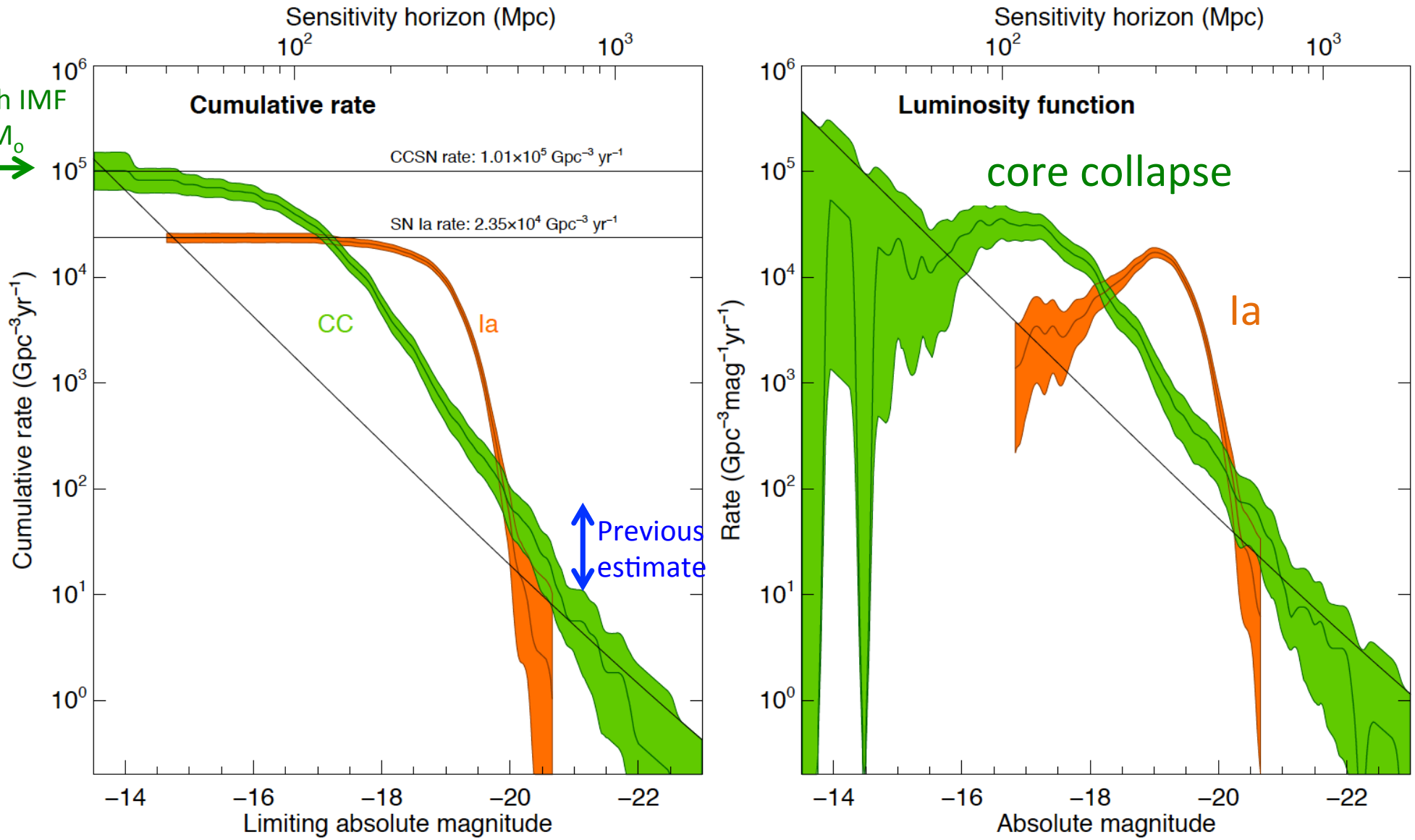
Supernova Rates and Luminosities



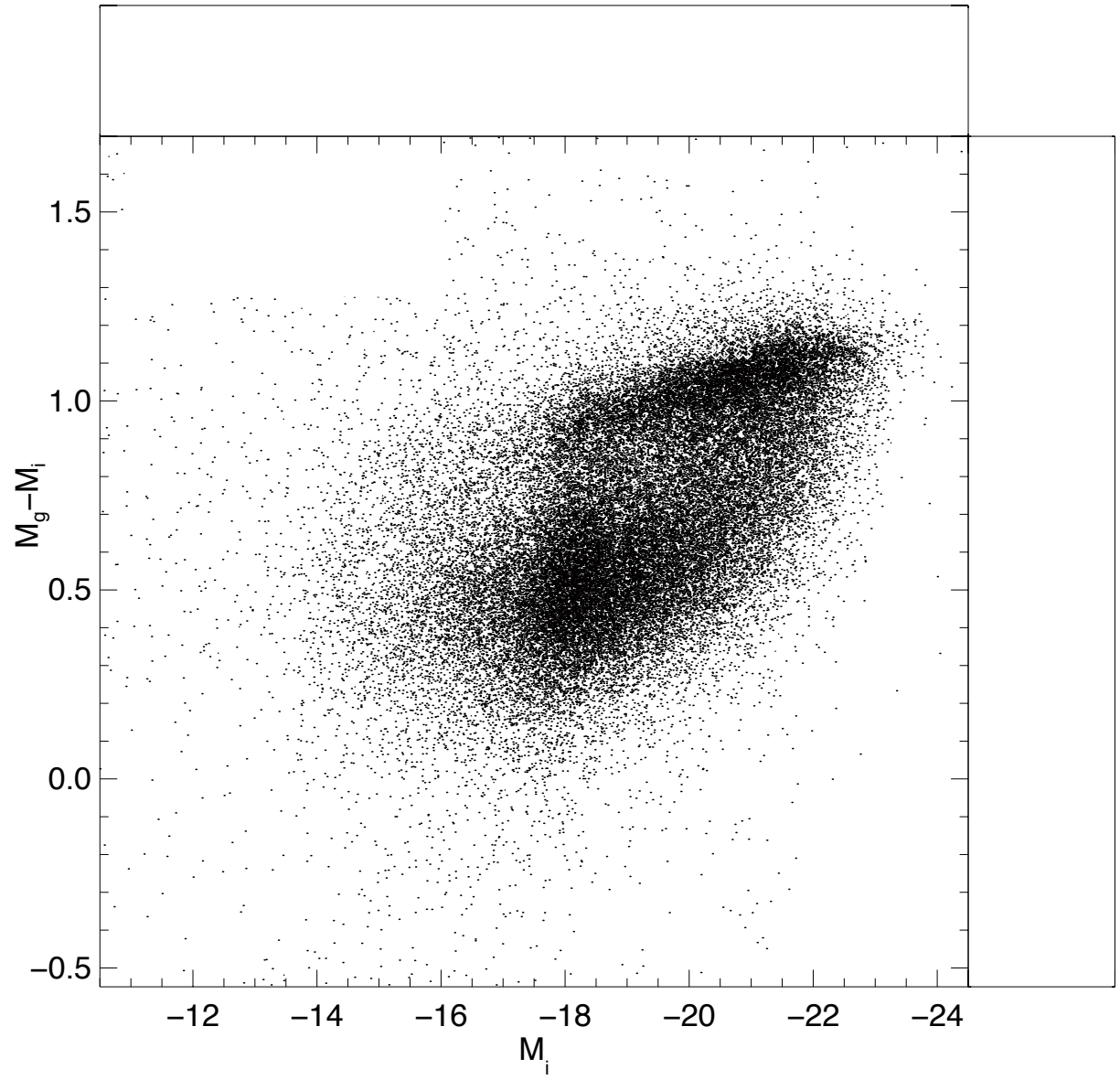


Supernova Rates and Luminosities

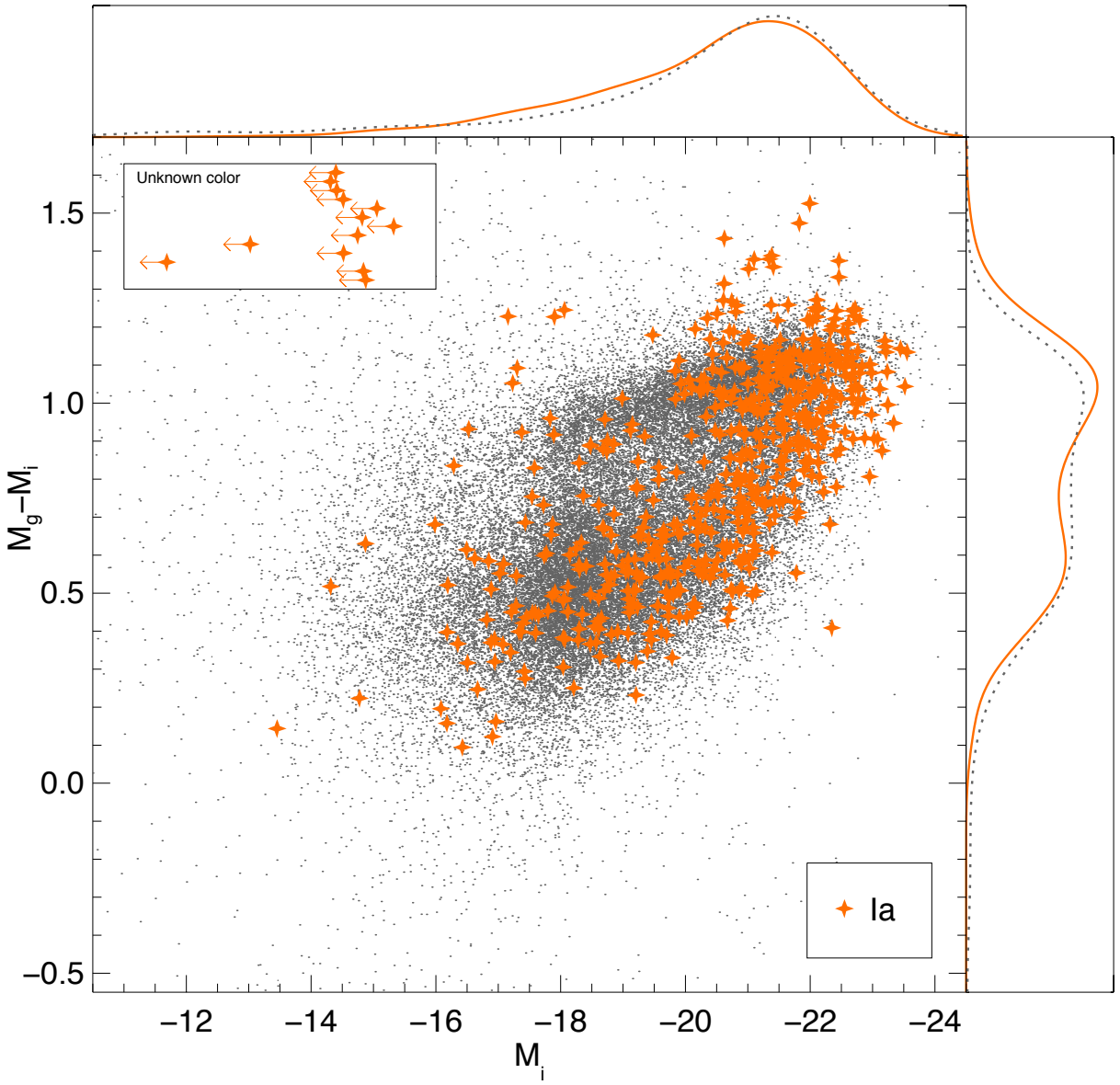
Consistent with IMF for $M_{ZAMS} > 8\ M_o$

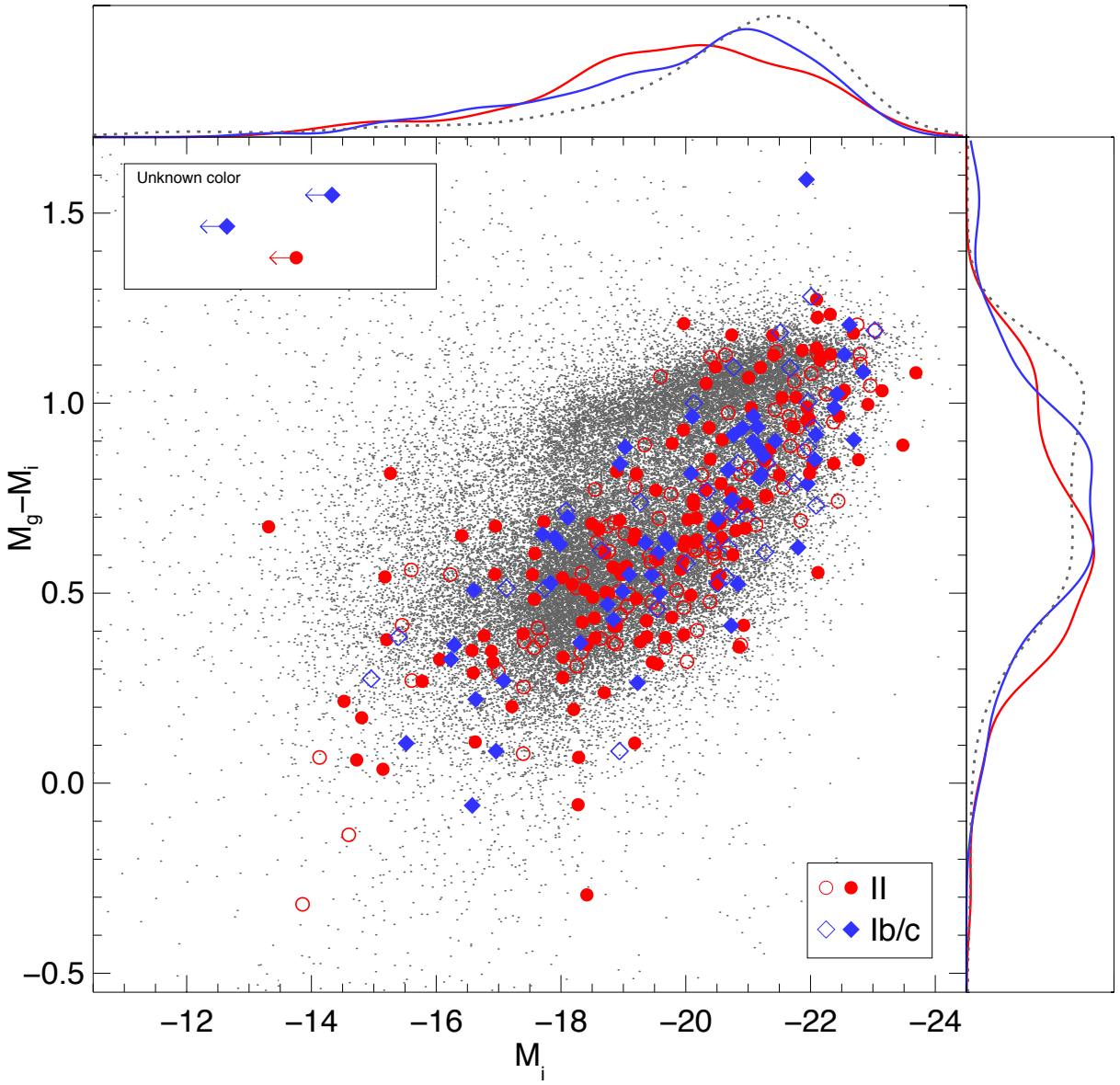


SDSS Galaxies



Host Galaxies





Summary

- We don't have to classify everything – just all of something! Focus on transients at m<18.5 satisfying quality (coverage+visibility) and purity (CV/AGN-rejection) cuts
- Diversity in timescales, luminosities seen in all classes: will constrain physics and progenitors
- CCSN rate matches IMF+SFR; no "missing" SNe
- No difference in II vs. Ibc hosts yet

Served Up Publicly in Real Time

Survey description and statistics:

- https://sites.astro.caltech.edu/ztf/bts/

Live catalog with light curves, classifications, pretty host galaxy images, and much more:

- https://sites.astro.caltech.edu/ztf/bts/explorer.php

(These are public versions – internal links also exist with additional classifications and information.)