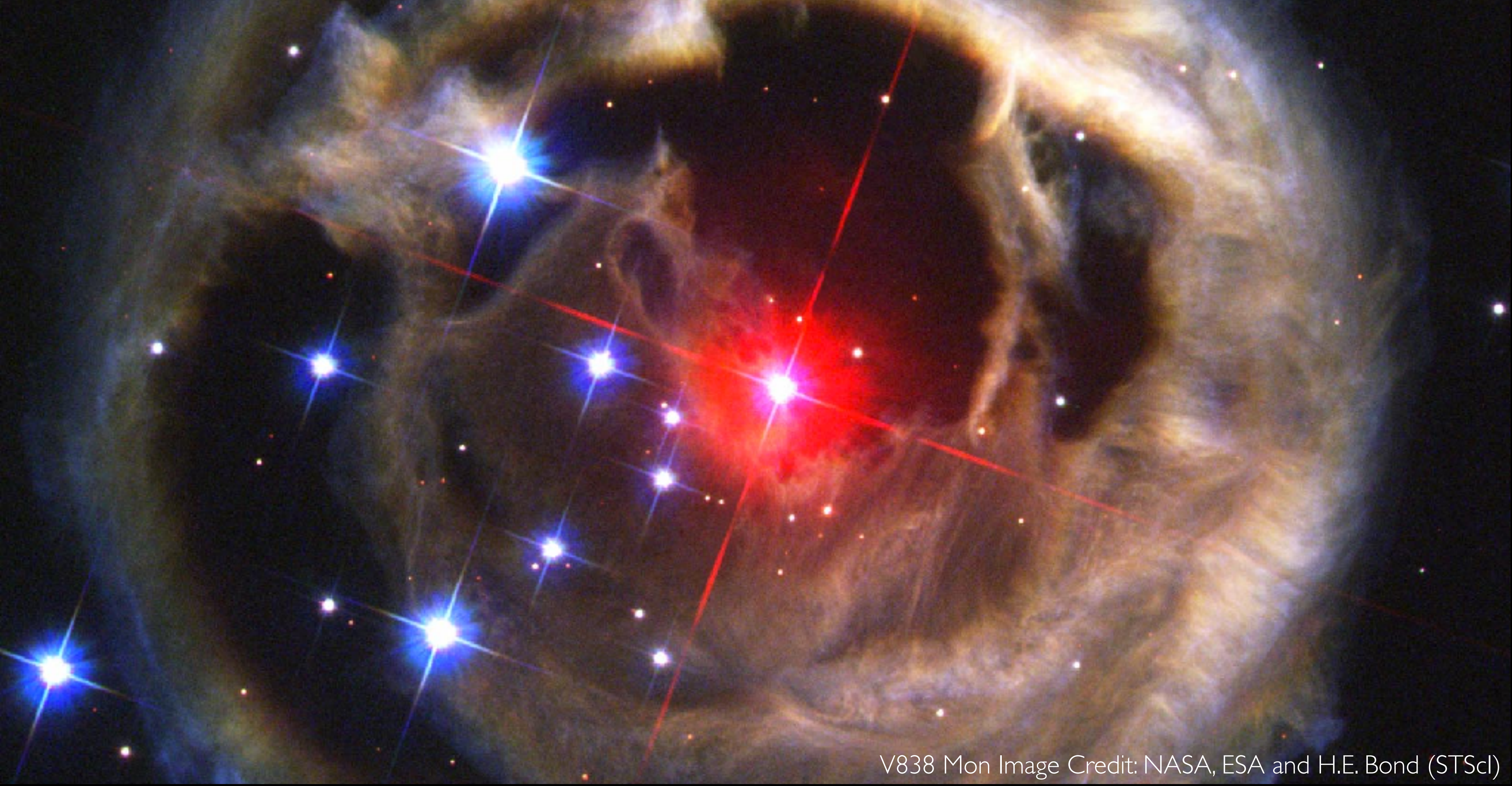


Infrared Transients and Common-Envelope Events

Jacob Jencson
Steward Observatory, University of Arizona
Tucson, AZ

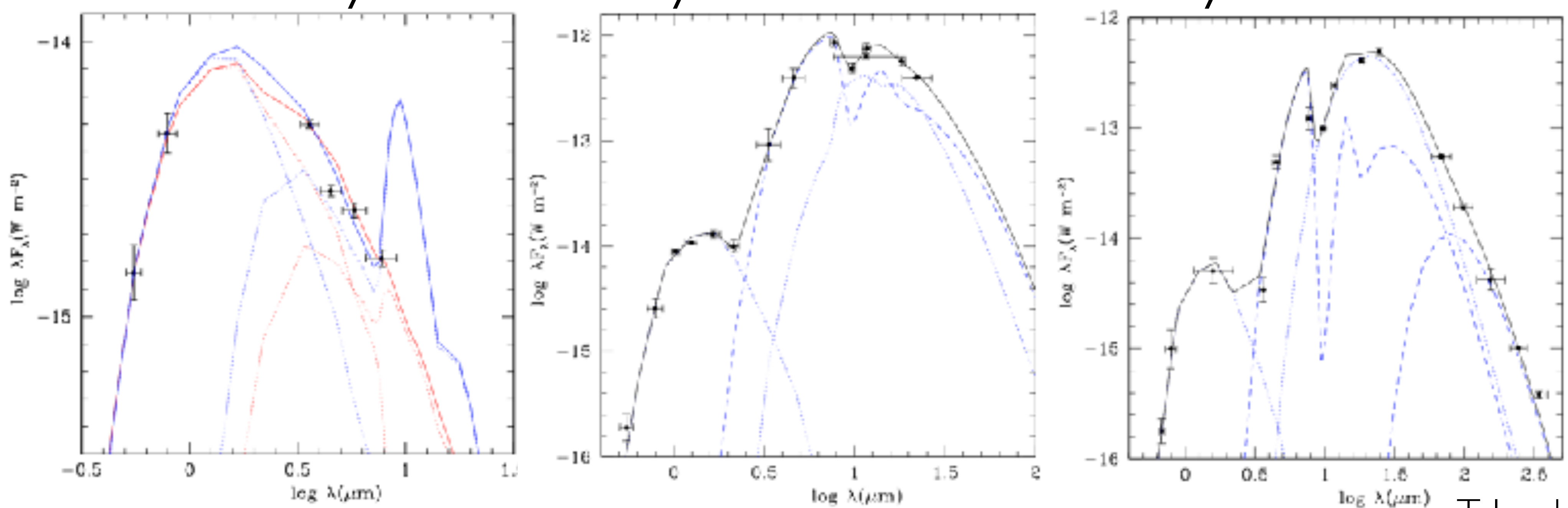
LANL Common Envelope Meeting
Los Alamos, NM
June 2, 2022

Dust dominates the spectra of LRNe as they evolve.

V41309 Sco: -1 year

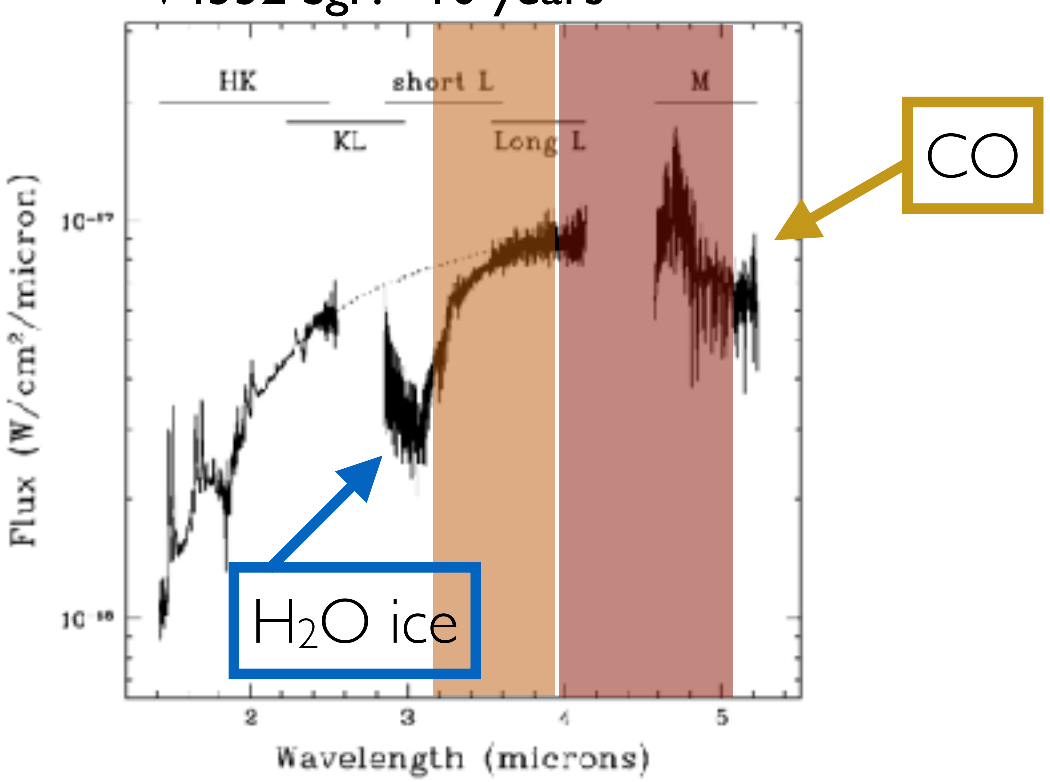
+2 years

+4 years



Tylenda & Kamiński 2016

V4332 Sgr: +10 years

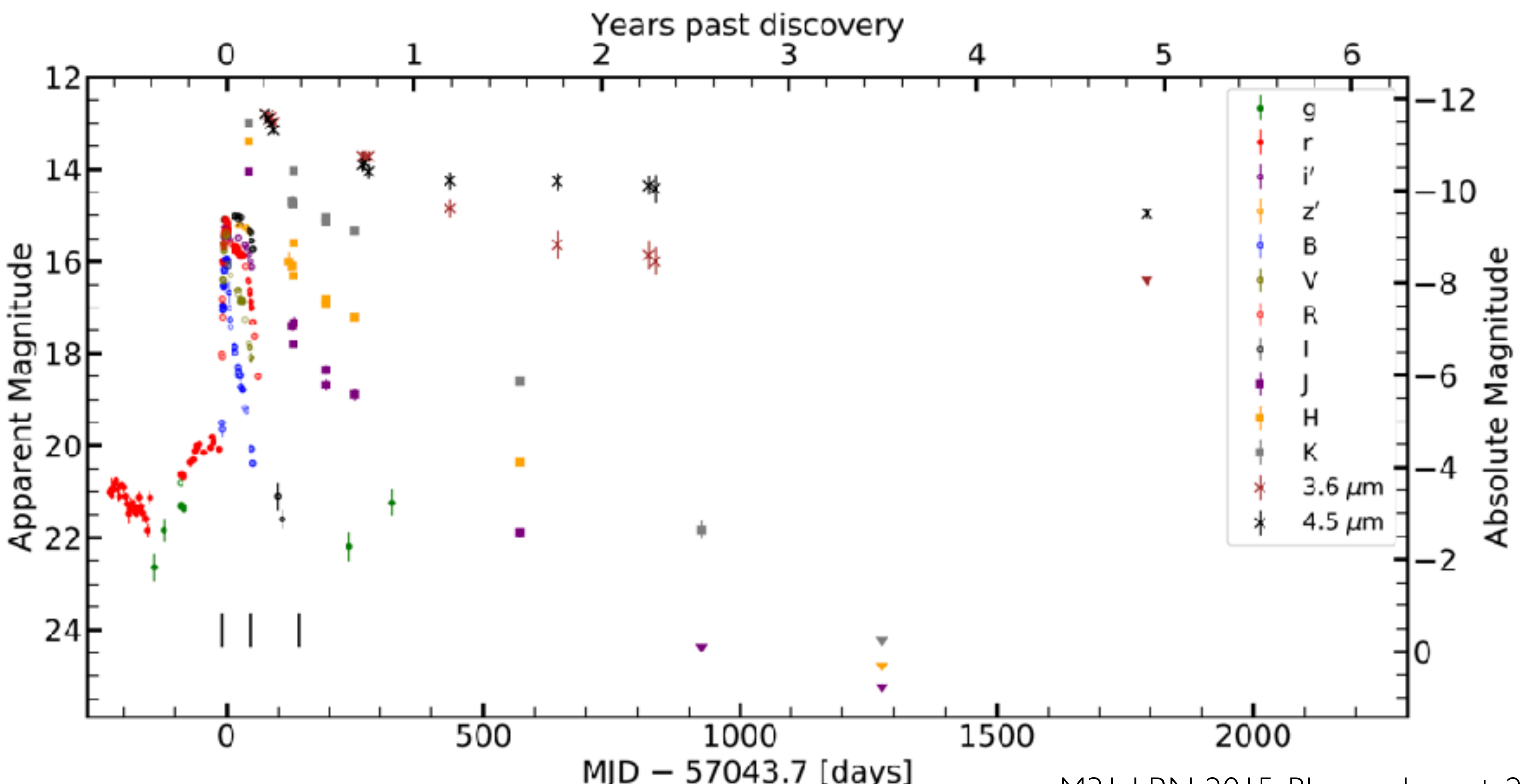


Banerjee+ 2005

Overdensity of dust in flattened disk in V838 Mon (Chesneau+ 2014)

Signs of dust formation in V4332 Sgr (Martini+ 1999, Banerjee+ 2007) and evidence for disk geometry from polarization (Kaminski+ 2011).

Bright IR emission far outlasts the optical transient.



M31-LRN-2015, Blagorodnova+ 2020

Infrared emission is an important probe of common-envelope related transients.

Cool, dense outflows of LRNe are **favorable to dust formation.**
(e.g., Metzger & Pejcha 2017, Iaconi+ 2020, previous talk by Chris Mauney).

Long-lived IR emission appears to be ubiquitous in these transients.
(e.g., Mould+ 1990, Crause+ 2003, Lynch+ 2004, Banerjee+ 2005, Nicholls+ 2013, Smith+ 2016, Tylenda & Kamiński 2016, Blagorodnova+ 2017, 2020, Mauerhan+ 2018).

Well studied luminous red novae have been **almost exclusively identified via their optical emission** (Nadia and Nathan's talks)**.**

Are the optically discovered luminous red novae representative of the population of common envelope transients?

SPitzer **I**nfra**R**ed **I**ntensive **T**ransients **S**urvey: A targeted search of nearby galaxies for transients in the mid-IR

1690 hours over 6 years with *Spitzer*/IRAC

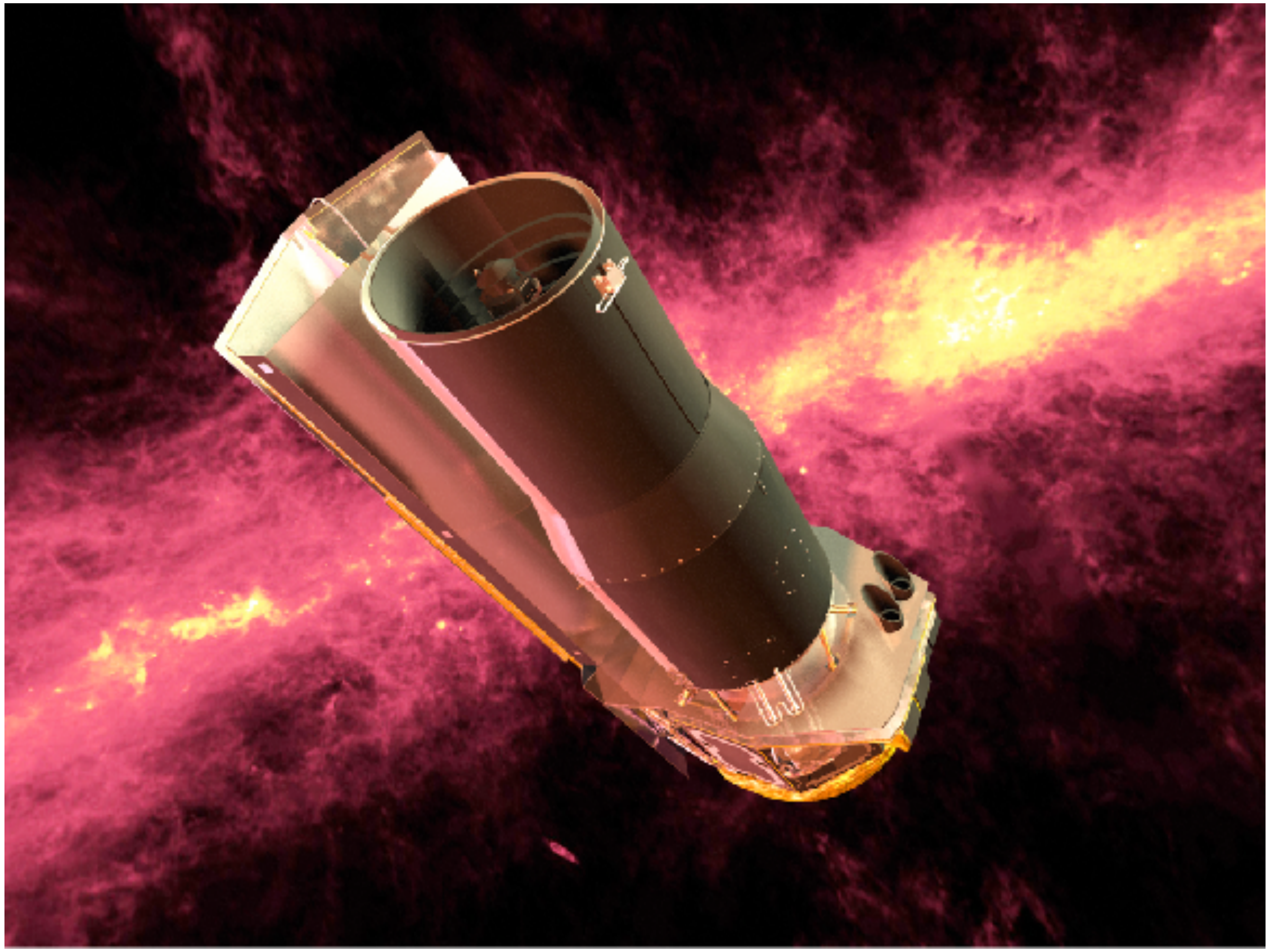
Cycles 10-12 (2014-2016)
194 galaxies x 10 epochs

Cycles 13-14 (2017-2019)
105 galaxies x 8 epochs

Sample within ~ 35 Mpc

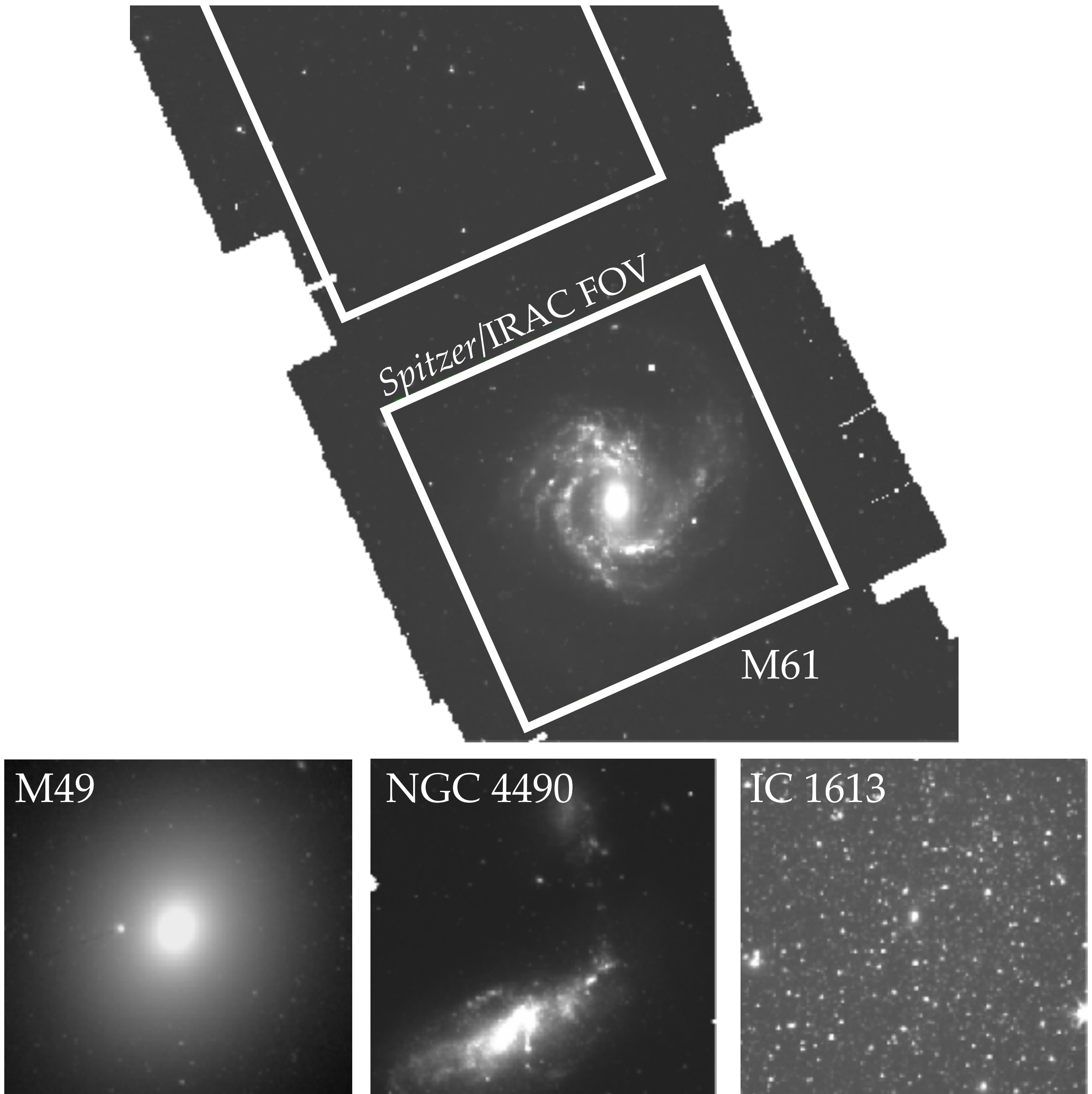
Depth of 20 mag (Vega) at [3.6] and 19 mag at [4.5]

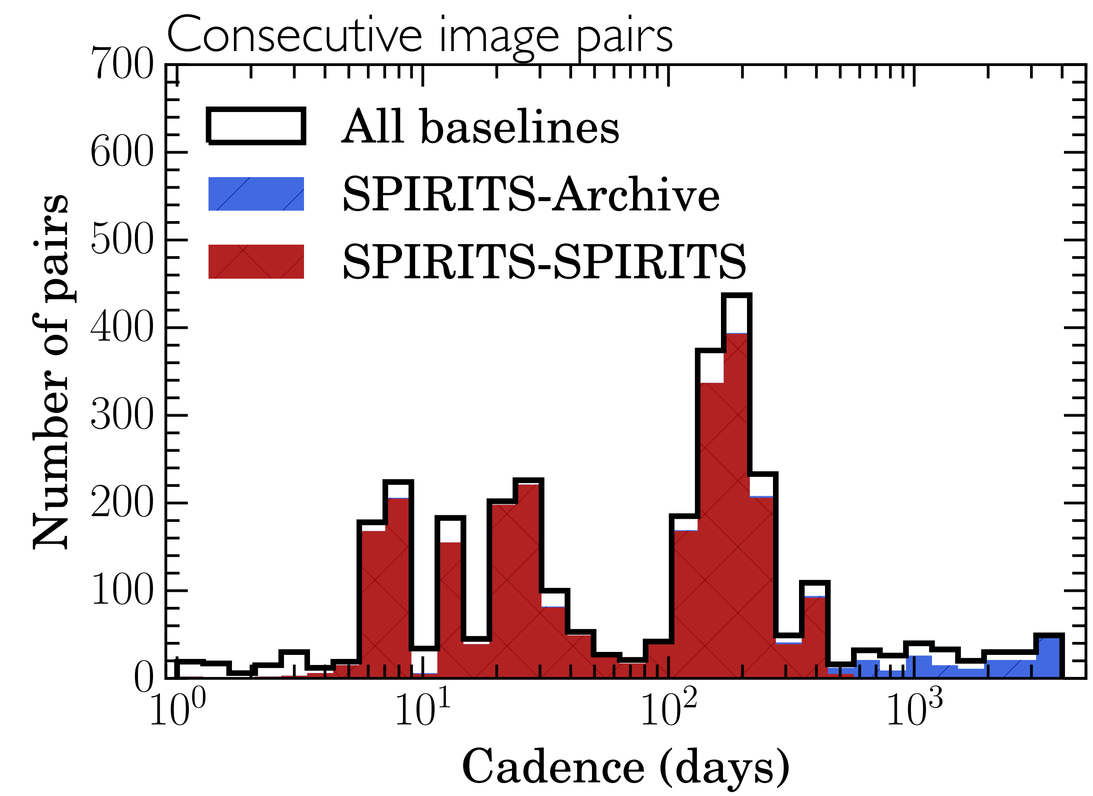
Cadence baselines spanning one week to several years

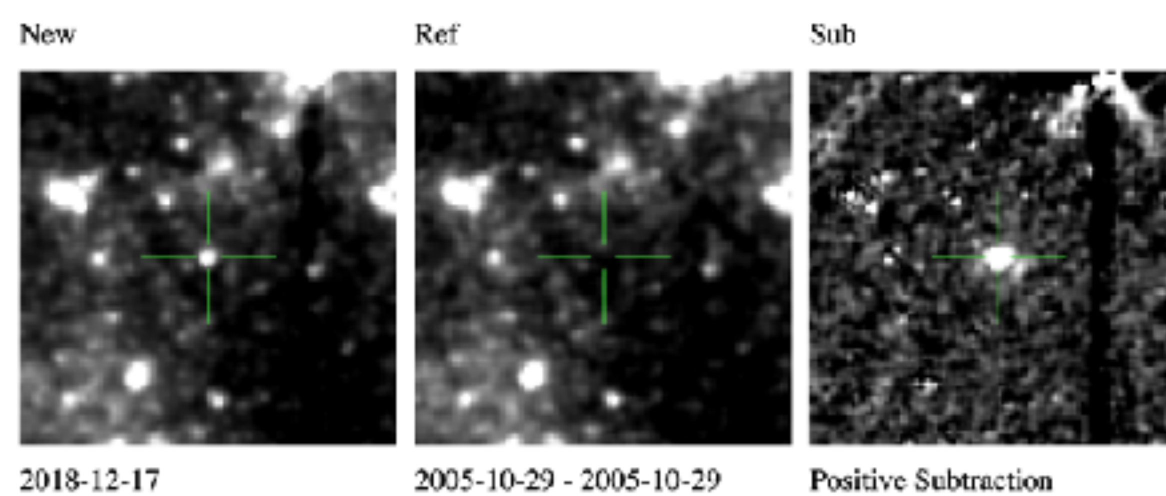


PI: M Kasliwal, Project Scientist: J Jencson
Team: S Adams, R Lau, H Bond, S Tinyanont, M Hankins, D Perley, F Masci, G Helou, L Armus, S Van Dyk, A Cody, M Boyer, J Bally, O Fox, R Williams, P Whitelock, R Gehrz, N Smith, J Johansson, E Hsiao, M Phillips, N Morell, C Contreras, M Ressler+

SPitzer **I**nfra**R**ed **I**ntensive **T**ransients **S**urvey: A targeted search of nearby galaxies for transients in the mid-IR





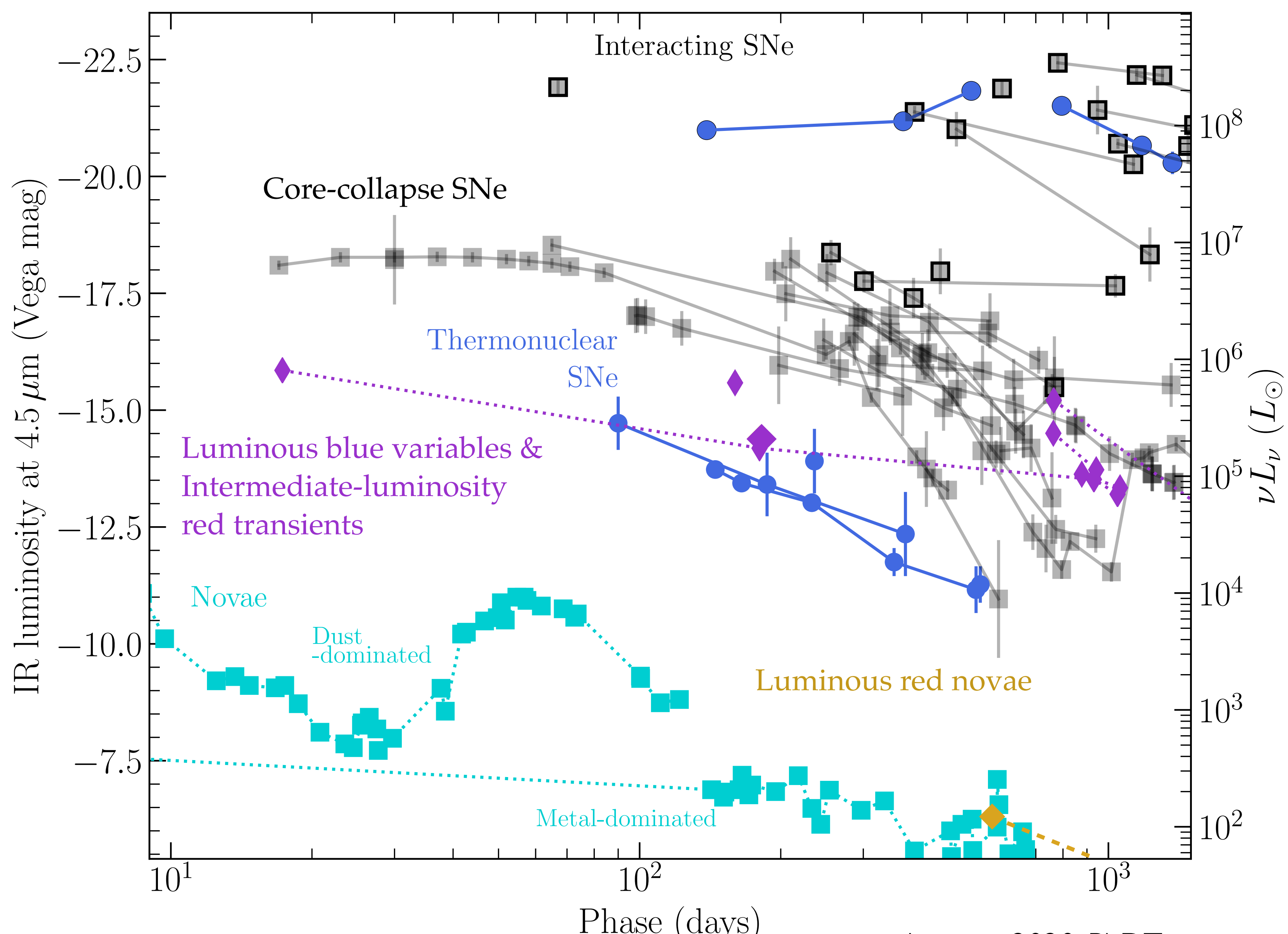


SPIRITS discovered a huge diversity of IR transients.

Identified 80+ transients:

- 50+ known supernovae
- 10 newly discovered luminous IR events (Jencson+ 2019)
- 24 e**SP**ecially **R**ed **I**ntermediate-luminosity **T**ransient **E**vents (**SPRITE**s;
- Kasliwal+ 2017, Jencson+ 2019, Bond+ 2022)

2014



Jencson 2020, PhDT

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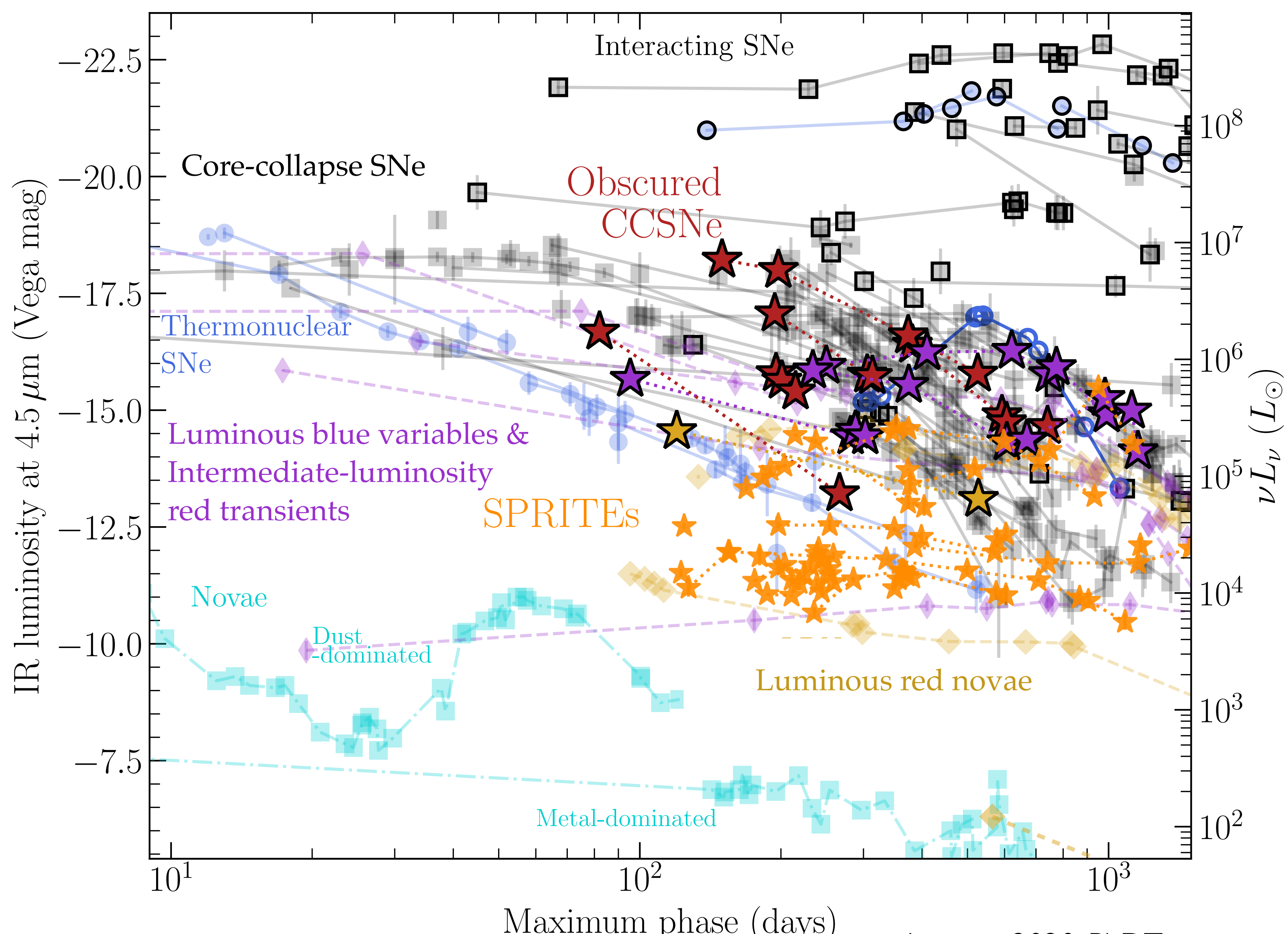
2019



Jencson 2020, PhDT

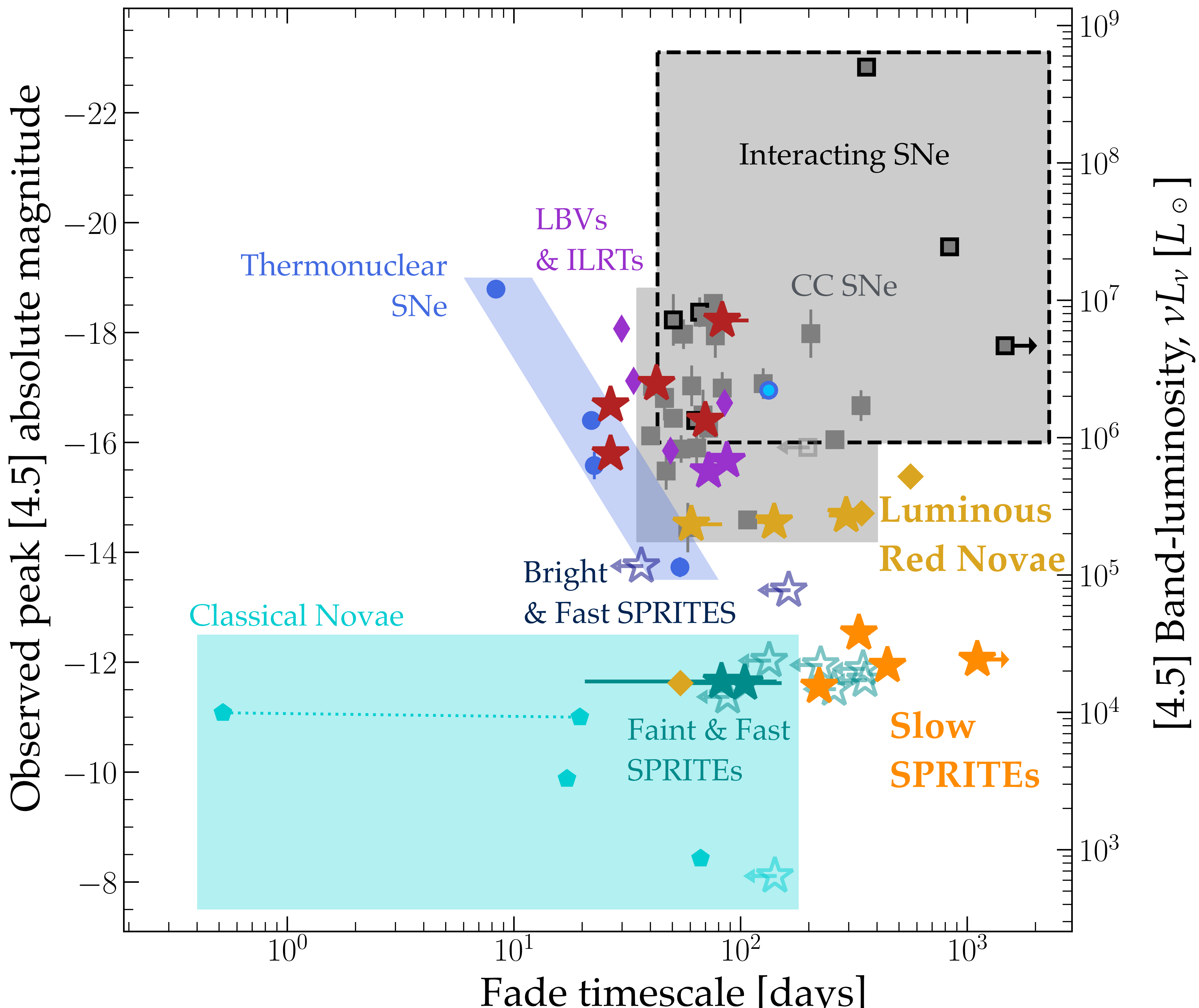
A first census of extragalactic transients in the IR:

SPRITE classes

Faint and Fast
- Present in only one visibility window
- Abundant in nearest galaxies
- Likely dominated by dusty novae

Bright and Fast
- Too bright to be novae (> Eddington)
- Origin unknown

Slow
- Duration > 1 year
- Reminiscent of LRNe



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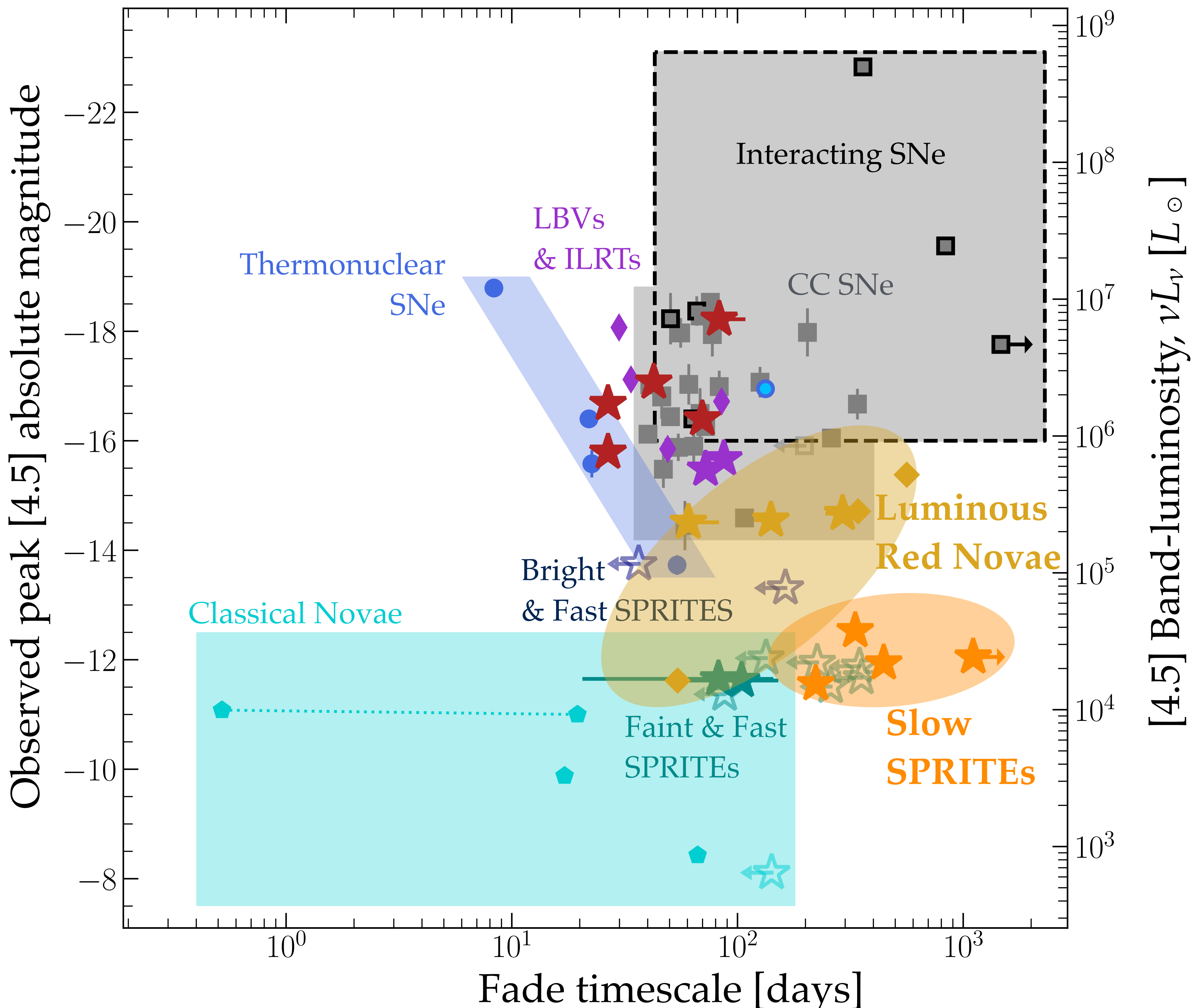
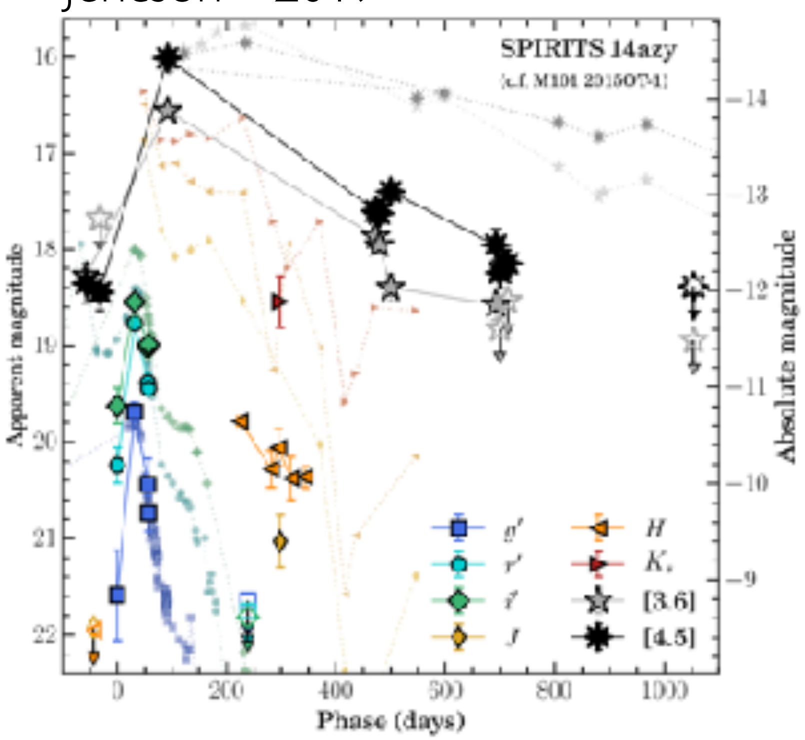
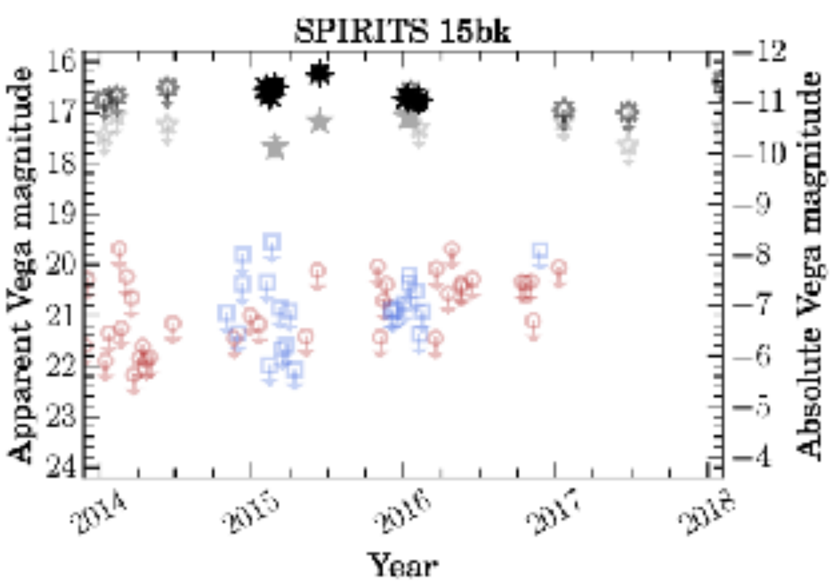
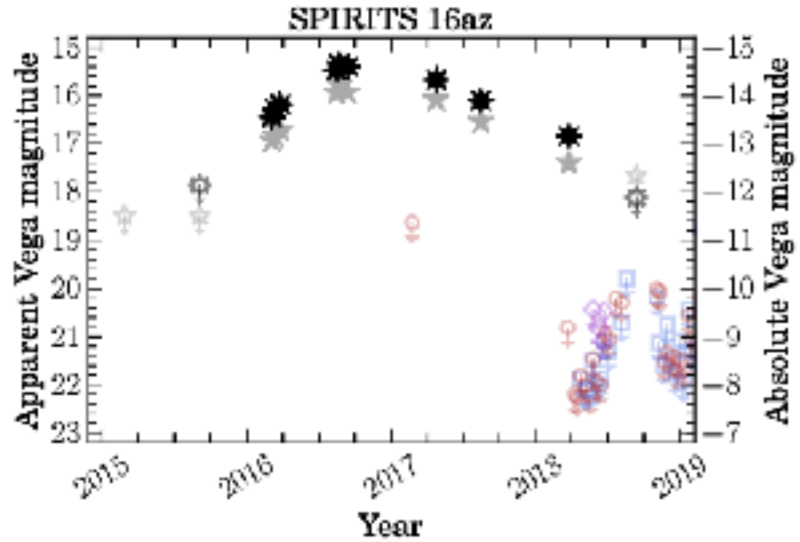
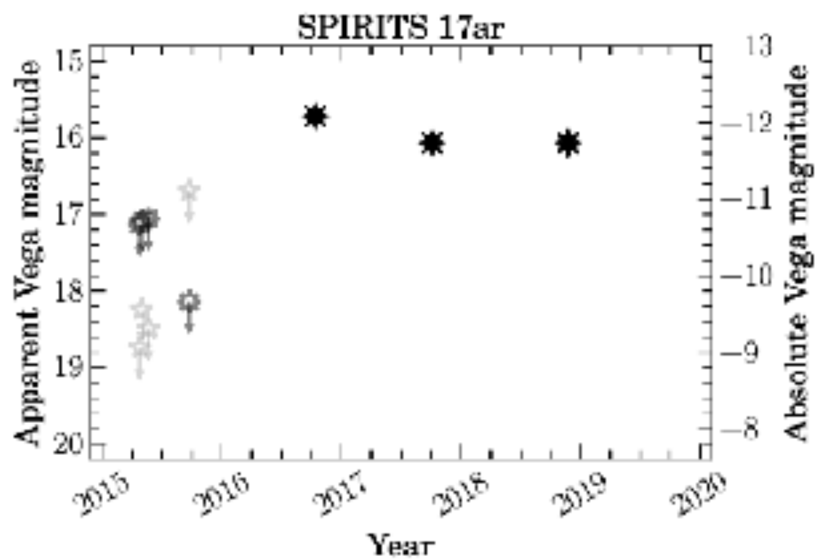


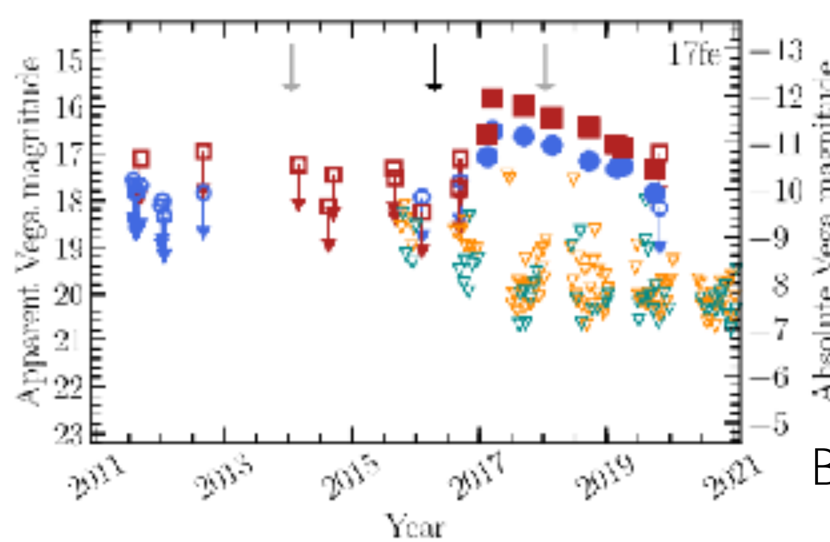
Jencson+ 2019

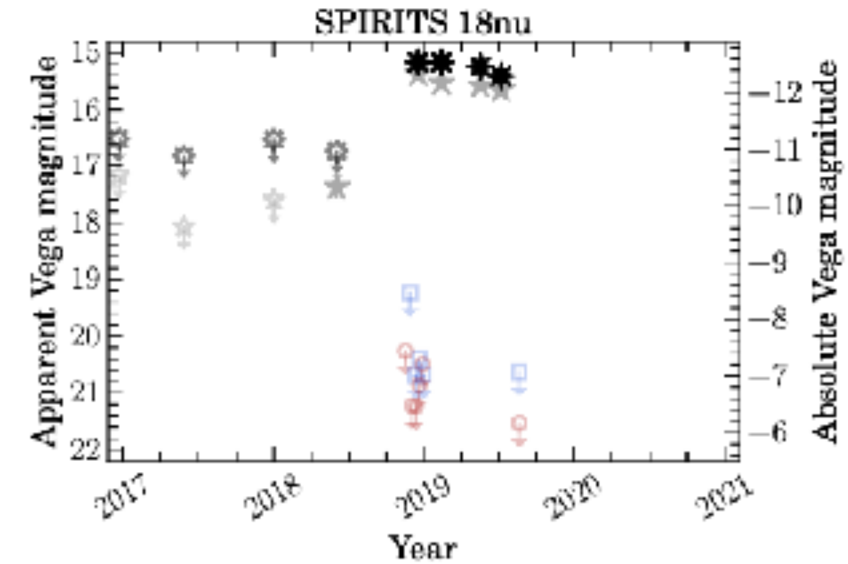


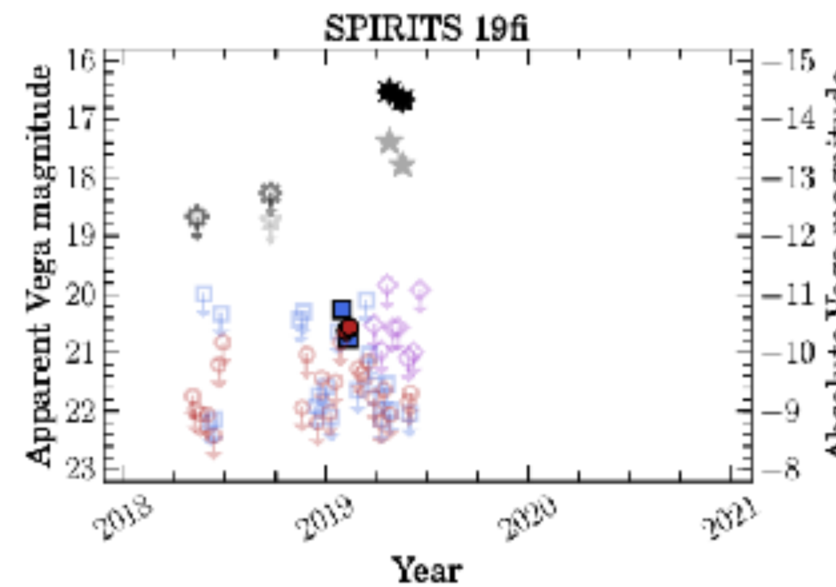






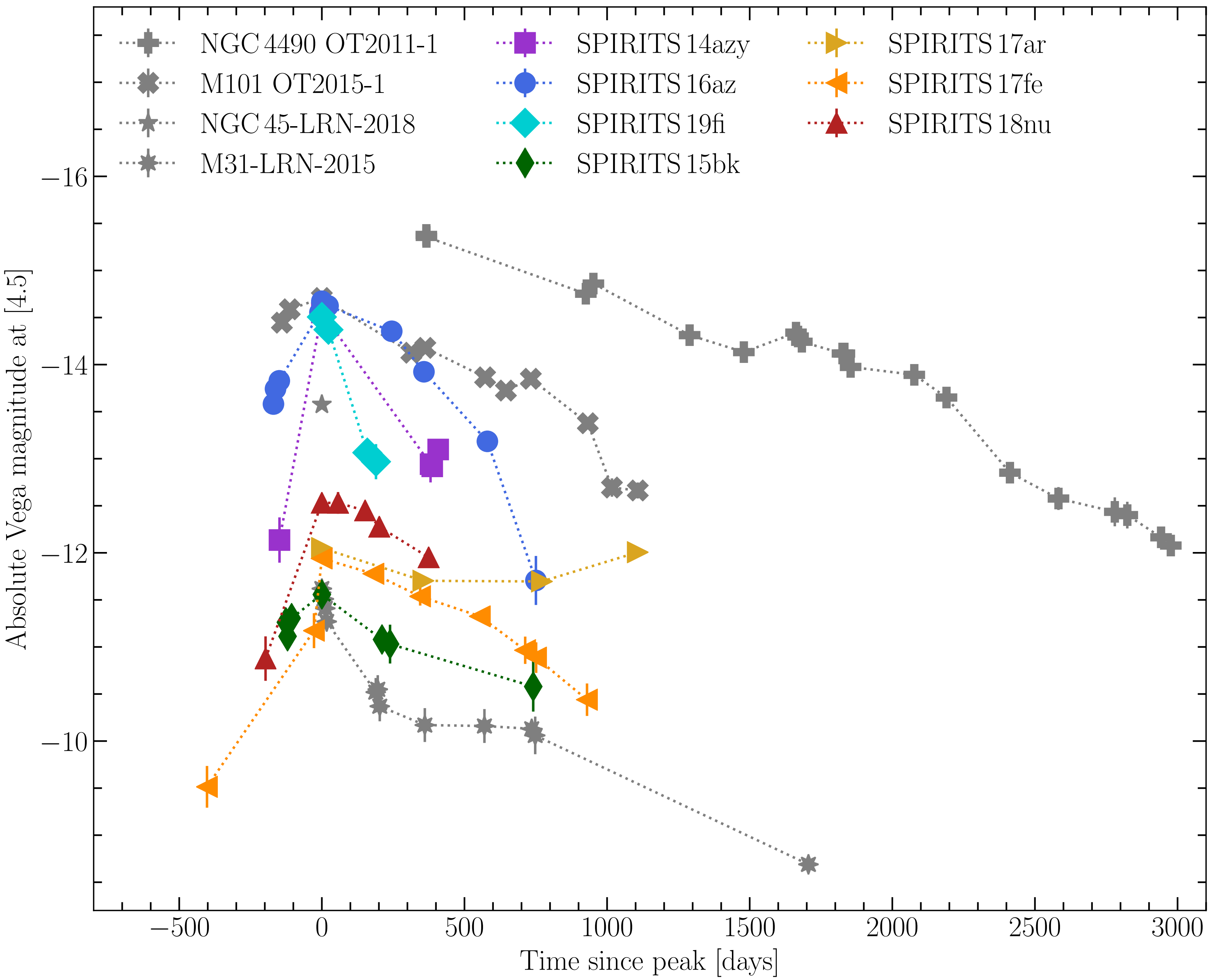


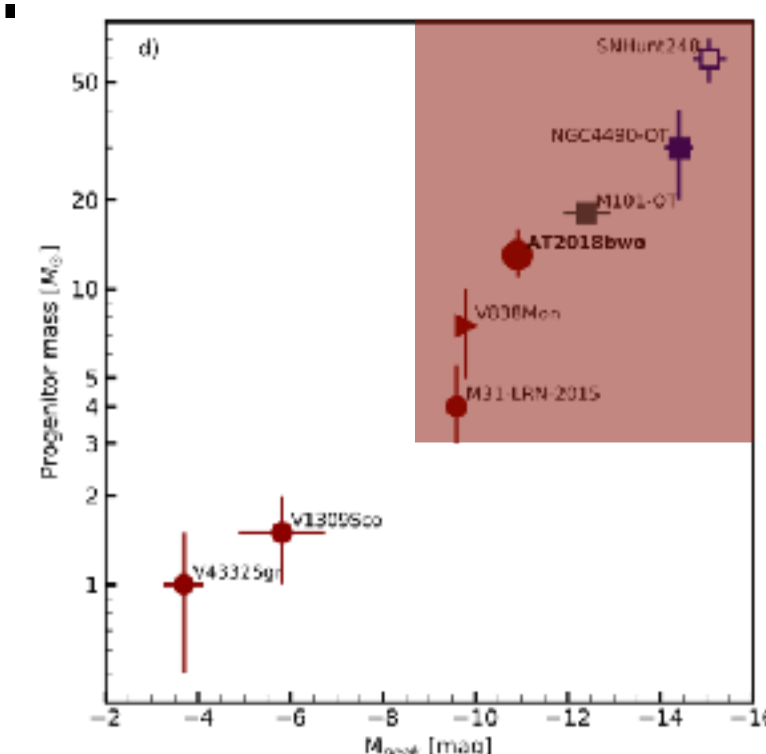




Bond+ 2022

Light curves show precursor emission, rise to peak, and slow decline.





Blagorodnova+ 2021

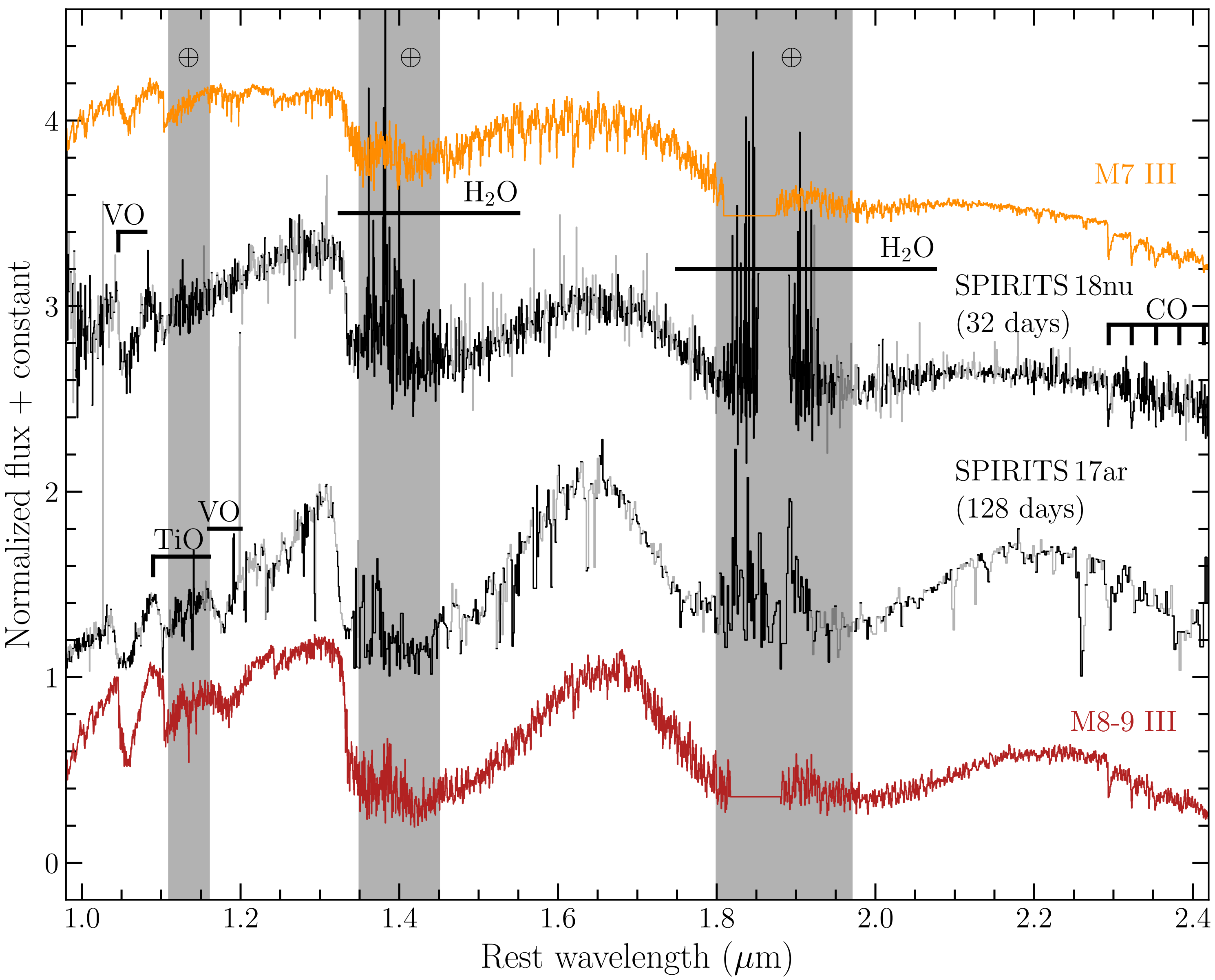
Comparison data:
NGC 4490 OT2011-1
(Smith+ 2016)

M101 OT2015-1
(Blagorodnova+ 2017)

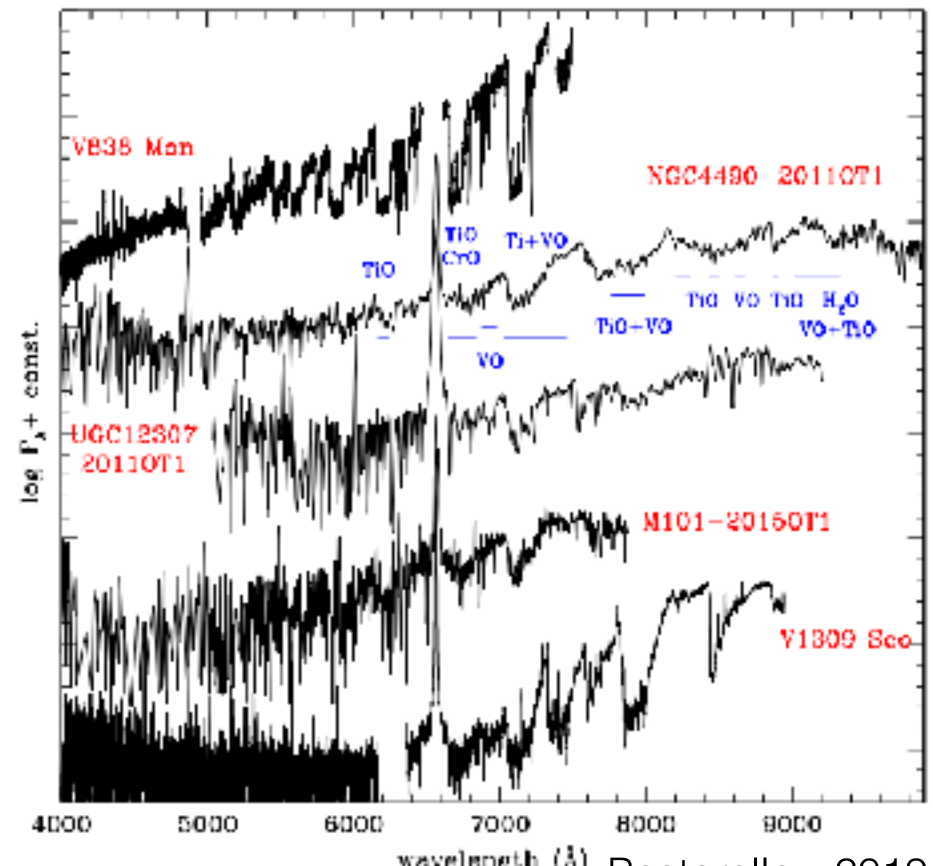
M31-LRN-2015
(Blagorodnova+ 2020)

SPRITE spectra are dominated molecular features.

SPRITE Spectra:

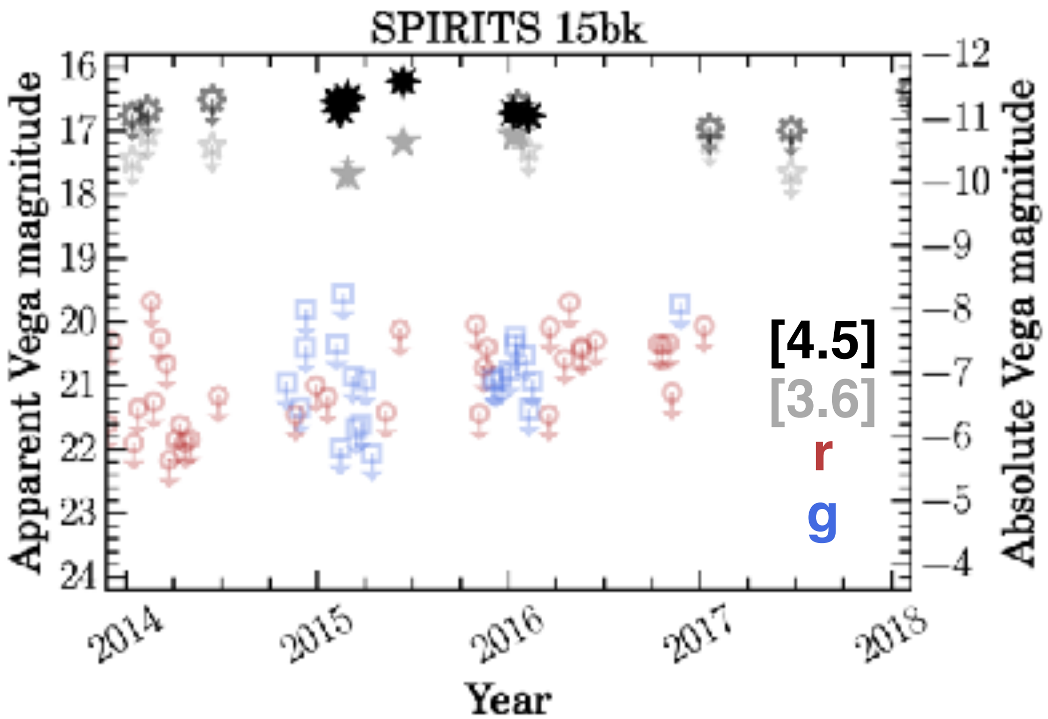


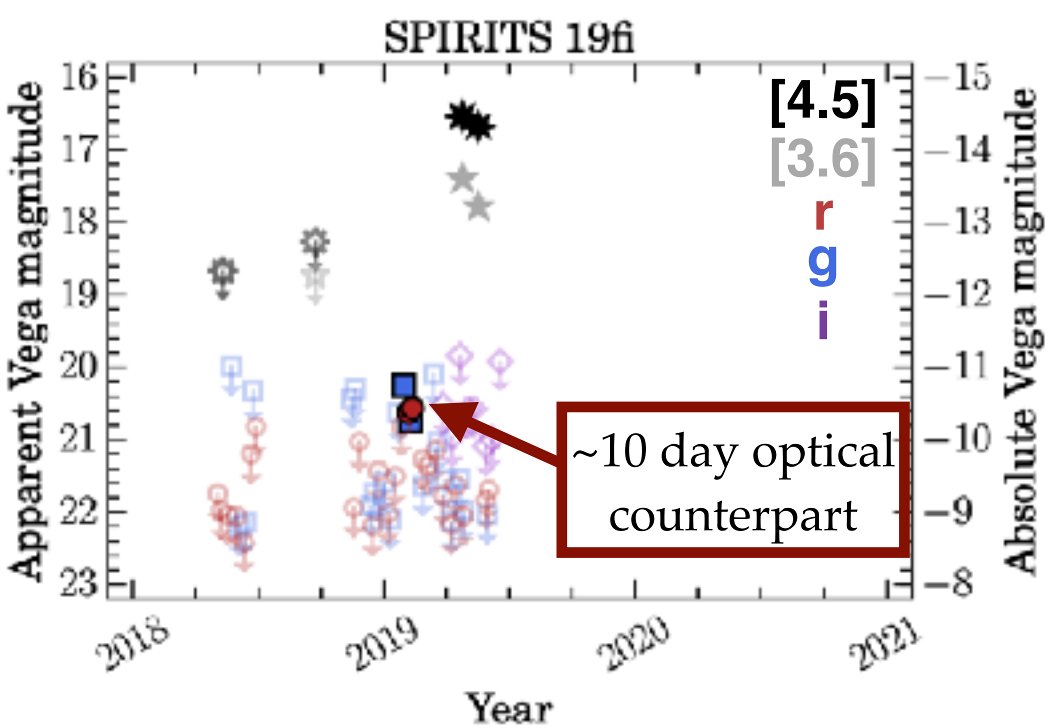
Molecules in LRN optical spectra:

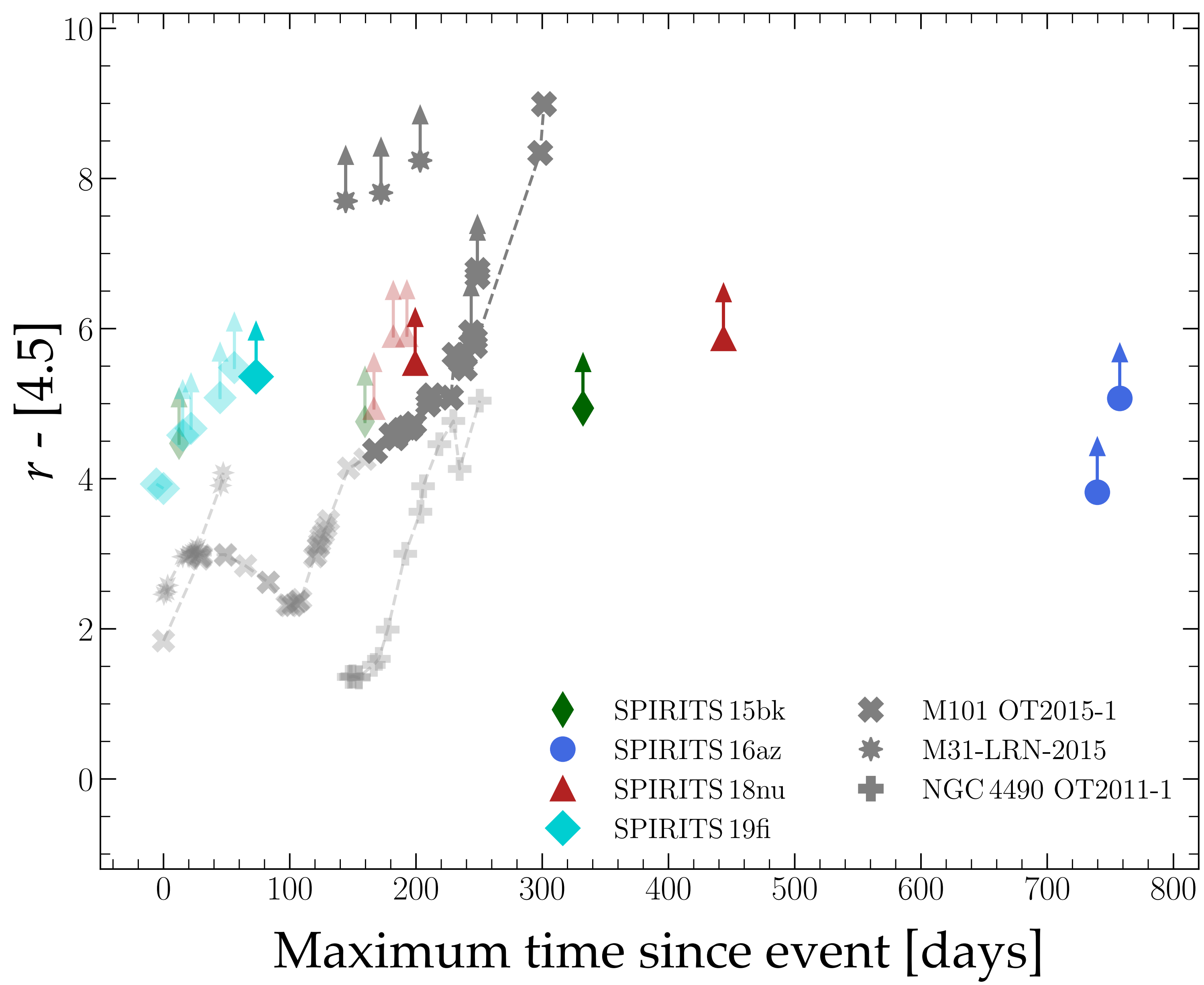


Pastorello+ 2019, see also Nadia's talk

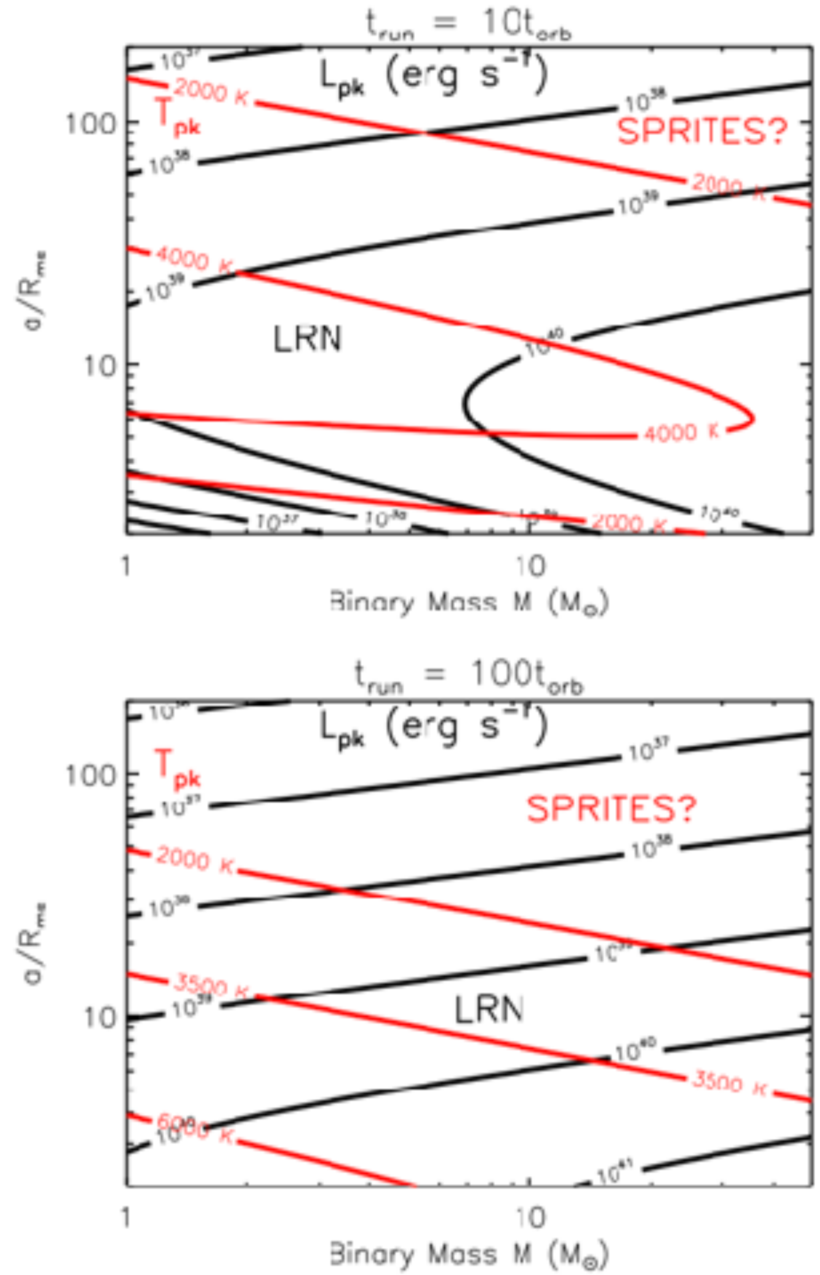
Deep optical constraints suggest rapid dust formation.







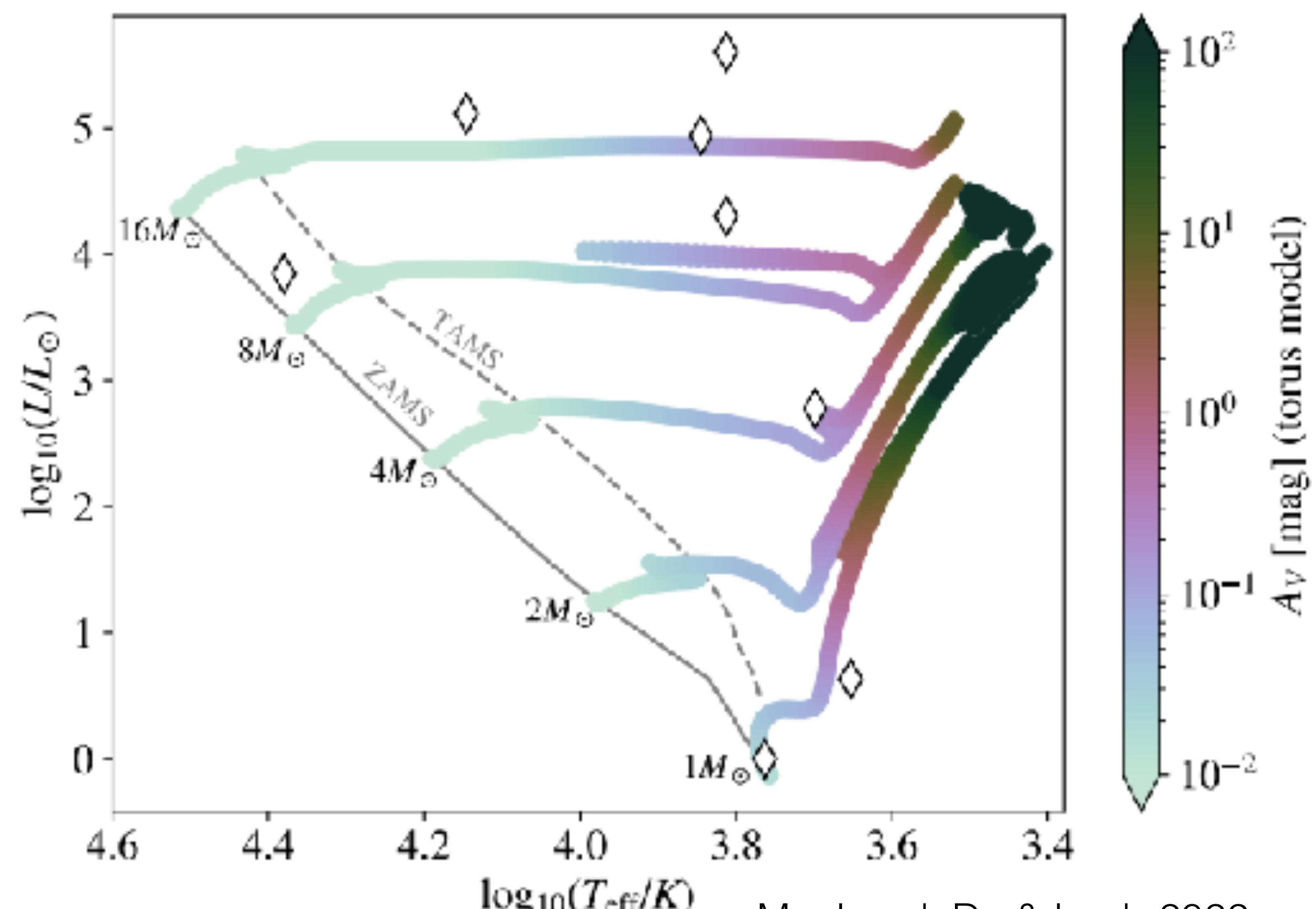
Which systems may produce SPRITEs?



Metzger & Pejcha 2017

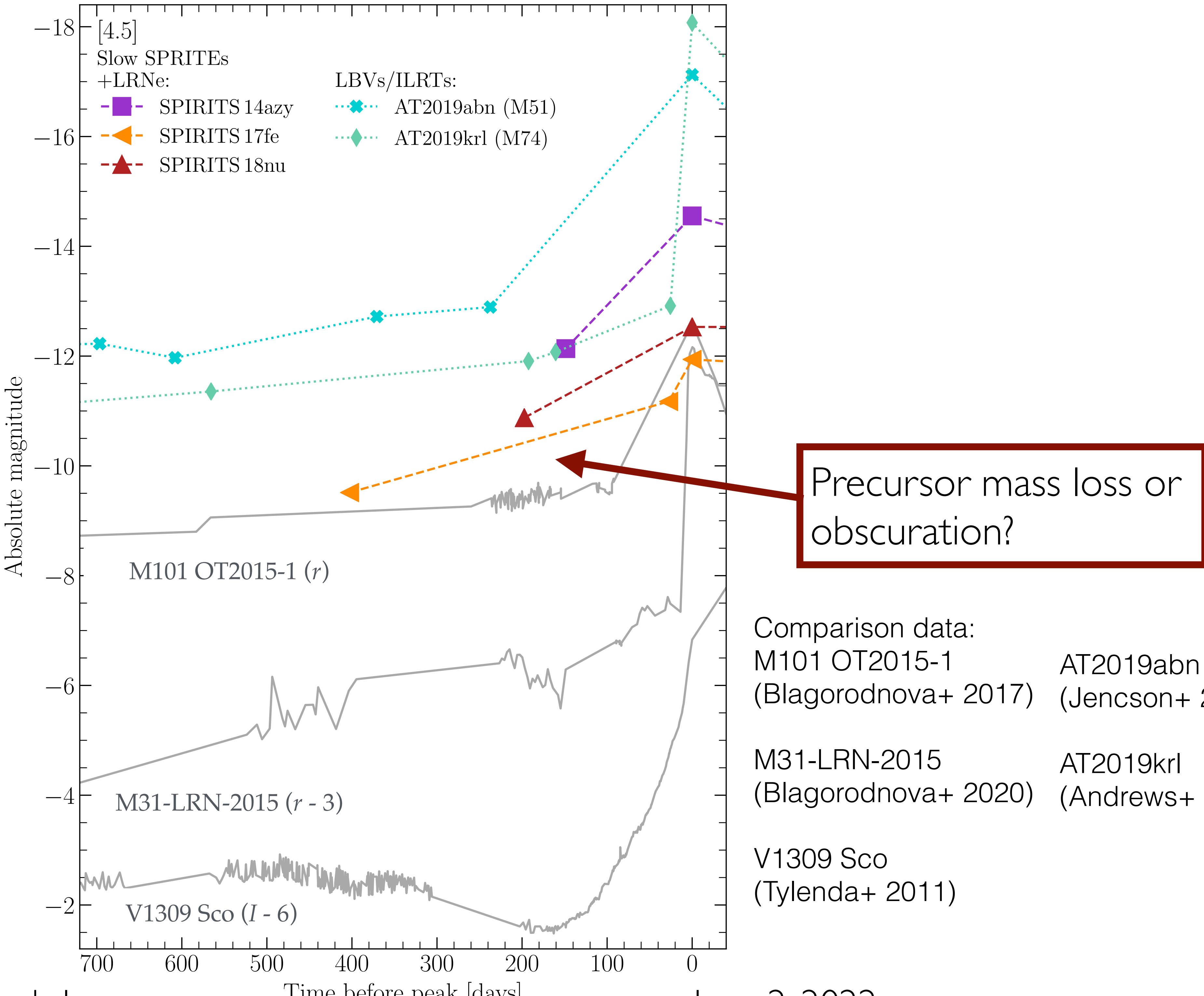
Weaker shocks in some systems may permit earlier dust formation.

Extended giants may be completely obscured by dust formation prior to coalescence.



MacLeod, De & Loeb 2022

Precursor emission may be ubiquitous in CE transients and other massive star outbursts.



Comparison data:

M101 OT2015-1 (Blagorodnova+ 2017)

M31-LRN-2015 (Blagorodnova+ 2020)

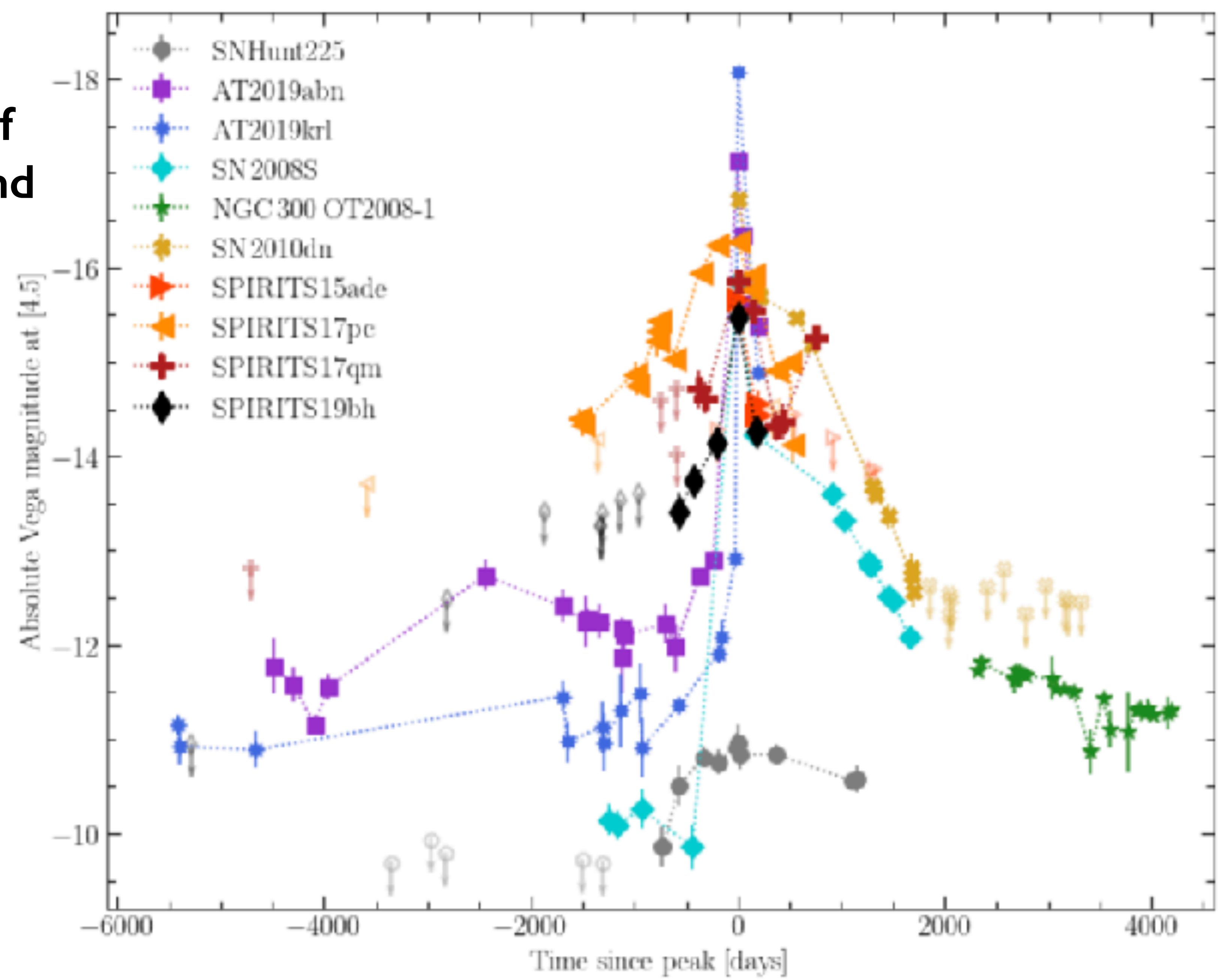
V1309 Sco (Tylenda+ 2011)

AT2019abn (Jencson+ 2019a)

AT2019krl (Andrews+ 2021)

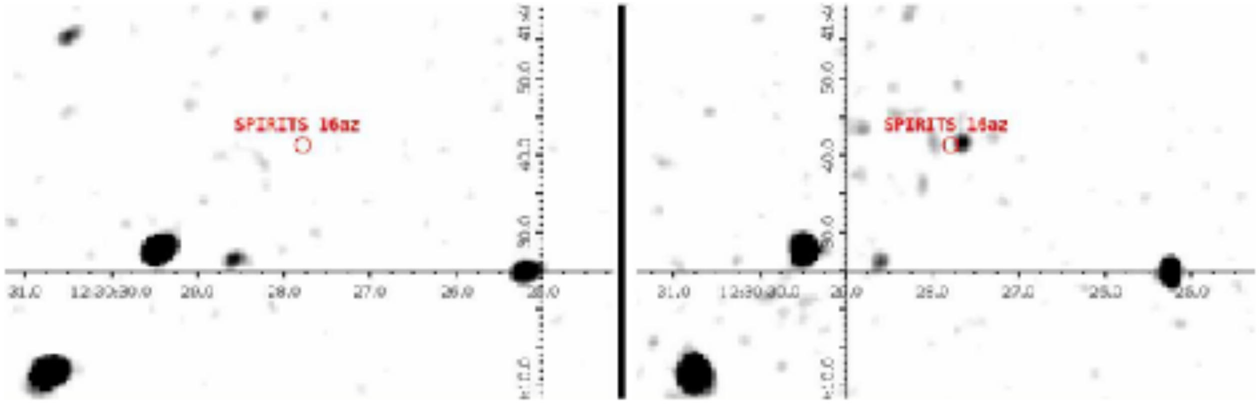
Precursor emission may be ubiquitous in CE transients and other massive star outbursts.

Spitzer light curves of LBV-like outbursts and ILRTs:



Searching for progenitors

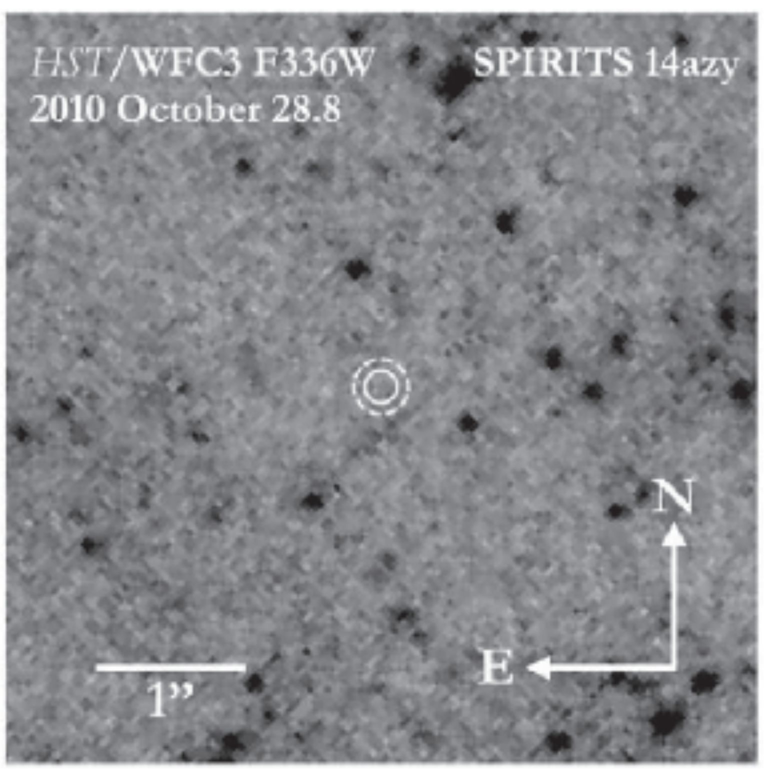
SPIRITS 16az



X-ray counterpart detected in Chandra imaging in 2000, gone in 2004.

CE event in a HMXB system?

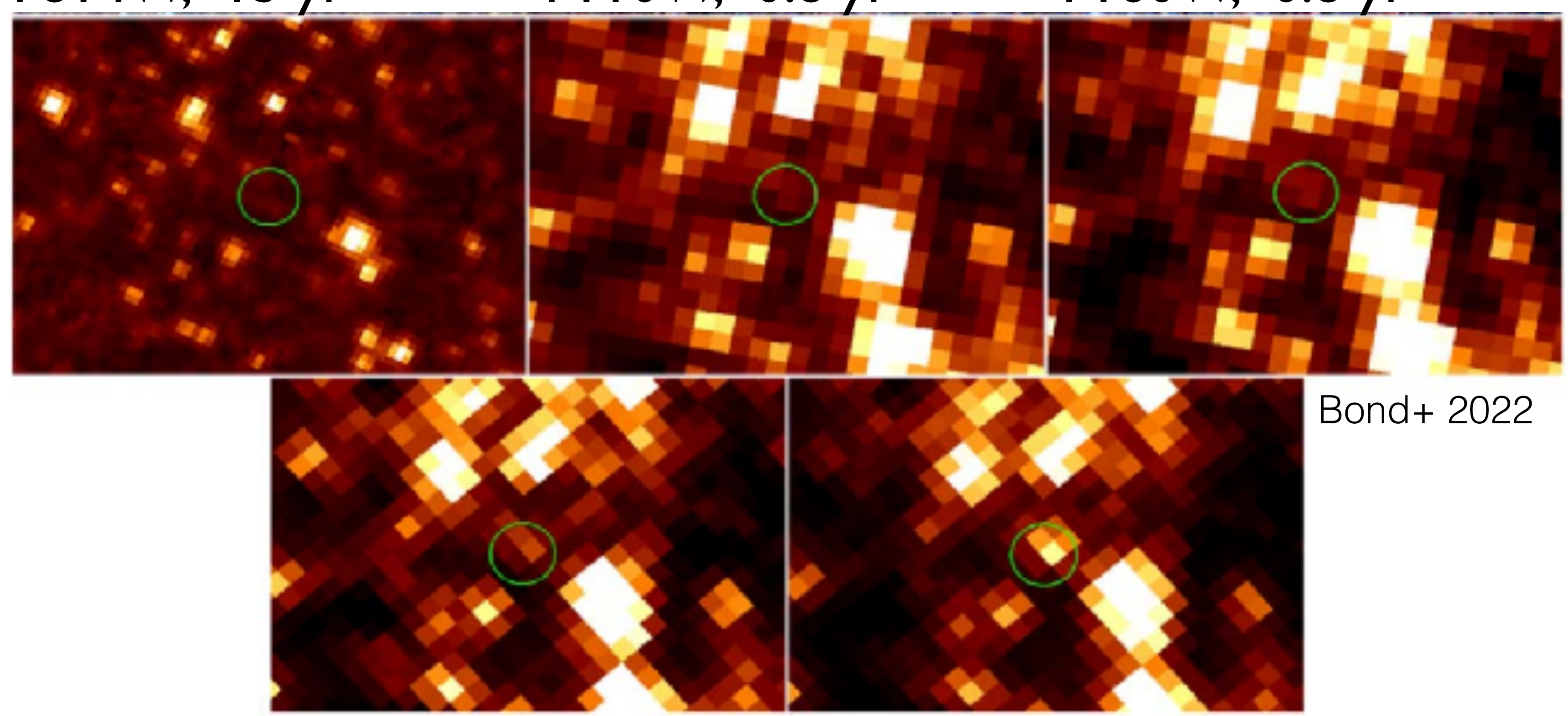
Oskinova+ 2019



Jencson+ 2019

SPIRITS 17fe

F814W, -13 yr F110W, -0.8 yr F160W, -0.8 yr



F110W, +0.8 years F160W, +0.8 years

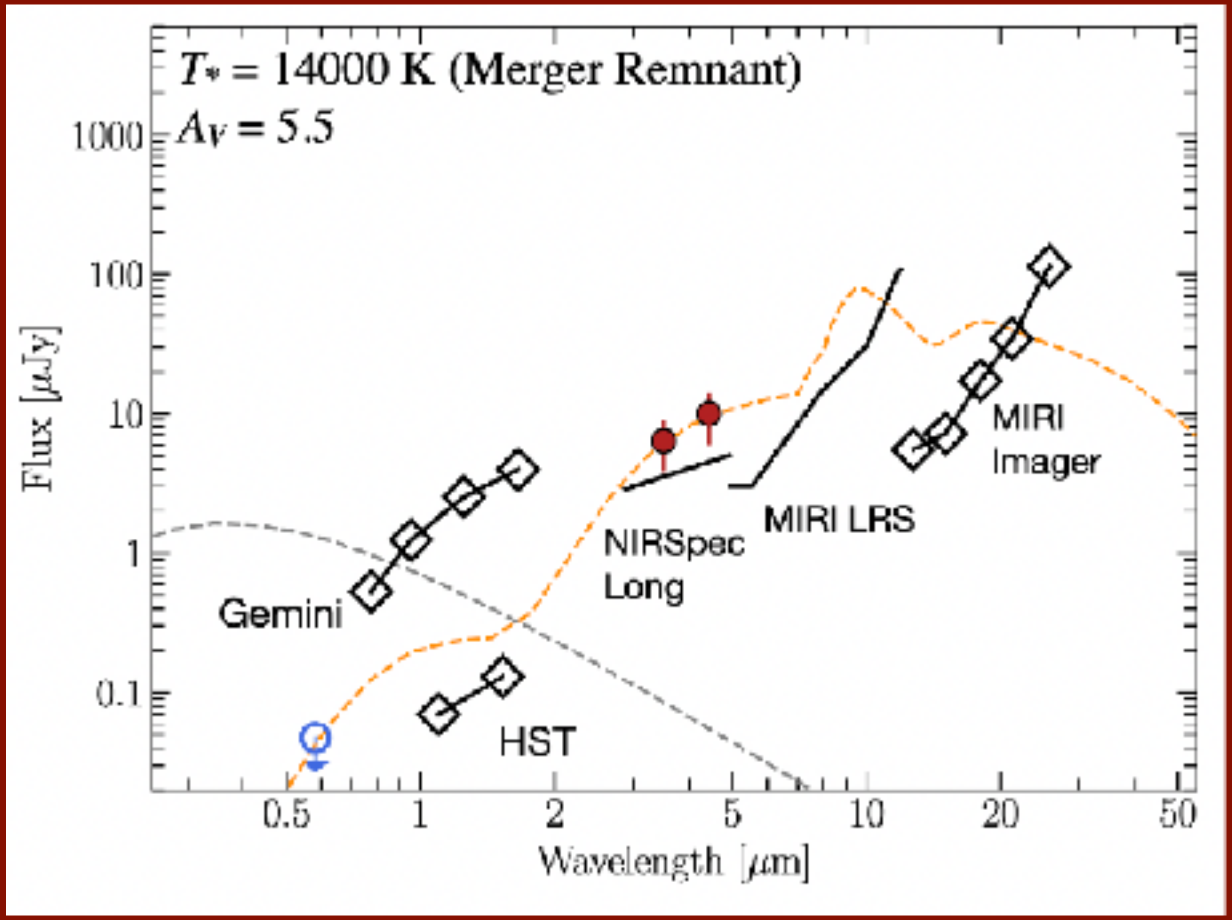
Bond+ 2022

What next?

JWST will soon offer new opportunities for mid-IR spectroscopy

- Approved GTO time (w/ PI M. Ressler) to observe SPIRITS transients

SPIRITS 18nu



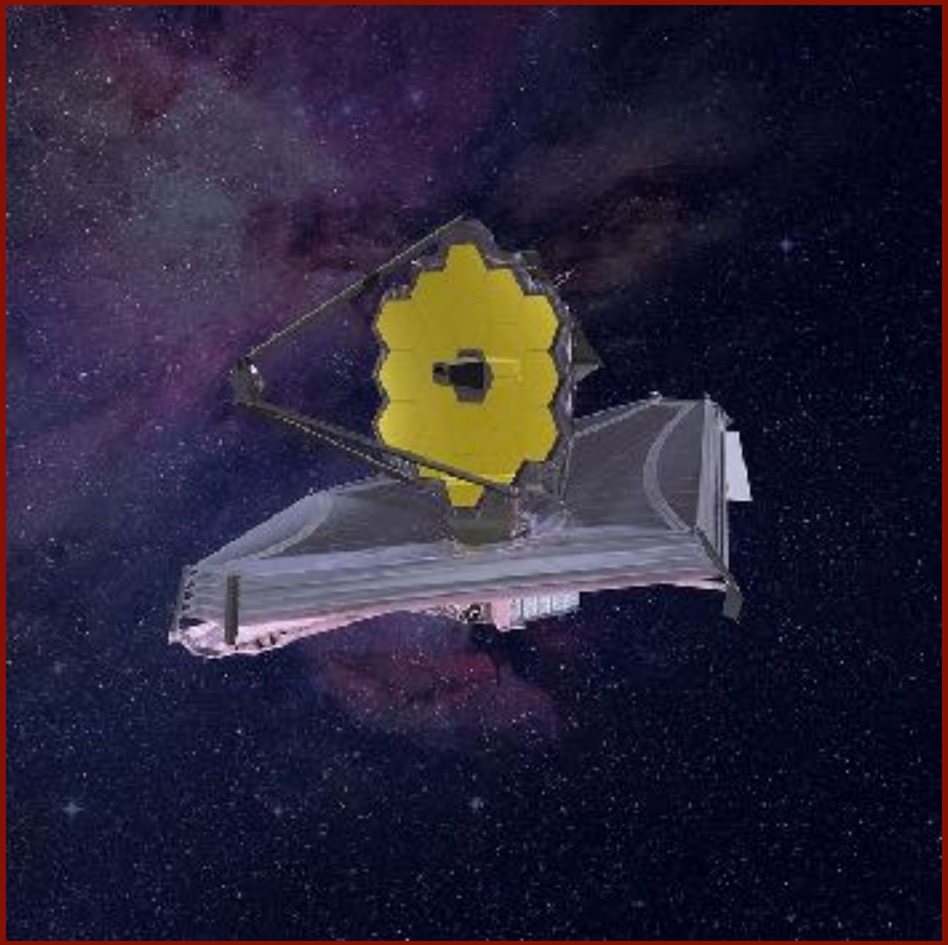
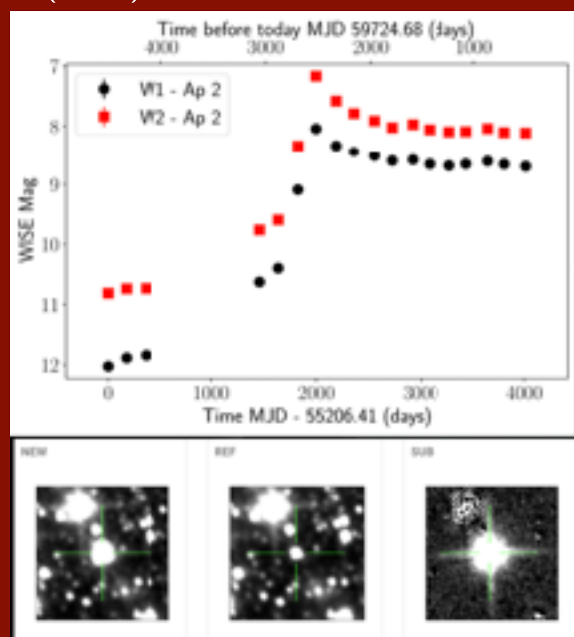


Image credit: Northrop Grumman

What next?

Ongoing and Upcoming IR searches

Mining NEOWISE for missed Galactic events:
Led by Kishalay De (MIT)



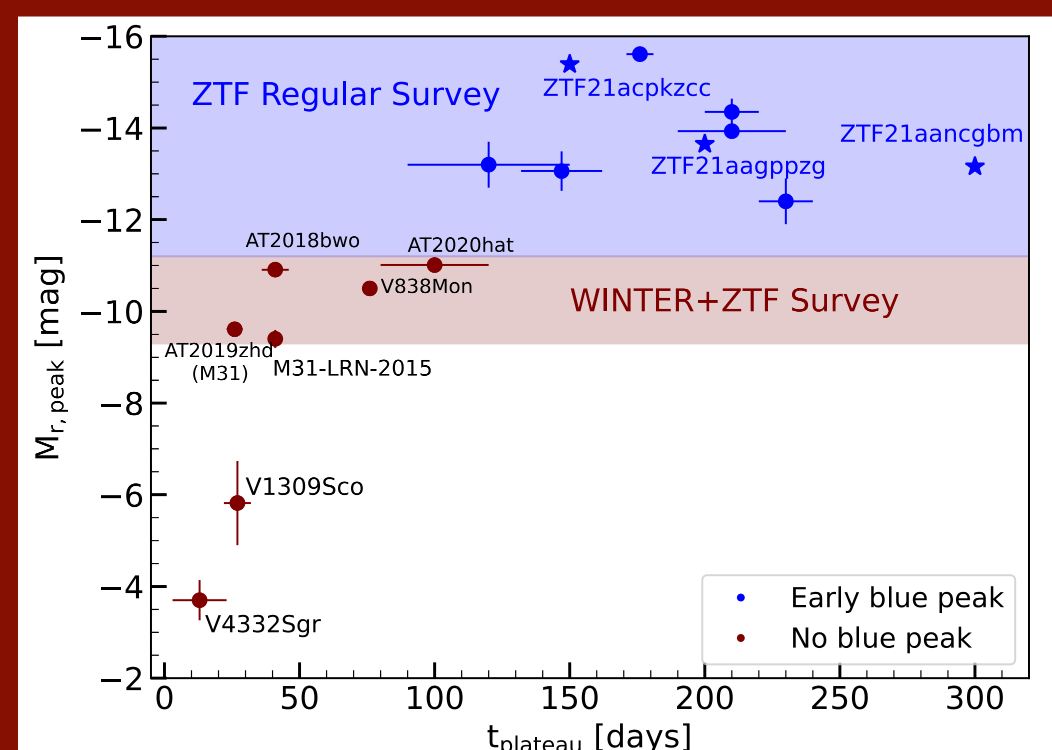
Transient Searches with Roman:

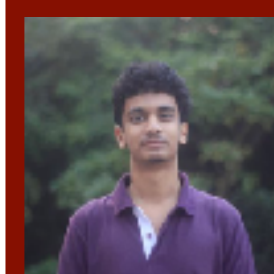
Rubin/LSST:
Deep optical modern (incl. red filters) will be sensitive to precursors and some obscured outbursts.

Ground-based searches:
WINTER (PIs Kasliwal, Simcoe)

- 1-meter telescope at Palomar
- All-sky J-band survey to 21 mag
- Search for obscured LRN (Karambelkar)

Also Gattini-IR (Palomar), DREAMS (Siding Spring)





Summary

Despite the ubiquity of IR emission in LRNe, the sample of well studied events have been primarily identified via their optical emission.

Over six years, SPIRITS conducted a first census of extragalactic transients in the IR.

A new class of transients called SPRITEs is generally consistent with some hallmark properties of luminous red novae, but whose optical counterparts are suppressed by dust formation.

Questions & Discussion Topics

What are the progenitors of SPRITEs and what set of common-envelope systems might they probe?

What can be learned from studying their remnants (Tomasz Kaminski talk tomorrow) and environments?

What is the nature of the IR precursor emission?

How can the IR help us disentangle the zoo of transients? What can we learn from IR spectroscopy with *JWST*?

-What can the molecular and dust properties of the ejecta tell us about the progenitors?