The luminosity gap

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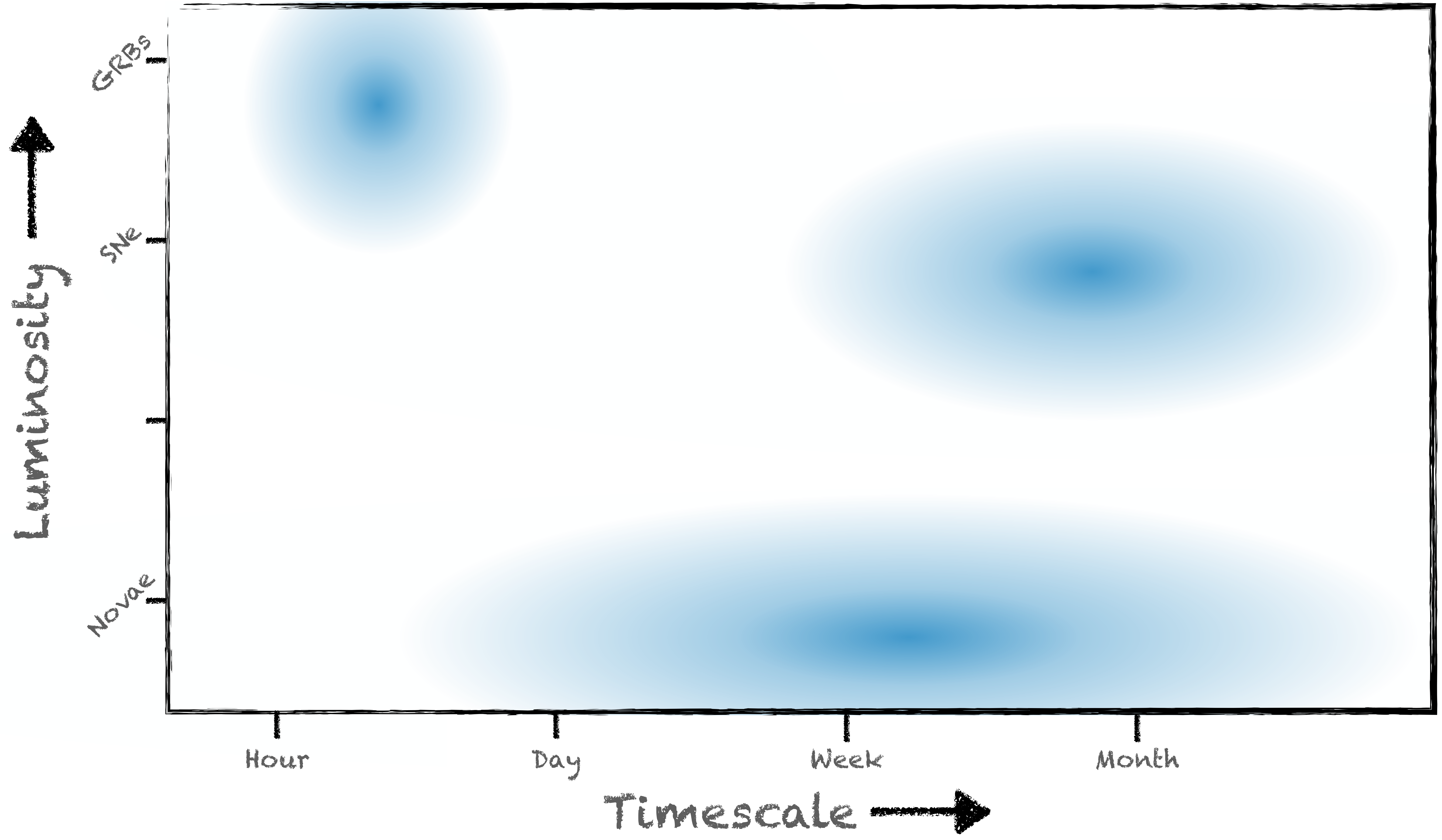
Image: ESO / Gender / Colombari

The luminosity gap



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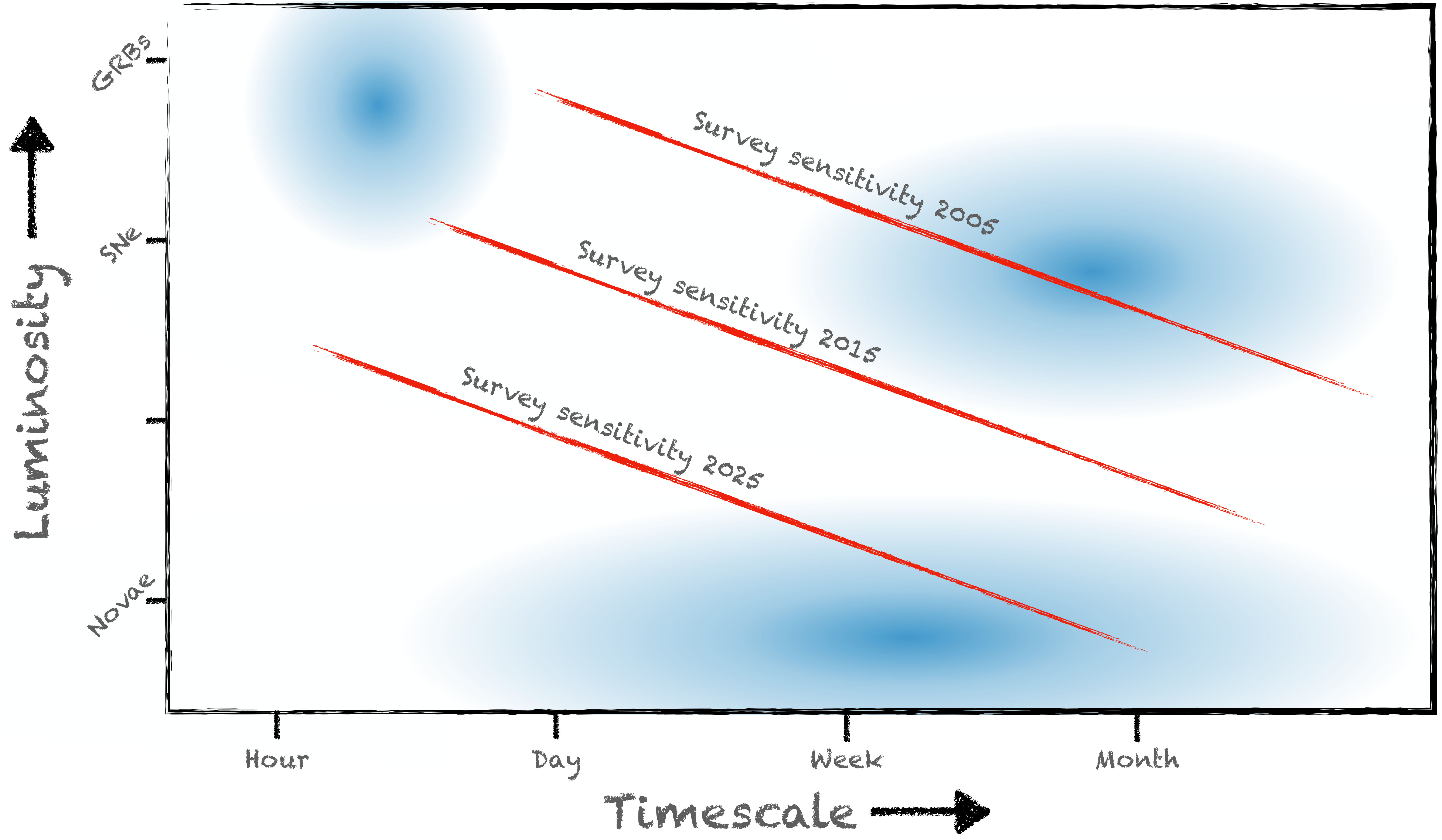

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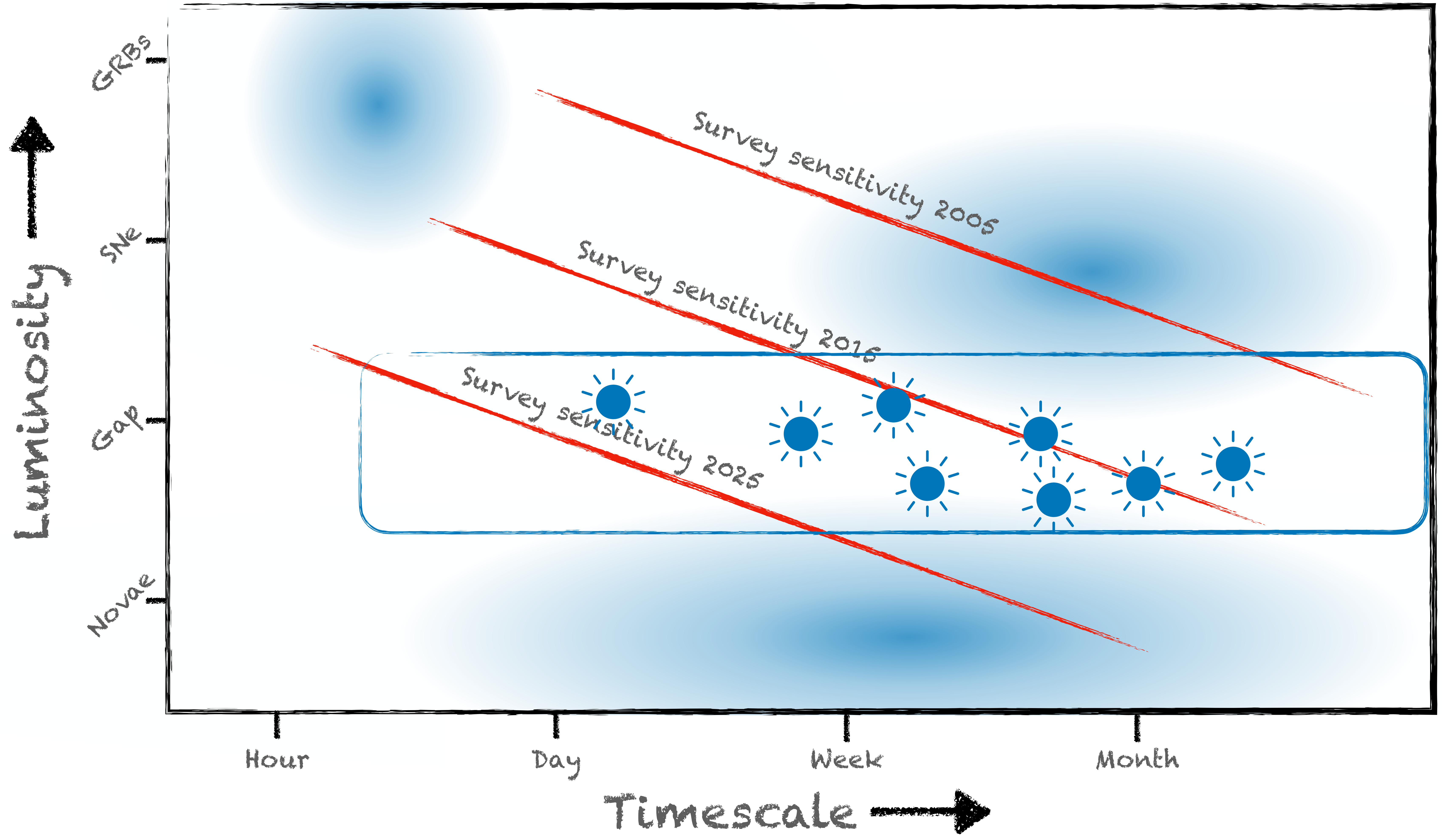
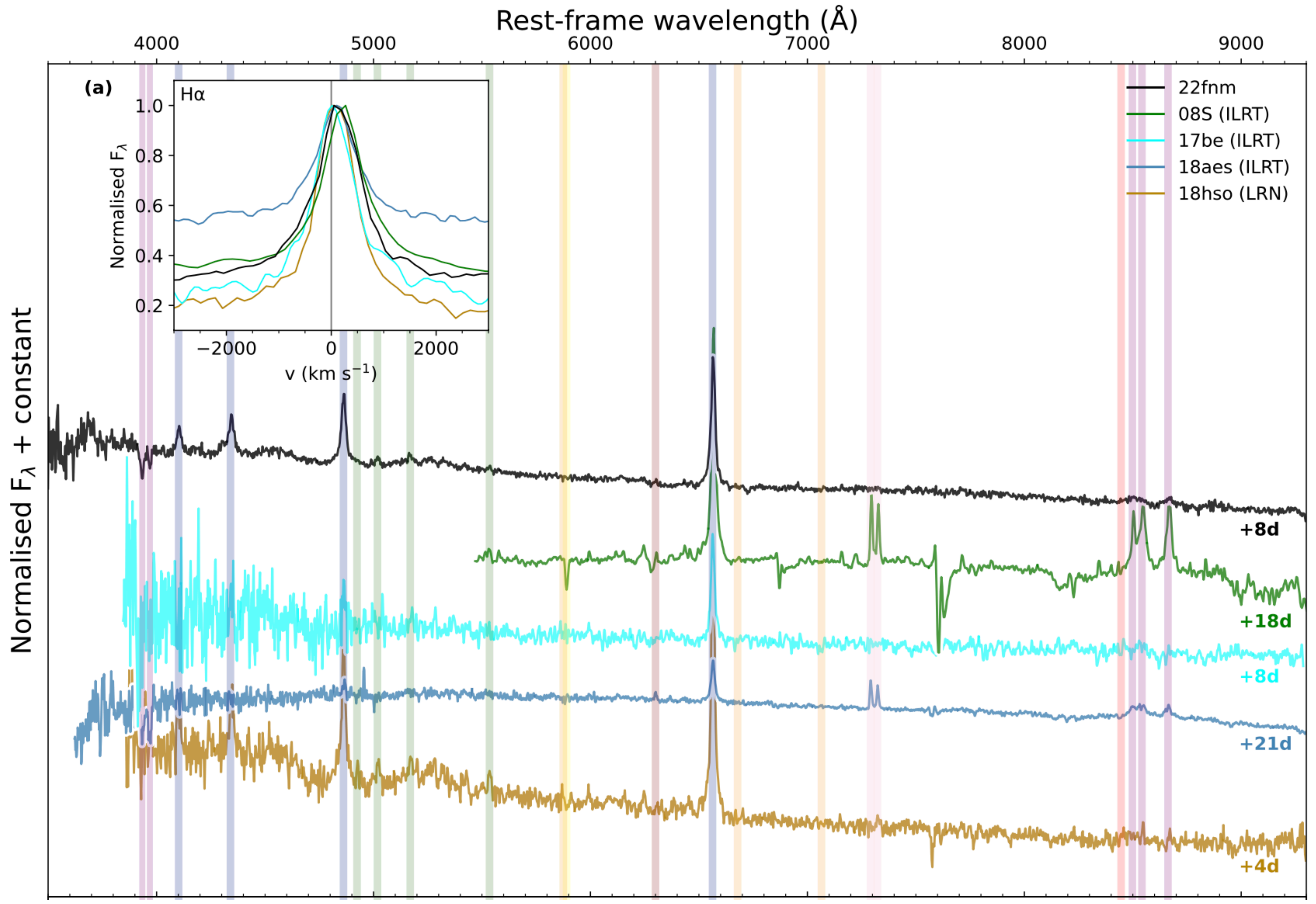


Spectroscopy

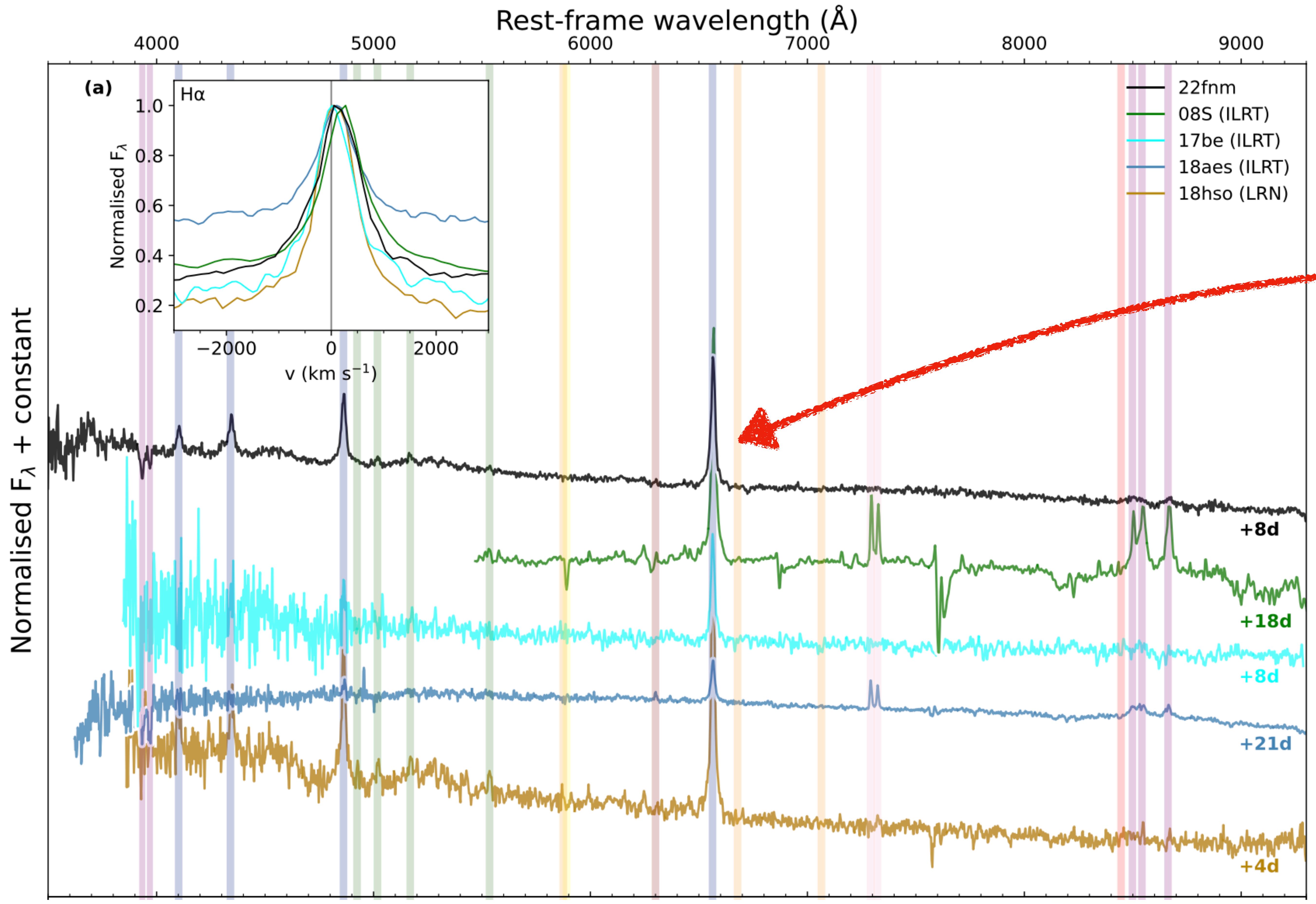


Moran+ 2024

Narrow emission lines (v<1000 km/s)

Dominated by H, sometimes Ca and other narrow lines

Spectroscopy



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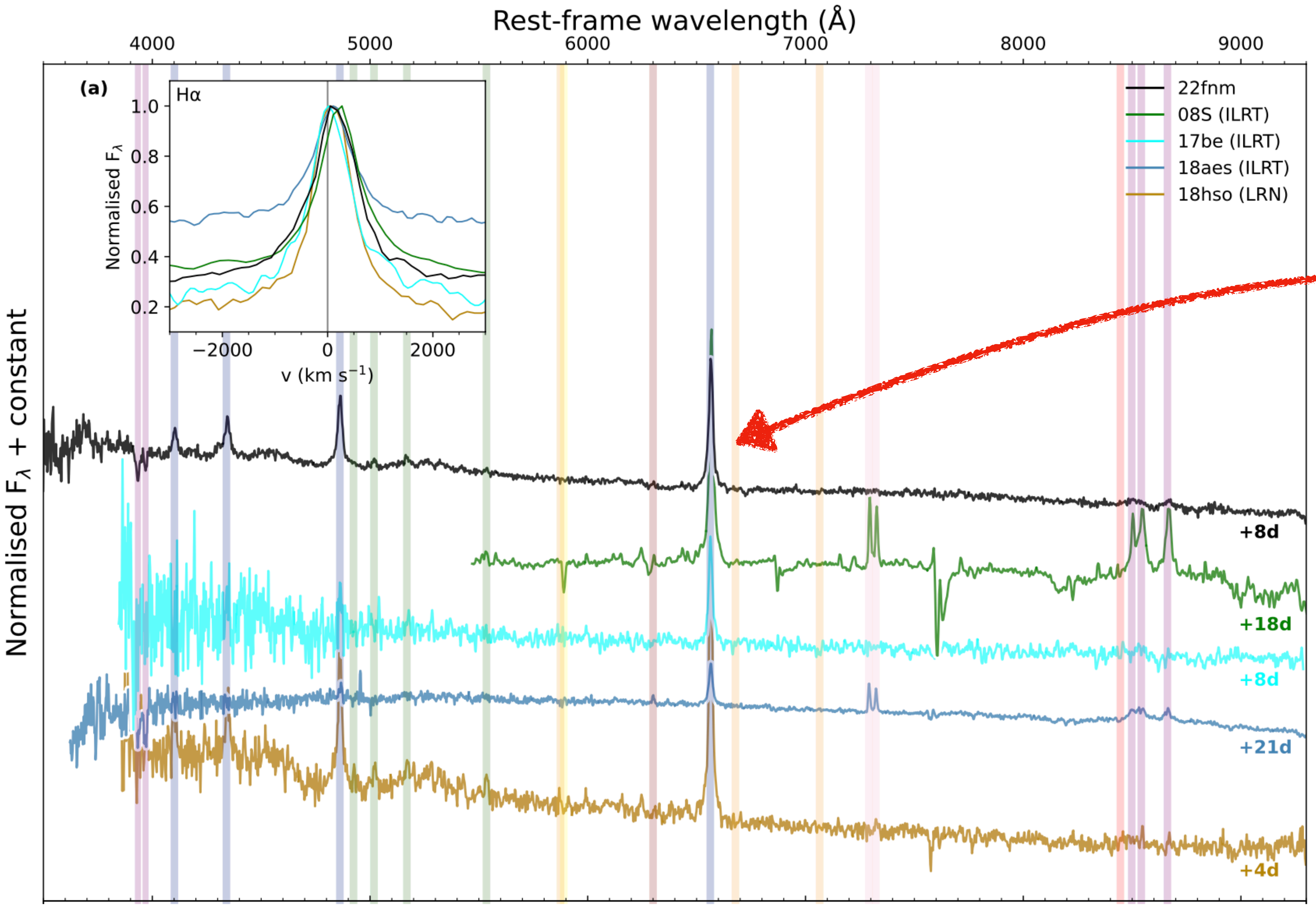

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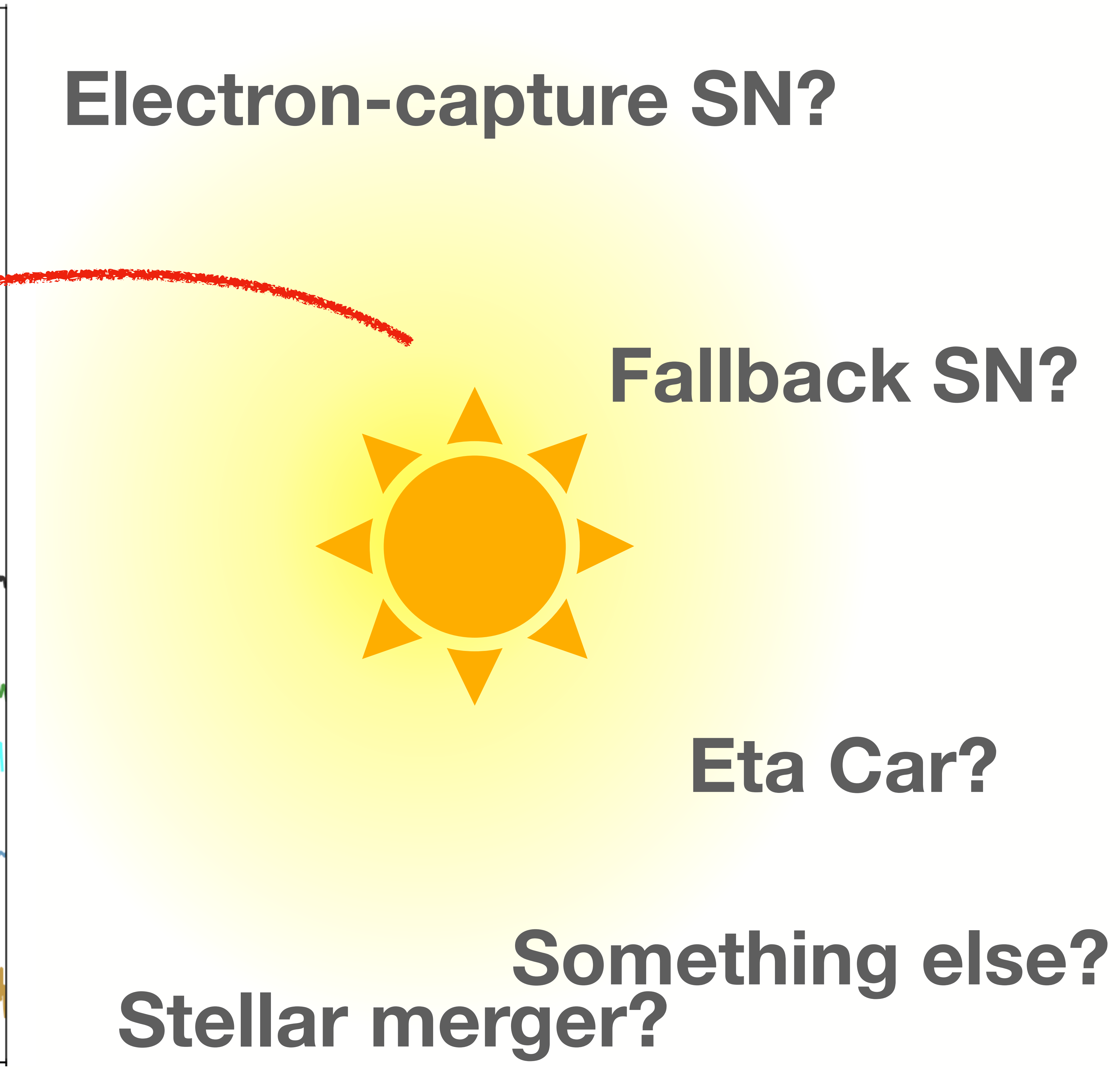
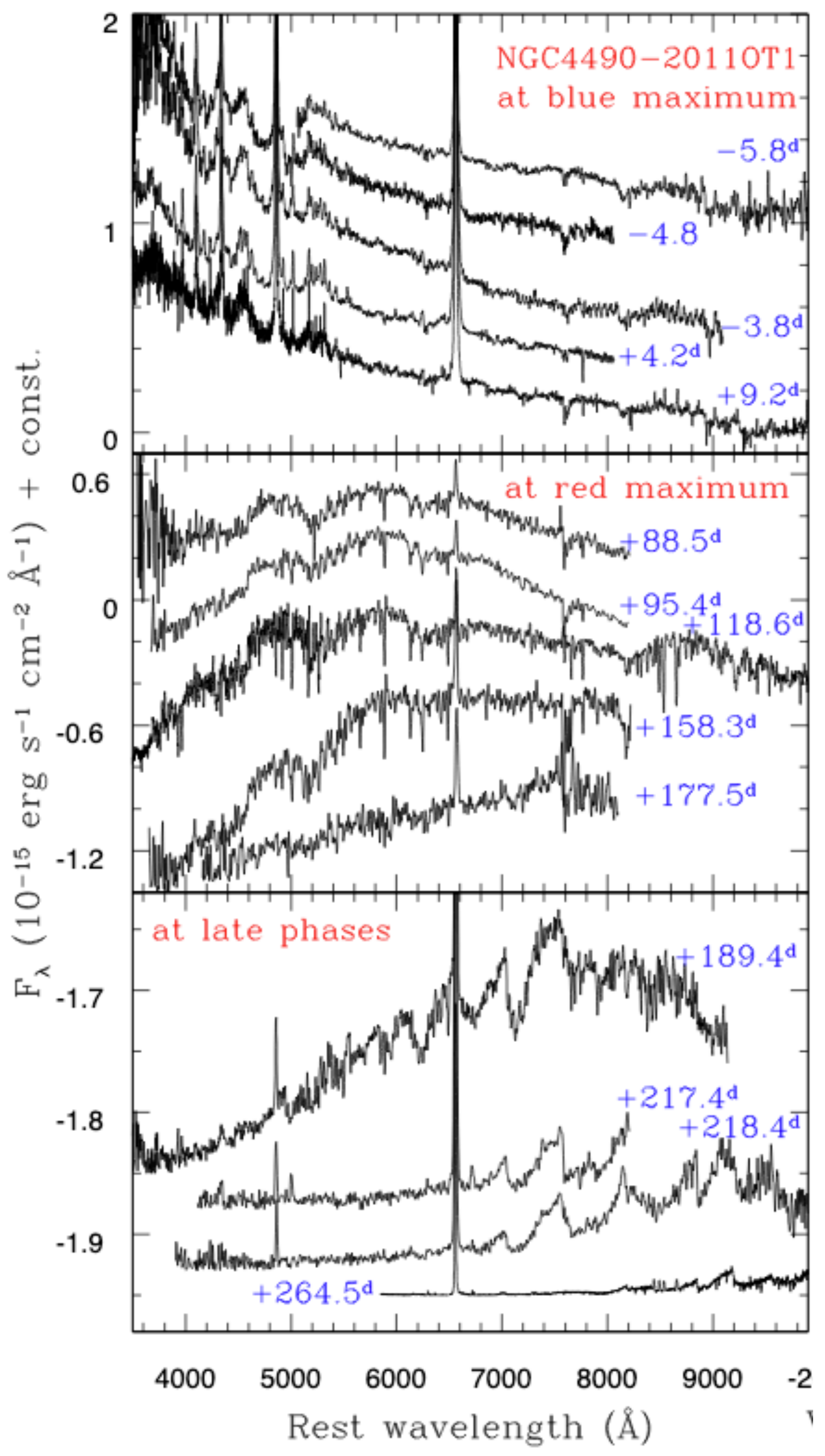
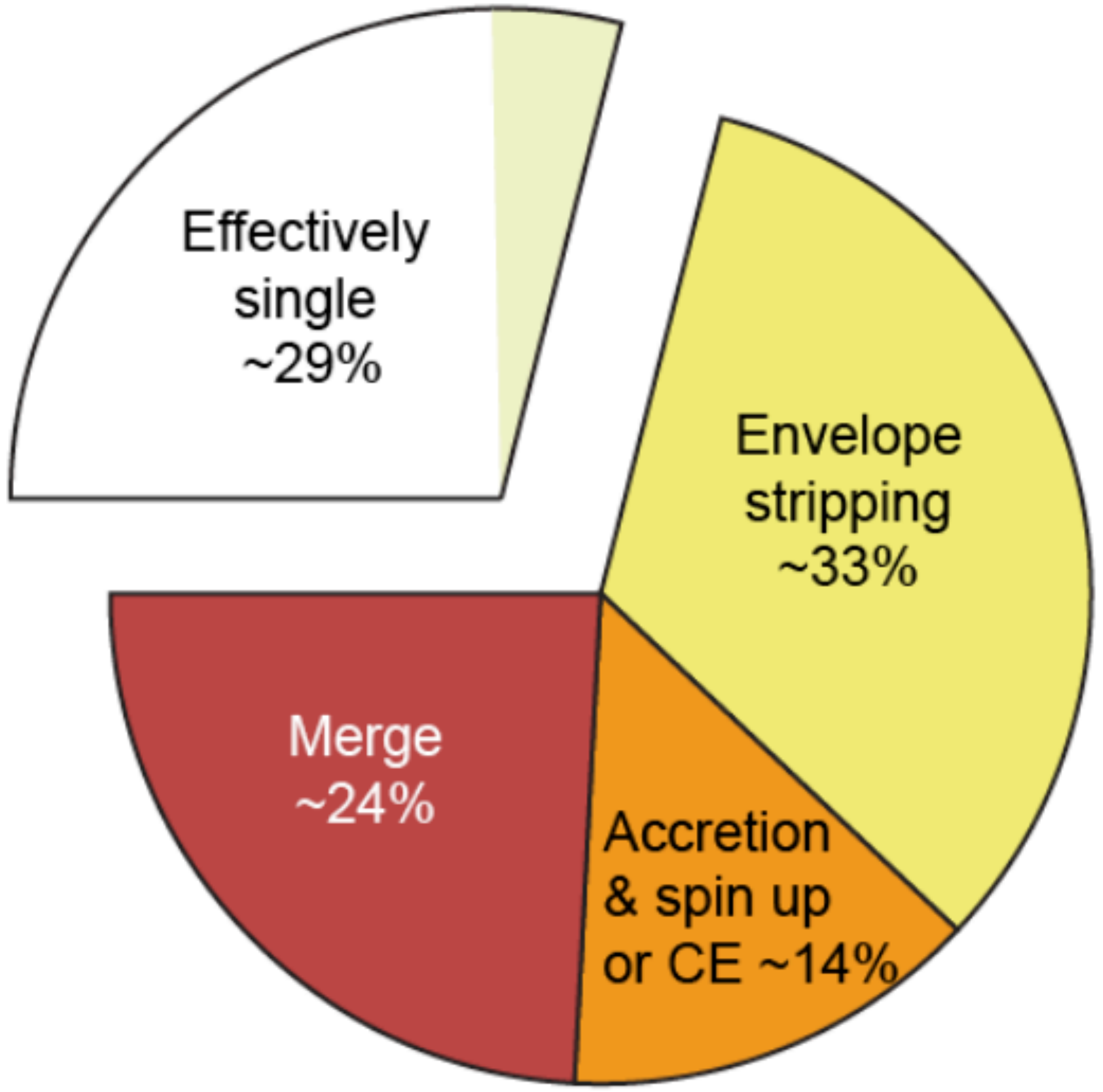


Luminous Red Novae

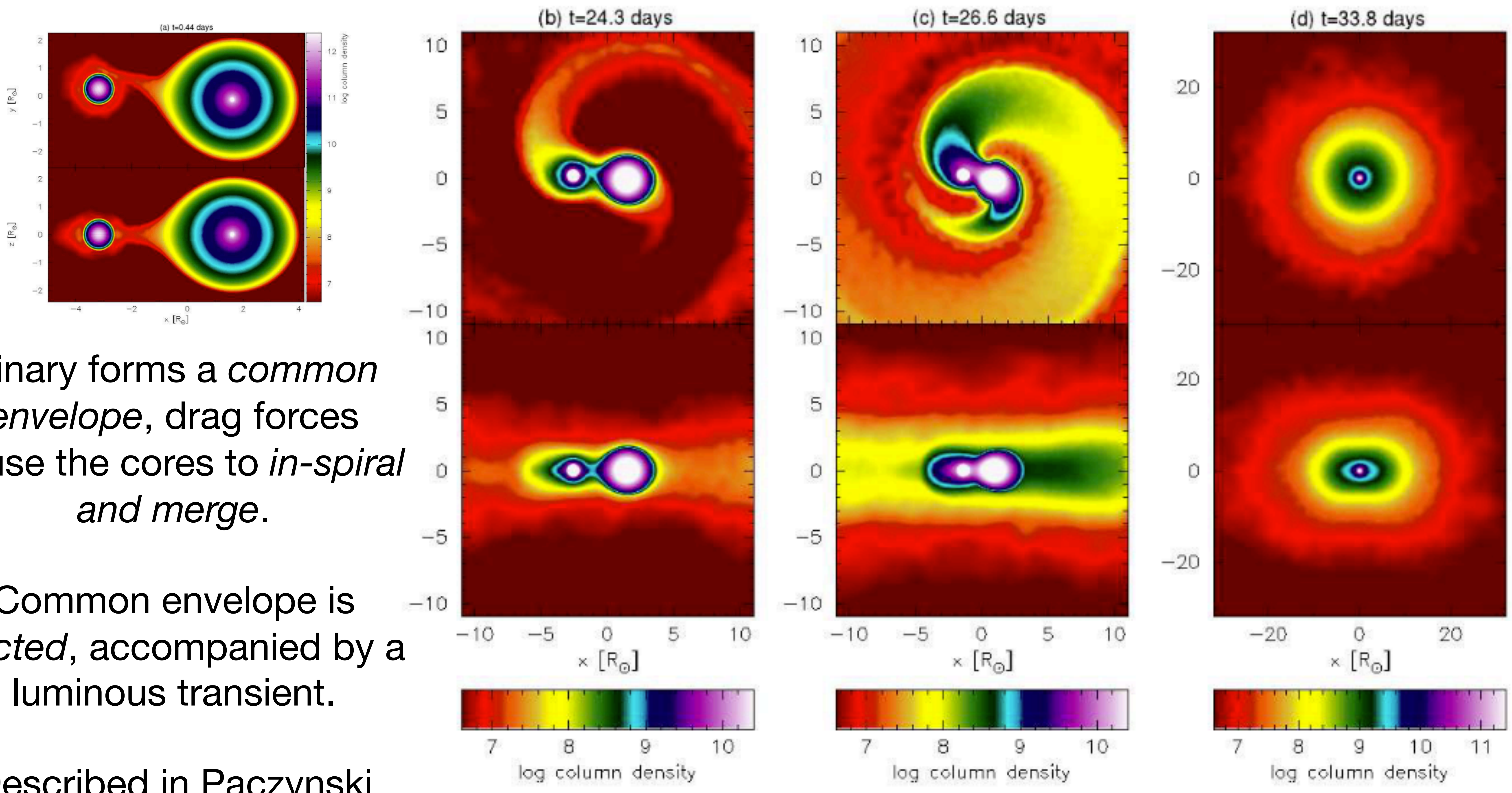


Massive star binaries



Sana et al. (2012)

What happens when they merge?



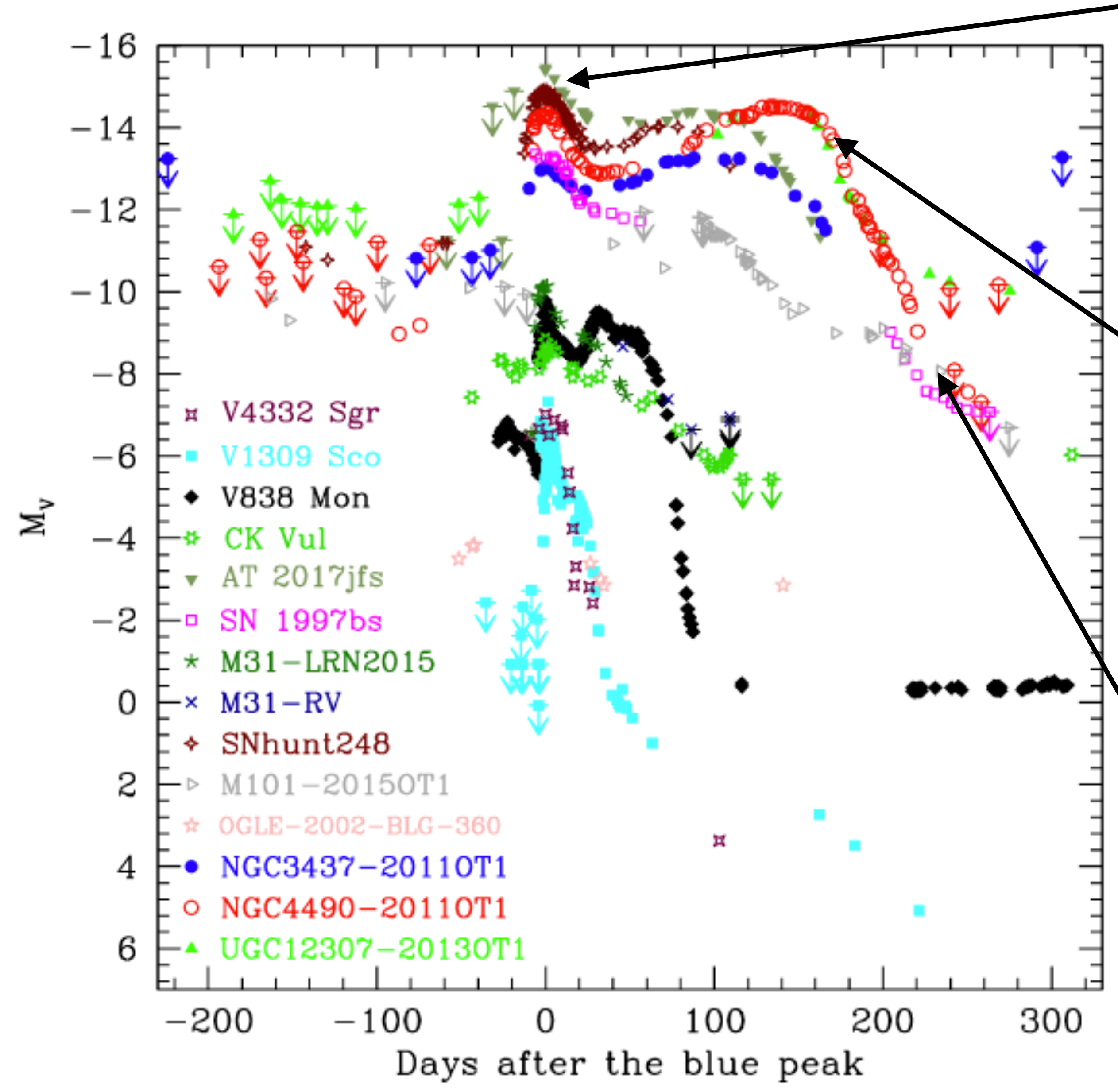
Binary forms a *common envelope*, drag forces cause the cores to *in-spiral and merge*.

Common envelope is *ejected*, accompanied by a luminous transient.

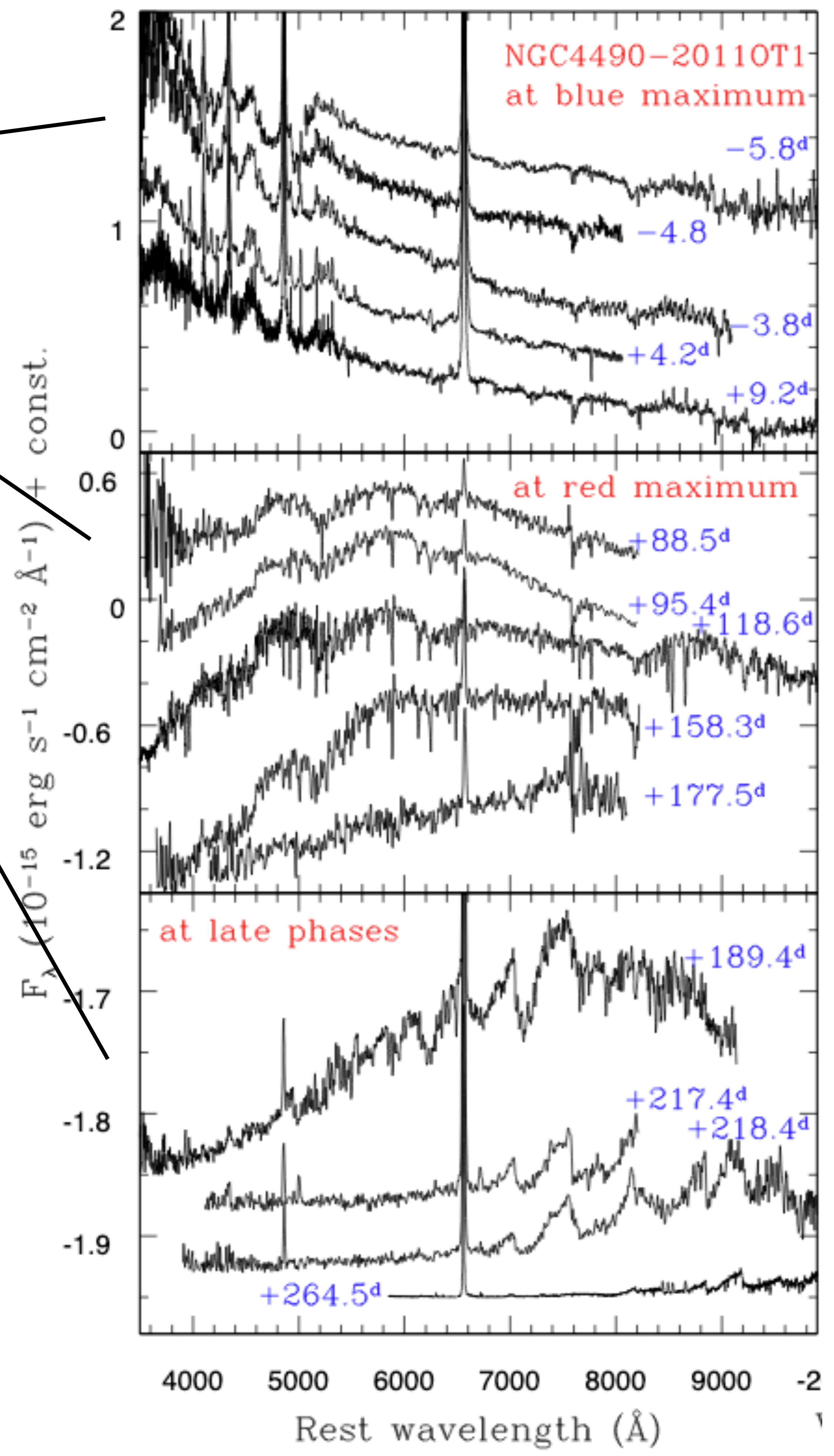
Described in Paczynski (1976), Iben & Livio (1993)

Ivanova et al. (2013)

Luminous Red Novae



Pastorello (incl. MF) et al. (2019)



Hot and blue
Ejection of envelope? Shock heating of (common) envelope

Cooler, narrow metal lines
Recombination powered? Interaction of ejecta with equatorial wind? Merger of cores?

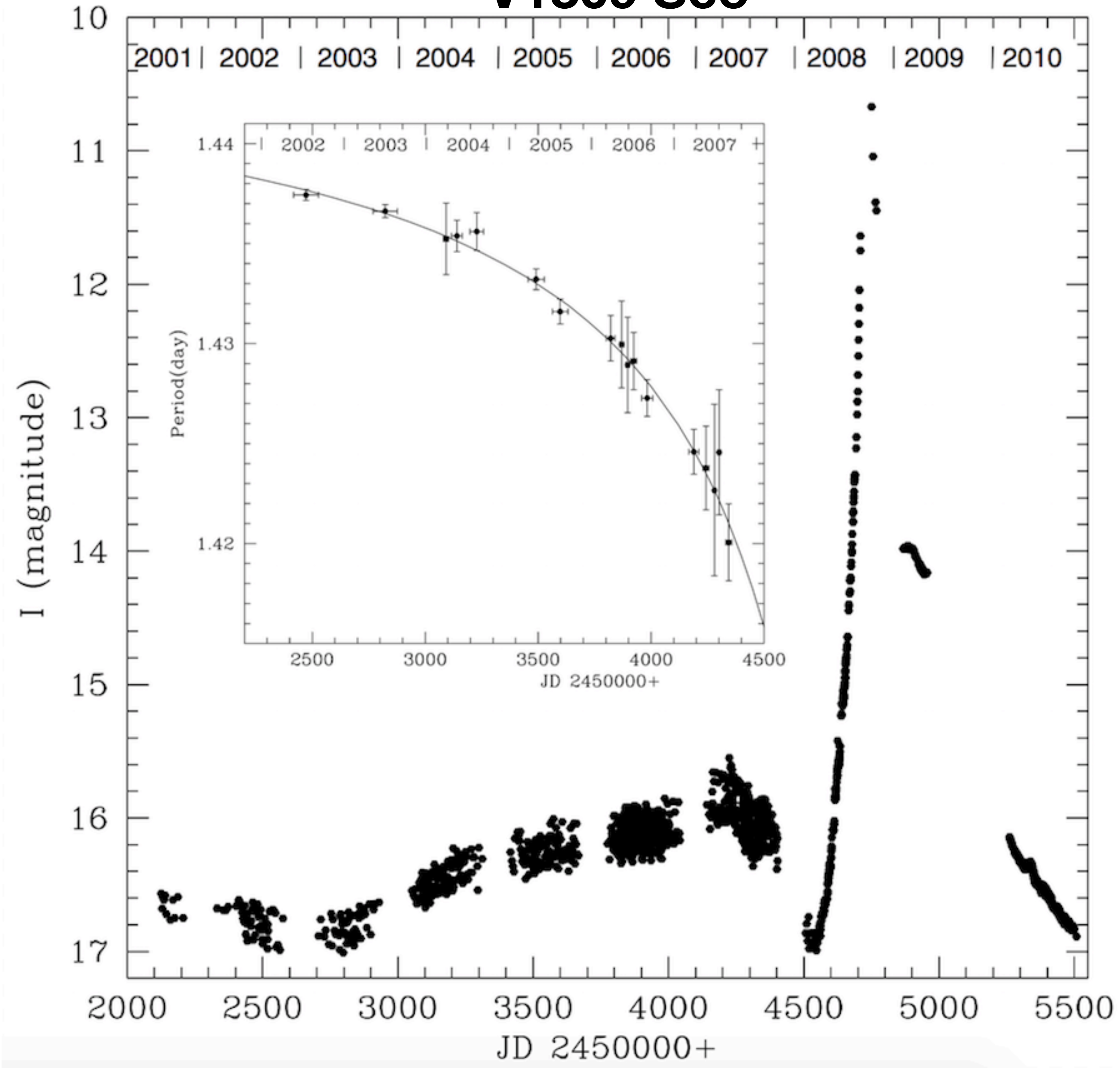
Cool, molecular bands
Surviving merger product?

Modeling and theory discused in many papers, including Pejcha et al. (2014, 2016, 2017), MacLeod et al. (2017), Metzger & Pejcha (2017), Lipunov et al. (2017), Tylenda et al. (2011), Nandez et al. (2014)

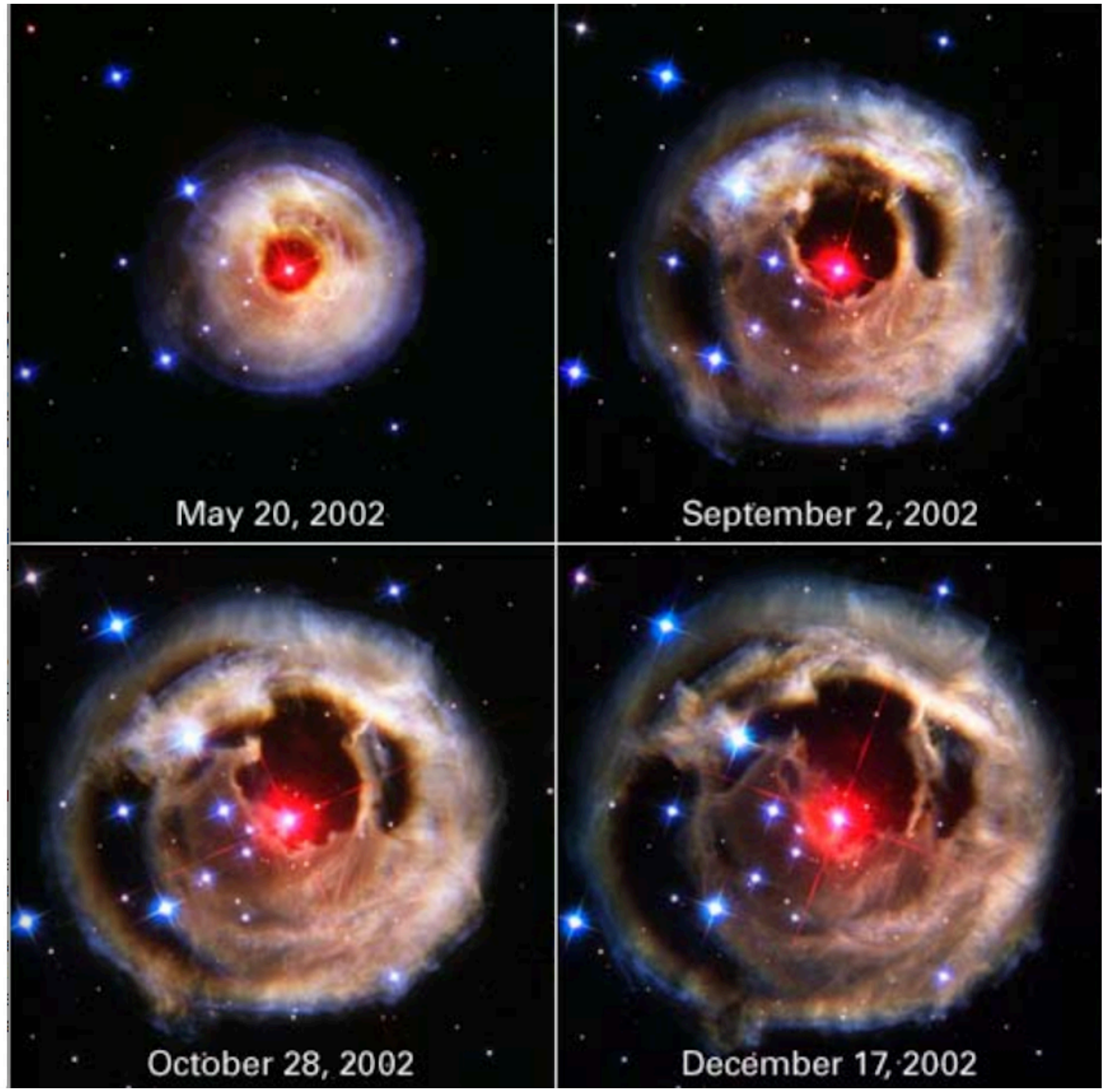
Mergers in the MW

Tylenda et al. (2011)

V1309 Sco



V838 Mon



Bond (2003)

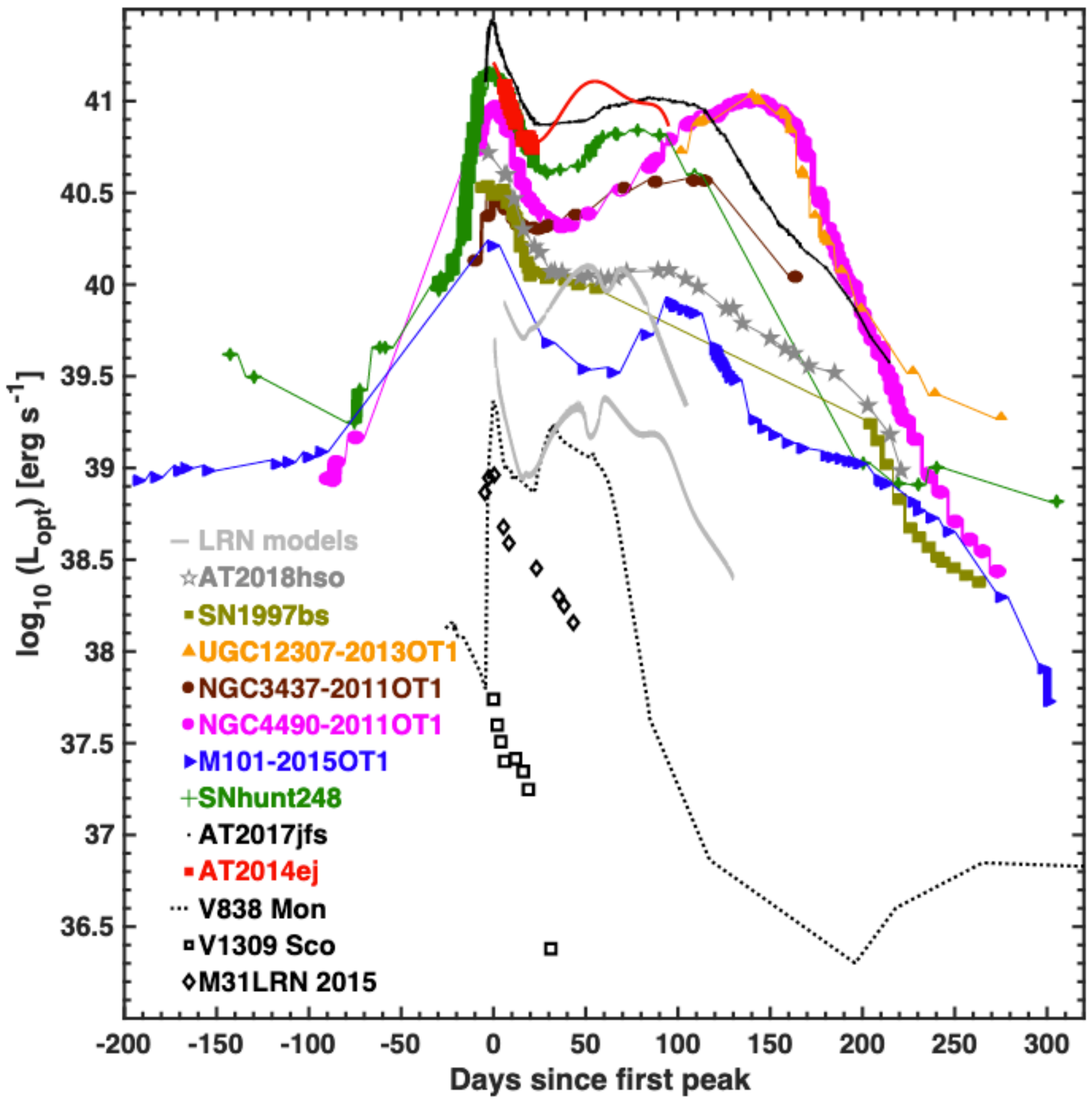
Other indirect evidence in MW - for example existence of blue stragglers...

Luminous Red Novae

Mergers compared to some models (light grey lines) from Metzger & Pejcha (2017). The models are for 10 and 30 M systems and are a factor 10 - 100 fainter than most observed mergers and a factor ~2 too rapid!

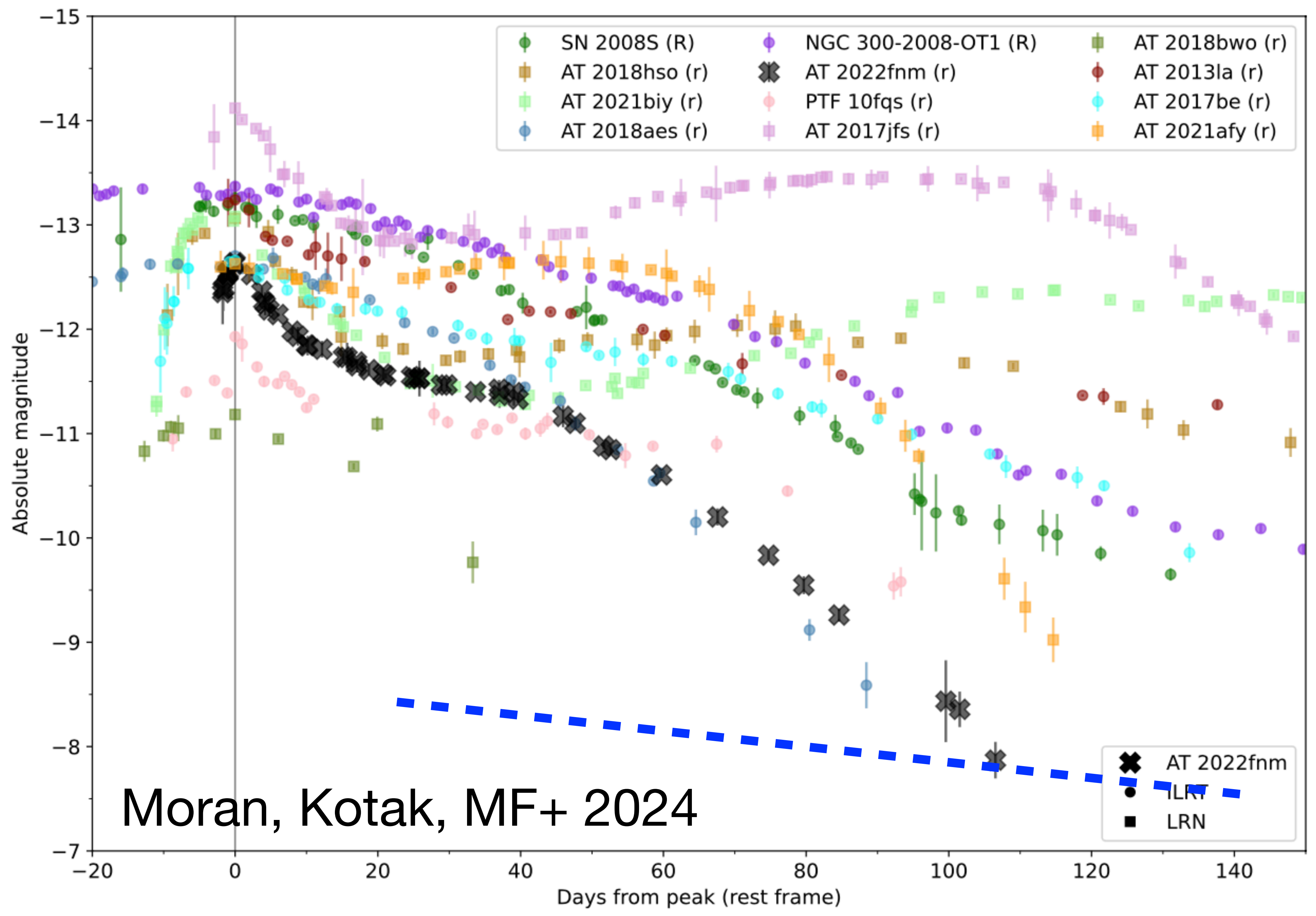
Much work to be done…

- What is value of α_{CE}
- What is the geometry? (too faint for specpol)
- How can we distinguish them from other gap transients?
- Can mergers trigger CCSNe?
- Progenitor luminosity and peak absolute magnitude correlation slope shallower than predicted by theory ($\propto M^{0.5}$; Metzger & Pejcha 2017)



Stritzinger, Taddia, MF et al. (2020)

Intermediate Luminosity Red Transients (ILRTs)



Probably electron capture SNe in ~8 $M_\odot$ stars (see work by Botticella et al. 2009 on prototypical SN2008S)

Less than 10^{-4} $M_\odot$ of Ni produced

See also work by Adams et al. 2016; Valerin et al. 2024

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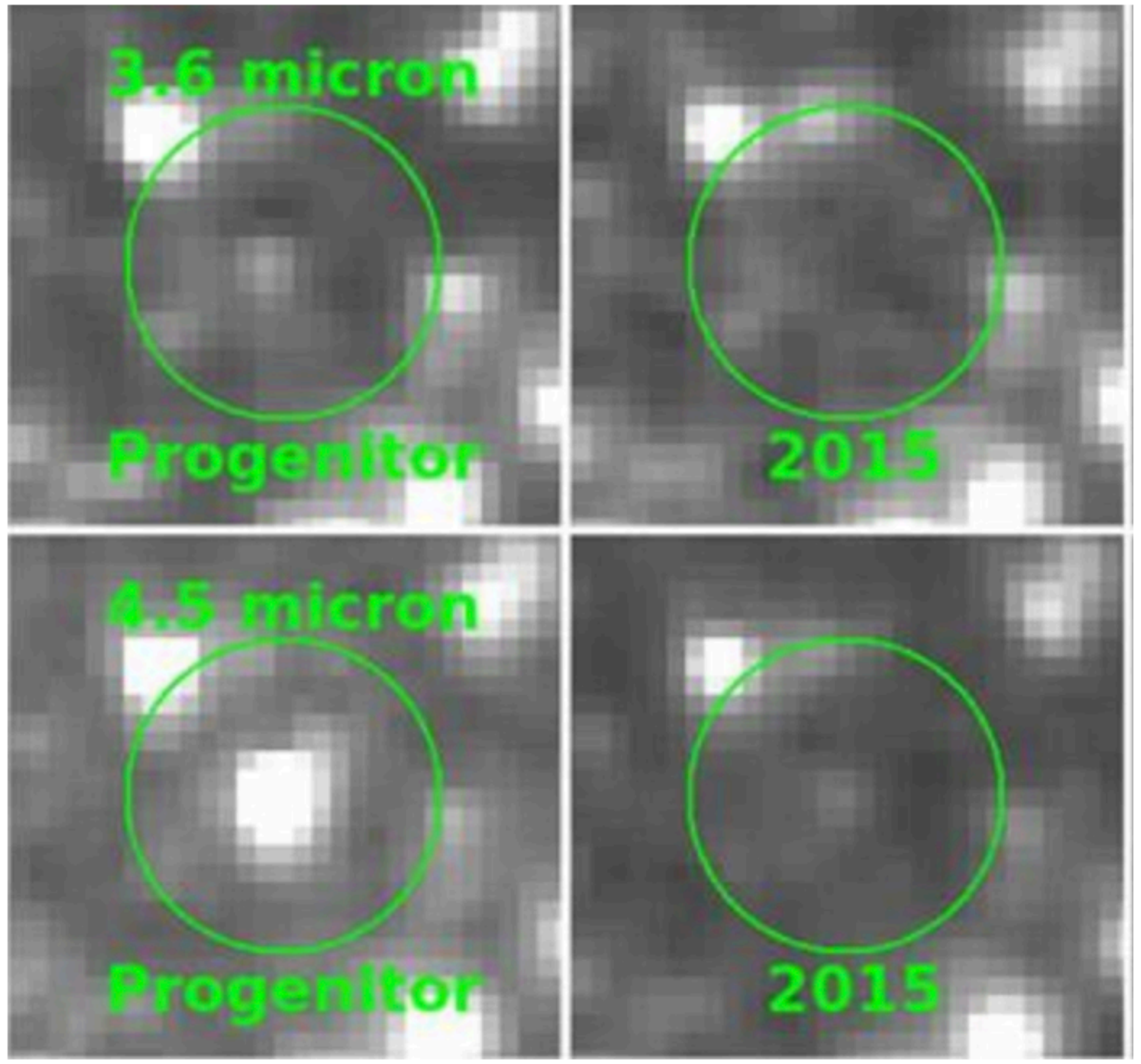
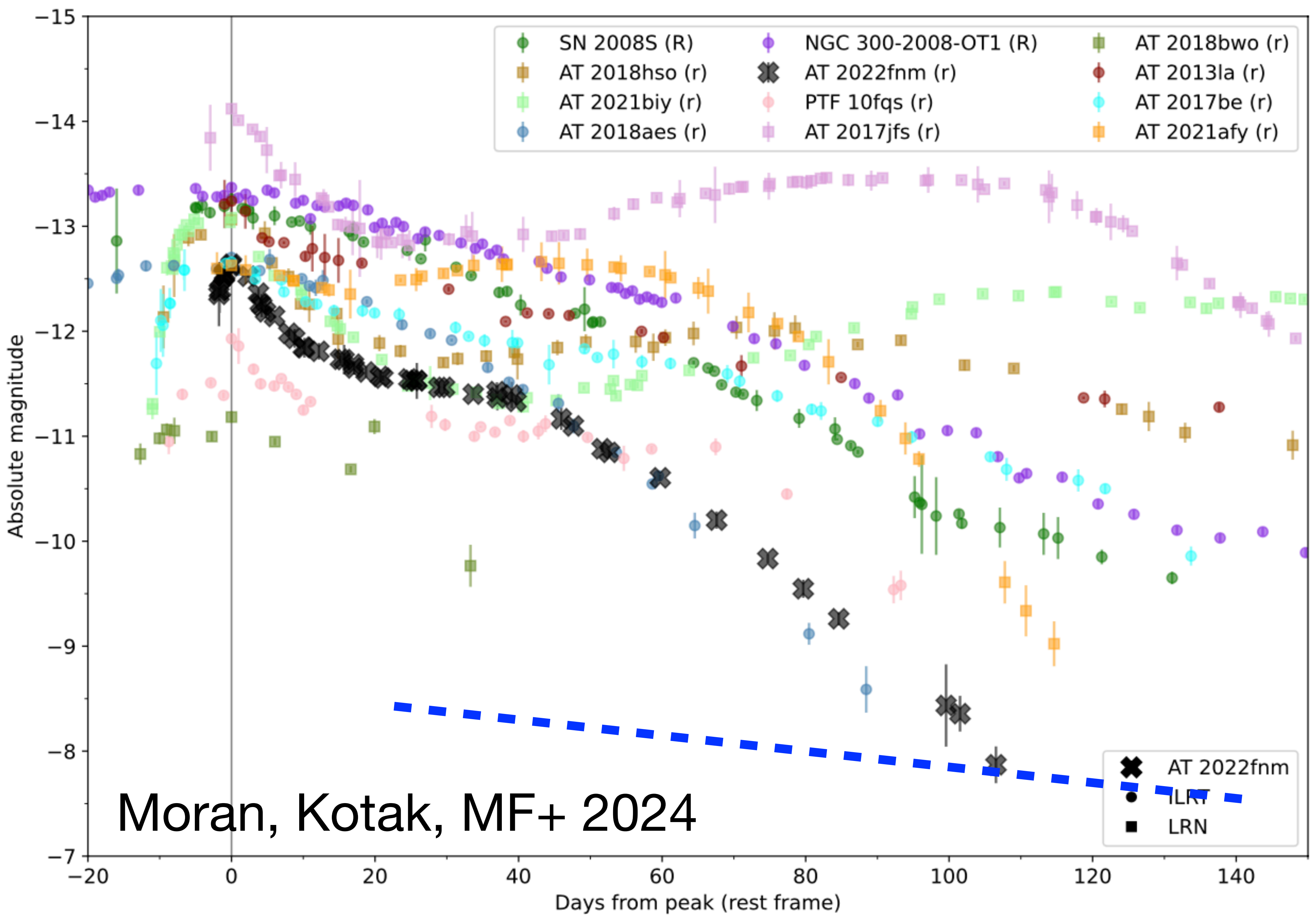


Adams+ 2016



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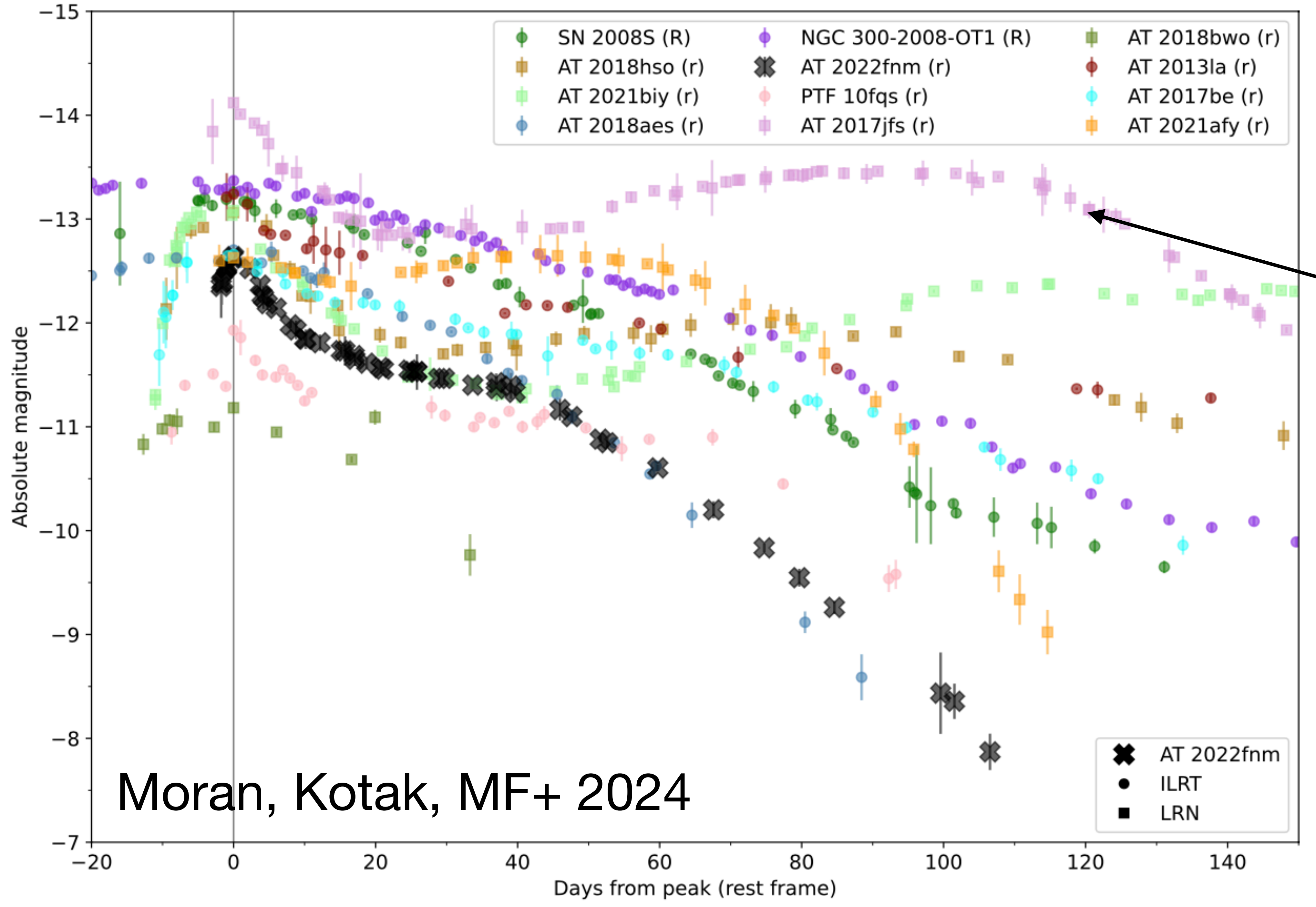
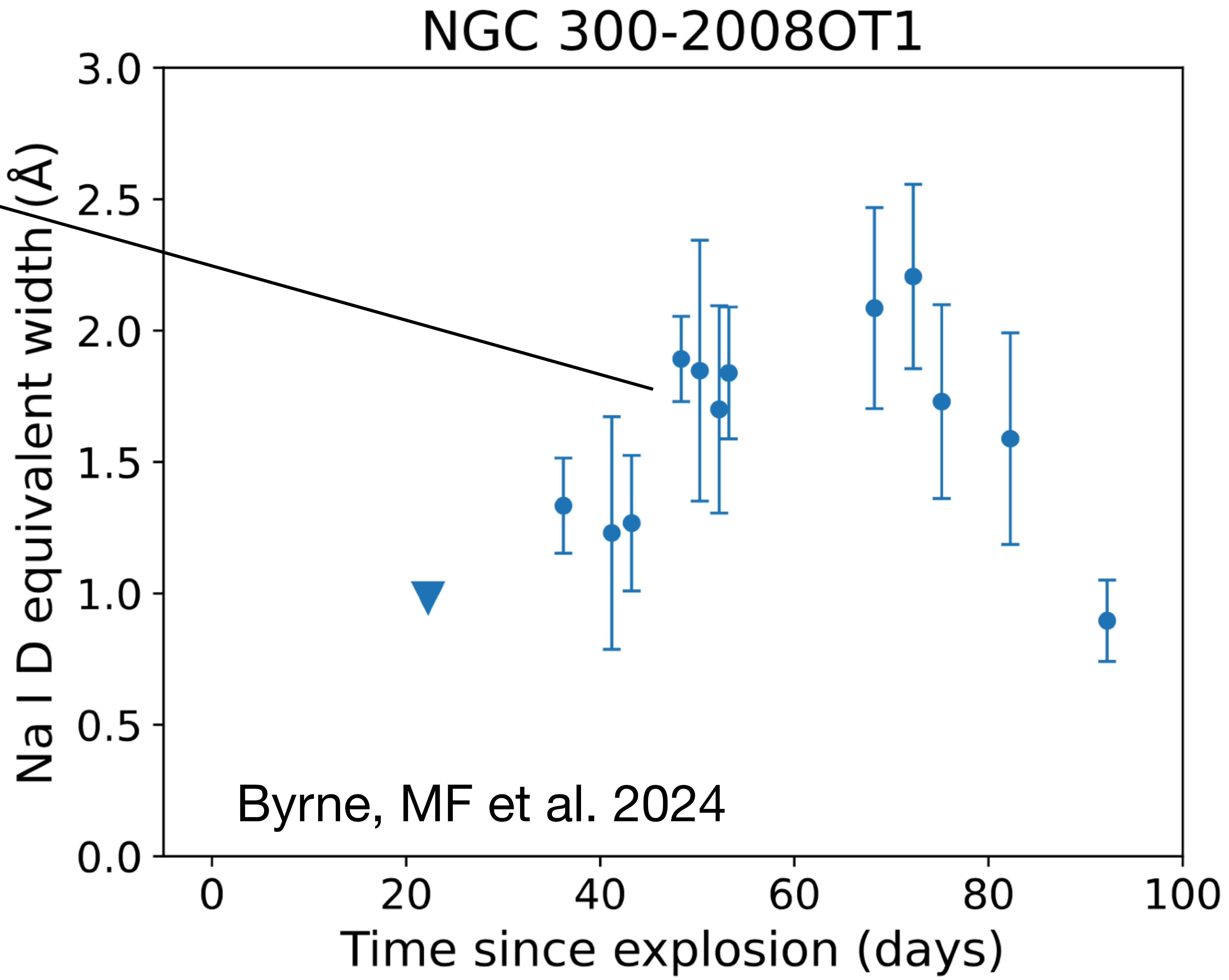
Complex CSM around ILRTs

Dust enshrouded SAGB stars with variable mass loss?



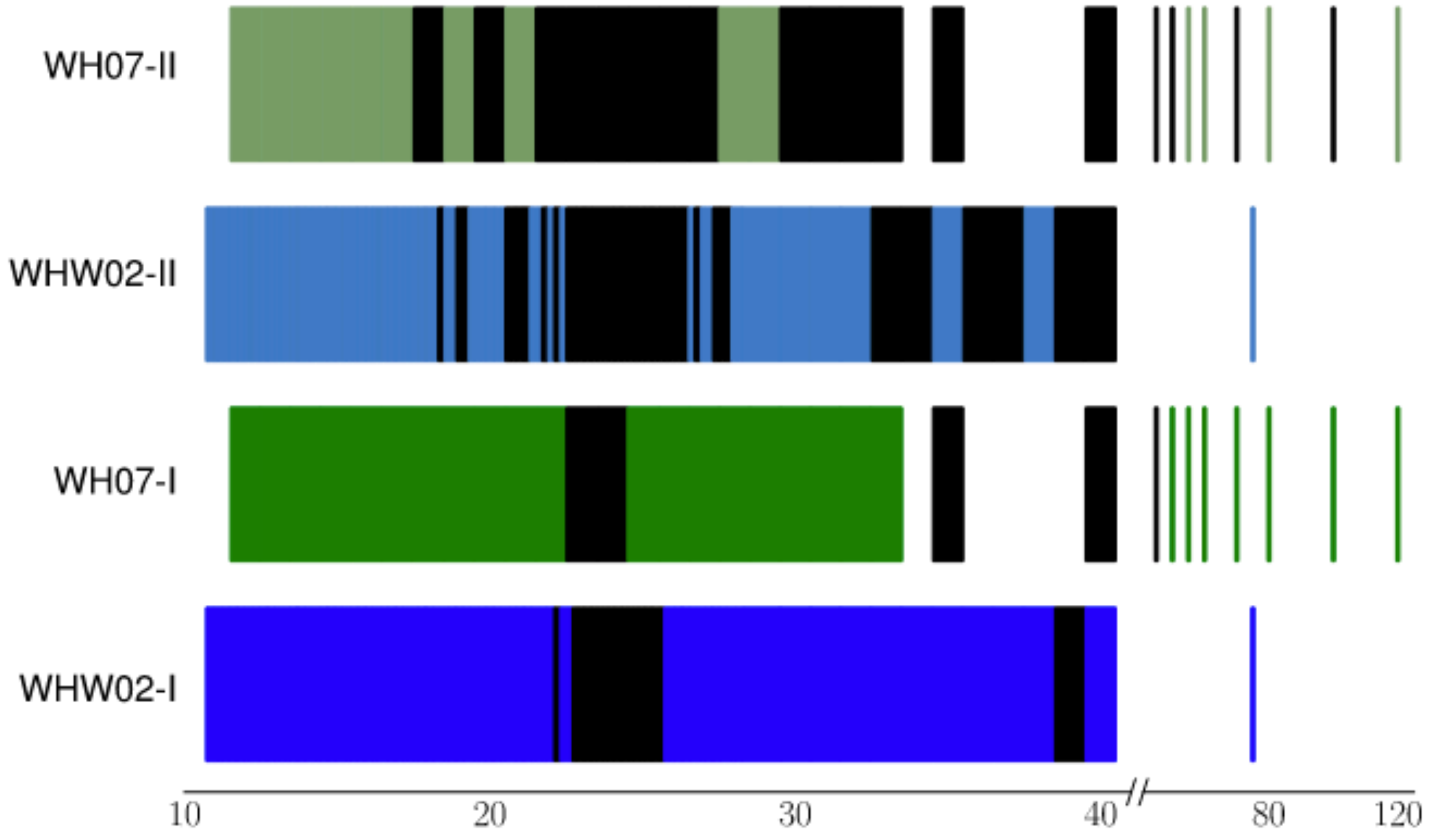


RSG problem

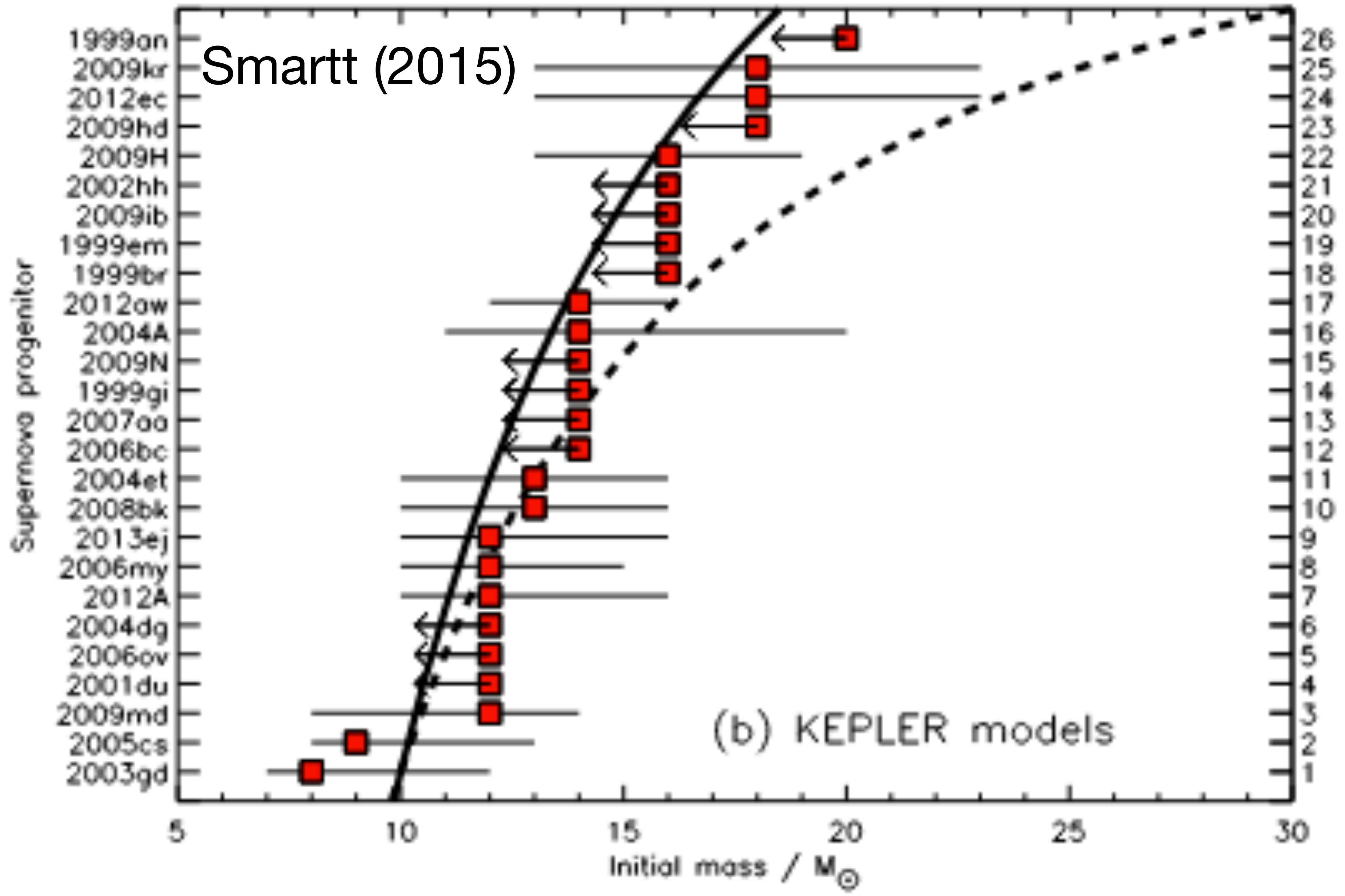
An apparent absence of high mass (>16 $M_\odot$) Red Supergiants exploding as core-collapse SNe.

Perhaps they collapse to form black holes *without* a successful explosion.

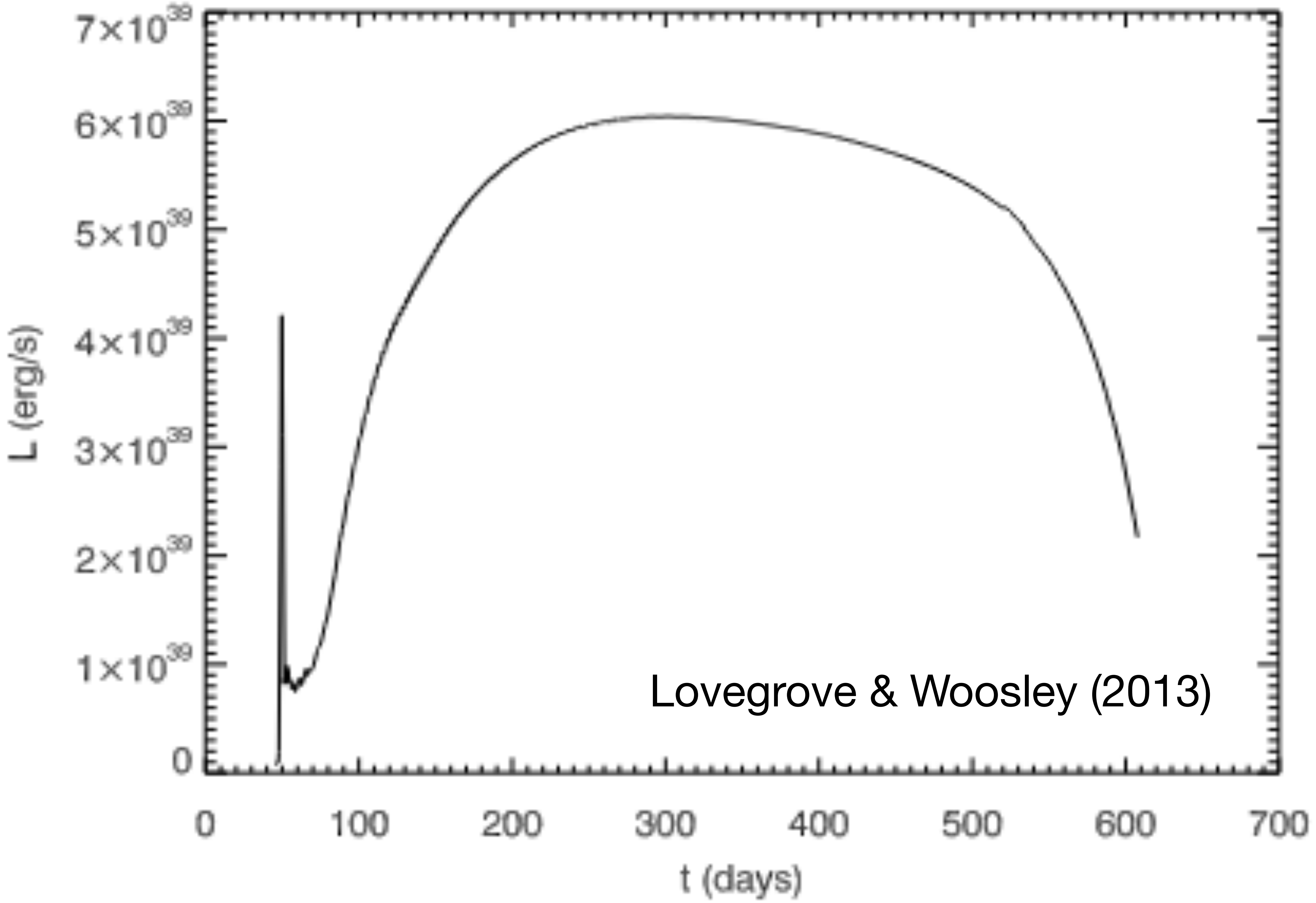
Also evidence from theory…



Ebinger+ (2019)



What might a failed SN look like?

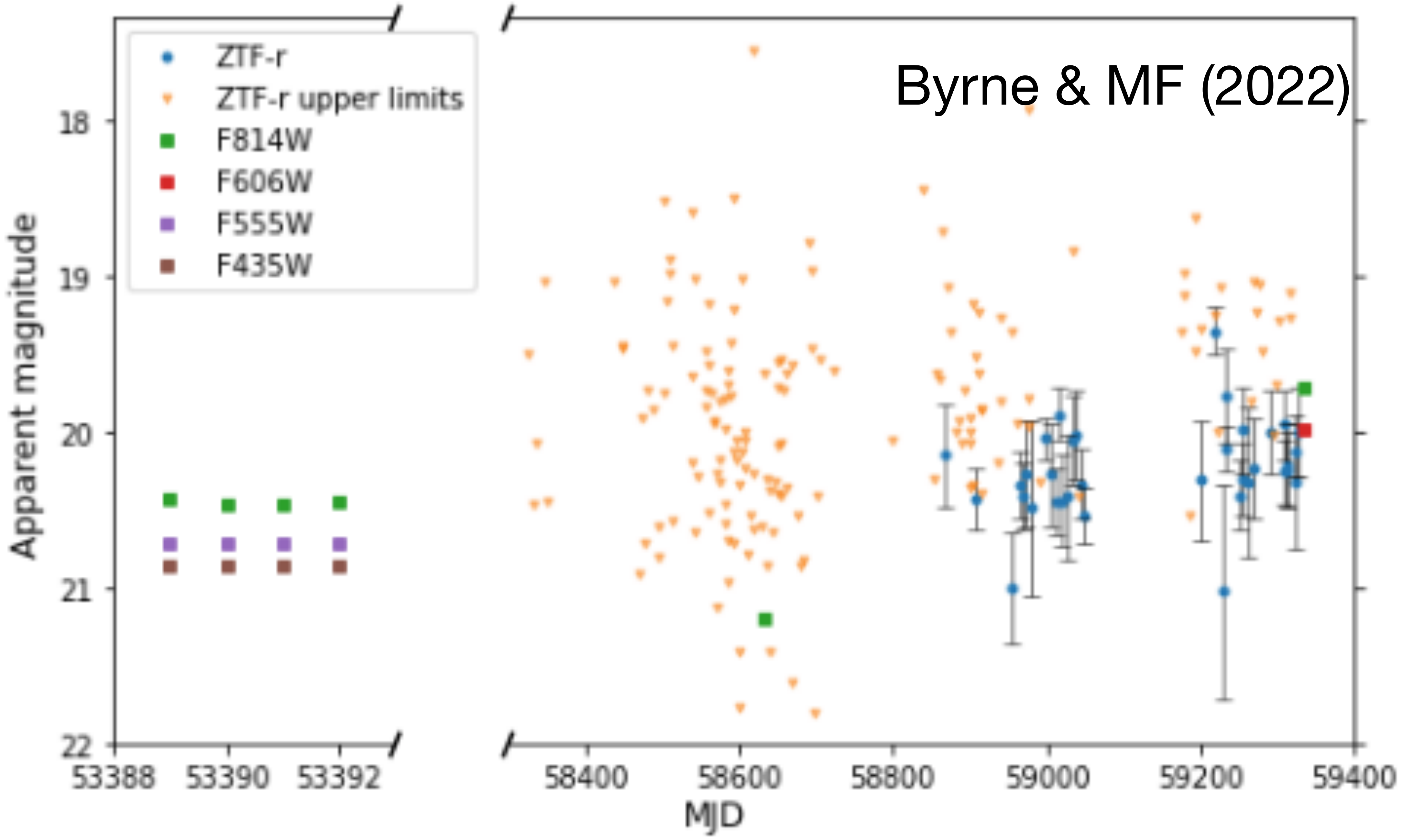


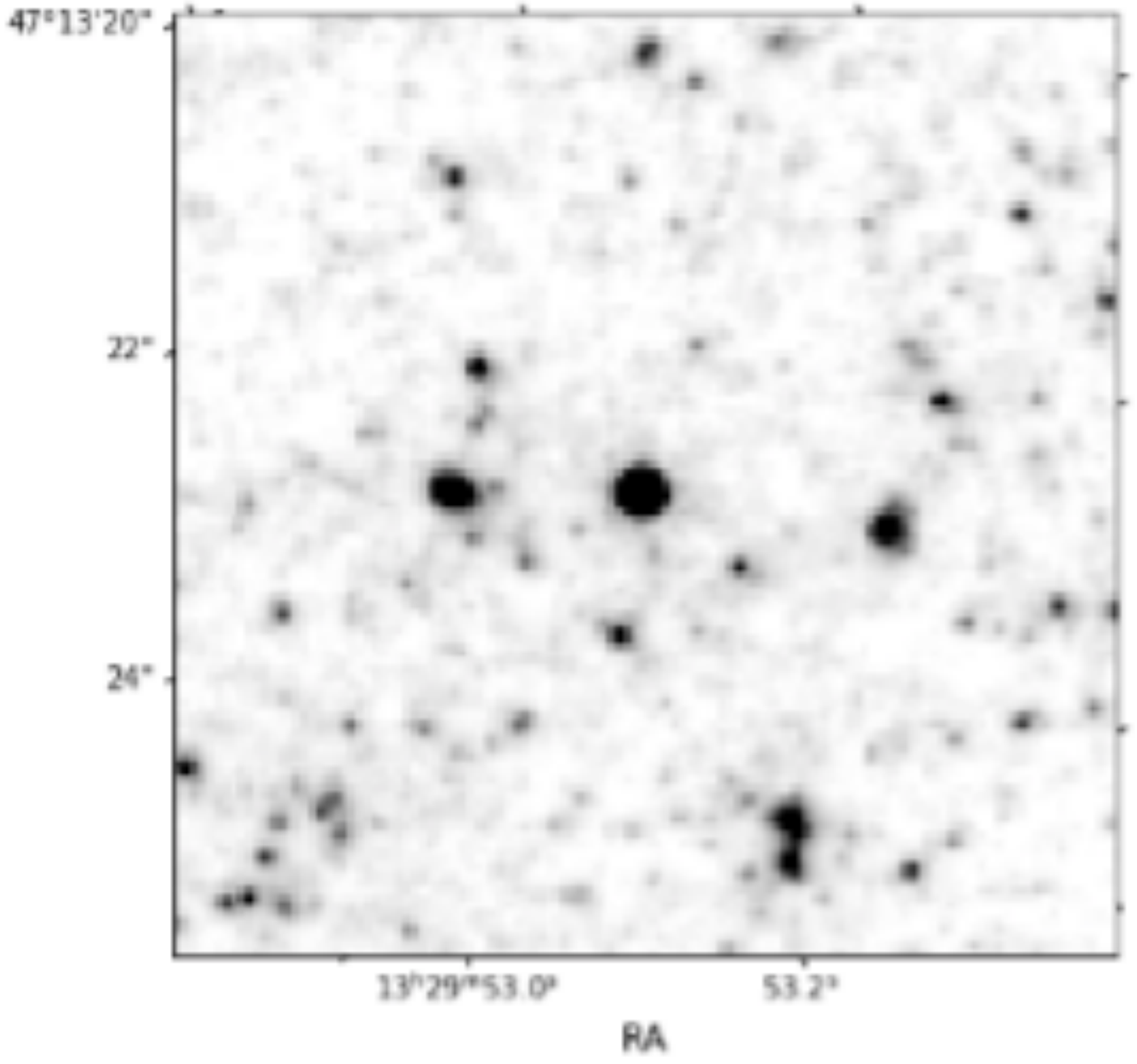
First suggested by Nadezhin (1980)

Star loses ~0.1 $M_{\odot}$ to neutrinos. Weak shock unbinds outer layers of envelope. Faint, cool. recombination powered transient characterised by low velocities!

No outbursts associated with failed SNe… (so far)

Failed SNe must be less common than CCSNe (based on ZTF / PTF reanalysis)





But interesting transients found - e.g. 30 $M_\odot$ YSG that suddenly fades by 1 mag, then brightens by 1 mag!

The future for gap transients

A gap transient with *r*~-12 transient must be closer than 25 Mpc to be detected by ZTF, ATLAS, GOTO etc.

With Rubin, it will be detectable at 150 Mpc

>200× greater volume!

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How do we follow them up - spectroscopy at mag ~24 (but maybe not so helpful)?

How do we distinguish between the classes?

Constrain physics of late stellar evolution, binaries and more…

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Post-credits rant

Humans can’t remember names like SN2025abcdaegwg

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TNS starts each year issuing names at SN2026aaa

SN2026A — SN2026zz are kept in reserve. These names are only issued on special request - when one is following a SN, or want to write a paper on them.

Downside is some SNe have duplicate names

Benefit - every SN we care about (and discuss) has a human-friendly designation