The dusty progenitor of the Type II SN 2017eaw

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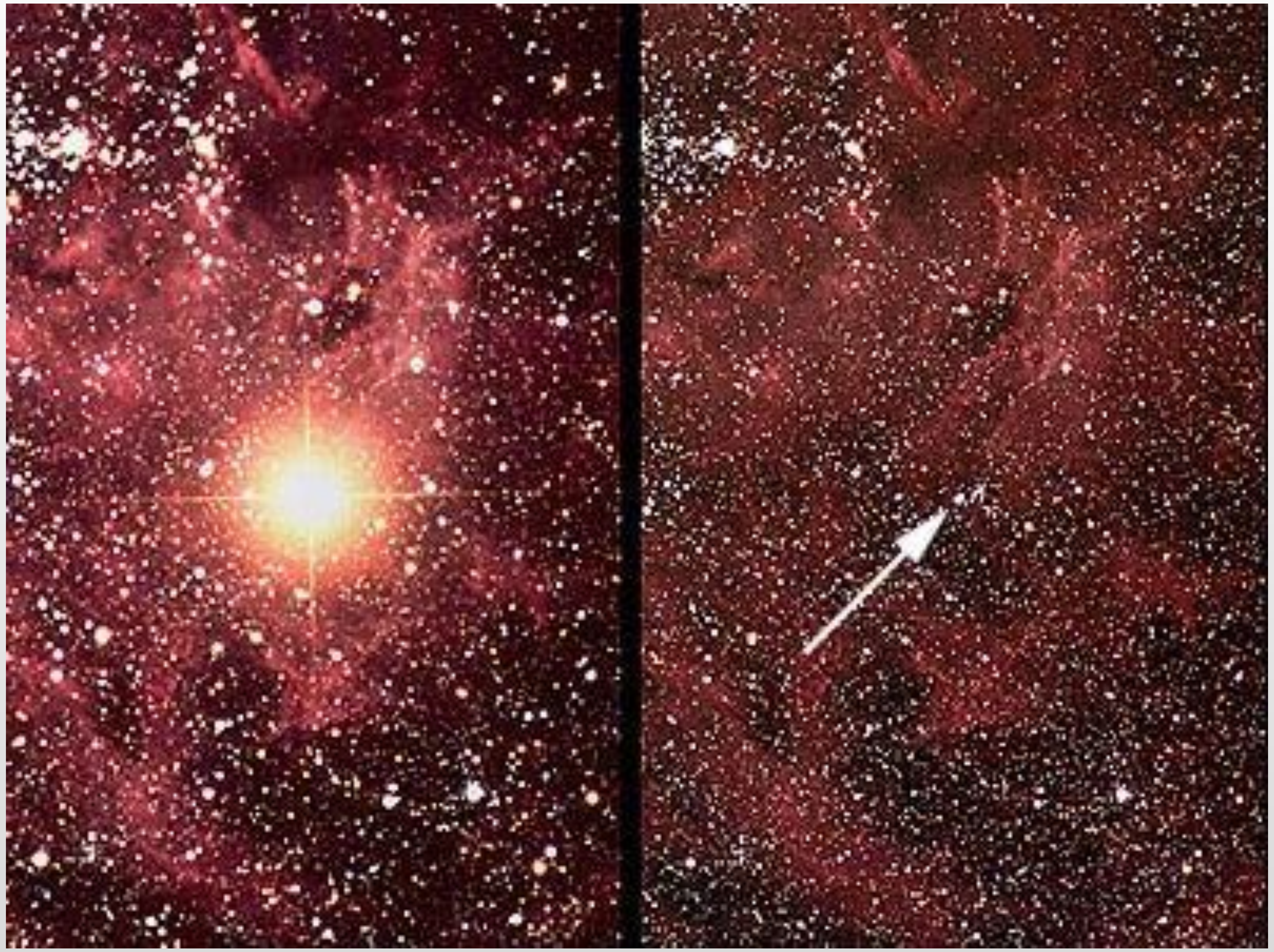
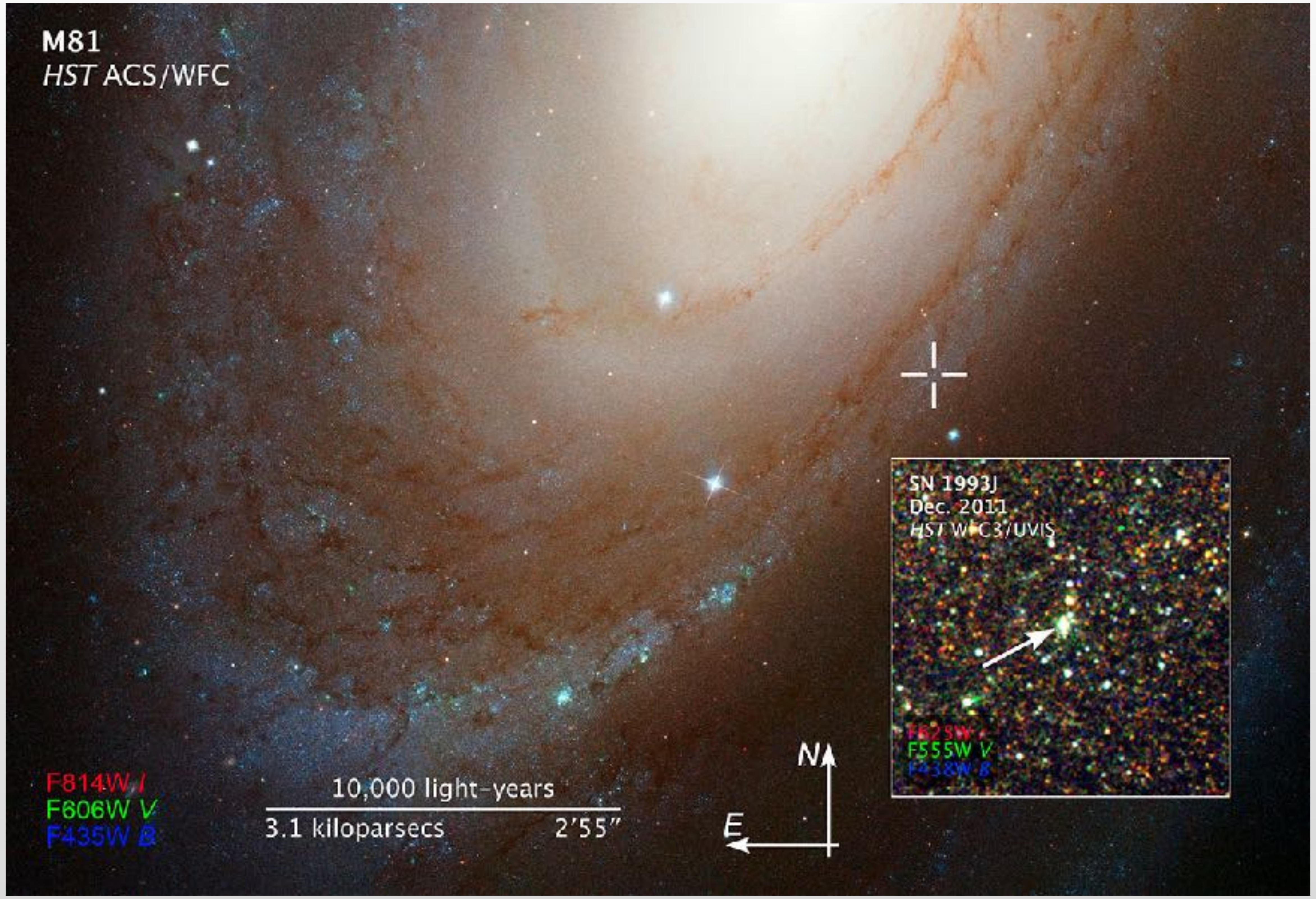
Progenitor Stars of Type II Supernovae



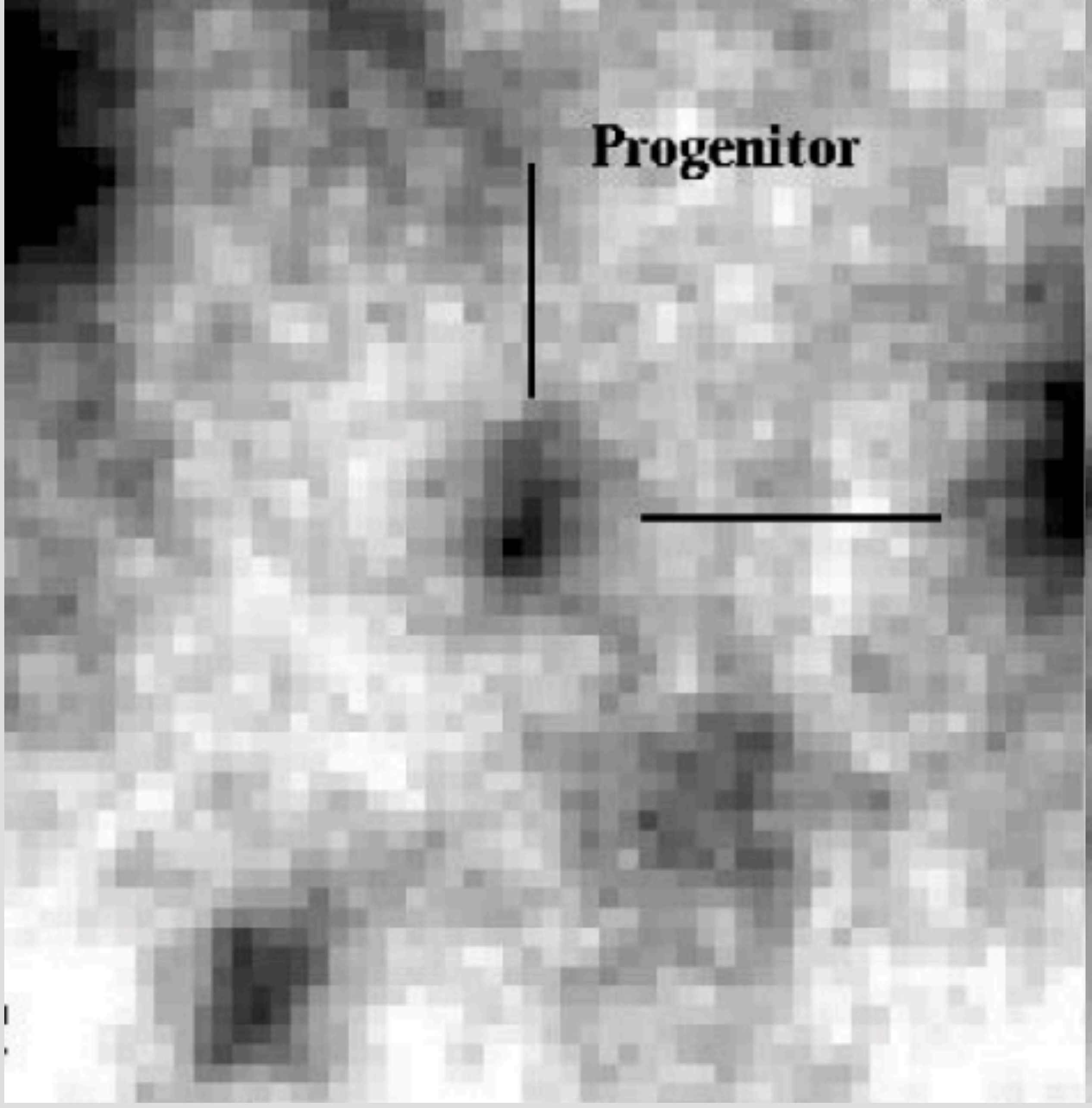
Sonneborn+87; Gilmozzi+87; Podsialowski92



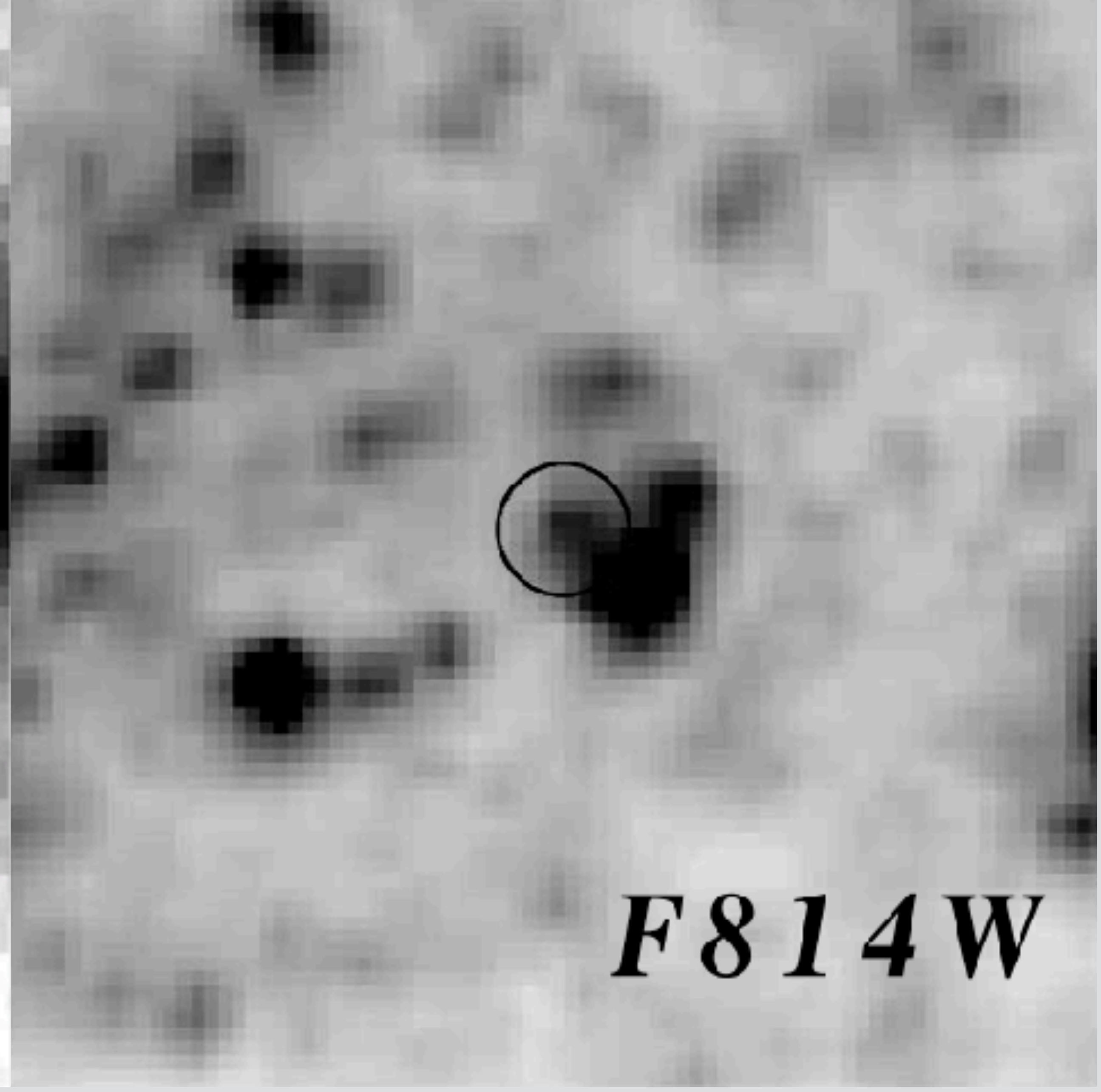
Aldering+94;Van Dyk+02

SN 1987A (II-pec)
Blue (B3 I) supergiant progenitor

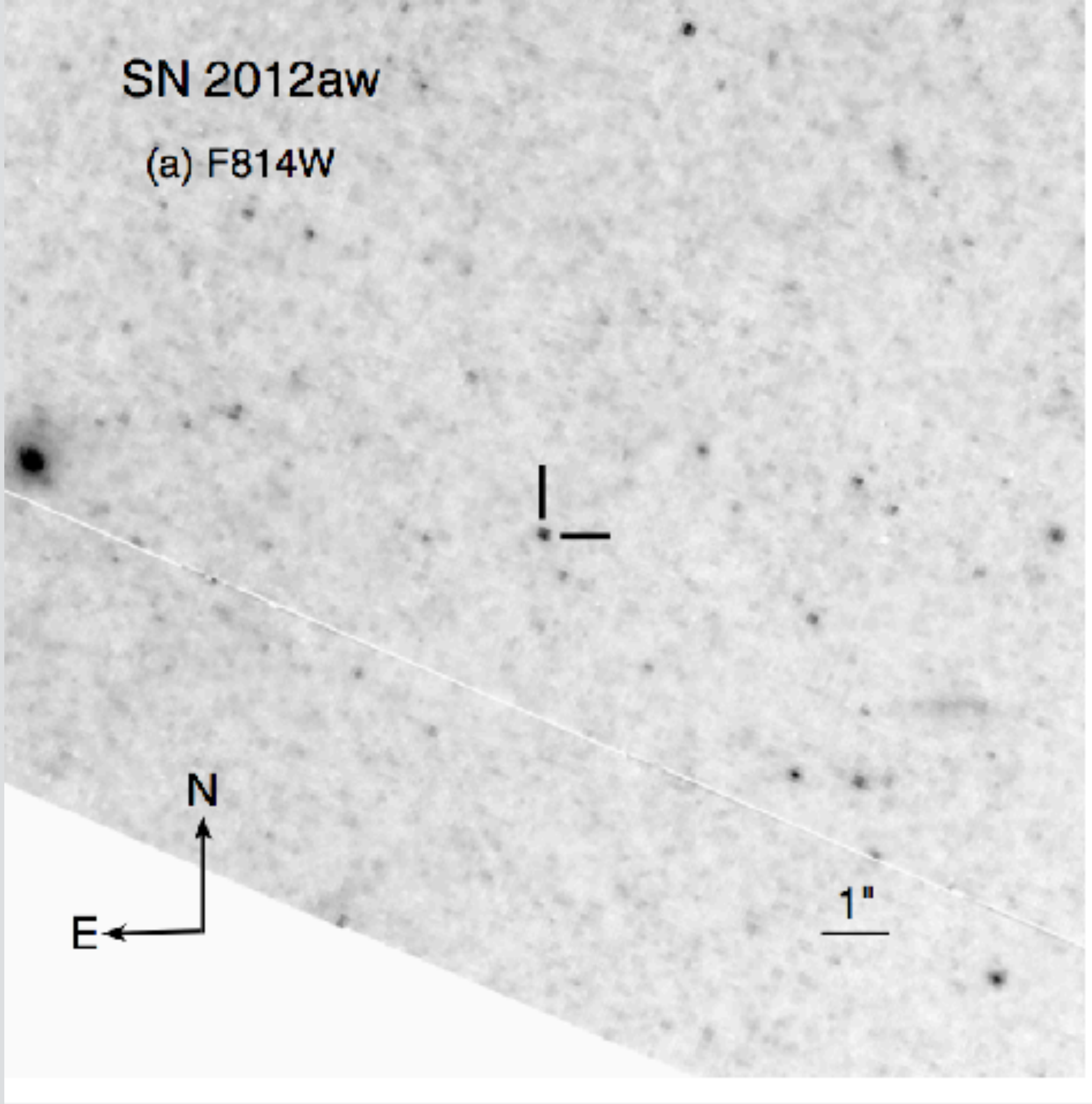
SN 1993J (IIb)
Yellow (early K I) supergiant progenitor



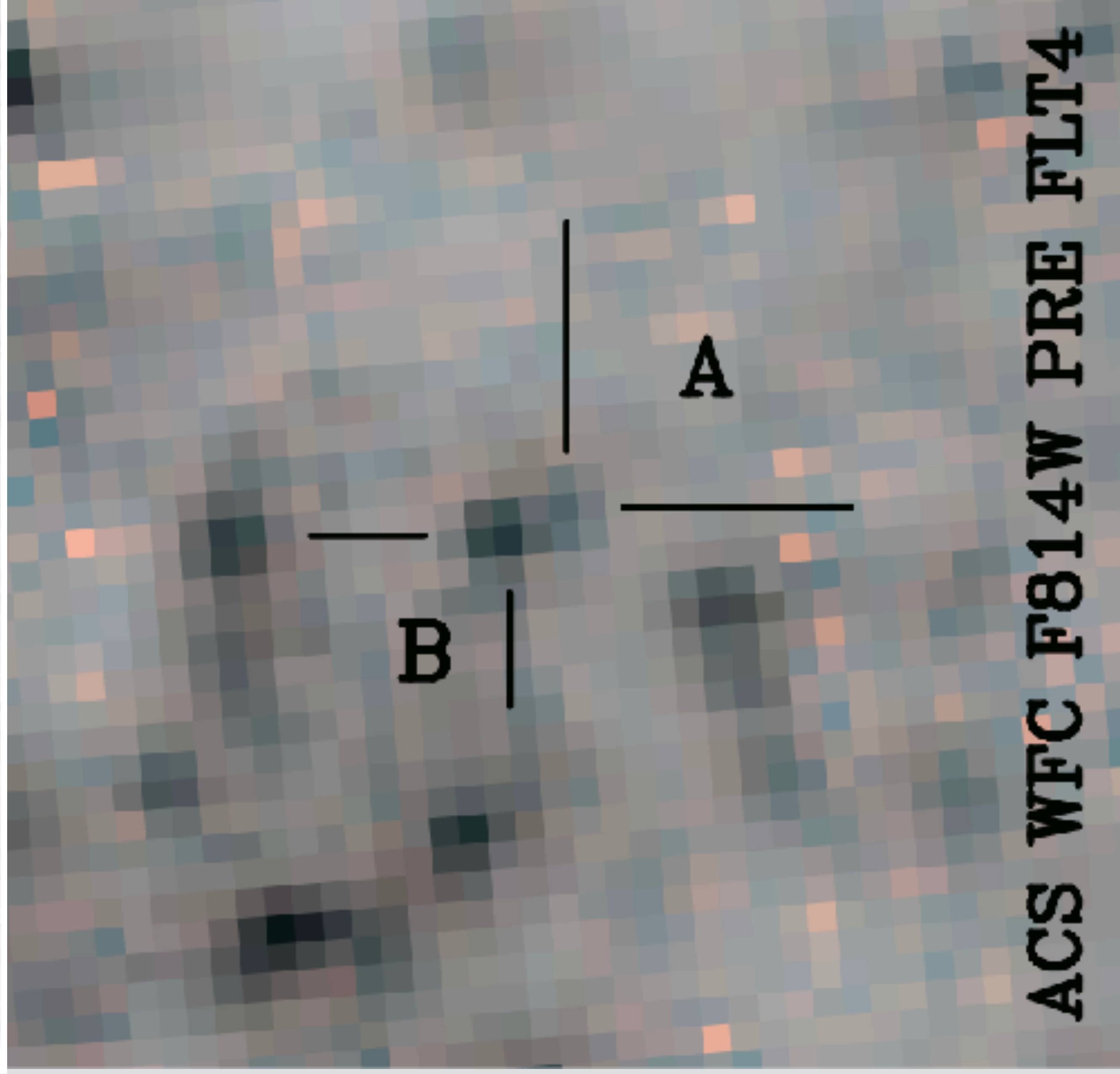
SN 2003gd
(9 Mpc; Smartt+2004)



SN 2005cs
(7 Mpc; Li+2006)



SN 2012aw
(10 Mpc; Van Dyk+2013)



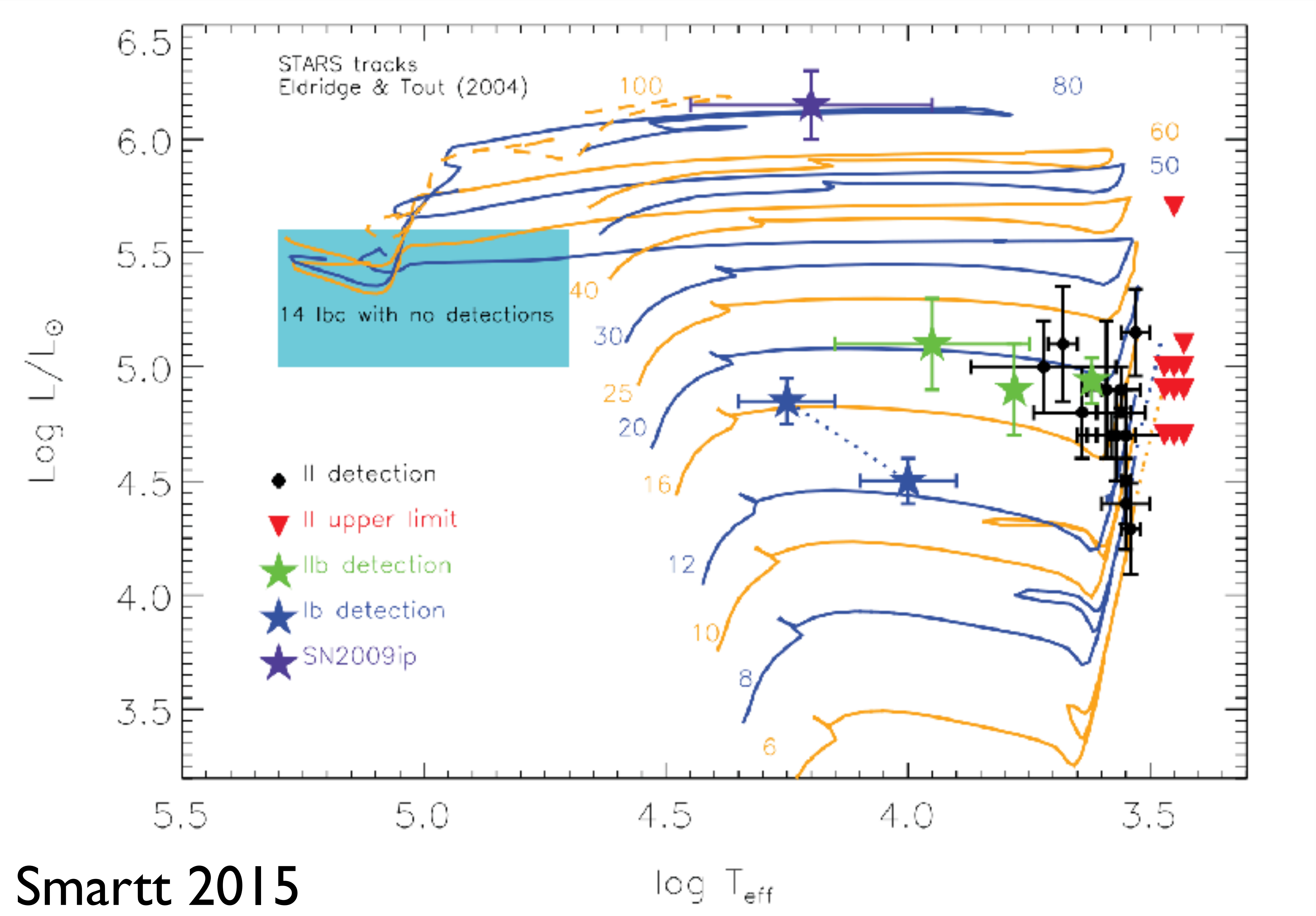
SN 2012ec
(17 Mpc; Maund+2013)

HST enables detection of massive progenitor stars up to ~30-40 Mpc

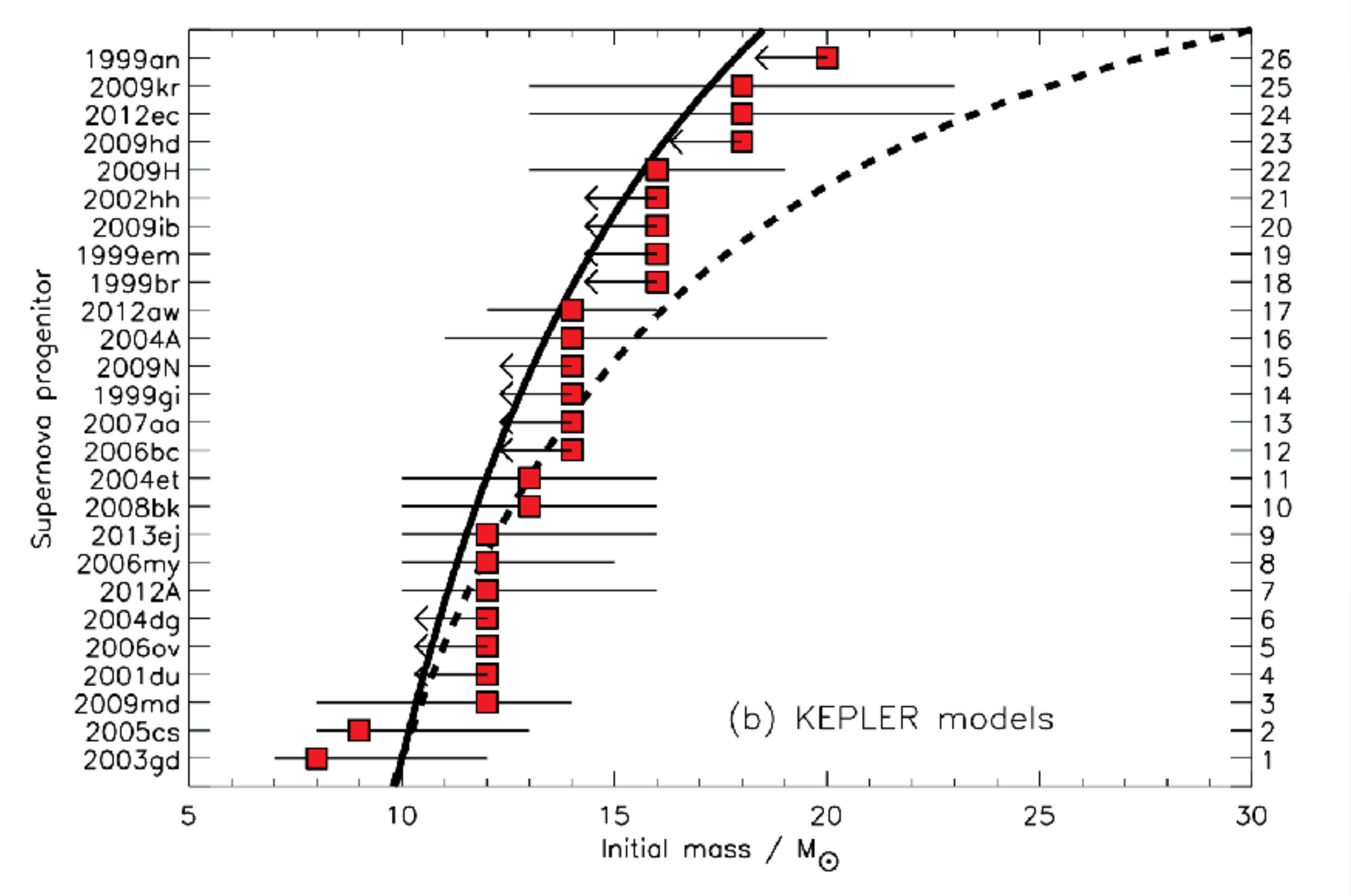
There are >~20 confirmed progenitor stars of SNe II

Mostly RSG progenitors of SNe II-P

What happens to the high-mass RSGs?



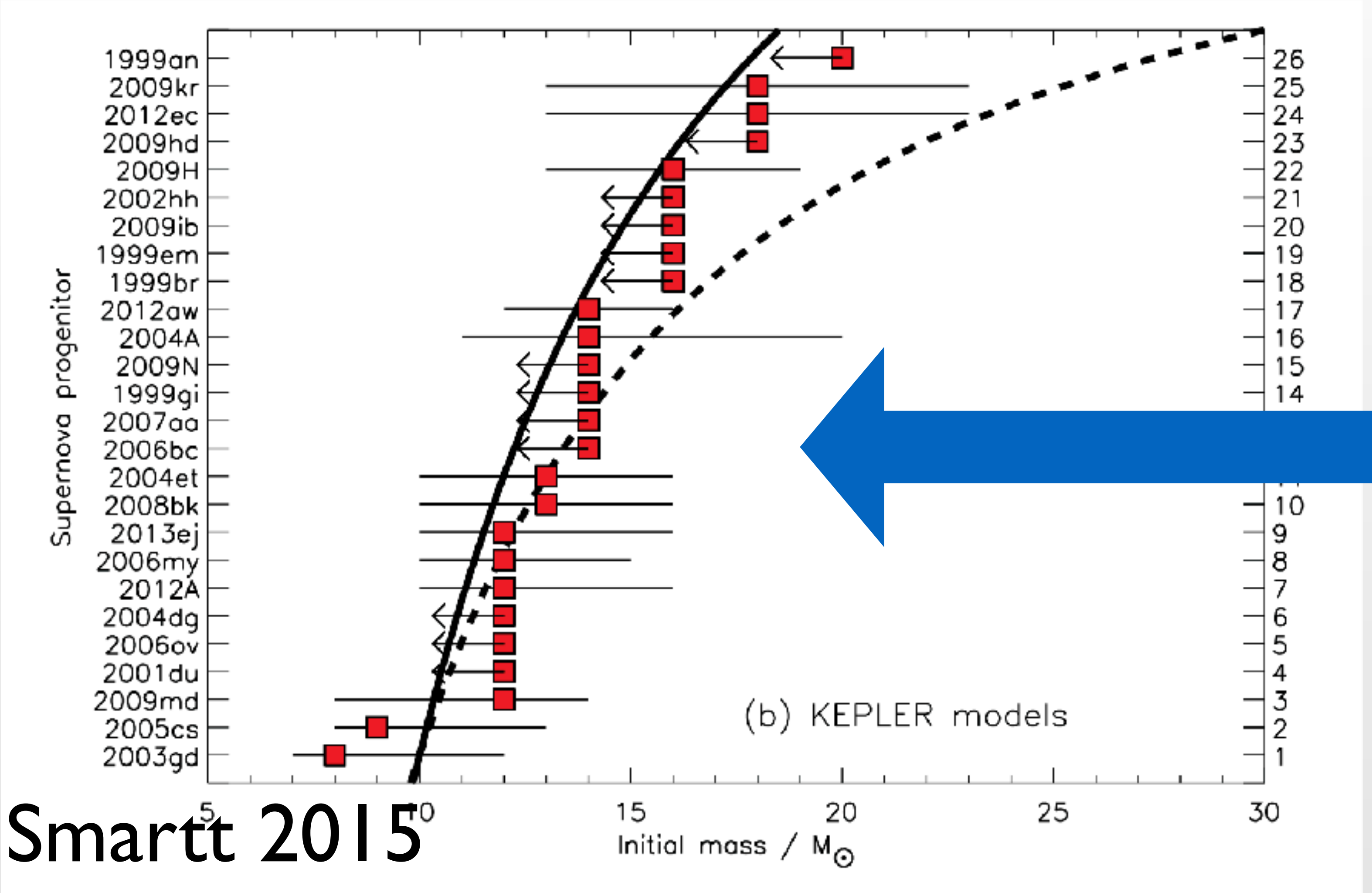
Smartt 2015



No RSG progenitor stars with log L > 5.2 are observed to exist

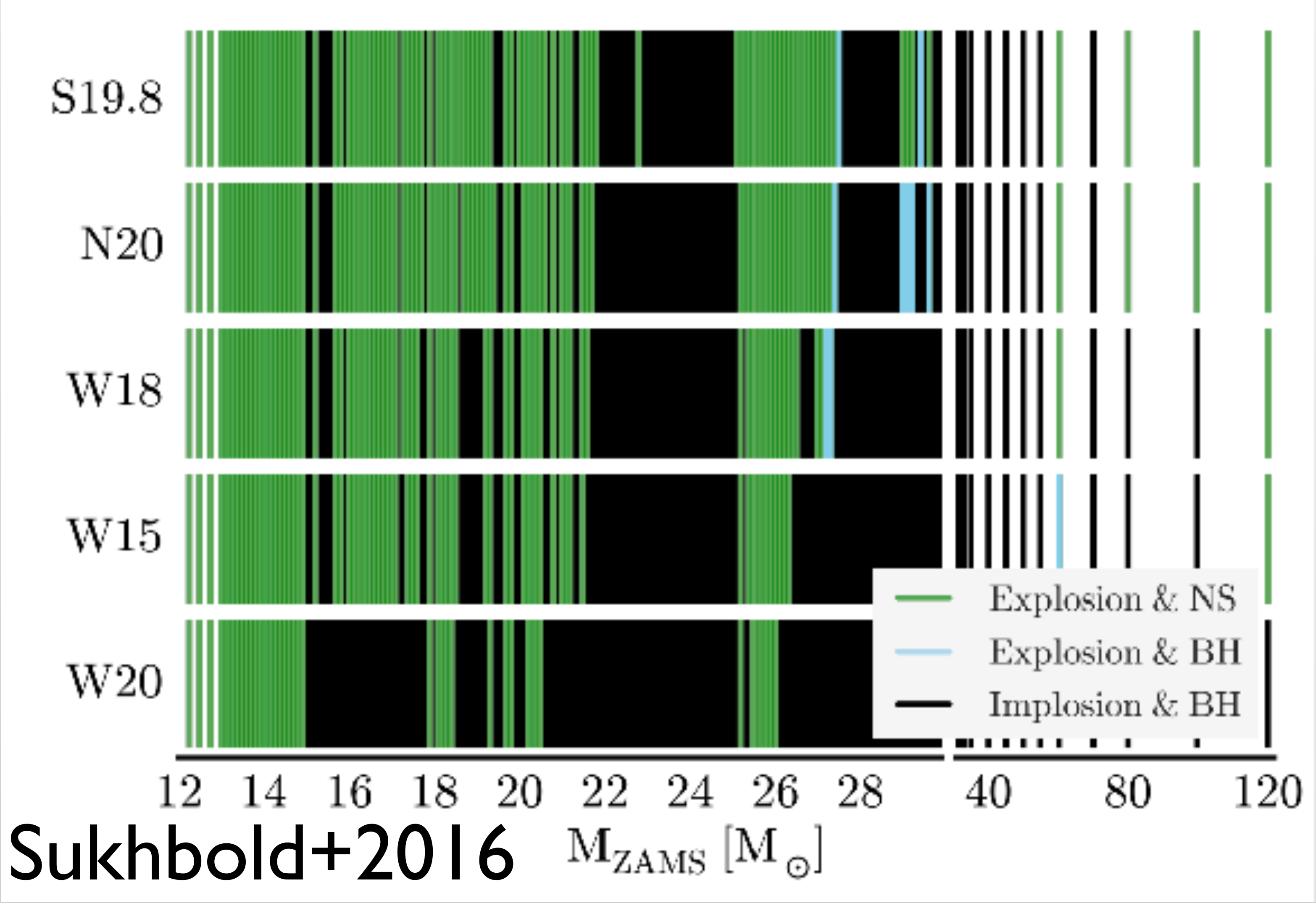
We know RSGs with log L = 5.2-5.5 (Minit = 17-25) exist (AH Sco, UY Sct, KW Sgr, etc.). Why no SN progenitor stars in this range?

A mass threshold for successful SNe from RSGs?



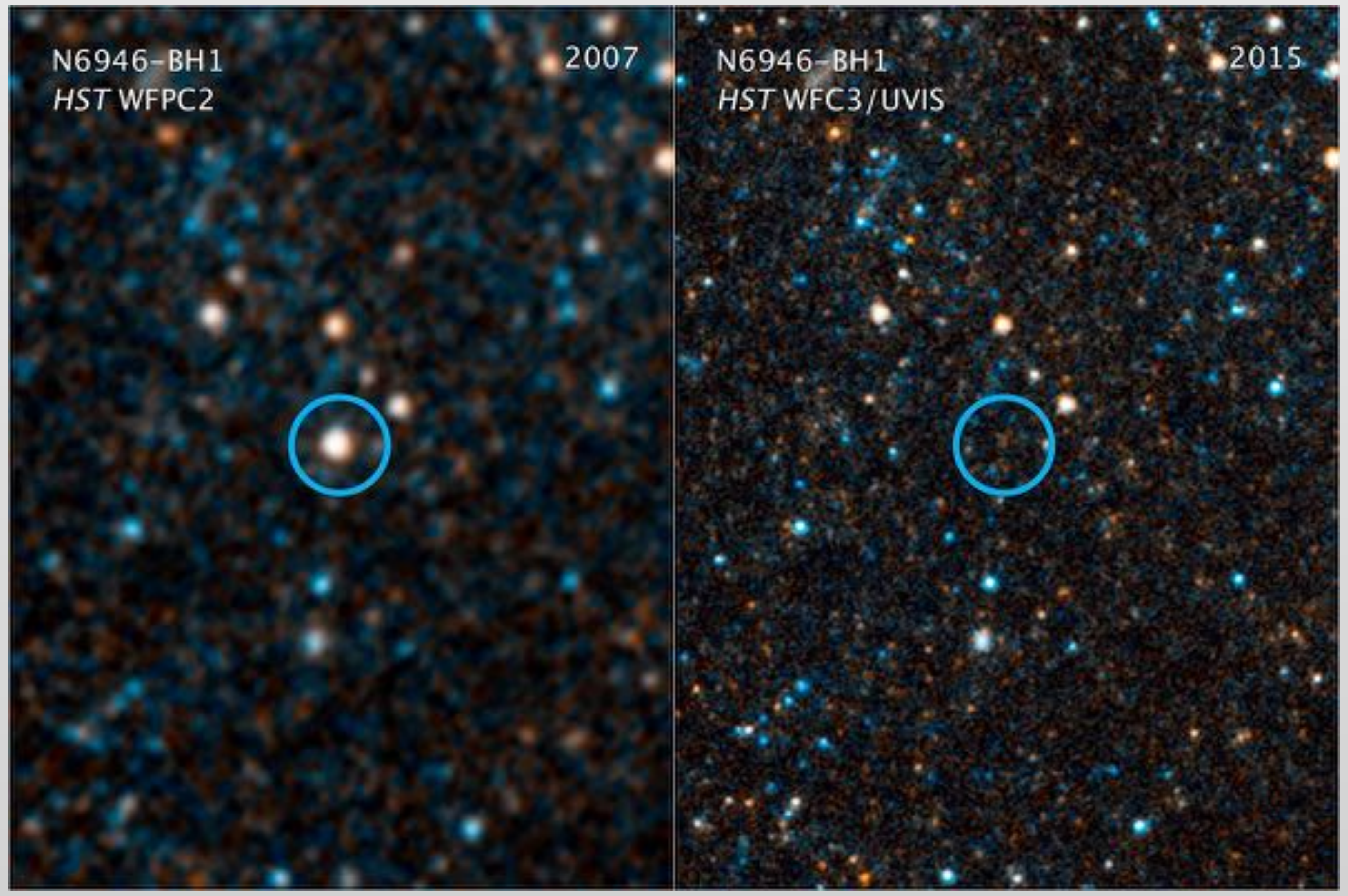
Smartt 2015

Statistically this distribution is consistent with an IMF drawn from stars with $4.3 < \log L < 5.2$ (roughly Minit = 8-17)



Sukhbold+2016

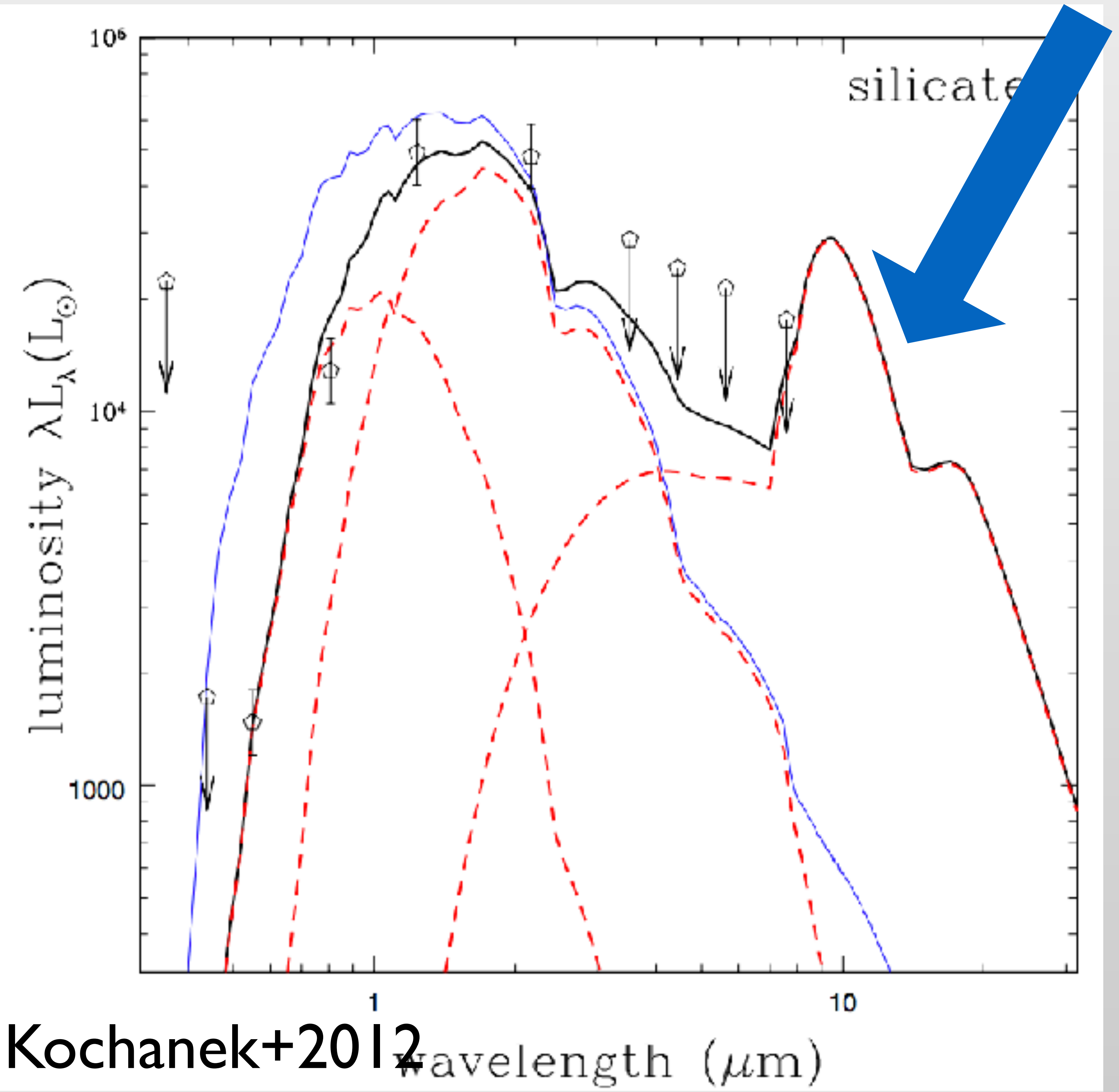
Is this a fundamental limit and high-mass RSGs collapse to BH?



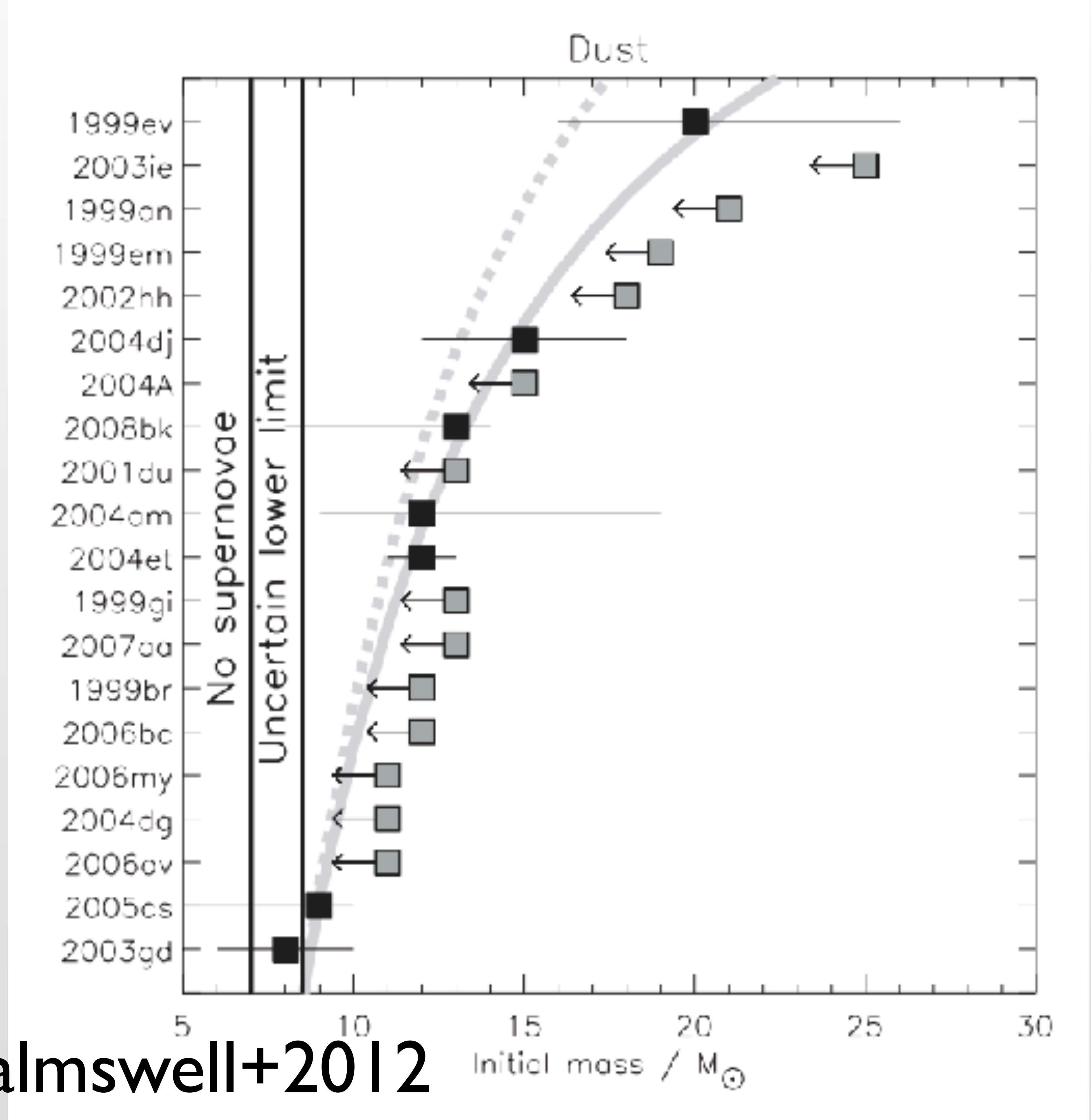
Credit: NASA/OSU
See Adams+2017

Dust obscuration

Dust can hide optical light from RSGs into the mid-infrared (where pre-explosion imaging is usually unavailable/unconstraining)



Kochanek+2012



Walmswell+2012

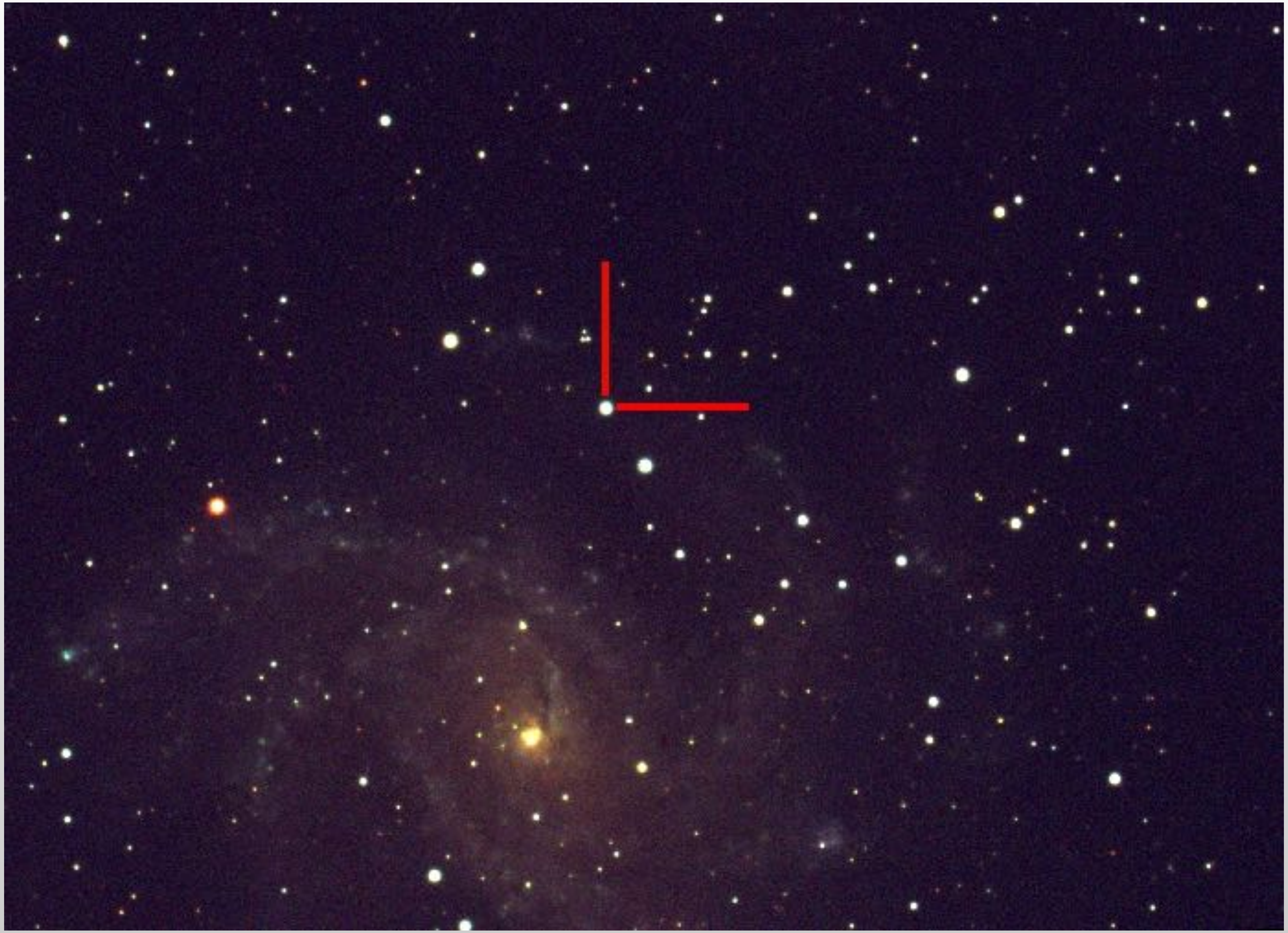
At very high CSM densities, RSGs could be SN IIn progenitors (like VY CMa; Smith+2008)

But these stars might be completely enshrouded in dust and go undetected

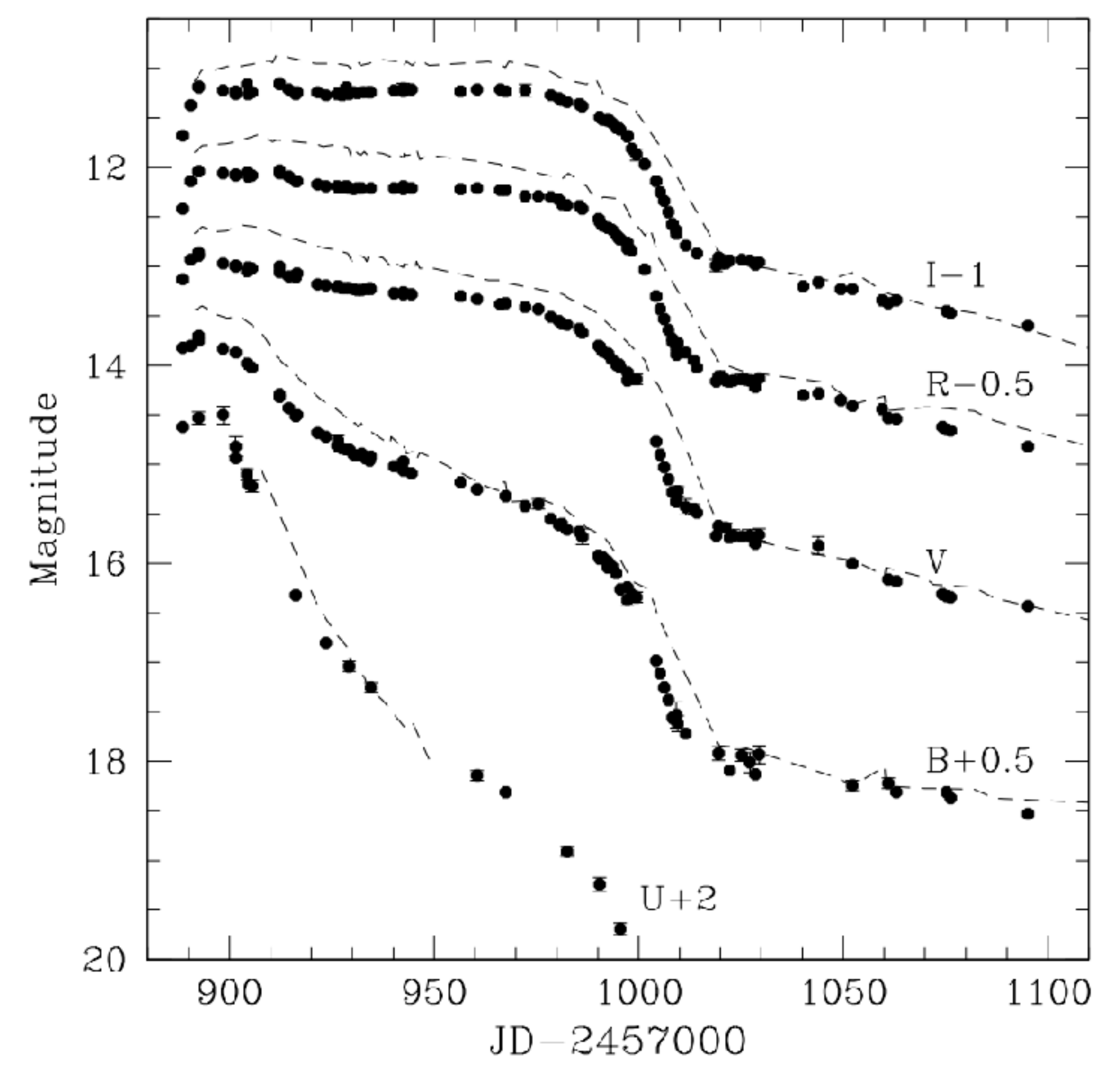
SN 2017eaw in NGC 6946

D=6.7 Mpc

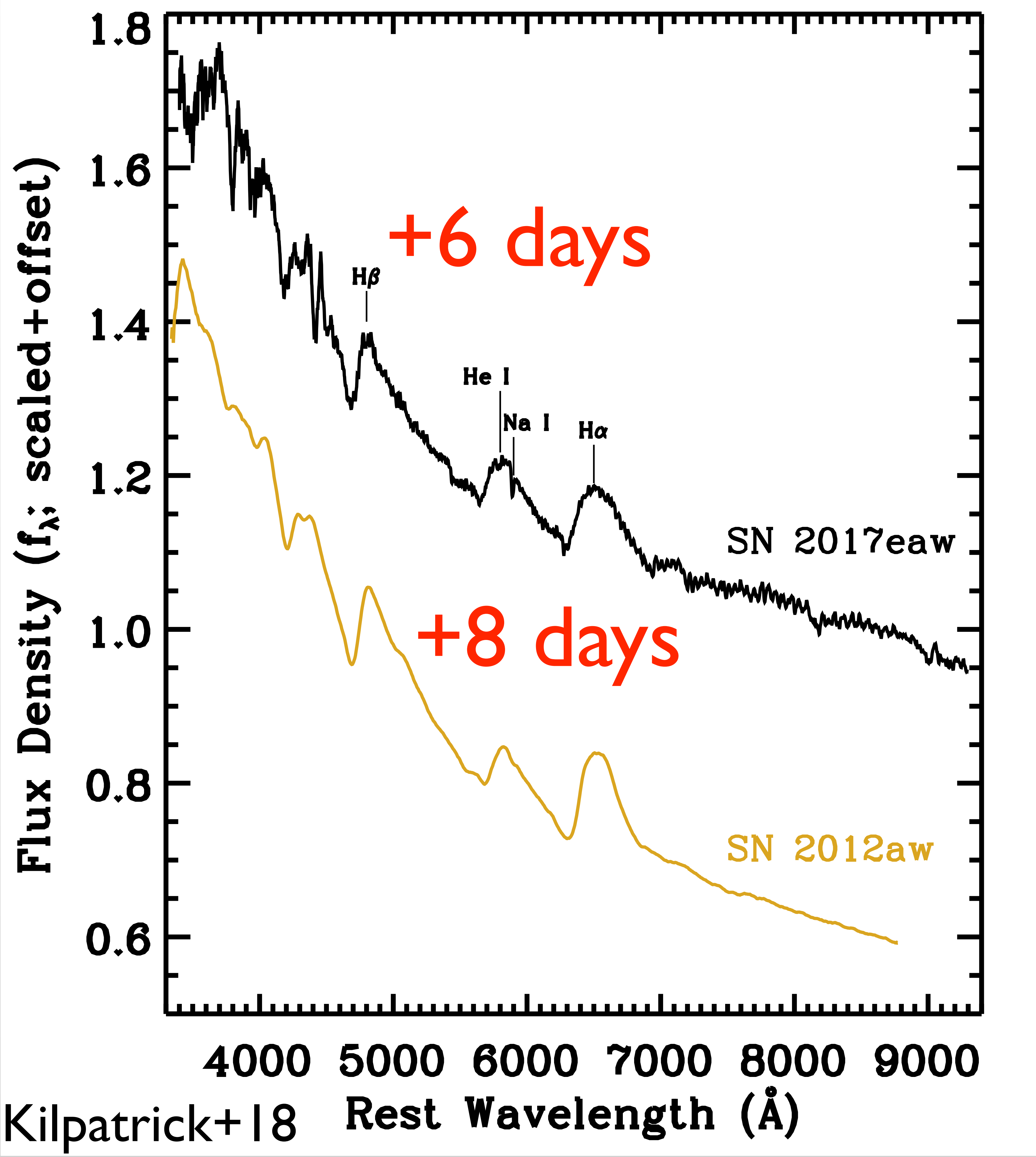
Host to >10 SNe and SN impostors over the past century



SN 2017eaw in NGC 6946



Tsvetkov+18

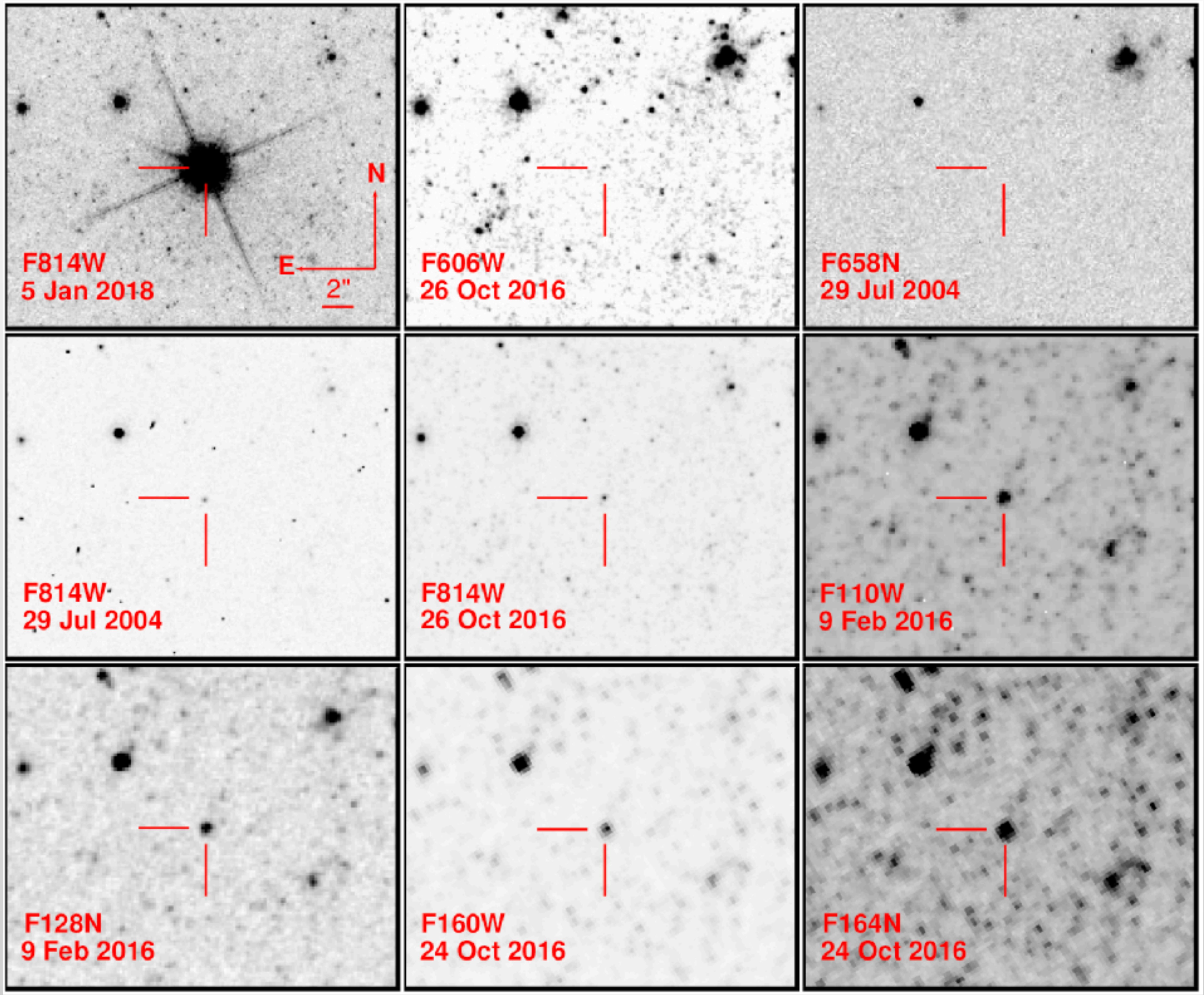


+6 days

+8 days

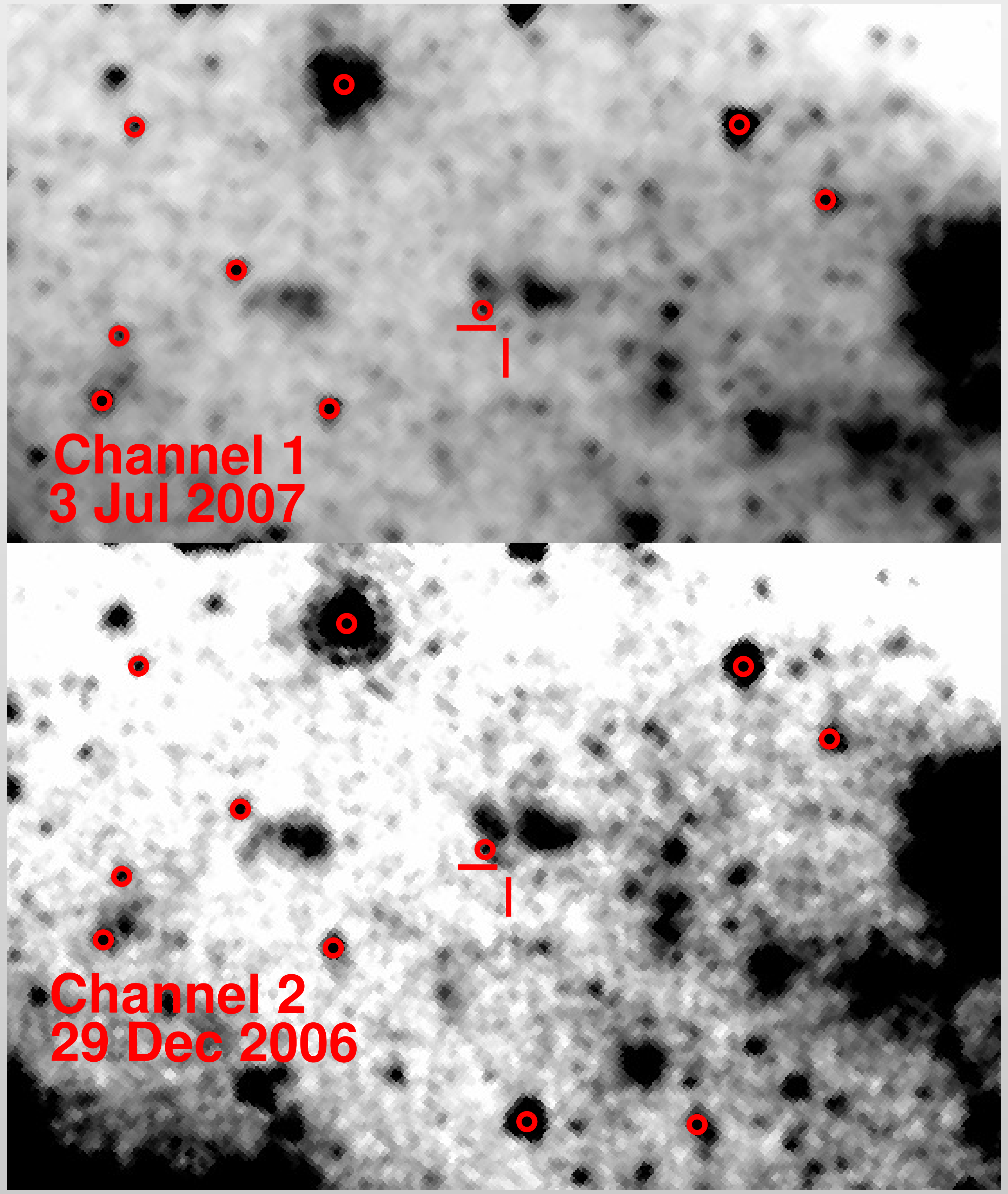
Kilpatrick+18

Progenitor of SN 2017eaw

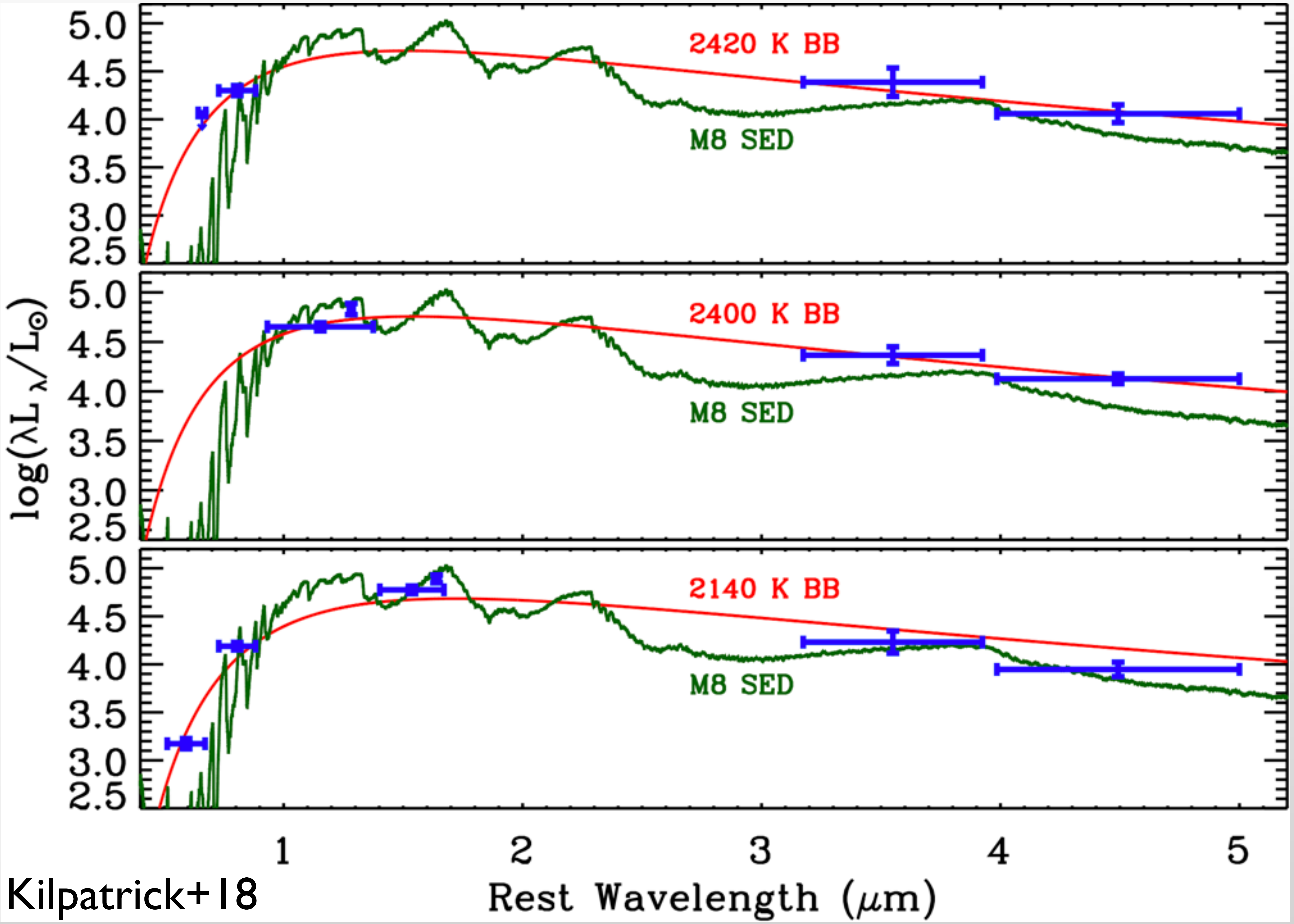


Kilpatrick+18

Progenitor system is in multiple epochs of pre-explosion imaging from optical to mid-infrared



Progenitor of SN 2017eaw



Kilpatrick+18

-12.7 yr

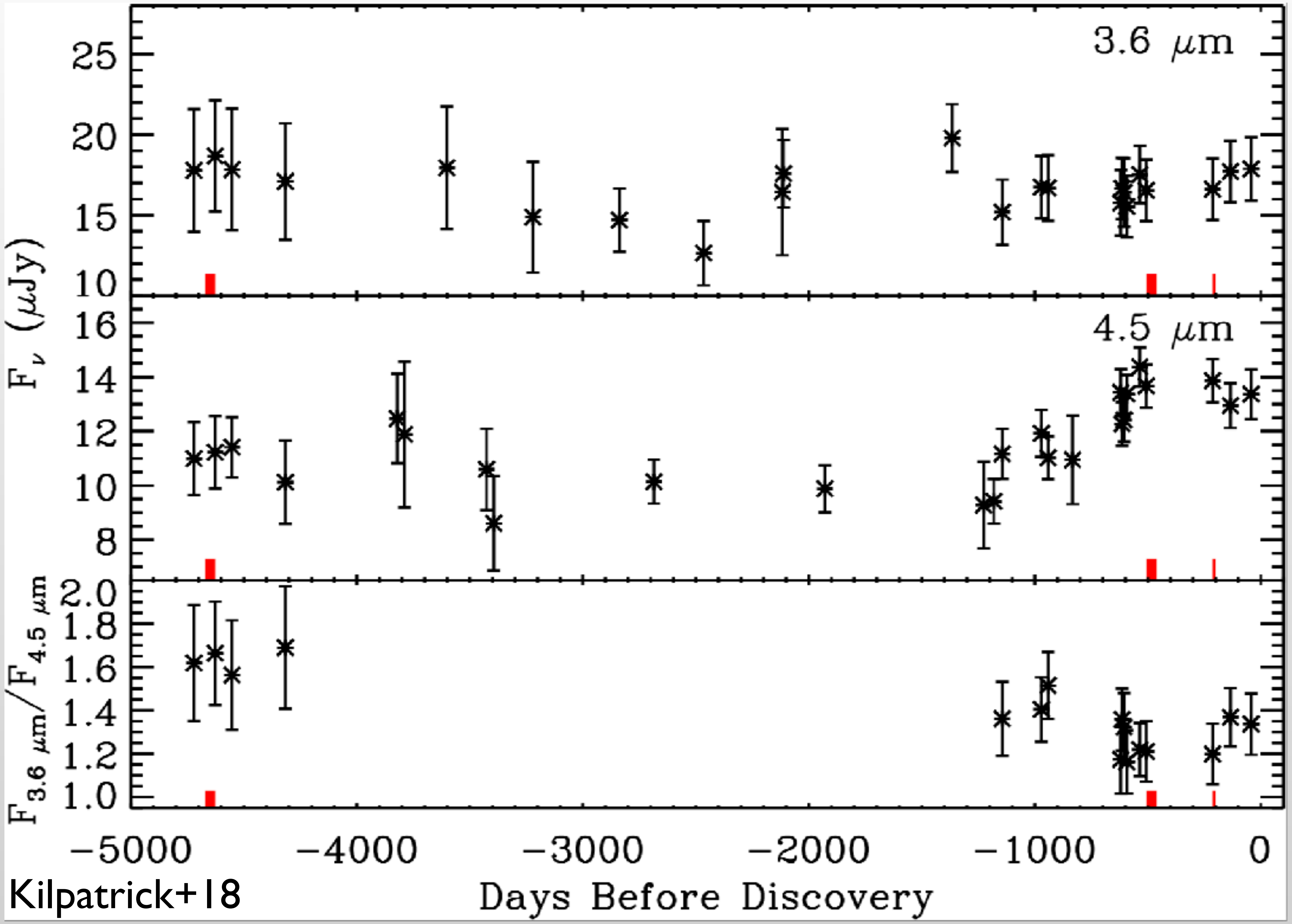
-1.3 yr

-0.6 yr

Constant luminosity+ Decreasing temperature

Full SED cannot be fit with a single component (either dust-like or cool supergiant)

Progenitor of SN 2017eaw

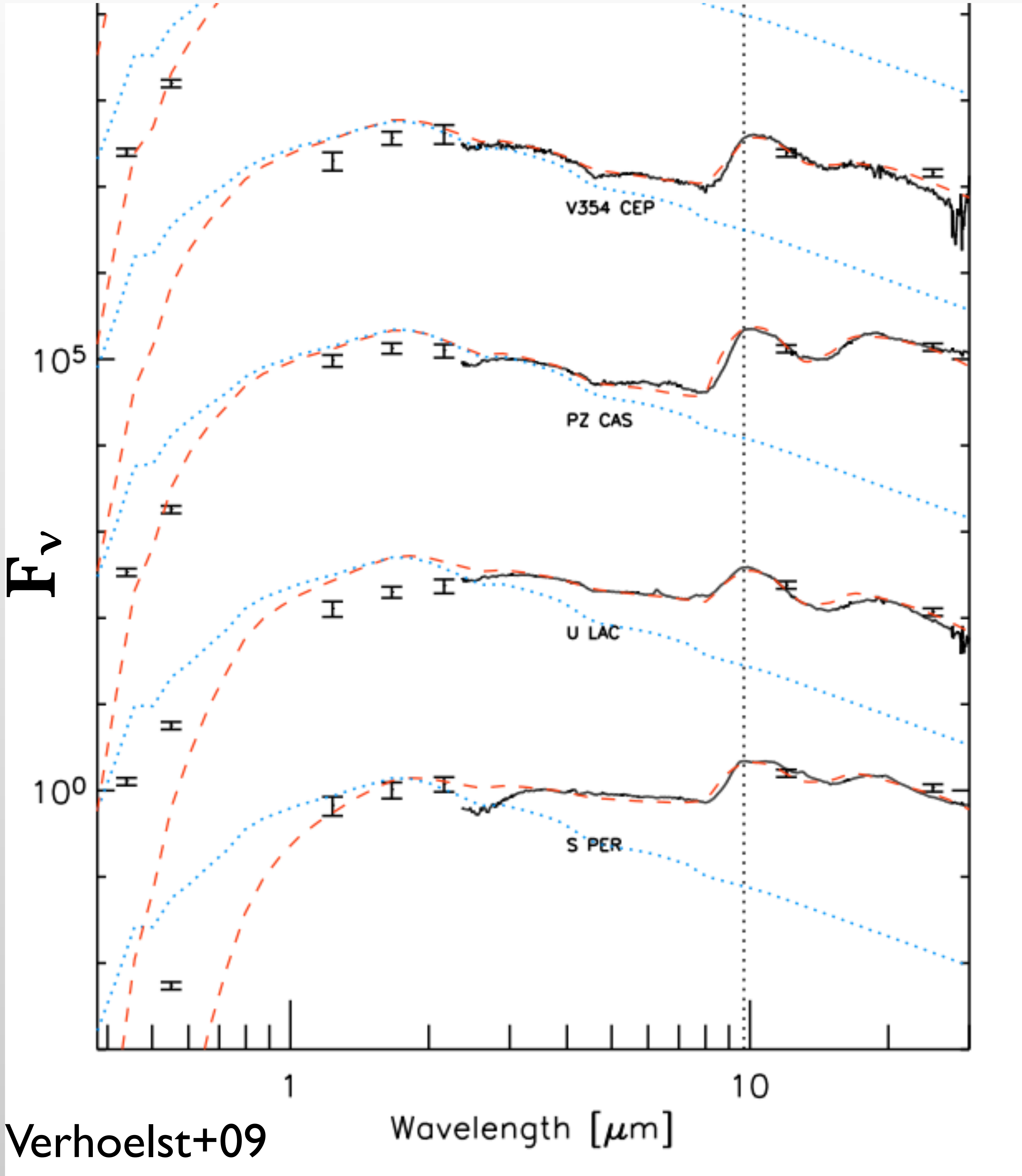


Kilpatrick+18

Dusty RSG SEDs

SEDs of RSGs with dusty winds peak near 1.5-2 microns

The intrinsic SED is reddened and dust emission features are observed in mid-infrared spectra

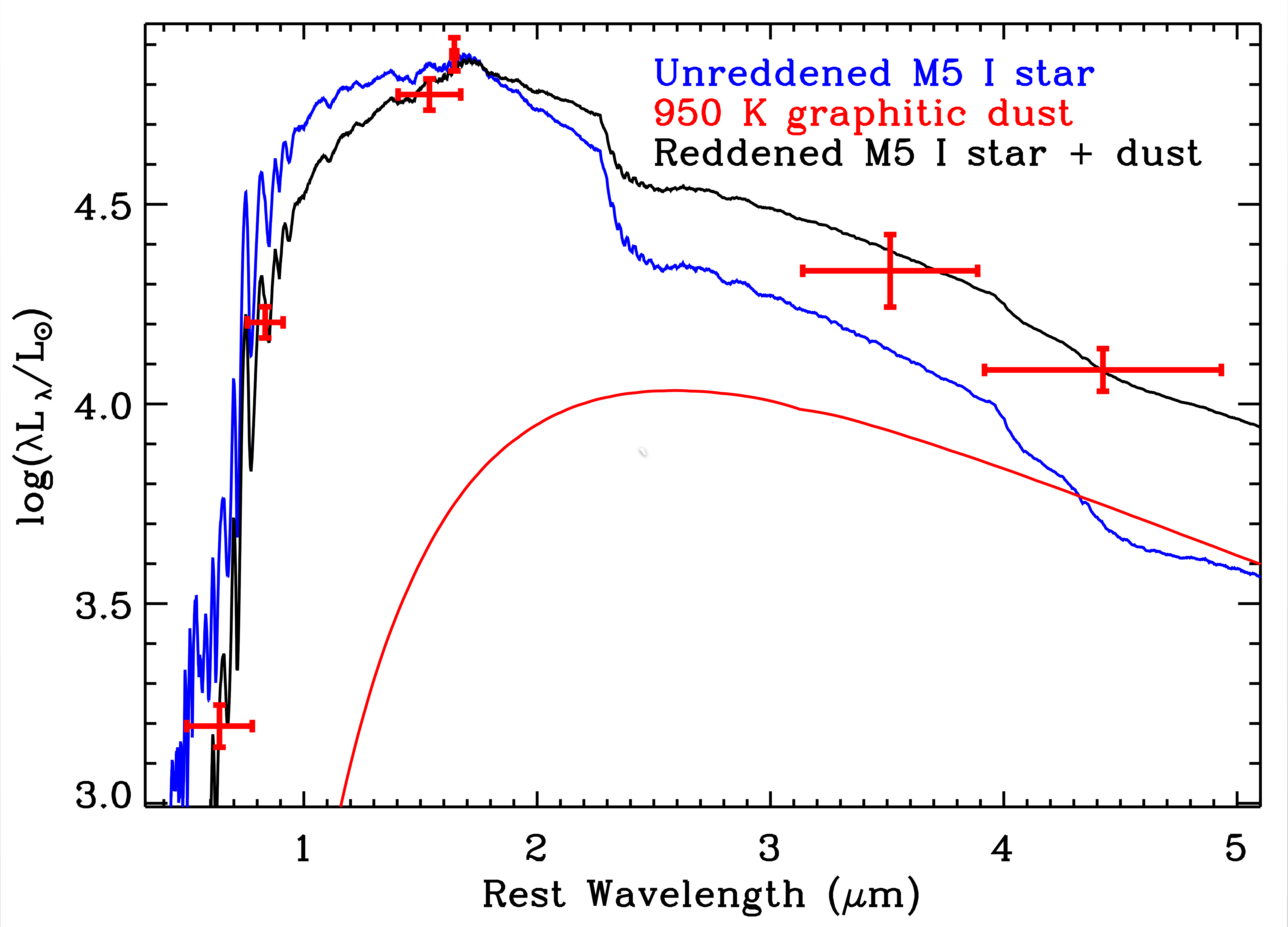


Verhoelst+09

Progenitor of SN 2017eaw

Start with stellar SED and pass flux through CSM that absorbs/re-emits

Simultaneously fit L_*, T_*, CSM extinction, Tdust

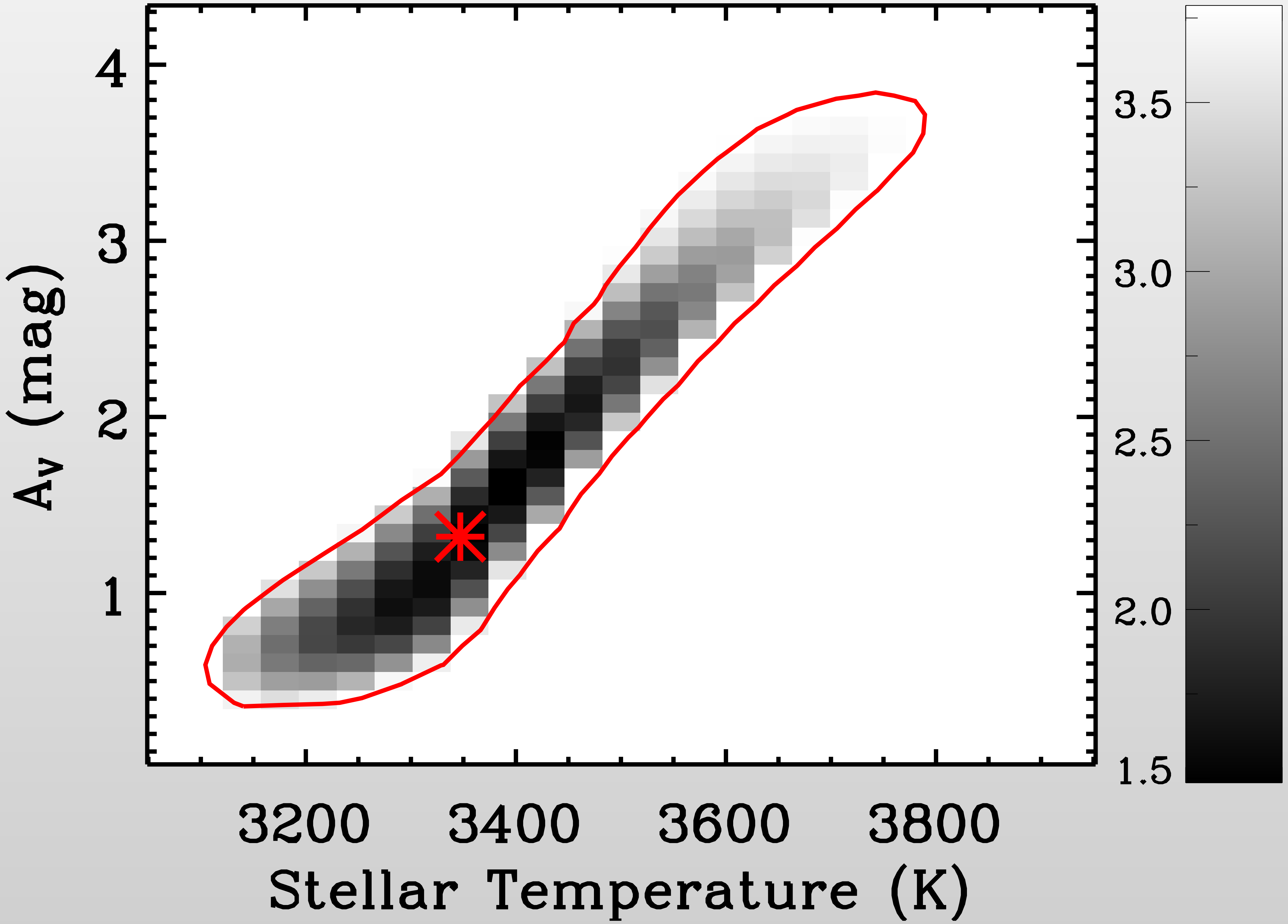


Snapshot of SN 2017eaw progenitor system 200 days before core-collapse

- log L_* = 4.9, T_*=3350 K, M=13 Msun
- Total dust mass is >10^{-5} Msun
- Mass-loss rate is 10^{-6} Msun/yr

With caveats:

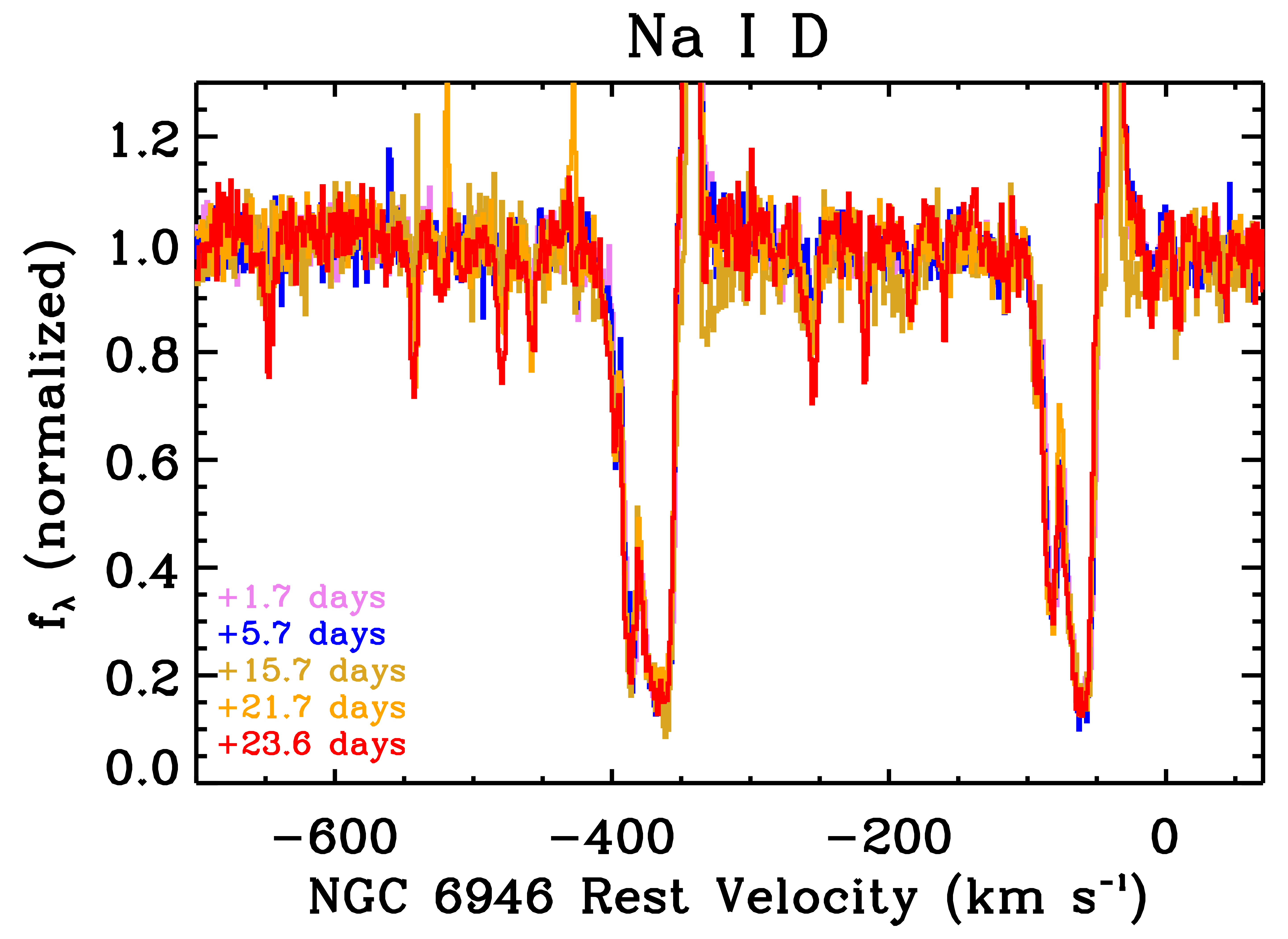
- Degeneracy in T_* and CSM - need better MIR constraints
- We have no constraint on the dust geometry or wind speed
- Systematic uncertainties in model: for stellar rotation, metallicity and dust composition, grain size distribution



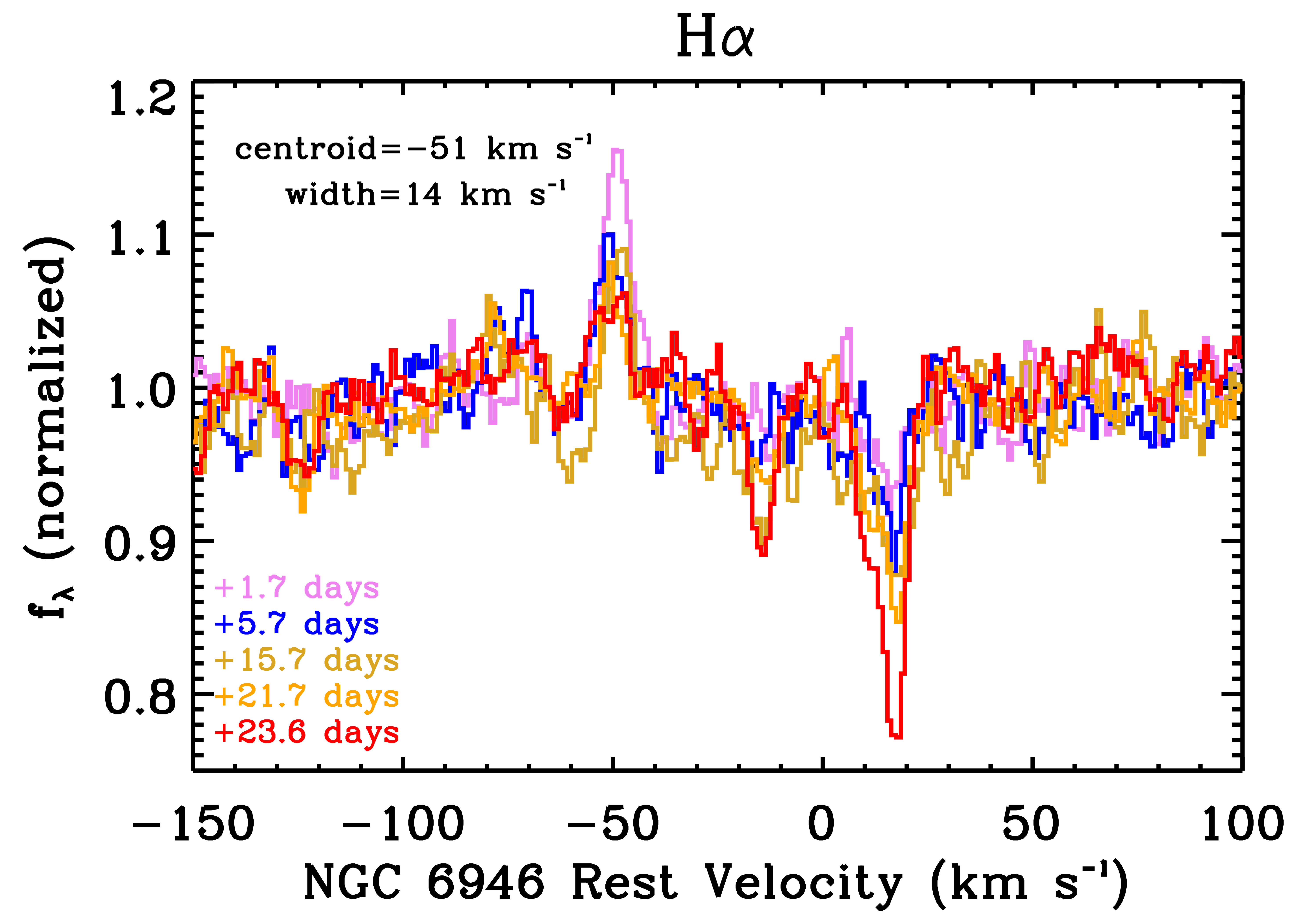
Spectra of SN 2017eaw probe environment

Resolution = 100,000

For sufficiently bright SNe (V < 13.5 mag), we can resolve ~2 km/s

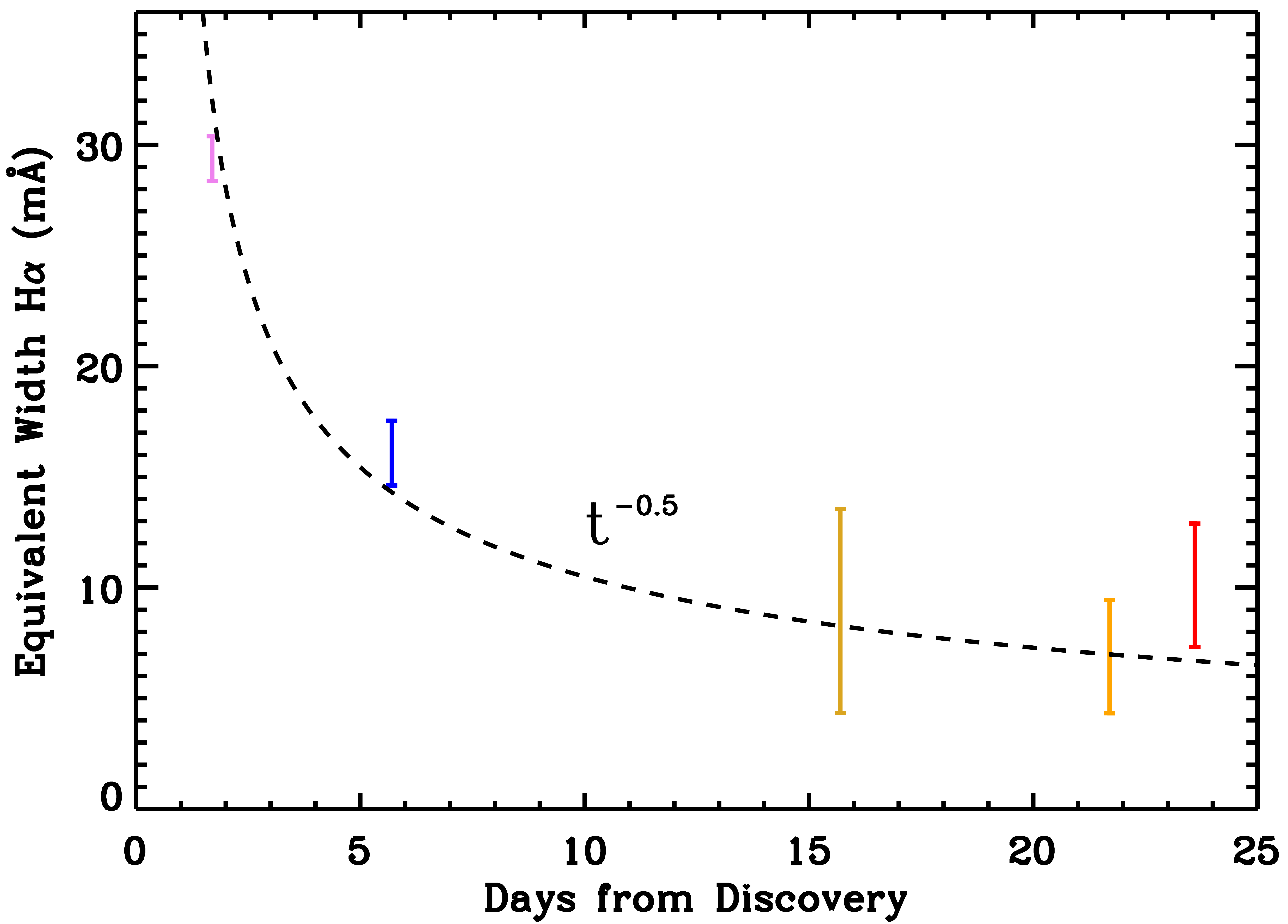


Spectra of SN 2017eaw probe environment



Summary

- The SN 2017eaw pre-explosion counterpart is consistent with a 13 Msun RSG
- Its SED cooled with time as mid-infrared emission increased, consistent with an expanding photosphere due to a dusty wind
- High-resolution spectra reveal a structured wind environment around SN 2017eaw
- SN 2017eaw is a relatively normal SN II, suggesting that all SN II progenitor systems need to be considered in the context of dust obscuration and complex circumstellar environments


Equivalent Width Hα (mÅ)
0
10
20
30
t⁻⁰·⁵
0
5
10
15
20
25
Days from Discovery