The population of Type II supernova progenitor stars with new mid-infrared limits

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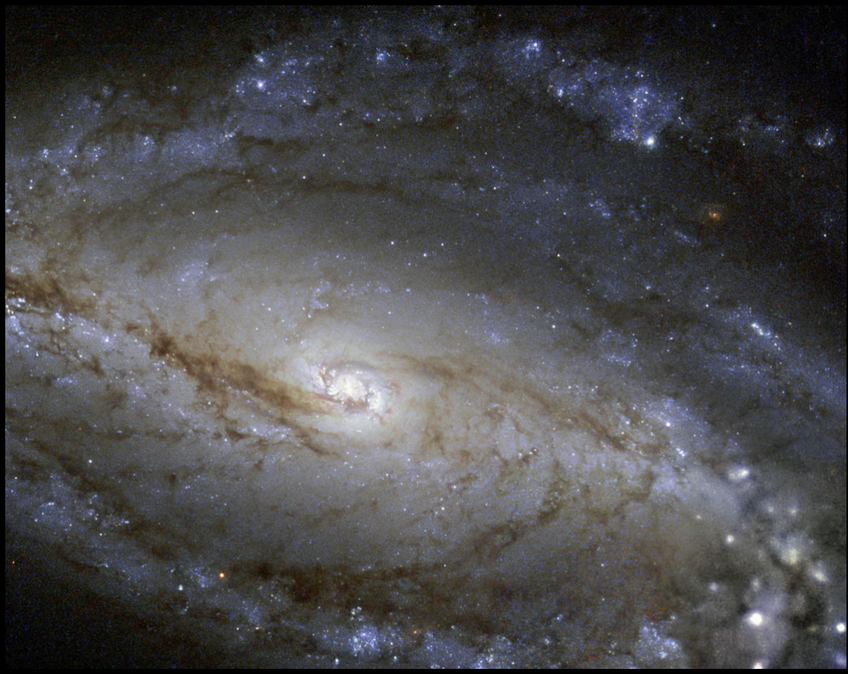
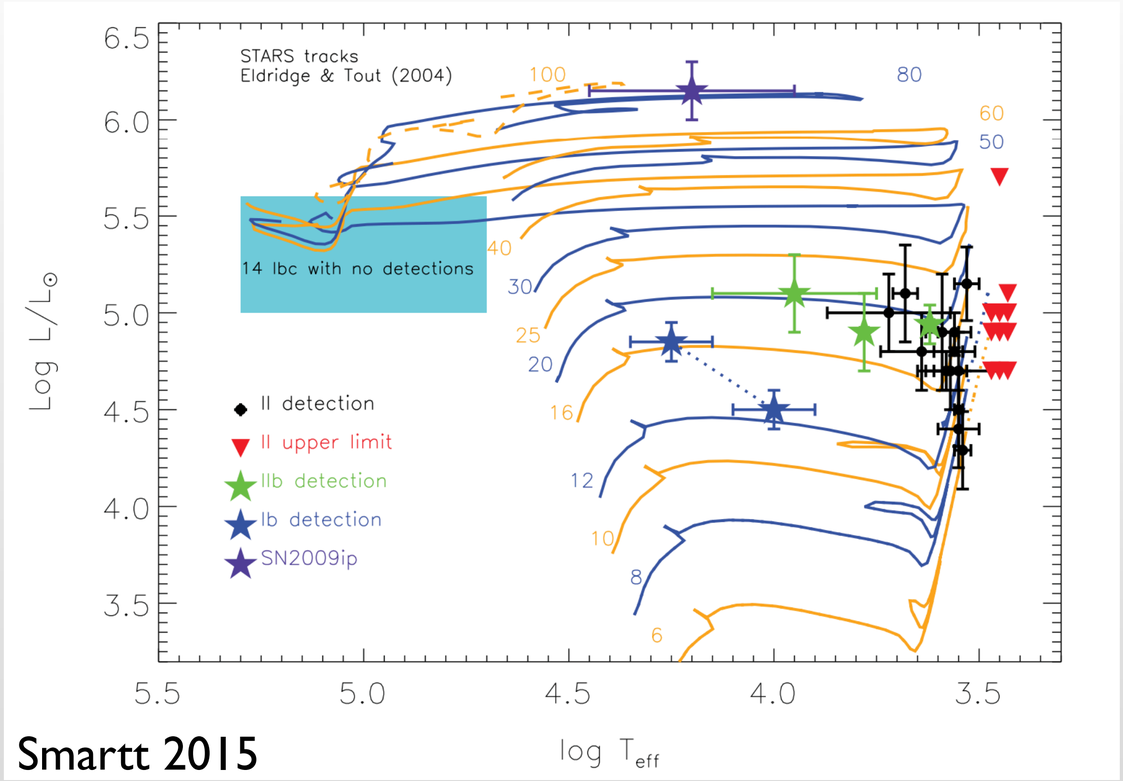
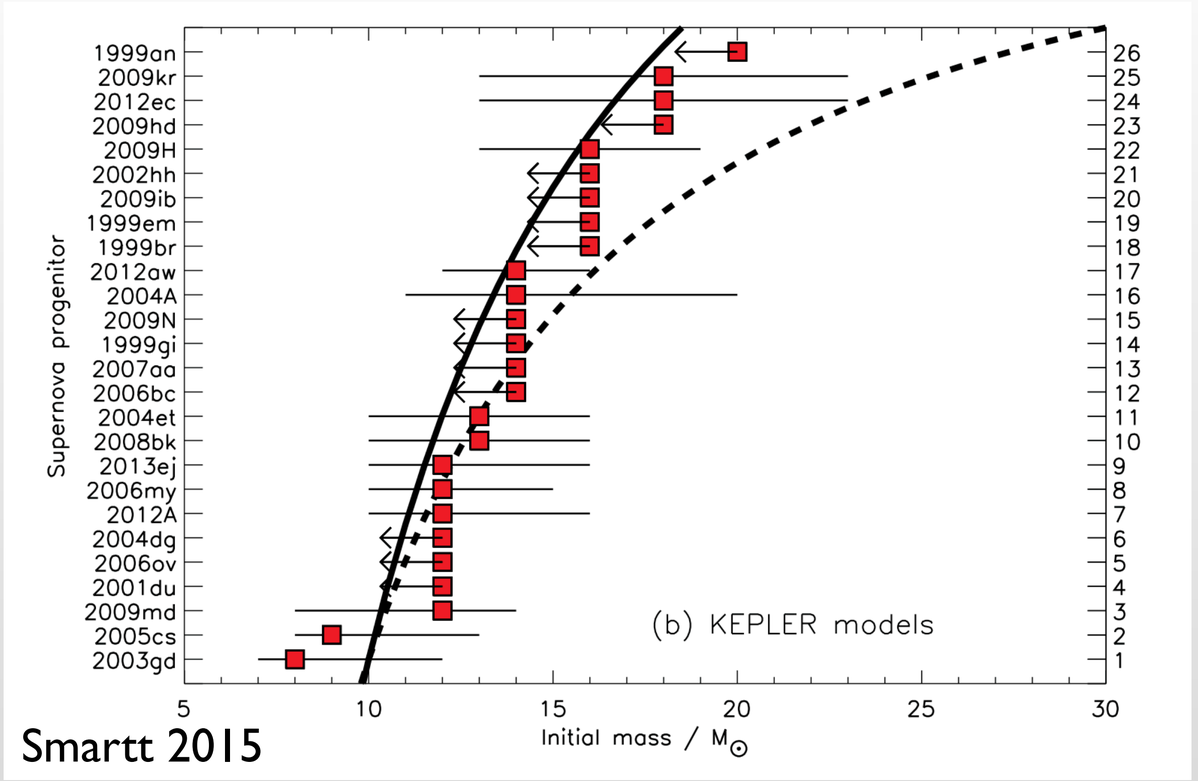


What happens to the high-mass RSGs?



Smartt 2015

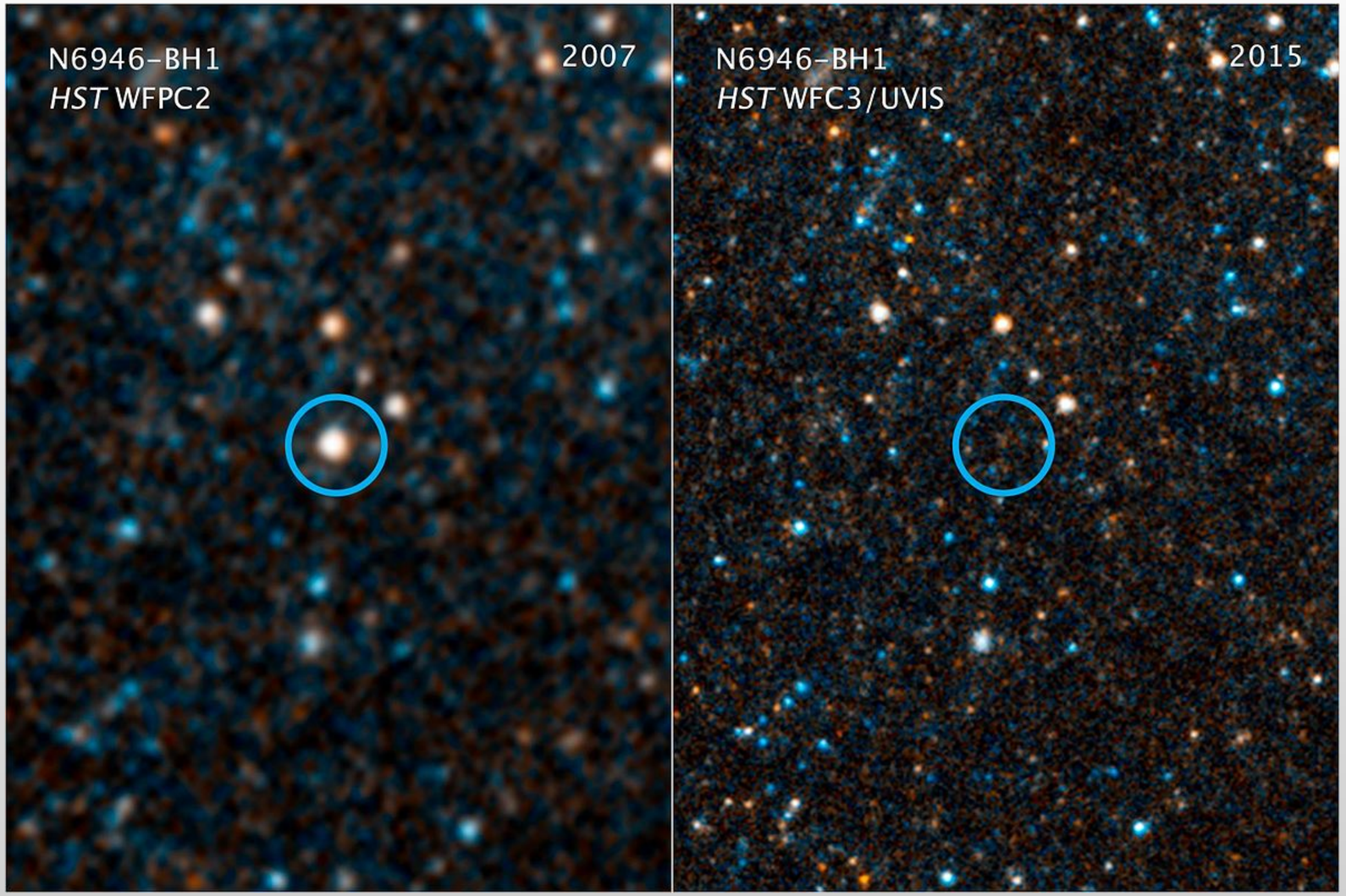


Smartt 2015

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

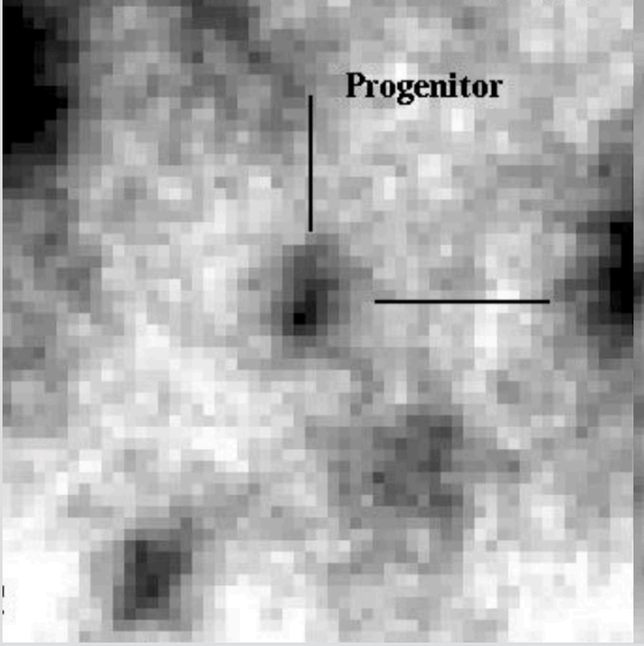
We know RSGs with log L = 5.2-5.5 exist (AH Sco, UY Sct, KW Sgr, etc.). Why no SN progenitor stars in this range?

A mass threshold for successful SNe from RSGs?

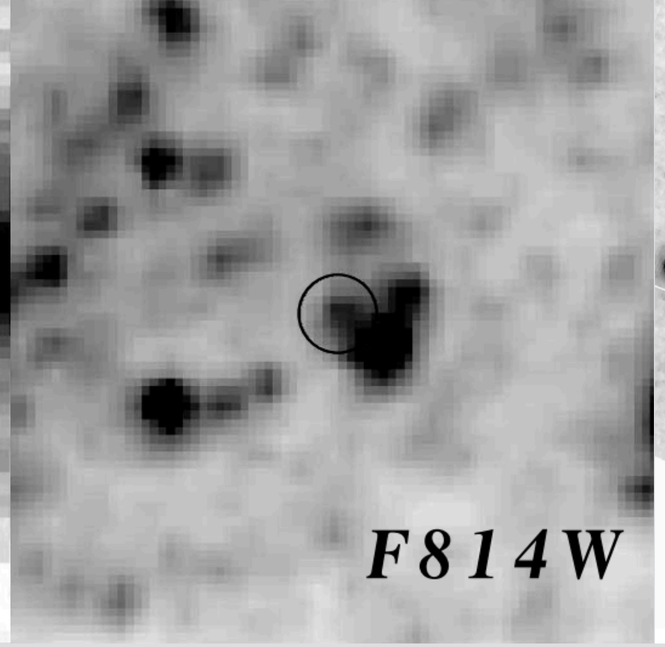


Credit: NASA/OSU
See Adams+2017

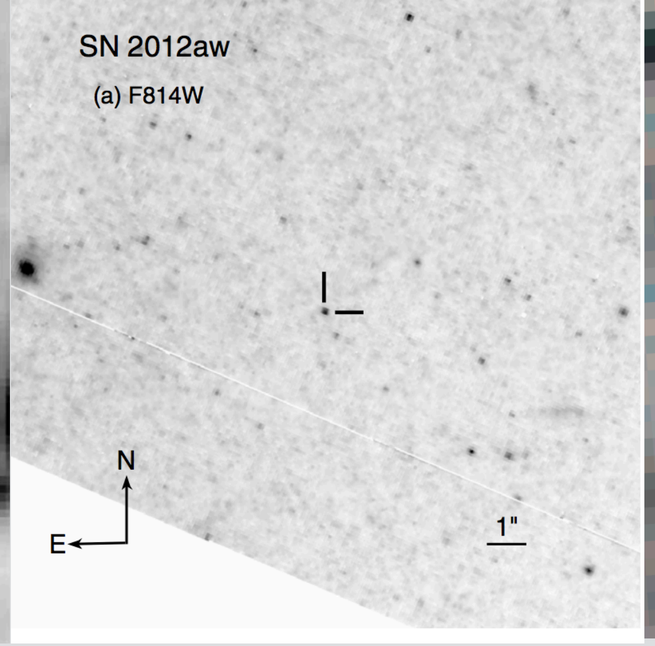
Is this a fundamental limit and high-mass RSGs collapse to BH?



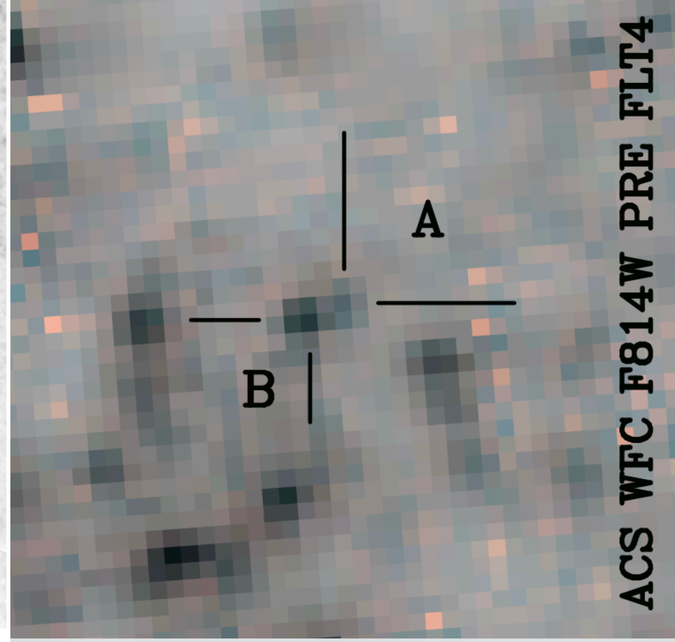
SN 2003gd
(9 Mpc; Smartt+2004)



SN 2005cs
(7 Mpc; Li+2006)



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



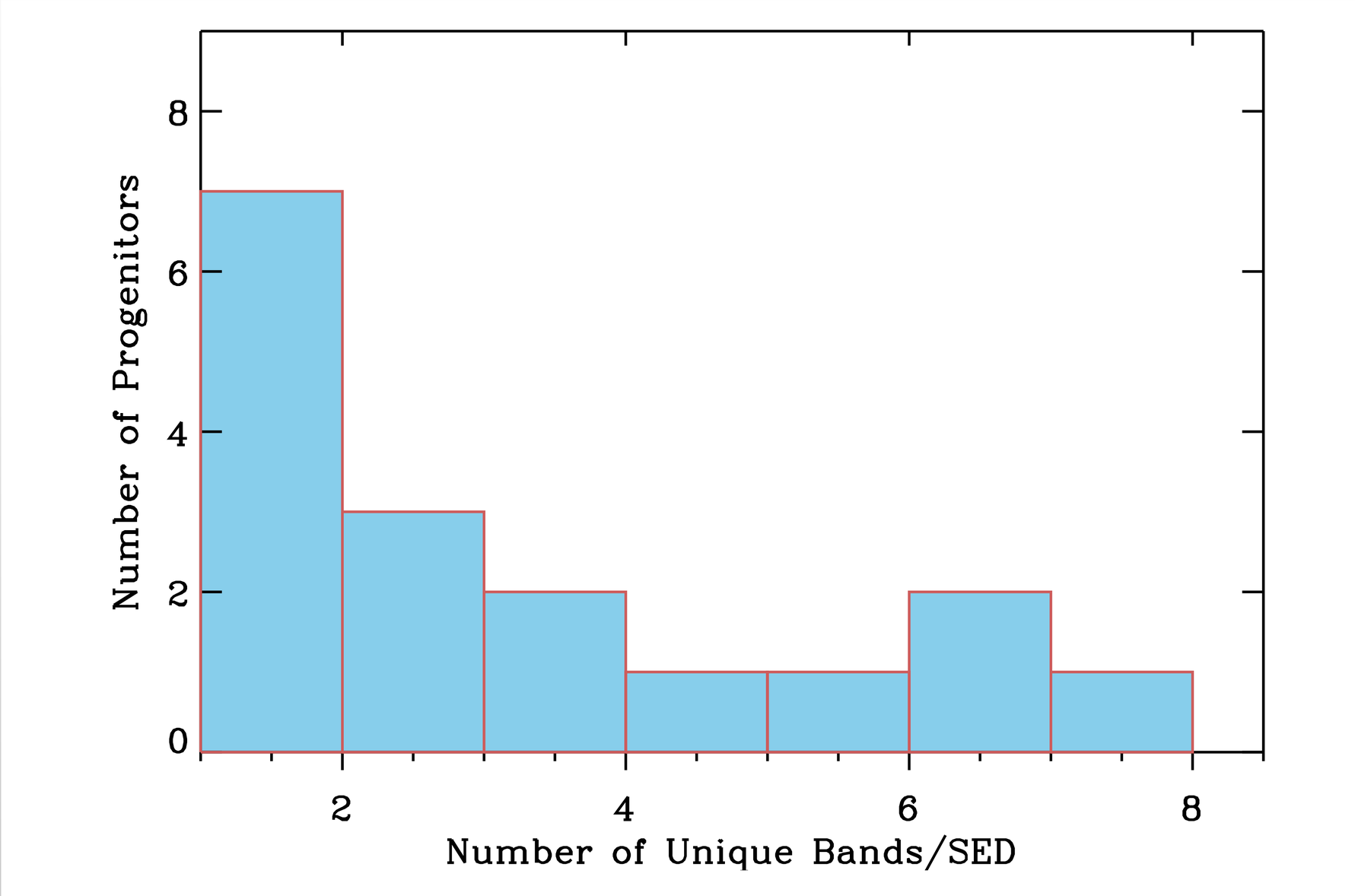
SN 2012ec
(17 Mpc; Maund+2013)

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

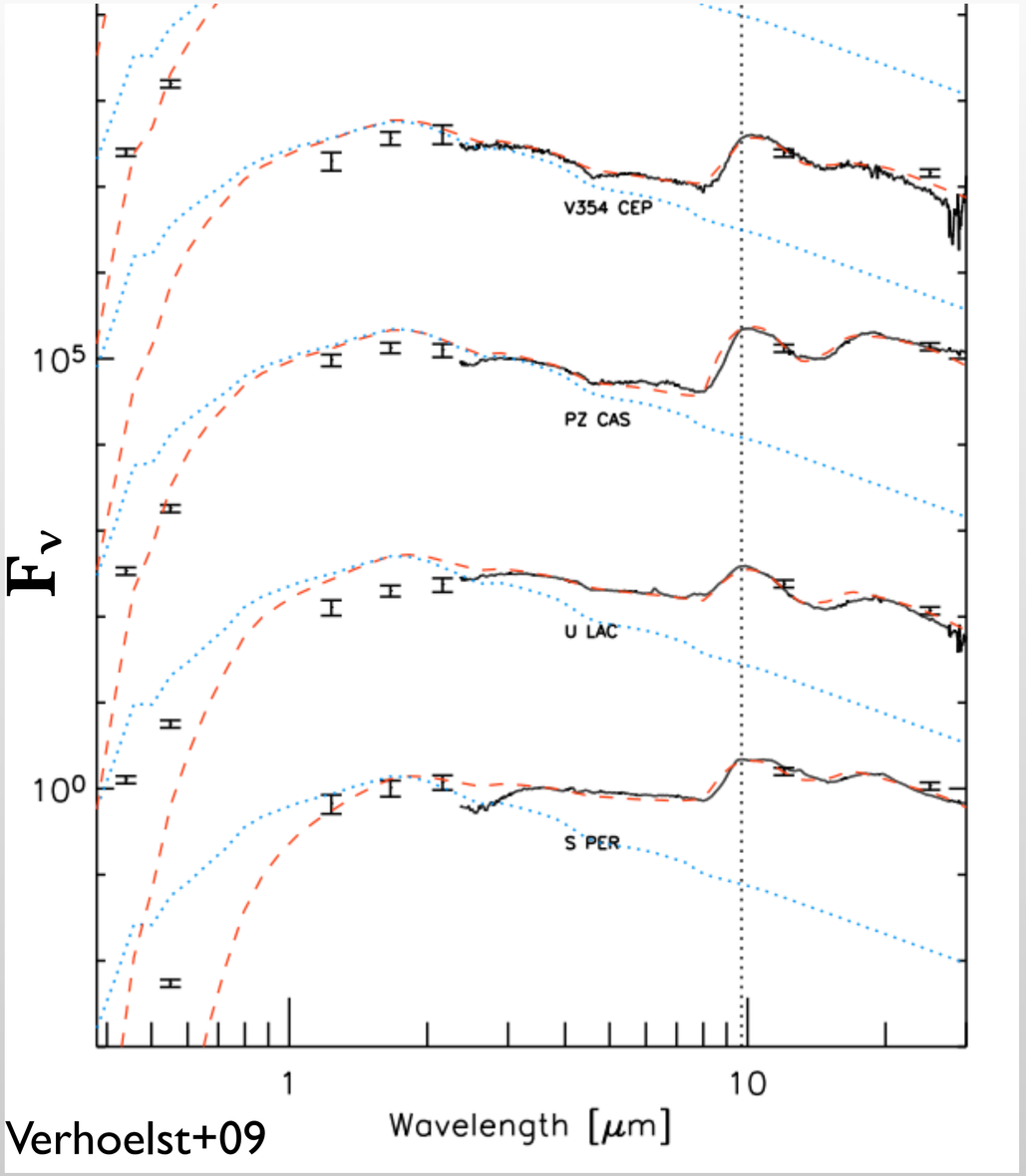
What data go into RSG mass measurements?



Red supergiants are dusty

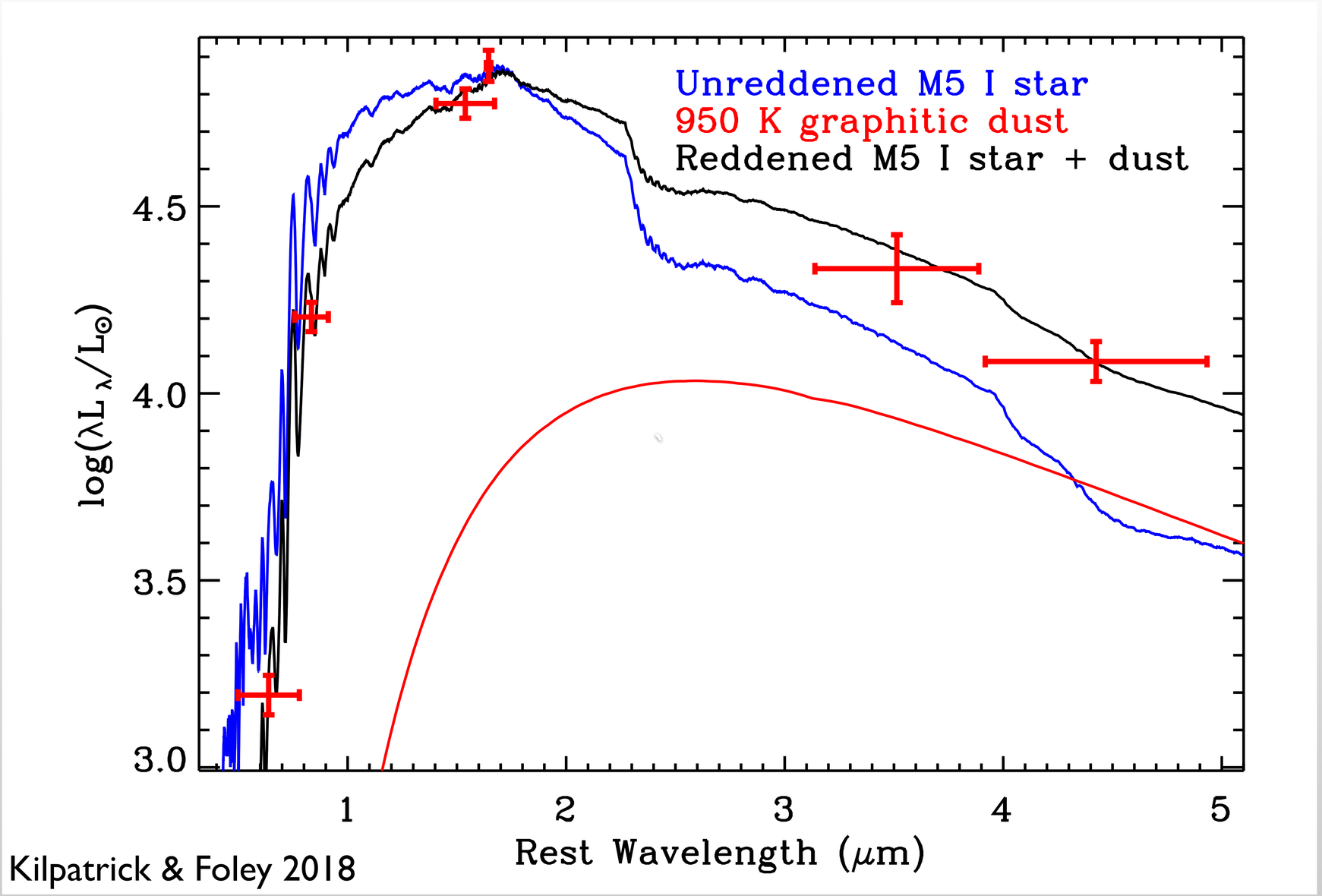
SEDs of RSGs peak at 1-2 microns and have significant dust emission >3 microns

Observed SED =
Reddened intrinsic star +
Dust emission



Verhoelst+09

~17% of RSGs only have optical constraints



Kilpatrick & Foley 2018

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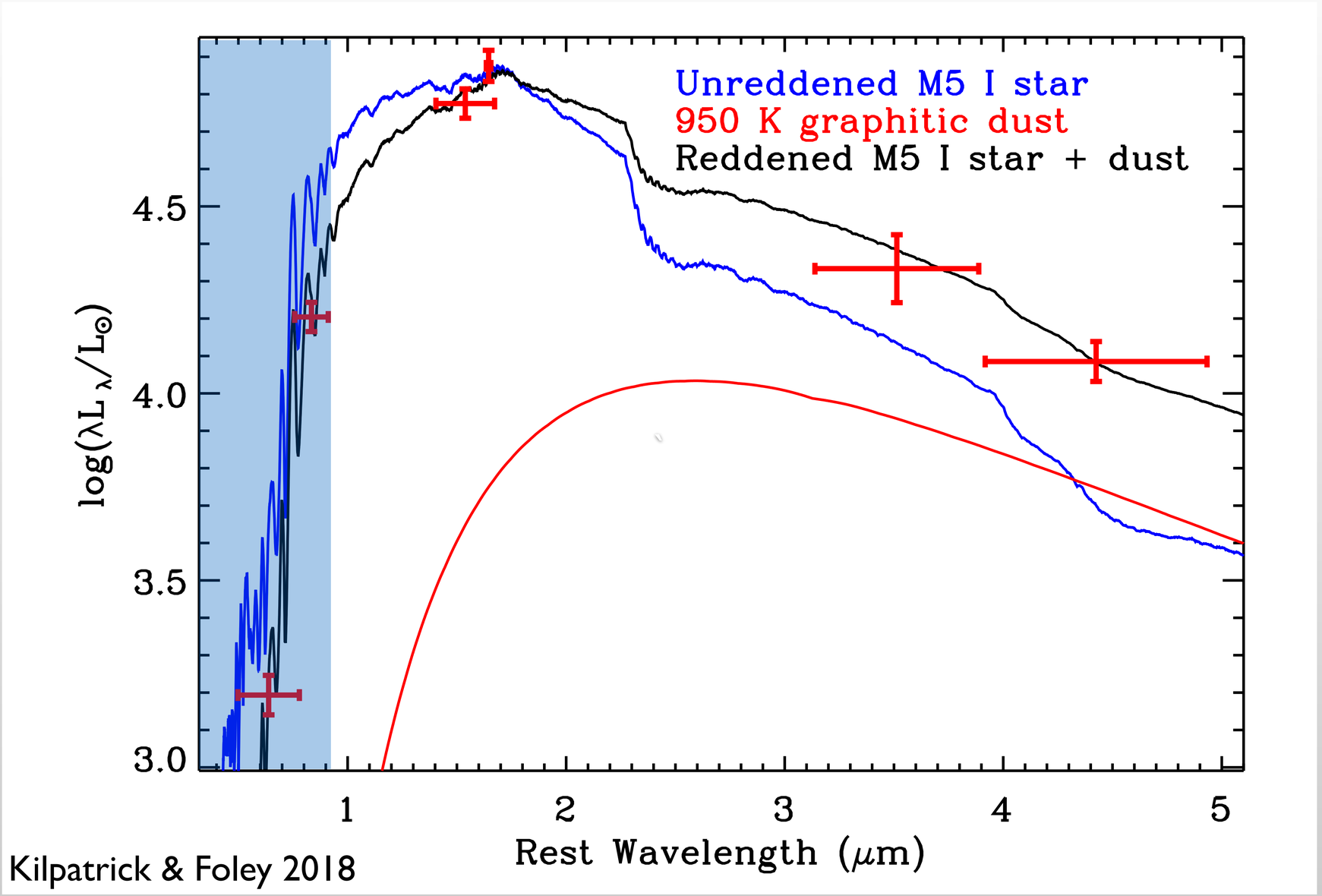

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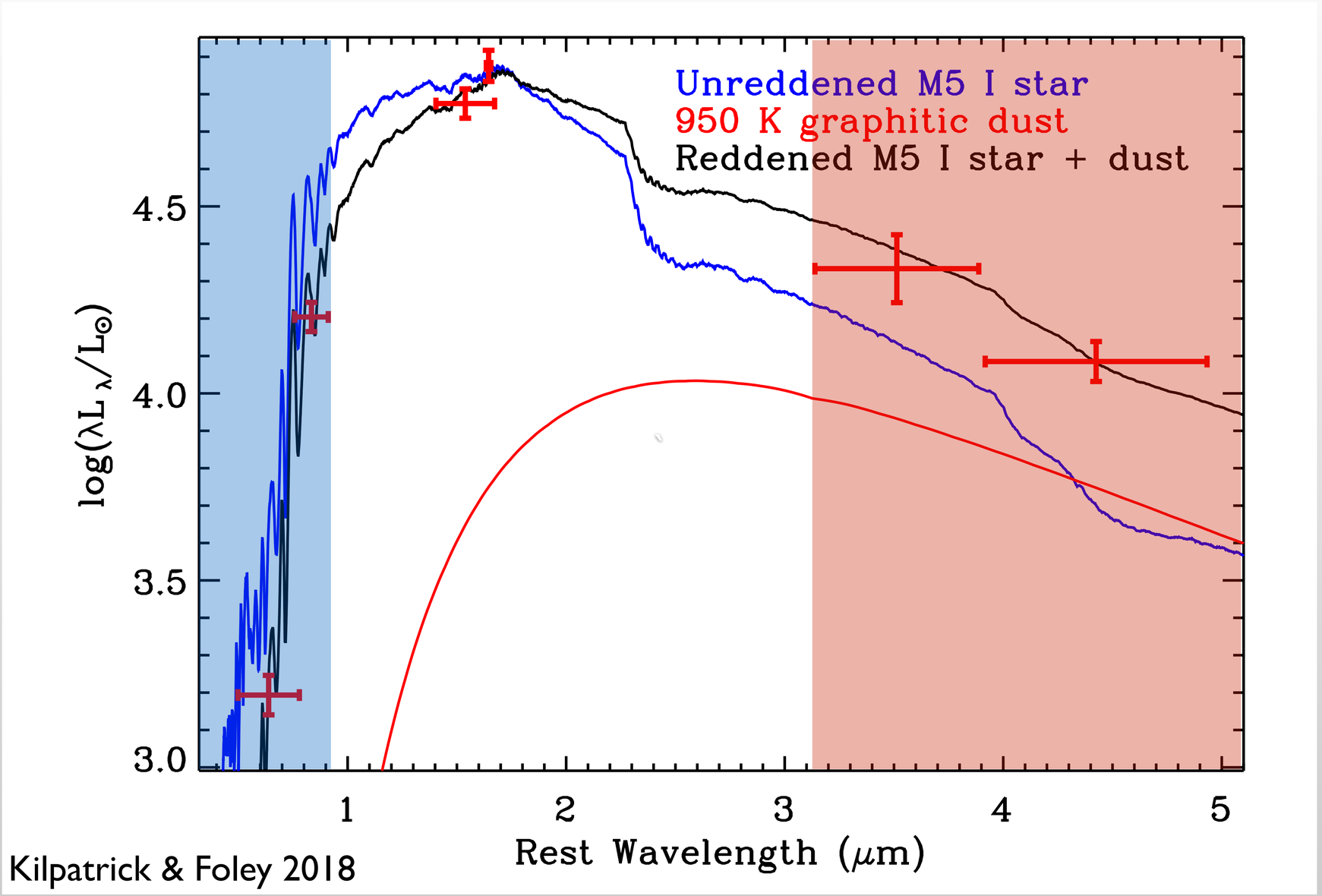
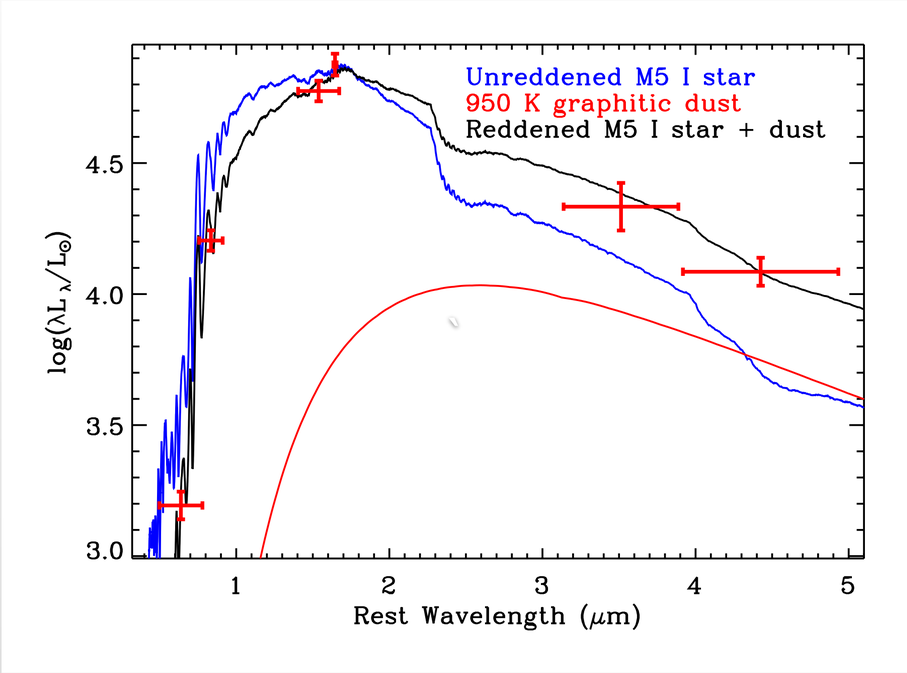


Kilpatrick & Foley 2018

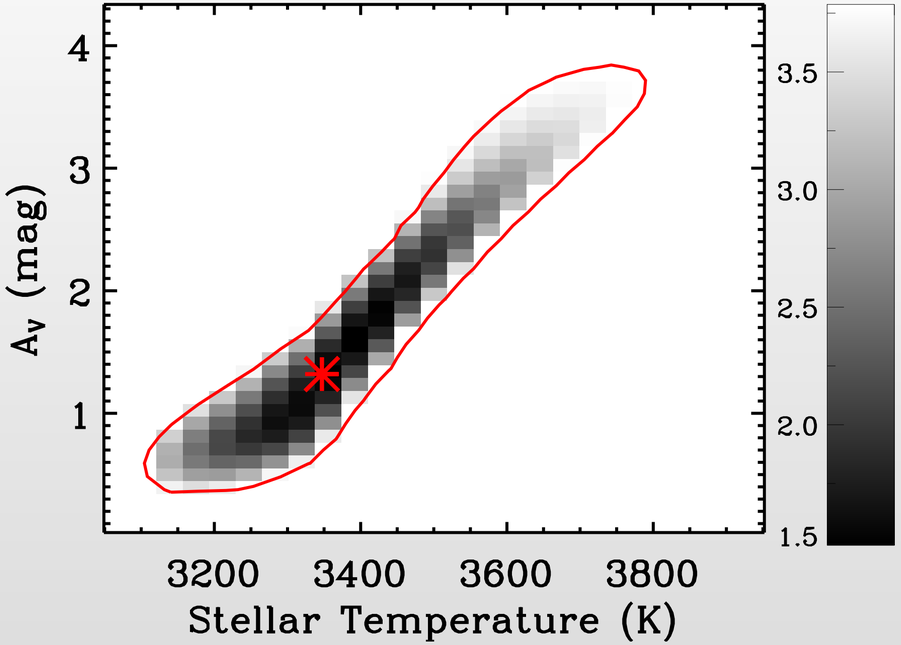
Progenitor of SN II 2017eaw

Four parameters: L_*, T_*, CSM extinction, T_{dust}

Modeling 0.6-5 μm SED reveals 10-60% more luminosity than we would infer from the optical SED alone

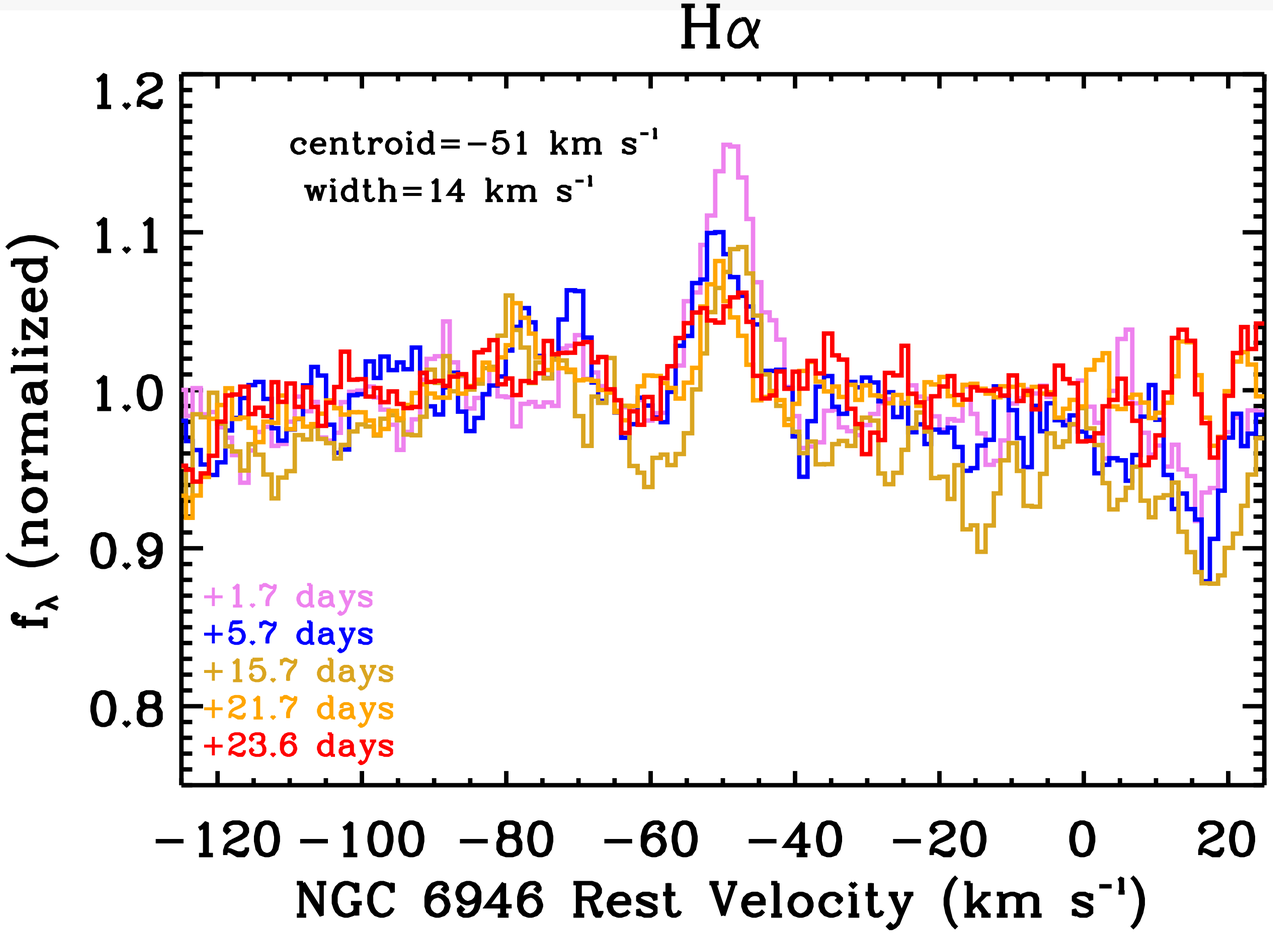


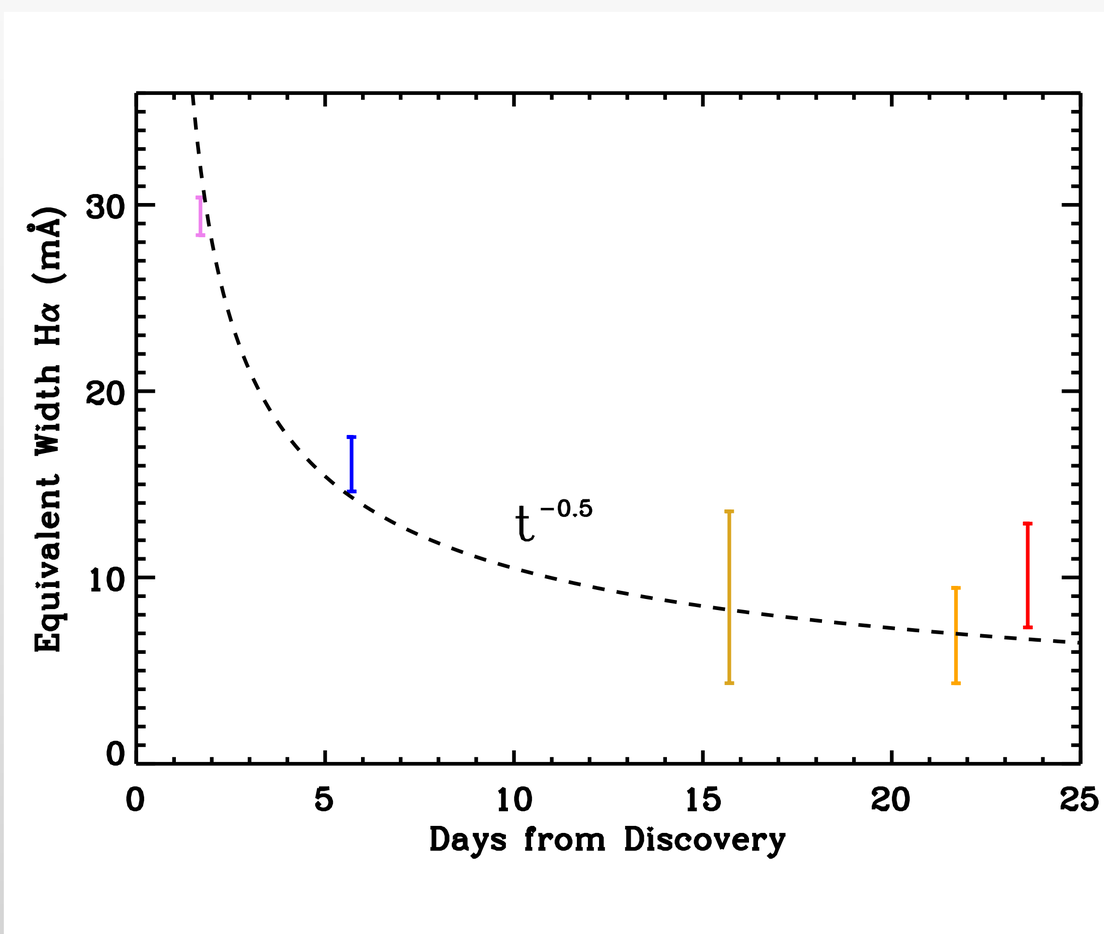
Kilpatrick & Foley 2018



Systematic uncertainties: stellar rotation, metallicity, dust composition, grain size distribution, wind speed, dust geometry

High-resolution spectra probe this environment

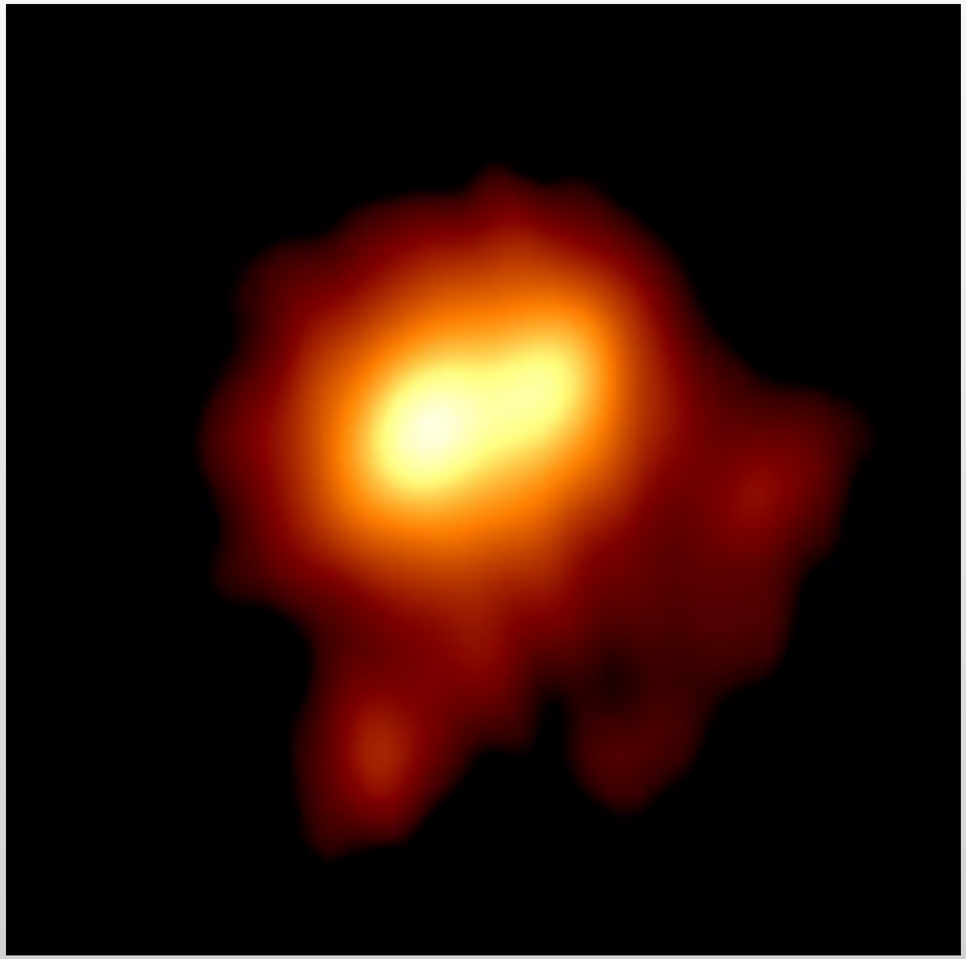




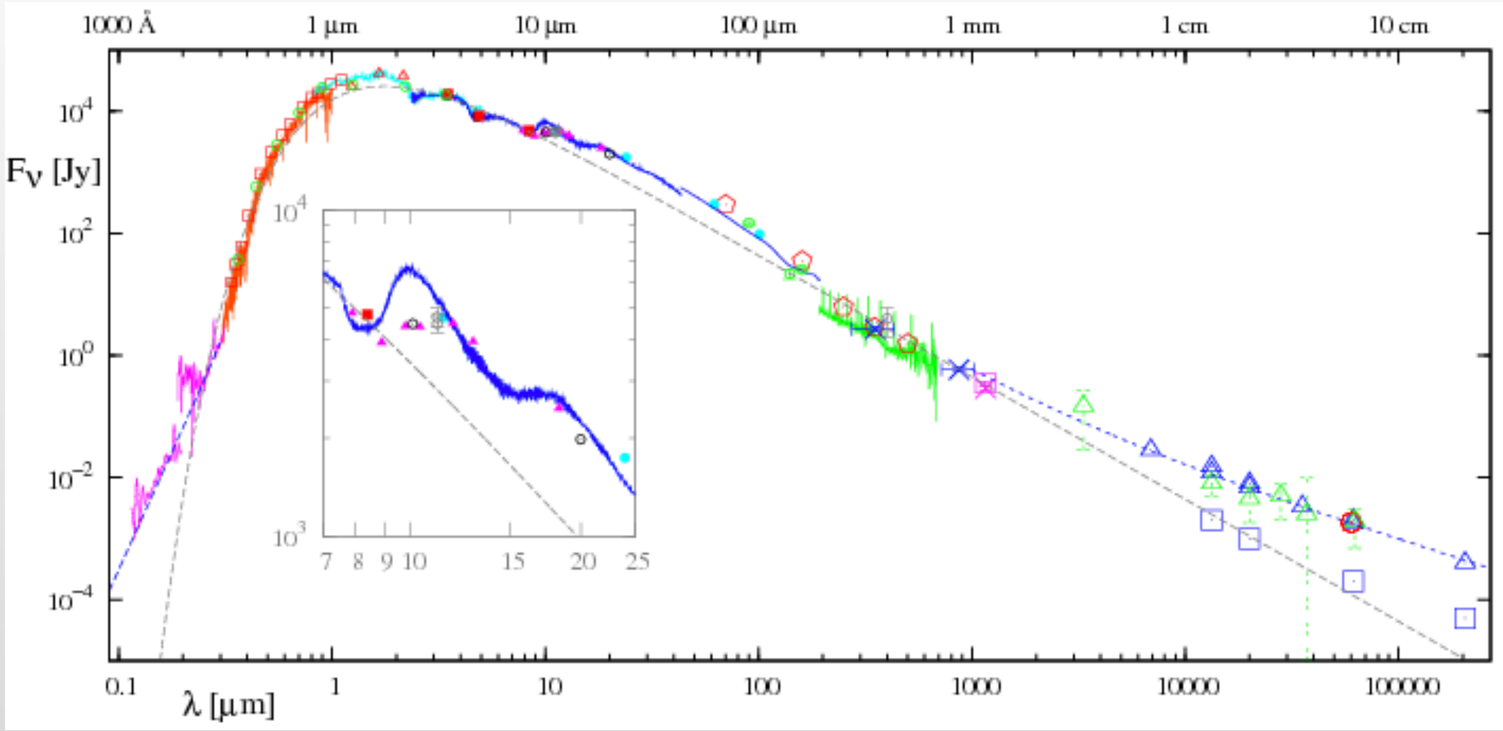
Hα implies wind speed = 14 km s^{-1}

mass-loss rate = 10^{-5} $M_\odot$/yr

Can we probe this material around RSG progenitors?



Betelgeuse; Richards+2013

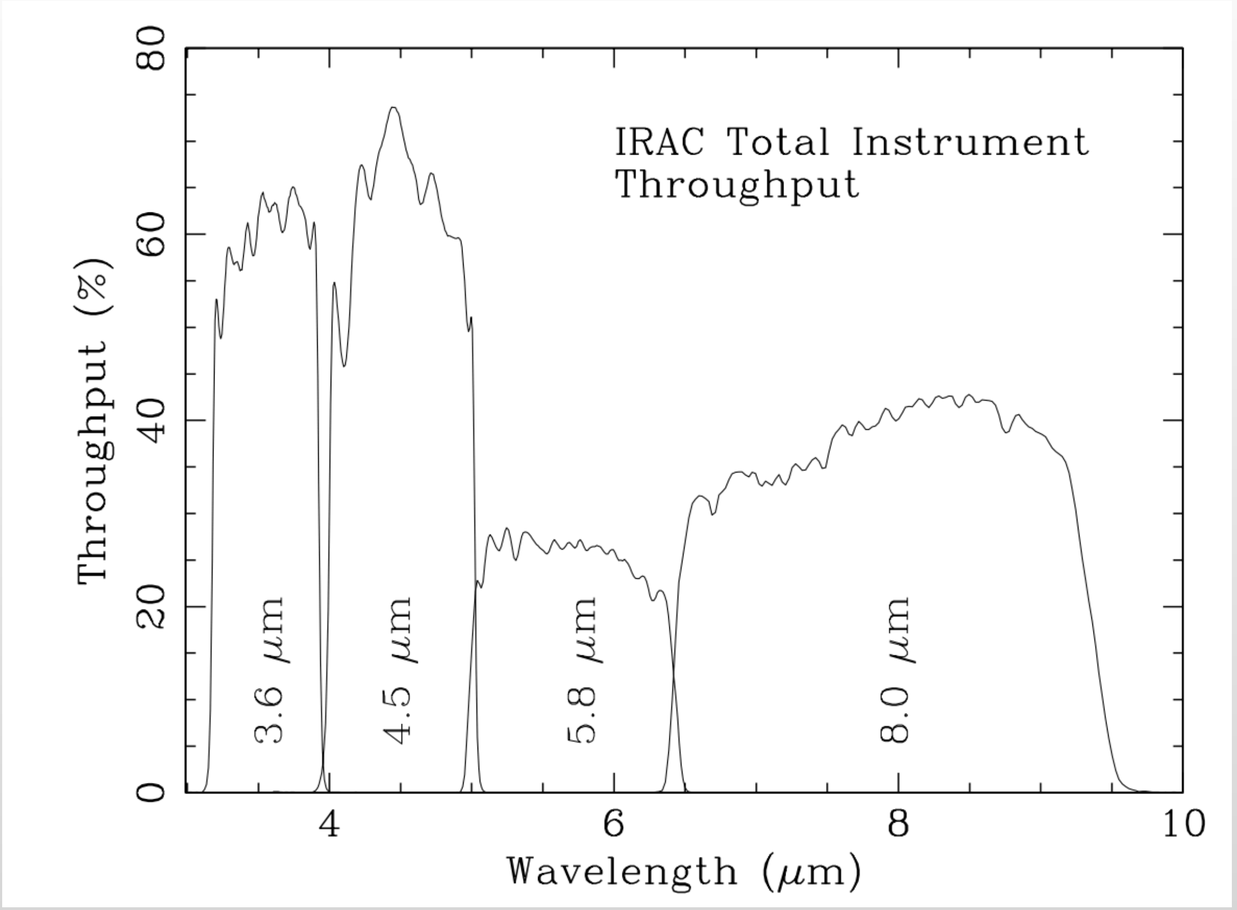


Full Betelgeuse SED; Kaminski+2013

Go to the infrared *(as red as possible!)*

Spitzer/IRAC probes hot dust around SN II progenitors

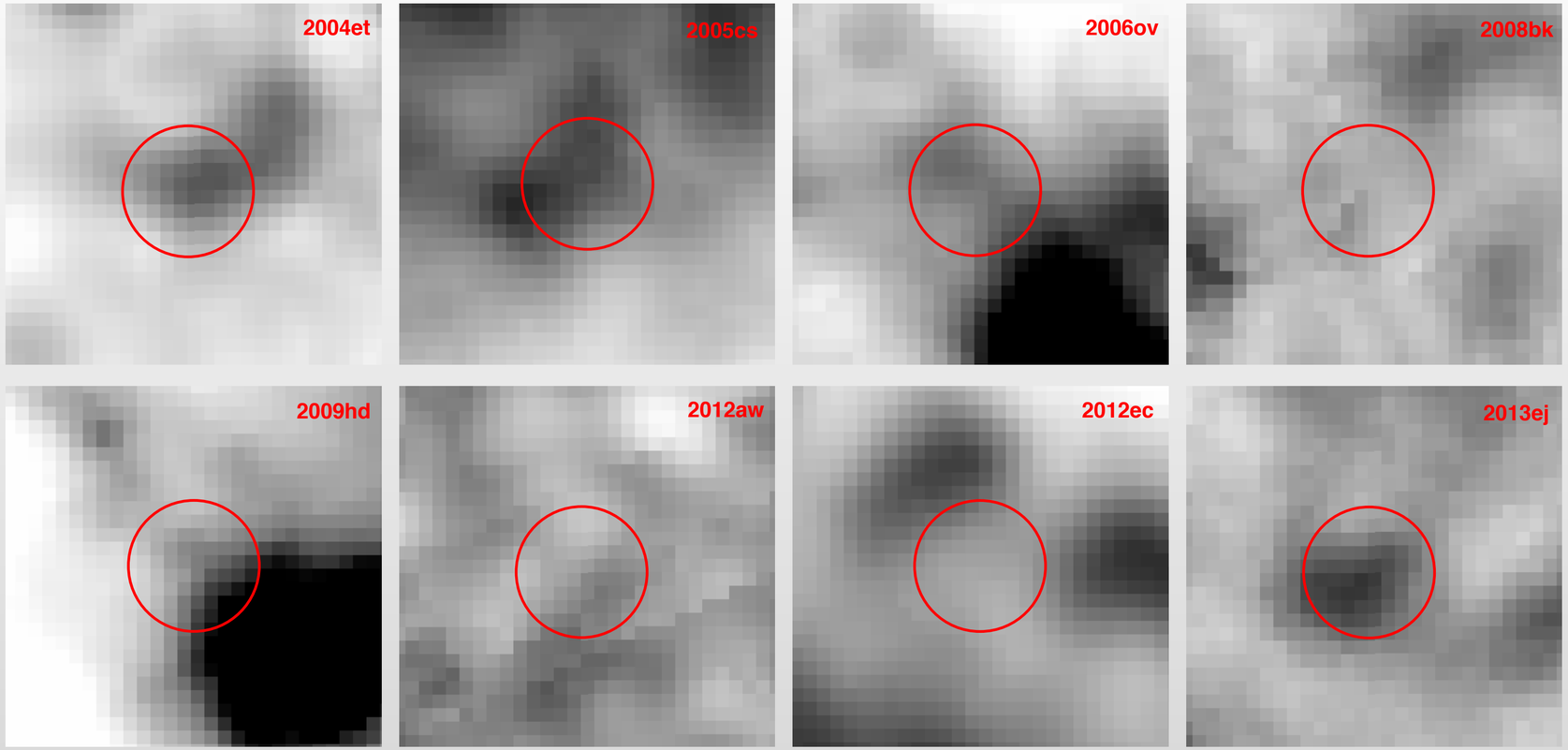
NGC 6946 from SINGS; Kennicutt+2003



Fazio+2004

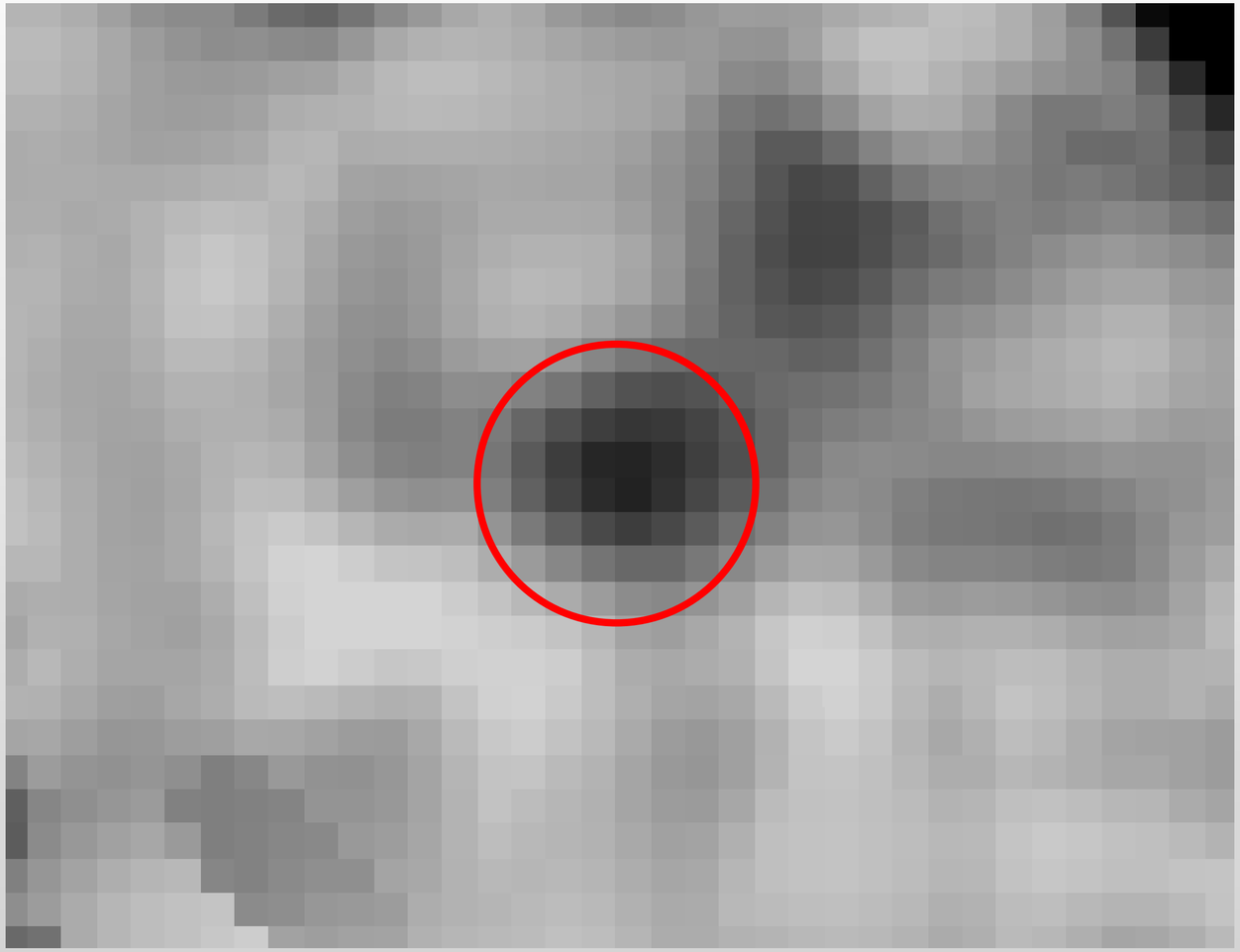
Limits are typically 21-23 mag
Probes 2017eaw-like RSGs to 10-20 Mpc

4/8 exhibit evidence for mid-IR excess at SN location



But you have to go back and verify that the SN is gone...

Spitzer is currently best way to probe this material!



Kilpatrick+2019, in prep.

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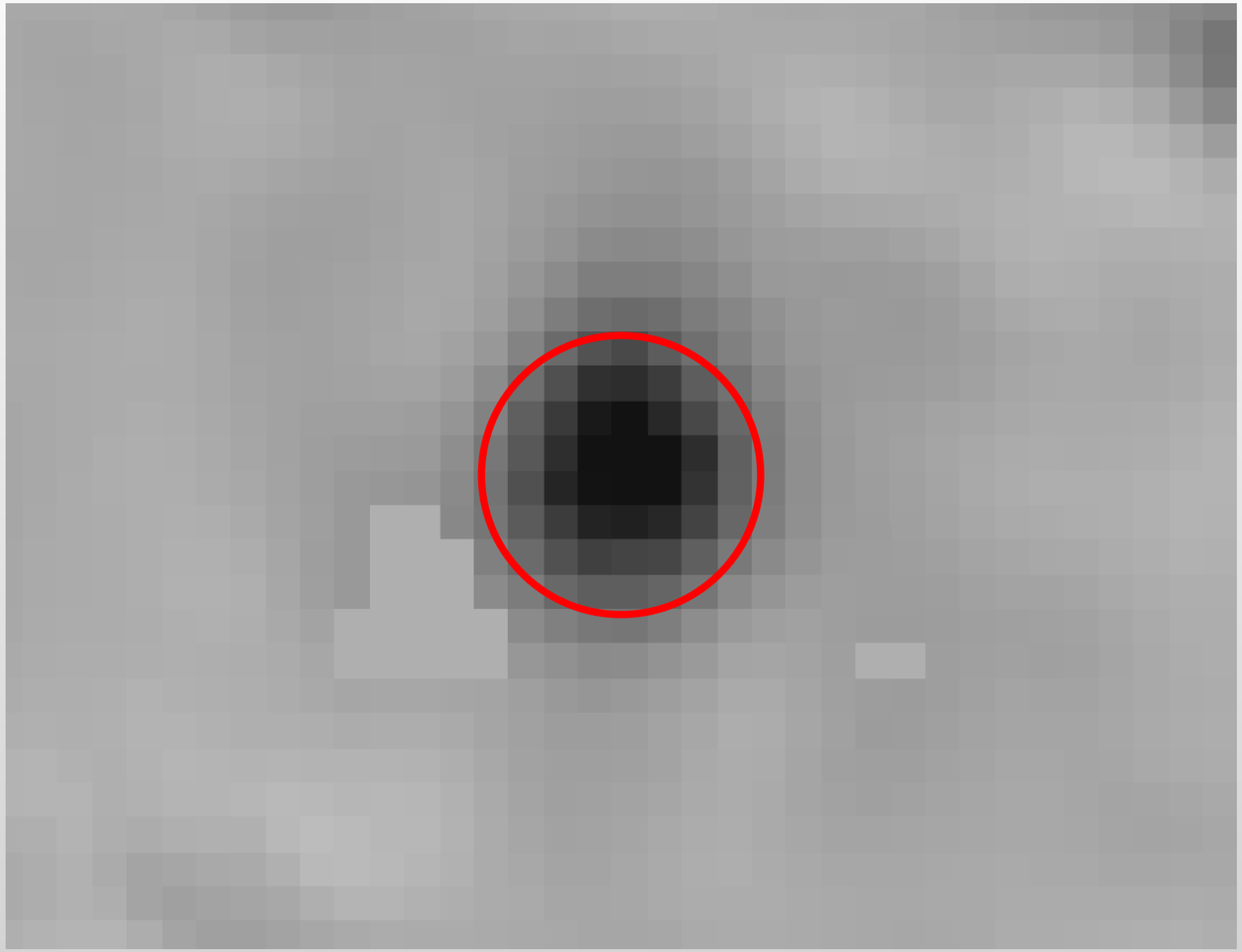
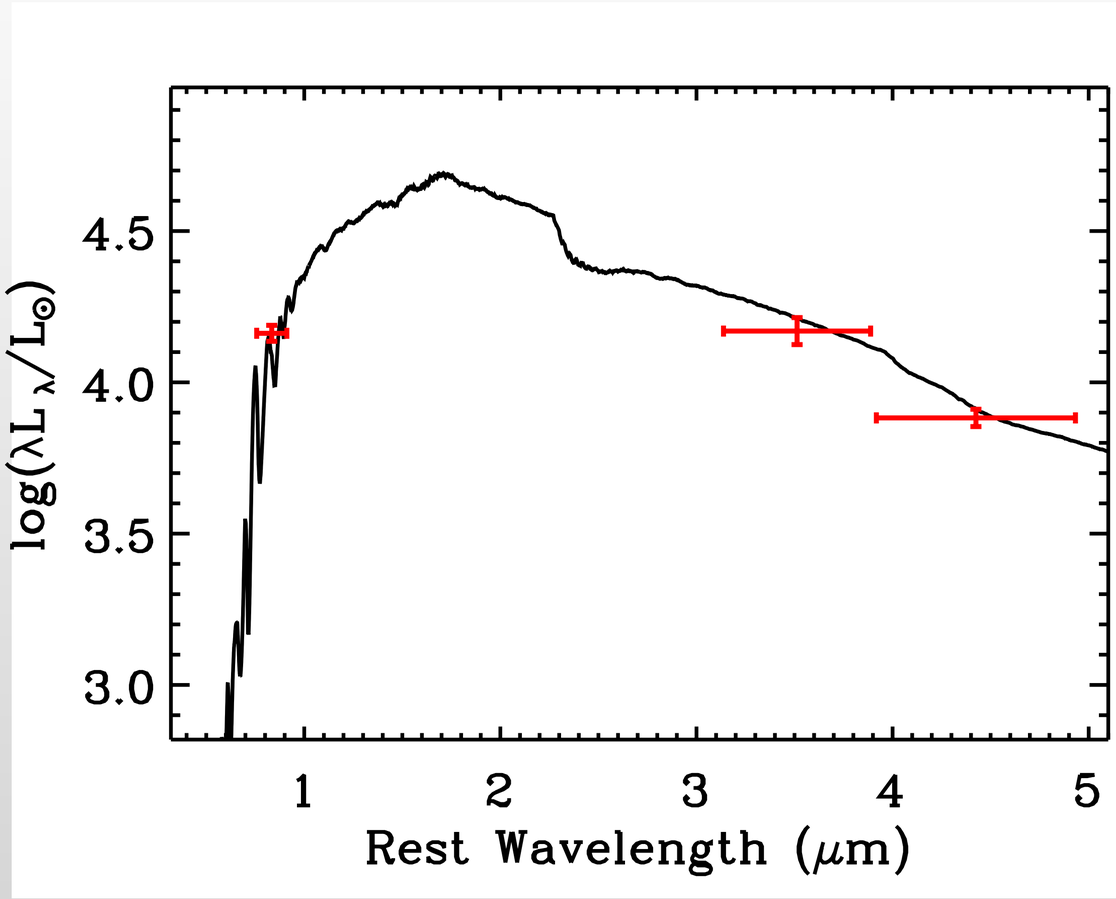


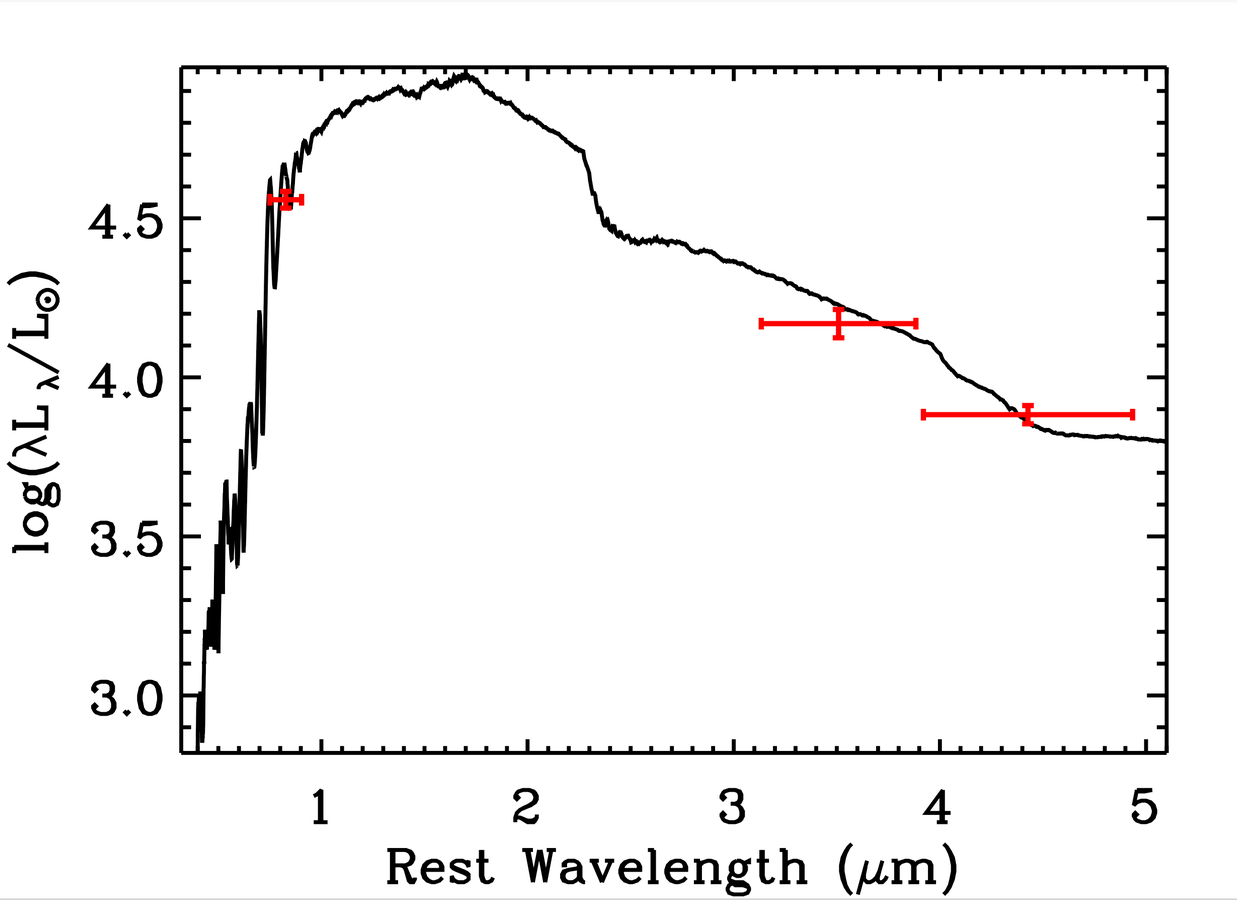
Kilpatrick+2019, in prep.

25% of these SNe exhibit a significant mid-IR excess



SN 2004et

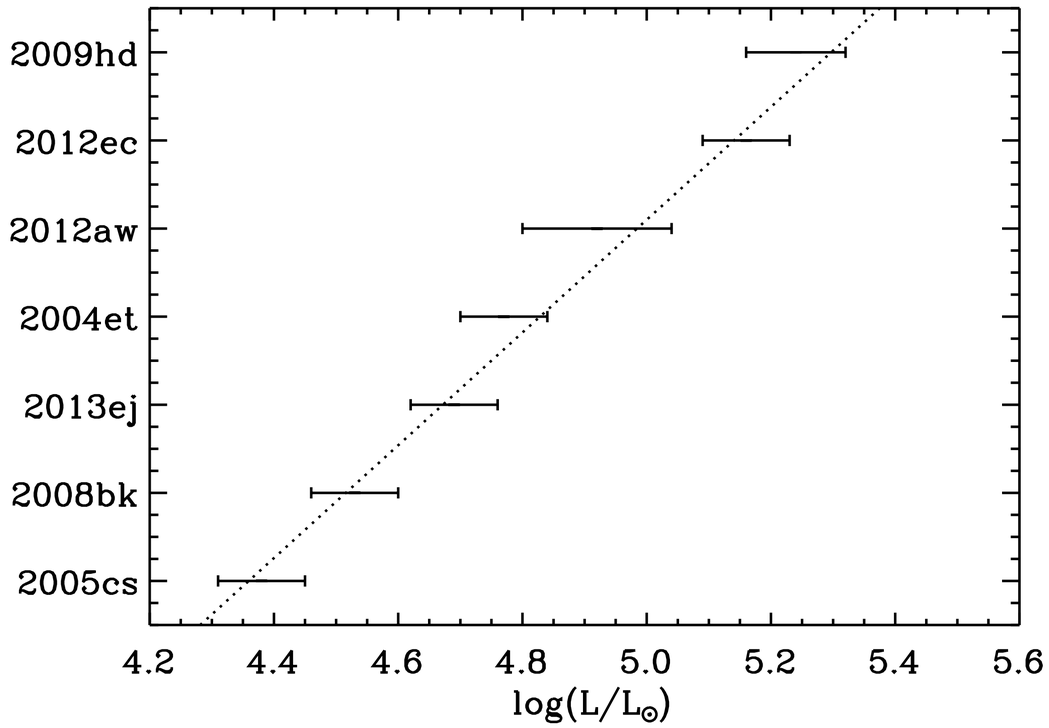
log L = 4.77 → 4.90

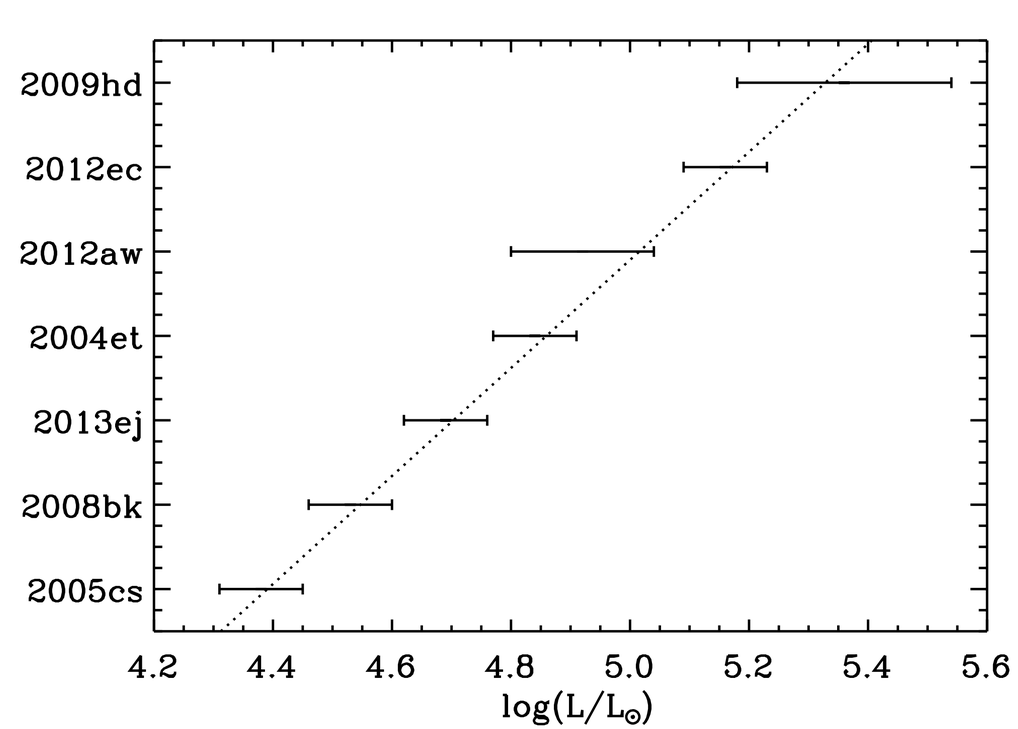


SN 2009hd

log L = 5.24 → 5.36

Inferred luminosities are up to 40% brighter

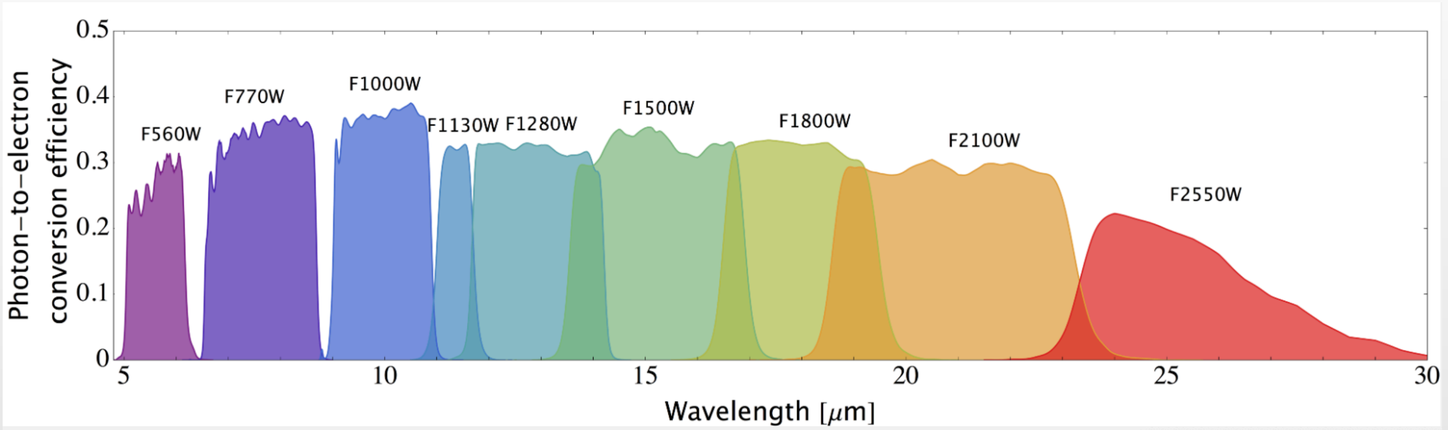




Maximum luminosity pushed to $\log(L/L_\odot) = 5.35$ ($M = 24\ M_\odot$) , but also very hard to constrain

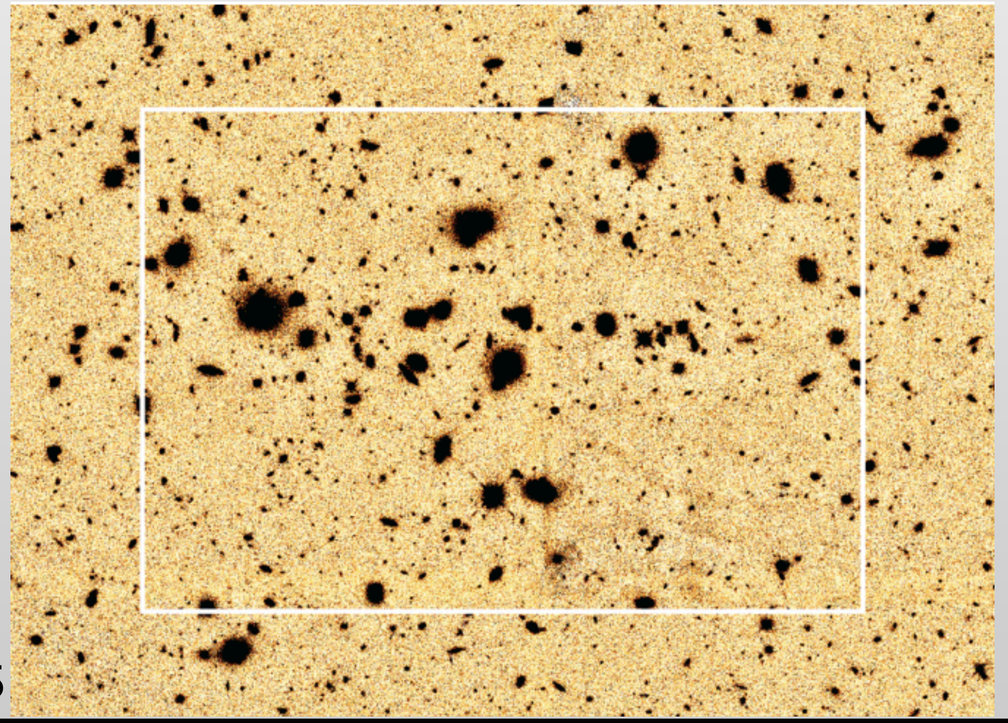
Future of progenitor star studies: *JWST*

5-28 micron broadband photometry with *JWST*/MIRI



***HST*-like depth resolution at 5-8 microns and 0.82 arcsec resolution at 25 micron**

Extremely important to get SN host galaxies *early*



G. Rieke+2015

Summary

- **We are starved for photons and spectrum looking at Type II supernova progenitors**
- **SNe with mid-IR excess have systematically higher luminosities (10-60%) when properly accounted for**
- **Very difficult to infer a maximum luminosity for RSGs as a whole with poorly constrained SEDs**
- ***Spitzer* can help constrain hot dust, but *JWST* will constrain all types of dust**