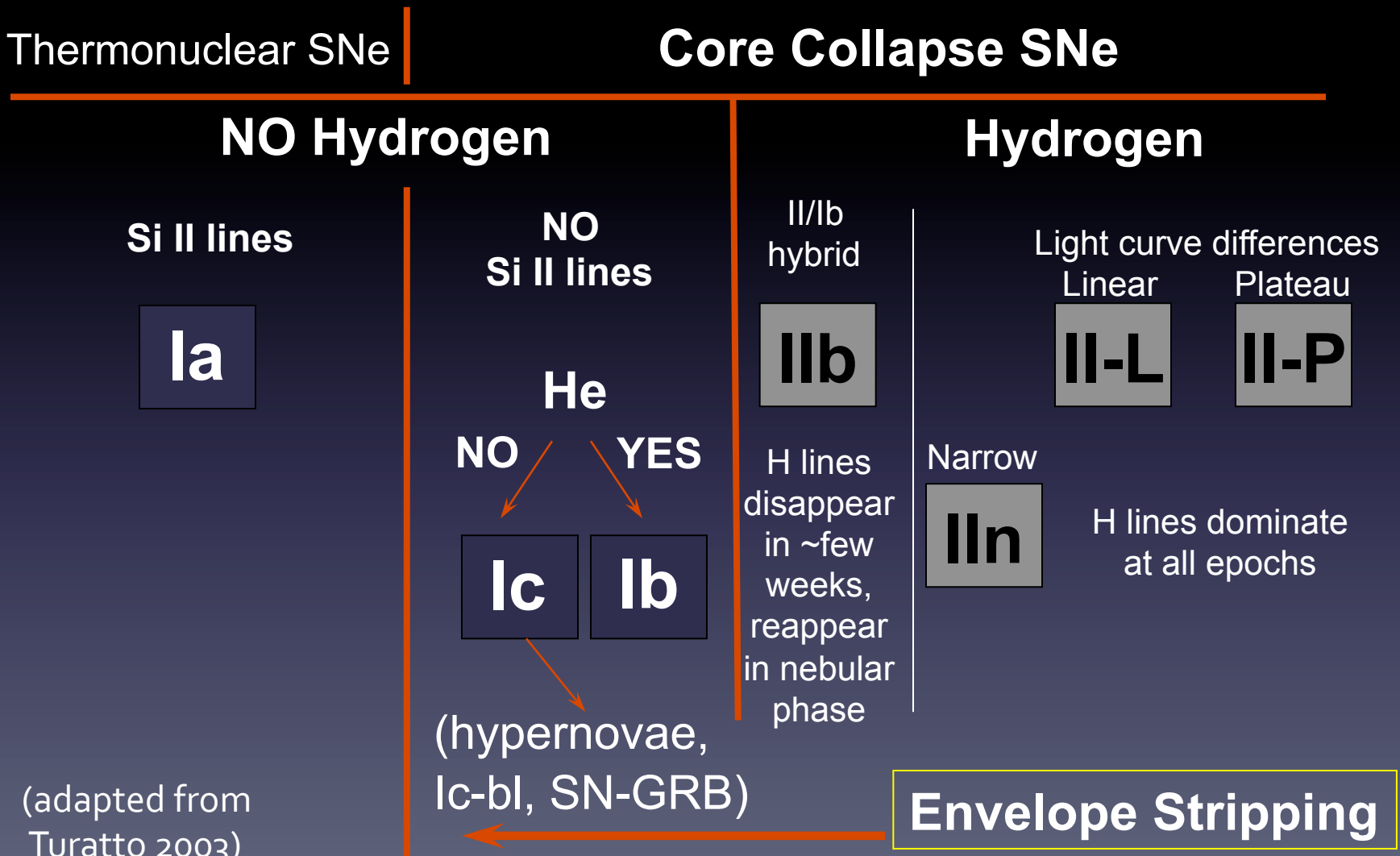
Core-Collapse SN Progenitors

Schuyler Van Dyk (IPAC/Caltech)

Core-Collapse SNe: Classification



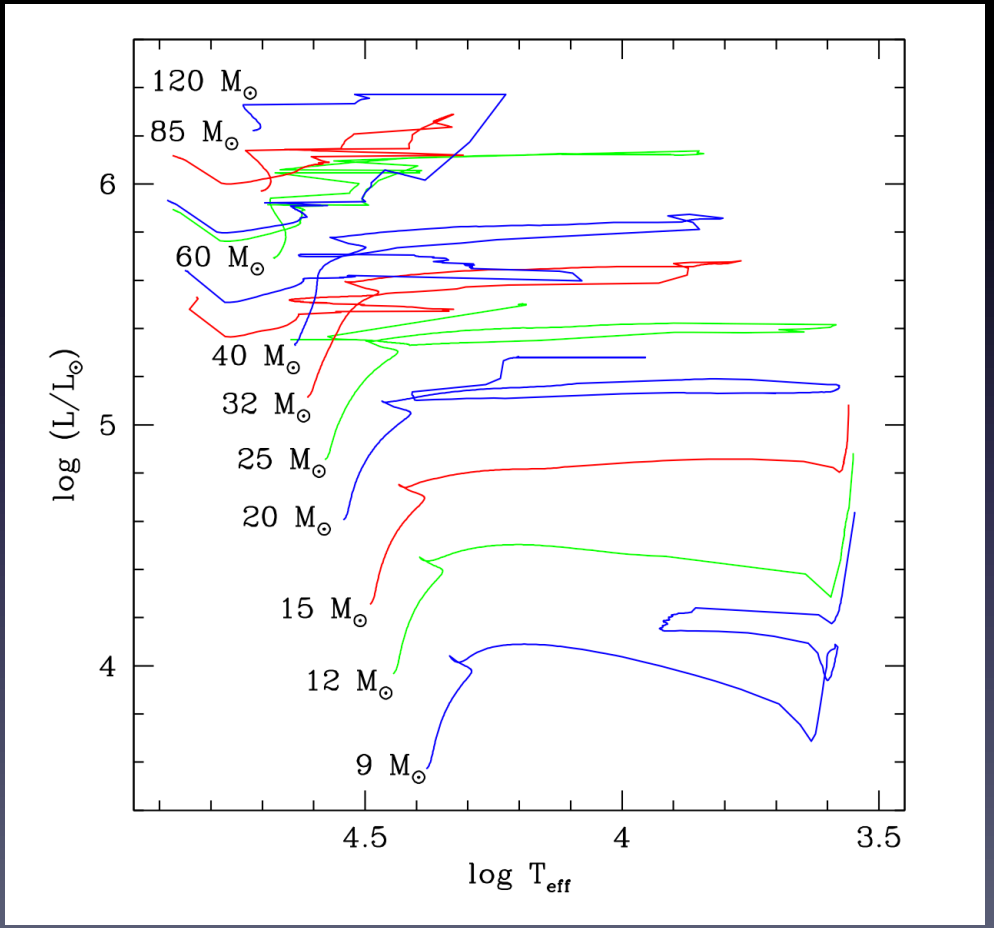
(adapted from Turatto 2003)

Evolution of Massive Stars

What do theoretical stellar evolutionary tracks predict/explain?

Rotating, solar Z models (Ekstrom et al. 2012)

Rotating models agree better with the revised Humphreys-Davidson Limit on RSGs at ~25 $M_\odot$ (Levesque et al. 2005, Crowther 2007)

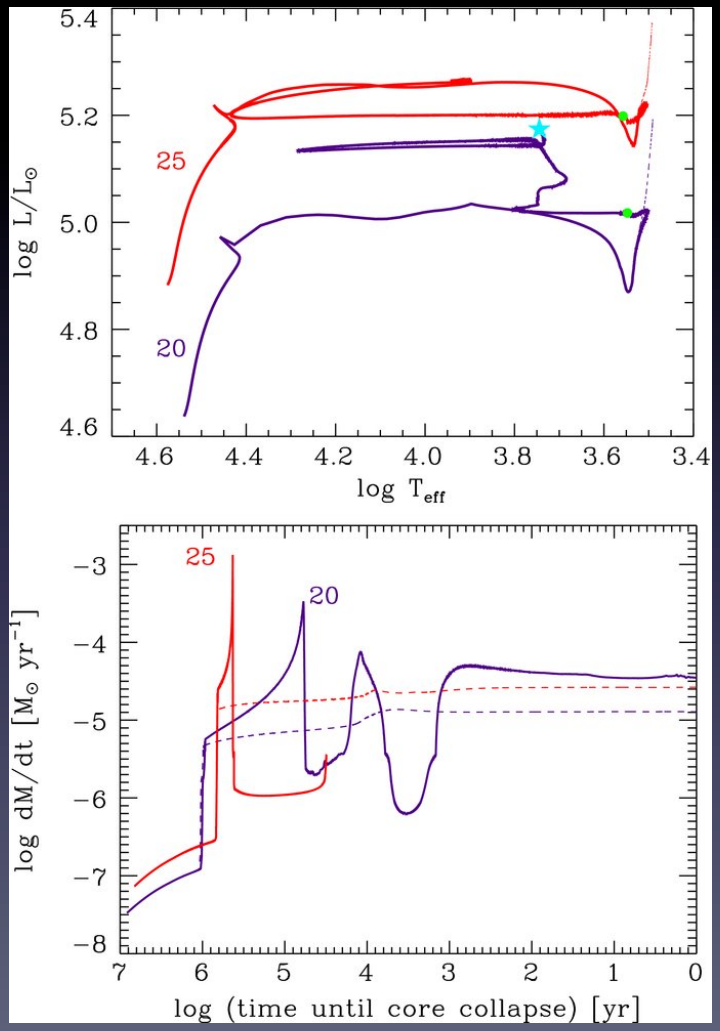


Evolution of Massive Stars

What do theoretical stellar evolutionary tracks predict/explain?

Departure from standardized Mass loss formulation

Pulsationally-driven superwinds from RSGs, solar Z (Yoon & Cantiello 2010)

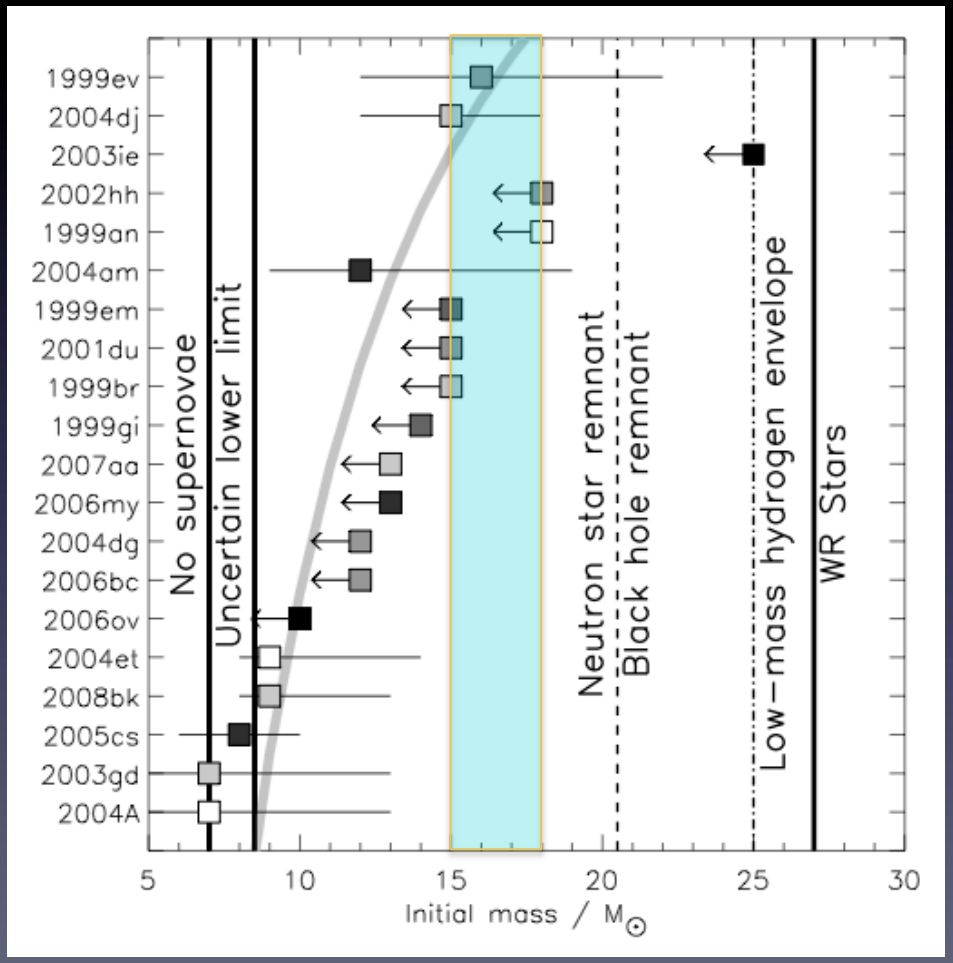


Direct Identification of SN Progenitors

We have precious few (19 +/-) examples:

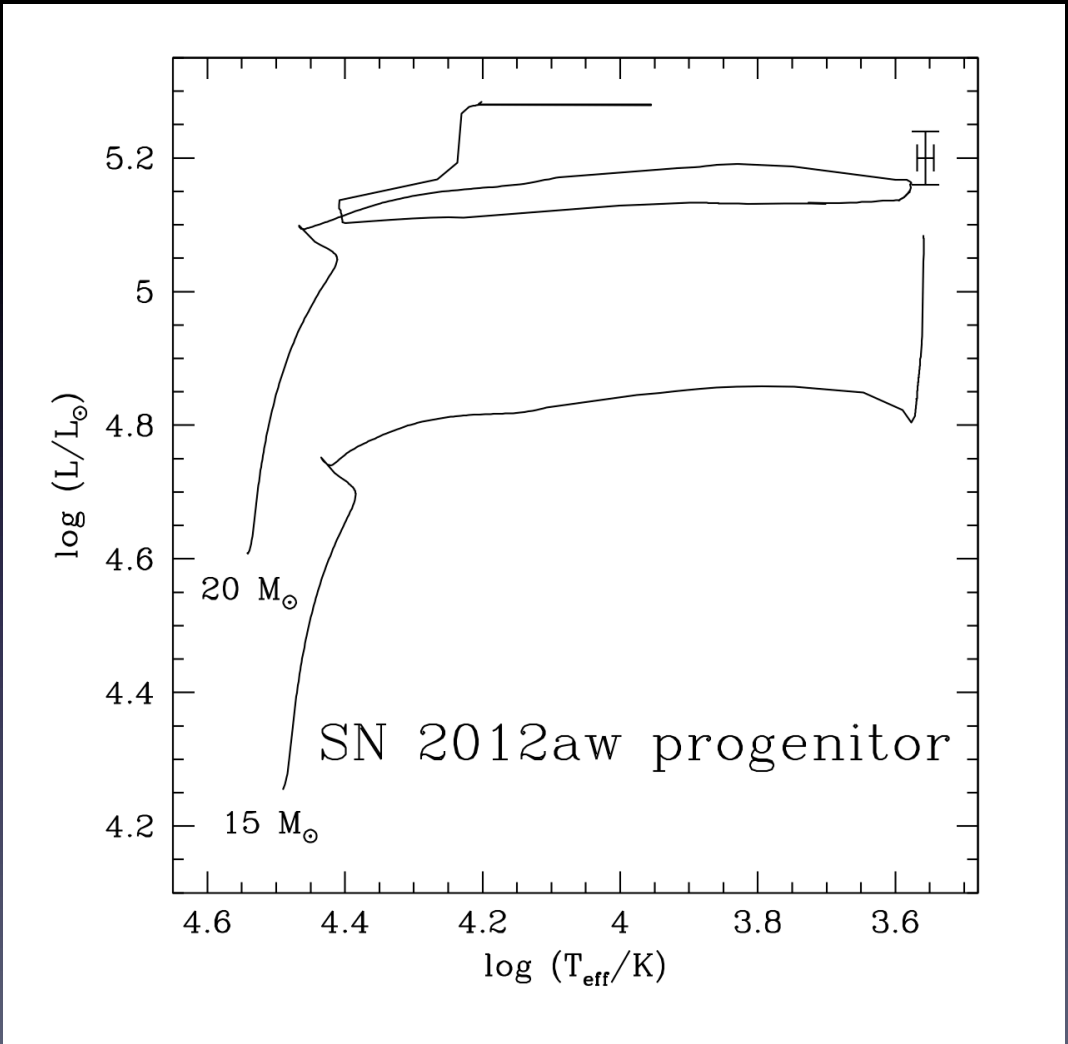
SN 1978K, 1987A, 1993J, 1999ev, 2003gd, 2004A, 2004et, 2005cs, 2005gl, 2008ax, 2008bk, 2008cn, 2009hd, 2009kr, 2009md, 2010jl (?), 2011dh, 2012A, 2012aw

Mass Range (?) of SNe II-P Progenitors



Smartt et al. (2009)

SN II-P 2012aw in M95

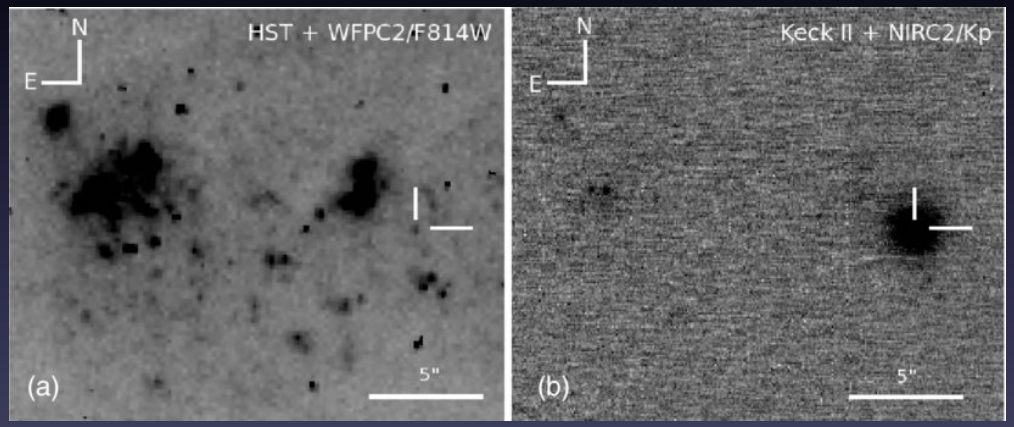


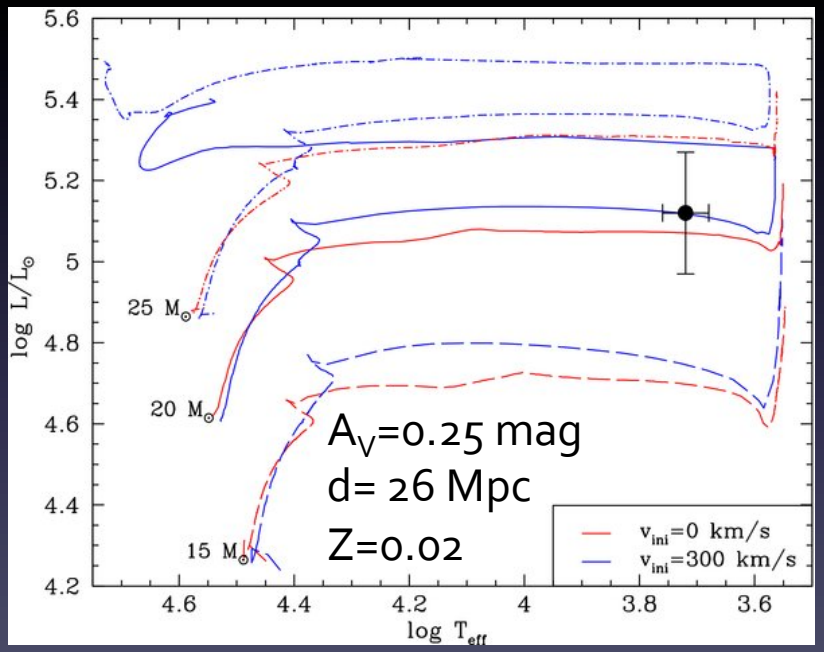
Van Dyk et al.
(2012,
in revision)

$M_{ini} \approx 16\text{--}17\ M_{\odot}$

SN II-L Progenitors

SN 2009kr in NGC 1832 (Elias-Rosa et al. 2010)

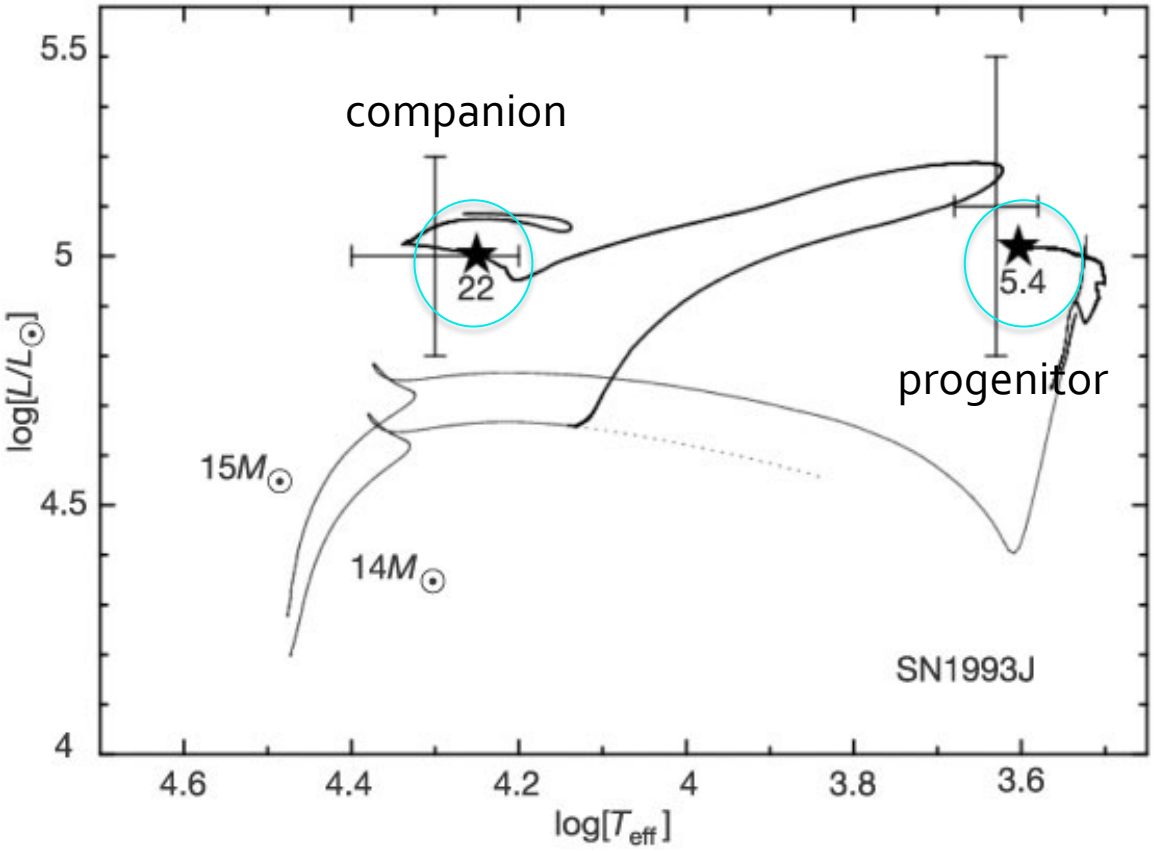




Yellow supergiant (!) with $M_{ini} = 18 - 24\ M_{\odot}$

(also Fraser et al. 2010; $M_{ini} = 15\ ^{+5}_{-4}\ M_{\odot}$)

SN IIb Progenitors

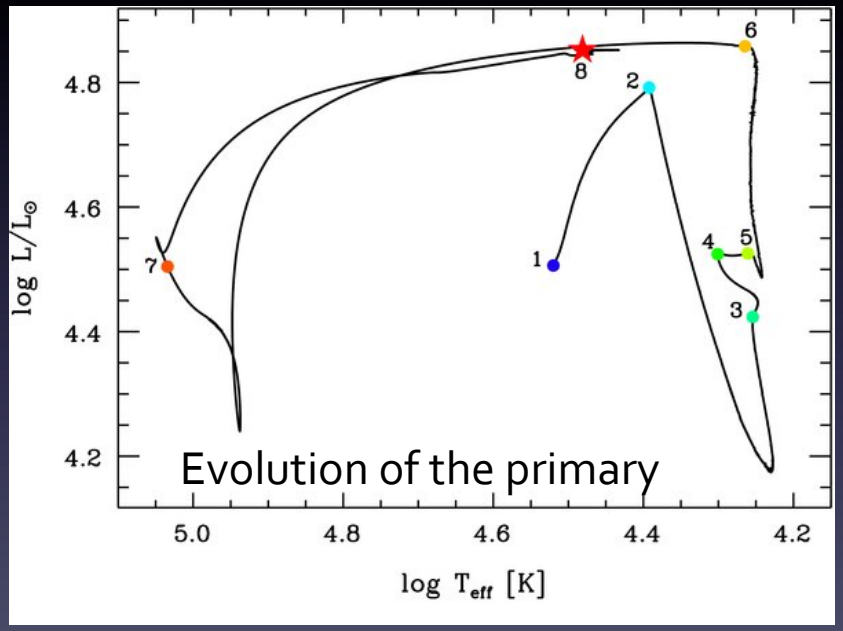


Maund et al. (2004),
Maund & Smartt (2009)

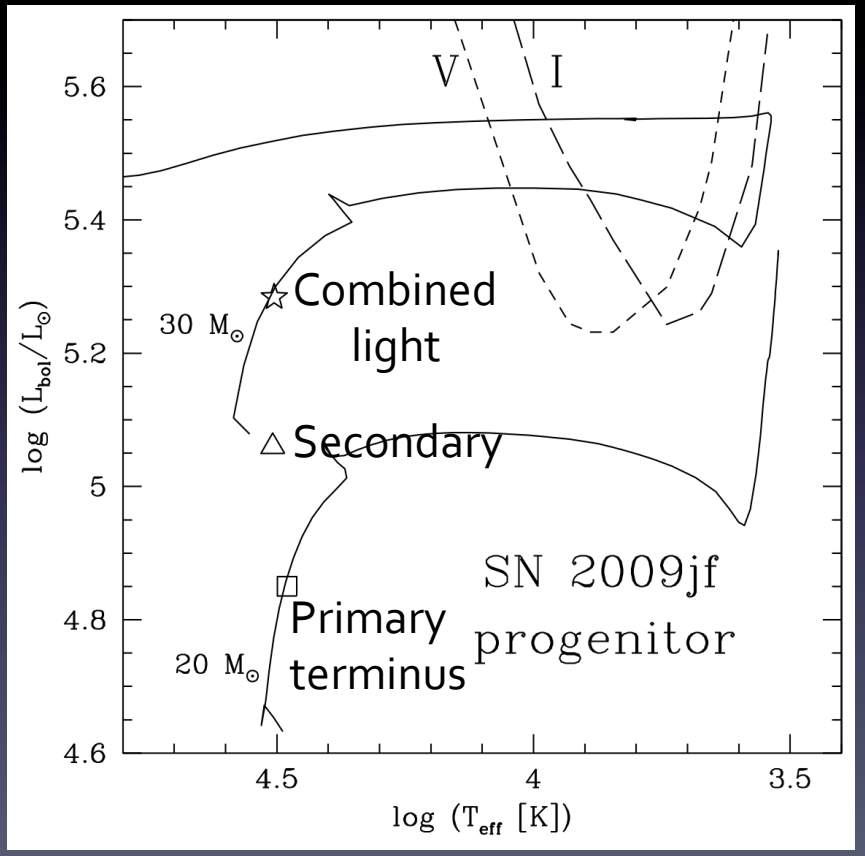
Chevalier & Soderberg (2010): SNe IIb from *extended* ($R \approx 10^{13}$ cm) progenitors, e.g, SN 1993J, and from *compact* ($R \approx 10^{11}$ cm) progenitors, e.g., SN 2008ax & 2011dh

SN Ib Progenitors

SN Ib 2009jf in NGC 7479 (Van Dyk et al., in prep.)

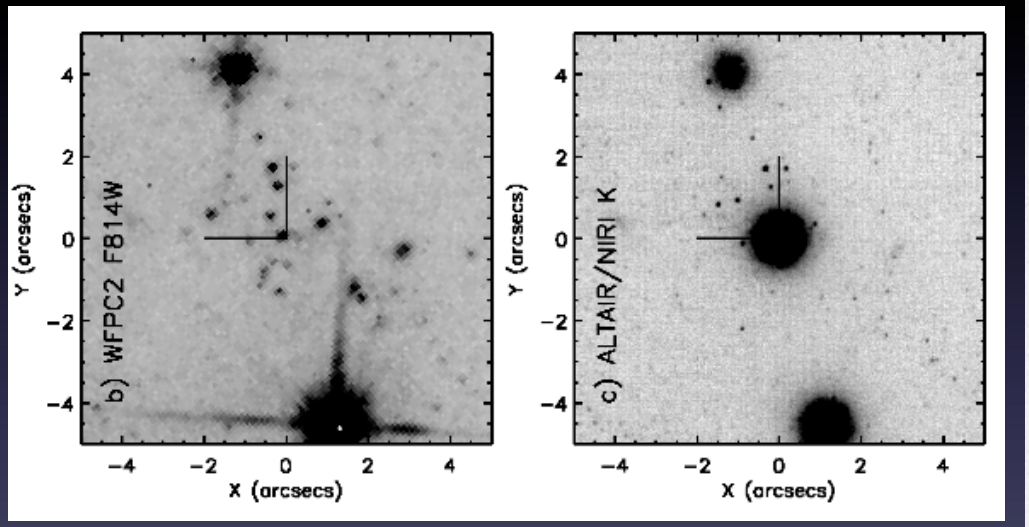


Yoon, Woosley, & Langer (2010)



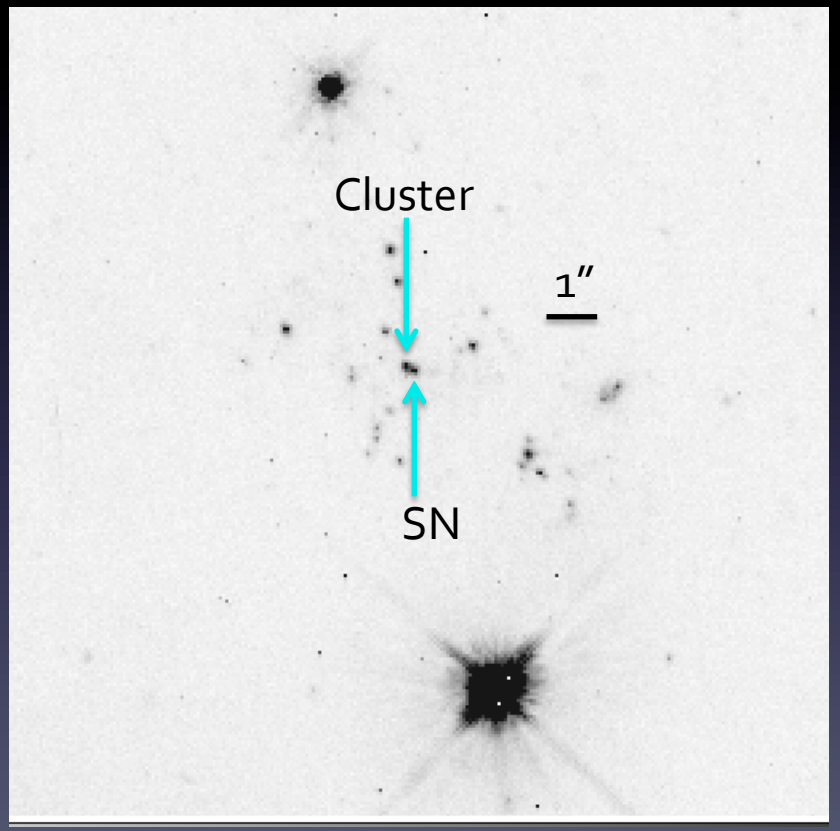
SN Ic Progenitors

SN Ic 2007gr in NGC 1058 (Crockett et al. 2008)



Not very restrictive limits,
based on properties of star cluster

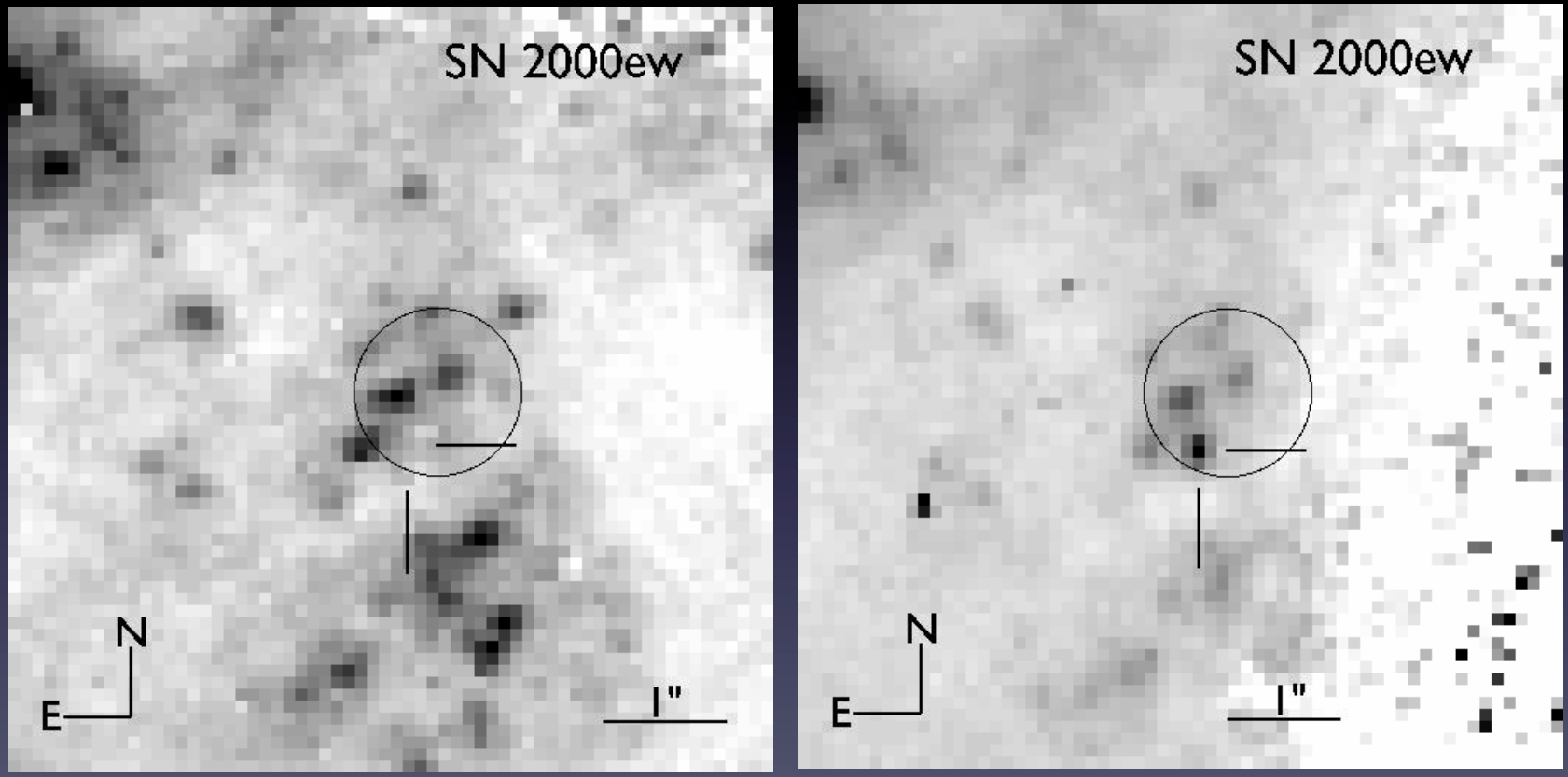
may not be in the cluster after all



HST WFPC2 F555W from 2008

SN Ic Progenitors

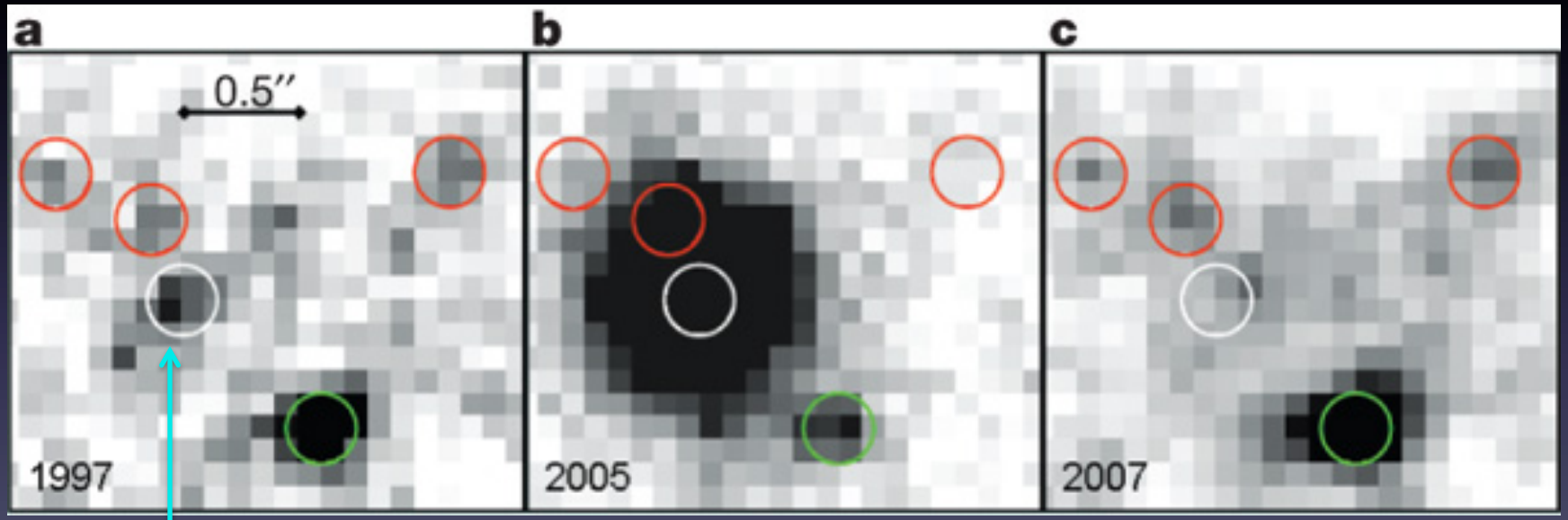
e.g., SN Ic 2000ew in NGC 3810 (Van Dyk, Li, & Filippenko 2003a)



Also, SN 2003jg in NGC 2997, SN 2004cc in NGC 4568, SN 2005V in NGC 2146, etc. (Elias-Rosa et al. in prep.) --- *These are all highly extinguished*

SN IIn Progenitors

SN 2005gl in NGC 266 (d = 66 Mpc)
(Gal-Yam et al. 2007; Gal-Yam & Leonard 2009)



HST WFPC2 F547M
$M_V \approx -10.3$ mag (!!)

Keck-II NIRC2 AO

HST WFPC2 F547M

Provocative (?) Questions

- What is the lower mass limit for core collapse?
- Are stars at ~8 $M_{\odot}$ really undergoing core collapse?
- How much does the core care about the overlying layers?
- What influence does binary interaction (mass transfer) have on the core?
- What is the "transition" core mass dividing NS from BH as remnant? (And, is this sensitive to metallicity? rotation? B-field?)
- How to produce asymmetries in the explosion?
- Does the presence of a jet have an effect on core collapse? Is the jet's presence necessary for core collapse?
- Does the core play a role in the late stage mass loss prior to explosion?
- Does the core play a role in pre-SN eruptions or outbursts?