The progenitors and evolution of sub-luminous Type IIP supernovae

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Sub-luminous Type IIP SNe

- Low absolute mag (M_R=-15)
- Low photospheric line velocities (~2000 kms^{-1})
- Low ejected ^{56}Ni mass

(Pastorello et al. 2004)

examples include SNe 1997D, 2005cs, 2008bk, 1999br, 2006ov...

(Turatto et al. 1998; Pastorello et al. 2006; Filippenko et al. 1999; Pastorello et al. 2004)

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(Turatto et al. 1998; Pasto
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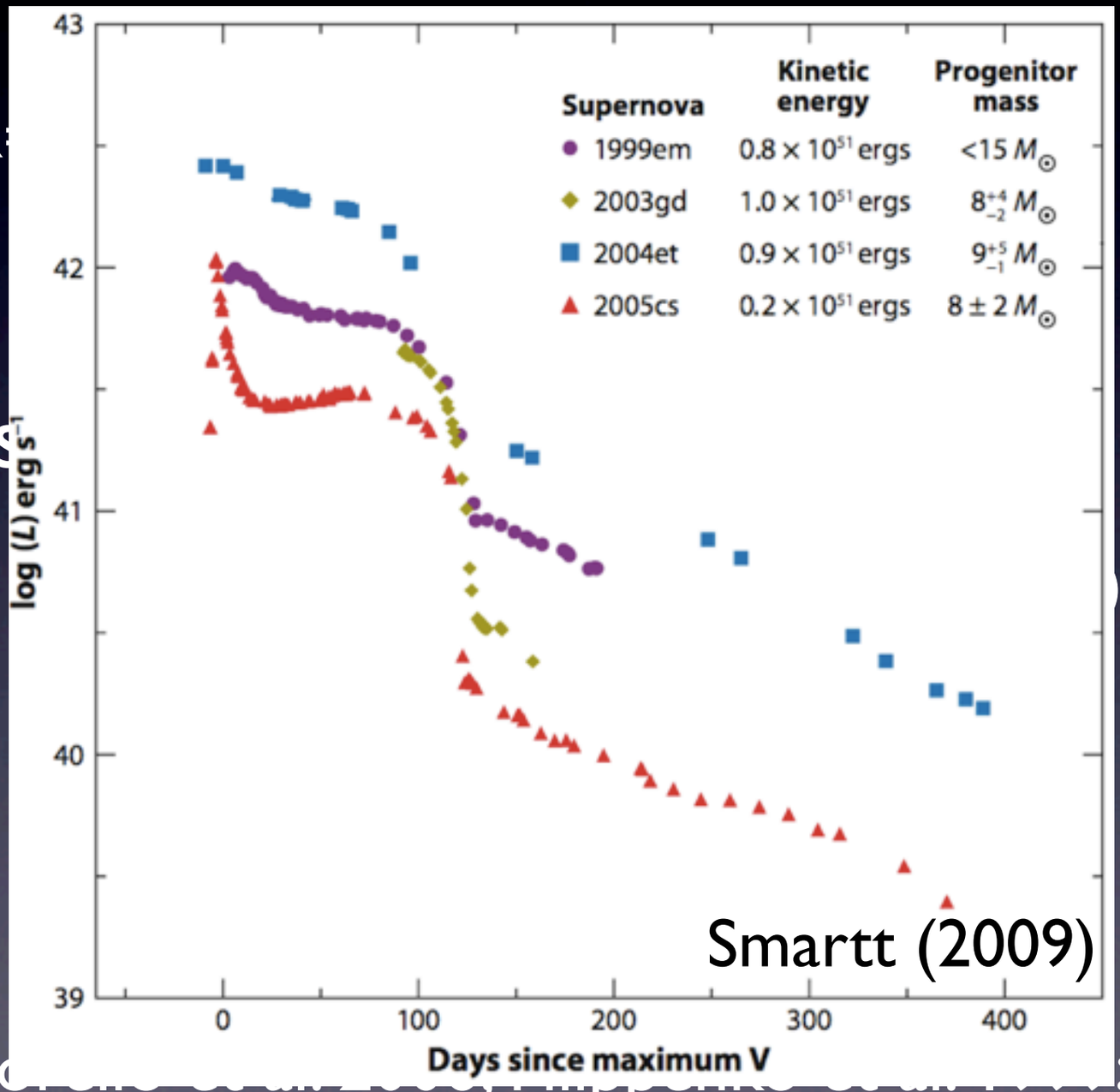


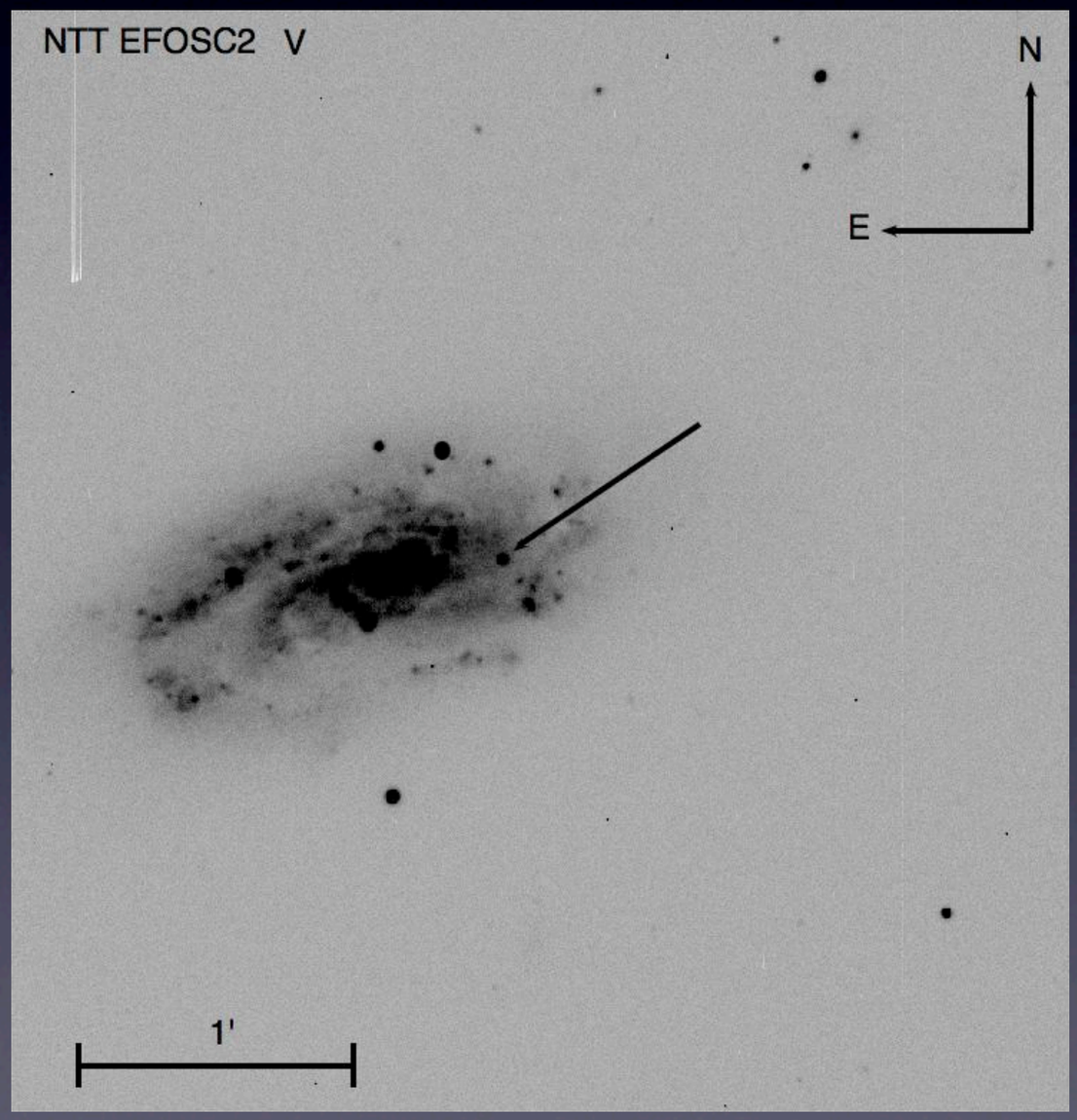
Smartt (2009)

Progenitor detections and problems

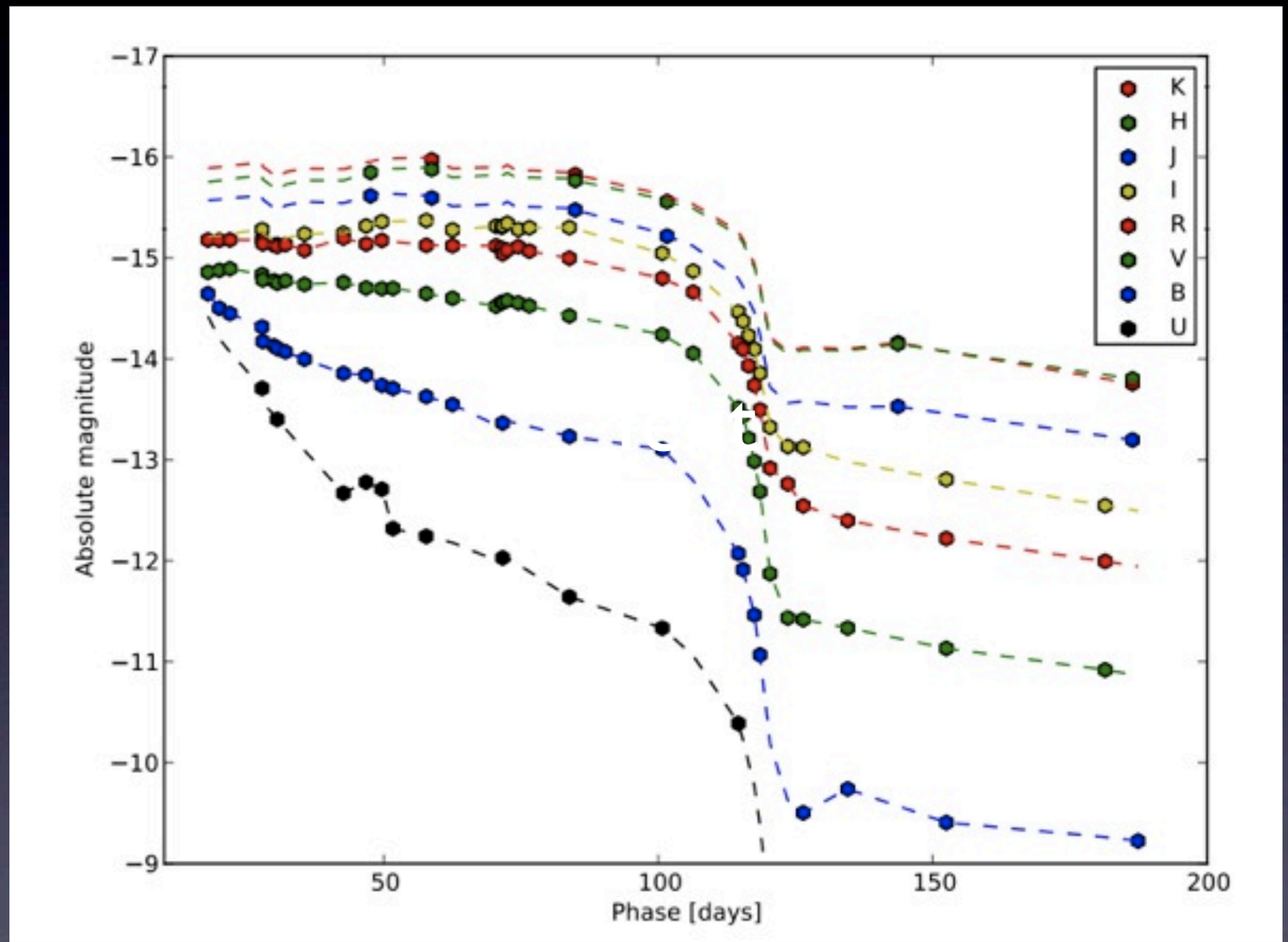
- SNe 2005cs and 2008bk both found to have low mass (7M and 8.5) progenitors
- SNe 1999br and 2006ov have limits (<12M and <10M)
- Can rule out bright SAGB progenitors for these SNe
- Can also rule out massive progenitors and BH by fallback (for SN with progenitors)

SN 2009md - Discovery

- Found by Itagaki in NGC 3389
- Sc type spiral at a distance of ~21.5 Mpc
- Archival WFPC2 data - F555W (V) and F814W (I)



Monitoring



ESO LARGE PROGRAM: SUPERNOVA VARIETY AND NUCLEOSYNTHESIS YIELDS (PI: S. BENETTI)

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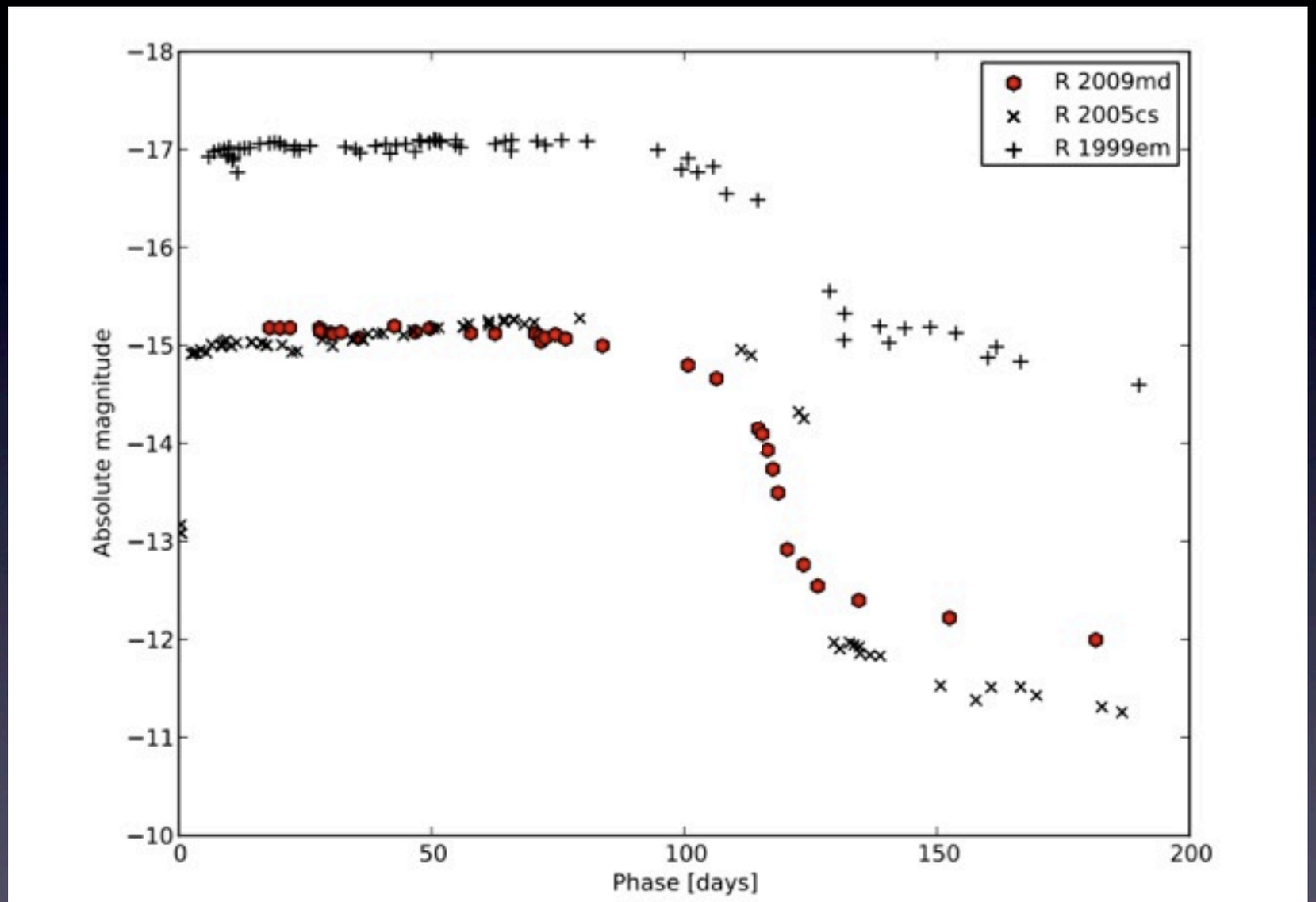

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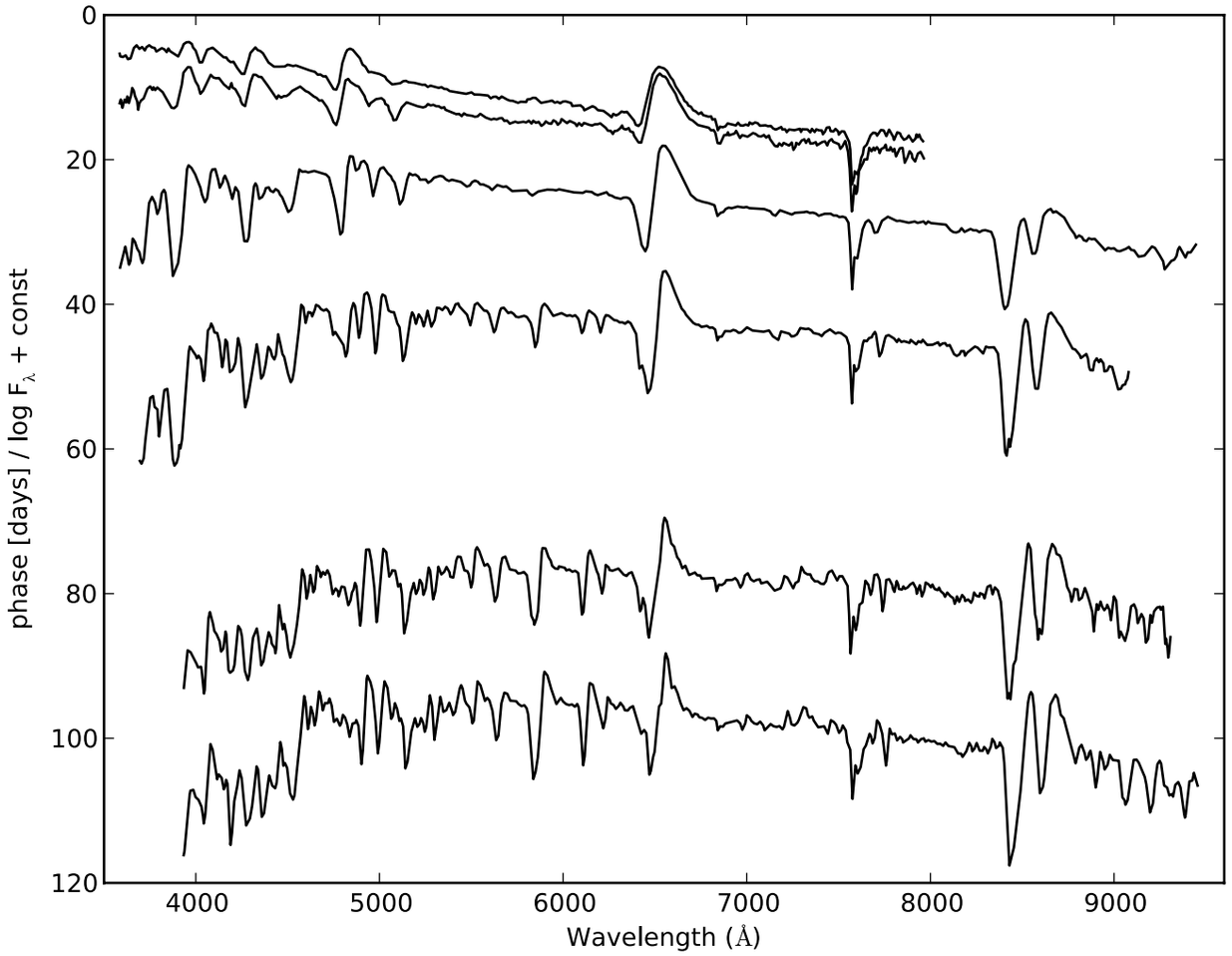
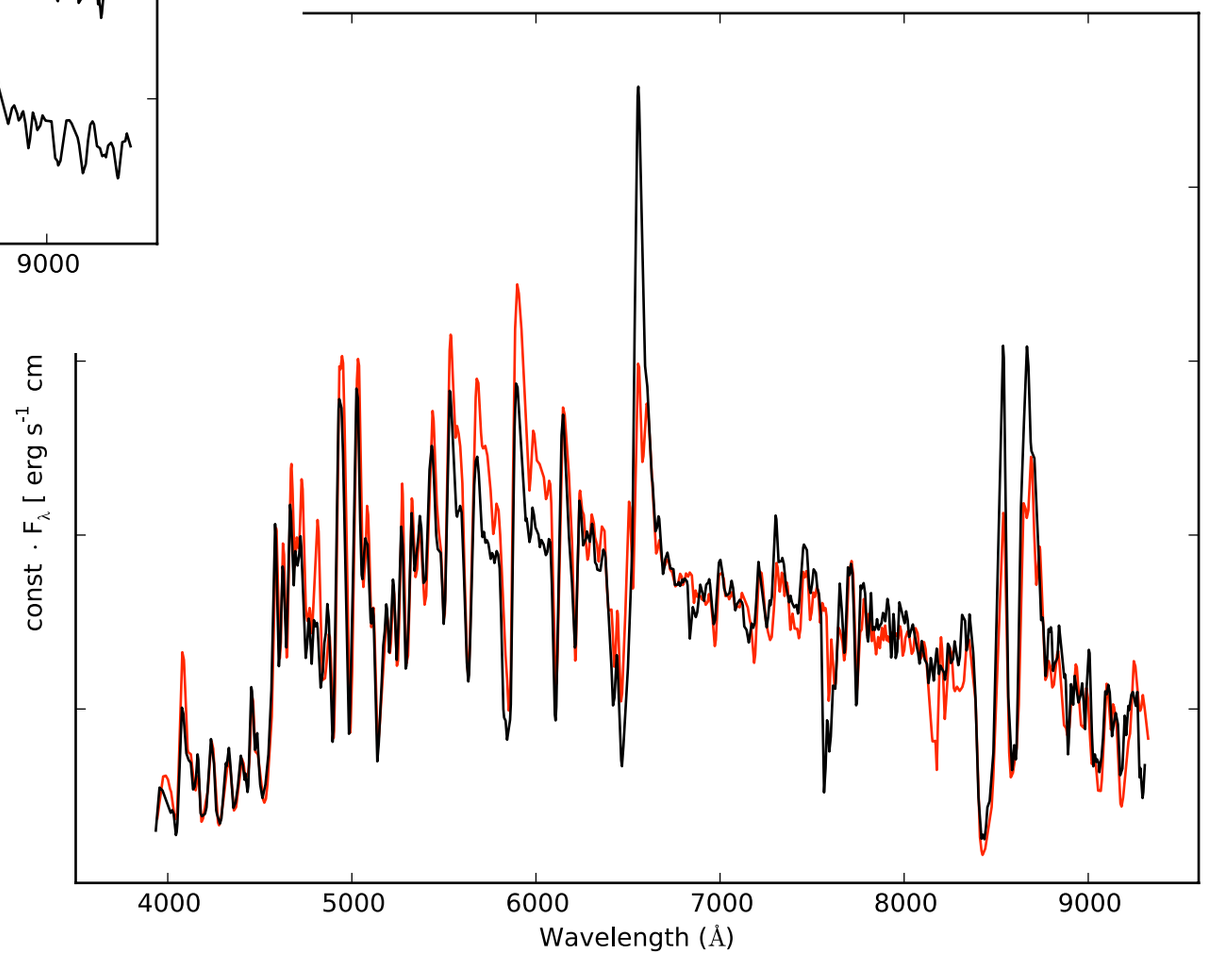
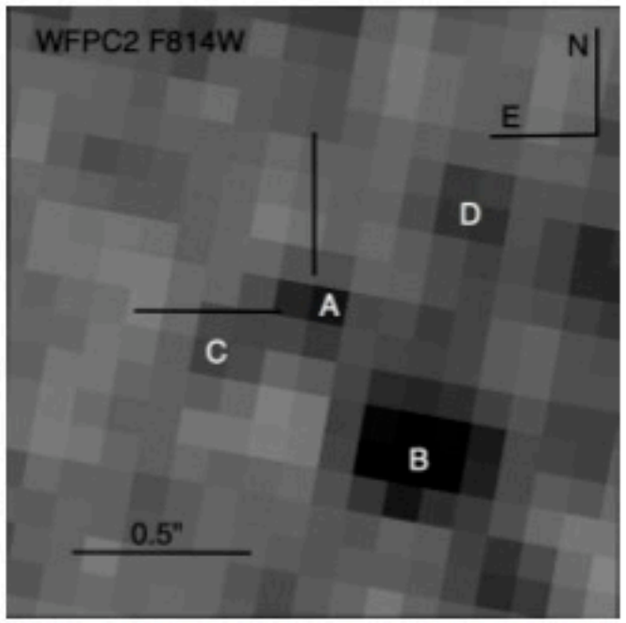
Spectra

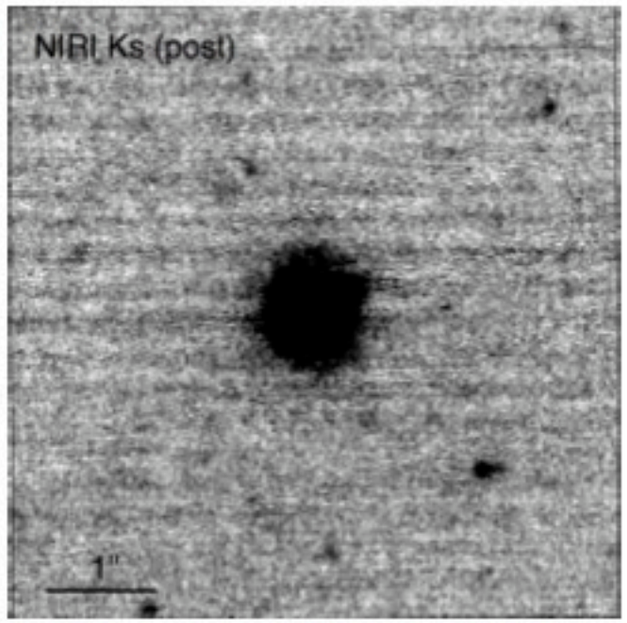

0
20
40
60
80
100
120
phase [days] / log F_λ + const
4000
5000
6000
7000
8000
9000
Wavelength (Å)


const · F_λ [erg s^{-1} cm
4000
5000
6000
7000
8000
9000
Wavelength (Å)

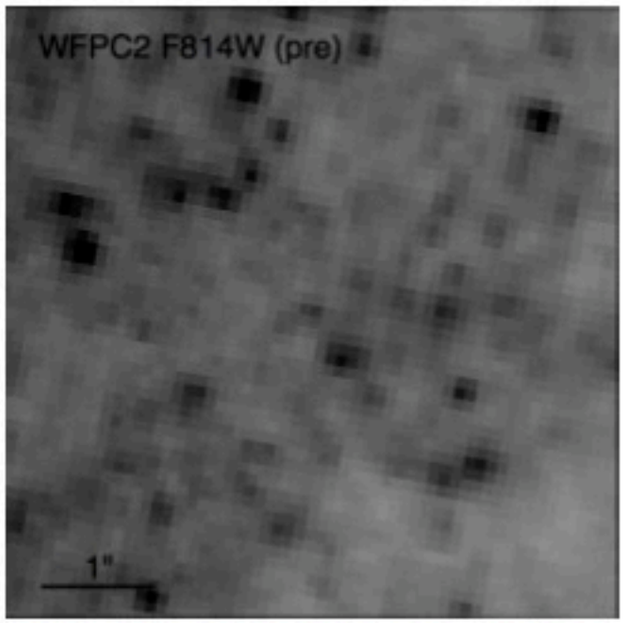
Progenitor



(a) Blow-up of progenitor (Source A, at intersection of lines) together with nearby sources (B, C and D)



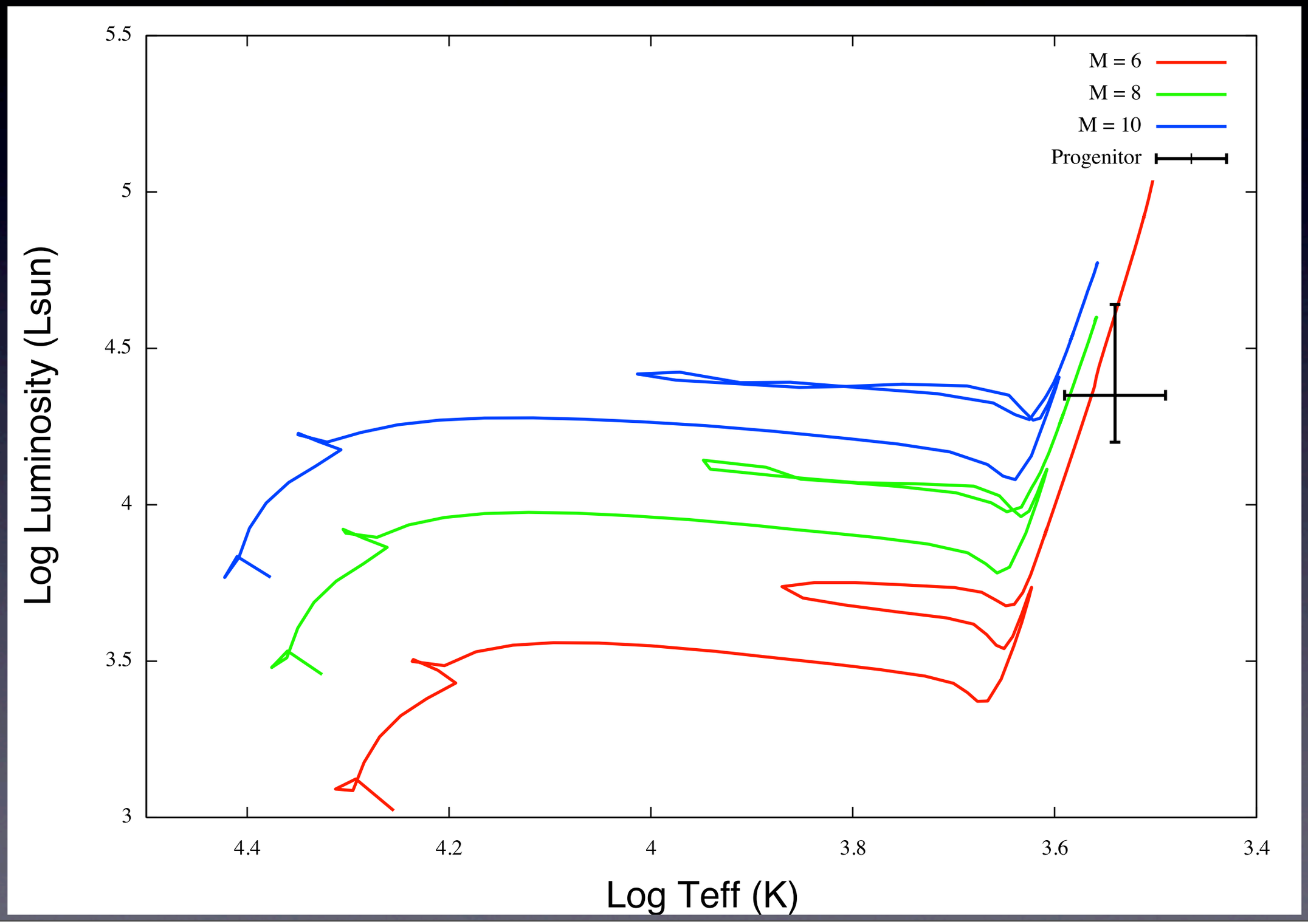
(b) Section of Gemini NIRI post-explosion image, centered on supernova



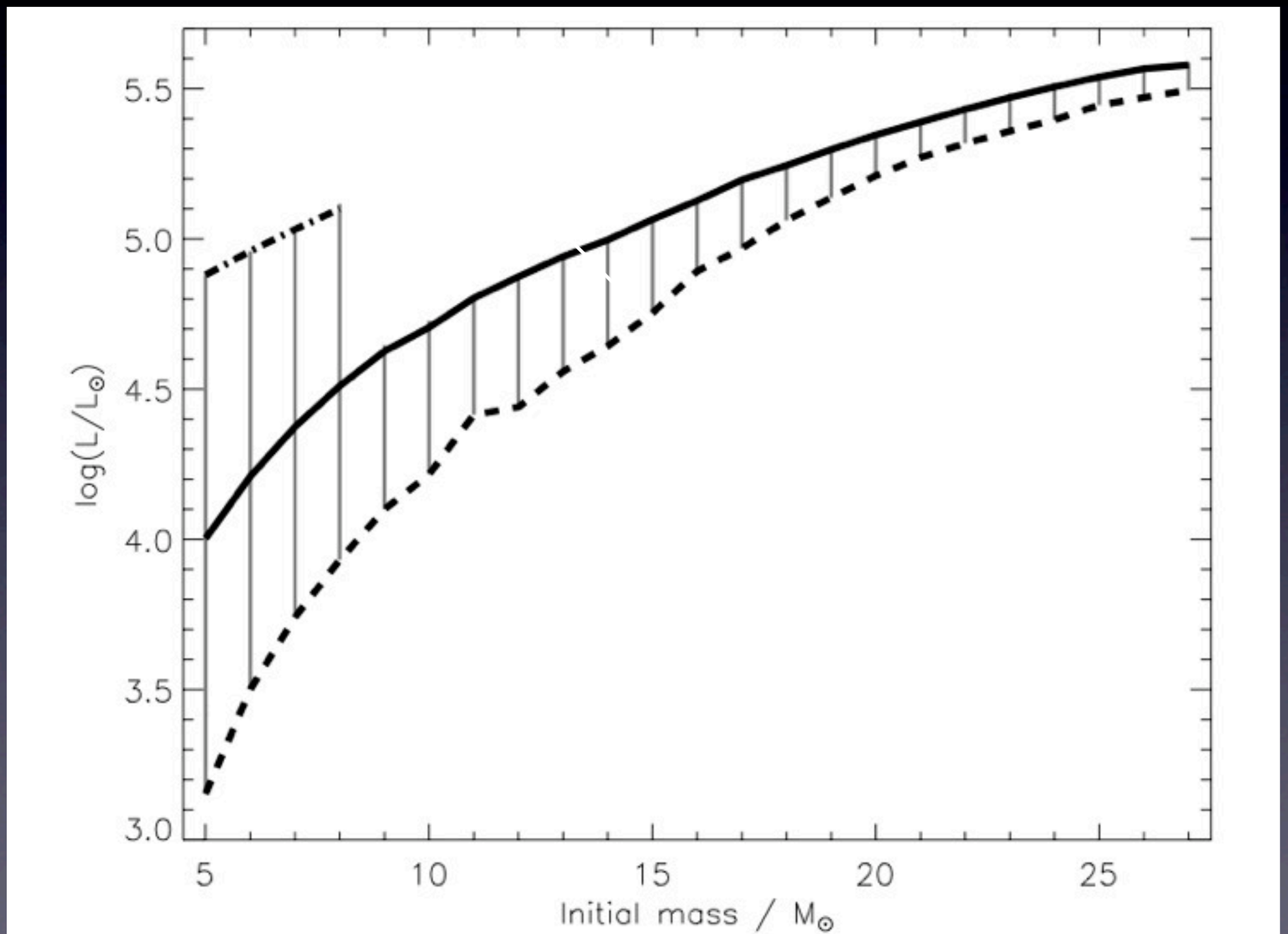
(c) Section of HST WFPC2 pre-explosion image, centered on supernova location

ONGOING VLT+GEMINI PROGENITOR PROGRAM

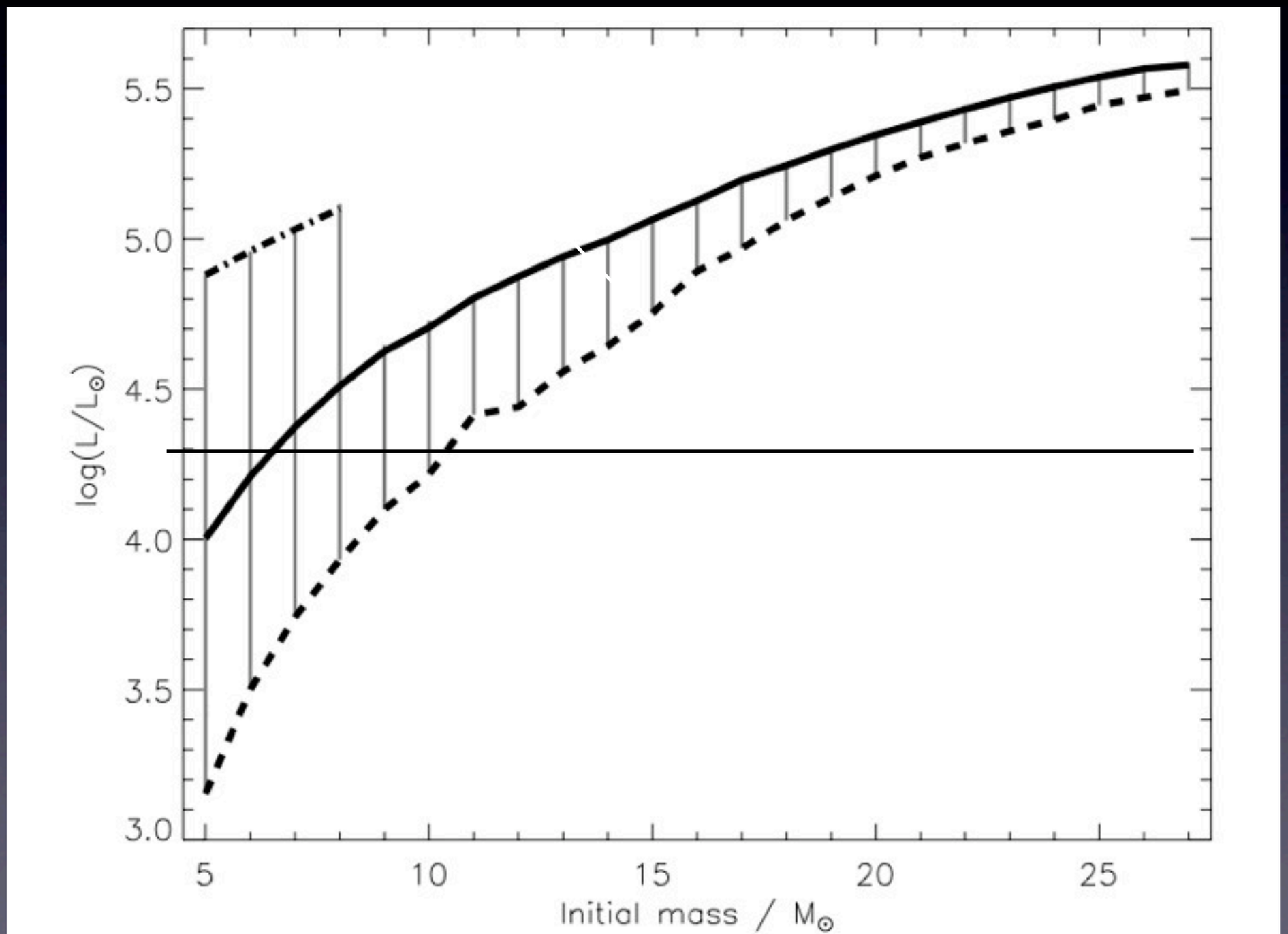
Progenitor


M = 6
M = 8
M = 10
Progenitor
Log Luminosity (Lsun)
Log Teff (K)
5.5
5
4.5
4
3.5
3
4.4
4.2
4
3.8
3.6
3.4

Progenitor characterization



Progenitor characterization



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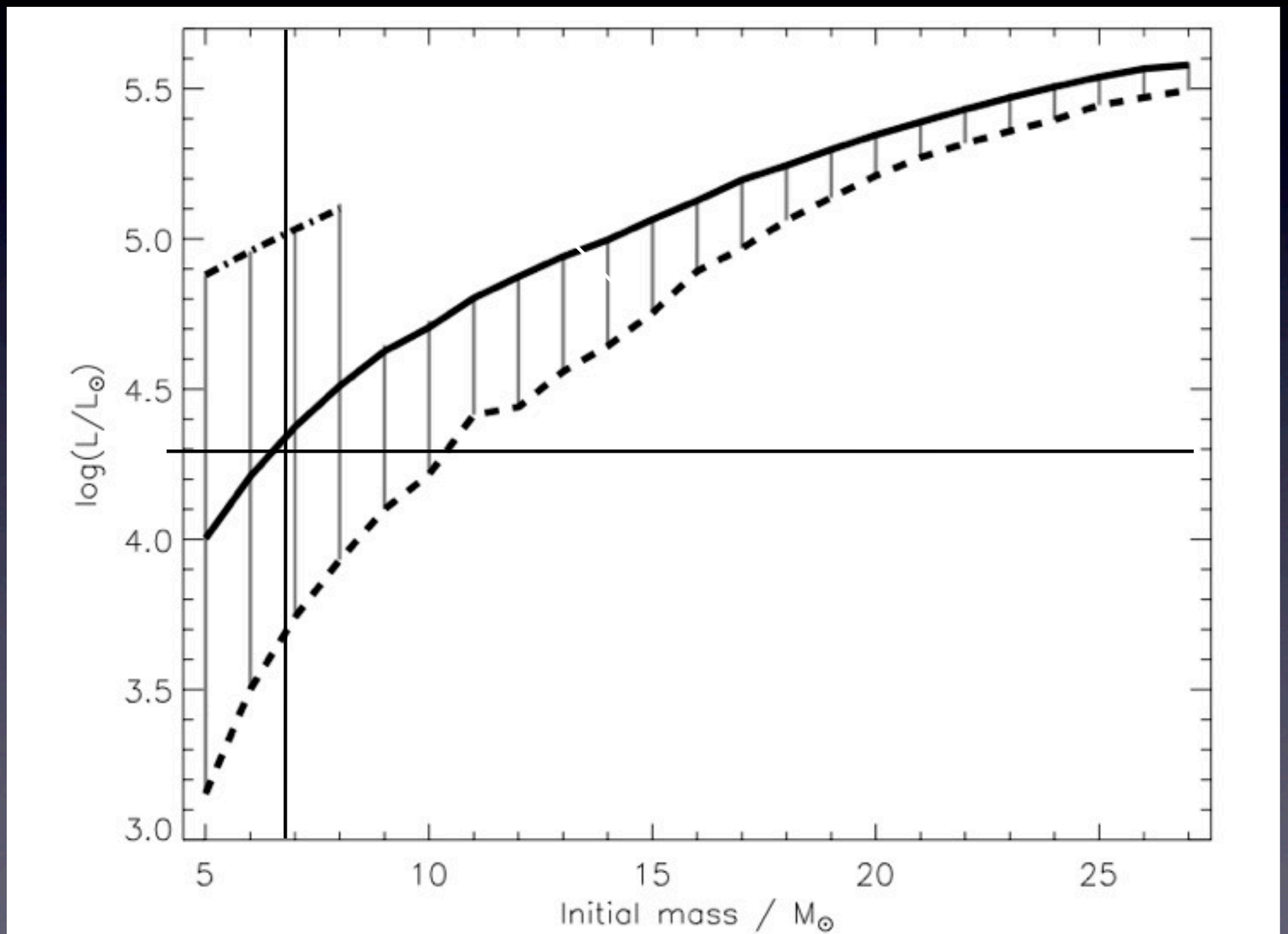
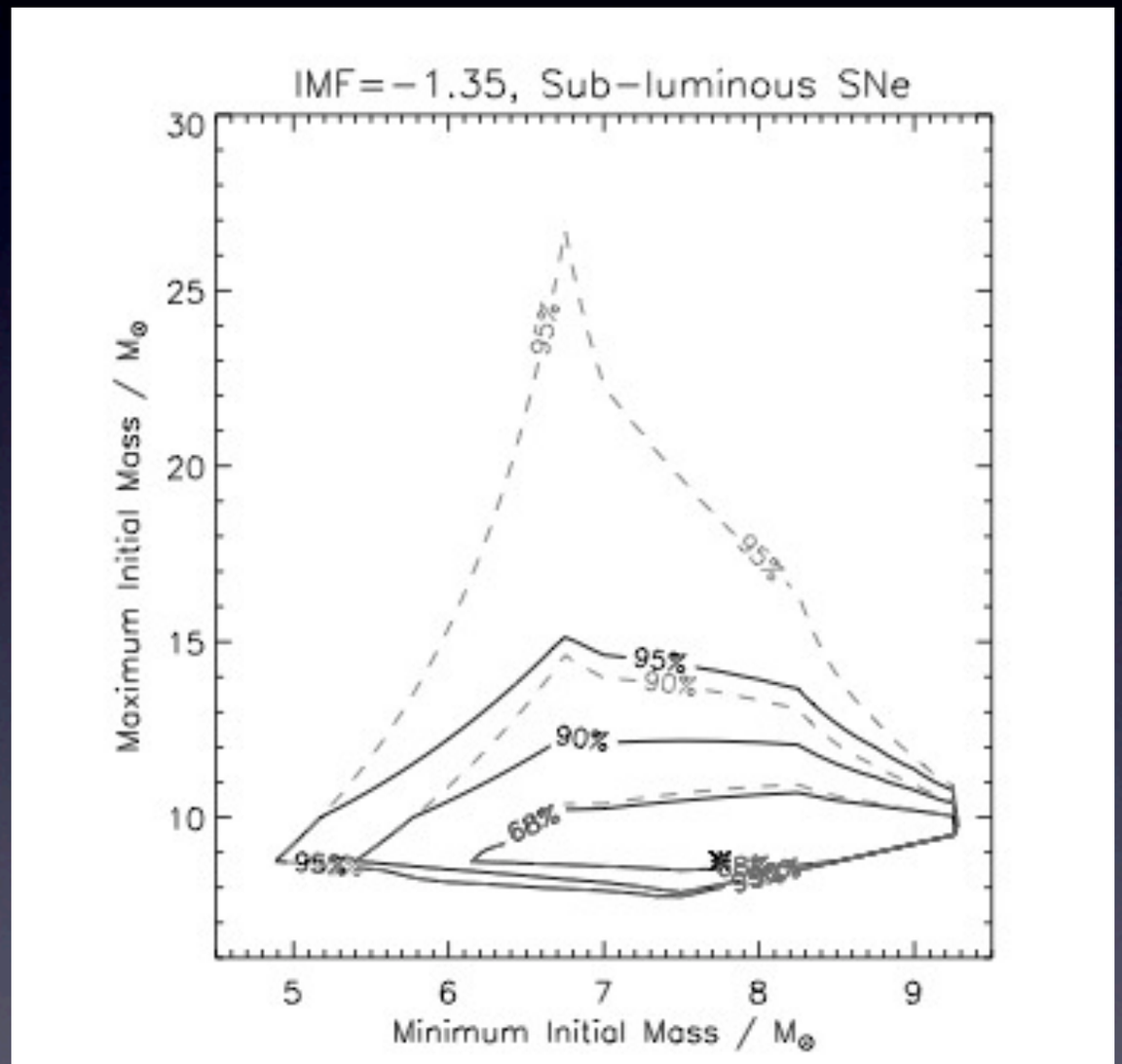


Mass range

- Maximum liklihood plot with masses of sub-luminous IIP progenitors
- Can *not* rule out high mass (~25M) population of faint fallback SNe...yet

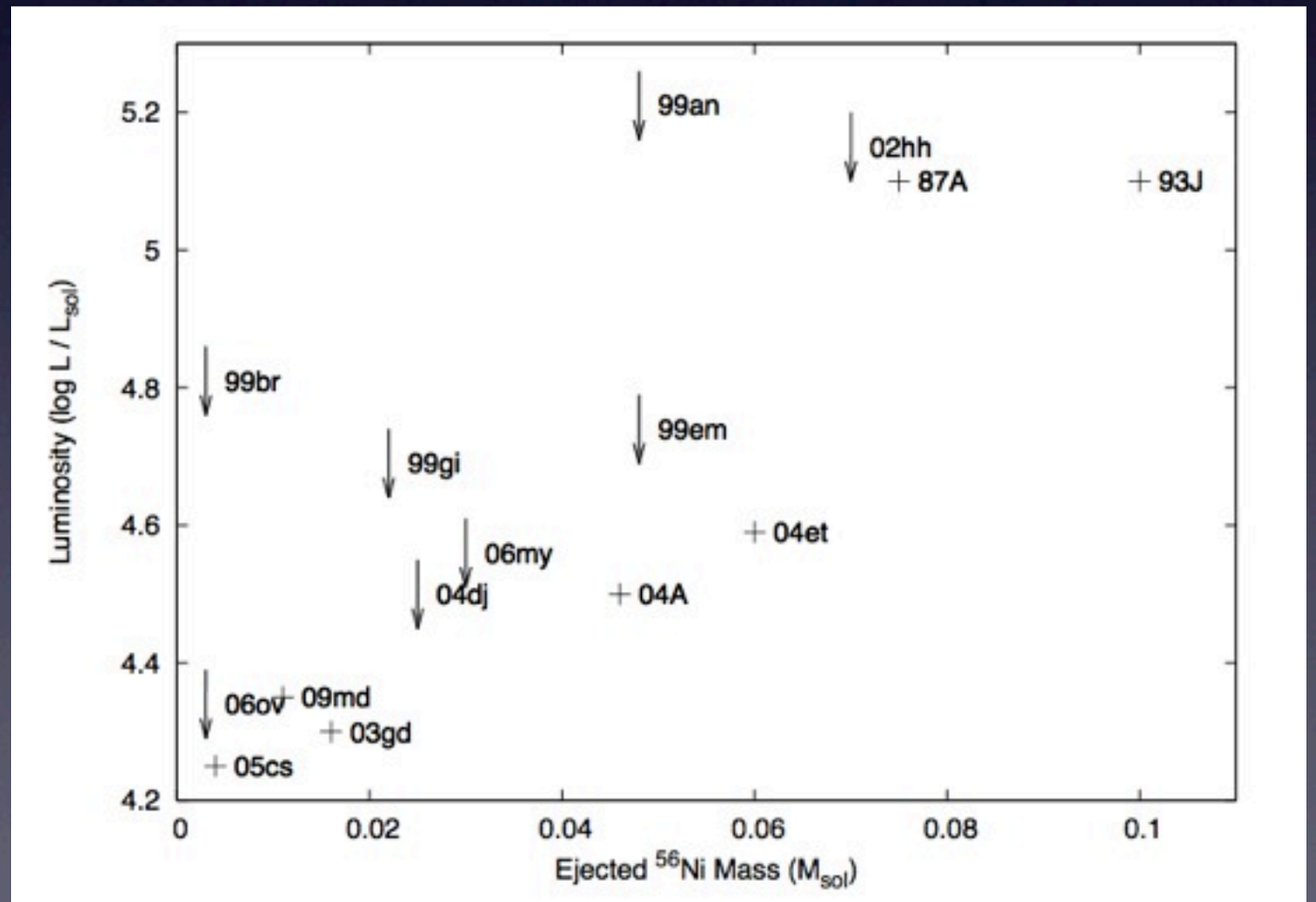


Energy and ^{56}Ni Mass

- Ejected ^{56}Ni measured from radioactive tail $M_{Ni56} = (5.8 \pm 1.4) \times 10^{-3}$ M

- Explosion energy from (analytic modeling) = $(1.7 \pm 1.0) \times 10^{50}$ erg

- Low ^{56}Ni mass and energy



Conclusions

- Intersection of theory and observations of SNe and massive stars
- 09md further supports low mass progenitor scenario for sub-luminous IIP SNe. But issues with models remain.
- Work with stellar models will further elucidate progenitor characteristics.

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Thanks for listening... Questions?