Ultraviolet-Bright Type IIP Supernovae from Massive Red Supergiants
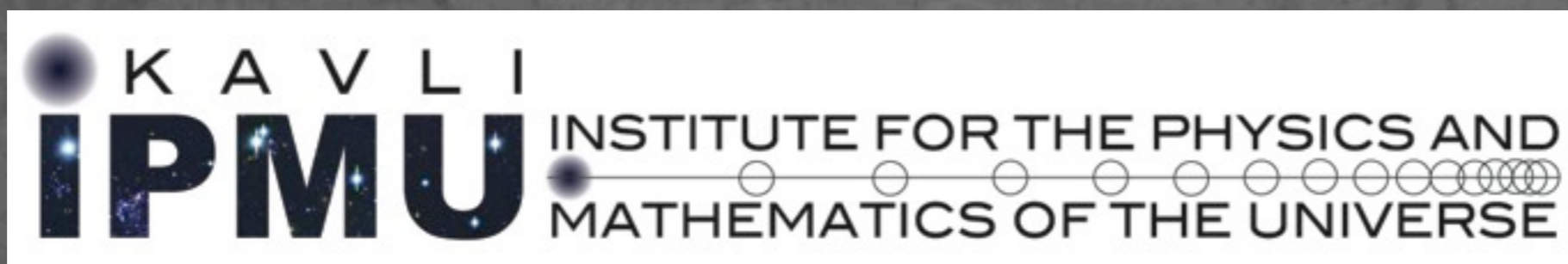
Takashi Moriya

N. Tominaga, S. I. Blinnikov, P. V. Baklanov, E. I. Sorokina
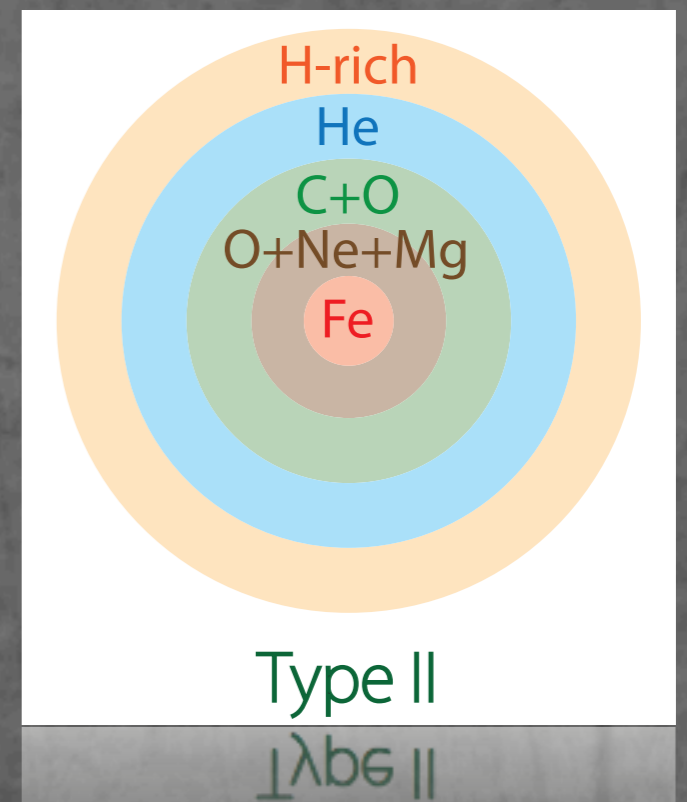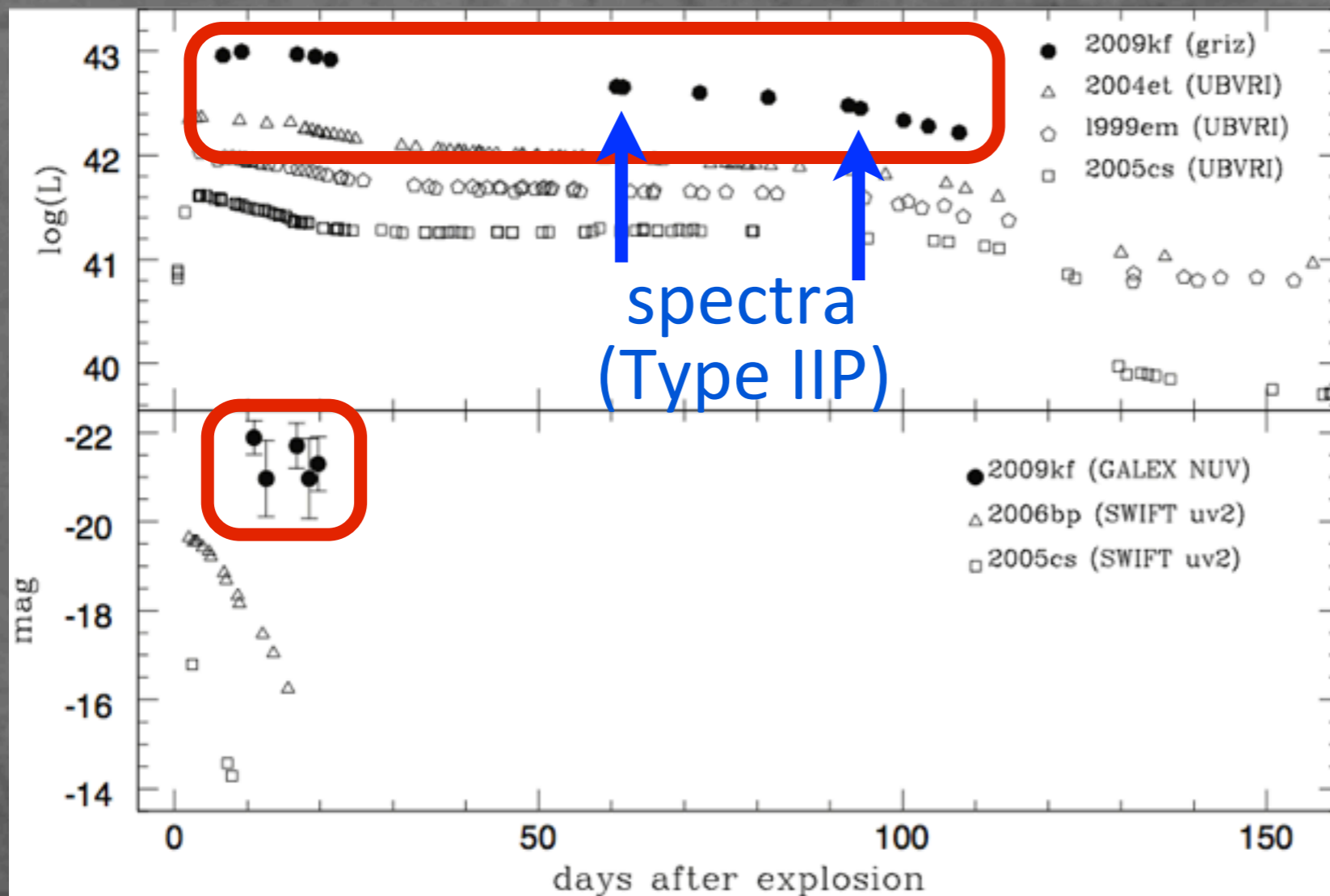
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Contents

- UV-bright Type IIP SN 2009kf

- Effect of dense CSM around RSGs on SN LCs

- Implication for Type IIP SN progenitors
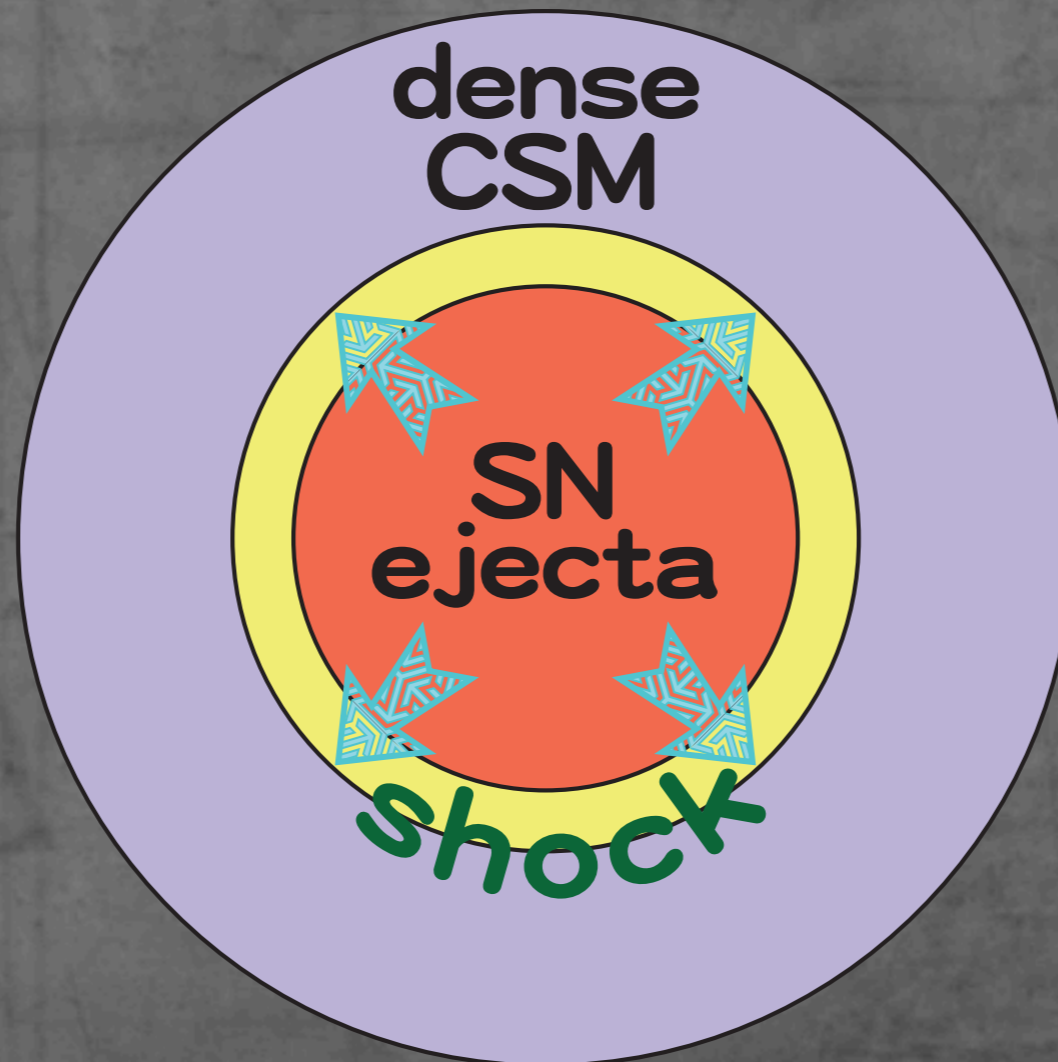
- What determines the upper mass of SNe IIP?
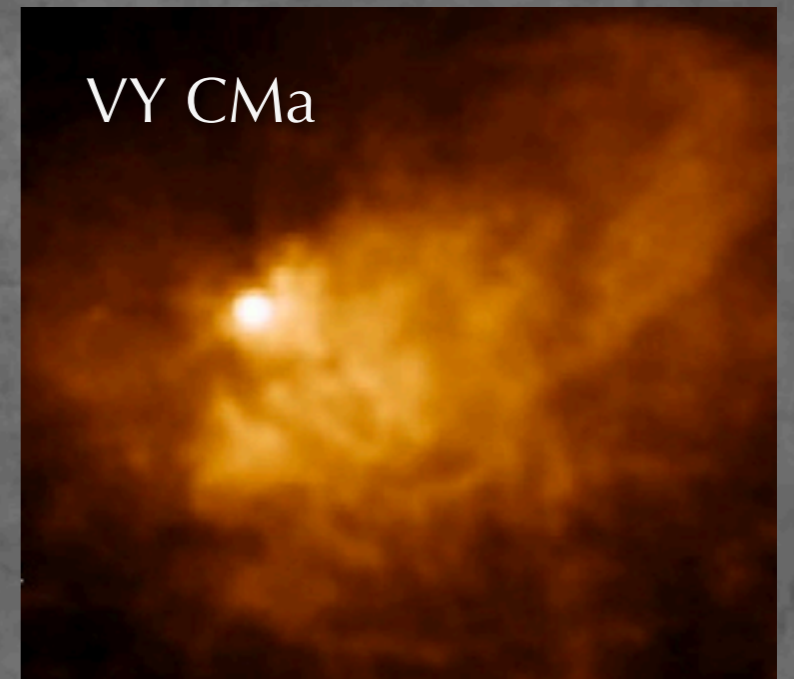
Ultraviolet-Bright Type IIP SN

SN 2009kf

spectra
(Type IIP)

H-rich
He
C+O
O+Ne+Mg
Fe

Type II

Why UV-Bright?

- CSM interaction?
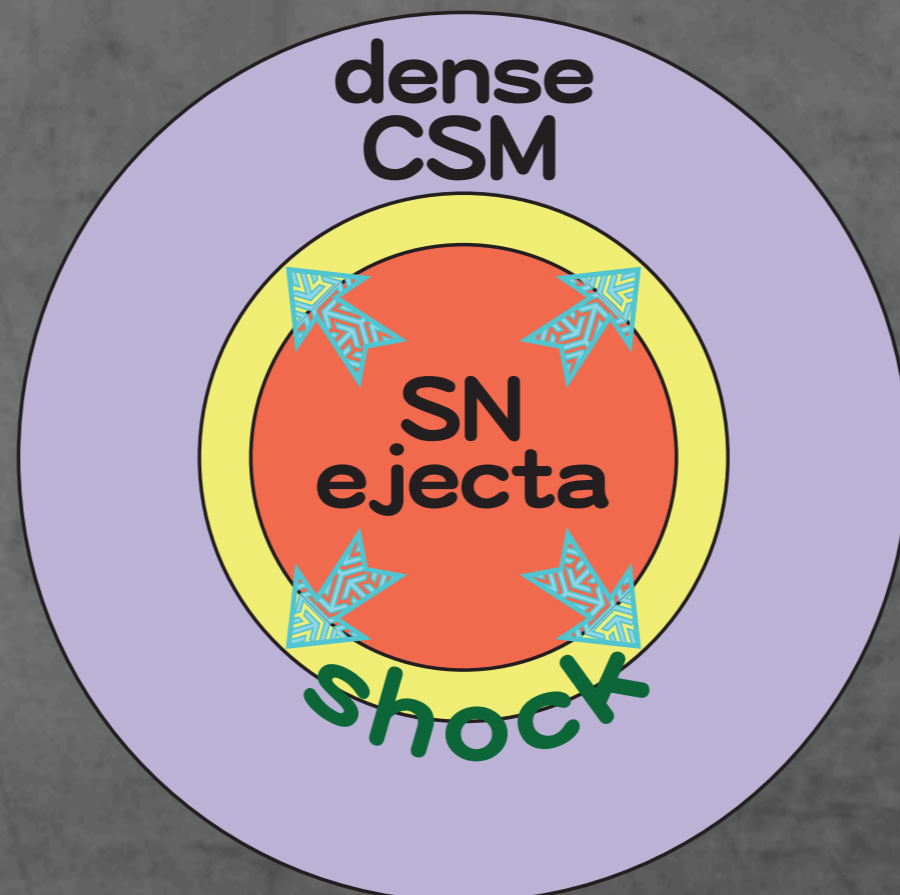
RSGs Exploded in Dense CSM?

- Extensive mass loss of RSGs

  - e.g., VY CMa (Smith+ '09)

    $$1 - 2 \times 10^{-3}\ M_\odot\ \mathrm{yr}^{-1}$$

VY CMa

- Several suggested mechanisms

  - e.g., pulsation (Yoon+ '10)

Effect of dense CSM around RSGs on LCs?
= the origin of SN 2009kf?

RSGs Exploded in Dense CSM

- 1D multi-group radiation hydrodynamics

- STELLA code (Blinnikov et al.)

Initial Conditions

- RSG inside: s13, s15, s18, s20 (Woosley+ '02)
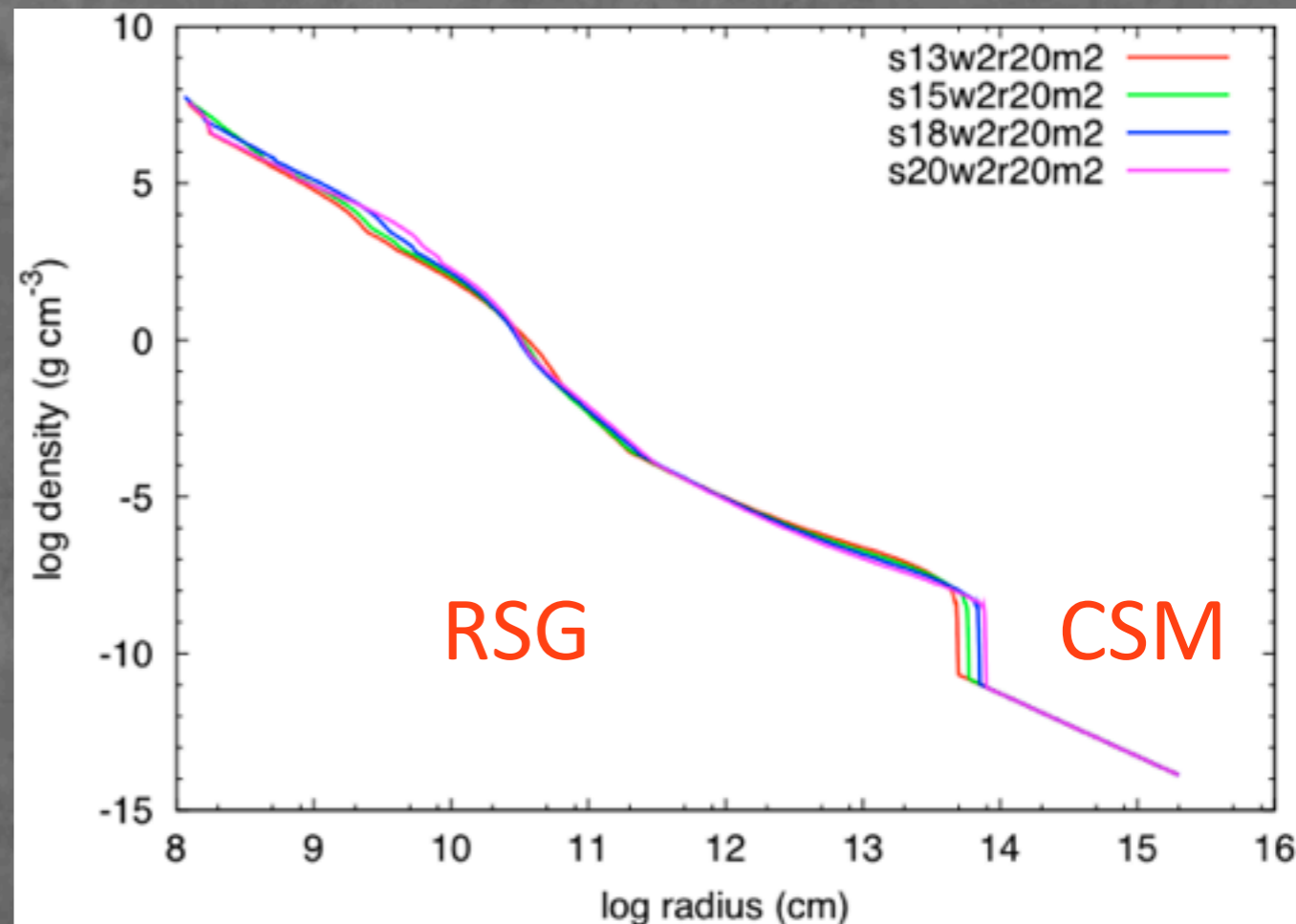
- CSM (10 km/s)

- $\rho \propto r^{-2}$

- Mass-loss rate ($M_\odot$ yr^{-1})
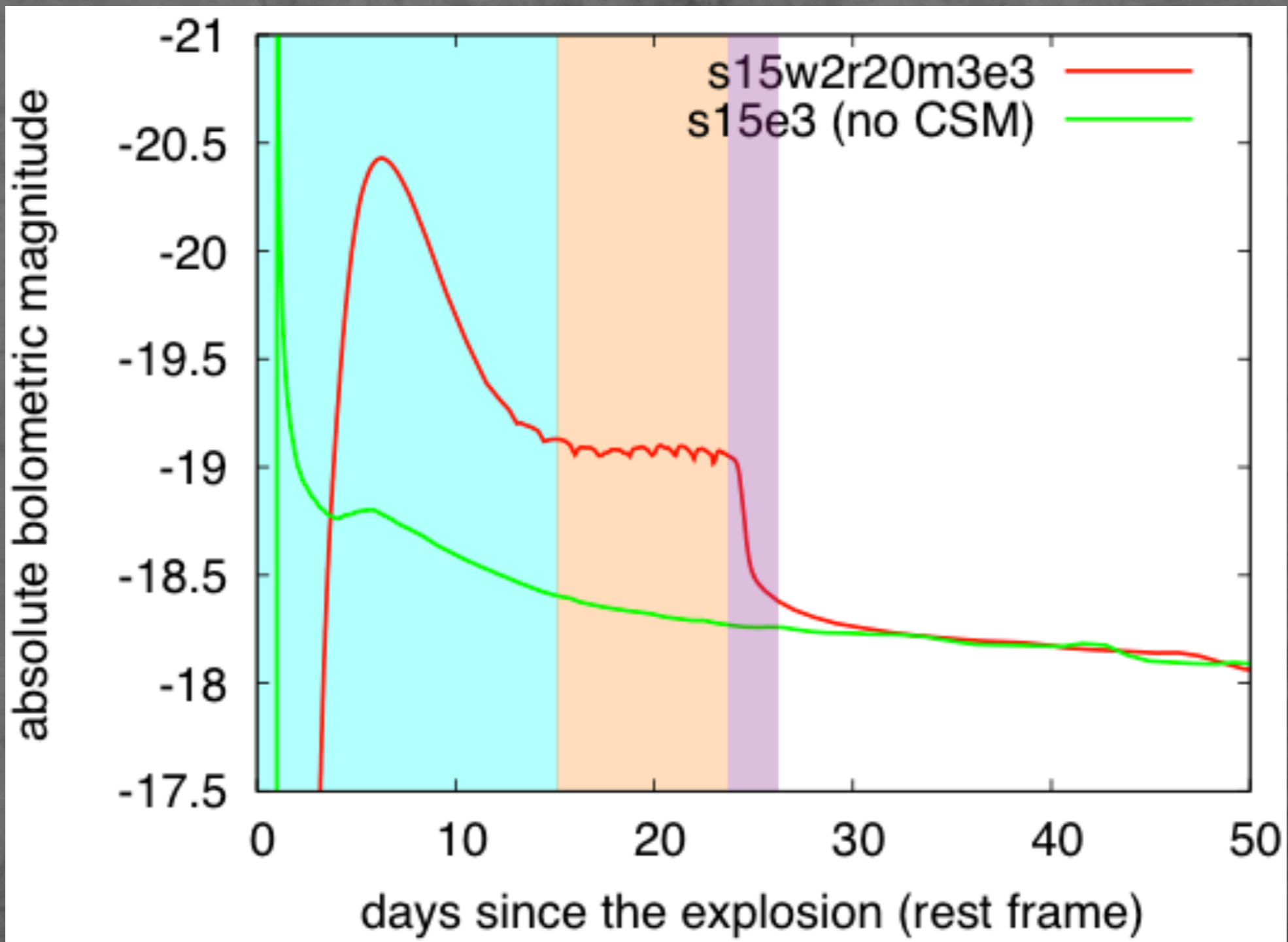
  - $10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}$

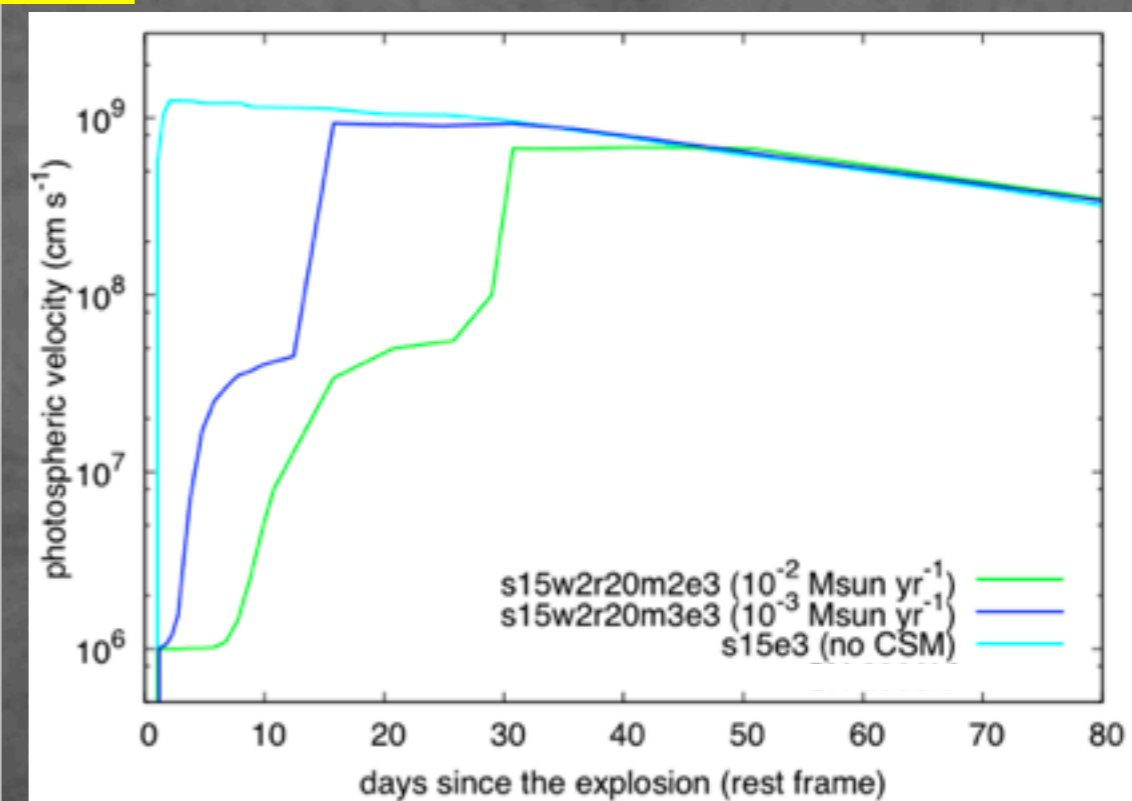- Radius (10^{15} cm)

  - 0.5, 1, 2, 3 (15, 30, 45, 60 yrs)

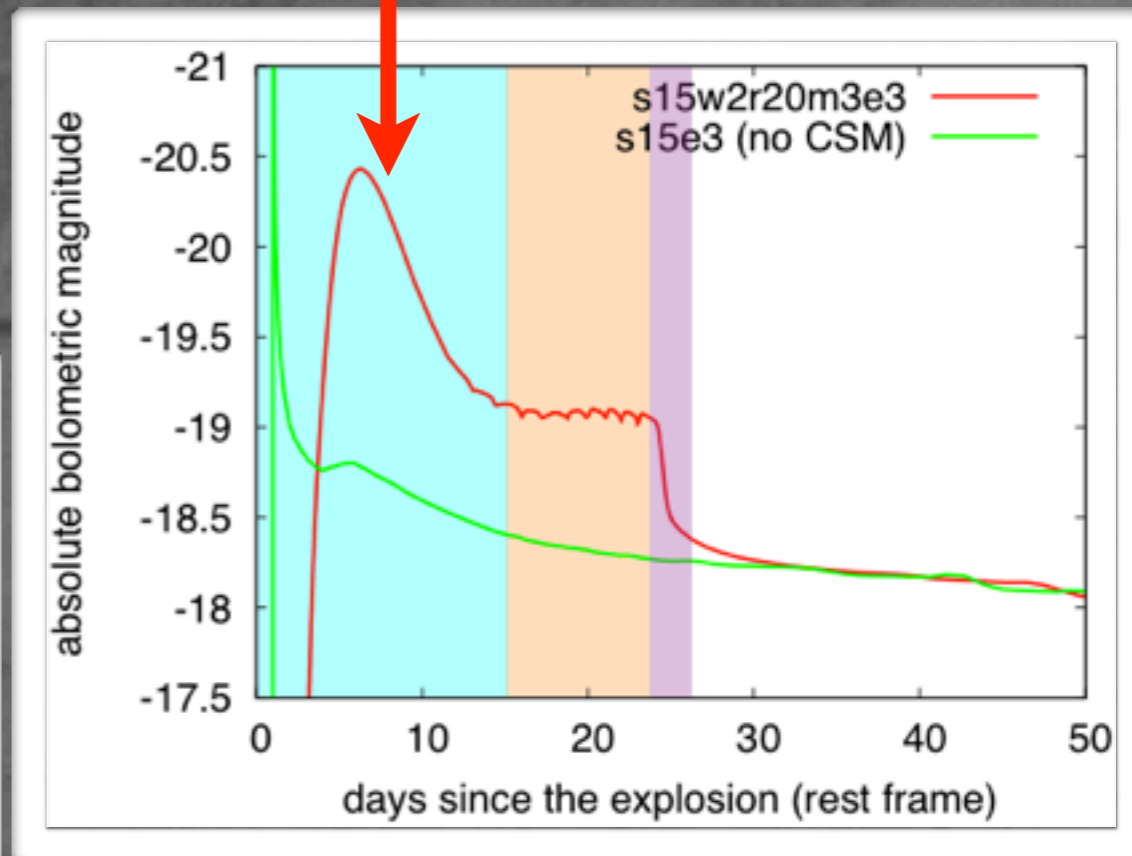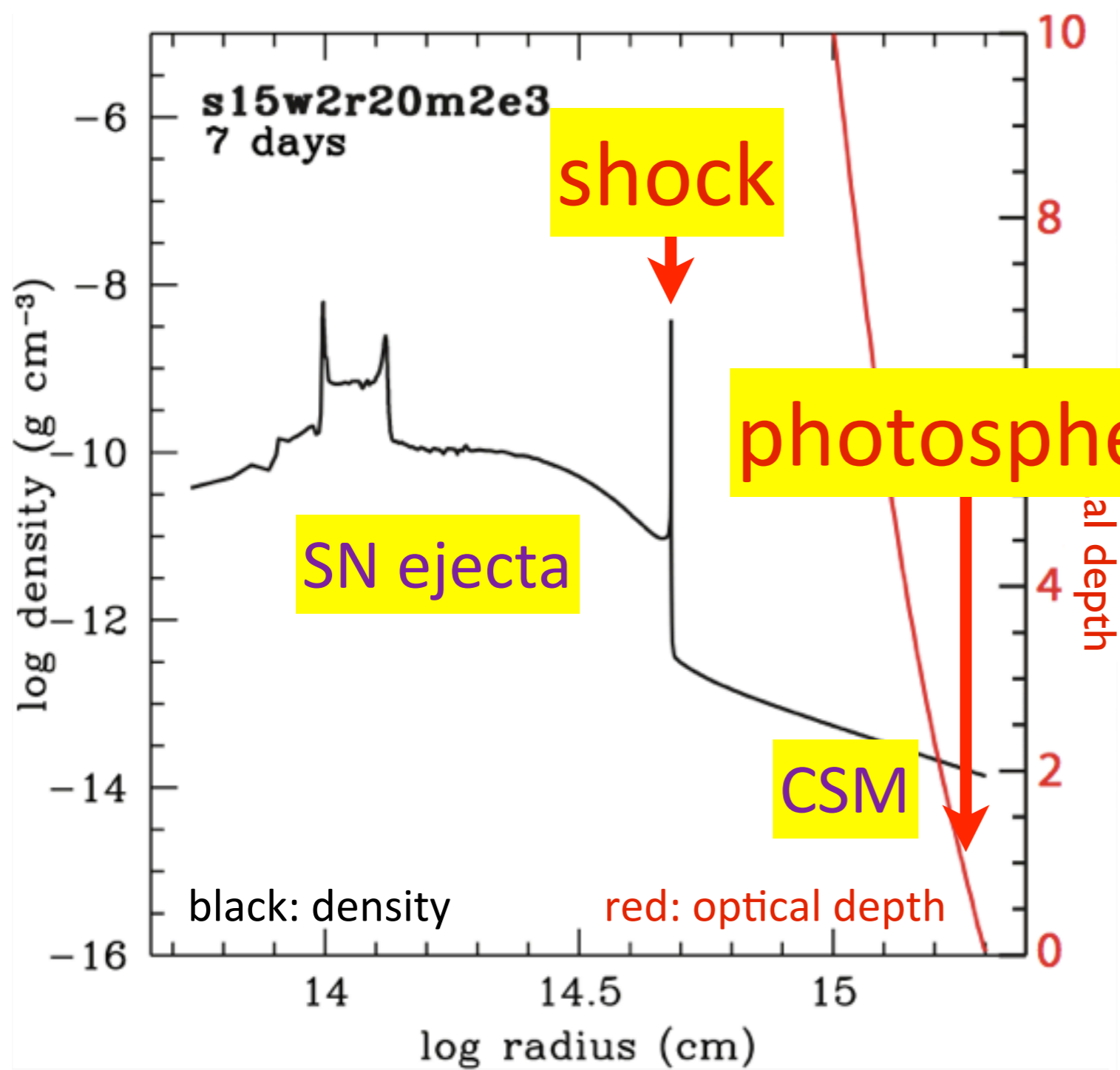Example: s15, 10^{-2} $M_\odot$ yr^{-1}, 60 years $\rightarrow$ $0.6 M_\odot$, 2×10^{15} cm

Effect on Light Curves

Effect on LCs
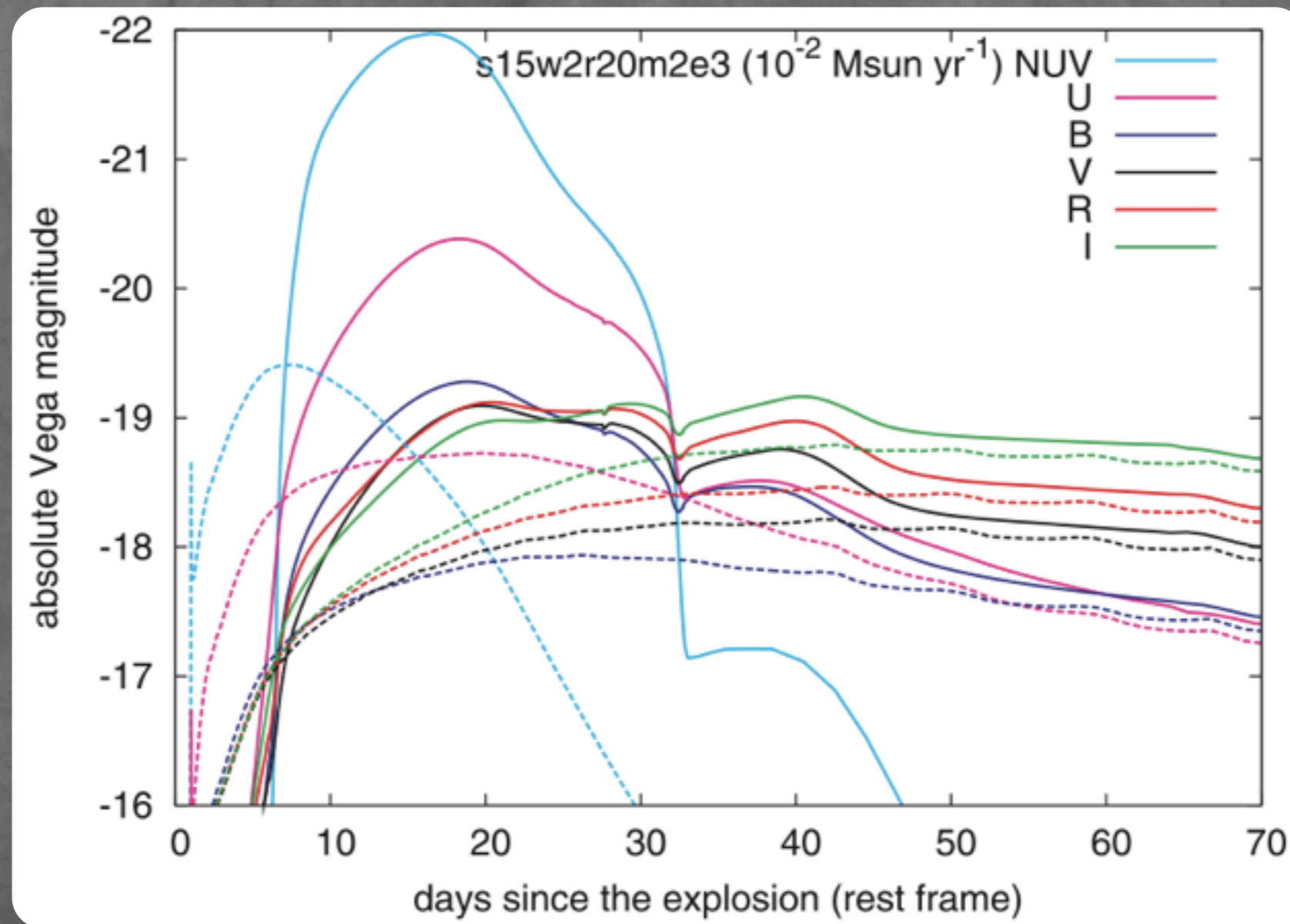

black: density   red: optical depth

Effect on Light Curves
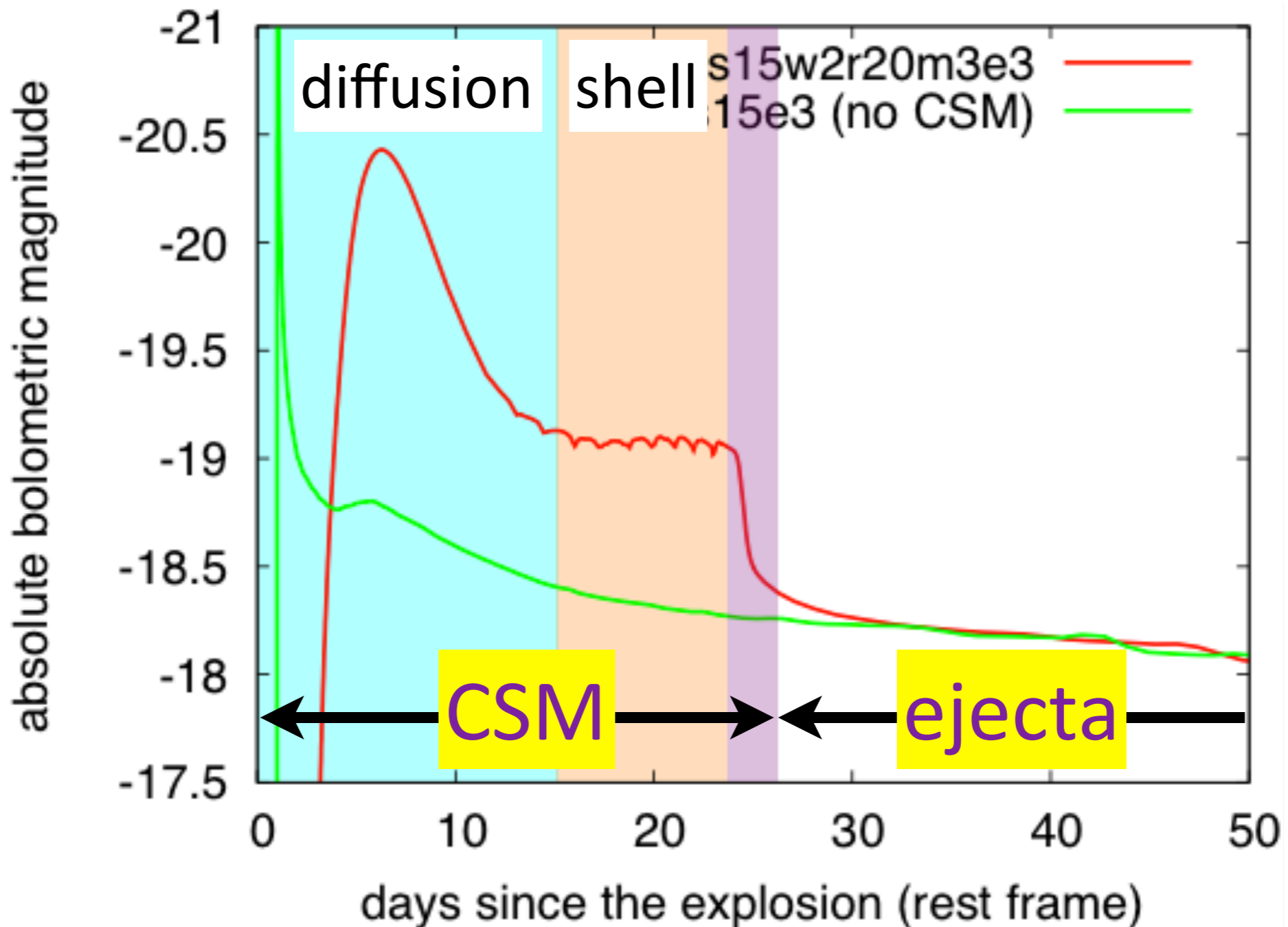
Effect on Light Curves

- UV-Bright

Moriya et al. (2011)

SN 2009kf

Consistent with SN ejecta + CSM model
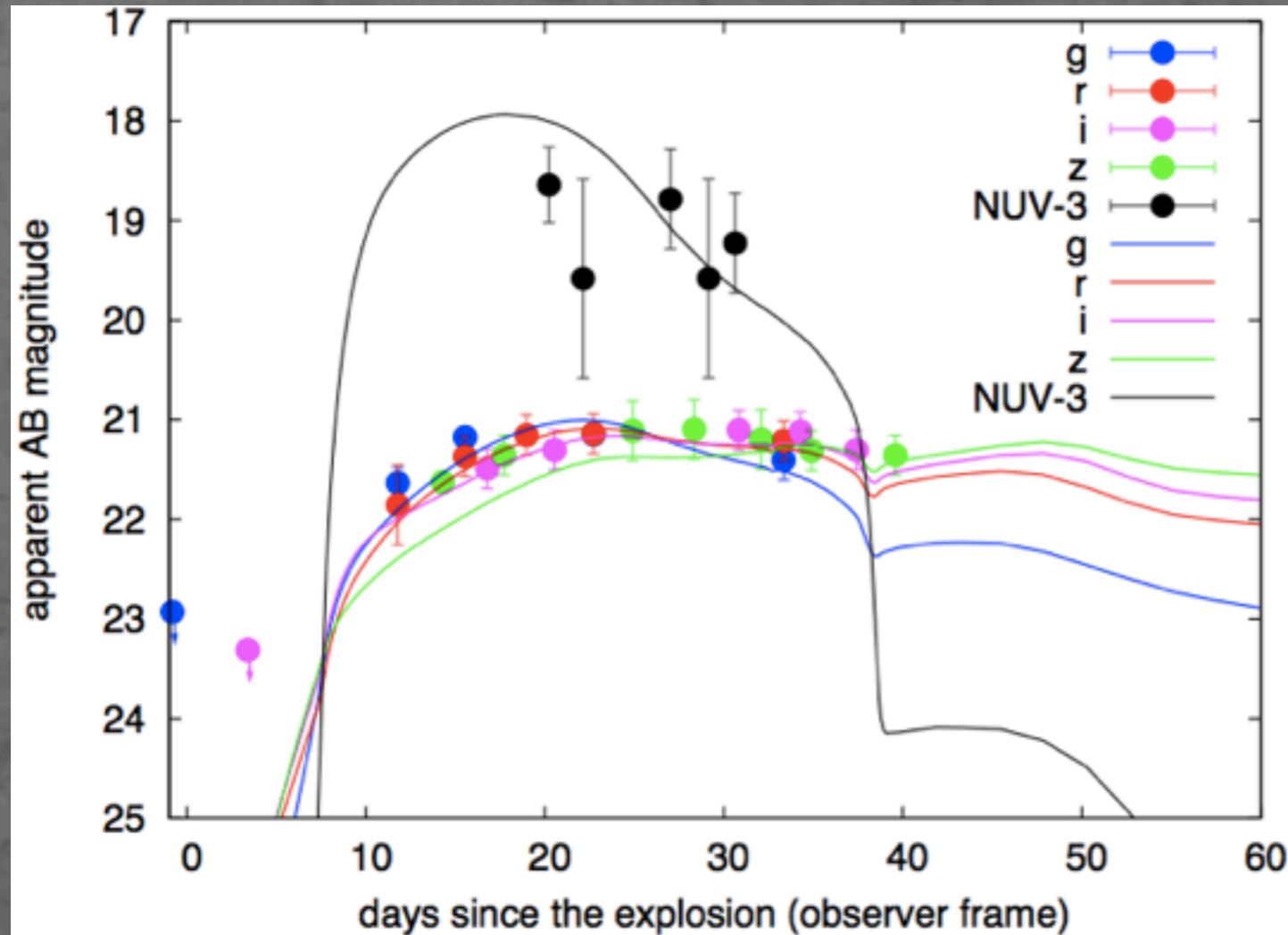
Progenitor inside

s15

3×10^{51} erg

CSM

$\rho \propto r^{-2}$

2×10^{15} cm

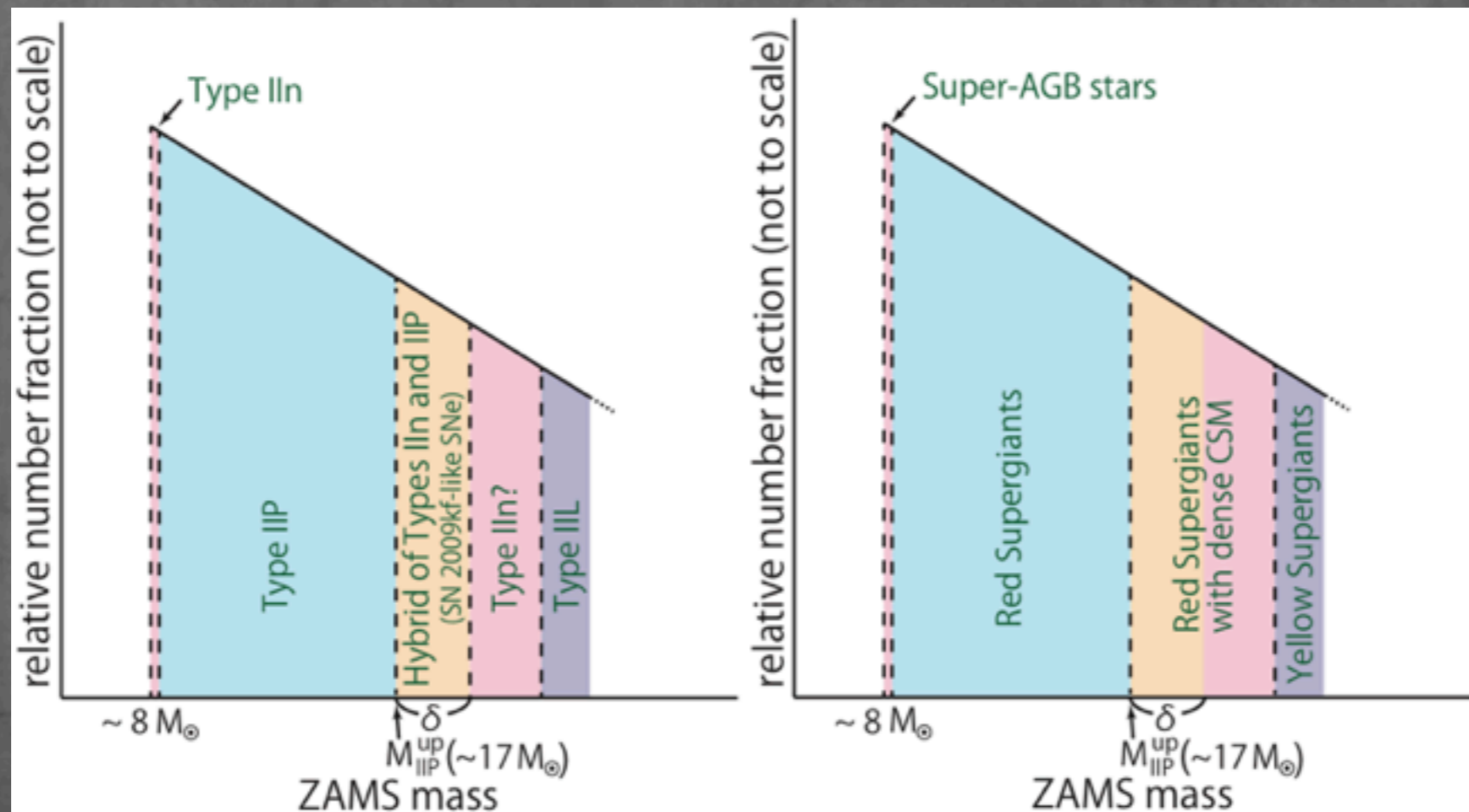$10^{-2} \ M_\odot \ \mathrm{yr}^{-1} \ (0.6 M_\odot)$

Moriya et al. (2011)
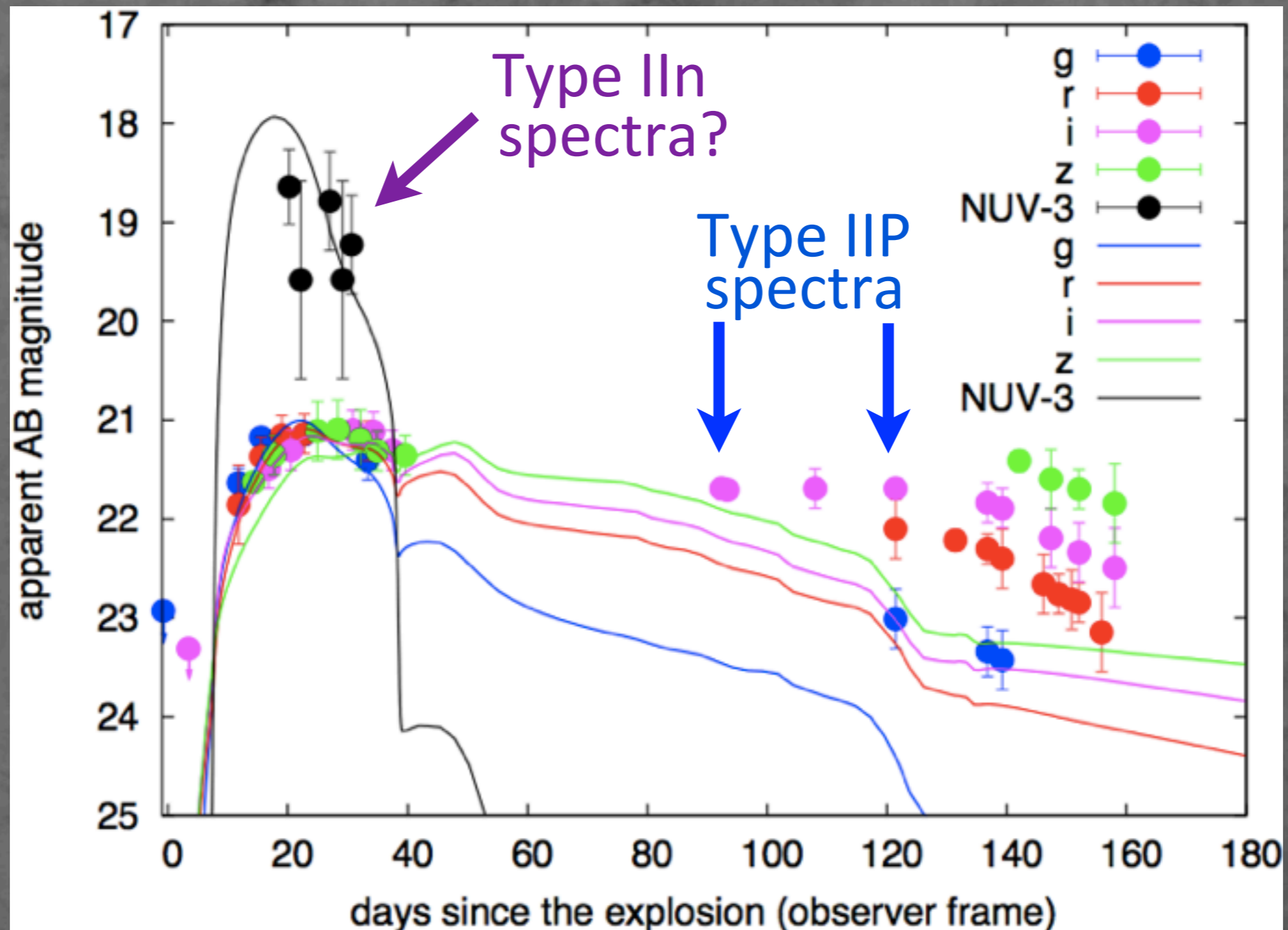
SN 2009kf

A hybrid of Type IIn & IIP? c.f. SN 1987C (Schlegel+ '98)

Implications

- SN 2009kf: high energy = massive RSGs? (Hamuy '03)

- RSGs at high-mass end experience extensive mass loss?

- A key for the RSG problem?

Summary

- UV-bright Type IIP SN 2009kf

  - Progenitor: a RSG exploded in dense CSM

- SN 2009kf = very massive RSG?

  - massive RSGs experience extensive mass loss?

  - such mass loss mechanisms can determine the upper mass limit of Type IIP SN progenitors