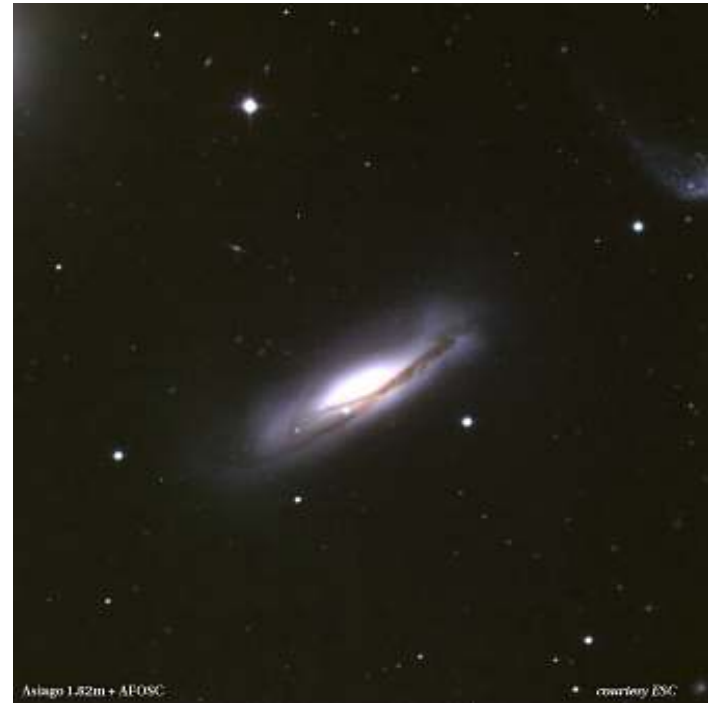
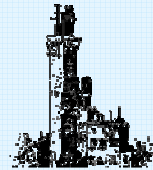


SNe 2002ic-2005gj: Type Ia or Core Collapse SNe?

Stefano Benetti



INAF – Osservatorio Astronomico di Padova



Accretion and Explosion:
The Astrophysics of Degenerate Stars **May 17th, 2007**

SN 2002ic

- SII & SII lines
- H α
- ➔ first SNIa for which H has been unequivocally detected

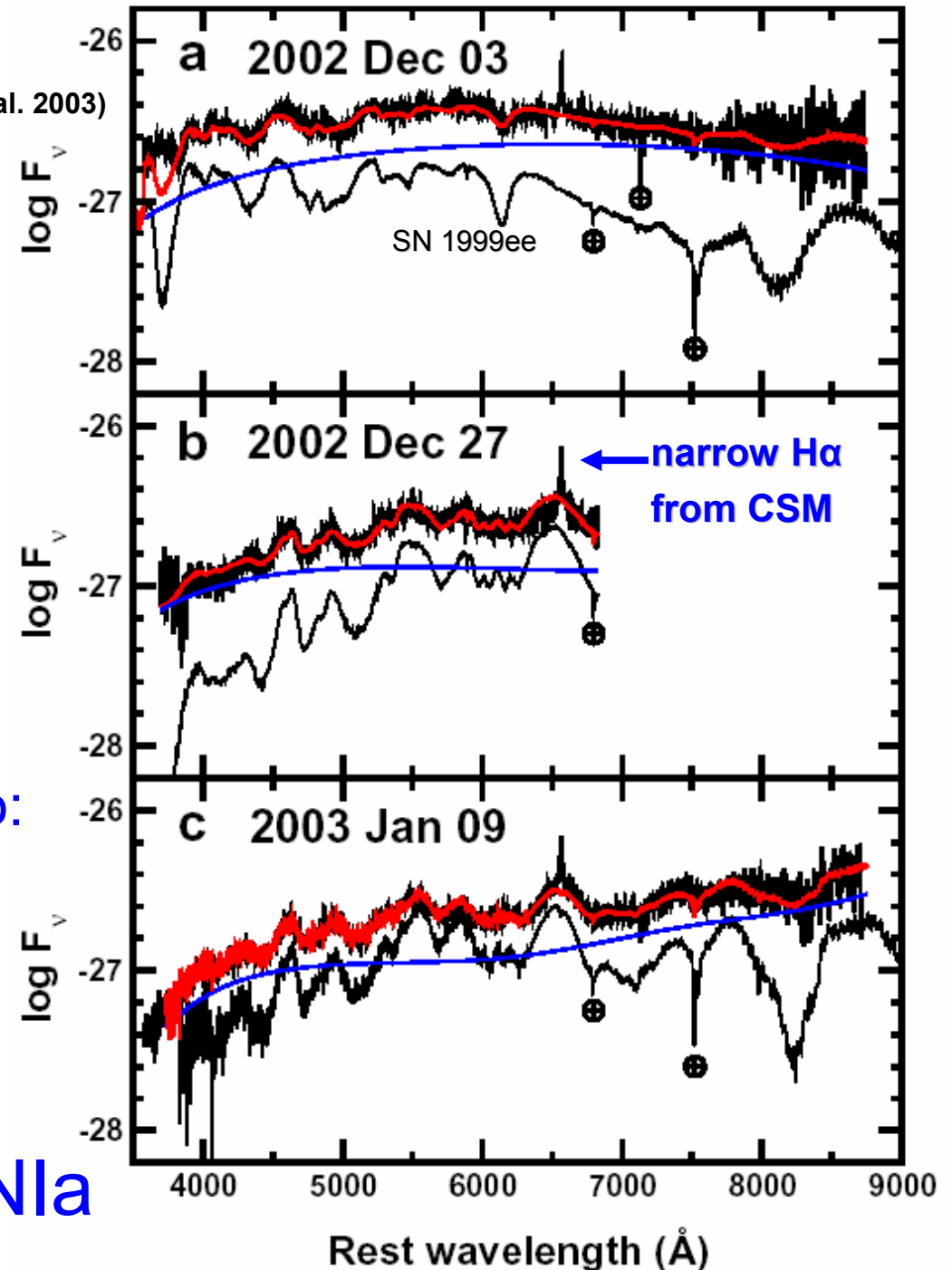
Need a strong, varying continuum at all epochs to:

- increase the flux
- reduce the contrast
- change the SED

➔satisfactory fit

➔CSM interacting SNIa

(Hamuy et al. 2003)



Observations →

- $M(H) = 1-6 M_{\odot}$ (Hamuy et al. 2003; Chugai & Yungelson 2004; Wang et al. 2004) near the site of a thermonuclear explosion
- Asymmetry of H emitted gas ($p > 1\%$, Wang et al. 2004)
- They are rare (SN 2005gj, Aldering et al. 2006)

Possible interpretations:

- the explosion of a WD in a binary system with a post-AGB companion (Hamuy et al. 2003)
- the explosion of the C/O core of a 25 M_{\odot} star (SN 1.5 Iben & Renzini 1983) (Hamuy et al. 2003; Imshennik & Dunina-Barkovskaya 2005)
- the merger of a WD with the C/O core of an AGB star during a common-envelope phase (Livio & Riess 2003)
- the explosion of a WD in a SS X-ray system with delayed dynamical instability-triggered mass loss (Han & Podsiadlowski 2006).

But then came SN 2004aw! SNIa or SNIc?

Circular No. 8312

Central Bureau for Astronomical Telegrams INTERNATIONAL ASTRONOMICAL UNION

Mailstop 18, Smithsonian Astrophysical Observatory, Cambridge, MA 02138, U.S.A.
IAUSUBS@CFA.HARVARD.EDU or FAX 617-495-7231 (subscriptions)
CBAT@CFA.HARVARD.EDU (science)
URL <http://cfa-www.harvard.edu/iau/cbat.html> ISSN 0081-0304
Phone 617-495-7440/7244/7444 (for emergency use only)

SUPERNOVA 2004az IN UGC 6853

Further to *IAUC* 8311, D. Singer and W. Li report the LOSS discovery, on KAIT images taken on Mar. 21.32 and 23.39 UT, of an apparent supernova (mag ~ 17.8) located at $\alpha = 11^{\text{h}}52^{\text{m}}48^{\text{s}}.22$, $\delta = +29^{\circ}20'51''.7$ (equinox 2000.0), which is $11''.9$ east and $67''.2$ north of the nucleus of UGC 6853. A KAIT image taken on Jan. 29.40 showed nothing at this position (limiting mag ~ 19.0).

T. Matheson, P. Challis, and R. Kirshner, Harvard-Smithsonian Center for Astrophysics, report that a spectrum (range 370–750 nm) of SN 2004az, obtained by P. Berlind on Mar. 25.26 UT with the F. L. Whipple Observatory 1.5-m telescope (+ FAST spectrograph), shows it to be a type-Ia supernova several weeks past maximum brightness.

SUPERNOVA 2004aw IN NGC 3997

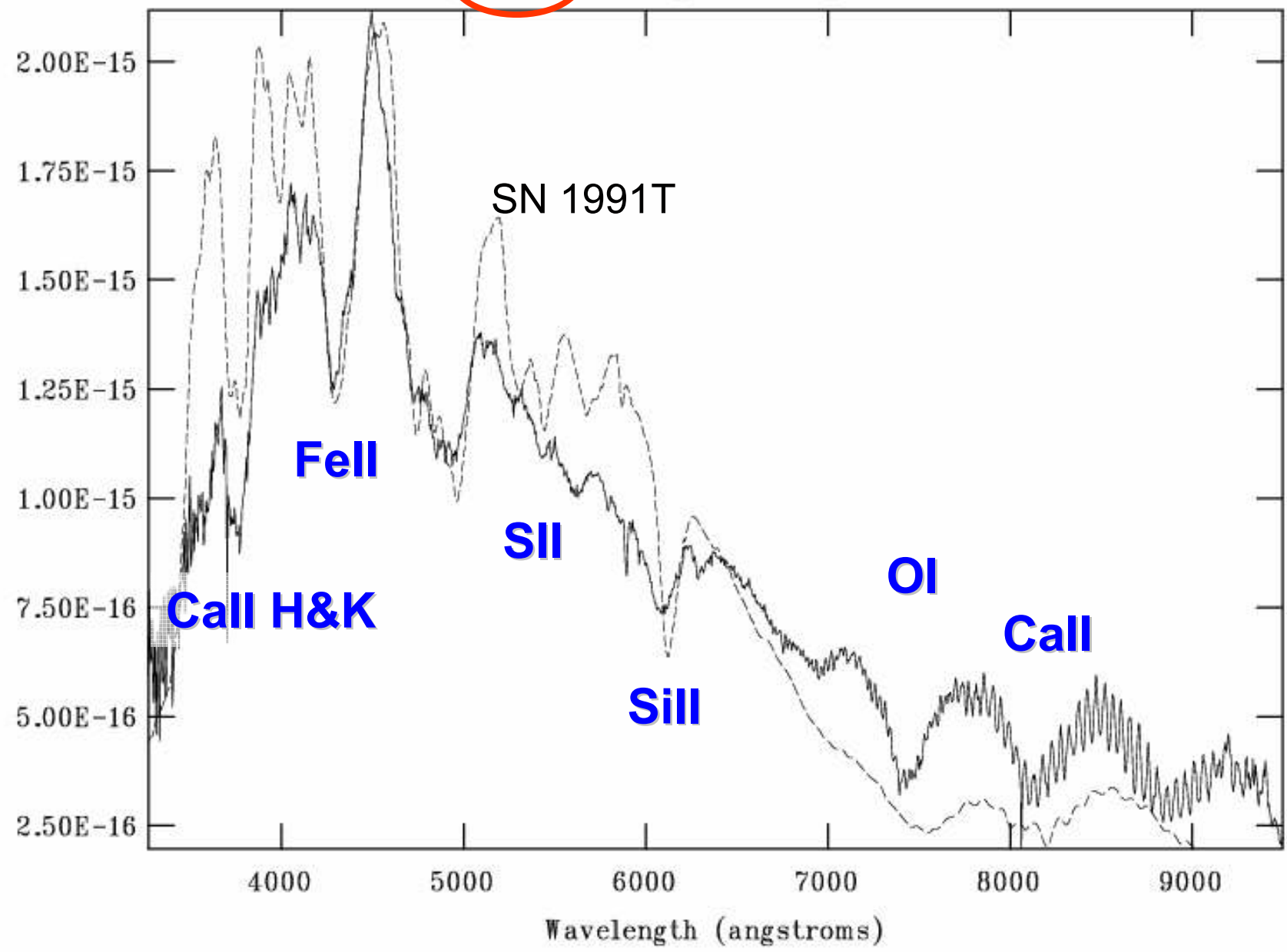
S. Benetti, N. Elias-Rosa, G. Blanc, H. Navasardyan, M. Turatto, and L. Zampieri, Osservatorio Astronomico di Padova; E. Cappellaro, Osservatorio Astronomico di Capodimonte; and M. Pedani, Telescopio Nazionale Galileo (TNG), on behalf of the ERTN (*IAUC* 7987), obtained a spectrum of SN 2004aw (cf. *IAUC* 8310, 8311) with the TNG (+ Dolores; range 335–995 nm; resolution 1.4 nm) on Mar. 24.94 UT. The supernova has now evolved to resemble the spectrum of SN 1991T, a few days after maximum, and is therefore classified as type Ia. This also accounts for the fact that the narrow interstellar absorption line seen in the supernova spectrum indicates a reddening of $E(B - V) \sim 0.30$ in the host galaxy. The expansion velocity deduced from the Si-II 635.5-nm feature is ~ 12600 km/s.

SUPERNOVA 2004ay IN UGC 11255

Matheson *et al.* add that a spectrum of SN 2004ay (cf. *IAUC* 8311), obtained by Berlind on Mar. 26.49 UT, shows it to be a type-IIIn supernova.

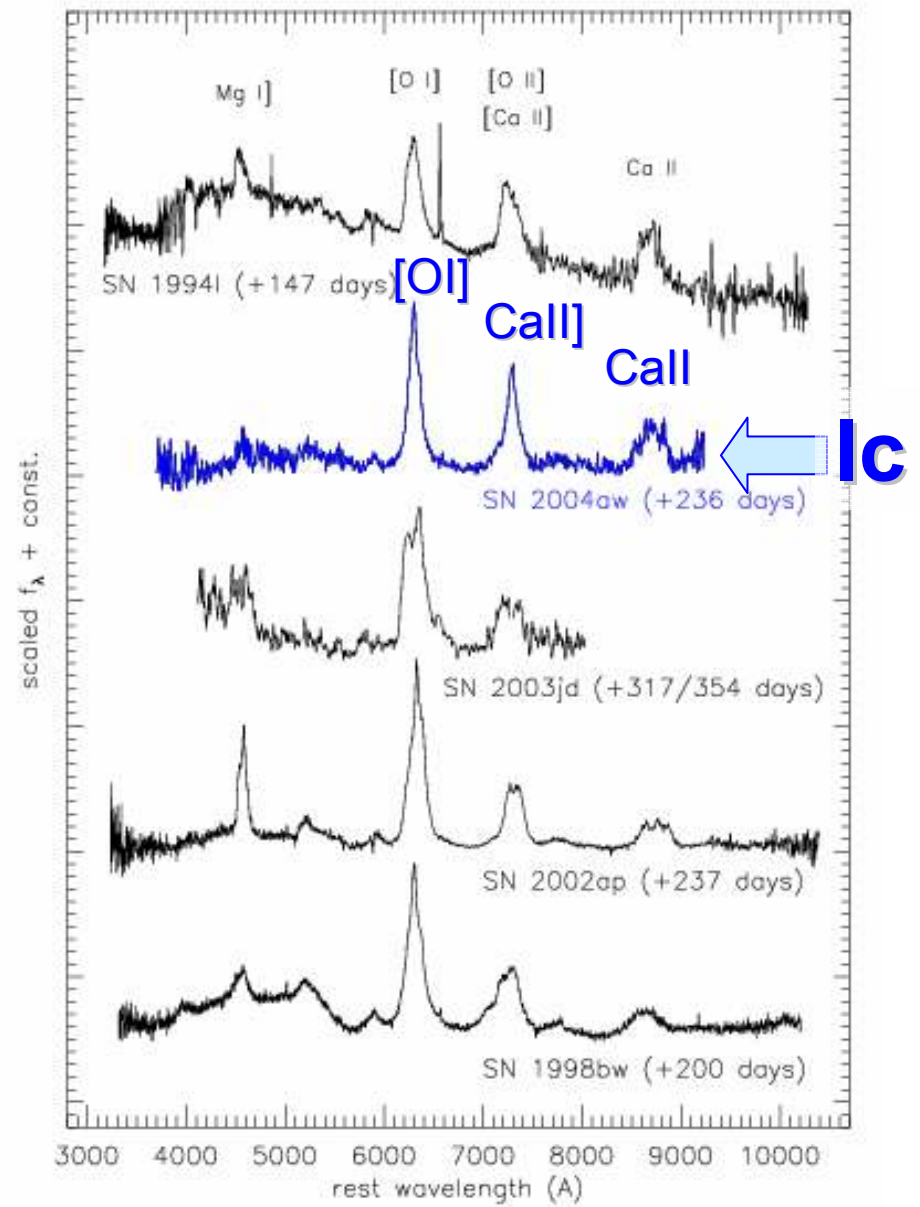
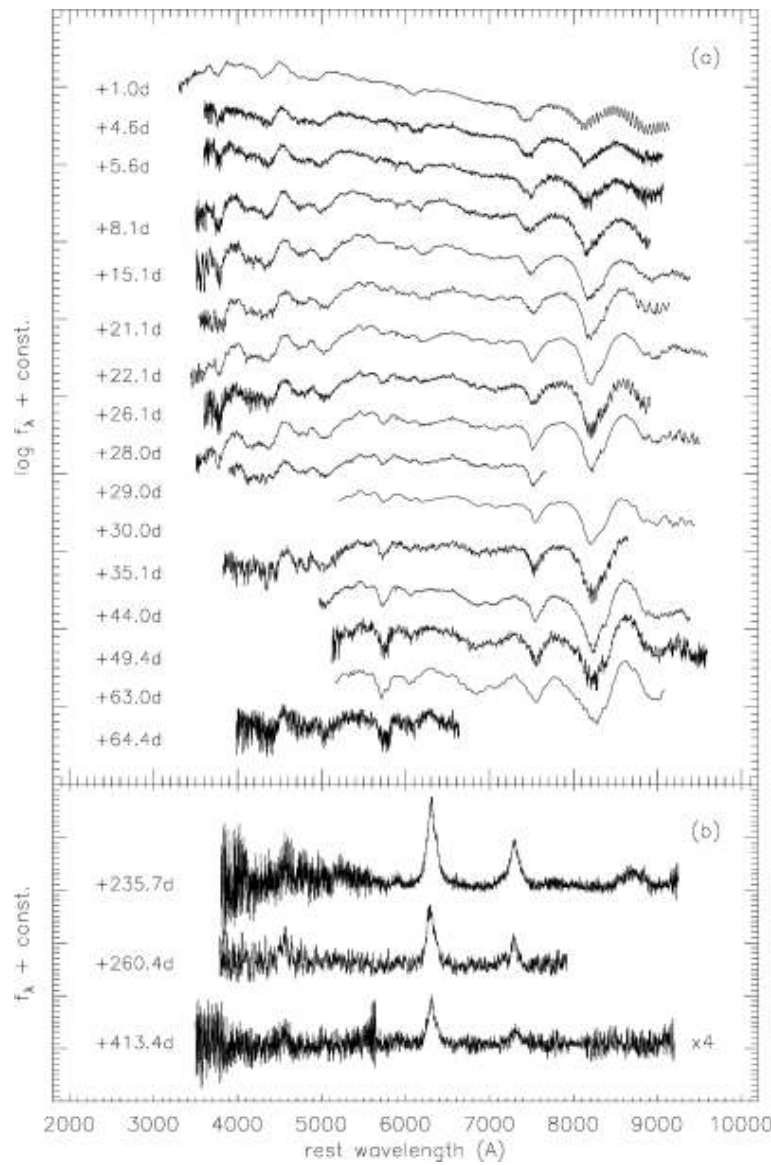
SUPERNOVAE 2002lt AND 2002lv

Further to *IAUC* 8311, T. Schrabback adds that the data analysis was done with D. Wuttke, H. Knuth, and J.-M. Miralles.



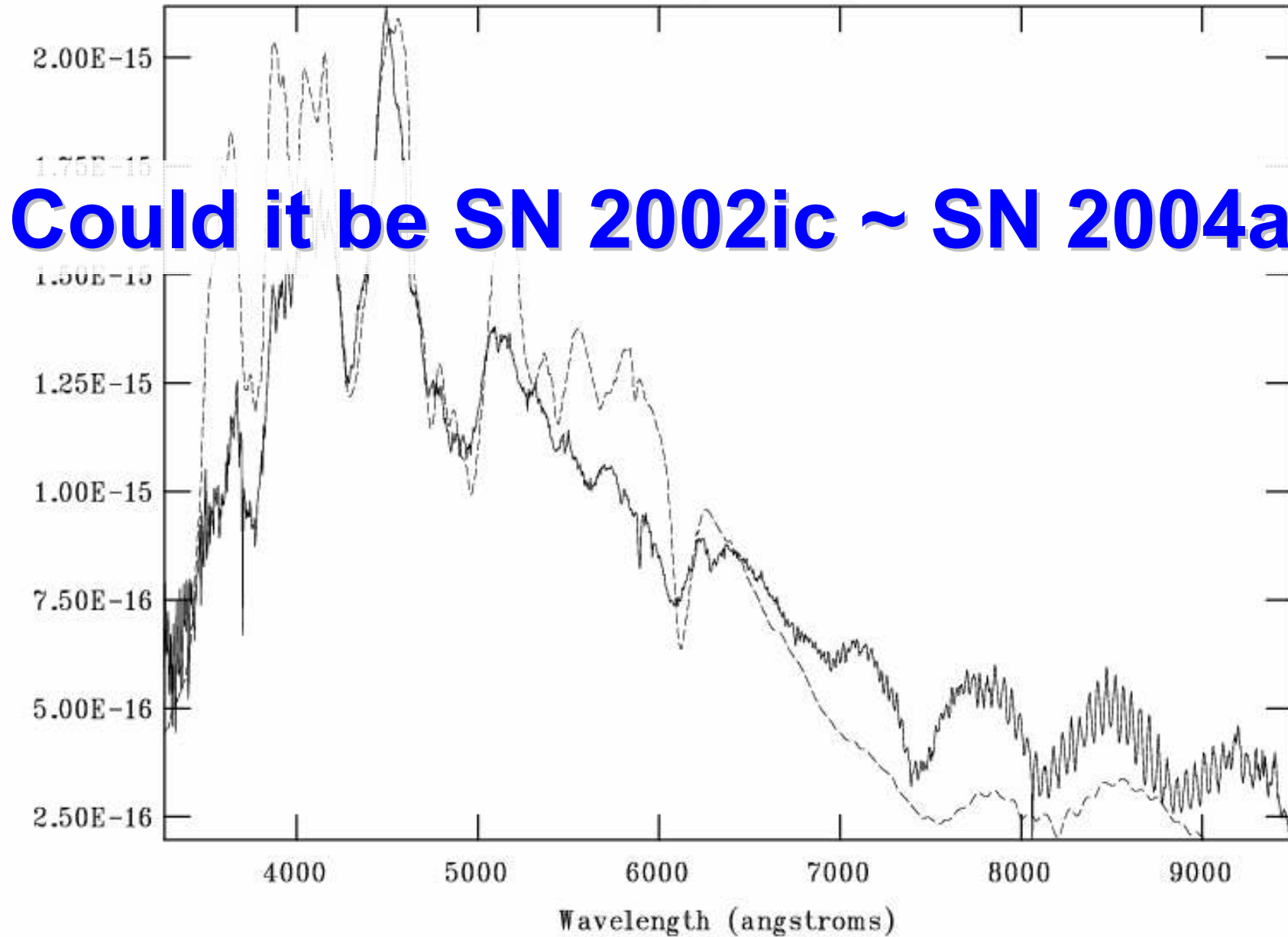
SN Ic!

SN 2004aw

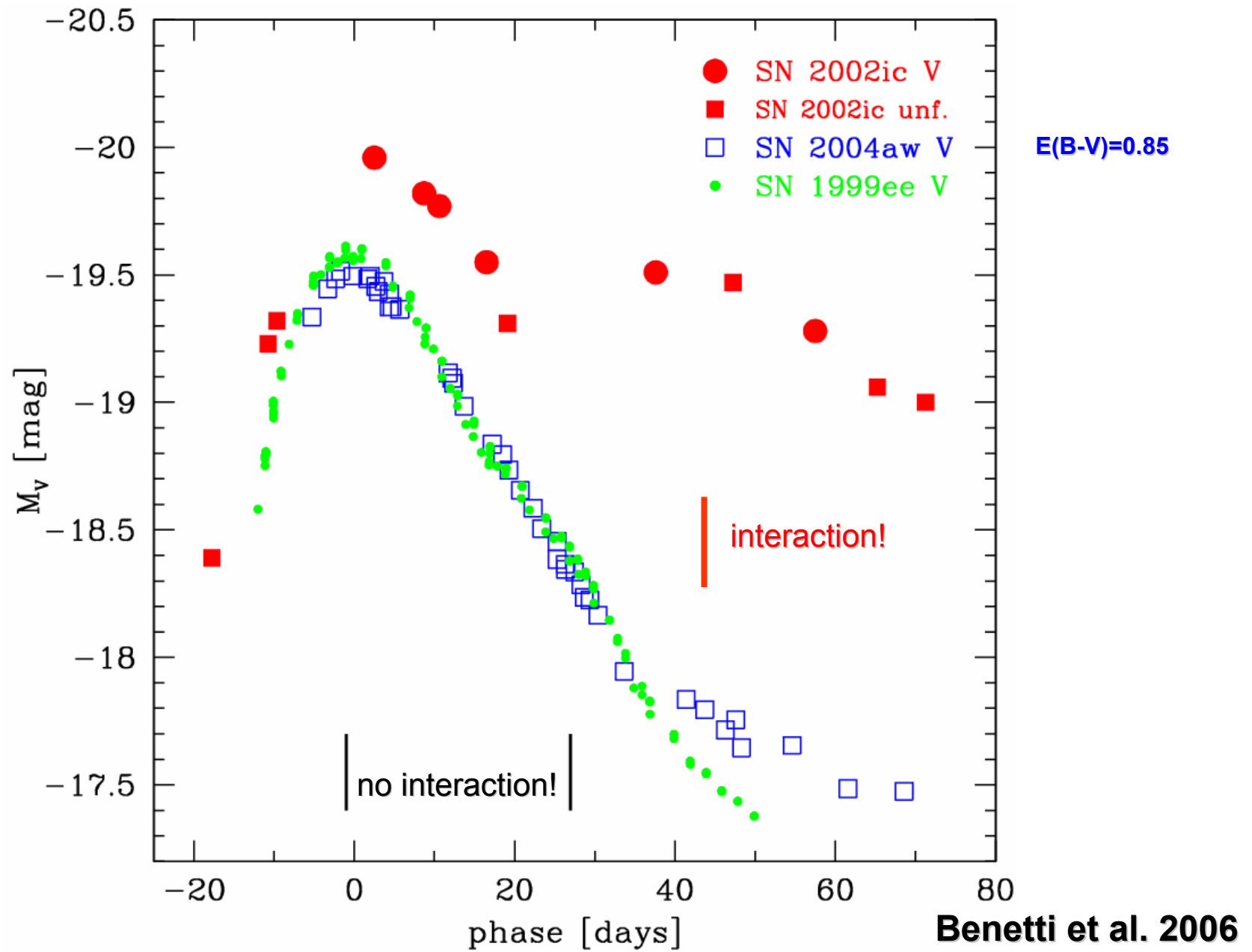


Taubenberger et al. 2006 (tanks to ESC on Type Ia SNe!)

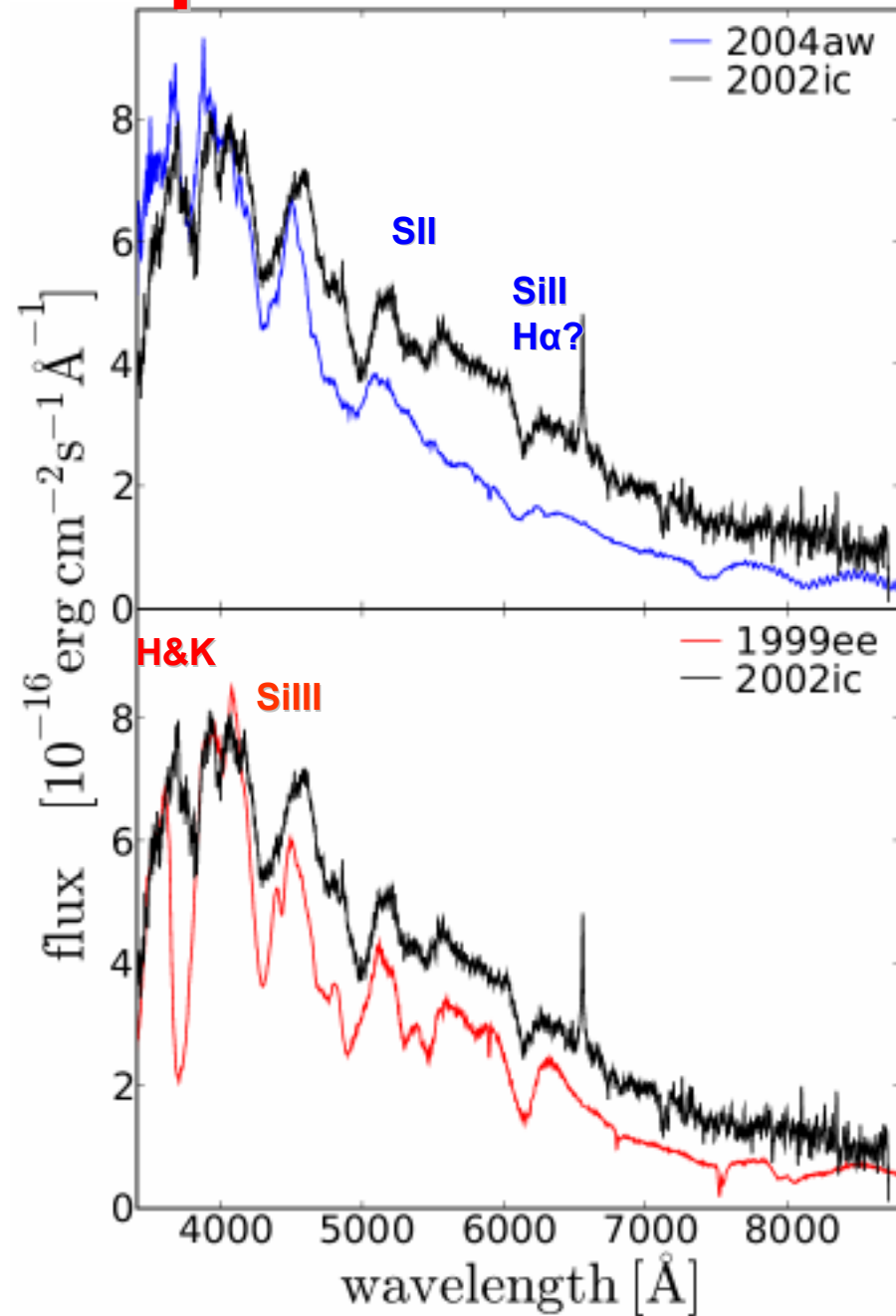
NOAO/IRAF V2.12.1-EXPORT sbenetti@graspa.pd.astro.it Thu 12:32:35 25-Ma
[2004aw_z0_der]: 1200. ap:1 beam:1



M_V light curve



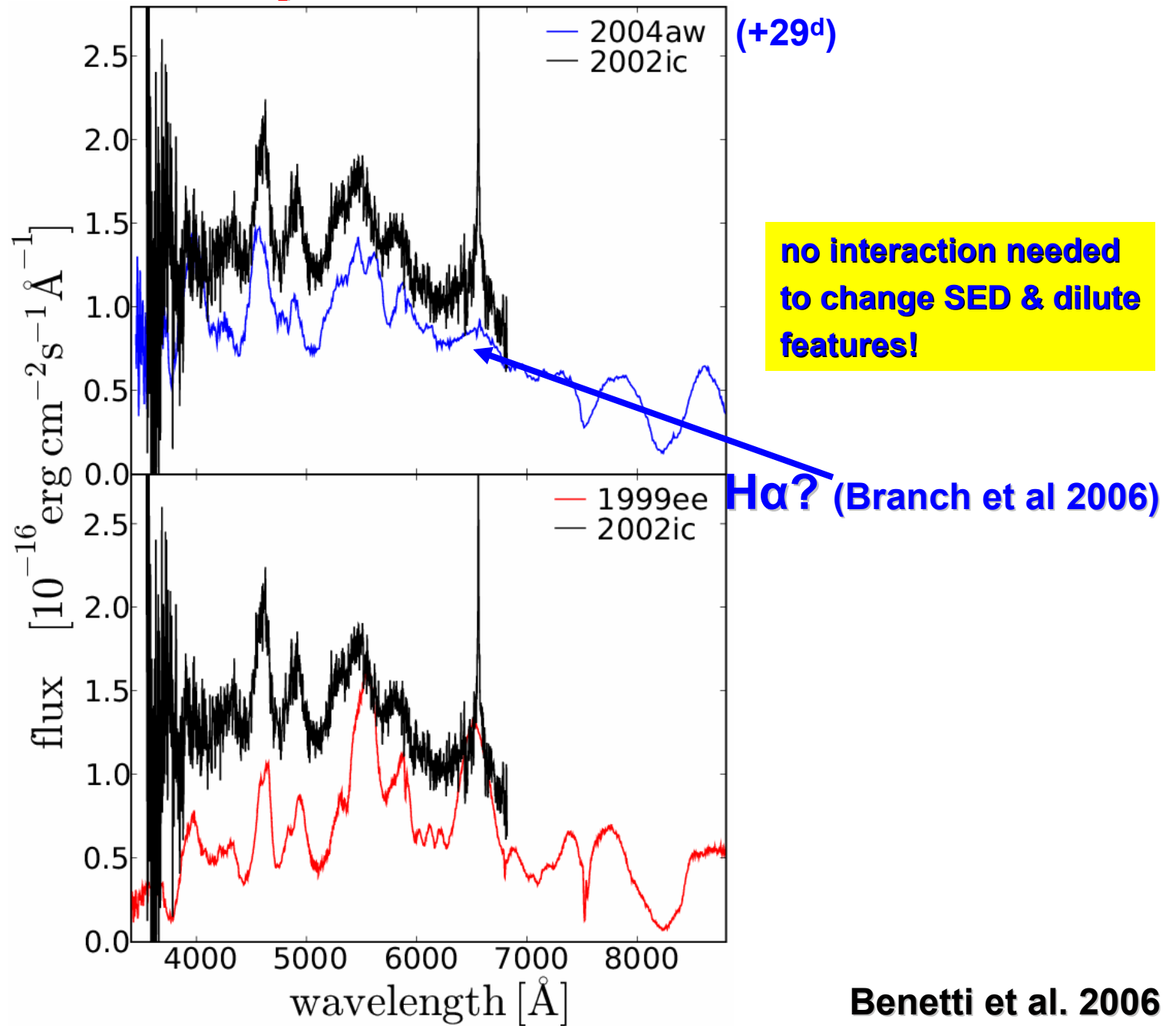
Comparison at max



$E(B-V)=0.85$

no interaction needed
to change SED & dilute
features!

Comparison at +29^d

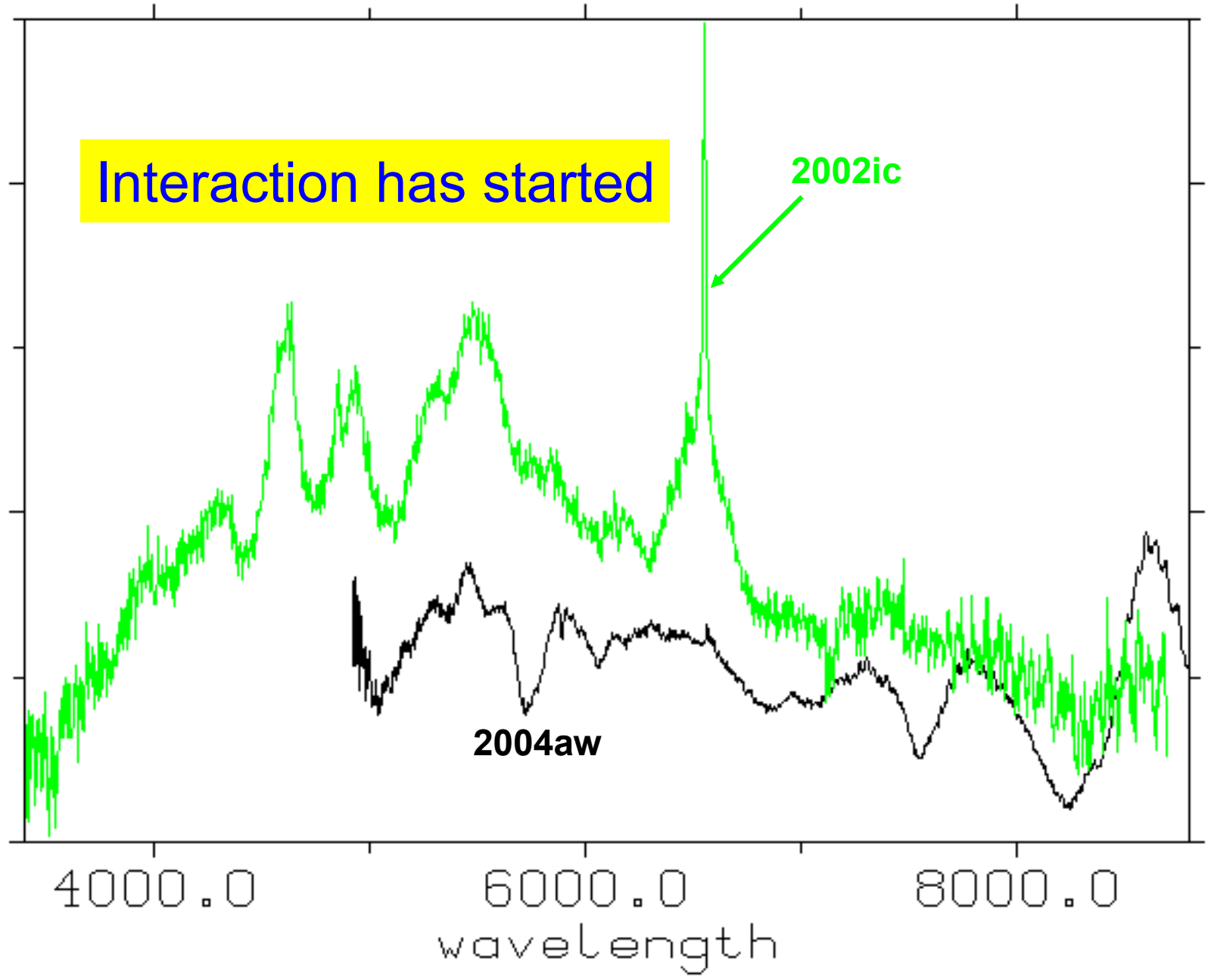


+45^d

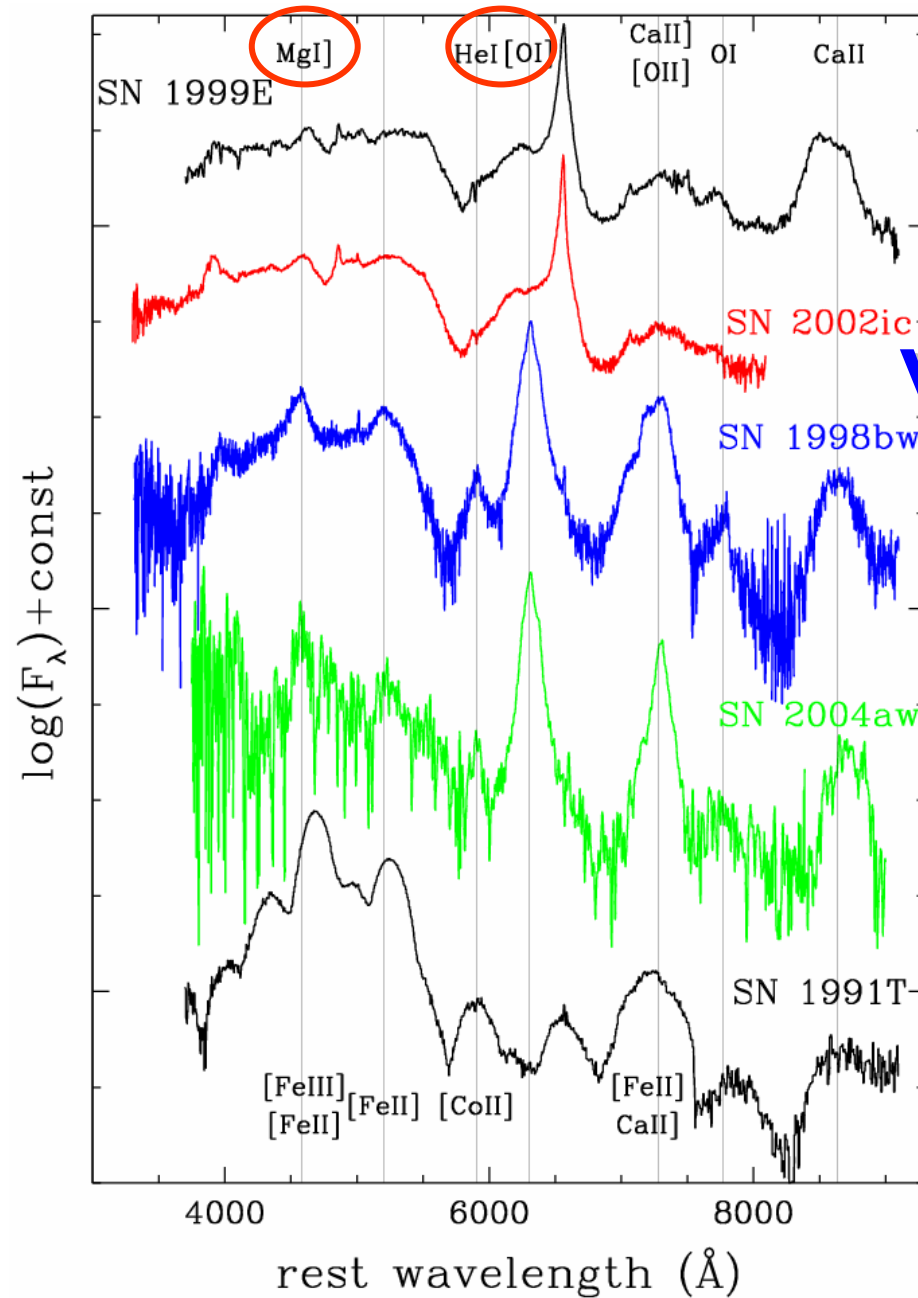
Interaction has started

2002ic

2004aw



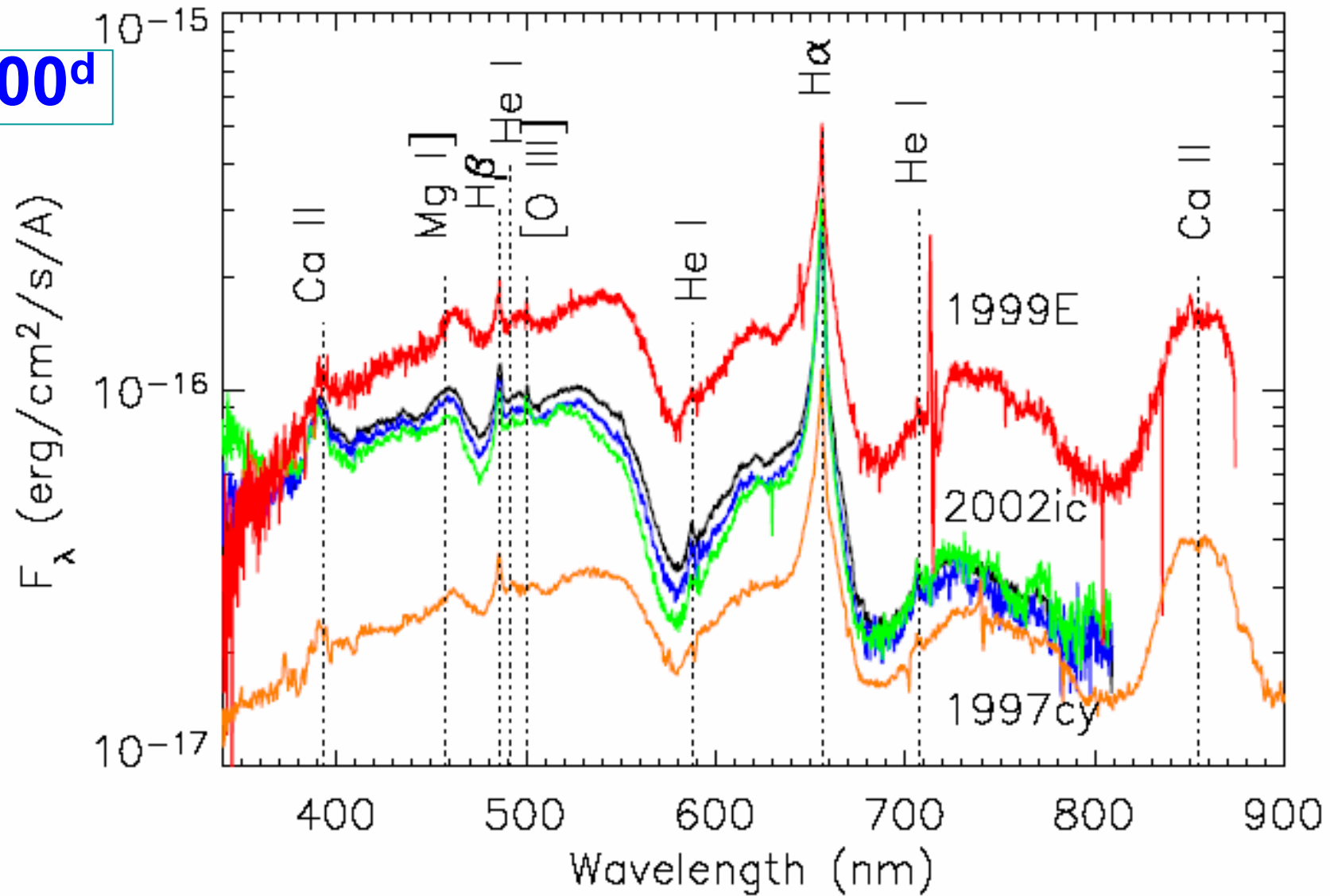
Comparison late phases ($>200^d$)



very similar!

SNe 1997cy - 1999E ~ SN 2002ic

200^d

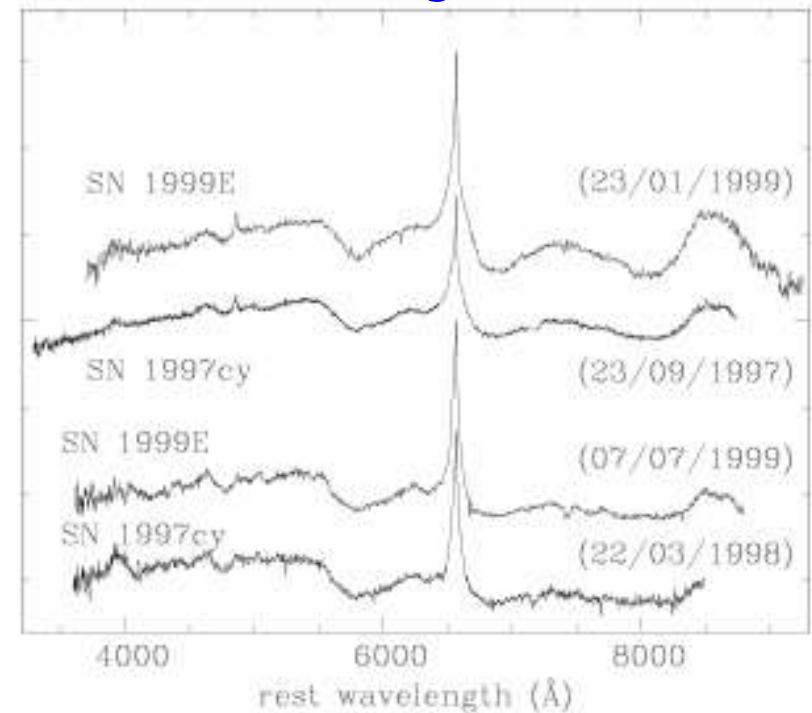
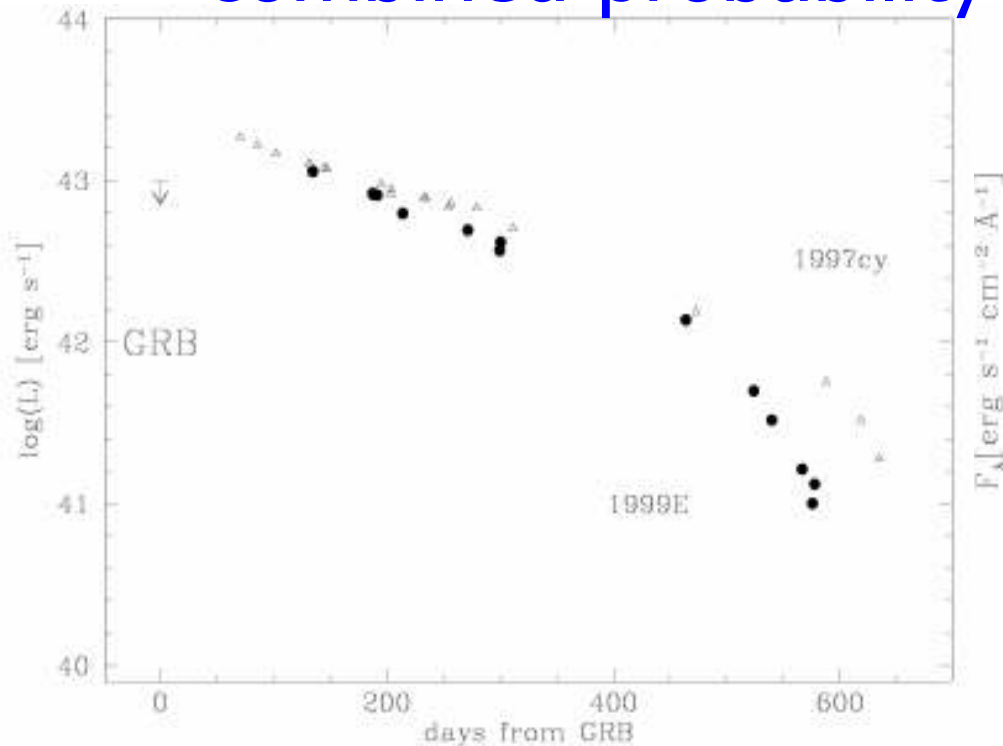


Wang et al. 2003

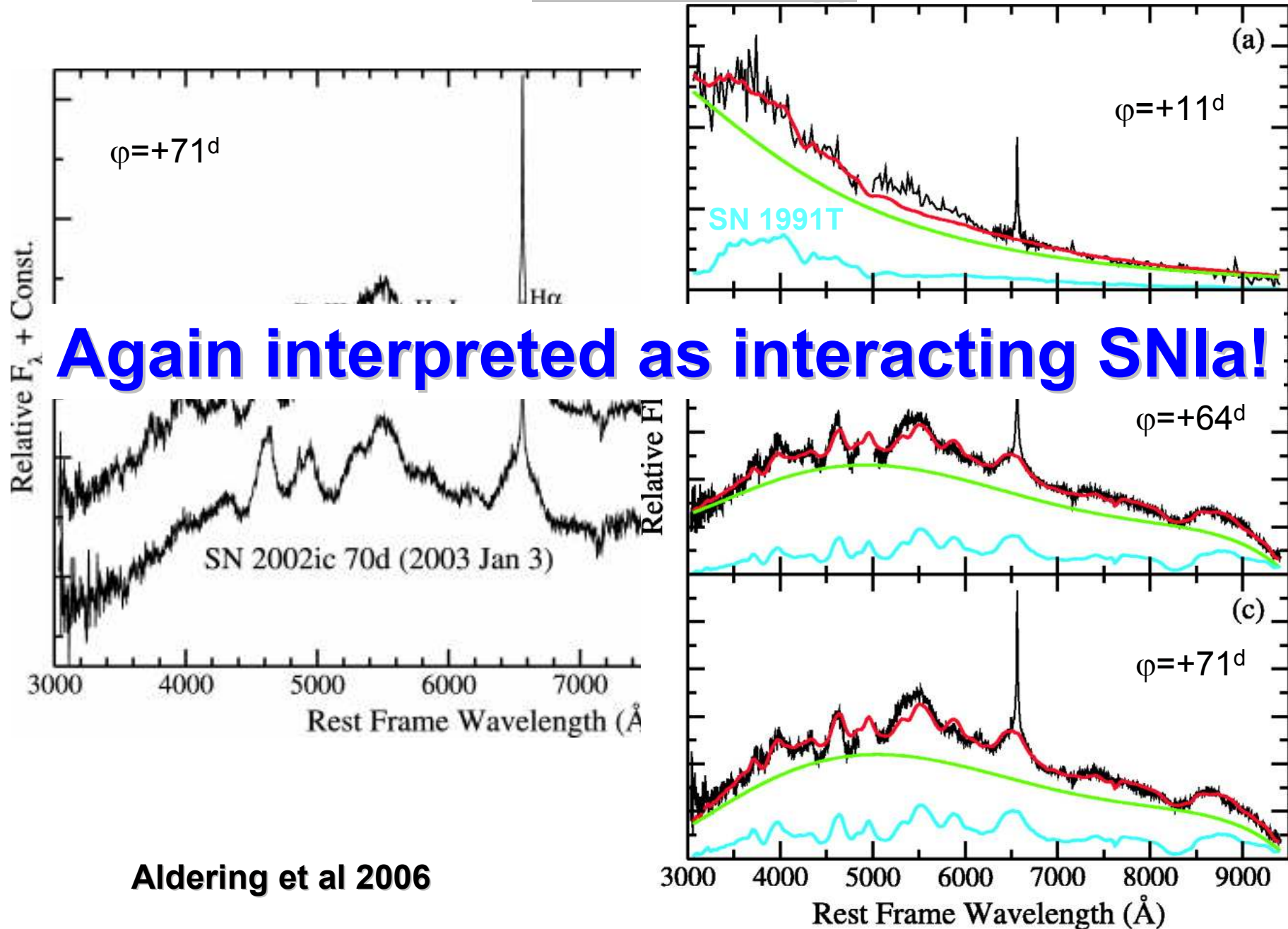
SNe 1997cy & SN 1999E

- the only 2 objects with such features (before 2002ic)
- both associated to BATSE GRBs!

combined probability \Rightarrow 0.2% change association

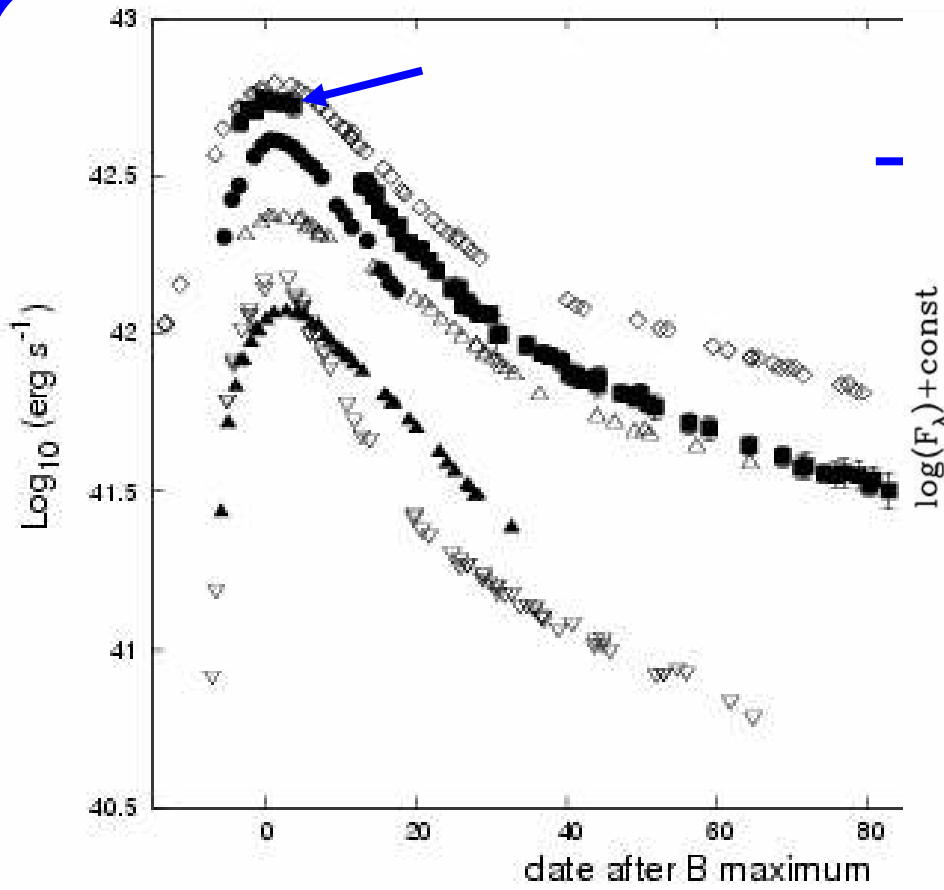


What about SN 2005gj?



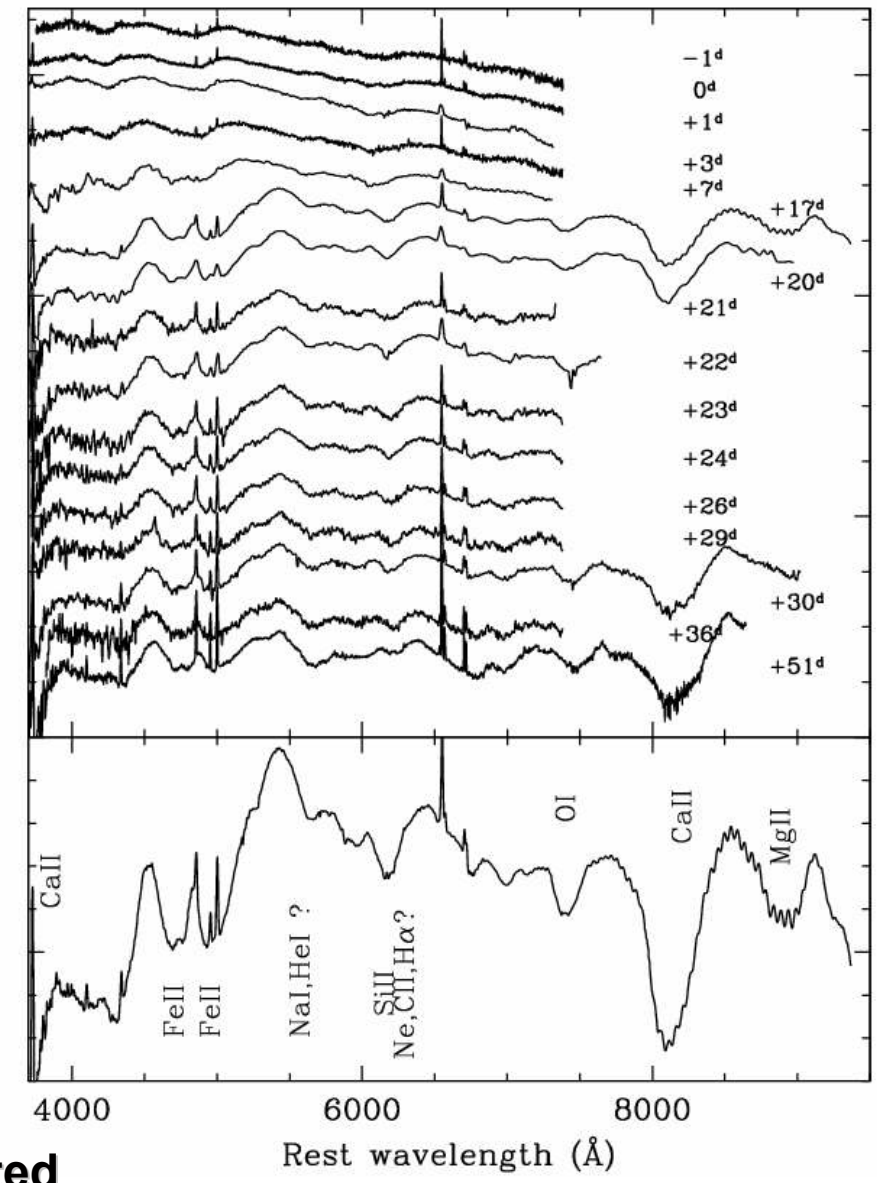
Aldering et al 2006

short parenthesis: SN 2003jd paper

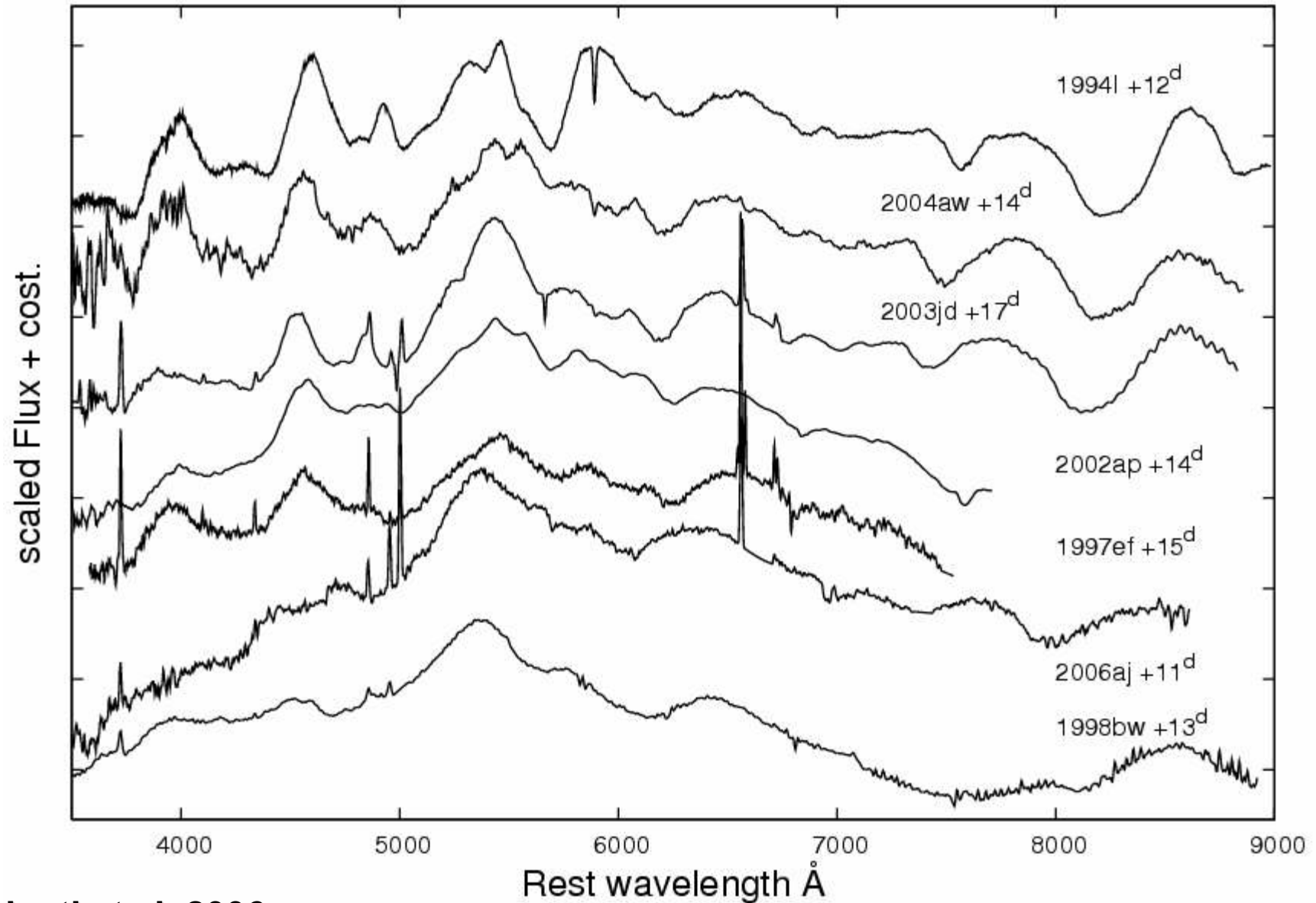


World-wide collaboration: [Berl](#)

from [Valenti et al. 2006](#), to be submitted

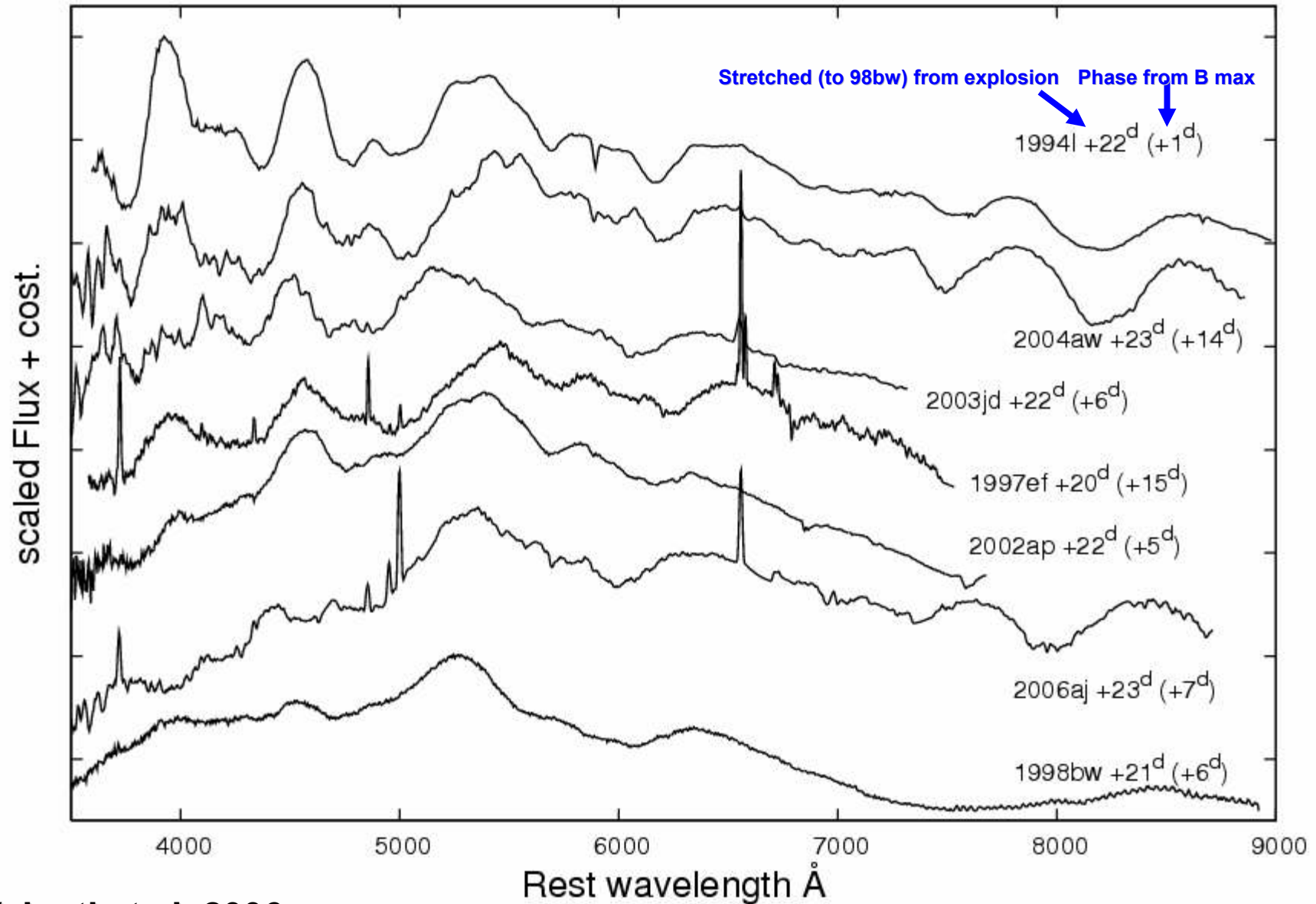


SN Ic spectra at similar phase

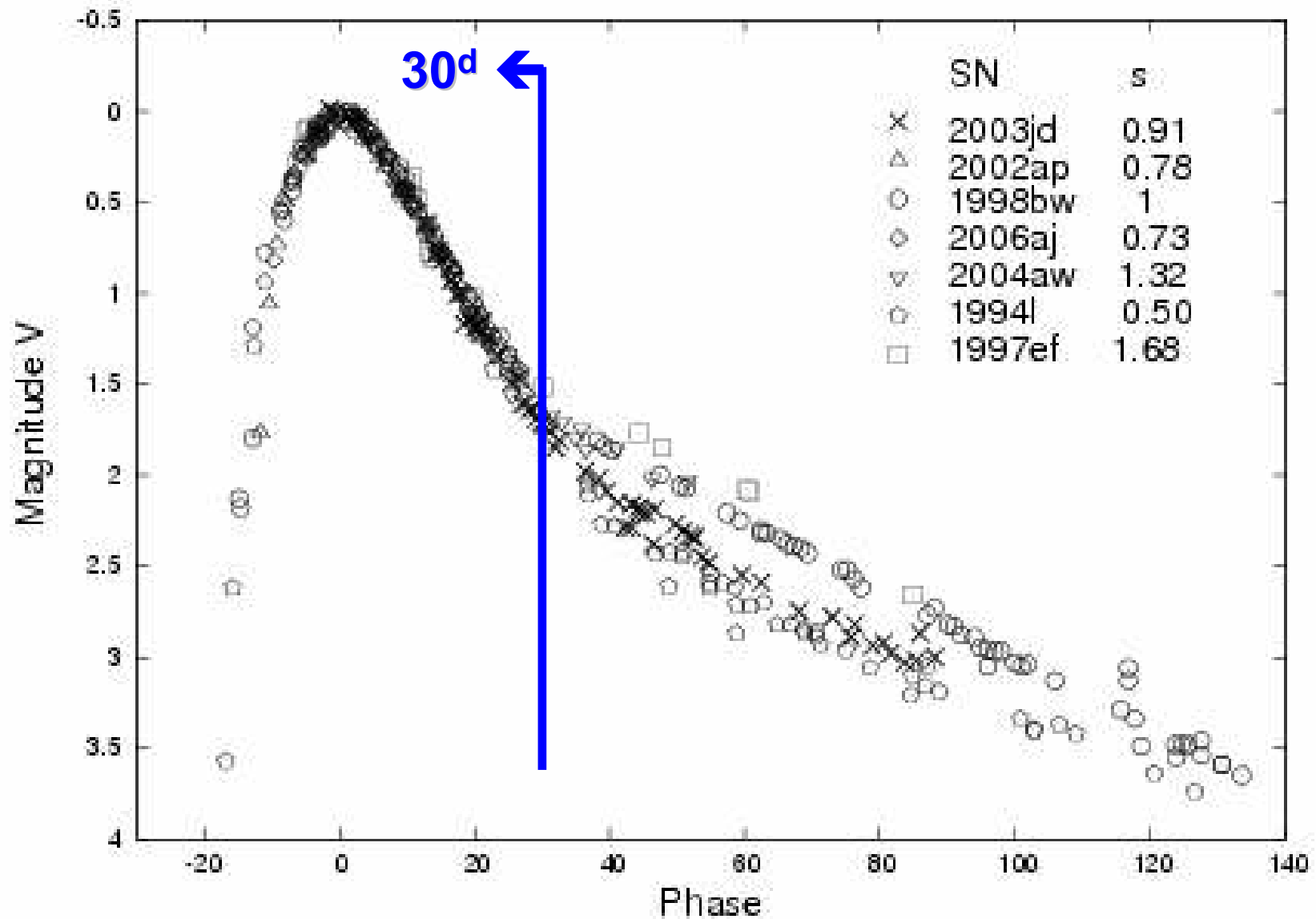


Valenti et al. 2006

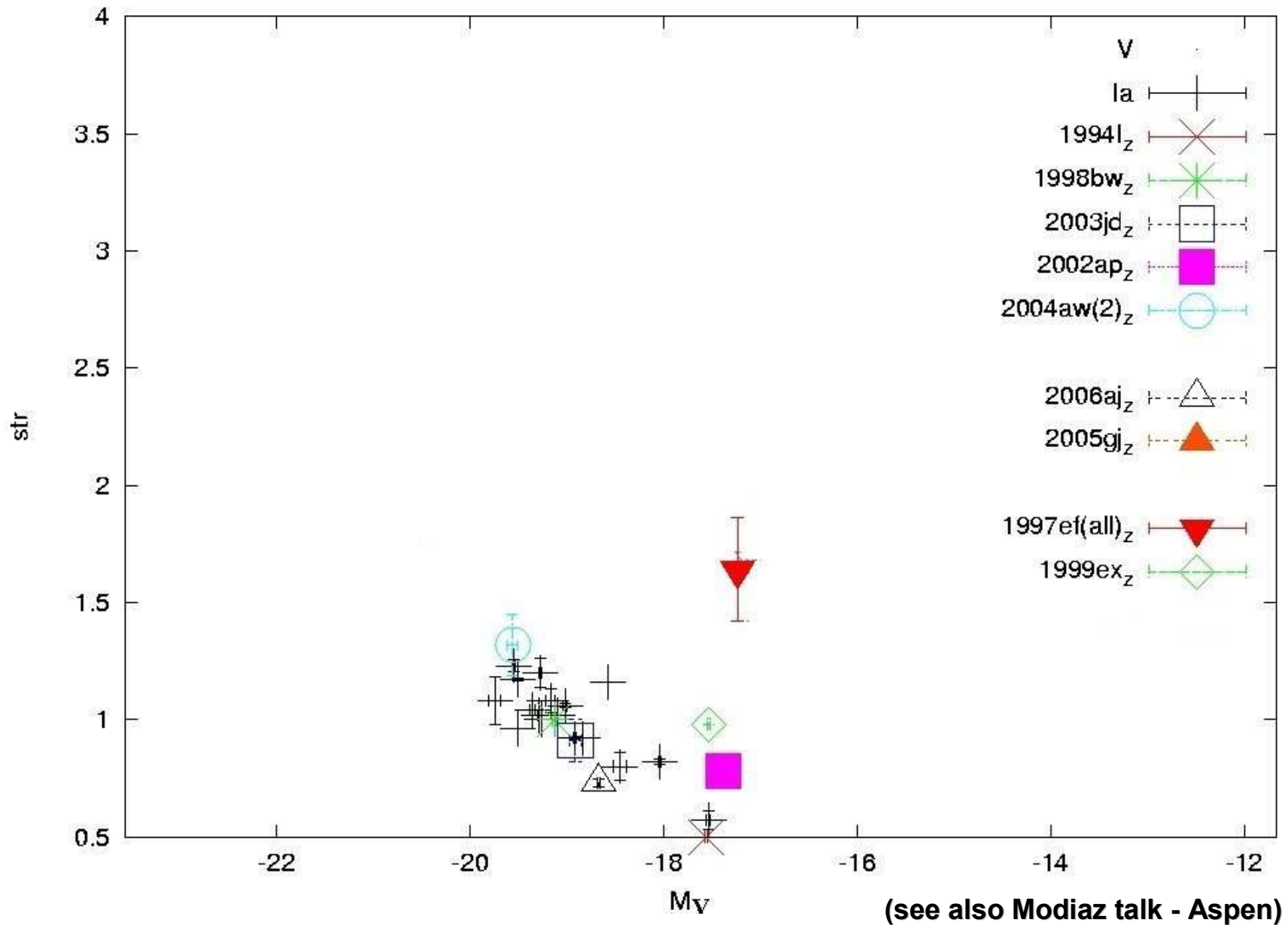
Better if time stretched!



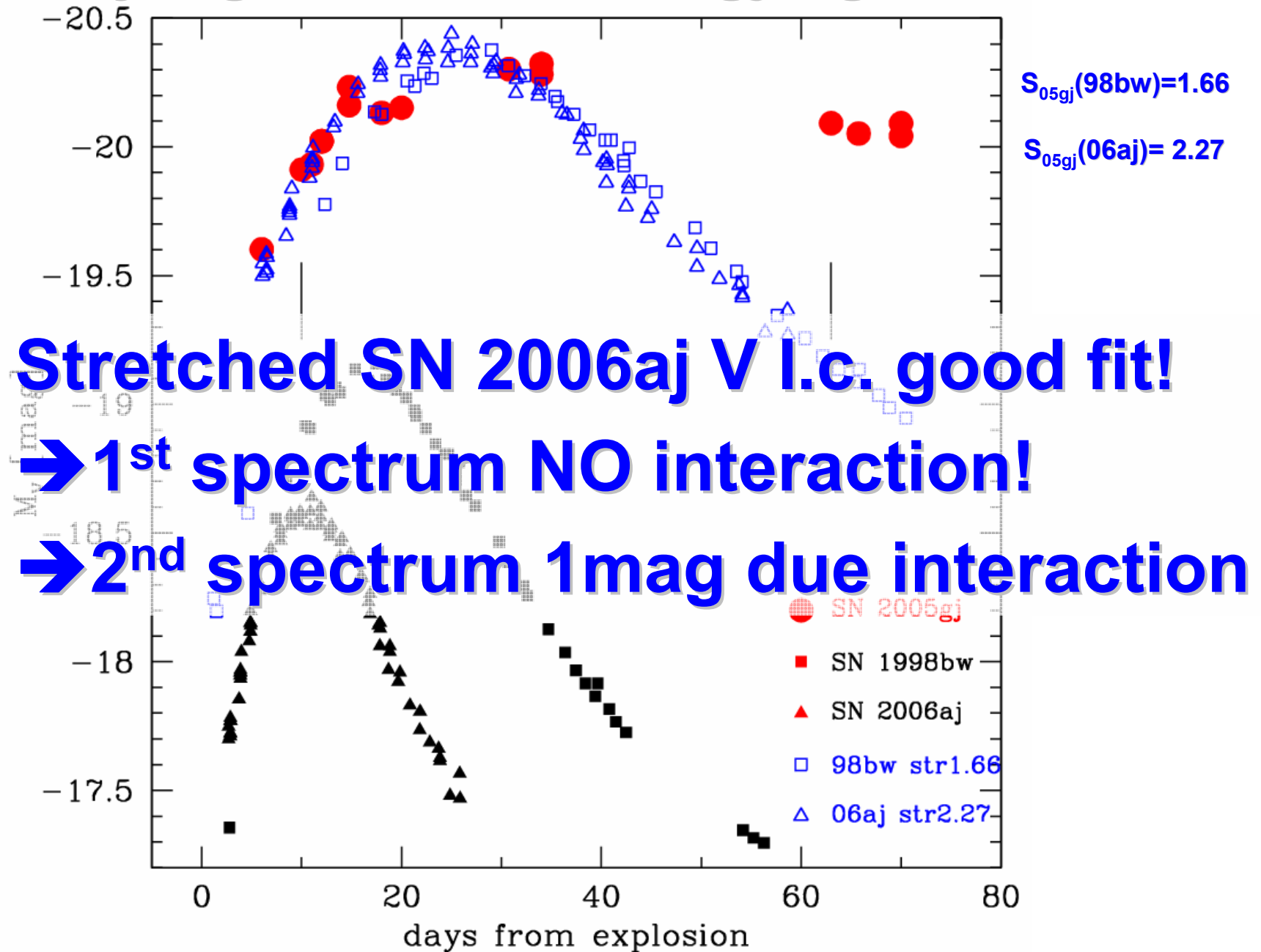
...what about photometry?

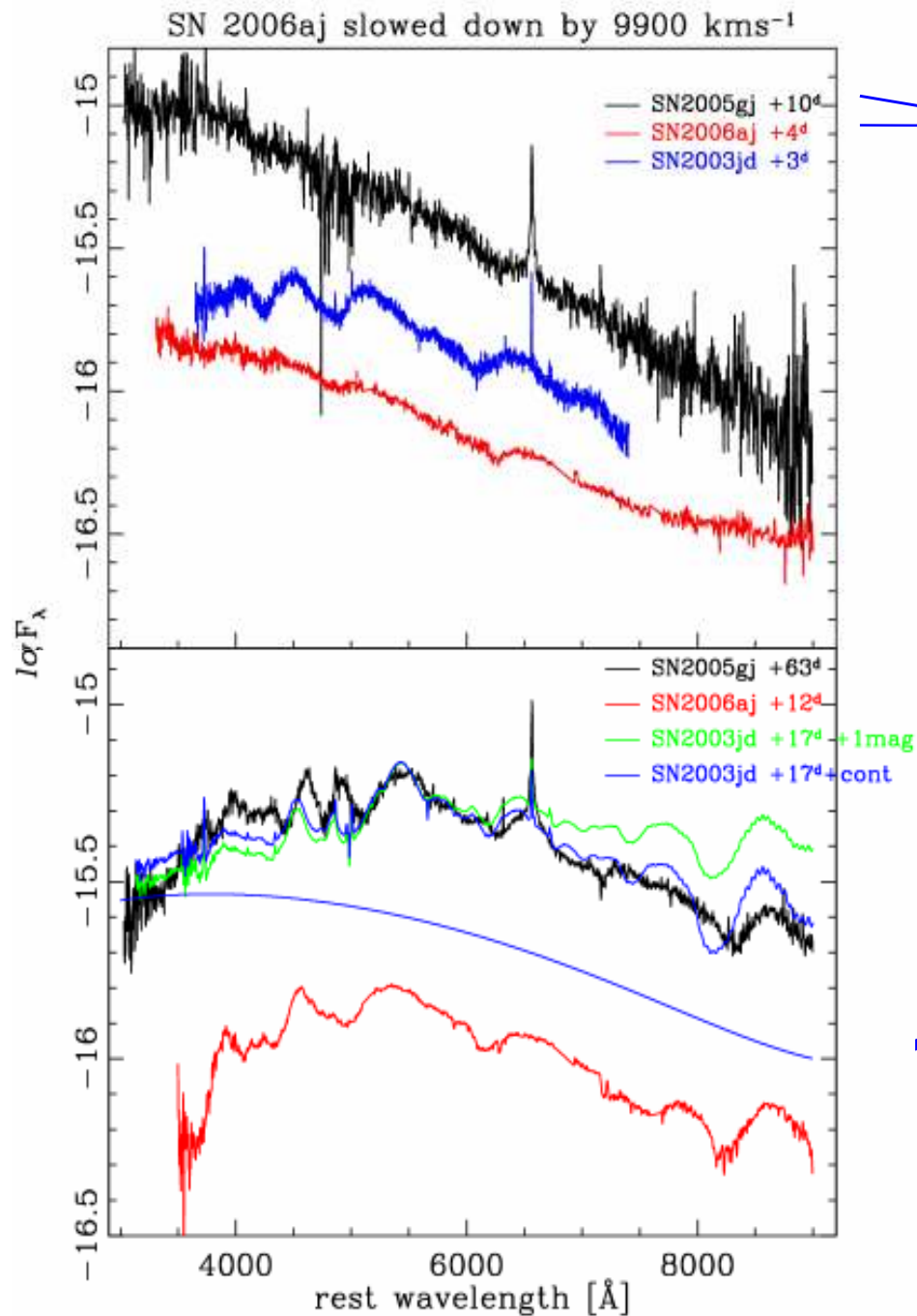


Does stretch correlates with L?



Playing with SN 2005gj light curve!





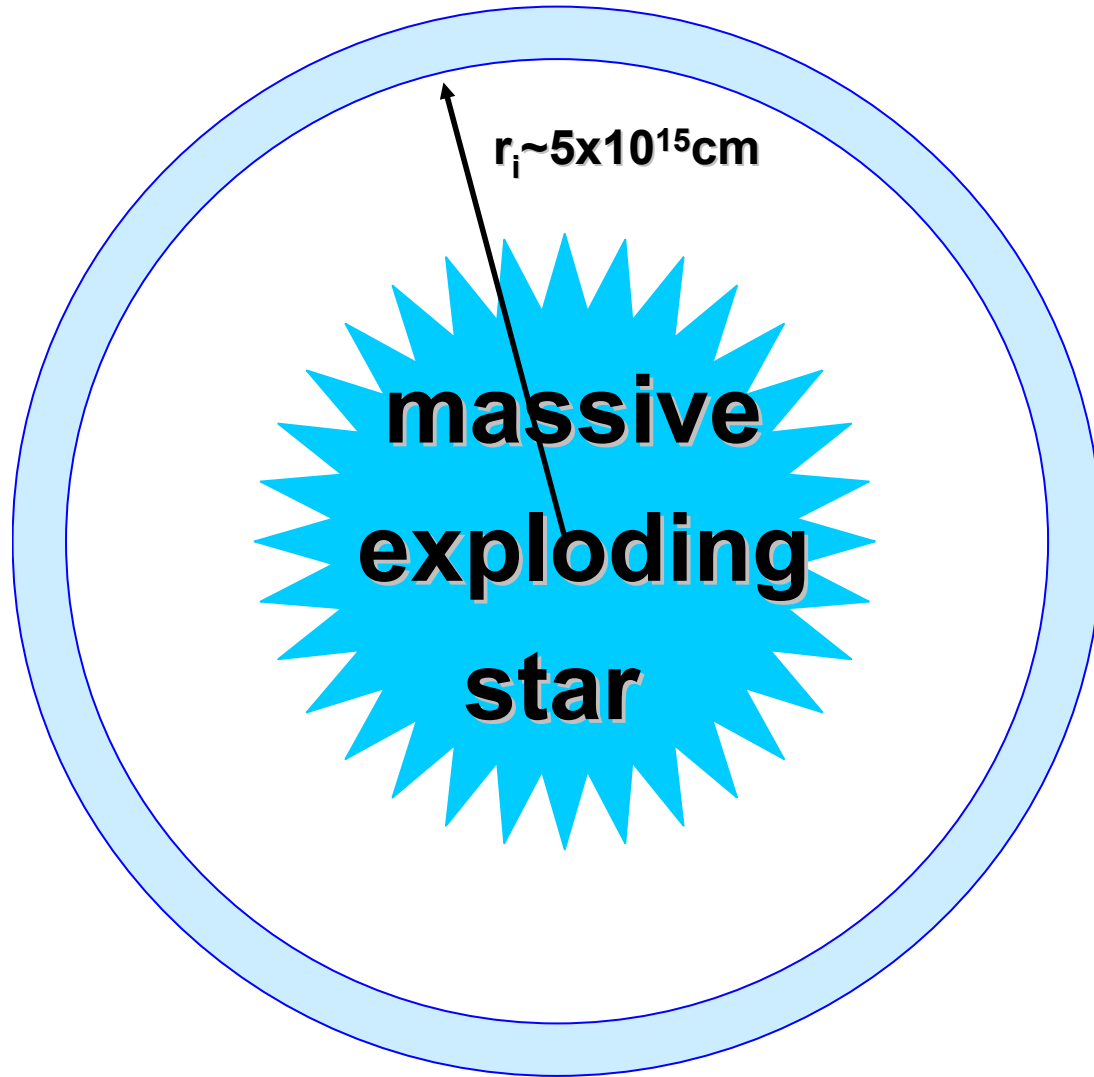
→ $s=2.5$ ($s_{ph}=2.27$)!

1st spectrum!
no interaction!

2nd spectrum!
1mag interaction

Possible progenitor configuration:

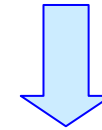
H shell lost $\sim 8\text{yr} < 05\text{gj}$



(if $u_w > 200 \text{km/s}$ &
 $v_{\text{max}}(05\text{gj}) \sim 16000 \text{km/s}$)

$M_{\text{shell}} < 20 M_{\odot}$

$M_{\text{dot}} \sim 0.01 - 0.03 M_{\odot} \text{yr}^{-1}$

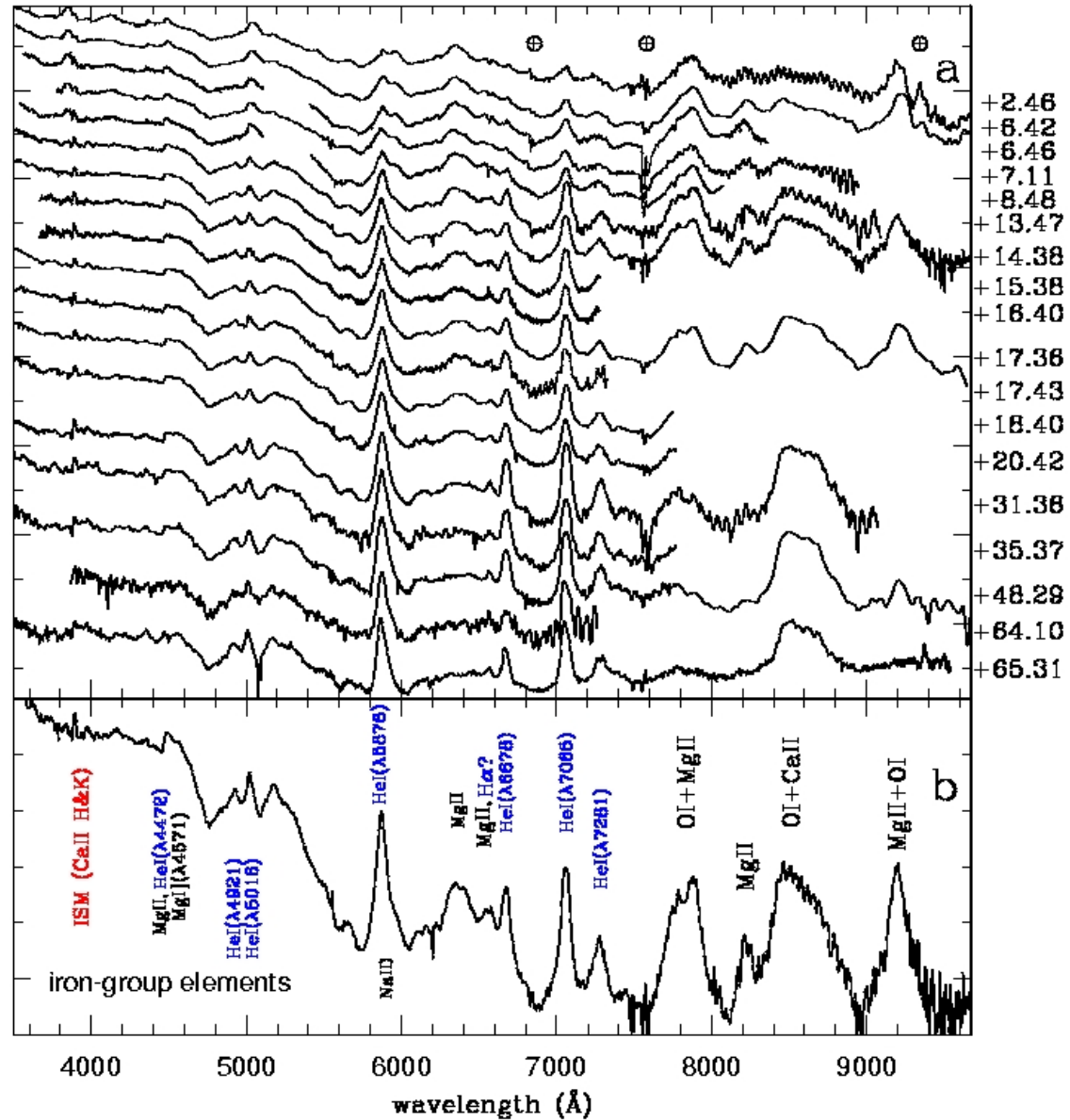
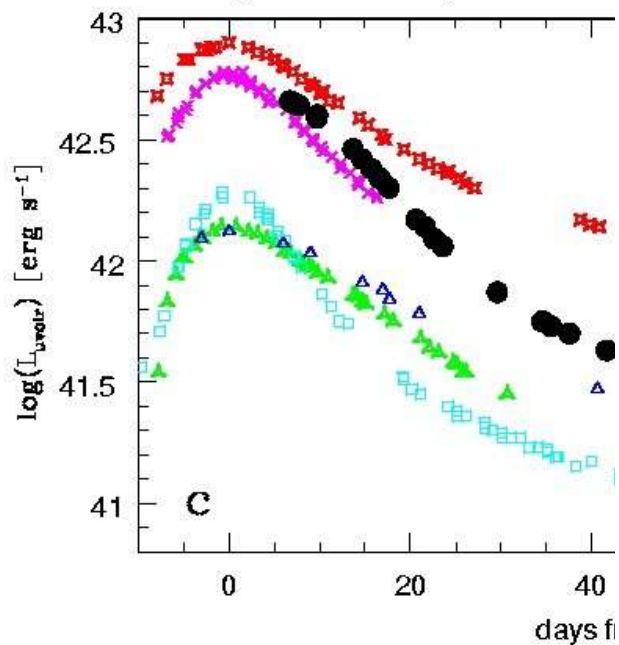
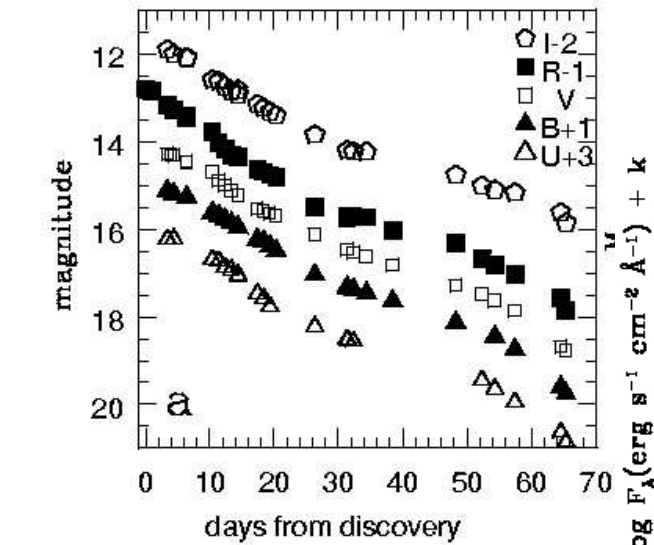


LBV-like outburst?

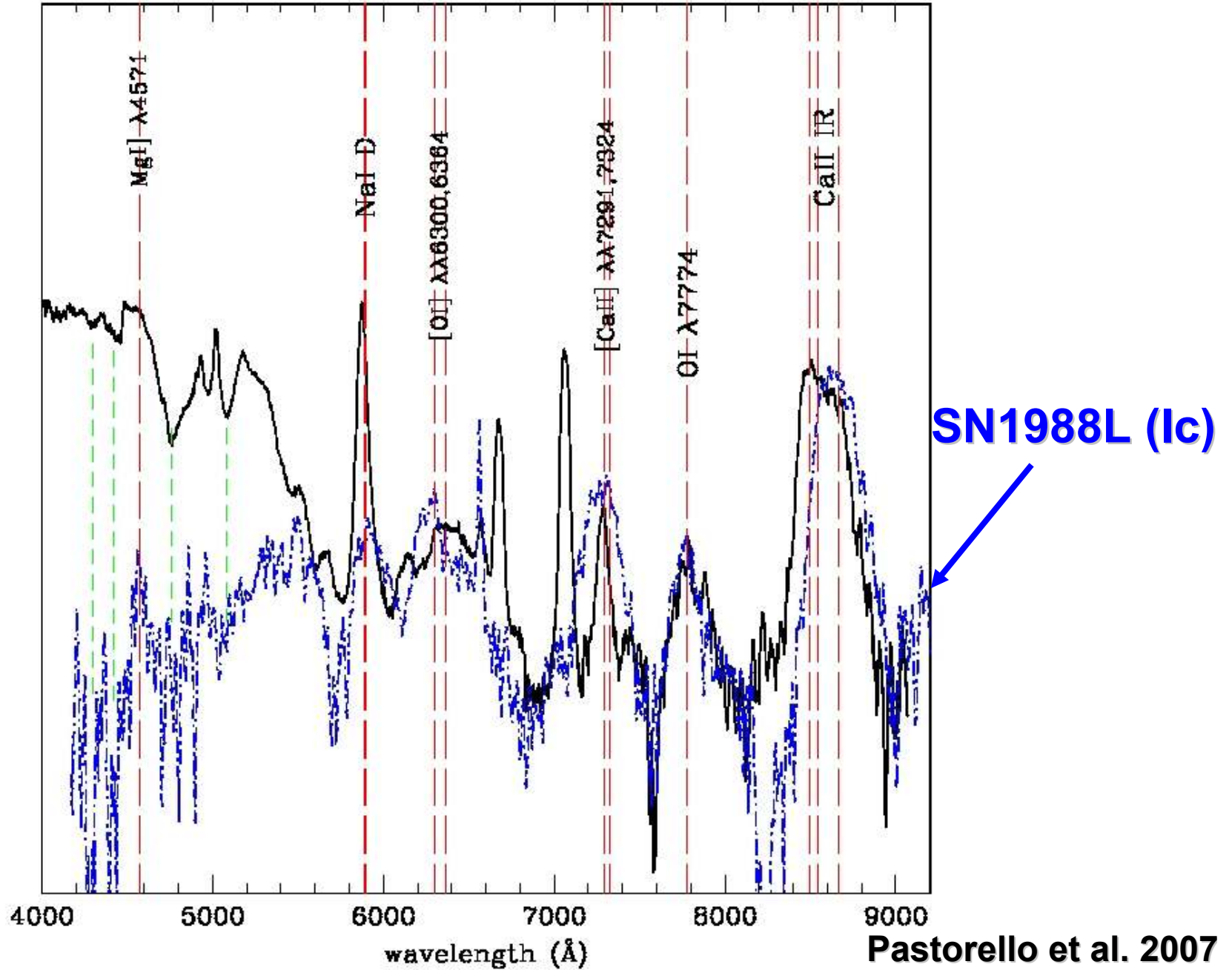
other SNe?!?

SN 2006jc! Pastorello et al. 2007, Nature in press

(see also Foley et al. 2007)

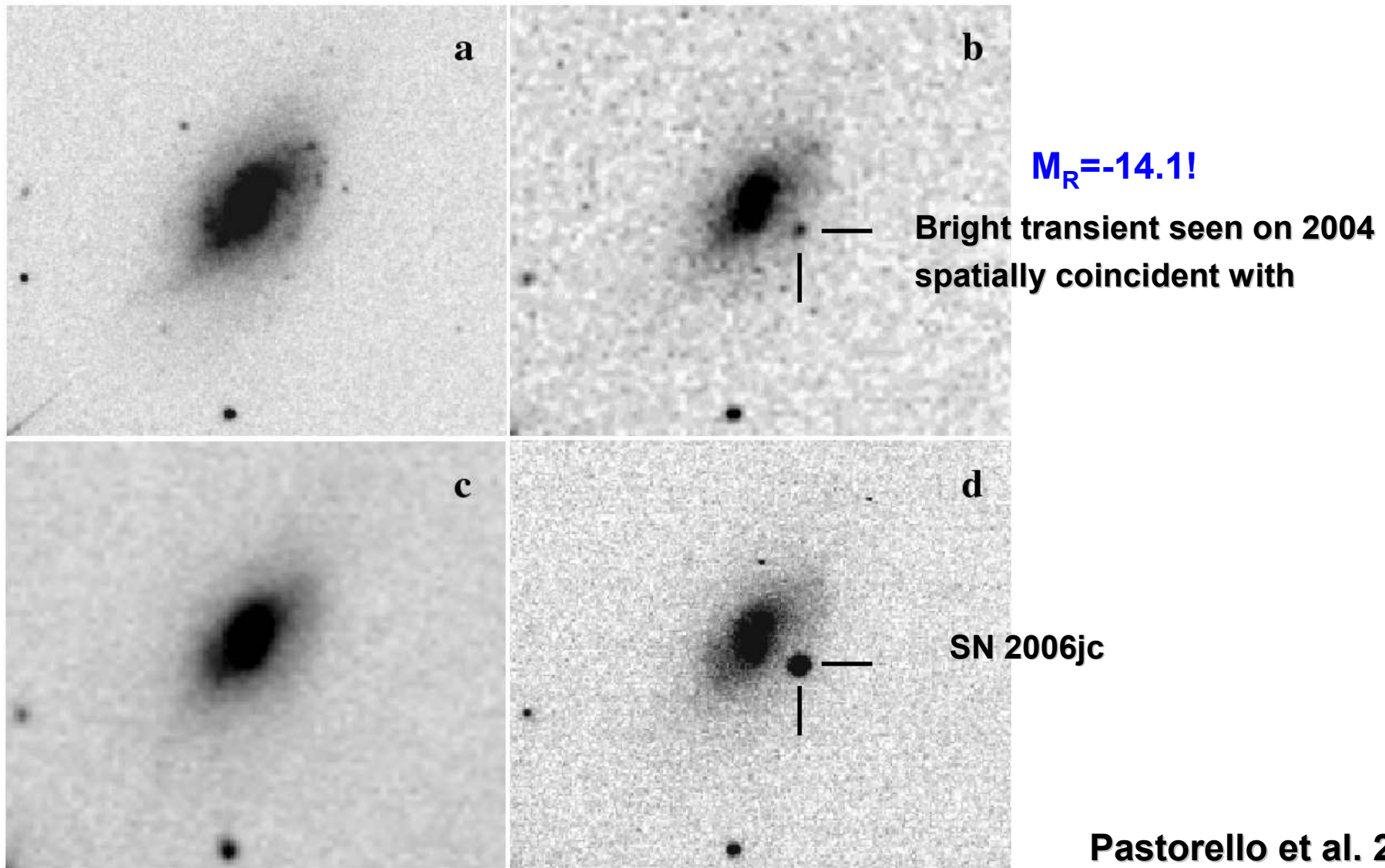


SN1c inside He-rich CSM



He-shell lost two years before expl.?

first time we see a burst in a SN progenitor!



Pastorello et al. 2007

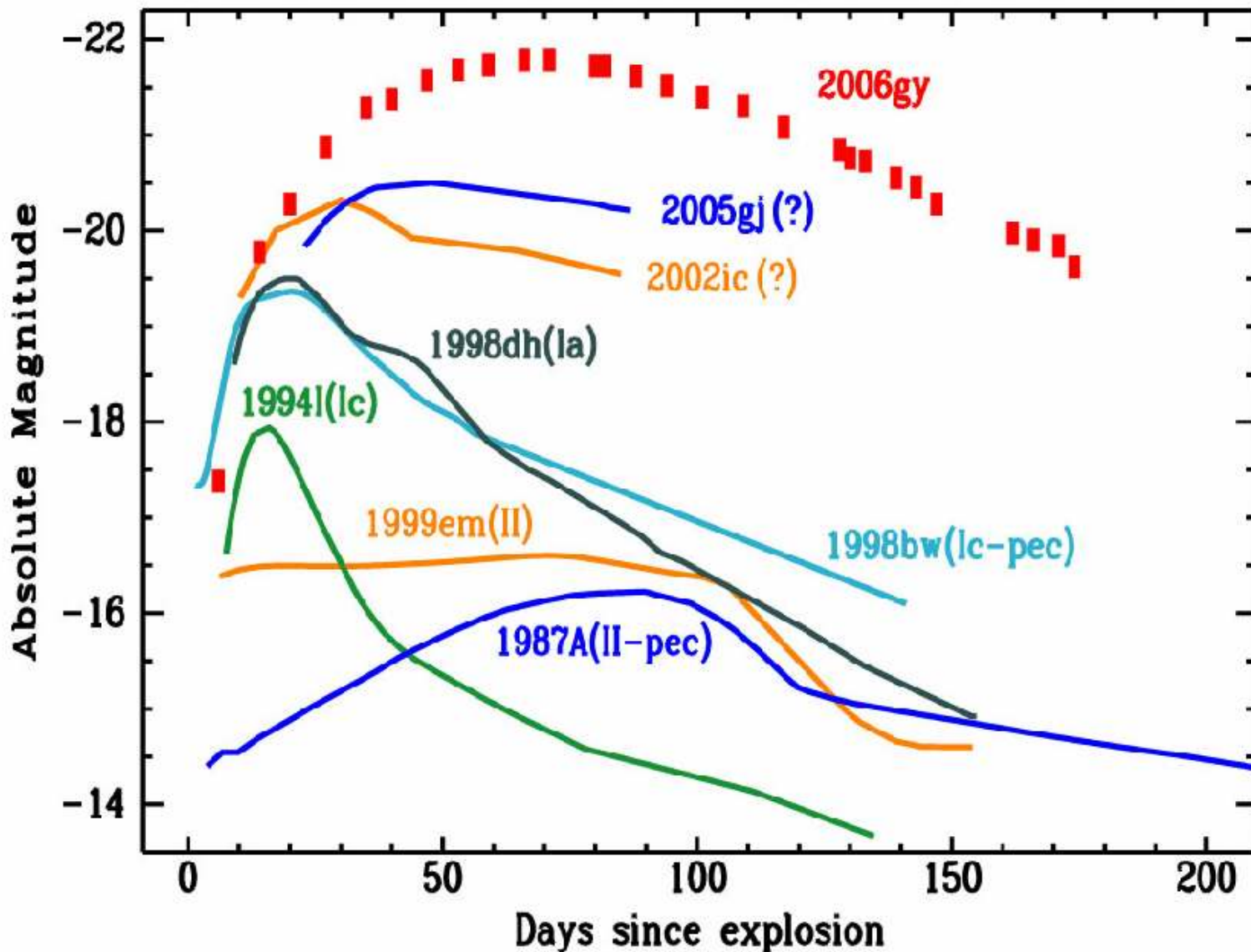
Possible scenarios for outbursts & Progenitors (including SNe2002ic-like):

Giant outbursts of LBV?: could be for outbursts, but LBV are not supposed to be precursors of SNe! Unless, new explosion mech: see Smith et al 2007 for SN 2006gy

LBV-like outbursts of WRs?: never seen before! & WRs are still losing H &/or He → young WRs (lifetime is ~200,000 yr not few years!)

Binary systems?: outbursts from LBV – SNe from evolved WRs

A joke(?) with SN 2006gy (il bestione) Ic:



Stretch_{98bw}(06gy) vs M_V(06gy) goes:

