

SN

UNVEILING TYPE IIb SN PROGENITORS: the case of the fast and faint SN2011hs.

SN Workshop at IPMU
12-14 Dec. 2012

Filomena (Milena) Bufano --

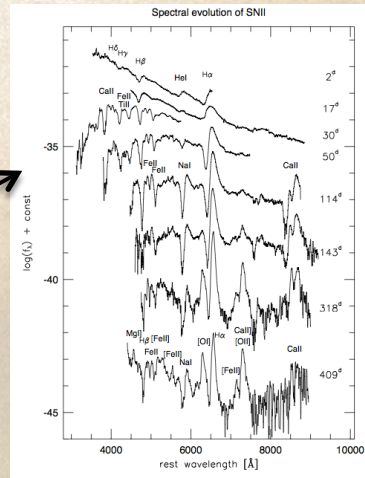
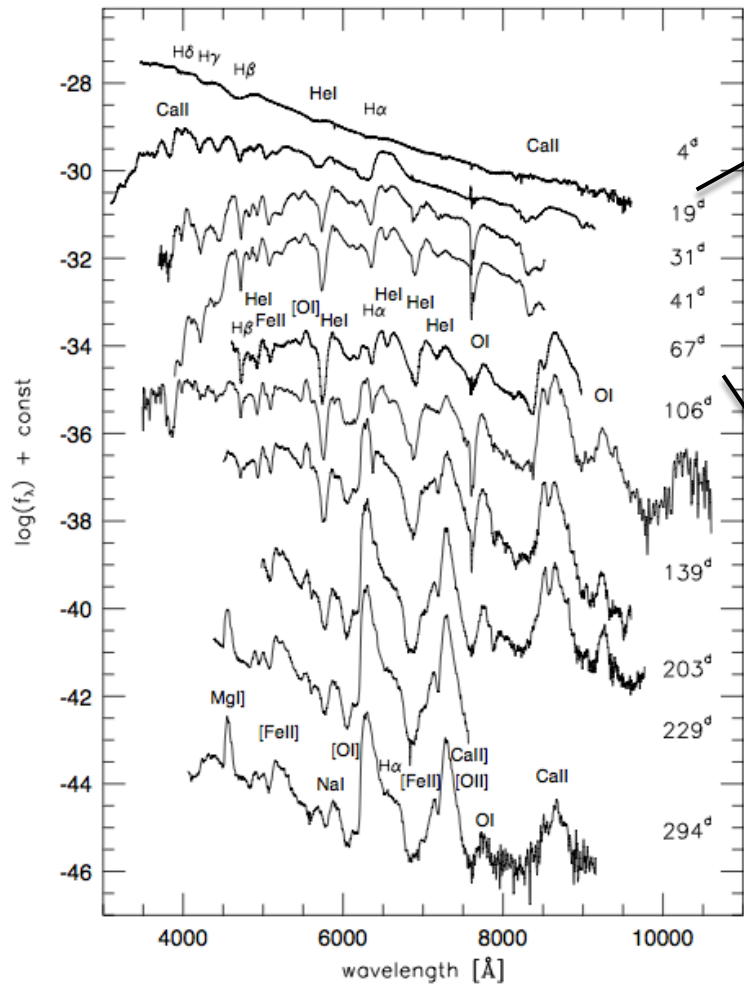
Universidad Andrés Bello



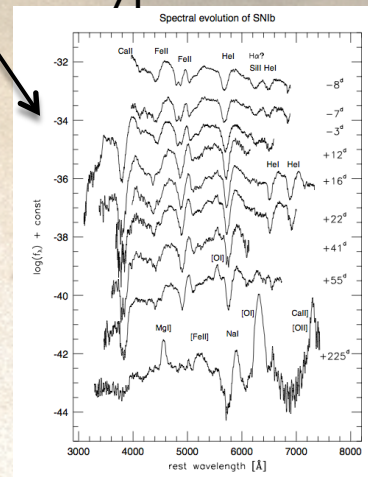
What's a Type IIb SN ?

Type II SN

Spectral evolution of SN 1993J

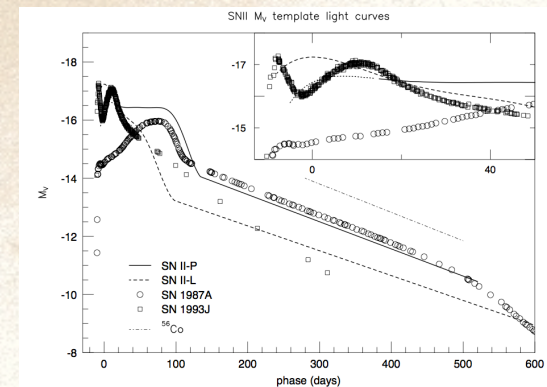
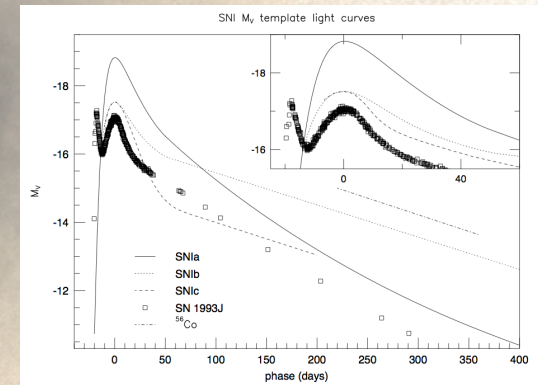


Type Ib SN

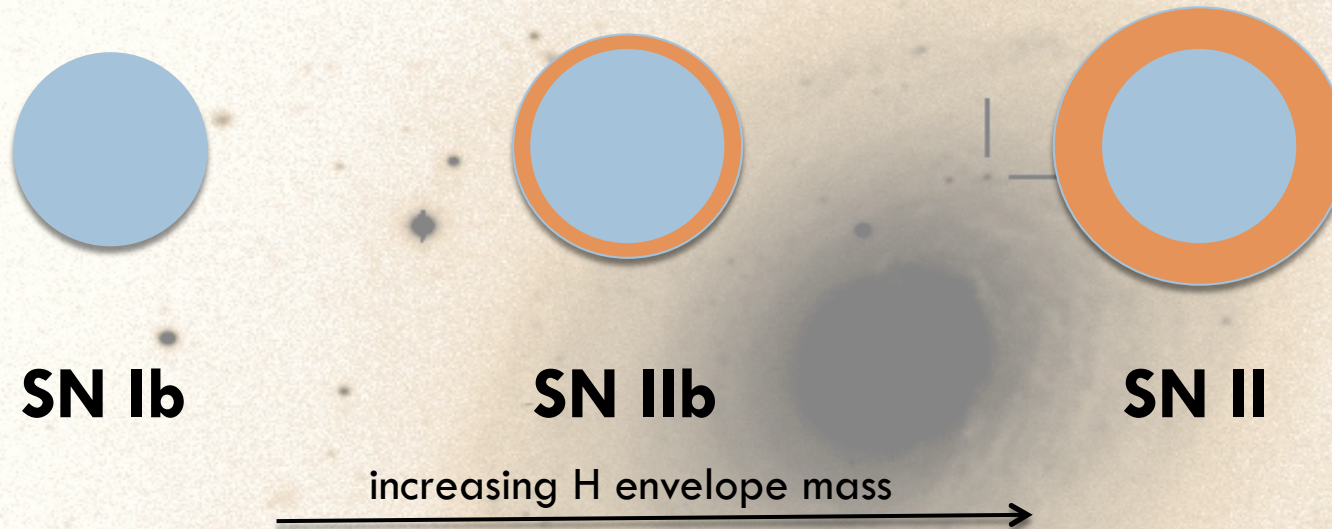


SN 1993J- the prototype

SN



What's a Type IIb SN progenitor?



Their progenitor kept only a thin hydrogen layer ($\sim 0.01 M_{\odot}$, Nomoto 1993, *Nature* **364**, 507) at the time of the explosion, but the mechanism is still under debate.

MASS LOSS
MECHANISM :

stellar winds in a massive SINGLE star ($M \geq 30M_{\odot}$, $M_{\text{He core}} \geq 8M_{\odot}$)

mass transfer in a close BINARY SYSTEM ($M_{\text{He core}} \geq 3-6M_{\odot}$)

What's a Type IIb SN progenitor?

PROGENITOR ? :

EXTENDED star like a RSG/YSG

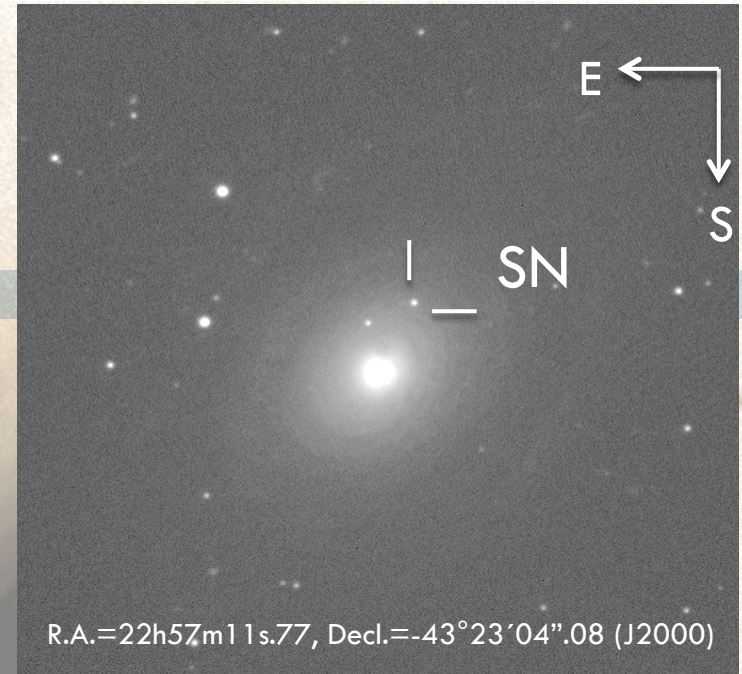
SN 1993J progenitor star detected in pre-explosion images (Maund+, 04)

SN 2011dh, pre-imaging and modelling compatible to a Yellow SG star
(Maund+, 11; Bersten+,12)

COMPACT star like a Wolf Rayet star (similar to SNe Ic)

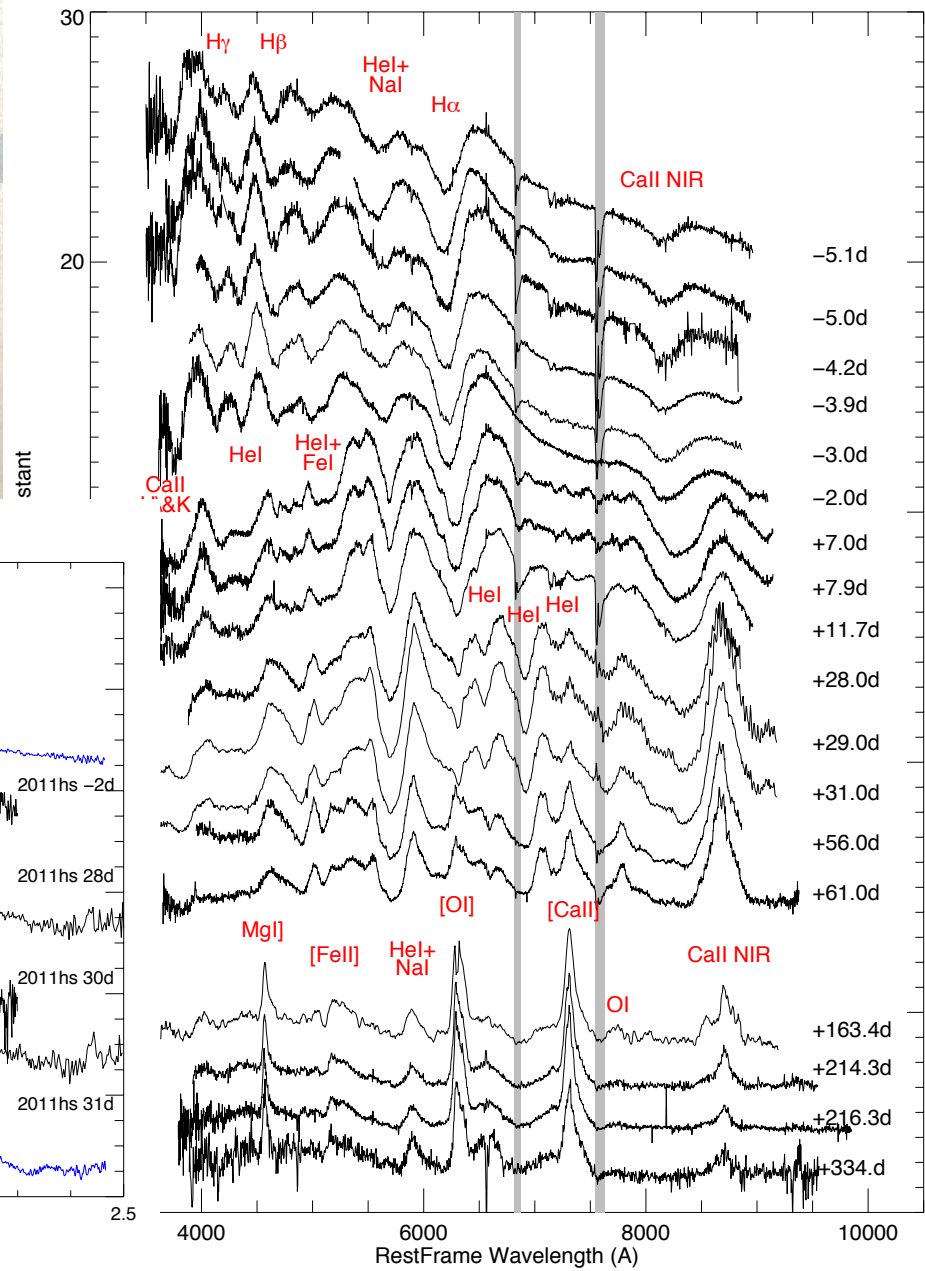
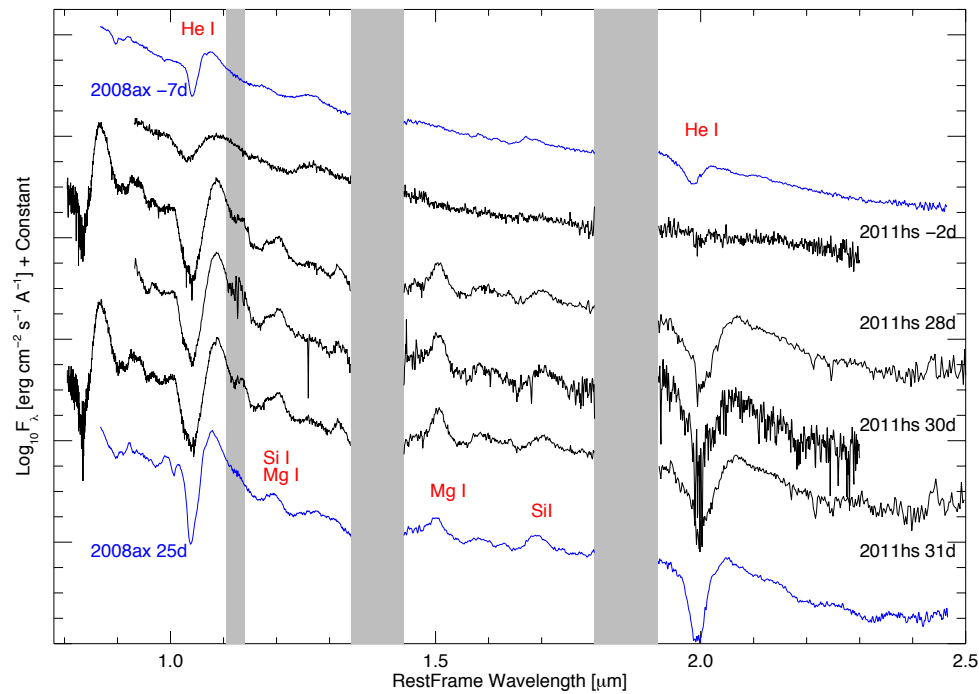
Obtain information about the progenitor and the geometry of the explosion through the direct detection in pre-explosion images, the nebular spectral lines and the light curve fitting..

SN 2011hs:

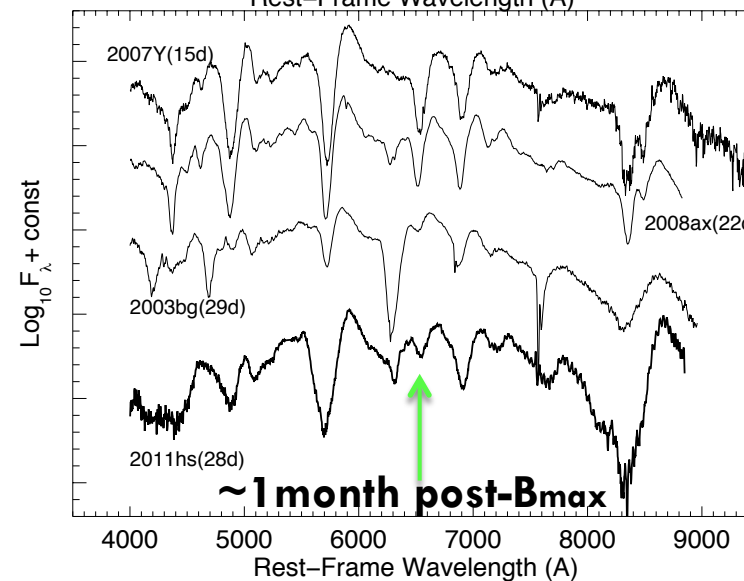
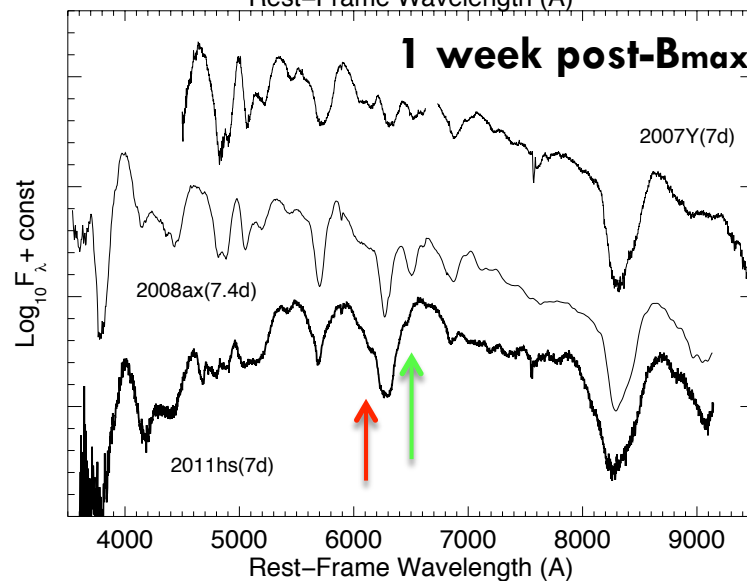
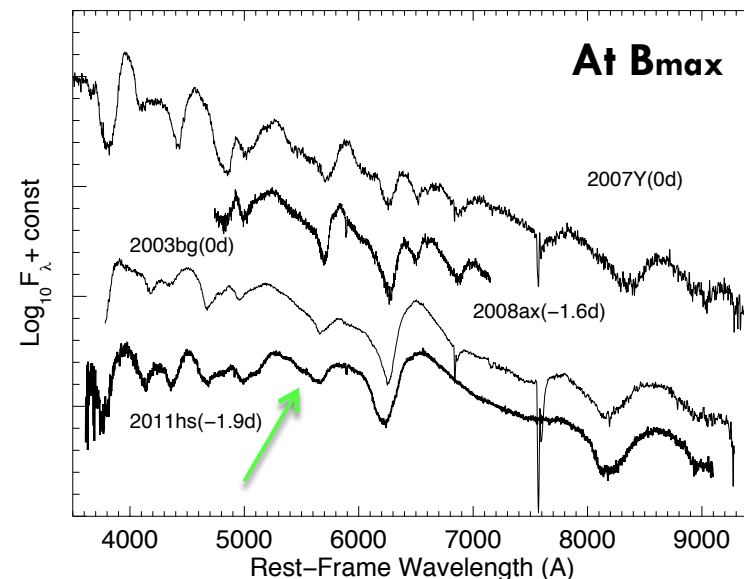
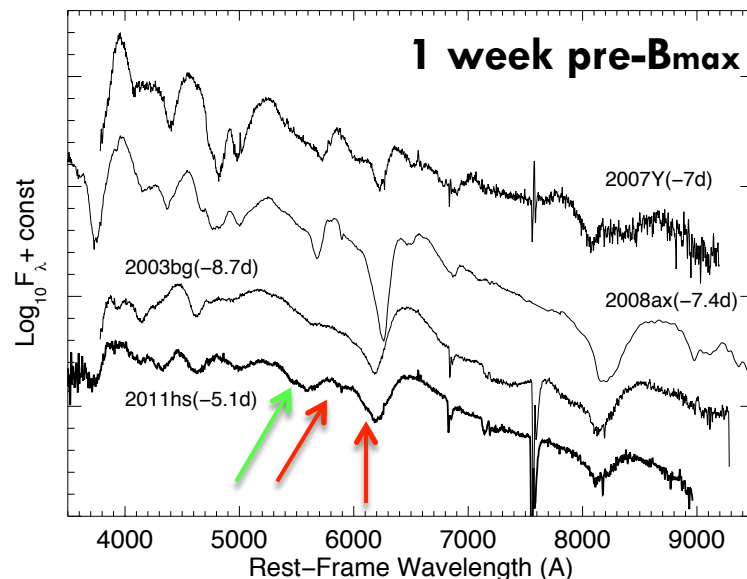


- Discovered at **very early phase**
(on Nov. 12.5 UT; Milisavljevic et al. 2011, CBET 2902)
- Nearby SN: $z=0.0064 \pm 0.0001$ (from host galaxy H_α emission line)
 $\rightarrow \mu = 32.11 \pm 0.03$ mag ($H_0=73$ km s $^{-1}$ Mpc $^{-1}$, $\Omega_\Lambda=0.73$ and $\Omega_M=0.27$)
- $E(B-V)_{\text{Milky Way}} = 0.013$ mag (Schlegel et al. 1998, ApJ, 500, 525)
- $E(B-V)_{\text{Host}} = 0.158 \pm 0.011$ mag (using EW(NaID) relation from Turatto et al, 2003)
- **Very high line velocities**, resembles the fast expanding SN IIb, SN2003bg
(Hamuy+09; Mazzali+09)
- No significant X-ray emission is detected at the SN position (Atel 3678, Margutti+, 11).
- RADIO observations available, modulation of light curves?

Spectral Evolution



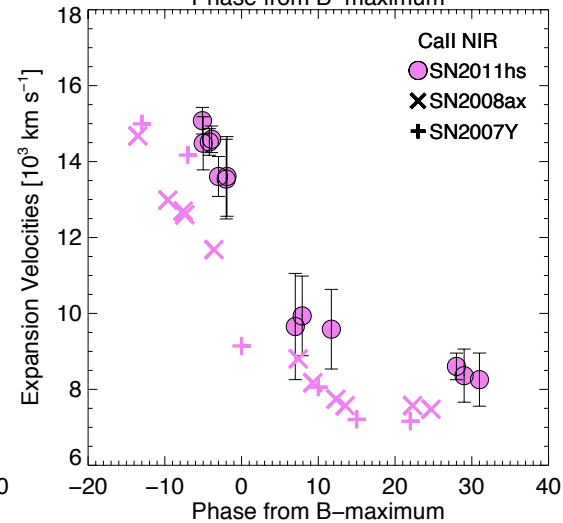
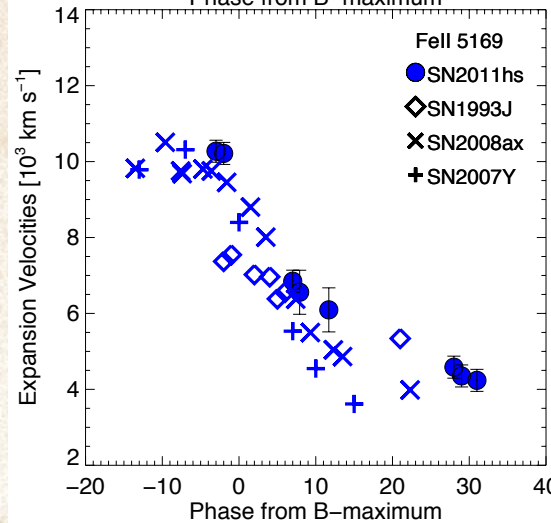
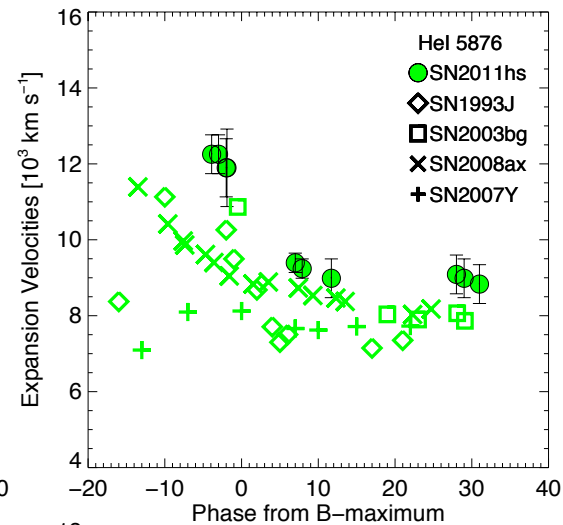
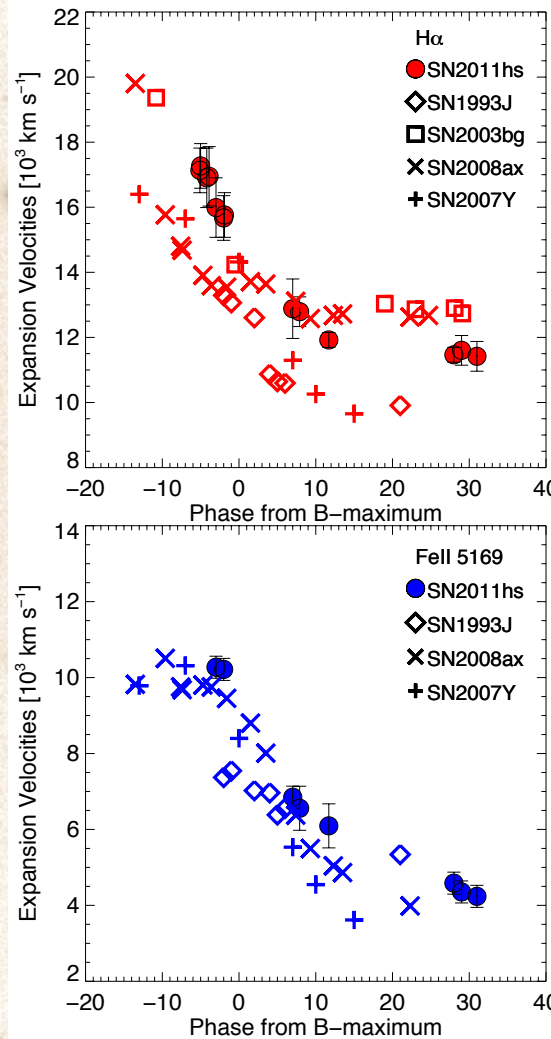
Spectral Comparison



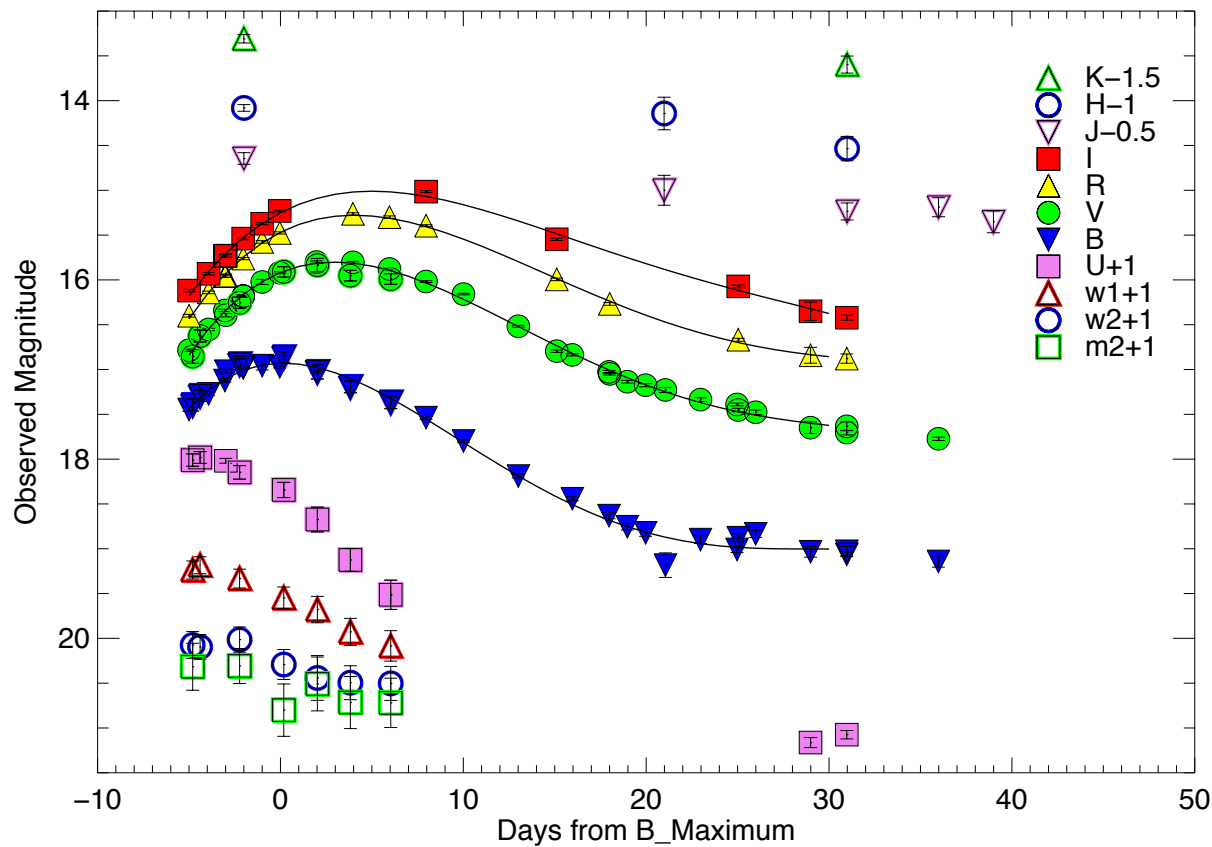
Expansion Velocities

minimum position measurements

High E_k/M_{ej}



Light Curves



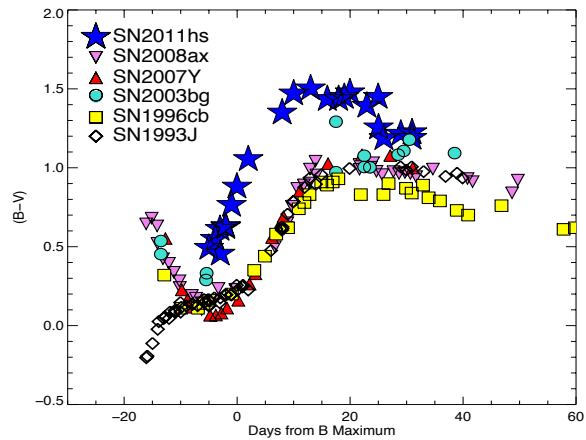
SN

	JD	m	M(?)
B _{max}	55885.5	16.93	-15.85
V _{max}	55888.5	15.80	-16.81
R _{max}	55889.5	15.28	-17.24
I _{max}	55890.5	15.01	-17.39

(low order polynomial fit)

Bluer band light curves peak very early and much fainter.. reddening problem?

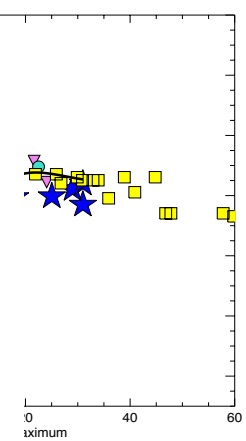
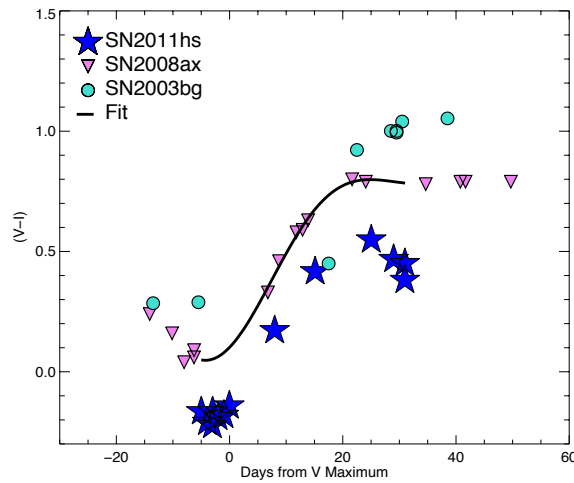
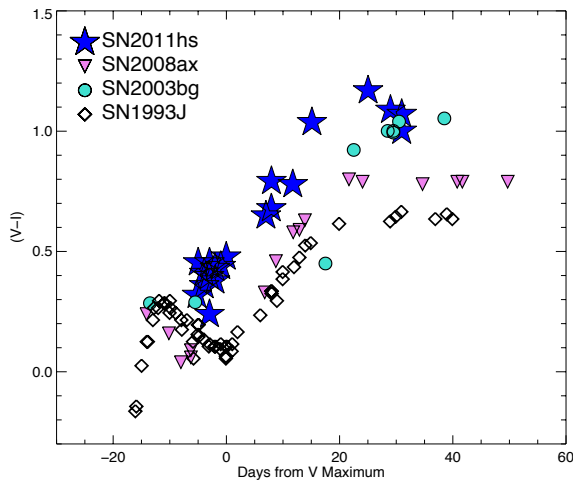
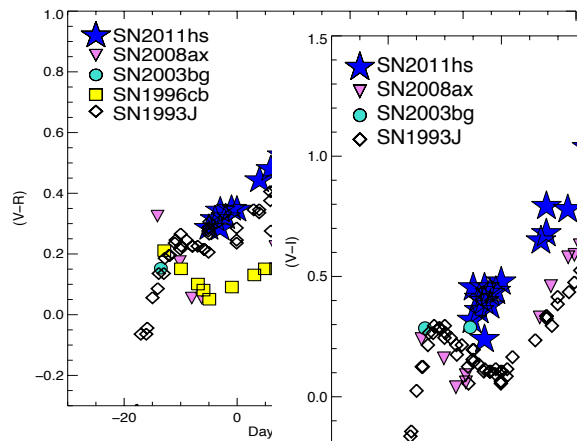
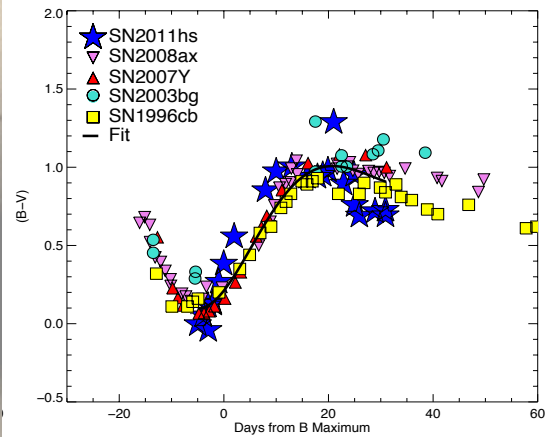
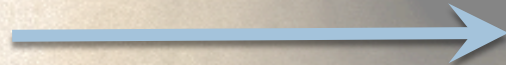
Color Curves



Color Excess

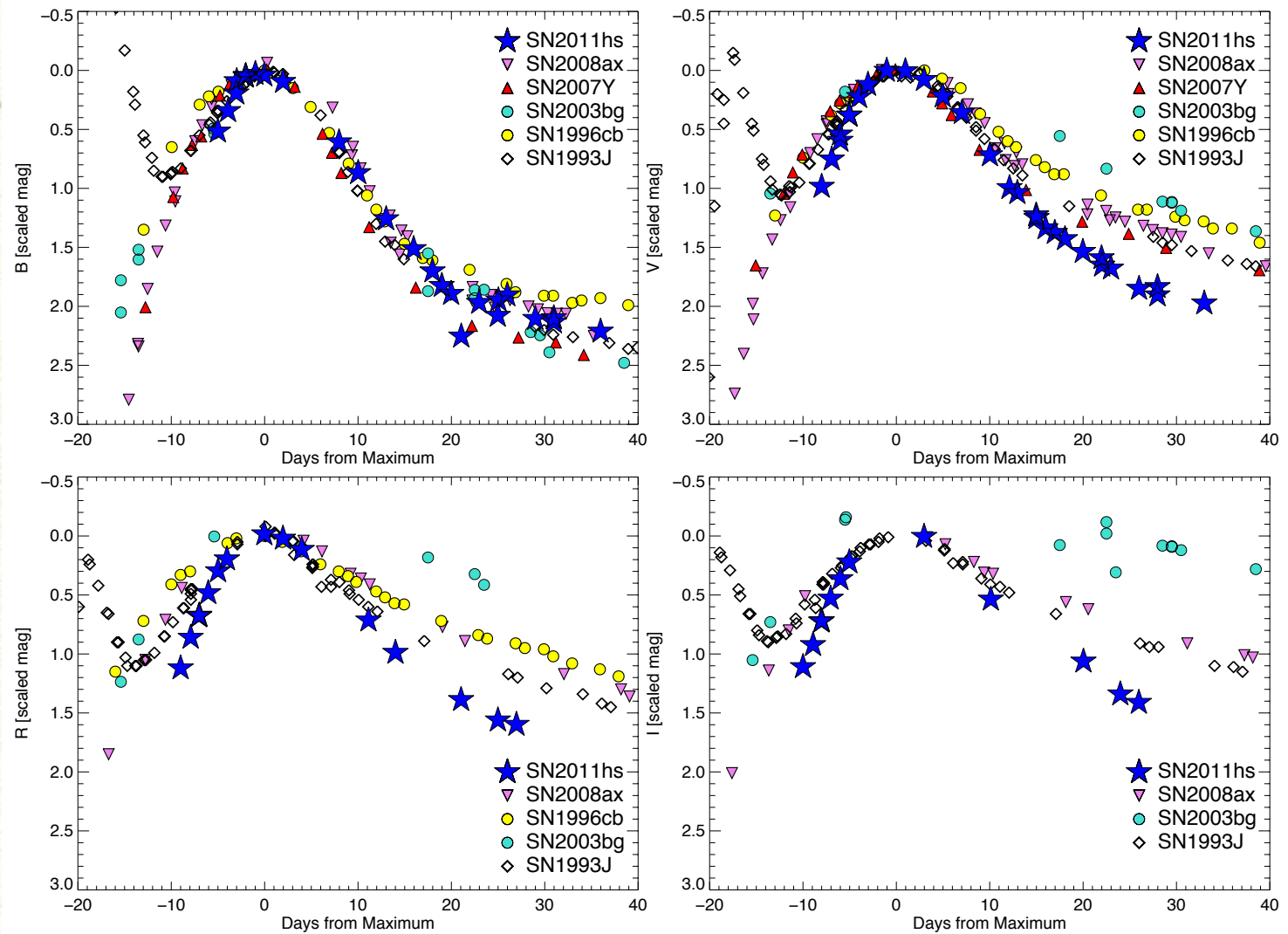


new A_v



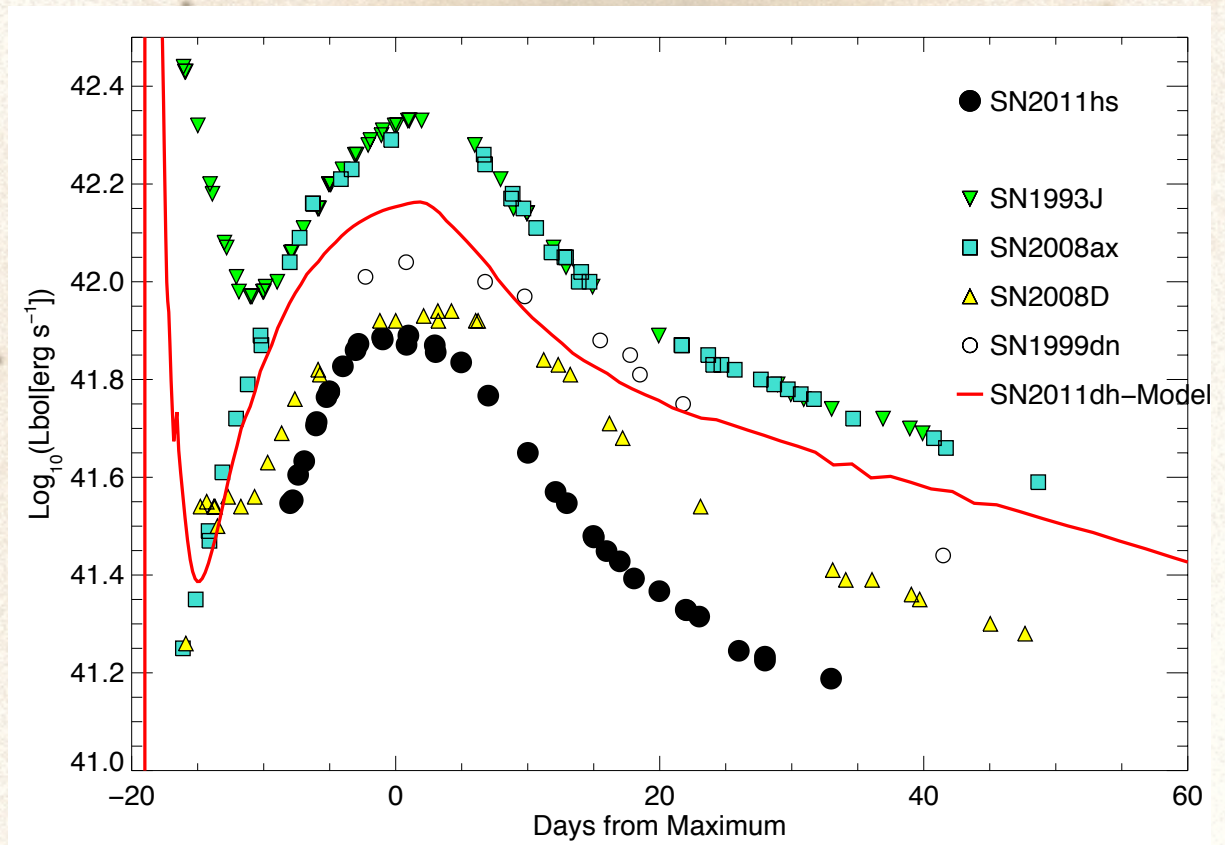
Too high correction: intrinsic difference or different dust properties (different R_v)?

Light Curve Comparison



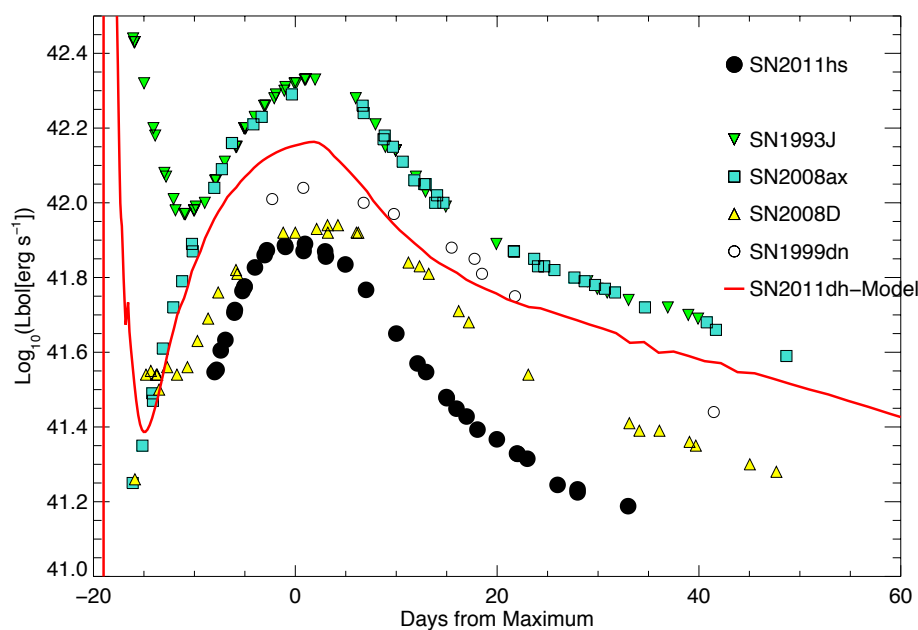
Pseudo-Bolometric Light Curve

narrow and faint!



$$M_{56\text{Ni}, 11\text{hs}} \sim M_{56\text{Ni}, 08\text{D}} \leq 0.09 M_{\odot}$$

Explosion parameters



Arnett's relations

$$\tau_{peak} \propto M_{ej}^{+3/4} E_k^{-1/4}$$

$$v_{ph} \propto M_{ej}^{-1/2} E_k^{+1/2}$$

**Pseudo-bolometric light curve shape
+ expansion velocity of FeII @ maximum
and compared with previous SE-SNe**

Mejecta ~ 1-1.3 Msun Ek ~ 0.8-1.8 foe

**Melina's modelling
needed !**

Table 5. Properties of various SE-SNe.

SN	Type	$M_{B,max}$	μ^a (mag)	$E(B-V)_{tot}$ (mag)	^{56}Ni mass (M_{\odot})	Ejecta mass (M_{\odot})	E_{kin} (10^{51} erg)	Reference
2008ax	IIb	-17.32 ± 0.50	29.92 ± 0.29	0.4 ± 0.1	0.07–0.15	2–5	1–6	This work
		-17.32 ± 0.50	29.92 ± 0.29	0.4 ± 0.1	0.07–0.15	1.9–4.0	0.7–2.1	Maurer et al. (2010a)
		-16.87	29.92 ± 0.29	0.3	0.06	2.9	0.5	Roming et al. (2009)
		-17.06	29.92 ± 0.29	0.3	0.11	2.3	1.5	Tsvetkov et al. (2009)
2008D	Ib	-16.30	32.16	0.6 ± 0.2	0.05–0.10	3–5	2–4	Soderberg et al. (2008)
			32.45	0.65	0.09	7	6	Mazzali et al. (2008)
			29.84 ± 0.16	0.09 ± 0.02	0.06–0.10	2.0–3.5	1–4	Hunter et al. (2009)
2007gr	Ic	-16.75	29.84 ± 0.16	0.09 ± 0.02	0.06–0.10	2.0–3.5	1–4	Hunter et al. (2009)
2007Y	Ib/IIb	-16.20	31.43 ± 0.55	0.11	0.06	1–2	0.5–2.0	Stritzinger et al. (2009)
1999ex	Ib/c	-17.42	33.54 ± 0.23	0.30 ± 0.04	0.16	5–6	2.7	Stritzinger et al. (2002)
1993J	IIb	-17.23	27.80 ± 0.08	0.2	0.10–0.14	1.9–3.5	1.0–1.4	Young et al. (1995)
			27.80 ± 0.08	0.2	0.10	1.3	0.7	Richardson et al. (2006)

Further Observed SNe IIb

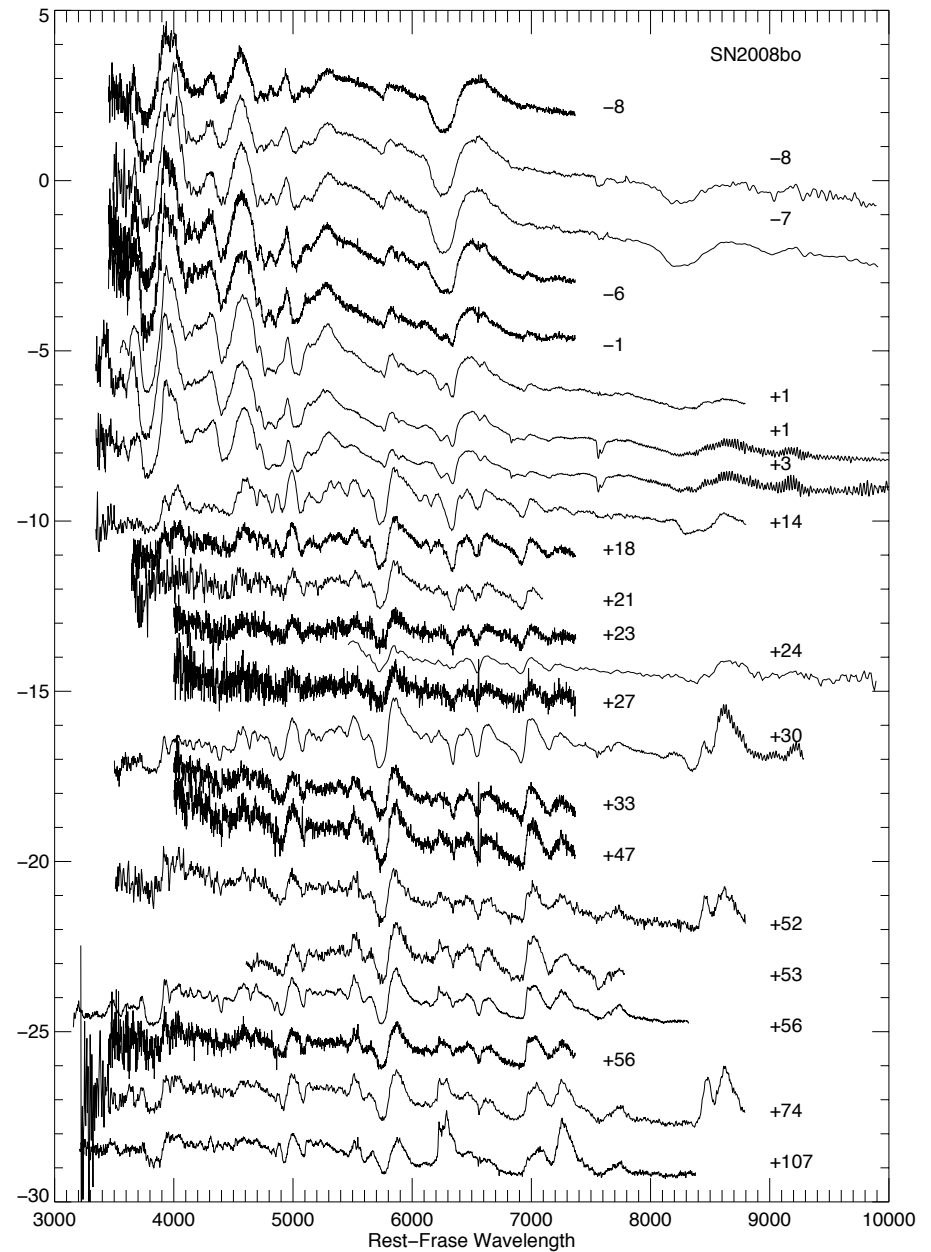
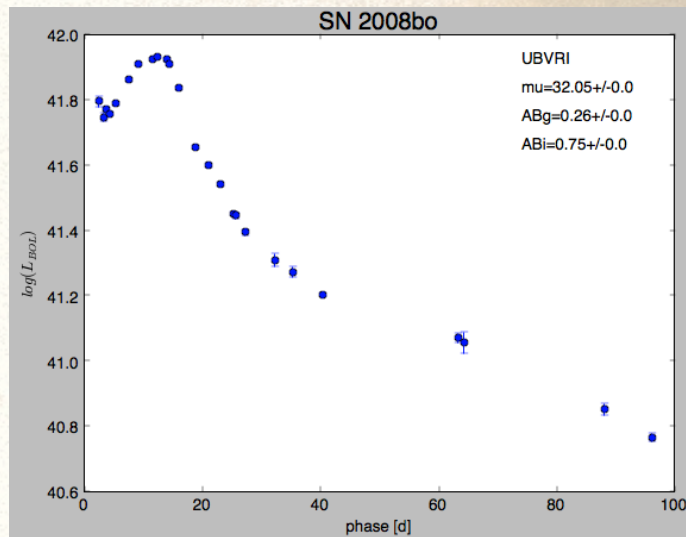
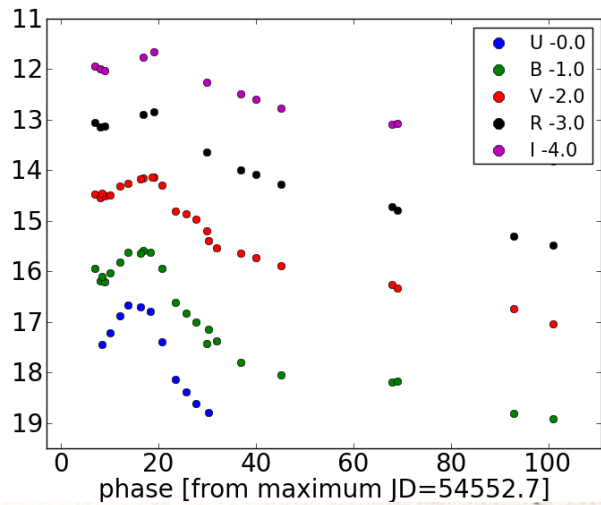
we have a sample of well observed SNe IIb
waiting for being modeled ...



SN

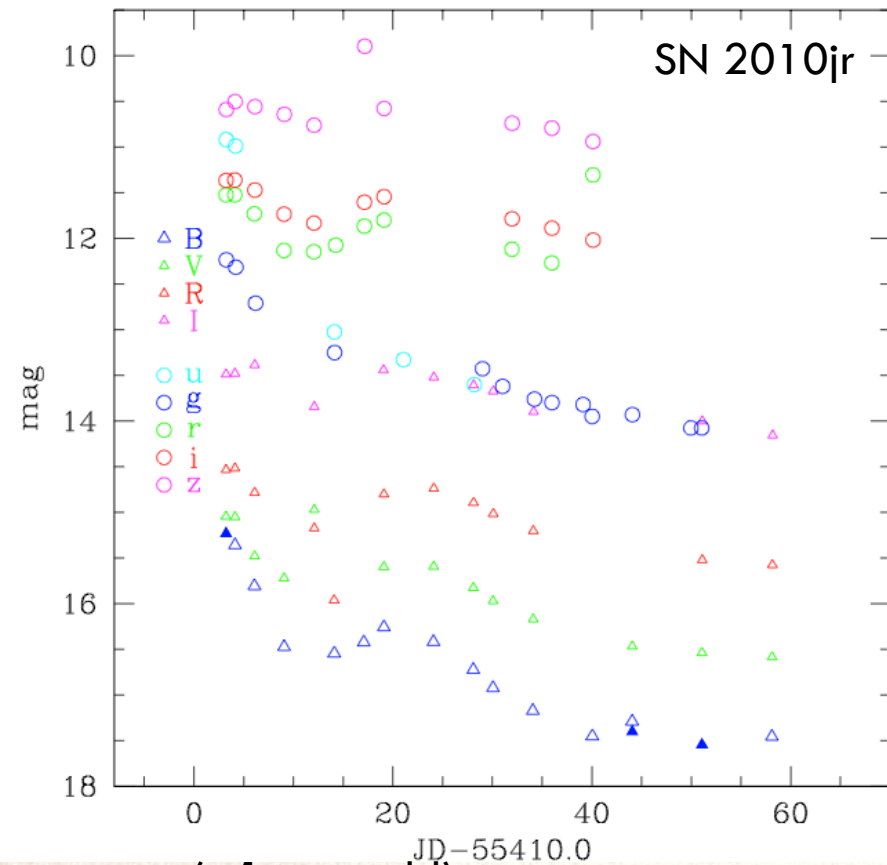
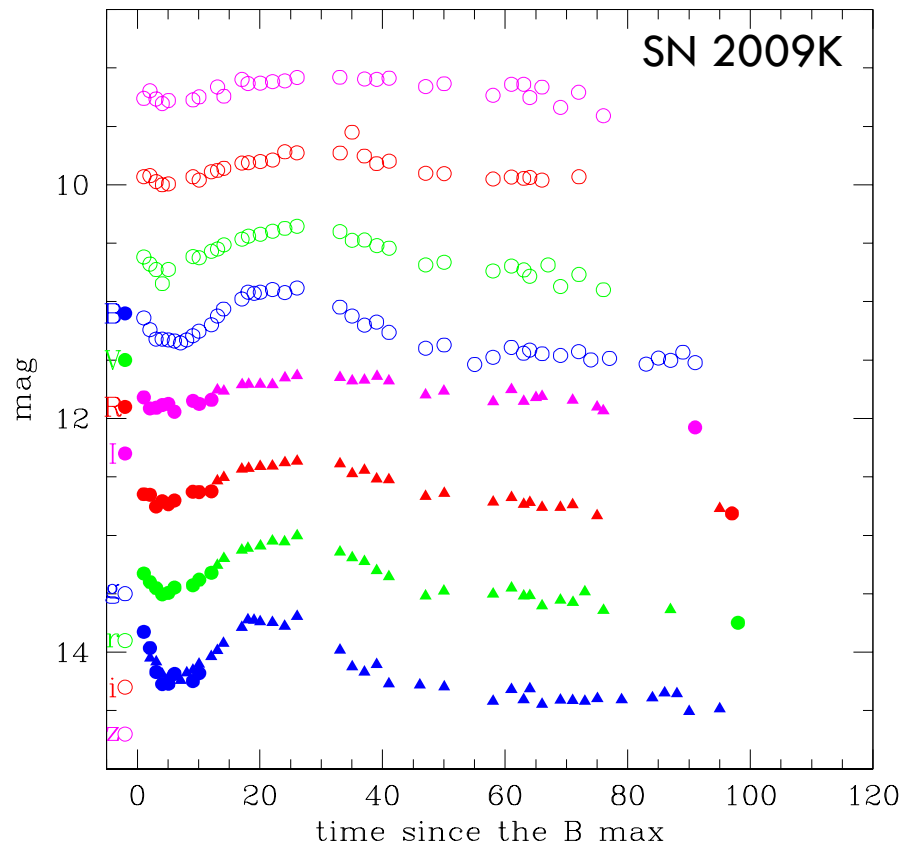
Further Observed SNe IIb:

□ SN 2008bo



Further Observed SNe IIb:

□ SN 2009K & SN 2010jr



Few spectra at early epochs. Nebular phase spectra (~1 year-old).....

...and further more (SN 2011cb, 2012dy, ect.)

Stay Tuned...

A dark circular spot, possibly a hole or a mark, is centered in the lower half of the image. To its right, there is a small L-shaped scale bar with the letters 'SN' next to it. The background is a light, textured surface with some faint, scattered dark spots.

SN

..Arigatou Gozaimasu!