2012 December 14th
Supernova meeting @ IPMU, Tokyo University

Photometric and Spectroscopic Observations of Type Ib Supernova SN 2012au by Kanata-Telescope

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Supernova list Kanata-telescope observed

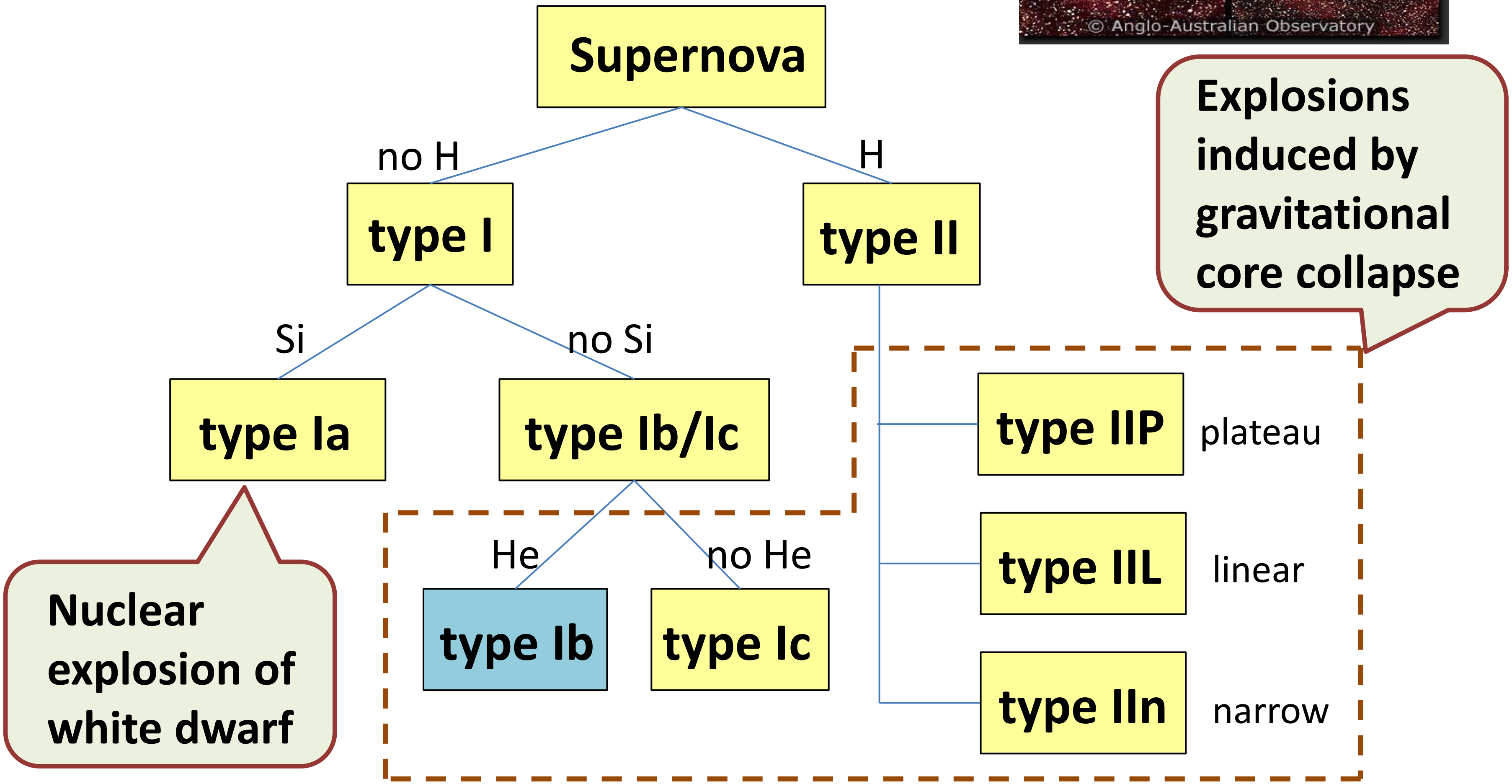
（from current year）

	type	First obs	Last obs	Number of obs.	P.I.	comment
SN 2012Z	Ia	2012/02/03	2012/10/26	32	Yamanaka	
SN 2012au	Ib	2012/03/15	Cont…	65 + α	Takaki	
SN 2012aw	IIP	2012/03/28	Cont…	77＋α	Ueno	
SN 2012dn	Ia	2012/07/12	2012/11/07	64	Yamanaka	
SN 2012ec	IIP	2012/08/17	Cont…	35＋α	Ueno	
SN 2012fg	IIP	2012/10/07	Cont…	28＋α	Takaki	
SN 2012fh	Ic	2012/10/20	Cont…	4＋α	Takaki	
SN 2012fr	Ia	2012/11/03	Cont…	16＋α	Yamanaka	

I N D E X

Type of supernova

Classified according to spectral features.



Characteristics of type Ib/c and motivation

Characteristics

- Core collapse（main sequence mass more than 8-10$M_\odot$?）
- H（and He for Ic）envelope has been already stripped.
- Progenitor's stellar wind? or Binary system？
- Hypernovae ： very large energy more than 10^{52}[erg].
- SNe associated with GRBs are (all) type Ic hypernovae.

  → An unified picture is not come along yet.

from light curve

- Luminosity change
- Estimate ^{56}Ni mass

from spectrum

- Distribution, velocity
- Estimate metallicity

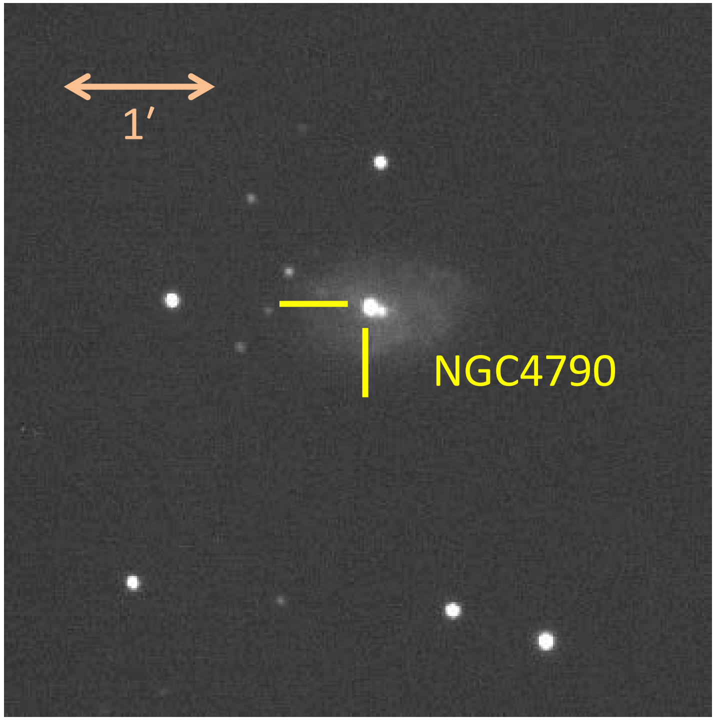
from both

- Kinetic energy
- others…

There are not so many Ib SNe observed with high density in terms of time. → We want to probe the features of progenitor!

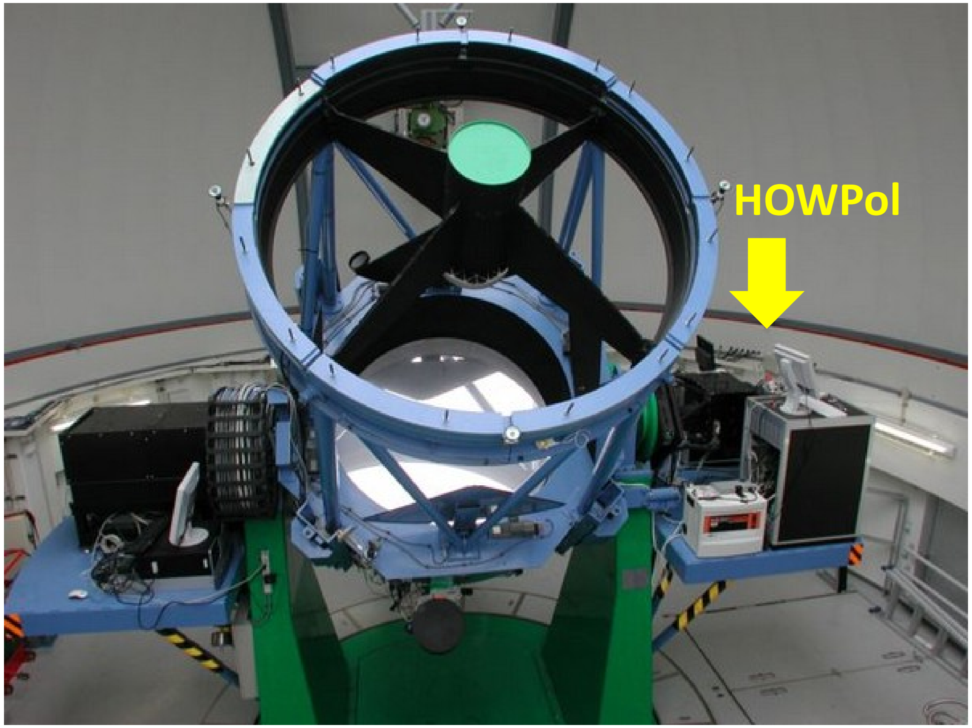
Observations

SN 2012au



Discovered on March 14th
type Ib SN at NGC4790, 23.6Mpc
RA ：12:54:52.2
Dec ：-10:14:50.2

Kanata Telescope（1.5m）-HOWPol

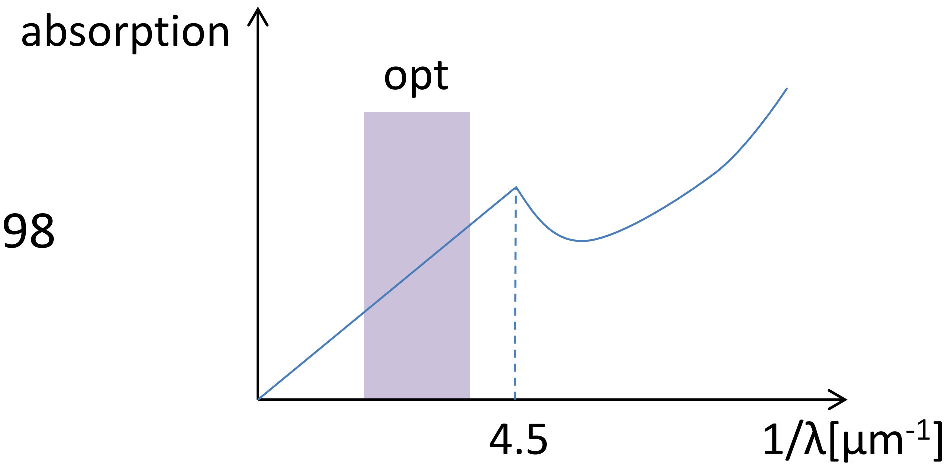


From March 15^{th} to August 19^{th}
photometry ：B,V,Rc,Ic,z′
spectroscopic ：low dispersion（R～400）

Extinction correction

From our galaxy

Use dust map studied in Schlegel +98
E(B-V)=0.048[mag]

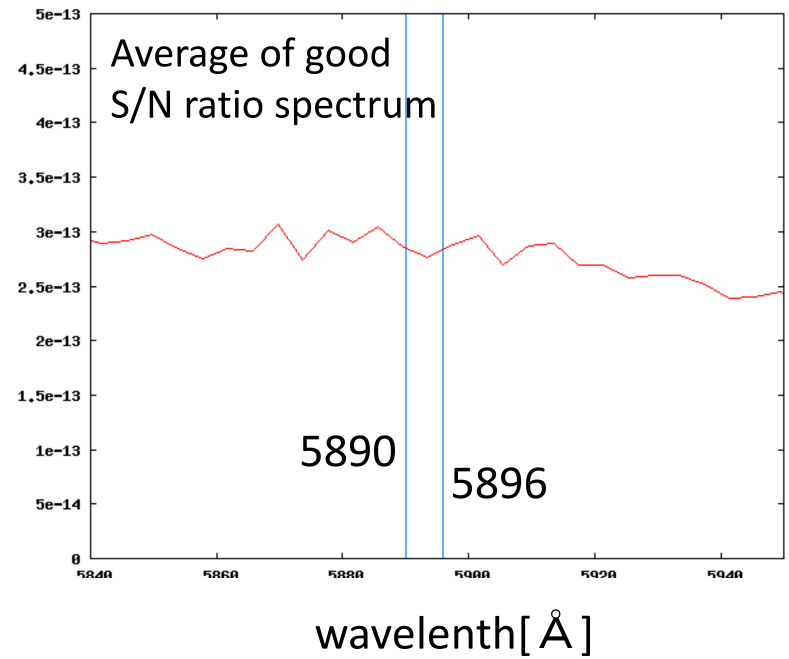


From host galaxy

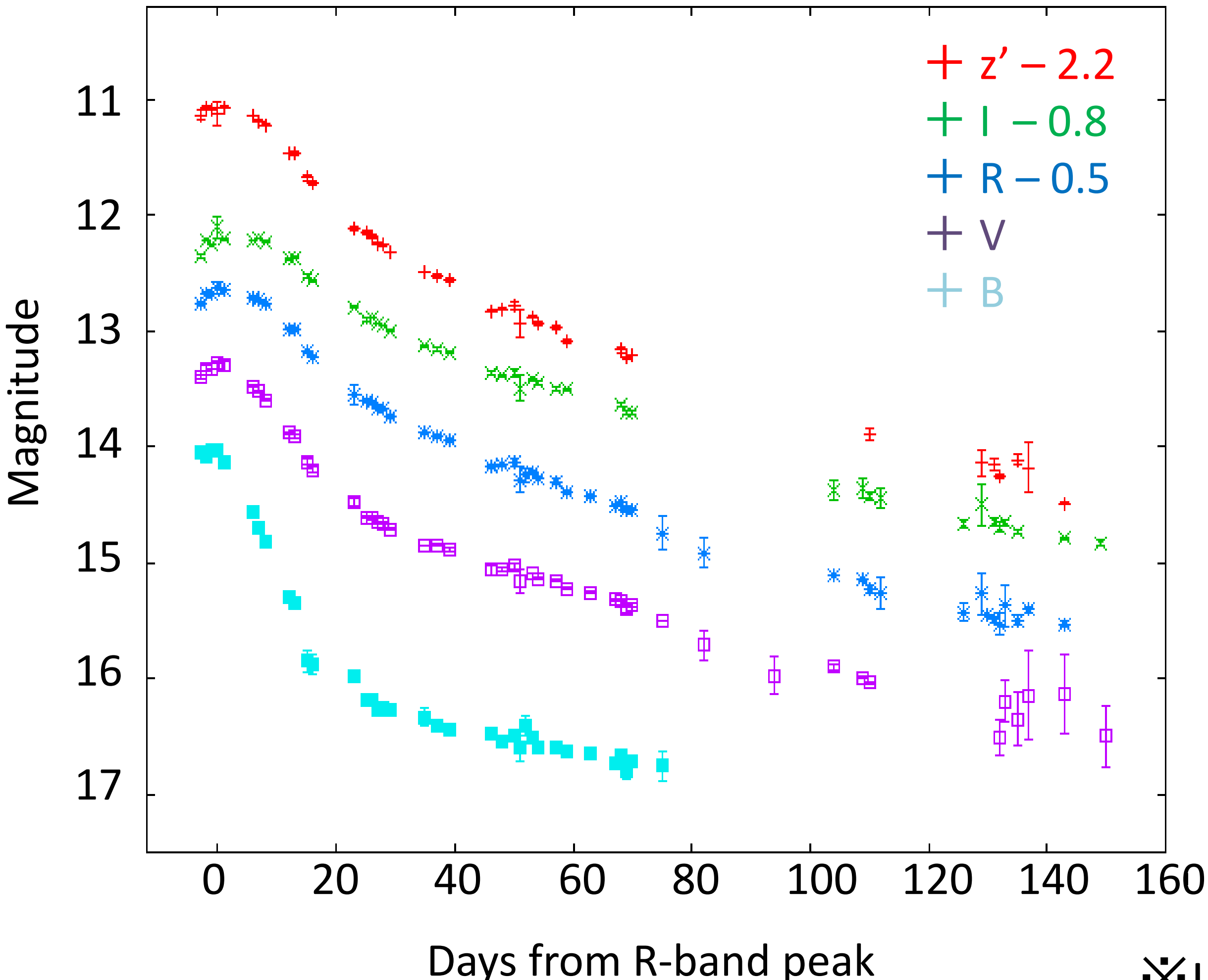
Use NaD line absorption
EW≦0.34[Å](upper limit)
Relation between EW and E(B-V)
(Poznanski +12)

$$\log_{10}(E_{B-V}) = 1.17 \times EW - 1.85 \pm 0.08 + \log_{10}(3.1/R_V)$$

Assume Rv as 3.1
E(B-V)≦0.035[mag]：influence is limited
→ treat as 0mag



Light Curve（galactic extinction is corrected）

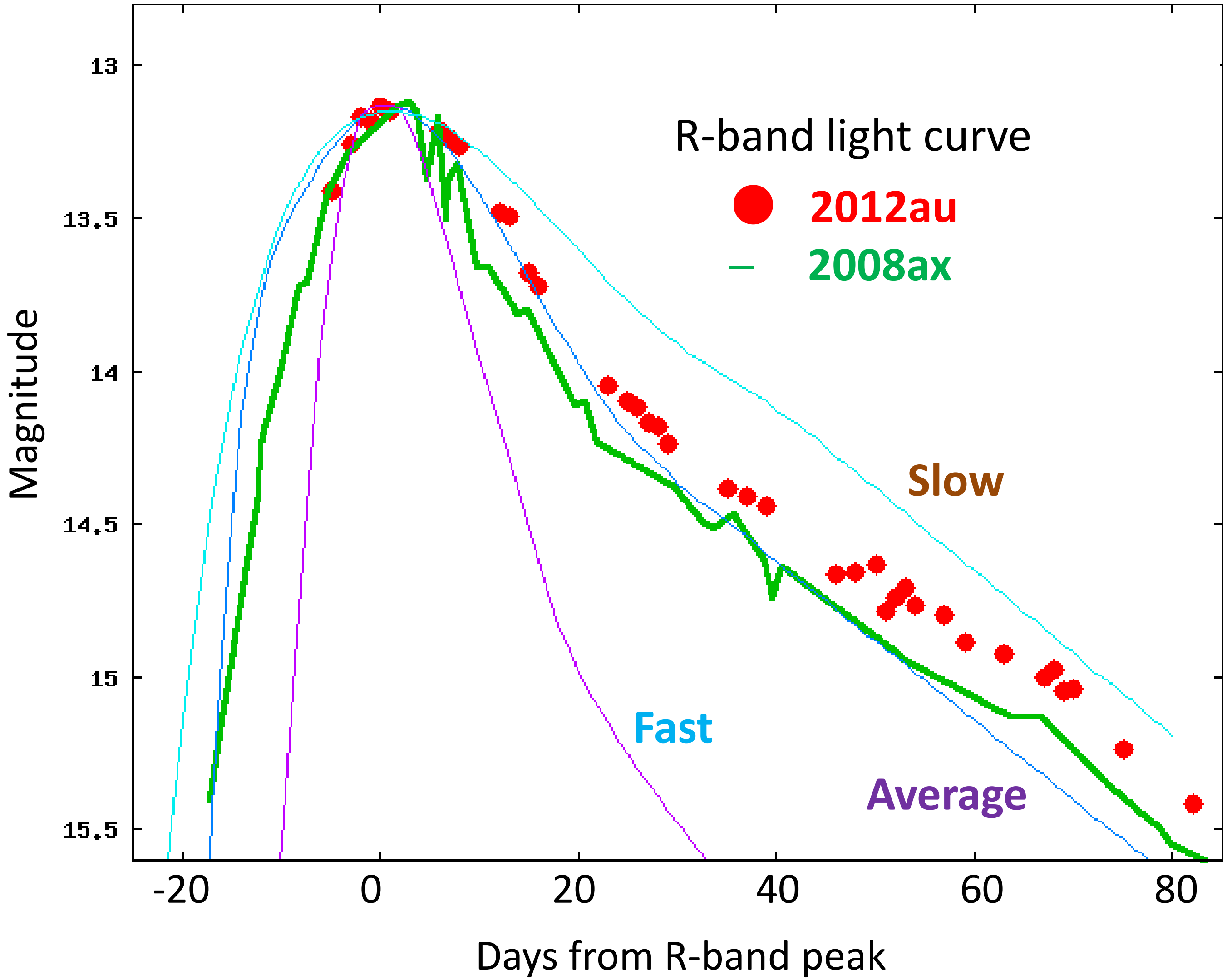


- observed until 150d
- Peak magnitude
  R～ 13.13mag
- Absolute magnitude
  R～ -18.74mag

Very bright for type Ib！

※Ibc average：-16.09±1.24
（Li +11）

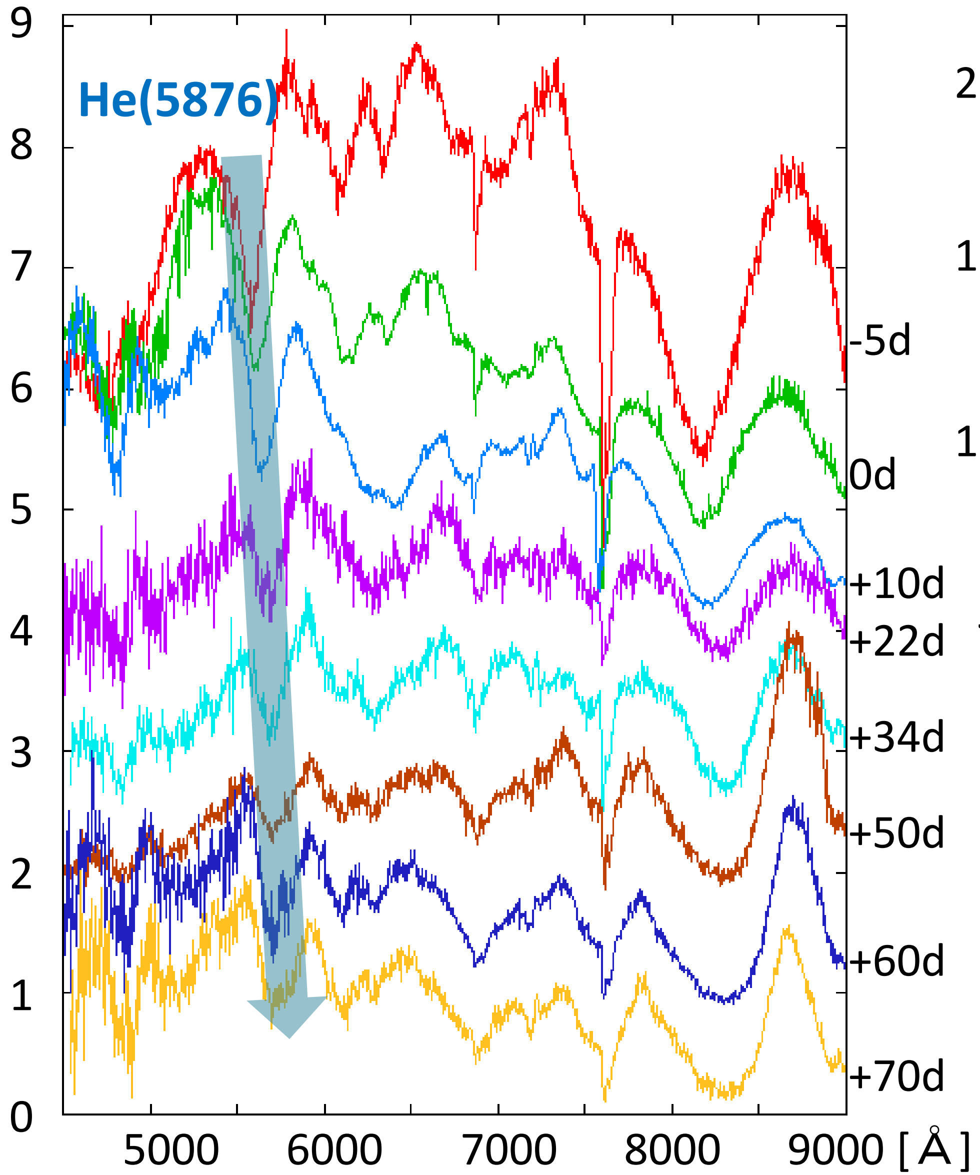
Compare with typical light curve



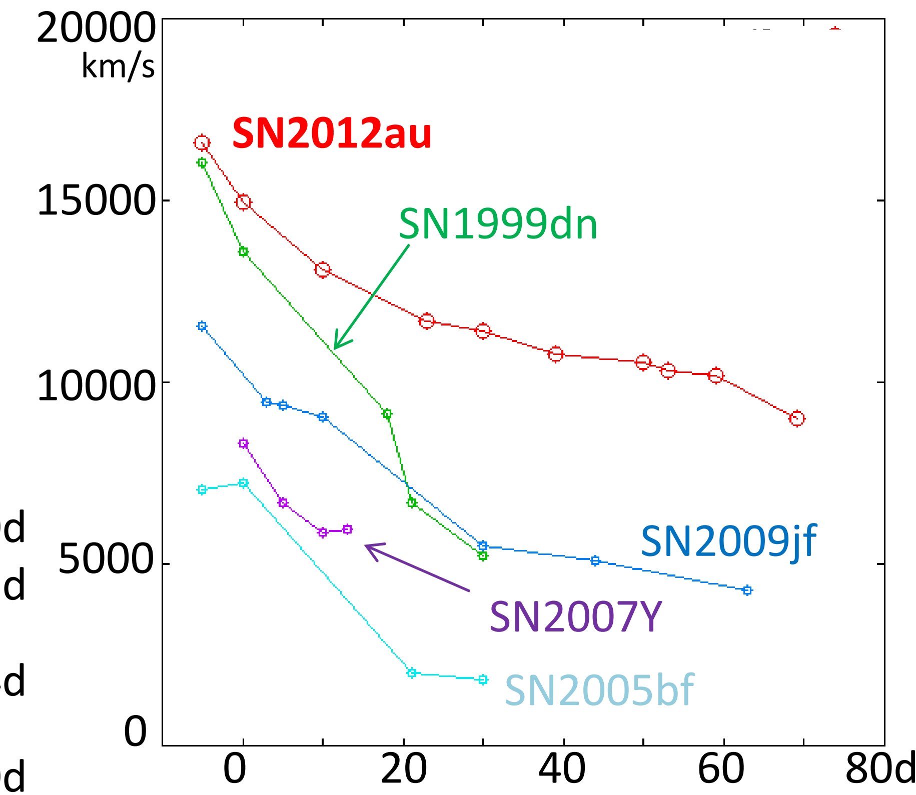
Slightly slow evolution compared with typical light curve.

LOSS; Li +11

Spectrum



He 5876 Line velocity comparison



He line velocity is faster than other type Ib !

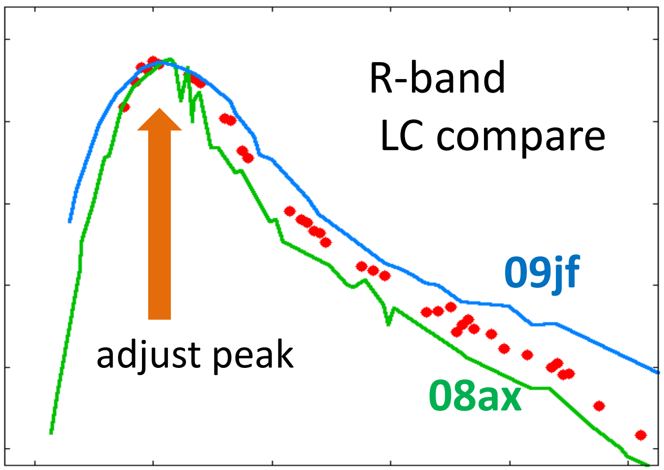
Quasi-bolometric luminosity

Assume that sum of B,V,R,I flux is 60% of total flux!（Tomita +03）

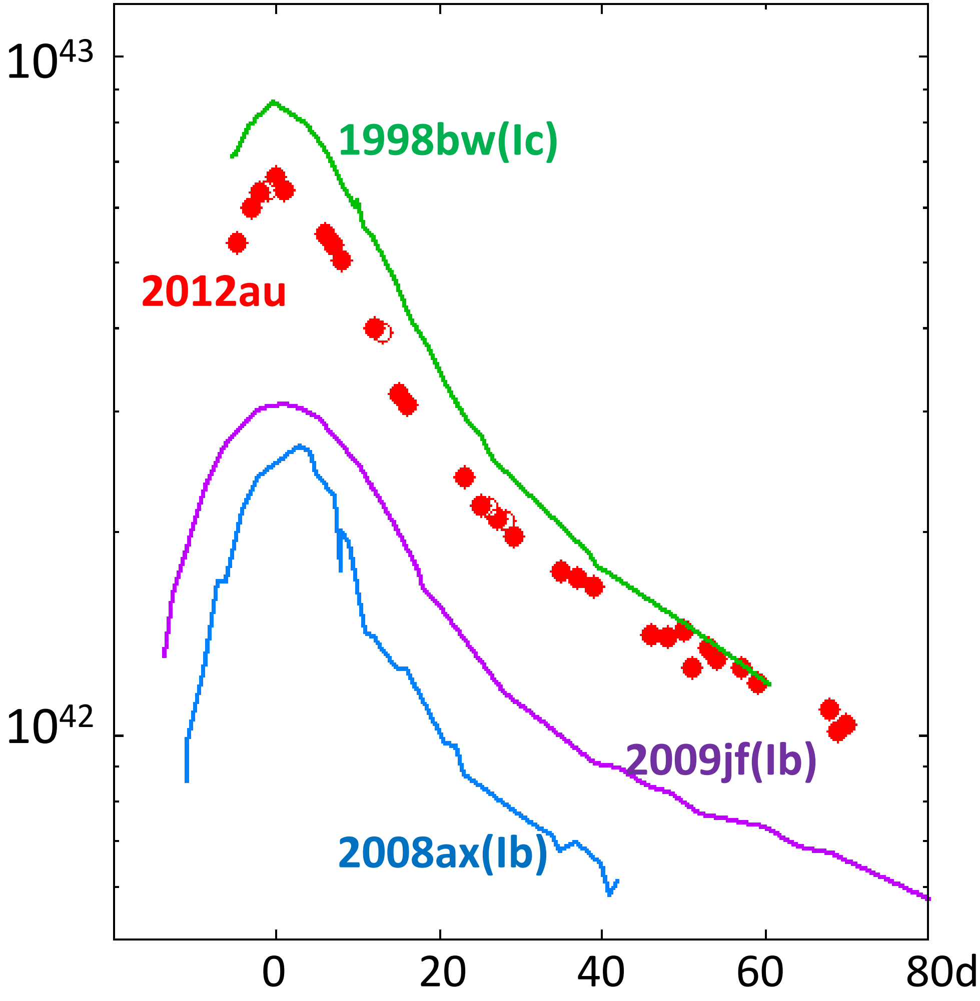
Peak luminosity

Lmax = 6.7 × 10^{42} [erg/s]

Comparable to hypernova 98bw



12au : evolution between 08ax and 09jf



^{56}Ni mass, ejected mass and kinetic energy

^{56}Ni mass

$$L_{max} = \left(6.45e^{\frac{t_r}{8.8d}} + 1.45e^{\frac{t_r}{111.3d}}\right) \times \left(\frac{M_{Ni}}{M_{\odot}}\right) \times 10^{43} [erg/s]$$ (Stritzinger +05)

Assign $L_{max} = 6.7 \times 10^{42}$[erg/s]、$t_r$ = 20d → $M\_^{56}Ni = 0.4M_{\odot}$

Ejected mass and kinetic energy

$$t_r \propto \kappa^{1/2} \cdot M_{ej}^{3/4} \cdot E_k^{-1/4}$$

$$v \propto E_k^{1/2} \cdot M_{ej}^{-1/2}$$

→ 08ax：$M_{ej} = 2\text{~}5M_{\odot}$、$E_k = (1\text{~}6) \times 10^{51}$[erg]
（Taubenberger +11）for scaling

- tr：rising time
- κ：absorption coefficient
- M_{ej}：ejected mass
- E_k：kinetic energy
- v：envelope velocity

→ $M_{ej} = 2\text{~}6M_{\odot}$
$E_k = (2\text{~}10) \times 10^{51}$[erg]

※include rather uncertainness！

Comparison with other SNe Ib/c

Compare physical quantity

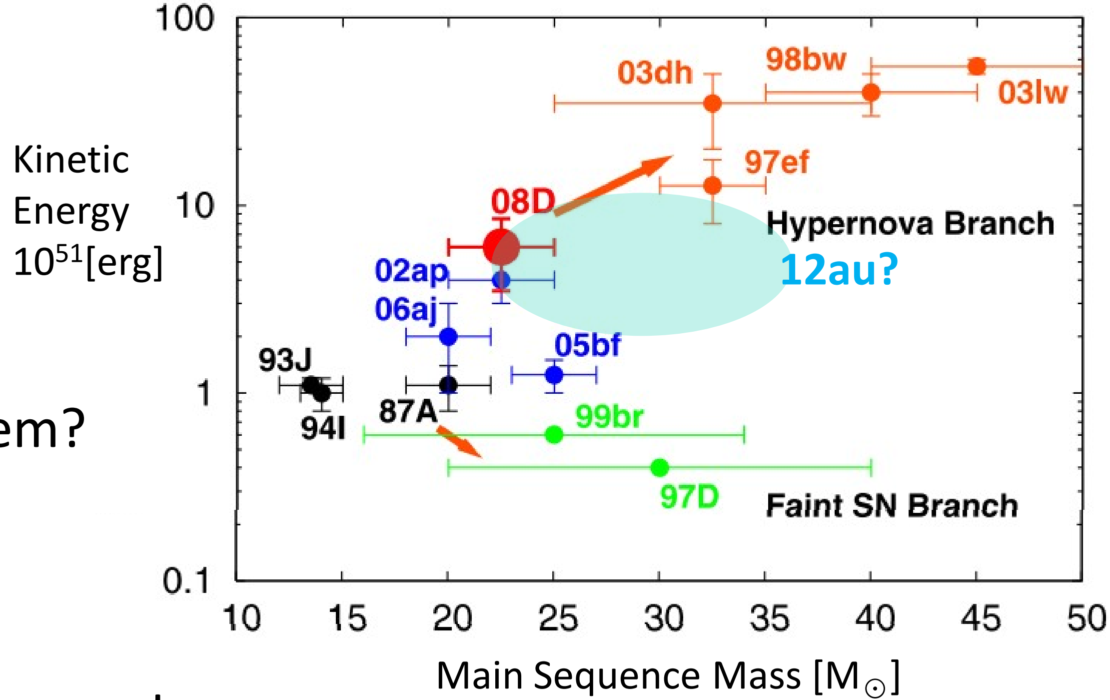
	type	Lmax 10^{42}[erg/s]	M_Ni [$M_\odot$]	M_ej [$M_\odot$]	E_k 10^{51}[erg]
12au	Ib	6.7	0.4	2~6	2~10
08ax		2.4	0.1	2~5	1~6
09jf		3.0	0.2	4~9	3~8
98bw	Ic (hypernova)	9.0	0.4	10~12	7~50

→ type Ib, but a little close to hypernova

Taubenberger +11
Sahu +11
Nakamura +00

Expected progenitor model (preliminary)

- It is perhaps all right that progenitor is very massive.



Nomoto +11

- Single star? or Binary system?
  → Binary system can strip He envelope even if not a massive star
  → No necessity being binary system

- Host galaxy have little metallicity?
  → Not so influenced by stellar wind, so He envelope remained?

Discuss now…

Summary

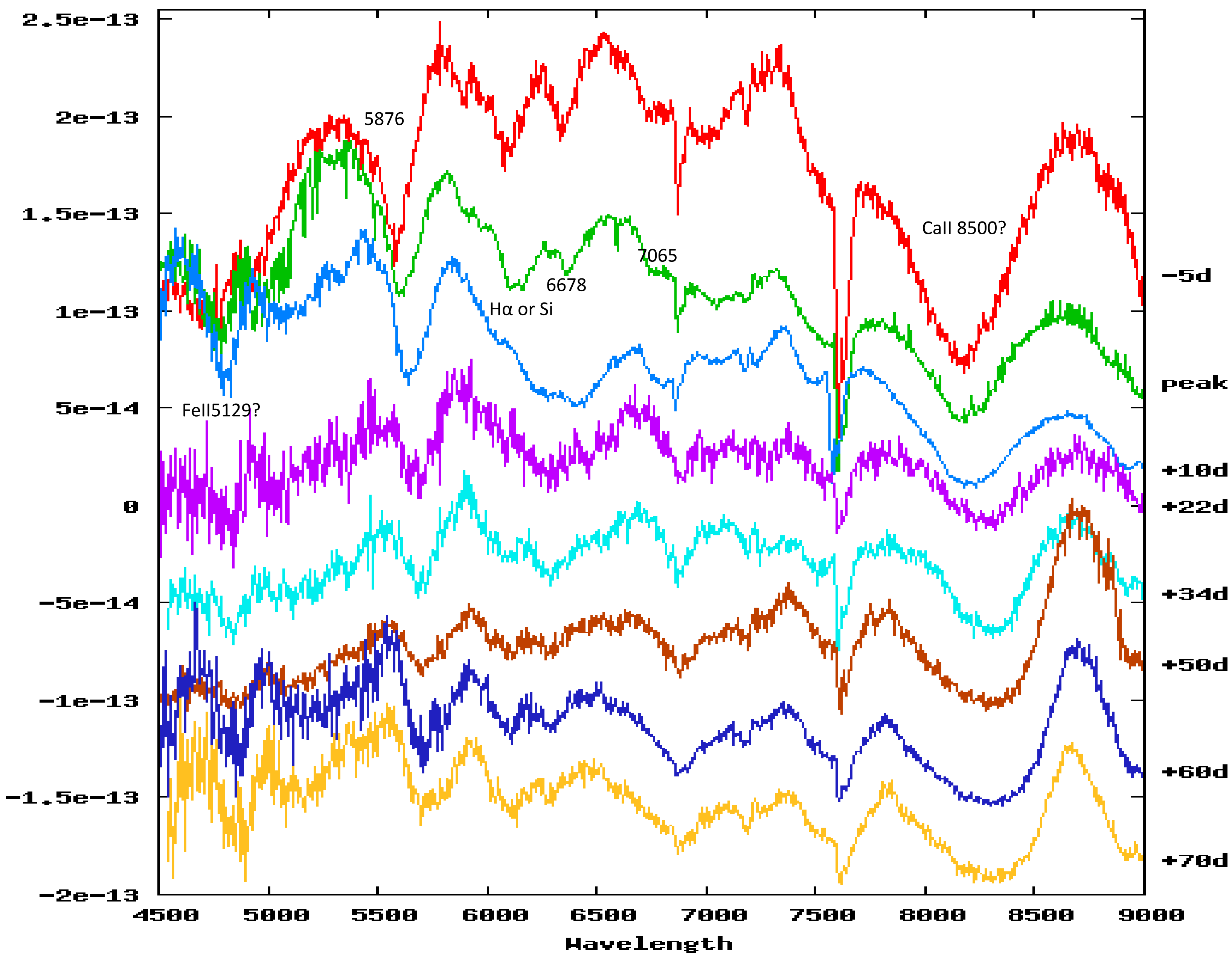
- We got a precious sample of type Ib SN which progenitor is really not sure.

- Results
  LC evolusion is a little slow than typical Ib.
  He line velocity is faster than other Ib.

- Discussion
  Bolometric luminosity and 56Ni mass is little less than hypernova.
  Ejected mass and kinetic energy is one step short of hypernova.

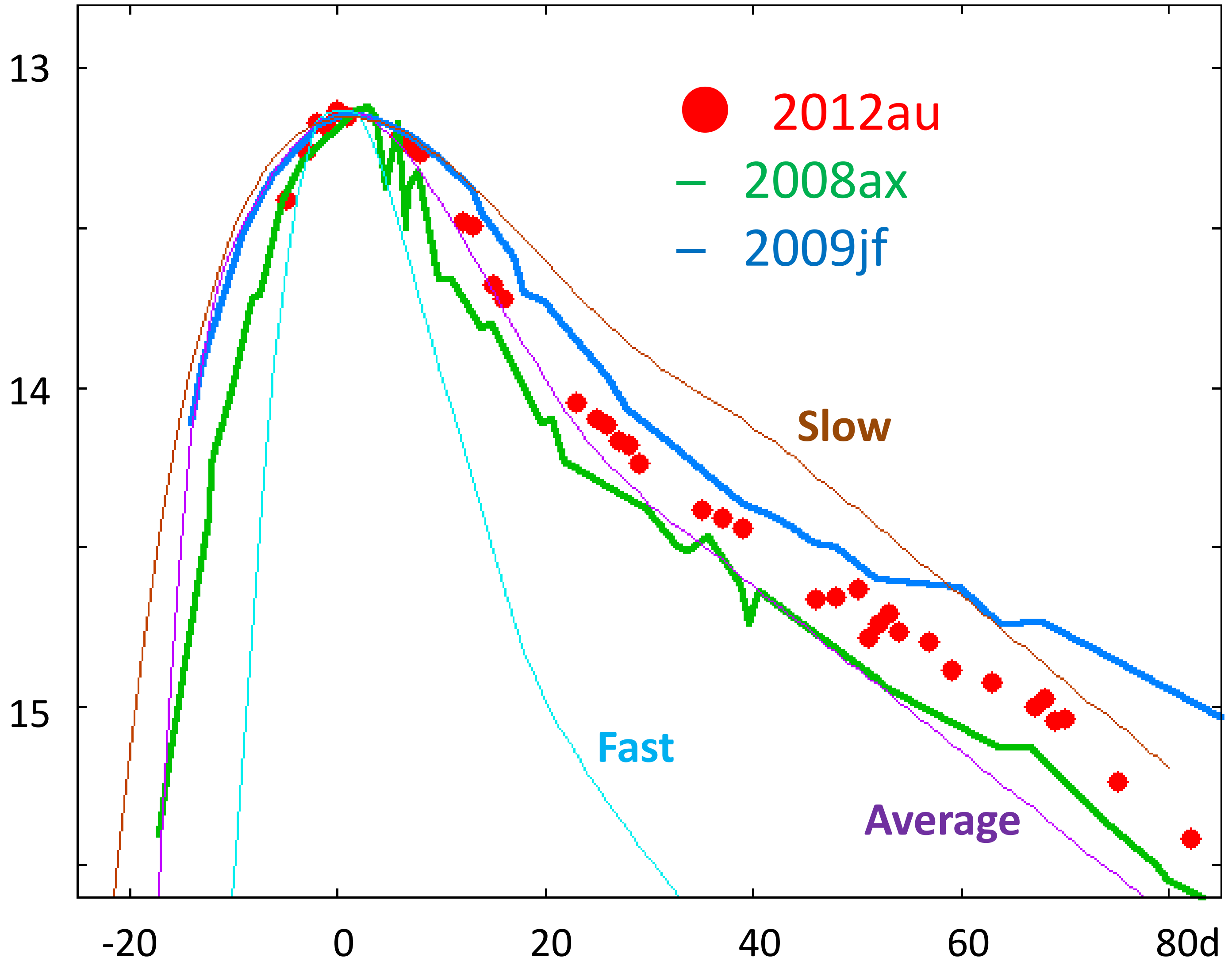
- Expected model
  For example, a massive star made many 56Ni, but He envelope was not stripped because stellar wind didn't have a profound effect?

- Nebular-phase observation
  From November late, we can observe SN 2012au by Kanata again.

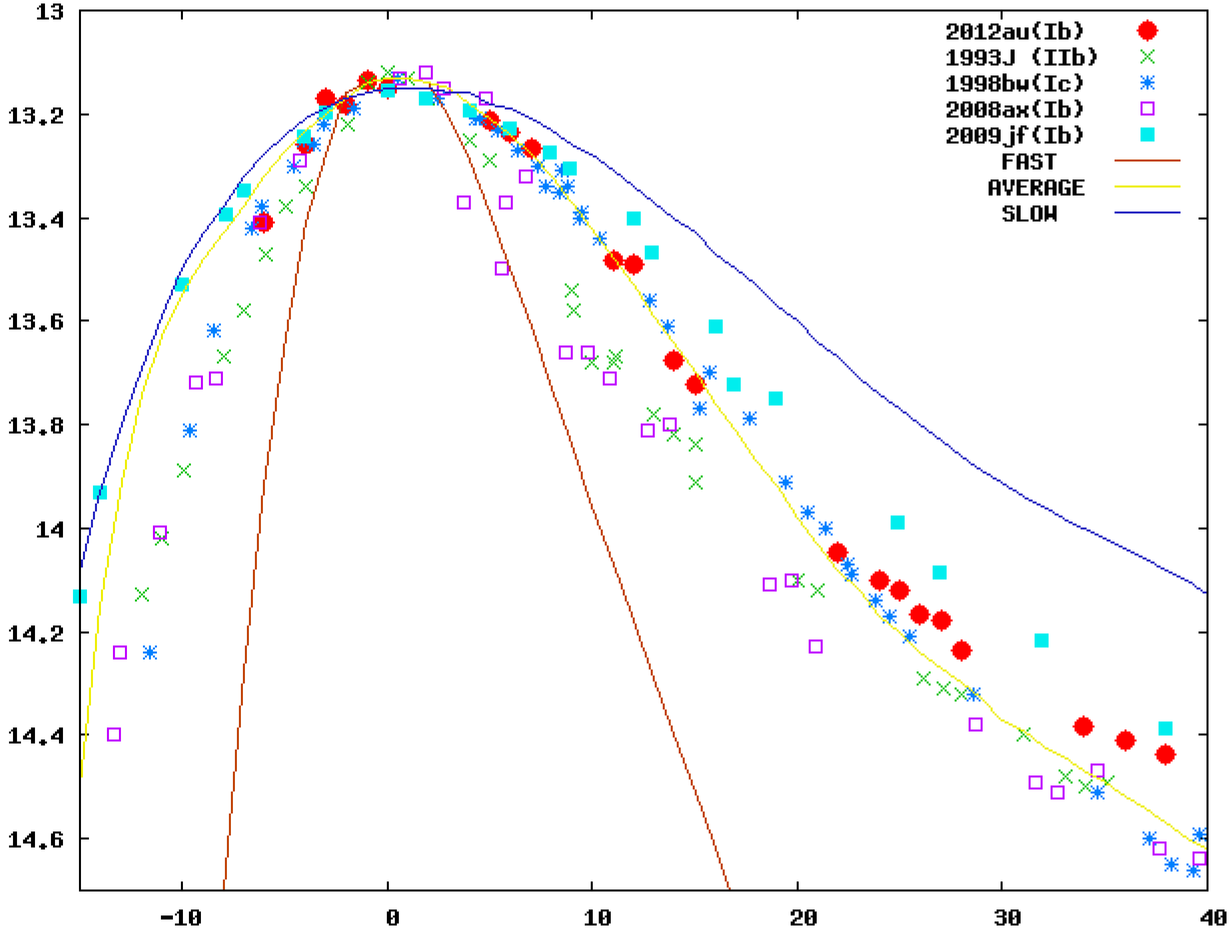


2.5e-13
2e-13
1.5e-13
1e-13
5e-14
0
-5e-14
-1e-13
-1.5e-13
-2e-13
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
Wavelength
5876
CaII 8500?
7065
6678
Hα or Si
FeII5129?
-5d
peak
+10d
+22d
+34d
+50d
+60d
+70d

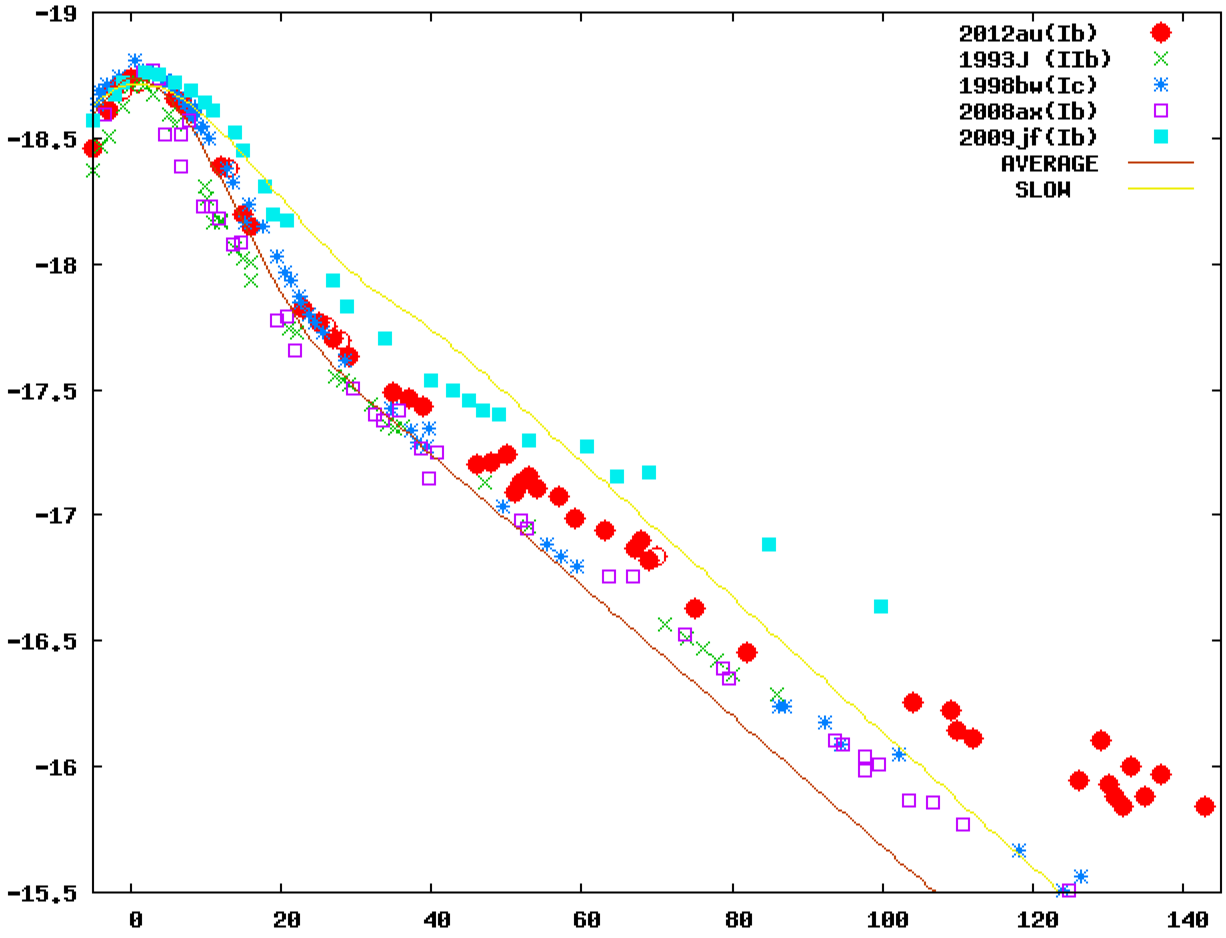
Compare LC with 08ax,09jf and LOSS



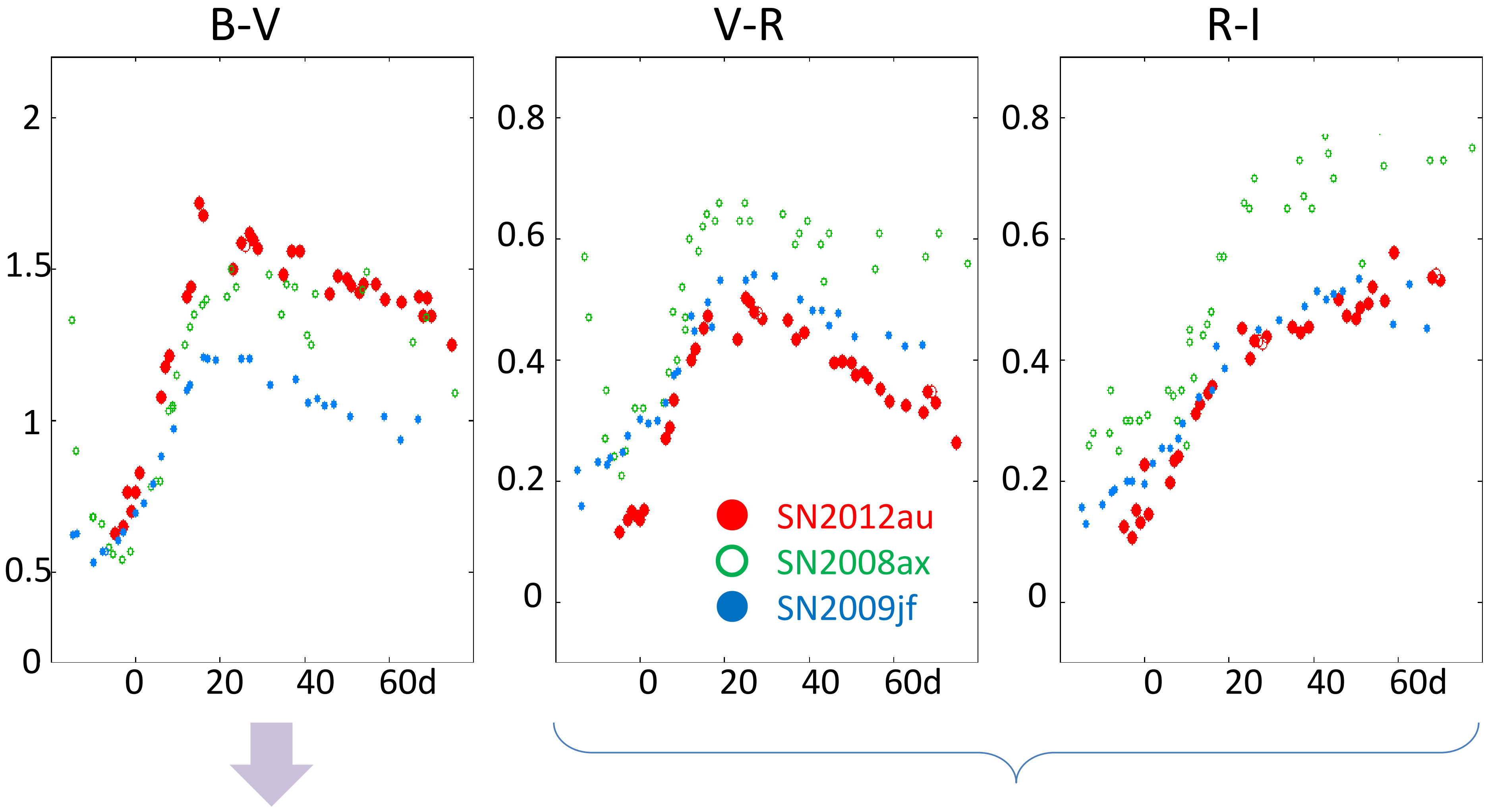
Detail compare using around peak



Detail compare using late phase



Compare color



Similar to SN2008ax

Similar to SN2009jf

Distance uncertainness

We use 23.6Mpc as distance, but how about using 16.9Mpc ?

Calculated by Tully-fisher relation

Calculated by redshift

	23.6Mpc	16.9Mpc
m-M	31.87	31.14
R absolute_mag	-18.74	-18.01
Peak luminosity[erg/s]	6.7×10^{42}	3.4×10^{42}
$M_{Ni}[M_\odot]$	0.36	0.18

Result : somewhat larger than typical.