Multi-wavelength Observations of the Enduring Type IIn Supernovae 2005ip and 2006jd

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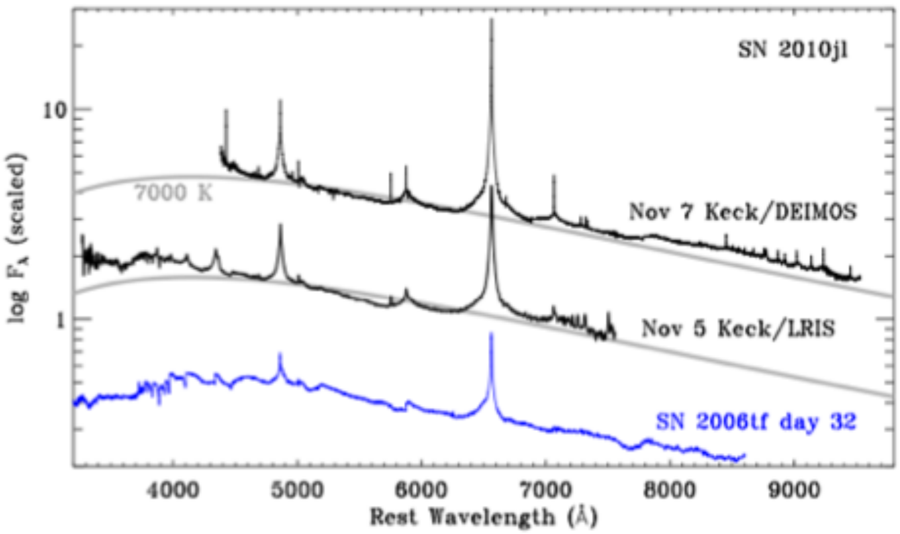
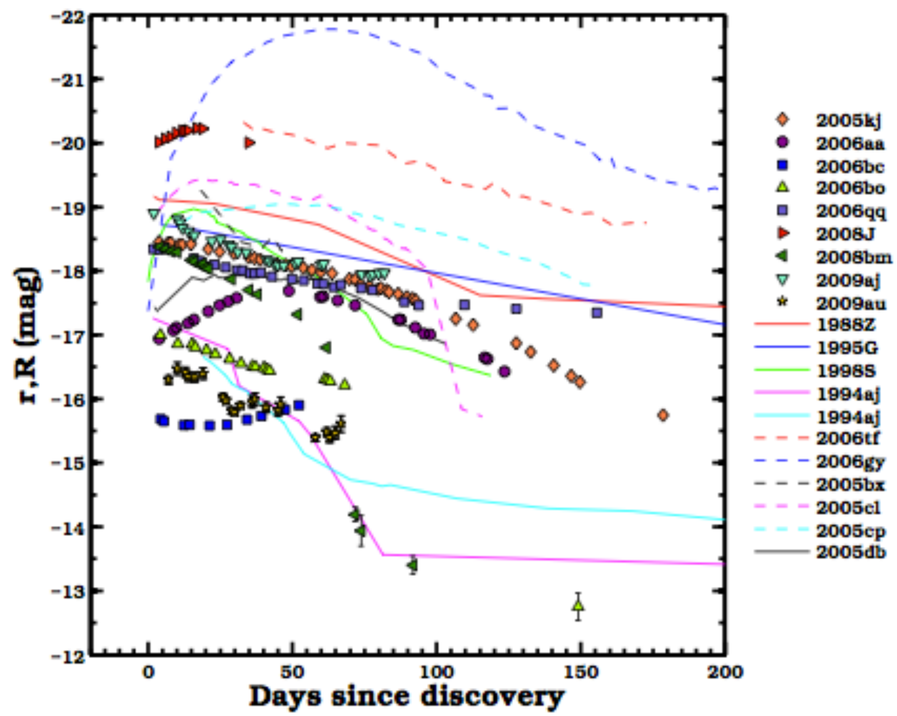
& Francesco Taddia (SU)

DEPARTMENT OF
PHYSICS AND
ASTRONOMY
STAFF PAGES

Basic Observational Properties



Smith et al. (2011)



Taddia et al., in prep.

The detailed study of a handful of SN-IIn indicate the existence of dust:

(i) newly formed *warm* and/or (ii) pre-existing *cold* dust components which range anywhere from 10^{-5} to 10^{-1} $M_\odot$ (see review by Gall et al. 2011)

Collaborators for this project
(spanning 4 continents)

Multi-wavelength Observations of the Enduring Type IIn Supernovae 2005ip and 2006jd[1]

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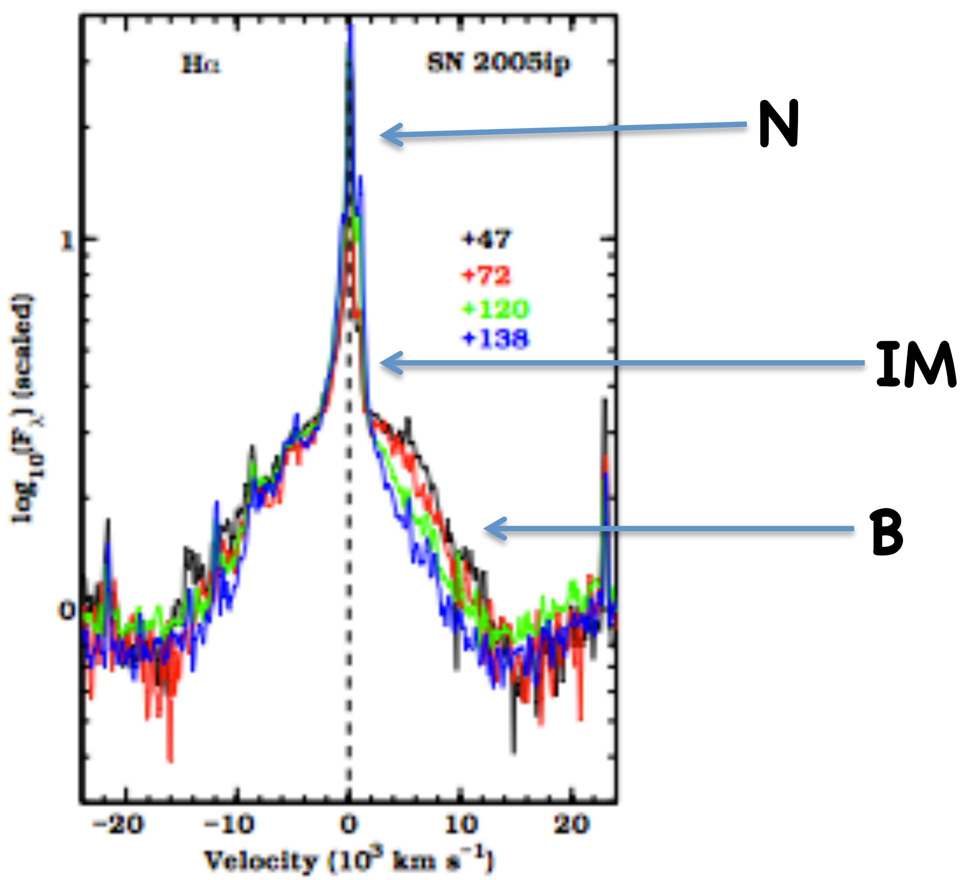
Some SN-IIn and their Progenitors

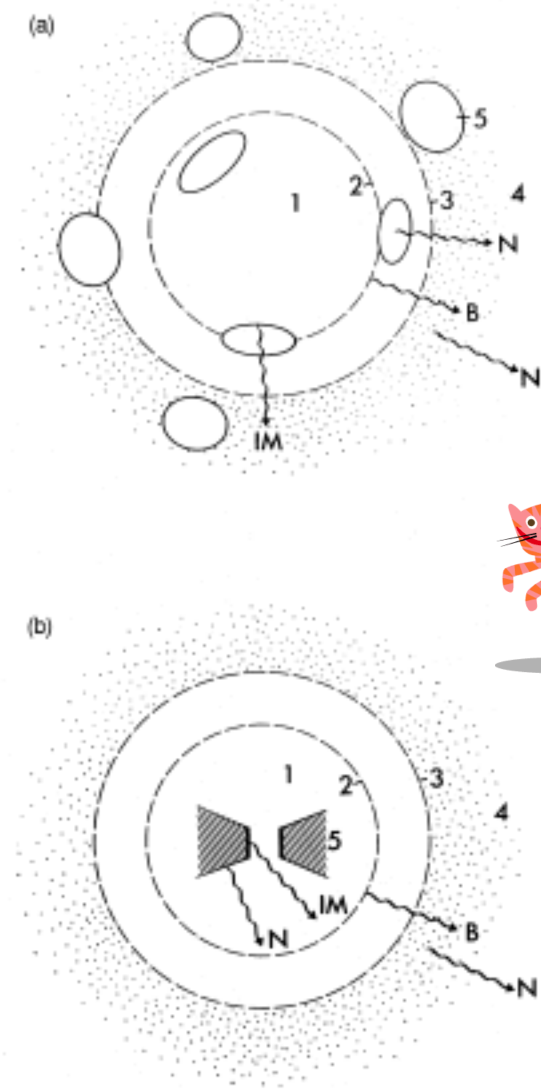
- Low-luminosity objects, e.g. 1994W/2009kn interacting SN (Sollerman et al. 1998; Kankare et al. 2012) or two interacting shells (Dessert et al. 2009)
- High-luminosity objects, e.g. 2006gy interacting SN with spherically symmetric dense shell(s) of material (e.g. Moriya et al. 2012)
- Intermediate luminosity SN-IIn, e.g. 1988Z: SN-clumpy wind interaction and/or asymmetric SN-wind interaction (Chugai & Danziger 1994)?

➔

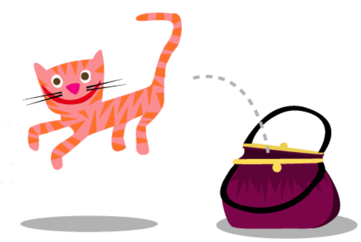
Clumpy wind or asymmetric SN-wind interaction?



Stritzinger et al. (2012)



SN 2005ip

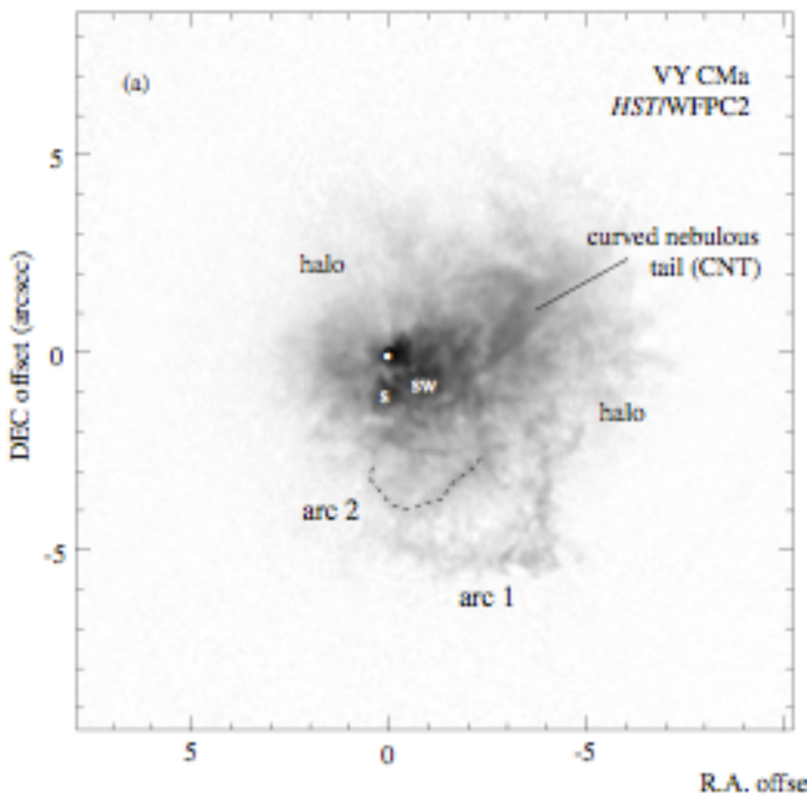


SN 2006jd

Chugai & Danziger (1994)

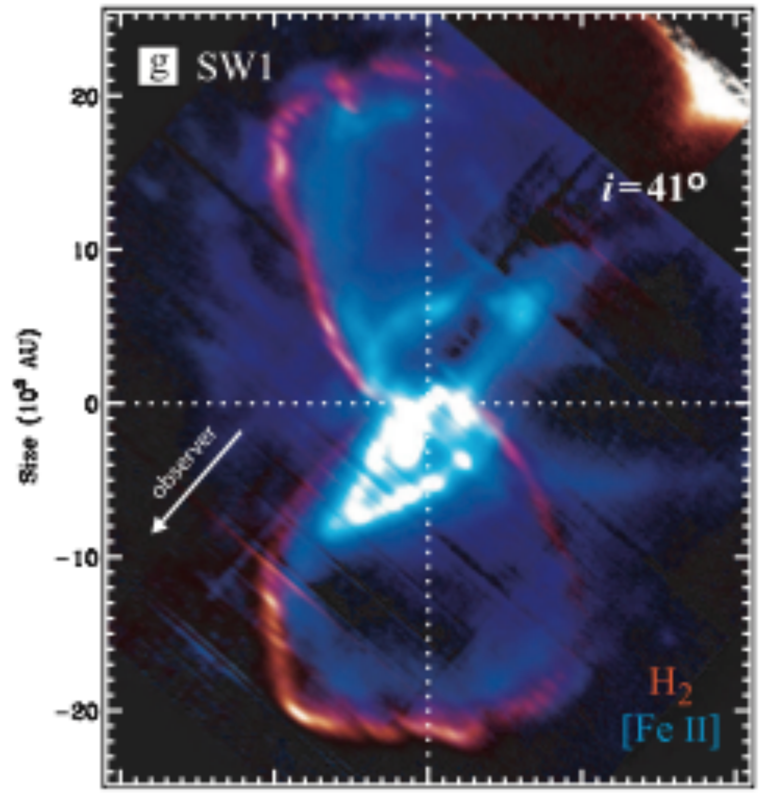
Any observational evidence that these models reflect nature?

VY Canis Majoris



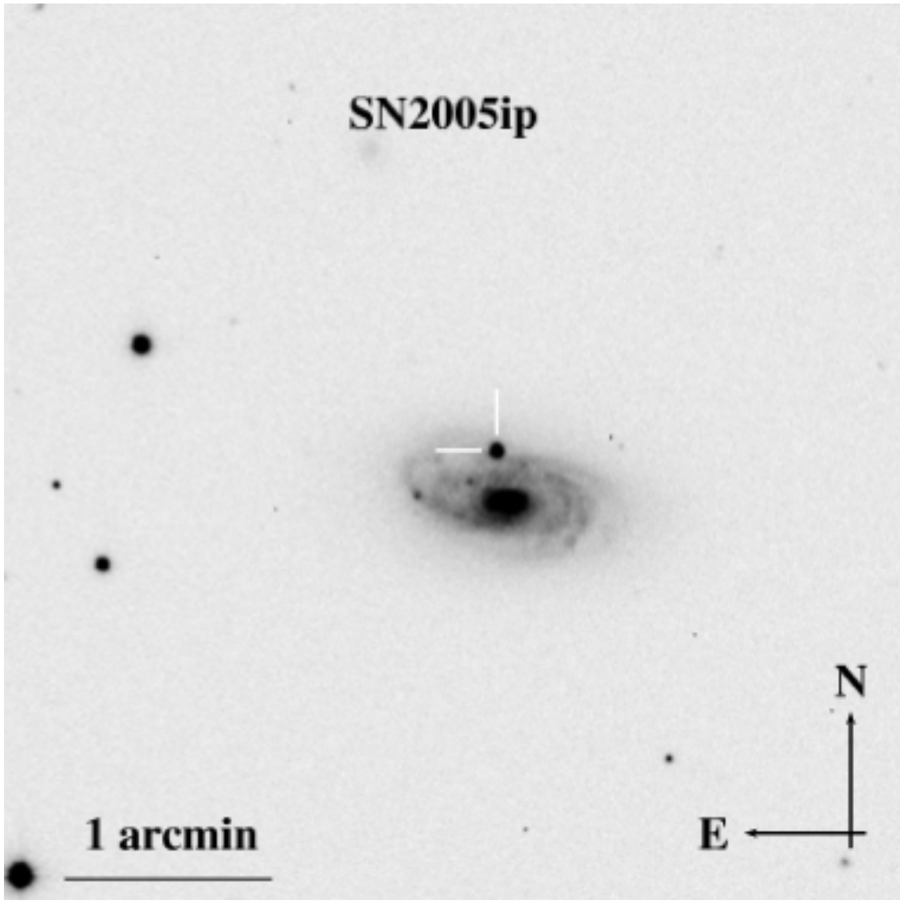
Smith et al. (2009)

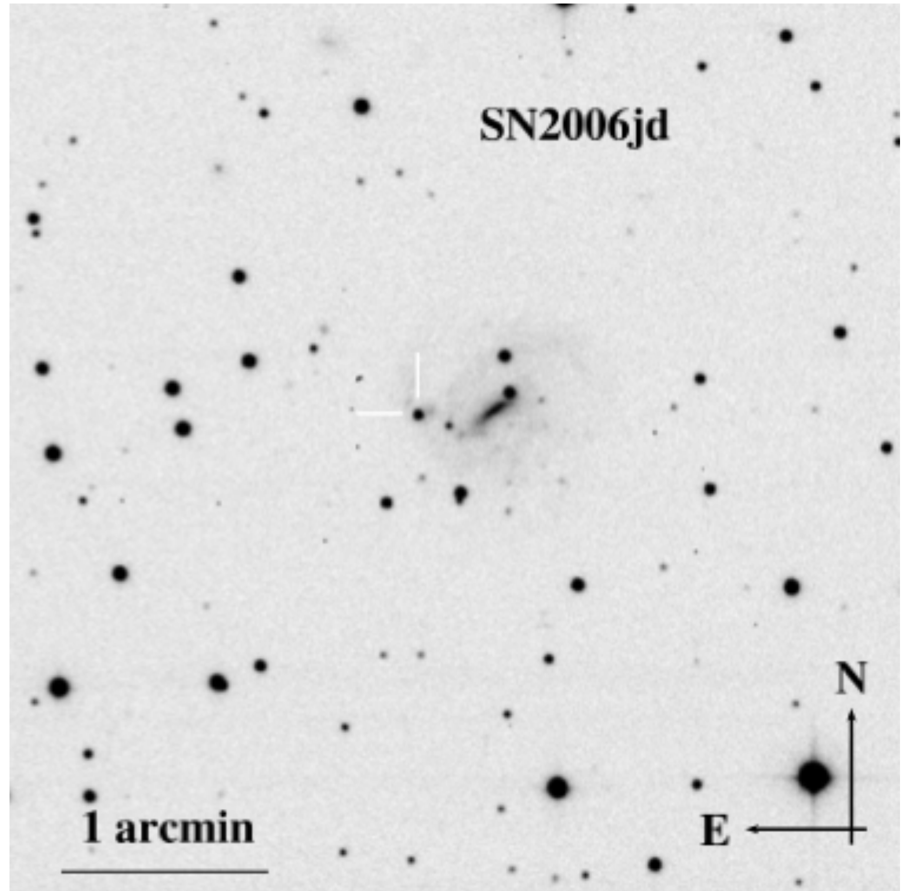
η Carinae



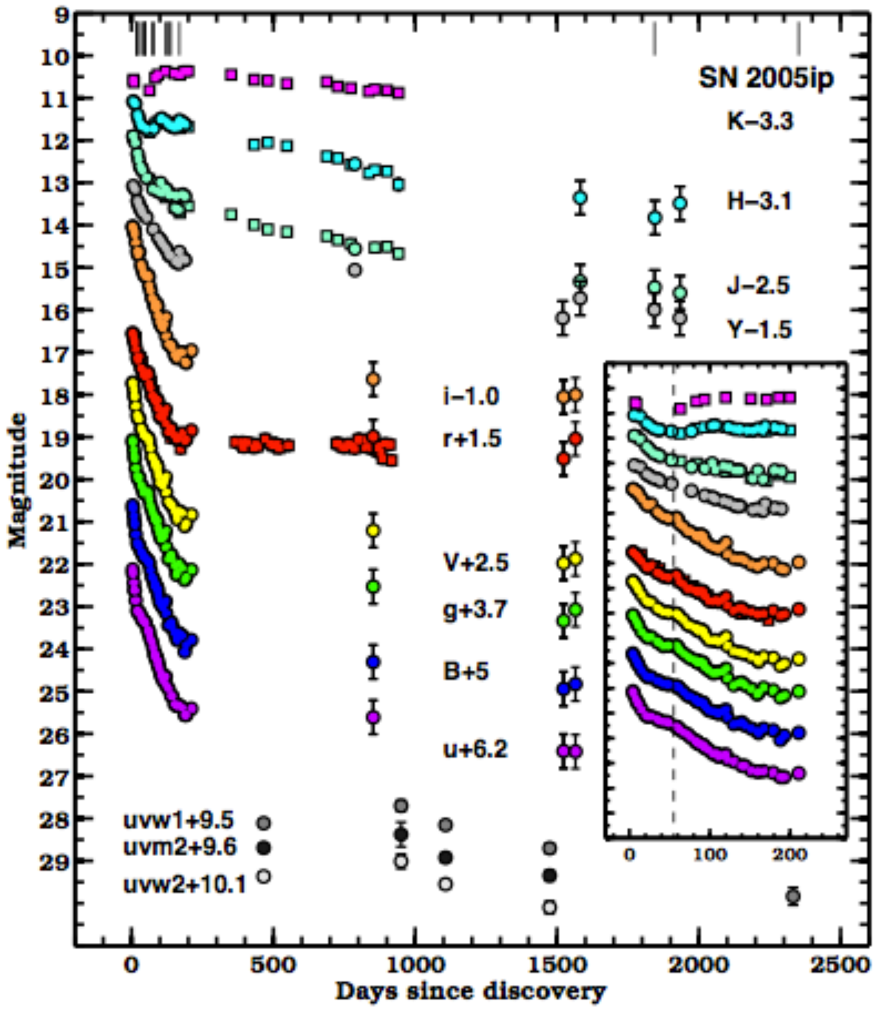
Smith (2006)

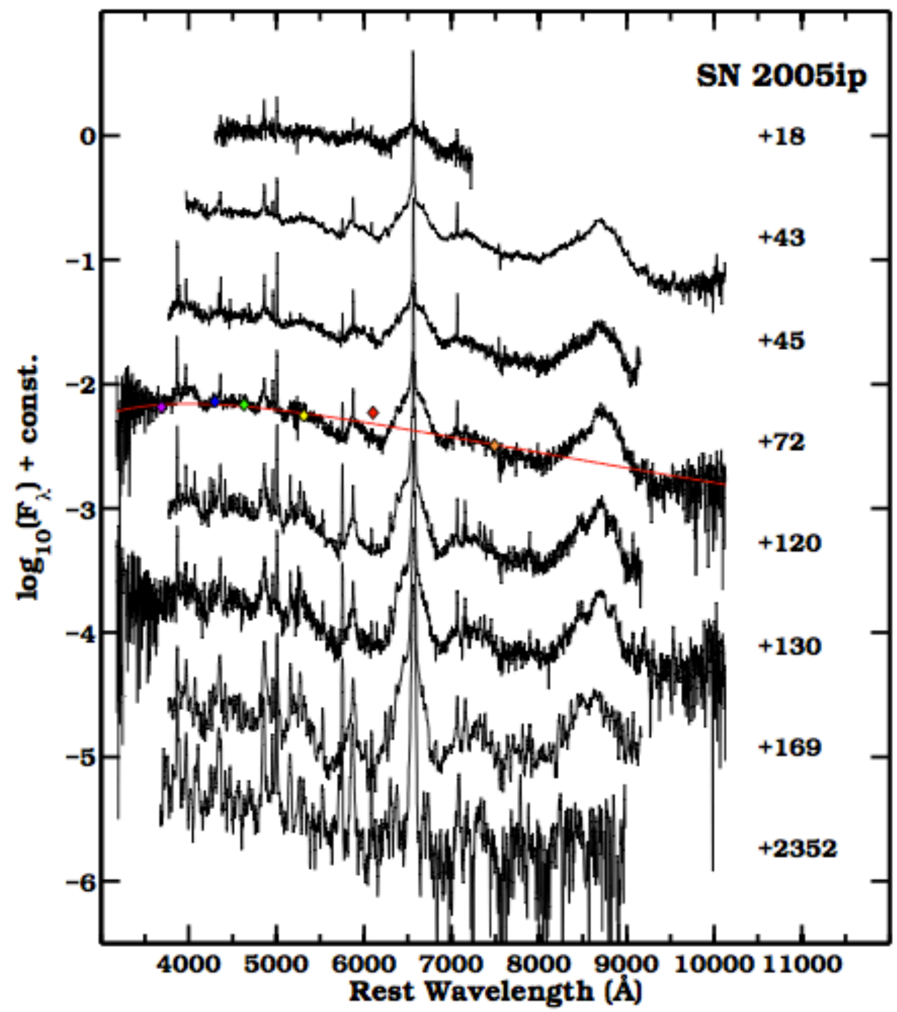
Carnegie Supernova Project: Observations of SNe 2005ip and 2006jd





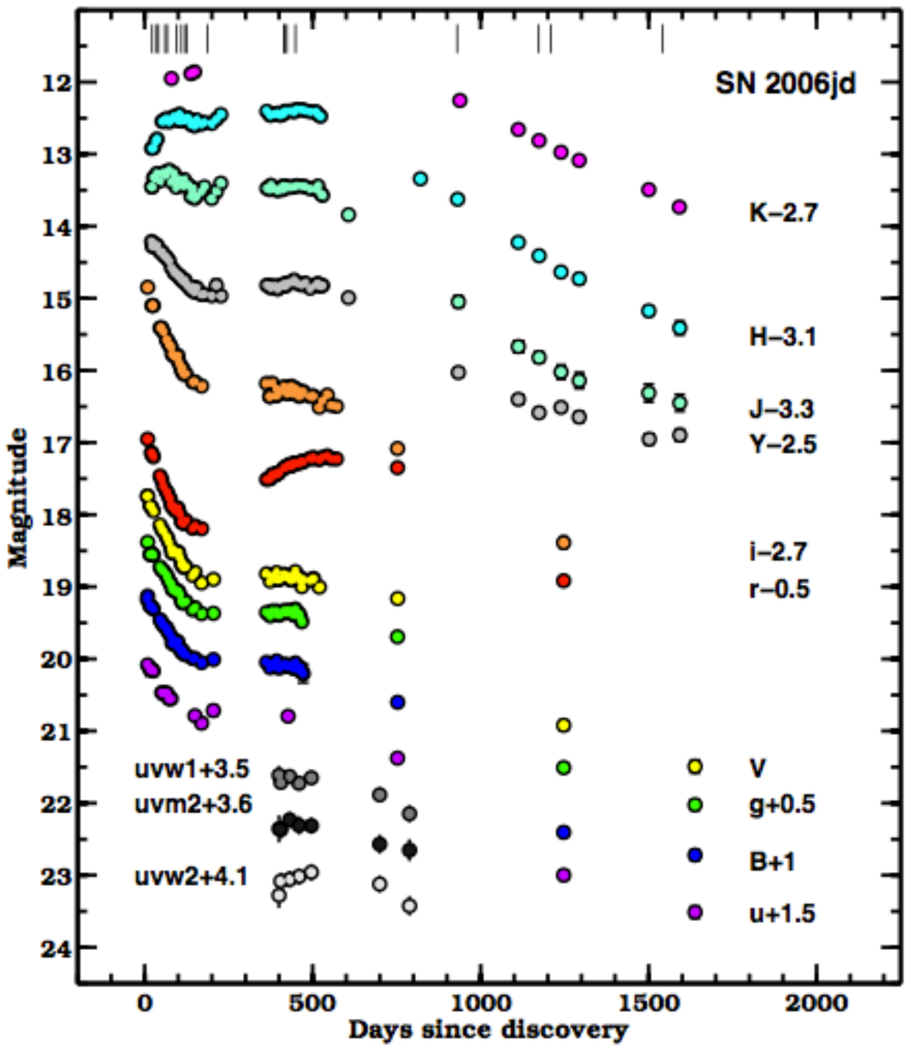
Supernova 2005ip

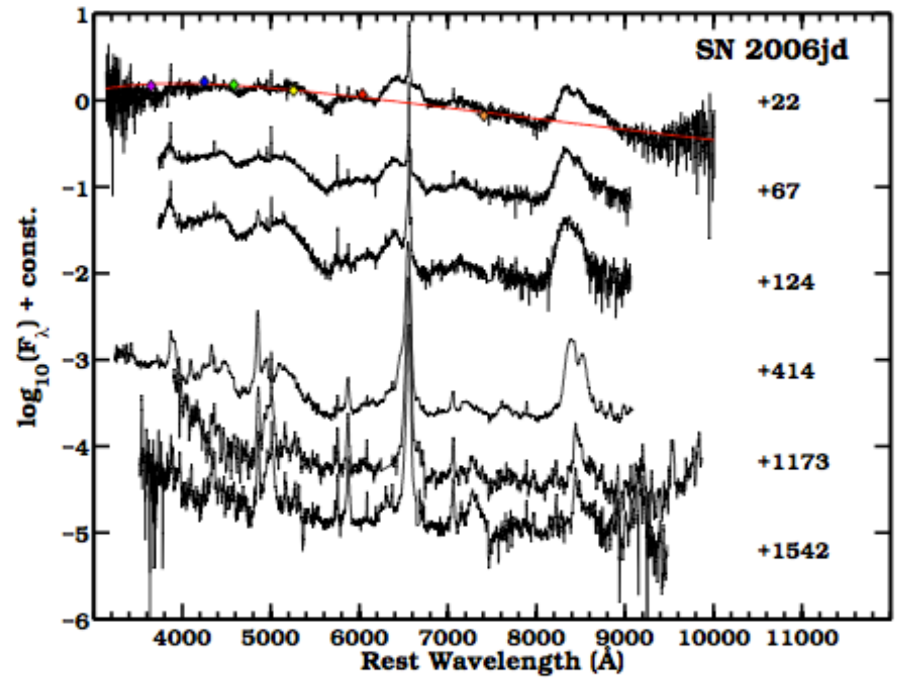




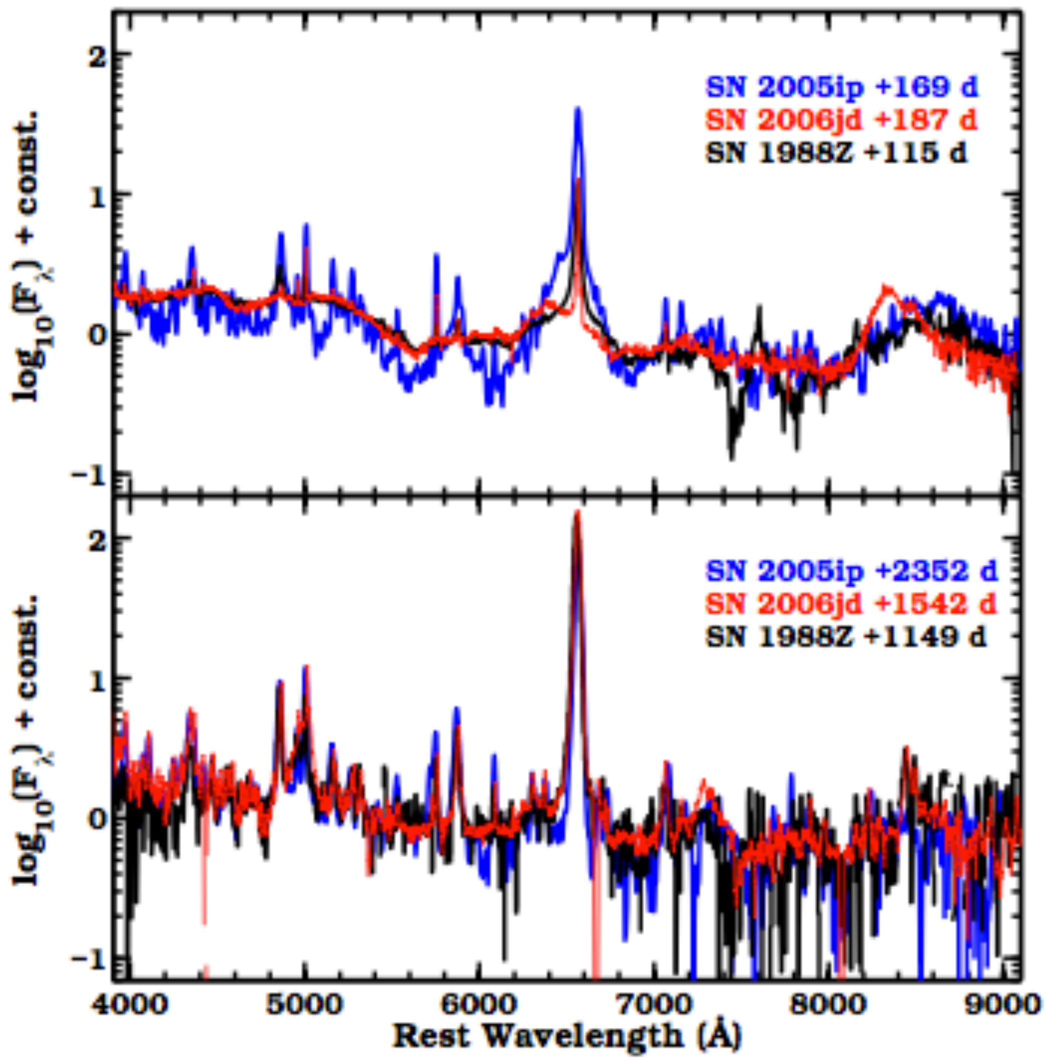
r- and NIR-band squares are from Smith et al. (2009), Fox et al. (2009), respectively

Supernova 2006jd



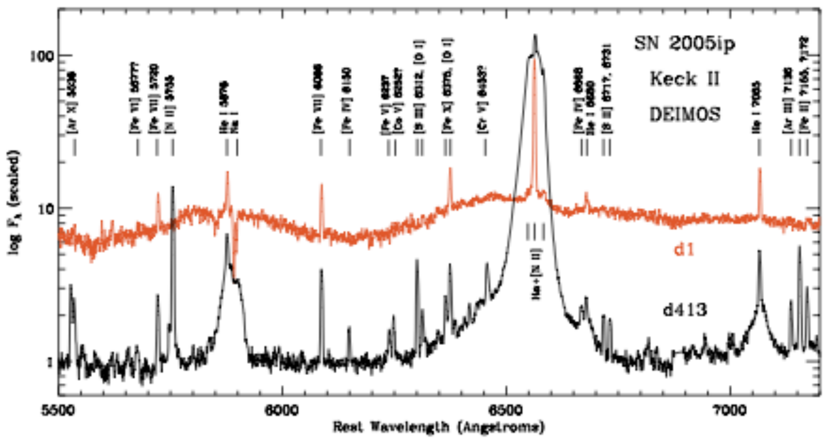


Comparison of early- and late-phase spectra

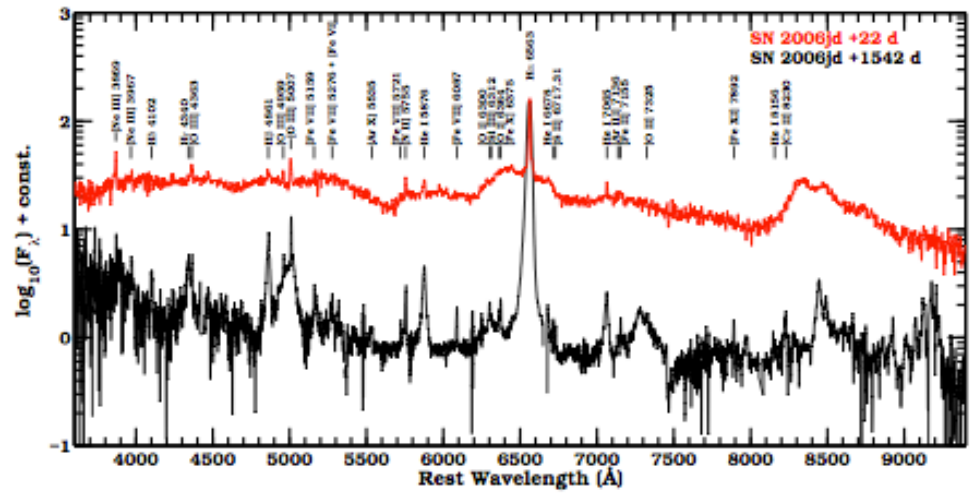


Quite similar optical SEDs, however a closer look reveals diversity….

High-Ionization Coronal lines



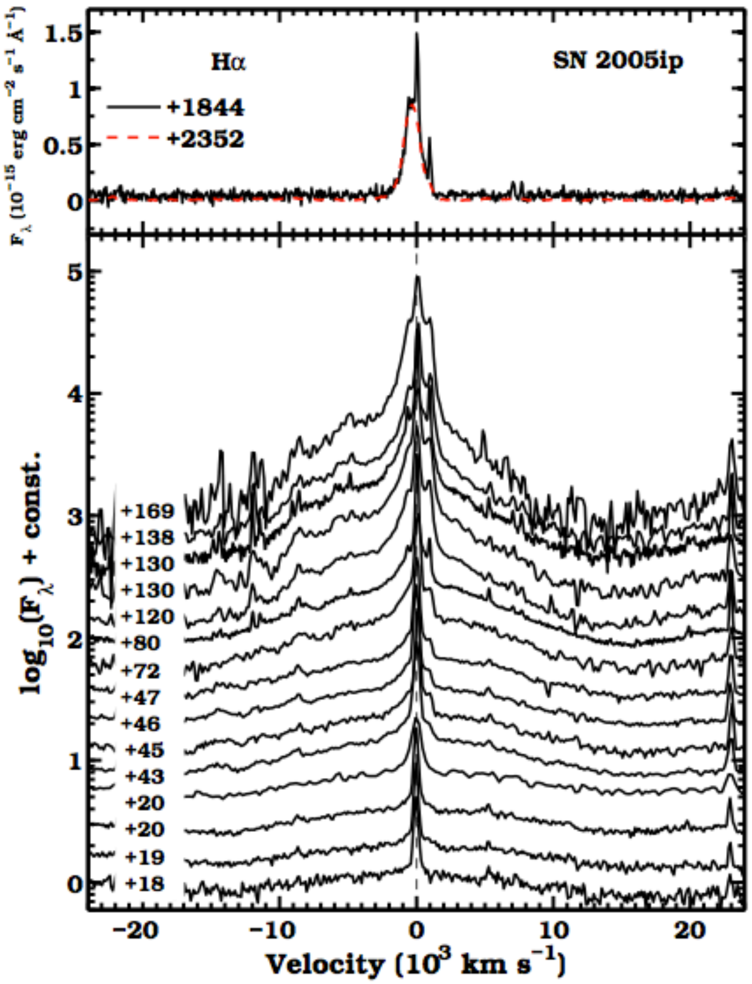
Smith et al. (2009)



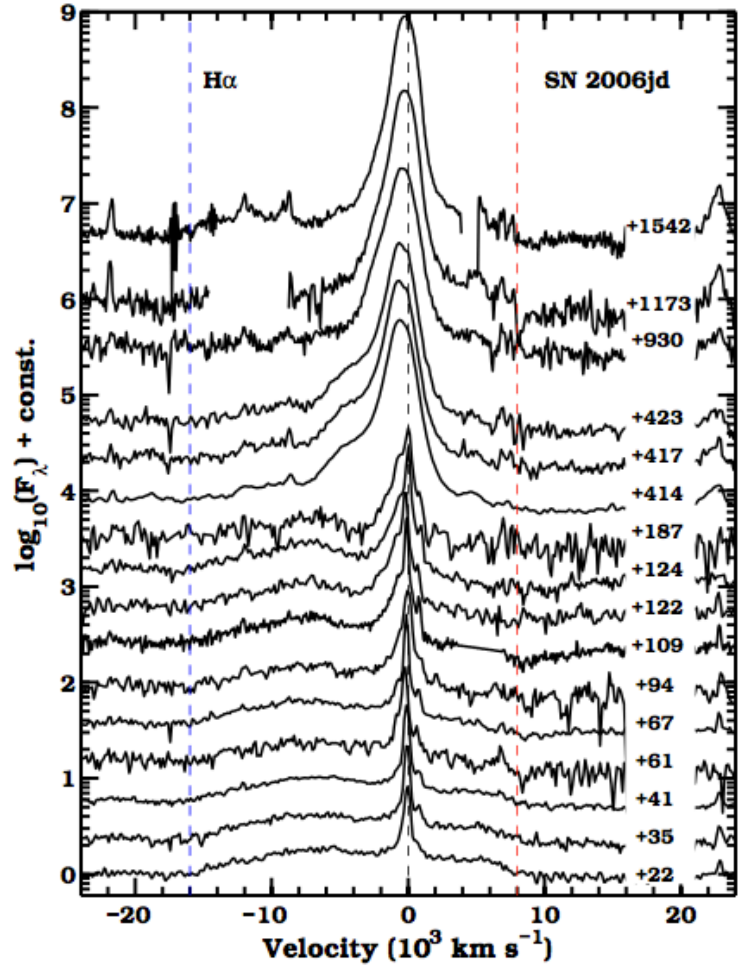
Stritzinger et al. (2012)

Coronal lines are observed to turn on early and last over the duration of the observations, however, in SN 2005ip they appear sooner and reach higher ionization potentials

Evolution of Hα line profiles



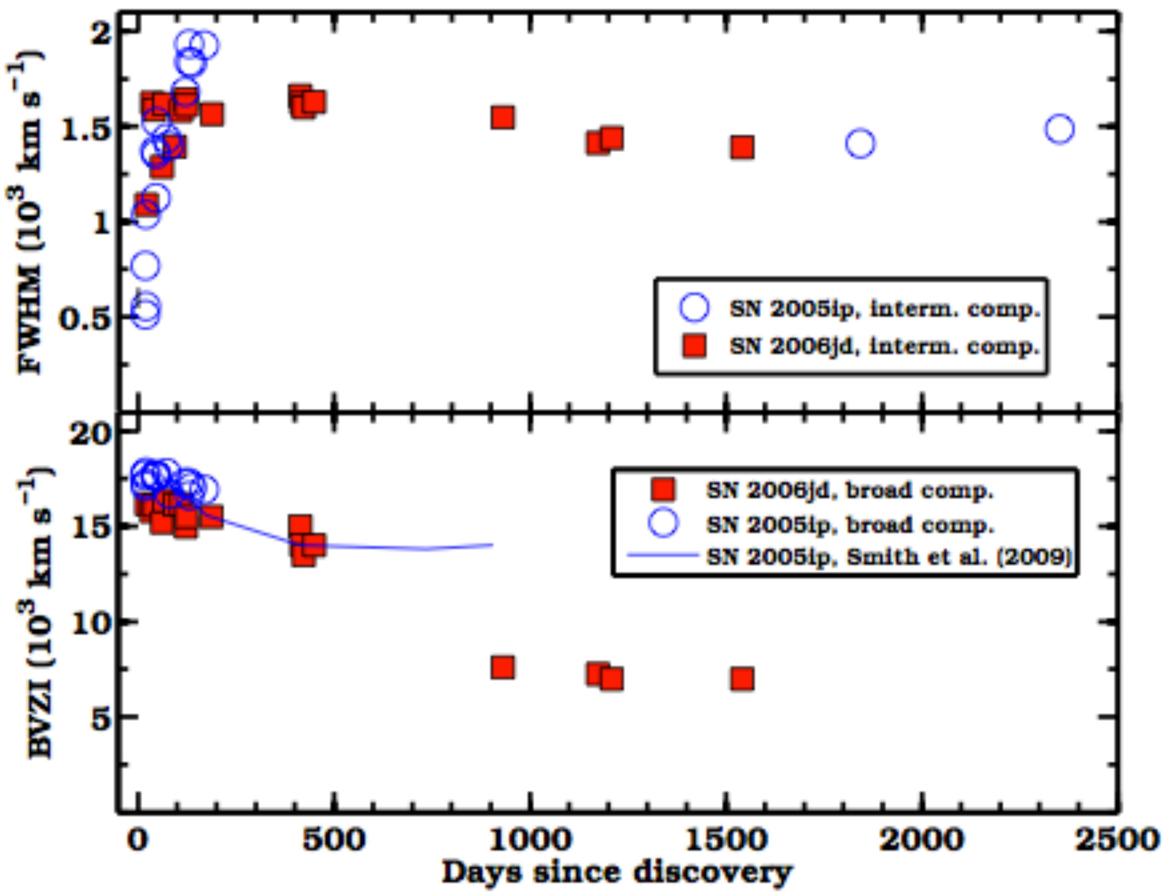
Symmetric broad component



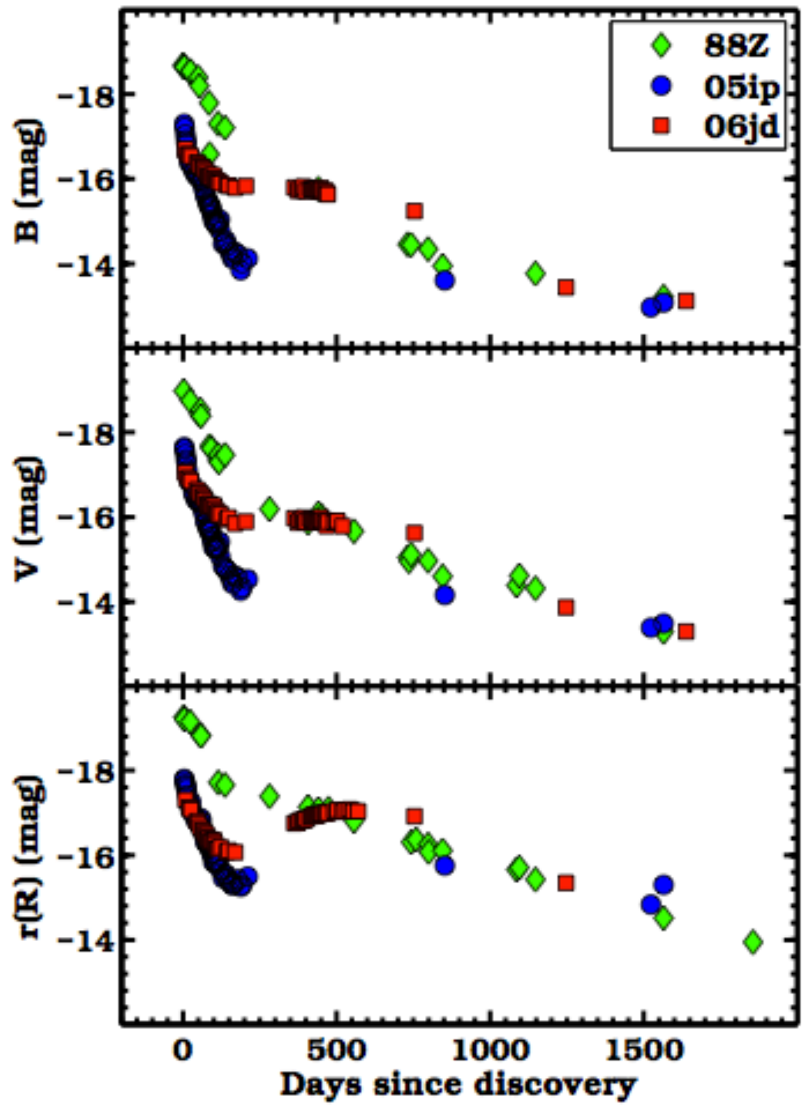
Asymmetric broad component

Evolution of broad- and intermediate width Hα components

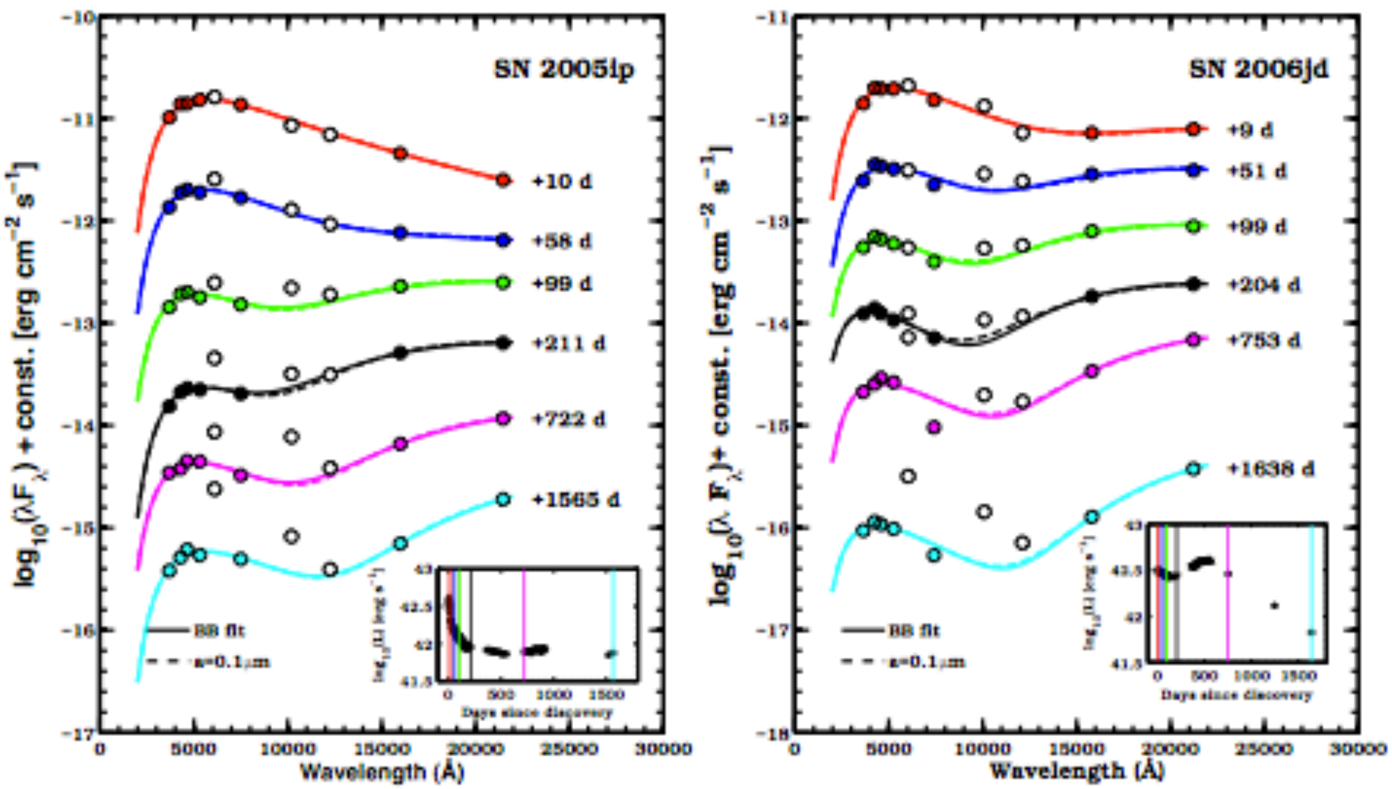
Providing Insight on the geometry of the CSM



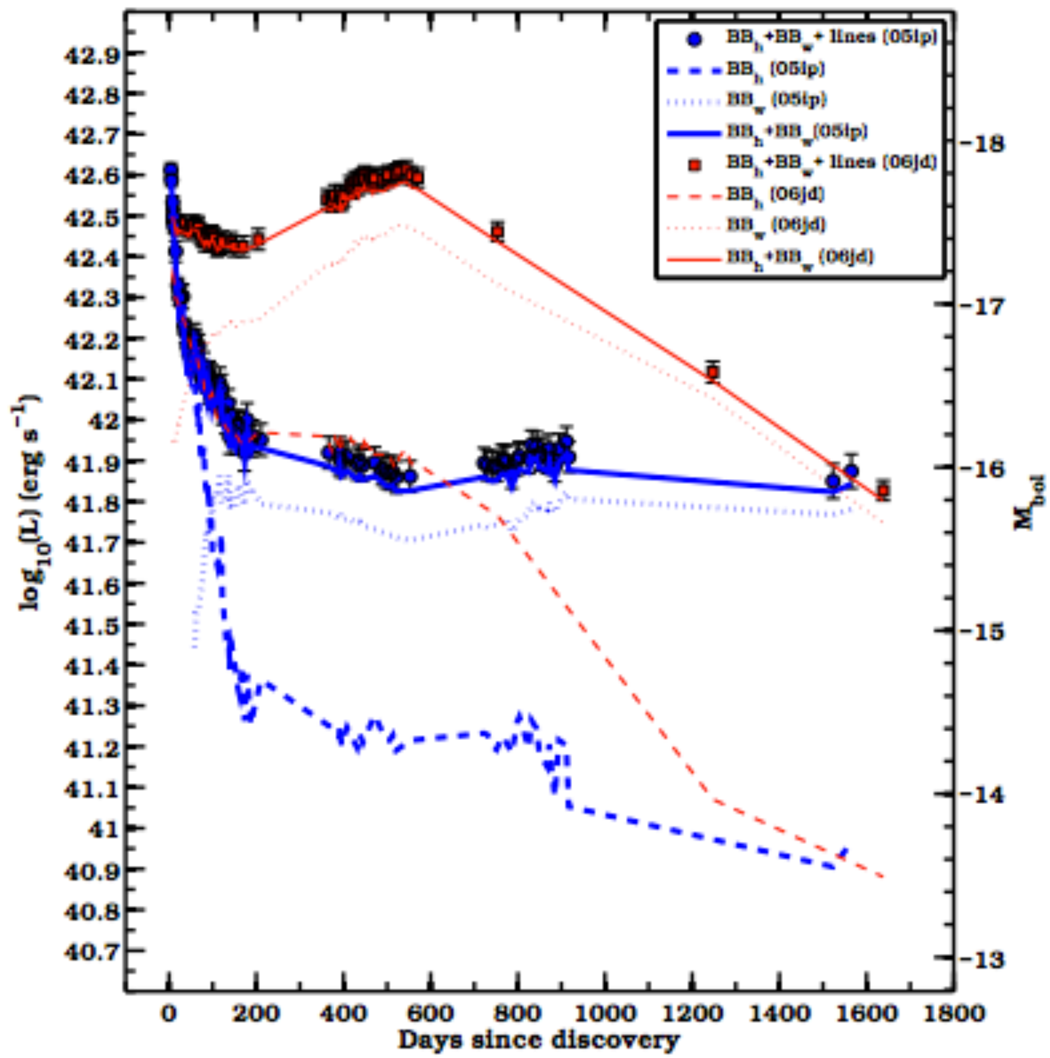
Comparison of absolute *BVr*-band light curves



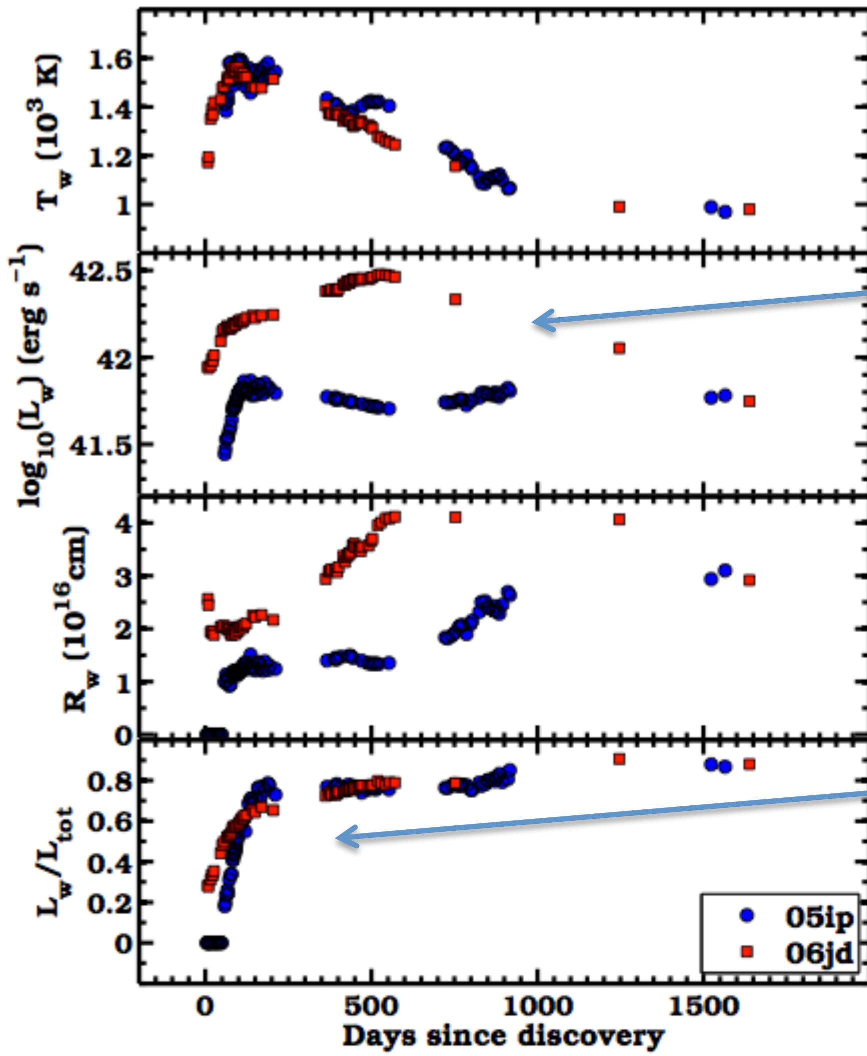
Black-body Fits to Broad-band Photometry



Lower limits on UVOIR luminosity



Constraints on warm component from *BB* fits to *HK*-band photometry



Presence of a warm dust component

Increased emission over time. Evidence for dust condensation?

Warning on discussion of DUST

"I would rather be ashes than dust!"

Jack London

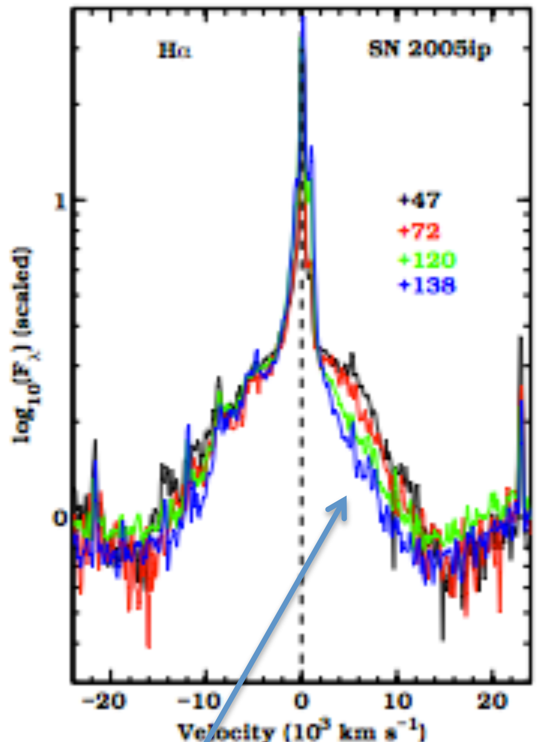
A few unknown or poor constrained parameters:

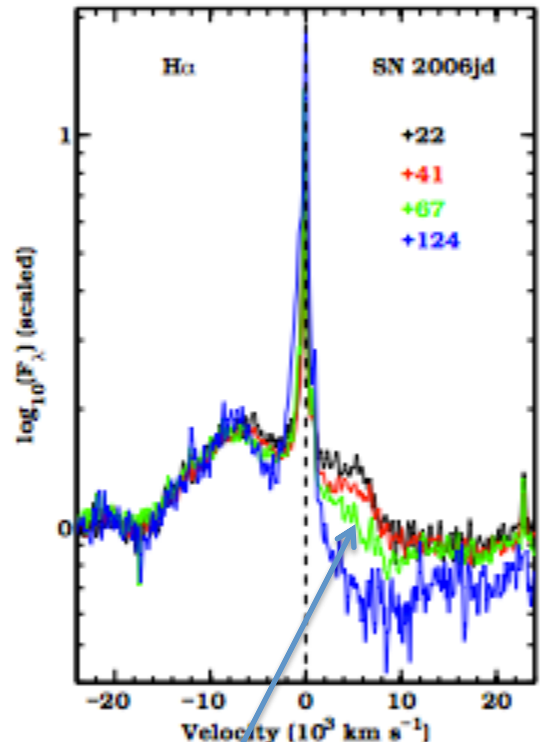
- grain composition
- grain size
- covering factor, i.e. geometry and distribution of the dust
- dust absorption vs. dust emission functions
- destruction efficiency
- etc... (see expert: Nozawa-san)

Indicators for Dust Formation in Type IIn Supernovae

- A rapid drop in optical flux, accompanied by an increase in IR emission ✔
- Long-duration IR excess ✔
- Increased attenuation of red-wing of emission line profiles ...???

Early Phase Warm Dust Condensation



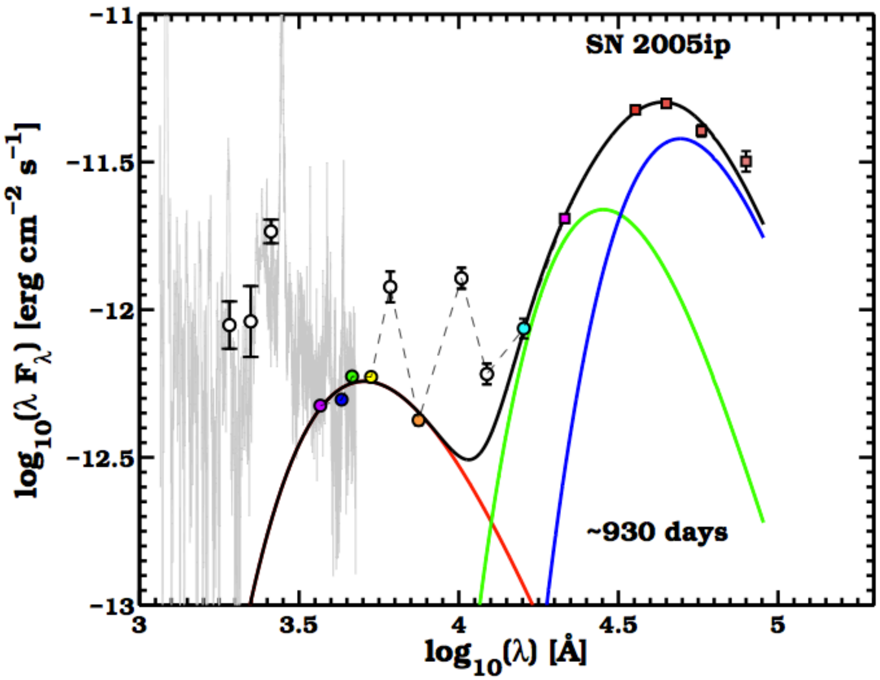


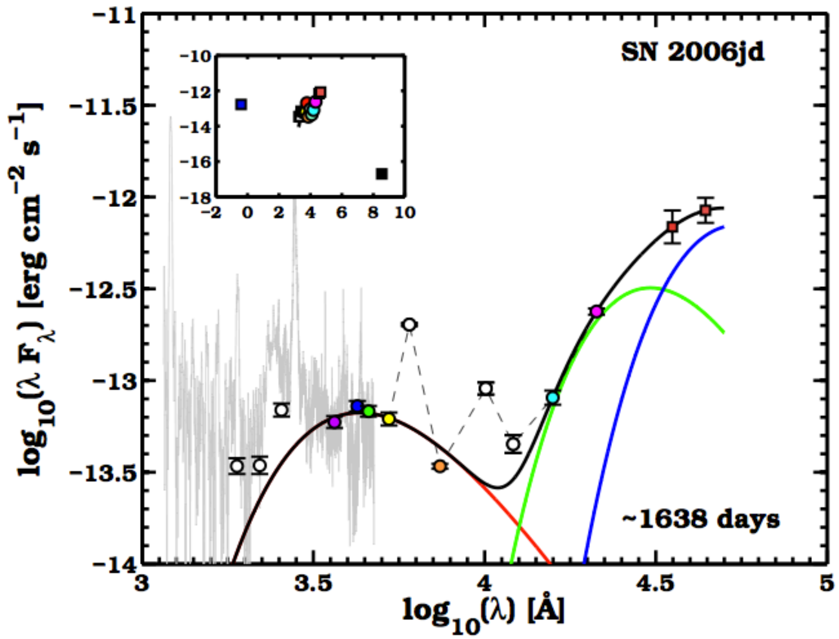
Yes!!!

Maybe or maybe not? Attenuation can be explained by occultation of the ejecta by disk.

Evidence of a pre-existing Cold Dust Component from *Spitzer* MIR Observations

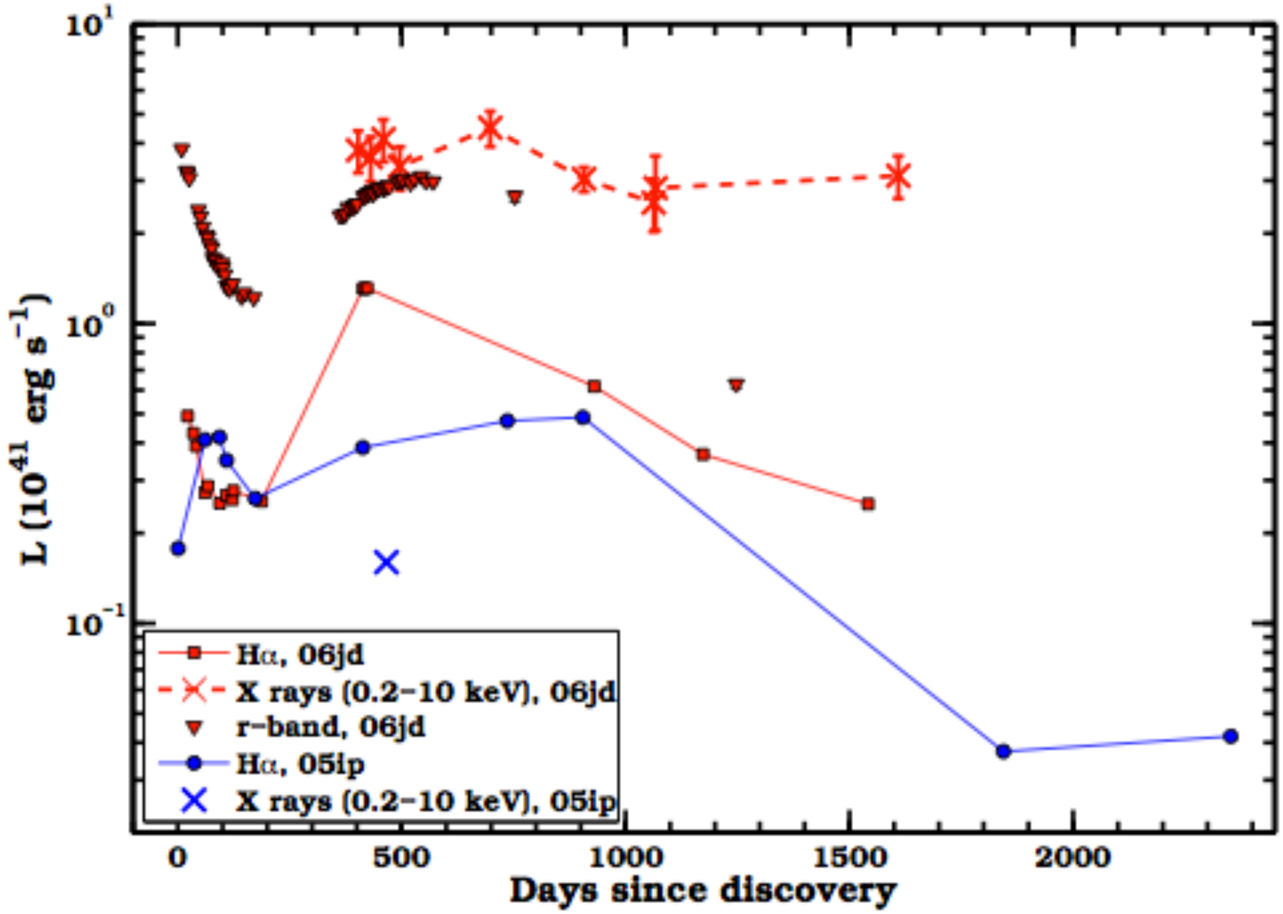
see also Fox et al. (2010, 2011)





Dust mass	SN 2005ip	SN 2006jd
Warm	0.2–6x10^{-4} $M_\odot$	0.7–9.8x10^{-4} $M_\odot$
Cold	0.01 $M_\odot$	0.02 $M_\odot$

X-ray and Hα emission



SN 2005ip: Immler & Pooley (2007)
SN 2006jd: Chandra et al. (2012)

Putting the pieces of this puzzle

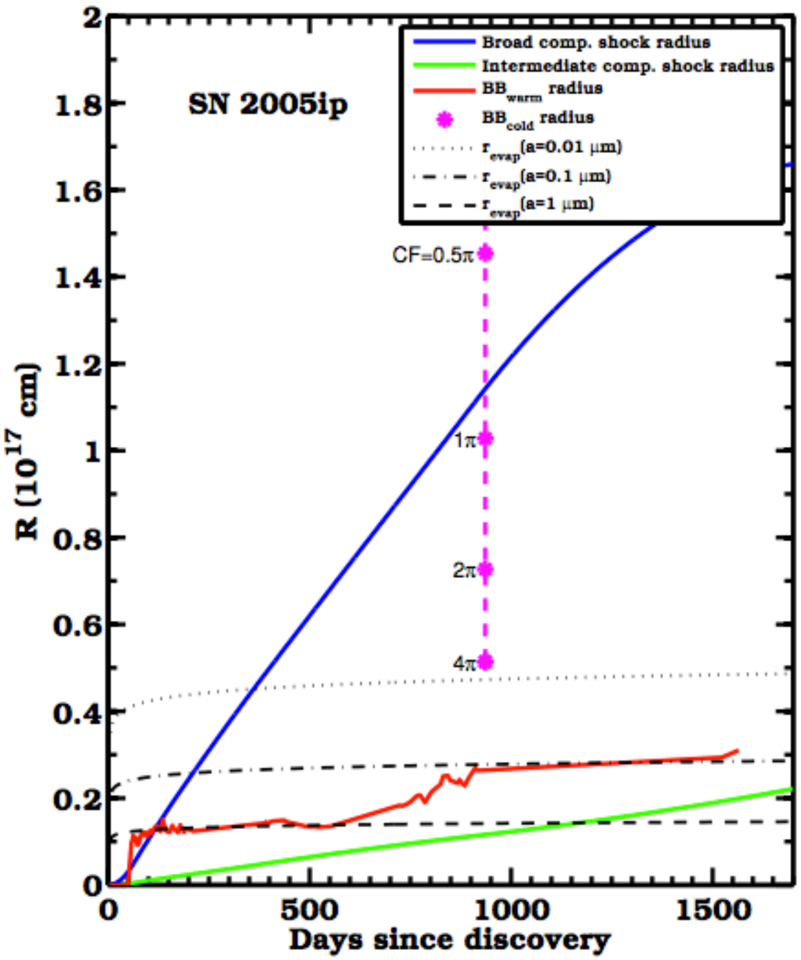
1. SN 2005ip

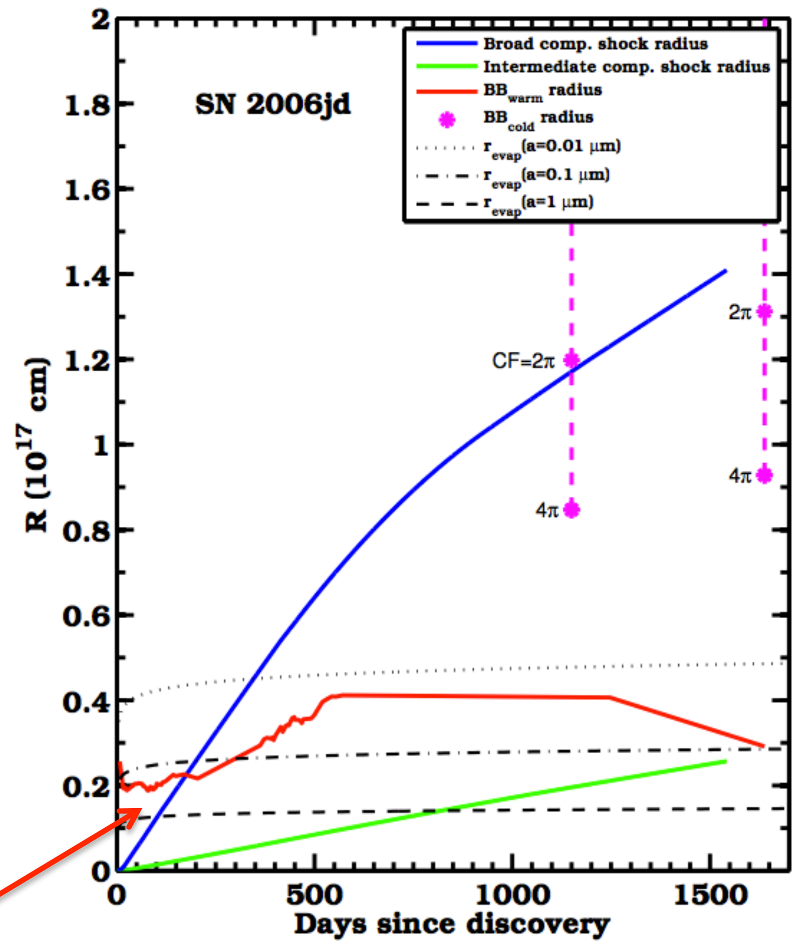
- Symmetric broad Hα profile
- High-ionization lines that turn on early and remain for the duration of obs.
- X-ray luminosities and a range of densities derived from intermediate-width components

2. SN 2006jd

- Asymmetric broad Hα profile
- r-band excess (SN shock interaction with dense shell)
- flat and long lasting X-ray emission (again dense shell)
- densities on the order of > 10^6 cm^3 (again dense shell)

Putting the pieces of this puzzle II.





Consistent with location of pre-existing warm dust component associated with dense shell!

Conclusions

SNe 2005ip and 2006jd exhibit many similarities, however diversity is apparent including, amongst others:

- light curve morphologies
- X-ray luminosities
- ionization potential of the coronal lines

The progenitor of SN 2006jd appears to be aligned with an Eta Car-like star, while the observational signatures of SN 2005ip are best explained with RSG-like progenitor having a (clumpy) super-wind, or perhaps mass ejections of a less extreme nature, e.g. pulsation-driven winds (Herger et al. 1997; Cantiello & Yoon 2010).

Finally, the range of SN-IIn luminosities is most likely connected to the mass-loss history of the progenitor during its pre-SN phase.