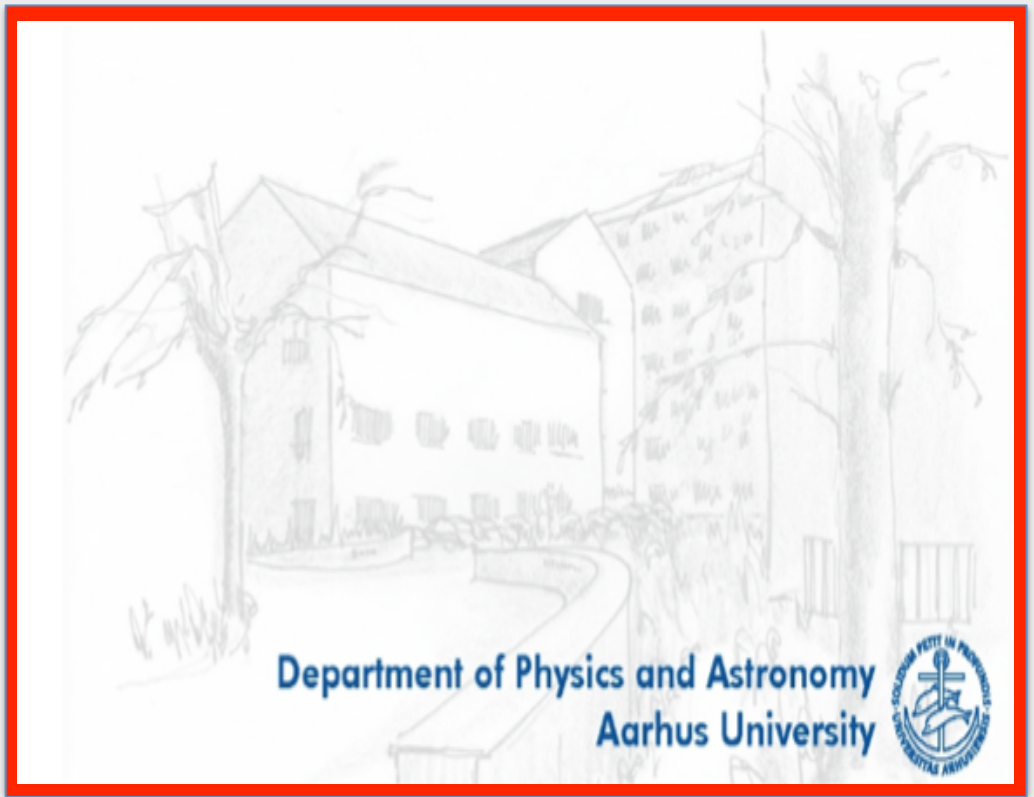
CSP-II working group meetin 2013

Maximilian Stritzinger
Århus University

Housed in "Eagles Nest"



Current Work Packages

Recent Past

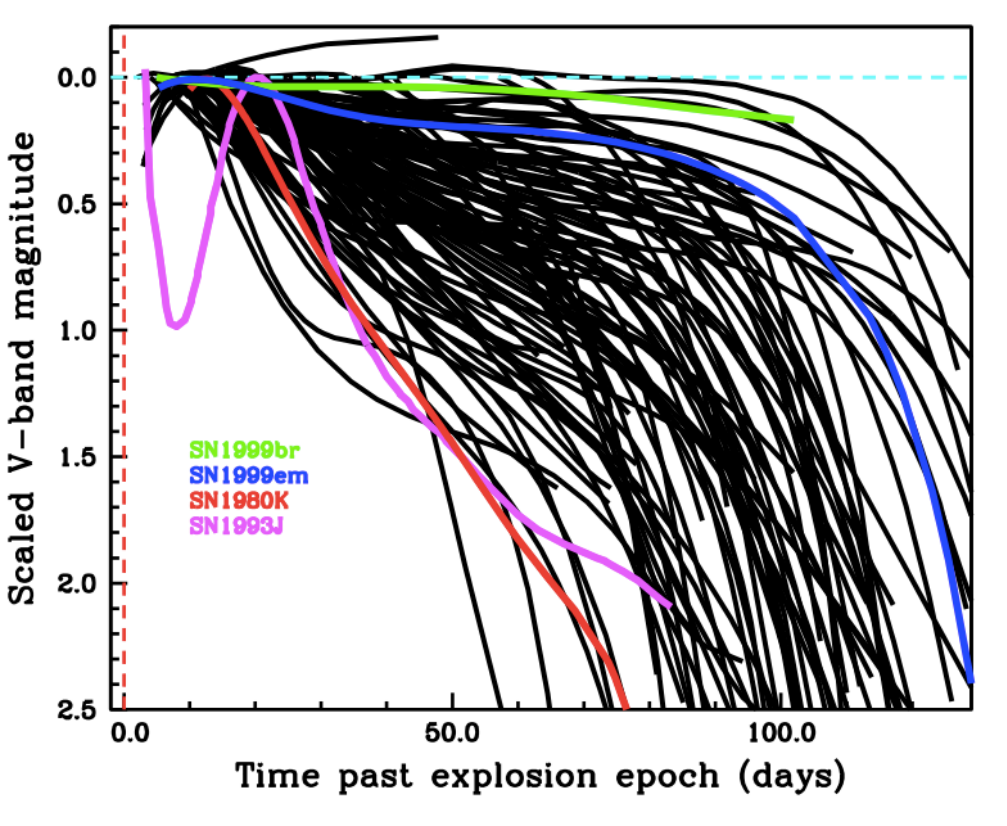
- *SNe IIn*
  2005ip/2006jd Stritzinger et al. 2012
  Sample paper Taddia, MS., et al. 2013
- *SN 2008J CSM/Type Ia: Taddia, MS., et al. 2012*

Current

- Near-IR K-corrections (Let's bury this project!)
- CSP Type Ibc SN sample
- The faint and fast SN 2010ae

Type IIP Supernovae: results are coming...

- 116 V-band light curves
- Mean M_V=-16.7 σ=1.01
- Brighter the SN, the faster its decline at all phases (linear correlation)
- Range in plateau time-scales
- Type IIL SN are either very rare or non-existent!



Anderson et al., submitted

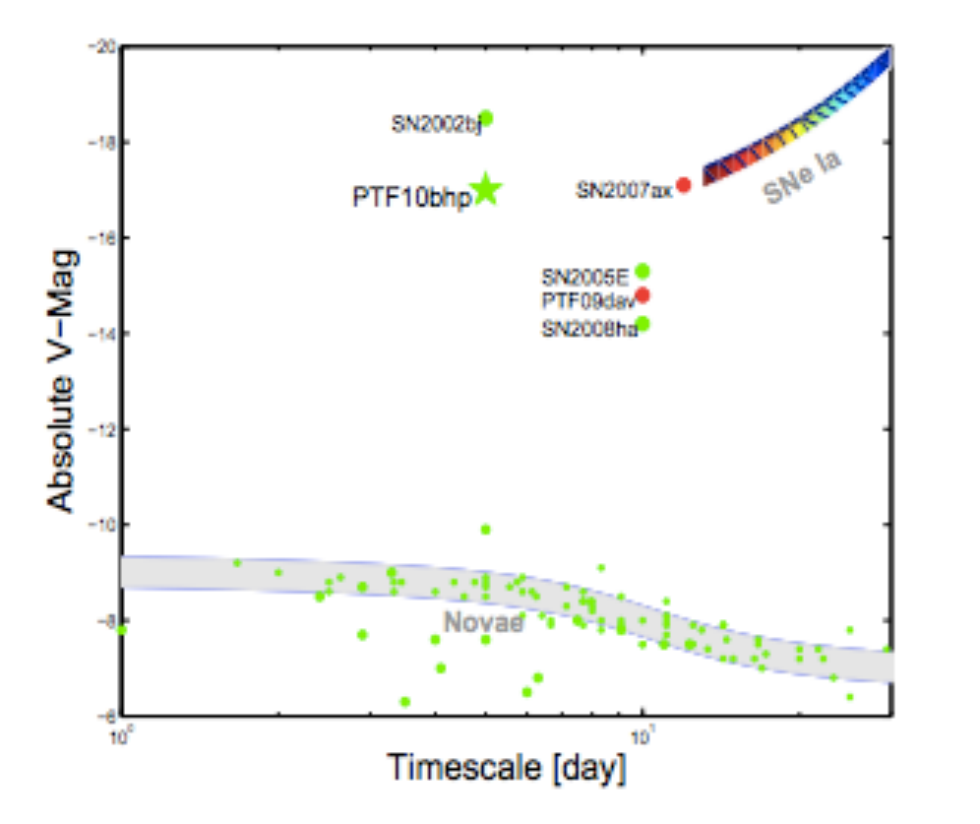
News Flash

- *CSP-I NIR spectroscopy sample of ~100 spectra 2/3 reduced*

→ *This includes All VLT & Sofi data (SOAR+OSIRIS is left)*

- *All CSP-II VLT NIR spectra are reduced (20hrs)*

Bridging the Gap



Kasliwal et al. 2010

Optical and Near-IR Observations of the Faint and Fast 2008ha-like Supernova 2010ae*

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Abstract

A comprehensive set of optical and near-infrared (NIR) photometry and spectroscopy is presented for the faint and fast 2008ha-like SN 2010ae. Contingent on the adopted value of host extinction SN 2010ae reached a peak brightness of $\sim -13.8 > M_V > -15.3$ mag, while modeling of the UVOIR light curve suggests it produced 0.003–0.007 $M_\odot$ of ^{56}Ni, ejected $\sim$ 0.30–0.60 $M_\odot$ of material, and had an explosion energy of $\sim$ 0.04–0.30$\times 10^{49}$ erg. The values of these explosion parameters are similar to the peculiar SN 2008ha –for which we also present previously unpublished early phase optical and NIR light curves– and places these two transients at the faint end of the 2002cx-like SN population. Detailed inspection of the post maximum NIR spectroscopic sequence reveals the presence of a multitude of spectral features, which are identified through SYNAPPS modeling to be mainly attributed to Co II. Comparison with published NIR spectra of SN 2005hk and new NIR spectra of SNe 2008ge, 2010ae, and 2012Z reveals these features to be ubiquitous to the 2002cx-like SN subclass. A visual-wavelength spectrum of SN 2010ae obtained +252 days past maximum reveals a strong resemblance to a similar epoch spectrum of SN 2002cx. However subtle difference in the strength and ratio of Calcium emission features, as well as diversity amongst similar epoch spectra of other 2002cx-like SNe indicates a range of physical conditions of the ejecta, highlighting the heterogeneous nature of this peculiar class of transients.

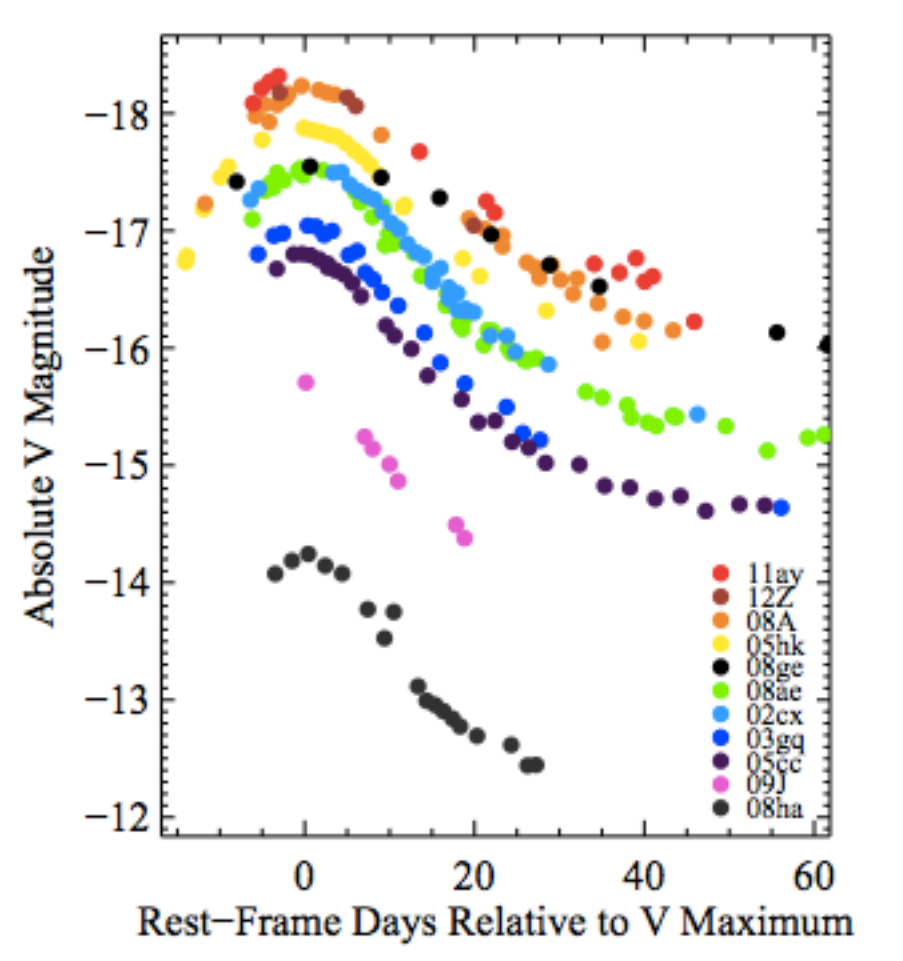
Key words. supernovae: general – supernovae: individual: SN 2008ha, SN 2010ae

Summary of SNe Iax (2002cx-like)

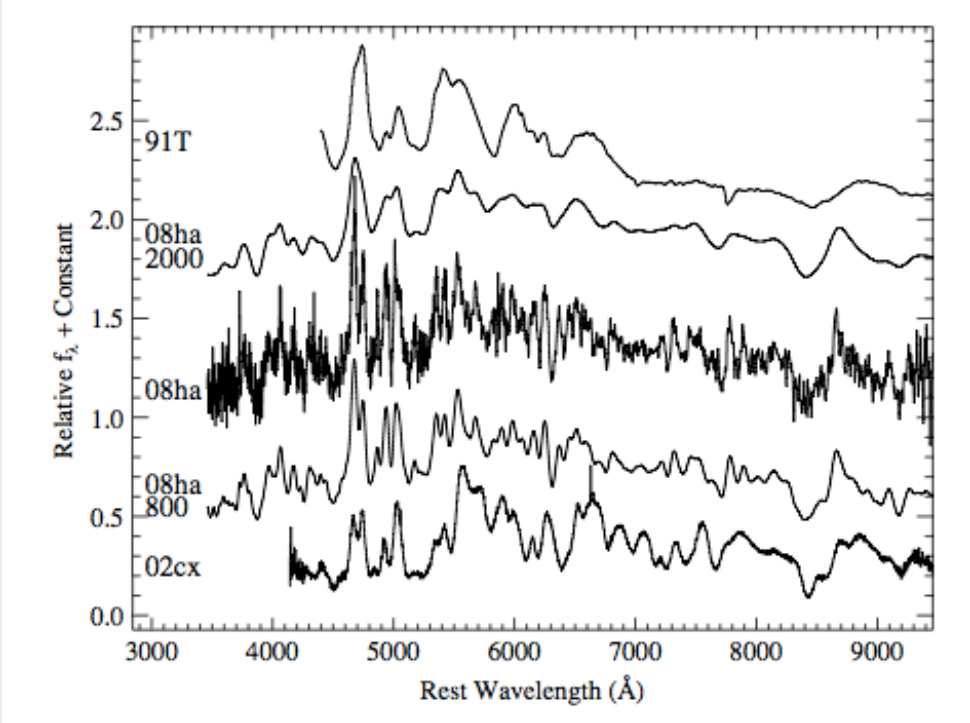
- Bizarre & Coarsely similar to normal SNe Ia
- Significant range in luminosity (-18.5 < M < -14 mag)
  → small ^{56}Ni content, and do not *really* obey a LWR
- NIR bands peak well after optical bands
- No secondary maximum in the NIR
- Hot spectra with low velocities
- Small inferred ejected mass ≤ 0.5 $M_{\odot}$
- Late phase spectra are just odd, not truly nebular!

- Tend to occur in late-time galaxies, low metallicity?
- 1/3 of the overall SNe Ia rate (Foley et al. 2013)

SN 2008ha the first extreme faint and fast SN Iax



Foley et al. (2013)

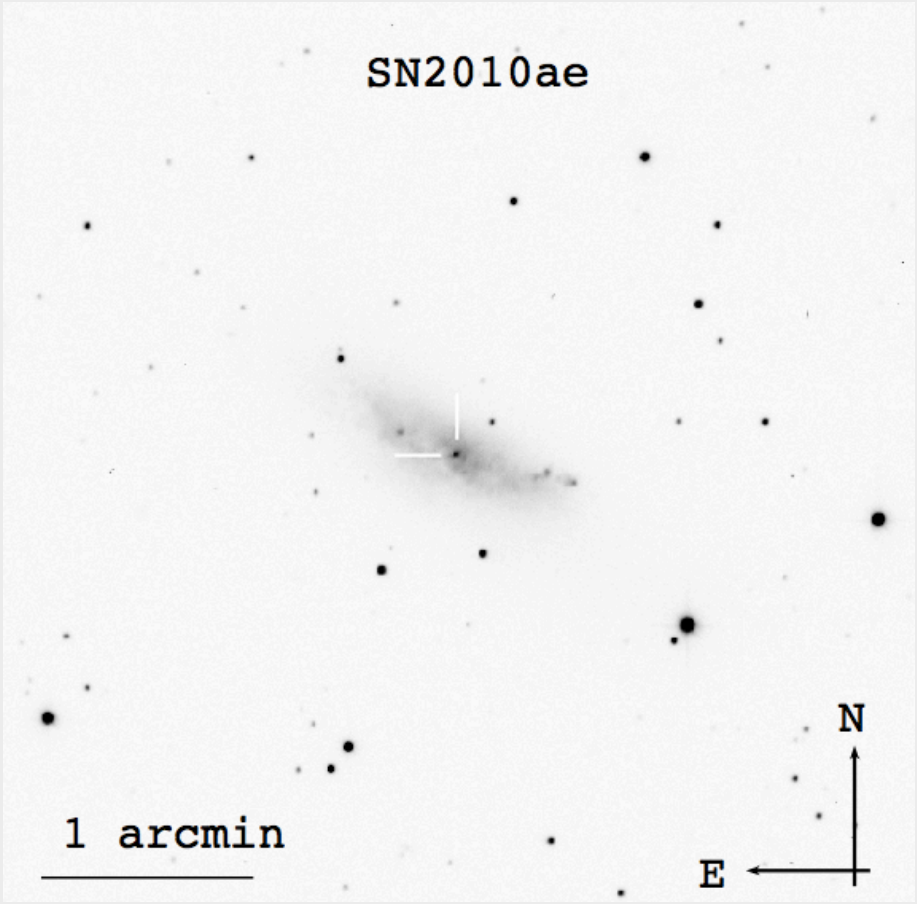


Foley et al. 2009;
see also Valenti et al. (2009)

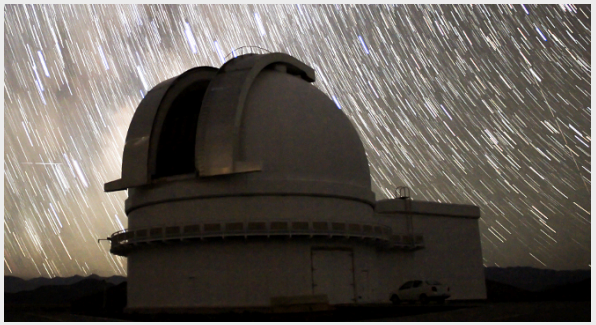
Supernova 2010ae

- Discovered by CHASE within a week of explosion (Pignata et al. 2010)

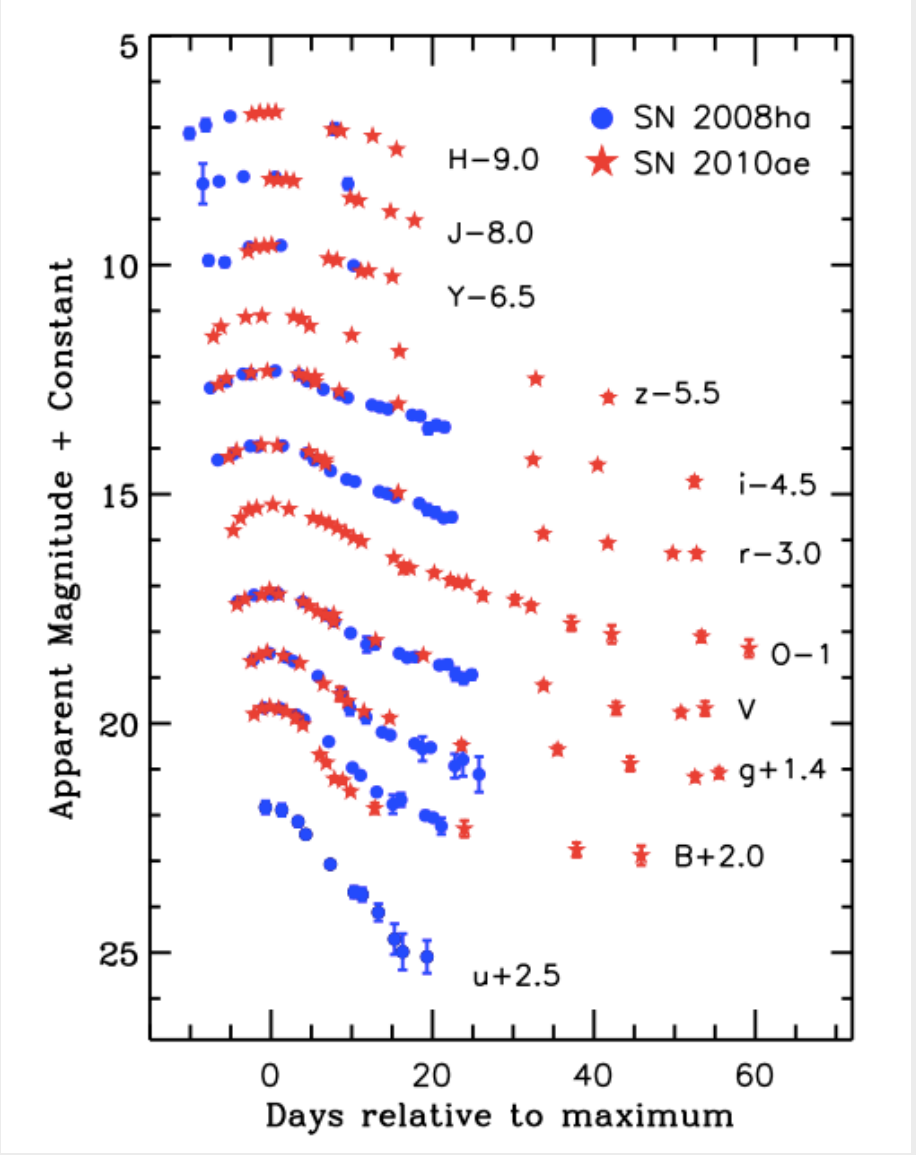
- Classified as a bright SN, but soon after realized it to be a low-luminosity 2002cx-like



Optical and Near-IR Light Curves

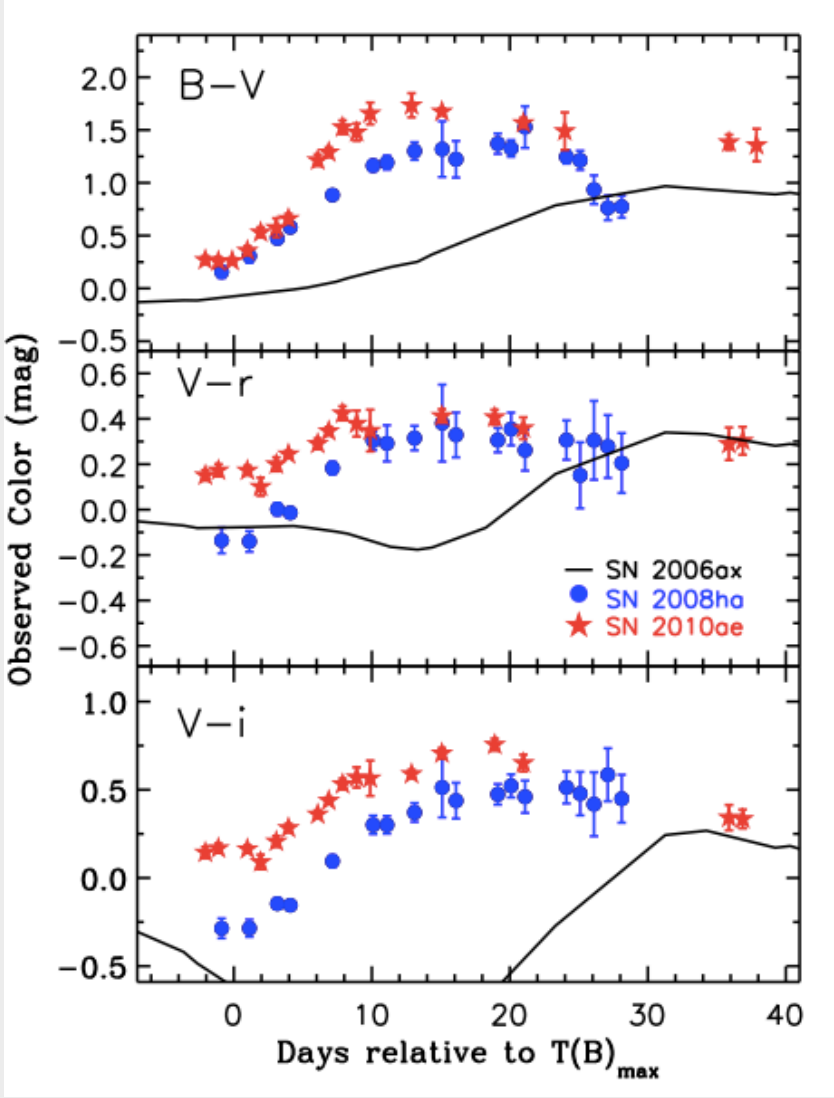


- NIR bands peak ≈ 7 days *after* the optical

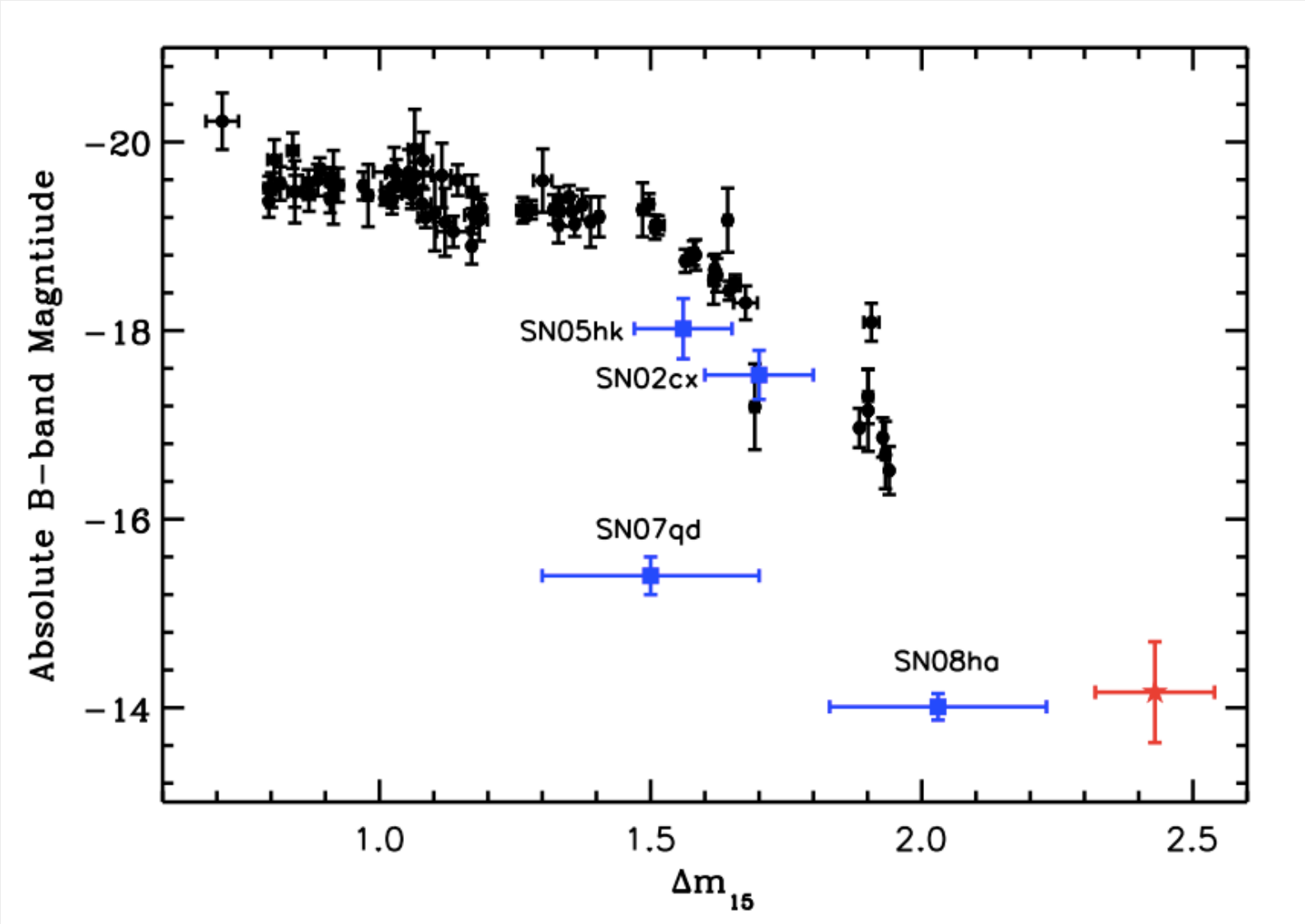


Reddening is *poorly* constrained

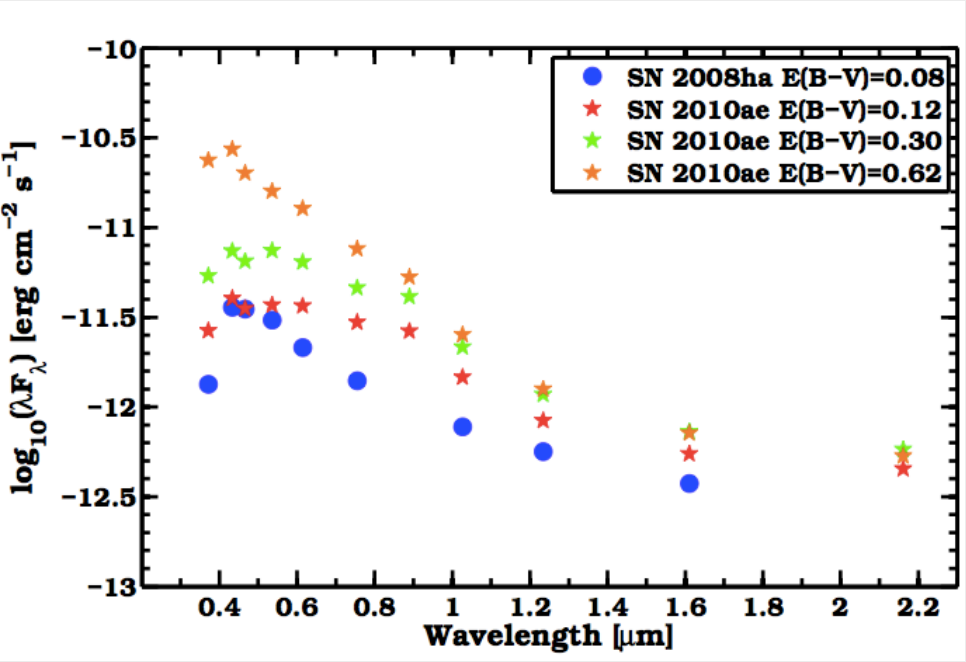
- NaID1 = 0.74±0.06 Å;
  NaID2 = 0.58±0.06 Å
- Galactic Na I and EBV relations imply EBV_{host}=0.45 mag
- Combined with Milky Way gives EBV_{tot}=0.62±**0.42** mag
- Choice a range from MW to moderate to total

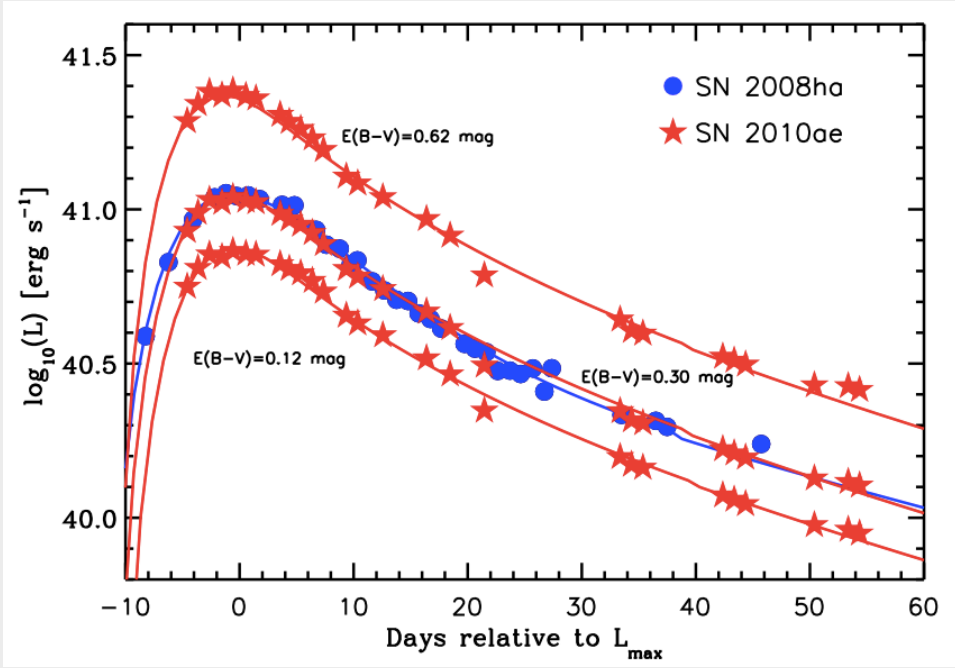


Abs. Mag. vs. dm15



SEDs & UVOIR LC analysis

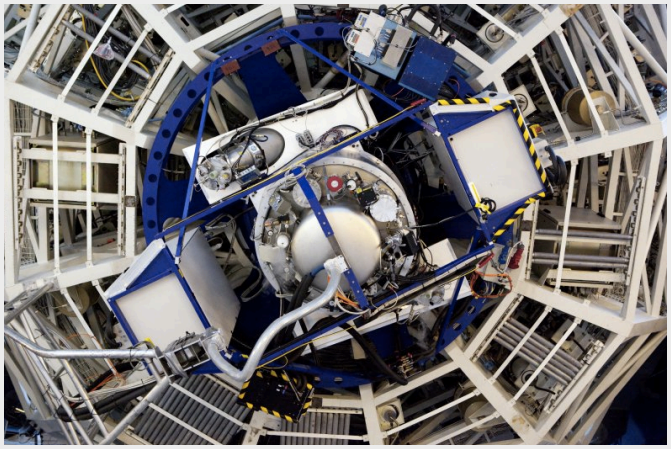


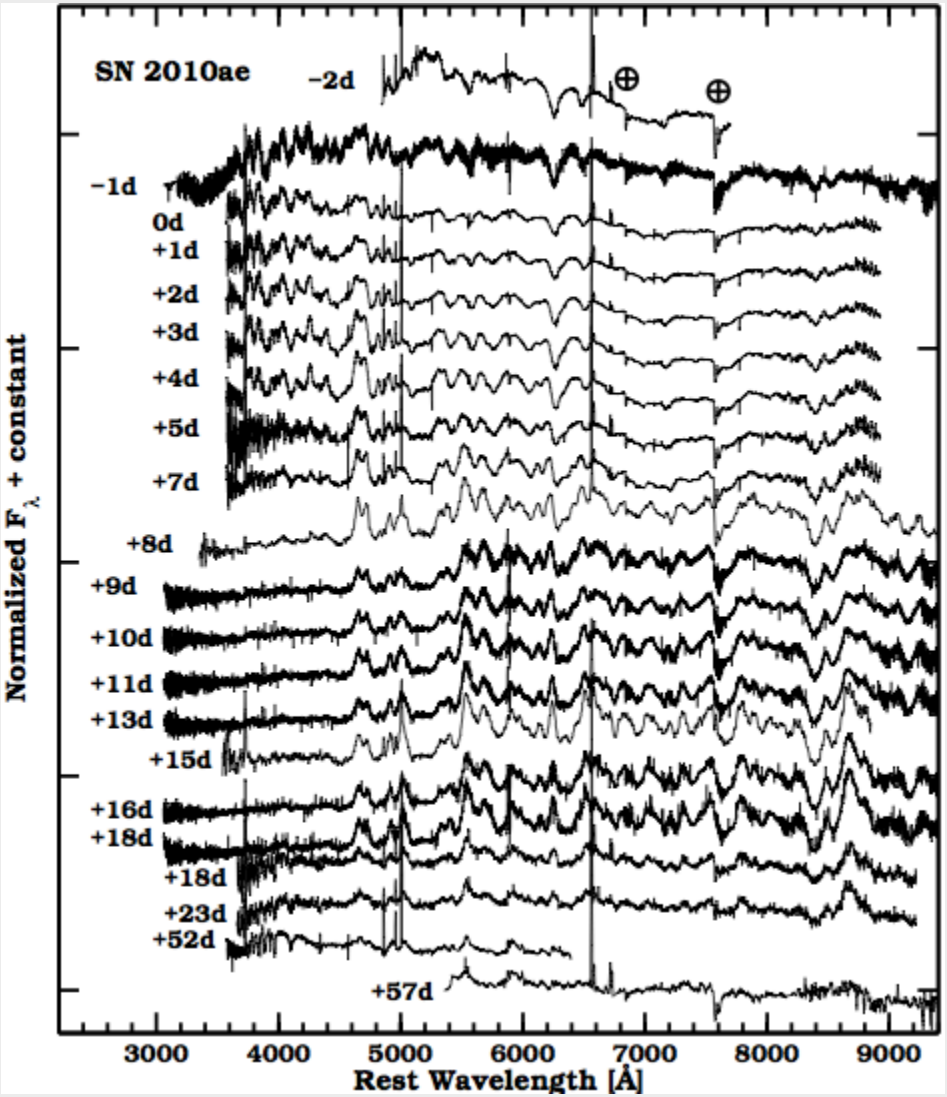


Arnett's equations give:

- ^{56}Ni content ≈0.003-0.007 $M_\odot$
- Ejecta Mass ≈0.3-0.6 $M_\odot$
- E_K ≈0.04-0.30x10^{49} erg

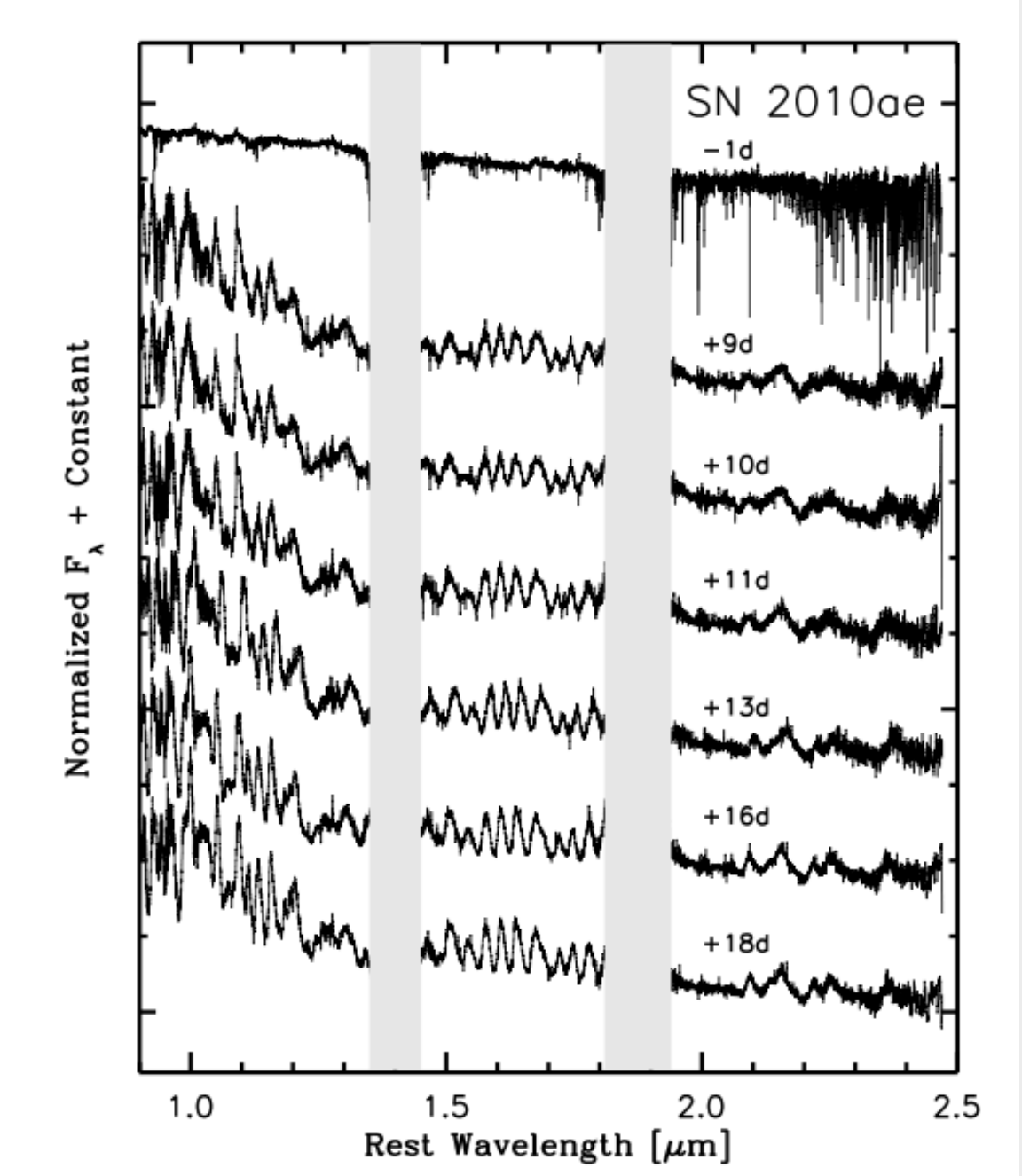
Optical Spectroscopy



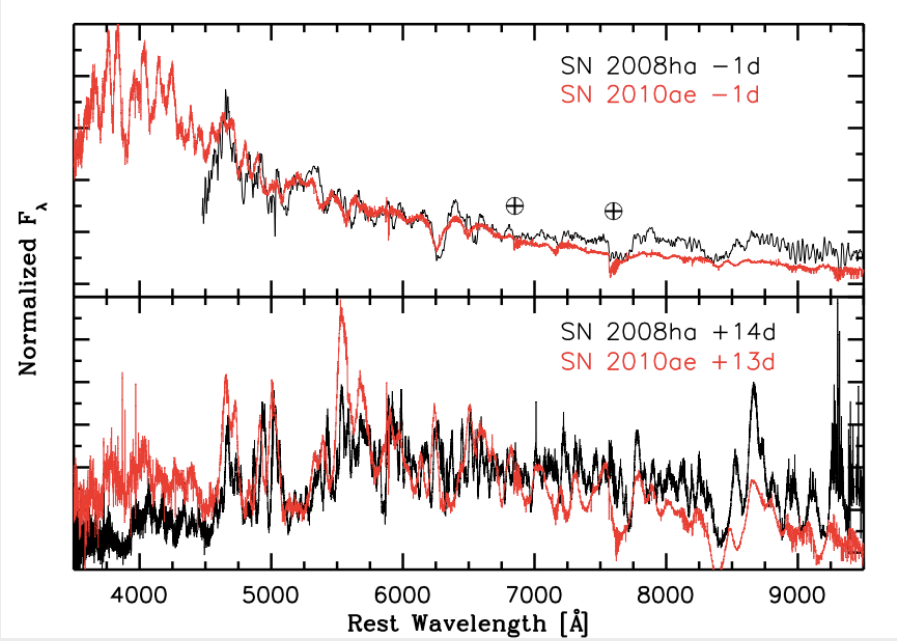


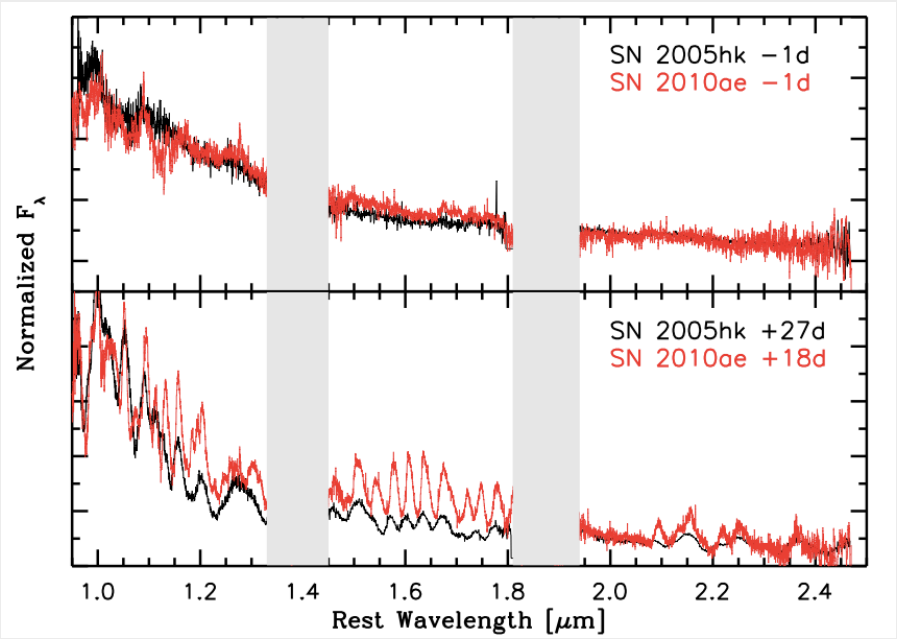
etcetera

NIR Spectra

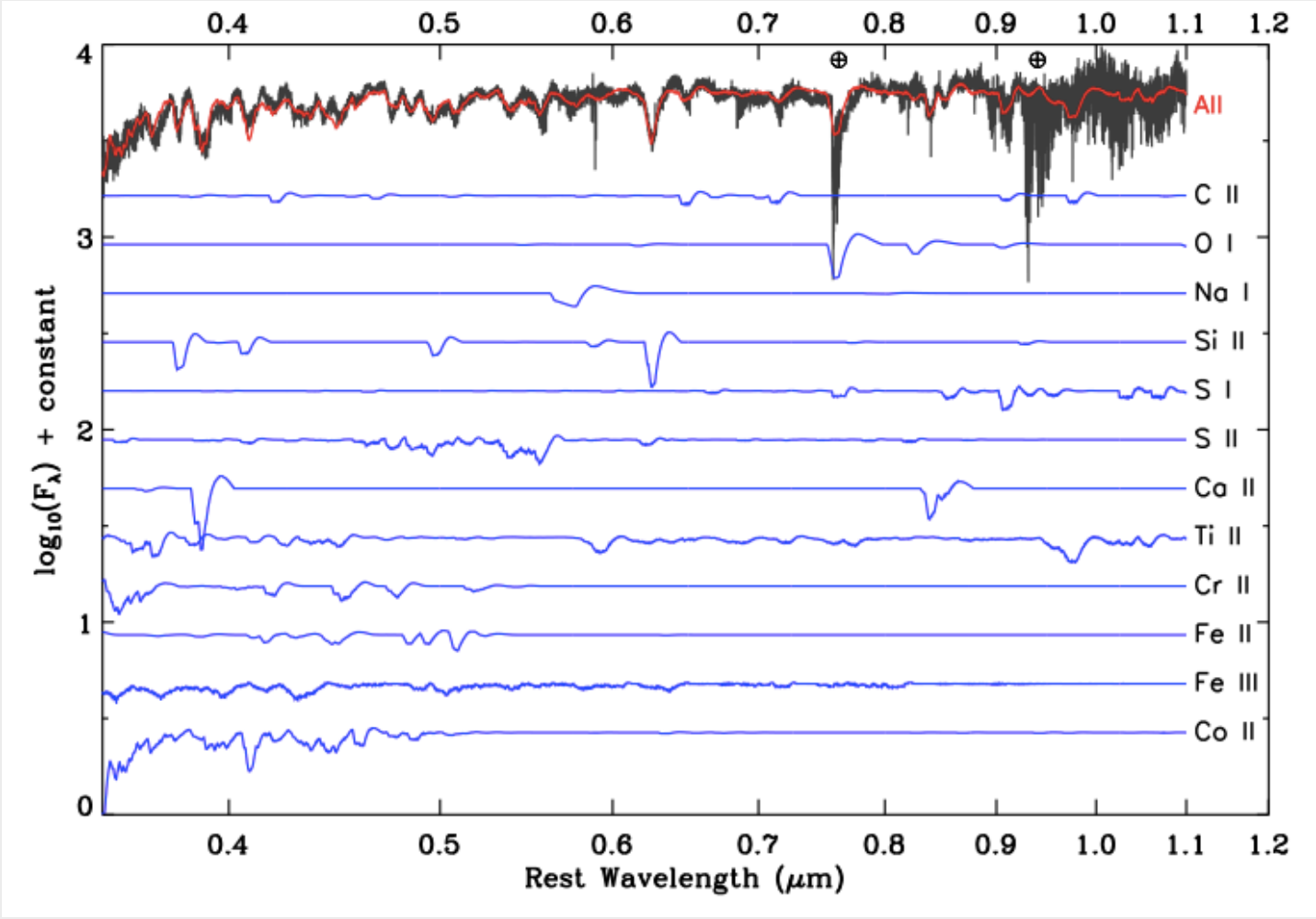

SN 2010ae
−1d
+9d
+10d
+11d
+13d
+16d
+18d
Normalized F_λ + Constant
1.0
1.5
2.0
2.5
Rest Wavelength [μm]

Spectral comparison to SN 2008ha



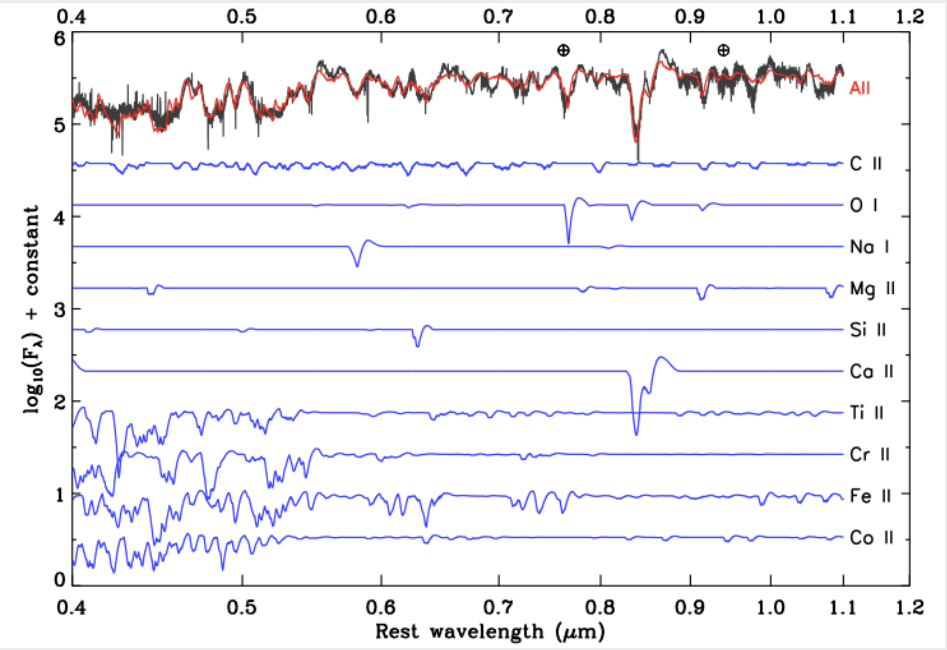


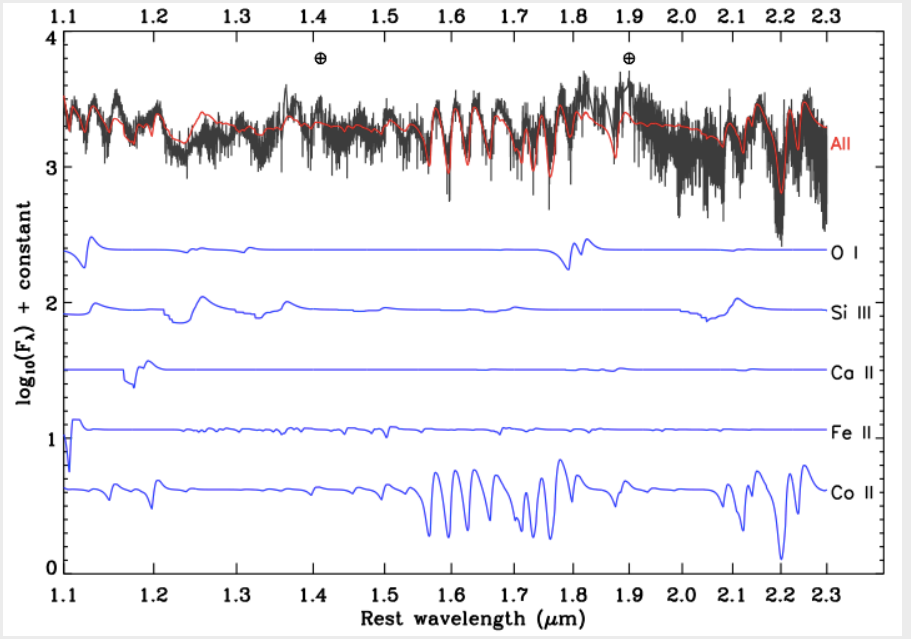
ID of spectral features I.



via SYNAPPS

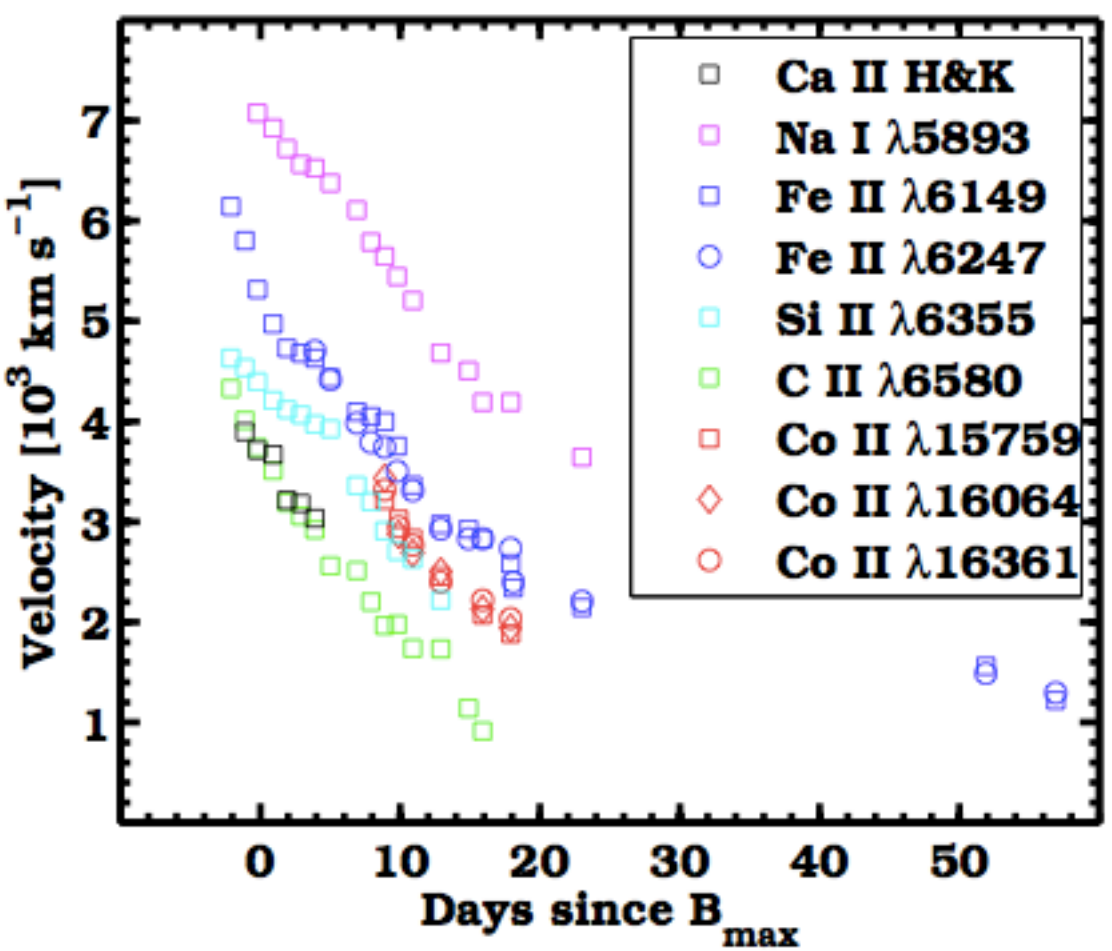
ID of spectral features II.



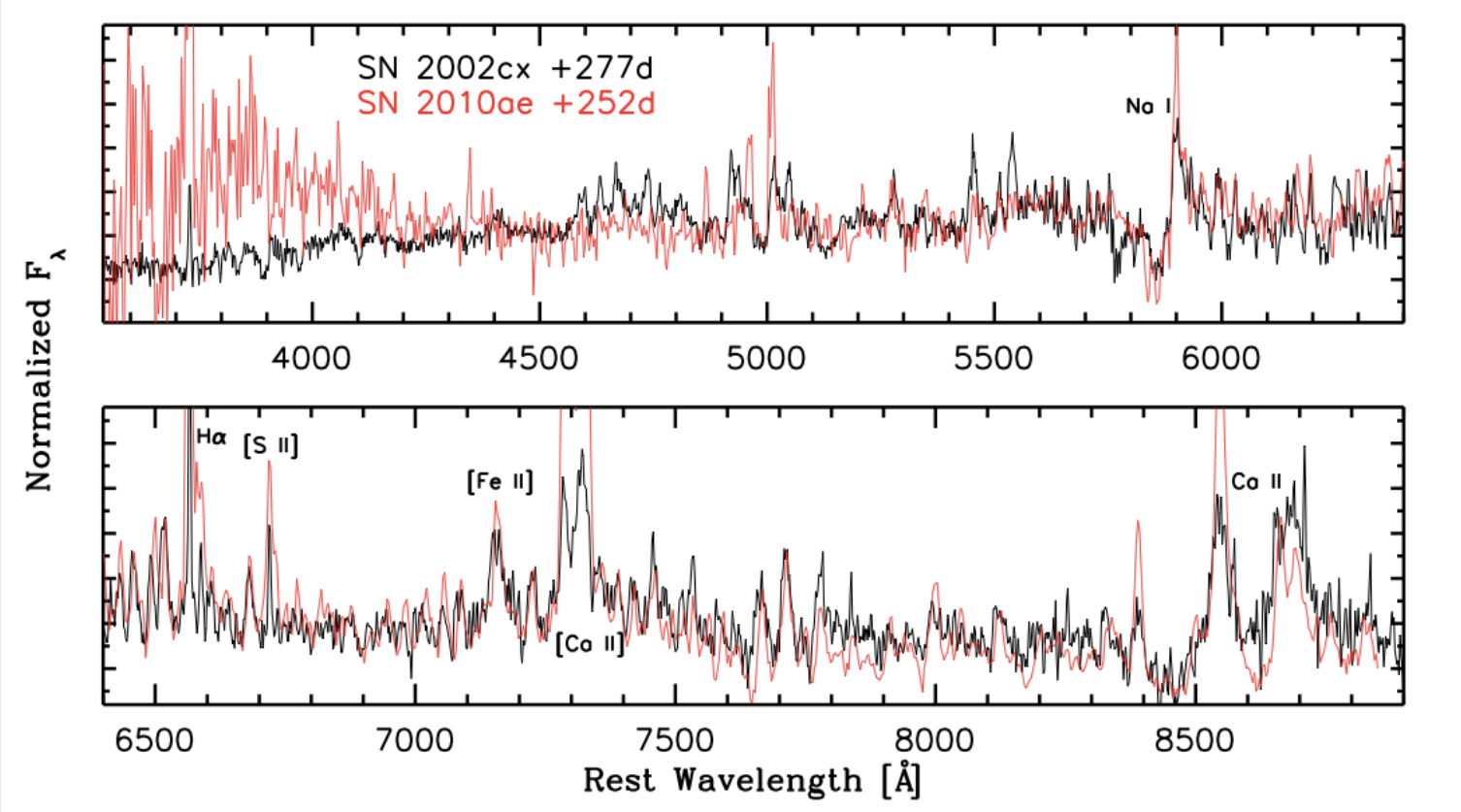


via SYNAPPS

Optical and NIR Line Velocities

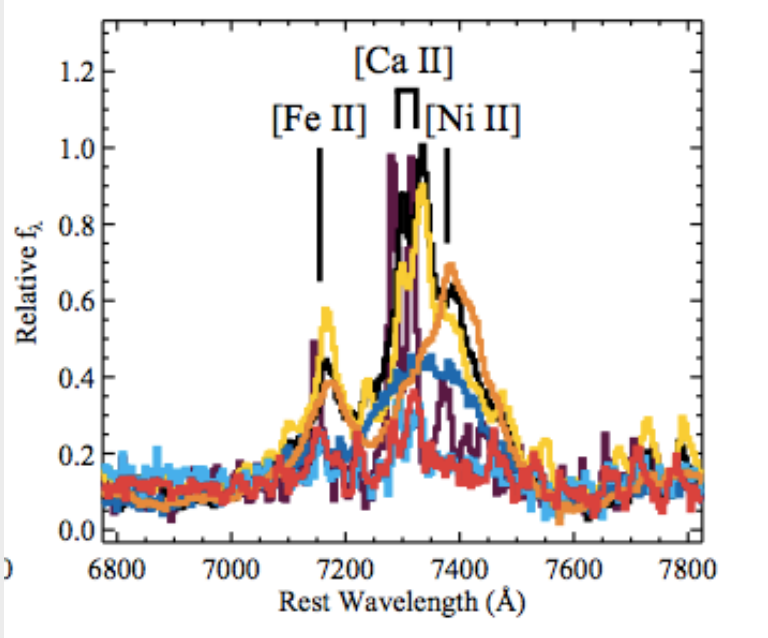


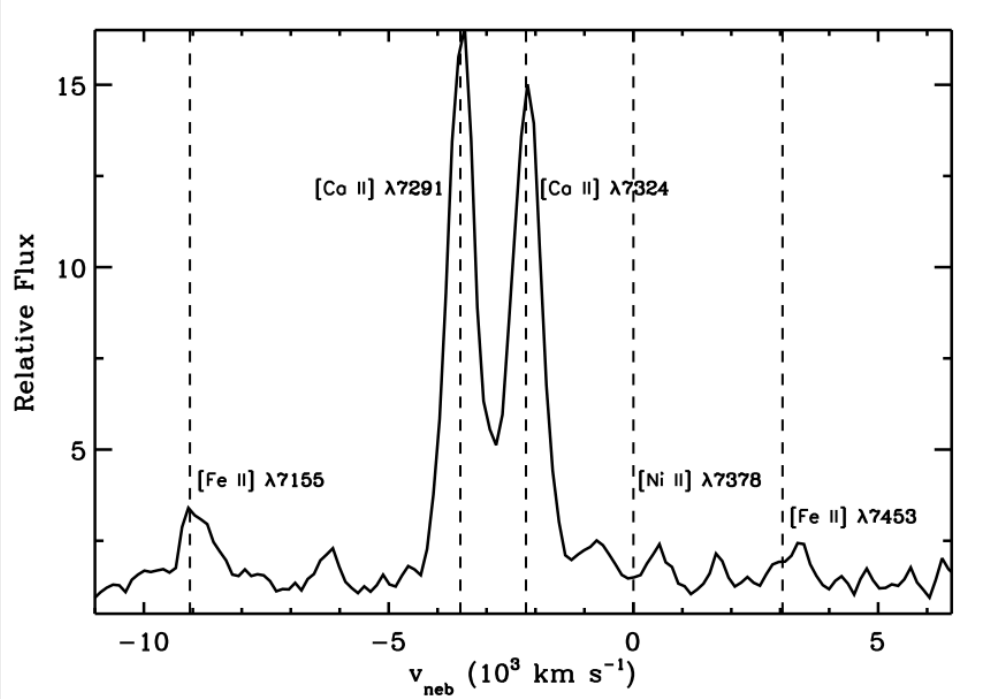
Late phase VLT spectrum



- No Fe III/Fe II
- No Oxygen
- Prevalent Ca lines
- Like 2002cx, *but not exactly*

What does late phase spectrum reveal?





Foley et al. (2013)

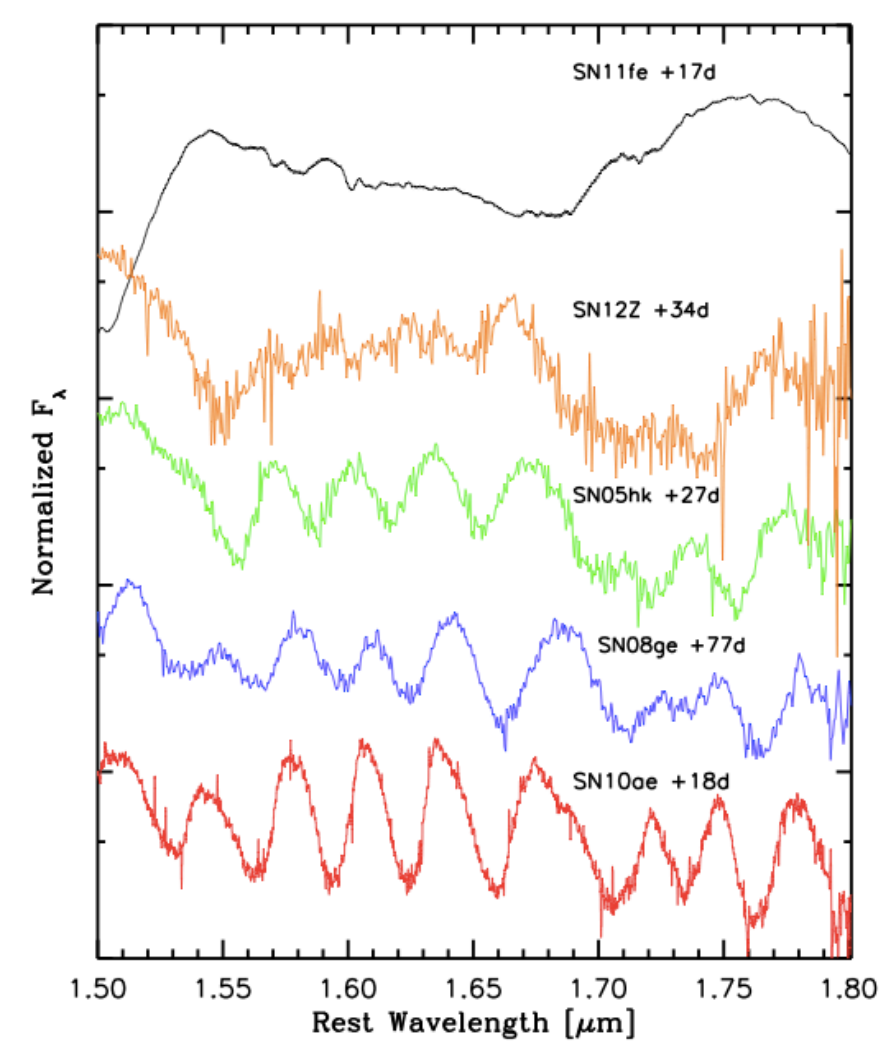
- No stable Ni (like 2002cx and unlike 2008ge)
- No appreciable velocity offsets for [Fe II], [Ca II], Ca NIR tripet
- Prevalent [Ca II] and Ca lines, unlike 2002cx
- Ejecta of SN2010ae is a factor of 4 less than 2002cx, or several 1000 K less hot
- Diversity in stable Ni (+Fe) could be either consistent or not with failed-deflagration?

New Insight from NIR spectroscopy

- Co II features are ubiquitous to SN Iax
- Smaller velocities

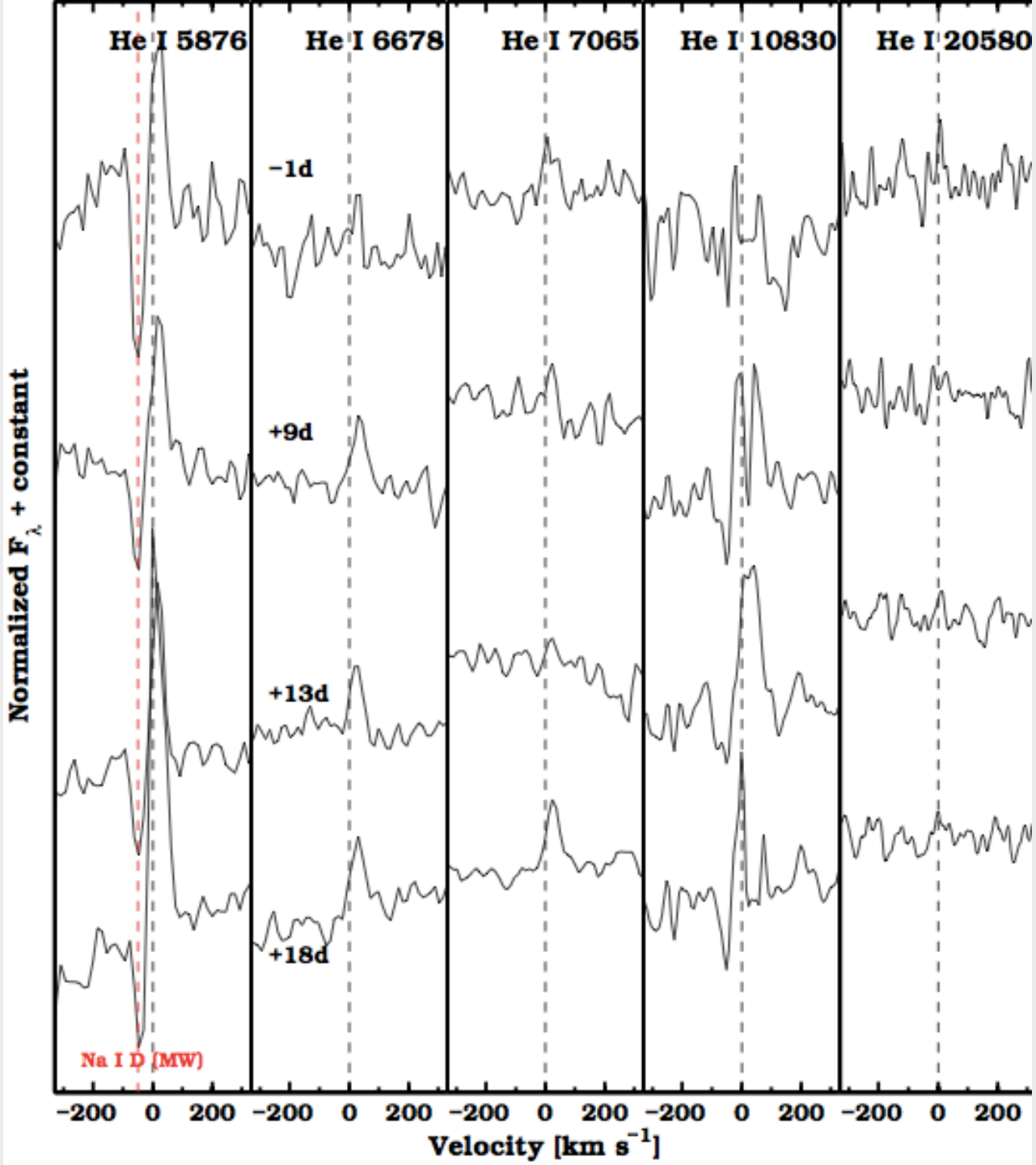
→less blending
→more prevalent features!

- Faint and fast objects are linked to the brighter end of the SN Iax distribution



Present findings

- SN 2008ha is NOW not alone
- Both faint and fast SN Iax are located in a LMC-like metallicity environment
- Narrow FWHM=50 km/s Helium lines are observed in SN2010ae (Mark will dictate!)
- Modeling of exploding WDs leaving a bound remnant may explain the brighter objects, but problems to reconcile with the low Ni yields of the faintest objects (Kromer et al. 2013, Fink et al. 2013)
- v_{ph}, optical and NIR require 60% difference in SYNAPPS?


He I 5876
He I 6678
He I 7065
He I 10830
He I 20580
−1d
+9d
+13d
+18d
Na I D (MW)
Normalized F_λ + constant
−200
0
200
Velocity [km s^{-1}]