

Two in One
Intrinsic Properties of two fast
declining SN Ia in the same Galaxy

Christa Gall



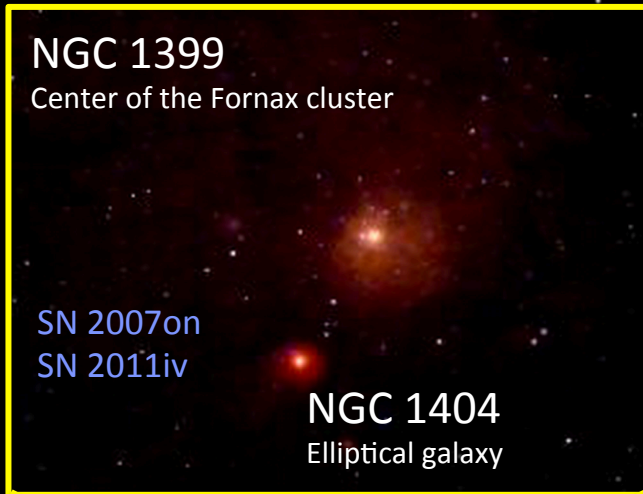
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Department of Physics and Astronomy
in collaboration with the *Carnegie Supernova Project*

Supernovae in the Fornax galaxy cluster

NGC 1399
Center of the Fornax cluster

SN 2007on
SN 2011iv

NGC 1404
Elliptical galaxy

A yellow-bordered box containing a photograph of the NGC 1399 galaxy cluster. The cluster consists of several galaxies, with a prominent bright orange-red elliptical galaxy at the center. Two supernovae are marked with red dots and labeled: SN 2007on and SN 2011iv. The text 'NGC 1399 Center of the Fornax cluster' is at the top, and 'SN 2007on SN 2011iv' is on the left. 'NGC 1404 Elliptical galaxy' is at the bottom right. A yellow circle at the bottom center of the box is connected by lines to other galaxy boxes.

NGC 1365
Star forming spiral

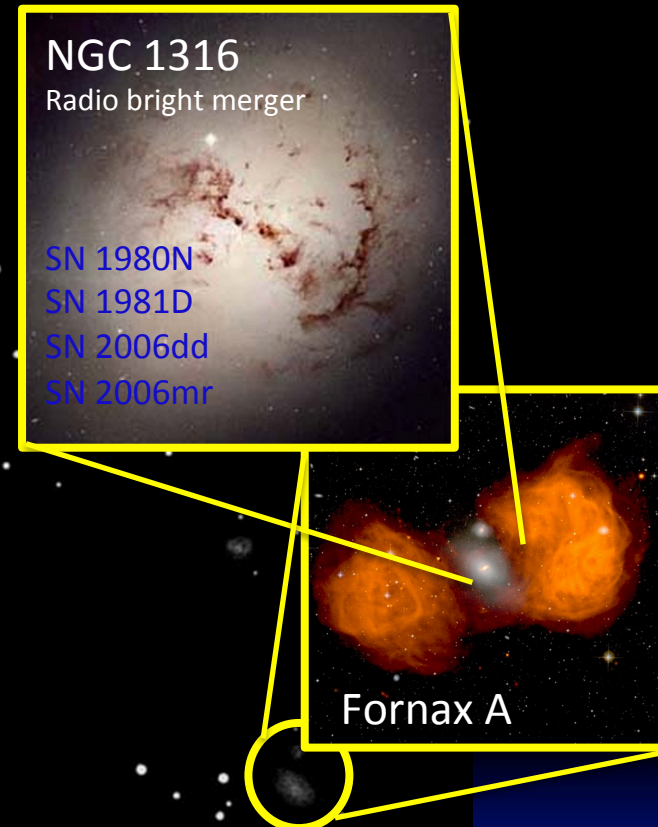
SN 2001du
SN 2012fr

A yellow-bordered box containing a photograph of the NGC 1365 galaxy, a star-forming spiral galaxy. The galaxy is shown in blue and white, with a bright central region. Two supernovae are marked with white dots and labeled: SN 2001du and SN 2012fr. The text 'NGC 1365 Star forming spiral' is at the top, and 'SN 2001du SN 2012fr' is at the bottom. A yellow circle at the bottom center of the box is connected by lines to other galaxy boxes.

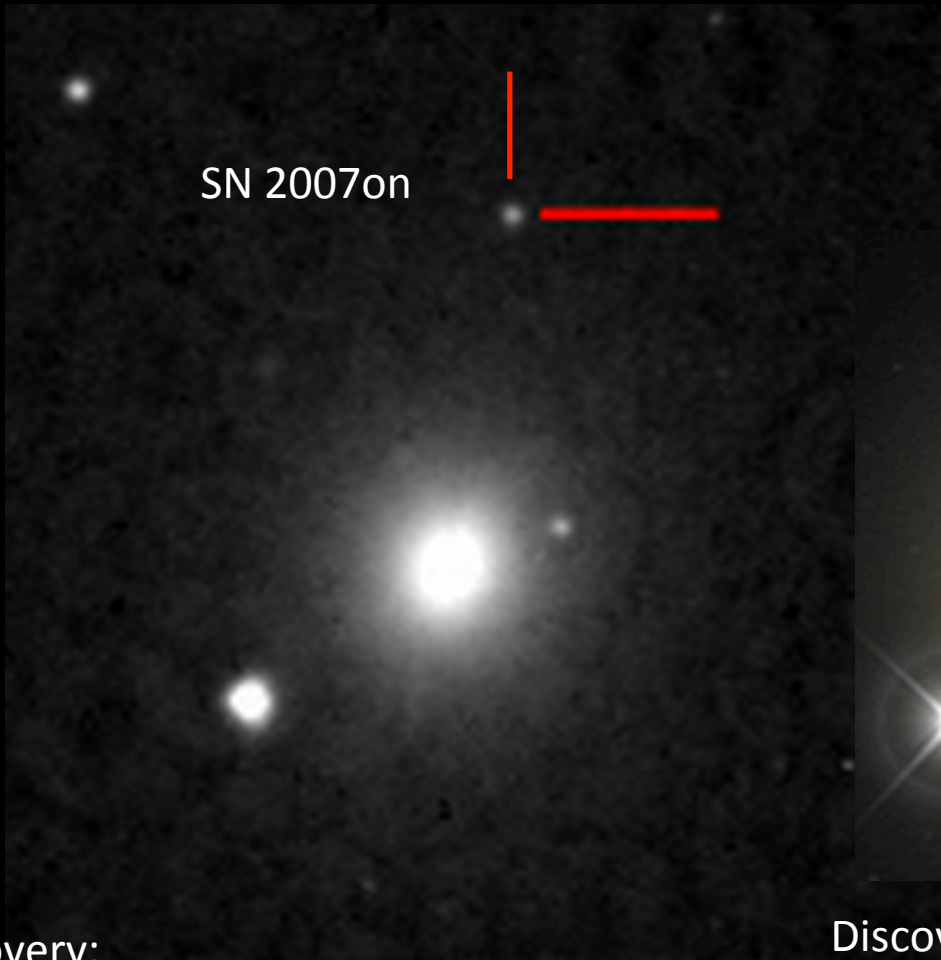
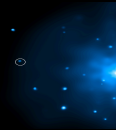
NGC 1316
Radio bright merger

SN 1980N
SN 1981D
SN 2006dd
SN 2006mr

Fornax A

A yellow-bordered box containing a photograph of the NGC 1316 galaxy merger. The image shows two galaxies in the process of merging, with a bright central region. Four supernovae are marked with blue dots and labeled: SN 1980N, SN 1981D, SN 2006dd, and SN 2006mr. The text 'NGC 1316 Radio bright merger' is at the top, and the supernova labels are on the left. 'Fornax A' is at the bottom right. A yellow circle at the bottom center of the box is connected by lines to other galaxy boxes.

SN 2007on & SN 2011iv in NGC 1404

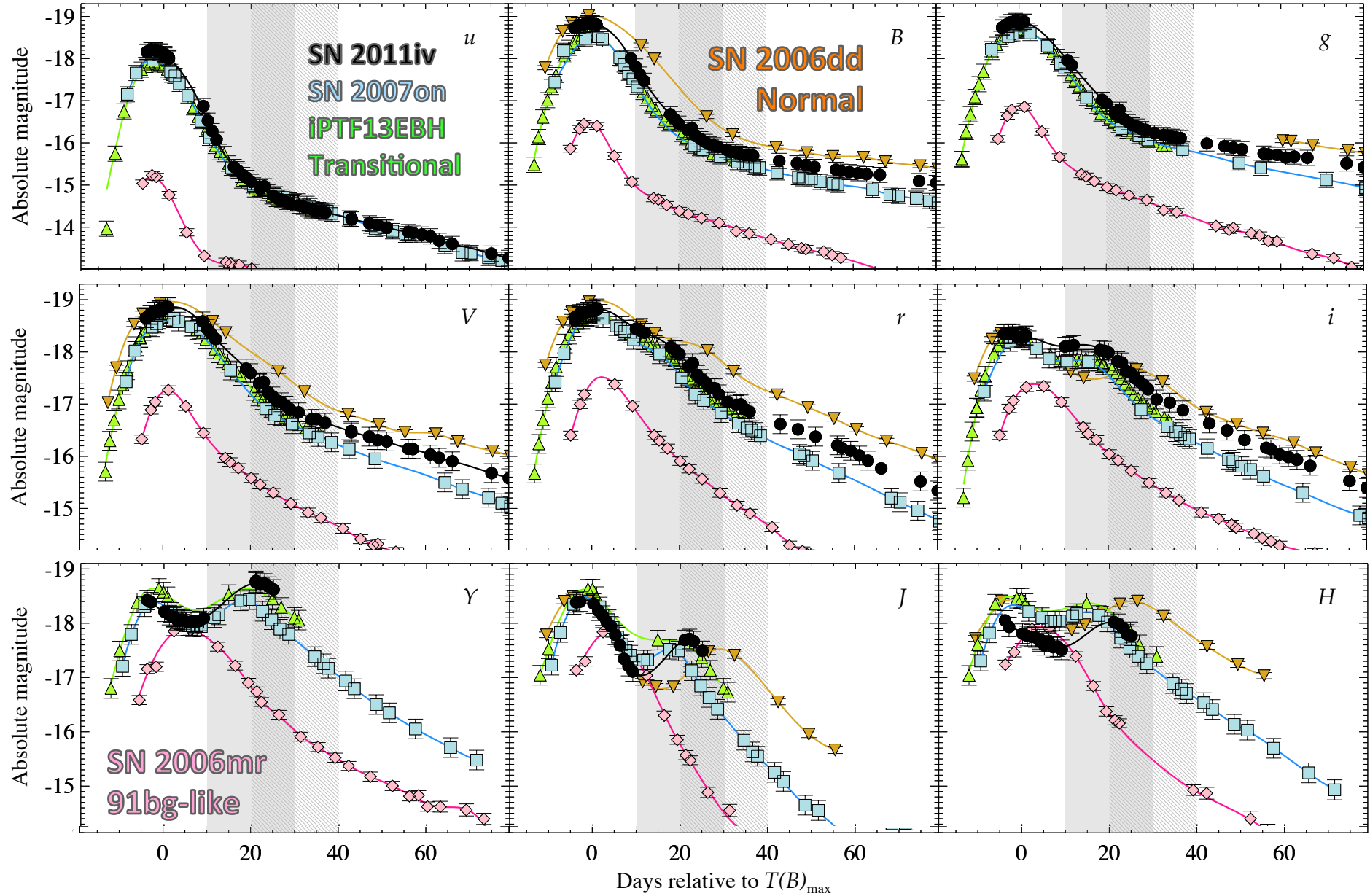


Discovery:
November, 2007, 0.25m robotic TAROT

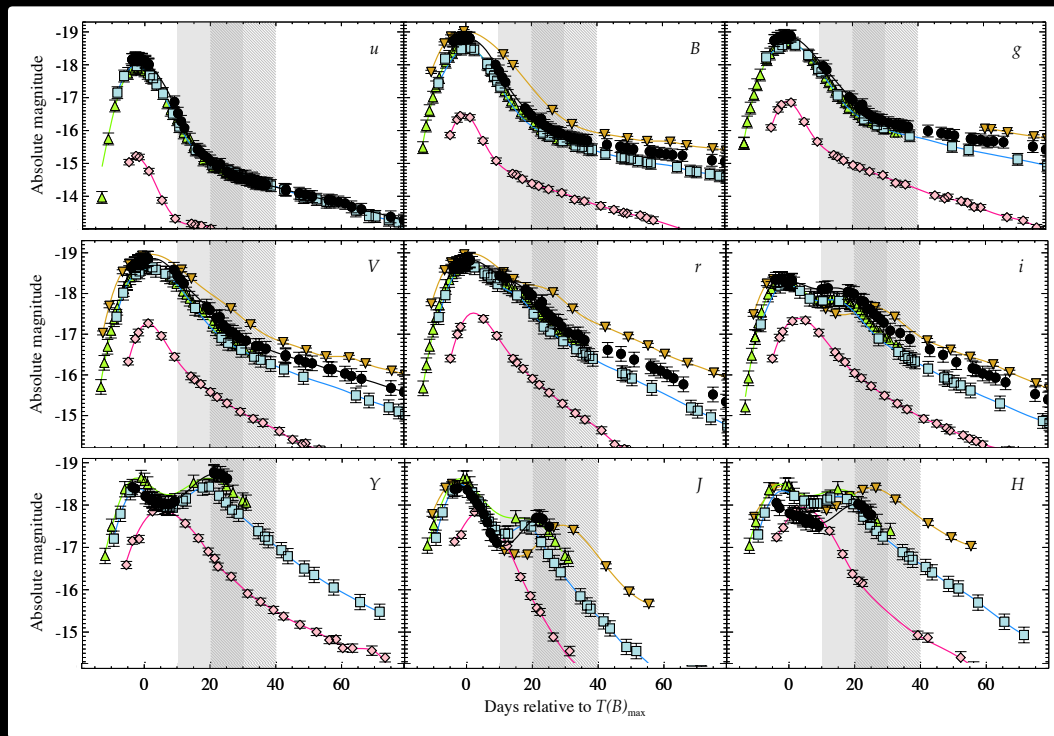


Discovery:
December, 2011, Stu Parker, New Zealand
CBET 2940

Photometry



Photometry



SNooPy light curve fitter
 EBV, MAX_model
 (Burns et al. 2011)

Transitional

Transitional

91bg-like

Normal

Parameter

SN 2011iv

SN 2007on

iPTF13EBH

SN 2006mr

SN 2006dd

$\Delta m_{15(B)}$

1.73 ± 0.01

1.96 ± 0.001

1.785 ± 0.012

1.82 ± 0.02

1.078 ± 0.025

s_{BV}

0.652 ± 0.007

0.576 ± 0.005

0.631 ± 0.023

0.220 ± 0.005

0.940 ± 0.004

$E(B-V)_{\text{host}}$

-0.018 ± 0.009

-0.057 ± 0.01

0.05 ± 0.02

-0.098 ± 0.047

0.043 ± 0.08

DM_{EBV}

31.189 ± 0.06

31.573 ± 0.06

33.603 ± 0.07

31.945 ± 0.085

31.157 ± 0.069

DM_{Tripp}

31.3 ± 0.18

31.57 ± 0.18

33.63 ± 0.18

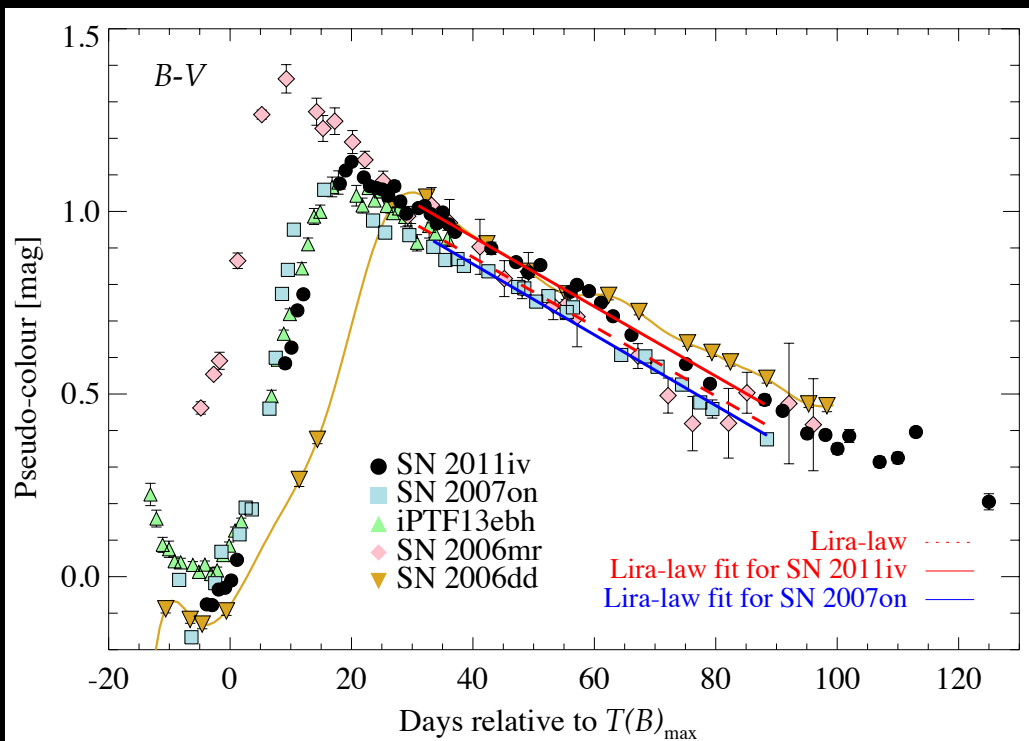
31.834 ± 0.106

31.276 ± 0.052

Hsiao et al. 2015

Stritzinger et al. 2010

B-V Color - Reddening



Lira law for unreddened SNe
(Folatelli et al. 2010)

Transitional

Transitional

91bg-like

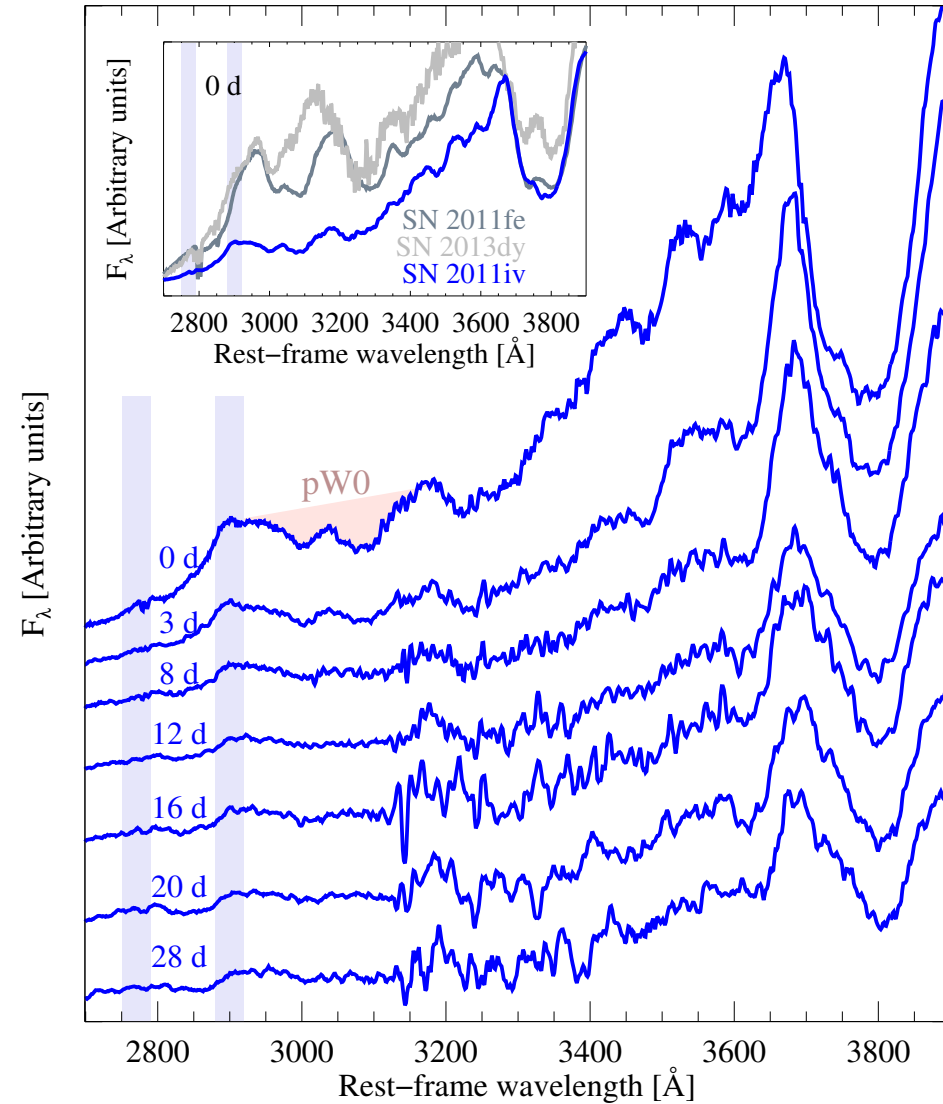
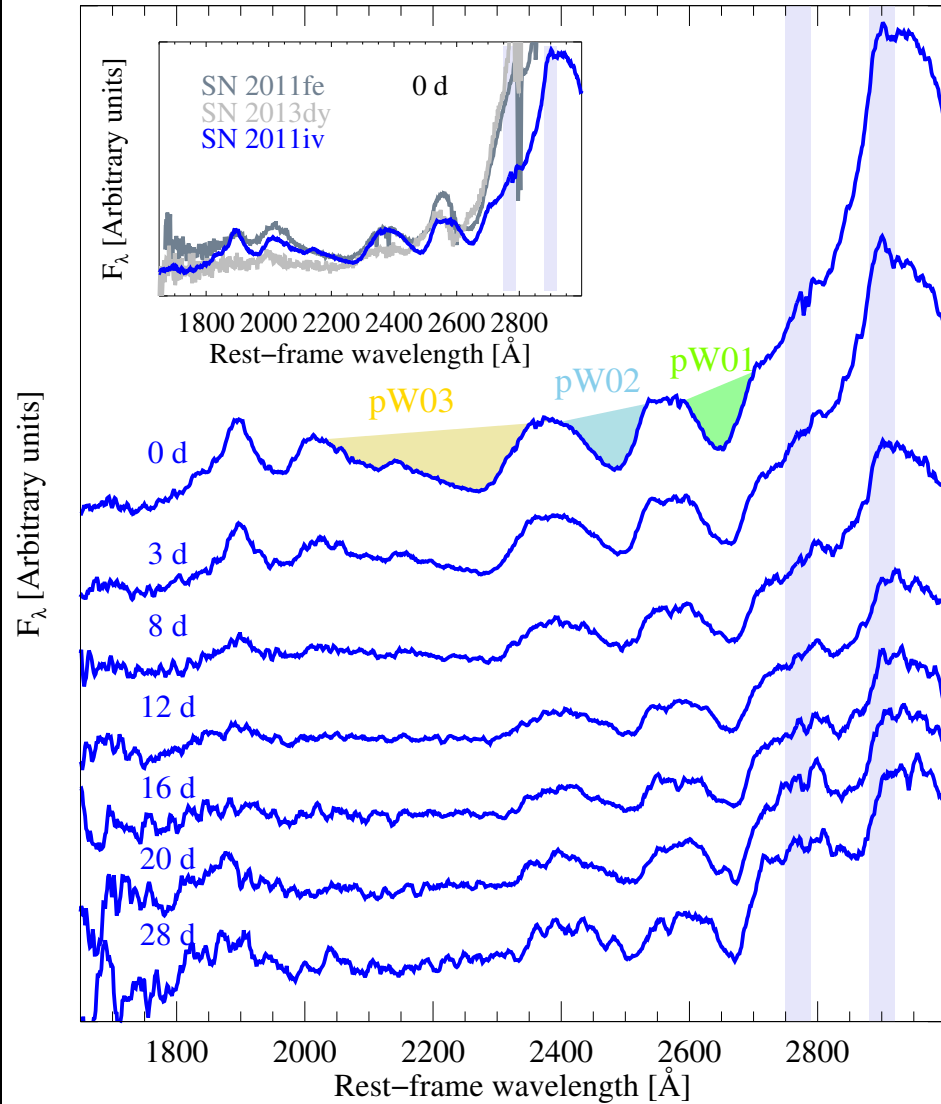
Normal

| Parameter | SN 2011iv | SN 2007on | iPTF13EBH | SN 2006mr | SN 2006dd |
|------------------------|--------------------|-------------------|--------------------|--------------------|-------------------|
| $\Delta m_{15}(B)$ | 1.73 ± 0.01 | 1.96 ± 0.001 | 1.785 ± 0.012 | 1.82 ± 0.02 | 1.078 ± 0.025 |
| S_{BV} | 0.652 ± 0.007 | 0.576 ± 0.005 | 0.631 ± 0.023 | 0.220 ± 0.005 | 0.940 ± 0.004 |
| $E(B-V)_{\text{host}}$ | -0.018 ± 0.009 | -0.057 ± 0.01 | 0.05 ± 0.02 | -0.098 ± 0.047 | 0.067 ± 0.06 |
| $E(B-V)_{\text{Lira}}$ | 0.055 ± 0.001 | -0.033 ± 0.01 | 0.0025 ± 0.002 | -0.002 ± 0.008 | 0.092 ± 0.009 |

Hsiao et al. 2015

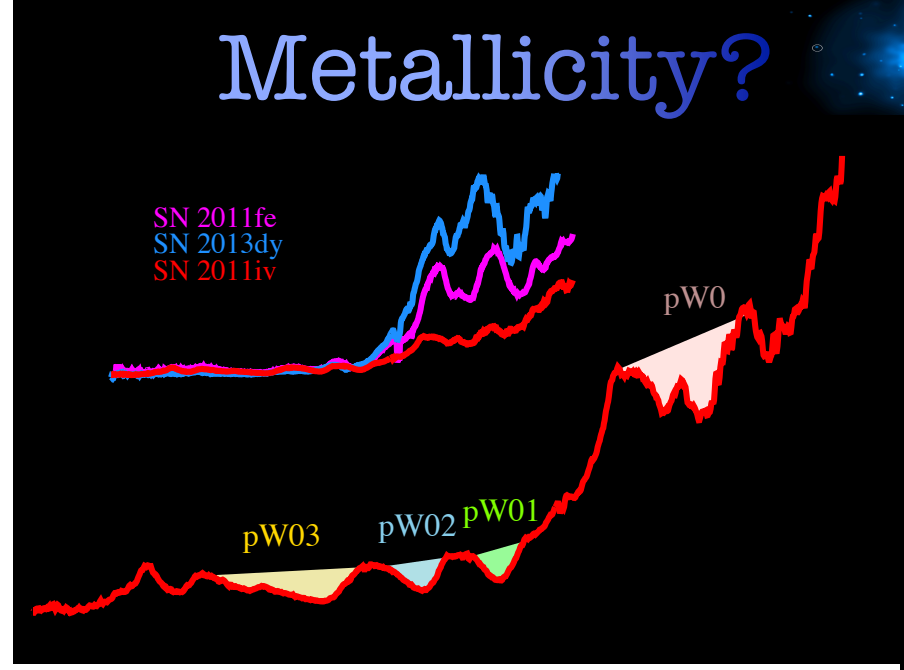
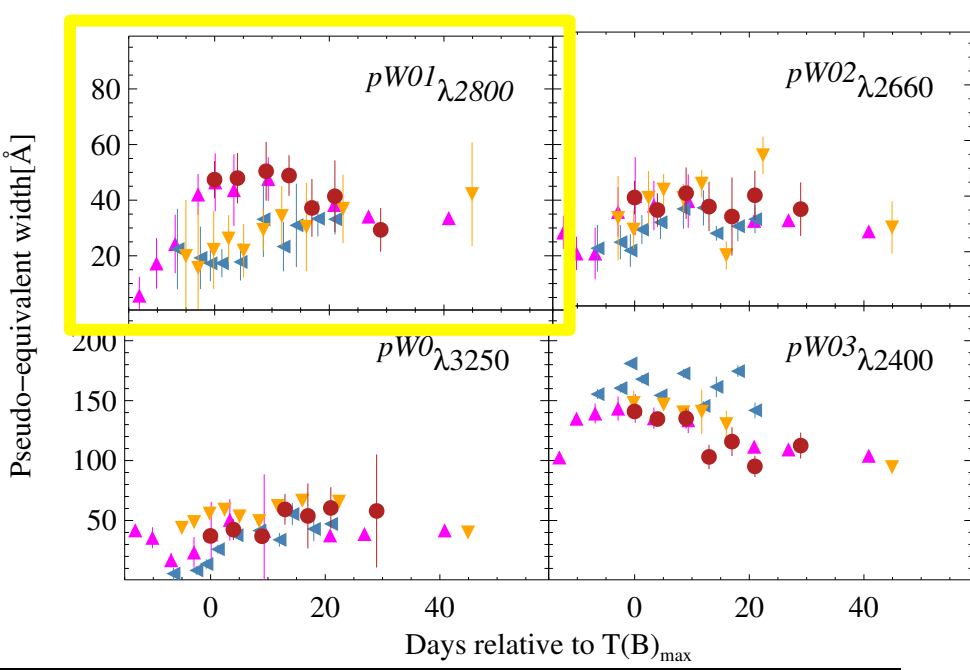
Stritzinger et al. 2010

HST UV Spectroscopy



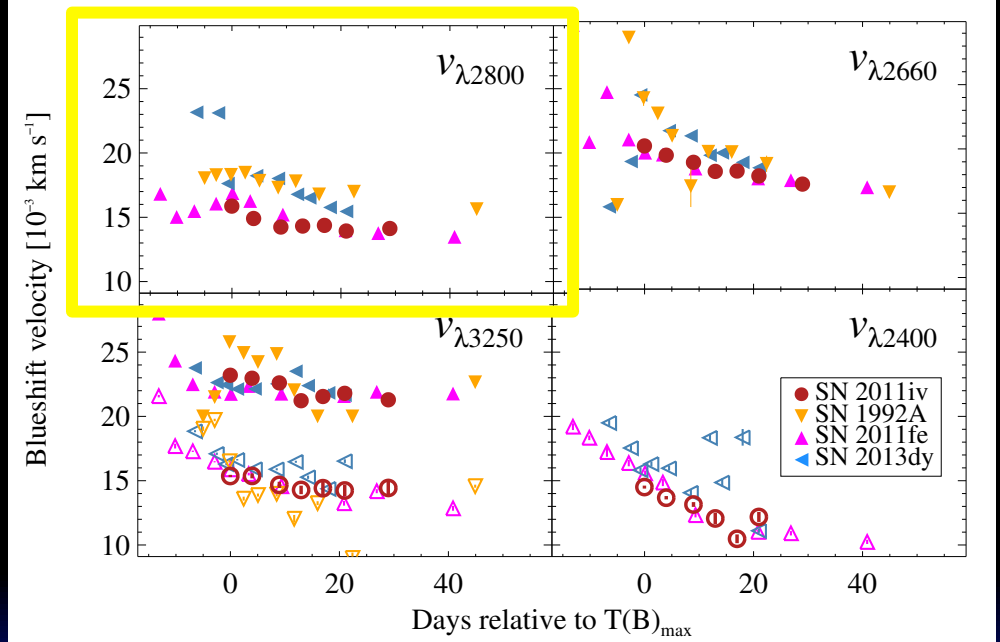
2011iv: Maximum brightness spectrum by Foley et al. 2012; 2011fe: Patat et al. 2013; 2013dy: Pan et al. 2015

Metallicity?



- UV-Continuum flux:
depends on various mechanism:
- explosion model
 - geometry and viewing angle effects
 - complexity incorporated in models

- Theory predicts metallicity effects:
- weaker UV features
 - larger blueshifts
- for increasing metallicity
(e.g., Lenz et al. 2001)



Spectroscopy

SN 2007on

17 optical spectra
-4 to +89 days
(Folatelli et al. 2013)
4 late phase spectra
+101 to +380

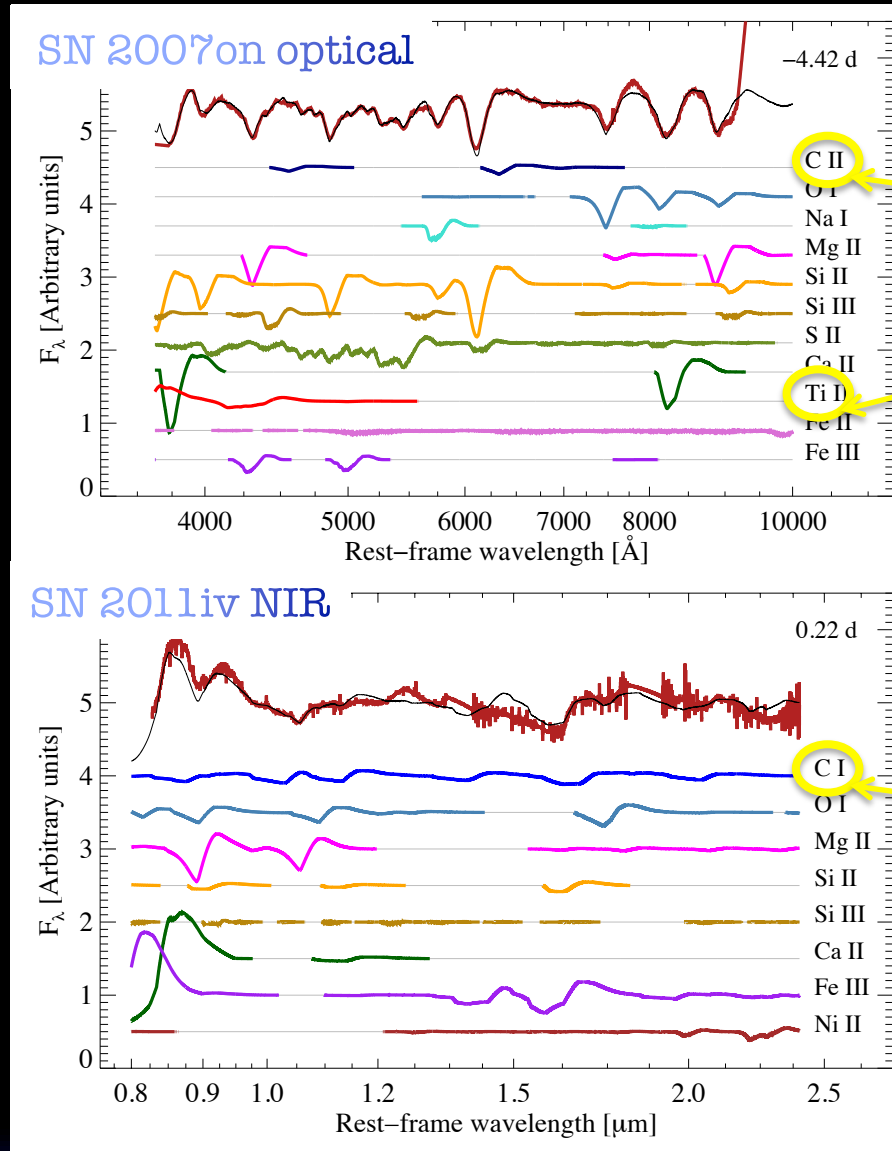
SN 2007on:

2 spectra
+33, +93 days

SN 2011iv

22 spectra
-7 to +42 days
2 late phase spectra
+141, +260

13 NIR spectra
+0.2 to +83 days



C II, pristine carbon

Ti II

SYNAPPS

C I, pristine carbon

Maximum UV—NIR brightness spectrum (Foley et al. 2012)

What are the differences?

SN 2007on

- Fainter ($M_{B,\max} = -18.598$ mag)
- Redder (early phase)
- Bluer (late phase)
- Faster declining (1.96)
- Lower color stretch(0.57)
- Weak titanium
- C I in the optical
- Lower ^{56}Ni mass ($0.25 M_{\odot}$)
- Away from the center
- Larger distance

SN 2011iv

- Brighter ($M_{B,\max} = -18.901$ mag)
- Bluer (early phase)
- Redder (late phase)
- Slower declining (1.73)
- Larger color stretch(0.65)
- No titanium
- C II in the NIR
- Larger ^{56}Ni mass ($0.4 M_{\odot}$)
- Close to the center
- Shorter distance

What makes them different?

- Temperature \longleftrightarrow ^{56}Ni mass
- Challenges in distance measurements vs physical differences
- Progenitor metallicity
- Progenitor mass

What makes them similar?

- Explosion mechanism
- Abundance stratification
- Layered structure



THANK YOU!
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