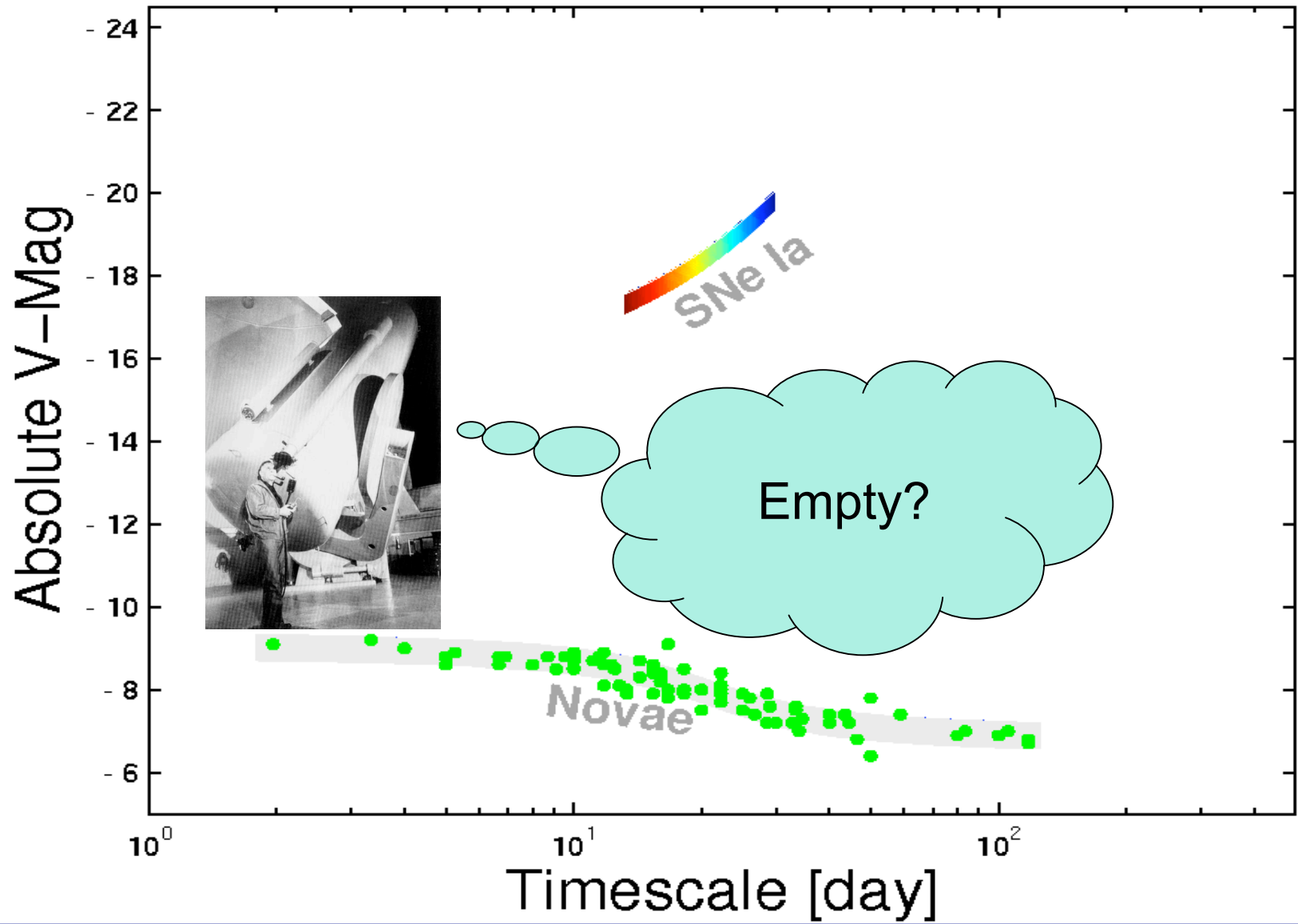


**LUMINOUS SUPERNOVAE
(PALOMAR TRANSIENT
FACTORY)**

S. R. KULKARNI

**DIRECTOR, CALTECH OPTICAL
OBSERVATORIES (COO),
CHAIRMAN, SPACE INTERFEROMETRY
MISSION (SIM)**

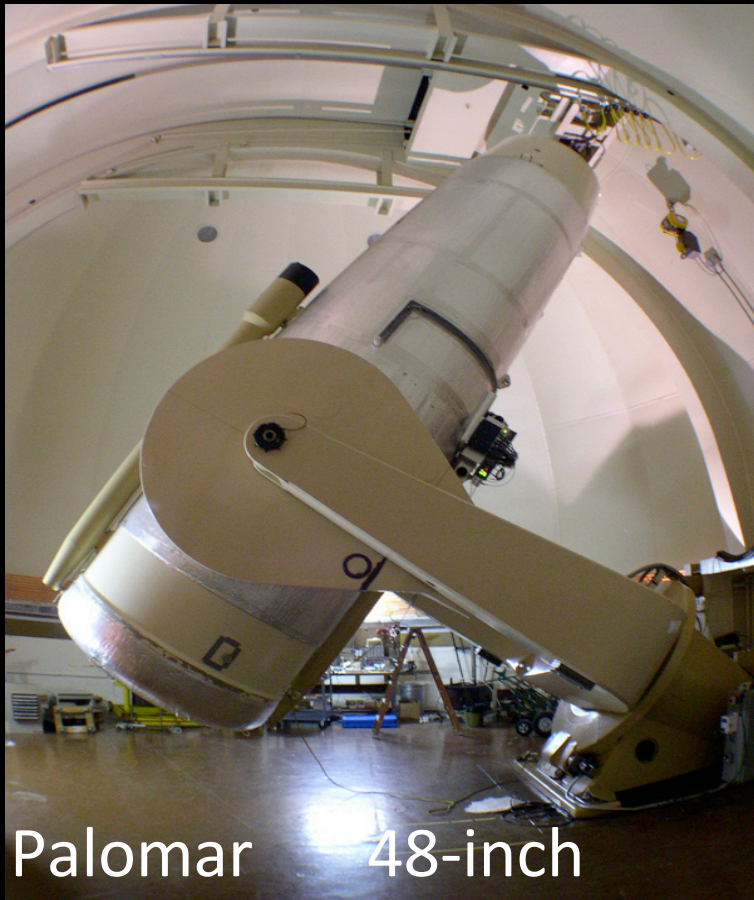


I. Palomar Transient Factory Overview

S. R. Kulkarni

Principal Investigator
and the PTF collaboration

A Novel Two-telescope Approach



Palomar 48-inch



Palomar 60-inch

PTF collaboration

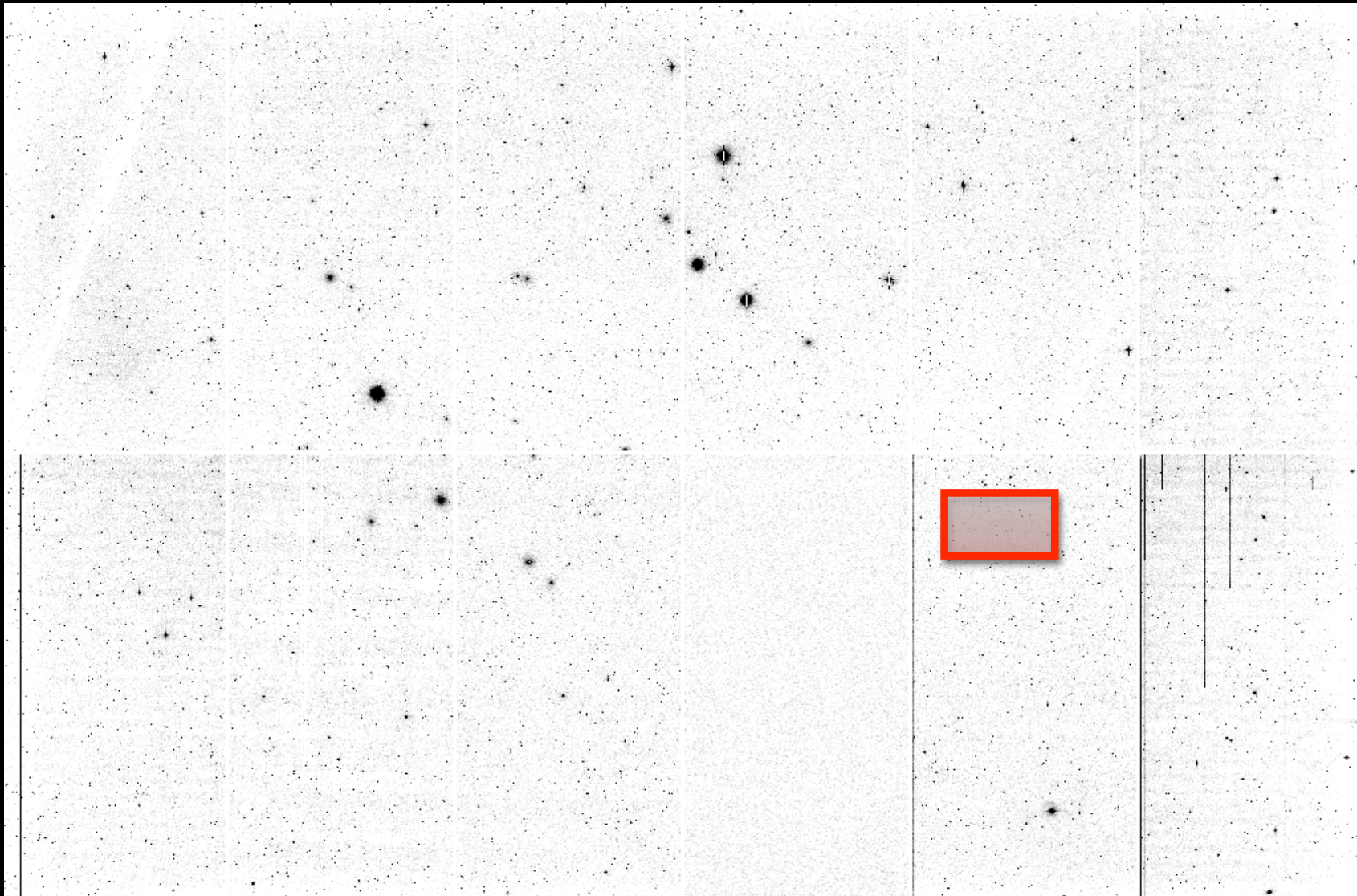


Caltech, LCOGT, Berkeley, LBL, IPAC, Columbia, Oxford, Weizmann

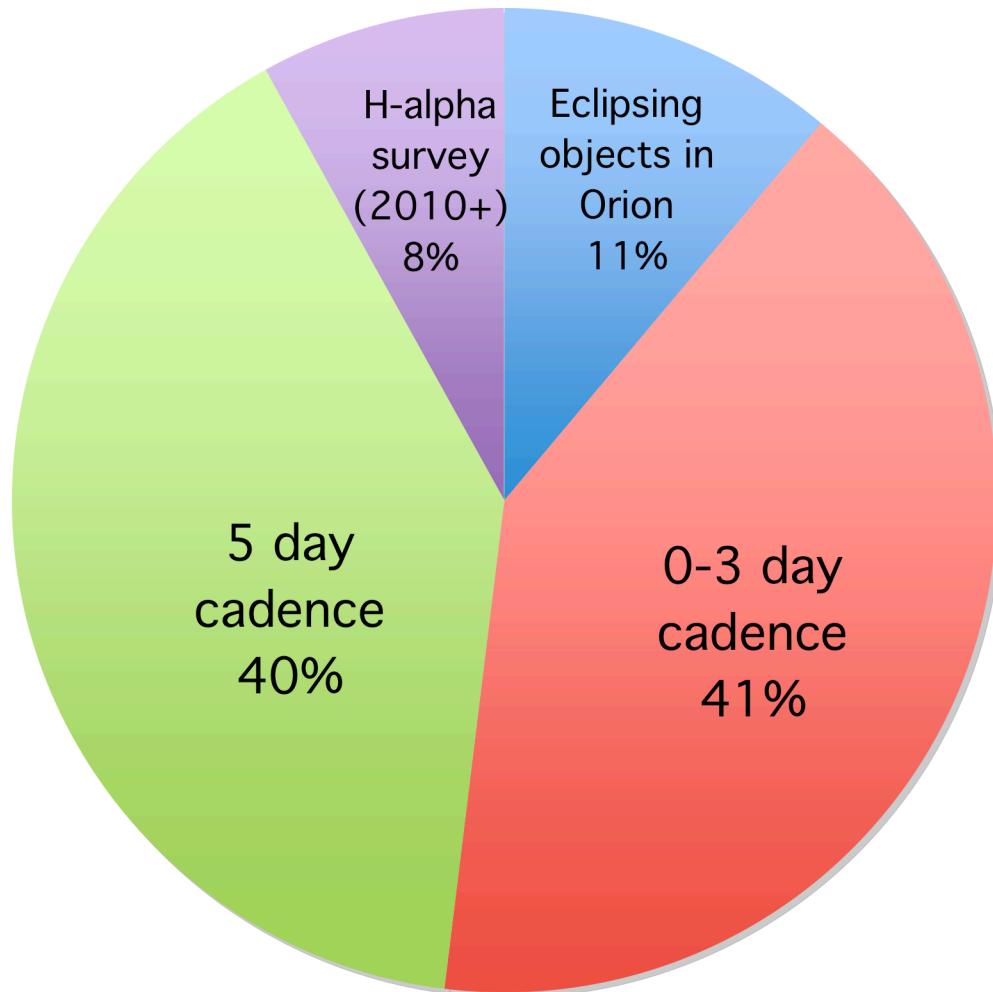


PTF overview

Data quality



PTF projects



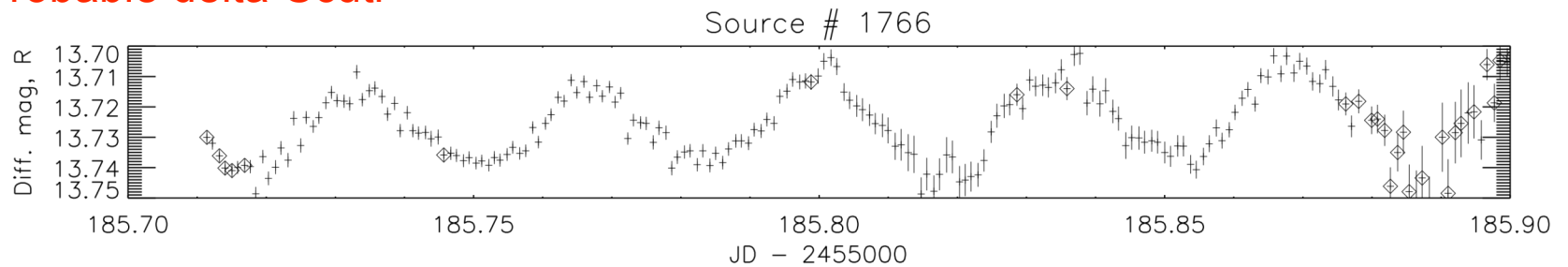
PTF Key Projects

Transients in nearby galaxies	Search for eLIGO/neutrino EM counterpart
Thermonuclear SNe	Core Collapse SNe
Blazars/AGN	Tidal Disruption Flares
H-alpha Sky Survey	Orphan GRB afterglow
AM CVn	CVs
Galactic dynamics	RR Lyrae
Flare stars	Rotation in clusters
Nearby Star Kinematics	Eclipsing stars and planets
Asteroids	KBOs

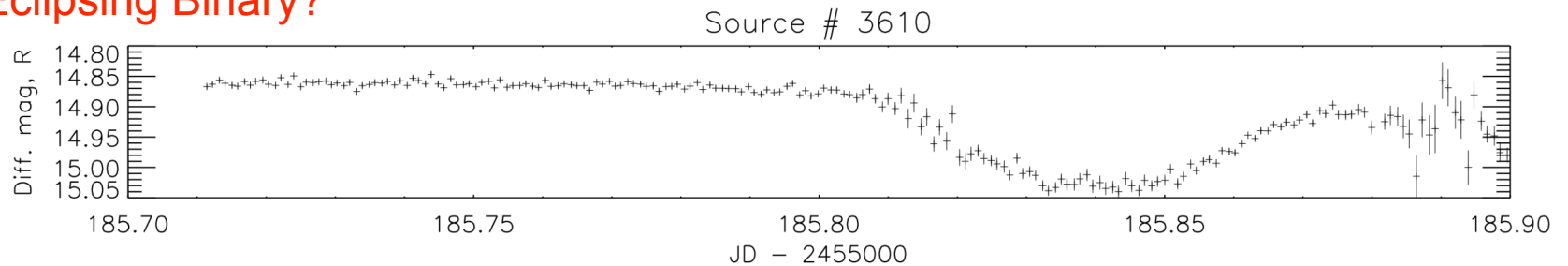
PTF Orion – Photometric Performance

e.g.'s over ~few hours

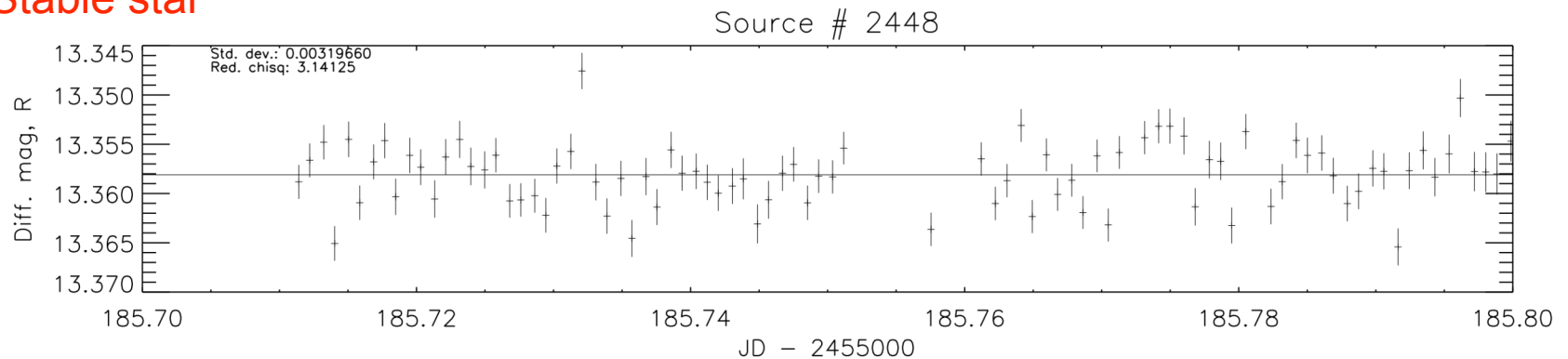
- Probable delta-Scuti



- Eclipsing Binary?



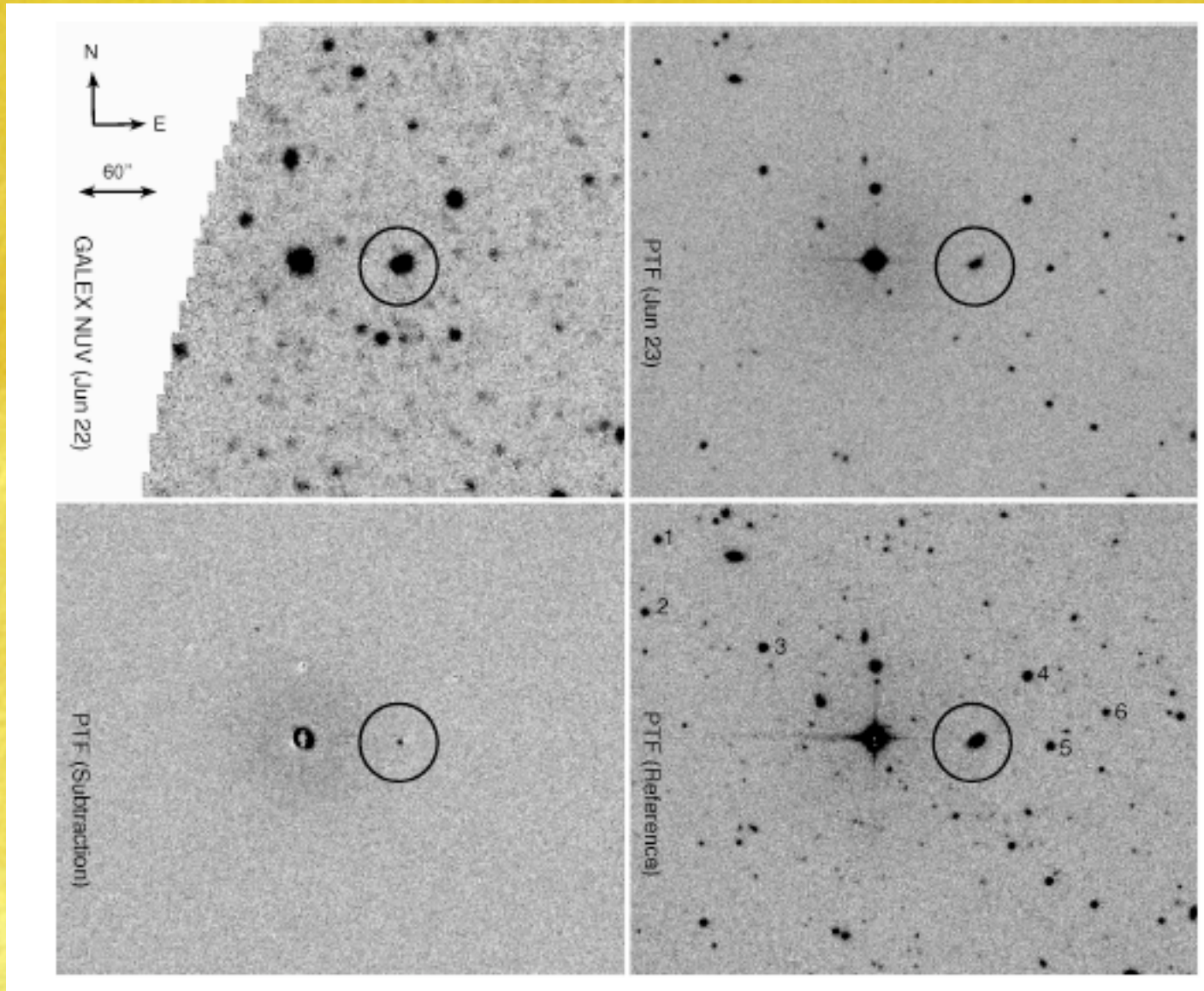
- Stable star



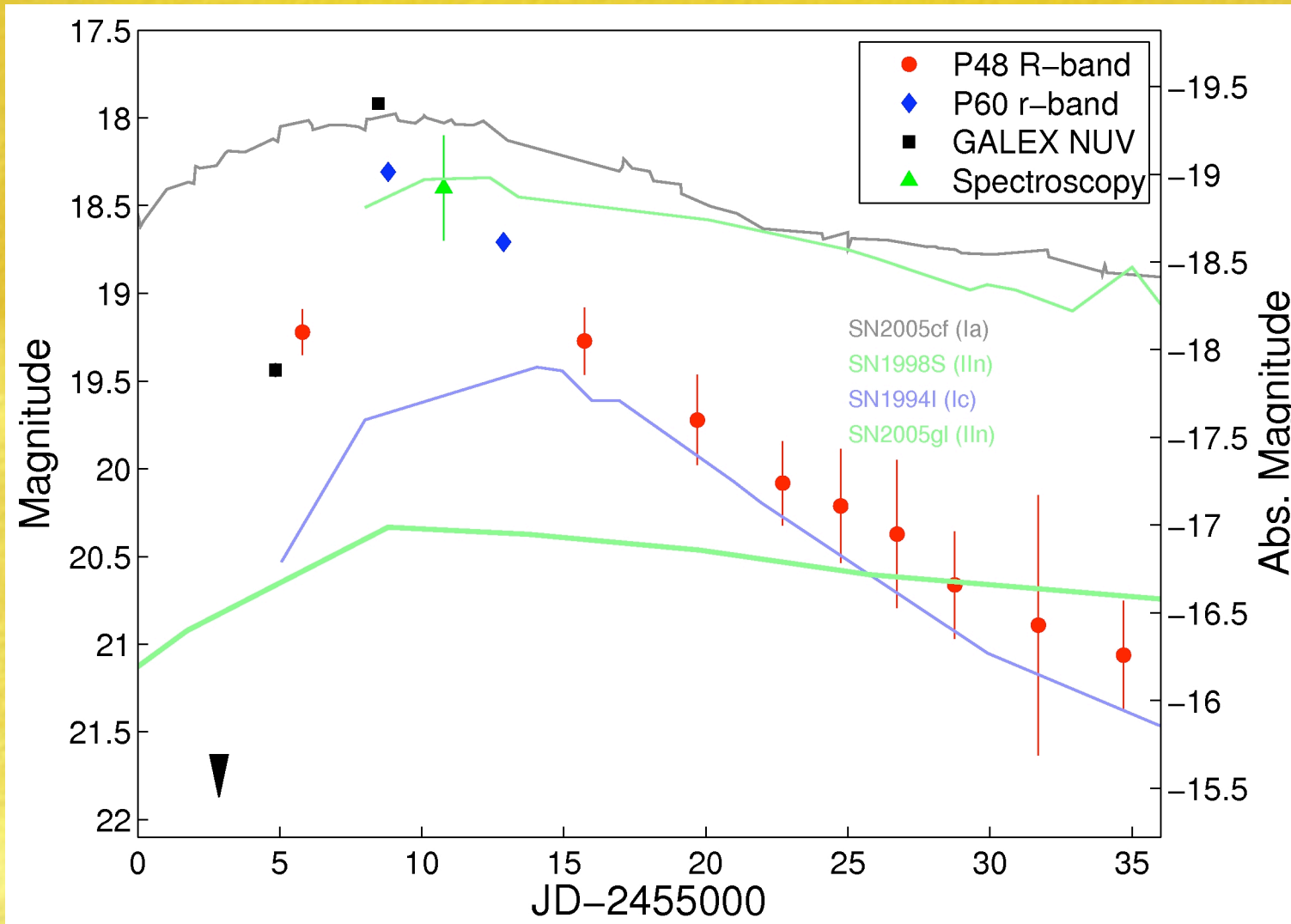
The background is a traditional Chinese ink wash painting on a light yellowish-gold paper. In the top left corner, there are three stylized pine trees with green needles and brown trunks. In the top right corner, there are three birds in flight, drawn with simple black lines. In the bottom right corner, there is a larger, more detailed pine tree with green needles and a dark brown trunk. The overall style is minimalist and elegant.

II. Shocking Results from PTF

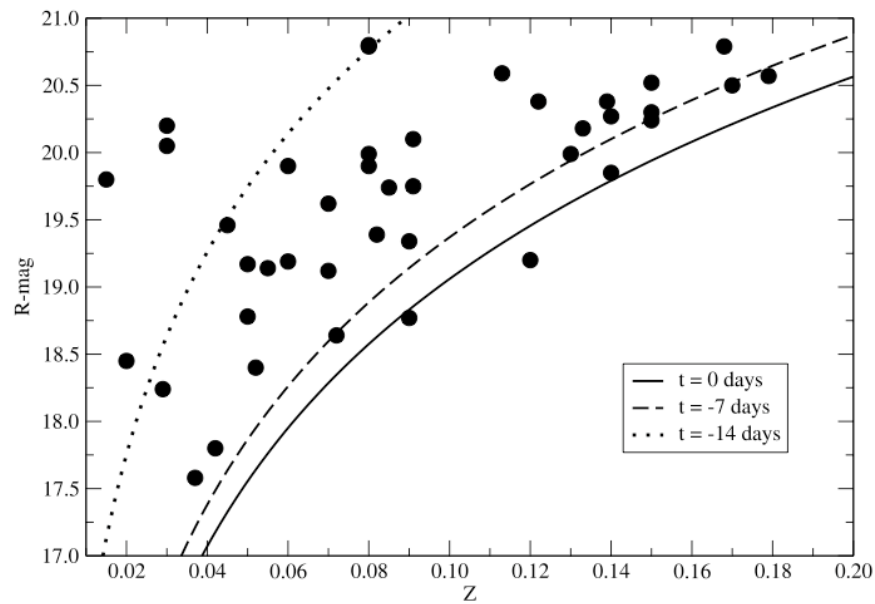
Shock breakout



PTF09uj (type IIn)

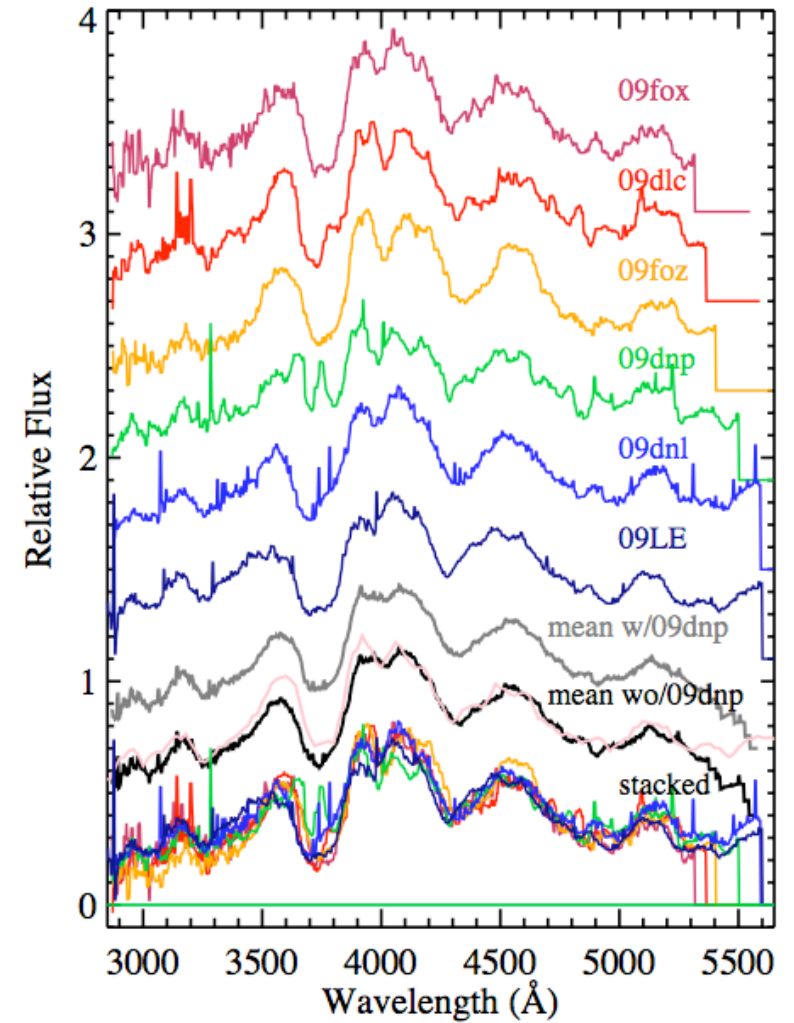
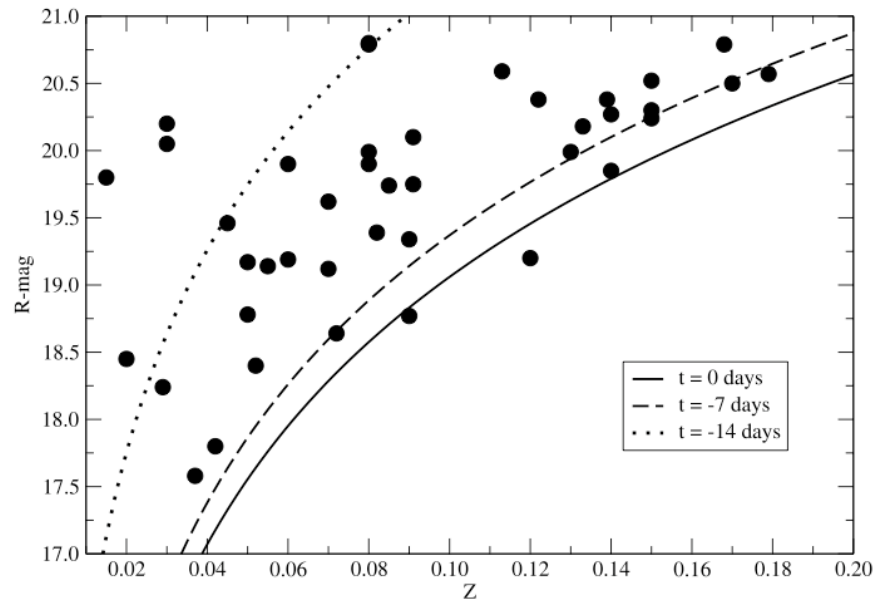


UV spectroscopy of local Ia



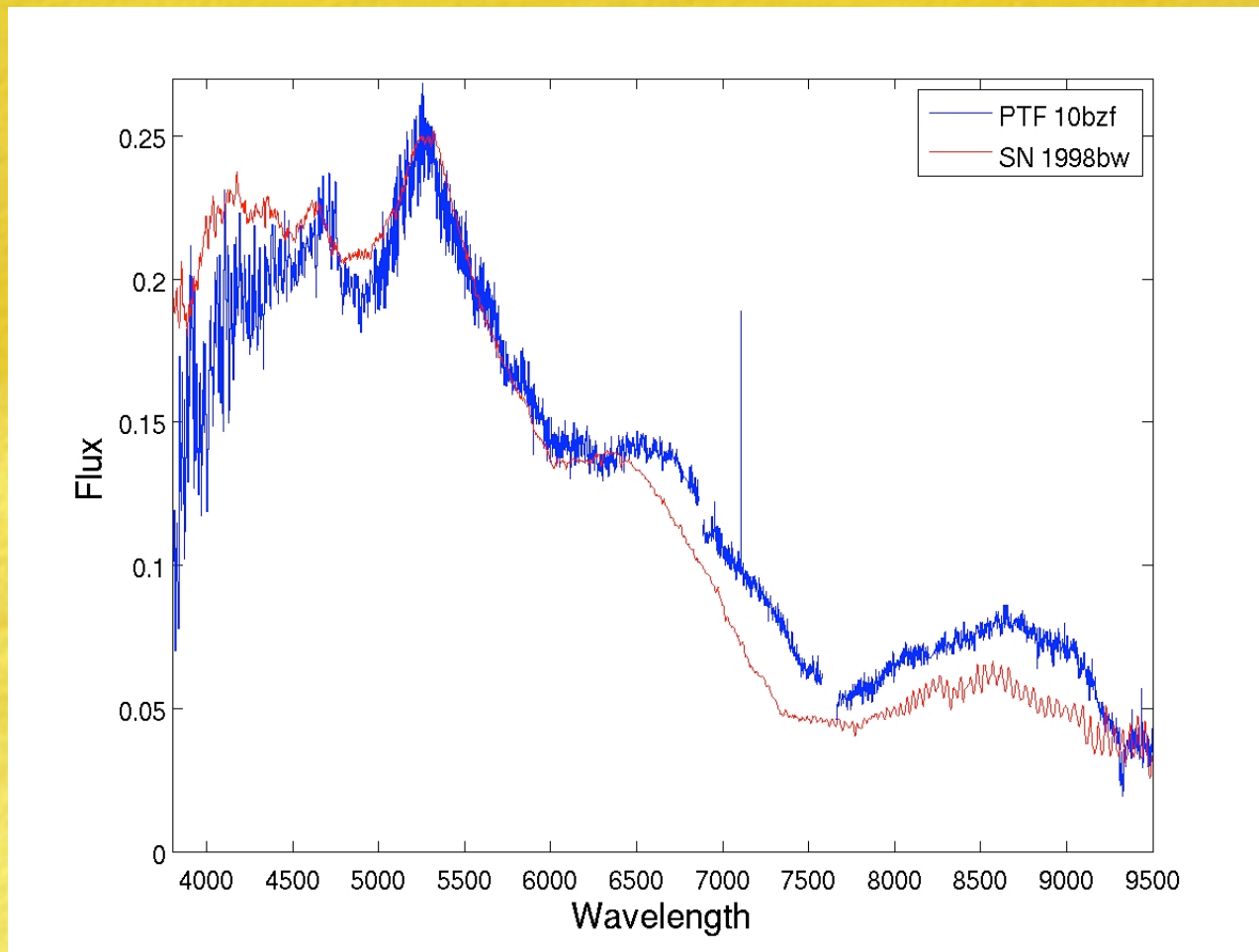
Nugent, Ellis, Howell, Sullivan ...

UV spectroscopy of local Ia



Nugent, Ellis, Howell, Sullivan ...

PTF10bzf (SN1998bw-like)



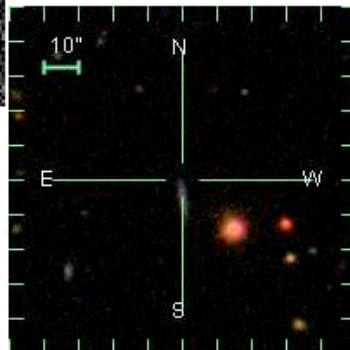
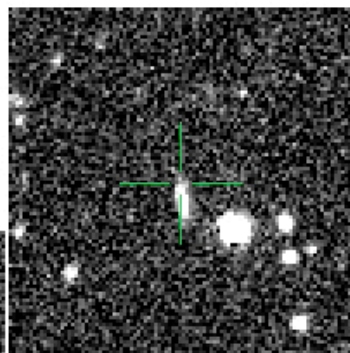
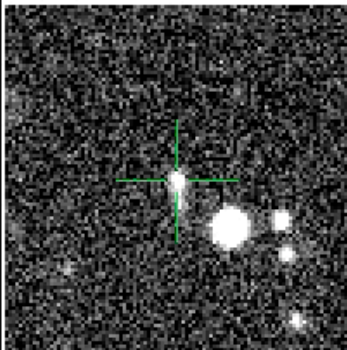
Z=0.0498 (220 Mpc)

Follow up is the key

PTF10bzf



Scanning Page



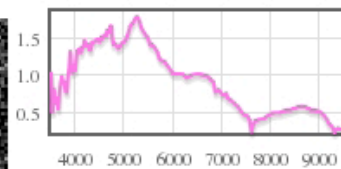
Check NED

Check SIMBAD

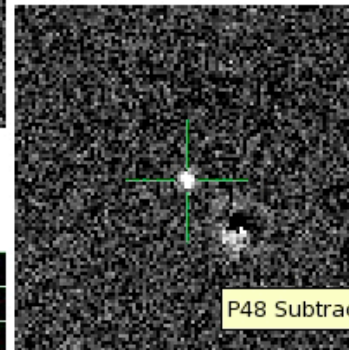
Get DSS Image

Check Skyview

SN Ib/c +3.9d

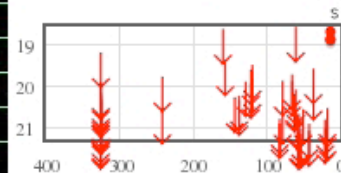


spectroscopic follow-up 0/1 done



P48 Subtracted Image (Feb 23, 2010)

r > 15.7 (10.4 d)



no phot fup requested

Comments:

- Mar 07 **MANSI** [info]: Observed Keck/LRIS 100307
- Mar 04 **ADAM** [info]: detected in J-band with PAIRITEL
- Mar 04 **AVISHAY** [redshift]: 0.0498
- Mar 04 **AVISHAY** [classification]: SN Ib/c
- Mar 04 **AVISHAY** [phase]: -4 days
- Mar 04 **AVISHAY** [comment]: Broad-line Ic, similar to 1998bw
- Mar 04 **PTFROBOT** [SDSS_class]: galaxy
- Mar 04 **PTFROBOT** [SDSS_photz]: 0.1572 +/- 0.0386
- Mar 04 **AHOWELL** [info]: ps file from superfit [view attachment]
- Mar 04 **AHOWELL** [info]: broad lined Ic similar to SN 1998bw at -3d. Redshift is 0.0498 from galaxy OII, H-alpha, H-beta, SII seen on 2d (not apparent in 1d). [view attachment]
- Mar 03 **AVISHAY** [info]: Gemini spectrum from Andy indicates possibly broad lined Ic
- Mar 01 **PETER** [type]: Transient
- Mar 01 **JOSH** [type]: Transient

Add a Comment:

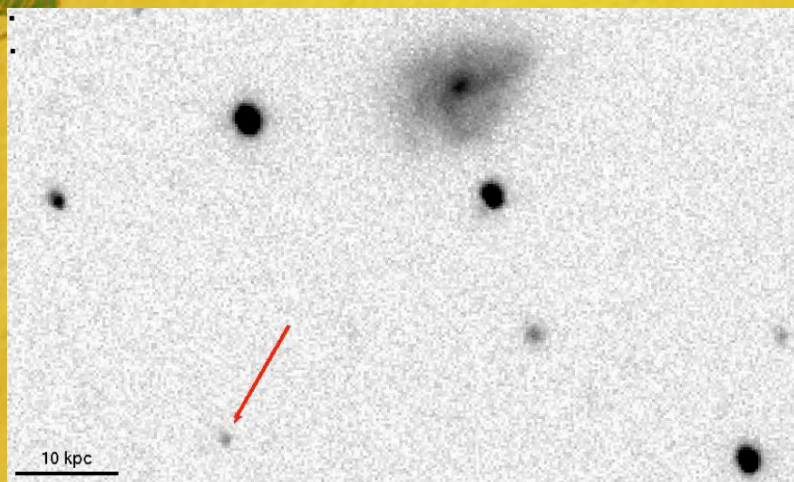
Attach File:

Browse...

info

Save Comment

PTF09dav: A Mystery

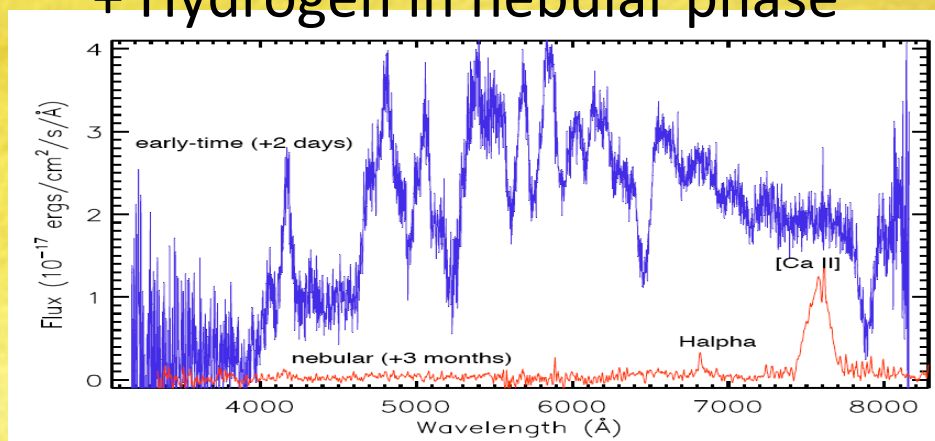
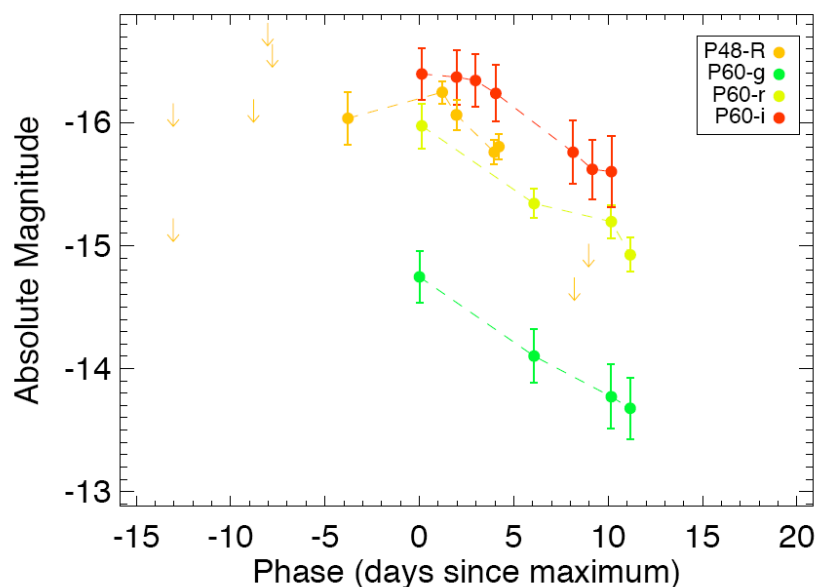


★ Location:
+ 40kpc from putative spiral host

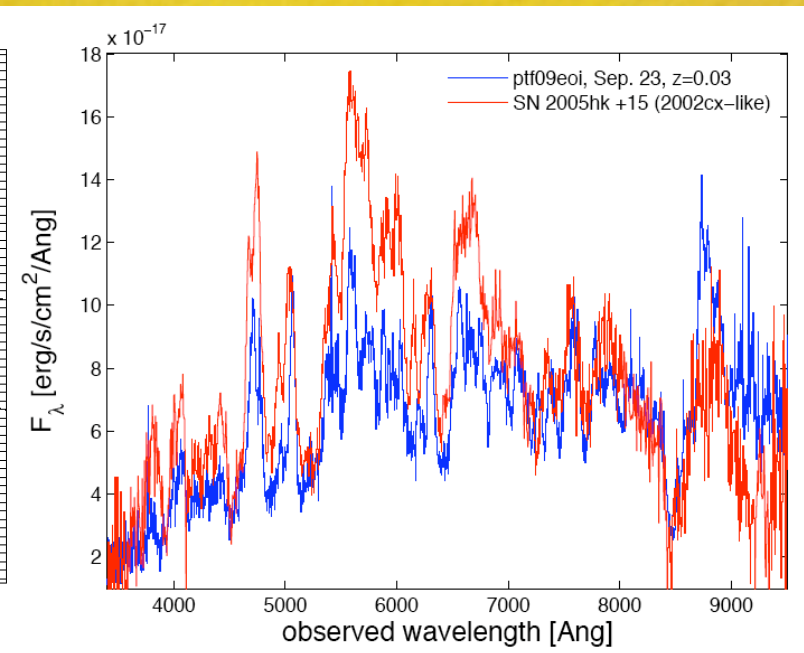
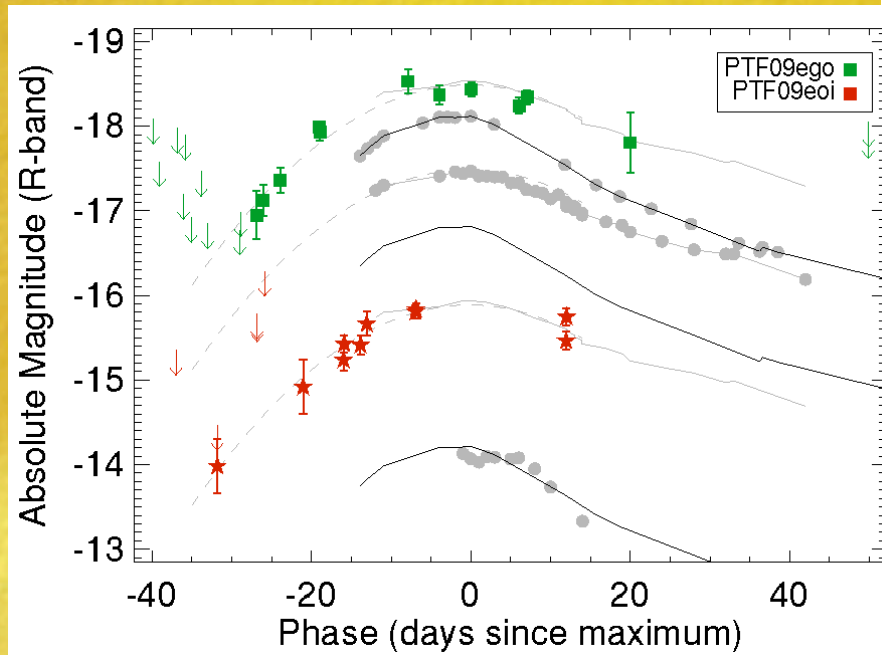
★ Peak Luminosity:
+ In the Gap, Mg = -14.7

★ Photometric Evolution:
+ Very fast, 1 mag in 10 days
+ Very red, g-r = 1.2

★ Spectrum:
+ Similar to SN1991bg but with He
+ Hydrogen in nebular phase

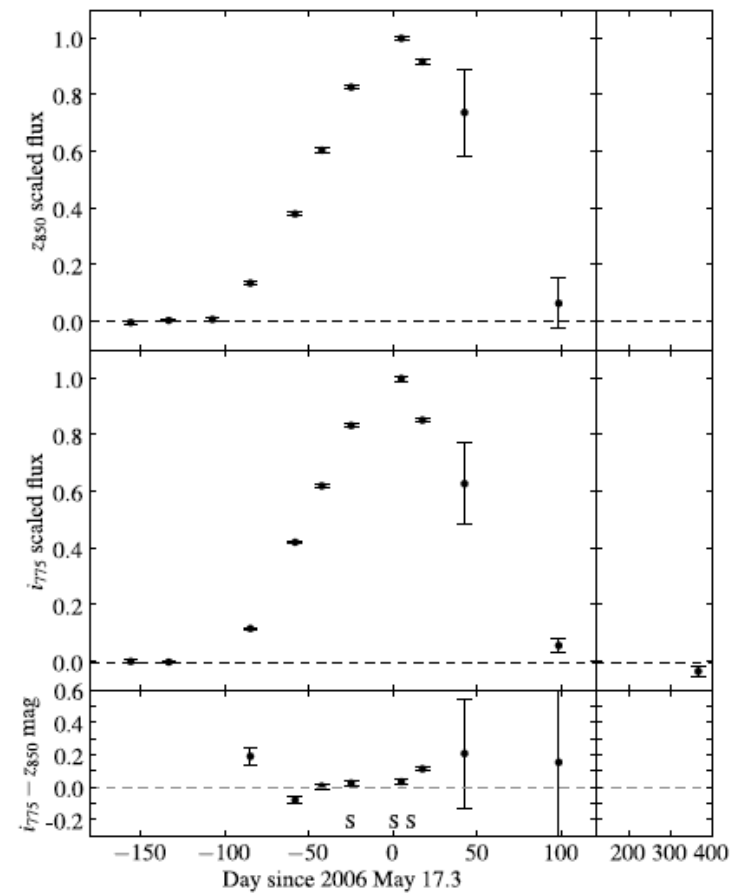
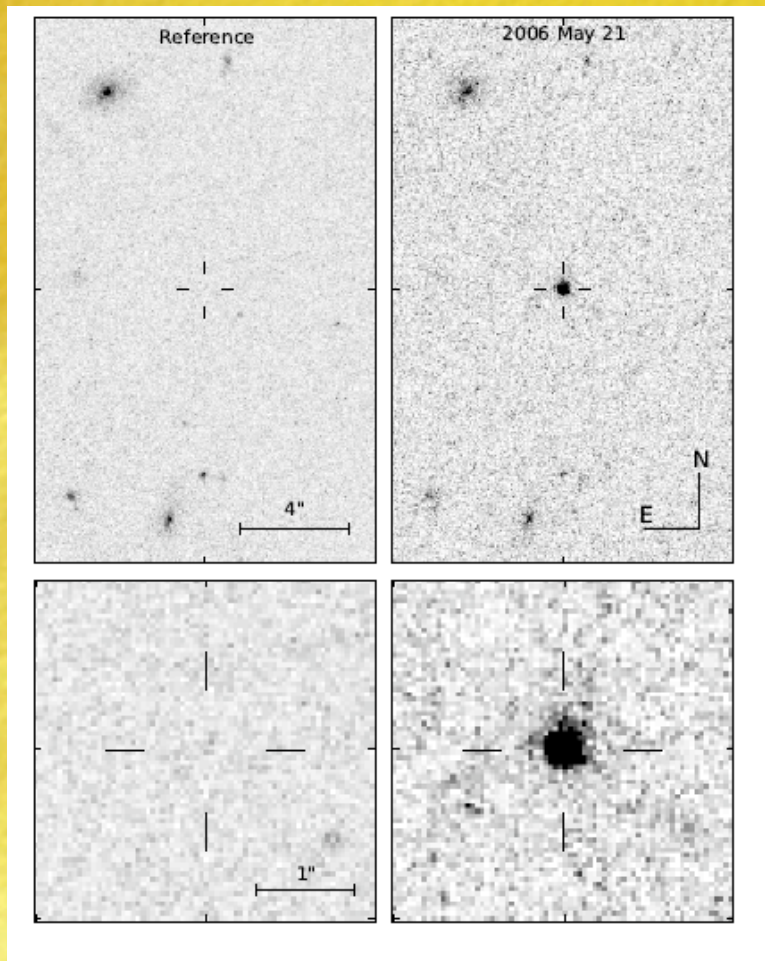


SN2002cx-family: Massive Stars?



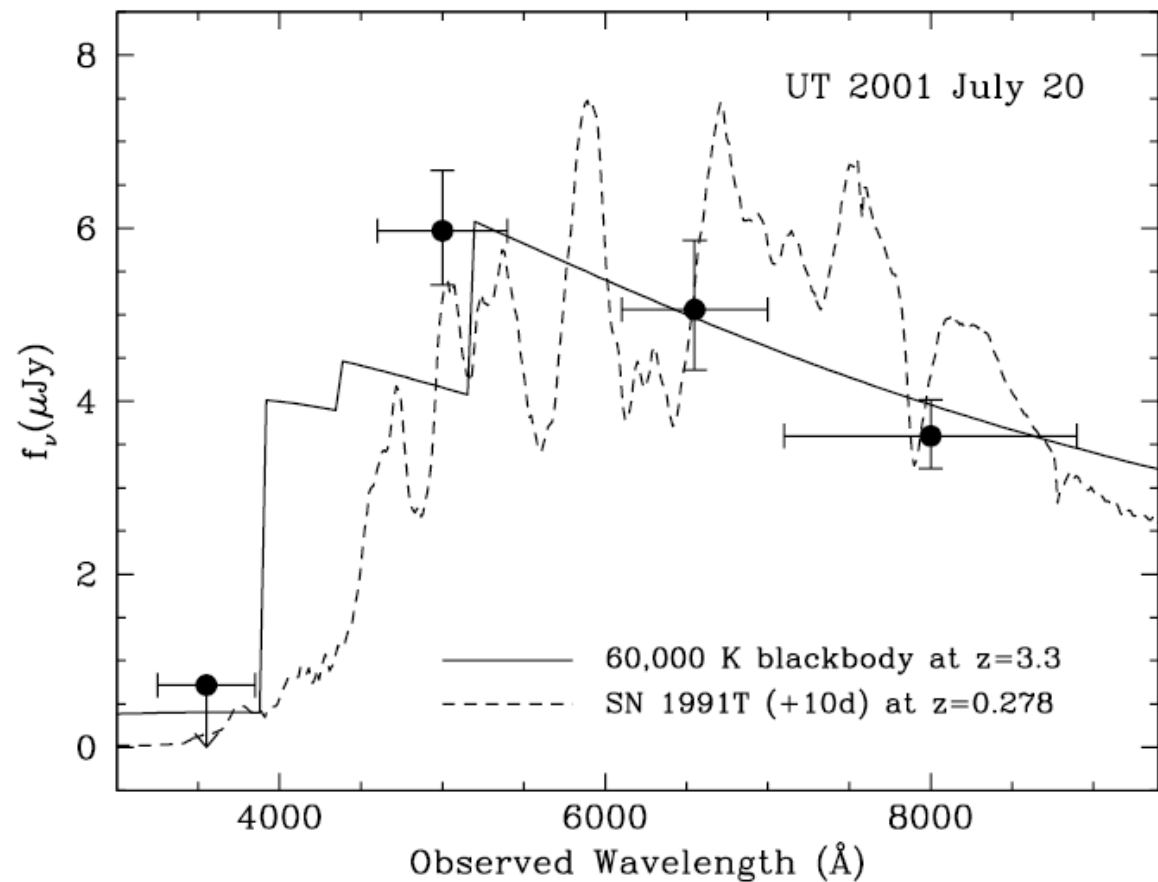
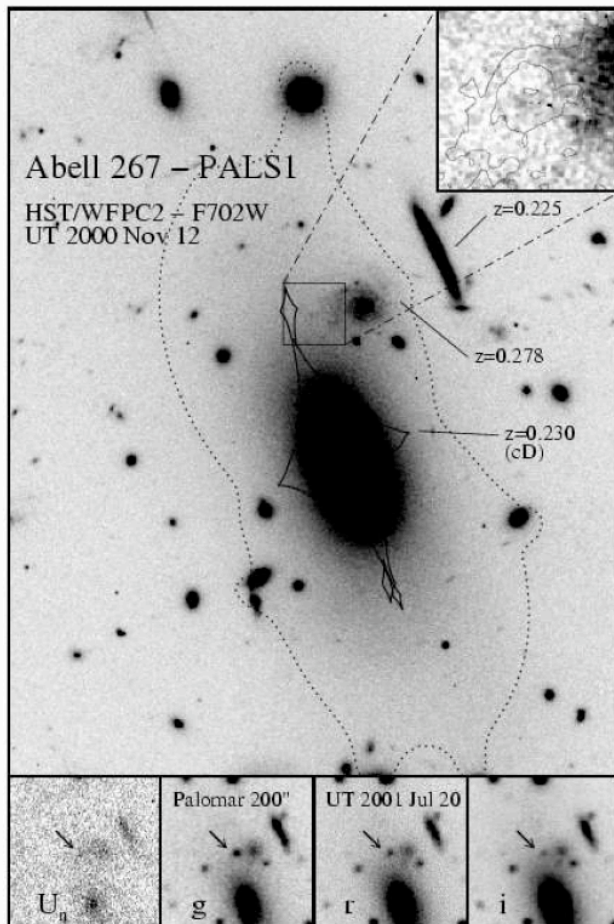
- ★ PTF09eoi bridges the gap between 2008ha and 2002cx
 - + Wide range in luminosity and hence, ejecta mass?
- ★ PTF09ego is the brightest member of this class
 - + If Ia, ejecta mass is 4.5 Msun! Cannot be a White Dwarf
- ★ Are these massive stars with cores collapsing into a black hole?

The Mysterious SCP06F6



Barbary et al.

The Mysterious Pals-1



Stern et al. 2004



III. The Luminous Supernovae

Lead: Robert Quimby



SNe From ROTSE-III

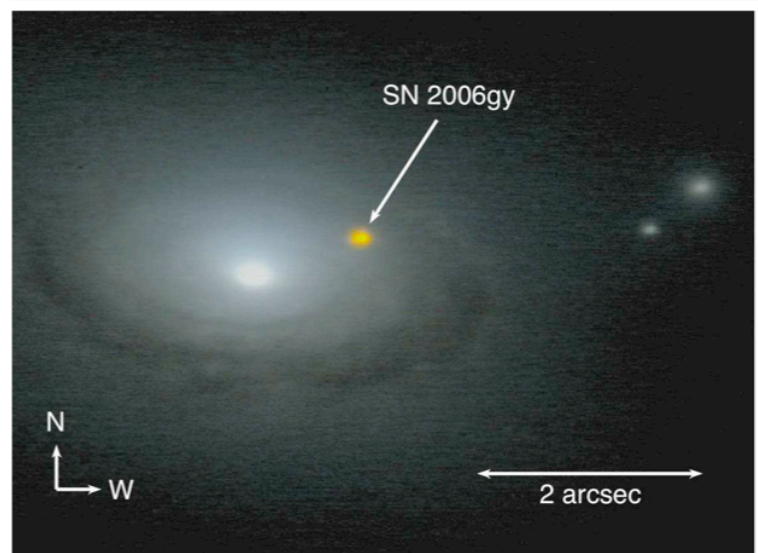


□ TSS/RSVP

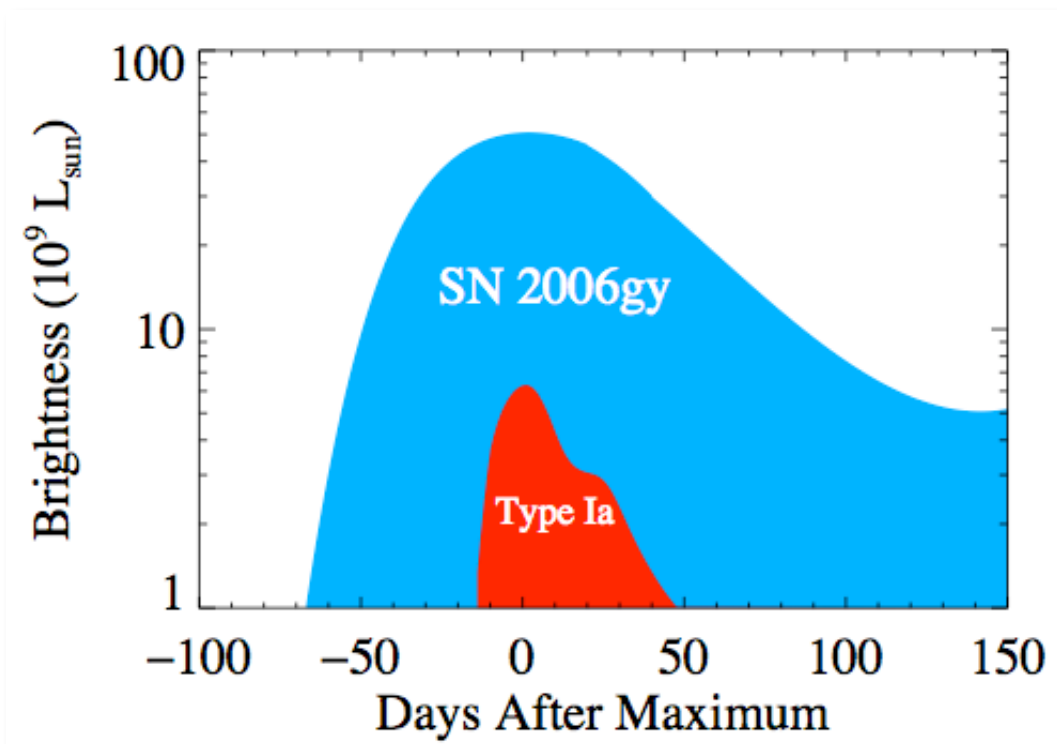
- **0.45-m ROTSE-IIIb telescope**
- **1.85 X 1.85 degree FoV**
- **1-3 day cadence, M_{lim} 18 to 19**
- **Target selection without (intentional)**
- **~80 SNe to date including 6 LSNe**
- **Only spectroscopically complete Transient Survey**



SN 2006gy



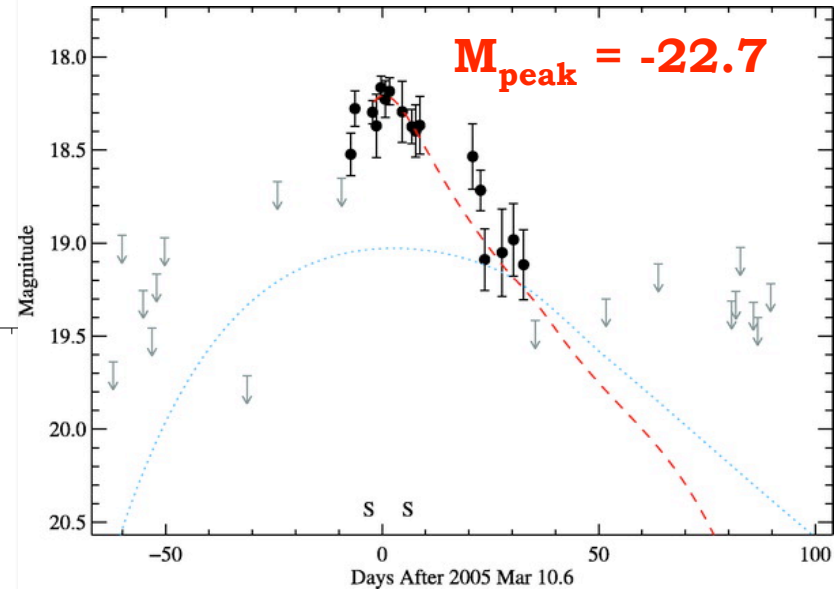
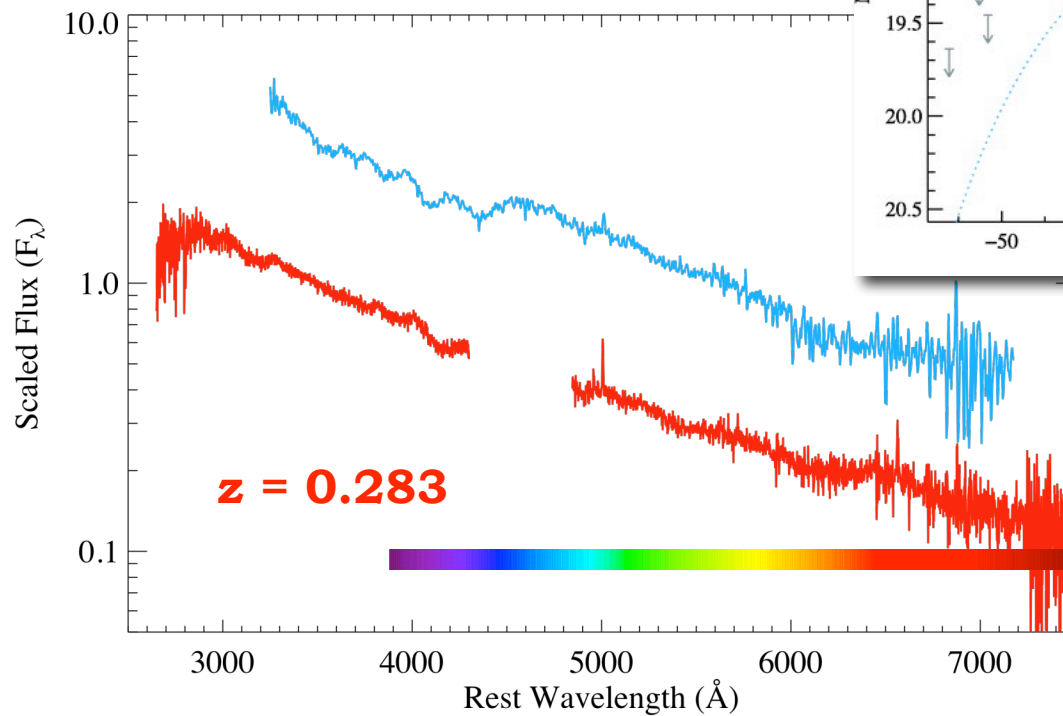
Smith et al. 2008



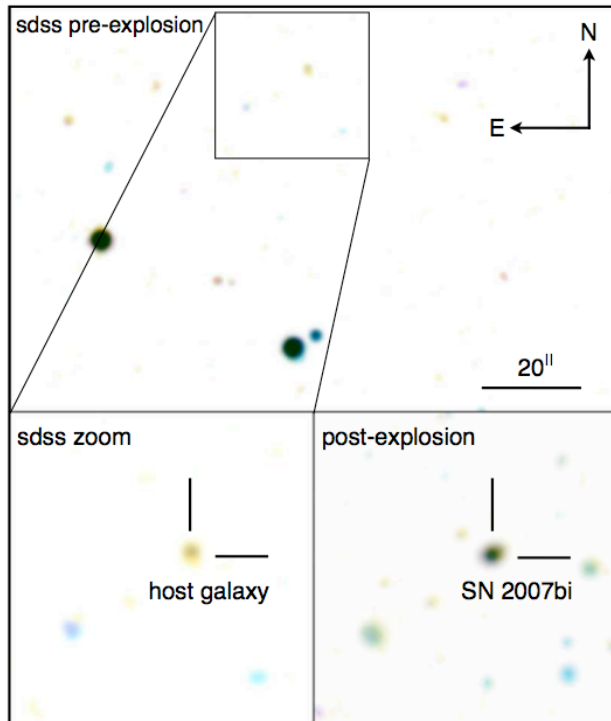
- Peak absolute magnitude nearly -22
- Brighter than -21 mag for ~ 100 days
- Integrated light $> 10^{51}$ erg
- See: Ofek+ 2007, Smith+ 2007, Smith & McCray 2007, Agnoletto+ 2009, Kawabata+ 2009...

SN 2005ap Observations

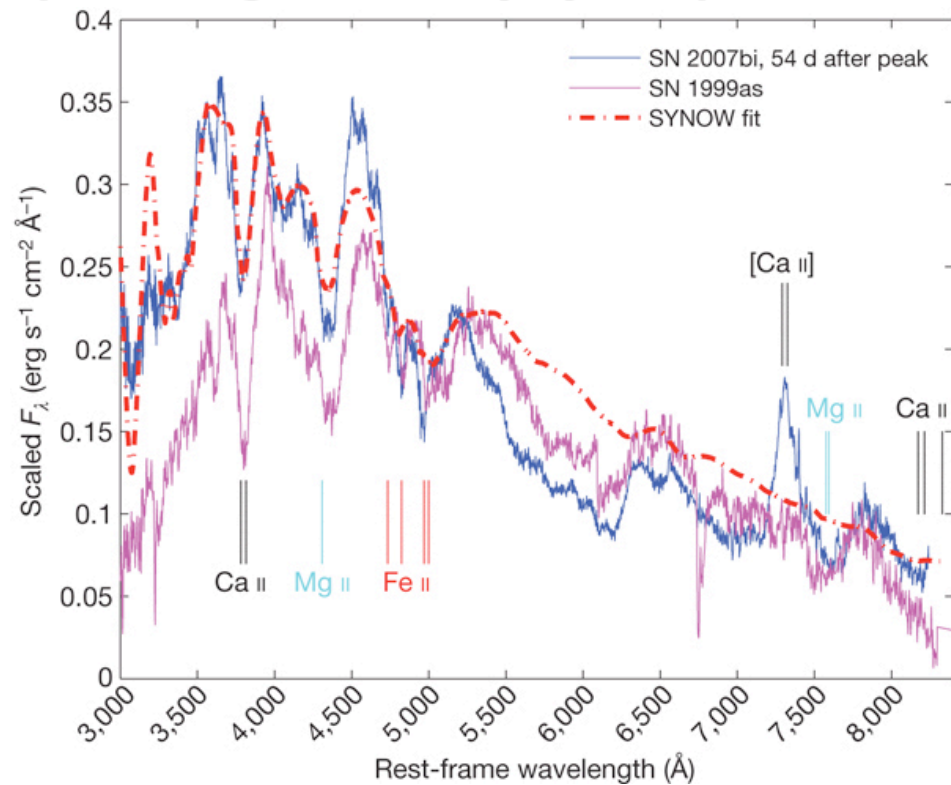
Quimby et al. 2007



PTF Dry Run: SN 2007bi

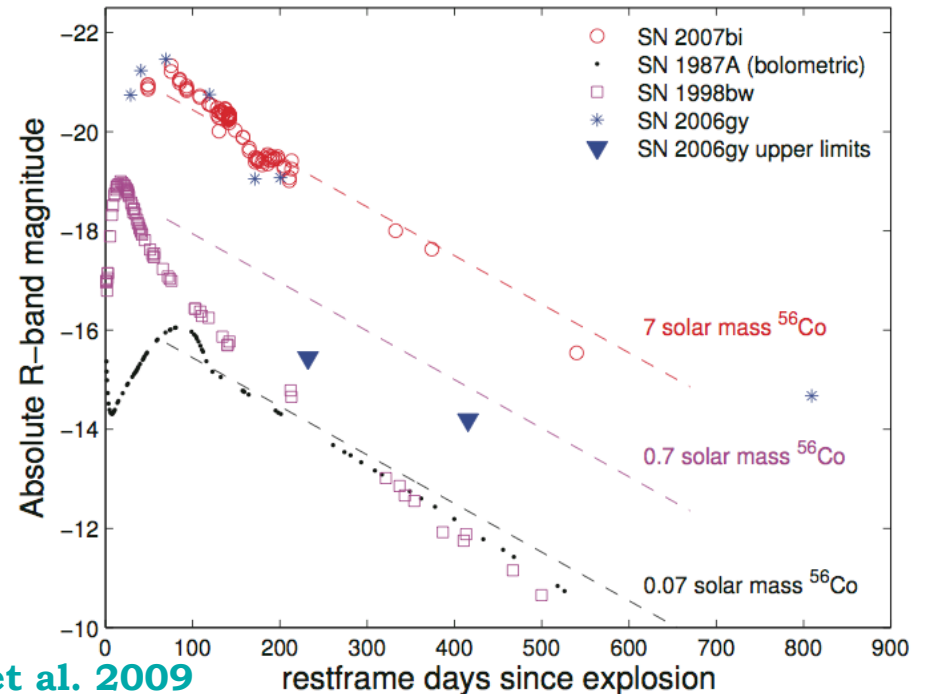
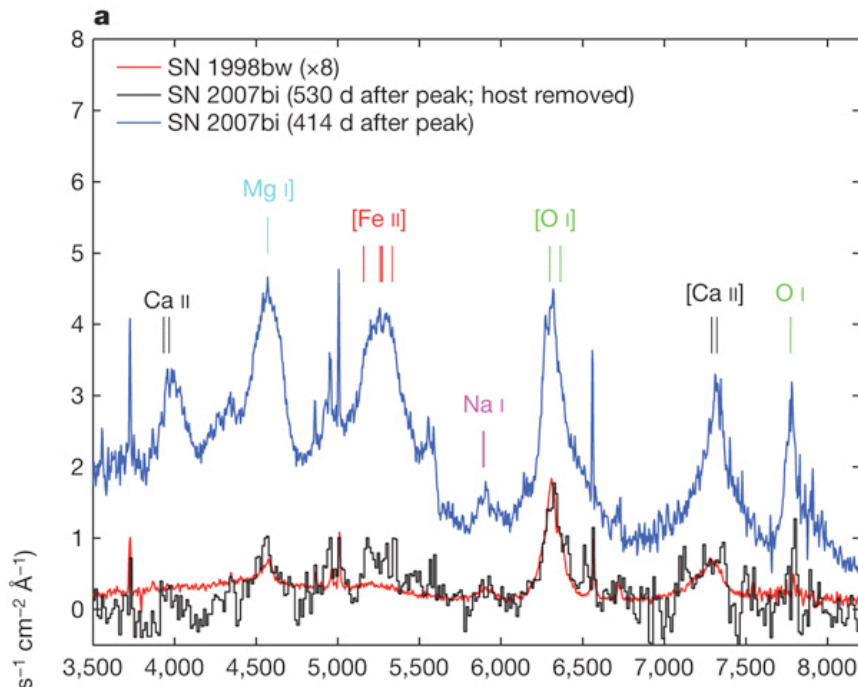


Young et al. 2010



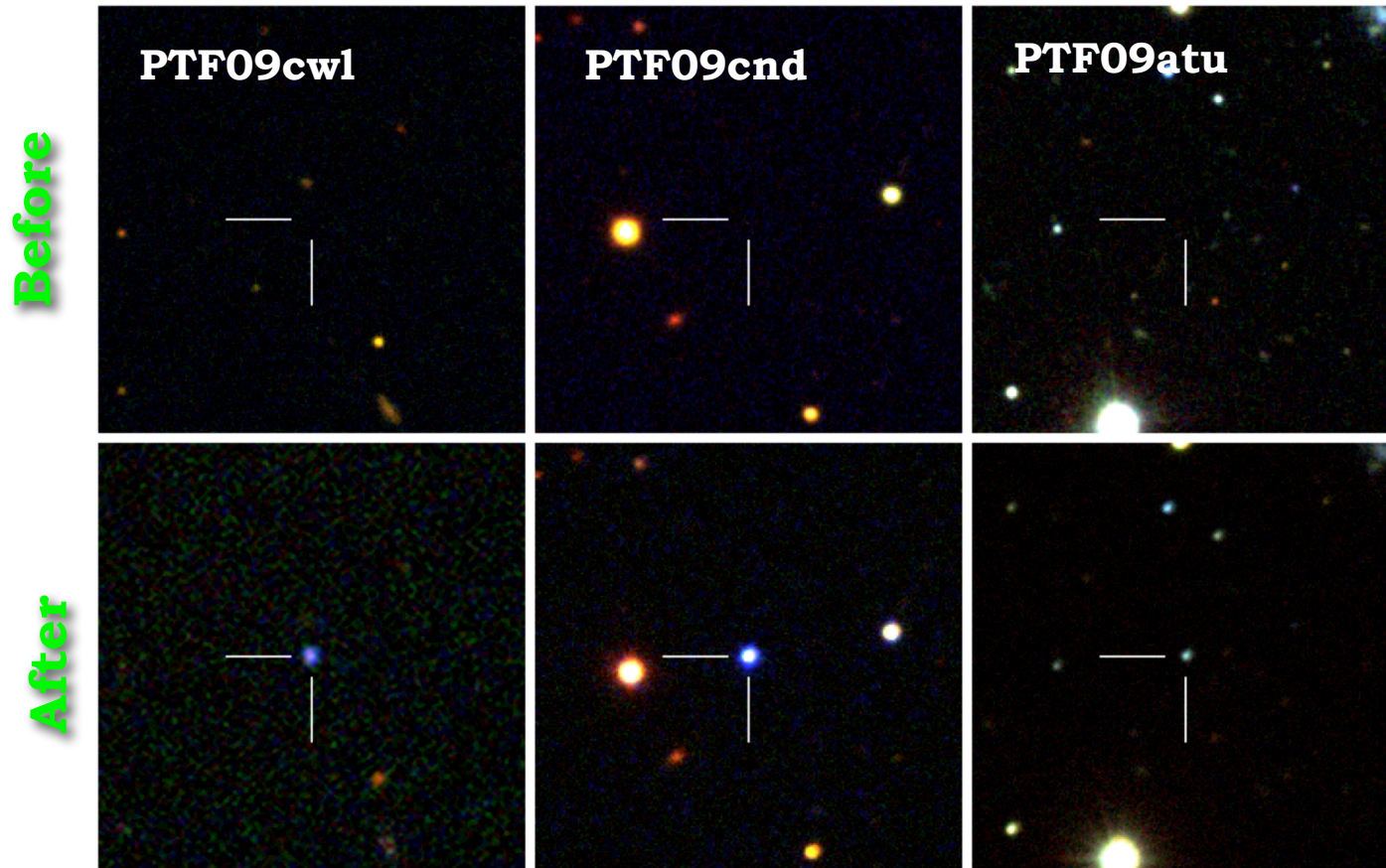
Gal-Yam et al. 2009

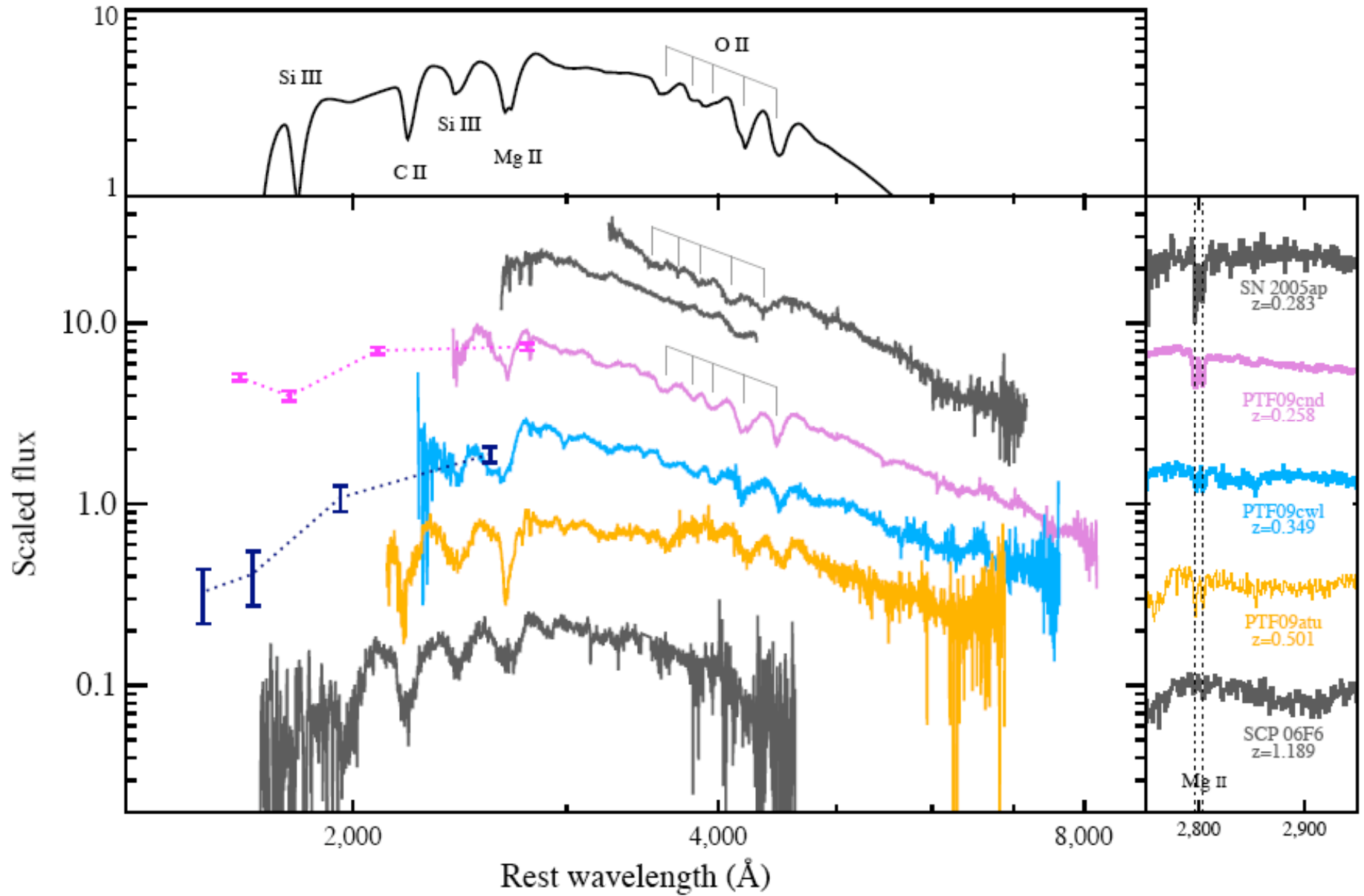
SN 2007bi: Nickel Rich



- Optical light curve decay rate consistent with the production of $\sim 7 M_{\odot}$ of ^{56}Ni
- Iron abundance in nebular spectra also consistent with the decay of $\sim 4\text{-}7 M_{\odot}$ of ^{56}Ni

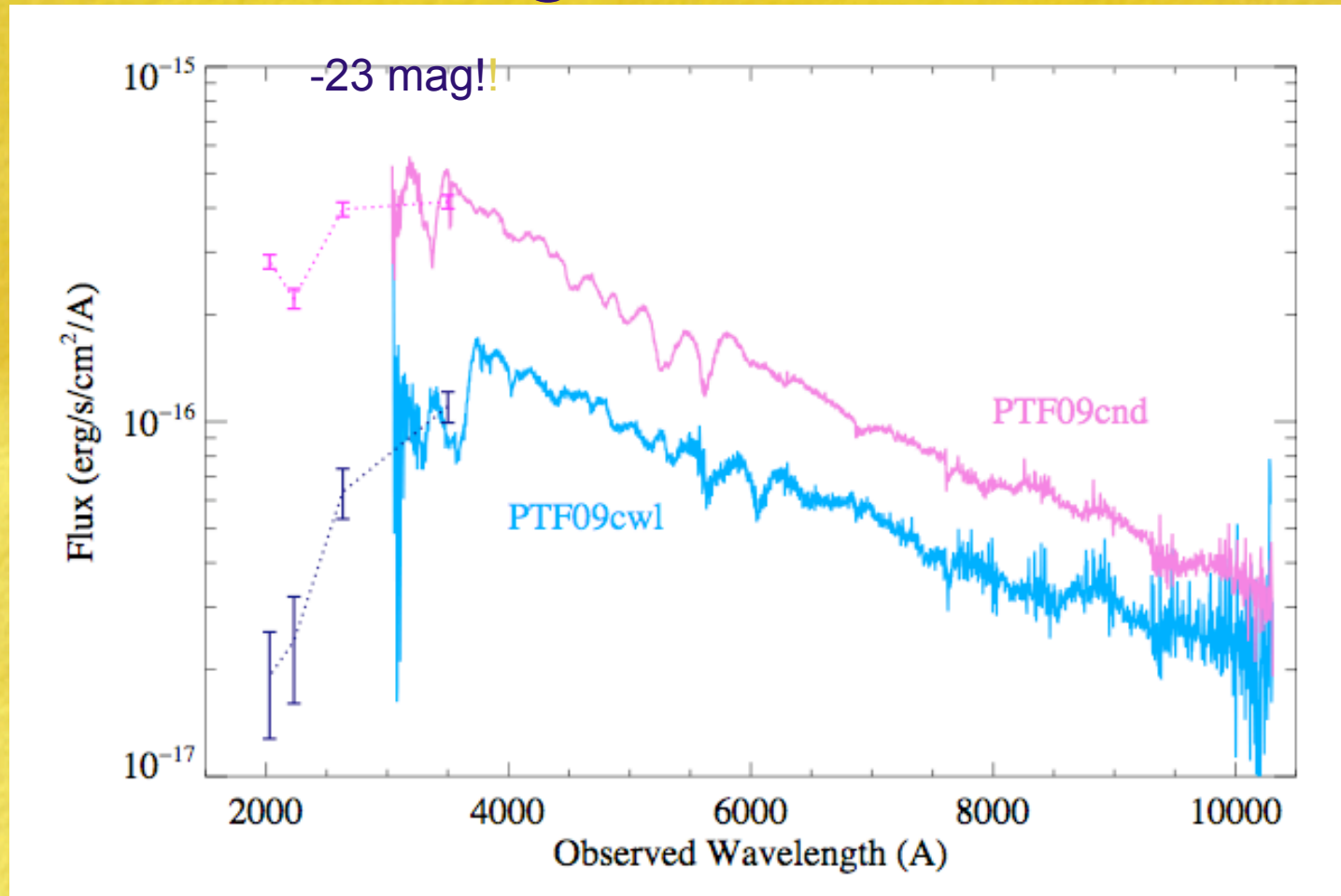
PTF Discovers 3 LSNe





Quimby et al.

Bright in UV



Swift satellite observations

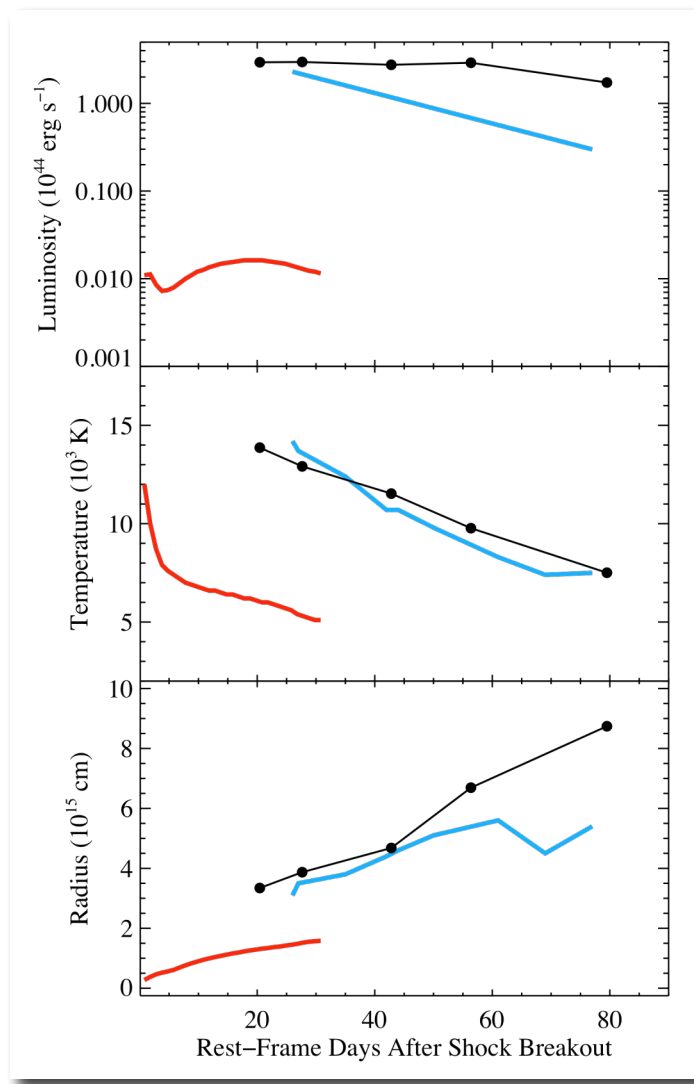
PTF09cnd: Early Time Summary

- ~50 day rise to (r-band) maximum
- UV bright through r-band maximum
- Principal spectroscopic lines from O II, Mg II
- No Hydrogen
- P-Cygni profiles dominated by absorption
- Effective temperature still $\sim 10^4$ K at (r-band) maximum despite ~50 days of expansion at $\sim 10,000$ km/s
- No narrow emission lines to suggest wind interaction

- Initial radius *possibly* quite large, but again, no H envelope

- Pulsational Pair-Instability Supernova?

PTF09cnd: BB Comparison



SN 2008D

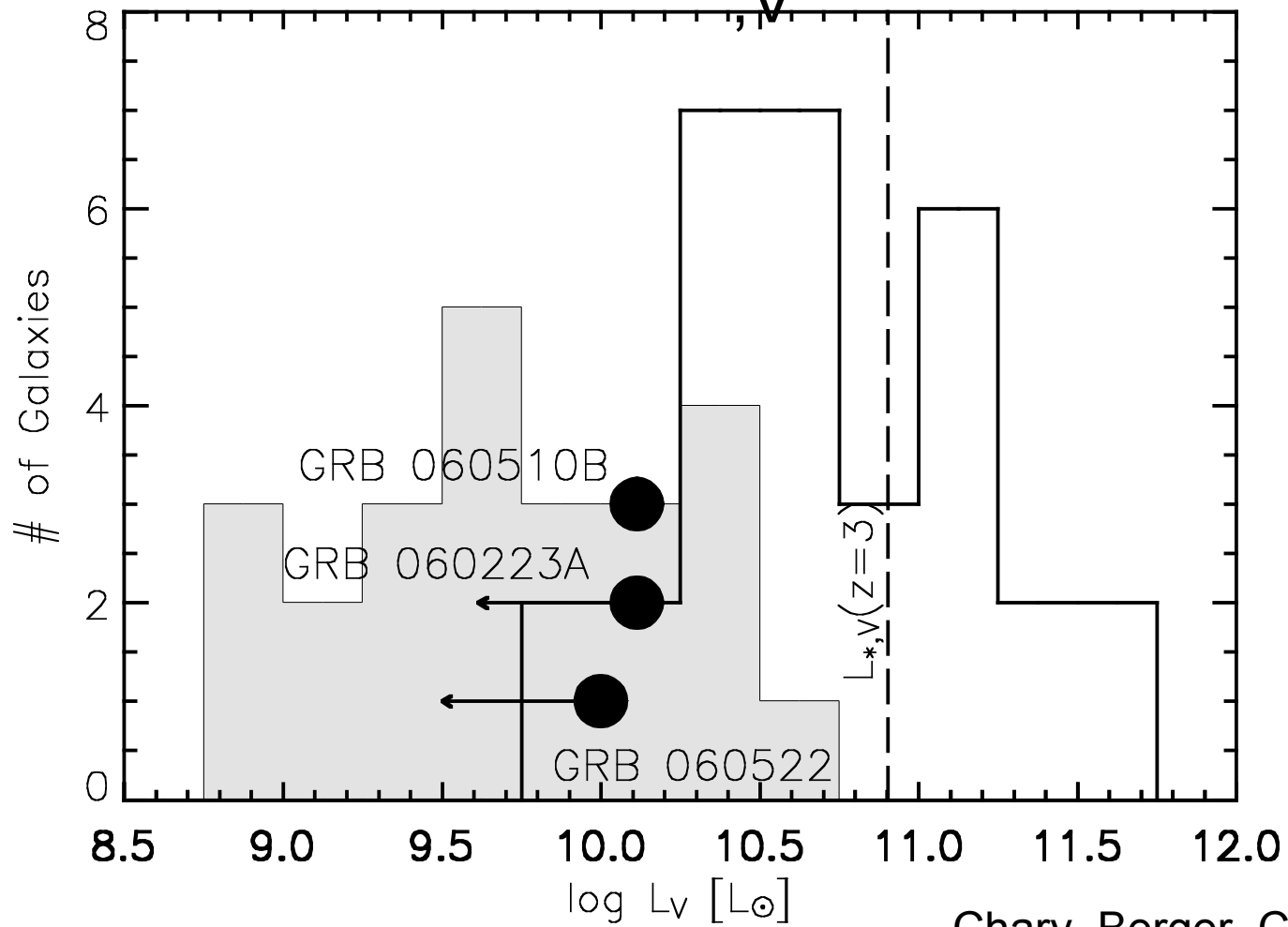
- Discovered by *SWIFT* during shock breakout (Soderberg et al. 2008)
- Type Ib/c
- Compact progenitor ($R_{\star} \sim R_{\odot}$)

SN 2008es

- Discovered by ROTSE-III (Gezari et al. 2009)
- Type II (very luminous, $M_{\text{peak}} < -22$)
- Likely extended progenitor ($R_{\star} > 5000 R_{\odot}$)

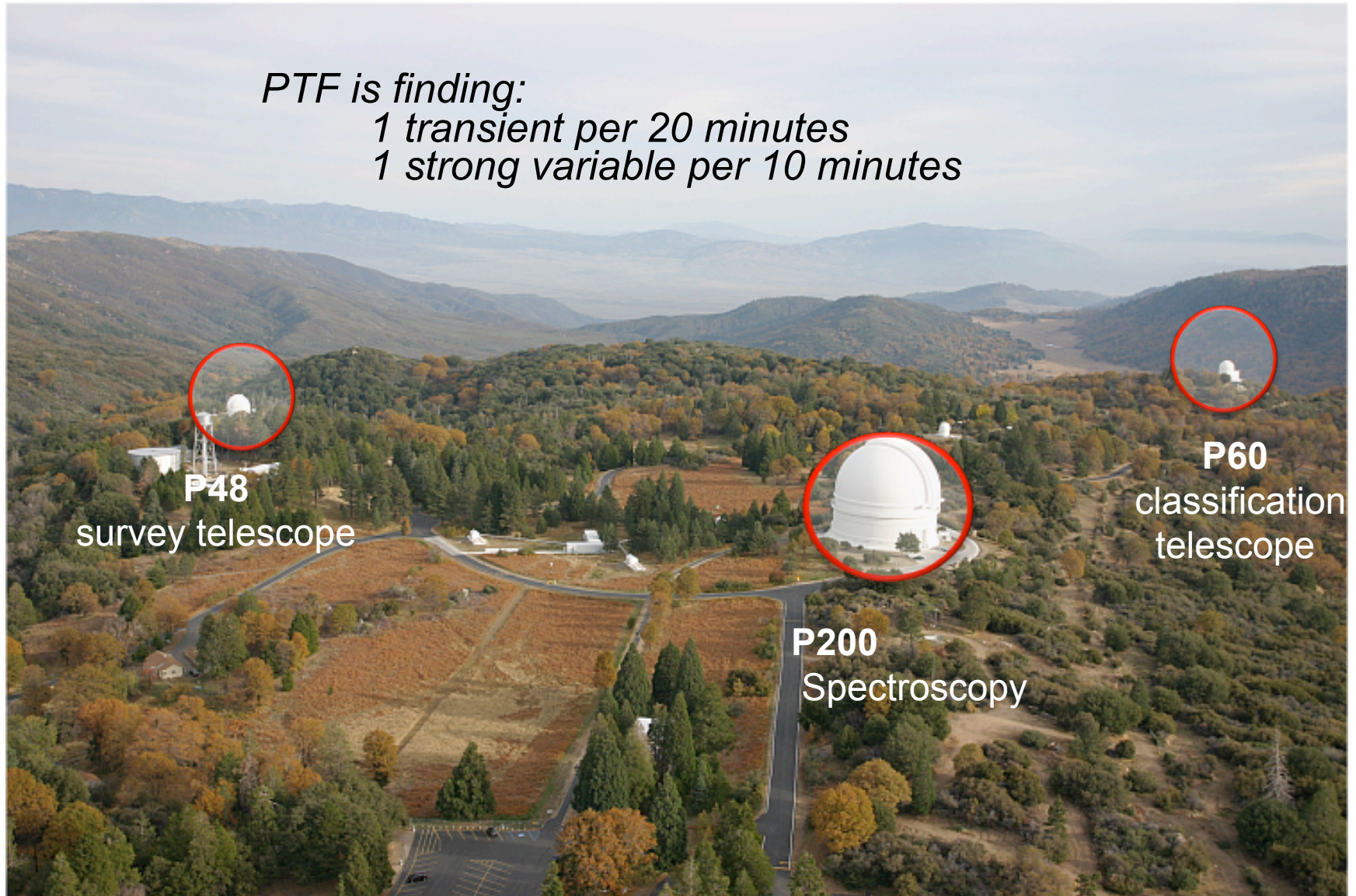
GRB hosts are faint, typically

$\sim 0.1 L_{*,V}$



Chary, Berger, Cowie 2007

*PTF is finding:
1 transient per 20 minutes
1 strong variable per 10 minutes*



P48
survey telescope

P200
Spectroscopy

P60
classification
telescope

