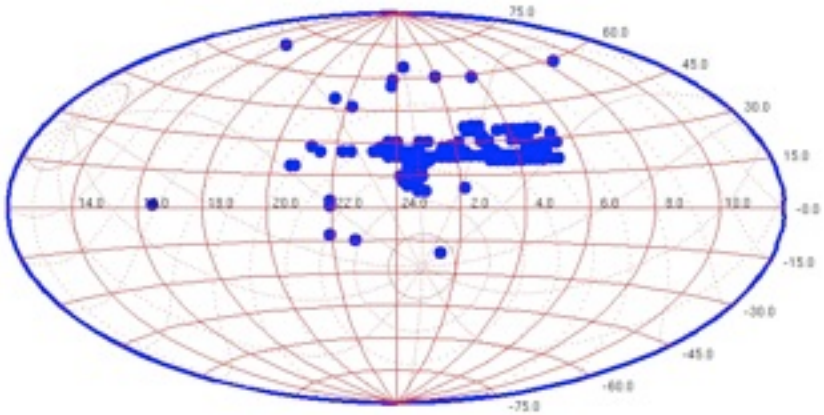
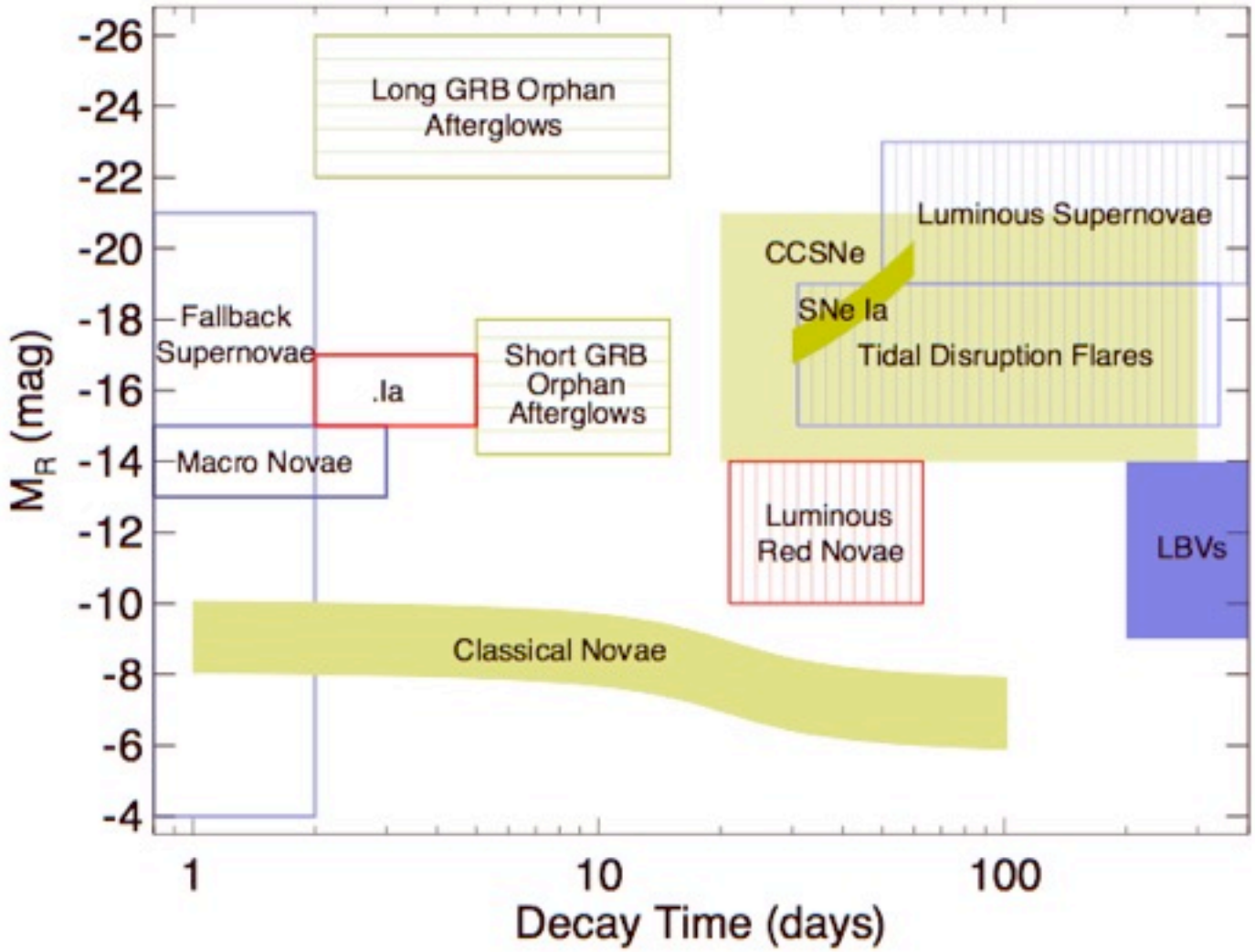
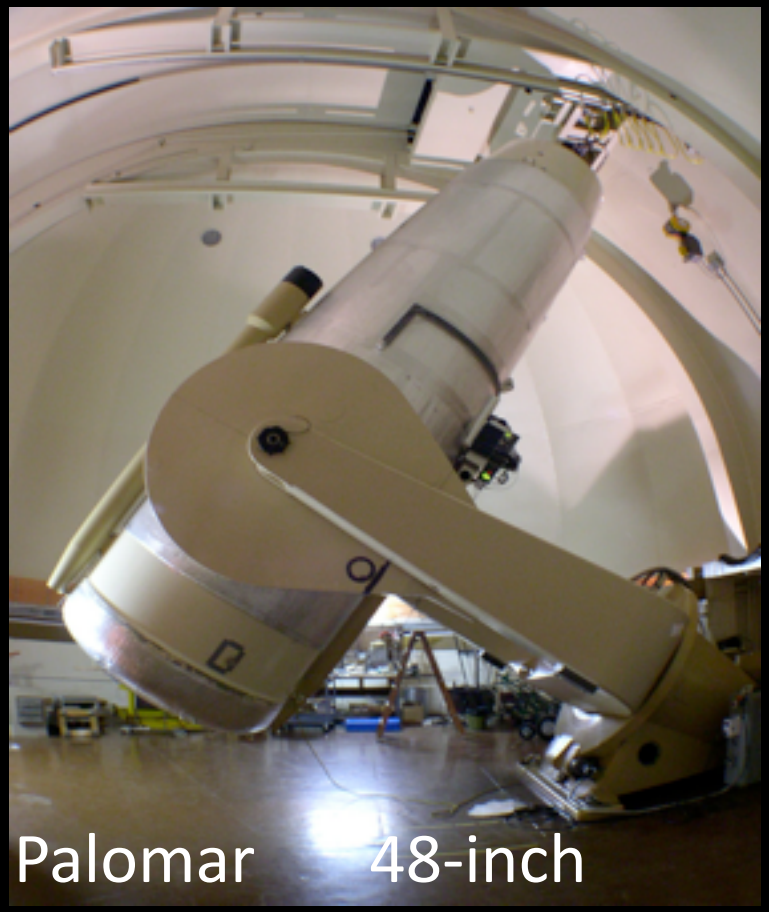

75.0
60.0
45.0
30.0
15.0
-0.0
-15.0
-30.0
-45.0
-60.0
-75.0
14.0
18.0
20.0
22.0
24.0
2.0
4.0
6.0
8.0
10.0

I. Palomar Transient Factory Overview

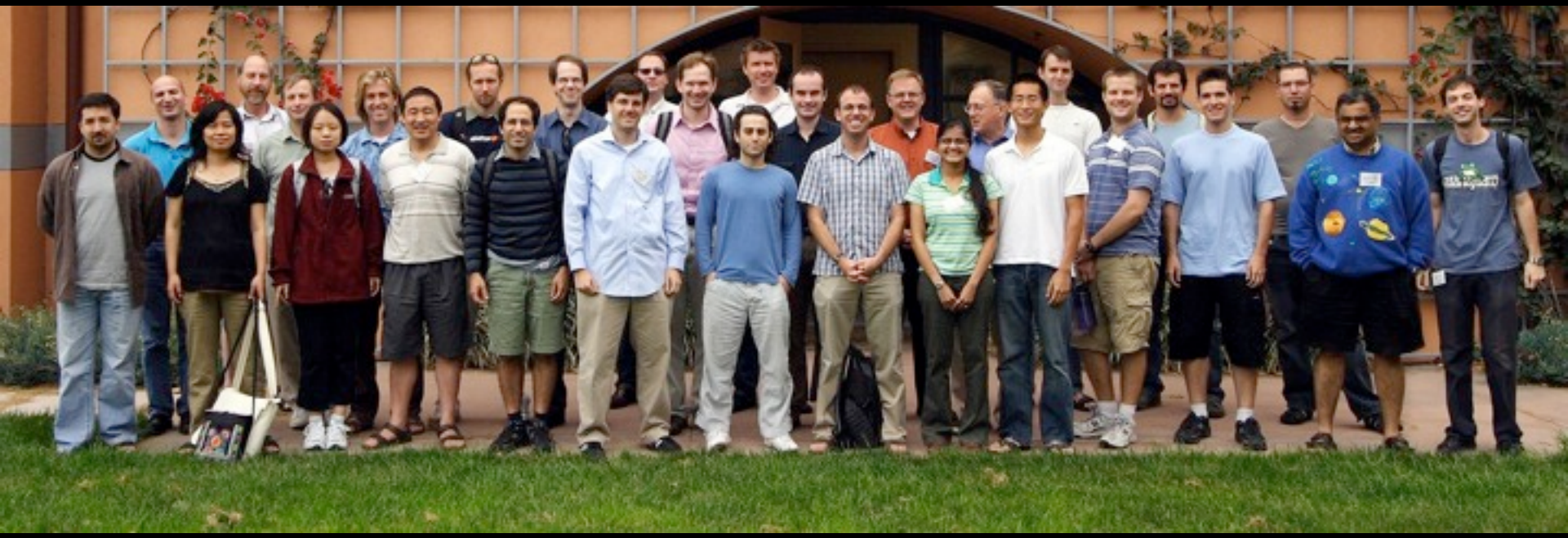
S. R. Kulkarni
Principal Investigator
and the PTF collaboration


Long GRB Orphan Afterglows
Luminous Supernovae
CCSNe
SNe Ia
Tidal Disruption Flares
Fallback Supernovae
.Ia
Short GRB Orphan Afterglows
Macro Novae
Luminous Red Novae
LBVs
Classical Novae
-26
-24
-22
-20
-18
-16
-14
-12
-10
-8
-6
-4
M_R (mag)
1
10
100
Decay Time (days)

A Novel Two-telescope Approcach



PTF collaboration



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

PTF overview

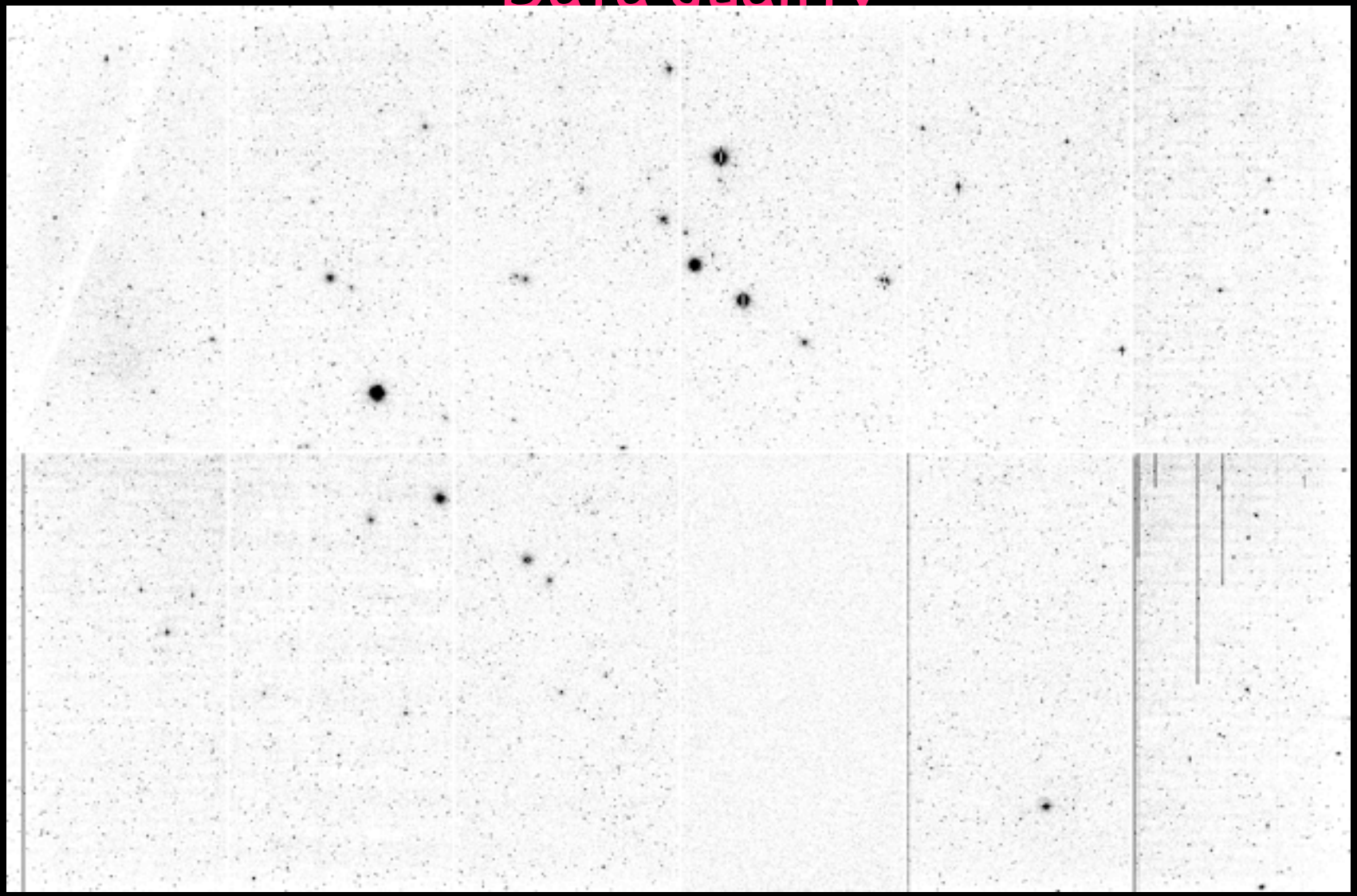
Data quality

- ★ First light: December 2008
- ★ First science run: March 2009

- ★ Typical seeing ~1.8″ (best 1.4″)
- ★ Lim. Mag (5σ) ~21 in g,R

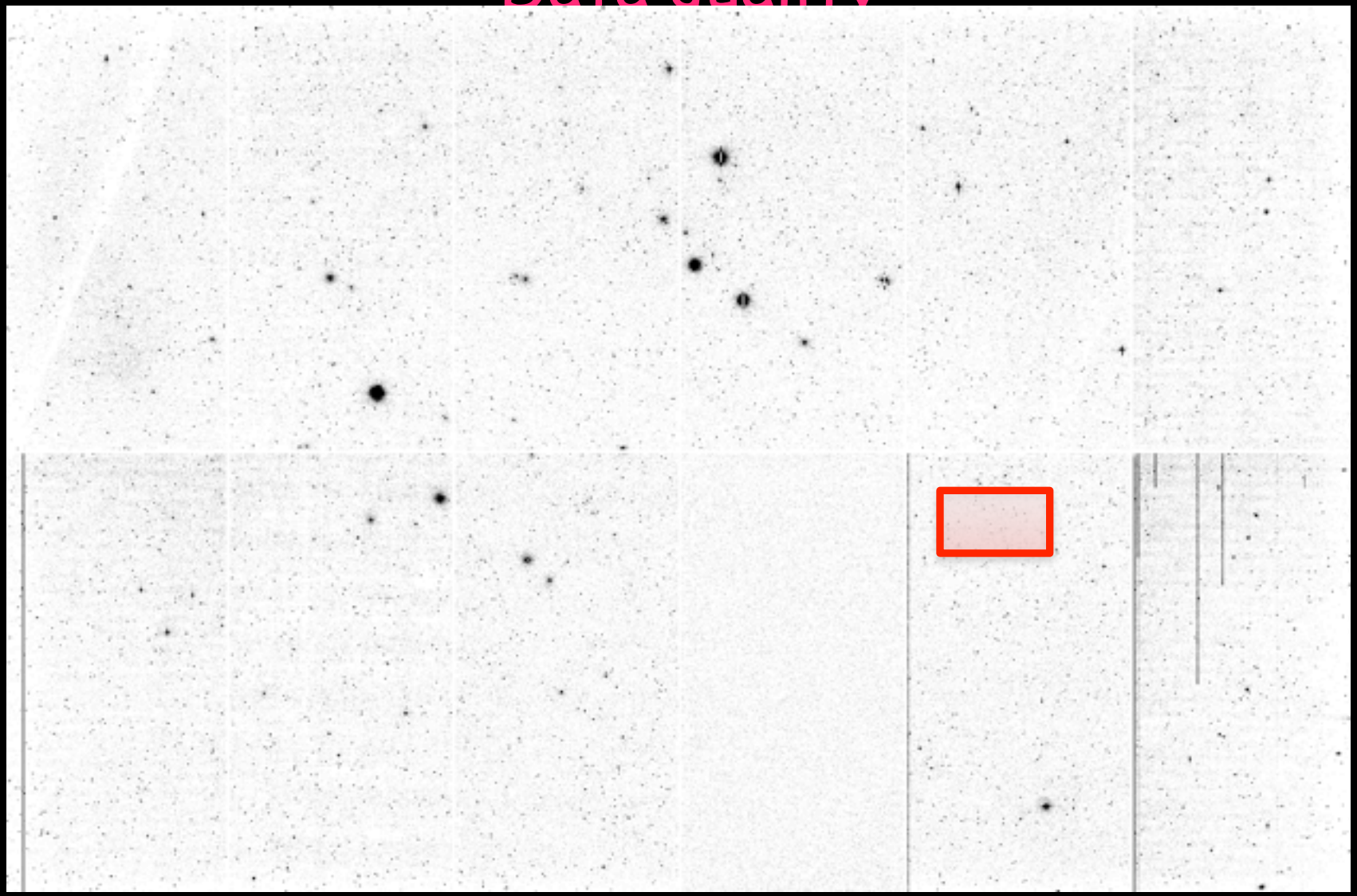
PTF overview

Data quality



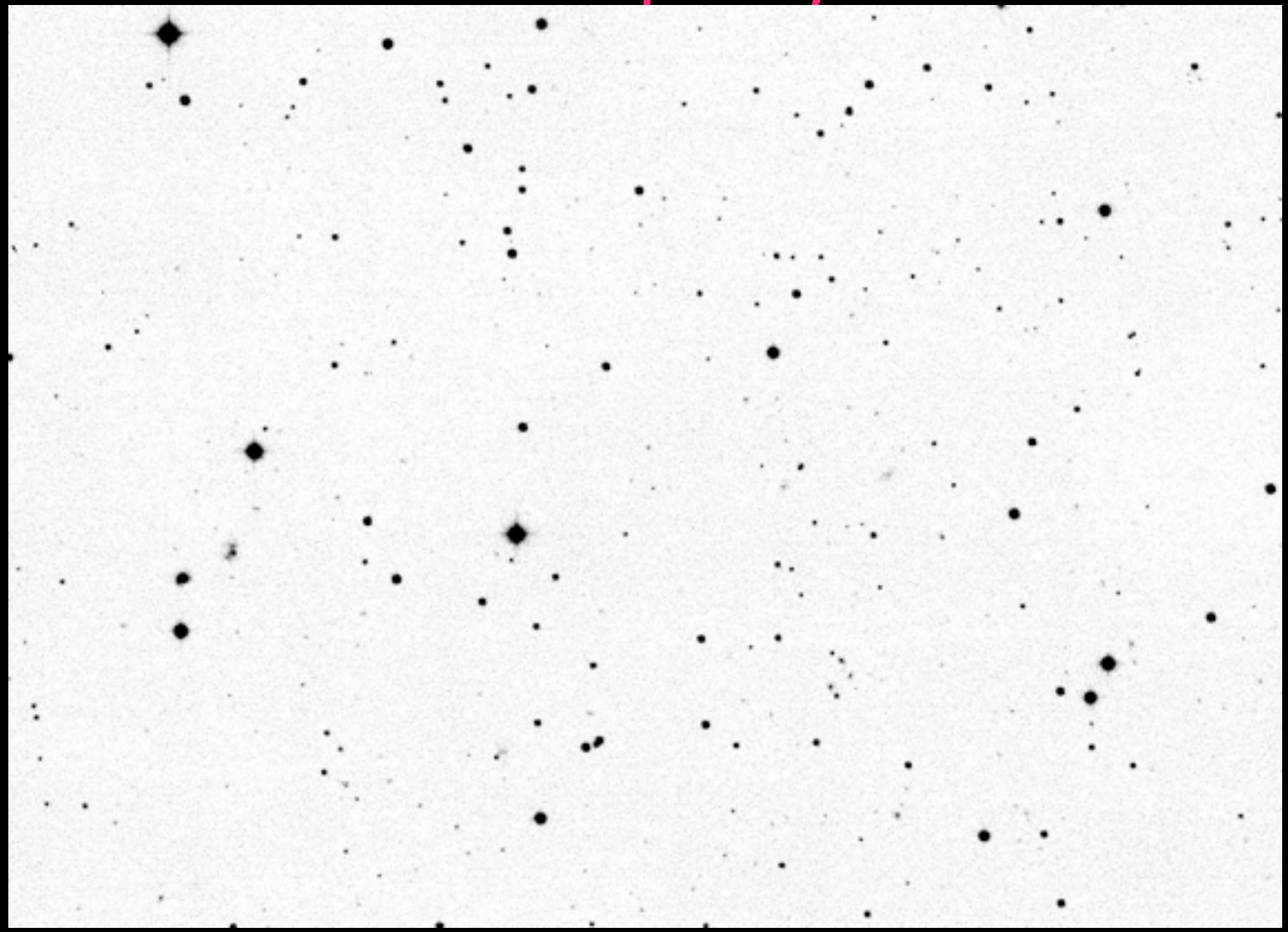
PTF overview

Data quality



PTF overview

Data quality



PTF software

- ★ Robotic operations
- ★ Robust and Long lived Sequencer
- ★ Two separate pipelines

  LBL image subtraction pipeline

  IPAC images and catalogue pipeline

Image subtraction

LBL image subtraction pipeline (Nugent)

- ★ Challenge: 0.5-1 M sources detected in Subtracted images each night!
- ★ after cleaning – large number of candidates (~10%)
- ★ However, only a few % are real variable/transients
- ★ Solutions:

  Machine vetting → Scientists

  Humans vetting → Scientists, Public (beta)

IPAC images & catalogue pipeline

Lead by J. Surace

- Data products:

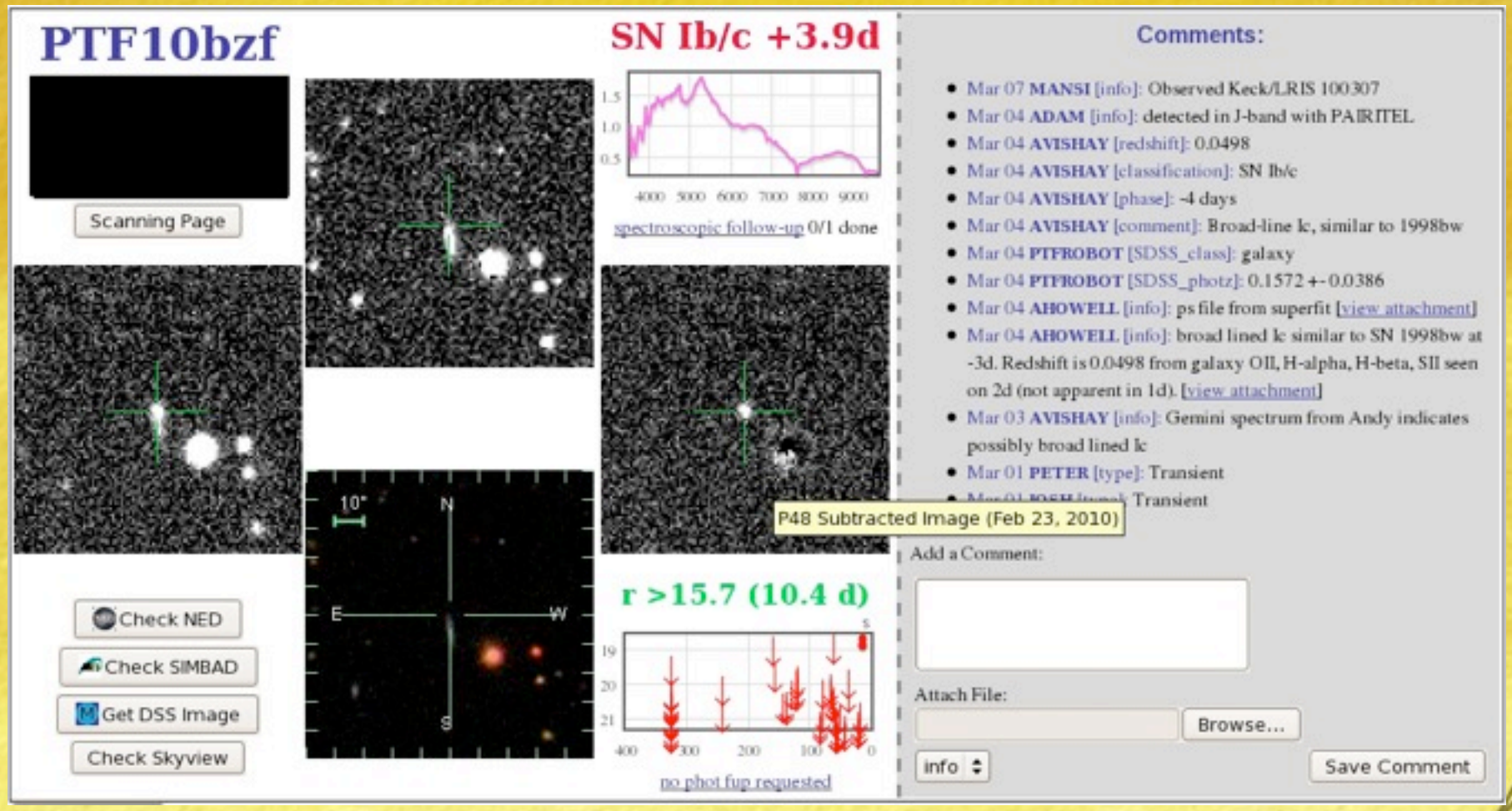
  Reduced images

  ~100TB per year

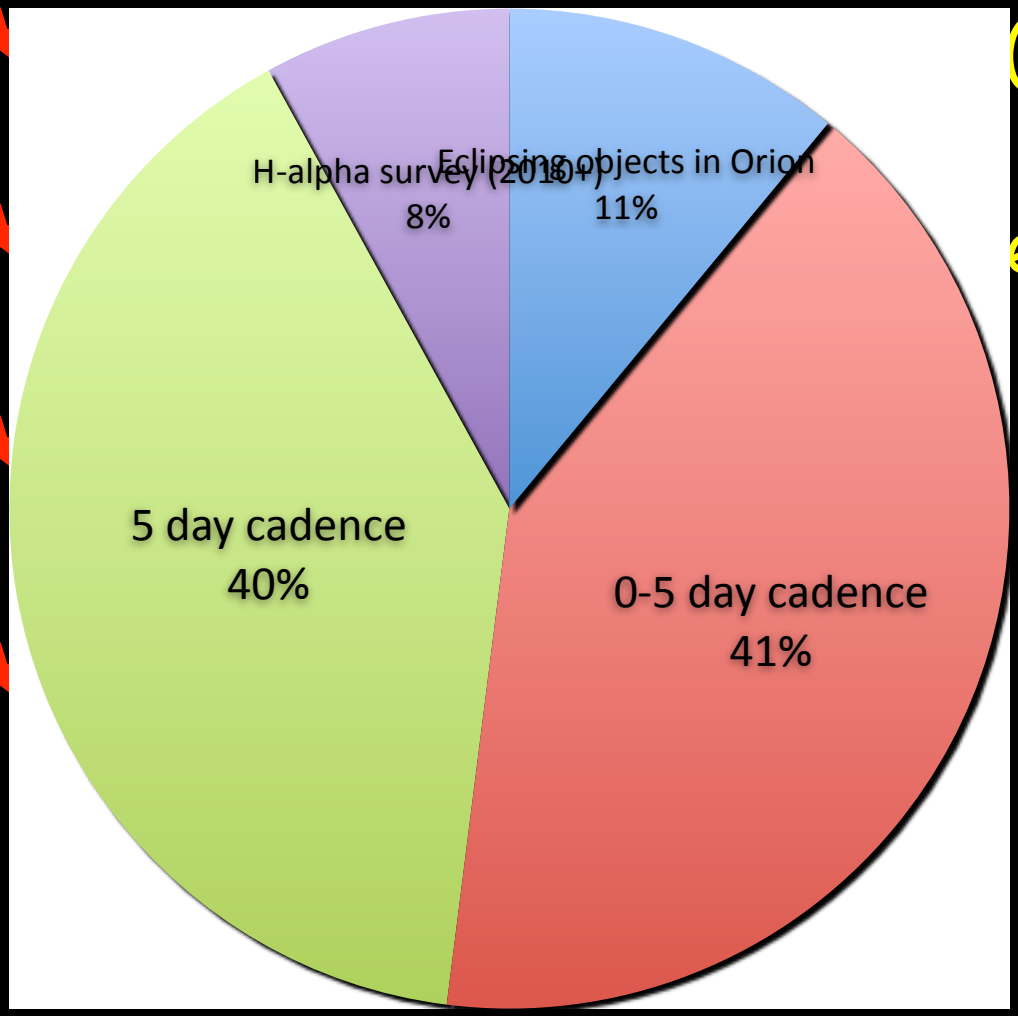
  Catalogue

  ~10^{12} sources per year (10 TB)

Follow up is the key



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

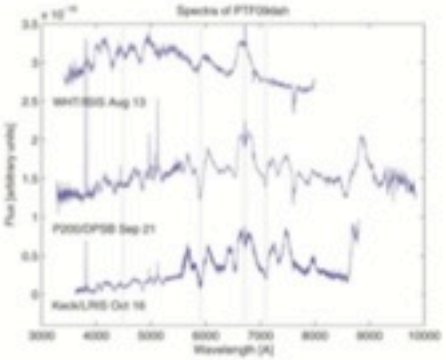
II. Shocking Results from PTF

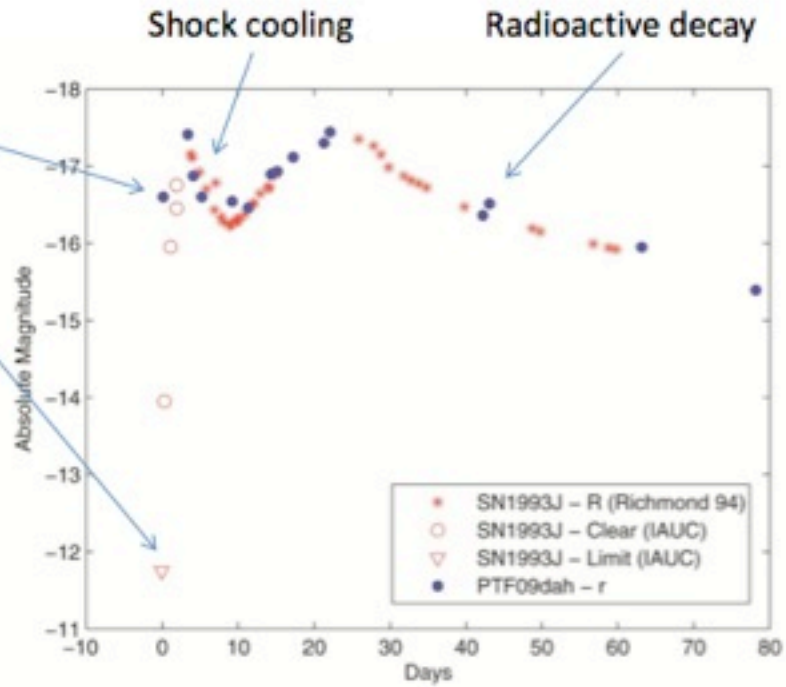
PTF09dah Discovered 1 day After Explosion

PTF09dah discovery

SN1993J non-detection

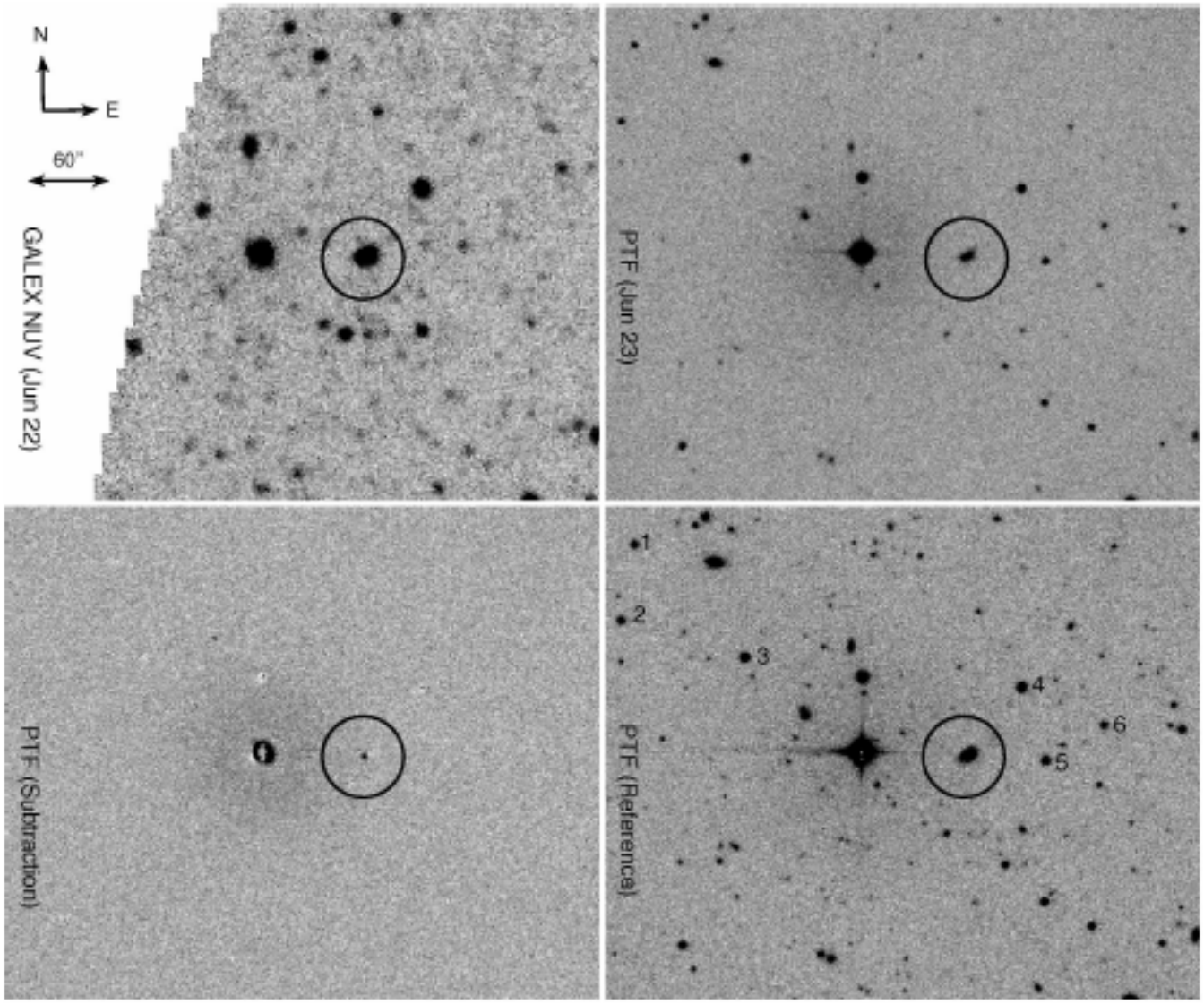
A type IIb supernova (emerging He lines):



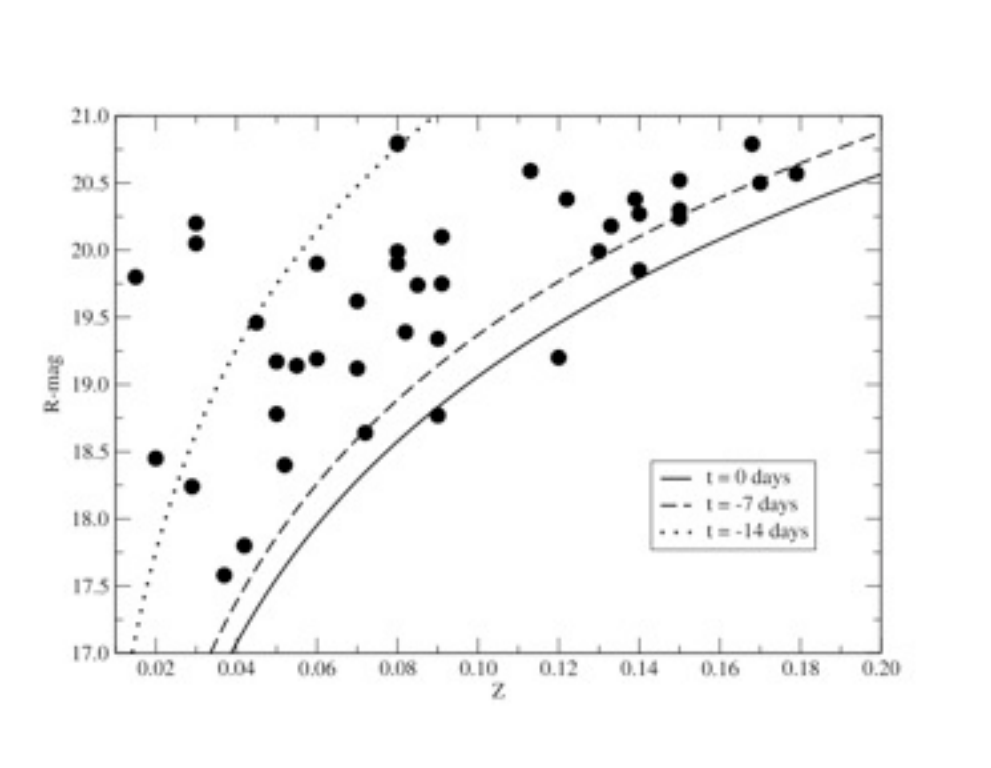


(Arcavi et al., in prep.)

Shock breakout

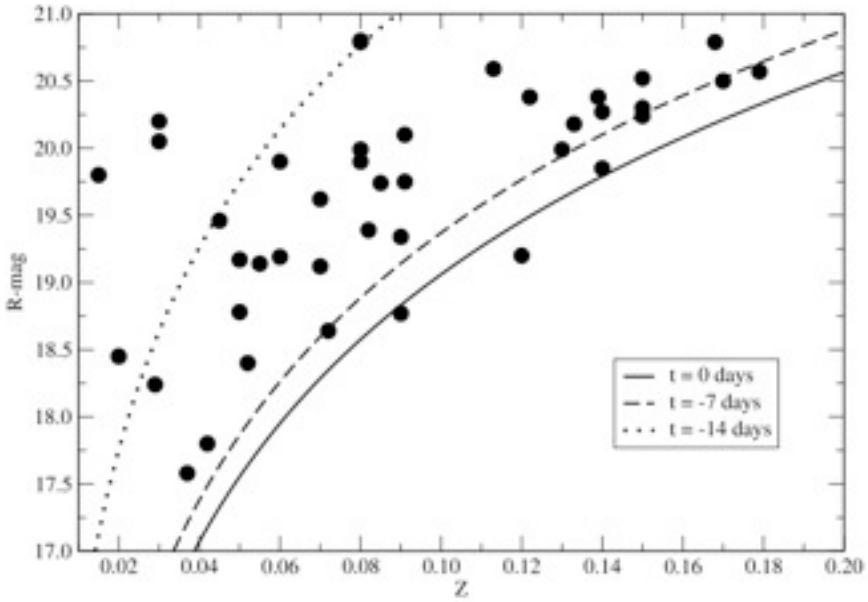


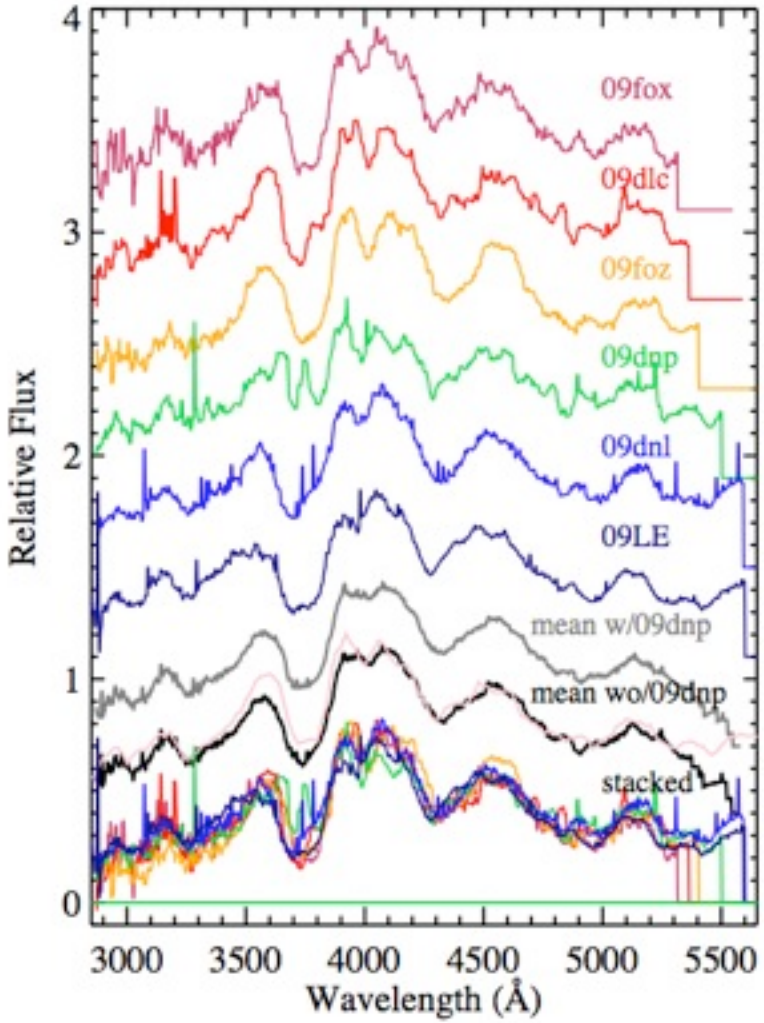
UV spectroscopy of local Ia



Nugent, Ellis, Howell, Sullivan …

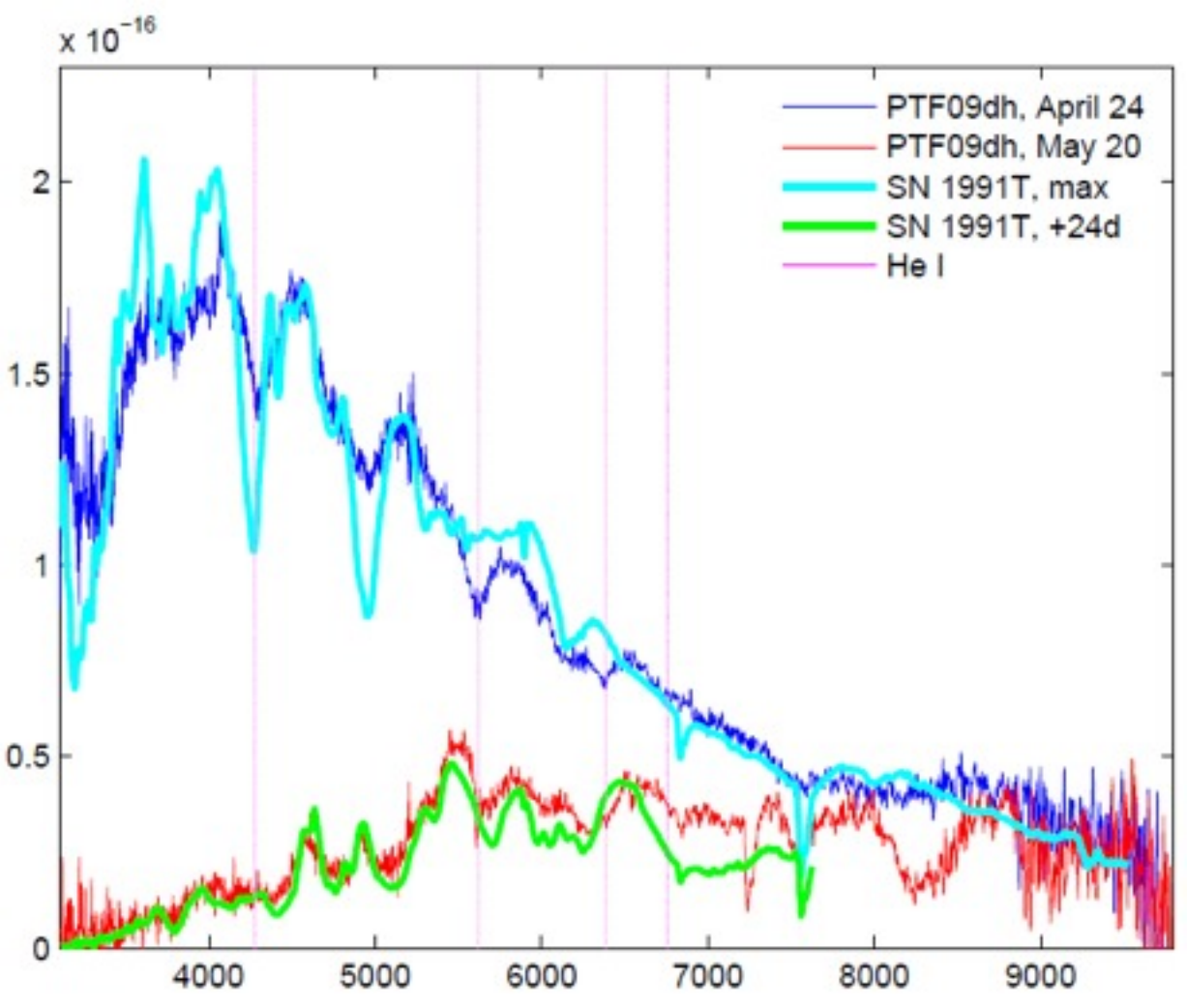
UV spectroscopy of local Ia





Nugent, Ellis, Howell, Sullivan …

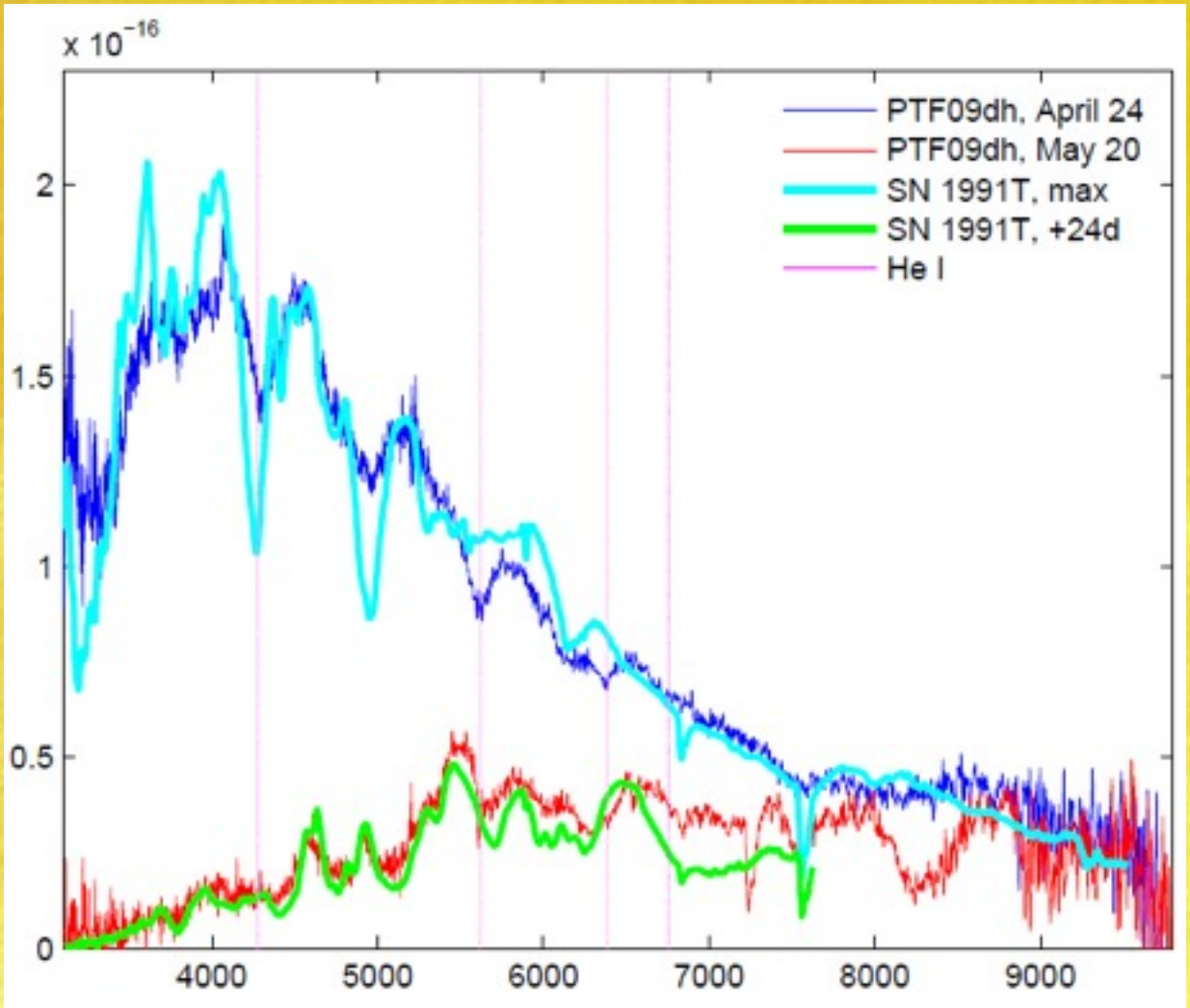
SNe Ia with He?



PTF09dh looks like SN 1991T (famous bright SN Ia) with He lines added

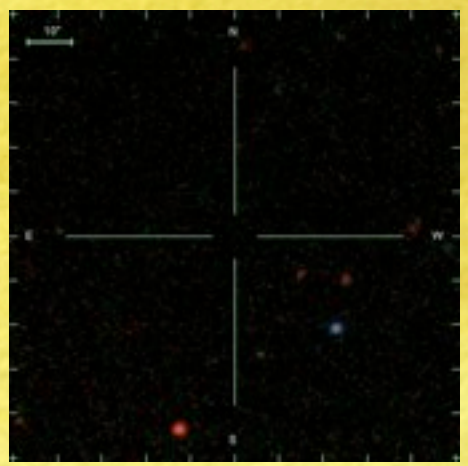
Dwarf host

SNe Ia with He?

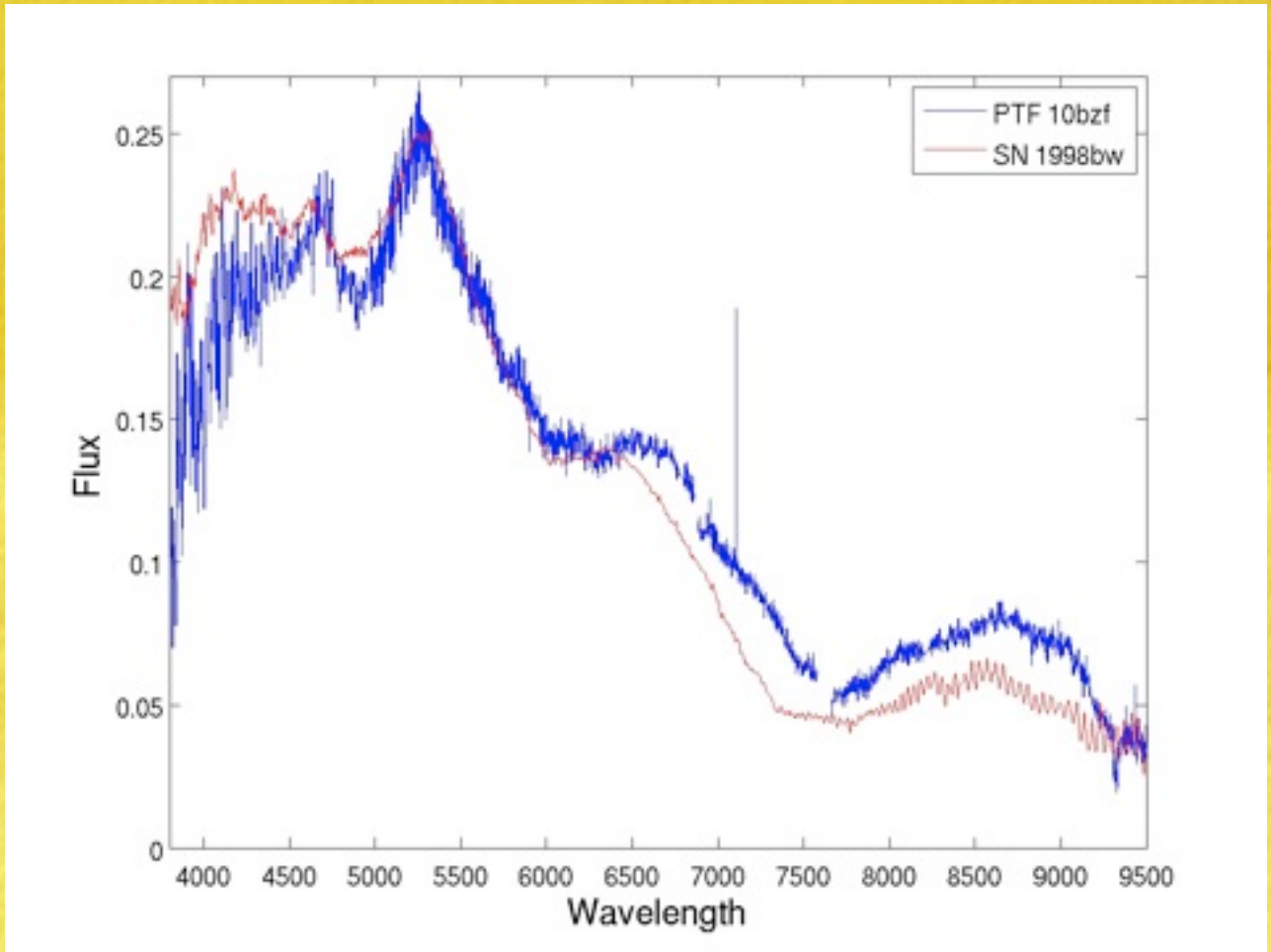


PTF09dh looks like SN 1991T (famous bright SN Ia) with He lines added

Dwarf host



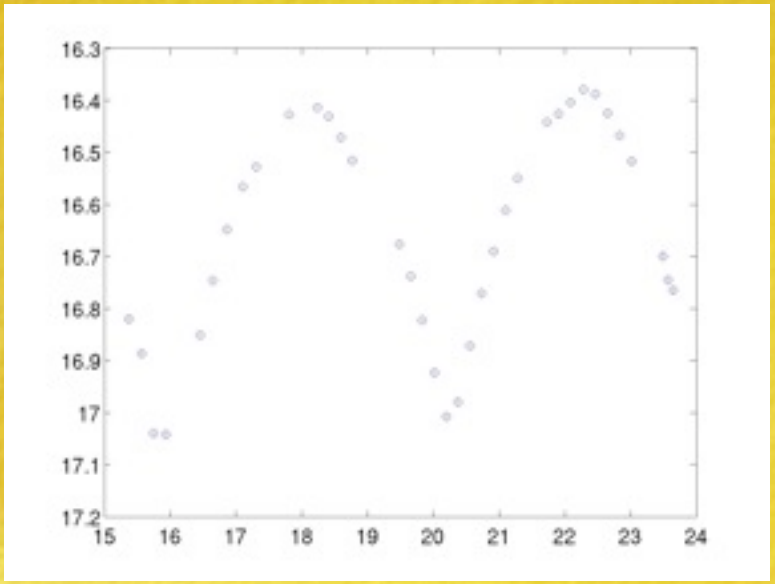
PTF10bzf (SN1998bw-like)

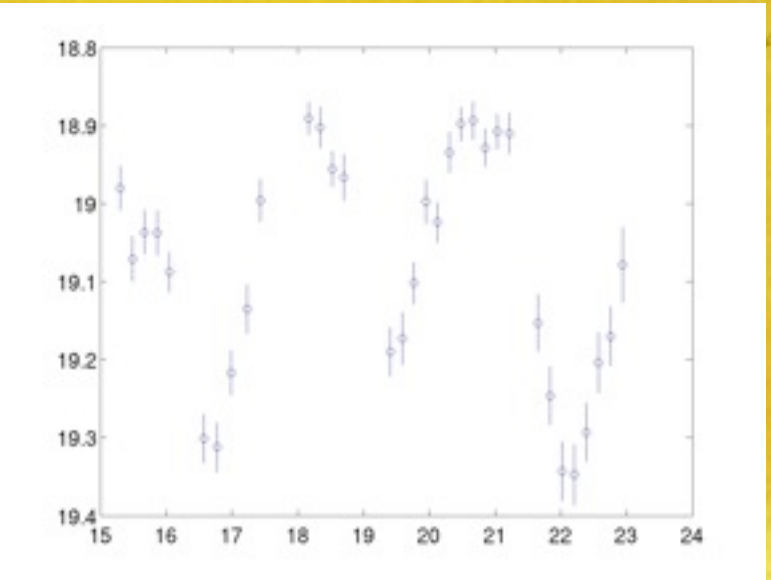


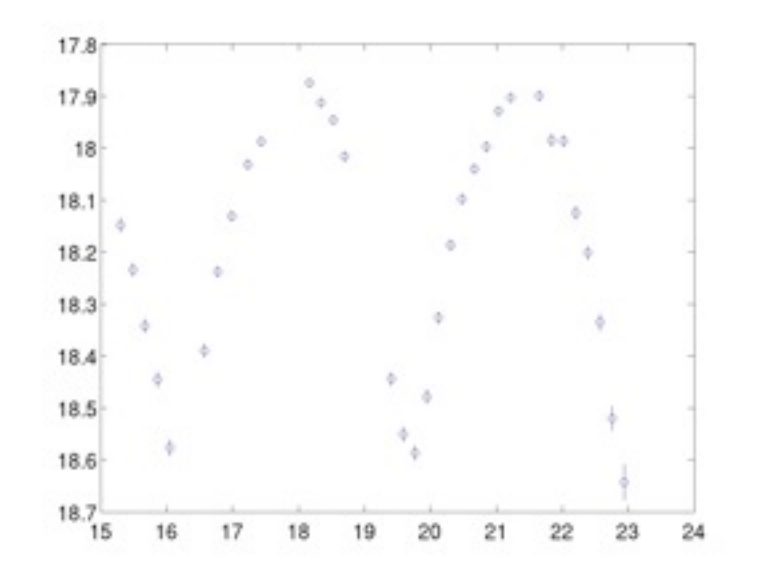
Z=0.0498 (220 Mpc)

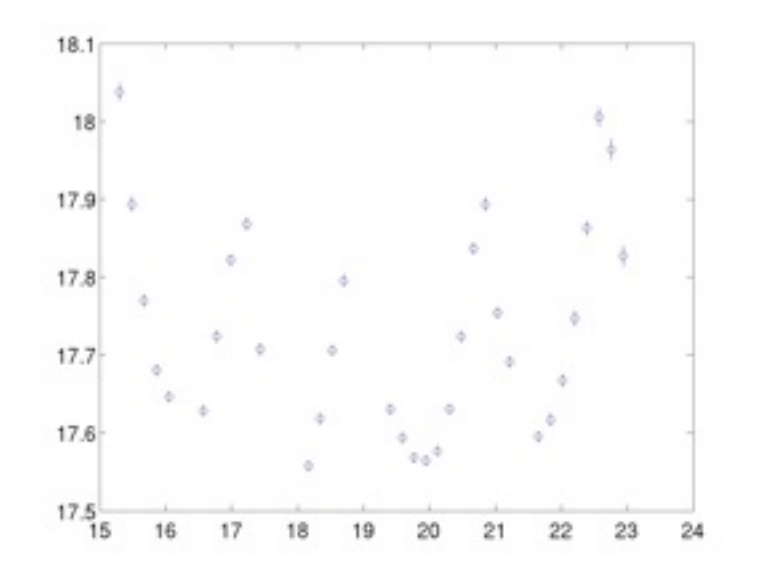
Precision Photometry (Stellar Astrophysics)

Asteroid Rotation Light Curves





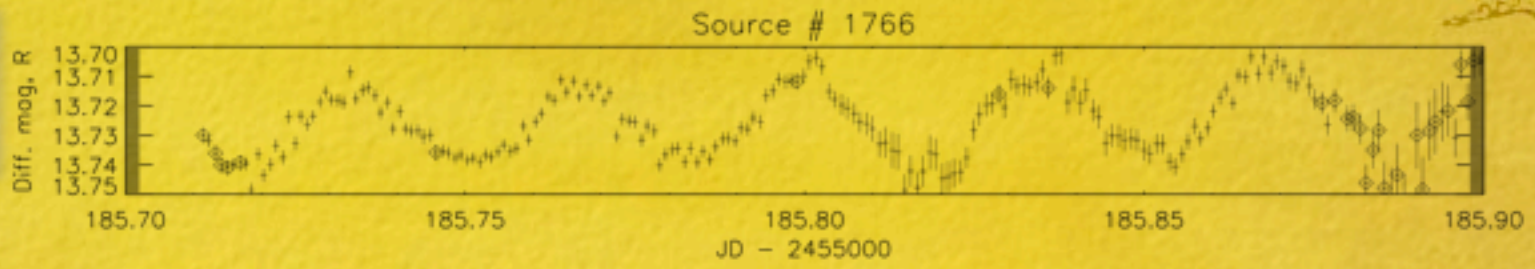




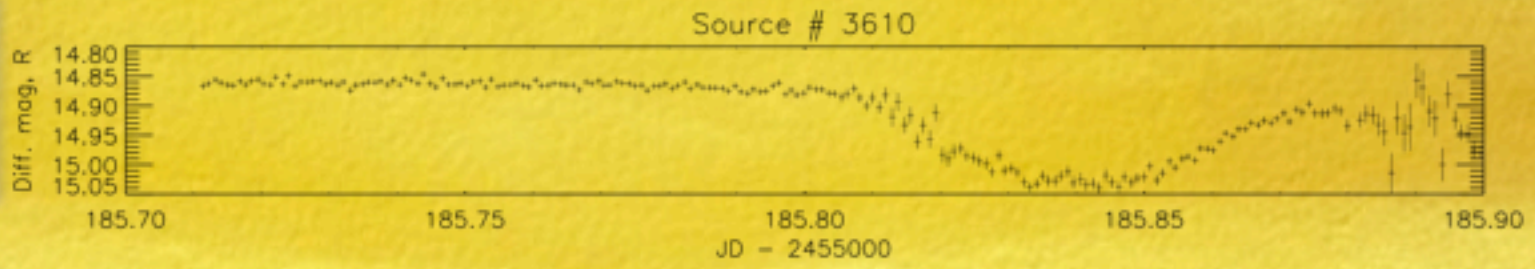
PTF Orion

– Obvious variables from initial test reduction of one night's data –

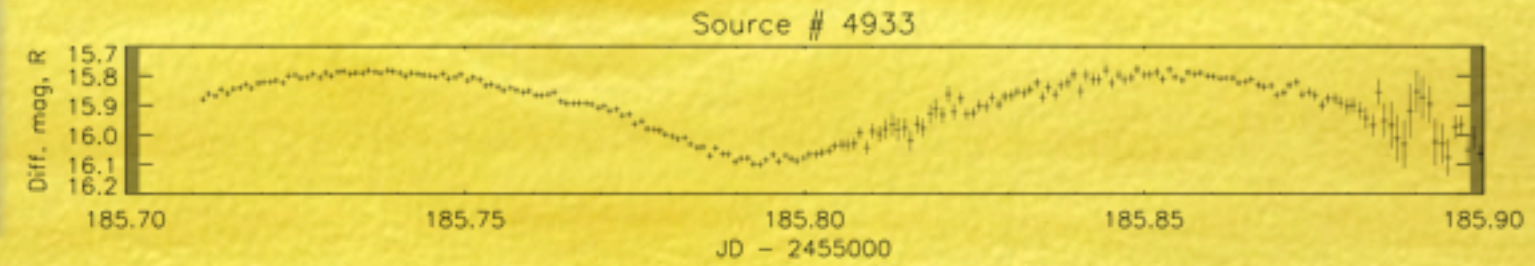
Probable δ-Scuti pulsating star



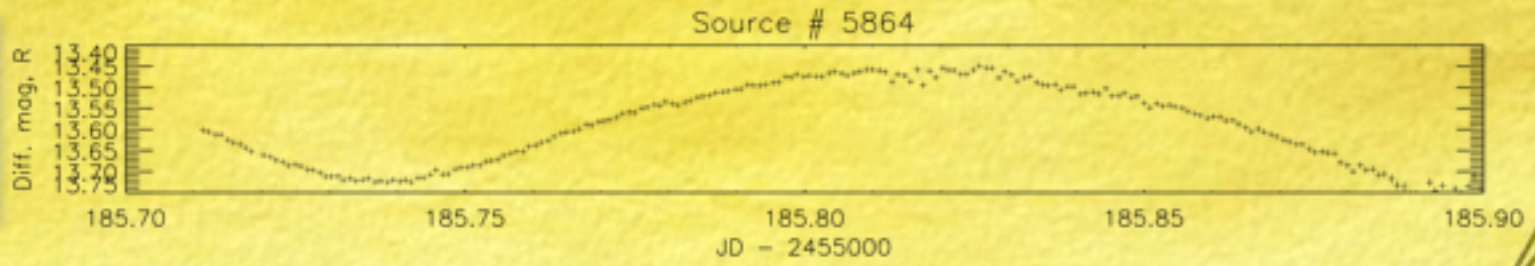
Eclipsing binary, short period, non-interacting; dK primary?



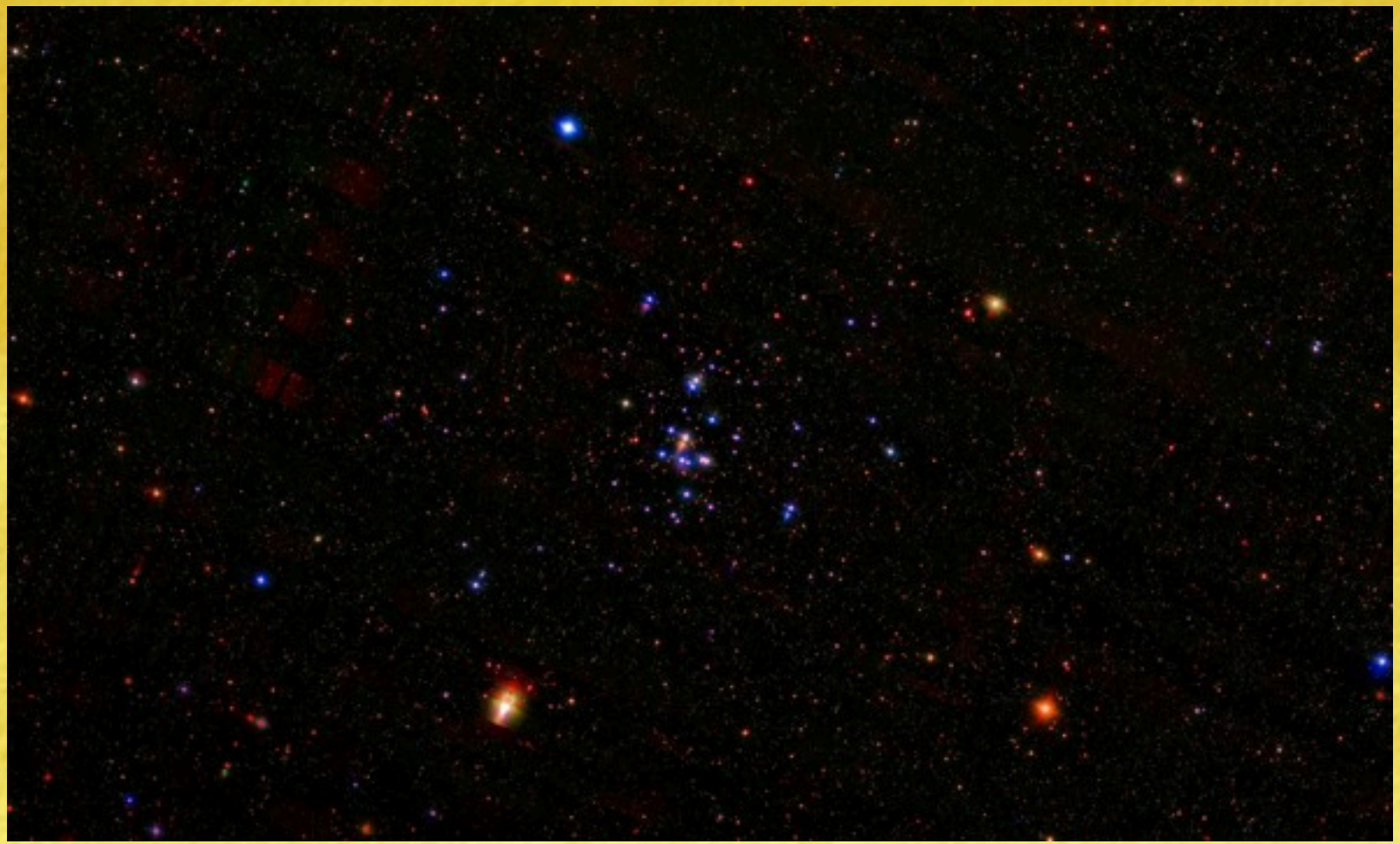
W Uma contact binary, P=2x~0.12d? Or multi-star-spot modulation?



P~0.17d – too short for rotation period; Another δ-Scuti?



The Columbia/Cornell/Caltech PTF (CCCP) Open Cluster Survey

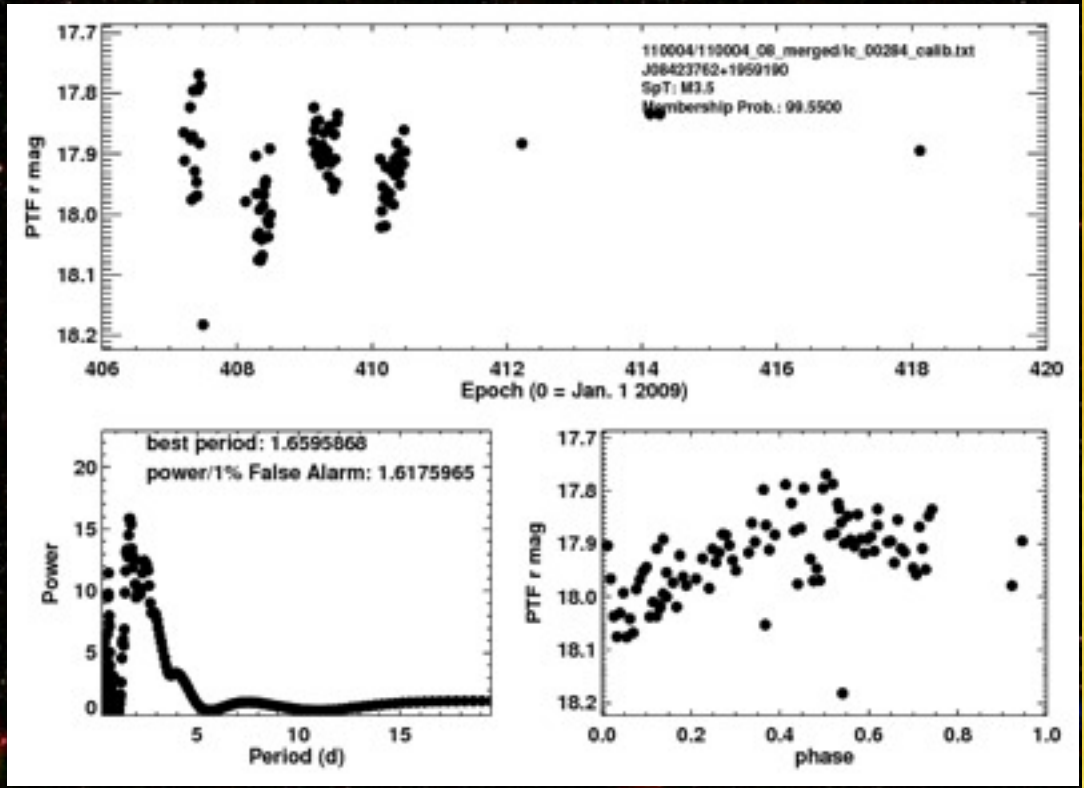


Columbia: Marcel Agüeros Jenna Lemonias Cornell: Kevin Covey Melissa Halford
Caltech/PTF: Nick Law Adam Kraus Lynne Hillenbrand Shri Kulkarni

Columbia: Marcel Agüeros Jenna Lemonias Cornell: Kevin Covey Melissa Halford
Caltech/PTF: Nick Law Adam Kraus Lynne Hillenbrand Shri Kulkarni

Early Results:

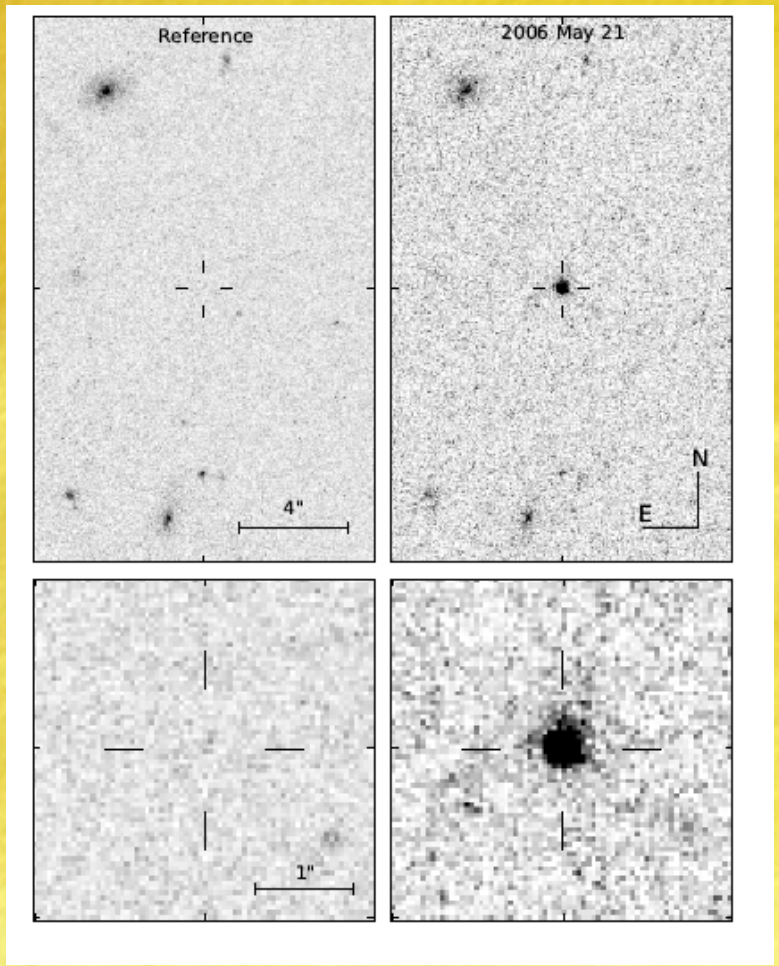
- Fast Rotators
- Flare Stars
- M dwarf eclipsing Binaries!

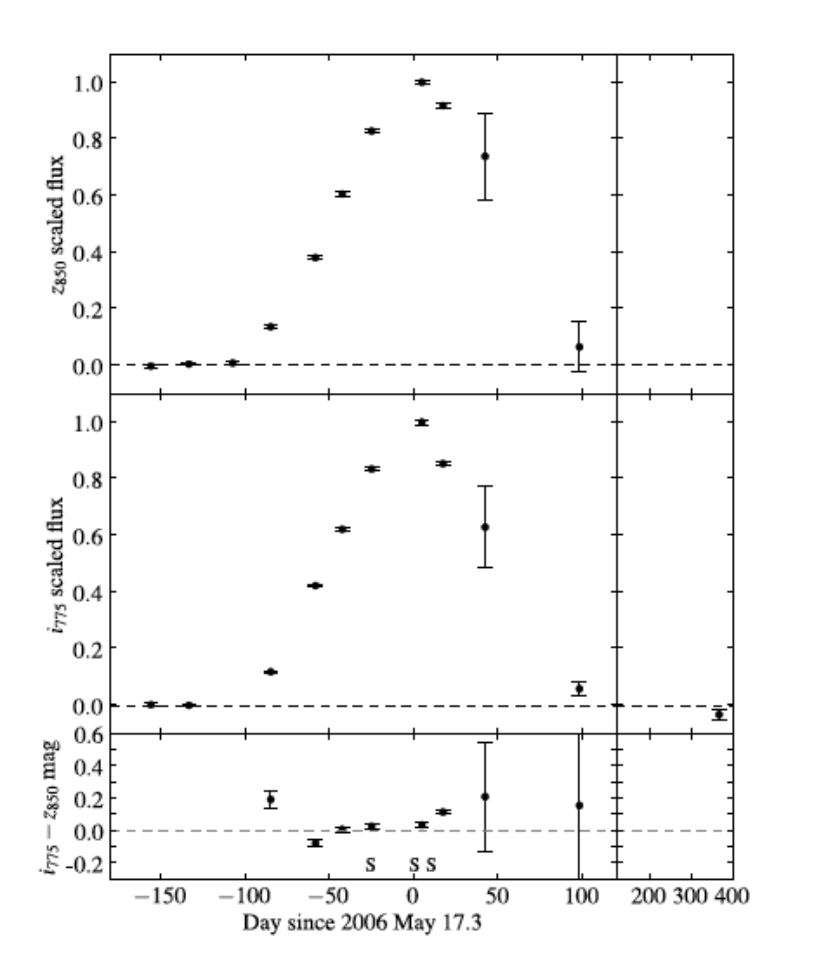


Columbia: Marcel Agüeros Jenna Lemonias Cornell: Kevin Covey Melissa Halford
Caltech/PTF: Nick Law Adam Kraus Lynne Hillenbrand Shri Kulkarni

"This new star sends out periodic pulses in a very appealing rhythm — I think I'll name it 'Bossa Nova.'"

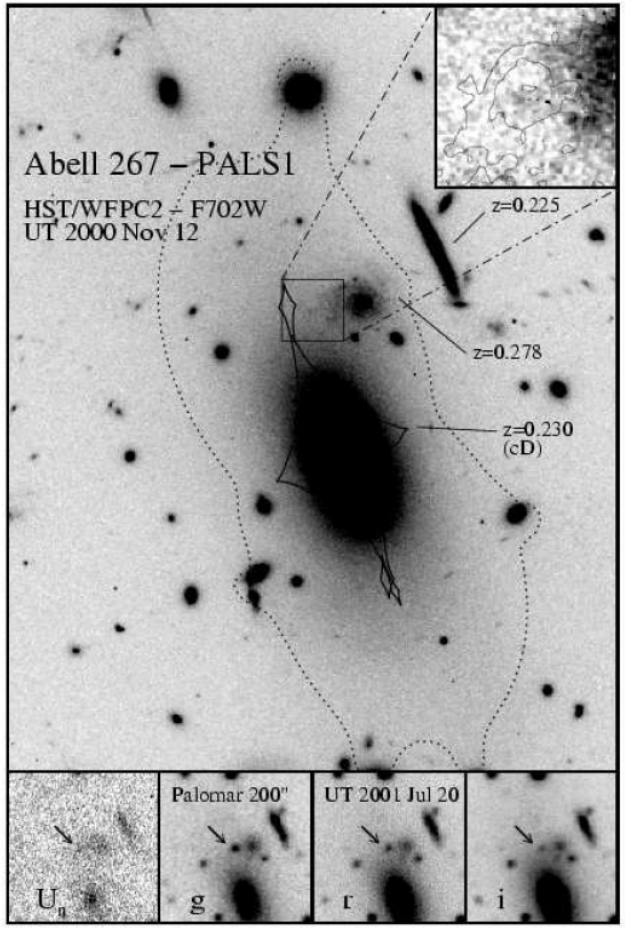
The Mysterious SCP06F6

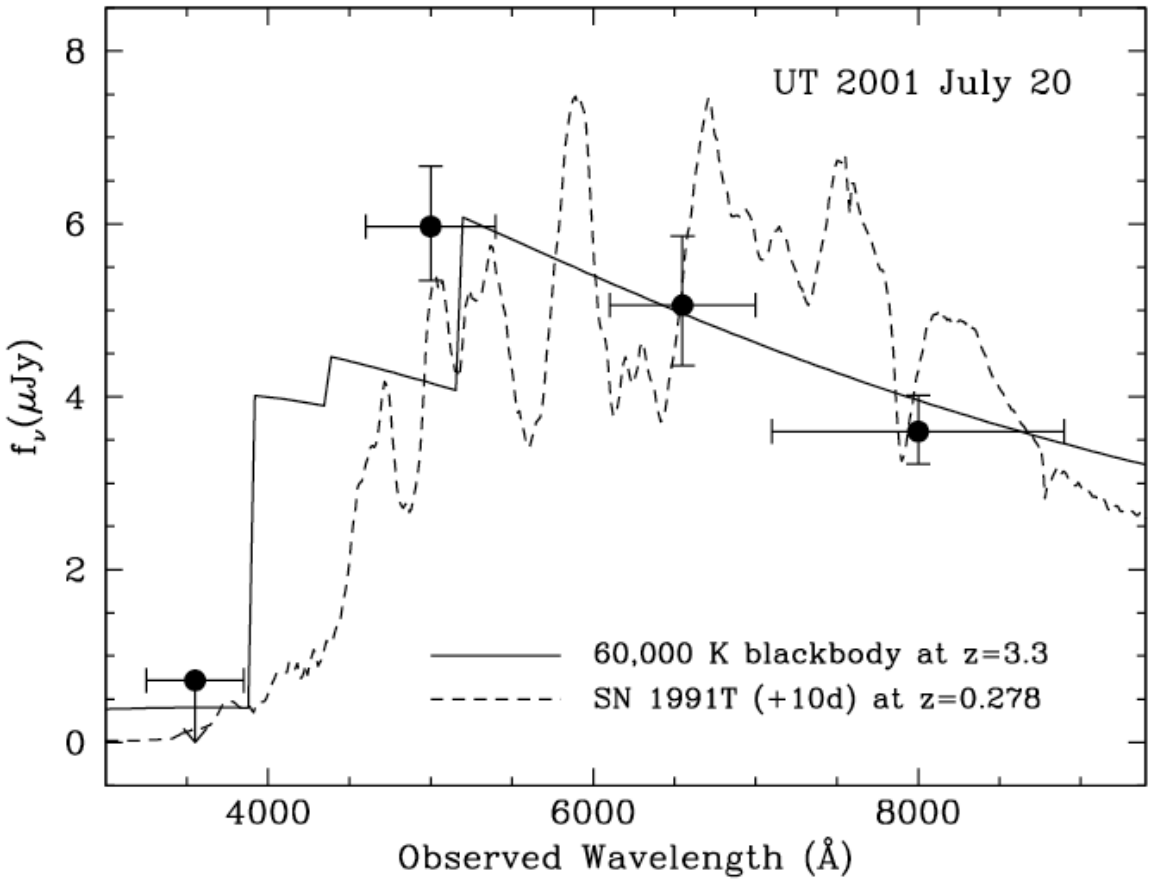




Barbary et al.

The Mysterious Pals-1





Stern et al. 2004

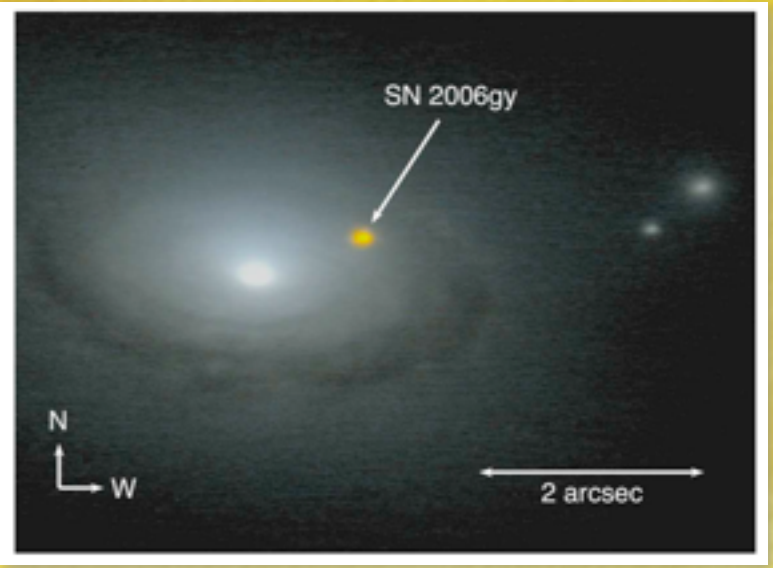
Luminous Supernovae

Lead: Robert Quimby

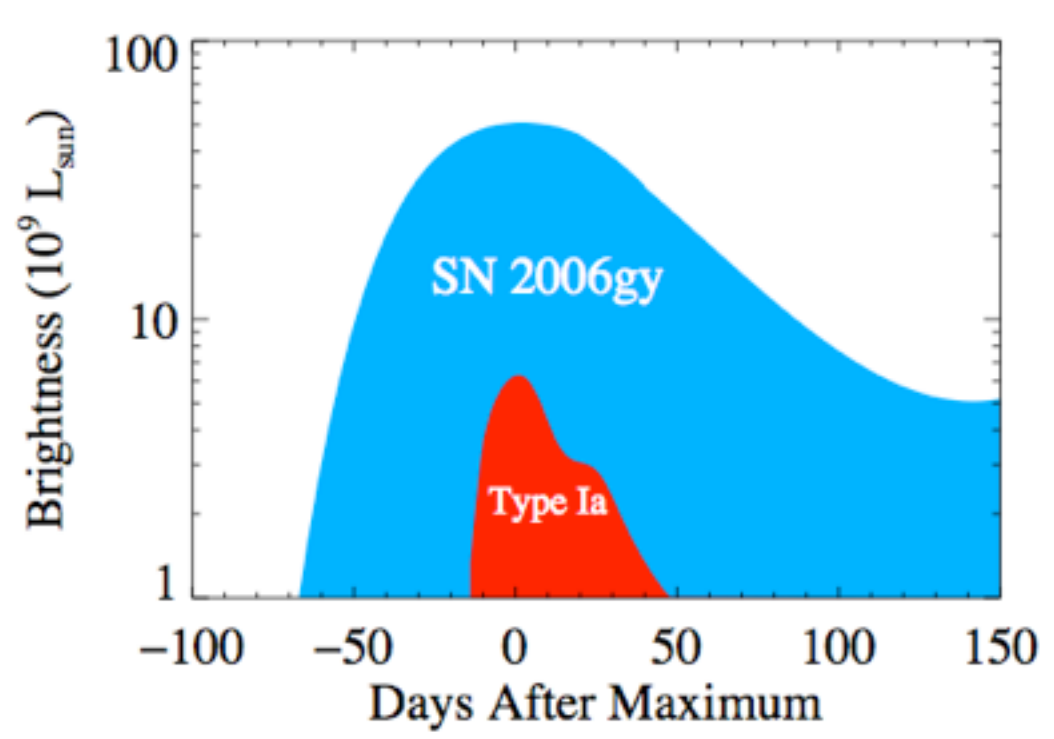
SNe From ROTSE-III

- **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



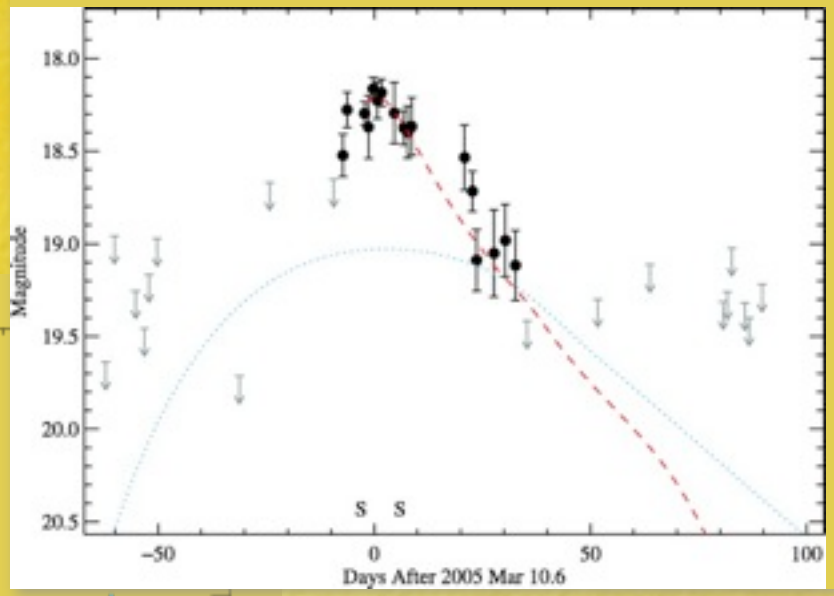
Smith et al. 2008

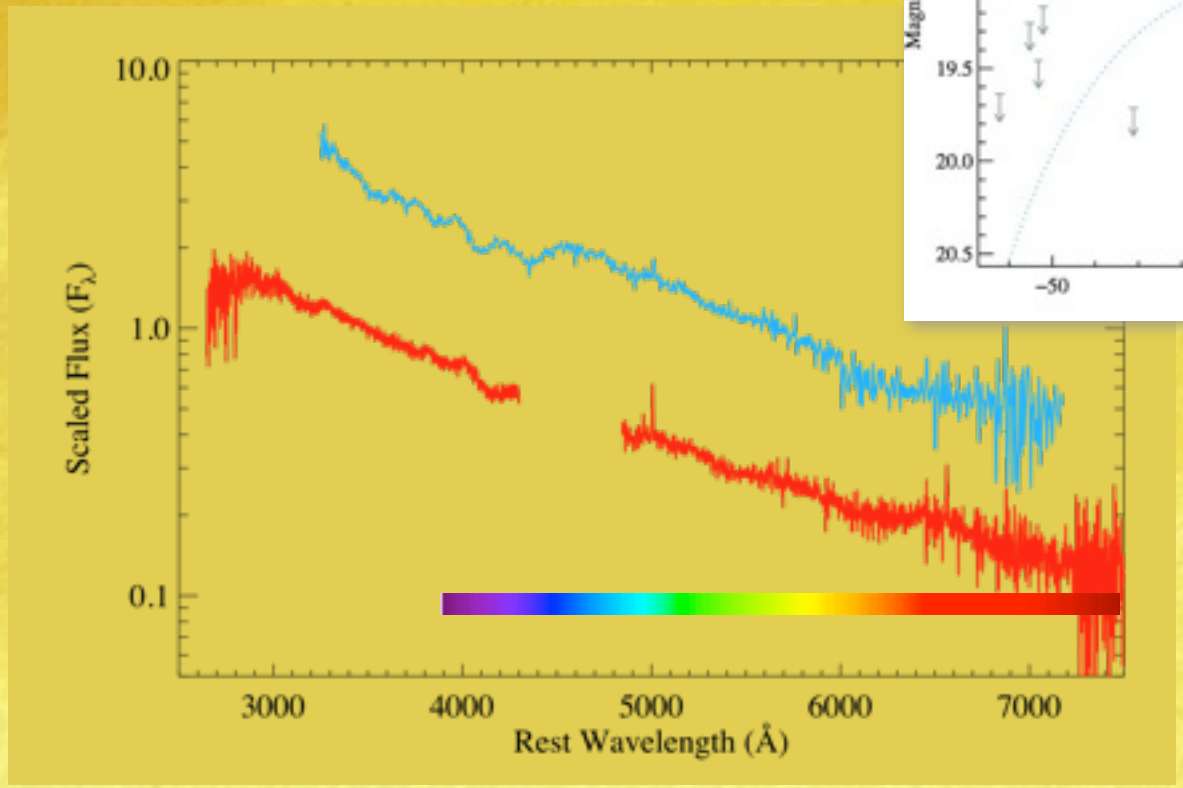


- Peak absolute magnitude nearly -22
- Brighter than -21 mag for ~100 days
- Integrated light >10^{51} erg
- See: Ofek+ 2007, Smith+ 2007, Smith & McCray 2007, Agnoletto+ 2009, Kawabata+ 2009...

SN 2005ap Observations

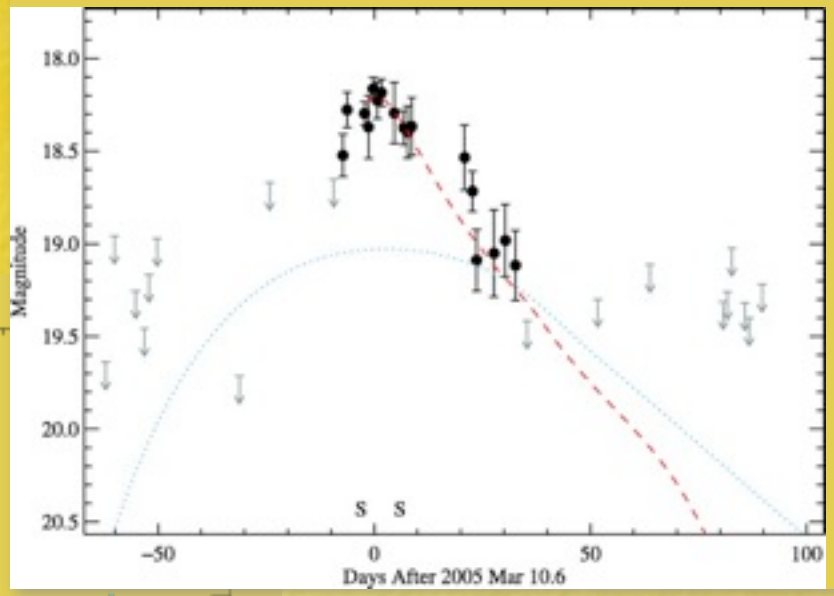
Quimby et al. 2007

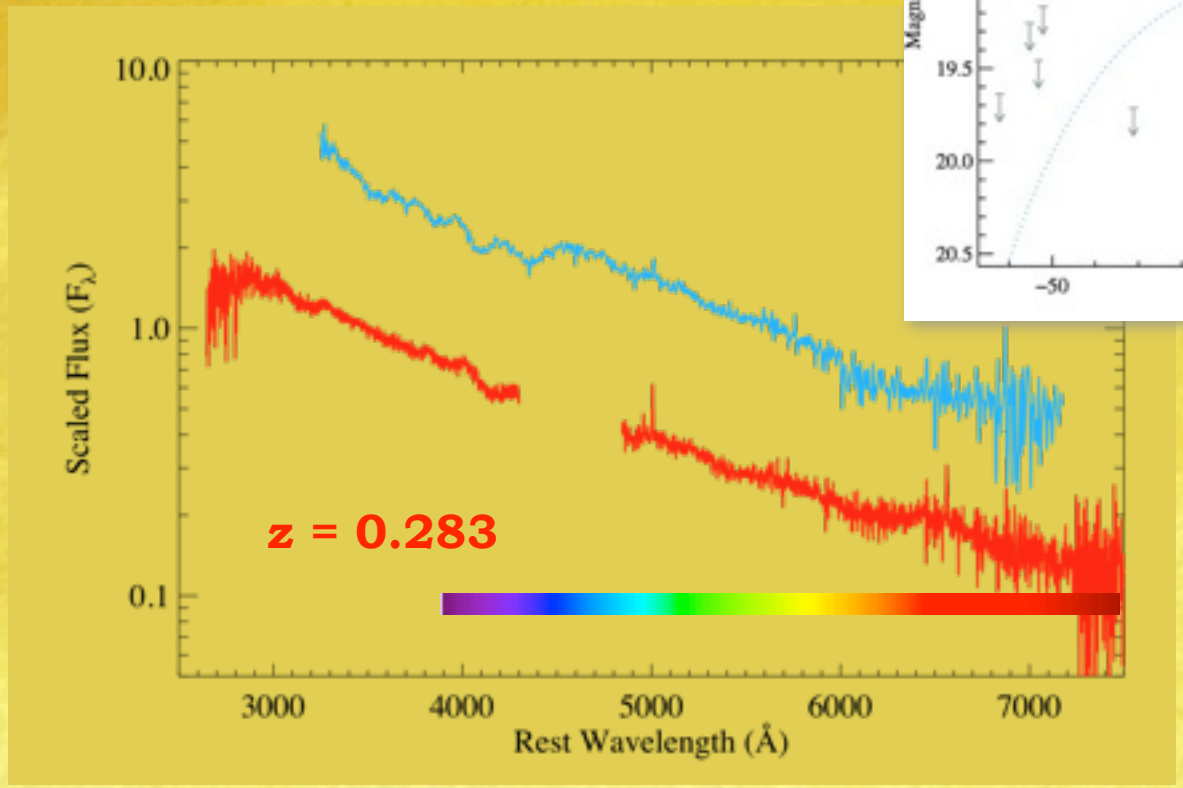




SN 2005ap Observations

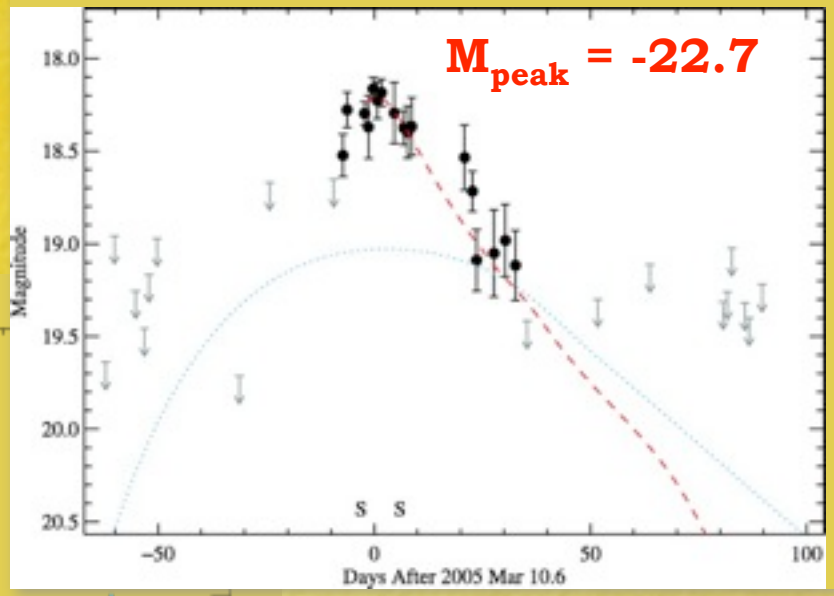
Quimby et al. 2007

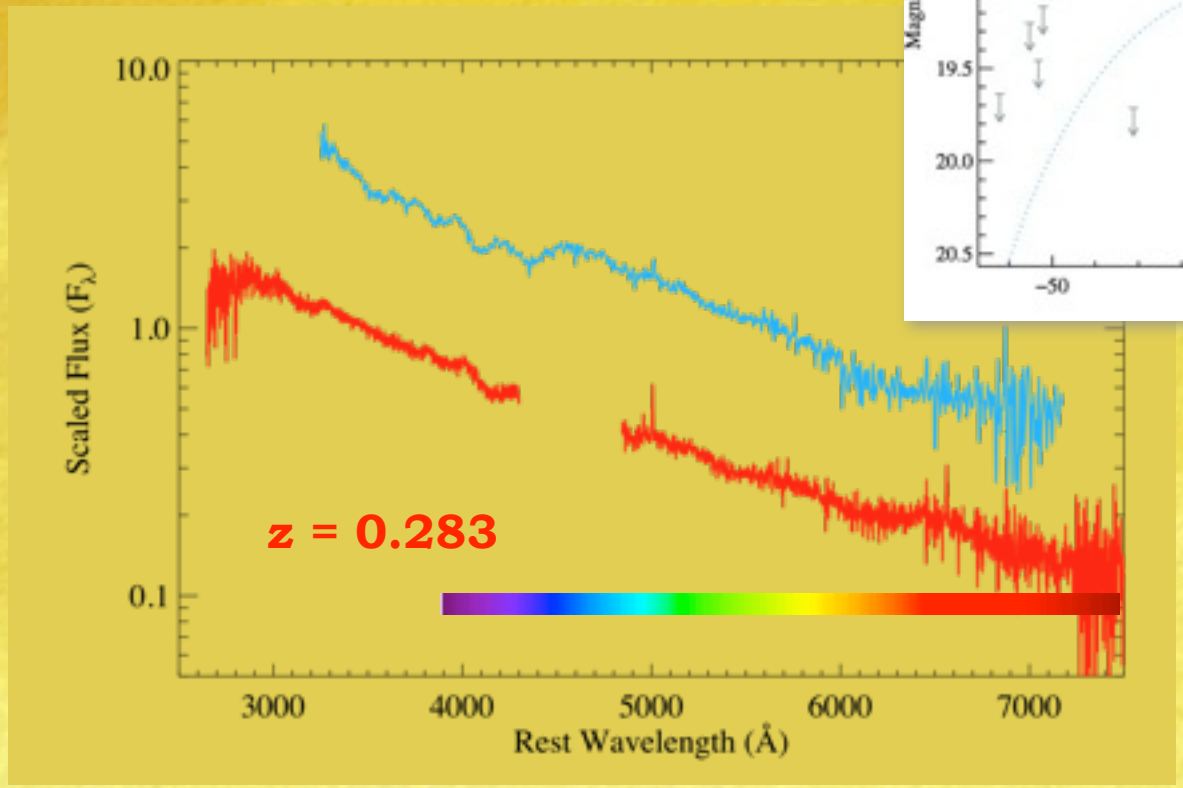




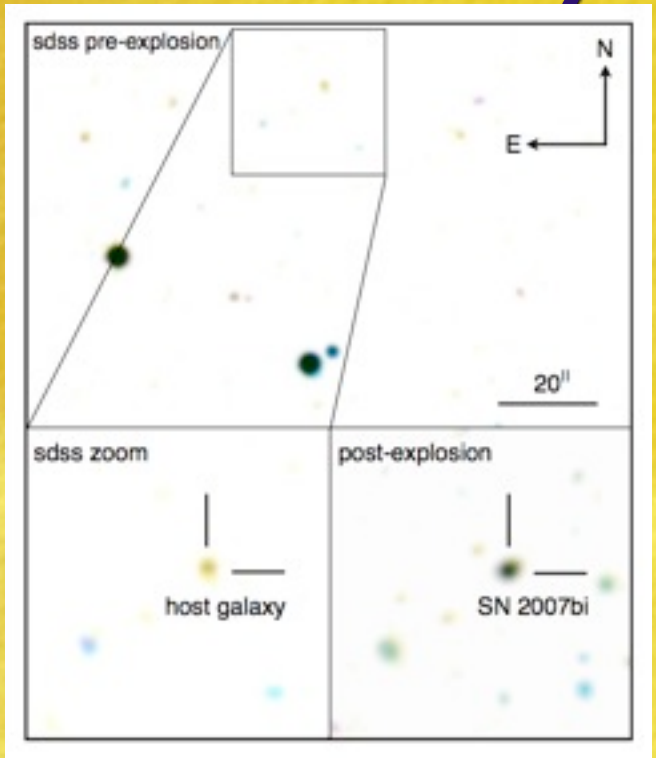
SN 2005ap Observations

Quimby et al. 2007

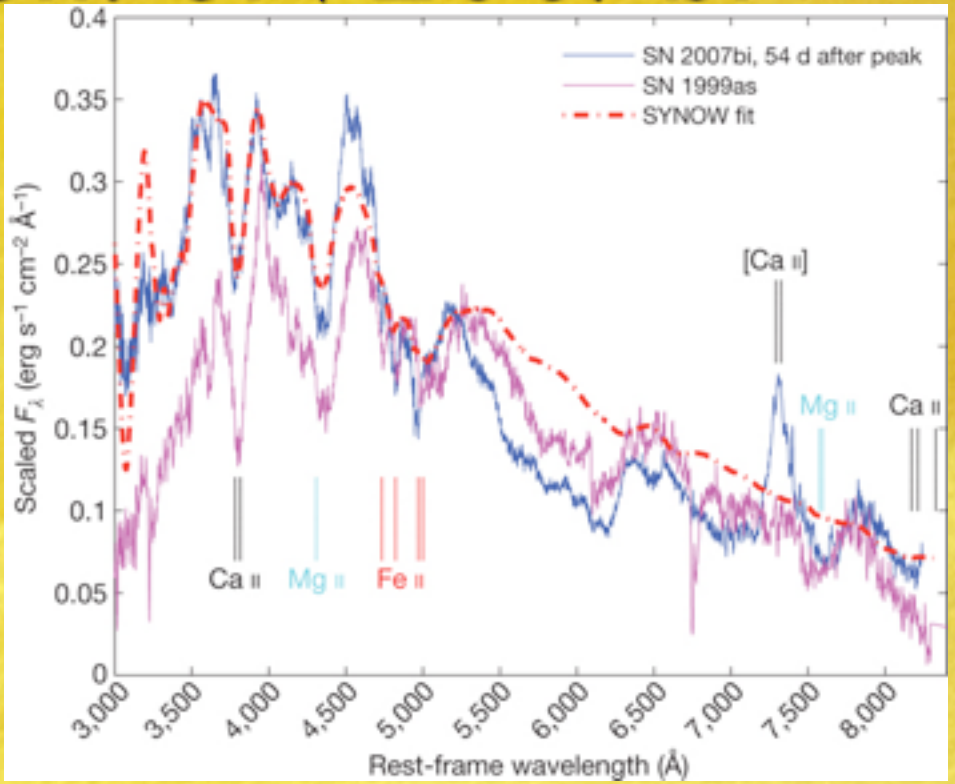




PTF Dry Run: SN 2007bi

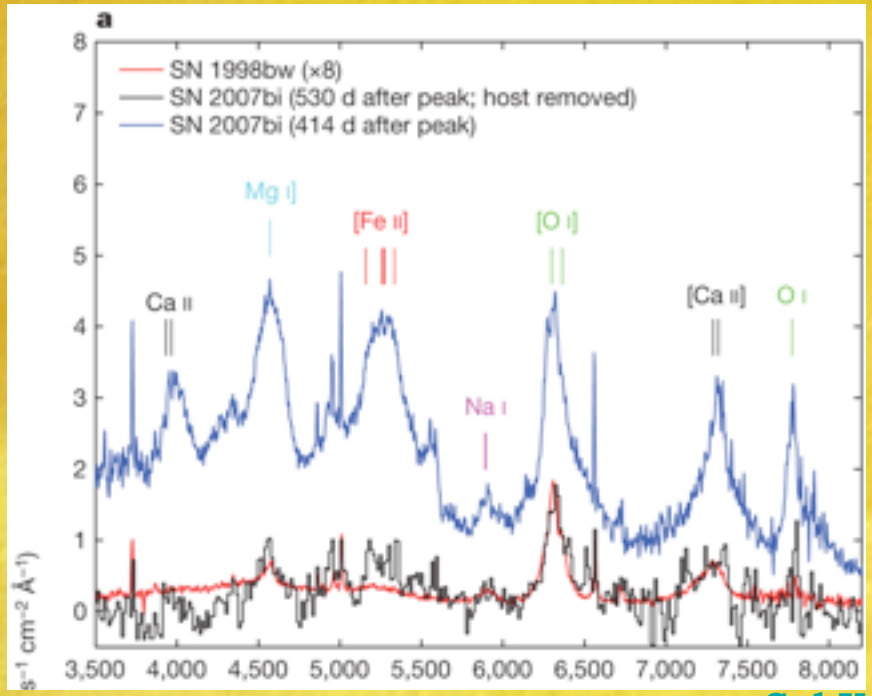


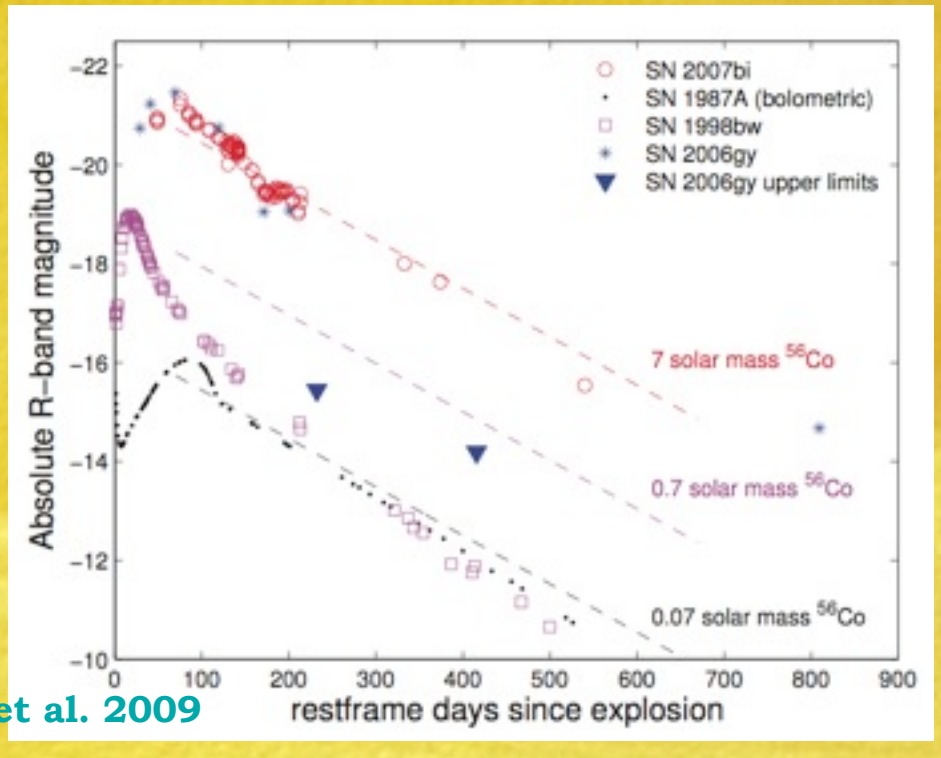
Young et al. 2010



Gal-Yam et al. 2009

SN 2007bi: Nickel Rich



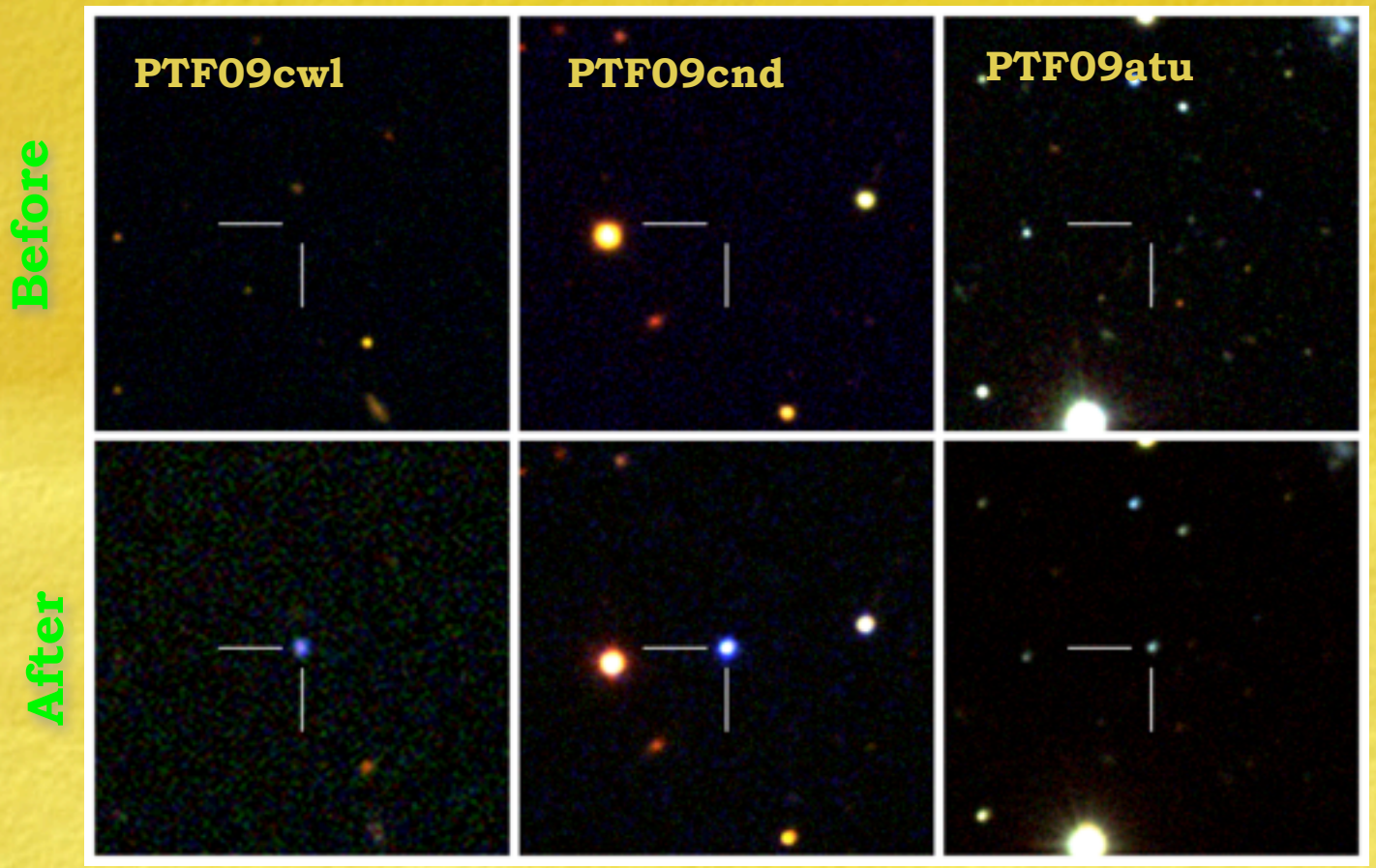


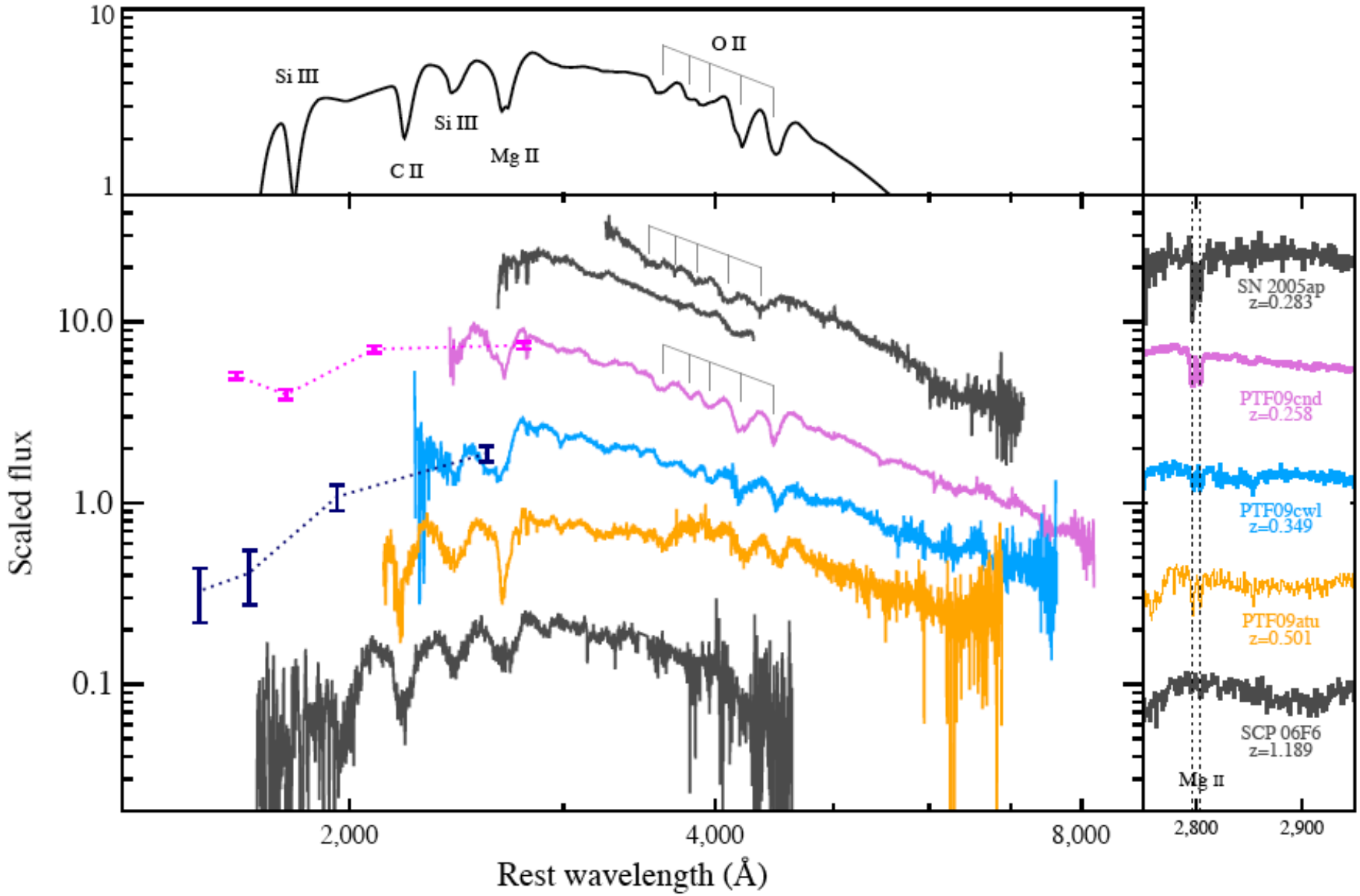
Gal-Yam et al. 2009

Optical light curve decay rate consistent with the production of ~7 $M_\odot$ of ^{56}Ni

Iron abundance in nebular spectra also consistent with the decay of ~4-7 $M_\odot$ of ^{56}Ni

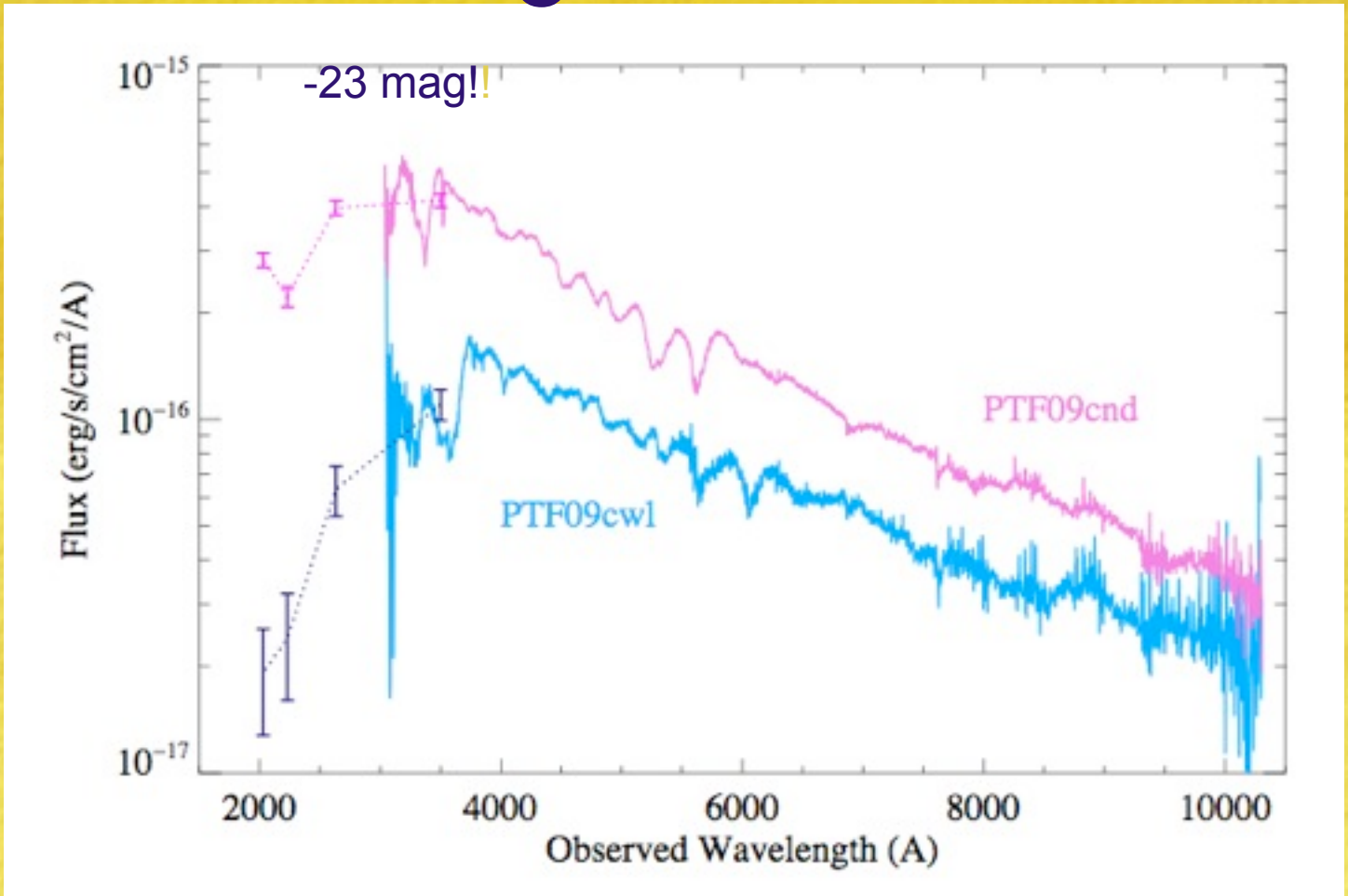
PTF Discovers 3 LSNe




10
1
Si III
C II
Si III
Mg II
O II
10.0
1.0
0.1
Scaled flux
2,000
4,000
8,000
Rest wavelength (Å)
SN 2005ap
z=0.283
PTF09cnd
z=0.258
PTF09cwl
z=0.349
PTF09atu
z=0.501
SCP 06F6
z=1.189
Mg II
2,800
2,900

Quimby et al.

Bright in UV



Swift satellite observations

PTF is finding:

1 transient per 20 minutes
1 strong variable per 10 minutes