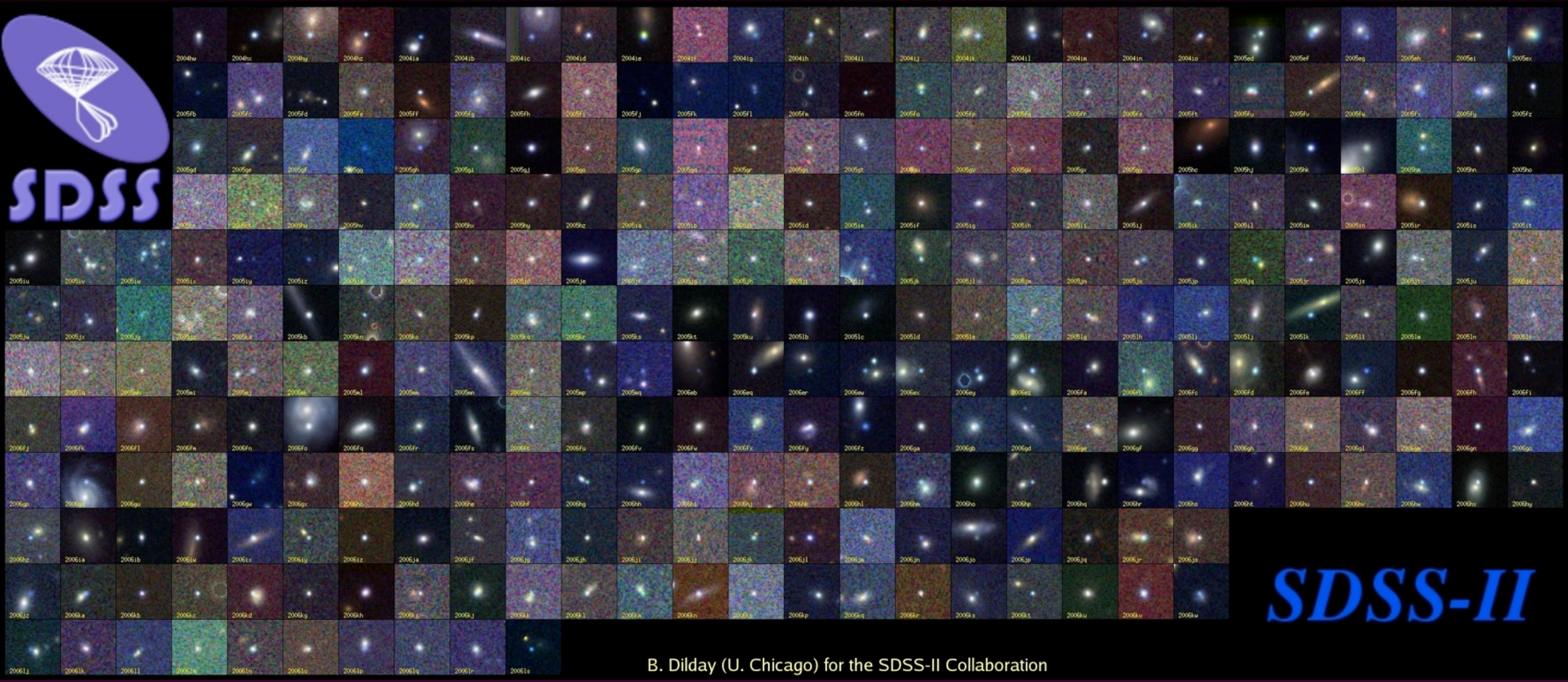
Cosmology and Astrophysics from the SDSS SN Survey

Saurabh Jha
KIPAC/SLAC

for the SDSS-II SN collaboration



University of Melbourne XXIII Texas Symposium on Relativstic Astrophysics December 13, 2006

SDSS-II SN Collaboration

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SAAO	B. Bassett, K. van der Heyden
U. Washington	A. Becker, C. Hogan
U. Munich	R. Bender, U. Hopp
Seoul Natl. U.	C. Choi, M. Im
Wayne State U.	D. Cinabro
Ohio State U.	D. L. DePoy, J. L. Prieto
U. Tokyo	M. Doi, K. Konishi, T. Morokuma, N. Takanashi, K. Tokita, N. Yasuda
U. Notre Dame	P. Garnavich
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U. Göttingen	W. Kollatschny
STScI	H. Lampeitl, A. Riess
U. Portsmouth	R. Nichol, M. Smith
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U. Pennsylvania	M. Sako
Penn State U.	D. Schneider
U. Texas	C. Wheeler

J. Frieman

with help from: J. Eastman, L. Watson, R. Assef, K. Schlesinger, A. Crotts, M. Stritzinger, J. Sollerman, A. Goobar, G. Leloudas, R. J. Foley, A. V. Filippenko, A. Aragon-Salamanca, M. Bremer, M. Turatto, P. Ruiz-Lapuente, F. Castander, A. Romer, C. Collins, J. Lucey, A. Edge, Y. Ihara

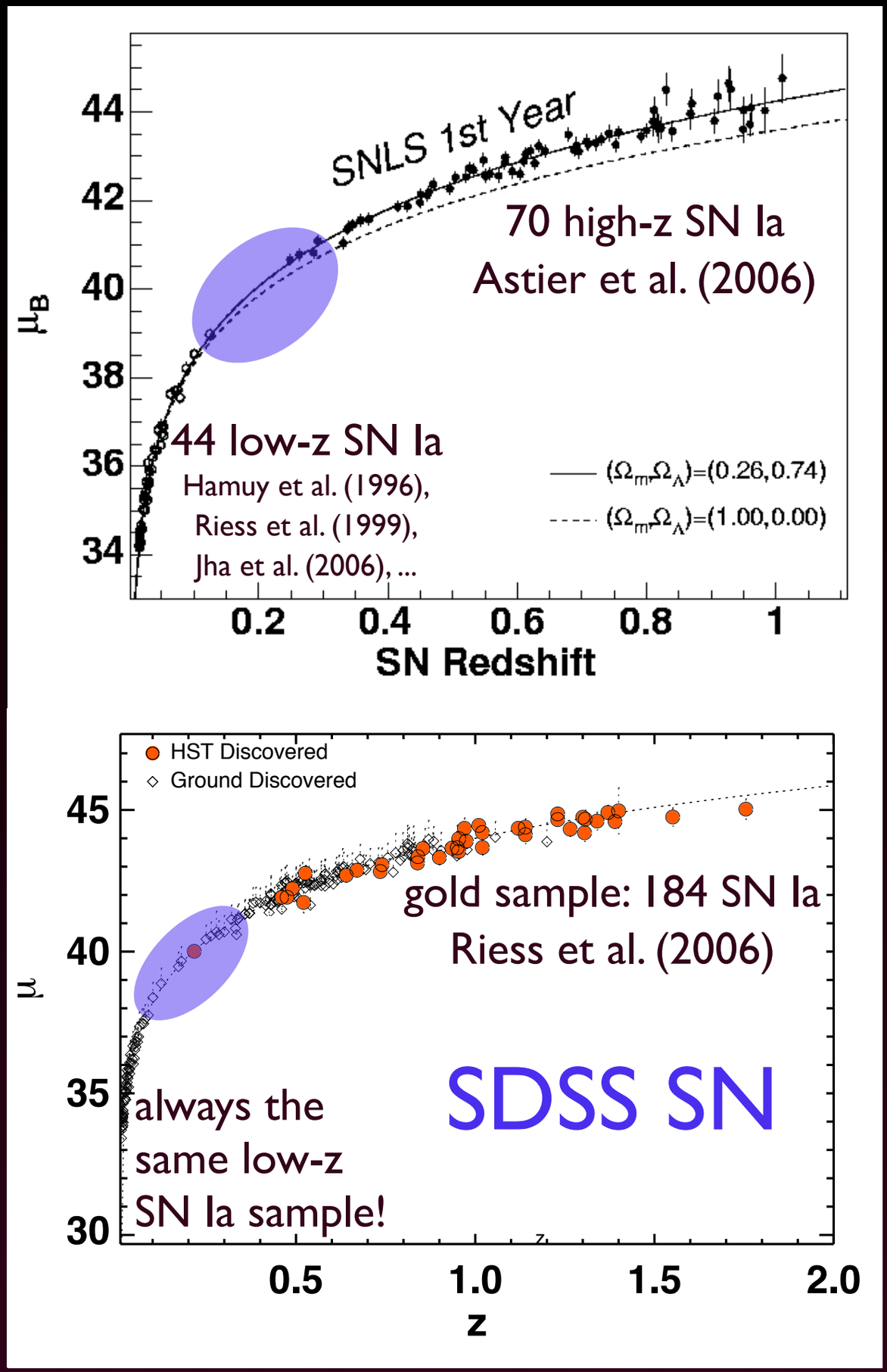
SN Ia Hubble Diagram

- main goal of the SDSS SN survey: fill in the SN Ia Hubble diagram at intermediate redshift, $0.1 \lesssim z \lesssim 0.3$
  - connect low-z with high-z
  - confirm concordance cosmology (or find some surprises!)

- challenges
  - peak magnitudes m ≃ 20-22
  - need to search hundreds of deg^2

→ SDSS 2.5m telescope + imager

http://sdssdp47.fnal.gov/sdsssn/sdsssn.html



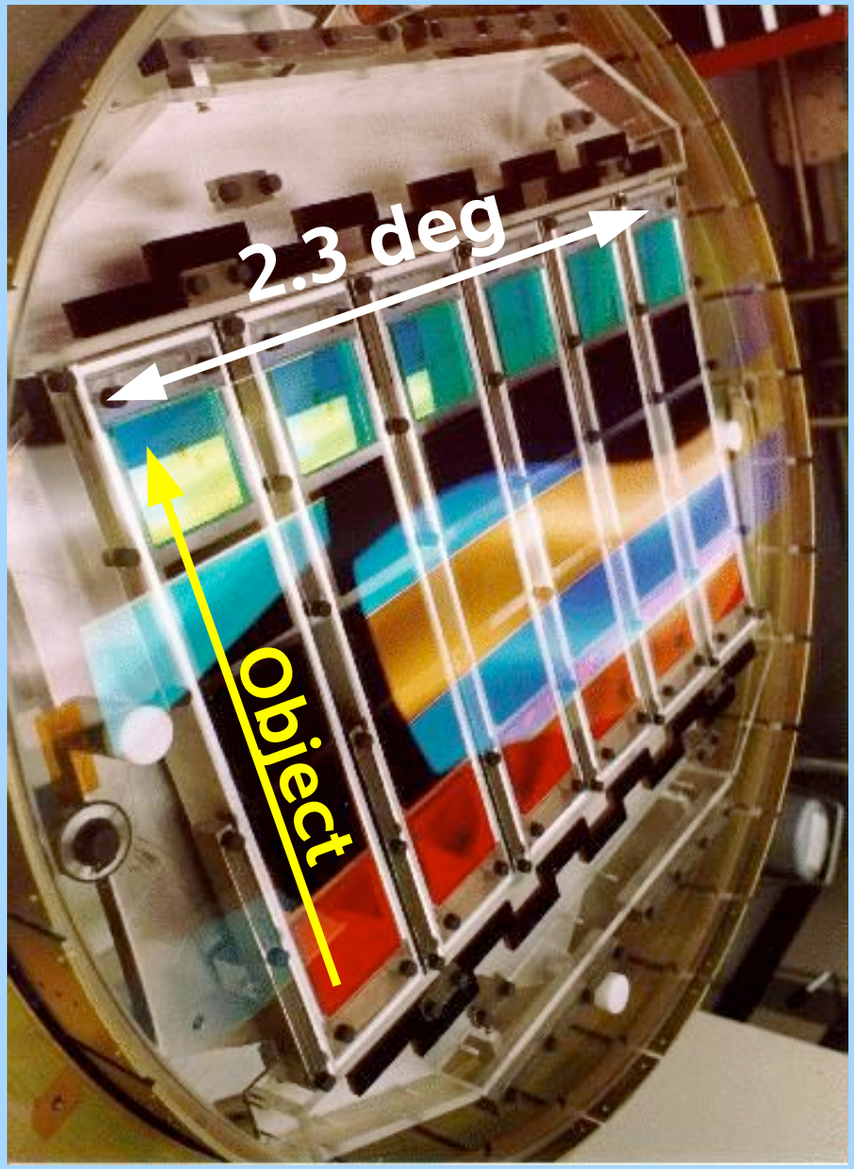
Apache Point Observatory
Southern New Mexico

2.5 m f/5 modified Ritchey-Chretien
- camera (u,g,r,i,z)
- spectrograph (640 fibers)

ARC-3.5m

NMSU-1m

0.5m photometric telescope (PT)

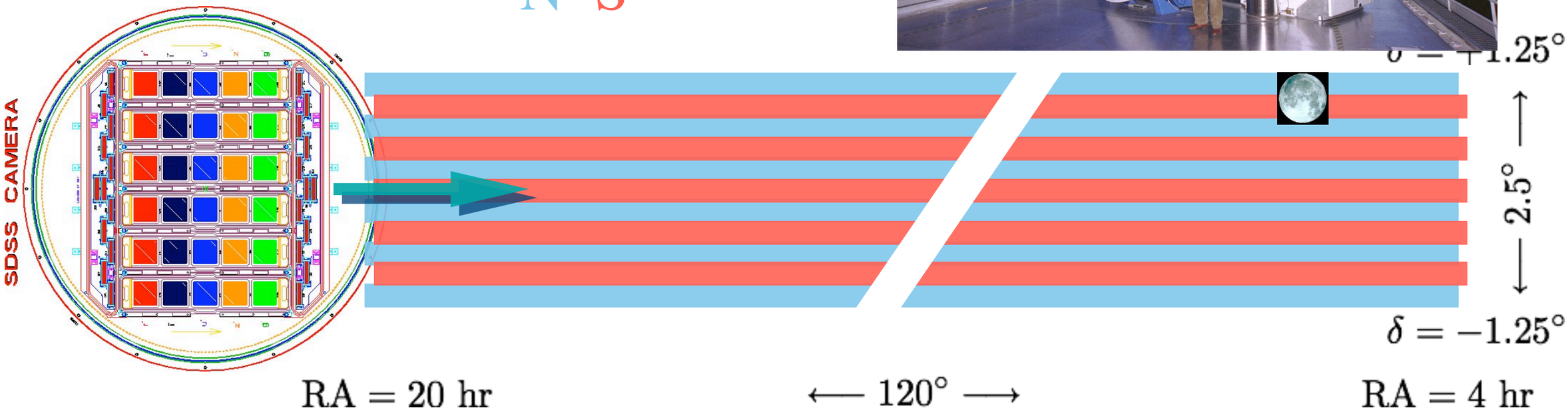


u	g	r	i	z
22.0	22.2	22.2	21.3	20.5

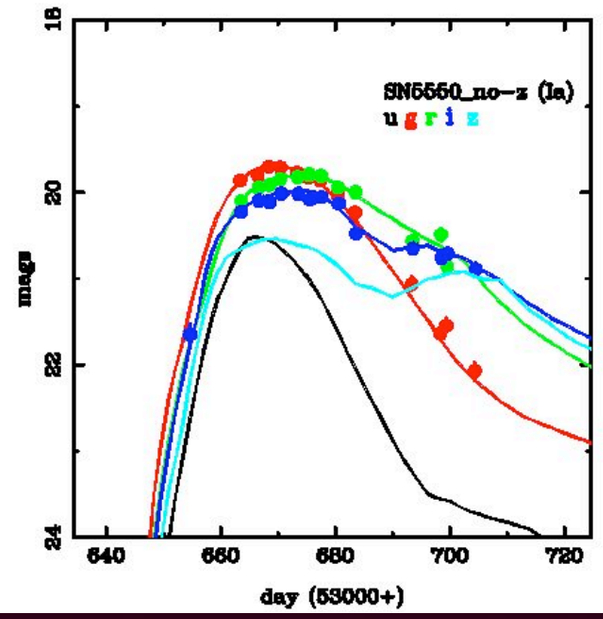
(56s, 95%, stars)

SNe Survey

September 1 – November 30 of 2005-2007
Scan 280 sq. degrees every 2 days
multi-color light curves
spectroscopic followup



- Type Ia supernovae (SNe)
  - spectroscopically confirm and obtain “well-measured” light curves of ~200 SN Ia from z = 0.05 ~ 0.4 in u,g,r,i and z
  - understand and minimize systematics of SN Ia
- Other SN-Types Ib/c, Type II
- Rates and Environment

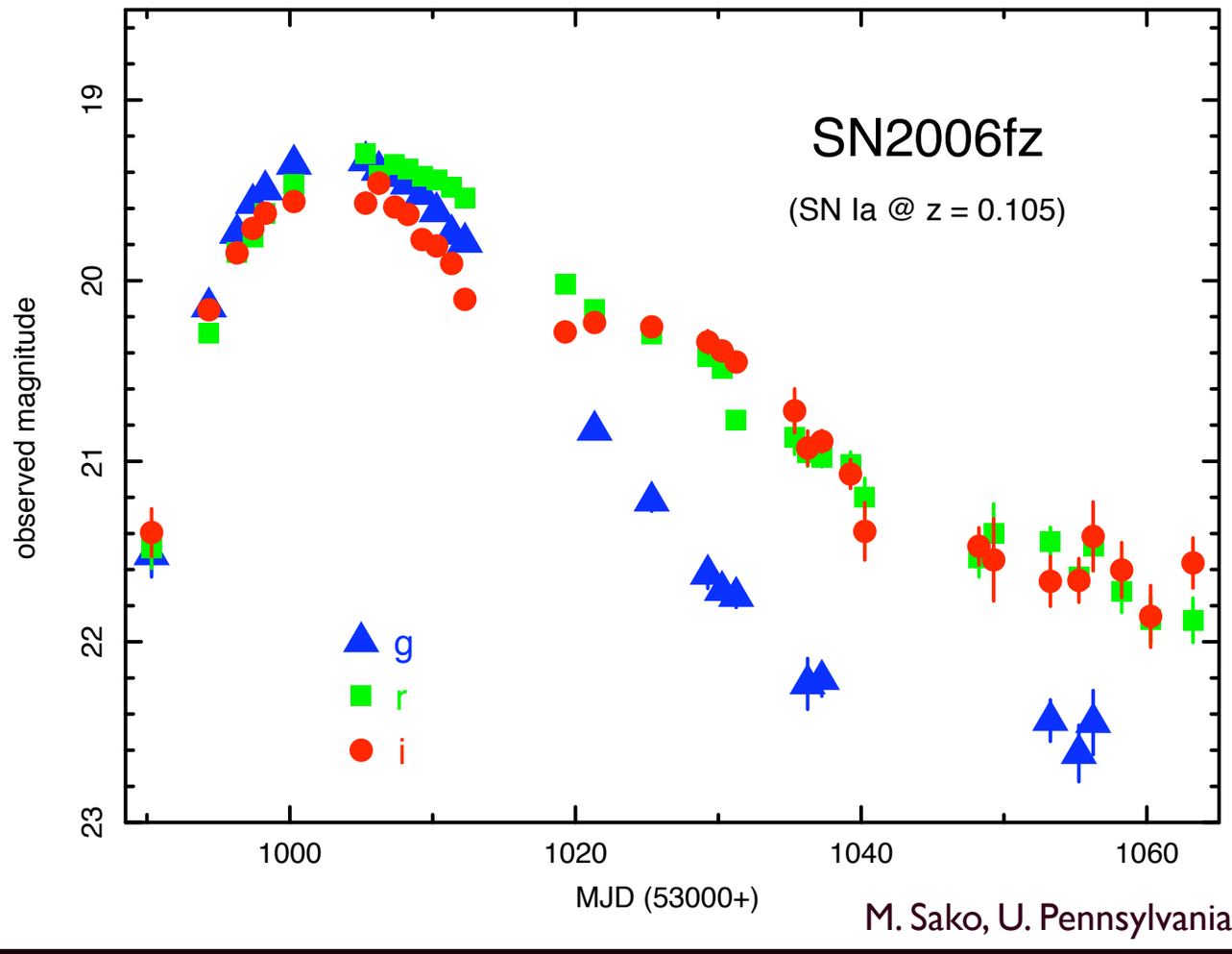


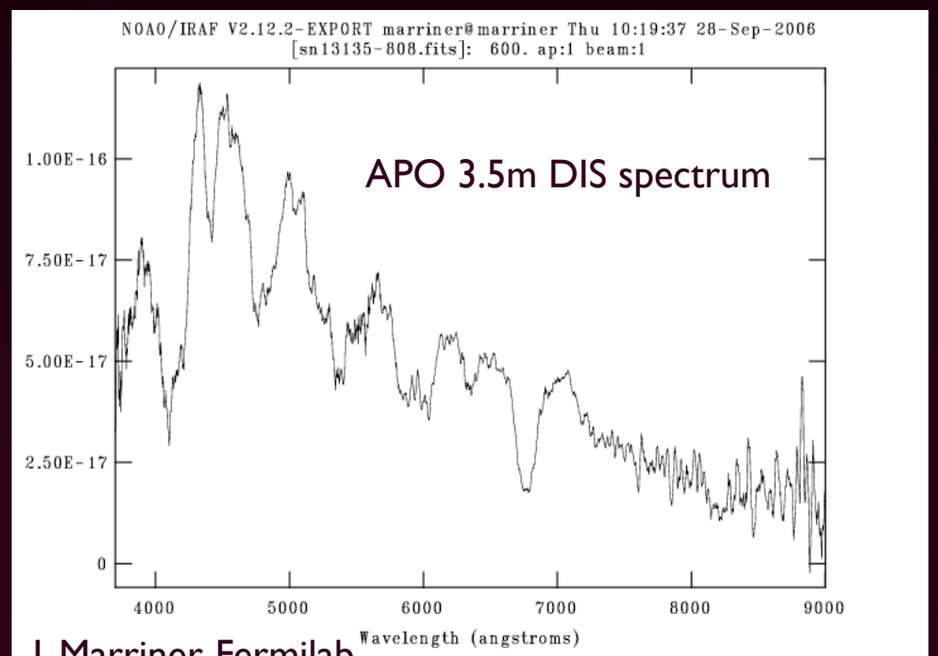
Details for Candidate SN13135

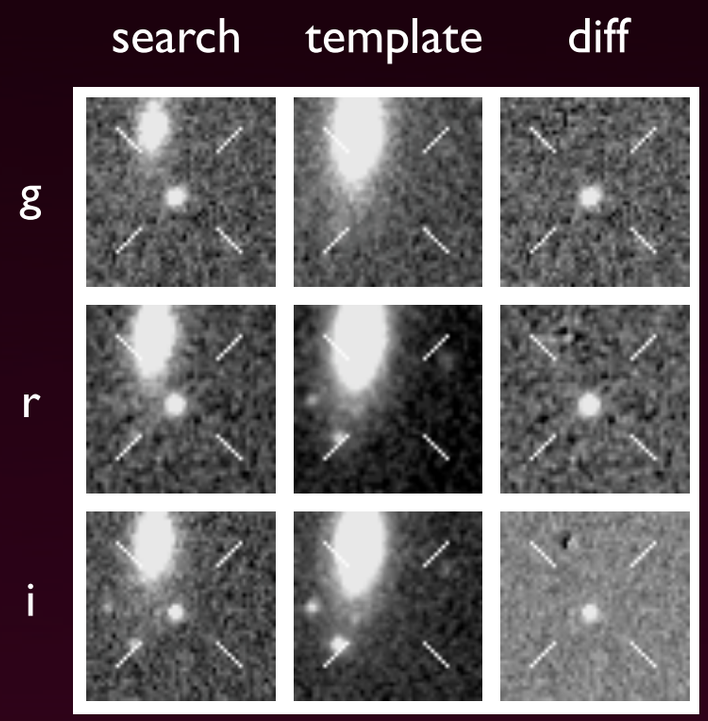
Initial RA (deg)	4.172303
Initial Dec (deg)	-0.424537
Averaged RA (deg)	4.172286
Averaged Dec (deg)	-0.424540
Averaged RA (hh:mm:ss)	0:16:41.35
Averaged Dec (dd:mm:ss)	-0:25:28.3
Redshift	0.1050
IUAC Name	2006fz
Observability	0.000
Time weight	0.000
Crowding weight	-1.000
Dust weight	-1.000
Entry date/time	2006-09-16 18:00:38

Fits

Fit type	Best	Criterion A	Criterion B
z fit	Ia	Ia	Ia
z constrained	Ia	Ia	Ia







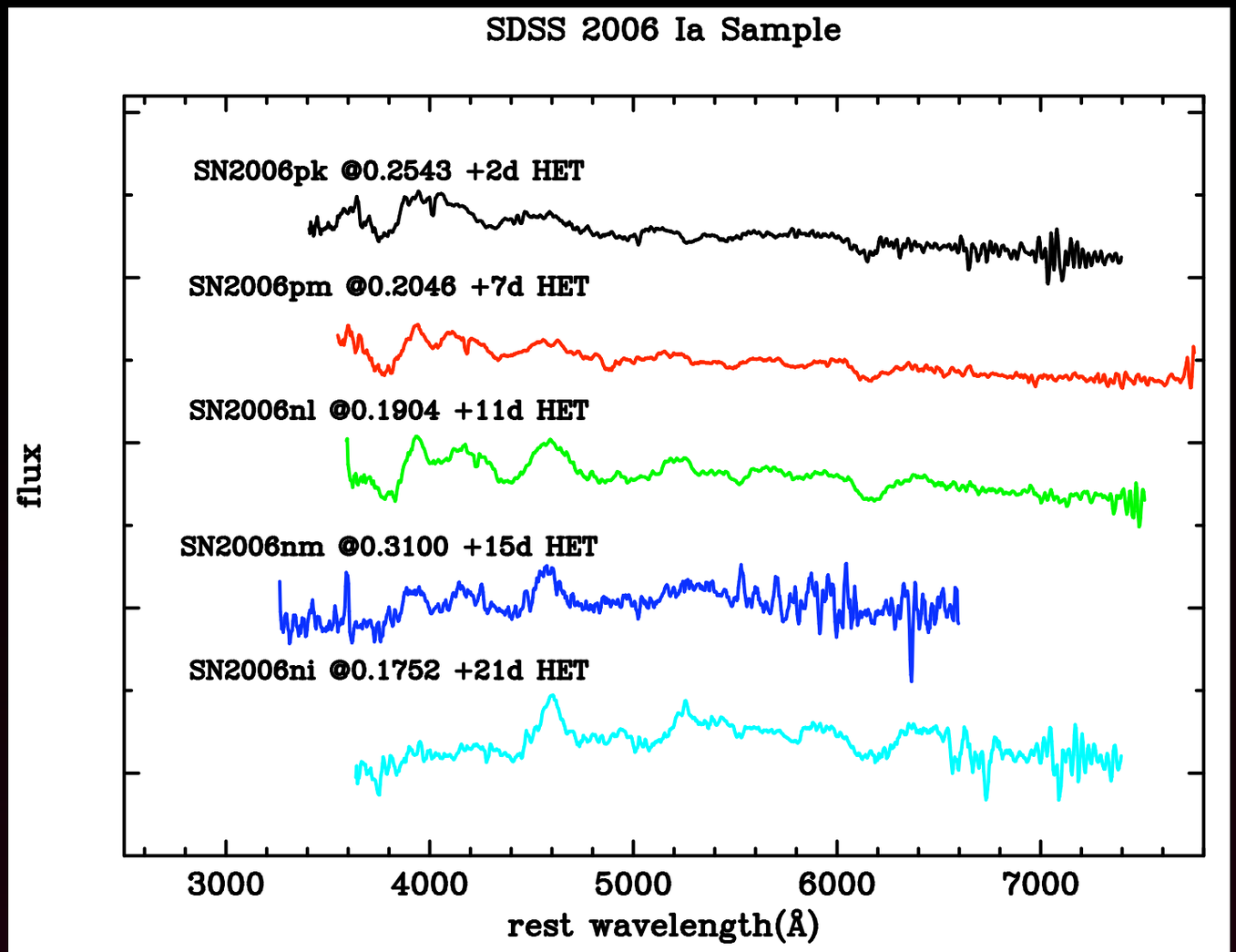
SN 2006fz
SN Ia z = 0.105

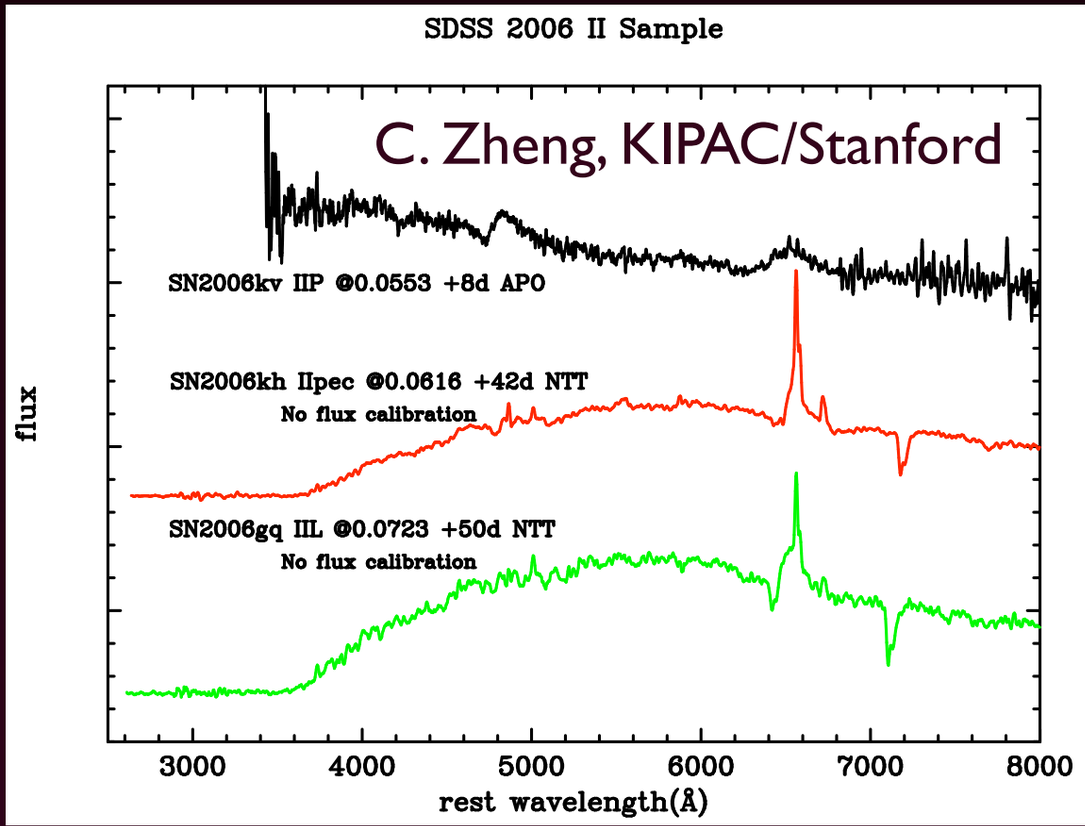
Bassett et al. (2007), CBET 627

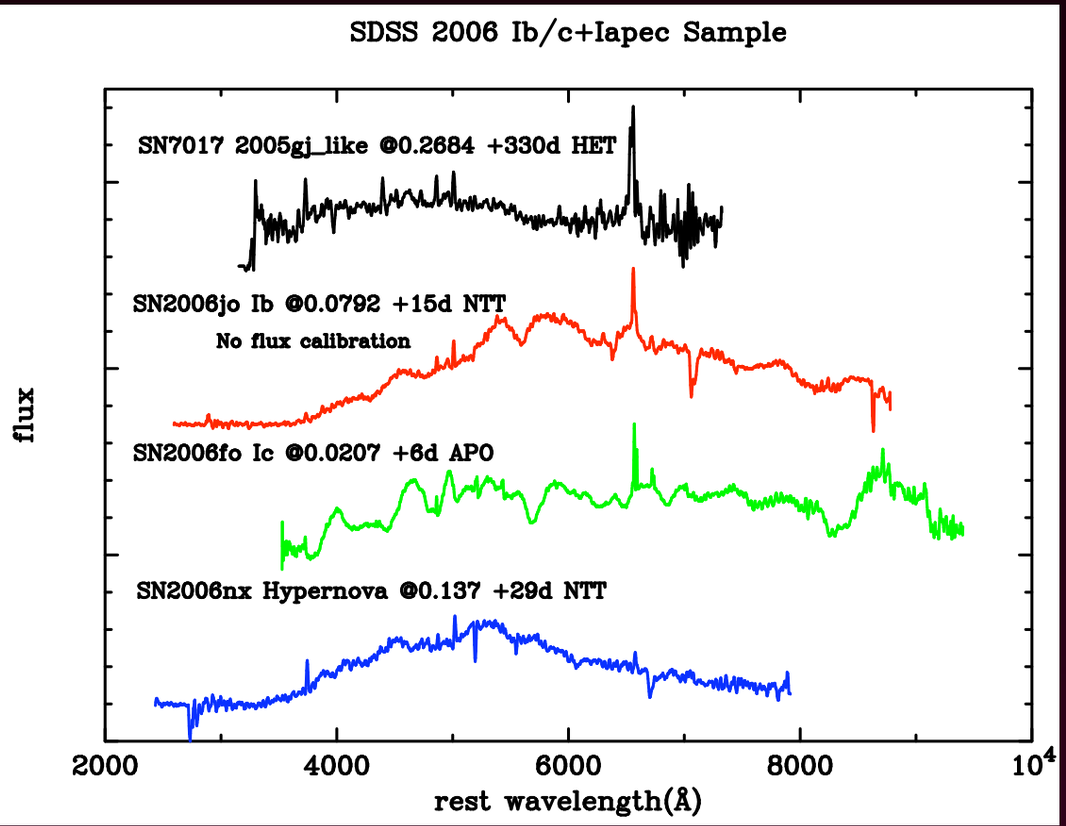
continual web page updates
follow-up is encouraged!

SN Spectroscopy

MDM 2.4m
NOT 2.6m
APO 3.5m
NTT 3.6m
KPNO 4m
WHT 4.2m
Subaru 8.2m
HET 9.2m
Keck 10m
SALT 10m







B. Dilday, U. Chicago

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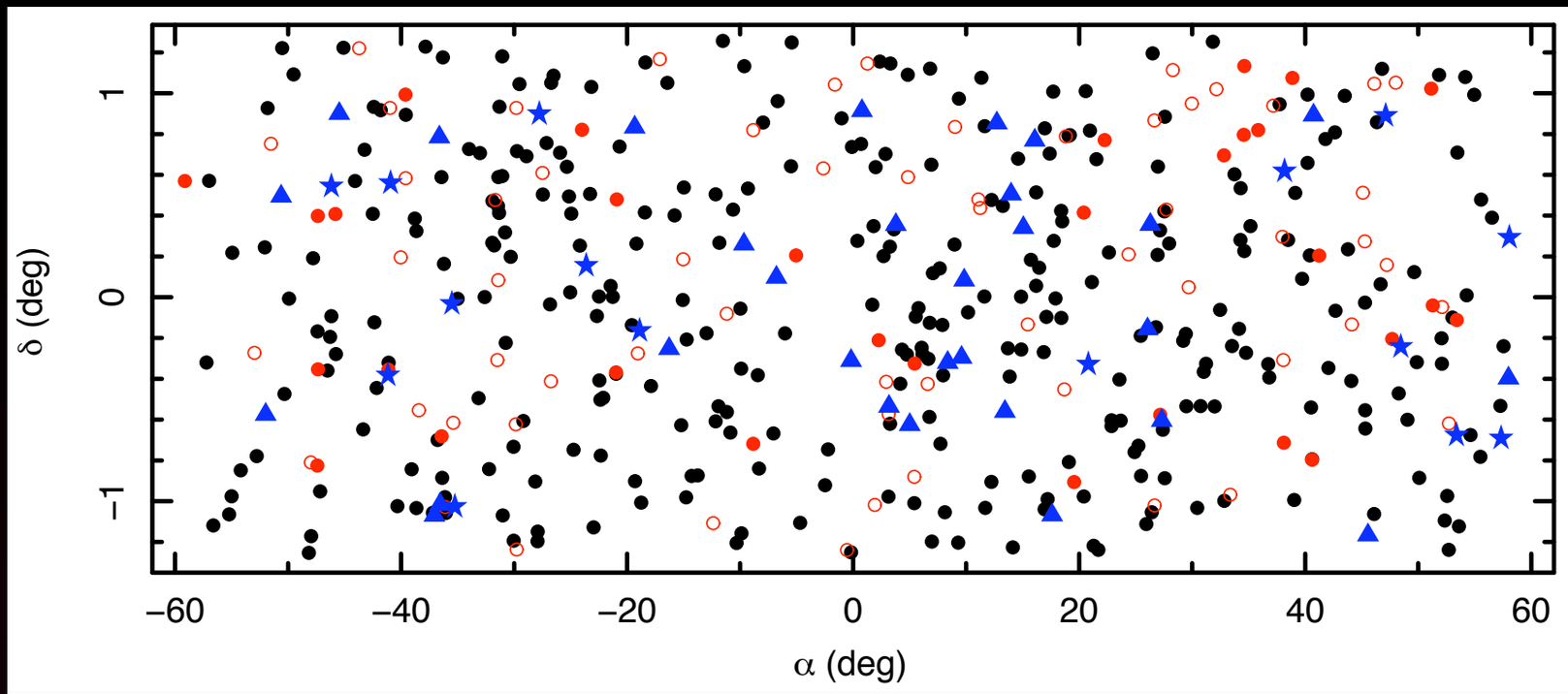
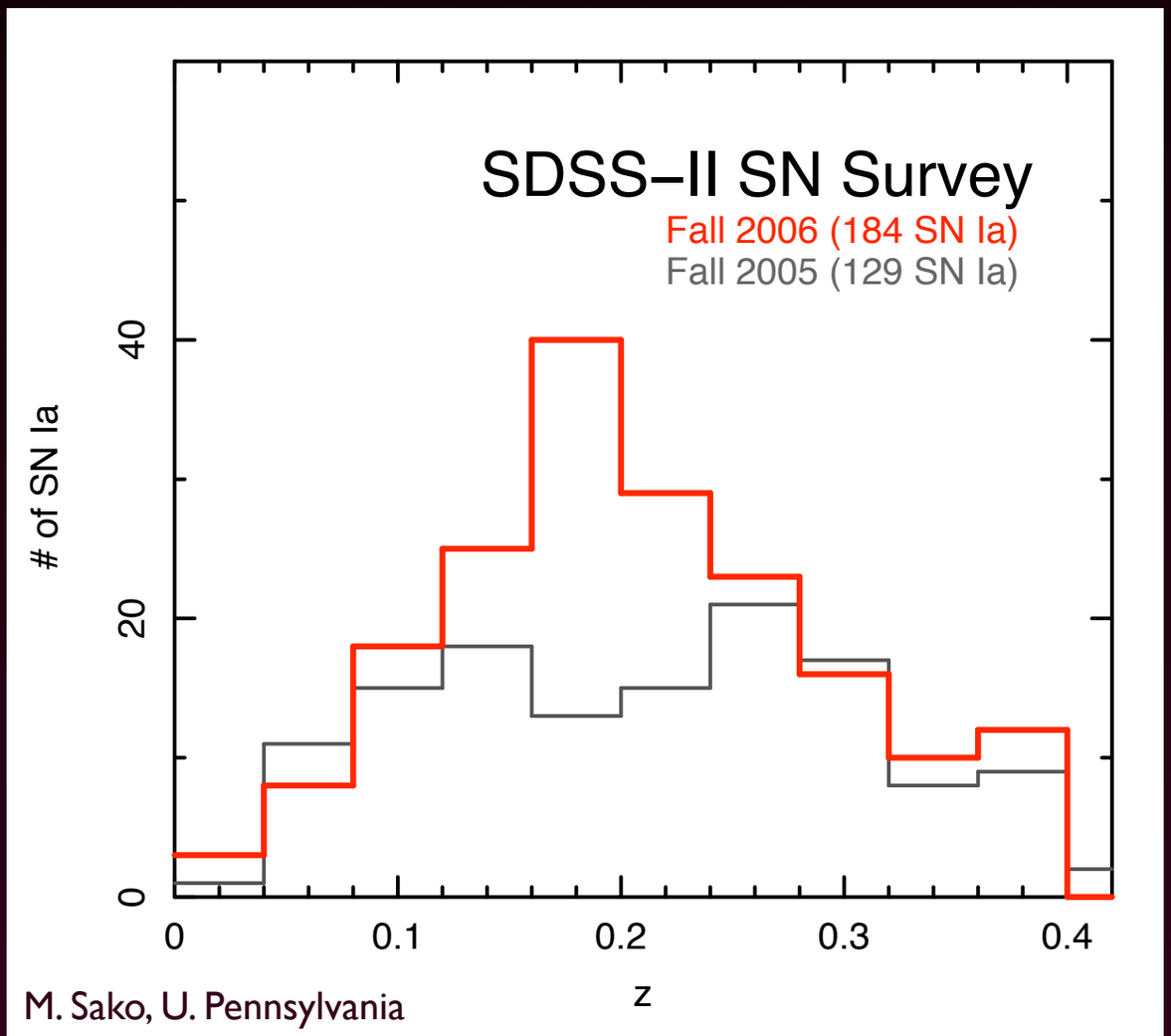


452 supernovae

spectroscopic SN Ia
probable SN Ia
core-collapse SN



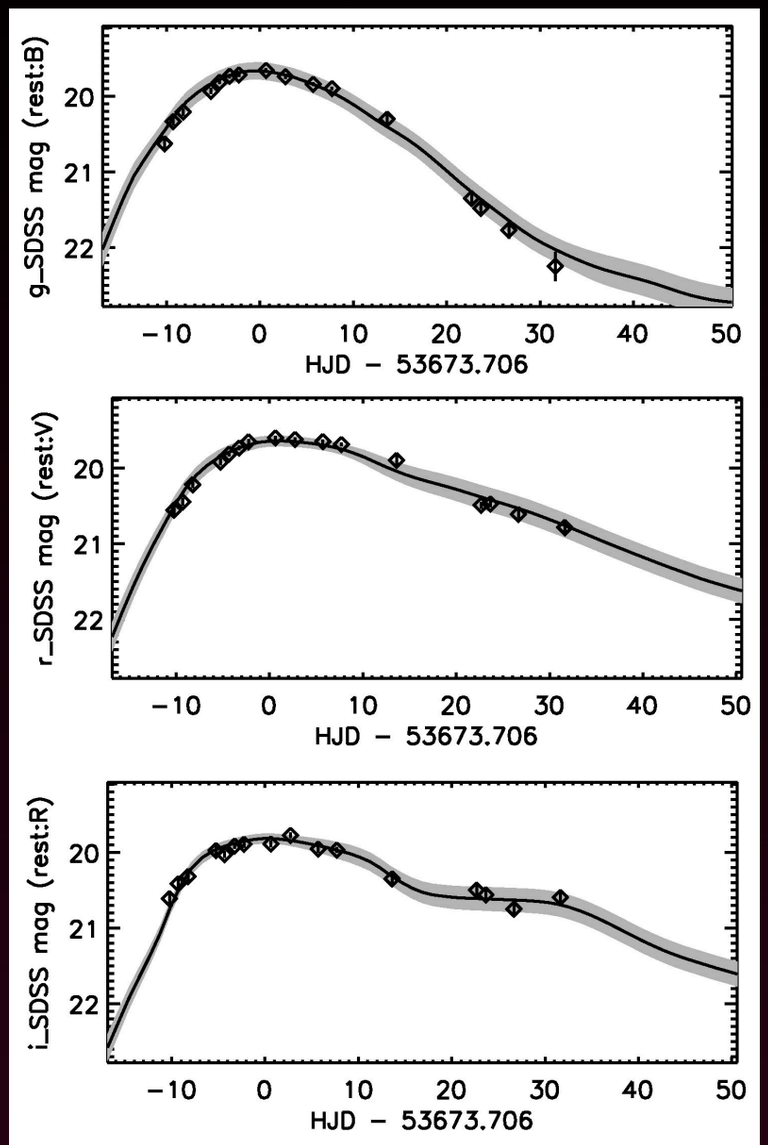
- 313 spectroscopically confirmed SN Ia in two years (2005/2006)

- Analysis of 129 SN Ia from the 2005 season nearly complete:
  - scene-modeling photometry
  - photometric calibration
  - rates, spectra, systematics
  - light-curve fitting & distances

MLCS2k2 light-curve fits

Jha, Riess, & Kirshner (2006, submitted)

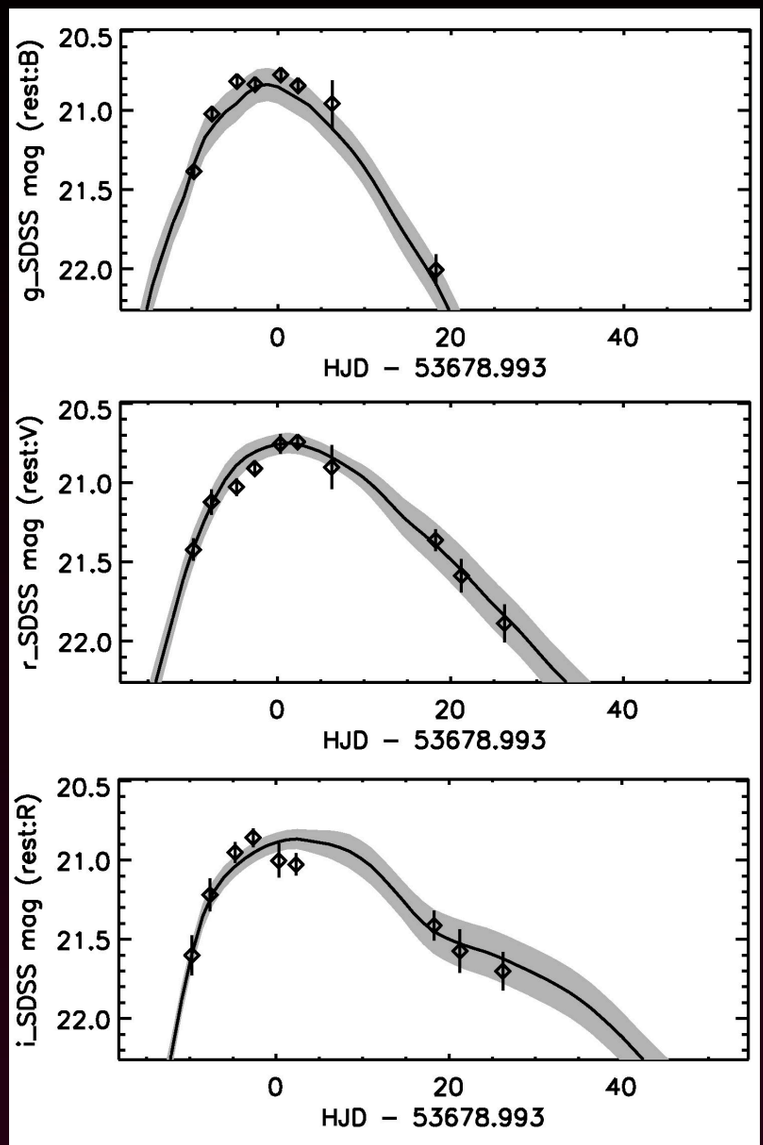
SN 2005ij z = 0.124



sn06406_SMP01_gri

t_0 = 53673.706 R_v = 3.10
Δ = −0.14 A_v = 0.20
$\mu_0 + 5 \log (H_0/65)$ = 39.12
$E(B-V)_{MW}$ = 0.08 z = 0.1240
χ^2/ν = 21.32/44

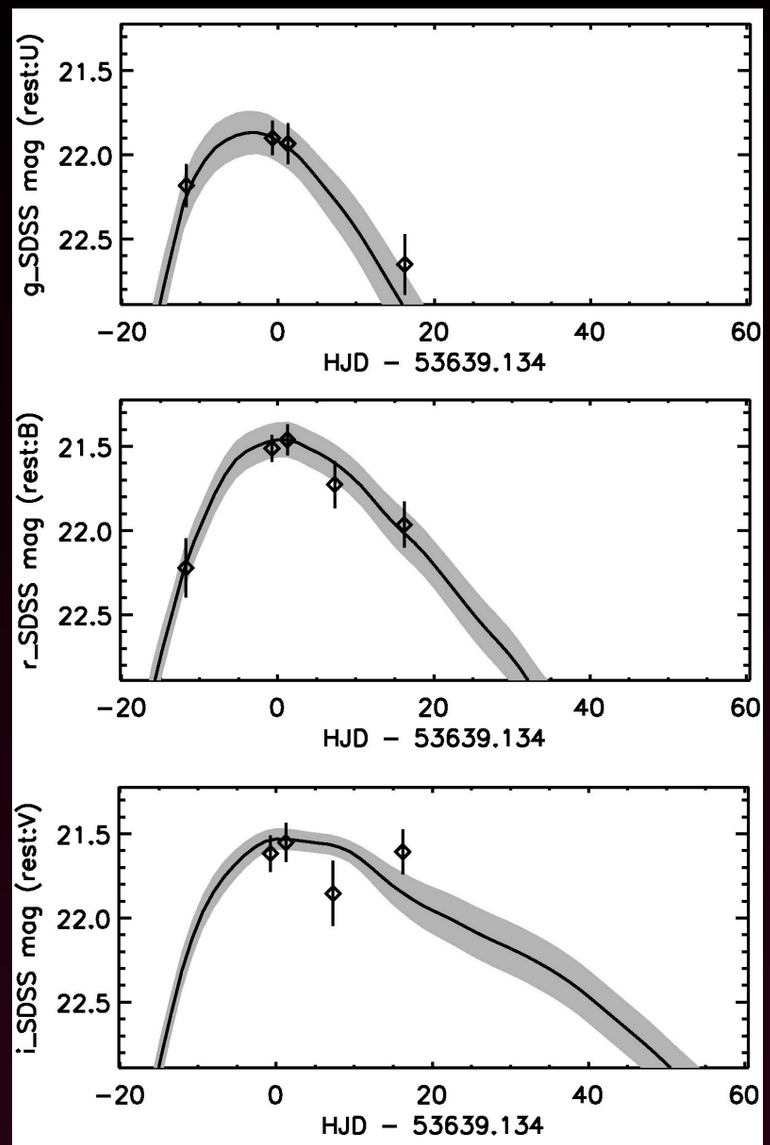
SN 2005ji z = 0.214



sn07473_SMP01_gri

t_0 = 53678.993 R_v = 3.10
Δ = −0.02 A_v = 0.09
$\mu_0 + 5 \log (H_0/65)$ = 40.50
$E(B-V)_{MW}$ = 0.02 z = 0.2140
χ^2/ν = 15.52/23

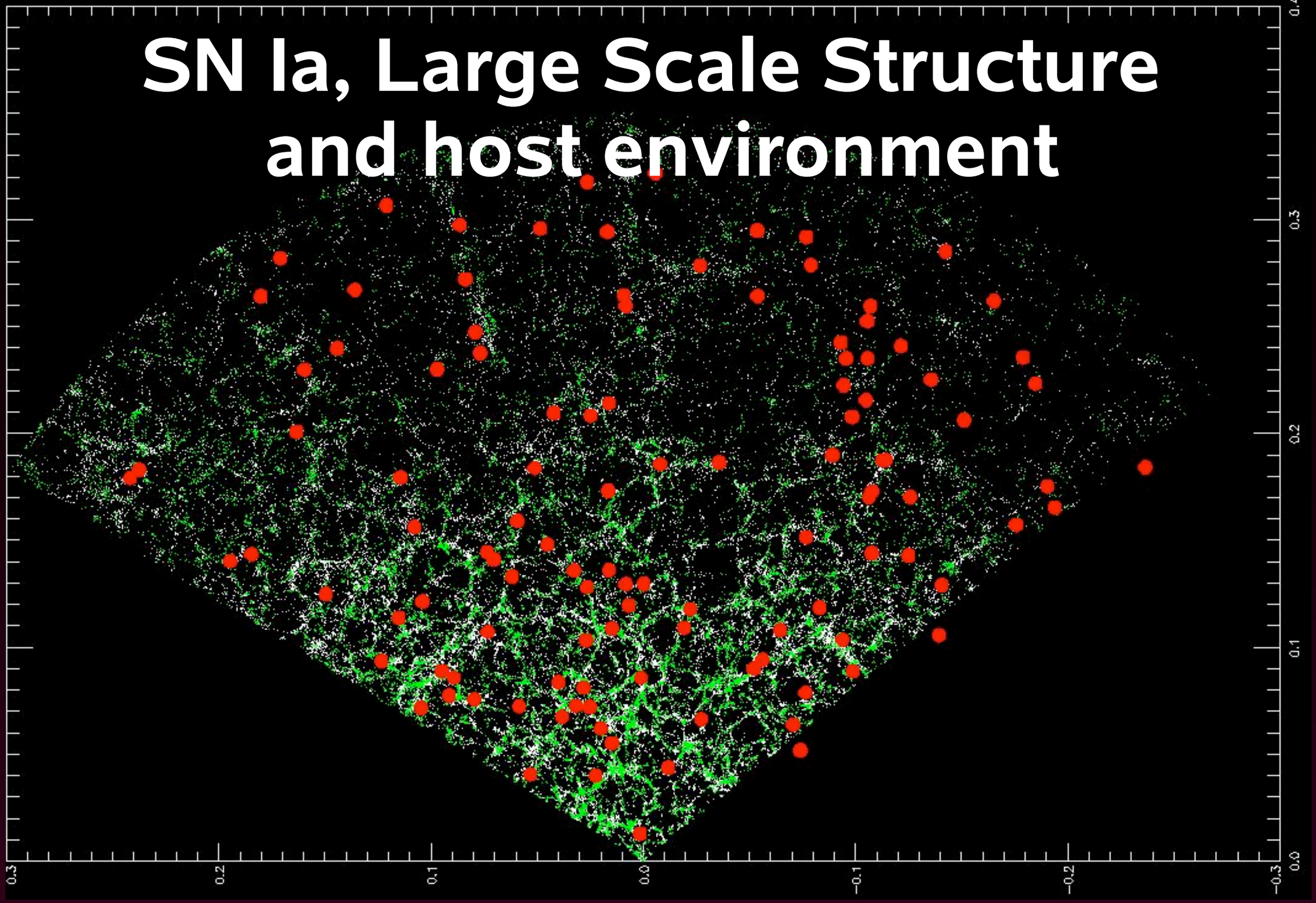
SN 2005fs z = 0.344



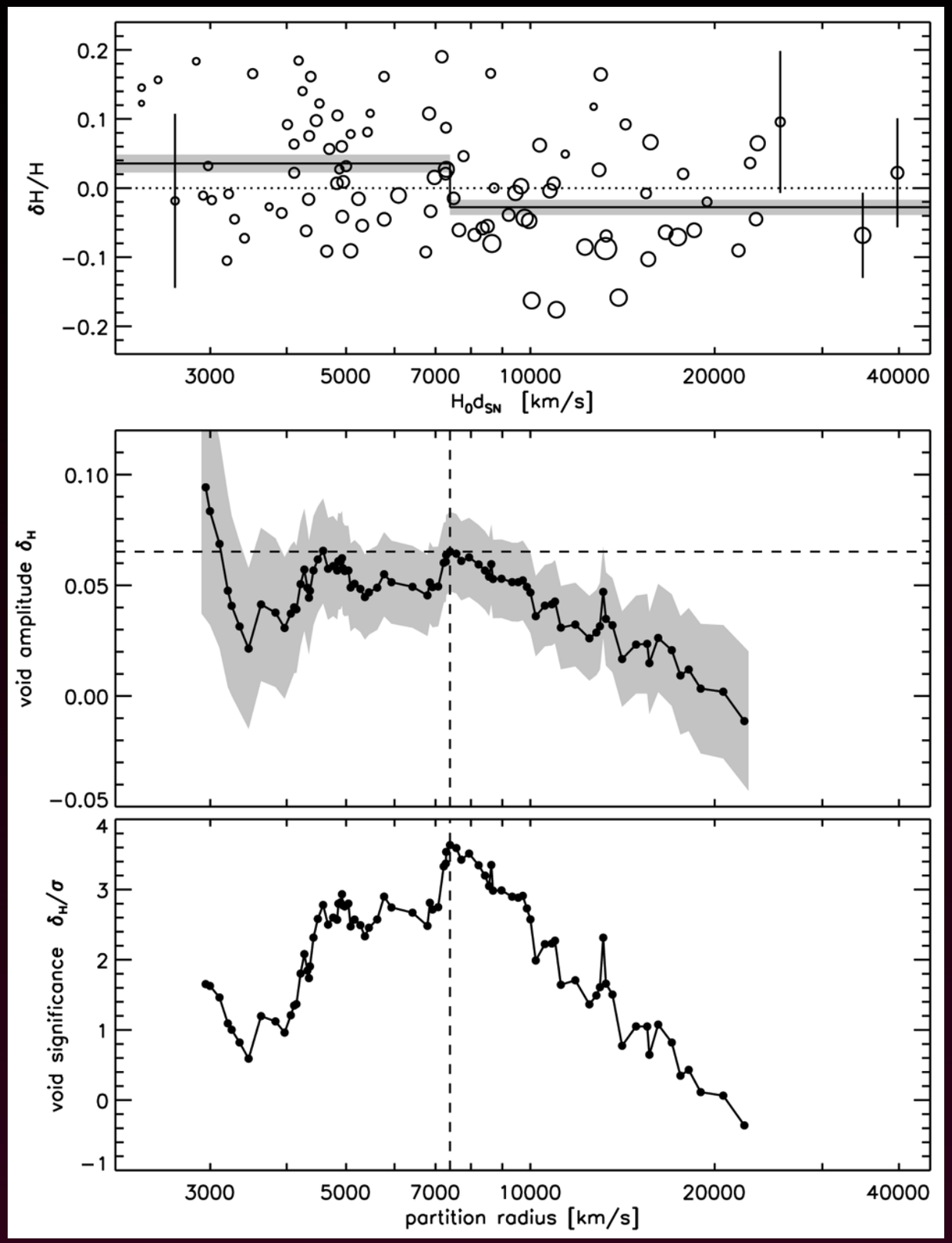
sn02533_SMP01_gri

t_0 = 53639.134 R_v = 3.10
Δ = −0.32 A_v = 0.10
$\mu_0 + 5 \log (H_0/65)$ = 41.56
$E(B-V)_{MW}$ = 0.03 z = 0.3440
χ^2/ν = 5.86/9

SN Ia, Large Scale Structure and host environment



A Hubble Bubble?

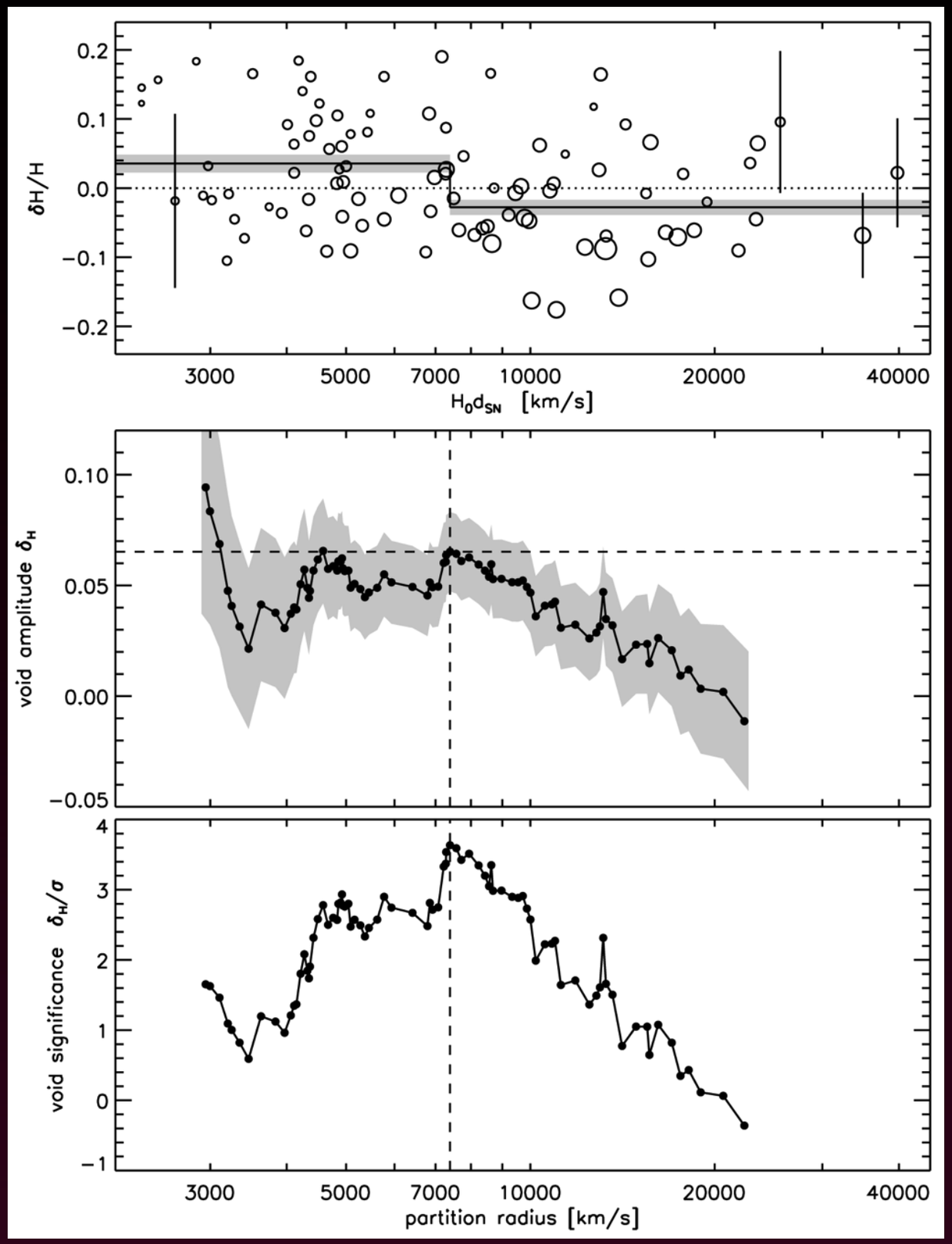


Jha, Riess, & Kirshner (2006)

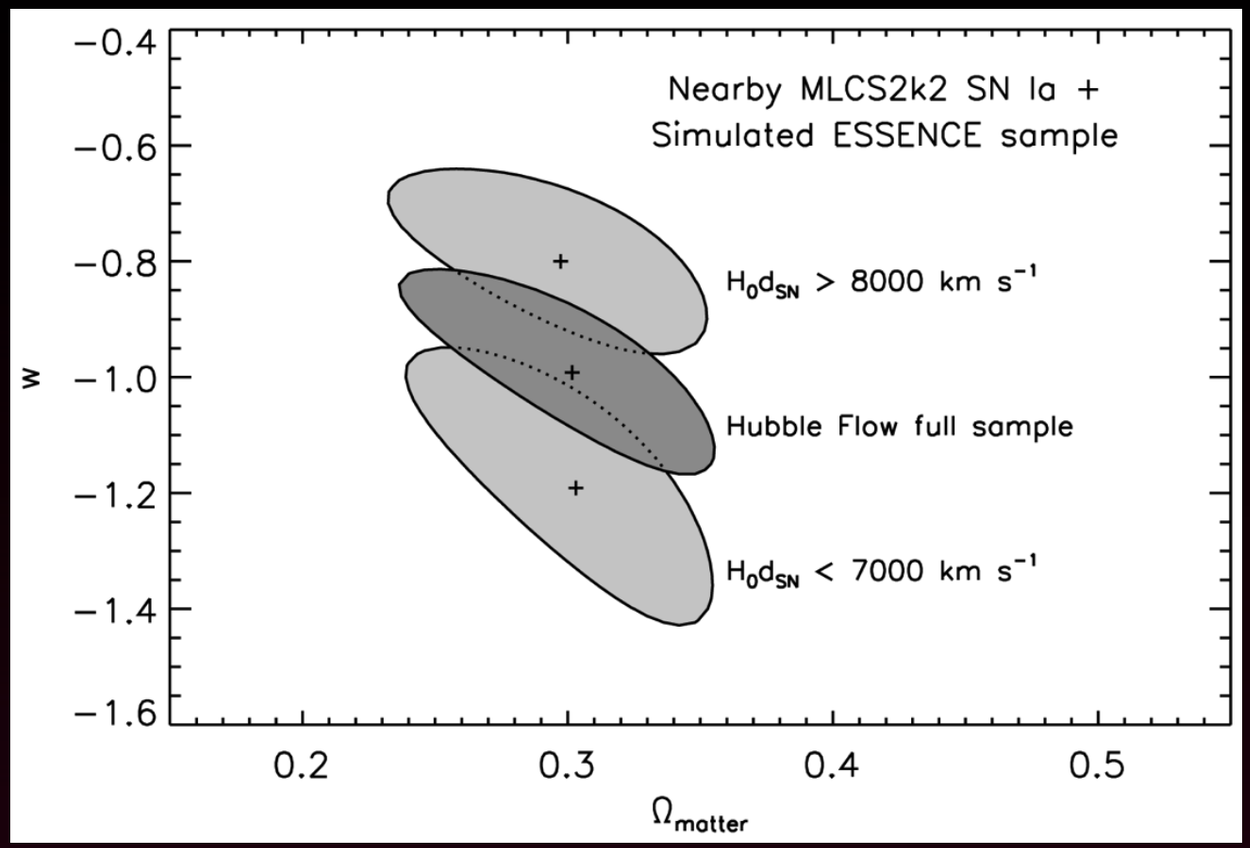
↕ a 6% difference in the expansion rate at a radius of 300 million light years

statistical signifcance is 3σ, but robust with subsamples, other distance techniques

A Hubble Bubble?



Jha, Riess, & Kirshner (2006)

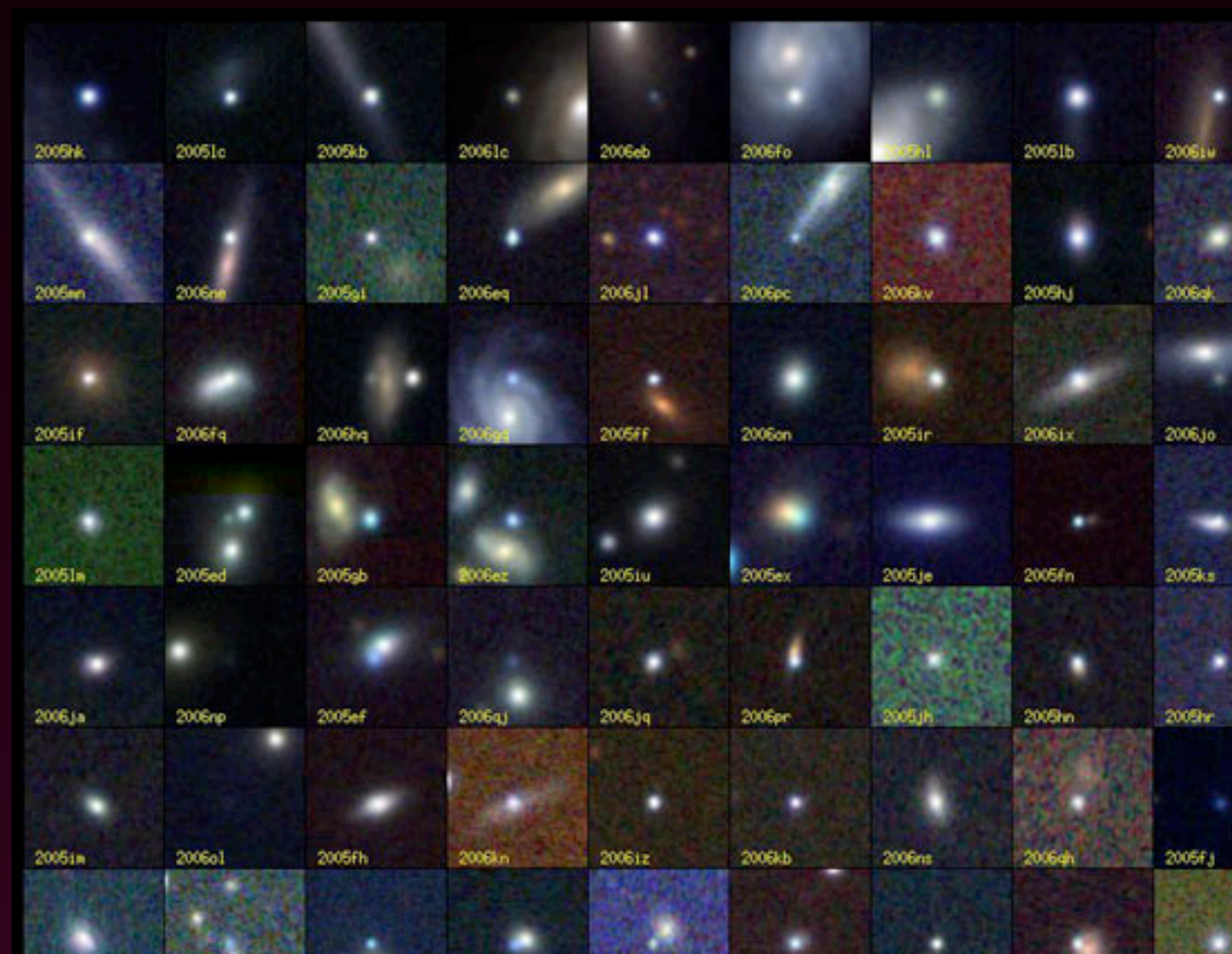


- a real local void?
- K-corrections?
- photometric offset?
  - new data vs. Calán/Tololo?
  - morphology/extinction?

urgent need to augment the low-z sample
→ SDSS could help!

“Peculiar” SN Ia: SN 2005hk

with SDSS-II,
A. Filippenko, R. Chornock, R. Foley, W. Li (UC Berkeley),
D. Branch (U. Oklahoma), and M. Phillips (LCO)



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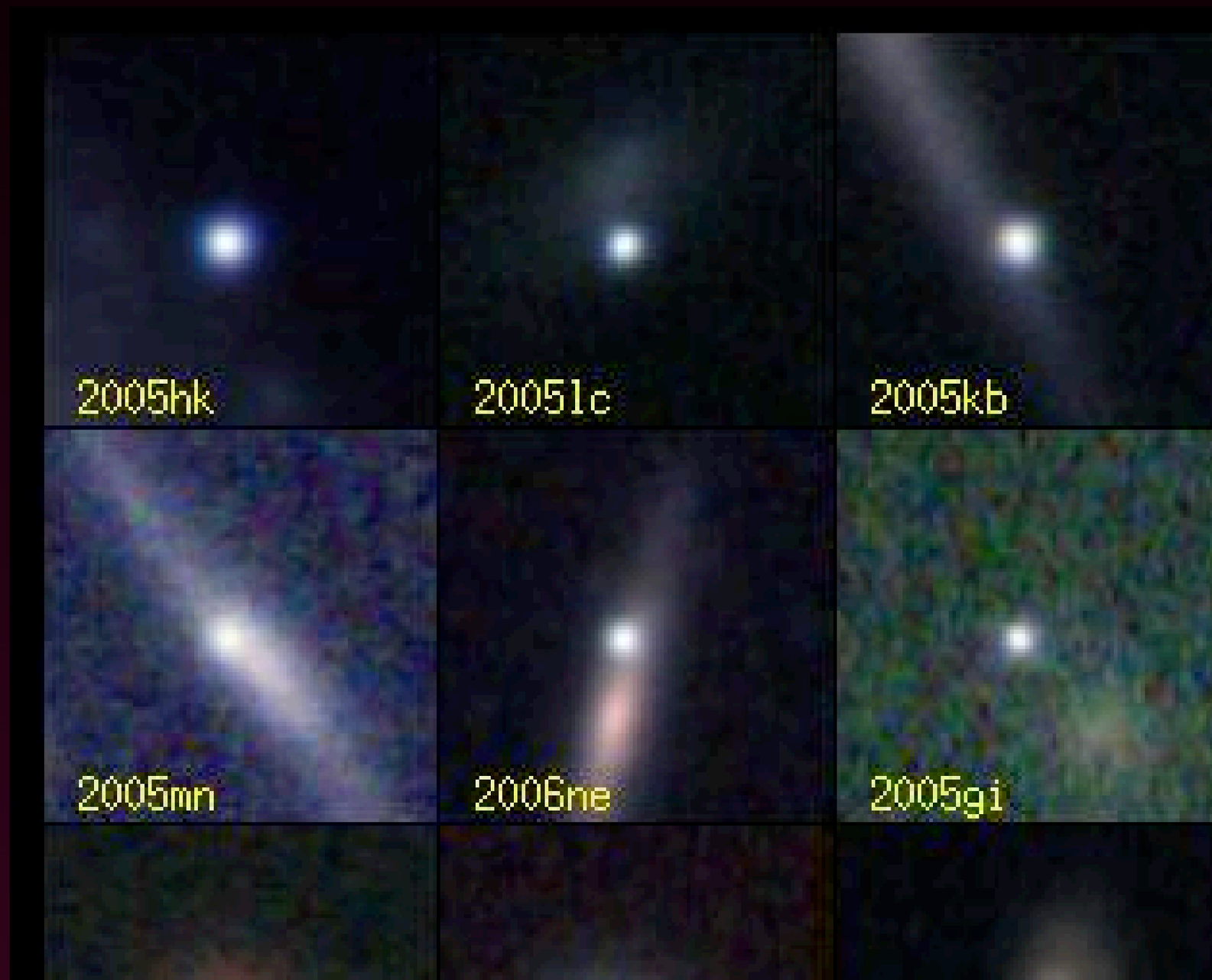
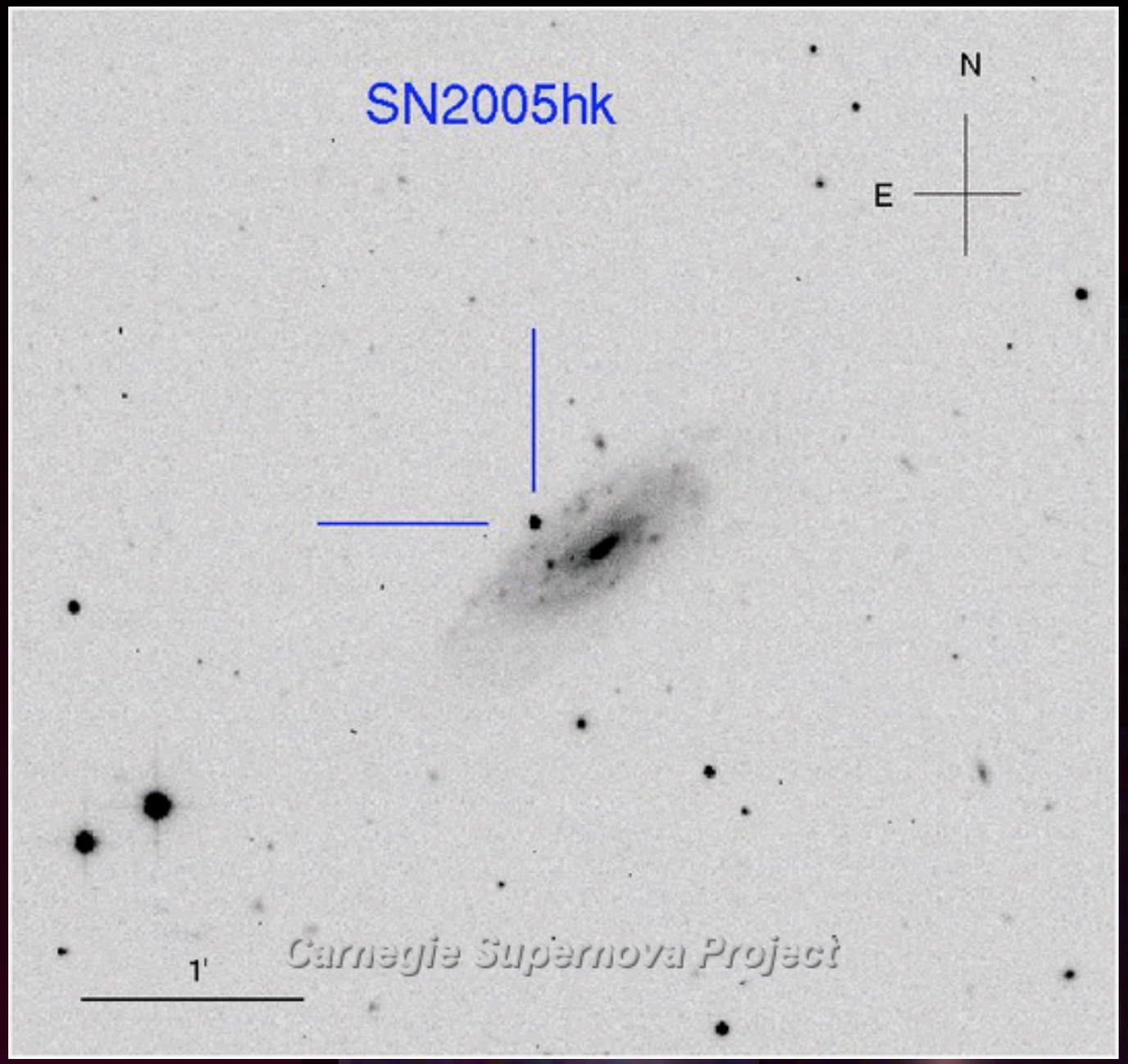
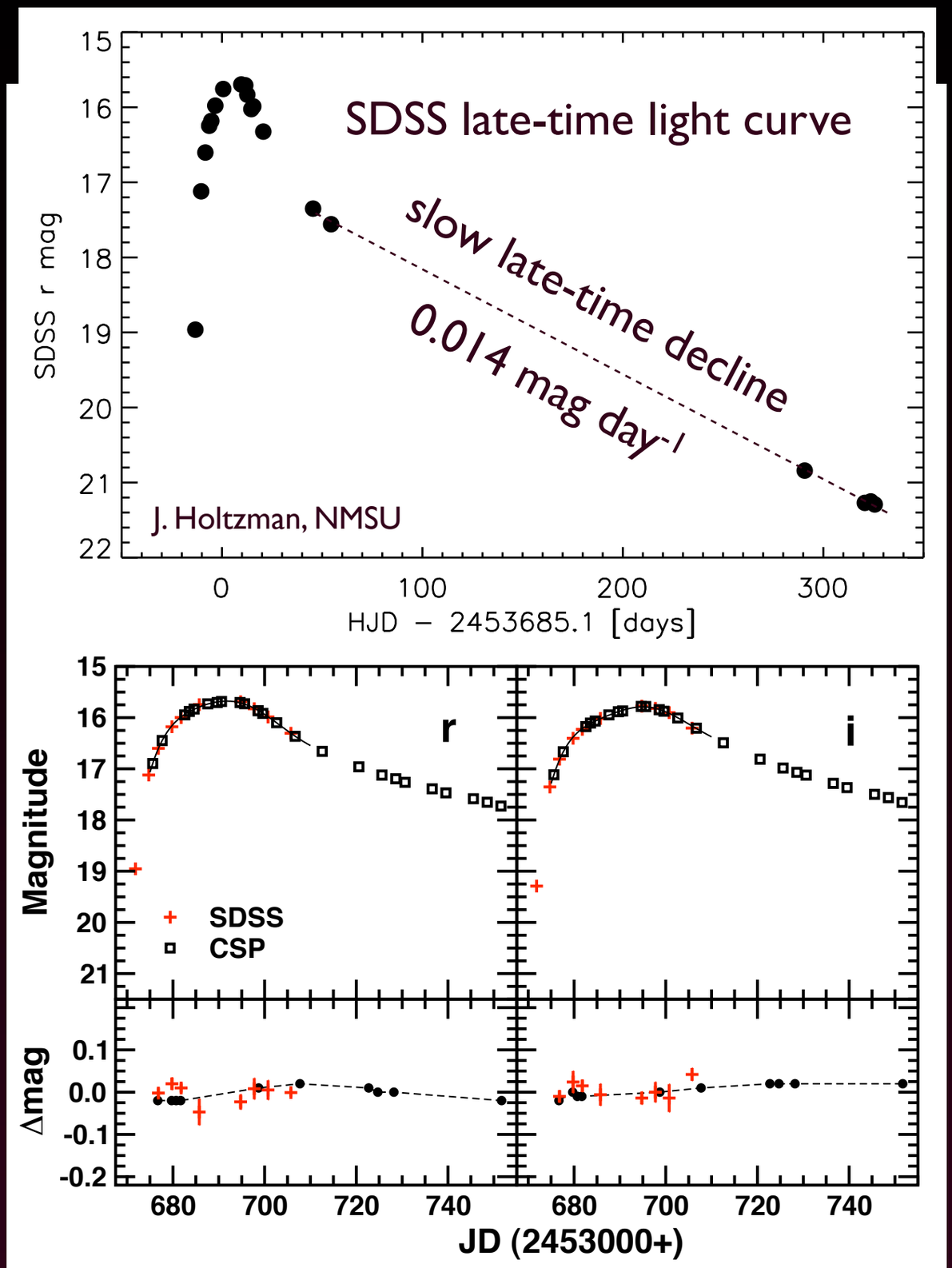


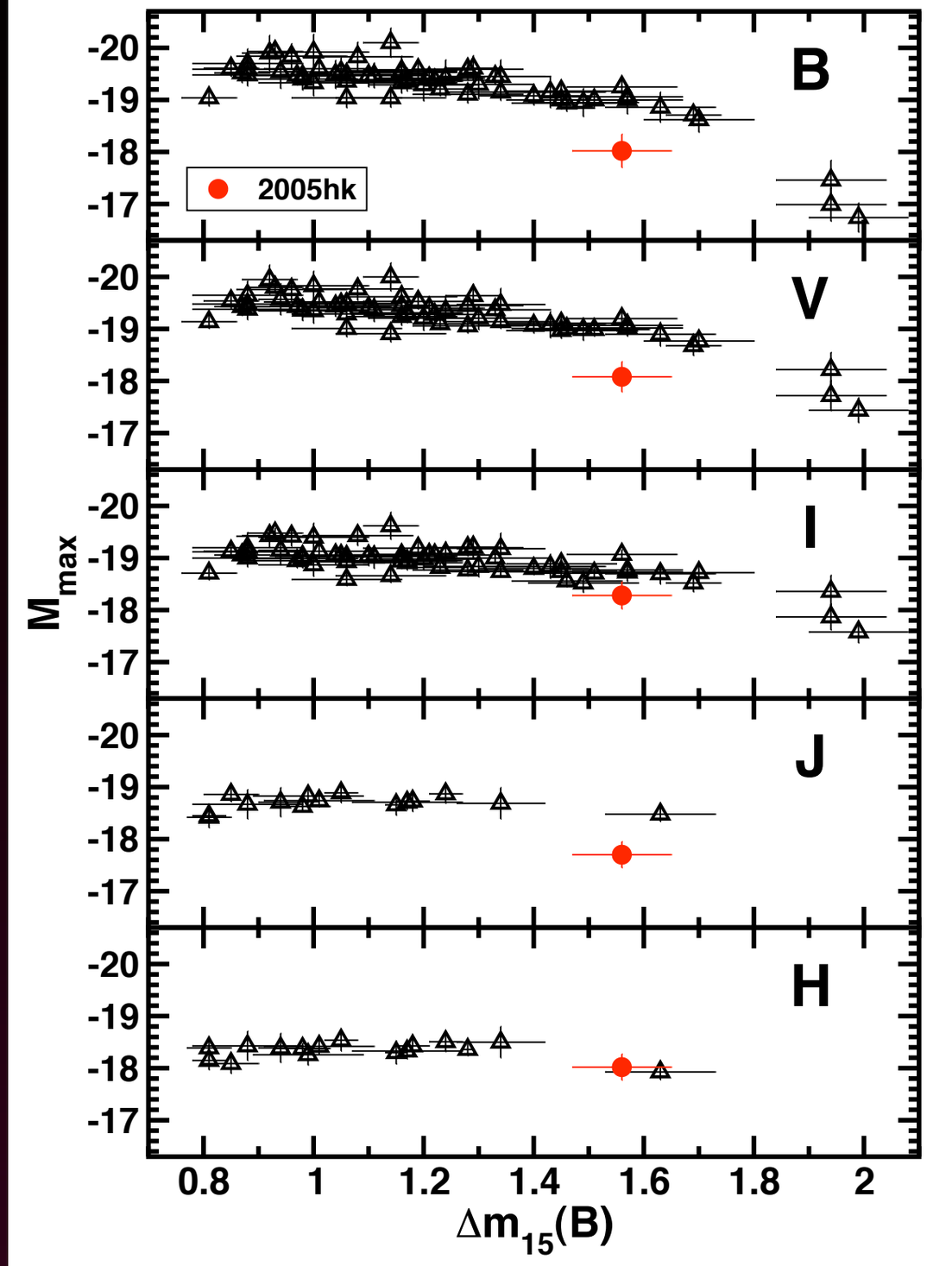
“Peculiar” SN Ia: SN 2005hk



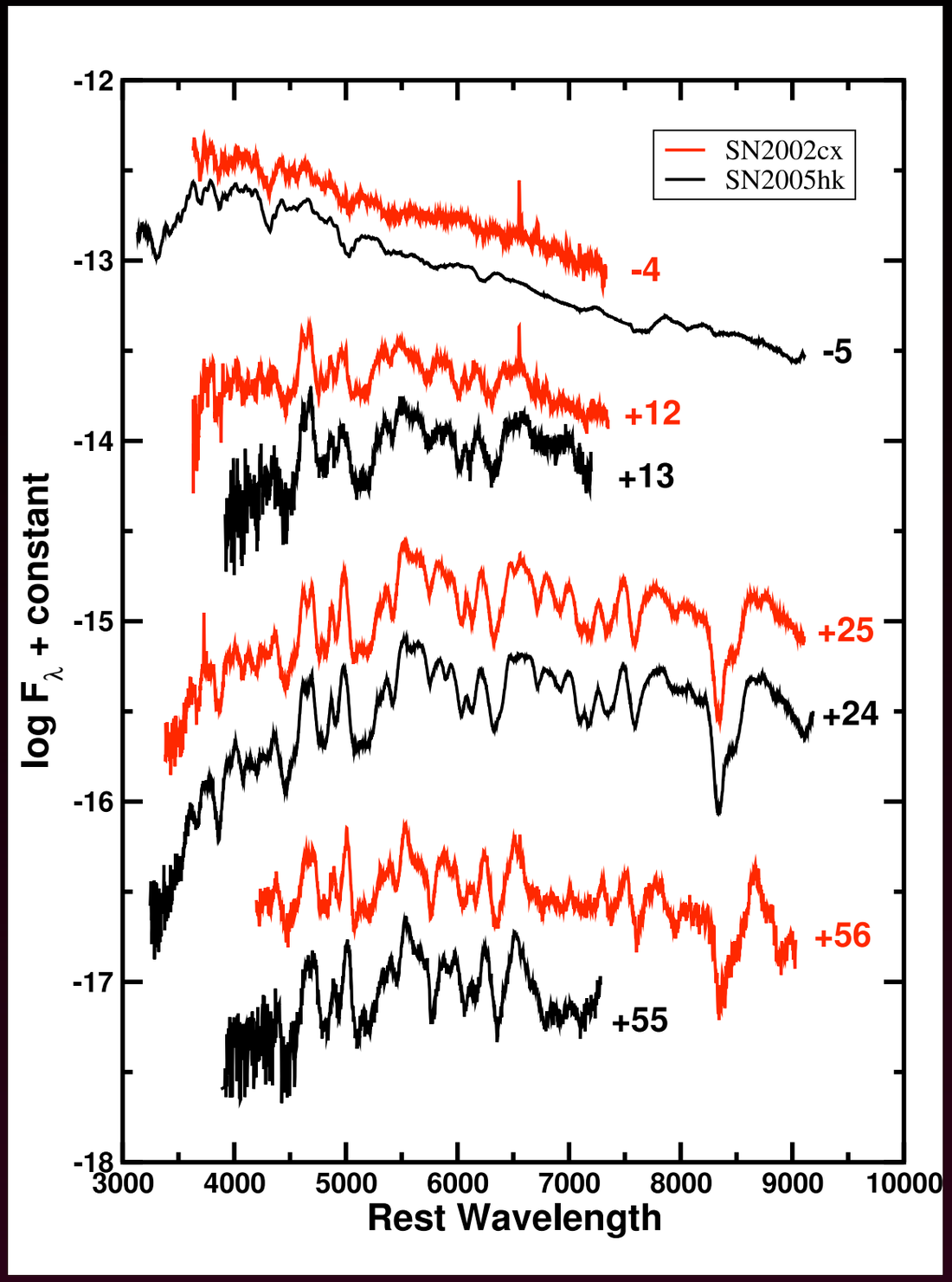
“Peculiar” SN Ia: SN 2005hk



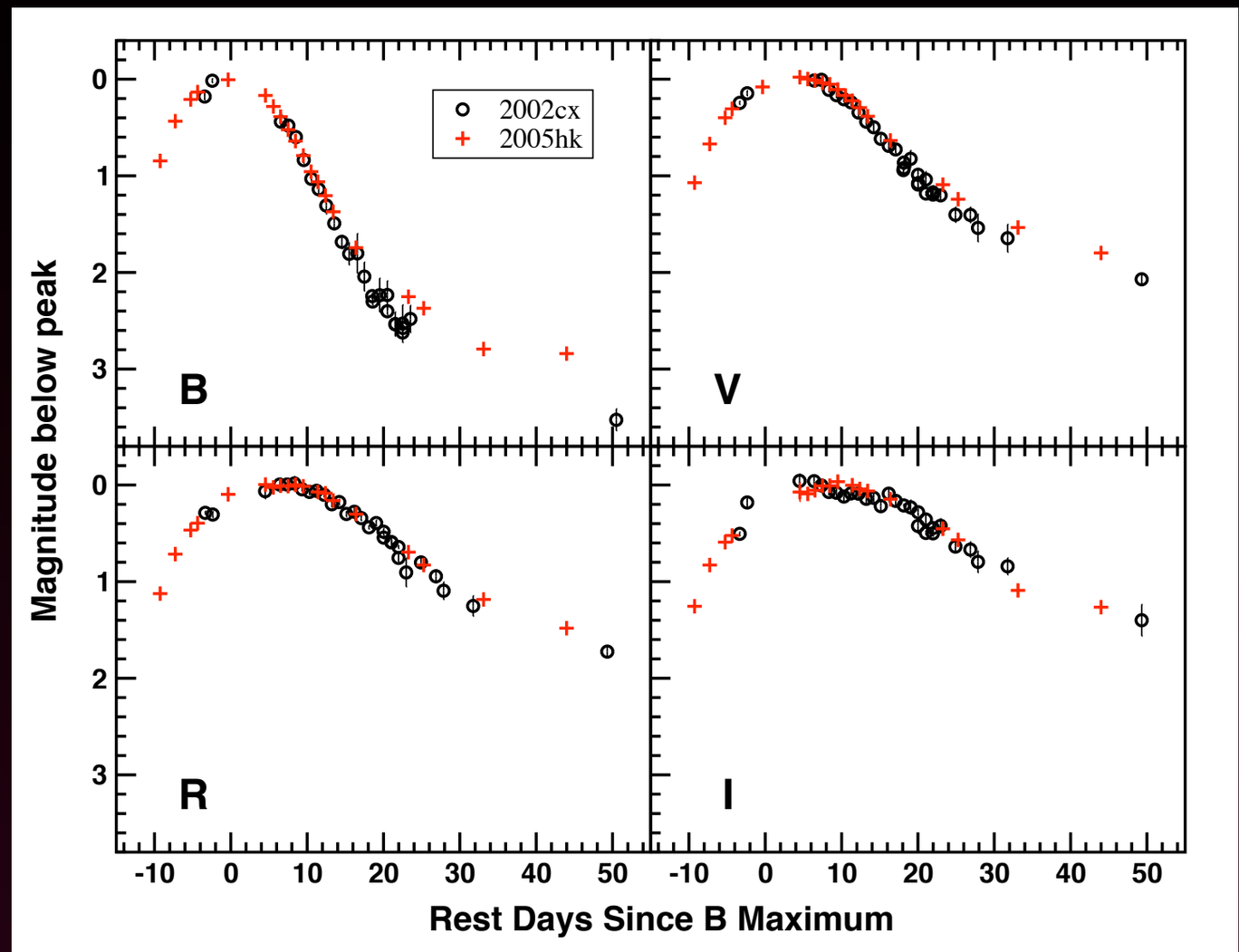
Phillips et al. (2006)



SN 2005hk: very similar to SN 2002cx

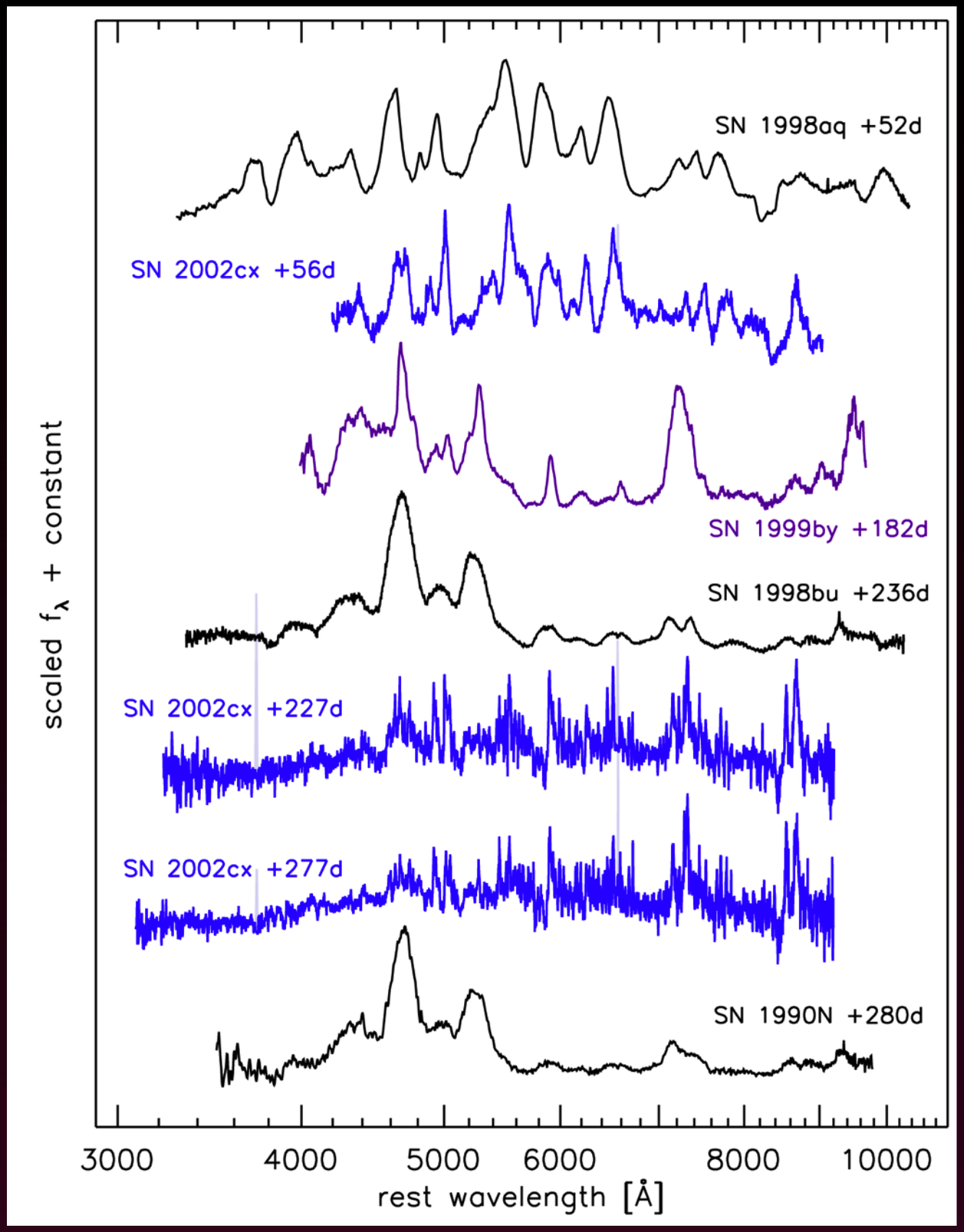


Li et al. (2003); Phillips et al. (2006)

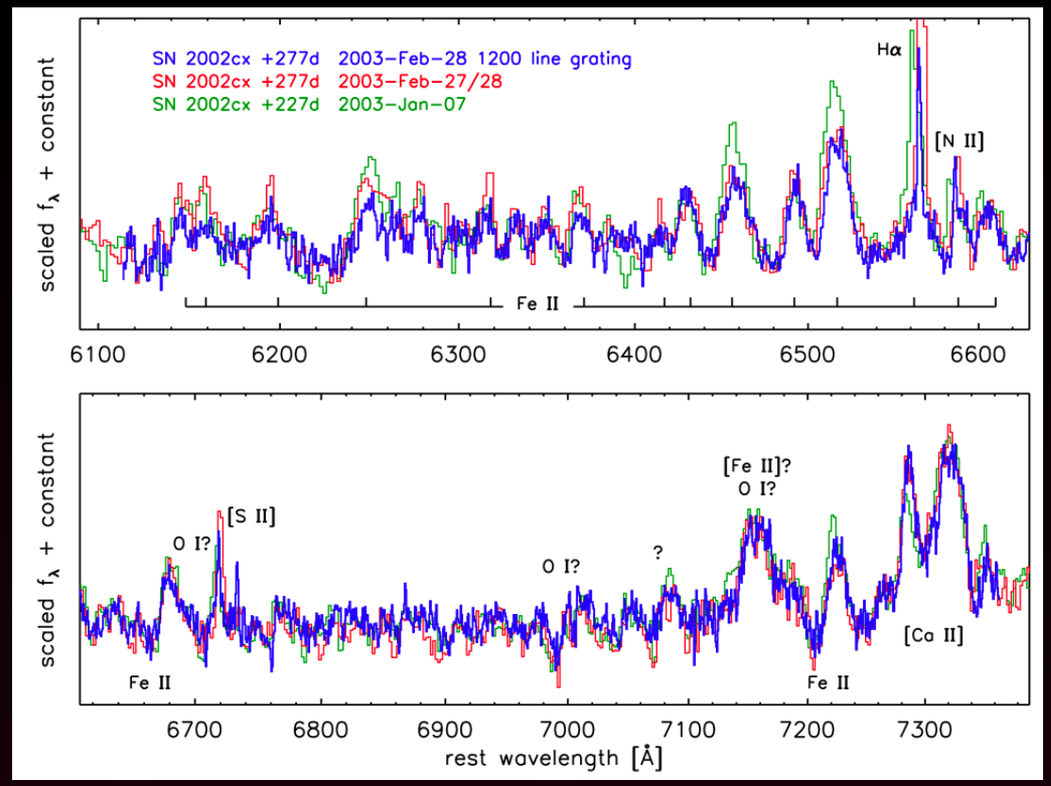


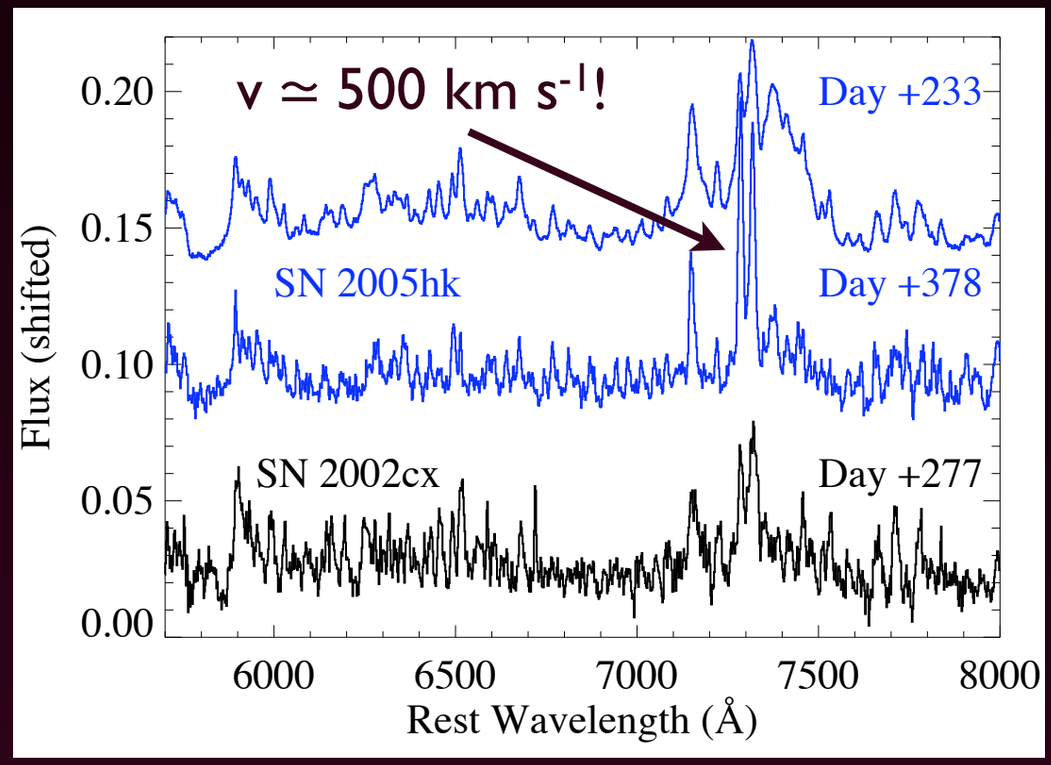
very low velocities (½ normal at max)
subluminous for its decline rate
slow late-time decline
... and they don't become nebular!

SN 2002cx Late-Time Spectra



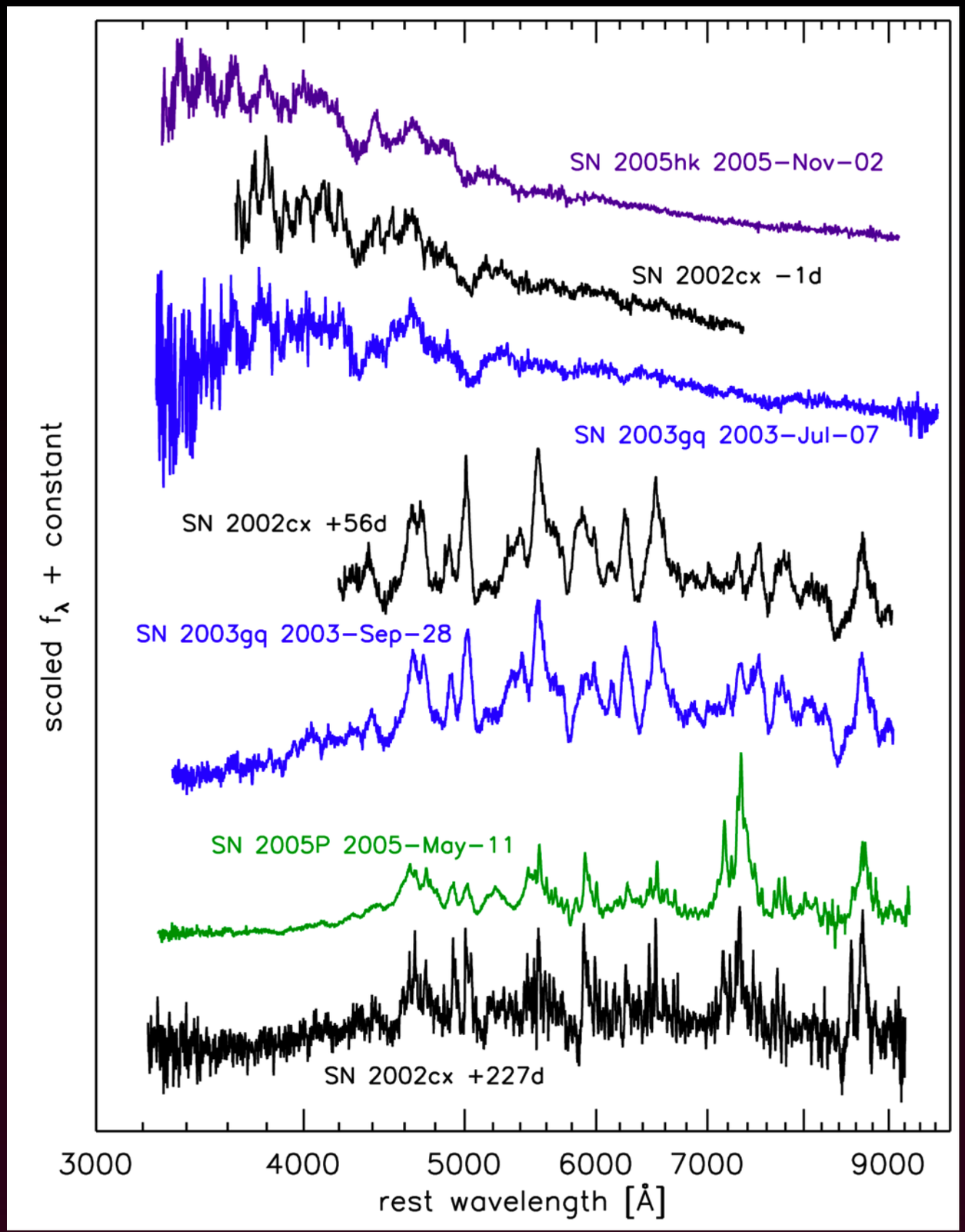
Li et al. (2003); Branch et al. (2004); Jha et al. (2006)





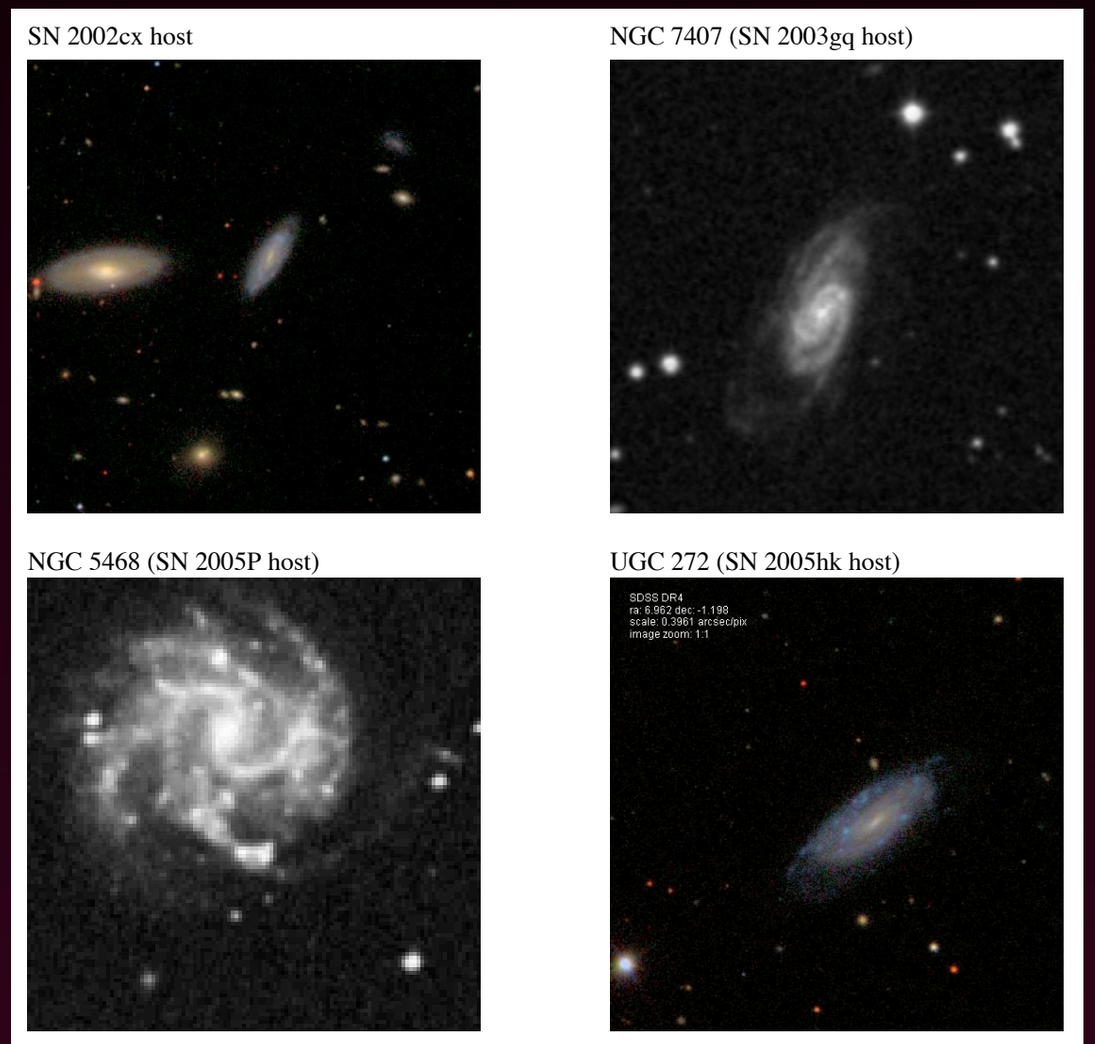
Chornock, Foley, & Filippenko (2006)

The SN 2002cx-like Subclass

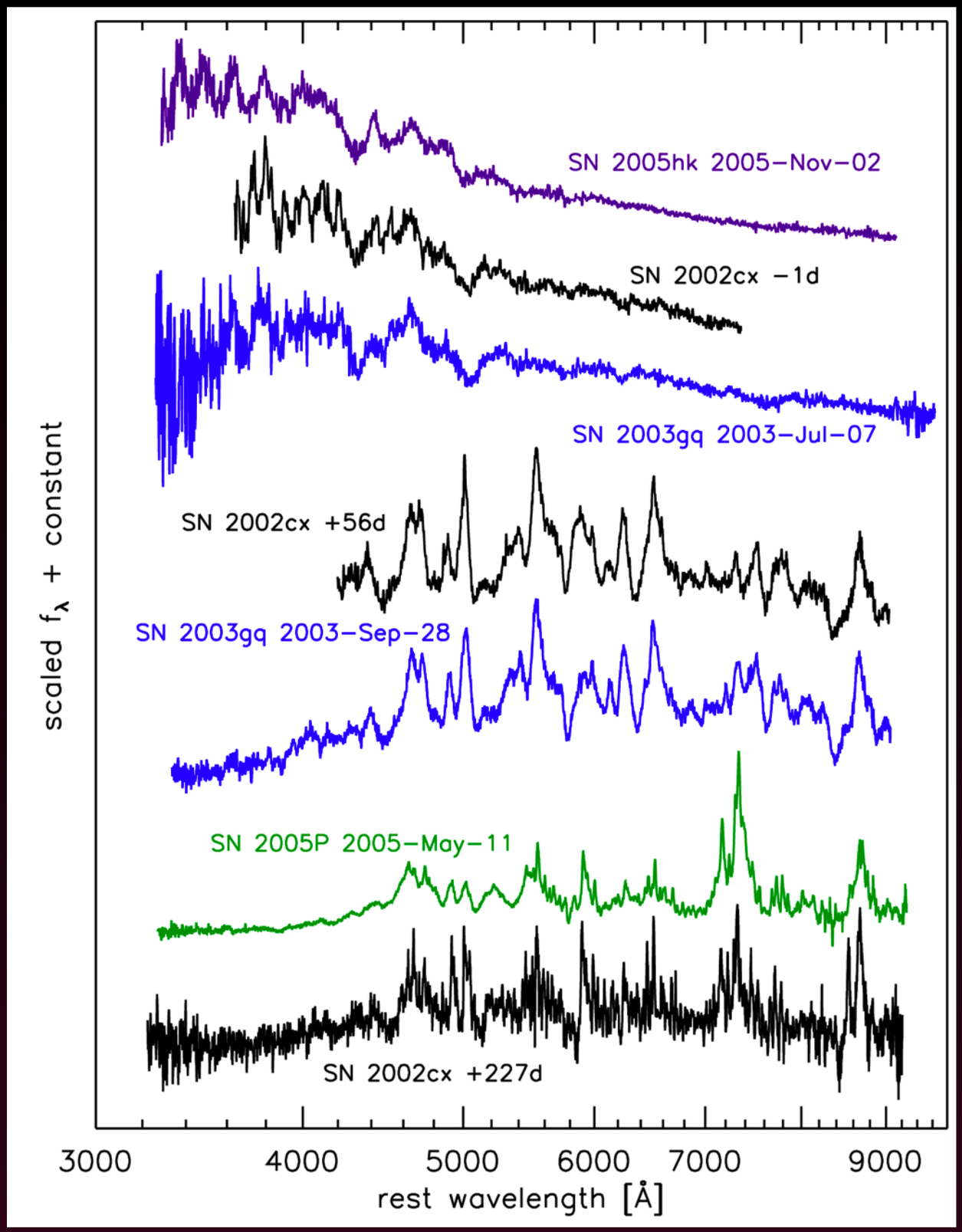


Jha et al. (2006)

- SN 2002cx, 2005hk, 2003gq, 2005P, 2005cc, 1991bj (Stanishev 2006)
- Like normal SN Ia, 2005hk has low polarization (Chornock et al. 2006)
- very low velocities and luminosities
- all in blue, late-type hosts



The SN 2002cx-like Subclass



Jha et al. (2006)

- SN 2002cx, 2005hk, 2003gq, 2005P, 2005cc, 1991bj (Stanishev 2006)
- Like normal SN Ia, 2005hk has low polarization (Chornock et al. 2006)
- very low velocities and luminosities
- all in blue, late-type hosts
- cosmological implications?
- progenitor models:
  - mixed layers, low ^{56}Ni mass
  - low-velocity unburned material
  - weak 3-d deflagration?
  - high mass and density at low velocity: "failed" SN Ia?
- peculiar objects may be the key to understanding normal SN Ia!