SDSS-II SN Survey: SNe & Hosts

Peter Garnavich
Notre Dame

and the SDSS-II SN collaboration

KITP/UCSB March 23, 2007

SDSS-II SN Collaboration

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Ohio State U.	D. L. DePoy, J. L. Prieto
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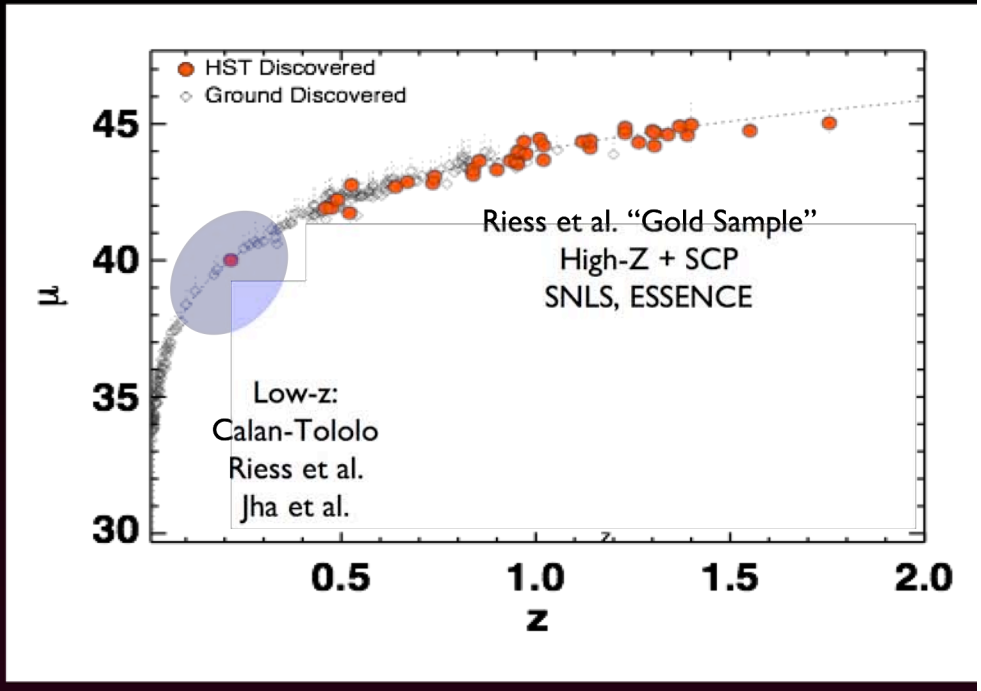
Penn State U.	D. Schneider
U. Texas	C. Wheeler

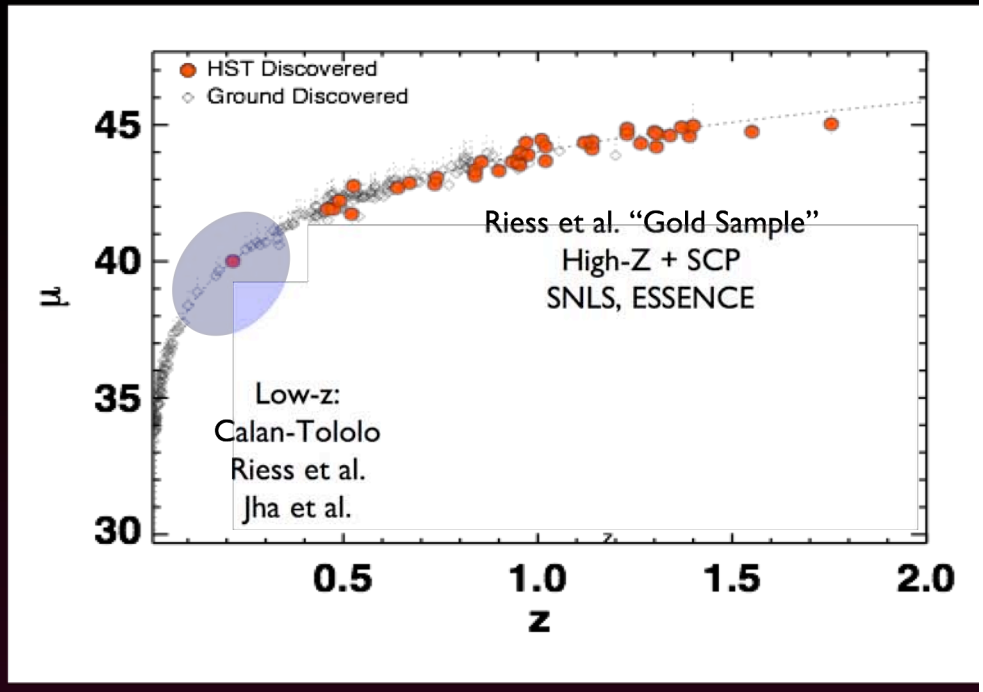
with help from: J. Eastman, L. Watson, R. Assef, K. Schlesinger, A. Crotts, M. Stritzinger, J. Sollerman, A. Goobar, G. Leloudas, R. J. Foley, A. V. Filippenko, A. Aragon-Salamanca, M. Bremer, M. Turatto, P. Ruiz-Lapuente, F. Castander, A. Romer, C. Collins, J. Lucey, A. Edge, Y. Ihara

SN Ia Hubble Diagram



SN Ia Hubble Diagram

- Main goals of the SDSS SN survey:



SN Ia Hubble Diagram

- Main goals of the SDSS SN survey:
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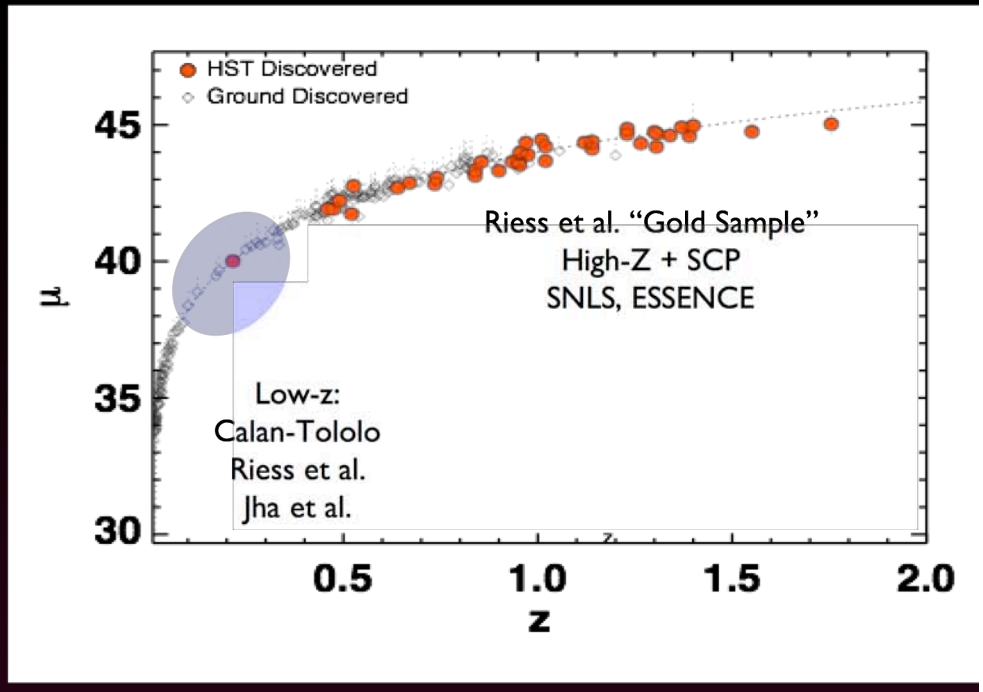

SN Ia Hubble Diagram

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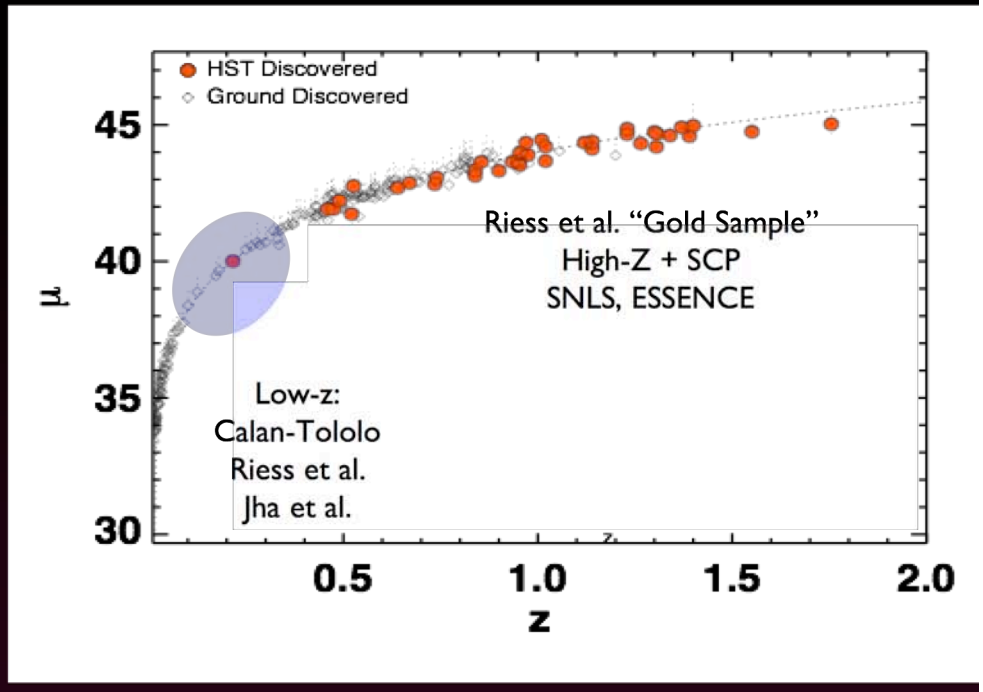
=>fill in the SN Ia Hubble diagram at intermediate redshift, $0.1 \lesssim z \lesssim 0.3$



SN Ia Hubble Diagram

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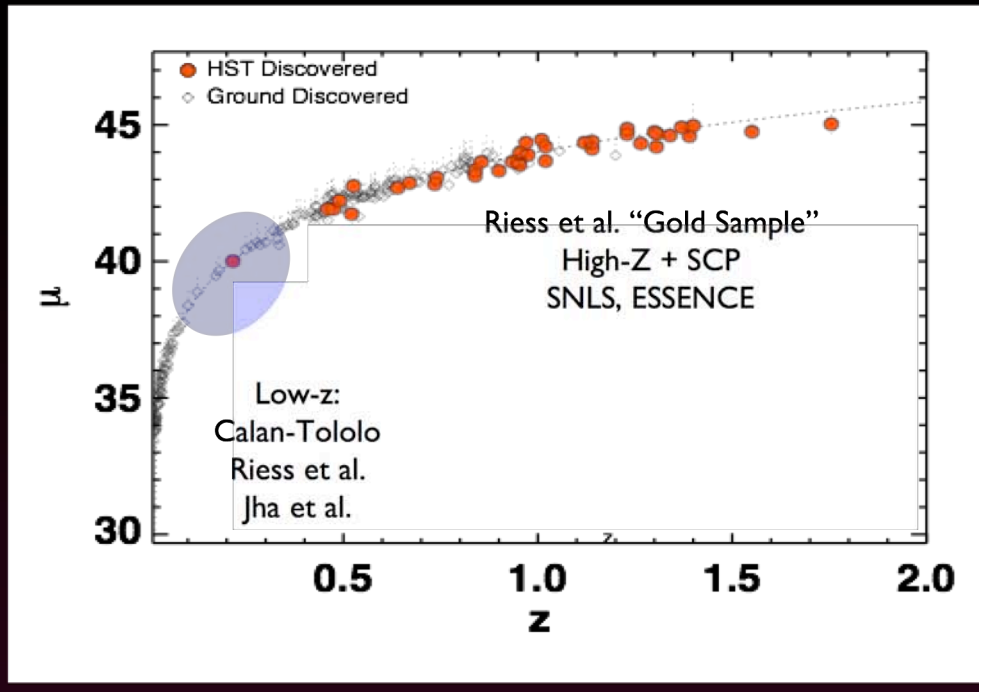
- =>connect low-z with high-z



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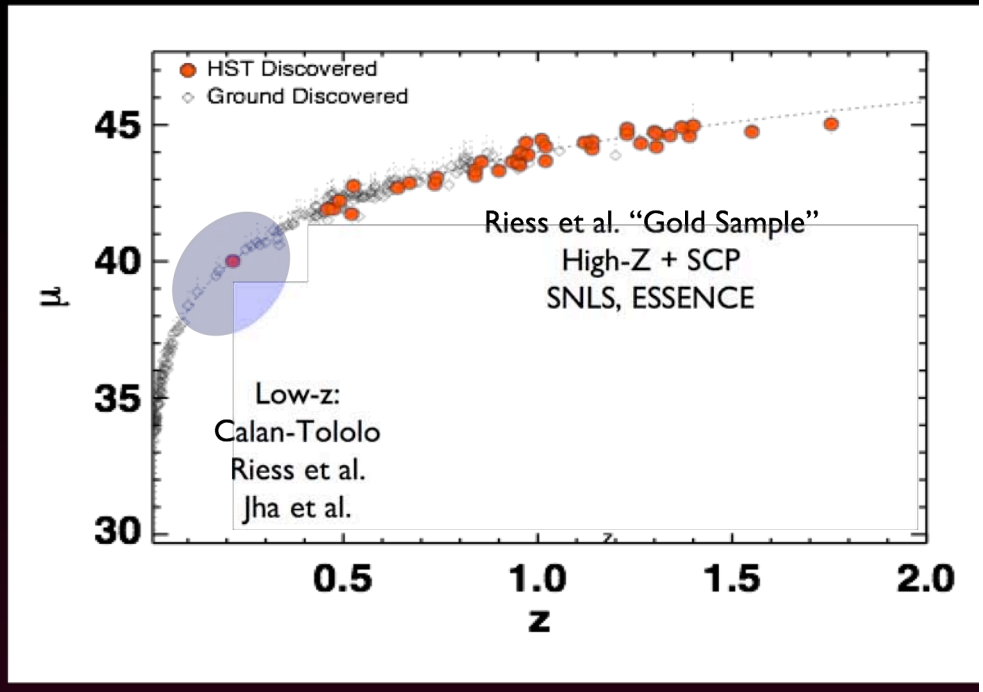
- =>confirm concordance cosmology



SN Ia Hubble Diagram

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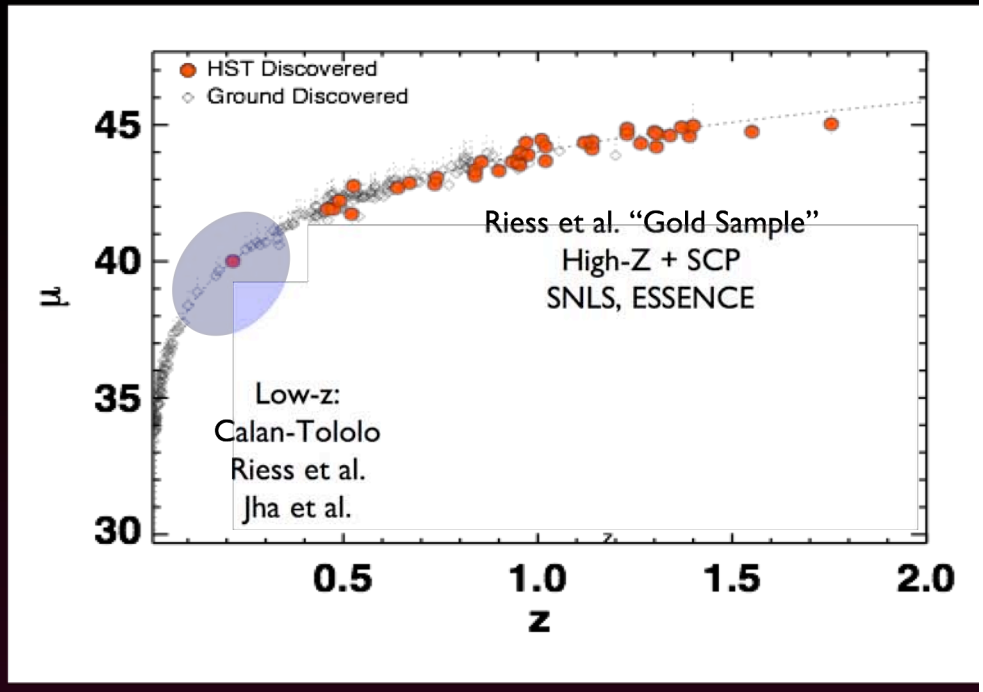
- =>confirm concordance cosmology (or not!)
- =>create a large, uniform sample of well-studied SNIa



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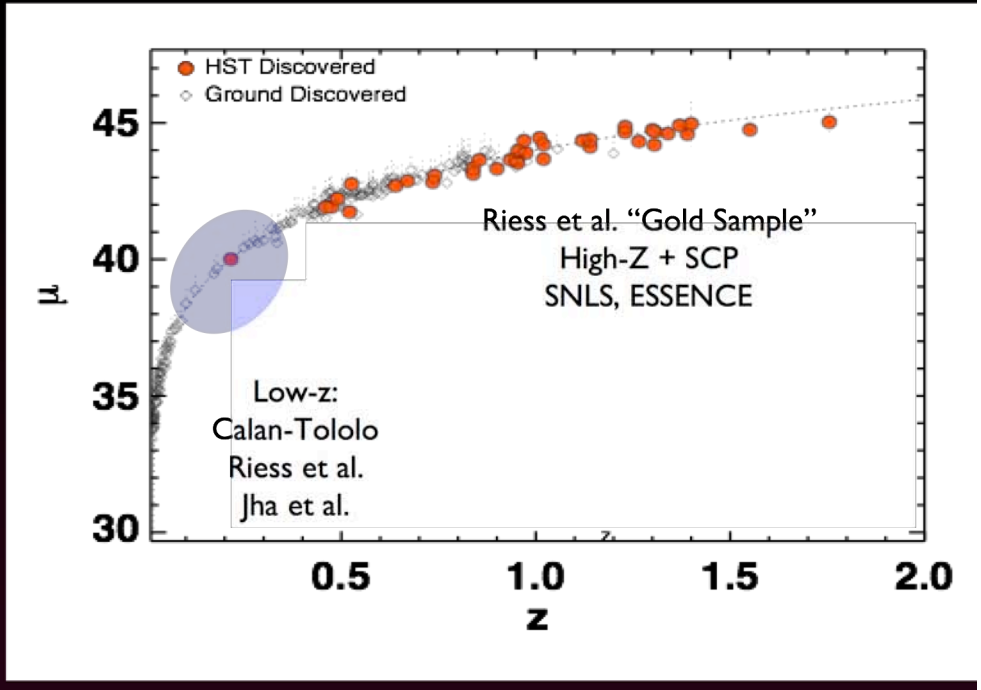
  - =>need to search hundreds of deg^2



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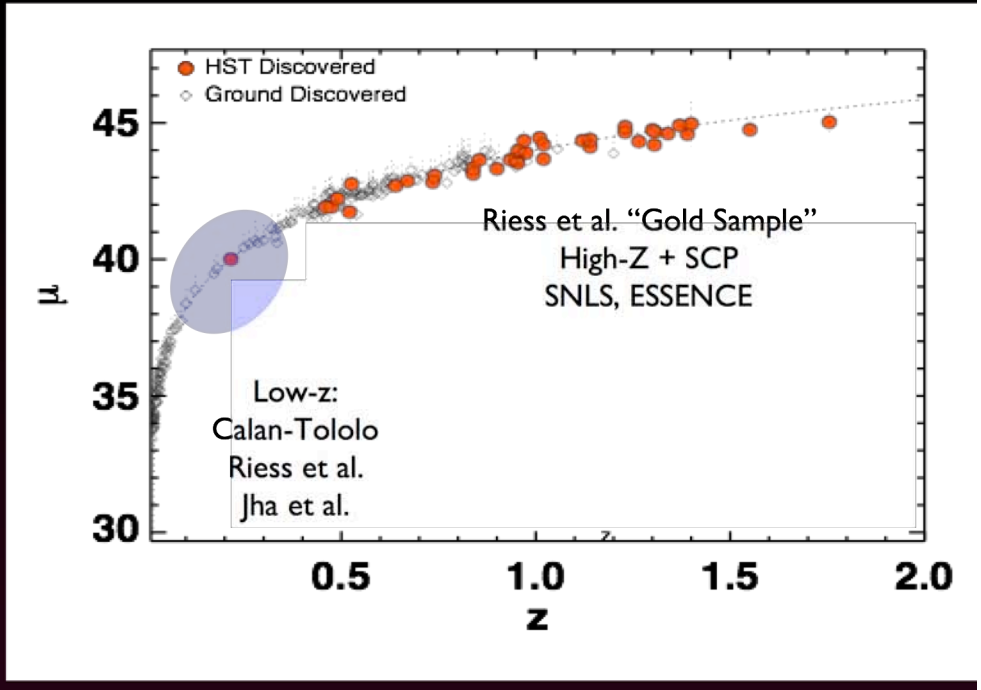
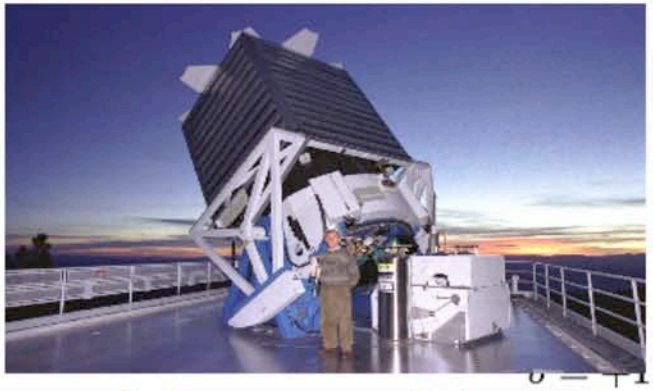


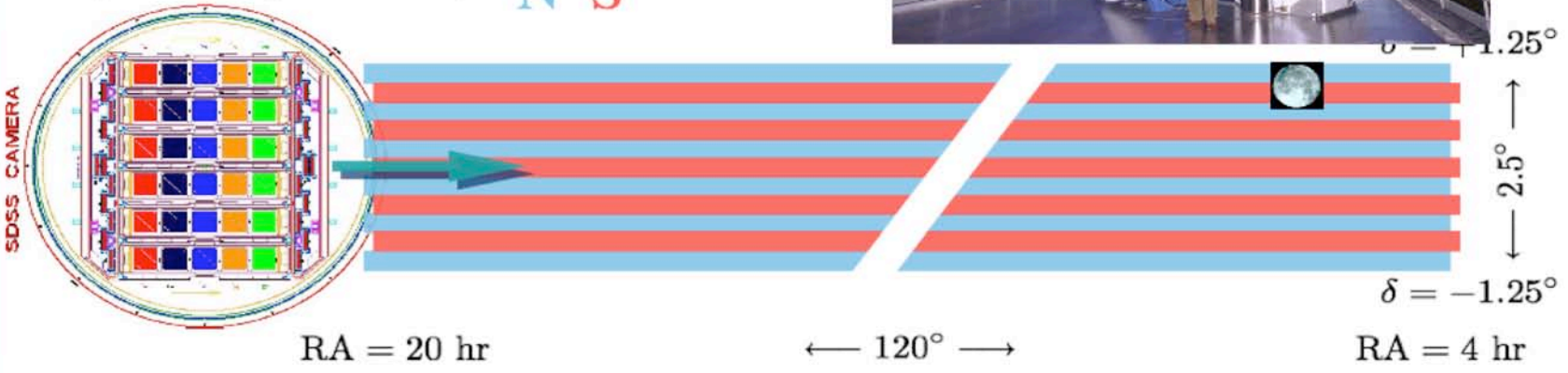
→ SDSS 2.5m telescope + imager

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

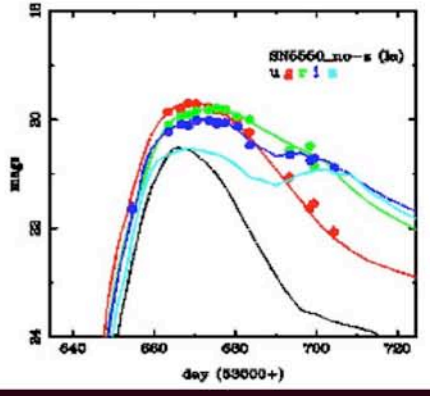
SNe Survey

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

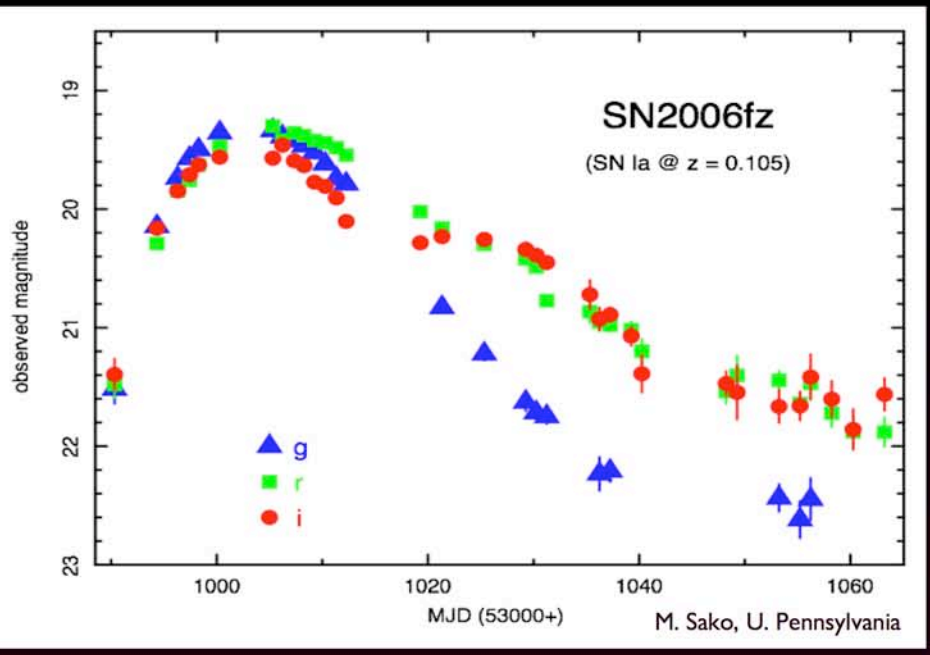


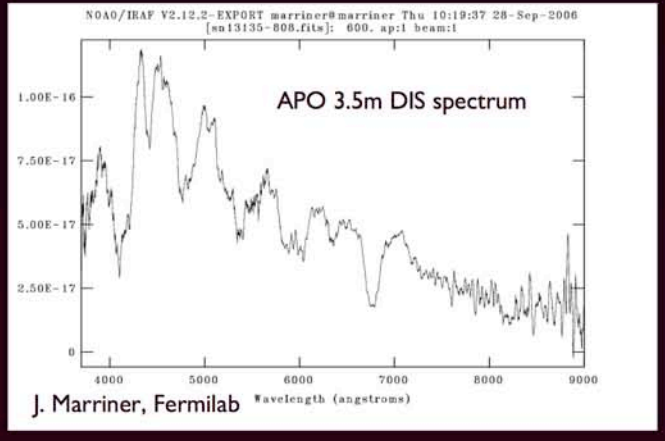
Details for Candidate SN13135

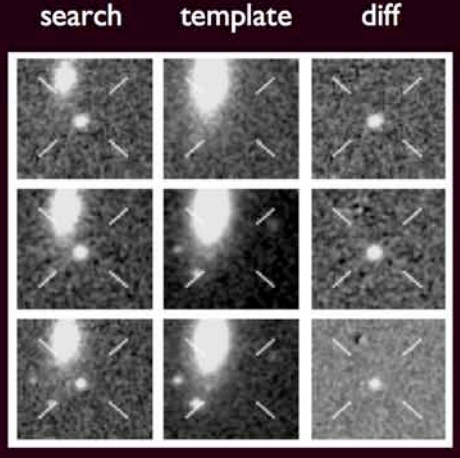
Initial RA (deg)	4.172303
Initial Dec (deg)	-0.424537
Averaged RA (deg)	4.172286
Averaged Dec (deg)	-0.424540
Averaged RA (hh:mm:ss)	0:16:41.35
Averaged Dec (dd:mm:ss)	-0:25:28.3
Redshift	0.1050
IUAC Name	2006fz
Observability	0.000
Time weight	0.000
Crowding weight	-1.000
Dust weight	-1.000
Entry date/time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

Fits

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



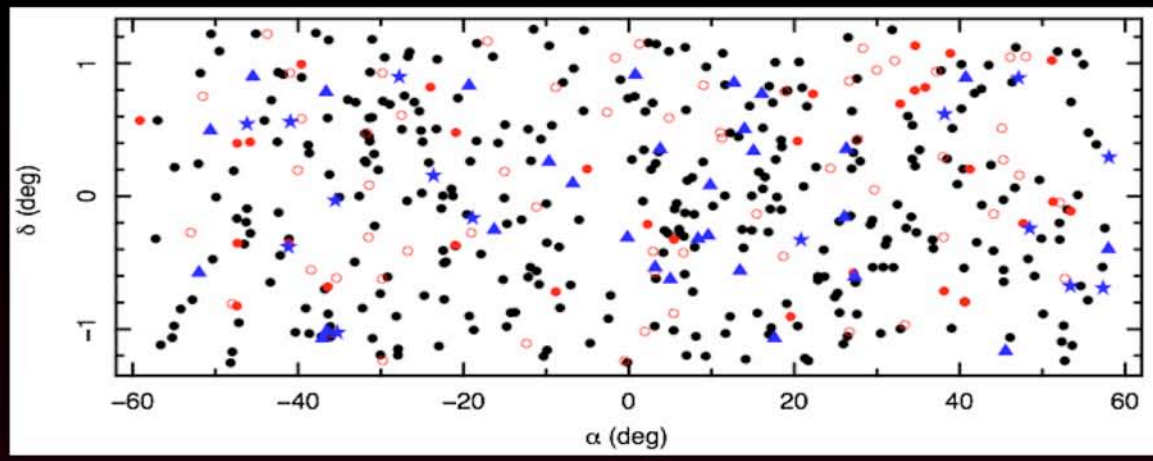




SN 2006fz
SN Ia z = 0.105

Bassett et al. (2007), CBET 627

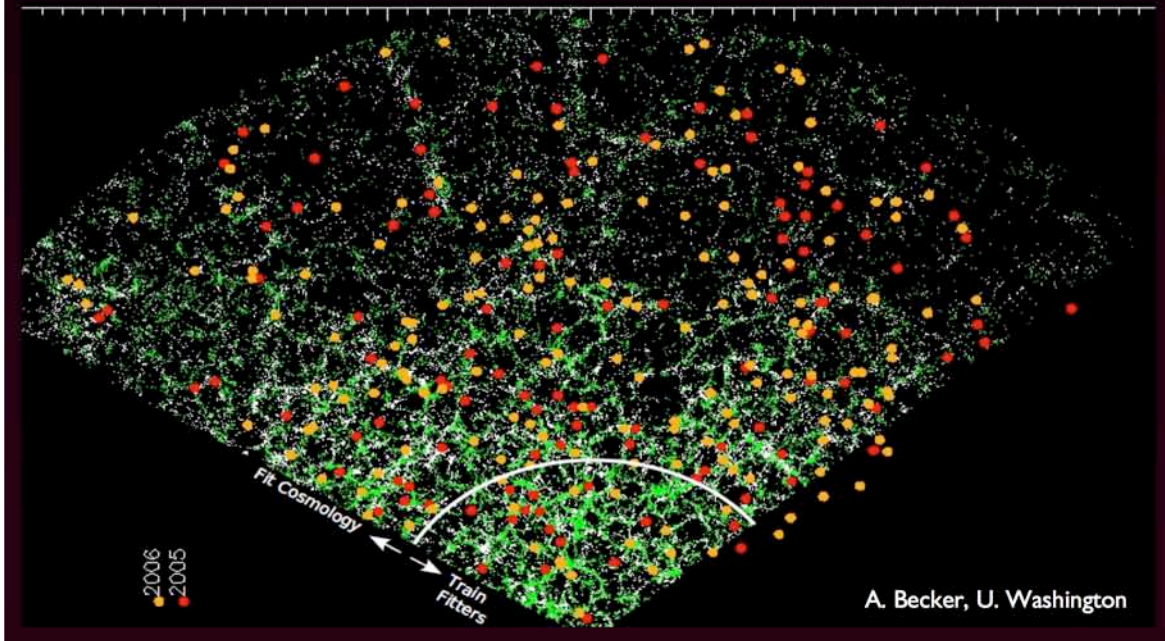
continual web page updates
follow-up is encouraged!

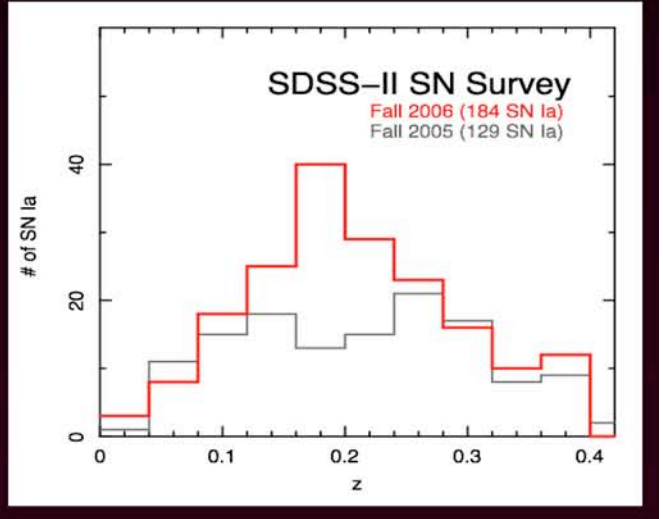


452 supernovae

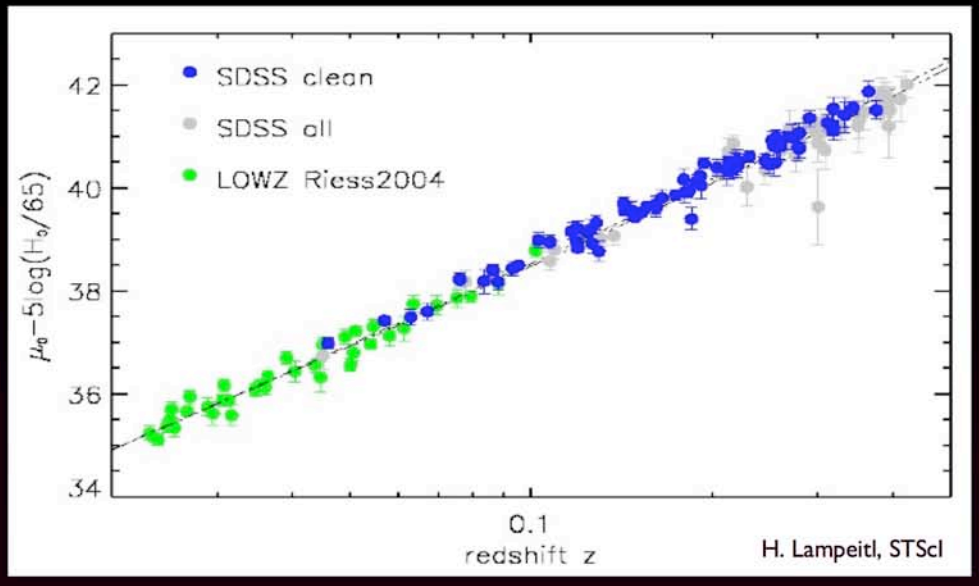
spectroscopic SN Ia (313)
probable SN Ia
core-collapse SN

M. Sako, U. Pennsylvania



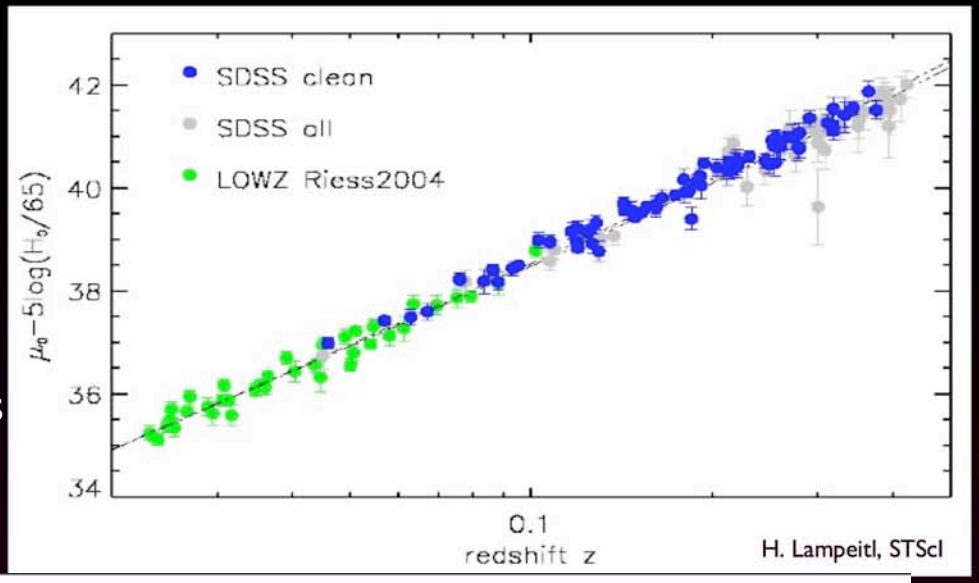


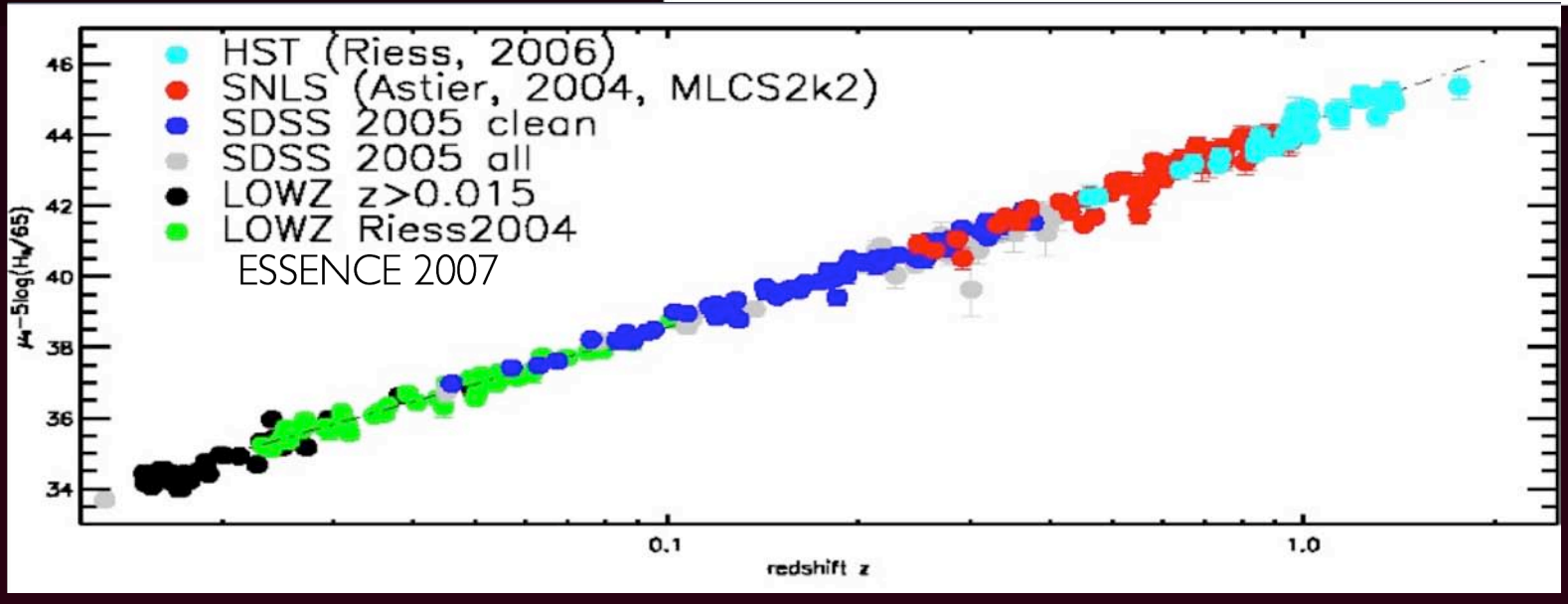
SDSS SN Hubble diagram
from fall 2005 data
(129 SN Ia in all, 74 "clean")
>300 total for 2005+06



SDSS SN Hubble diagram
from fall 2005 data
(129 SN Ia in all, 74 "clean")
>300 total for 2005+06

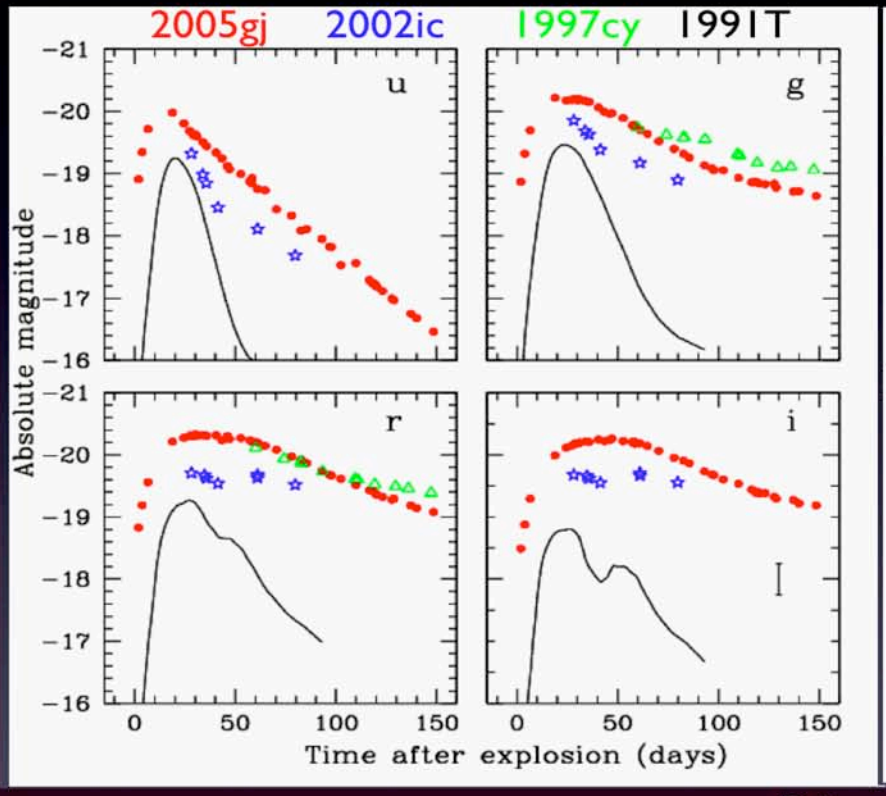
for the first time we have a continuous expansion history measured from SN to z > 1

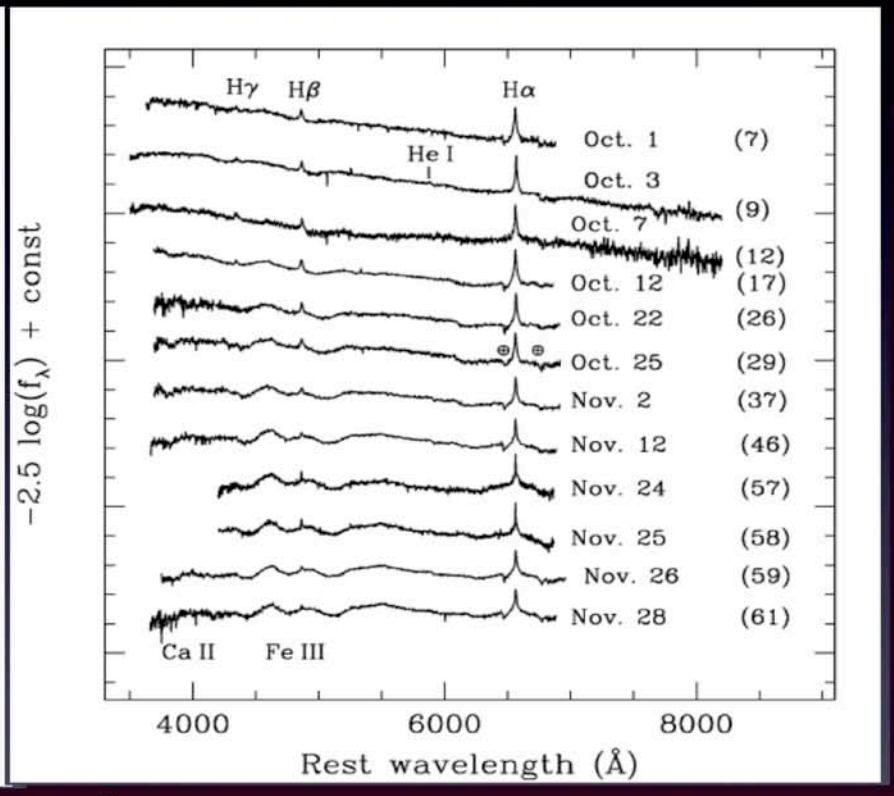




SDSS Finds Unusual Events:

SN 2005gj is an example. SN Ia (?) in a dense circumstellar environment.
Brighter than 2002ic and smooth decline (SDSS+CSP have a great light curve!)
Interaction from the start so mistaken for a IIn at first.

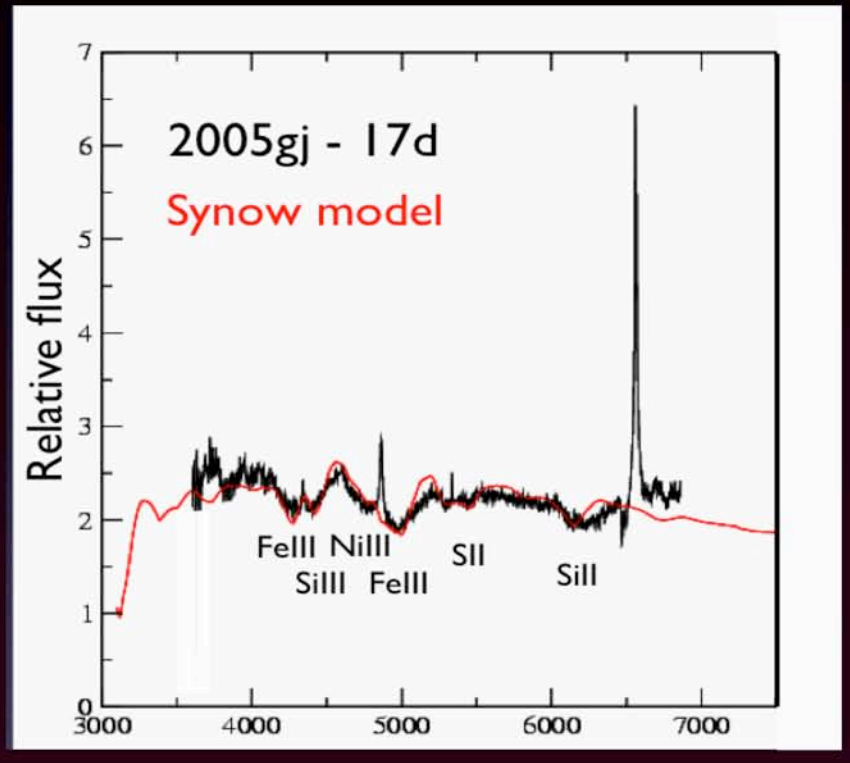




Prieto et al.

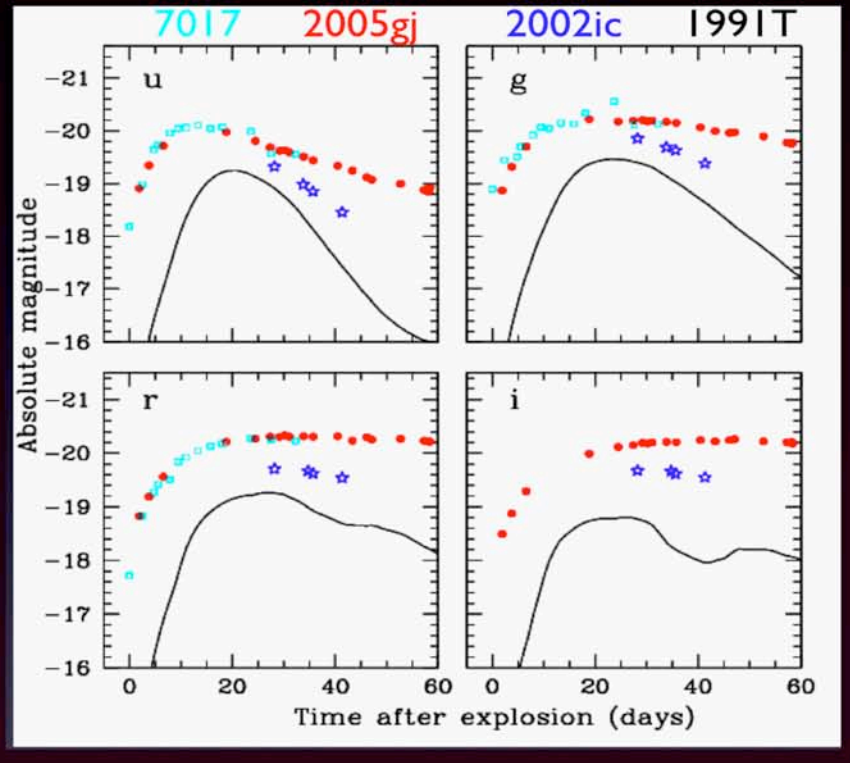
SN 2006gj Looks Like a Type Ia

Very good spectral fit to 91T + continuum.
See Si II and S II characteristic of Ia.



Parent et al.

More out there: SN 7017
Clone of 06gj at z=0.27

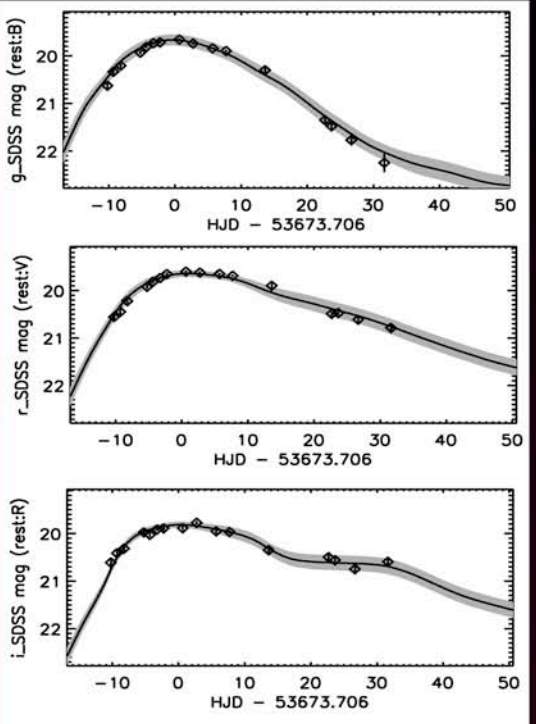


SDSS-II

MLCS2k2 light-curve fits

Jha, Riess, & Kirshner (2007, ApJ, in press)

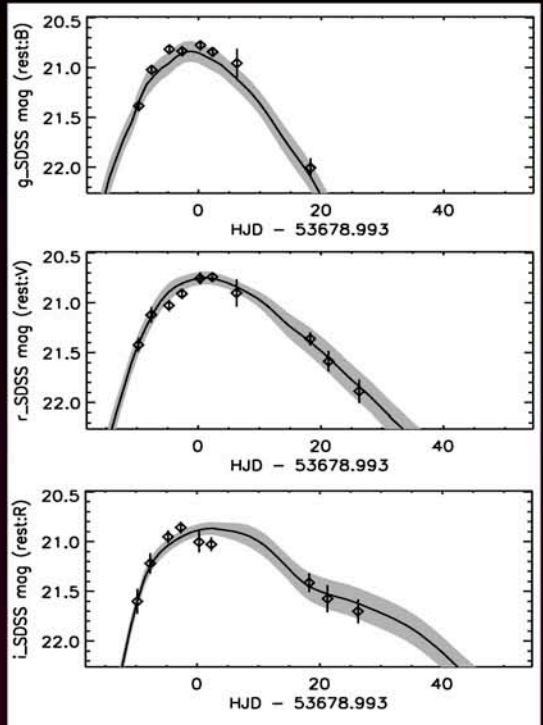
SN 2005ij z = 0.124



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

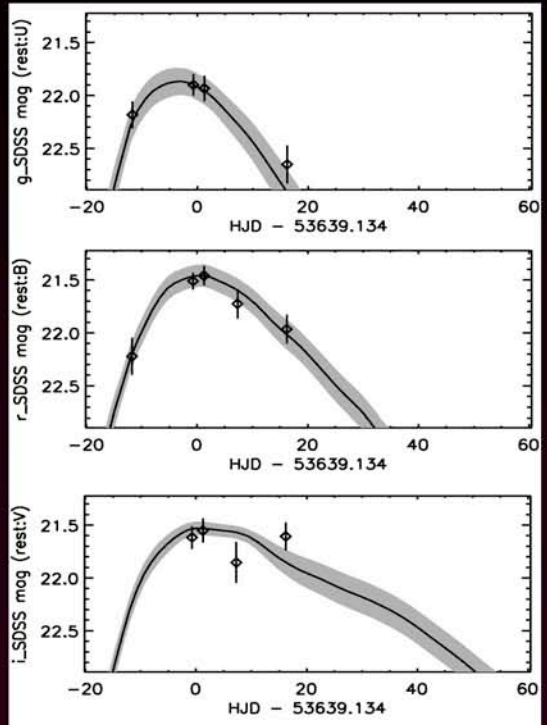
SN 2005ji z = 0.214



sn07473_SMP01_gri

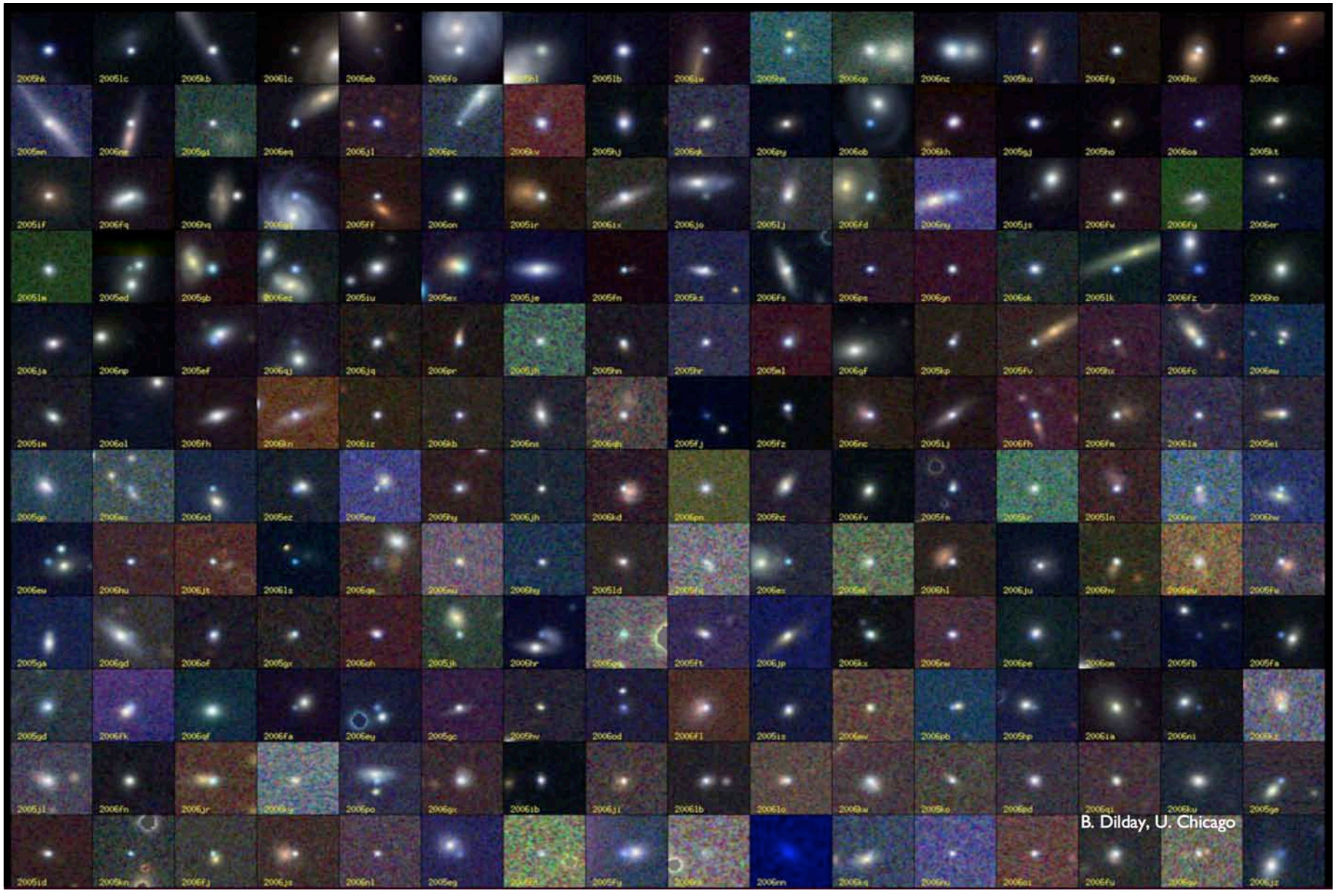
t_0 = 53678.993 R_V = 3.10
Δ = −0.02 A_V = 0.09
$\mu_0 + 5 \log (H_0/65)$ = 40.50
$E(B-V)_{MW}$ = 0.02 z = 0.2140
χ^2/ν = 15.52/23

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


B. Dilday, U. Chicago

SDSS Supernova/Host Characteristics:

2005: >100 well-observed supernovae, uniform discovery & analysis

SDSS is "Democratic" - find SN in all types of galaxies

- Decline Rate (luminosity)
- Extinction Distribution

- Host Galaxy Luminosity (number of stars)
- Host Galaxy Color (Star Formation Rate)

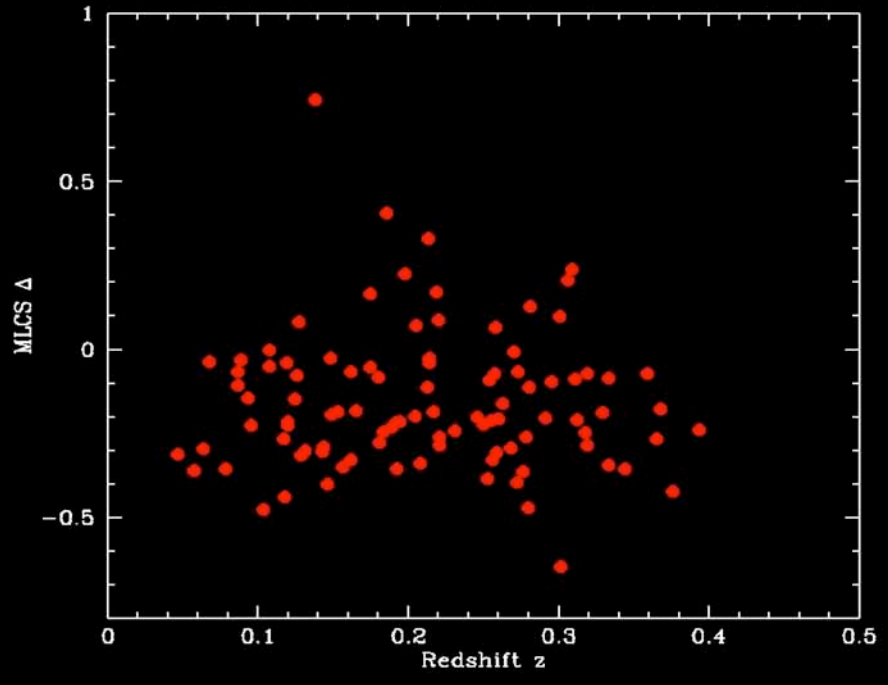
- Hubble Residuals
  - Galactocentric Distance
  - Extinction
  - Host SFR

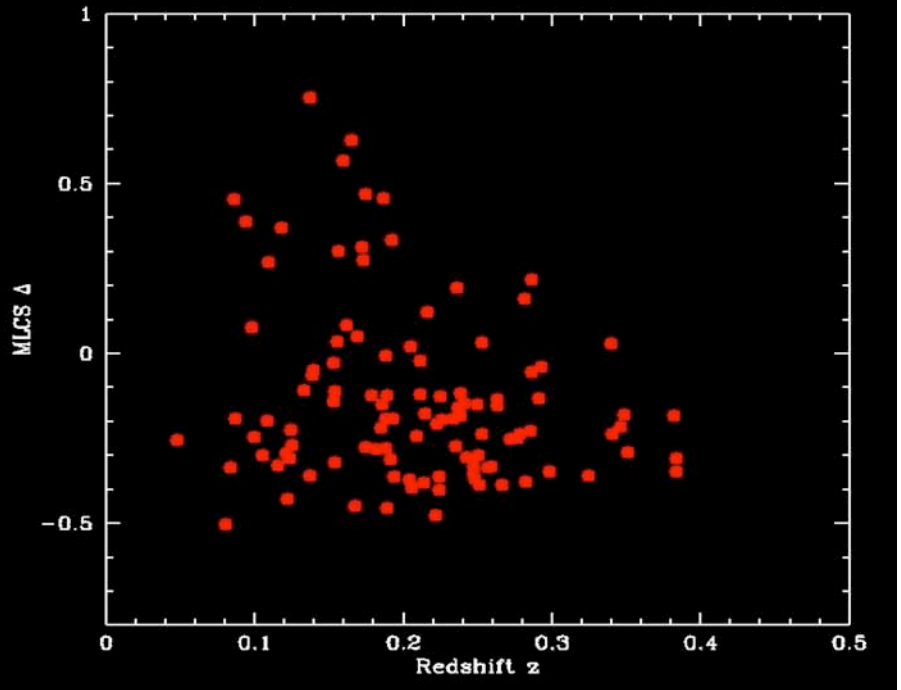
- Relative SN Rate by Host SFR

Luminosity vs Redshift: MLCS Δ parameter

~100 SDSS supernovae Ia in 2005

Which is real data and which is the simulation?





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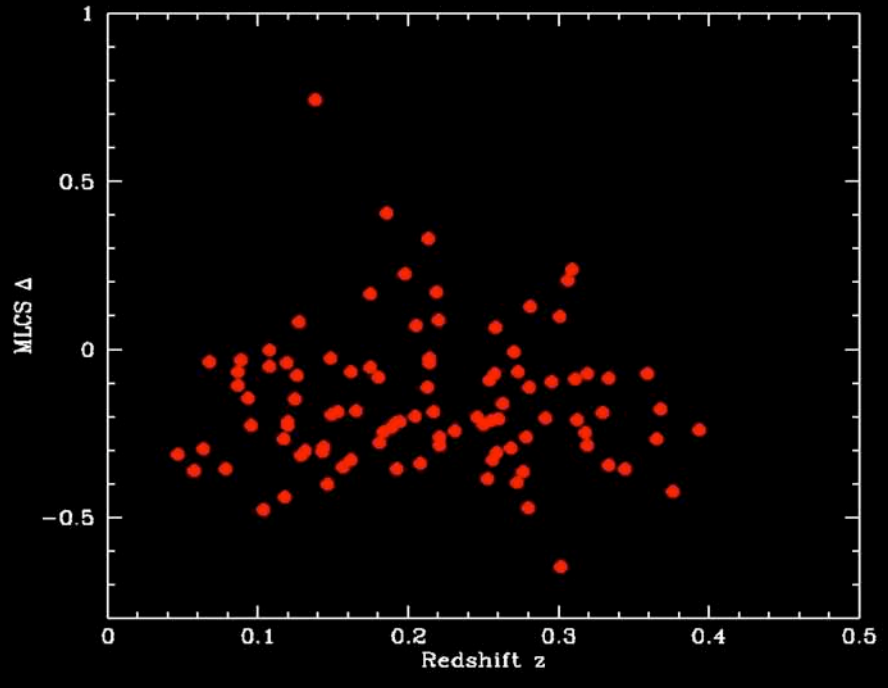
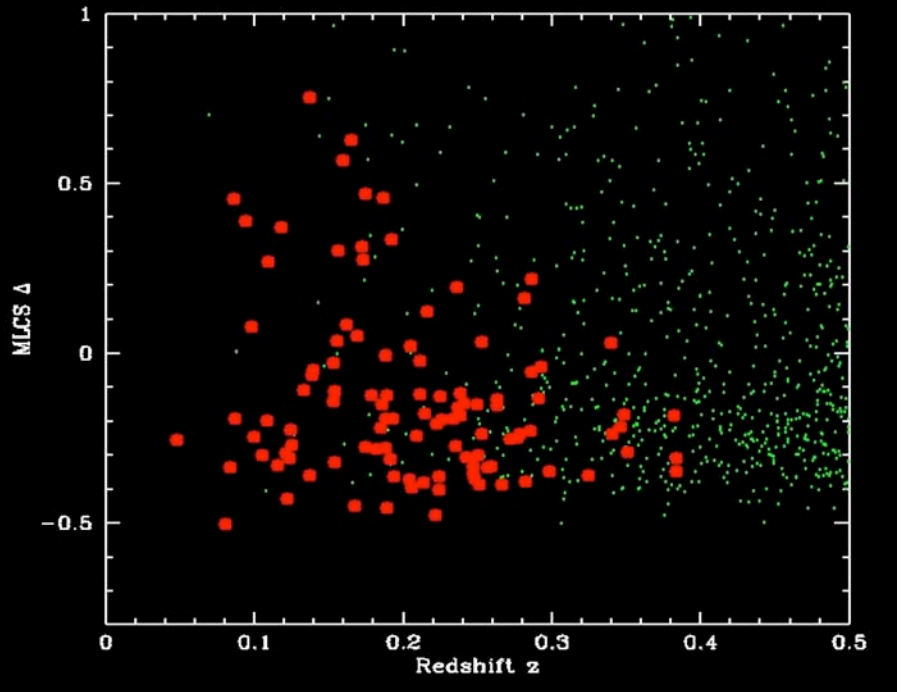




Fewer fast decliners than expected - Over represented in Low-z sample?
Selected against in SDSS color cut?

Host Extinction vs Galaxy Type:

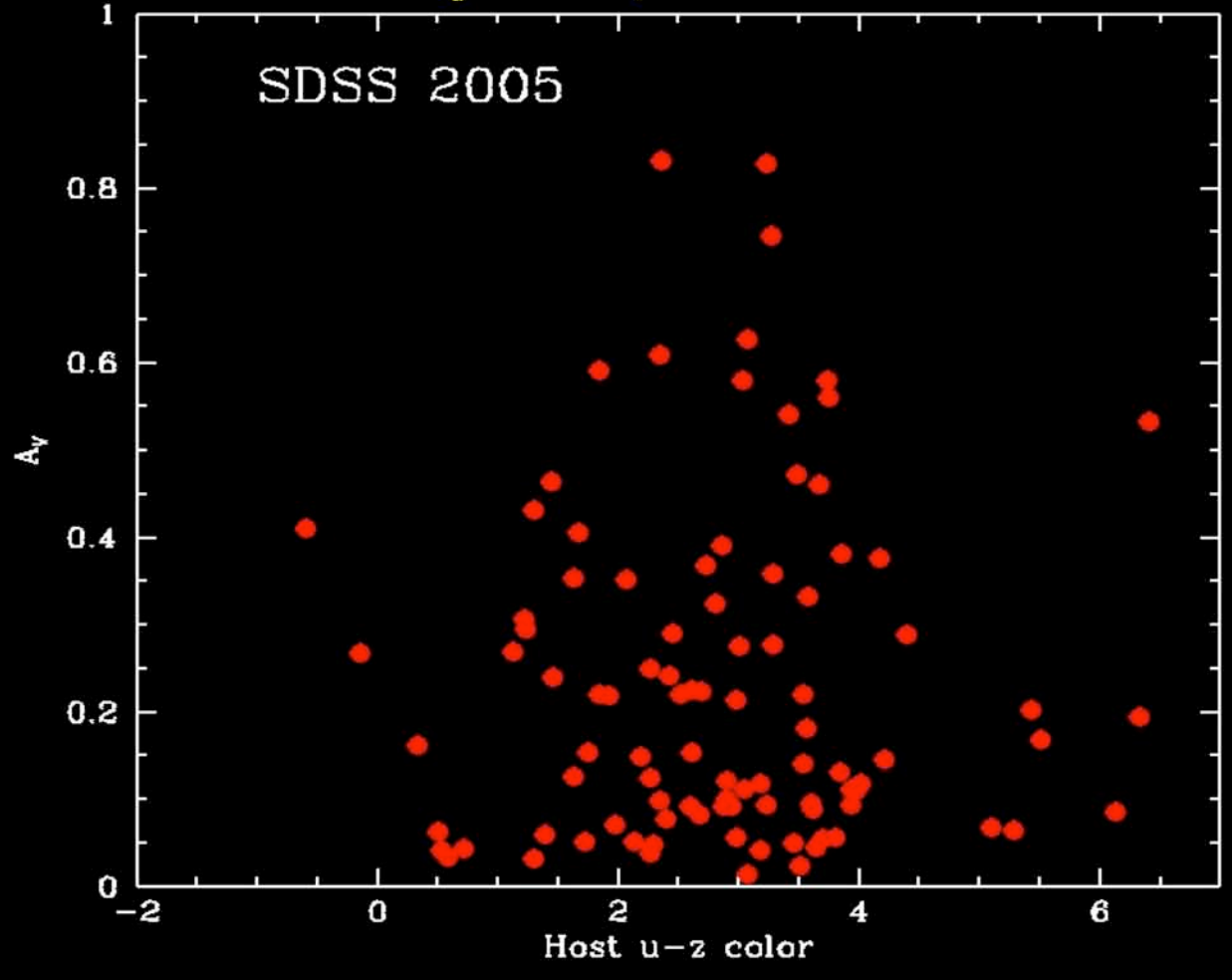
SDSS u is a good measure of the SFR.

SDSS z is a good measure of the number of stars in the galaxy

u-z is then the SFR/star = the specific SFR

u-z>4 may show lower dust extinction

SFR ~ $L_u^{1.19}$ Hopkins et al. 2004

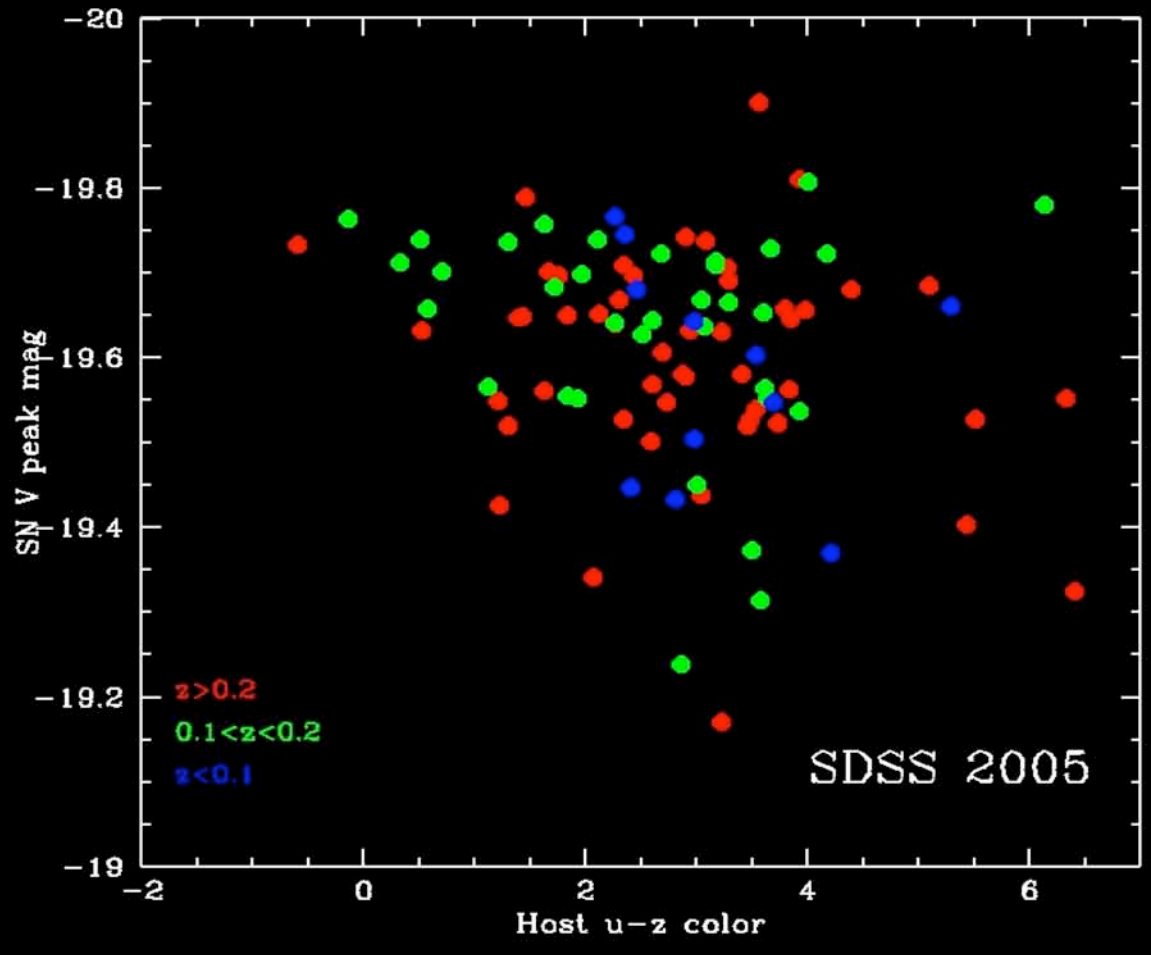


SN Luminosity vs Specific SFR:

Bright AND faint SNIa happen in galaxies with SSFR u-z >2

But only bright SNIa occur in u-z <1

Prompt SNIa have slow light curves - are brighter - make more ^{56}Ni



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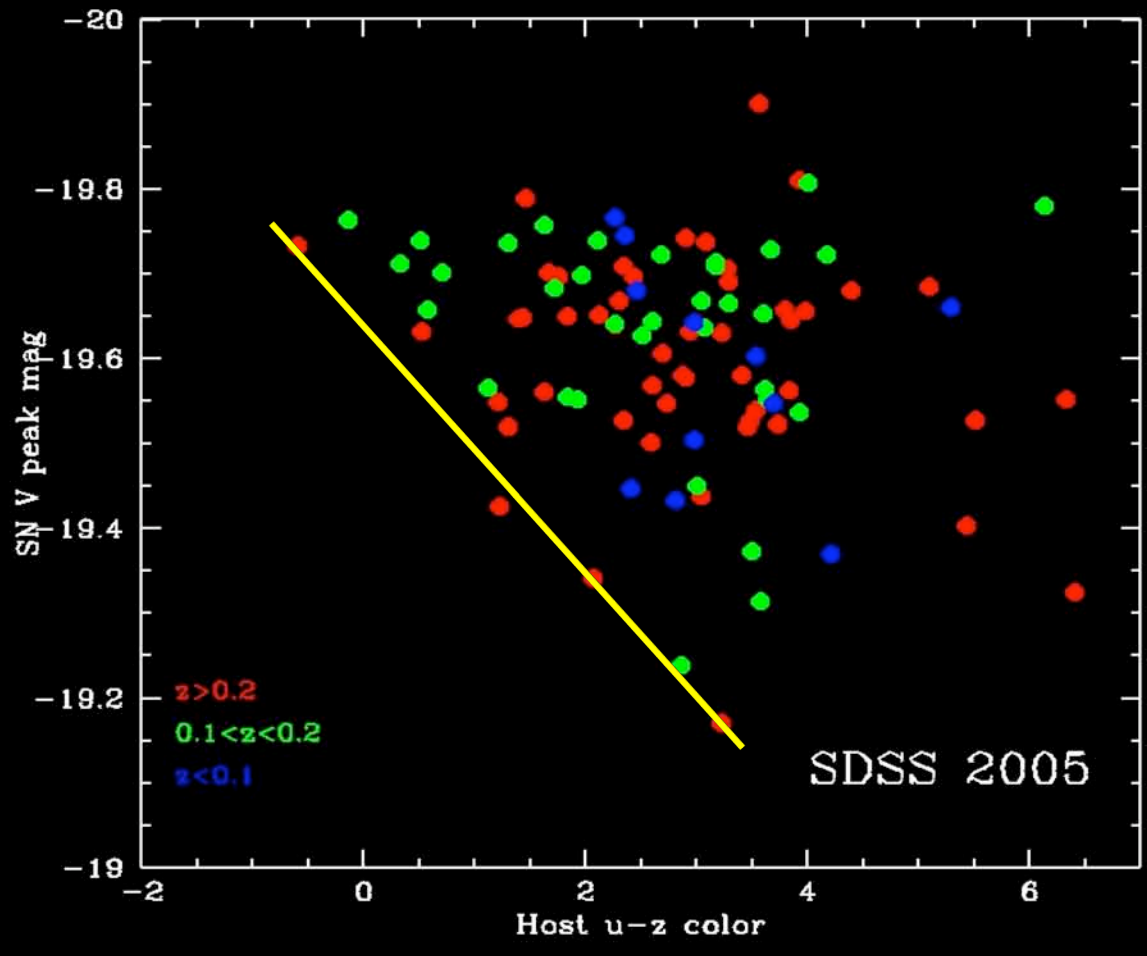
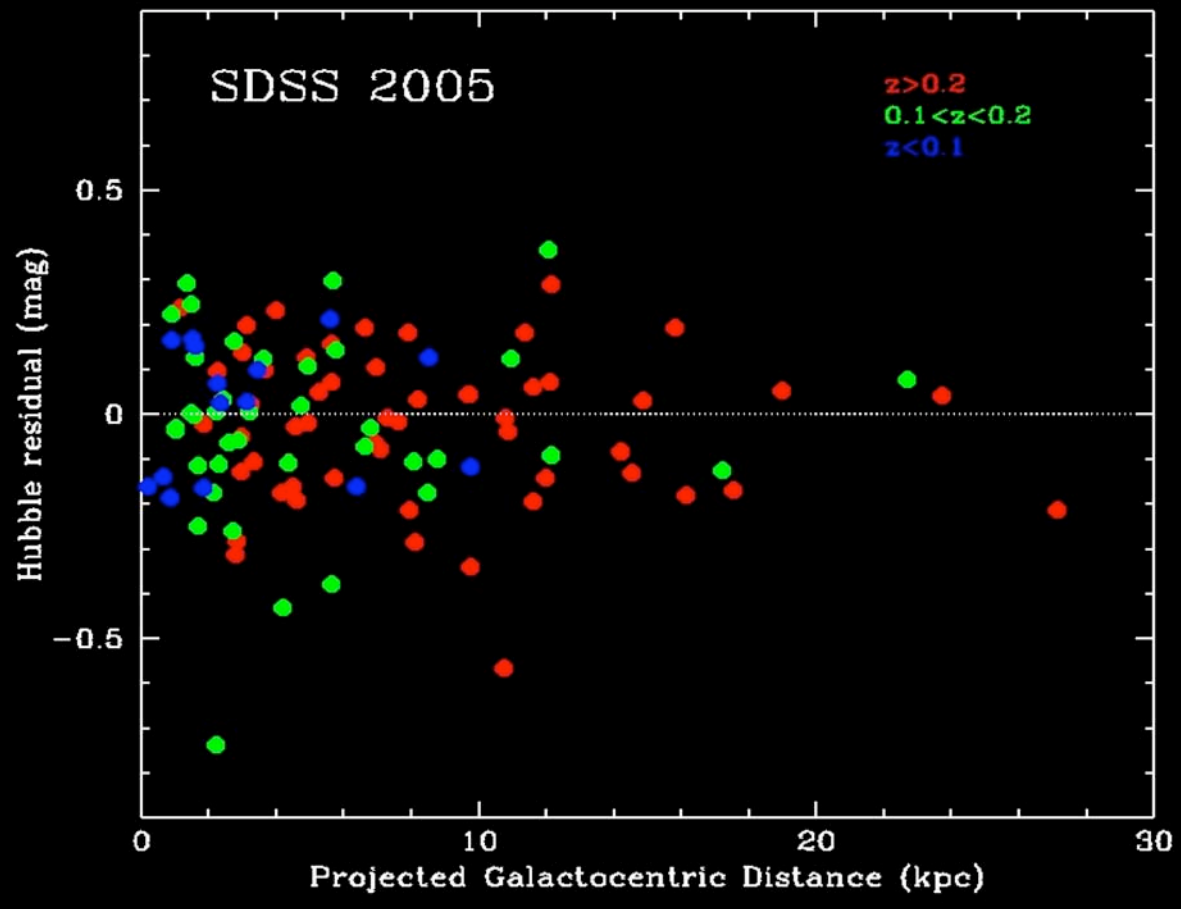


Hubble Residuals:

~0.20 mag dispersion may be due to a "third" parameter (width and color are the first two)

Projected Galacto-centric distance - expect high dispersion near center.



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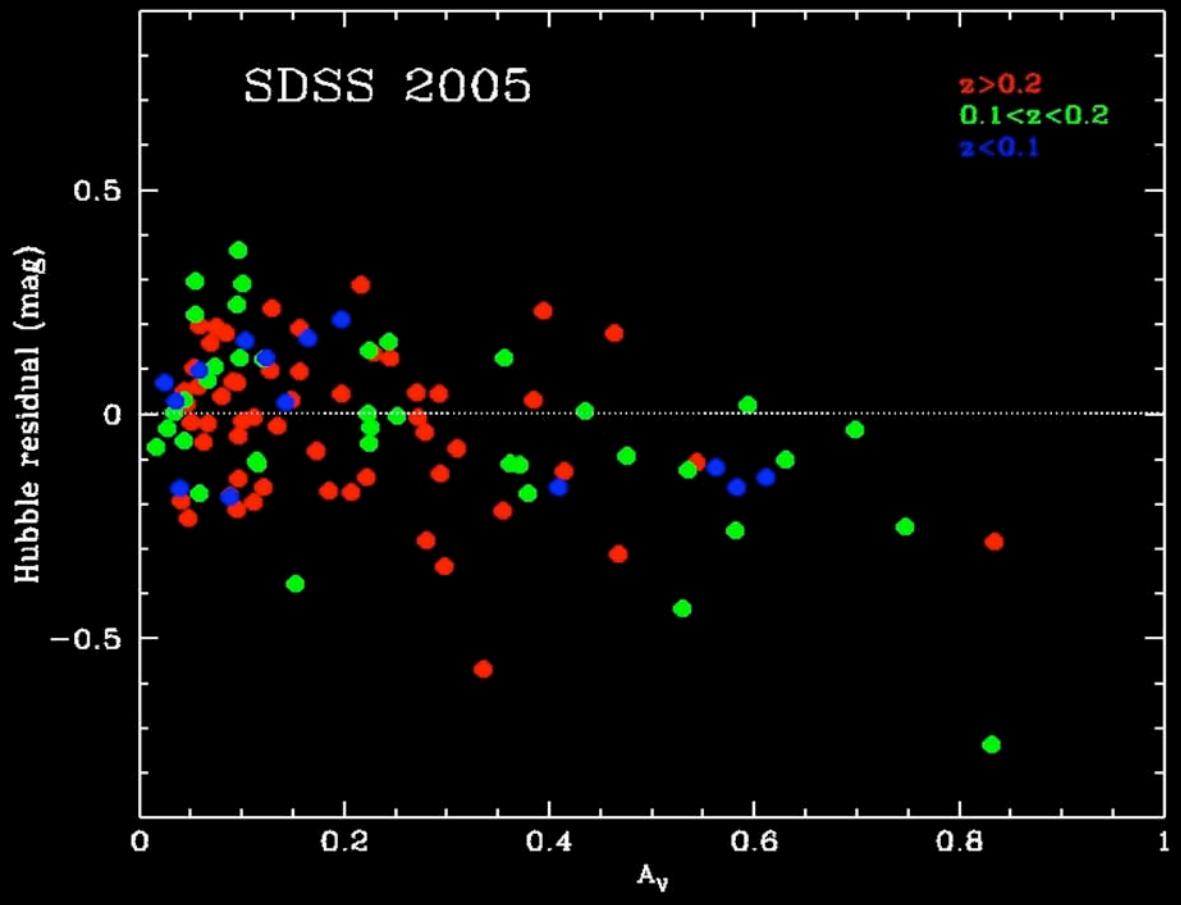
Extinction - clear correlation due to Baysian prior in MLCS



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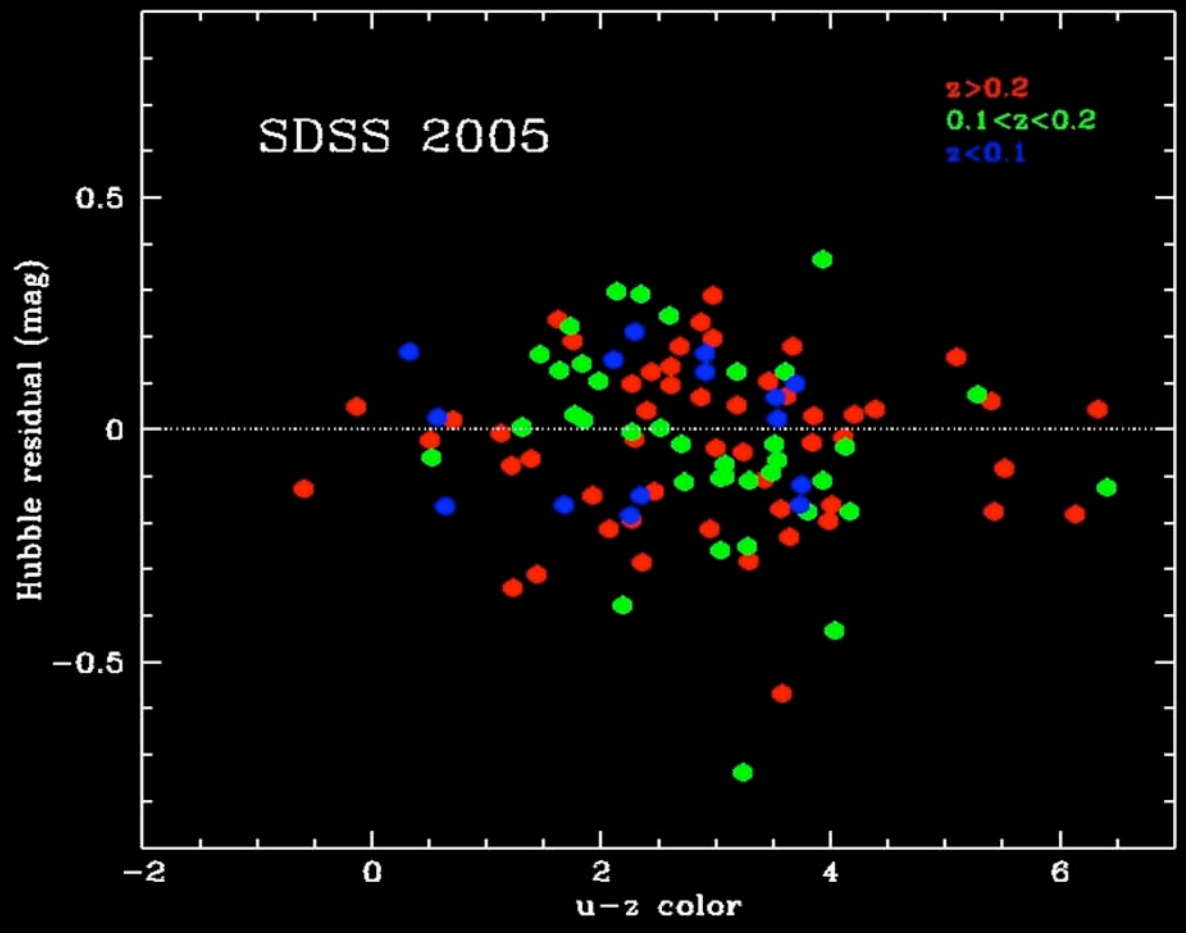


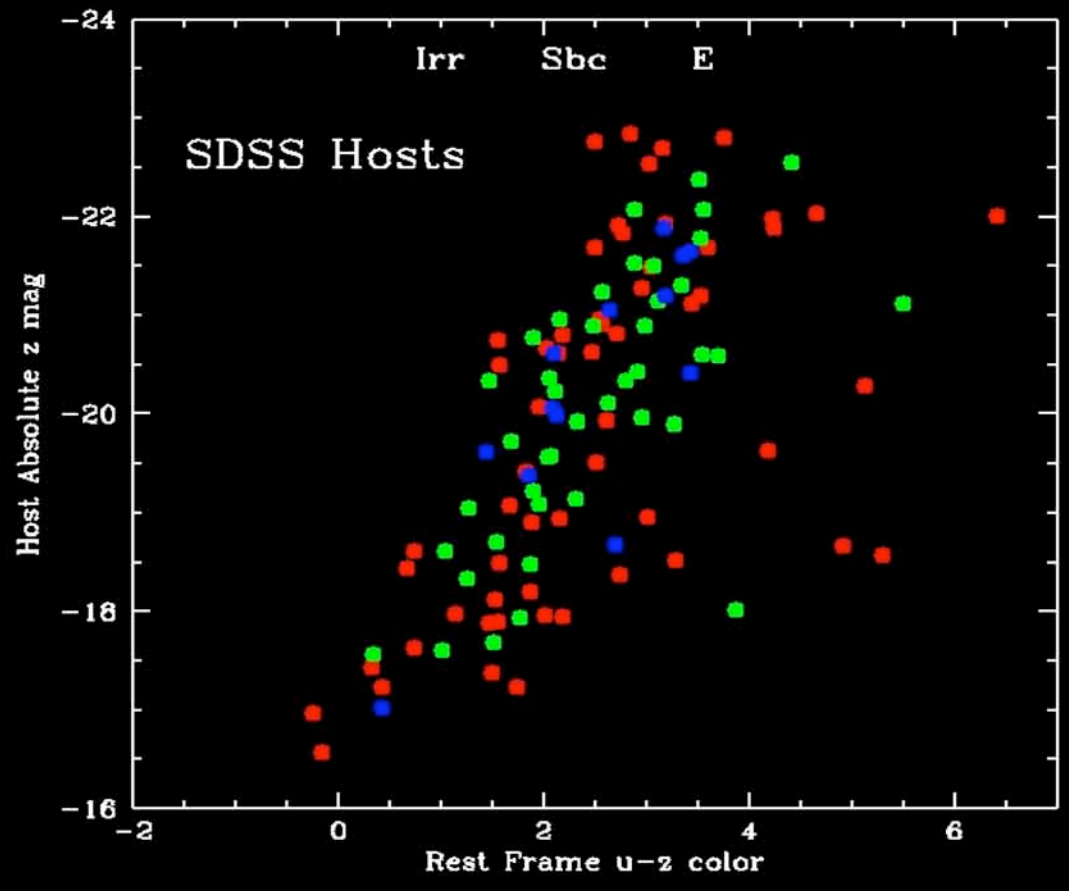
Specific SFR - no correlation. So even in extreme SSFR hosts MLCS works.

Host Color-Magnitude Diagram:

Number of stars in the host versus Specific Star Formation Rate.

Highest specific SFR hosts are also the smallest hosts.

How do these hosts compare with field galaxies in the SDSS?



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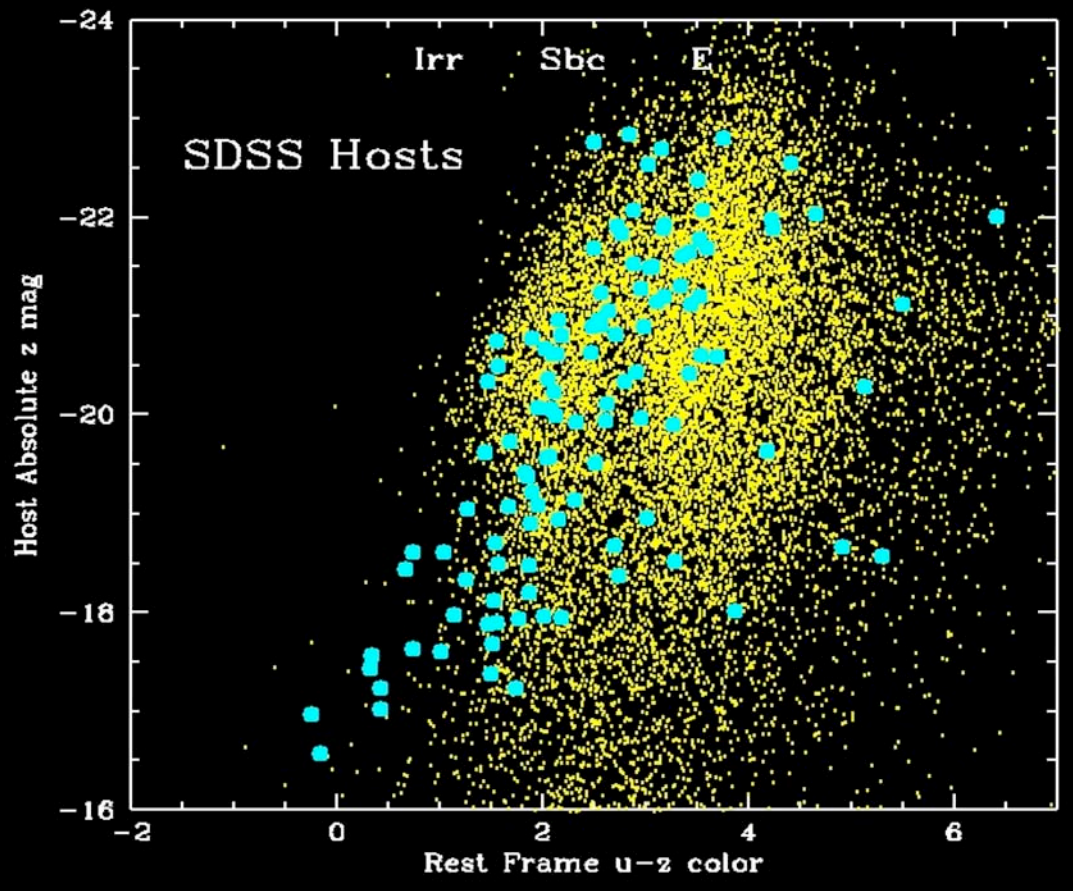
How do these hosts compare with field galaxies in the SDSS?

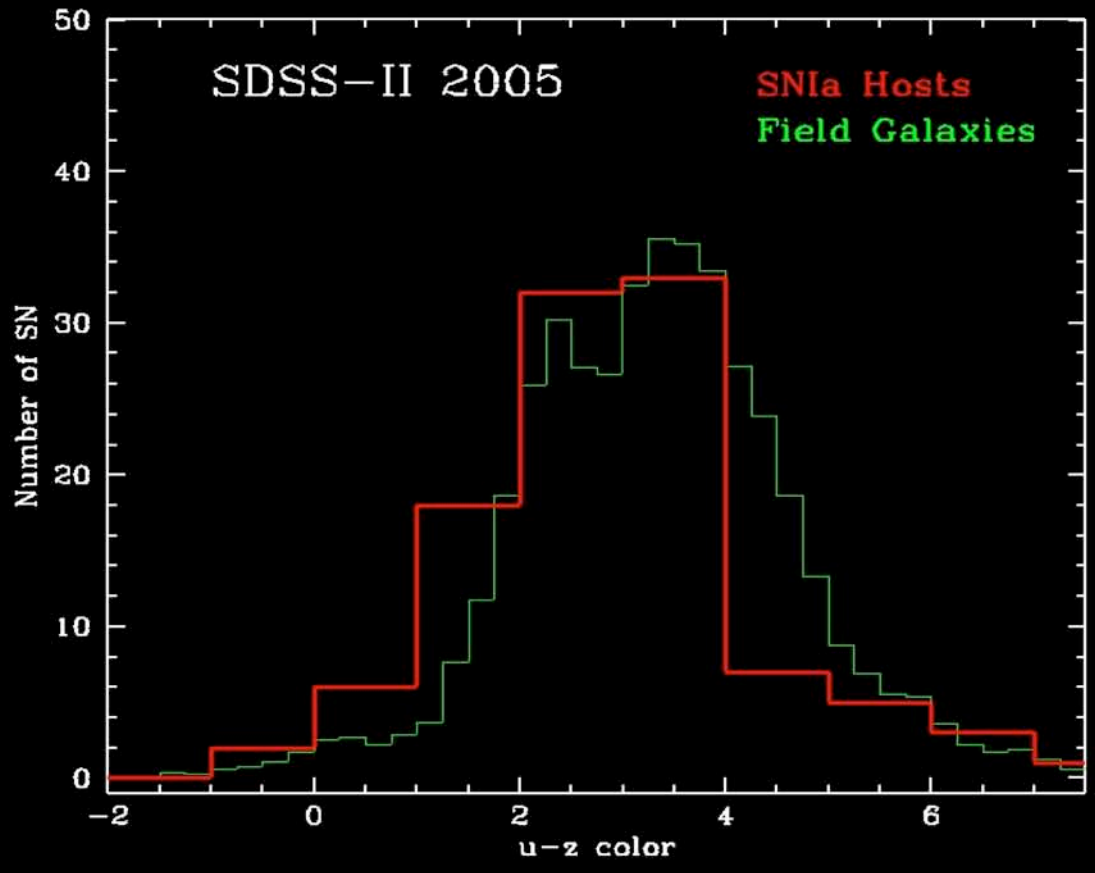
15000 SDSS galaxies out to photo-z <0.35



SNIa Host versus Galaxy/Stellar Frequency:

SNIa host frequency versus field galaxy frequency => SNIa rate per galaxy.

For u-z <2, the SNIa rate goes like the number of galaxies.



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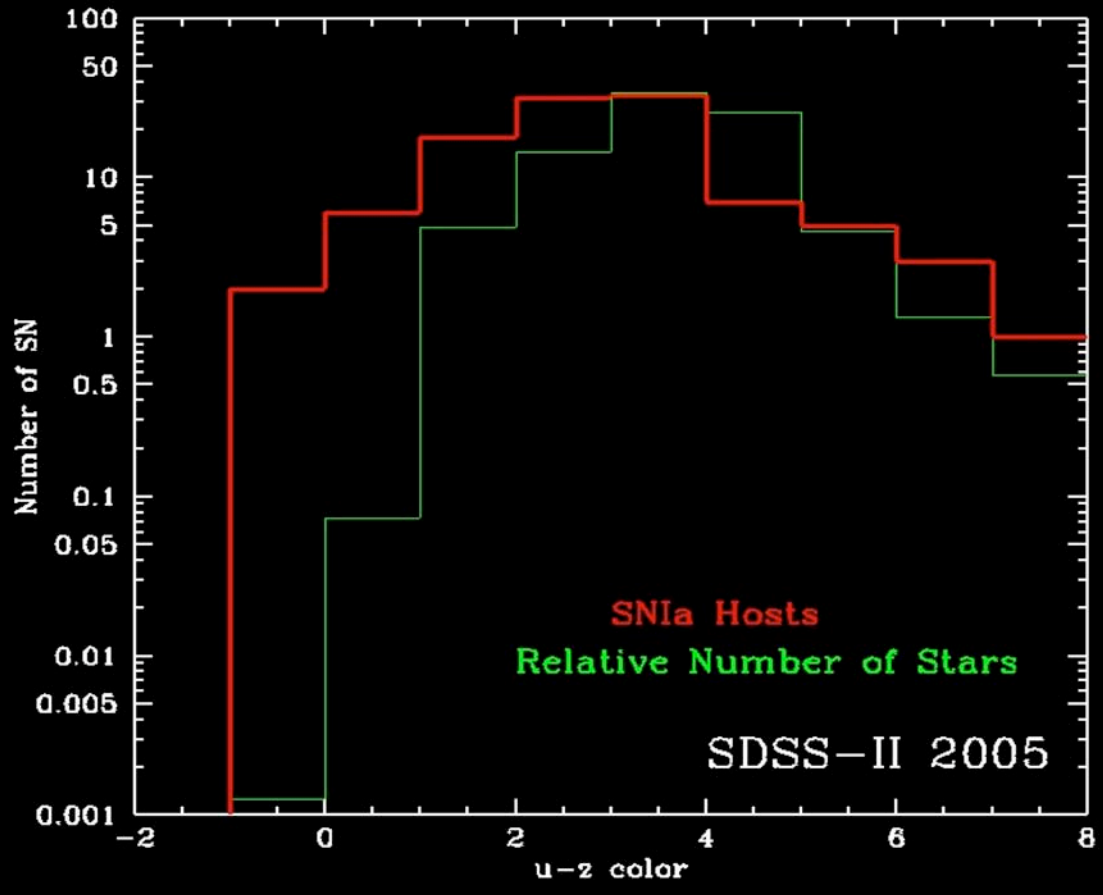
Convert the relative number of galaxies to the relative number of stars by summing over the z absolute magnitude

For u-z >4, the SNIa rate goes like the number of stars.

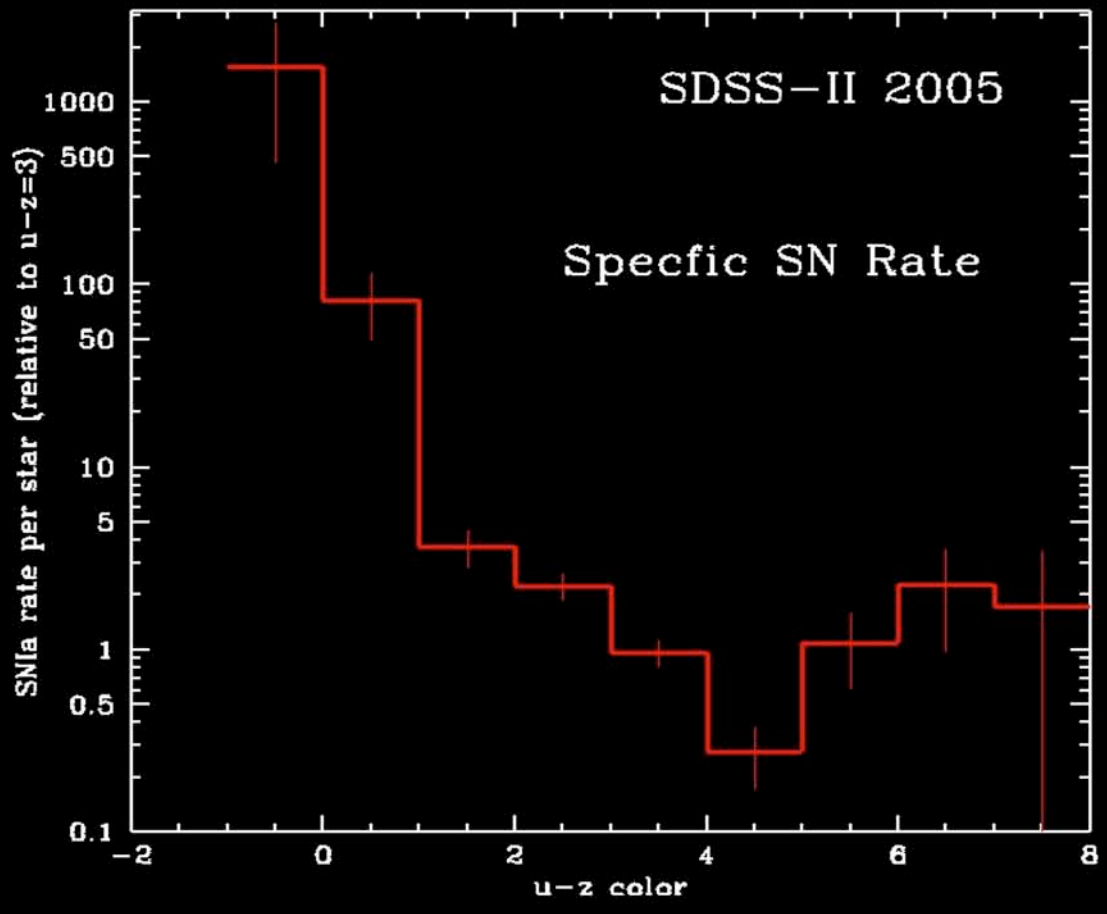


Specific SNIa Rate versus Specific SFR:

Divide the number of SNIa detected divided by the number of stars per SSFR bin.

Normalize to the rate at the u-z =3 bin.

Log (SNIa rate/star) goes as 0.9(u-z) for blue galaxies and is flat for red galaxies



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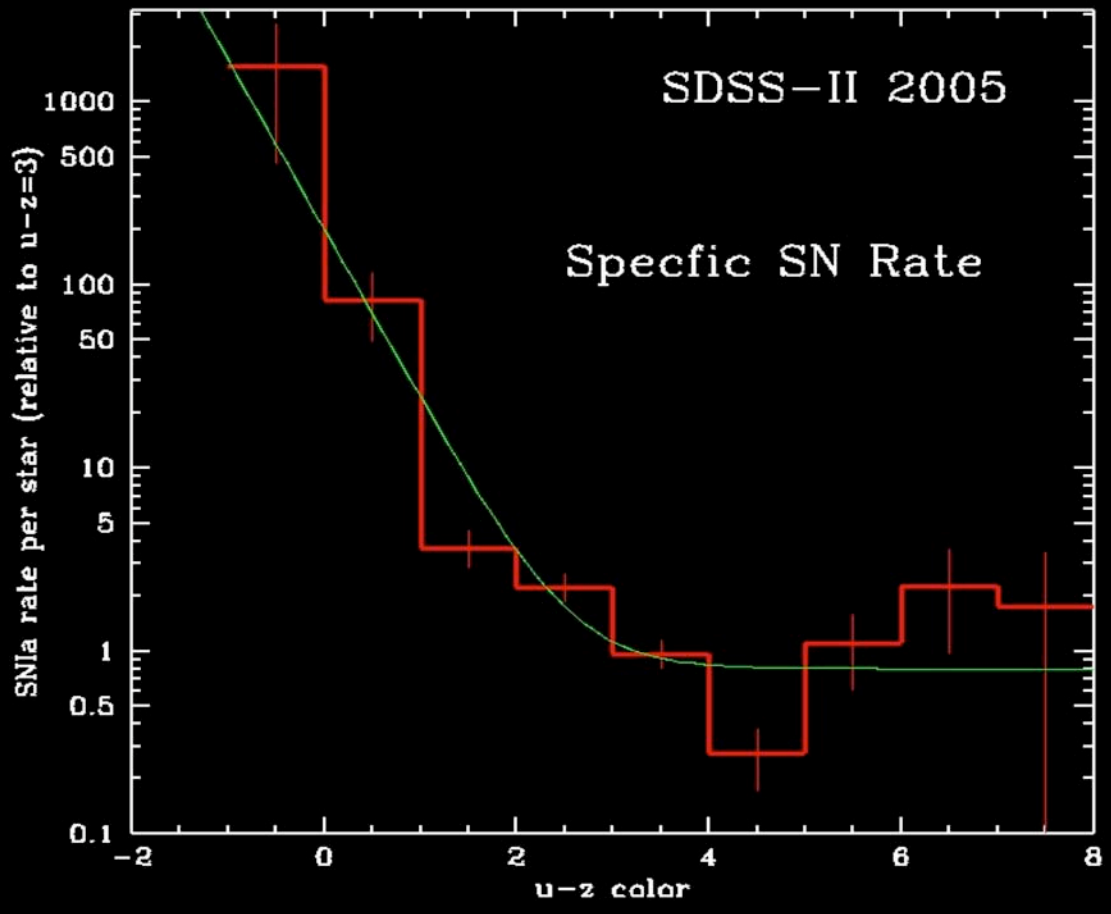
SN rate/star = $0.8+10^{-0.9(u-z)+2.3}$

See:
Mannucci et al. 2006
Sullivan et al. 2006
Scannapieco & Bildsen 2006



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- SDSS missing very fast decliners at z~0.1 to 0.2, or they aren't there
- SDSS finds only luminous SNIa in small, high SFR hosts: prompt channel makes lots of ^{56}Ni
- No correlation between Hubble residuals and SSFR: good for cosmology.
- Confirm the very high specific SNIa rate in high SSFR galaxies. See the that the rate goes like the number of stars for red galaxies.

B. Dilday, U. Chicago

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