SDSS-SN Hubble Diagram and Cosmology

The first season data
(2005)

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for the SDSS-SN Collaboration

Luminosity Distance & Cosmology

$$d_L = \sqrt{\frac{F}{4\pi L}}$$

$$d_L = c(1+z)\frac{1}{\sqrt{1-\Omega_0}H_0} S\left[\sqrt{1-\Omega_0}H_0 \int_0^z \frac{dz}{H(z)}\right]$$

$$S(x) = \sin(x) \ \forall \ \Omega_0 > 1$$
$$S(x) = x \ \forall \ \Omega_0 = 1$$
$$S(x) = \sinh(x) \ \forall \ \Omega_0 < 1$$

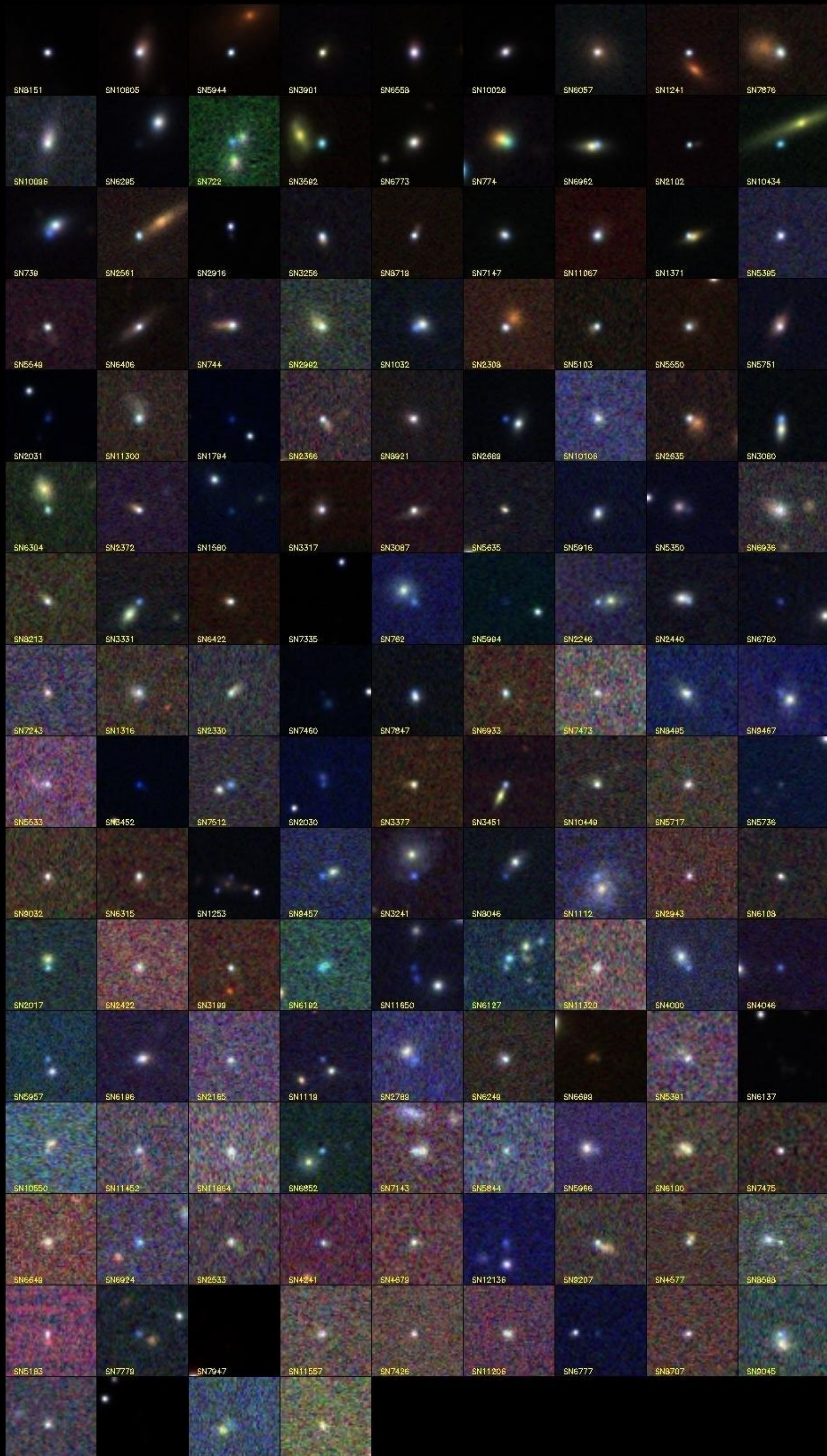
WMAP: $\Omega_0 = 1 \pm 0.04$

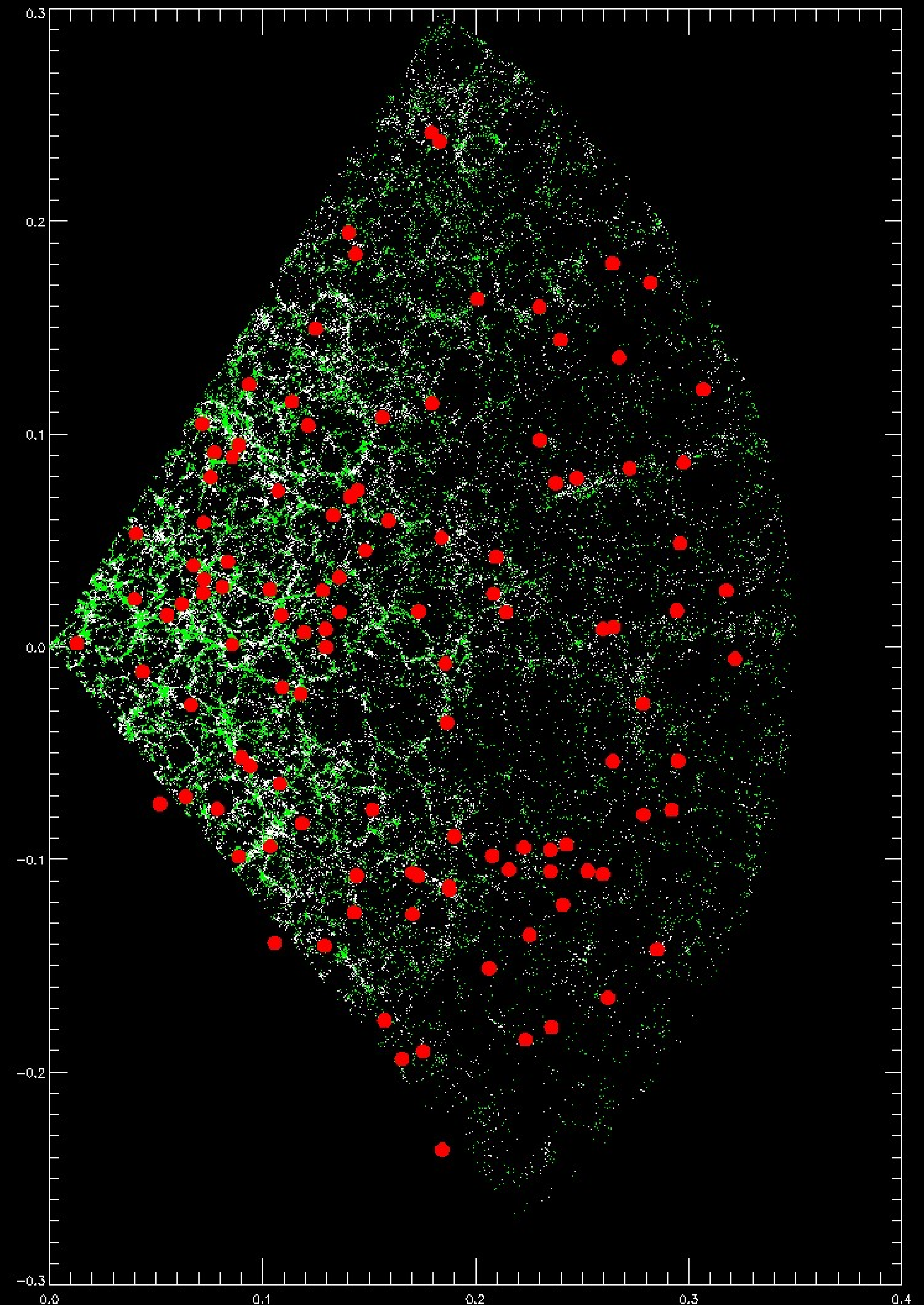
Friedmann Equation:

$$H^2(z) = H_0^2 \Sigma_x \left[\Omega_X \exp\left(3\int_0^z (1+w_x(u))\, d\ln(1+u)\right)\right]$$

Equation of state:

$$w_x = \frac{p_x}{\rho_x c^2} \quad w_\Lambda = -1 \quad w_{matter} = 0 \quad w_{radiation} = \frac{1}{3} \quad w_K = -\frac{1}{3}$$





0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
0.0
0.1
0.2
0.3
0.4

The Dataset / Selection Criteria

129 Type Ia SNe observed in 2005

- spectroscopic confirmed
- known redshift
- light curves in SDSS-(u,g,r,i,z)

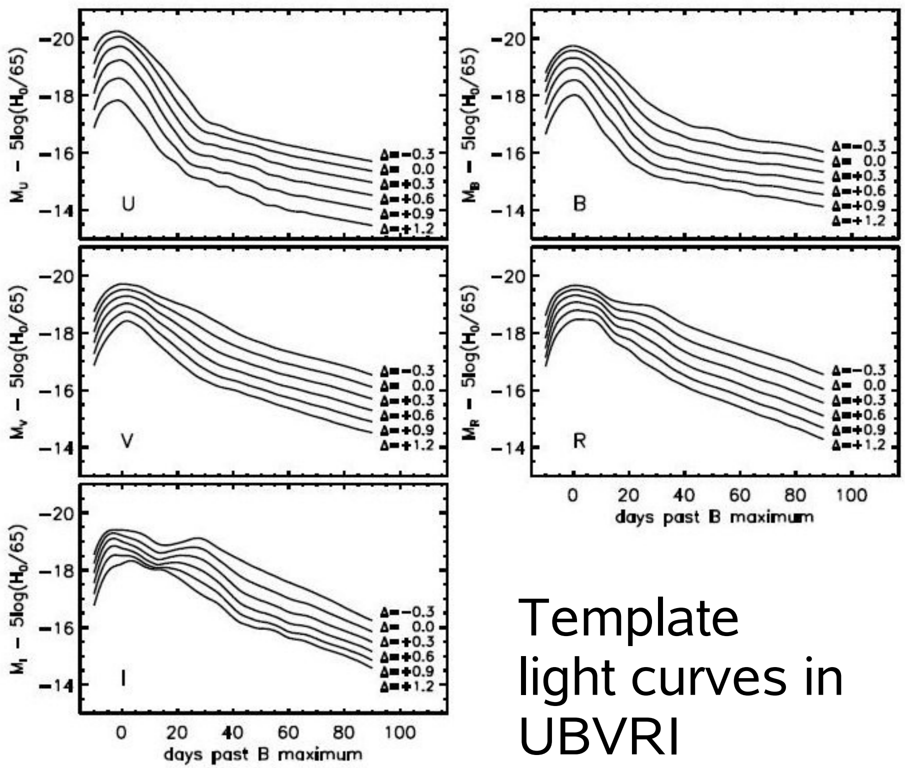
- Reliable 'scene modeling' photometry	118
- S/N > 5 for all photometric measurements	
- only g,r and i used (1x each)	
- at least 6 points on LC	106
- first measurement <10 days after max	103
- LC must span at least 15 days	79
- Av < 0.75	77
- $\chi 2$ / ndf < 4	74

MLCS2k2.V5 (S. Jha, astro-ph/0612666, Riess, ApJ 473,1996)

Multicolor Light Curve Shape Method / Bayesian Approach

$$m_x(t-t0) = M_x^0 + \mu_0 + \xi(\alpha_x + \beta_x / R_V) A_v + P_x \Delta + Q_x \Delta^2$$

galactic extinction
k-correction
time dilation z



Template light curves in UBVRI

Training Set of 37 SNIa:

$$M_x^0, P_x, Q_x$$

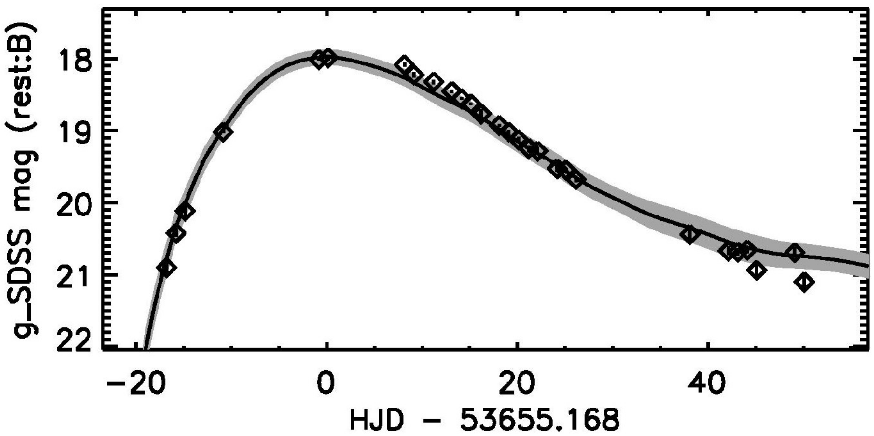
Simultaneous fit for:

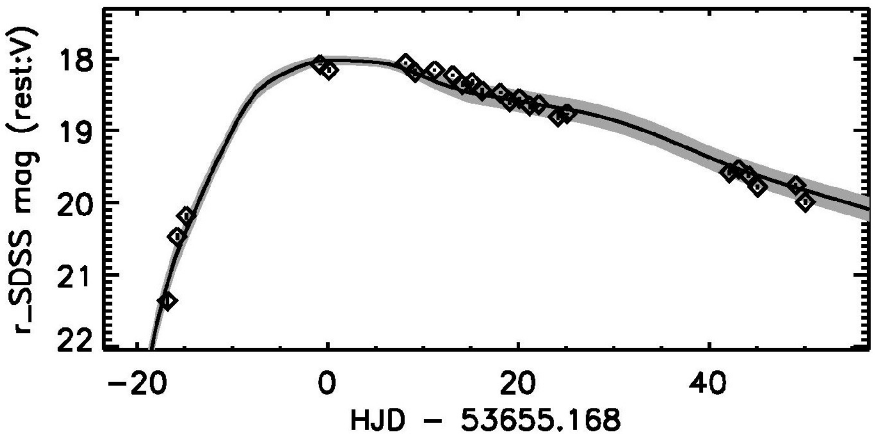
$$t_0, \mu_{0,} A_V^0, \Delta$$

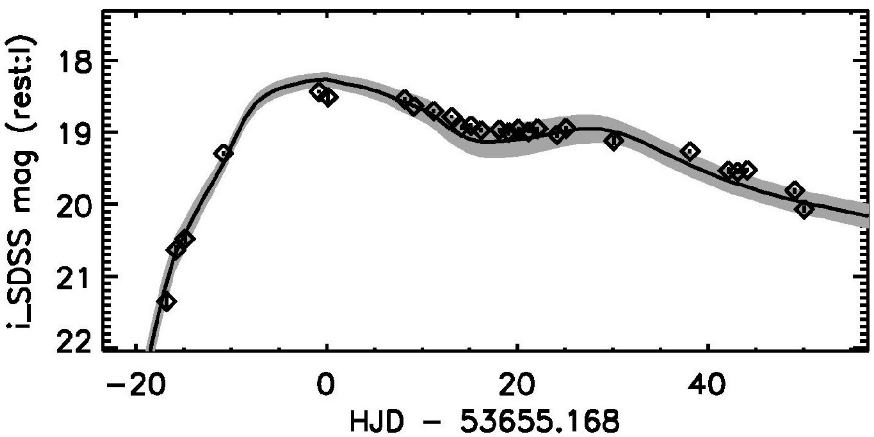
Various choices:
- rest frame passbands
- template lightcurves
- host galaxy extinction priors
- ...

Lightcurves

increase in redshift z







sn03901_SMP01_gri

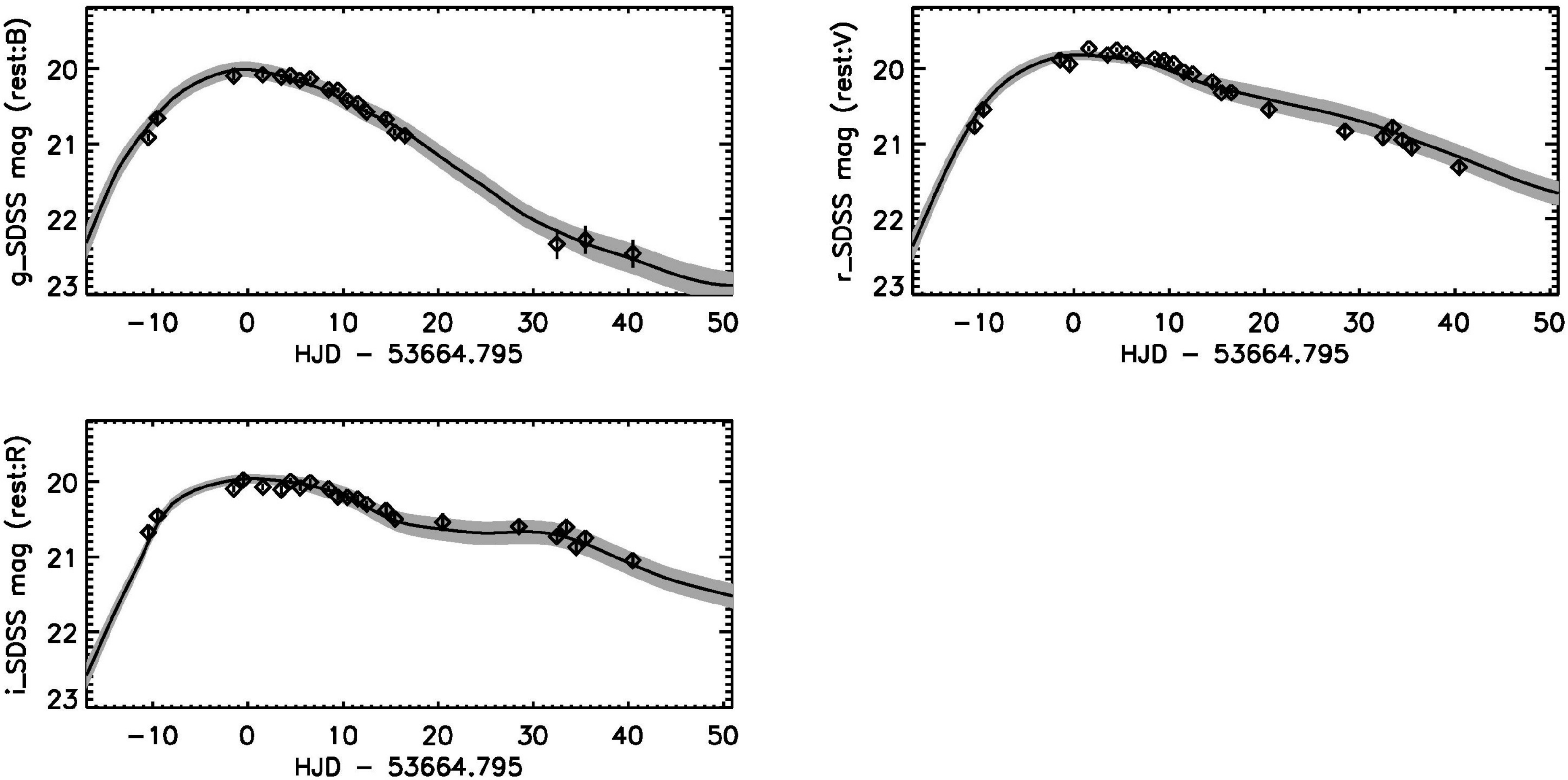
t_0 = 53655.168 R_V = 3.10

Δ = −0.26 A_V = 0.32

$\mu_0 + 5 \log (H_0/65)$ = 37.49

$E(B-V)_{MW}$ = 0.03   z = 0.0630

χ^2/ν = 49.54/76



sn05751_SMP01_gri

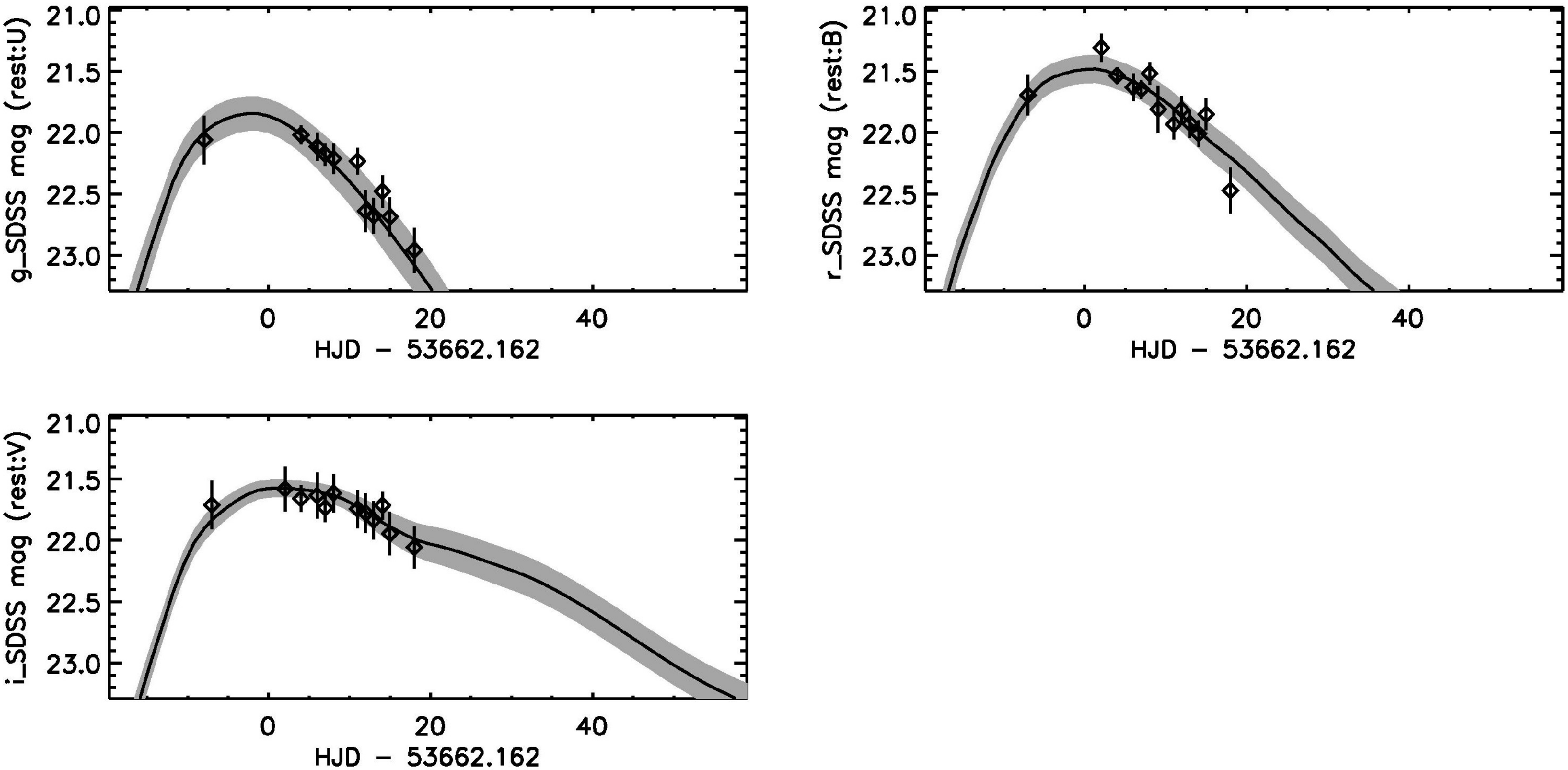
t_0 = 53664.795 R_V = 3.10

Δ = −0.30 A_V = 0.75

$\mu_0 + 5 \log (H_0/65) = 39.02$

$E(B-V)_{MW}$ = 0.02 z = 0.1310

χ^2/ν = 34.32/62



sn05844_SMP01_gri

t_0 = 53662.162 R_V = 3.10

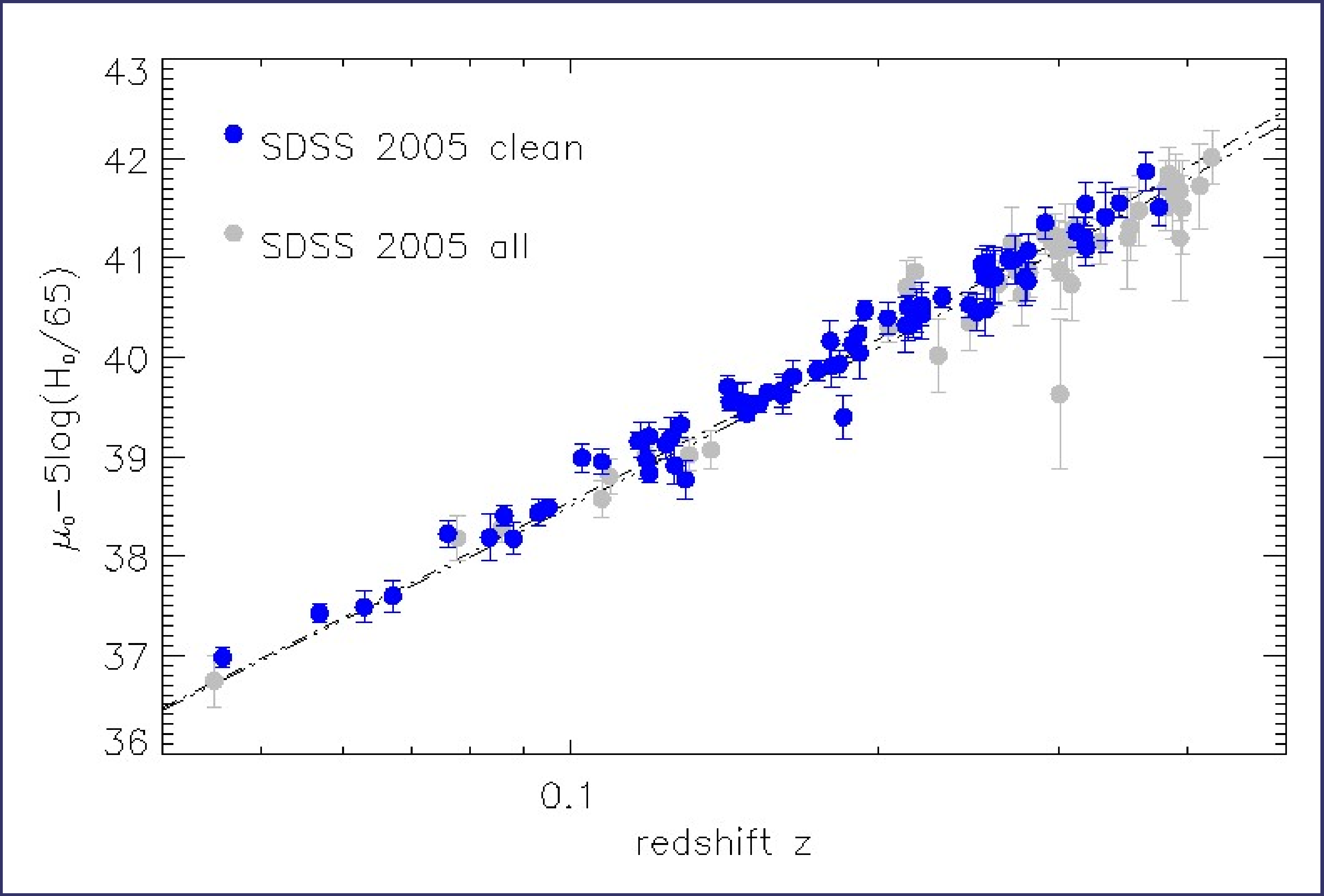
Δ = −0.18 A_V = 0.09

$\mu_0 + 5 \log (H_0/65) = 41.26$

$E(B-V)_{MW}$ = 0.11 z = 0.3120

χ^2/ν = 13.66/32

Hubble Diagram (I)



The Nearby Sample

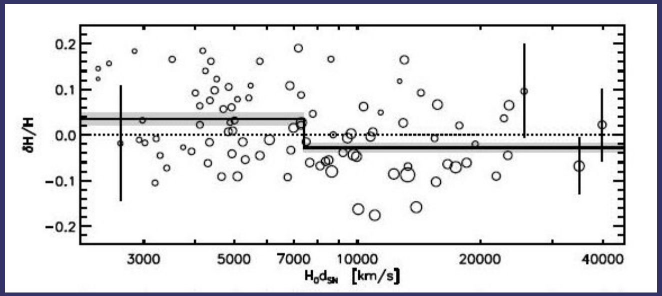
the low z SNe within the SDSS 2005 sample are not **yet** sufficient to do a self contained analysis (degeneracy between Ω_Λ and H_0)

in total 133 nearby SNe with z<0.125
(see S. Jha, astro-ph/0612666)

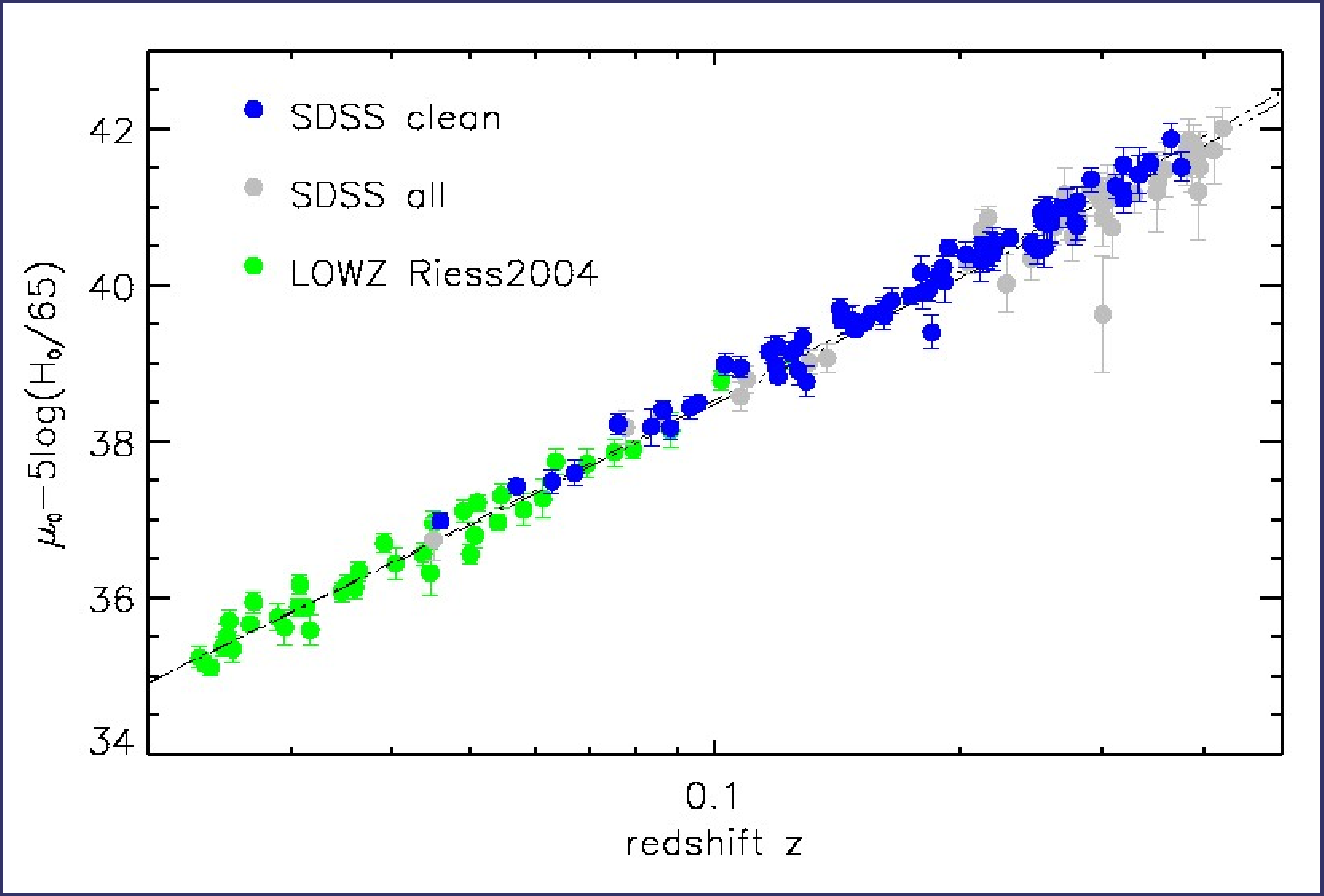
- selection criteria: same as Riess 2004 (39)
- z>0.0233 (49)
- z>0.0150 (71)

"Hubble Bubble"

Jha, 2006



Hubble Diagram (II)



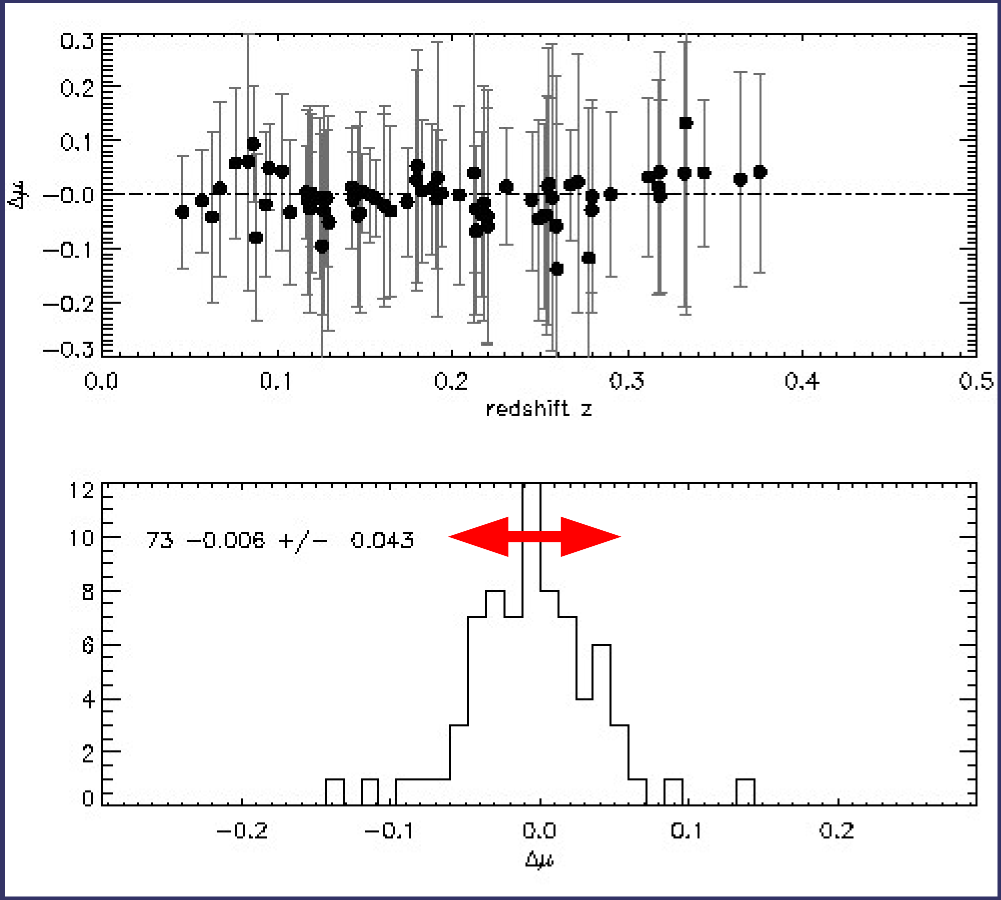
Systematic Effects

Experiment:
- photometric zeropoints
- filter response / atmosphere
  k-corrections (spec. libraries)
- selection bias
- reconstruction bias

Light emission & propagation:
- dust in host
  amount and absorption law
  priors on Av
- SNe evolution

Cosmology:
- lensing (high-z SNe)
- 'Hubble bubble'
- grey dust etc.

eg. spectral libraries:



Photometric Calibration

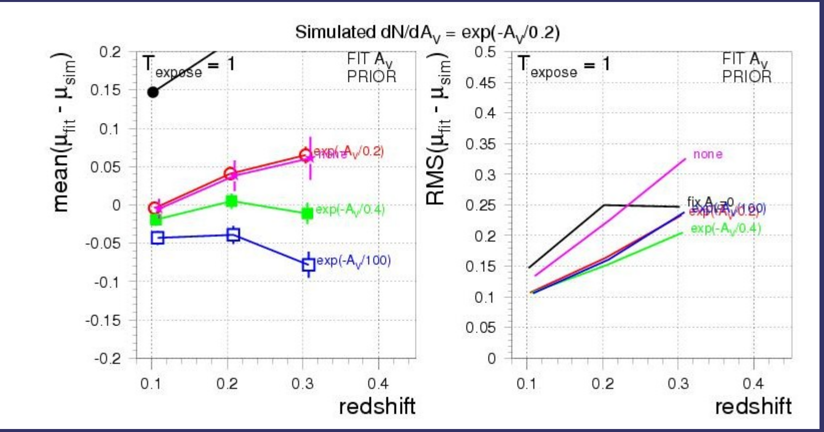
Table 3. AB Magnitude Offsets

Quantity	u	g	r	i	z
Δm_{WD}	-0.033	0.016	0.011	0.013	0.015
rms Δm_{WD}	0.021	0.010	0.013	0.009	0.007
Δm_{Solar}	-0.037	0.024	0.005	0.018	0.016
rms Δm_{Solar}	0.005	0.006	0.005	0.010	0.014
BD+17°4208	-0.033	0.011	0.000	0.009	0.003

Marriner et al.

how well do well are we tight
to the HST White Dwarf scale?

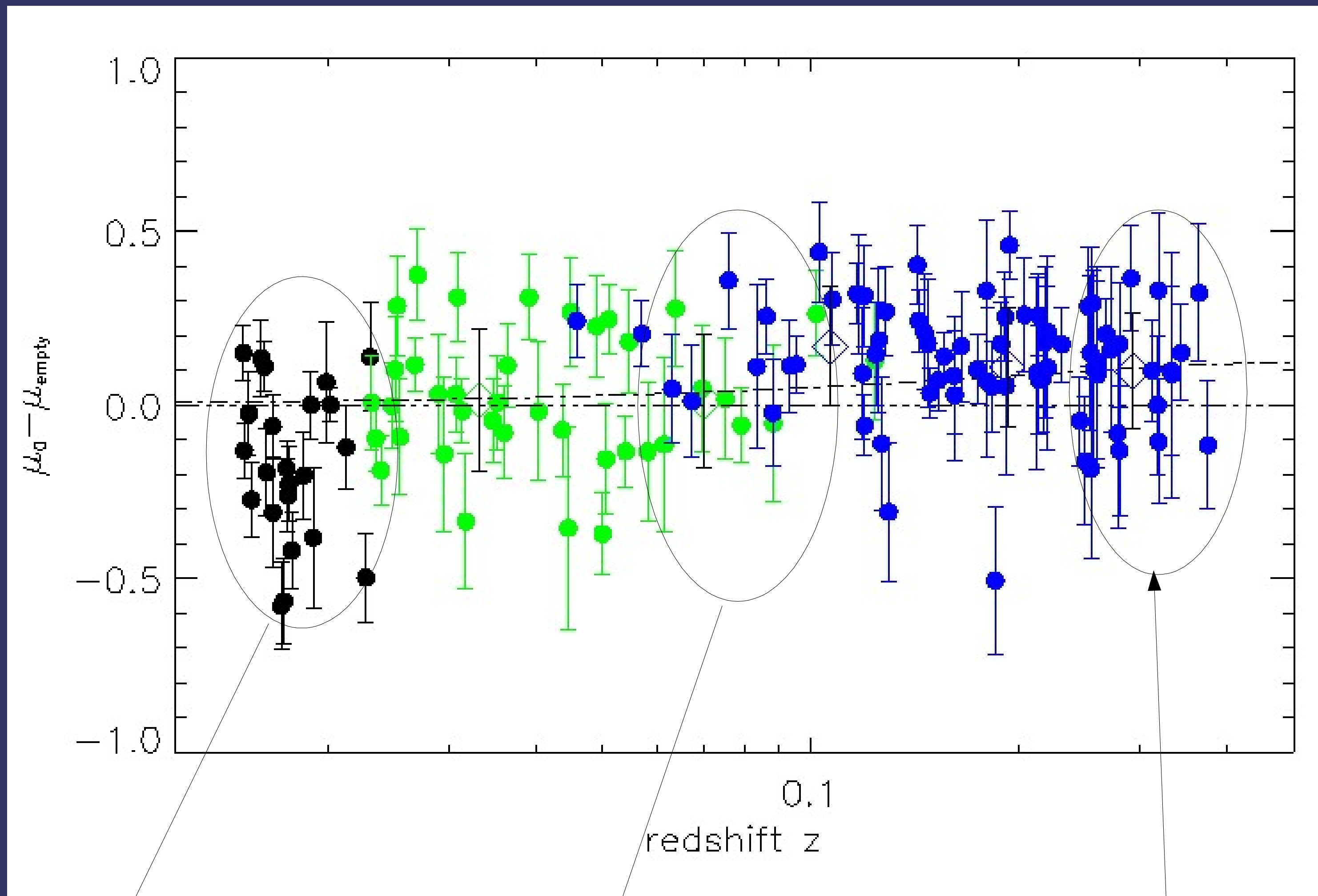
Monte-Carlo Studies



Kessler, Miknaitis, Cinabro et al.

- selection biases
- reconstruction biases
- influence of Av priors
- assesment of
systematic errors

Hubble Diagram Residuals

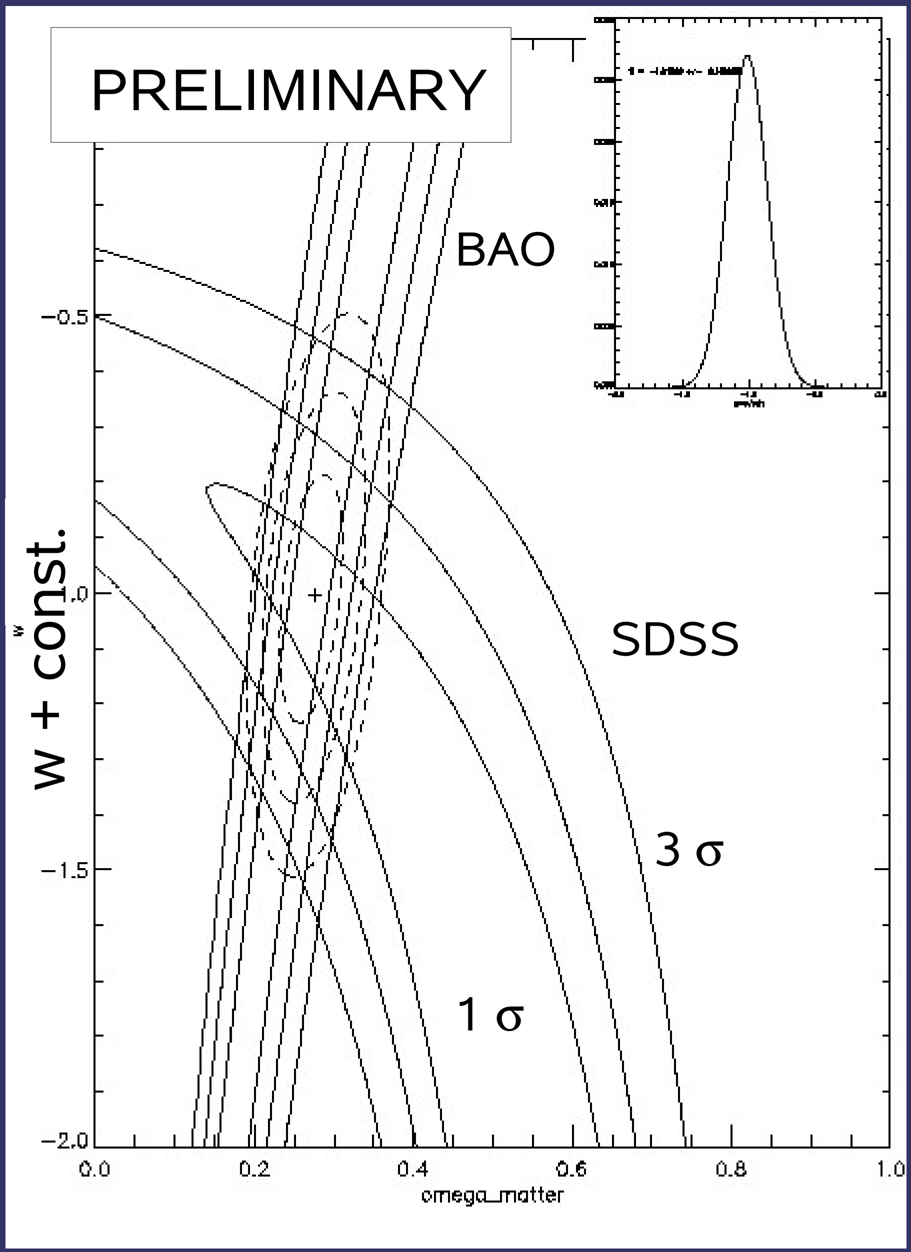


Hubble Bubble?
(Jha, 2006,
astro-ph/0612666)

zeropoints
passbands
k-corrections

Selection bias at
the faint end?

Constraints on w



- additional information necessary to constrain w

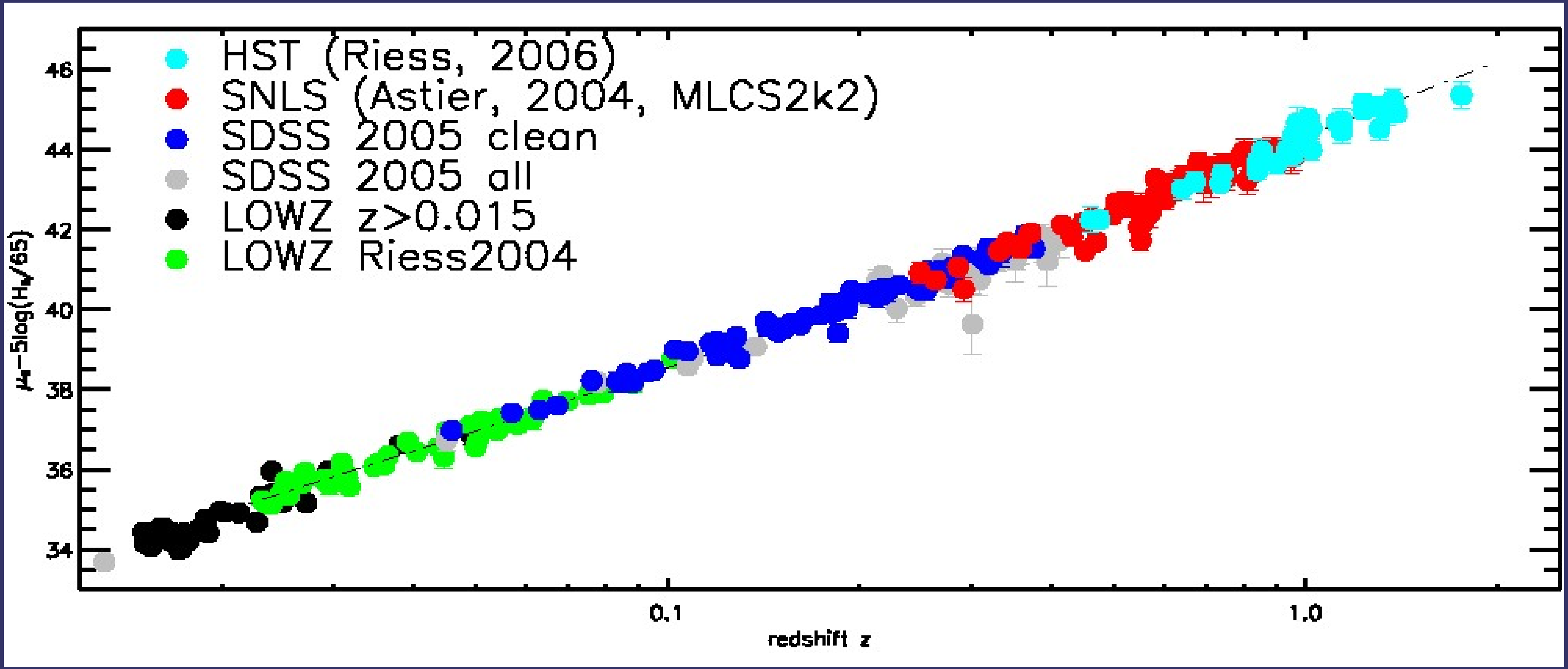
- assuming flat universe
- constraints from BAO (Eisenstein, et al., 2004) as prior (0<z<0.35)

- SDSS SNe data and BAO cover the same redshift range. No interpolation in w necessary

current status:

w = -? +/- 0.15 stat +/- ? sys

Outlook



- SDSS in combination with BAO provides a unique measurement on w at z<0.35

- assessment of systematic uncertainties under way

- analysis of SDSS SNe data in combination with other SNe data sets in progress