

Recent results on Type Ia Supernova colors

Vladan Arsenijevic

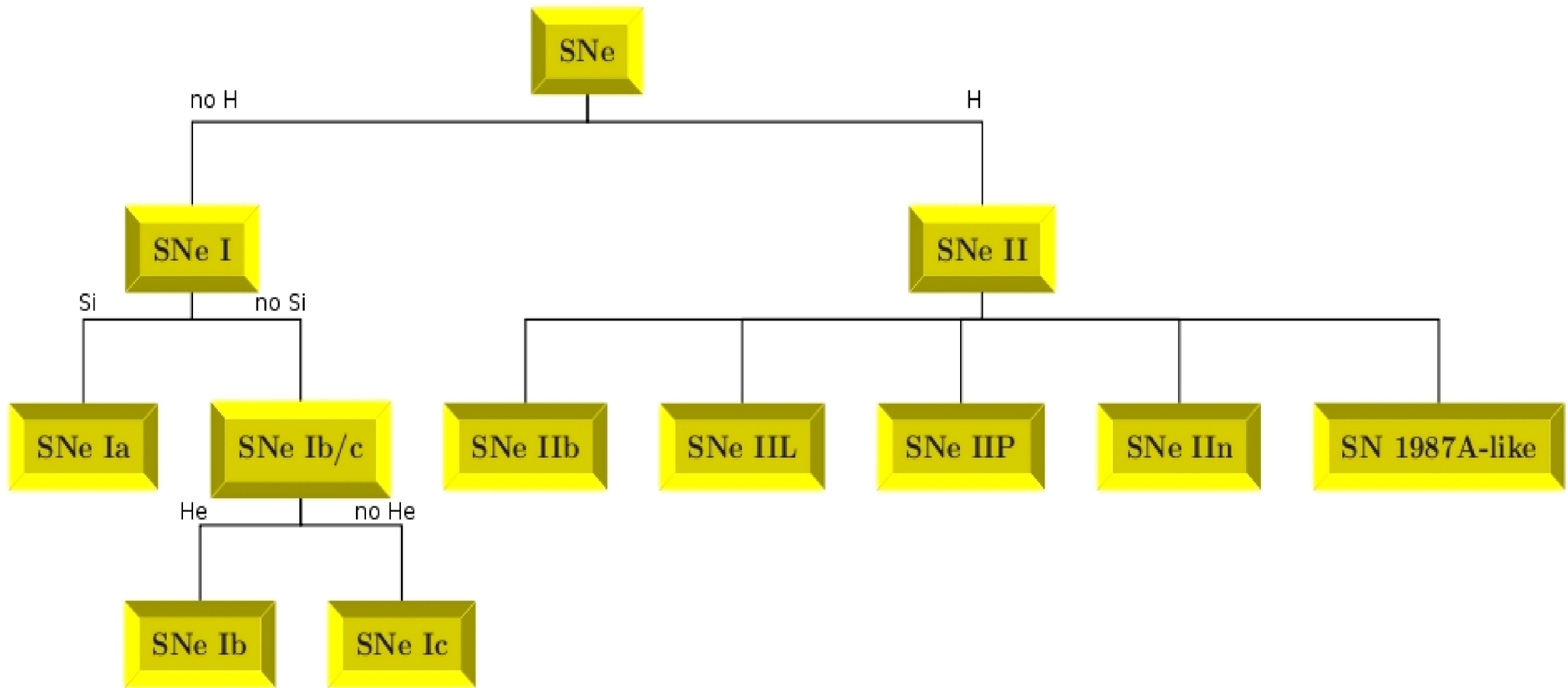


SIM/IDL, Faculdade de Ciências da Universidade de Lisboa

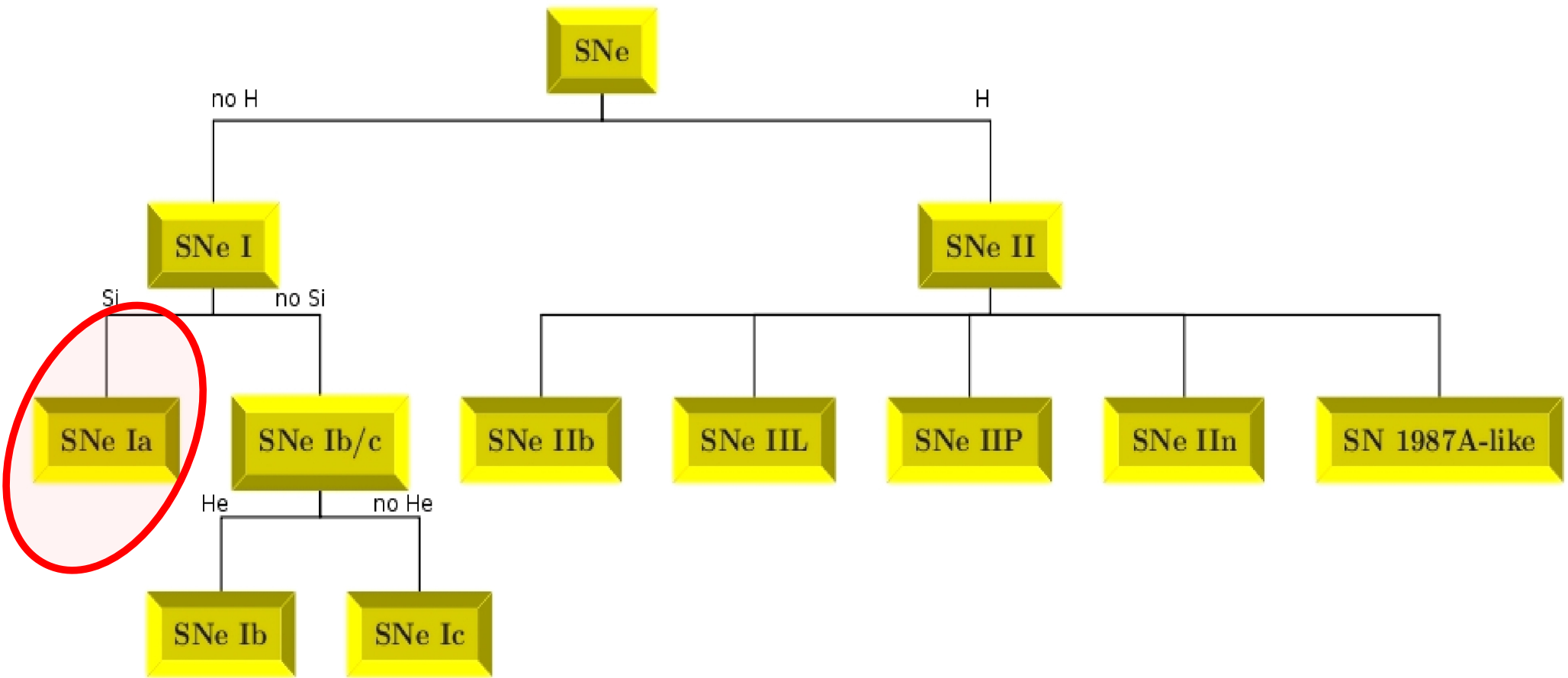
outline

- introduction on supernovae
- light-curve modeling
- luminosity/light-curve parameters relations
- more on color variation law
- disentangling dust and intrinsic effects
- conclusions

SN classification



SN classification

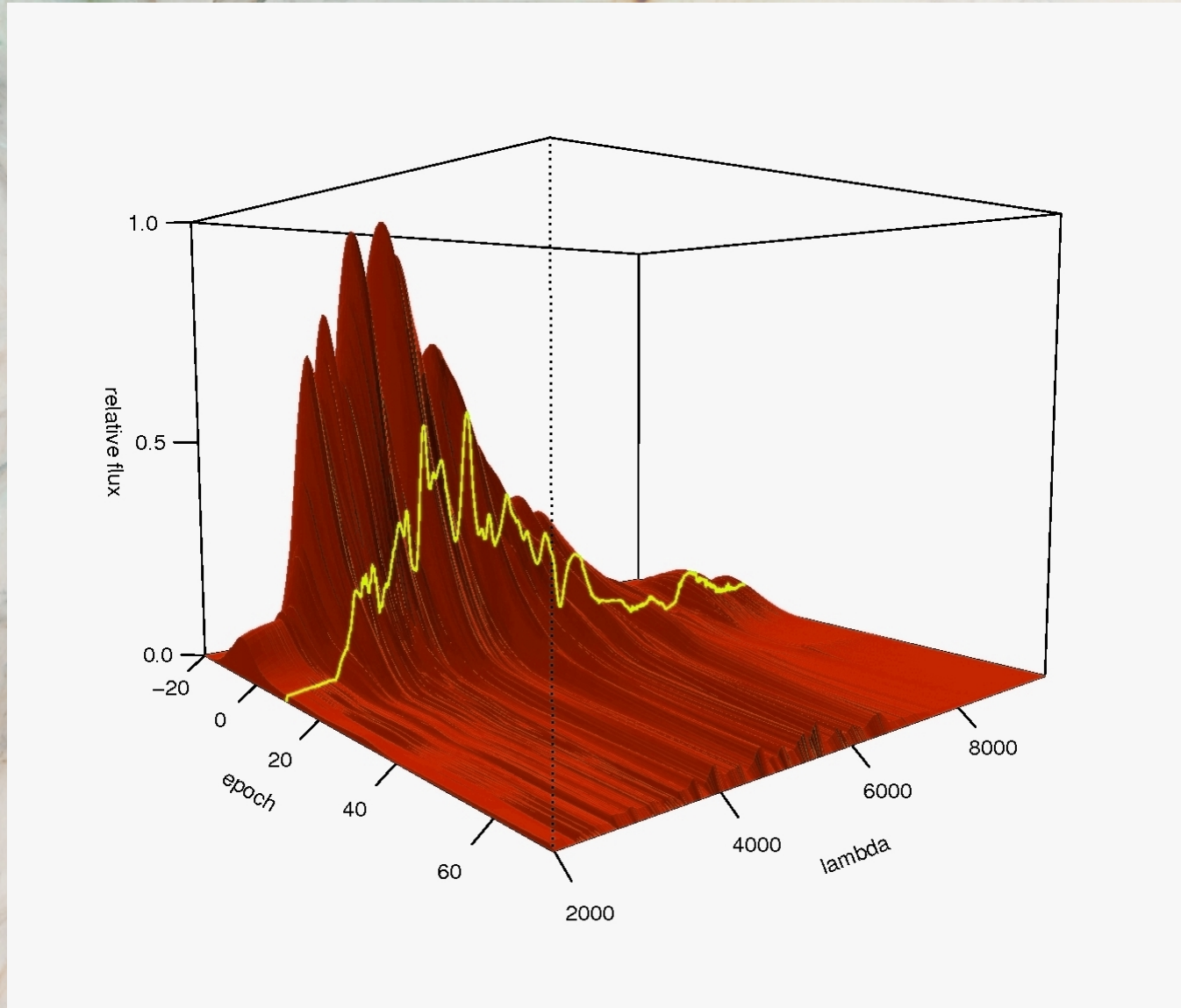


type Ia supernova

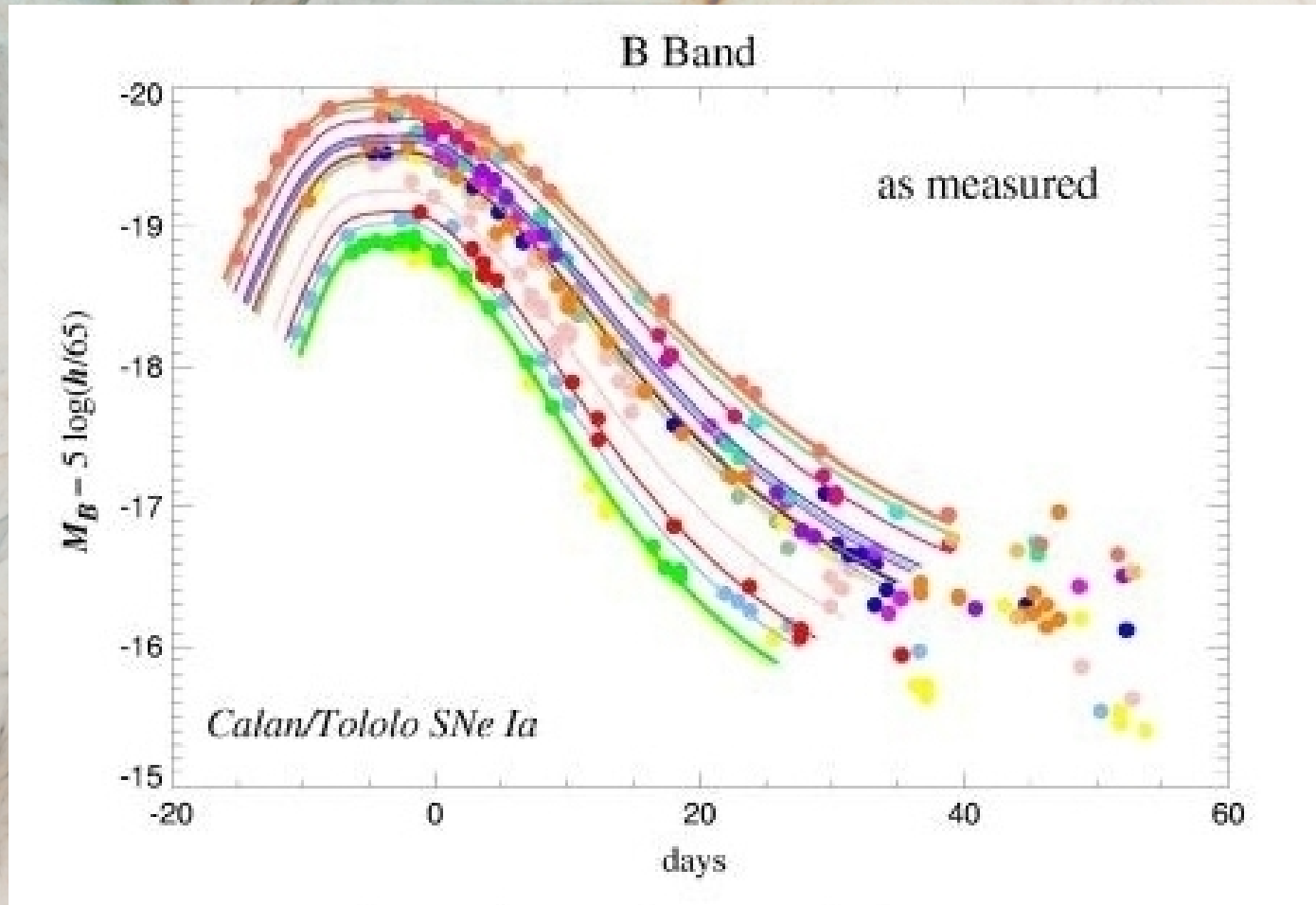
a thermonuclear explosion of C/O white dwarf in a binary system



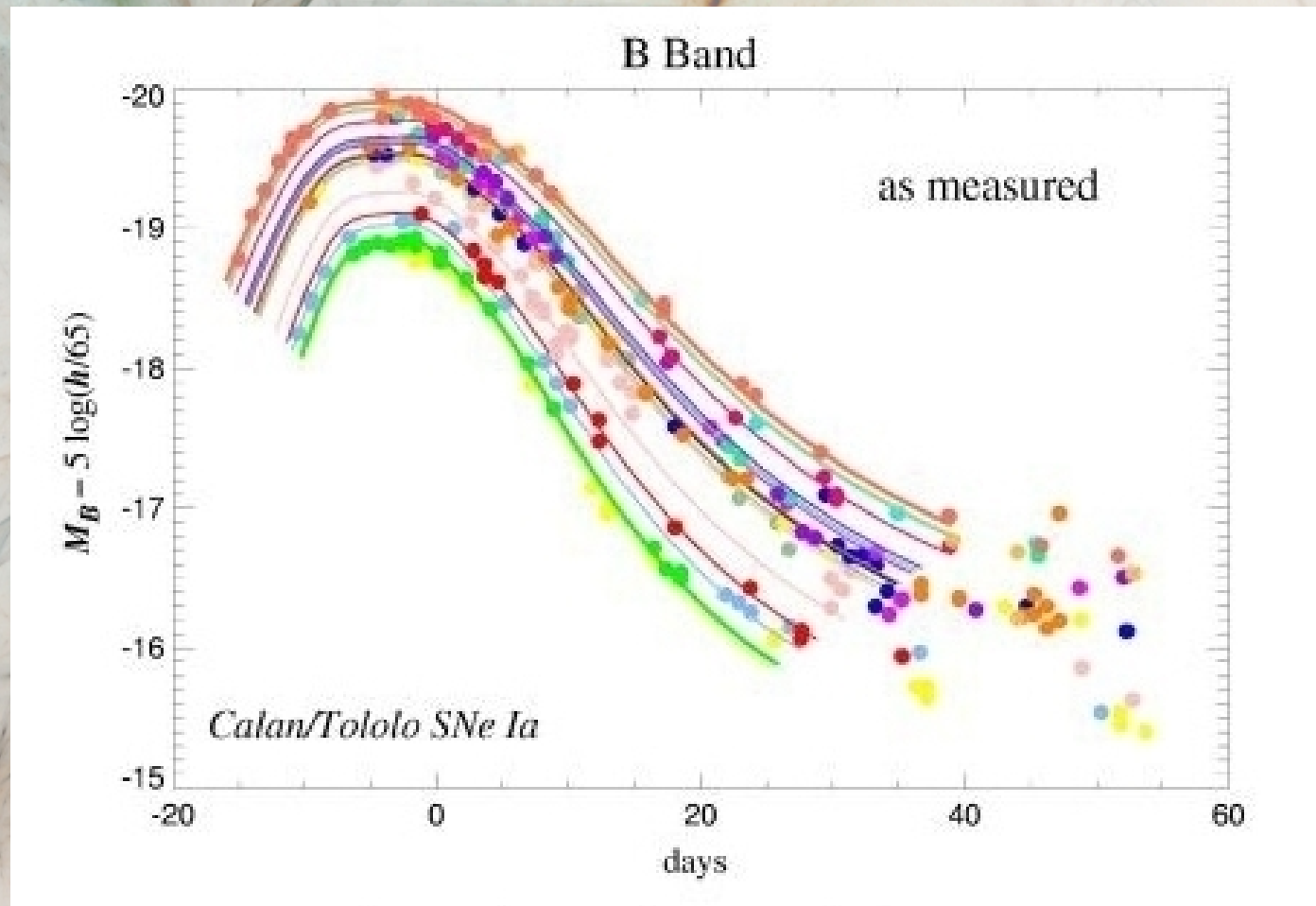
SN spectra



SN light-curves

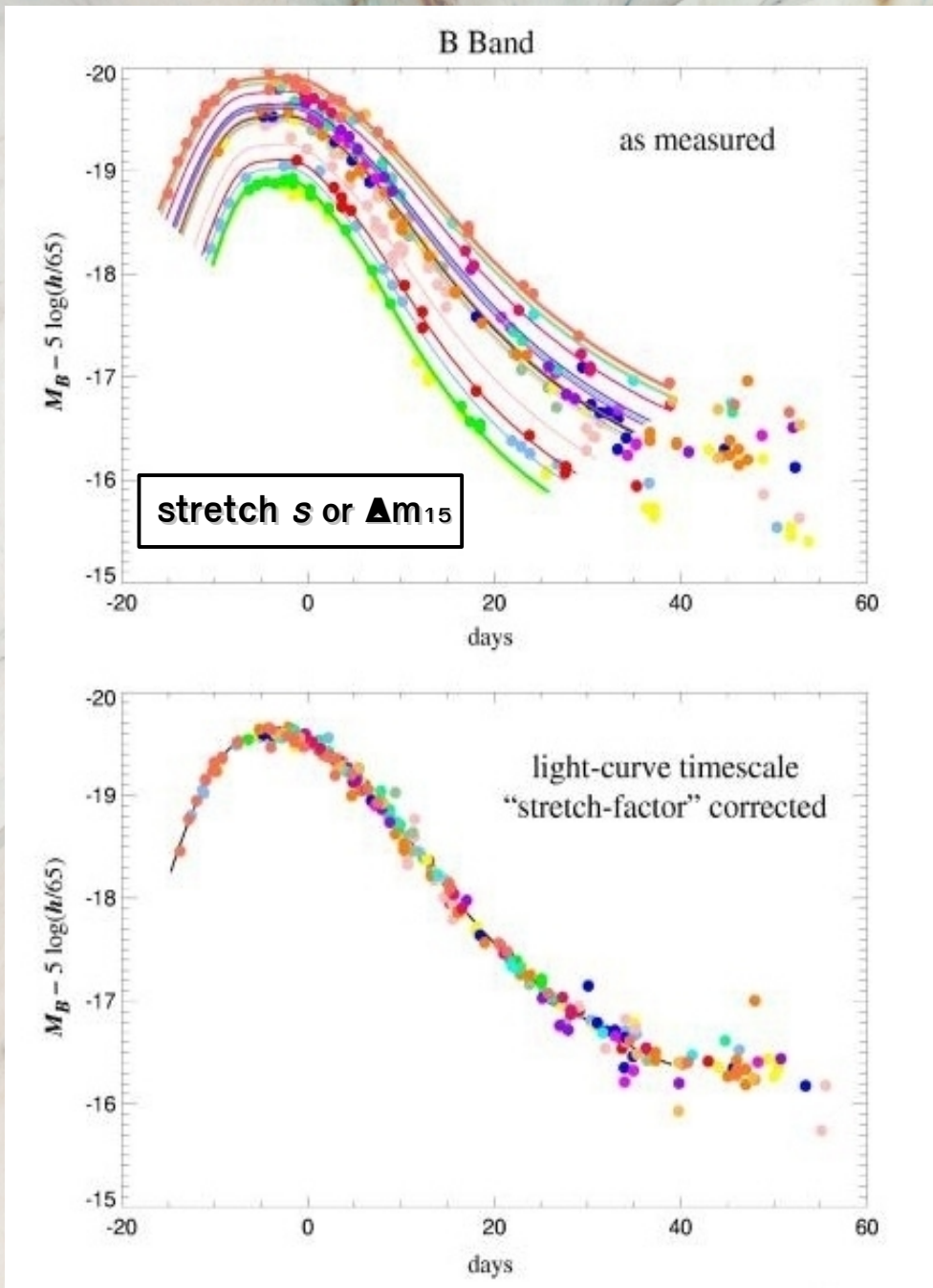


SN light-curves



a scatter in the peak luminosity of ~40%

SNe Ia as standard candles



$$\mu = 5 \log_{10}(d_L/10\text{pc})$$

in cosmology we use the *distance modulus*

SALT2 fitter:

$$\mu_B = m_B - M + \alpha_x x_1 - \beta c$$

intrinsic dispersion:

SALT: (0.13 ± 0.02) mags (Astier et al. 2006)

SALT2: 0.12 mags (Guy et al. 2007)

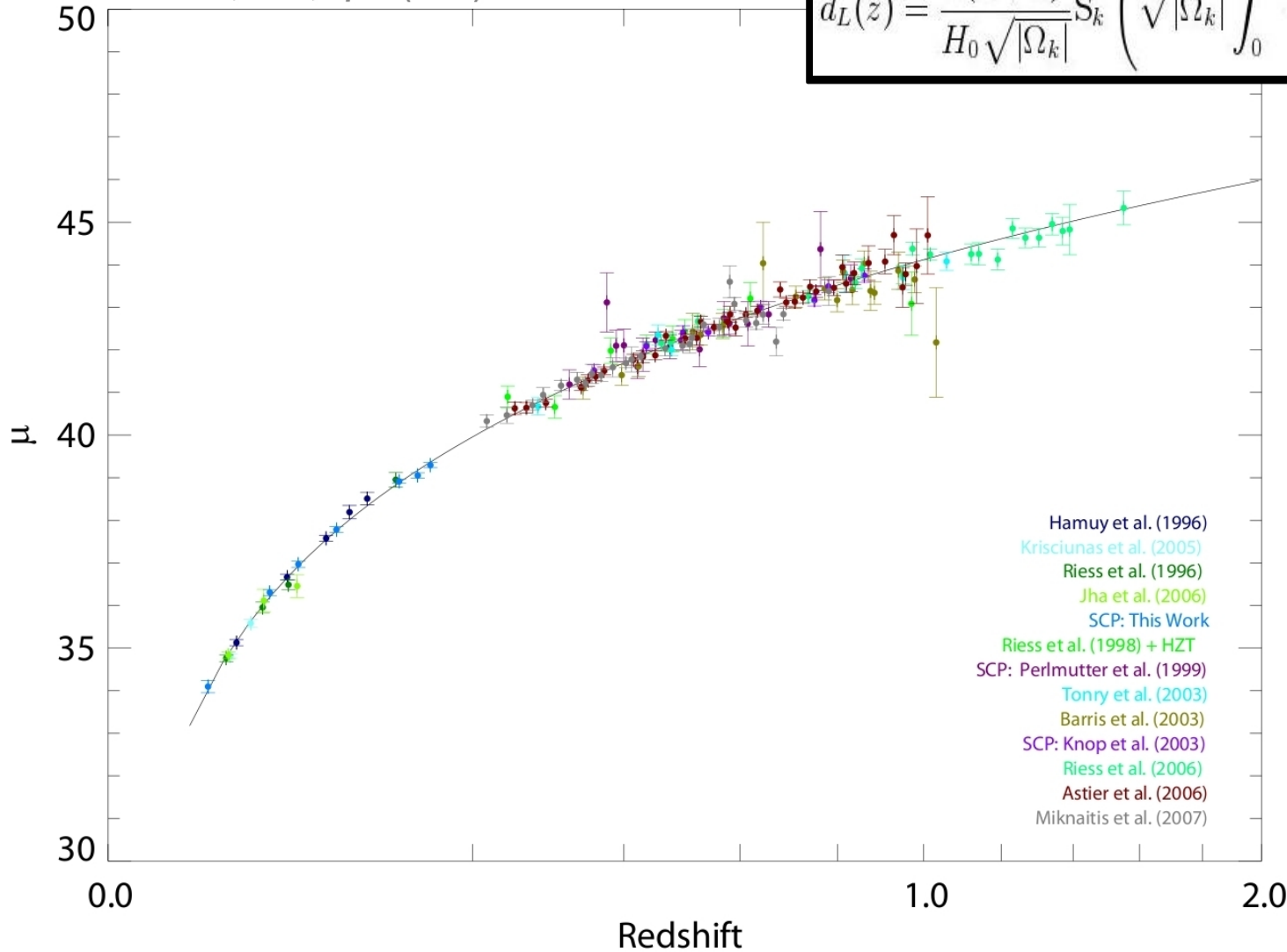
\Leftrightarrow accuracy in distance: $\sim 7\%$

SNe Ia as standard candles

$$\mu = 5 \log_{10}(d_L/10\text{pc})$$

Supernova Cosmology Project
Kowalski, et al., *Ap.J.* (2008)

$$d_L(z) = \frac{c(1+z)}{H_0 \sqrt{|\Omega_k|}} S_k \left(\sqrt{|\Omega_k|} \int_0^z \frac{dz'}{\sqrt{\sum_i \Omega_i (1+z')^{3(1+\omega_i)} + \Omega_k (1+z')^2}} \right)$$



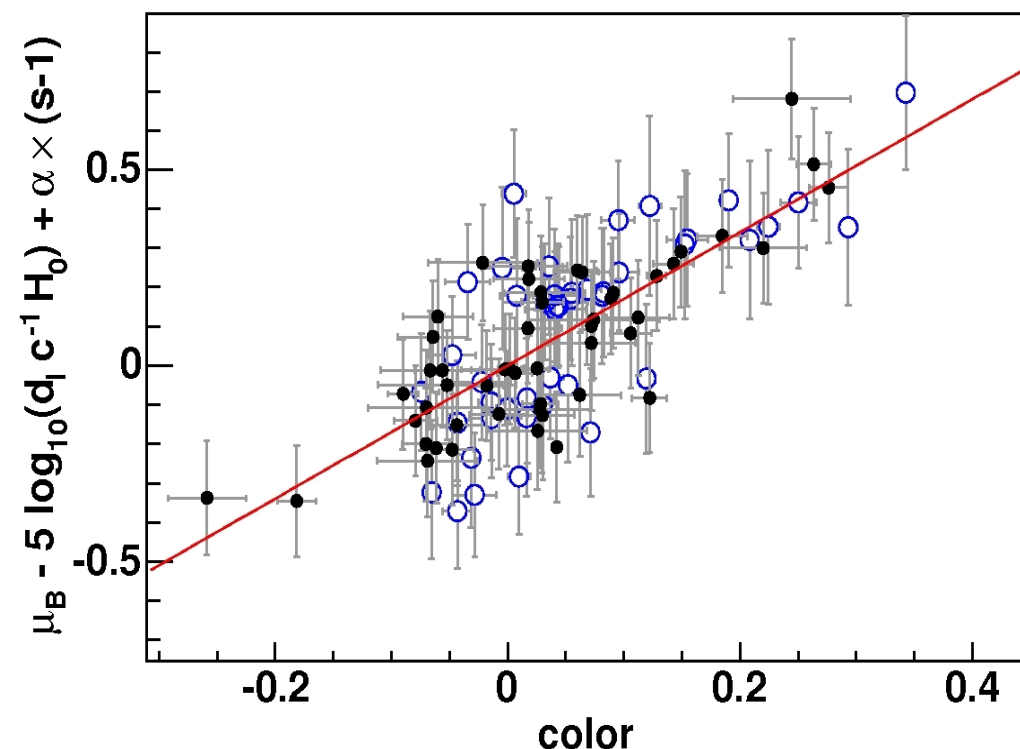
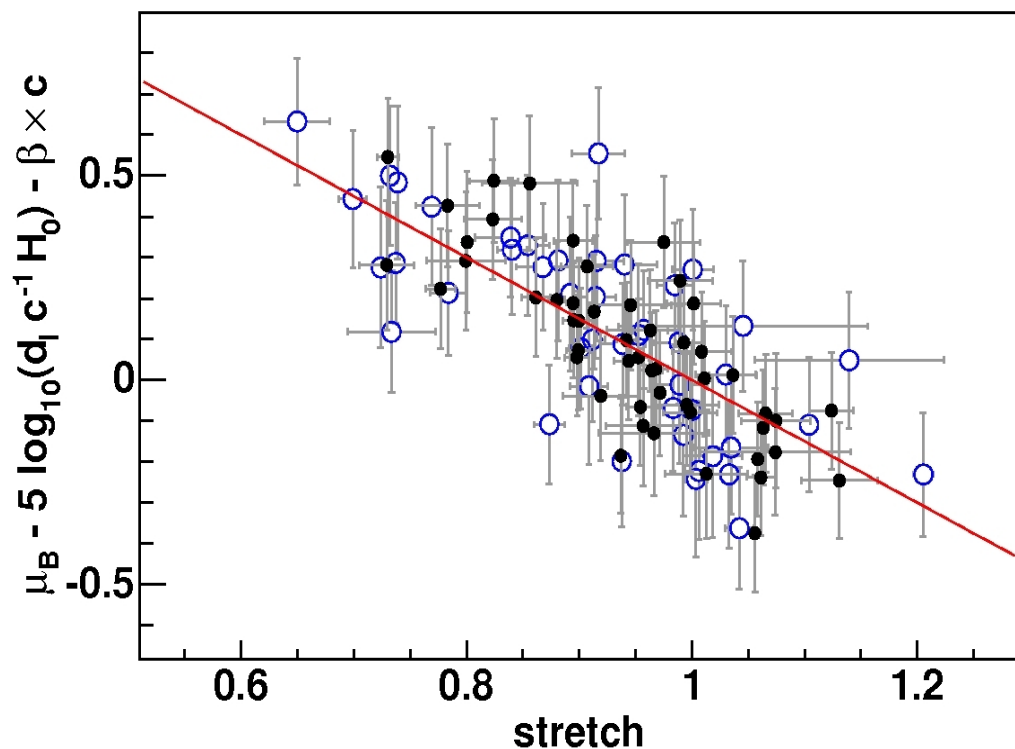
$$\Omega_M = 0.29 \pm 0.03$$

luminosity vs light-curve parameters

brighter - slower

brighter - bluer

Astier et al. 2006



$$\mu_B = m_B - M + \alpha(s - 1) - \beta c$$

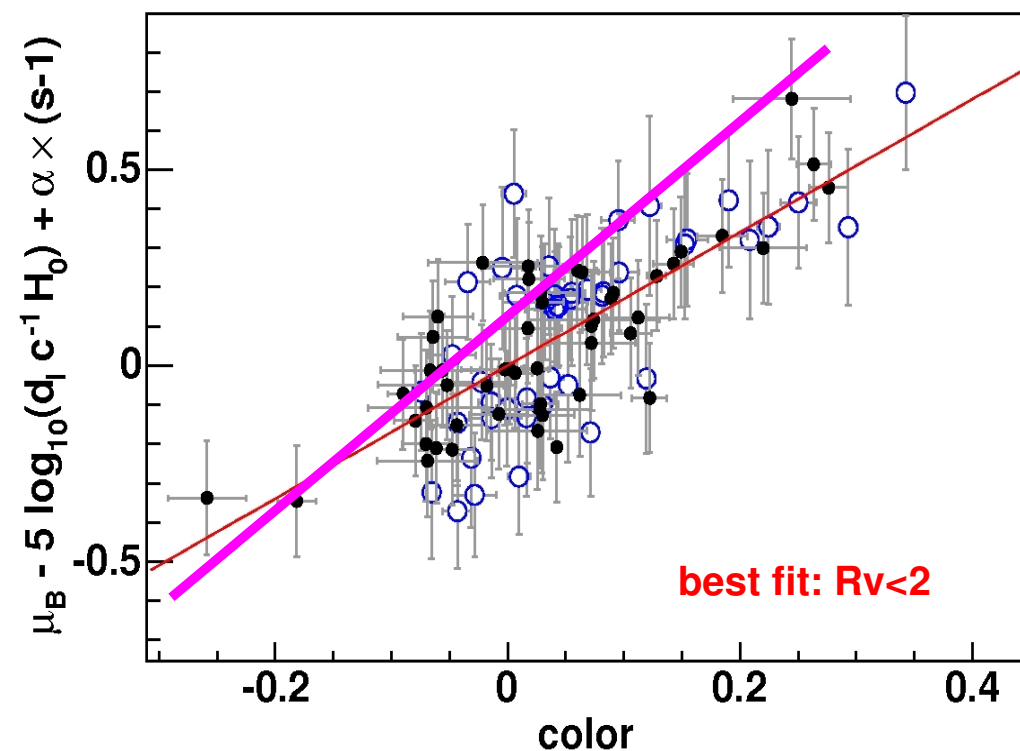
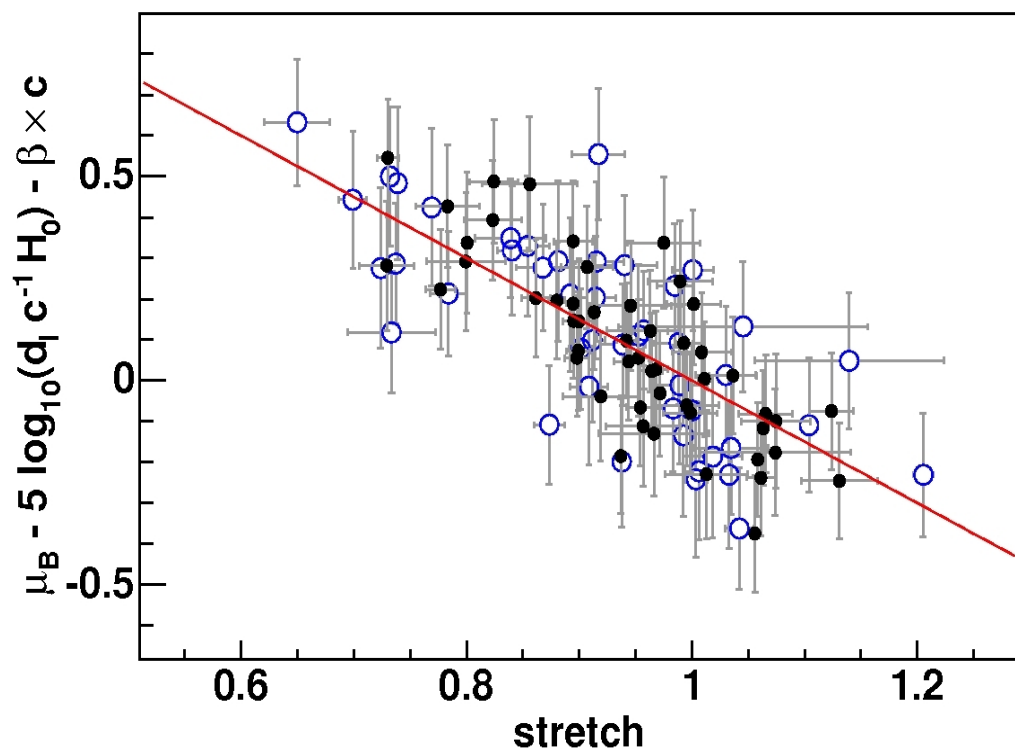
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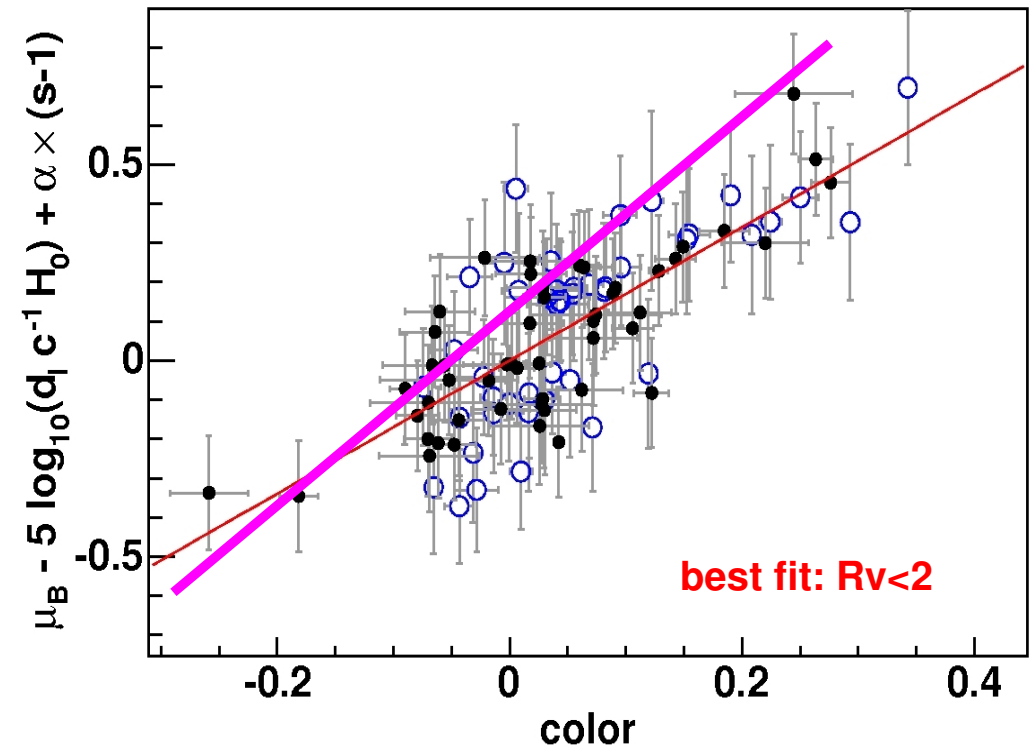
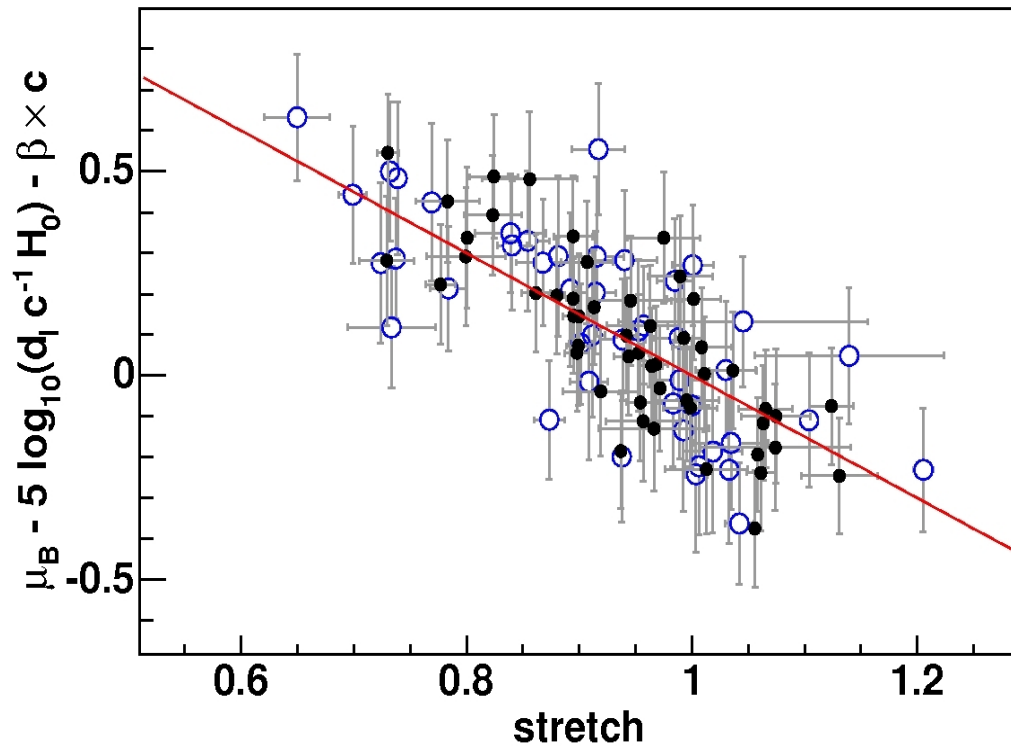
color – luminosity relation not compatible with Cardelli law, i.e. MW dust with $R_v=3.1$

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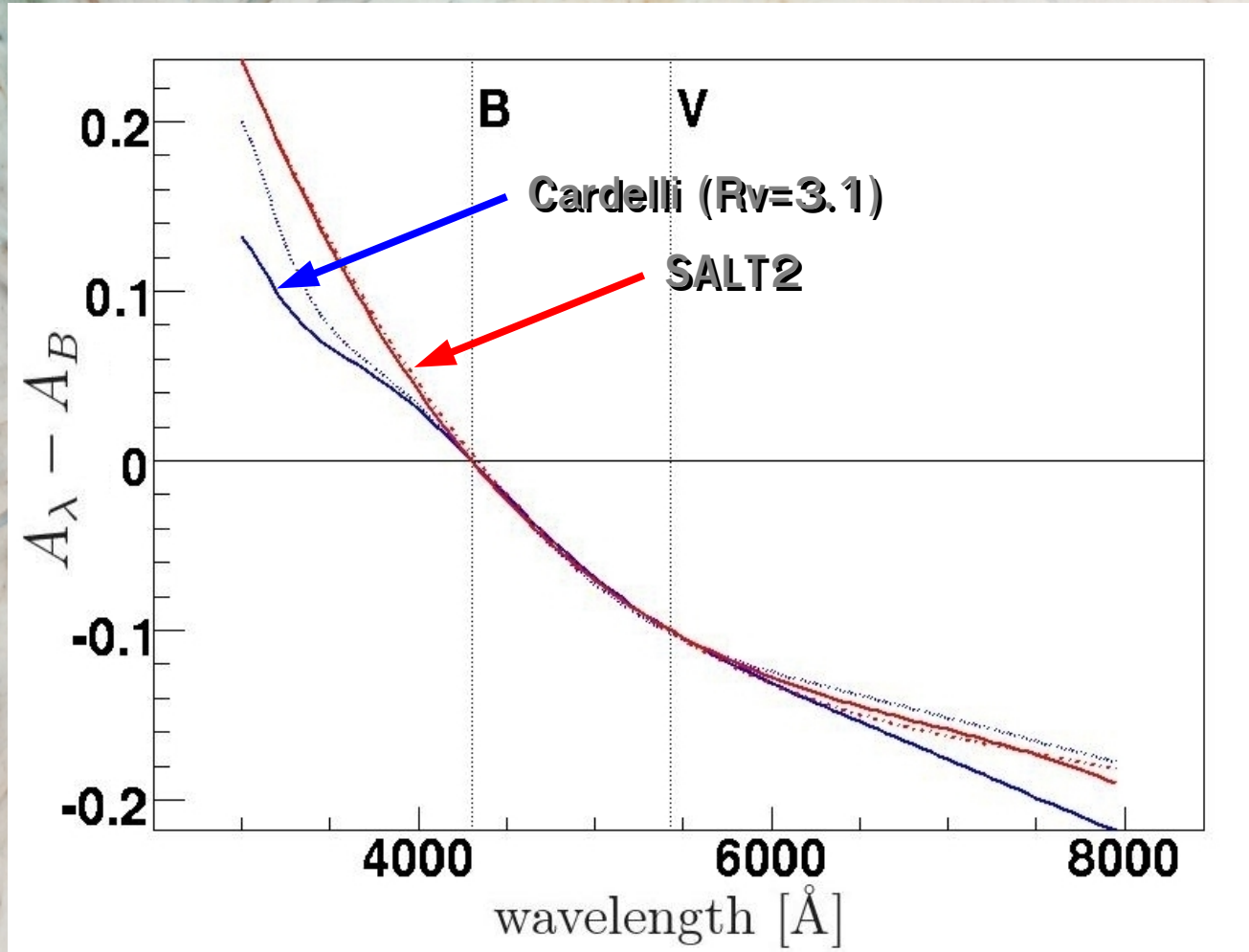
Astier et al. 2006



color - luminosity relation not compatible with Cardelli law, i.e. MW dust with $R_v = 3.1$

hot

color variation law



Guy et al. 2007

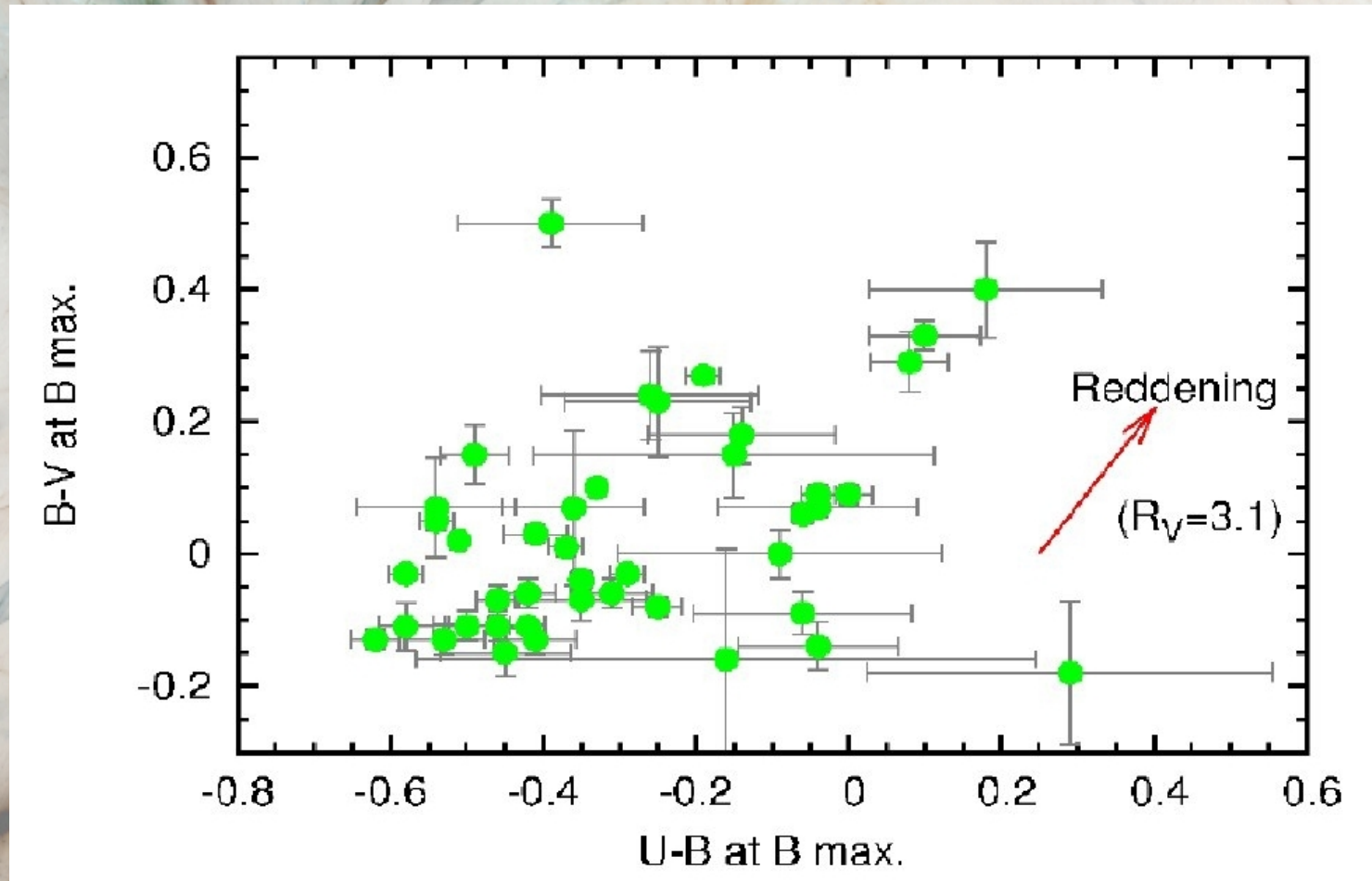
$$R_V = A_V / E(B - V)$$



ratio of total to selective extinction

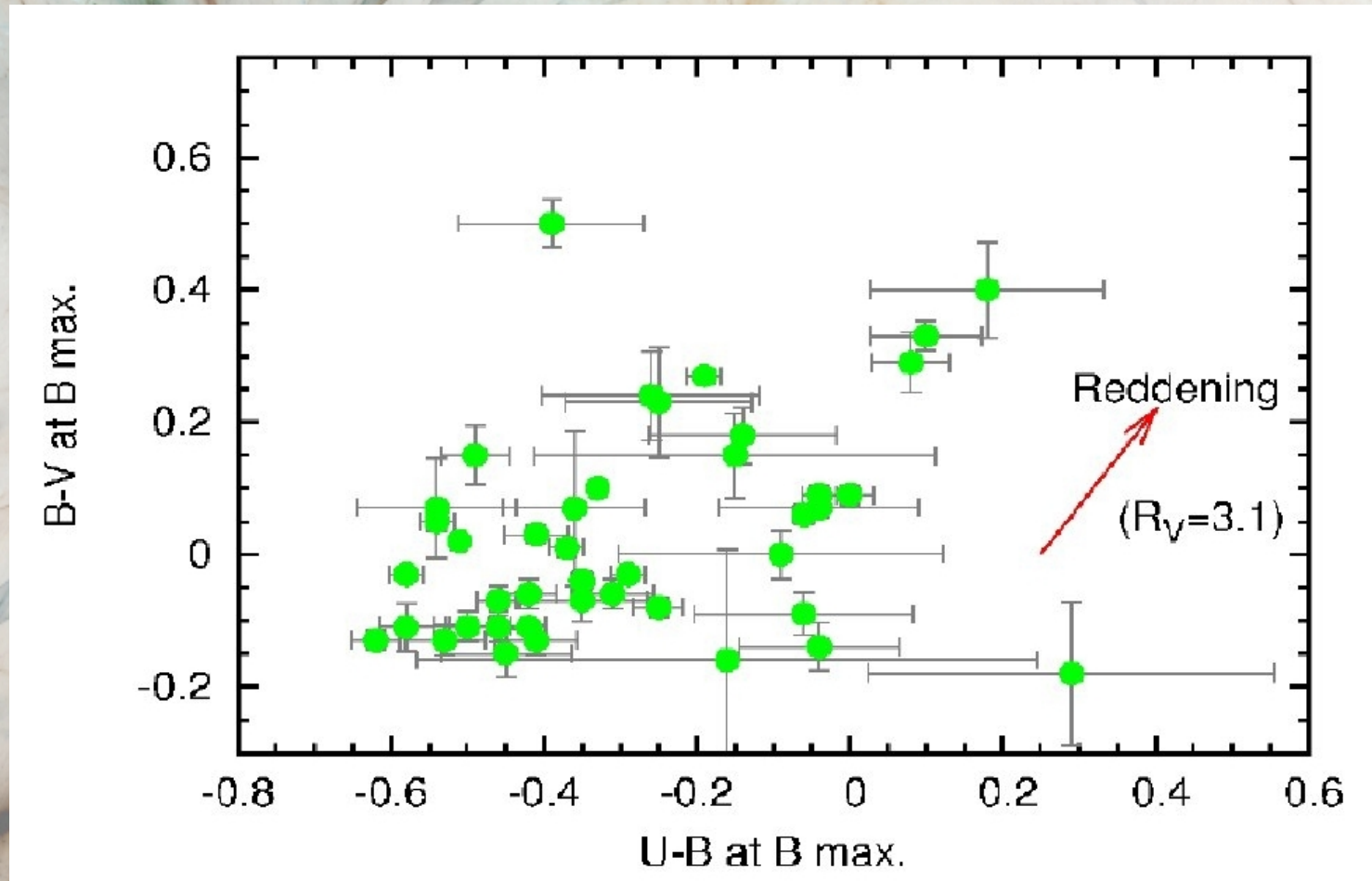
$$\beta \simeq R_B = R_V + 1$$

dispersion in color-color diagram (nearby SNe Ia)



Takanashi 2008

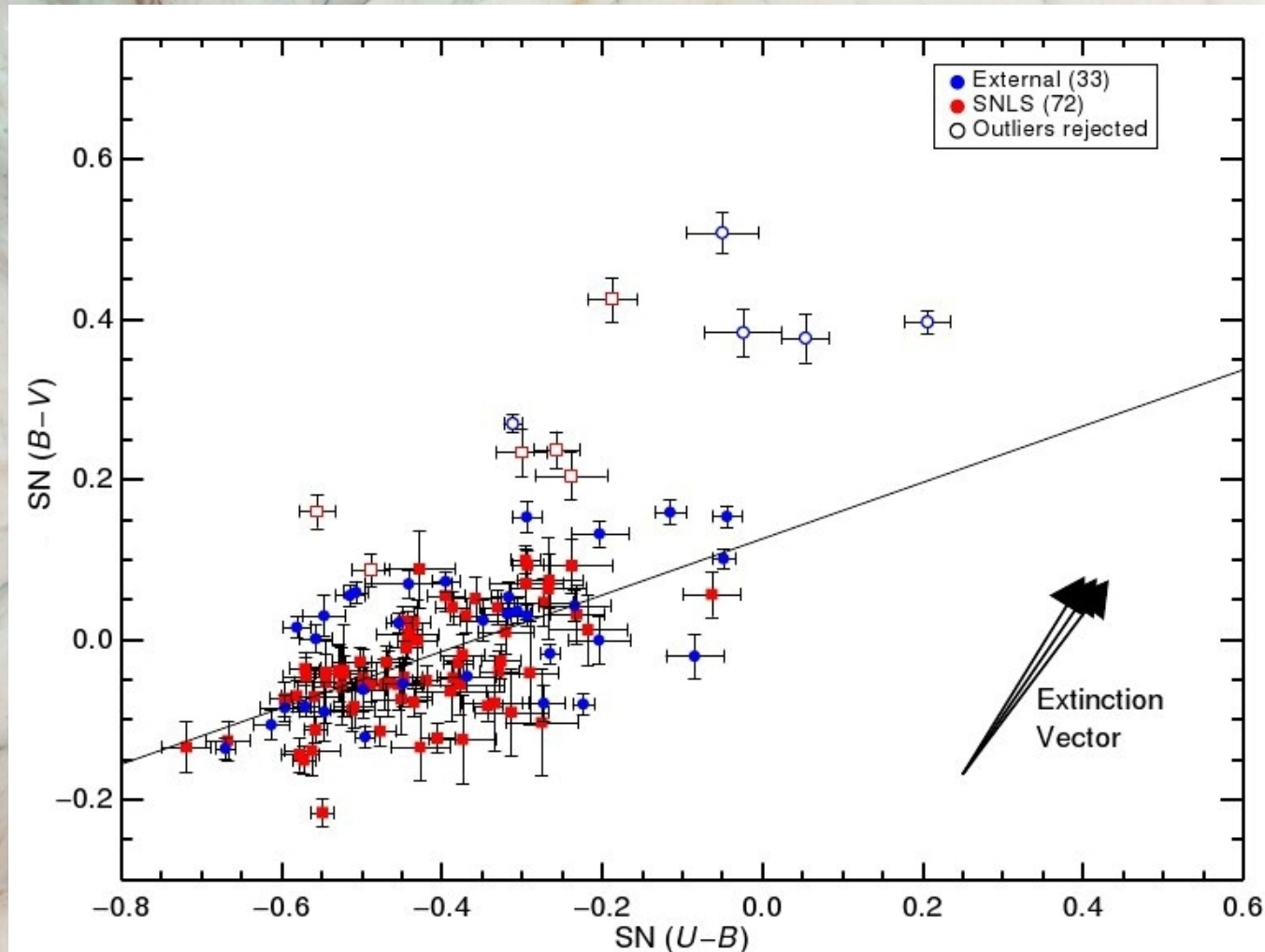
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Takanashi 2008

observed dispersion cannot be explained by the extinction in the MW and the host galaxies

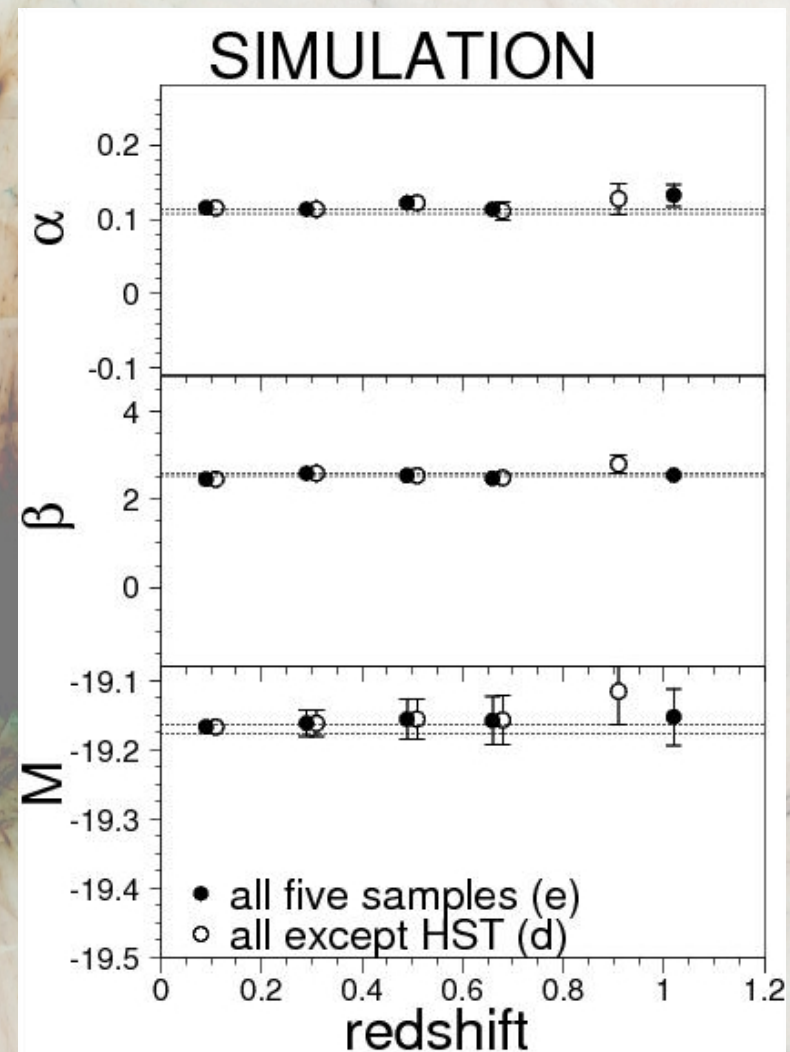
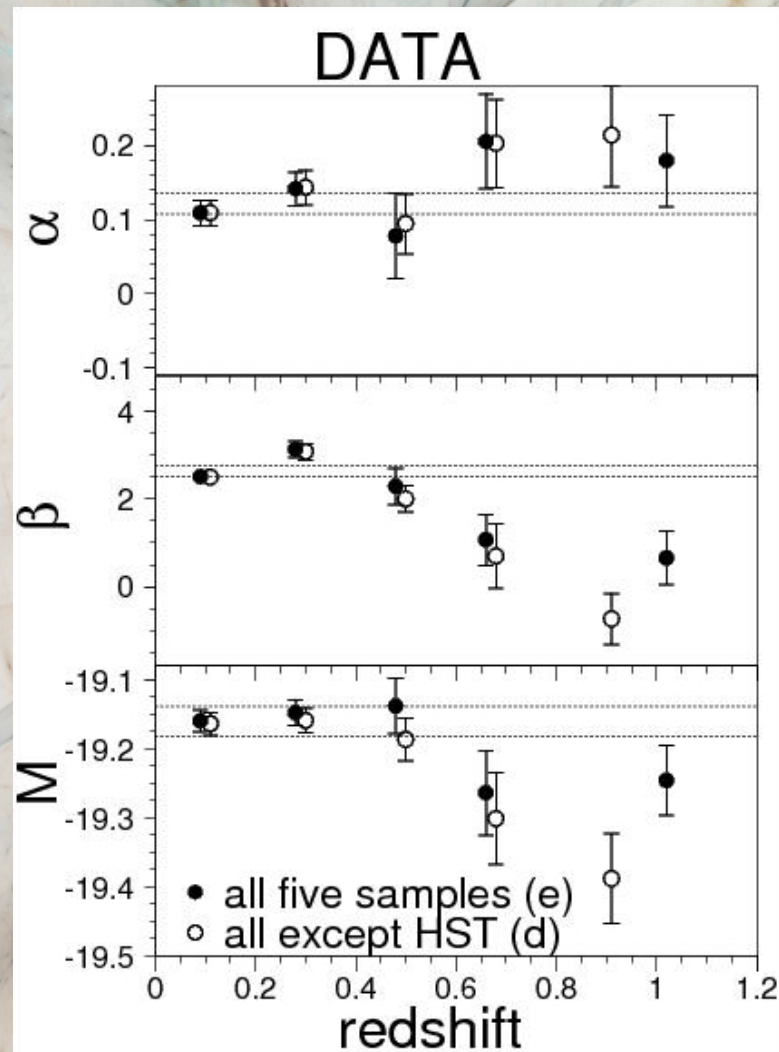
color-color diagram (high-z SNe Ia)



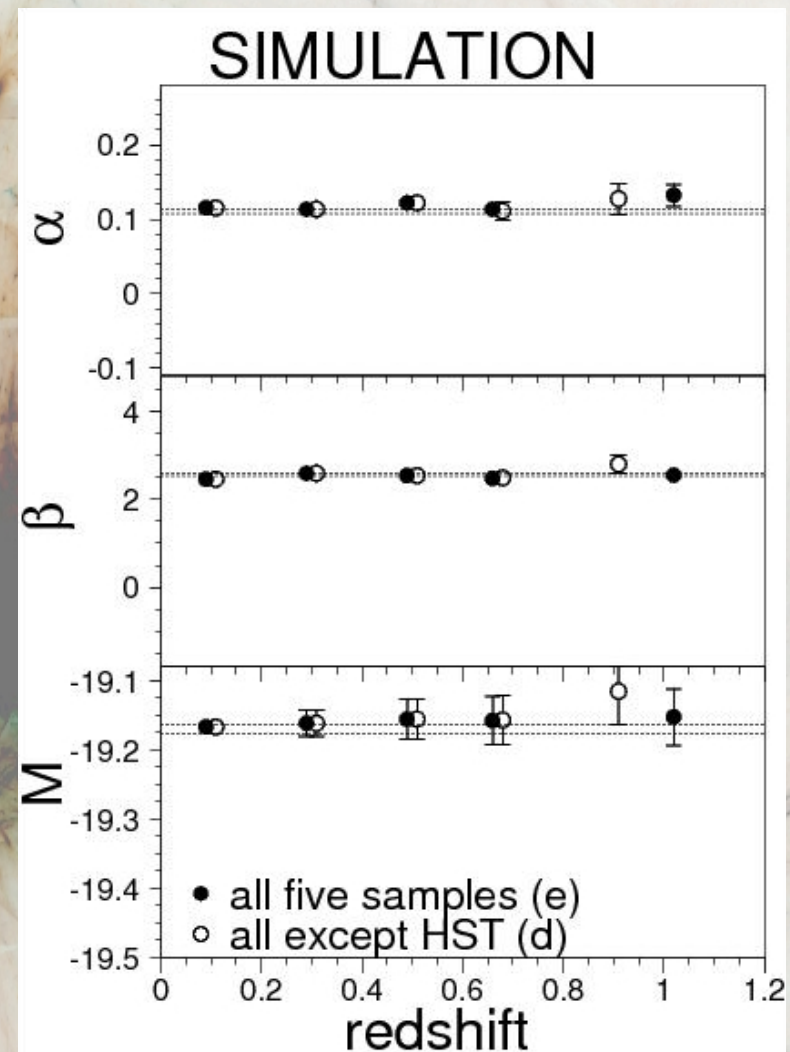
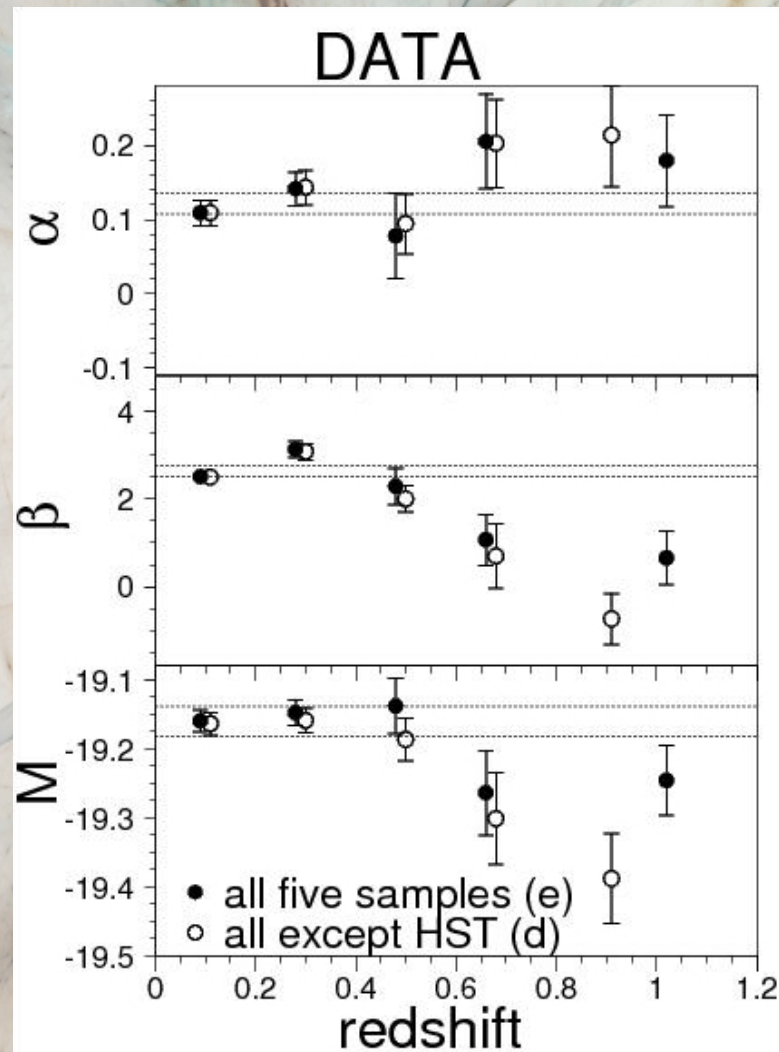
Conley et al. 2008

again, MW extinction laws do not seem to work → **combination of dust + intrinsic?**

evidence for redshift dependence of β



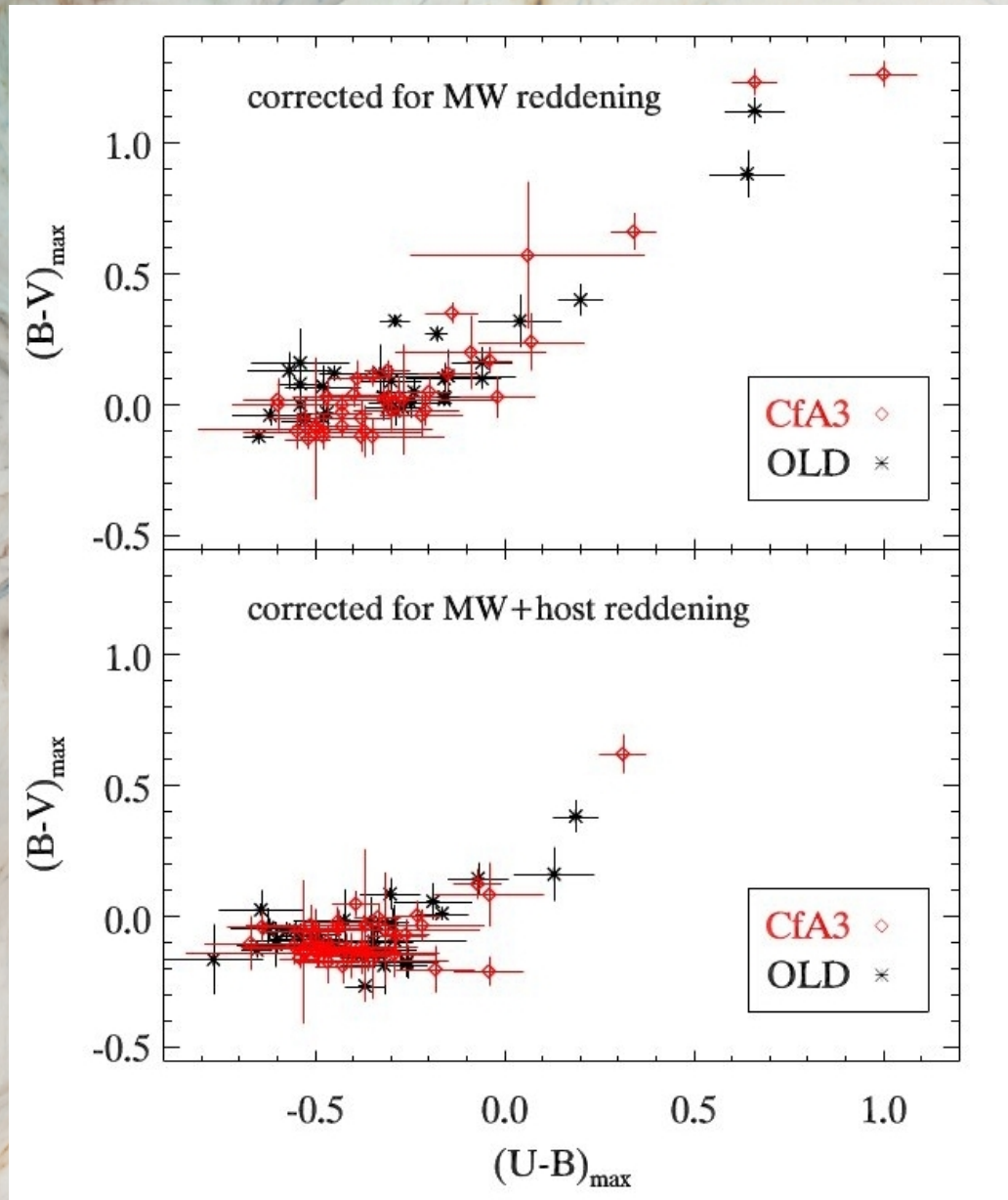
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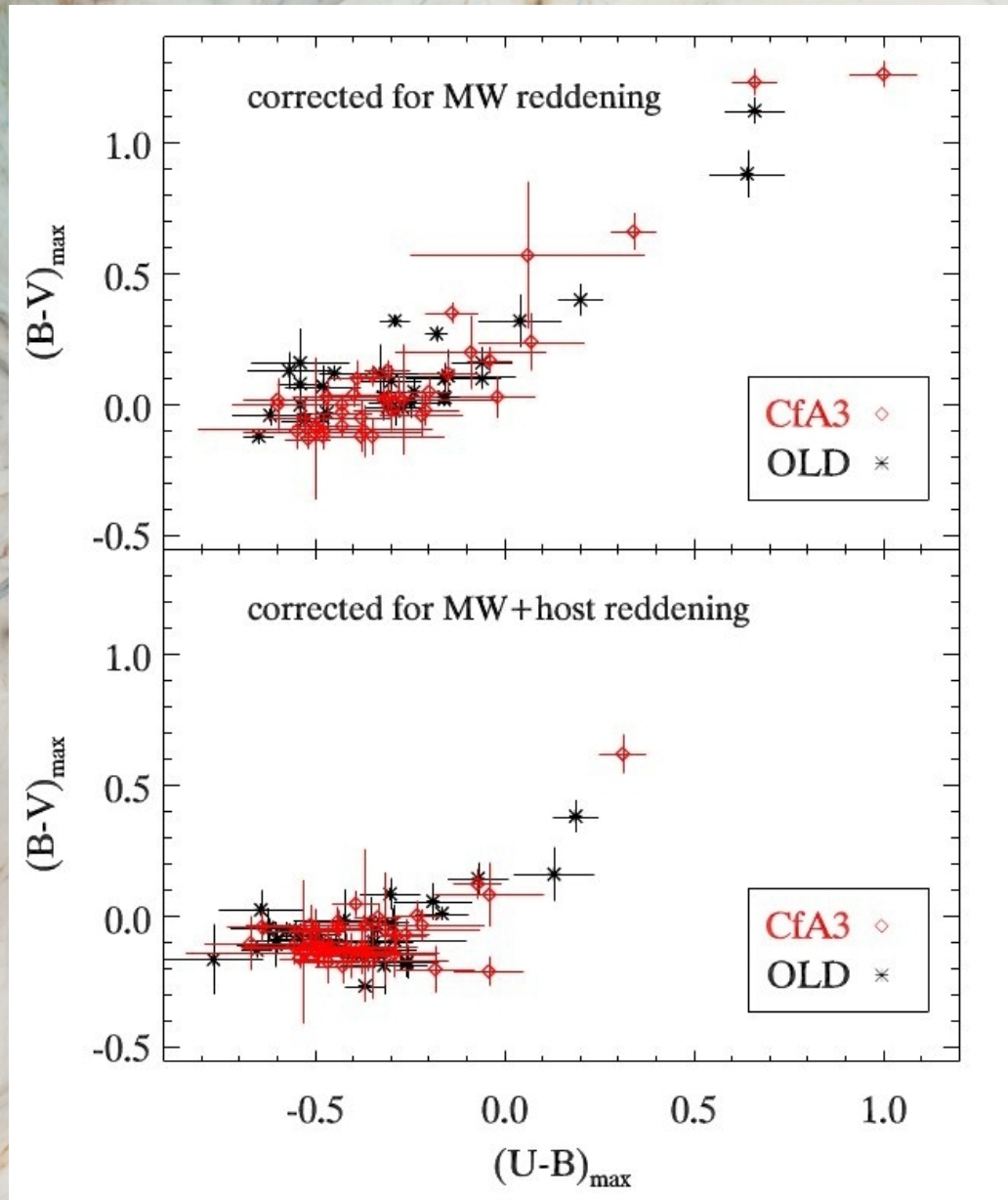
Kessler et al. 2009

SDSS-II SN sample: $R_V = 2.18 \pm 0.14_{\text{stat}} \pm 0.48_{\text{syst}}$

color-color diagram (nearby SNe Ia)

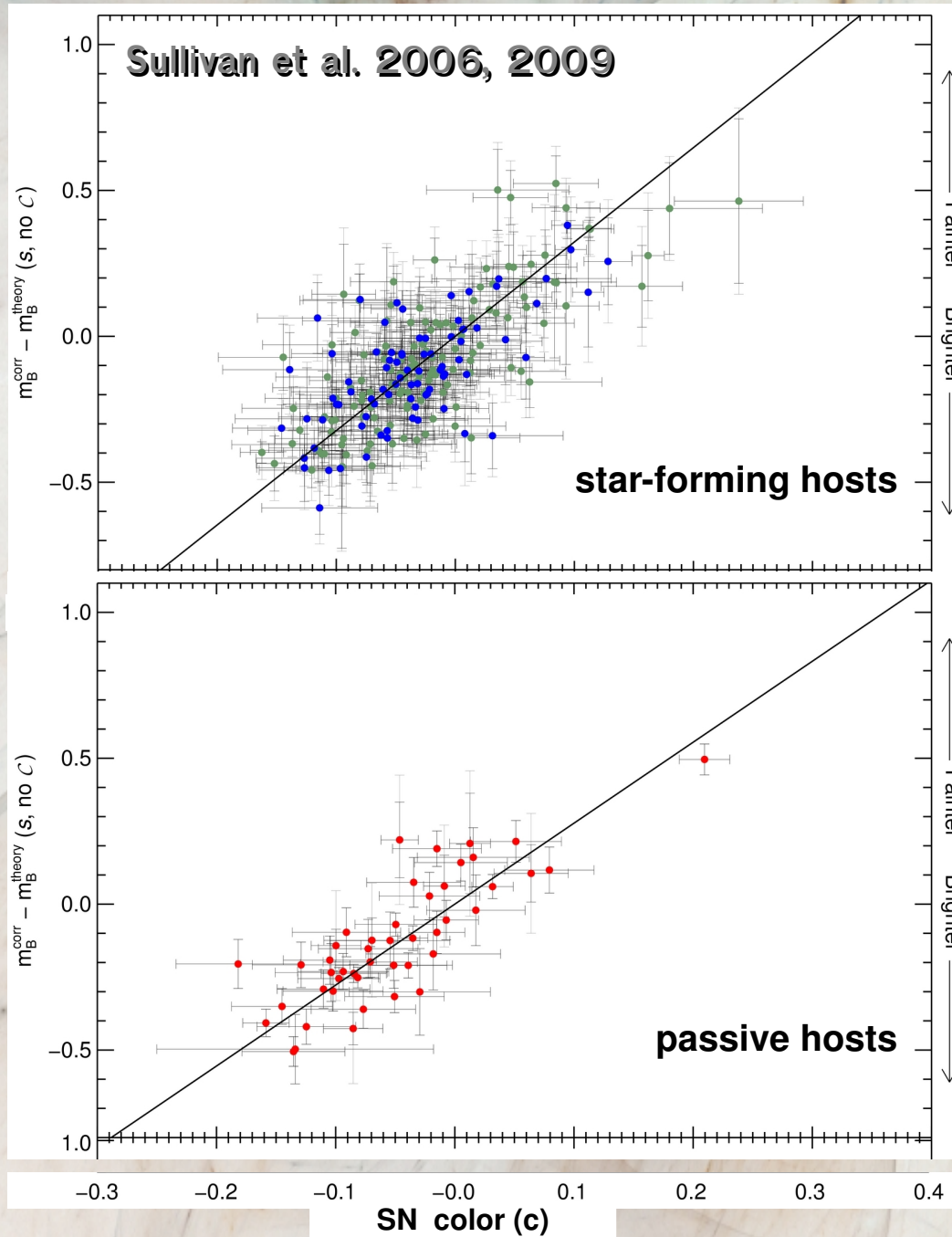


color-color diagram (nearby SNe Ia)



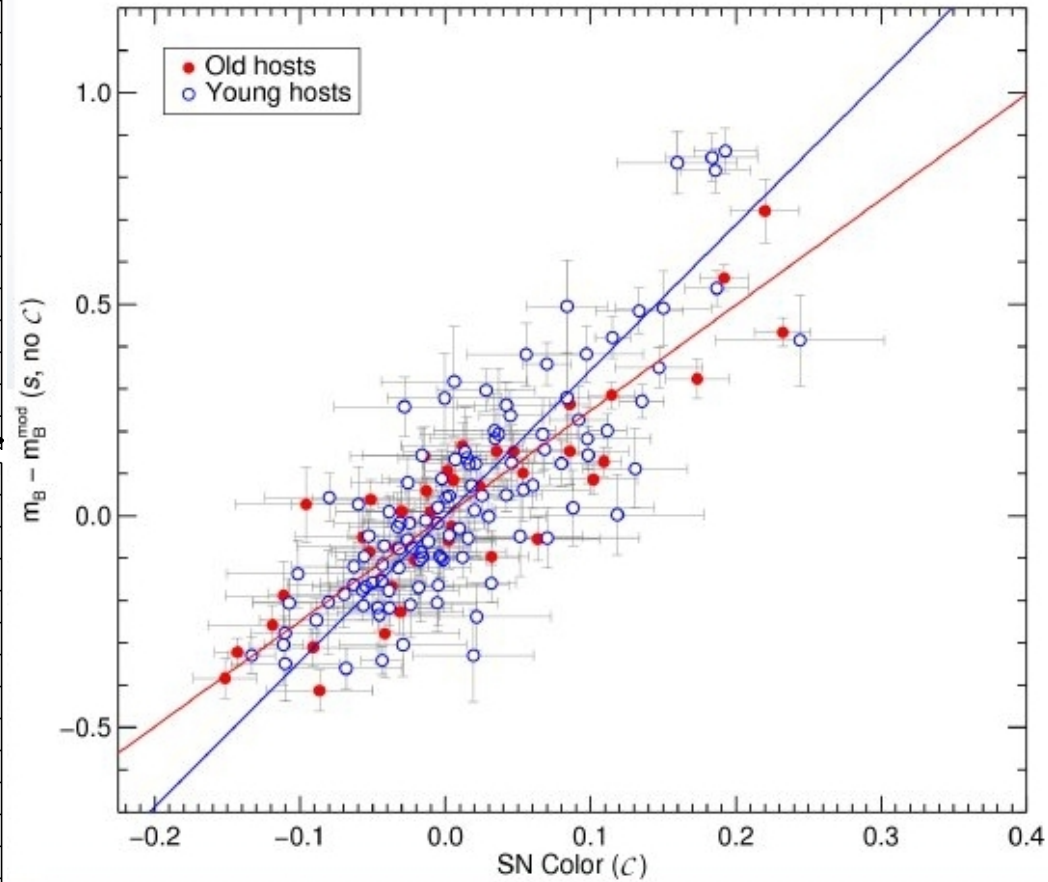
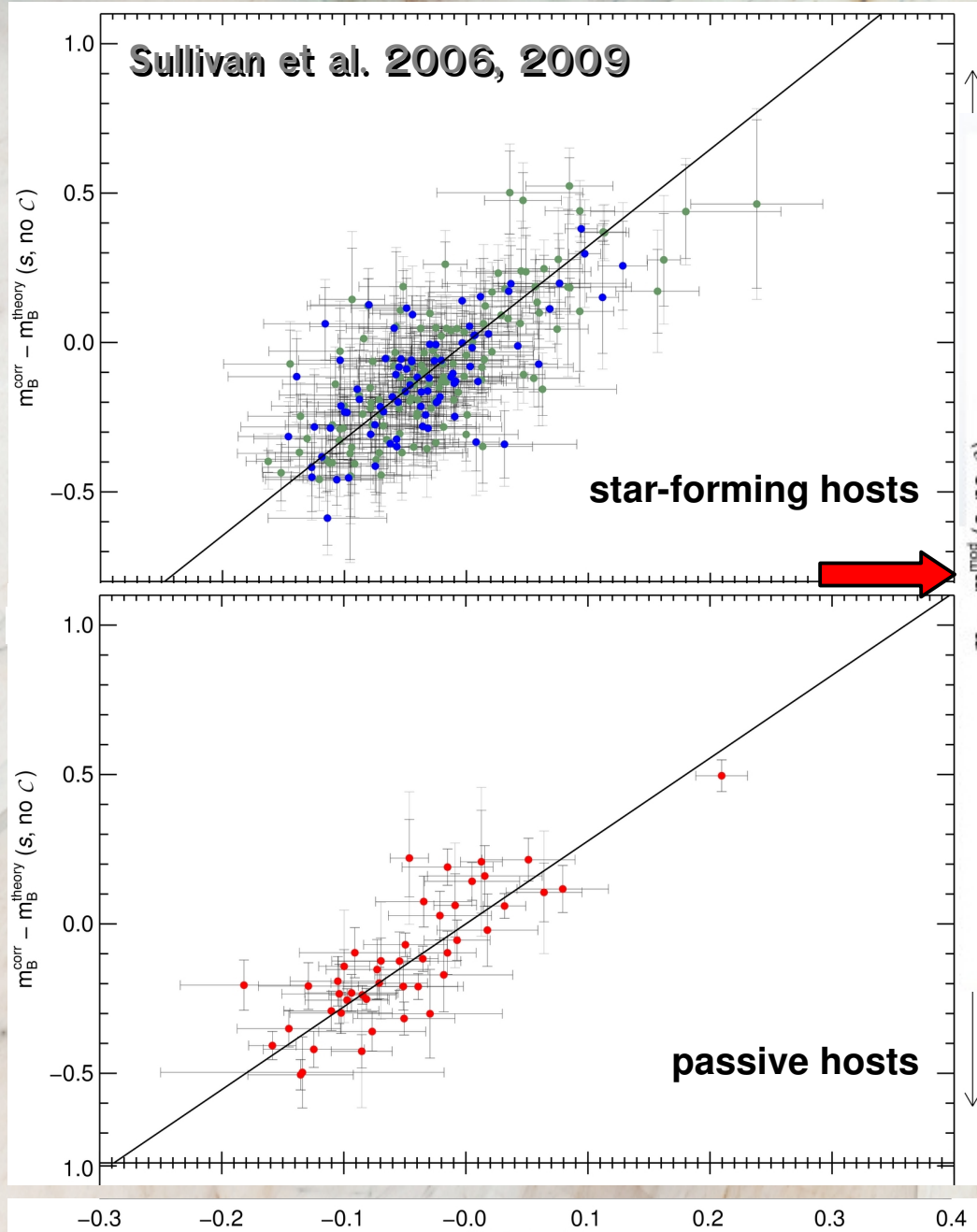
MLCS2k2 fitter, $R_v=1.7$
proposed tighter color range:
 $-0.2 < c < 0.1$

brighter - bluer relation: split by host types



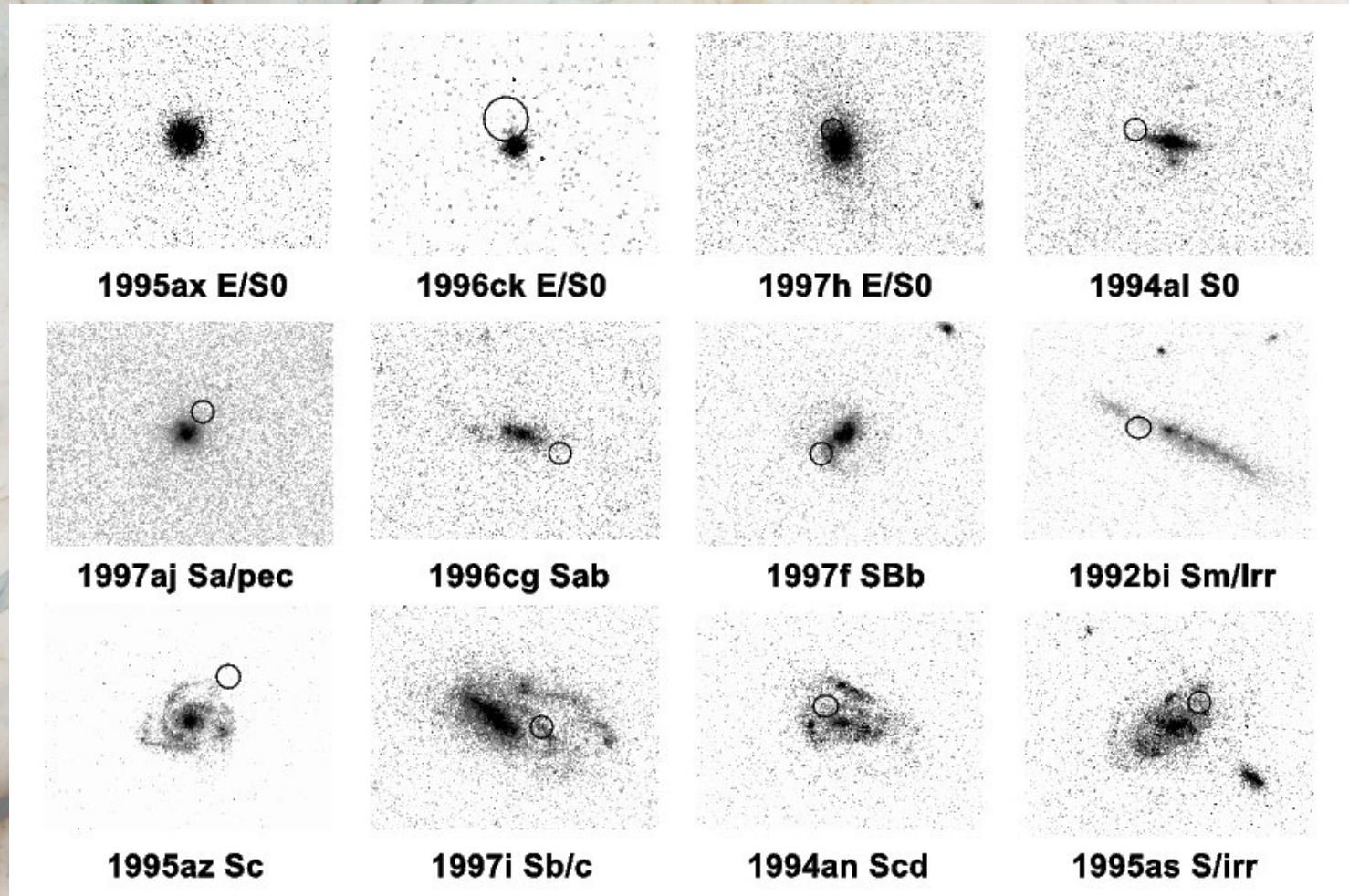
in order to have a unique color correction for all SNe:
passive host galaxies have dust or intrinsic color relation dominates over dust?

brighter - bluer relation: split by host types



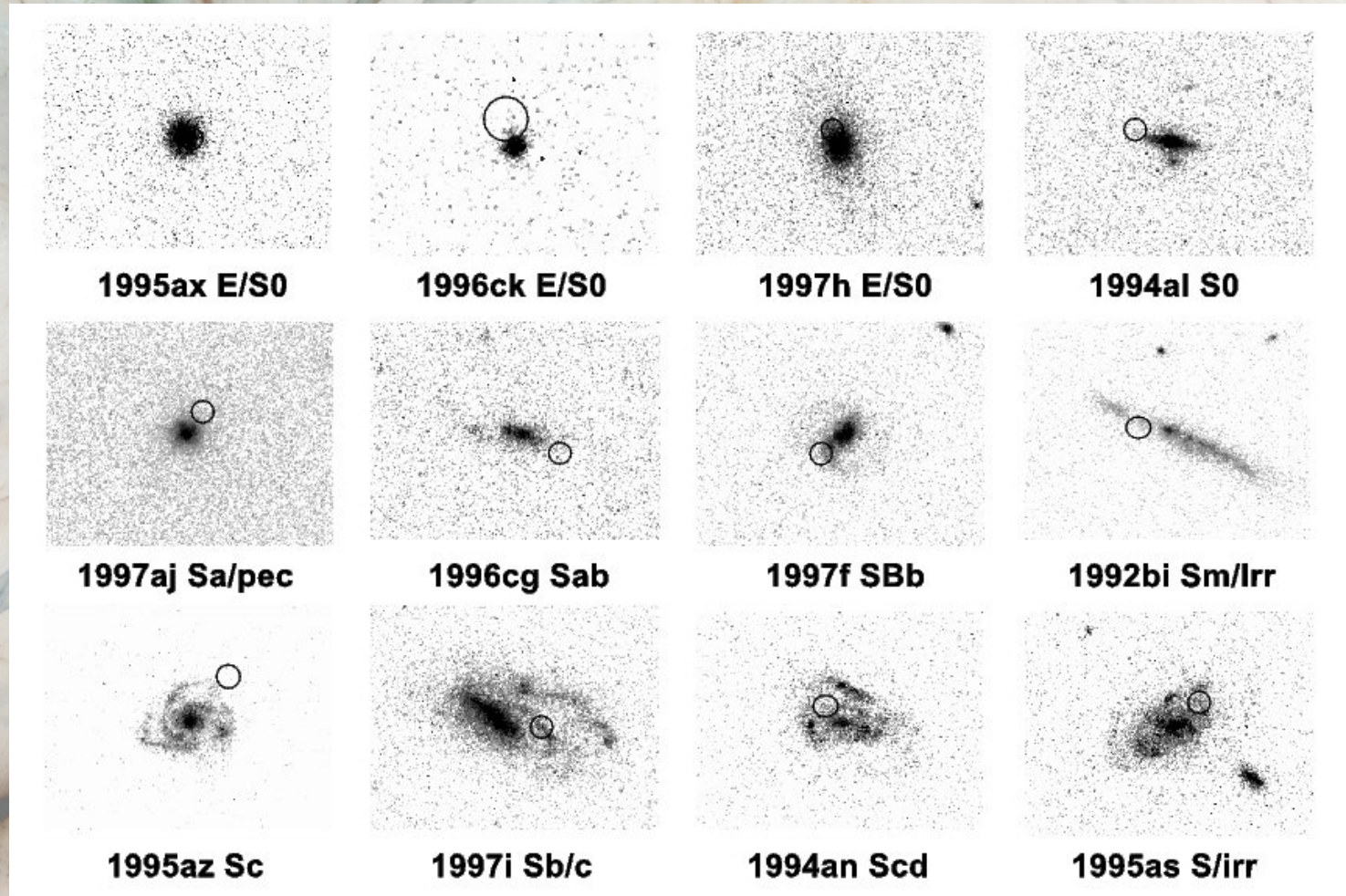
indications that R_V is larger in younger galaxies

host galaxy morphology



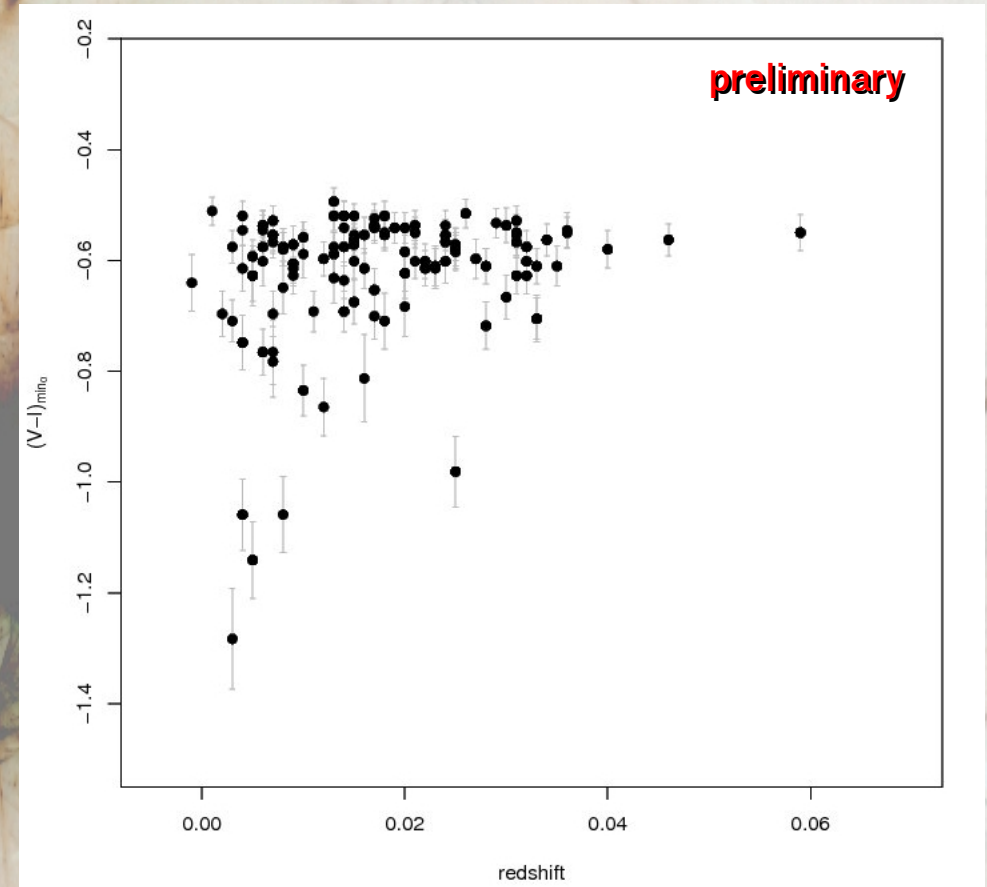
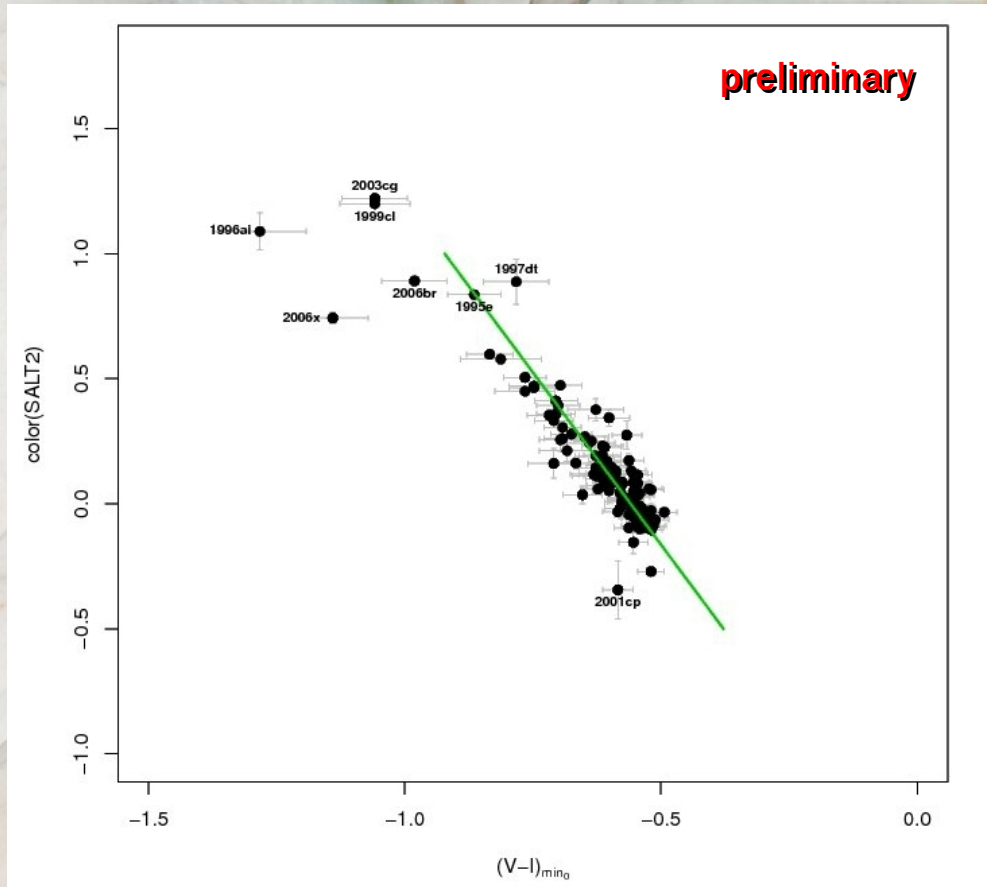
grains in dust size distribution (larger $R_v \Leftrightarrow$ larger dust grains)

host galaxy morphology



grains in dust size distribution (larger $R_v \Leftrightarrow$ larger dust grains): **trade-off**

$$(V-I)_{\text{obs}} = (V-I)_0 + E(V-I)_{\text{MW}} + E(V-I)_{\text{host}} + K_{V-I}$$



conclusions / future prospects

- color corrections are the dominant uncertainty ($\Delta R_v \sim 1 \Leftrightarrow \Delta w \sim 0.04$)
- more efforts needed to disentangle dust and intrinsic effects
- SNe in passive or elliptical galaxies seem more powerful probe for cosmology, but are rarer
- construct Hubble diagrams for subsamples based on host type
- study dust size distribution and potential dust evolution in galaxies

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thank you