Stretch-Parameterized Light Curves for High-Redshift SNIa Studies

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Aug 5 1997

This work was supported by the Director, Office of Science, Office of High Energy Physics, of the U.S.\ Department of Energy under Contract No. DE-AC02-05CH11231.

Objective

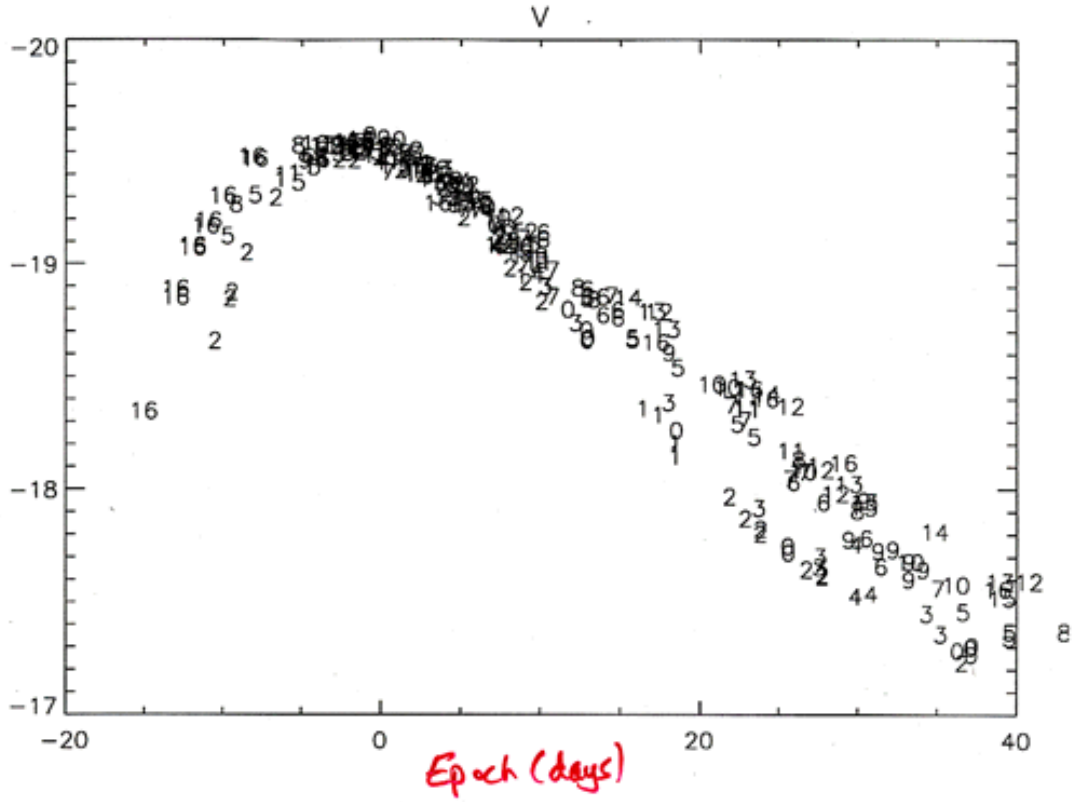
Create a SNIa lightcurve template optimized to fit hi-z SN magnitudes

- Continuous parametrization
- Simple model for lightcurves
- No biases
- B lightcurve a good magnitude indicator
- Measure host extinction (hmmm...)
- Template uncertainties and covariance
- Confined to B & V lightcurves at early epochs
- Low dispersion on Hubble diagram

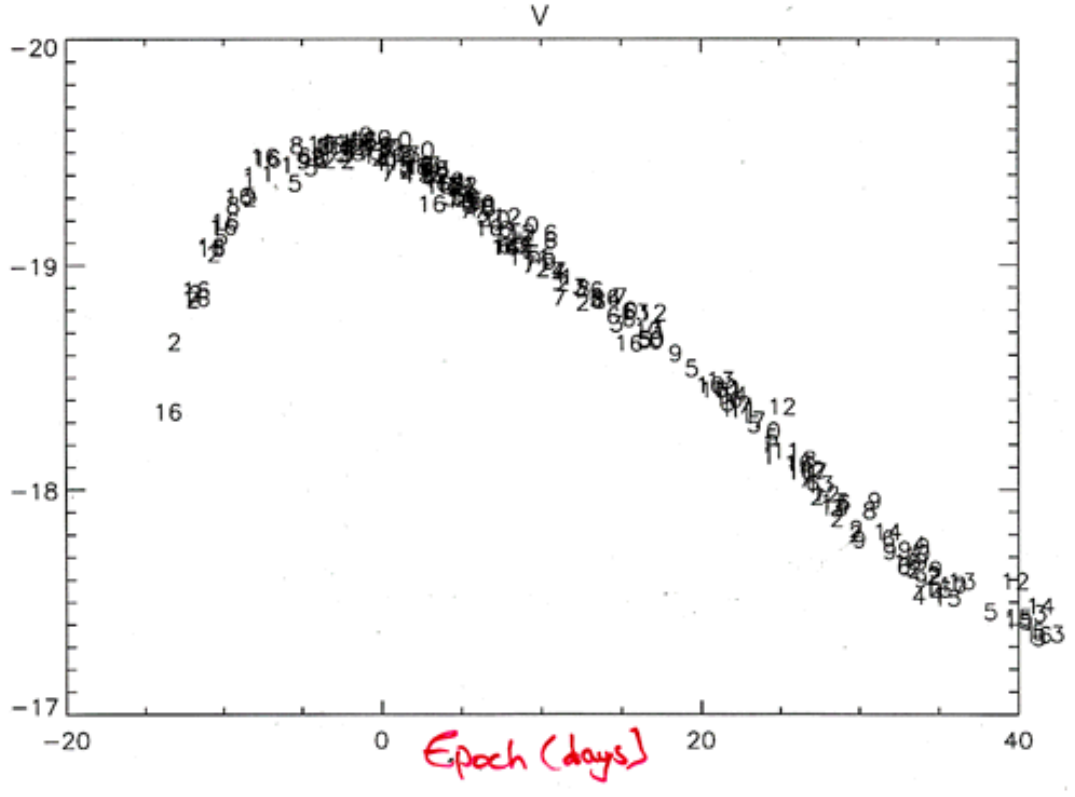
Plan

1. Motivate our template model
2. Describe the model
   (Perlmutter et al. ApJ 483, 565 (1997))
3. The template!
4. Testing the template.
5. Other interesting results

Hamuy et al. A.J. 112, 2408 1996

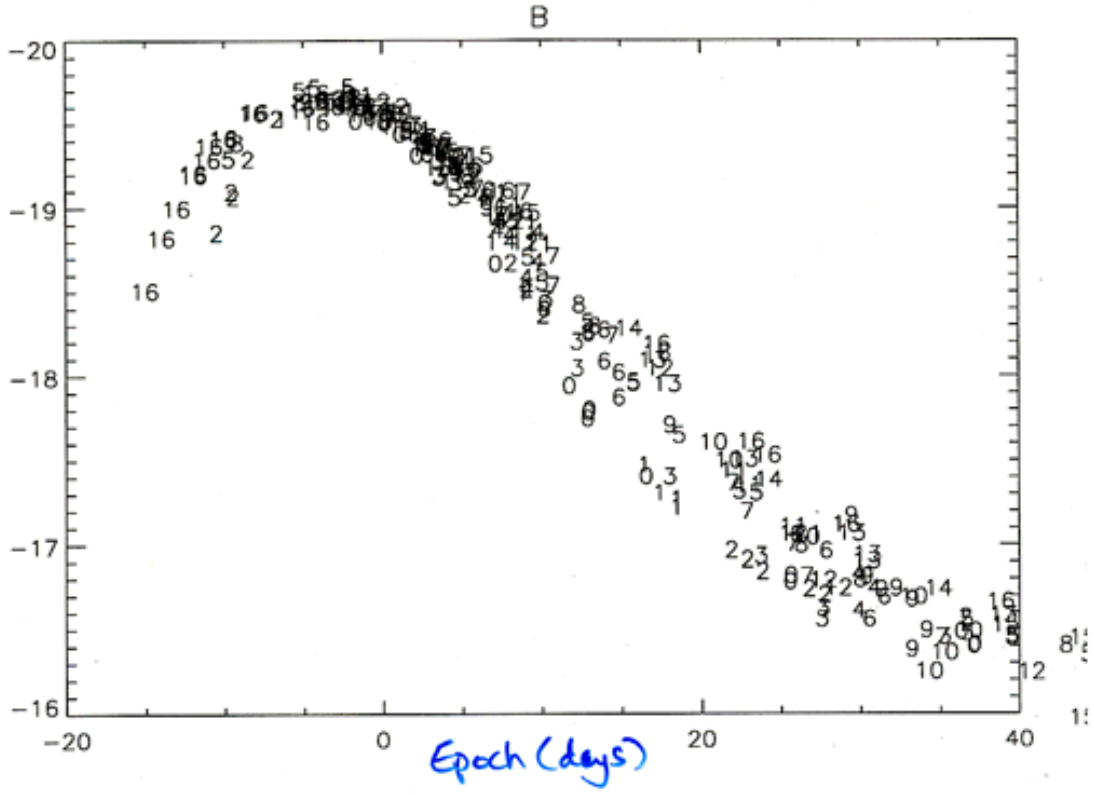


V

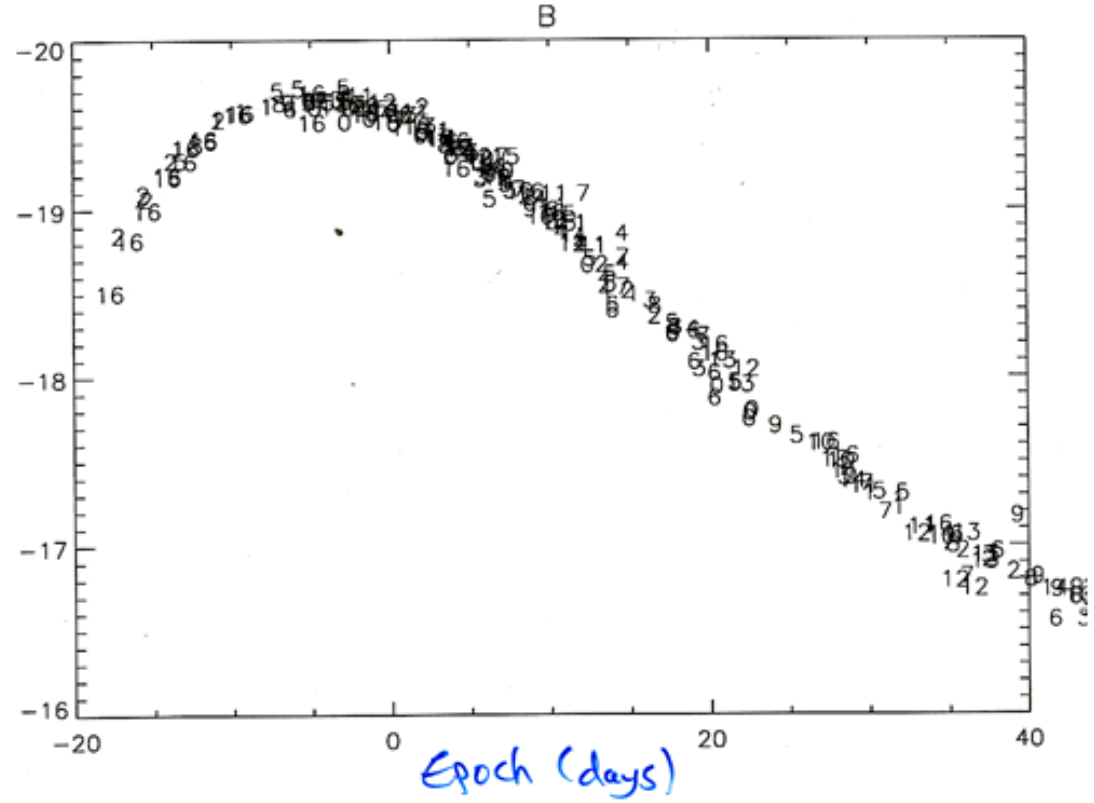


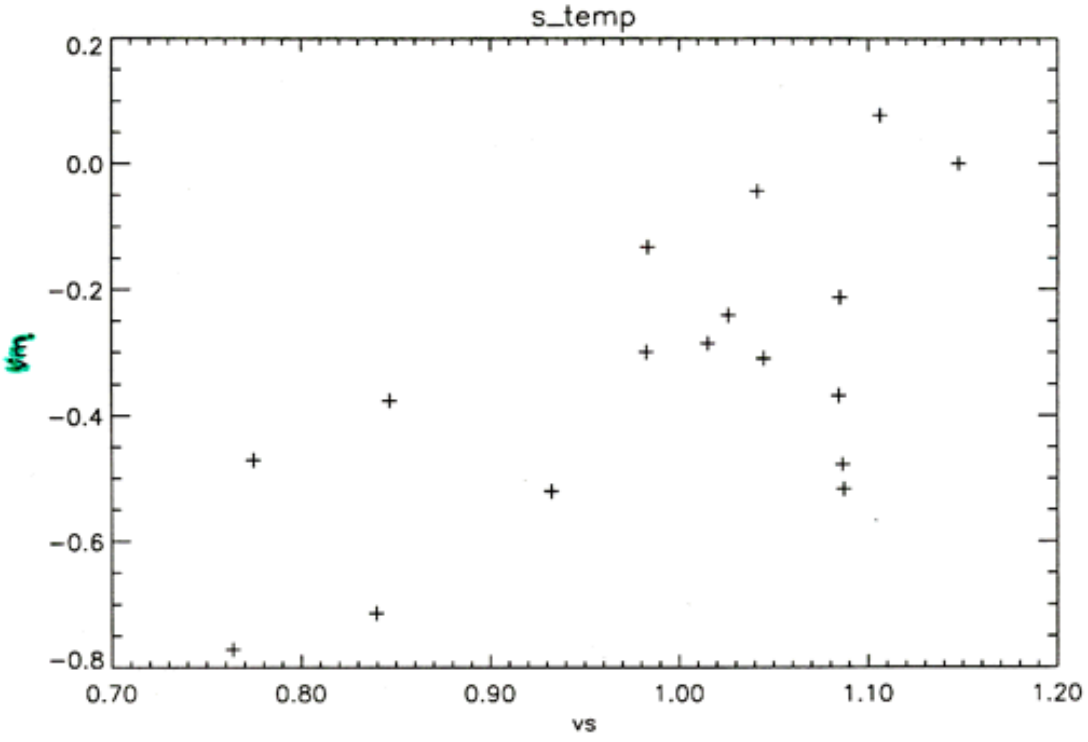
V

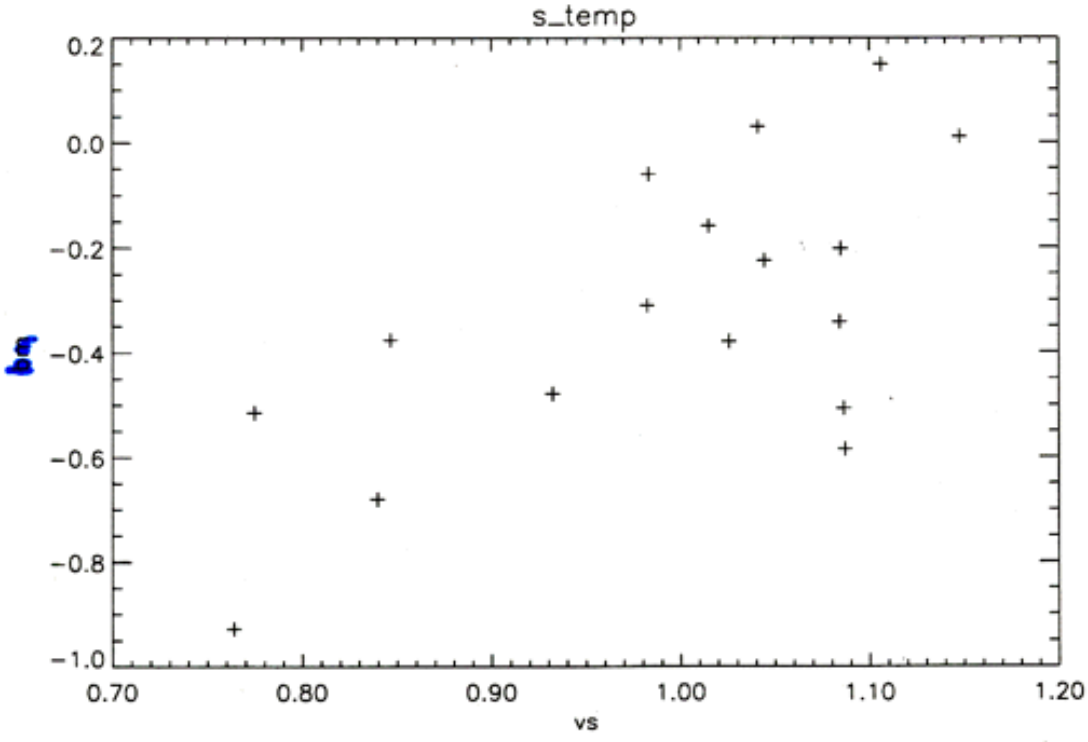
B

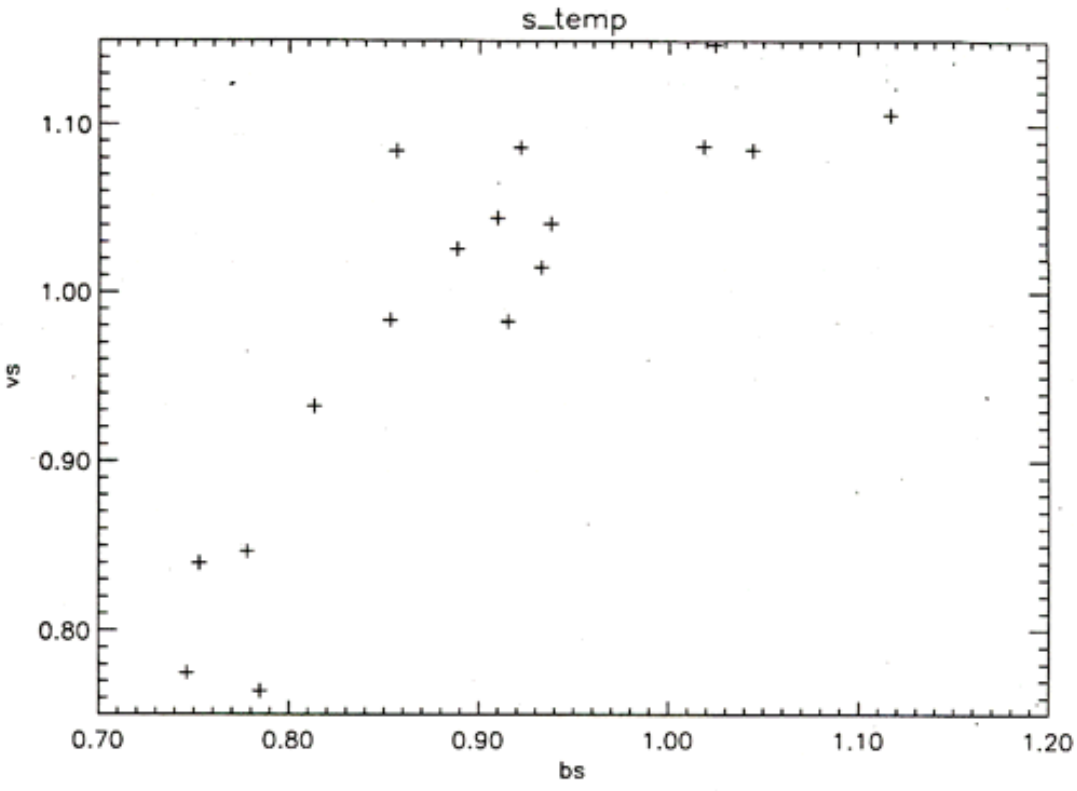

B
−20
−19
−18
−17
−16
−20
0
20
40
Epoch (days)

B

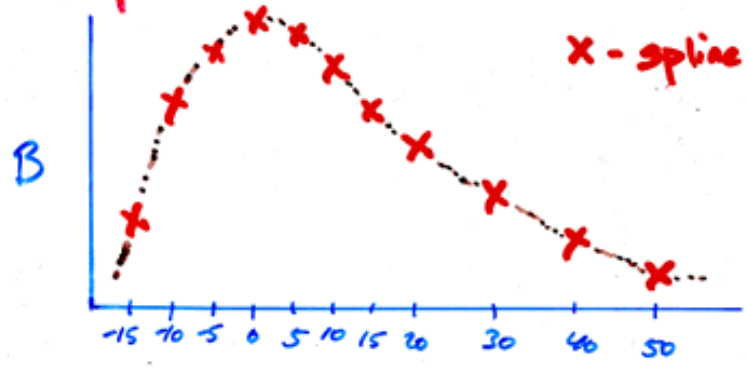

B
−20
−19
−18
−17
−16
−20
0
20
40
Epoch (days)


s_temp
0.2
0.0
−0.2
−0.4
−0.6
−0.8
0.70
0.80
0.90
1.00
1.10
1.20
vs

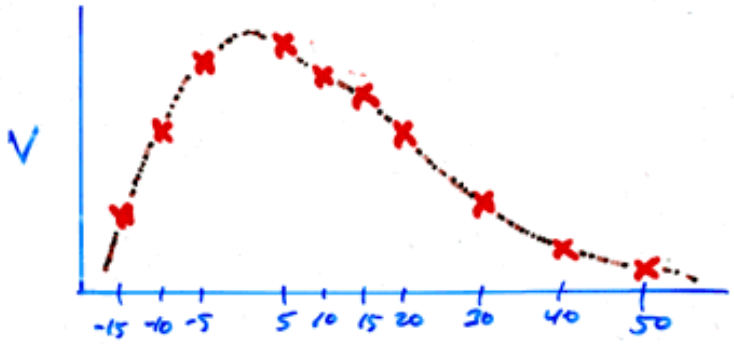

s_temp
0.2
0.0
−0.2
−0.4
−0.6
−0.8
−1.0
0.70
0.80
0.90
1.00
1.10
1.20
vs


s_temp
1.10
1.00
0.90
0.80
vs
0.70
0.80
0.90
1.00
1.10
1.20
bs

Template Model



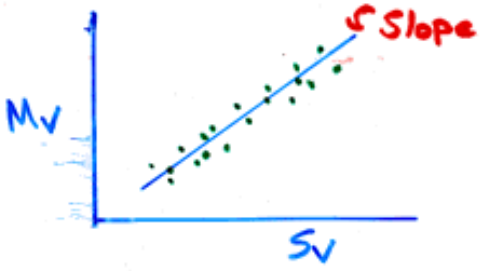
X - spline knots

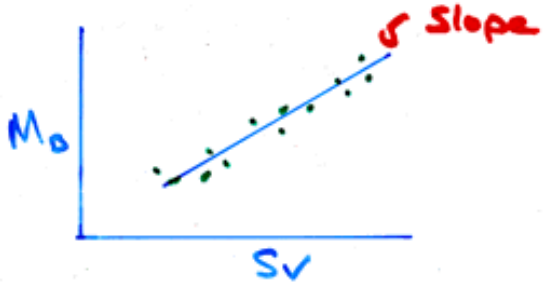


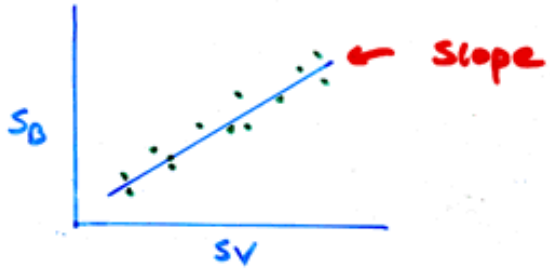
for $s_v = 1$

$M_V = -19.475$

$H_0 = 65$ km/s/Mpc



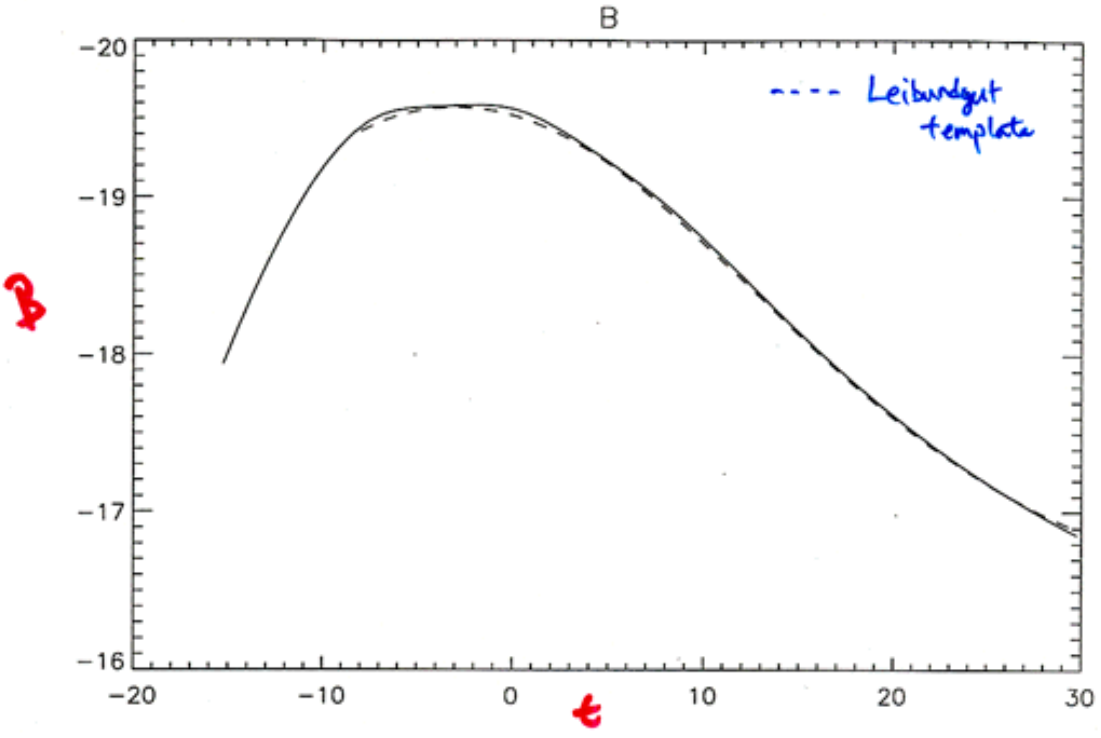


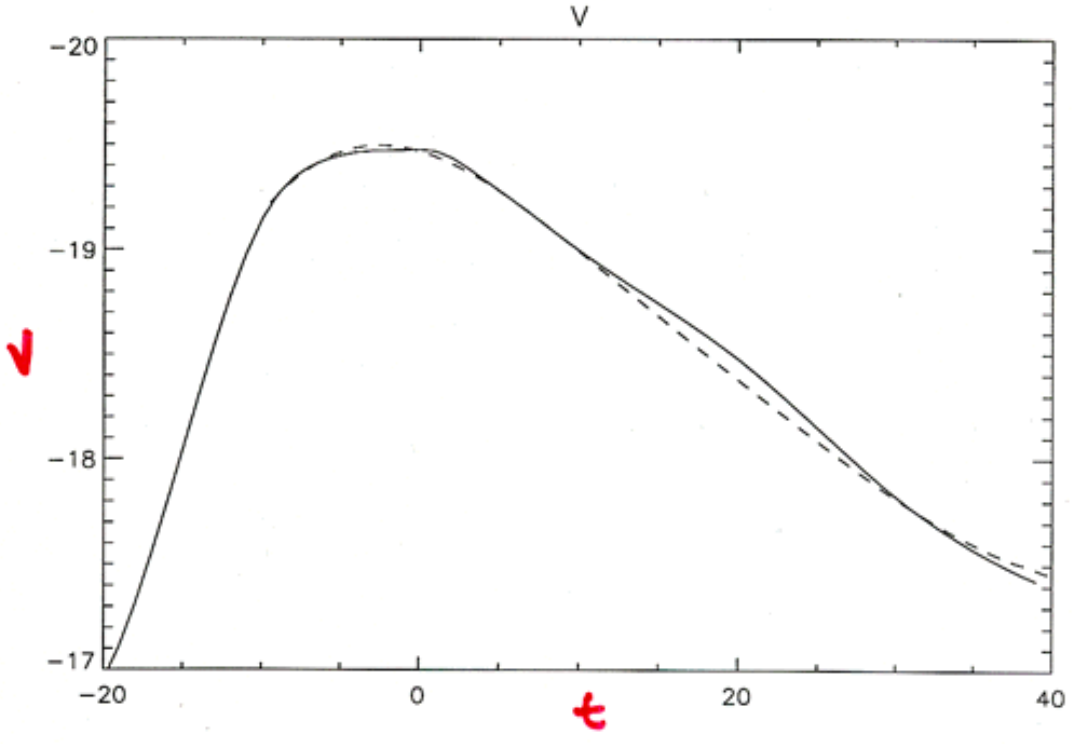


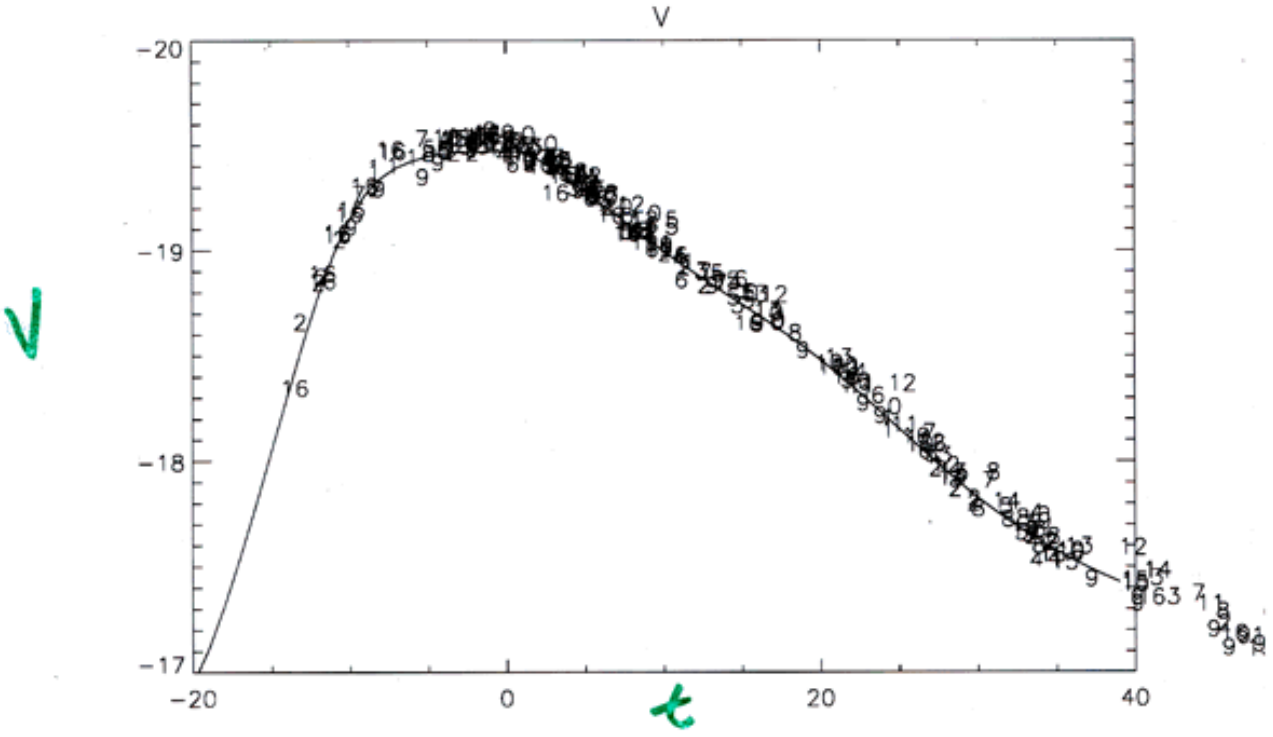
And for each supernova in the training set

s_V, t_{max}, $E(B-V)$ $\begin{cases} R_B = 4.1 \\ R_V = 3.1 \end{cases}$

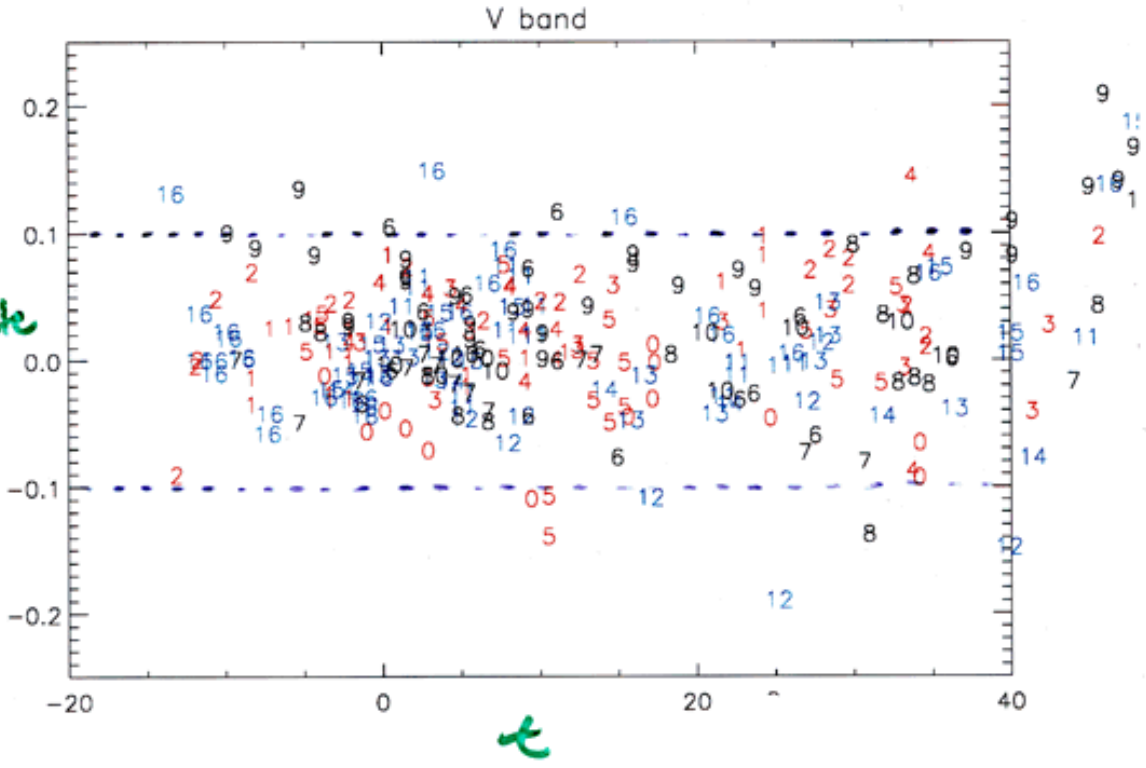
$\Delta t_{max} = 2.4$ days



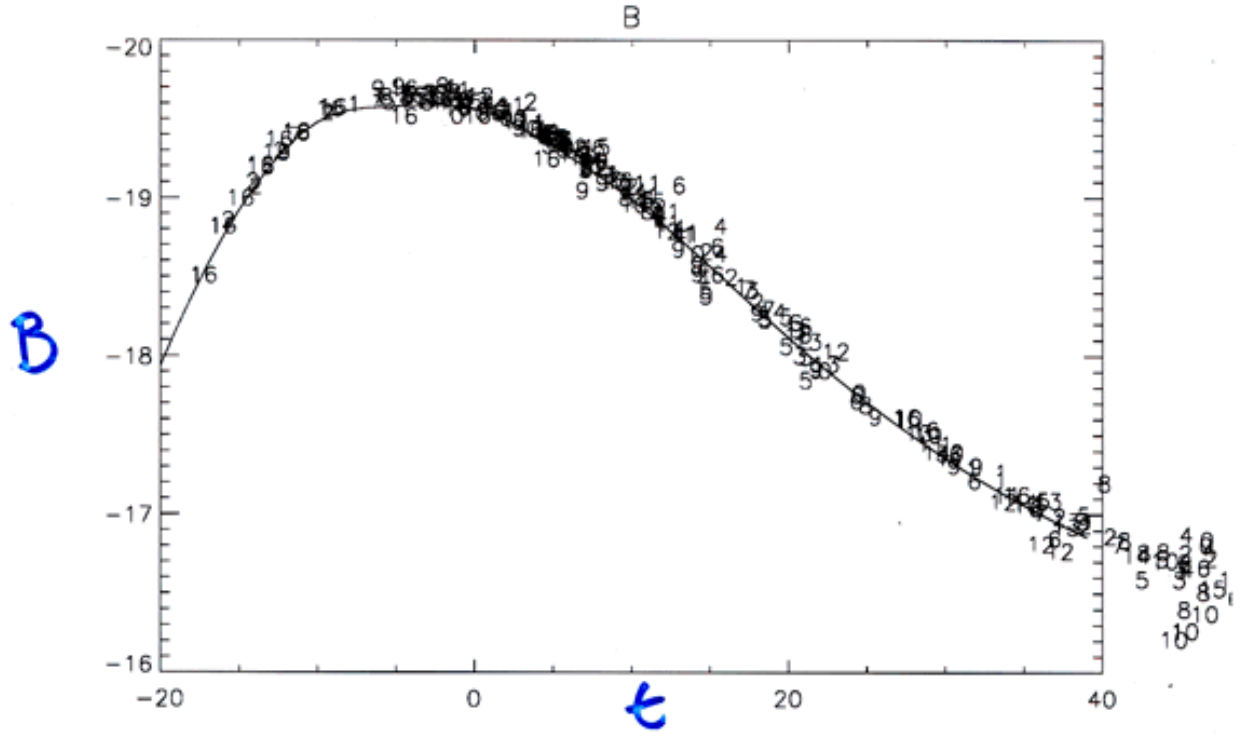


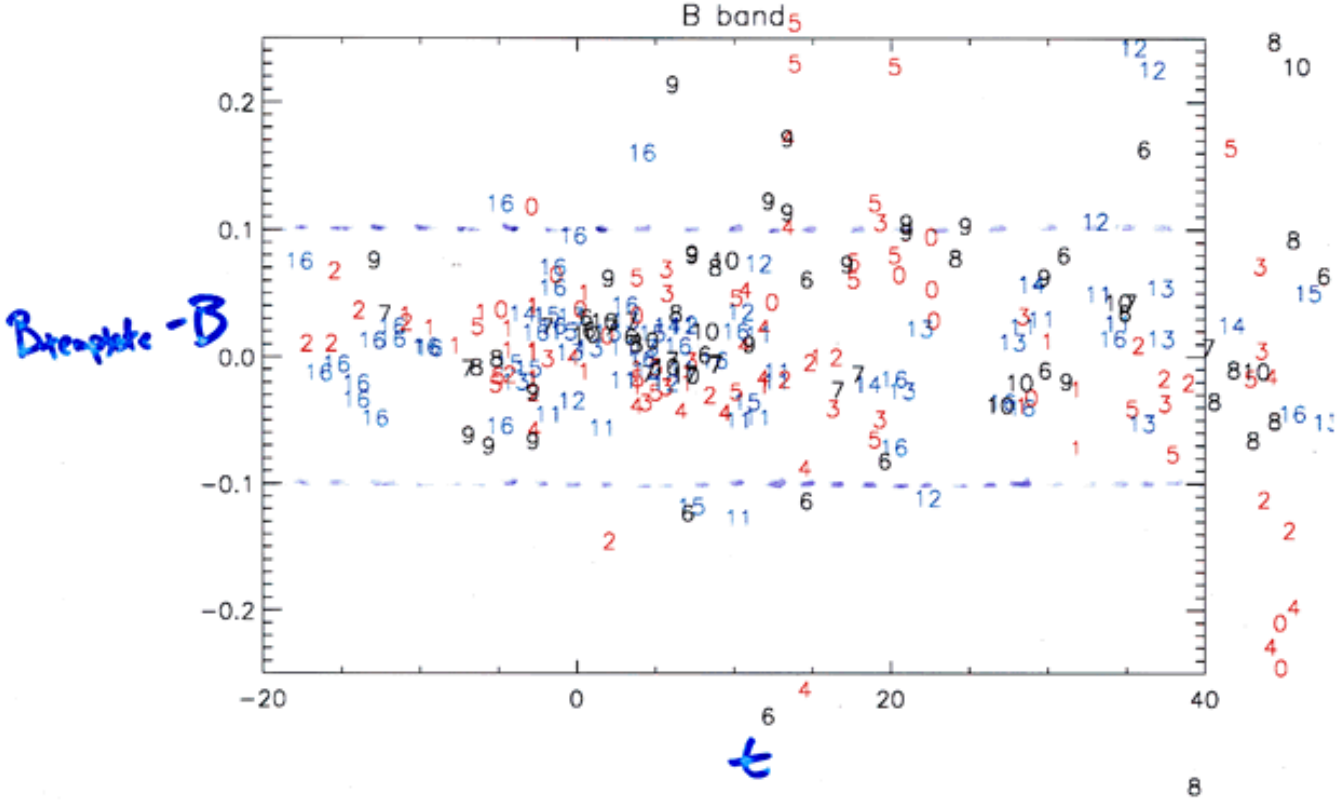


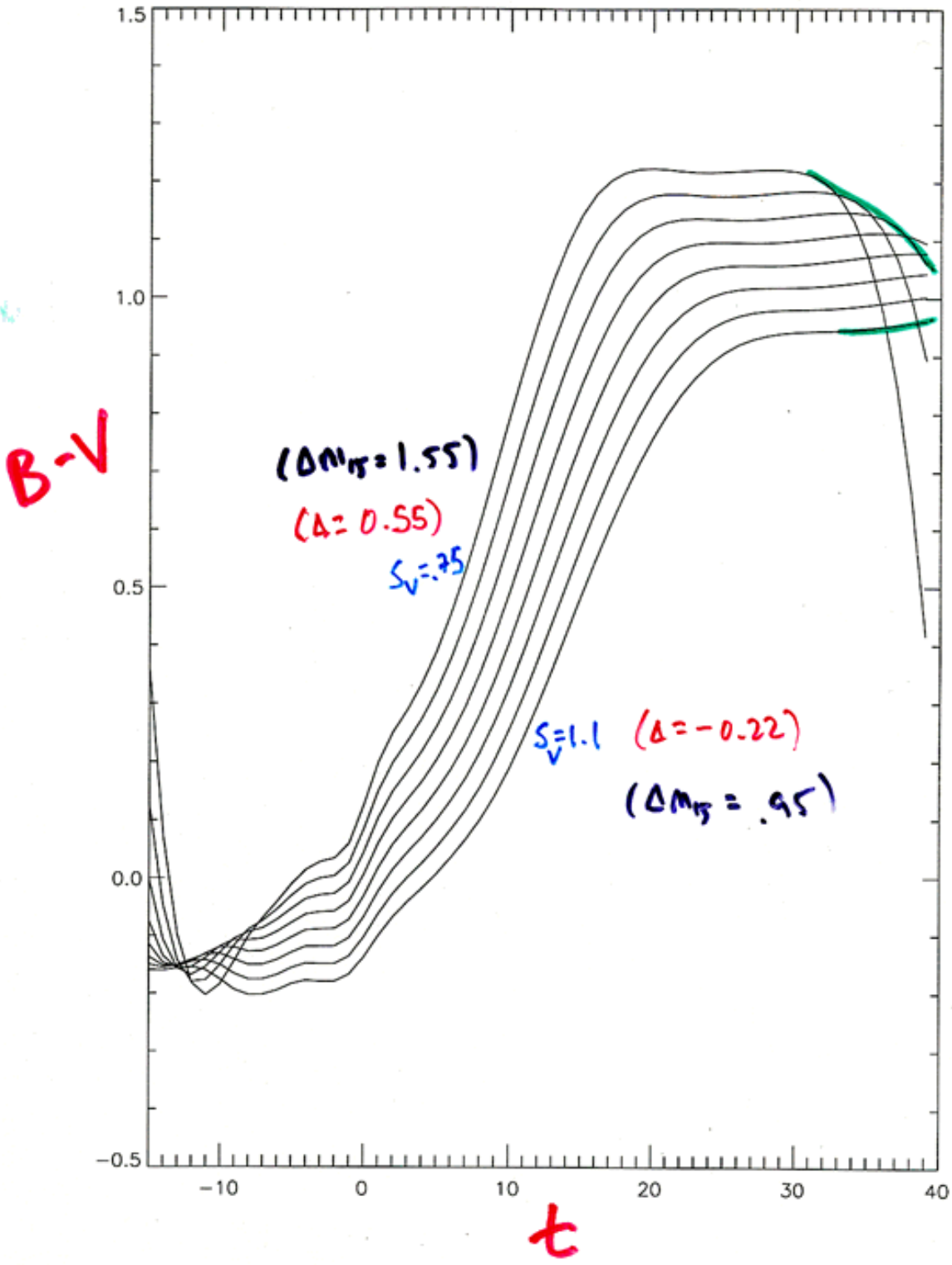
V

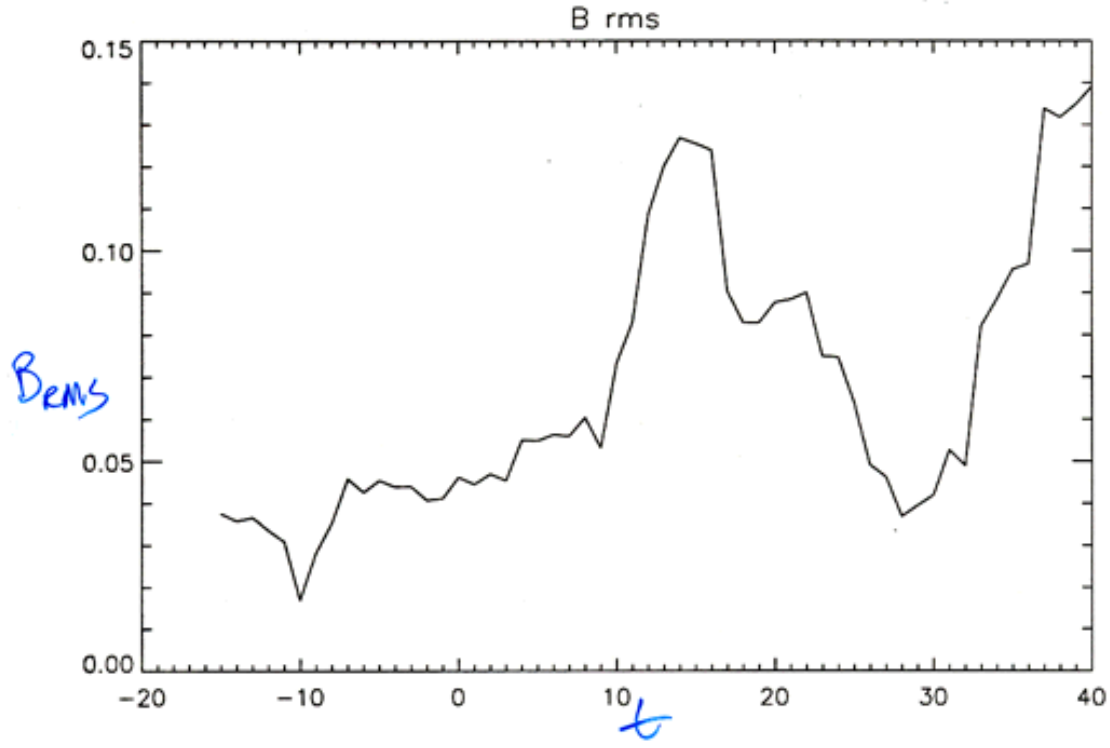


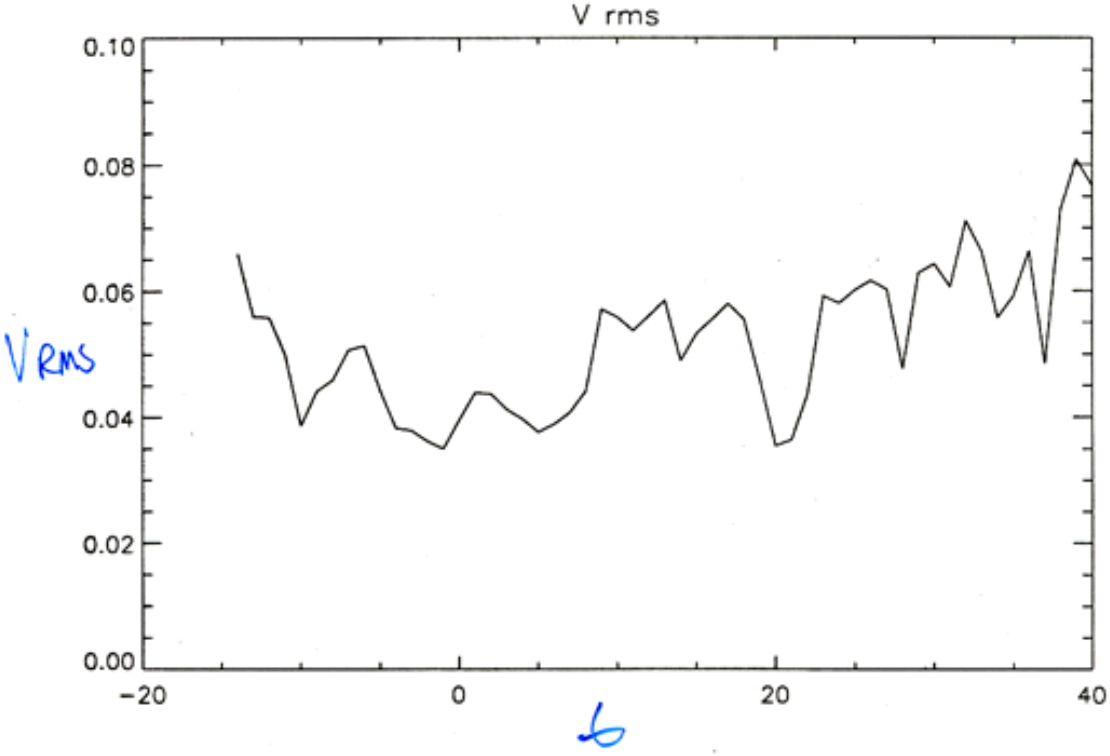
$-V+V_{Template}$

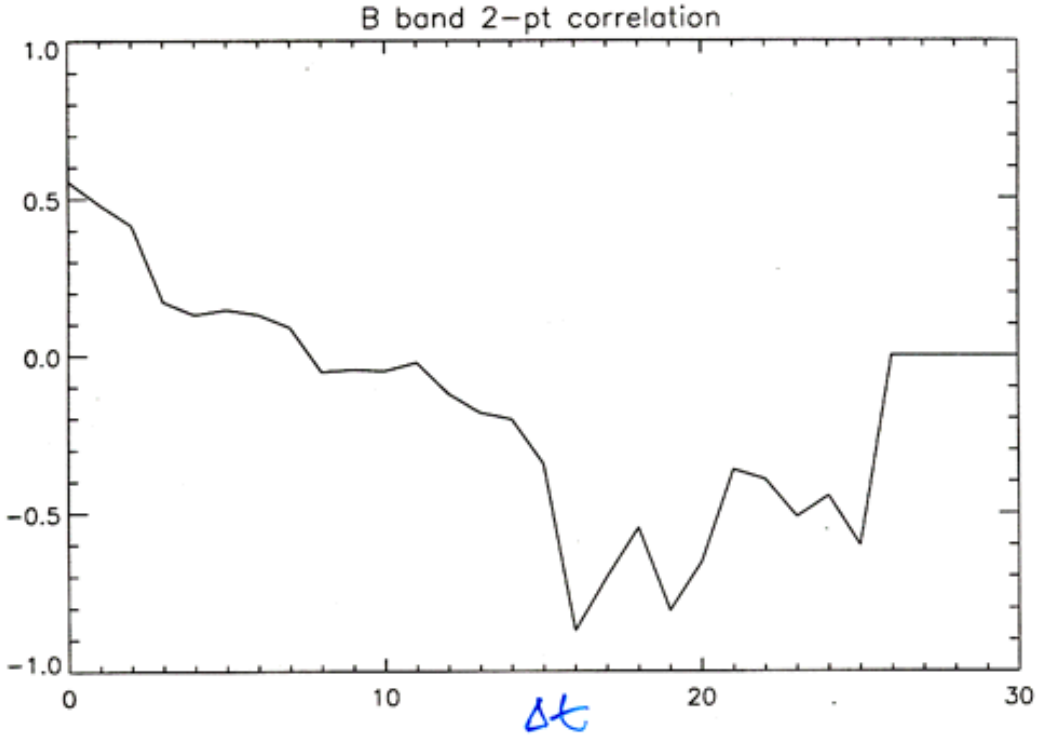

B
−20
−19
−18
−17
−16
−20
0
20
40
t
B

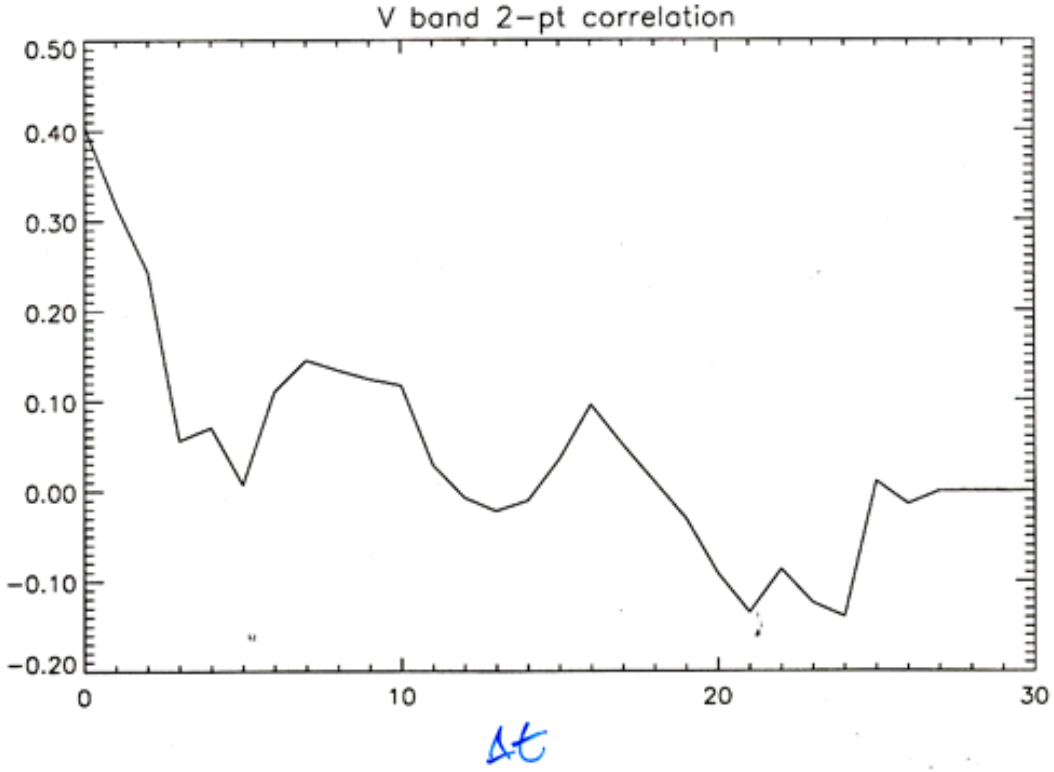

B band
0.2
0.1
0.0
−0.1
−0.2
−20
0
20
40
t
Bre-plate -B


1.5
1.0
0.5
0.0
−0.5
−10
0
10
20
30
40
B-V
t
(ΔM15 = 1.55)
(Δ = 0.55)
sV = .75
sV = 1.1
(Δ = −0.22)
(ΔM15 = .95)


B rms
0.15
0.10
0.05
0.00
−20
−10
0
10
20
30
40
B_{RMS}
t


V rms
0.10
0.08
0.06
0.04
0.02
0.00
−20
0
20
40
V_{RMS}
t

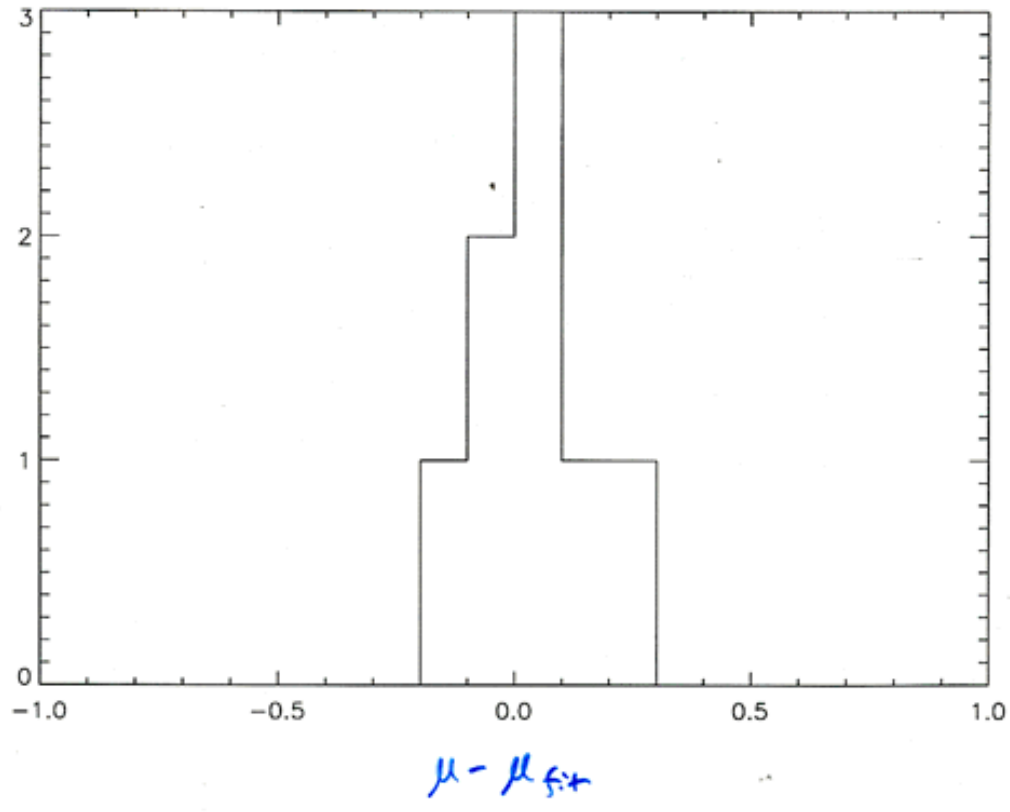

B band 2−pt correlation
1.0
0.5
0.0
−0.5
−1.0
0
10
20
30
Δt

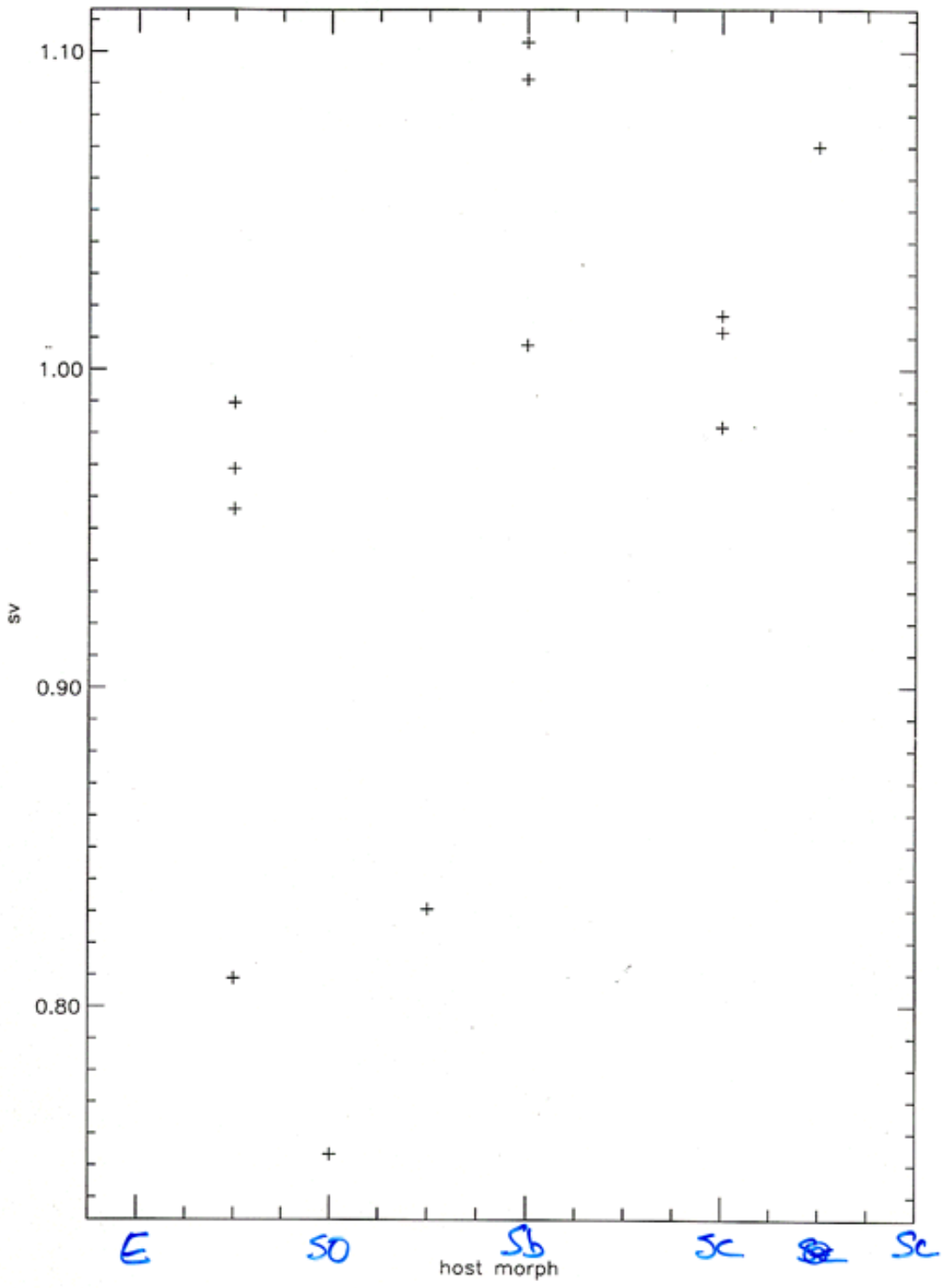

V band 2−pt correlation
0.50
0.40
0.30
0.20
0.10
0.00
−0.10
−0.20
0
10
20
30
Δt

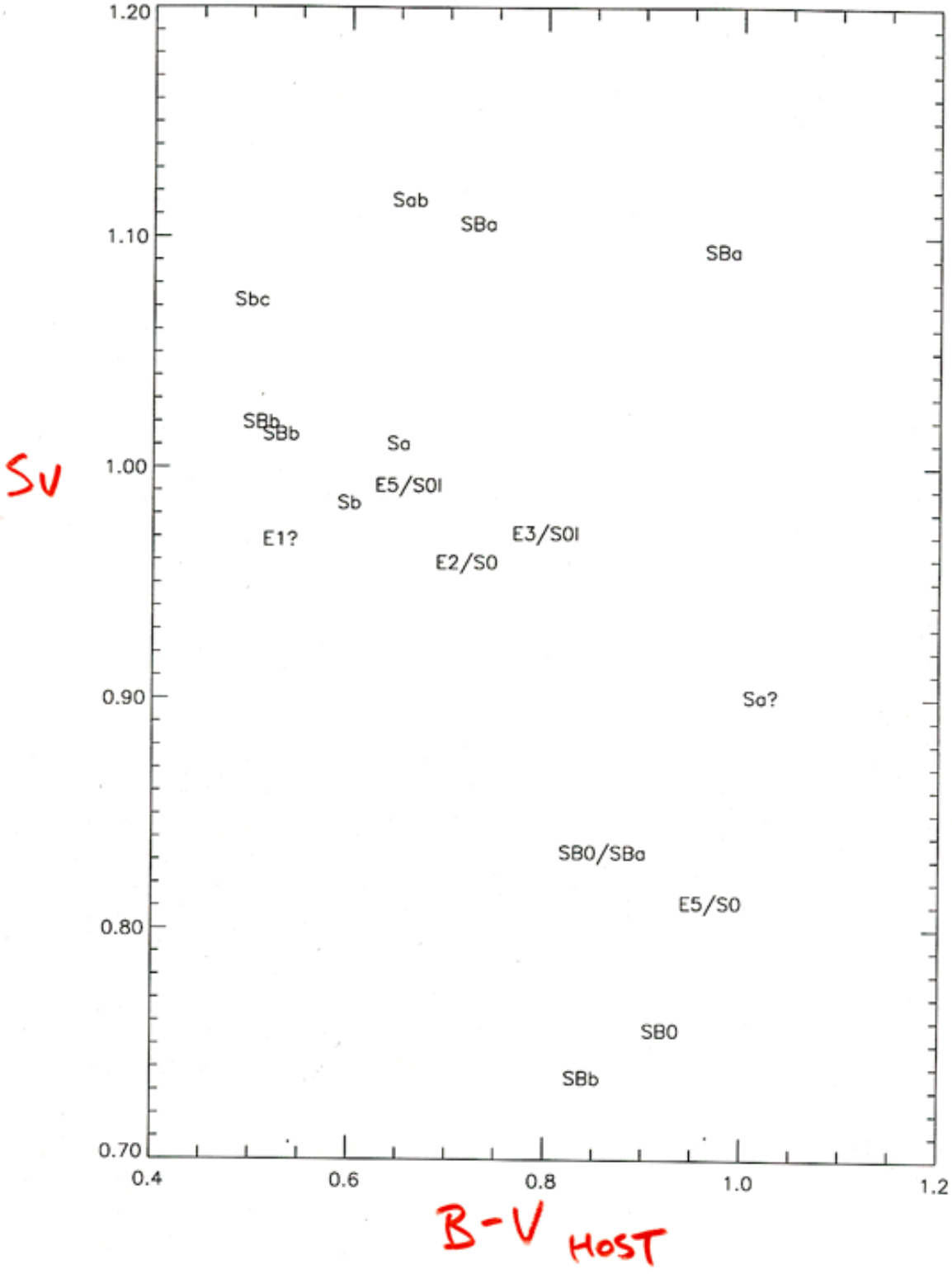
Result

- Split Hamuy et al. Sample magnitude dispersion from the Hubble diagram

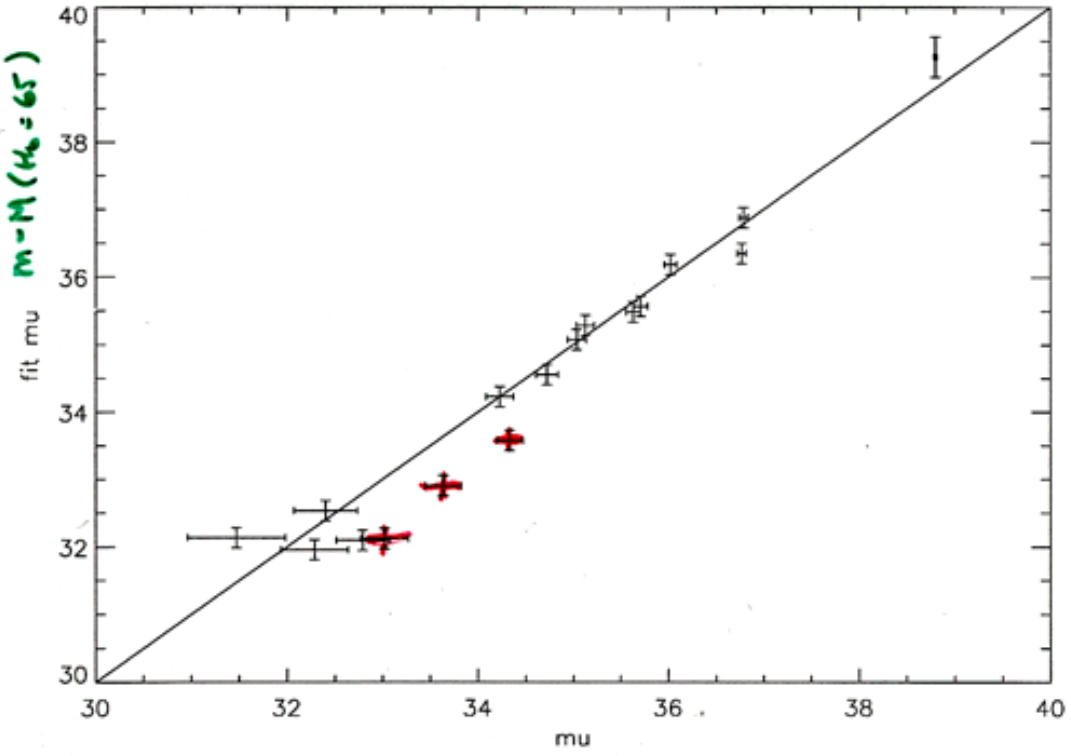
$$\sigma = 0.14 \text{ mag}$$




1.10
1.00
0.90
0.80
sv
E
S0
Sb
Sc
Sc
host morph

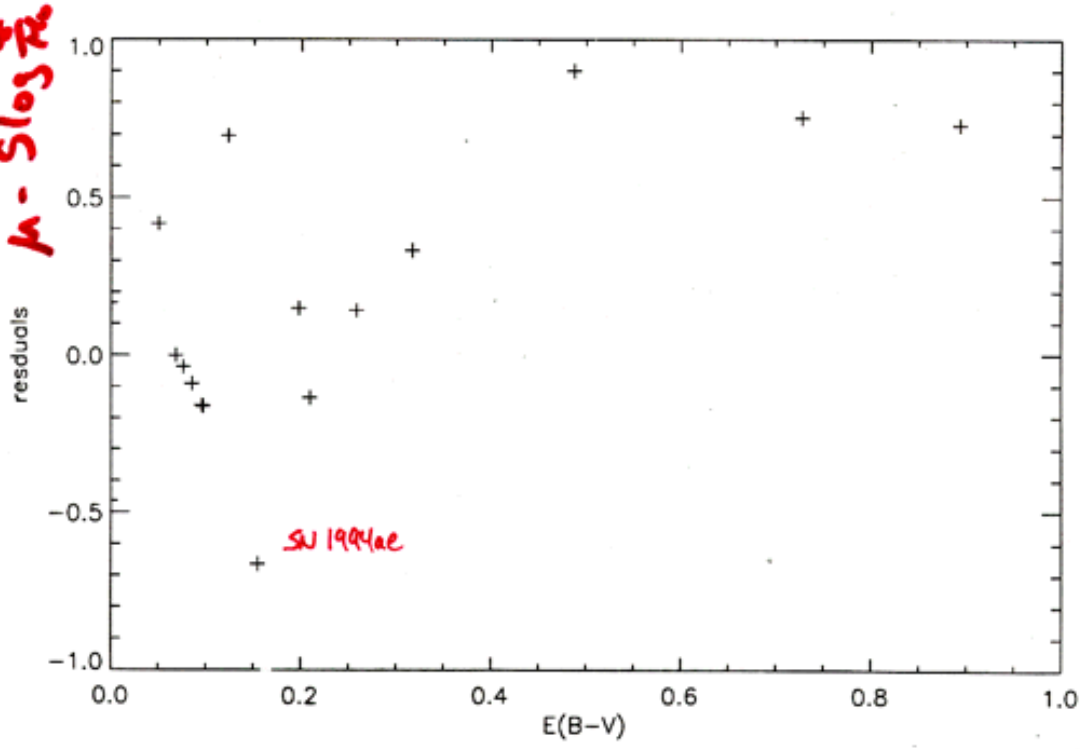

1.20
1.10
1.00
0.90
0.80
0.70
0.4
0.6
0.8
1.0
1.2
Sv
B-V HOST
Sab
SBa
SBa
Sbc
SBb
SBb
Sa
E5/S0I
Sb
E1?
E3/S0I
E2/S0
Sa?
SB0/SBa
E5/S0
SB0
SBb

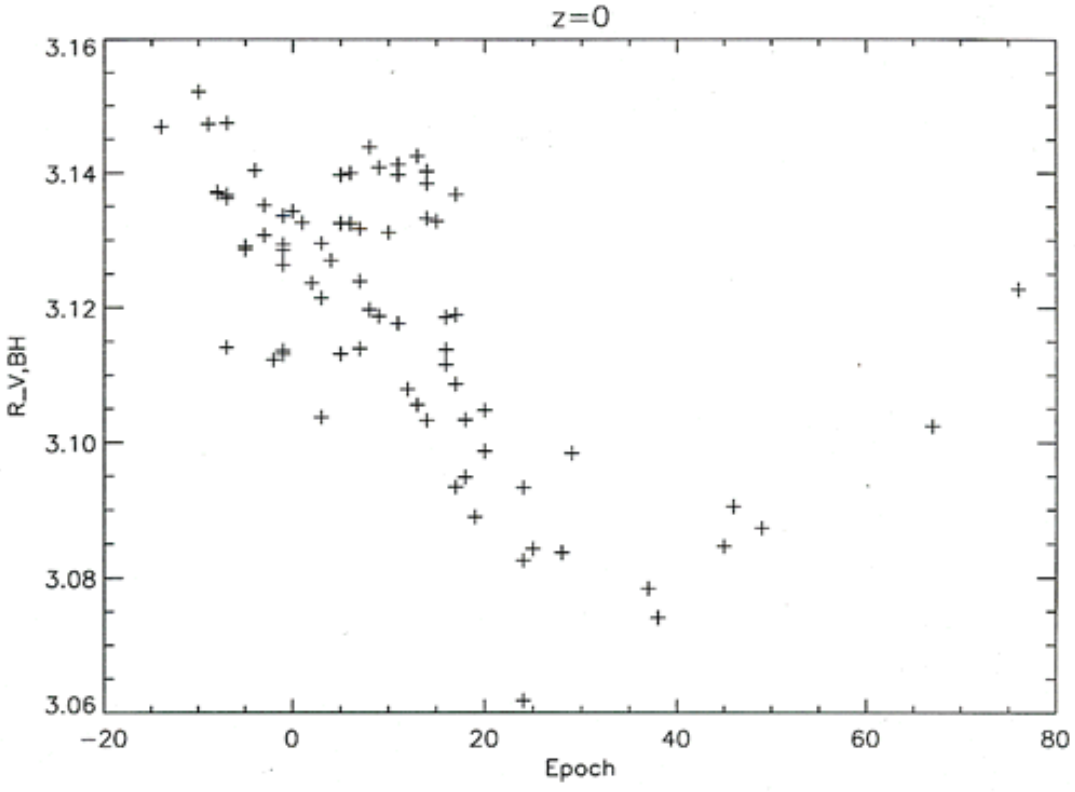
CfA SNe Ia (Riess et al.)

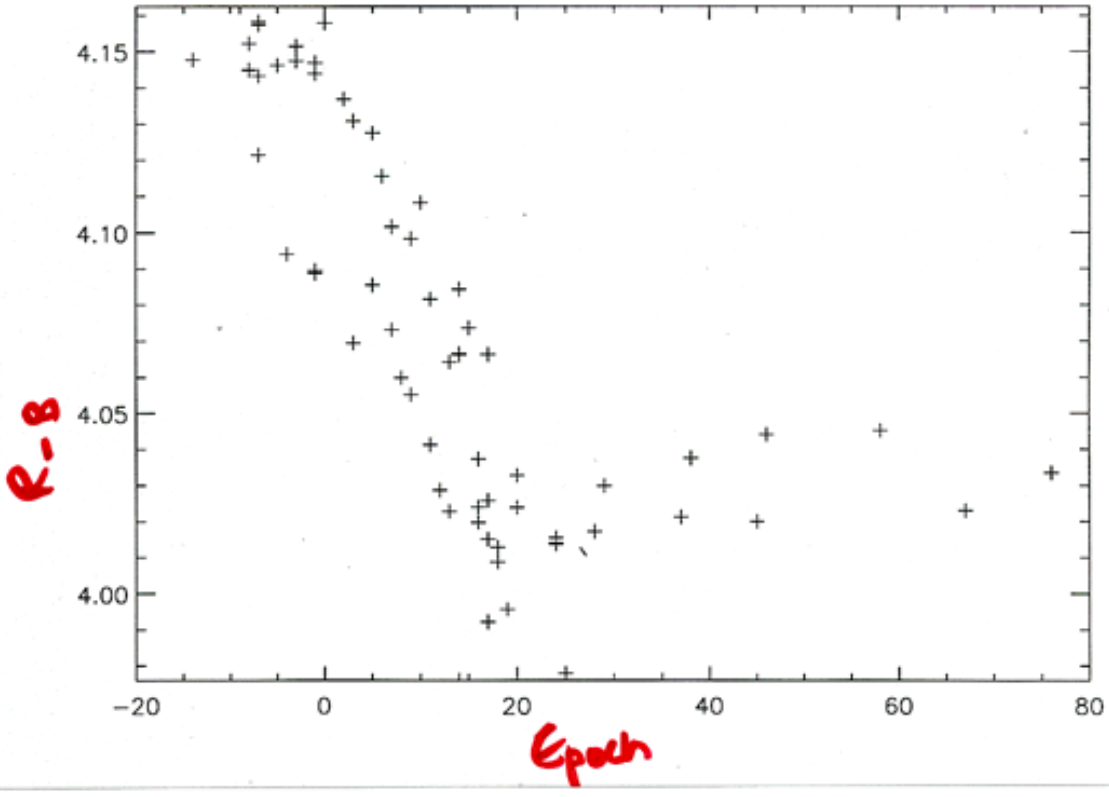


$5 \log \frac{cz}{H_0} + 25$ $H_0 = 65 \frac{km}{s\,Mpc}$

WRCS 6MRS21


μ - 5log
1.0
0.5
0.0
−0.5
−1.0
resduals
SN 1994ae
0.0
0.2
0.4
0.6
0.8
1.0
E(B−V)


z=0
R_V,BH
Epoch
3.16
3.14
3.12
3.10
3.08
3.06
−20
0
20
40
60
80


R-B
Epoch
4.15
4.10
4.05
4.00
−20
0
20
40
60
80

Conclusions

* Not optimized for low-z Type Ia's
  - B and V only
  - Early epochs
* Customize training set for the data
* Extinction (hmmm...)
* About as good as you can do with a single parameter
  - No biases in residuals
* Easy to use.
  - I give you the curves, you stretch them
* $\sigma = 0.14$ mag

Extinction

- Does not work well for $E(B-V) > 0.4$
  - B-V data only
- R_B, R_V depend on epoch & dust
  - High z !
- A problem for all template methods
- Biased against in mag-limited high-z searches
- Ridge line