Analysis of CSPI (part II)

Chris Burns, OCIW

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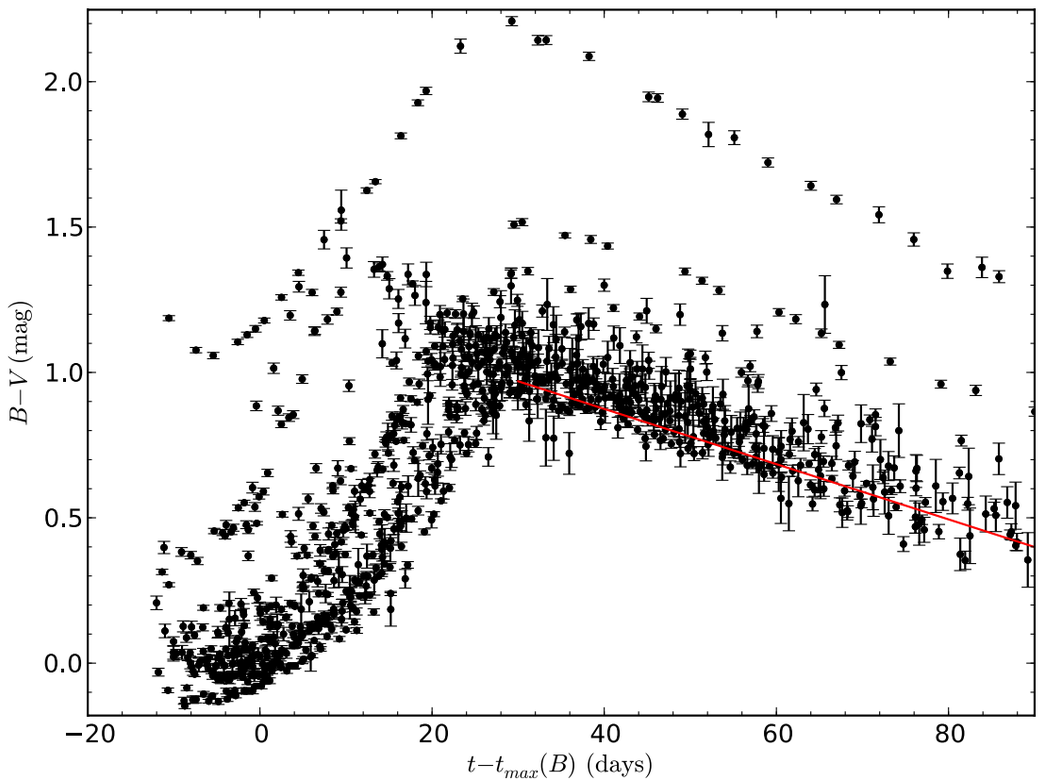
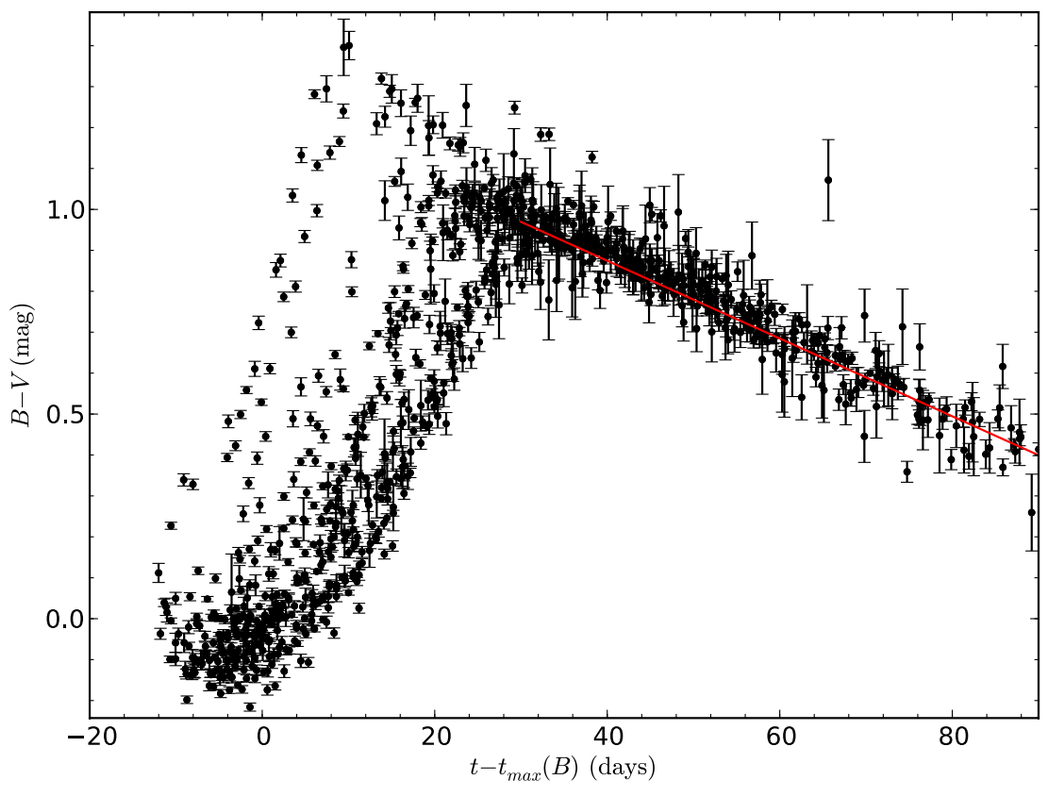
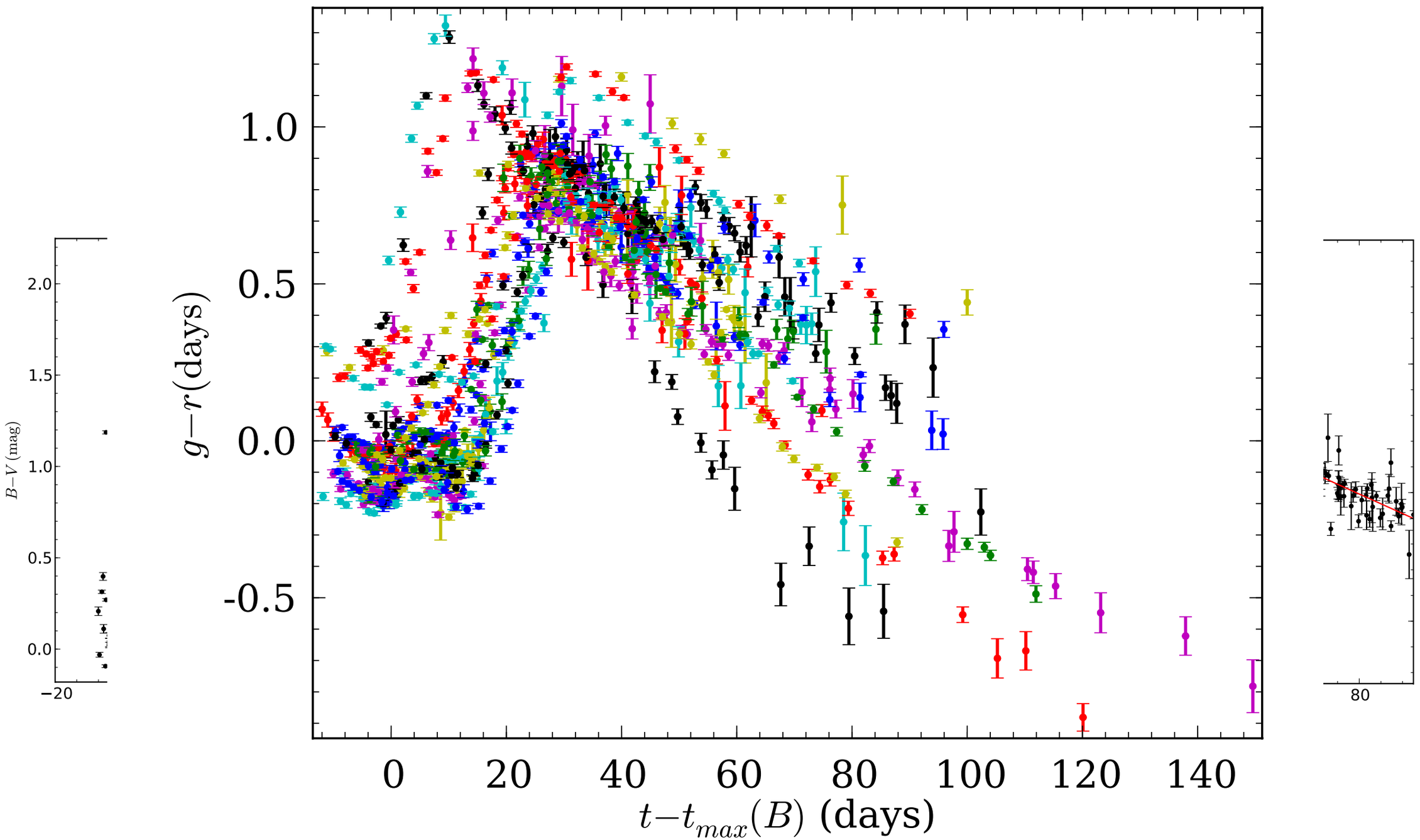
Outline

- Lira Law
- s_{BV} and SNooPy2
- Intrinsic colors, Reddening laws
- Standard Candleness in NIR
- Some grouchiness

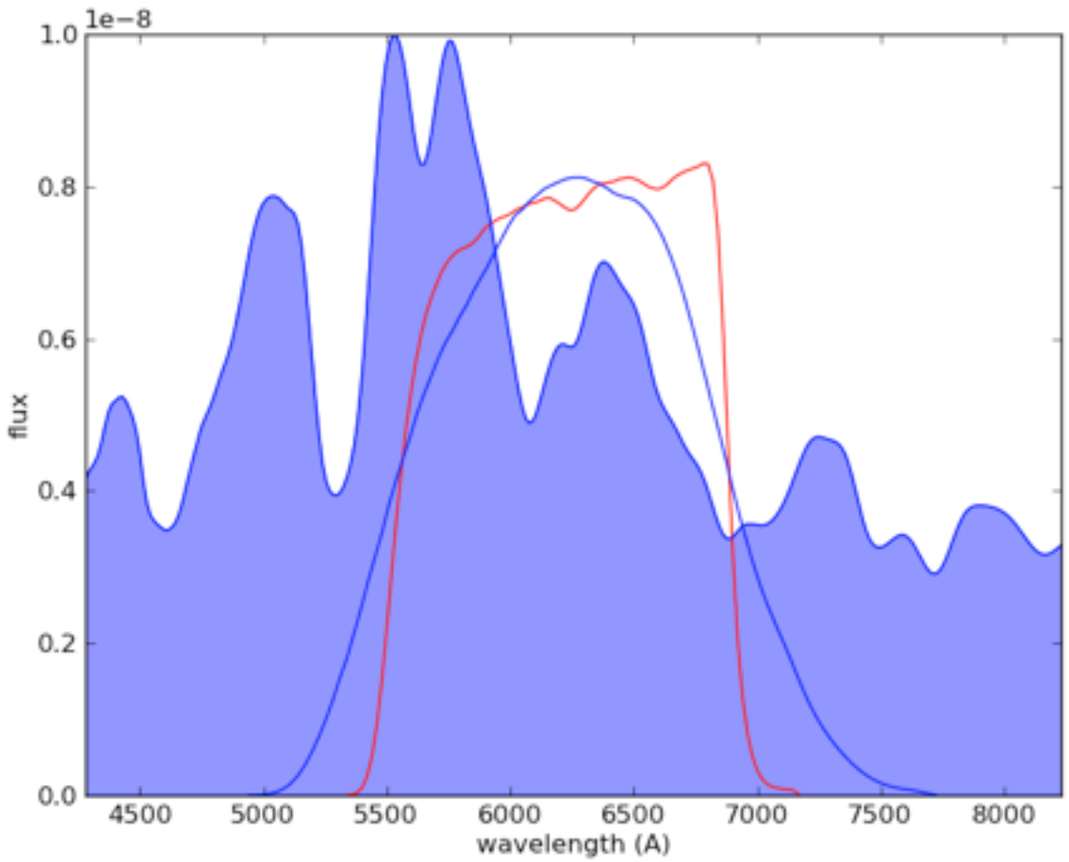
Lira Law

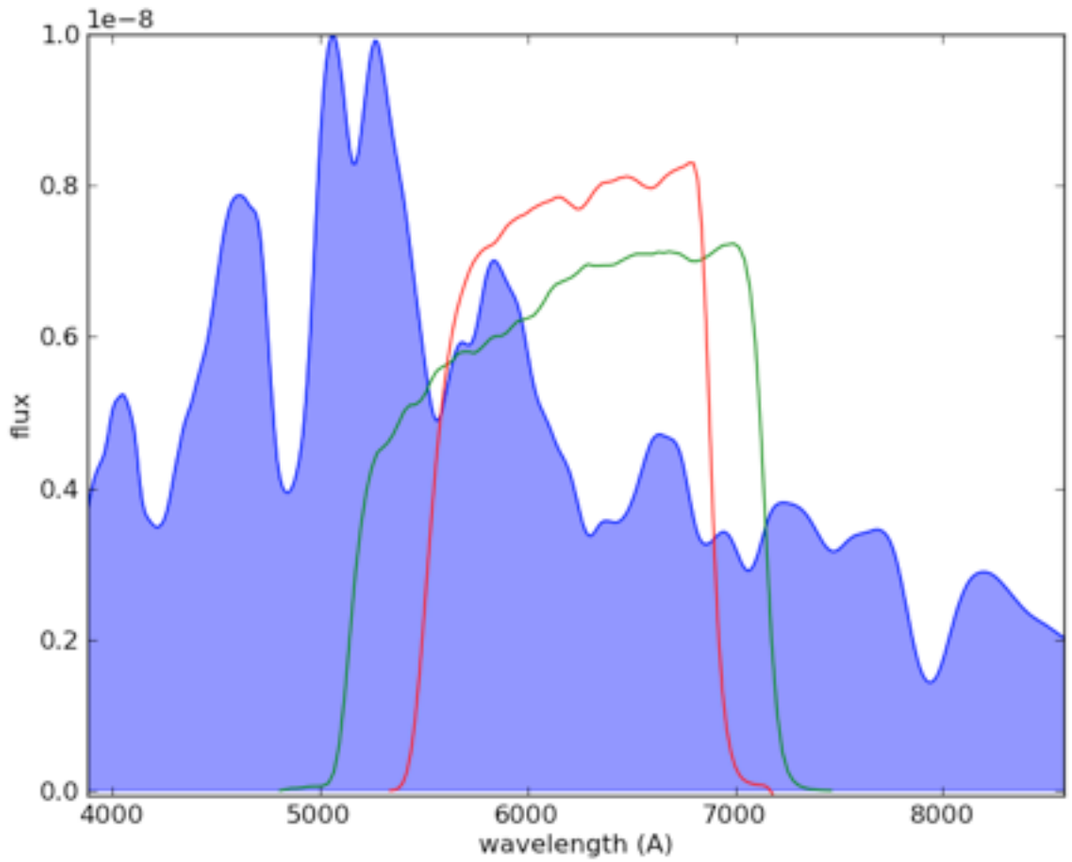

2.0
1.5
1.0
0.5
0.0
$B-V$ (mag)
−20
0
20
40
60
80
$t-t_{max}(B)$ (days)


1.0
0.5
0.0
$B-V$ (mag)
−20
0
20
40
60
80
$t-t_{max}(B)$ (days)

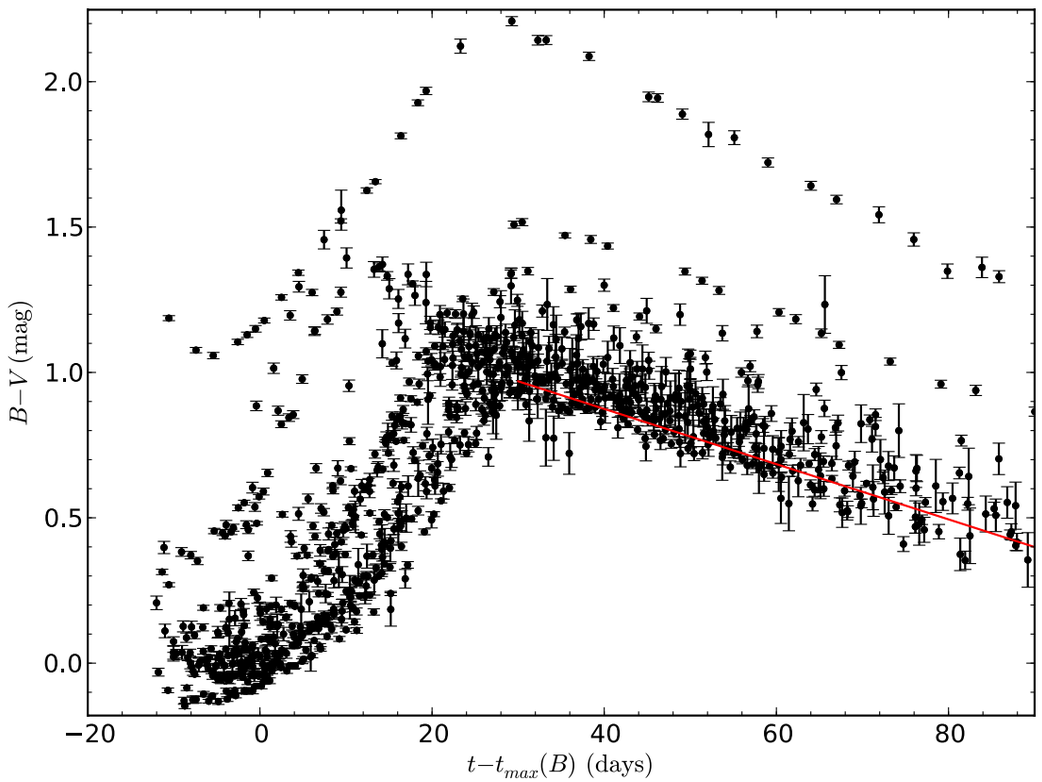

1.0
0.5
0.0
-0.5
$g-r$ (days)
0
20
40
60
80
100
120
140
$t-t_{max}(B)$ (days)
2.0
1.5
1.0
0.5
0.0
$B-V$ (mag)
−20
80

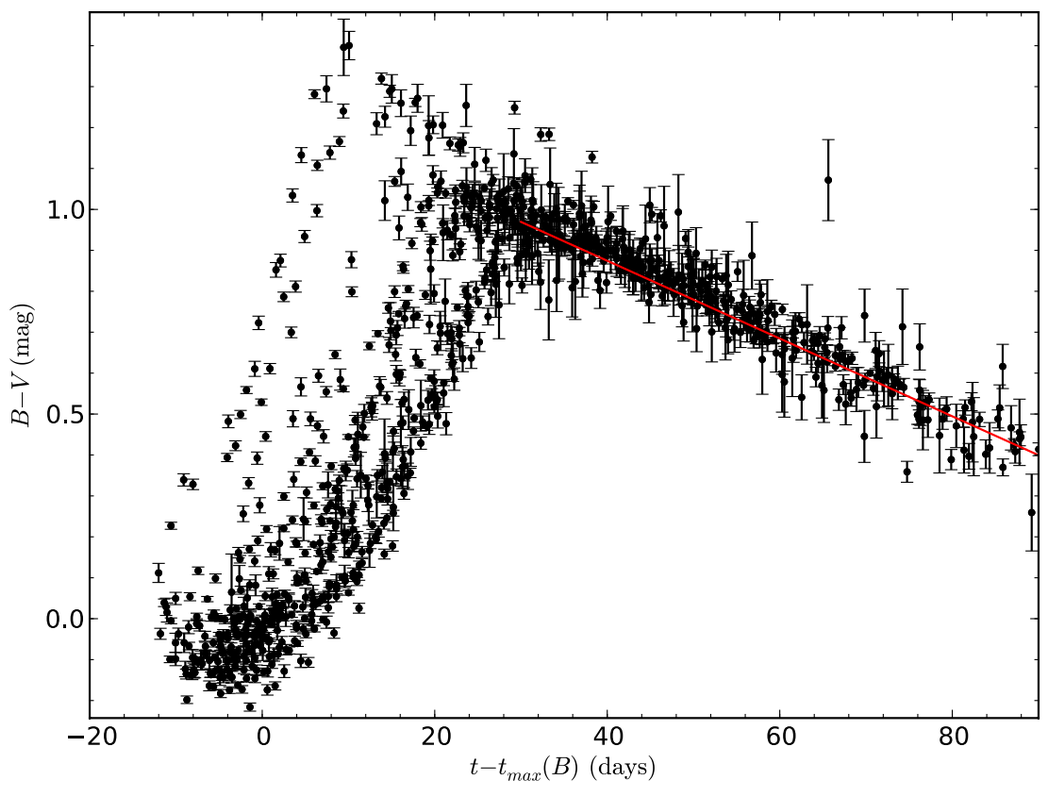
BV a better match at high-z

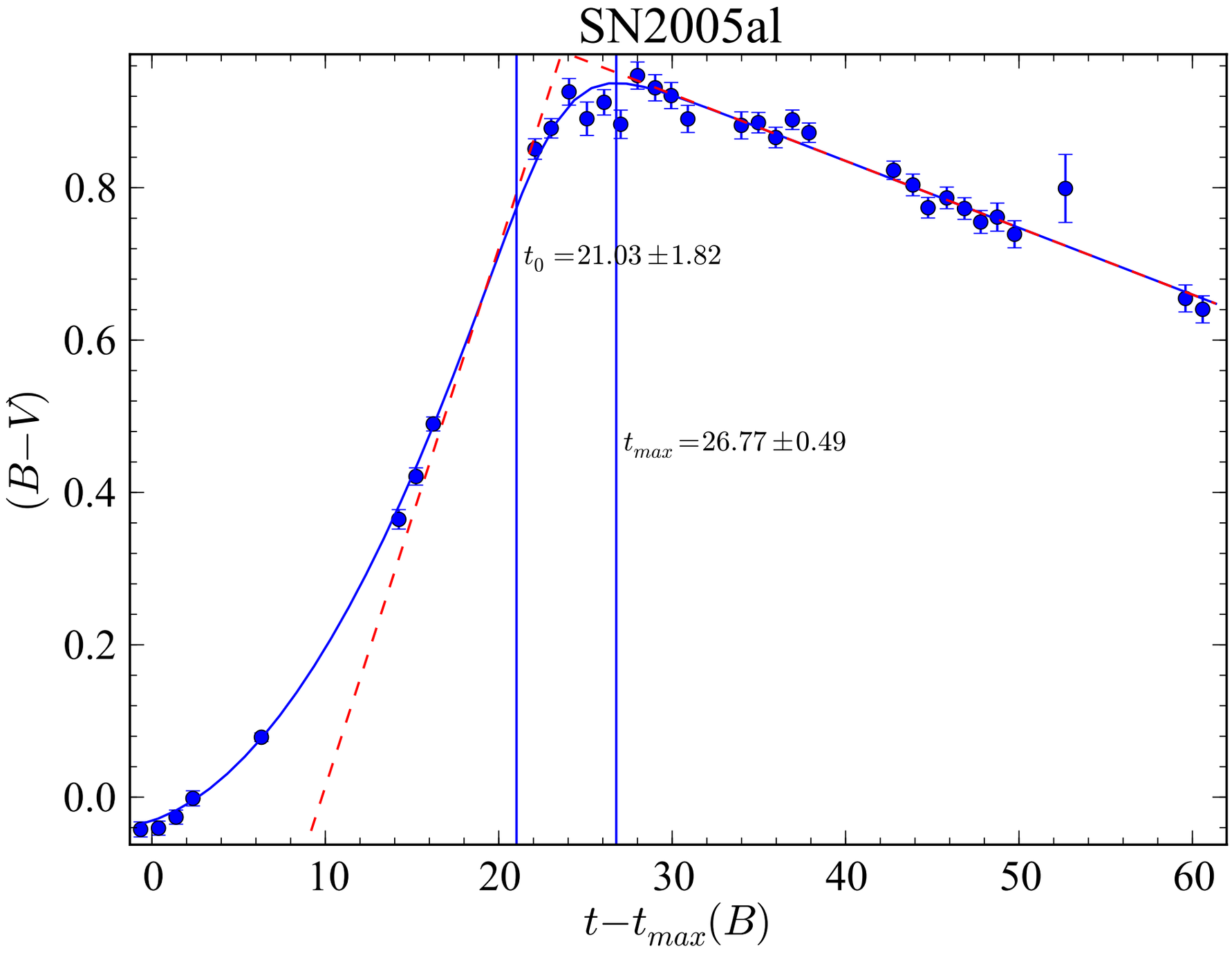




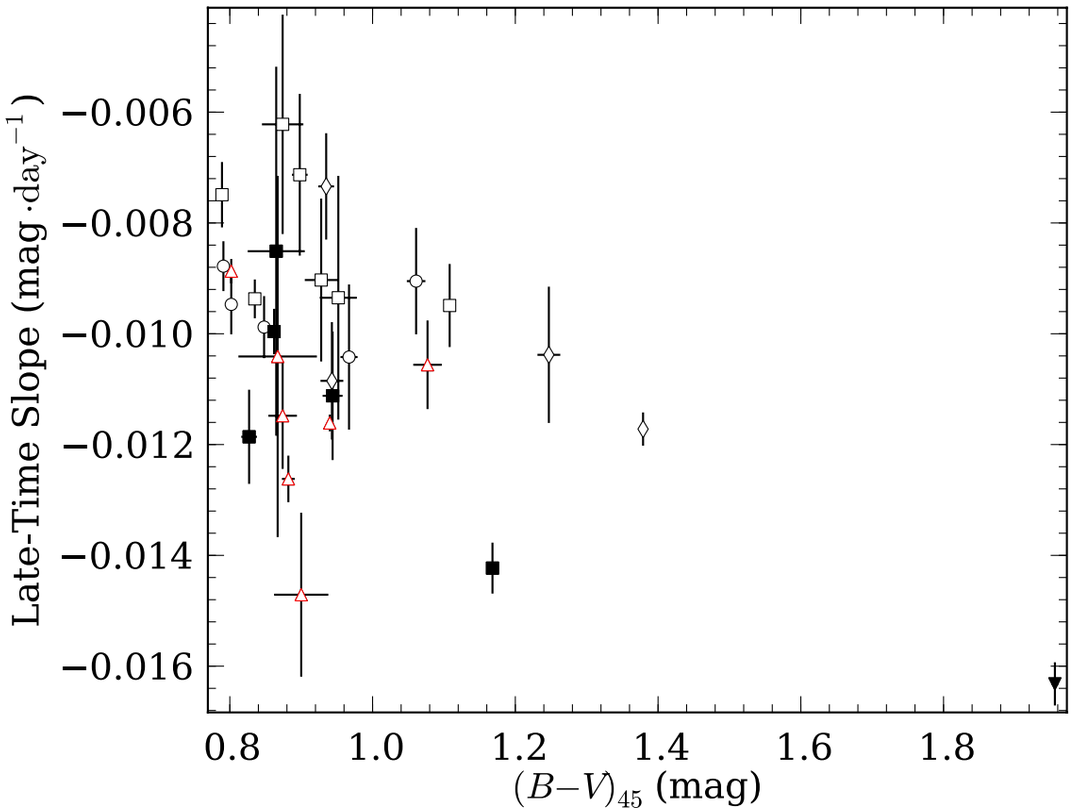
Lira Law

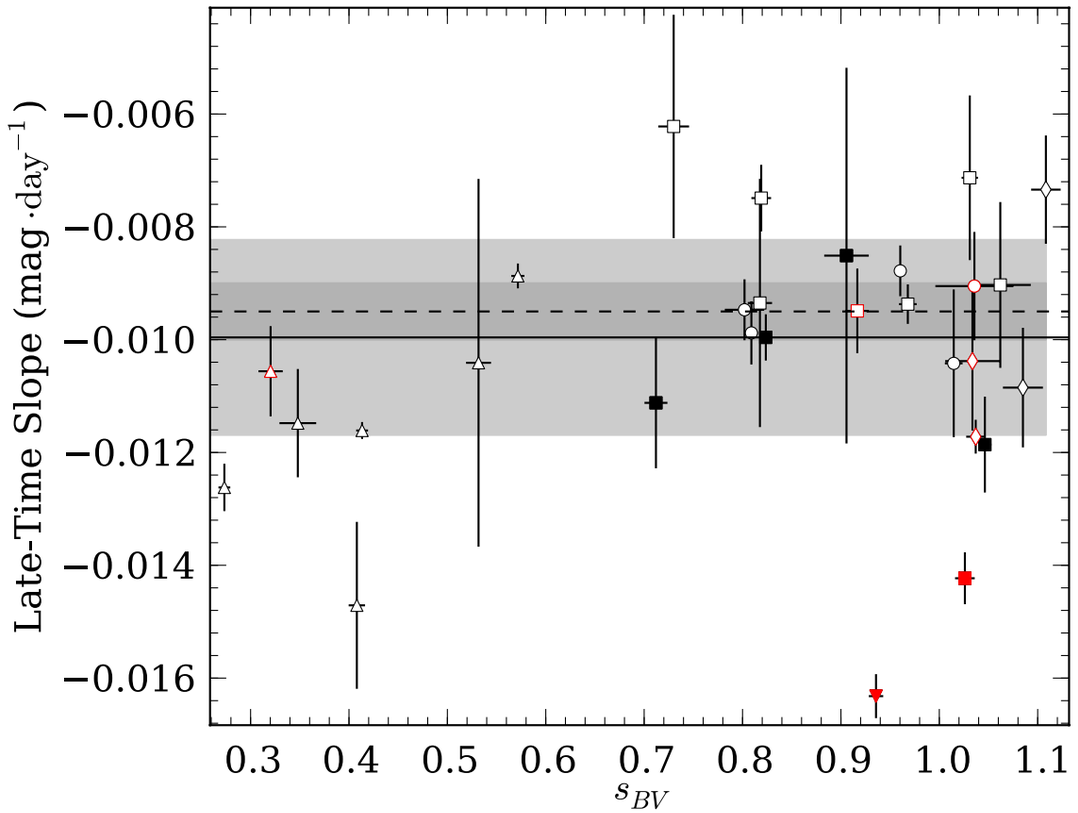

2.0
1.5
1.0
0.5
0.0
$B-V$ (mag)
−20
0
20
40
60
80
$t-t_{max}(B)$ (days)


1.0
0.5
0.0
$B-V$ (mag)
−20
0
20
40
60
80
$t-t_{max}(B)$ (days)

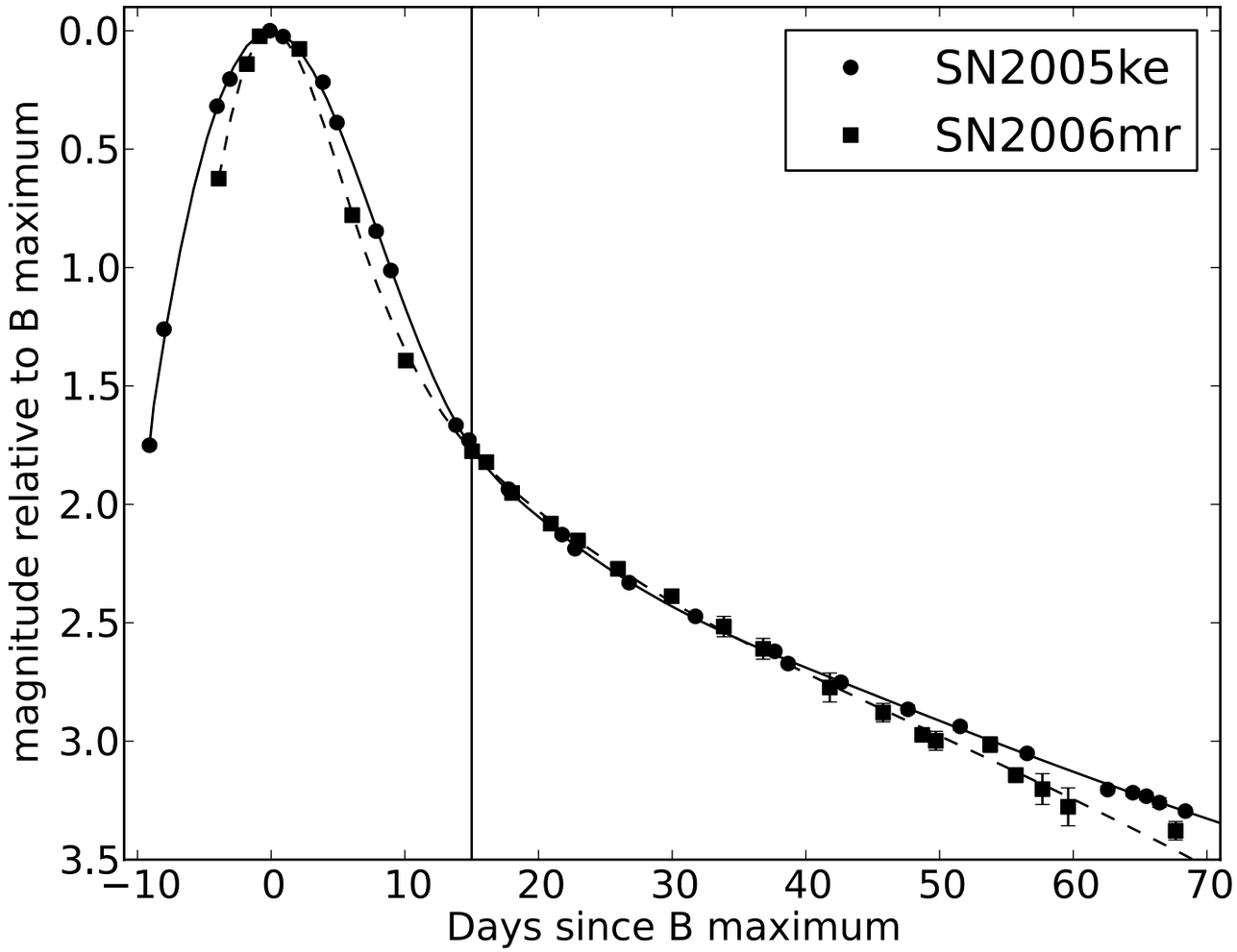

SN2005al
$t_0 = 21.03 \pm 1.82$
$t_{max} = 26.77 \pm 0.49$
$(B-V)$
0.0
0.2
0.4
0.6
0.8
0
10
20
30
40
50
60
$t - t_{max}(B)$

Late-time B-V Slope

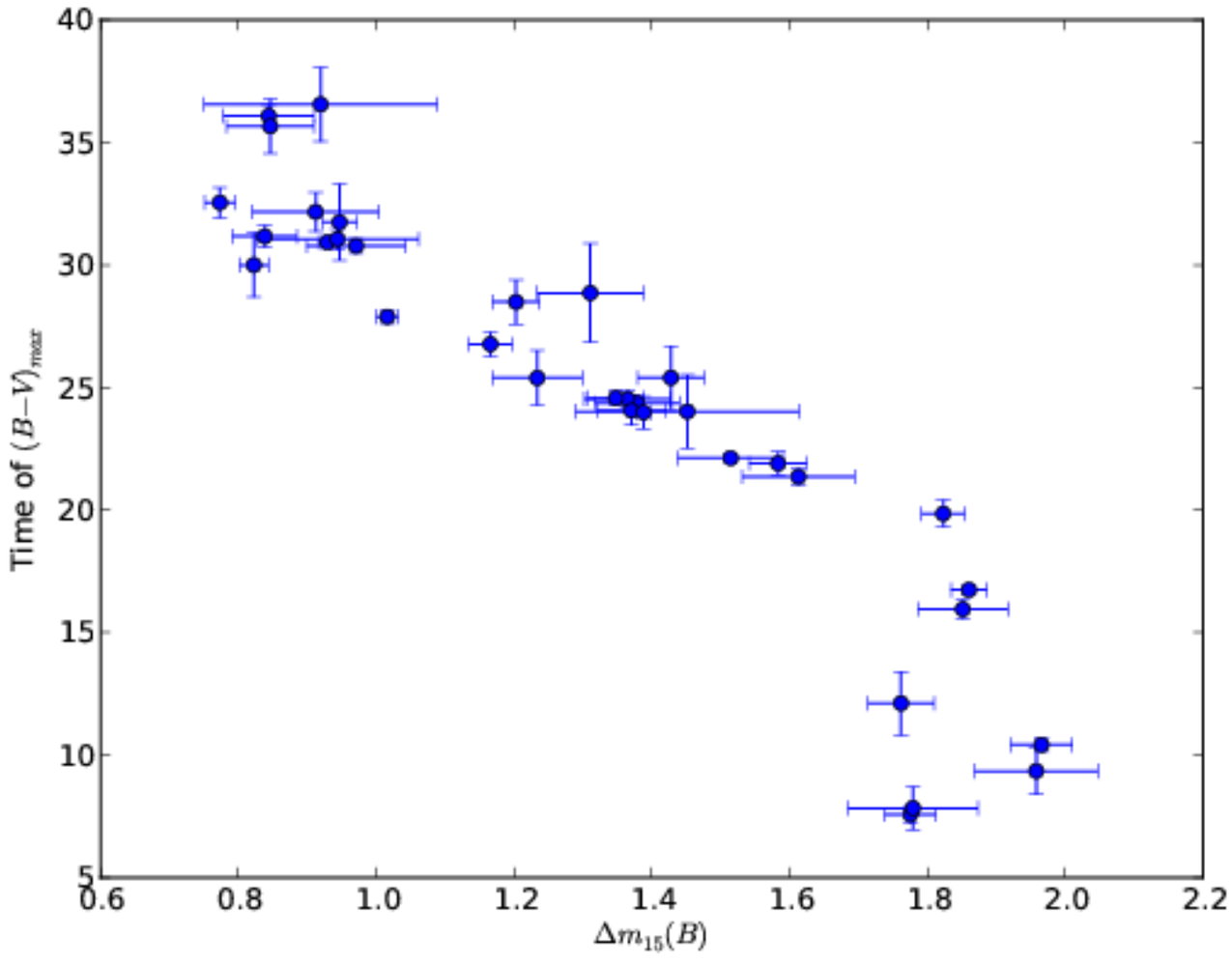




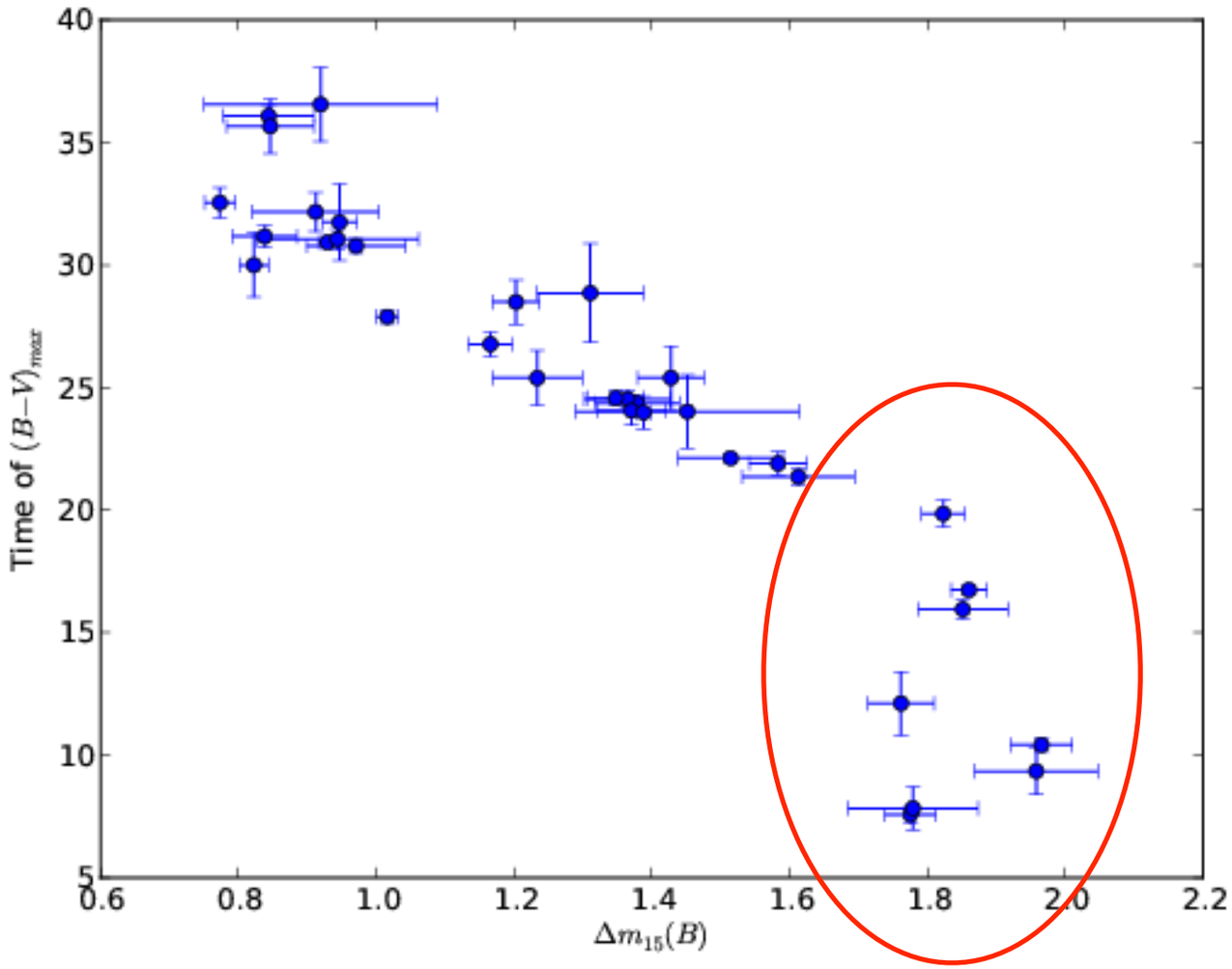
The Problem with Δm_{15}



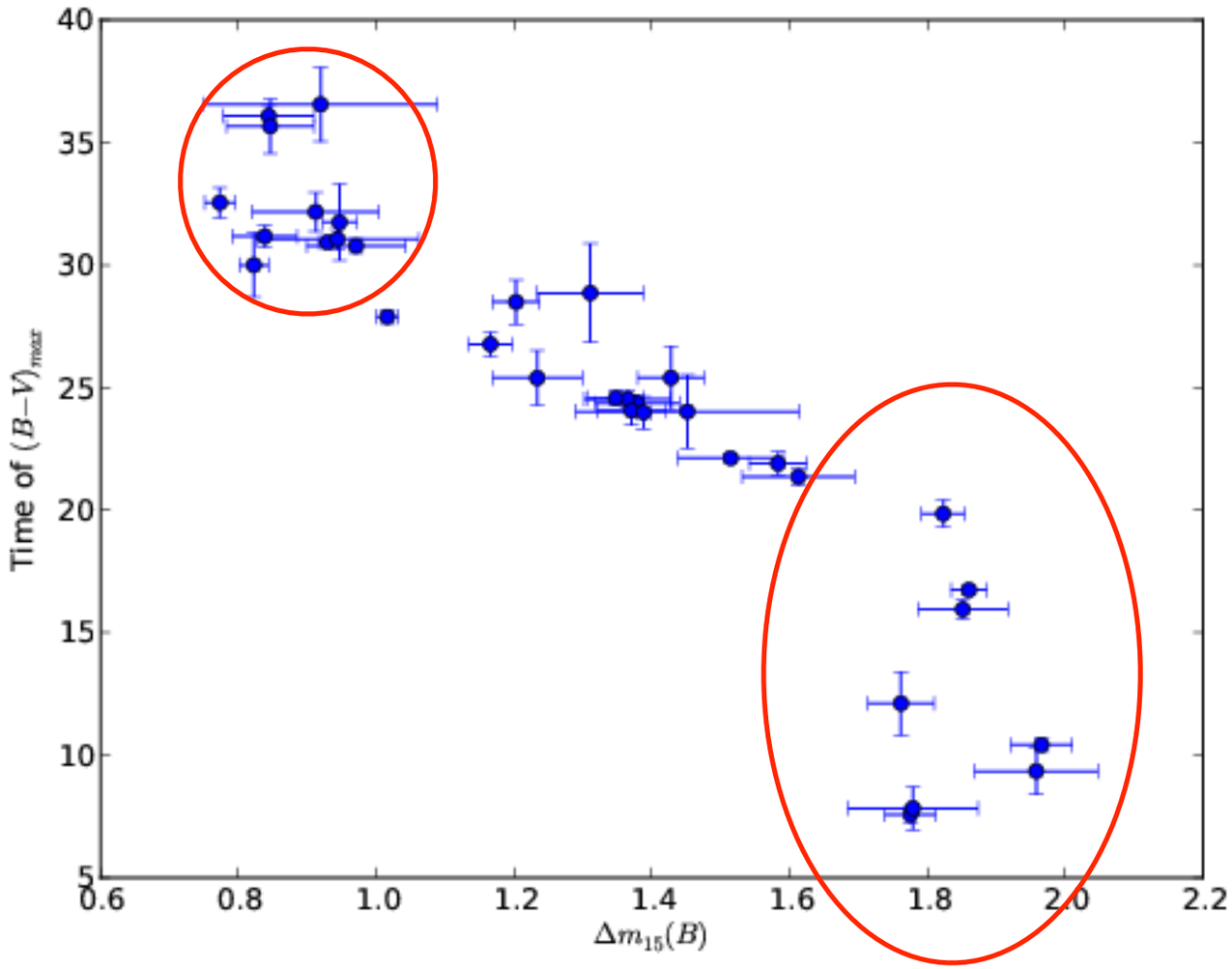
Only matters at Low-L?



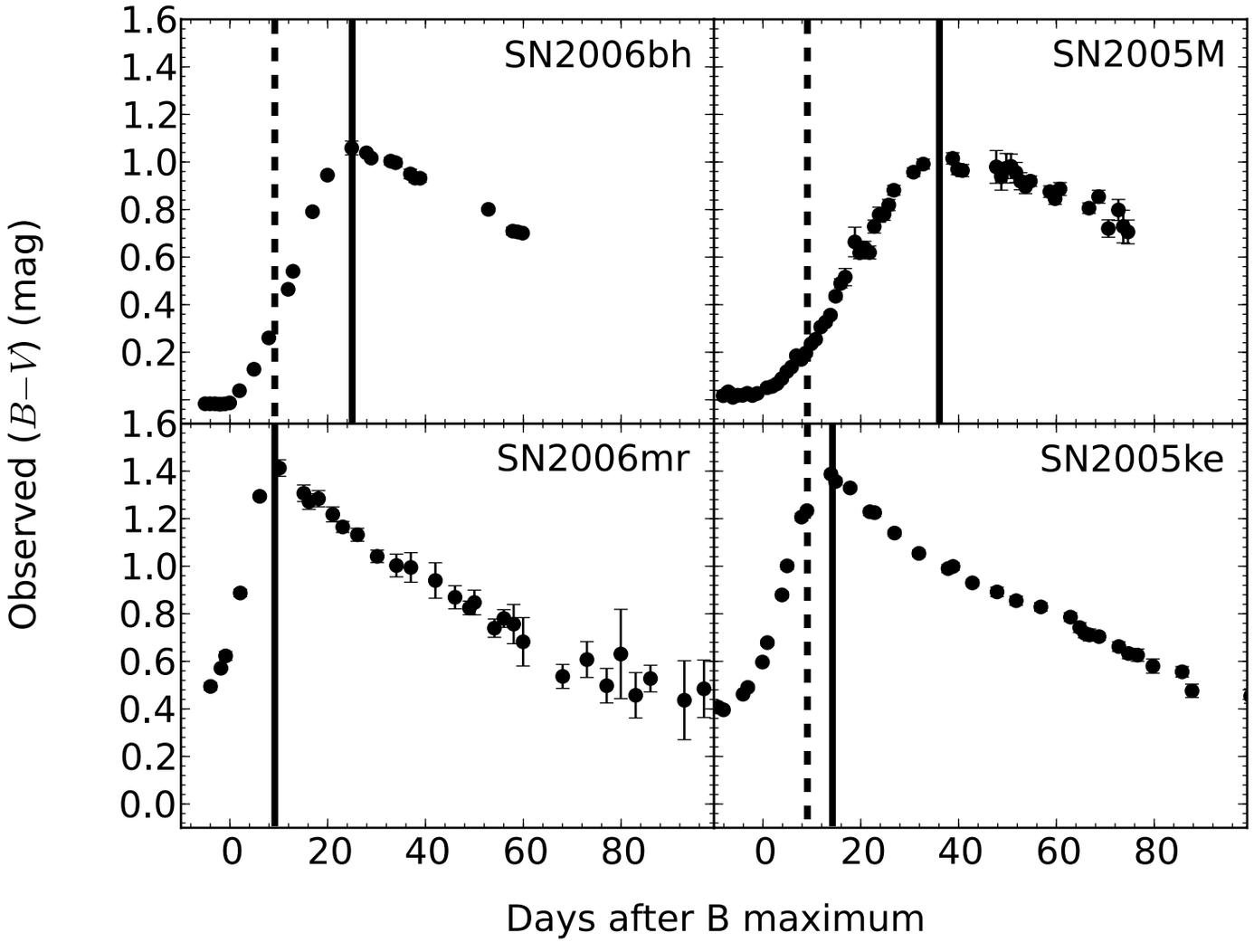
Only matters at Low-L?



Only matters at Low-L?



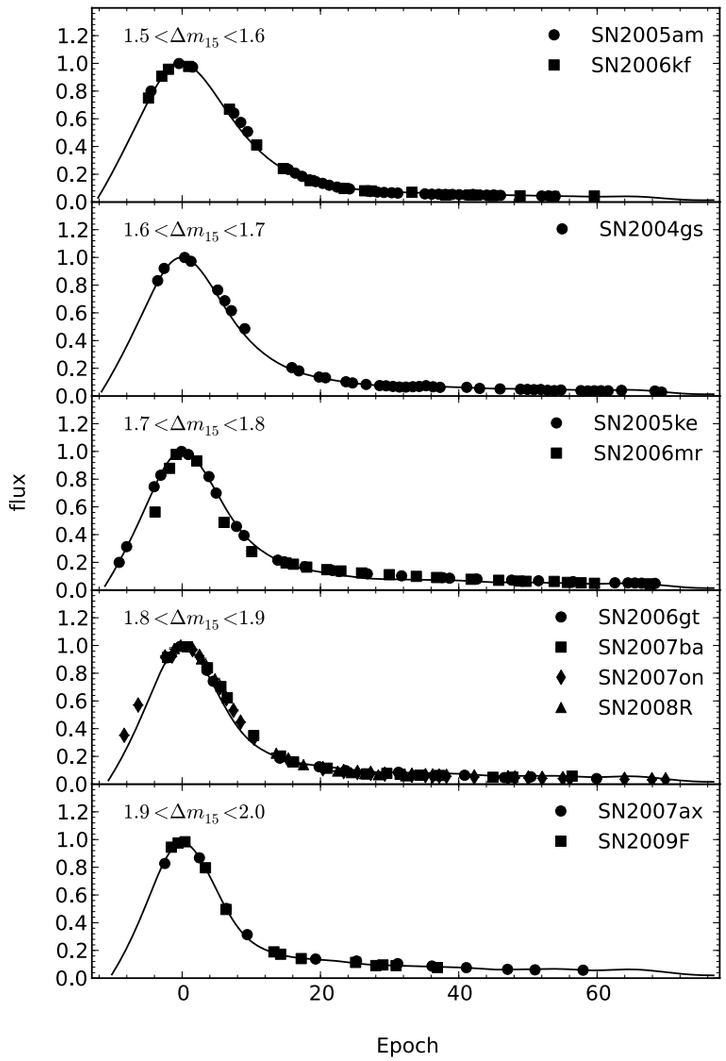
A Little C-Magic

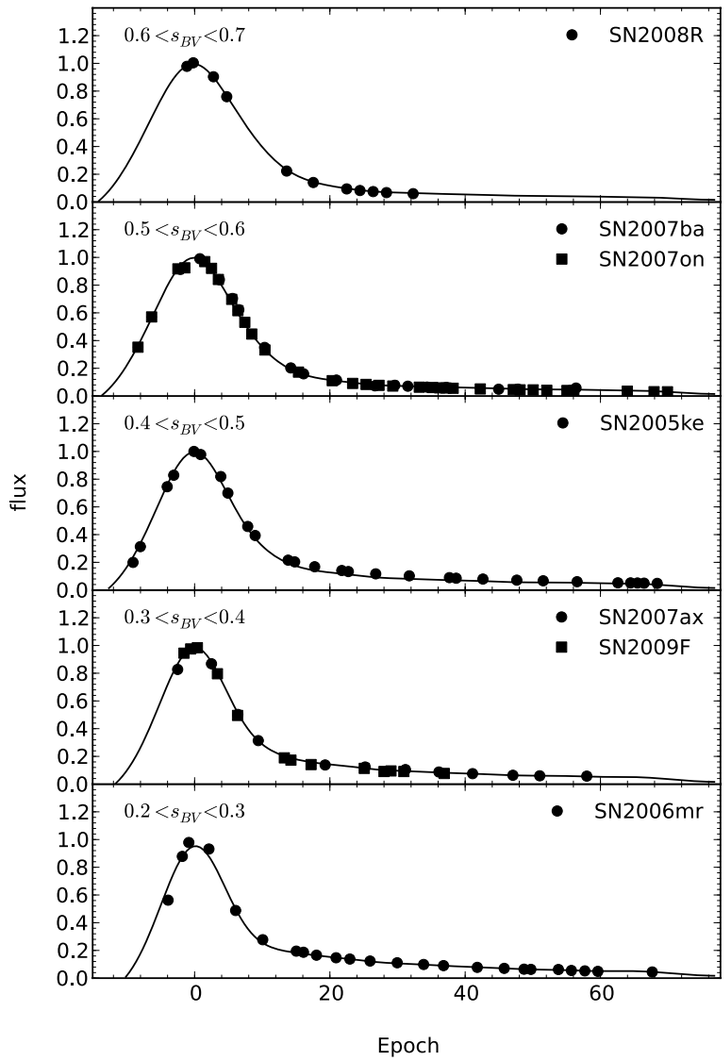


Define color stretch:

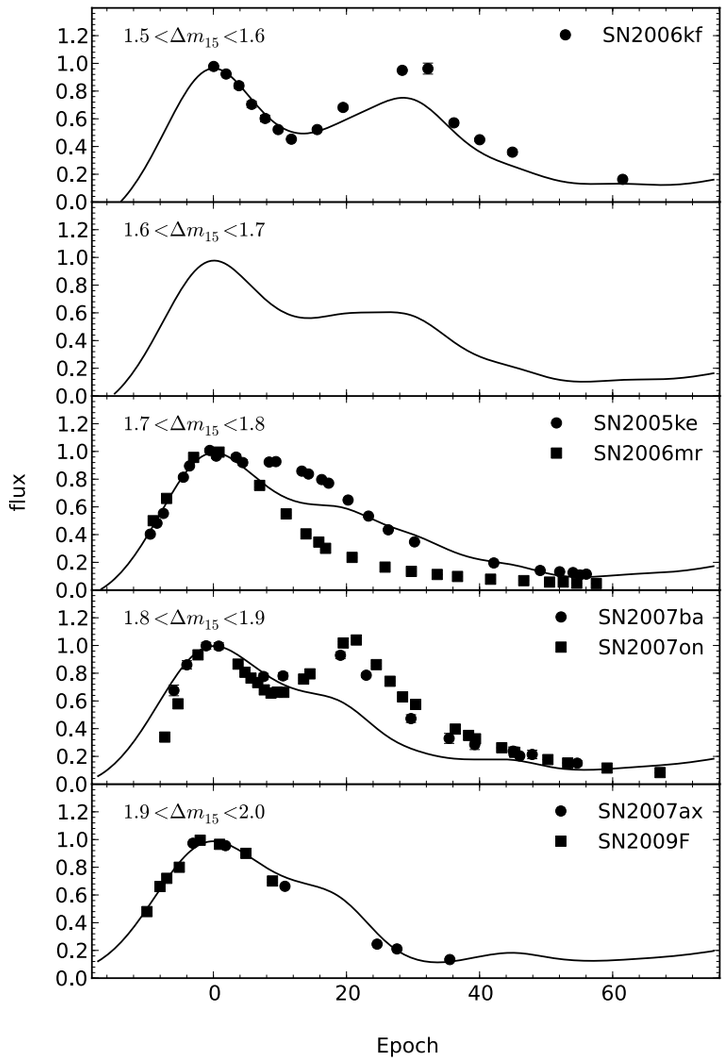
$$s_{BV} = \frac{t\left[(B-V)_{max}\right]}{30 \ \ \text{days}}$$

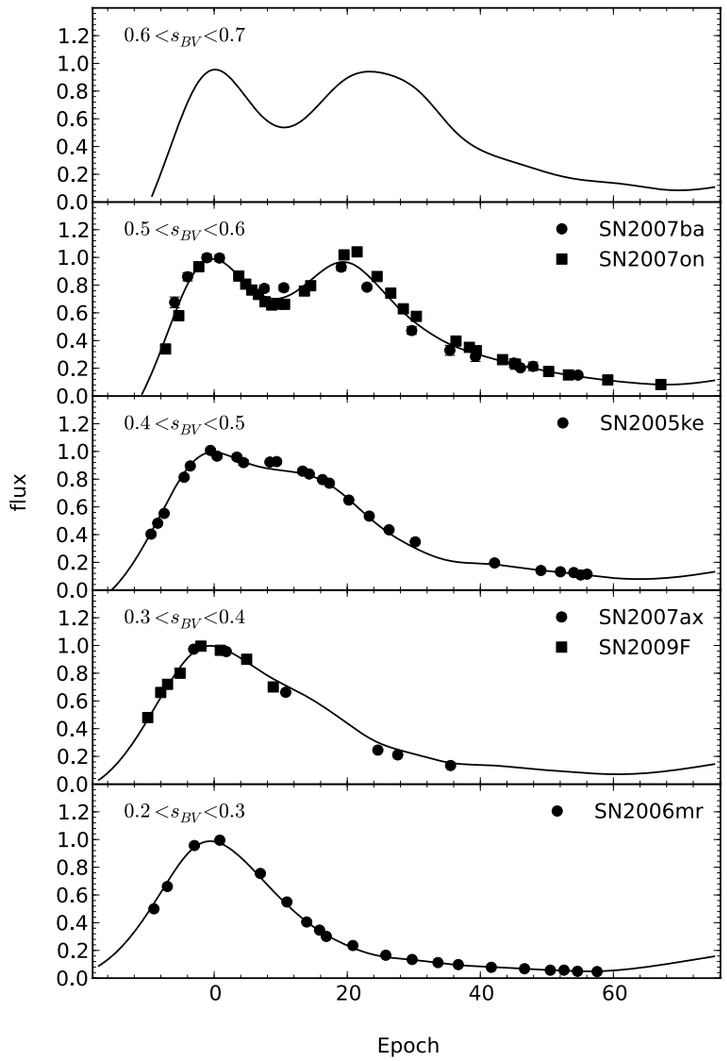
Hints in the Optical





NIR Really shows it





Mark Phillips, Eric Hsiao, Nick Suntzeff, Pamela Wyatt, Eric Persson, Wendy Freedman, Nidia Morrell, Sergio Gonzalez
Miguel Roth, Christopher Burns, Gaston Folatelli, Carlos Contreras, Barry Madore, Mario Hamuy

SNooPy2... Now with:

- GP-generated templates (s_{BV} and Δm_{15}) instead of GLoEs
- Eric Hsiao seal of approval for K-corrections
- Easy-install bootstrap script for installing python environment.
- Bolometric light-curve generator.

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-
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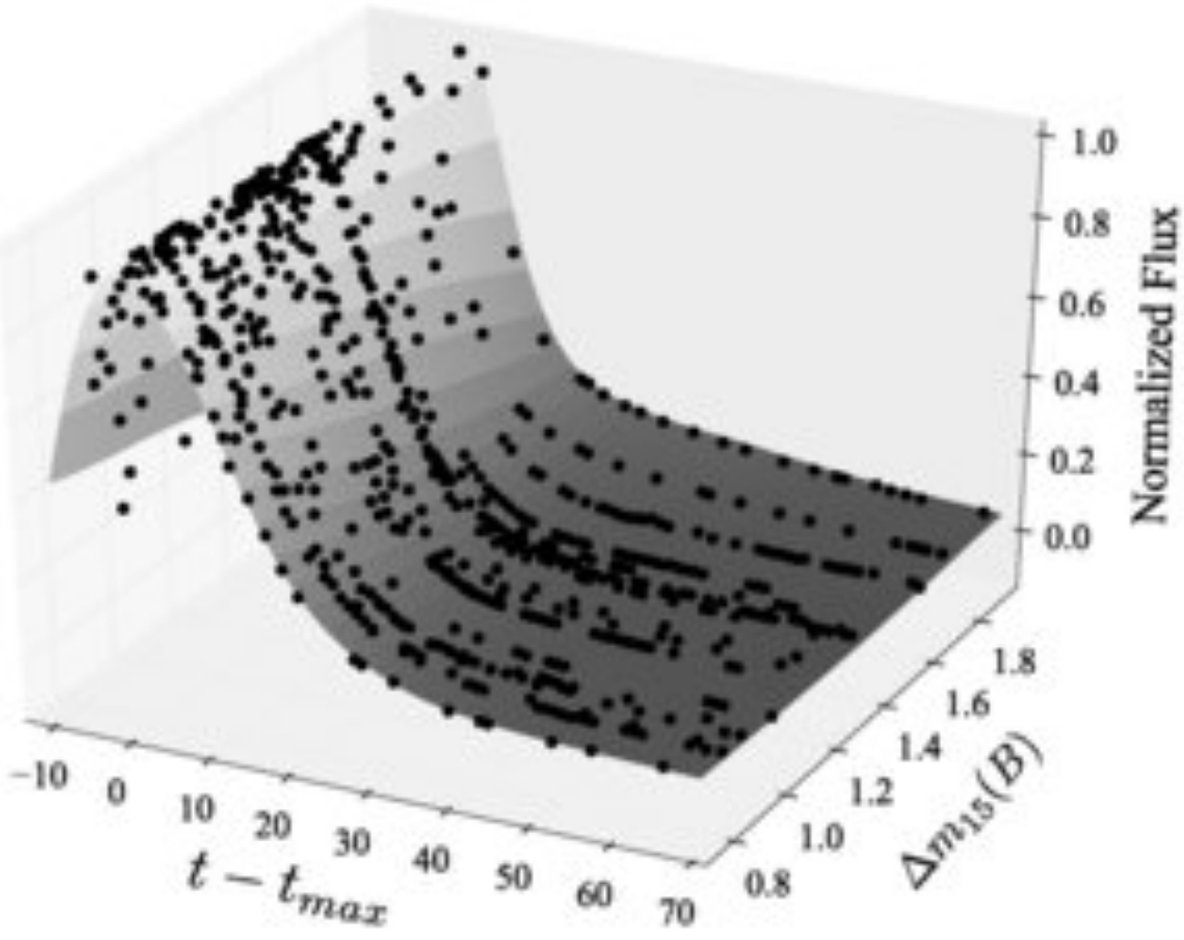
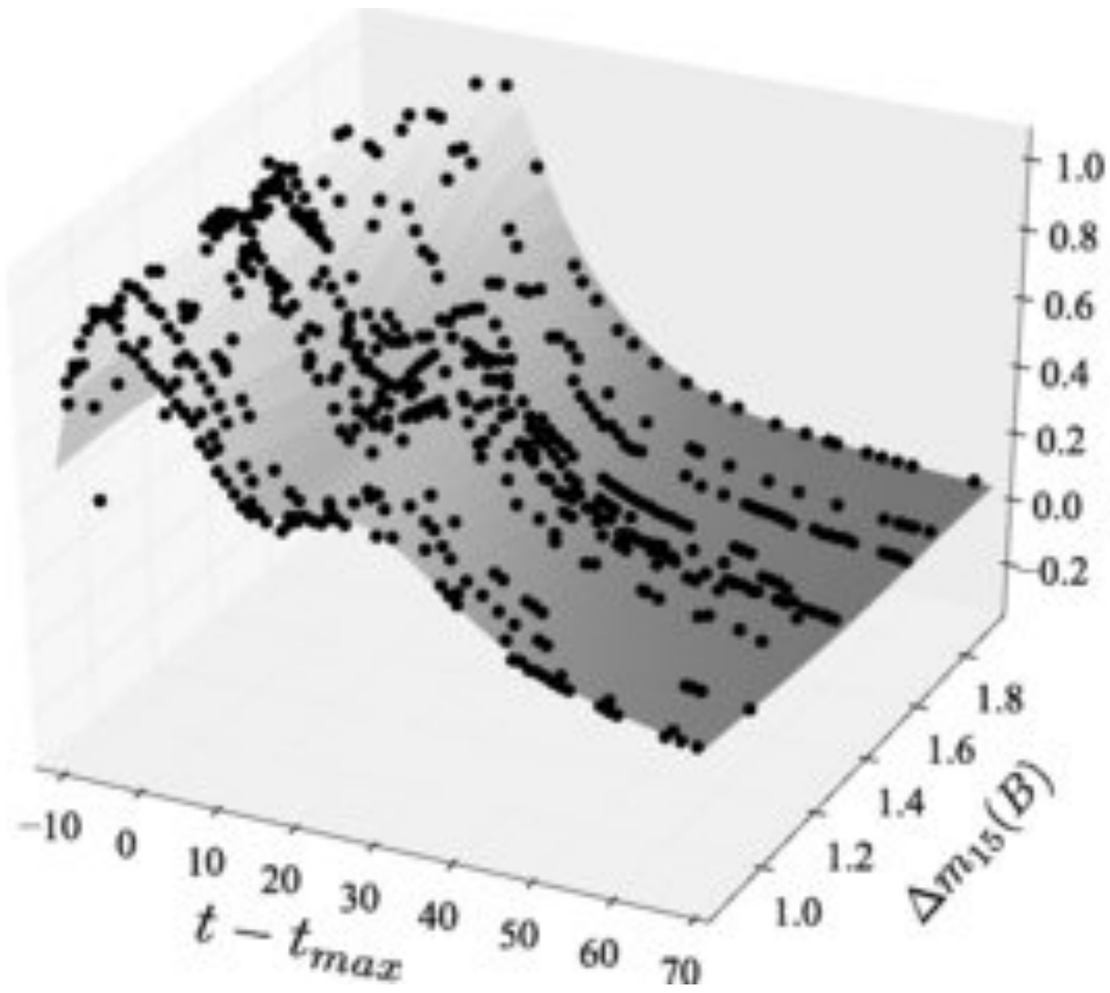
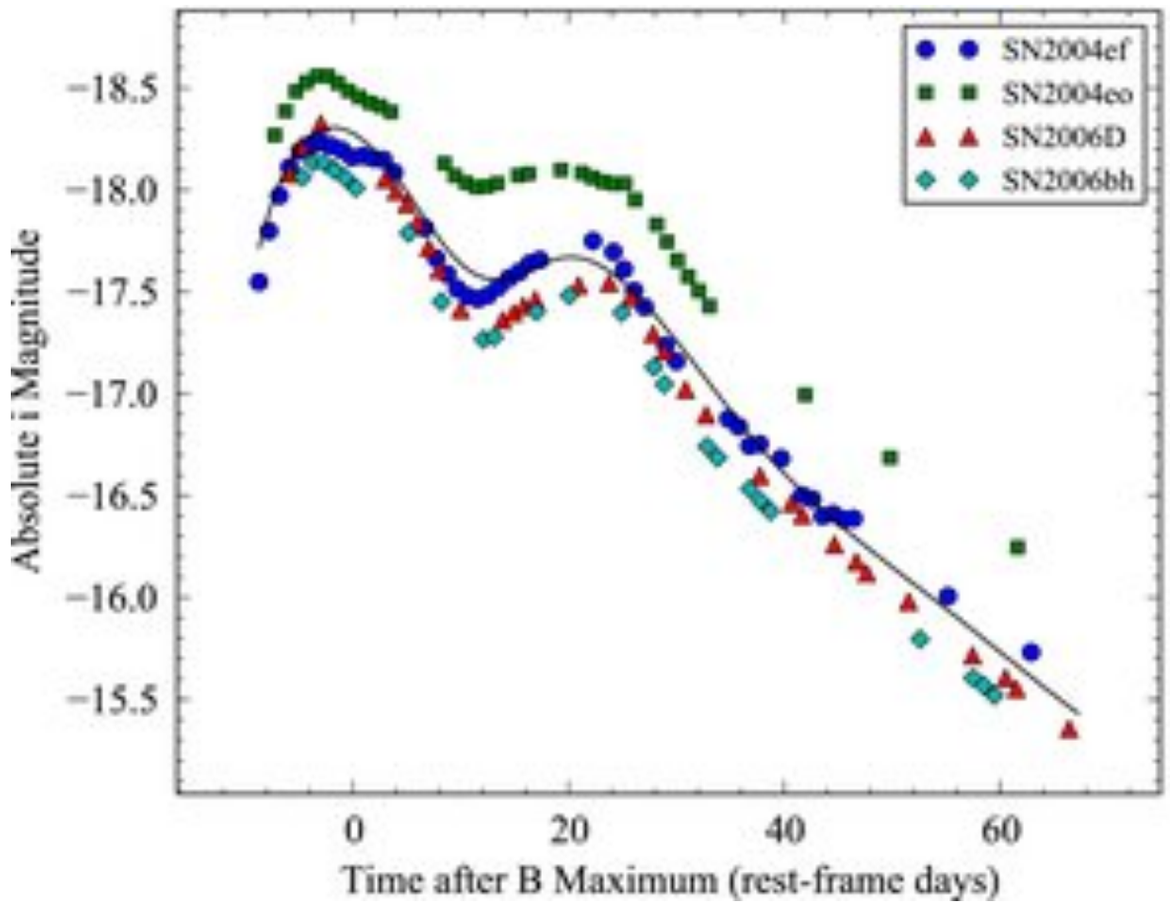
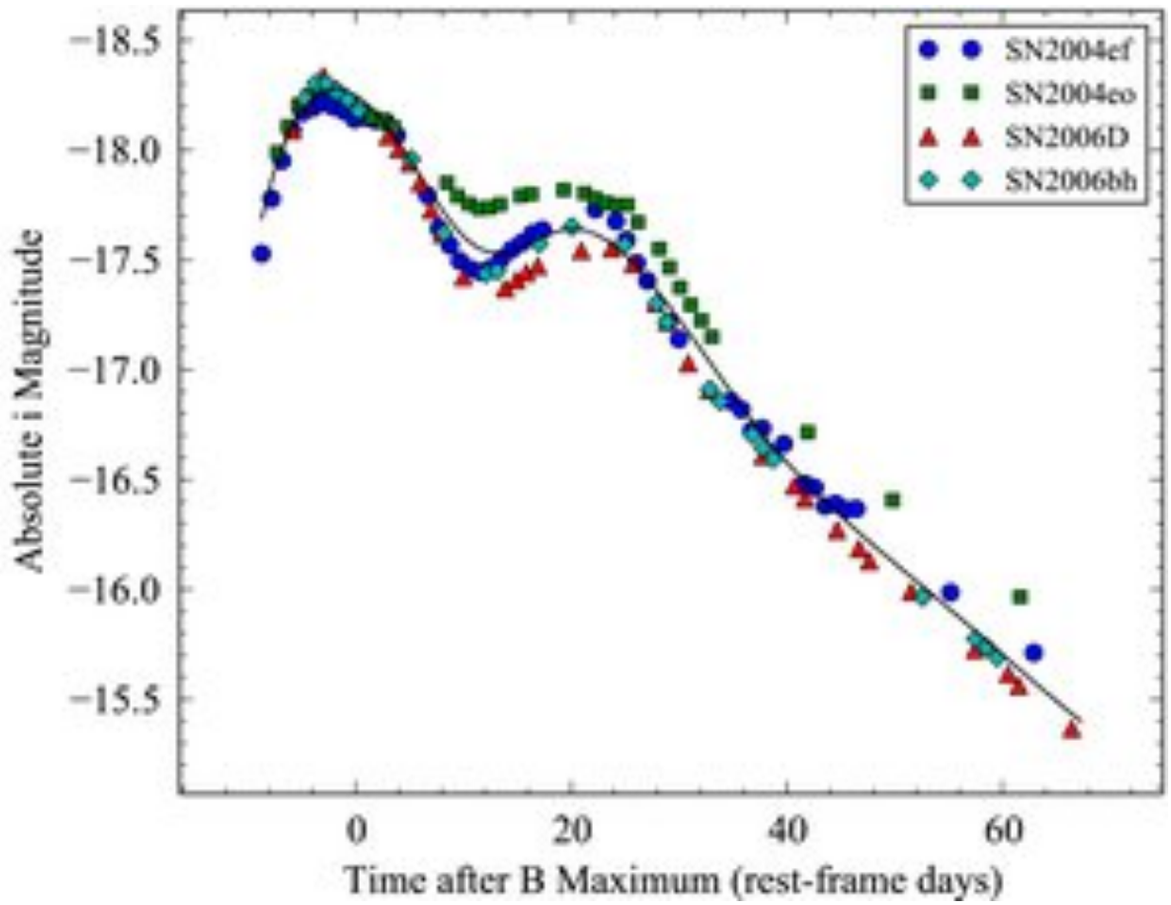
SNooPy2 uses GP's to "Krig"



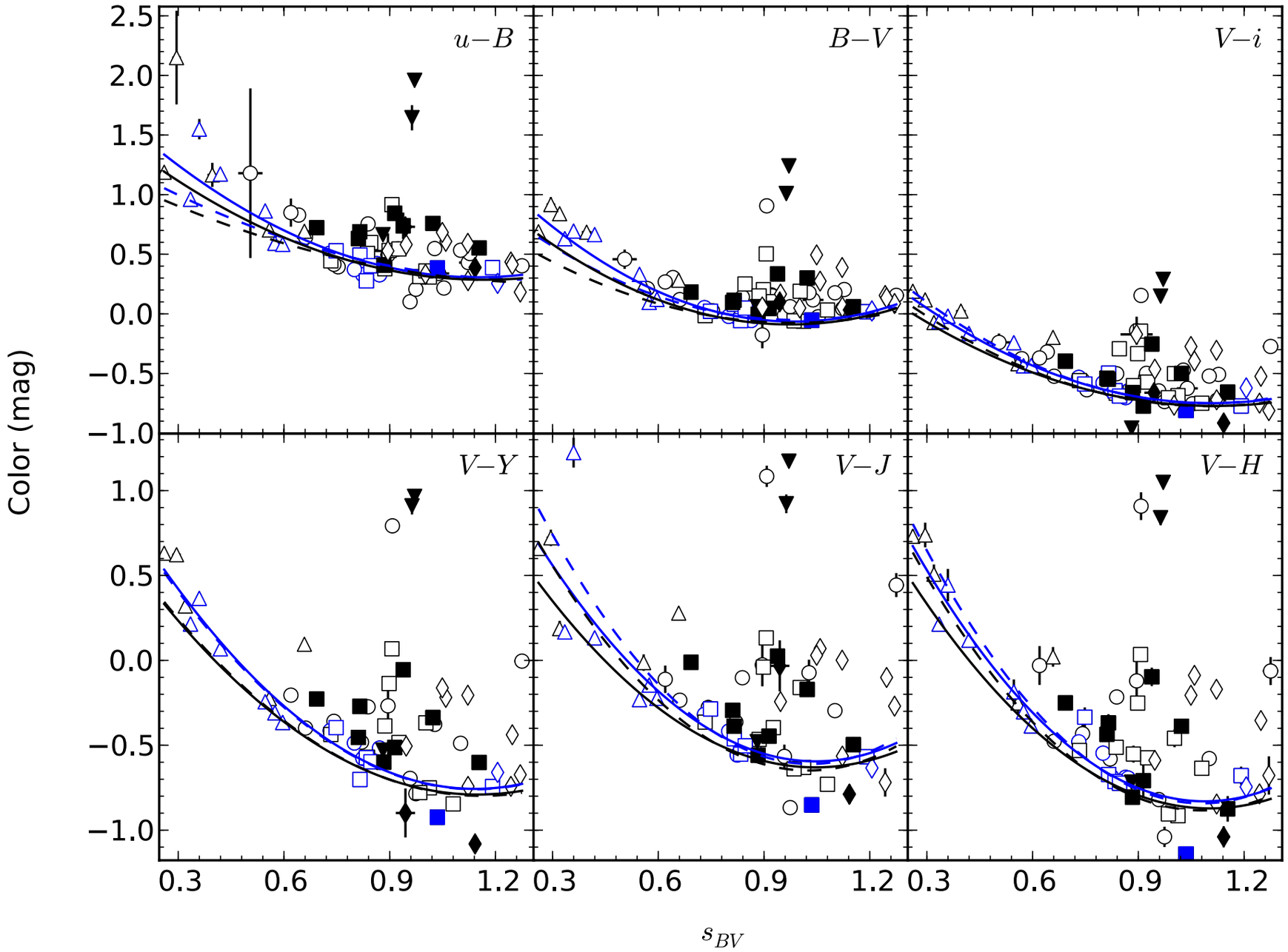


Unfortunately, sBV doesn't fix the NIR bump.

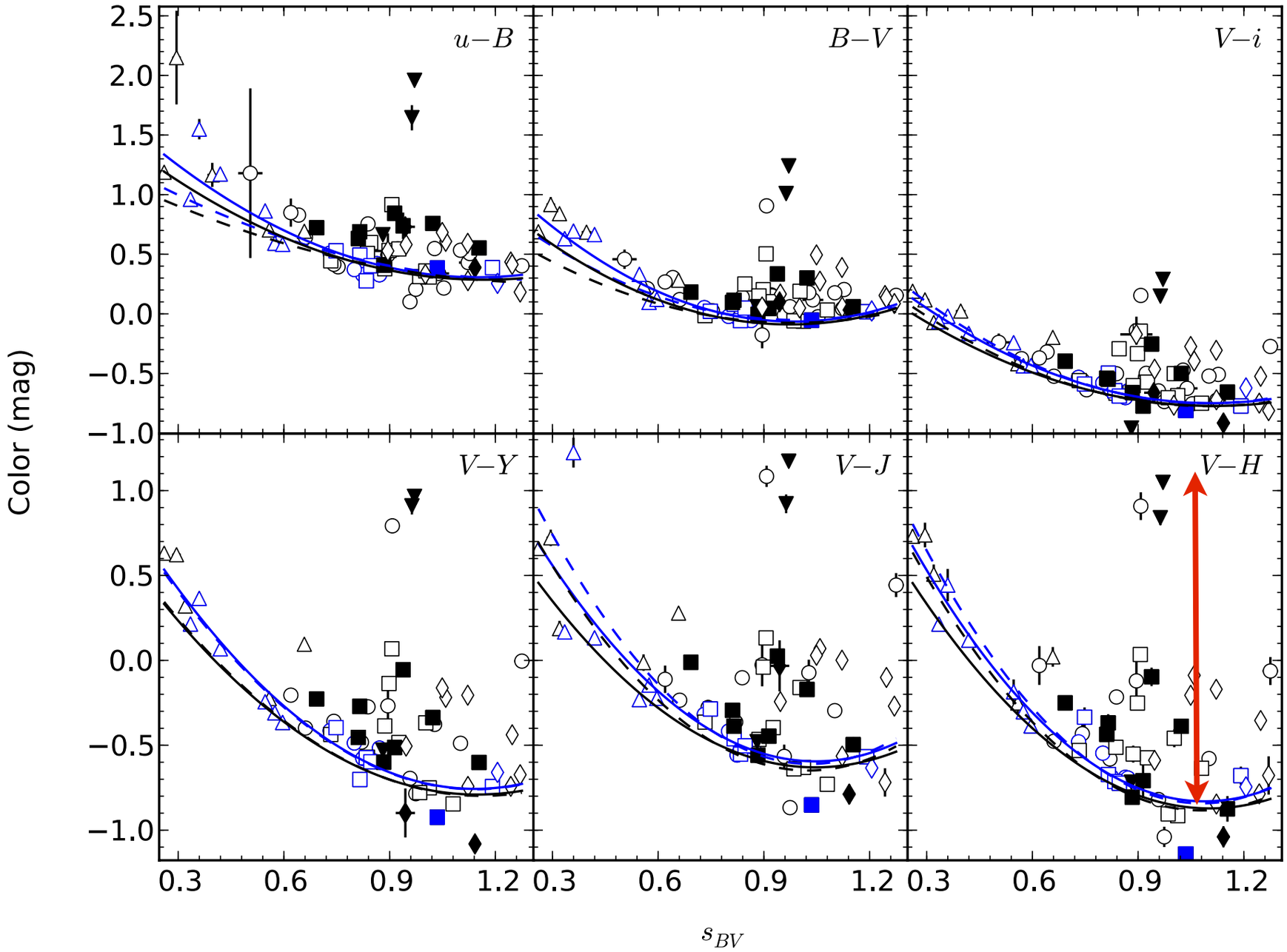




Intrinsic Colors vs. s_{BV}

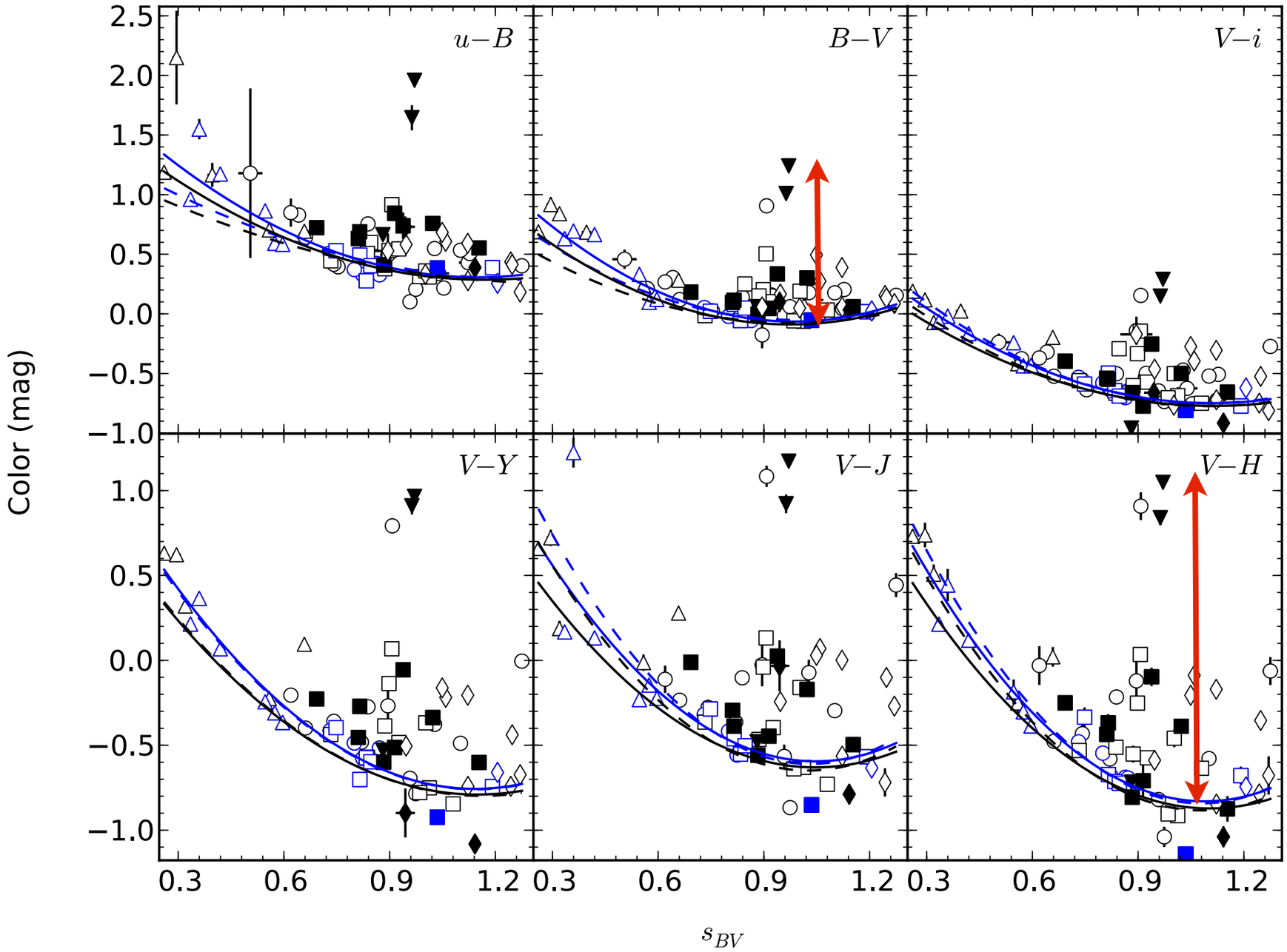


Intrinsic Colors vs. s_{BV}



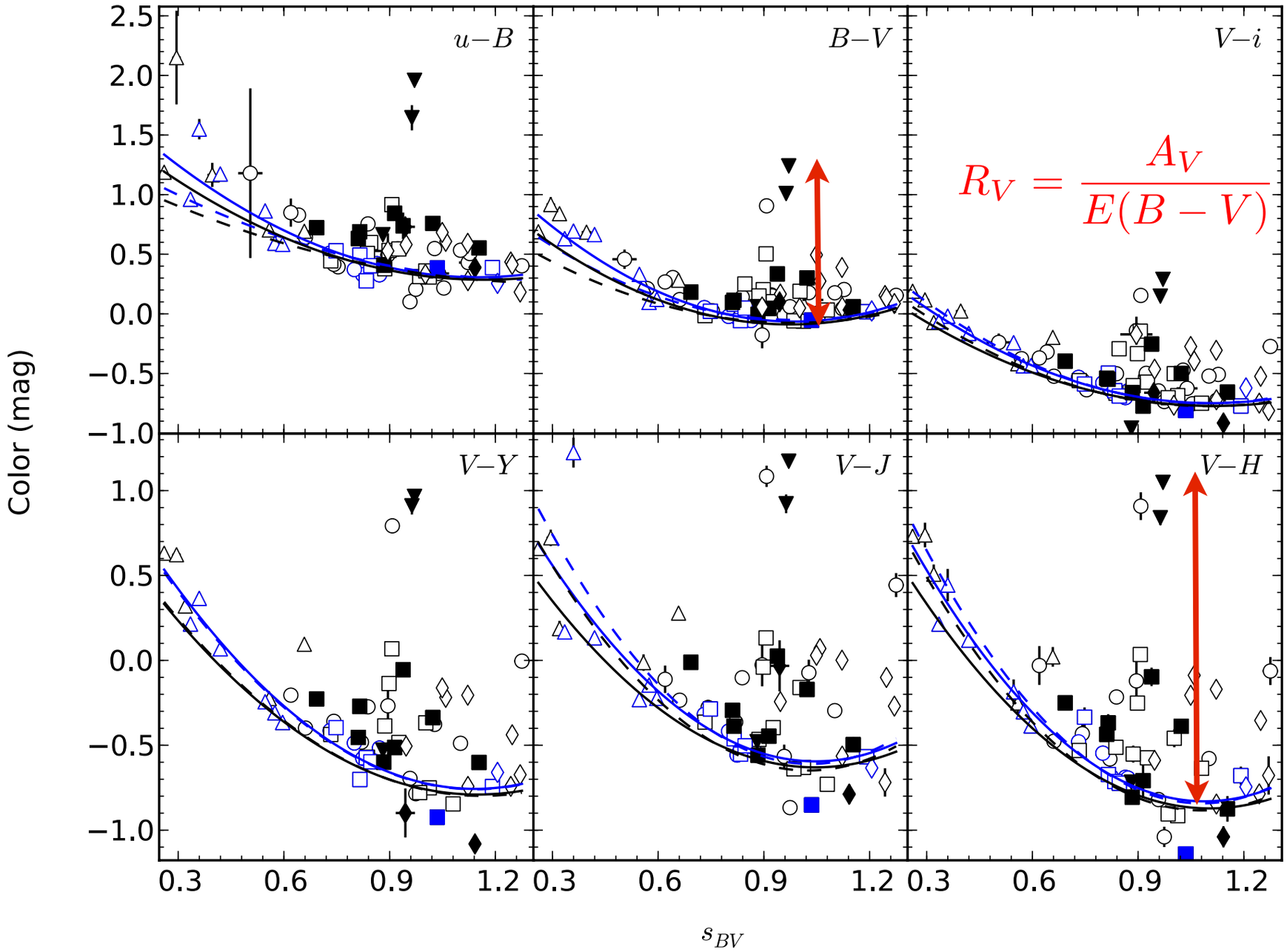
$$\frac{R_V - R_H}{R_V} A_V$$

Intrinsic Colors vs. s_{BV}



$$\frac{R_V - R_H}{R_V} A_V$$

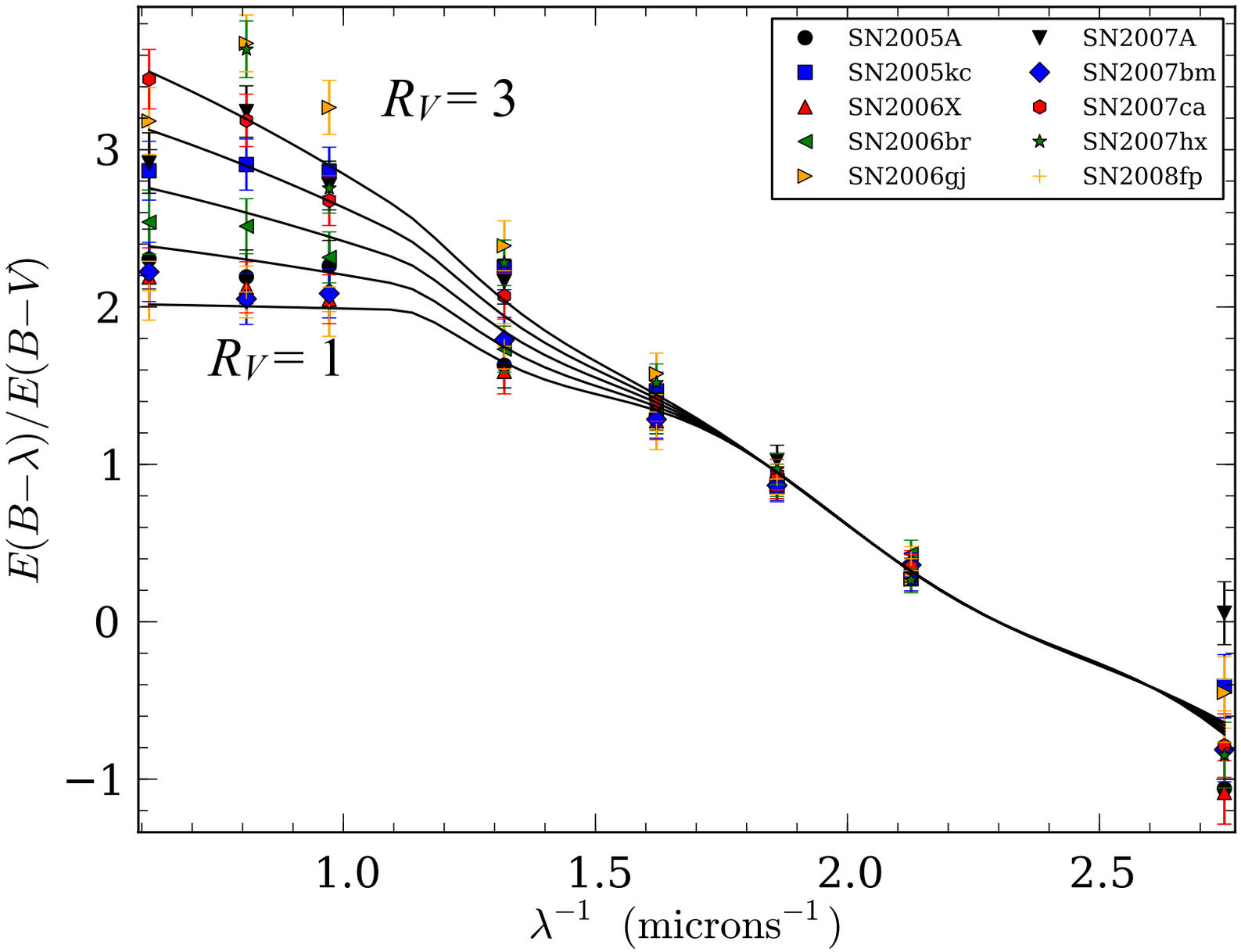
Intrinsic Colors vs. s_{BV}



$$R_V = \frac{A_V}{E(B-V)} \simeq \frac{E(V-H)}{E(B-V)}$$

$$\frac{R_V - R_H}{R_V} A_V$$

NIR pins down R_V



Goobar maybe fits u better?

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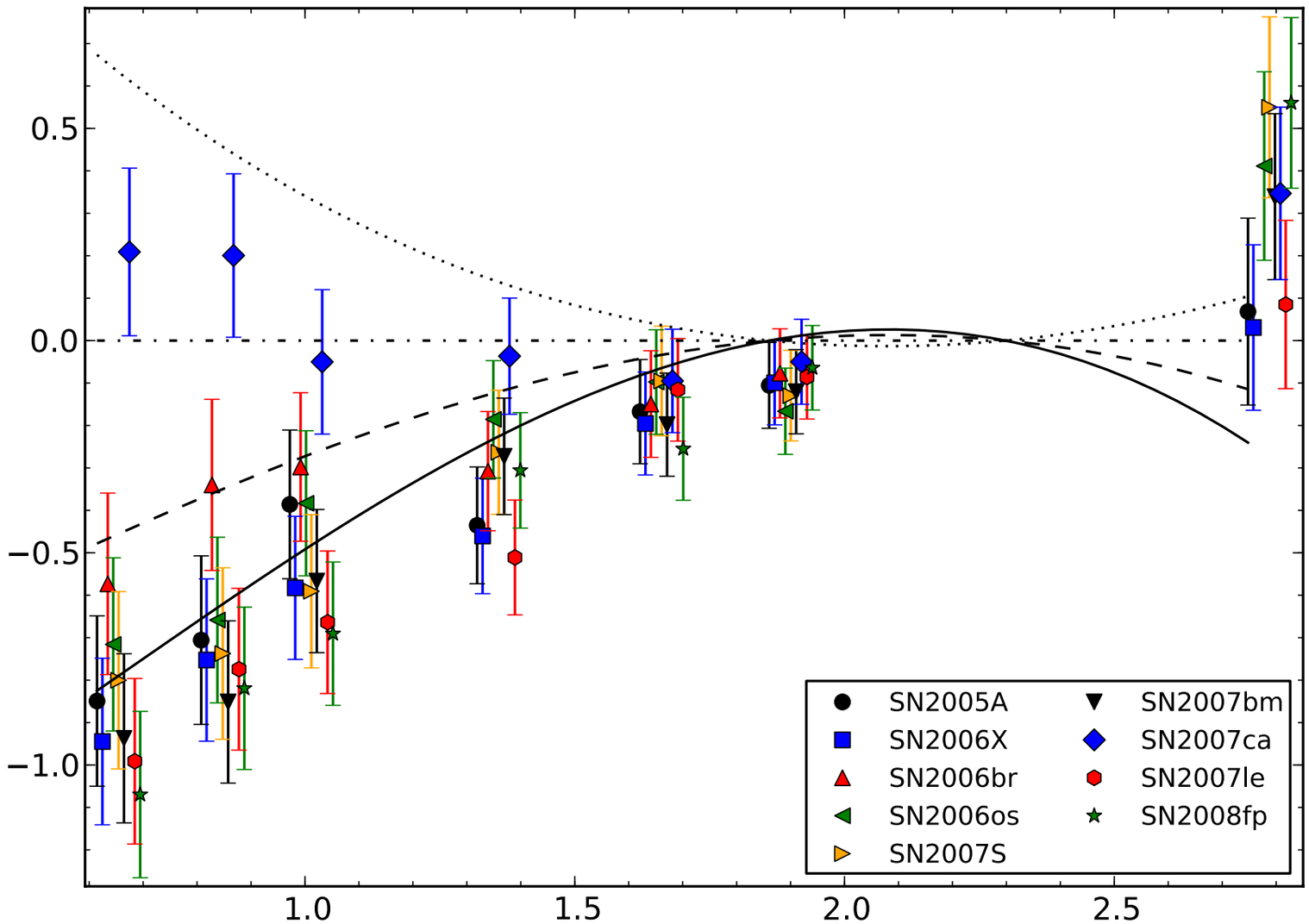
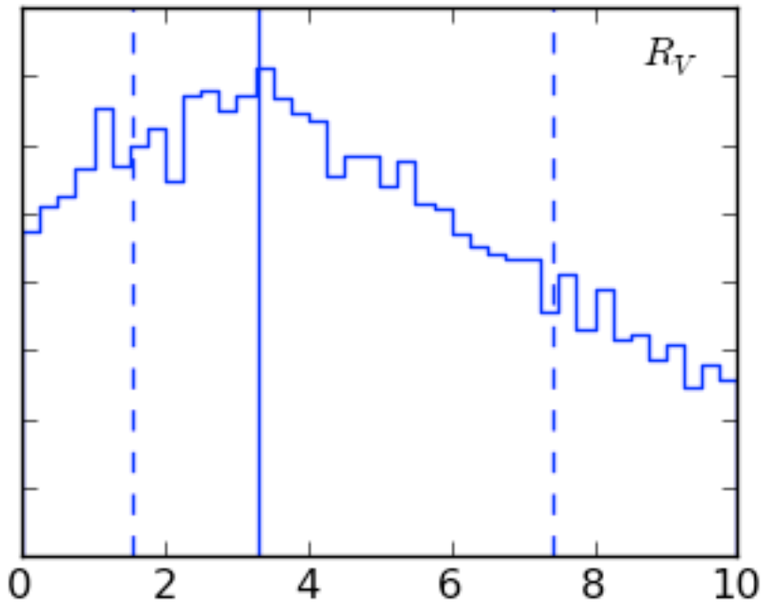
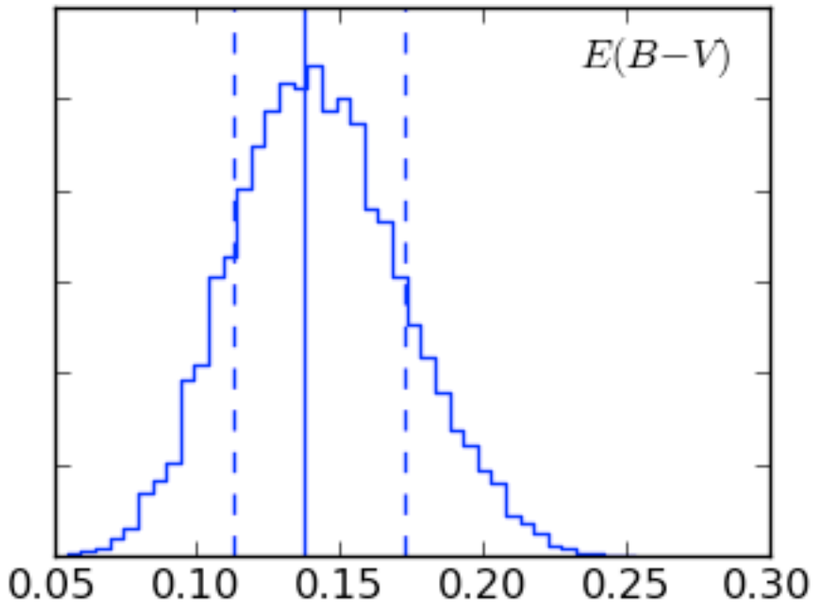
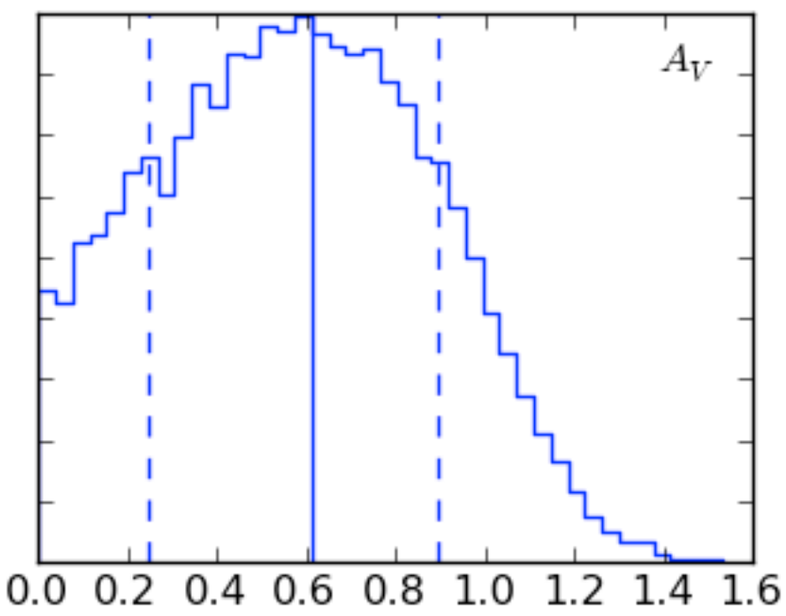
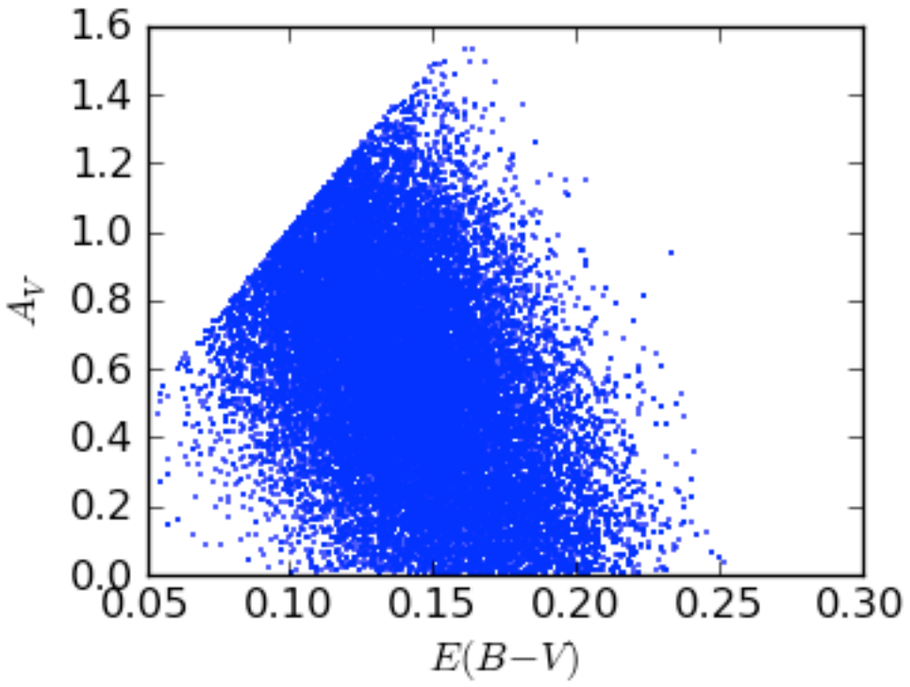


SN2007af optical

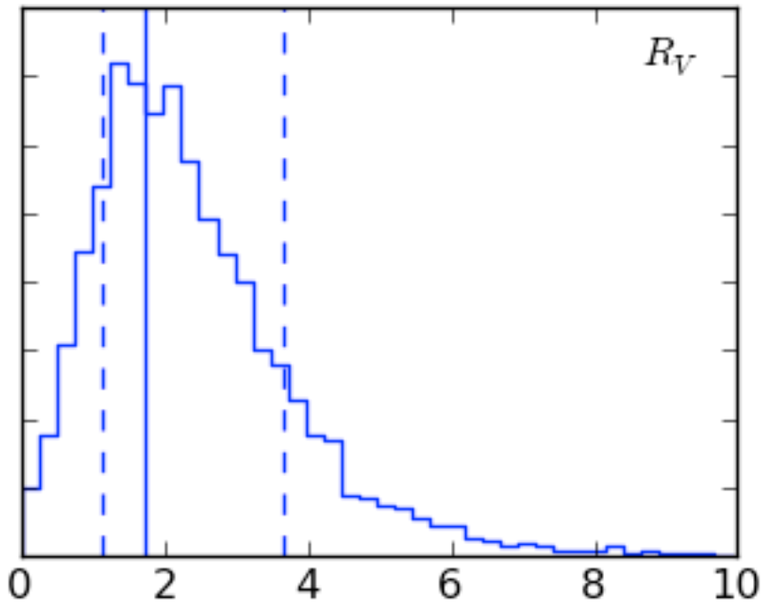


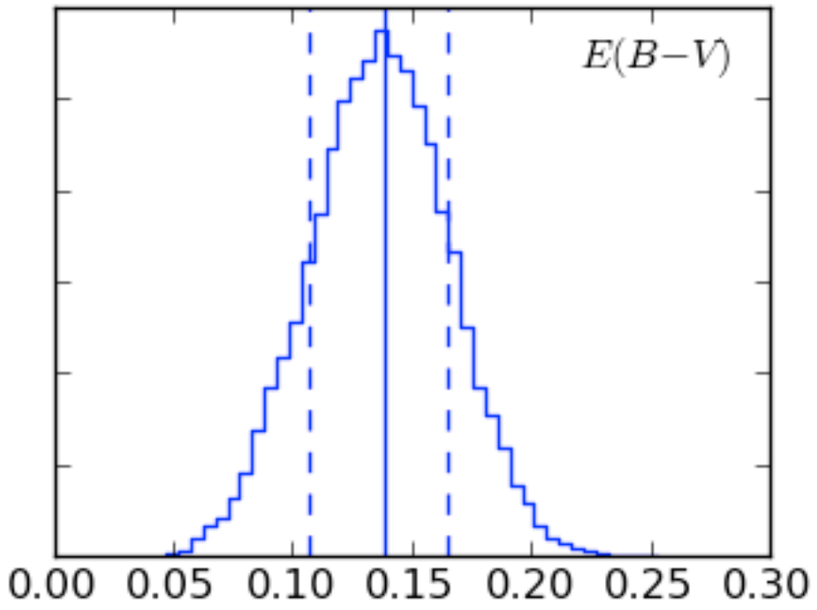


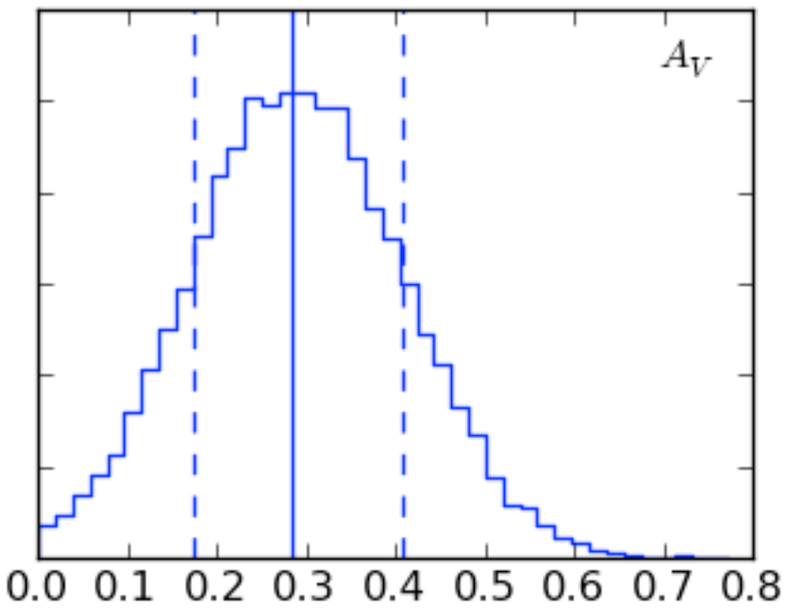


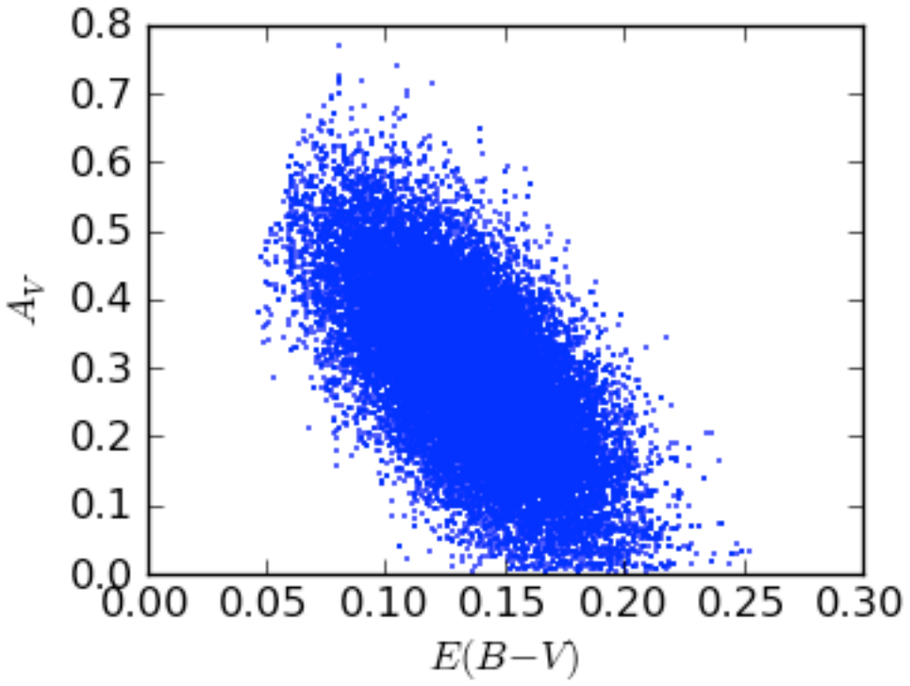


SN2007af optical + NIR

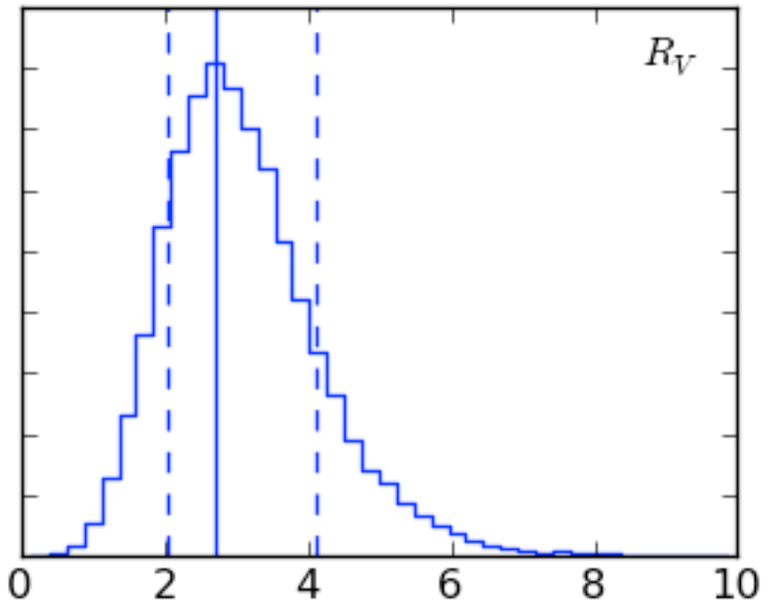


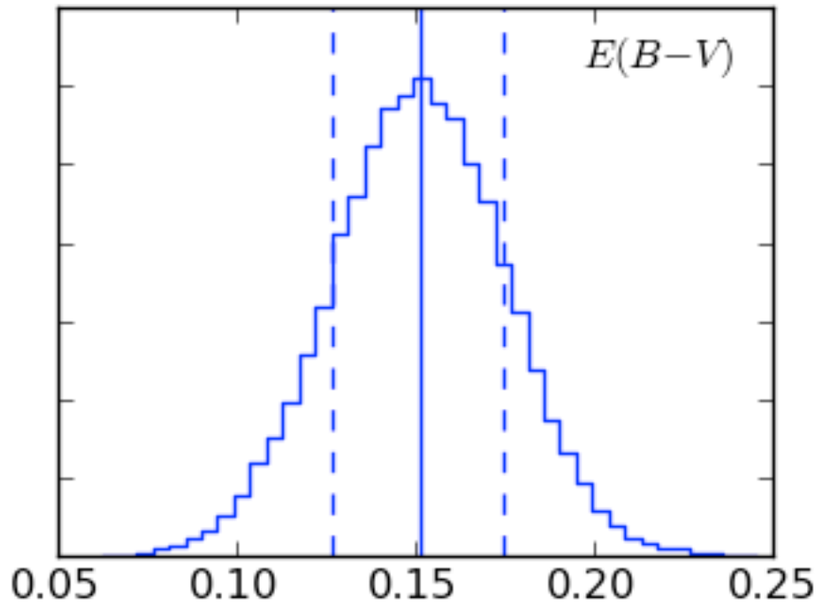


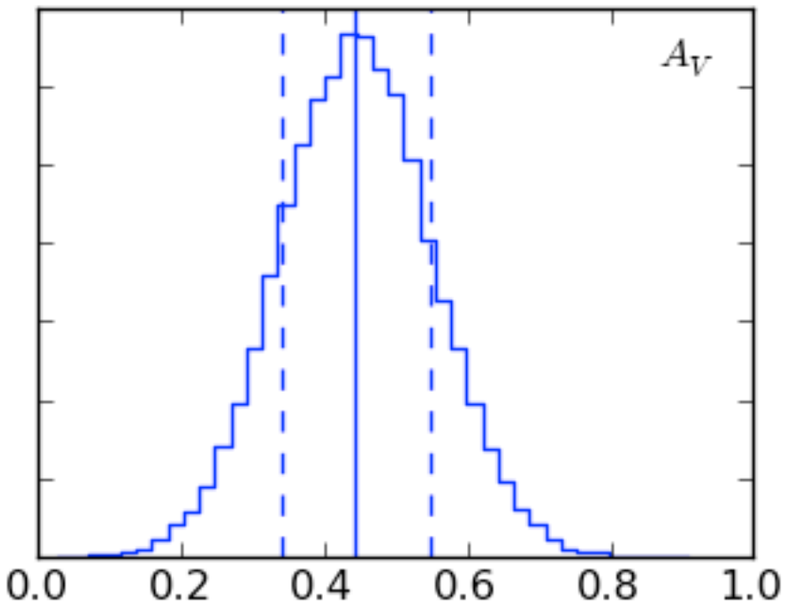


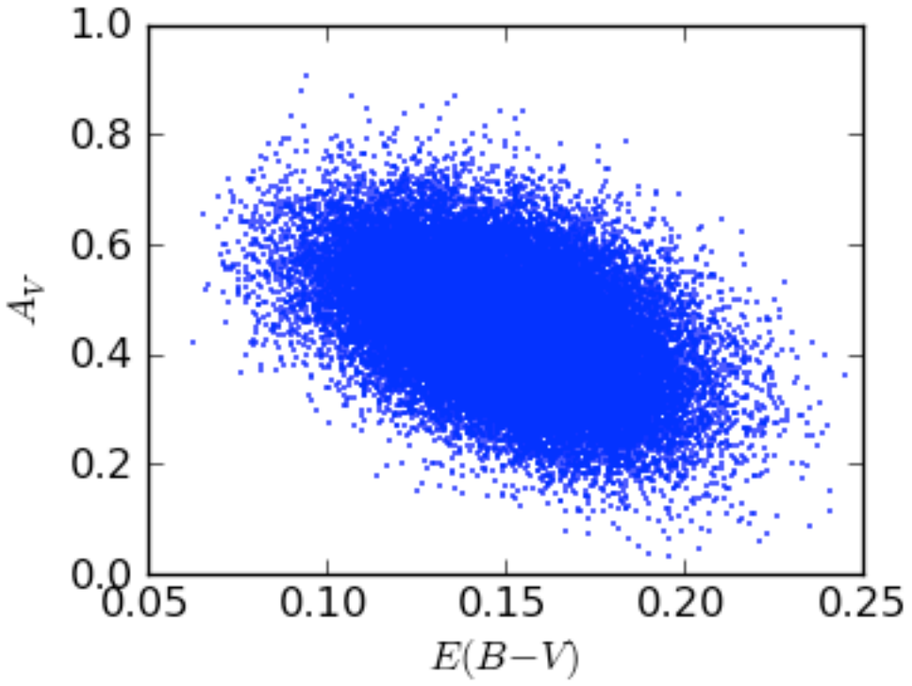


SN2004ef

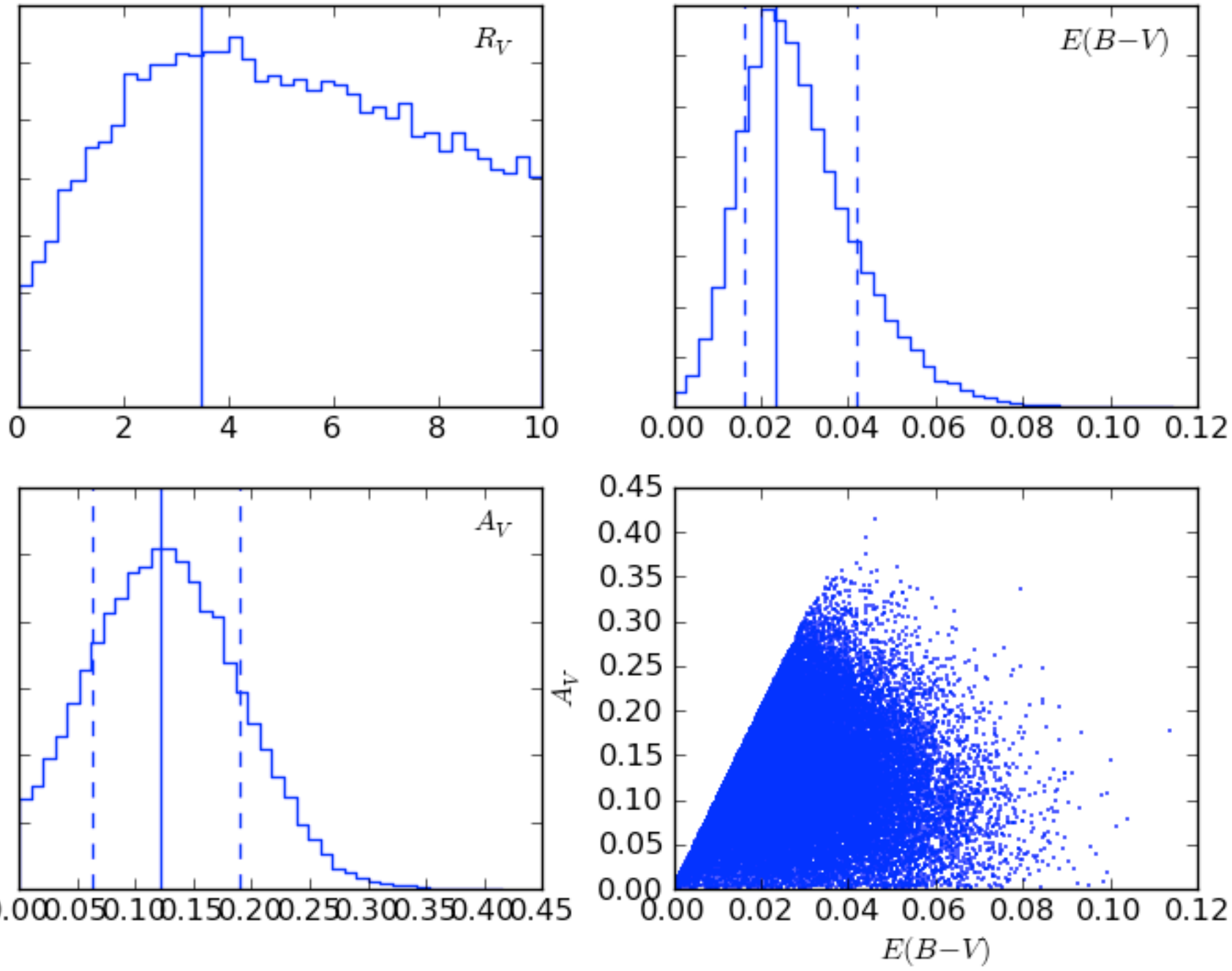

R_V
0
2
4
6
8
10


$E(B-V)$
0.05
0.10
0.15
0.20
0.25

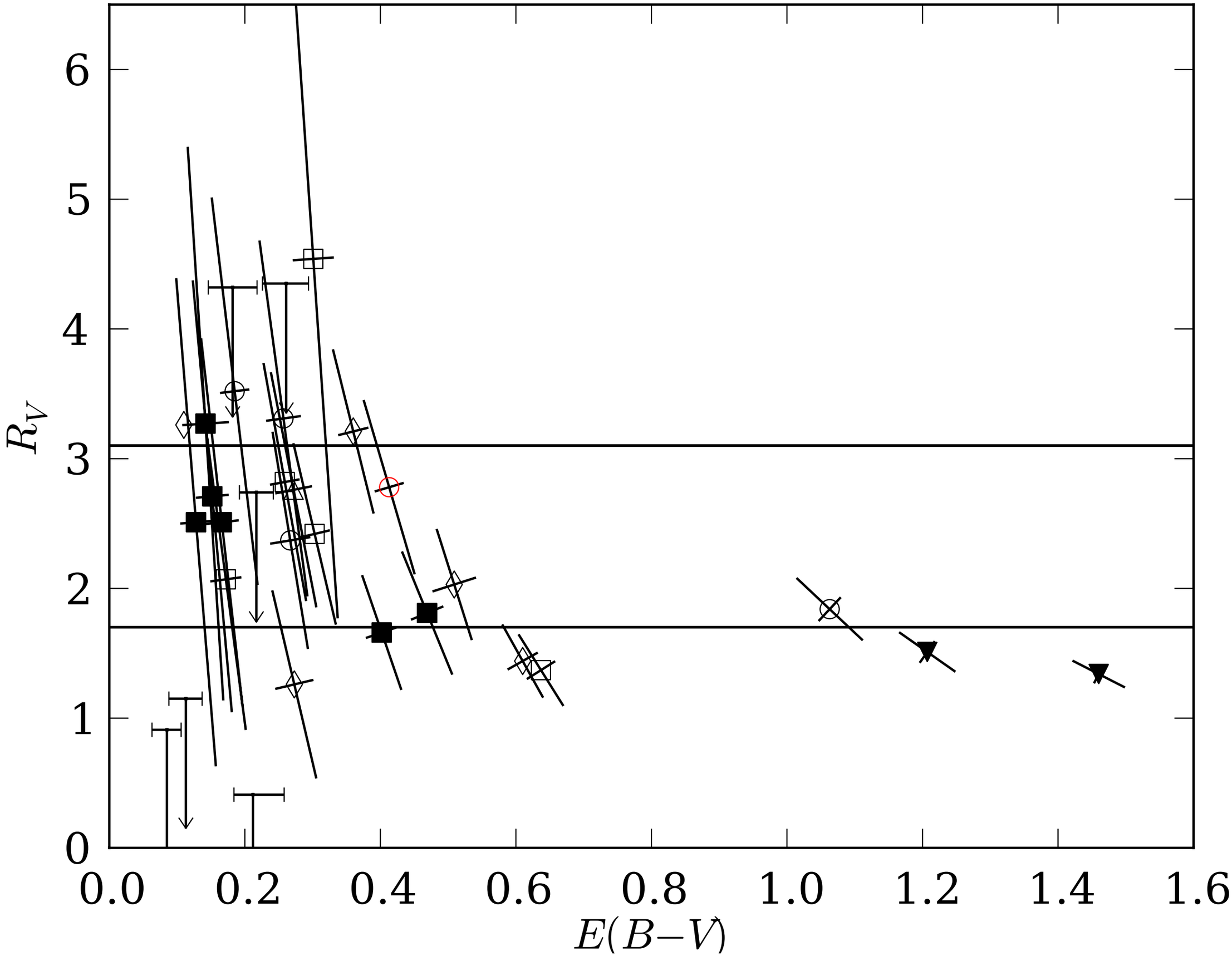

A_V
0.0
0.2
0.4
0.6
0.8
1.0


A_V
$E(B-V)$
0.0
0.2
0.4
0.6
0.8
1.0
0.05
0.10
0.15
0.20
0.25

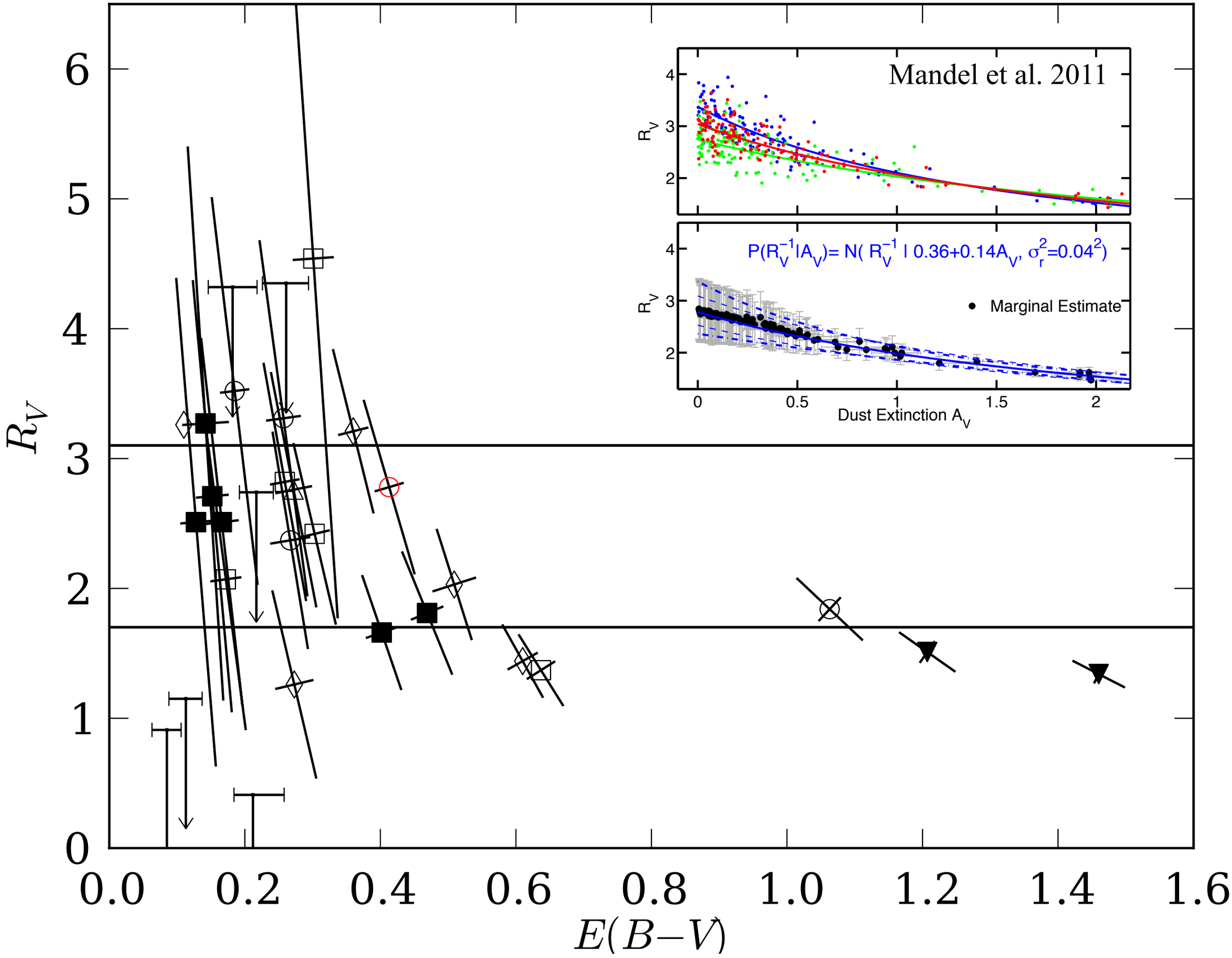
SN2004ey


R_V
0
2
4
6
8
10
$E(B-V)$
0.00
0.02
0.04
0.06
0.08
0.10
0.12
A_V
0.000.050.100.150.200.250.300.350.400.45
A_V
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.00
0.02
0.04
0.06
0.08
0.10
0.12
$E(B-V)$

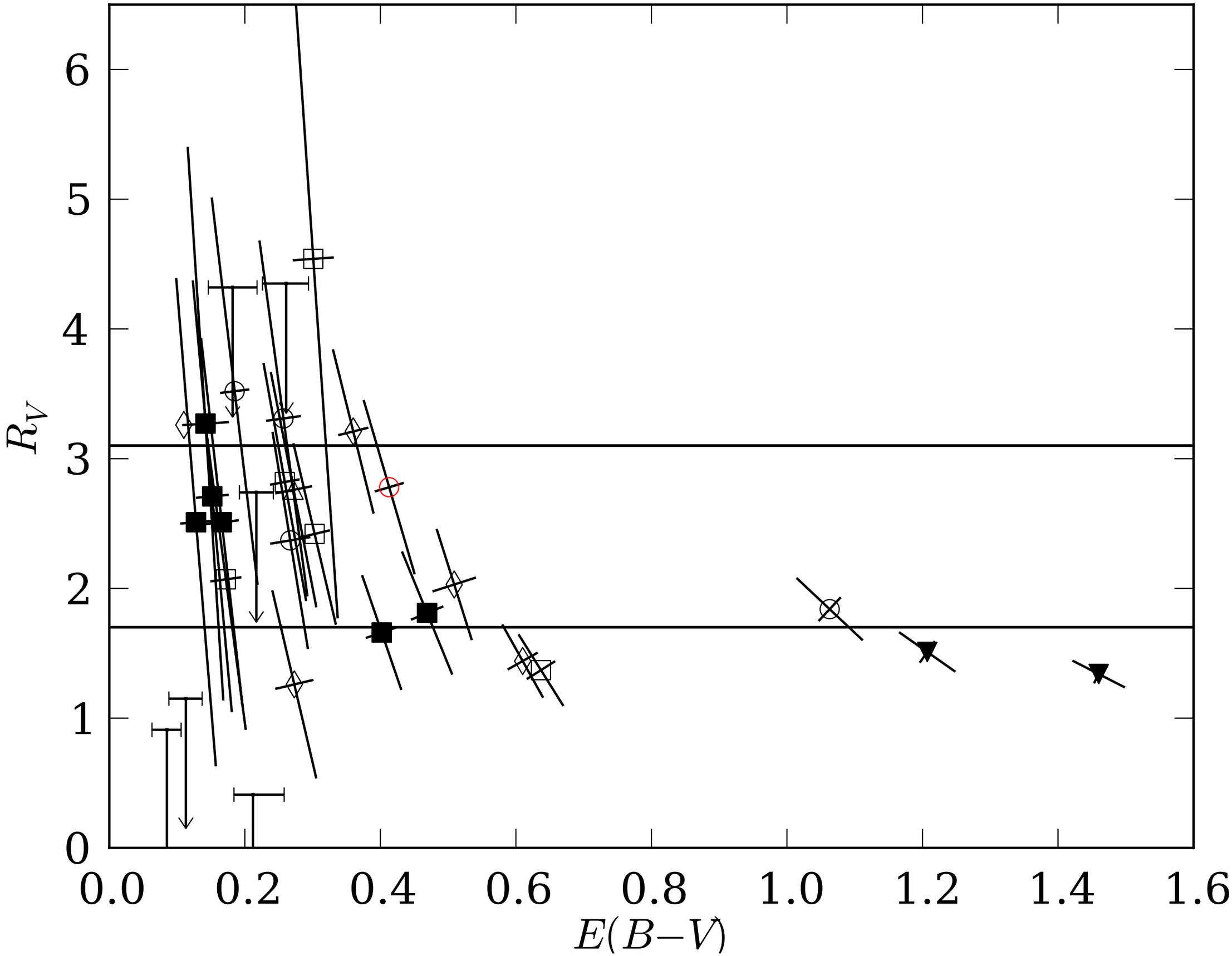
CSP OBJECTS



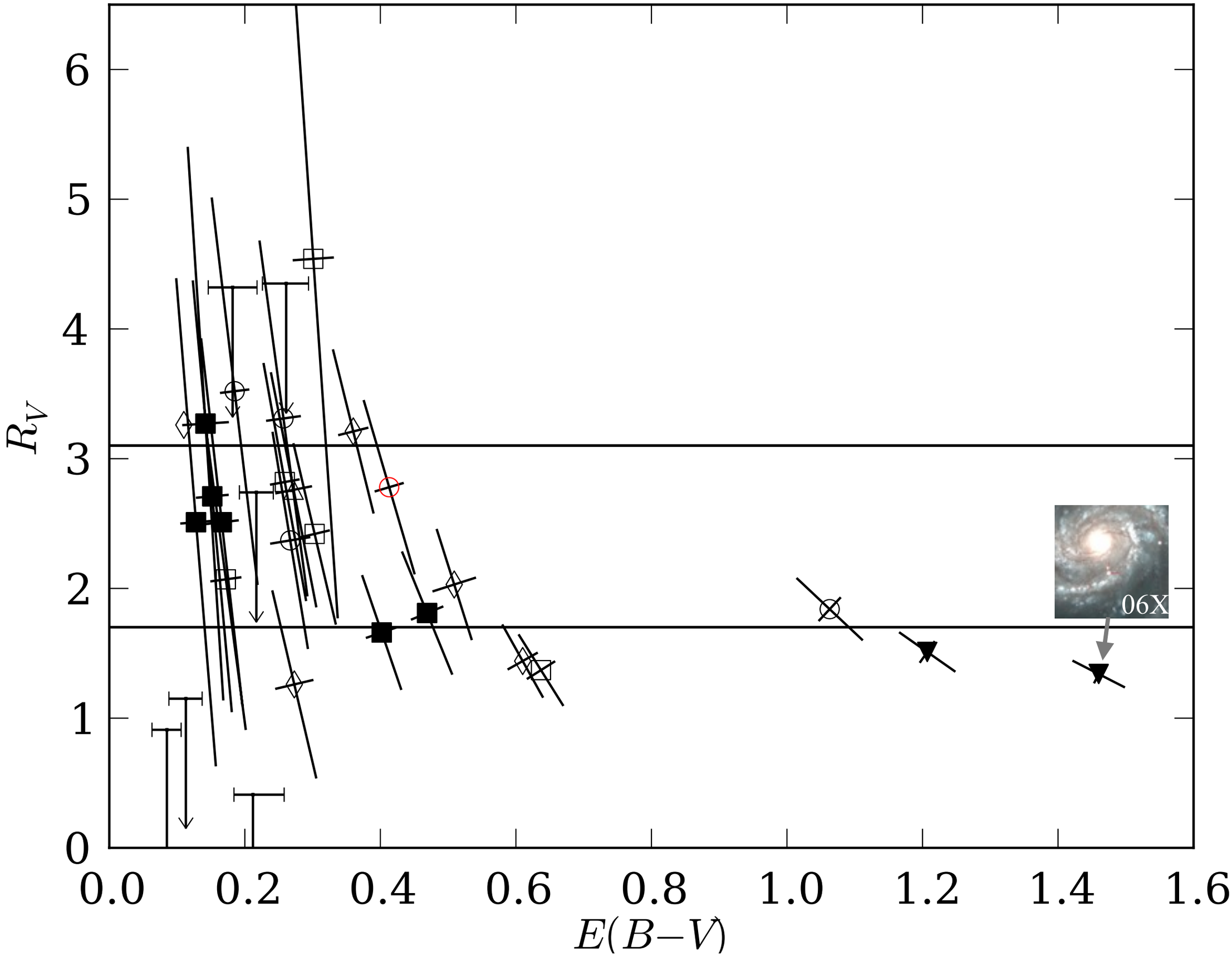
CSP OBJECTS


R_V
$E(B-V)$
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0
1
2
3
4
5
6
Mandel et al. 2011
$P(R_V^{-1}|A_V) = N(R_V^{-1} | 0.36+0.14A_V, \sigma_r^2=0.04^2)$
Marginal Estimate
Dust Extinction A_V
0
0.5
1
1.5
2
2
3
4

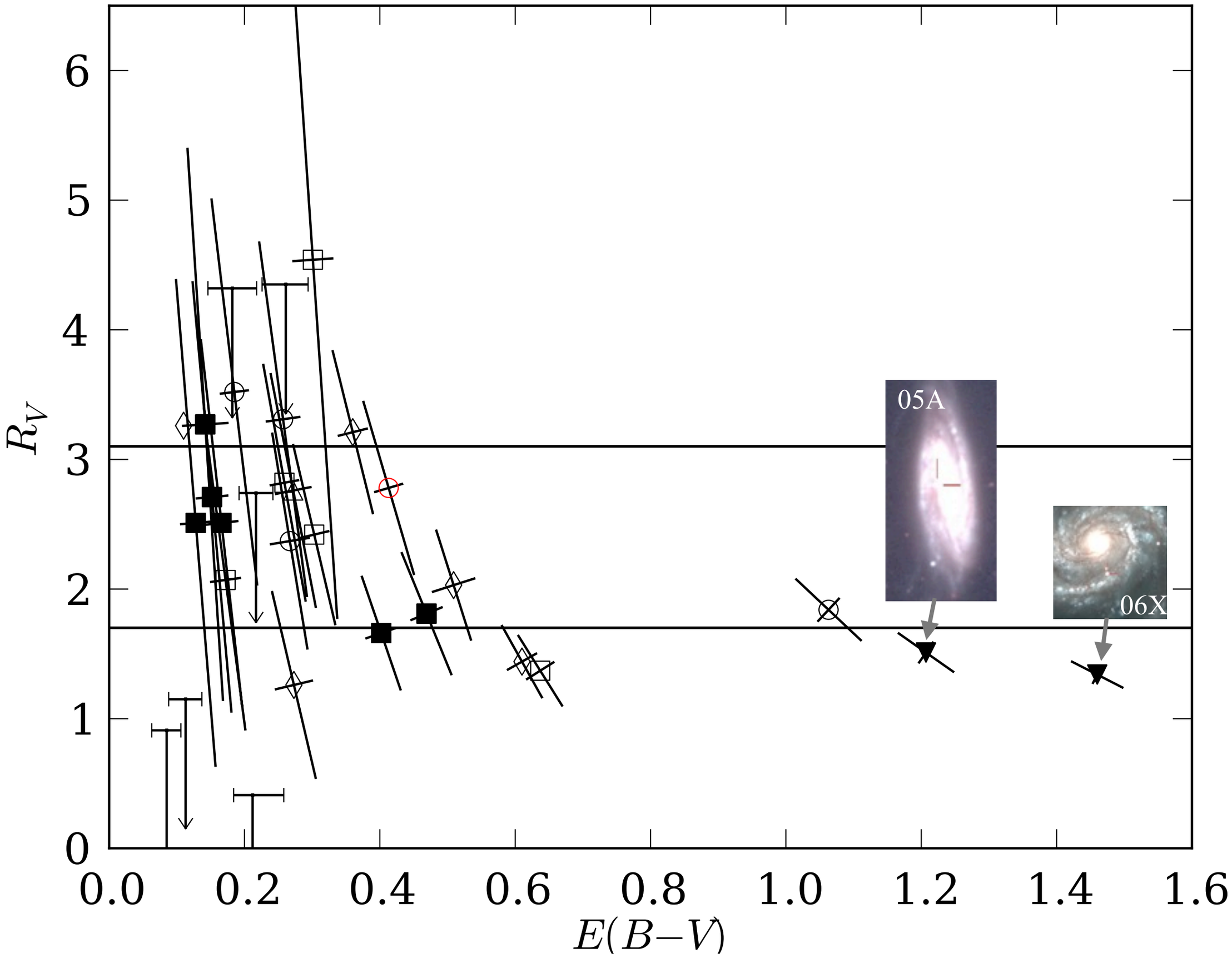
CSP OBJECTS



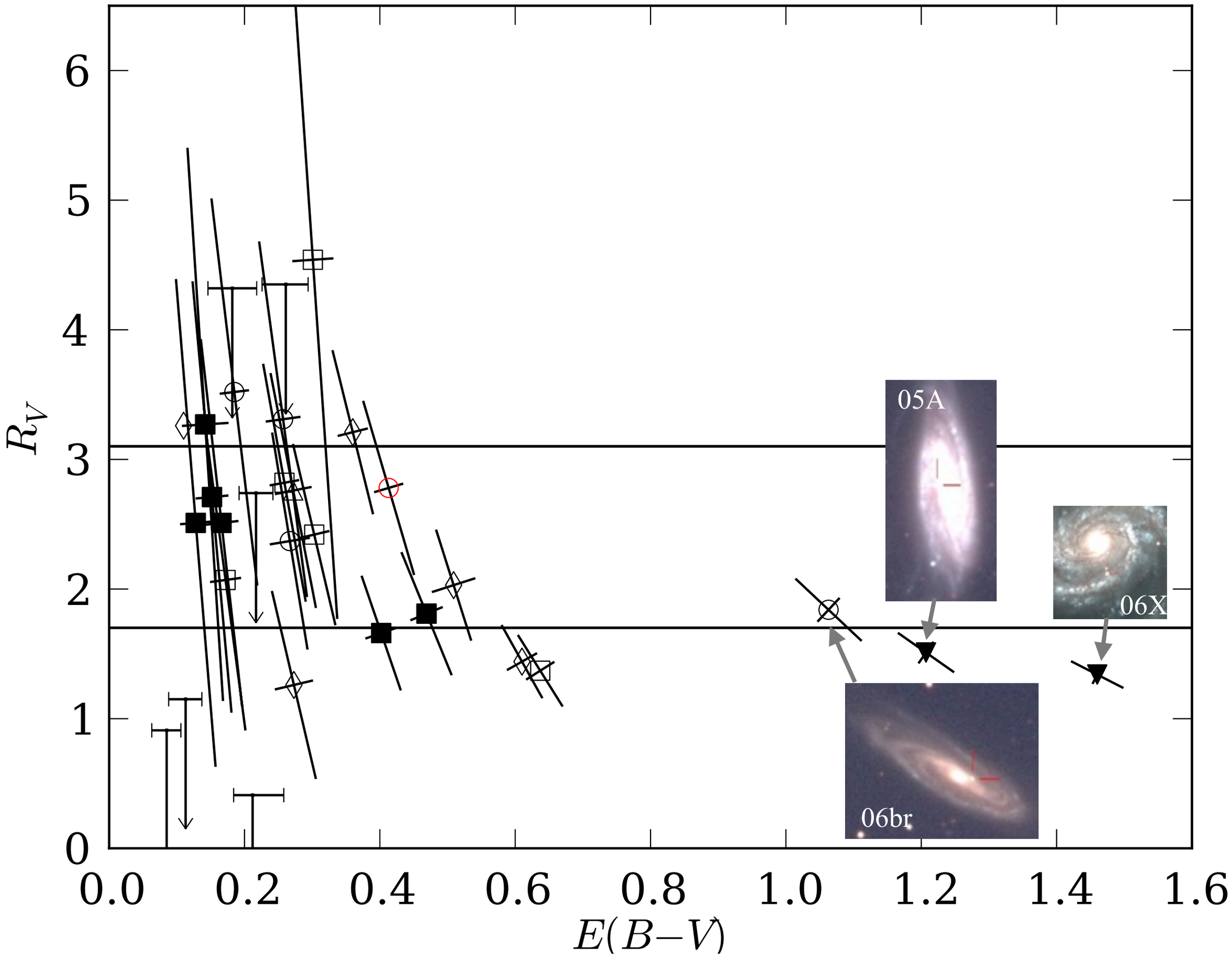
CSP OBJECTS



CSP OBJECTS



CSP OBJECTS



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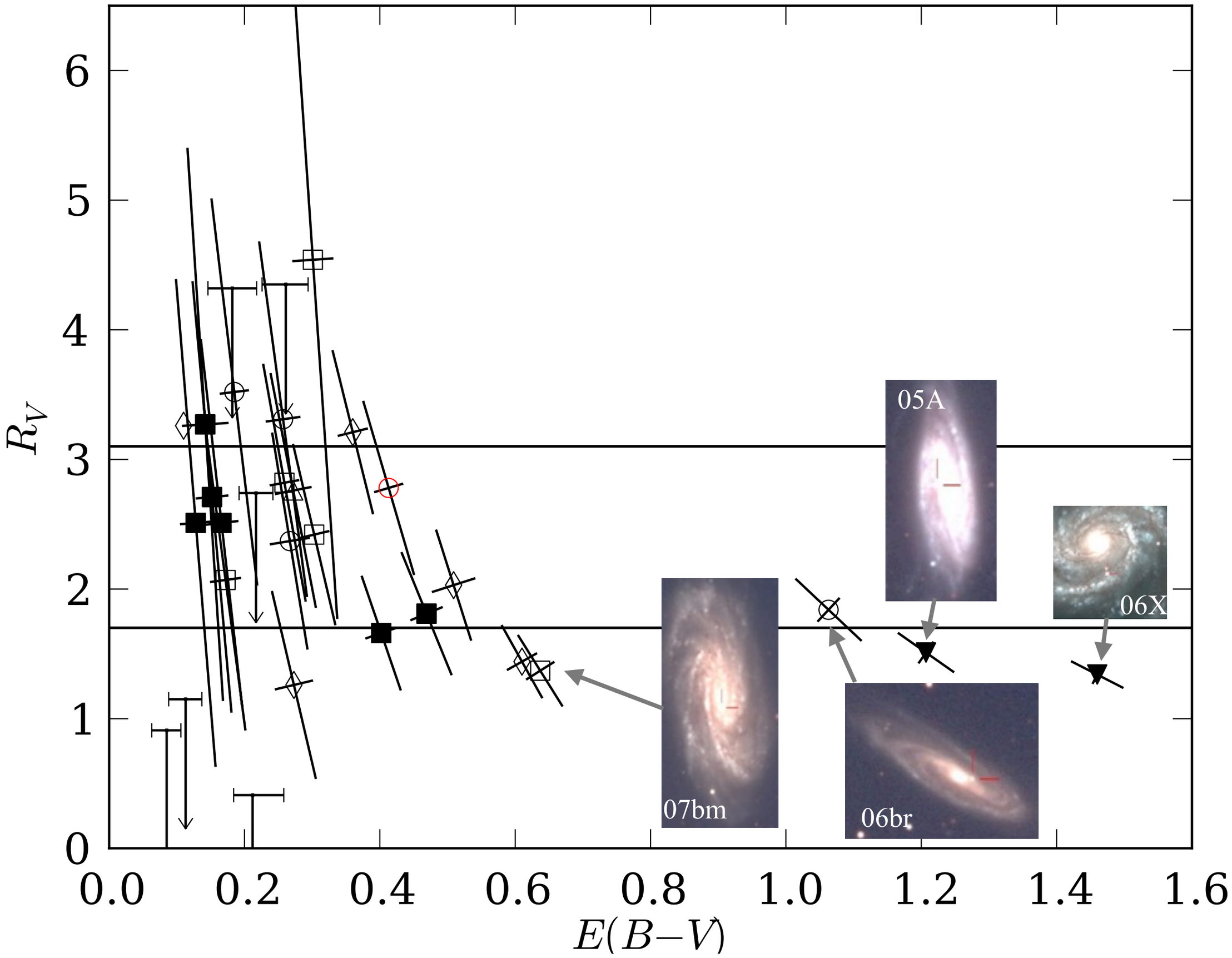
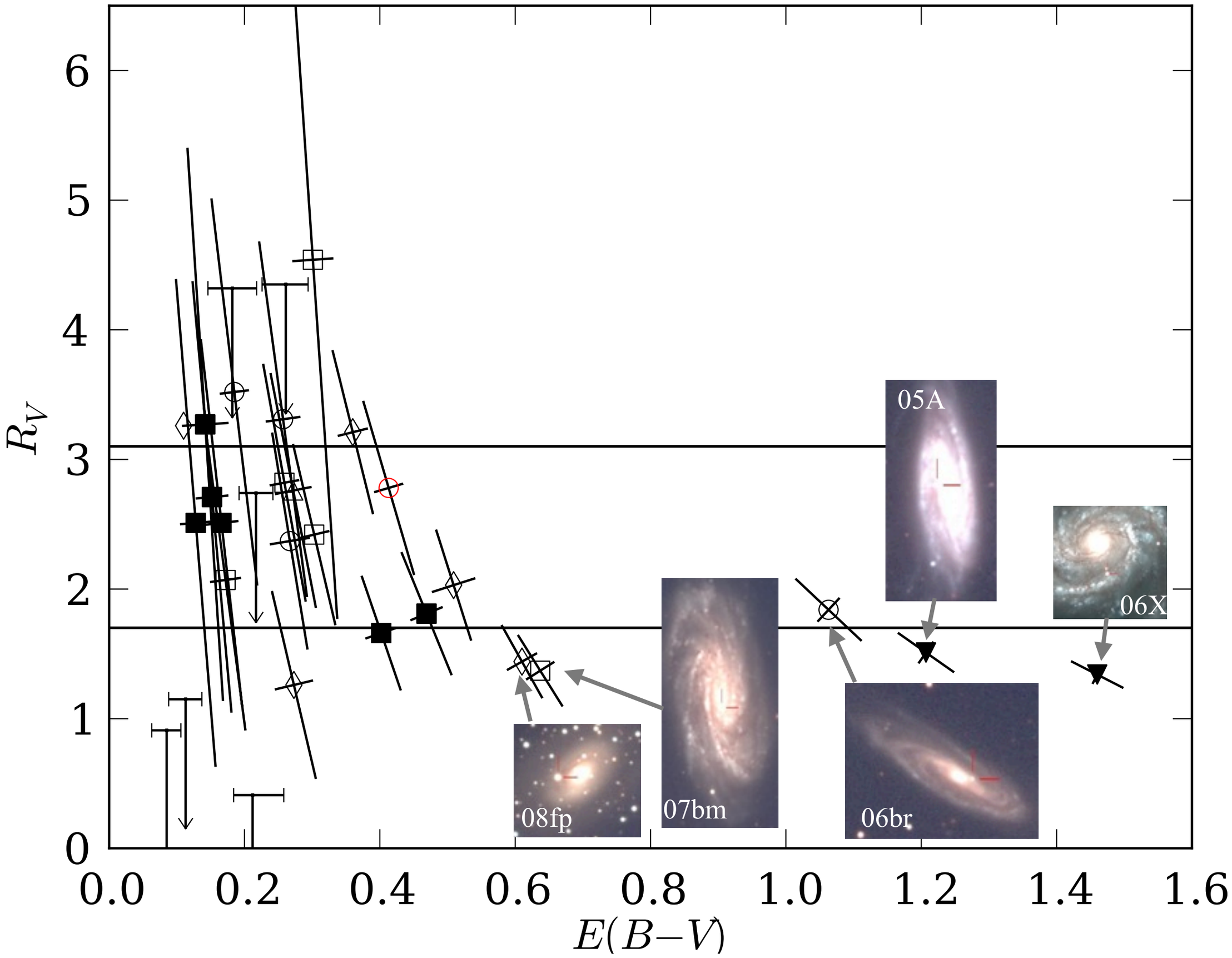
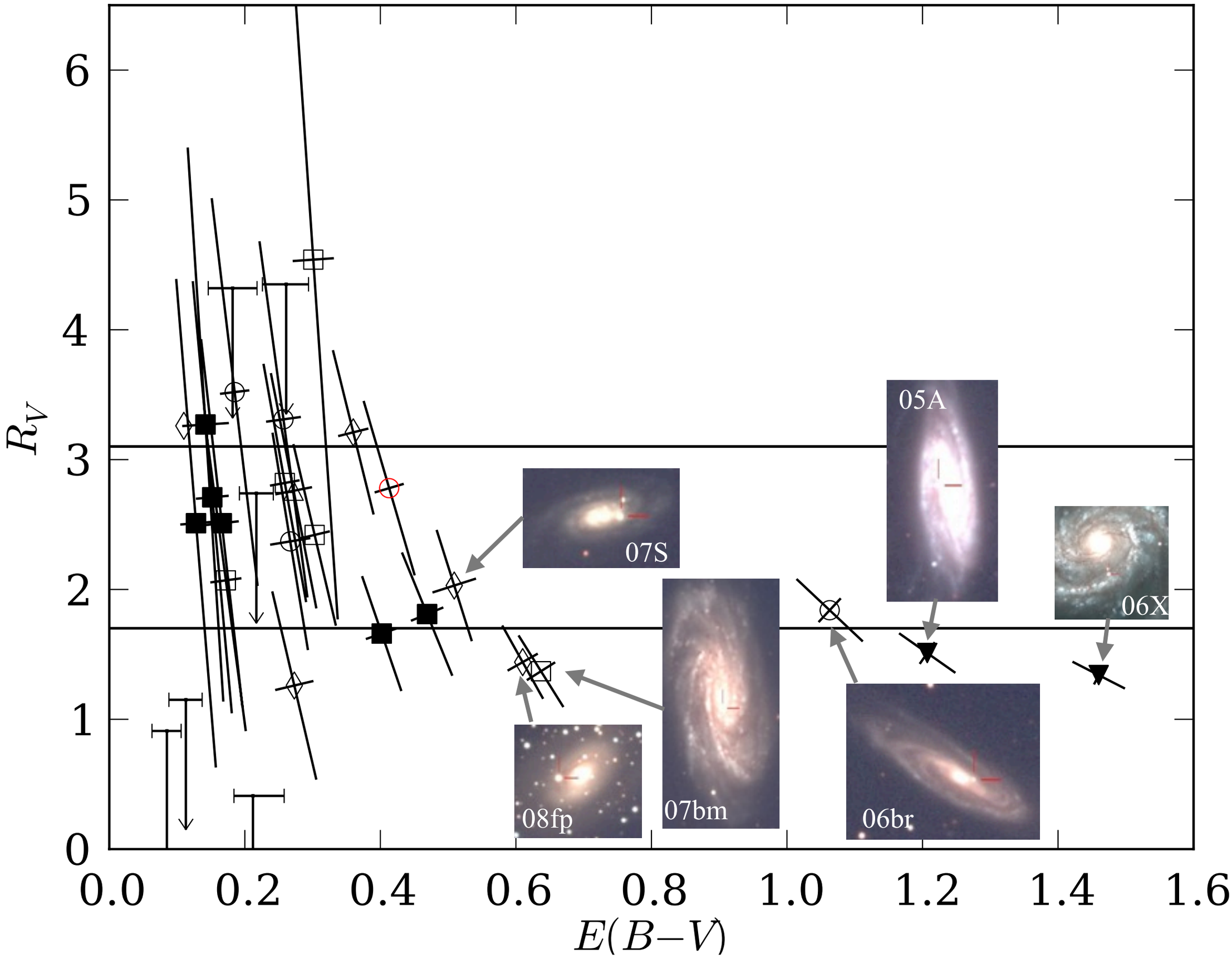


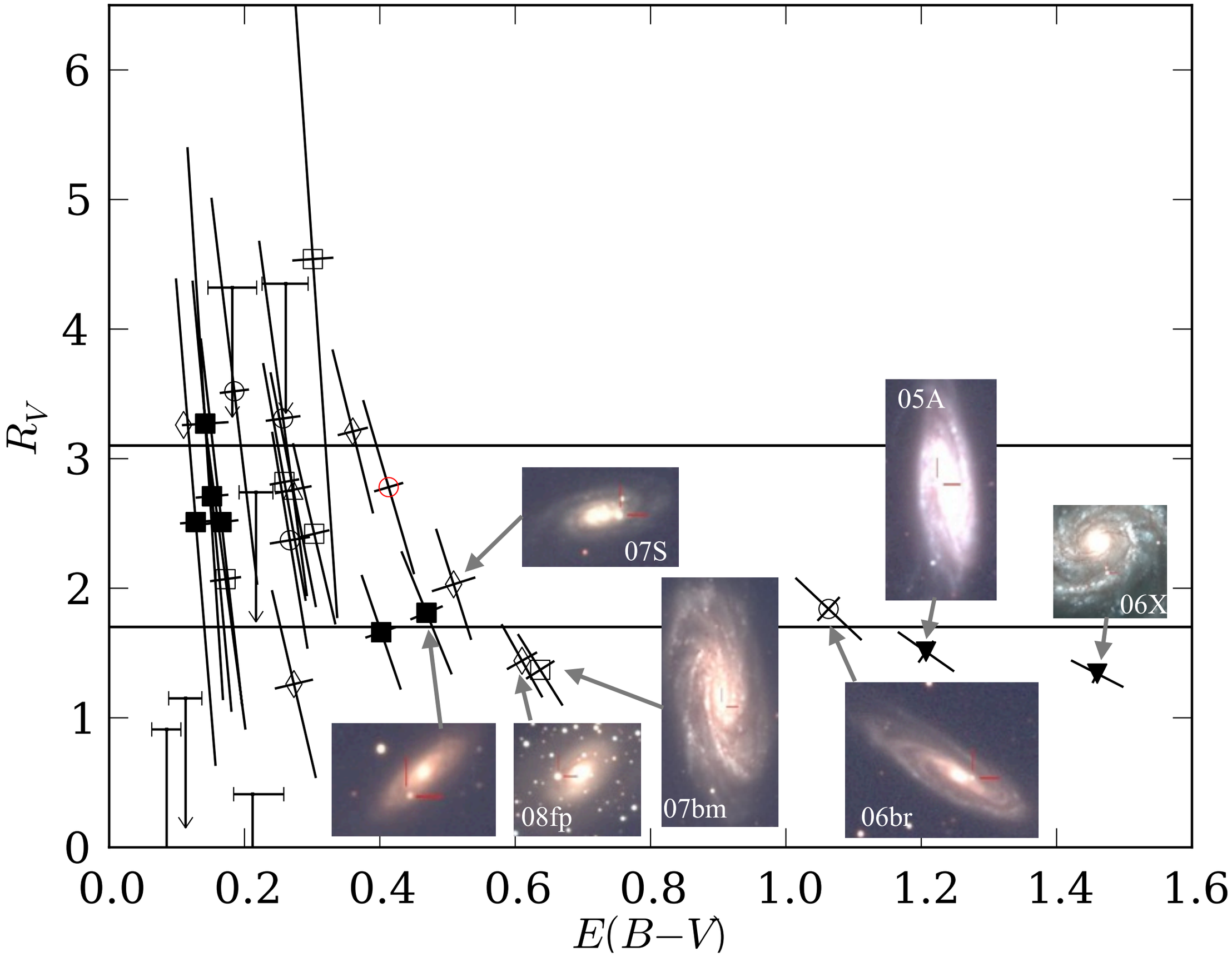
CSP OBJECTS



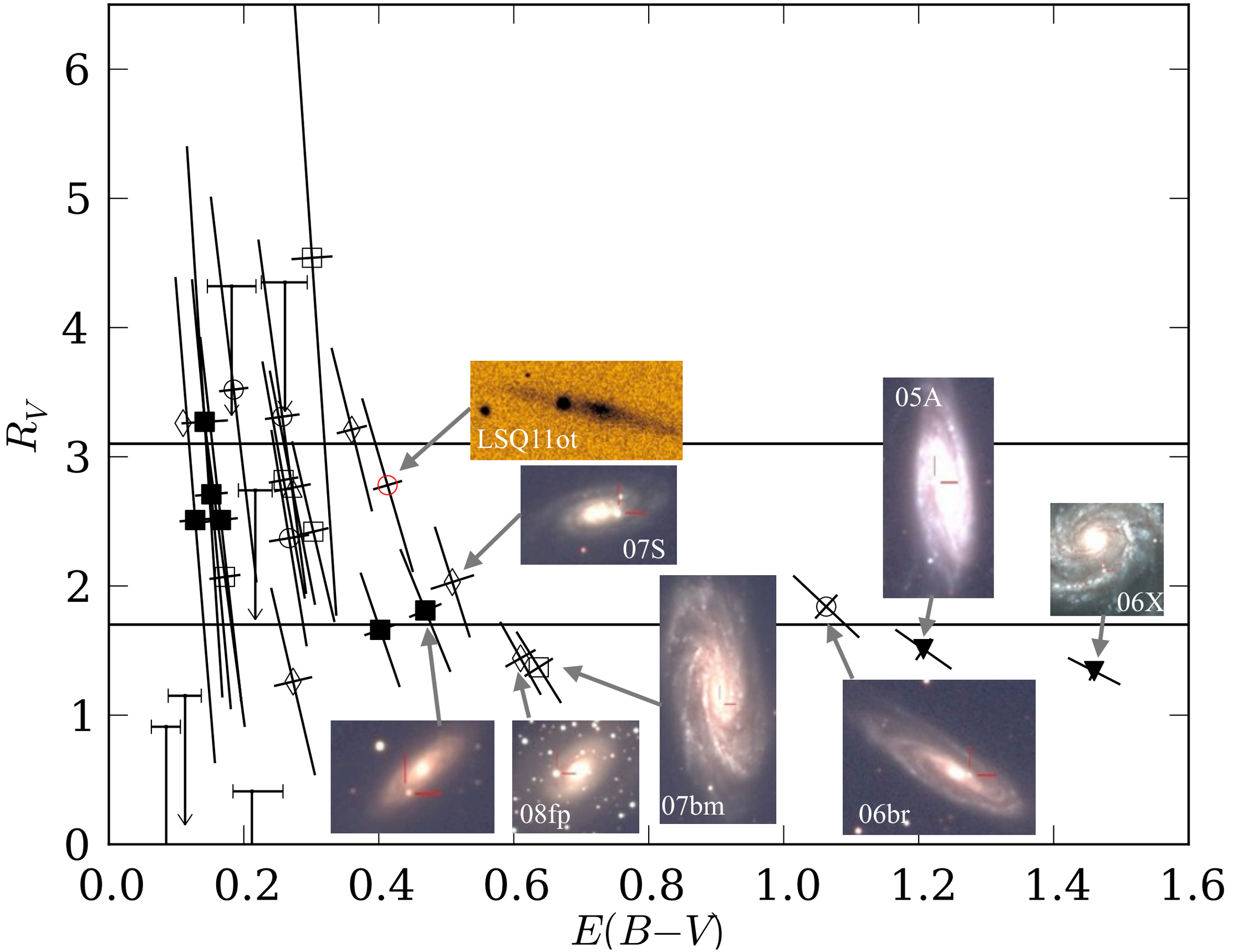
CSP OBJECTS


R_V
$E(B-V)$
0
1
2
3
4
5
6
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
05A
07S
06X
08fp
07bm
06br

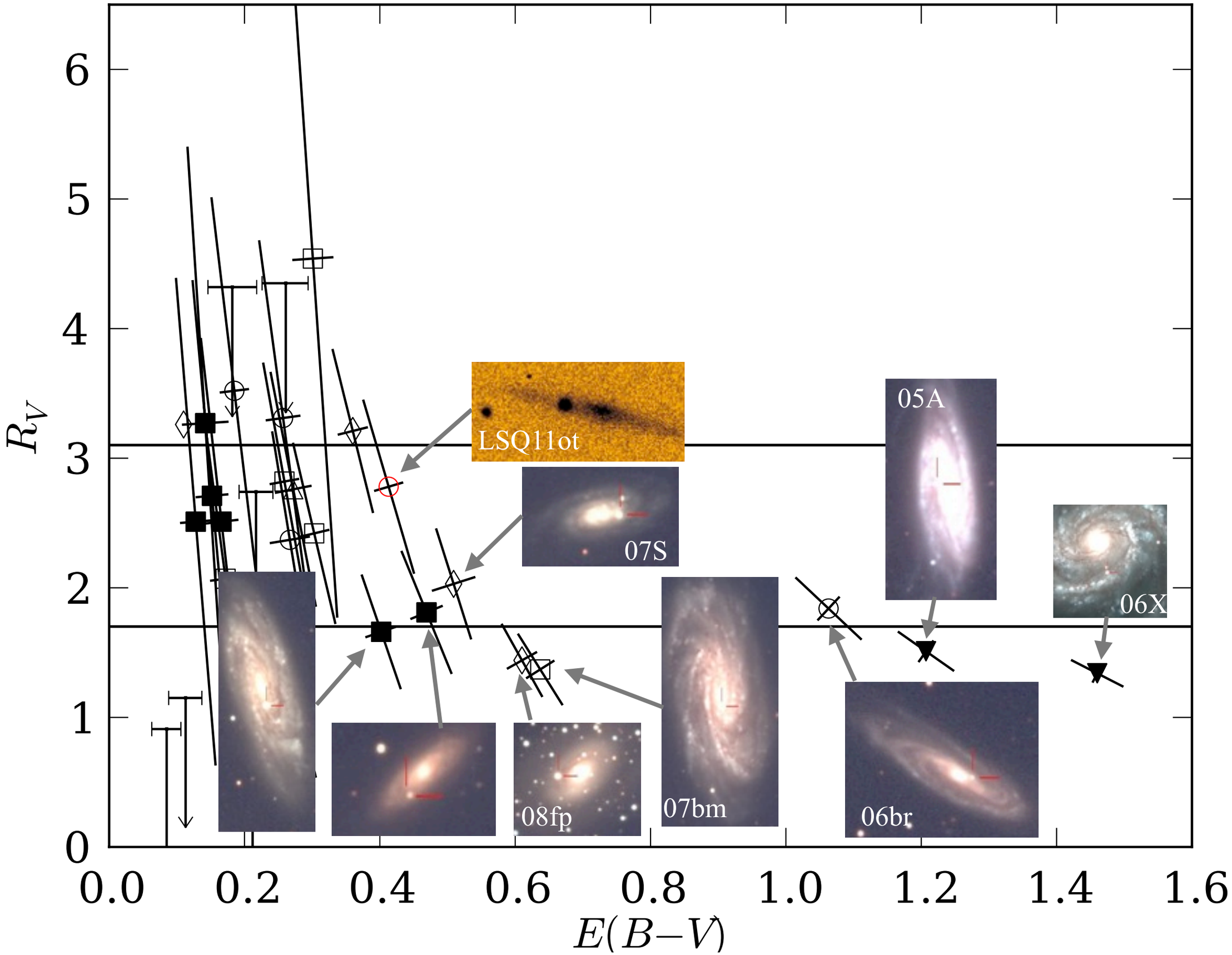
CSP OBJECTS


R_V
$E(B-V)$
0
1
2
3
4
5
6
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
05A
07S
06X
08fp
07bm
06br

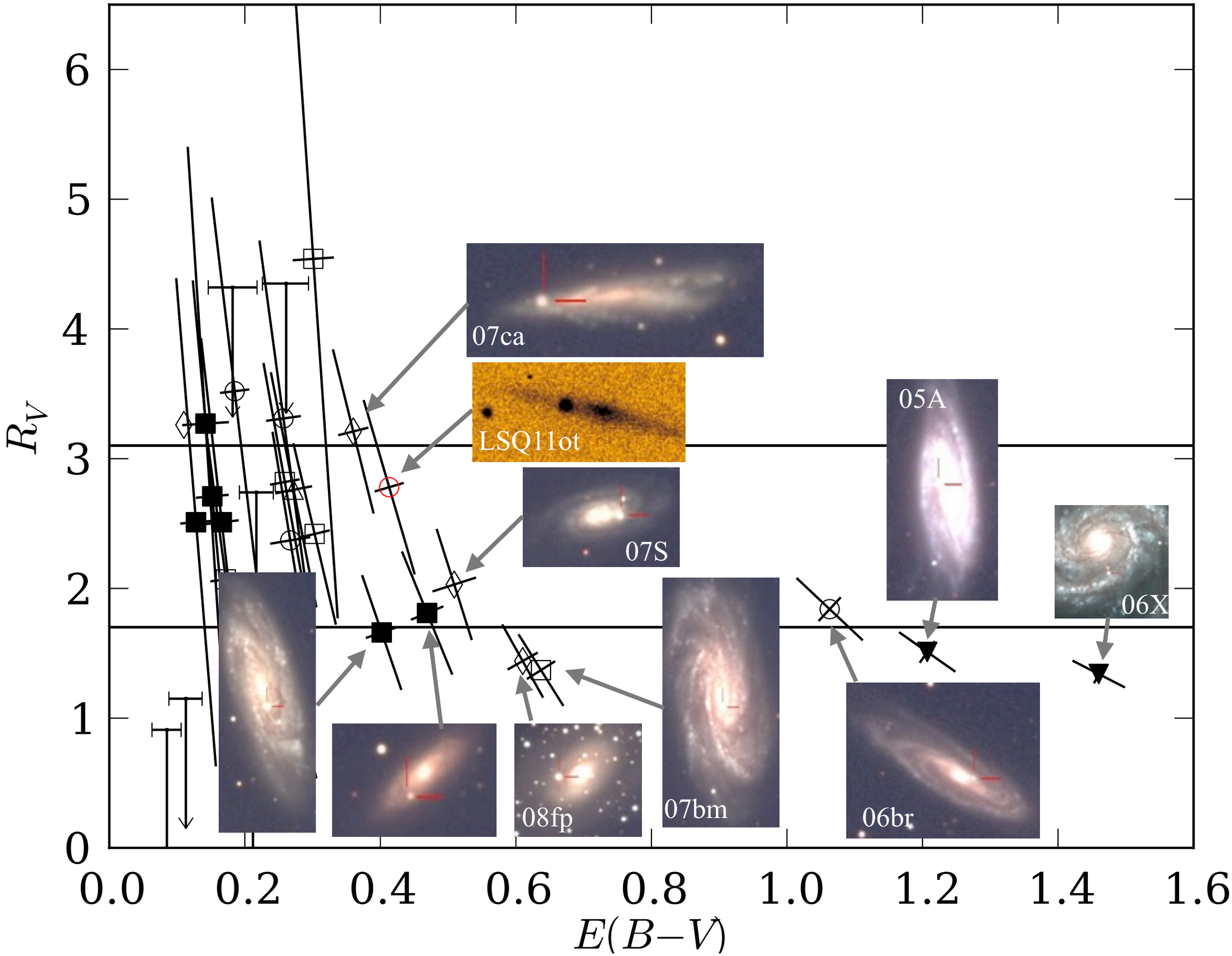
CSP OBJECTS


6
5
4
3
2
1
0
R_V
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
$E(B-V)$
LSQ11ot
07S
05A
06X
08fp
07bm
06br

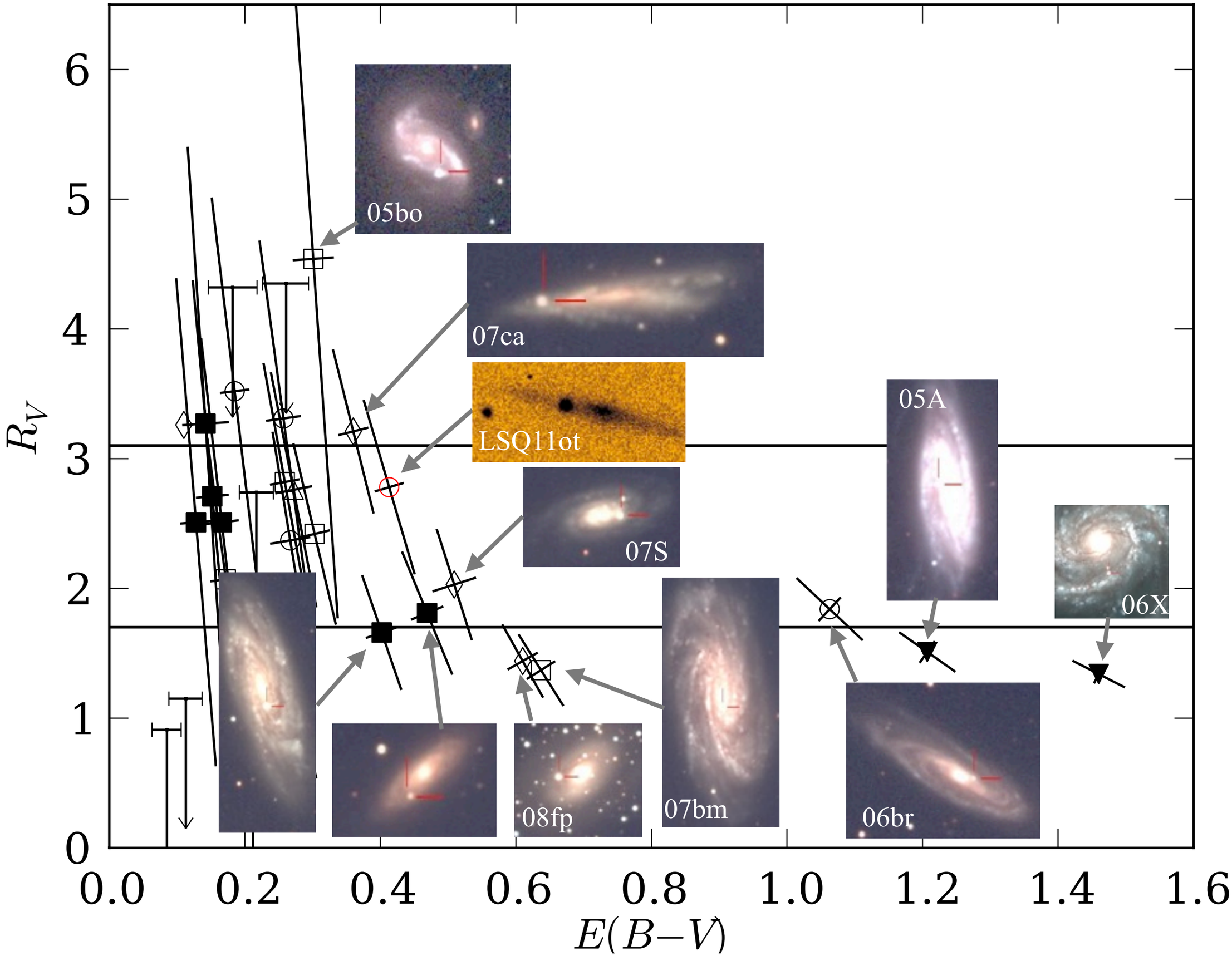
CSP OBJECTS


R_V
6
5
4
3
2
1
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
$E(B-V)$
LSQ11ot
07S
05A
06X
08fp
07bm
06br

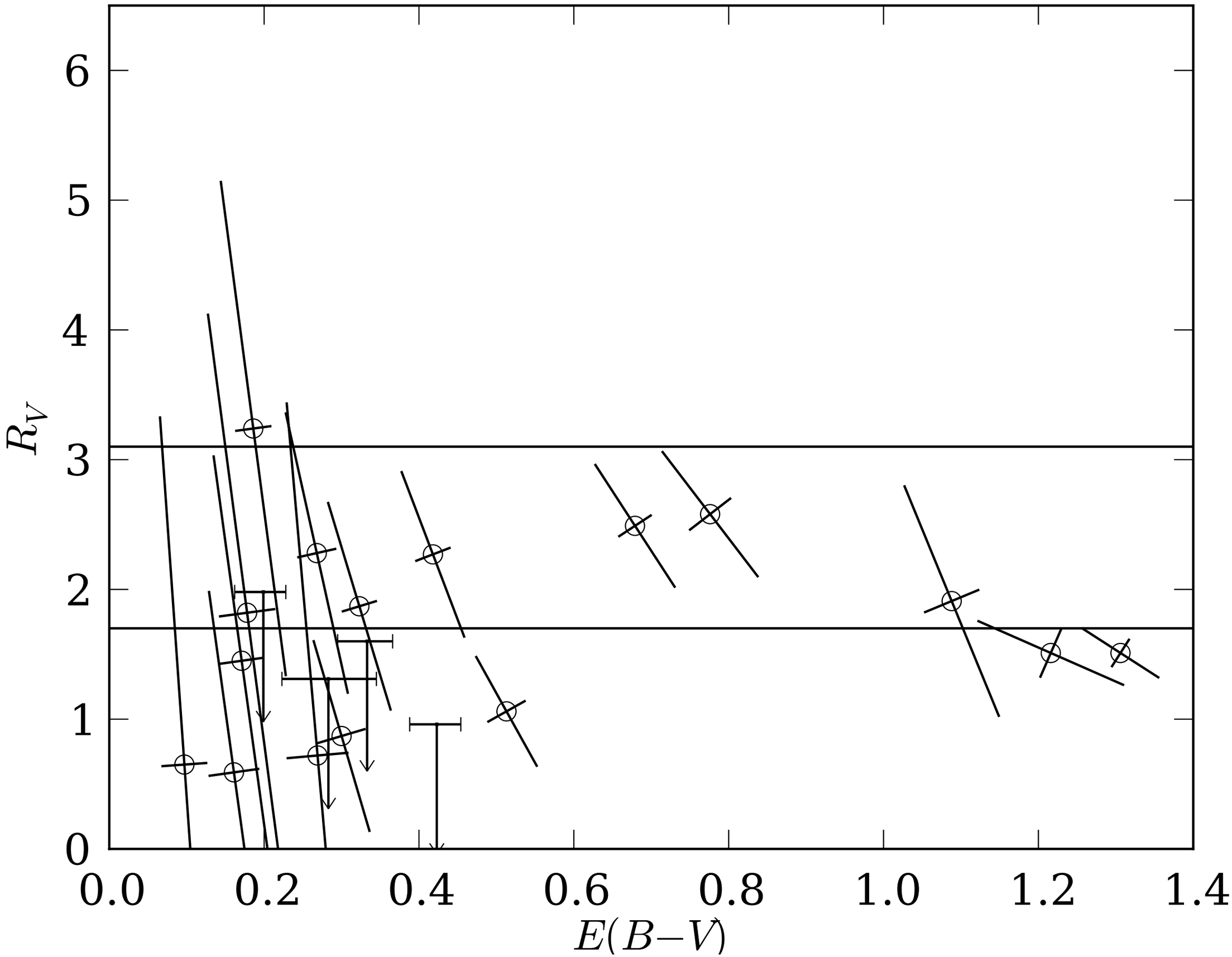
CSP OBJECTS


R_V
$E(B-V)$
0
1
2
3
4
5
6
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
07ca
LSQ11ot
07S
05A
06X
08fp
07bm
06br

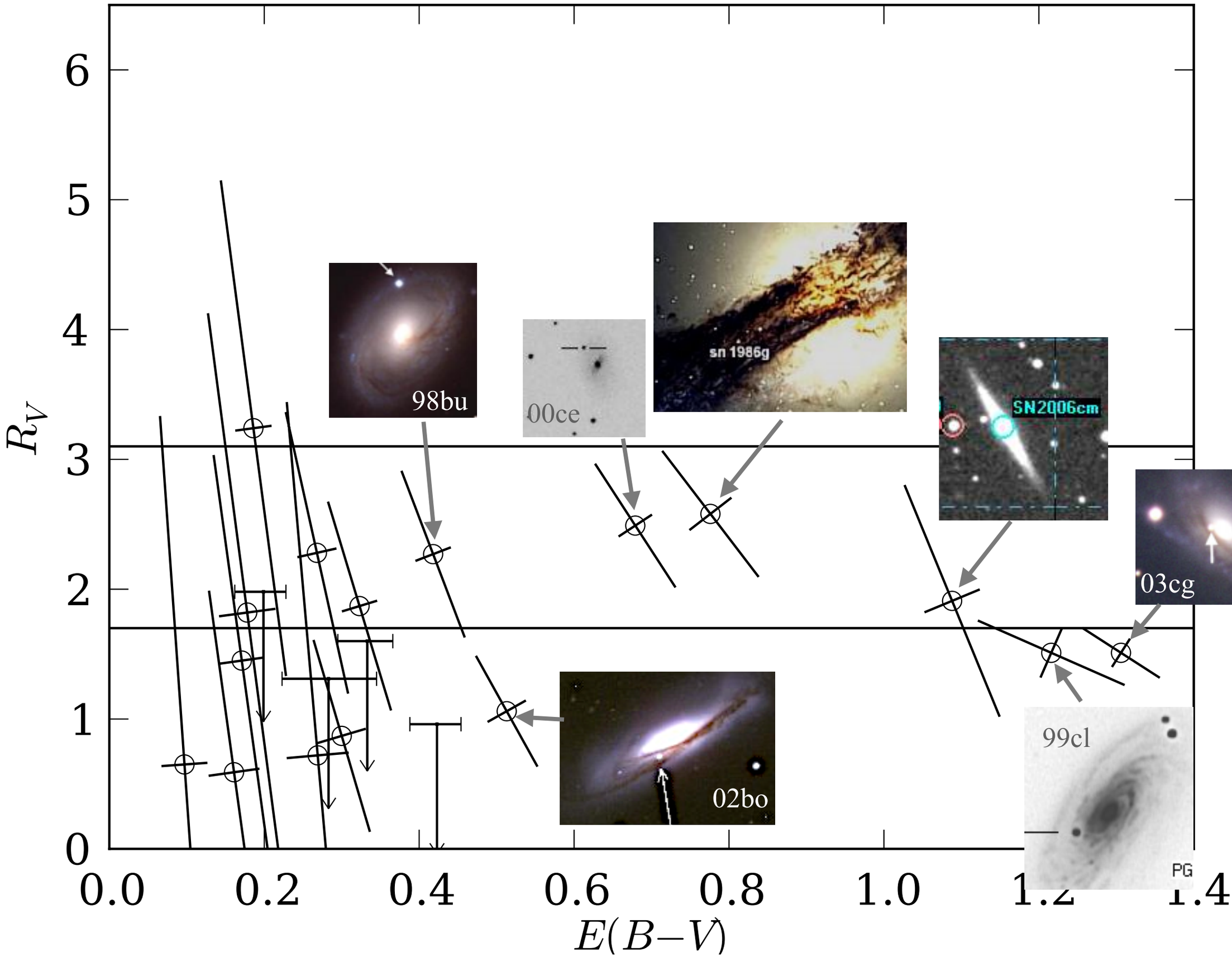
CSP OBJECTS


R_V
$E(B-V)$
0
1
2
3
4
5
6
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
05bo
07ca
LSQ11ot
07S
05A
06X
08fp
07bm
06br

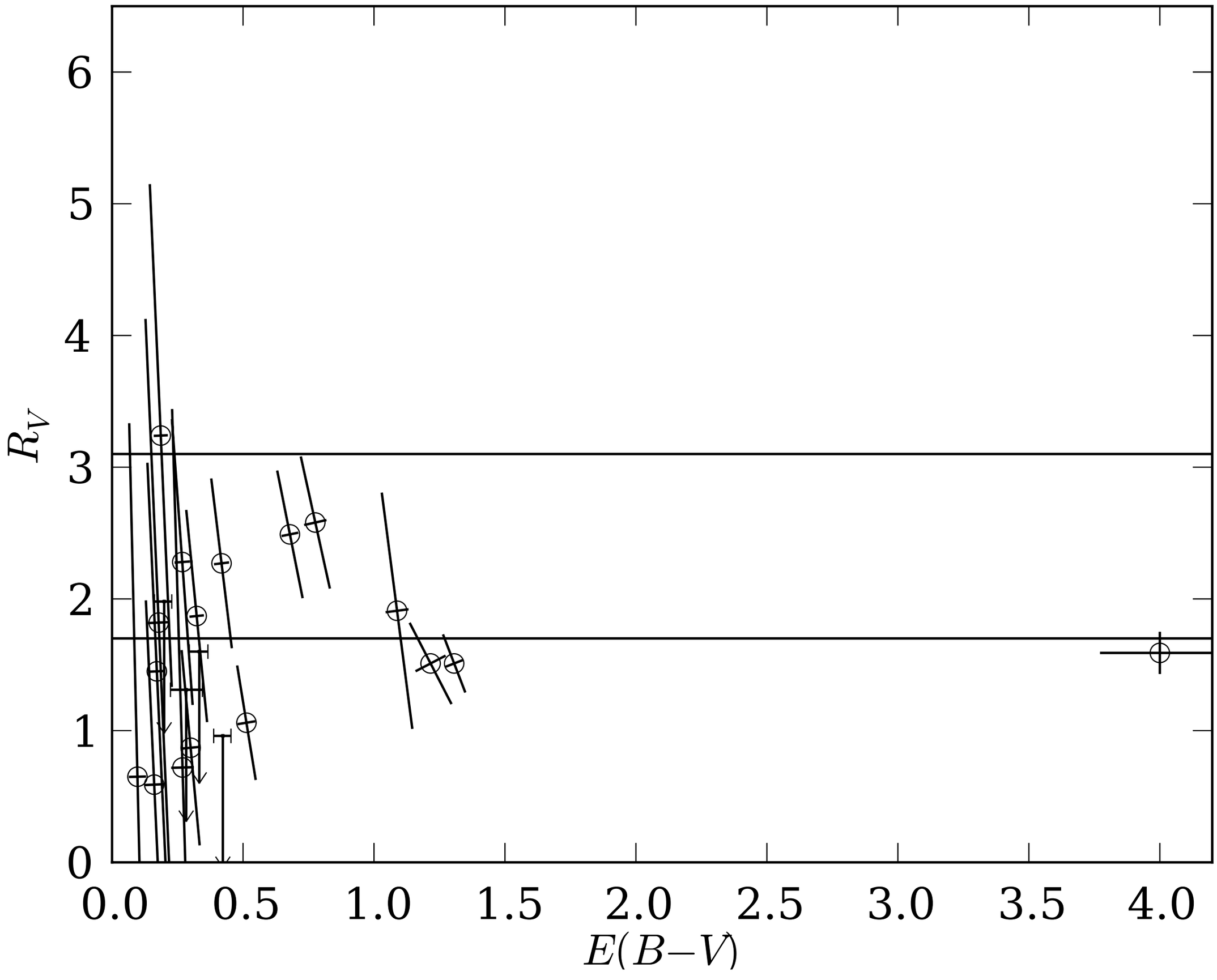
Literature



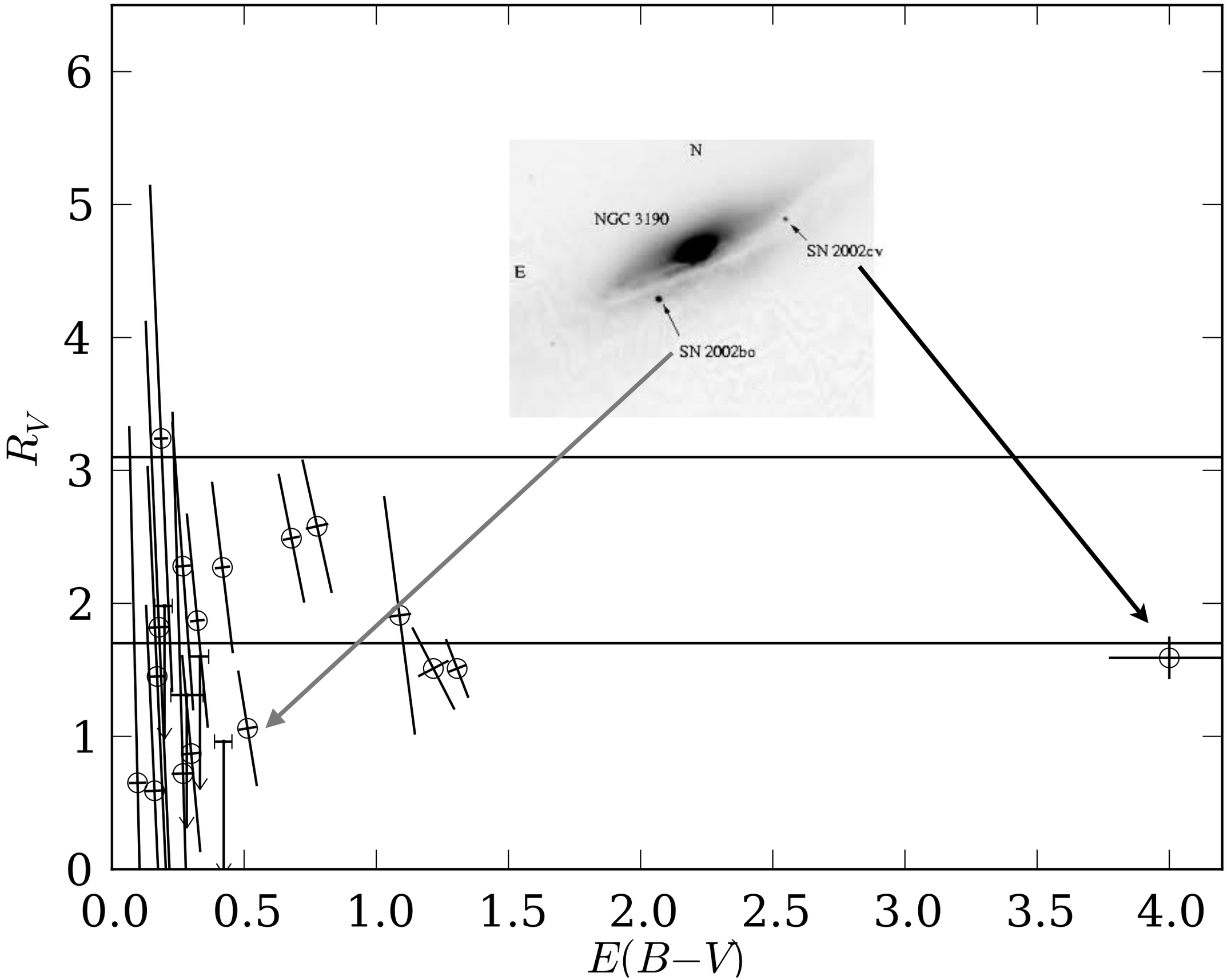
Literature


6
5
4
3
2
1
0
R_V
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
$E(B-V)$
98bu
00ce
sn 1986g
SN2006cm
03cg
02bo
99cl
PG

Consistent R_V for one host?

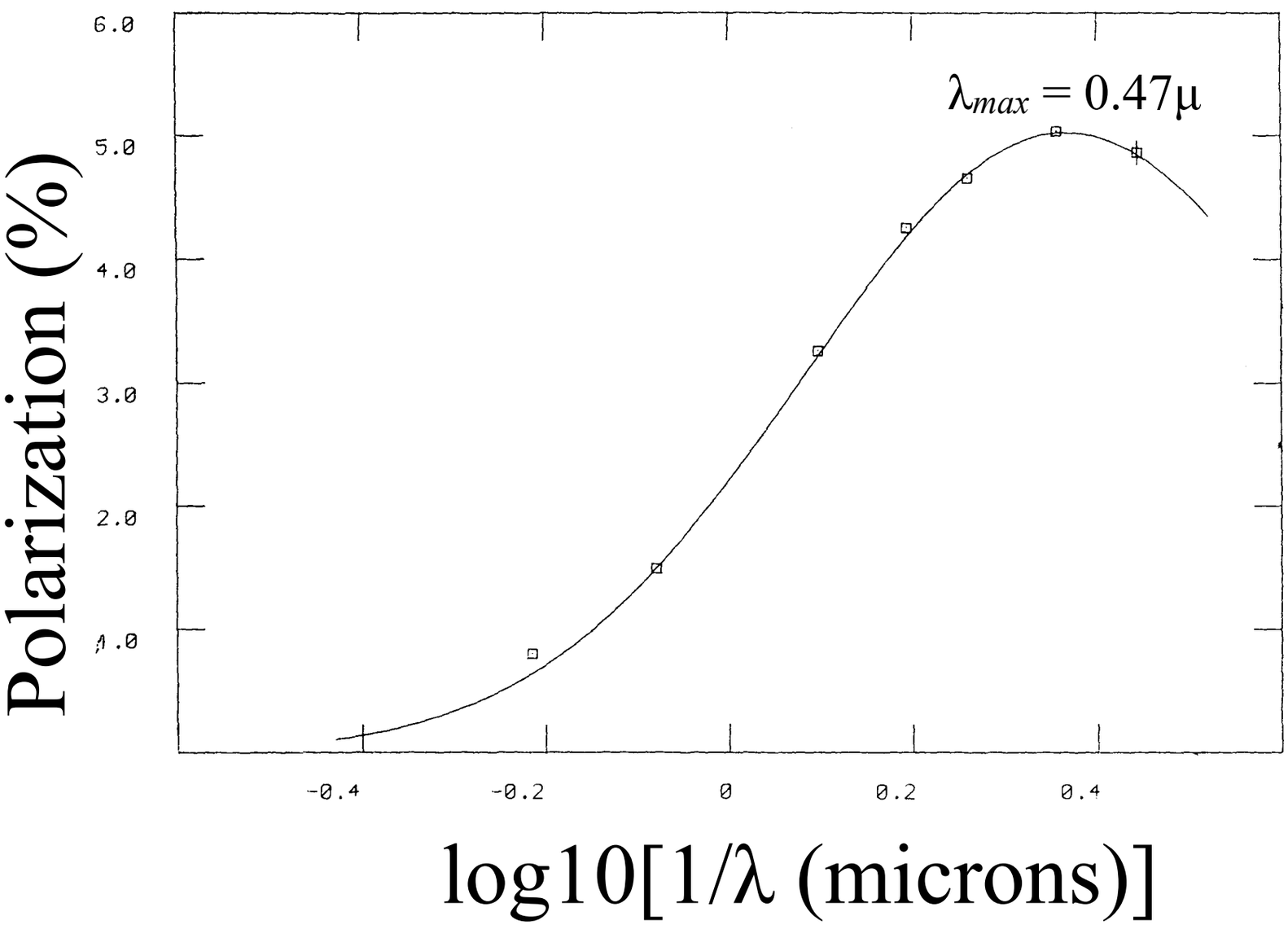


Consistent R_V for one host?

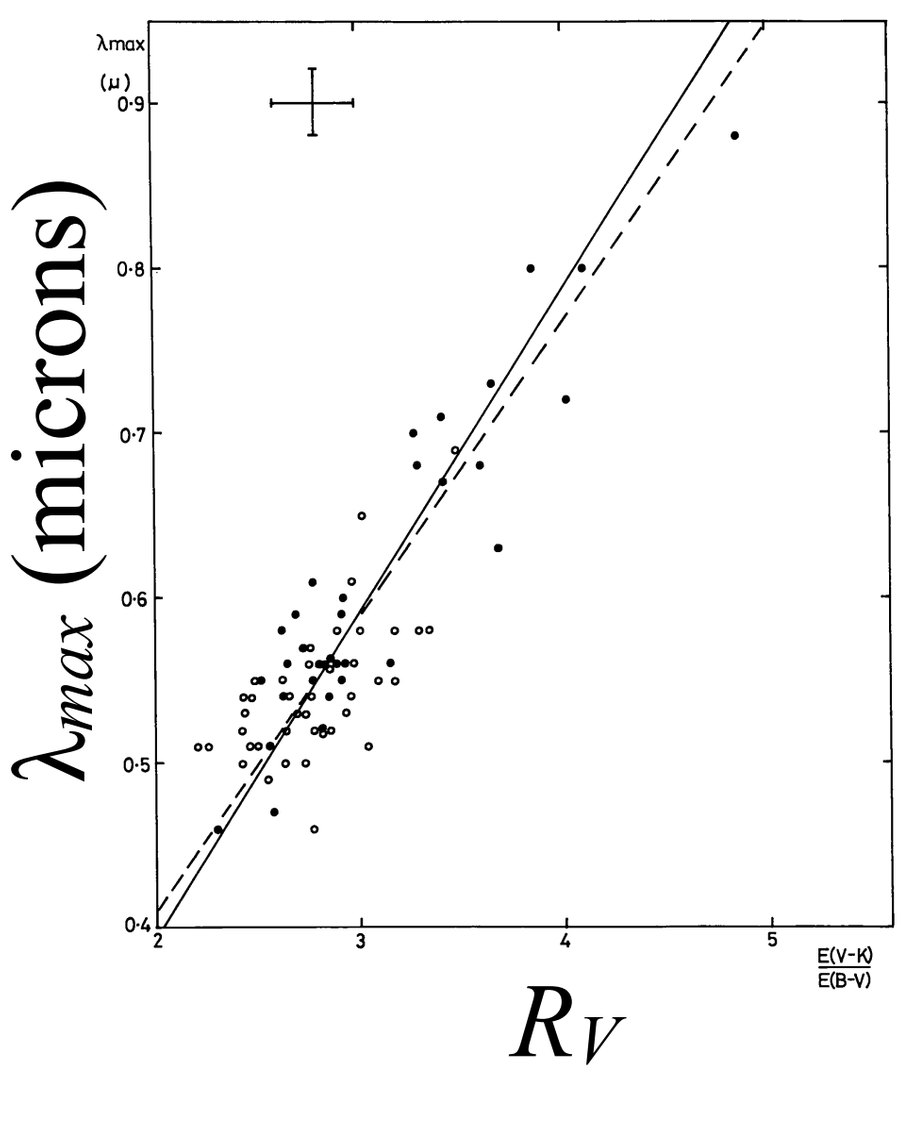


Polarization of SN1986G

Hough et al. 1987

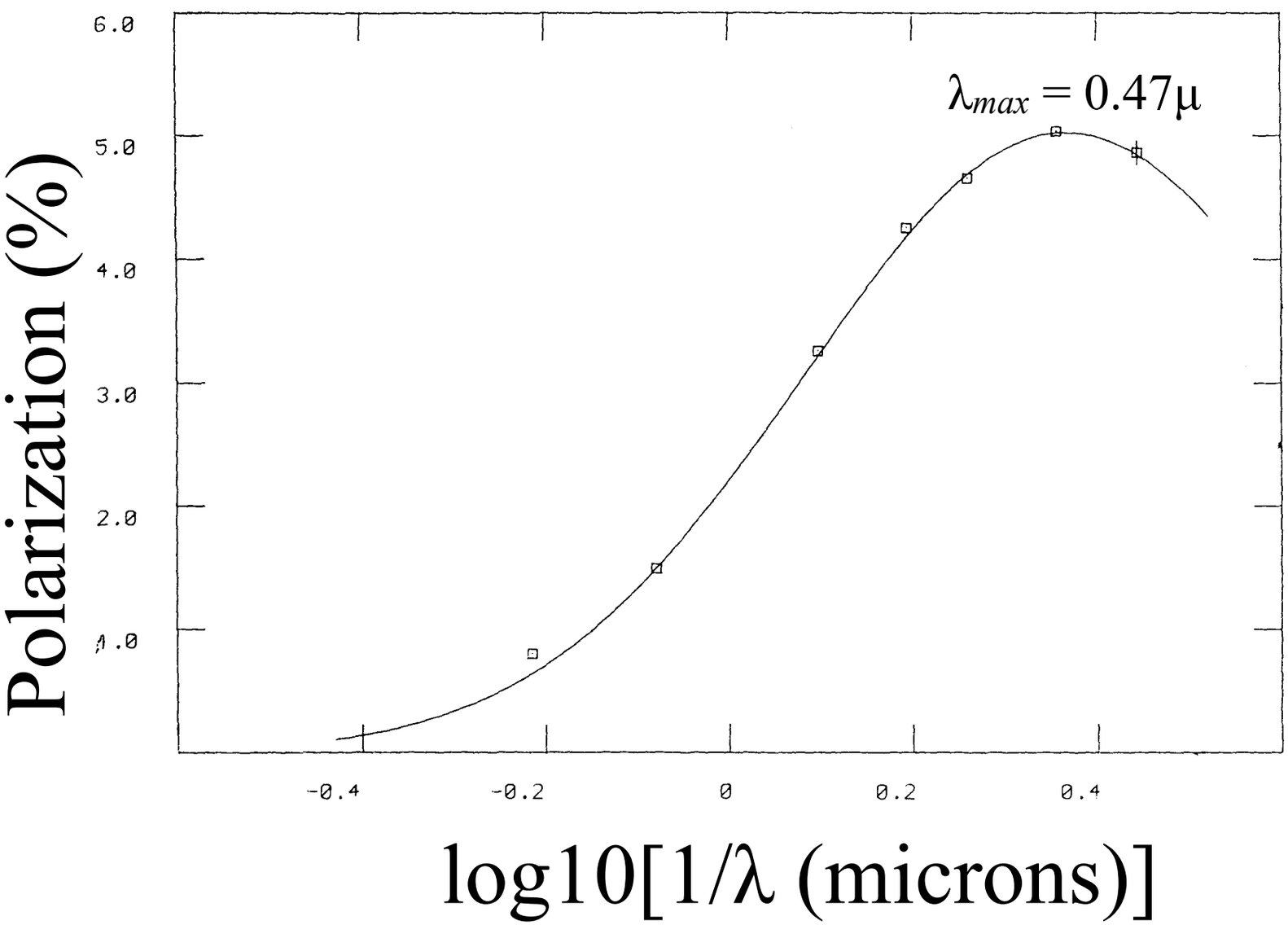


Whittet et al. 1978

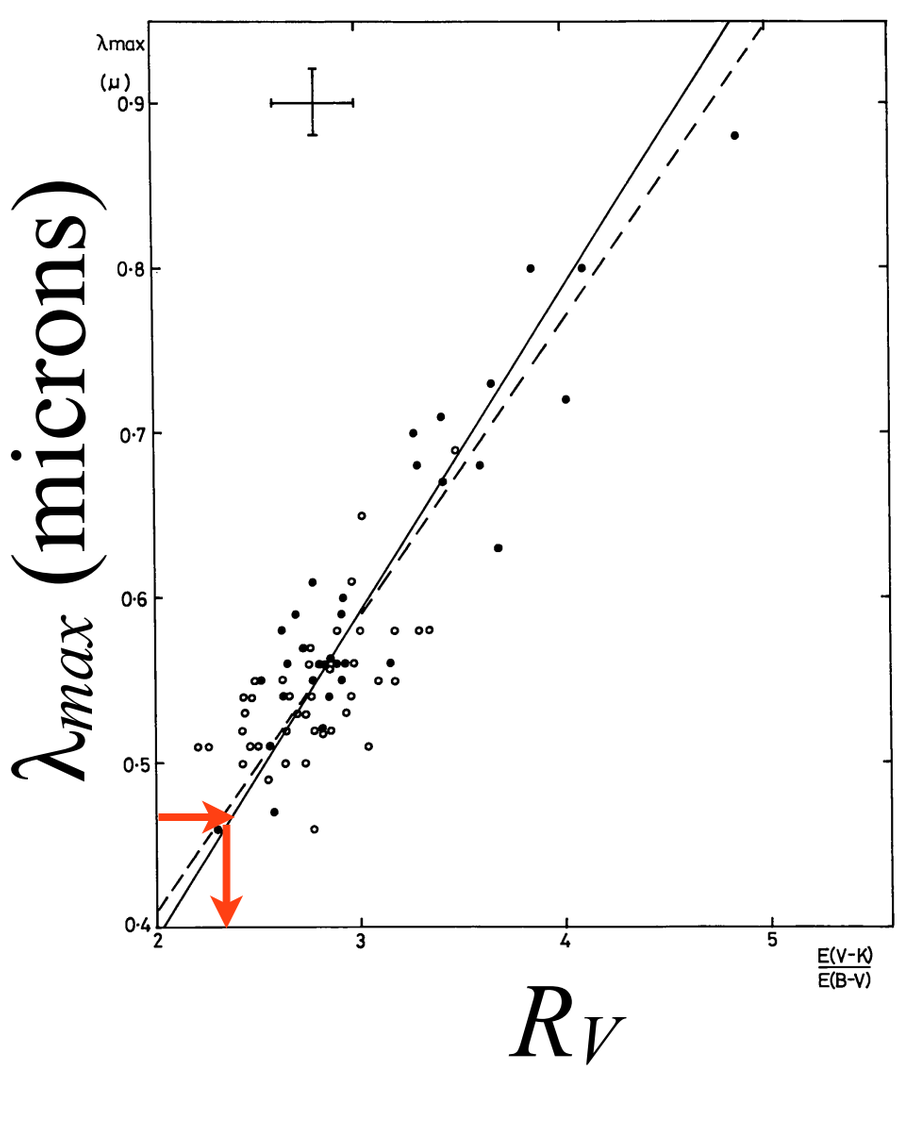


Polarization of SN1986G

Hough et al. 1987

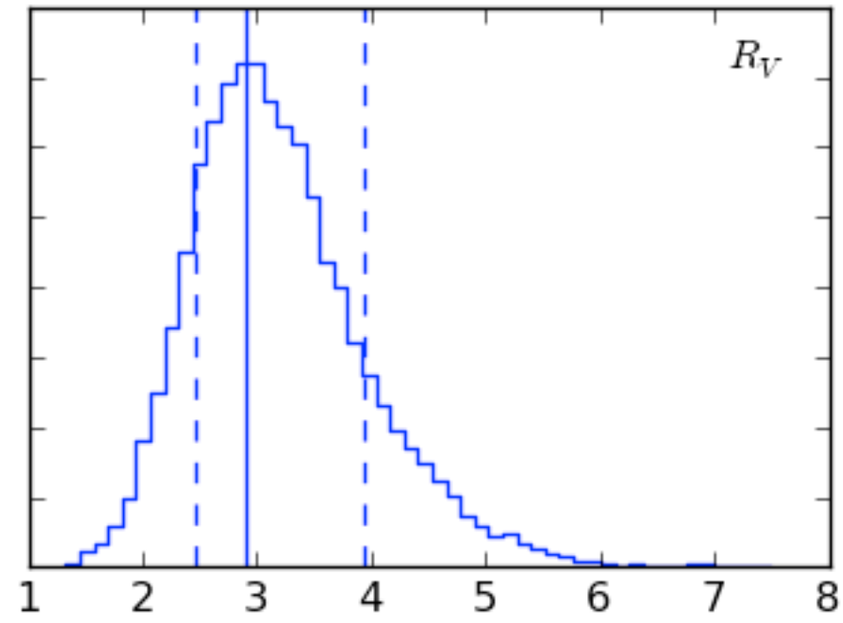


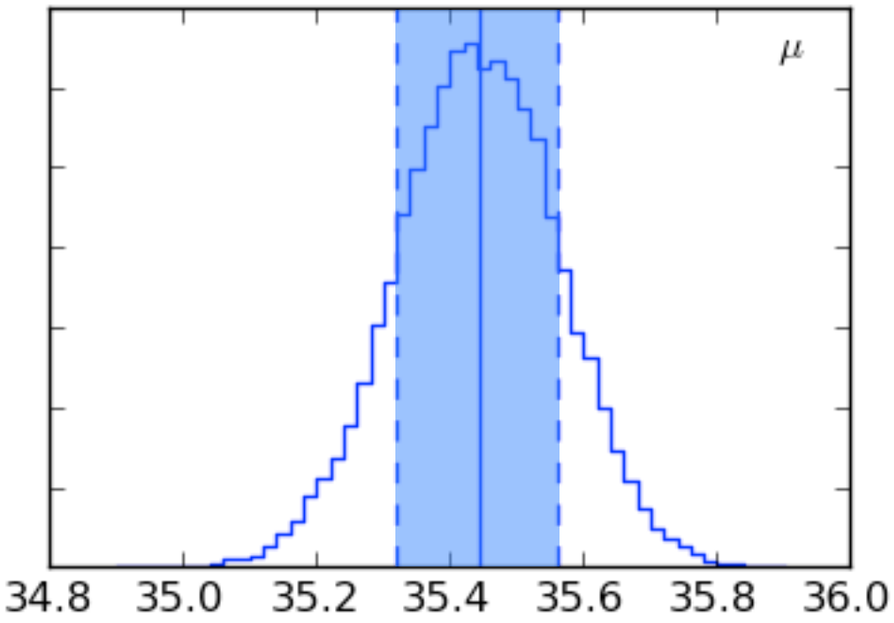
Whittet et al. 1978

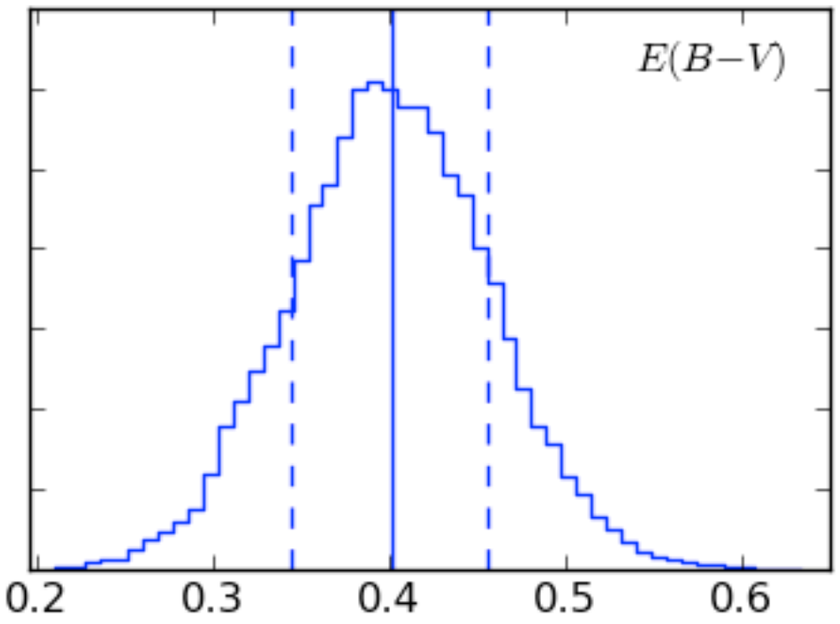


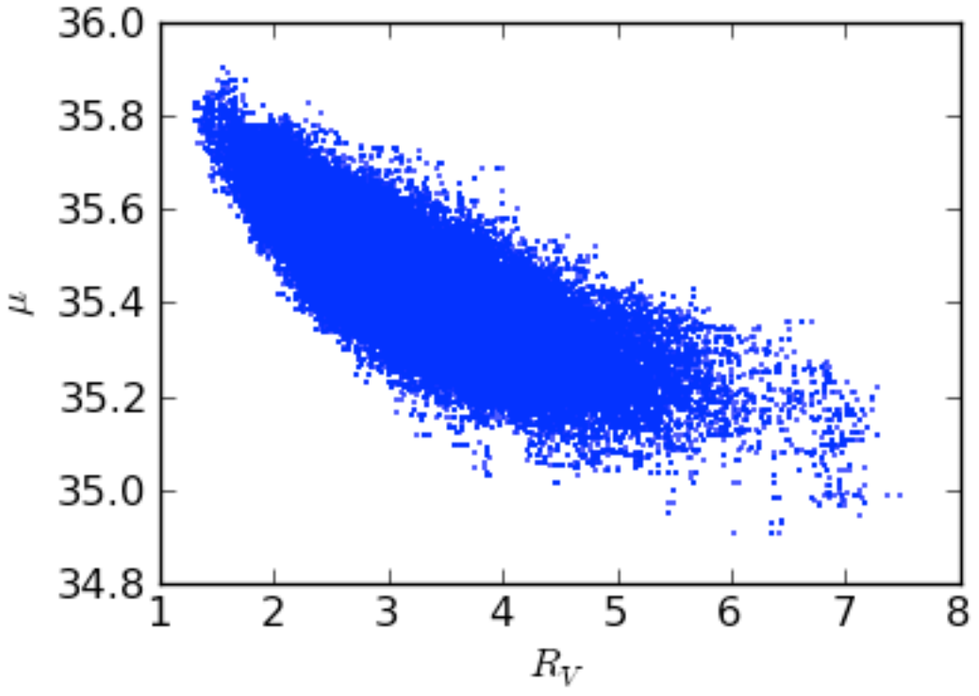
A single β may "work" for cosmology, but may not for individual galaxies

LSQ11ot


R_V
1
2
3
4
5
6
7
8

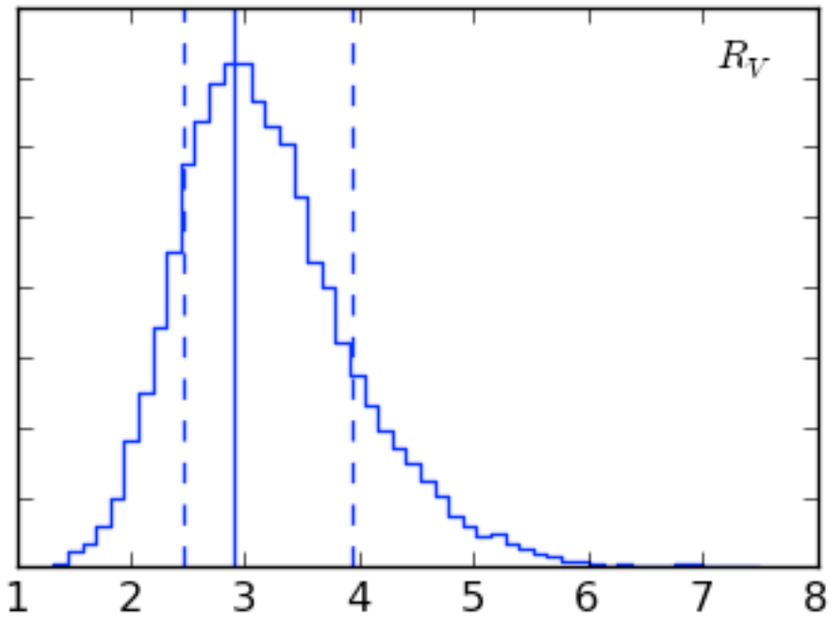

μ
34.8
35.0
35.2
35.4
35.6
35.8
36.0

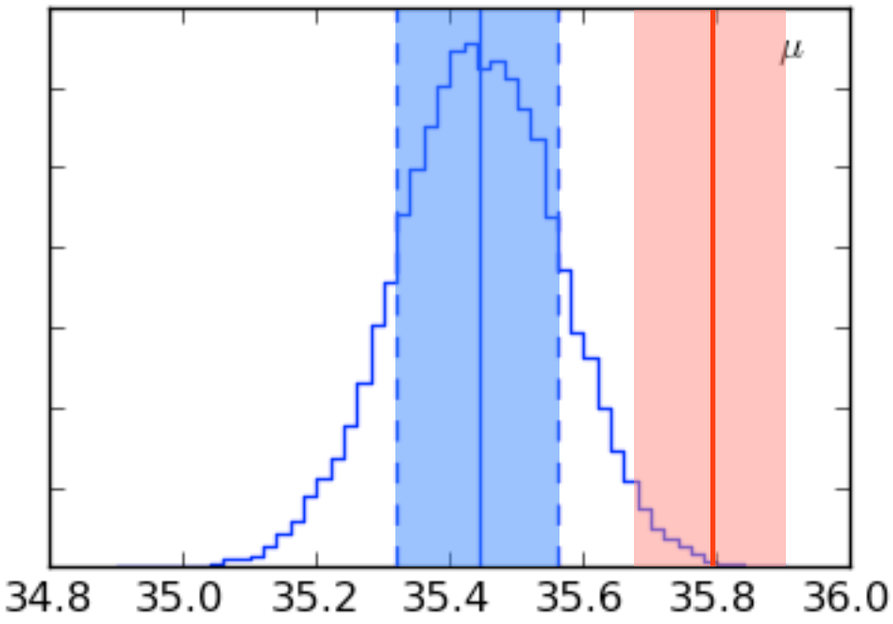

$E(B-V)$
0.2
0.3
0.4
0.5
0.6

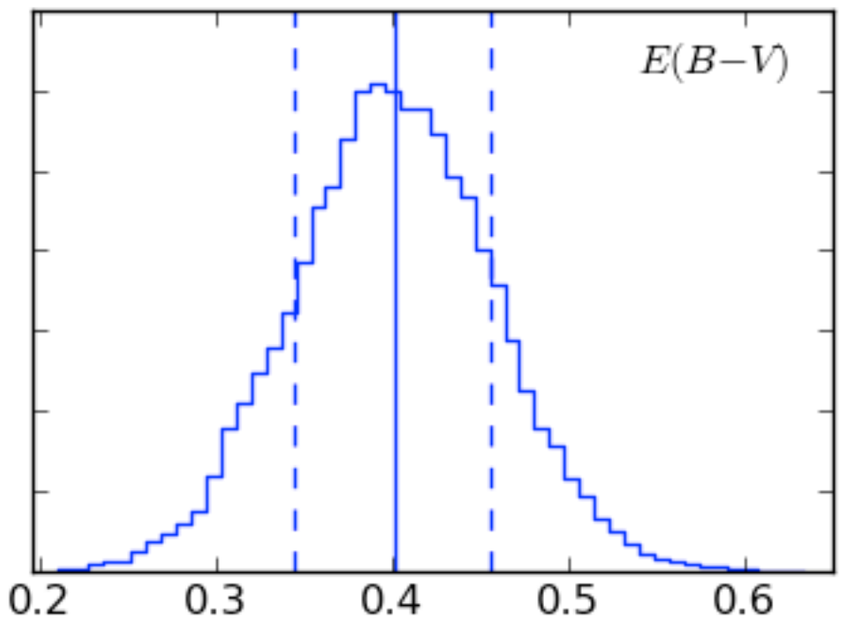

μ
R_V
36.0
35.8
35.6
35.4
35.2
35.0
34.8
1
2
3
4
5
6
7
8

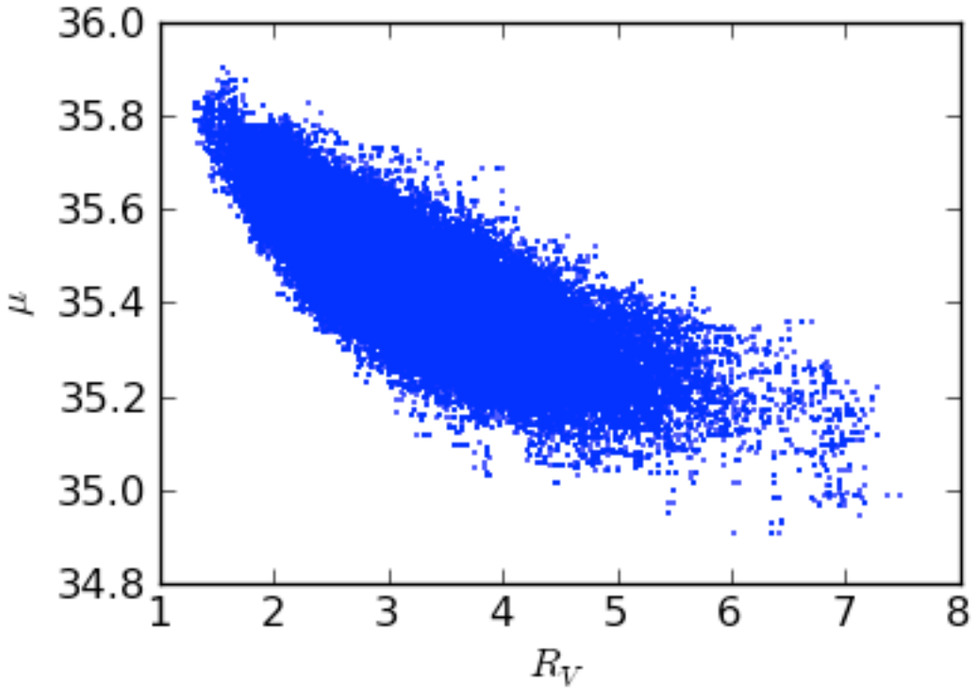
LSQ11ot

$R_V = 1.7$



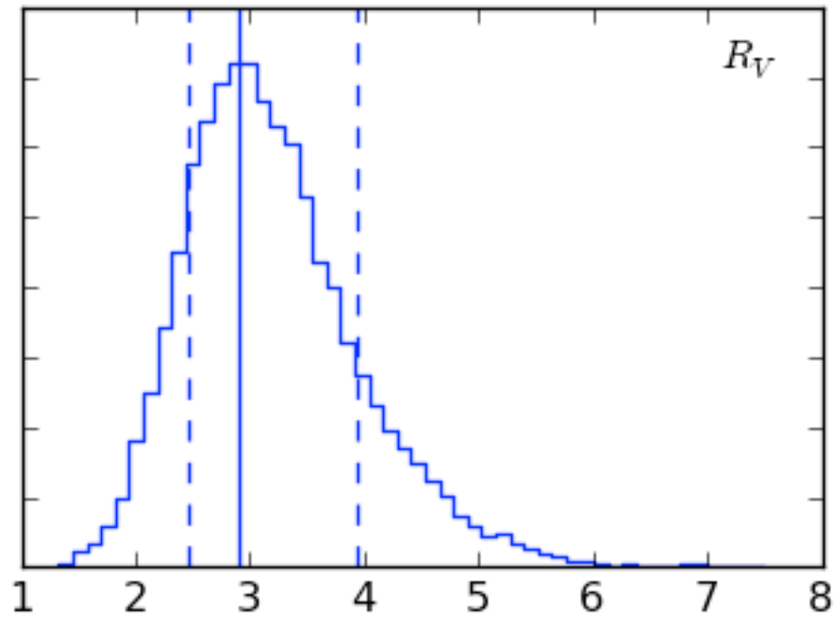


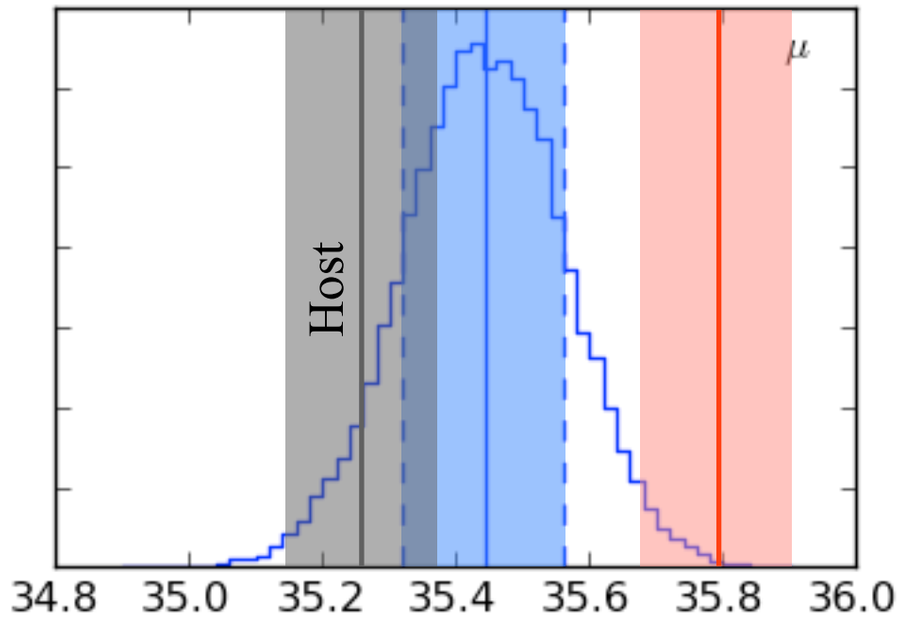


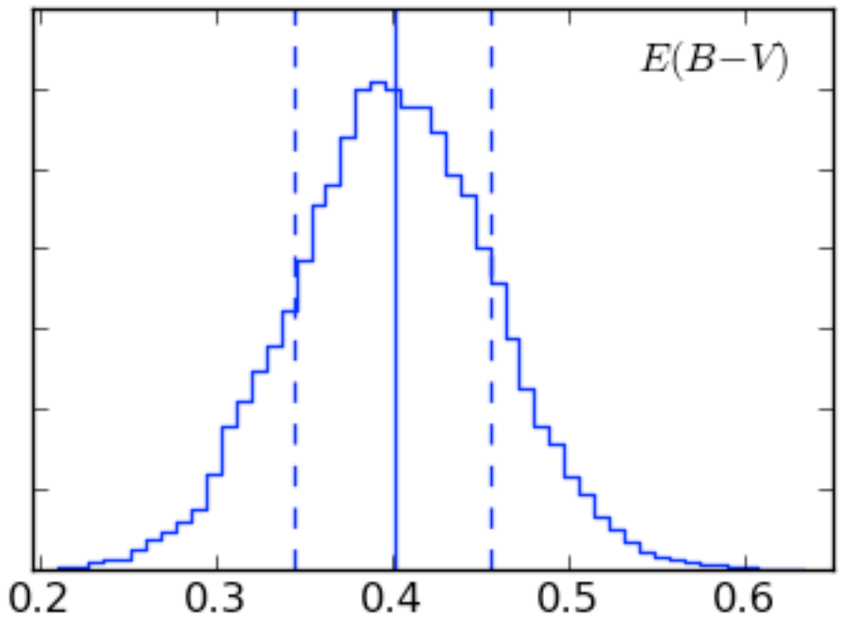


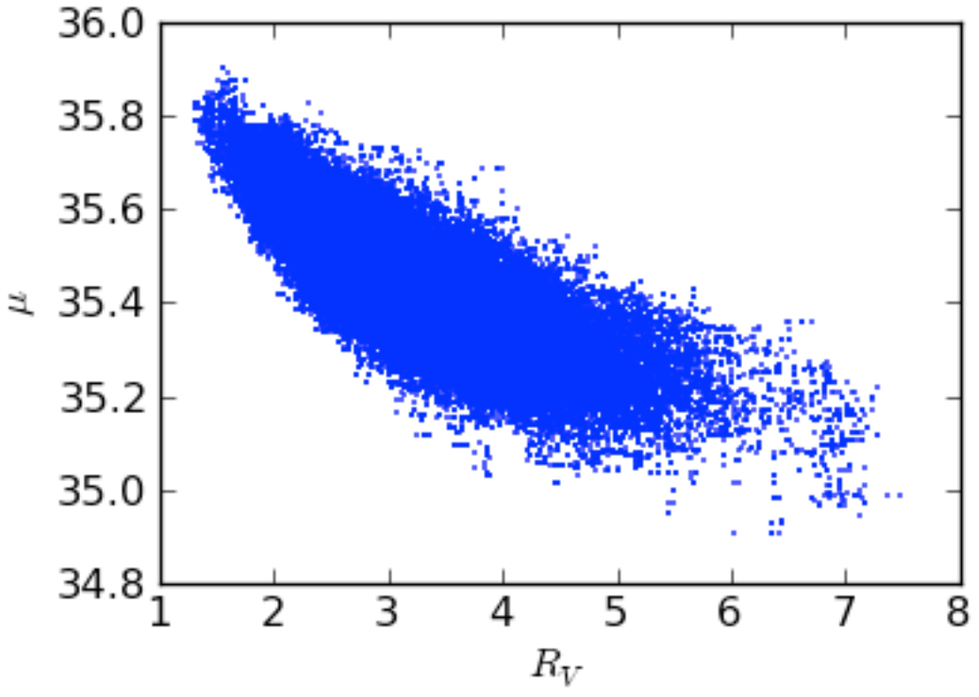
LSQ11ot

$R_V = 1.7$



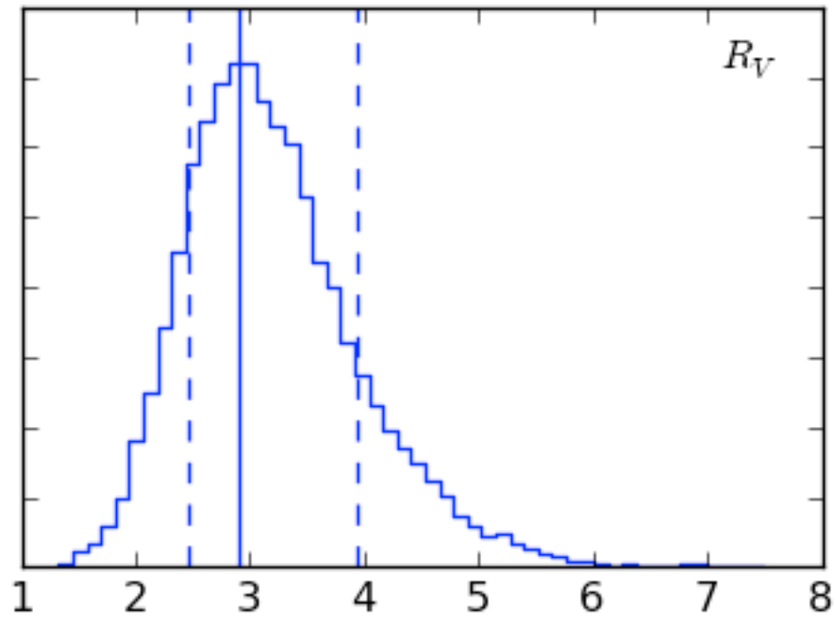


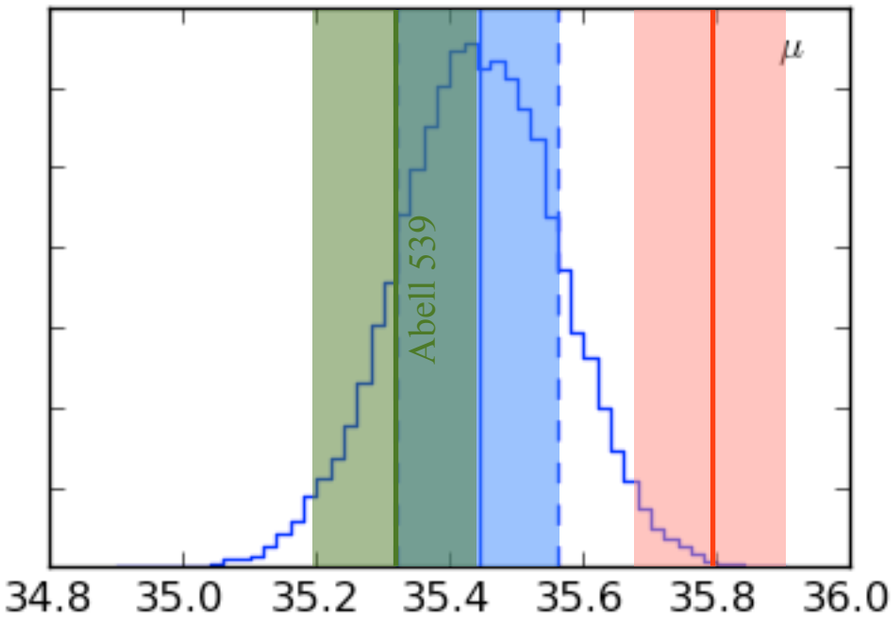


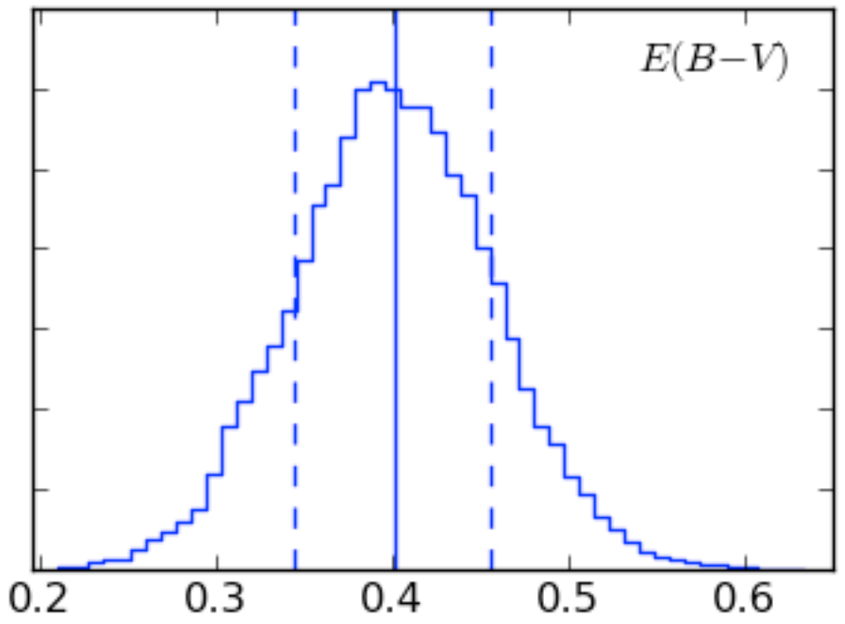


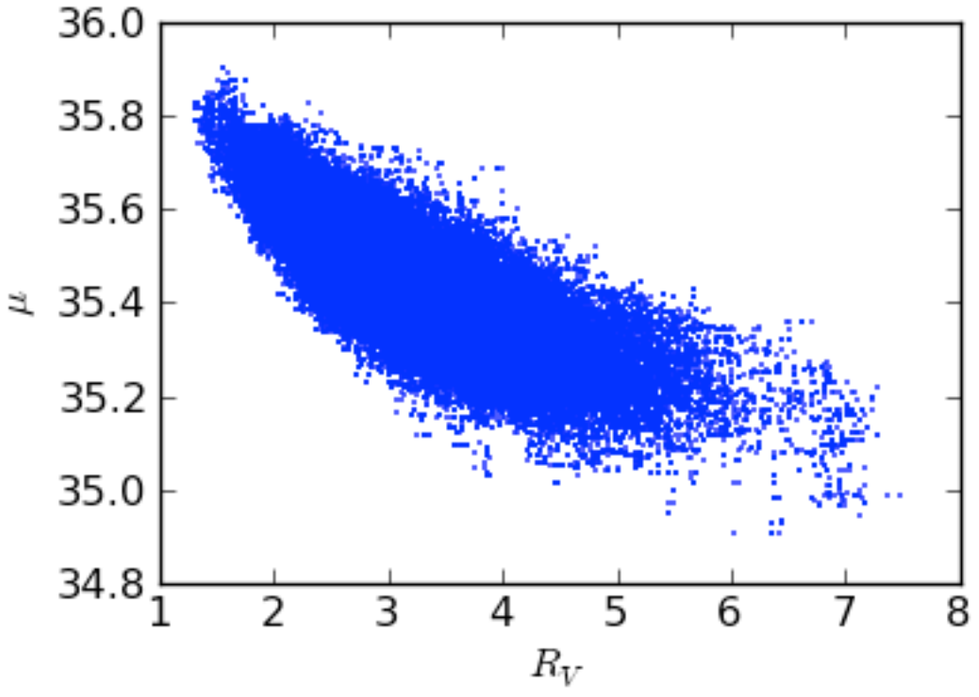
LSQ11ot

$R_V = 1.7$





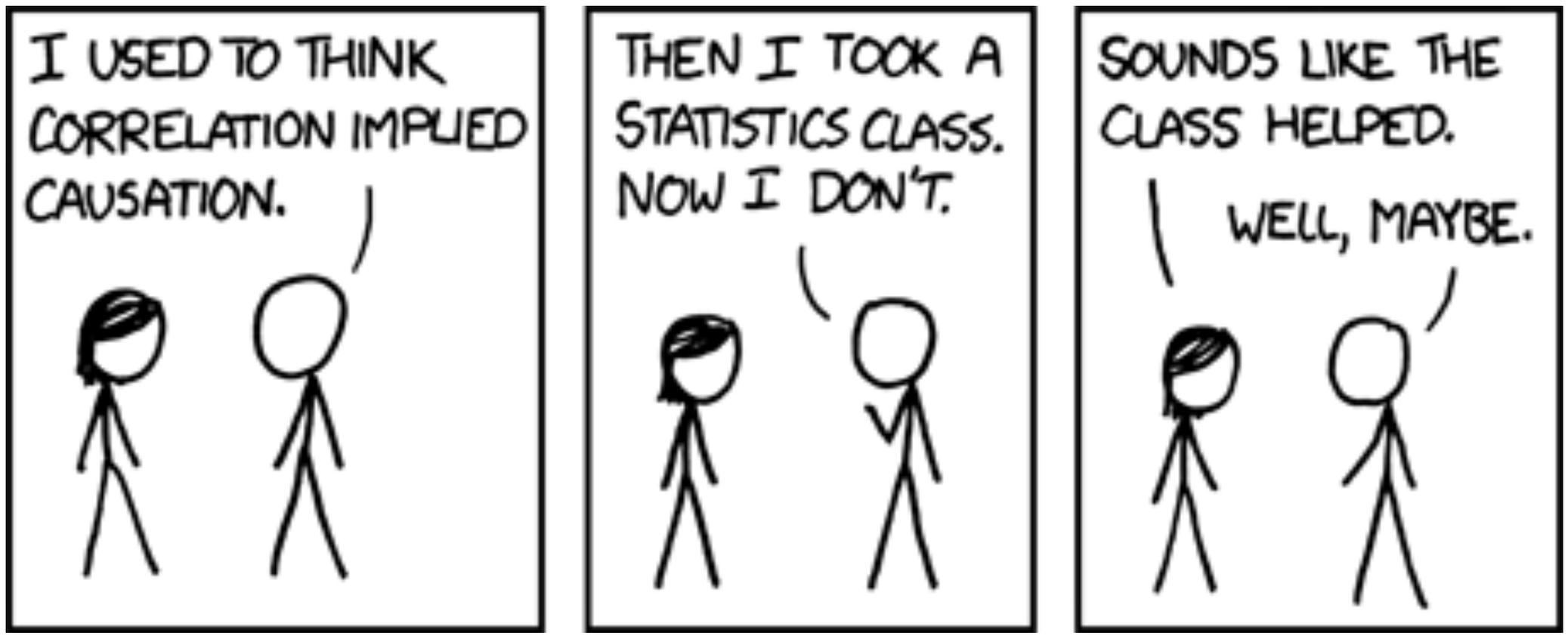


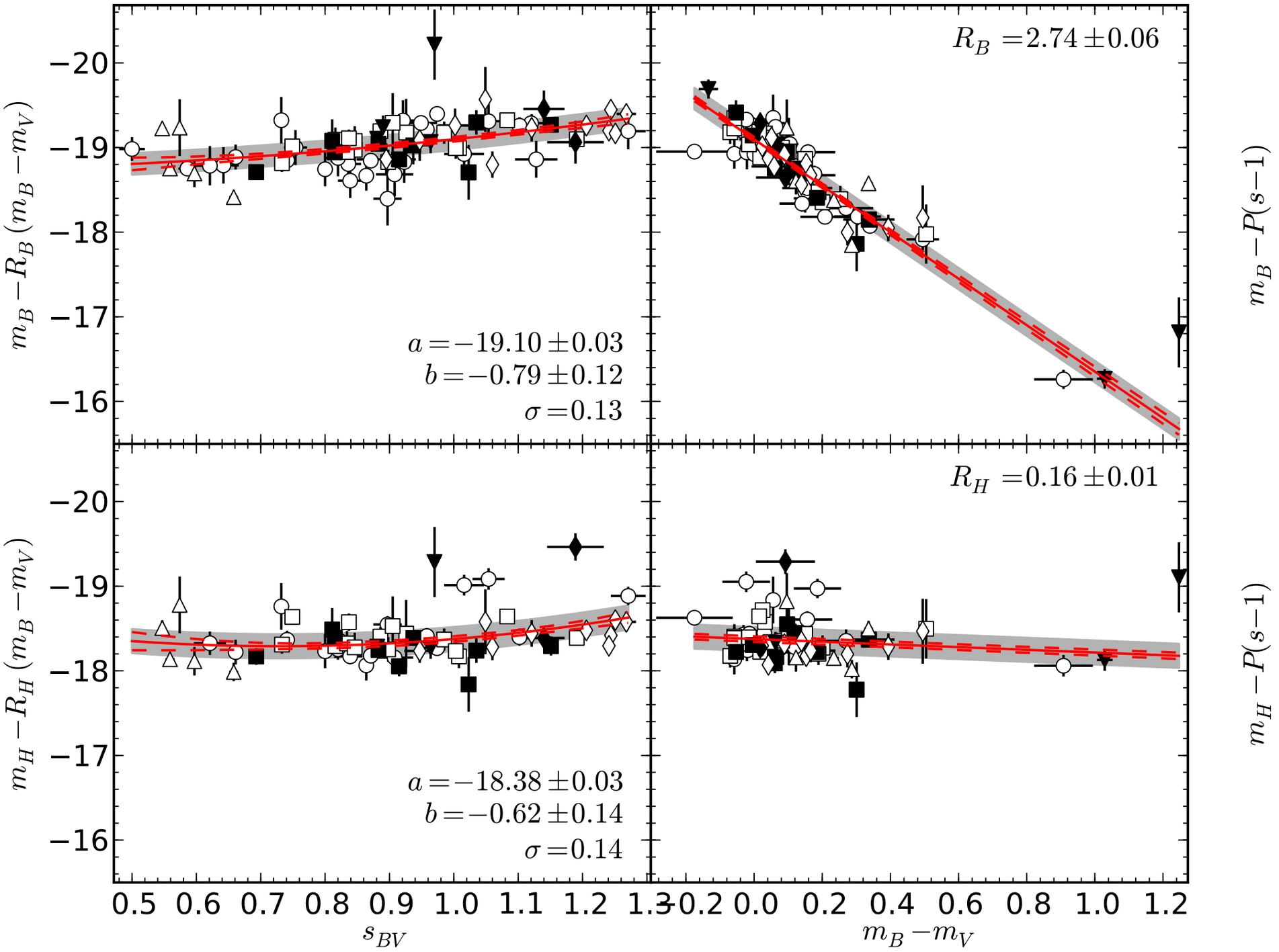


Why are Ia's red?

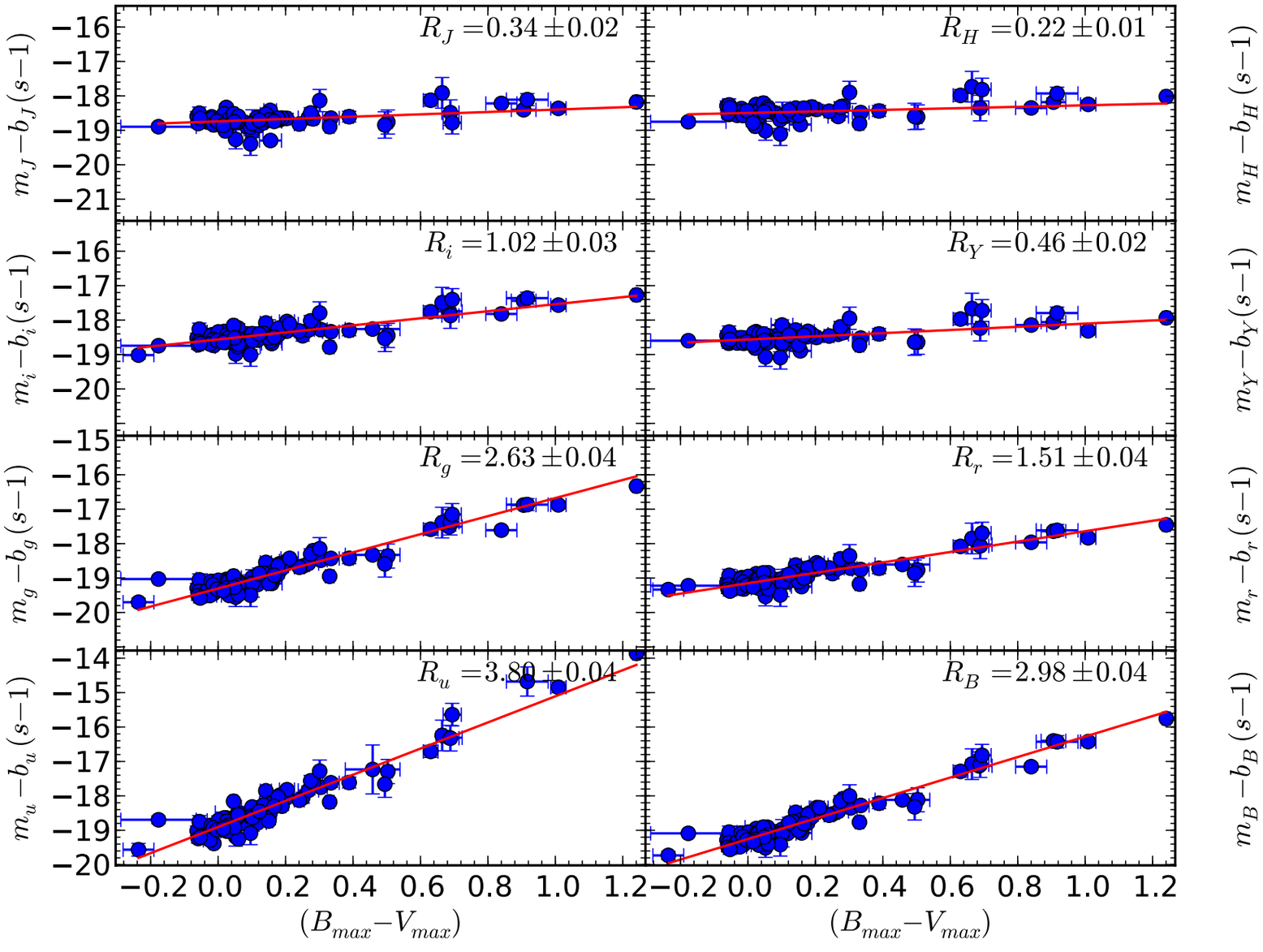
- It's ISM dust. Mostly.
- Looks like we can't count on R_V being a constant for SNe Ia.
- *Maybe* consistent within a single host?
- Need to see if R_V correlates with host properties.

NIR Standard Candleness

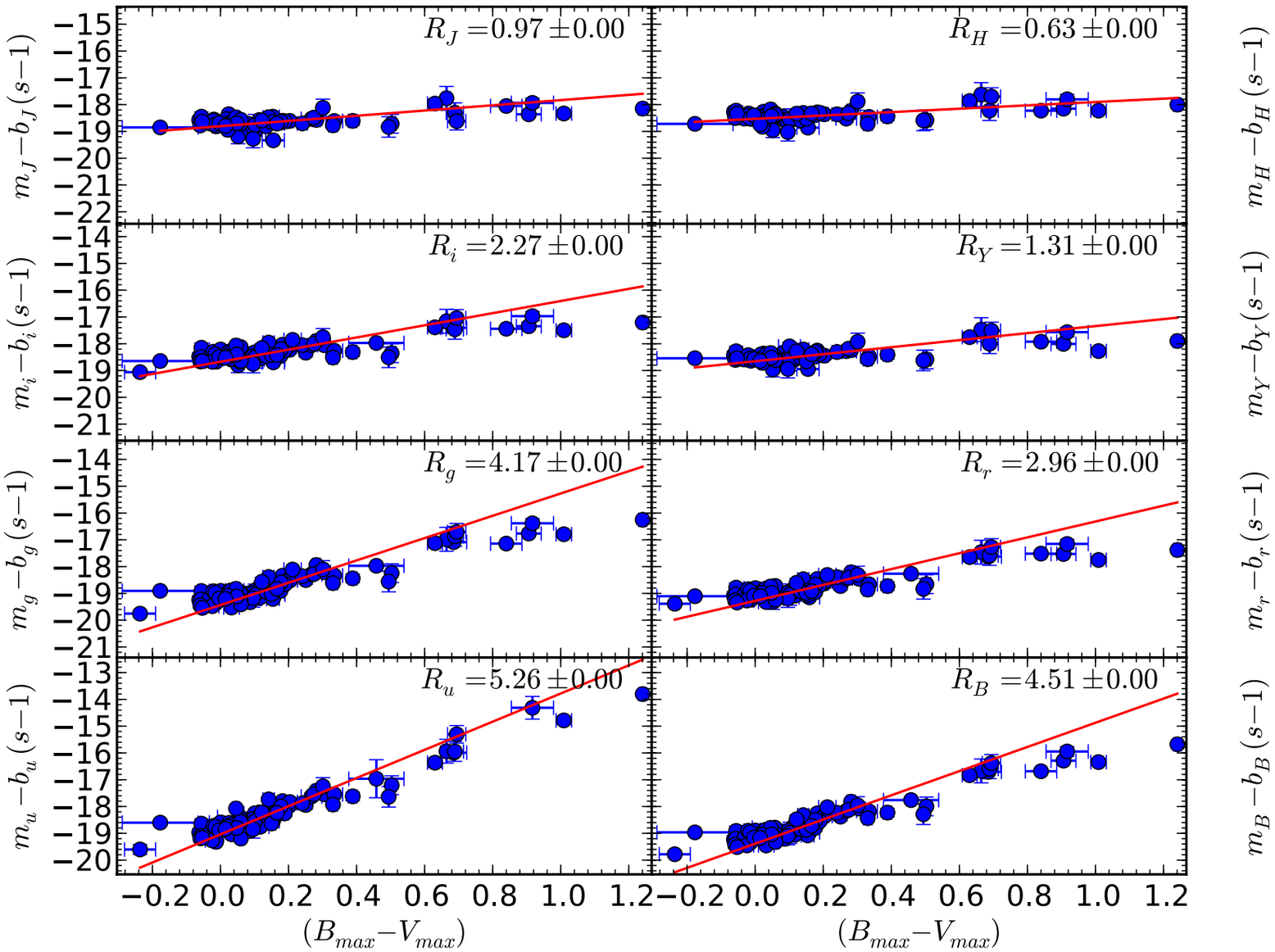



$R_B = 2.74 \pm 0.06$
$a = -19.10 \pm 0.03$
$b = -0.79 \pm 0.12$
$\sigma = 0.13$
$R_H = 0.16 \pm 0.01$
$a = -18.38 \pm 0.03$
$b = -0.62 \pm 0.14$
$\sigma = 0.14$
$m_B - R_B\,(m_B - m_V)$
$m_H - R_H\,(m_B - m_V)$
$m_B - P(s-1)$
$m_H - P(s-1)$
s_{BV}
$m_B - m_V$

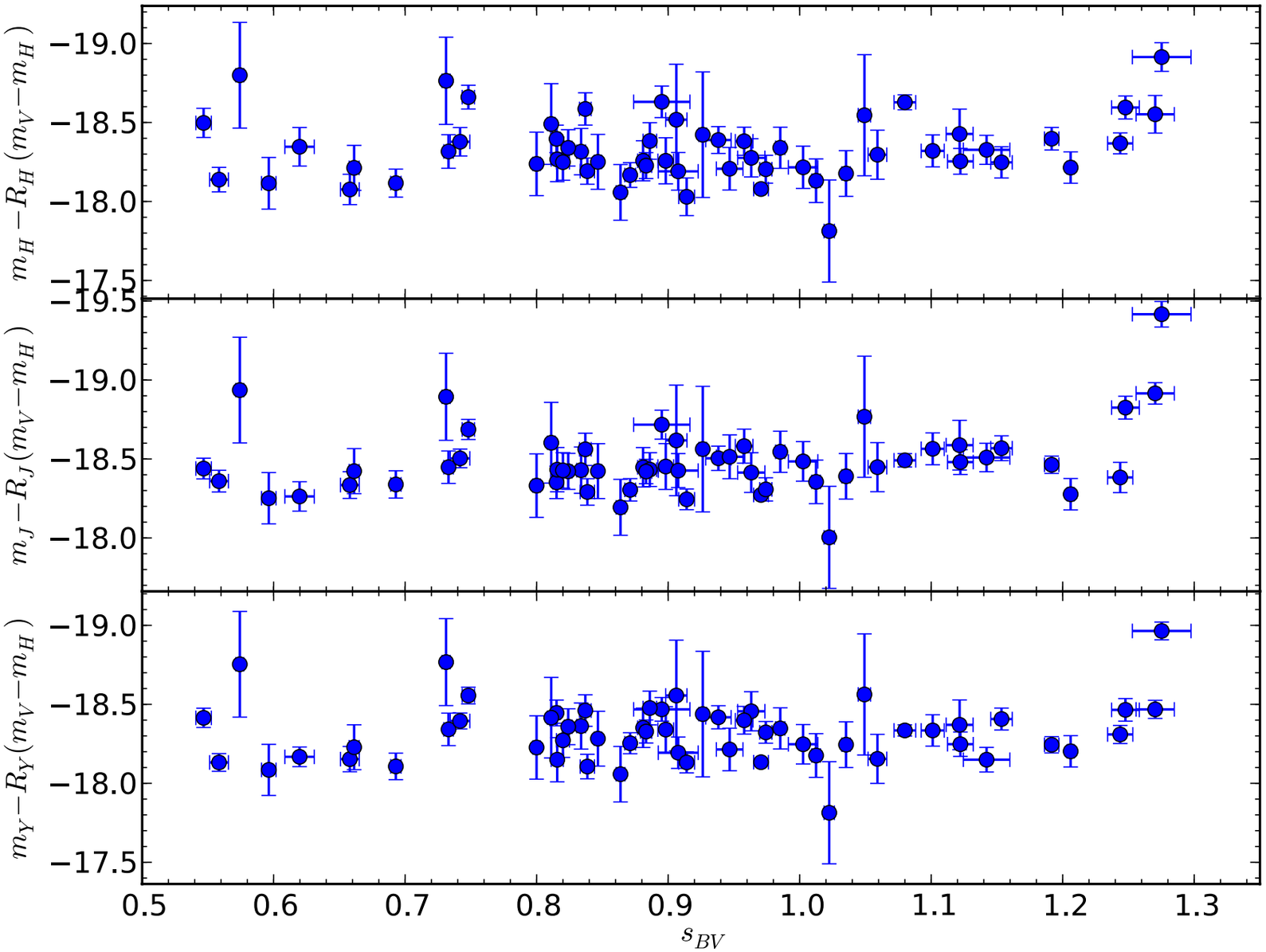
Color Corrections



Color Corrections



Is there a NIR stretch correction?

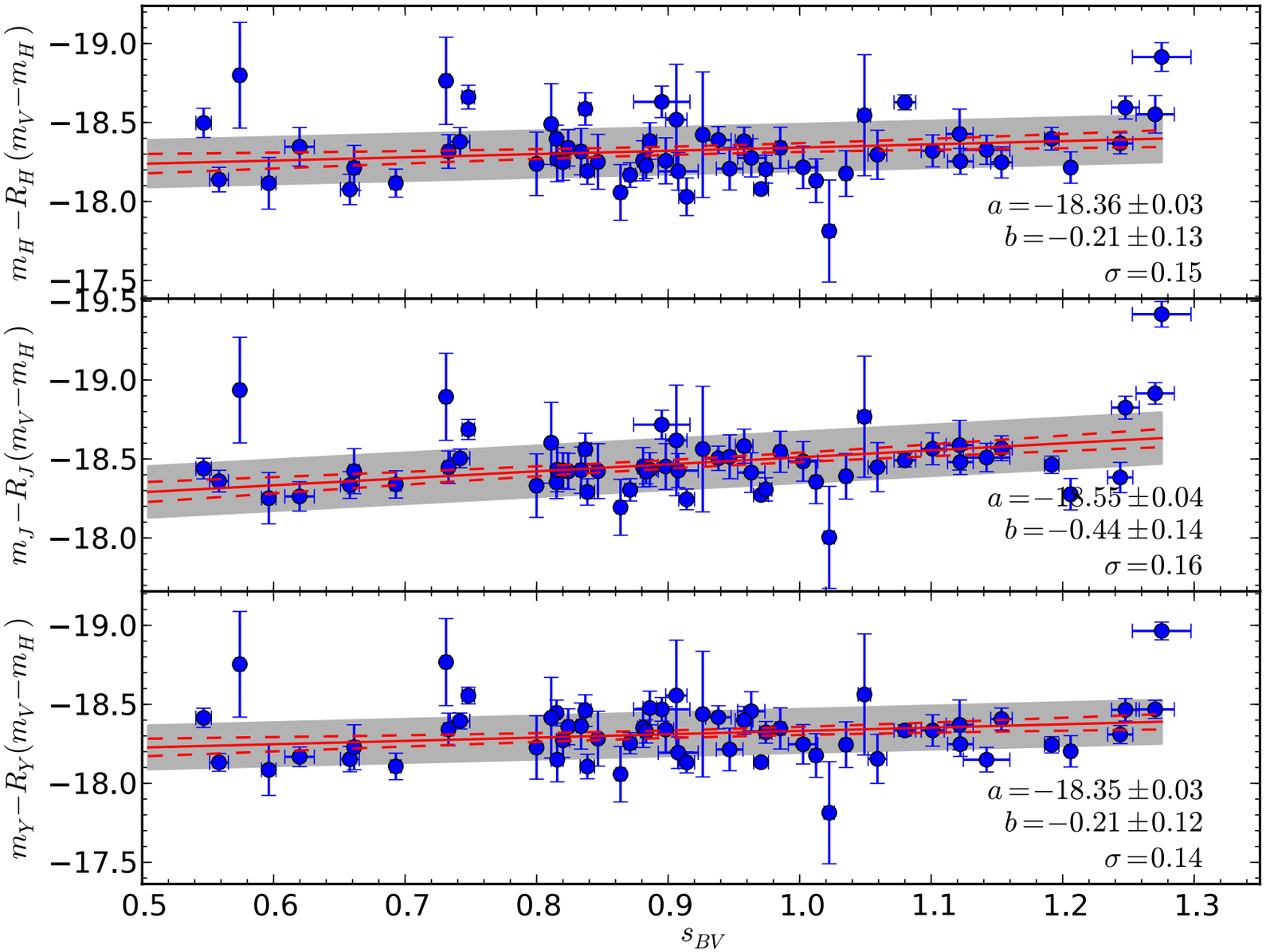


H

J

Y

Is there a NIR stretch correction?

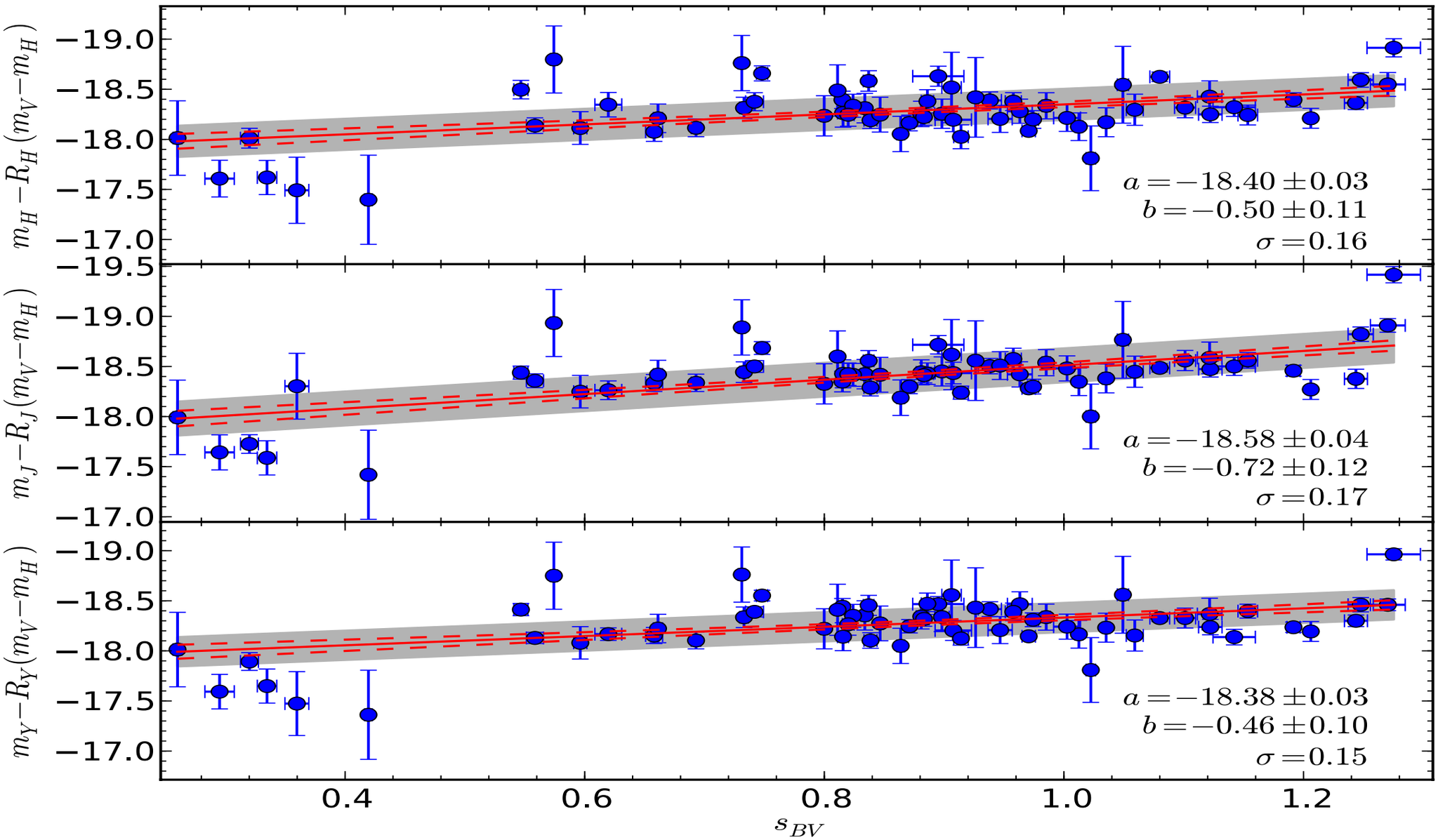


H

J

Y

Is there a NIR stretch correction?

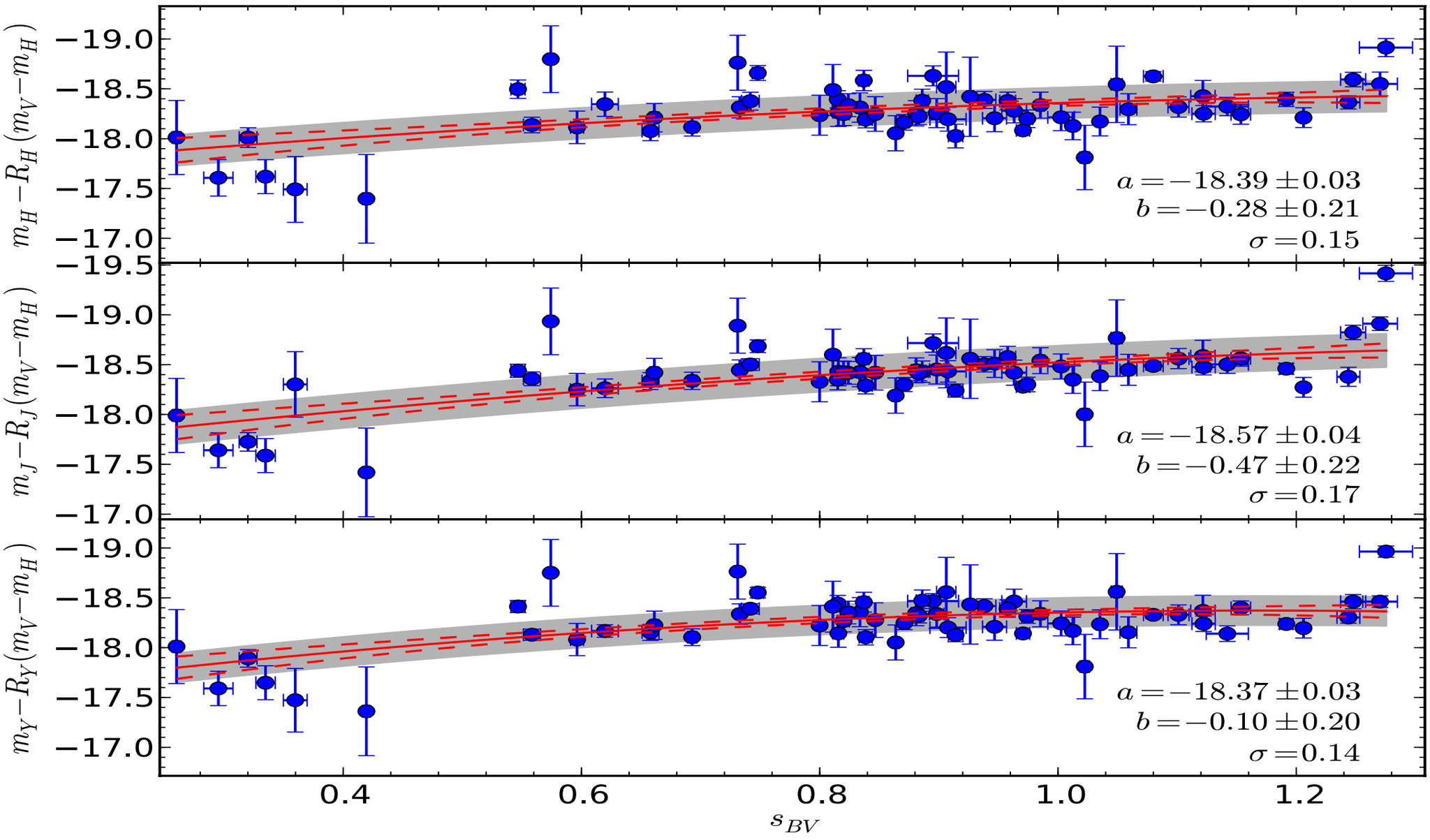


H

J

Y

Is there a NIR stretch correction?



NIR Phillips Relation

- Typically 0.15 mag intrinsic dispersion, but highly correlated among filters.
- If allow peculiar velocities to vary:
  $v_{pec} \simeq 480$ km/s
- Dispersion goes down to about 0.08 mag.
- CSPII will sample in the Hubble flow.
- Maybe low-s objects work in NIR?

Now a few words from...

Now a few words from...

NIR's great, but...

- Reducing dispersion doesn't get you very far. You need to reduce *systematics*

According to SNLS

Table 3
Detailed Summary of Systematic Uncertainties

Source	Ω_m	w	Relative Area[a]
Statistical only	$0.2763^{+0.0163}_{-0.0132}$	$-1.0430^{+0.0543}_{-0.0546}$	1.0
All systematics	$0.2736^{+0.0186}_{-0.0145}$	$-1.0676^{+0.0799}_{-0.0821}$	1.693
All systematics, except calibration	$0.2756^{+0.0164}_{-0.0133}$	$-1.0481^{+0.0573}_{-0.0580}$	1.068
All systematics, except host term	$0.2738^{+0.0186}_{-0.0145}$	$-1.0644^{+0.0790}_{-0.0809}$	1.677
All systematics, fixing α, β[b]	$0.2656^{+0.0179}_{-0.0144}$	$-1.1168^{+0.0807}_{-0.0824}$	1.641
Contribution of different systematics			
Calibration	$0.2750^{+0.0185}_{-0.0150}$	$-1.0581^{+0.0774}_{-0.0791}$	1.614
SN Ia model	$0.2767^{+0.0163}_{-0.0132}$	$-1.0403^{+0.0543}_{-0.0547}$	1.013
Peculiar velocities	$0.2761^{+0.0163}_{-0.0132}$	$-1.0452^{+0.0544}_{-0.0548}$	1.002
Malmquist bias	$0.2758^{+0.0163}_{-0.0132}$	$-1.0474^{+0.0548}_{-0.0553}$	1.014
Non-SN Ia contamination	$0.2763^{+0.0163}_{-0.0132}$	$-1.0430^{+0.0543}_{-0.0546}$	1.000
Milky Way extinction	$0.2762^{+0.0164}_{-0.0133}$	$-1.0441^{+0.0553}_{-0.0557}$	1.023
SN redshift evolution	$0.2763^{+0.0163}_{-0.0132}$	$-1.0408^{+0.0544}_{-0.0547}$	1.017
Host galaxy term	$0.2762^{+0.0163}_{-0.0132}$	$-1.0453^{+0.0556}_{-0.0562}$	1.029

Sullivan et al., 2011

According to SNLS

Table 3
Detailed Summary of Systematic Uncertainties

Source	Ω_m	w	Relative Area[a]
Statistical only	$0.2763^{+0.0163}_{-0.0132}$	$-1.0430^{+0.0543}_{-0.0546}$	1.0
All systematics	$0.2736^{+0.0186}_{-0.0145}$	$-1.0676^{+0.0799}_{-0.0821}$	1.693
All systematics, except calibration	$0.2756^{+0.0164}_{-0.0133}$	$-1.0481^{+0.0573}_{-0.0580}$	1.068
All systematics, except host term	$0.2738^{+0.0186}_{-0.0145}$	$-1.0644^{+0.0790}_{-0.0809}$	1.677
All systematics, fixing α, β[b]	$0.2656^{+0.0179}_{-0.0144}$	$-1.1168^{+0.0807}_{-0.0824}$	1.641
Contribution of different systematics			
Calibration	$0.2750^{+0.0185}_{-0.0150}$	$-1.0581^{+0.0774}_{-0.0791}$	1.614
SN Ia model	$0.2767^{+0.0163}_{-0.0132}$	$-1.0403^{+0.0543}_{-0.0547}$	1.013
Peculiar velocities	$0.2761^{+0.0163}_{-0.0132}$	$-1.0452^{+0.0544}_{-0.0548}$	1.002
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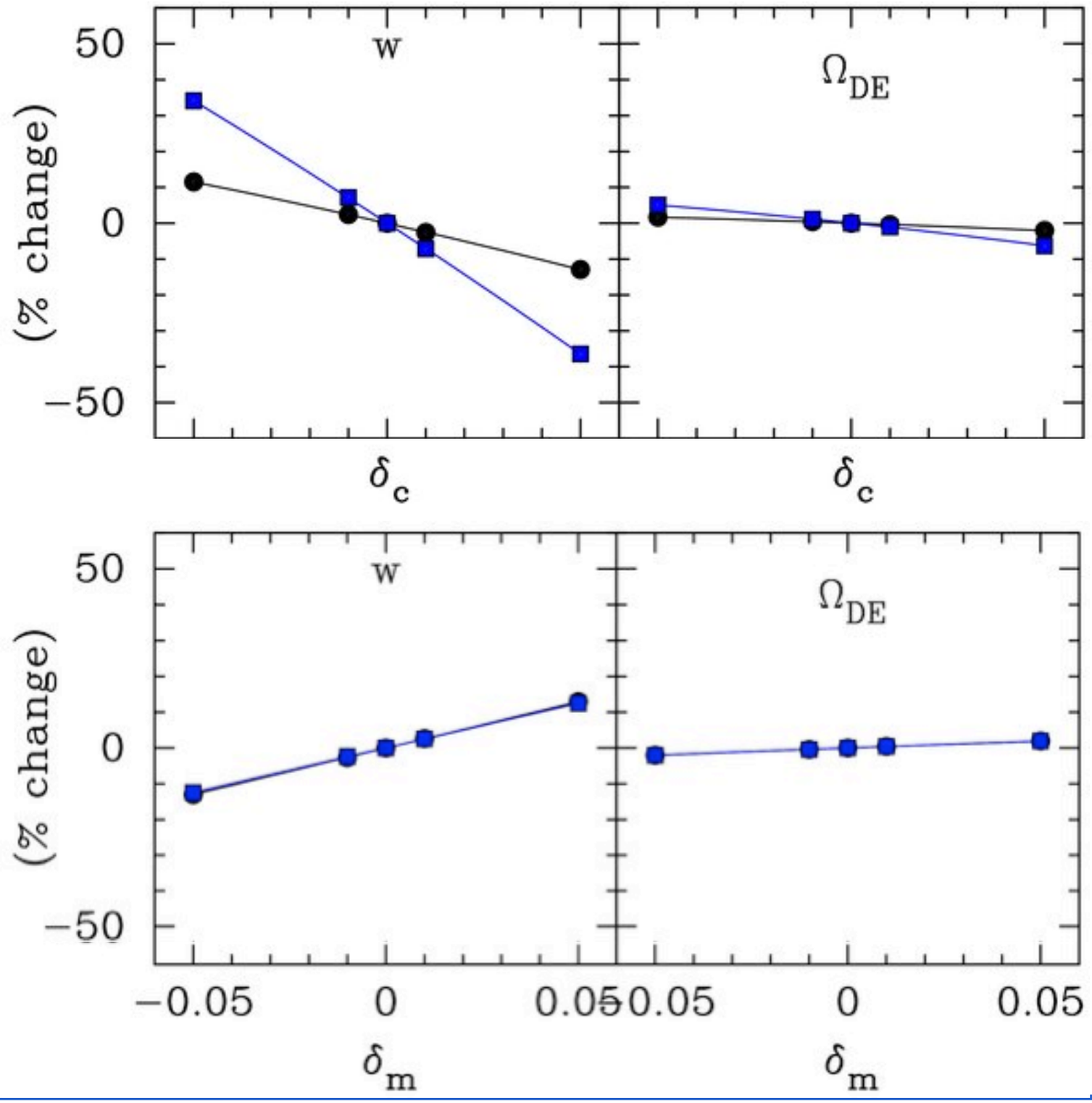
Sullivan et al., 2011

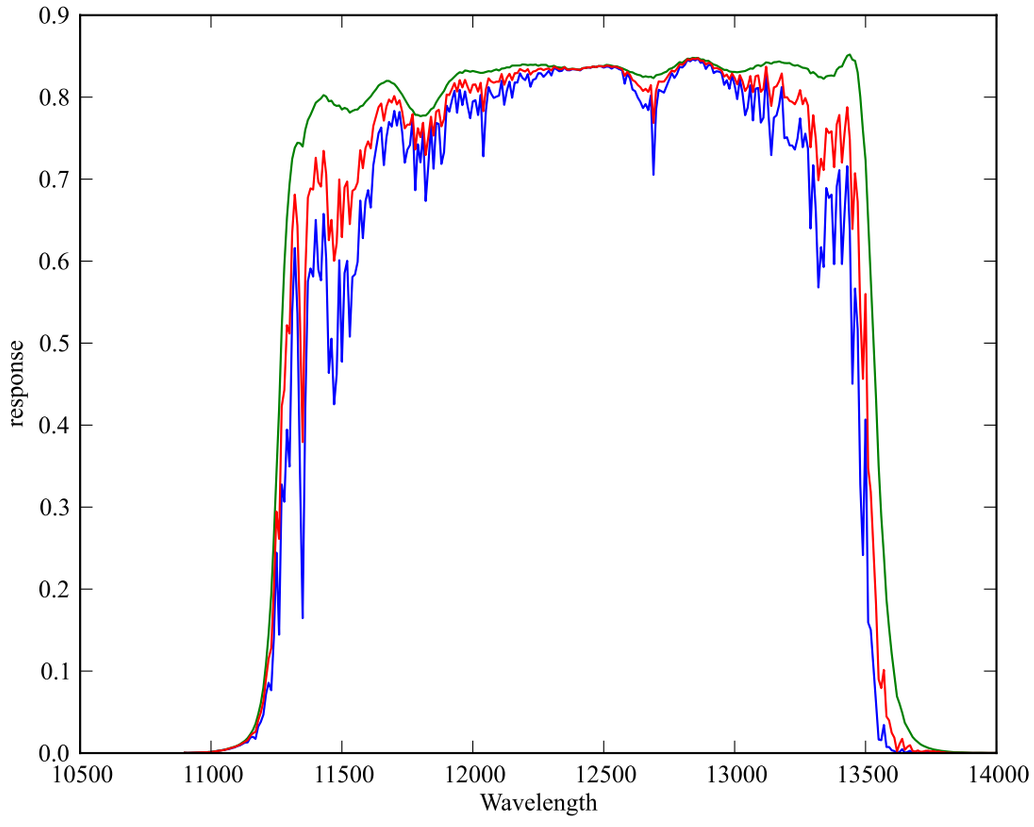
NIR's great, but...

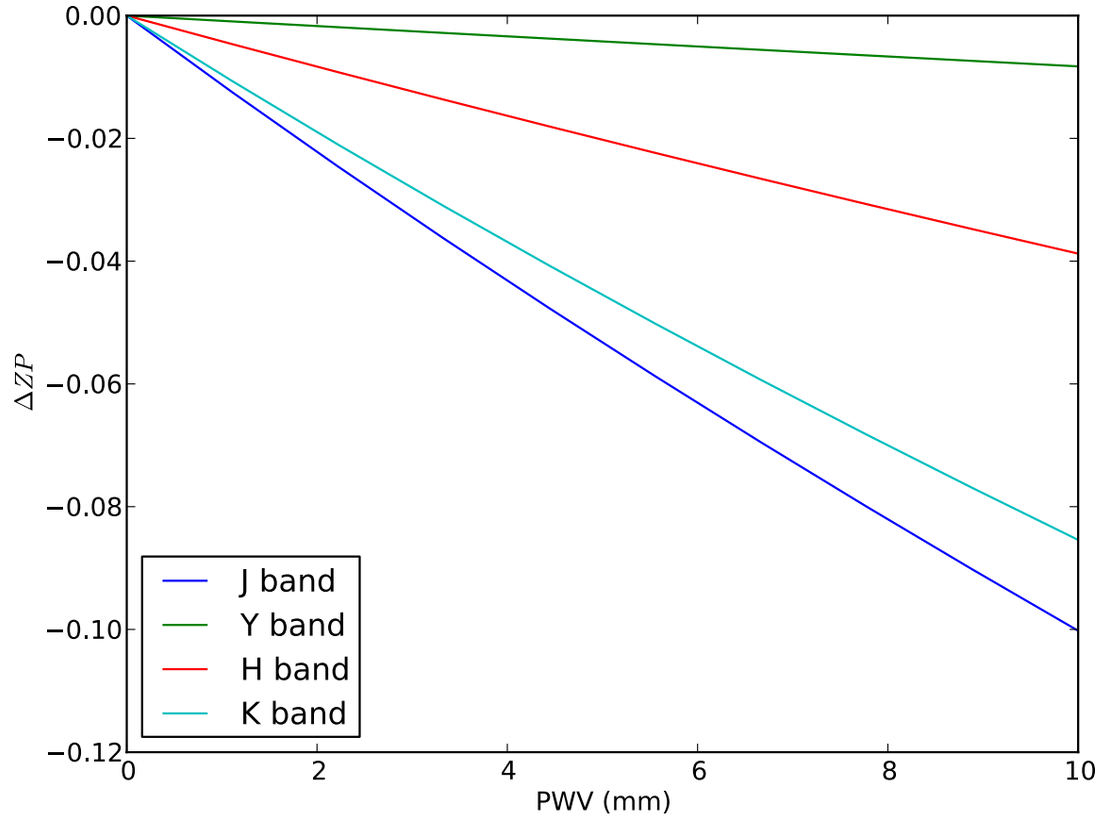
- Reducing dispersion doesn't get you very far. You need to reduce *systematics*
- Dust is not the biggest systematic; calibration is. We currently don't know our Y-band zero-point to be better than 0.03 mag. Y-X colors of Vega? BD+17???

Effects of a zero-point offsets between low and high-z



How well can we calibrate ground-based NIR?





See Blake & Shaw (2011)

NIR's great, but...

- Reducing dispersion doesn't get you very far. You need to reduce *systematics*
- Dust is not the biggest systematic; calibration is. We currently don't know our Y-band zero-point to be better than 0.03 mag. Y-X colors of Vega? BD+17???
- Precipitative Water Vapor may be the limiting factor. Can we correct for this?