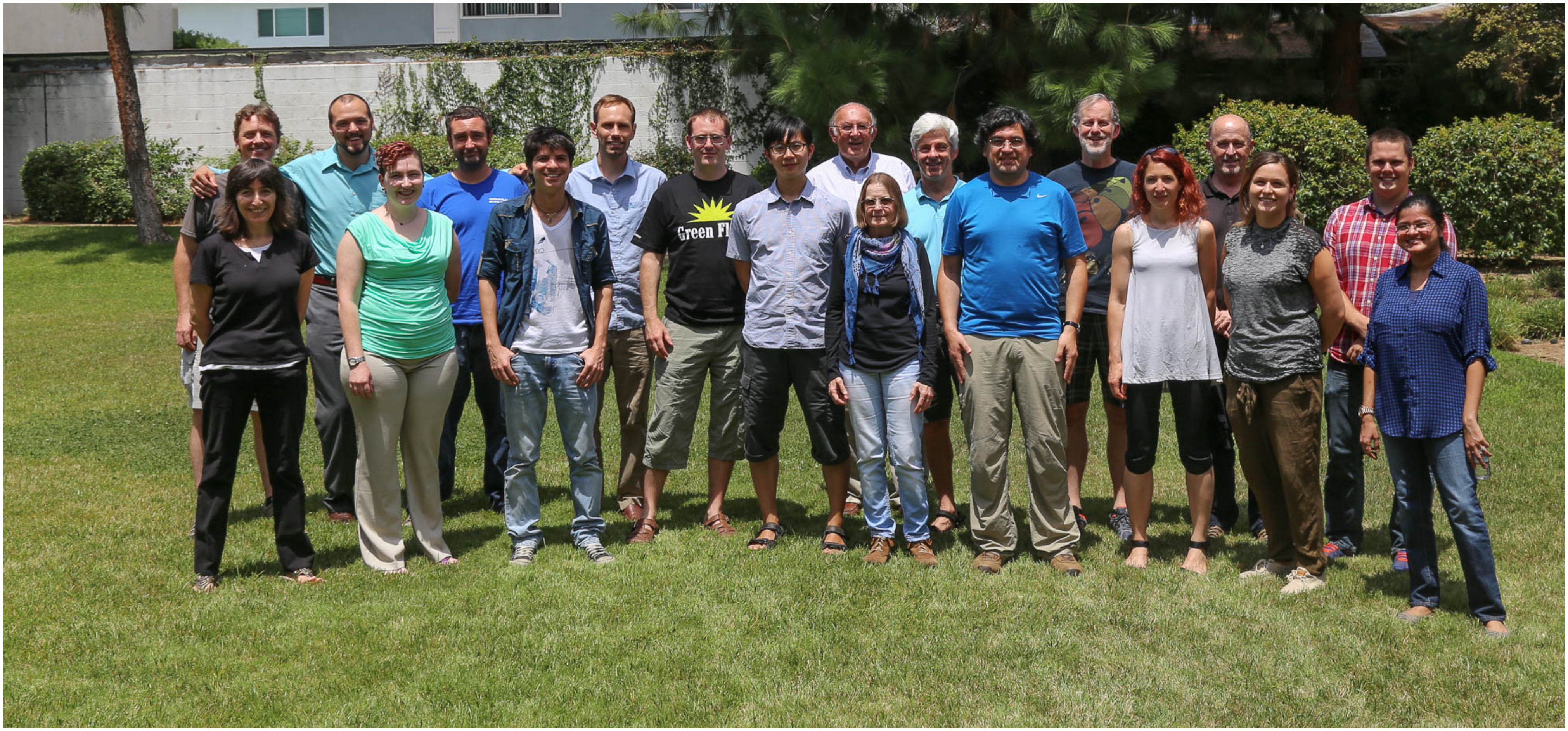
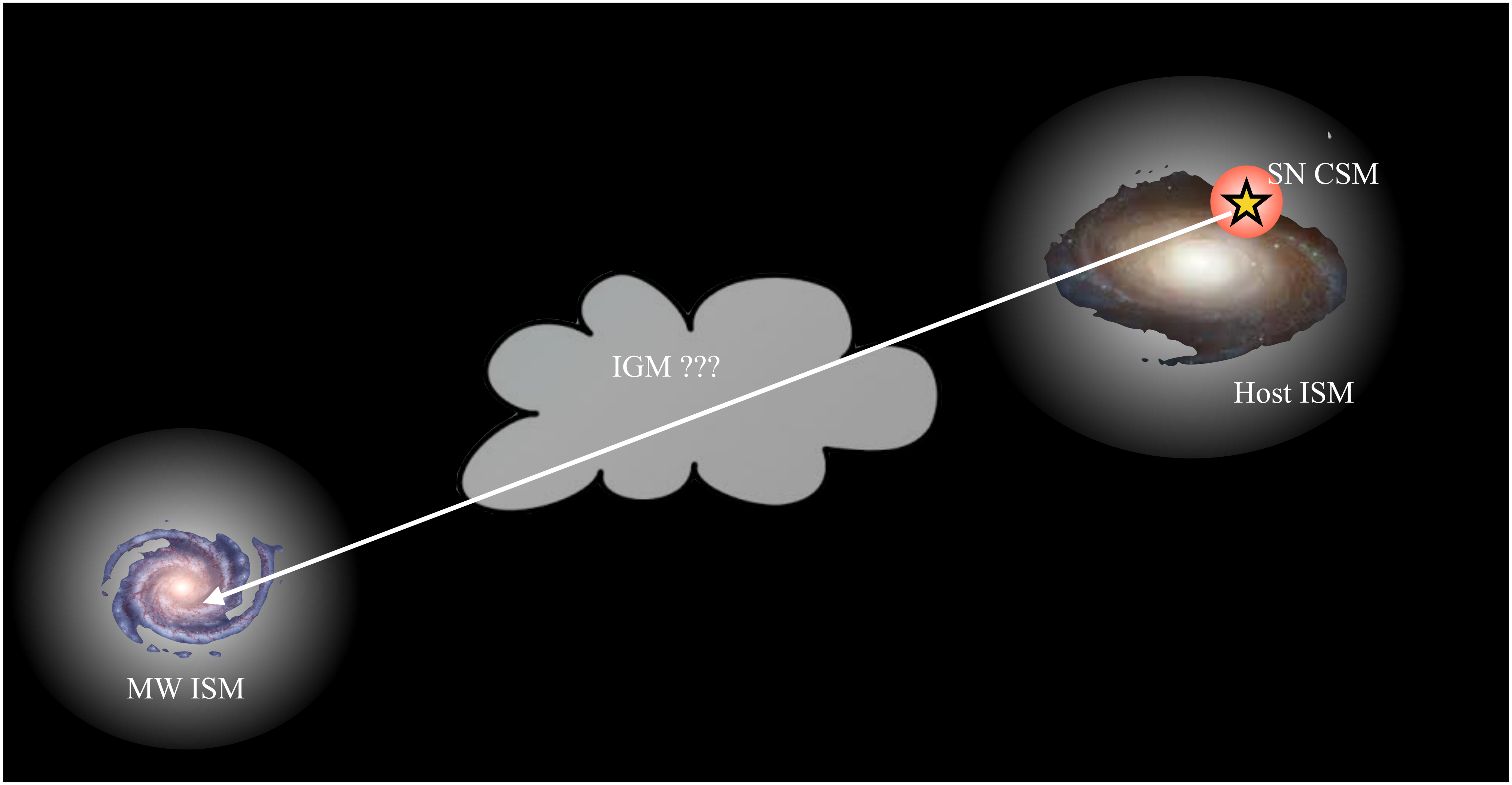
# What (if anything) Does the Dust Tell Us?

Chris Burns, OCIW

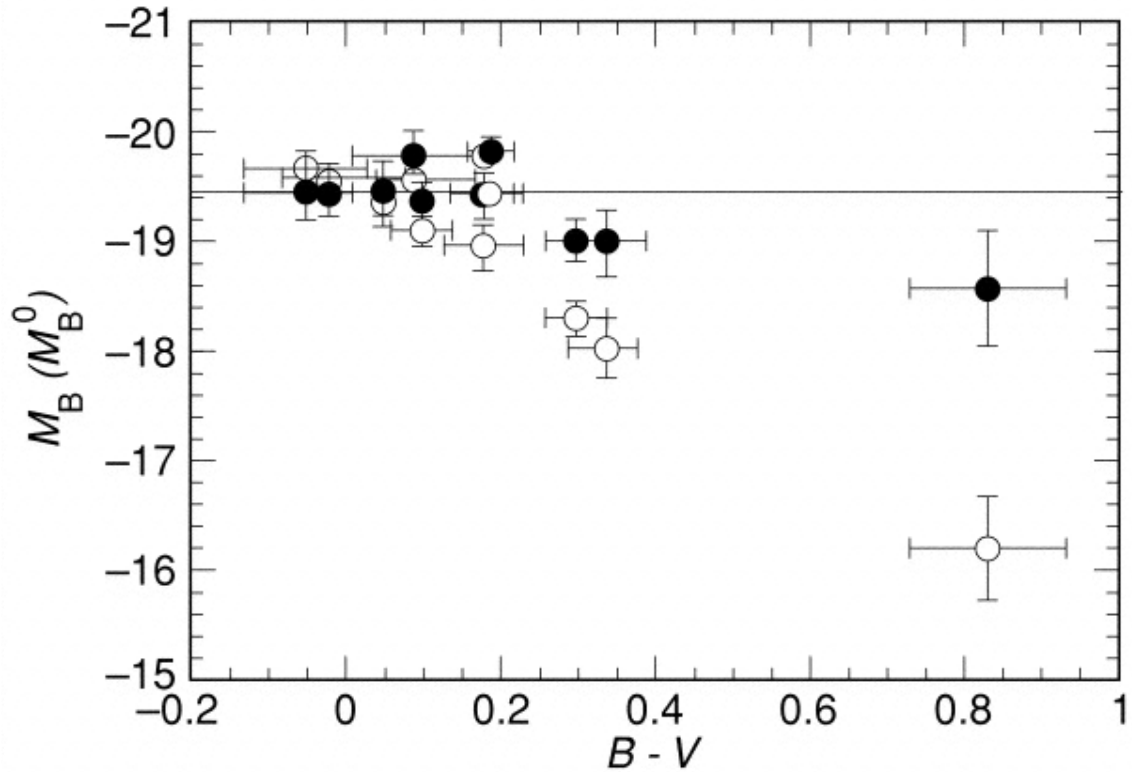
# Those Responsible



# Where's the Dust?



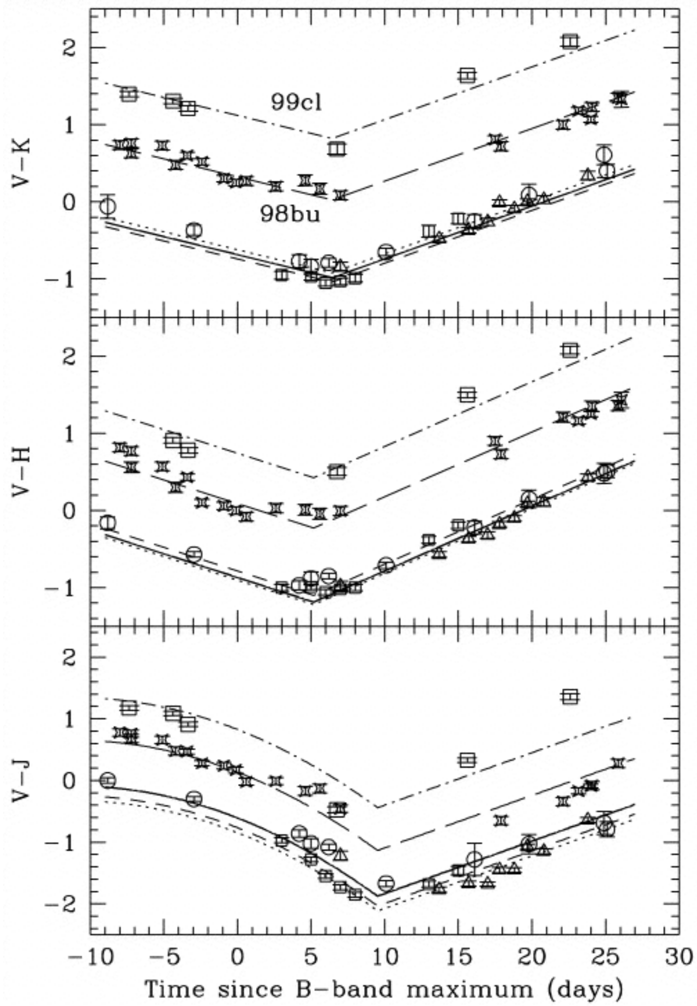
# Tripp & Branch 1999




$R_B = 2.4$

"It's dust + physics"

# Krisciunas et al. (2000)



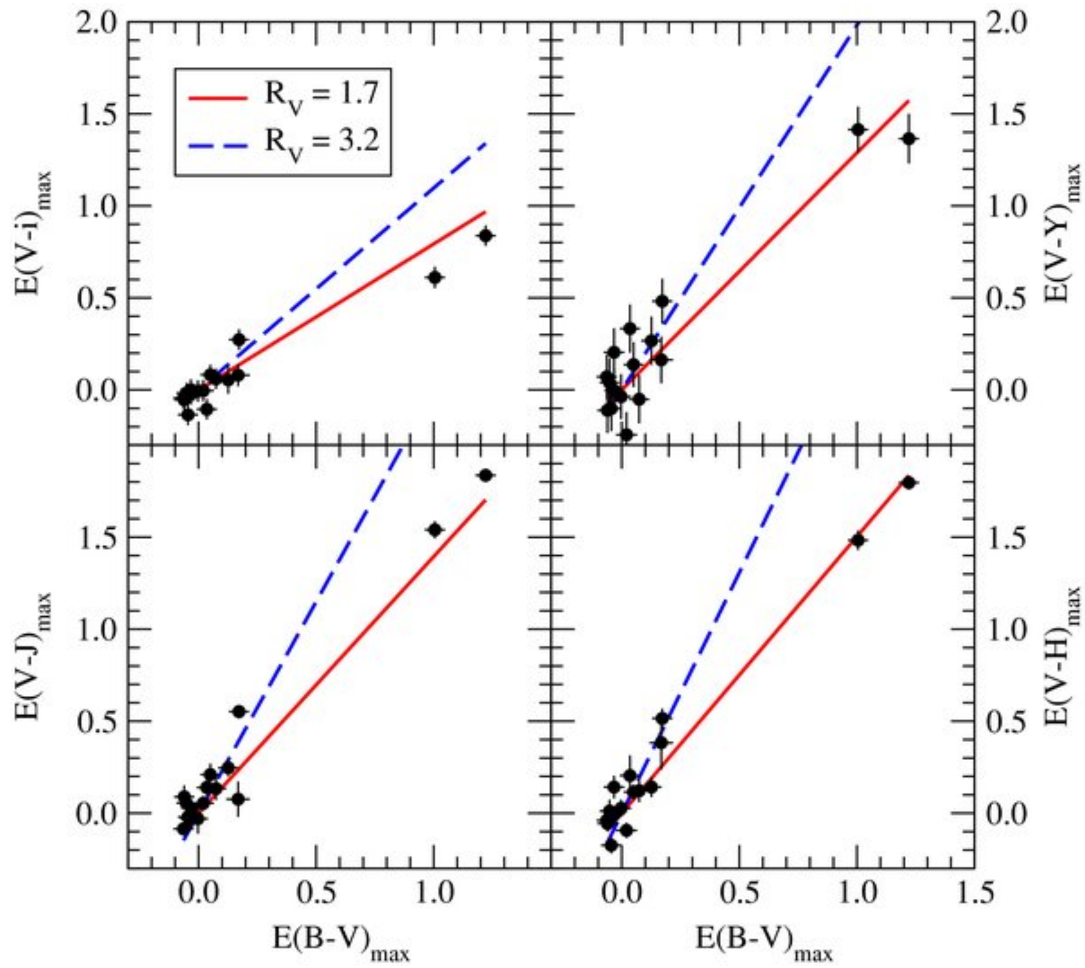

SN1999cl:

optical colors: $A_V = 3.53$
NIR colors: $A_V = 2.01$

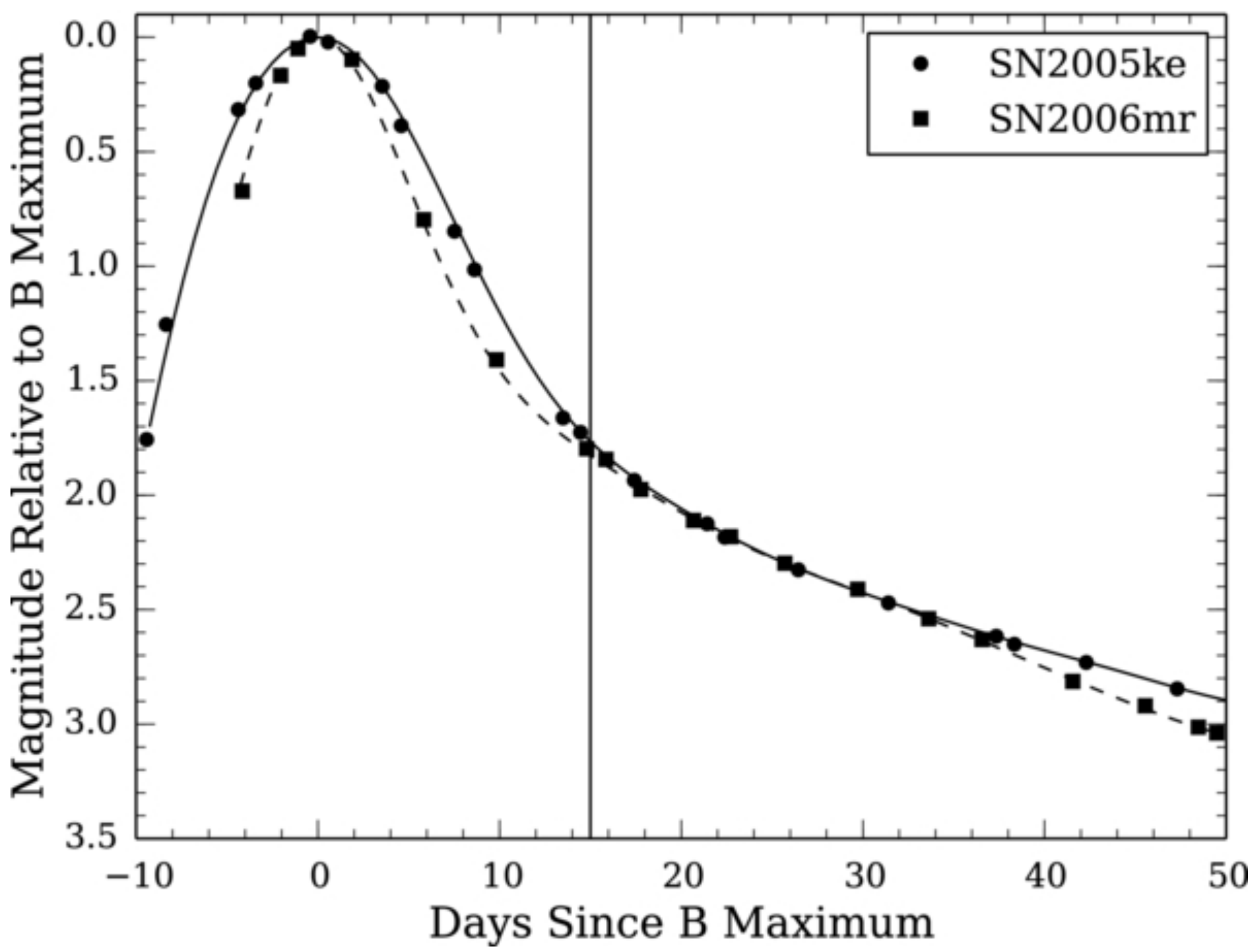
$R_V = 1.8$

"unrealistic"

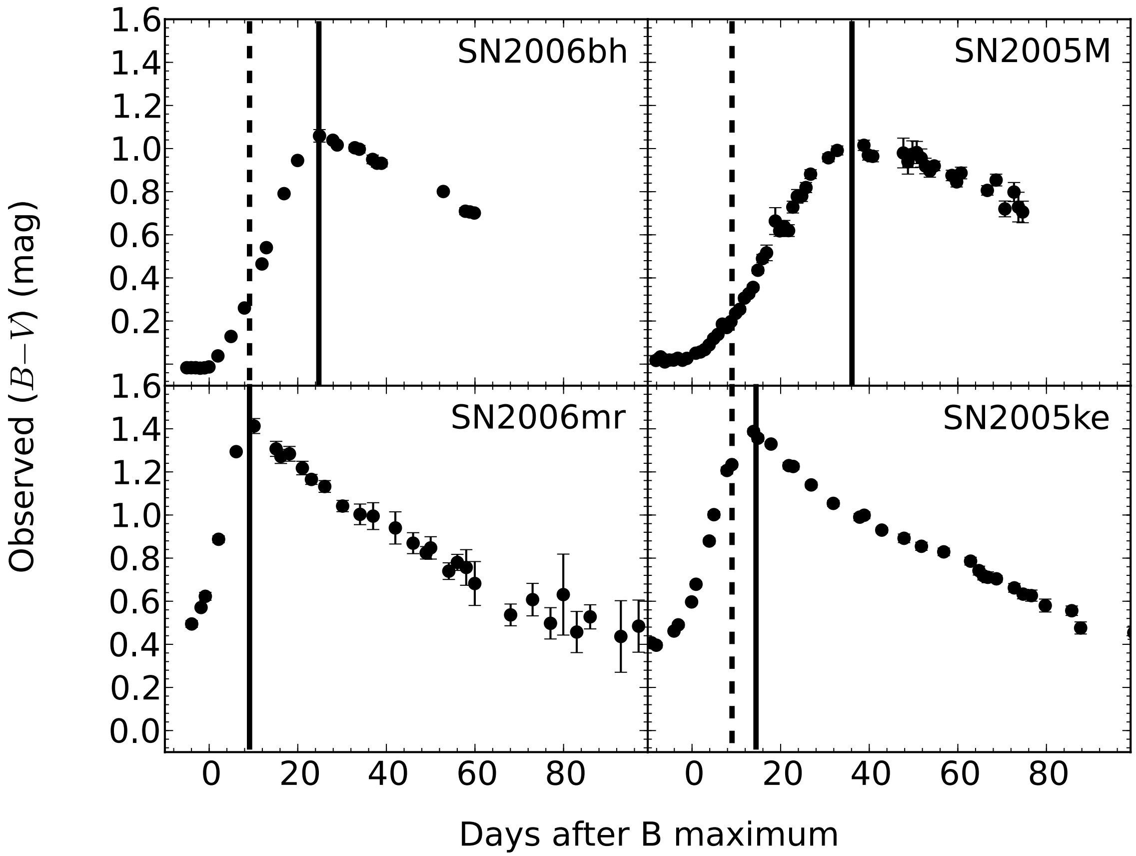
# Folatelli et al. (2010)



# Aside: Δm15 has issues

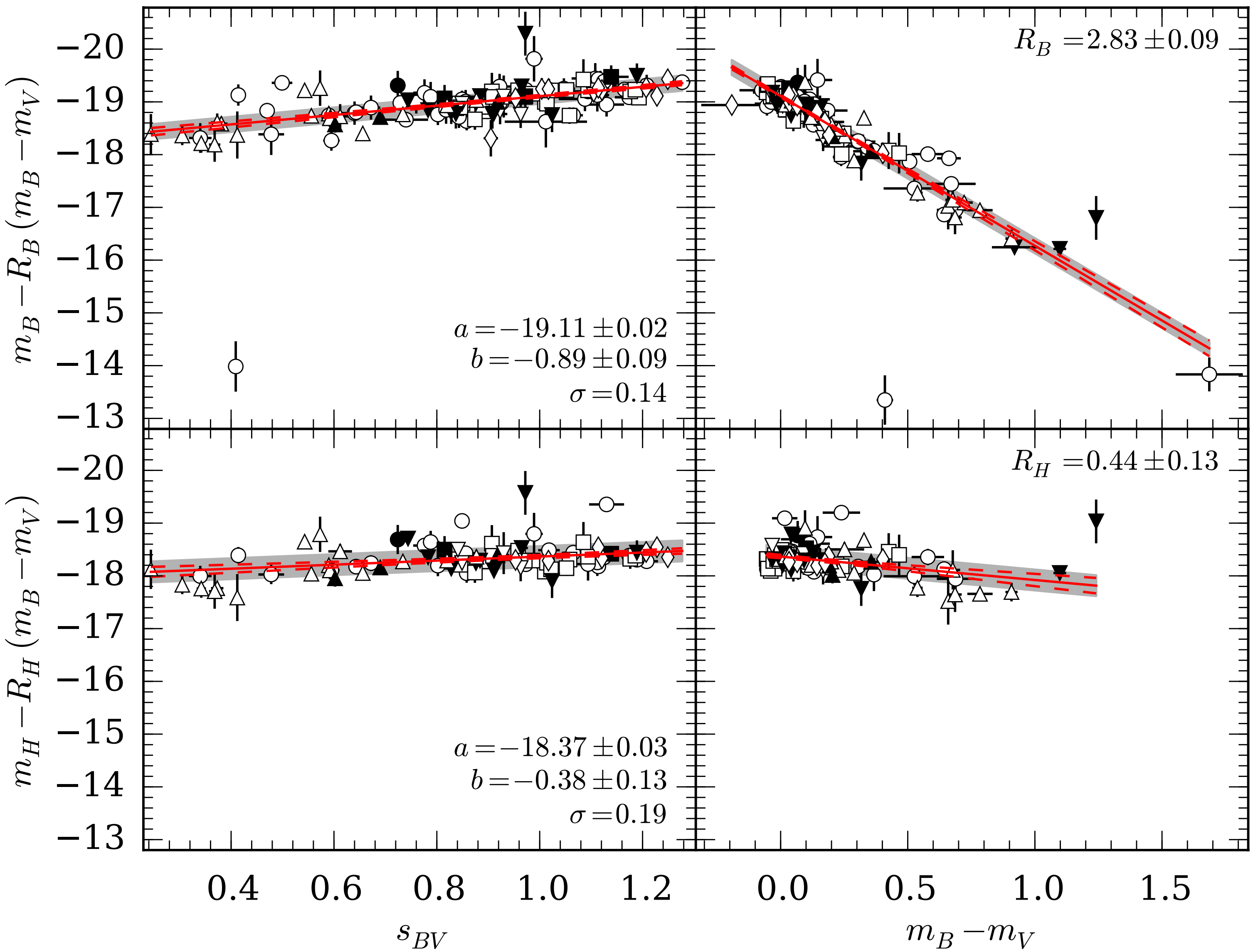


# A Little C-Magic

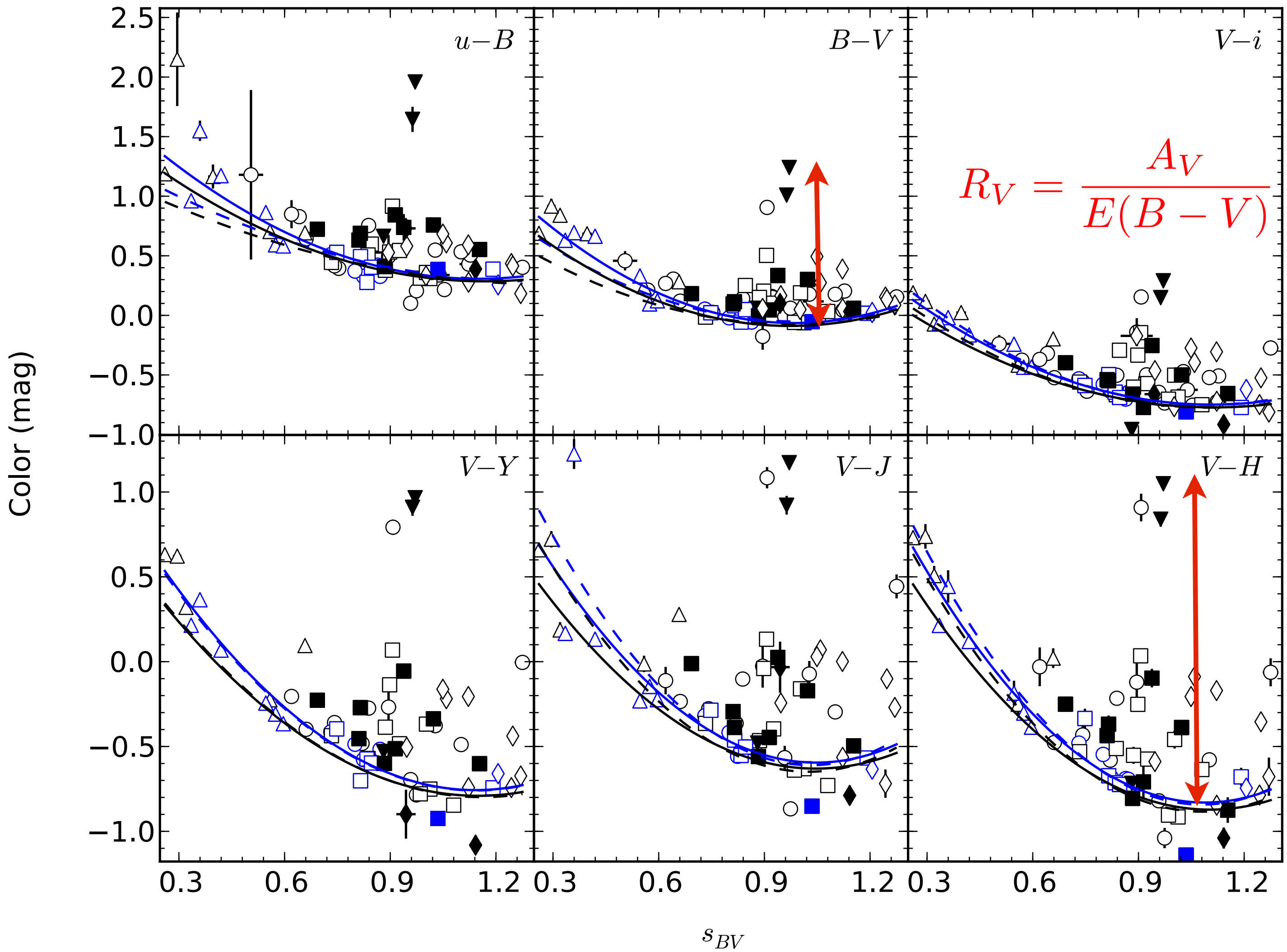



Define color stretch:

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

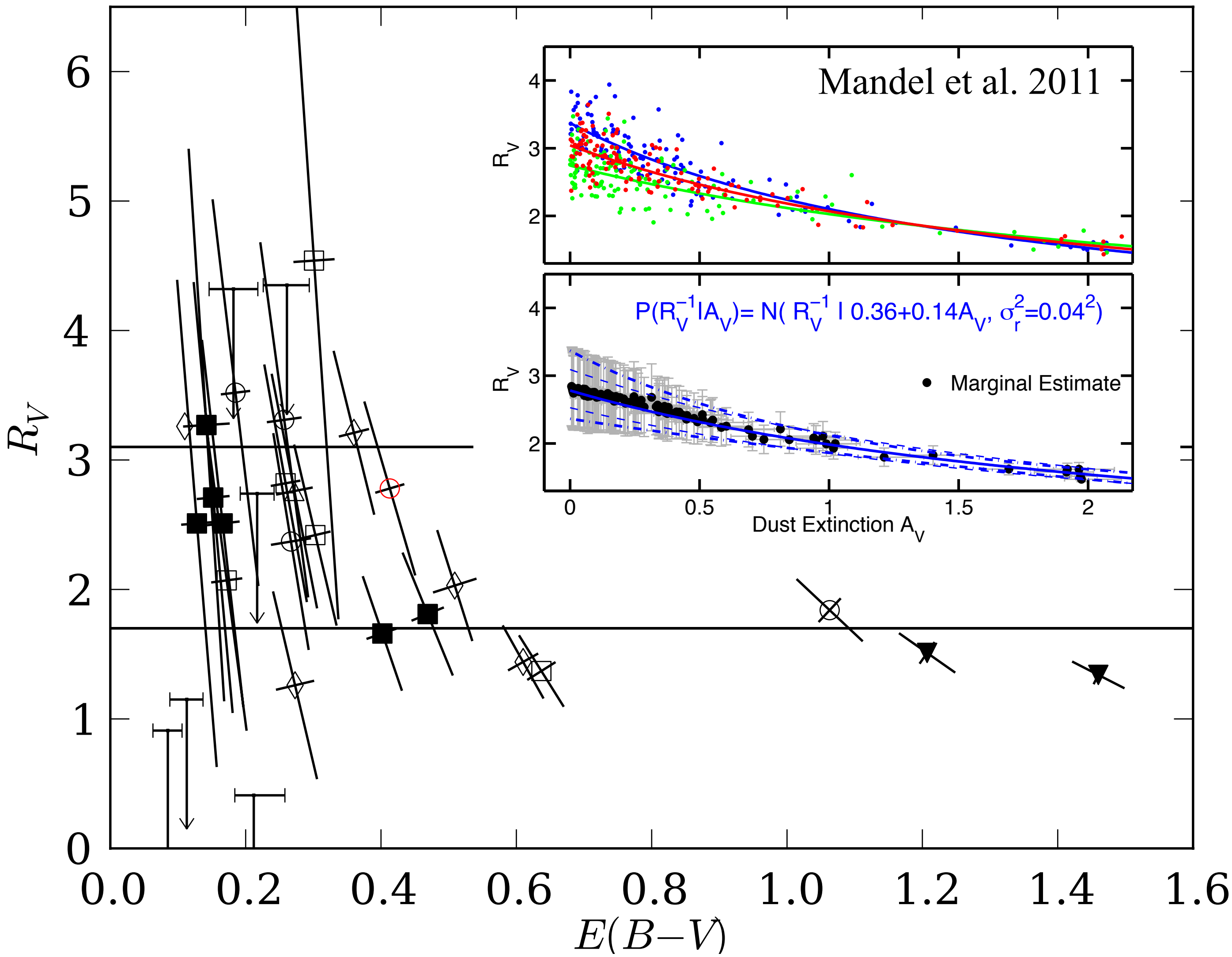

$R_B = 2.83 \pm 0.09$
$a = -19.11 \pm 0.02$
$b = -0.89 \pm 0.09$
$\sigma = 0.14$
$R_H = 0.44 \pm 0.13$
$a = -18.37 \pm 0.03$
$b = -0.38 \pm 0.13$
$\sigma = 0.19$
$m_B - R_B\,(m_B - m_V)$
$m_H - R_H\,(m_B - m_V)$
$s_{BV}$
$m_B - m_V$

# Intrinsic Colors vs. $s_{BV}$



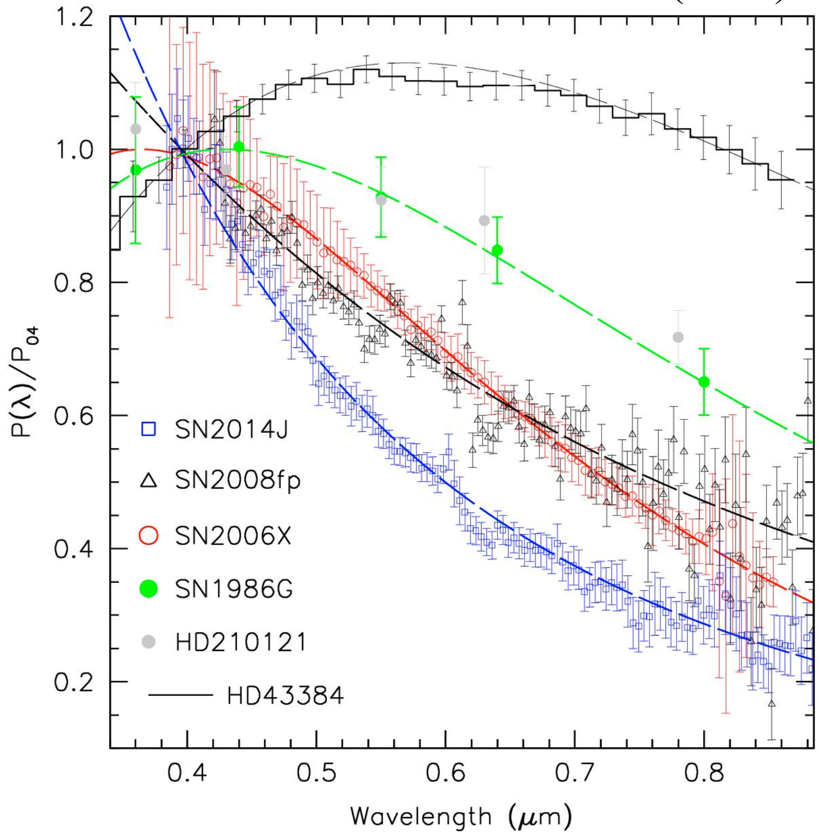

$$R_V = \frac{A_V}{E(B-V)} \simeq \frac{E(V-H)}{E(B-V)}$$

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

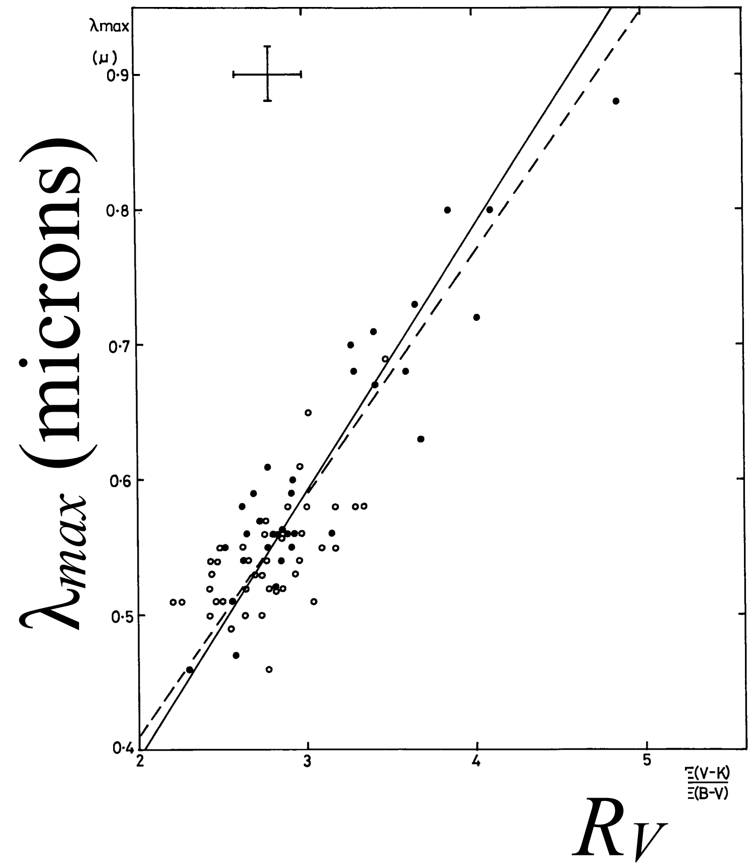

Mandel et al. 2011
$P(R_V^{-1}|A_V) = N(R_V^{-1} | 0.36+0.14A_V, \sigma_r^2=0.04^2)$
Marginal Estimate
Dust Extinction $A_V$
$R_V$
$E(B-V)$

# These low $R_V$ are *real*.

Patat et al. (2015)

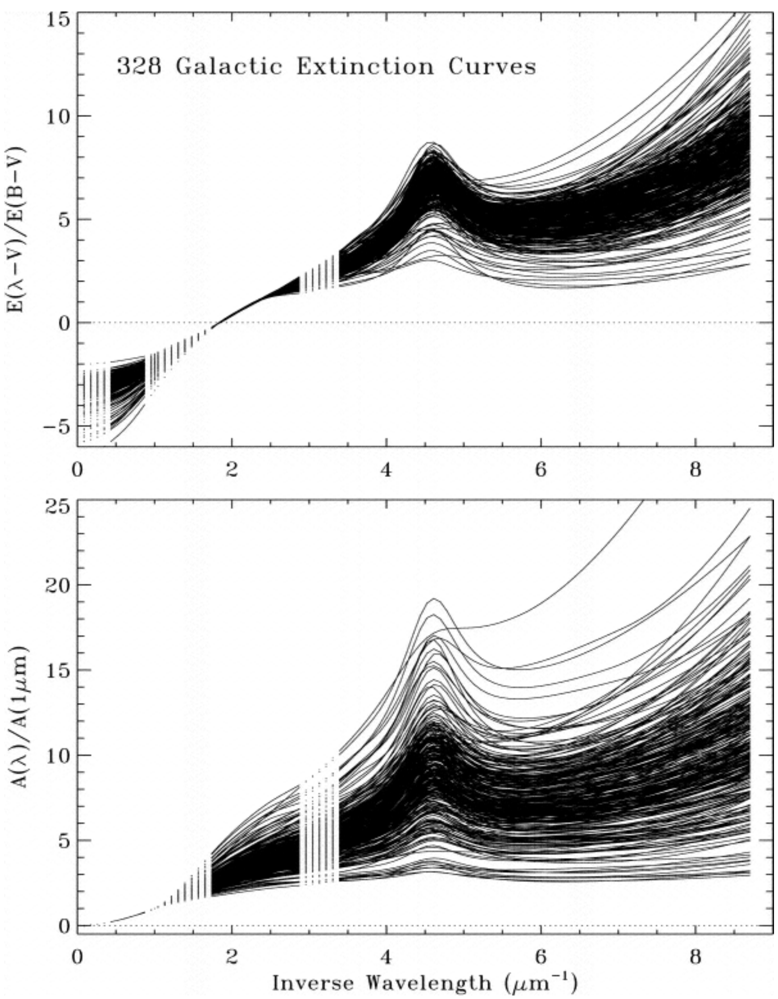


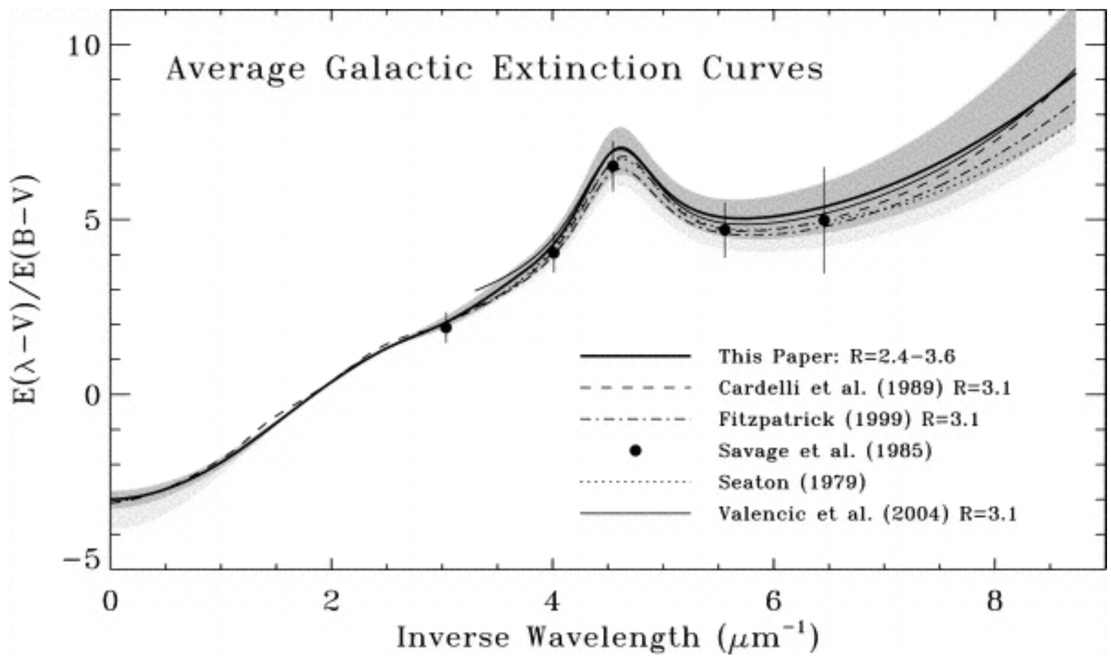

Whittet et al. (1978)




"objects show a pronounced continuum polarization at position angles remarkably well aligned with the local spiral arms of their hosts"

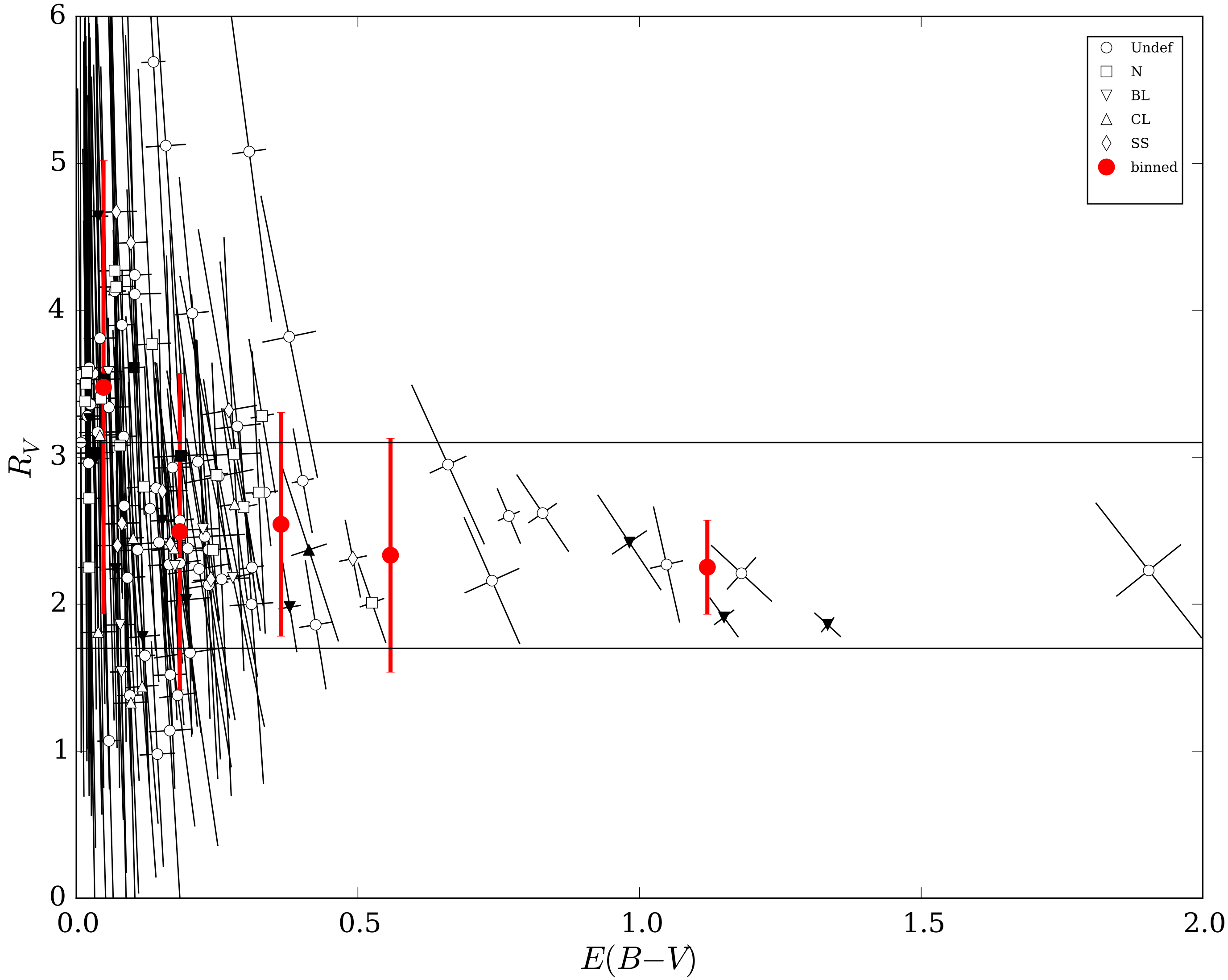
# $R_V$ isn't the whole story.



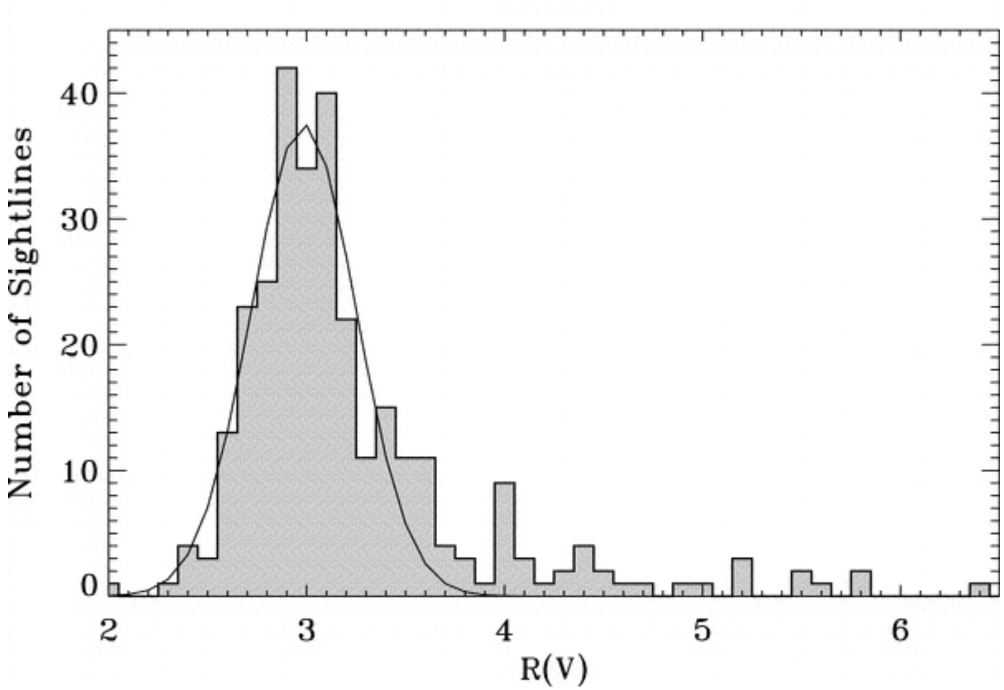



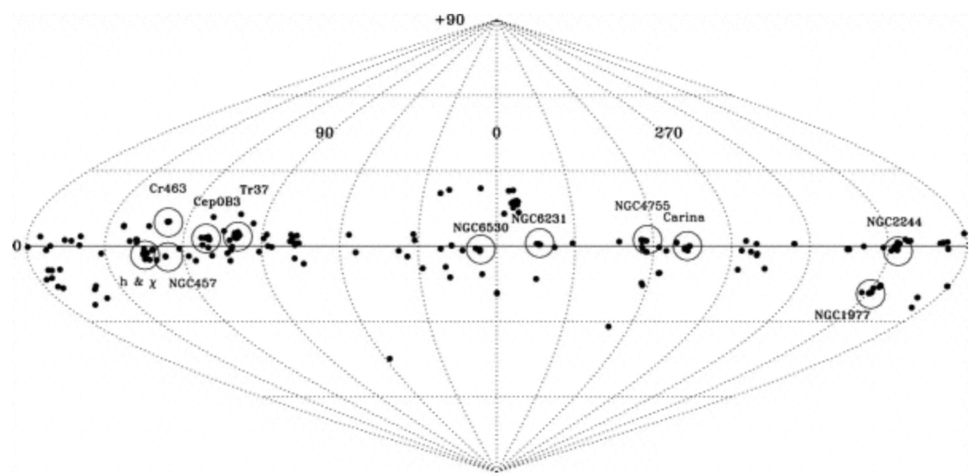

Fitzpatrick & Massa (2007)

# CSPI + PARITEL using F99



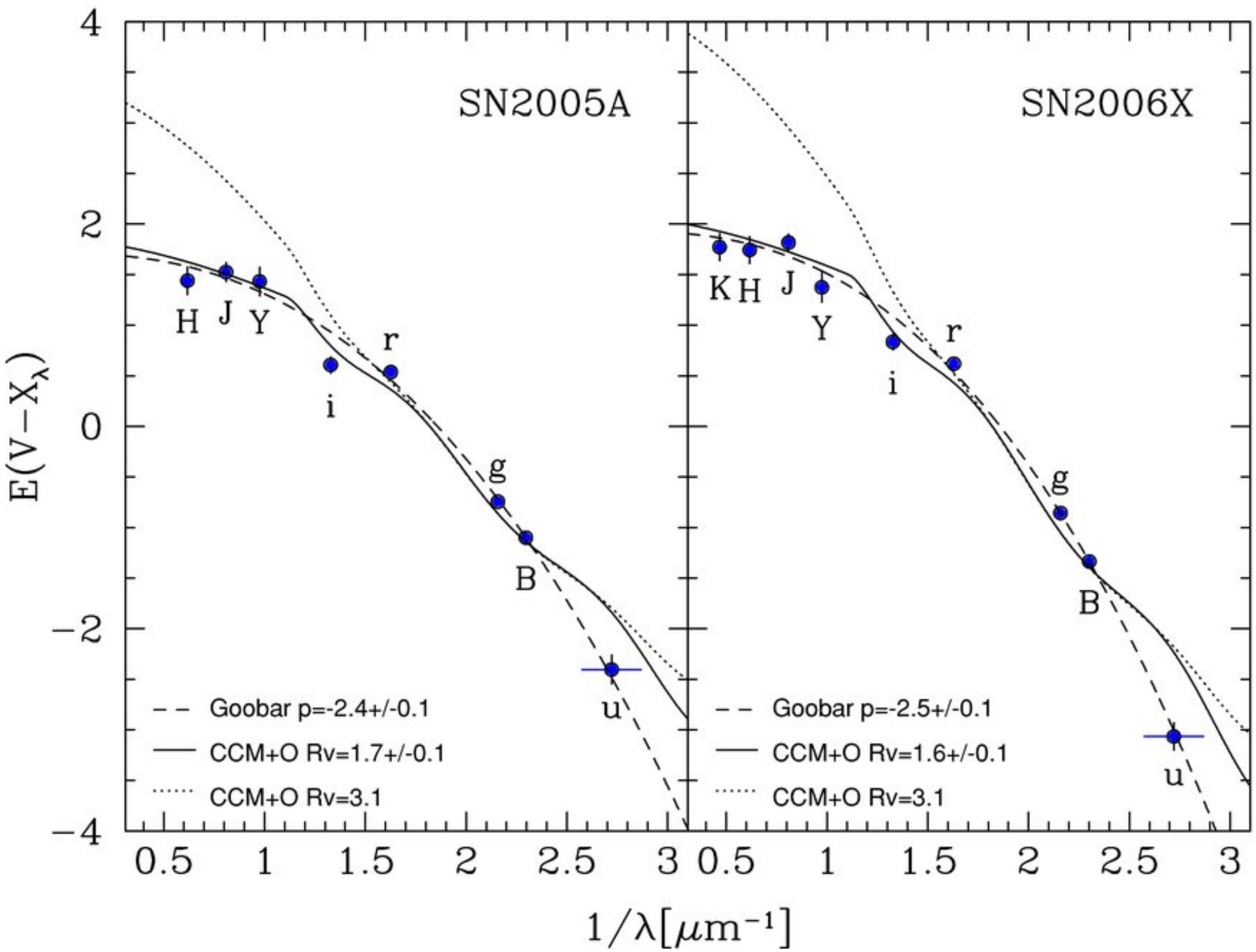
# These low $R_V$ seem crazy.



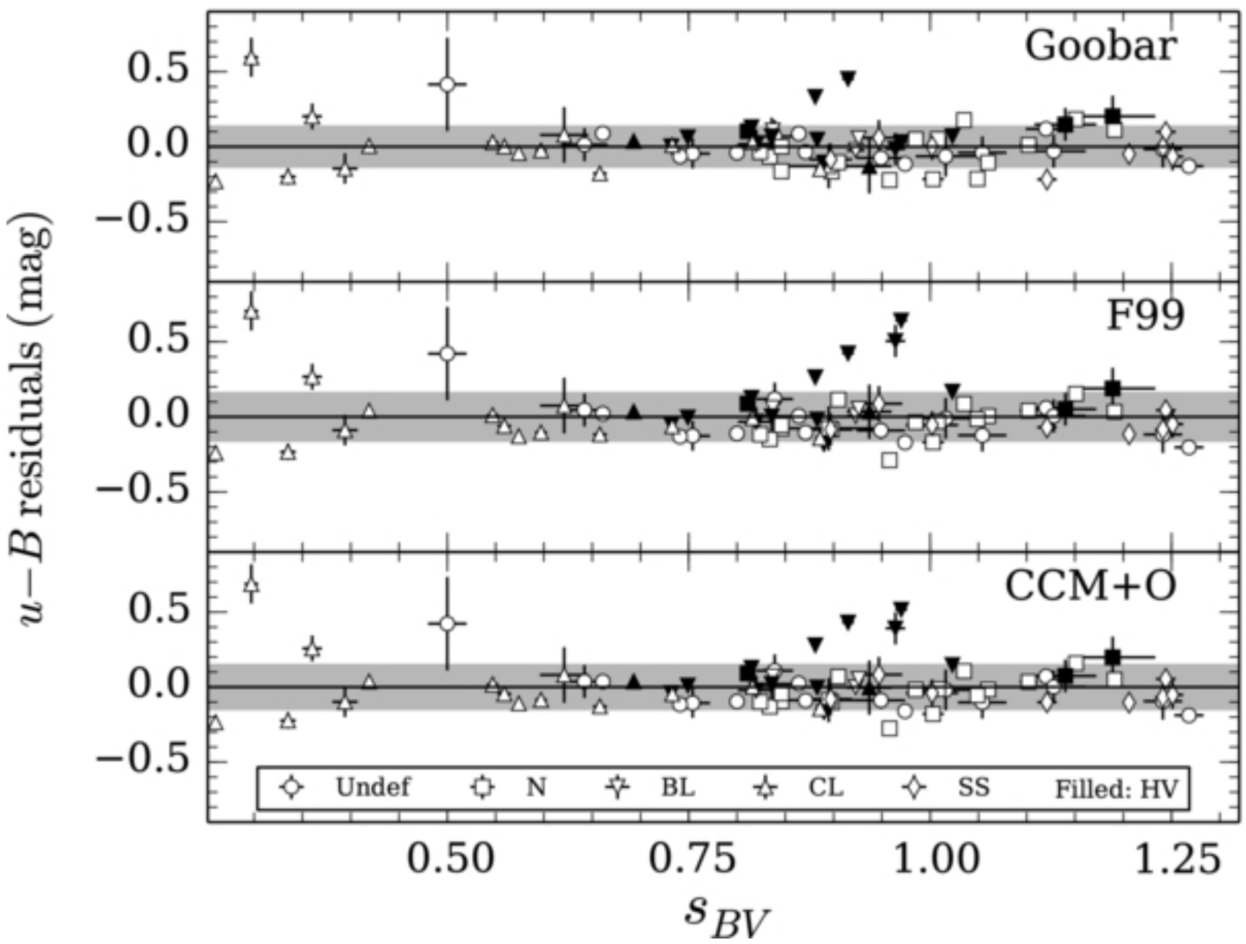




Fitzpatrick & Massa (2007)

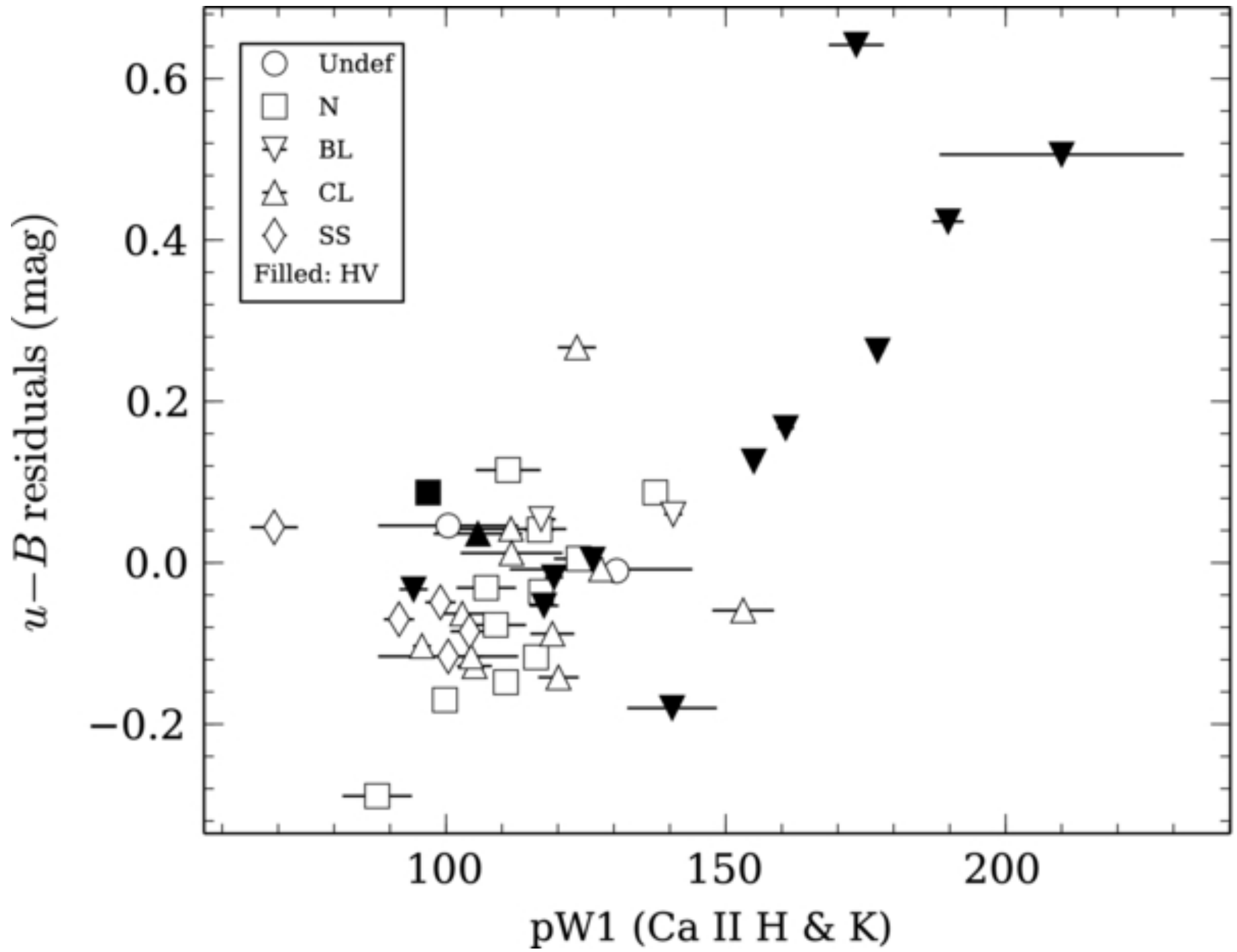
# Maybe CSM!

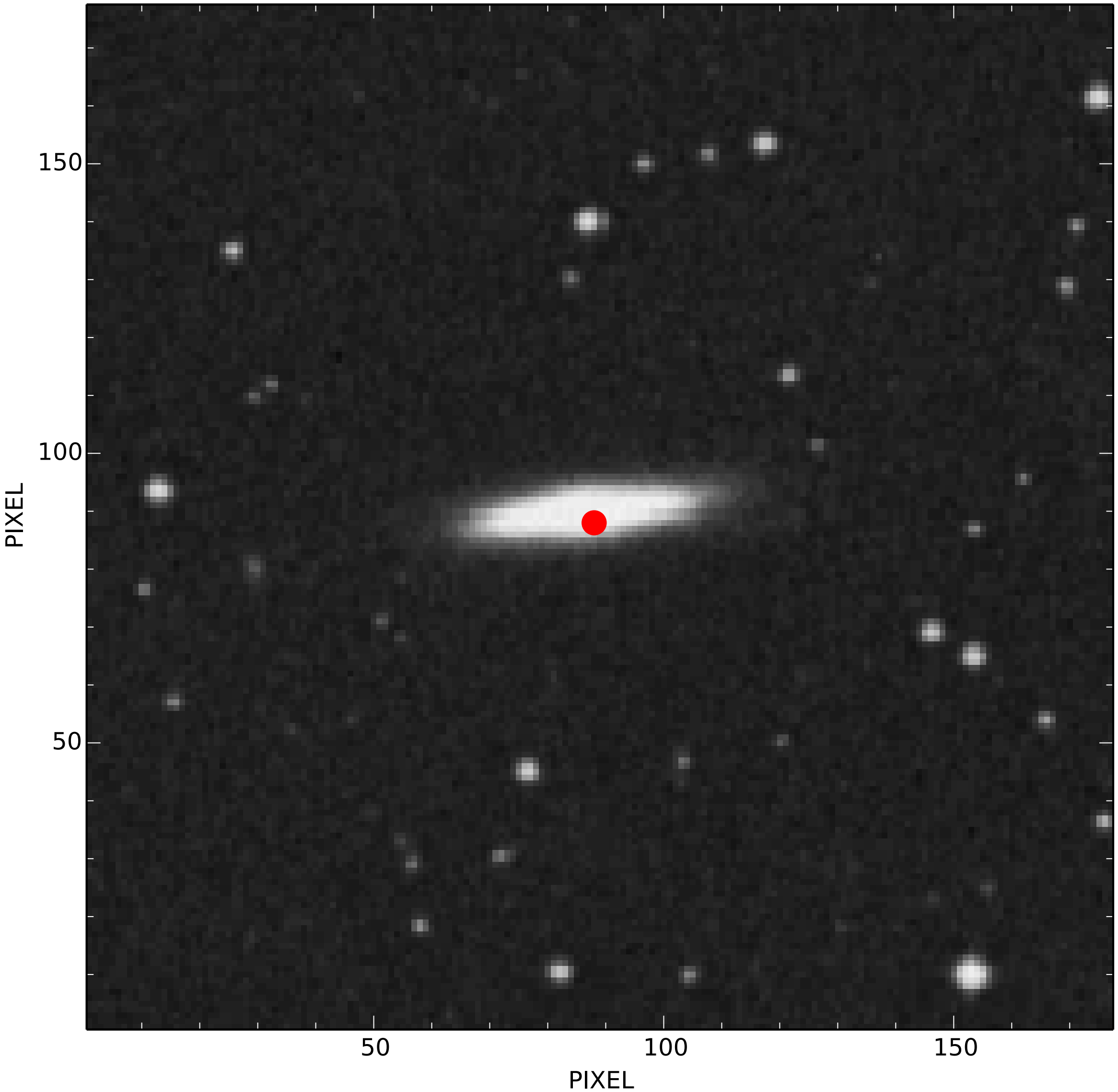

SN2005A
SN2006X
E(V−X$_\lambda$)
1/λ[μm$^{-1}$]
H
J
Y
i
r
g
B
u
K
Goobar p=-2.4+/-0.1
CCM+O Rv=1.7+/-0.1
CCM+O Rv=3.1
Goobar p=-2.5+/-0.1
CCM+O Rv=1.6+/-0.1
CCM+O Rv=3.1
4
2
0
−2
−4
0.5
1
1.5
2
2.5
3

# Extinction Laws



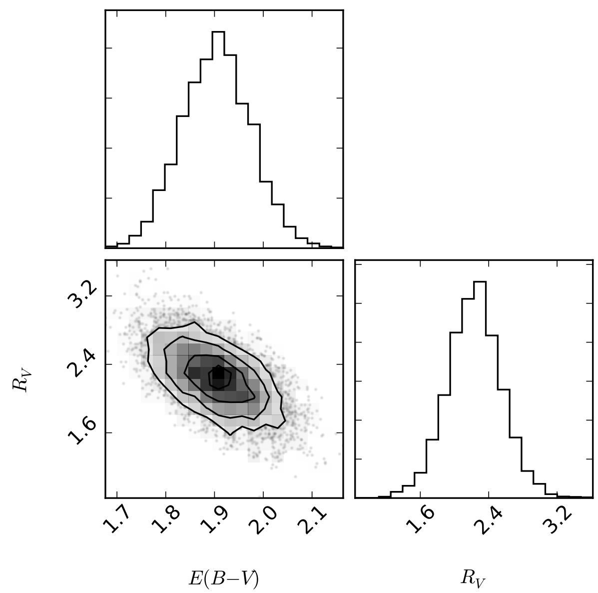
# Spectral Features

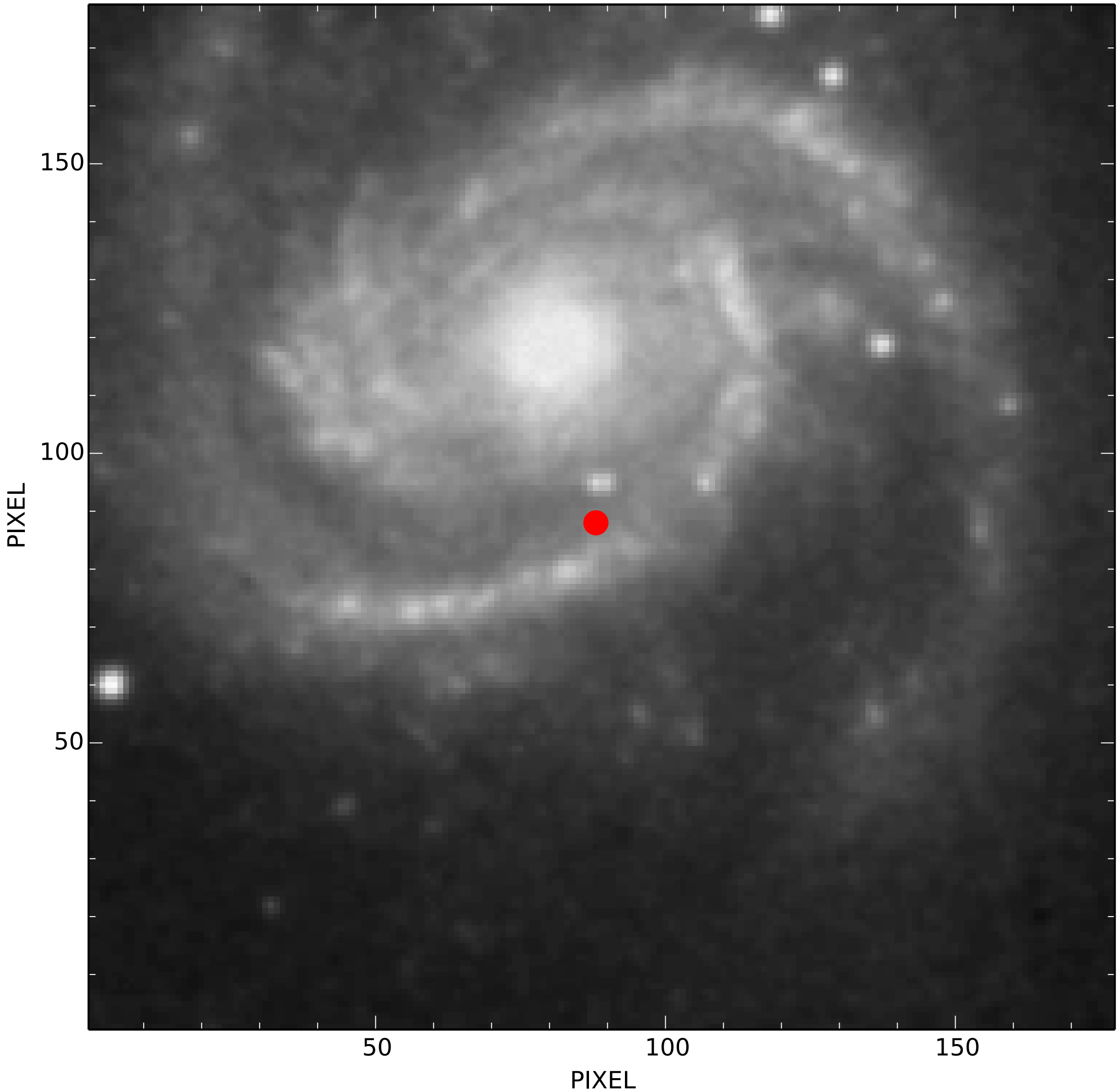





# SN2008cd

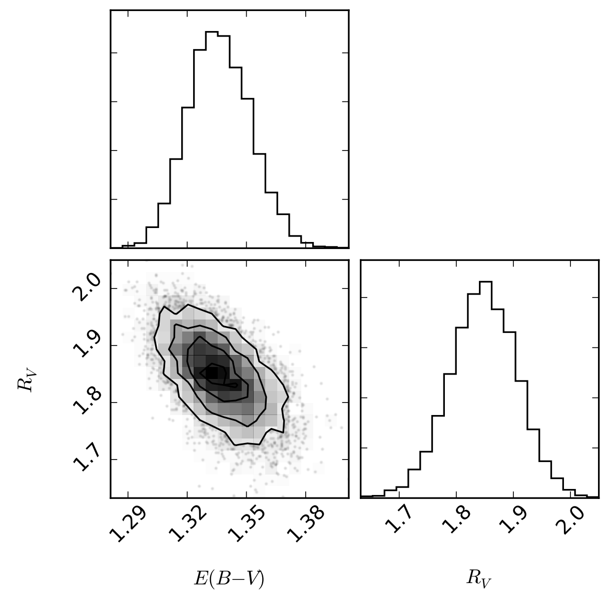
$$E(B\text{-}V) = 1.90\ (07)$$
$$R_V = 2.23\ (31)$$

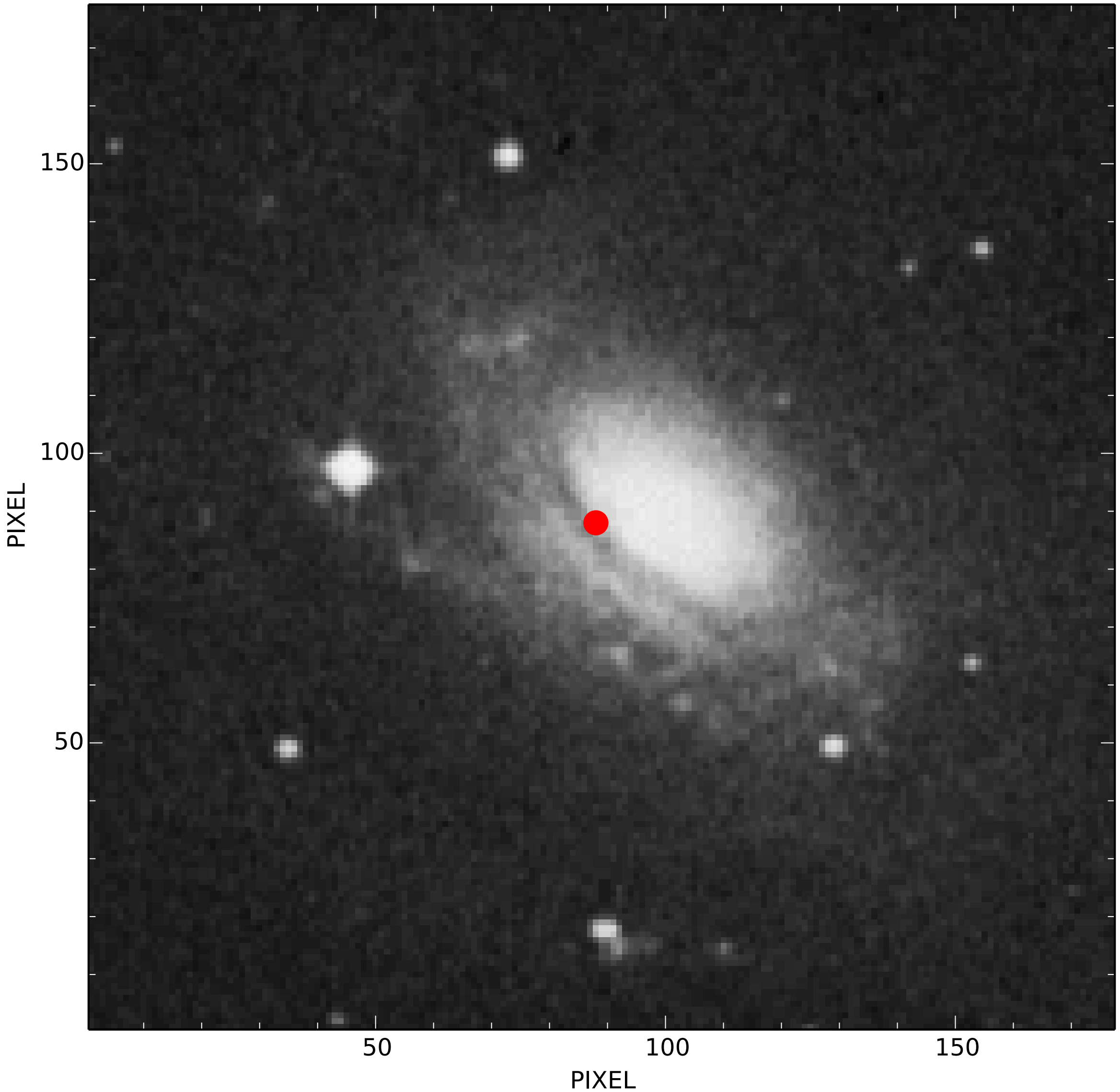





# SN2006X

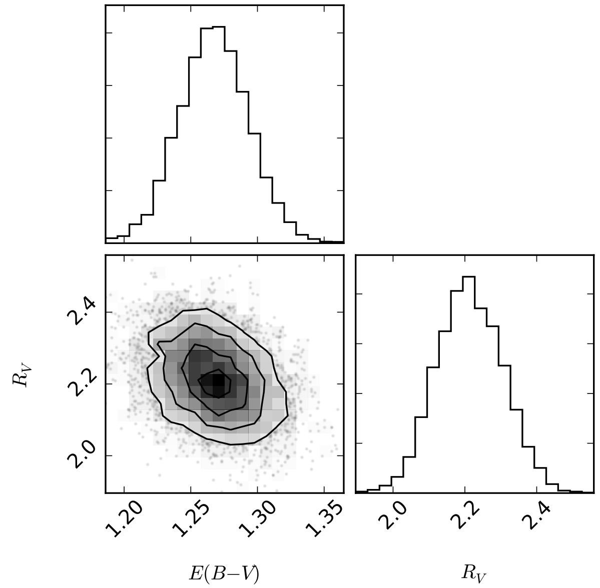
$$E(B\text{-}V) = 1.33\ (02)$$
$$R_V = 1.86\ (06)$$

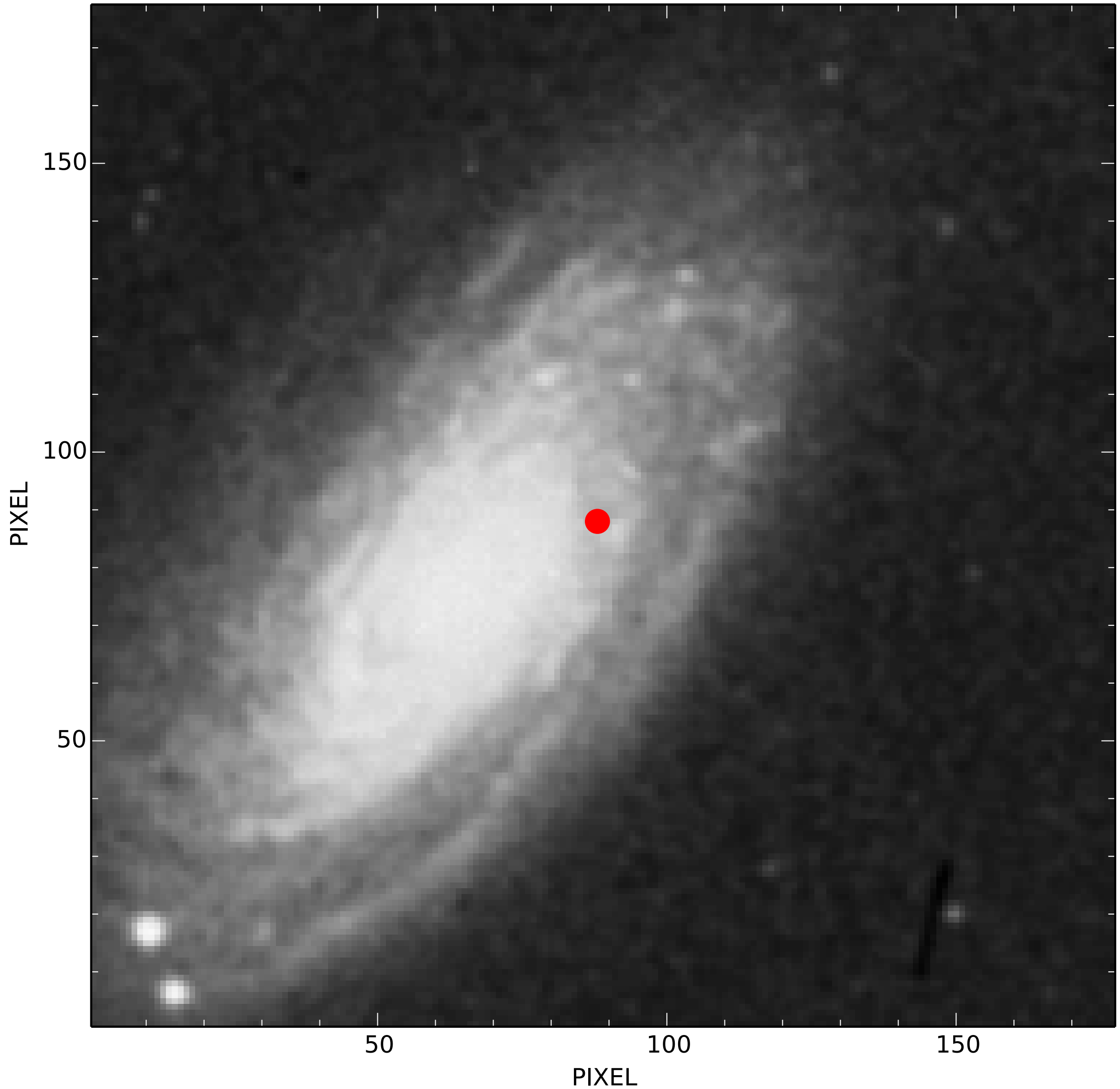





# SN2003cg

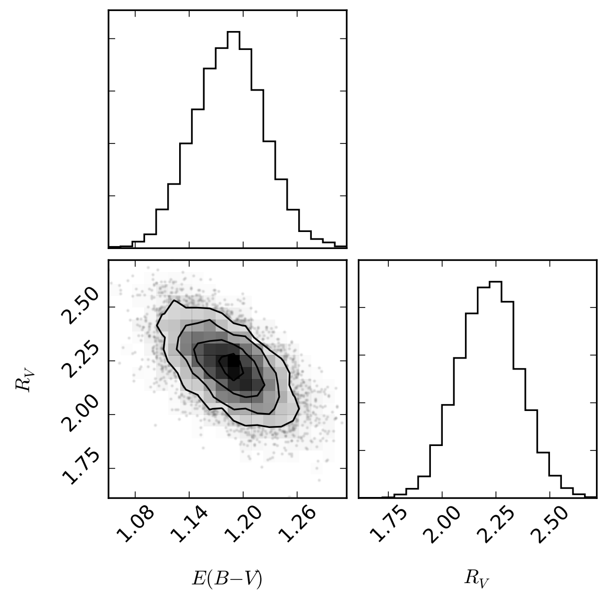
$$E(B\text{-}V) = 1.27\ (03)$$
$$R_V = 2.21\ (09)$$

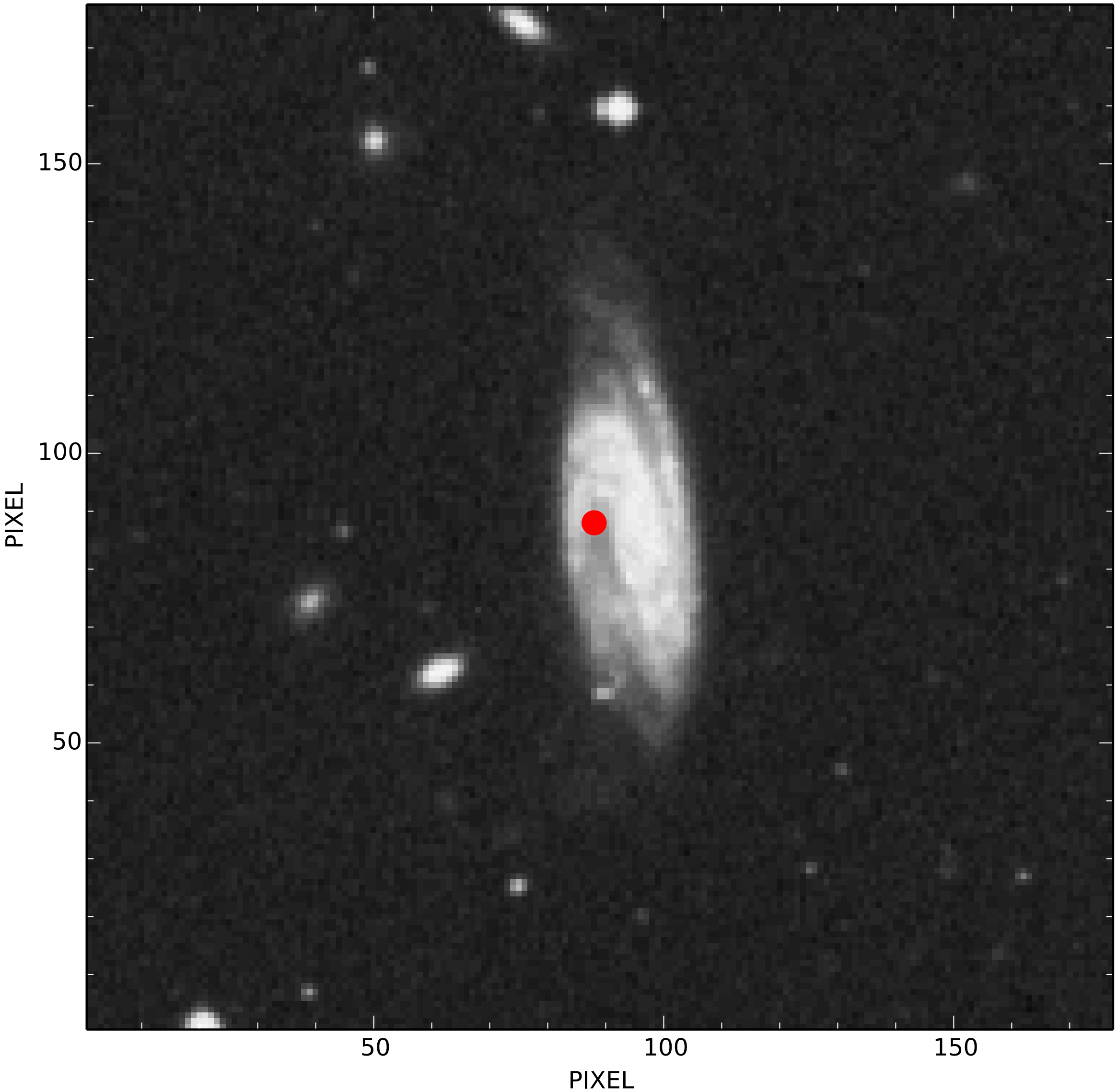





# SN1999cl

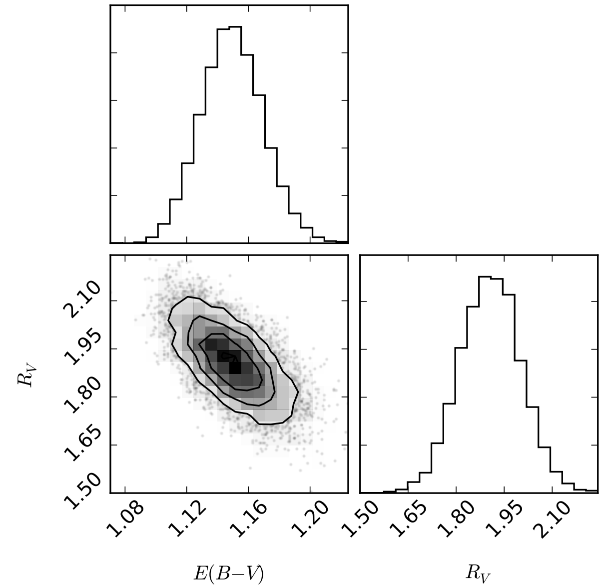
$$E(B\text{-}V) = 1.18\ (04)$$
$$R_V = 2.22\ (14)$$

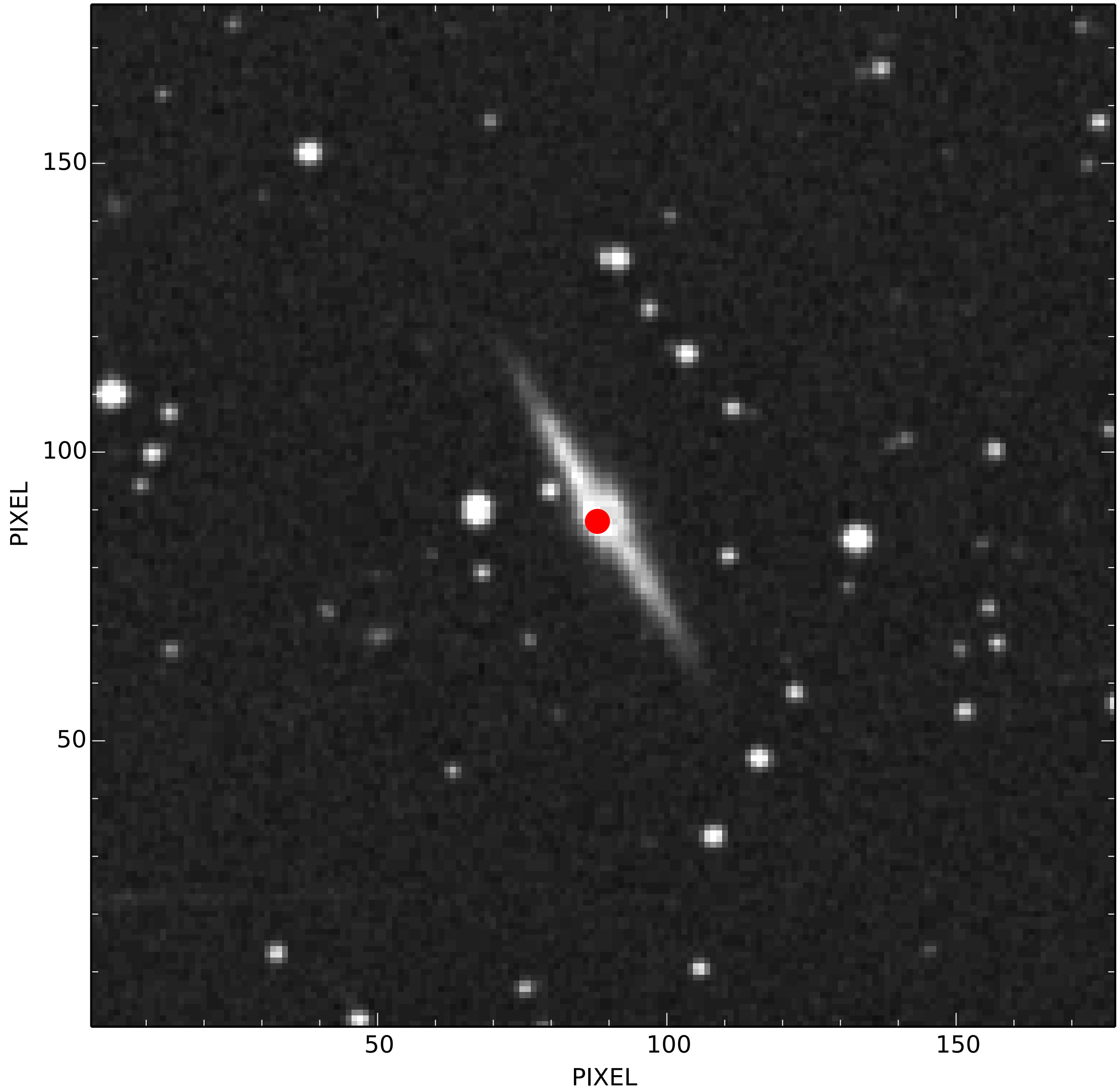





# SN2005A

$$E(B\text{-}V) = 1.15\ (02)$$
$$R_V = 1.91\ (09)$$

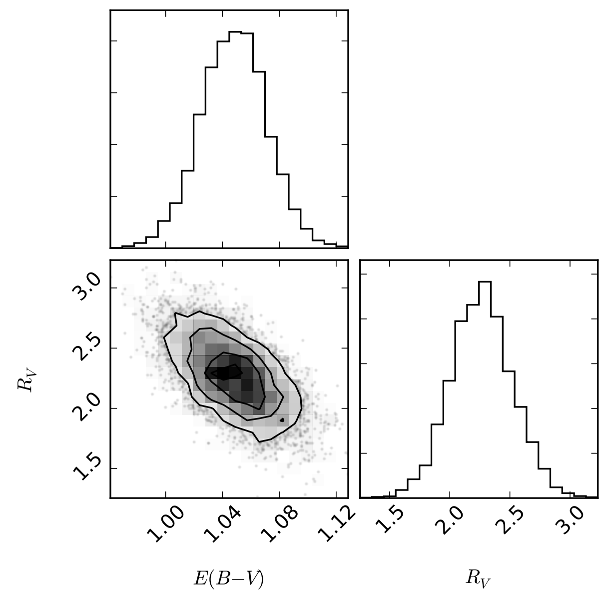





# SN2006cm

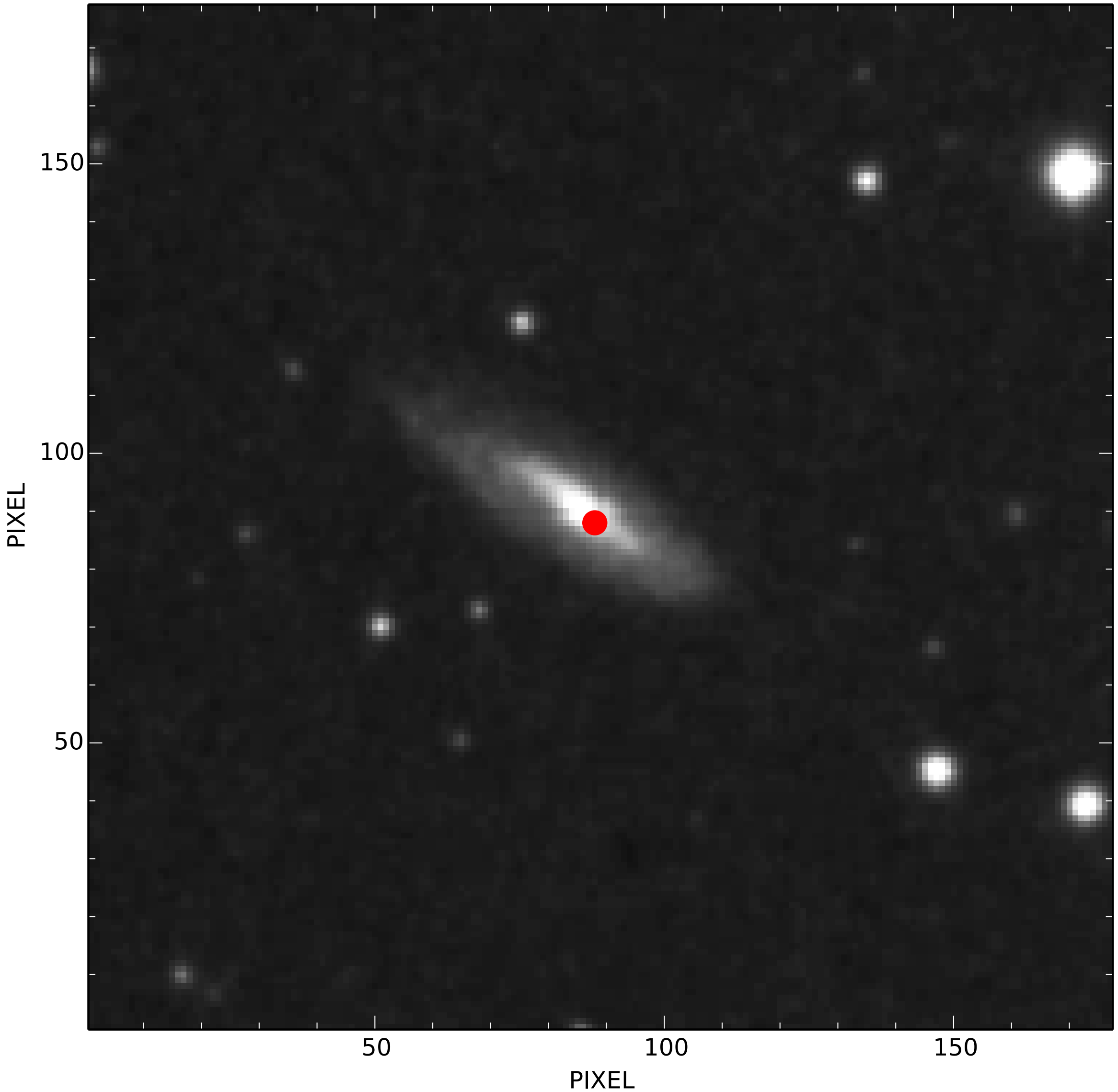
$E(B\text{-}V) = 1.05\ (02)$

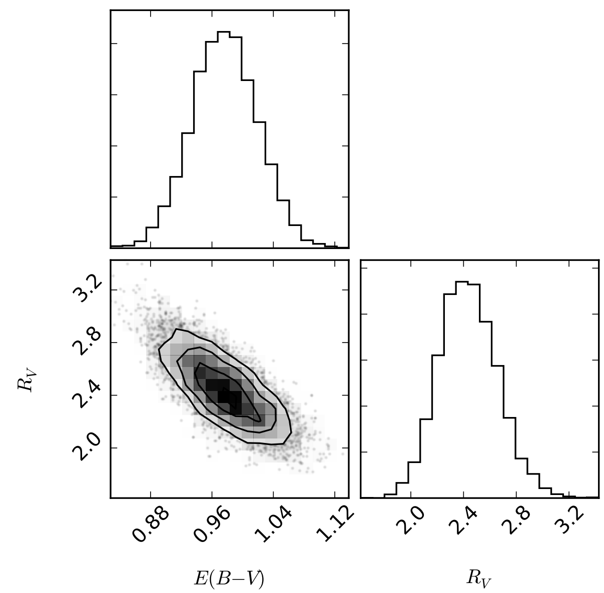
$R_V = 2.27\ (26)$

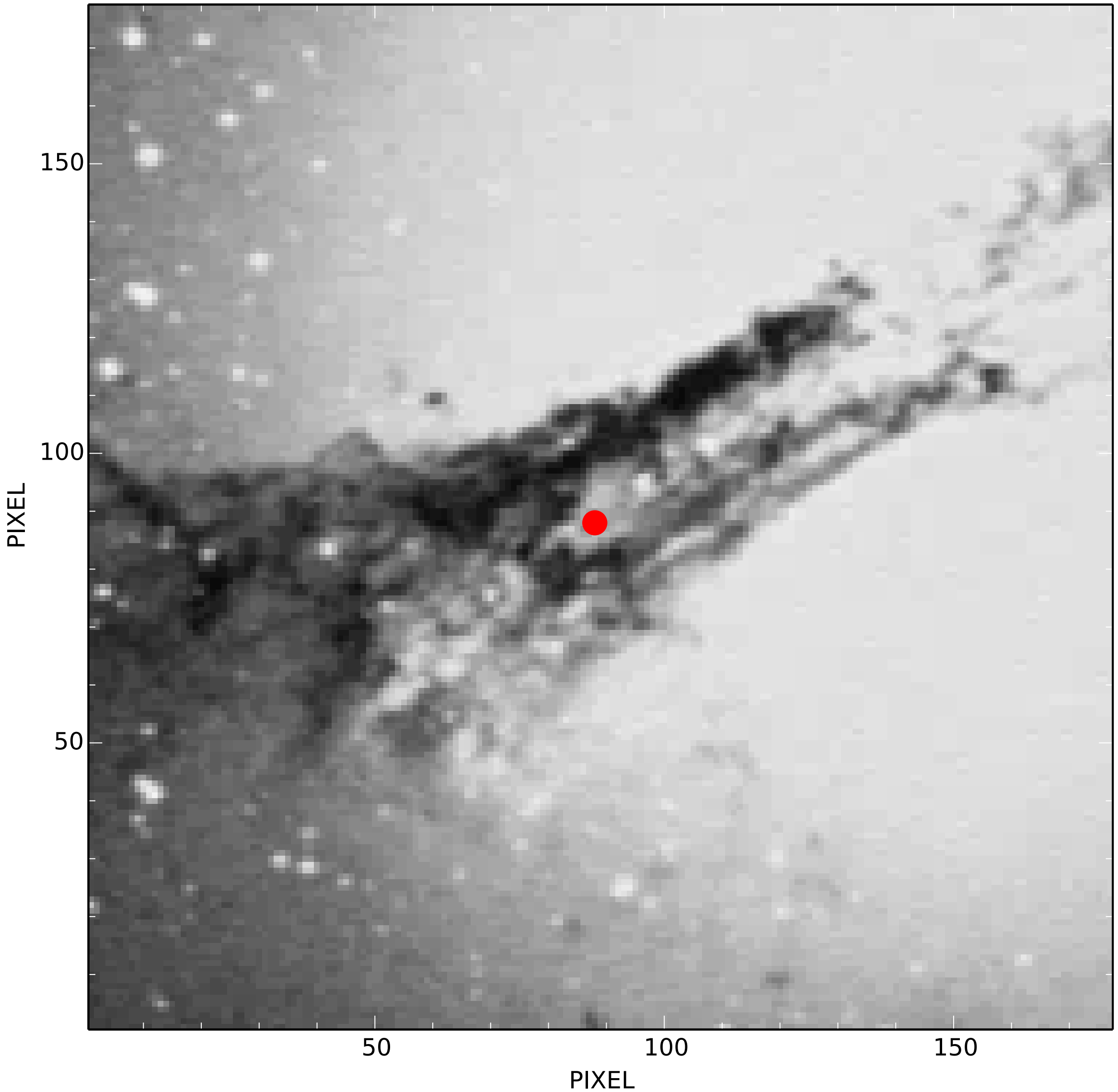


# SN2006br

$$E(B\text{-}V) = 0.98\ (04)$$
$$R_V = 2.44\ (22)$$

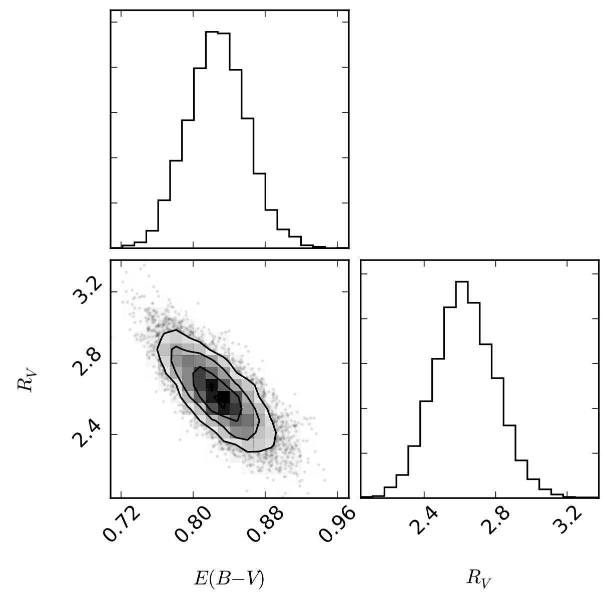


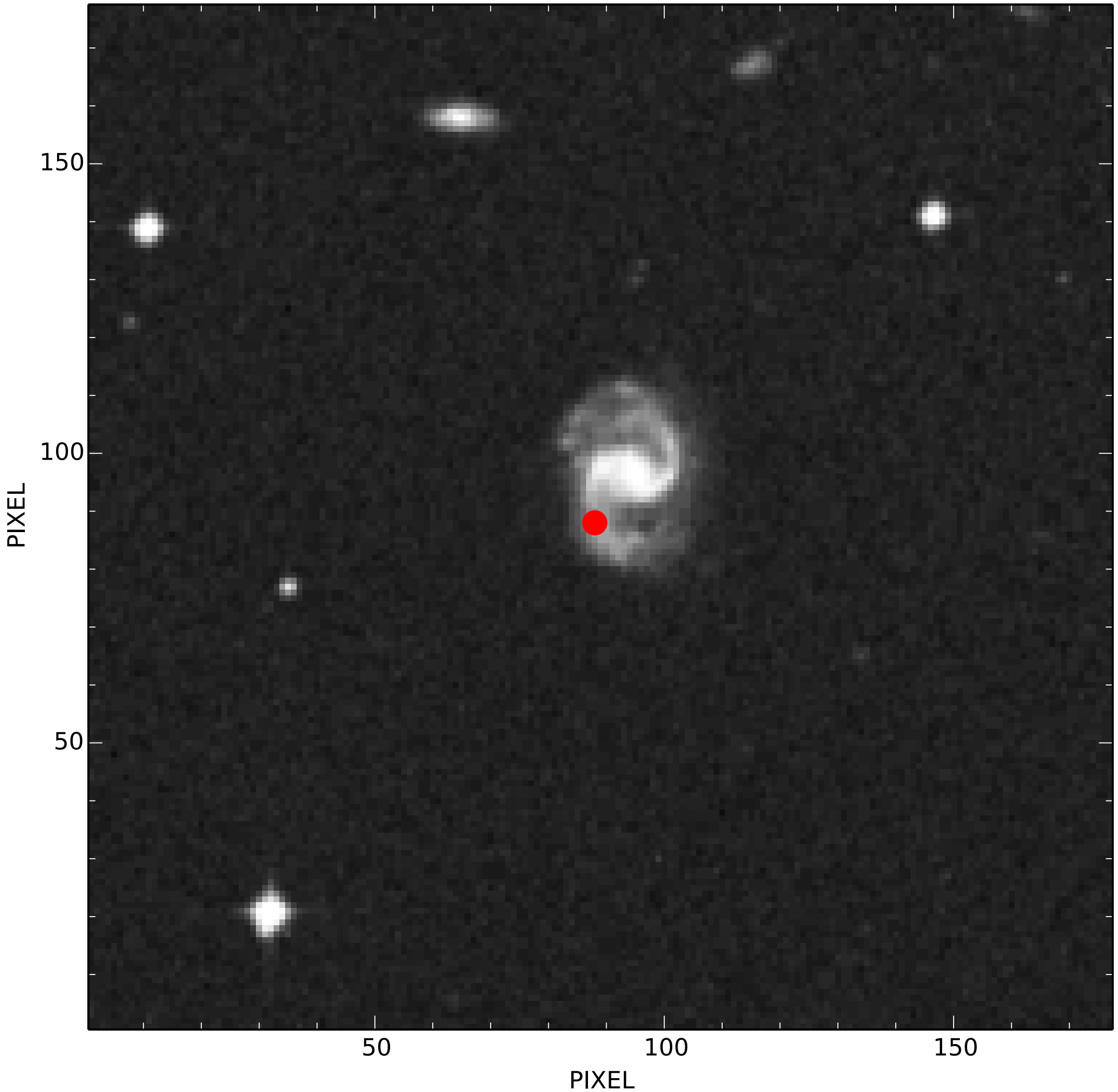






# SN1986G

$$E(B-V) = 0.83\ (03)$$
$$R_V = 2.63\ (18)$$

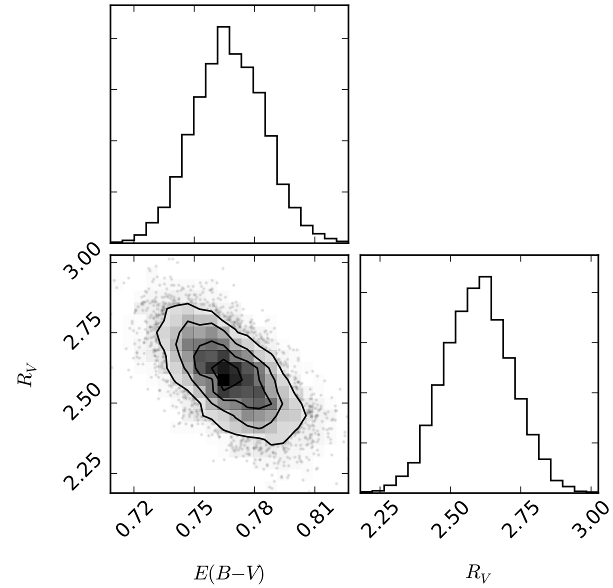




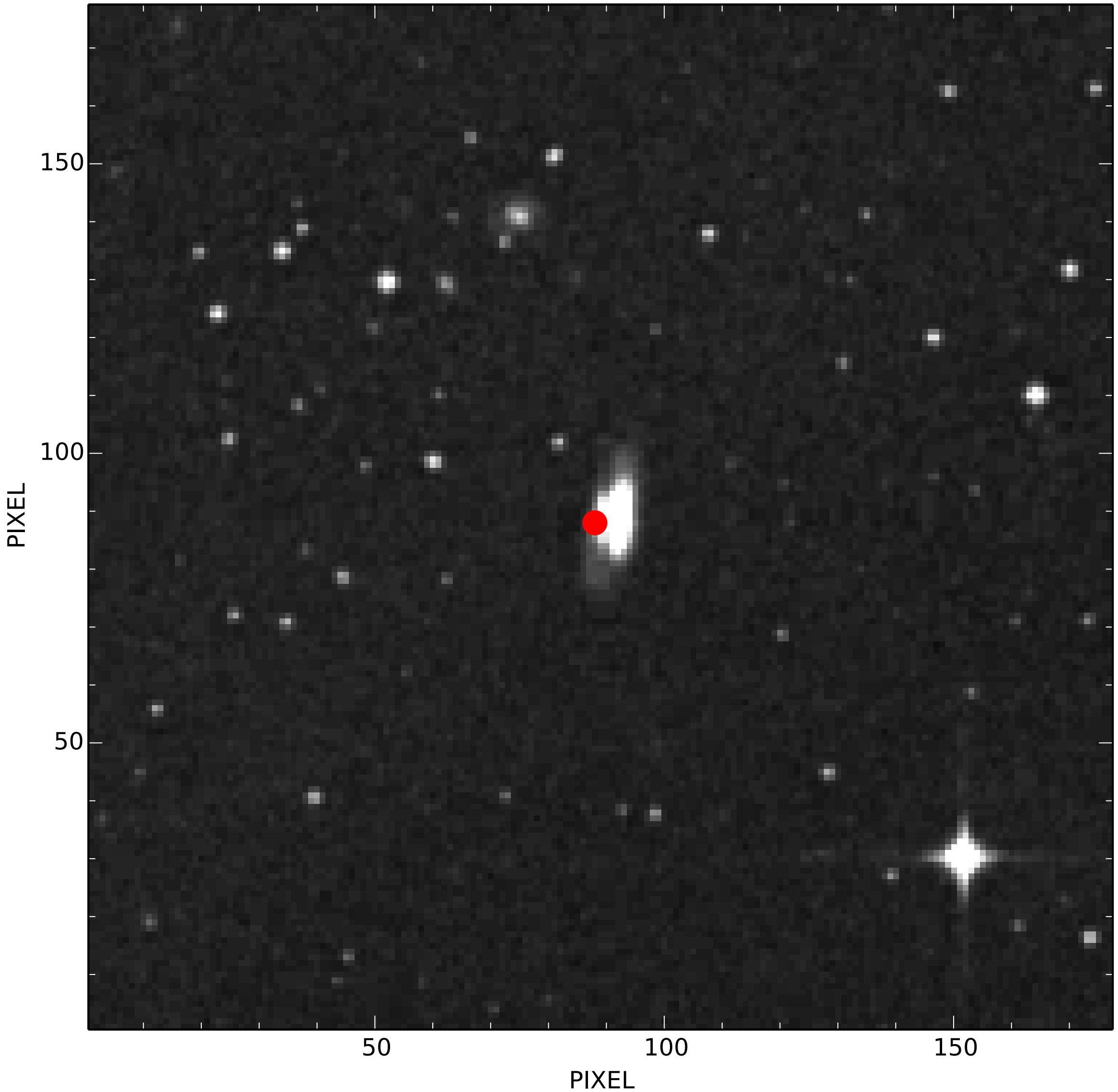

# SN2009I

$E(B\text{-}V) = 0.77\ (02)$

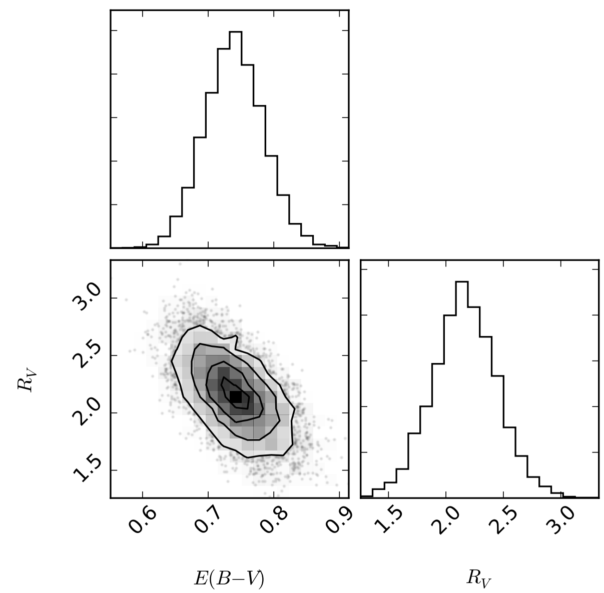
$R_V = 2.60\ (12)$

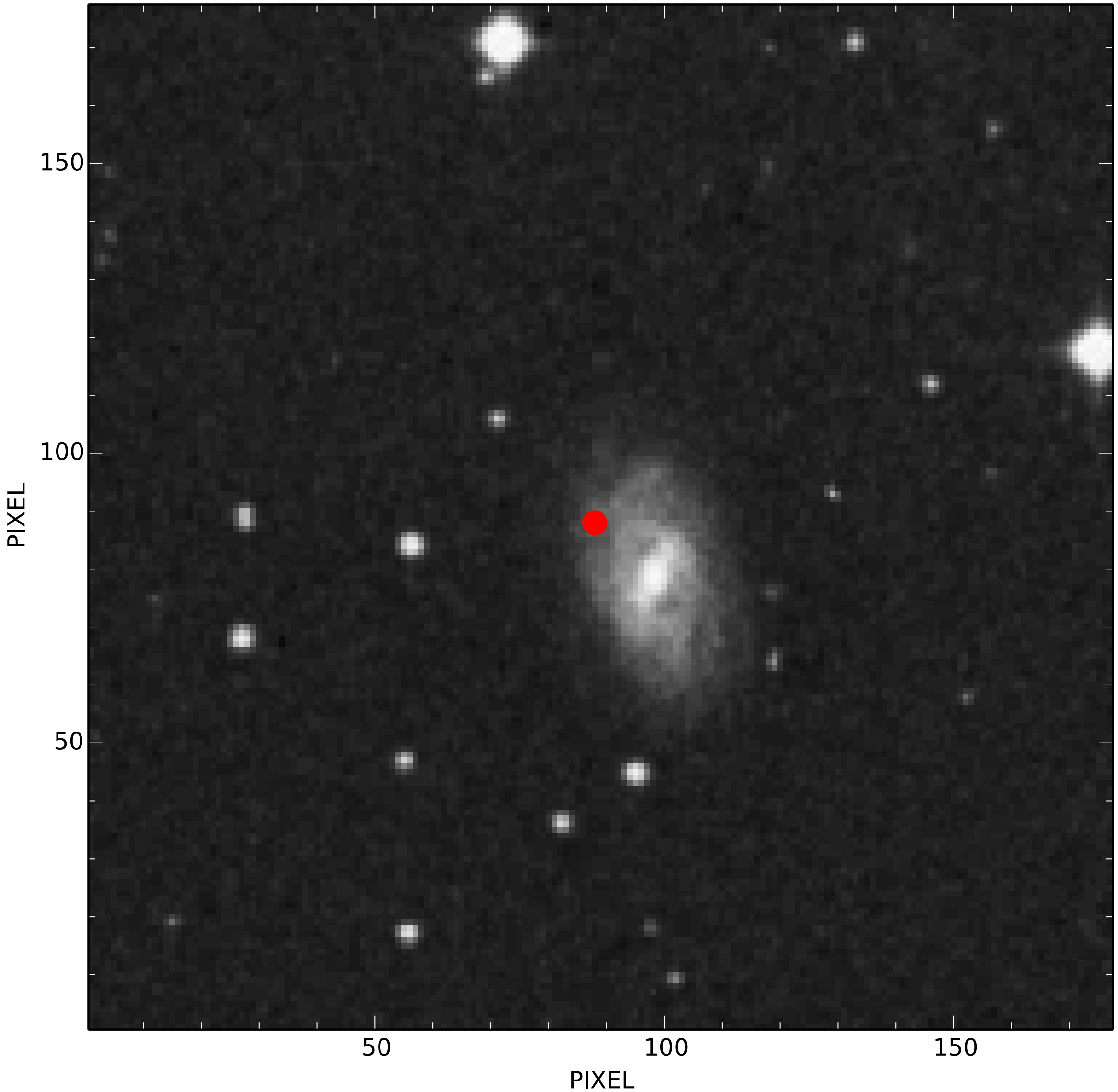


# SN2007cg




$$E(B\text{-}V) = 0.74\ (05)$$
$$R_V = 2.16\ (30)$$

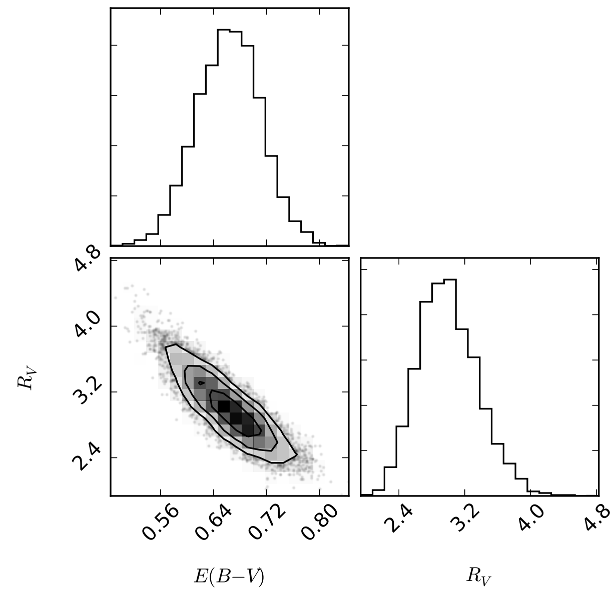


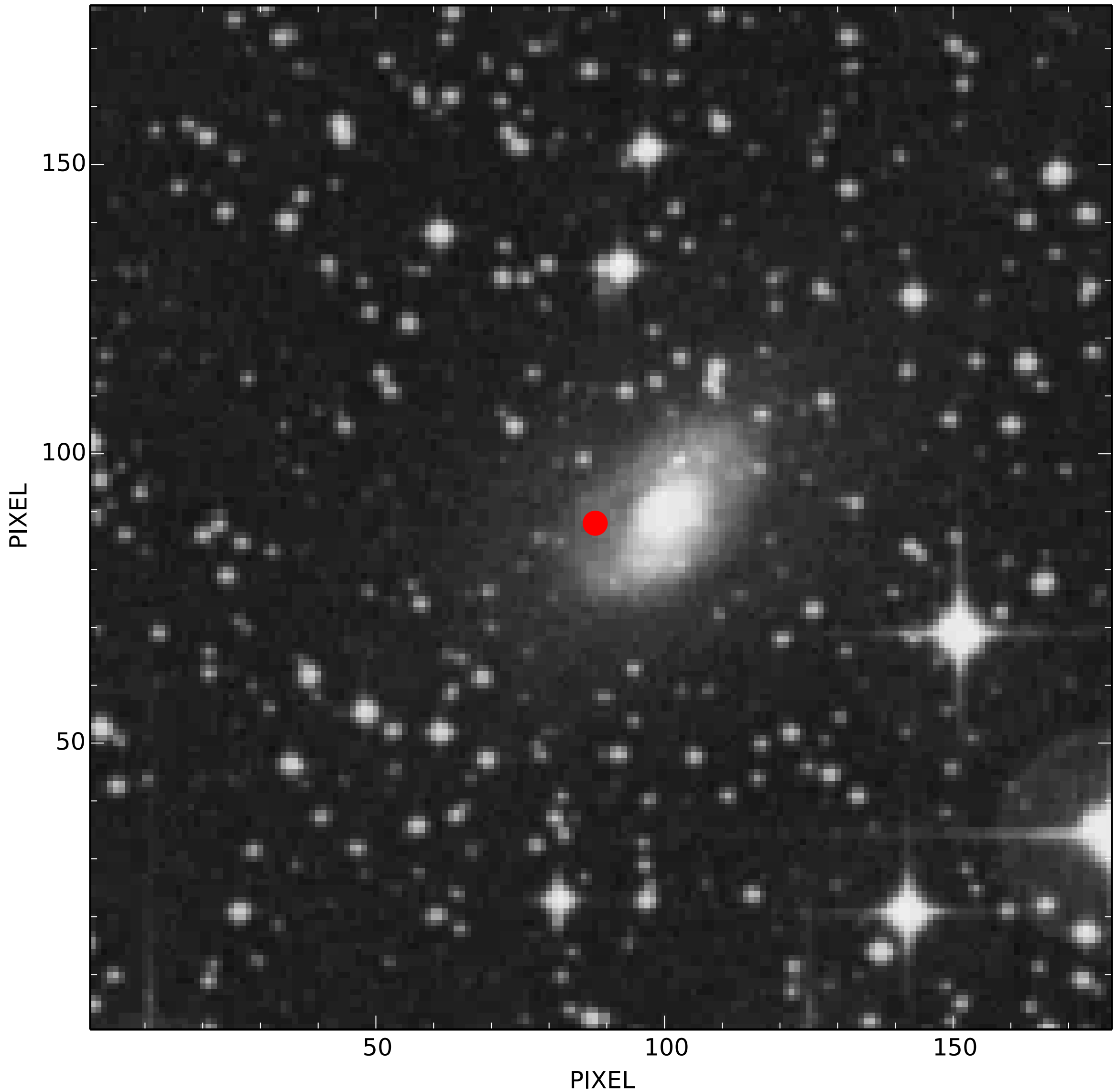



# SN2000ce

$E(B\text{-}V) = 0.66\ (05)$

$R_V = 2.99\ (36)$

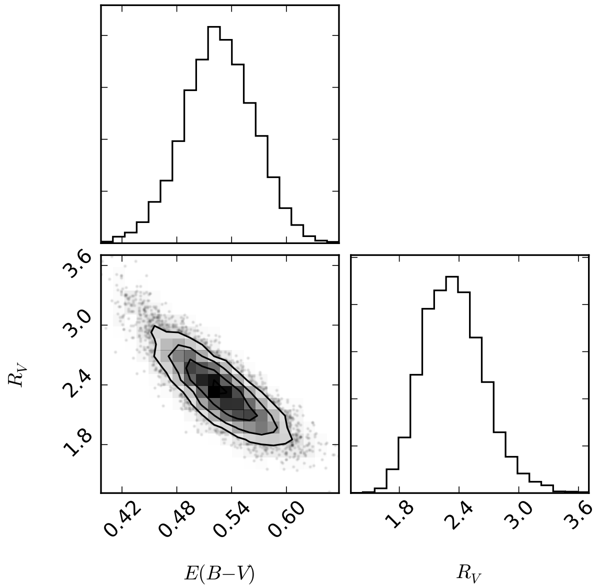


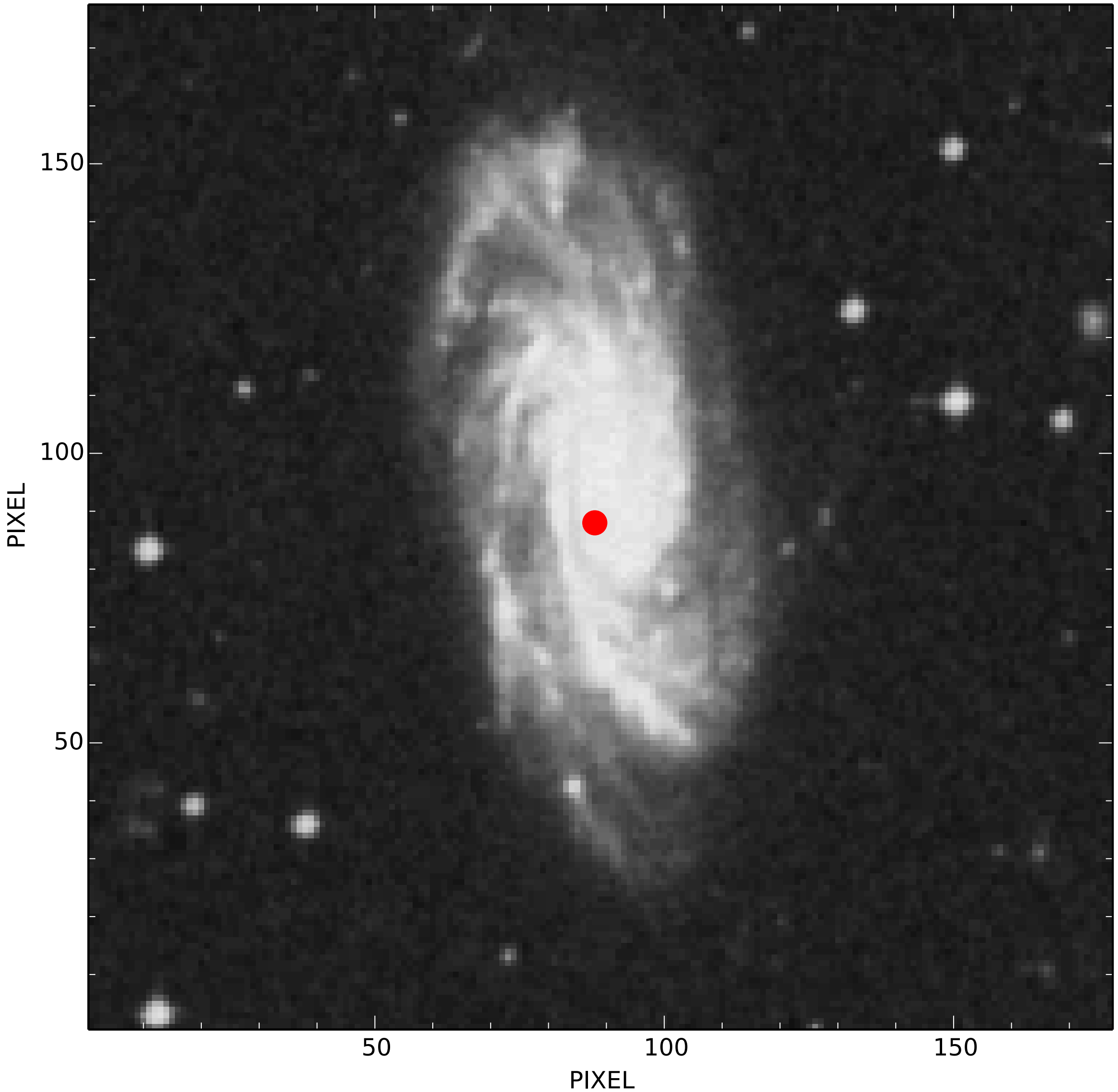



# SN2008fp

$E(B\text{-}V) = 0.53\ (04)$

$R_V = 2.33\ (31)$

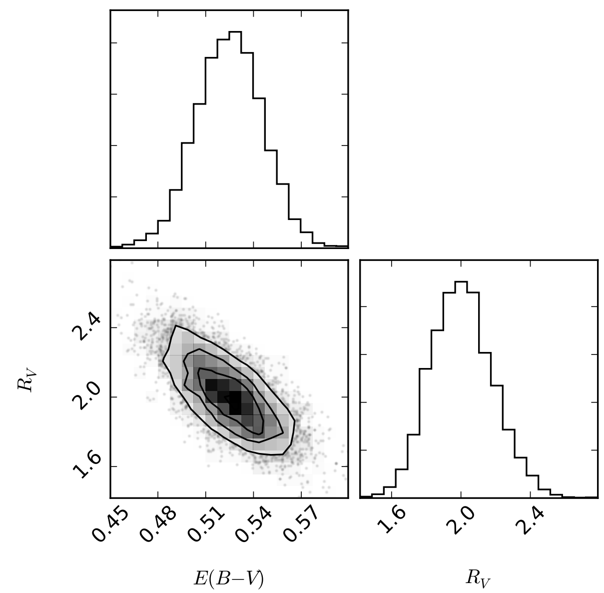


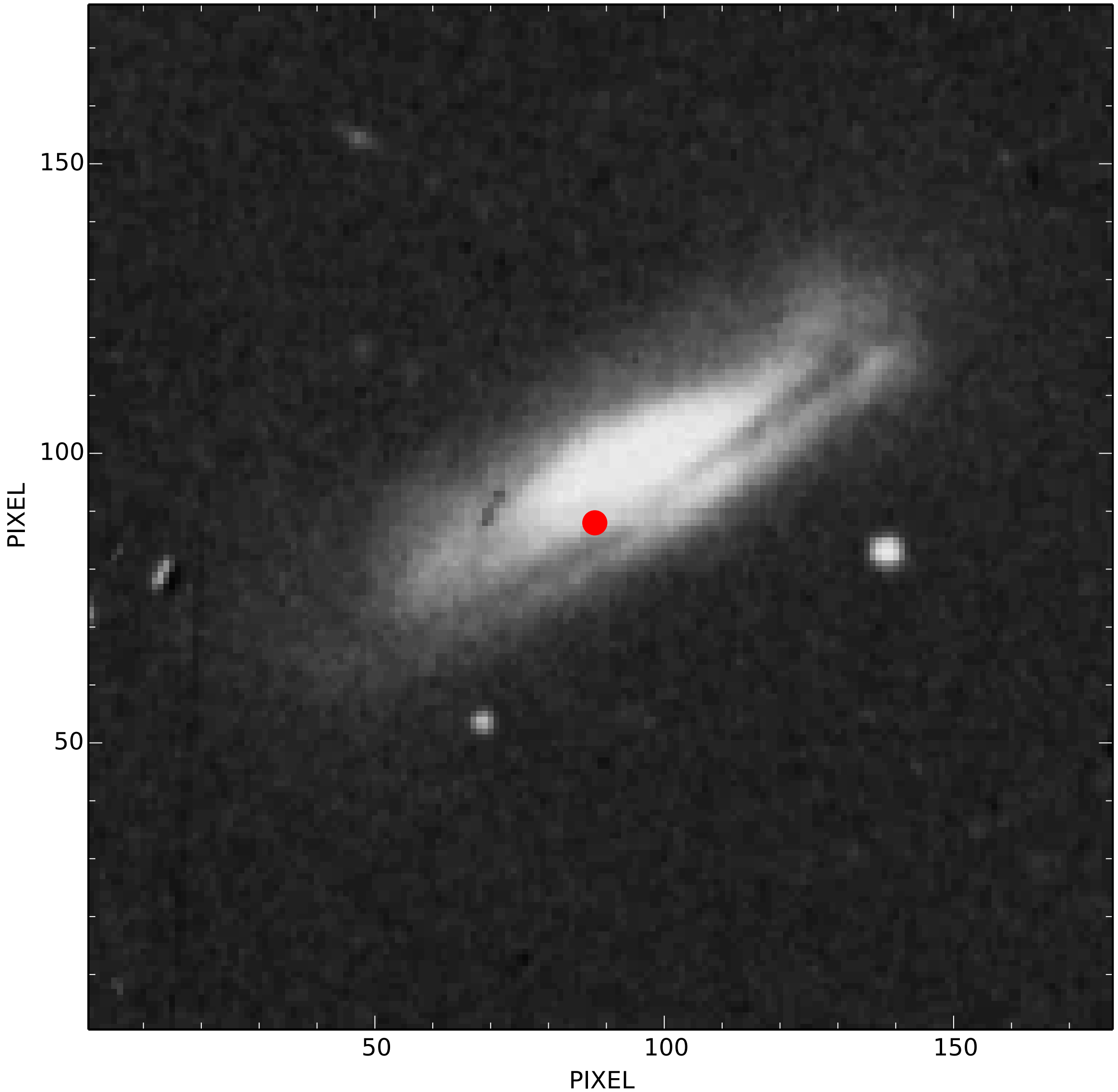



# SN2007bm

$E(B-V) = 0.53\ (02)$

$R_V = 2.02\ (18)$

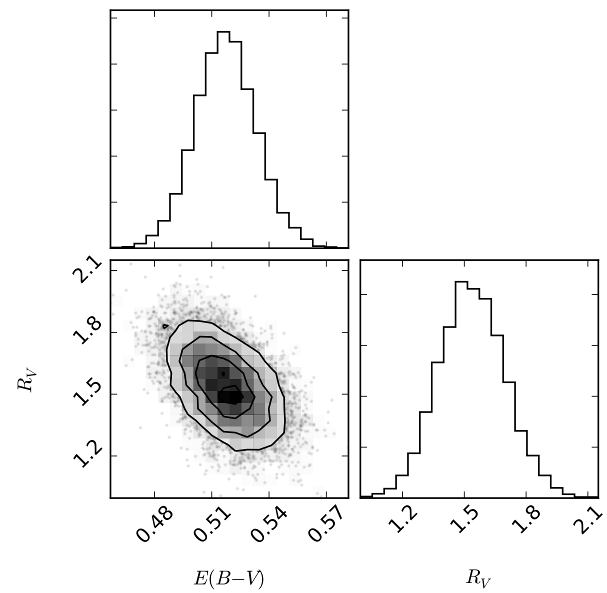


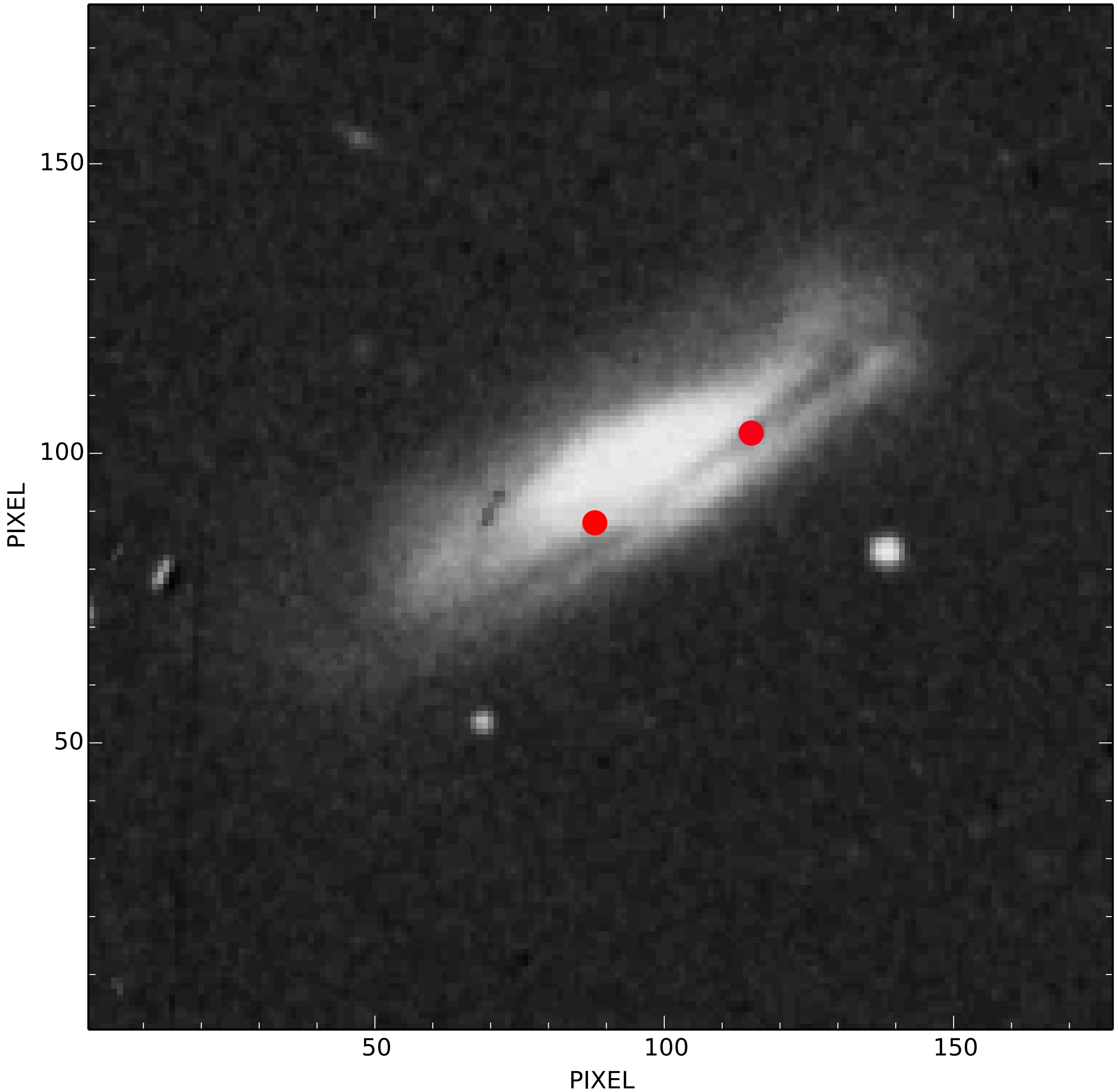



# SN2002bo

$E(B\text{-}V) = 0.52\ (17)$

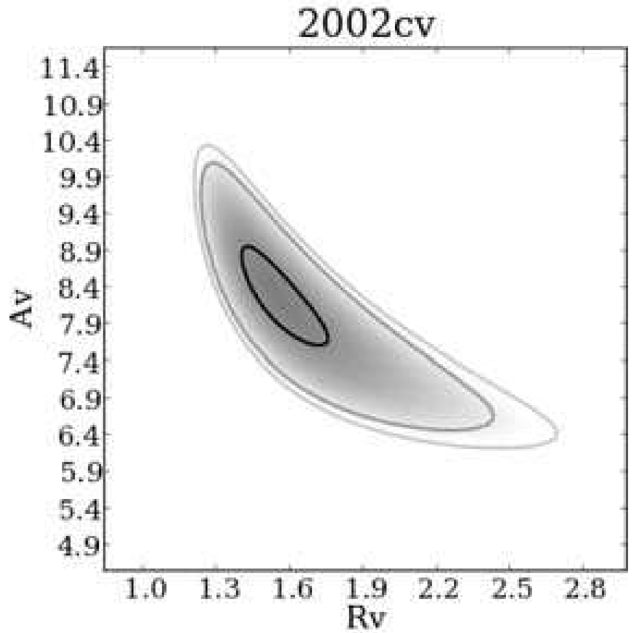
$R_V = 1.56\ (17)$





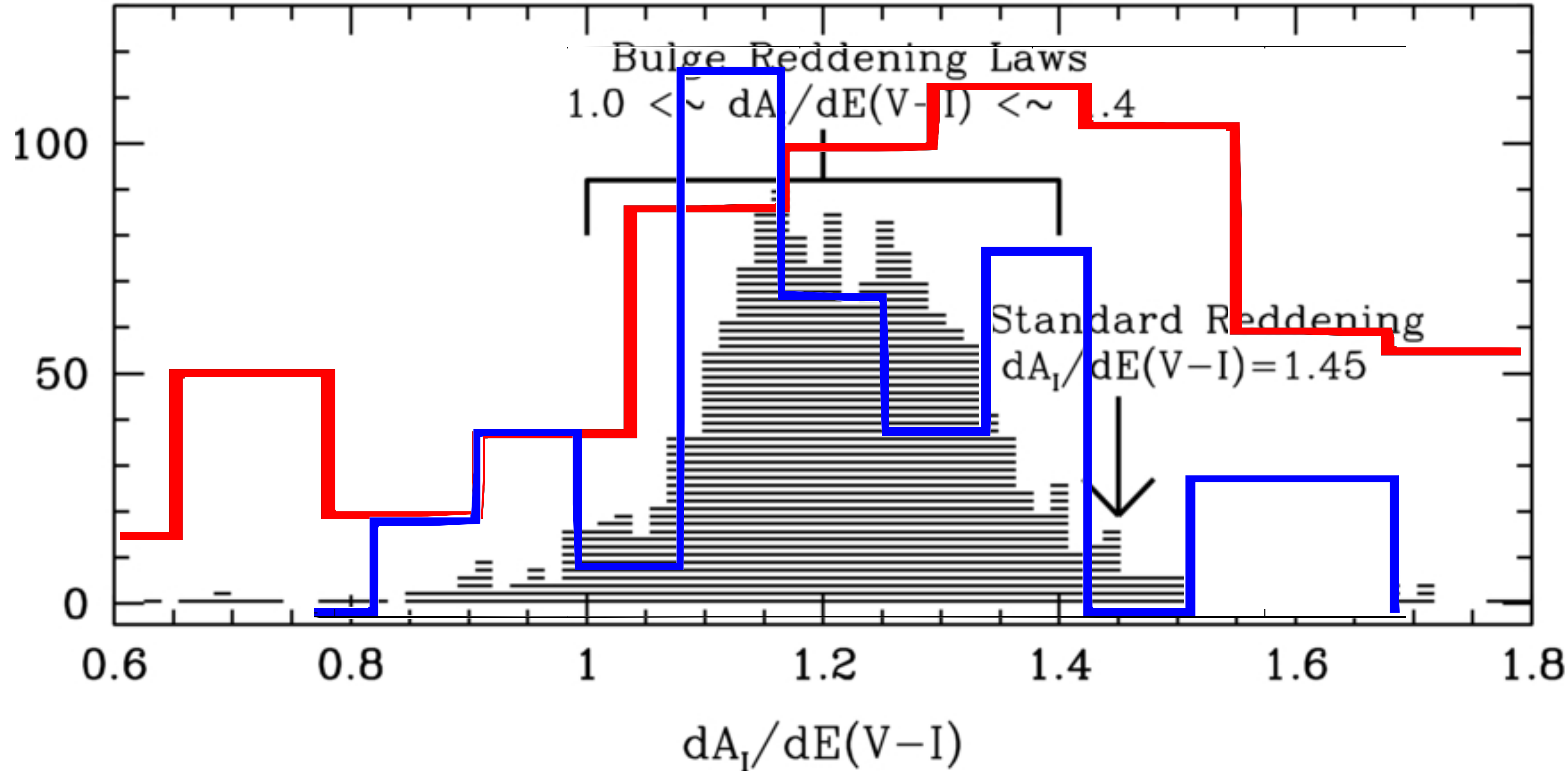

# SN2002cv

$$E(B\text{-}V) = 5.25\ (22)$$
$$R_V = 1.60\ (10)$$




Elias-Rosa+2008

# Nataf et al. 2013: $R_I$ in the MW Bulge



# ~~Summary~~ Vague Notions

- Low $R_V$ is probably “normal” ISM.
- Don’t need CSM, though it certainly exists in some cases.
- Can the distribution of $R_V$ tell us something about the environments of Ia progenitors?
- Where are the high $E(B-V)$, $R_V = 3.1$ events?