Thermonuclear Supernovae in highly reddened environments

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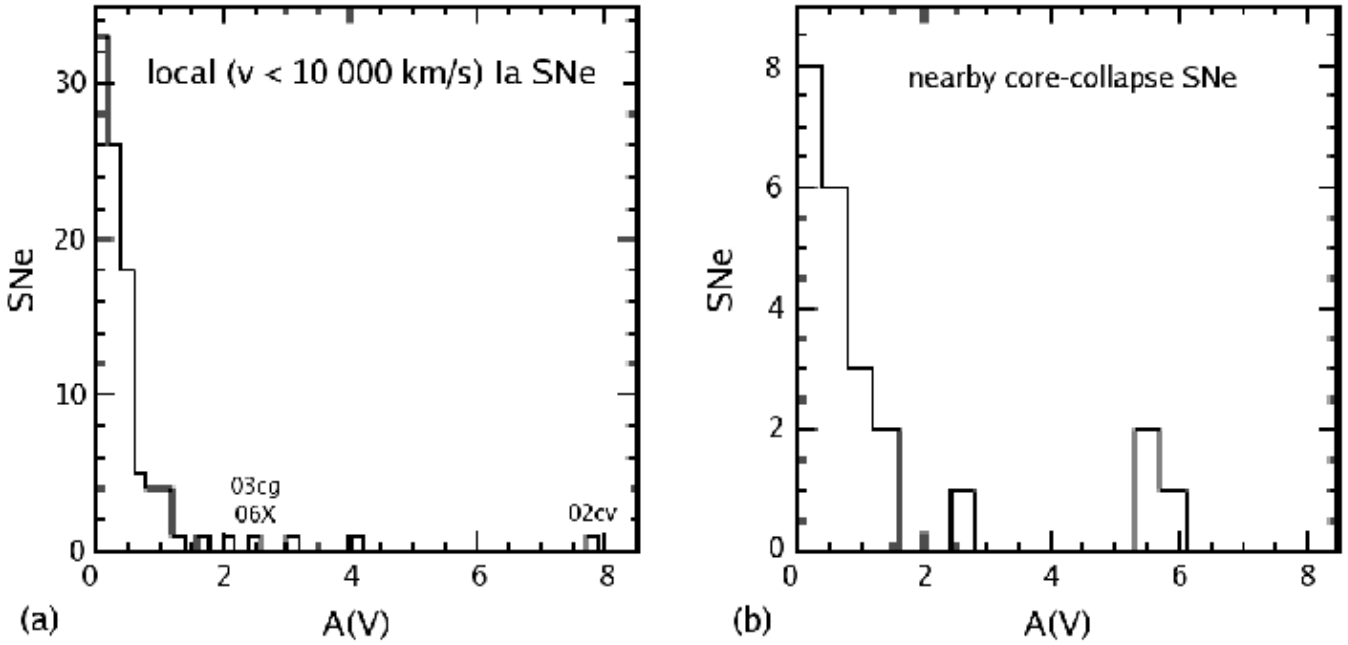
Dust and Supernovae

- SNe important role in **generation** and **evolution** of the **ISM**;
- SNe -> **8% of dust** content of the **ISM** (Gehrz et al. 1989);
- SNe allow the analysis of **reddening law** and the study of the diversity in the **physical characteristics of dust** responsible for extinction



Mattila et al. 2004

Outline

SNe Ia

SN 2003cg

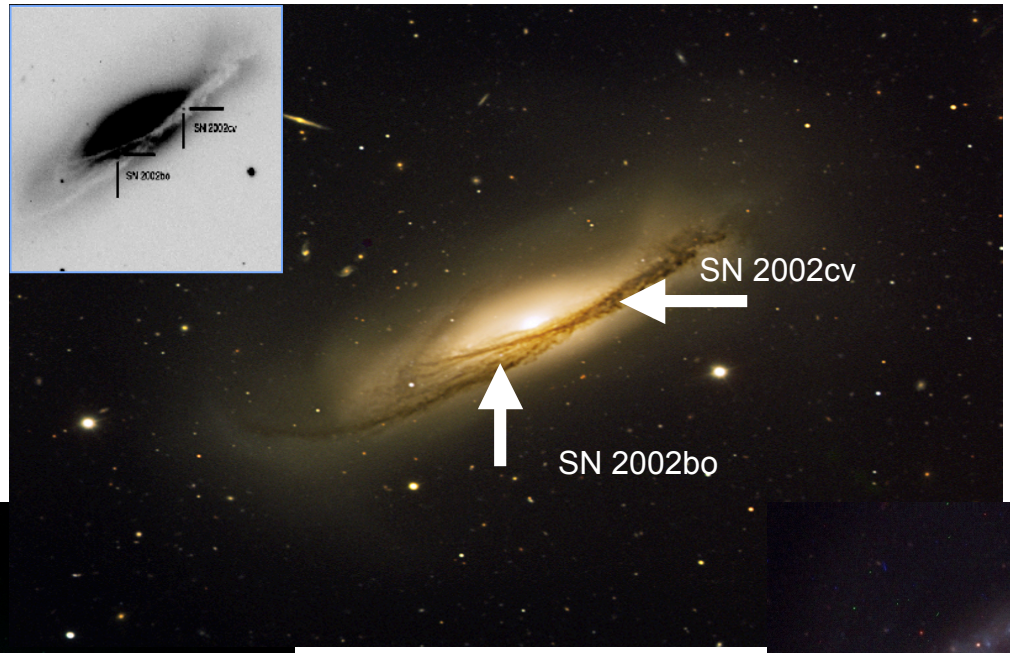
SN 2002cv

SN 2006X

Dust

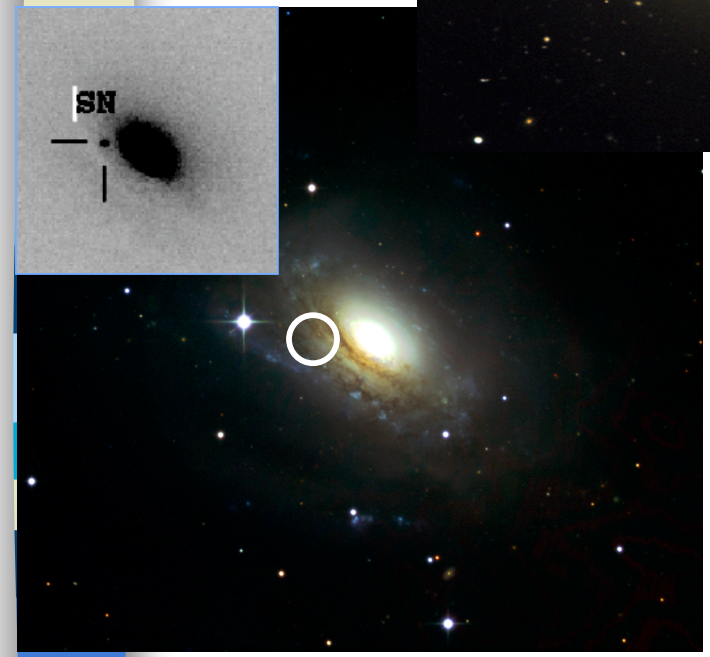
SNe Ia

SN 2002cv



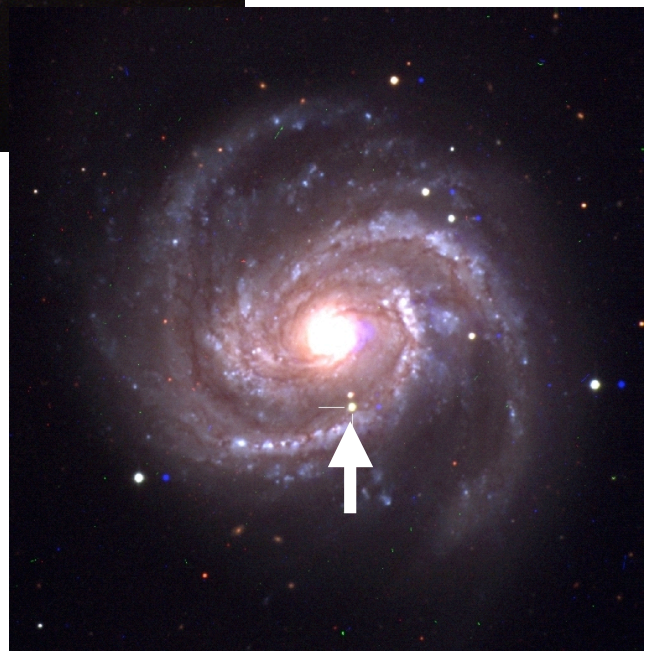
Elias-Rosa et al. 2007
in preparation

SN 2003cg



Elias-Rosa et al. 2006

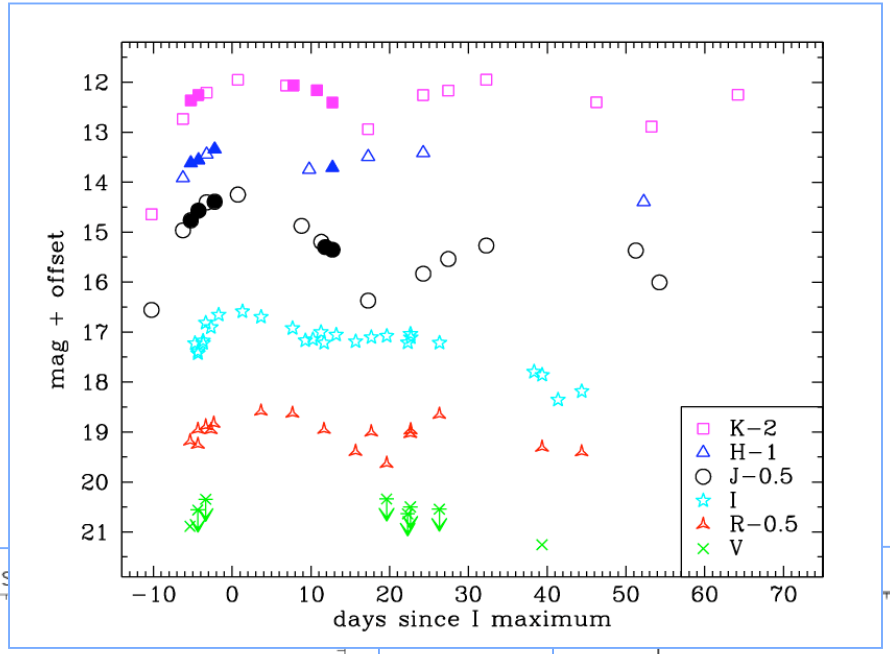
SN 2006X



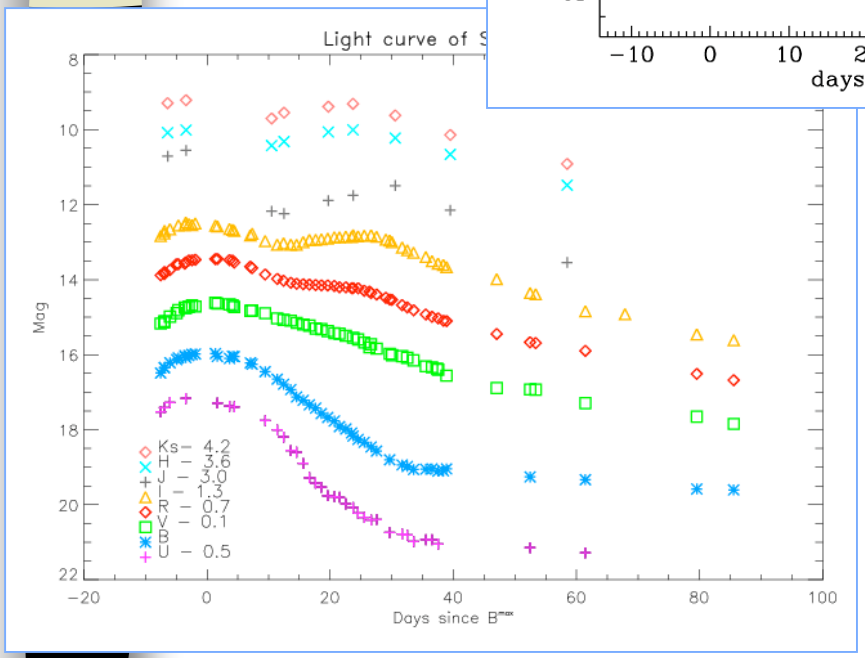
Elias-Rosa et al. 2007 in preparation

Light curves:

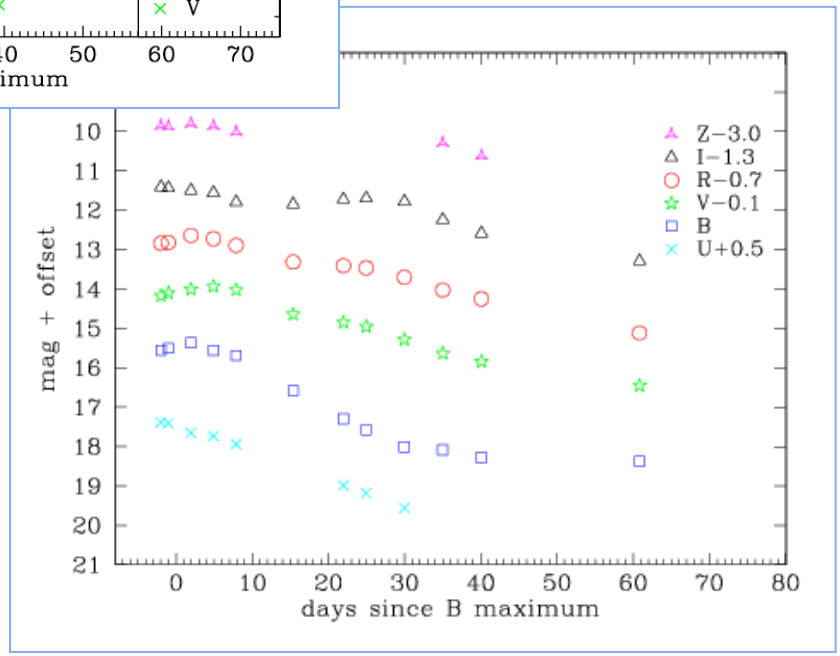
SN 2002cv



SN 2003cg

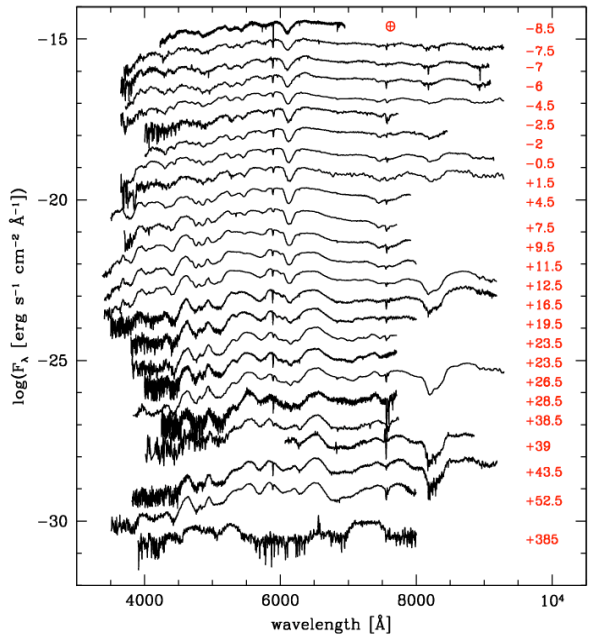


SN 2006X

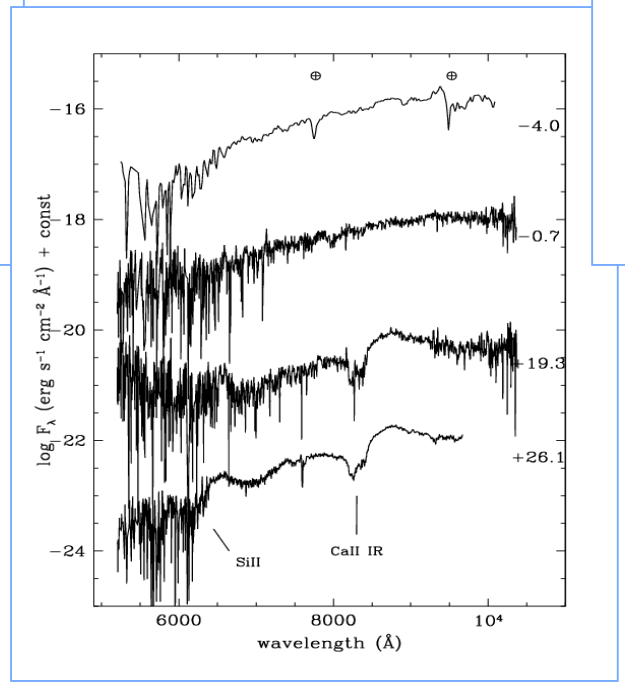


Spectra:

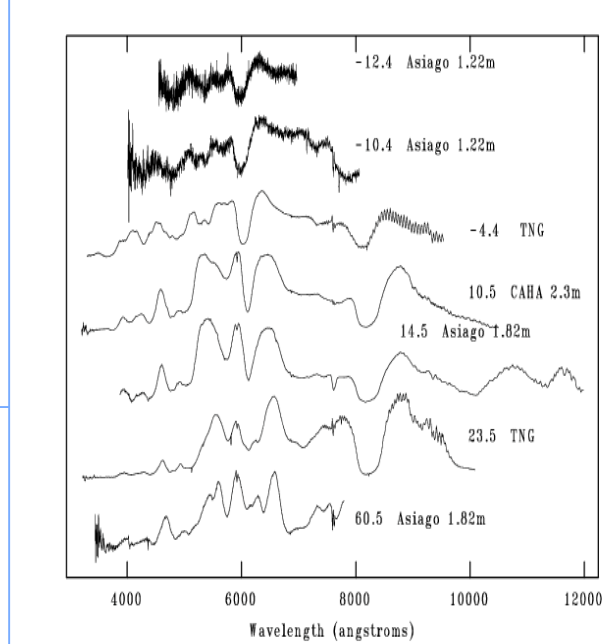
SN 2003cg



SN 2002cv



SN 2006X



Cardelli's extinction law:

Extinction law = $A(\lambda)/A(V)$

⇩

Parameterization:
the average R_v-dependent Extinction Law

$$A(\lambda)/A(V) = a(x) + b(x)/R_v$$

($x = \lambda^{-1}$)

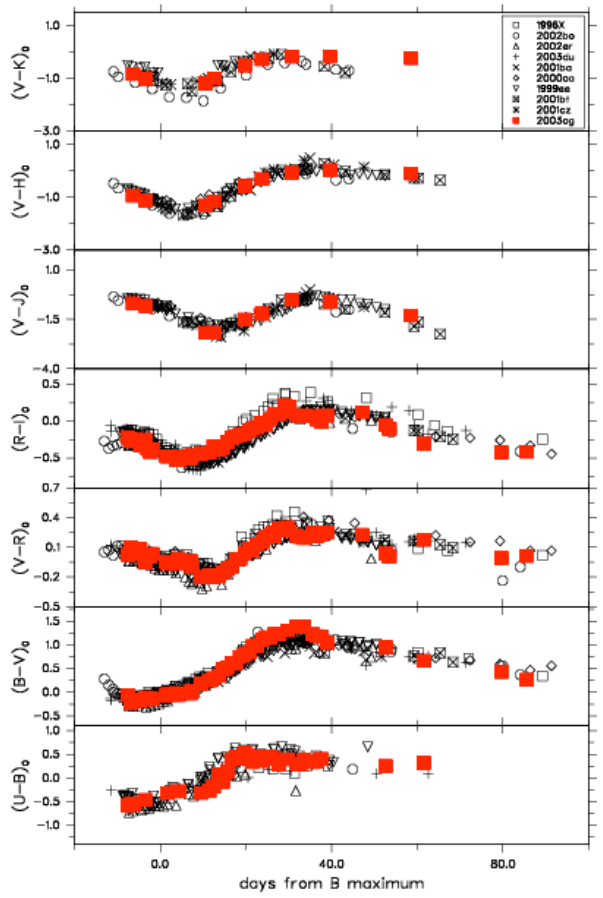
⇩

R_v affects the shape of the extinction curves
(particularly at the shorter wavelengths)

Cardelli et al. 1989

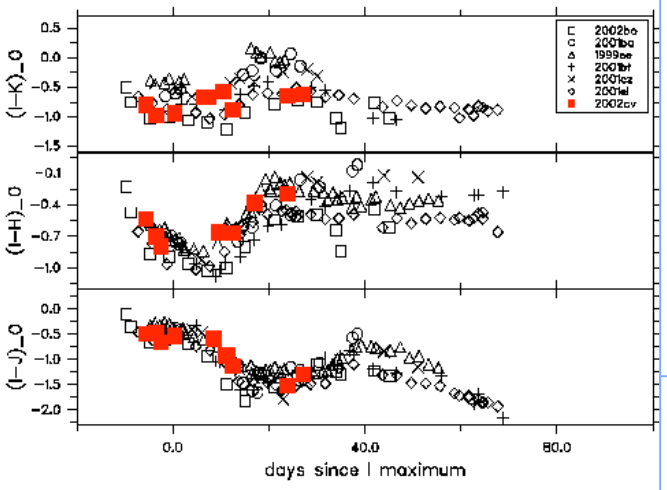
Colour curves:

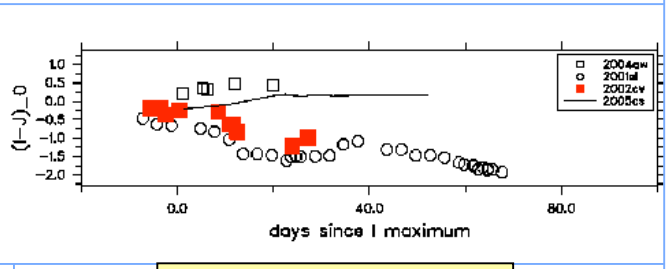
SN 2003cg



$A_V = 2.62 \pm 0.28$
$R_V = 1.97 \pm 0.29$

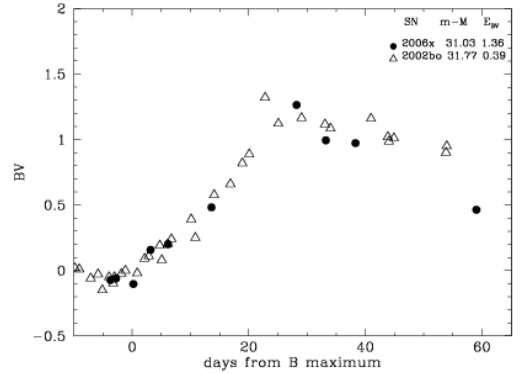
SN 2002cv

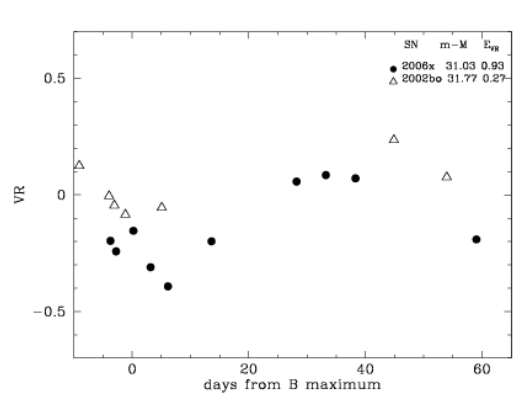




$A_V = 8.99 \pm 0.30$
$R_V = 2.04 \pm 0.30$

SN 2006X





Extinction:

(Similar Δm_{15} and spectra features)

Unreddened SN — F_λ^0, d_0

Reddened SN — F_λ, d

Corrected by **redshift** and **Galactic reddening**
Put at **same distance** -> $F_\lambda^{0'} = (d_0/d)^2 F_\lambda^0$

$A(\lambda) = -2.5 \log (F_\lambda / F_\lambda^{0'})$
normalize to $A(V)$

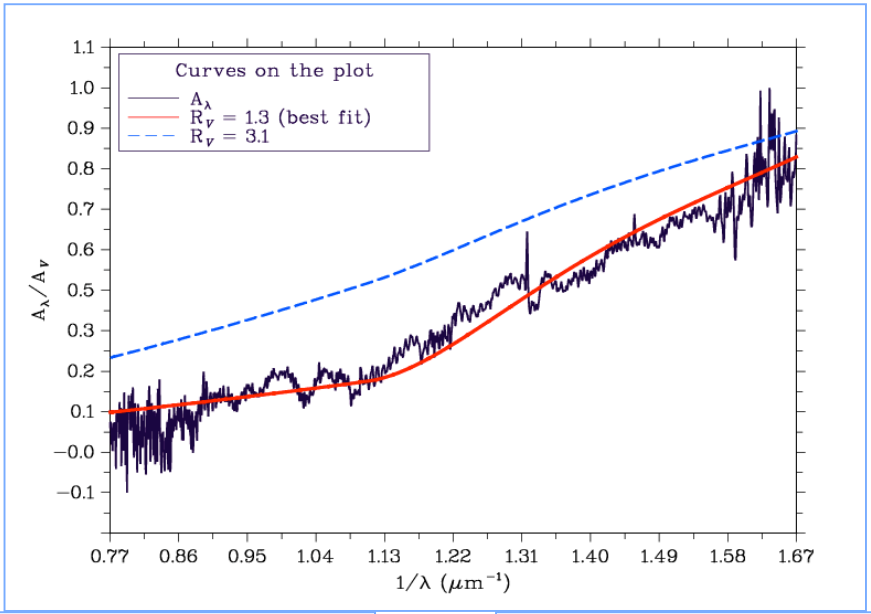
ratio = **observed extinction curve**

to be compared with the
theoretical Cardelli's extinction law.

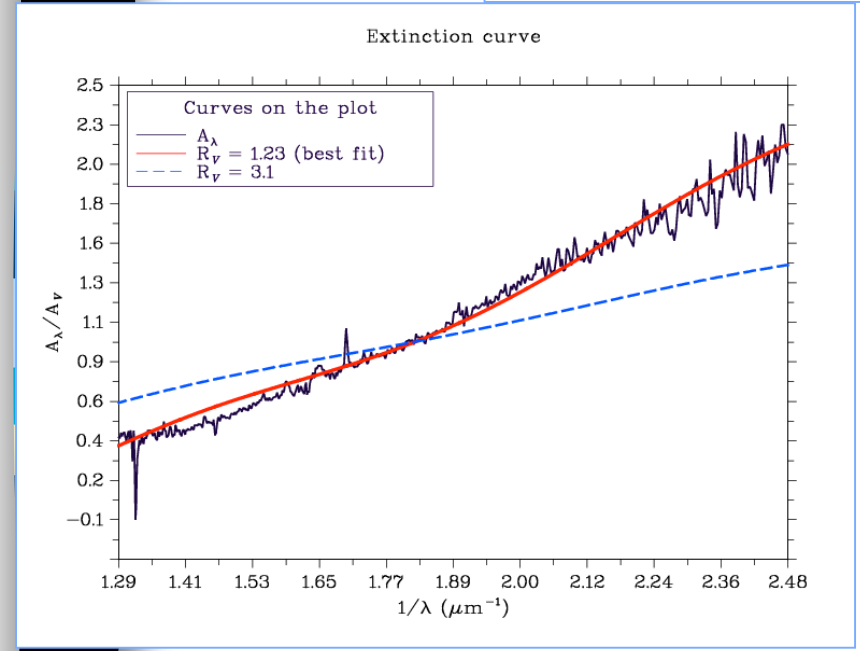
Elias-Rosa et al. 2006

Extinction:

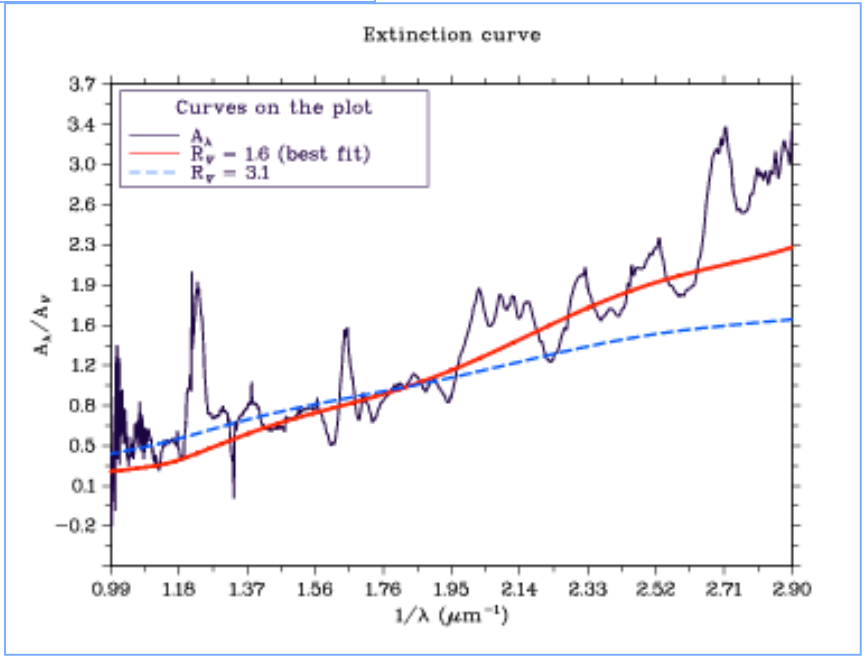
SN 2002cv

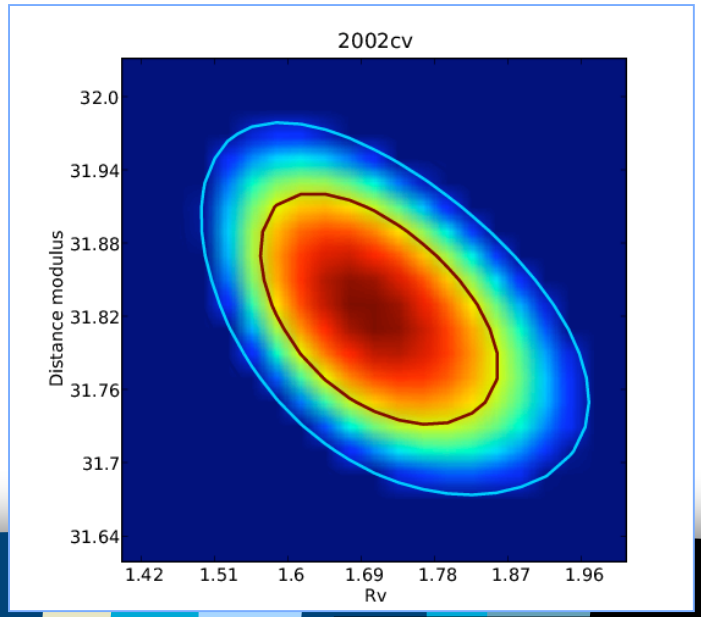


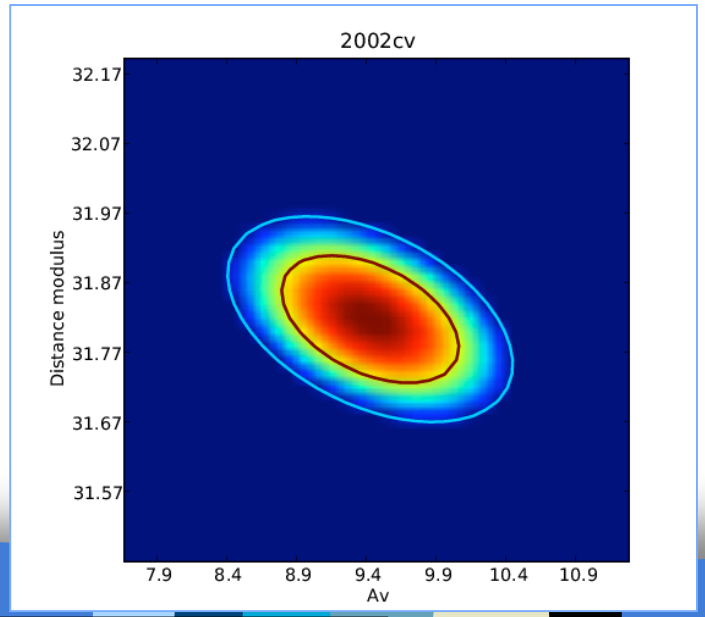
SN 2003cg



SN 2006X

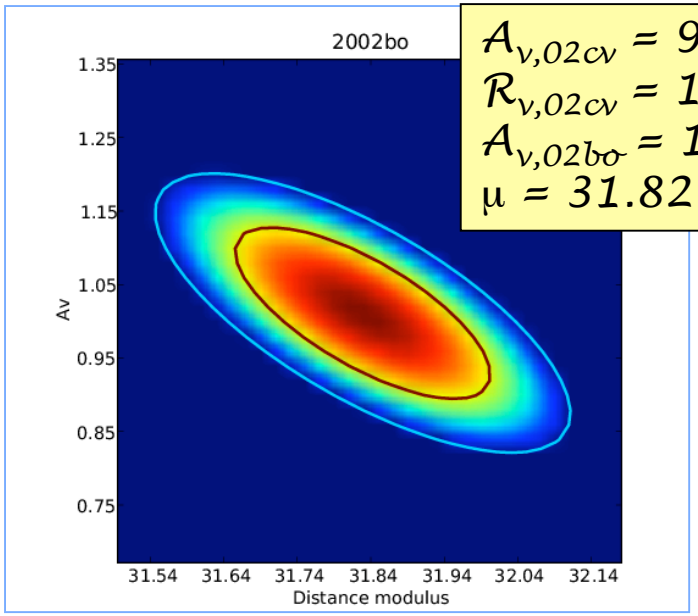


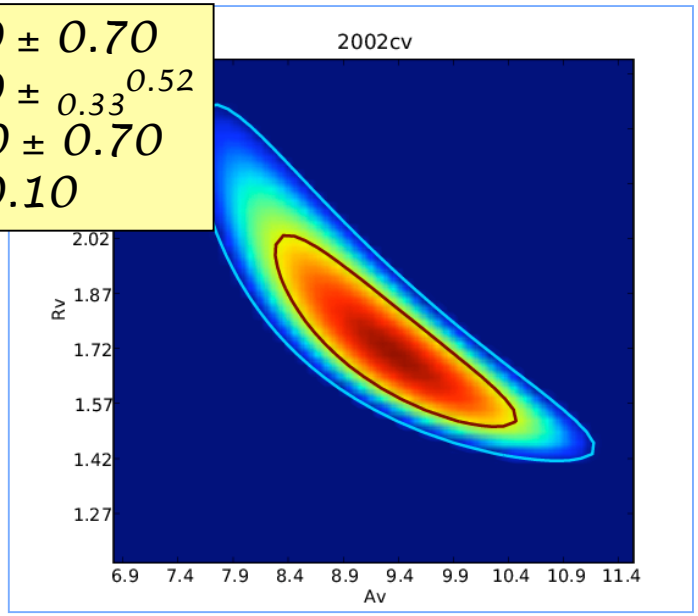




SN 2002cv - SN 2002bo

$A_{v,02cv} = 9.40 \pm 0.70$
$R_{v,02cv} = 1.70 \pm {}^{0.52}_{0.33}$
$A_{v,02bo} = 1.00 \pm 0.70$
$\mu = 31.82 \pm 0.10$





Elias-Rosa et al. 2007

Extinction:

SN 2003cg

$E(B-V) = 1.33 \pm 0.11$
$R_V = 1.80 \pm 0.19$

SN 2002cv

$E(B-V) = 5.12 \pm 1.09$
$R_V = 1.73 \pm 0.54$

SN 2006X

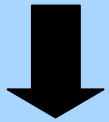
$E(B-V) = 1.27 \pm 0.37$
$R_V = 1.56 \pm 0.30$

In all cases R_V is << 3.1

$A_V = R_V \times E(B-V)$

Dust:

R_V is related to the characteristics of dust along the line of sight

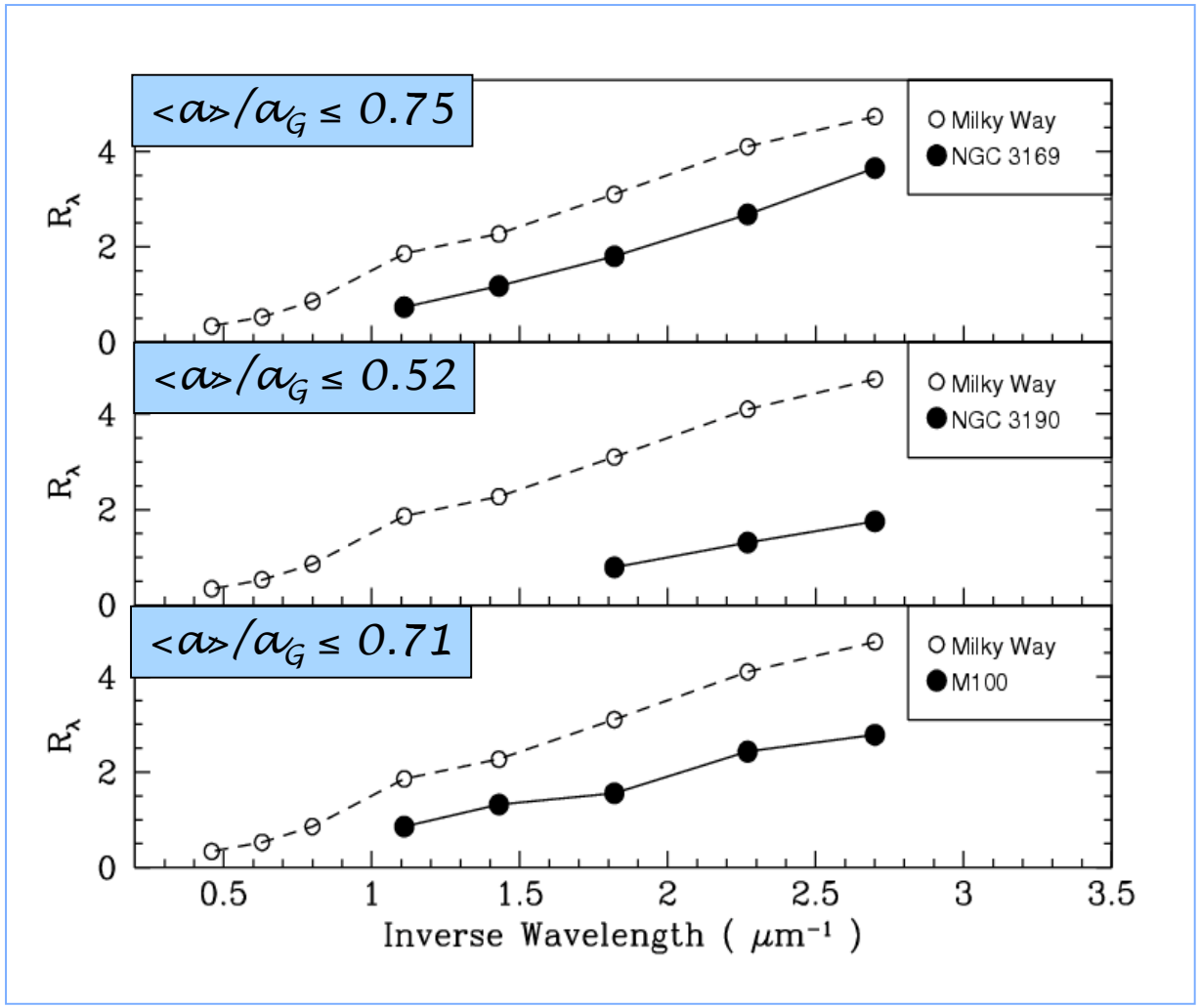


SNe Ia are useful for grain properties study

- Relative grain sizes for the host galaxies
- EW(NaID) vs. E(B-V)
- Low R_v

Dust:

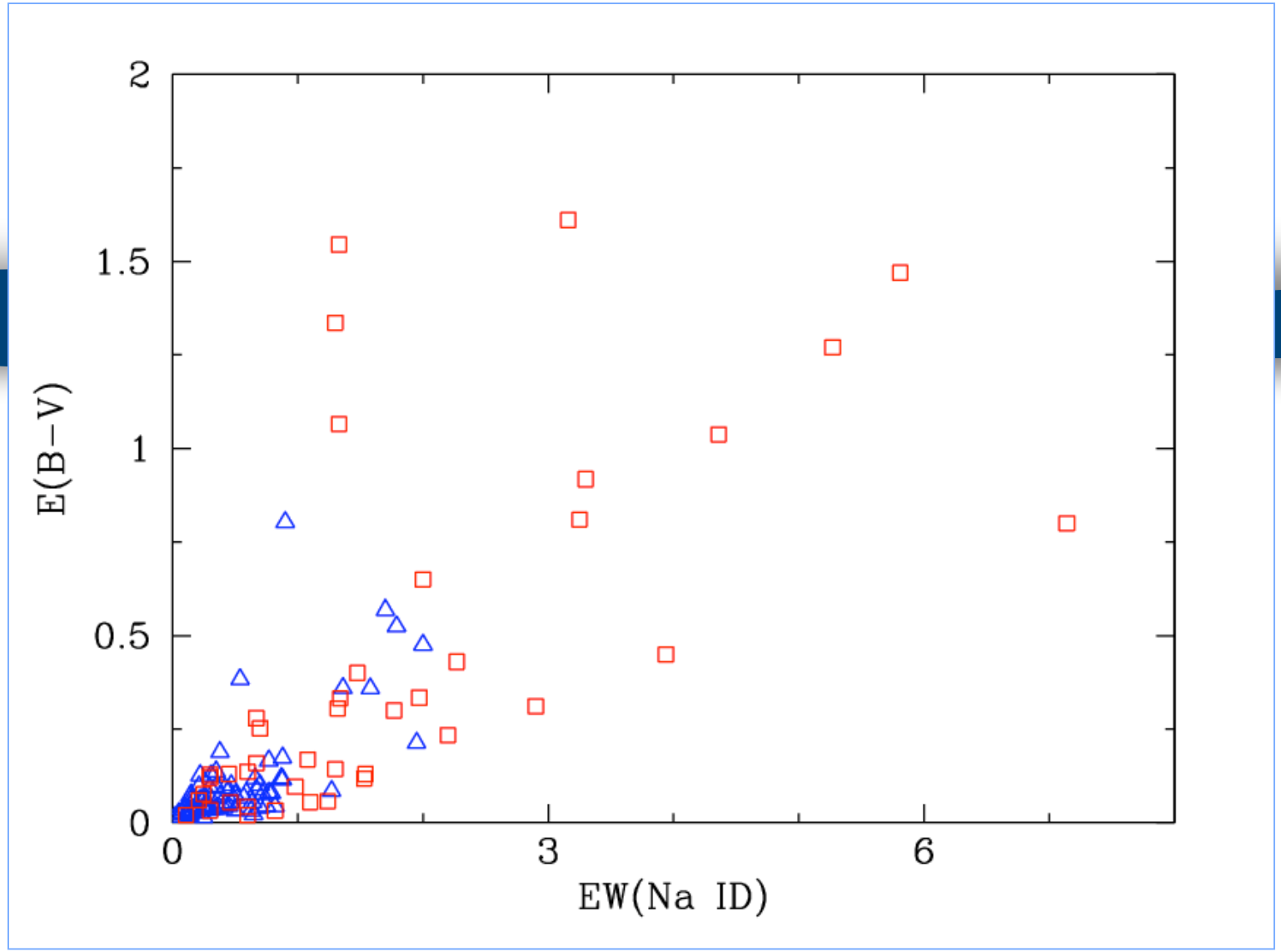
Relative grain sizes for the host galaxies



Goudfrooij et al. 1994, Patil et al. 2007

Dust:

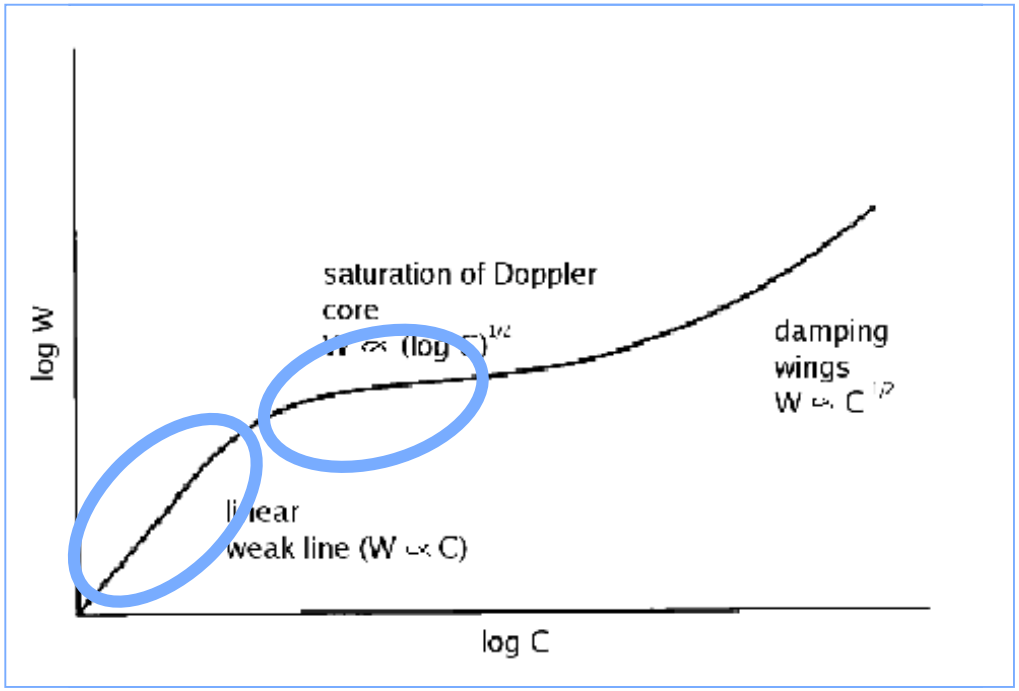
EW(NaID) vs. E(B-V)



Dust:

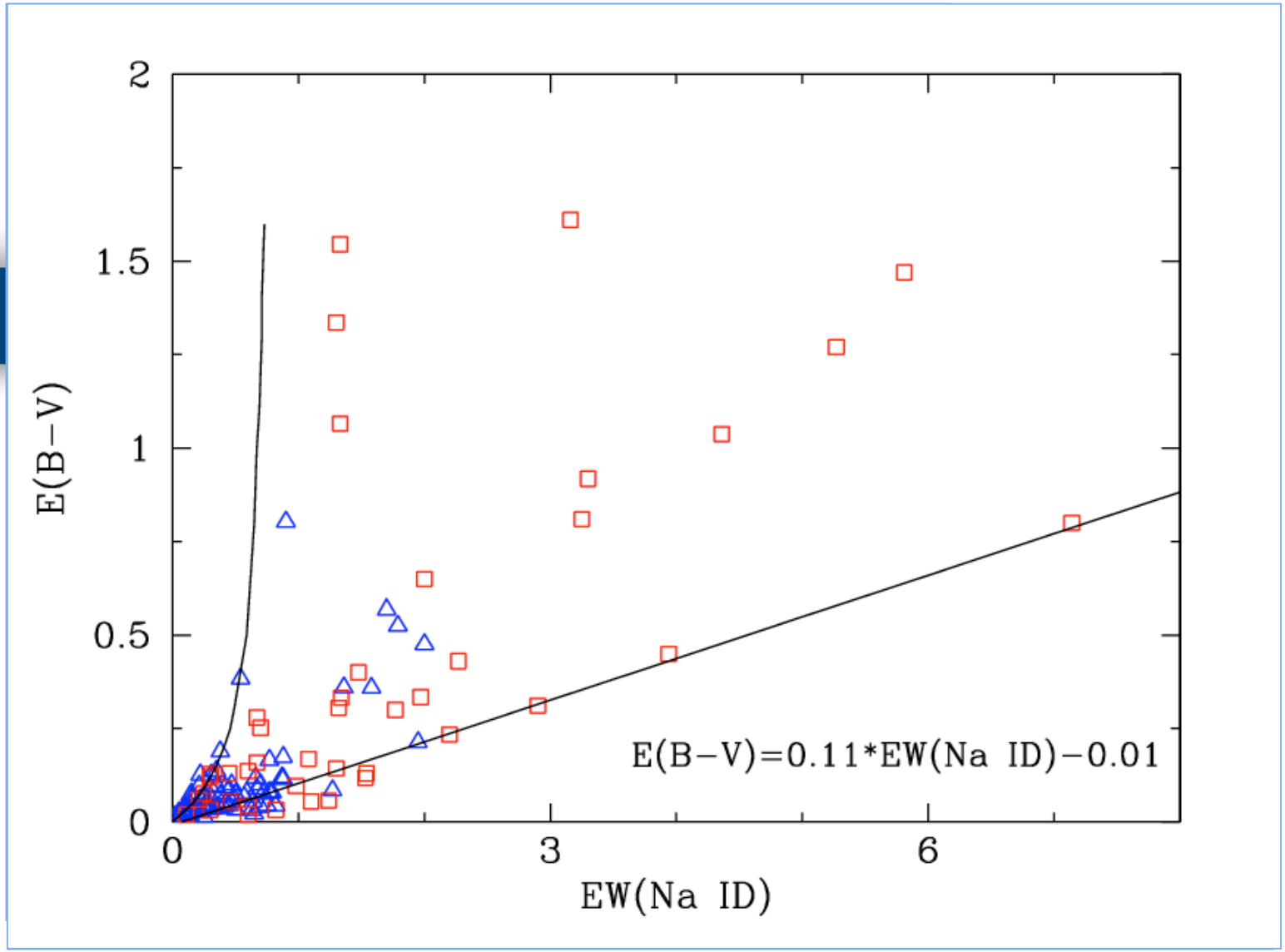
EW(NaID) vs. E(B-V)

- Position and type of the host galaxies
- Not constant dust-to-gas ratio
- Not unique value of R_v
- Number of clouds and saturated lines



Dust:

EW(NaID) vs. E(B-V)



Dust:

Low R_V

from the study of SNe

R_V =	3.1	(Savage & Mathis 1979)
	~ 2 - 5.5	(Geminale & Popowski 2005)
	0.7	(Capaccioli et al. 1990)
	0.5	(Branch & Tammann 1992)
	2.3	(Della Valle & Panagia 1992)
	2.5	(Phillips et al. 1999)
	1.8	(Krisciunas et al. 2000)
	2.5	(Altavilla et al. 2004)
	1.55	(Krisciunas et al. 2005)
	1.1 & 3.1	(Pozzo et al. 2006)
	1.8	(Elias-Rosa et al. 2006)
	2.7	(Jha et al 2006)
	1.73	(Elias-Rosa et al. 2007)

Dust:

Low R_v

→ small size of the dust grain
→ galaxies with well defined dust lanes
(Goudfrooij et al. 1994, Patil et al. 2007)
→ diffuse clouds (Whittet 1992)
→ light echo scenario (Wang 2005)

→ mix of effects?
→ circumSN dust?

Conclusions:

- The study of **high reddened SNe** is important to:
  - characterize the SNe extinction at low E(B-V);
  - understand the physical **characteristics of dust.**

- R_V is **not always 3.1**, it can be **lower** than 3.1.

- Low values of $R_V \Rightarrow$ small grain sizes, well defined dust lane, "circumSN" dust.

- **EW(NaID)** can give us **limits for E(B-V)**

Future work:

- extension to other wavelengths: UV (SWIFT)
- study of high resolution spectra of Sne Ia