SNLS First Year Data Set
From Sne light curves to cosmology

- Differential Photometry of SNe Ia
- Calibration against Secondary Catalogs
- Results & Numbers
- Distance Estimate from Sne light curves
- SNLS First Year Hubble diagram

Differential Photometry of Sne light curves

4 steps:

1) Treatment of Elixir images:

- Catalog of objects
  + Background suppression with Sextractor
- Match to Astrometric Catalog to improve WCS
- Computation of weight maps (uses Elixir Flats)
  74412 images on disk in CCIN2P3 of fields D1,D2,D3 and D4

2) Alignment of images:

- (4 fields) x (4 bands) x (36 CCDs) groups of images aligned to a geometrical reference (the image of best quality, i.e. Best seeing)
- PSF model of reference using Daophot
- PSF match of all images to the reference using Alard method
  => Photometric alignement to the reference.

3) Differential Photometry of all spectroscopically id. SNe Ia.

(more next slides ..)

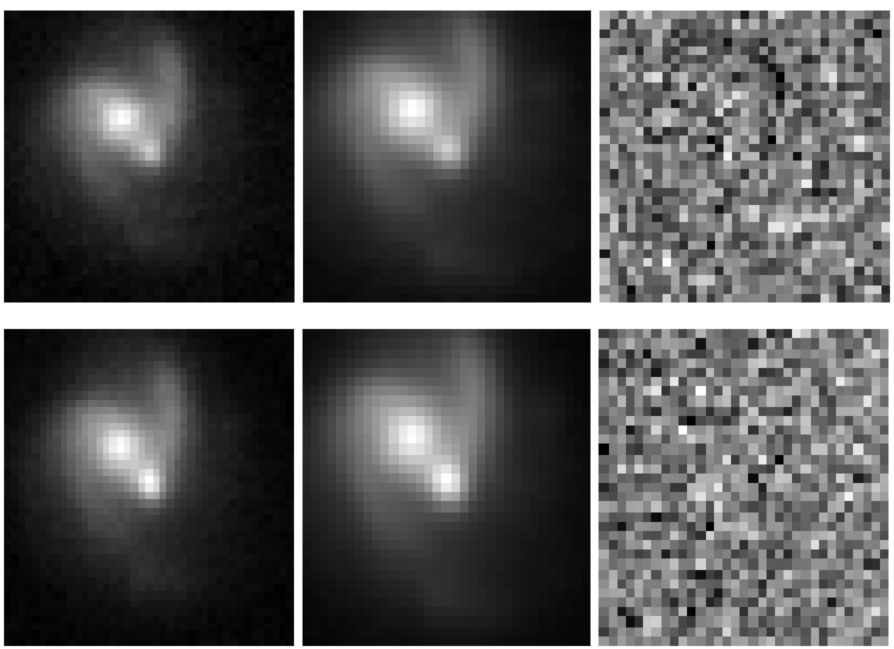
4) Calibration of Photometry againt Secondary Catalog

(more next slides ..)

Differential Photometry of SNe light curves
Simultaneous Fit

$$I(x,y) = \text{Flux} \times \left[\text{Kernel} \otimes \text{PSF}_{\text{best}}\right](x - x_{sn}, y - y_{sn})$$
$$+ \left[\text{Kernel} \otimes \text{Galaxy}_{\text{best}}\right](x,y) + \text{Sky}$$

- Fit galaxy(i,j) on a vignette (at best resolution)
- Can fit constant background
- Fit accurate Sn position (takes info. of all images)
- Robustification to identify for instance dead pixels
- Needs a set of images a priori without Sn



Data model residuals

Differential Photometry of SNe light curves
Simultaneous Fit

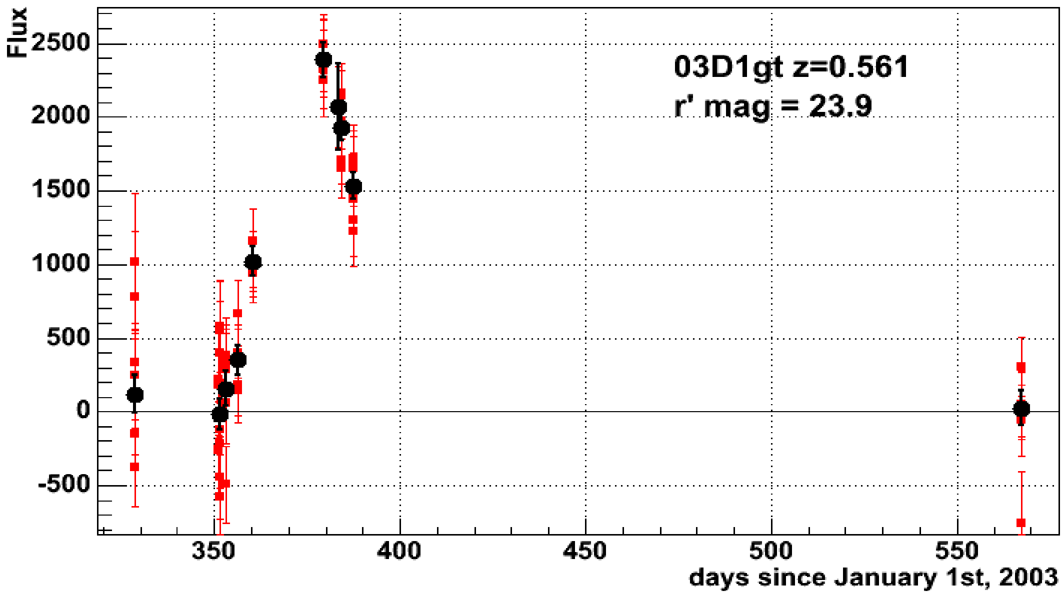
One photometric point per individual exposure

number of exposures:

D1	g'= 68	r'=145	i'=192	z'= 48
D2	g'= 43	r'= 69	i'= 96	z'= 30
D3	g'=112	r'=188	i'=325	z'=103
D4	g'= 97	r'=145	i'=202	z'= 92

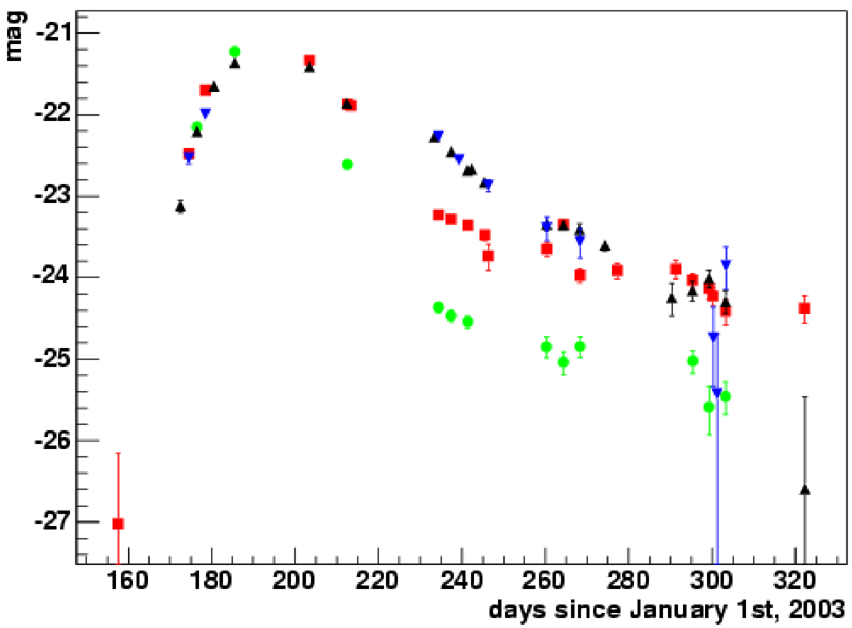
Fit results imposing a constant flux per night

- Use full covariance of fluxes per expo.
  (correlations due to fit of position and galaxy)
- Reject outliers, due for instance to cosmic ray on Sn position



Differential Photometry of SNe light curves

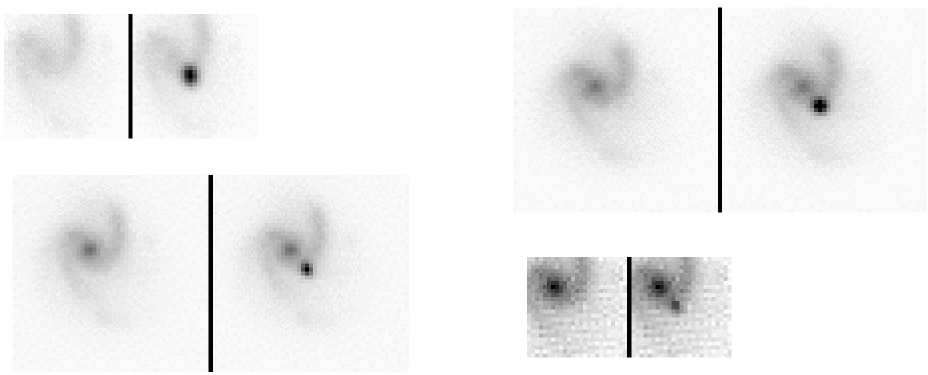
Two examples

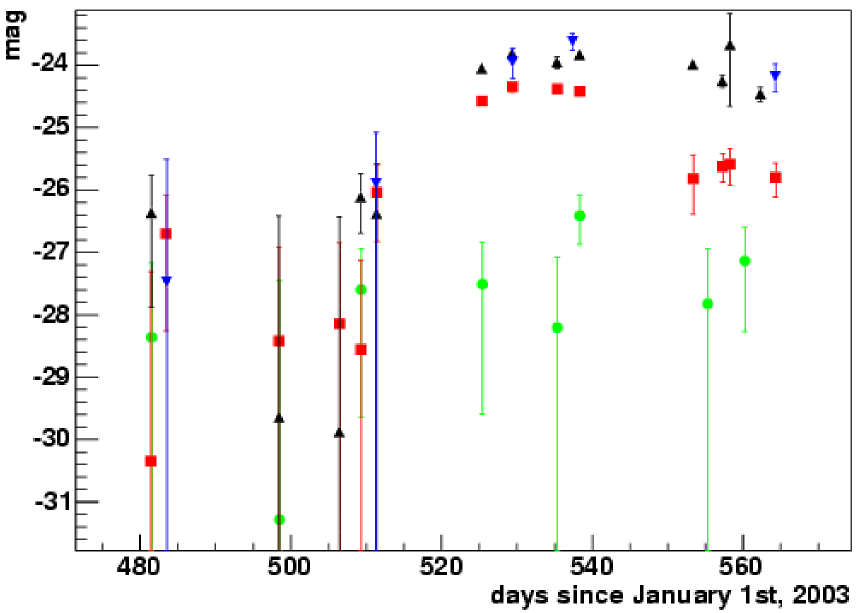


"Nearby" 03D4ag z=0.28

Symbols: g' r' i' z'

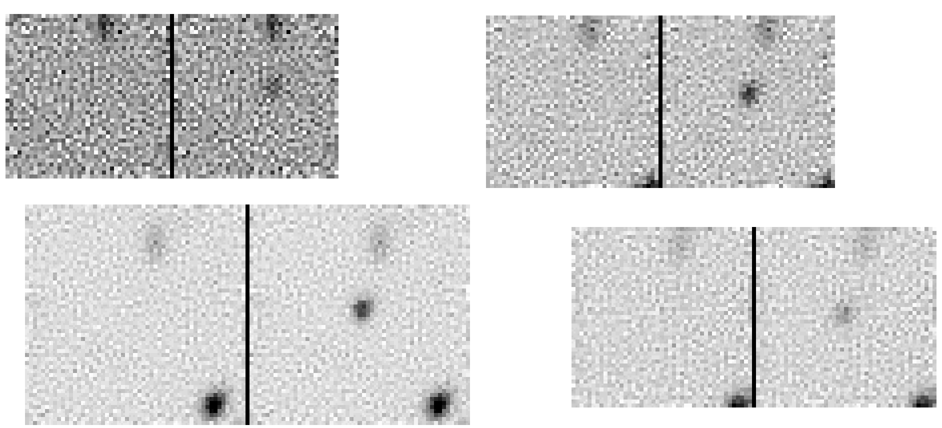
Model with/without Sn:





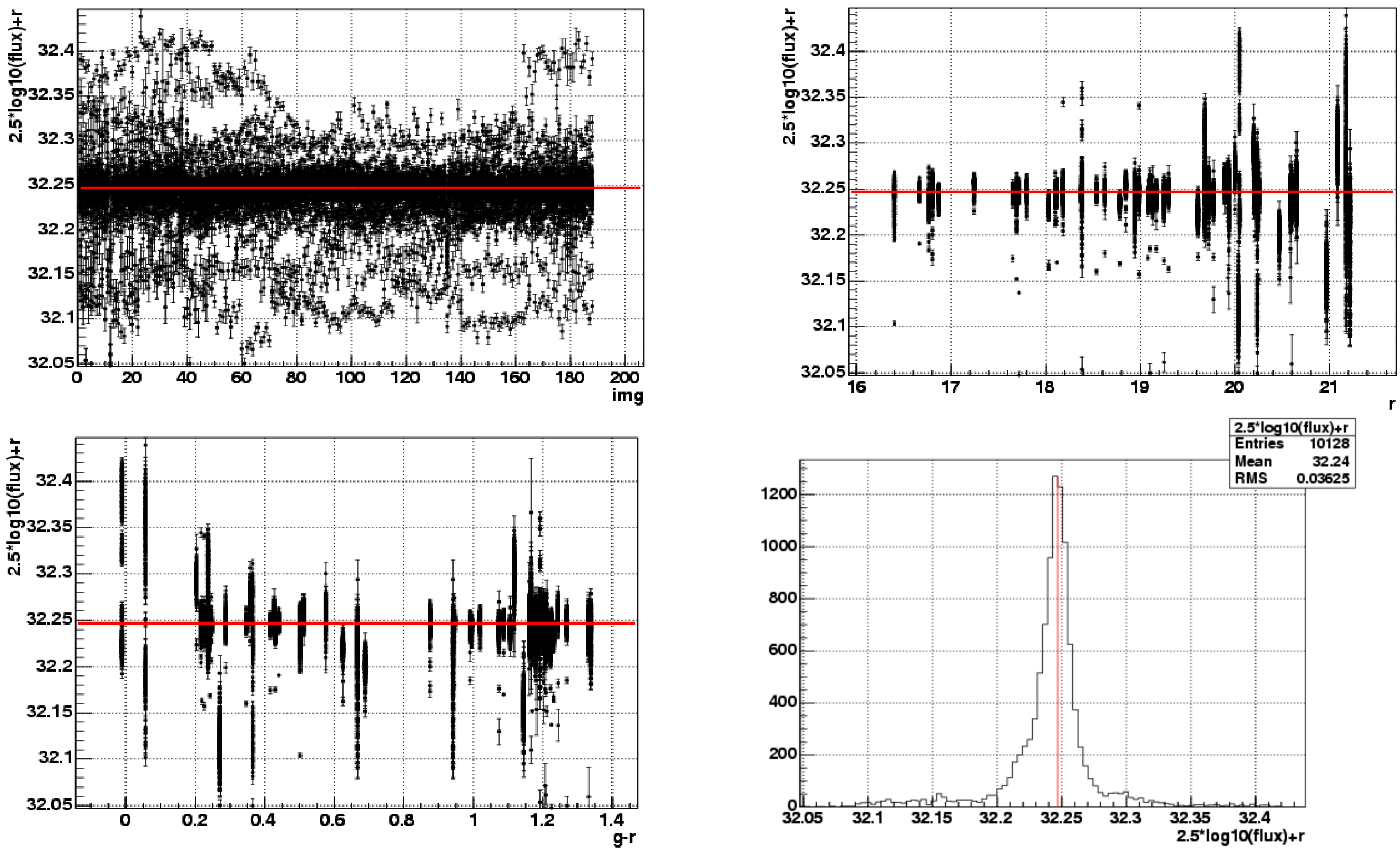
High z 04D3ml z=0.95

Model with/without Sn:



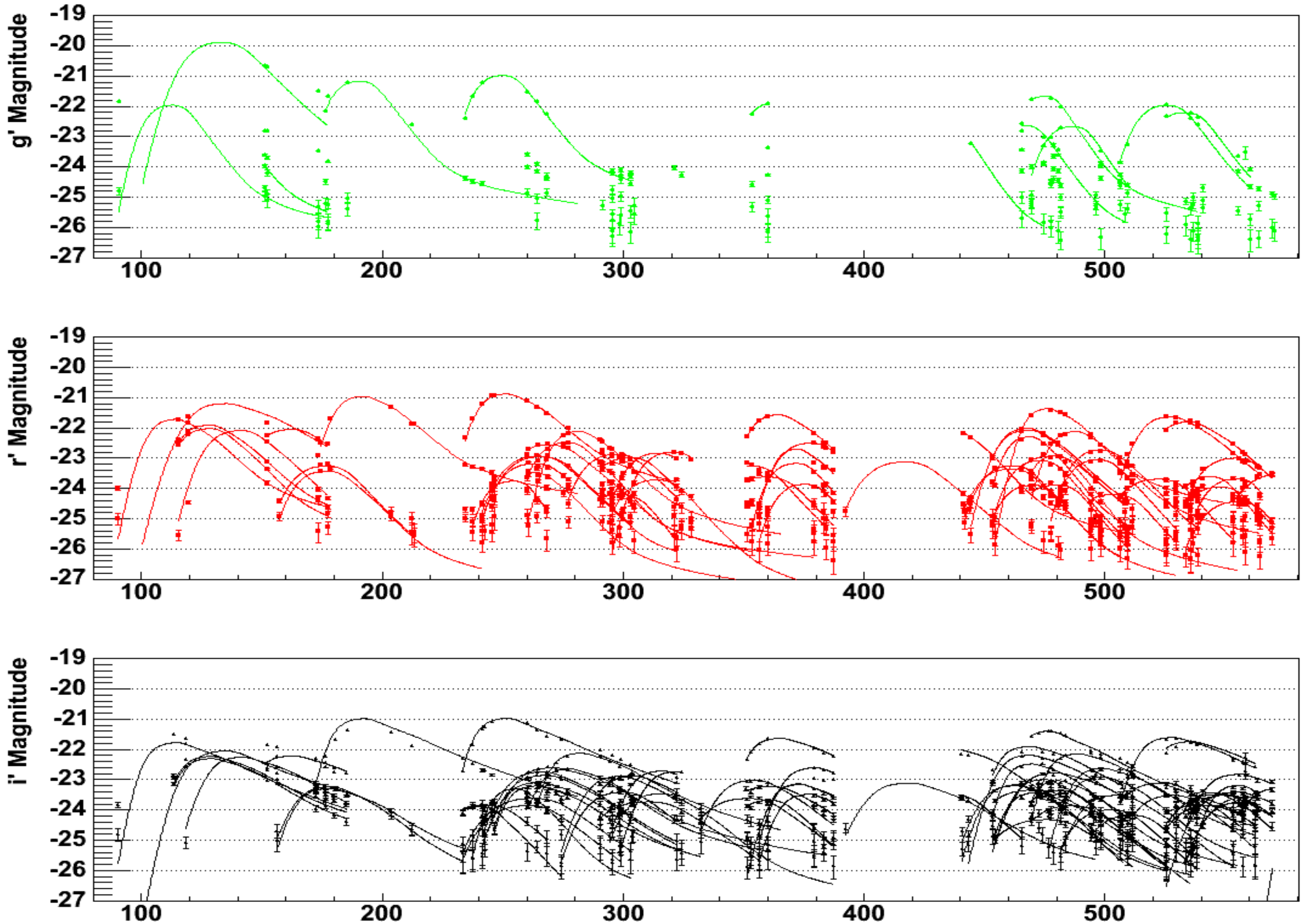
Calibration against Secondary Catalogs

- Use same photometry as for Sne
  (but force galaxy=0)
- Compute fluxes of all sec. stars in all aligned images
- Fit Zero Point



Differential Photometry: few numbers

- Analysis of data up to **July, 2004**
- **110** SNe Ia/Ia? with at least one photometric point
- **79** Sne with well sampled light curves
- **59** with lightcurves in at least two MegaCam filters (needed to estimate colors)

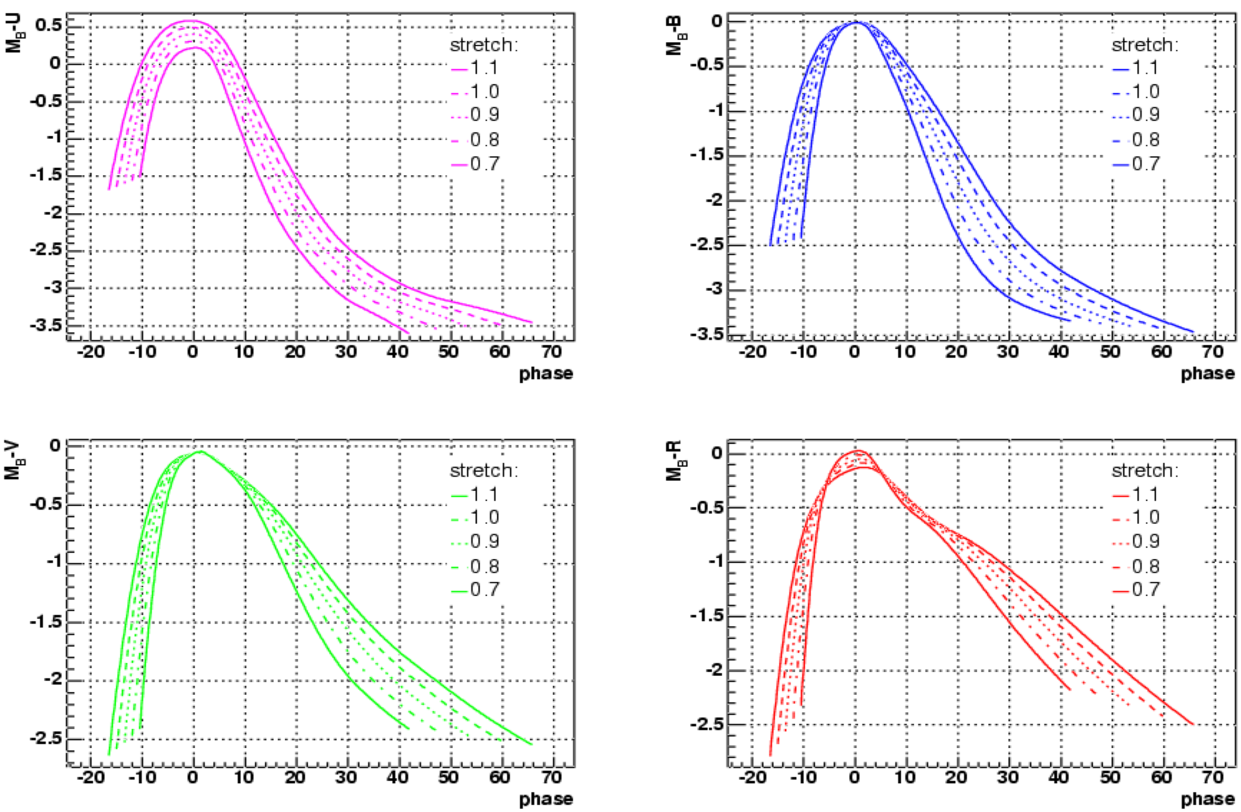


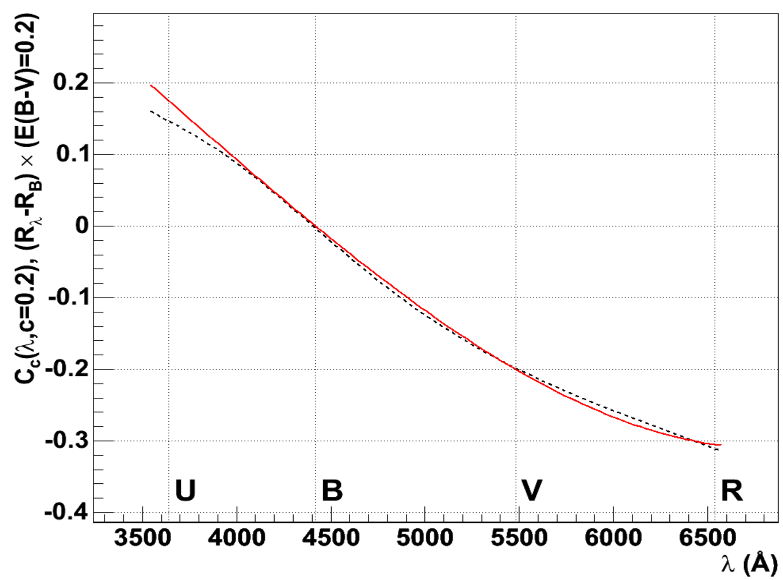
Multi-color light curve fit with a **Spectral Adaptive Light curve Template (SALT)**

Model SNe Ia SED as a function of

- phase (date with respect to B-band maximum)
- lambda (rest-frame wavelength)
- stretch (dilatation of phase axis in B-band)
- color =E(B-V) at B-band maximum

Trained with a sample of nearby SNe Ia in UBVR





Distance Estimate with SALT

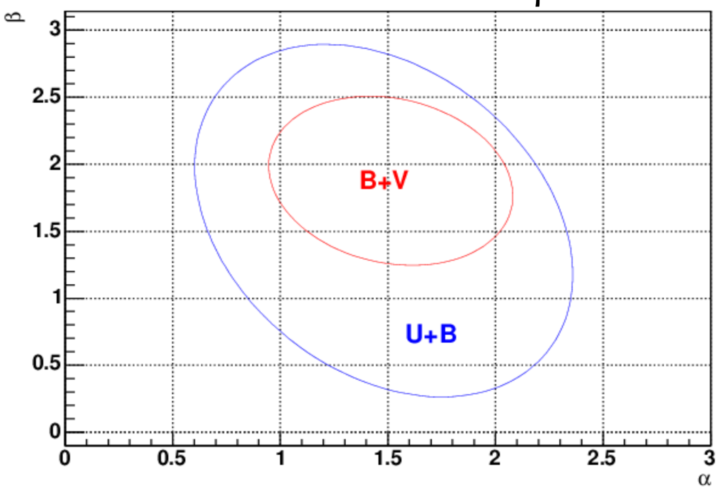
For each SN, the fit leads to 3 parameters:
global intensity (m_B), stretch (s), color (c)

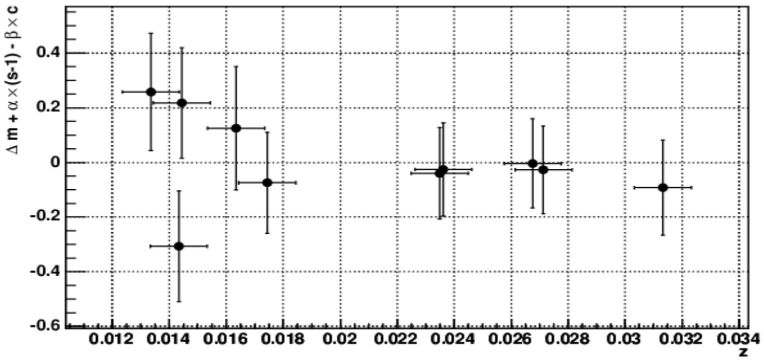
Distance estimate:

$$m_B(z) - M'_B - \alpha\,(s-1) + \beta\,c = 5\ \log_{10}\left(\frac{d_L\,H_0}{c}\right)$$

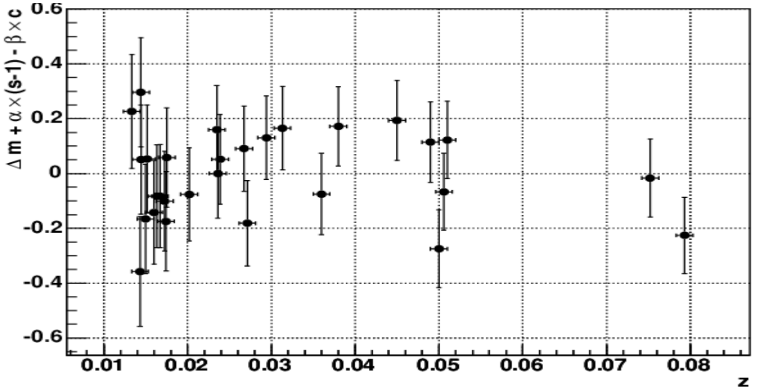
On a test sample of nearby Sne,
using either U+B or B+V bands

68 % C.L. for α and β



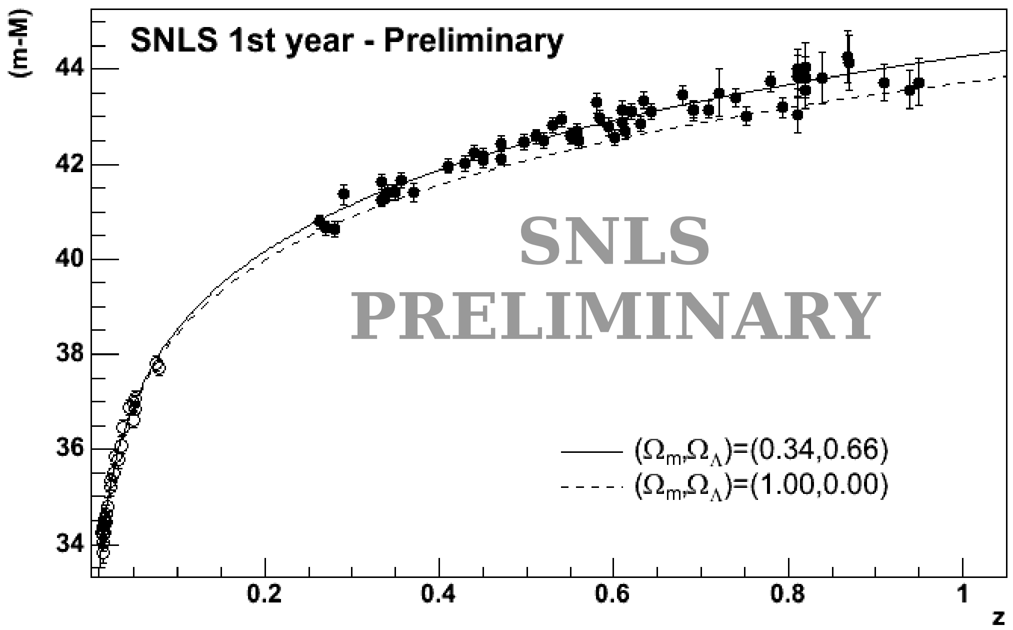


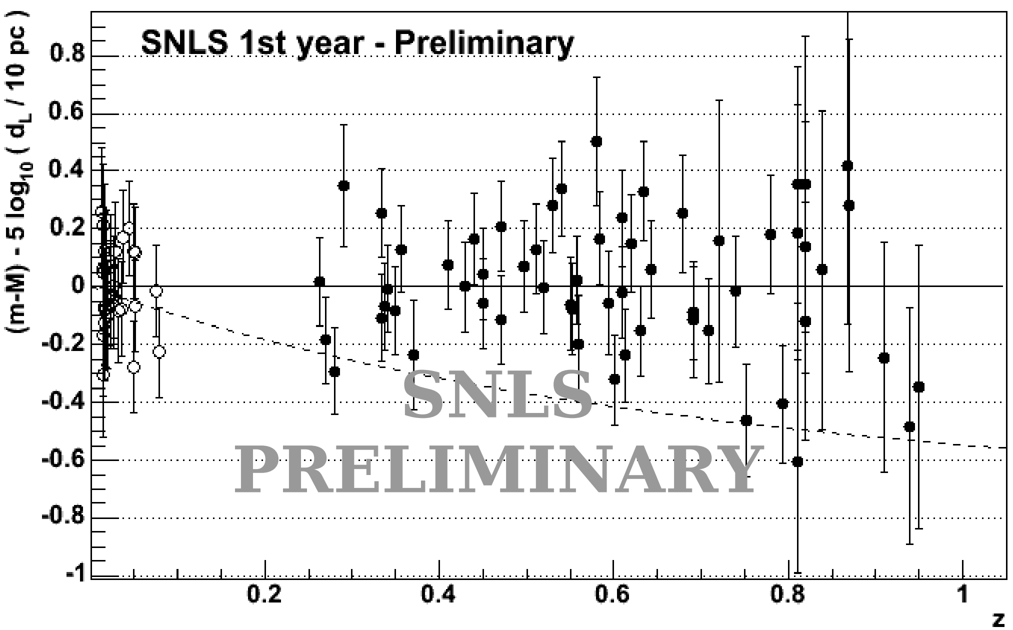
Residuals to
Hubble Diagram
in U+B



in B+V

Hubble diagram of SNLS 1st Year





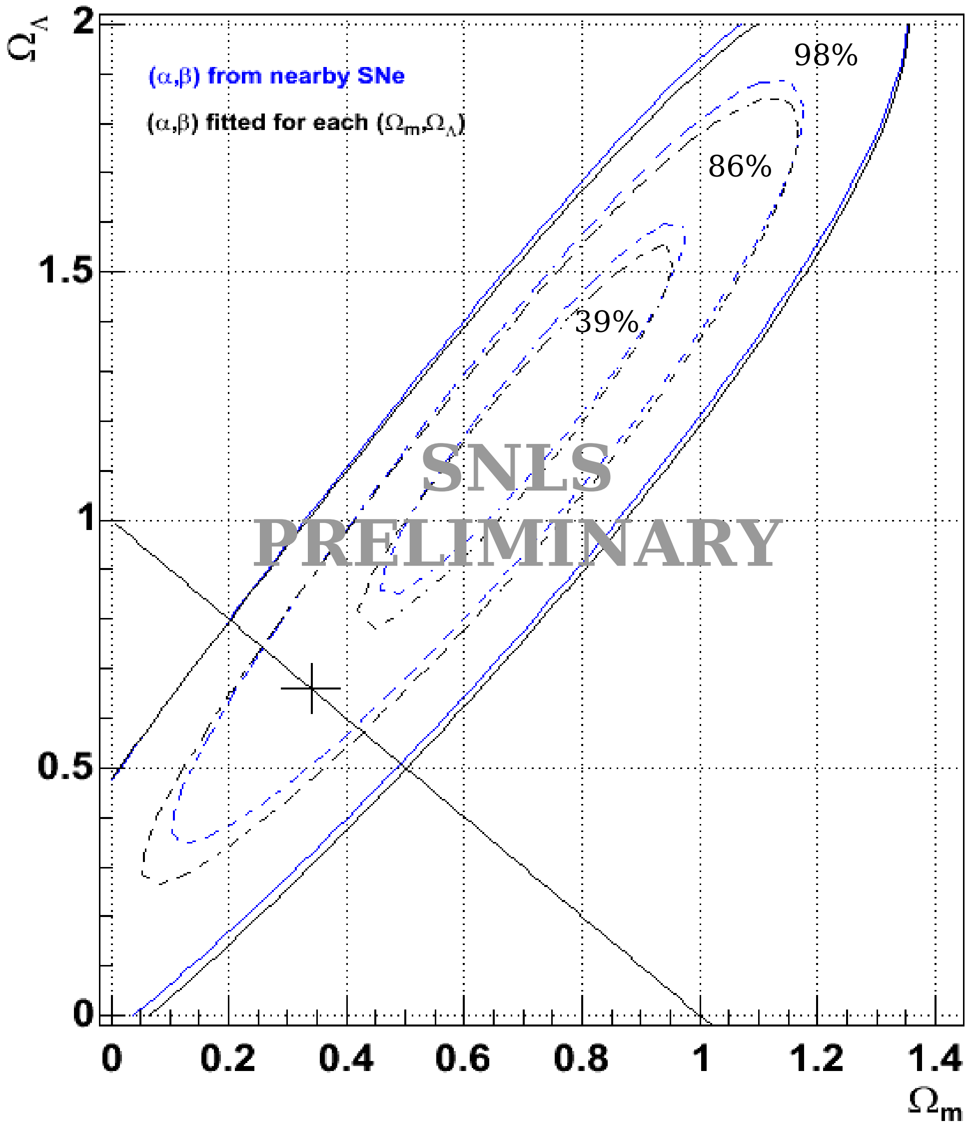
Distances estimated with
α=1.5 β=1.8 M'=23.8

X^2=1 for an additionnal intrinsic dispersion of 0.15 mag.

Errors take into account covariance matrix of fitted parameters m_B,s,c.

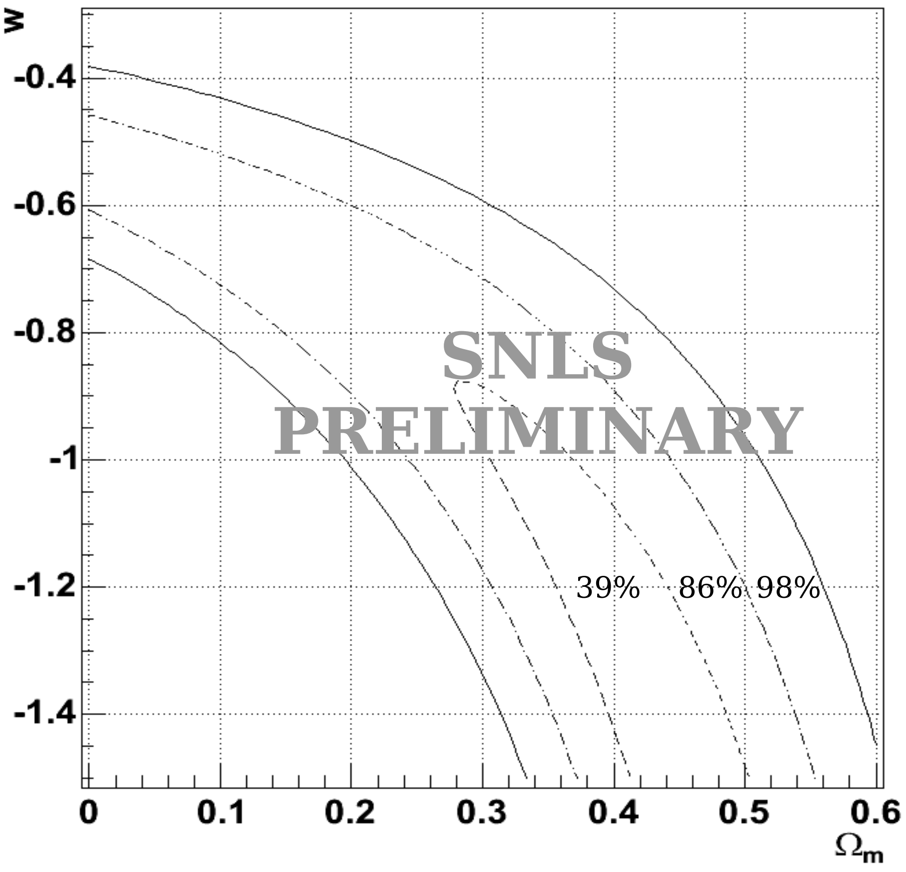
Next, cosmological fit -->

Cosmological parameters



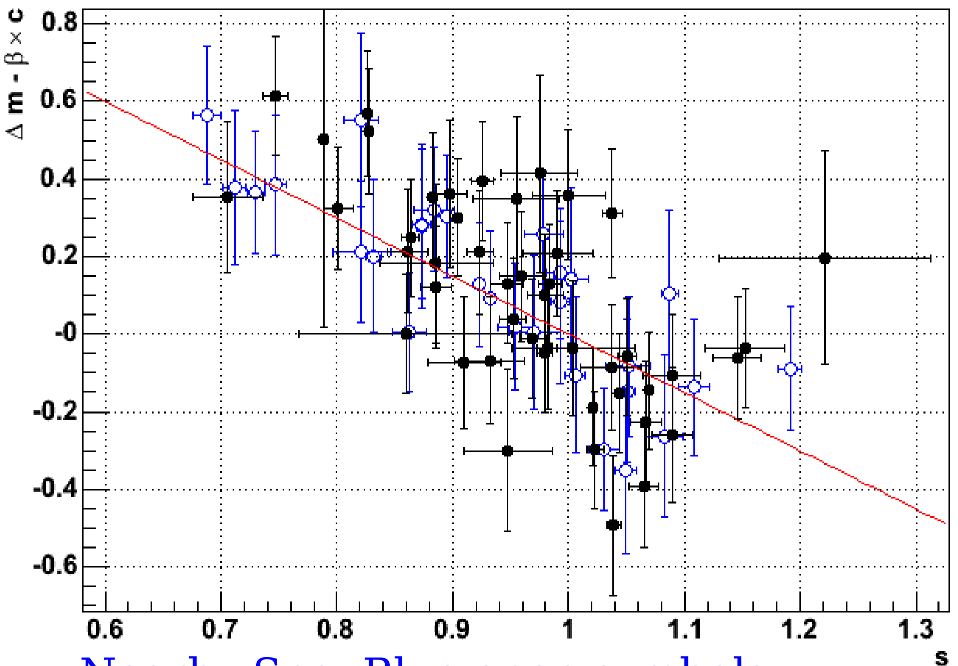
Best fit for $Omega_T$=1 and w=-1(cosmological constant):

$Omega_M$=0.34 +- 0.05

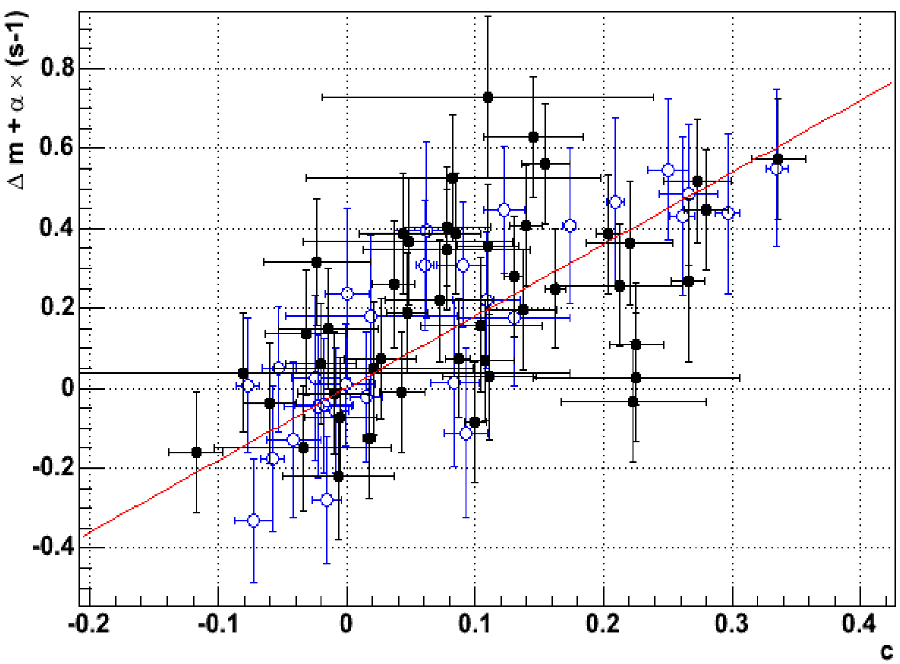


Comparison of Nearby & SNLS SNe Ia

Brighter - slower

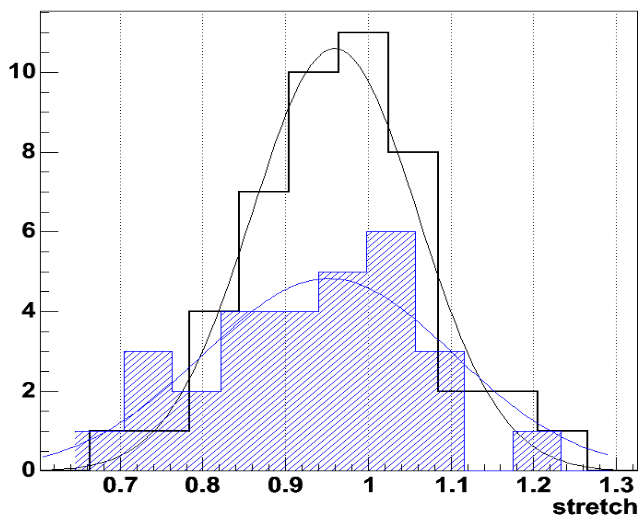


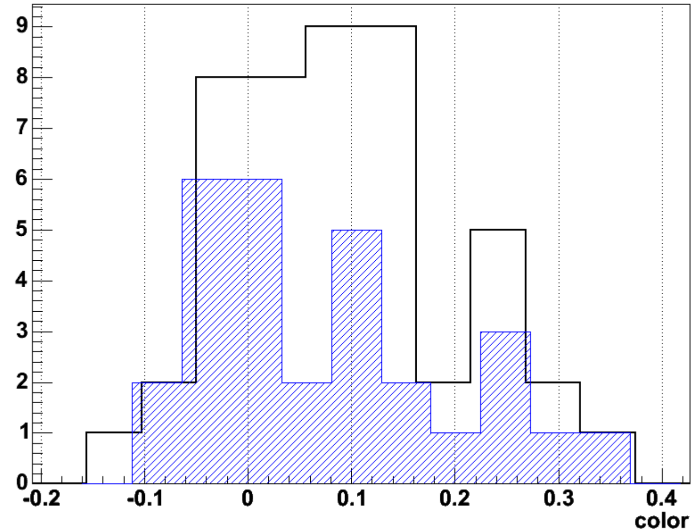
Brighter - bluer



Nearby Sne: Blue open symbols

SNLS Sne: Black filled symbols





About z>0.8 supernovae

- r' corresponds to rest-frame far UV
  => cannot be used to estimate distances
  => fit with i' and z' light curves only

- Large errors on z' magnitudes:

  - Exposure time z' = ½ i'
  - Number of exposures z' = ½ i'
  - Instrument sensitivity z' << i'

  => at z=0.9 (03D4ai), $\sigma(i')=0.03$ mag, $\sigma(z')=0.1$ mag

- Rest-frame wavelength lever arm of i'--z' = ½ (B—V)
  => $\sigma(B\text{-}V)_{restframe} = 2\,\sigma(i'\text{-}z')$
  => error on distance modulus = $\beta\,\sigma(B\text{-}V)$ = 0.4 mag !

- We have to model SNe Ia SED in far UV
- **We need more stat in z'**

To Conclude

We are on a good track ...
Confirmation of acceleration of expansion.
Better than Perlmutter (98) & Riess (99) -> use color-corrected distance estimate without prior on color.

Papers in preparation:

- 1st year Gemini spectroscopy
- 1st year VLT spectroscopy
- 1st year Cosmology

Time sampling critical

no small gaps (for light curve fit accuracy)
no large gaps (many SNe lost, ex: MegaCam failure, MOS)
=> 1 month off = 2 month equivalent of stat. lost

Need more z'

Current precision marginal at redshift>0.8
But needed for cosmology !

Many systematics to study: selection bias, rise time ...