AAS 211th Meeting

Poster 105.11

Type Ia Supernova Rate as a Function of Redshift From The First 3 Years of The SuperNova Legacy Survey

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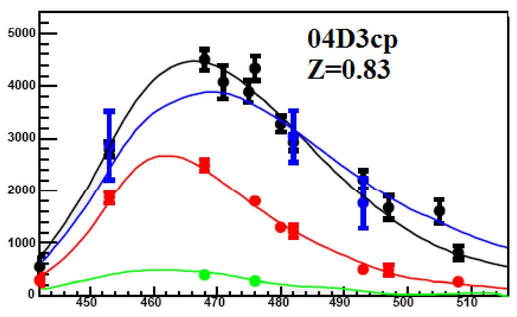
We present a measurement of the Type Ia supernova (SN Ia) rate as a function of redshift, based on the first 3 years of the SuperNova Legacy Survey (SNLS). Supernova candidates were detected and light-curves derived on images obtained for the deep survey of the Canada-France-Hawaii Telescope Legacy Survey (CFHTLS), covering four 1 square degree fields, while spectroscopy of SNe Ia candidates was obtained at VLT, Gemini and Keck telescopes. A complete re-processing of the imaging survey was performed with an automated procedure, producing a sample of 434 SN Ia candidates without human selection. 213 of these candidates had been spectroscopically followed and identified during the "real-time" operations. A detailed "on image" SN Ia simulation was performed to derive precise detection and identification efficiencies. Using both photometric and spectroscopic redshift (when available), we have derived a SN Ia explosion rate in redshift bins of 0.1 between z=0.2 and z=1.2 and compared this measurement with predictions based on cosmic star formation history models.

Detection Pipeline



Variable Objects detection

- **Full Data Re-Processing**
- variable objects are detected by **image subtraction on successive epochs**
- Construction of multi color light curve (g', r' i', z')
- Each object is associated to an host galaxy with photometric redshift
- Spurious subtraction residuals eliminated by a neural network

Photometric selection of type Ia supernovae

- Human free automated photometric selection
- Multi color light curve fit (SALT2) :
  Fitted parameters : color, stretch , flux normalization
  Redshift fixed (photometric or spectroscopic)

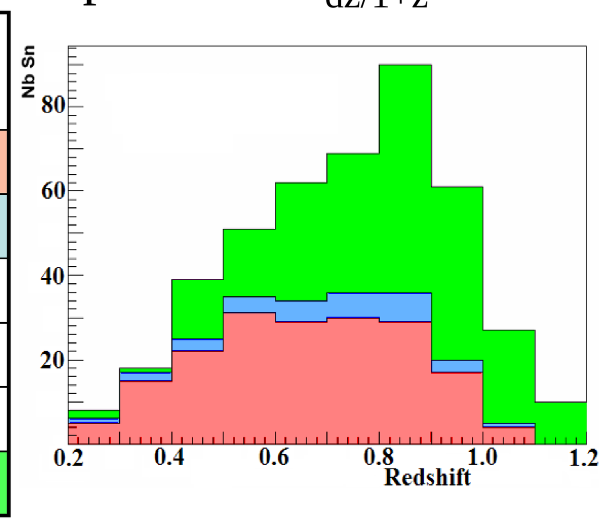
Selected Ia like objects

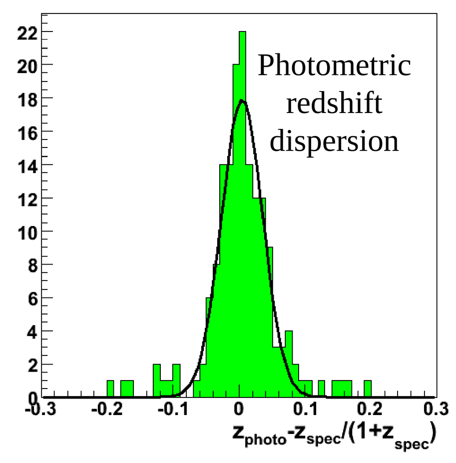
434 objects selected as type Ia supernovae with 182 spectroscopically confirmed.

Spectroscopically followed objects used as test sample :

- No contamination with spectroscopic redshift
- 2% contamination with photometric redshift
- Photometric redshift dispersion : $\sigma_{dz/1+z}$ = 0.03 + outliers

Spec type	Detected	Ia Selected
Sn Ia	196	182
Sn	53	31
Sn II	24	0
Sn I b/c	7	0
AGN/Var	9	0
No spec	2762	221





Simulation and Detection efficiency

Detailed **"on image"** Sn Ia simulation

- SNe are added on all images before subtraction with a synthetic PSF
- **Position and redshift randomized according to an host galaxy**
- **Parameterized supernovae light curve** (stretch, extinction, intrinsic dispersion, date of max)

Simulated images processed with our detection pipeline :

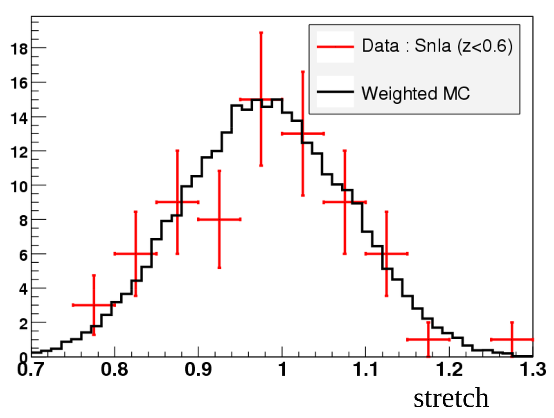
- **720 000 sne have been simulated on 3 years of images (about 200 000 images processed)**
- All distributions (stretch, color,…) have been enlarged to study efficiency correlation to these parameters

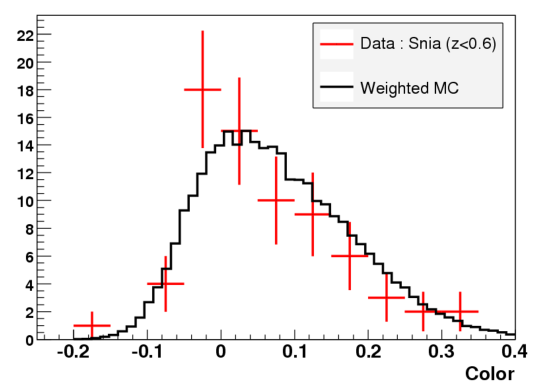
Detection Efficiency Study

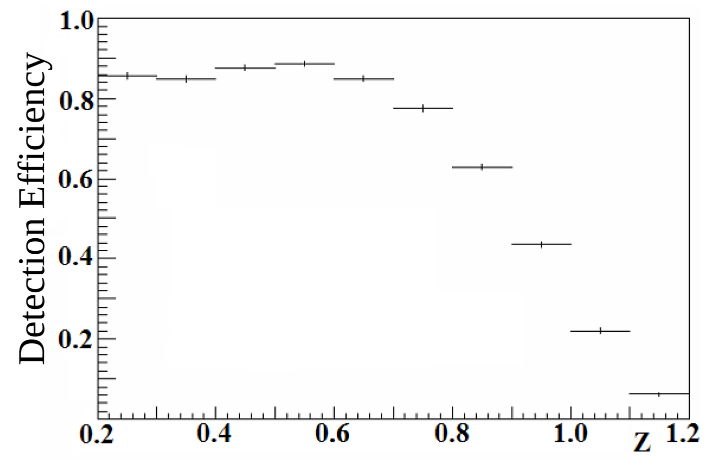
- Optimal detection efficiency : 90% **for i' < 23.9** (magnitude at max)
- Detailed study on other parameters (stretch, color, contrast,…)
- Color and stretch distribution are unbiased for z < 0.6

Detection Efficiency vs Redshift

Simulation have been weighted to match observed distribution (color, stretch, intrinsic dispersion, contrast, position SN/host) and to compute an overall detection efficiency as a function of redshift.







Type Ia explosion rate measurement

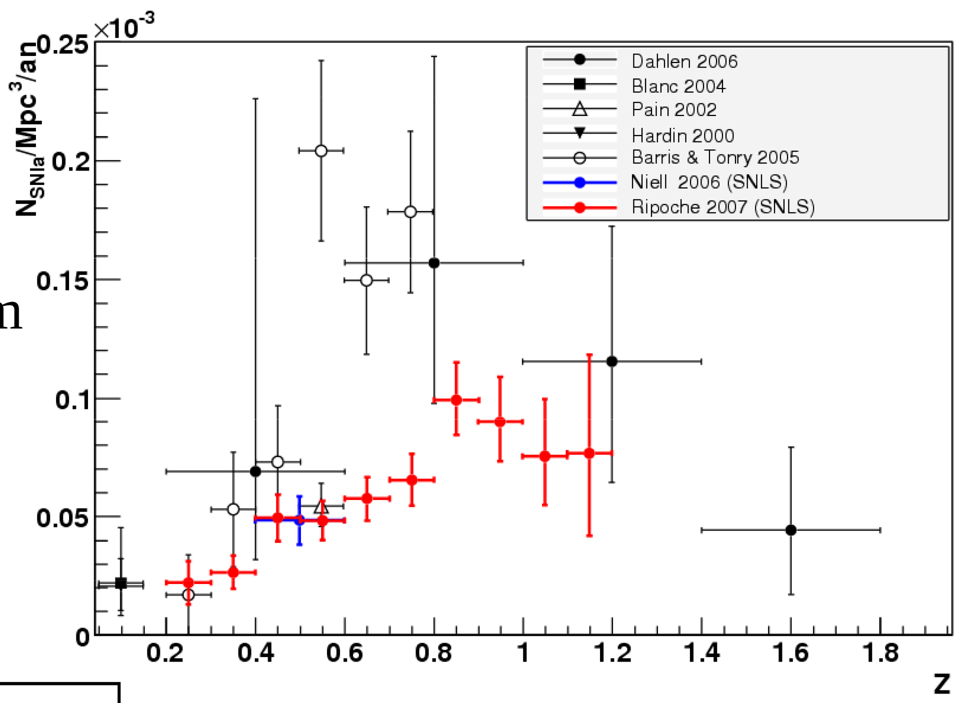
SnIa explosion rate per comoving volume unit with ΛCDM (0.7;0.3) and H_0 = 70.0 km.s^{-1}.Mpc^{-1}

$$Rate(z) = \frac{(1+z)}{\Delta t \times V(z,\Delta z)} \frac{N_{SnIa}}{eff(z)}$$

Rate measurement is "deconvolved" from redshift dispersion.

Preliminary

$$Rate(0.65) = 5.56^{+0.92}_{-0.91} \times 10^{-5} \text{ SnIa/Mpc}^3\text{/yr}$$

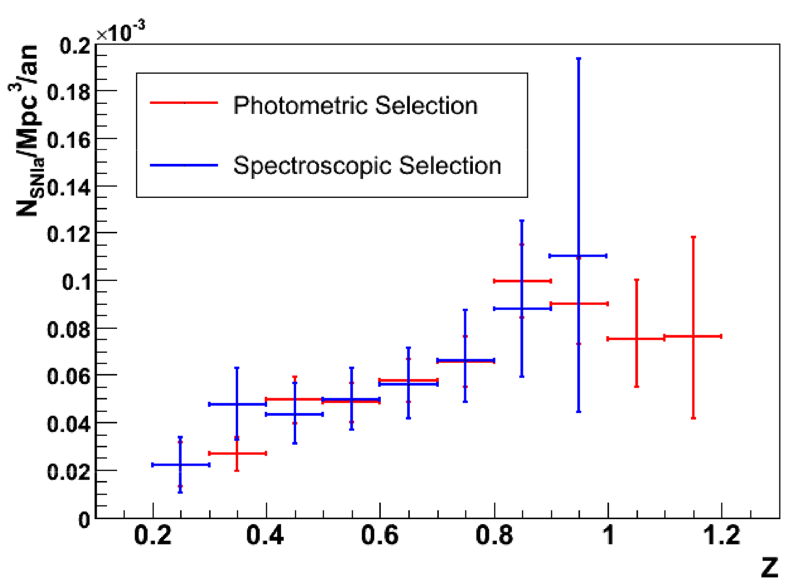


Cross Check : Spectroscopic selection

A second rate measurement have been compute using only spectroscopically confirmed SnIa.

- No contamination
- No redshift dispersion
- But reduced redshift range

Good compatibility



Fits and Models

Simplest rate evolution model :

$$Rate(z) = R_0 (1+z)^{\alpha} \quad R_0 = 1.50 \pm 0.39 \times 10^{-5} \text{ SnIa/Mpc}^3\text{/yr}$$
$$\alpha = 2.65 \pm 0.47$$

Delayed star formation rate (SFR) :

$$Rate(t) = k \int_{t_F}^{t} SFR(t') \times \phi(t - t')dt' \qquad \sigma/\tau = 0.2 \text{ (fixed)}$$

$$\phi(t) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{1}{2}\left(\frac{t-\tau}{\sigma}\right)^2} \qquad \tau = 3.62 \pm 0.24 \text{ Gyr}$$