# Supernova Rate From The SUDARE survey


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# Outline

- Introduction to SN rate
- Photometric classification
- Volumetric rate
- Rate per unit of mass

Cappellaro, E. et al. 2015, A&A, 584, id.A62

Botticella, M. T. et al. 2017,  A&A, 598, id.A50

# CC SNe rates

$$r^{CC}(z) = N^{CC} \times \text{SFR}$$

$N^{CC}$ = number of CC SN progenitors from one solar mass of stellar population

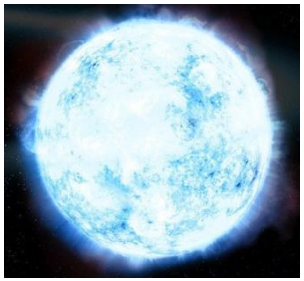
$$N^{CC} = \frac{\int_{m_L^{CC}}^{m_U^{CC}} I(m)dm}{\int_{m_L}^{m_U} mI(m)dm}$$

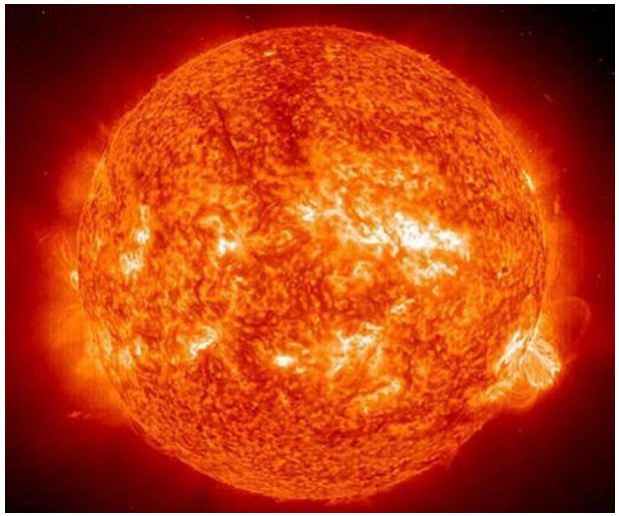
I(m)=IMF

SFR=> Star formation rate

# SNe Ia rates

Double degenerate





Single degenerate

$$r^{Ia}(t) = N_a P^{Ia} \int_{\tau_a}^{\min(t,\tau_x)} f^{Ia}(\tau)\varphi(t-\tau)d\tau$$

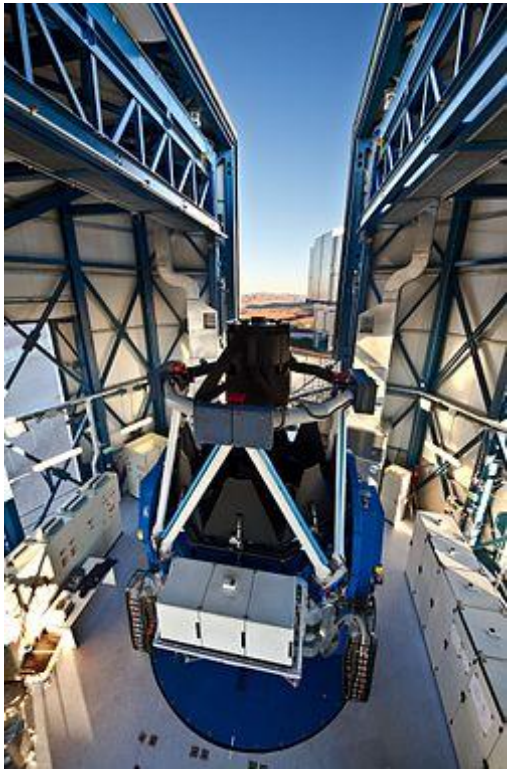
$N_\alpha$ => number of stars per unit mass of the stellar generation
$P^{Ia}$ => realization probability of the SN Ia scenario
$f^{Ia}(\tau)$ => distribution function of the delay times
$\varphi(t-\tau)$ => star formation rate at the epoch $t$-$\tau$.

# SUDARE
# (Supernova Diversity and Rate Evolution)

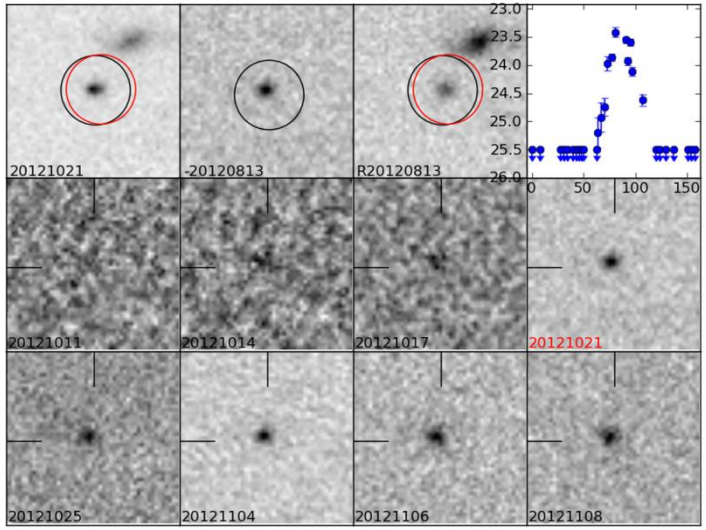
Survey instrument => VST+OMEGACAM (1°x1° FoW) in the g,r i filters

Monitoring frequency => **r** every ~3 days, **g** and **i** once a week.

We use also public available J H Ks deep VISTA images from VIDEO & UltraVISTA

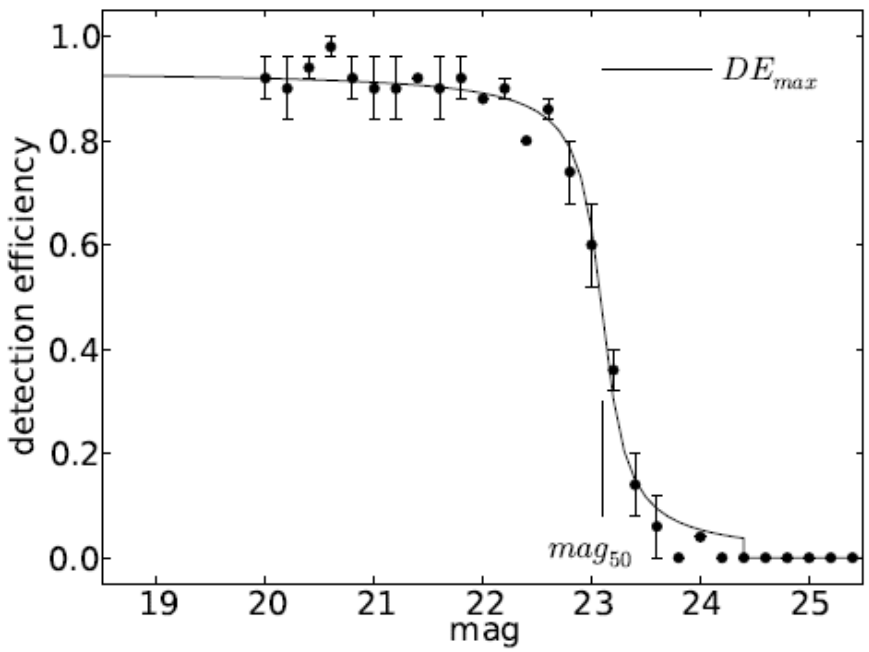


Searching fields: CDFS (E. Capellaro) & COSMOS (G. Pignata)

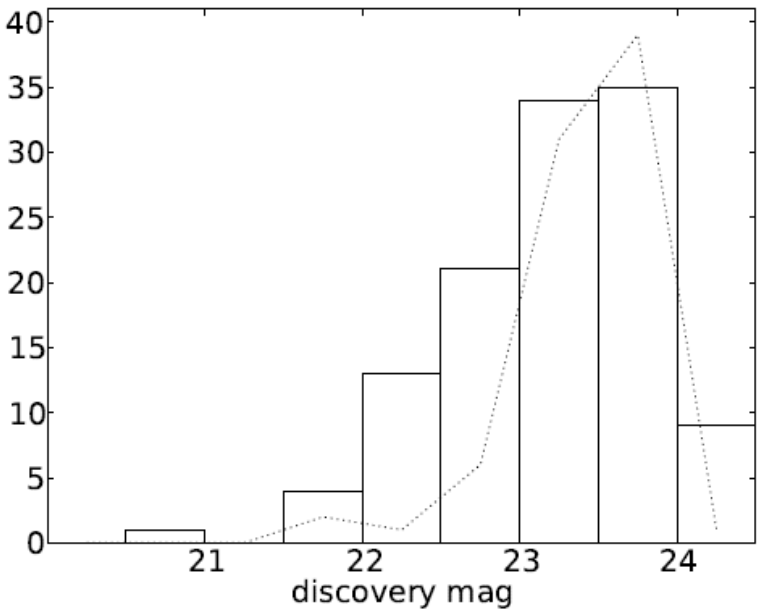



Preliminary results based on 117 SNe

# Detection efficiency



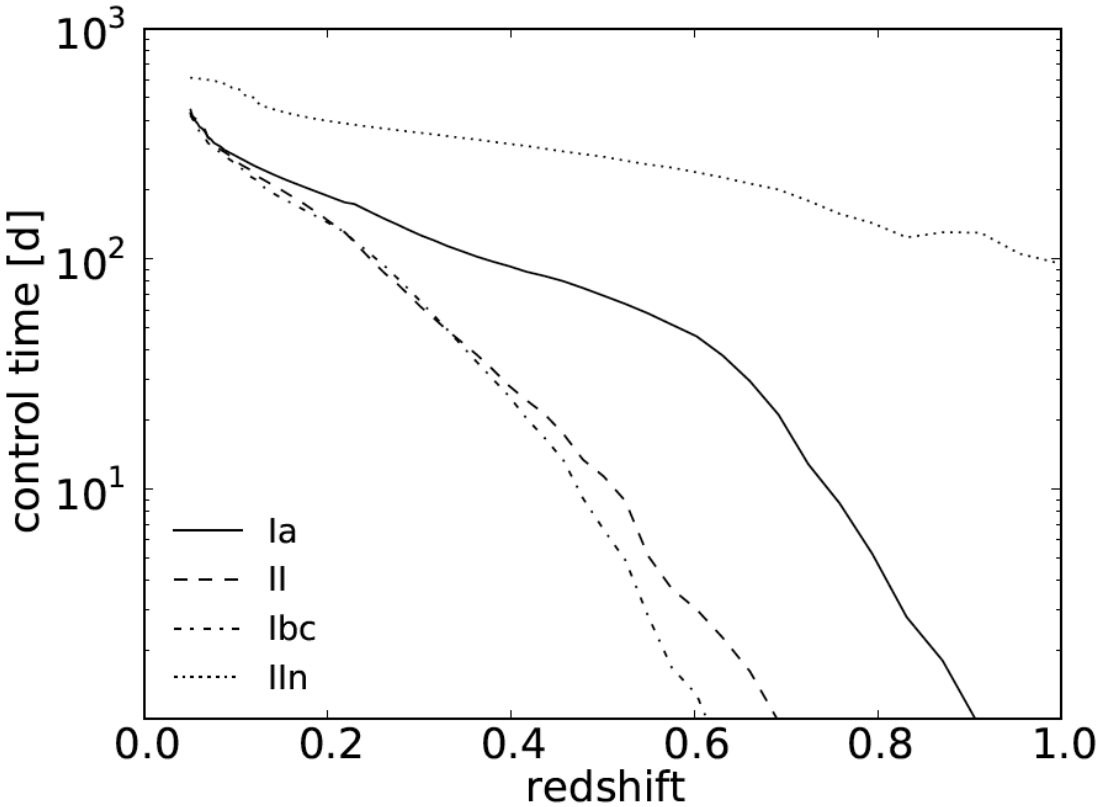

Artificial star experiment




Discovery magnitude

Both estimations give consistent results

# Control Time




Cappellaro+2015

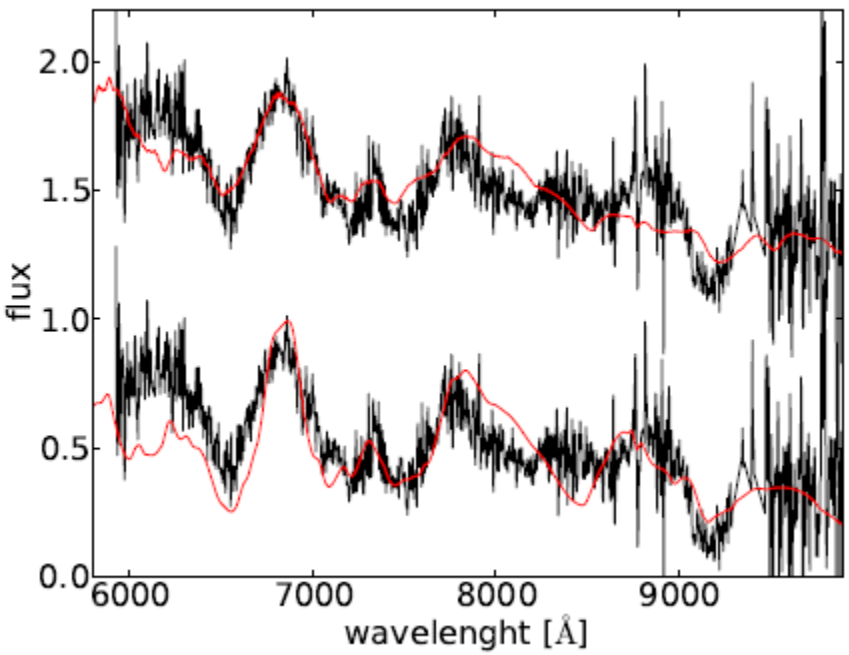
$$CT_{\mathrm{SN}}(z) = \sum_{\mathrm{SNi}} \sum_{\mathrm{E_{BV}}} f_{\mathrm{SNi}}\, g_{\mathrm{E_{BV}}}\, \mathrm{CT}_{\mathrm{SNi,E_{BV}}}(z).$$

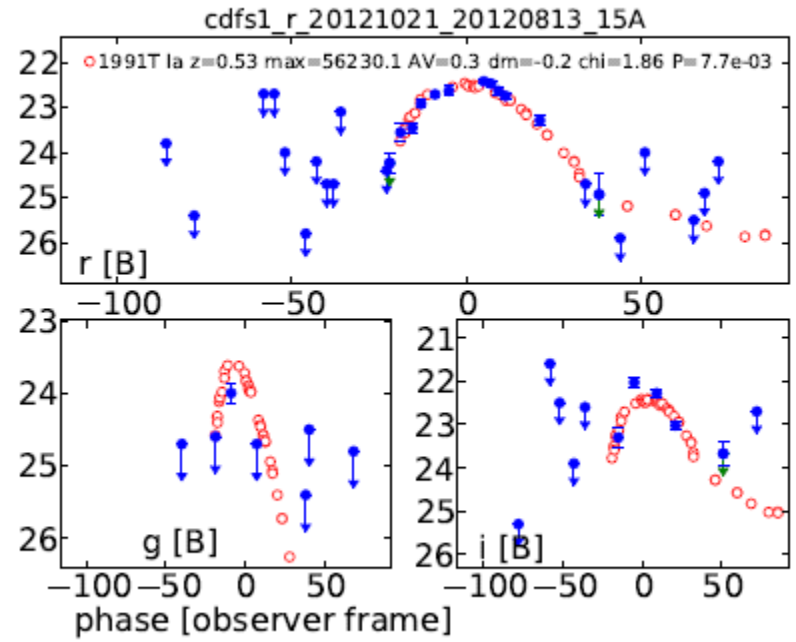
$f_{SNi}$ => subtype distribution

$g_{E(B-V)}$ => colour excess distribution

# Candidates SN classification

Photometric classification based on template comparison

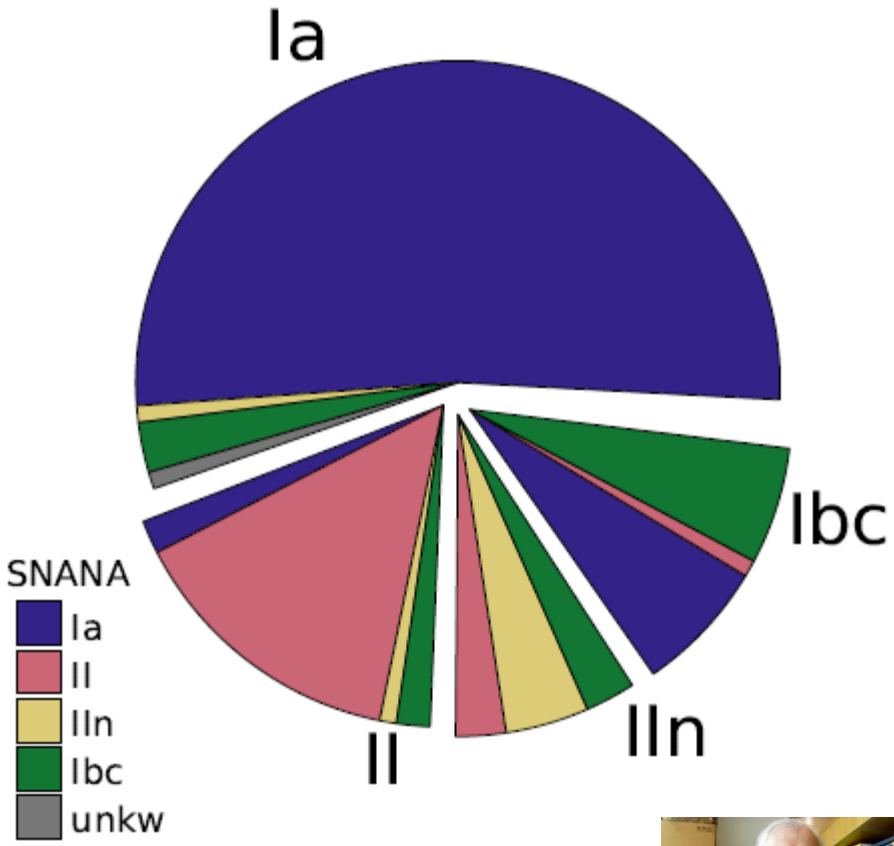


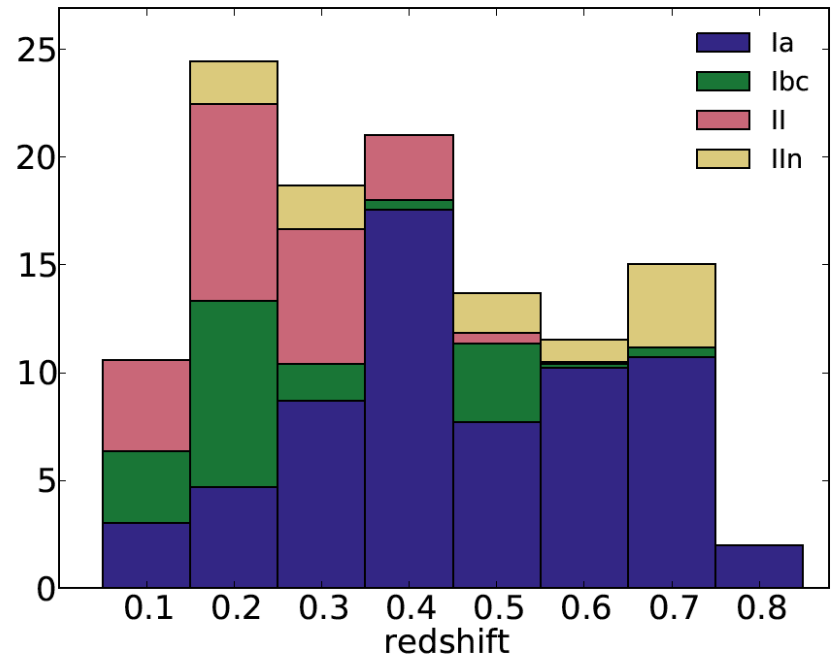

Best fit with a Type Ic at -9 SN2007gr (top)
But also compatible with a Type Ia SN1991T at +14

Photometric classification say Type Ia
The epoch of the peak is not compatible with the spectroscopic classifications

# Photometric classification

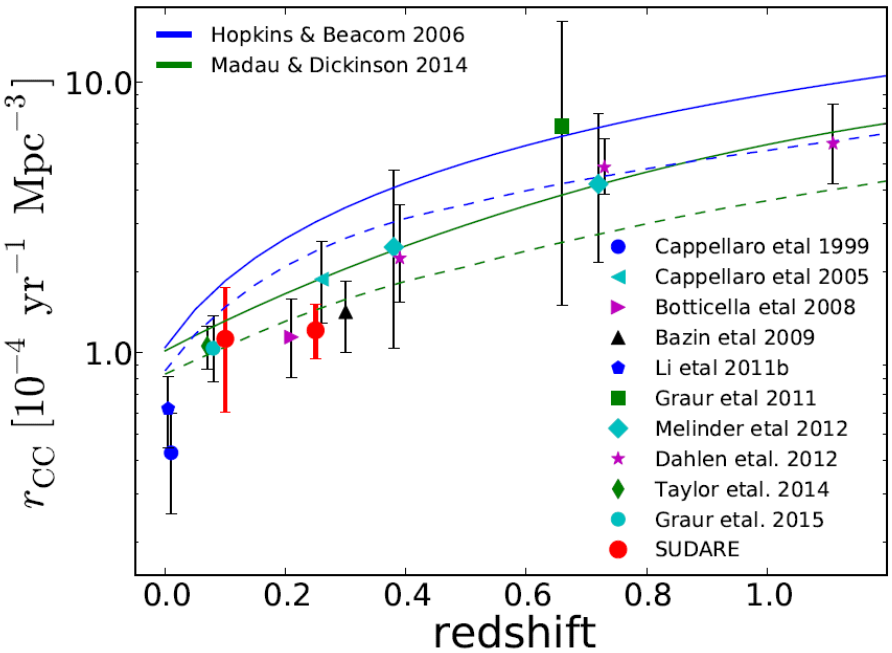


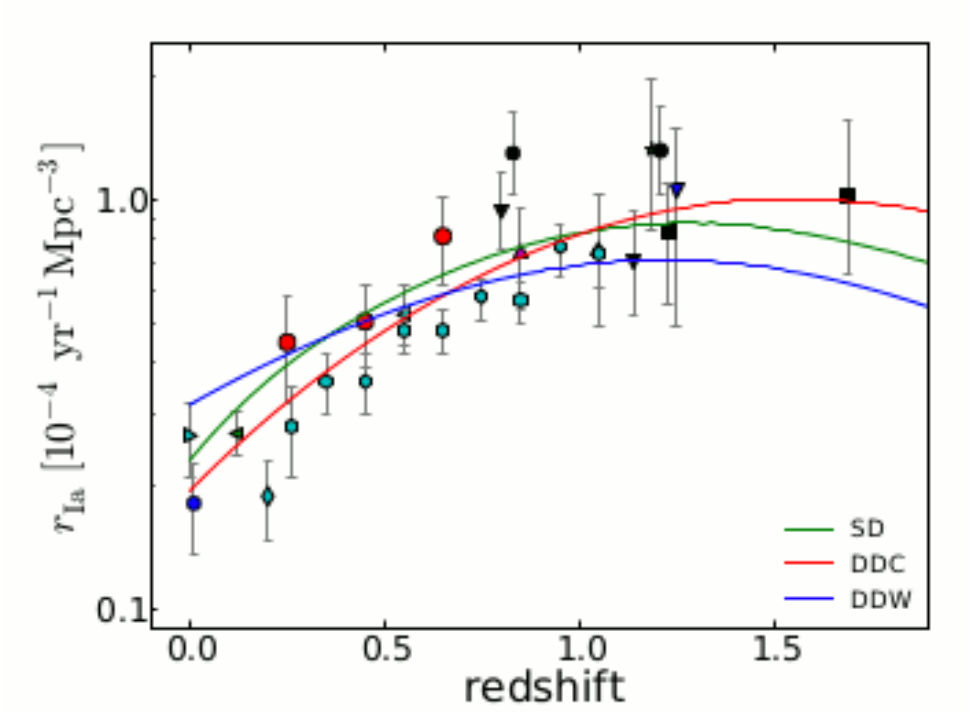

| | SUDARE | SNANA |
|---|---|---|
| Ia | 67 | 72 |
| II | 22 | 21 |
| IIn | 11 | 7 |
| Ib/c | 17 | 15 |
| All | 117 | 115 |




Now we are developing a new tool base on machine learning (P. Huijse & Pablo Estévez)

# Volumetric rate



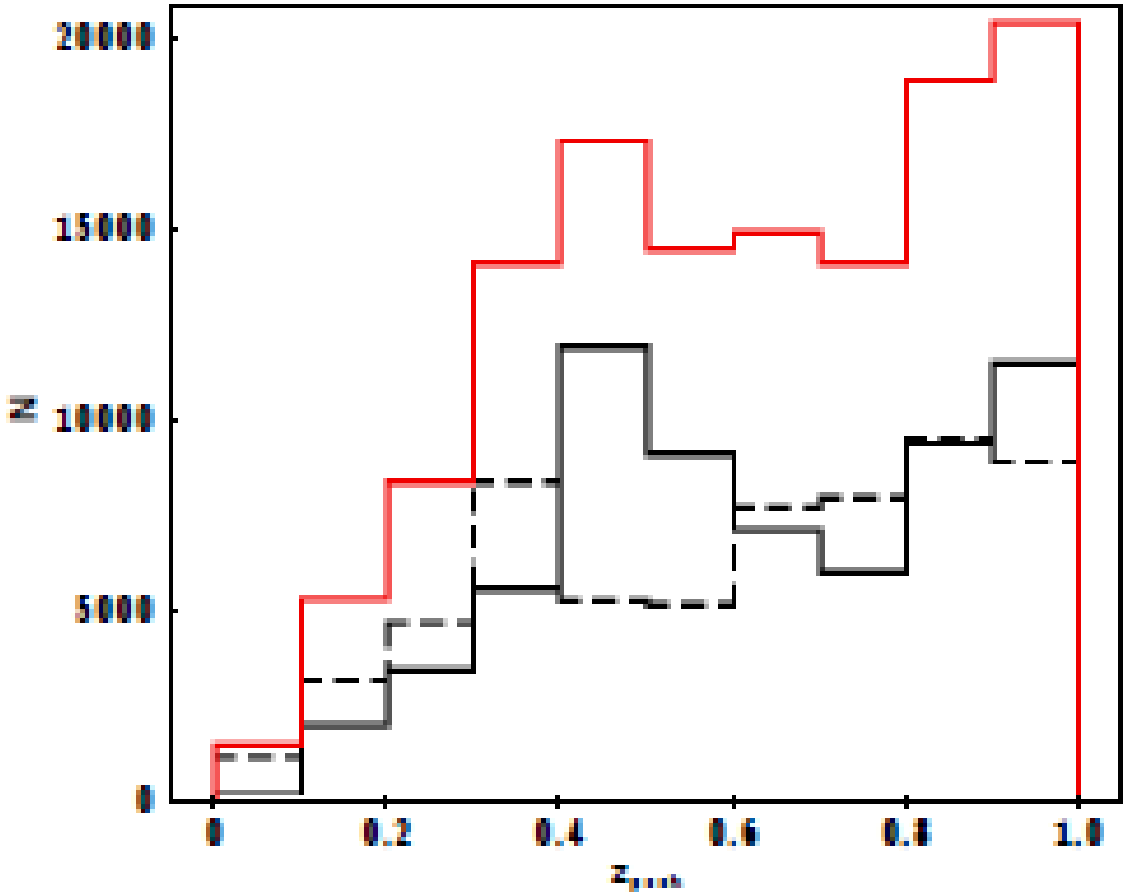




Cappellaro+2015

One corrected for hidden CC SN (Mattila+ 12) our data agree more with M&D+14 SFH

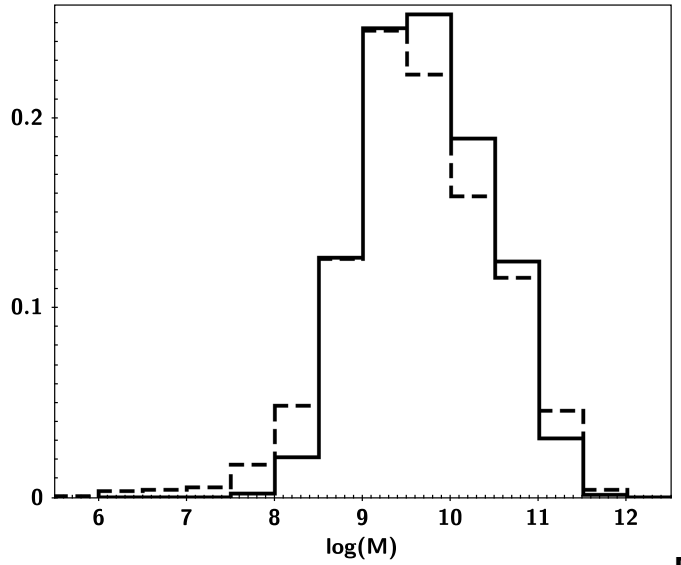
The dispersion of the rate measurements for SNe Ia still do not allow to disentangle among the two different progenitor scenarios.

# Galaxies redshift distribution

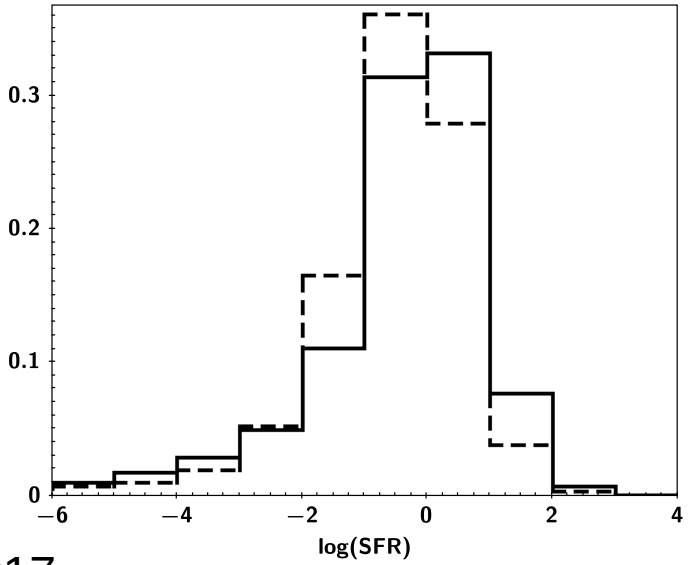



Galaxies redshift obtained with EASY (Baramer+08)

# Galaxies mass, SFR & sSFR estimation

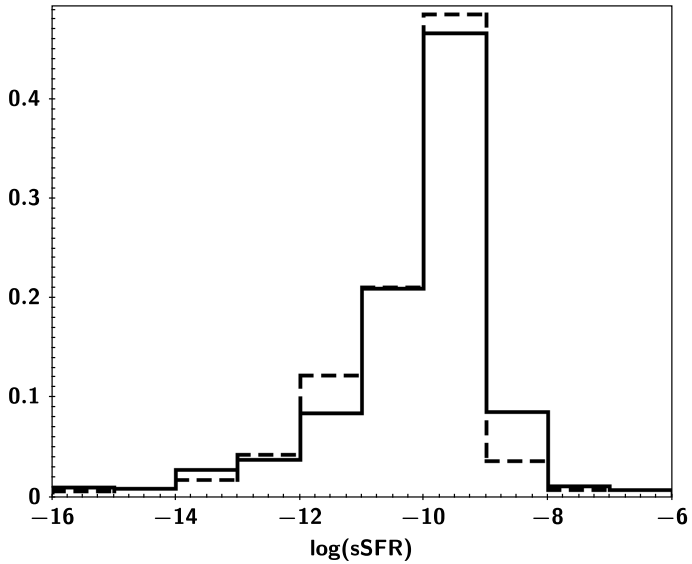



**MASS**




**SFR**

Botticella+2017



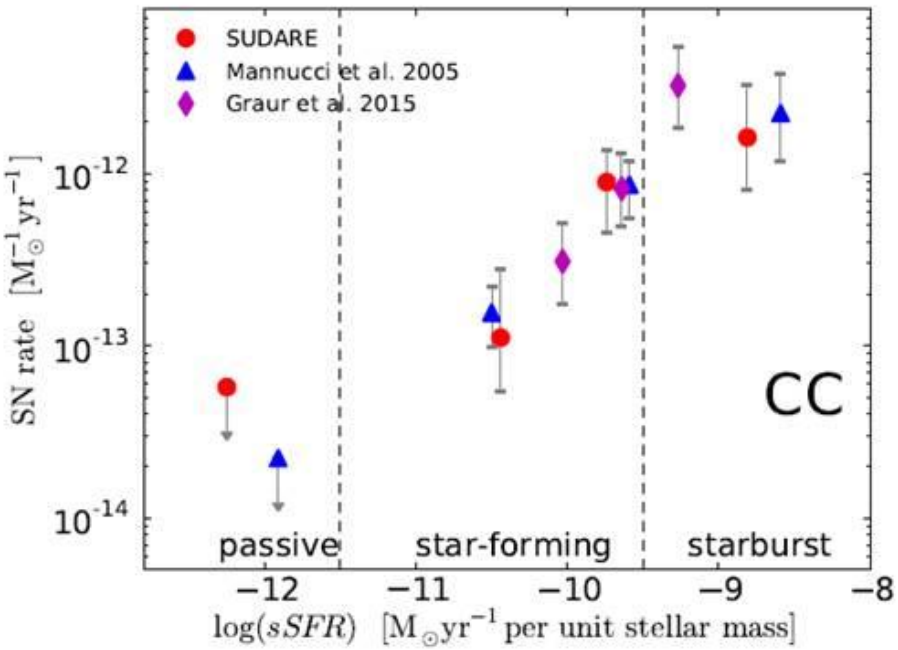

**sSFR**

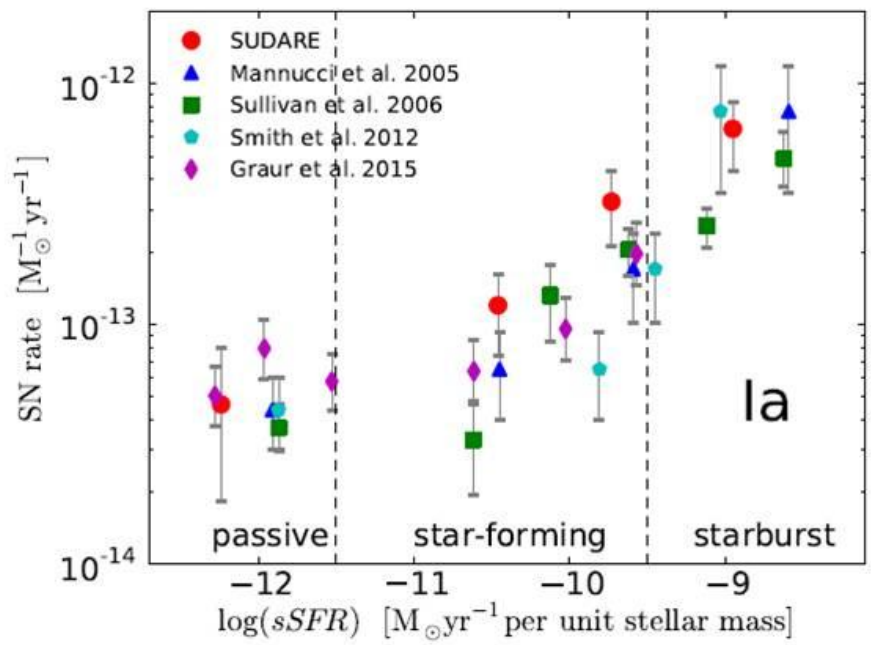
Galaxies Mass and SFR with FAST5 code (Kriek+09)

To select the galaxies we applied the following cut:

$K_s < 23.5$ $0.15 < z < 0.75$ $Qz < |1$

# Rate per unit of mass in function of the specific star formation

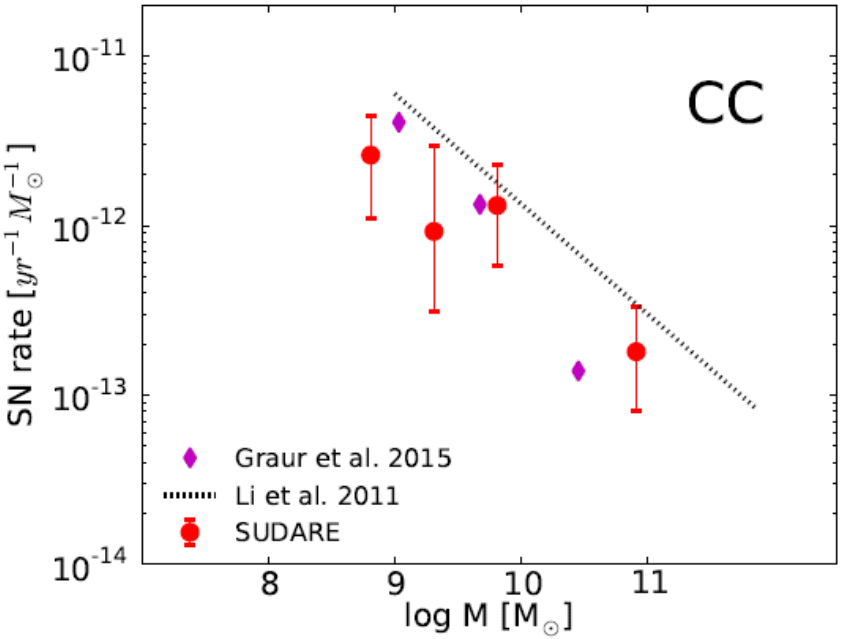


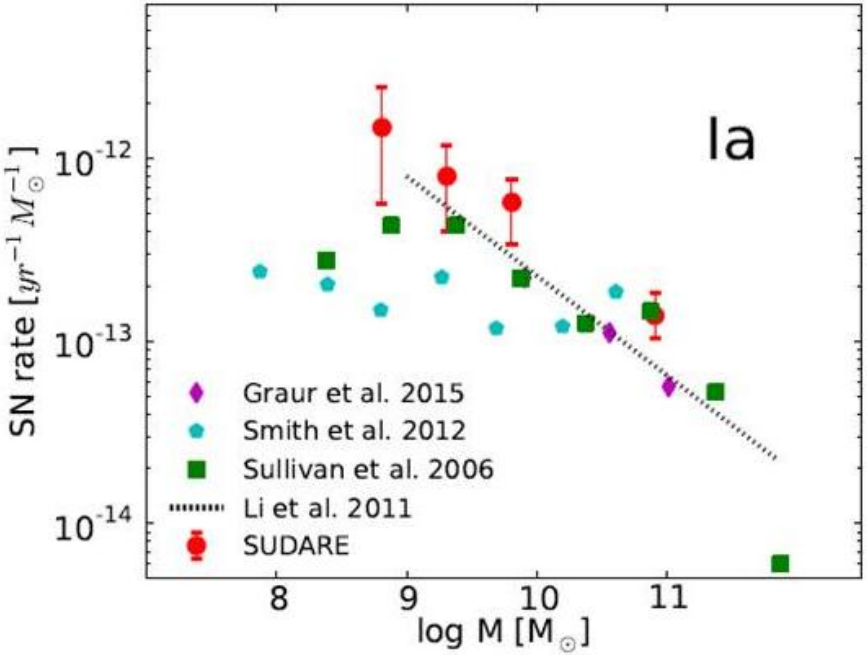




Botticella+2017

We found that the SN Ia rate per unit mass is higher in the star-forming galaxies with respect to the passive galaxies suggesting DDT less populated at long delay times than at short delays

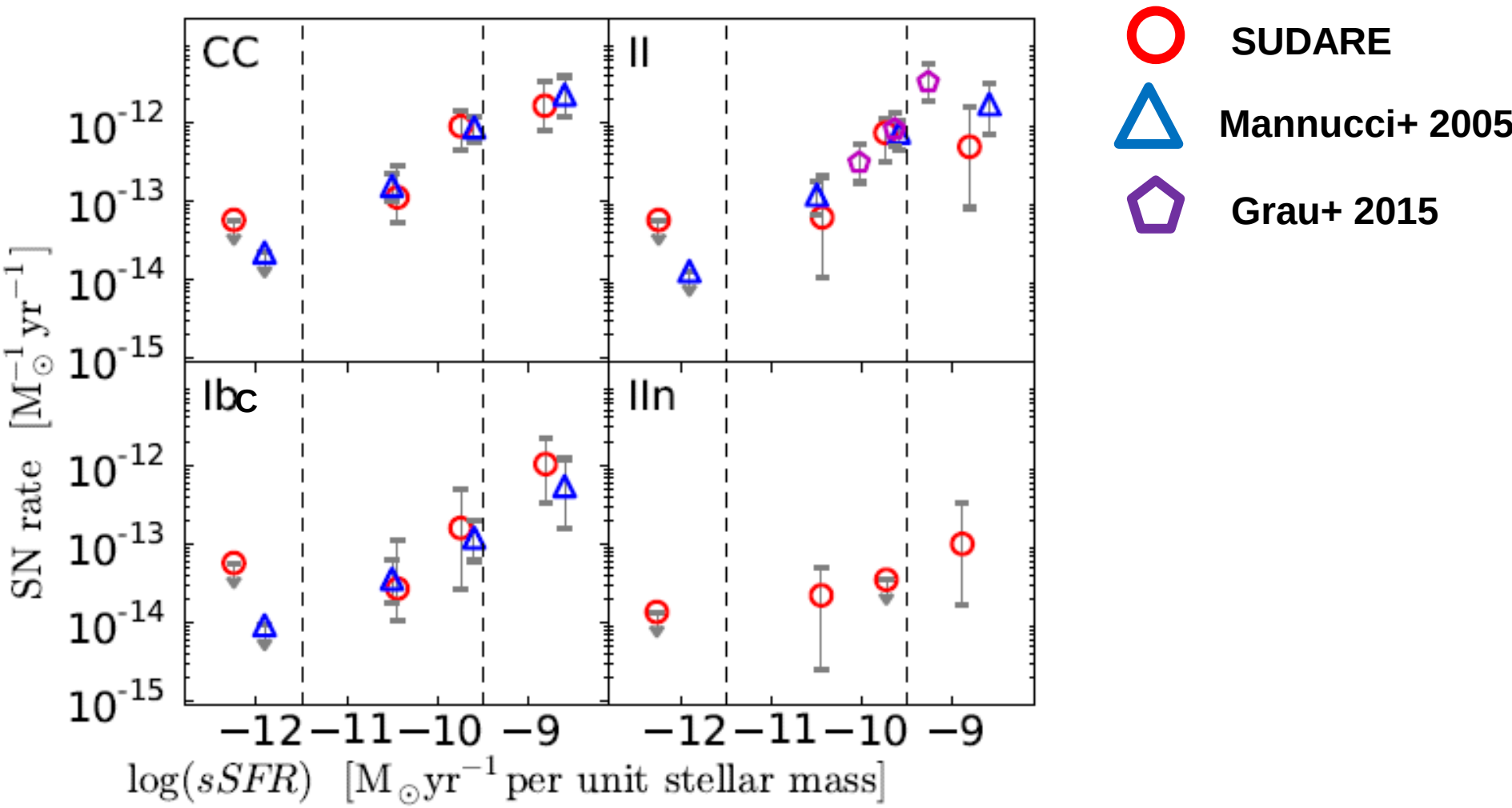
# Rate per unit of mass in function of the galaxy mass




Botticella+2017

# CC SN subtype rate



# Work in progress

Improve the photometric classification.

Compare the IR SN rates with optical SN rate on the full SN sample.

# Summary

In the volumetric rate, the expected number of CC SN is compatible with what predicted assuming SFH of M&D+14. But at higher redshift some problems still exists

We found that the SN Ia rate per unit mass is higher in the star-forming galaxies with respect to the passive galaxies Confirming the suggestion that DDT less populated at long delay times than at short delays.

There still a lot of room to improve extinction correction and photometric classification.

Thank you