Study of the redshift completeness of the zwicky transient facility survey with supernovae

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ZTF completeness redshift from Supernovae

- Goal of the study
- Method and tools
- Results (preliminary)
- Next steps

- ZTF is a astronomical survey based on the detection of transient objects such as supernovae.
- Type Ia supernovae (SNe Ia) are standardizable thus representing precise and reliable distance indicators.
- The Hubble diagram of SNe Ia can be used to measure accurately cosmological parameters.

- ZTF is a flux-limited survey with observations affected by the Malmquist bias : a larger number of bright SNe Ia is observed at high-redshift → distance measurements are biased.

- Bias effects appear for $z \geq z_{complete}$ (redshift completeness)
- Malmquist bias effects can be corrected for but :
  - source of systematic uncertainties ($z \geq z_{complete}$)
  - impact on $N_{SN}(z)$ with a decrease if $z \geq z_{complete}$

$z_{complete}$ has an impact on the fraction of higher-z SNe Ia critical to measure cosmological parameters with high accuracy.

Method to estimate $z_{complete}$

- Use faint SNe Ia
- $z_{complete}$
  - faint SNe Ia can not be observed = inaccurate measured distances

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quality criteria (light curve+SN parameters)

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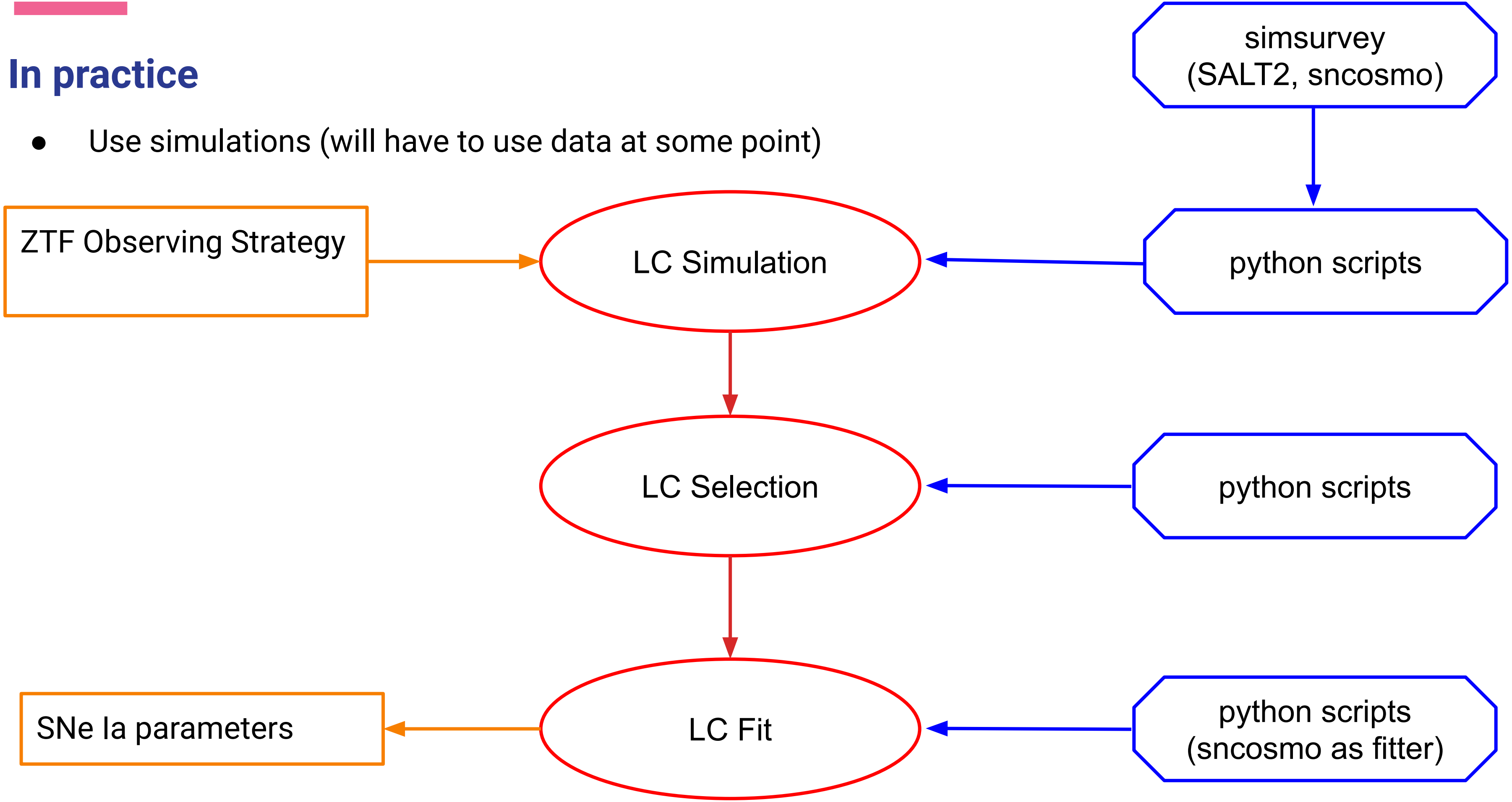
Observing Strategy (cadence, number of visits per night, …)

In practice

- Use simulations (will have to use data at some point)



Simulation of light curve

Install simsurvey
install simsurvey_tools and different files in data

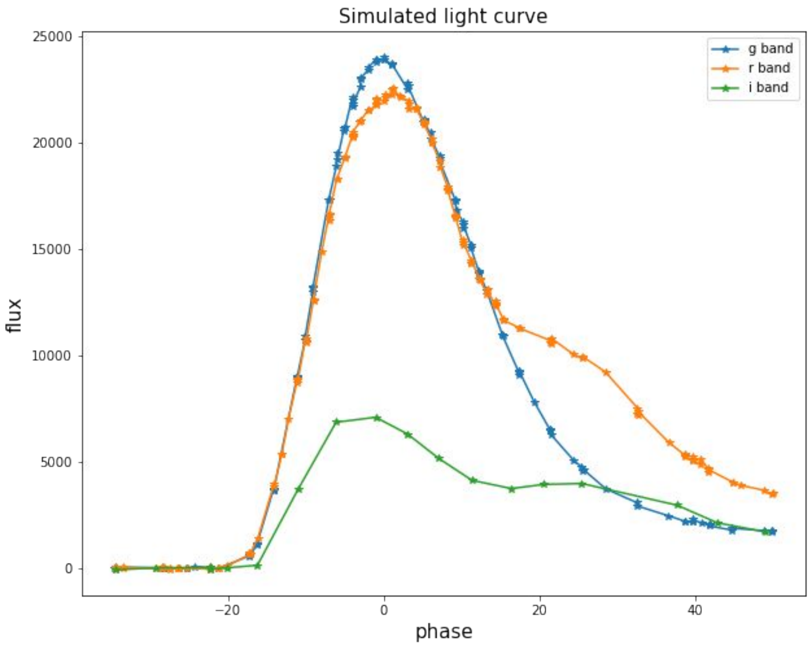
https://github.com/ZwickyTransientFacility/simsurvey

Generate light curves

↓

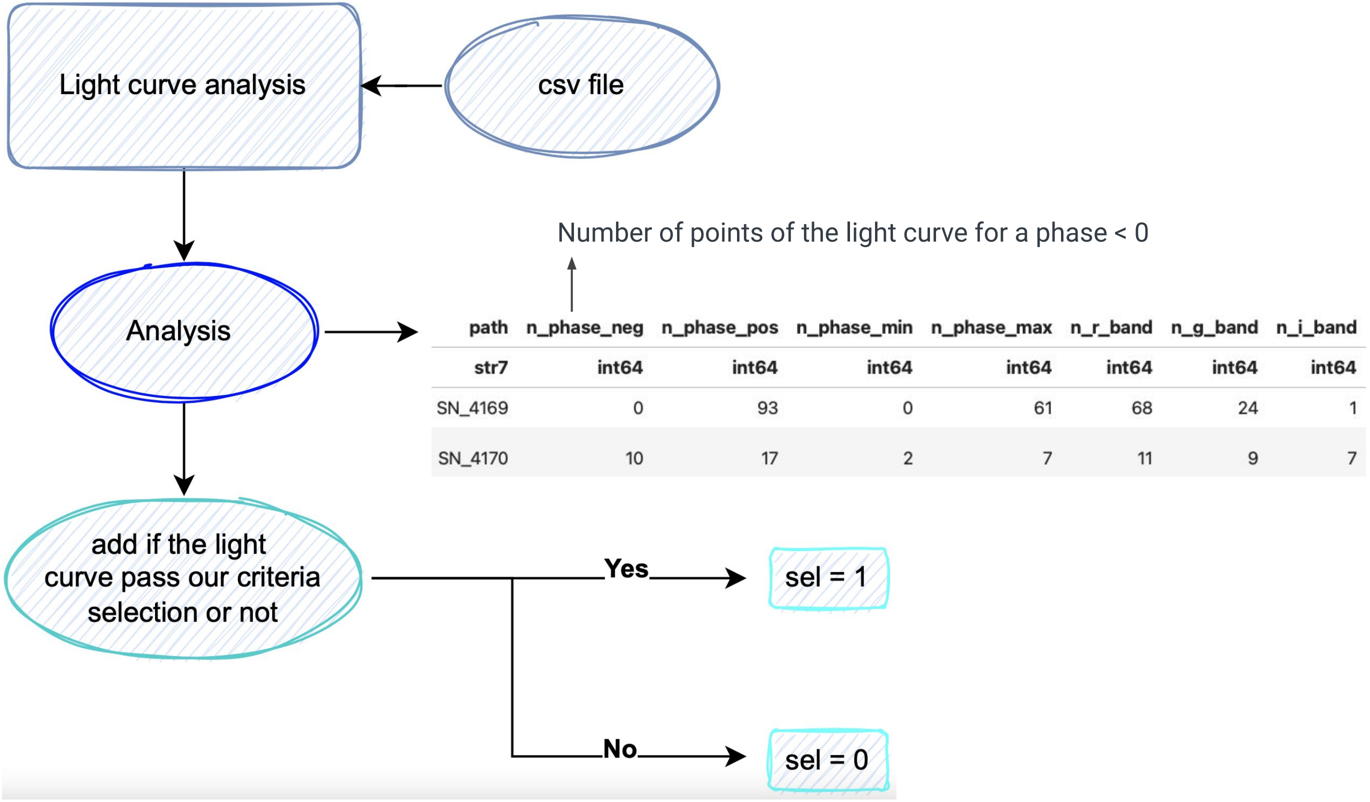
Writting data and meta data on hdf5 file

Parameters
number of transient
range redshift : (0.01, 0.1)
seed : 70
ndet (required number of detection) : 1
threshold (S/N for detection) : 1
template : salt2



Analysis

- $SNR > 1$
- $N_{LC_p}(phase < 0)$
- $N_{LC_p}(phase > 0)$
- $N_{LC_p}(phase_{min})$
- $N_{LC_p}(phase_{max})$
- $N_{LC_p}(g_{band})$
- $N_{LC_p}(r_{band})$
- $N_{LC_p}(i_{band})$



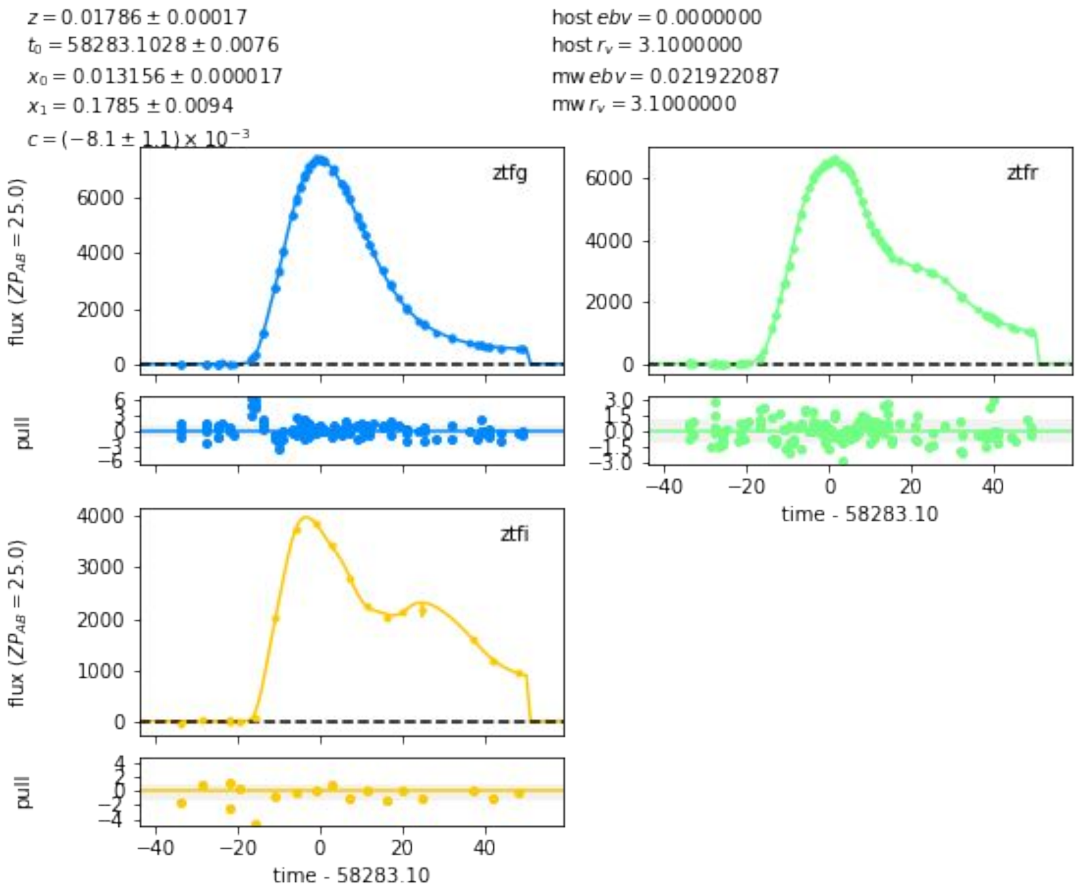
path	n_phase_neg	n_phase_pos	n_phase_min	n_phase_max	n_r_band	n_g_band	n_i_band
str7	int64	int64	int64	int64	int64	int64	int64
SN_4169	0	93	0	61	68	24	1
SN_4170	10	17	2	7	11	9	7

Fit

Fit parameters
• z not fixed by default
• z bounds : (lc_z - 0.001, lc_z + 0.001)
• source : salt2-extended, version 1.0
• effects : dustmap
• model set mwebv extinction

LC selection :

- $Nb_{phase<0} \geq 4$
- $Nb_{phase>0} \geq 10$
- $Nb_{phase\leq 10} \geq 1$
- $Nb_{phase\geq 20} \geq 1$



Error on color parameters

$\mu = M_b + \alpha x_1 - \beta_c$

$\sigma_\mu = f(\sigma_{M_b}, \sigma_{x_1}, \sigma_c, \sigma_{x_1 c})$

We observe that : $\sigma_\mu \approx \beta\sigma_c$ with β considered as known and $\beta = 3$.

For 2 SNe Ia with the same x_1 and c we observe that their intrinsic dispersion is $\approx \sigma_{\text{int}} = 0.12$.

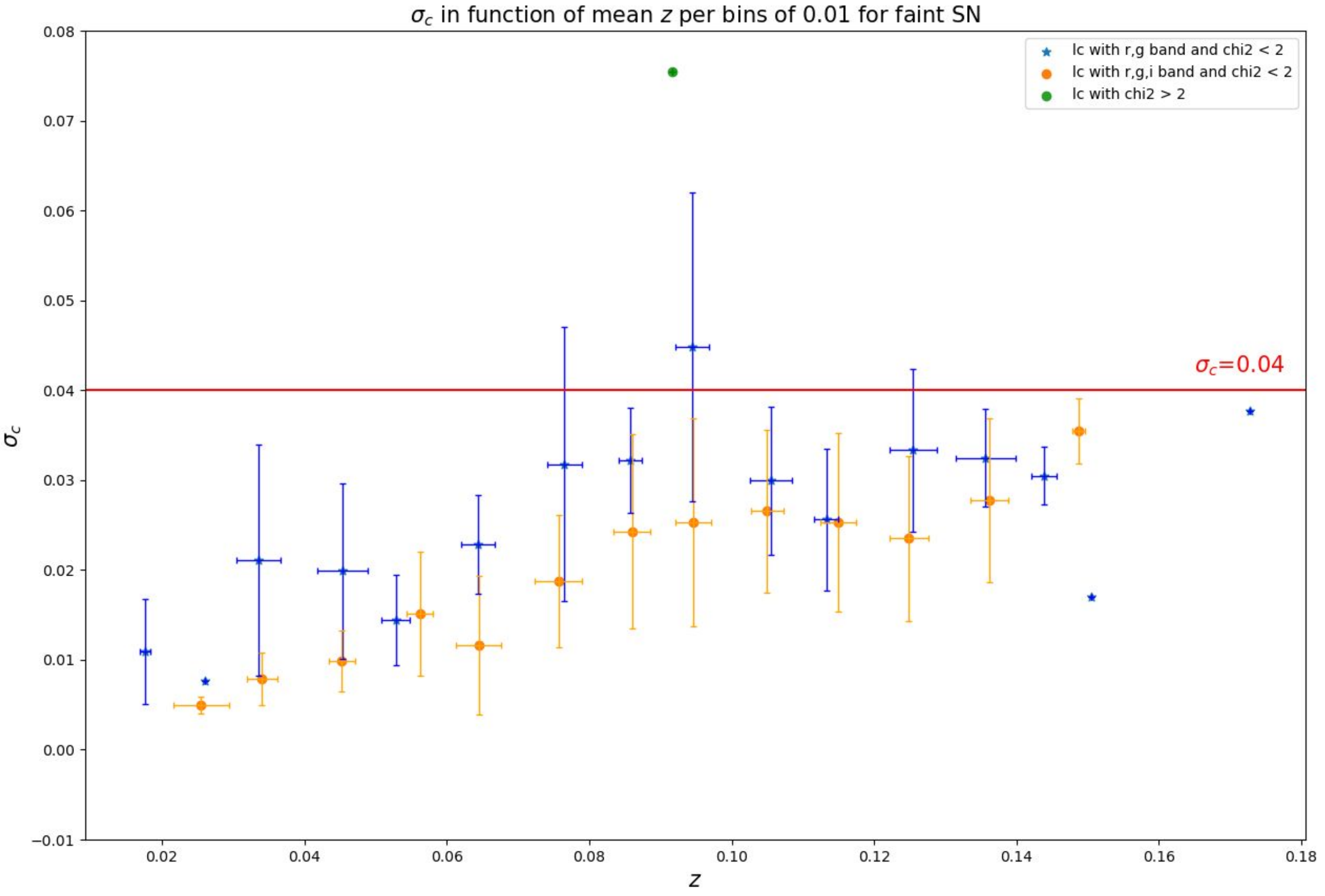
To distinguish 2 Sne Ia : σ_c have to be $< \sigma_{int}$:

$\sigma_c \approx \beta\sigma_c < 0.12$

$\sigma_c \approx 3\sigma_c < 0.12$

$\sigma_c < 0.12/3 = \mathbf{0.04}$

Result



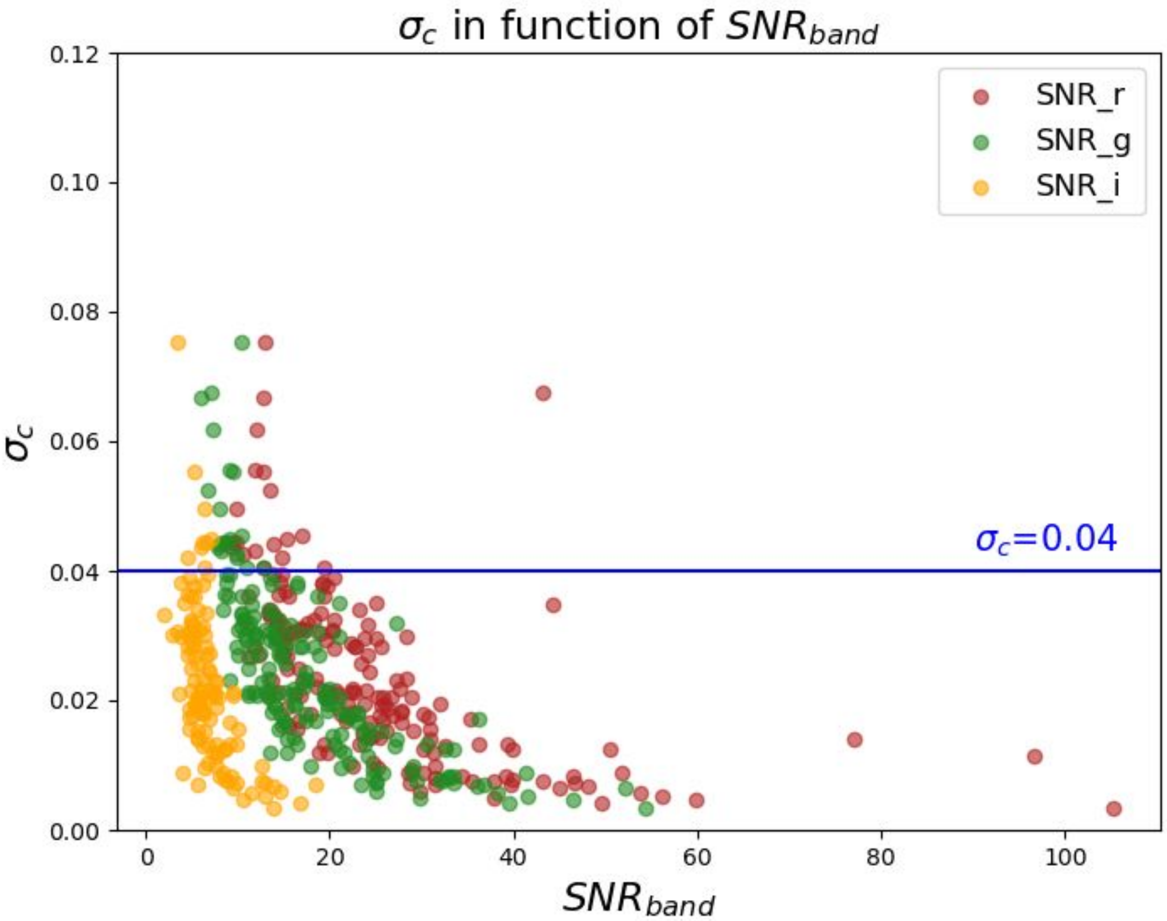
σ_c in function of mean z per bins of 0.01 for faint SN
lc with r,g band and chi2 < 2
lc with r,g,i band and chi2 < 2
lc with chi2 > 2
σ_c=0.04
σ_c
z
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
−0.01
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18

Result

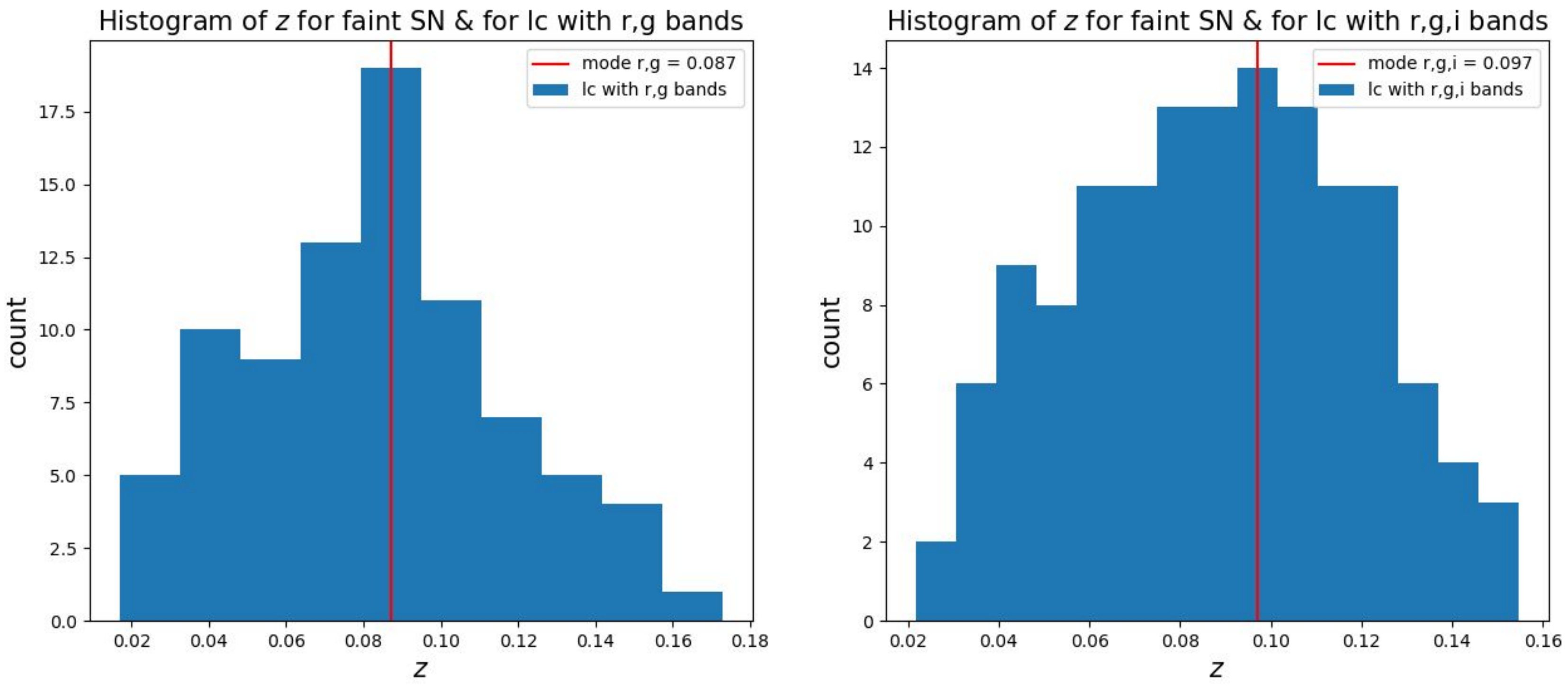
σ_c vs SNR_{band} for faint SNe Ia :

SNR = signal to noise ratio

$$SNR_{band} = \sqrt{\sum_{i=1}^{N} \left(\frac{flux}{flux_{err}} \right)^2}$$



Result


Histogram of z for faint SN & for lc with r,g bands
mode r,g = 0.087
lc with r,g bands
count
z
Histogram of z for faint SN & for lc with r,g,i bands
mode r,g,i = 0.097
lc with r,g,i bands
count
z

What is next

- Study of :
  - cadence
  - season length
  - number of visits per night

  -> correlations with $z_{complete}$

- Estimate $z_{complete}$ for areas of the sky → systematic scan of the space

- Study the impact of dust on light curve simulations