Probing local anisotropies using type Ia Supernova data

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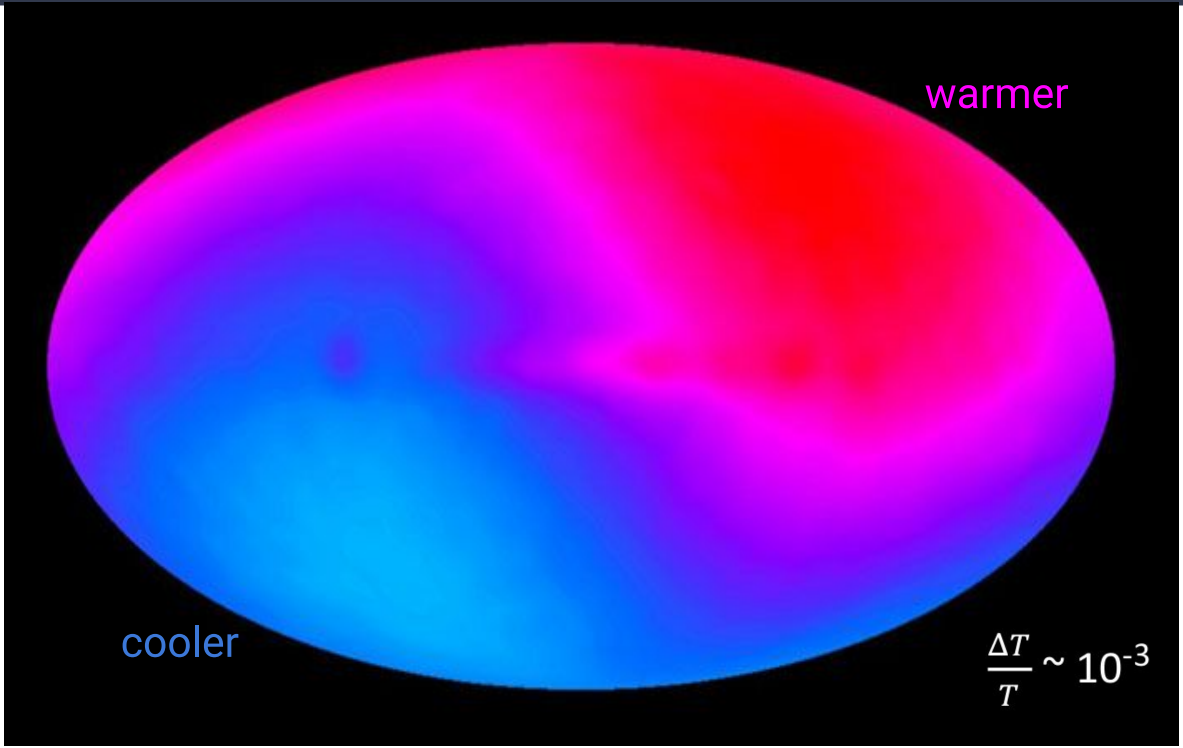
Speaker : Mélissa AMENOUCHE
(melissa.amenouche@clermont.in2p3.fr)
PhD Advisor : Philippe Rosnet

Anisotropies and bulk flow



Our Local Group motion
620 ± 15 km/s toward
l = 271.0 ± 2°,
b = 29.6 ± 1.4°
(Planck Collaboration I 2019)

Bulk flow with dipole method

- Dipole velocity model (Bonvin et al. 2006):

$$\tilde{d}_L(z,\vec{n},\vec{v_d}) = d_L(z) + \frac{(1+z)^2}{H(z)}\vec{n}.\vec{v_d}$$

isotropic universe   Effect of bulk flow

- Minimize χ^2-statistic to find dipole velocity :

$$\chi^2 = \sum_i \frac{\left|\mu_i - 5\log\left(\tilde{d}_L(z_i,\vec{n_i},\vec{v_d})\right) - 25\right|^2}{\sigma_i^2}$$

Anisotropies and bulk flow

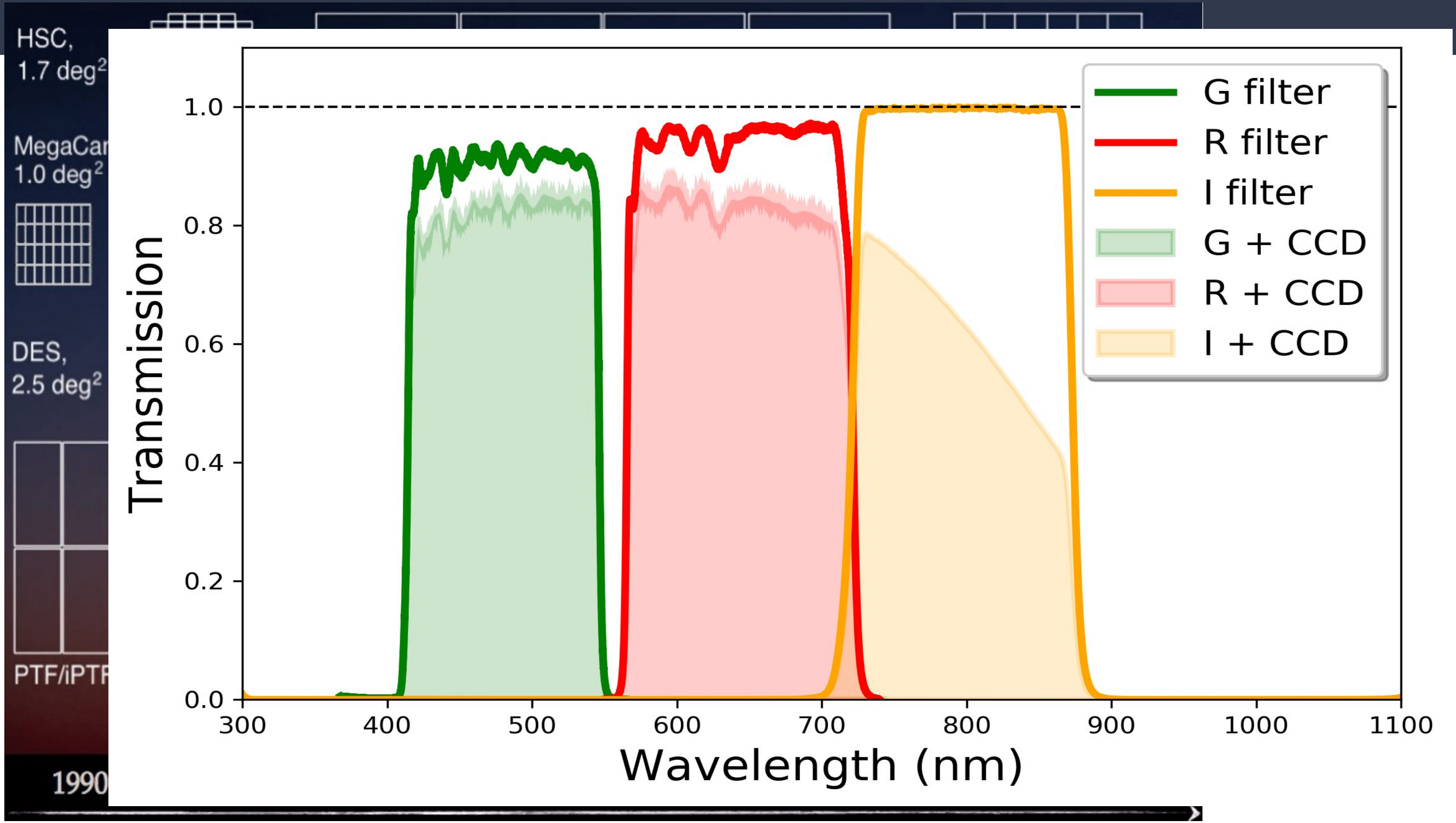
Reference	Obj. Type	No. Obj.	Redshift[a]	Distance[a] (h^{-1} Mpc)	v_{bf} (km s^{-1})	l (degree)	b (degree)
Kashlinsky et al. (2010)	kSZ	516	<0.12	<345	934 ± 352	282 ± 34	22 ± 20
		547	<0.16	<430	1230 ± 331	292 ± 21	27 ± 15
		694	<0.20	<540	1042 ± 295	284 ± 24	30 ± 16
		838	<0.25	<640	1005 ± 267	296 ± 29	39 ± 15
Dai et al. (2011)	SN Ia	132	<0.05	<145	188 ± 120	290 ± 39	20 ± 32
		425	>0.05	>145	⋯	⋯	⋯
Weyant et al. (2011)	SN Ia	112	<0.028	<85	538 ± 86	250 ± 100	36 ± 11
Ma et al. (2011)	galaxies and SN Ia	4536	<0.011	<33	340 ± 130	285 ± 23	9 ± 19
Colin et al. (2011)	SN Ia	142	<0.06	<175	260 ± 130	298 ± 40	8 ± 40
Turnbull et al. (2012)	SN Ia	245	<0.05	<145	245 ± 76	319 ± 18	7 ± 14
Feindt et al. (2013)	SN Ia	128	0.015–0.035	45–108	243 ± 88	298 ± 25	15 ± 20
		36	0.035–0.045	108–140	452 ± 314	302 ± 48	−12 ± 26
		38	0.045–0.060	140–188	650 ± 398	359 ± 32	14 ± 27
		77	0.060–0.100	188–322	105 ± 401	285 ± 234	−23 ± 112
Ma & Scott (2013)	galaxies	2404	<0.026	<80	280 ± 8	280 ± 8	5.1±6
Rathaus et al. (2013)	SN Ia	200	<0.2	<550	260	295	5
Appleby et al. (2015)	SN Ia	187	0.015–0.045	45–130	⋯	276 ± 29	20 ± 12
Planck Collaboration et al. (2014)	kSZ	95	0.01–0.03	30–90	<700	⋯	⋯
		1743	<0.5	<2000	<254	⋯	⋯

Some observations have detected bulk flow

No consensus on the dections

G. J. Mathews et al. (2016)

The Zwicky Transient Facility (ZTF) overview

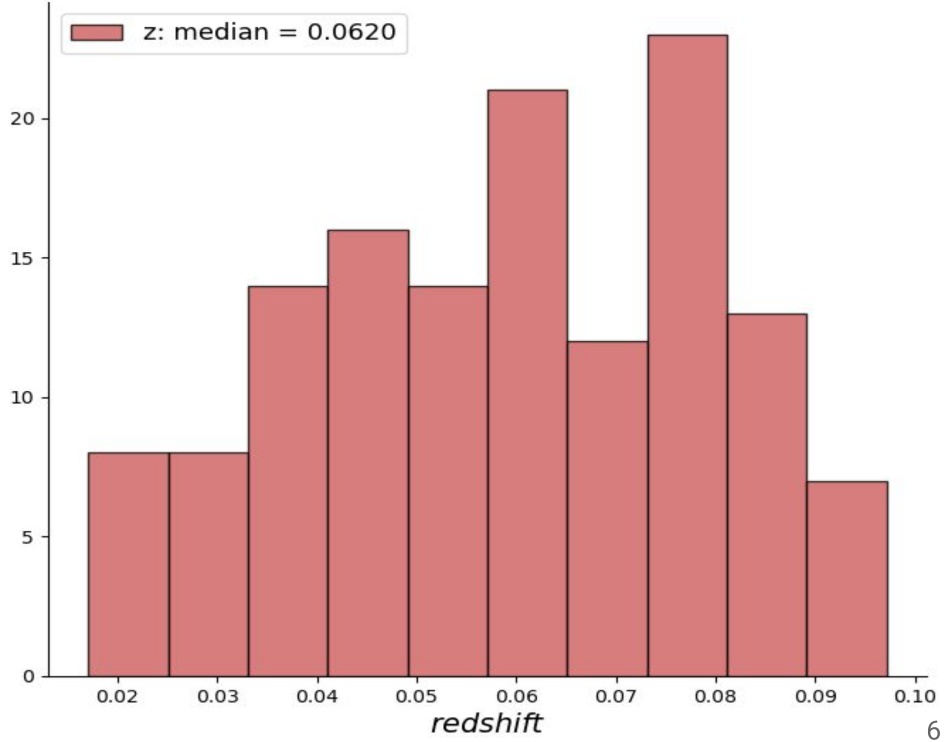


Sample Presentation

-First Year sample : ~ 300 Supernovae

-LC on G and R band

-Spectroscopic redshift

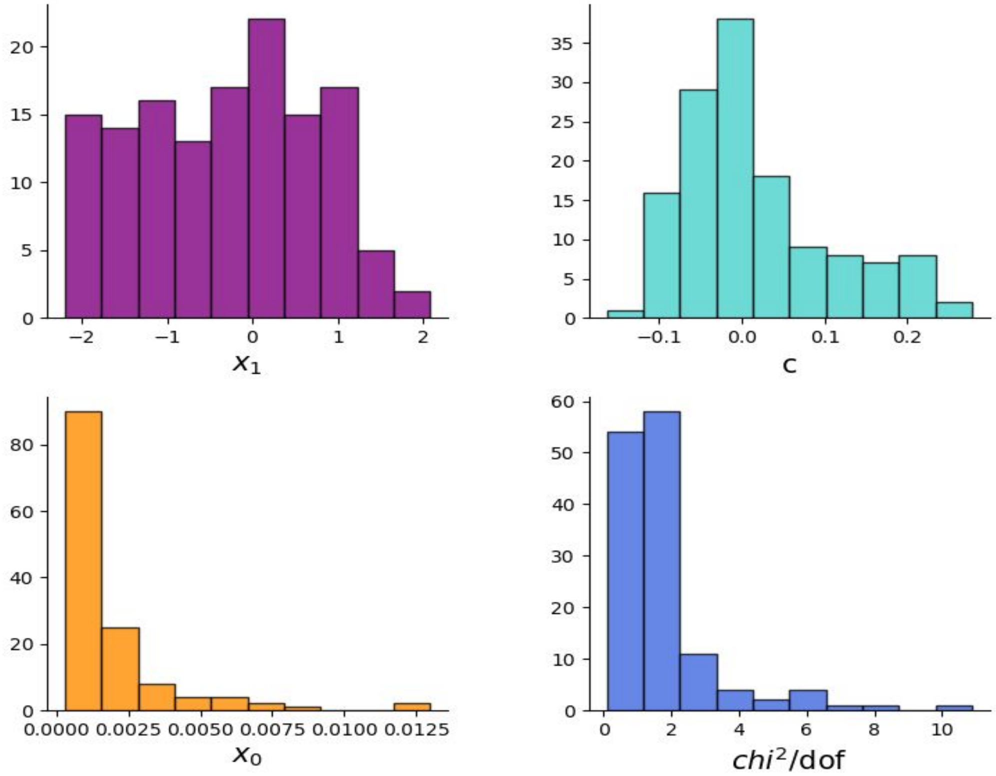


Cosmological sample : SALT2 parameters

Some criteria :

- at least 3 points between -10 and +10 days
- $-3 < \mathbf{x_1} < 3$
- $-0.3 < \mathbf{c} < 0.3$
- 4 sigma cut (to exclude outliers)

136 gold supernovae



Hubble diagram

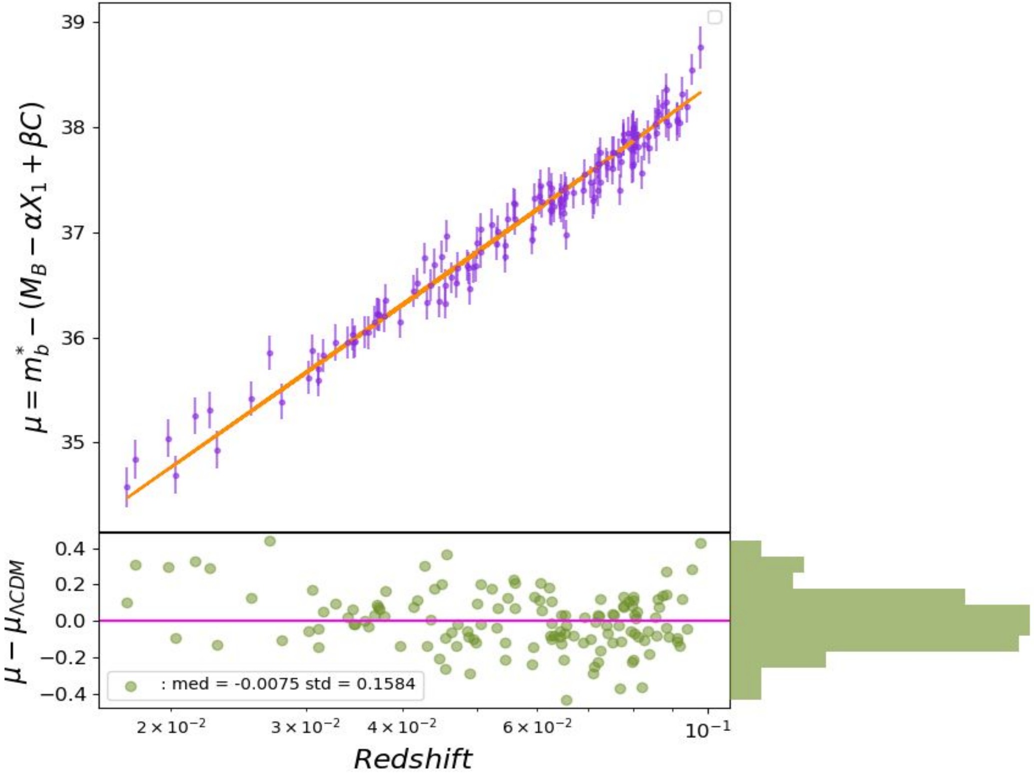
With :

$$\mu_{\Lambda CDM} = 5 \times \log_{10}(d_L) + 25$$

Fitting $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$, M_B and σ_{int} using :

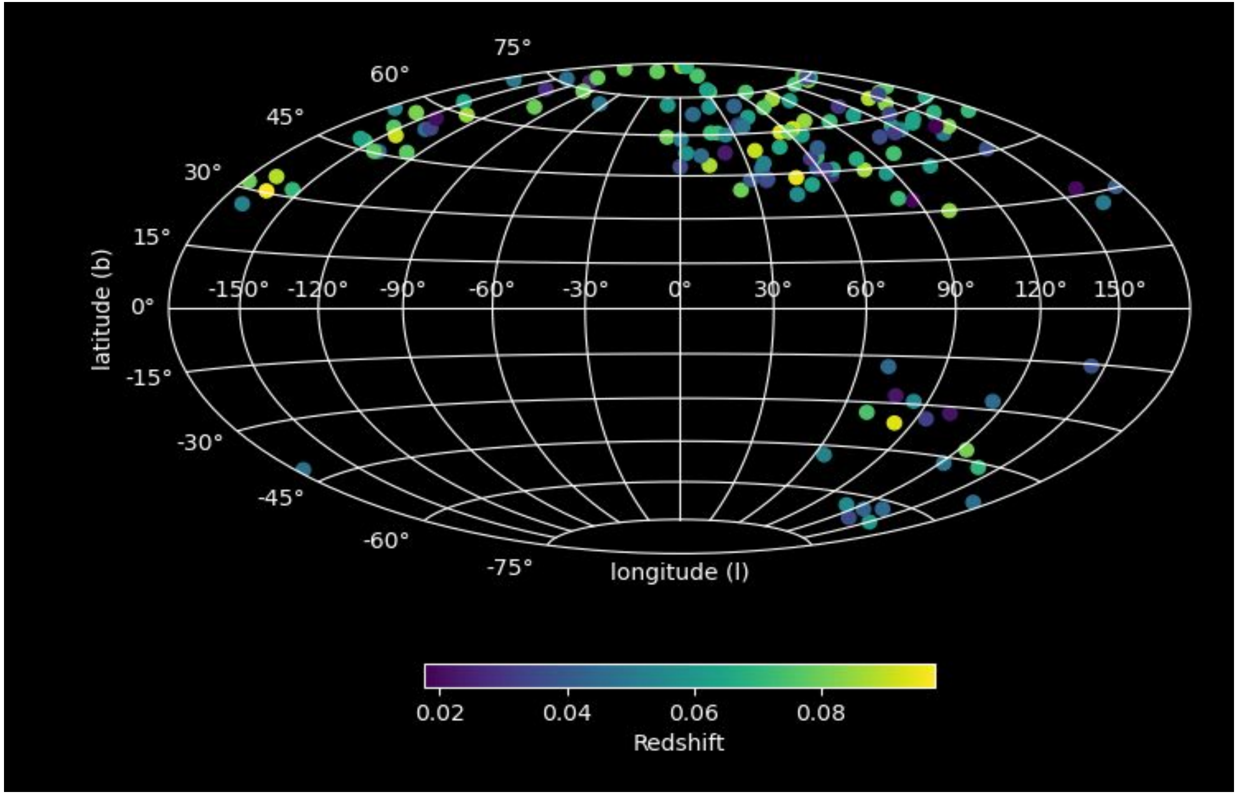
$$REML = \sum_i \omega_i(\mu_i - \mu_{\Lambda CDM})^2 -$$

(Betoule et al. 2014)



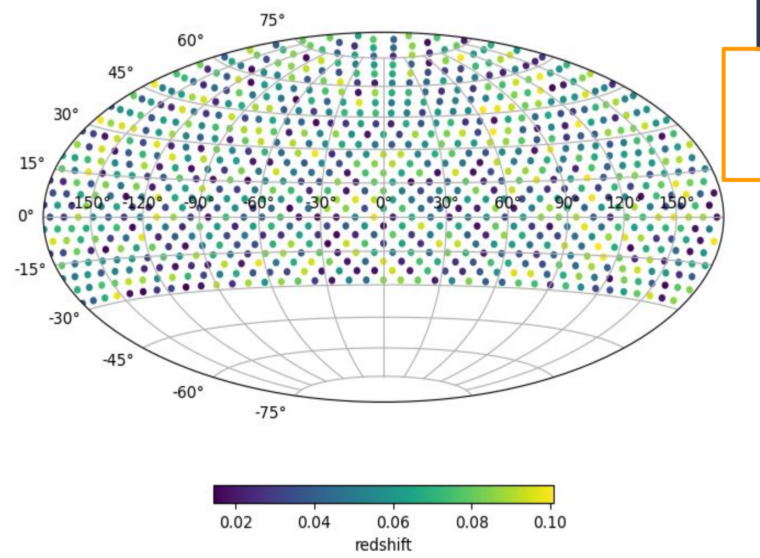
Errors source : salt2 fit and peculiar velocities

ZTF DR1 sky map

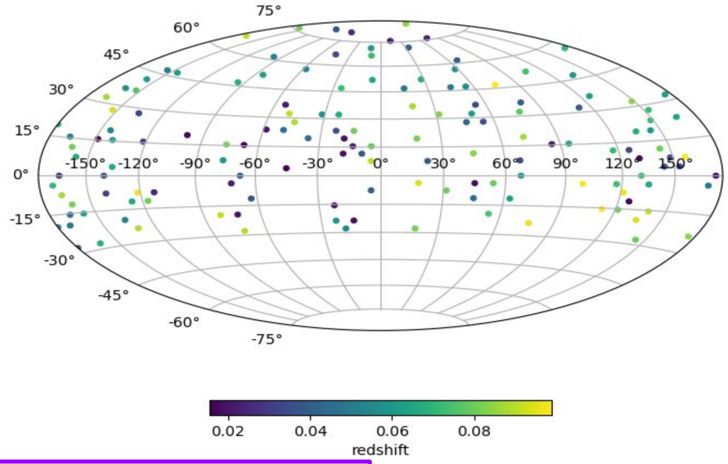


Simulations

n times



Generate couples of (ra, dec) in a sphere and associated reshift

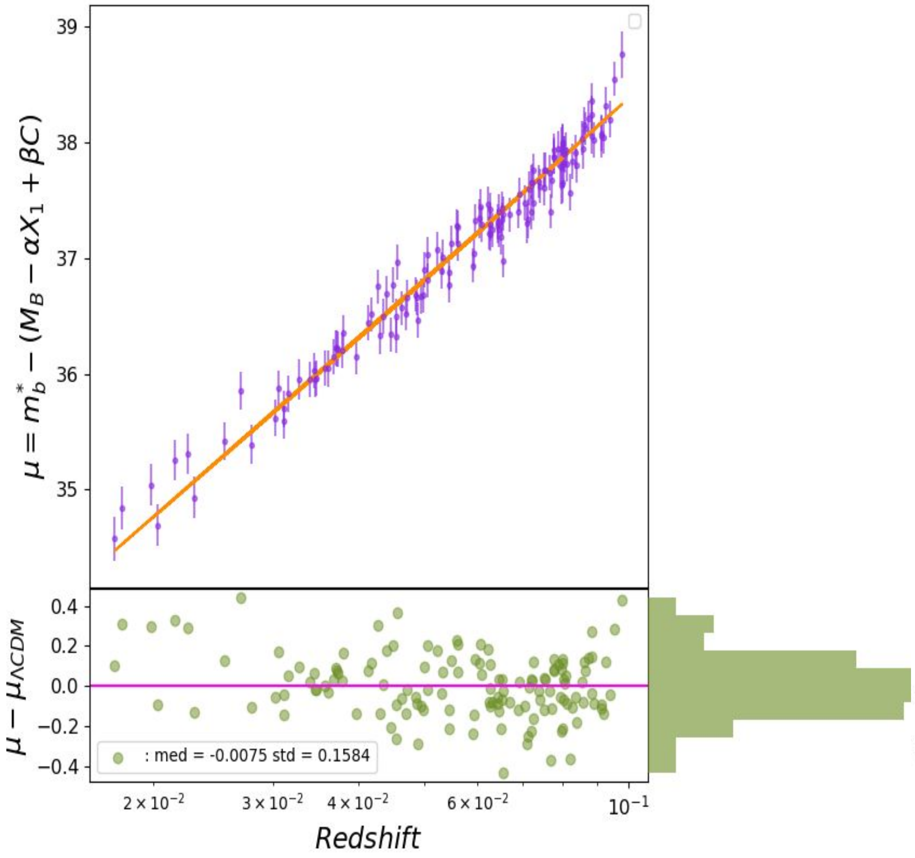


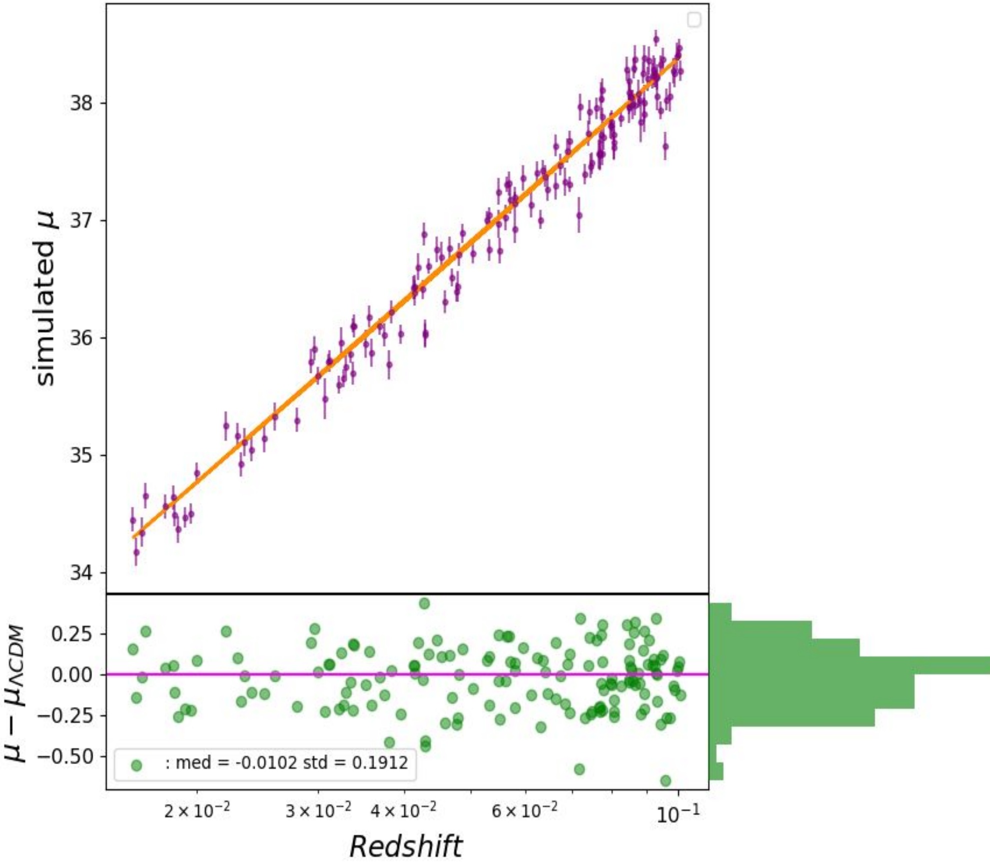
Select randomly a sample (same size as ZTF)

-Generate distance modulus and associated errors without any dipole
-Divide the sample into redshift shells
-Fit v_d, l_d, b_b

Glimpse on one run

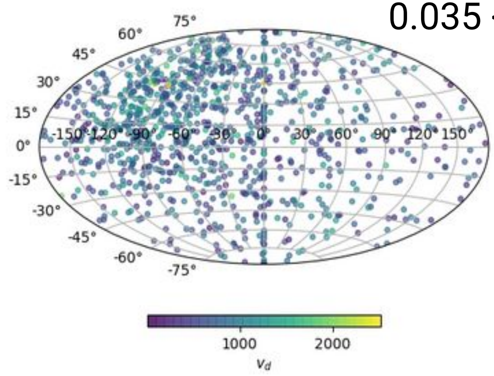
One simulation

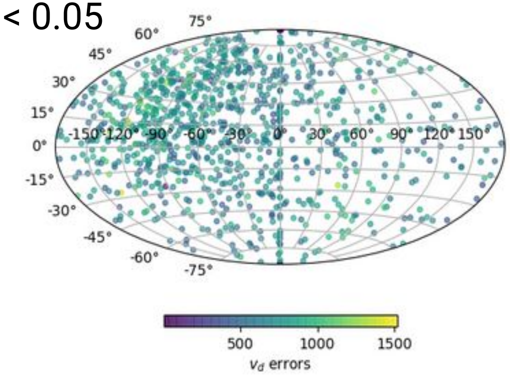


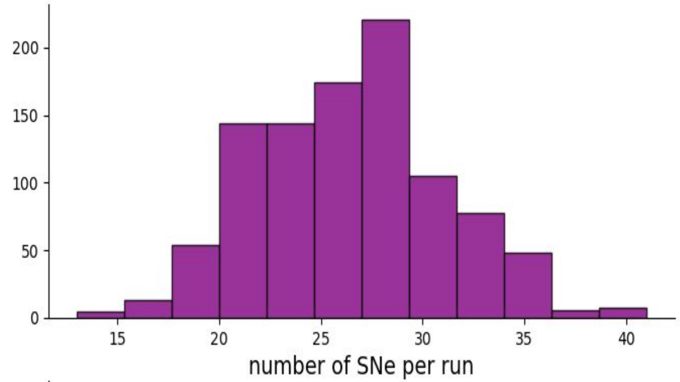


Dipole velocity maps (preliminary)

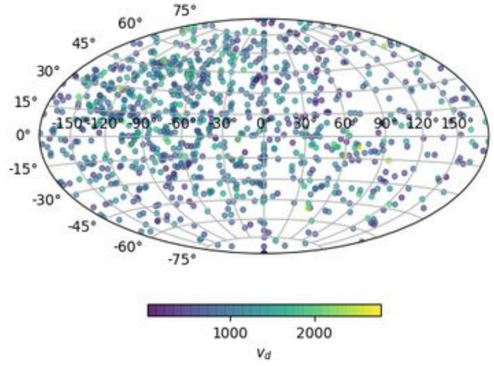
$0.035 < z < 0.05$

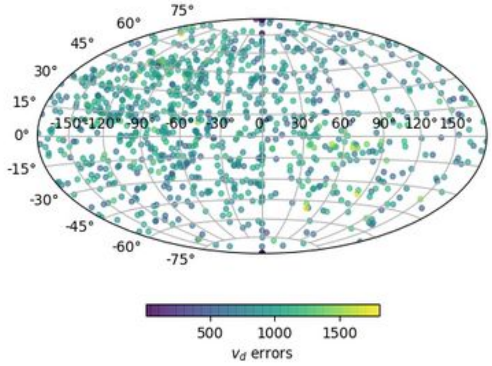


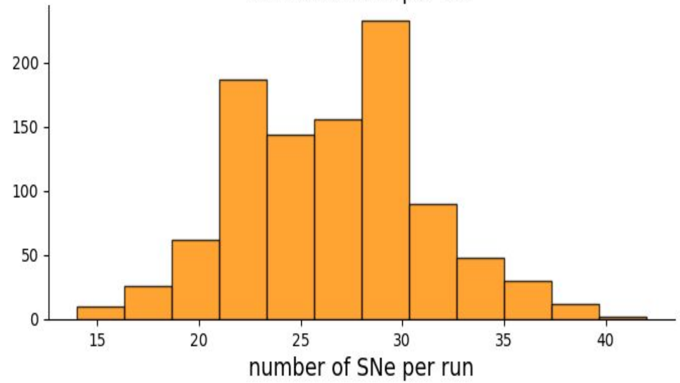




$0.05 < z < 0.065$







Prospectives

- Insert randomly dipole and catch it
- Apply on real data
- Improve the simulations (or use simsurvey) to investigate the systematics
- A joint fit : Hubble diagram and dipole