ZTF DR2 SNIa and the Large Scale Structure

Overview of current and future analyses

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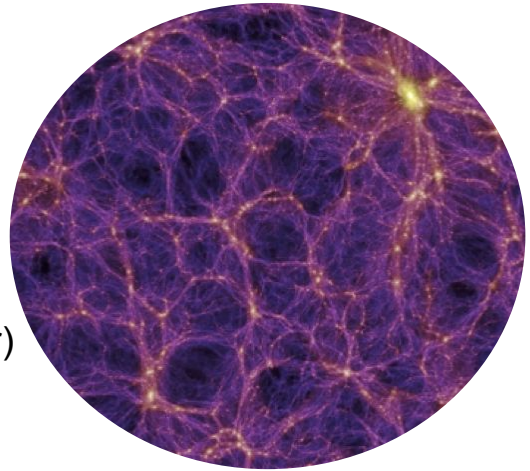
The large scale structure and the SNIa within.

The unprecedented statistic of ZTF SNIa samples the underlying galaxy density field, and subsequent Large Scale Structure (LSS).

LSS → Network of matter shaping large structures : Filaments, Voids and Clusters

Specific density environment for SNIa

→ SNIa properties (stretch and colour) dependent on LSS ?



SNIa also sensitive to growth of structure

→ Constrain structure growth with SNIa ?

ZTF SNIa and Voids

PRELIMINARY

Void sample

Low redshift galaxies :
DR7 SDSS VAGC galaxy catalogue
(Blanton 2005)

Redshift-limited : **z < 0.105 - ~300000 N_g**

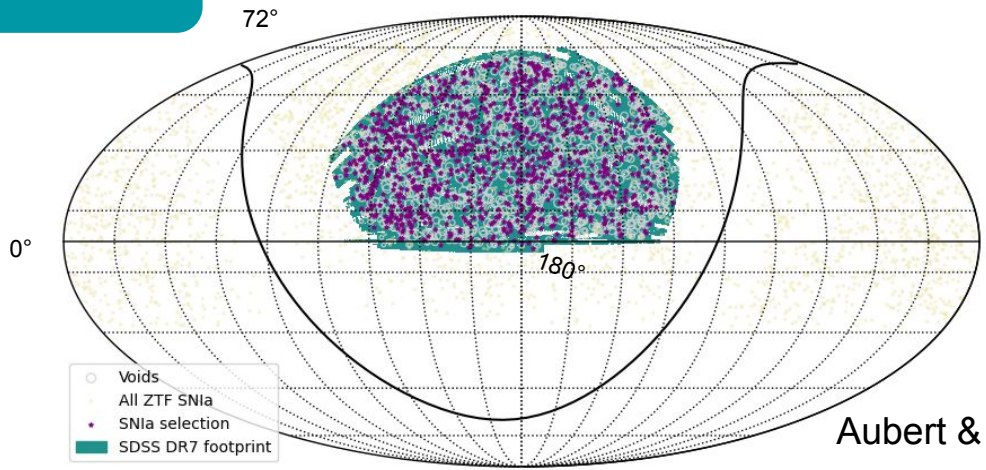
VoidFinder

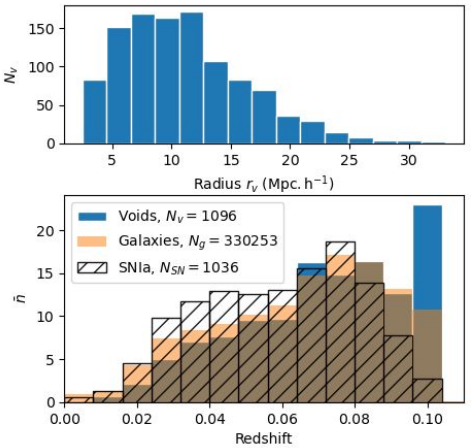
Voronoi tessellation based algorithm :
Revolver based on ZOBOV
(Nadathur 2019 , Neyrinck 2008)

~1000 N_v

SNIa sample

All SN available deep into the SDSS DR7 footprint with **z < 0.1 , ~1000 N_{SN}**





Aubert & al, in prep.

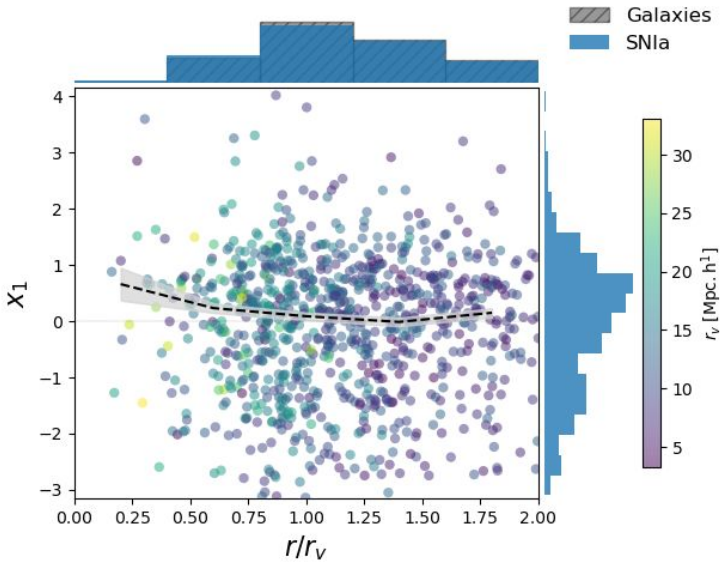
Intrinsic properties in the vicinity of voids

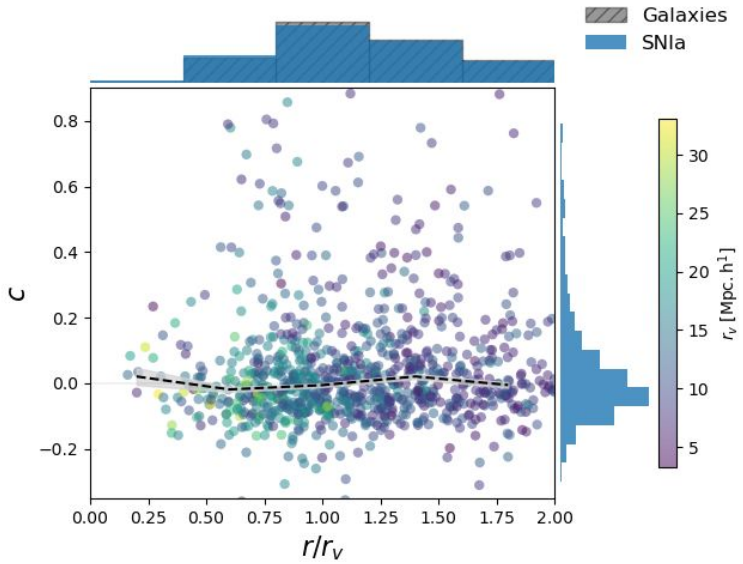
PRELIMINARY

Void centric distribution of the intrinsic parameters.

→ 3D distance matching between SNIa and void centre.

4% of SNIa at **0.5 r/r$_v$**





Aubert & al, in prep.

Intrinsic properties w.r.t local density

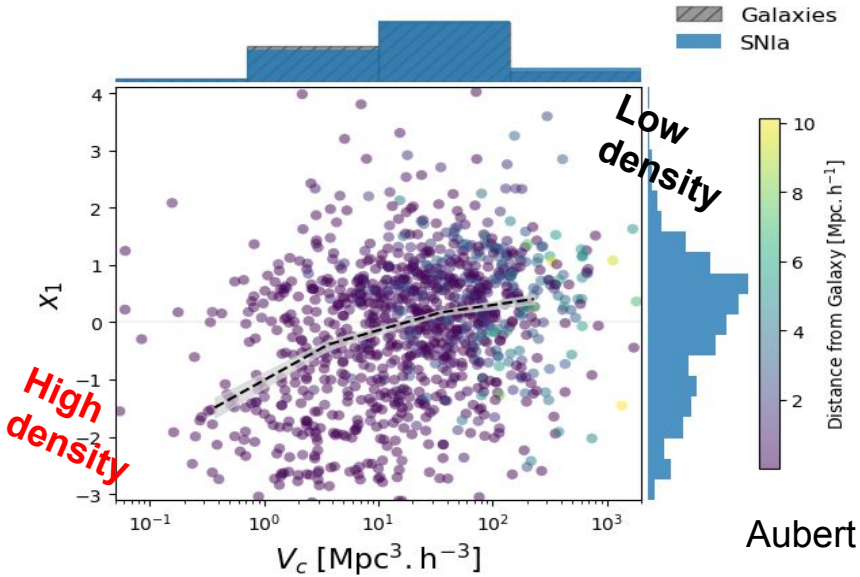
PRELIMINARY

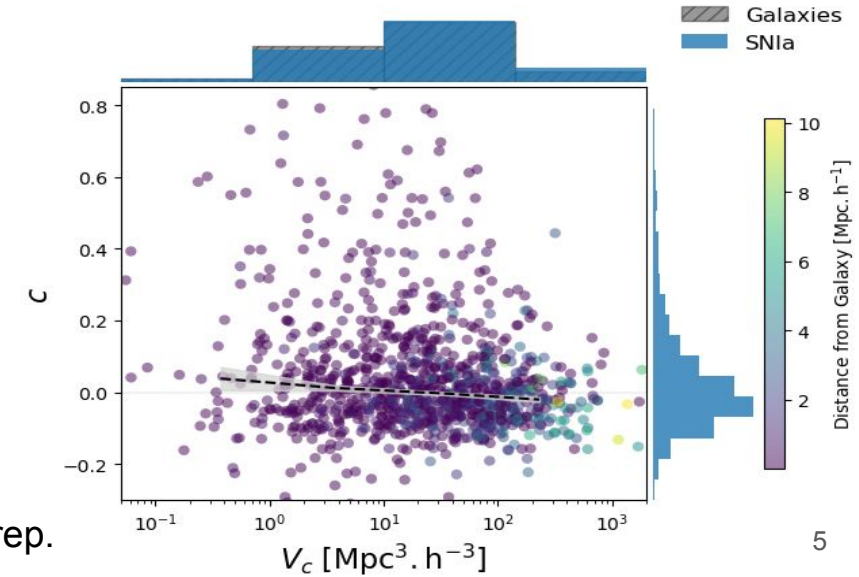
Voronoi volume distribution of the intrinsic parameters

Each galaxy is attributed a volume by the Voronoi Tesselation (*byproduct of the voidfinder)*

→ 3D distance matching between SNIa and nearest galaxy.

Property of the **Voronoi tesselation :** $1/V_c$ = local density.





Aubert & al, in prep.

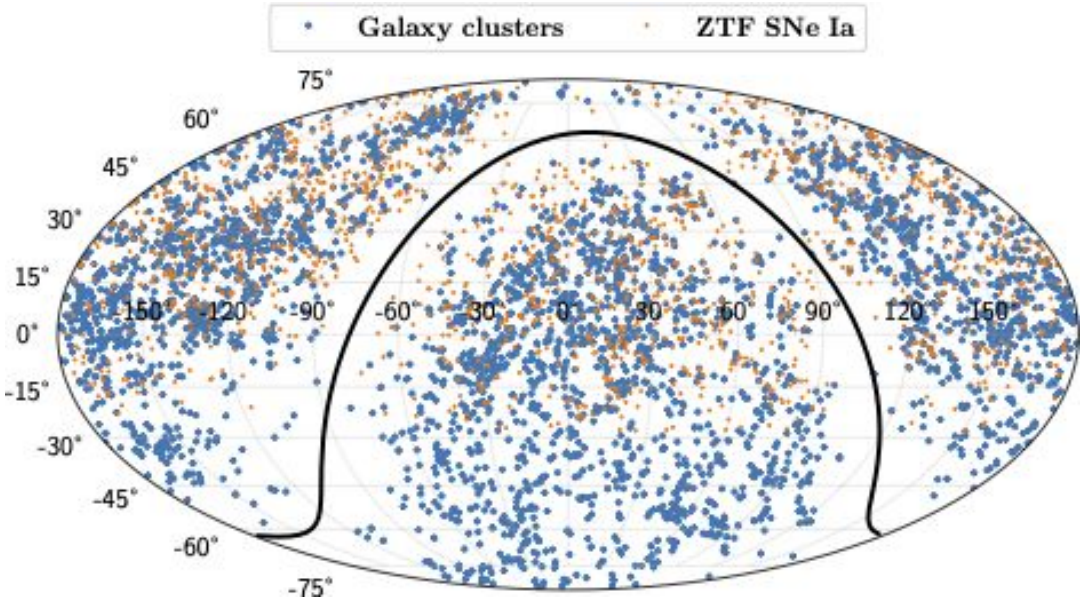
ZTF SNIa and Clusters

Cluster sample

7913 galaxy clusters selected.
→ Multiple detection various surveys
Planck SZ-2, MCXC, SPT, ACT, SDSS

1457 SNIa selected
→ Colour -0.3 < c < 0.3
→ Stretch -3 < x_1 < 3
→ Good light curve sampling

SNIa sample



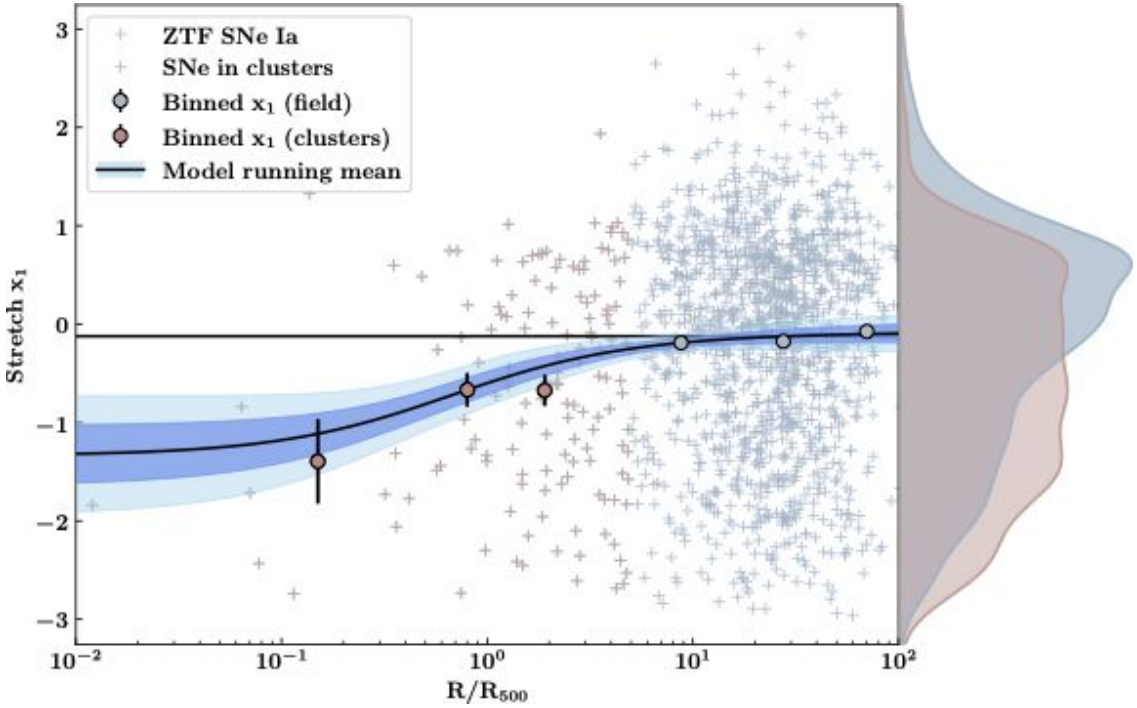
Ruppin et al, in prep

Intrinsic properties w.r.t r/R_{500}

PRELIMINARY

Strong dependency of the stretch w.r.t r/R_{500}

→ 3D matching between SNIa and nearest cluster.



~10% of SNIa are within 5 R_{500}

Stretch evolves with R_{500}

Ruppin et al, in prep

Modelling the environmental drift

PRELIMINARY

Stretch distribution can be modelled by two populations.

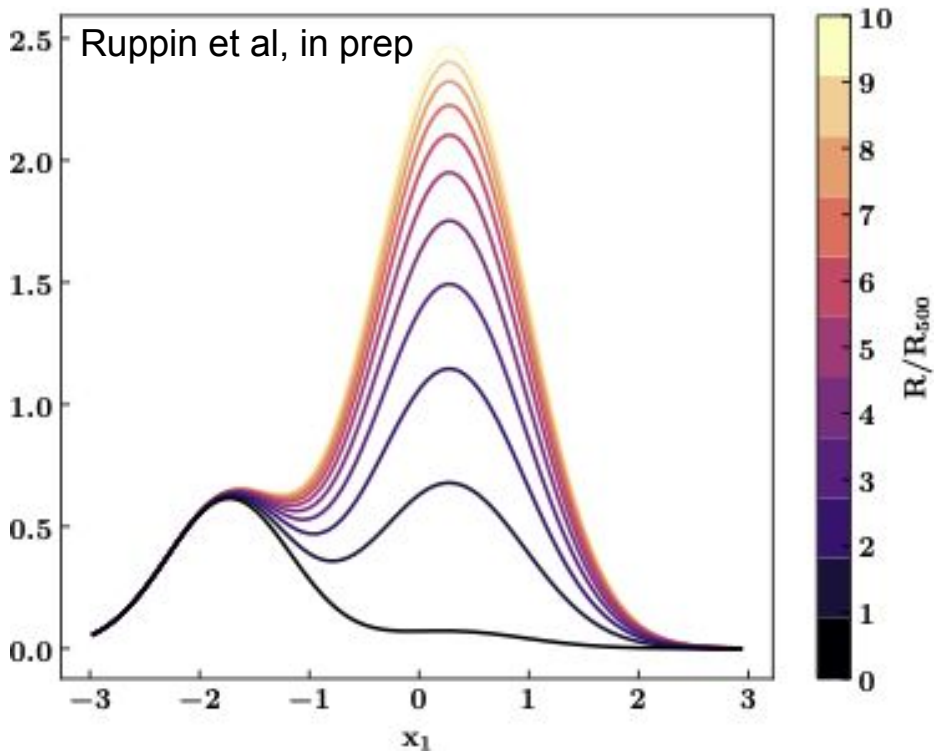
→ The stretch distribution varies in redshift (Nicolas et al 2021)

Redshift drift

→ The stretch depends on proximity to over(under) dense environment :

Environmental drift

Can be modelled as a function of r/R_{500}



Redshift + Environmental drift modelled SNIa stretch PDF.

Are SNIa properties dependent on LSS environment ?

There is indeed an environmental drift for the stretch.

No dependency was detected for the colour.

Can SNIa peculiar velocities constrain cosmology ?

As for all redshifts, SNIa's contain information of peculiar velocities (PV)

$$1 + z_{\rm obs} = (1 + \bar{z})(1 + \frac{v}{c})$$

Cosmo

Peculiar velocities :
Growth + additional effects

Dual information from the SNIa → Distance modulus and redshift

Peculiar velocities and SNIa

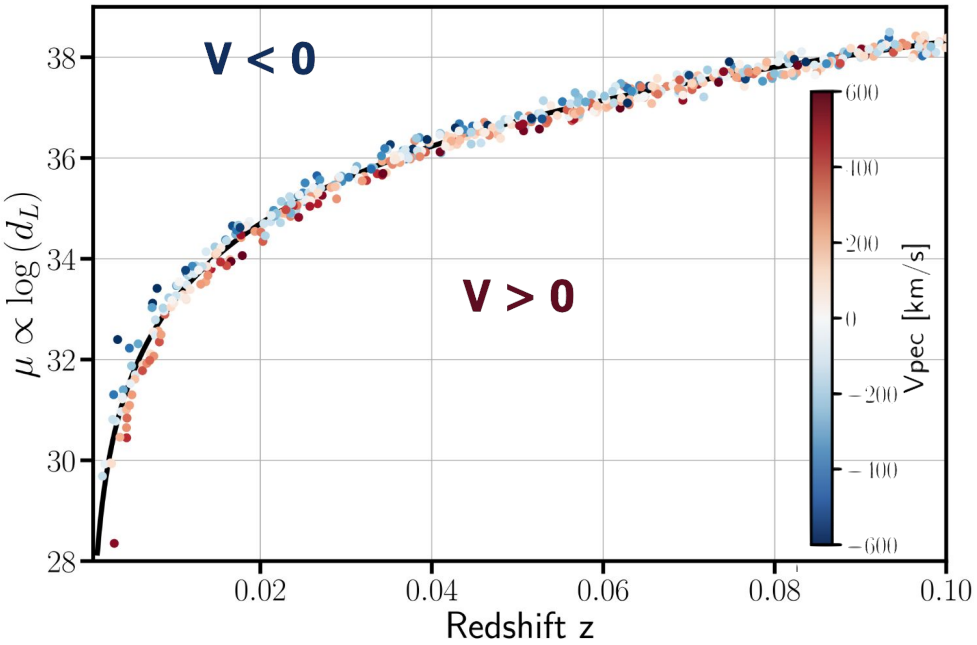
Unlock $f\sigma_8$ constraint with SNIa :

→ Need realistic simulations of SNIa samples with LSS velocities

SNSIM survey simulator

27 ZTF Boxes

1Gpc.h^{-1} box from Outer Rim N-Body simulation (Heitmann 2019)



Carreres et al 2023, & Phd Thesis

Probing the growth of structure with ZTF SNIa

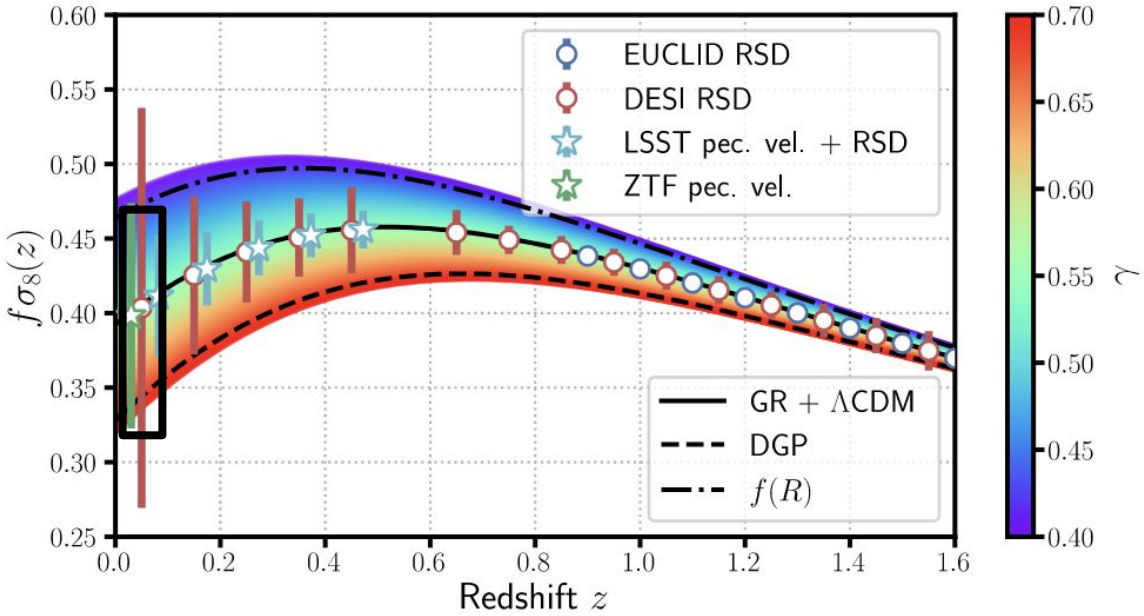
→ Test of max. likelihood analysis of the Hubble Diagram to constrain $f\sigma_8$

Realistic 6-year ZTF data forecast.

Selection of cosmological grade SNIa :
~1600 SNIa z < 0.06

$f\sigma_8$ **25% precision in DR2-like sample** (~700 SNIa).

Current calibration syst.



Carreres et al 2023 , & Phd Thesis

Probing the growth of structure with ZTF SNIa

PRELIMINARY

→ Forward-modelling method development

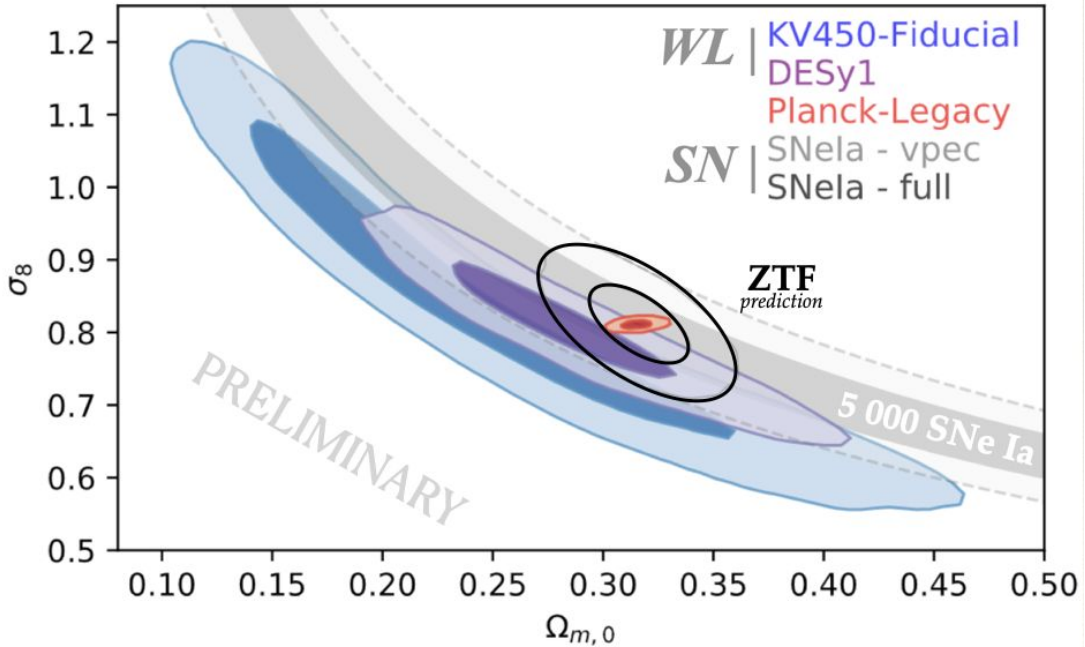
Only low redshift SNIa (z<0.1) needed

~5000

$$\sigma_8 - \Omega_m$$

27% precision

Combining PV & Hubble diagram



Credits: M.Rigault & R. Graziani

Peculiar velocities and low redshift Hubble Diagram.

PRELIMINARY

Test impact of peculiar velocities corrections on the low redshift Hubble Diagram :

PV corrections

→ Fixed dispersion

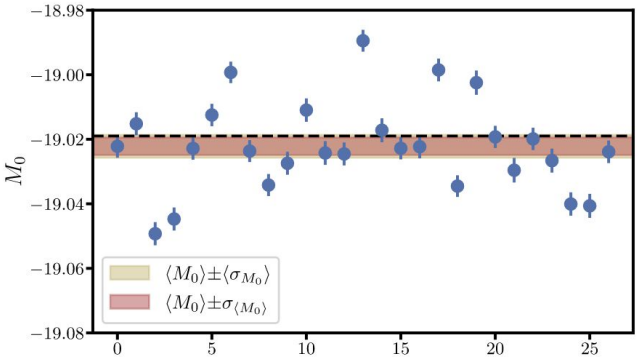
→ Use of reconstructed local velocities

→ Neglect cosmic variance

→ Neglect error on velocities

Use of SNSim to investigate corrections :

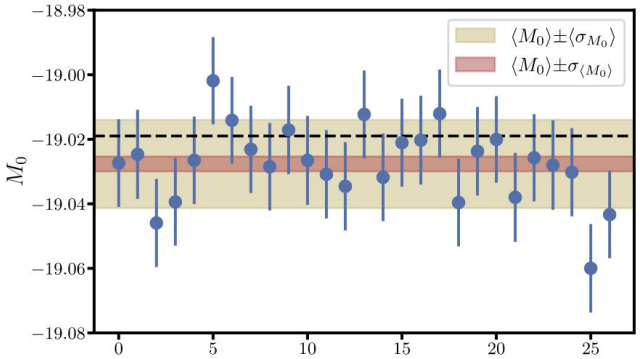
Fixed dispersion



H_0 and M_0 are degenerate

x4 error on M_0

Velocity covariance



B. Carreres, D. Rosselli & al, in prep

Concluding remarks on LSS and ZTF.

With ZTF SNIa can no longer be considered as independent from the LSS :

Environmental : **Statistics allows us to investigate the environmental dependencies**

→ **Evidence of environmental drifts.**

→ Uncover potential new selection effects
(e.g cluster selection as targets for high redshift SNIa sample)

Cosmological : **New aspects to consider in the cosmological constraint.**

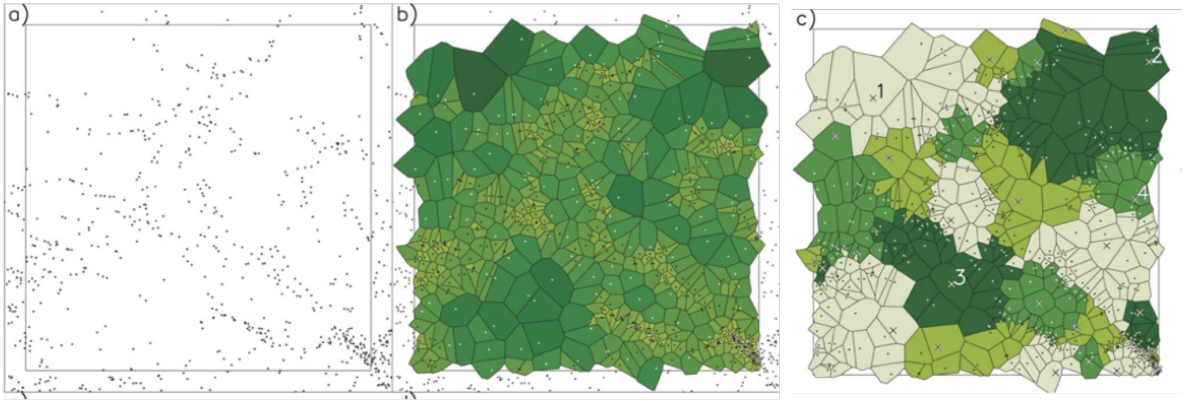
Unlock new probe → $f\sigma_8$

Refine the HD analysis → Velocity covariance

Complementary slides

Voronoi tesselation based algorithm
→ Revolver (Nadathur 2019) , VIDE (Sutter 2014)

ZOBOV, (Neyrinck 2008)



Tracer distribution | Voronoi tesselation | Watershed transform

Local volume around galaxies. V

Void centre $X_v = \frac{\sum_i V_i X_i^g}{\sum_i V_i}$

Radius $R_v = \left(\frac{3}{4\pi} \sum_i V_i \right)^{1/3}$

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