

Possible velocity systematic on the Hubble diagram fit


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Context :

Fitting Hubble Diagram :

Minimizing $\chi^2 = \Delta\mu^T C^{-1} \Delta\mu$

$$\Delta\mu = m_B + \alpha x_1 - \beta c - \boxed{M_0} - \boxed{\mu_{\text{th}}} \quad \text{Cosmology is fixed}$$


$$\boxed{M_{0,\text{true}} + 5 \log \frac{h_{\text{true}}}{h_{\text{fid}}}}$$

Context :

Our simulations :

27 ZTF mocks from OuterRim simulated using



Simulations of the ZTF survey with **correlated** peculiar velocities !

How to take velocity systematics into account ?

Until now :

Diagonal error term : $\sigma_{\mu-v} = \frac{5}{\ln 10} \frac{\sigma_v}{z}$

JLA : $c\sigma_v = 150 \text{ km. s}^{-1}$

Pantheon : $c\sigma_v = 250 \text{ km. s}^{-1}$

But not so much low-z SNe Ia....

**ZTF is the largest SNe Ia sample at low-z, we have to check if
the diagonal term is enough**

Already proposed in [Davis et al. 2011](#):

$$\sigma_{\mu-v} = \frac{5}{c \ln 10} \frac{\sigma_v}{s}$$

Full covariance matrix

$$C_{ij}^{vv} = \frac{(aHf)^2}{4\pi^2} \int_0^{+\infty} dk P_{\theta\theta}(k) W_{ij}(k; \mathbf{x}_i, \mathbf{x}_j).$$

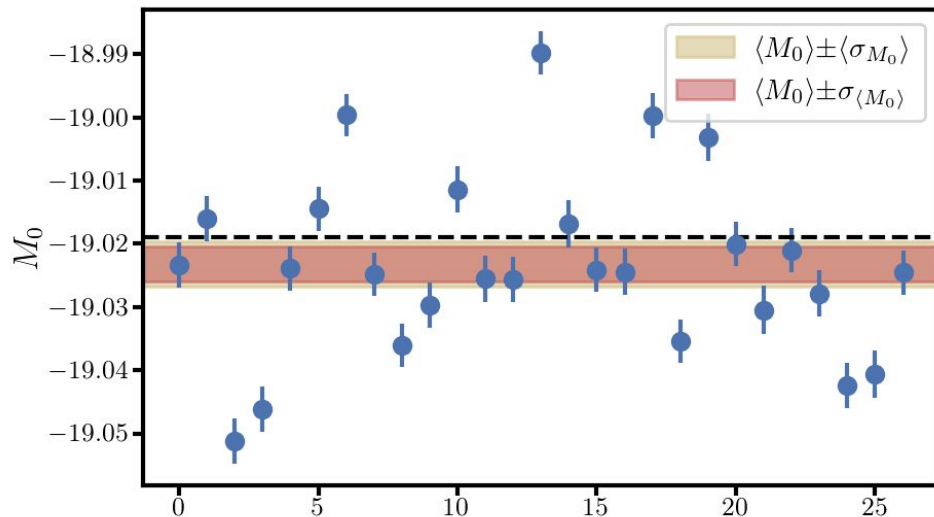
Here we **did not attempt to fit cosmology** we fix all parameters. Linear power spectrum computed with CAMB.

Impact on our simulated mocks :

Fit without taking into account velocities :

Standard deviation of the 27 mocks : $\text{STD}(M_0) \simeq 0.014$

Average uncertainty : $\sqrt{\langle \sigma_{M_0}^2 \rangle} \simeq 0.0036$



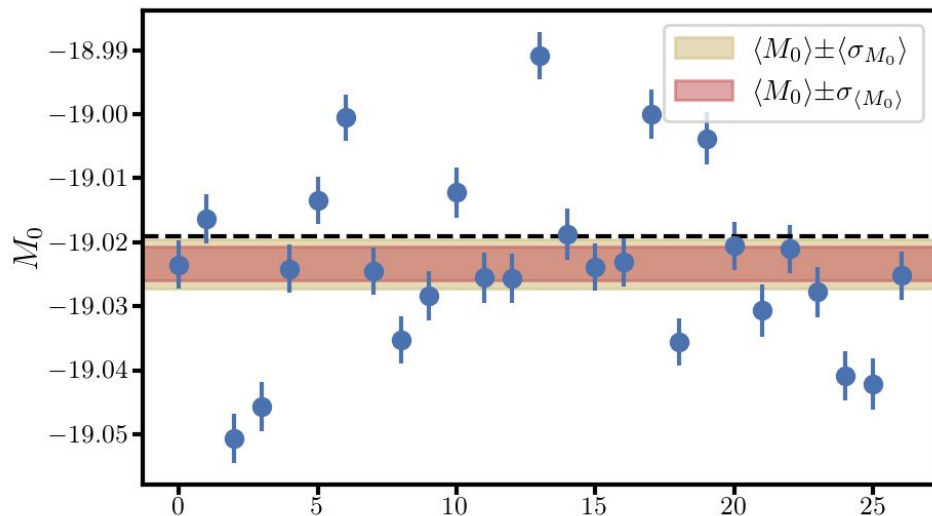
Sample variance not accounted...

Impact on our simulated mocks :

Fit with JLA like term: $c\sigma_v = 300 \text{ km. s}^{-1}$

Standard deviation of the 27 mocks : $\text{STD}(M_0) \simeq 0.014$

Average uncertainty : $\sqrt{\langle\sigma_{M_0}^2\rangle} \simeq 0.0038$



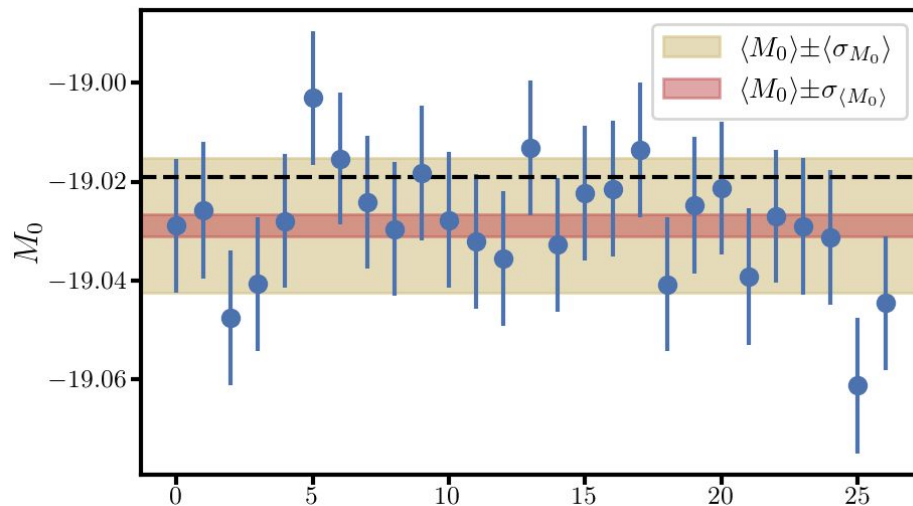
No major change, sample variance still not accounted...

Impact on our simulated mocks :

Fit with full covariance:

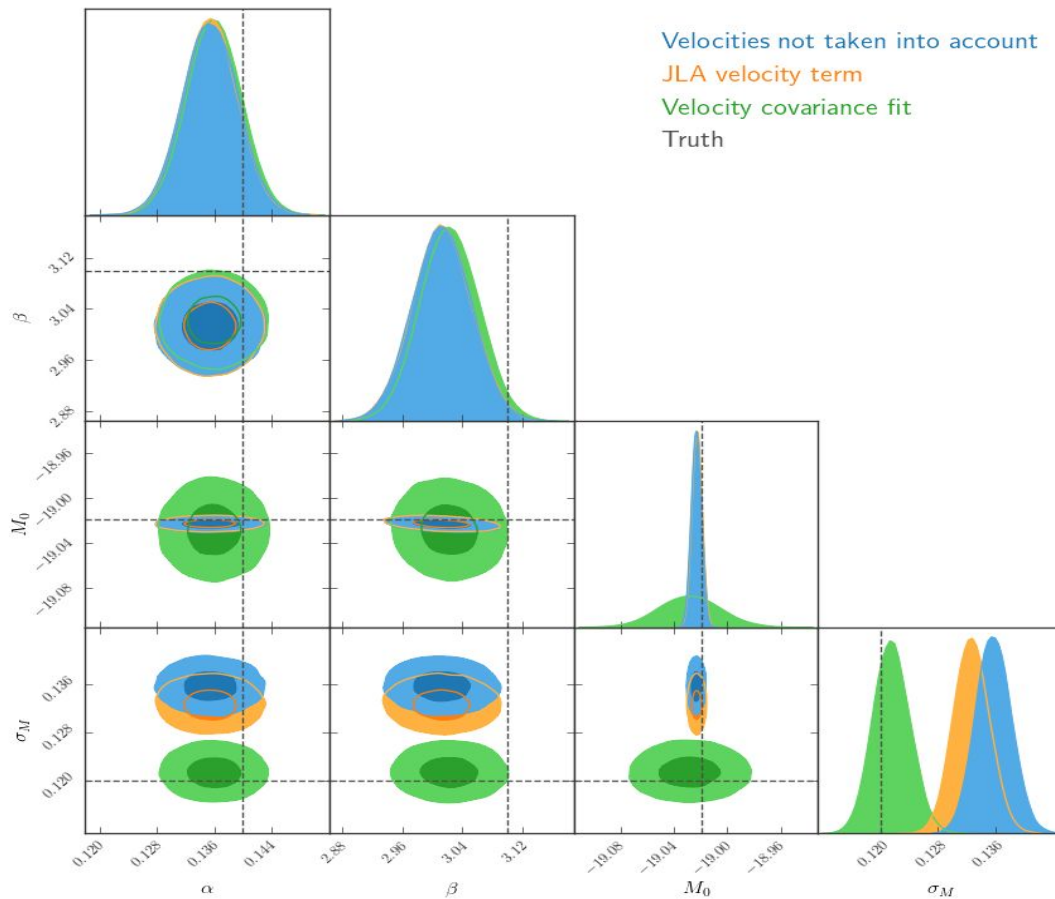
Standard deviation of the 27 mocks : $\text{STD}(M_0) \simeq 0.012$

Average uncertainty : $\sqrt{\langle \sigma_{M_0}^2 \rangle} \simeq 0.0136$

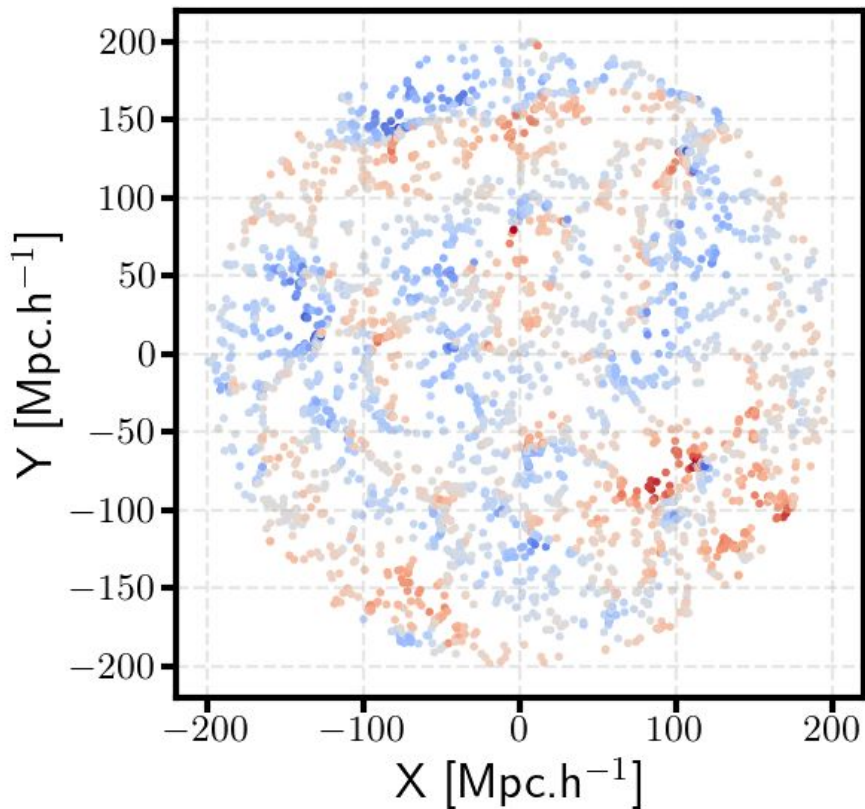


Sample variance is taken into account

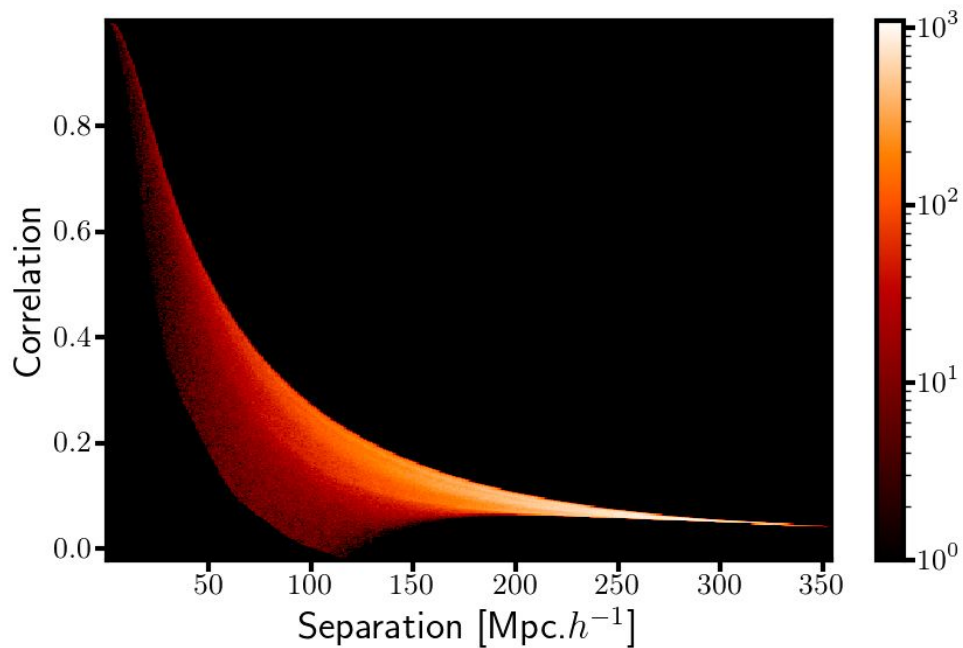
Impact on our simulated mocks :



Velocities correlated on large scales :



It seems that these correlations have to be taken into account within the ZTF volume



First test on data !

Use of Madeleine' code for the selection : 919 SNe Ia $|x_1| < 3, |c| < 0.3, \sigma_{x_1} < 1, \sigma_c < 0.1$

Without taking into account full velocity covariance : $\sigma_{M_0} = 0.008$

With taking into account full velocity covariance : $\sigma_{M_0} = 0.017$

The error is multiplied by ~ 2 .

This systematic is not take into account in current ZTF - TRGB H0 measurement.

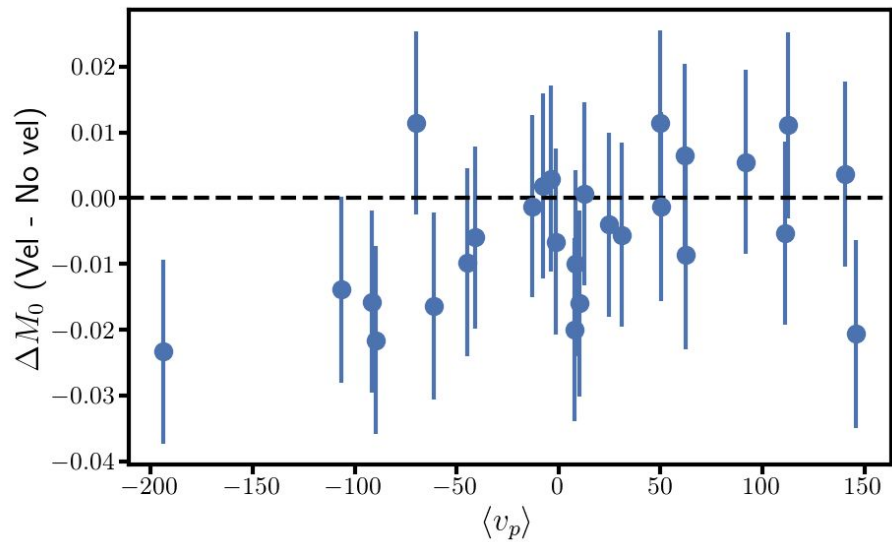
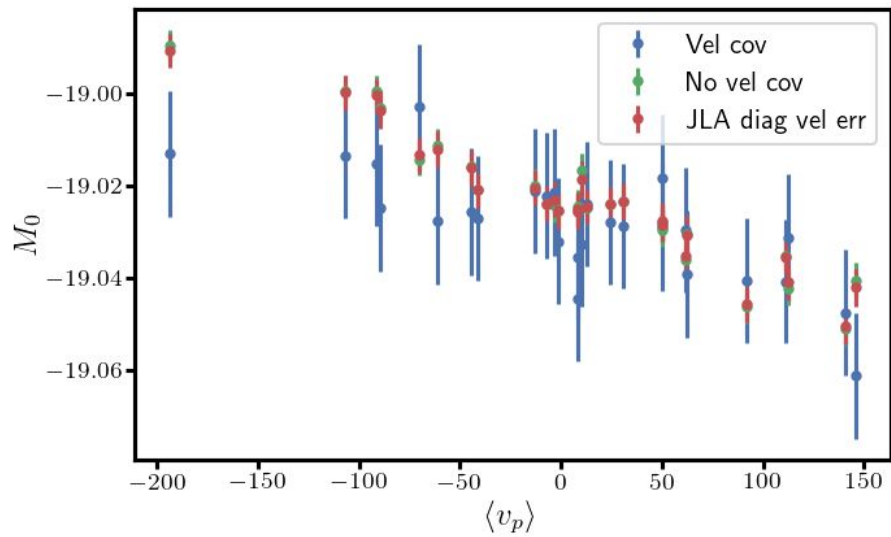
Conclusion

- Velocities don't seem to have any effect on alpha or beta
- Velocities correlations have an effect on M0 fit error

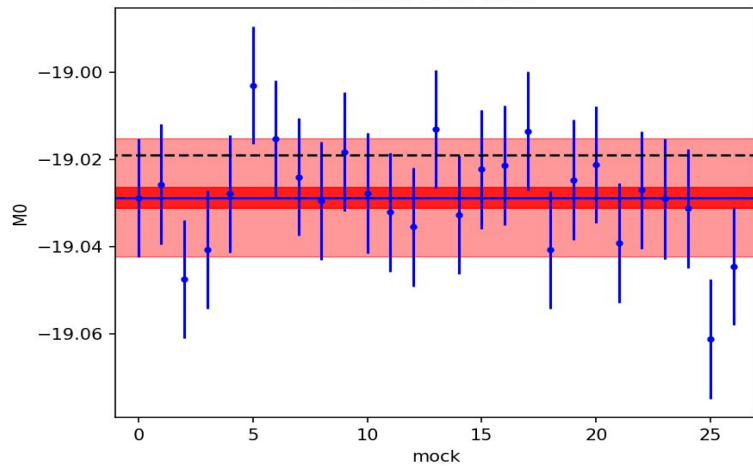
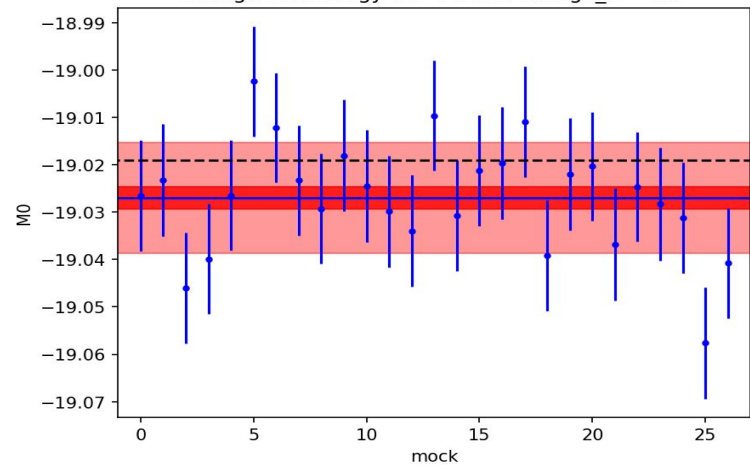
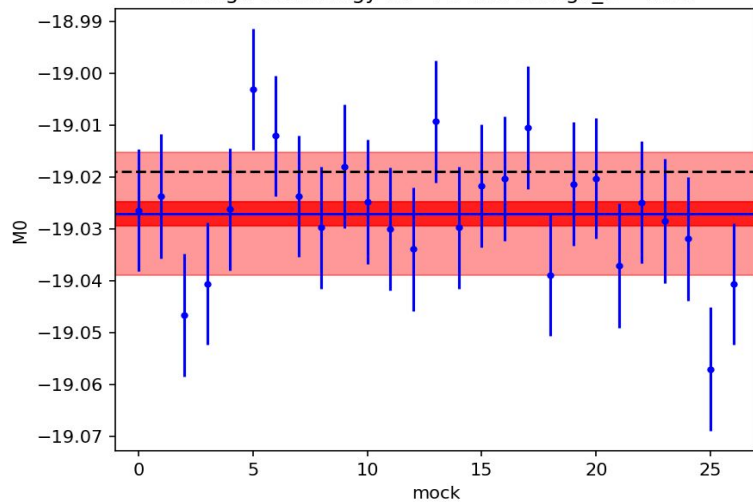
Next steps :

- Measure the impact in the error budget of the H0 measurement
- (small) DR2 paper on the velocity systematic in the ZTF sample ?

Backup Slides



normal Covariance

Change Cosmology $H_0=72$ and $\Omega_c = 0.1$ Change Cosmology $H_0=70$ and $\Omega_c = 0.12$ Change scale $k_{\max} = 0.25$ 