



Redshift evolution of the underlying SNIa stretch distribution

<https://doi.org/10.1051/0004-6361/202038447>

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Wednesday, 24 November 2021



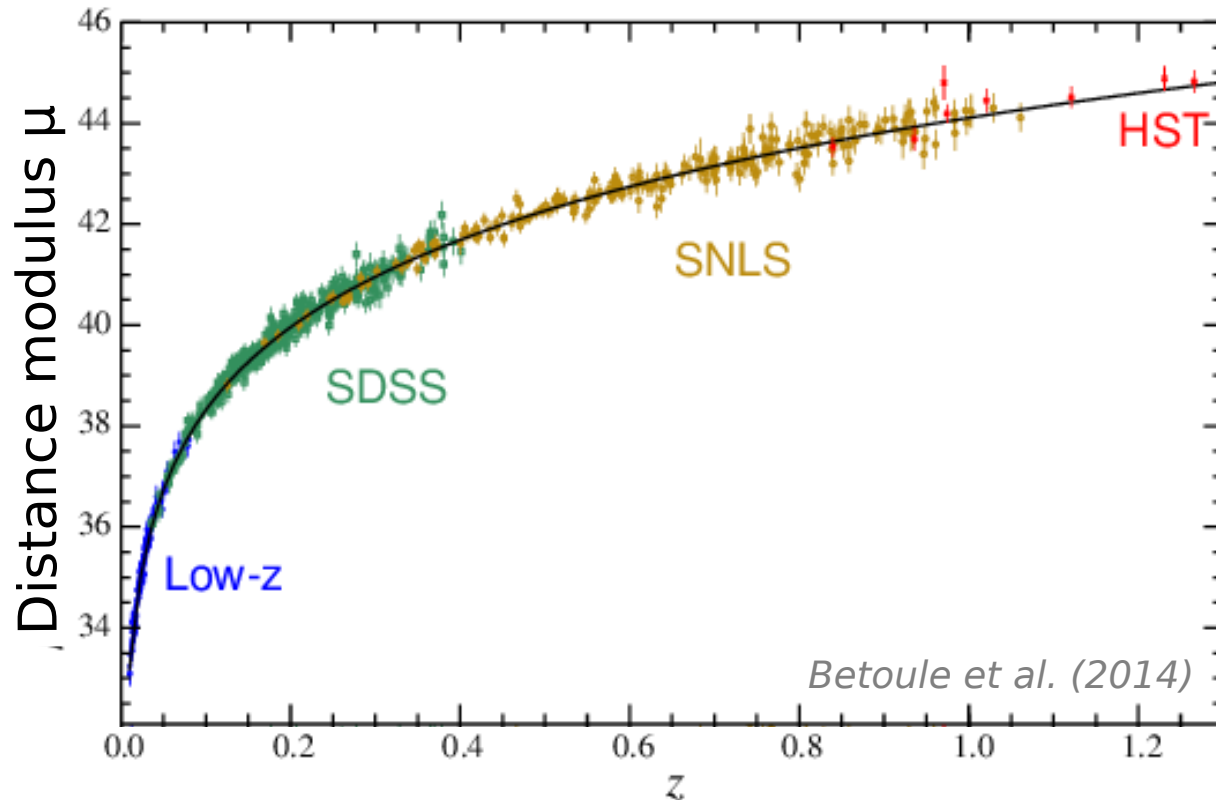
Observational Cosmology

Observed → Intrinsic

$$\text{Distance modulus: } \mu = m - M = 5 \log(d_L) - 5$$

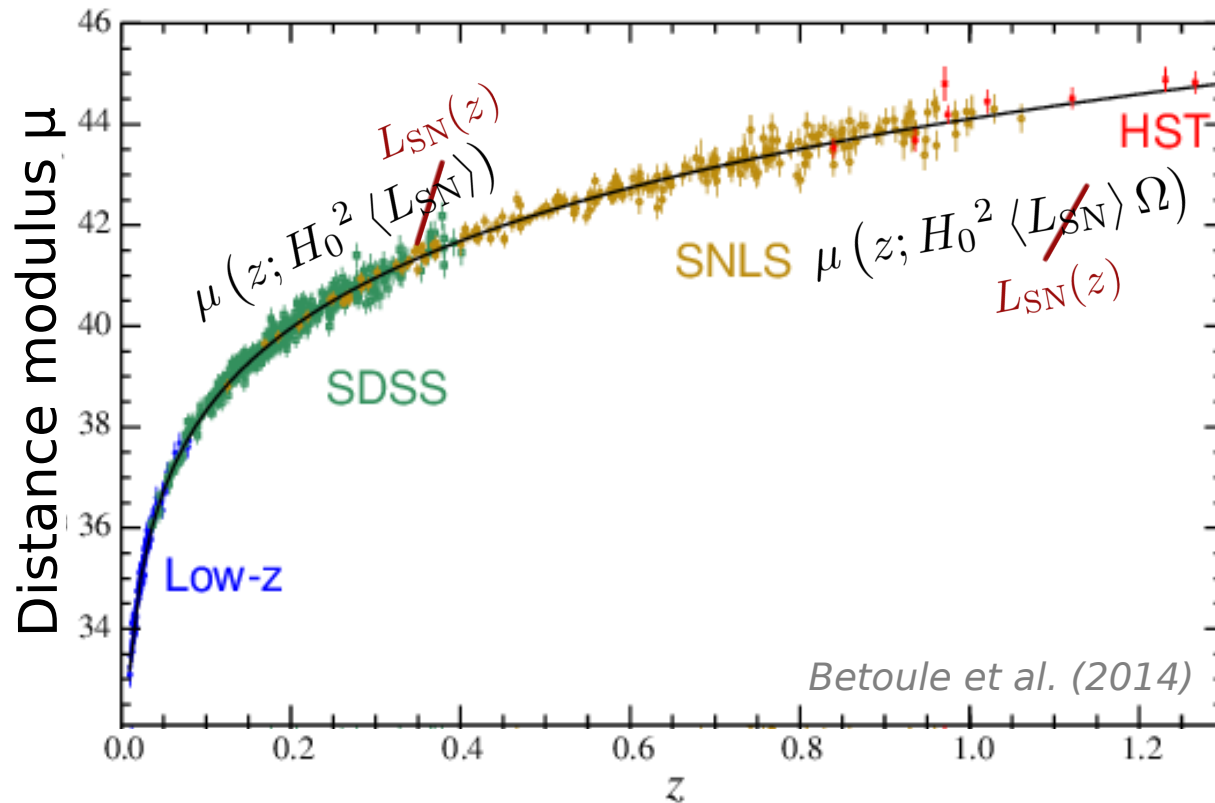
$$\text{Distance: } d_L = (1+z) \times \frac{c}{H_0} \left(\int_0^z dz' \left[\Omega_R (1+z')^4 + \Omega_M (1+z')^3 + \Omega_\Lambda \right]^{-1/2} \right)$$

Hubble const Radiation Matter Dark Energy



Systematic errors

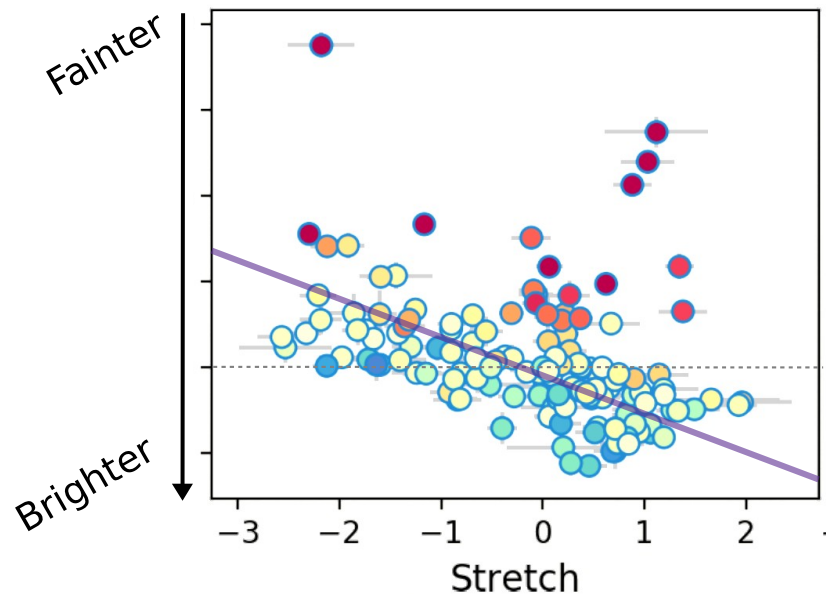
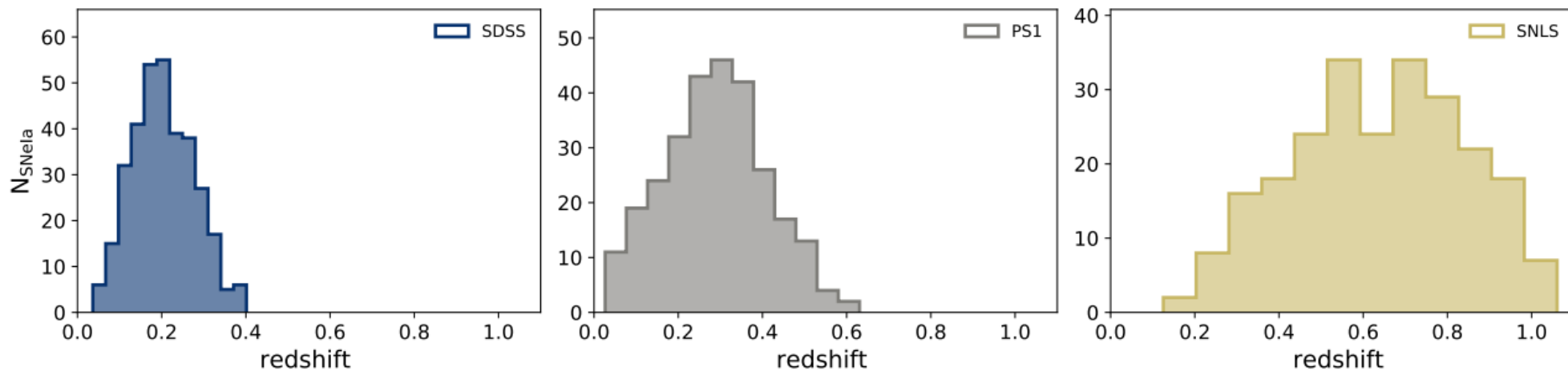
Standardized distance modulus: $\mu = m_B - M + (\alpha x_1 - \beta c)$



Can we see a redshift evolution of supernovae through the stretch?

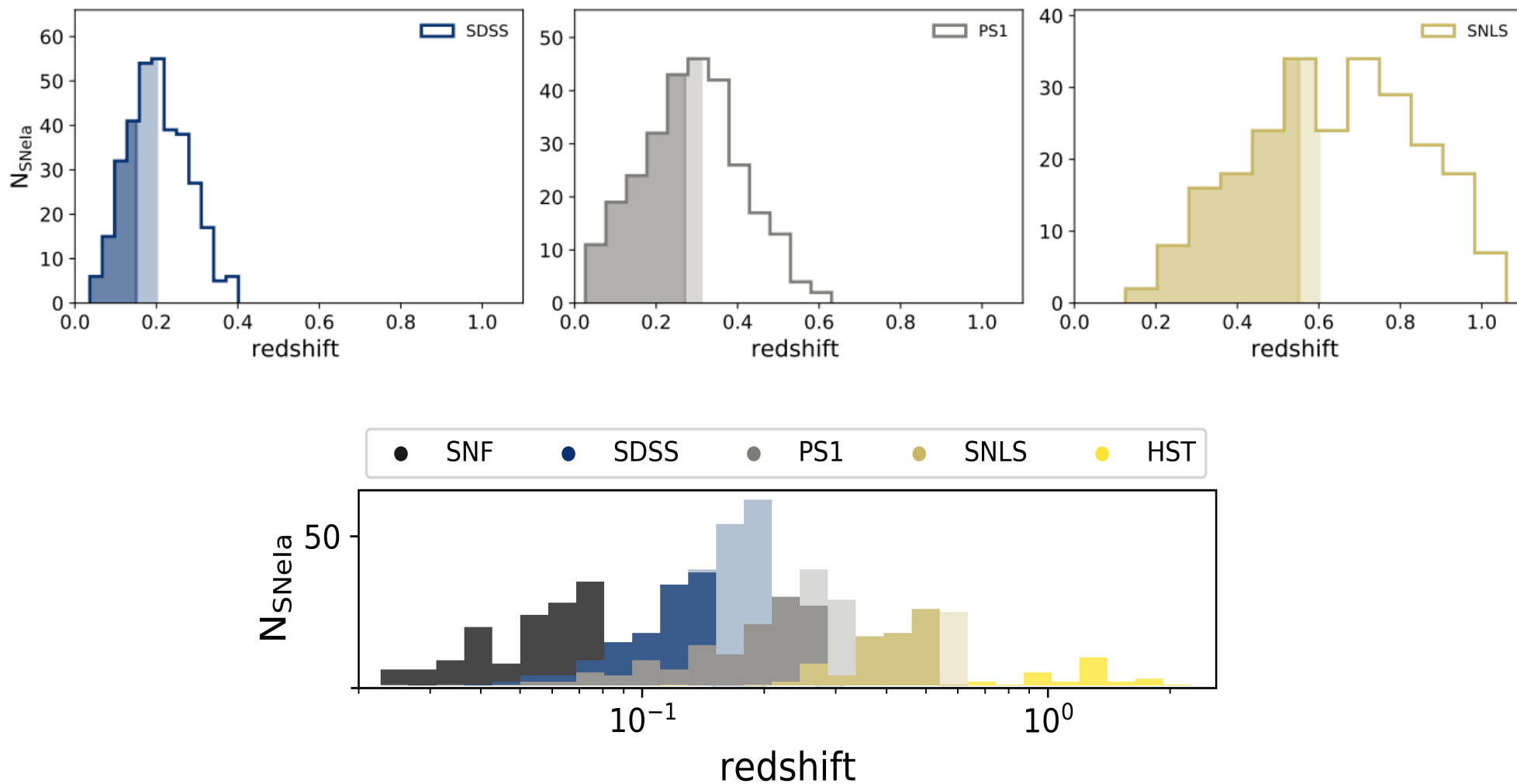
Complete sample free from selection effects

Nicolas et al. (2021)



Complete sample free from selection effects

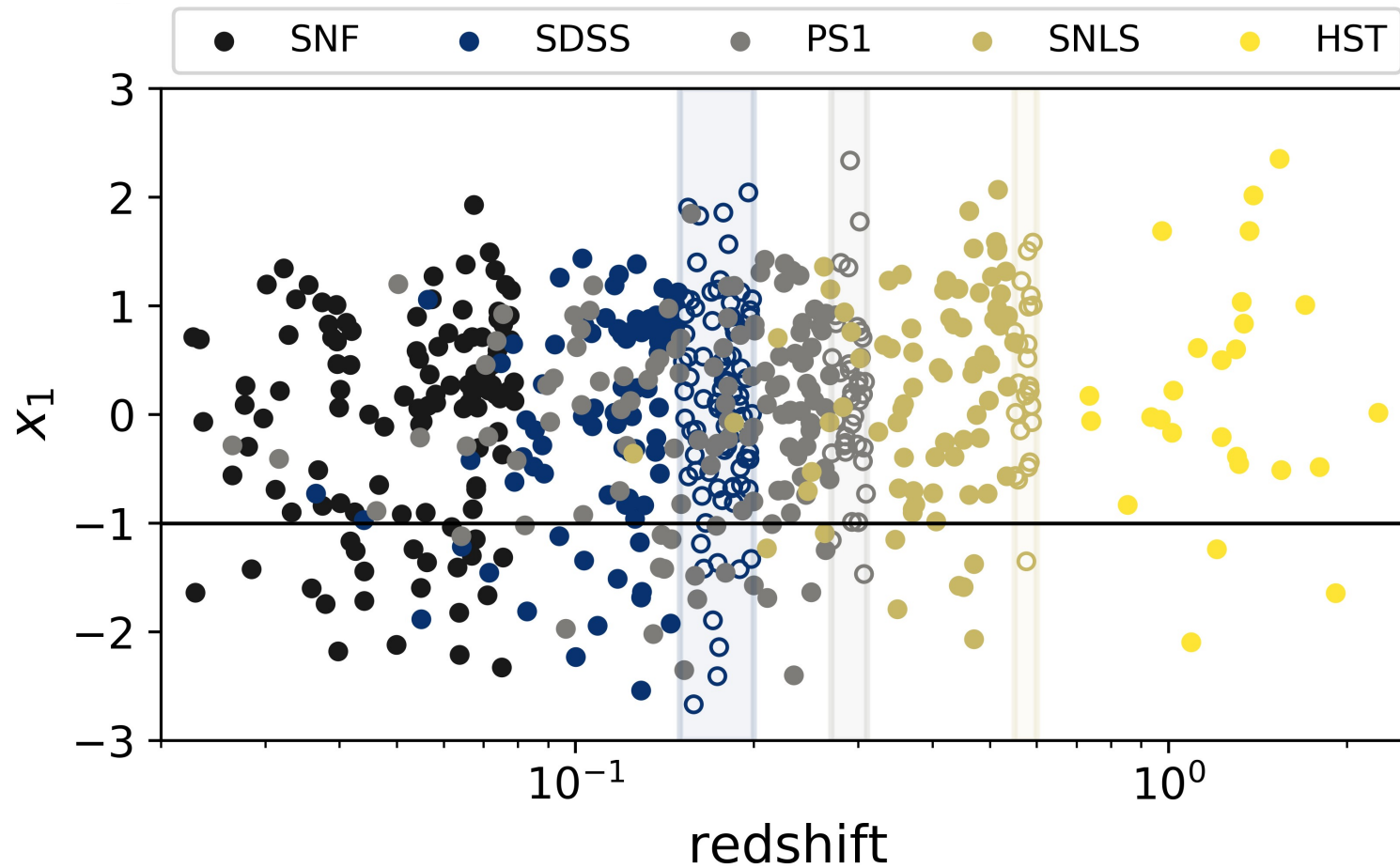
Nicolas et al. (2021)



Complete sample

free from selection effects

Nicolas et al. (2021)

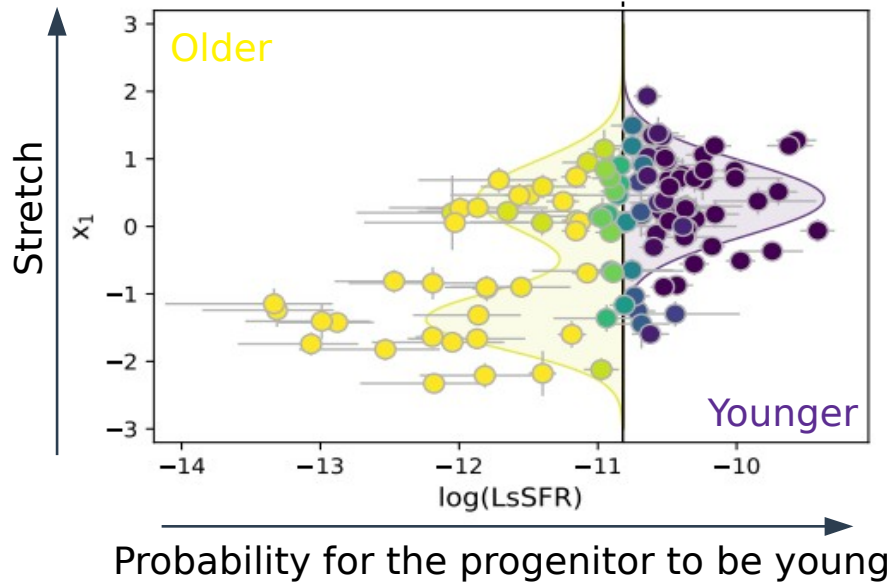


Why do we expect a stretch evolution?

Nicolas et al. (2021)

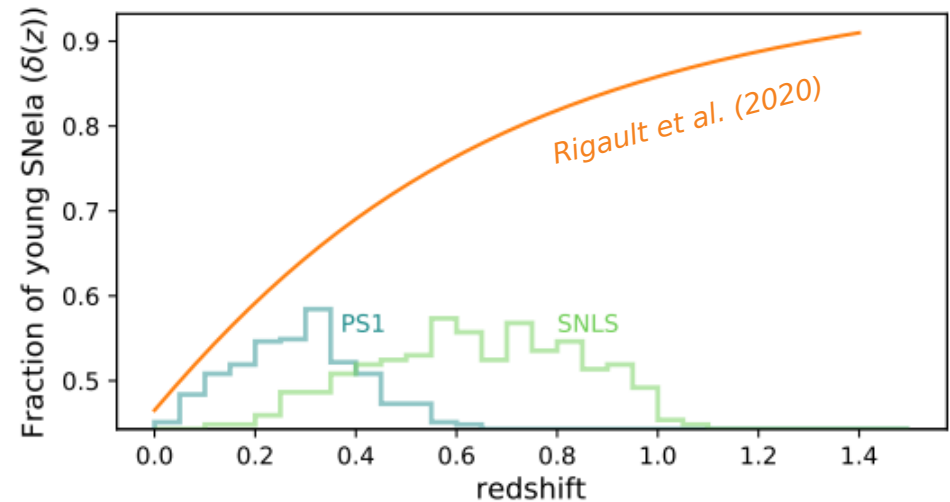
$$a \times \mathcal{N}(\mu_1, \sigma_1) + (1 - a) \times \mathcal{N}(\mu_2, \sigma_2)$$

$$\mathcal{N}(\mu_1, \sigma_1)$$



$$\text{SNe} = f(\text{environment})$$

$$\text{Environment} = f(\text{redshift})$$



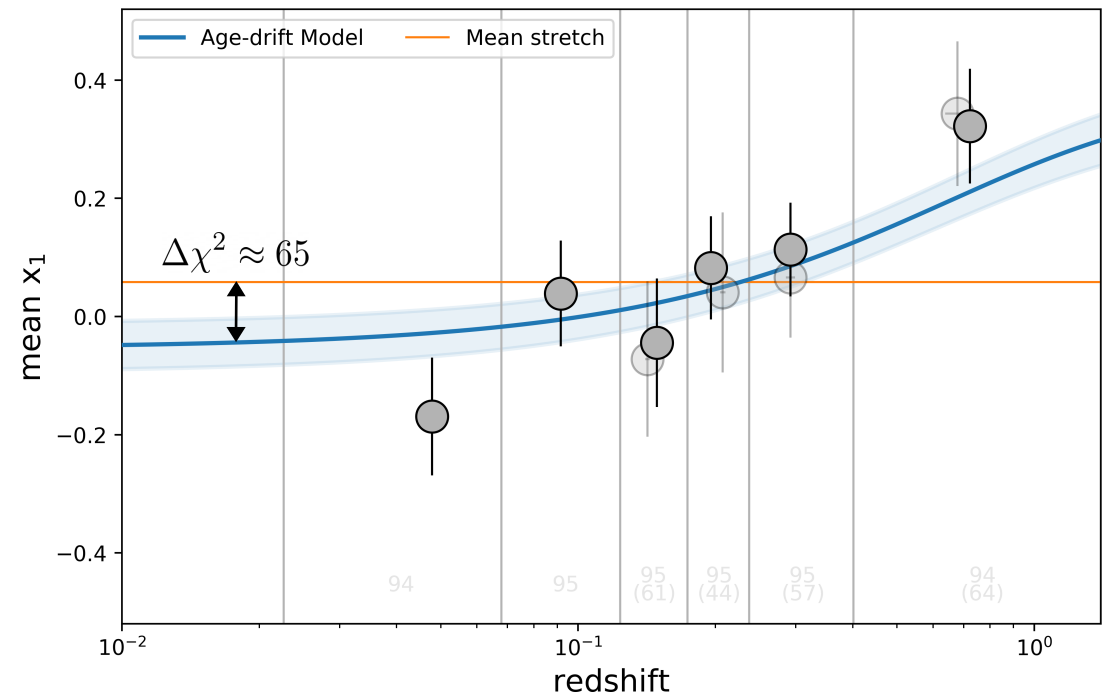
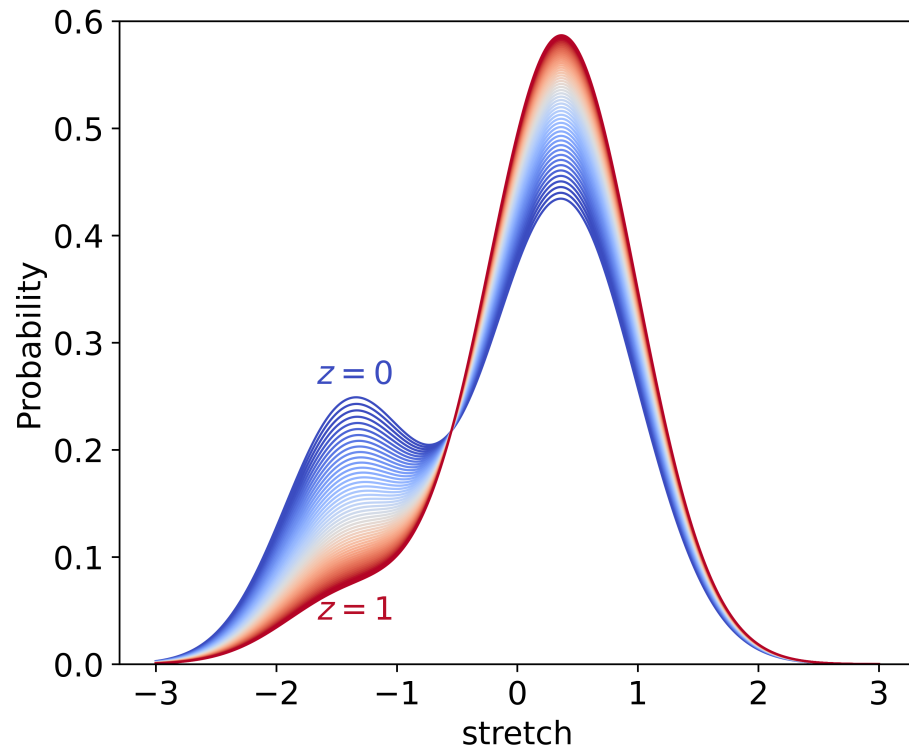
$$\delta(z) = (K^{-1} \times (1 + z)^{-\phi} + 1)^{-1}$$

Rigault et al. (2020), $K=0.87$, $\phi=2.8$

Implementation to dataset

Nicolas et al. (2021)

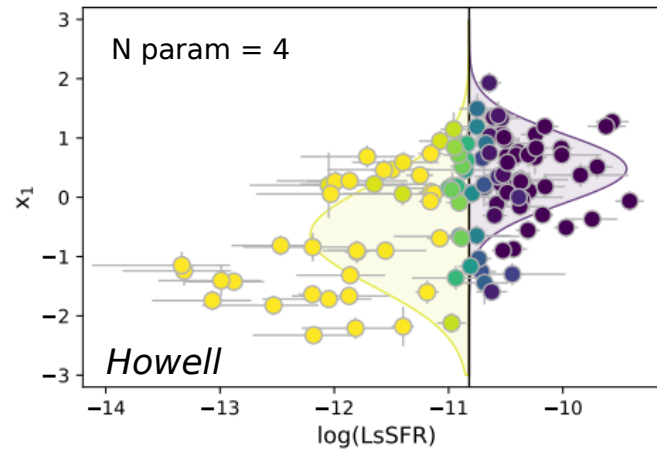
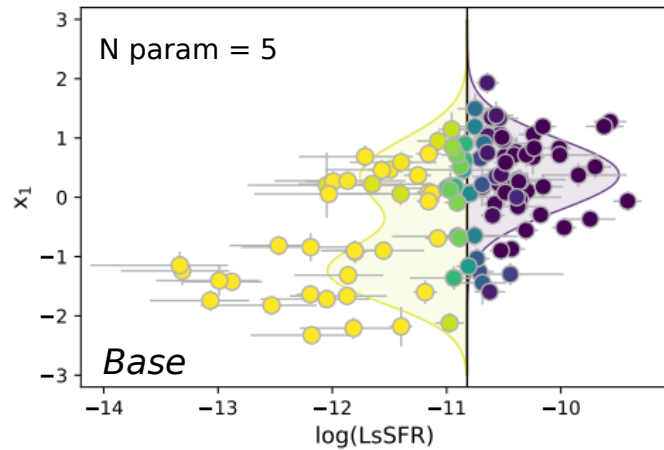
$$\langle X_1(z) \rangle = \delta(z) \times \mu_1 + (1 - \delta(z)) \times (a\mu_1 + (1 - a)\mu_2)$$



Other models

Nicolas et al. (2021)
Cf Howell et al. (2007)

Underlying stretch model per age population



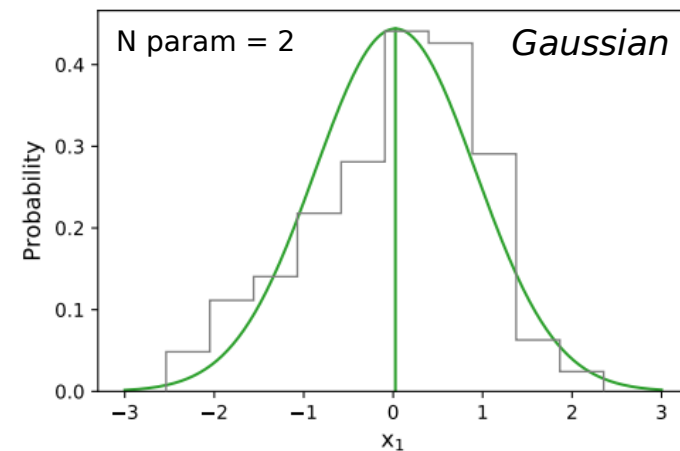
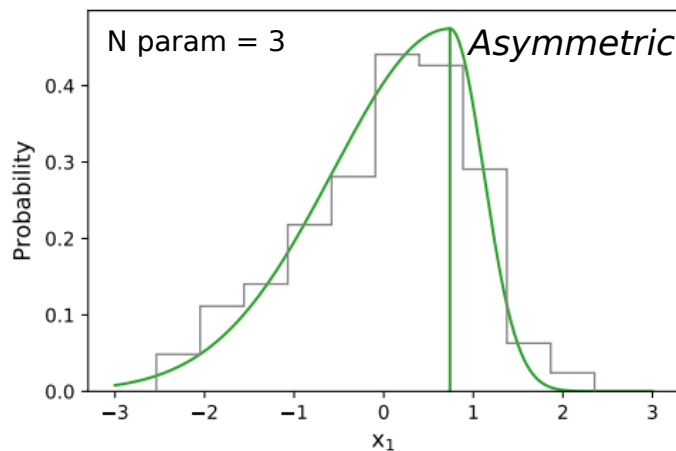
+

Drift

$$\delta(z) = (K^{-1} \times (1+z)^{-\phi} + 1)^{-1}$$

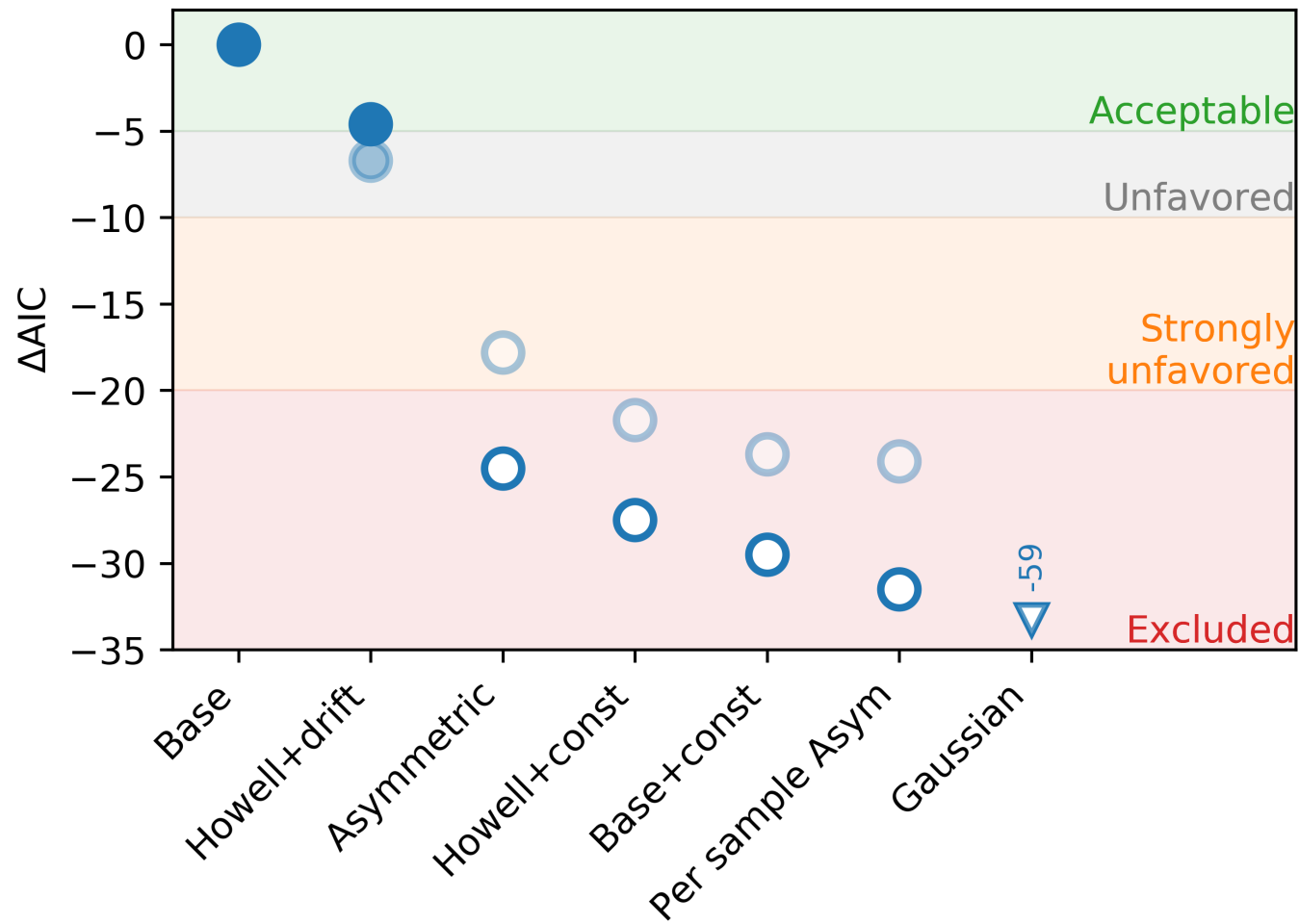
Or no drift

$$\delta(z) = \text{cst}$$



Comparison results

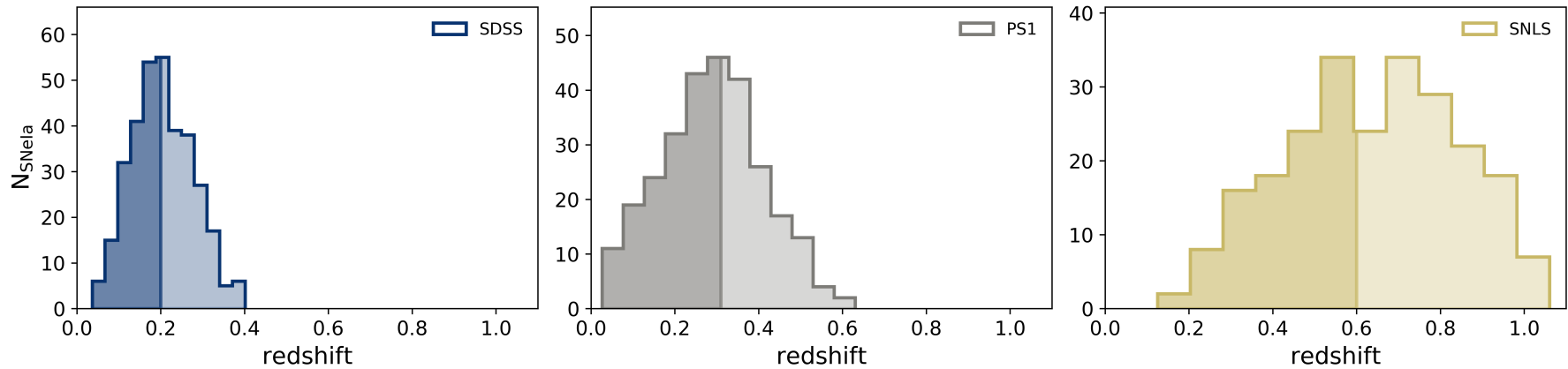
Nicolas et al. (2021)



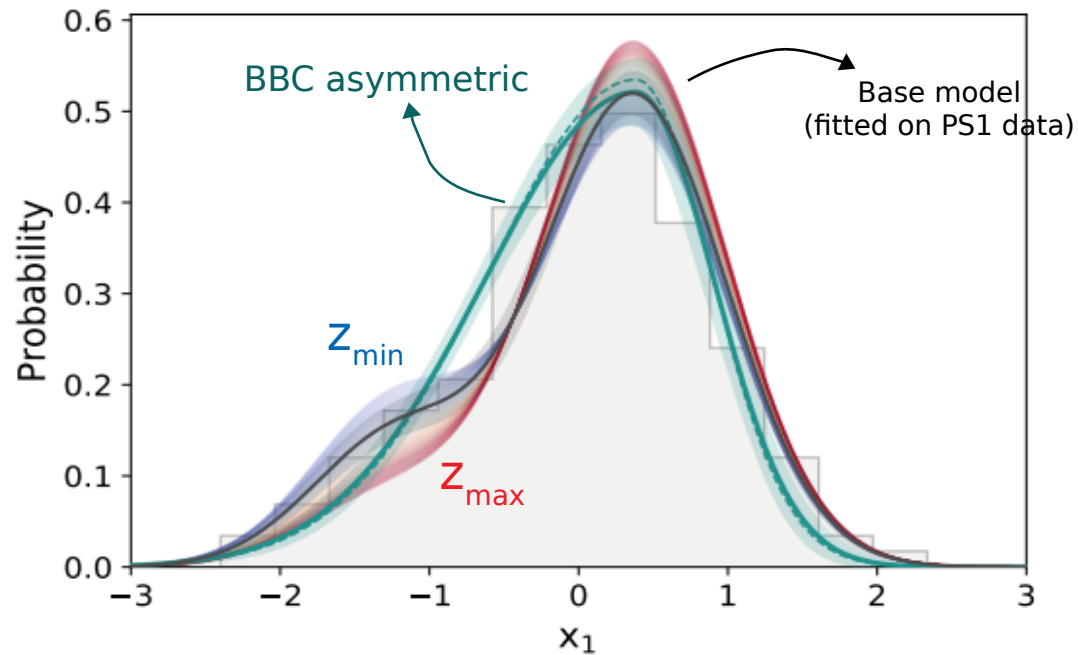
What's the impact on cosmology?

An example with the BBC modeling

Nicolas et al. (2021)

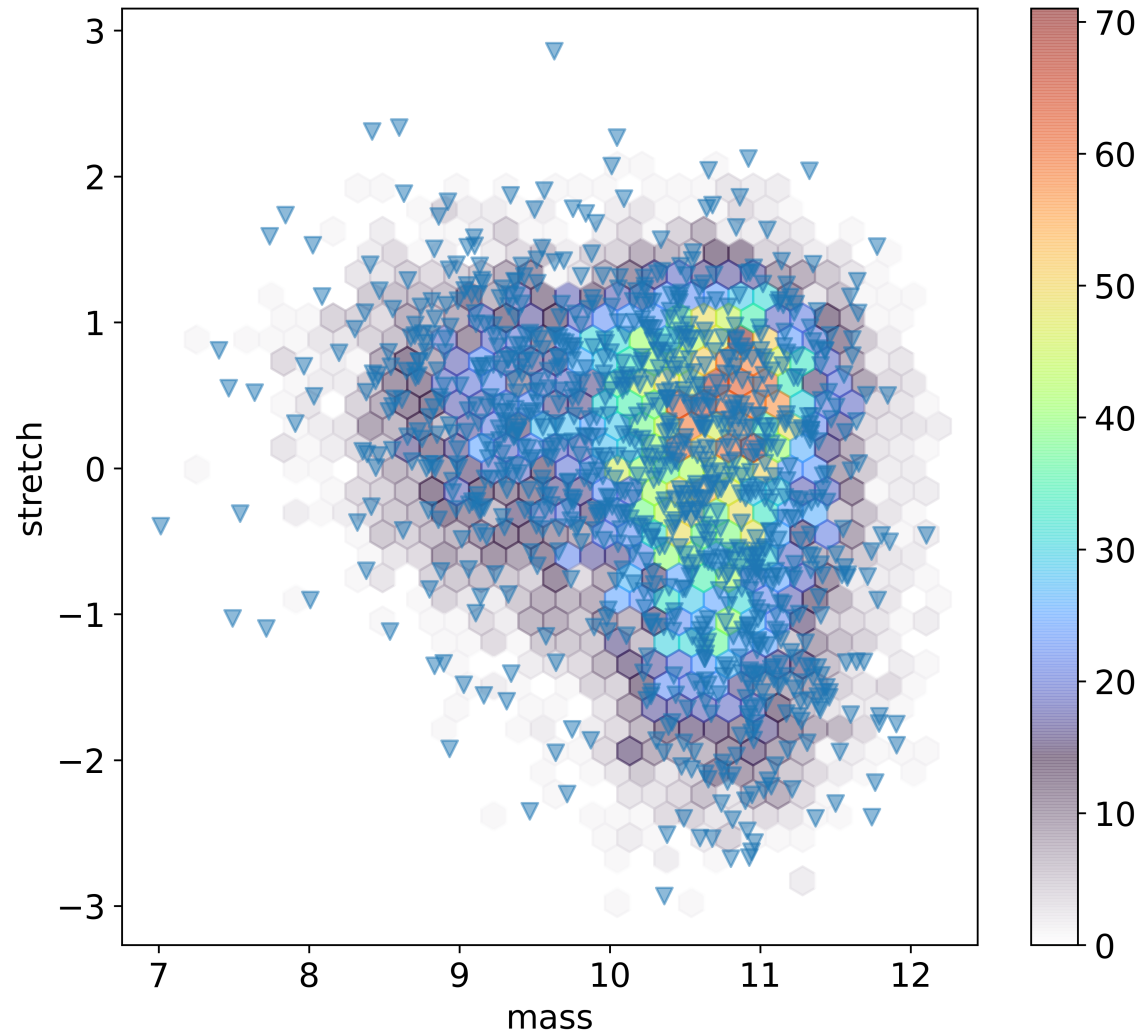


PS1 stretch underlying distribution



Actually using the model

Simulating SNe with SNANA





Thank you!

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Magnitude-limited surveys from the Pantheon dataset

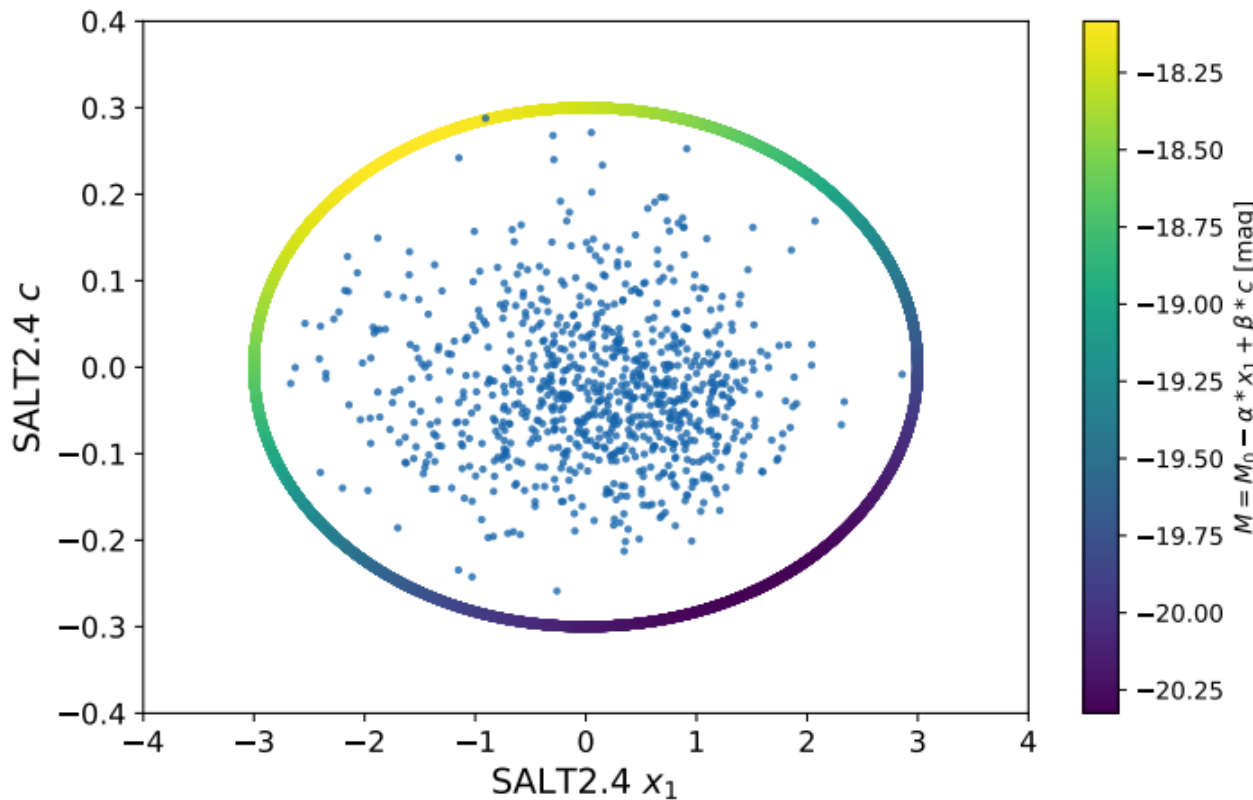
$$m_{\text{lim}} = 24.8 \text{ mag} \quad (\text{SNLS})$$

$$\mu(z) = m - M(x_1, c) \Leftrightarrow m = \mu(z) + M(x_1, c)$$

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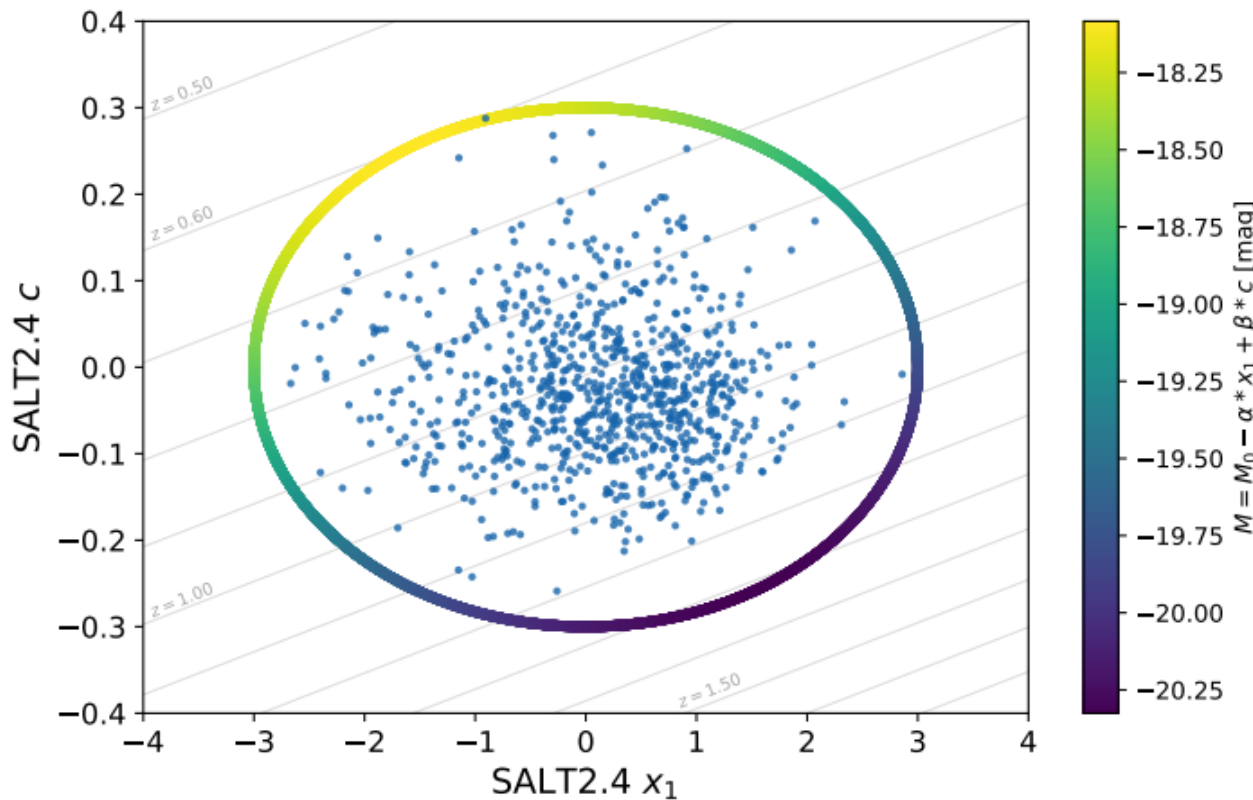


$$M_{\text{min}}^{t_0-5} = -18.00 \text{ mag}$$
$$x_1 = -1.66$$
$$c = 0.25$$

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Complete sample

Testing the construction

Nicolas et al. (2021)

