Type Ia Supernovae standardisation and its dependence on environment with ZTF

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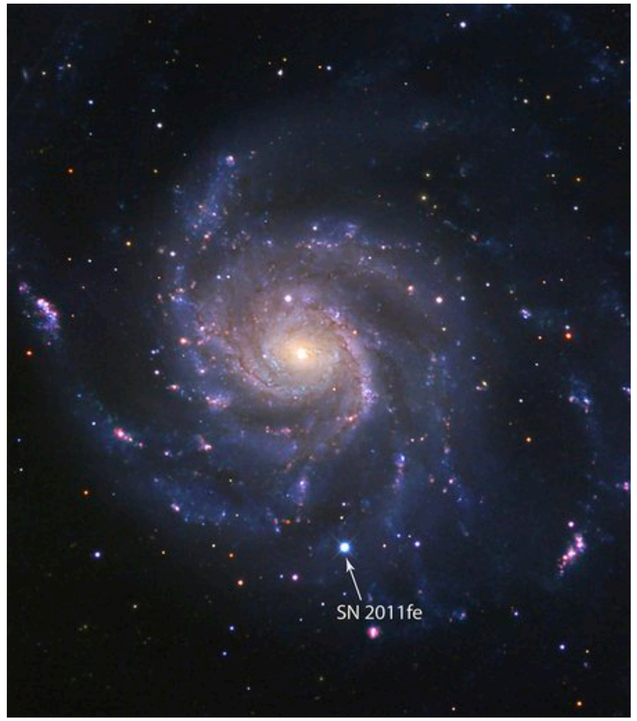
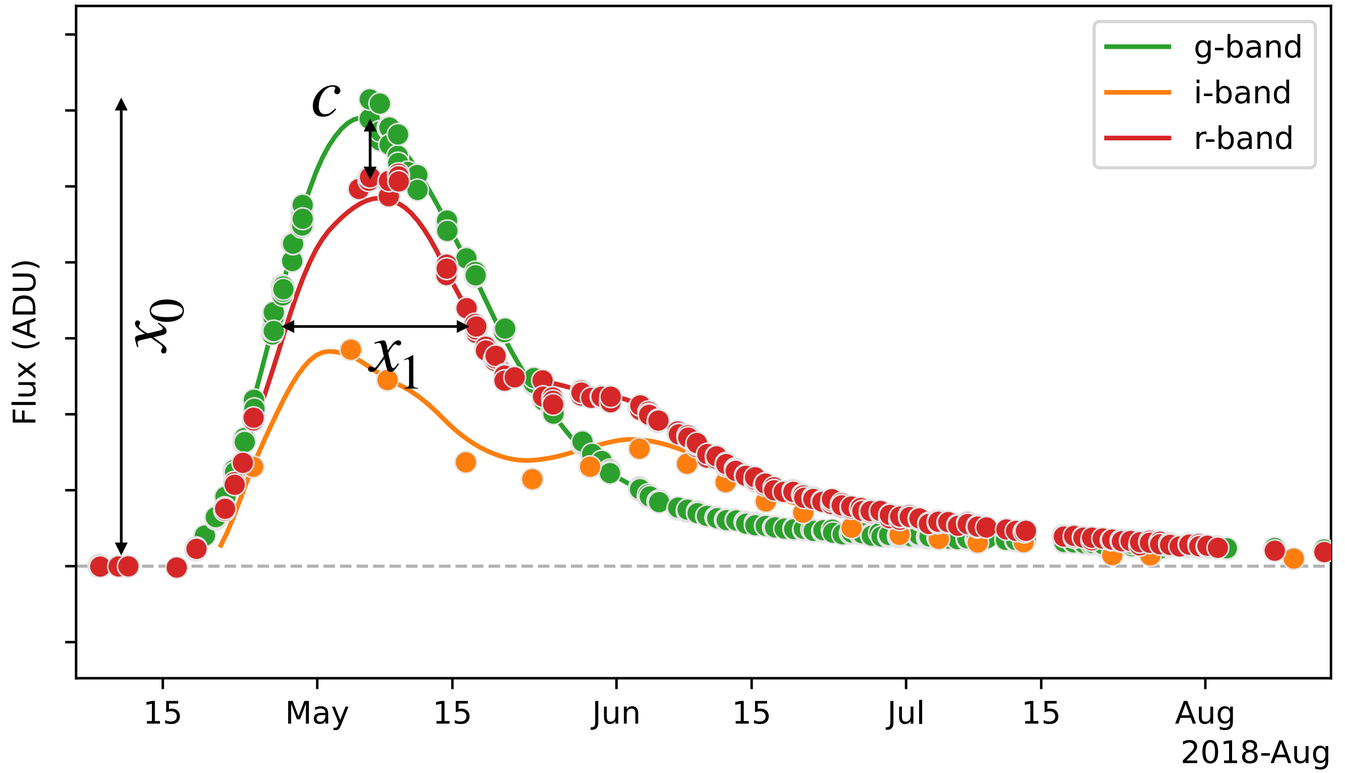
GDR CoPhy @ IP2I, Lyon - 22nd May 2024

Type Ia supernova



Credits: B.J. Fulton/
LCOGT/Caltech



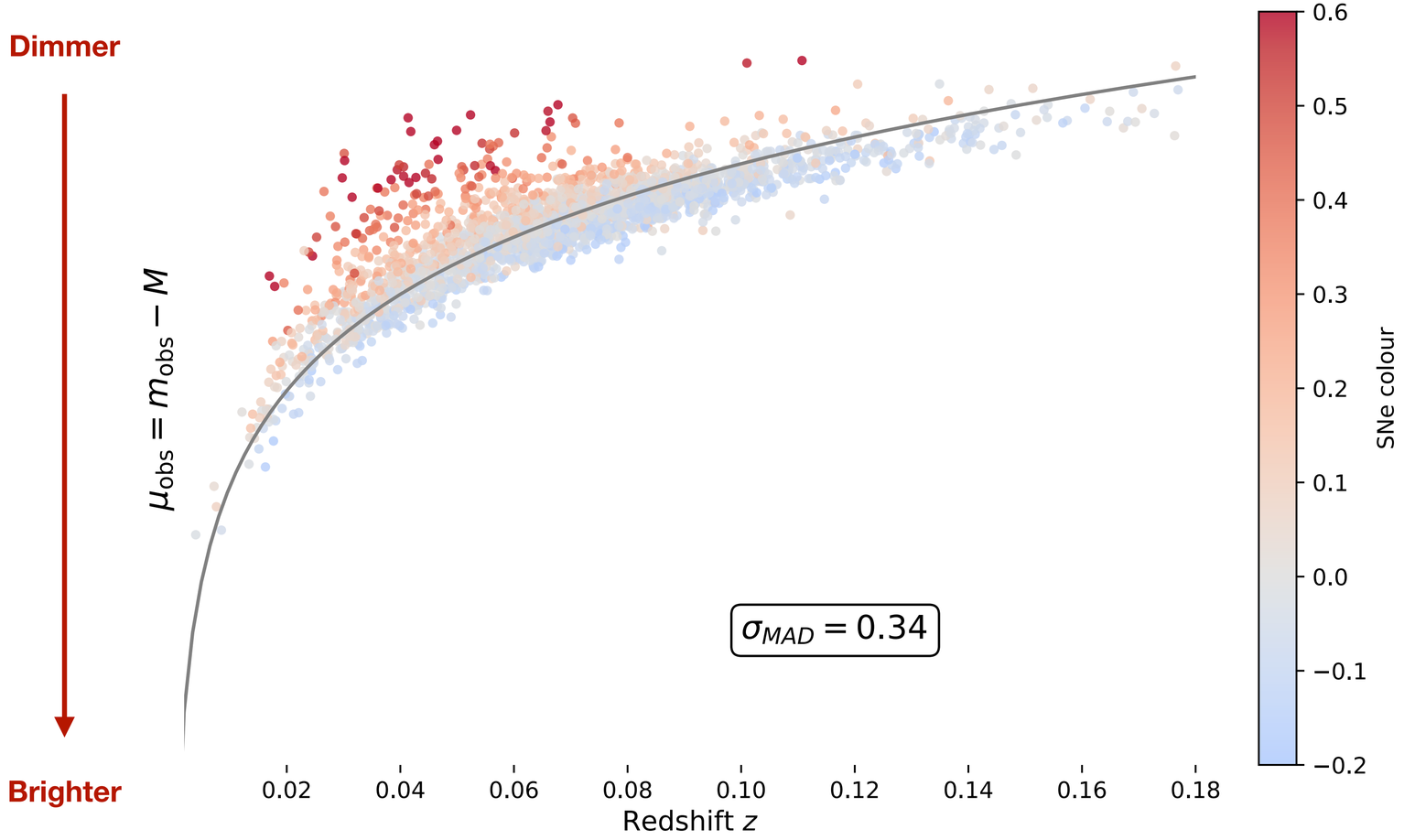
x_0

x_1

c

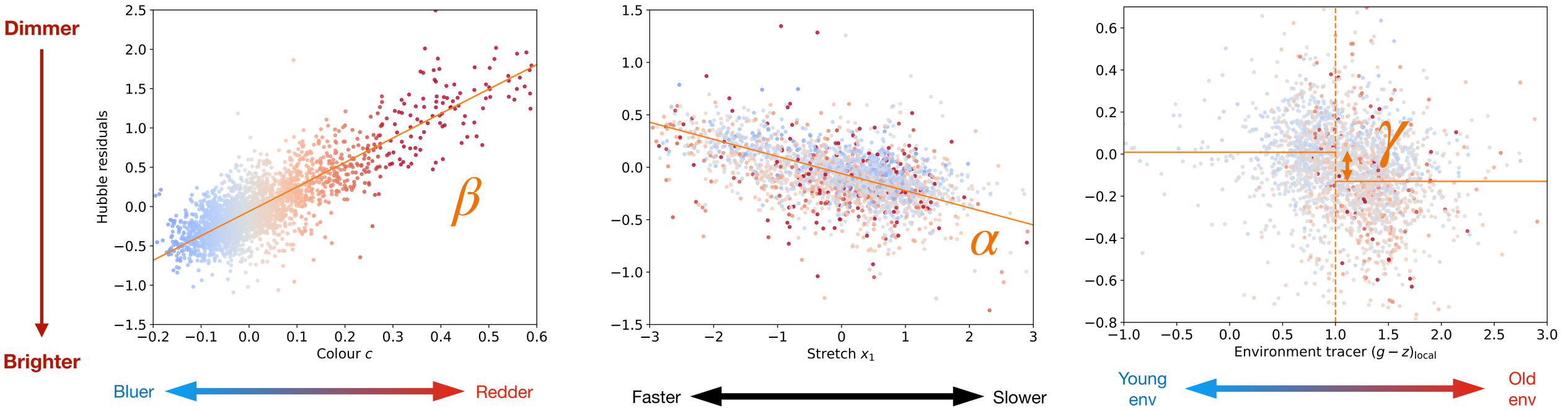
Cosmology with SNe

ZTF Hubble diagram



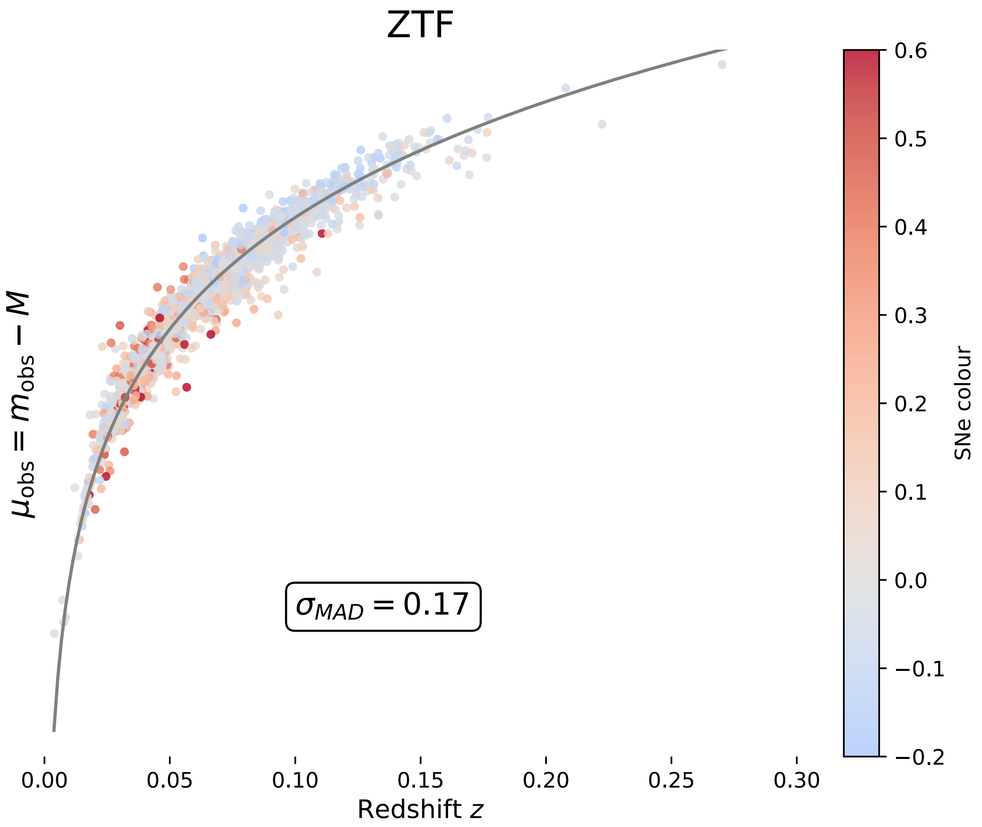
Cosmology with SNe

Standardisation

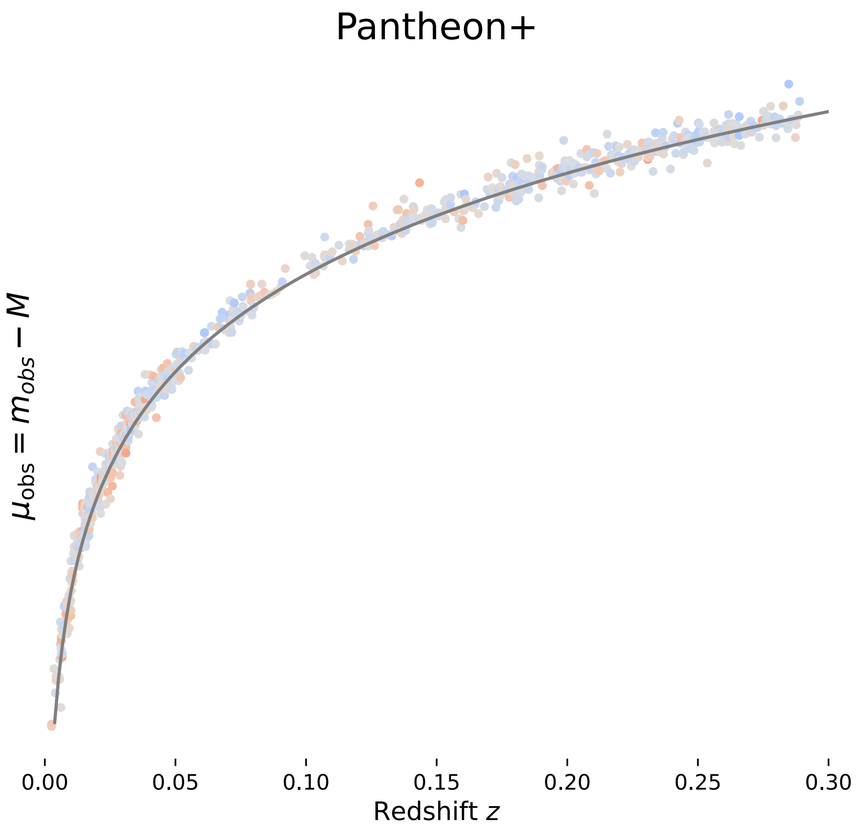


$$\mu_{\text{obs}} + M = m_{\text{obs}} - \beta c + \alpha x_1 + p\gamma$$

Cosmology with SNe



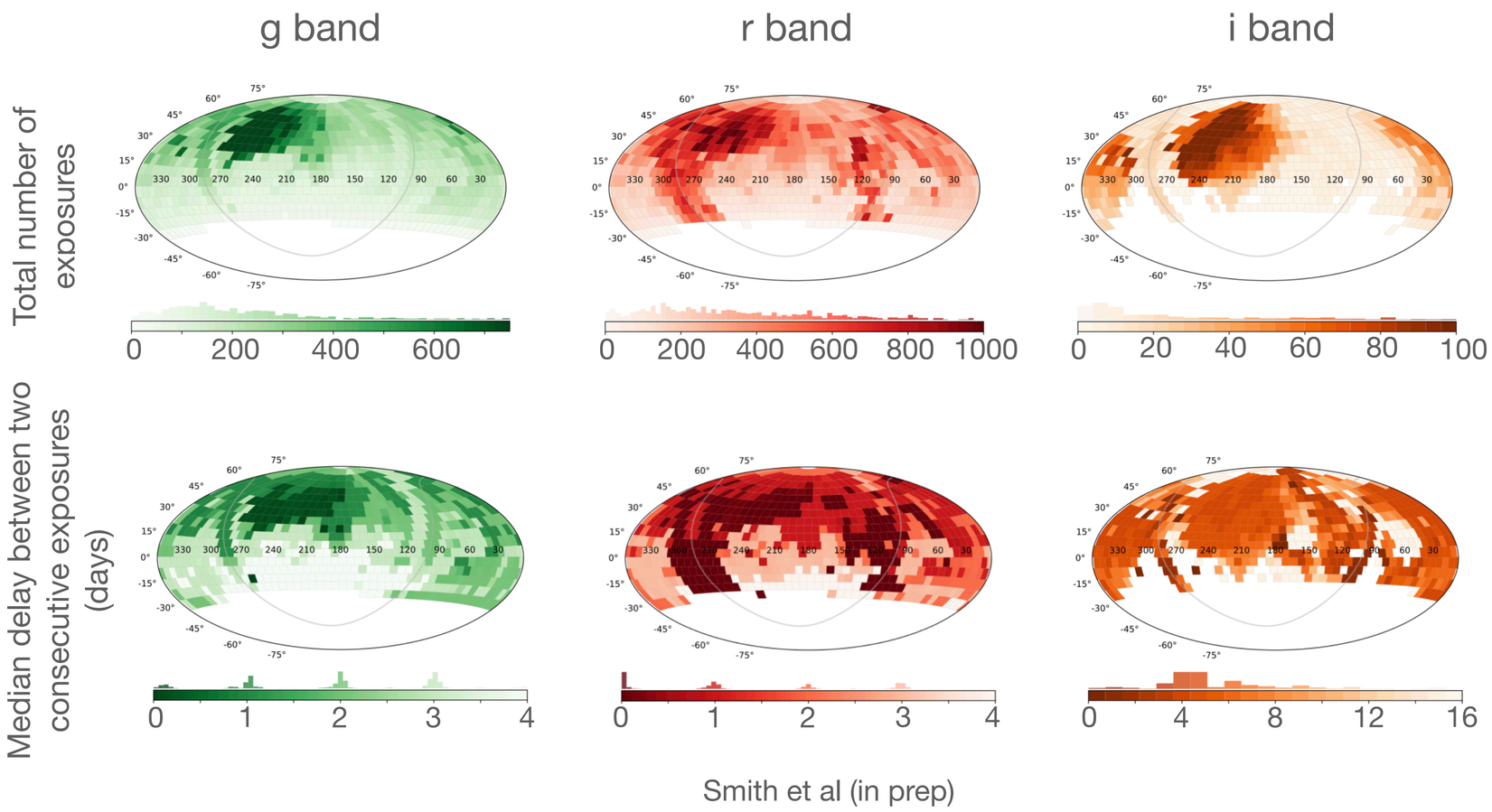
2483 SNe - 1 survey



1164 SNe - 20 surveys
Largest survey at low z : ~180 SNe

Brout et al 2022
Scolnic et al 2022

ZTF SN Ia DR2



Smith et al (in prep)

3628 SNe
Confirmed SNe Ia

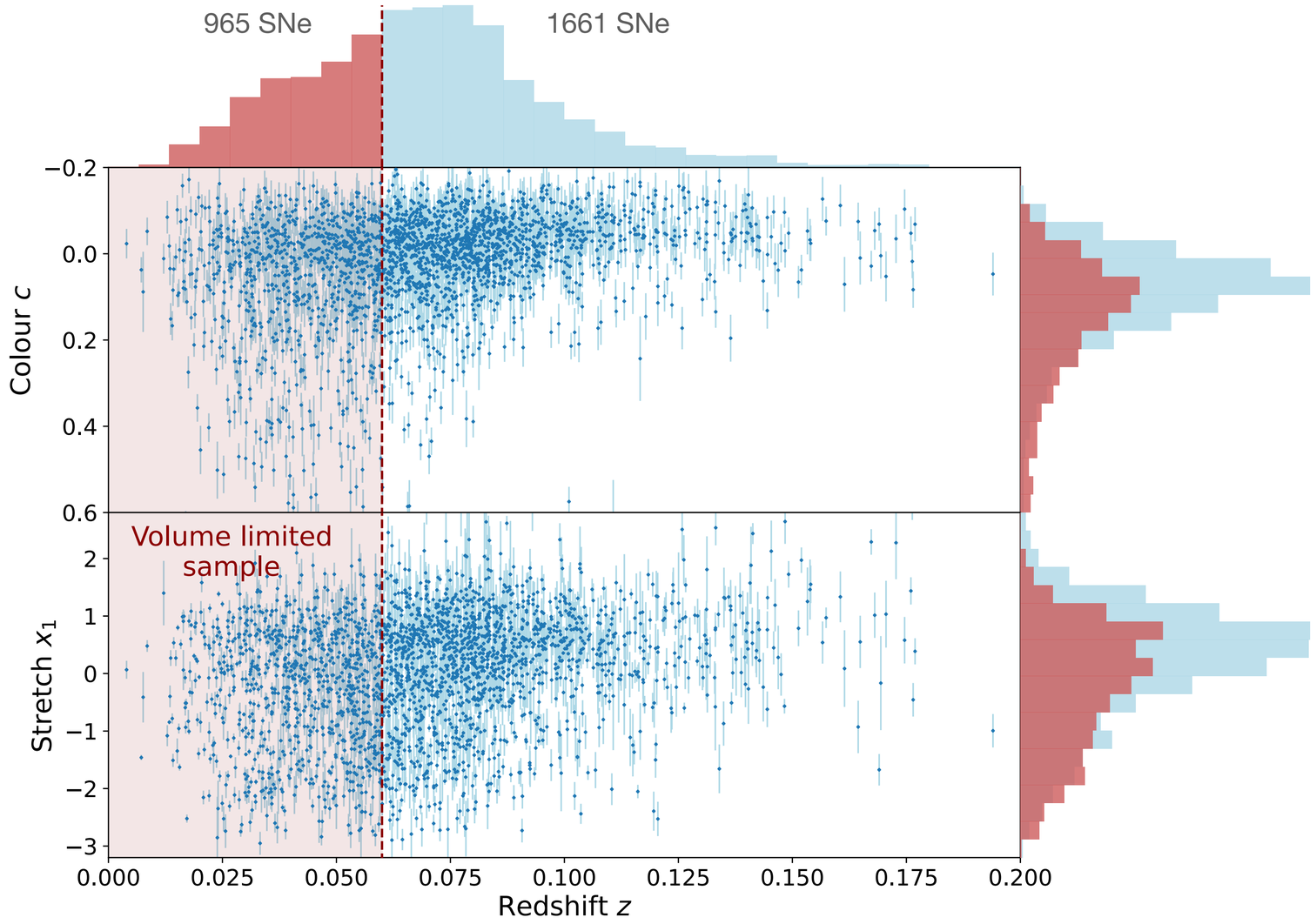
2959 SNe
with well-sampled lightcurves

ZTF SN Ia DR2

Volume limited sample

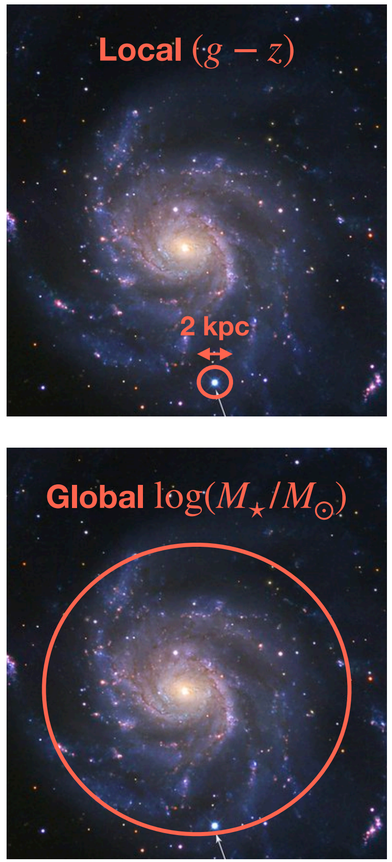
- $z < 0.06$
- Quality cuts:
  - Lightcurve sampling
  - $(x_1, x_1^{\mathrm{err}})$
  - (c, c^{err})
  - t_0^{err}
  - SN Ia type
  - SALT fit probability χ^2_{SALT}

927 SNe in the final sample



ZTF SN Ia DR2

Environment proxies



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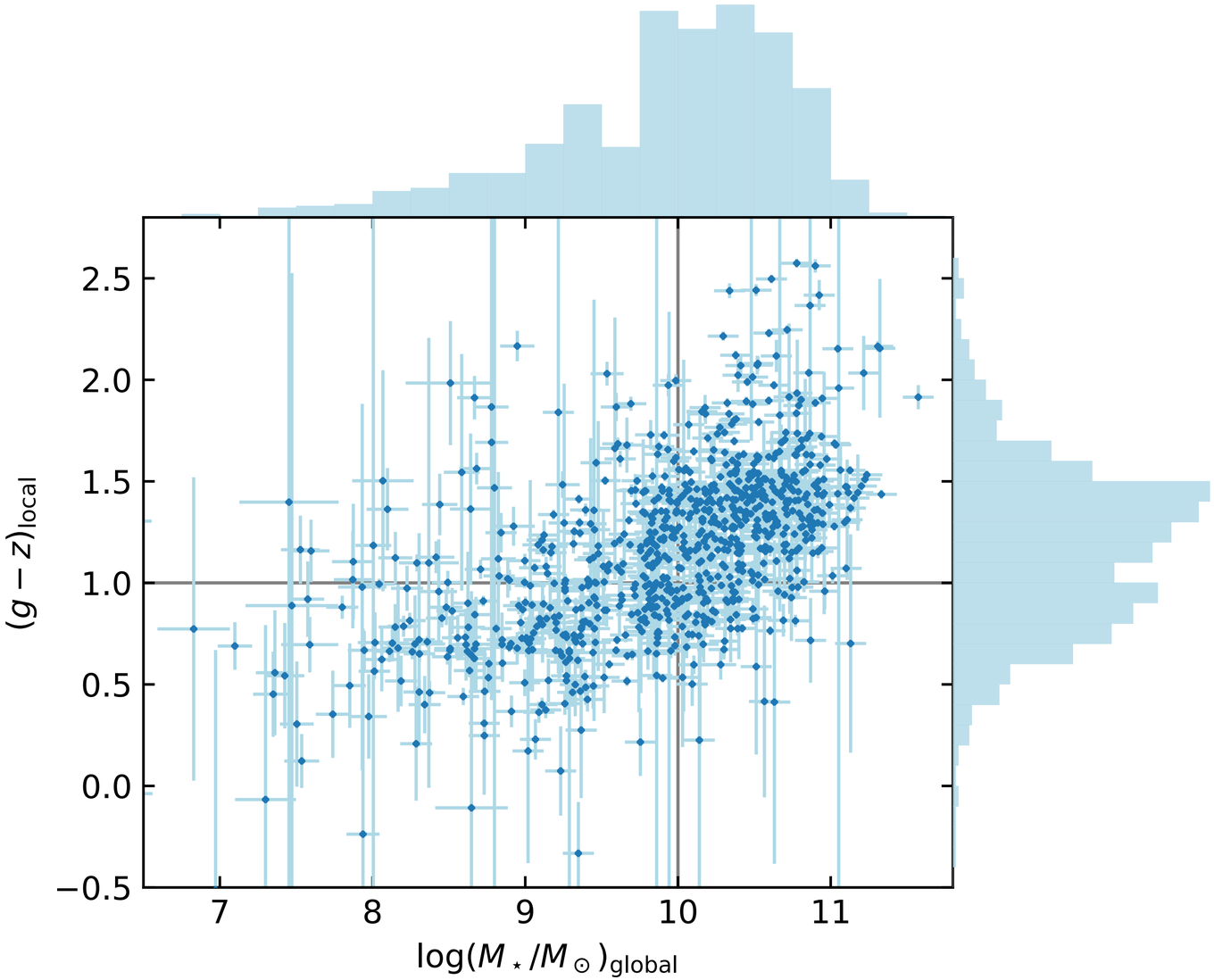
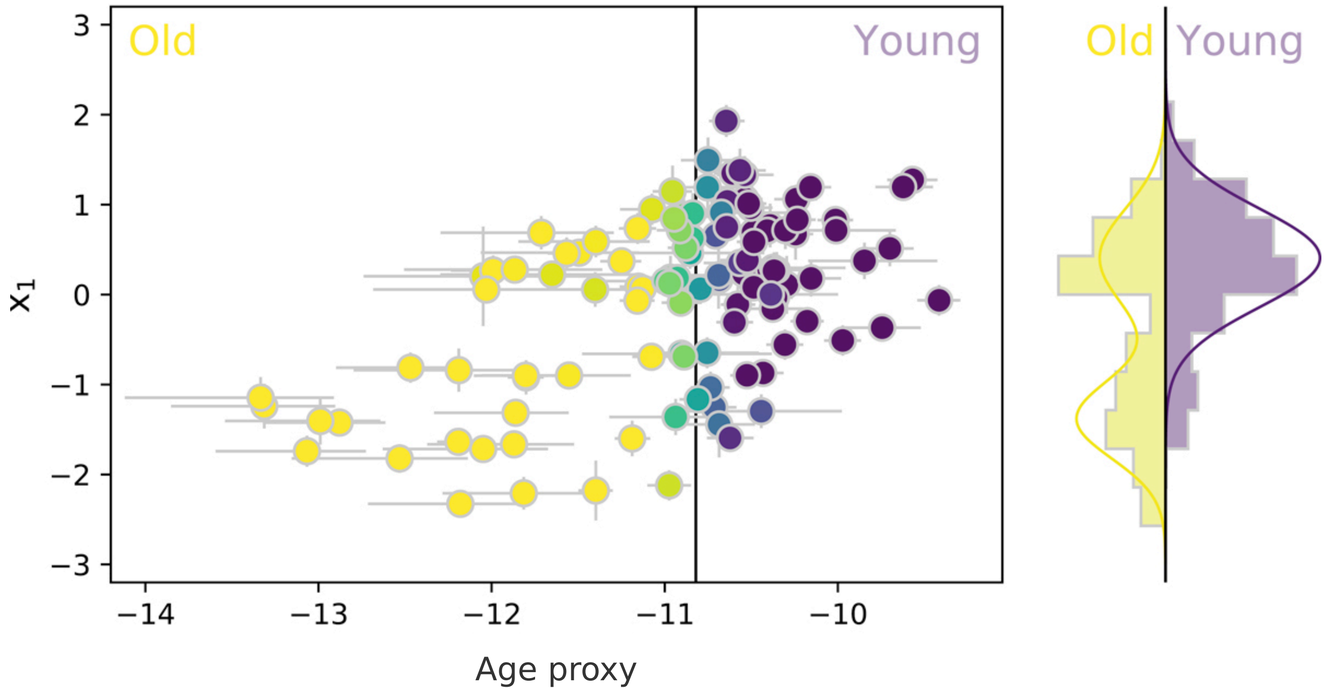
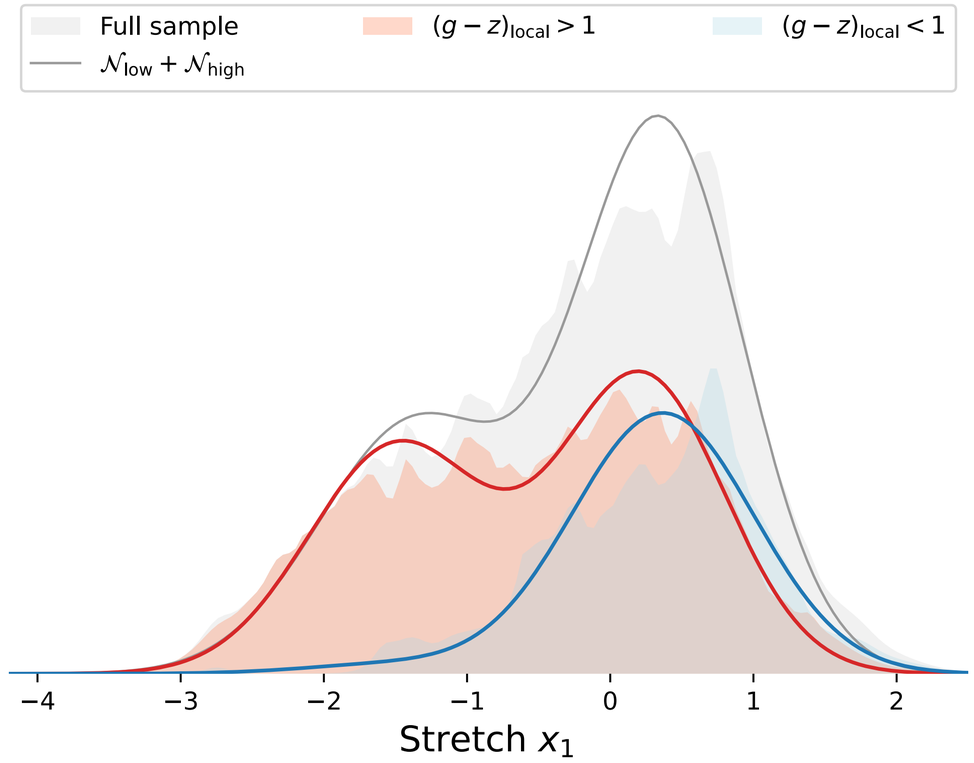


Stretch
Distribution



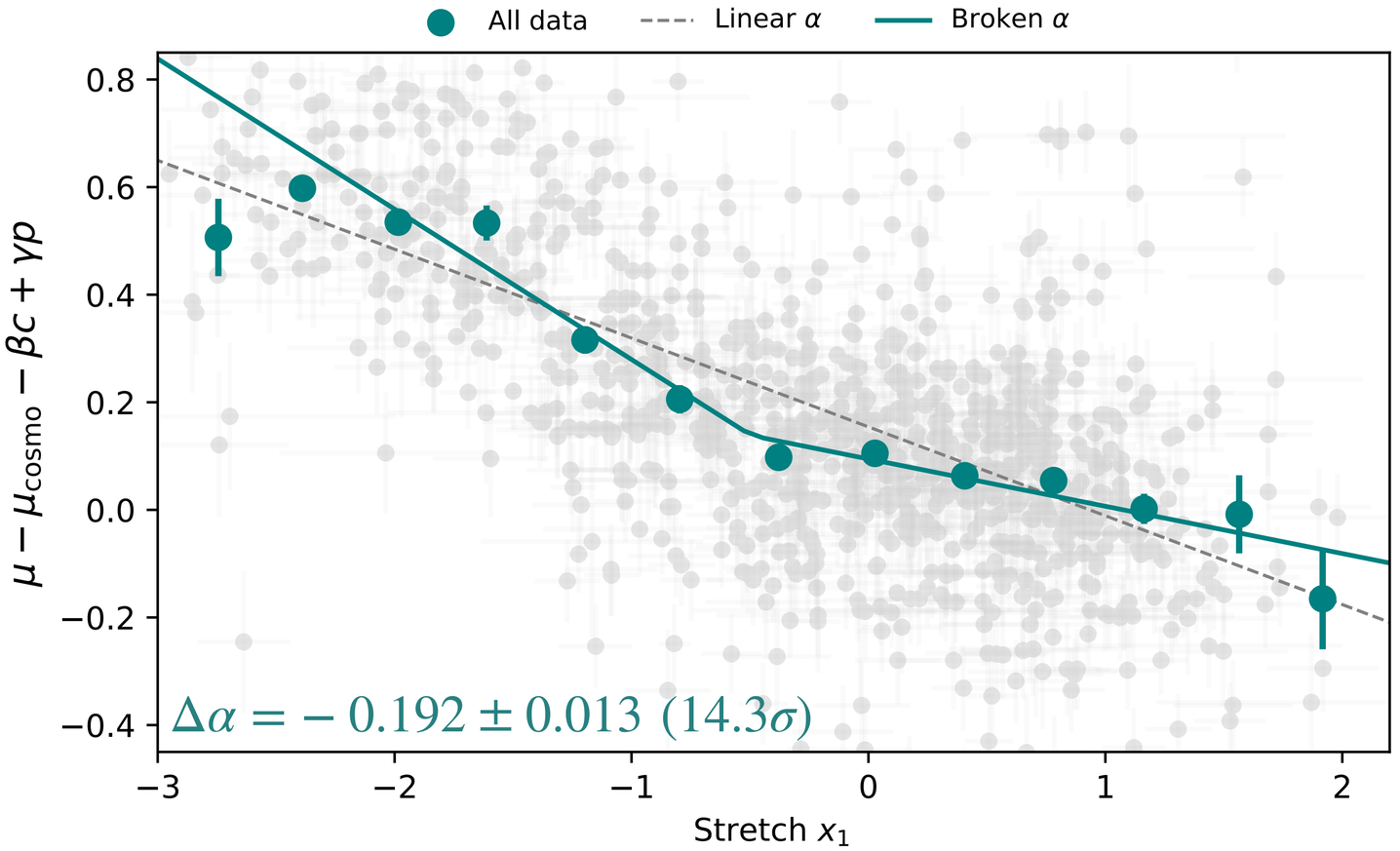
Nicolas et al (2021)
SNfactory - 114 SNe



Ginolin et al (2024a, in prep)

Stretch

Non linearity of the stretch-residuals relation

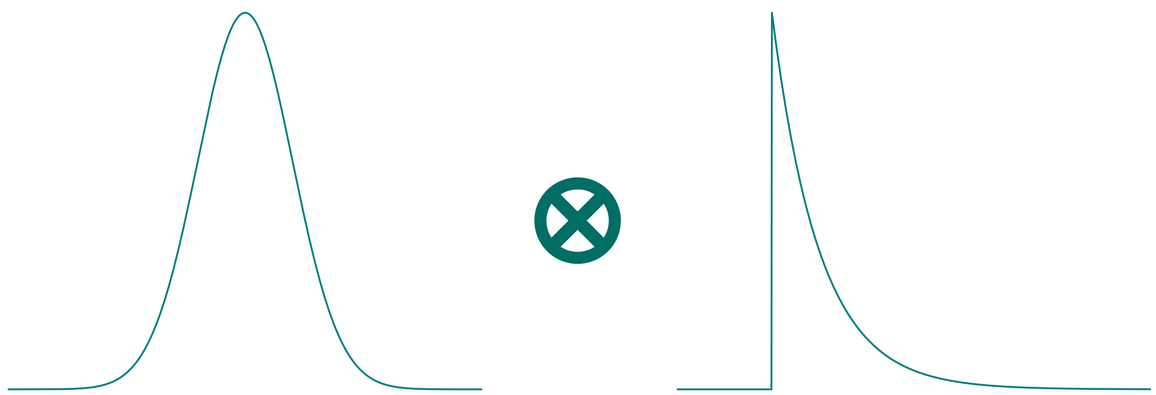


Ginolin et al (2024a, in prep)

Colour
Distribution

Intrinsic colour

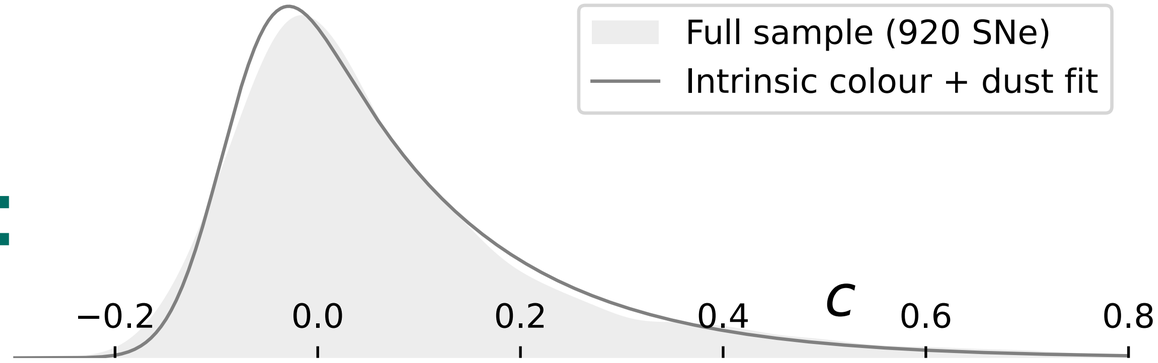
Dust reddening



$\mathcal{N}(c, c_{\text{int}}, \sigma_c)$

$e^{-c\tau}$

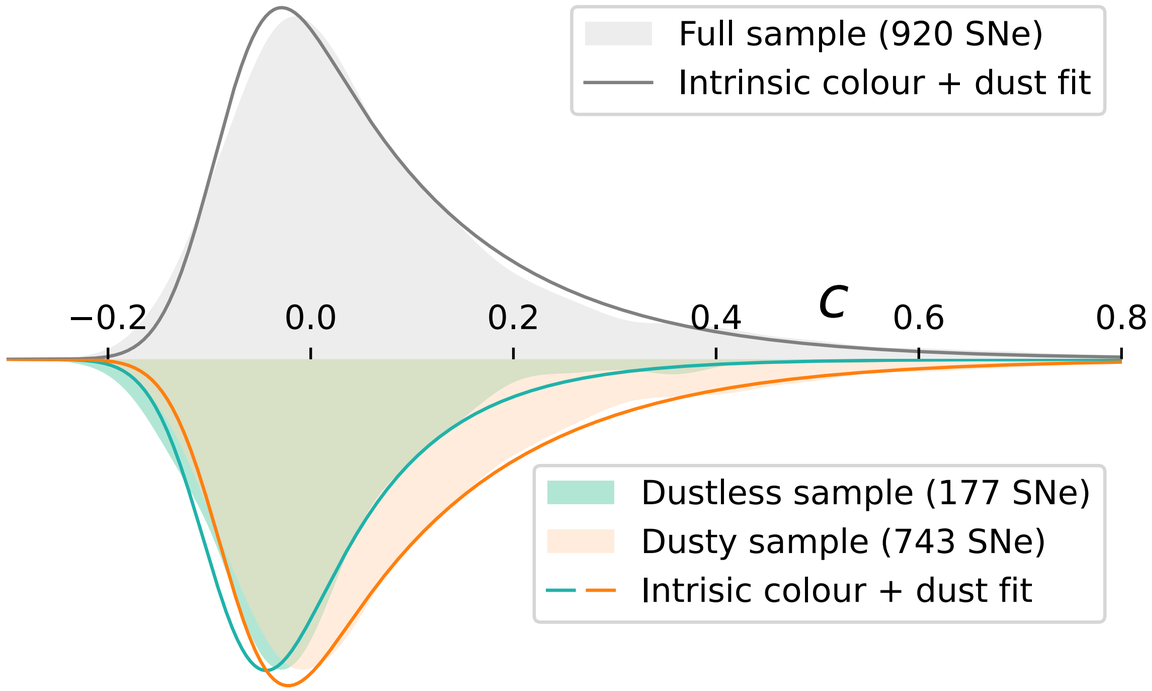
Brout & Scolnic (2020)



Ginolin et al (2024b, in prep)

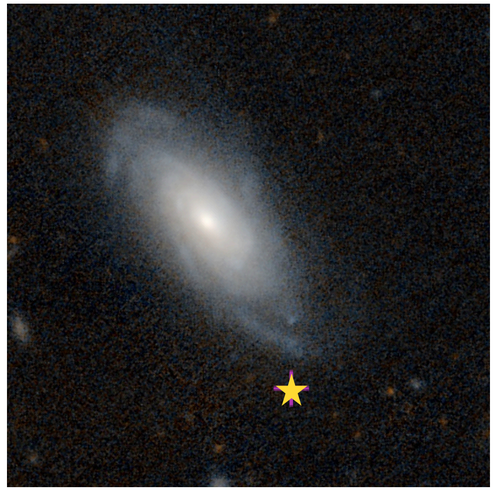
Colour

Dustless & dusty subsamples



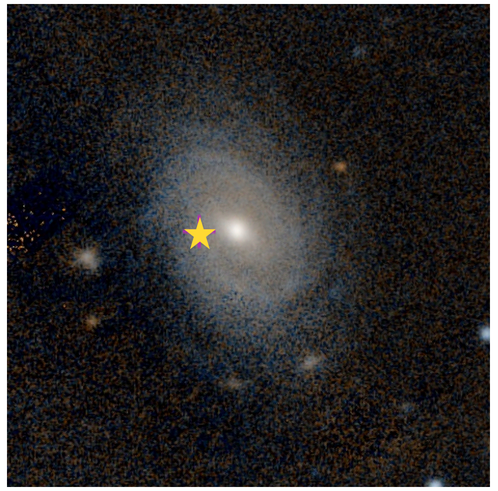
Ginolin et al (2024b, in prep)

« Dustless » example



ZTF18aahfzea

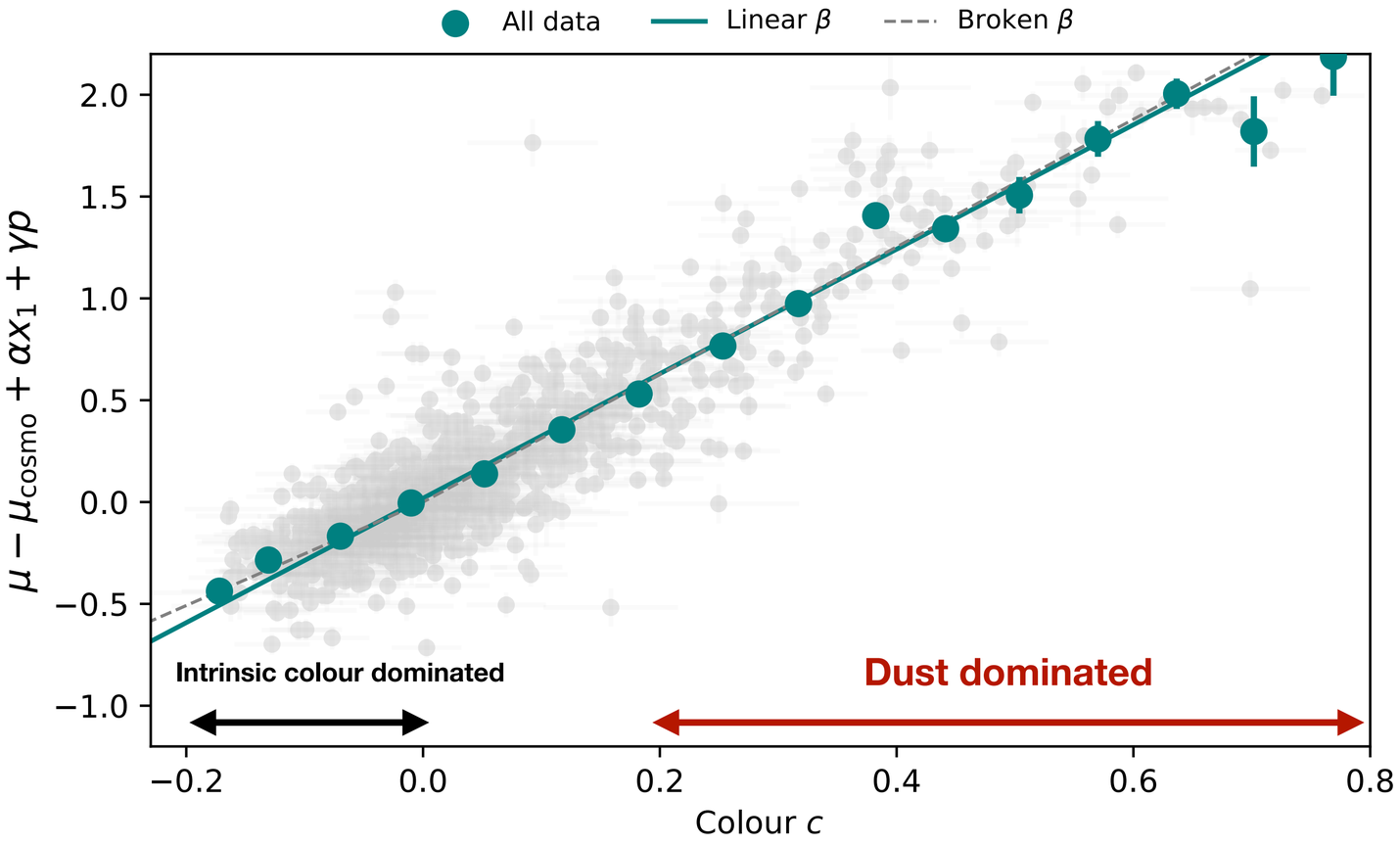
« Dusty » example



ZTF18aaqfziz

Colour

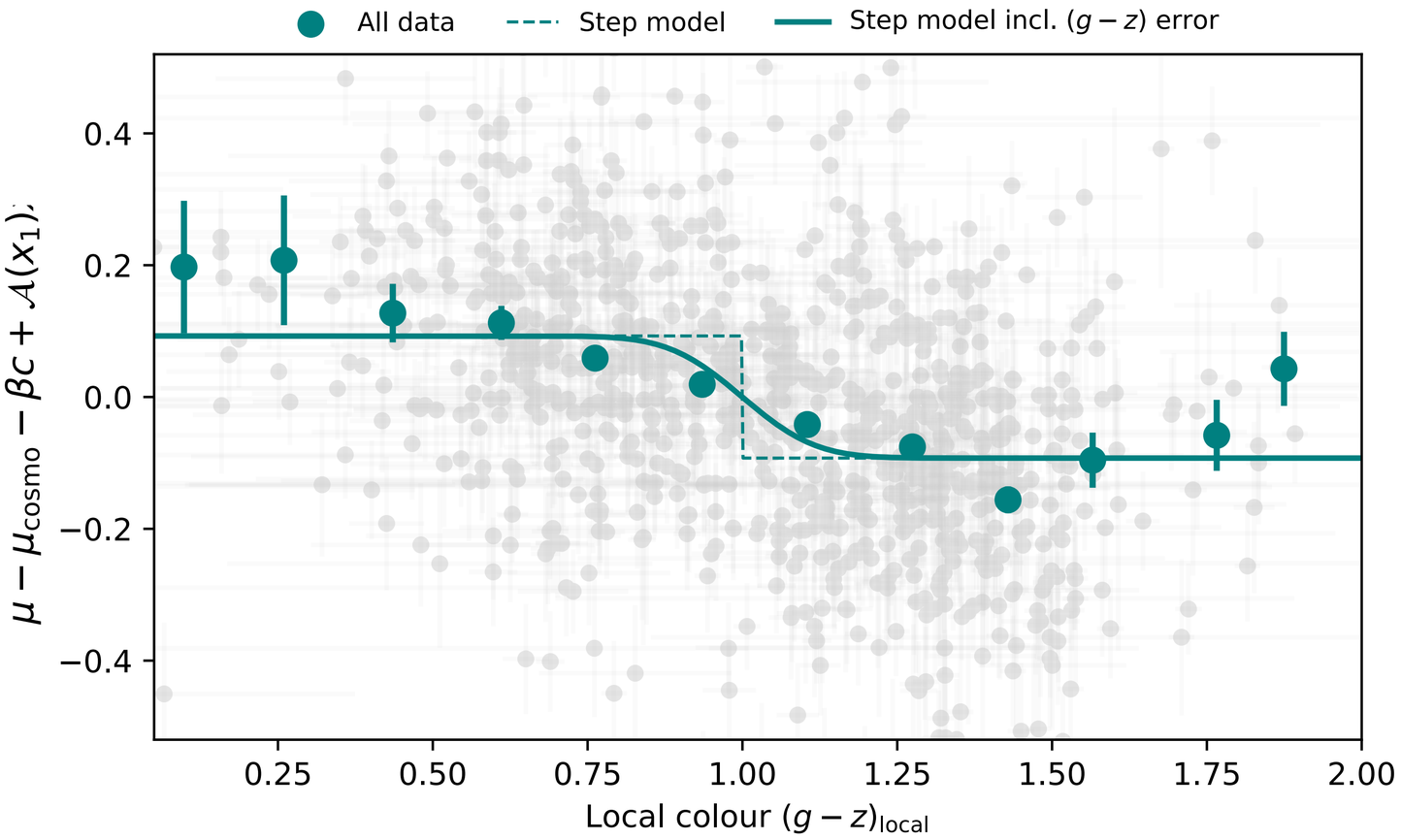
Linearity of the colour-residuals relation



Ginolin et al (2024b, in prep)

Environmental step

Pantheon+ step: $\gamma \sim 0.05$



$$\gamma = 0.156 \pm 0.024 \text{ mag}$$

$$\gamma_{\text{broken}-\alpha} = 0.185 \pm 0.010 \text{ mag}$$

Ginolin et al (2024a, in prep)

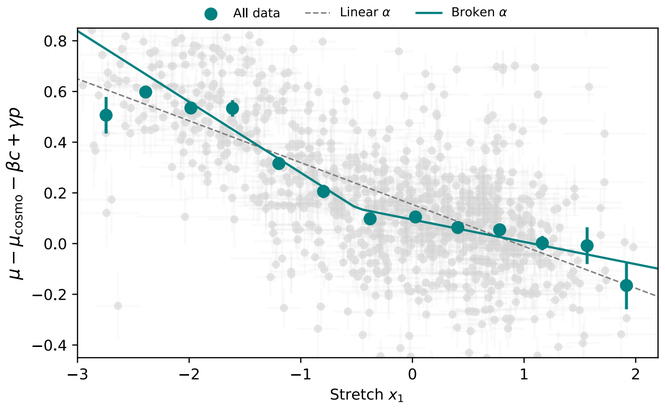
Conclusion

ZTF SN Ia DR2:

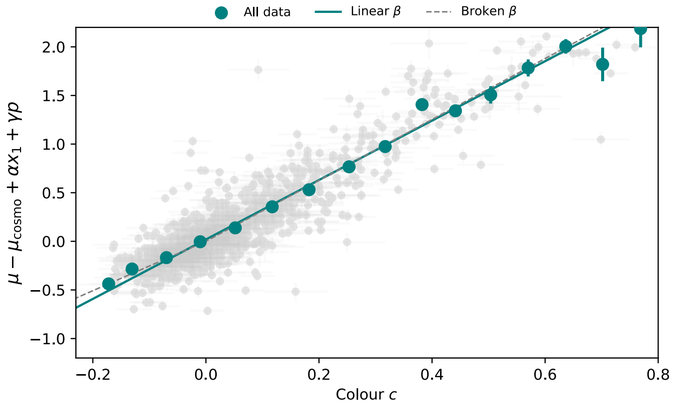
3628 SNe - 2959 SNe in the cosmo dataset

Largest low-z Type Ia supernovae single-survey sample
High cadence
High quality (spectroscopically confirmed Ia + redshift)

Broken-α at 14σ



Linear β



Environmental step $\gamma \sim 0.15$