

The ZTF SN Ia DR2 sample

On behalf of the ZTF-Cosmo collaboration

Madeleine GINOLIN - 28th October 2024

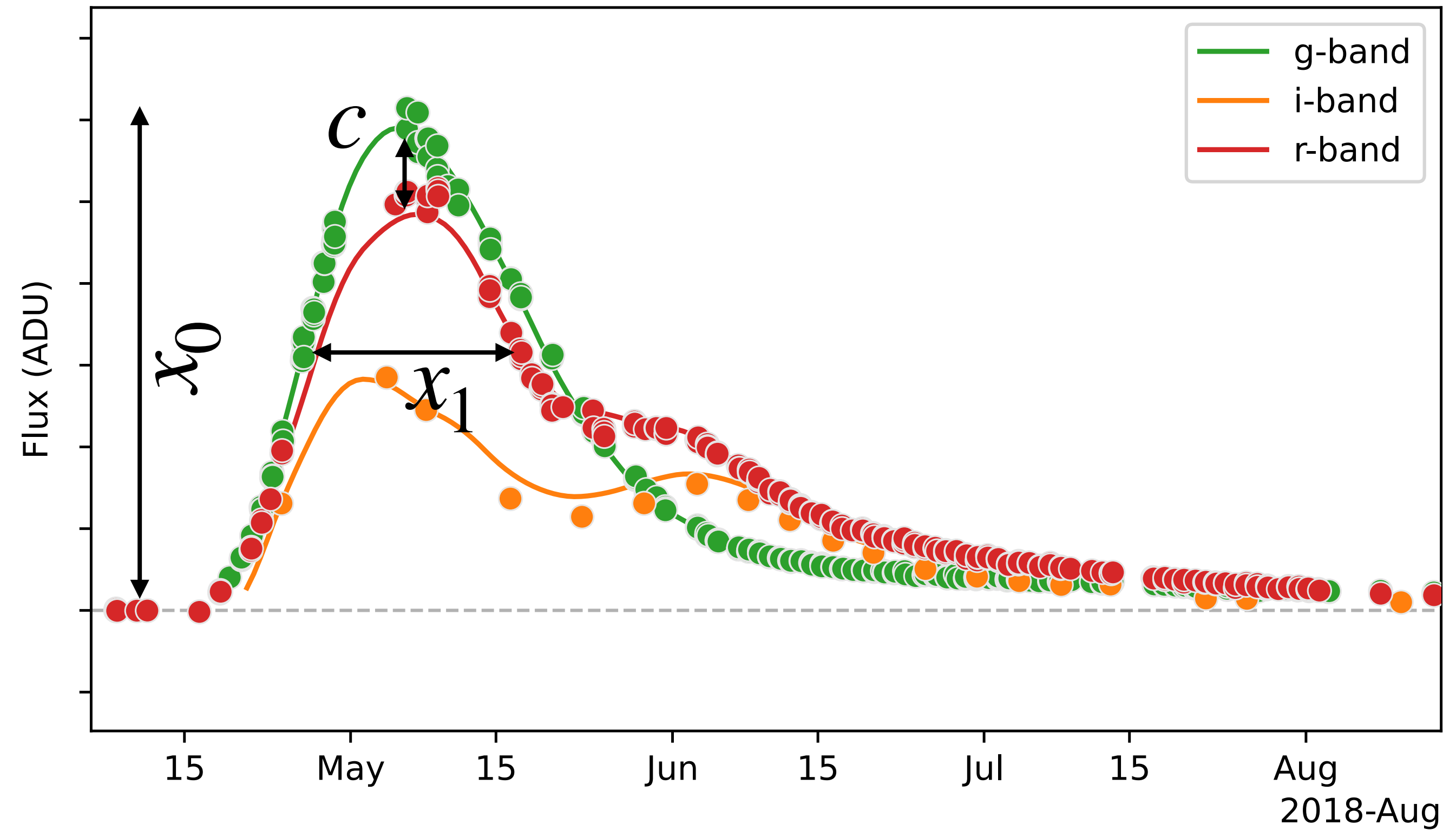


Type Ia Supernovae

Lightcurve

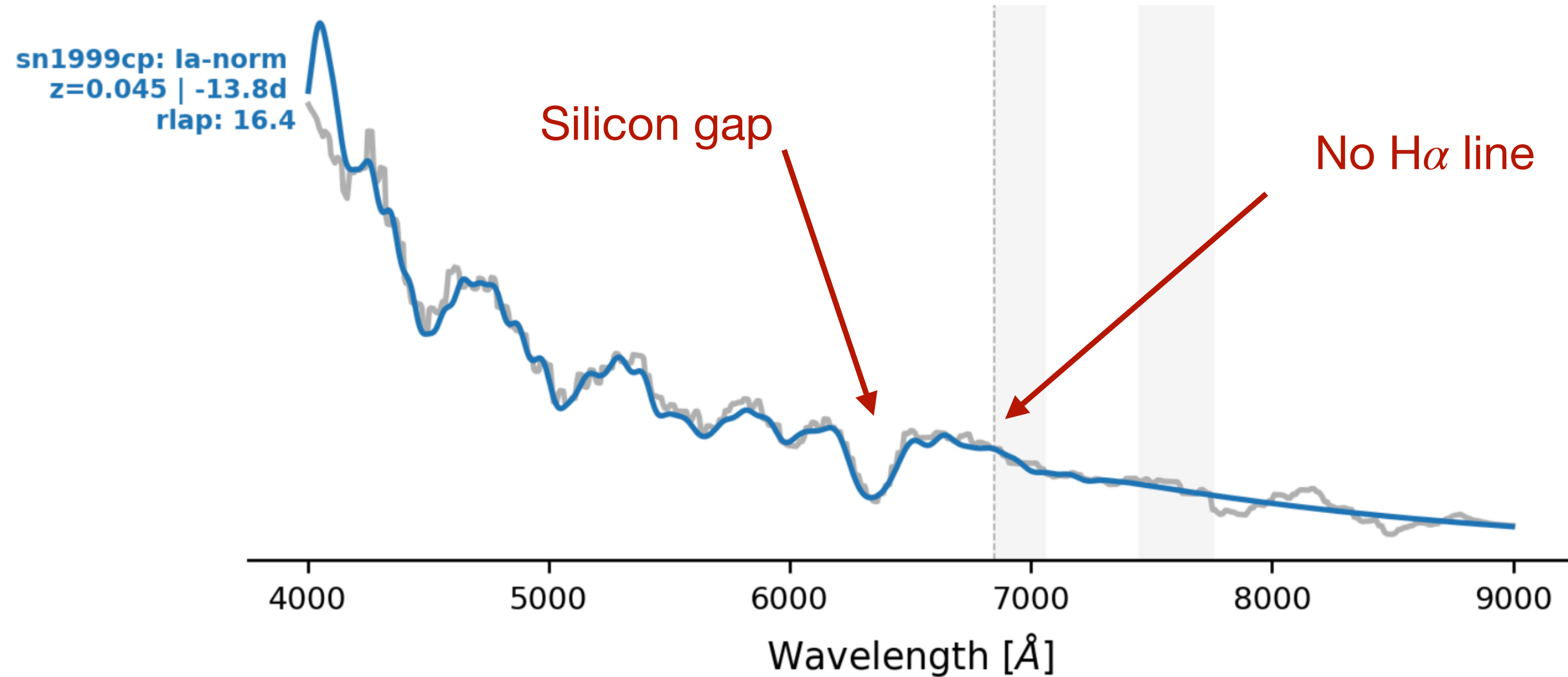


B.J. Fulton/LCOGT/Caltech

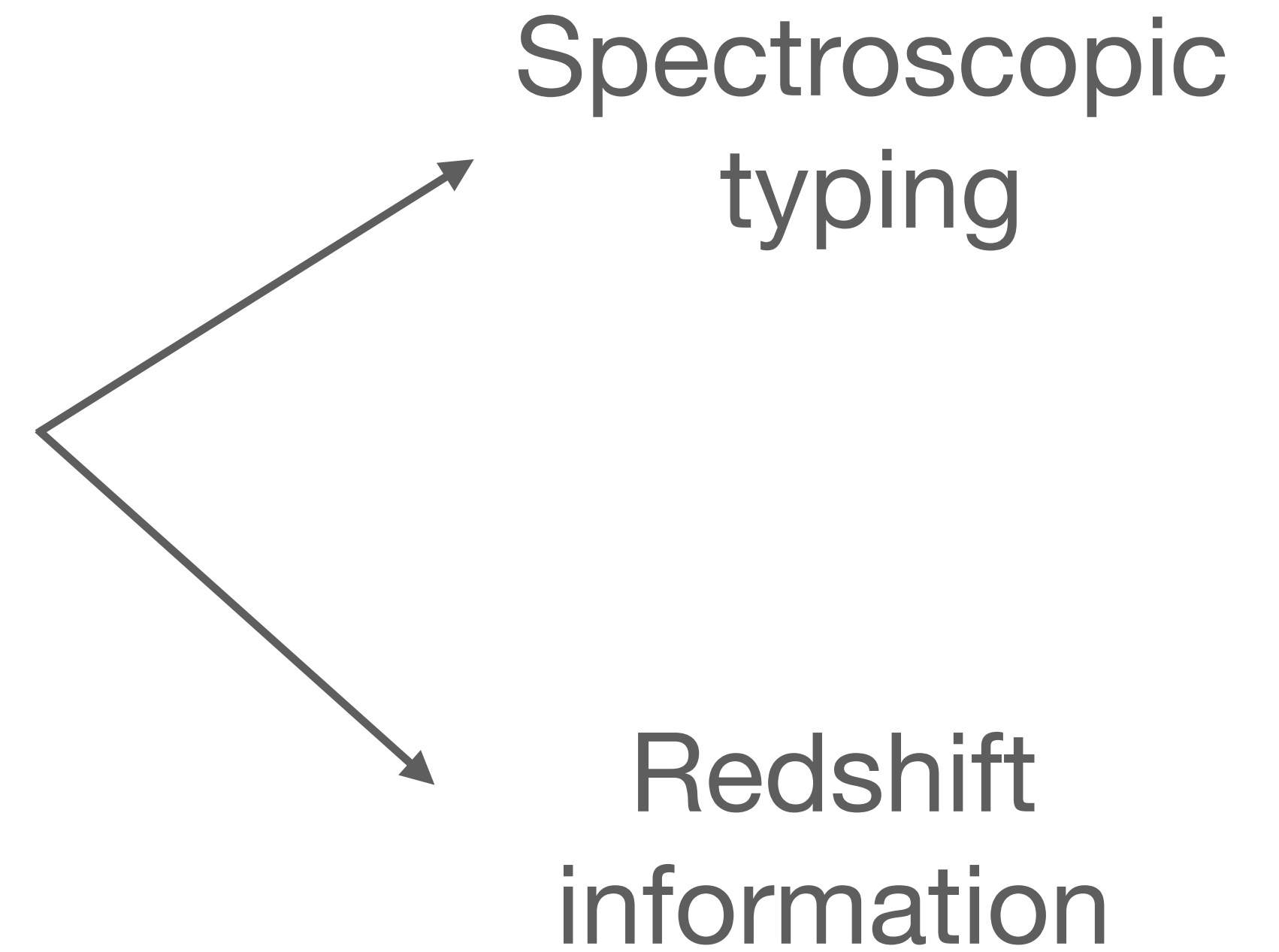


SALT2.4 (Guy et al 2007)

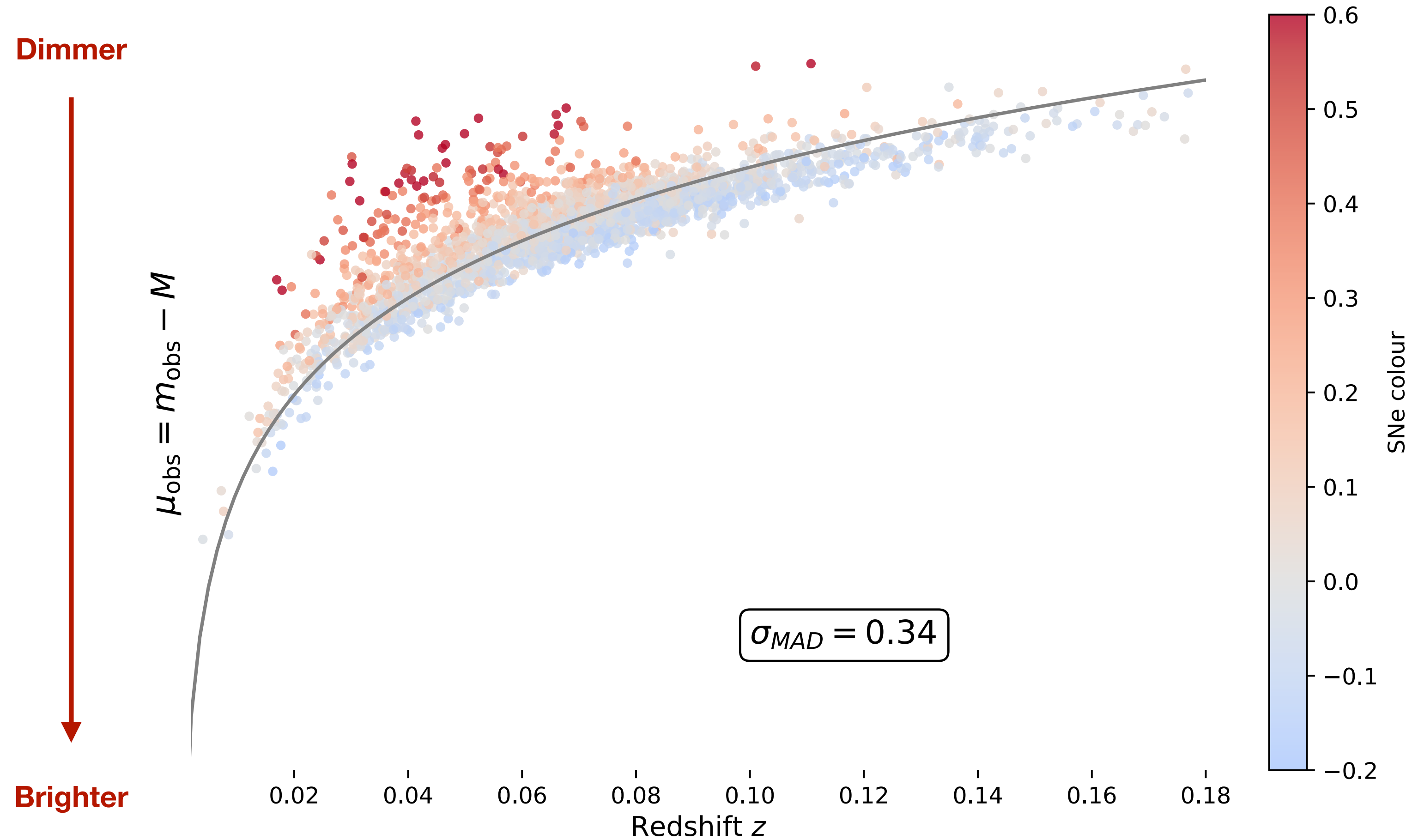
Type Ia Supernovae Spectrum



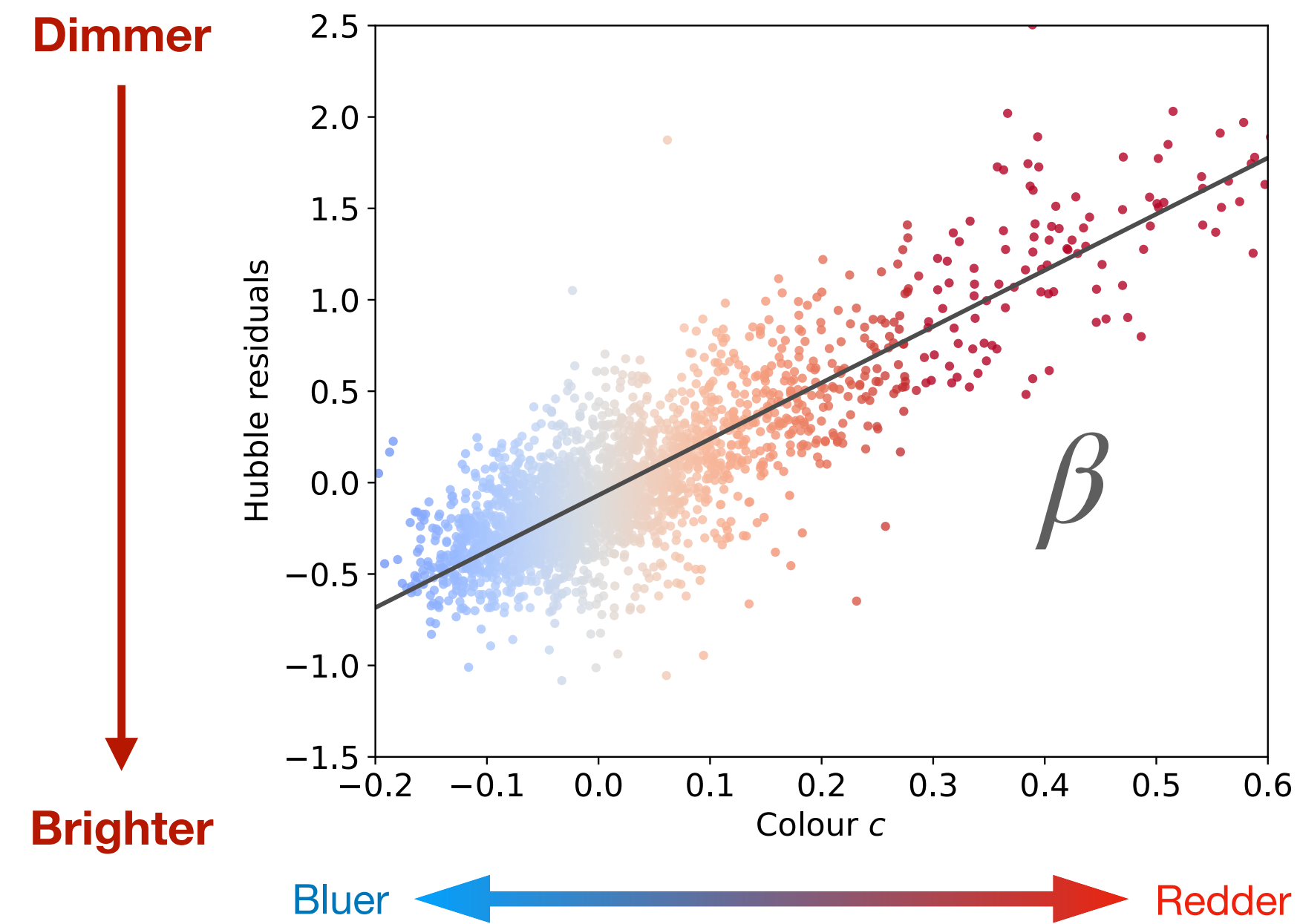
SNID (Blondin & Tonry 2007)



Type Ia Supernovae Standardisation

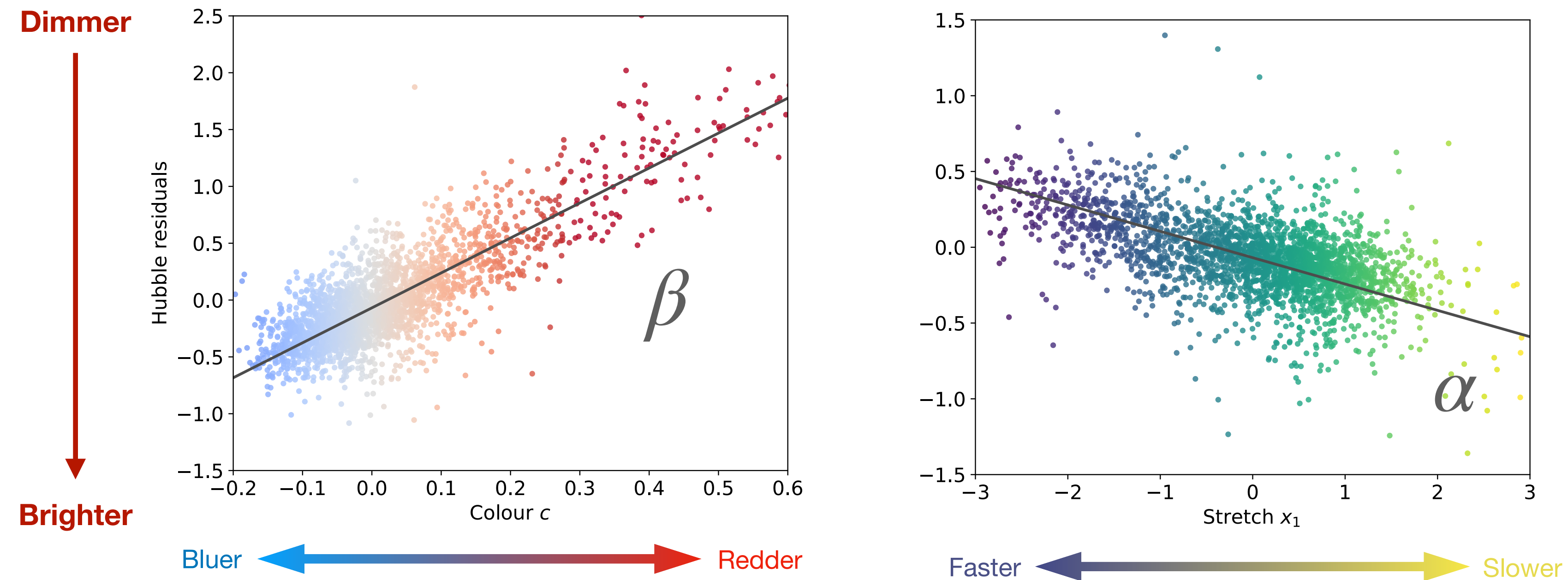


Type Ia Supernovae Standardisation



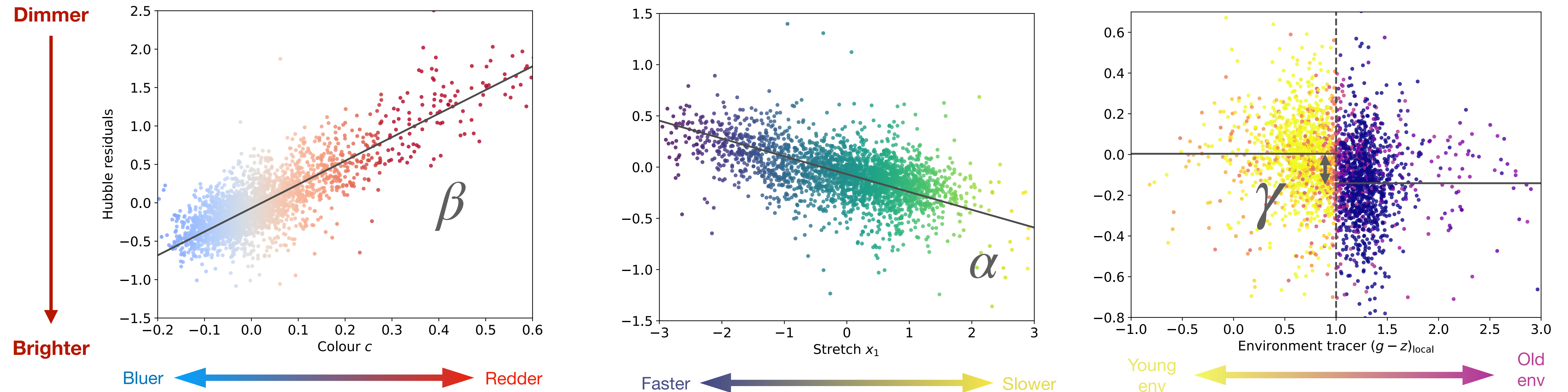
$$\mu_{\text{obs}} + M = m_{\text{obs}} - \beta c$$

Type Ia Supernovae Standardisation



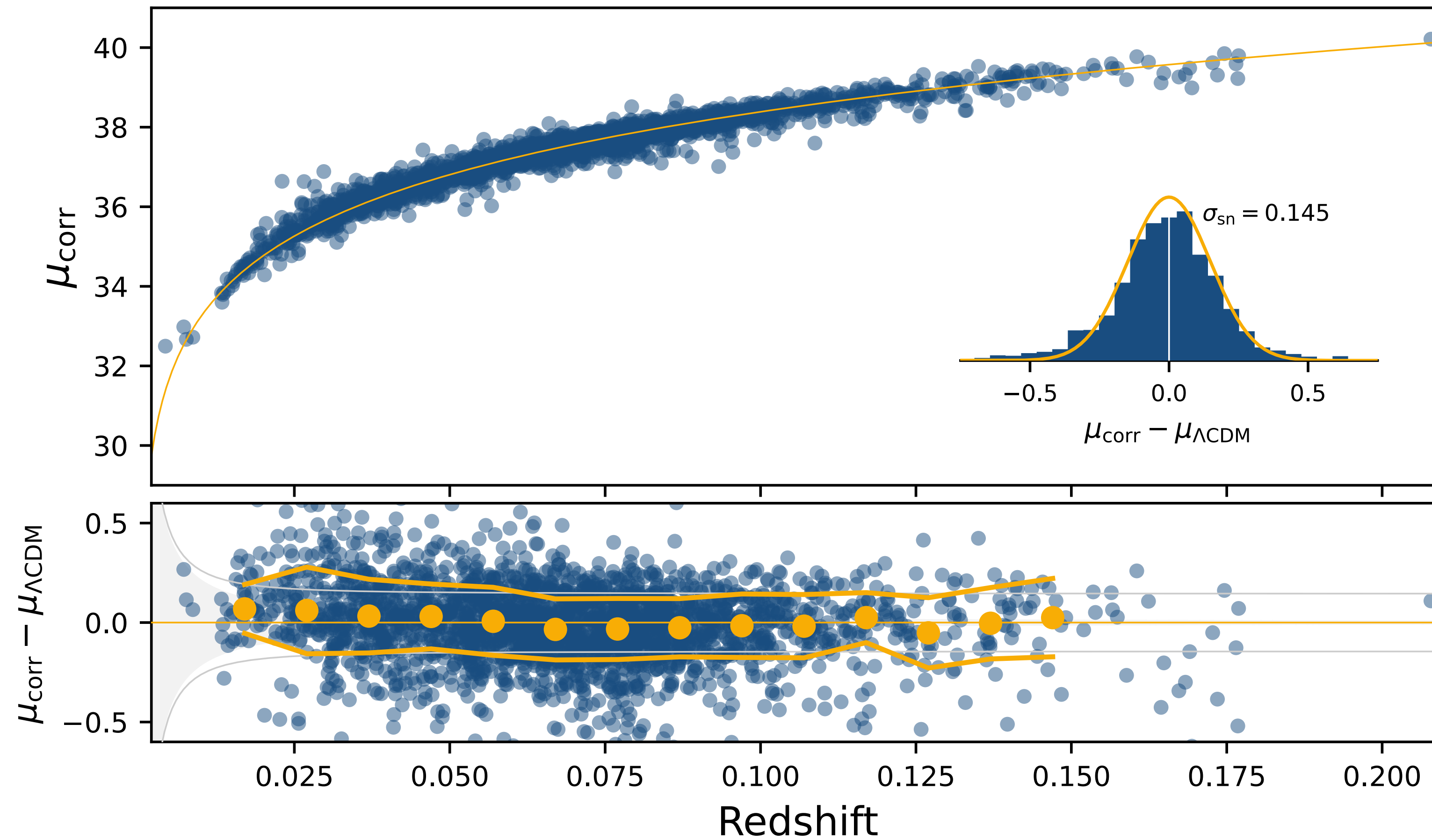
$$\mu_{\text{obs}} + M = m_{\text{obs}} - \beta c + \alpha x_1$$

Type Ia Supernovae Standardisation



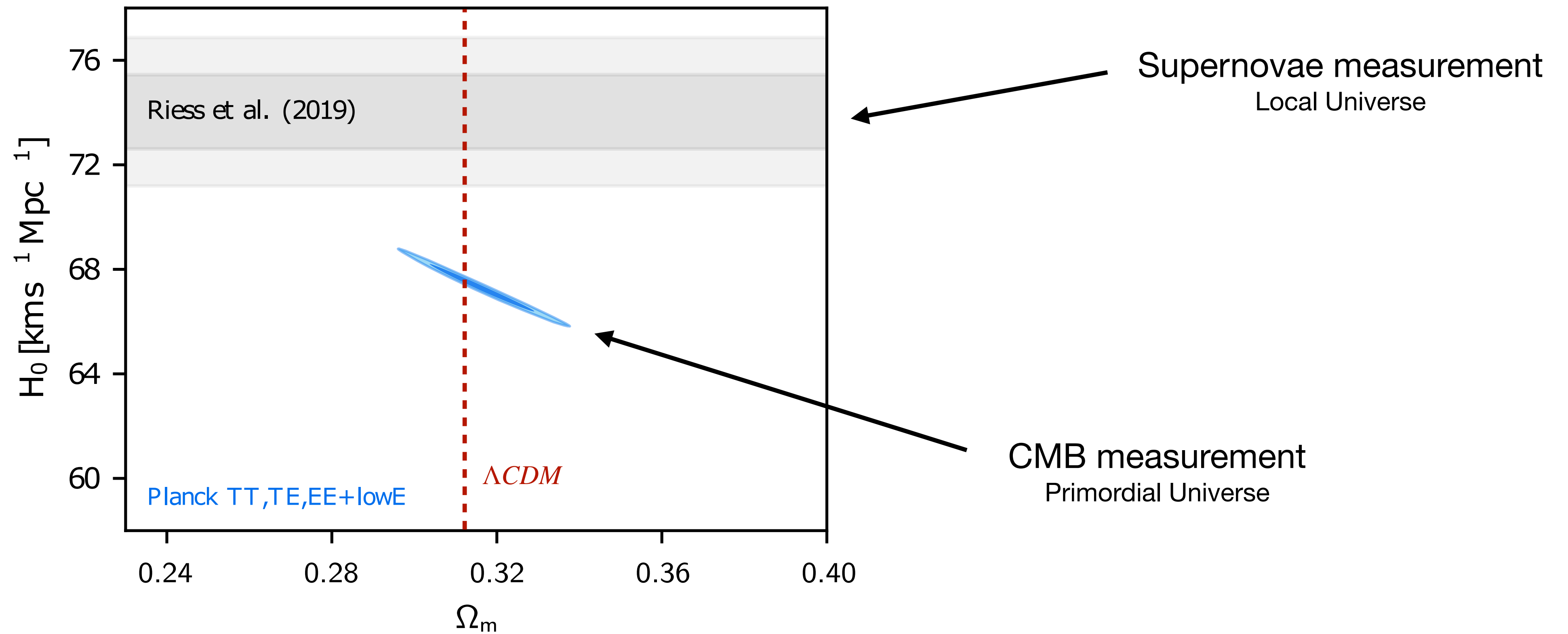
$$\mu_{\text{obs}} + M = m_{\text{obs}} - \beta c + \alpha x_1 + p\gamma$$

Type Ia Supernovae Standardisation



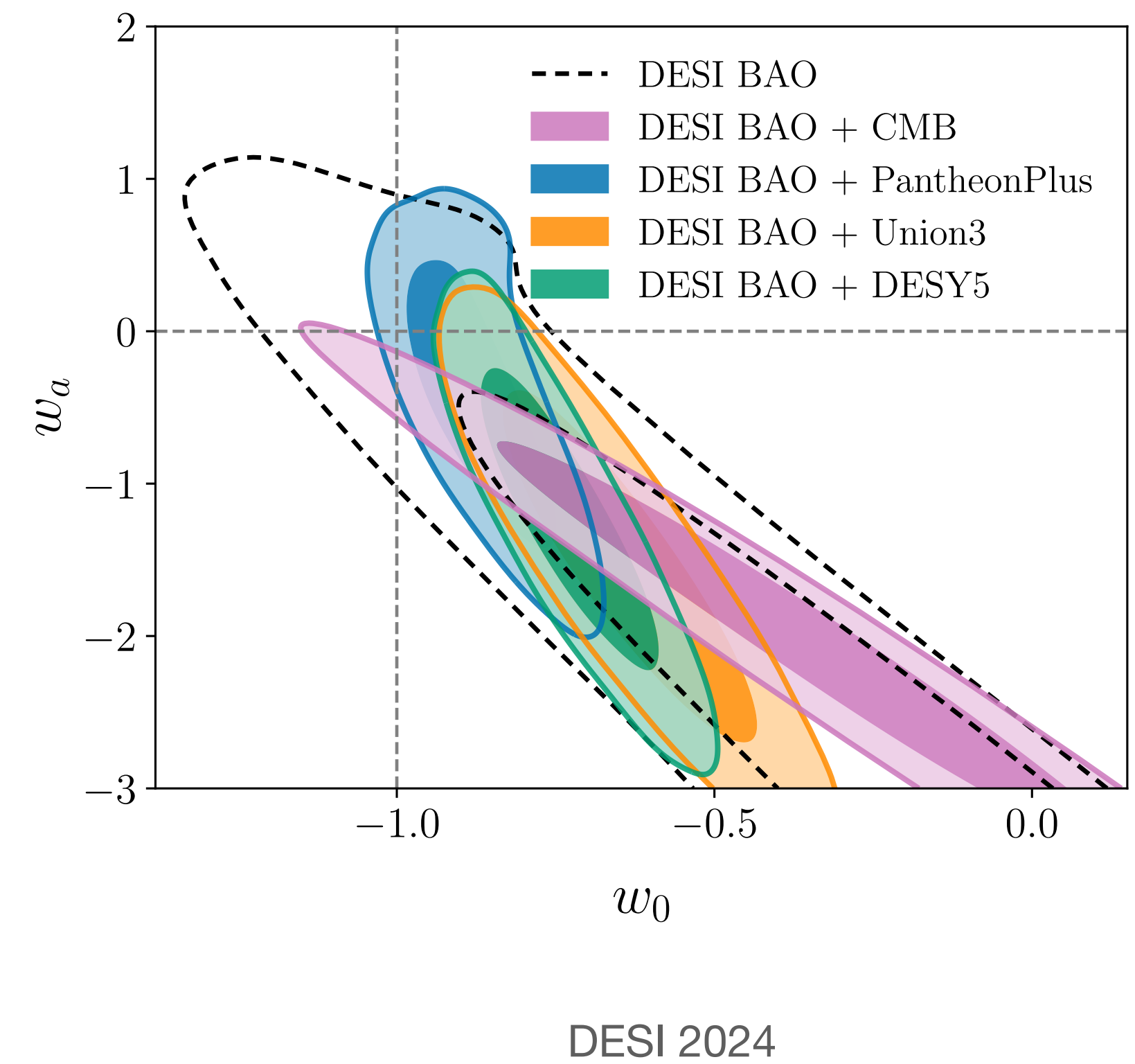
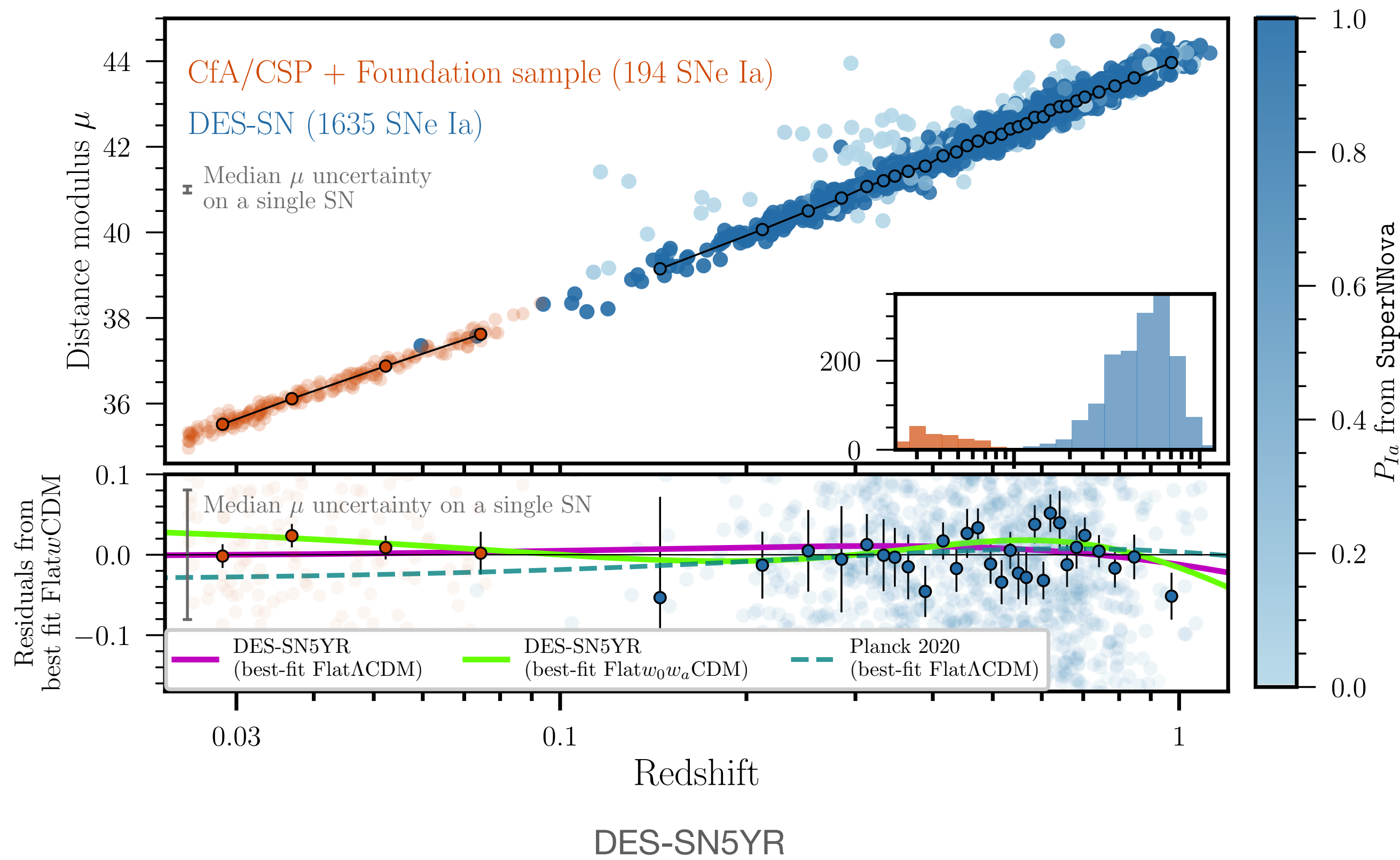
ZTF SN Ia DR2 Overview

Hubble tension



Adapted from Planck collaboration (2020)

Evolving dark energy



ZTF

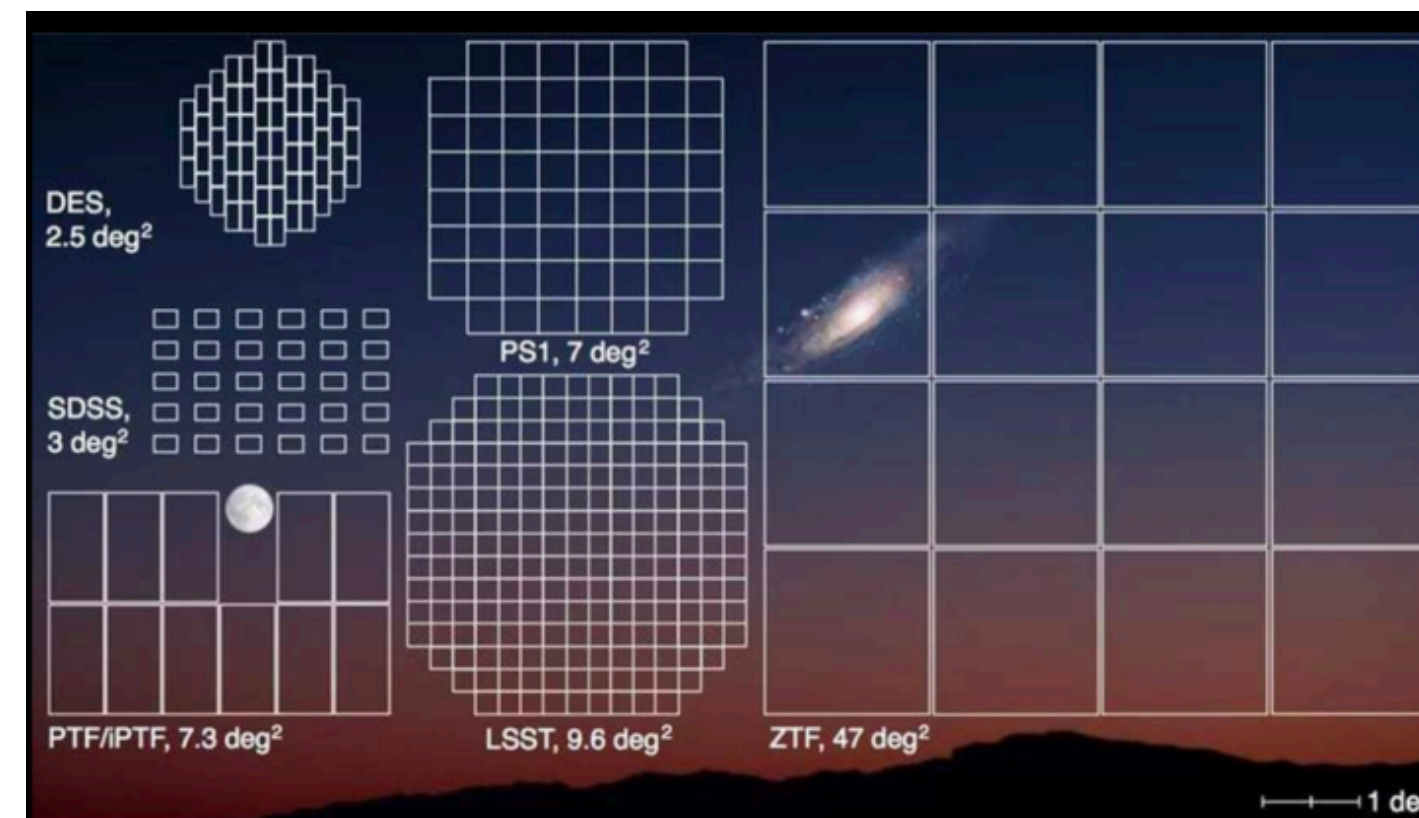


ZTF



Zwicky Transient Facility

Large FoV
Short exposures
3 bands (g, r, i)
Depth of 20.5 mag in r
(SN Ia at $z \sim 0.1$)

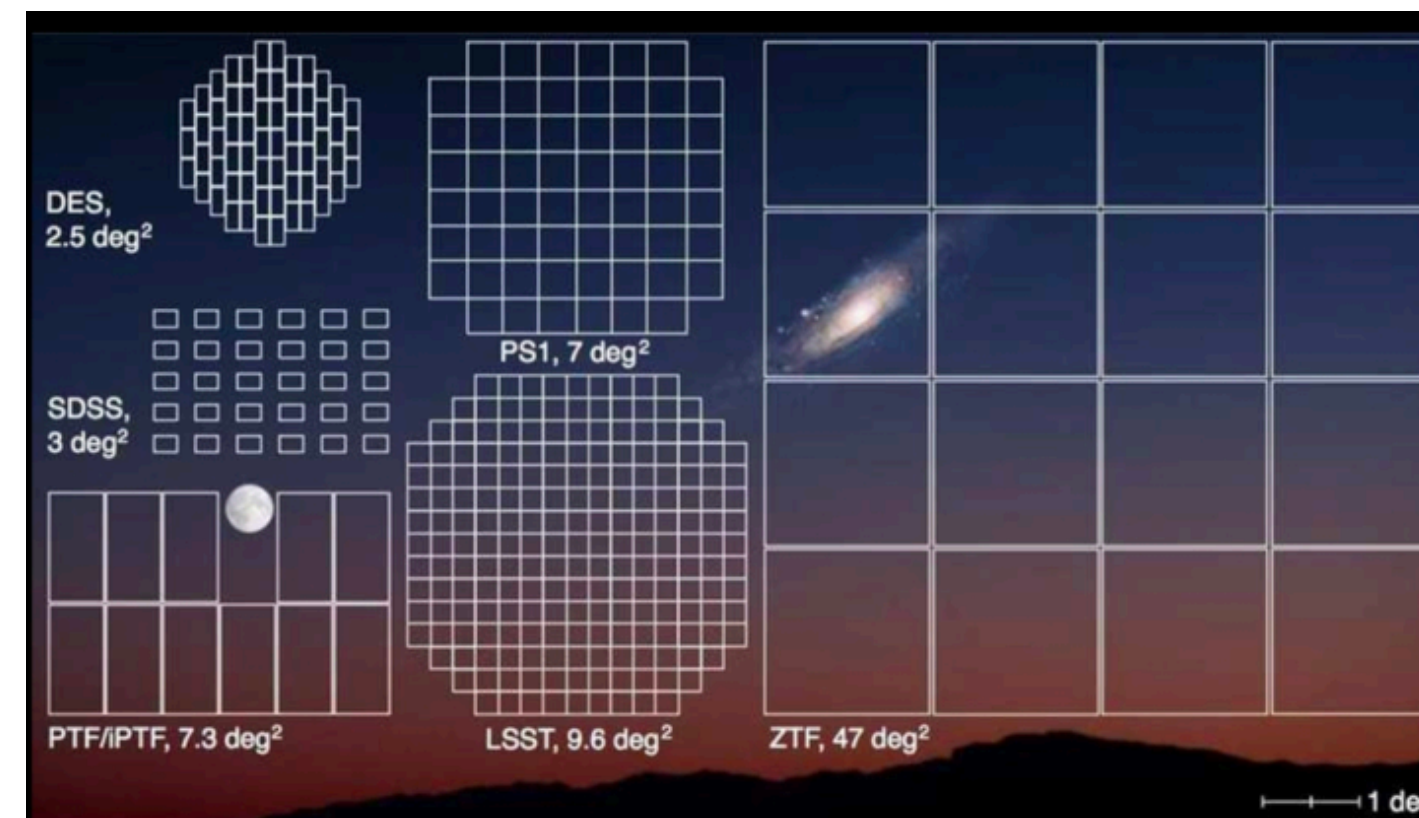


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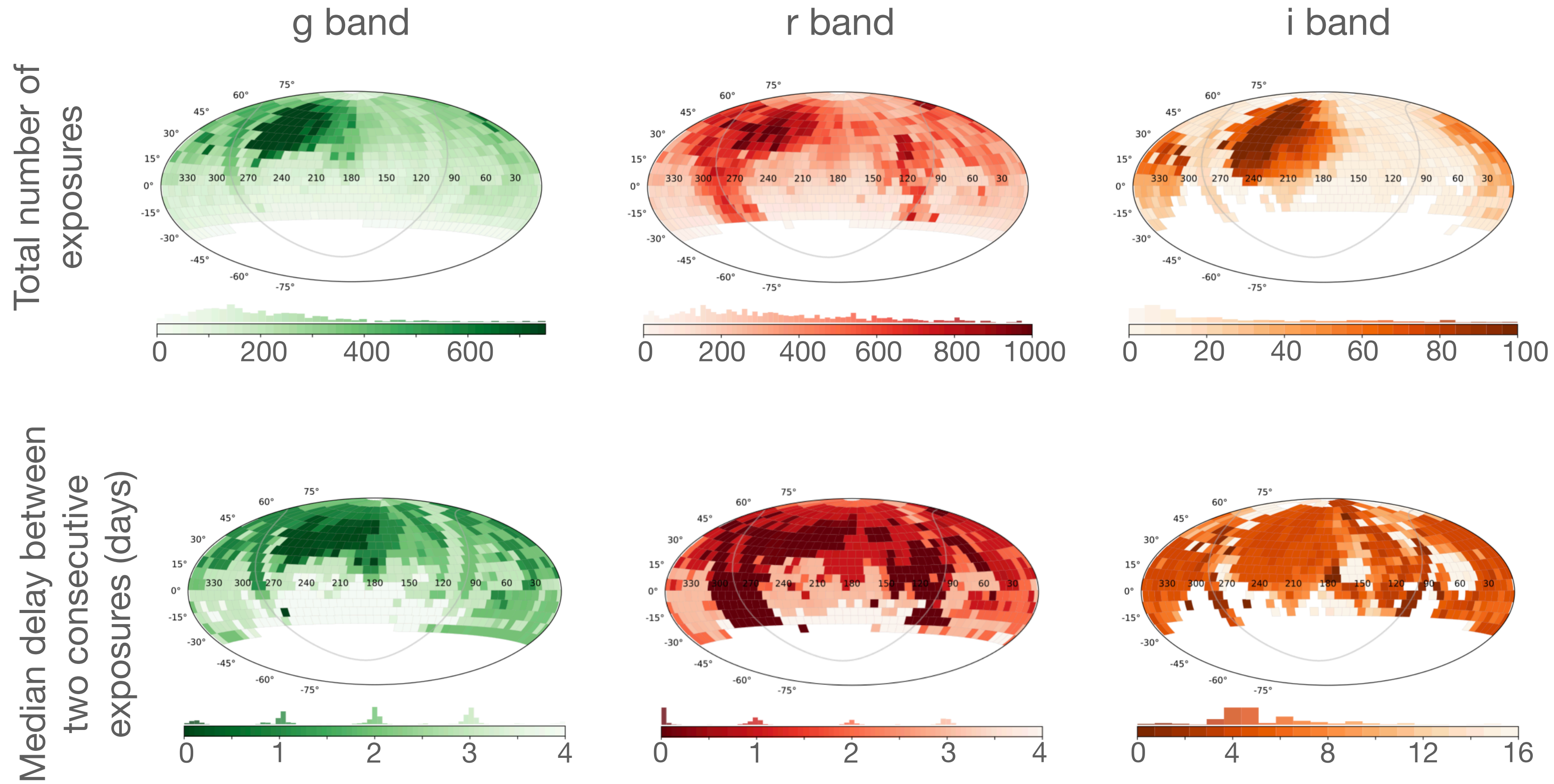


SEDmachine

Low resolution
~1h exposures

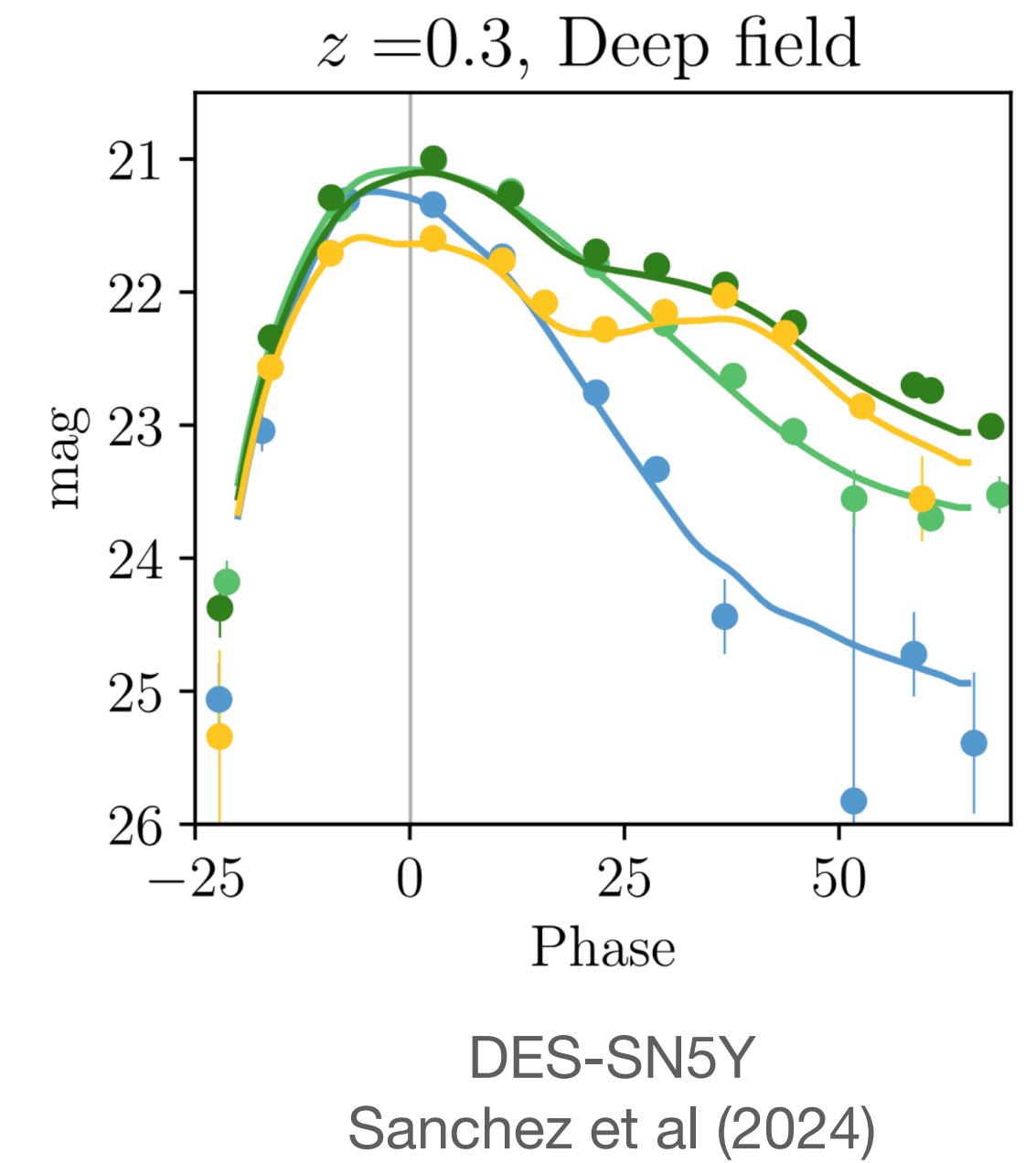
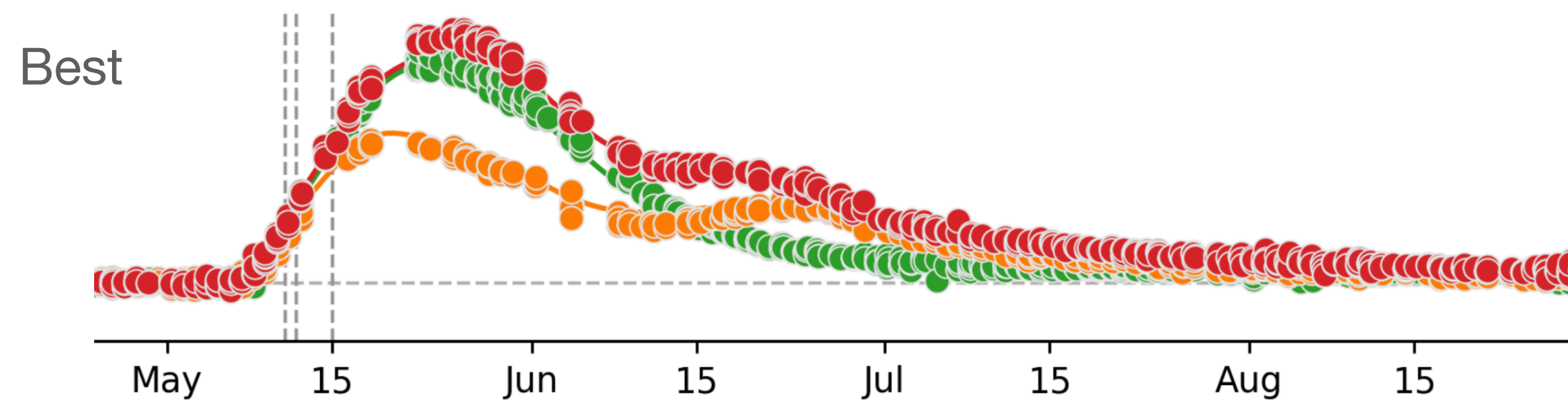
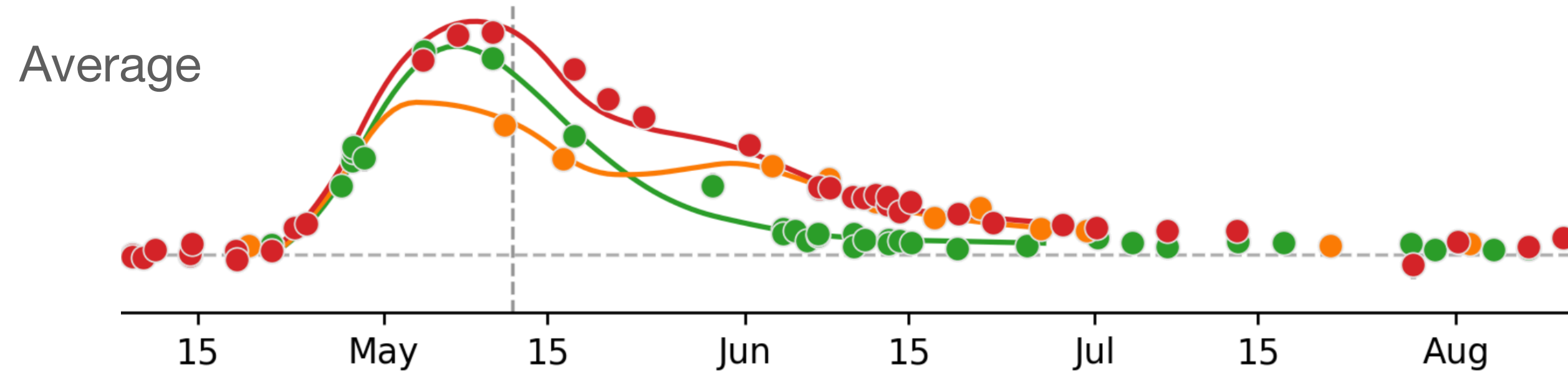
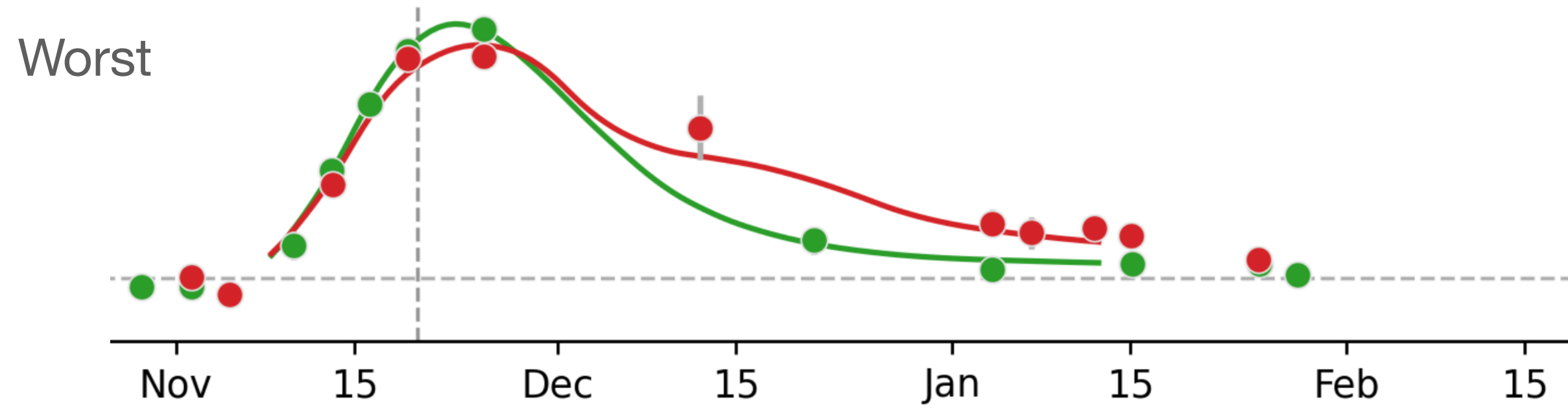
ZTF SN Ia DR2 - Data

Cadence



ZTF SN Ia DR2 - Data

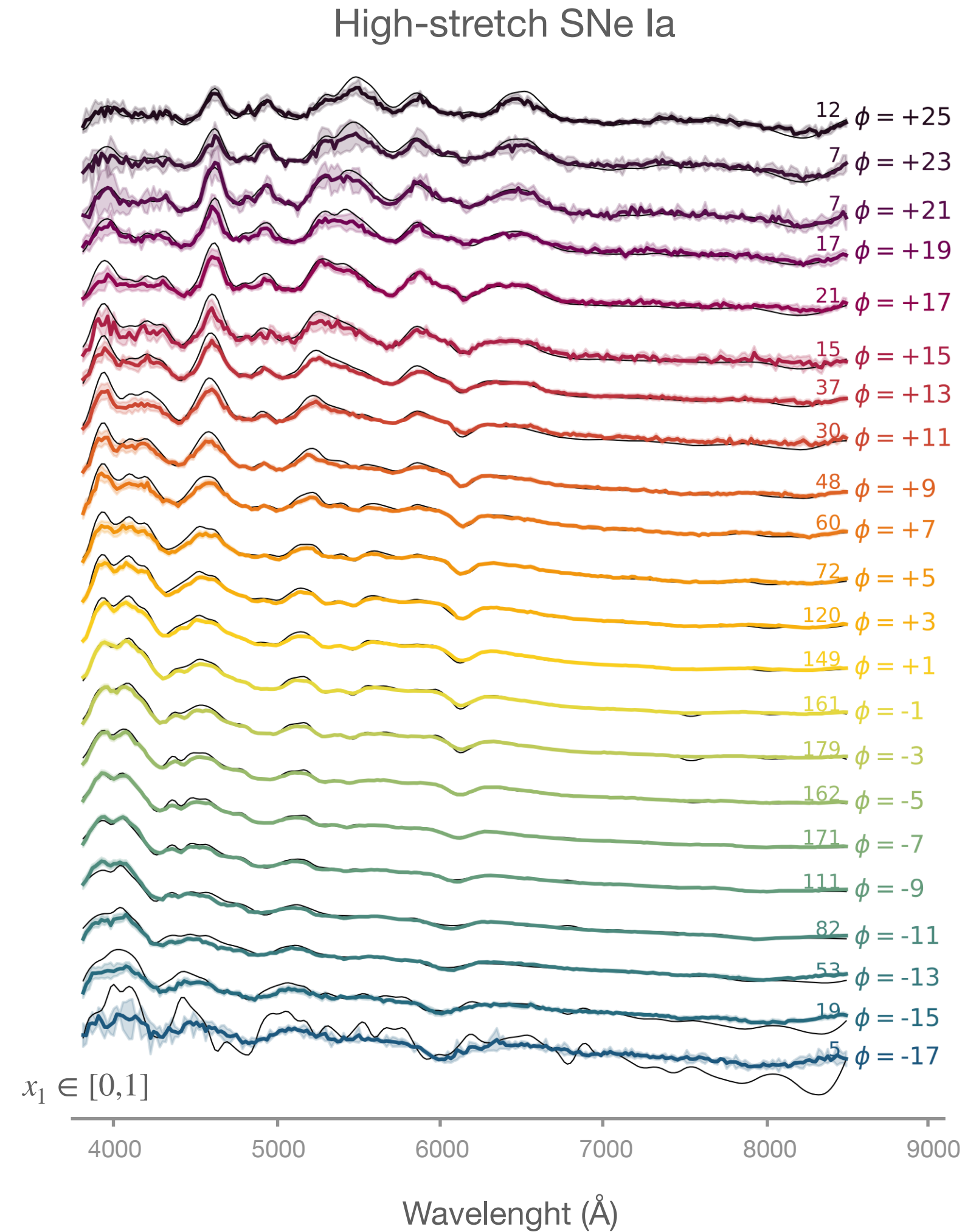
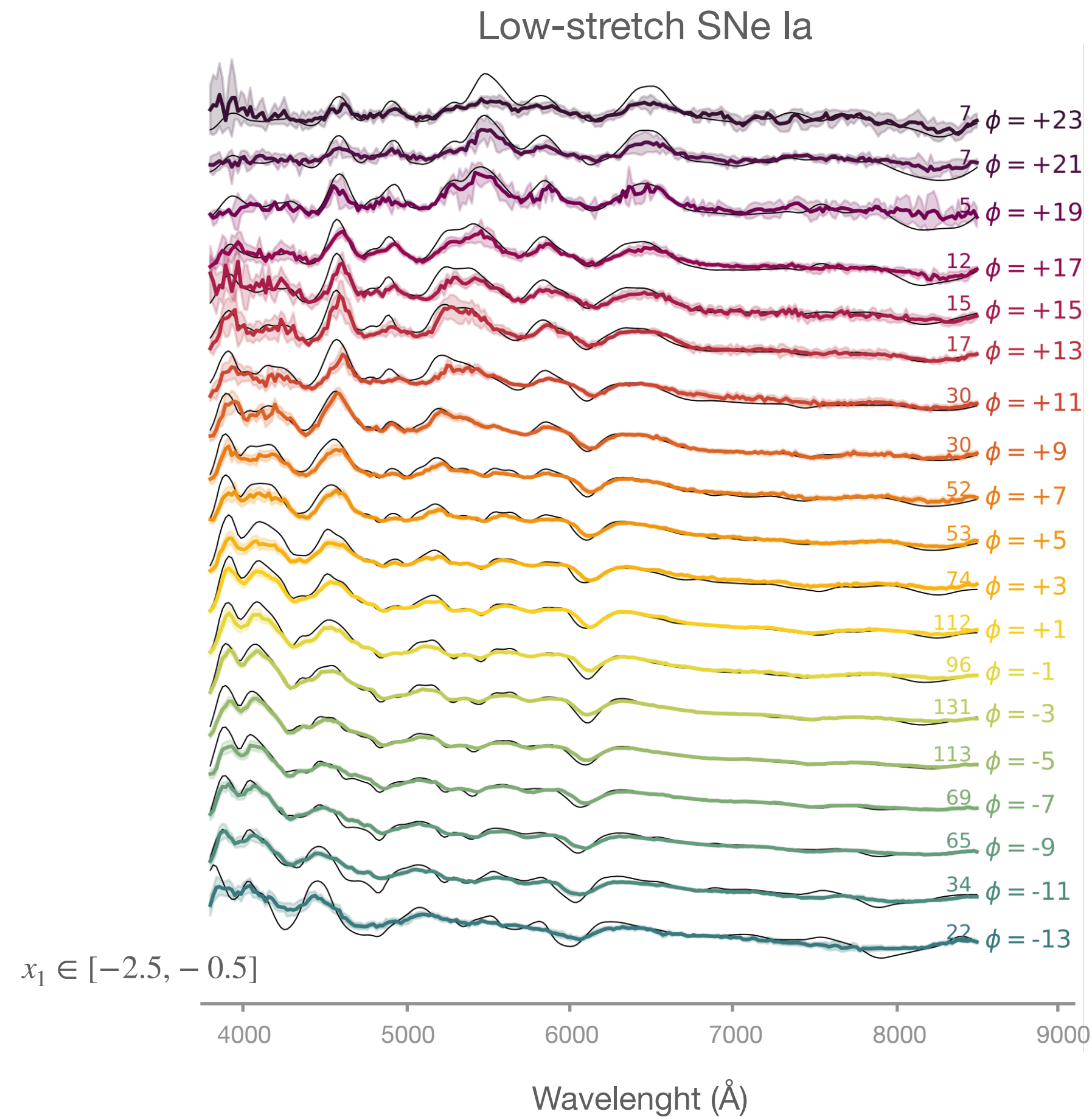
Lightcurves



ZTF SN Ia DR2 - Data

$\mathcal{O}(5000)$ spectra

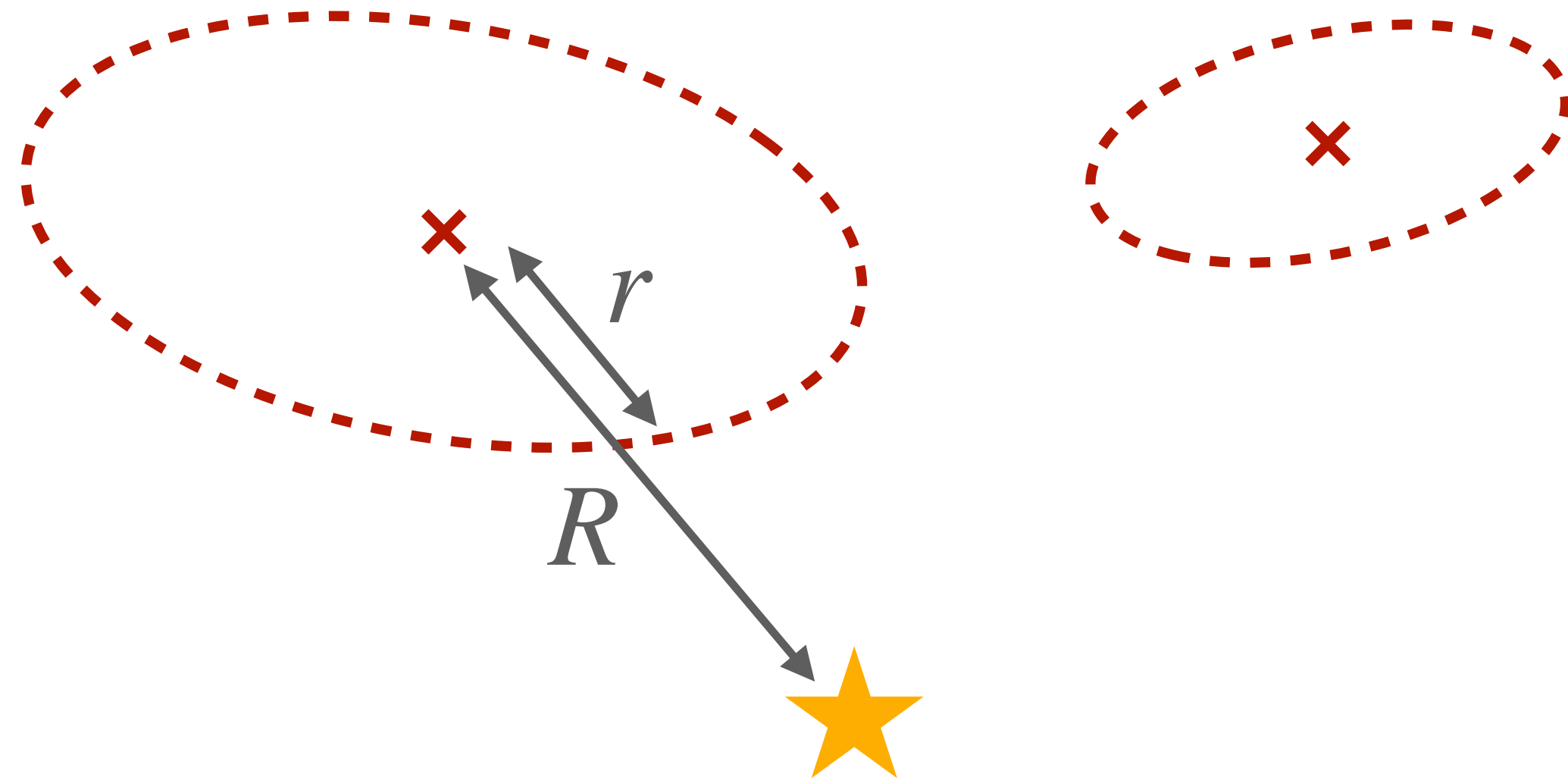
Spectra



Johansson et al (2024)
Smith et al (2024)

ZTF SN Ia DR2 - Data

Host association

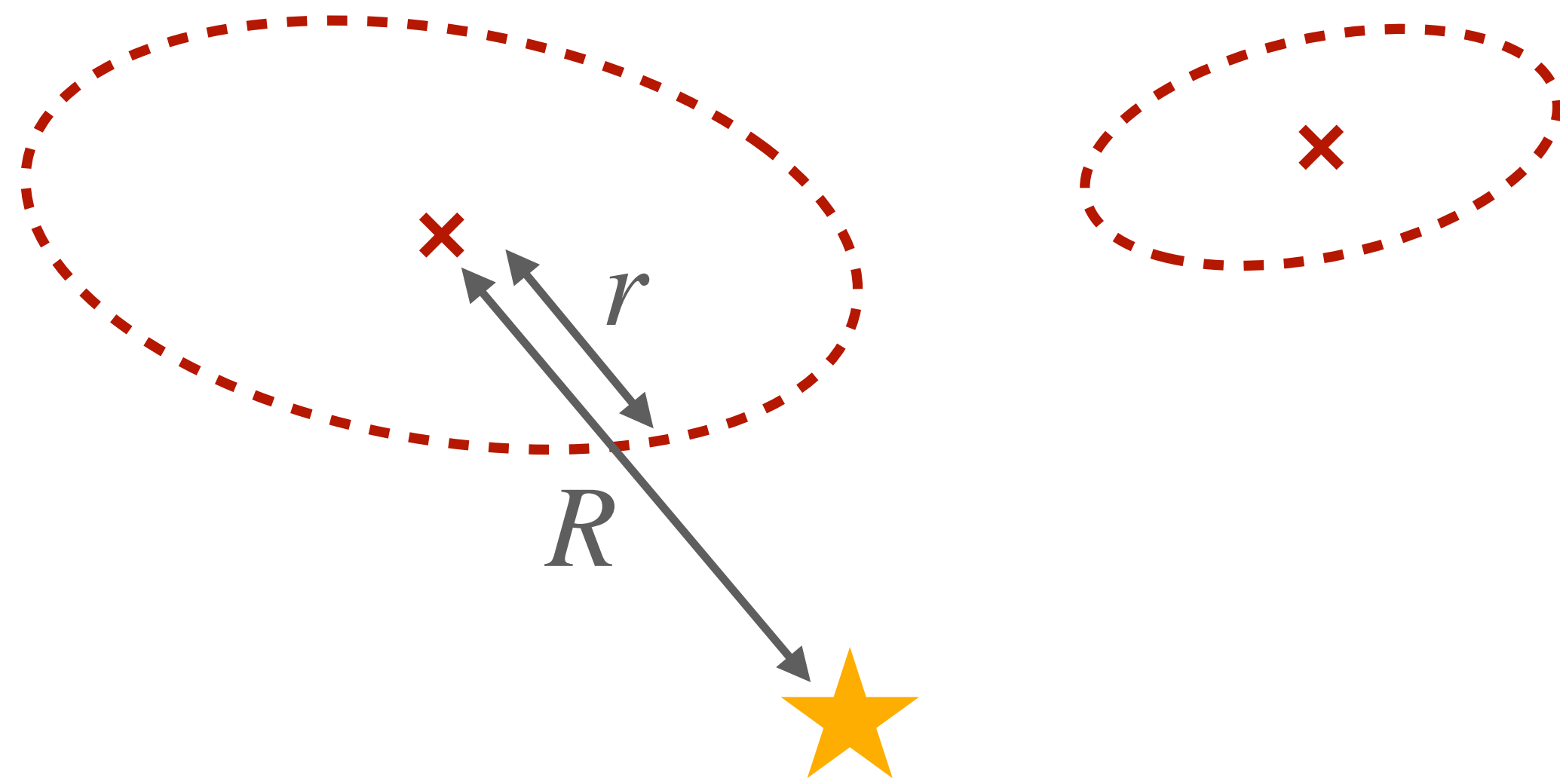


$$\text{dDLR} = \frac{R}{r}$$

dDLR technique
(Sullivan et al 2006, Gupta et al 2016)

ZTF SN Ia DR2 - Data

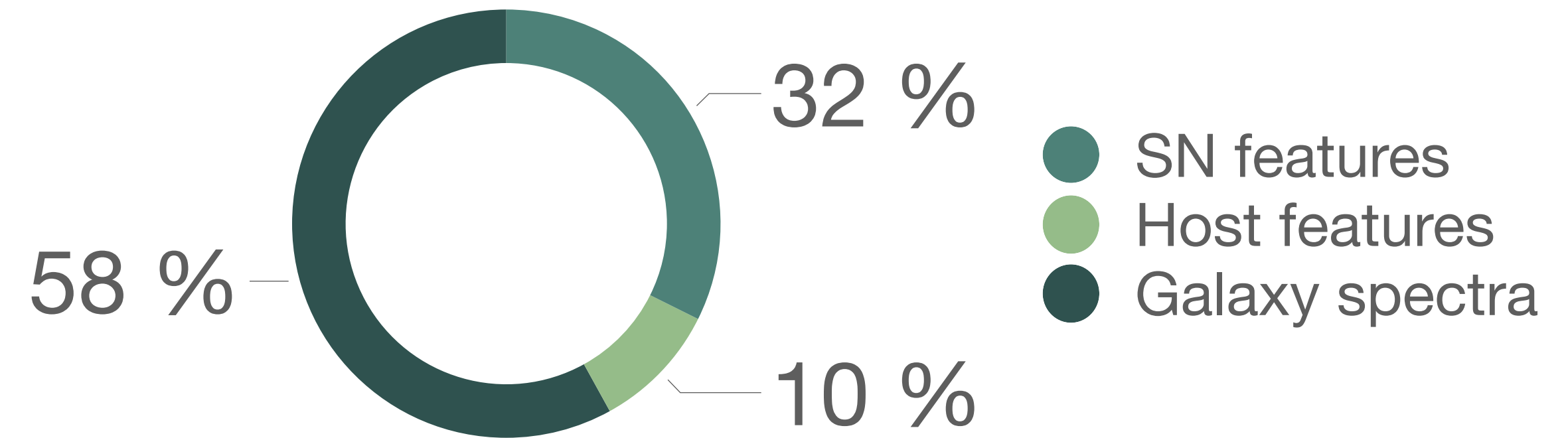
Host association



$$\text{dDLR} = \frac{R}{r}$$

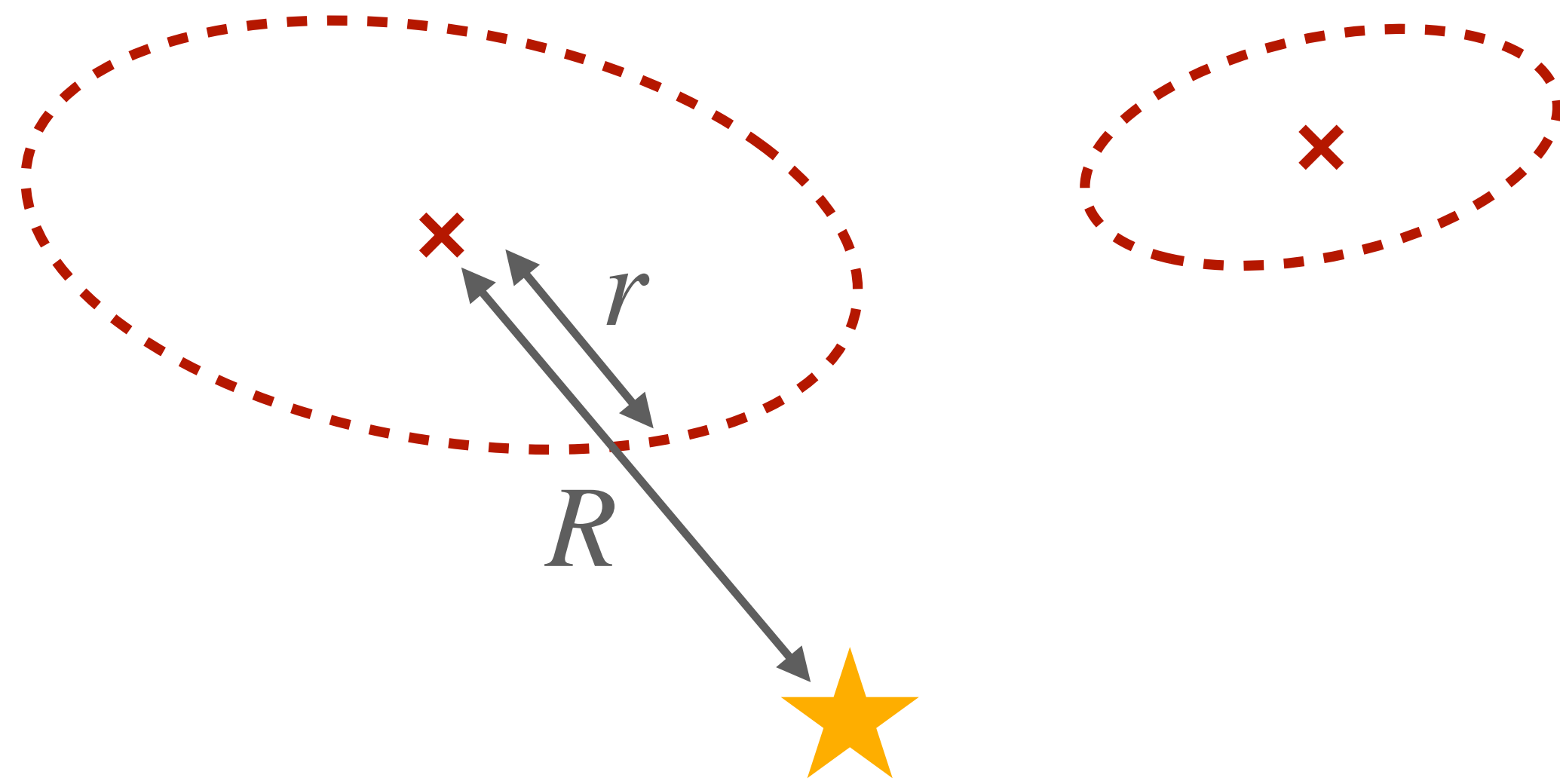
dDLR technique
(Sullivan et al 2006, Gupta et al 2016)

Redshifts



ZTF SN Ia DR2 - Data

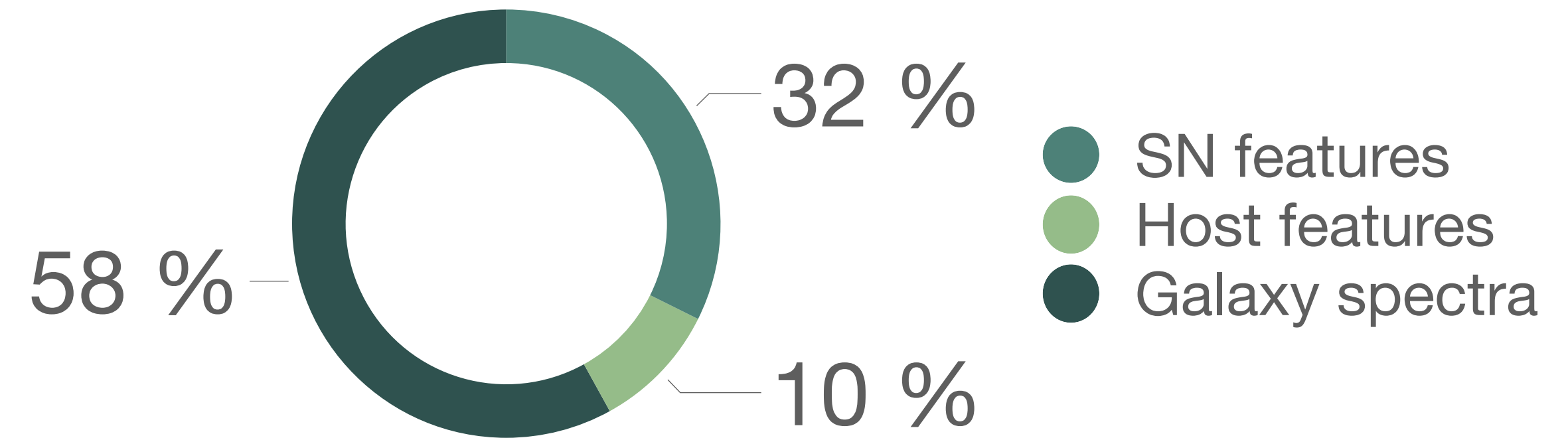
Host association



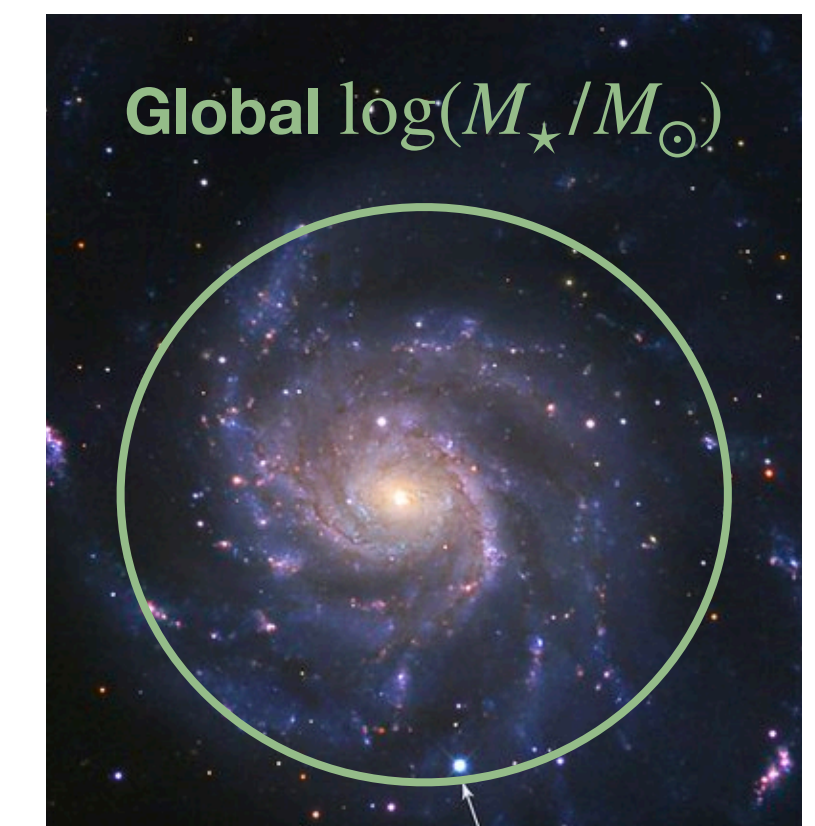
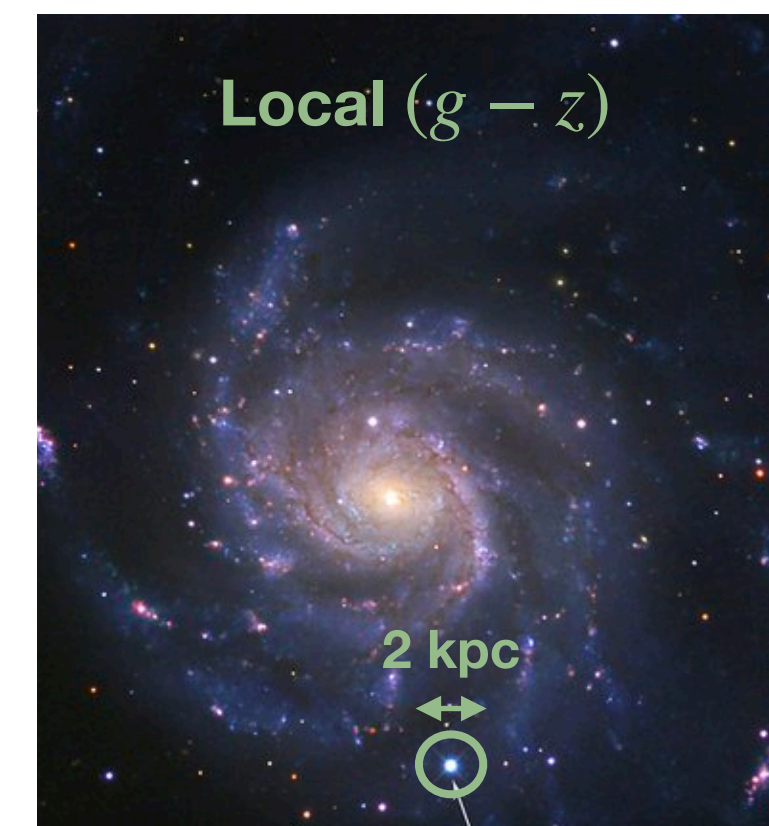
$$\text{dDLR} = \frac{R}{r}$$

dDLR technique
(Sullivan et al 2006, Gupta et al 2016)

Redshifts



Environment properties



Credits: B.J. Fulton/LCOGT/Caltech

ZTF SN Ia DR2 - Data

Numbers

2.5 years of data

3628 SNe

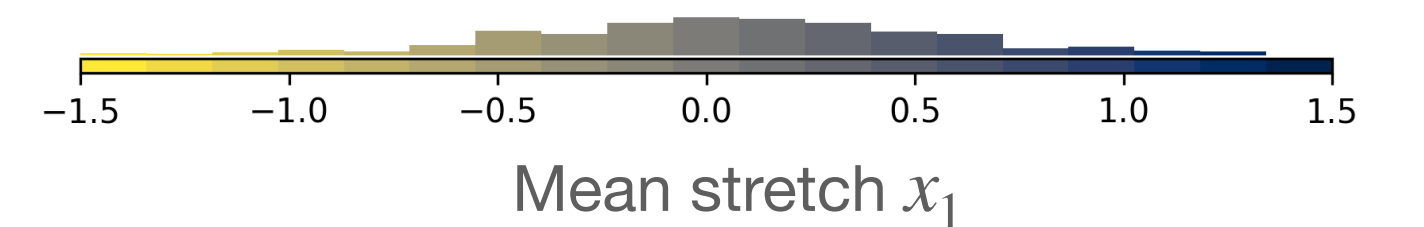
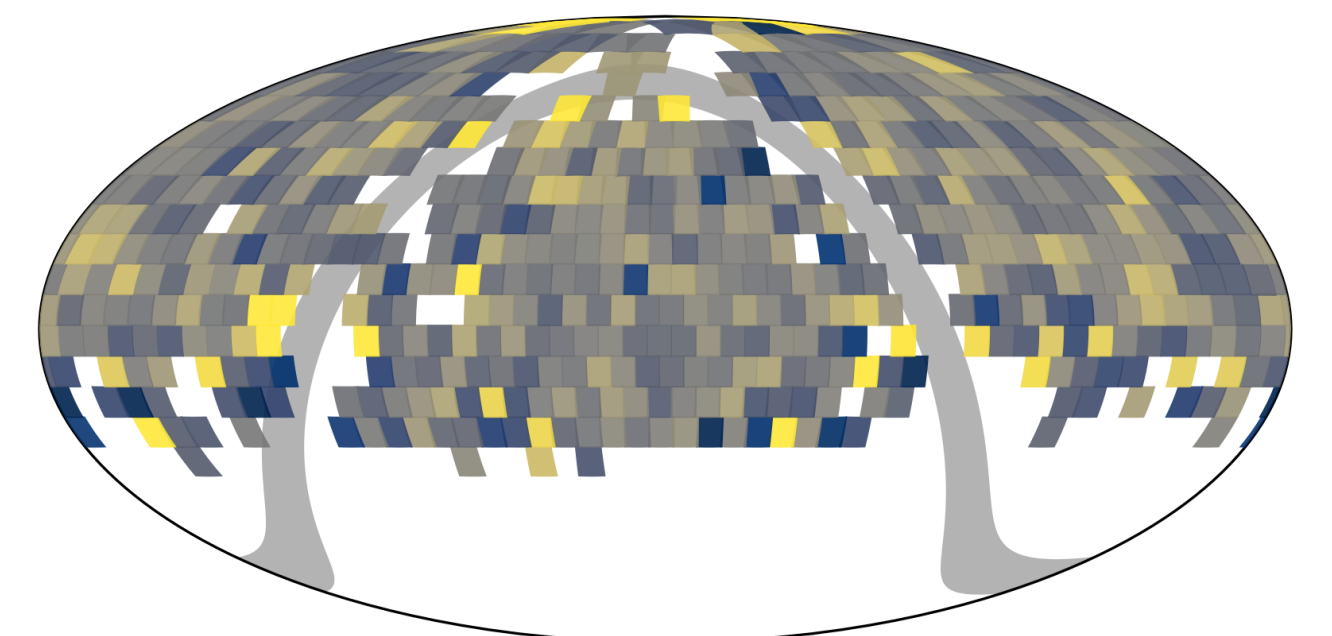
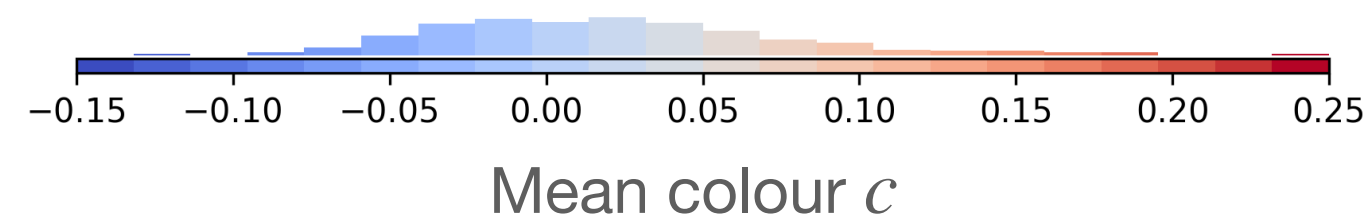
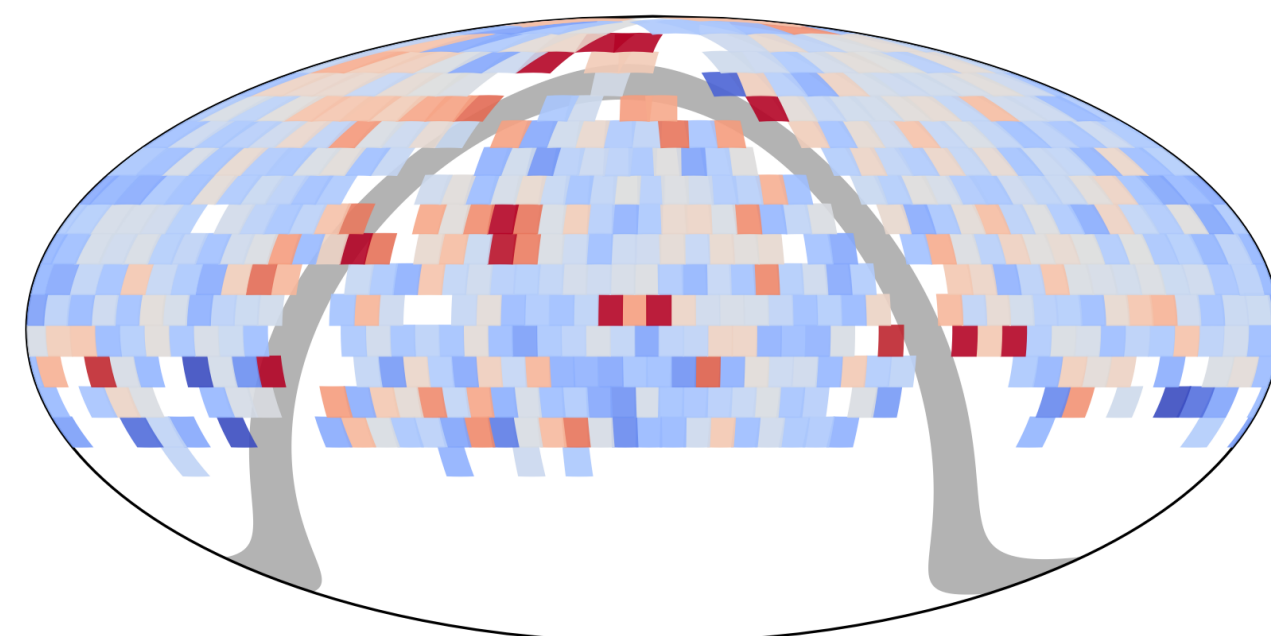
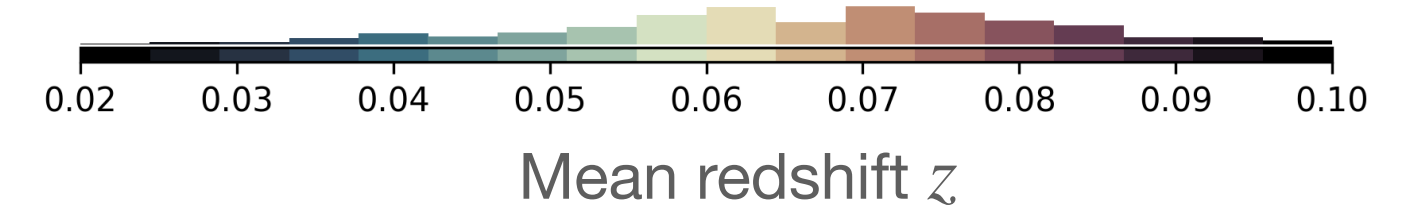
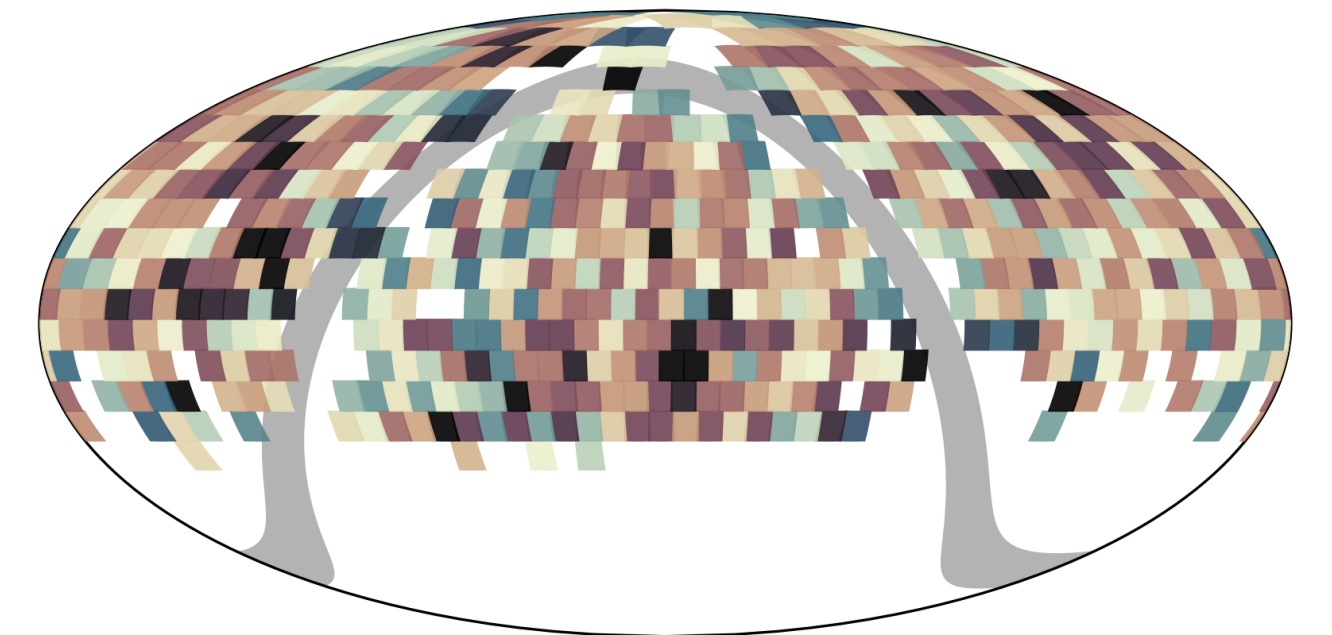
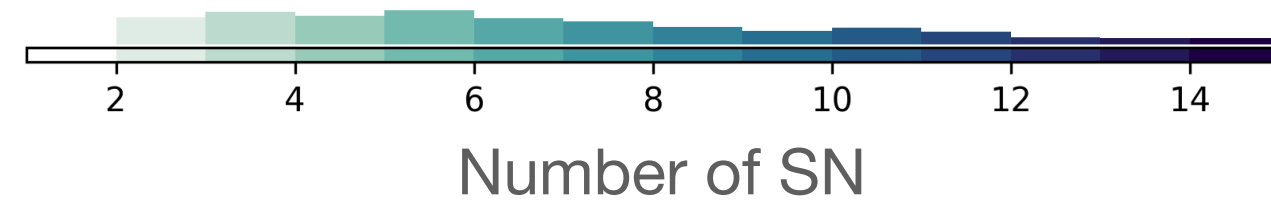
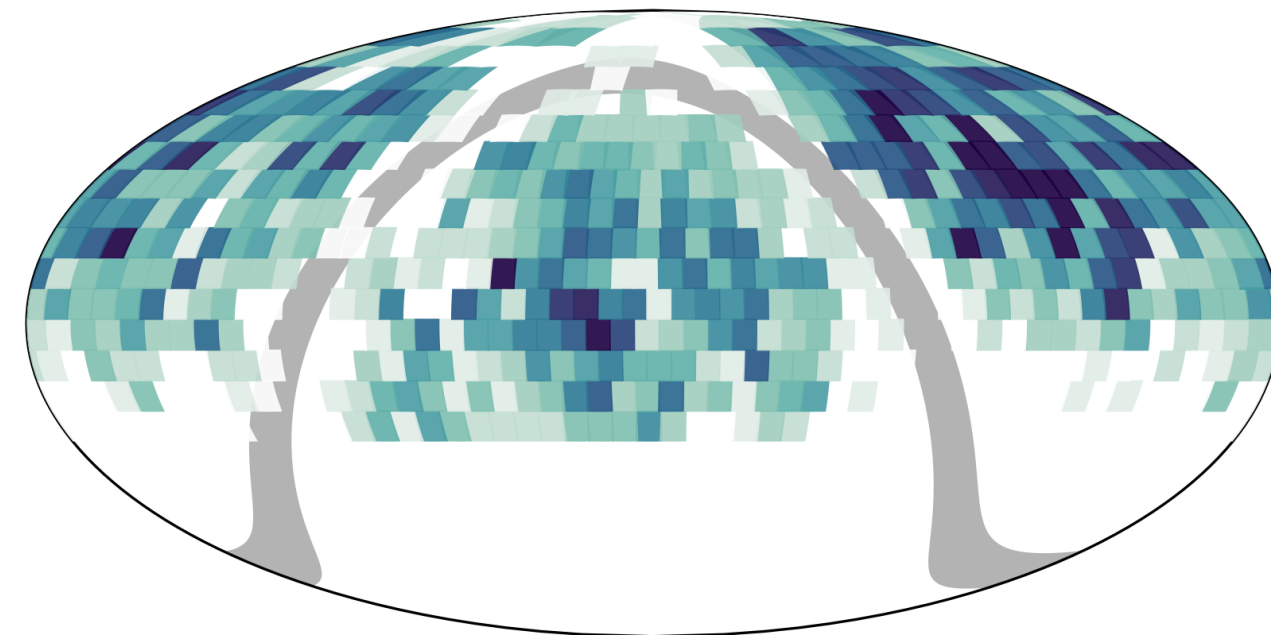
Confirmed SNe Ia

2977 SNe

with well-sampled lightcurves

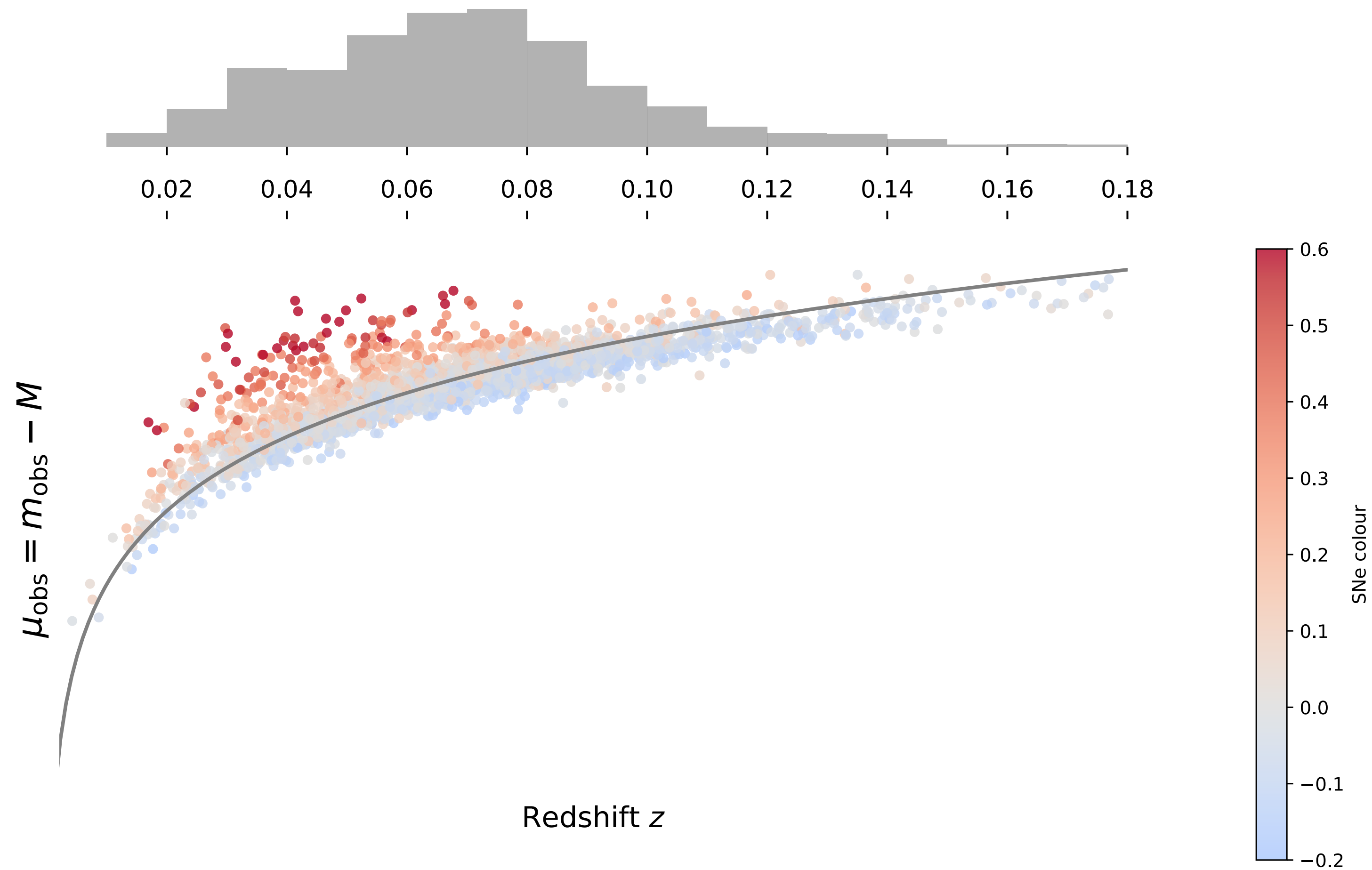
2628 SNe

usable for cosmology



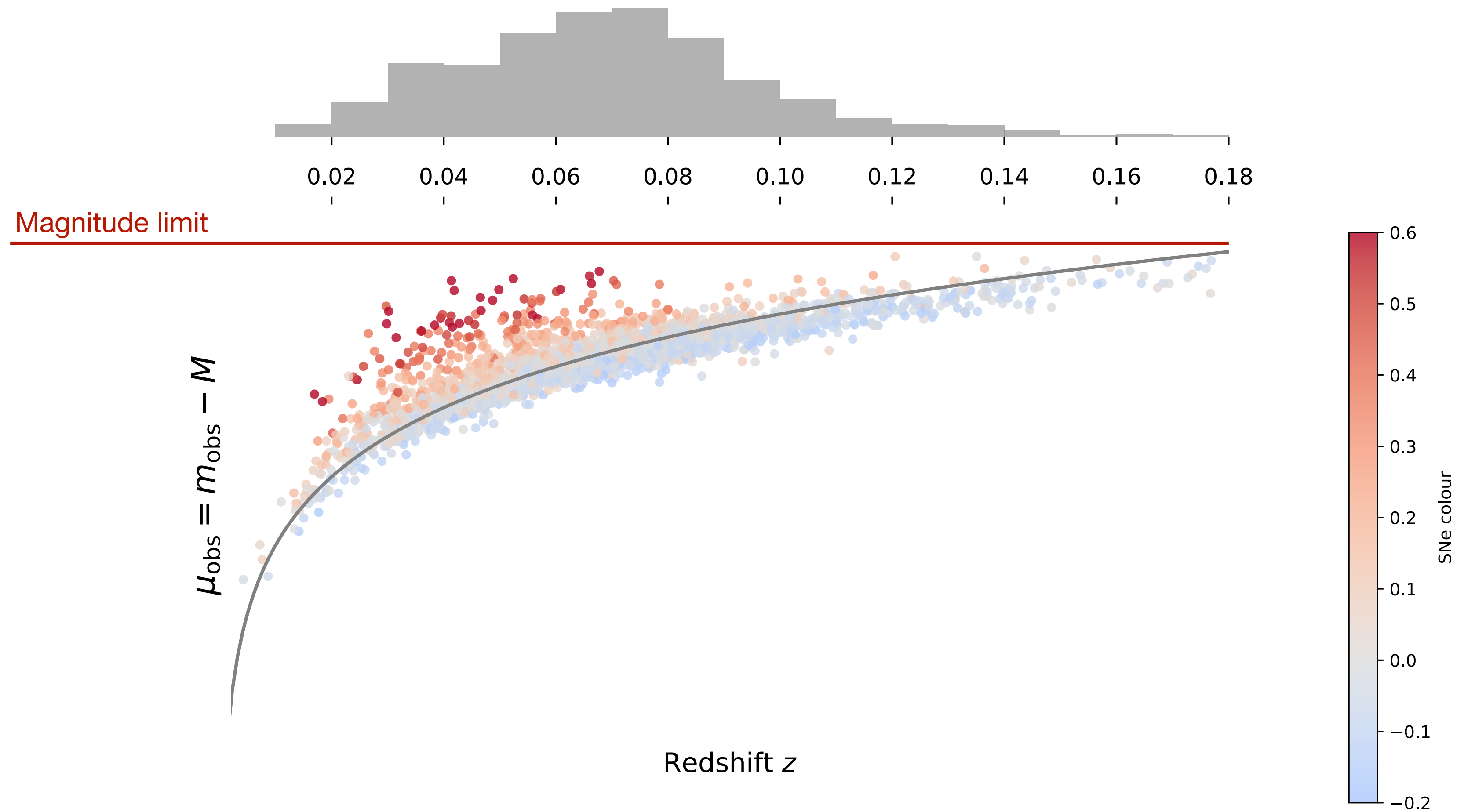
ZTF SN Ia DR2 - Data

Volume limited sample



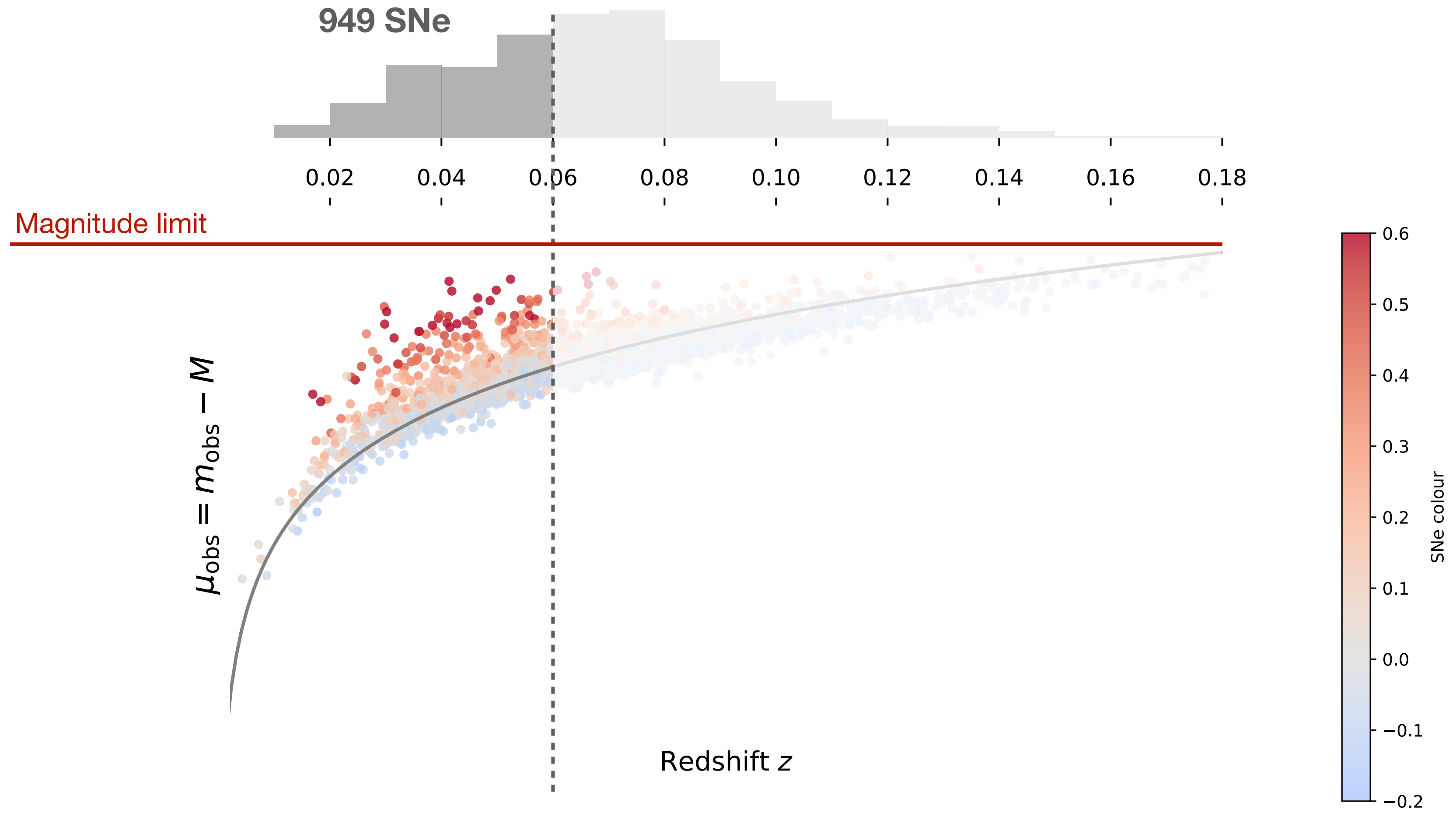
ZTF SN Ia DR2 - Data

Volume limited sample



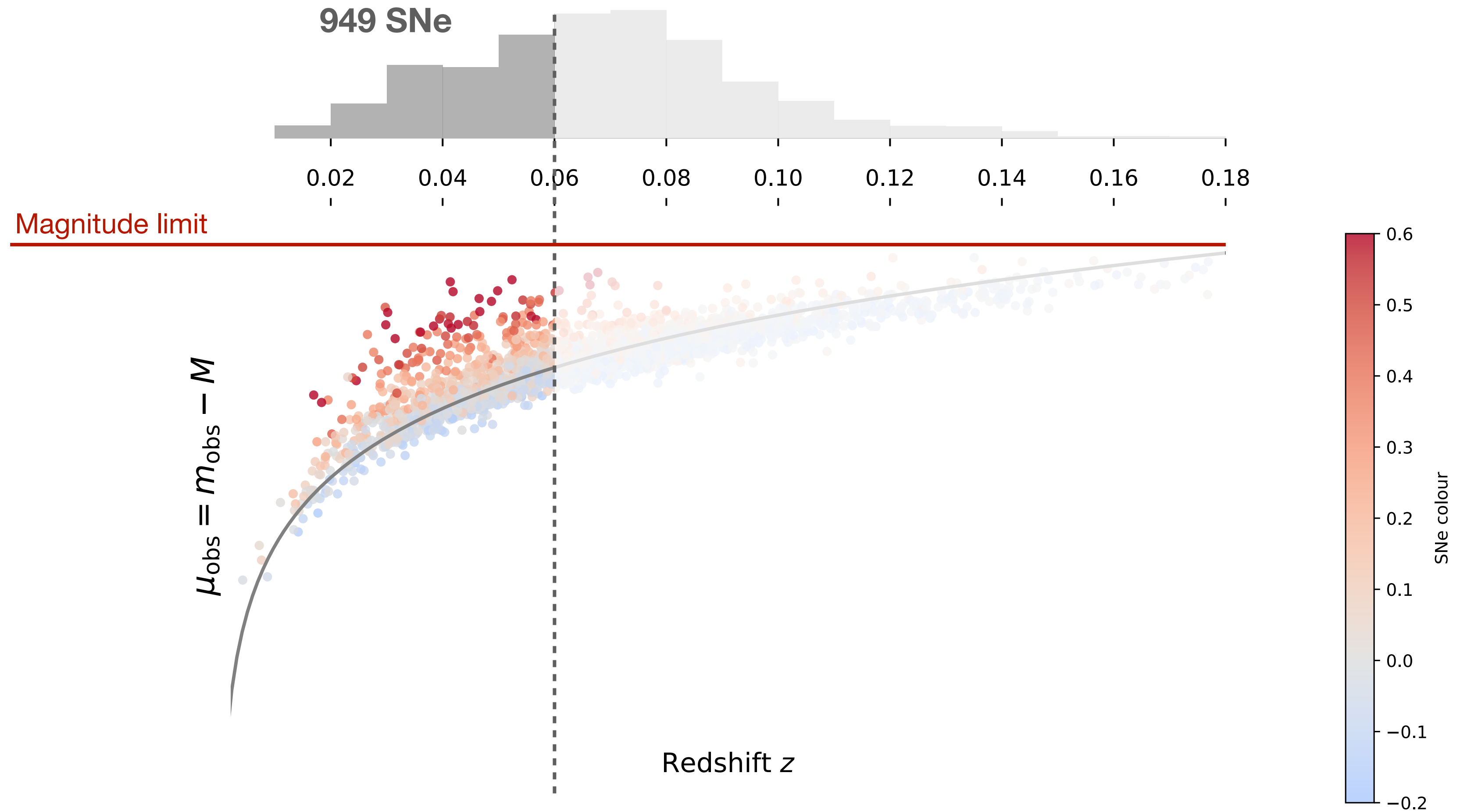
ZTF SN Ia DR2 - Data

Volume limited sample



ZTF SN Ia DR2 - Data

Volume limited sample



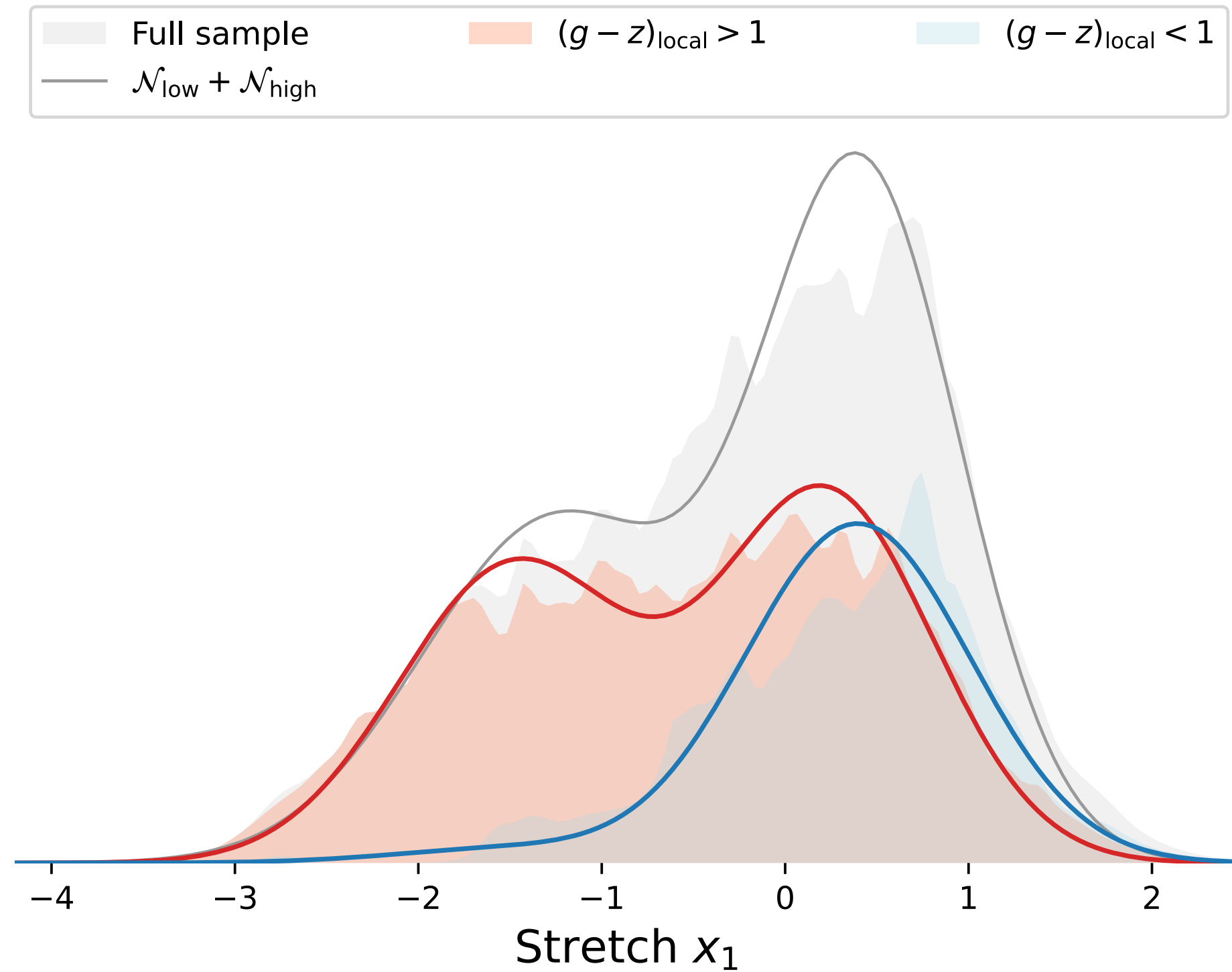
Redshift cut at $z < 0.06$

➔ No selection biases

Validated with simulations of the
DR2 sample
(Amenouche et al 2024)

ZTF SN Ia DR2 - Results

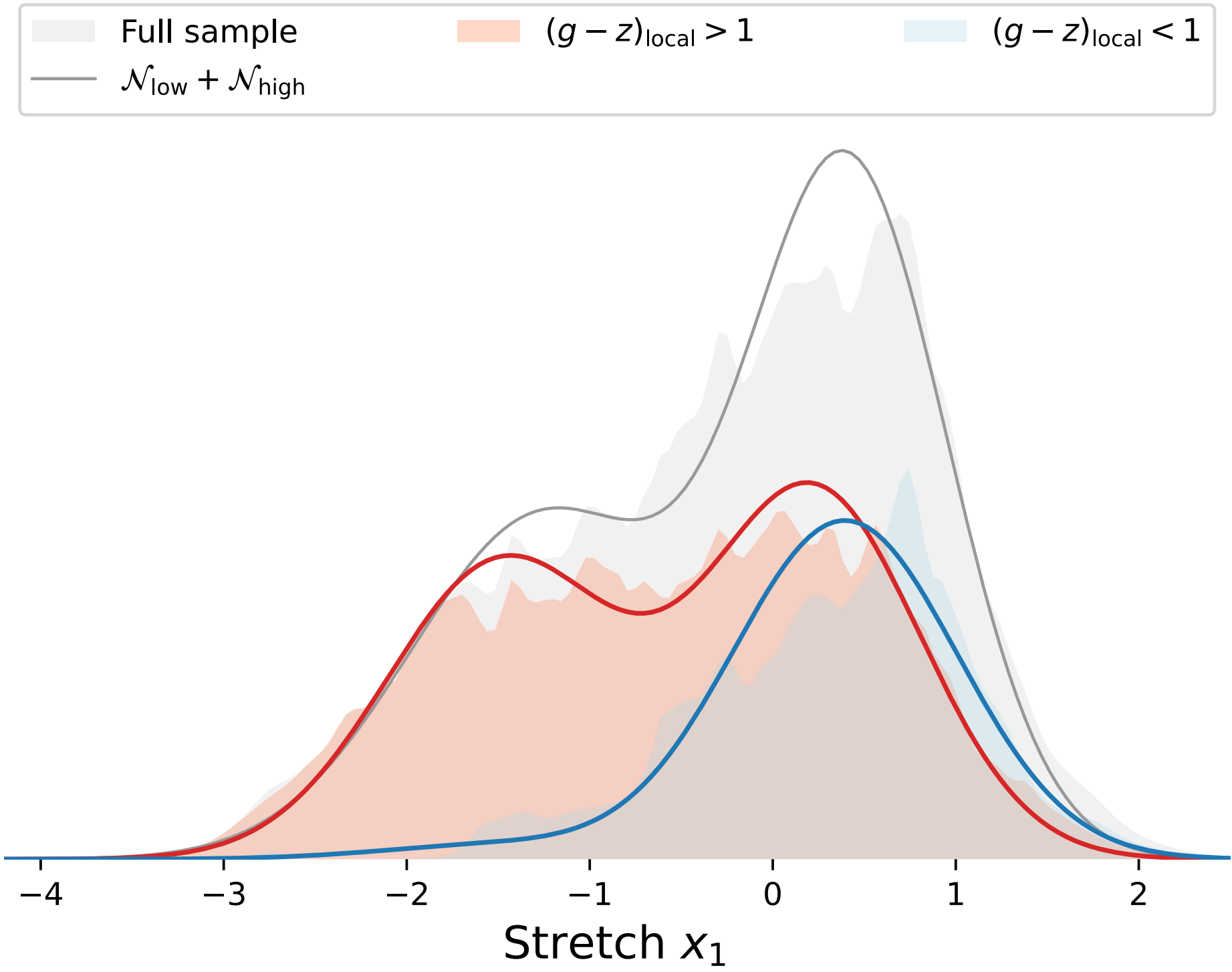
Stretch distribution



Ginolin et al (2024a)

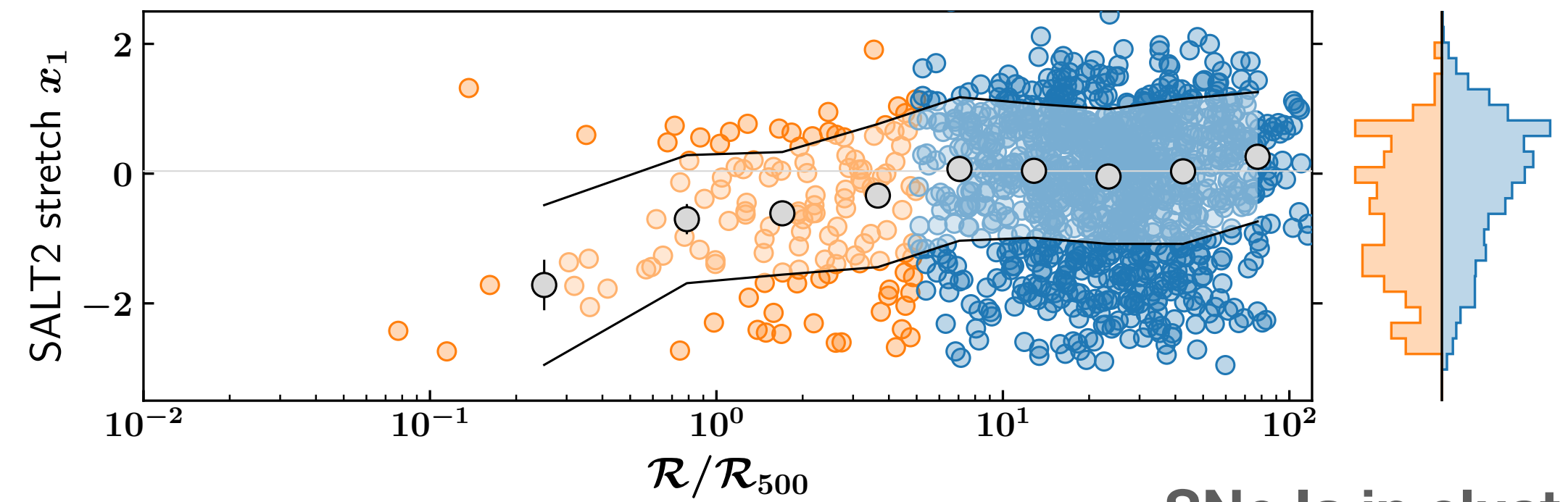
ZTF SN Ia DR2 - Results

Stretch distribution



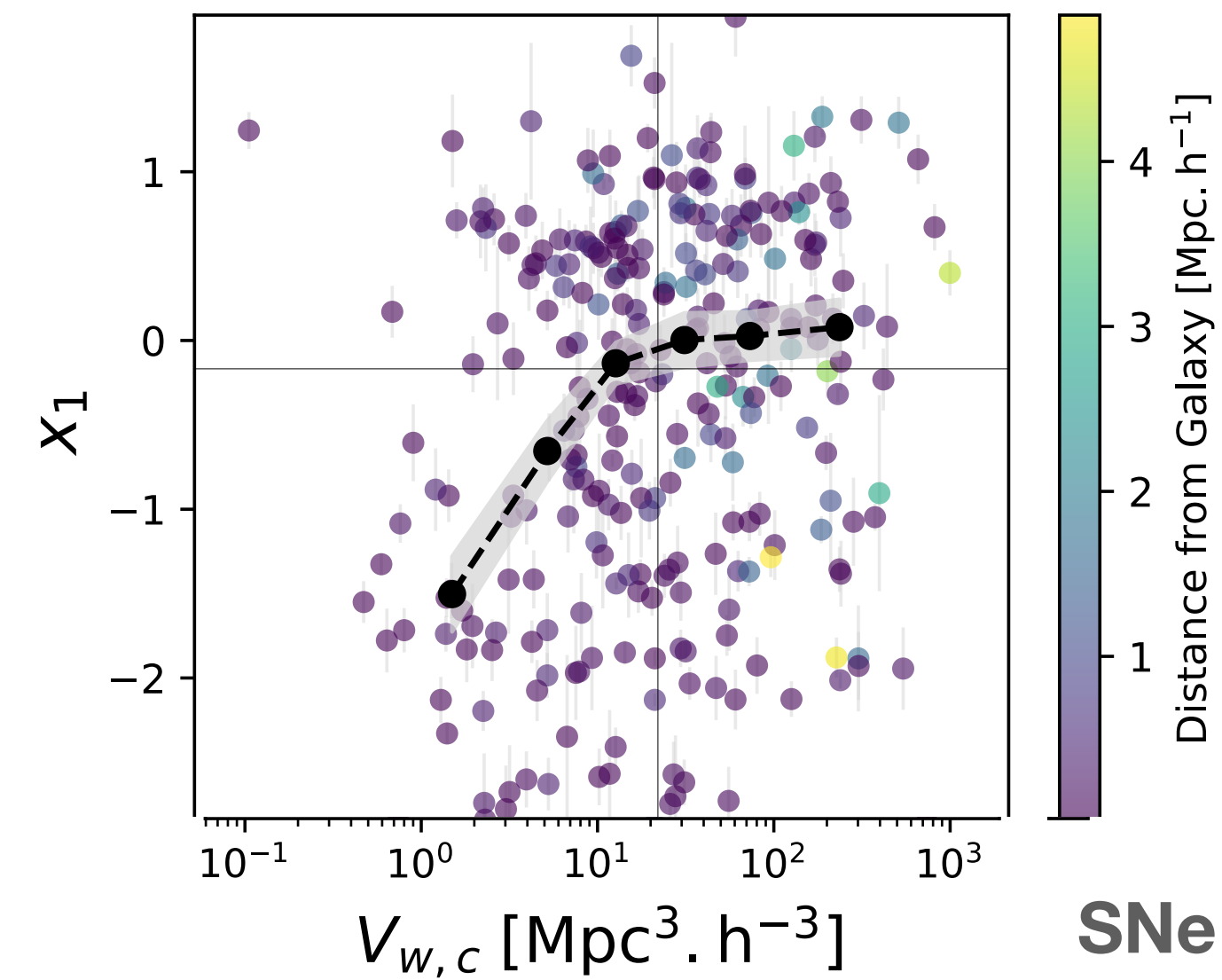
Ginolin et al (2024a)

See Florian and Marie's talks



SNe Ia in clusters

Ruppin et al (2024)

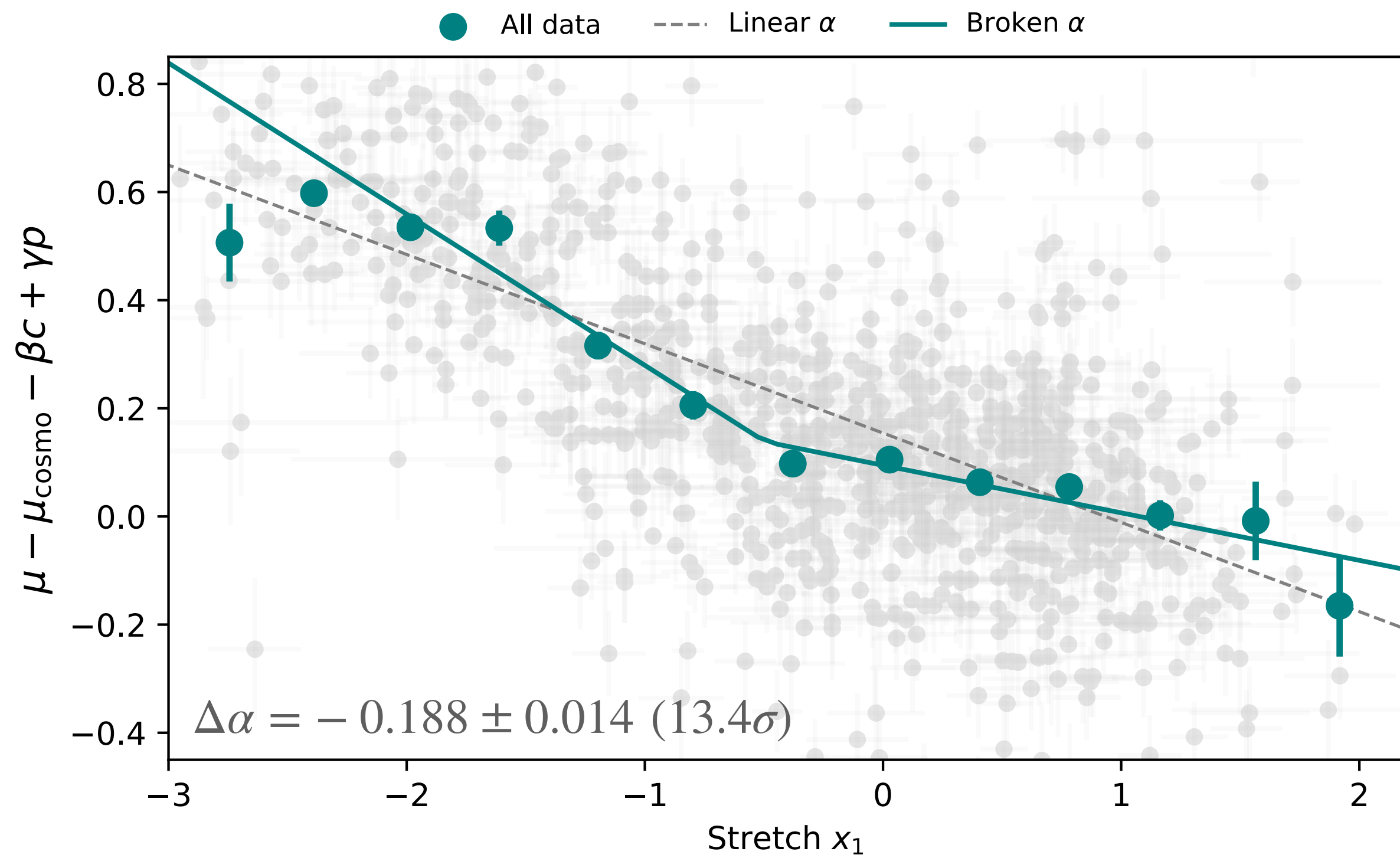


SNe Ia in voids

Aubert et al (2024)

ZTF SN Ia DR2 - Results

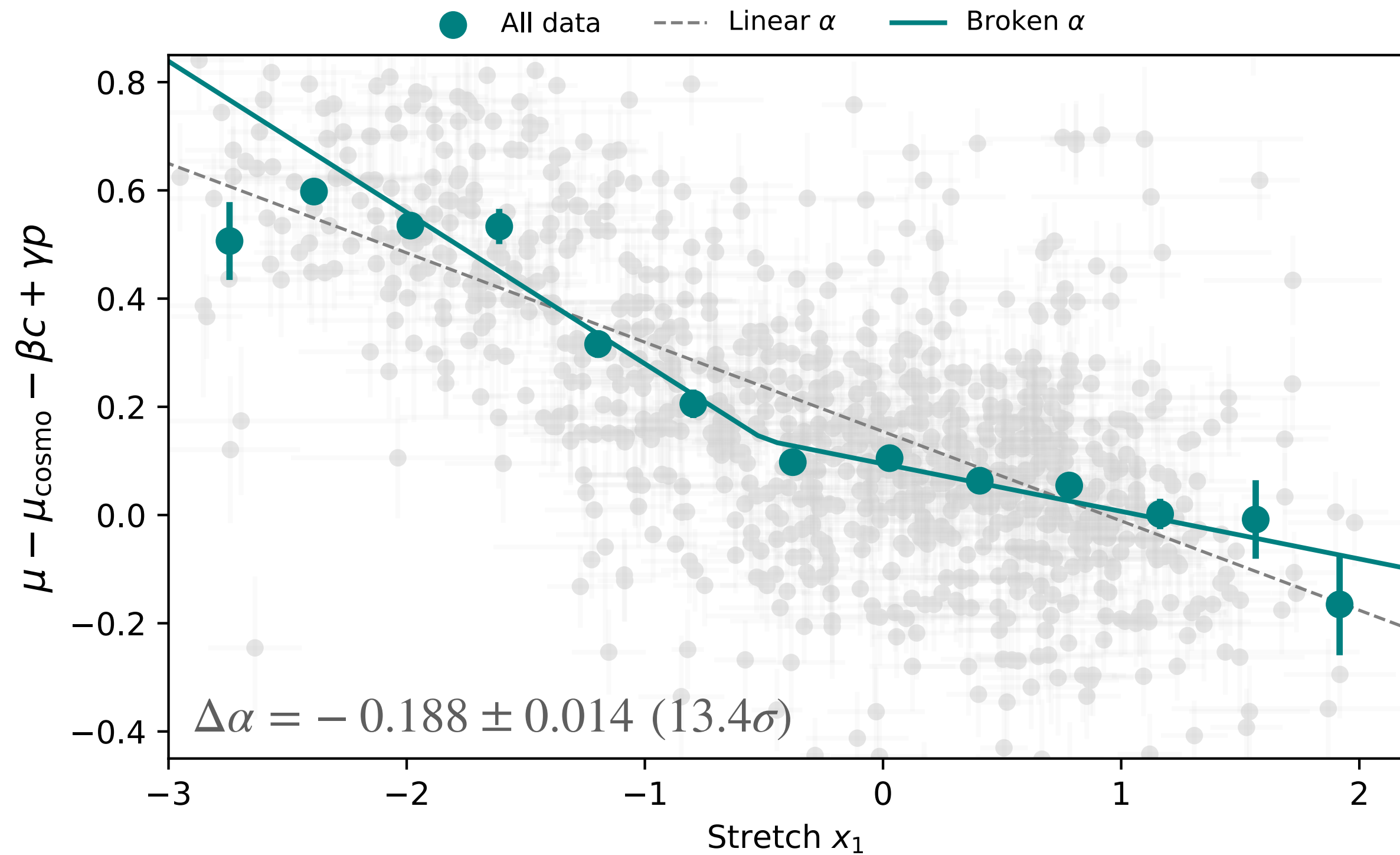
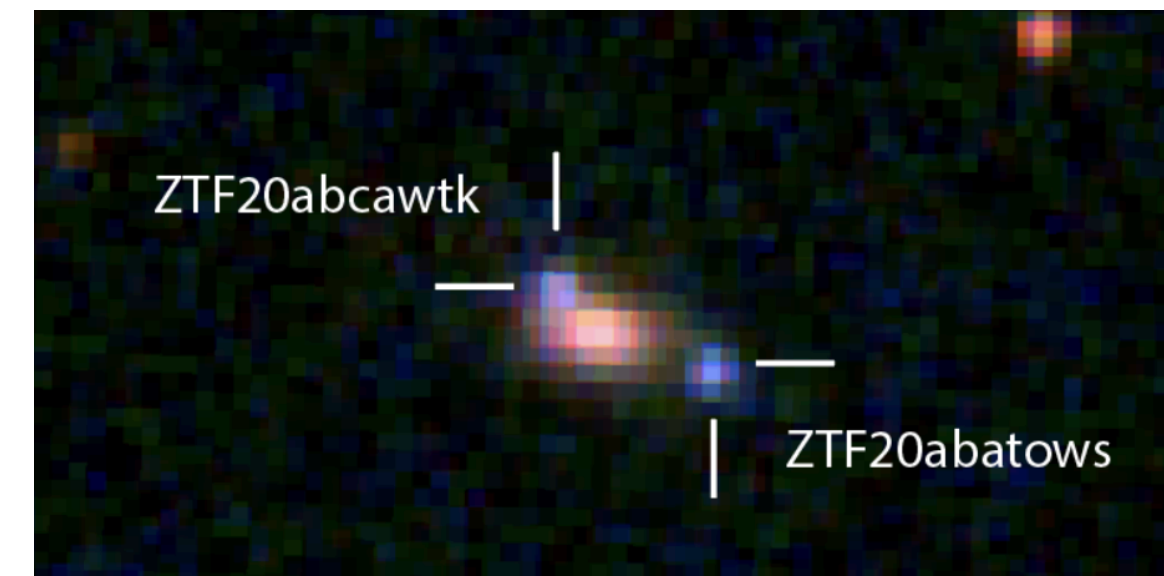
Stretch standardisation



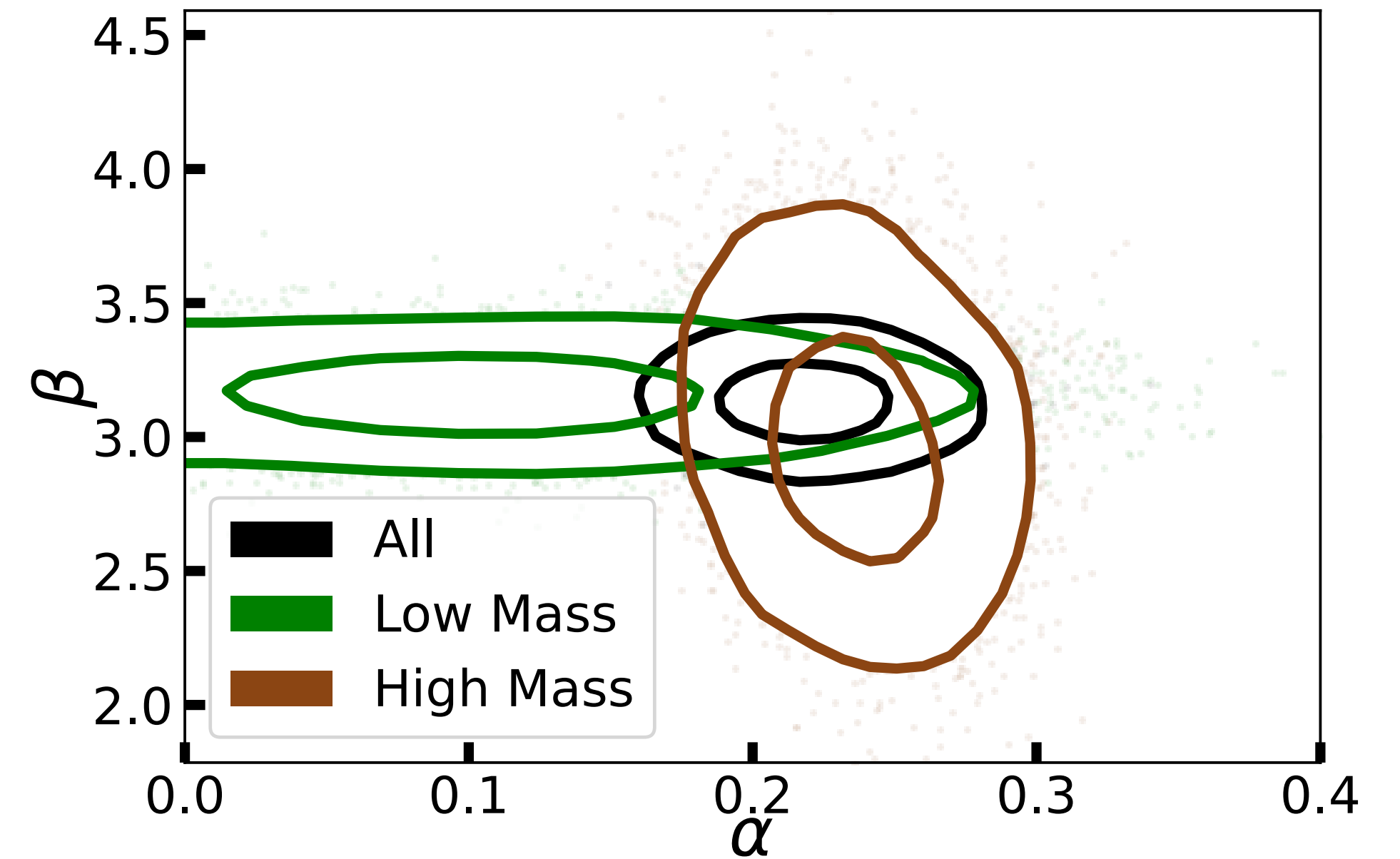
Ginolin et al (2024a)

ZTF SN Ia DR2 - Results

Stretch standardisation



Ginolin et al (2024a)

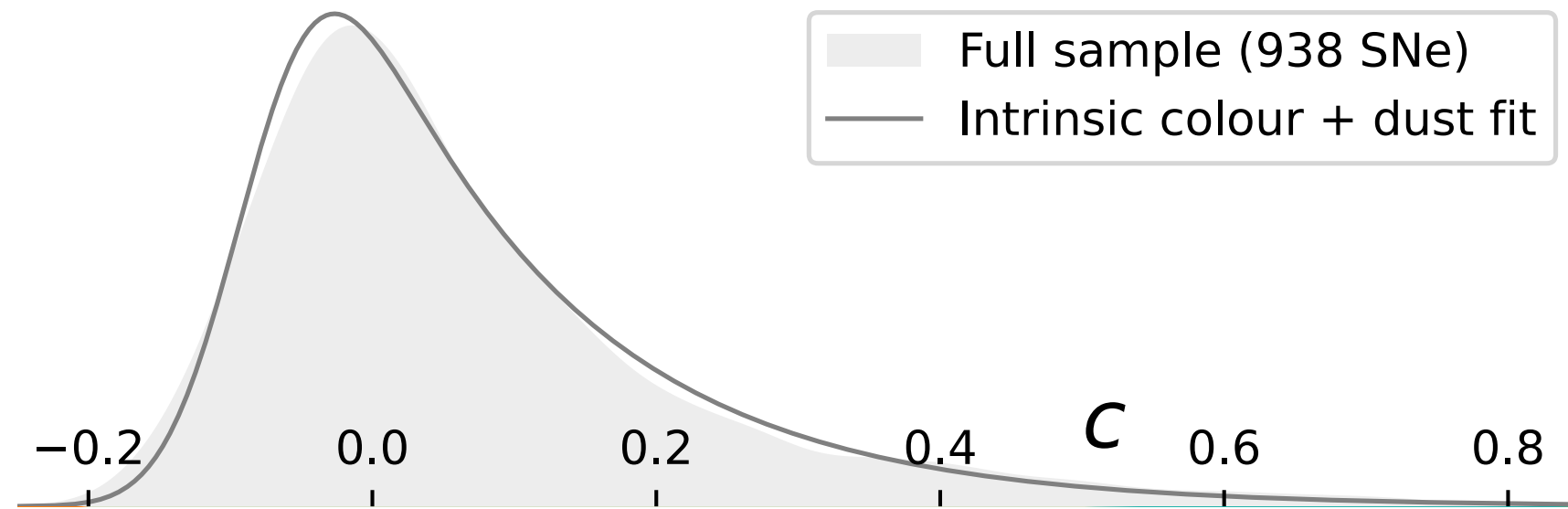


SNe Ia siblings

Dhawan et al (2024a)

ZTF SN Ia DR2 - Results

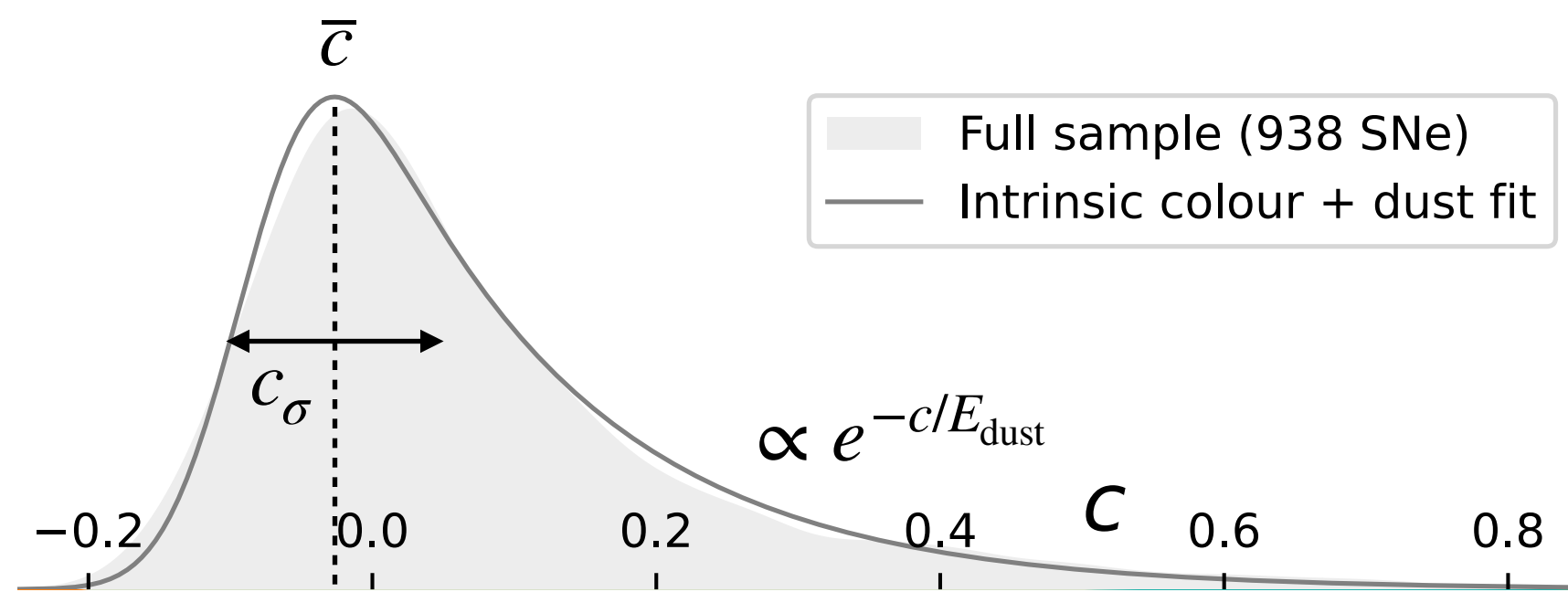
Colour distribution



Ginolin et al (2024b)

ZTF SN Ia DR2 - Results

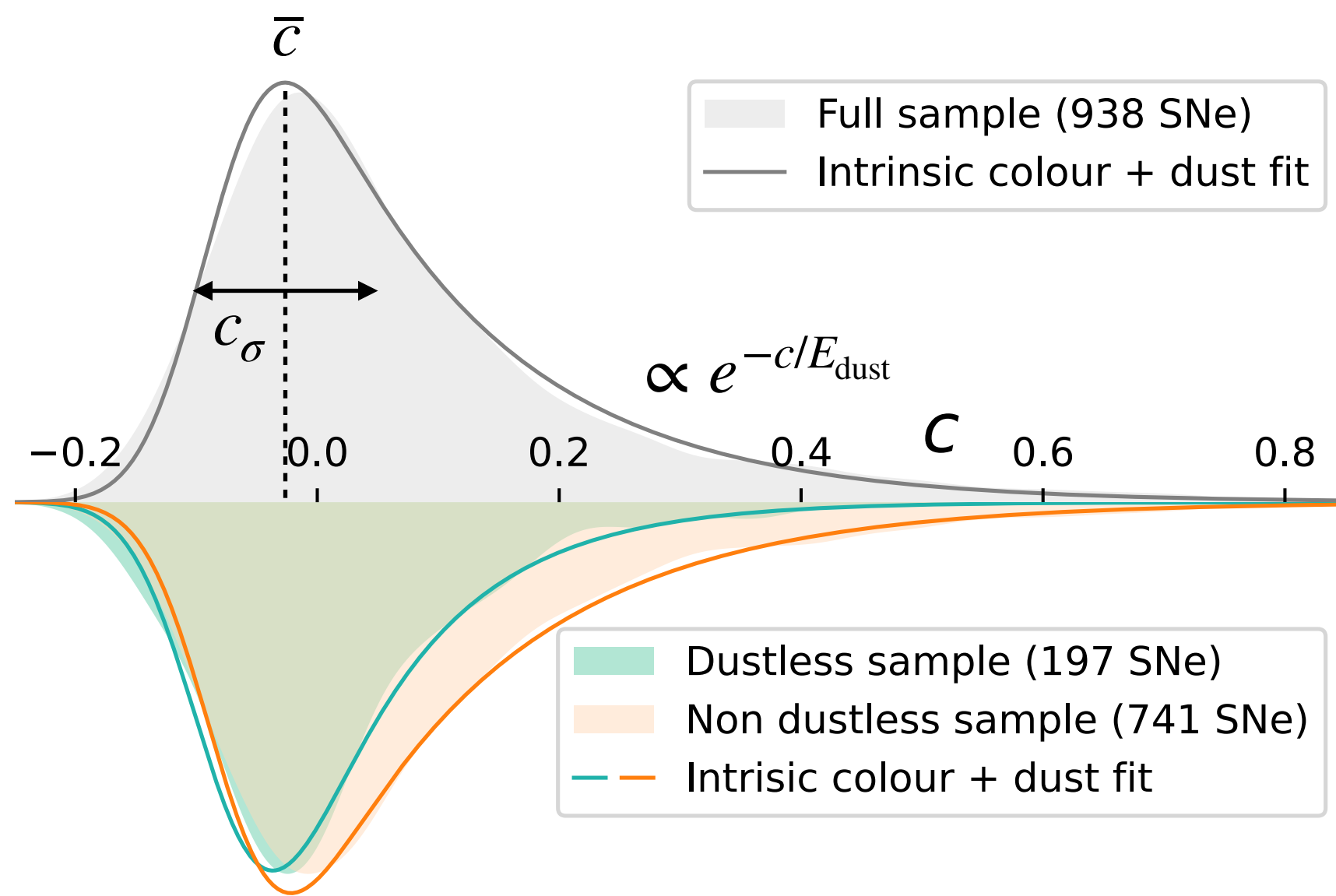
Colour distribution



Ginolin et al (2024b)

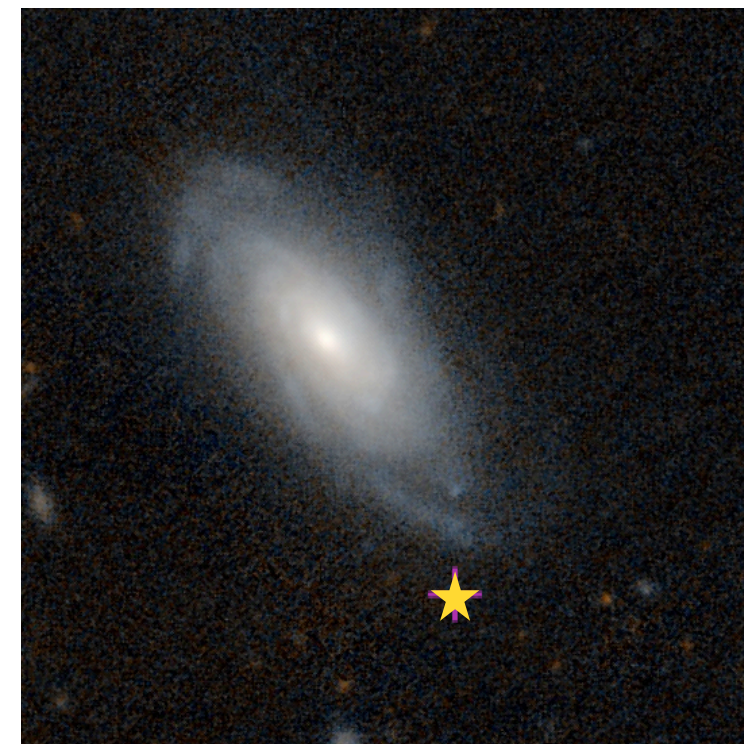
ZTF SN Ia DR2 - Results

Colour distribution



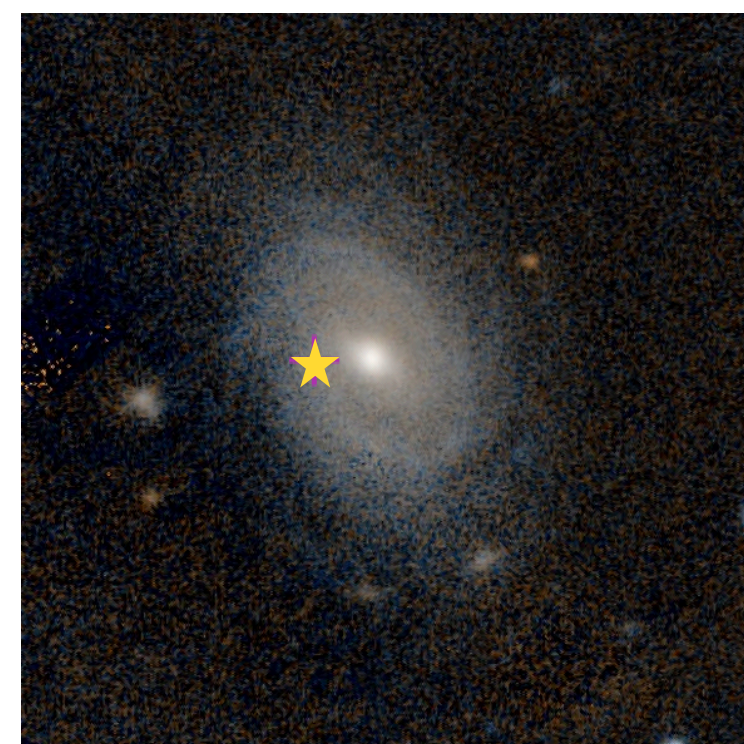
Ginolin et al (2024b)

« Dustless » example



ZTF18aahfzea

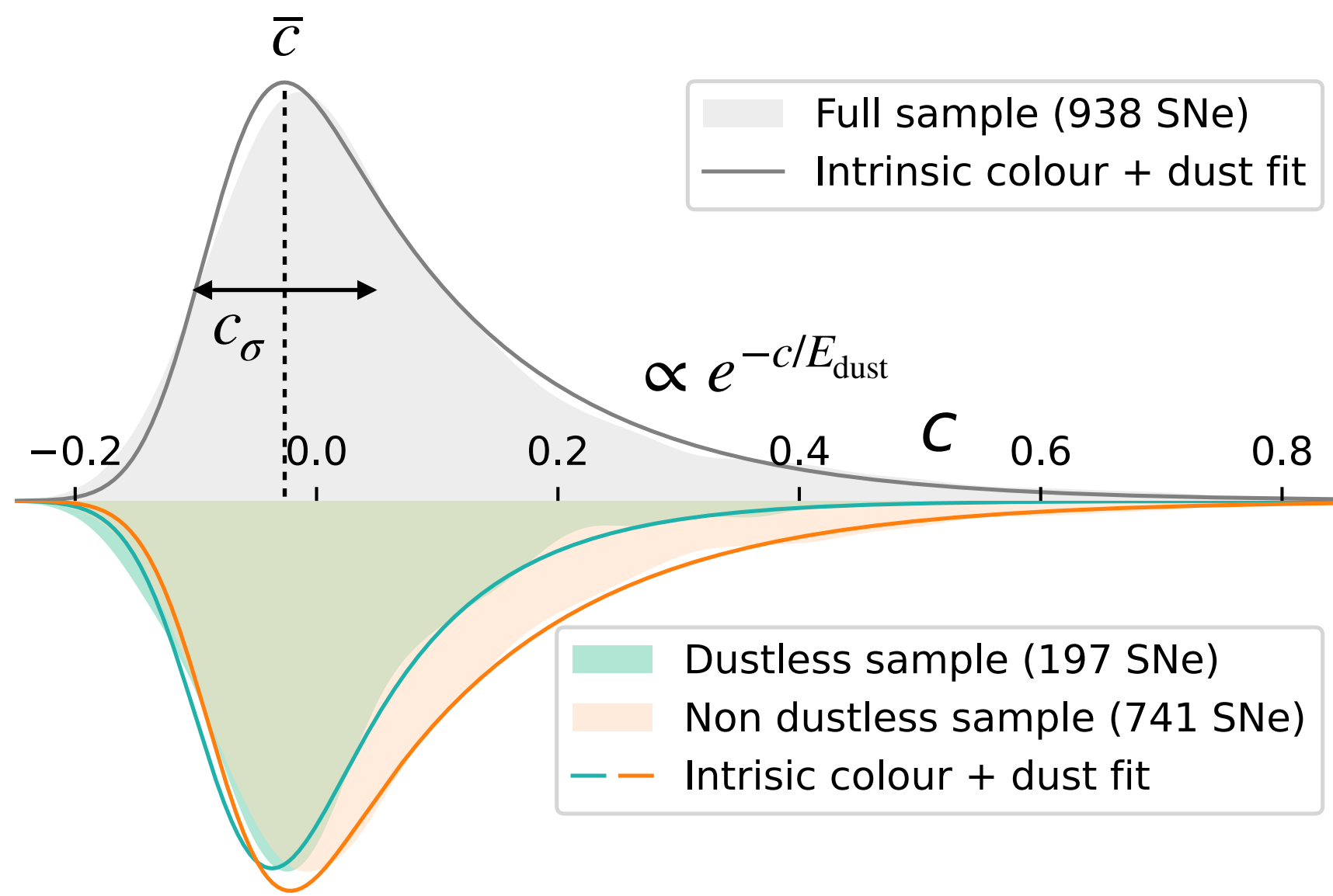
« Non dustless » example



ZTF18aaqfziz

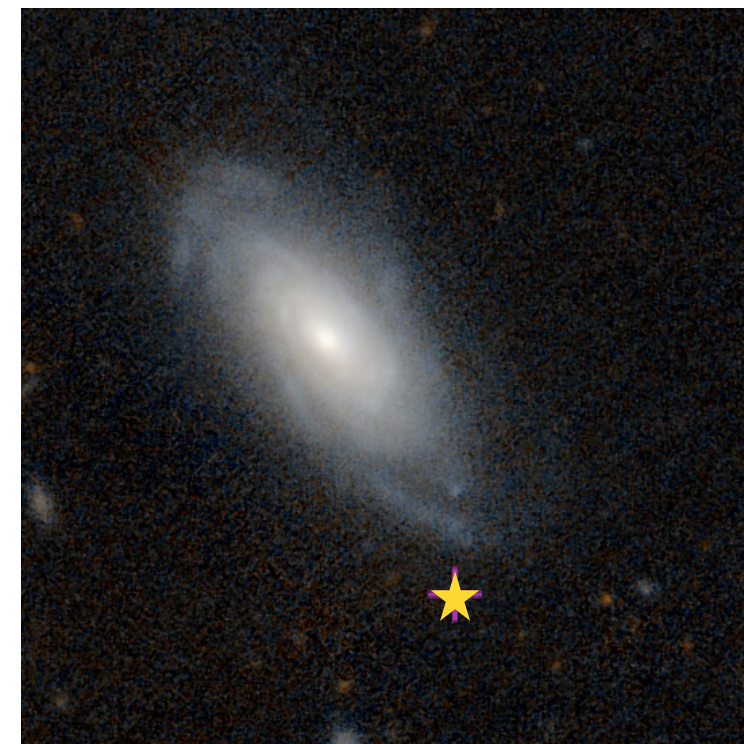
ZTF SN Ia DR2 - Results

Colour distribution



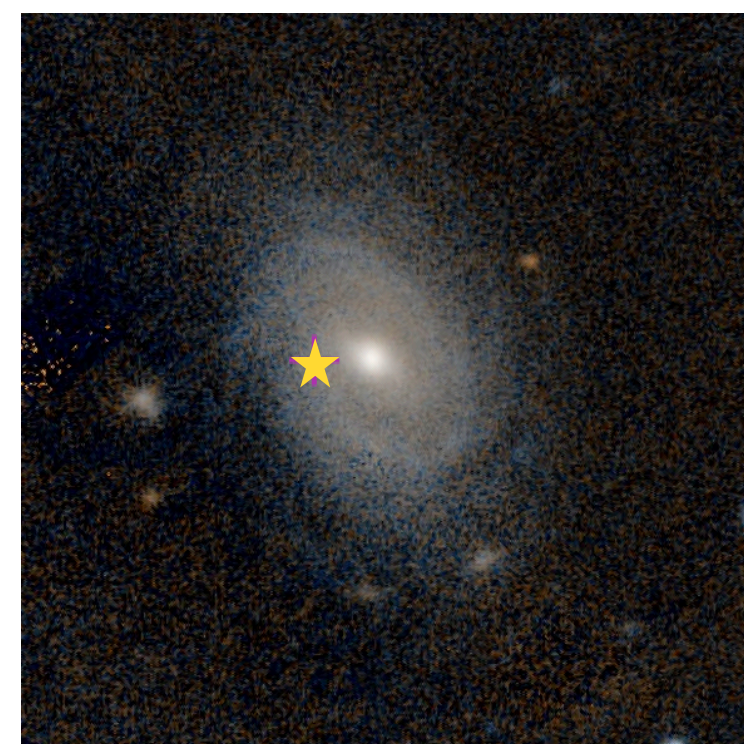
Ginolin et al (2024b)

« Dustless » example

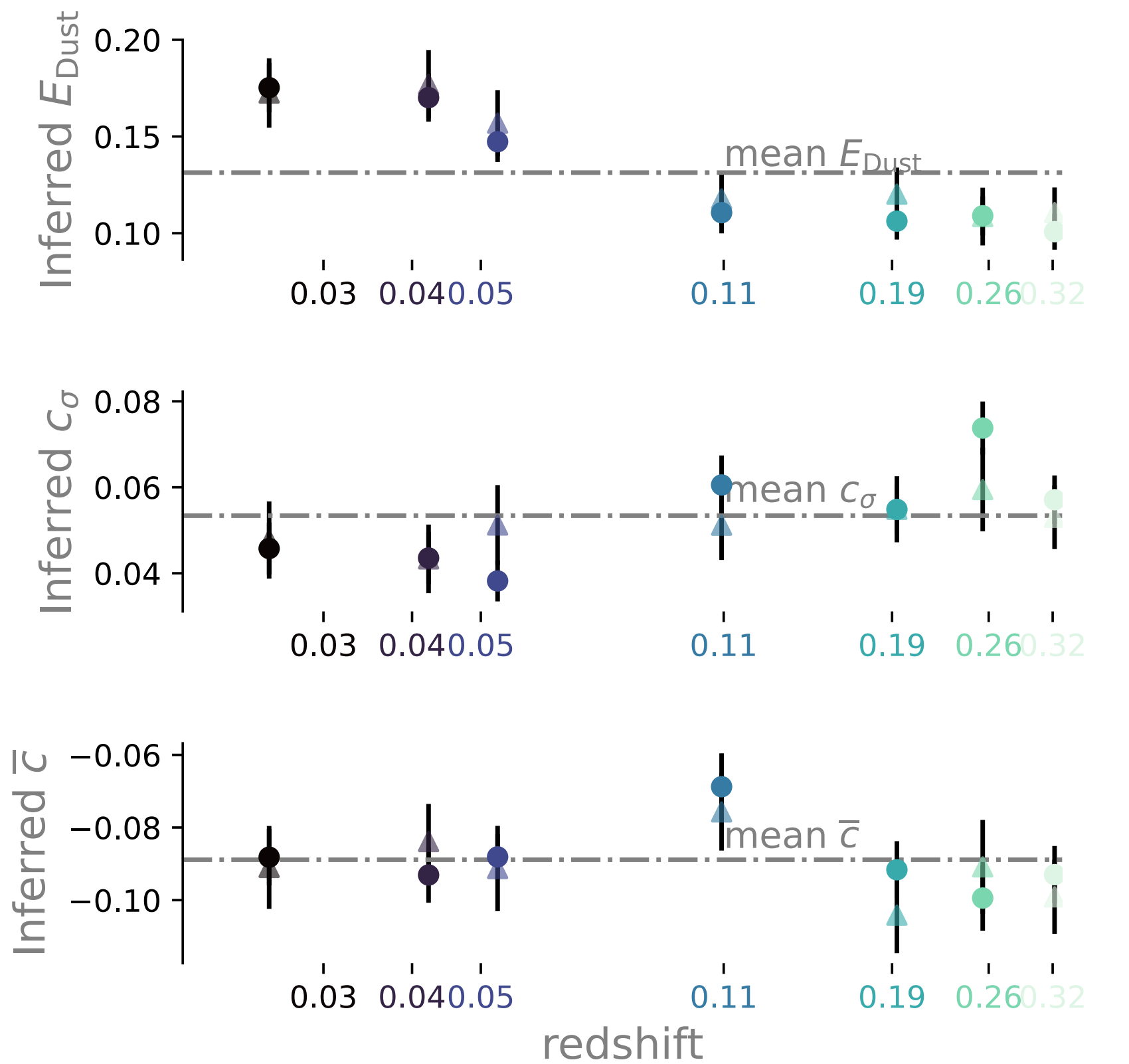


ZTF18aahfzea

« Non dustless » example



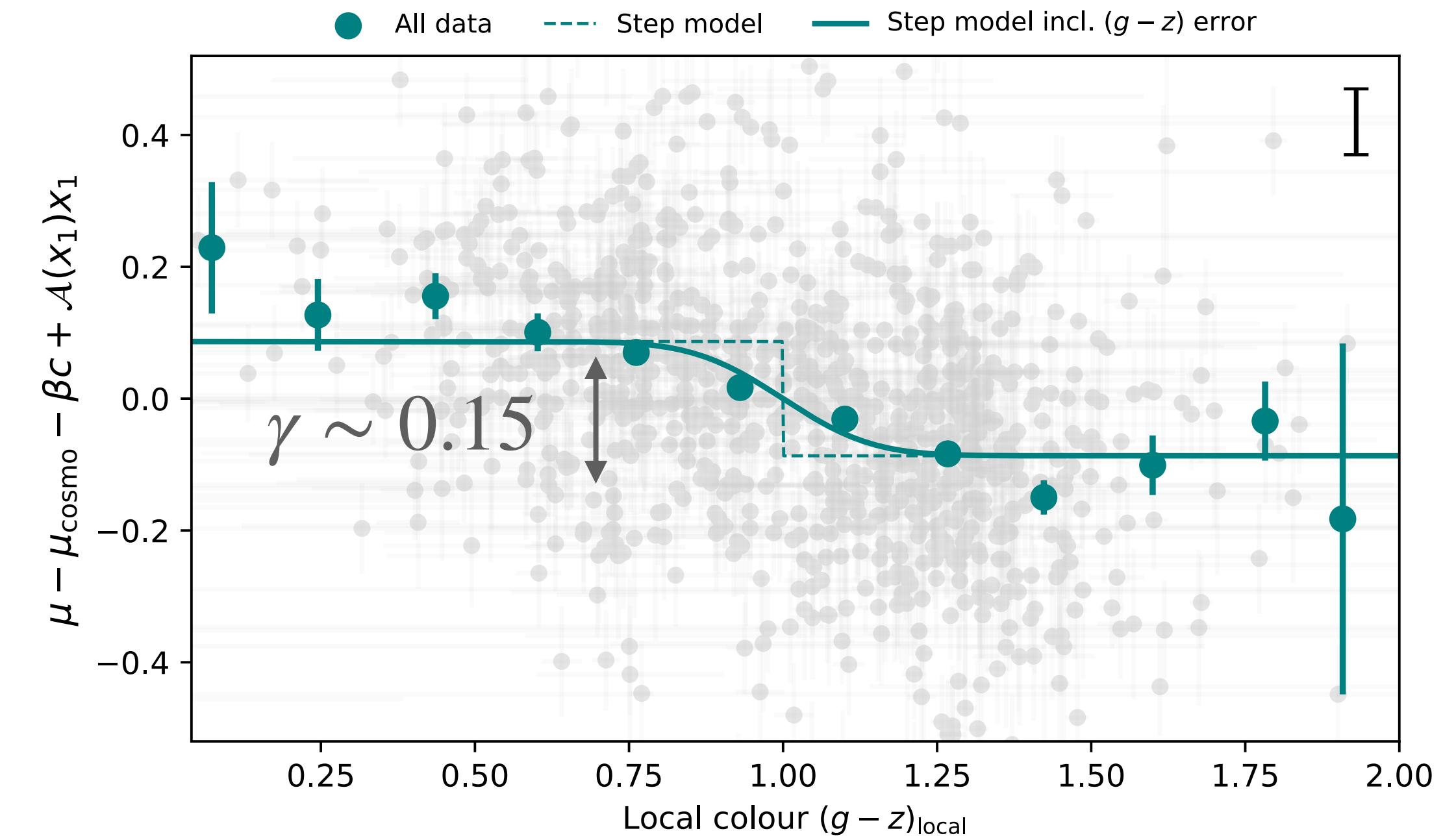
ZTF18aaqfziz



Popovic et al (2024c)

ZTF SN Ia DR2 - Results

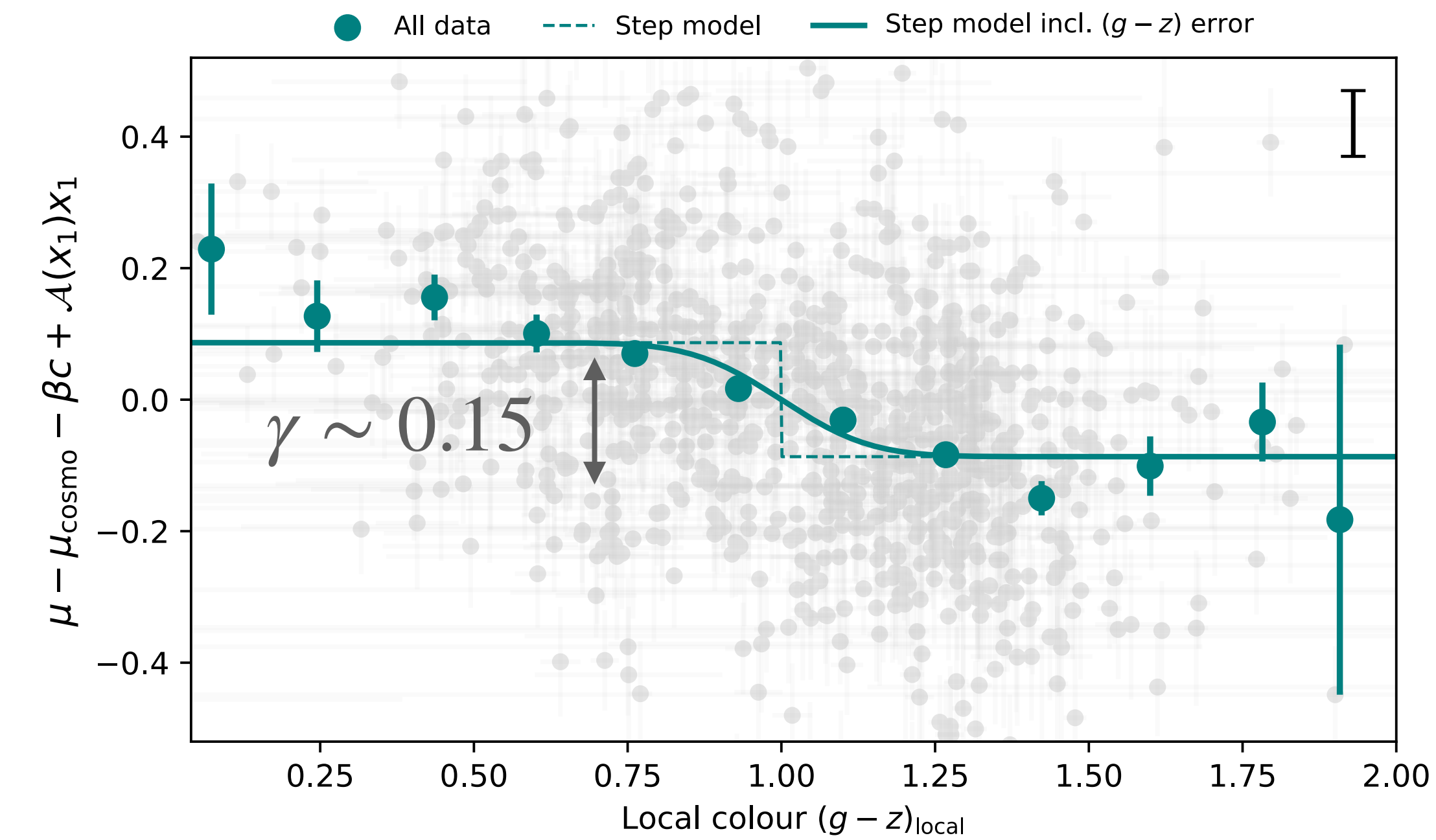
Environment step



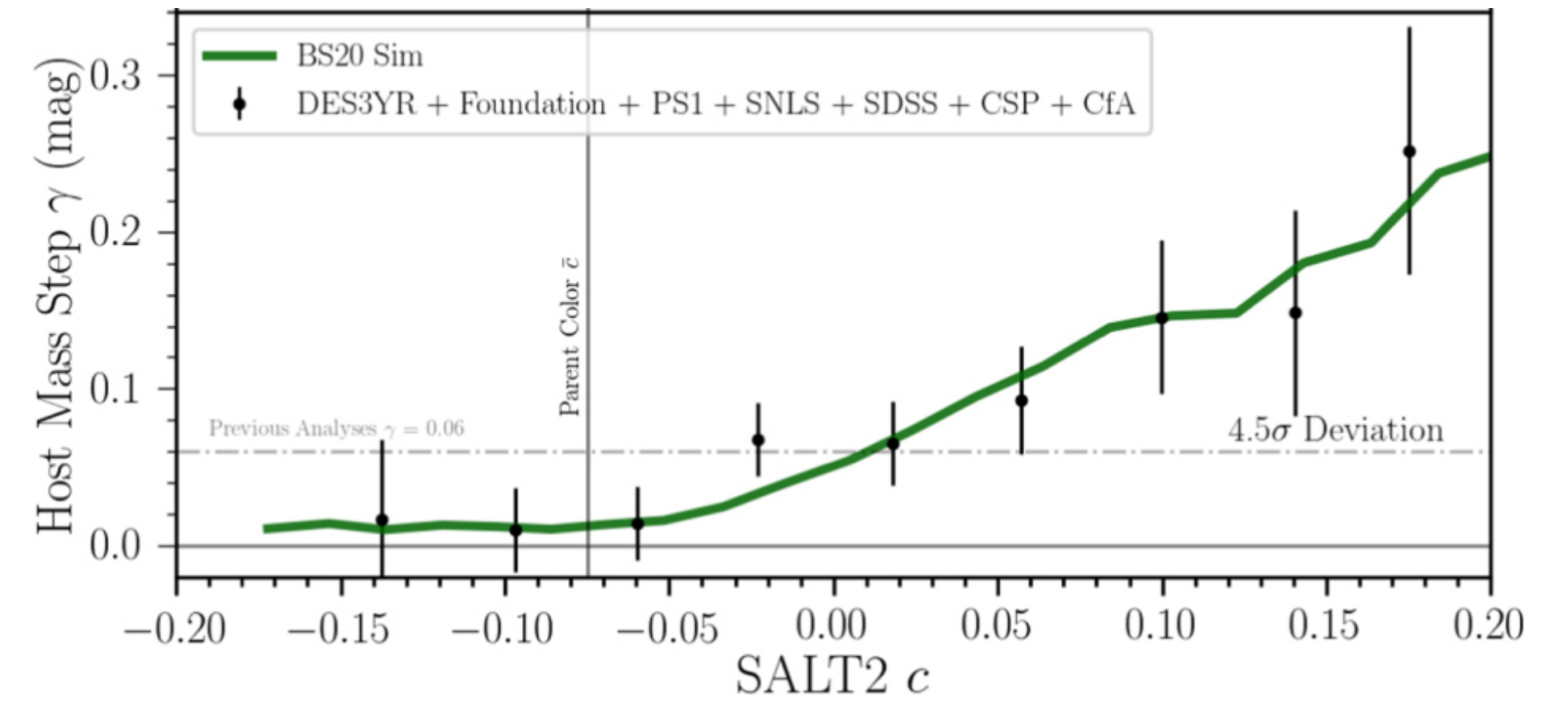
Ginolin et al (2024a)

ZTF SN Ia DR2 - Results

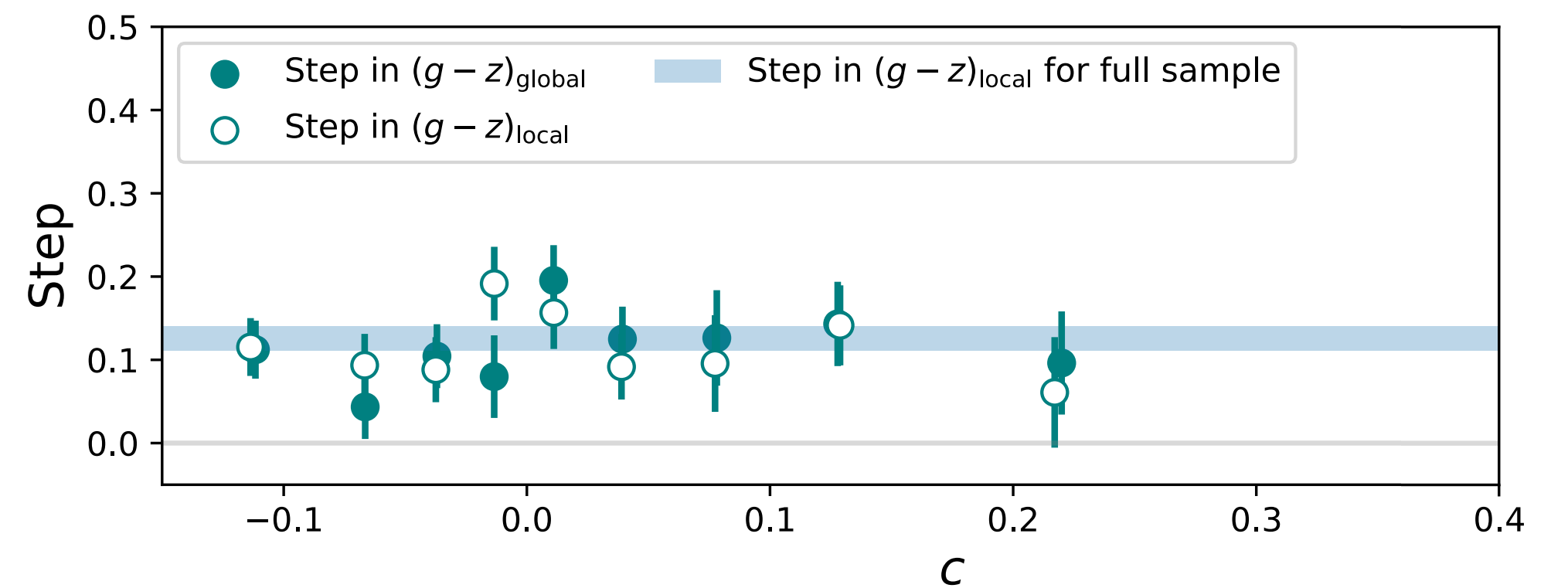
Environment step



Ginolin et al (2024a)



Brout & Scolnic (2021)

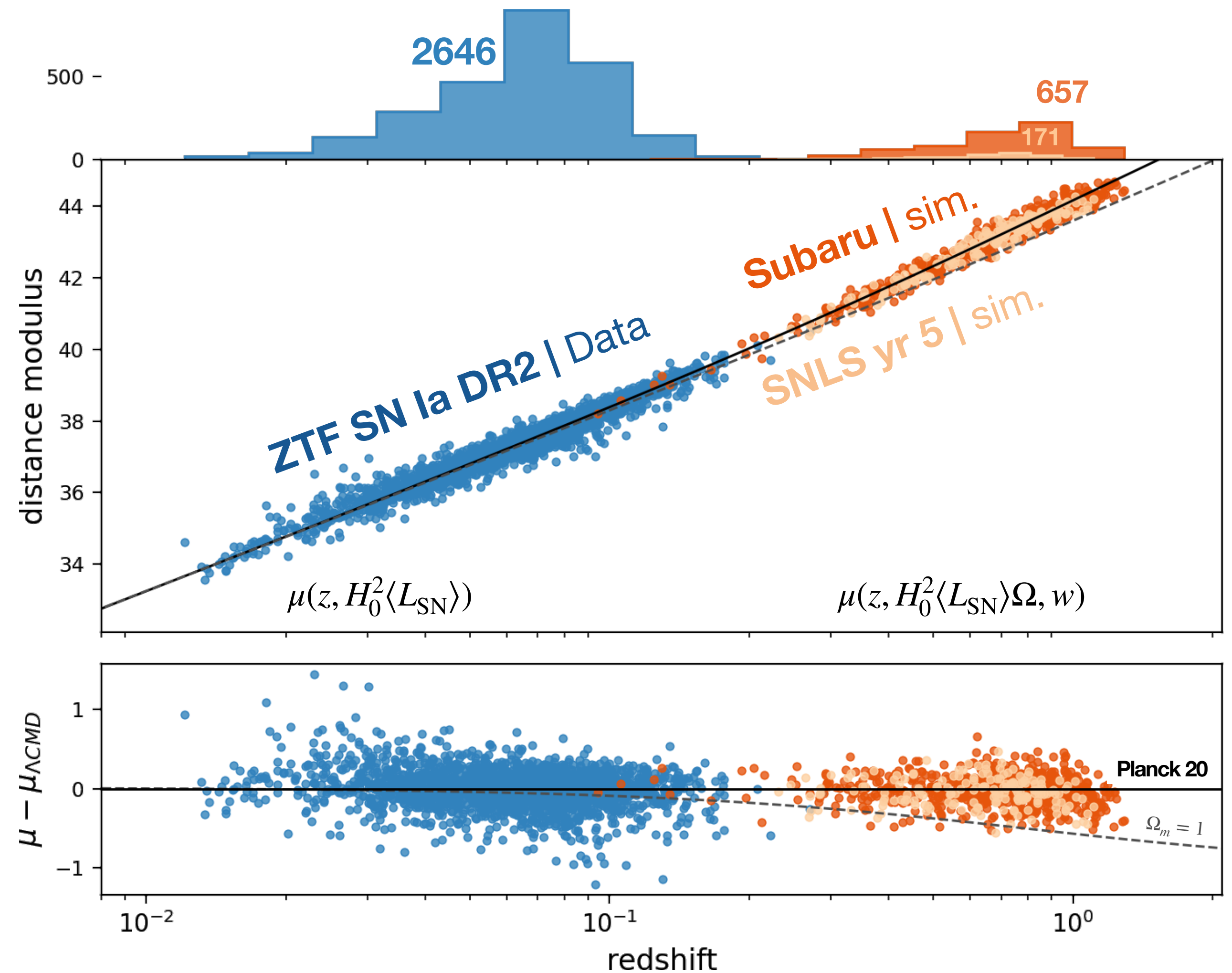
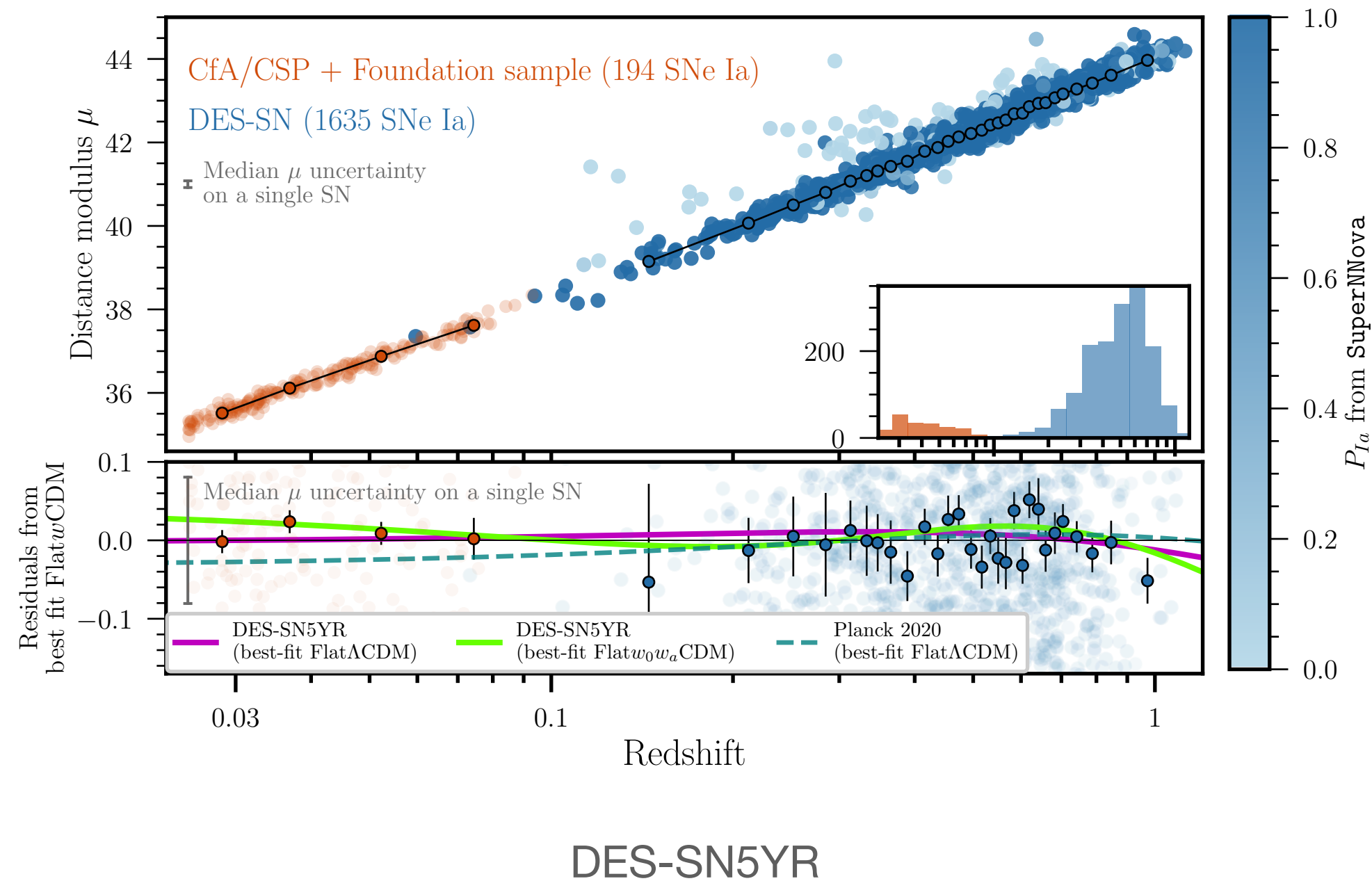


Ginolin et al (2024b)

ZTF DR2.5

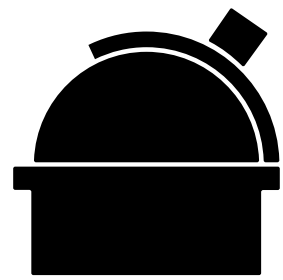
Lemaître

See Mahmoud and Dylan's talks



ZTF DR2.5

Distance ladder



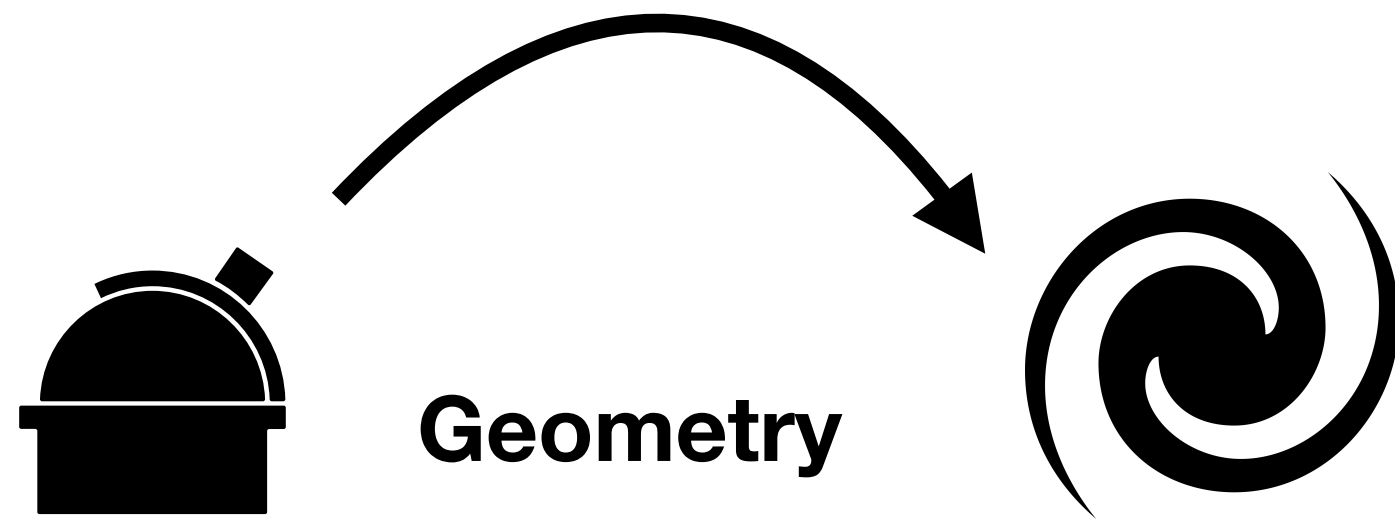
0



Redshift

ZTF DR2.5

Distance ladder



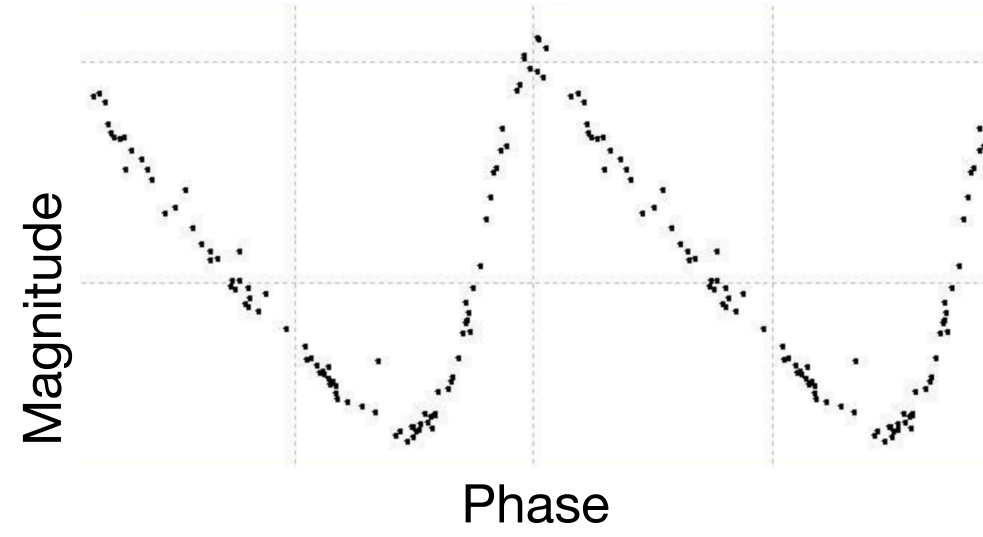
0

$< 10^{-3}$

Redshift

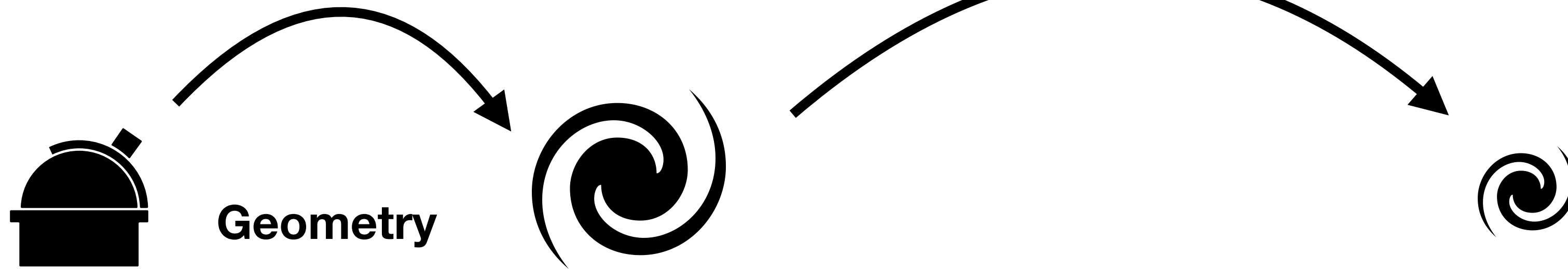
ZTF DR2.5

Distance ladder



Riess et al (2021)

Cepheids



0

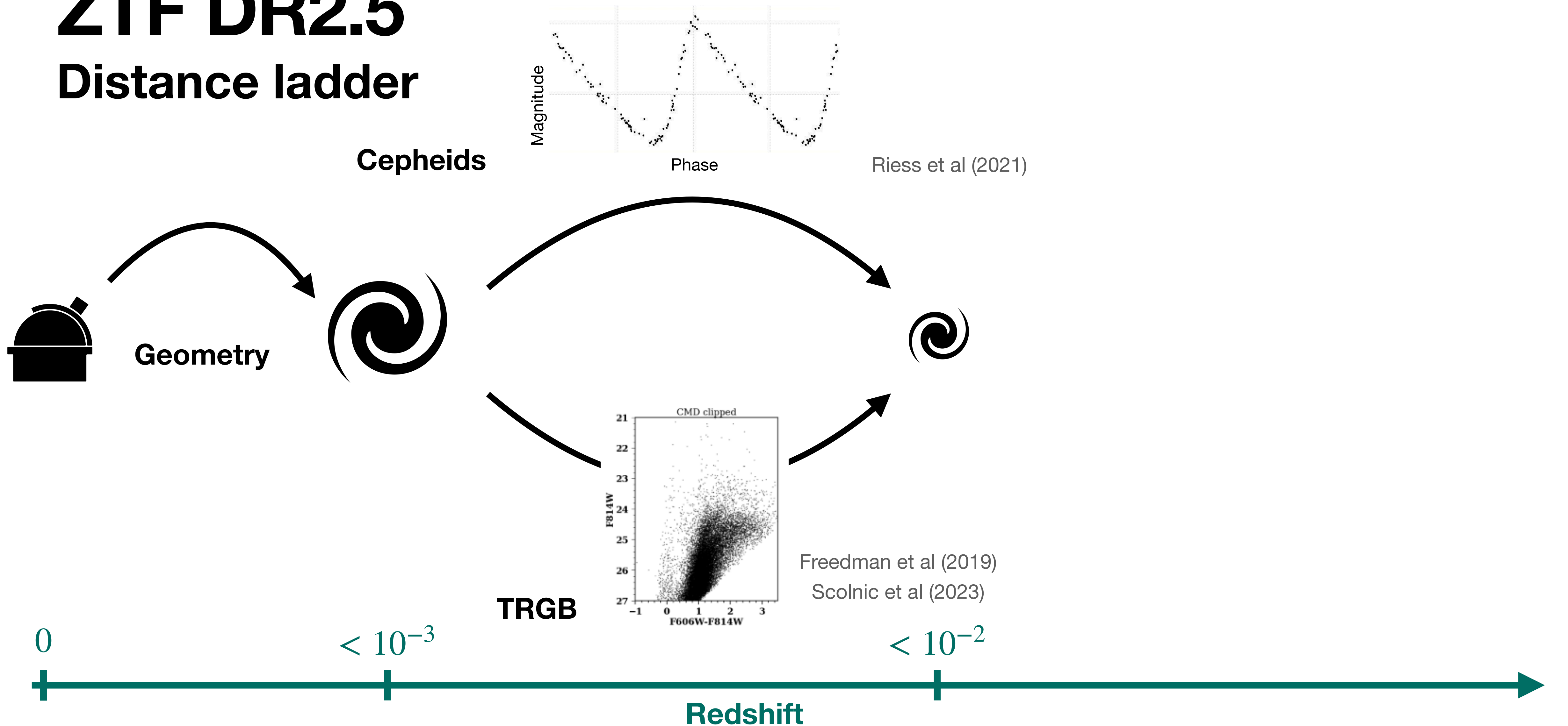
$< 10^{-3}$

$< 10^{-2}$

Redshift

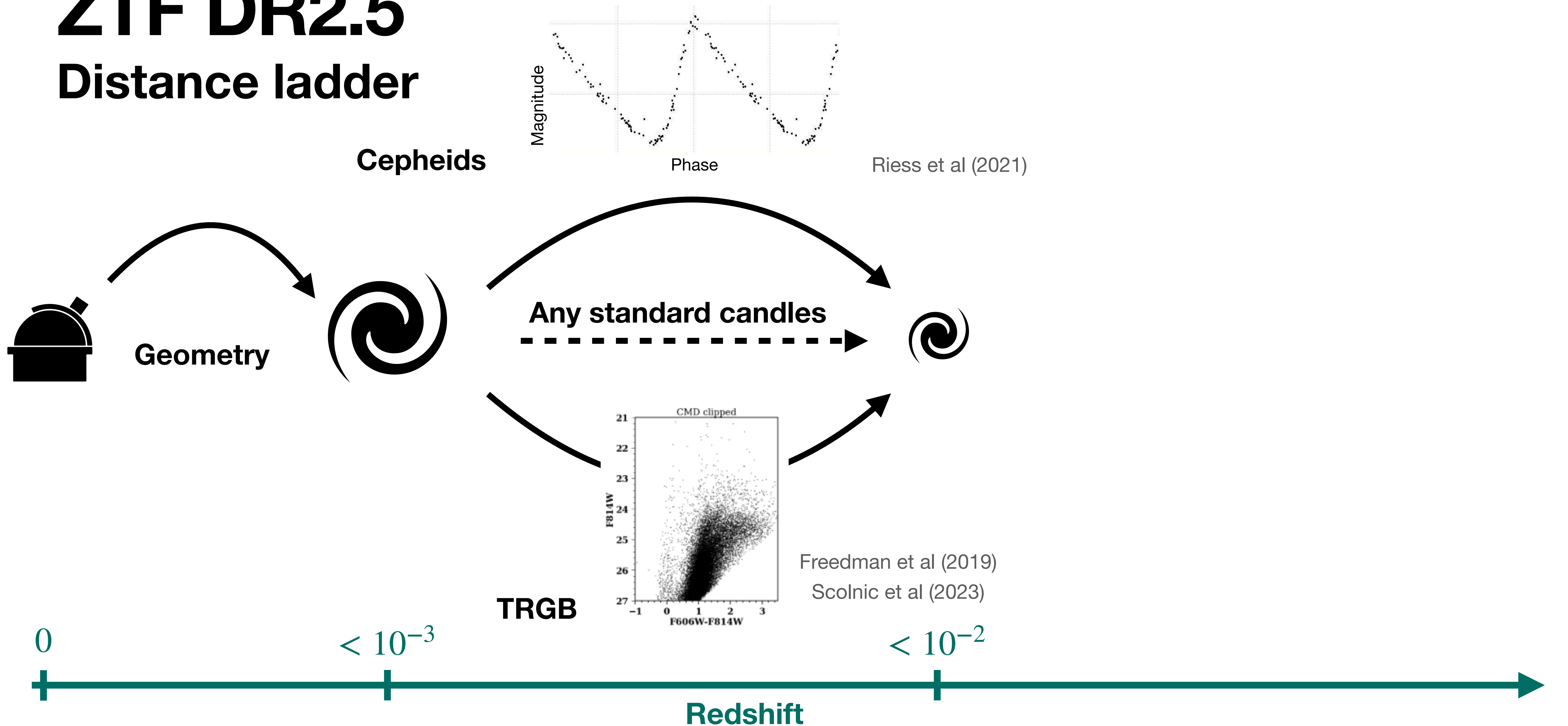
ZTF DR2.5

Distance ladder



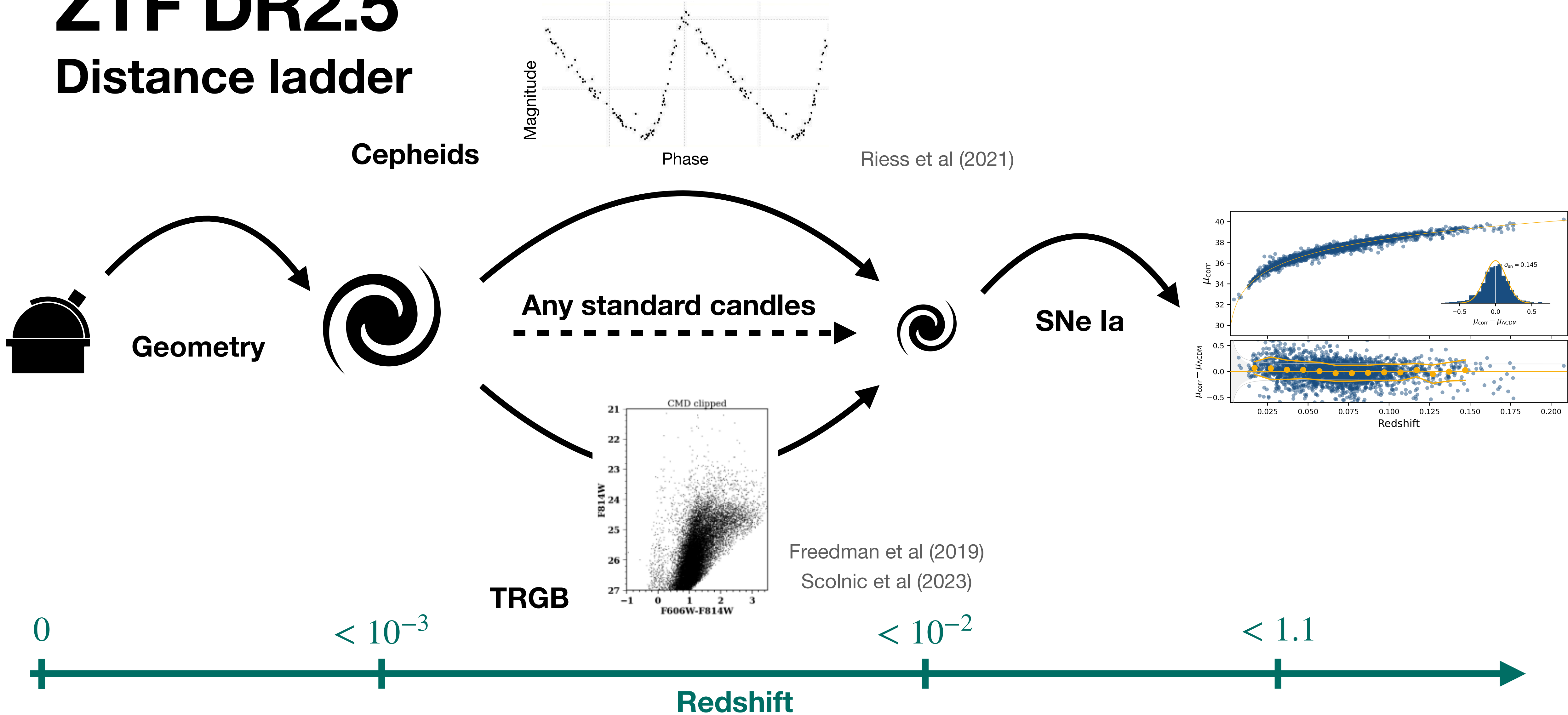
ZTF DR2.5

Distance ladder



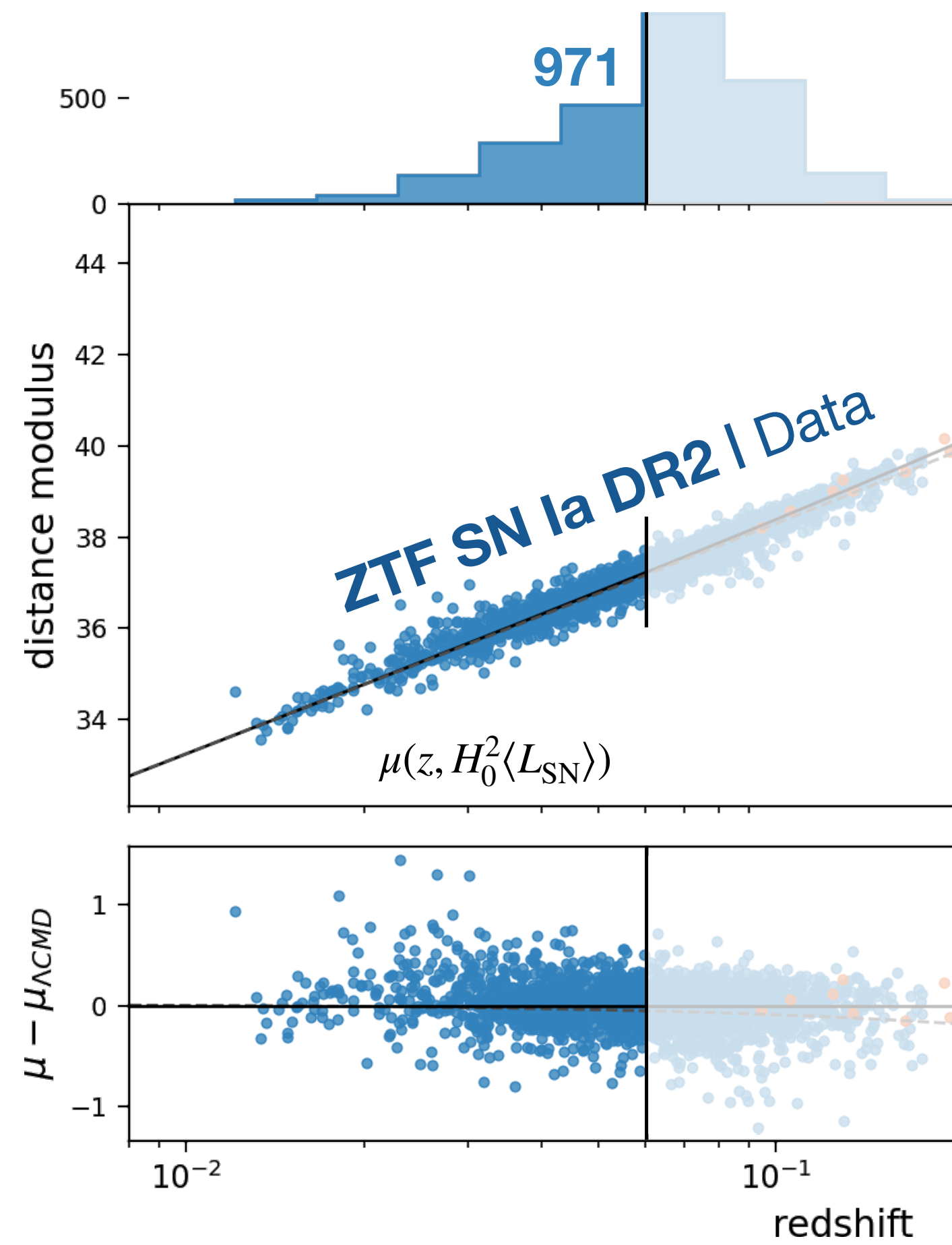
ZTF DR2.5

Distance ladder



ZTF DR2.5

H_0



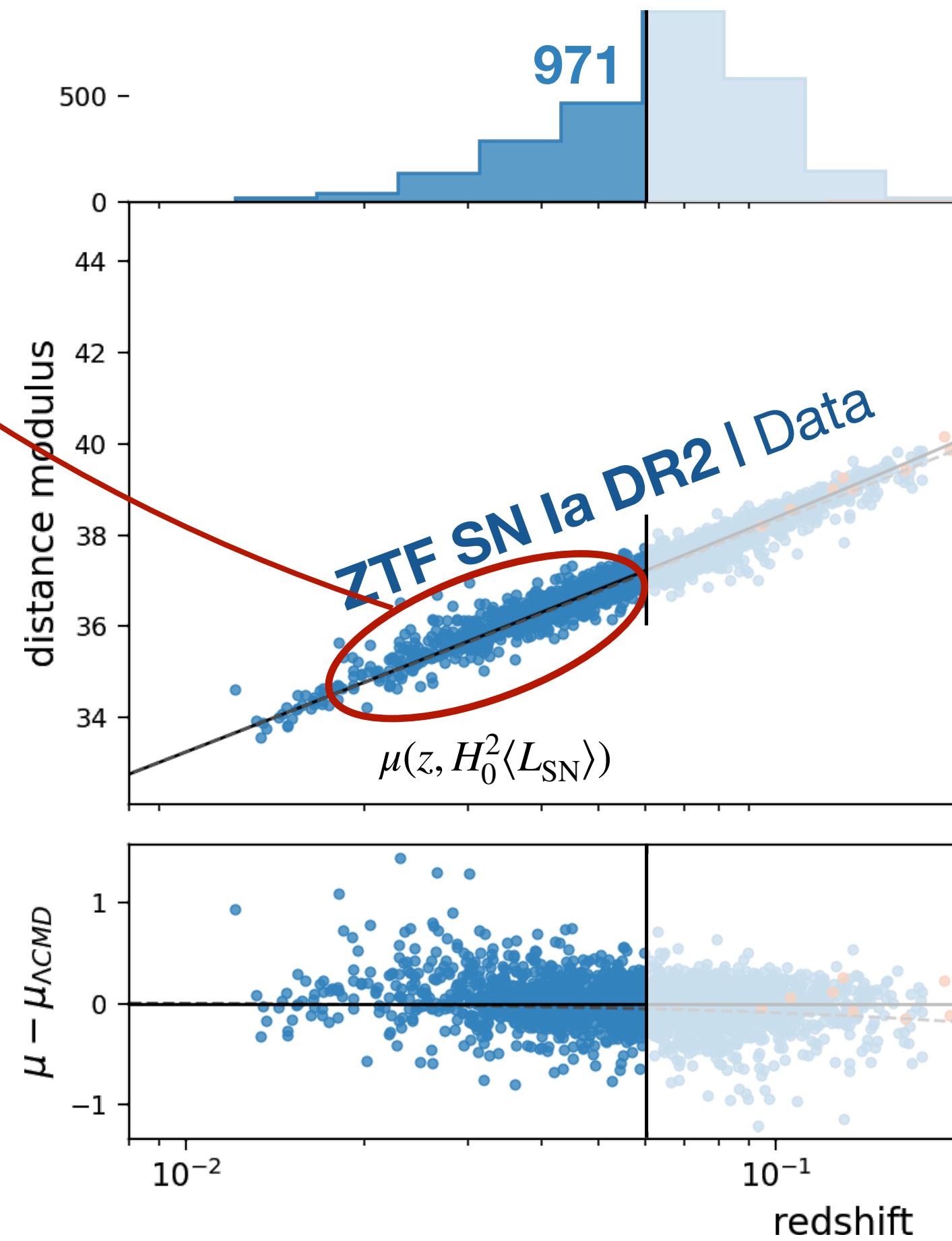
ZTF DR2.5

H_0

Volume limited sample

$$z < 0.06$$

No selection biases

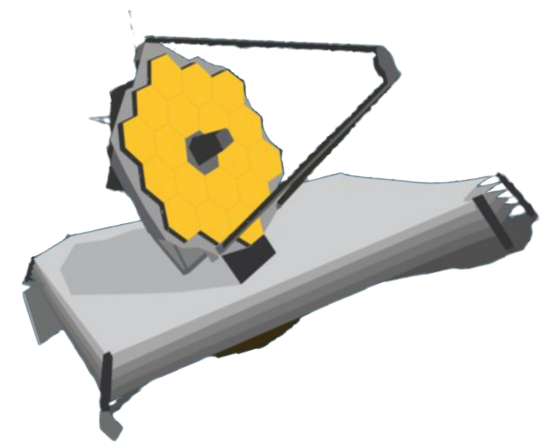


ZTF DR2.5

H_0

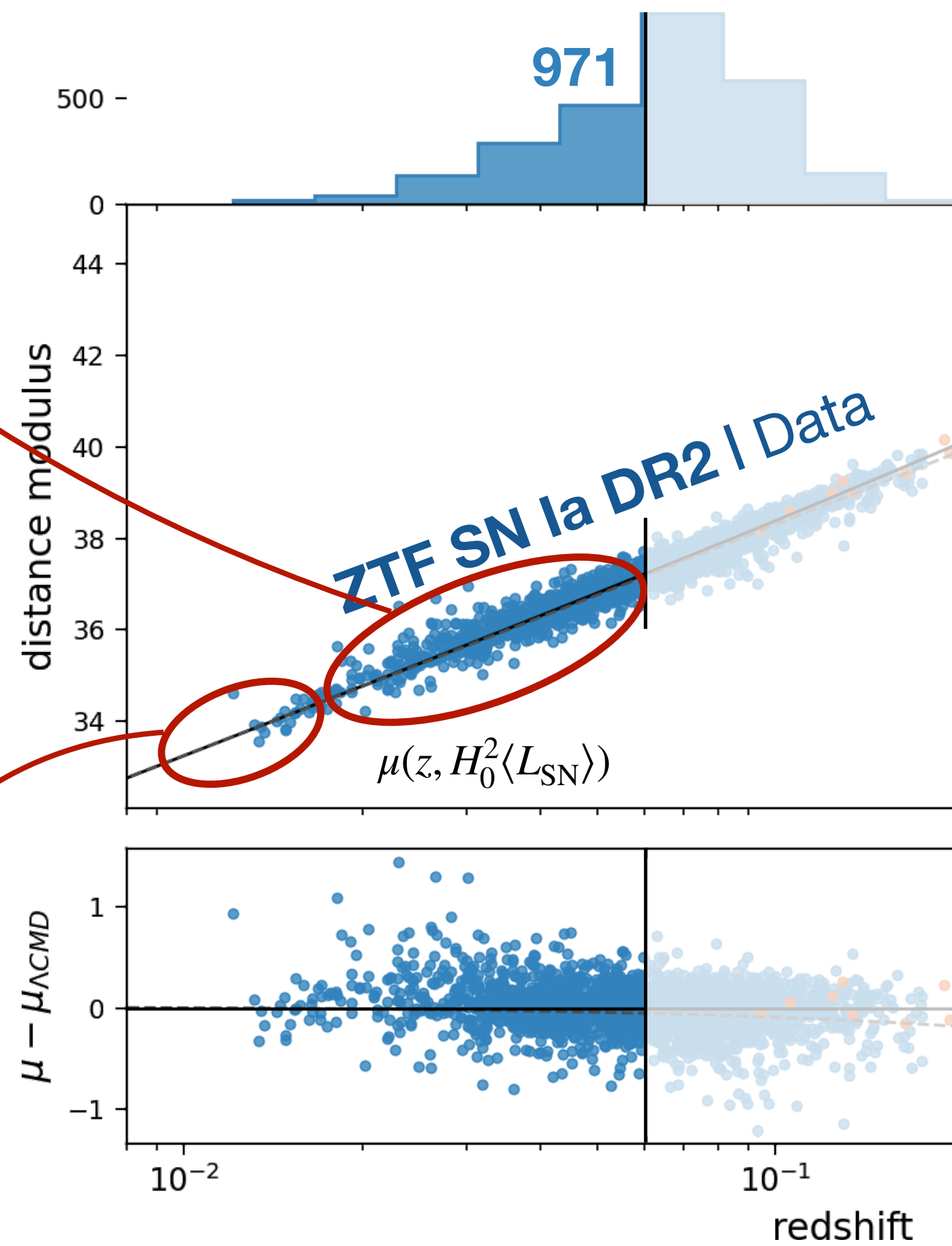
Volume limited sample

$z < 0.06$
No selection biases



Calibrator sample

$d < 50$ Mpc
TRGB with JWST



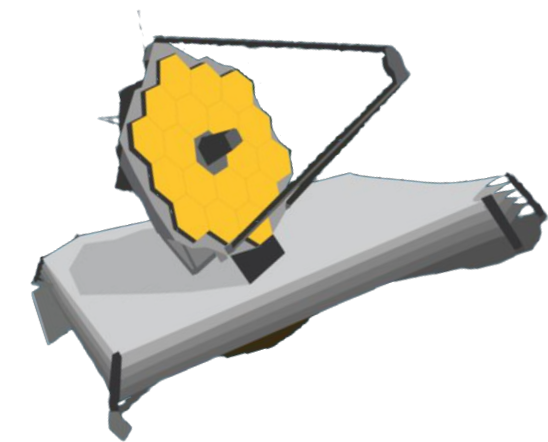
ZTF DR2.5

H_0

See Chloé's talk

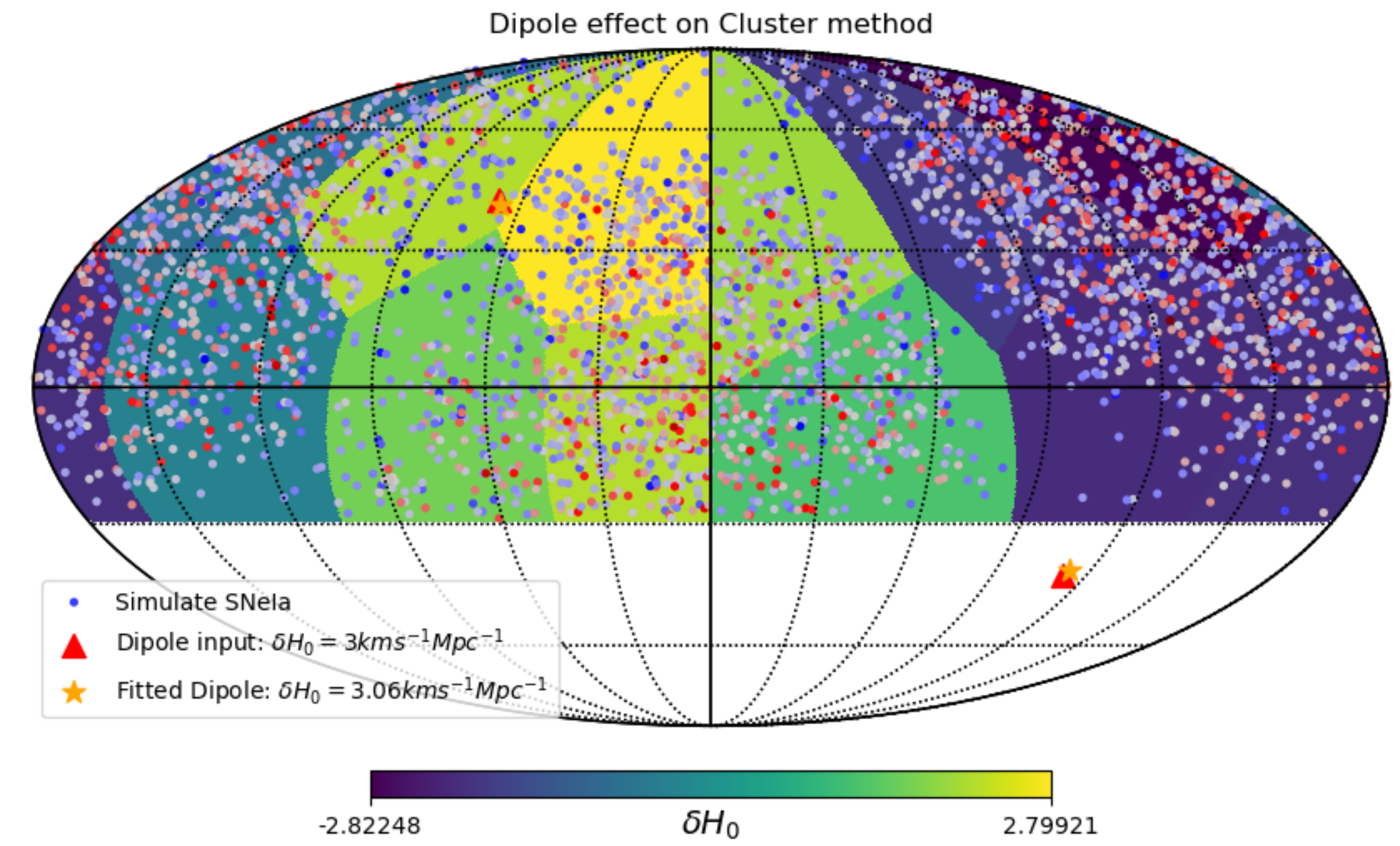
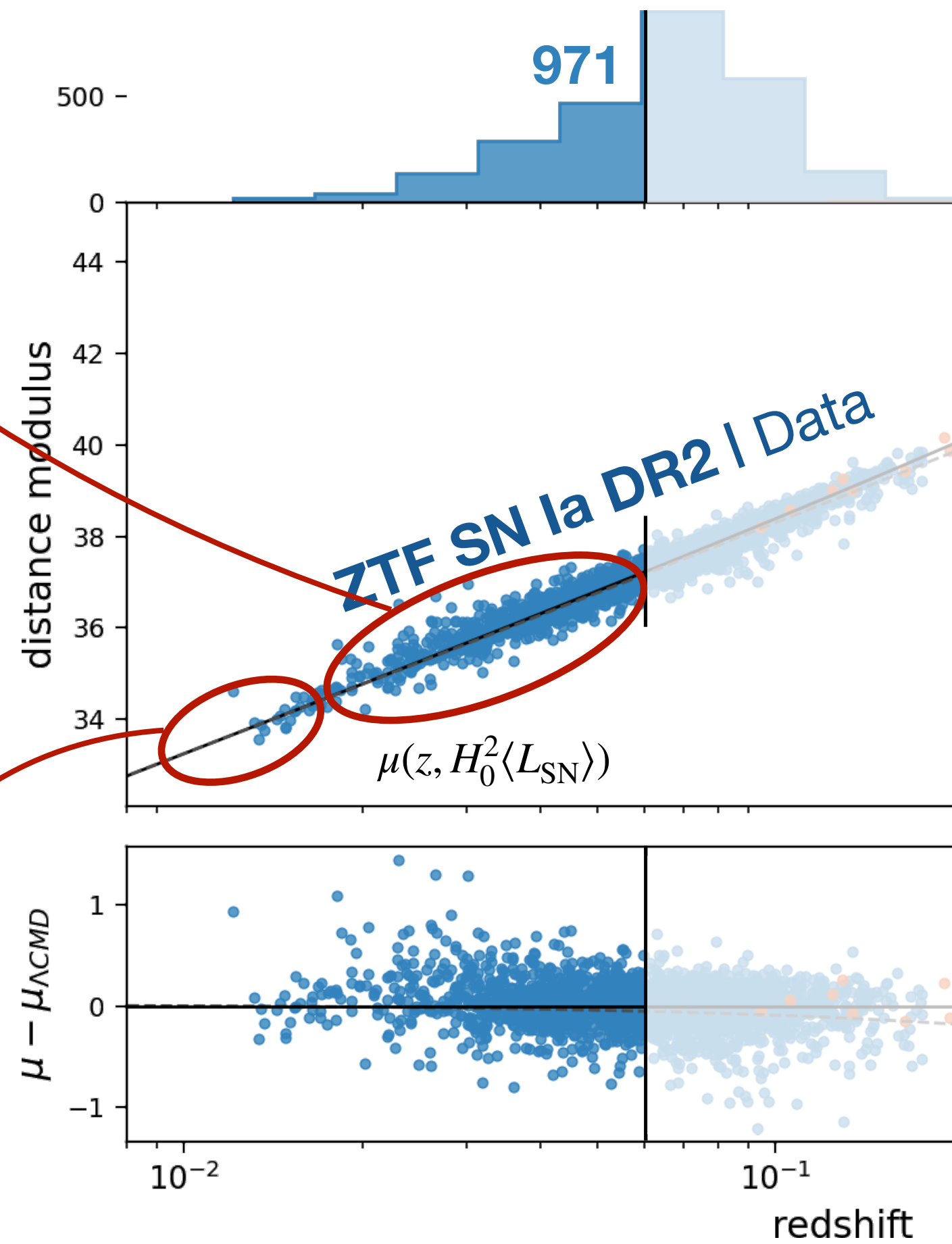
Volume limited sample

$z < 0.06$
No selection biases



Calibrator sample

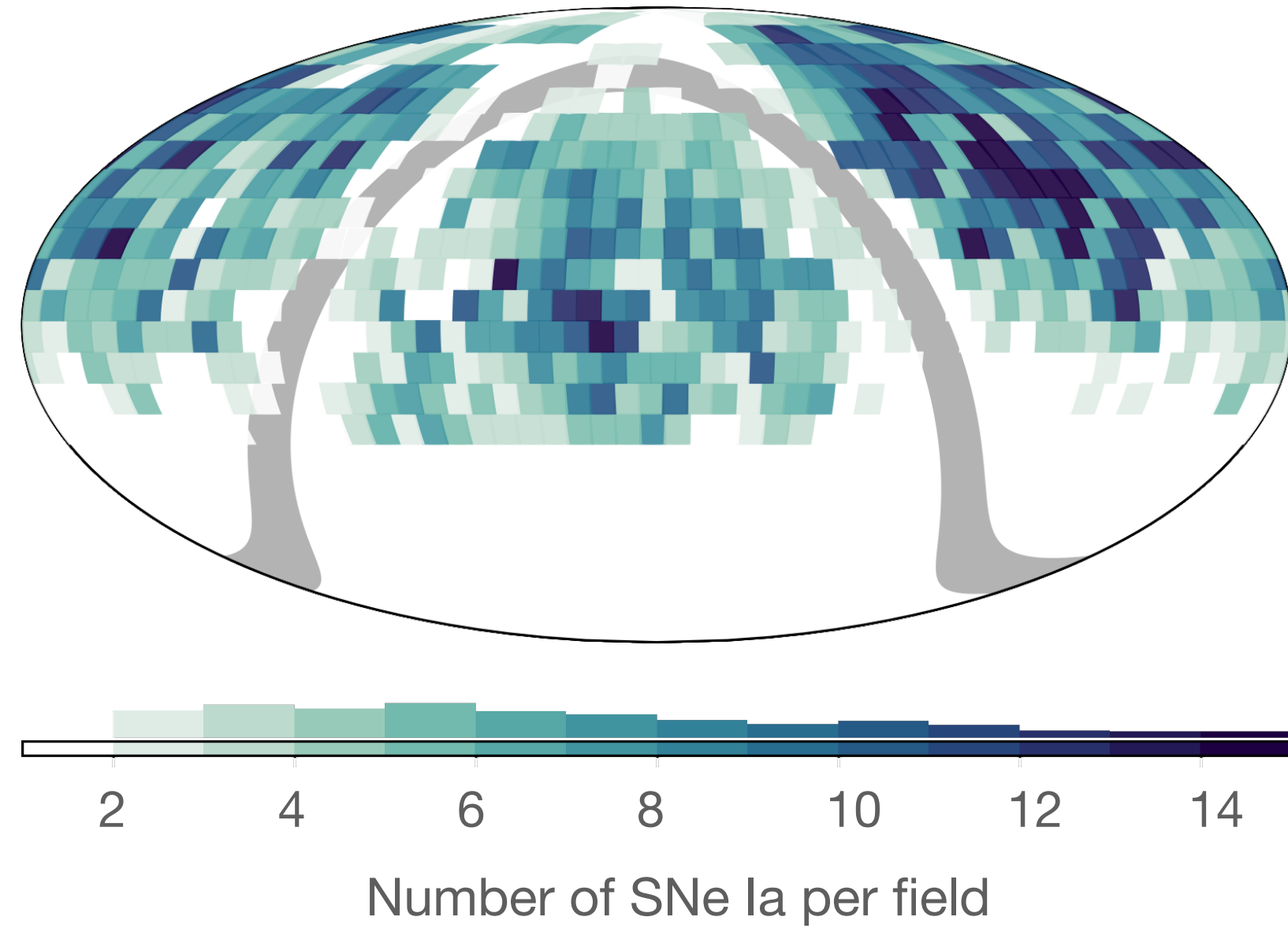
$d < 50$ Mpc
TRGB with JWST



Barjou-Delayre et al (in prep)

ZTF DR2.5

$f\sigma_8$

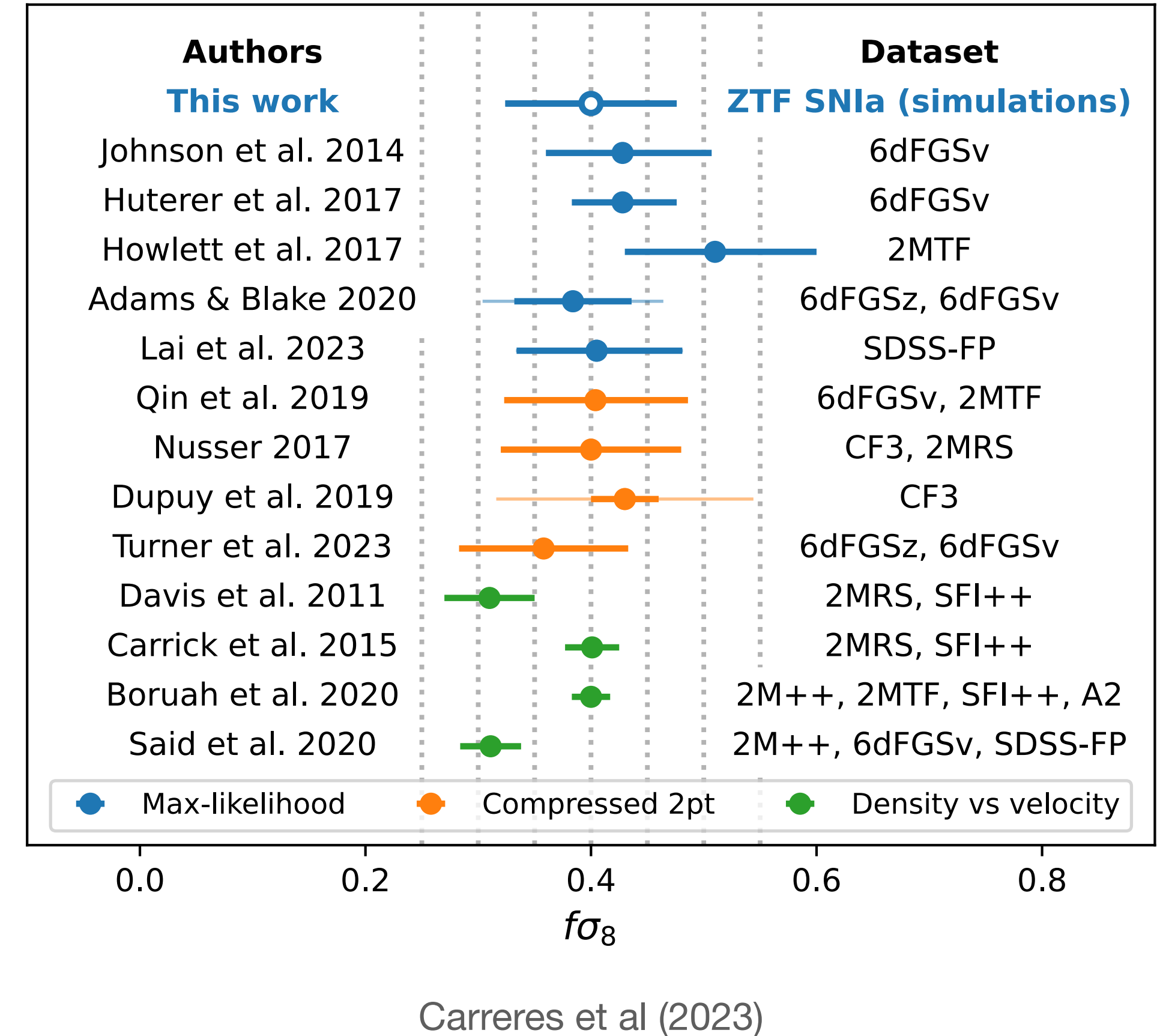


Observed redshift
(What we have)

$$(1+z) = (1+\bar{z})\left(1 + \frac{v}{c}\right)$$

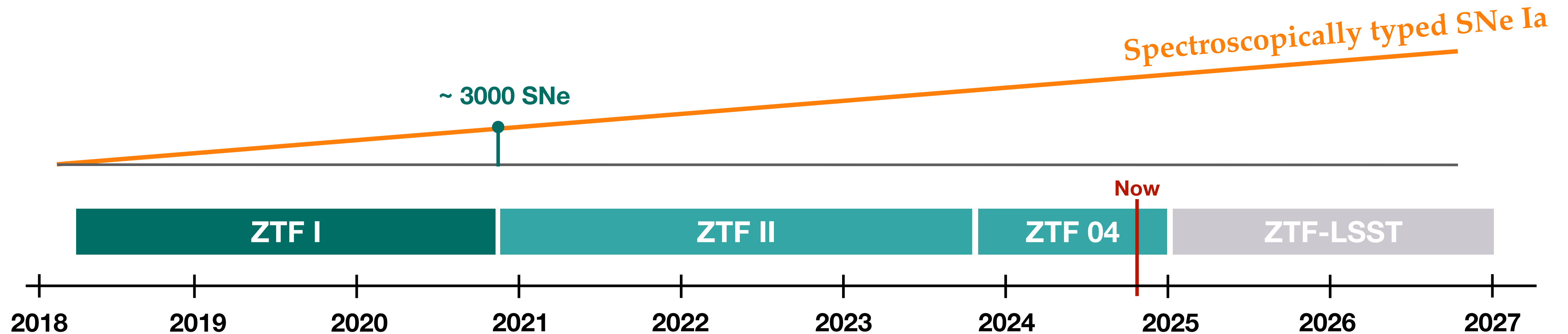
Cosmology redshift
(from distance)

v Peculiar velocity
(What we want)



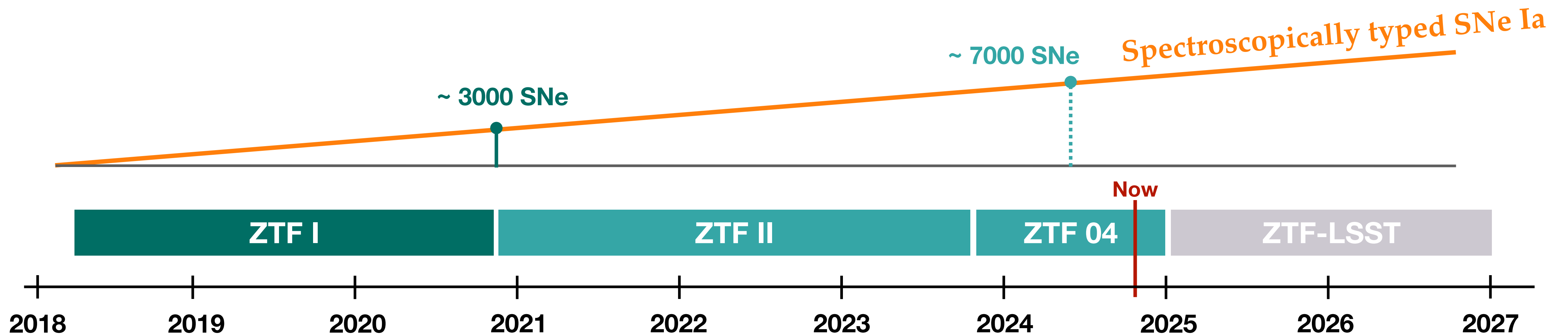
ZTF DR3

Photometric classification



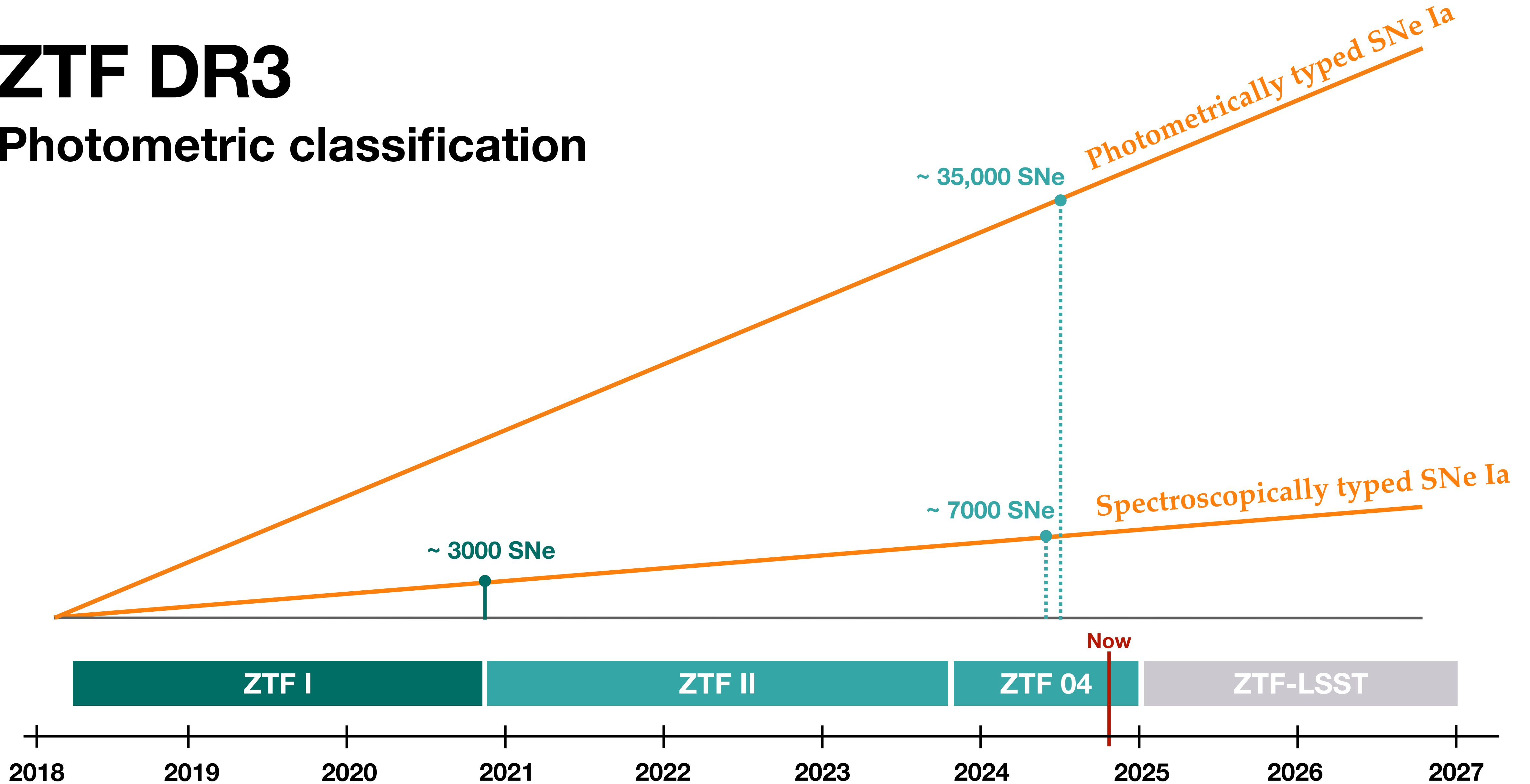
ZTF DR3

Photometric classification

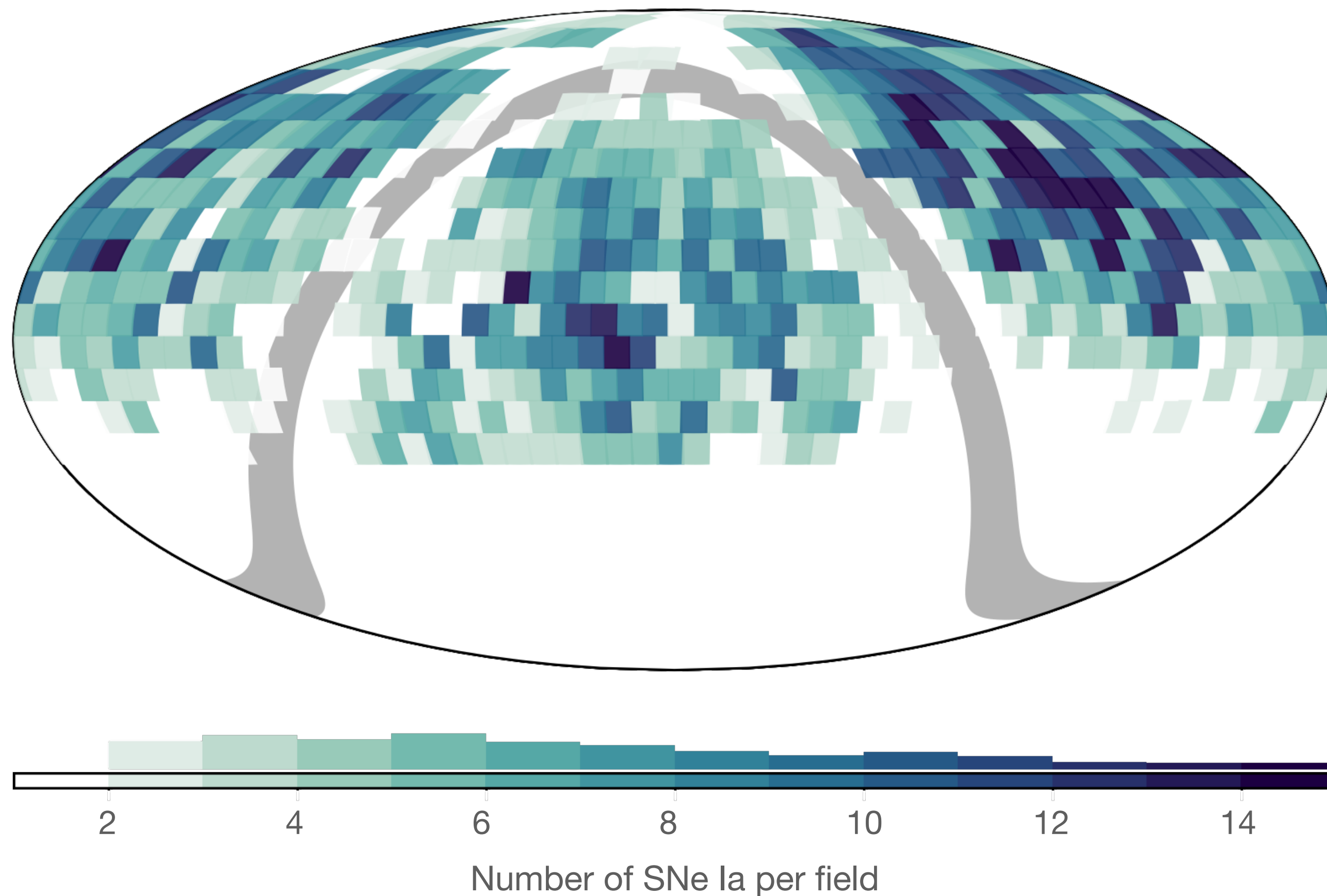


ZTF DR3

Photometric classification



Conclusion



A&A special issue

Rigault+, Smith+

- Simulation (Amenouche+)
- SNe in voids (Aubert+)
- Peculiar velocity impact (Carreres, Rosselli+)
- Stretch and steps standardisation (Ginolin+)
- Colour standardisation (Ginolin+)
- Photometry (Lacroix+)
- Colour evolution with redshift (Popovic+)
- Lightcurve residuals (Rigault+)
- SNe in clusters (Ruppin+)
- Spectral diversity (Burgaz+, Johansson+)
- Low mass hosts SNe Ia (Burgaz+)
- Secondary maximum (Deckers+)
- Siblings (Dhawan+)
- Photometric diversity (Dimitriadis+)
- High velocity features (Harvey+)
- Lightcurve modeling (Kenworthy+)
- Bulge vs disk SNe (Senzel+)
- Late-time CSM interactions (Terwel+)