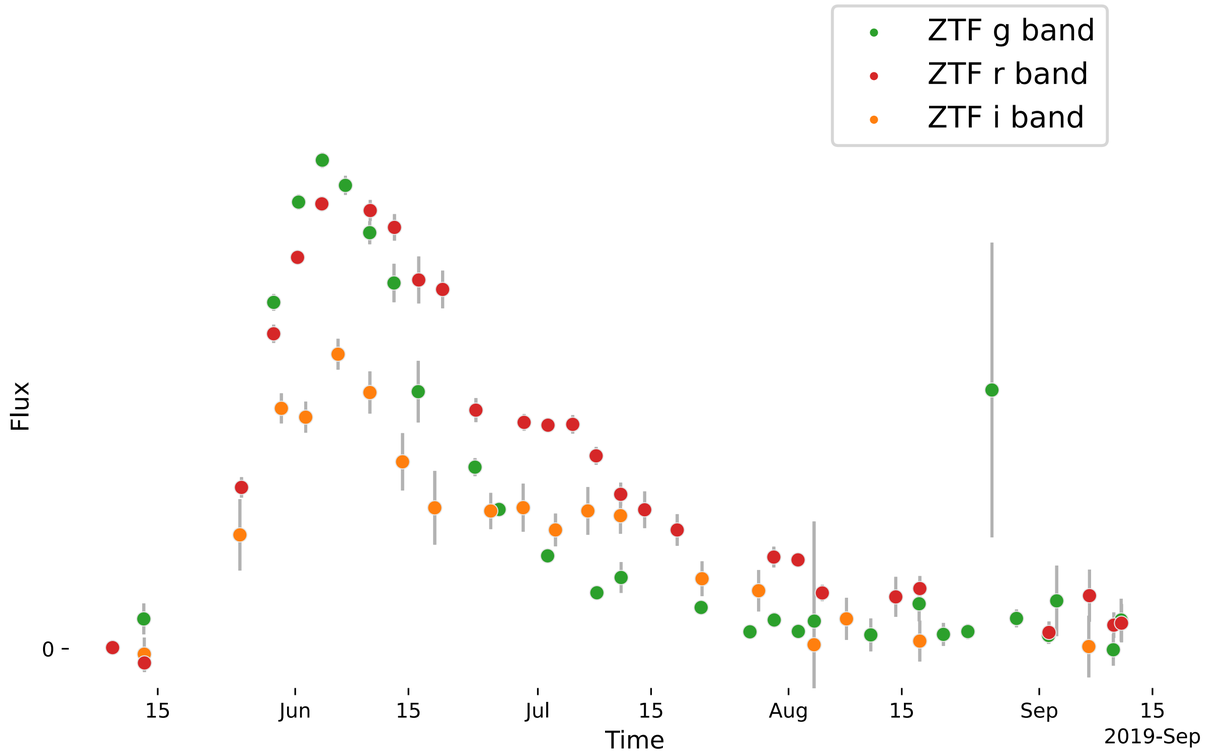
The ZTF SN Ia DR2 and beyond

On behalf of the ZTF-Cosmo collaboration

Madeleine GINOLIN - 7th November 2025

Type Ia Supernovae

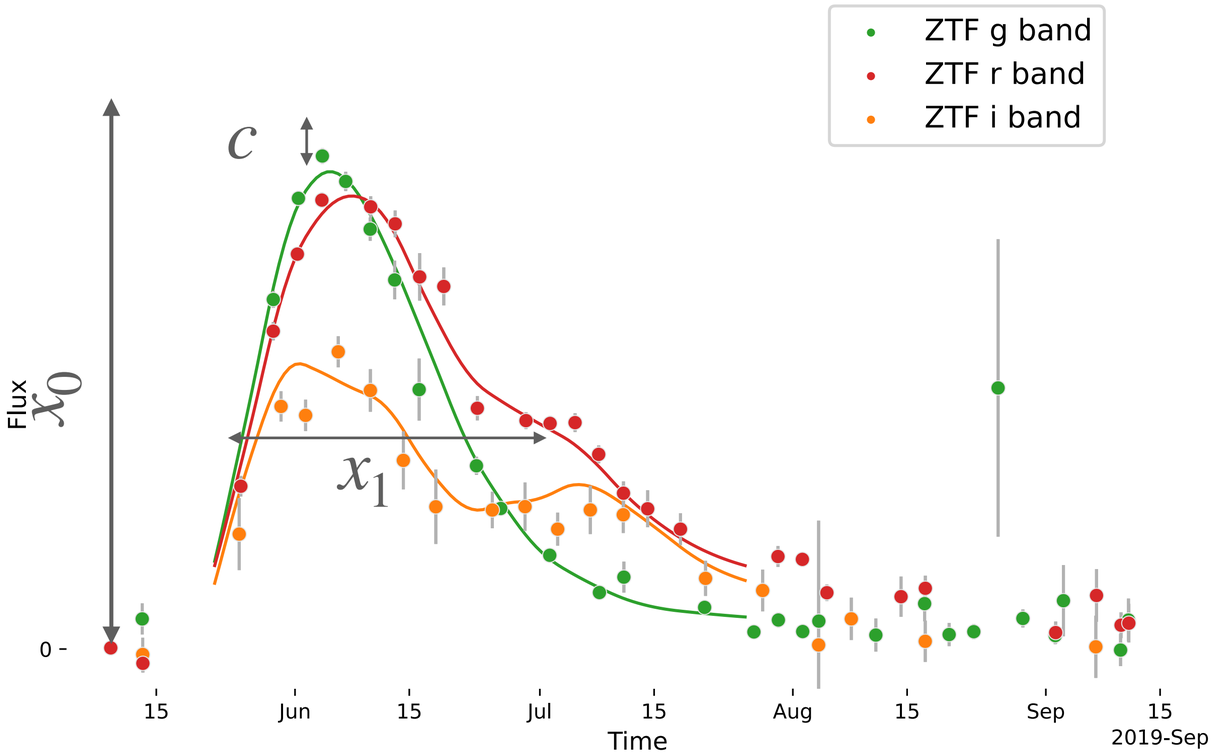
Lightcurve



SALT2 - Guy+07
SALT2.4 - Guy+10, Betoule+14
SALT3 - Kenworthy+21

Type Ia Supernovae

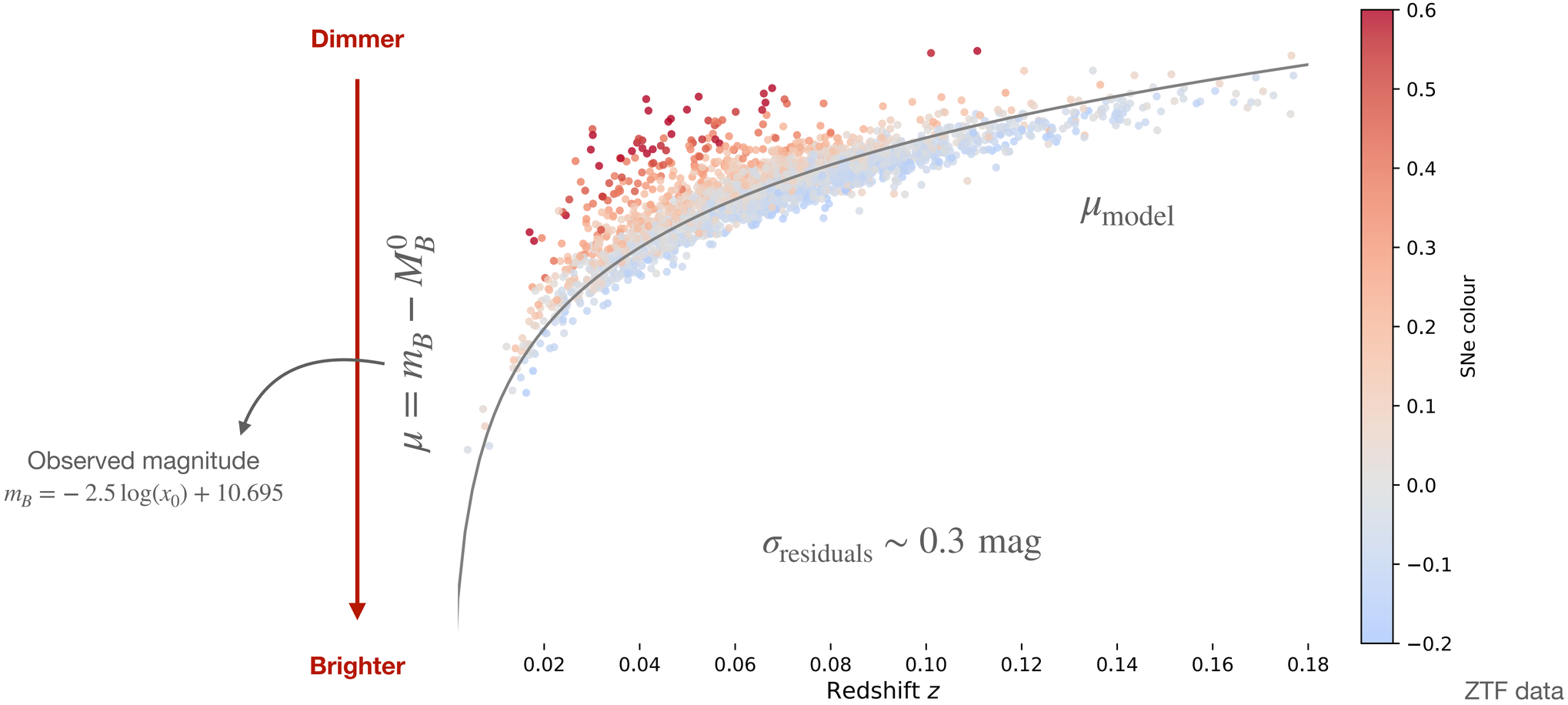
Lightcurve



SALT2 - Guy+07
SALT2.4 - Guy+10, Betoule+14
SALT3 - Kenworthy+21

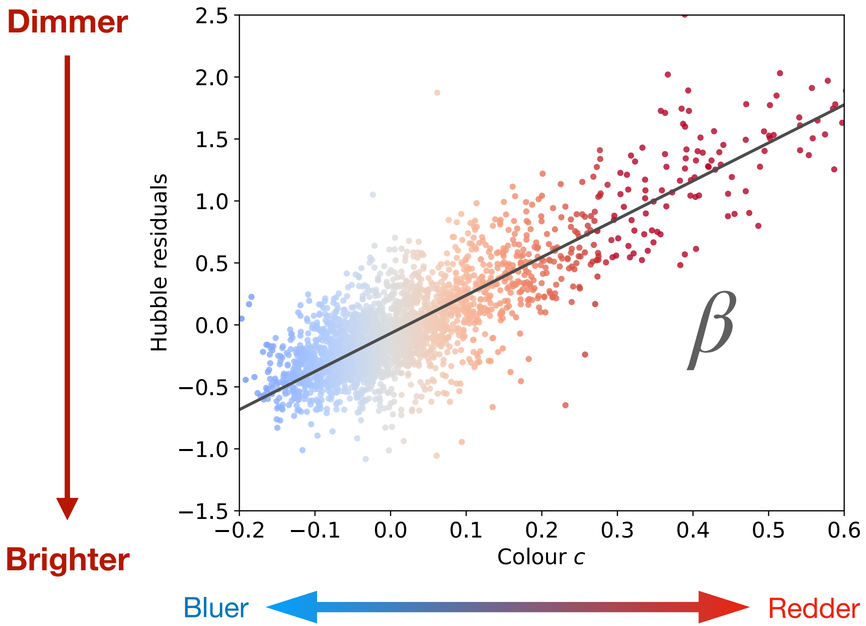
Type Ia Supernovae

Standardisation



Type Ia Supernovae

Standardisation

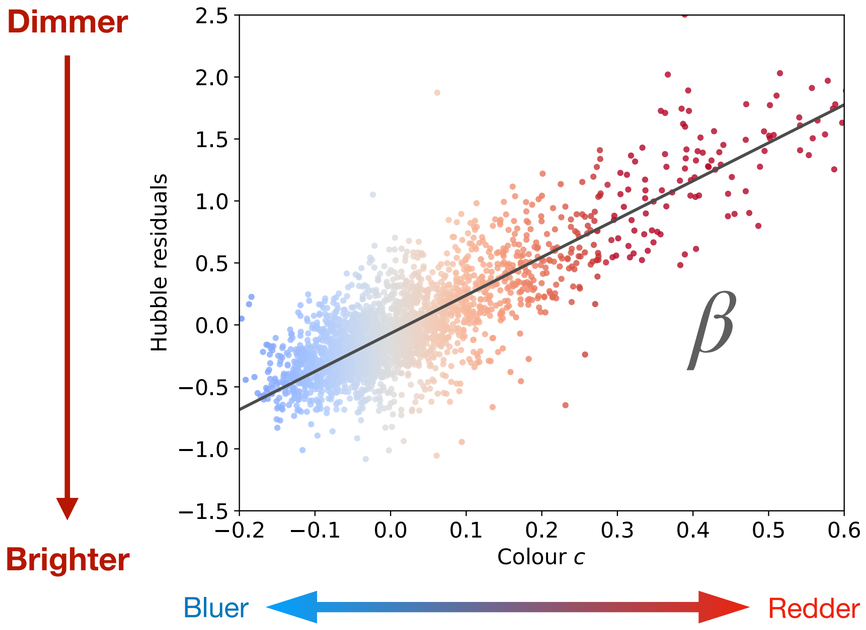


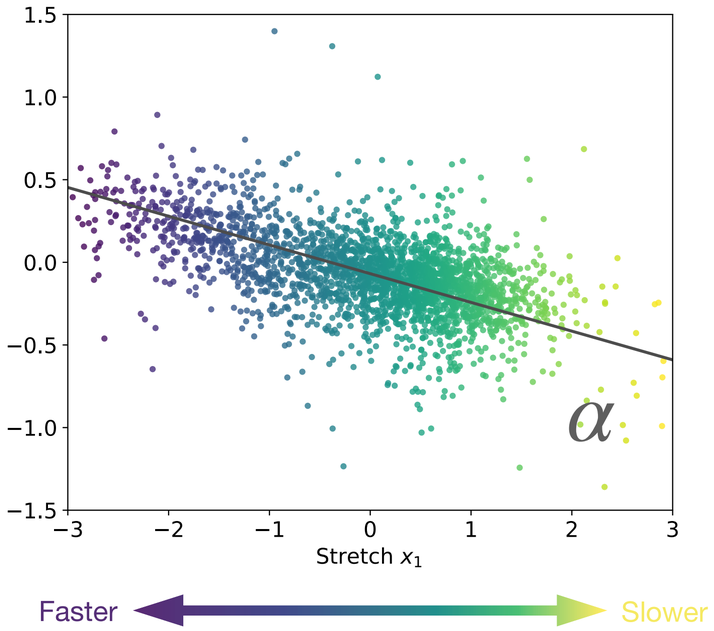
$$\mu^0 + M_B^0 = m_B - \beta c$$

ZTF data

Type Ia Supernovae

Standardisation



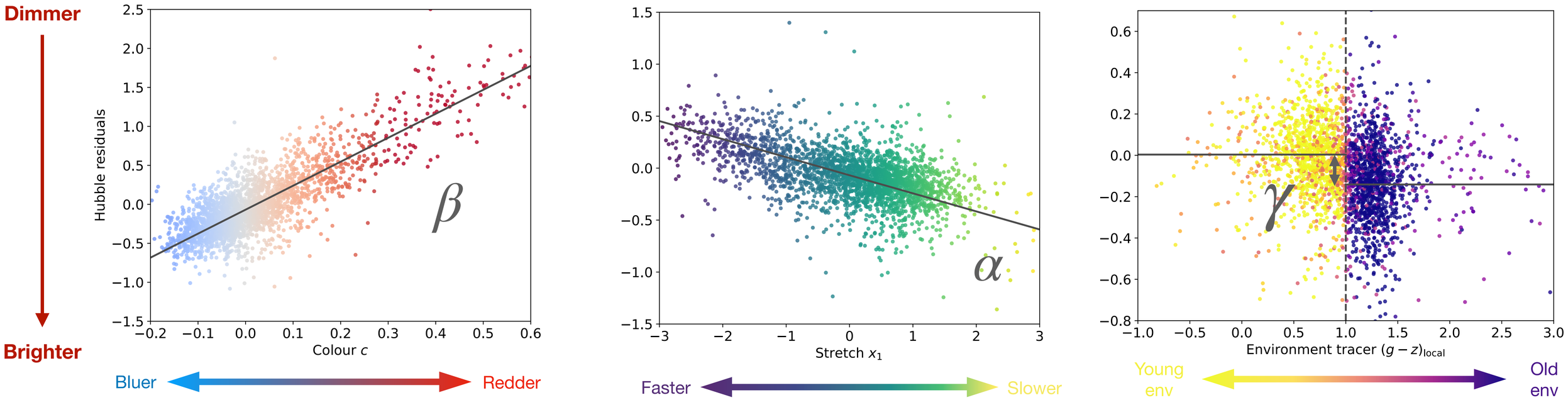


$$\mu^0 + M_B^0 = m_B - \beta c + \alpha x_1$$

ZTF data

Type Ia Supernovae

Standardisation



$$\mu^0 + M_B^0 = m_B - \beta c + \alpha x_1 + p\gamma$$

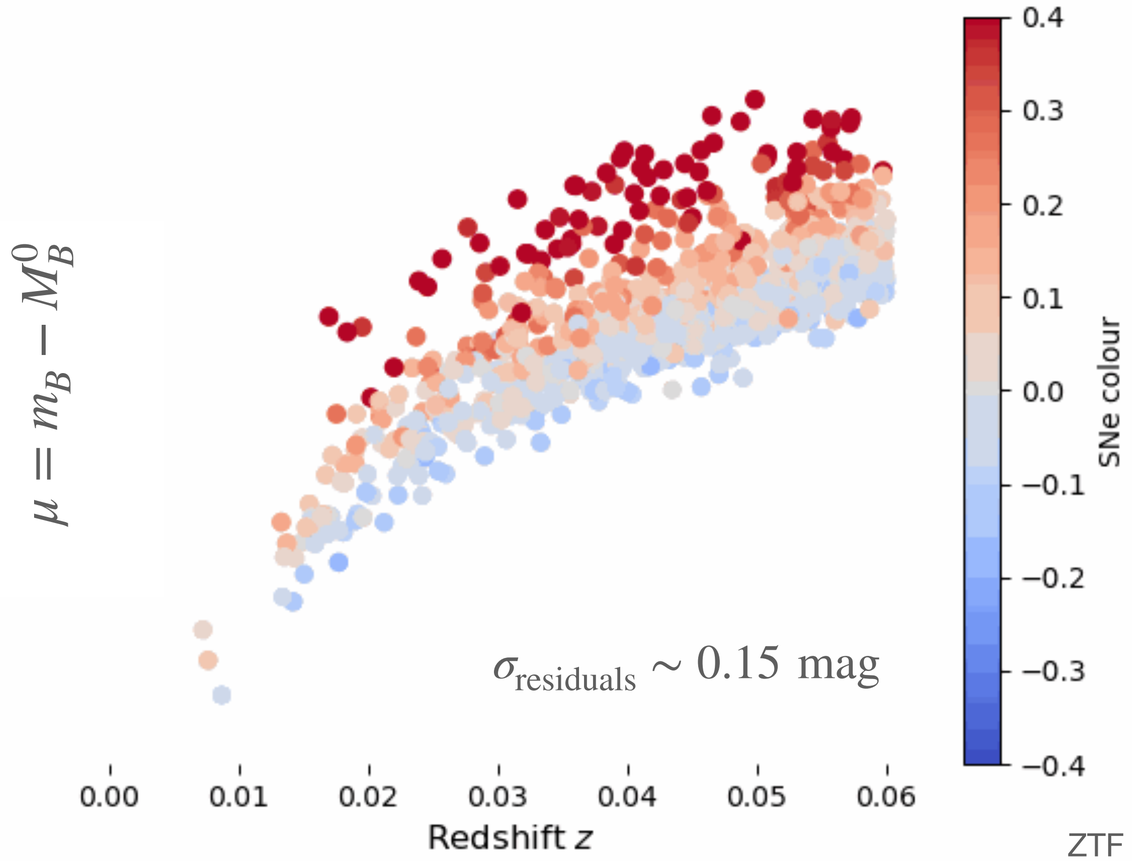
ZTF data

Type Ia Supernovae

Standardisation

$$\mu^0 + M_B^0 = m_B - \beta c + \alpha x_1 + p\gamma$$

Tripp 98



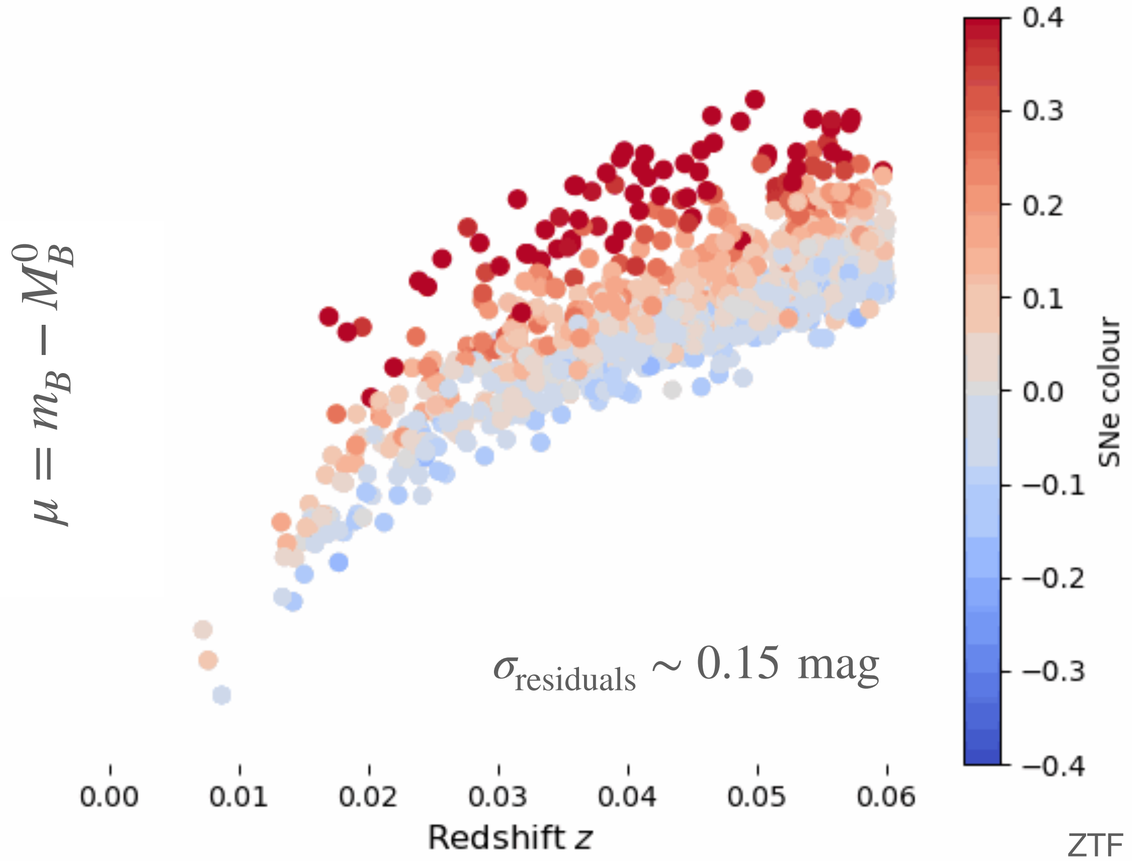
ZTF data

Type Ia Supernovae

Standardisation

$$\mu^0 + M_B^0 = m_B - \beta c + \alpha x_1 + p\gamma$$

Tripp 98

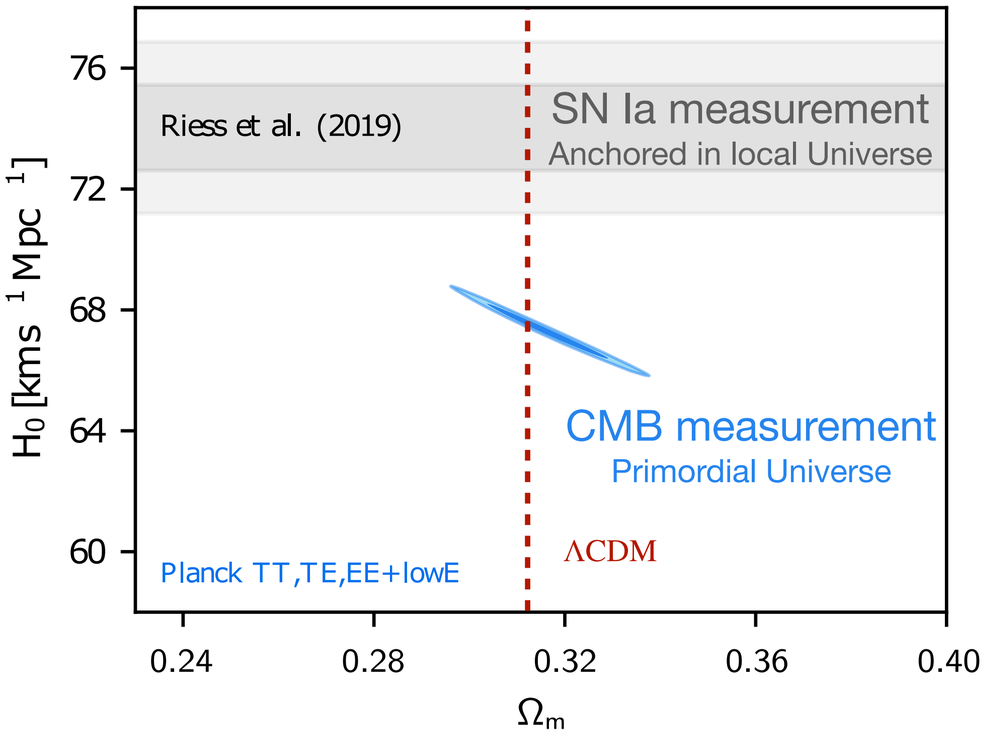


ZTF data

Cosmology

Current issues

Hubble tension

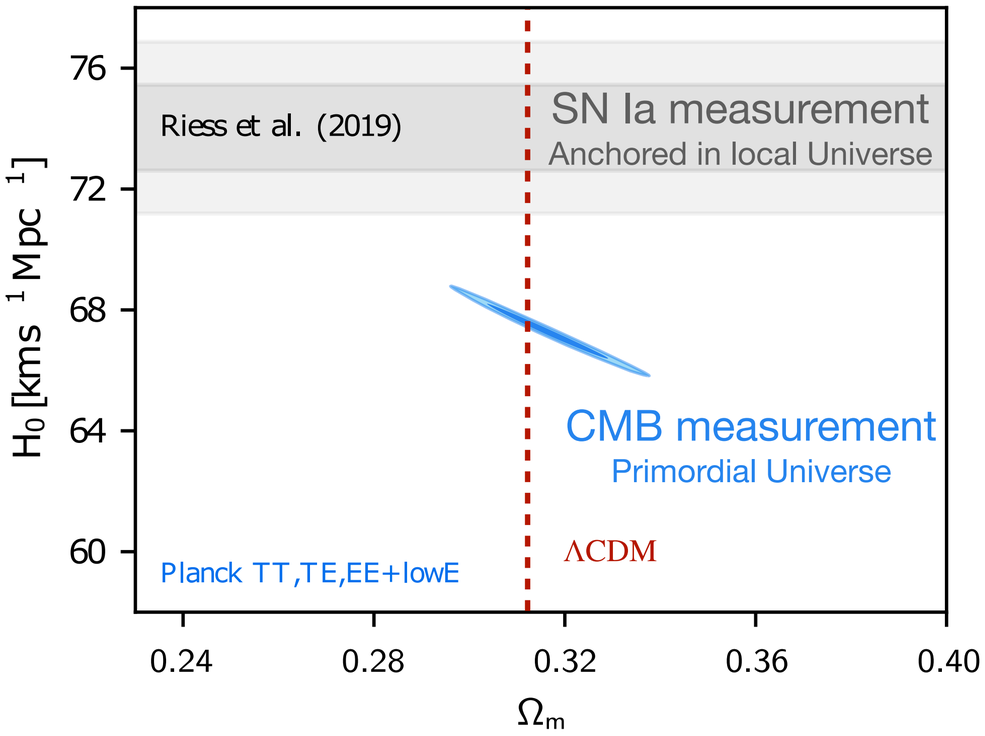


Planck Collaboration 2018

Cosmology

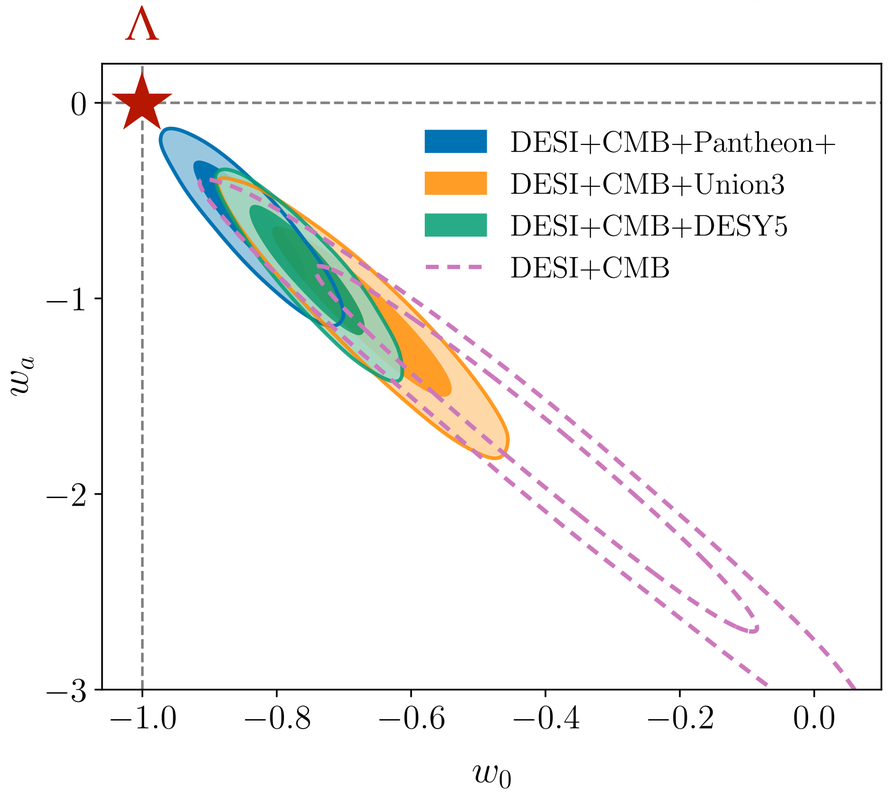
Current issues

Hubble tension



Planck Collaboration 2018

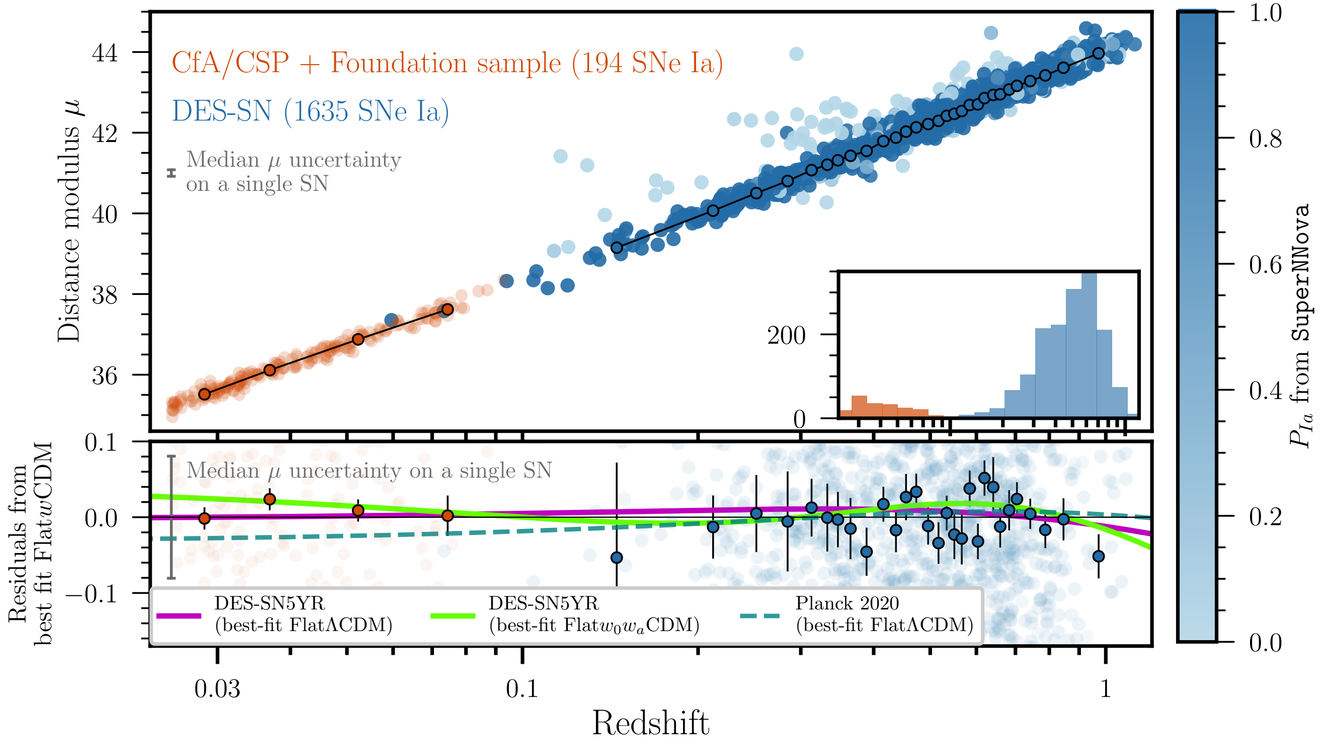
Evolving dark energy



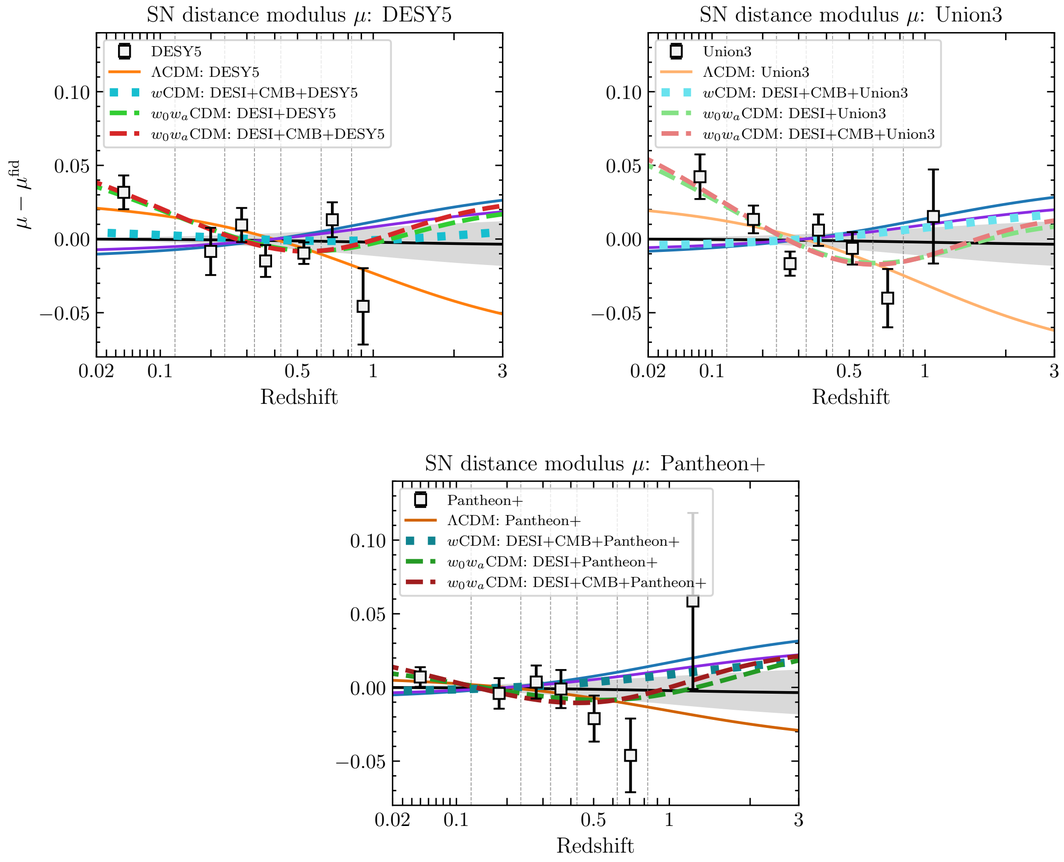
DESI DR2
DESI Collaboration 2025

Cosmology

Evolving dark energy



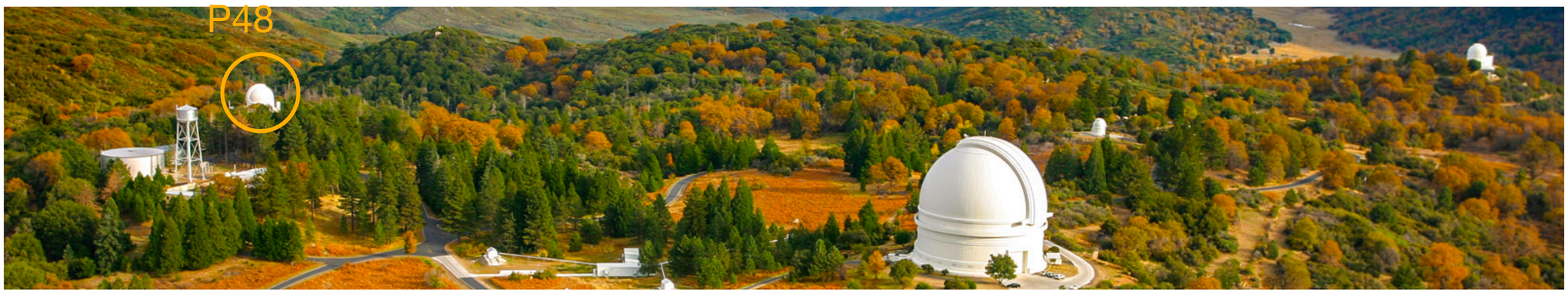
DES-SN5Y
DES Collaboration 2024



DESI DR2
DESI Collaboration 2025

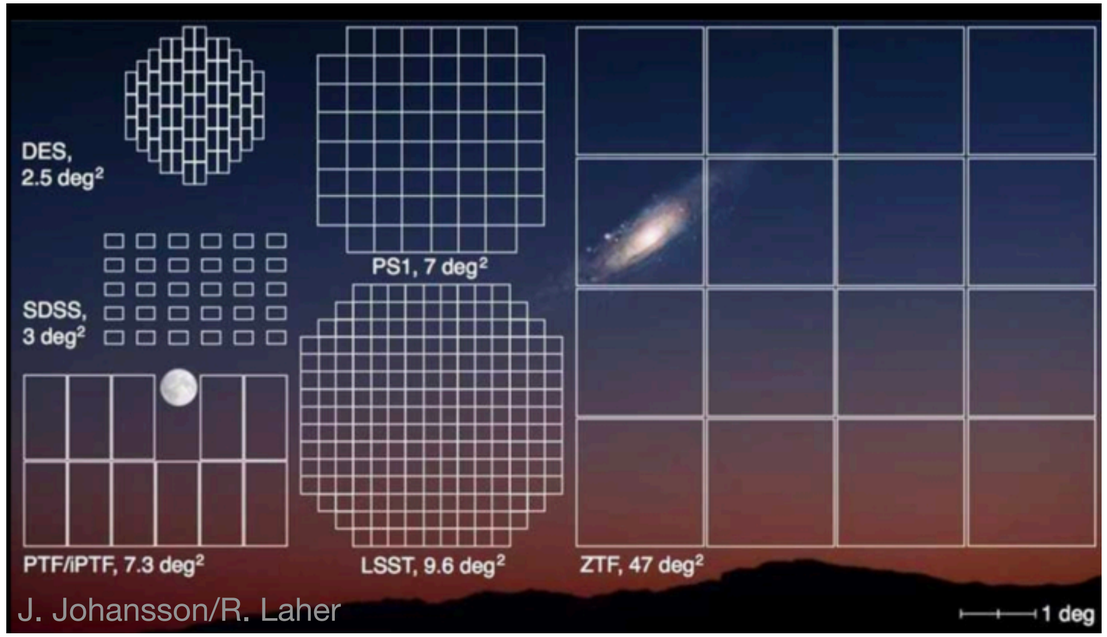
ZTF

ZTF



Zwicky Transient Facility

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

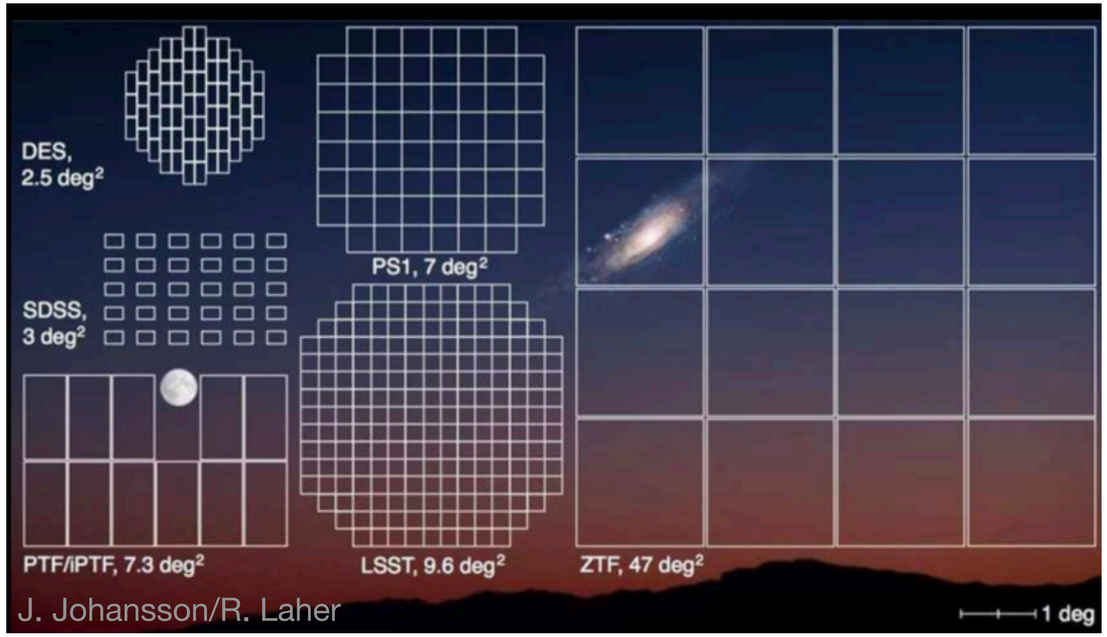


J. Johansson/R. Laher

ZTF

Zwicky Transient Facility

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



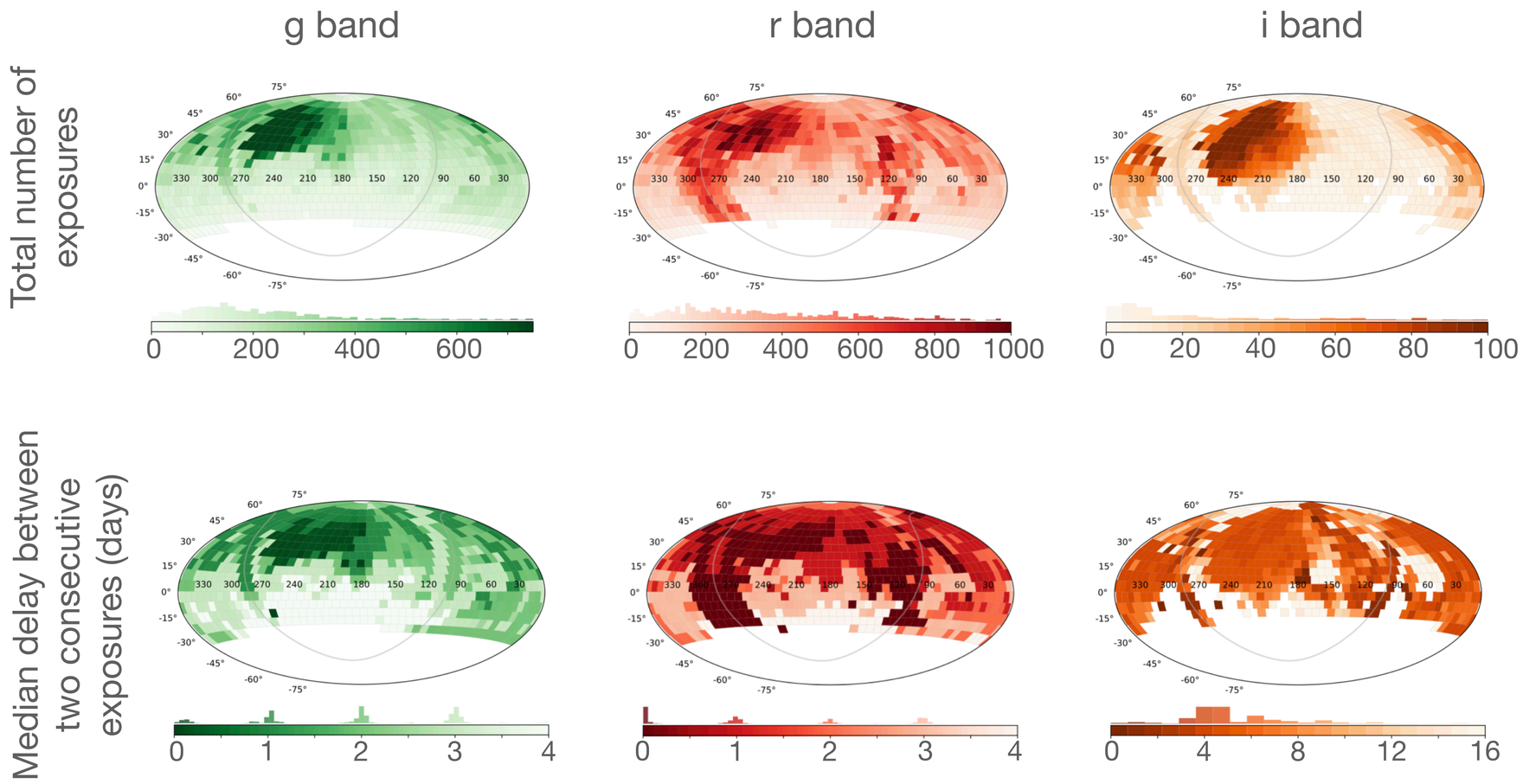
J. Johansson/R. Laher

SEDmachine

Low resolution
~ 30 min exposures
Depth of 19.5 mag in r

ZTF SN Ia DR2 - Data

Cadence



Rigault+25a: ZTF SN Ia DR2 overview

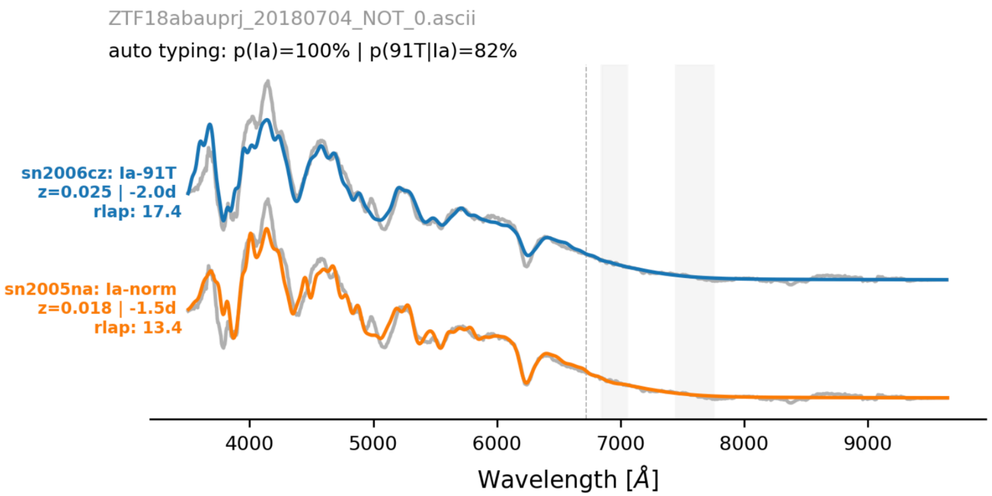
ZTF SN Ia DR2 - Data

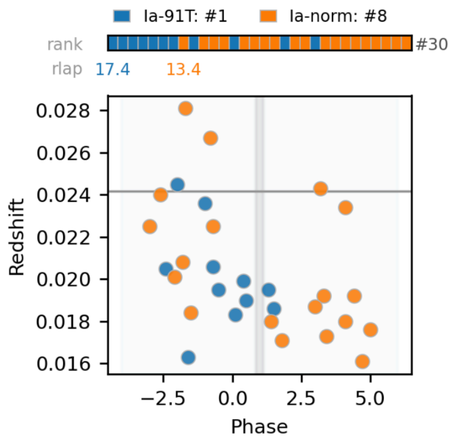
Spectroscopic typing

SNID
Blondin & Tonry 07

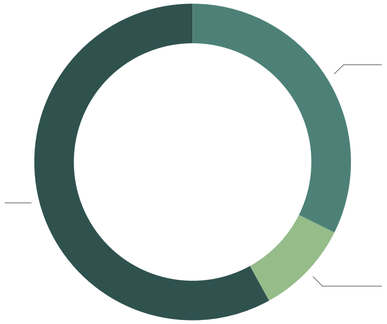
2.5 years of data

3,628 SNe
Confirmed SNe Ia





Redshift origin

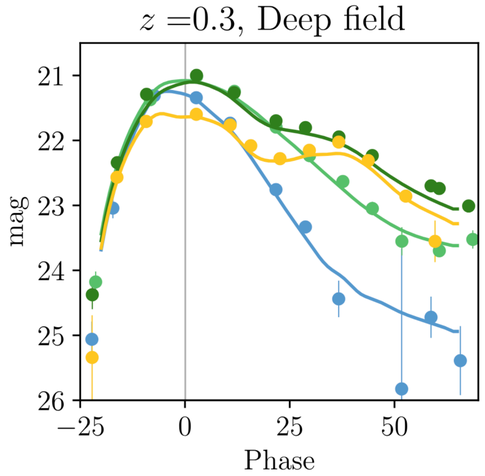


- SN features
- Host features
- Galaxy spectra

Rigault+25a: ZTF SN Ia DR2 overview

ZTF SN Ia DR2 - Data

Light curves

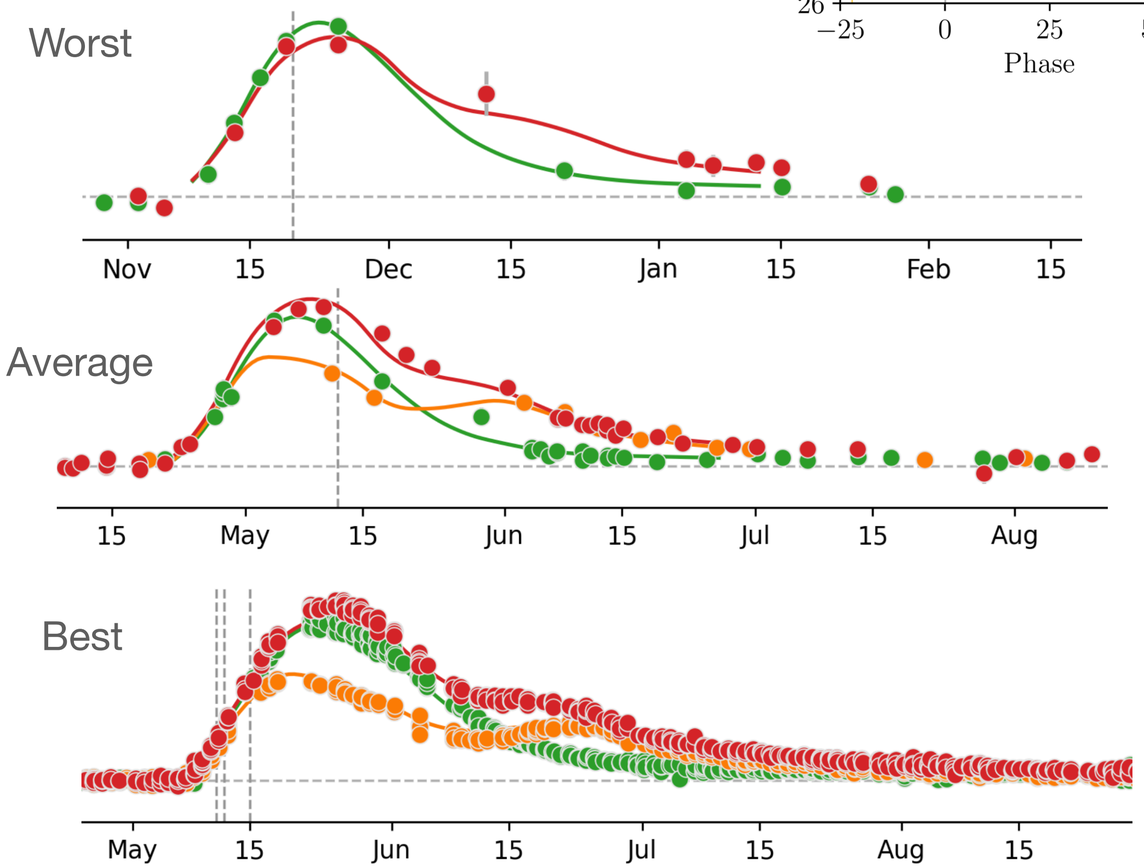


DES-SN5Y
Sanchez+2024

2.5 years of data

3,628 SNe
Confirmed SNe Ia

2,960 SNe
with well-sampled lightcurves



Rigault+25a: ZTF SN Ia DR2 overview

ZTF SN Ia DR2 - Data

Cosmo sample

2.5 years of data

3,628 SNe

Confirmed SNe Ia

2,960 SNe

with well-sampled lightcurves

2,629 SNe

usable for cosmology

Rigault+25a: ZTF SN Ia DR2 overview

Table 1. ZTF cosmology science working group DR2 sample statistics.

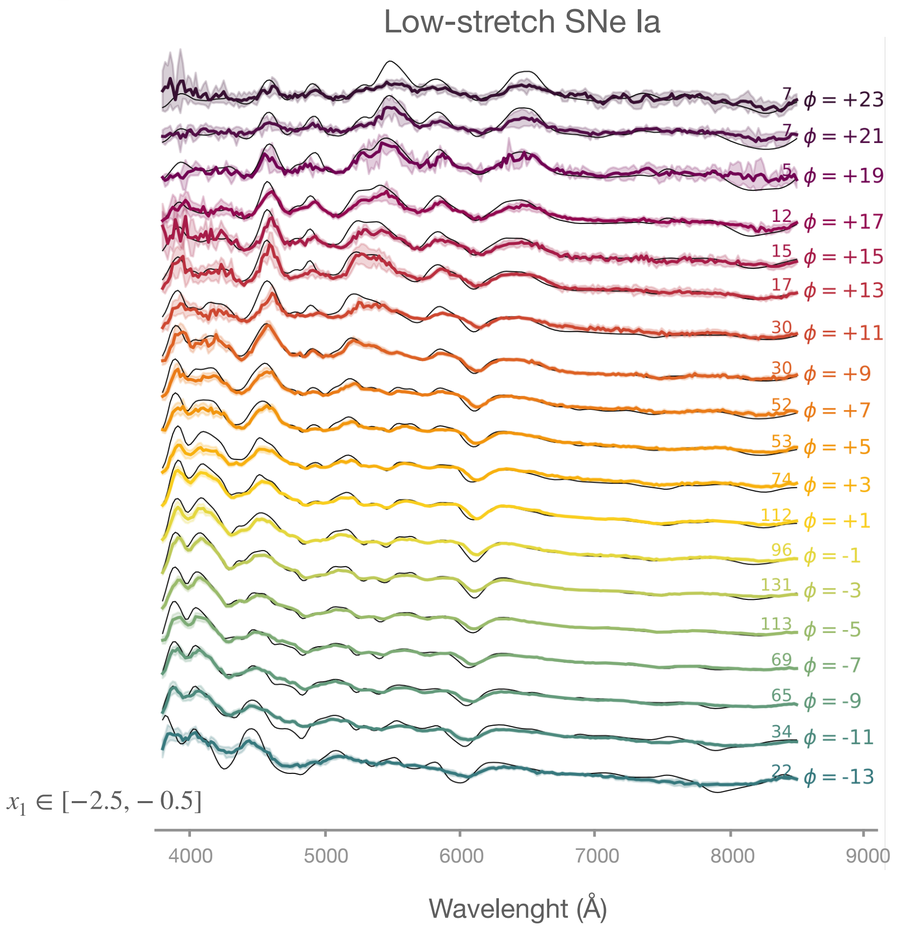
Cuts	n targets	Removed	% Removed
Master list	3795	–	–
+ ZTF light curve	3778	17	0.4
+ a spectrum	3668	110	2.9
+ confirmed "Ia"	**3628**	40	1.1
Basic cuts			
Good light curve sampling	2960	668	18.4
$x_1 \in [-3, +3]$	2899	61	2.1
$c \in [-0.2, 0.8]$	2861	38	1.4
$\sigma_{t_0} \leq 1$	2836	25	0.9
$\sigma_{x_1} \leq 1$	2822	14	0.5
$\sigma_c \leq 0.1$	2809	13	0.4
"fitprob"$\geq 10^{-7}$	**2667**	142	5.1
Subsample examples			
Volume limited ($z \leq 0.06$)	994	1673	62.7
Non-peculiar SNe Ia	2629	38	1.4

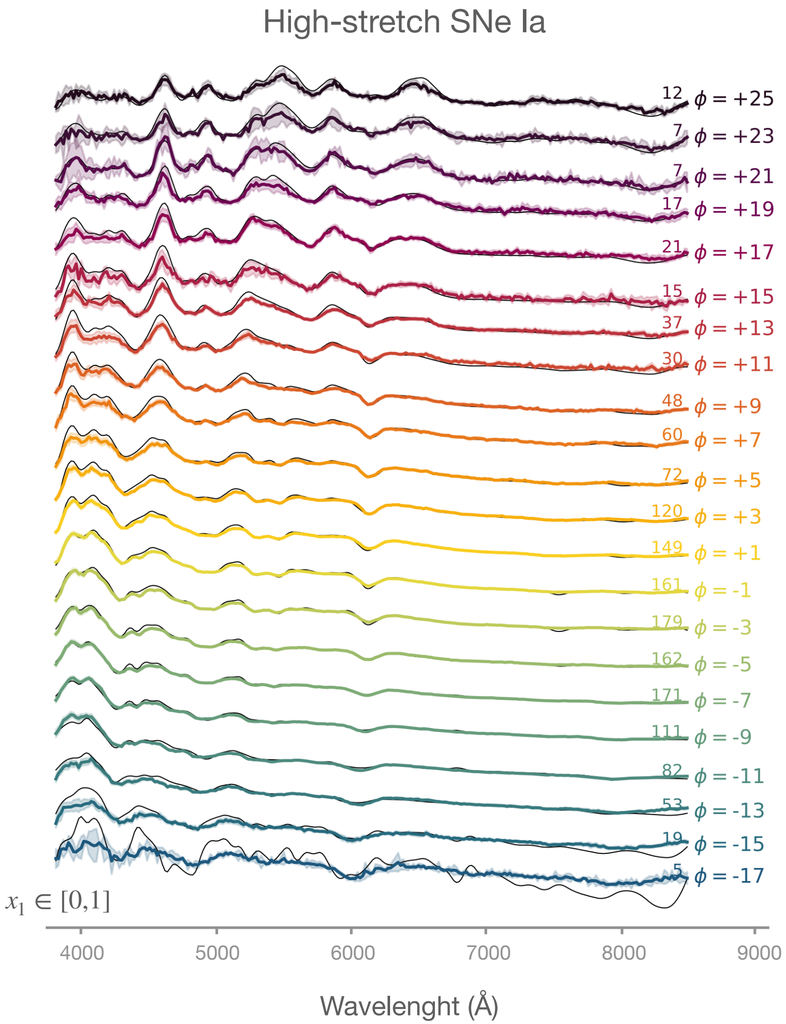
Data available at ztfcosmo.in2p3.fr

ZTF SN Ia DR2 - Data

$\mathcal{O}(5000)$ spectra

Spectra

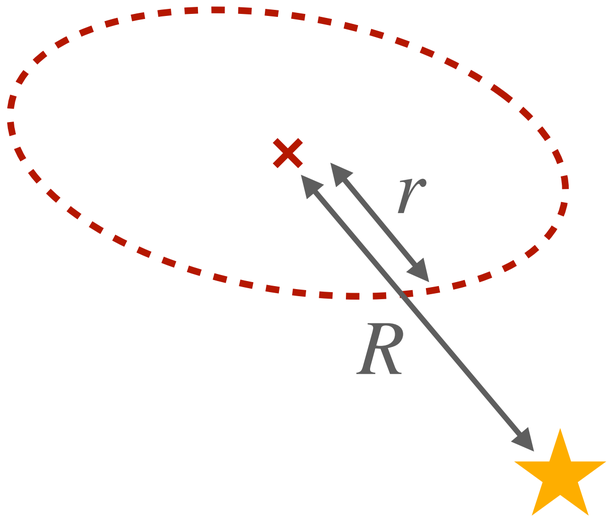




Johansson+ (in prep)

ZTF SN Ia DR2 - Data

Host association

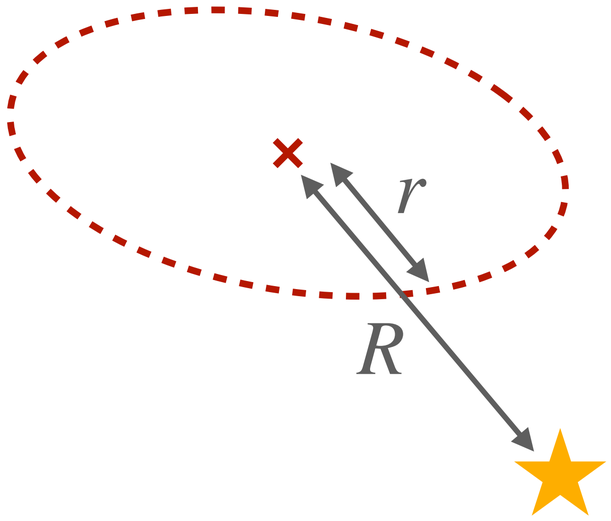


$$d_{\mathrm{DLR}} = \frac{R}{r}$$

Sullivan+06
Gupta+16

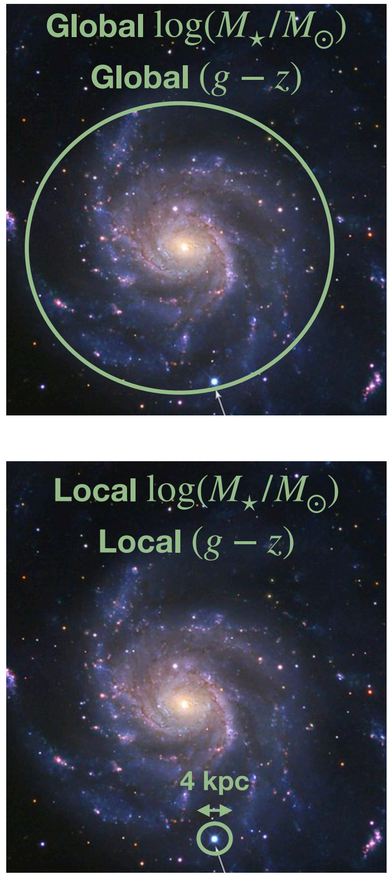
ZTF SN Ia DR2 - Data

Host association



$$d_{\mathrm{DLR}} = \frac{R}{r}$$

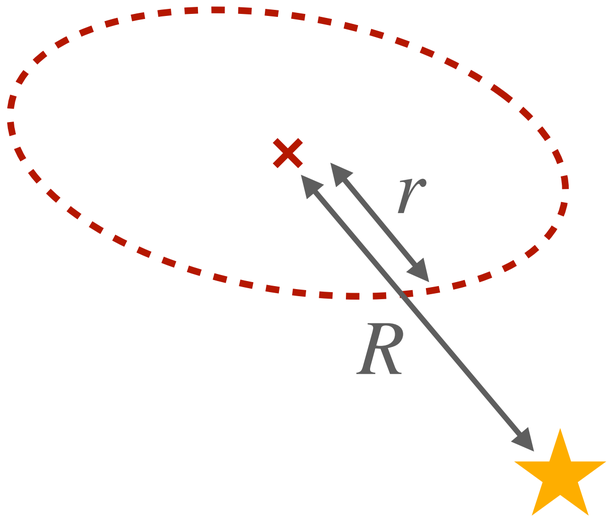
Sullivan+06
Gupta+16



B.J. Fulton/LCOGT/Caltech

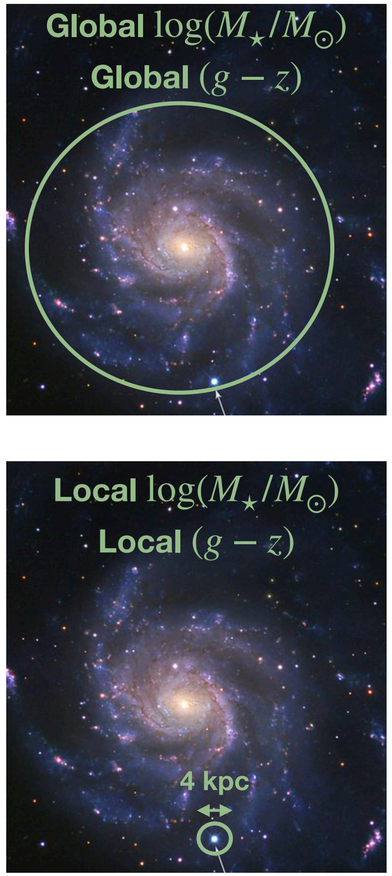
ZTF SN Ia DR2 - Data

Host association

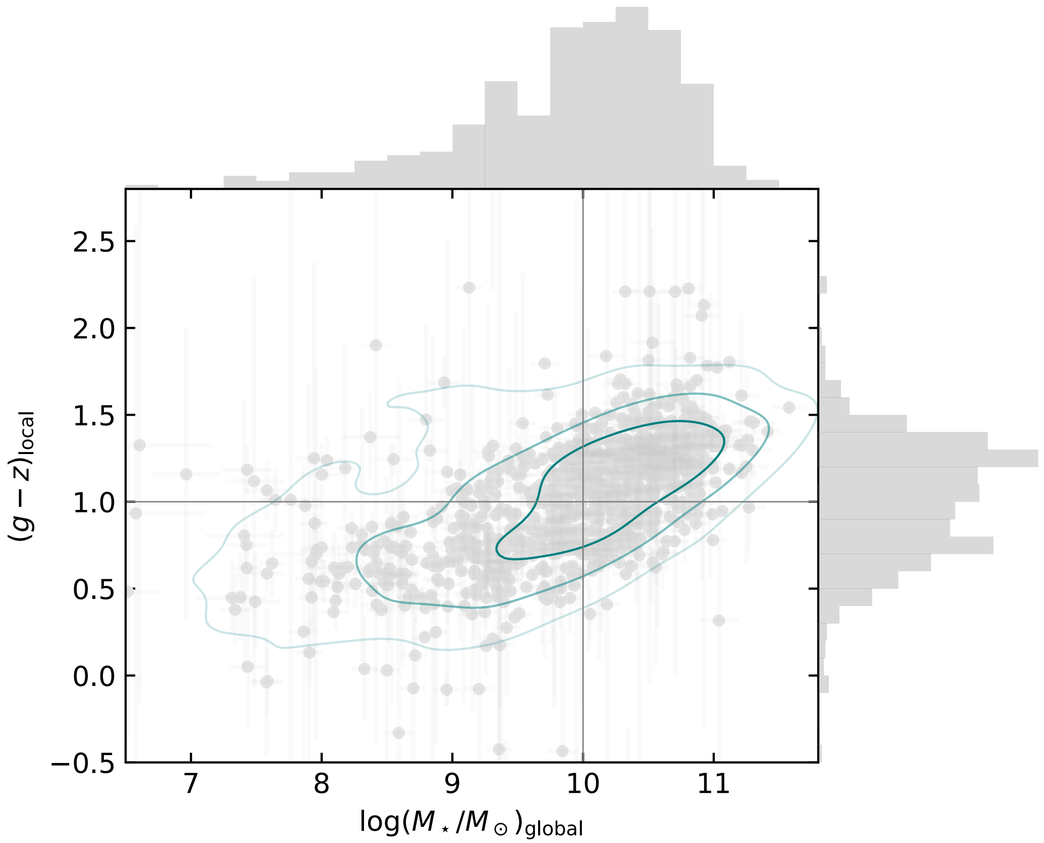


$$d_{\mathrm{DLR}} = \frac{R}{r}$$

Sullivan+06
Gupta+16



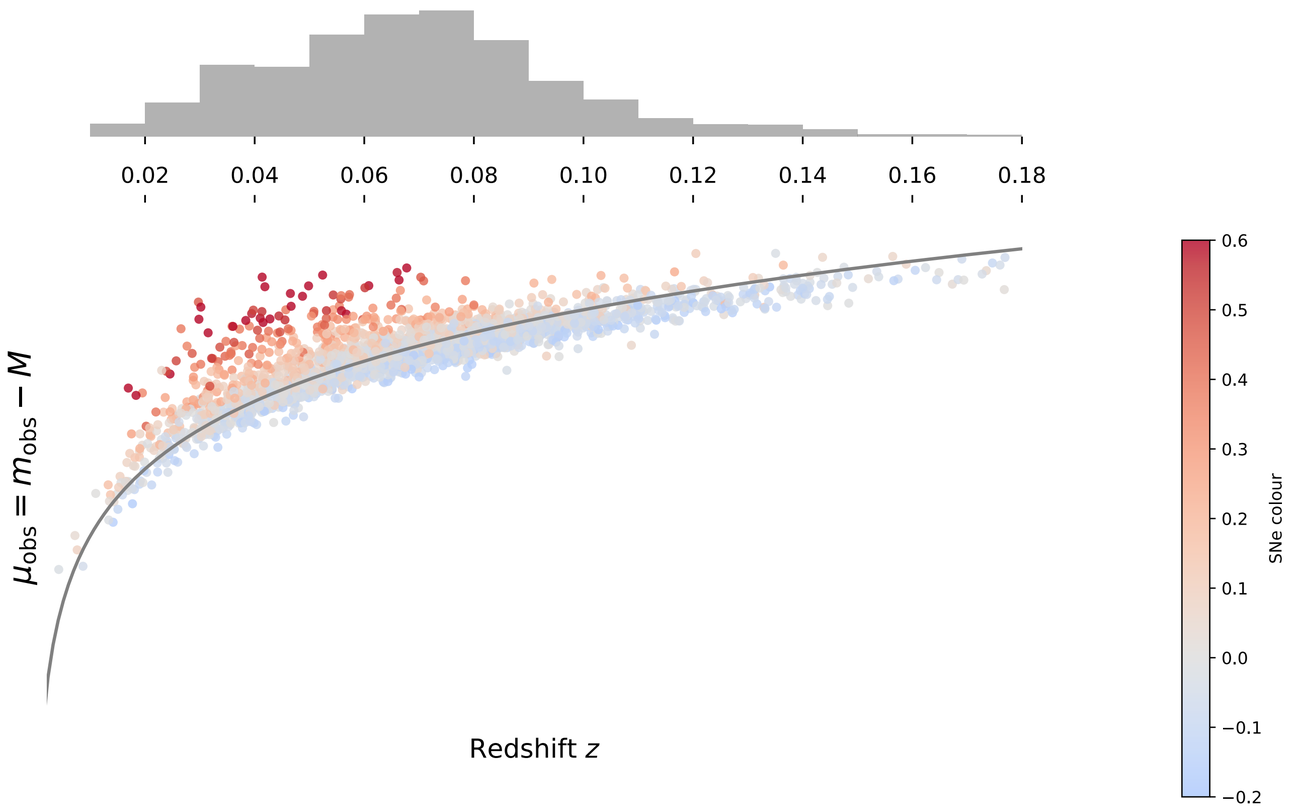
B.J. Fulton/LCOGT/Caltech



Ginolin+25b

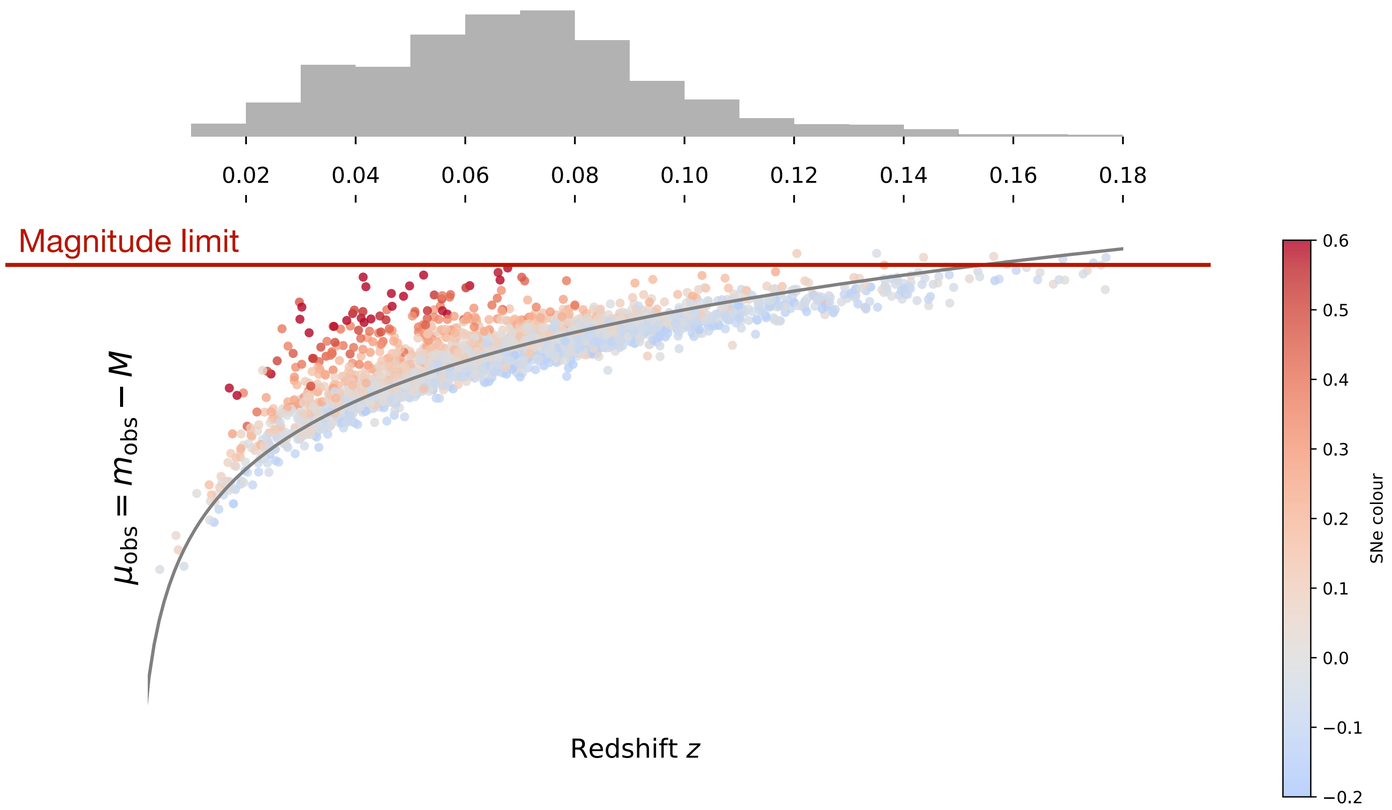
ZTF SN Ia DR2 - Data

Volume limited sample



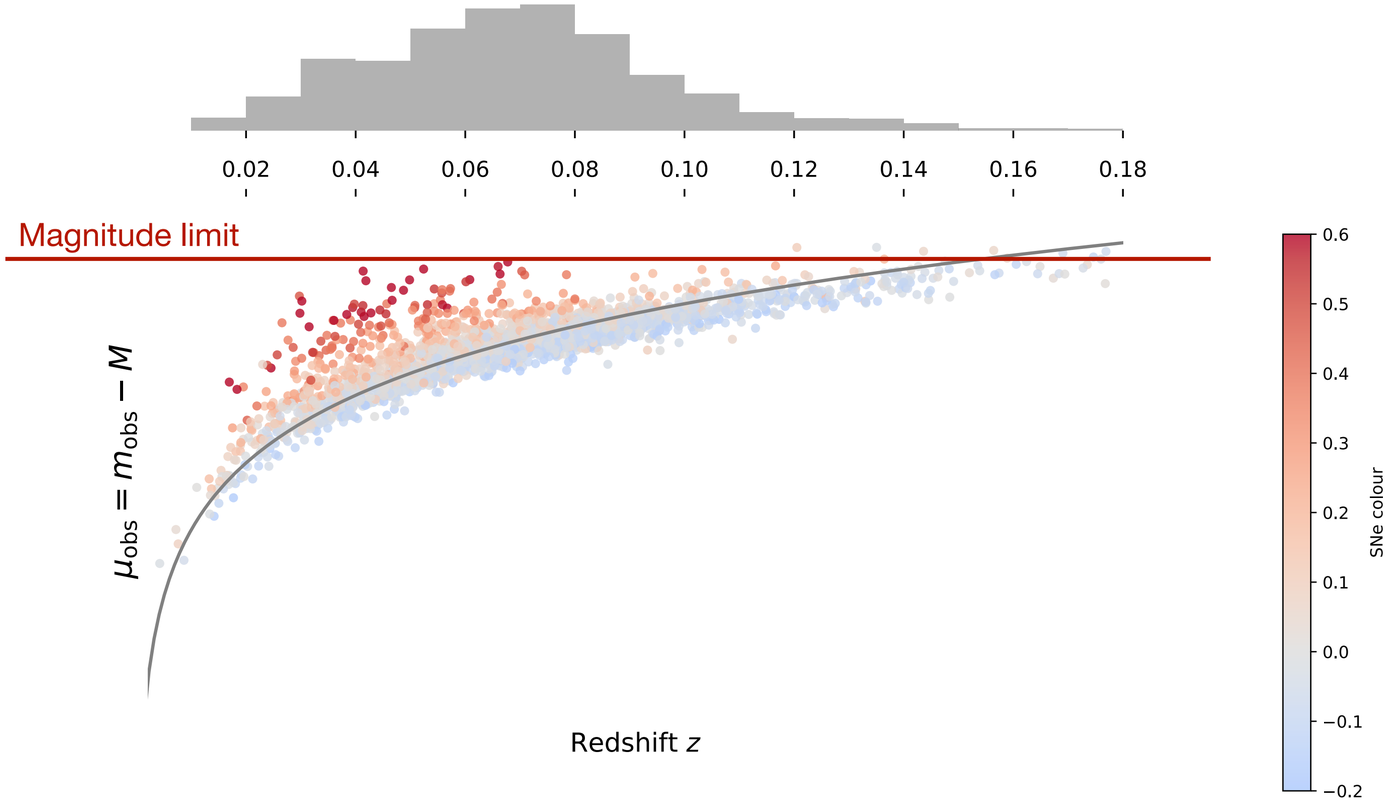
ZTF SN Ia DR2 - Data

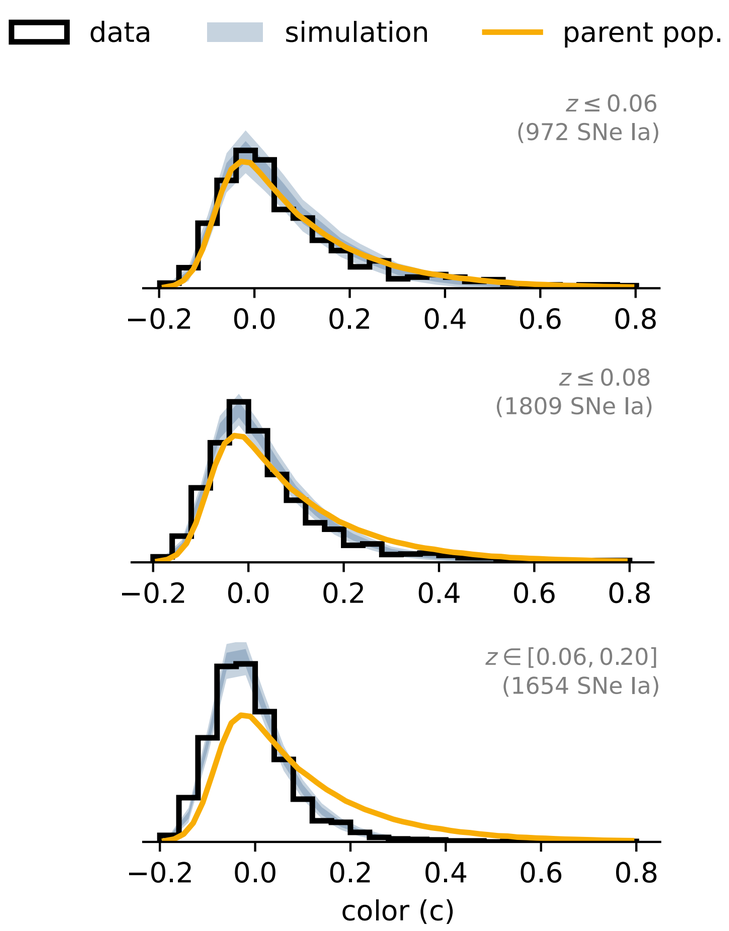
Volume limited sample



ZTF SN Ia DR2 - Data

Volume limited sample

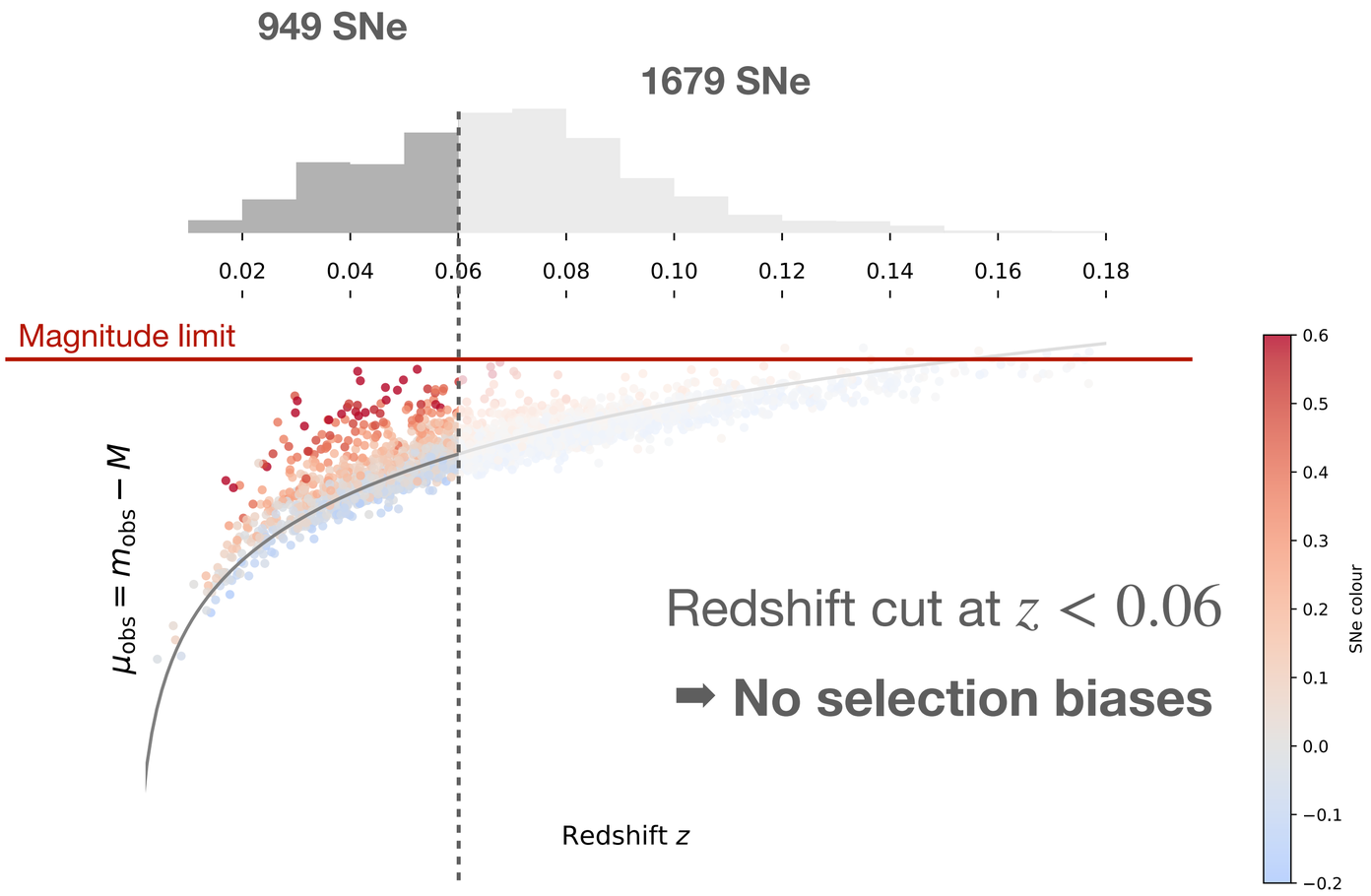




Rigault+25a: ZTF SN Ia DR2 overview
Amenouche+25

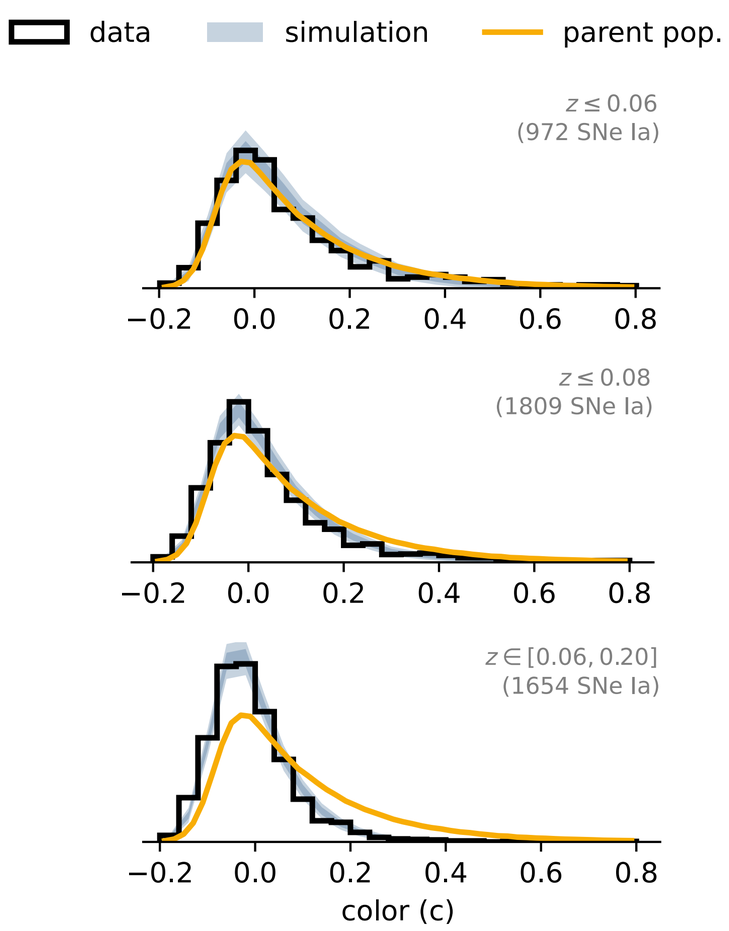
ZTF SN Ia DR2 - Data

Volume limited sample



Redshift cut at $z < 0.06$

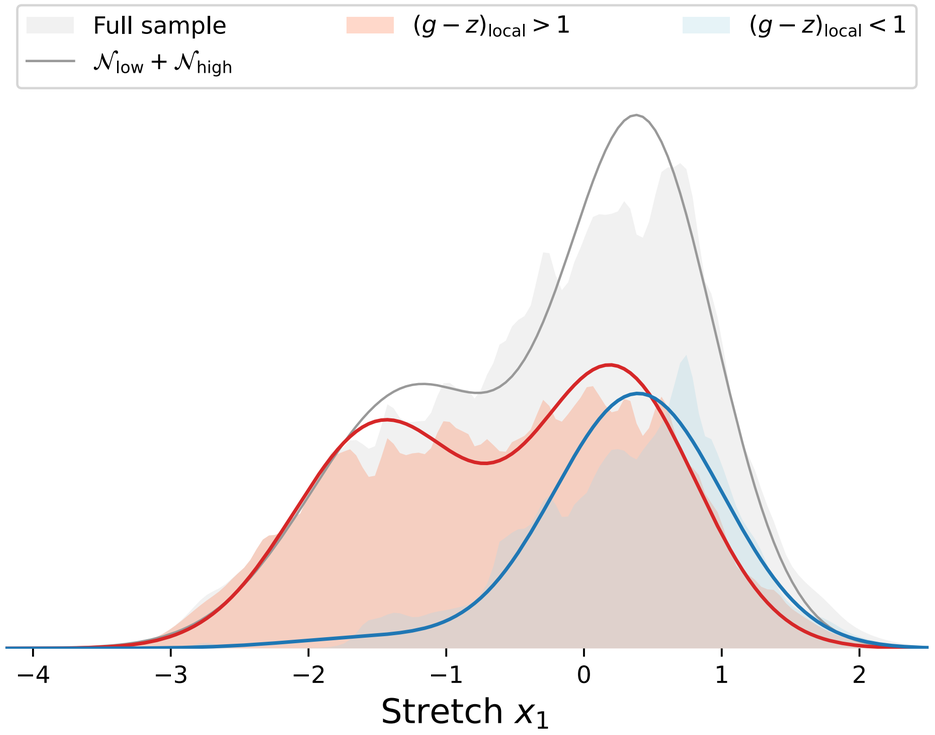
➡ **No selection biases**



Rigault+25a: ZTF SN Ia DR2 overview
Amenouche+25

ZTF SN Ia DR2 - Results

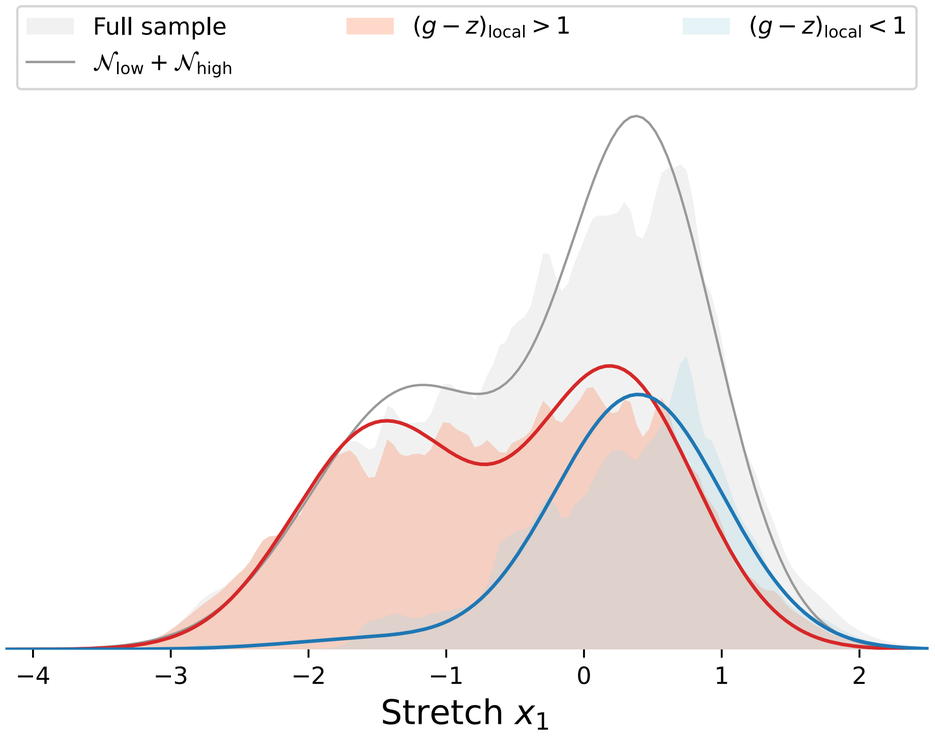
Stretch distribution



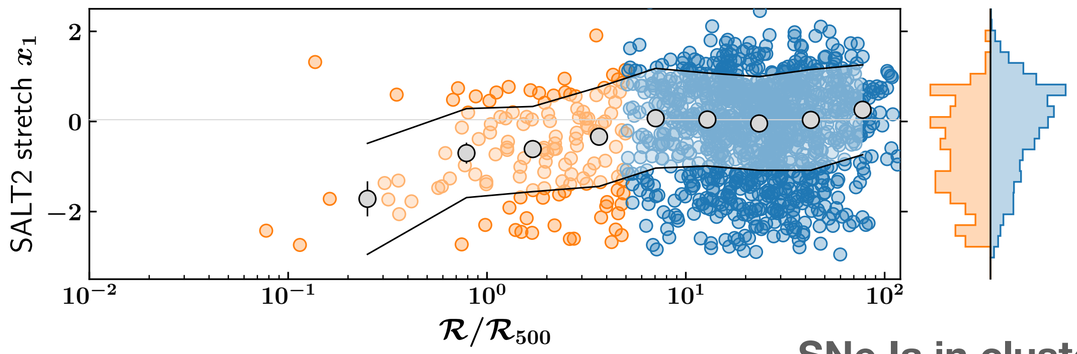
Ginolin+25b

ZTF SN Ia DR2 - Results

Stretch distribution

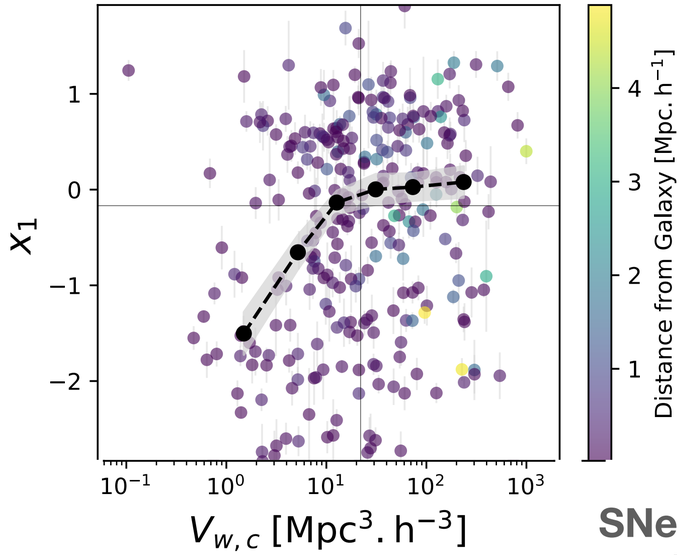


Ginolin+25b



SNe Ia in clusters

Ruppin+25

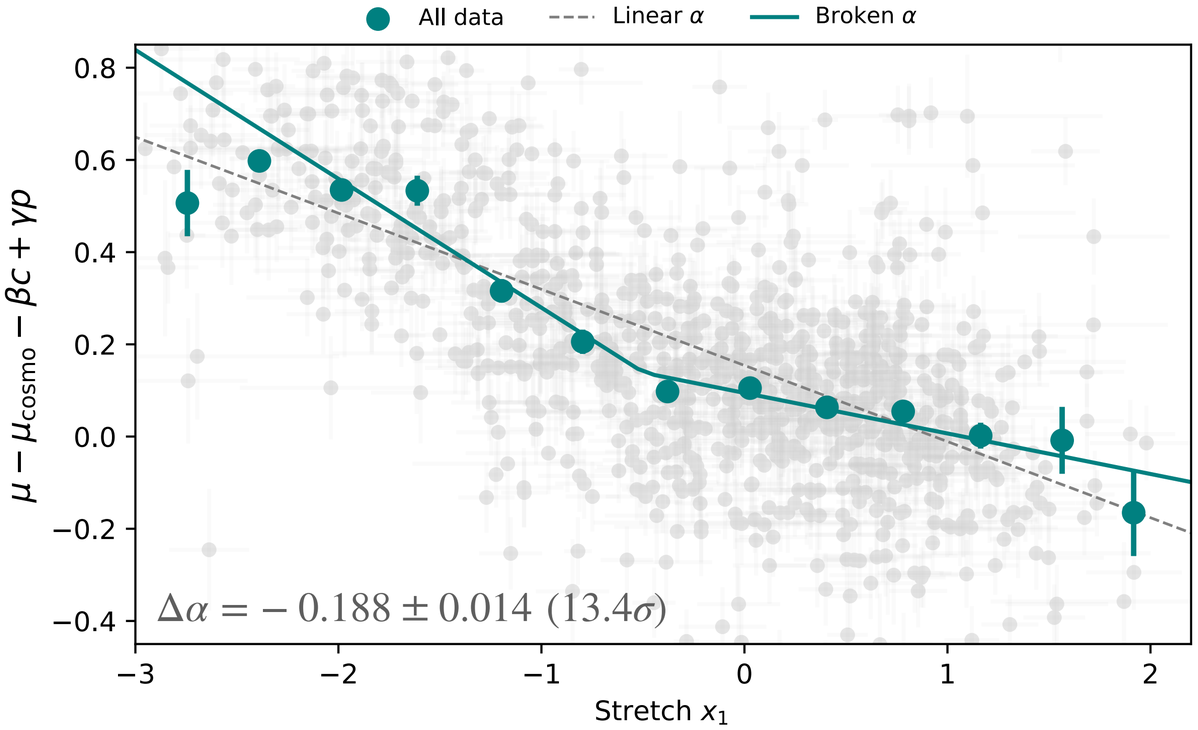


SNe Ia in voids

Aubert+25

ZTF SN Ia DR2 - Results

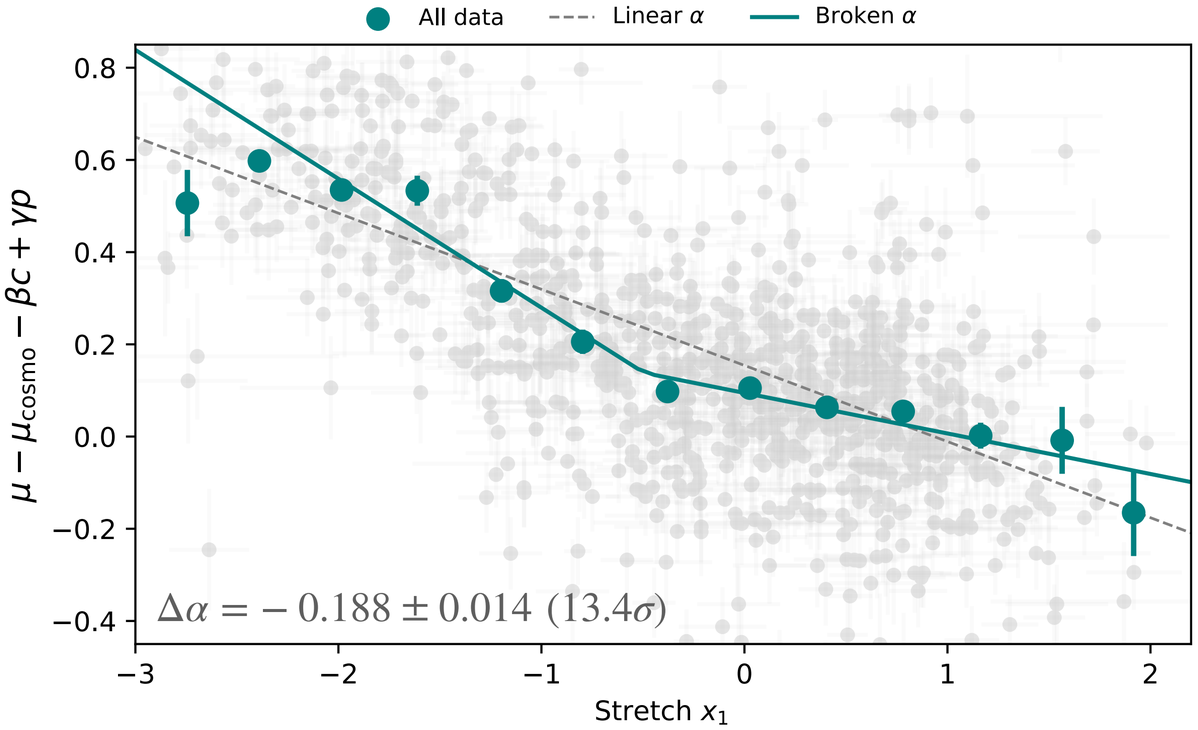
Stretch standardisation



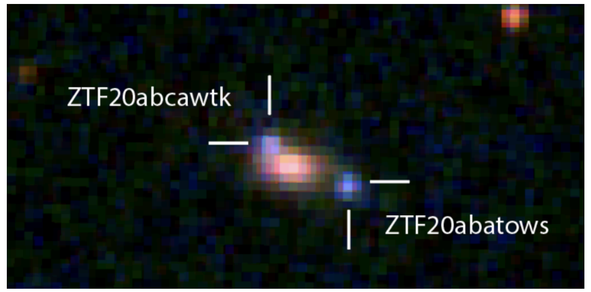
Ginolin+25b

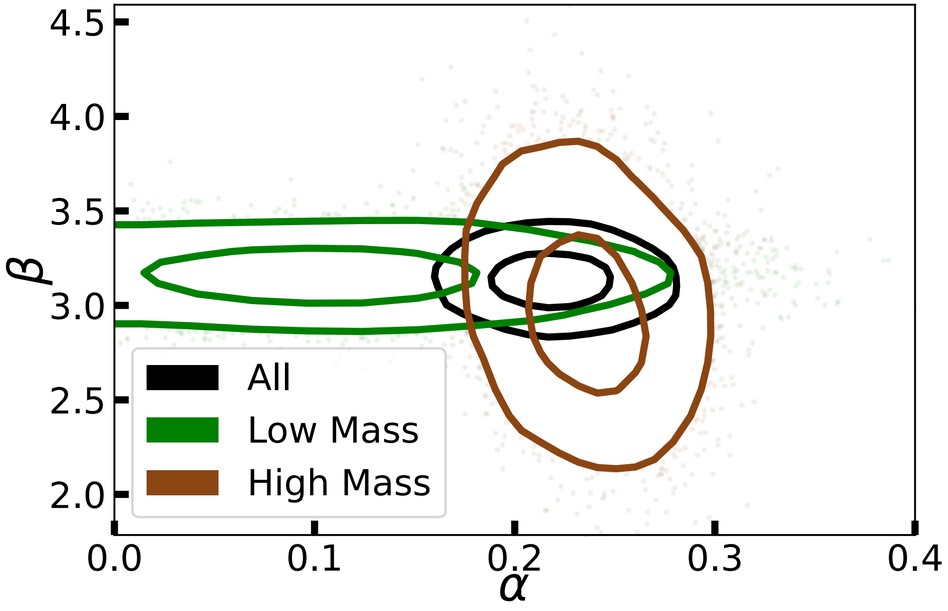
ZTF SN Ia DR2 - Results

Stretch standardisation



Ginolin+25b



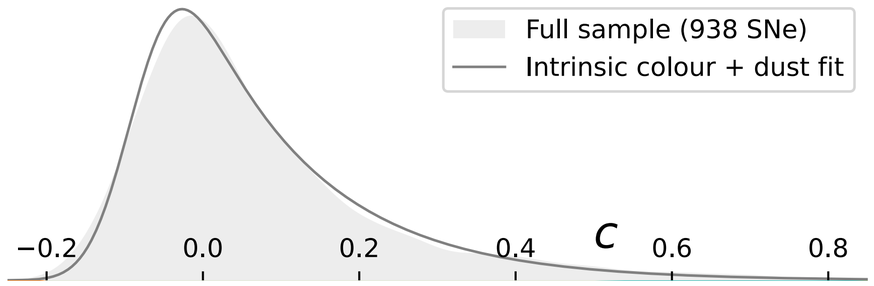


SNe Ia siblings

Dhawan+24a

ZTF SN Ia DR2 - Results

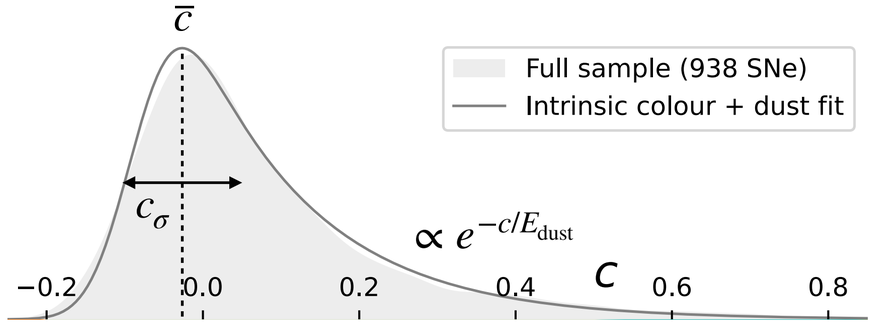
Colour distribution



Ginolin+25a

ZTF SN Ia DR2 - Results

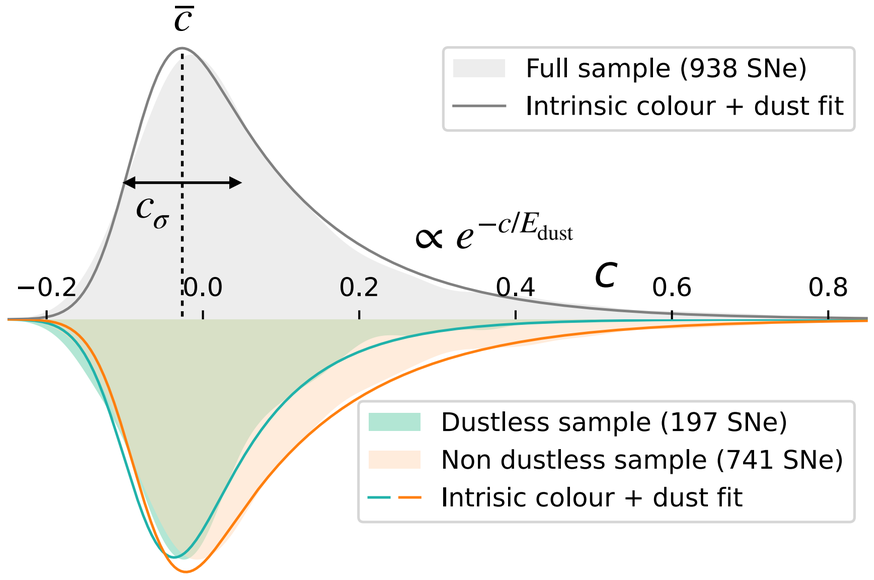
Colour distribution



Ginolin+25a

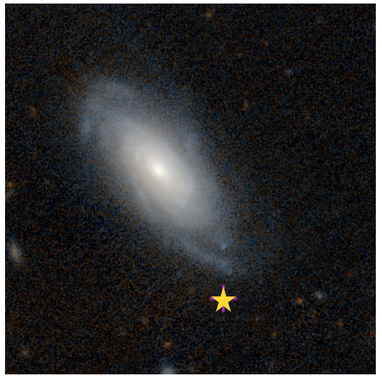
ZTF SN Ia DR2 - Results

Colour distribution



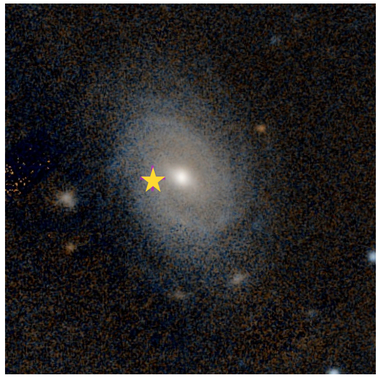
Ginolin+25a

« Dustless » example



ZTF18aahfzea

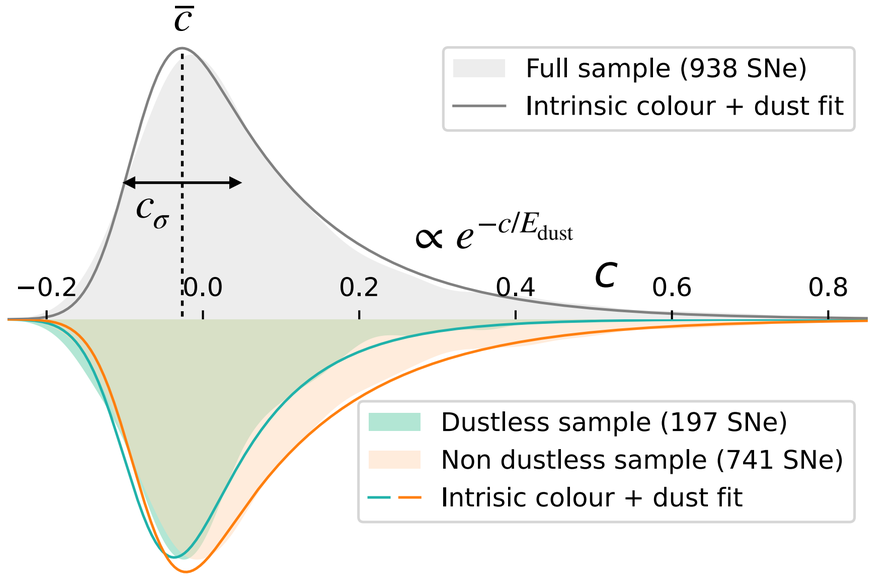
« Non dustless » example



ZTF18aaqfziz

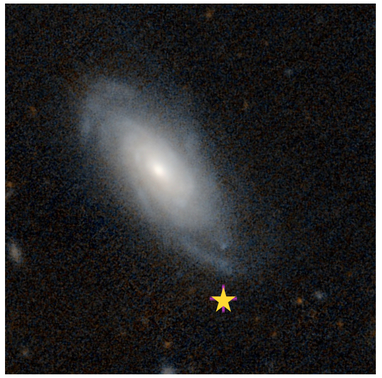
ZTF SN Ia DR2 - Results

Colour distribution



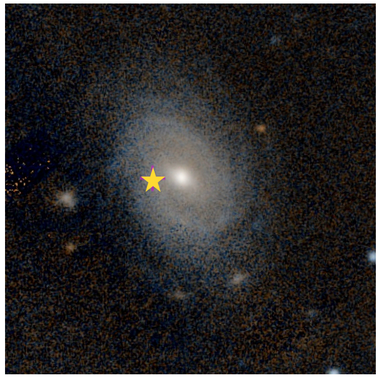
Ginolin+25a

« Dustless » example

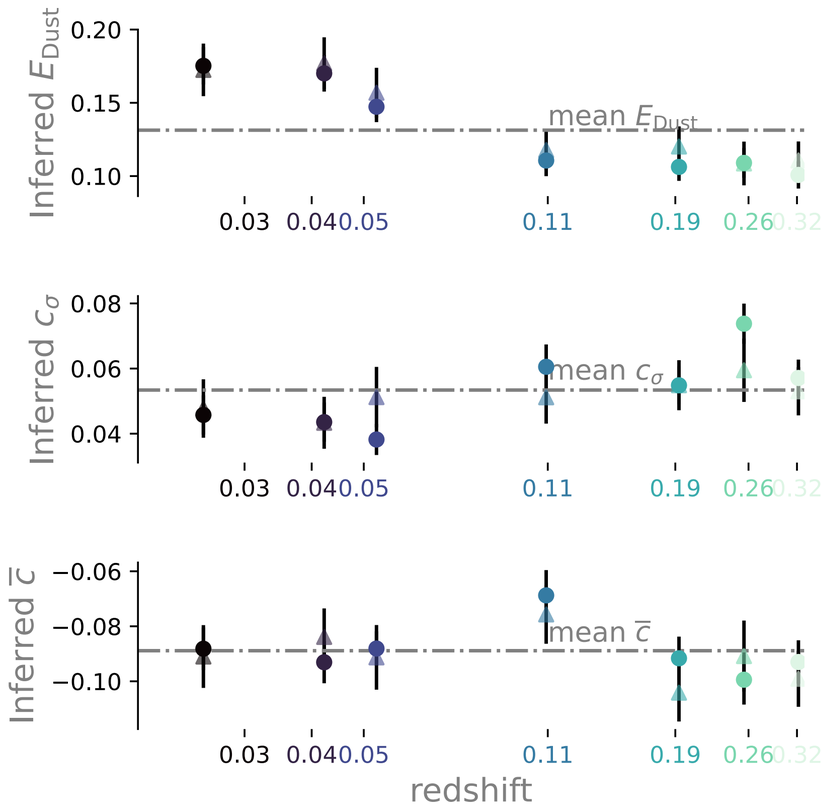


ZTF18aahfzea

« Non dustless » example



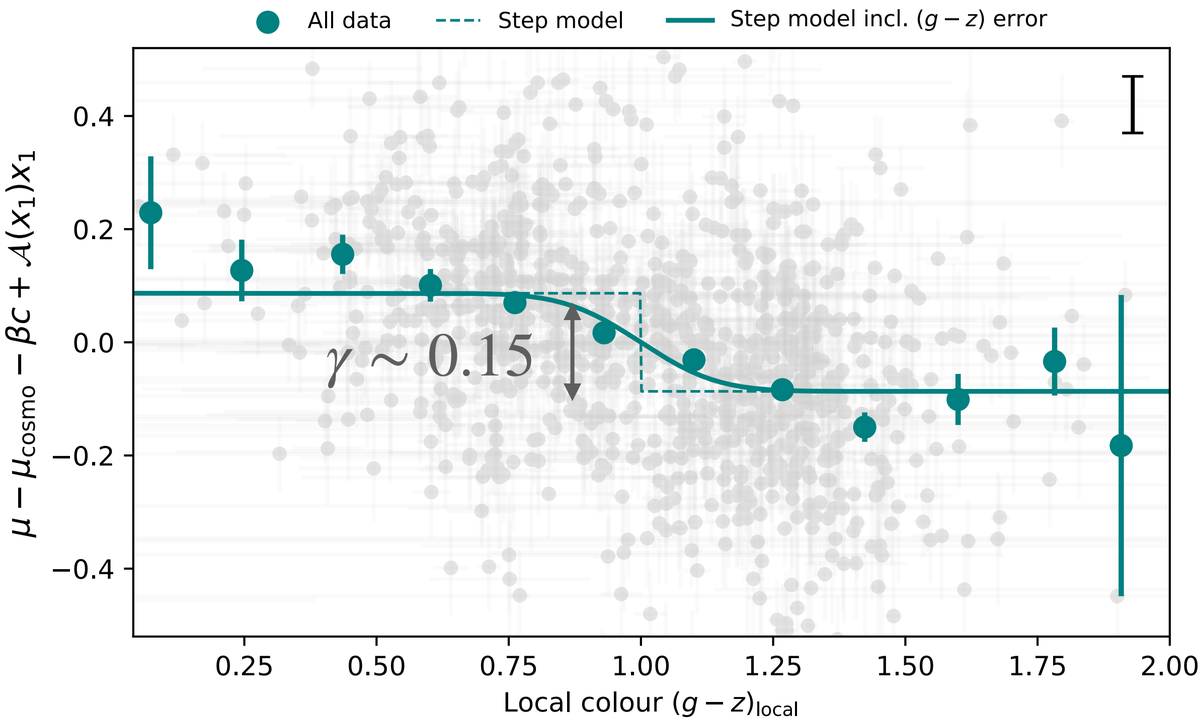
ZTF18aaqfziz



Popovic+25a

ZTF SN Ia DR2 - Results

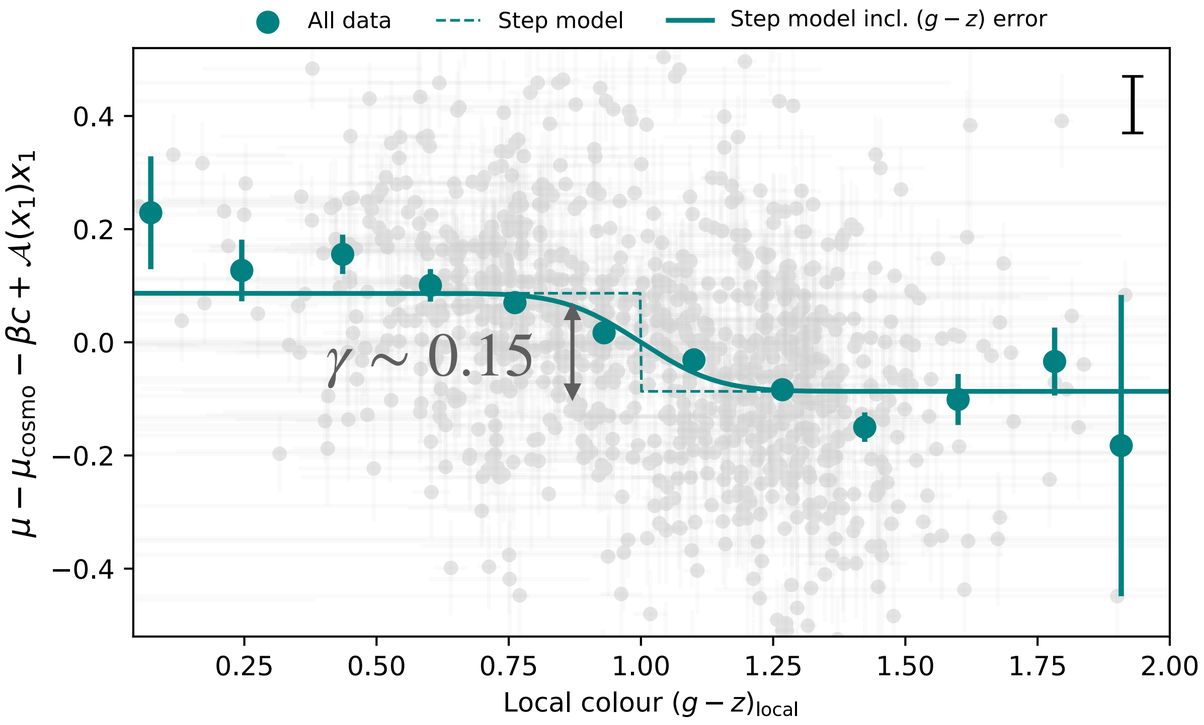
Environmental step



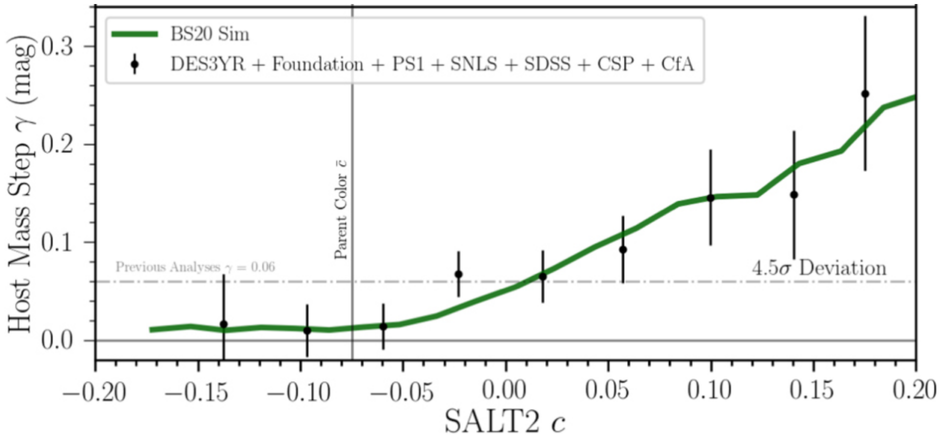
Ginolin+25a

ZTF SN Ia DR2 - Results

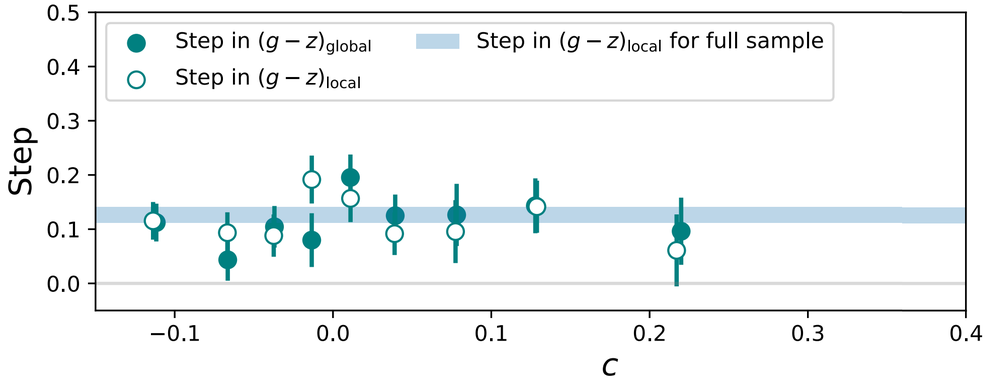
Environmental step



Ginolin+25a



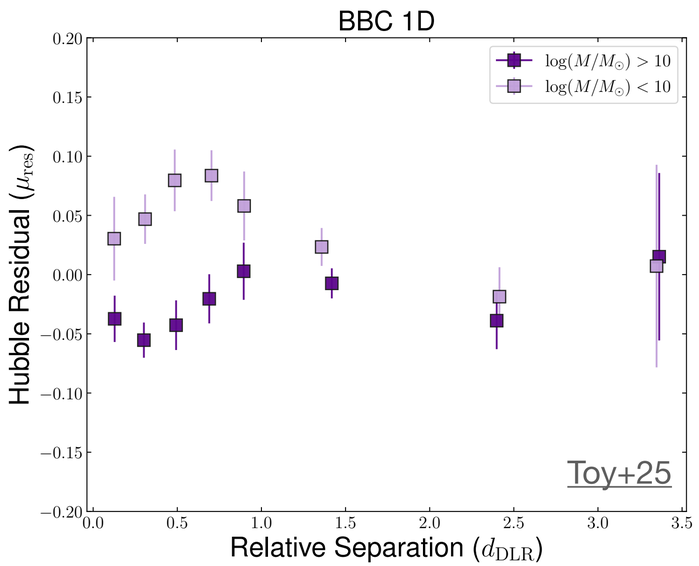
Brout + Scolnic 21

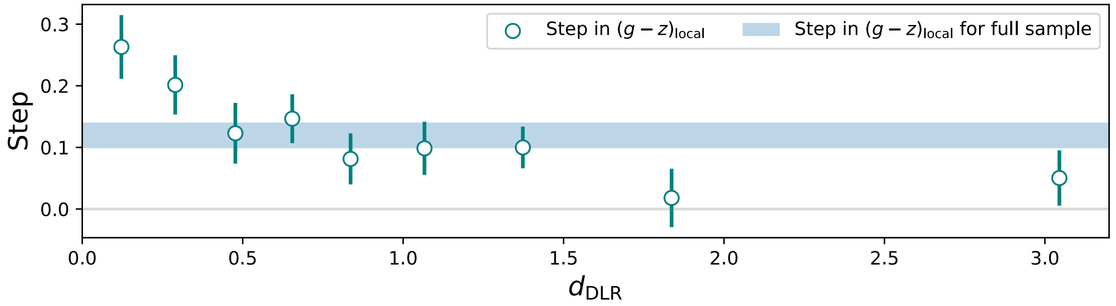


Ginolin+25b

ZTF SN Ia DR2 - Results

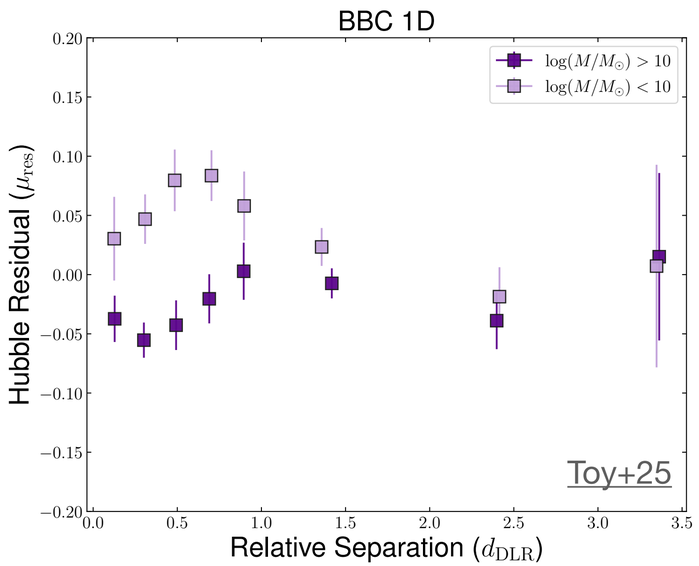
Environmental step

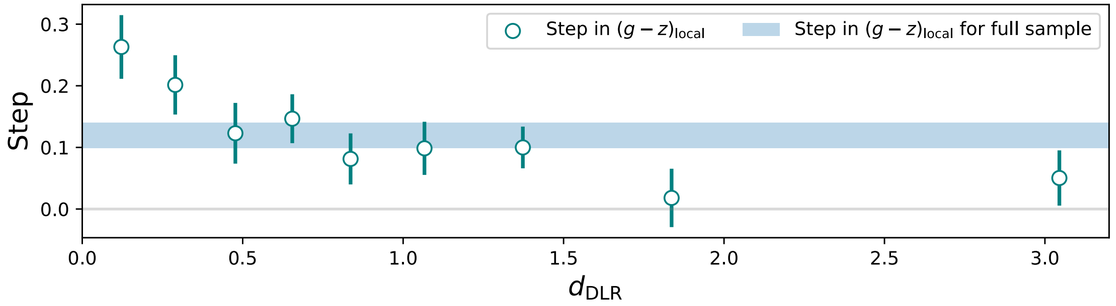


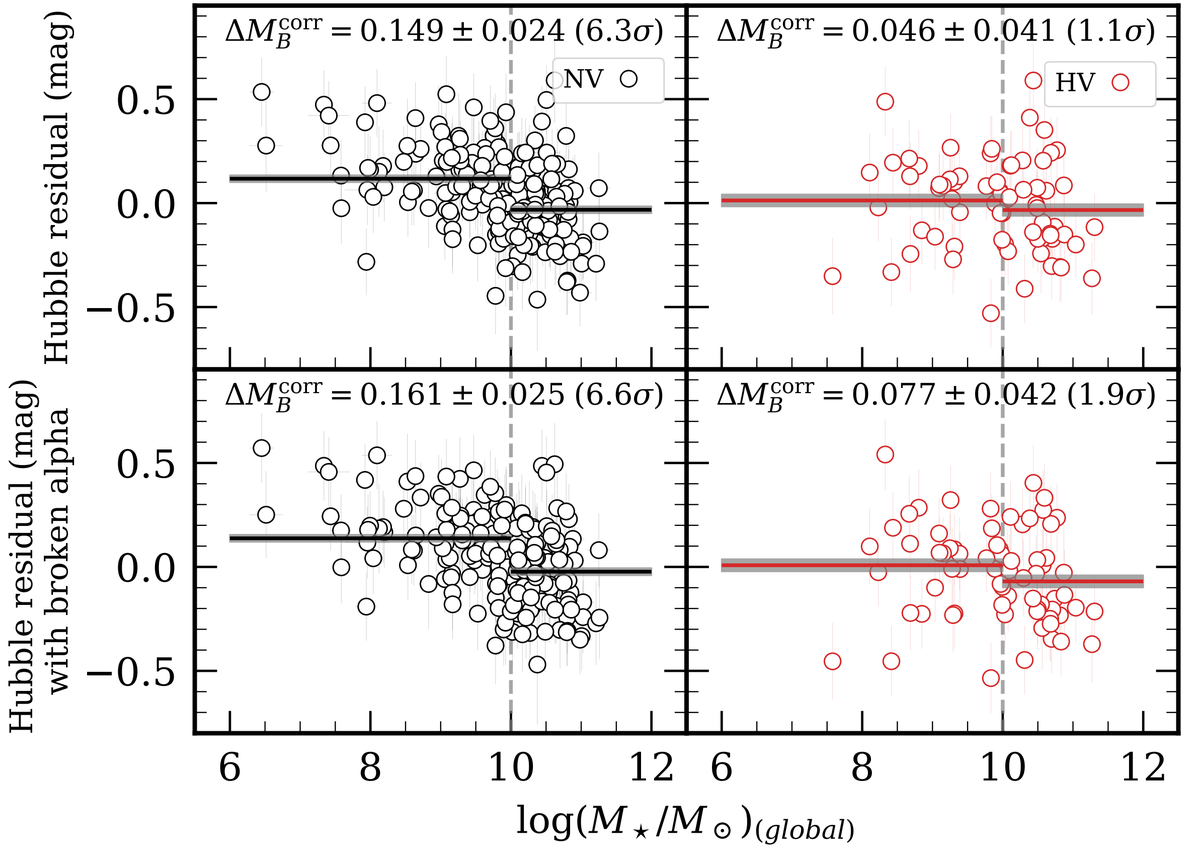


ZTF SN Ia DR2 - Results

Environmental step



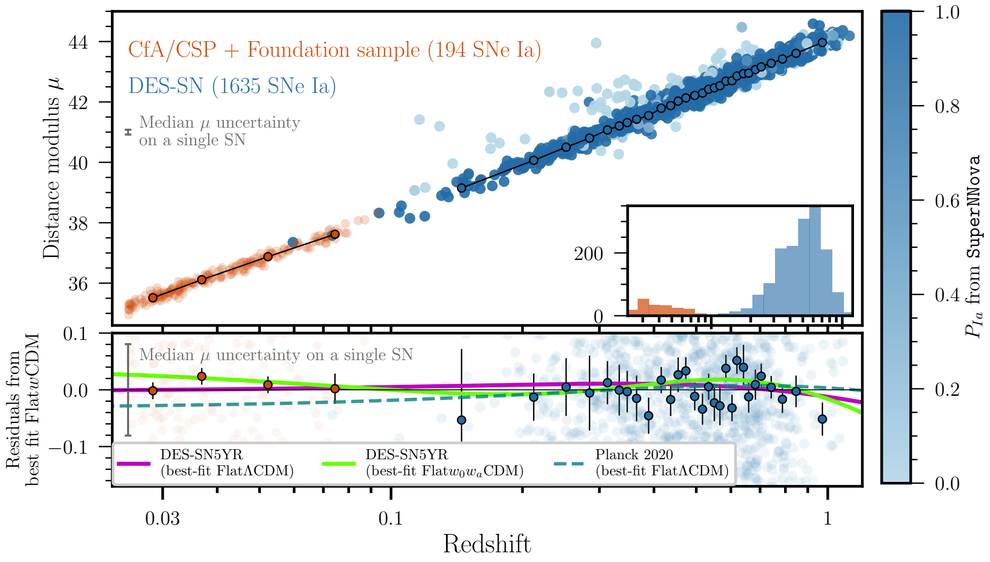




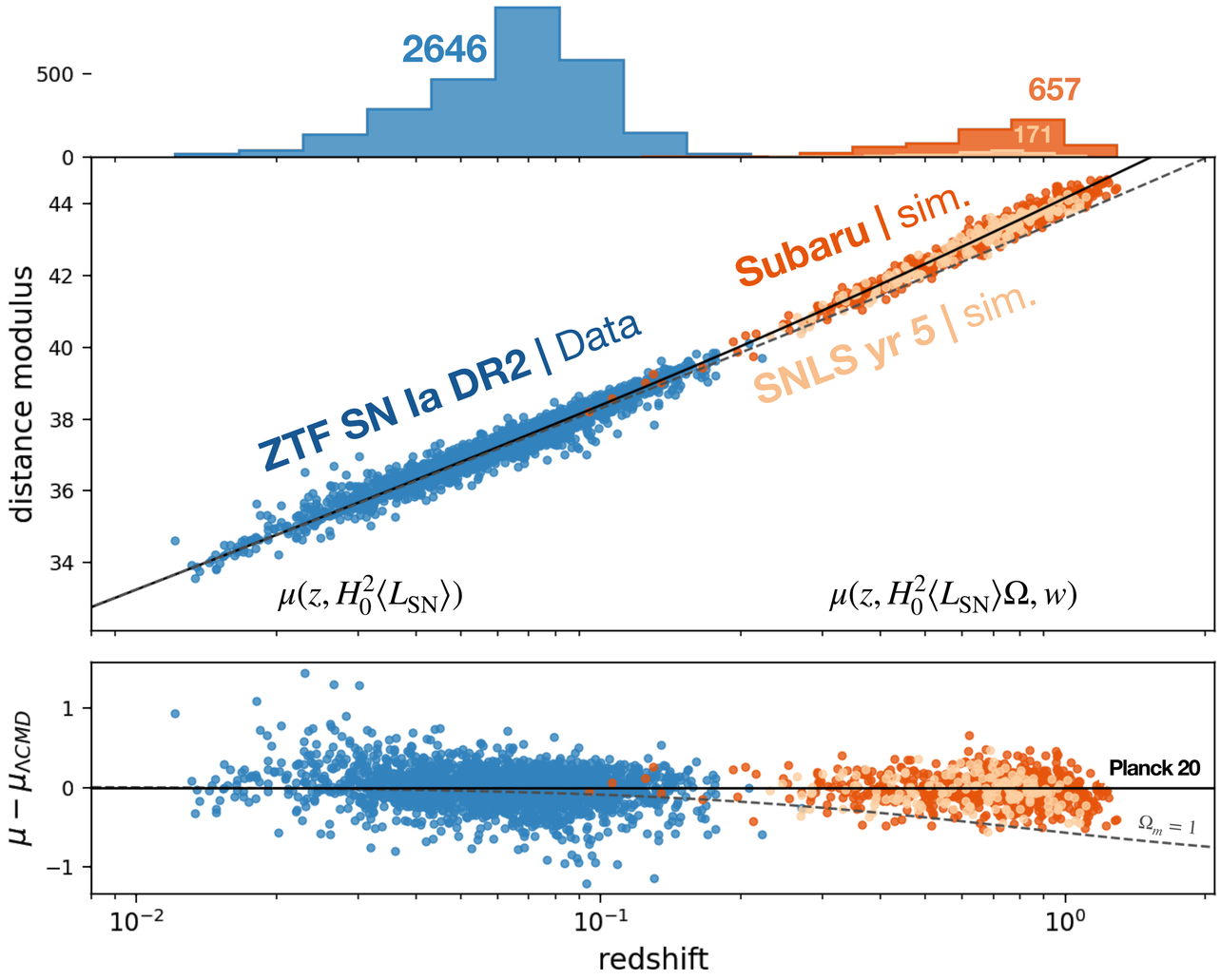
Burgaz+25c

ZTF DR2.5

Photometry



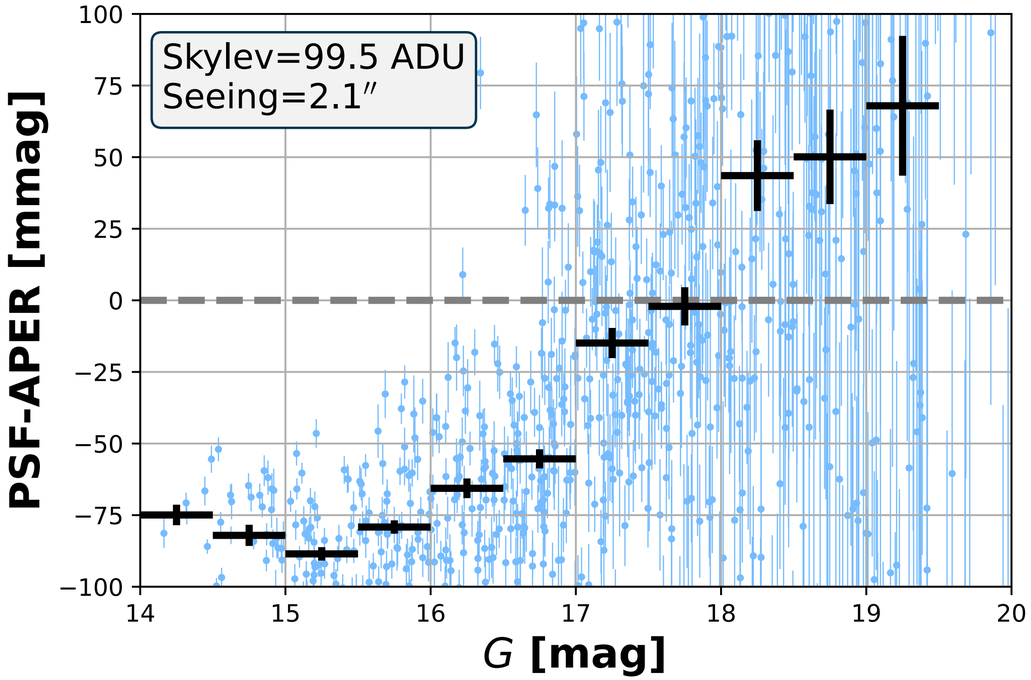
DES-SN5Y
DES Collaboration 2024



ZTF DR2.5

Photometry

Scene modelling

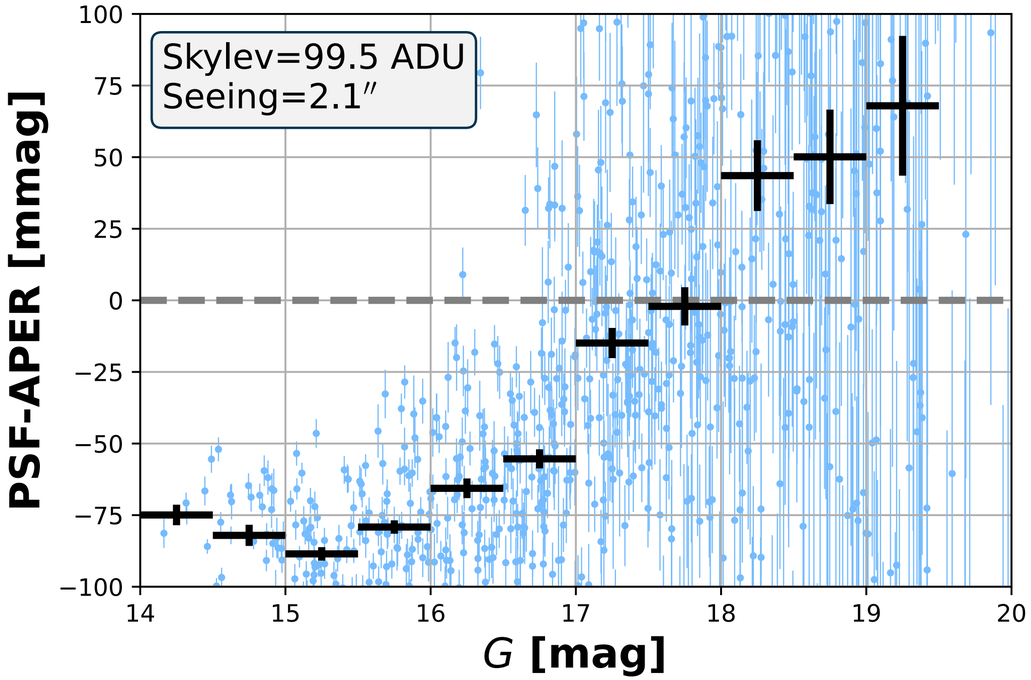


Lacroix+25

ZTF DR2.5

Photometry

Scene modelling



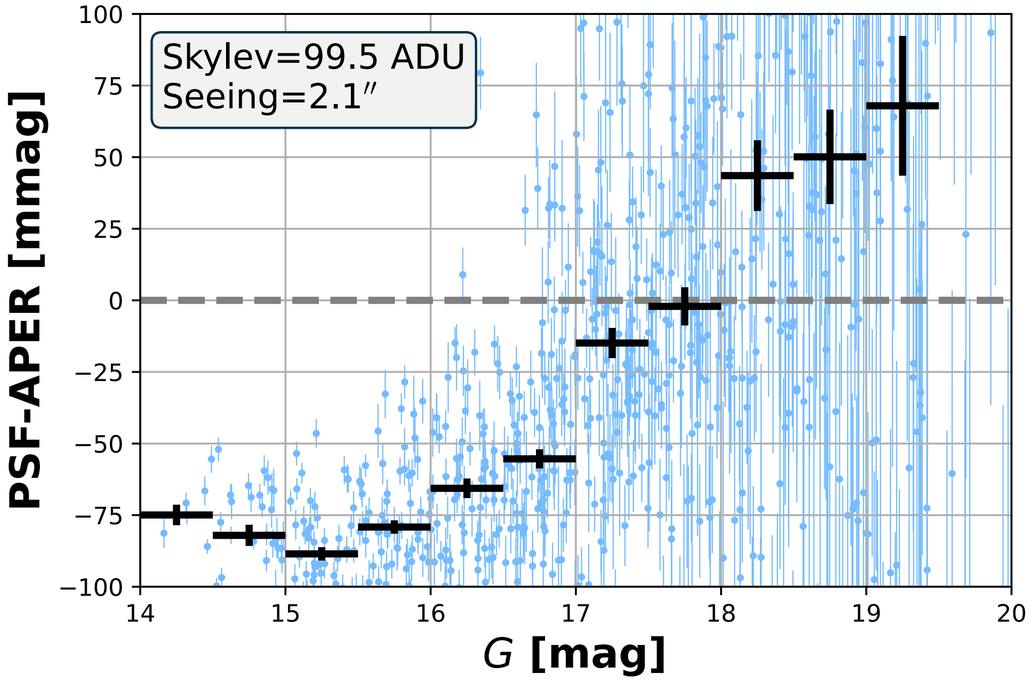
Lacroix+25

In situ filter measurements

ZTF DR2.5

Photometry

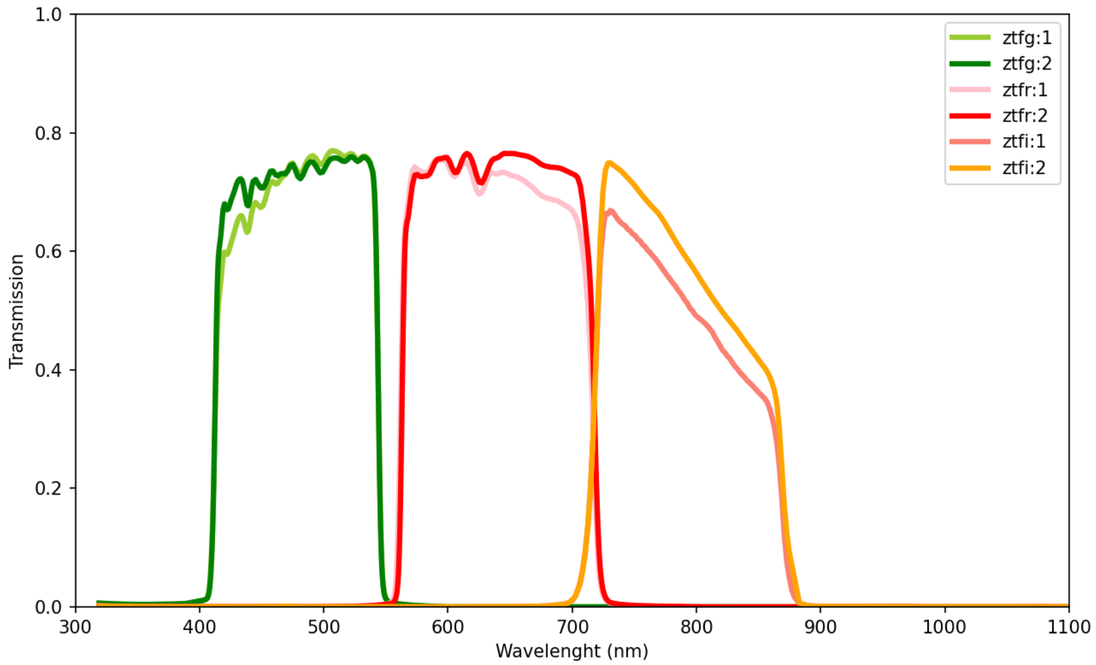
Scene modelling



Lacroix+25

In situ filter measurements

CCD13 (1, single-coated) vs CCD11 (2, double-coated)



Van den Abeele+ (in prep)
Aubert+ (in prep)

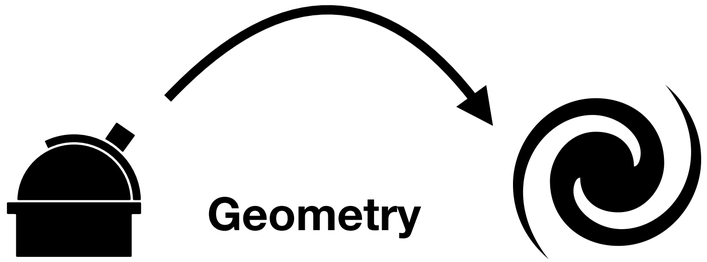
ZTF DR2.5

Distance ladder

Rigault+25a: ZTF SN Ia DR2 overview

ZTF DR2.5

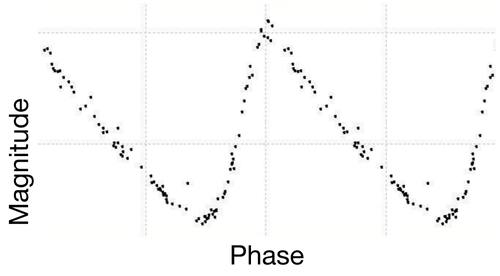
Distance ladder



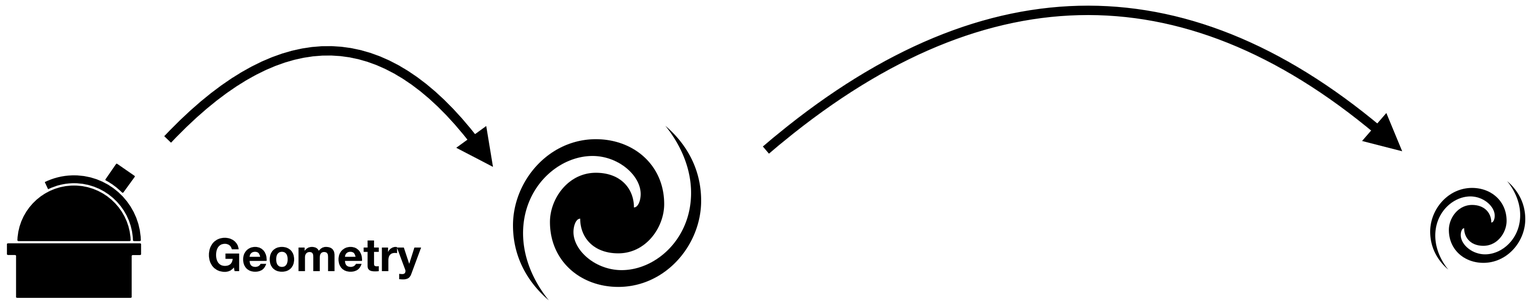
Rigault+25a: ZTF SN Ia DR2 overview

ZTF DR2.5

Distance ladder



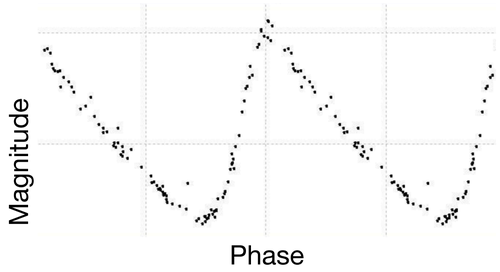
Riess+21



Rigault+25a: ZTF SN Ia DR2 overview

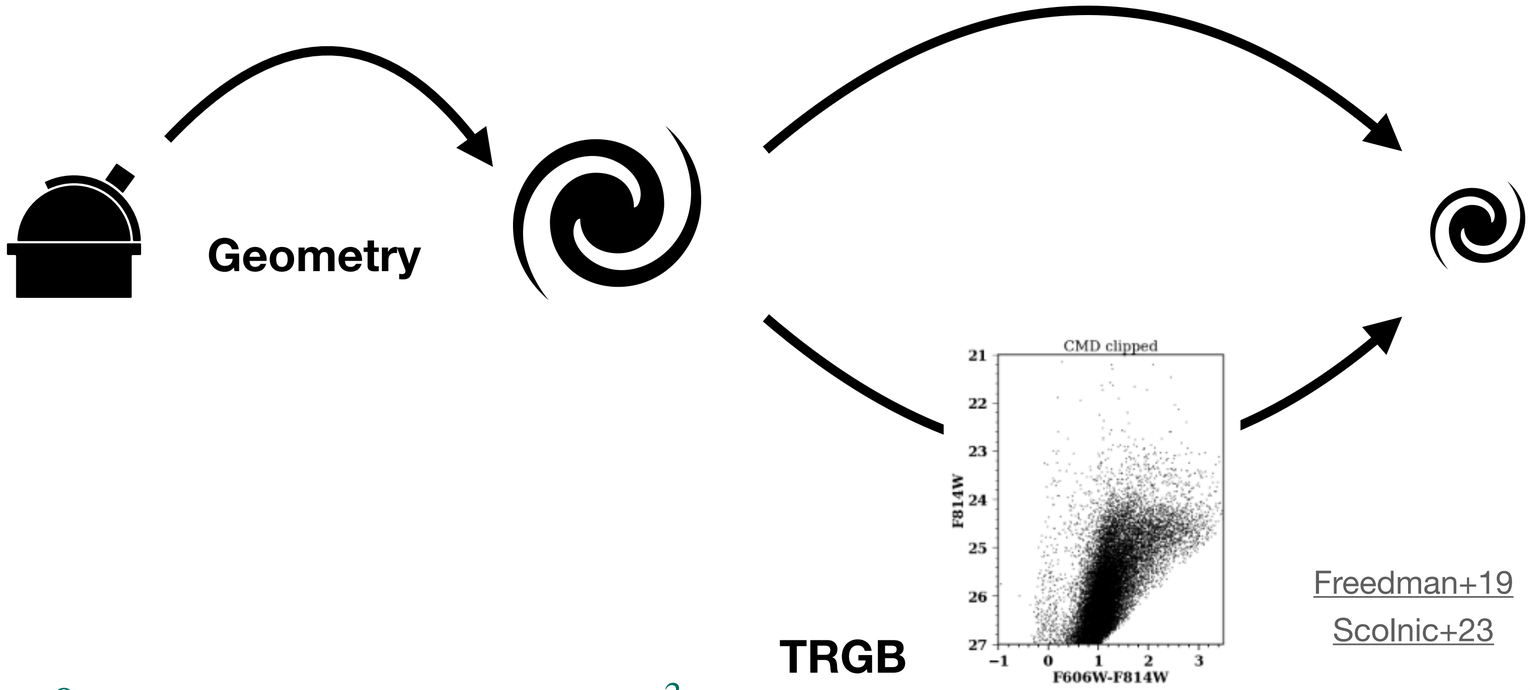
ZTF DR2.5

Distance ladder



Cepheids

Riess+21



Freedman+19

Scolnic+23

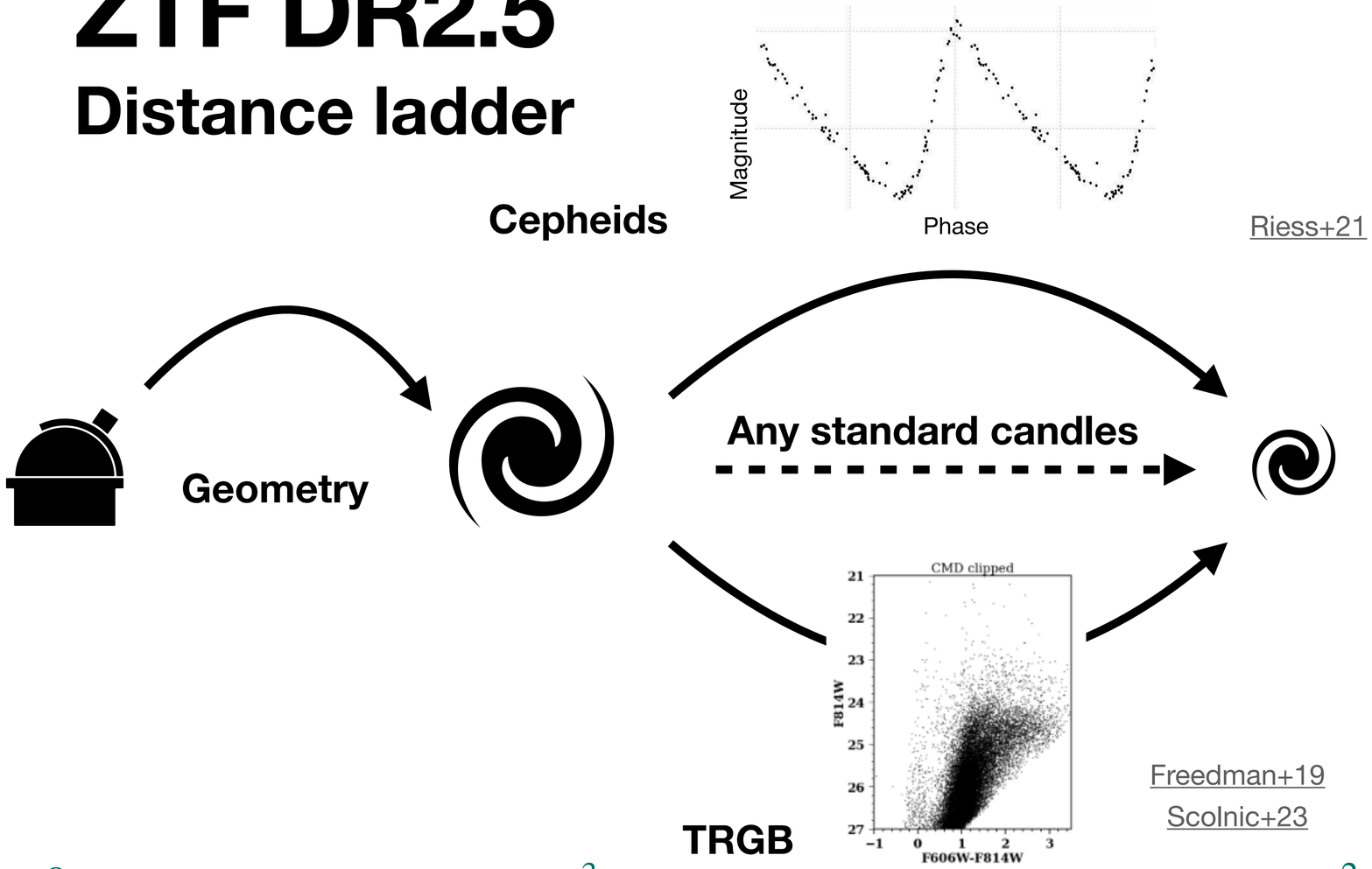
Rigault+25a: ZTF SN Ia DR2 overview

0 $< 10^{-3}$ $< 10^{-2}$

Redshift

ZTF DR2.5

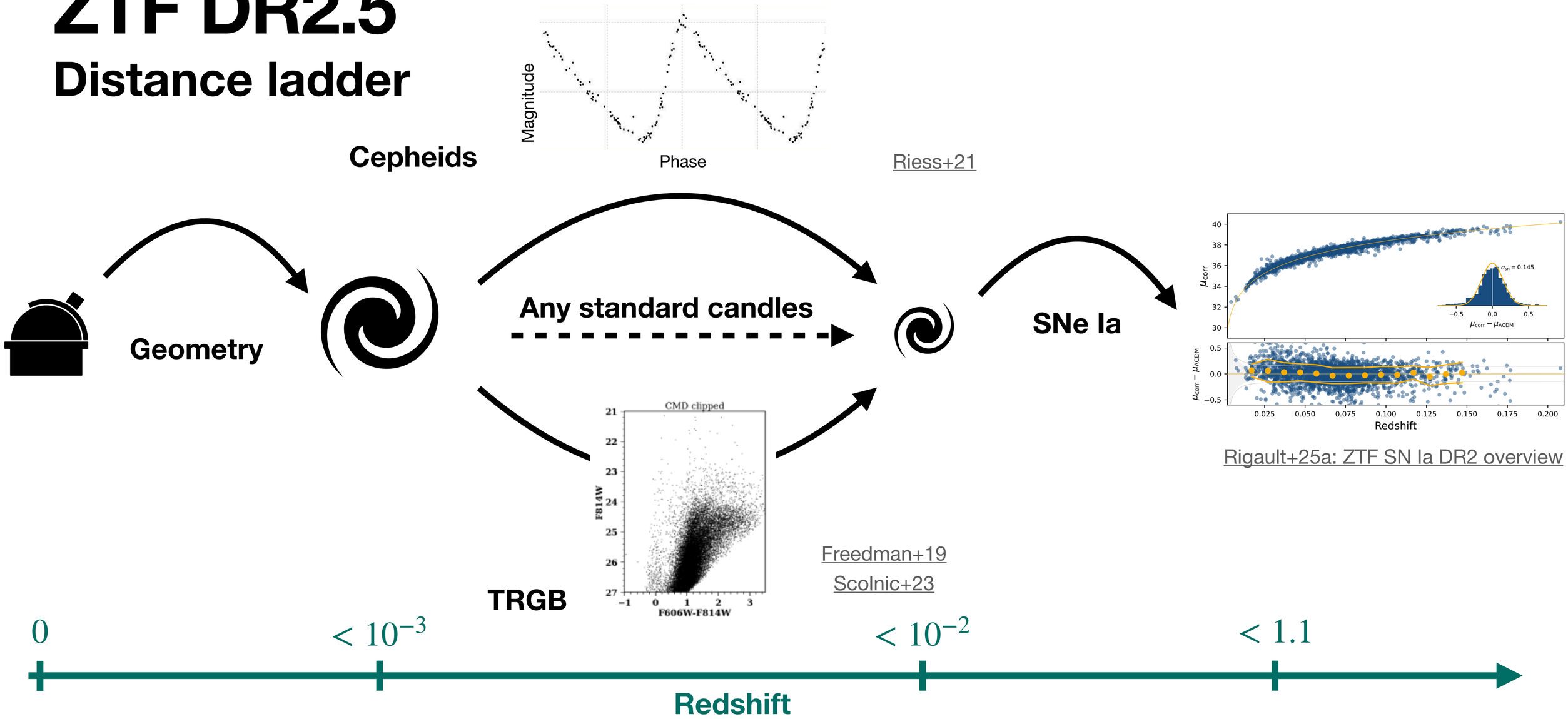
Distance ladder



Rigault+25a: ZTF SN Ia DR2 overview

ZTF DR2.5

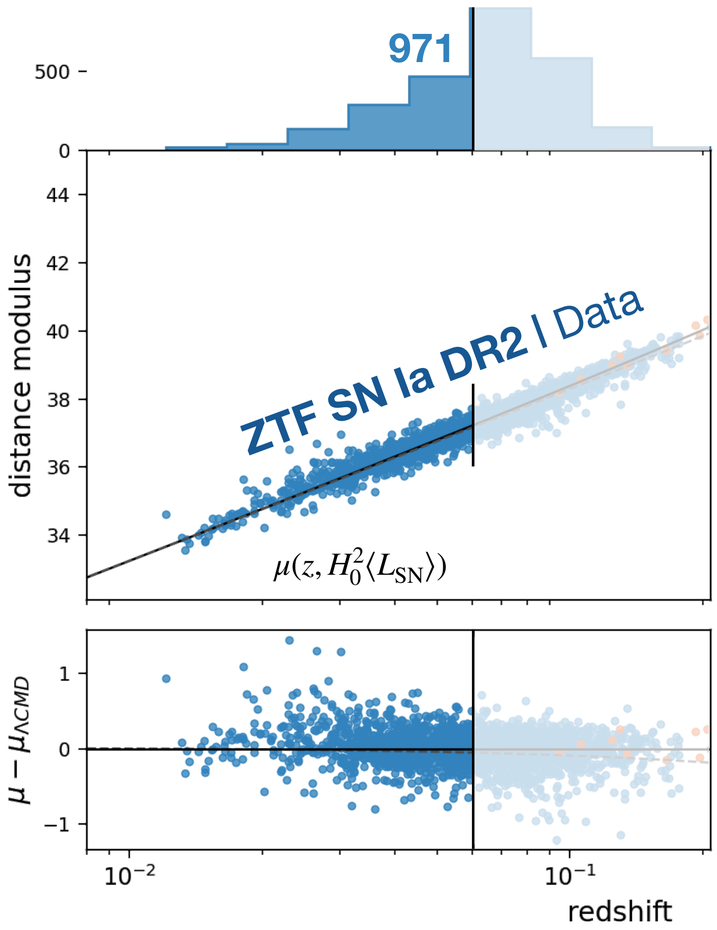
Distance ladder



Rigault+25a: ZTF SN Ia DR2 overview

ZTF DR2.5

H_0


971
500
0
44
42
40
38
36
34
distance modulus
ZTF SN Ia DR2 | Data
$\mu(z, H_0^2\langle L_{SN}\rangle)$
1
0
−1
$\mu - \mu_{\Lambda CMD}$
10^{-2}
10^{-1}
redshift

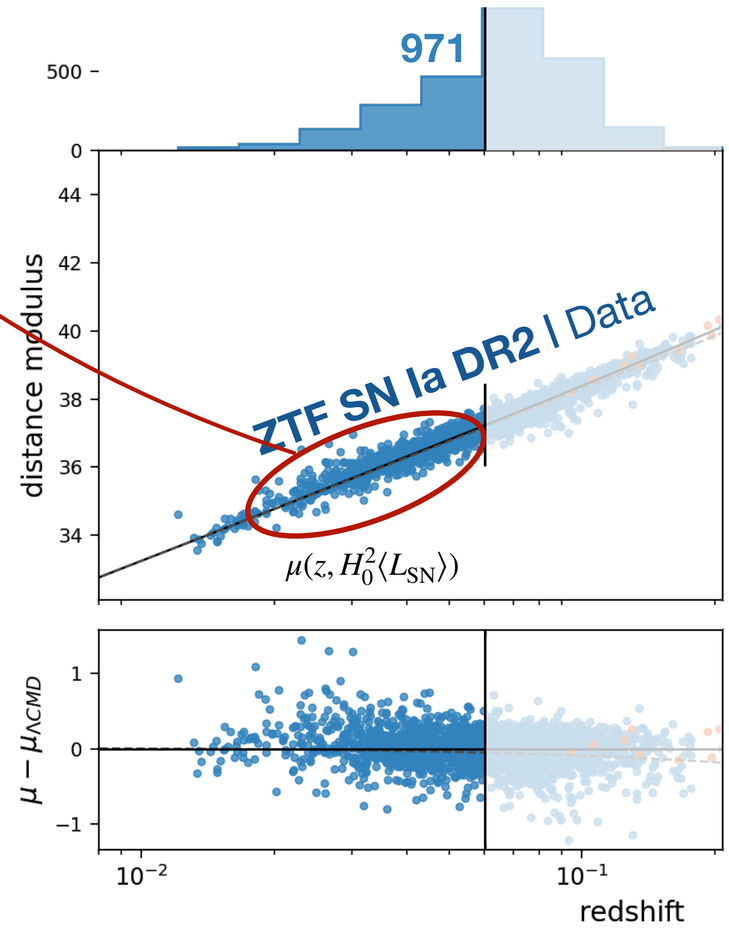
ZTF DR2.5

H_0

Volume limited sample

$z < 0.06$

No selection biases



ZTF DR2.5

H_0

Volume limited sample

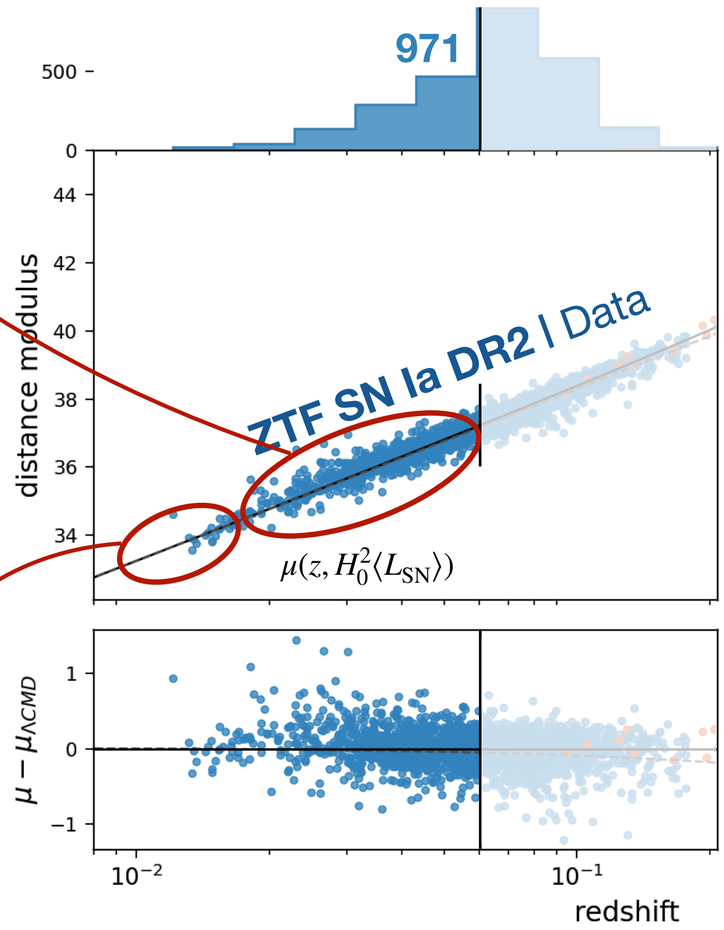
$z < 0.06$

No selection biases

Calibrator sample

$d < 50$ Mpc

TRGB with JWST



ZTF DR2.5

H_0

See Chloé's talk

Volume limited sample

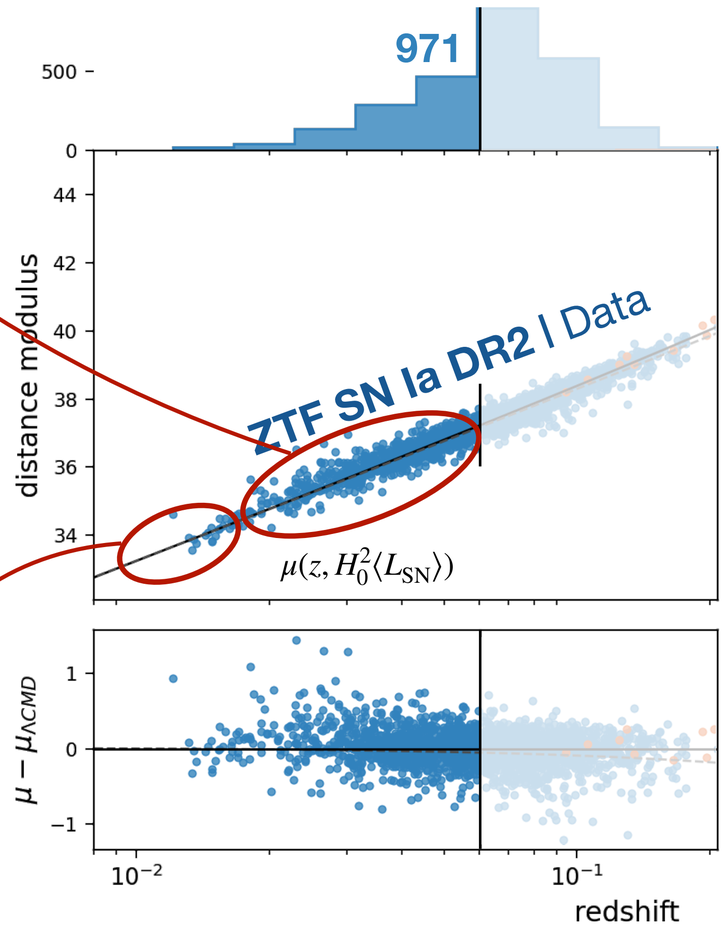
$z < 0.06$

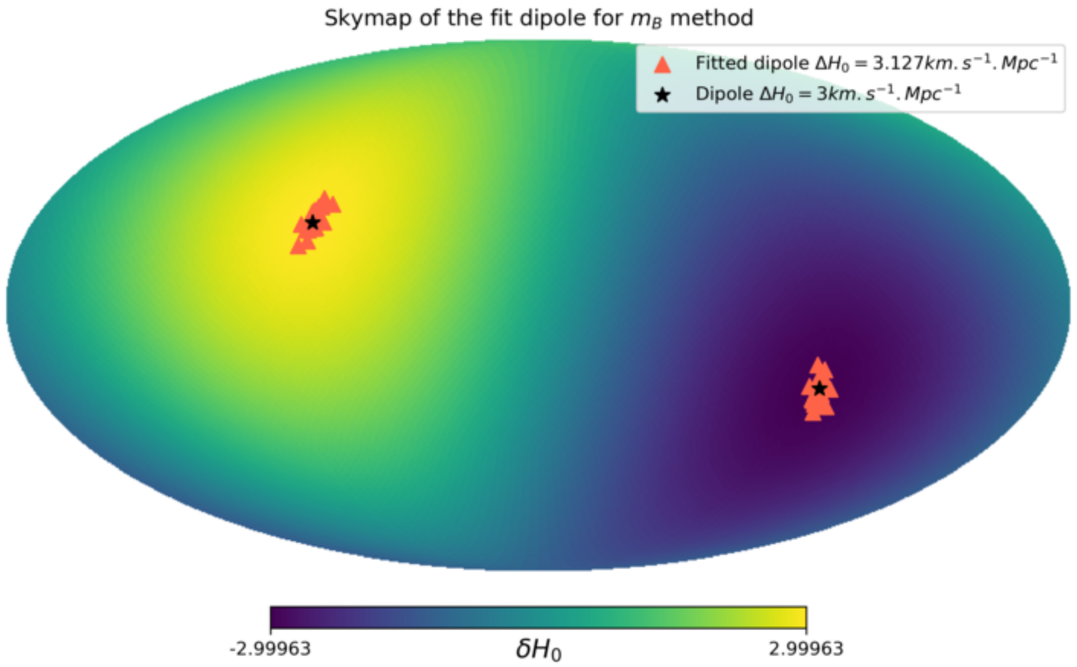
No selection biases

Calibrator sample

$d < 50$ Mpc

TRGB with JWST



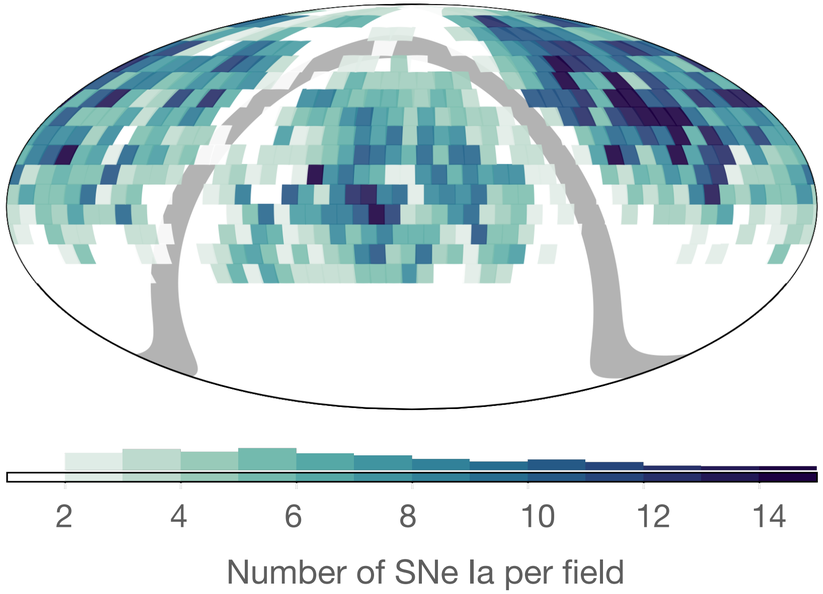


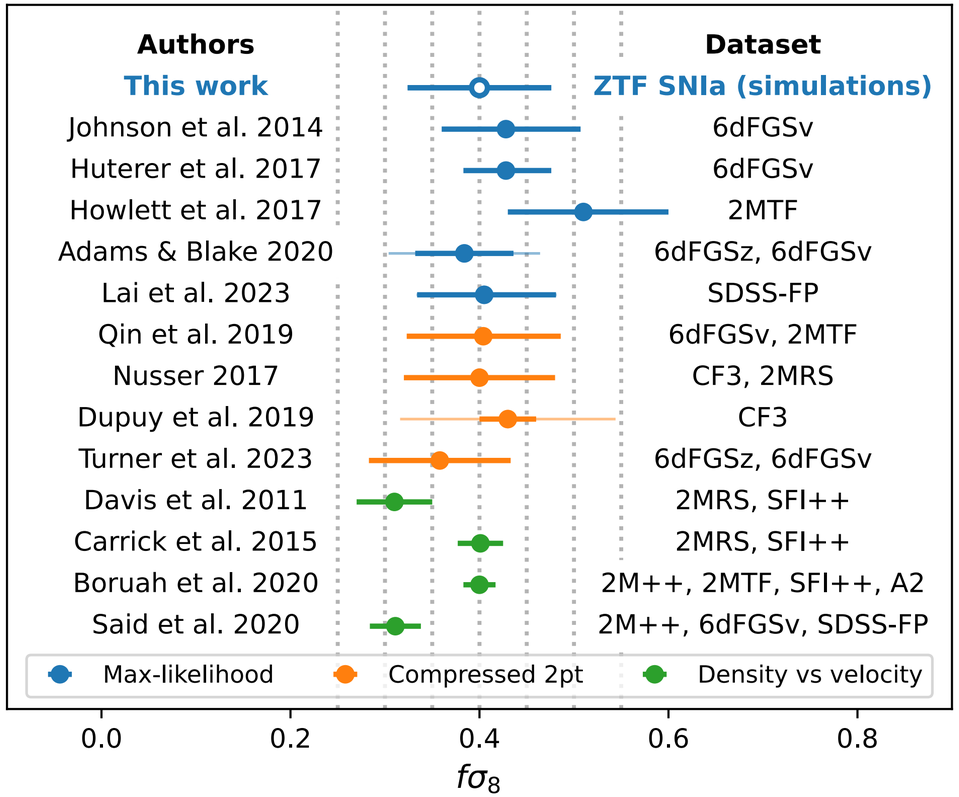
Barjou-Delayre+ (in prep)

ZTF DR2.5

See Rafael and Pauline's talks

$f\sigma_8$





Carreres+23

Observed redshift
(What we have)

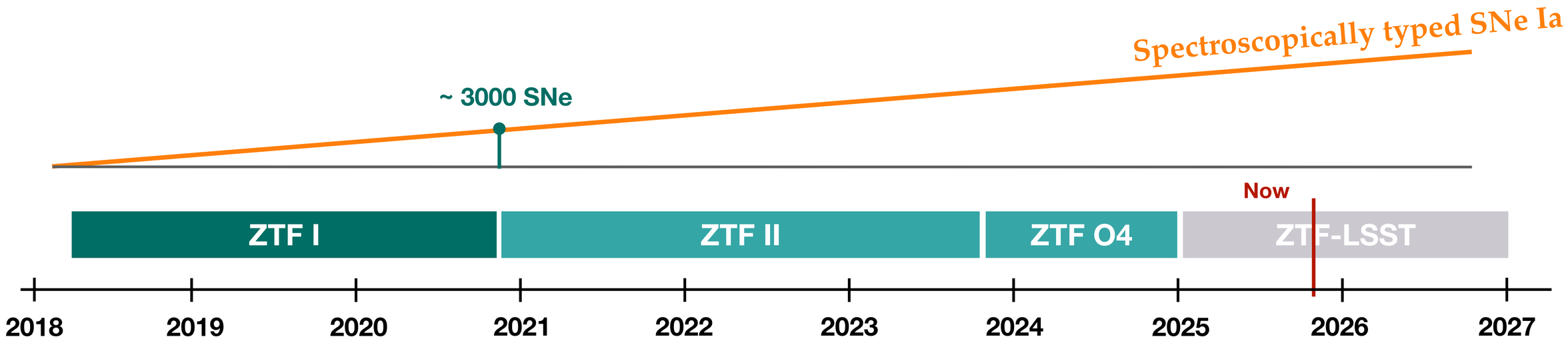
$$(1+z) = (1+\bar{z})(1+\frac{v}{c})$$

Peculiar velocity
(What we want)

Cosmology redshift
(from distance)

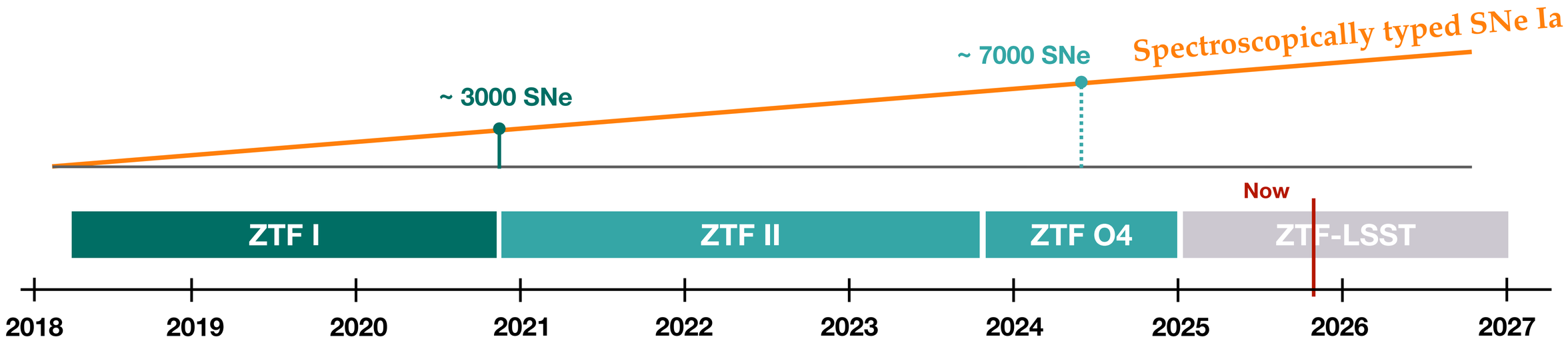
ZTF DR3

Full 5 year sample



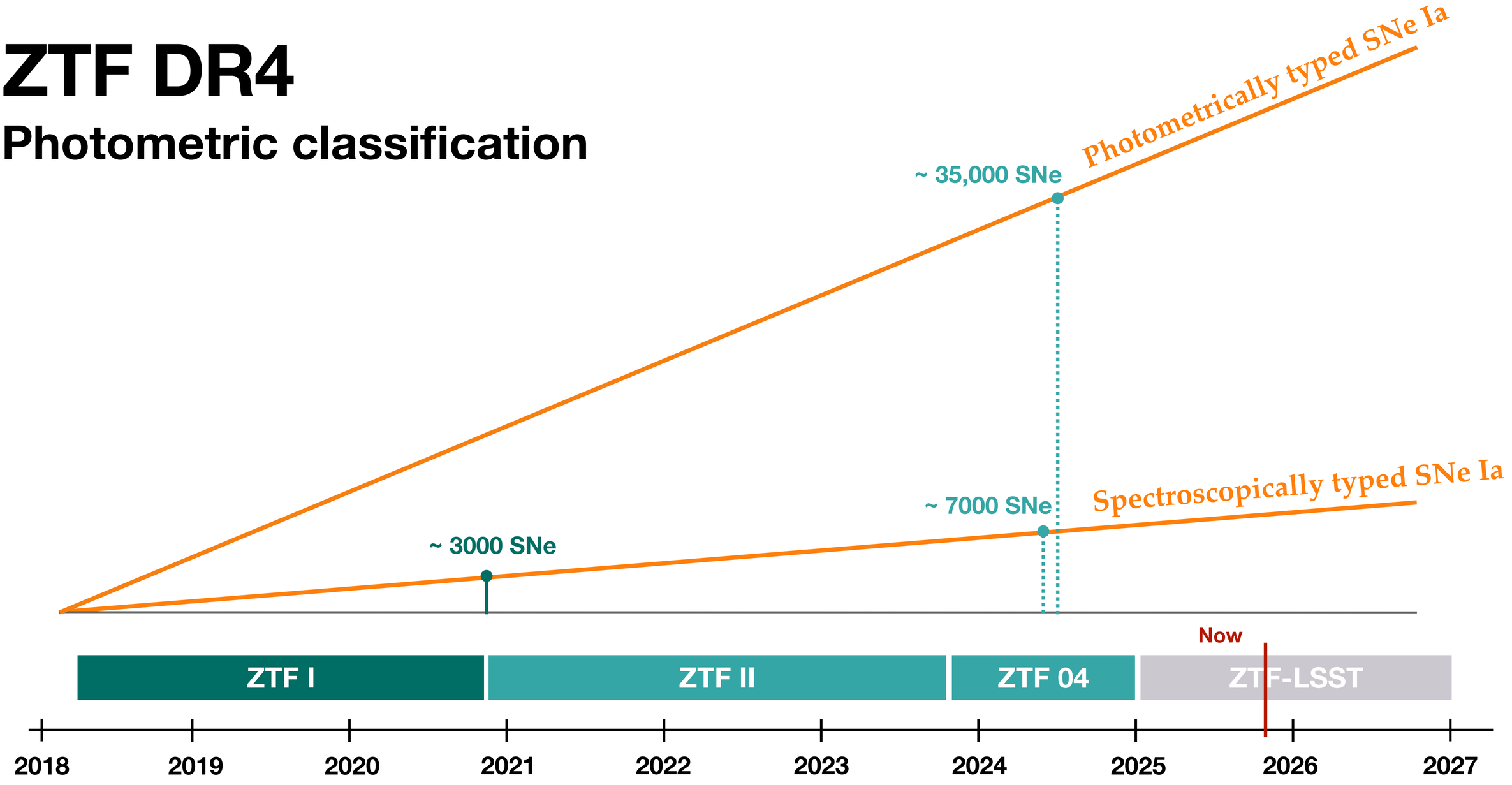
ZTF DR3

Full 5 year sample

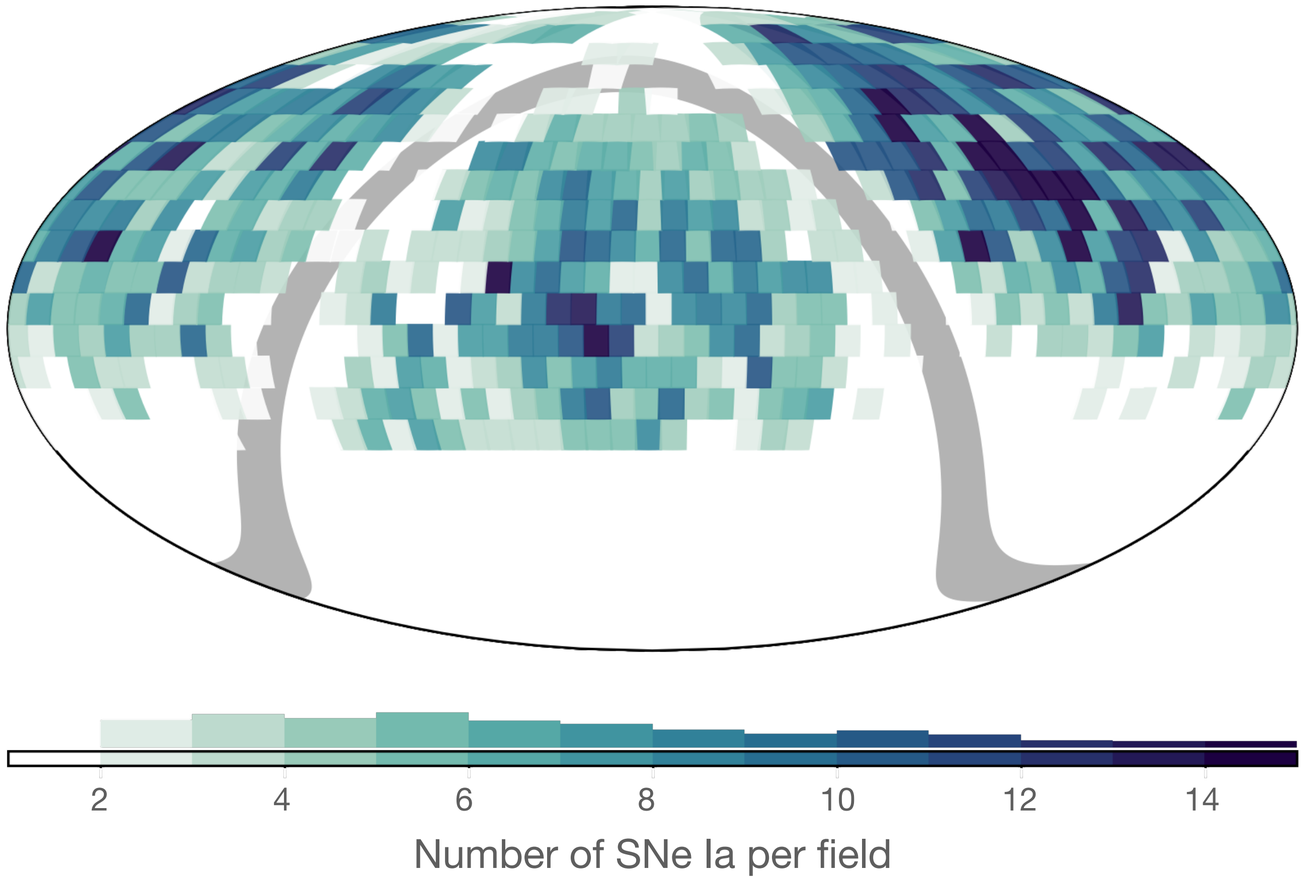


ZTF DR4

Photometric classification



Conclusion



ztfcosmo.in2p3.fr

A&A special issue

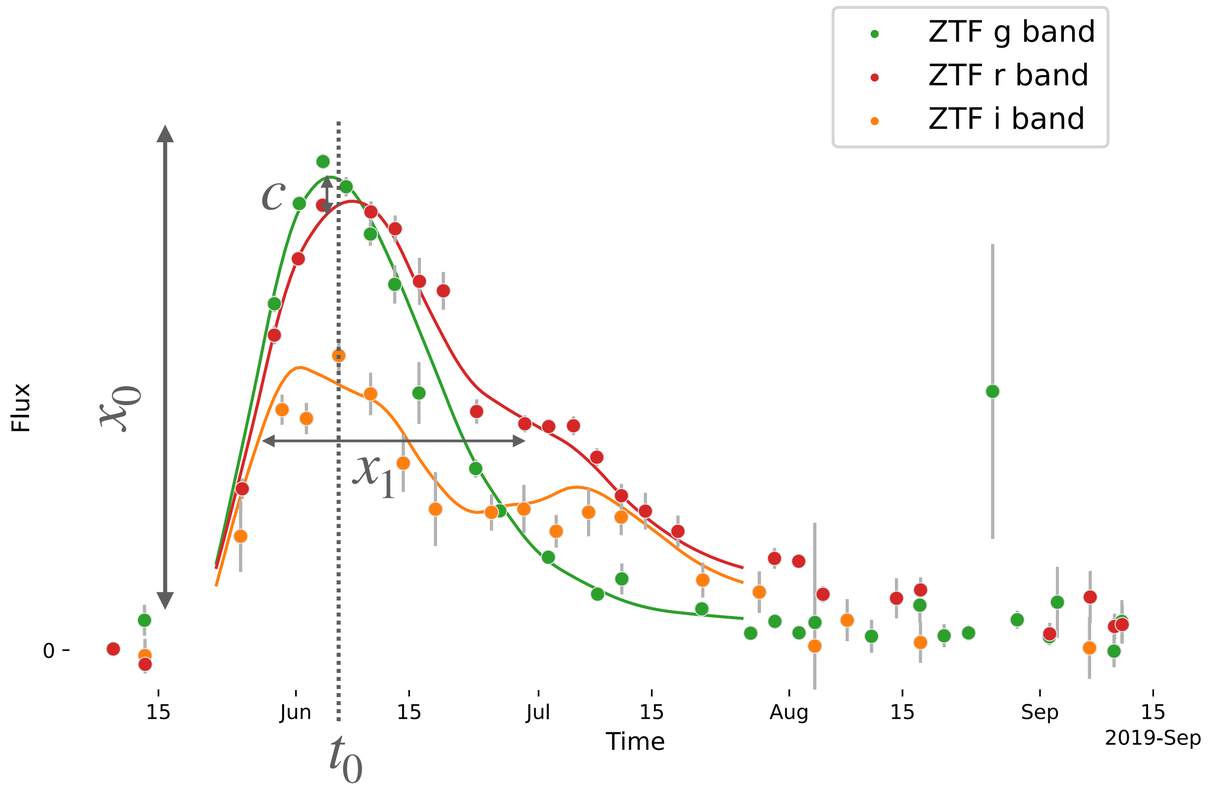
Rigault+

- **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+)

Backup

SNe Ia

Light curve fitting



Flux of the SN:

$$F(t - t_0, \lambda) = x_0[M_0(t - t_0, \lambda) + x_1 M_1(t - t_0, \lambda)]\exp(cCL(\lambda))$$

Parameters relative to the observation

t: rest time of the observation

λ: rest-frame wavelength

Parameters relative to the SN

x_0: amplitude

x_1: stretch

c: colour

t_0: time of the peak

SALT2 - Guy+07
SALT2.4 - Guy+10, Betoule+14
SALT3 - Kenworthy+21

Cosmology with SNe Ia

Distance ladder

Geometry **Cepheids** **SNe Ia**