LSST France 2020:

SNeIa Host Analyses

Some USNAC results

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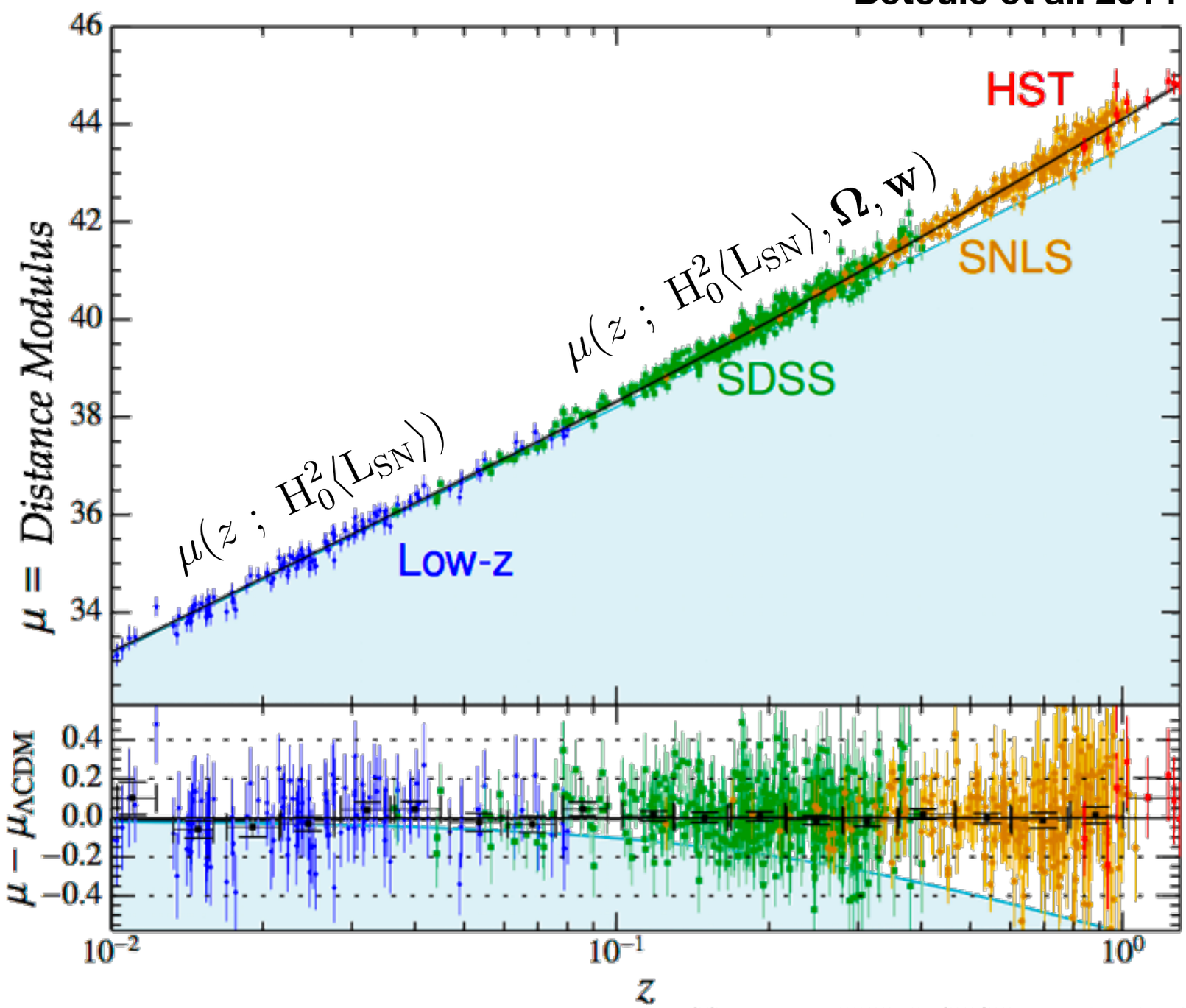
SN Cosmology | Dark Energy

Betoule et al. 2014



$\Omega_m = 0.295$
$\Omega_\Lambda = 0.705$

$\Omega_m = 1$
$\Omega_\Lambda = 0$

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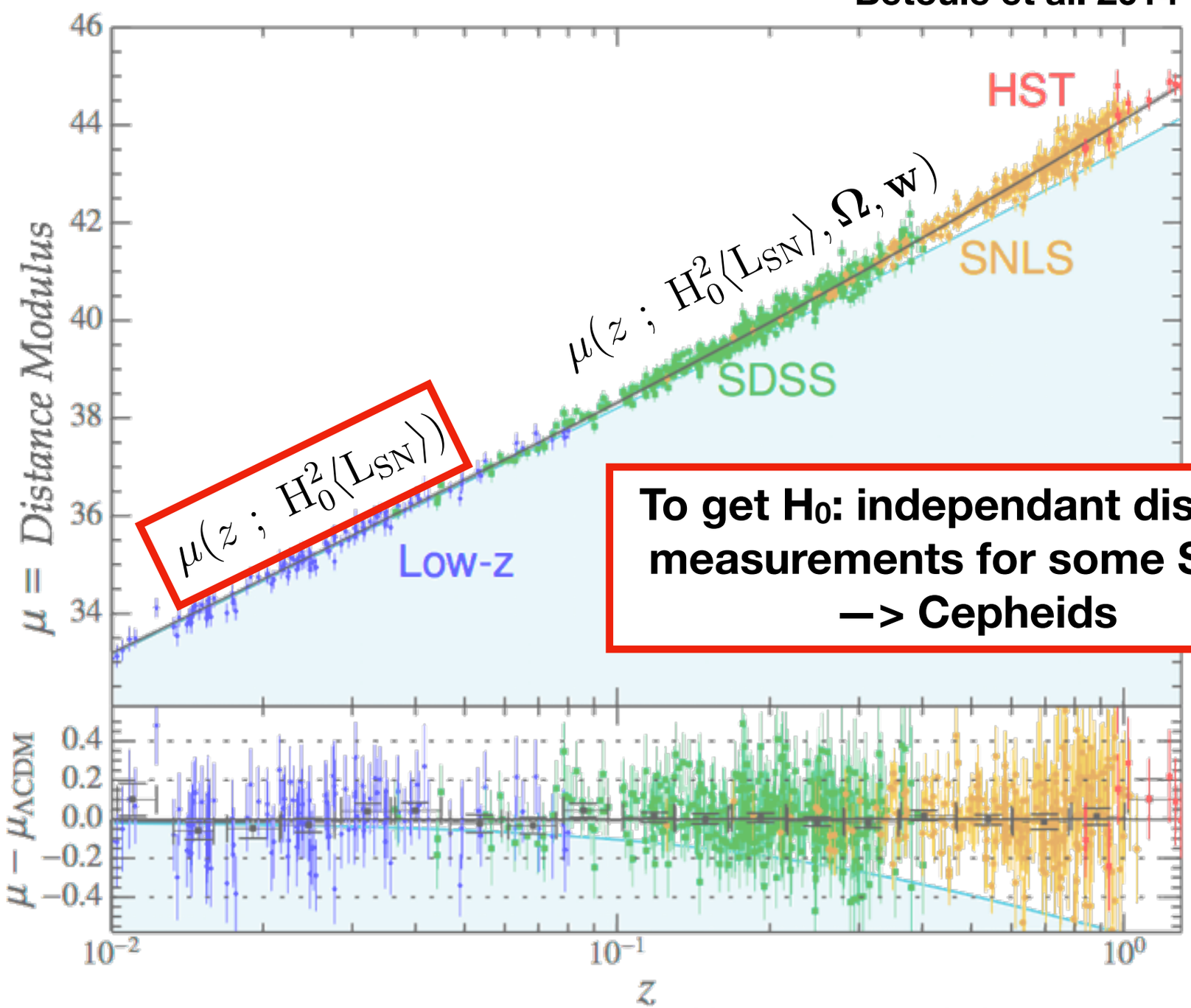
SN Cosmology | H_0

Betoule et al. 2014



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To get H_0: independant distance measurements for some SNeIa —> Cepheids

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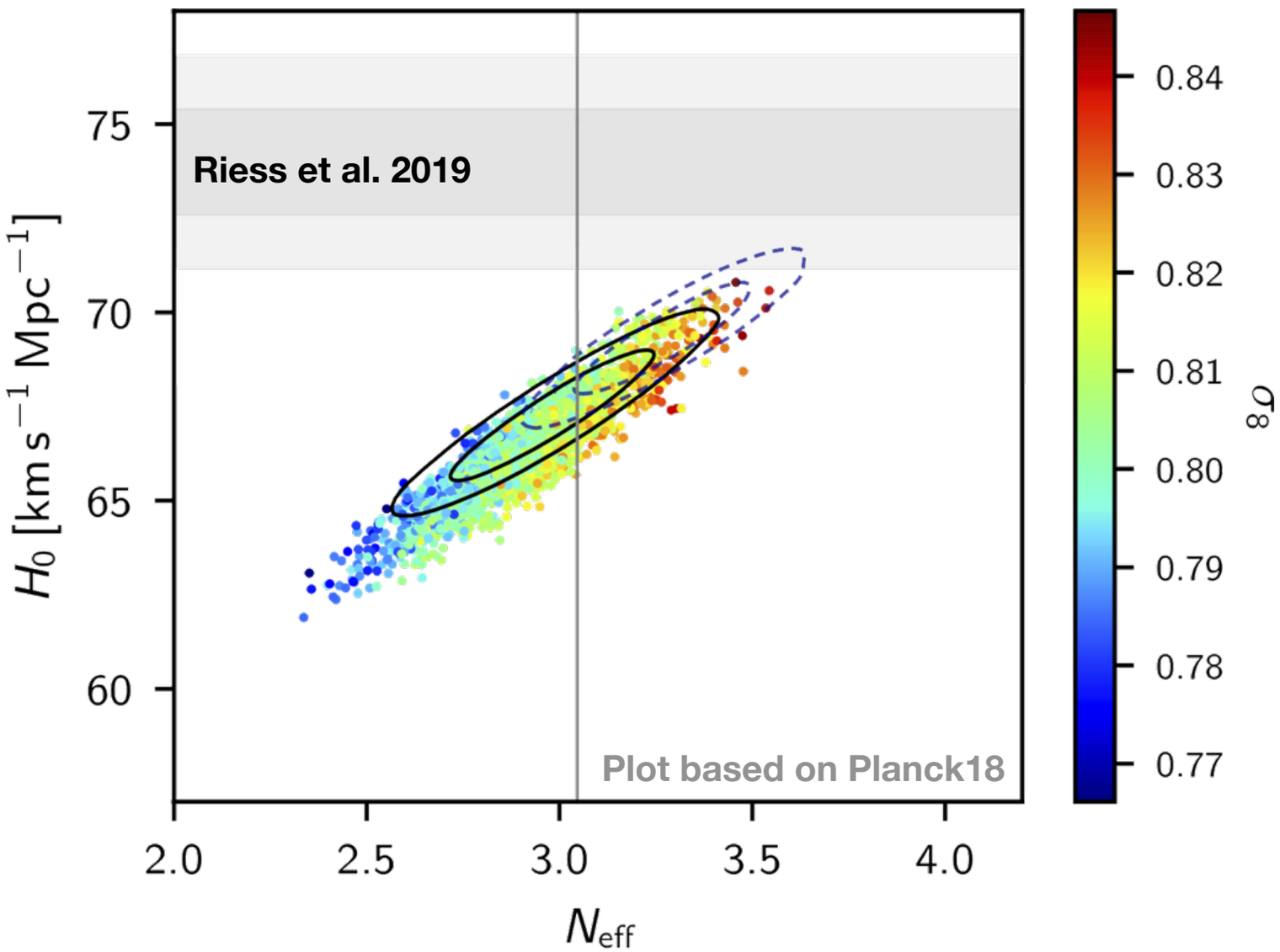
H_0 tension ?



Credits : Mickael Rigault

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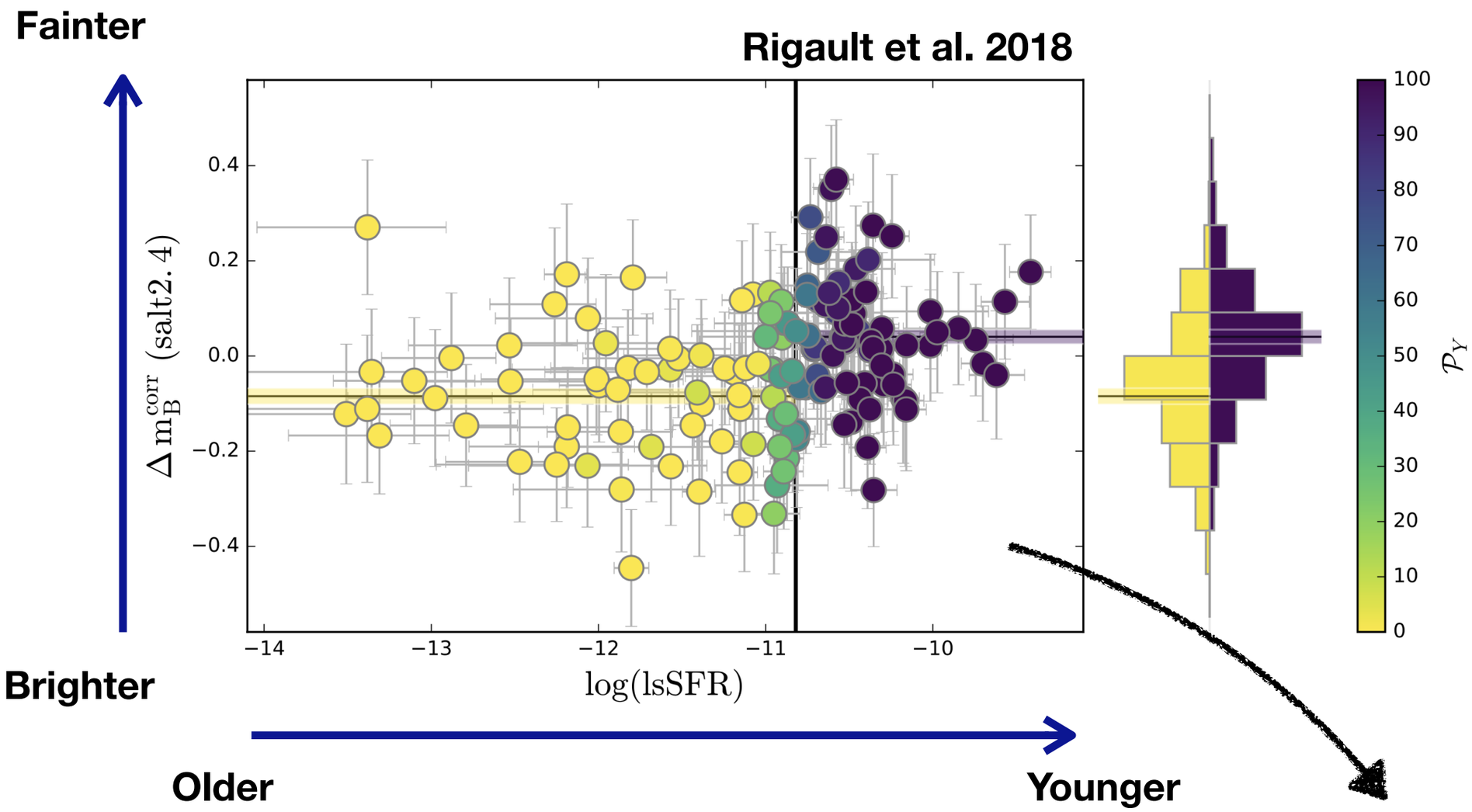
H_0 & Astrophysical bias



Δ HR = 0.163 ± 0.029 mag

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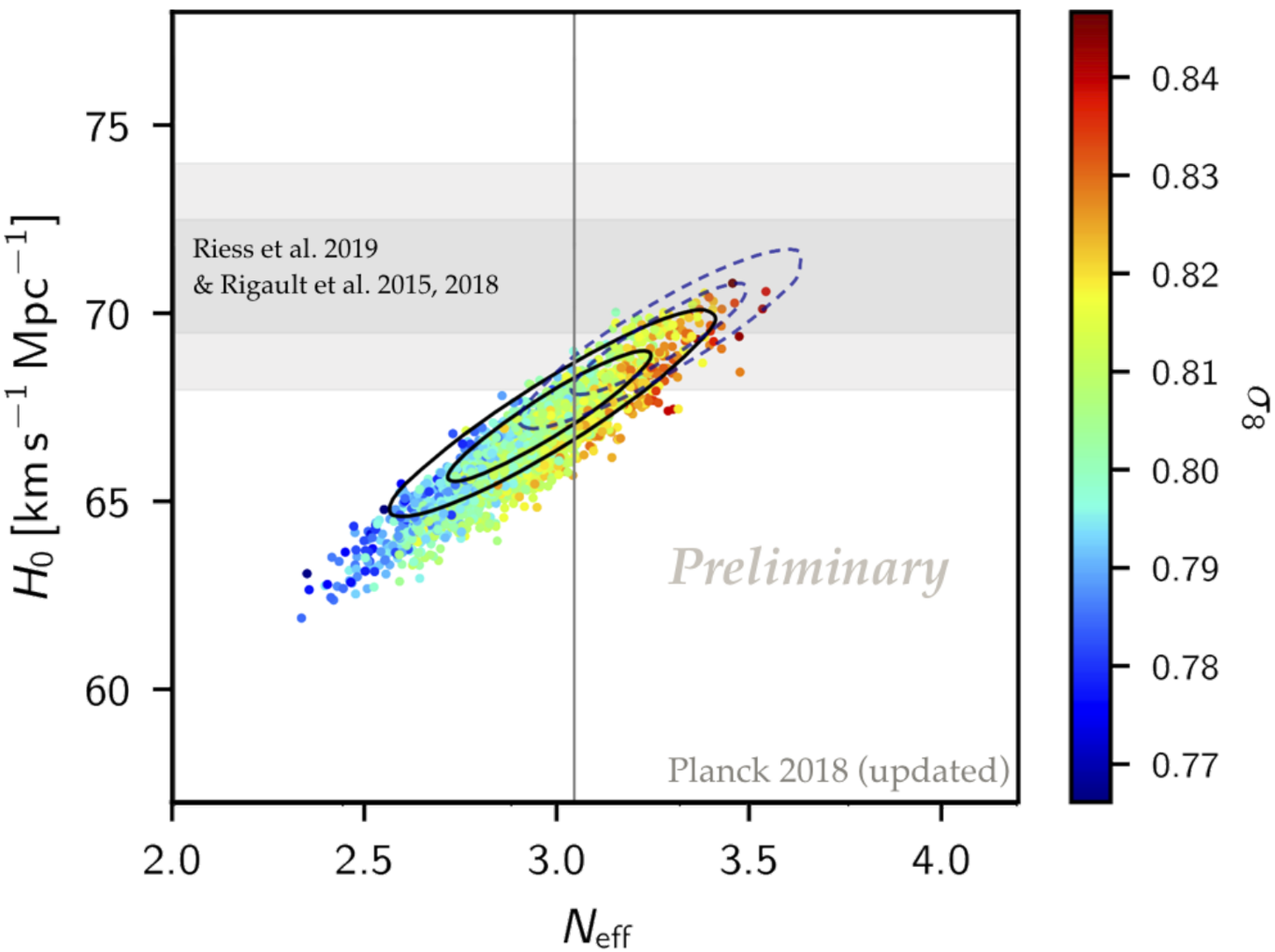
Amplitude of magnitude offset -> scale of H_0 bias



Astrophysical bias on H_0
Up to 3% if :

1. Different fraction of prompt
   ~95% in Cepheid-SN
   vs. ~50% in Hubble flow-SN

2. Magnitude difference between prompts and delayed SNeIa
   age step ~0.15 mag

SH0ES $H_0 = 73.5$ leads to
$H_0 = 71.5^* \pm 1.6$ km s^{-1} Mpc^{-1}

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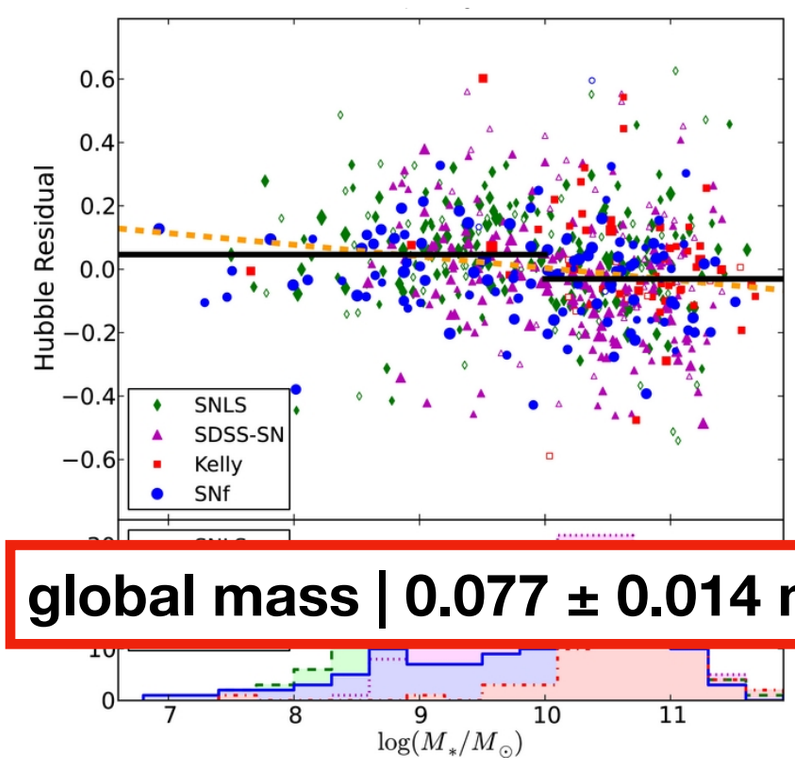
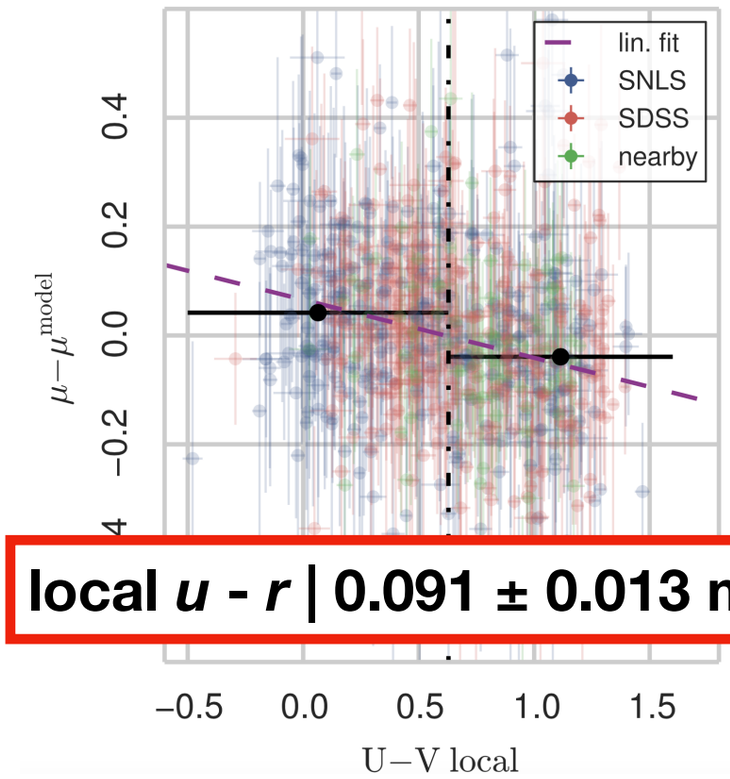
Various environmental tracers give different magnitude steps

Childress et al. 2013



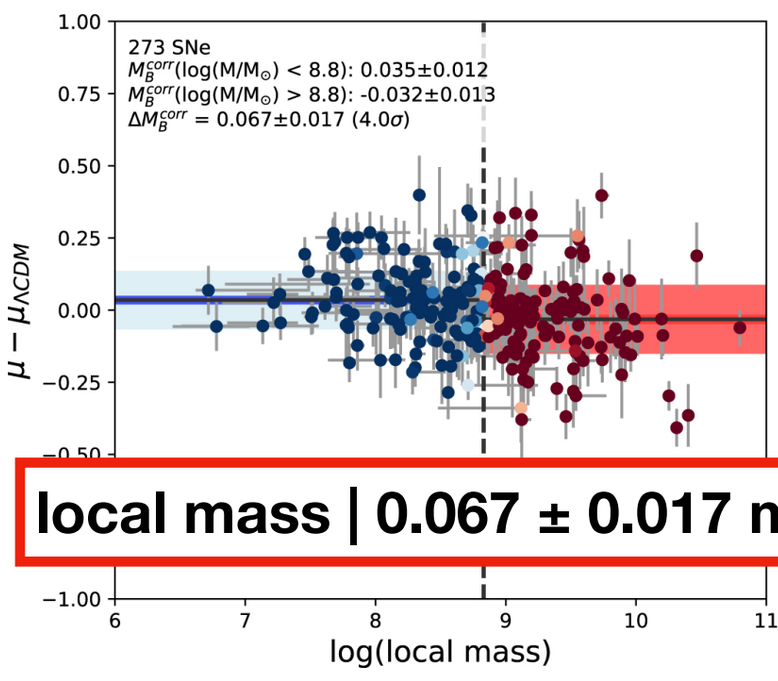
global mass | 0.077 ± 0.014 mag

Roman et al. 2017

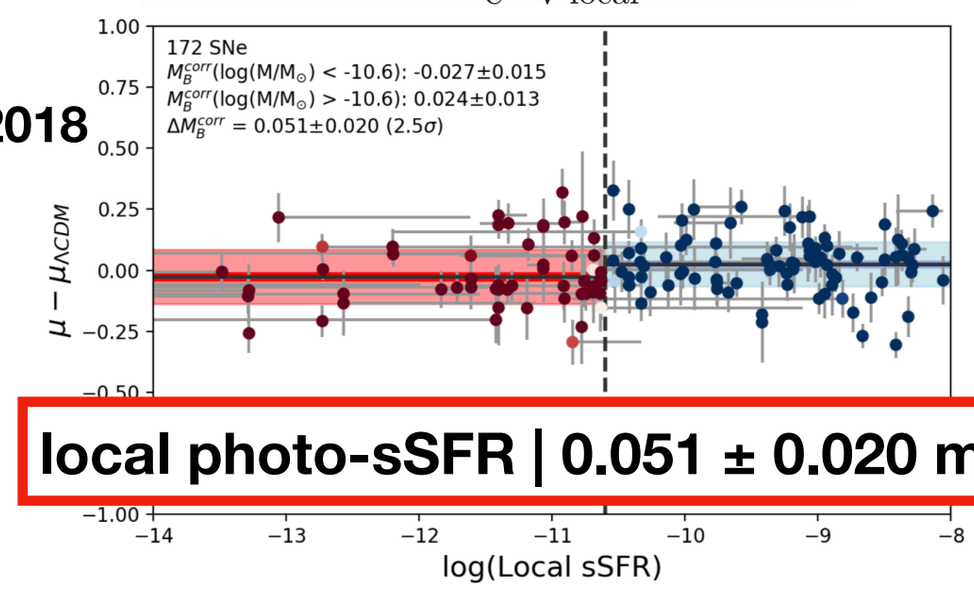


local *u* - *r* | 0.091 ± 0.013 mag

Jones et al. 2018



local mass | 0.067 ± 0.017 mag



local photo-sSFR | 0.051 ± 0.020 mag

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Assumption

- Various tracers find different magnitude step values?
- The Type Ia Supernovae can be split into two populations, depending on the age of their progenitor:

—> Prompt / Delayed SNeIa

- Different tracers, but measuring the same effect.
- How are the environmental tracers accurate to measure the progenitor age?

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Age tracers

- Local specific Star Formation Rate (LsSFR) } SNIFS
- Stellar masses
- Colors
- Morphology
- Photometric LsSFR

} SDSS + PanSTARRS

SNeIa sample : The Nearby Supernova factory (SNf)

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Age tracers
—> reference choice

Reference

- Local specific Star Formation Rate (LsSFR) } SNIFS
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SNeIa sample : The Nearby Supernova factory (SNf)

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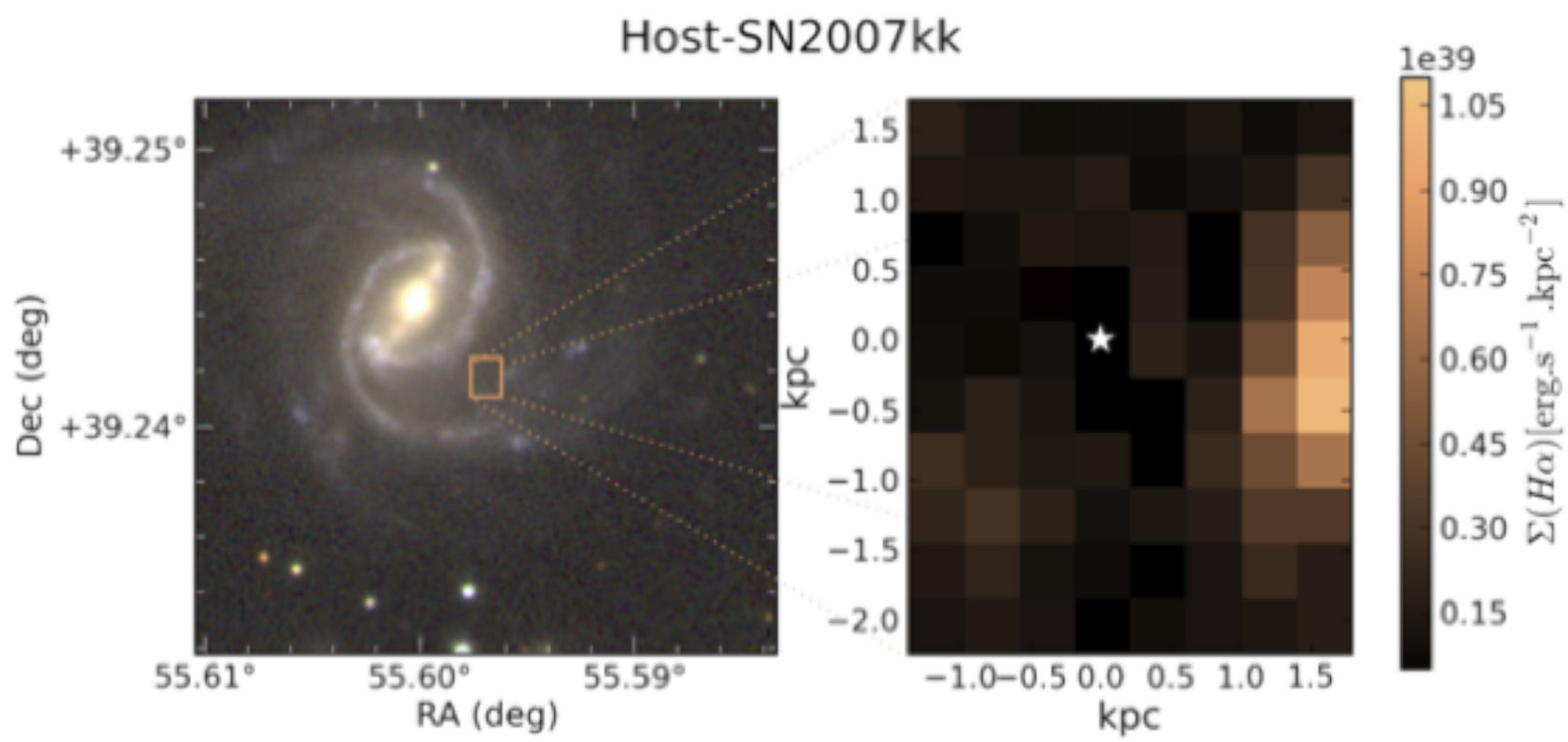
Concept of Contamination



Misclassification = Tracer Inaccuracy

e.g. ***Spiral → Young Progenitor***

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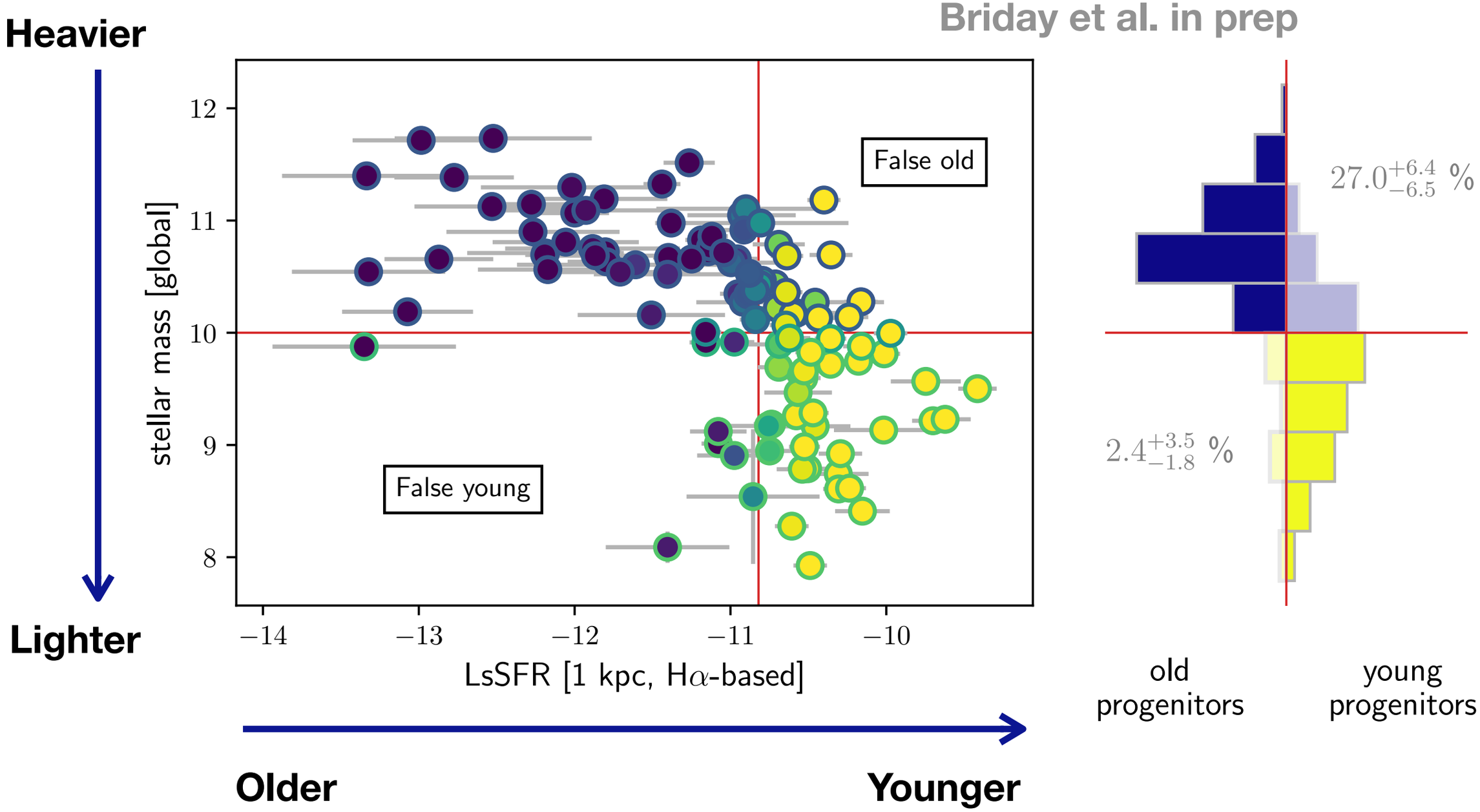
Are All tracers probing the same things ?

— Global mass vs. LsSFR —

Preliminary
Briday et al. in prep



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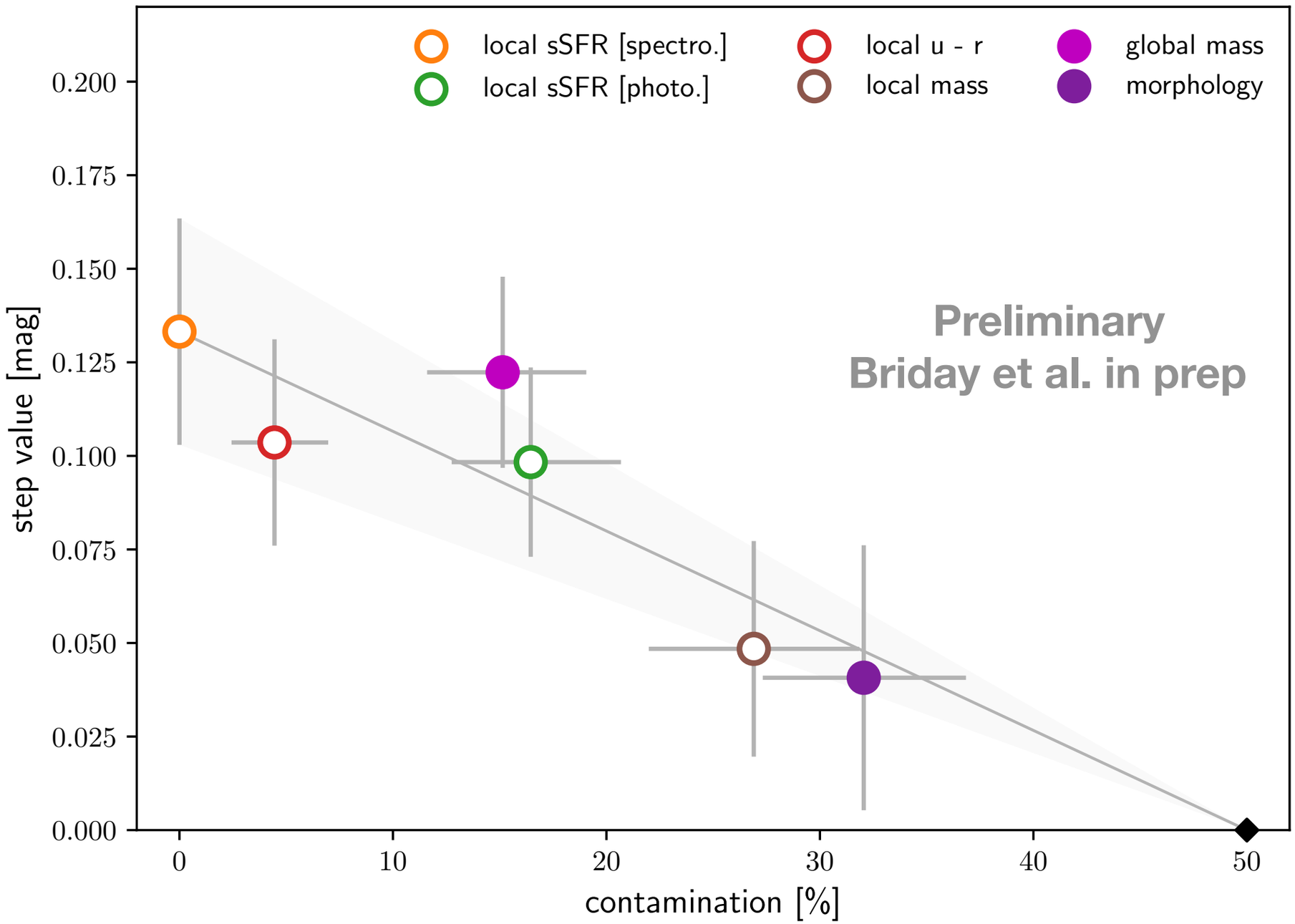
The Contamination Diagonal



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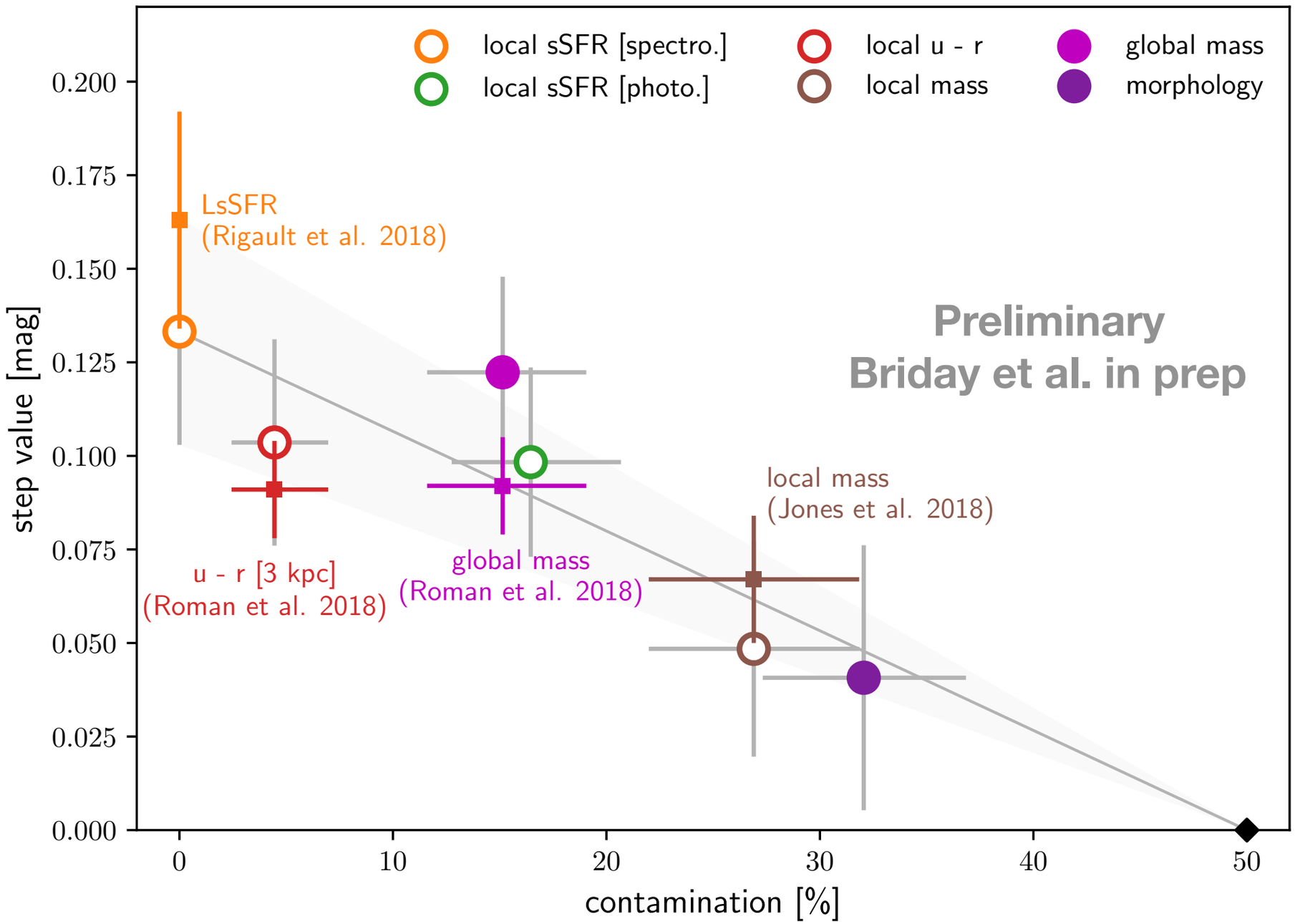
The Contamination Diagonal

— what about literature data ? —



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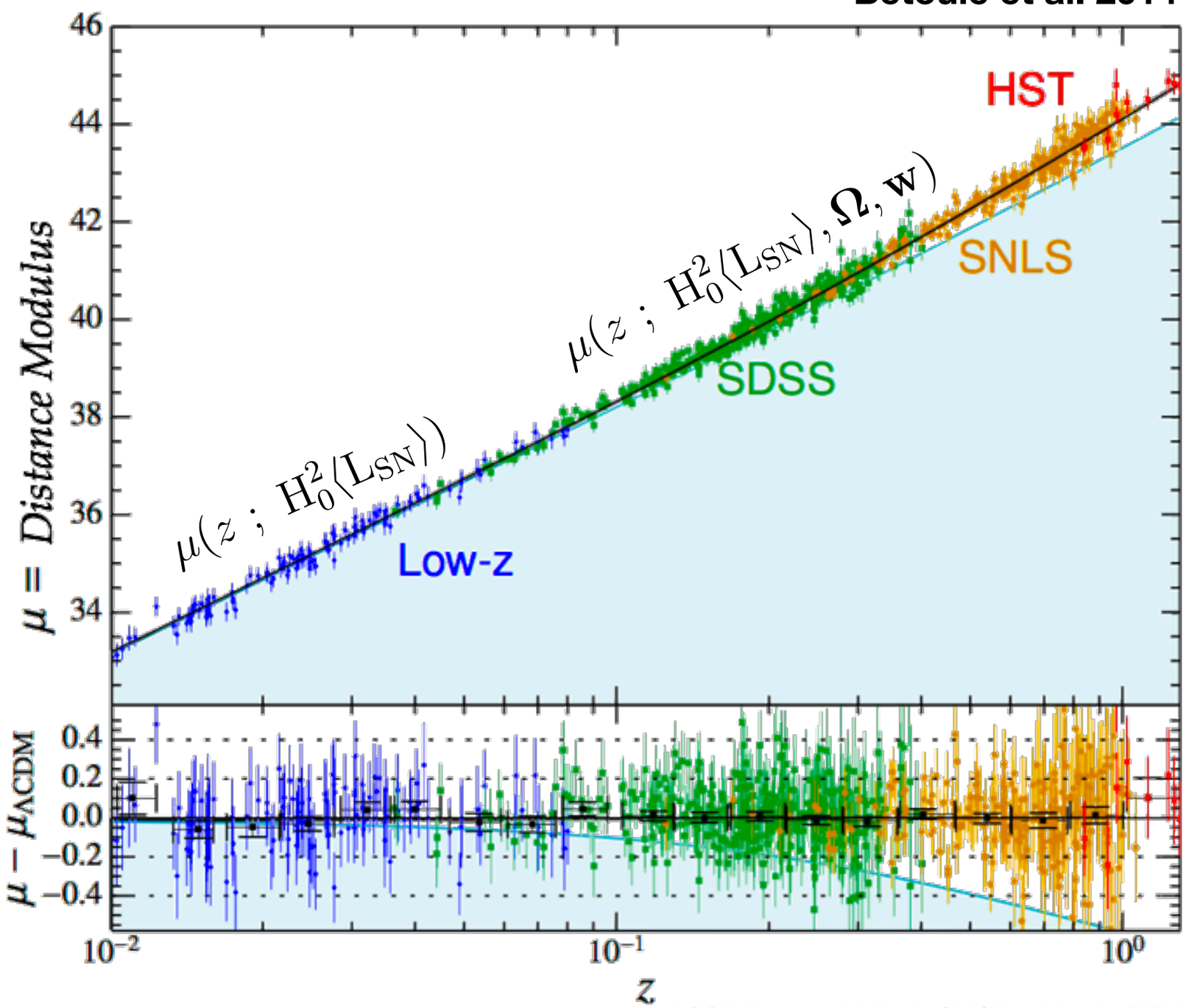
Hubble diagram

Betoule et al. 2014



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Hubble diagram

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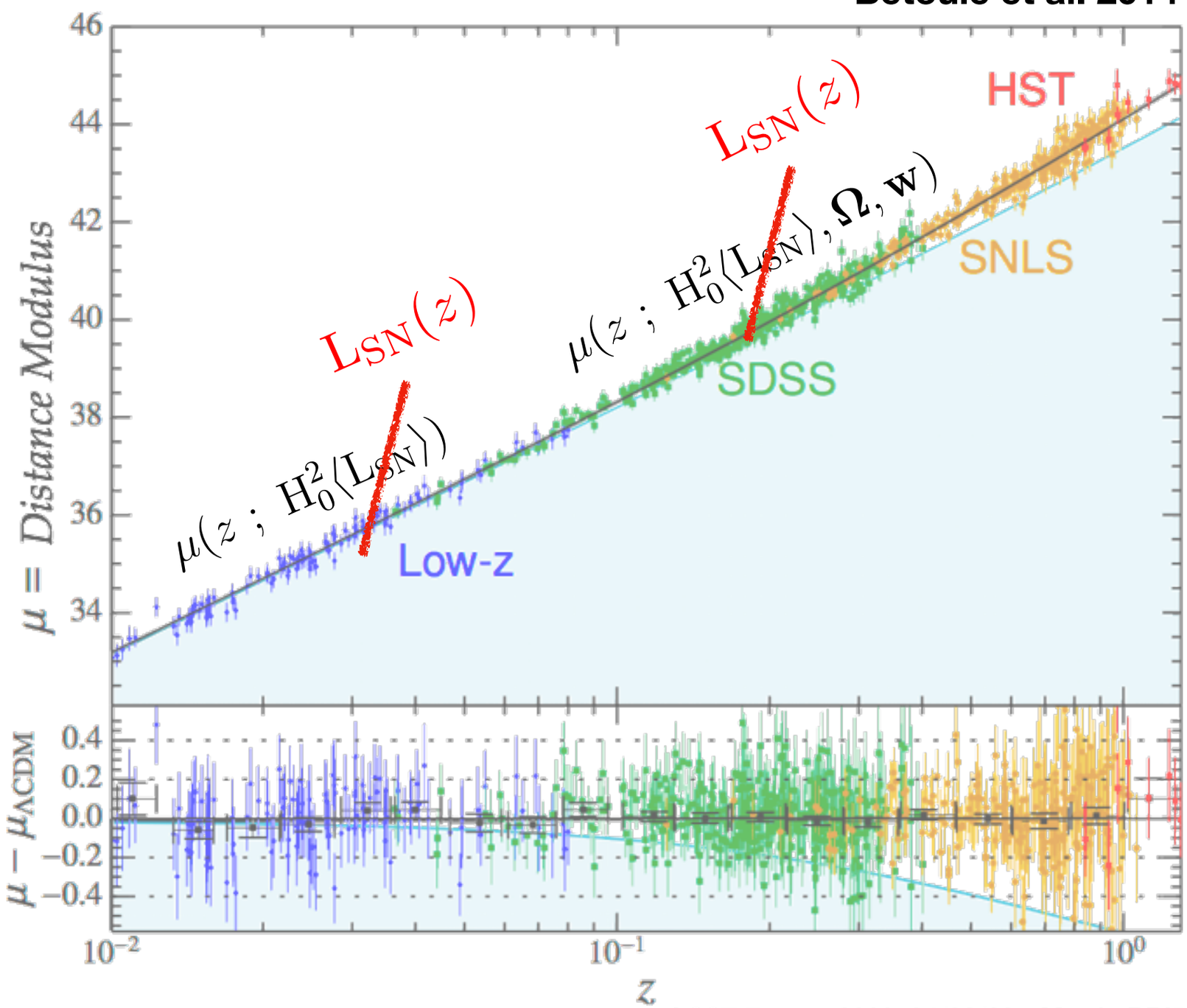

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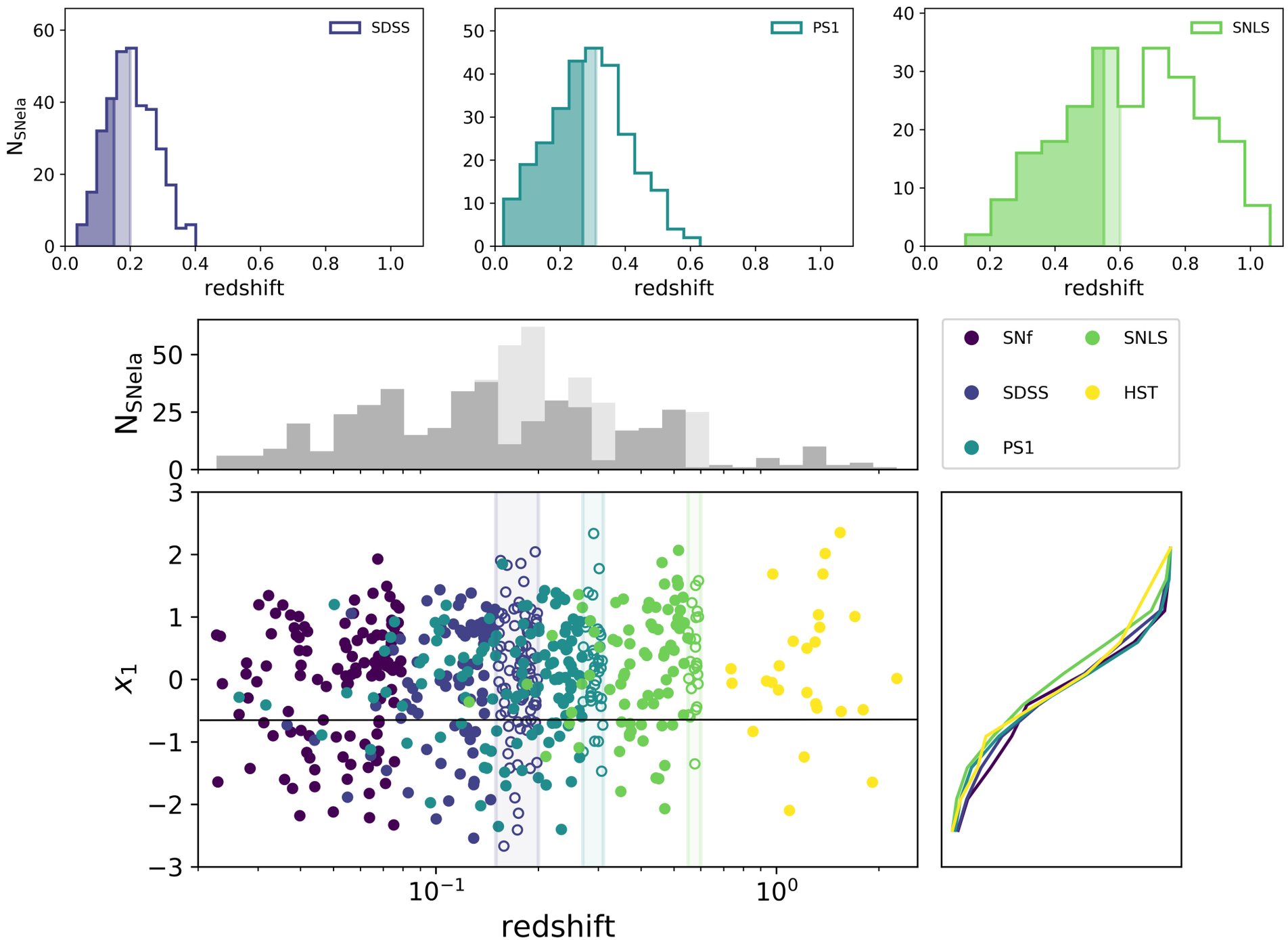
Complete sample

— free from selection effects —



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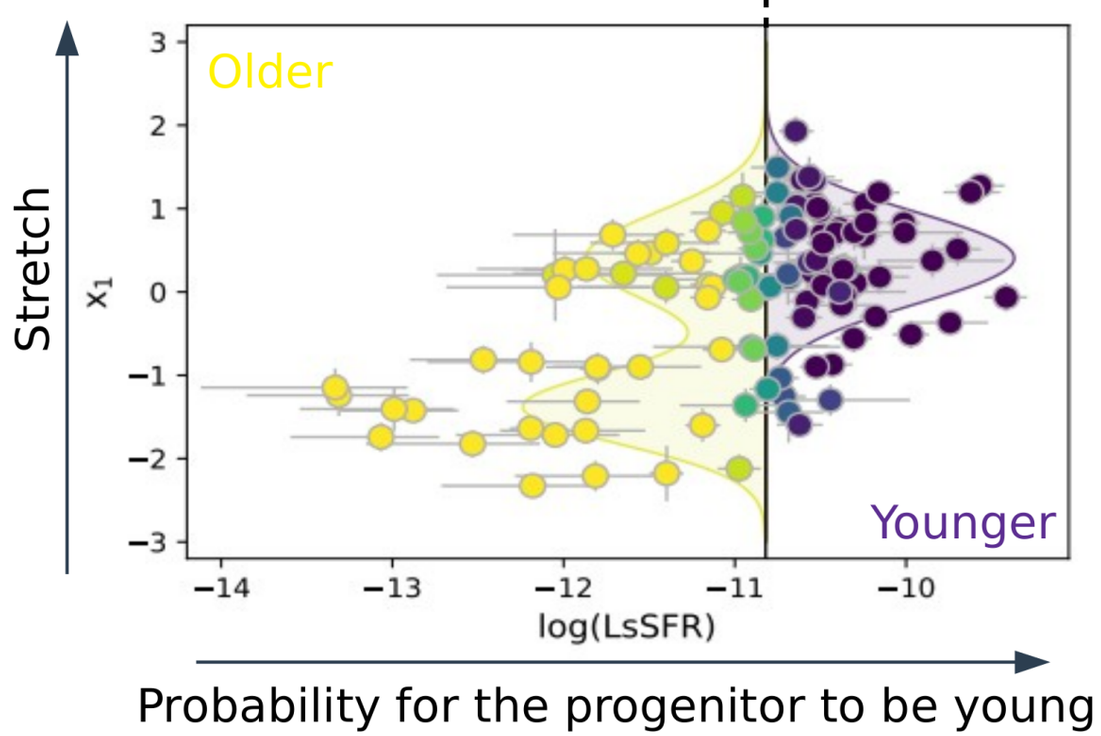
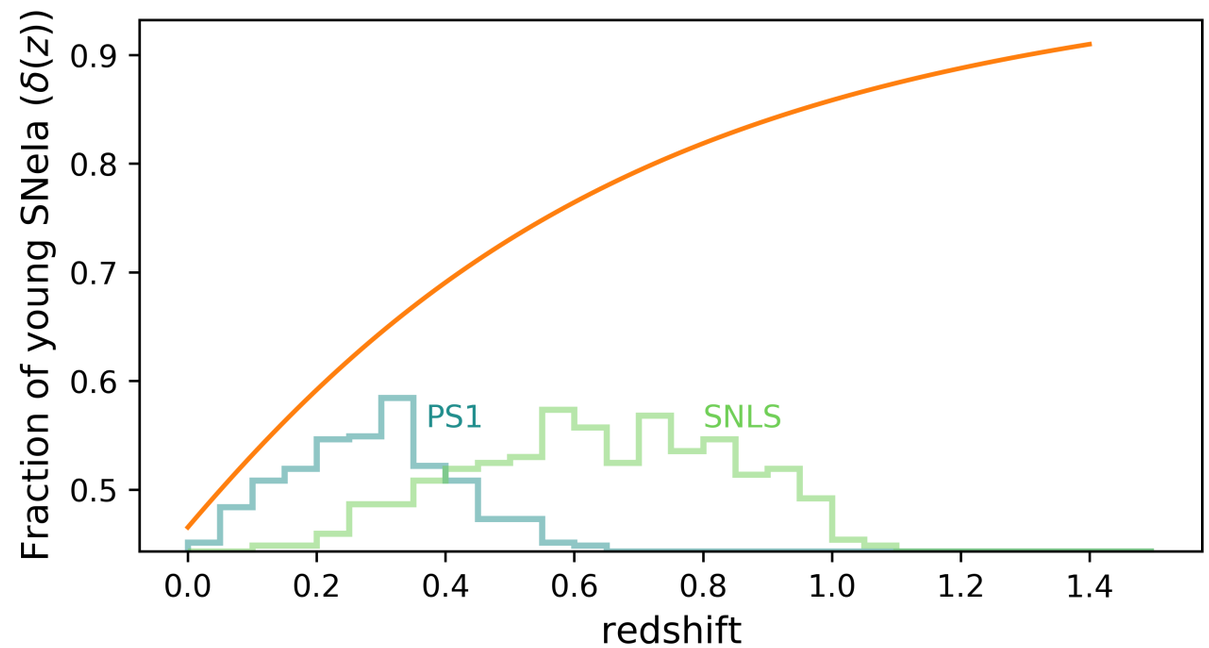
Why do we expect a stretch evolution?

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

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





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

Rigault et al. (2018), K=0.87, Φ=2.8

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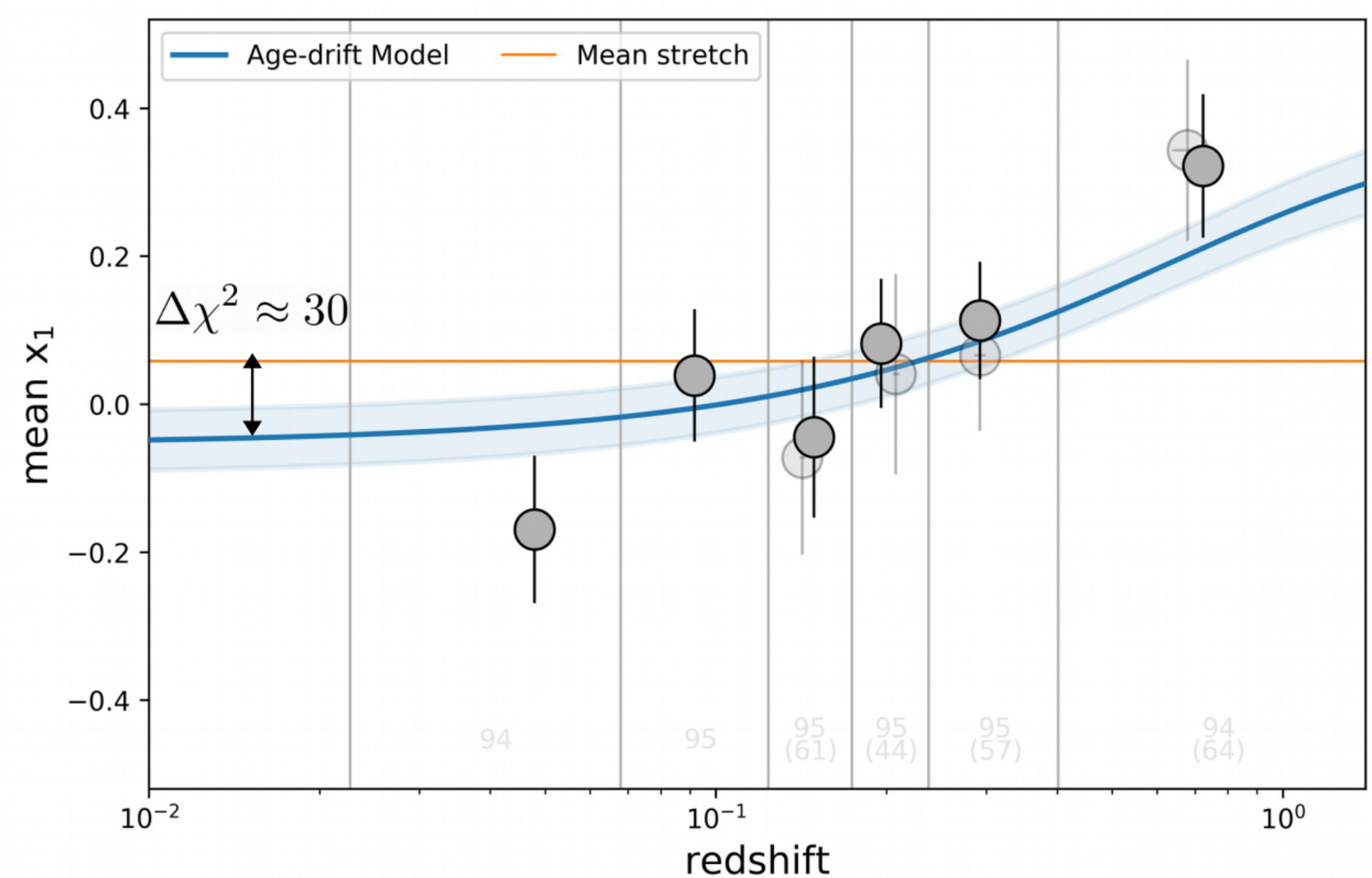
Implementation to dataset

Nicolas et al. (in prep)

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



Comparison with all data combined

Model fitted on **all** data

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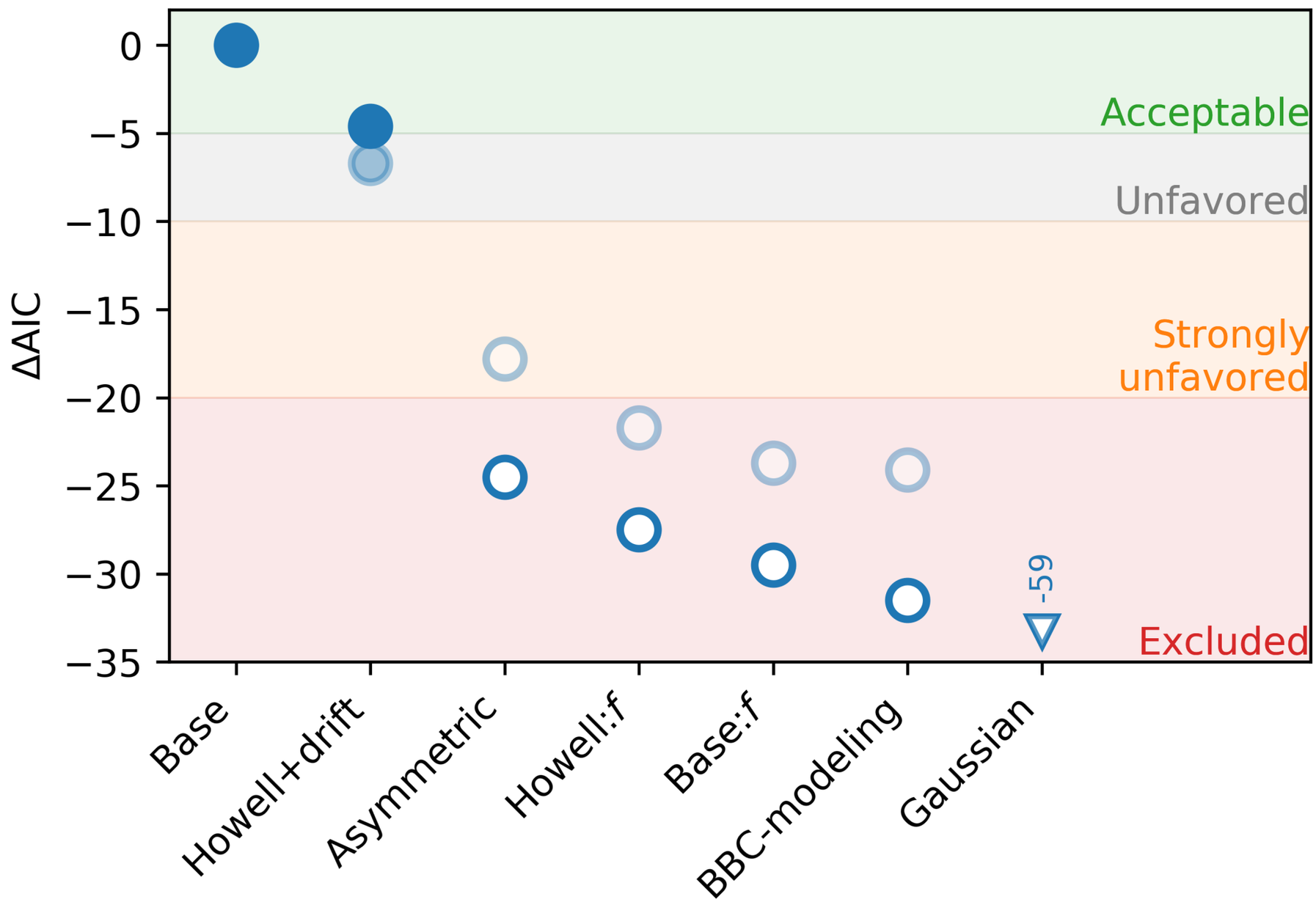
Comparison results



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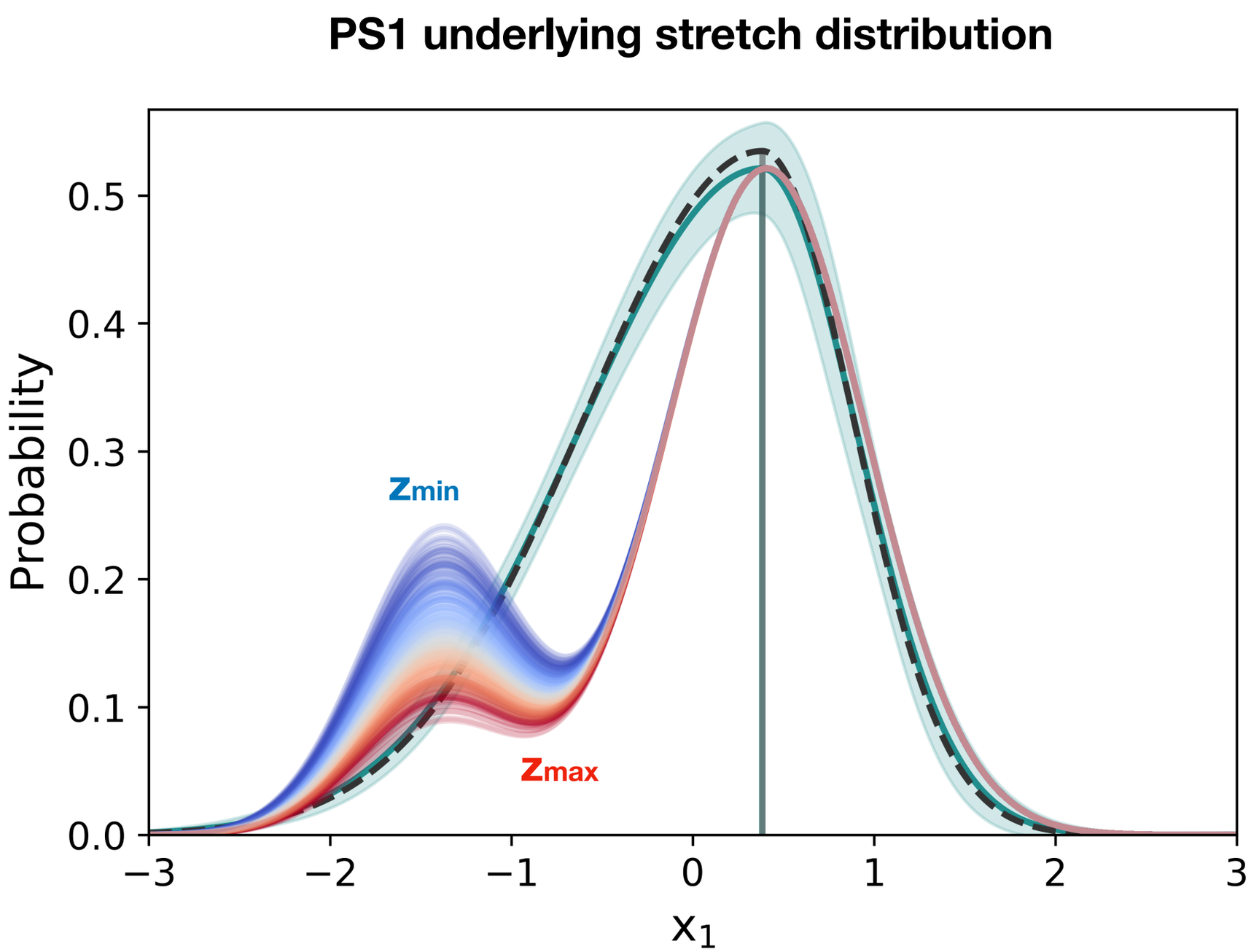
BBC modeling



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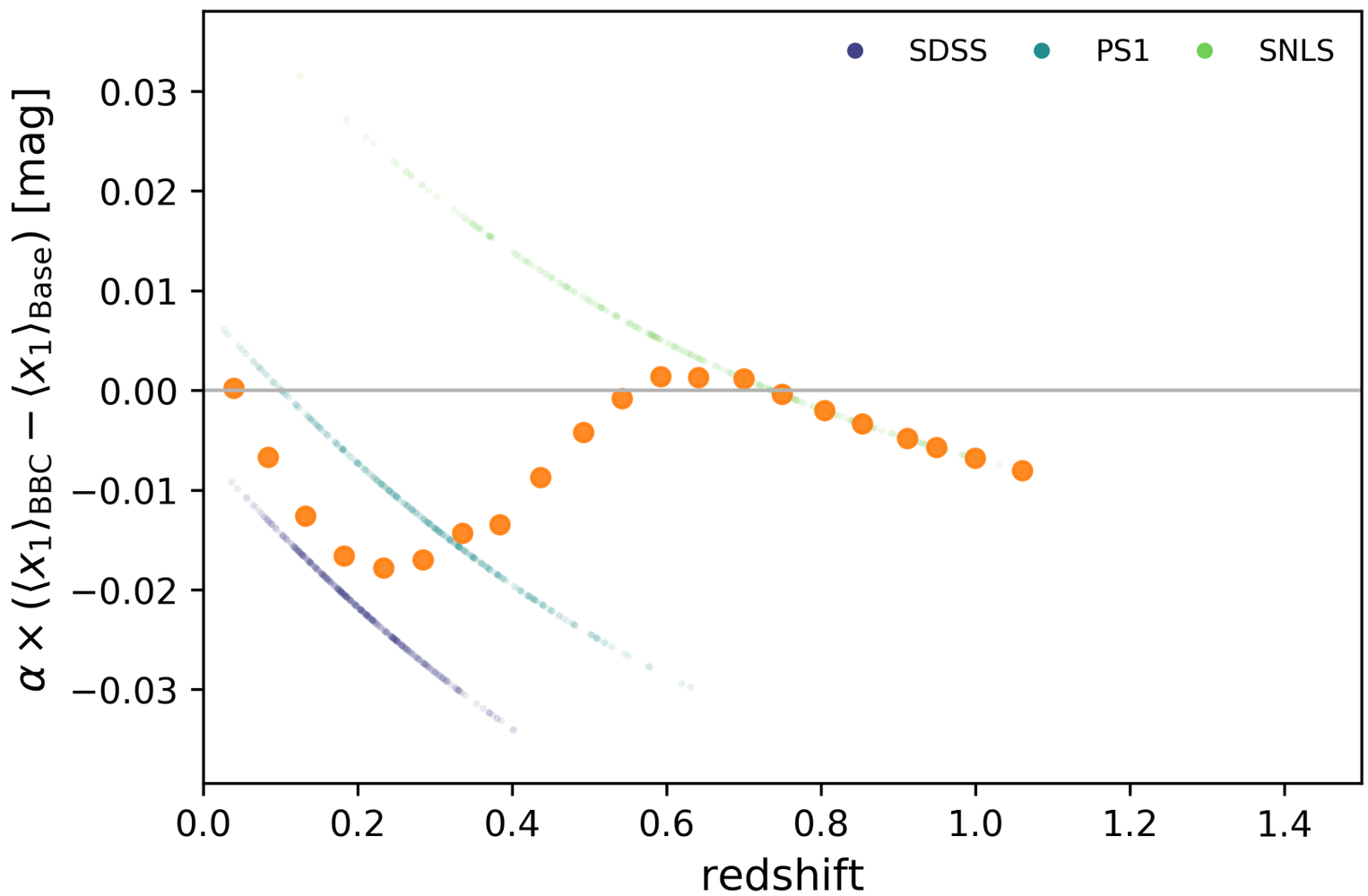
Cosmology impact



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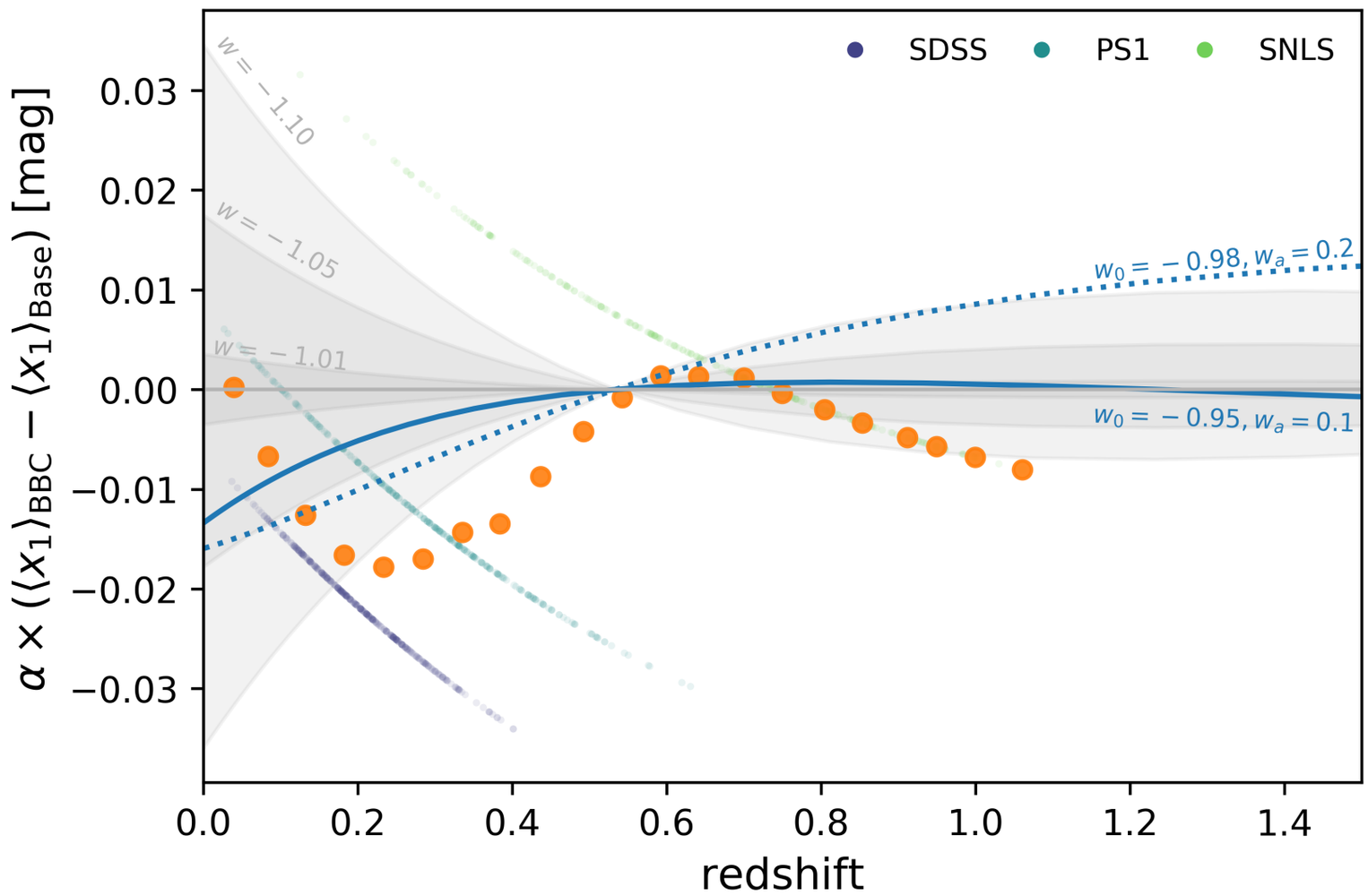
Cosmology impact



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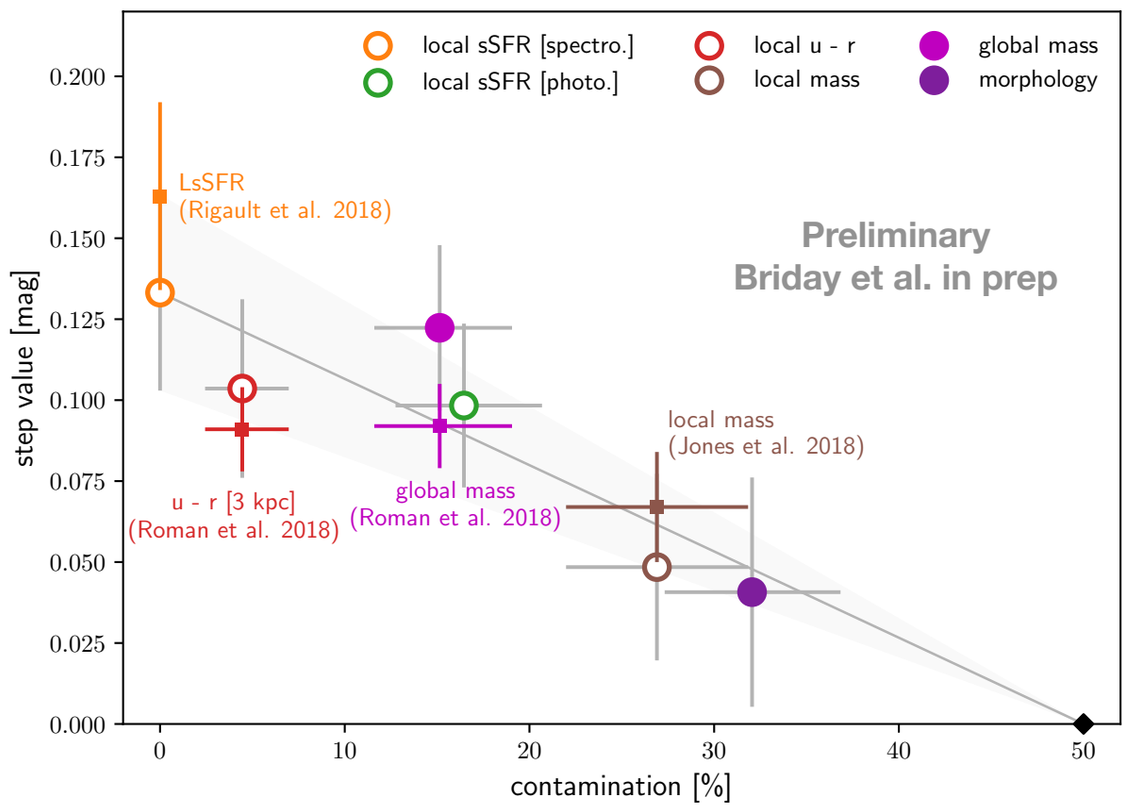
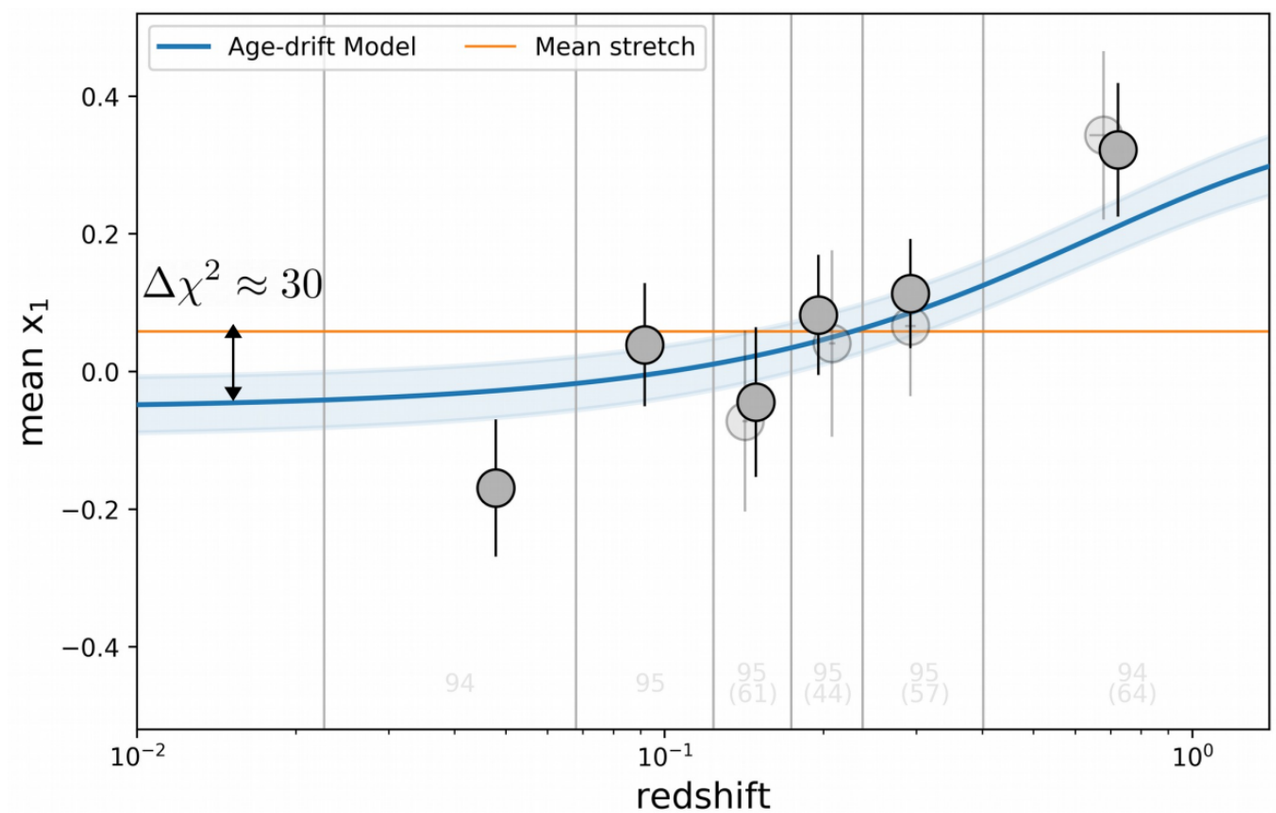
Conclusions



Understand why ≠ analyses found ≠ steps.

Clarify that age-bias is driving the host biases



Showing SN stretch redshift drift

Good agreement with age-drifting model

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Thanks for your attention

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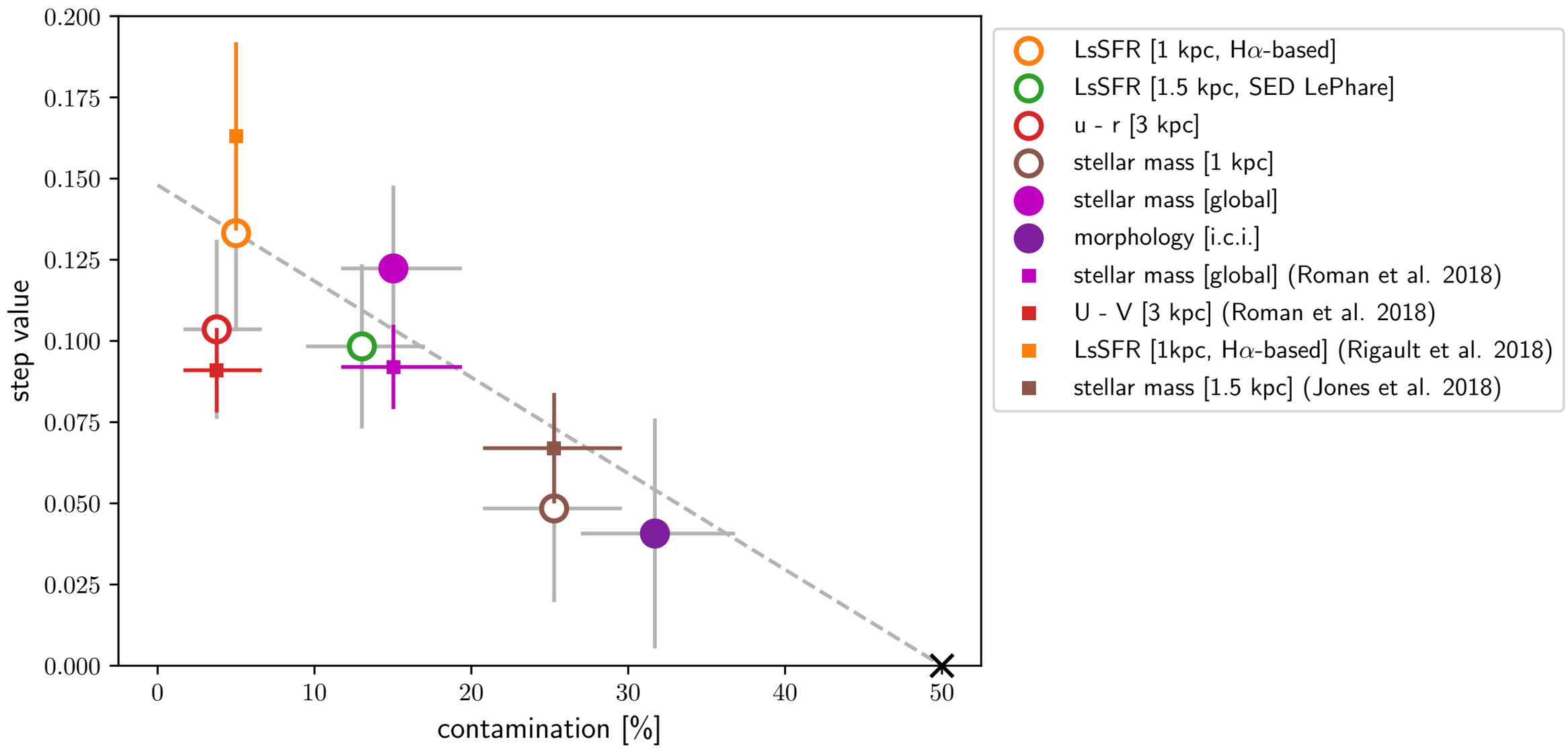
Back-up



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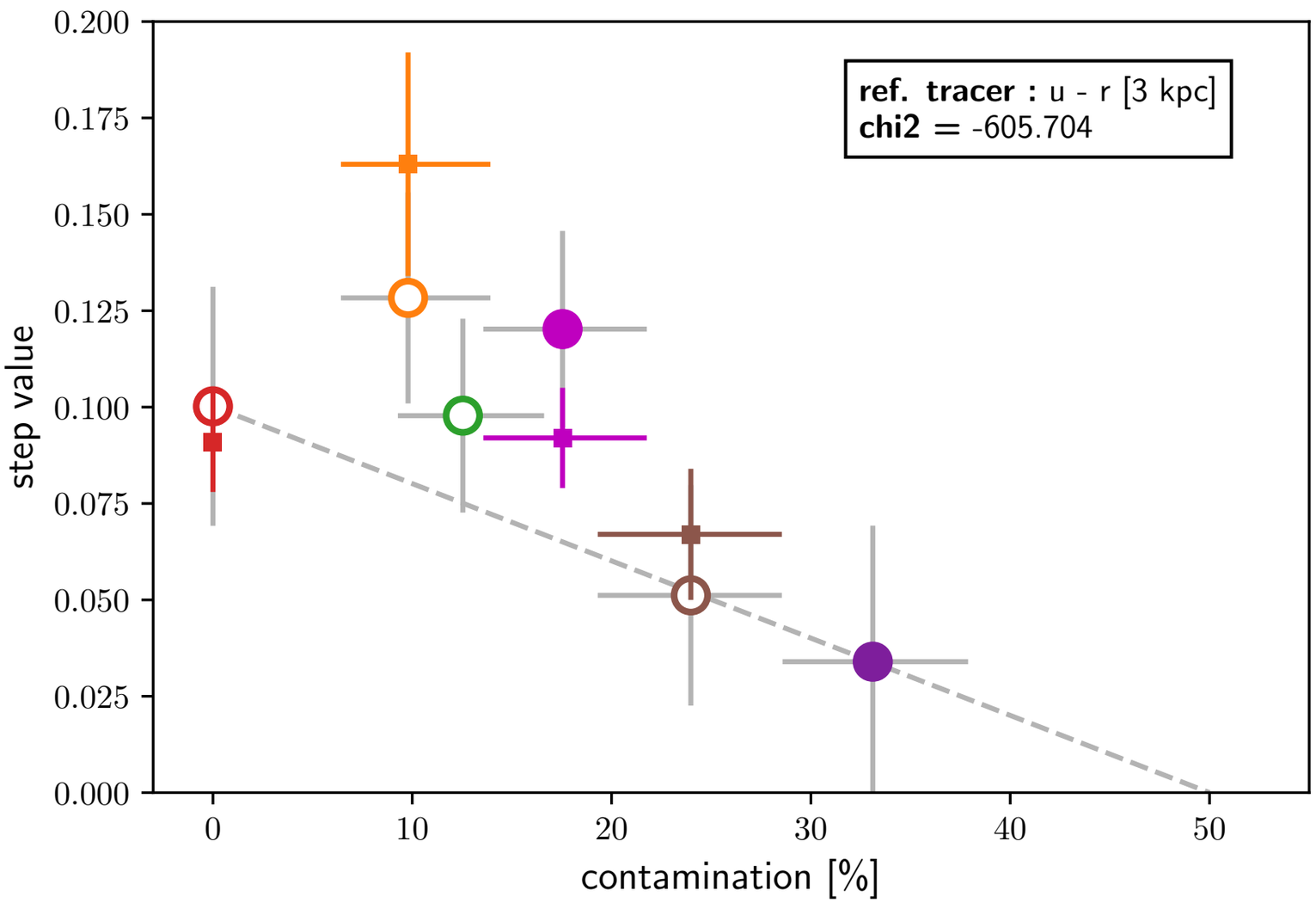

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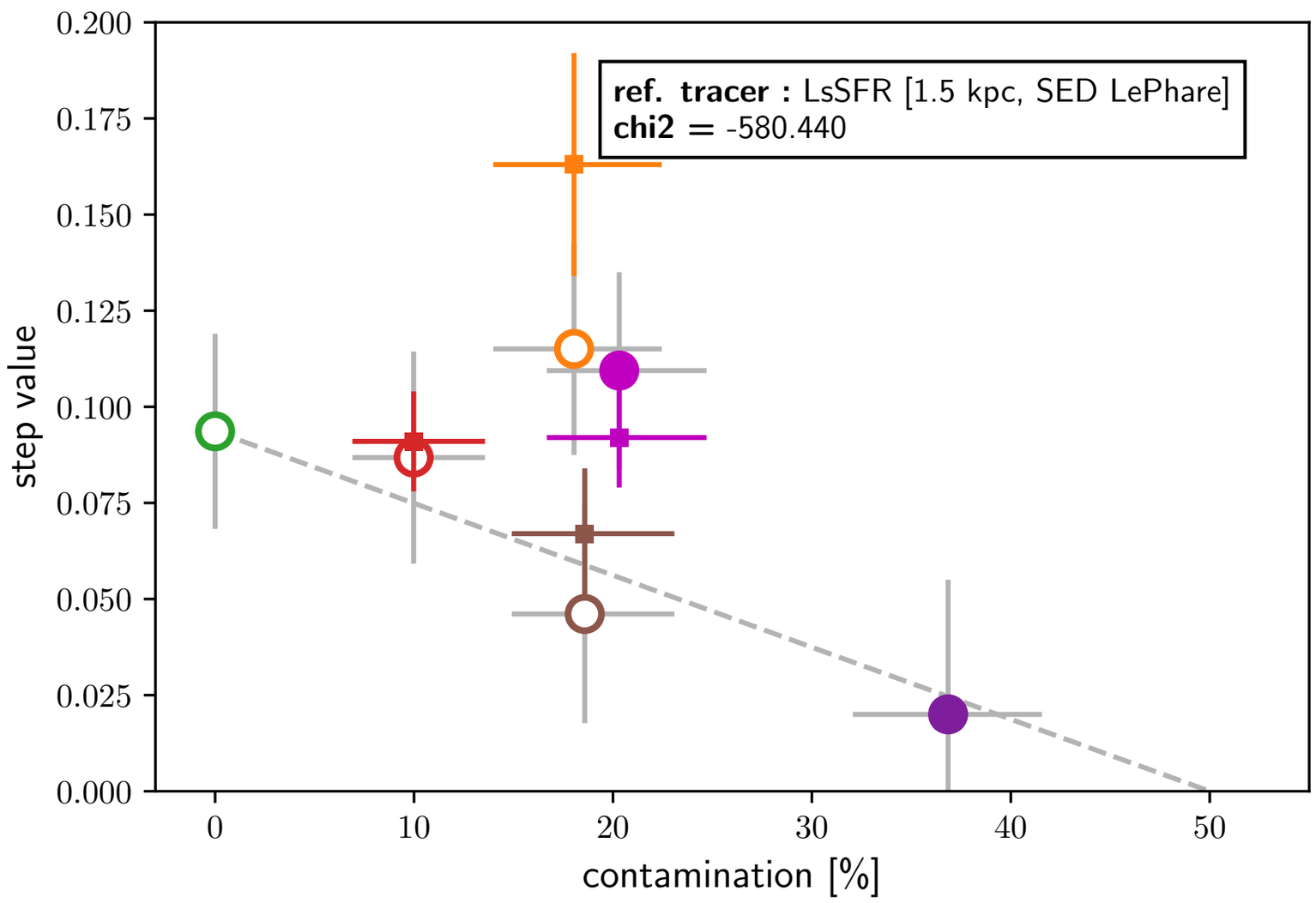

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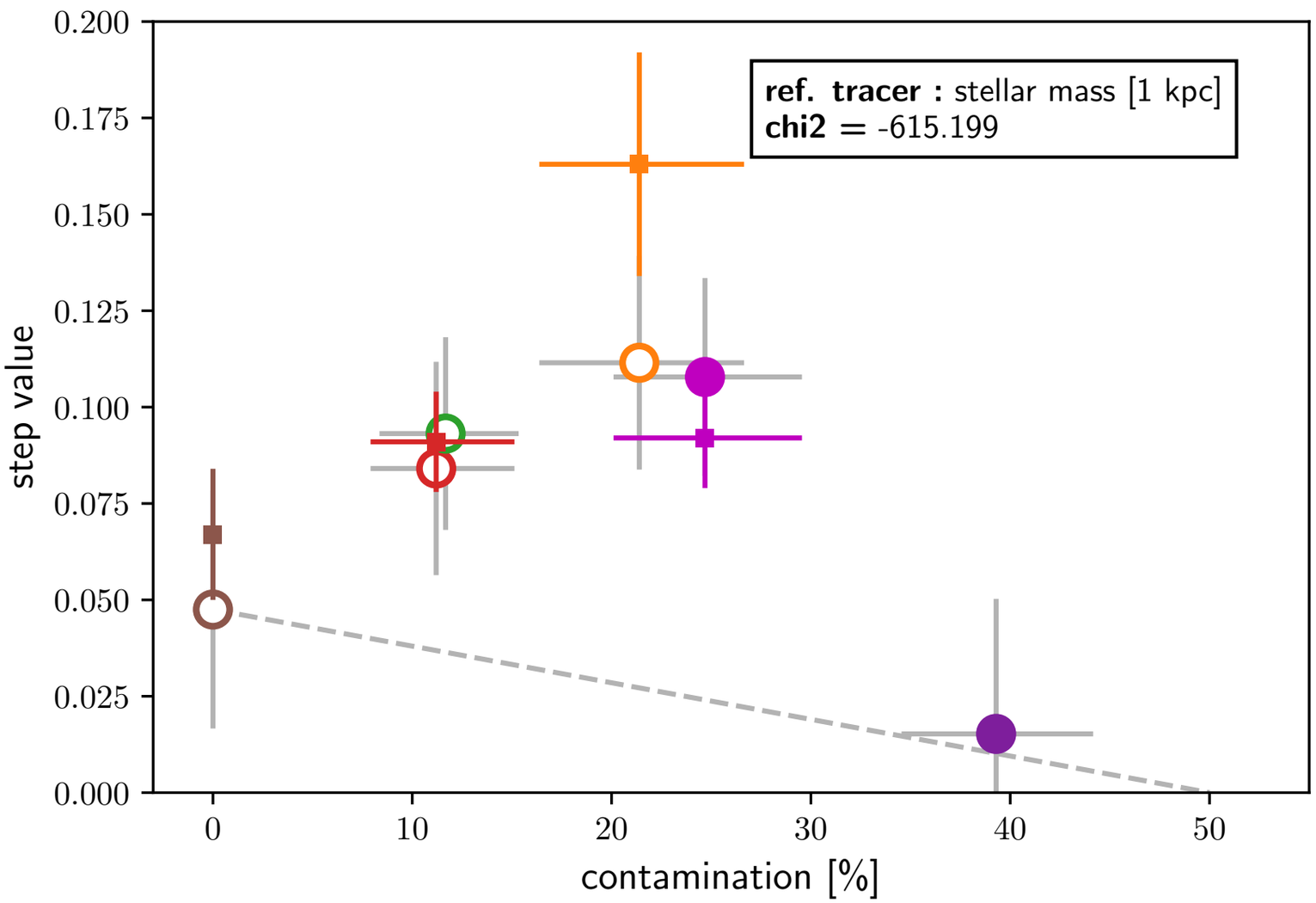

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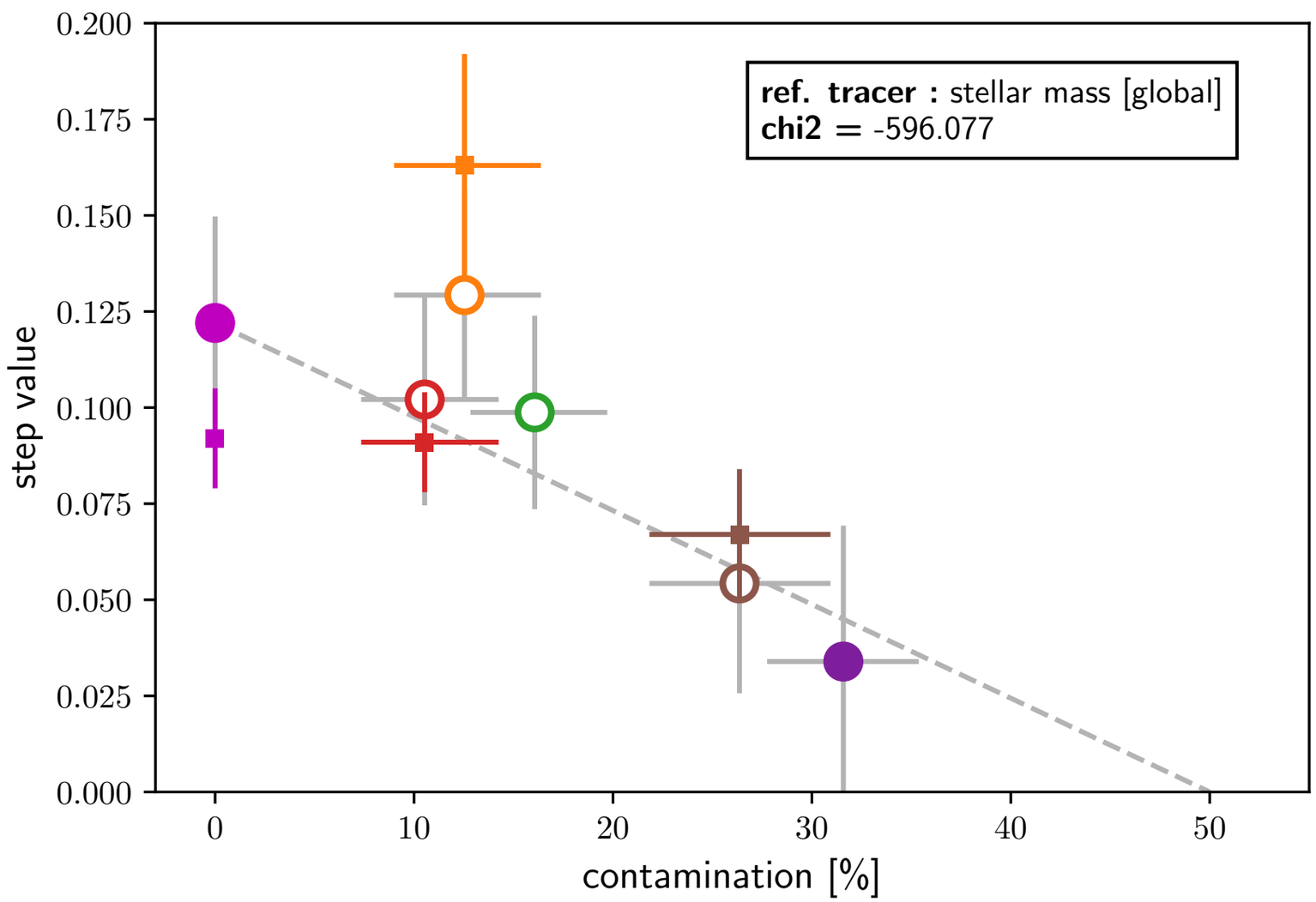

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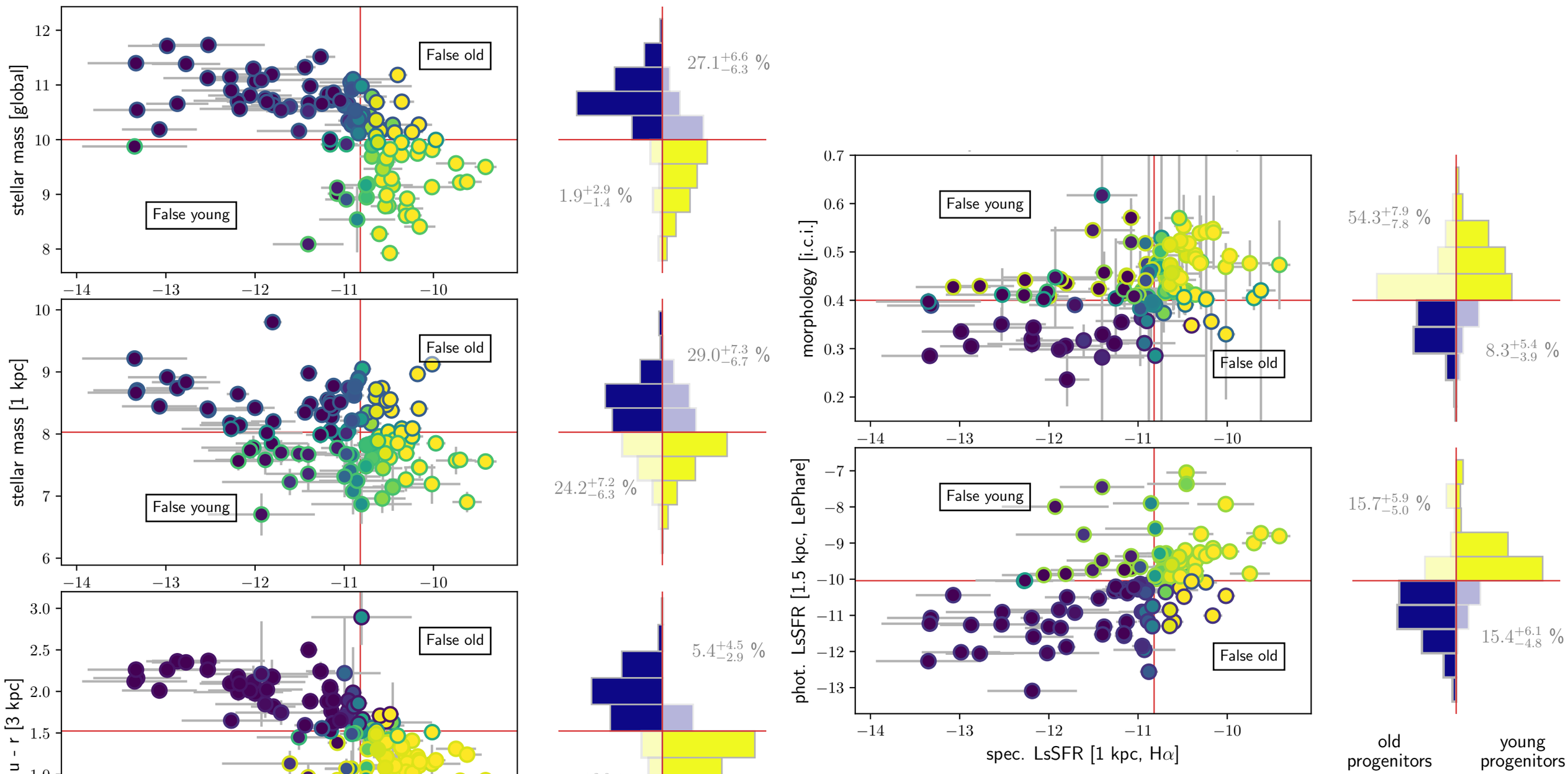

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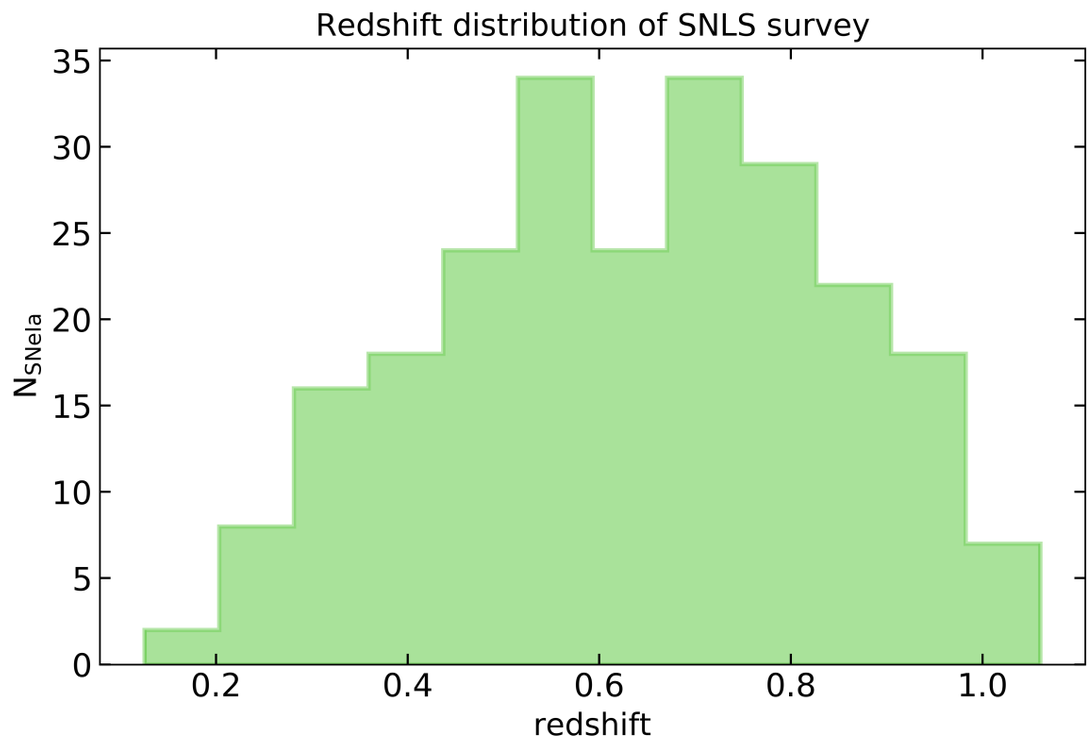
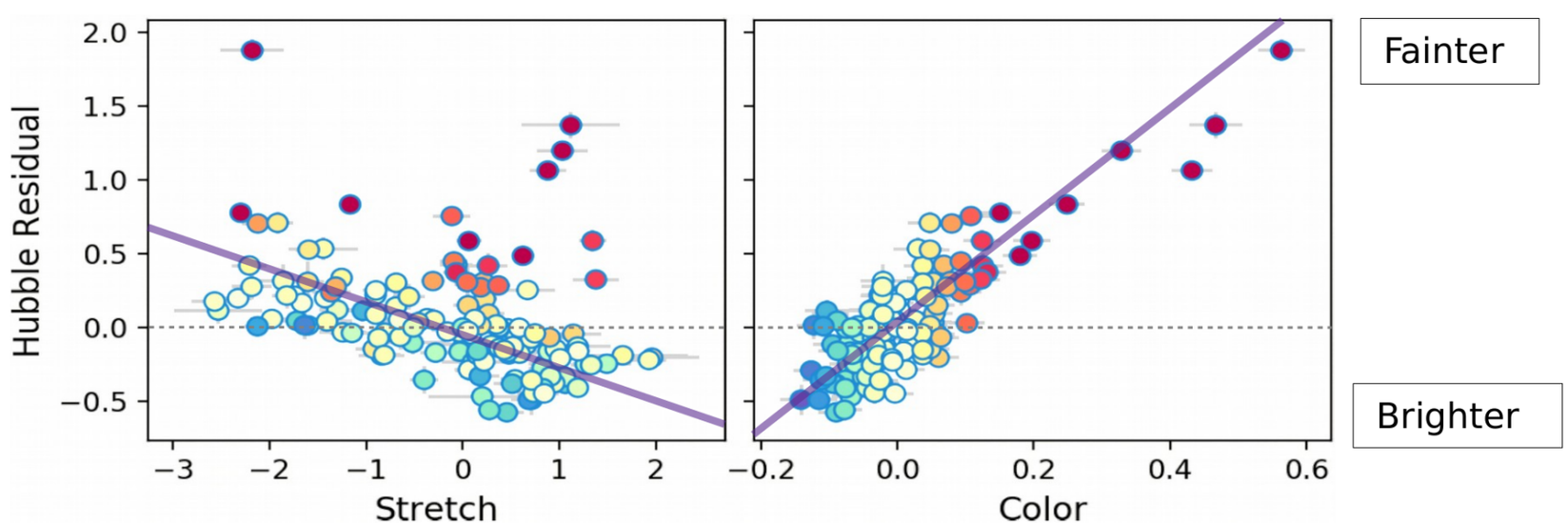
Selection effects





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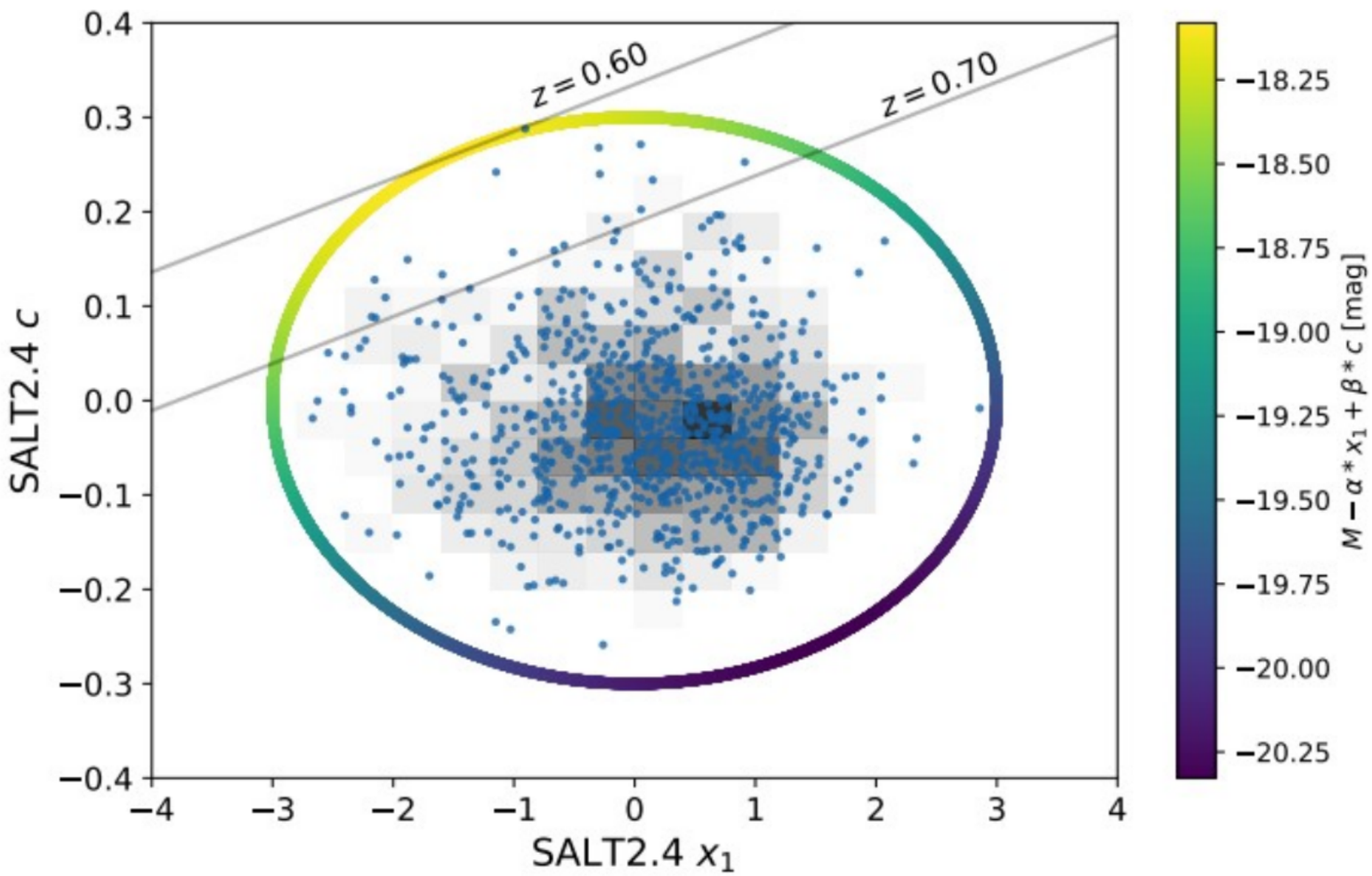
Magnitude-limited surveys from the Pantheon dataset

$$m_{\mathrm{lim}} = 24.8\,\mathrm{mag}$$ (SNLS)

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



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

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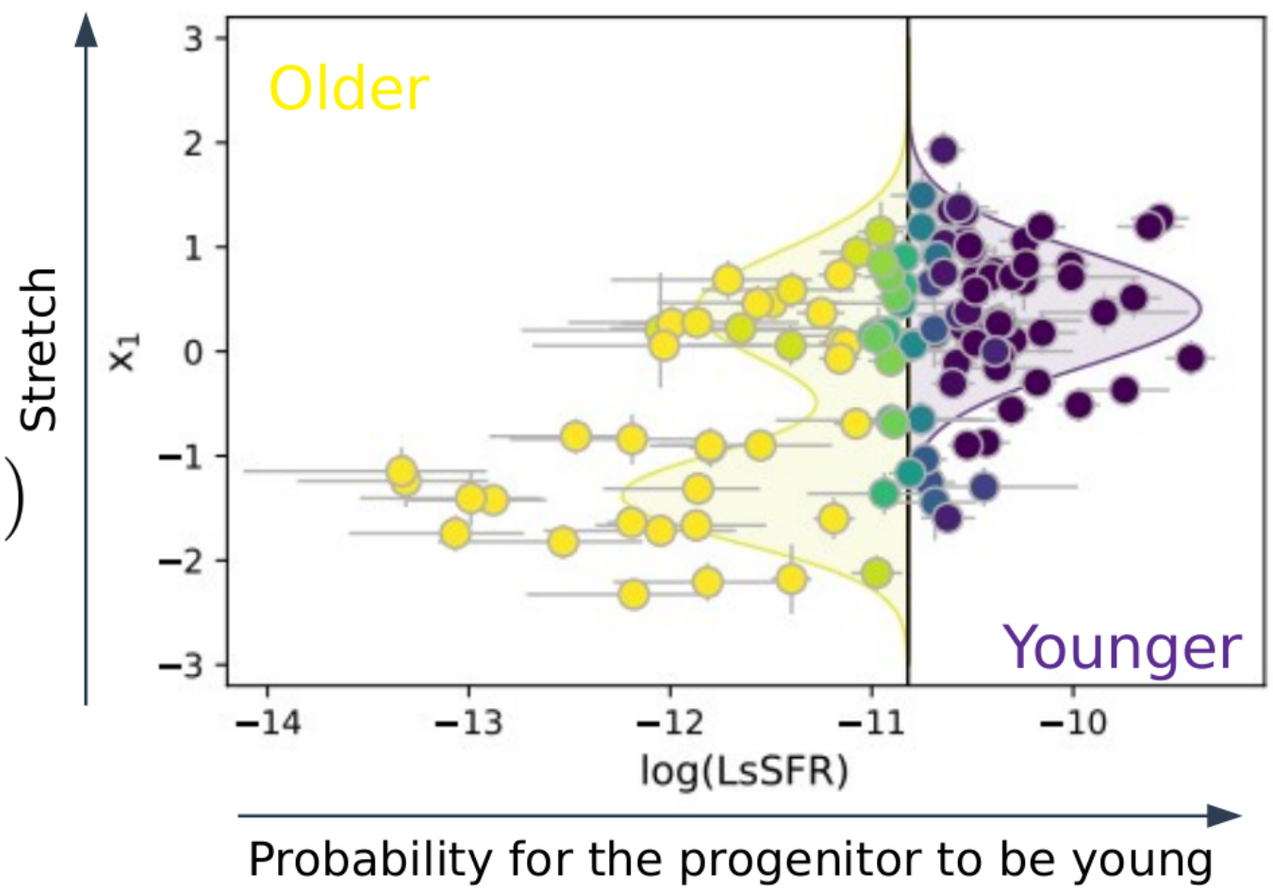
Base model

Nicolas et al. (in prep)

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



$$\mathcal{N}_1 \equiv \mathcal{N}(\boxed{\mu_1}, \boxed{\sigma_1})$$

$$X_1 = p(\text{young}) \times \mathcal{N}_1 + (1 - p(\text{young})) \times (a\mathcal{N}_1 + (1 - a)\mathcal{N}_2)$$

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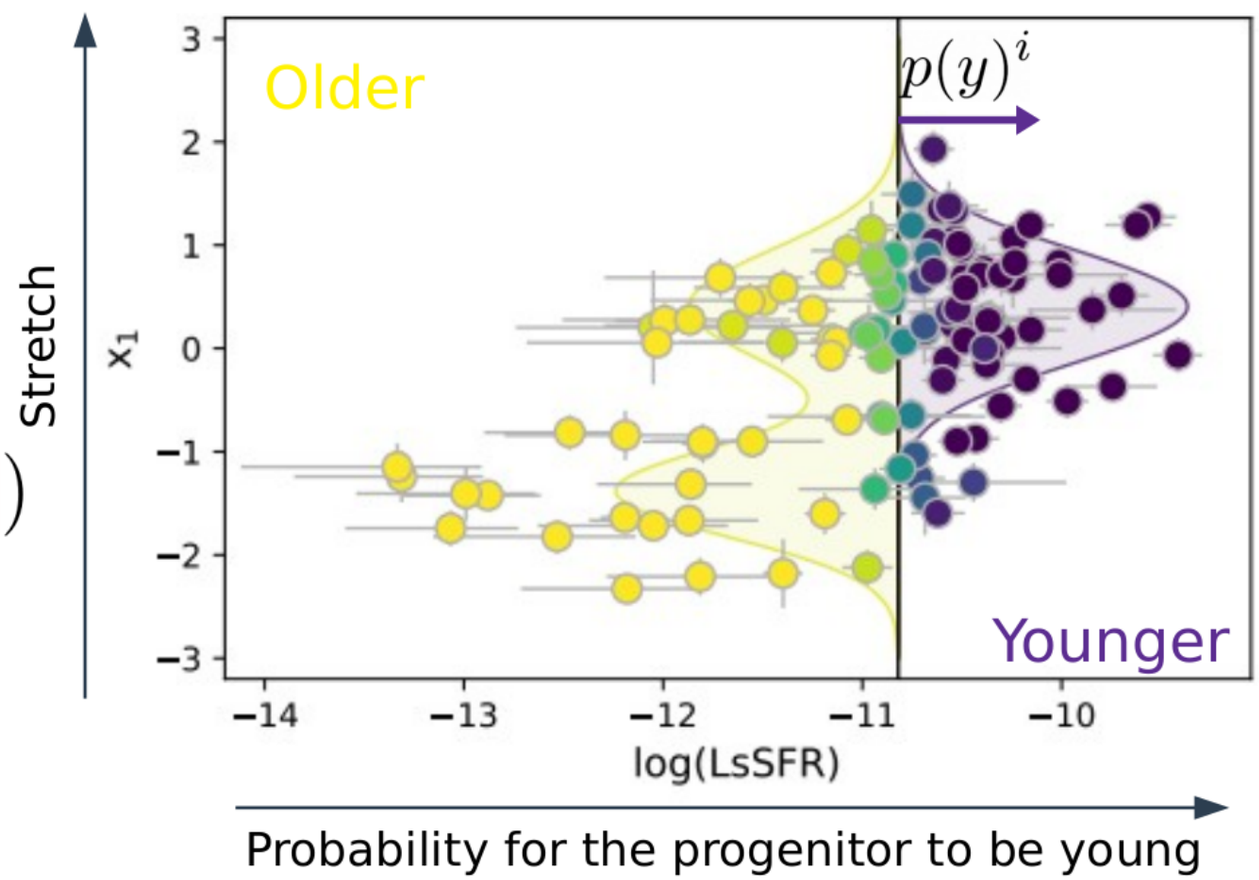
Base model

Nicolas et al. (in prep)

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



$$\mathcal{N}_1 \equiv \mathcal{N}(\mu_1, \sigma_1)$$

Underlying stretch distribution

$$X_1 = p(\text{young}) \times \mathcal{N}_1 + (1 - p(\text{young})) \times (a\mathcal{N}_1 + (1-a)\mathcal{N}_2)$$

In SNf

$$\mathcal{P}\left(x_1^i; p(y)^i\right) = p(y)^i \times \mathcal{N}_1(x_1^i) + (1 - p(y)^i) \times (a\mathcal{N}_1(x_1^i) + (1-a)\mathcal{N}_2(x_1^i))$$

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Base model

Nicolas et al. (in prep)

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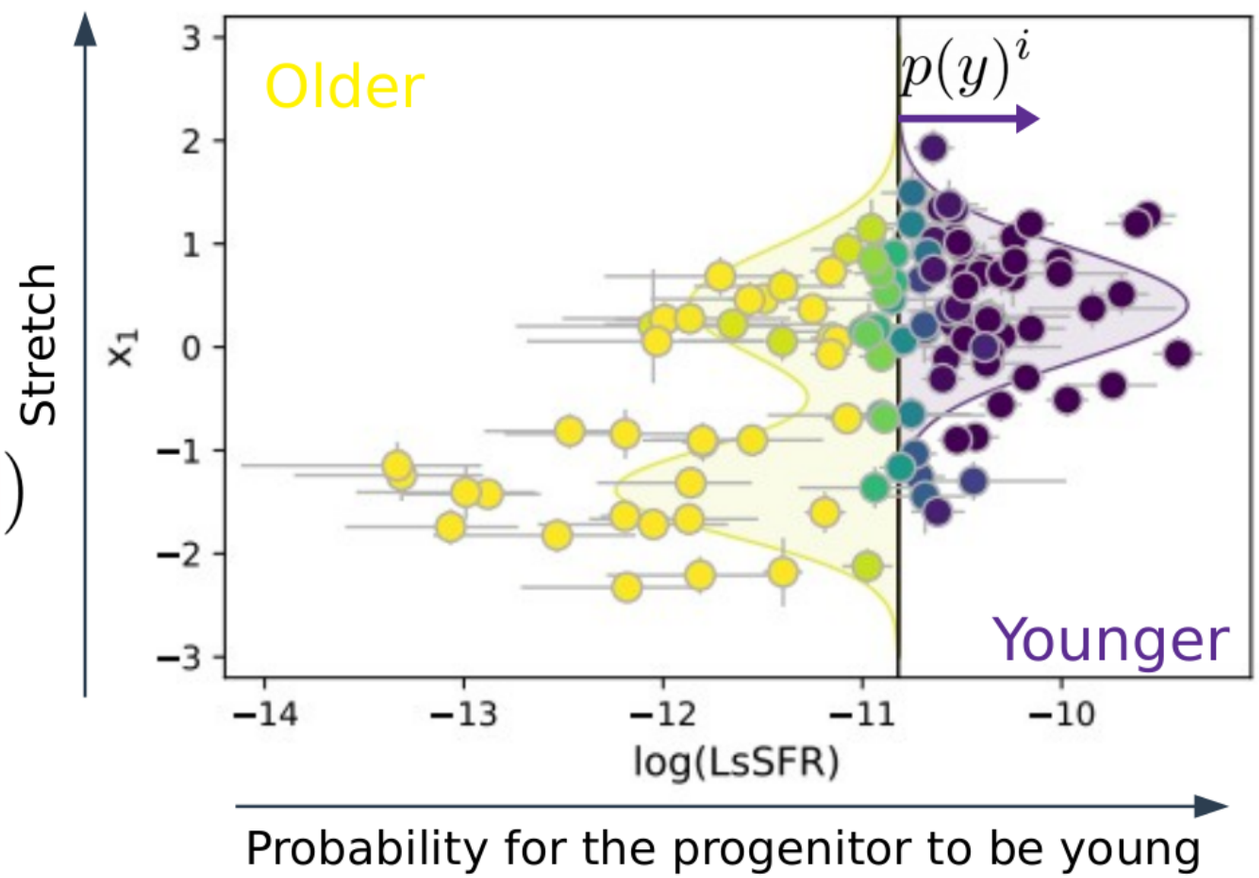

$$\mathcal{N}_1 \equiv \mathcal{N}(\mu_1, \sigma_1)$$

Underlying stretch distribution

$$X_1 = p(\text{young}) \times \mathcal{N}_1 + (1 - p(\text{young})) \times (a\mathcal{N}_1 + (1-a)\mathcal{N}_2)$$

Not in SNf

$$\mathcal{P}\left(x_1^i; z^i\right) = \delta(z^i) \times \mathcal{N}_1(x_1^i) + (1 - \delta(z^i)) \times (a\mathcal{N}_1(x_1^i) + (1-a)\mathcal{N}_2(x_1^i))$$

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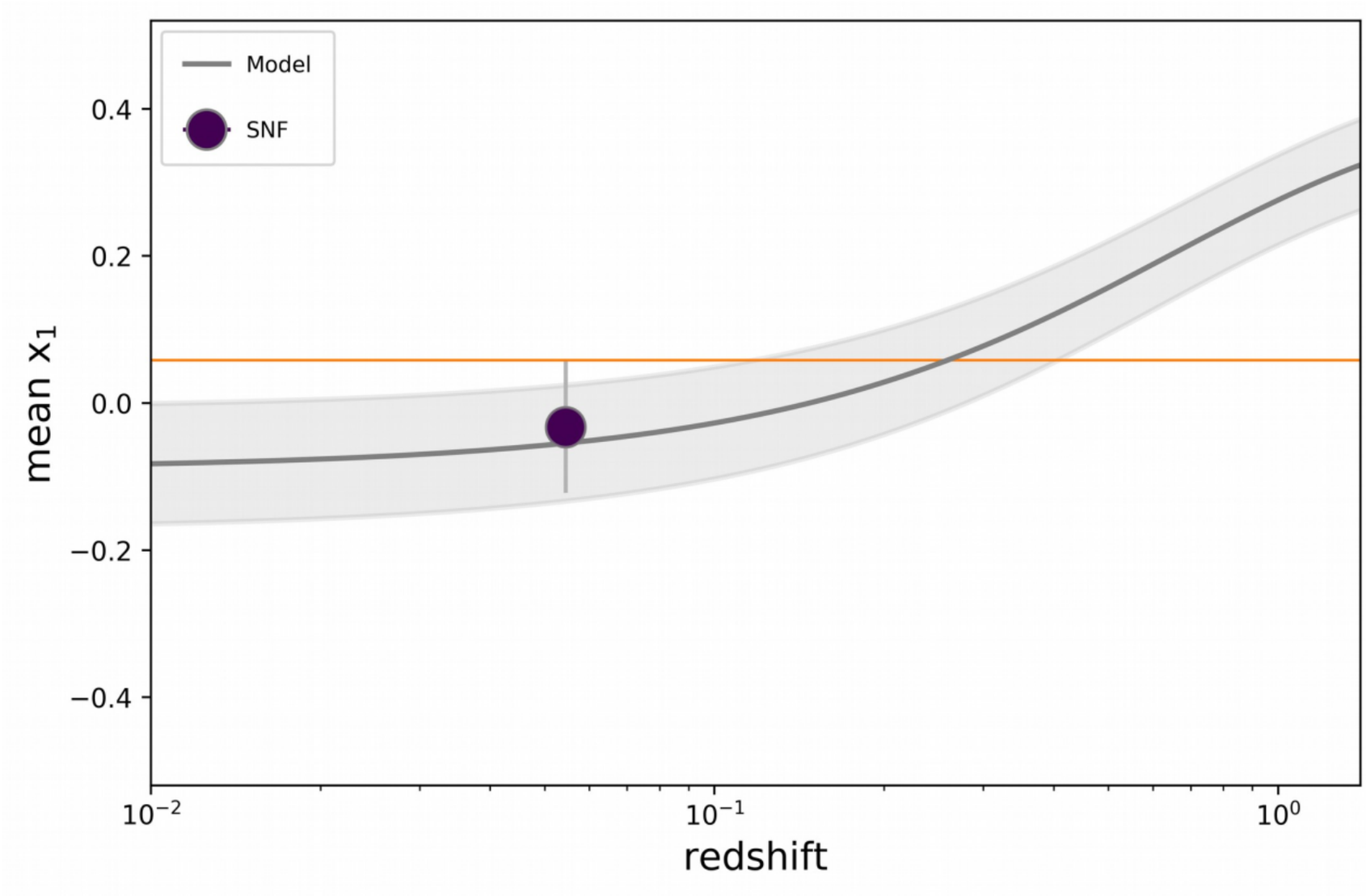
Implementation to dataset

Nicolas et al. (in prep)

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



Comparison with other surveys

Model fitted on **SNf** data

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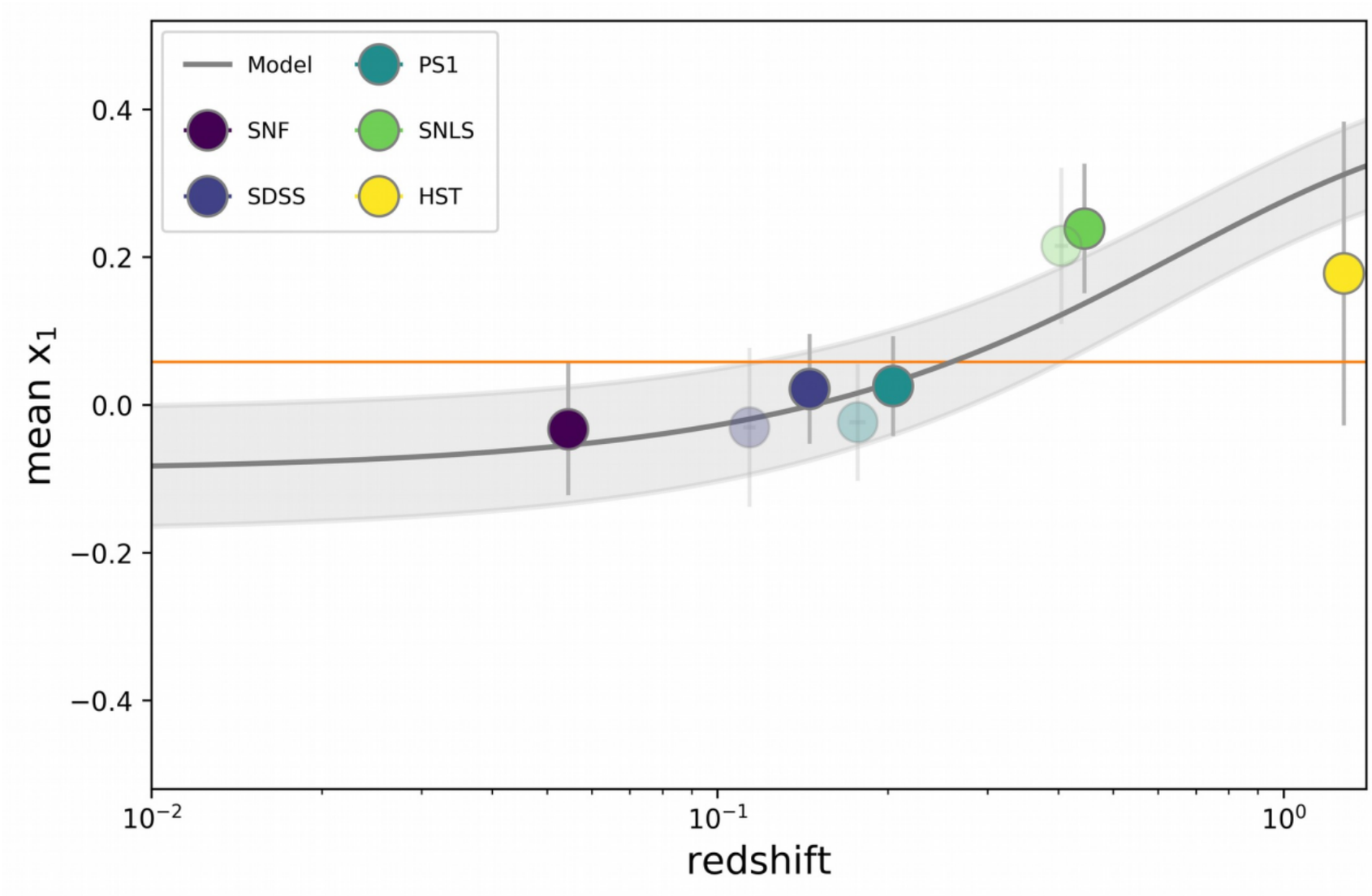
Implementation to dataset

Nicolas et al. (in prep)

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



Comparison with other surveys

Model fitted on **SNf** data

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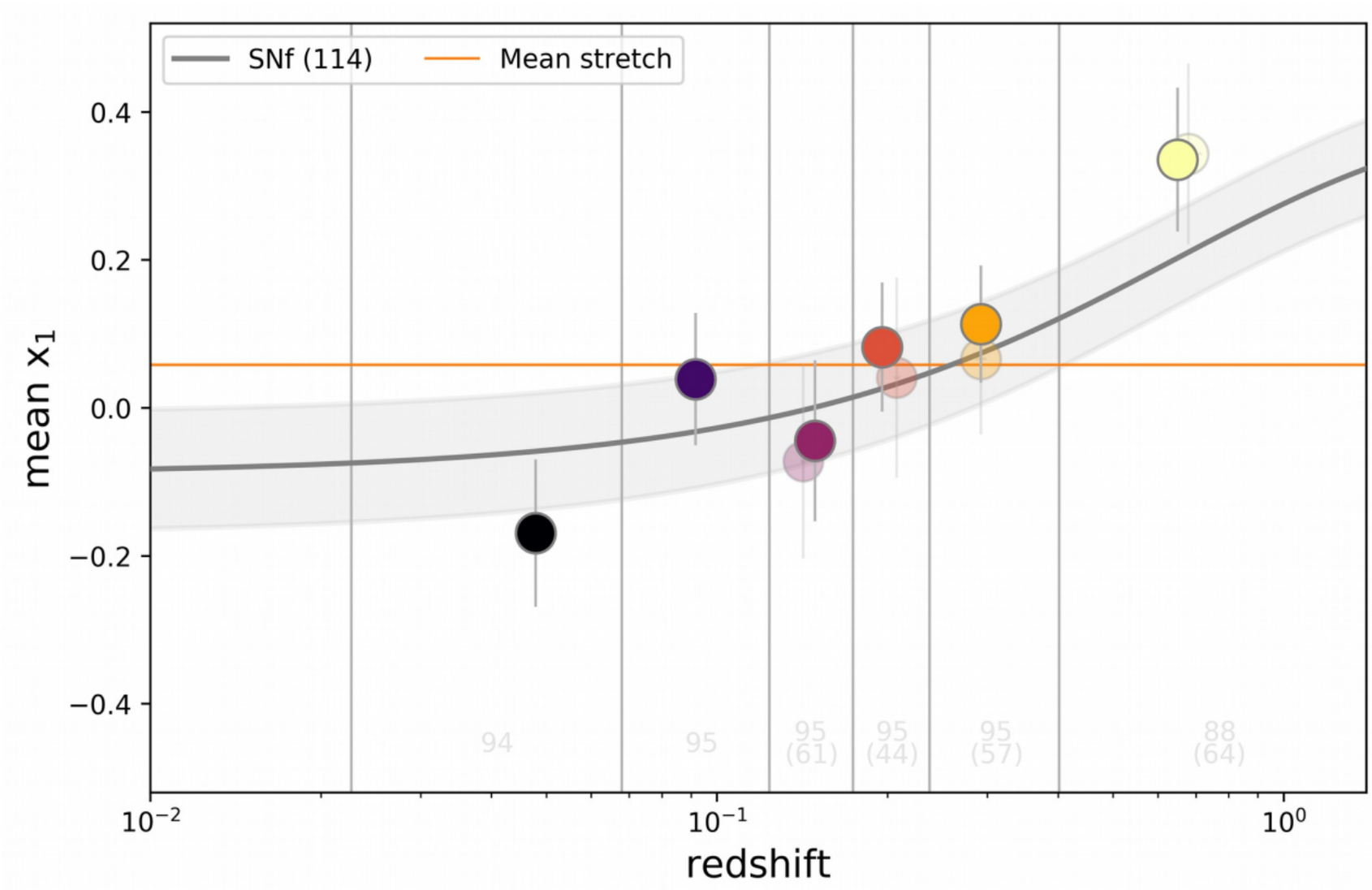
Implementation to dataset

Nicolas et al. (in prep)

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



Comparison with all data combined

Model fitted on **SNf** data

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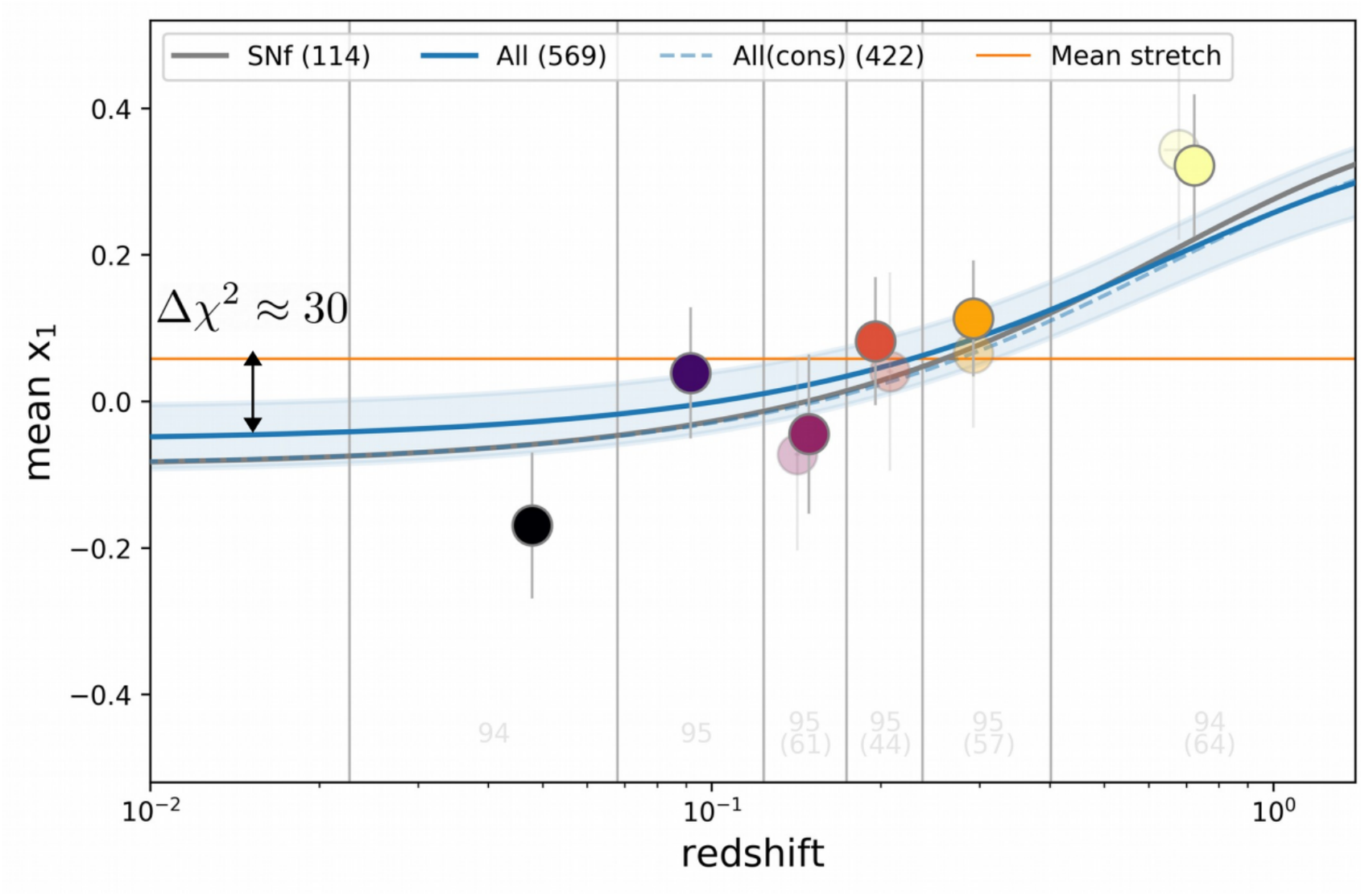
Implementation to dataset

Nicolas et al. (in prep)

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



Comparison with all data combined

Model fitted on **all** data

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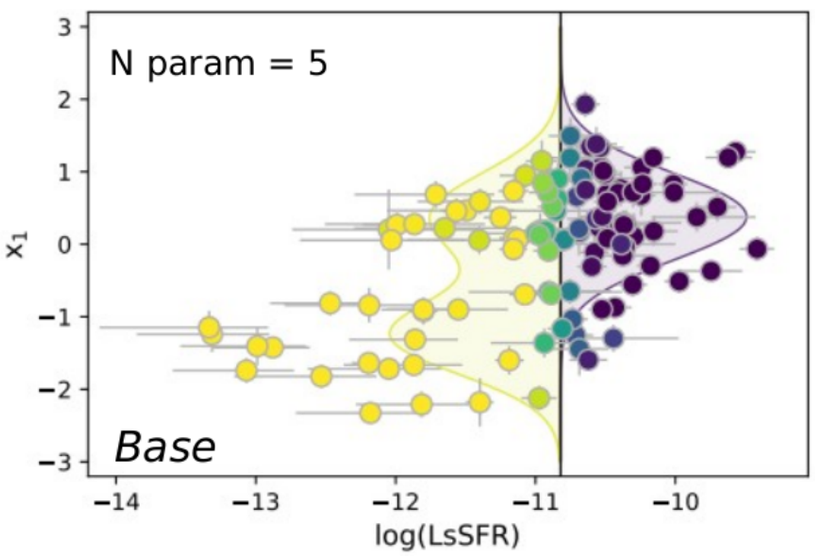
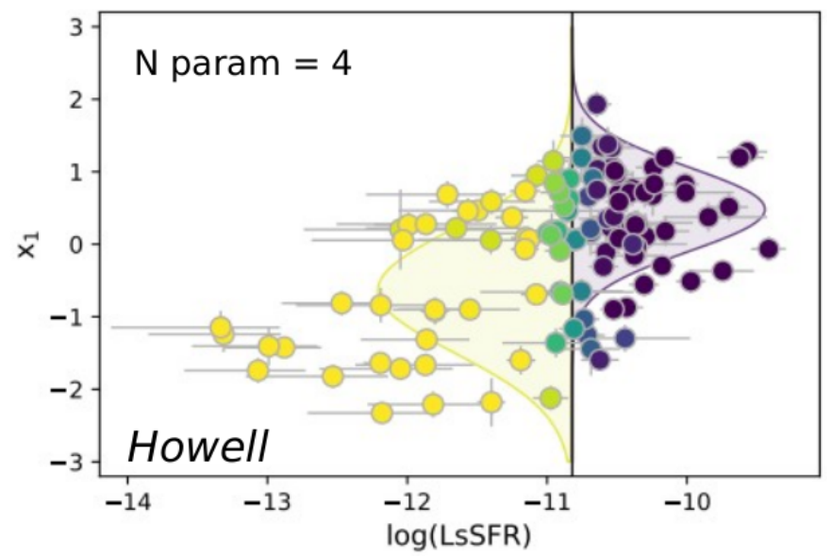
Other models

Nicolas et al. (in prep)
Cf Howell et al. (2007)

Underlying stretch model per age population





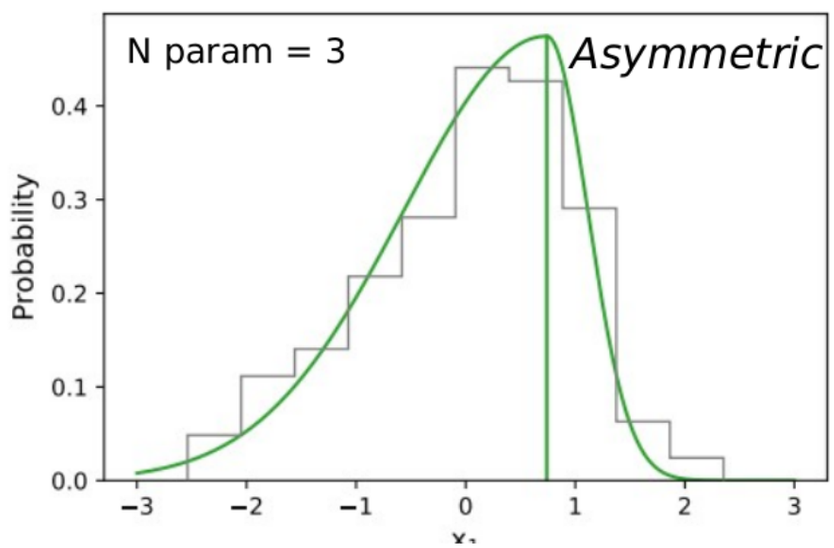
+

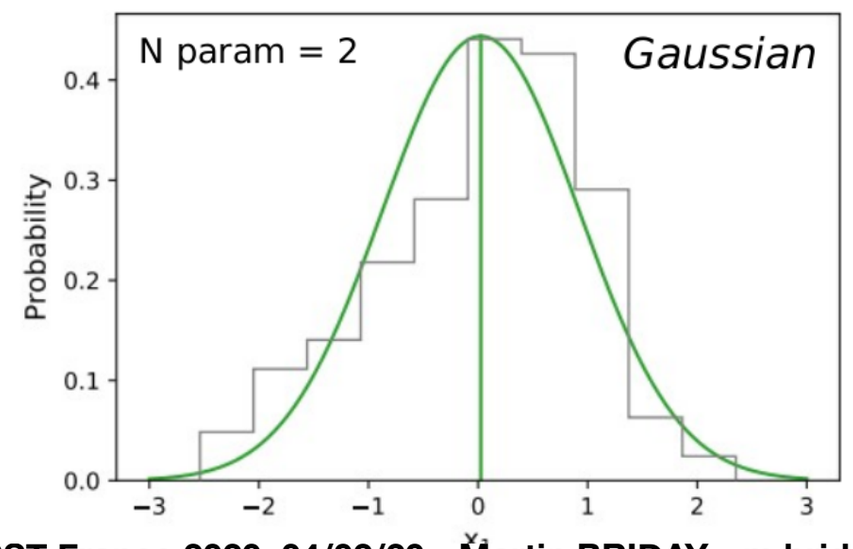
Drift

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

Or no drift

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





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Comparison method

$$\mathrm{AIC} = 2k - 2\ln(L)$$

$$k = \text{number of free parameters}$$

Values	Conclusion
$0 < \lvert\Delta\mathrm{AIC}\rvert < 5$	Acceptable
$2 < \lvert\Delta\mathrm{AIC}\rvert < 10$	Unfavored
$10 < \lvert\Delta\mathrm{AIC}\rvert < 20$	Strongly unfavored
$20 < \lvert\Delta\mathrm{AIC}\rvert < \infty$	Excluded

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Back-up

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