Automated mining of the ALMA Archive in the COSMOS Field (A^{3}COSMOS):

Measuring the dust and gas content of thousands of high-z star-forming galaxies

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Journées de la SF2A — S10 : Dust in galaxies: from the local interstellar medium to distant galaxies — 7-10 June 2022

Why starting a continuous ALMA data mining effort for COSMOS?

- COSMOS is a blind survey…

  …but no full/coordinated ALMA continuum coverage on the horizon

- The ALMA archive is ever-growing, particularly wherever there is rich ancillary data…

  …but one needs to continuously keep track of it

- The ALMA archive is well accessible…

  …but science-ready product still demands human interaction / expertise / infrastructure

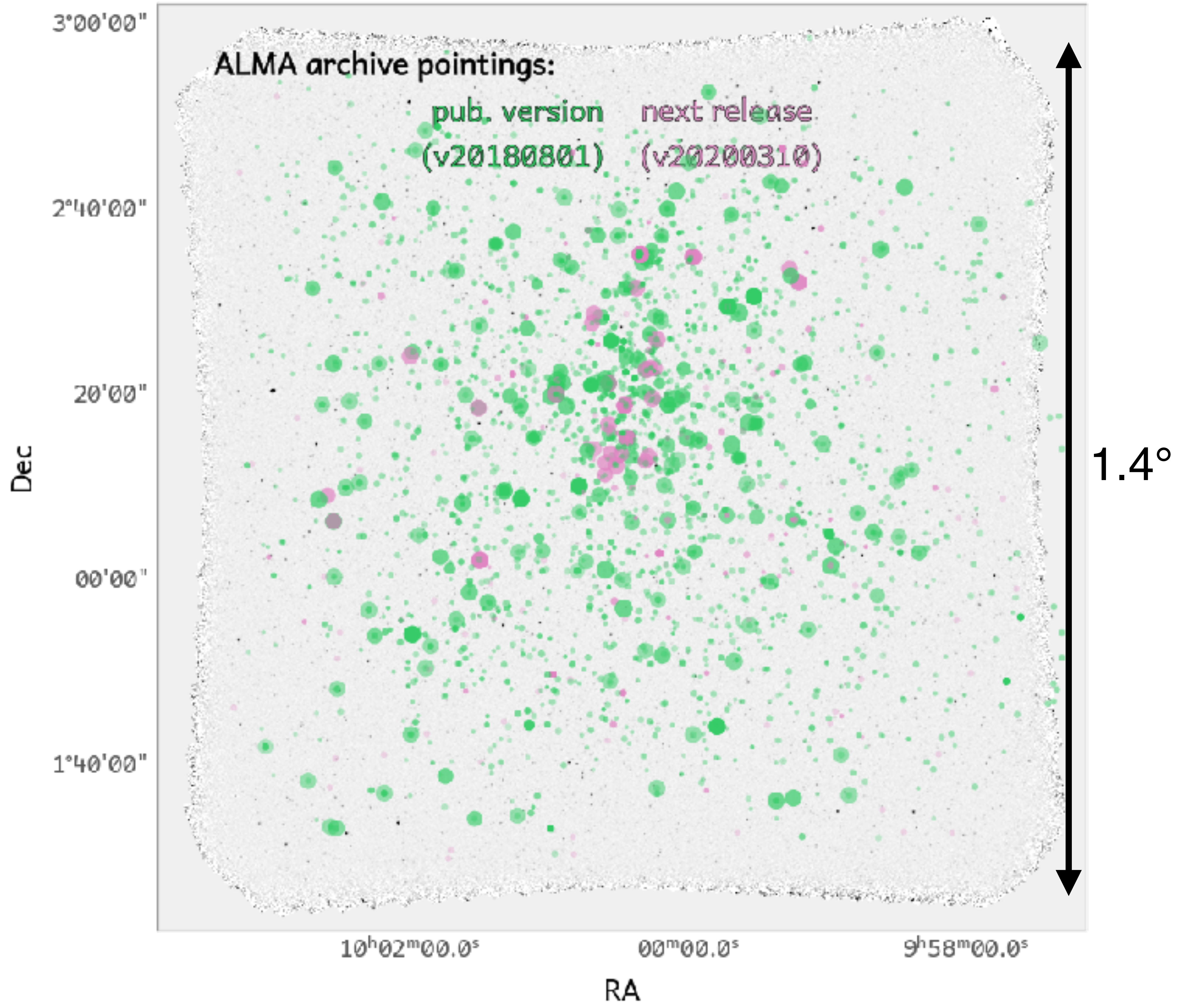
- The ALMA archive could provide science-ready coherently-reduced images…

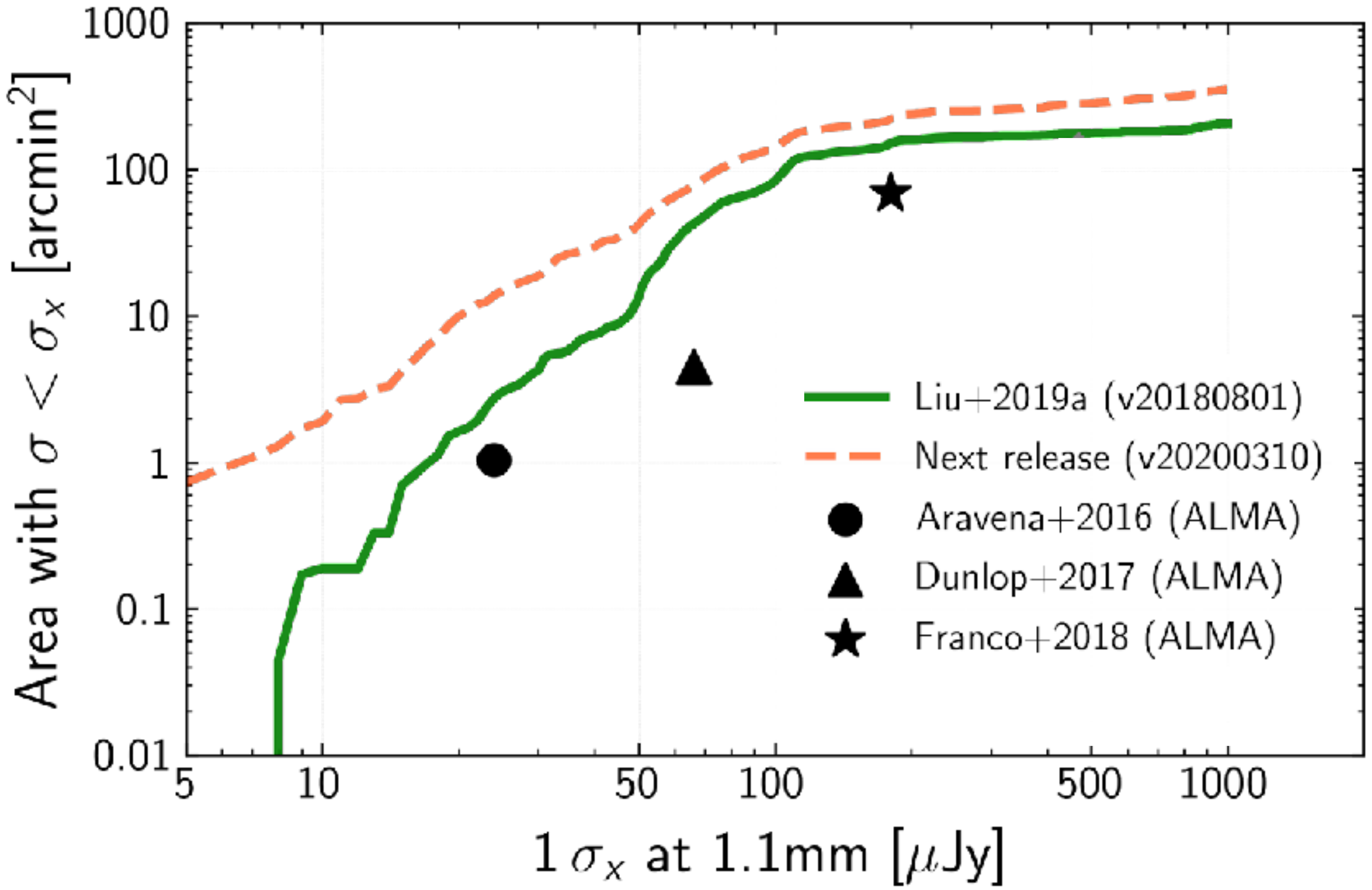
  …but cataloging should be performed consistently to be added to the COSMOS multi-λ archive

The A^3COSMOS team has the expertise and resources to tackle these challenges!

What does the ALMA archive contain?

The ever-growing ALMA archive allows for the “creation” of deep/wide (sub)mm surveys





E.g, the COSMOS ALMA archive contains already enough data to “create” a blind continuum (though not contiguous) survey as deep and large as the to-date largest blind survey conducted with ALMA, i.e., the GOODS-S-ALMA survey @1.1mm (PI: D. Elbaz)

Liu+19a

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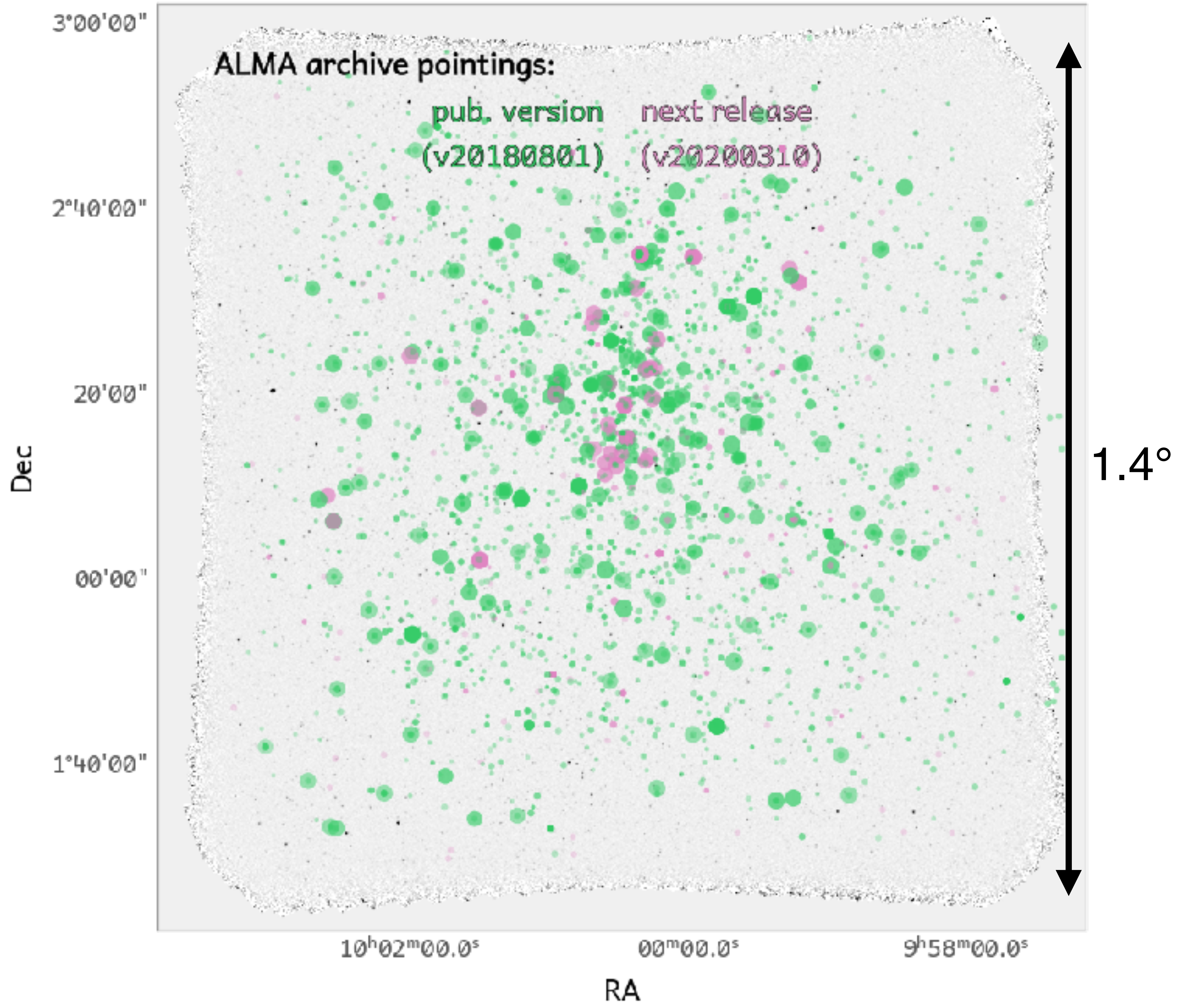

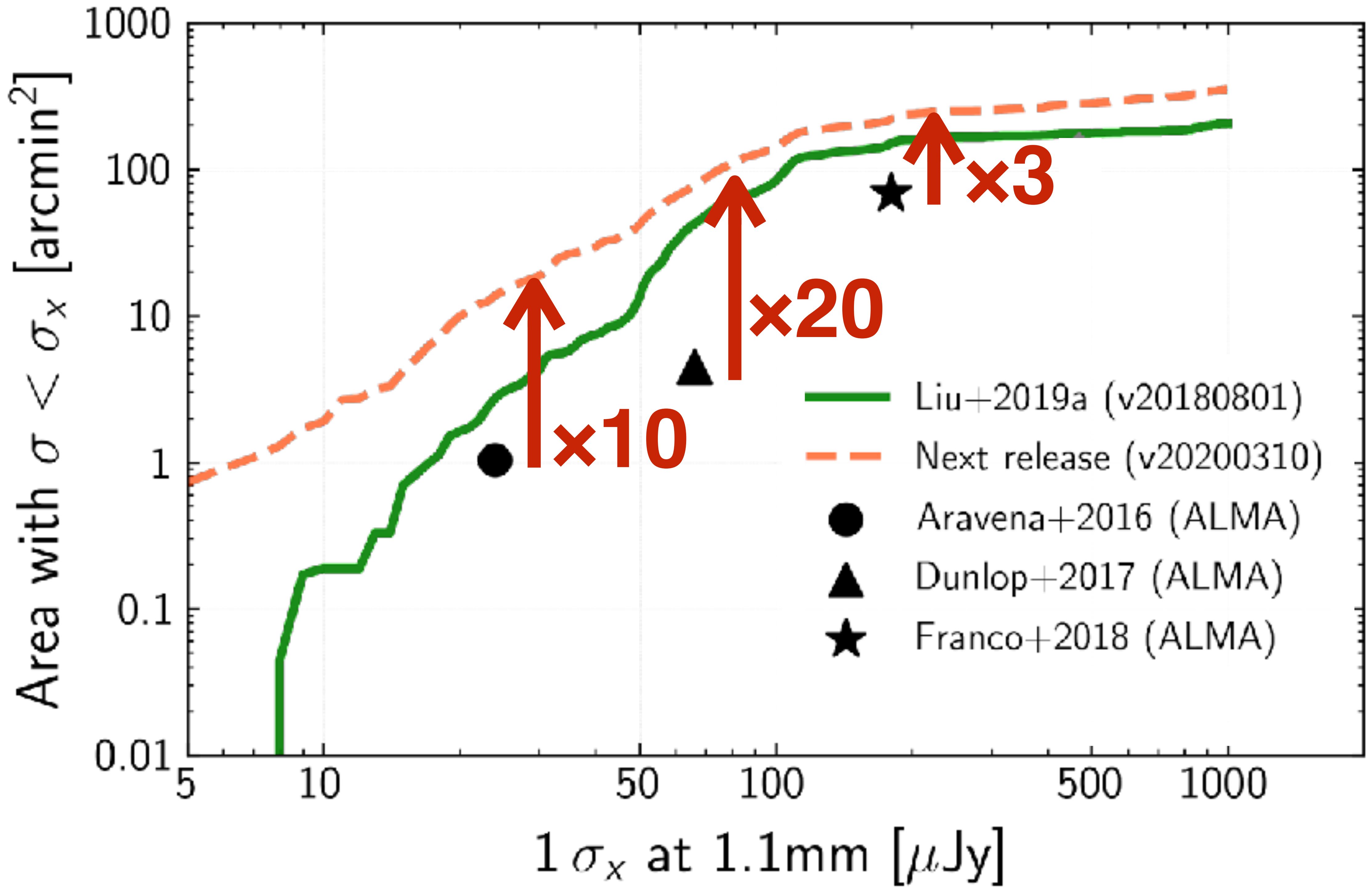

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A³COSMOS: Current Status

A³COSMOS includes all ALMA data in COSMOS publicly available as of the 2021-08-27:

3231 images in total, coming from 183 ALMA projects

Info Type	Band 3	Band 4	Band 5	Band 6	Band 7	Band 8	Band 9
Number of images	319	95	8	1241	1524	40	4
Sum beam area ($arcmin^2$)[a]	245.1	33	1.5	159.2	99.20	1.42	0.067
Mean beam size (arcsec)	1.94	1.65	2.05	1.17	0.78	0.59	0.20
Mean rms noise (mJy $beam^{-1}$)	0.021	0.030	0.025	0.069	0.138	0.044	0.654
PYBDSF $S/N_{peak} > 5.40$	128	81	6	802	1146	25	8
GALFIT $S/N_{peak} > 4.35$[b]	174	105	9	967	1241	27	6

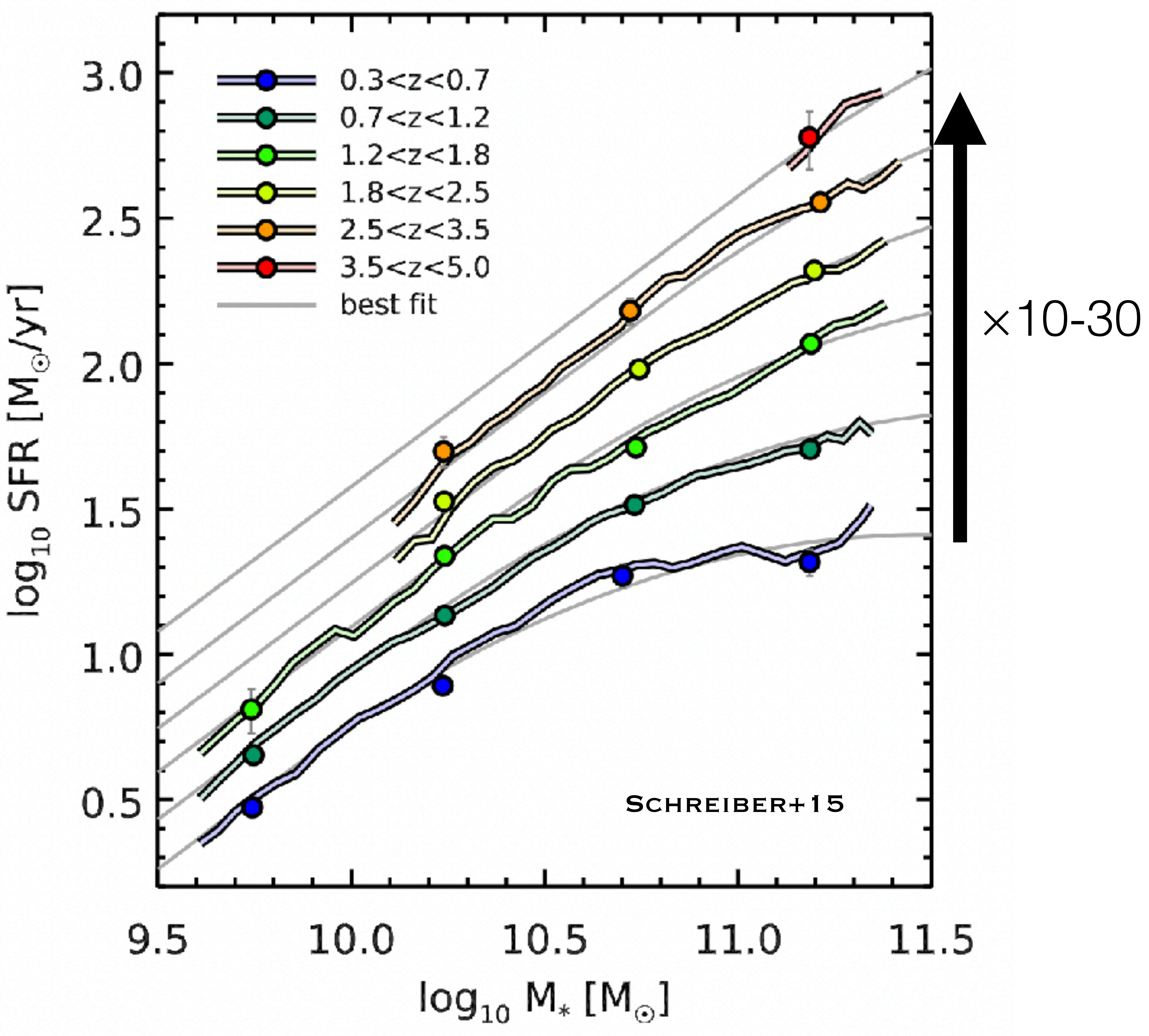
https://sites.google.com/view/a3cosmos/data

This next release should be online by end of August 2022

S. Adscheid, BM, in prep - Liu+19a

A³COSMOS: Cold molecular gas evolution out to $z \sim 5$

The main sequence of star-forming galaxies



What can we explain that star formation in MS galaxies increase by a factor ×10-20 from z~0 to z~4 ?

Larger gas content ?

or

Higher star formation efficiency ?

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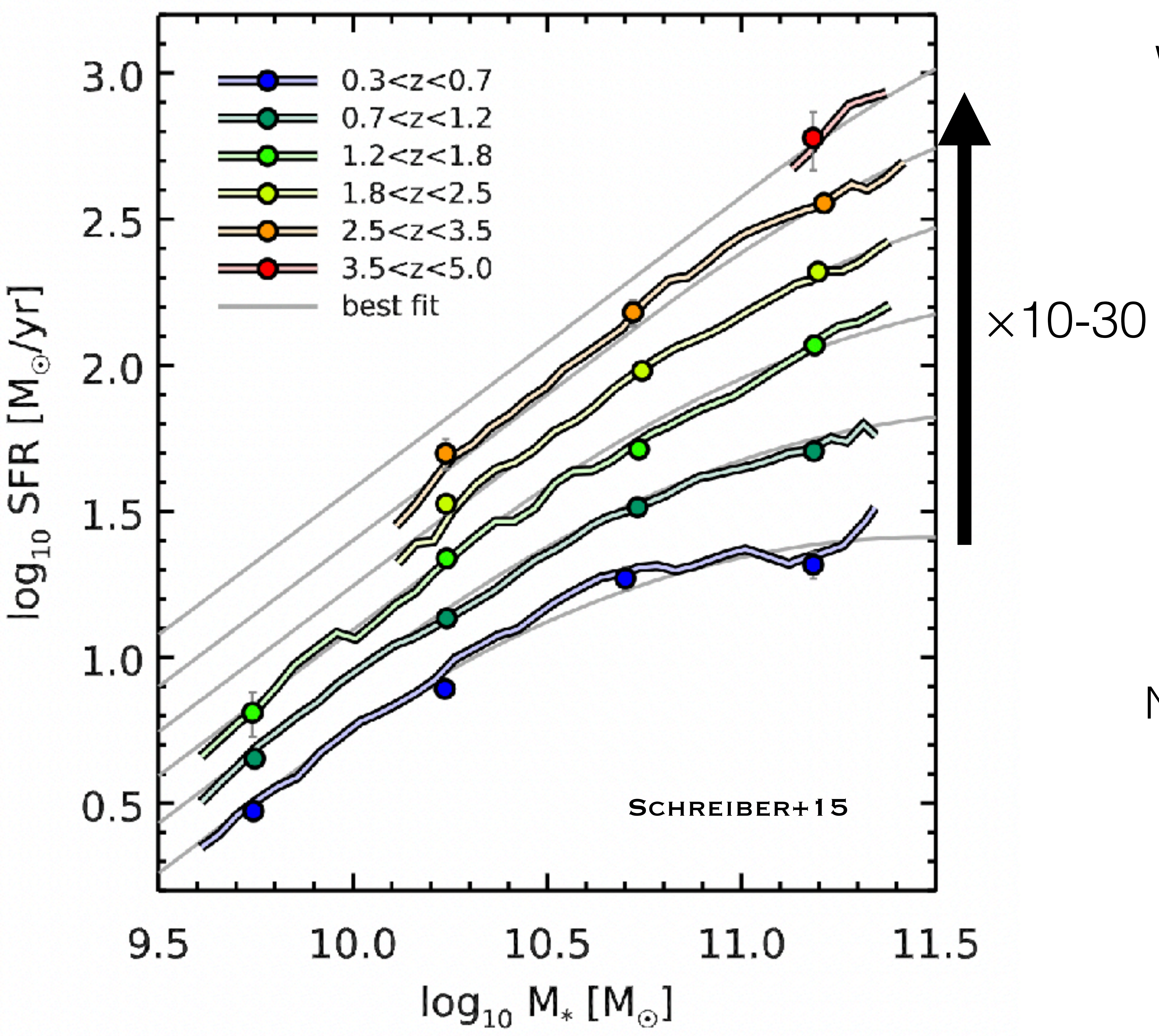

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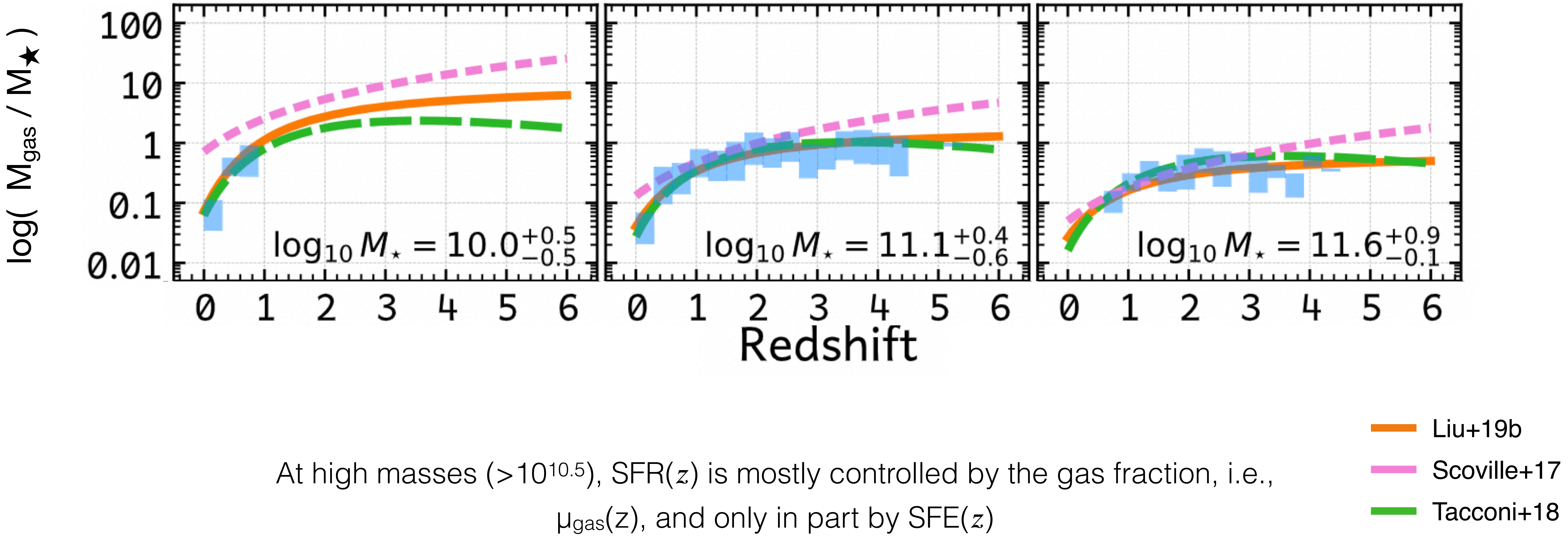
Need to assemble large and unbiased sample of high-z galaxies with accurate gas mass measurements:

—> CO line (very expensive even with ALMA)

—> dust RJ-tail emission (A³COSMOS)

A³COSMOS: Cold molecular gas evolution out to $z \sim 5$

By combining ~700 (sub)mm-detected galaxies from A³COSMOS with ~1000 CO-detected galaxies from the literature, we parametrised the cold molecular gas scaling relations with stellar masses, offset from the MS and cosmic time

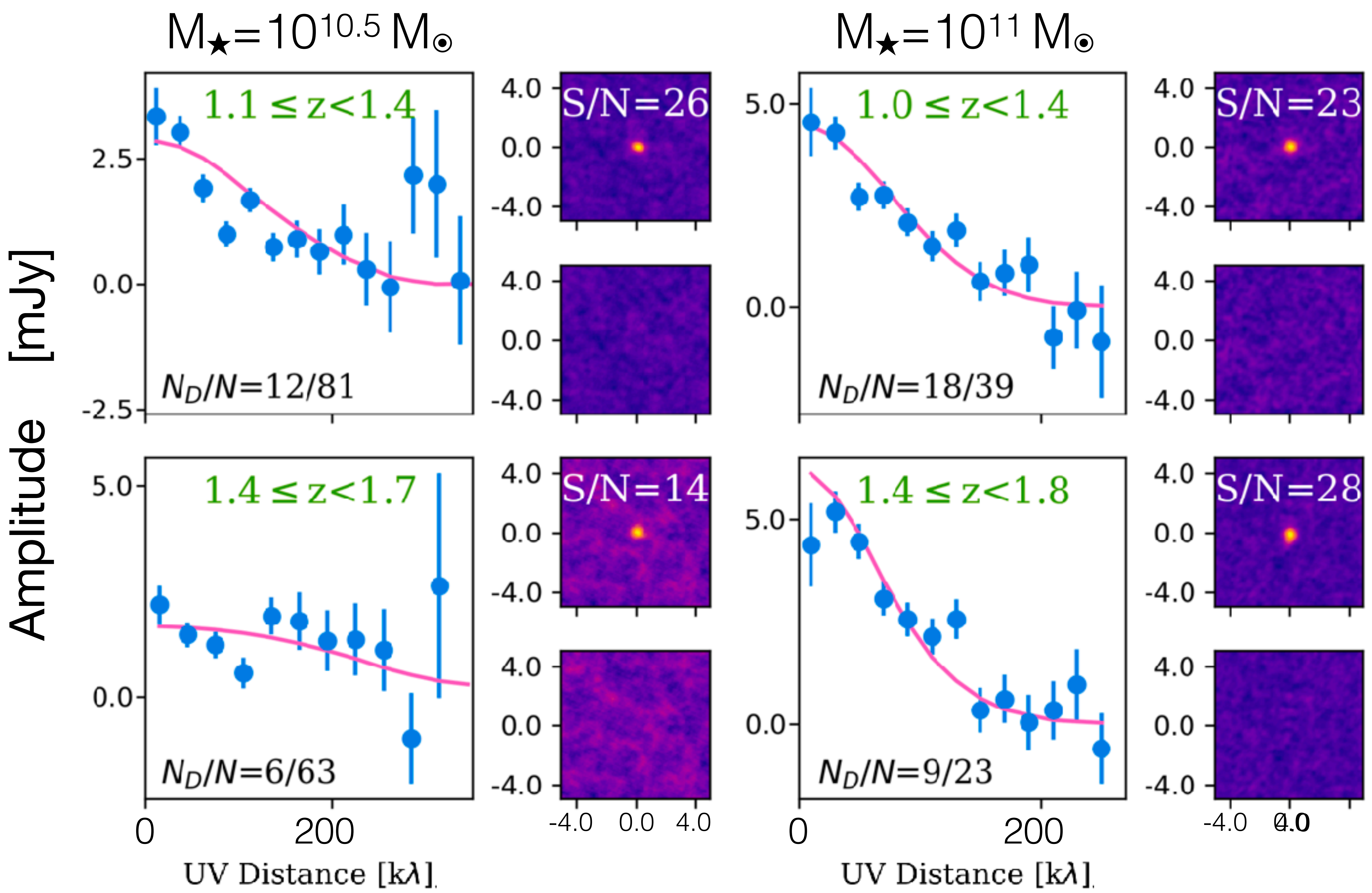


At high masses ($>10^{10.5}$), SFR(z) is mostly controlled by the gas fraction, i.e., $\mu_{gas}(z)$, and only in part by SFE(z)

Liu+19b

A^{3}COSMOS: A census on the molecular gas mass and extent of MS galaxies

By developing an dedicated *uv*-stacking method, we unleash the full capability of the A^{3}COSMOS archive.



Measure for the first time the gas content and extent of a **mass-complete** sample of $>10^{10}\,M_\odot$ MS galaxies up to z~4

Down to $>10^{10}\,M_\odot$, SFR(z) is mostly controlled by the gas fraction and only in part by SFE(z)

Small gas reservoir
—> Accretion of fresh gas from the IGM

At all redshifts and stellar masses, MS galaxies have relatively compact SF extent, with $R_e\lesssim2.5$kpc,

Main sequence galaxies evolve along a seemingly universal KS relation (slope~1.13)

T.M. Wang, BM+22 (in prep)

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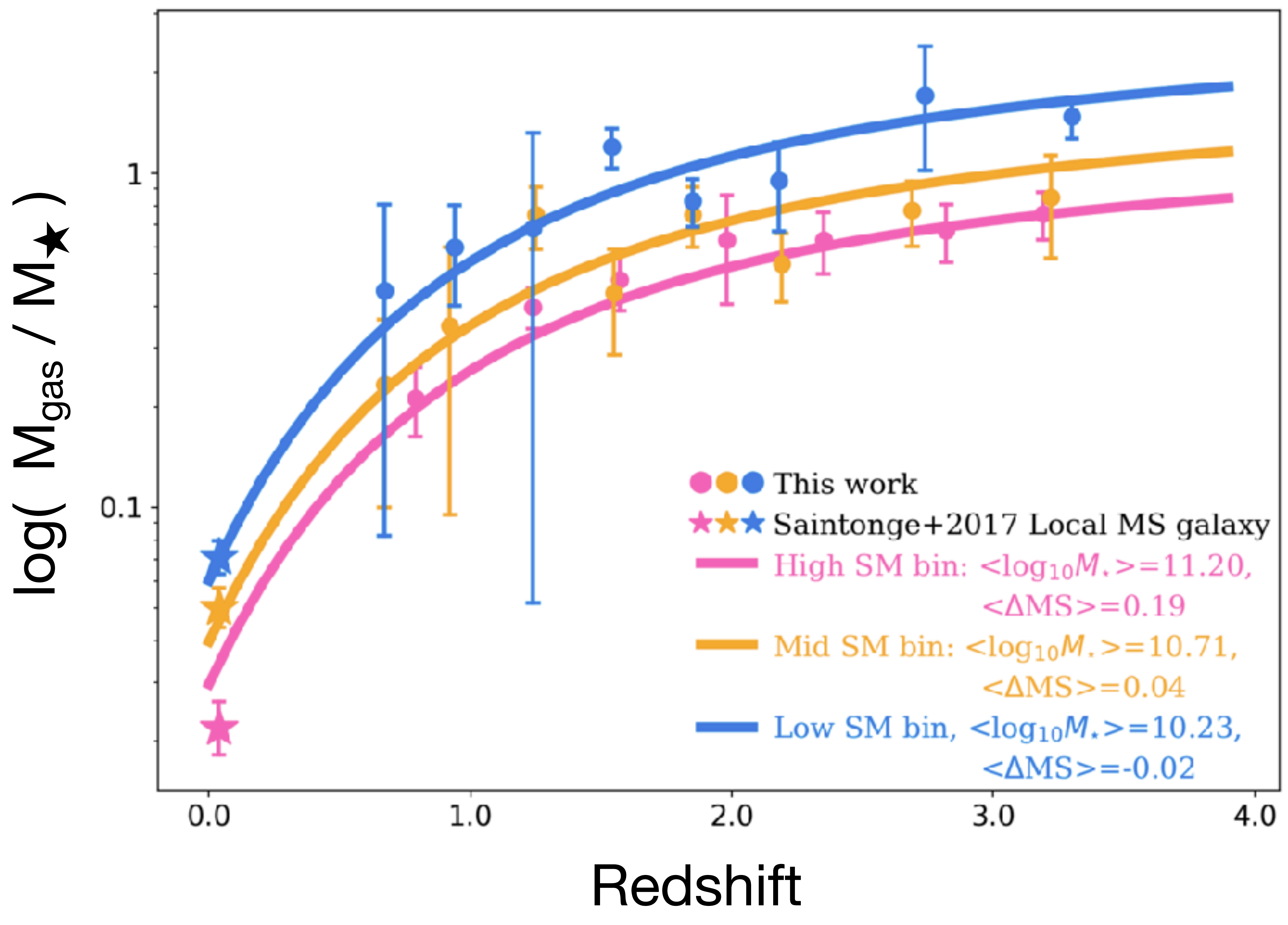

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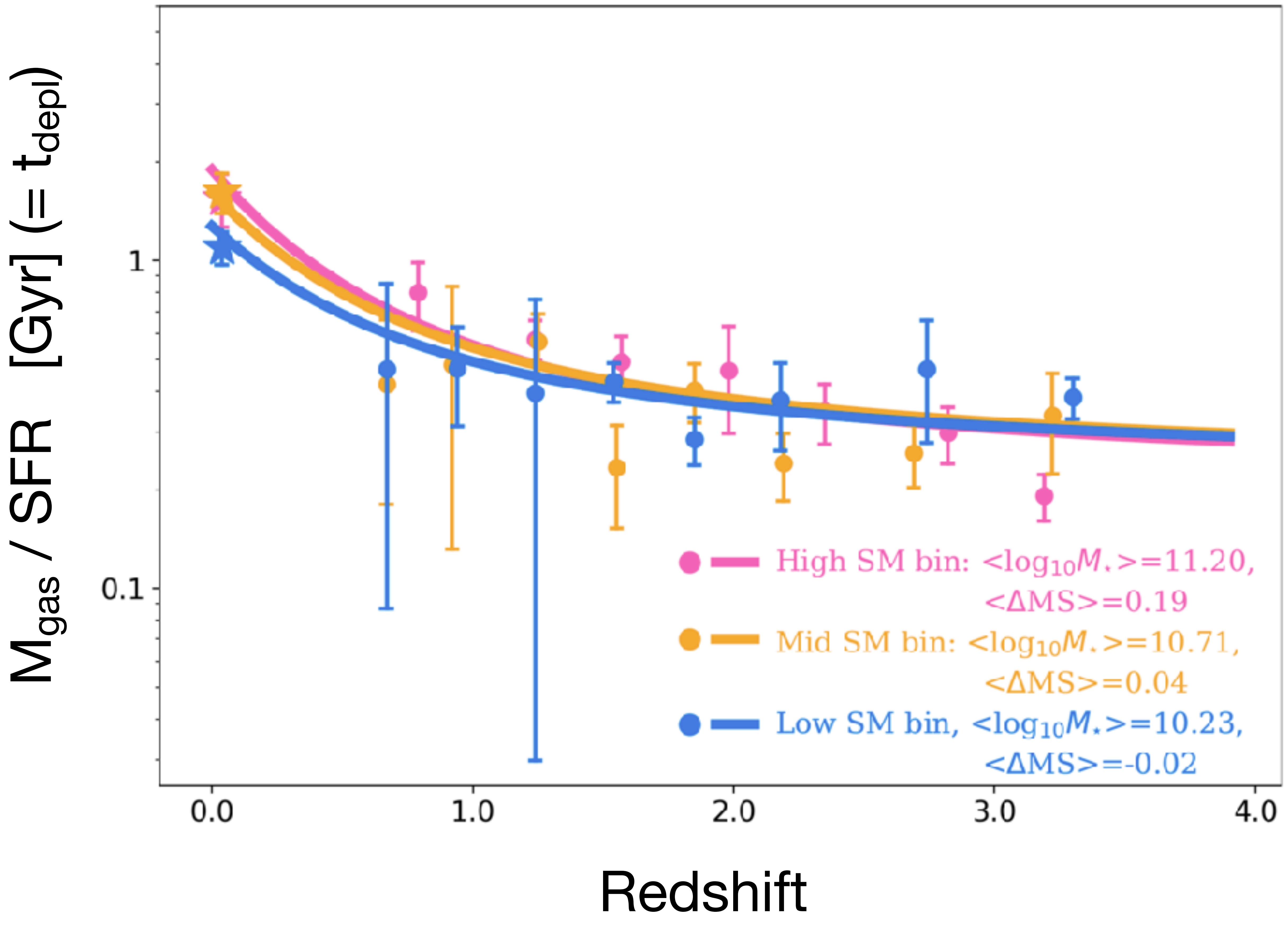

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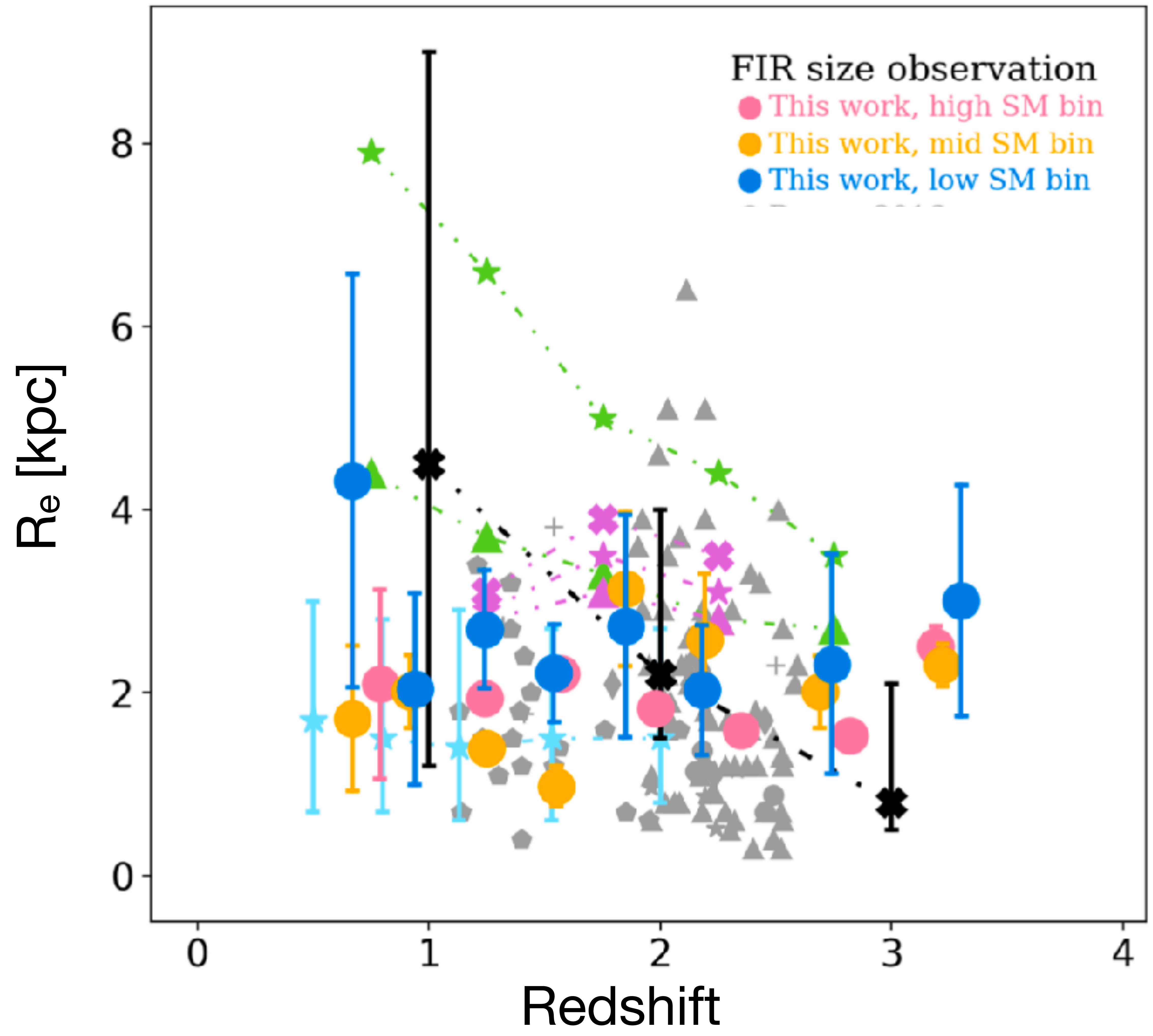

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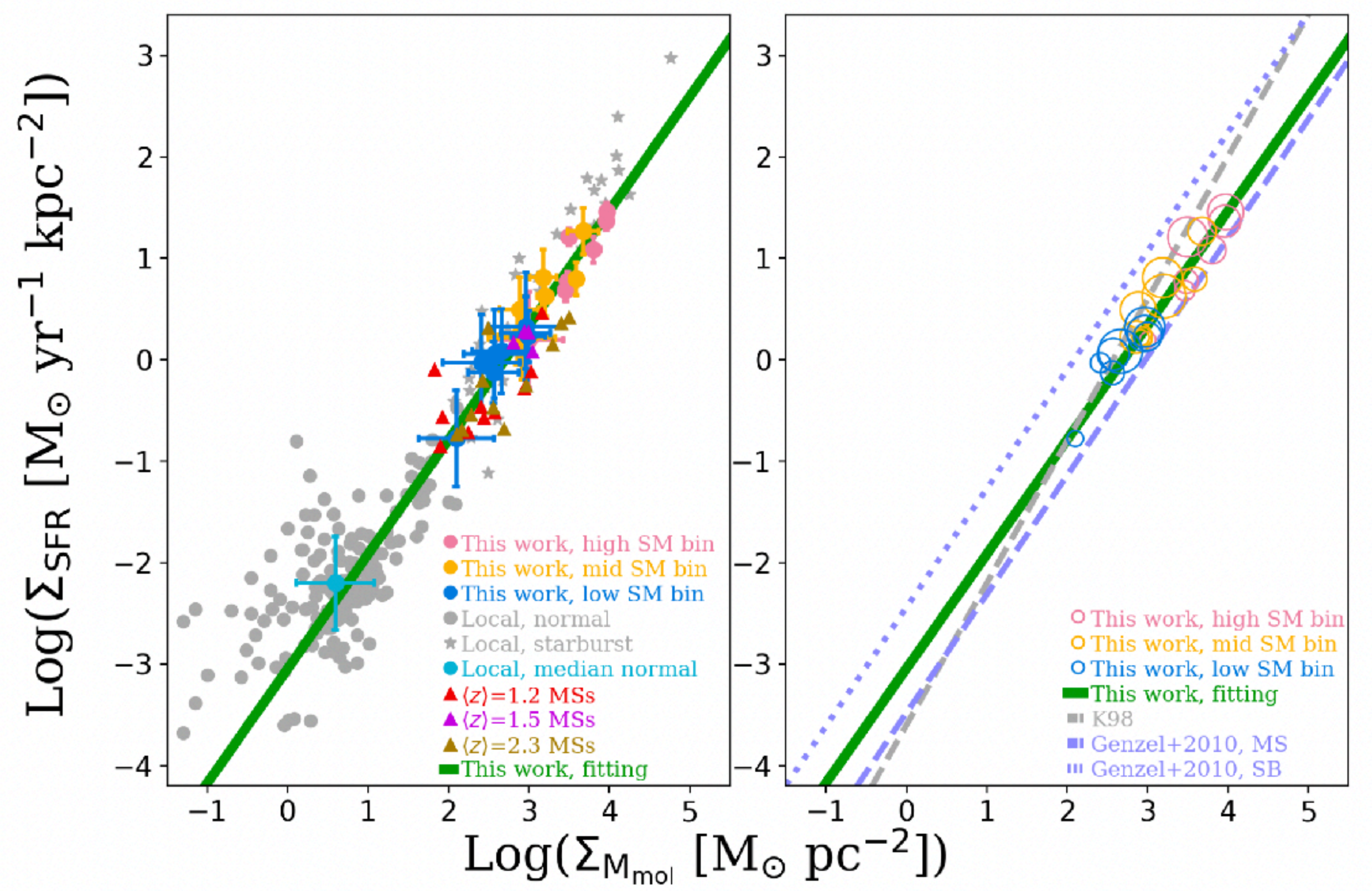

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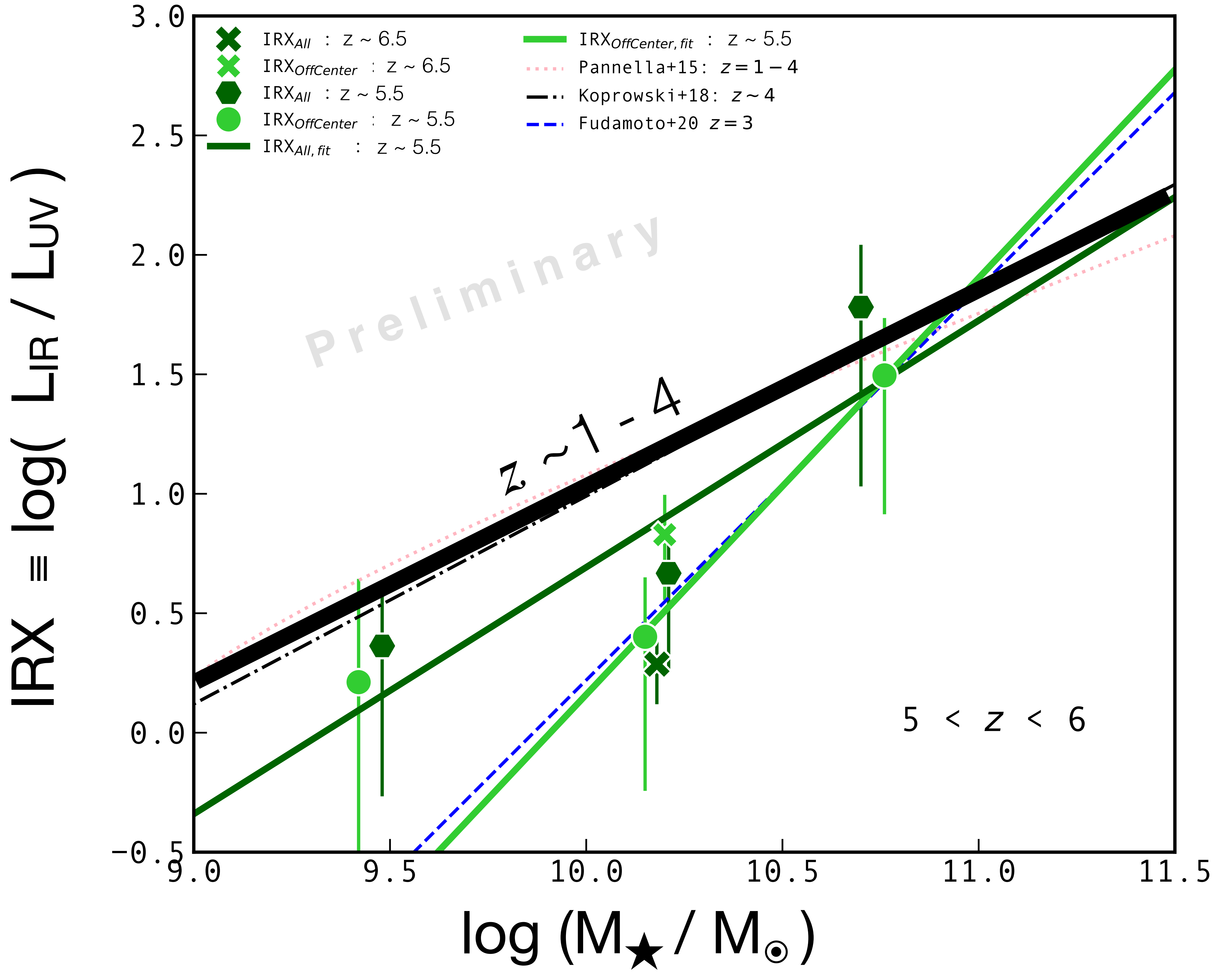
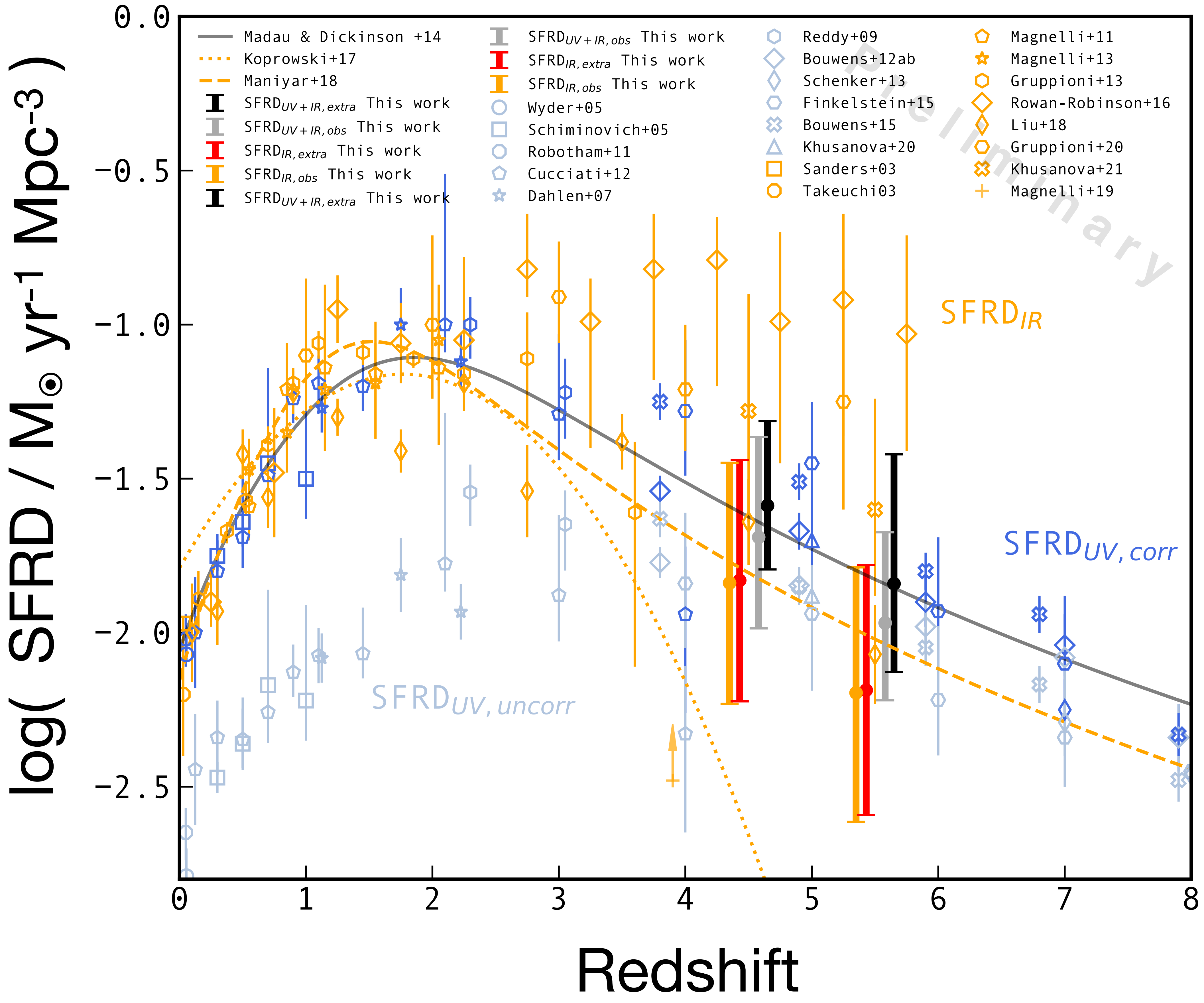
A³COSMOS: On-going project

The dust-obscured SFRD at $z \sim 5.5$

(uv-based stacking analysis of mass-complete sample of SFGs)





Steeper IRX - M★ relation at $z \sim 5.5$

The dust-obscured SFRD account for ~40% of the total SFRD at $z \sim 5.5$

BM + in prep; Fudamoto+19

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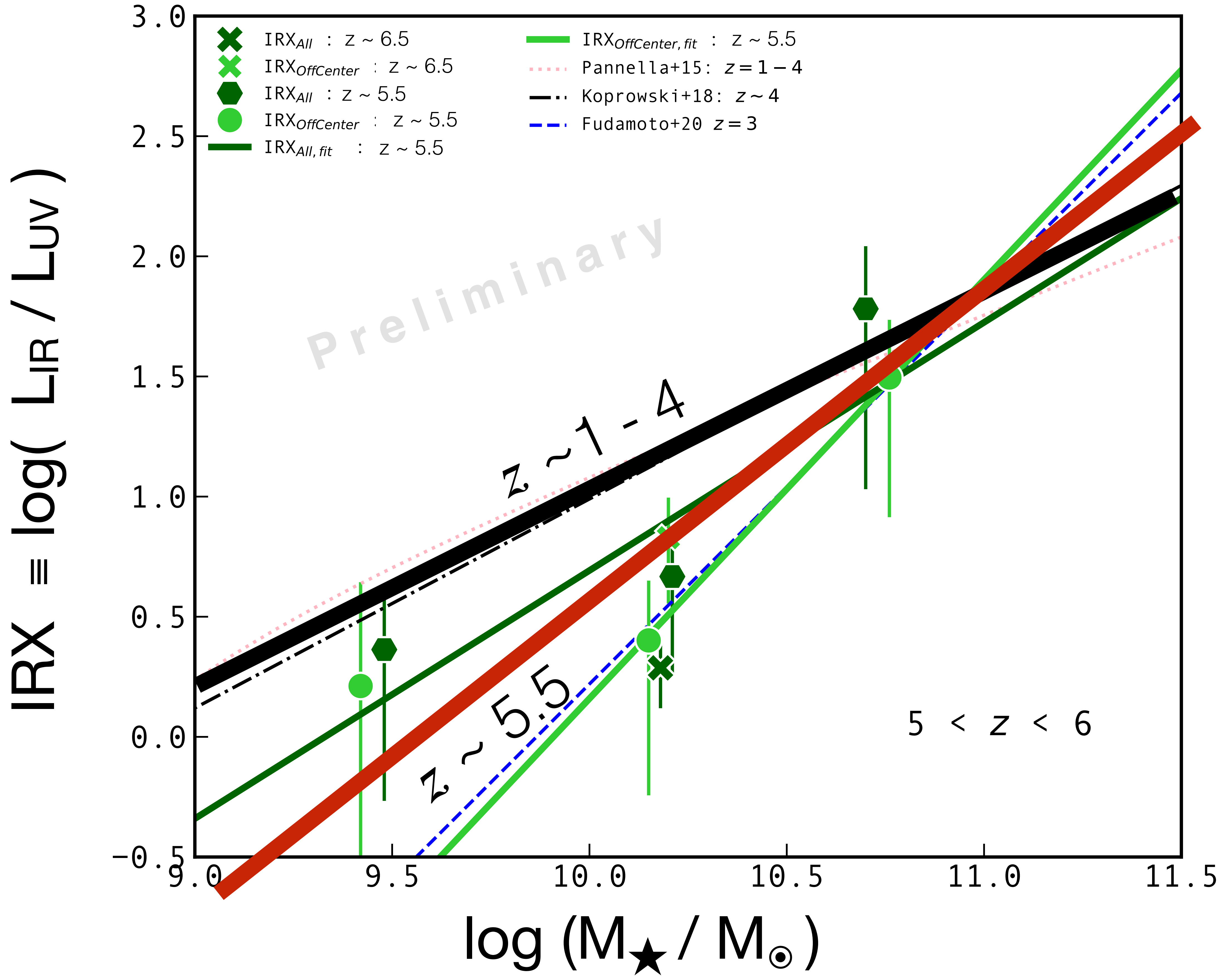

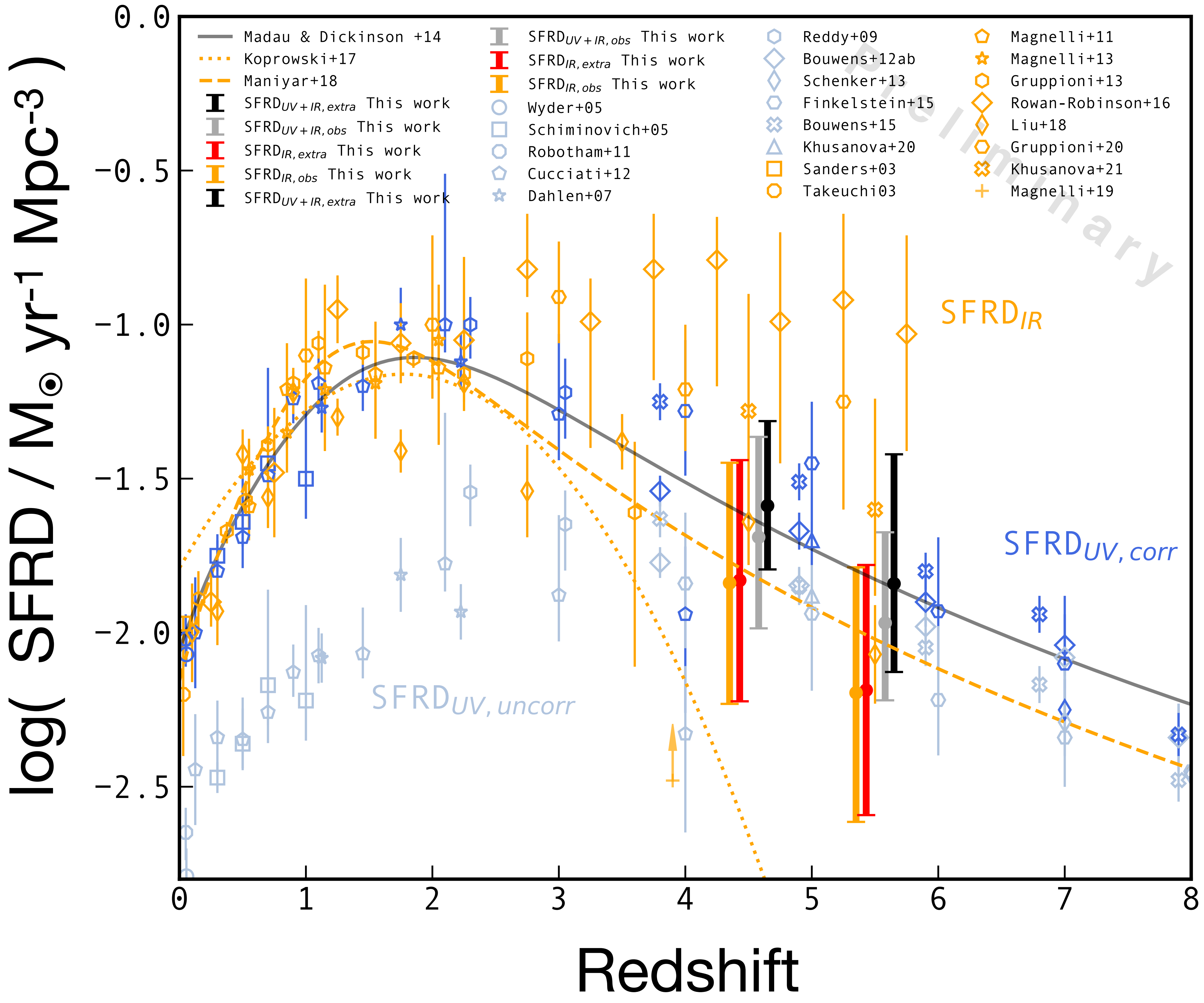

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Summary

- The A^{3}COSMOS database is up and running. It provides an ever-growing view on the (sub)mm emission of high-z galaxies

- The latest release of A^{3}COSMOS includes all ALMA projects in COSMOS available as of the 10th of March 2020 : https://sites.google.com/view/a3cosmos/data

- The development of a dedicated *uv*-based stacking analysis tool unleashes the full capability of the A^{3}COSMOS archive:
  - Down to $>10^{10}$ $M_{\odot}$ and up to $z\sim4$, the SFRs of MS galaxies is controlled by their gas content
  - MS galaxies have relatively compact star-forming extent, with Re $\lesssim$ 2.5 kpc
  - MS galaxies evolve along a seemingly universal KS relation (slope~1.13)

- We are extending this database toward GOODS-S and UDS as well as starting to exploit the spectroscopic capabilities of the A^{3}COSMOS database, stay tuned !

THANKS