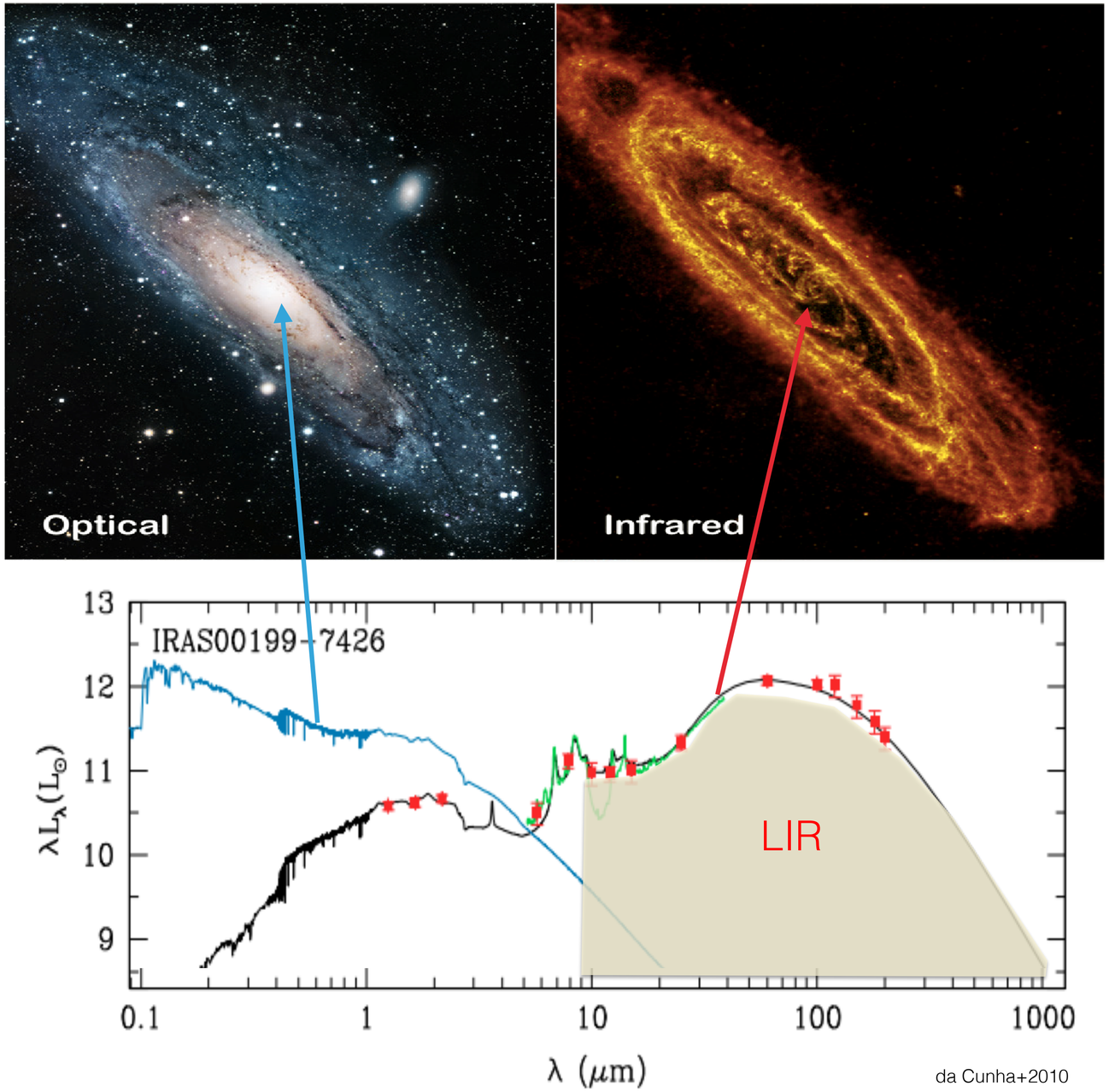
MARCO VIERO, CALTECH

HOT DUST AT HIGH-Z

TRACING STAR FORMATION

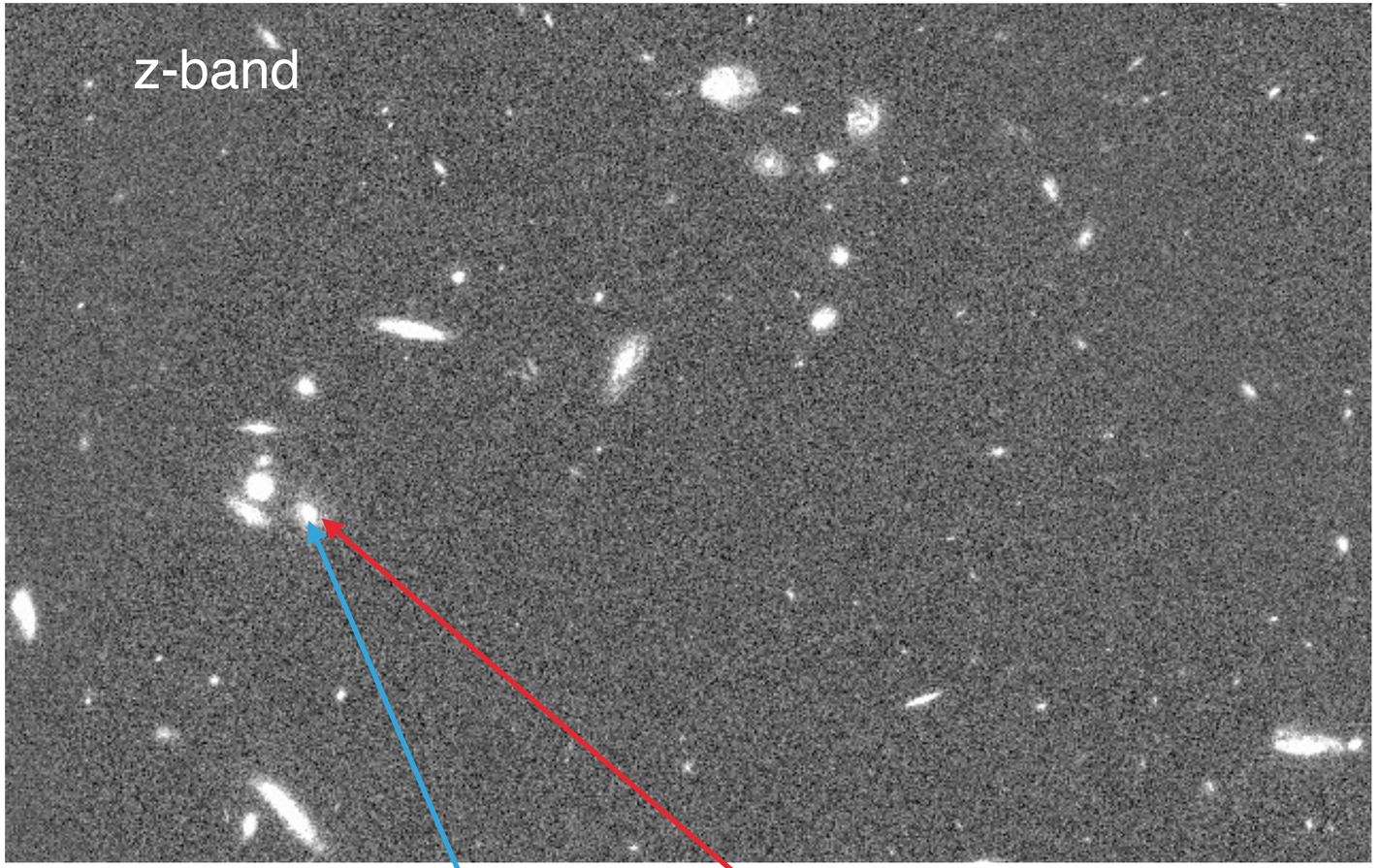
- Optical and Infrared complementary, but trace different parts of galaxy.
- Infrared luminosity (LIR) is a robust tracer of star formation

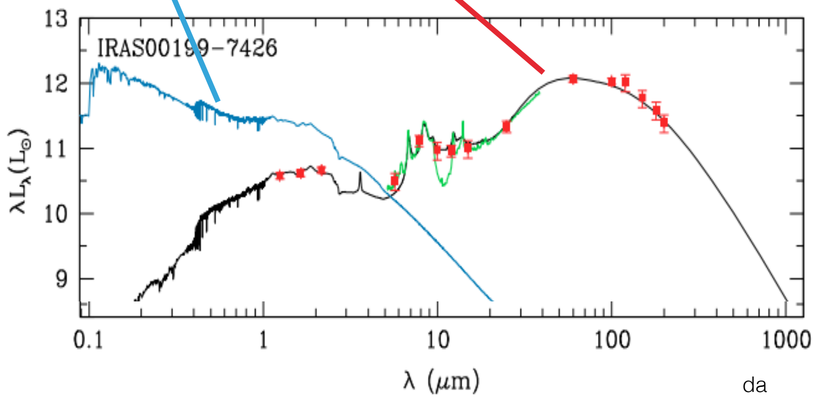


da Cunha+2010

SOURCE CONFUSION

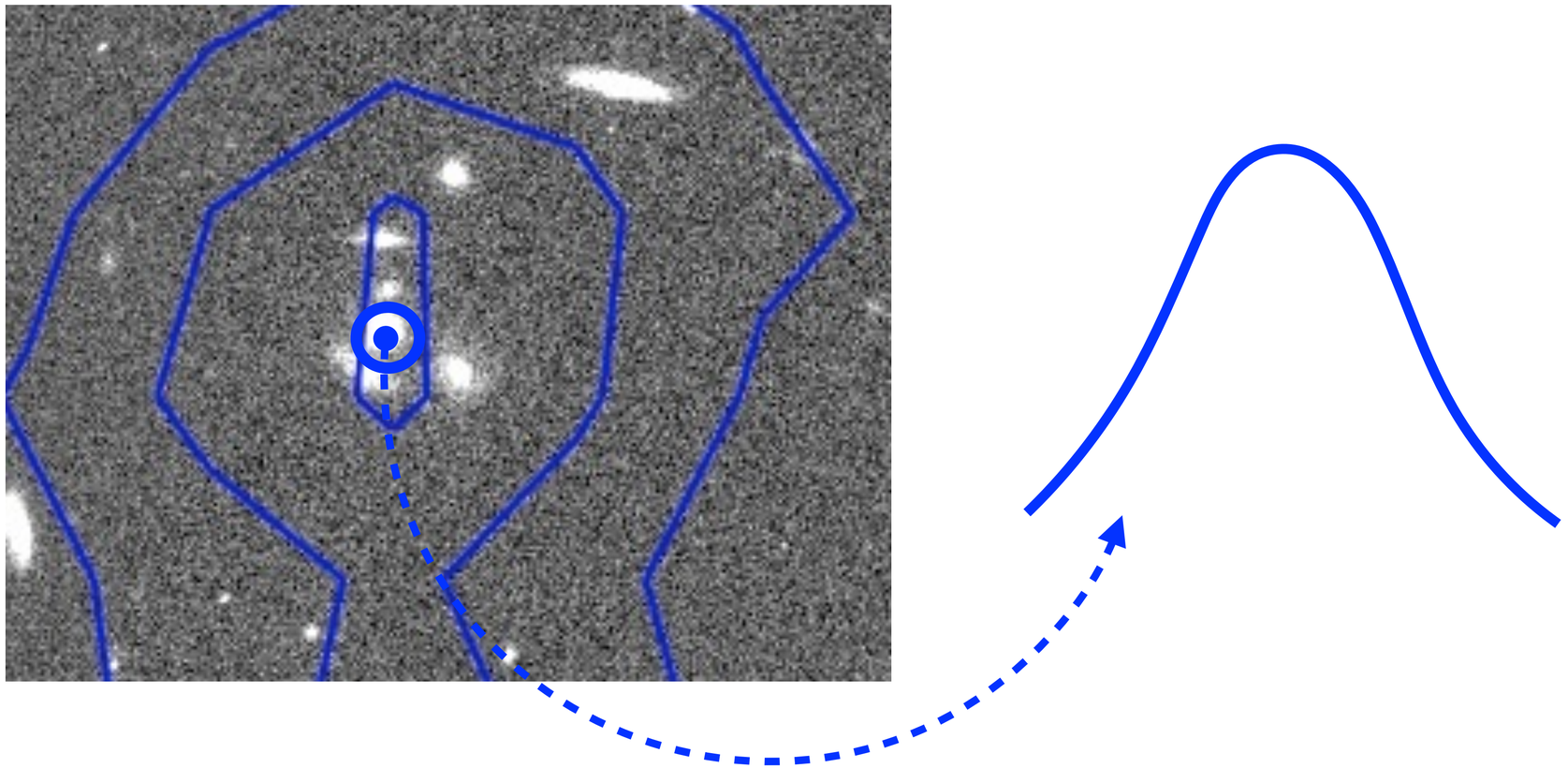
- Only 15% of the flux is resolved into discrete sources (in SPIRE), representing 1% of the objects.
- Confusion noise is a fundamental limitation.



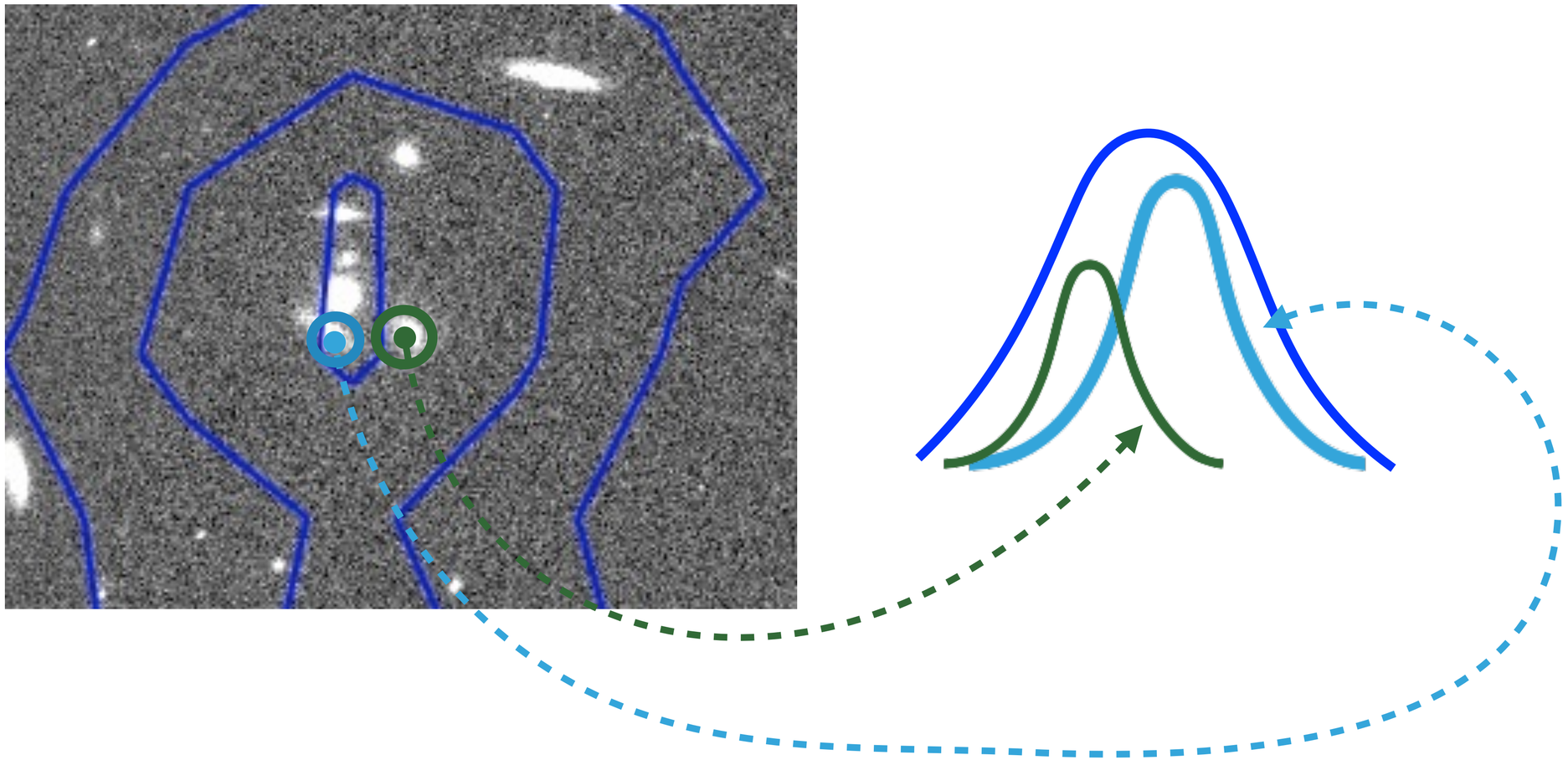


da

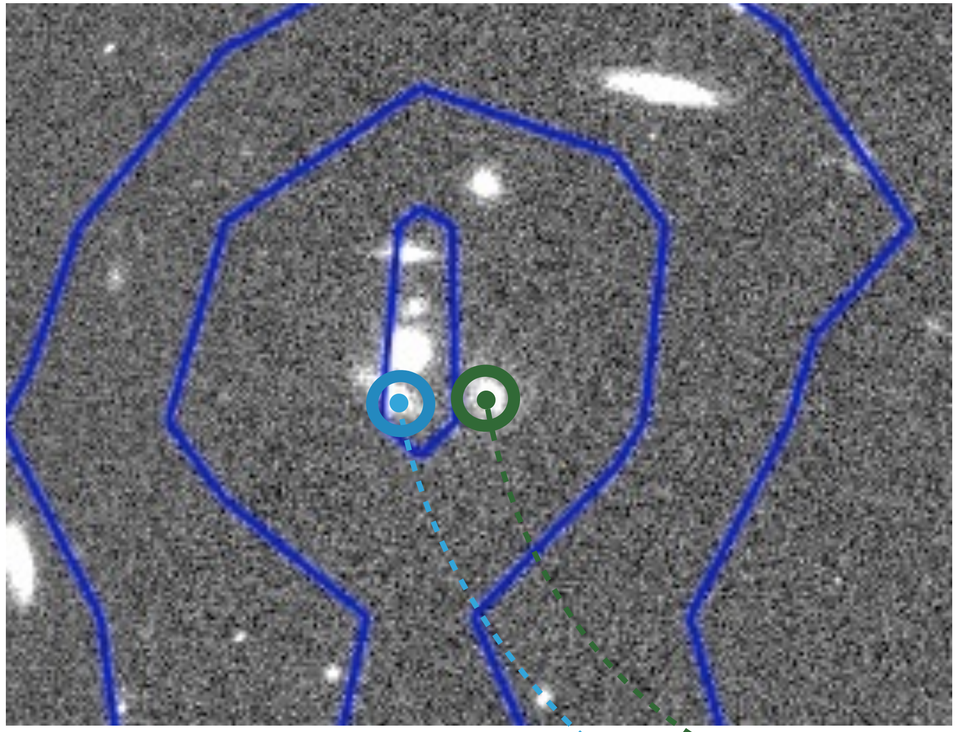
FORCED-PHOTOMETRY DECOMPOSITION



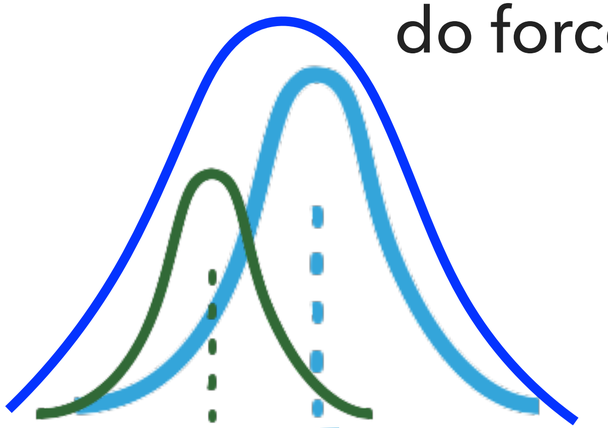
FORCED-PHOTOMETRY DECOMPOSITION



FORCED-PHOTOMETRY DECOMPOSITION



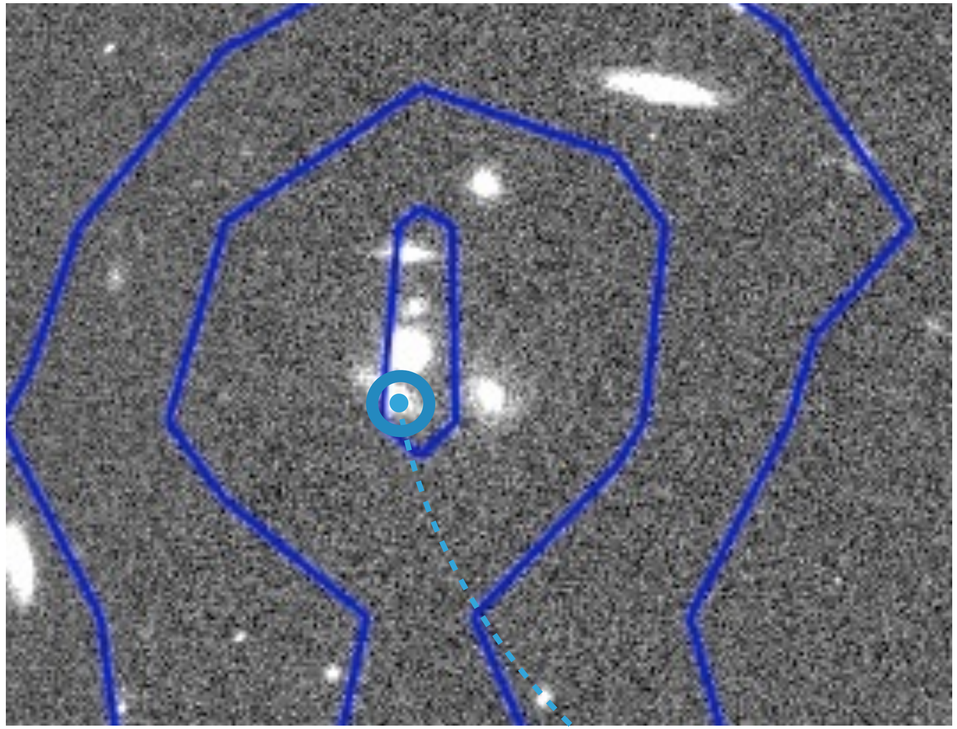
With positional priors can do forced photometry



Position 1

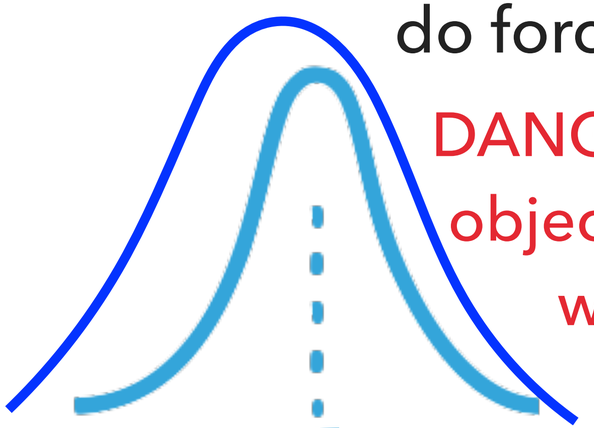
Position 2

FORCED-PHOTOMETRY DECOMPOSITION



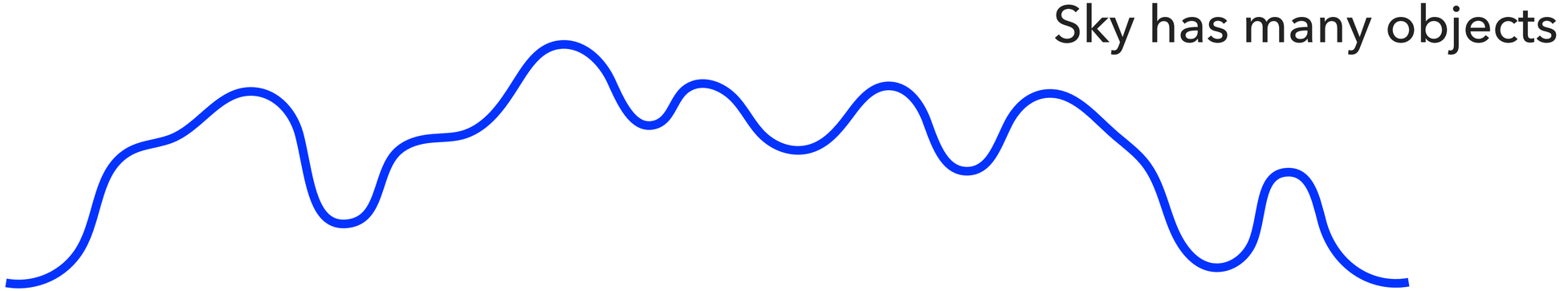
With positional priors can do forced photometry

DANGER: Not fitting all objects simultaneously will result in a bias!



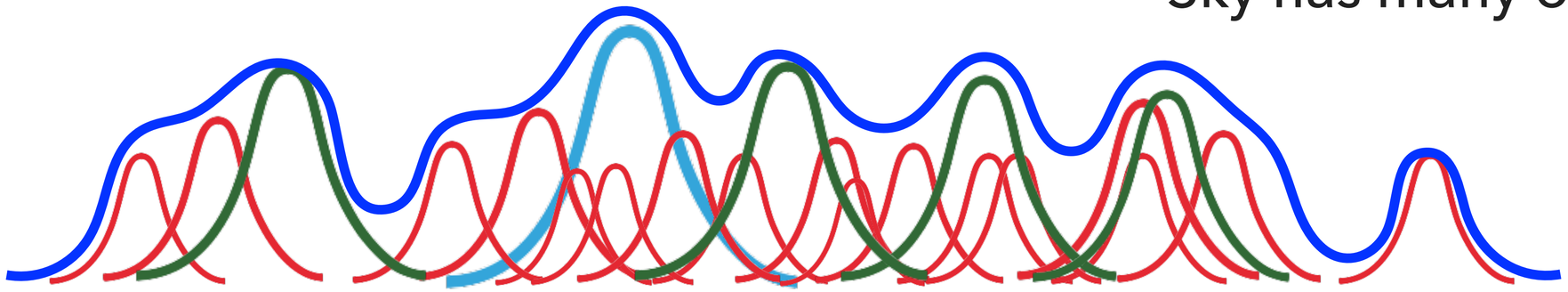
Position 2

SIMSTACK: MULTI-OBJECT FORCED-PHOTOMETRY



SIMSTACK: MULTI-OBJECT FORCED-PHOTOMETRY

Sky has many objects

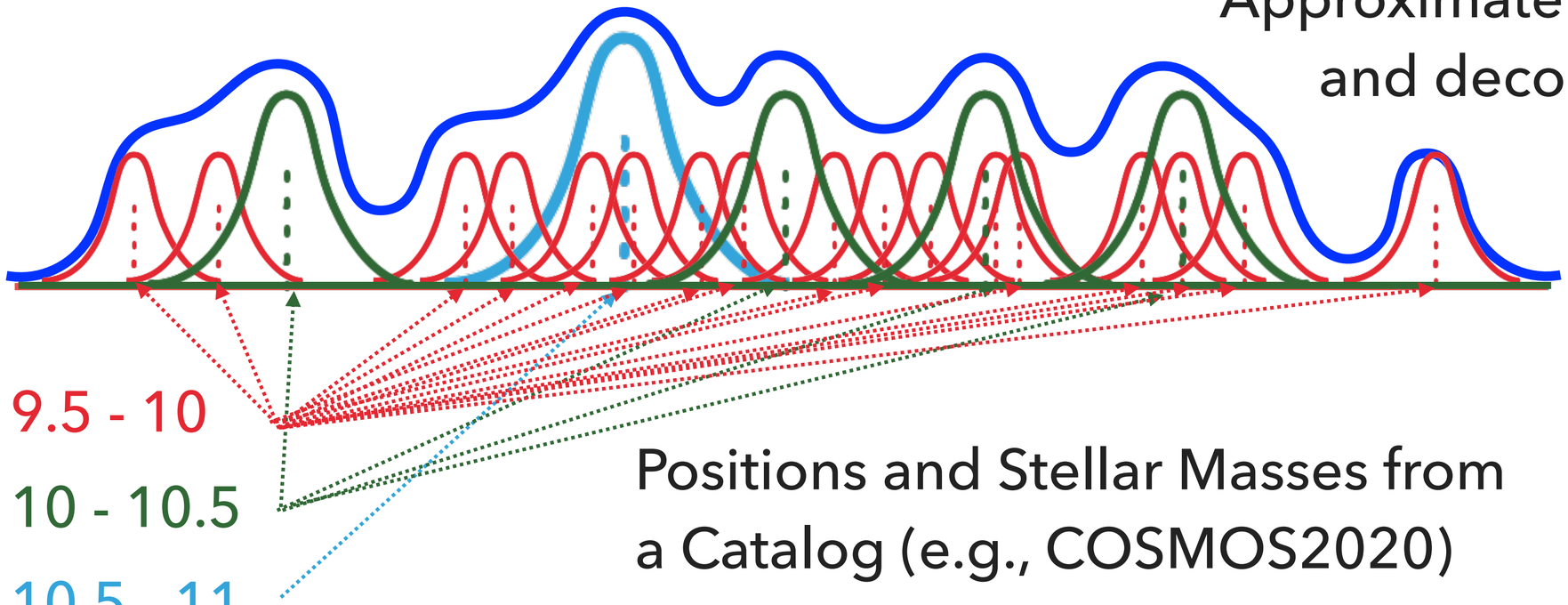


log(M/Mo) = 9.5 - 10

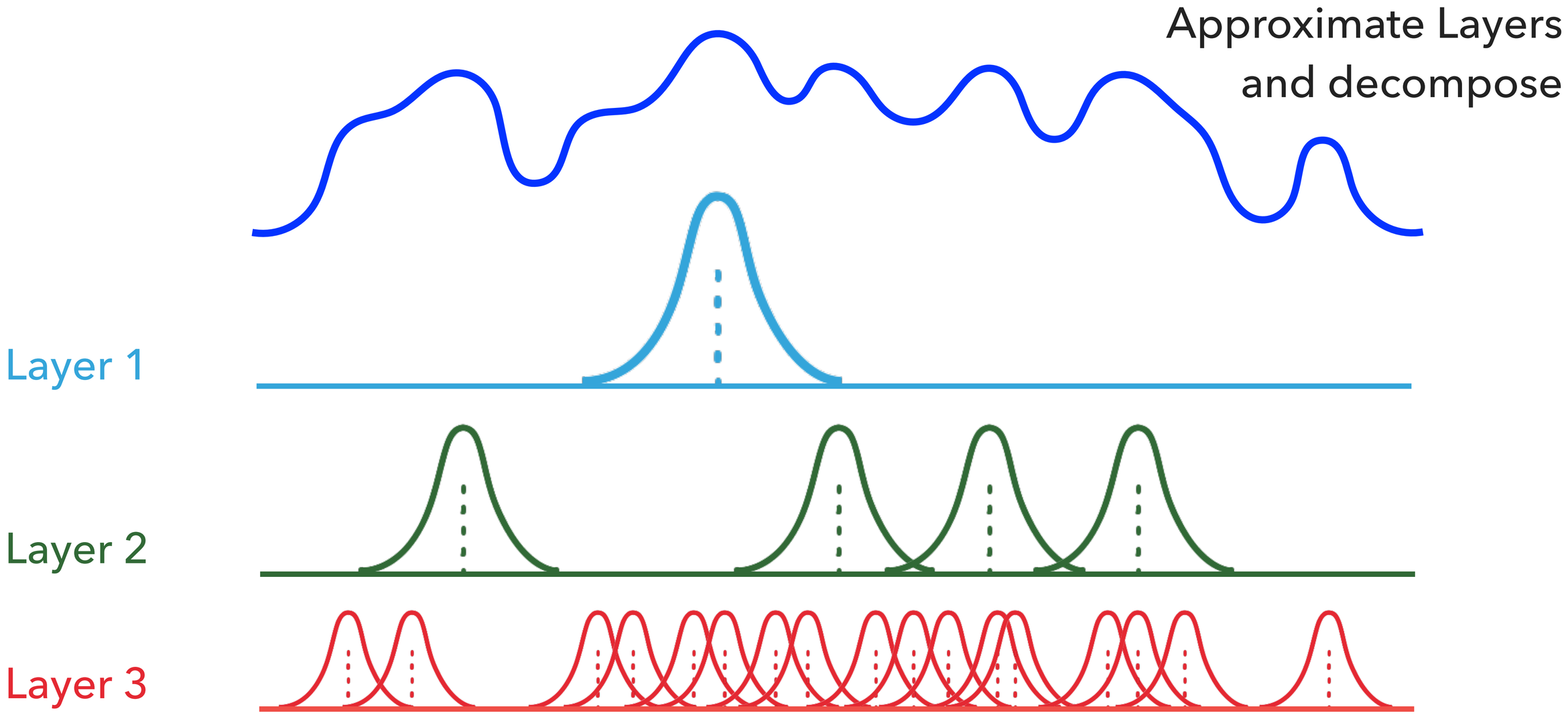
log(M/Mo) = 10 - 10.5

log(M/Mo) = 10.5 - 11

SIMSTACK: MULTI-OBJECT FORCED-PHOTOMETRY



SIMSTACK: MULTI-OBJECT FORCED-PHOTOMETRY



SIMSTACK: MULTI-OBJECT FORCED-PHOTOMETRY

For each map independently, fit:

9 Redshift Layers

x

4 Stellar Mass Layers

x

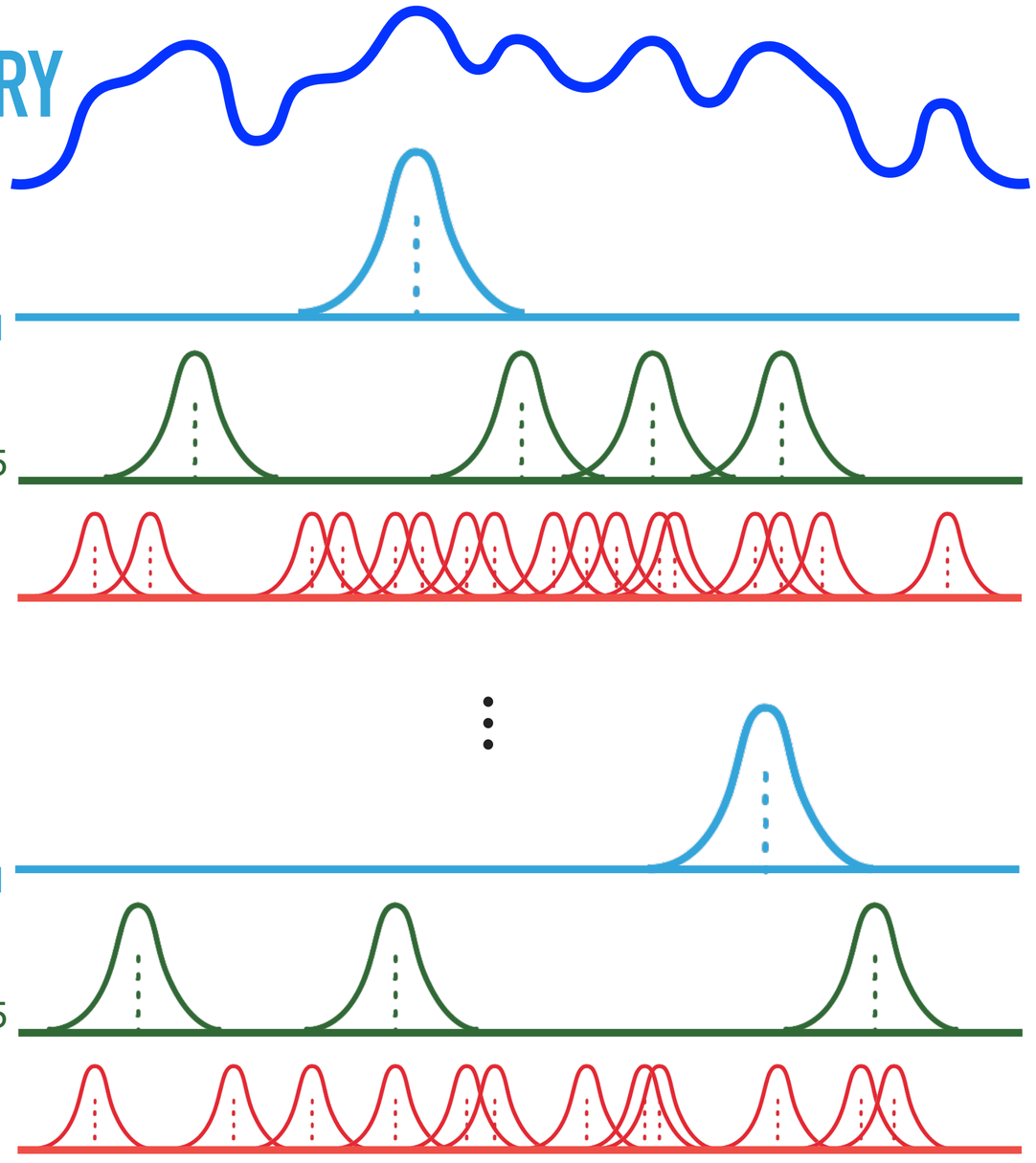
2 Types (Star-Forming/Quiescent)

+

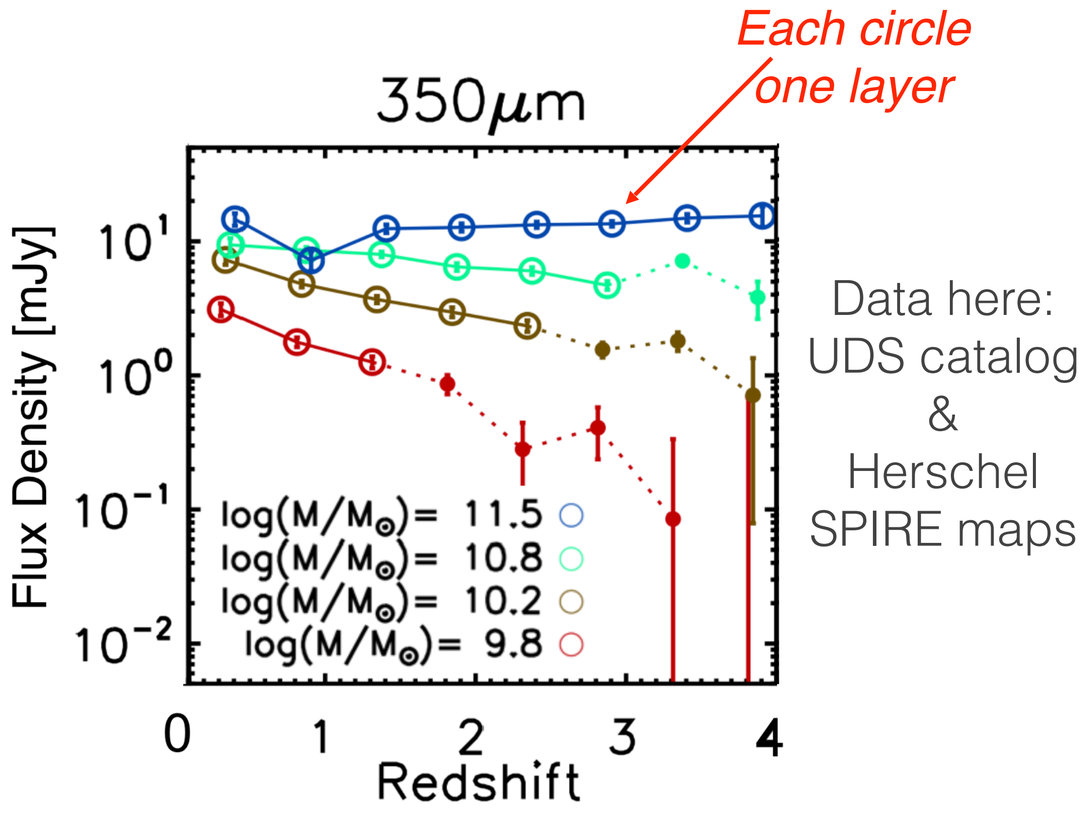
1 Foreground Layer

=

73 Layers Simultaneously

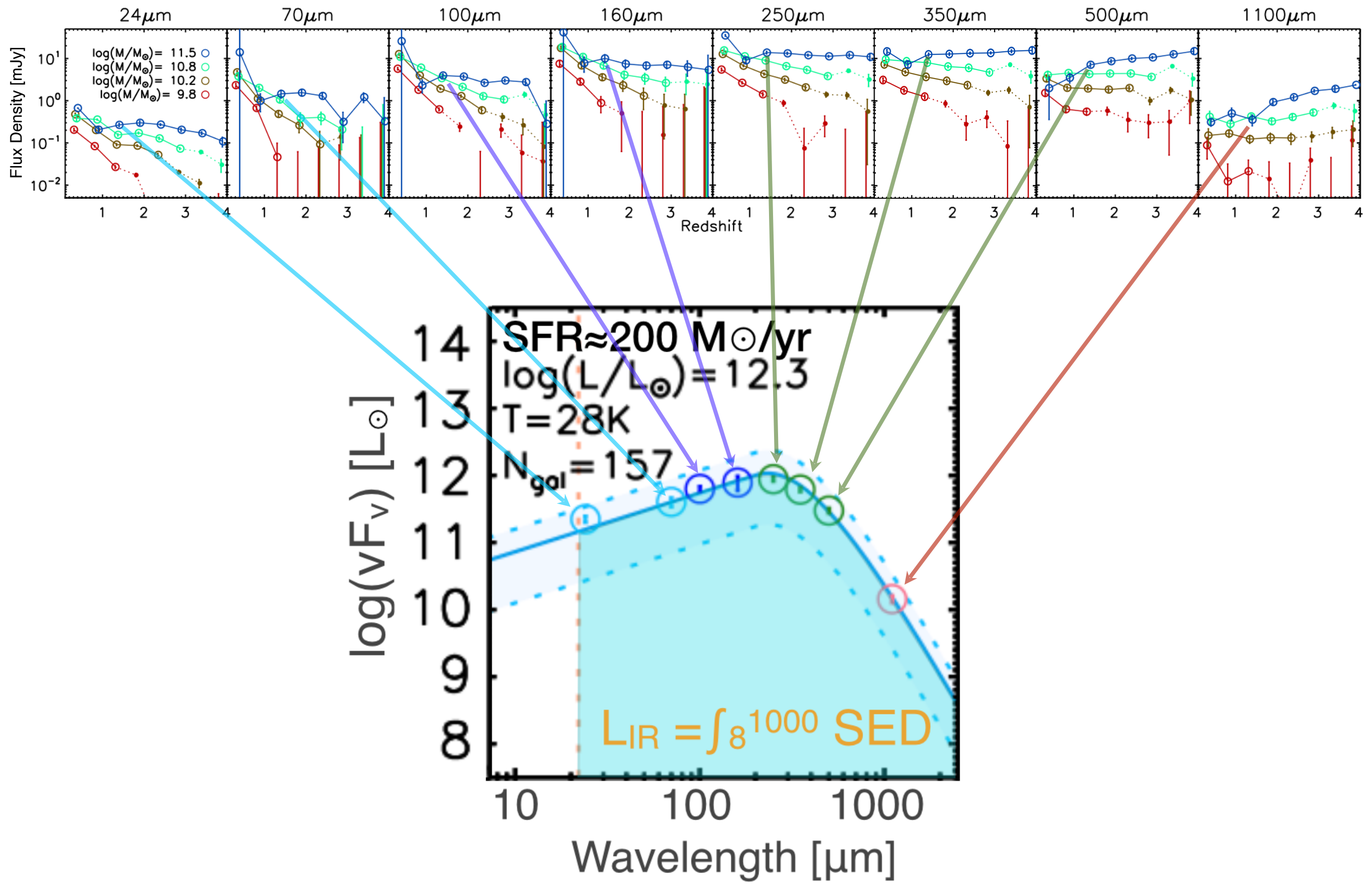


SIMSTACK IN PRACTISE

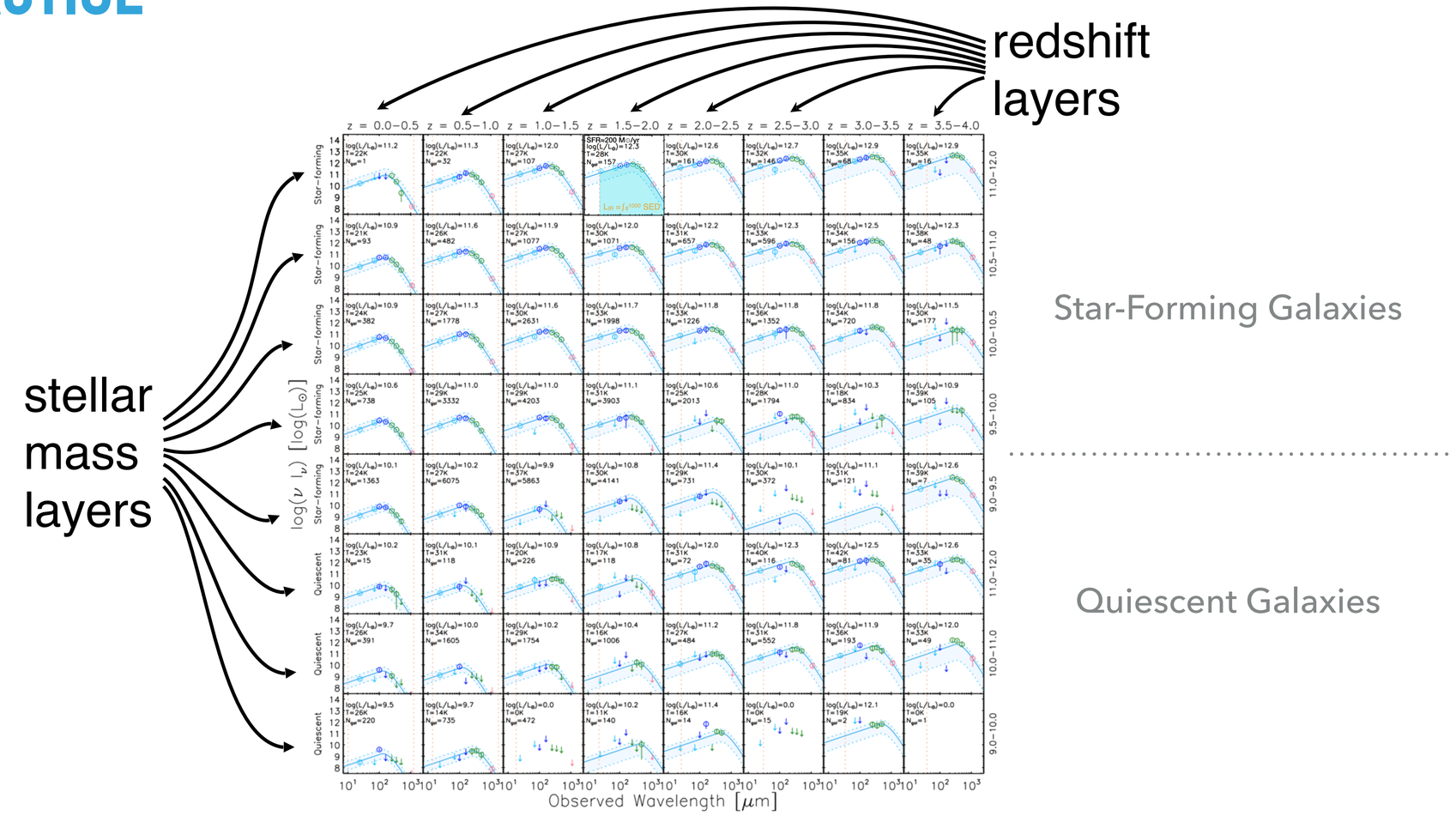


Data here:
UDS catalog
&
Herschel
SPIRE maps

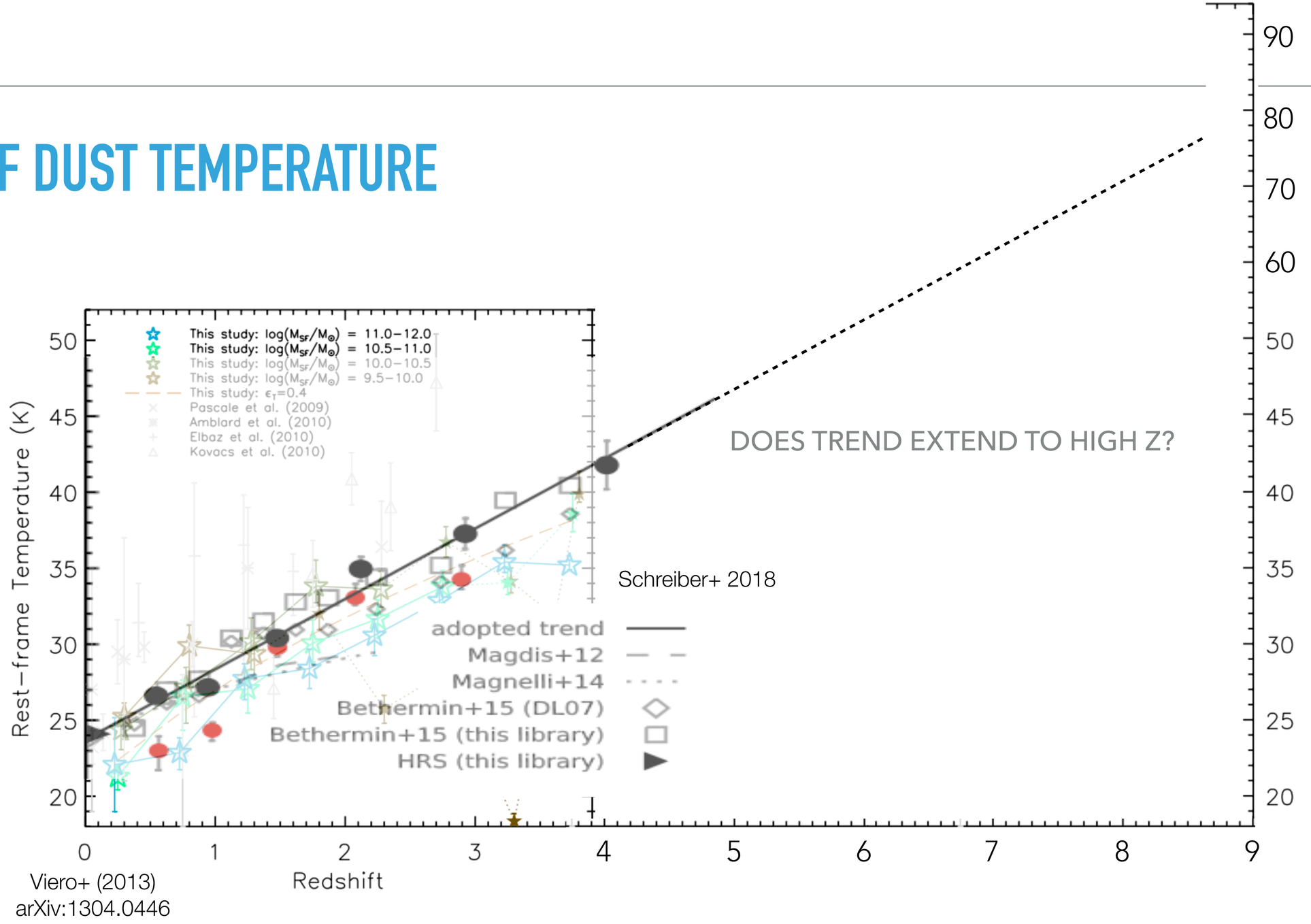
SIMSTACK IN PRACTISE



SIMSTACK IN PRACTISE



EVOLUTION OF DUST TEMPERATURE

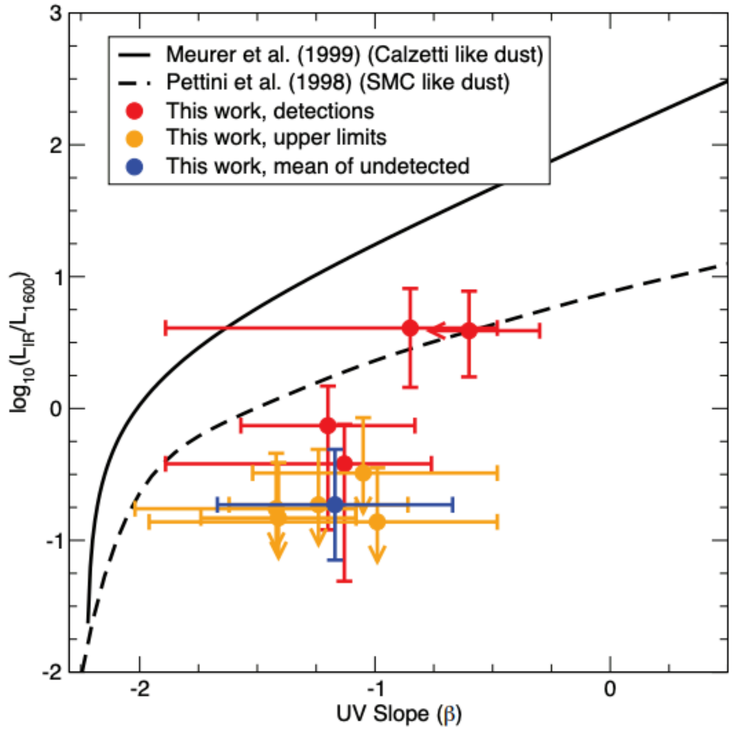


Viero+ (2013)
arXiv:1304.0446

THE CASE FOR HOT DUST

- Resolve IRX-β deficit (Capak+2014 arXiv:1503.07596)
- Resolve unrealistic Dust Masses e.g., Mdust = 5e6 -> 5e5 Msun in MACS0416 Y1 (z = 8.3) (Bakx+2020 arXiv:2001.02812)
- ALMA bias against hot galaxies (Chen+2021 arXiv:2110.14135)

P (L)



10.5 < log(L/Lsun) < 11
11 < log(L/Lsun) < 11.5
11.5 < log(L/Lsun)

Capak+ 2015

JAN 13, 2022, 5:20 PM — TRUE STORY

marco viero Jan 13, 5:20 PM

I reworked simstack for python 3, but also made it a lot more streamlined and easy to use.
It took a lot of work

I downloaded cosmos2020, 5.6 gigs!, and stacked out to redshift 7

Lorenzo Moncelsi Jan 13, 5:25 PM

cool!

marco viero Jan 13, 5:26 PM

Sorry, to 6

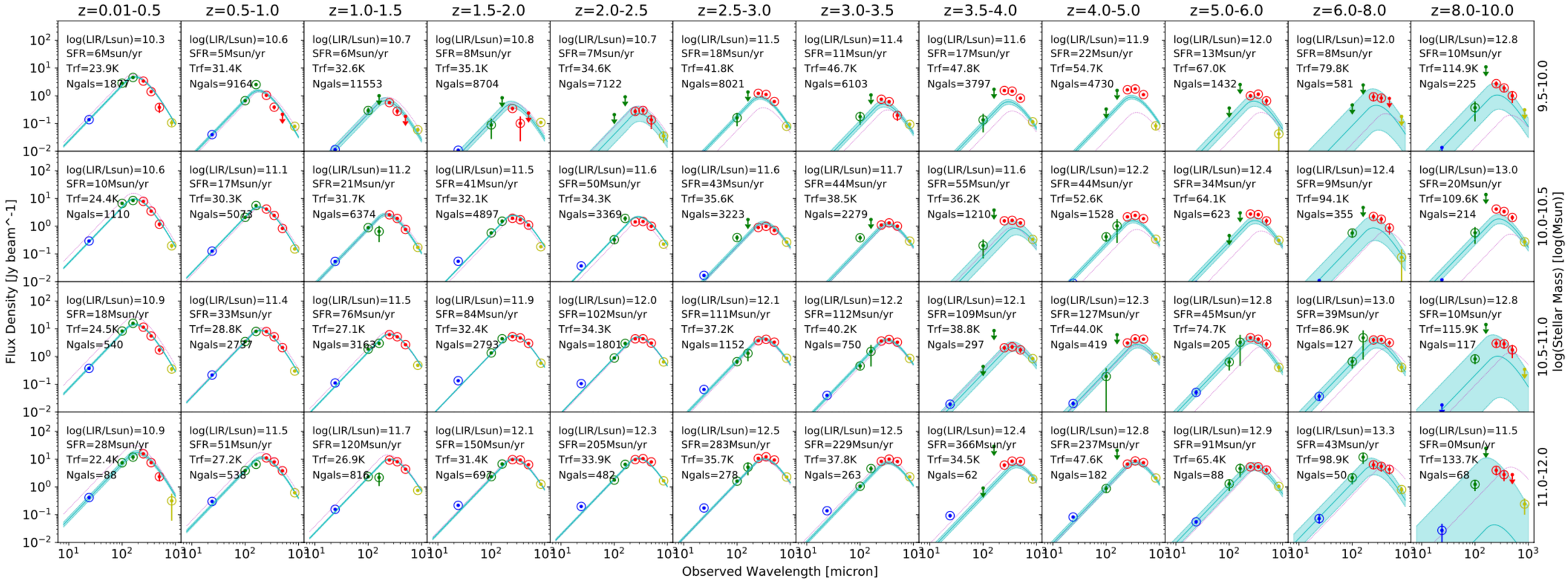
I don't know the answer yet!

THE DATA

- Catalog
  (Weaver+2022 arXiv:2110.13923)
  - 111,227 galaxies over 1.6 deg2
  - FARMER/LePhare photometry/photo-z's
  - redshifts 0 - 10
  - Split into star forming/quiescent (NUVrj)

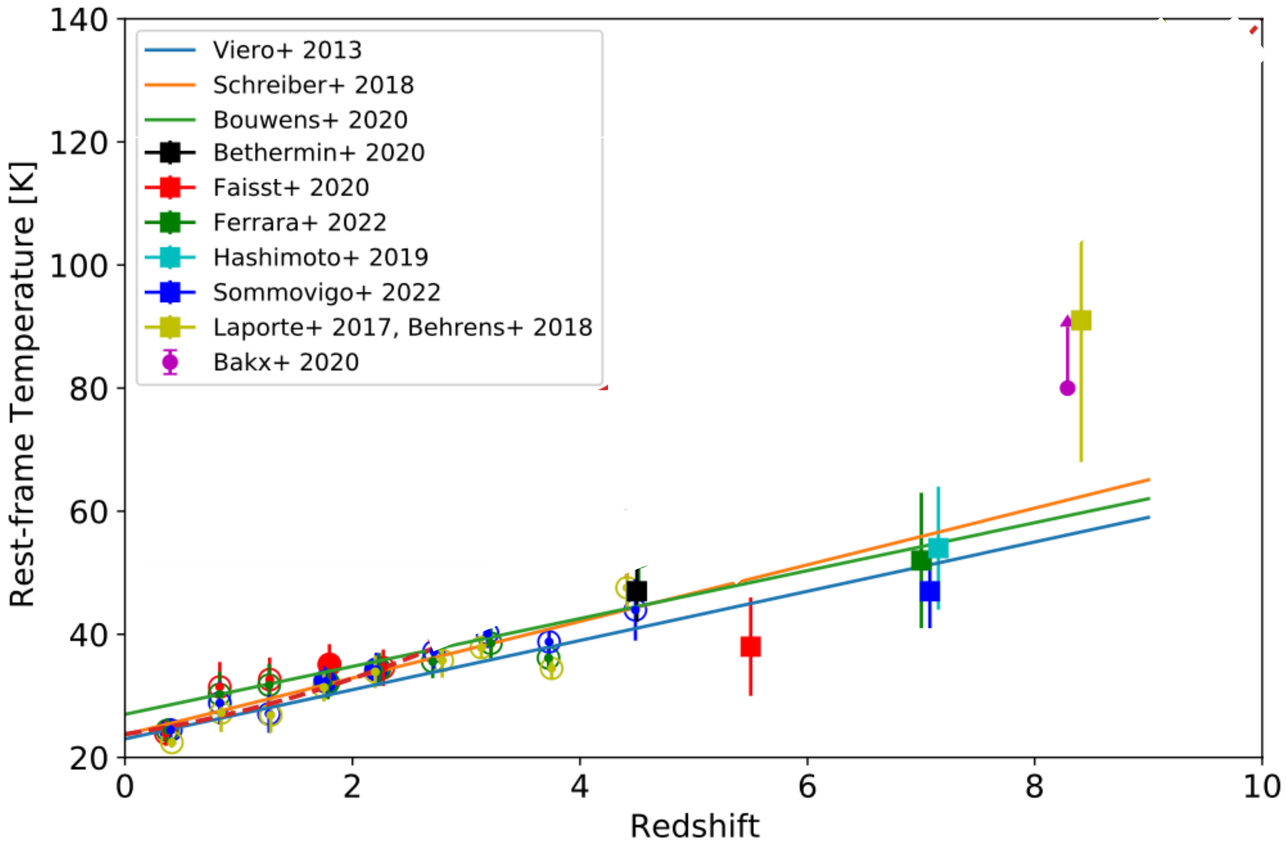
- Maps
  - Spitzer/MIPS (24μm)
  - Herschel/PACS (100 & 160μm)
  - Herschel/SPIRE (250, 350, 500μm)
  - S2CLS (850μm)

SIMULTANEOUS STACK TO Z = 10



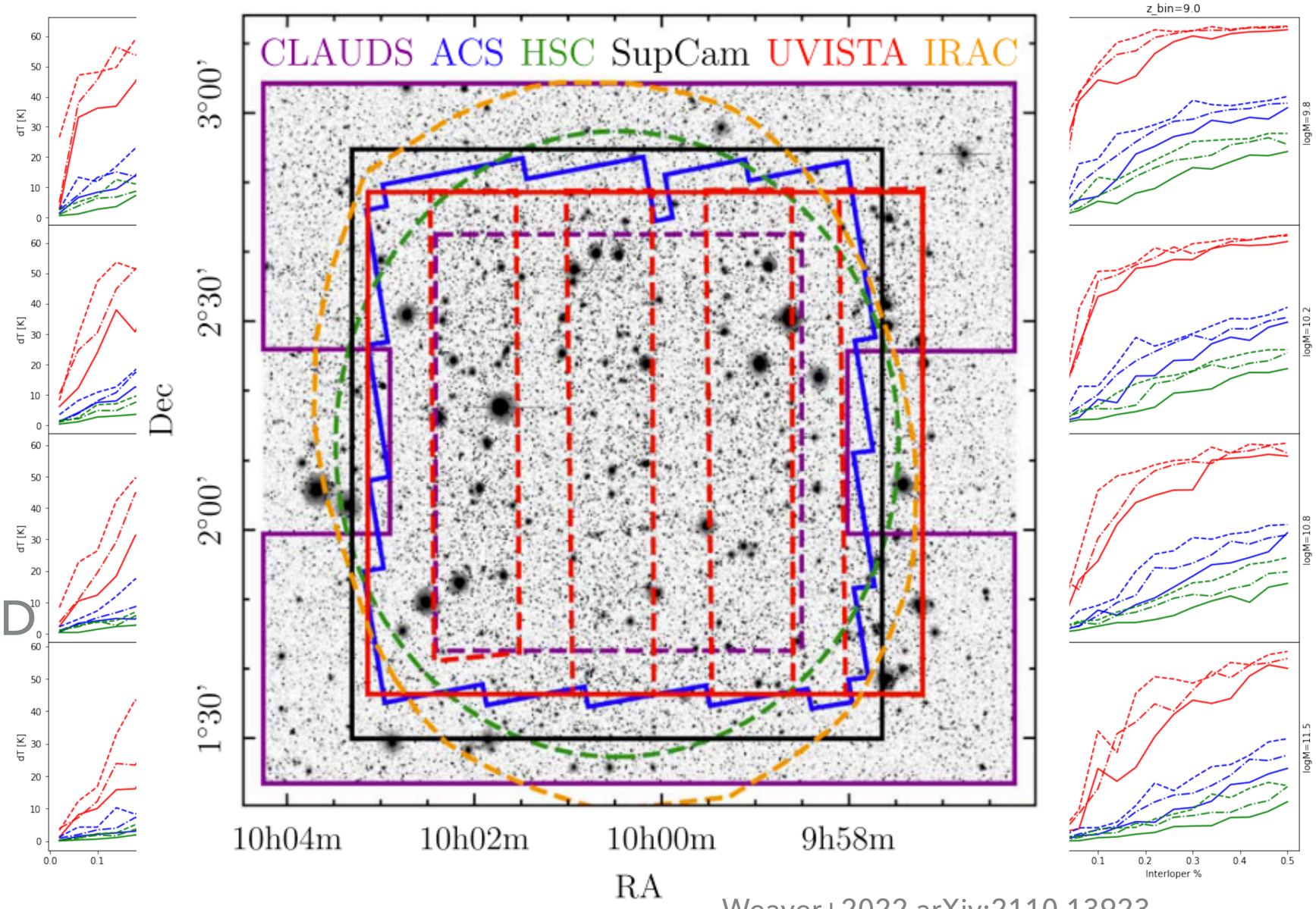
EXCESS HEATING AT Z > 4

- ALPINE/ALMA objects mostly line up with existing trends (T=50 at z~7).
- Two objects much hotter (T=80K at z=8.3).
- Full sample agrees at z < 4, and rises rapidly at higher z.



IS IT REAL?

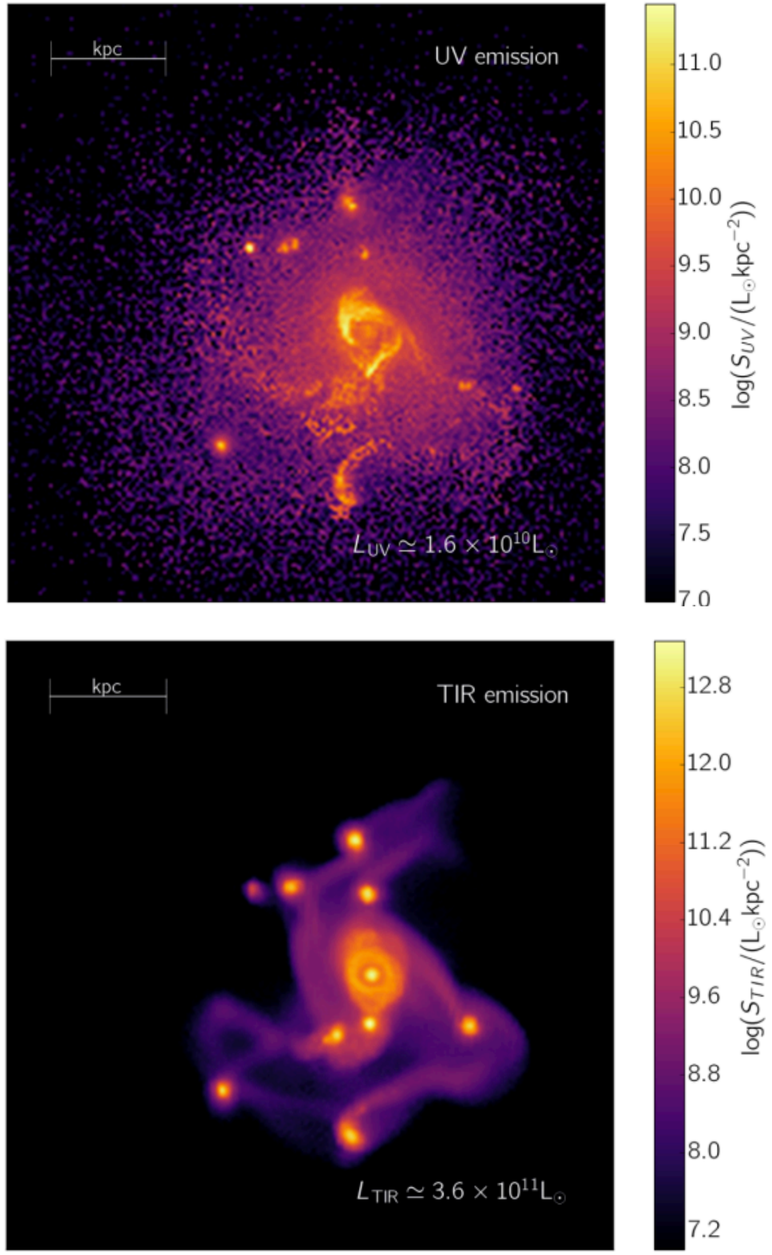
- High-z affected by interlopers?
- Repeated in ultradeep stripes, consistent result.
- Could the model SED be too simple?

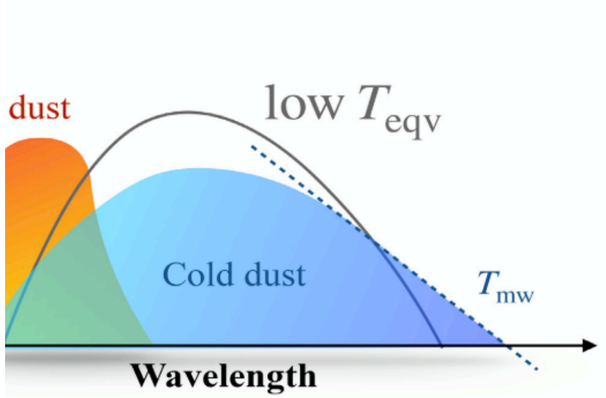


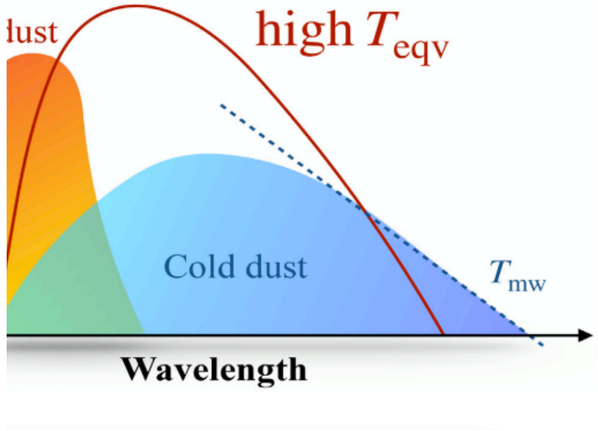
Weaver+2022 arXiv:2110.13923

SOURCES OF HOT DUST

- Simulations show compact, hot dust regions (e.g., Behrens+ 2018)
- Evolving sSFR (Liang+ 2019)
- POP II dust abundant (De Rossi+ 2018)
  - silicate rich
  - low metallicity





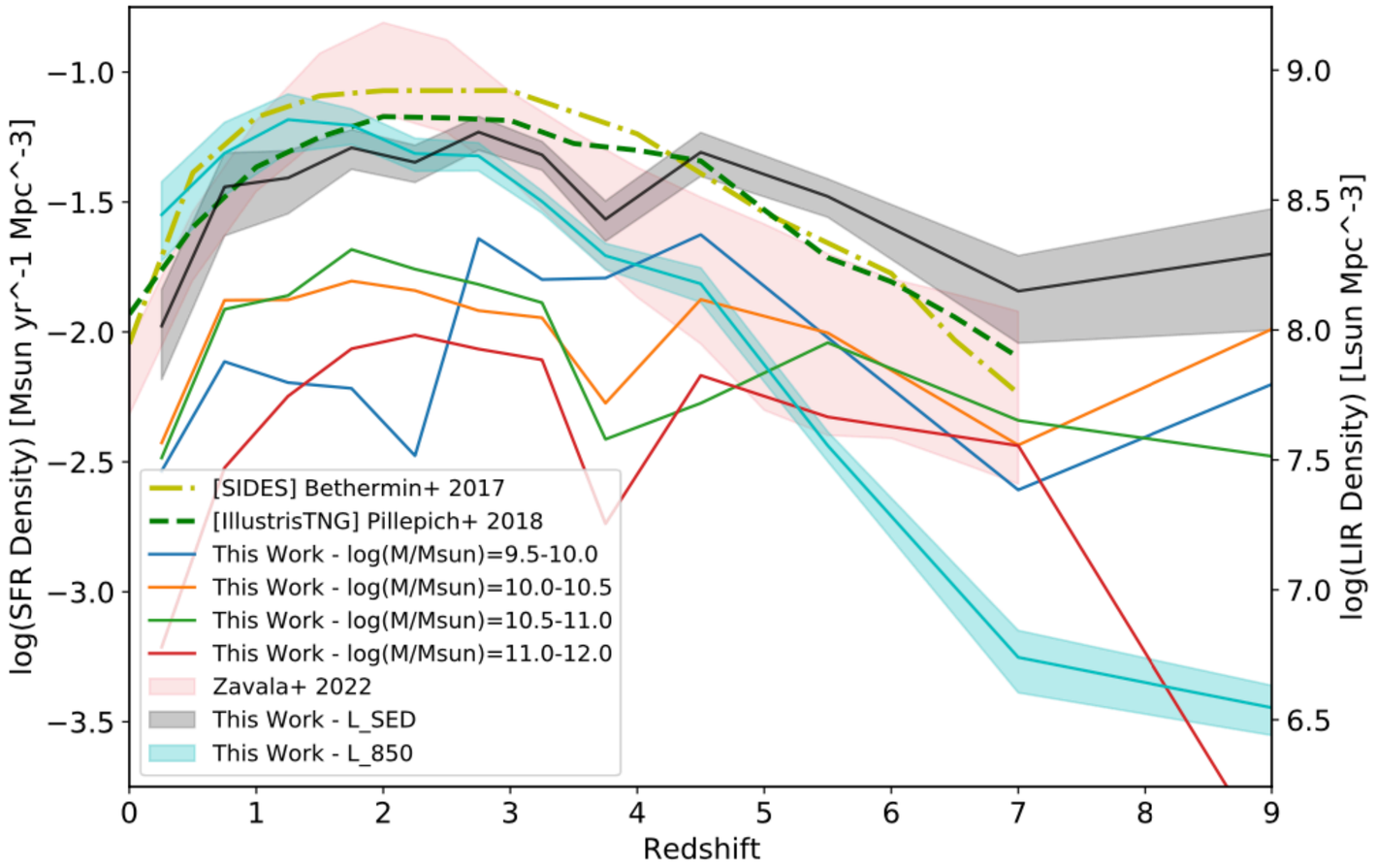


Liang+ 2019 arXiv:1902.10727

Behrens+ 2018 arXiv:1802.07772

STAR FORMATION HISTORY

- Exceeds previous estimates at higher z.
- Agreement with models.
- Rise at z > 7 unusual.



FIND JUPYTER NOTEBOOKS TO REPRODUCE THE MEASUREMENT ON GITHUB

- Instructions and code at https://github.com/marcoviero/simstack3
  - Install, Download Data, Setup configuration file, and GO. Easy!

vim

```
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
; Example parameter file for simstack code
;
; Contact: Marco Viero (marco.viero@caltech.edu)
;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;;
[general]
binning = {"stack_all_z_at_once": 1, "add_background": 1, "crop_circles": 1}
error_estimator = {"bootstrap": {"initial_bootstrap": 1, "iterations": 150}, "write_simmaps": 0, "randomize": 0}
cosmology = Planck18

[io]
output_folder = PICKLESPATH simstack stacked_flux_densities
shortname = cosmos2020_farmer

drop_maps = 1
drop_catalogs = 0

[catalog]
path = CATSPATH cosmos
file = cosmos2020_FARMER.csv
;Catalog specific names for redshift, stellar mass, RA, and DEC
astrometry = {"ra":"ALPHA_J2000", "dec":"DELTA_J2000"}
classification = {"split_type":"nuvrj", "redshift":{"id":"lp_zBEST", "bins":"[0.01, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 5.0, 6.0, 8.0, 10]"}, "stellar_mass":{"id":"lp_mass_med", "bins":"[9.5, 10.0, 10.5, 11.0, 12.0]"}, "split_params":{"id":"sfg", "bins":{"UV-R":"res
tNUV-R", "R-J":"restR-J"}}  }

[maps]
; If noisemap is the second extension of the fits file, then noise and map are the same.
; Maps need to be in Jy/beam.  If they are not, add solid angle of beam to "area" to convert them.
mips_24    = {"wavelength": 24.0, "beam":{"fwhm":5.51,"area":1.328e-09}, "color_correction":1.24, "path_map": "MAPSPATH mips_24_GO3_sci_10.cutout.fits", "path_noise":"MAPSPATH mips_24_GO3_unc_10.cutout.fits"}
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pacs_red   = {"wavelength":160.0, "beam":{"fwhm":11.33,"area":4.658e-09}, "color_correction":1.0, "path_map": "MAPSPATH COSMOS_PACS160_20160728_img_avg.fits", "path_noise":"MAPSPATH COSMOS_PACS160_20160728_img_avg_noise.fits"}
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