

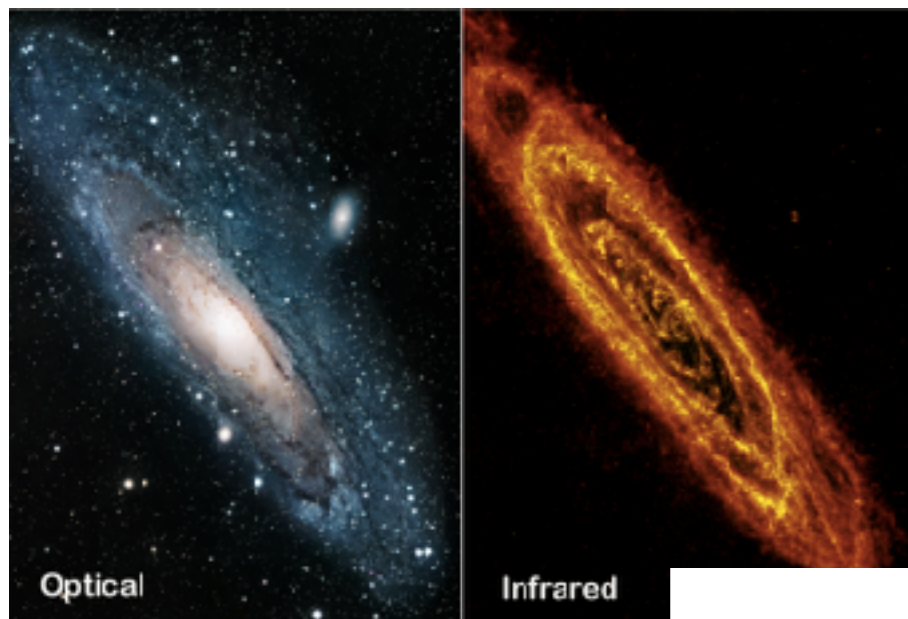
A dark, grainy image representing the Cosmic Infrared Background. It features several bright, white, irregularly shaped spots of varying sizes and orientations, scattered across the field. Overlaid on this background are blue, jagged, closed contours that delineate regions of higher intensity. The contours are somewhat irregular and interconnected, forming a network that encloses several of the bright spots.

Empirically Modeling Intensities in the Cosmic Infrared Background

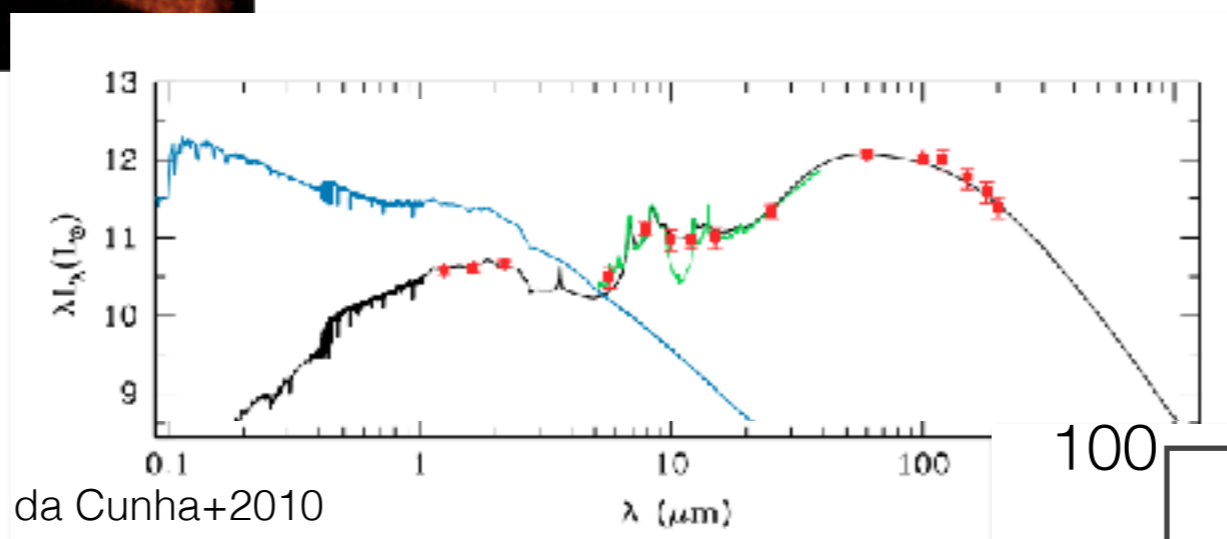
Marco Viero — KIPAC/Stanford

w/

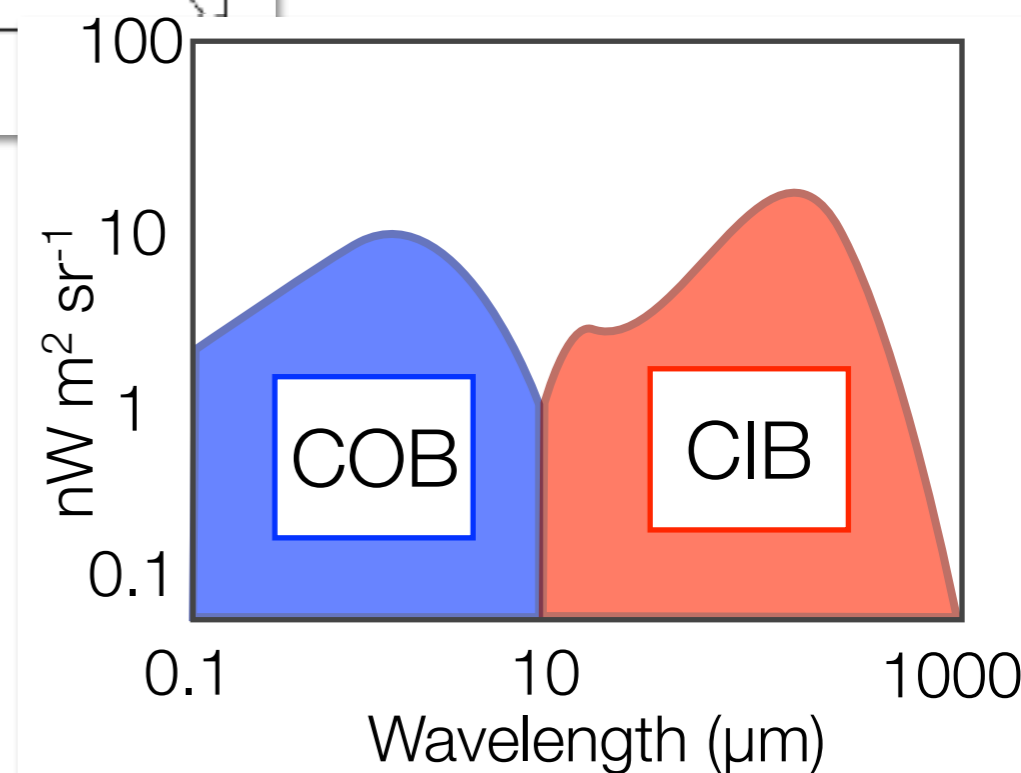
Lorenzo Moncelsi & Jason Sun (Caltech)



- Infrared/Submillimeter emission reprocessed starlight by dust
- IR/Submm traces star formation
- Half the emission is tied up in dust



- Want to know:
 - ➔ the full SED (including IR) of all galaxies
 - ➔ accurate characterization of secondary anisotropies



z-band

Challenge

Solution

- Treat images as a continuum intensity maps
- Use ancillary data
- Get creative

- Use the fact that intensity fluctuations are real signal



GOODS-S
Half 1

This panel shows a grayscale image of a galaxy field from the GOODS-S region, labeled 'Half 1'. It displays numerous galaxies of varying sizes and brightnesses against a dark background, with some prominent bright spots.

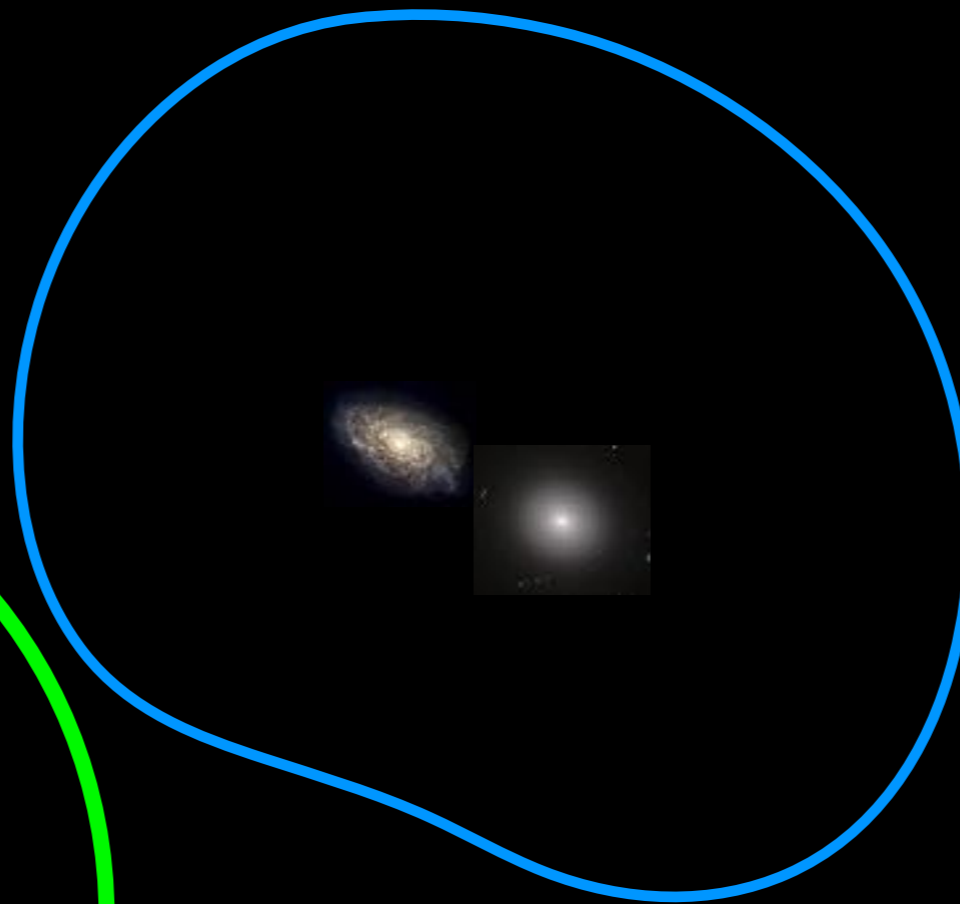


GOODS-S
Half 2

This panel shows a grayscale image of a galaxy field from the GOODS-S region, labeled 'Half 2'. It displays numerous galaxies of varying sizes and brightnesses against a dark background, with some prominent bright spots.

SPIRE Contour

SPIRE 250 μ m
18" Beam

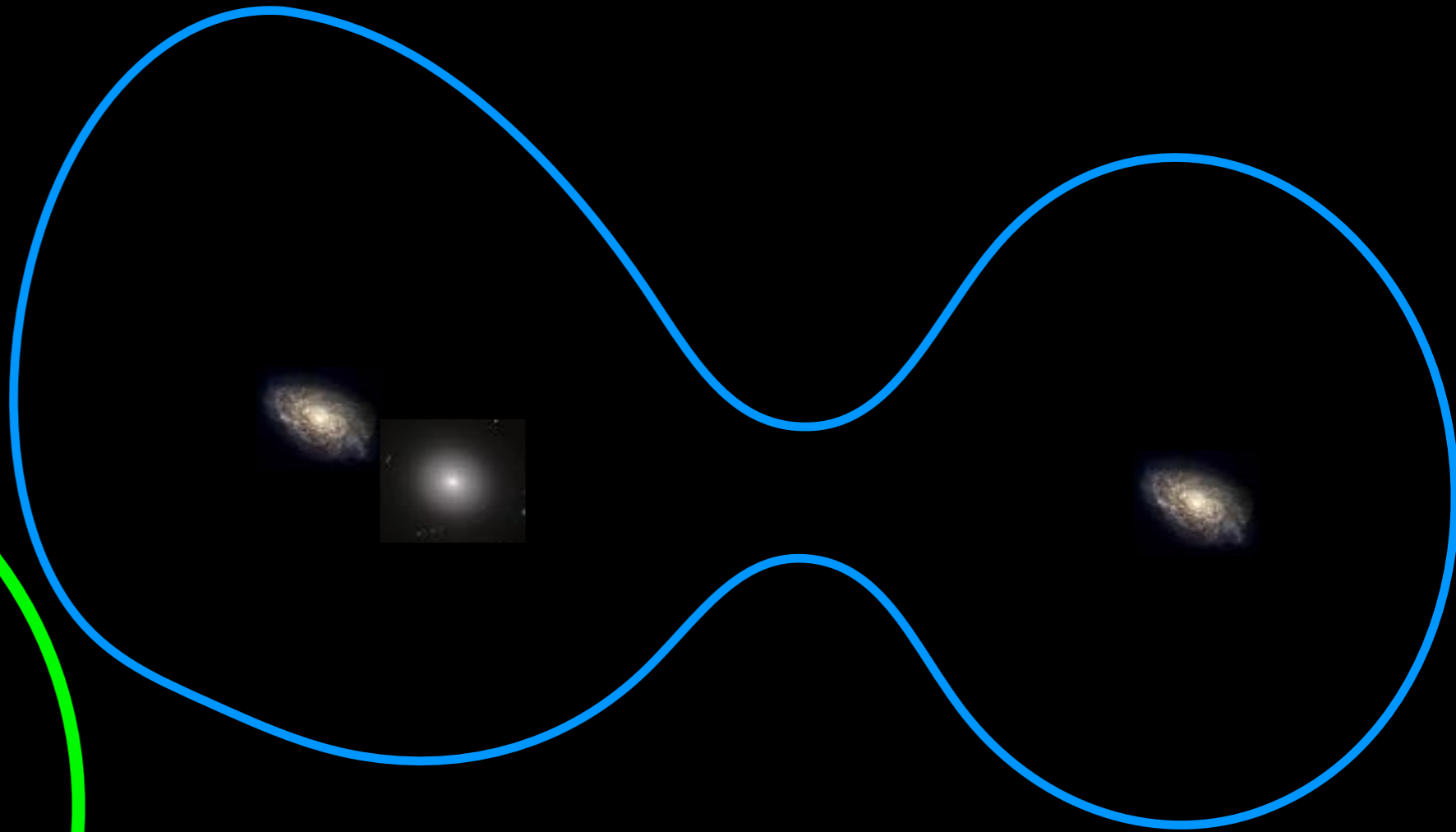


- Challenge: Difficult to attribute an individual submillimeter “source” to any single galaxy



SPIRE Contour

SPIRE 250 μ m
18" Beam



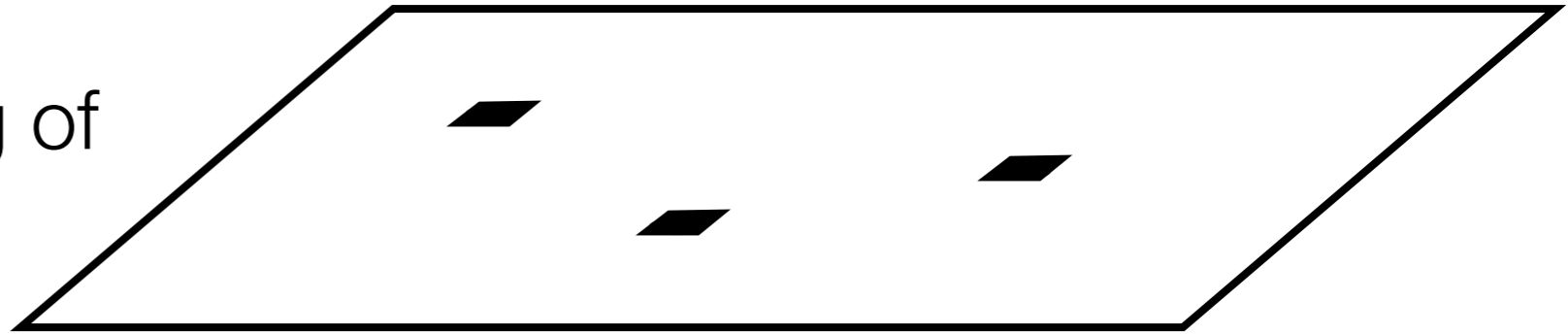
- Solution: Identify galaxies with similar *physical* properties, and then rely on ***statistics*** to fit ***fluctuations***

Assumptions

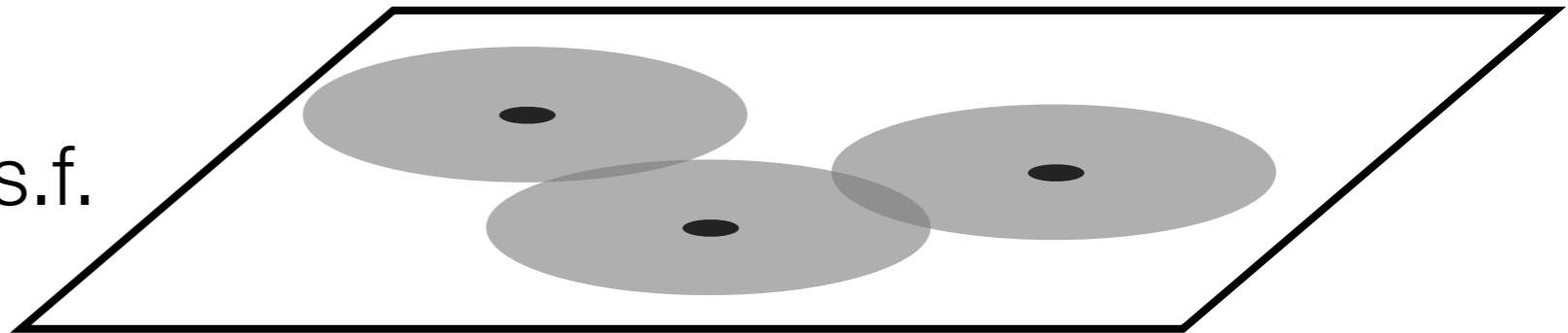
- Galaxies identified as “similar” will have similar FIR properties
- Catalog is reasonably complete (that’s *another* talk)
- [note: outliers (e.g., lensed galaxies) are ignored]

SIMSTACK: Continuum Intensity Fitting Algorithm

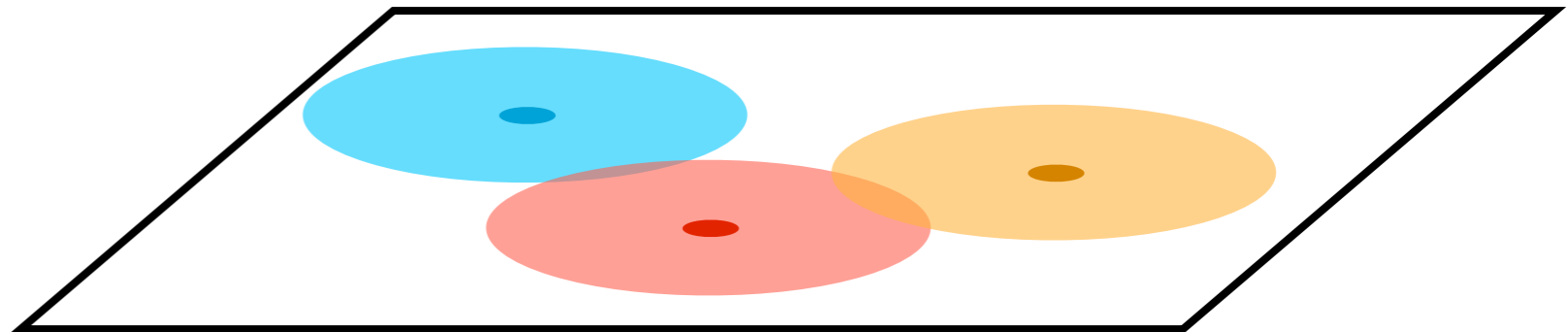
make hits map from catalog of similar objects



convolve with instrument p.s.f.



regress to find *mean* flux density



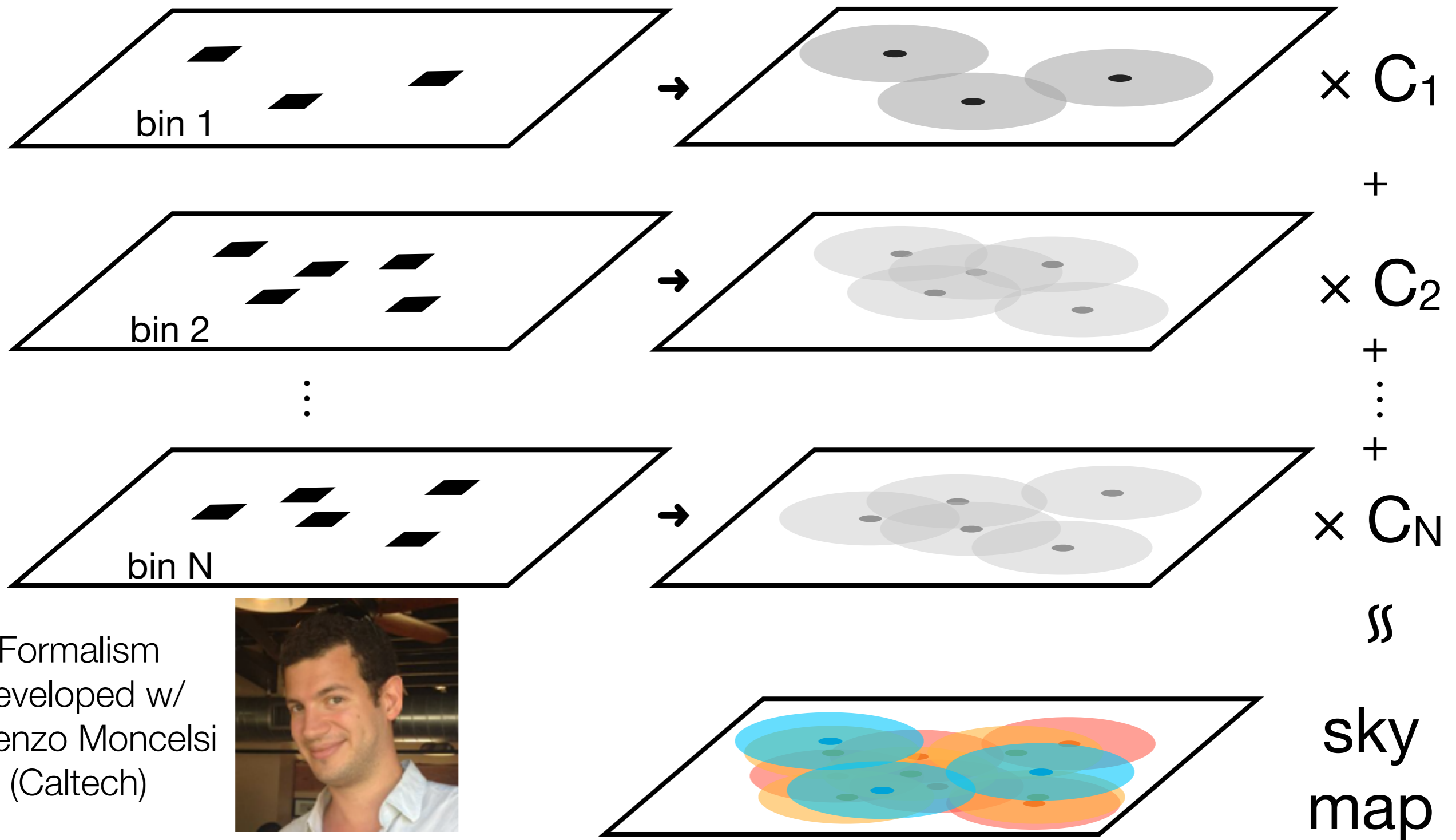
Formalism developed w/ Lorenzo Moncelsi (Caltech);
also see Kurczynski & Gawiser (2010), Roseboom et al. (2010)

SIMSTACK code publicly available (see arXiv:1304.0446):

IDL (old) – <https://web.stanford.edu/~viero/downloads.html>

Python (under development!**) – <https://github.com/marcoviero/simstack>**

SIMSTACK: Continuum Intensity Fitting Algorithm

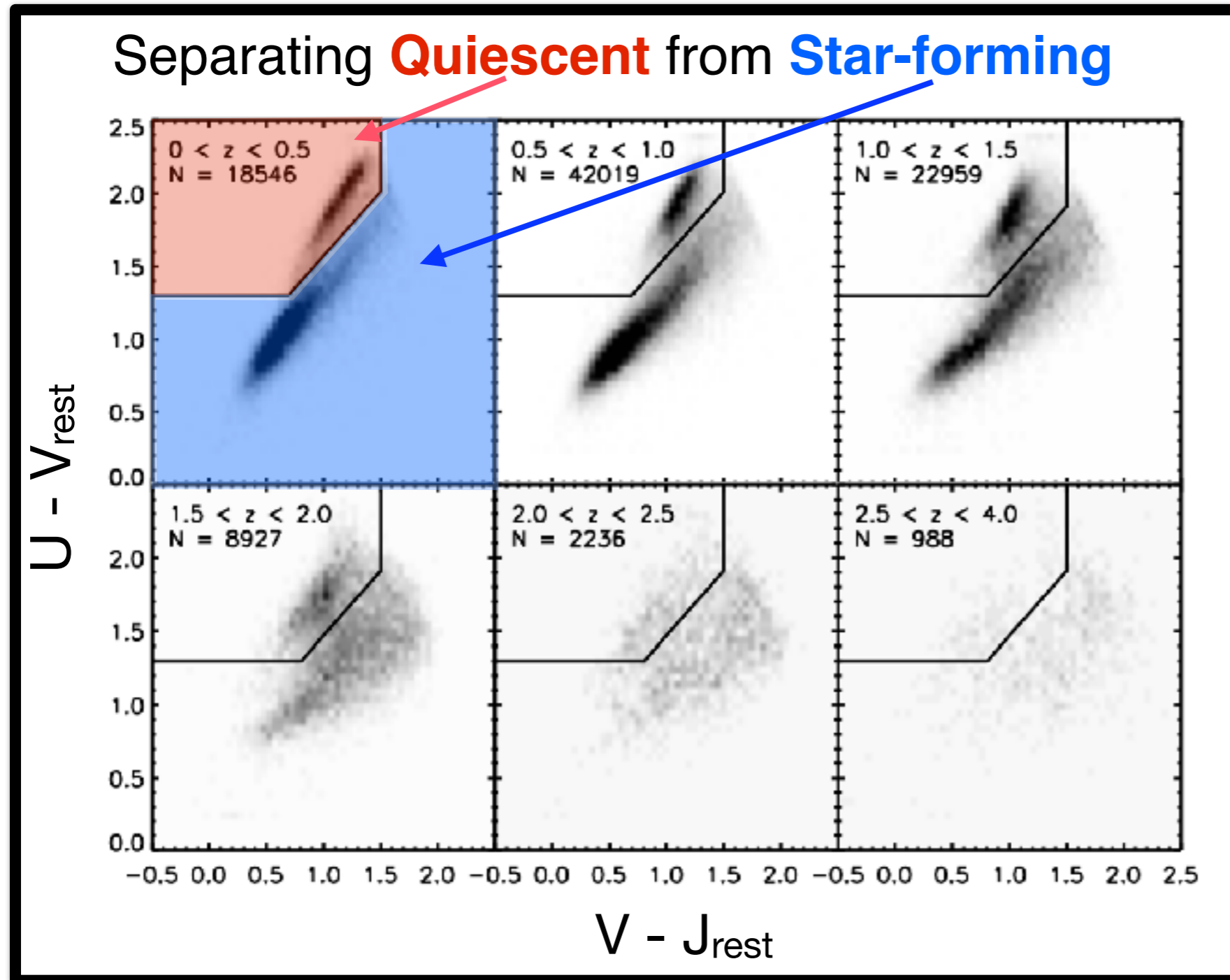


Formalism
developed w/
Lorenzo Moncelsi
(Caltech)



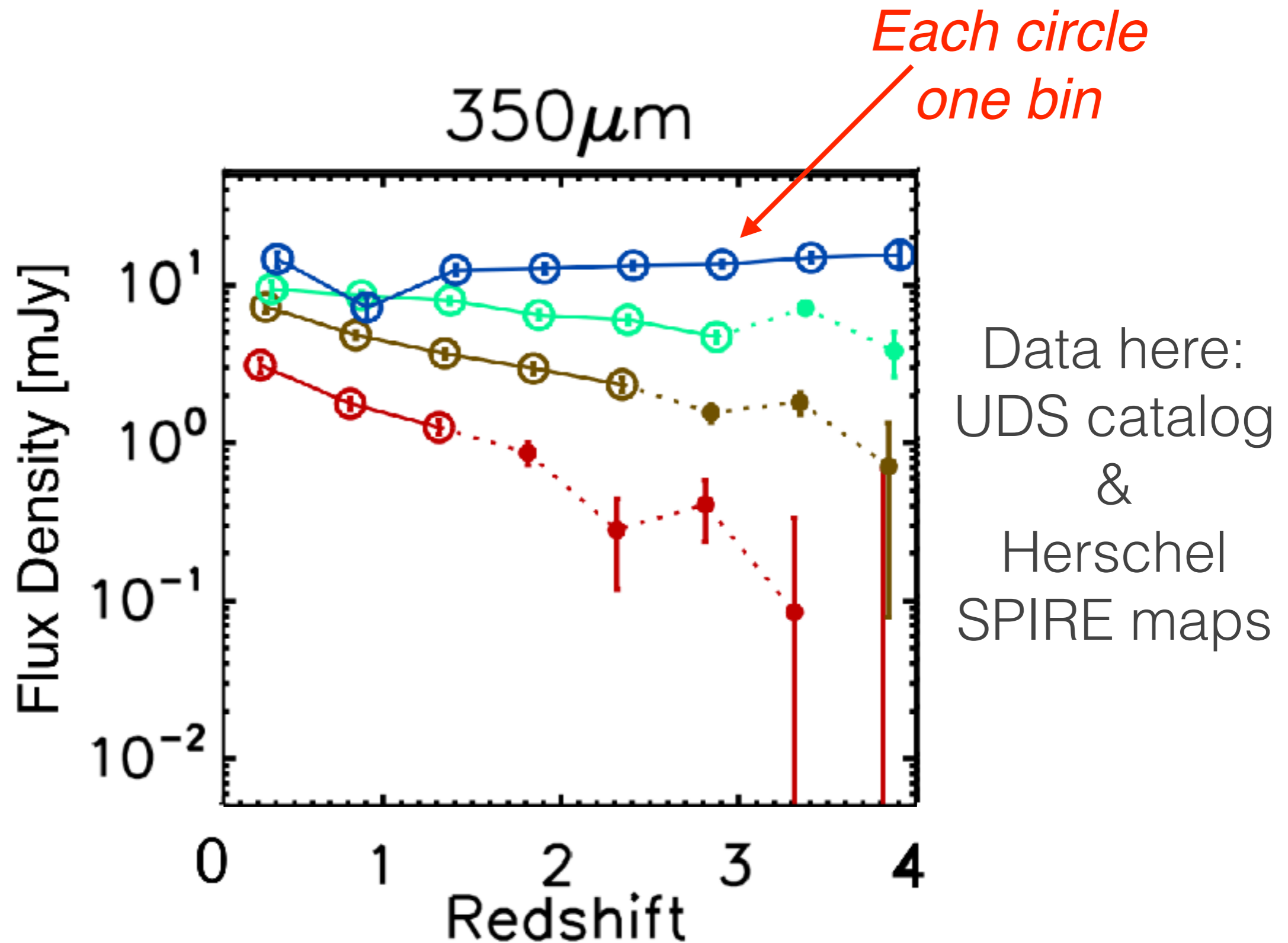
SIMSTACK code publicly available (see arXiv:1304.0446):

Python (under development!) — <https://github.com/marcoviero/simstack>

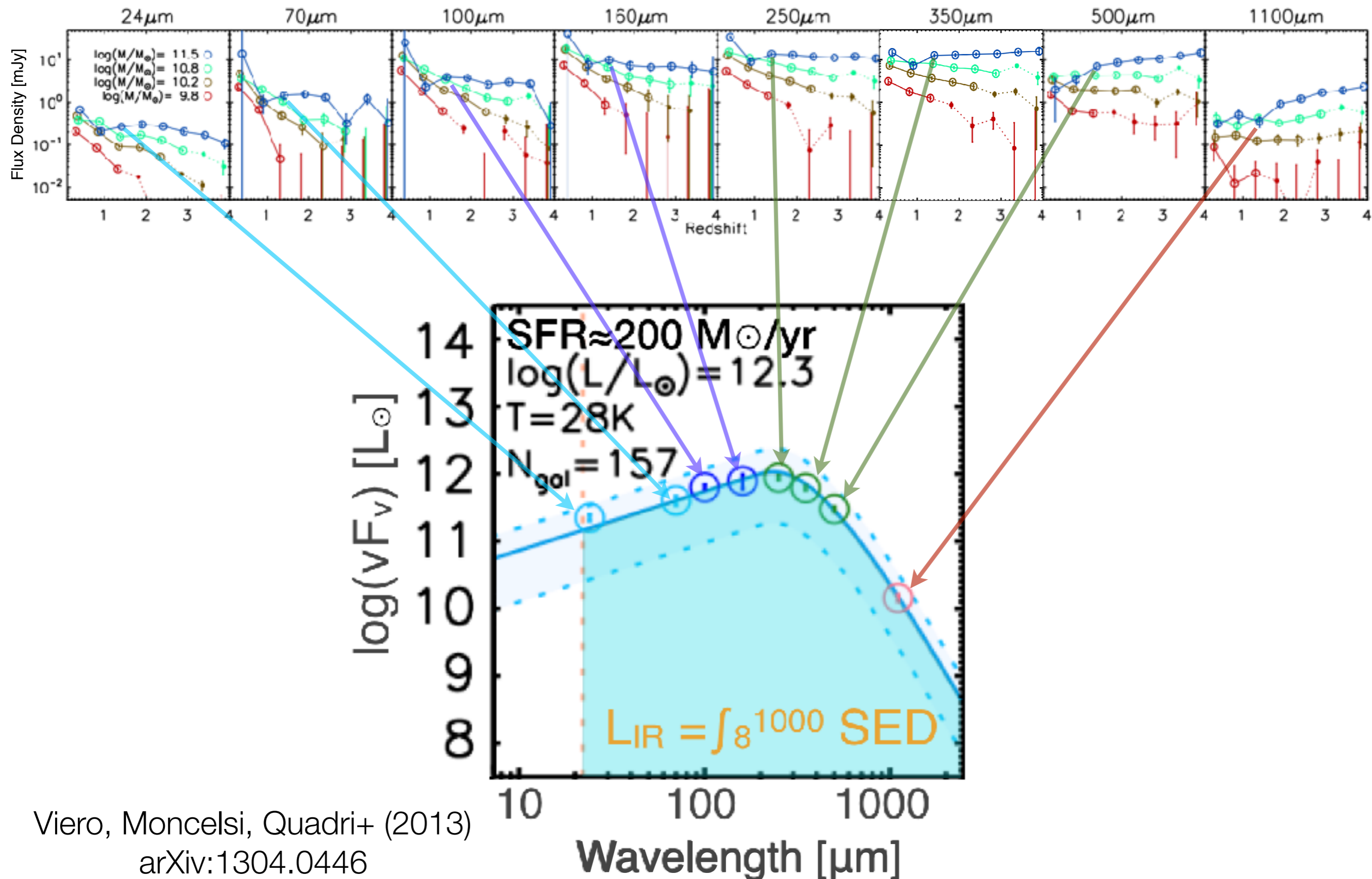


Muzzin et al. (2013)

- **Redshifts** - EAZY (Brammer 2008)
- **Masses** - FAST (Kriek 2009)
- **Colors** - UVJ (Williams 2009)



SIMSTACK: Flux Densities (M,z)

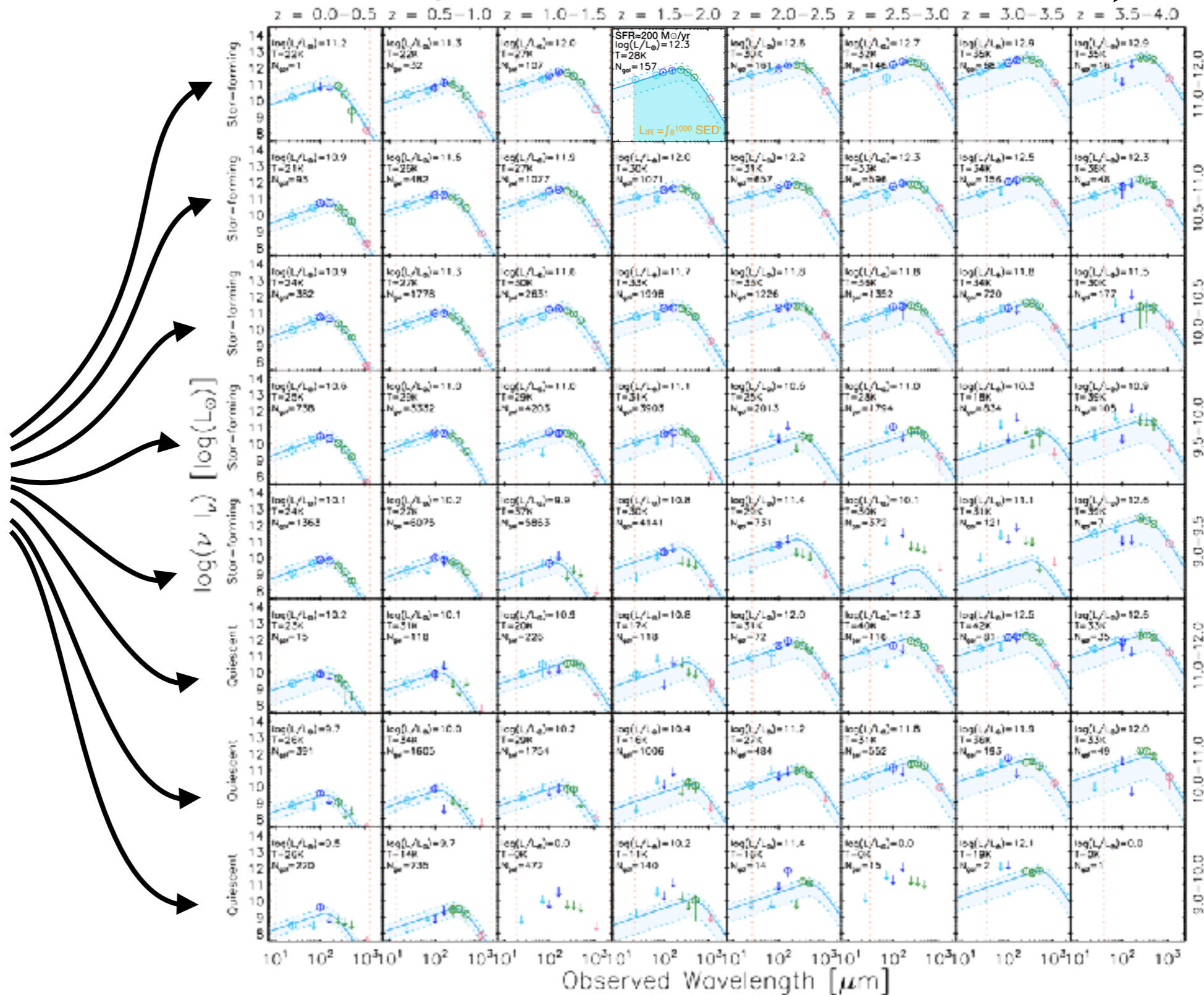


Viero, Moncelsi, Quadri+ (2013)
arXiv:1304.0446

SIMSTACK: SEDs

redshift slices

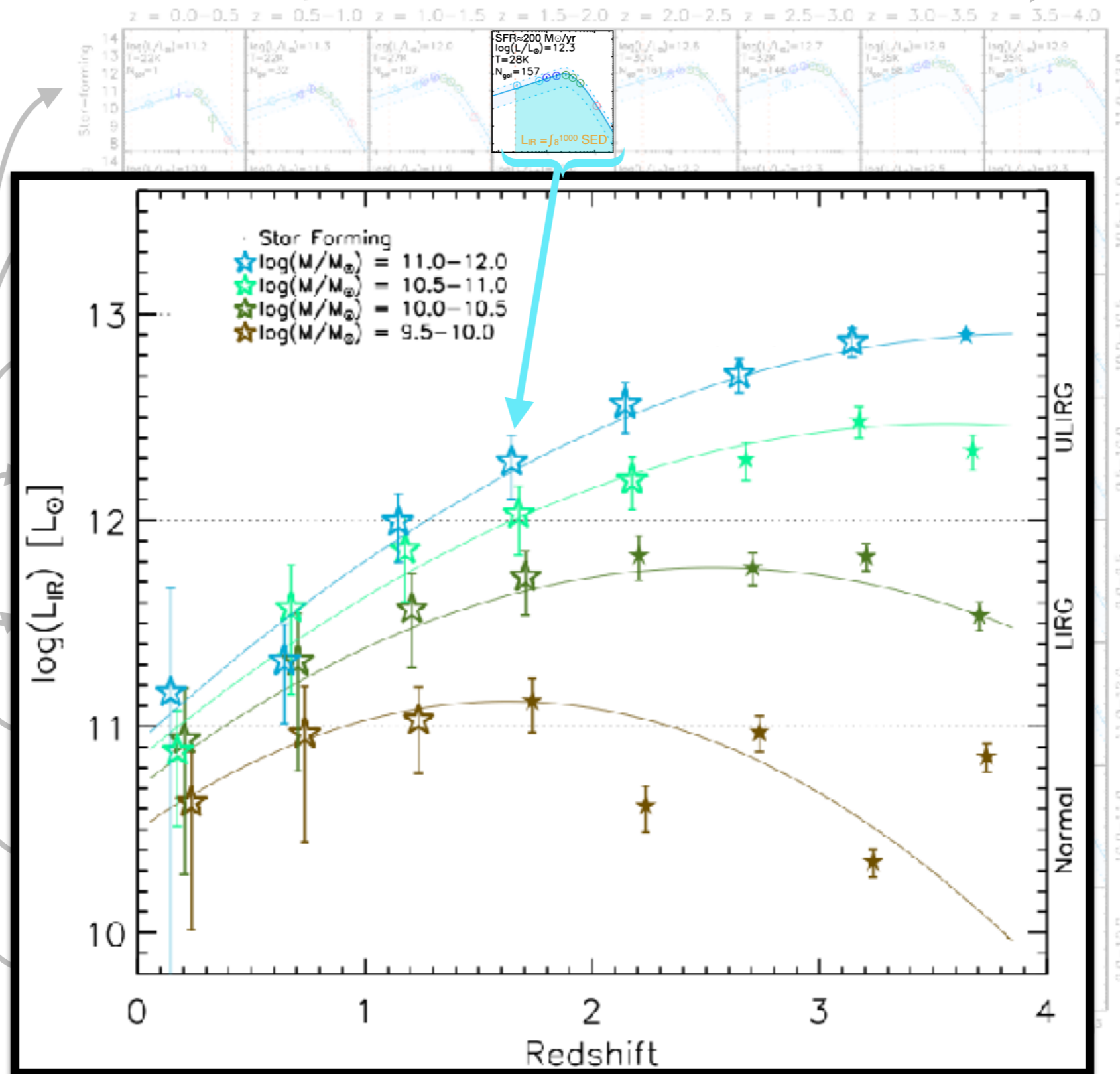
stellar mass slices



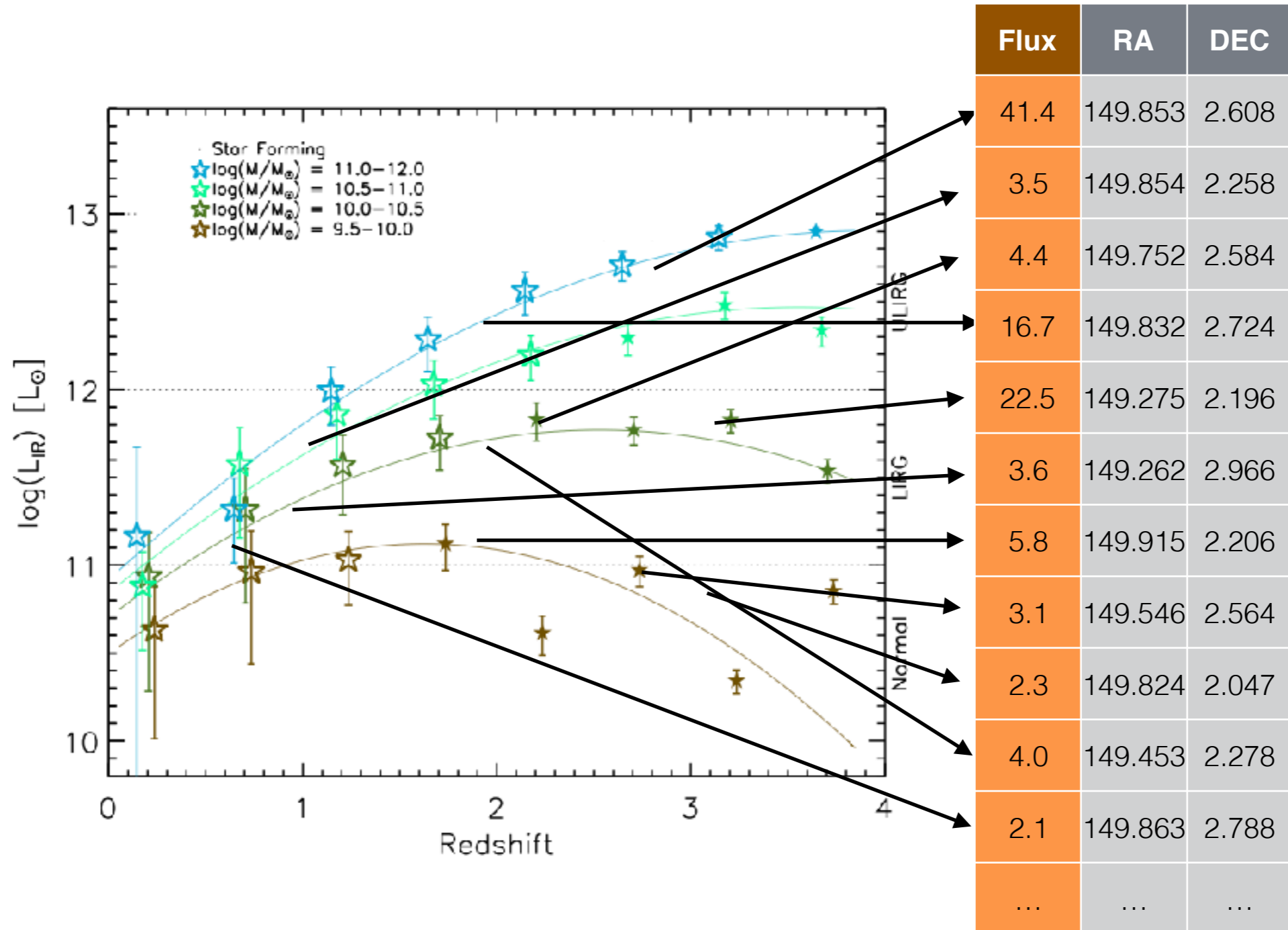
SIMSTACK: $L_{IR}(M, z)$

redshift slices

stellar mass slices

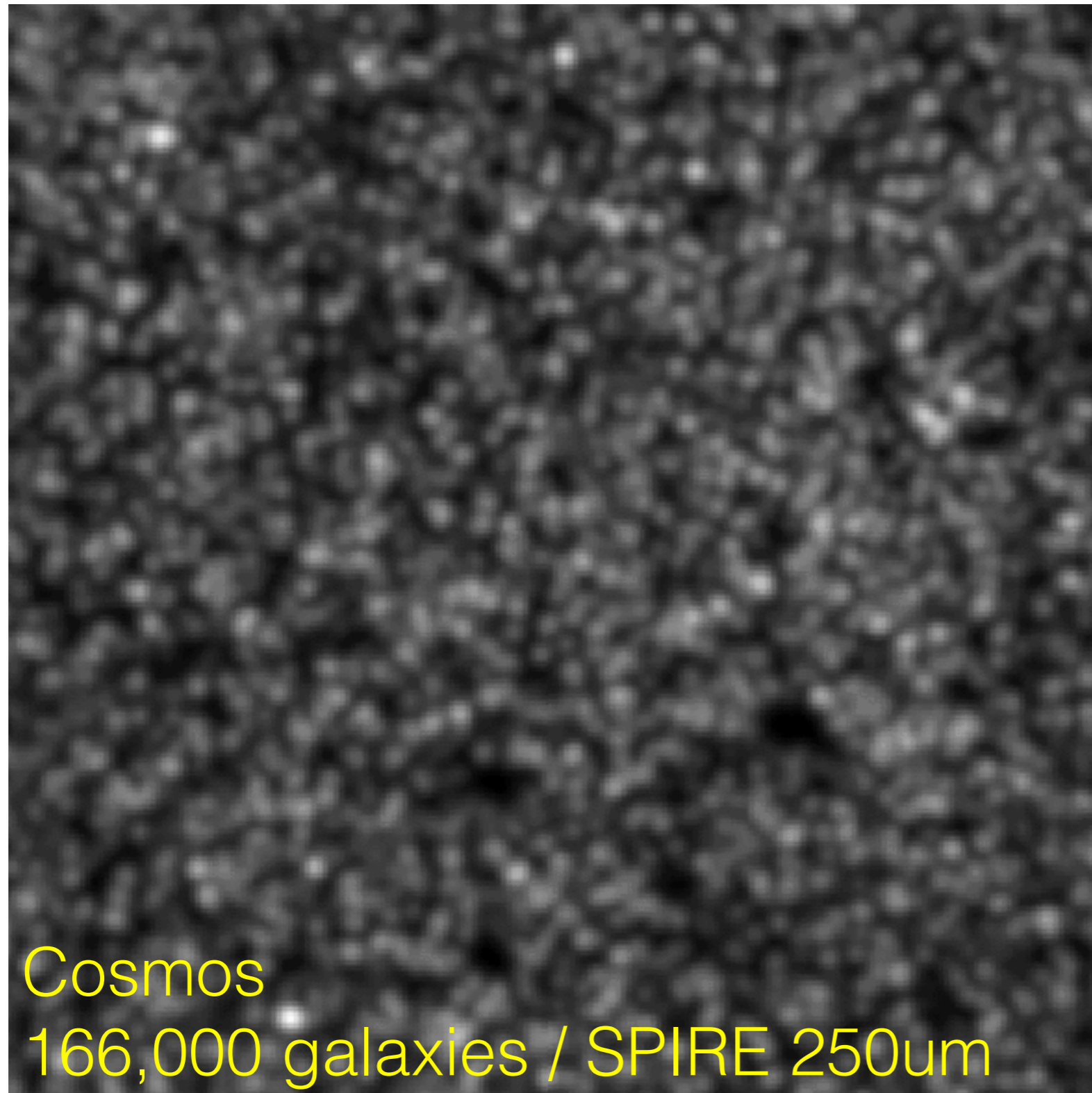


Simulating the Sky



Viero, Monceli, Quadri et al. (2013)
arXiv:1304.0446

SIMSTACK: simplest results



	Flux	RA	DEC
←	41.4	149.853	2.608
←	3.5	149.854	2.258
←	4.4	149.752	2.584
←	16.7	149.832	2.724
←	22.5	149.275	2.196
←	3.6	149.262	2.966
←	5.8	149.915	2.206
←	3.1	149.546	2.564
←	2.3	149.824	2.047
←	4.0	149.453	2.278
←	2.1	149.863	2.788
←

Simstack on Github

Python (**under development!**) :
<https://github.com/marcoviero/simstack>

- Just added:
 - Simstack from the command line
 - Edit the **.cfg** parameter file and run:

```
../run_simstack_cmd_line.py example.cfg
```
- Flexible. Can:
 - Toggle wavelengths
 - Bootstrap
 - Optimal binning (under development)

```
! The following example parameter file for simstack code
! Each line should have at most one parameter name and value
!
! Contact: Marco Viero (marco.viero@poli.it)
! =====
[general]
population_choices (see the catalog to split into groups with lib=group lib
) with size=library/library_size (s.f.)
population     = 4
bootstrap      = False @ 1 ; True/False, Initial number, number of iterations

[catalog] ; (seeology = fitted)
omega_0 = 0.005
omega_1 = 0.0010
omega_k = 0
h         = 0.0774

[io] ; Input/output
output_folder         = /output / LIBPAC TO/DIR
output_bootstrap_folder = /output/bootstrap_files/ ; Output folder for bootstraps
flux_statistics_folder = simstack_flux_statistics ; Will be saved to (output_folder)/(flux_statistics_folder)/var
ofirrone              = /output_data/colr/2_51000_vars

[catalog]
catalog_path = /data/mpi_care_mode/vercatalogs/vars/af
catalog_lib = C29105203_Lab/vars_0_1.Live

[binary]
split_and_binning = False @ 1 ; True/False, (optional) number of bins)
file_in_reader_kid = False
file_in_reader = False
read_write_files = False
write_files = False
read_write_files = 0.5 1.0 1.5
write_files = 0.0 0.5 10.0 10.0 11.0 12.0

[map_to_stack]
; True/False represents whether to stack them
map_21         = 21.0 -false
pocs_green     = 183.0 -false
pocs_red       = 258.0 -false
spnr_15M       = 258.0 1.0
spnr_17M       = 258.0 -false
spnr_18M       = 258.0 -false
spnr_19M       = 258.0 -false
scuba_150      = 150.0 -false
scuba_250      = 250.0 -false
critec         = 1000.0 -false

[map_path]
map_21         = /data/vars/lib/vars/catalog/
pocs_green     = /data/vars/lib/vars/catalog/
pocs_red       = /data/vars/lib/vars/catalog/
spnr_15M       = /data/vars/lib/vars/catalog/
spnr_17M       = /data/vars/lib/vars/catalog/
spnr_18M       = /data/vars/lib/vars/catalog/
spnr_19M       = /data/vars/lib/vars/catalog/
scuba_150      = /data/simstack/data/output/
scuba_250      = /data/simstack/data/output/
critec         = /data/simstack/data/output/

[map_file]
map_21         = map_21_150_scl_10.output.fits
pocs_green     = pocs_green_green_road_road.output.fits
pocs_red       = pocs_green_red_road_road.output.fits
spnr_15M       = critec-wvista-rpella_150mg_10_10ermcans_e_w_150scob_pocls_15M.signal.output.fits
spnr_17M       = critec-wvista-rpella_150mg_10_10ermcans_e_w_150scob_pocls_17M.signal.output.fits
spnr_18M       = critec-wvista-rpella_150mg_10_10ermcans_e_w_150scob_pocls_18M.signal.output.fits
spnr_19M       = critec-wvista-rpella_150mg_10_10ermcans_e_w_150scob_pocls_19M.signal.output.fits
scuba_150      = map150_nor_header.output.fits
scuba_250      = map250_nor_header.output.fits
critec         = critec_jcrit_karrtt20200225_nol2.output.fits

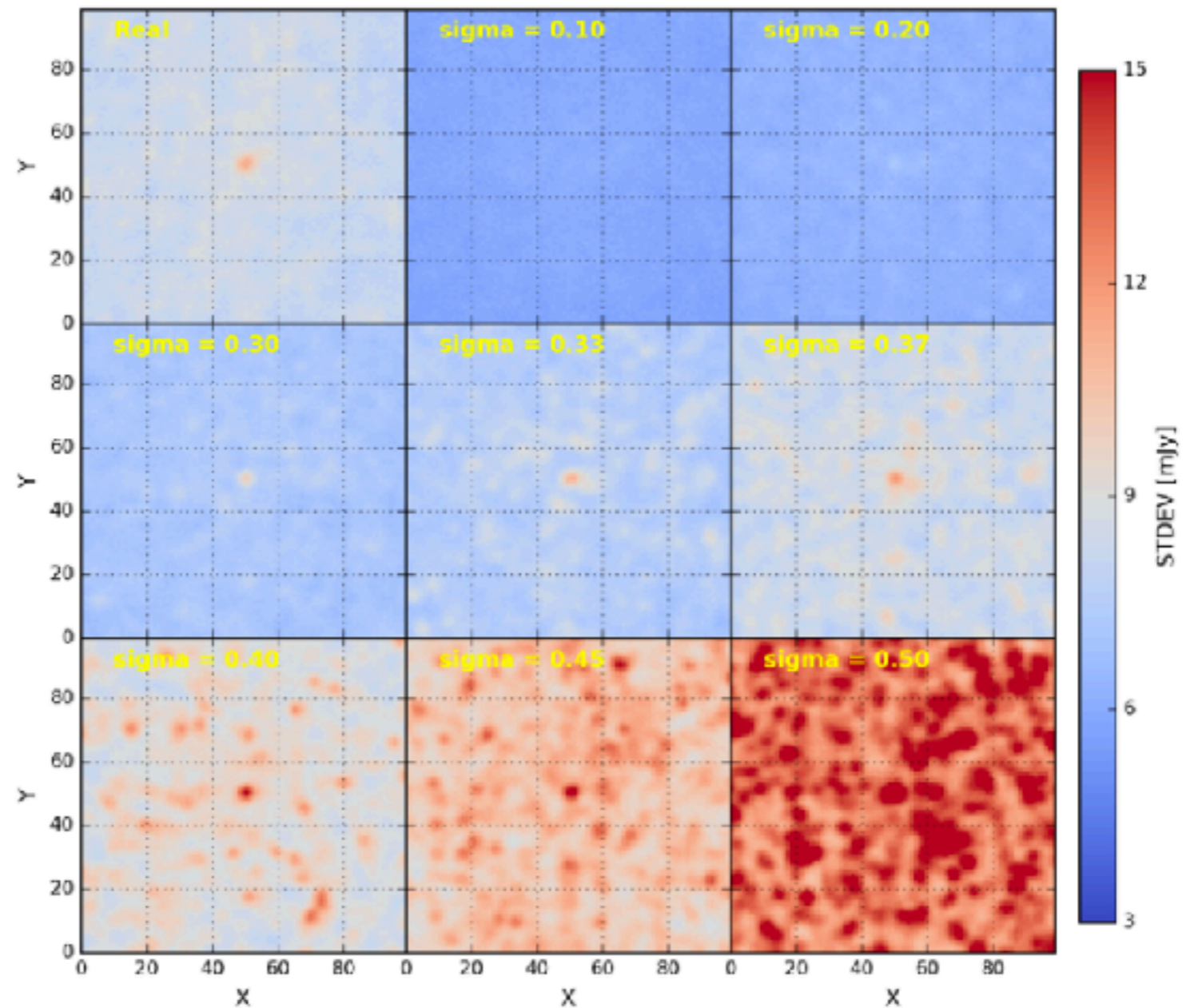
[read_files]
; If file exists, it will be read, else, it will be generated, see, see more as signal map
map_21         = map_21_150_scl_10.output.fits
pocs_green     = pocs_1000000_green_1000000.output.fits
pocs_red       = pocs_1000000_red_1000000.output.fits
spnr_15M       = critec-wvista-rpella_150mg_10_10ermcans_e_w_150scob_pocls_15M.output.fits
spnr_17M       = critec-wvista-rpella_150mg_10_10ermcans_e_w_150scob_pocls_17M.output.fits
spnr_18M       = critec-wvista-rpella_150mg_10_10ermcans_e_w_150scob_pocls_18M.output.fits
spnr_19M       = critec-wvista-rpella_150mg_10_10ermcans_e_w_150scob_pocls_19M.output.fits
scuba_150      = map150_nor_header.output.fits
scuba_250      = map250_nor_header.output.fits
critec         = critec_jcrit_karrtt20200225_nol2.output.fits

[board]
; If not file path, board, or effective beam
; If not board, or
; If not beam, or
map_21         = 15.0 1.0 0.0
pocs_green     = 6.7 1.0
pocs_red       = 11.2 1.0
spnr_15M       = 17.0 1.0
spnr_17M       = 23.0 1.0
spnr_18M       = 33.2 1.0
scuba_150      = 7.8 1.0
scuba_250      = 14.0 1.0
critec         = 10.0 1.0

[radio_params] ; (see them at 1. 2017 for explanation)
map_21         = 1.0
pocs_green     = 10.0
pocs_red       = 10.0
spnr_15M       = 1.010
spnr_17M       = 0.9904
spnr_18M       = 0.9805
scuba_150      = 1e-3
scuba_250      = 1e-3
critec         = 1.0
```

Quantifying Scatter with Simulations

- “Scatter” vs. Scatter:
 - intrinsic vs. lazy split of parent catalog
- Consequences for:
 - guiding masking strategies
 - interpreting power spectrum



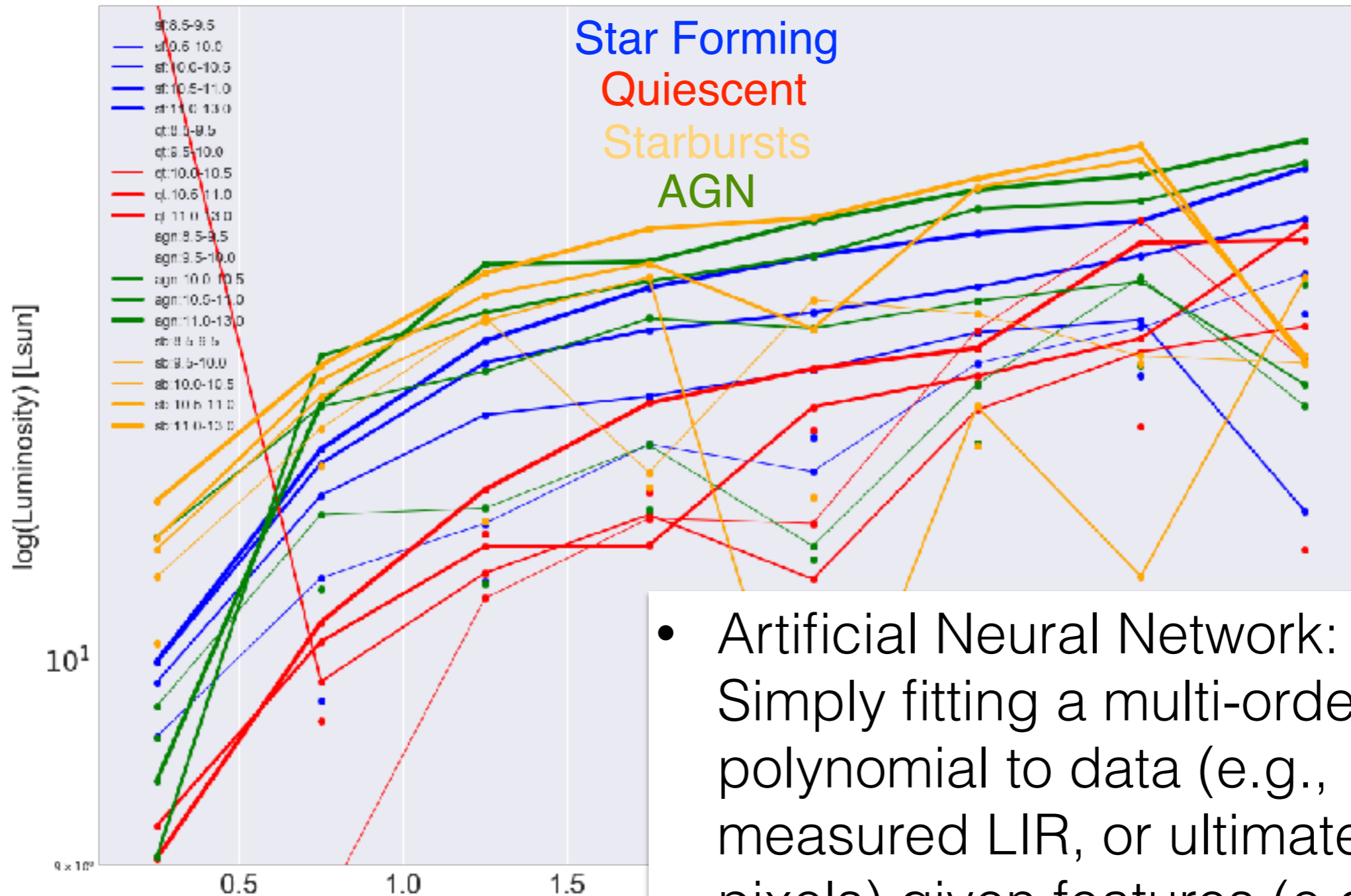
Sun, Monceli, Viero + (2016)
arXiv:1610.10095

Next Steps:

Explore Galaxy Features with Artificial Neural Networks (ANN)

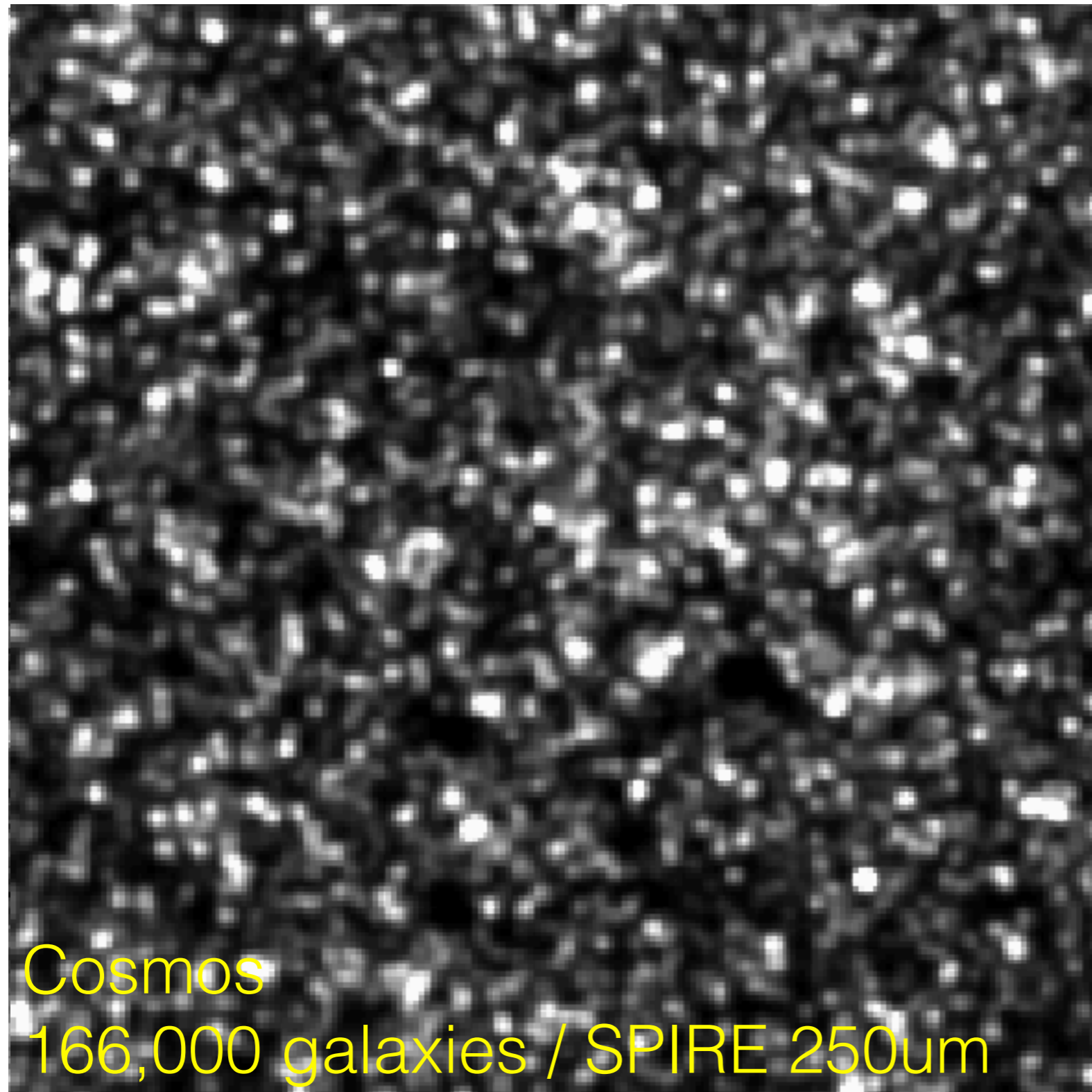
- Galaxies consist of more than just stellar mass and redshift, and are not only star-forming or quiescent, e.g.,
 - dusty/dust-free
 - AGN component
 - starburst
 - etc.
- Key is to identify “**features**” which correlate with Infrared Luminosity (LIR), and use them to “predict” LIR

Next Steps



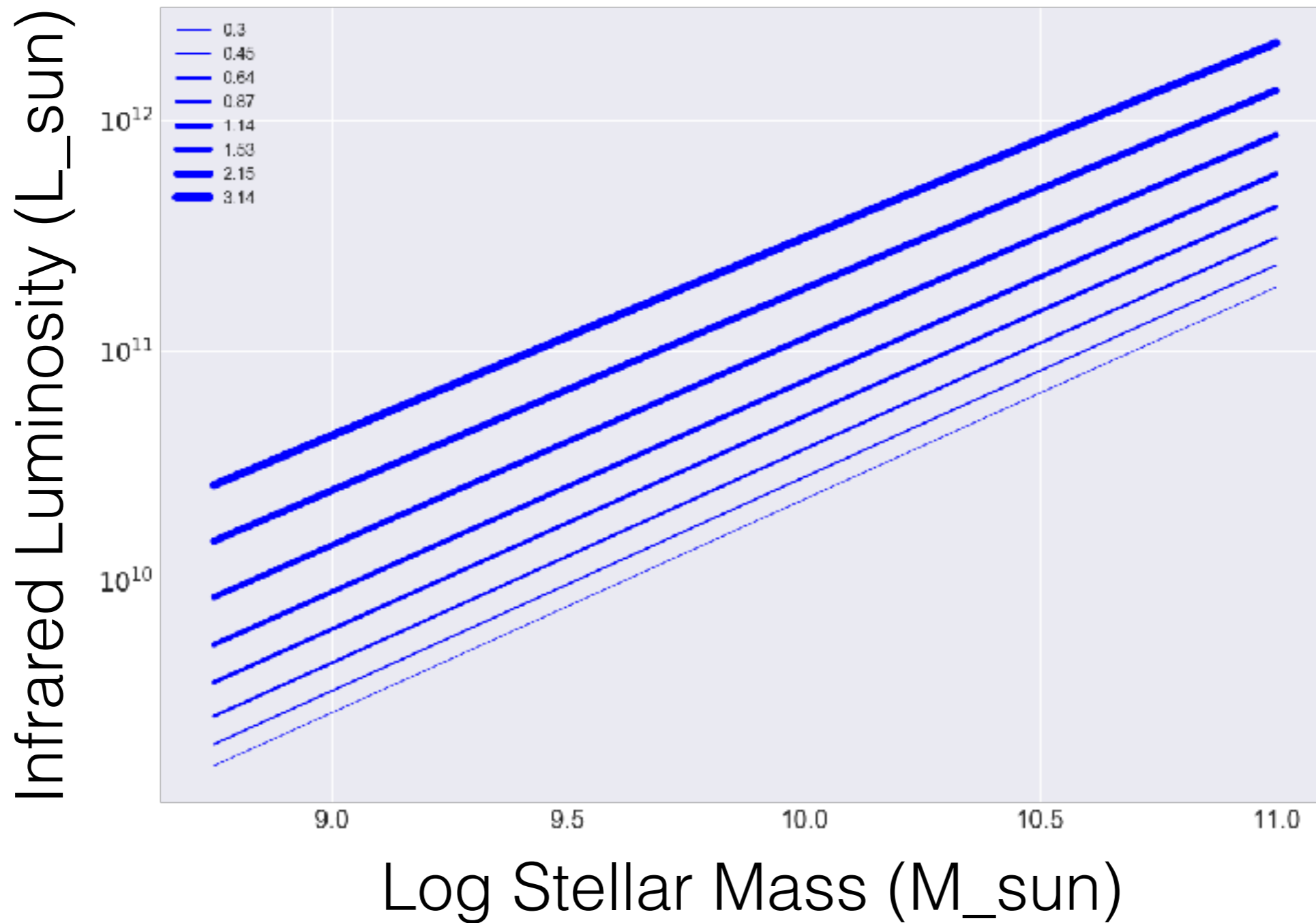
- Artificial Neural Network: Simply fitting a multi-order polynomial to data (e.g., measured LIR, or ultimately map pixels) given features (e.g., z , stellar-mass, AGN diagnostics, other...)

SIMSTACK: Artificial Neural Network Results

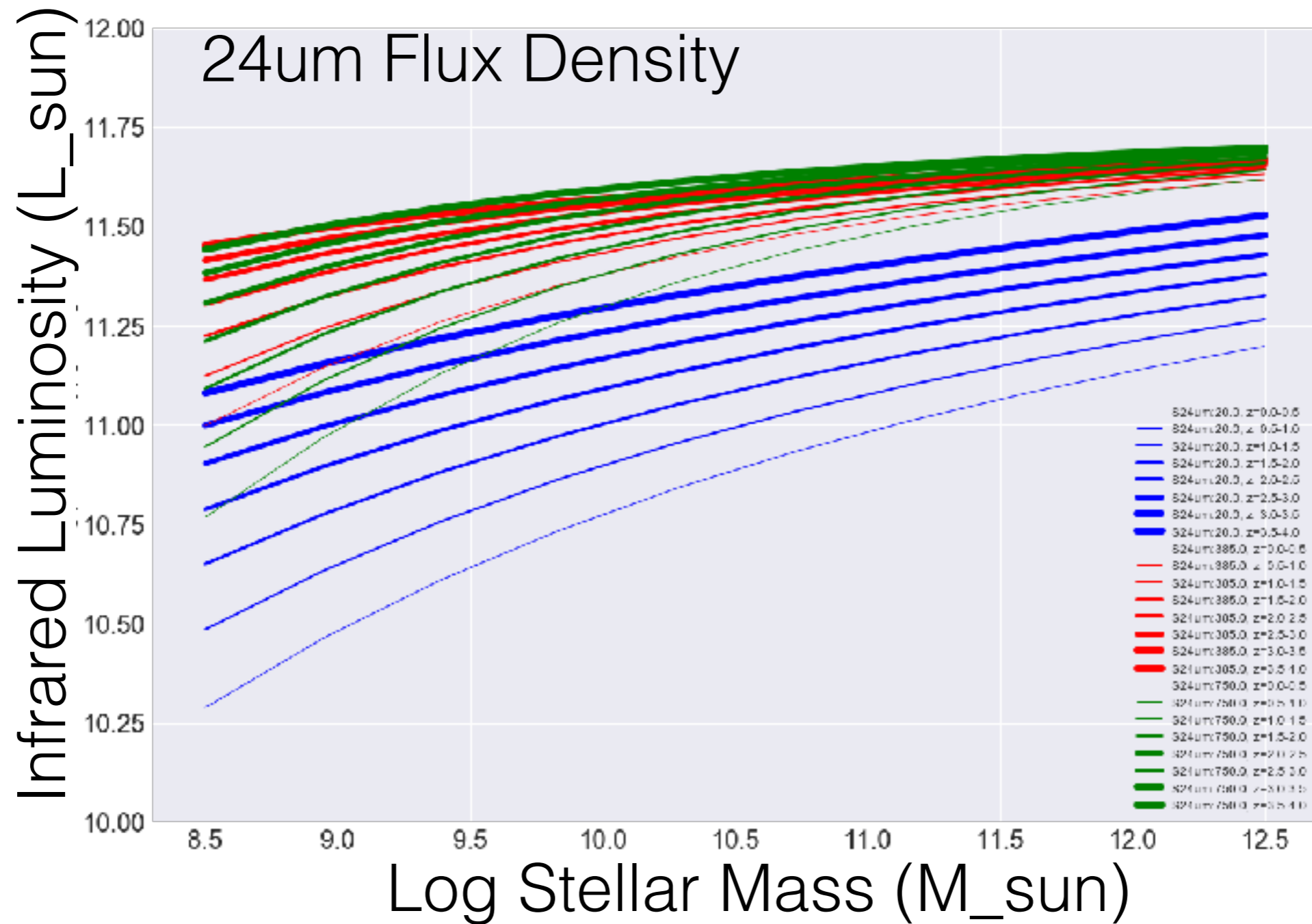


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←

Explore Secondary Effects on Main Sequence

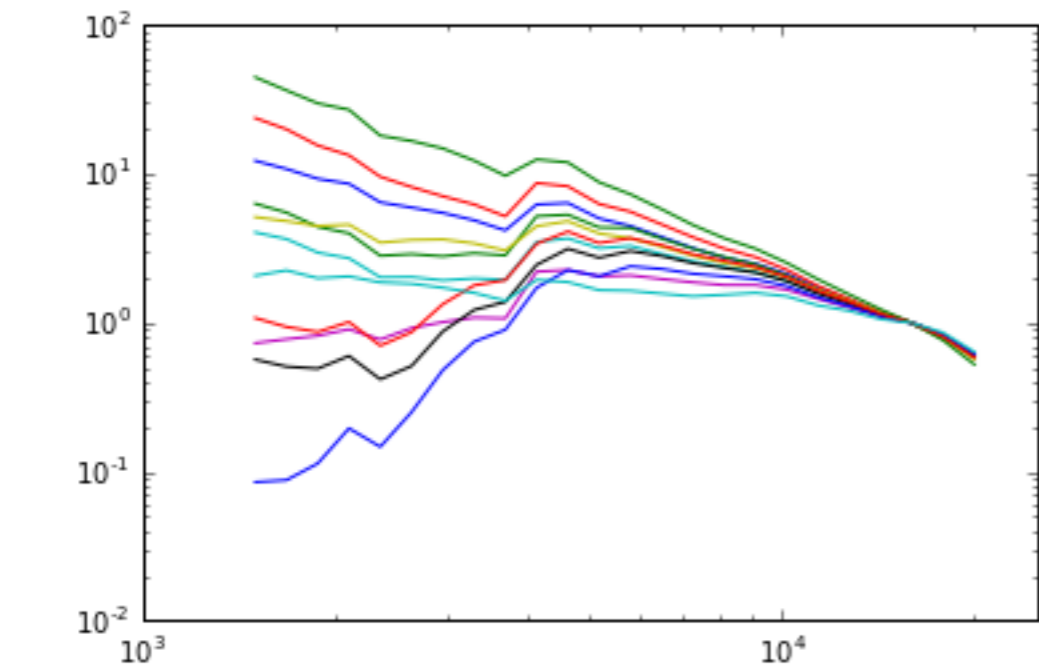


Explore Secondary Effects on Main Sequence

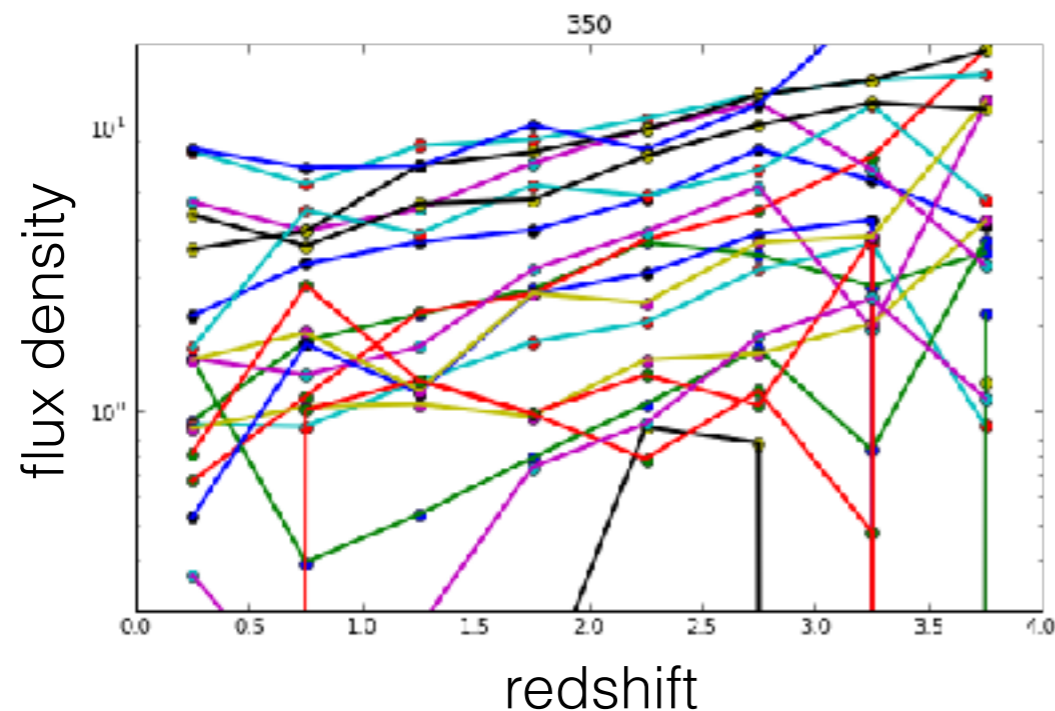
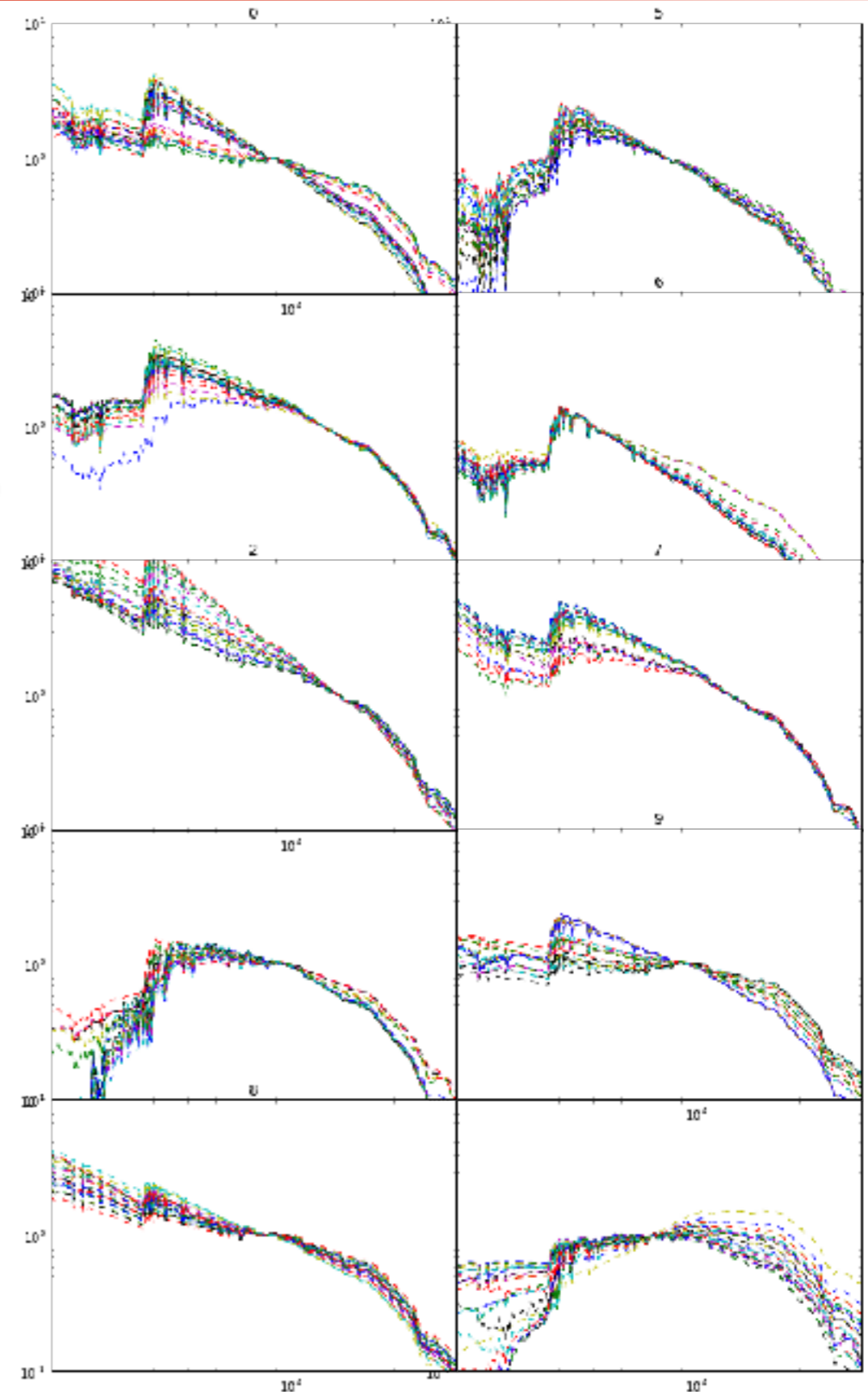


SIMSTACK: ANN to Deep Learning

- Full SED Categorization
 - map physical features to FIR flux



Split
into
layers



SIMSTACK

Summary

- Use all the data in the maps
- Ancillary data can be a powerful
- There are still challenges