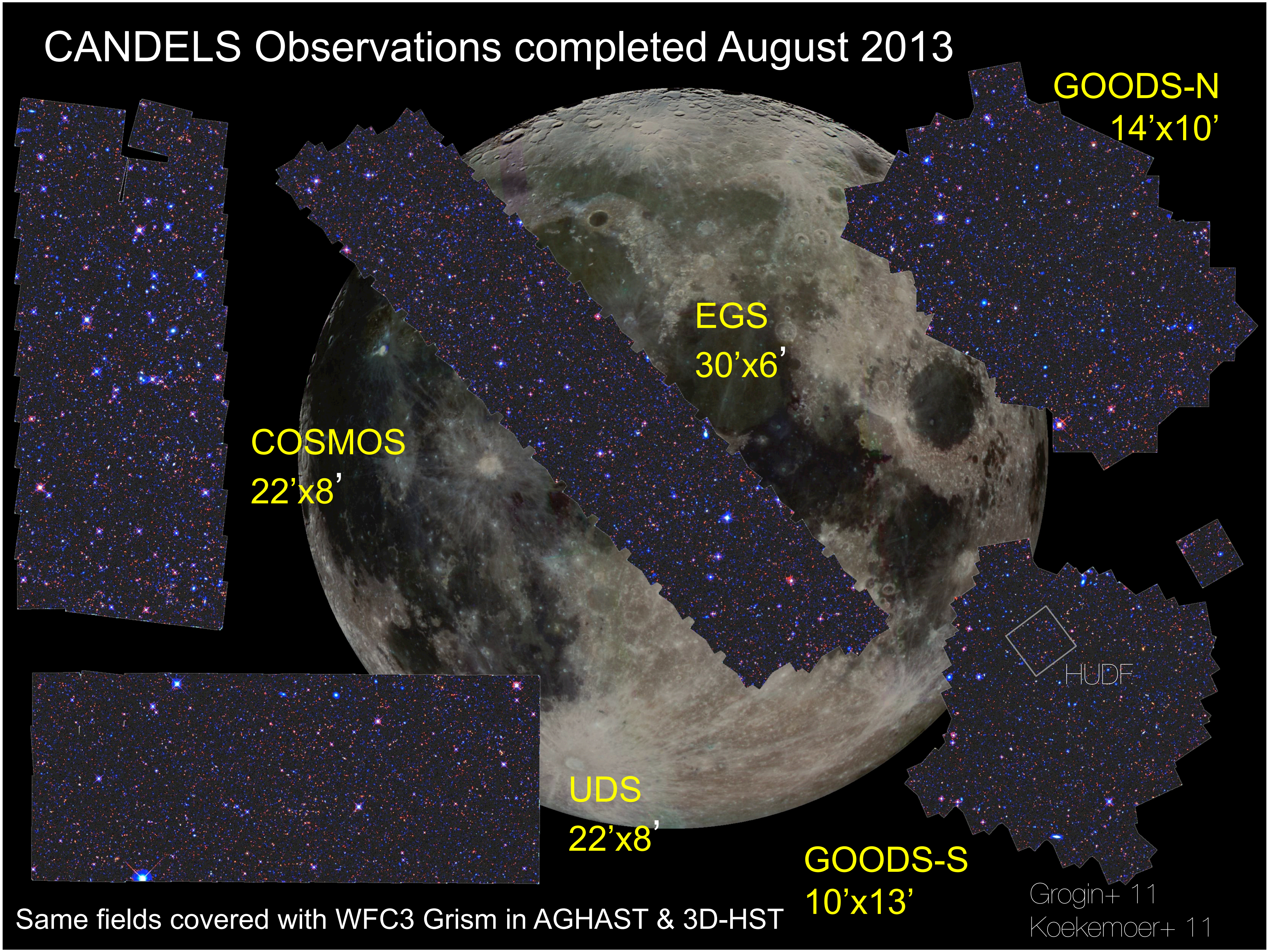
Making optimal use of the CANDELS data

Henry Ferguson

26 January 2015


CANDELS Observations completed August 2013
GOODS-N
14'x10'
EGS
30'x6'
COSMOS
22'x8'
HUDF
UDS
22'x8'
GOODS-S
10'x13'
Grogin+ 11
Koekemoer+ 11
Same fields covered with WFC3 Grism in AGHAST & 3D-HST

CANDELS data products

- HST images
  - CANDELS ACS + WFC3 mosaics
  - UV GOODS-N mosaic now available
- PSFs and PSF kernels
- Photometry:
  - SExtractor dual-mode matched-PSF photometry
  - TFIT template-fitting photomery for non-HST, based on HST priors

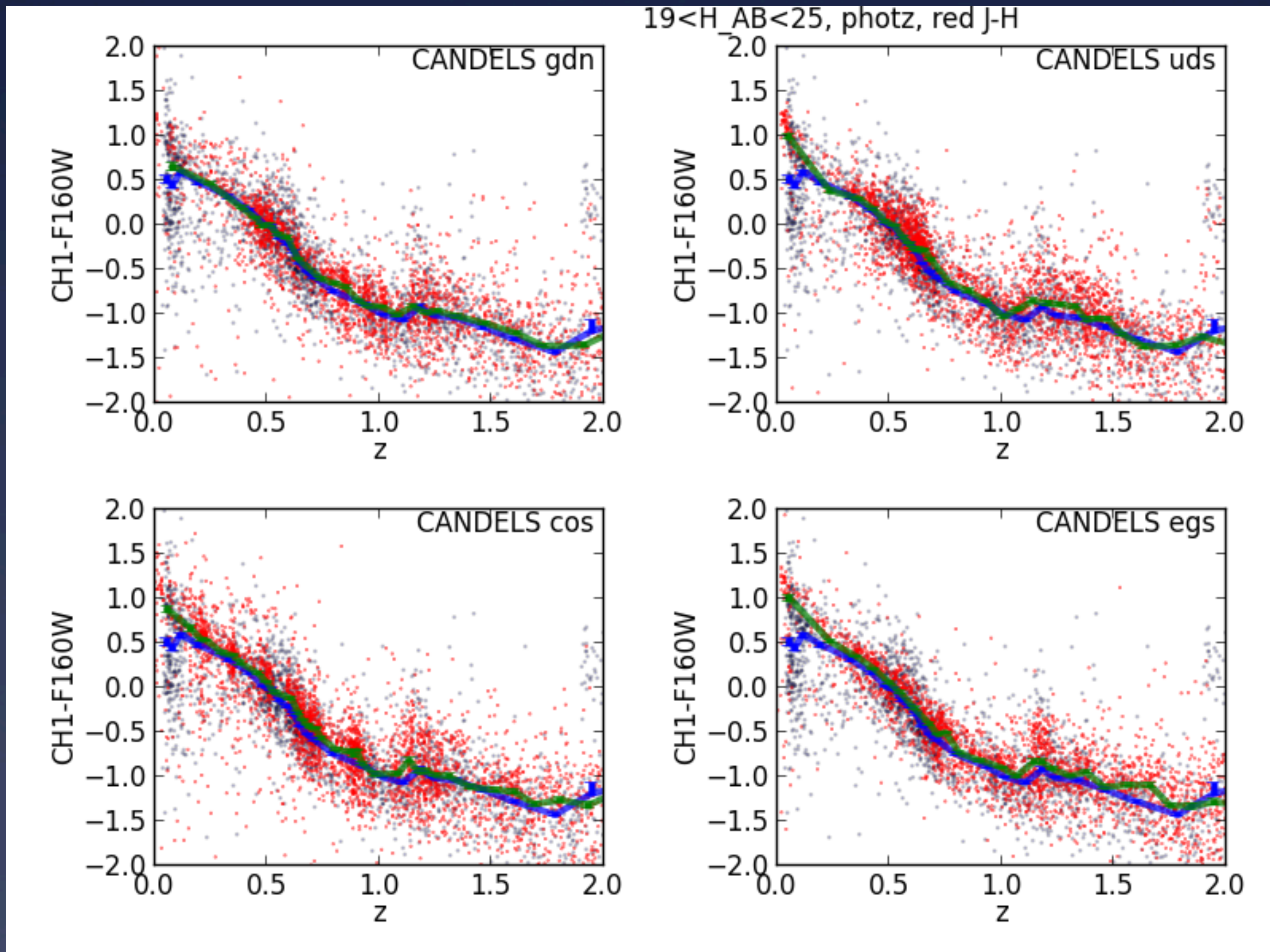
CANDELS data products

- Morphology
  - Visual morphology classifications
  - Galaxy Zoo classifications
  - Galfit single-band single-Sersic fits
  - Galfit multiple-band Sersic fits (underway)
  - CAS/Gini/M20 (underway)

CANDELS data products

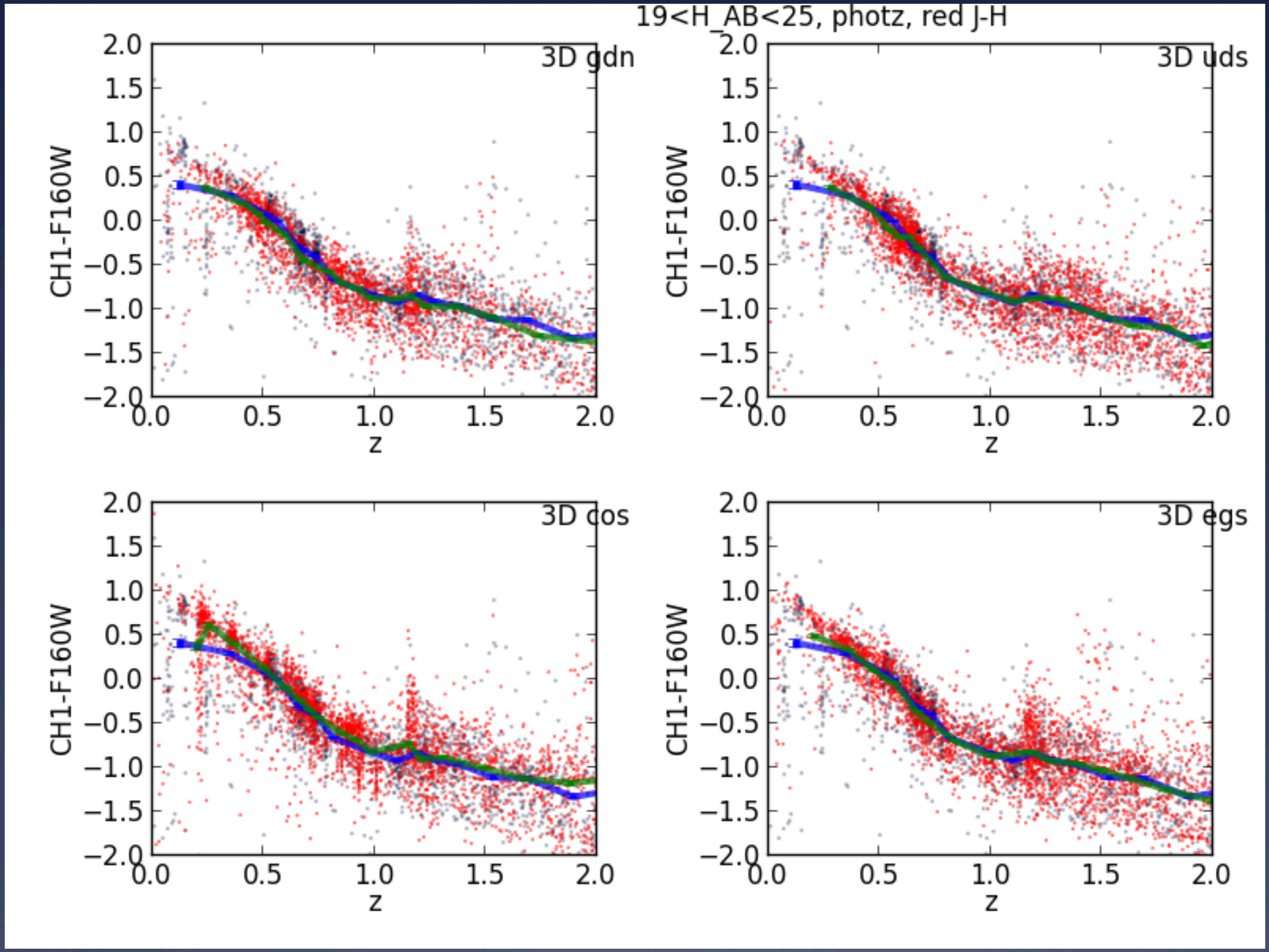
- Photometric redshifts
  - Consensus photometric redshifts
    - Bayesian consensus PDFs in progress
  - Hsu et al. GOODS-S
- SED-fitted parameters
  - Consensus Stellar Masses
    - Still in progress for GOODS-N
  - Individual fitted parameters:
    - Age, timescales, sfr, dust, metallicity…

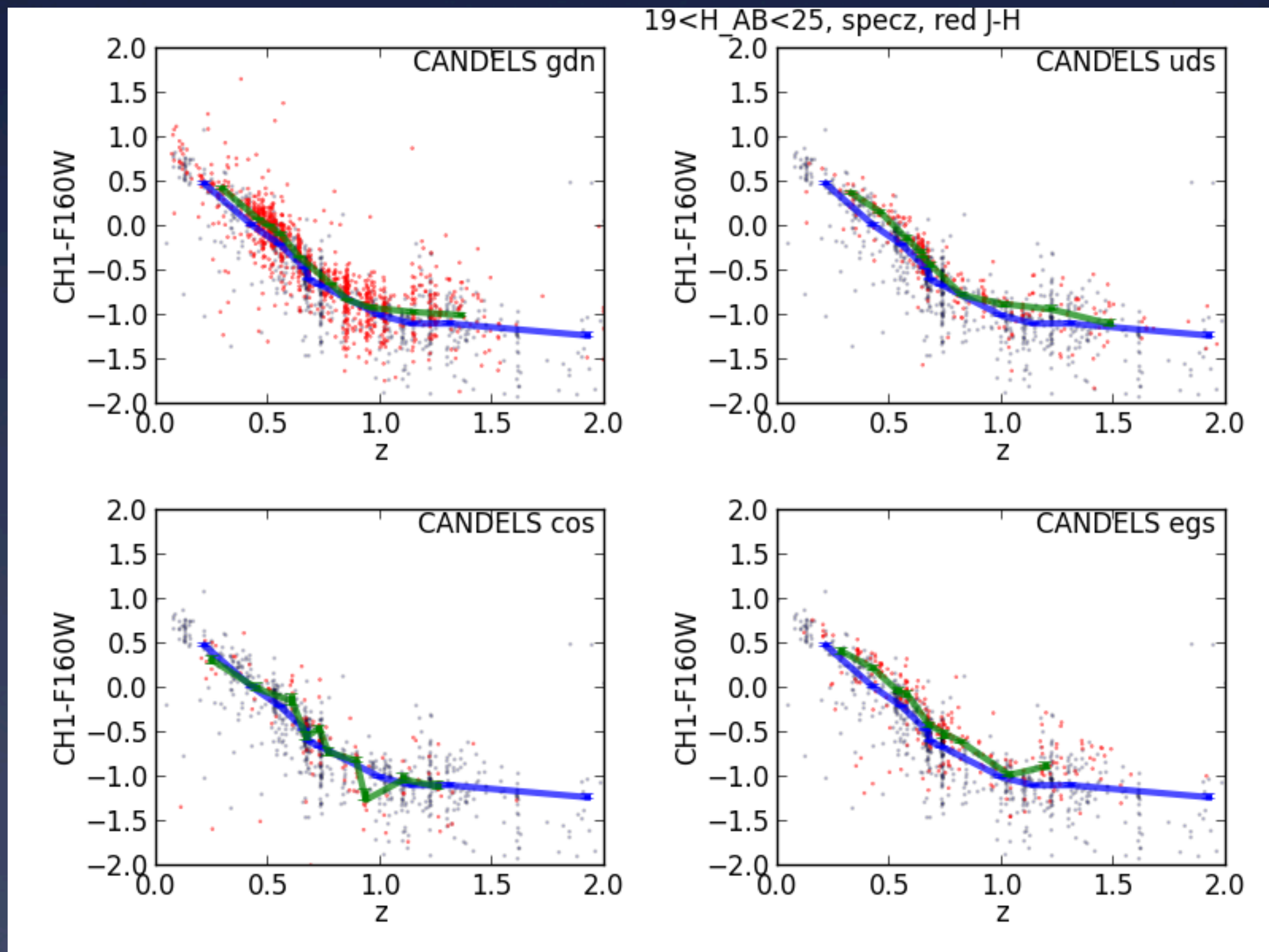
Consistency Checks…



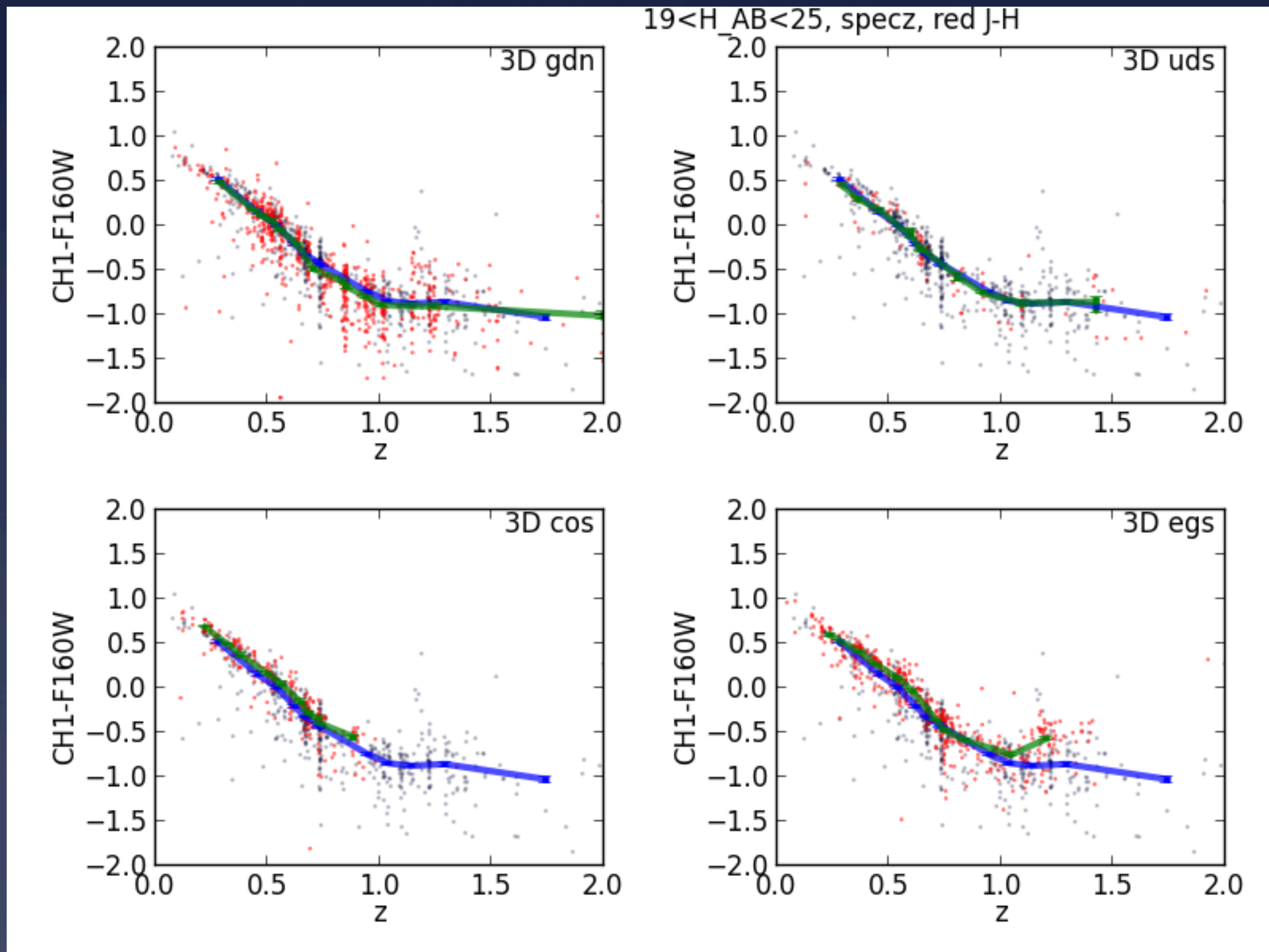
Select roughly the reddest half of the galaxies in J-H,
S/N > 10 in IRAC 19<HAB<25

Consistency checks…





19<H_AB<25, specz, red J-H
CANDELS gdn
CANDELS uds
CANDELS cos
CANDELS egs
CH1-F160W
z
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0


19<H_AB<25, specz, red J-H
3D gdn
3D uds
3D cos
3D egs
CH1-F160W
z
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
0.0
0.5
1.0
1.5
2.0

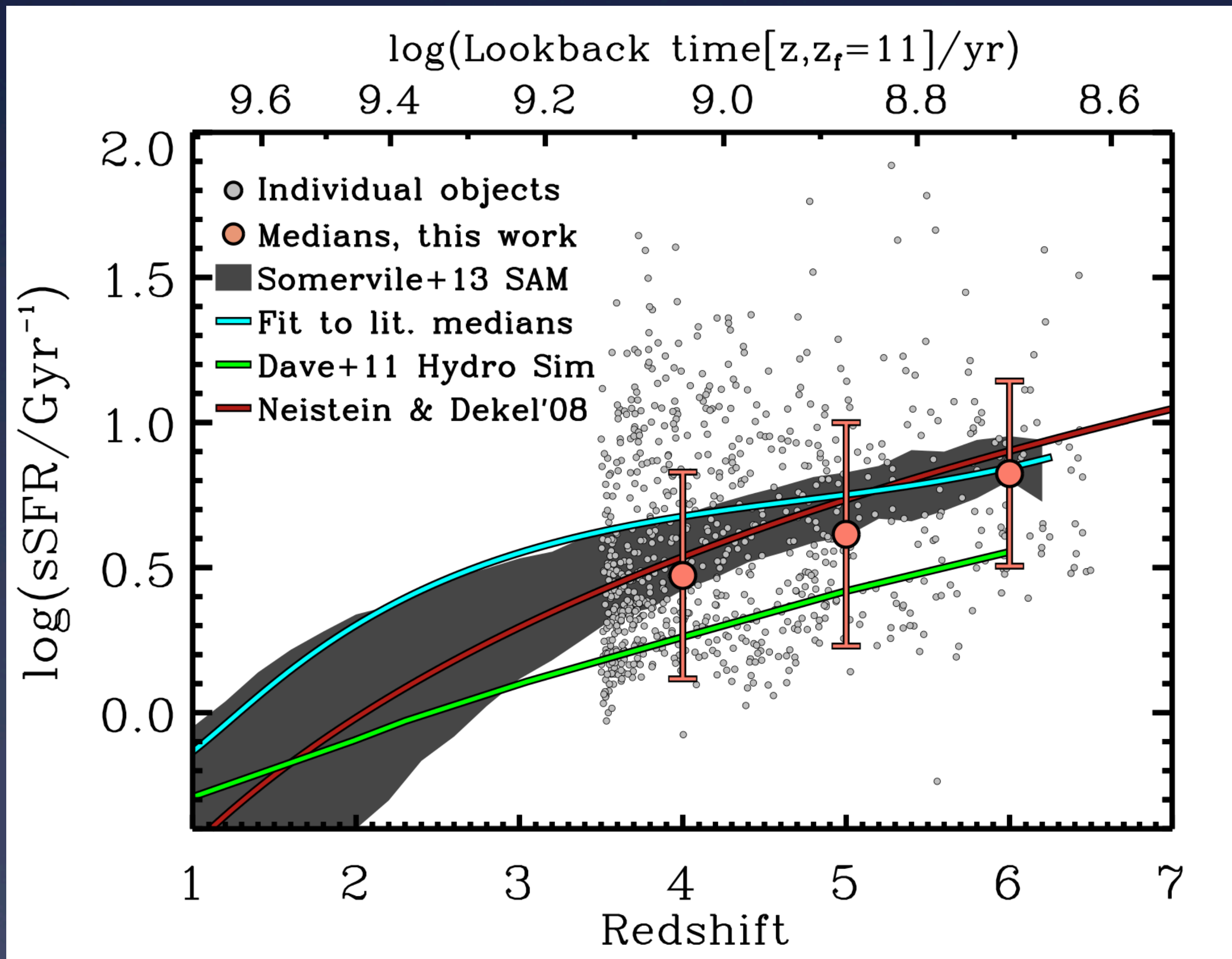
Stages of Optimization

- PSF-matched, matched aperture
  - SExtractor
- Template-fitting with positional priors
  - TFIT, TPHOT
- Deblending using positional and flux priors
  - Challenging!
- Hiearchical parameter estimation
  - Costly!

A few open science questions

- How stochastic is star-formation?
  - Relative importance of mergers vs. smooth accretion vs. clumpy flows
- How permanent is quenching
  - Are quenched galaxies continually rejuvenated?
- What is the connection between the dusty starburst phase, mergers, and quenching?

SSFR vs redshift

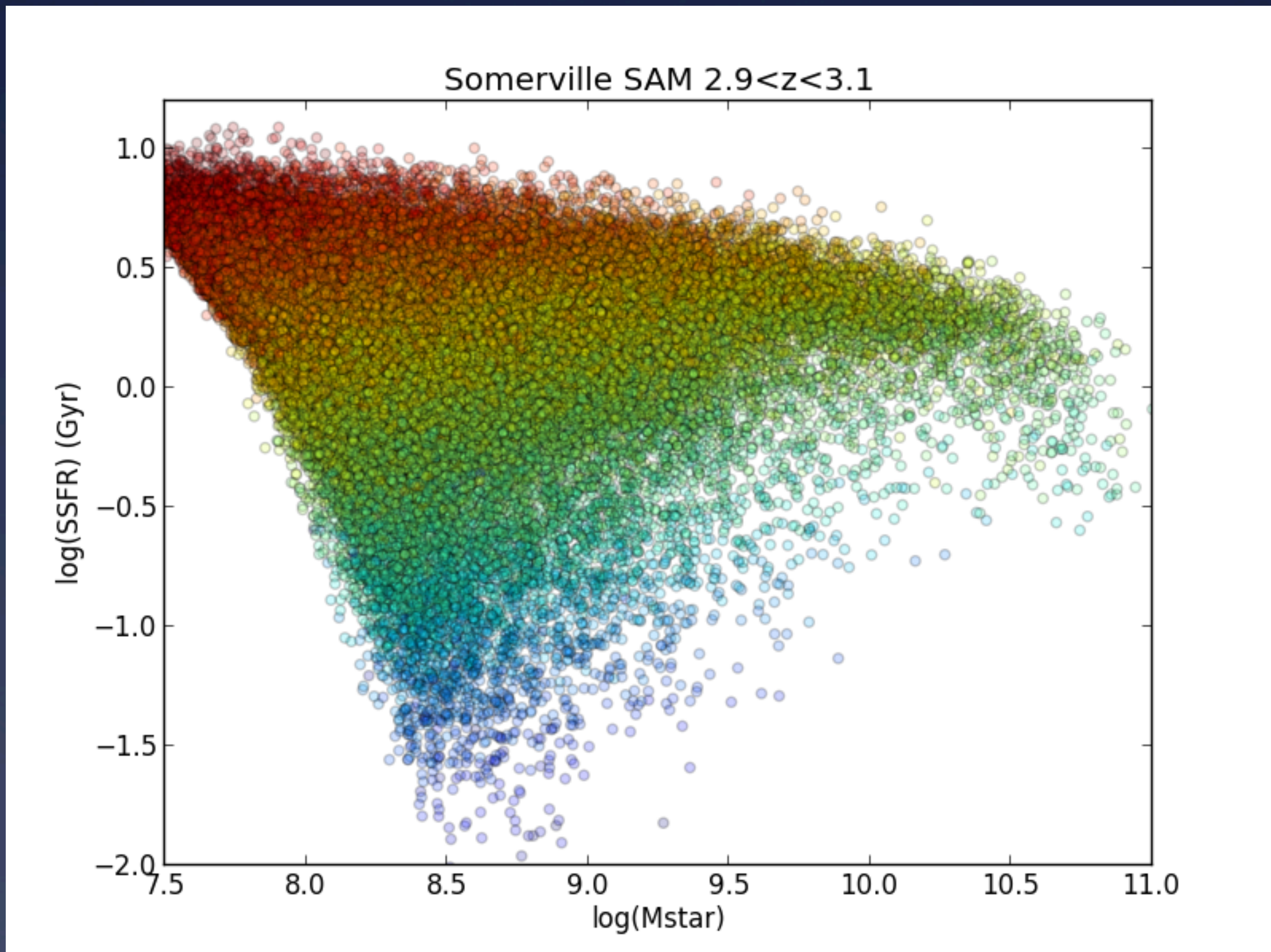


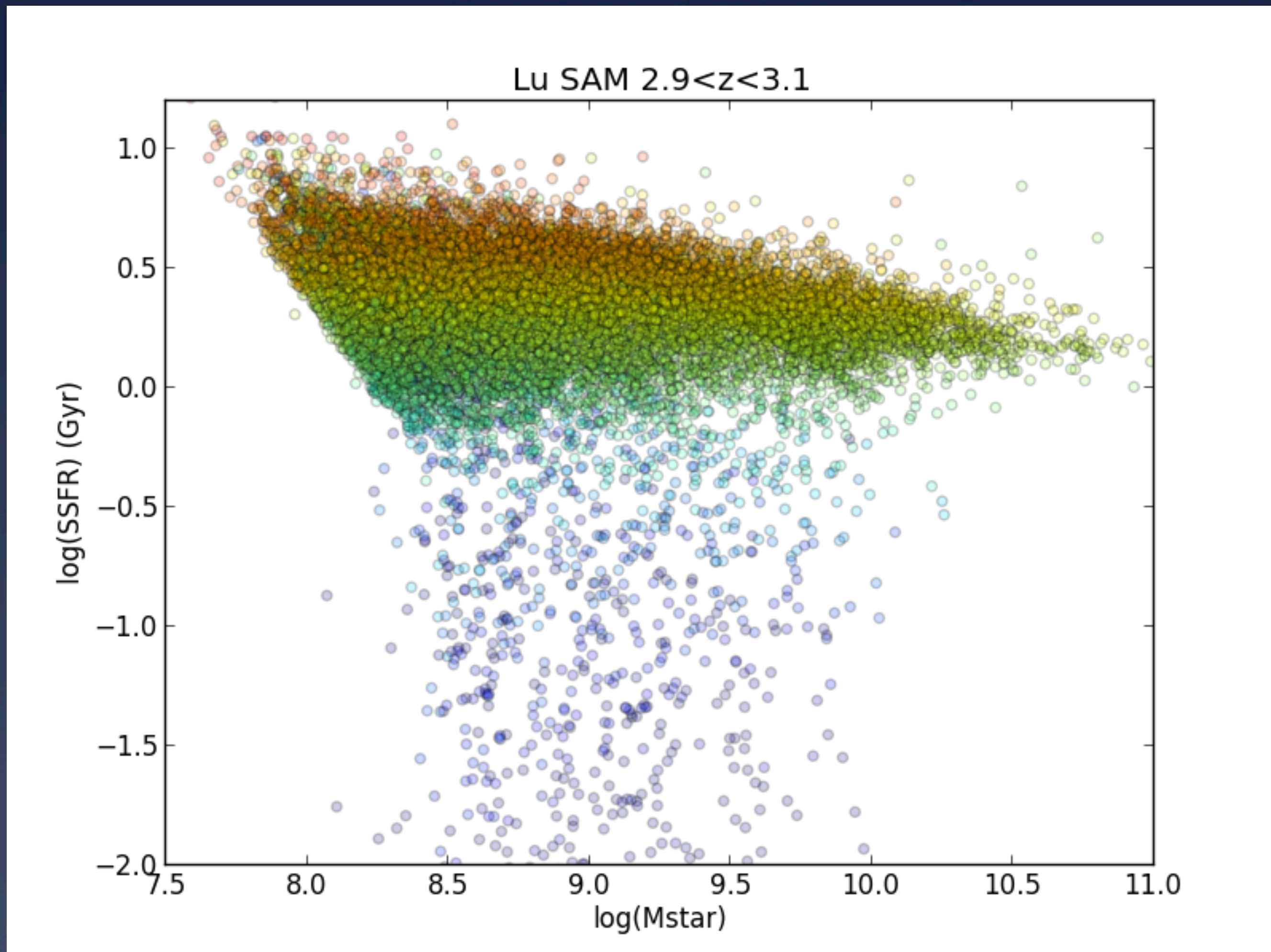
Salmon+ 15

CANDELS Semi-analytical models & mock catalogs

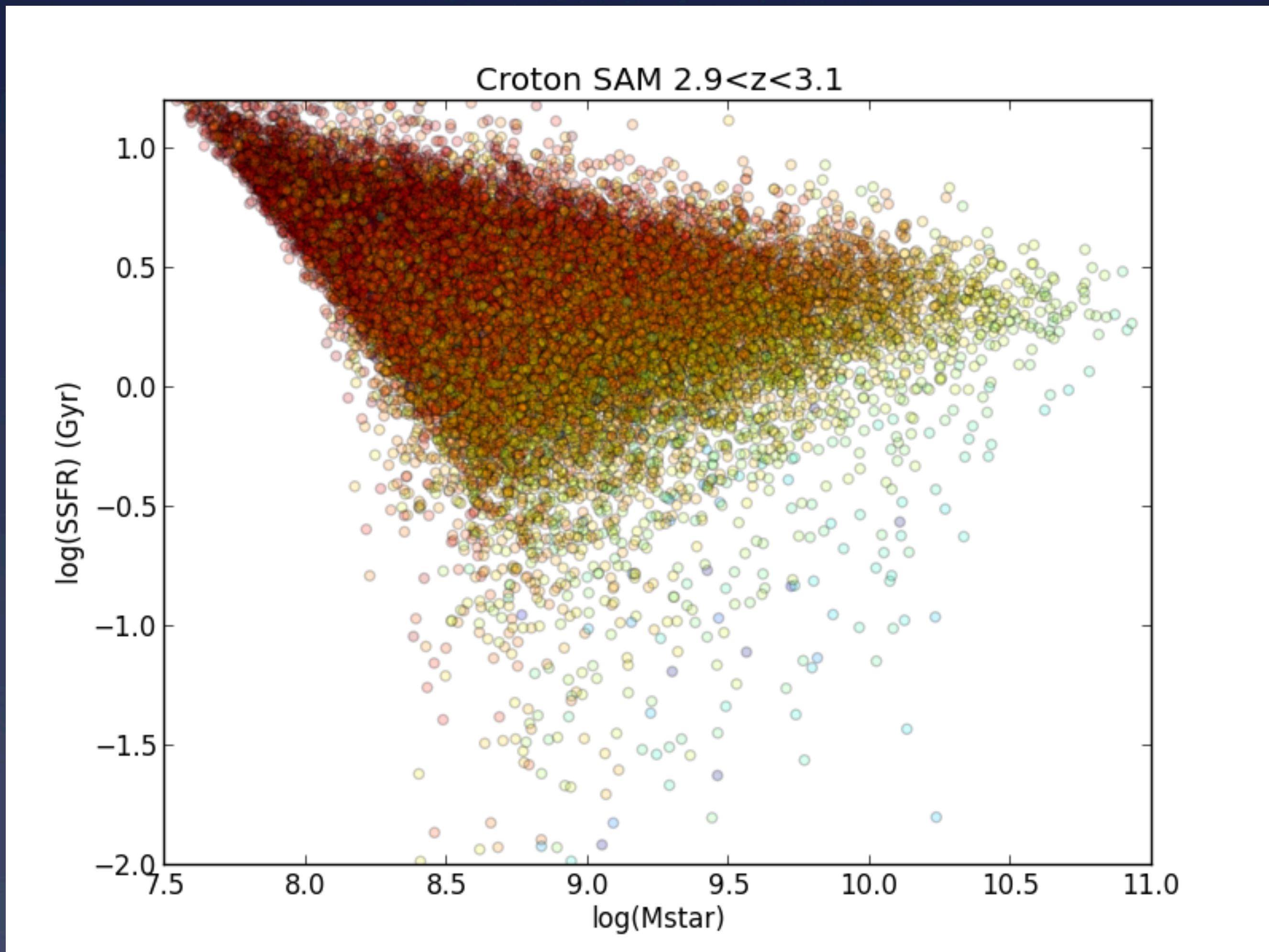
- Three independent SAMS
- Using the same halos from the Bolshoi simulation
- Tuning to match the same z=0 mass function
- Different choices for many of the key parameters

CANDELS SAM predictions





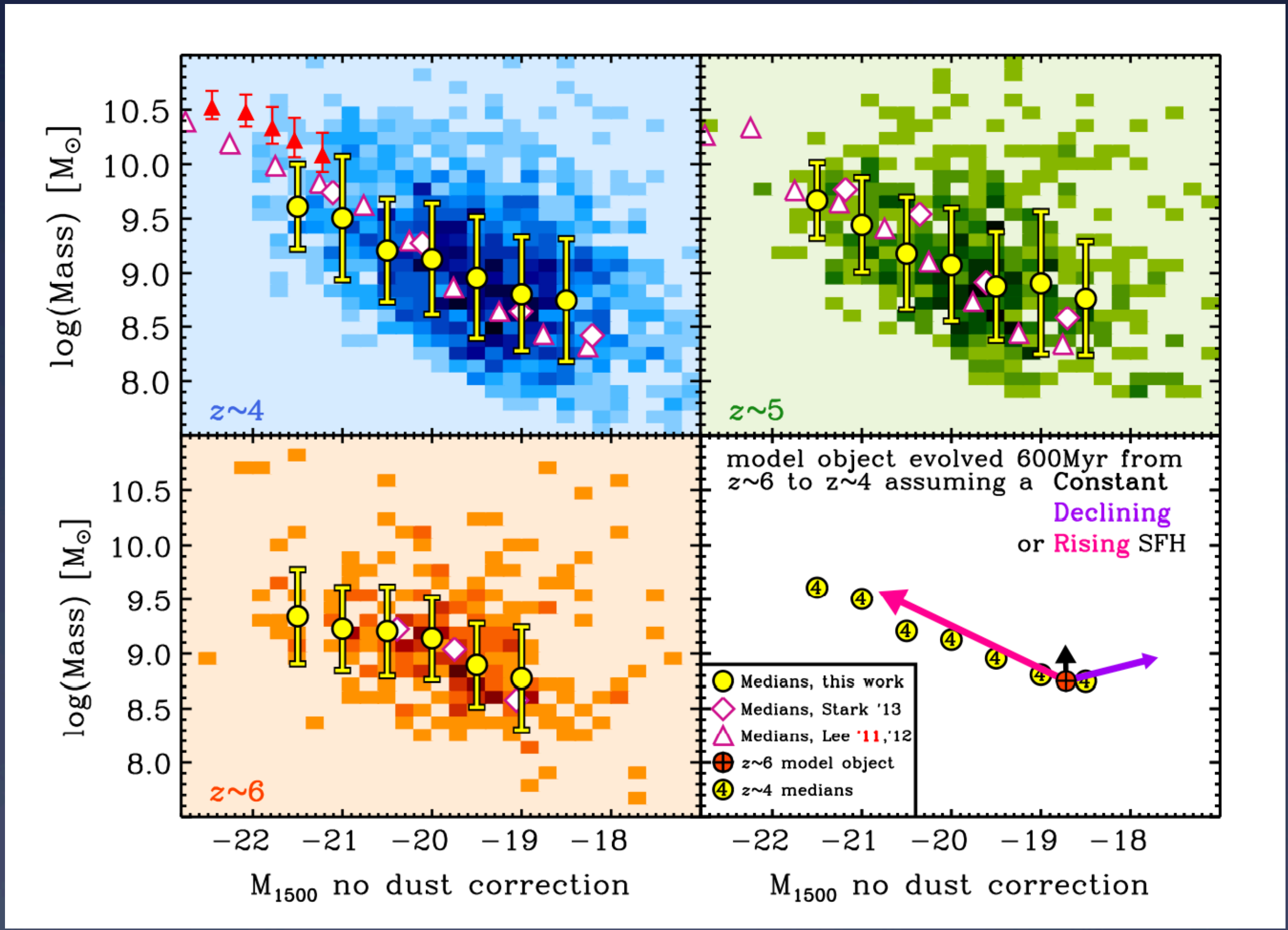
Lu SAM 2.9<z<3.1
log(SSFR) (Gyr)
log(Mstar)
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0



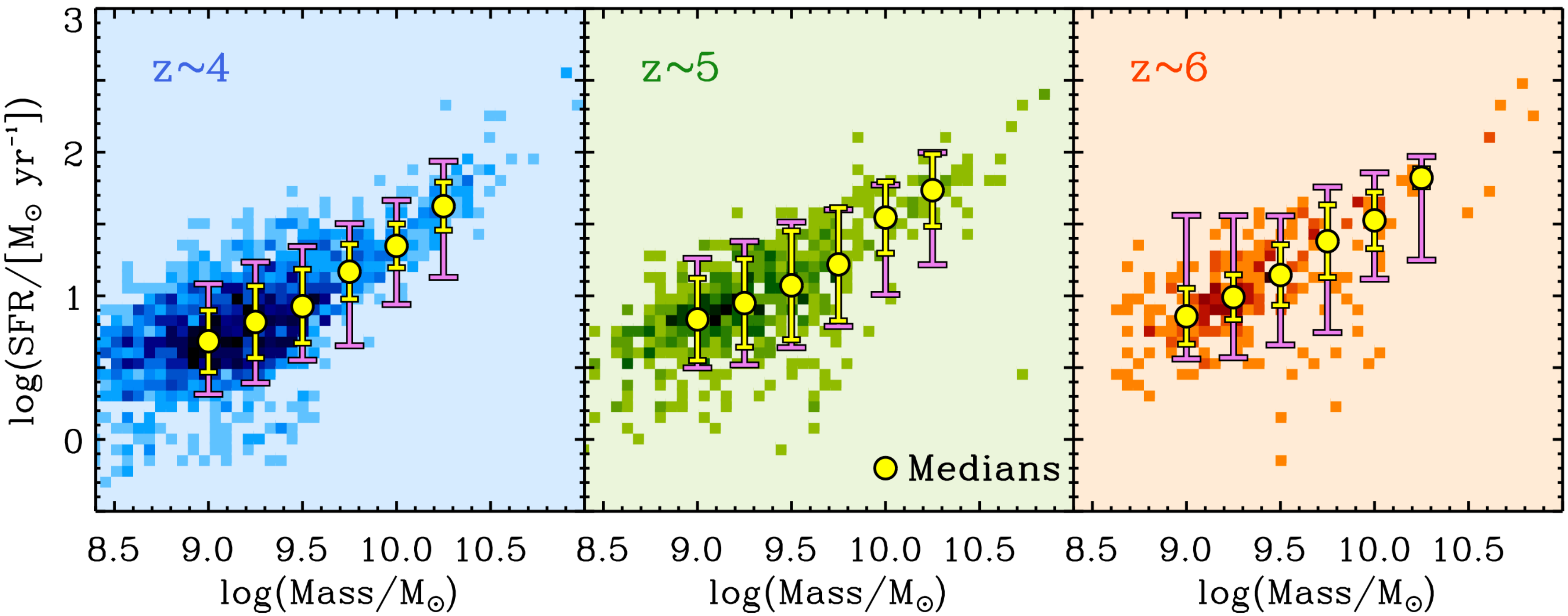
Croton SAM 2.9<z<3.1
log(SSFR) (Gyr)
log(Mstar)
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0

Derived quantities from observations

Lots of scatter in UV luminosity at fixed mass



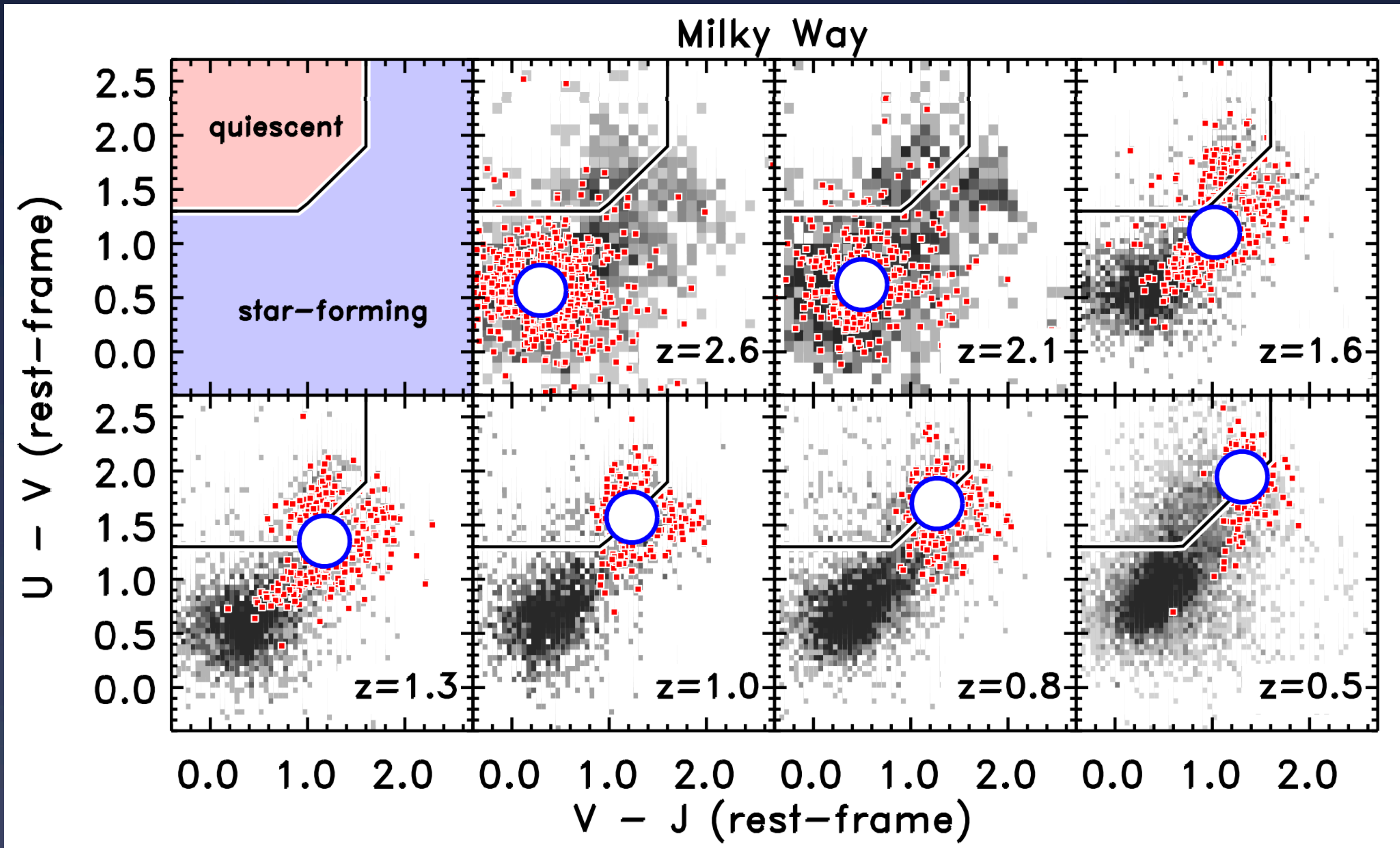
Salmon+15



Scatter in SFR at fixed M appears very small after correcting for extinction. Is this real, or due to correlated errors?

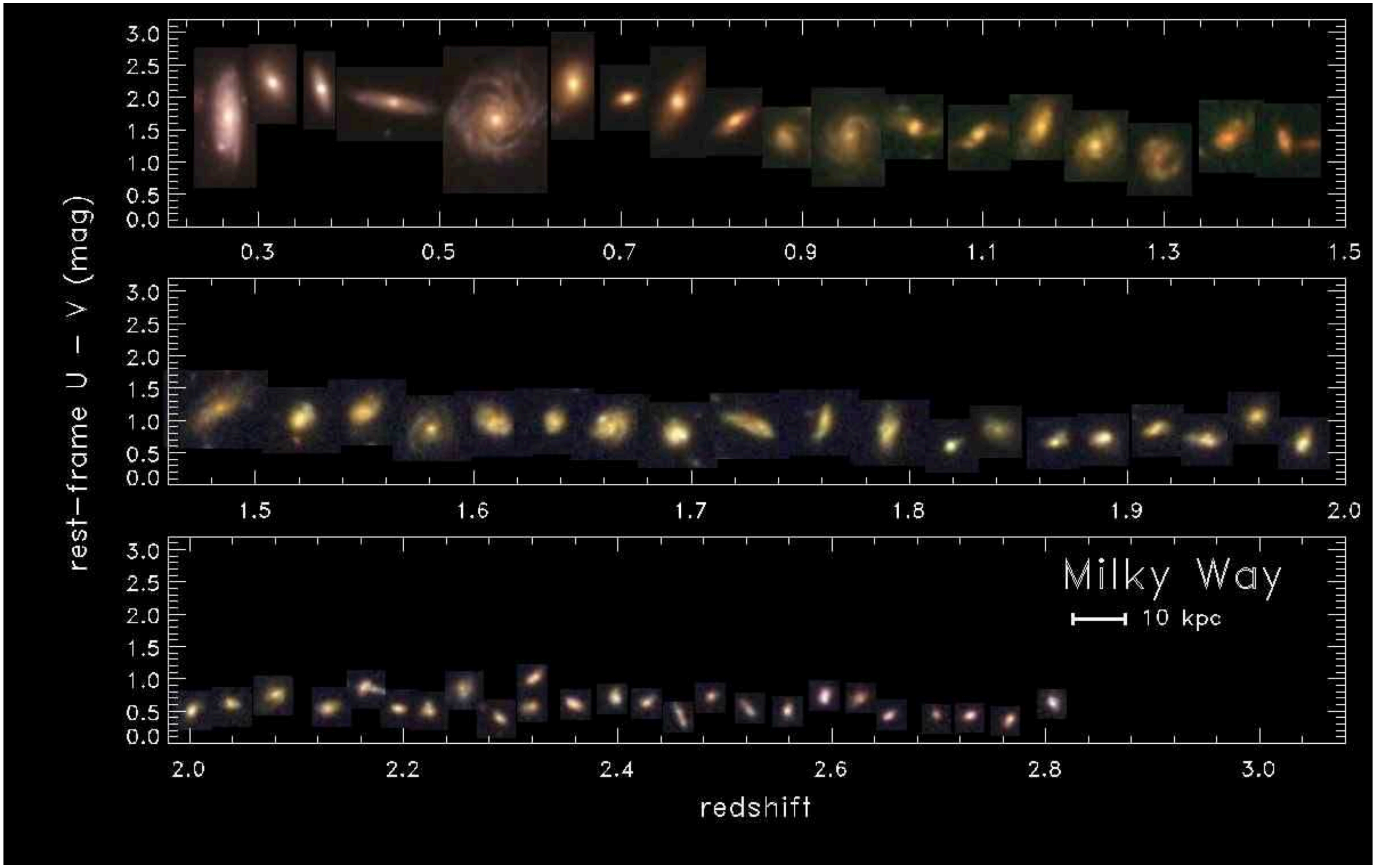
Salmon+15

What did the Milky Way look like 11 billion years ago?



Papovich+14 (CANDELS + ZFOURGE)
Also Van Dokkum+ 13 3D-HST

What did the Milky Way look like 11 billion years ago?

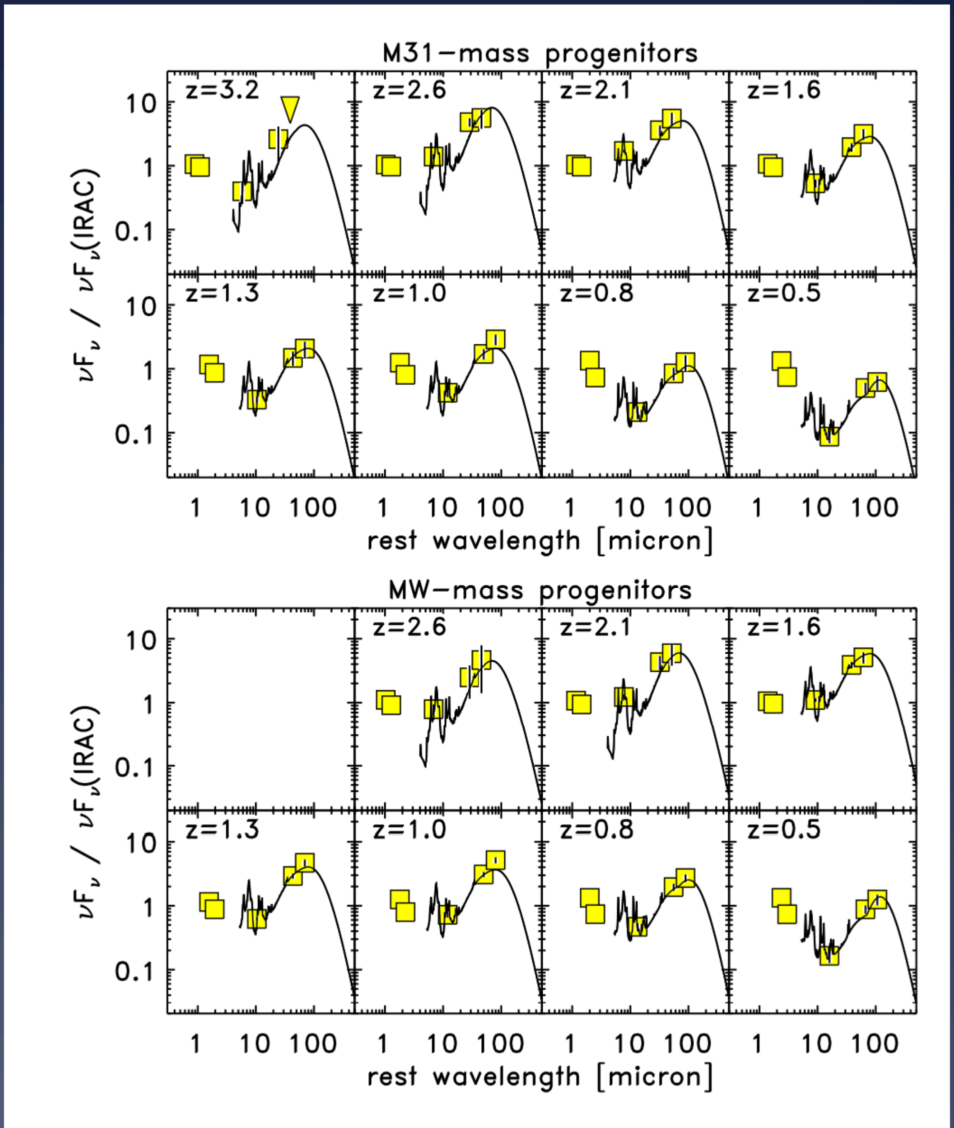


PAPOVICH ET AL.

Stacked SEDs

Stacked SEDs of M31 and Milky-Way-mass progenitors

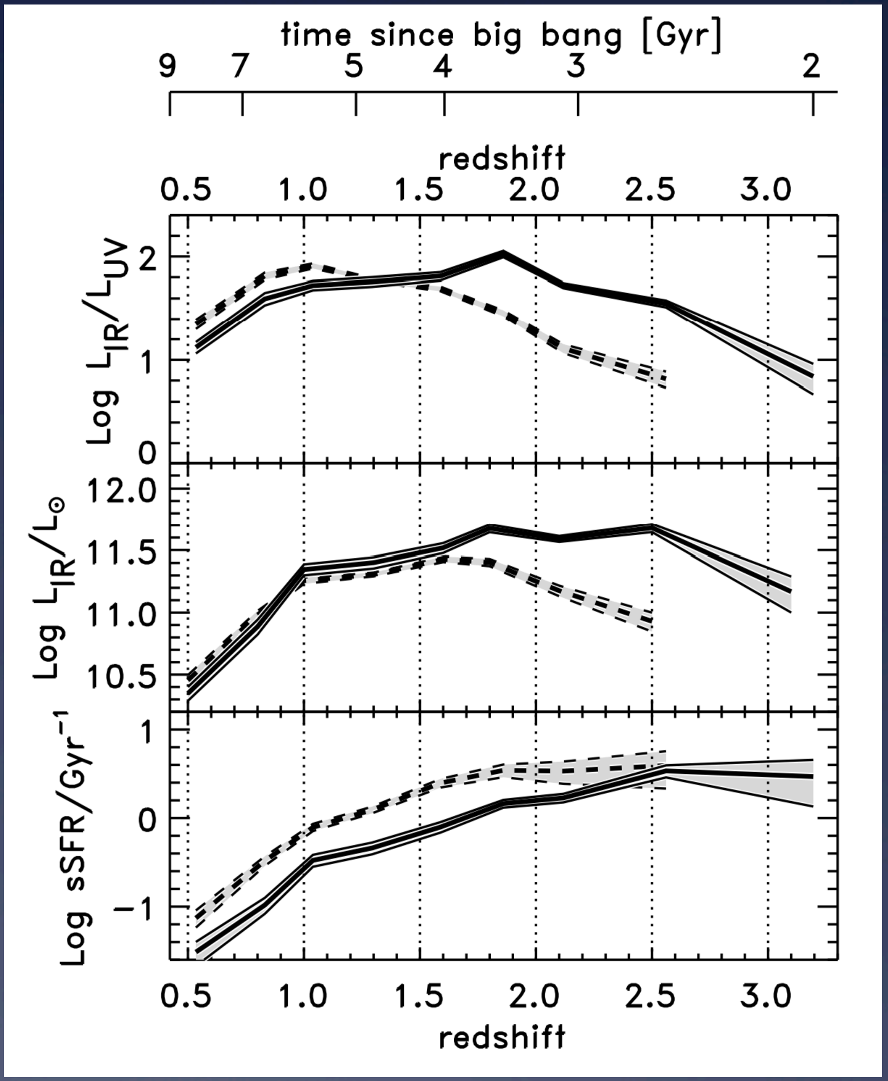
Next step: constrain the dispersion



Evolution L_{UV}, L_{IR}, SSFR

Stacked SEDs of M31 and Milky-Way-mass progenitors

Next step: constrain the dispersion

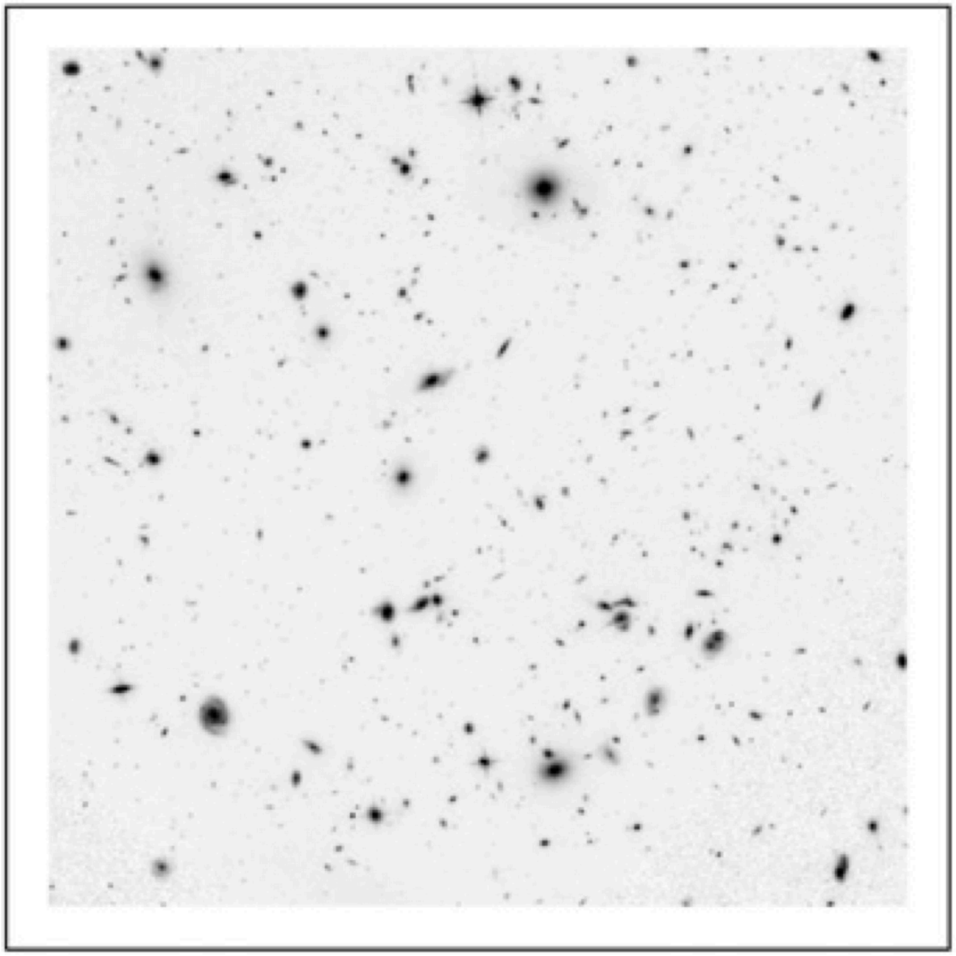


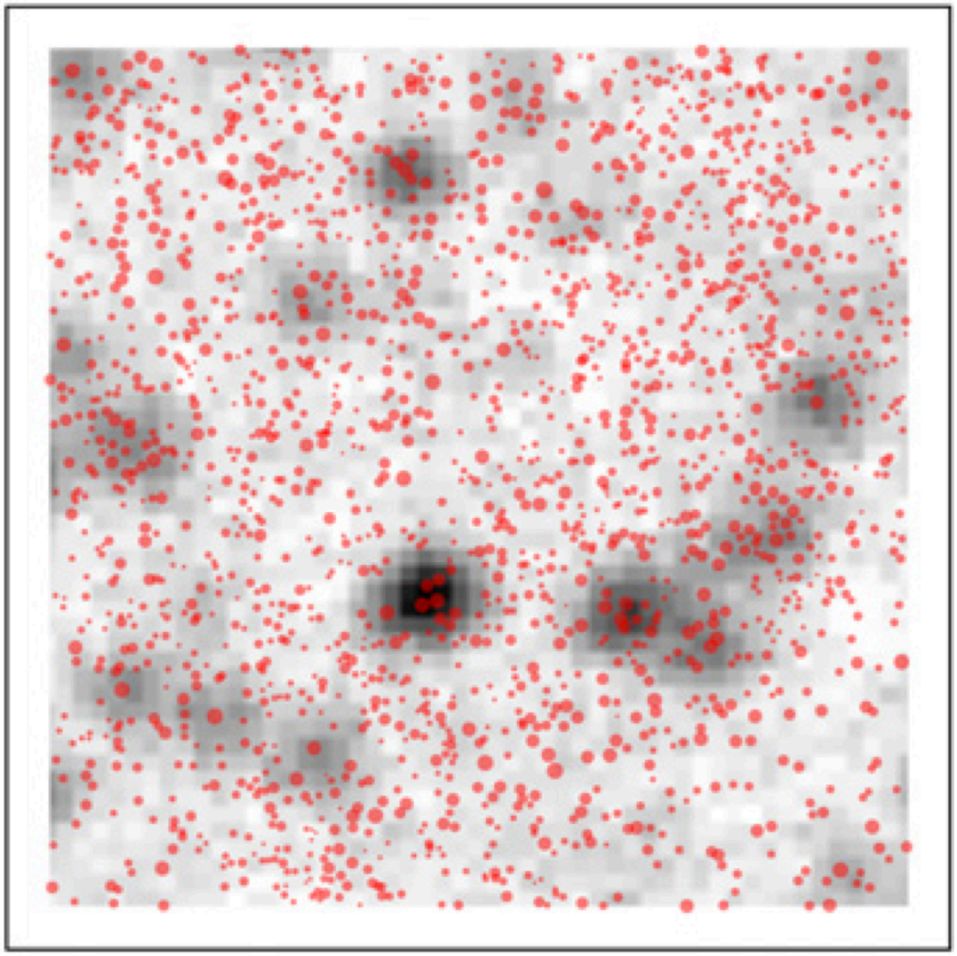
Important next step: constraining the scatter in far-IR fluxes

Approaches:

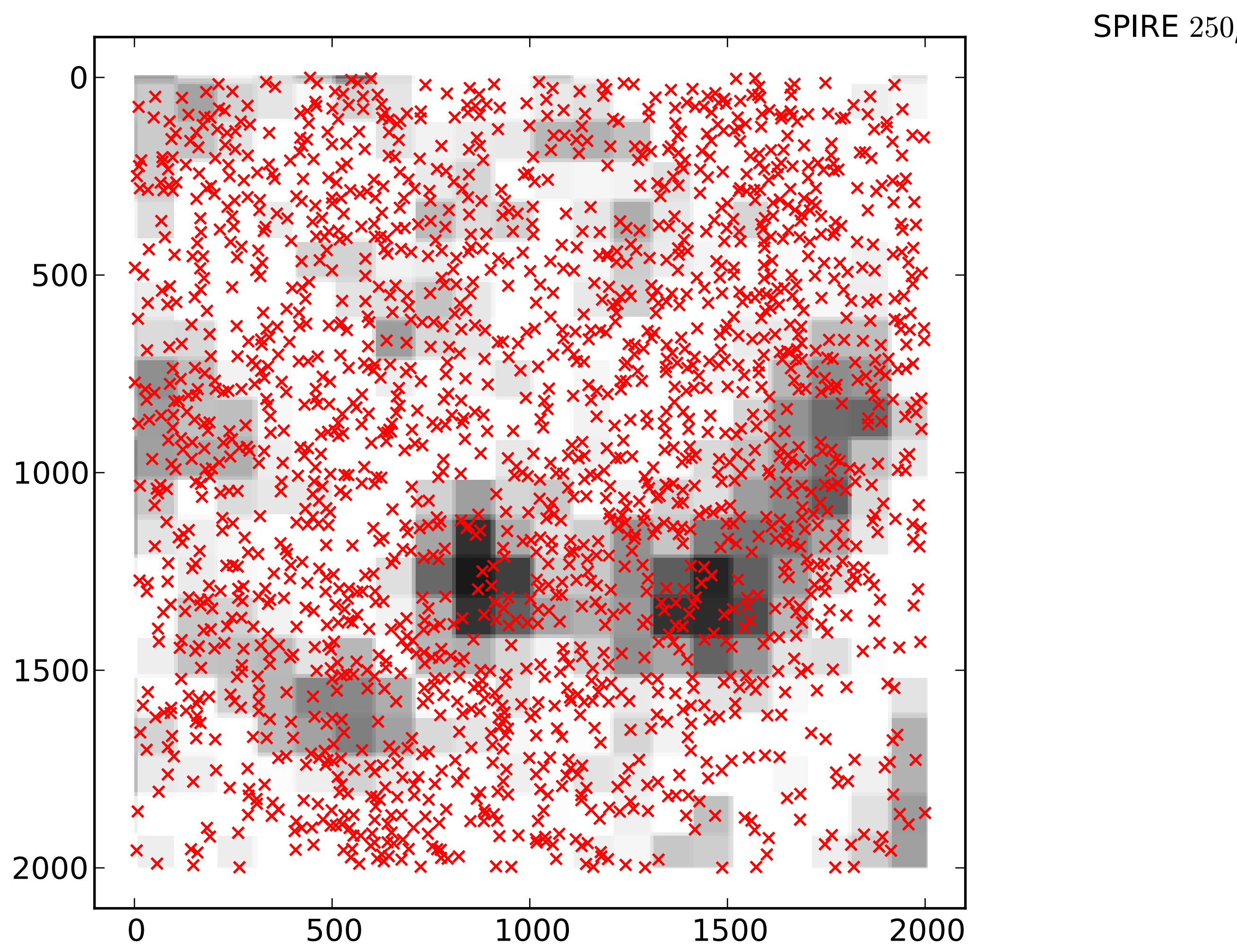
- Variance of stacks (Schreiber+ 15)
- Bayesian deconfusion (Safarzadeh+ in prep)

Herschel Deconfusion

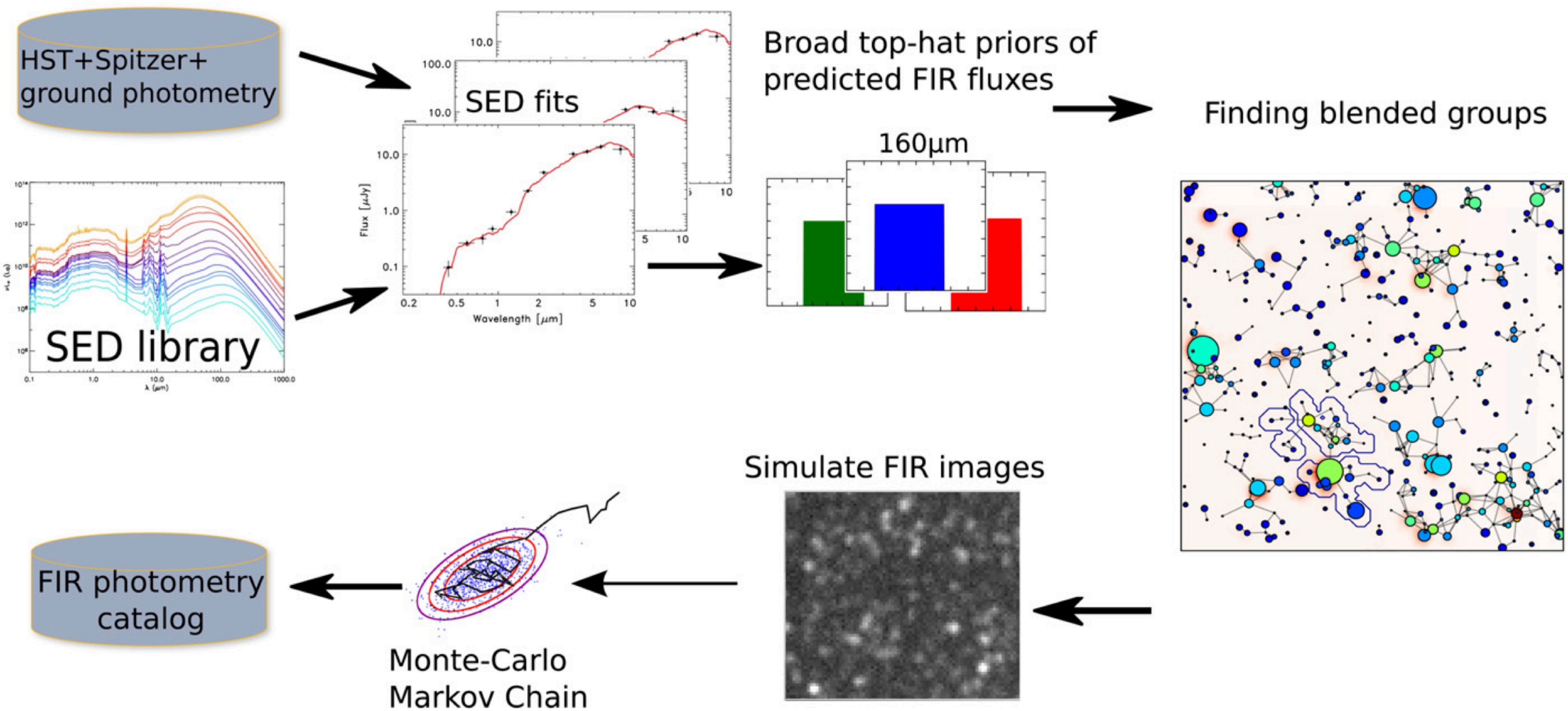


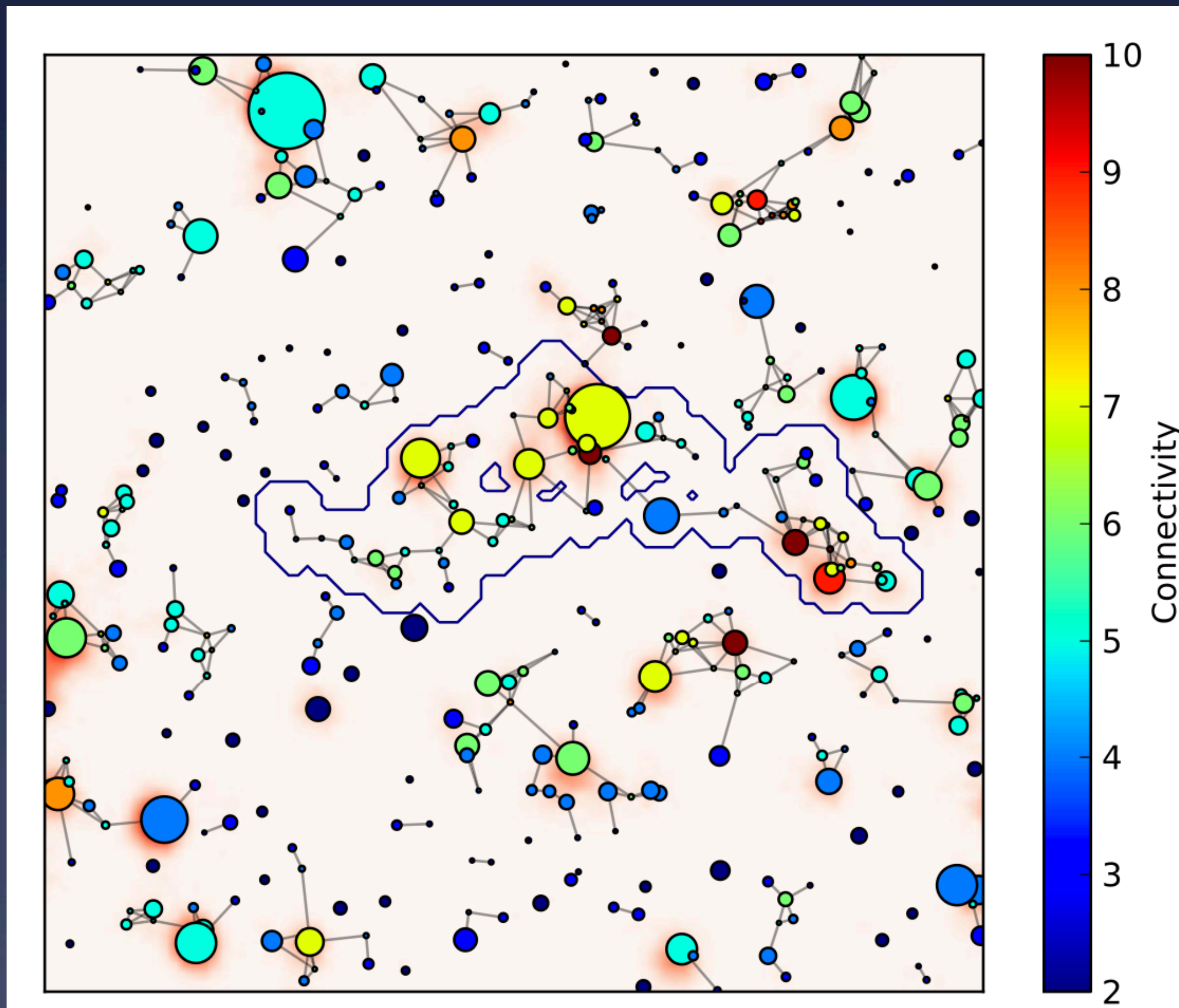


Herschel Deconfusion

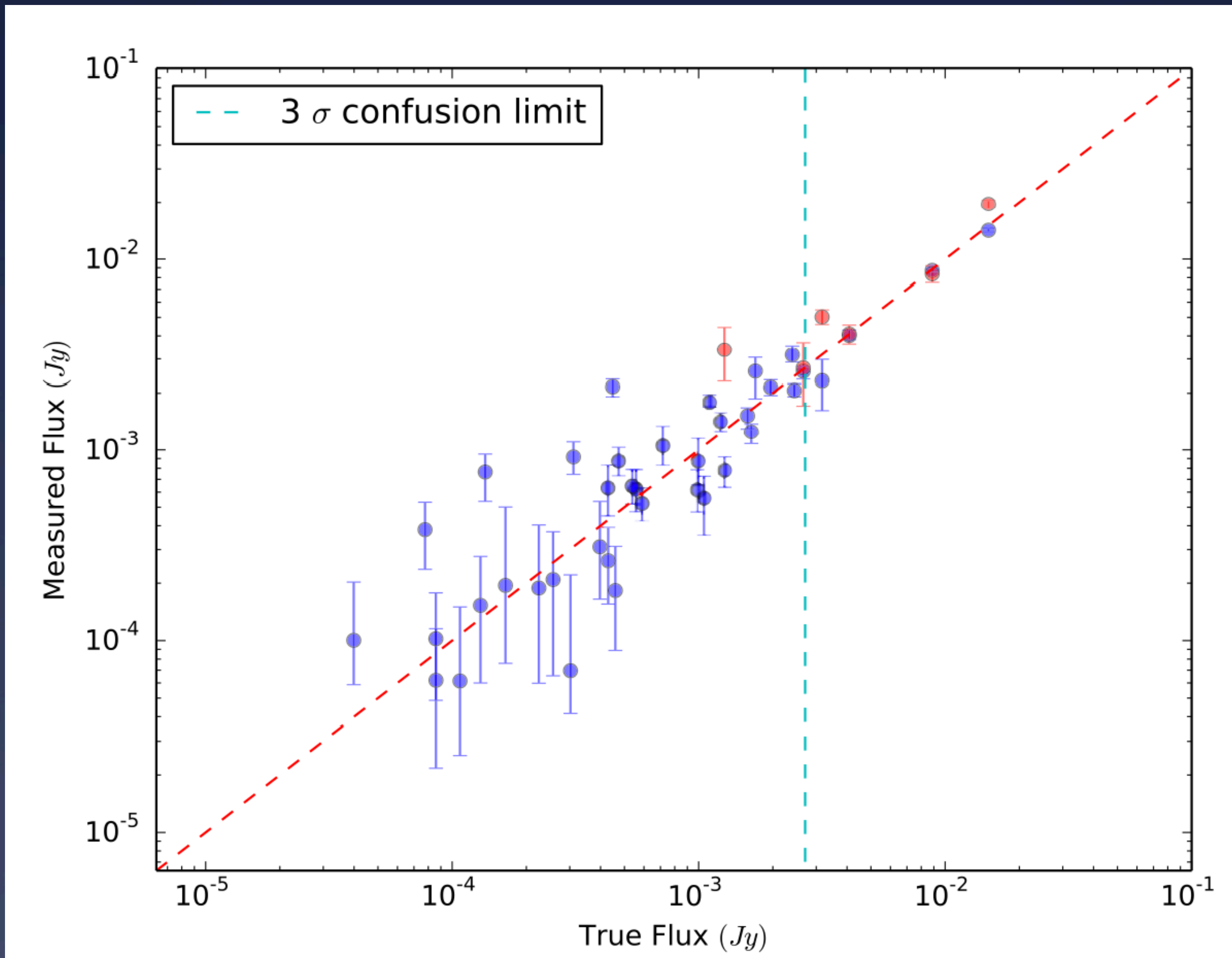


Flux priors and graphical segmentation

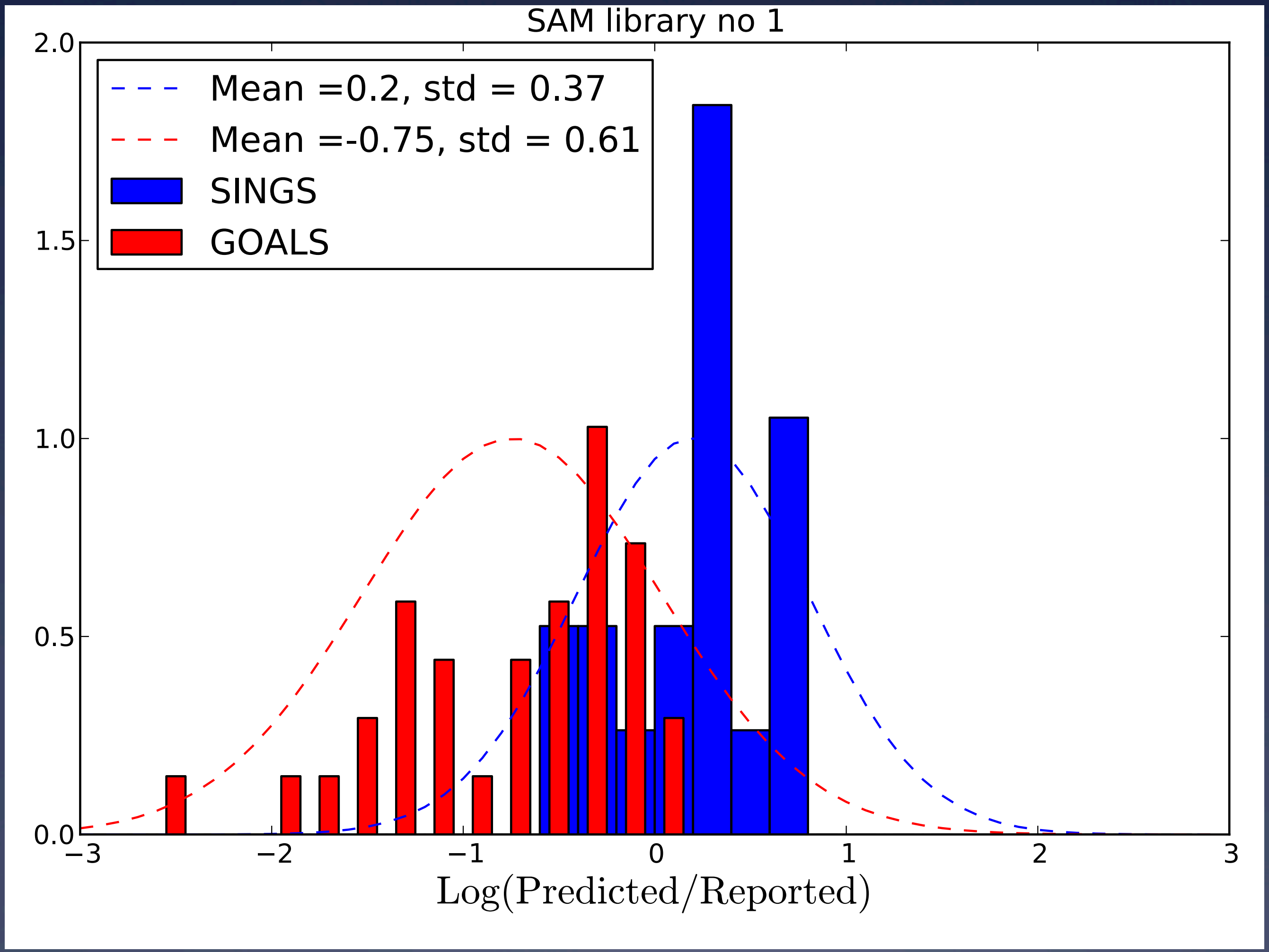




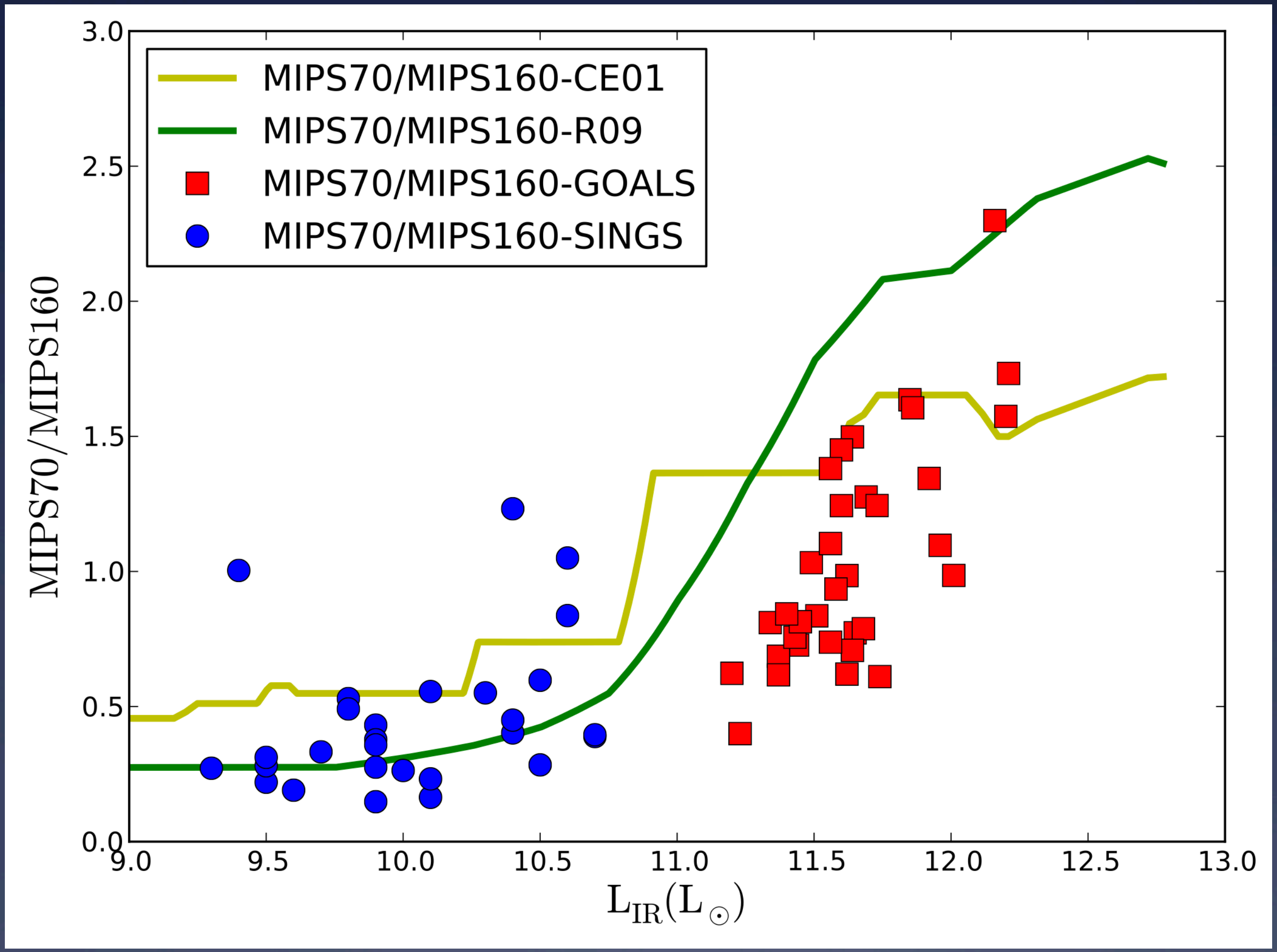
10
9
8
7
6
5
4
3
2
Connectivity


3 σ confusion limit
Measured Flux (Jy)
True Flux (Jy)
10^-1
10^-2
10^-3
10^-4
10^-5

How well can we predict the FIR from just the UV-optical SED?



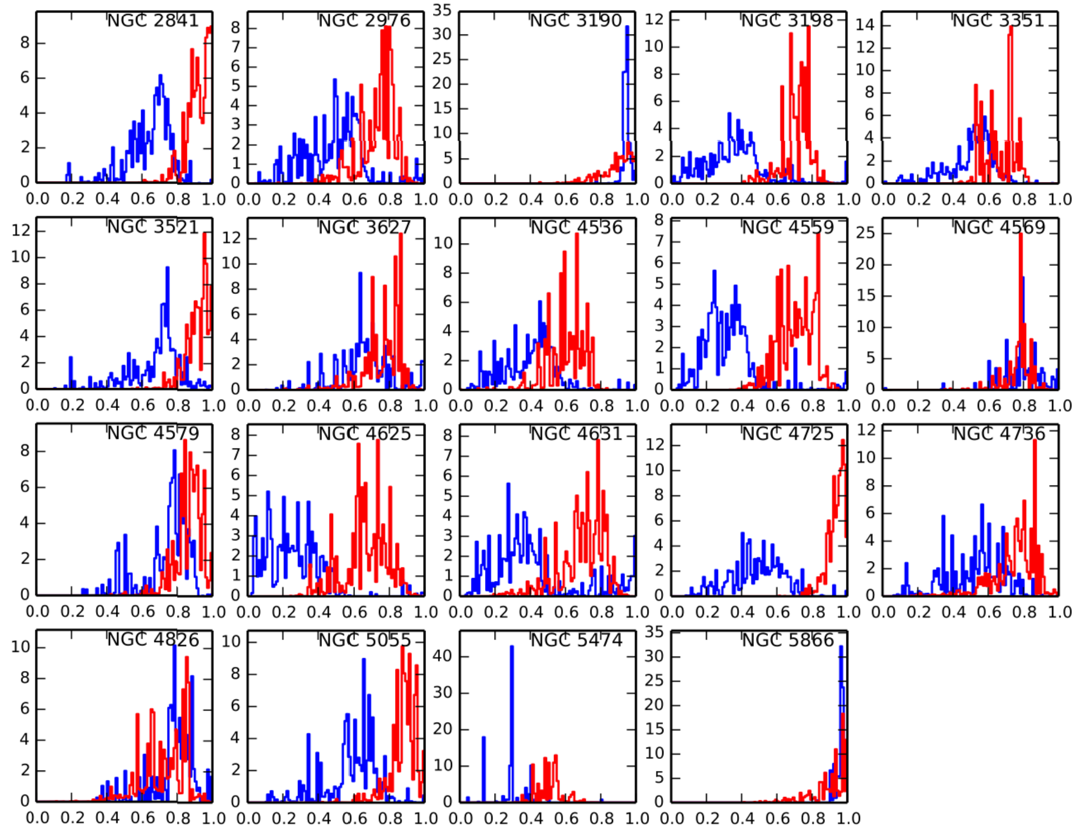
How about the Far-IR colors?



GOALS photometry: Galaxies are redder in the FIR than standard templates predict

Magphys: matching the optical and FIR libraries based on f_μ

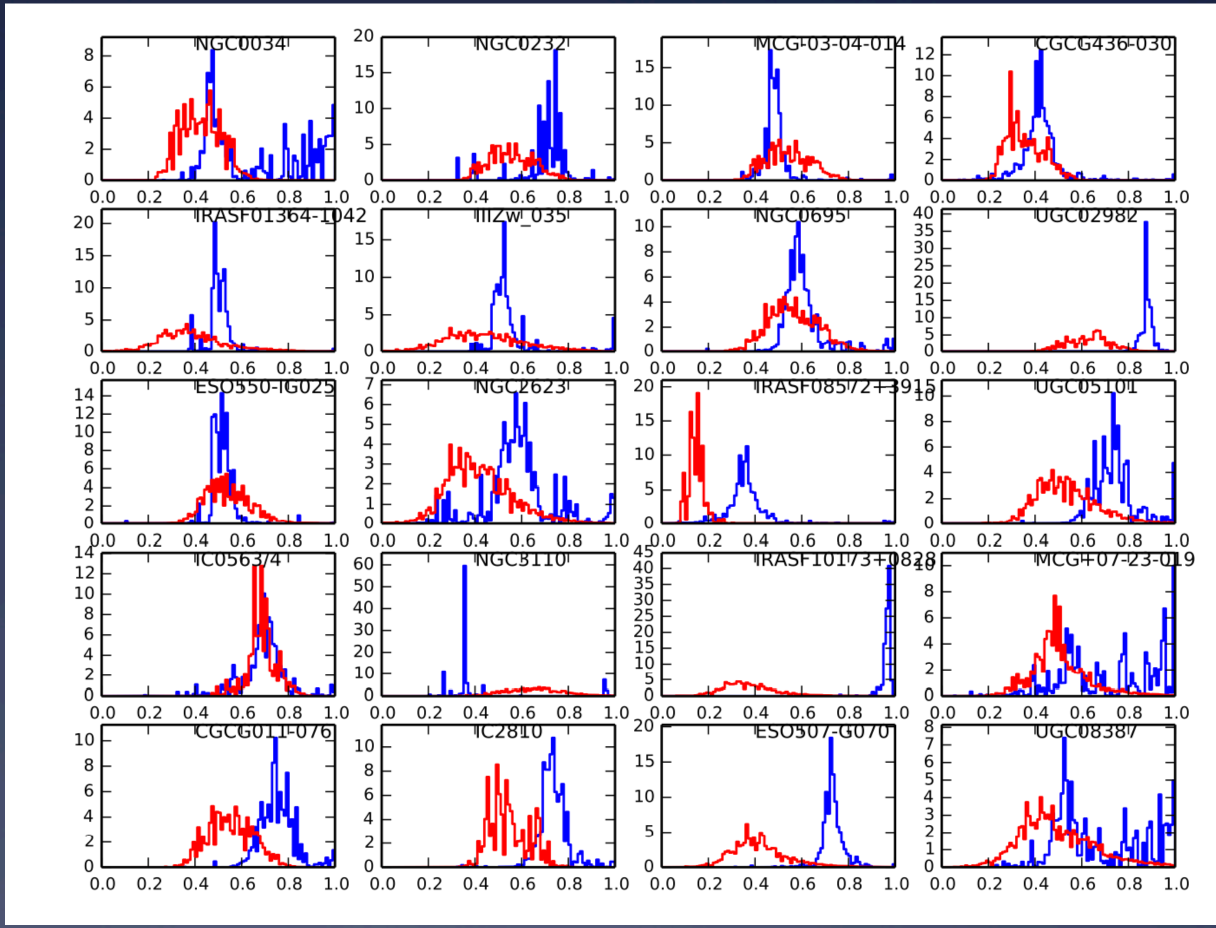
SINGS: f_μ from the optical is typically lower than f_μ from the FIR
=> Larger contribution from diffuse ISM than inferred from optical SED



Magphys: matching the optical and FIR libraries based on f_μ

GOALS: f_μ from the optical is typically higher than f_μ from the FIR

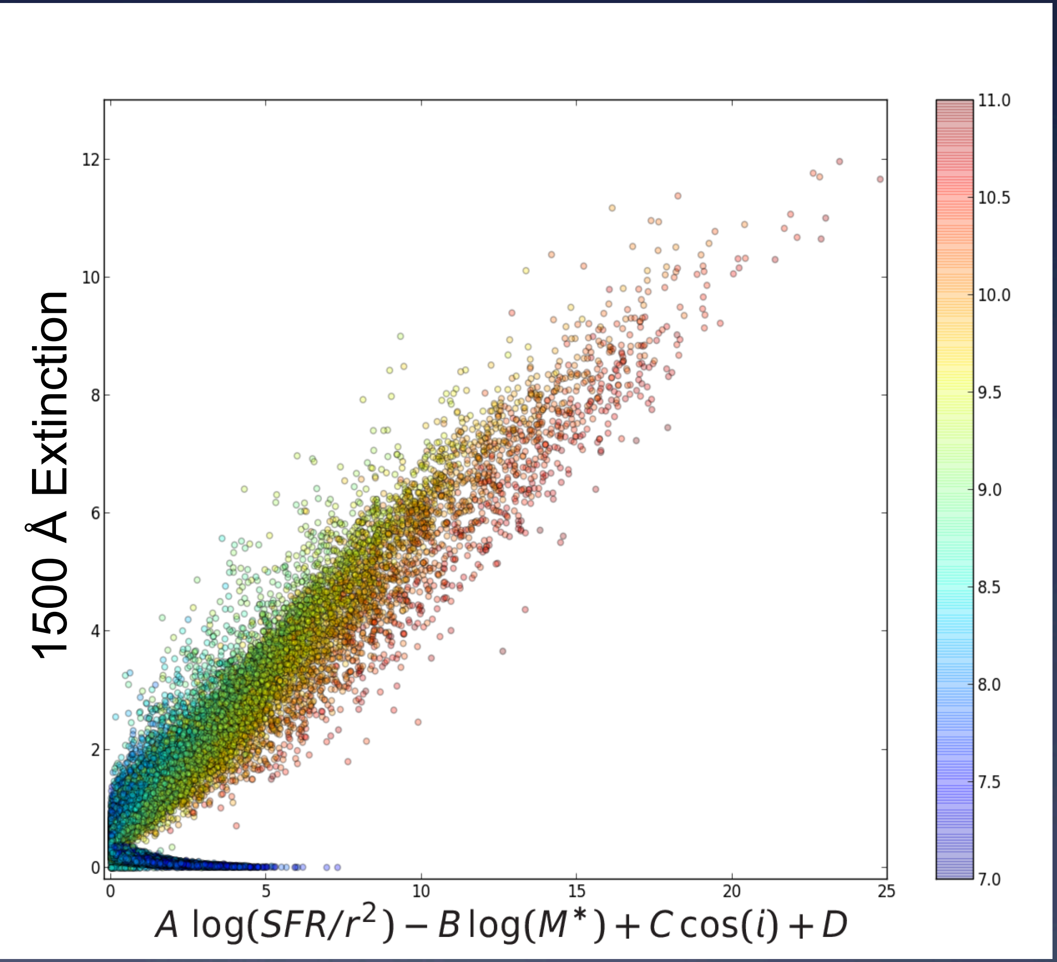
=> Smaller contribution from diffuse ISM than inferred from optical SED



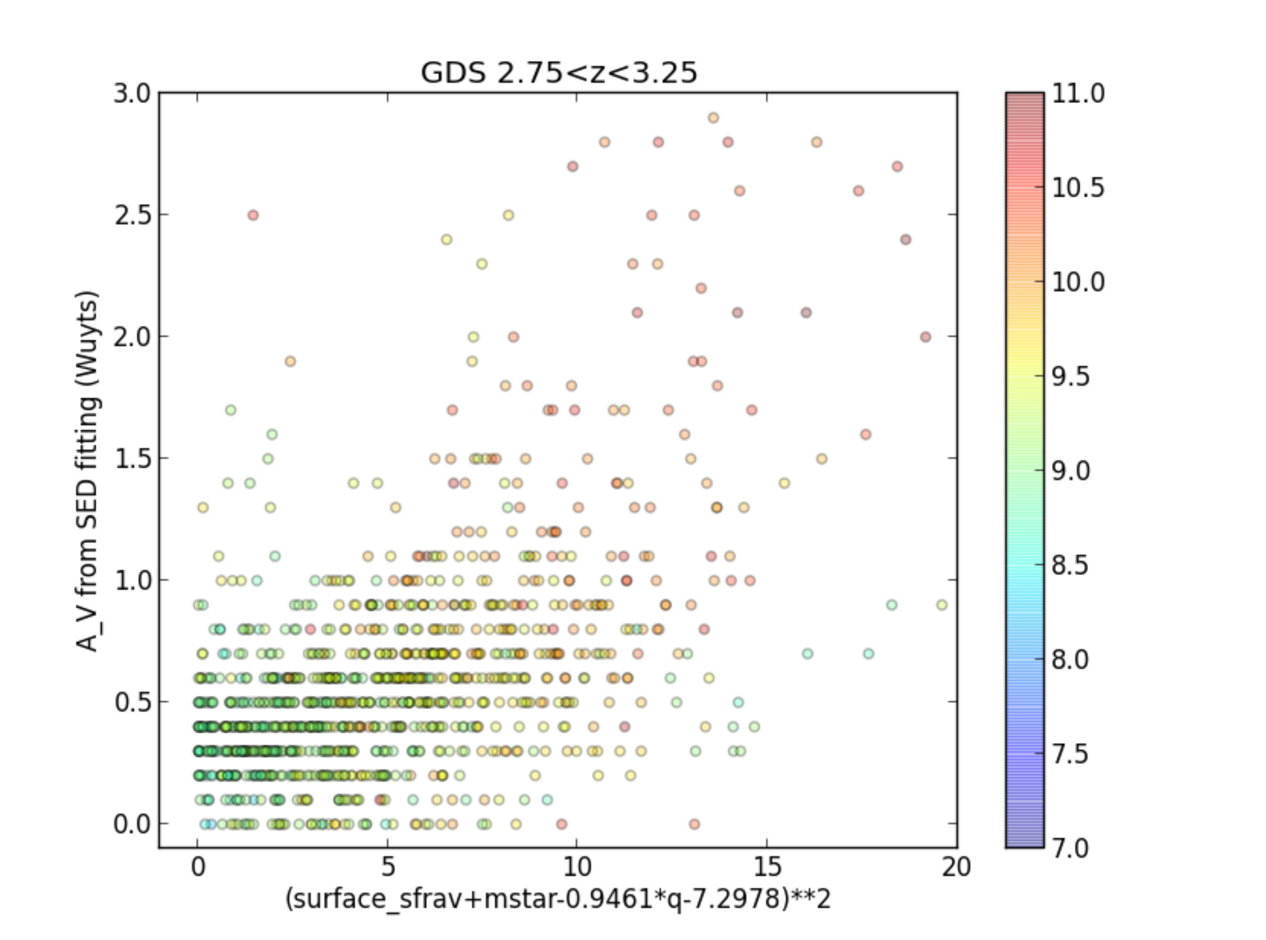
Extinction: Expected behavior

In the models, extinction scales with the column-density of metals

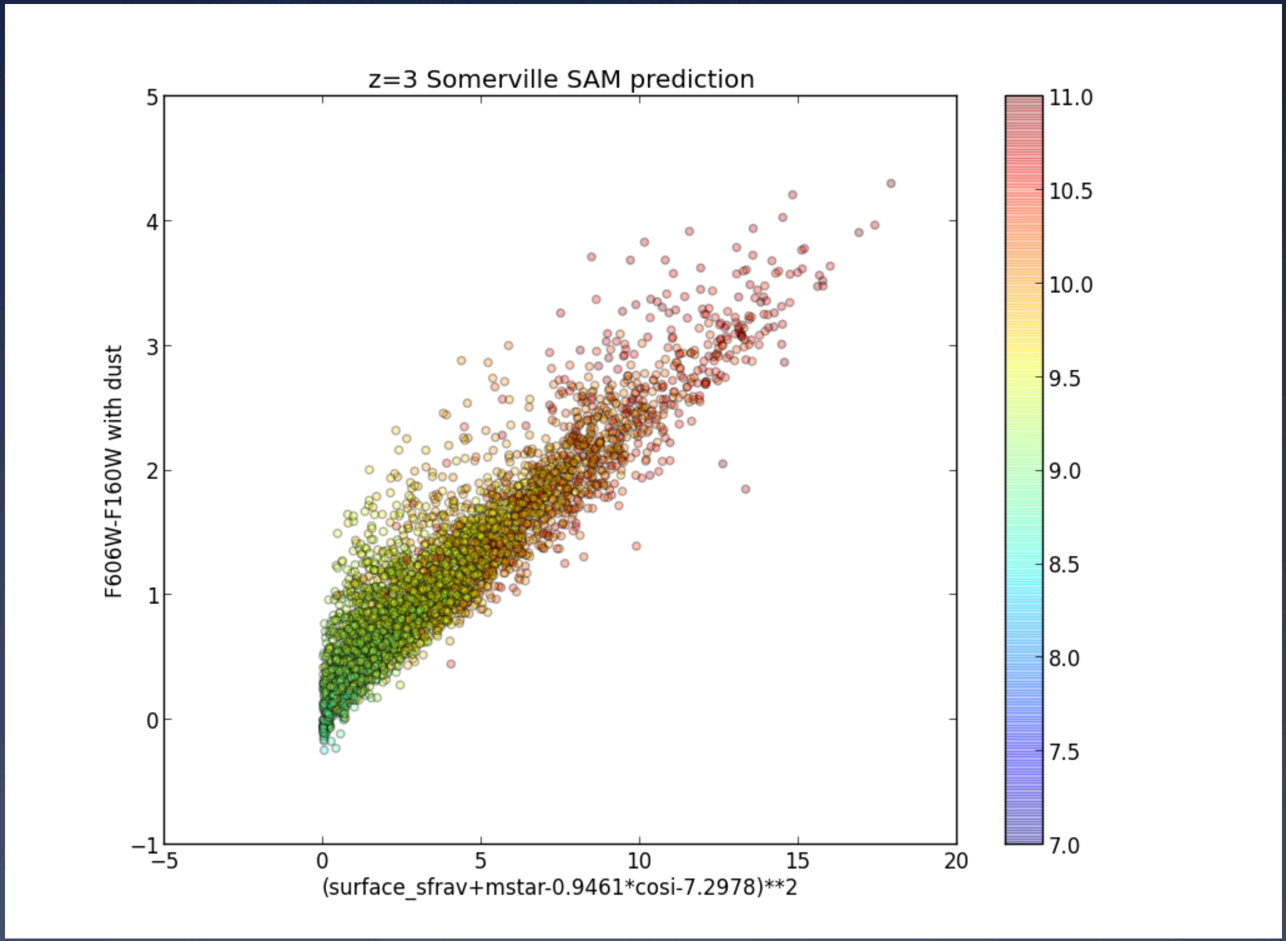
Observable proxies: star-formation-rate surface density, stellar mass, and inclination



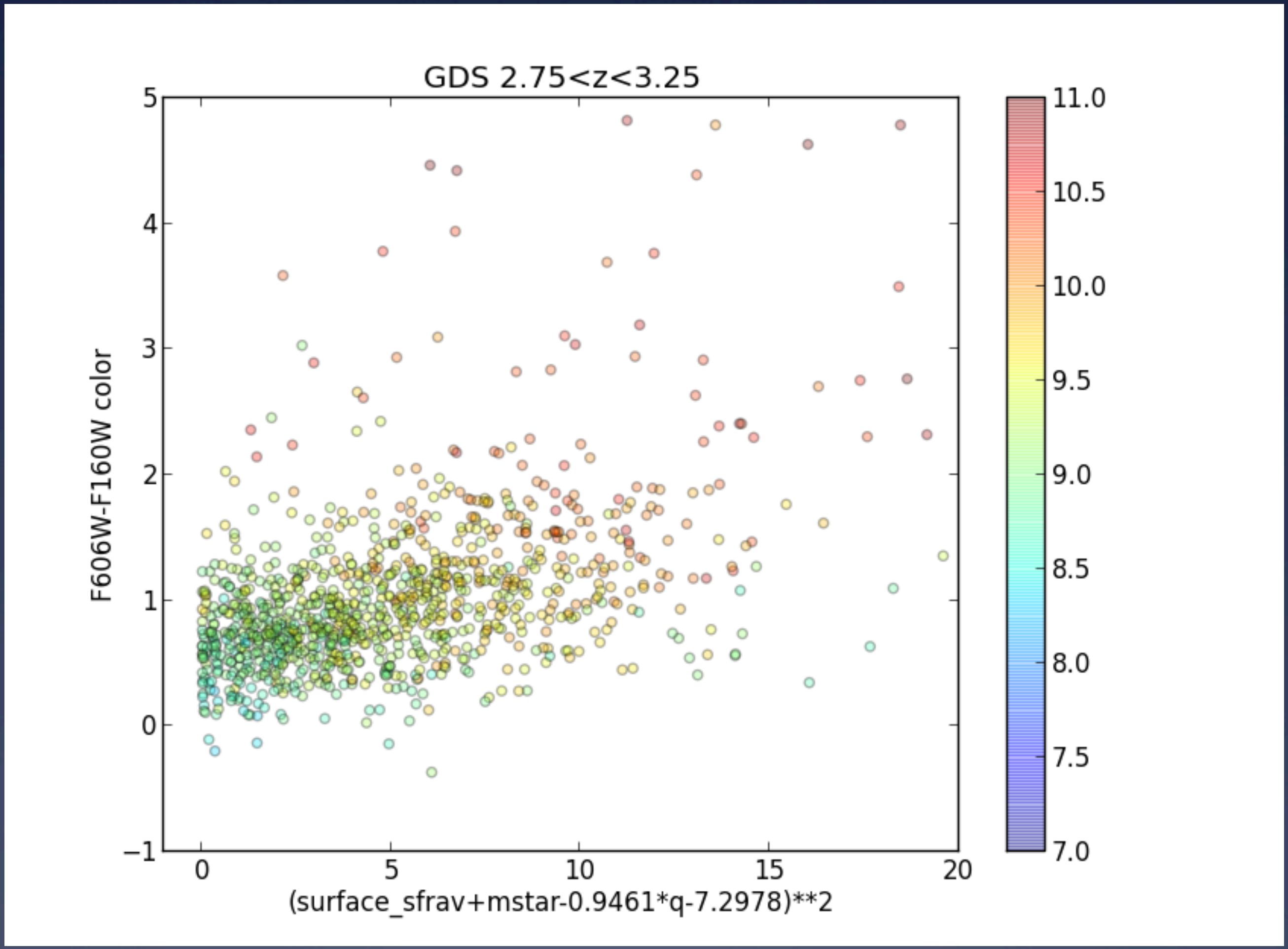
Extinction: Observed trend



Extinction: Expected behavior



Extinction: Observed trend



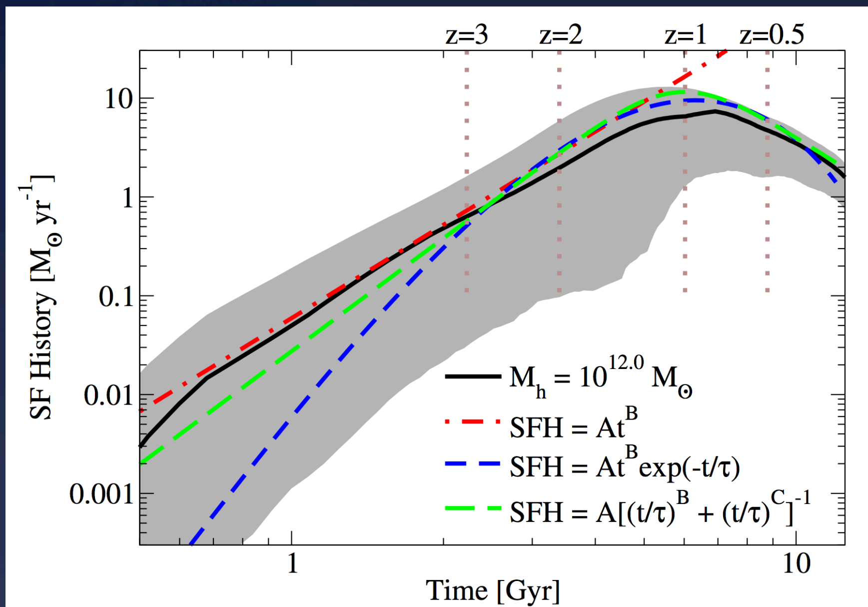
The plan

- Use the observations to constrain the parameters of:
  - Dust model (simple physically-motivated parametrization)
  - Star-formation histories
  - Scatter
- Bayesian hierarchical model:

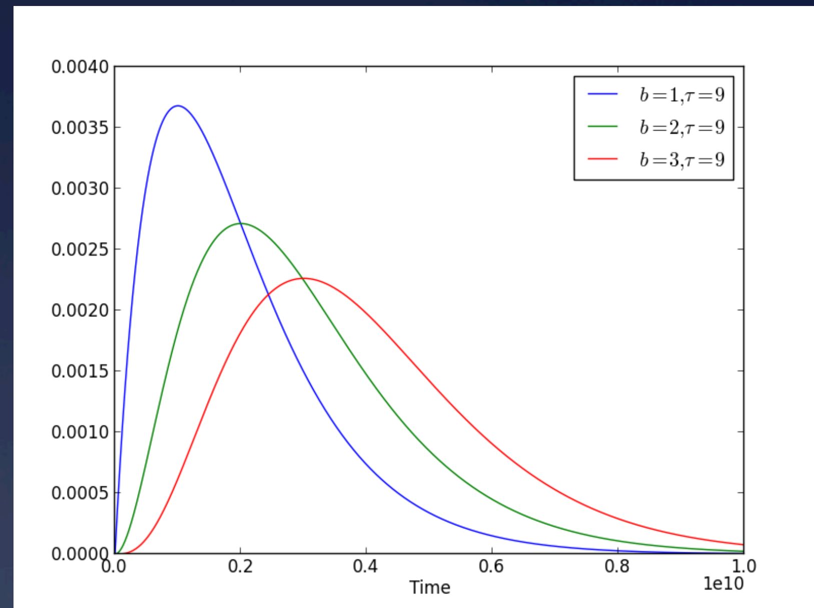
$$P(\phi, \theta_j \mid y) \propto P(y_j \mid \theta_j) P(\theta_j, \phi)$$

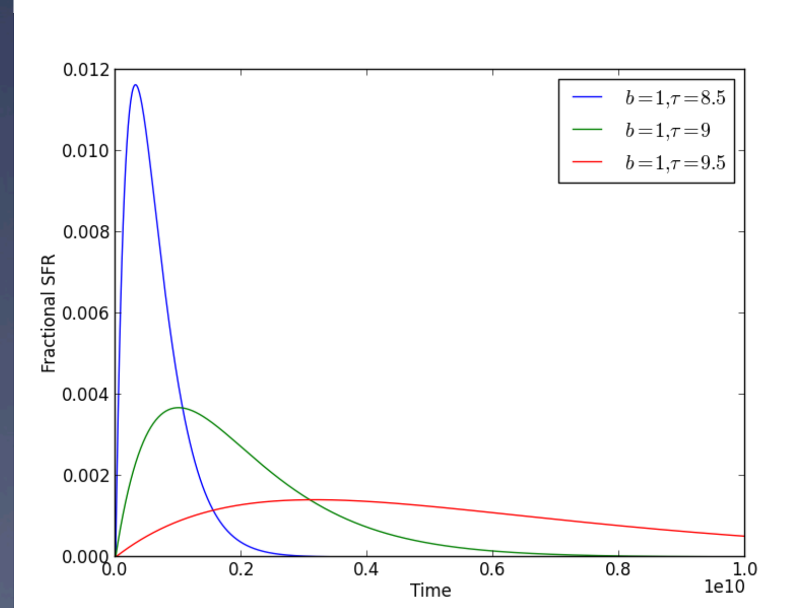
- Progress report…

Parametrized SFR



Behroozi+ 13

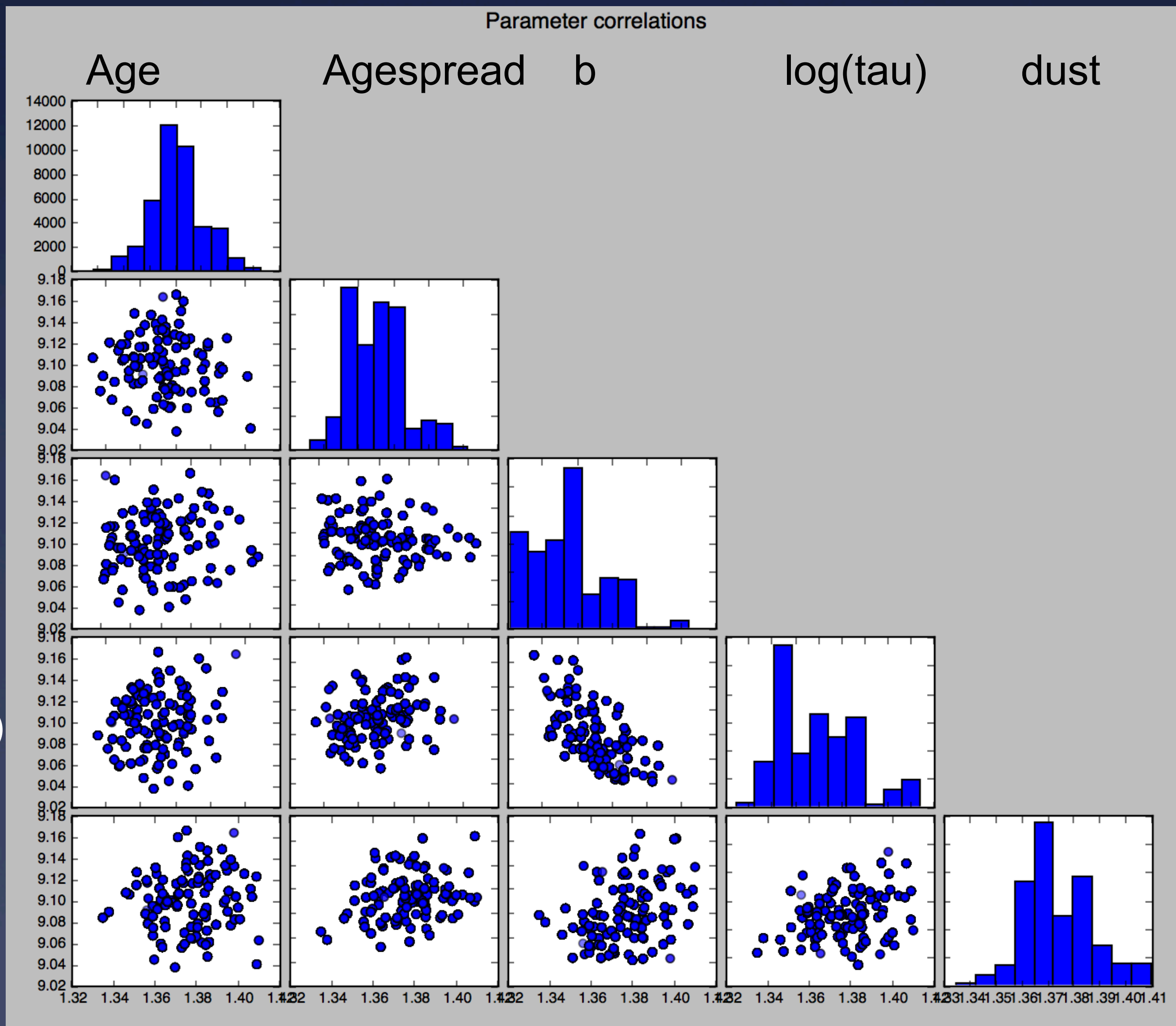




Simple two-parameter model:
SFR = $t^b\exp(-t/\tau)$

Additional parameters:
Age, age spread
Dust --- scale tau of Charlot & Fall model

Test with fake SEDs (5% errors)



Summary

- Need to take advantage of reasonable priors to push the data to the limits.
- Essential for constraining intrinsic scatter in physical parameters
- Scatter can be part of the hierarchical model