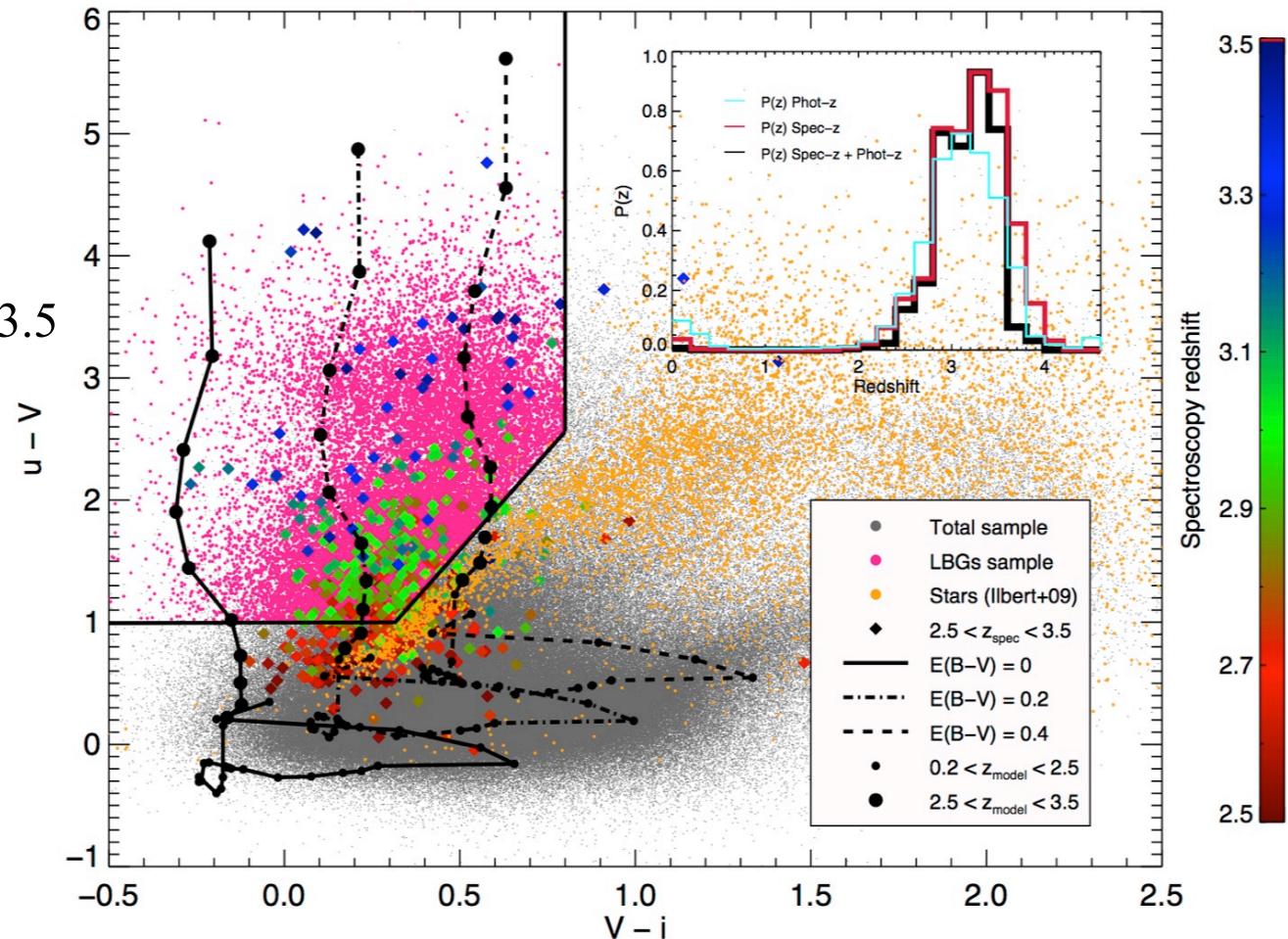


LBG sample

- COSMOS field (2 deg^2)
- Eliminate the low-z interlopers: $2.5 < z_{\text{photo}} < 3.5$
- $-\log(L_{\text{FUV}} [\text{L}_\odot]) > 10.20$
(Completeness 75%)
- $< z_{\text{photo}} > = 3.02 \pm 0.25$



Sample ~ 20.000 LBGs

Stacking analysis and Binning

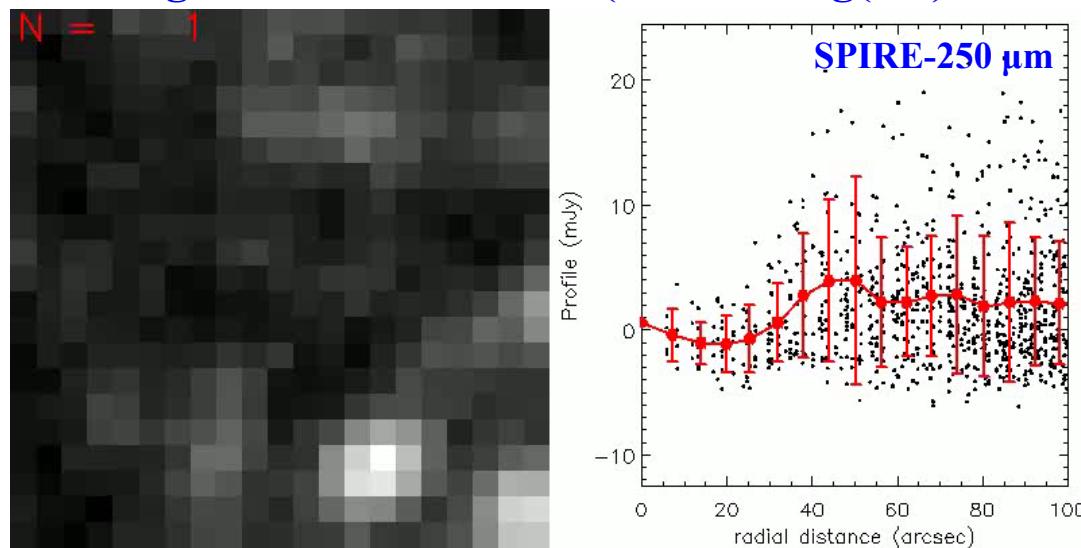
- LBG samples present incompleteness at IR, which increases at longer wavelength observations. For example, less than 0.05% of our LBGs sample is detected at SPIRE-250μm.
- The objective of this work is to obtain the rest-frame FUV to FIR emission for LBGs population at z~3.
- We performed stacking analysis form the Optical to mm available wavelength observations at COSMOS field.
 - **Optical:** SUBARU (B, V, r, i, and z bands)
 - **NIR:** UltraVISTA (Y, J, H, Ks)
 - **Mid-IR:** IRAC (3.6, 4.5, 5.8, 8μm) and MIPS (24 μm).
 - **Far-IR:** PACS (100 and 160μm) and SPIRE (250, 350, 500μm)
 - **mm:** AzTEC (1.1mm)
- Our Stacking analysis have been corrected by:
 - The incompleteness of our input catalogue in dense regions (Important for faint population)
 - The clustering of galaxies.
 - The contribution of the field sources.

Stacking analysis and Binning

	Interval	Nº of bins
L_{FUV}	$10.2 < \log(L_{\text{FUV}} [\text{L}_\odot]) < 11.4$	4
β_{UV}	$-1.7 < \beta_{\text{UV}} < 0.3$	4
M_*	$9.75 < \log(M_* [\text{M}_\odot]) < 11.5$	6
$M\beta 1$	1: $9.75 < \log(M_* [\text{M}_\odot]) < 10.65$ 2: $10.65 < \log(M_* [\text{M}_\odot]) < 11.5$	2 in M_* 3 in β_{UV}
$M\beta 2$	1: $-1.7 < \beta_{\text{UV}} < -0.8$ 2: $-0.8 < \beta_{\text{UV}} < 0.3$	2 in β_{UV} 5 in M_*

This configuration will give us **30** different bins to characterize the LBGs population at $z \sim 3$ **as a function of L_{FUV} , β_{UV} , M_* , and the combination of (β_{UV}, M_*)**

Stacking as a function of M_* ($10.25 < \log(M_*) < 10.5$)



SED-fitting analysis: CIGALE

CIGALE WORKFLOW

PCIGALE INIT

Give the context: input file, which modules to use, SED fitting or modelling, number of processors

SFH

2exp delayed comb fromfile

SSP

BC (2003) Maraston (2005) Starburst 99

Nebular emission

Continuum + lines

Attenuation Law

Modified (slope & 2175Å-bump)
Leitherer + Calzetti

Dust Models / Templates

Draine & Li (2007, 2014) Dale et al. (2014) Casey et al. (2012)

Addition IR component

Additional modified black body
(w/ or w/o energy balance)

AGN Emission

Fritz (2006)

Radio

NewModule.py

Redshifting + IGM

Simple Module

IGM from Meiksin (2006)

PCIGALE RUN

RUN:

- Parallelized for multi-core computers
- Easy creation of mock catalogs allowing to test degeneracies

CIGALE 'Classic'
Traditional SED Fitting (best model & Bayesian)

CIGALE 'Model'
Predicts « observed » SEDs and spectra

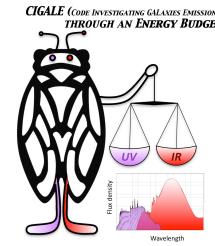
PCIGALE PLOT

SEDS (individual components)

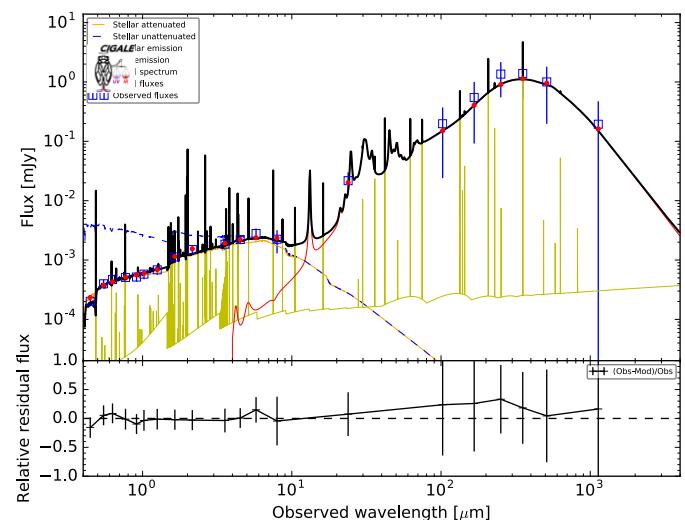
Probability Distribution Functions

χ^2 Distribution Functions

CIGALE is a self-consistent SED-fitting code designed to provide the main physical parameters of galaxies, by using Bayesian-like analysis and energy balance.

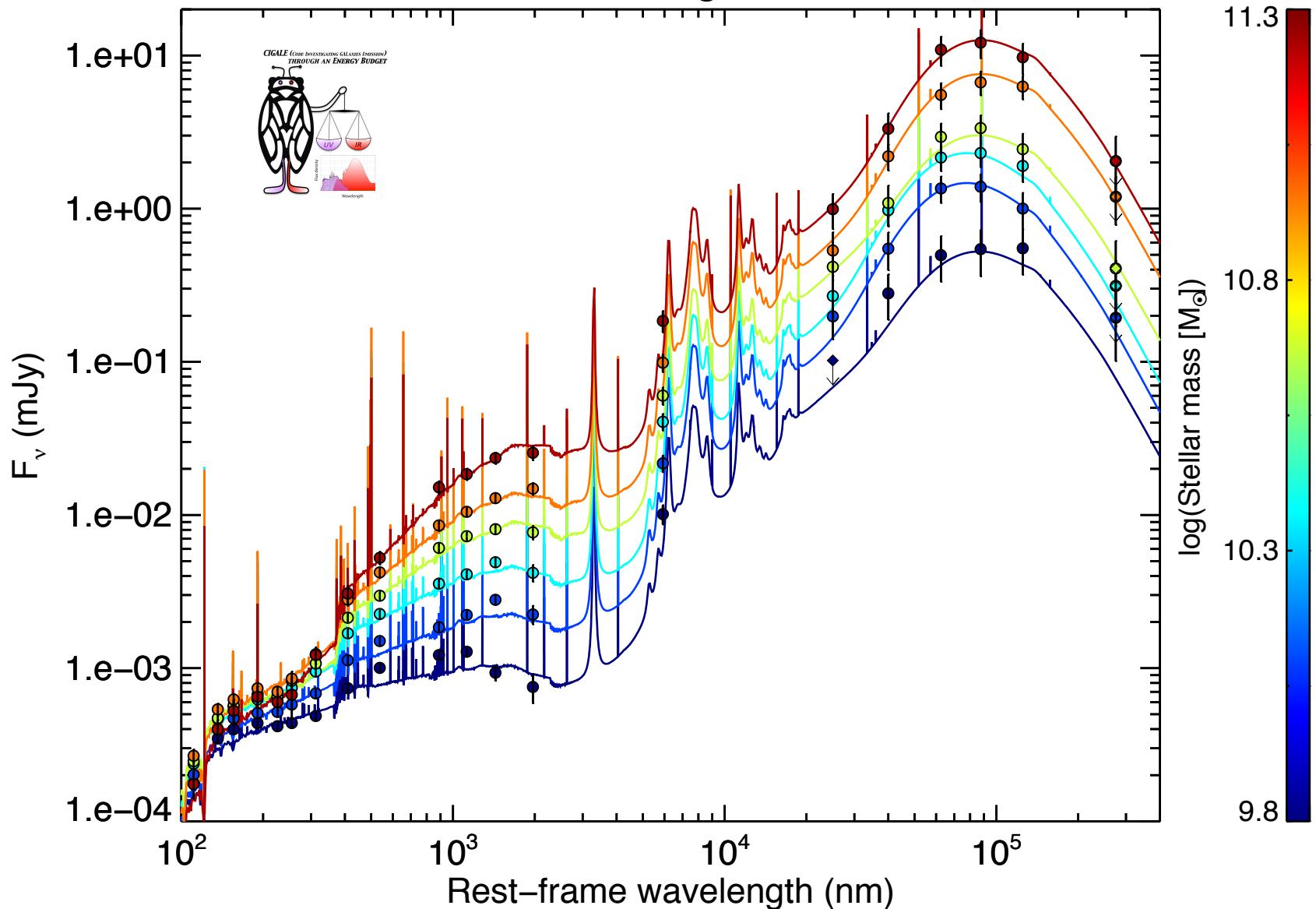


Best model for LBG_mass_1000_1025 at $z = 3.0$. Reduced $\chi^2 = 0.52$

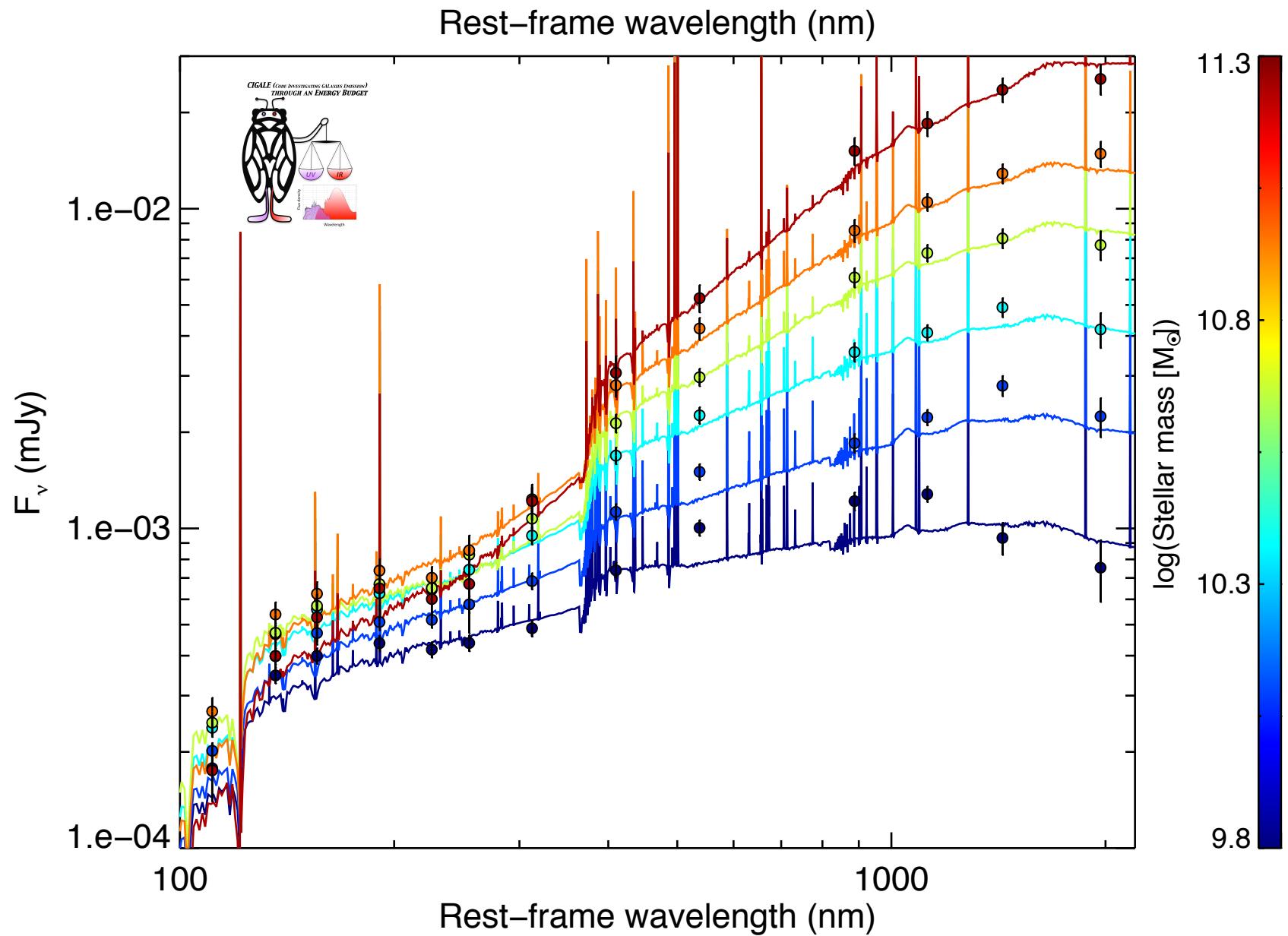


Stacked SEDs and SED-fitting results

UV to Far-IR SEDs from stacking as a function of stellar mass

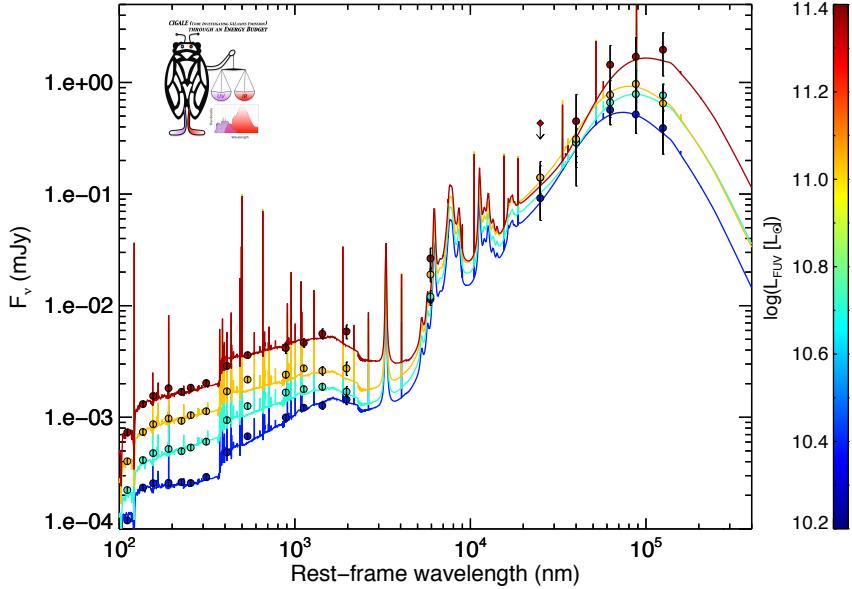


Stacked SEDs and SED-fitting results

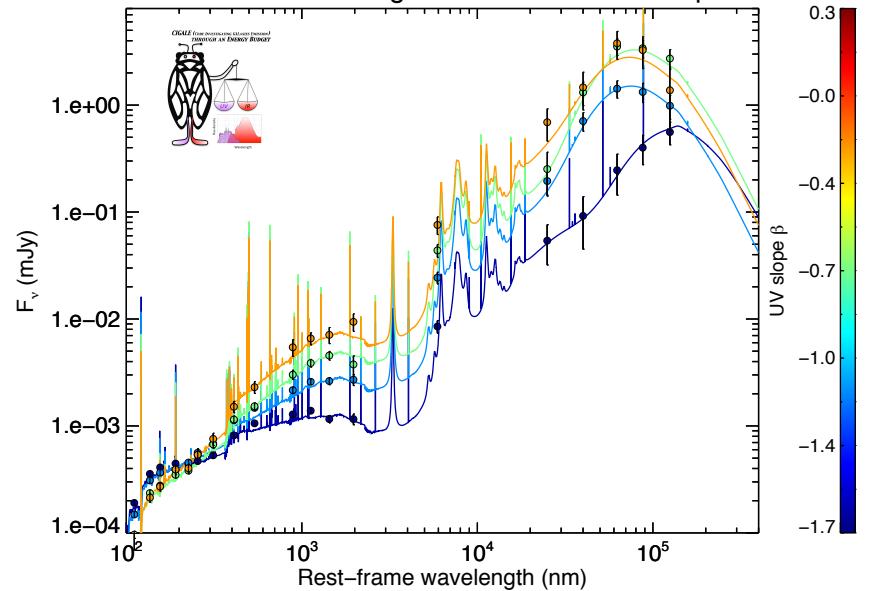


Stacked SEDs and SED-fitting results

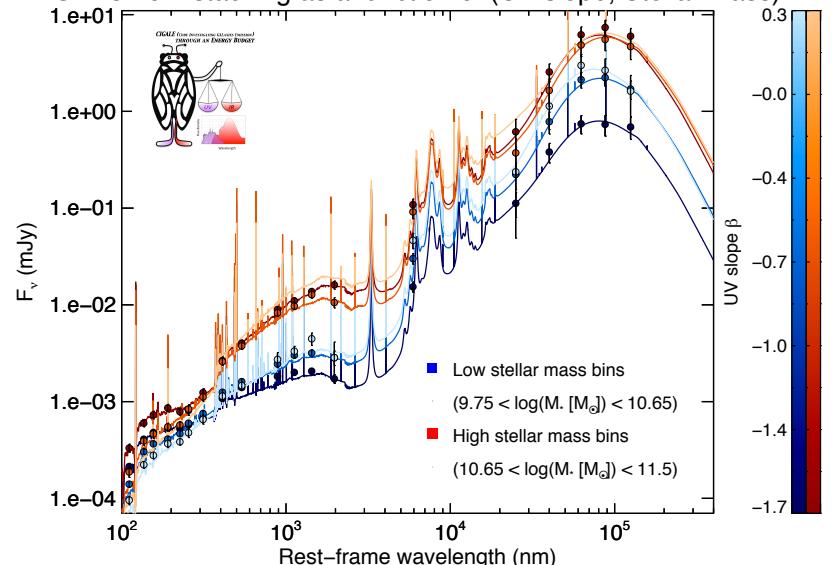
UV to Far-IR SEDs from stacking as a function of UV luminosity



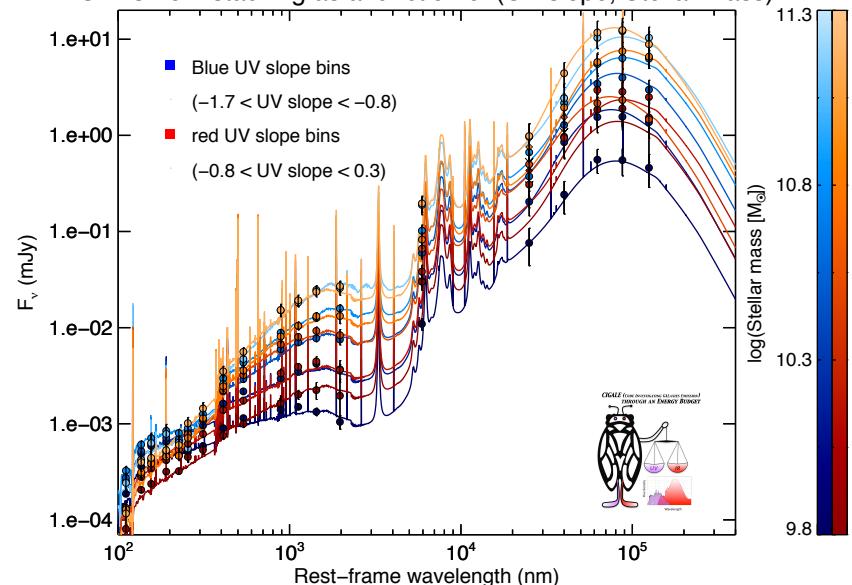
SEDS from stacking as a function of UV slope



SEDS from stacking as a function of (UV slope, Stellar mass)

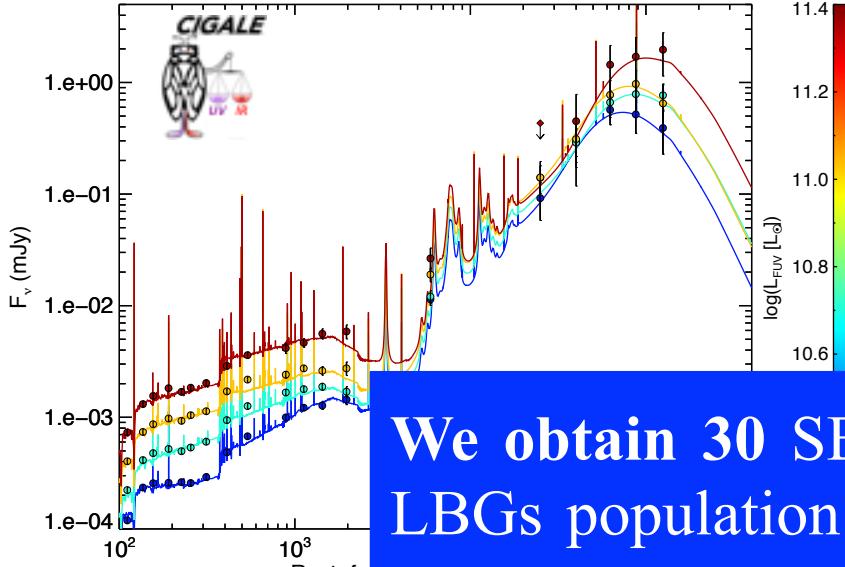


SEDS from stacking as a function of (UV slope, Stellar mass)



SEDs and SED-fitting analysis

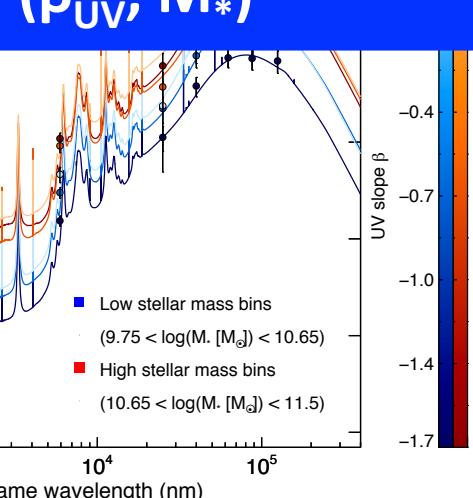
UV to Far-IR SEDs from stacking as a function of UV luminosity



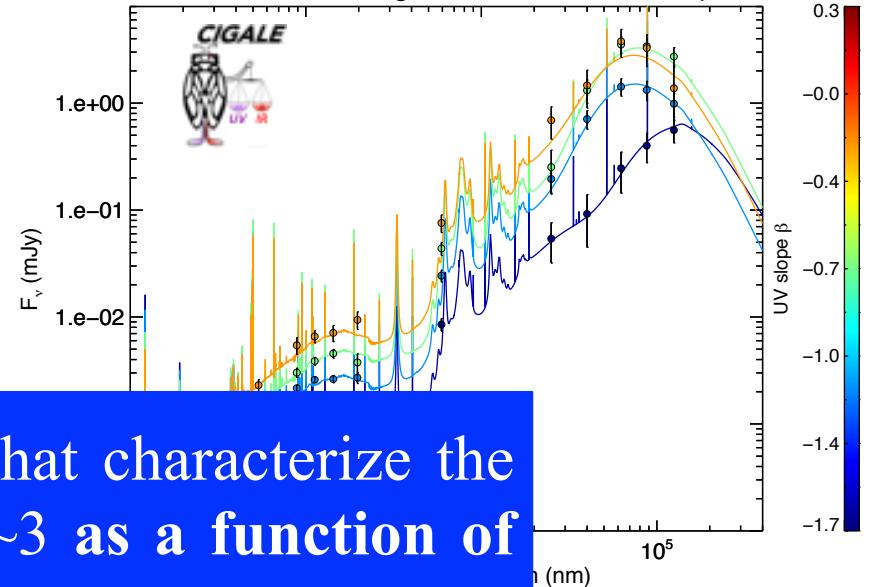
SEDs from stacking as a function of

Rest-frame wavelength (nm)

We obtain **30** SEDs that characterize the LBGs population at $z \sim 3$ as a function of L_{FUV} , β_{UV} , M_* , and the combination of (β_{UV}, M_*)

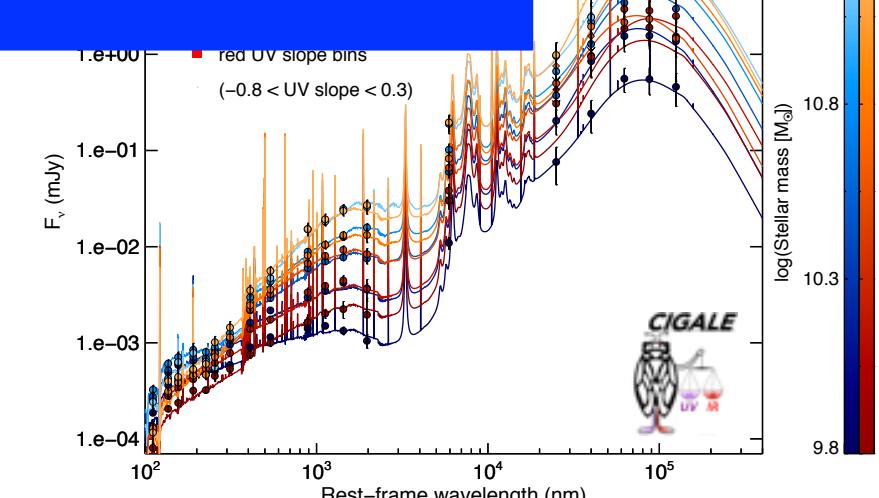


SEDs from stacking as a function of UV slope

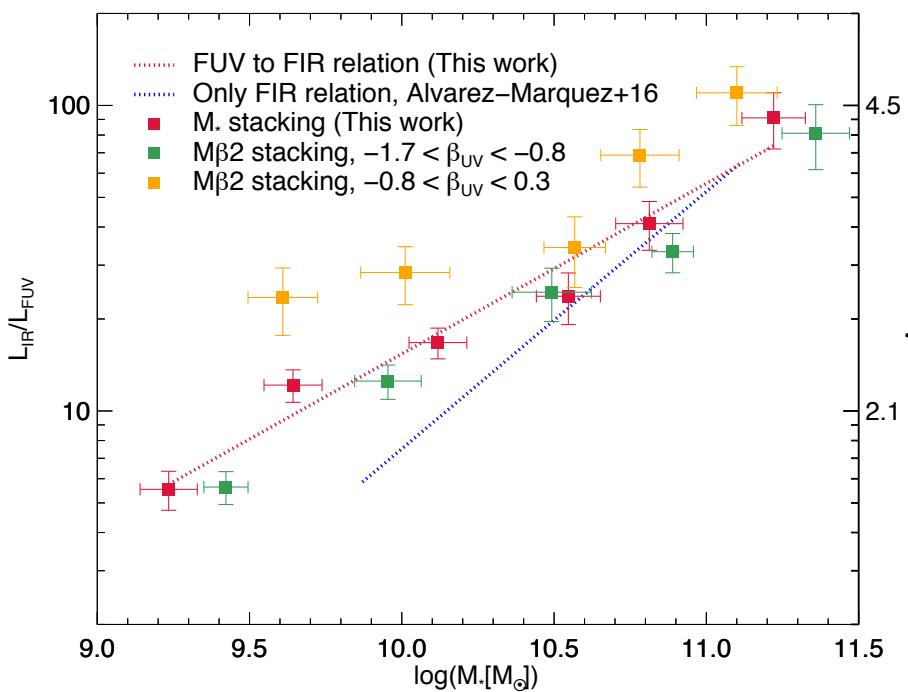
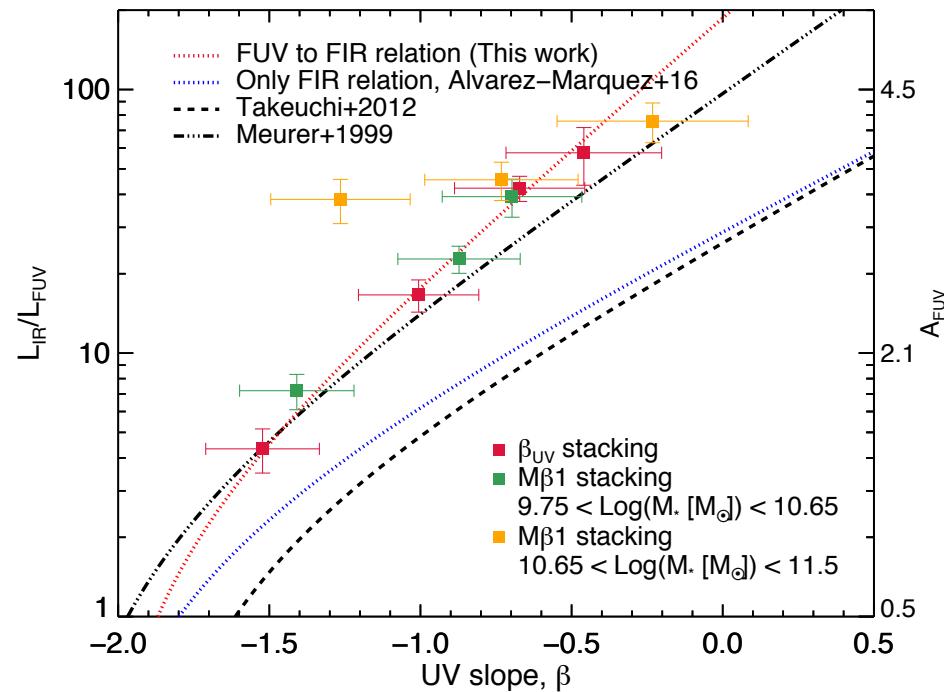


SEDs from stacking as a function of

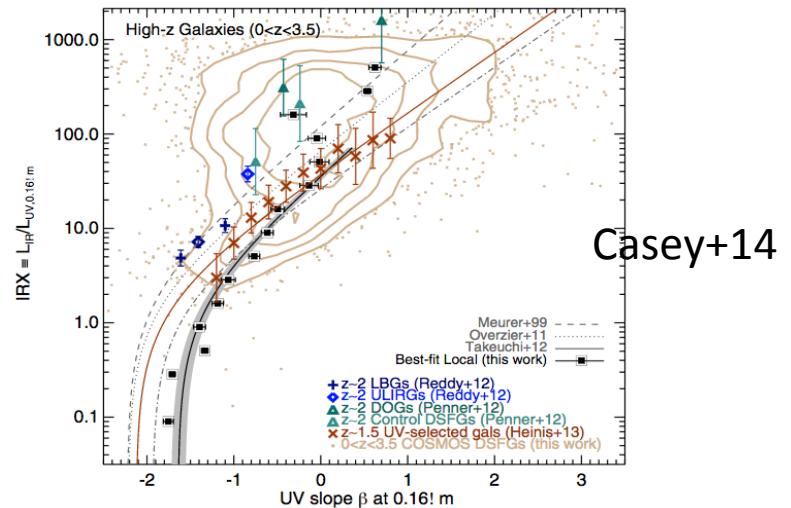
UV slope, Stellar mass



Dust attenuation for LBGs at z~3

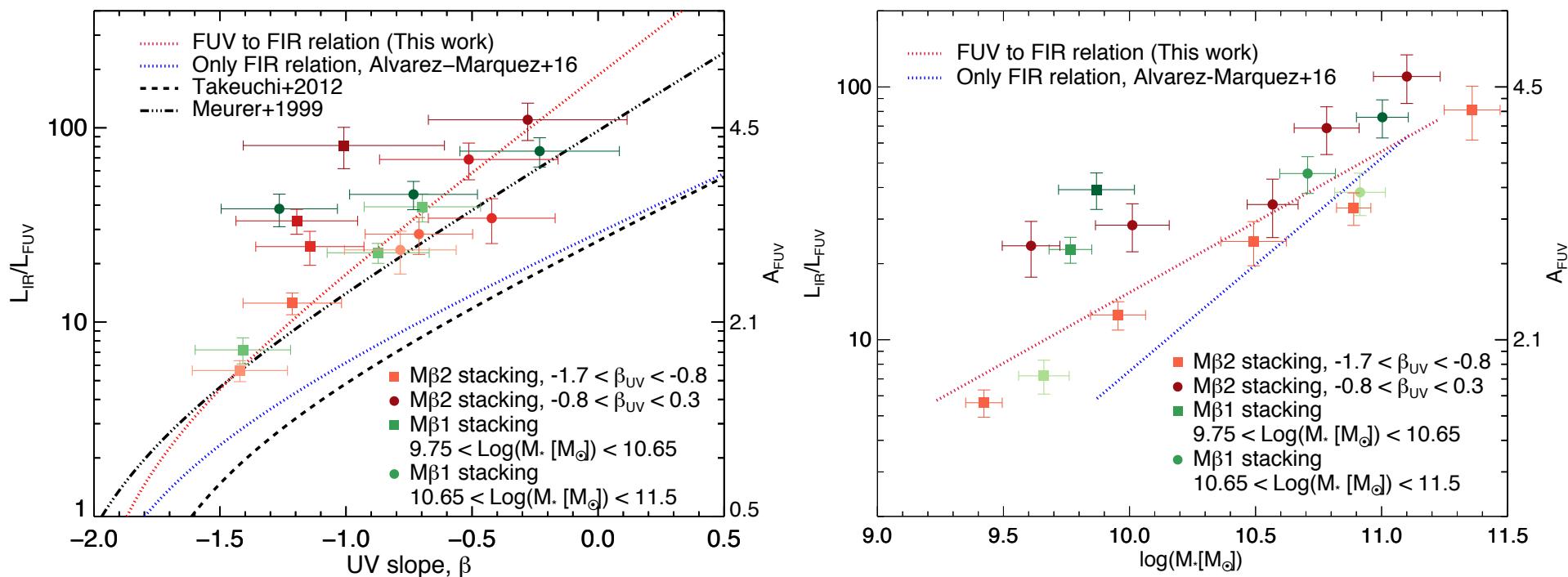


Interval		Nº of bins
β_{UV}	$-1.7 < \beta_{\text{UV}} < 0.3$	4
M_*	$9.75 < \log(M_* [\text{M}_\odot]) < 11.5$	6
$M\beta 1$	1: $9.75 < \log(M_* [\text{M}_\odot]) < 10.65$ 2: $10.65 < \log(M_* [\text{M}_\odot]) < 11.5$	2 in M_* 3 in β_{UV}
$M\beta 2$	1: $-1.7 < \beta_{\text{UV}} < -0.8$ 2: $-0.8 < \beta_{\text{UV}} < 0.3$	2 in β_{UV} 5 in M_*



Casey+14

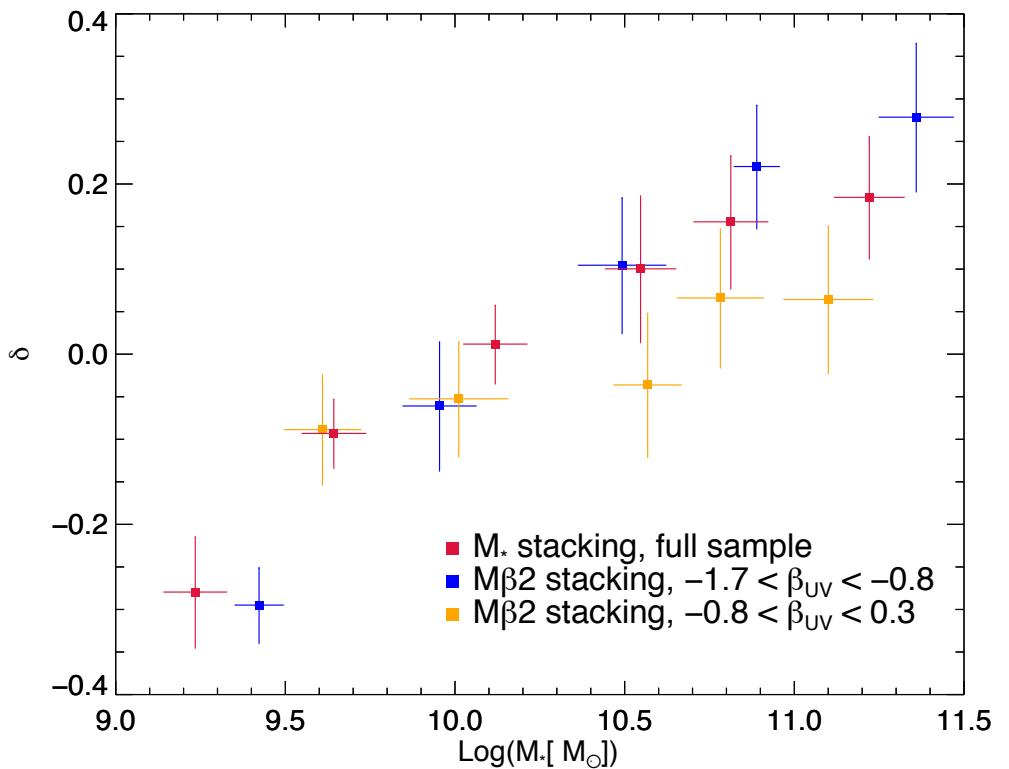
Dispersion on IRX- β_{UV} and IRX- M_* plane



	Interval	Nº of bins
M$\beta 1$	1: $9.75 < \log(M_*/M_\odot) < 10.65$	2 in M_*
	2: $10.65 < \log(M_*/M_\odot) < 11.5$	3 in β_{UV}
M$\beta 2$	1: $-1.7 < \beta_{\text{UV}} < -0.8$	2 in β_{UV}
	2: $-0.8 < \beta_{\text{UV}} < 0.3$	5 in M_*

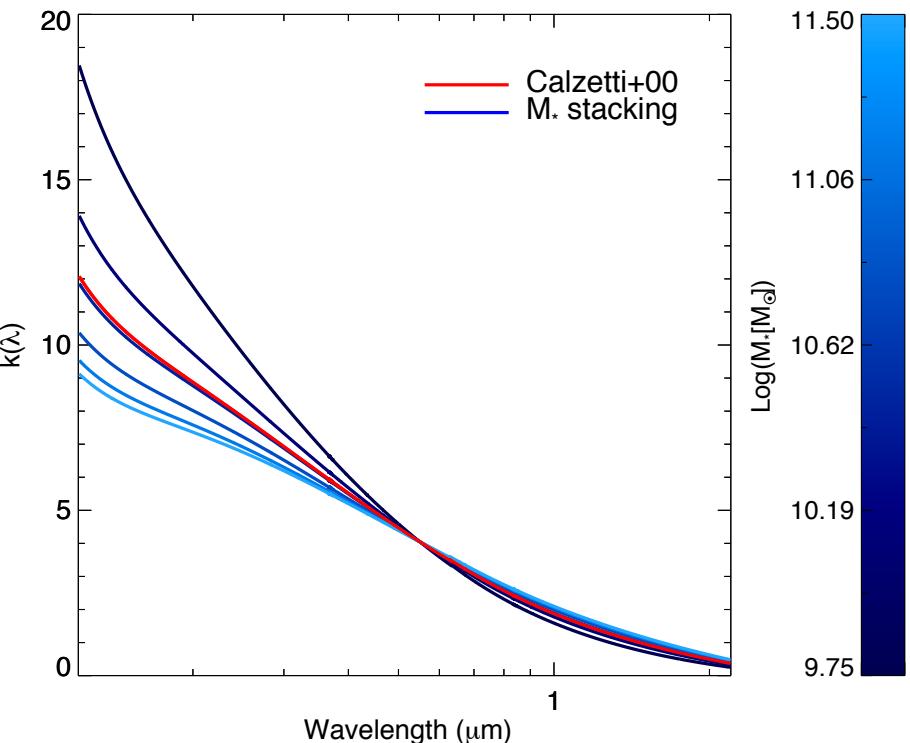
A combination of IRX, β_{UV} , and M_* , in a 3D plane, will present the best combination to obtain the dust attenuation of a galaxy, this will break the dispersion in the IRX- β_{UV} and IRX- M_* plane (working in progress).

Shape of the dust attenuation curve for LBGs at z~3



SED-fitting analysis we focus to obtain the shape of the dust attenuation curve.

Modify Calzetti law (Noll+2009)



- The SED-fitting analysis suggest an evolution of the shape of the dust attenuation law as a function of the M^* .

- High mass – flatter than Calzetti+00
- Low M_* -- Steeper than Calzetti+00

Next with JWST and Summary

JWST:

- NIRCam + MIRI will give access to the FUV to NIR spectrum domain at high-z ($z \sim 5-7$), that will provide a possibility to calculate the shape of dust attenuation.
- Additional data of ALMA will give a self-consistent amount of dust attenuation (IRX or A_{FUV}) for this high-z galaxies.

Summary

We perform a stacking analysis using large sample of LBGs (20.000) from Optical to mm observation in the COSMOS field:

- We obtain 30 different SEDs for LBGs at $z \sim 3$ as a function of LFUV, βUV , M^* , and the combination of (βUV , M^*).
- We present the mean dust attenuation as a function of βUV and M^* for our LBGs population.
- We investigate the dispersion on the $\text{IRX}-\beta\text{UV}$ and $\text{IRX}-M^*$ plane as a function of βUV and M^* .
- Shape of dust attenuation evolve with the M^* .