

SED FITTING WITH *CIGALE*: APPLICATIONS TO UV FAINT LBGS, SUBMM LENSES …

Denis BURGARELLA, Elodie GIOVANNOLI & Véronique BUAT,

LAM, Marseille

http://www.oamp.fr/cigale/

Outline



1. What is *CIGALE*?
2. A few applications of *CIGALE that you might find useful in galaxy clusters (or not)*
3. What's next in terms of wide-field observing facilities?

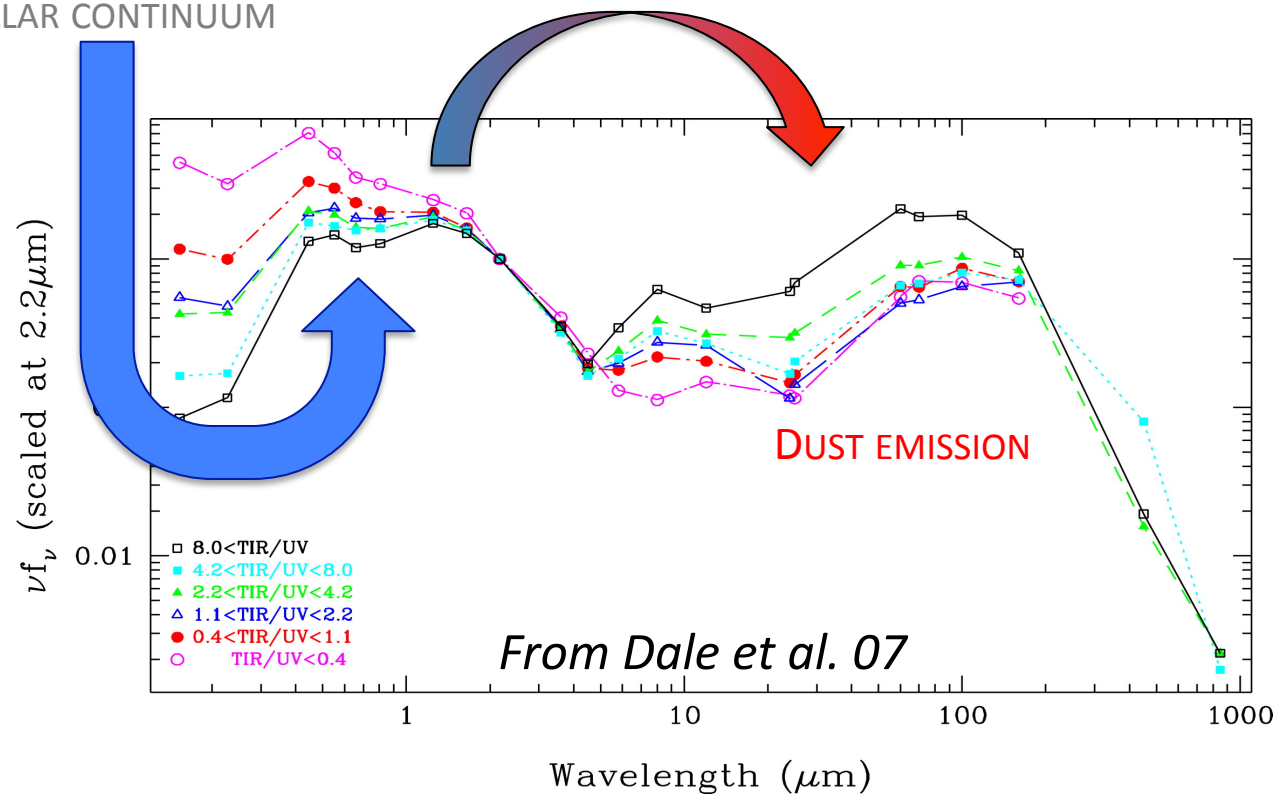


1. What is *CIGALE*?

CIGALE Basics (Noll et al. 2009)

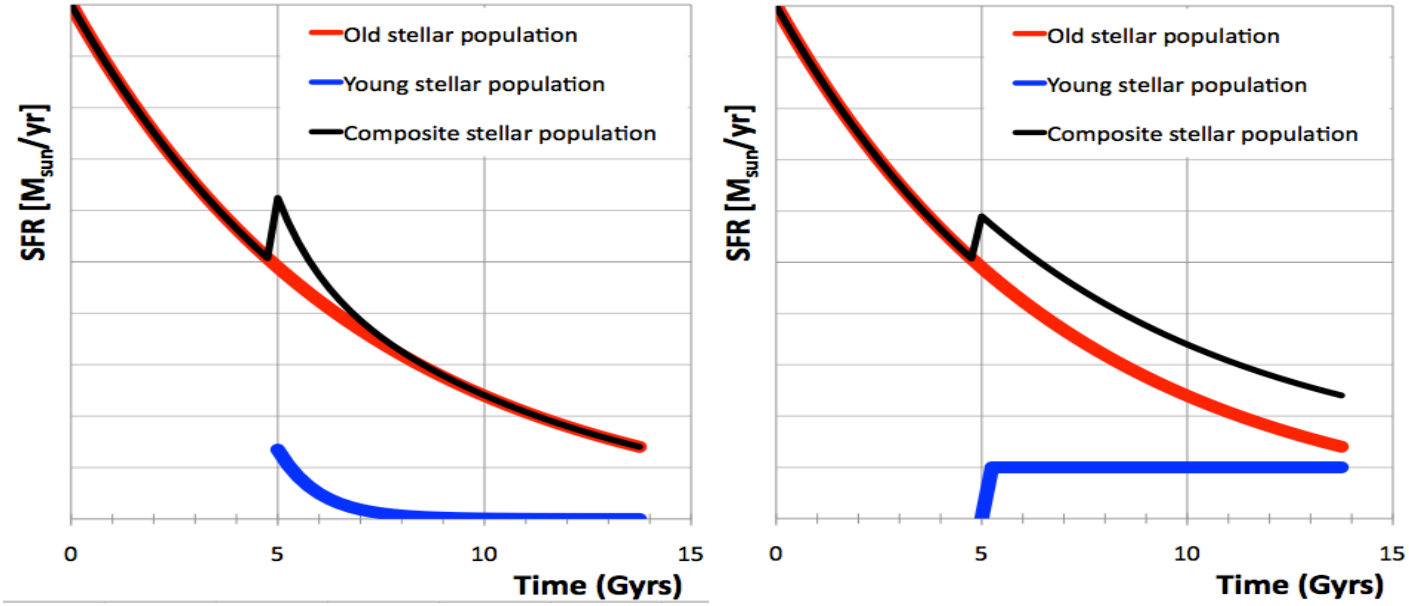
CIGALE combines **a UV-optical SED** & a **dust IR emitting** component (+ an AGN component in MIR): **the energetic balance is fully conserved between stellar and dust emissions**

OBSCURATION OF THE STELLAR CONTINUUM



STELLAR COMPONENT: TWO POPULATIONS

Populations synthesis models (Maraston 2005)



DUST ATTENUATION: DIFFERENT AMOUNTS FOR THE YOUNG AND OLD STELLAR POPULATION (BUT THE SAME ATTENUATION CURVE)

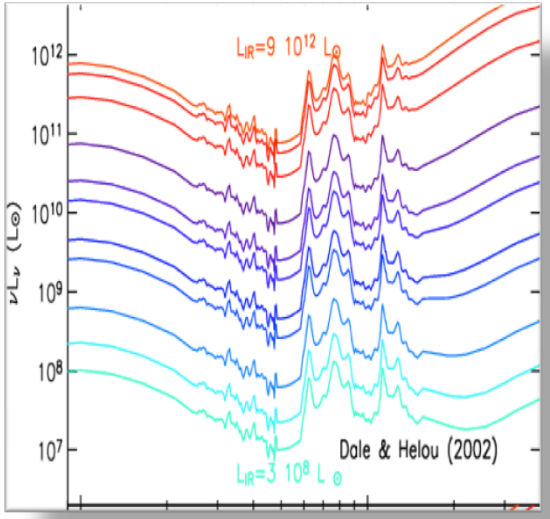
[Calzetti et al. (2000) + UV bump] × power law

$$k(\lambda) = A(\lambda) / E(B\text{-}V) \frac{E_{bump}\,\lambda^2\,\gamma^2}{(\lambda^2 - \lambda_0^2)^2 + \lambda^2\,\gamma^2} (\lambda / \lambda_V)^{\delta}$$

IR libraries

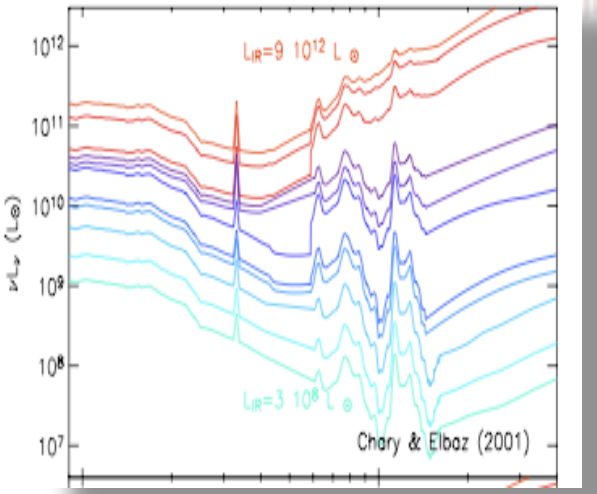
Dale & Helou (2002)

64 templates

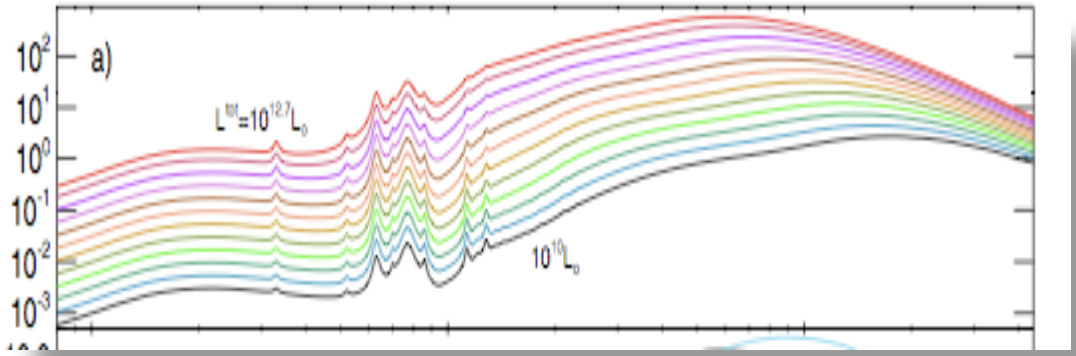


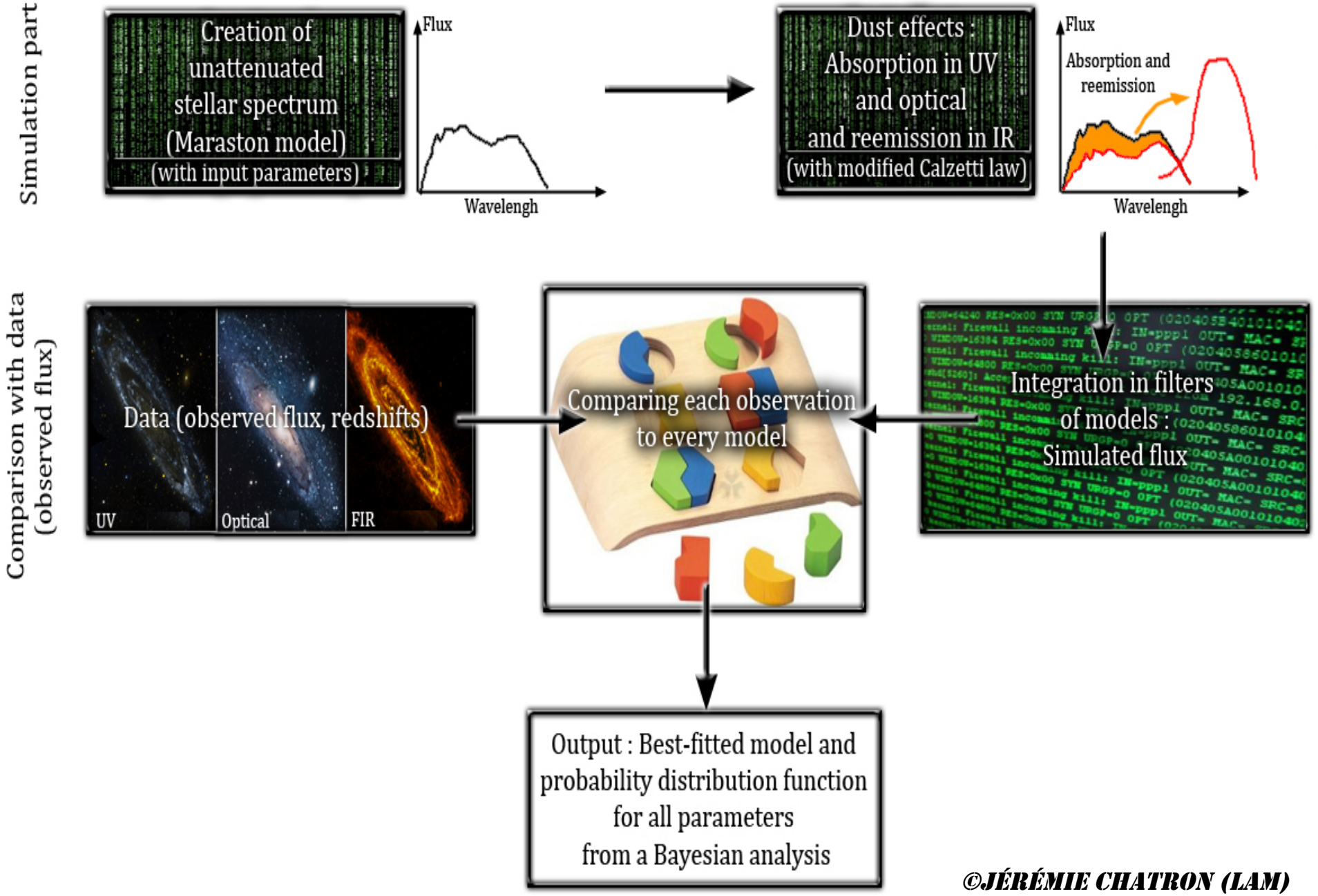
Chary & Elbaz (2001)

105 templates



Siebenmorgen & Krügel (2007: *~7000 SEDs*



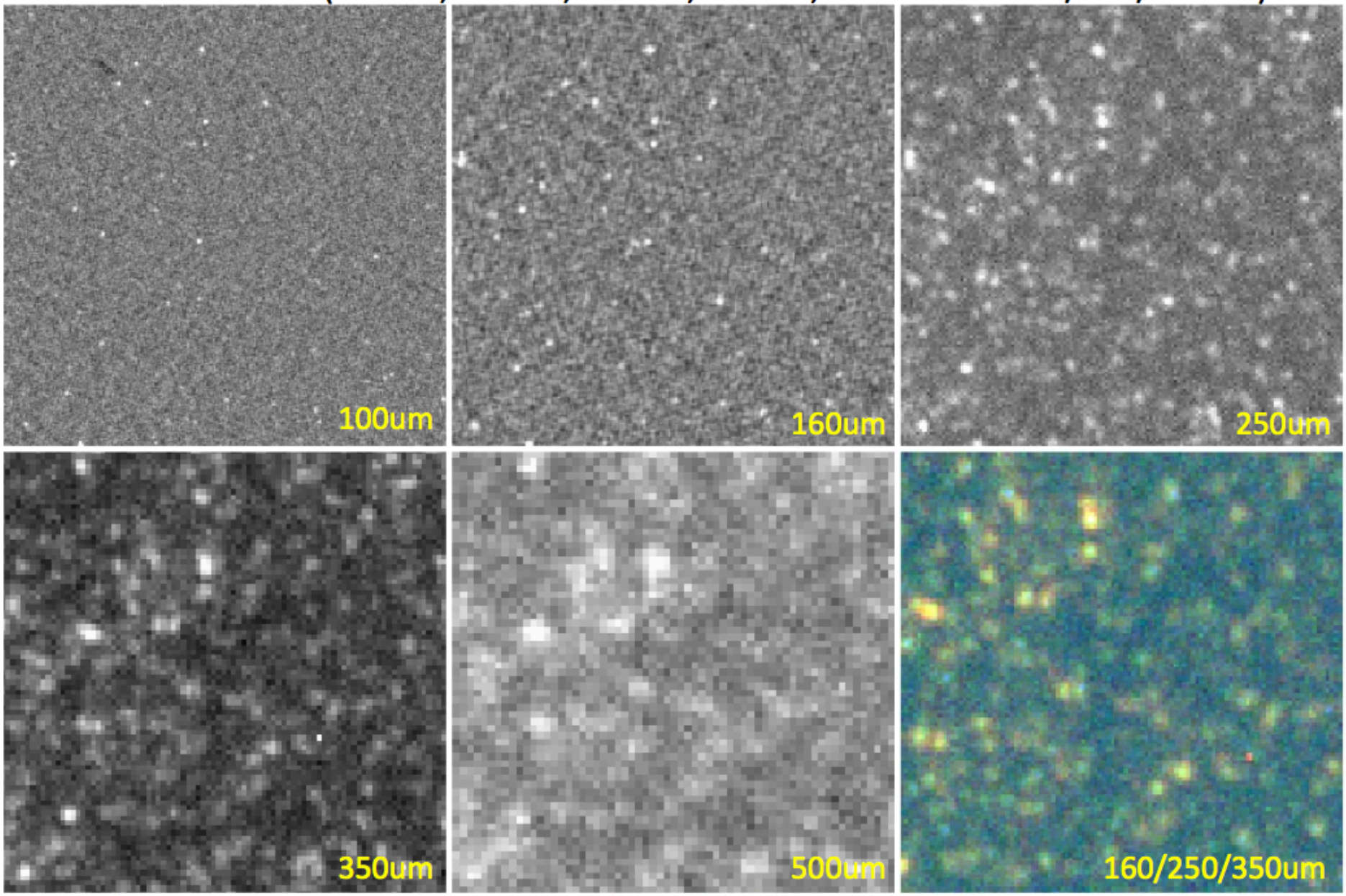

Simulation part
Creation of unattenuated stellar spectrum (Maraston model)
(with input parameters)
Flux
Wavelengh
Dust effects : Absorption in UV and optical and reemission in IR
(with modified Calzetti law)
Flux
Absorption and reemission
Wavelengh
Comparison with data (observed flux)
Data (observed flux, redshifts)
UV
Optical
FIR
Comparing each observation to every model
Integration in filters of models : Simulated flux
Output : Best-fitted model and probability distribution function for all parameters from a Bayesian analysis
©JÉRÉMIE CHATRON (LAM)



2. A few applications of *CIGALE*

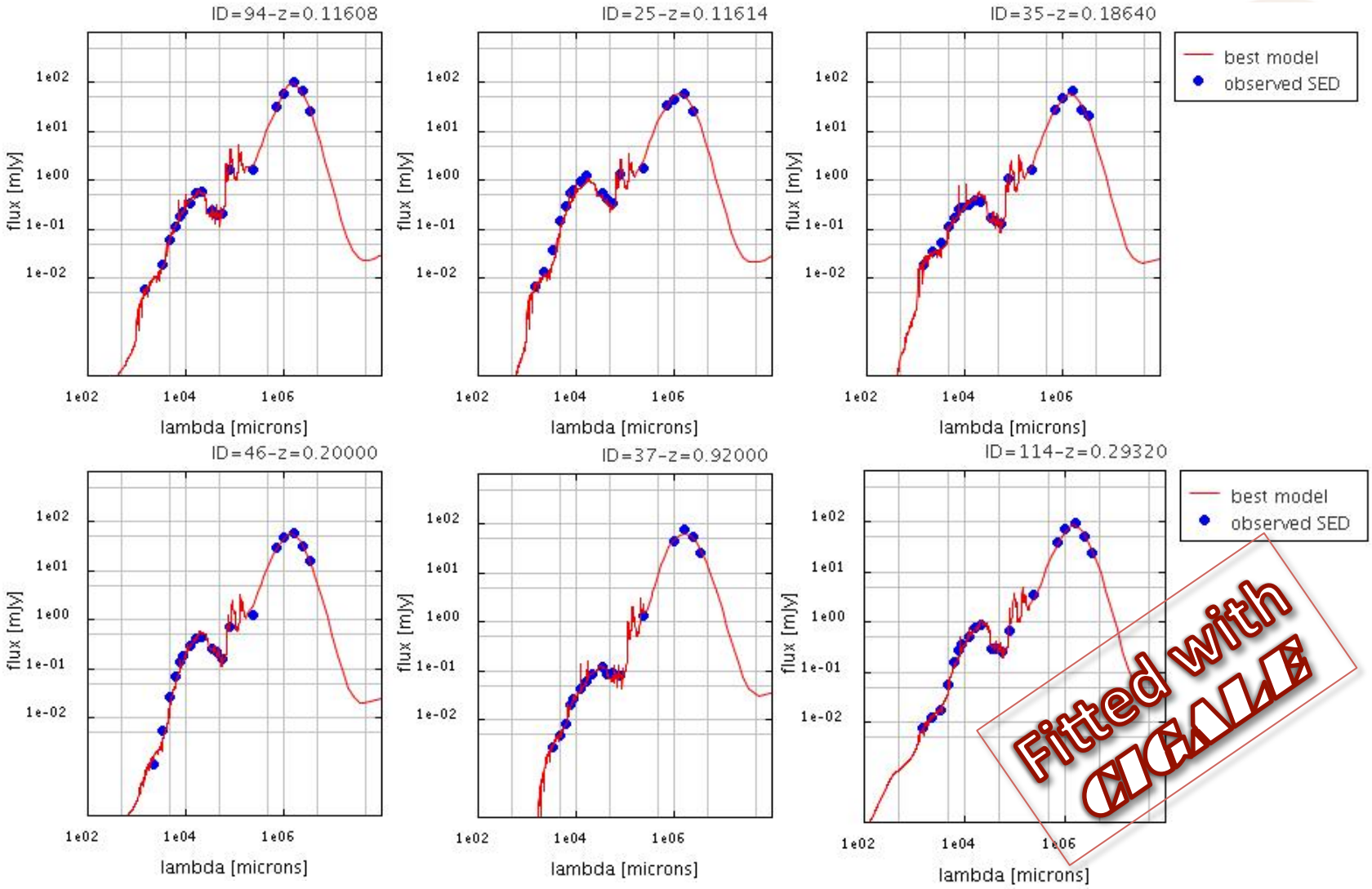
Tests in Lockman North

Lockman North (100um, 160um, 250um, 350um, 500um and 160/250/350um)

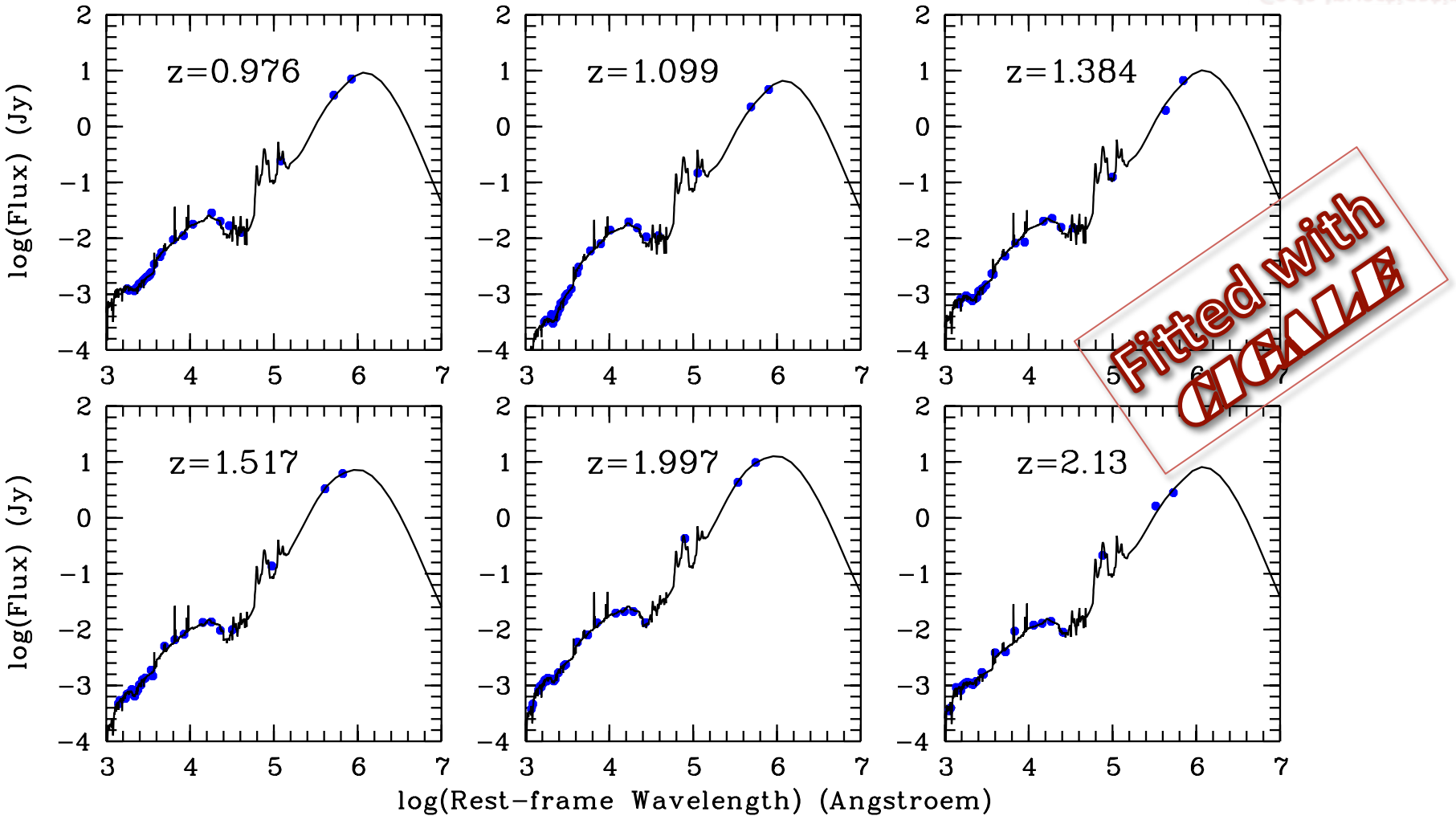


A few fits

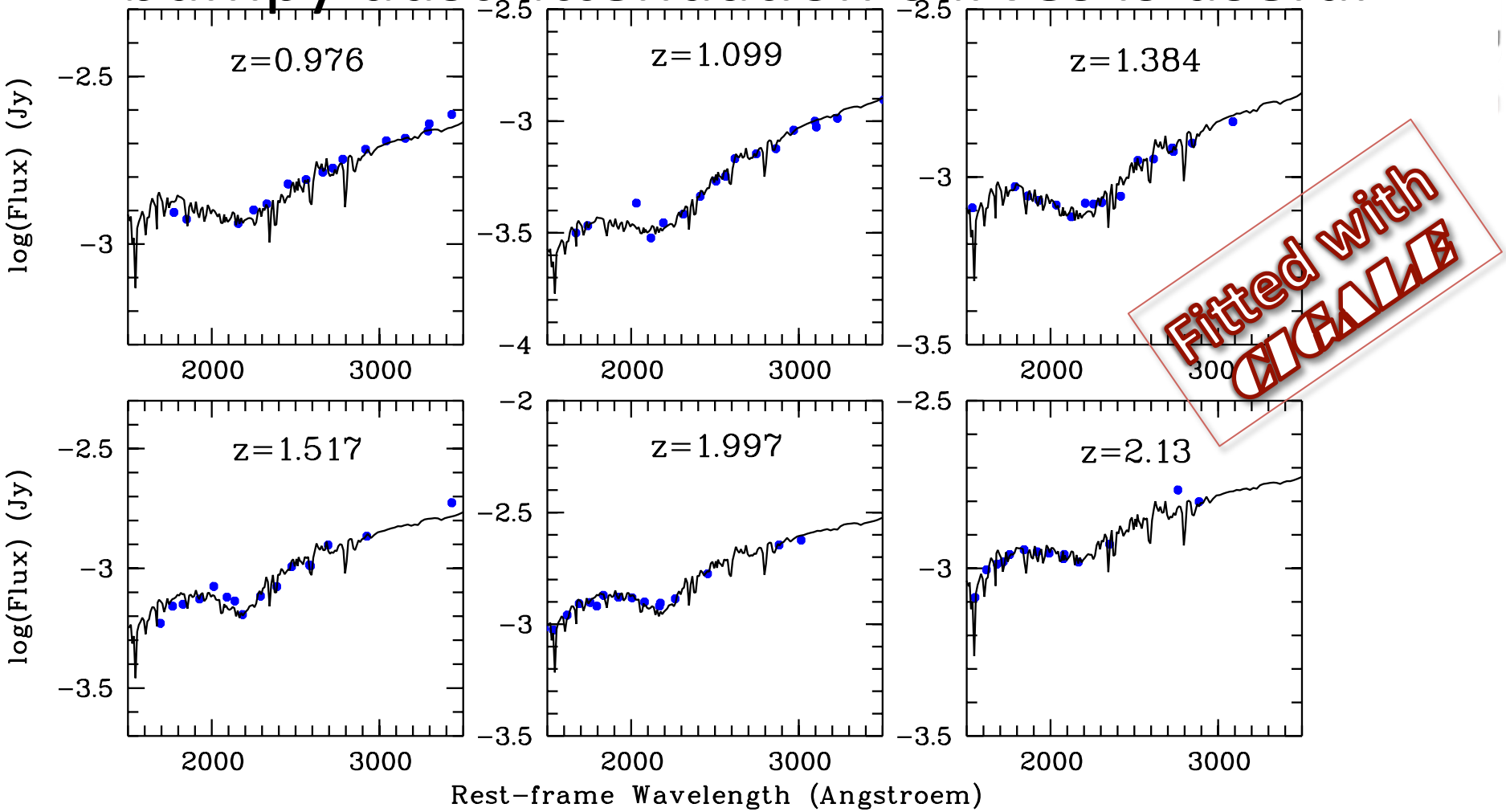
(OK … they are pretty good)



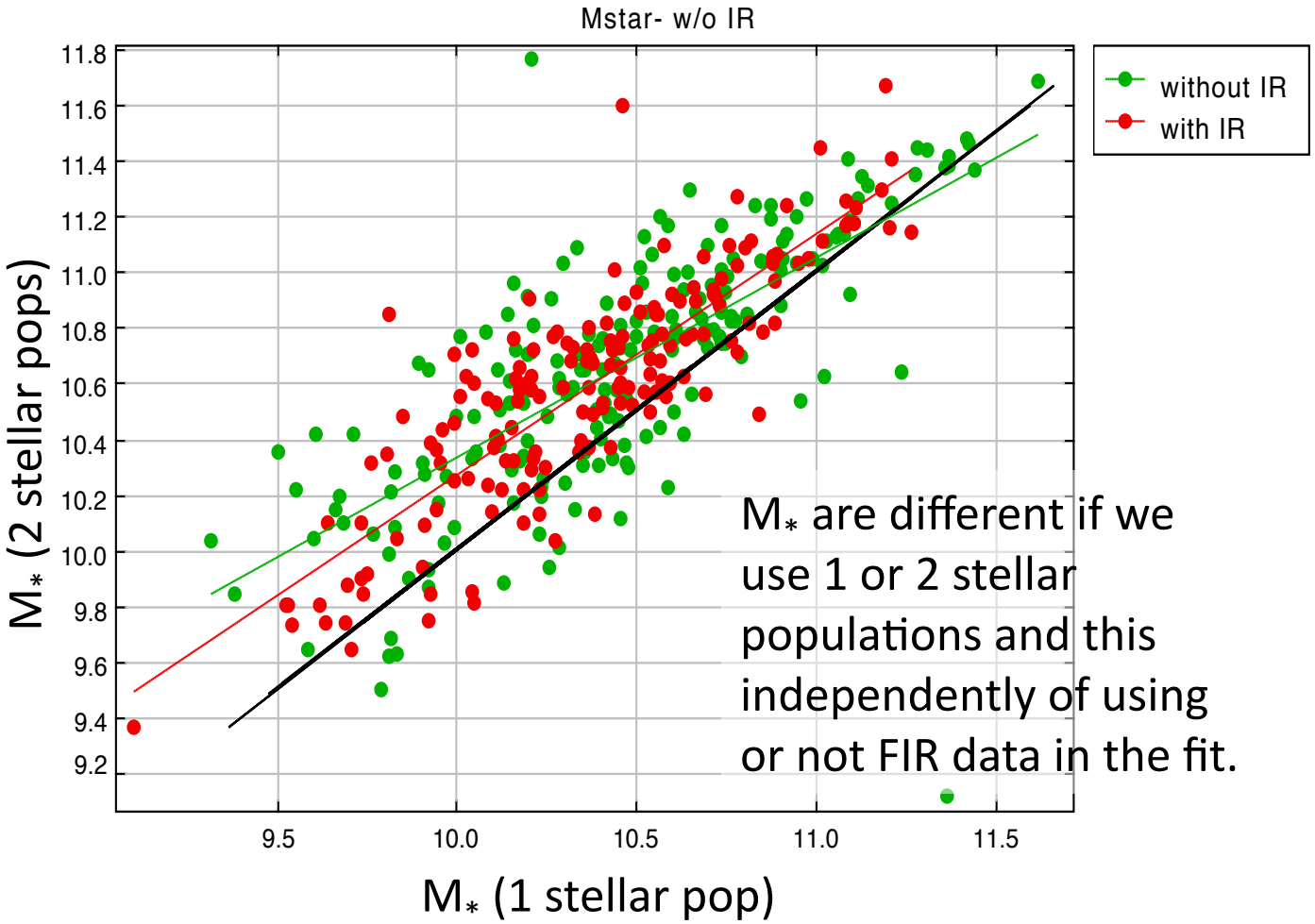
Fitting bumpy SEDs (Buat et al. 2011, GOOD-Herschel Project, P.I.: David Elbaz



Zooming in: that's why the possibility of using bumpy dust attenuation curves is useful

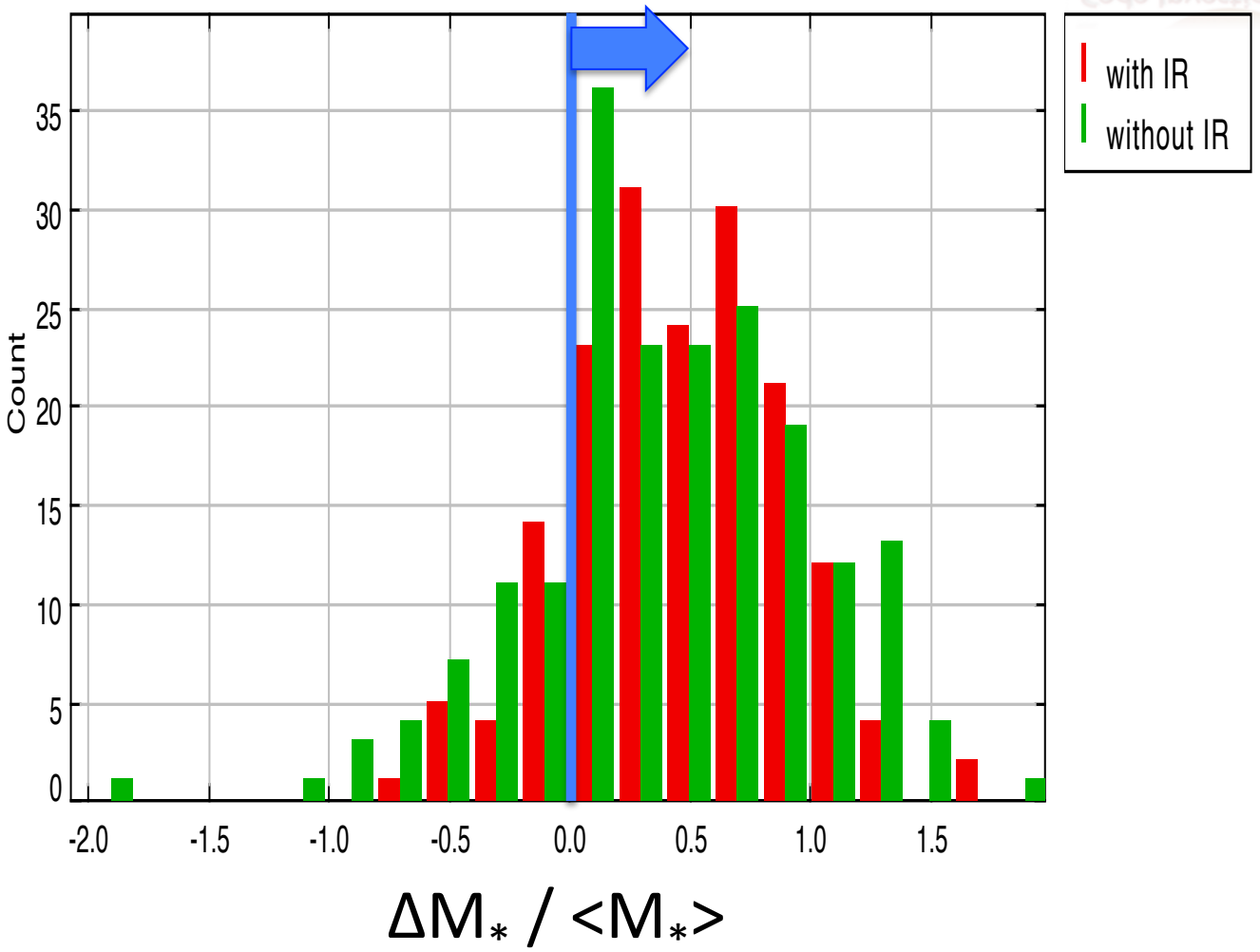


Tests using 1 and 2 stellar populations and a SED fitting w/ and w/o FIR by V. Buat



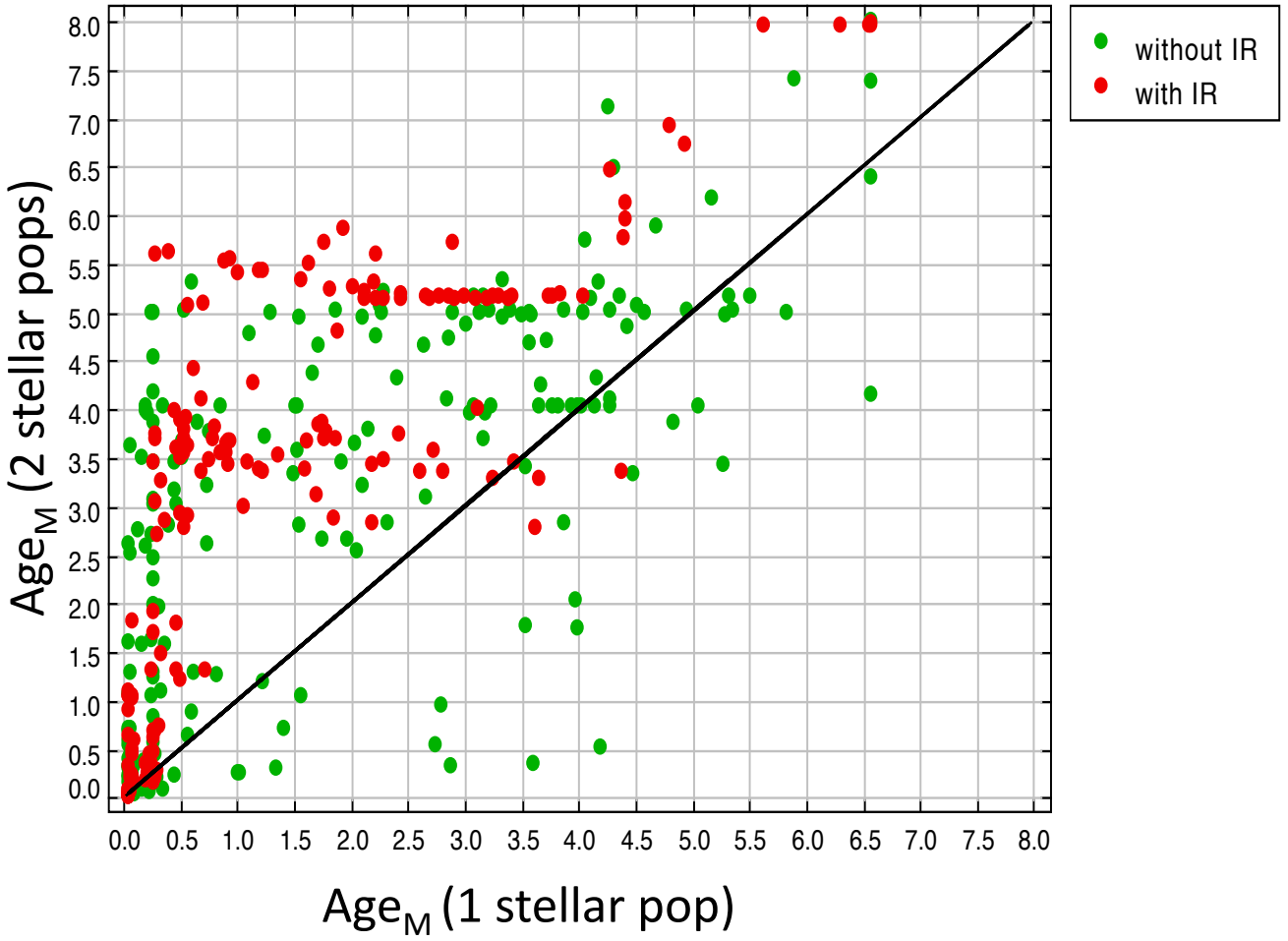
M_* are different if we use 1 or 2 stellar populations and this independently of using or not FIR data in the fit.

M_* shifted to higher values by 40% when fitting with 2 stellar populations as compared to 1 stellar population

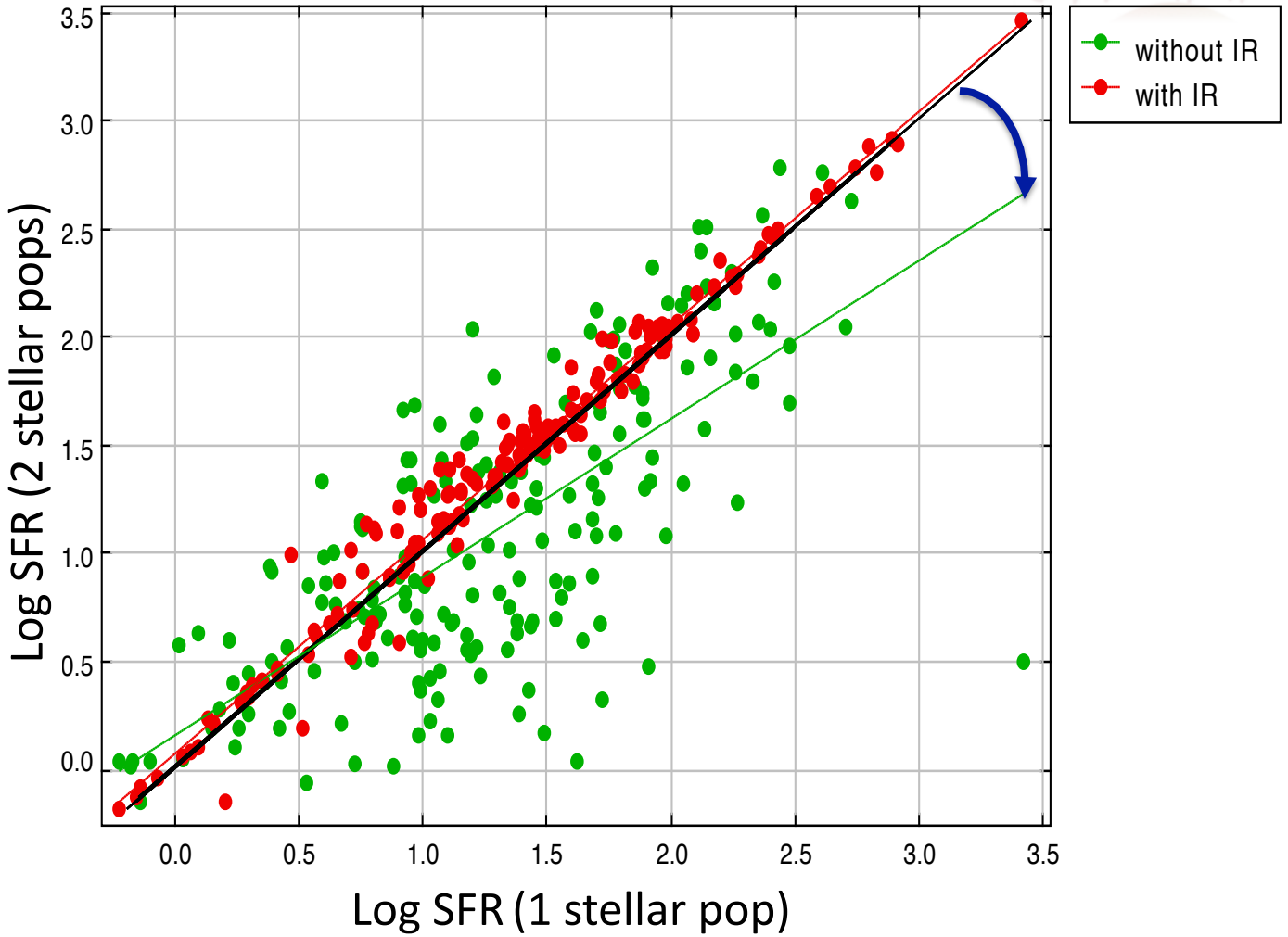


Why do we find larger M_* with 2 stellar populations ?

Ages are larger with 2 stellar populations which explains why M_* are different if we use 1 or 2 stellar populations (w/ or w/o FIR)



SFR underestimated when fitting without FIR data: we might be cautious on estimating stellar parameters in a first fit from optical data and L_{IR} in a second fit with FIR data.





- We need to use a global approach for the SED fitting from FUV to FIR
- Fitting without FIR (decoupling) is risky
- Stellar masses (and stellar pops. ages) are different when one or two stellar populations are assumed.

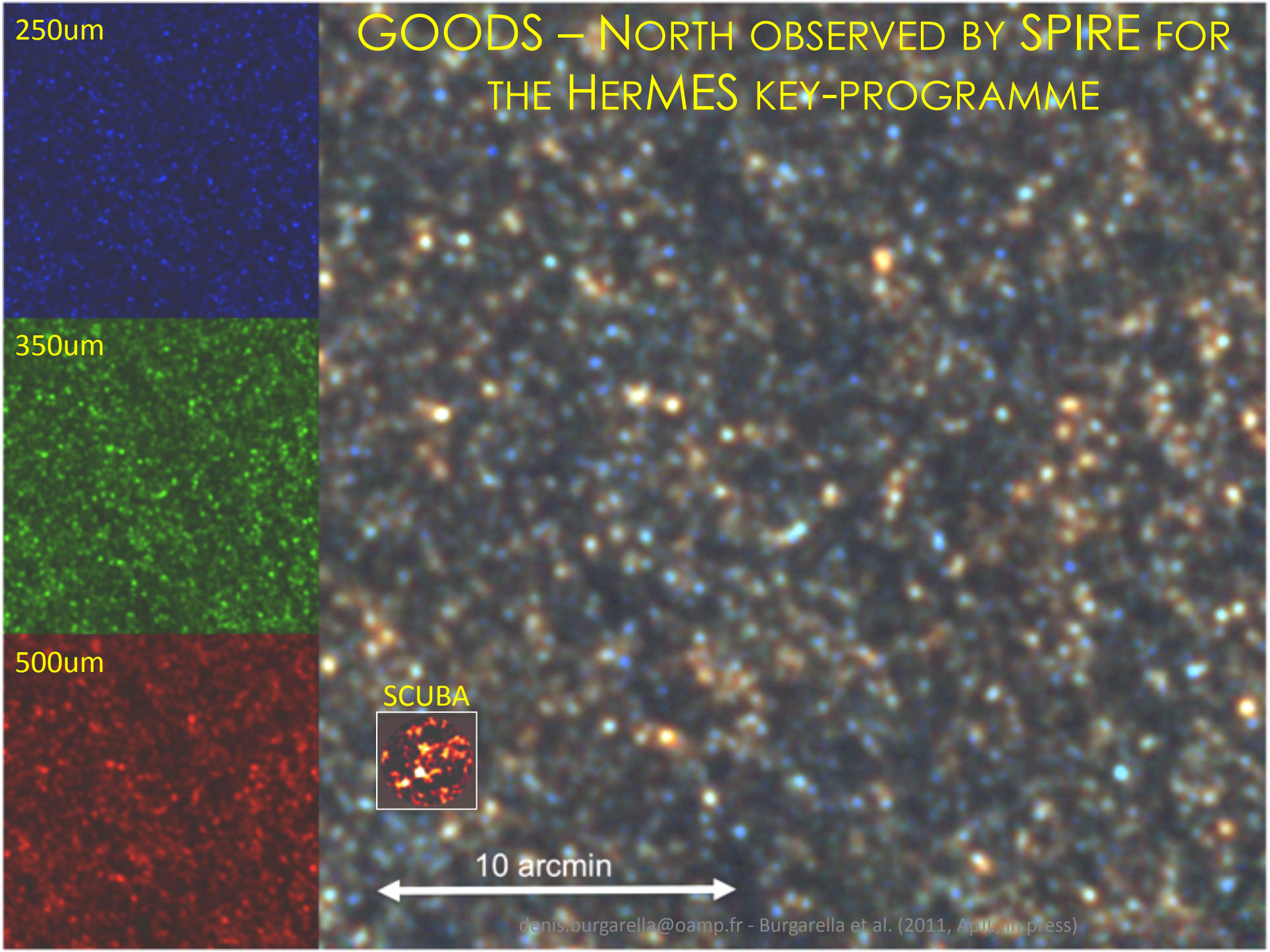
A few examples …



- The dust attenuation of UV-faint (Lyman break) galaxies at all redshifts
- SED fitting of sub-mm lensed galaxies



- The dust attenuation of UV-faint (Lyman break) galaxies


250um
350um
500um
GOODS – NORTH OBSERVED BY SPIRE FOR THE HERMES KEY-PROGRAMME
SCUBA
10 arcmin
denis.burgarella@oamp.fr - Burgarella et al. (2011, A&A, in press)

IR-bright LBGs at 0.5 < z < 2.0 from GALEX

- UV-bright:

log ⟨LFUV⟩ = 10.7 ± 0.7 $L_\odot$

- almost ULIRGs:

log ⟨Ldust⟩= 11.9 ± 0.3 $L_\odot$

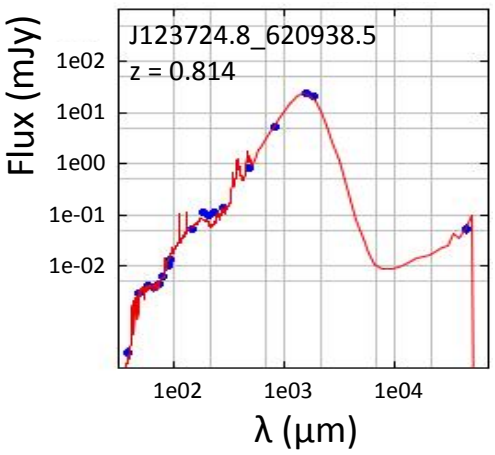
- massive (Magdis et al. 2010: log⟨M_*⟩ = 11 for z~3 LBGs detected at 8μm):

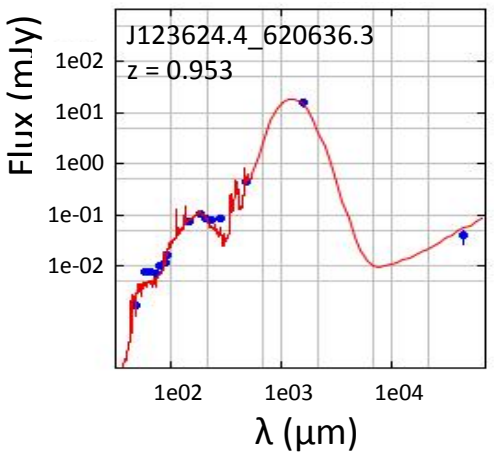
log ⟨M_*⟩ = 11.0 ± 0.5 M

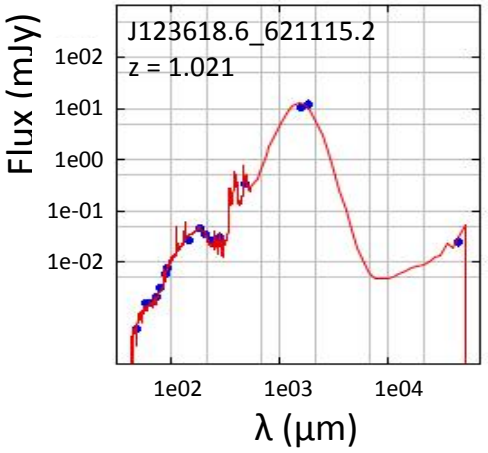
- Highly attenuatted:

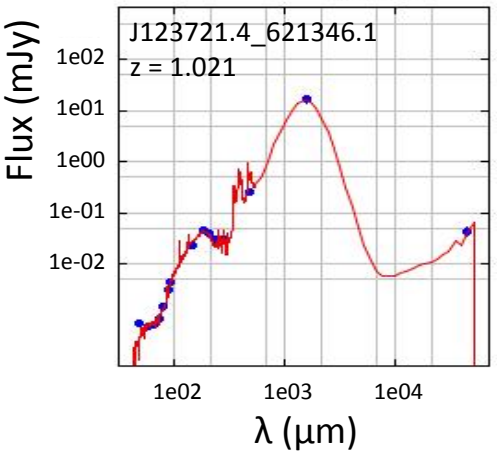
A_{FUV}=3.252

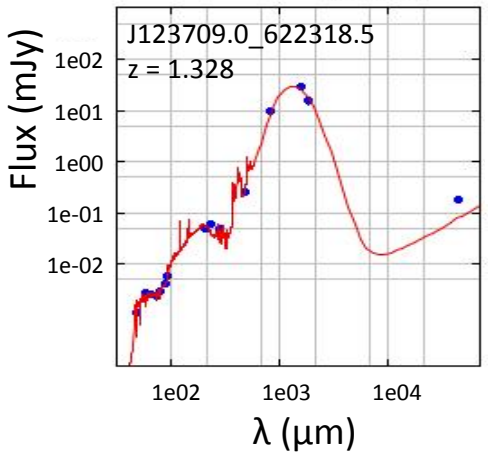
- consistent with no AGN

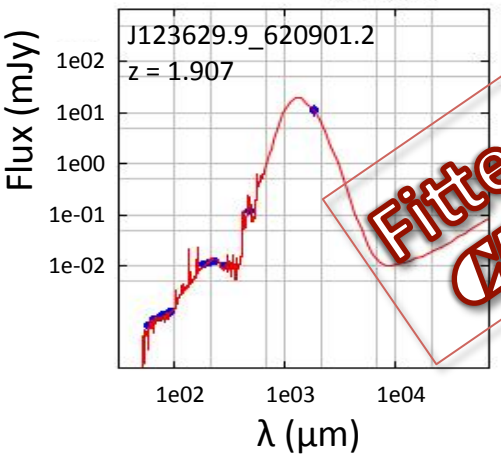




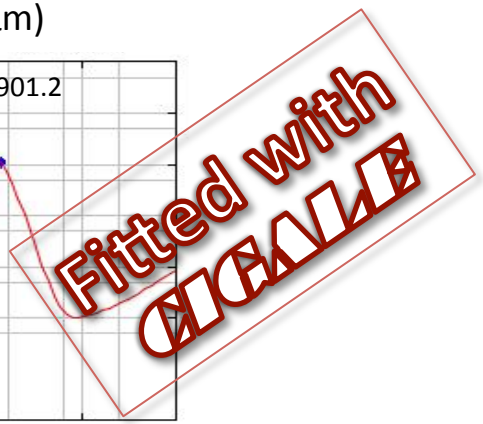












Reddy et al. 2010
(BM/BX galaxies @ z ~2 from 24um)

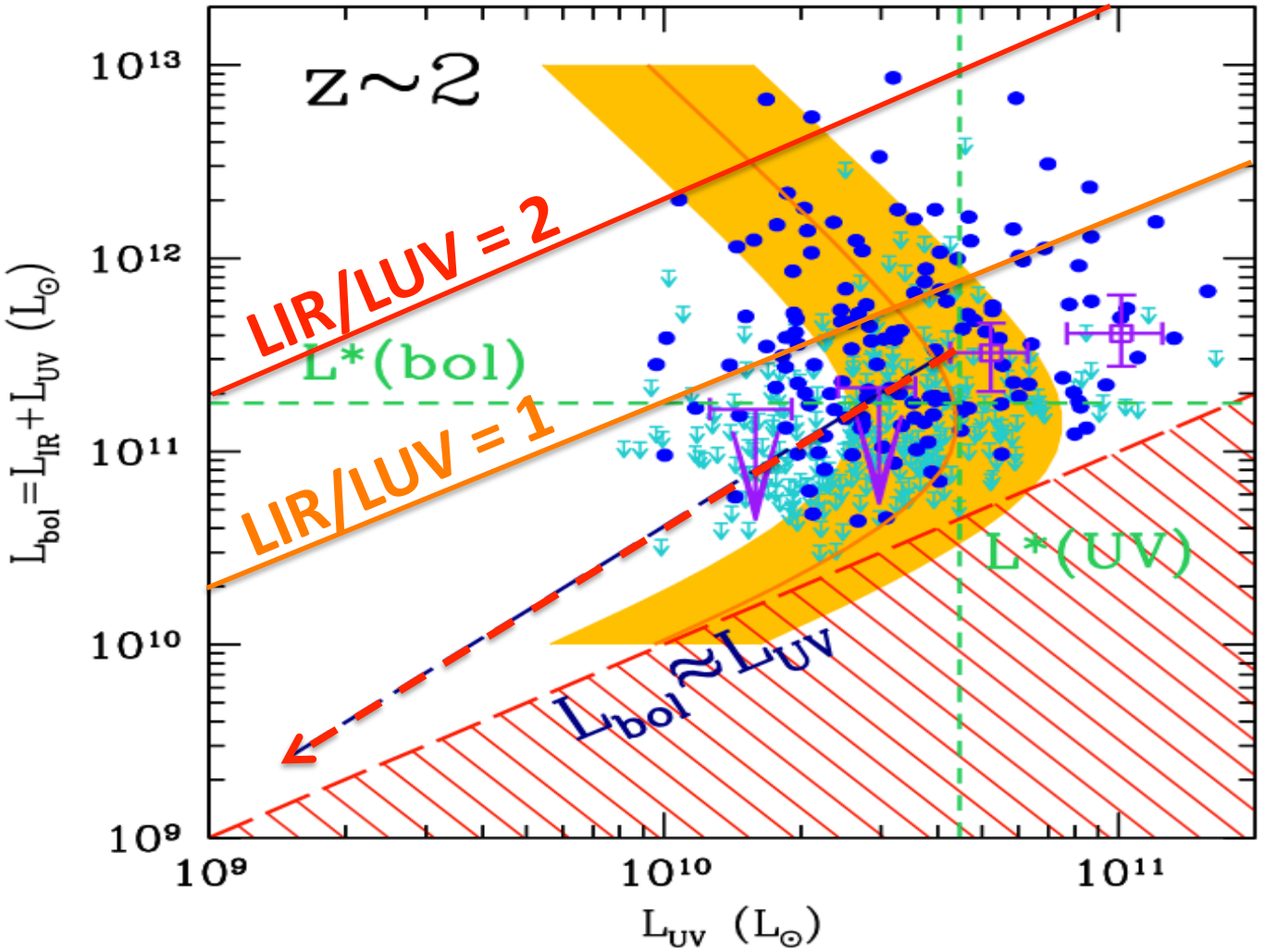
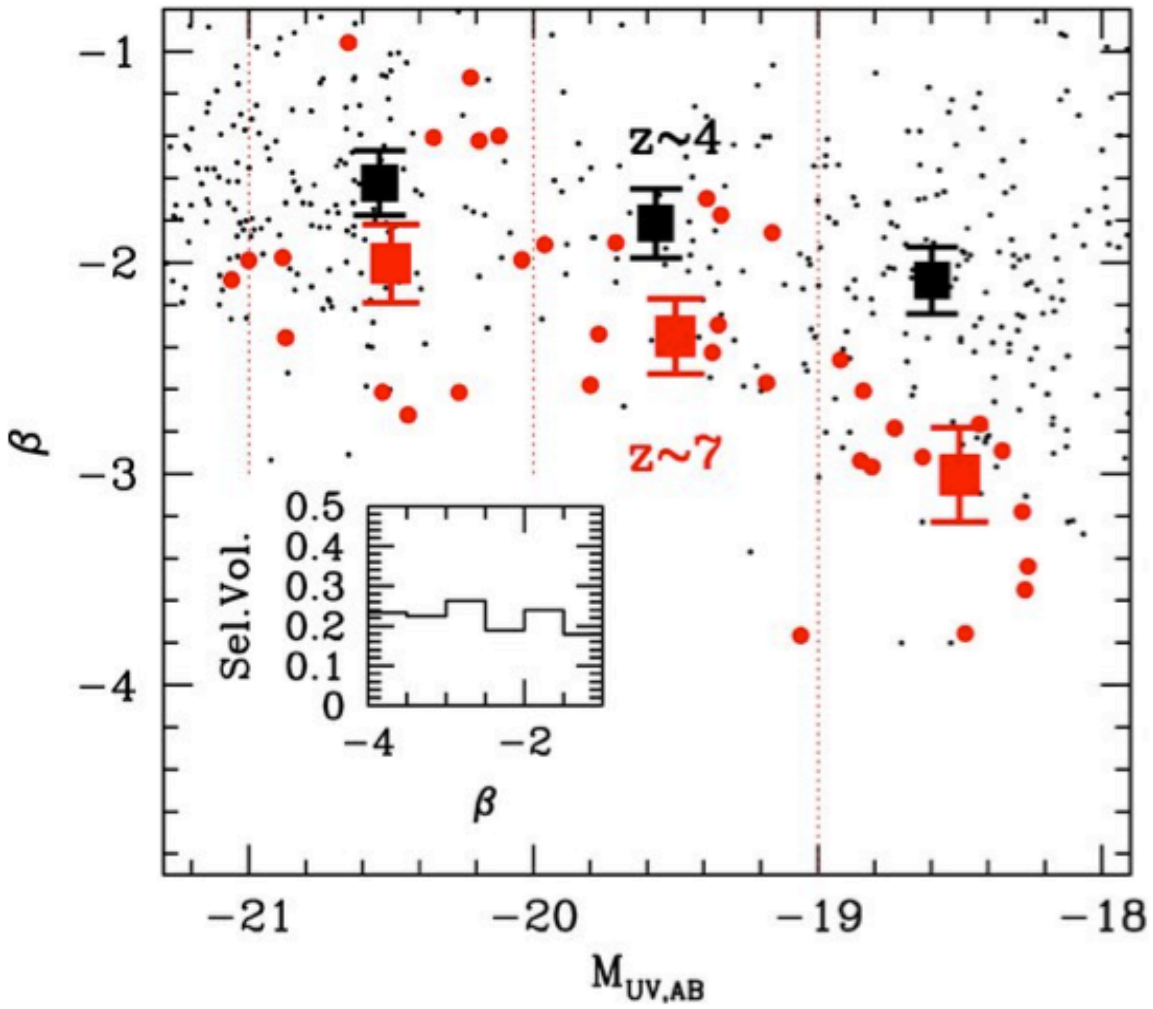


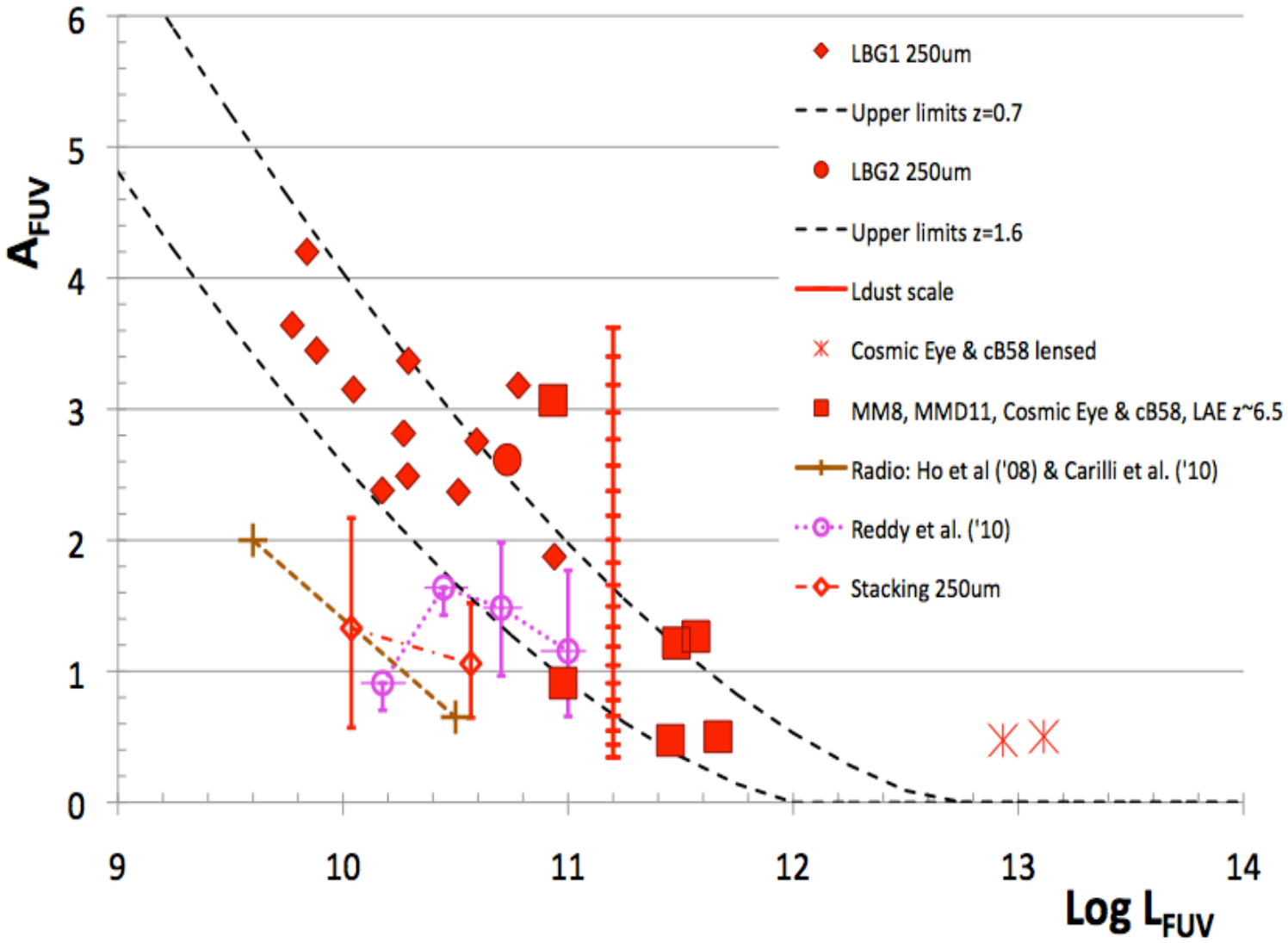
FIG. 13.— Bolometric luminosity (L_{bol}) versus observed UV luminosity (L_{UV}). Small points and arrows indicate galaxies detected and undetected, respectively, at 24 μm. The 24 μm stacked results are shown by the open squares and large arrows (*purple*). The shaded region denotes ± 1 σ about the mean relation implied by the correlation between L_{bol} and dust attenuation (Eq. 4). The hashed region indicates the area excluded by the fact that L_{bol} must be greater than L_{UV}. The dashed horizontal and vertical lines delineate the values of L^*_{UV} and L^*_{bol} at $z \sim 2$ (Reddy & Steidel 2009; Reddy et al. 2008), and the thicked dashed line shows the extrapolation of the relation to UV-faint galaxies (see text).

Bouwens et al. 2010
@ z ~ 4 and z ~ 7



Burgarella et al. (2011, ApJL) from Herschel FIR data (HerMES)

LBGs @ z > 2.8: Siana et al. (2008, 2009), Chapman et al. (2000), Chapman & Casey (2010), Tanvir et al. (2009), Boone et al. (2007), Webb et al. (2007)

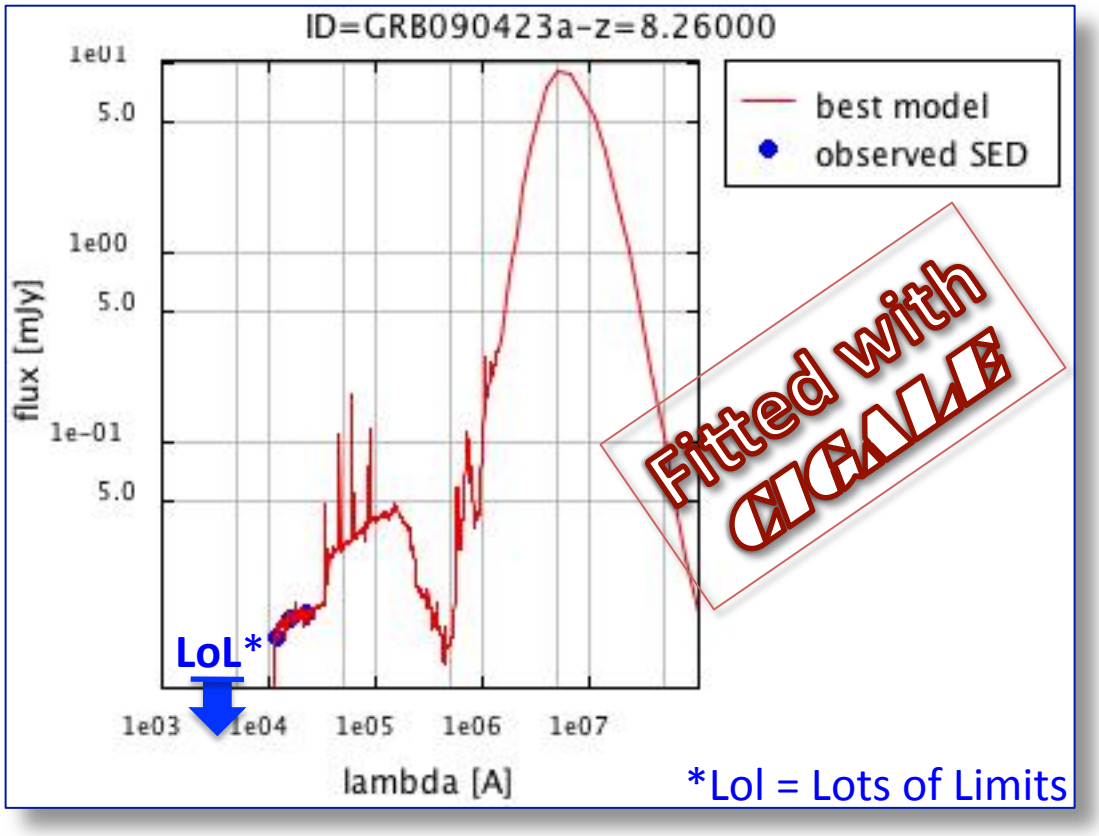


GRB090423 @ z=8.26 (Tanvir et al. 2009)

Log M_* = 11.0 ± 0.4
Log L_{dust} = 11.5 ± 3.5
Age ~ 50 Myrs

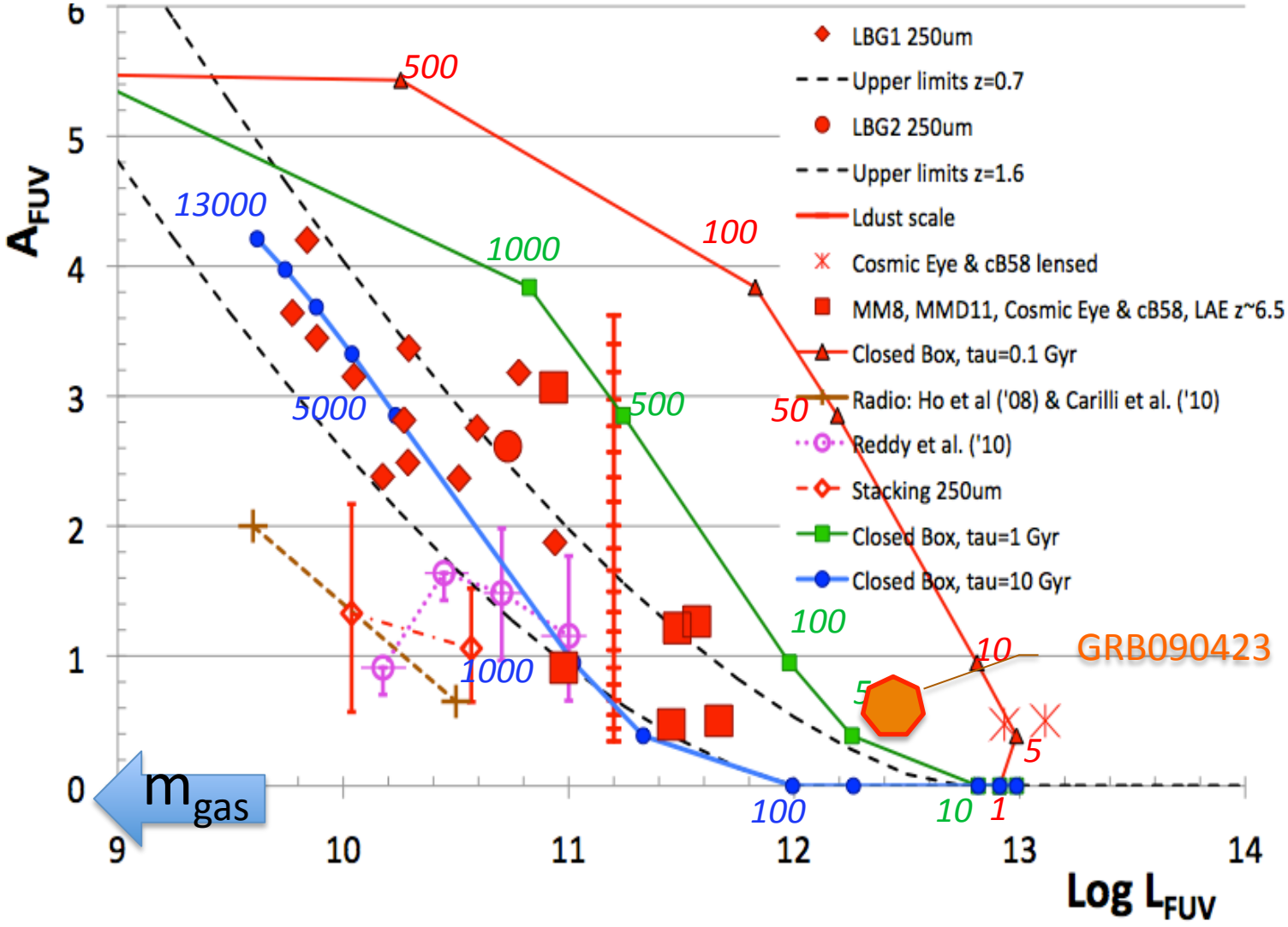
A_{FUV} = 0.58 ± 0.43
A_V = 0.19 ± 0.14
β_{FUV} = -1.98 ± 0.15

Dust Attenuation is very low !

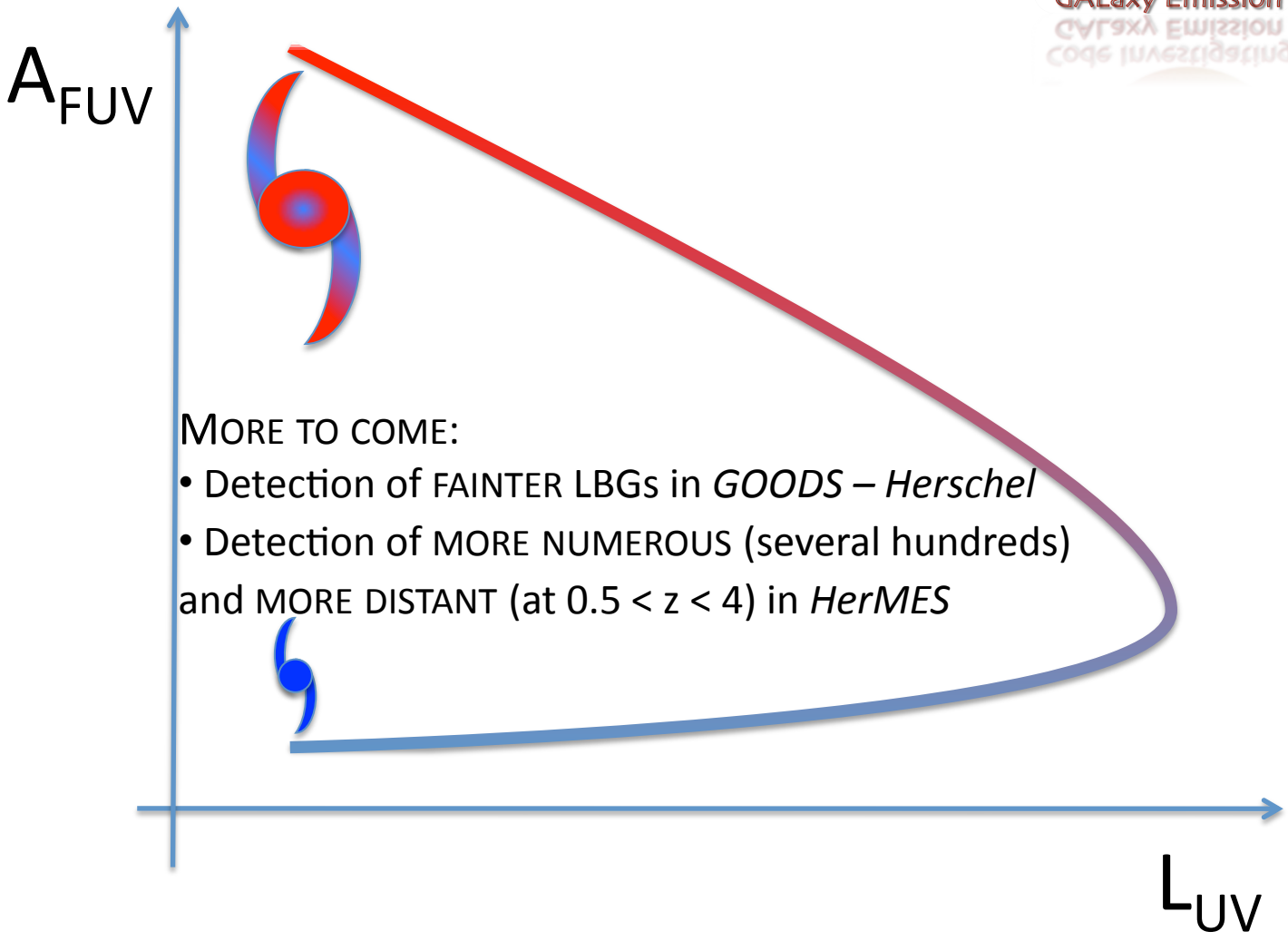


The initial mass of gas is set to
log $(M_{gas}/M_{\odot}) = 10.5$ to explain the z~1 LBGs
and $\log(M_{gas}/M_{\odot}) = 11.0$ (not plotted) for the z~2 LBGs.

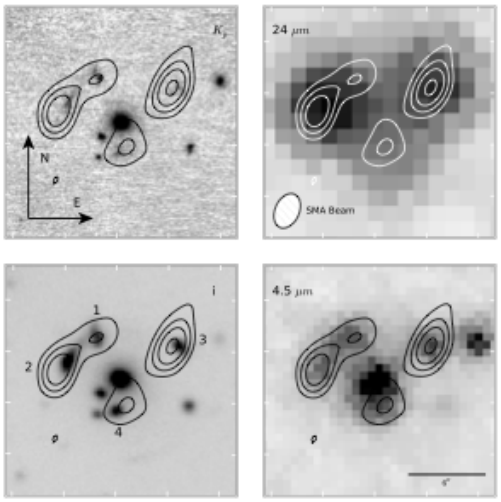
LBGs @ z > 2.8: Siana et al. (2008, 2009), Chapman et al. (2000), Chapman & Casey (2010), Tanvir et al. (2009), Boone et al. (2007), Webb et al. (2007)

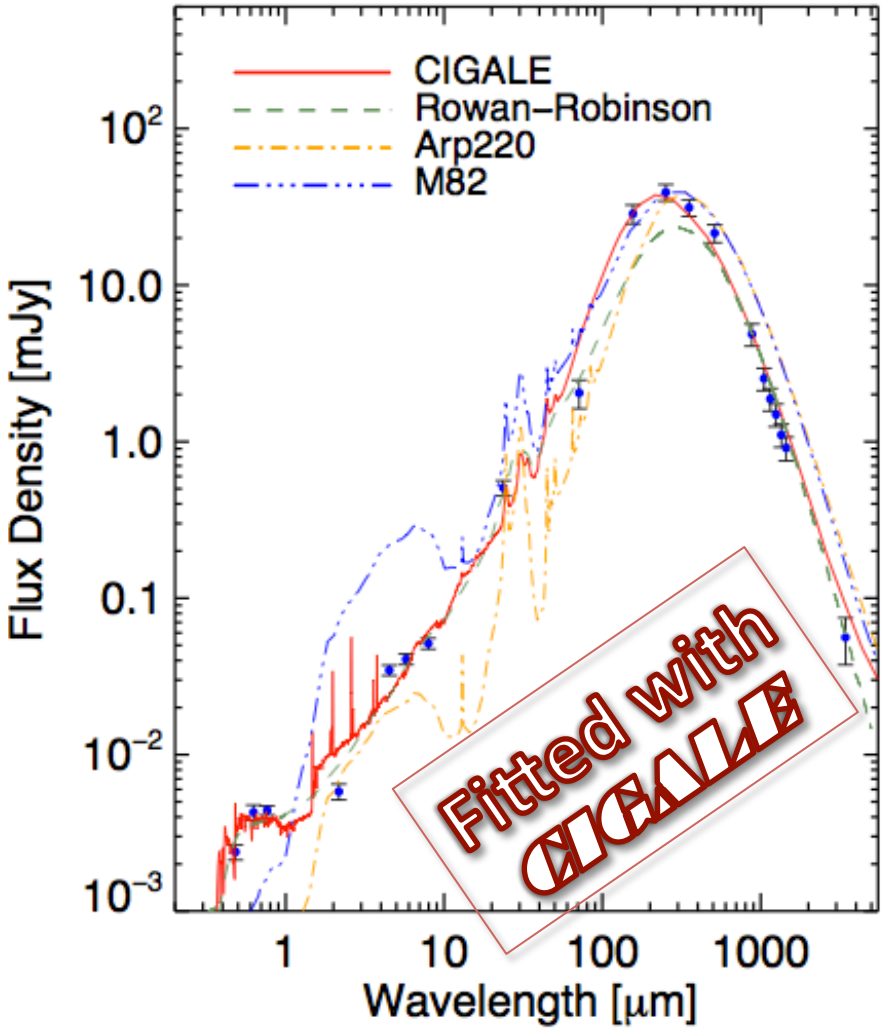


Two limiting regimes for UV-faint LBGs from FIR measurements



multiply-lensed submillimeter galaxy HERMES at z = 2.9575 J105751.1+573027 (Conley et al. 2011)



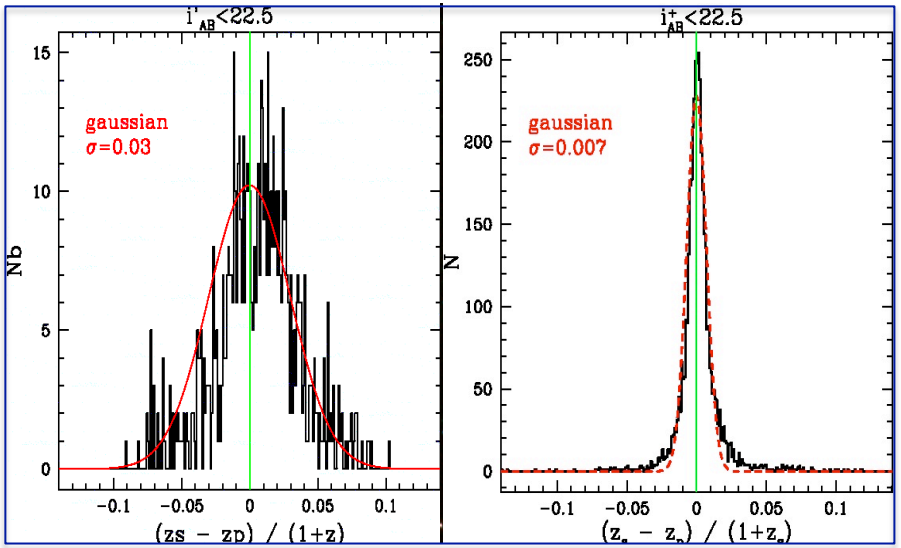


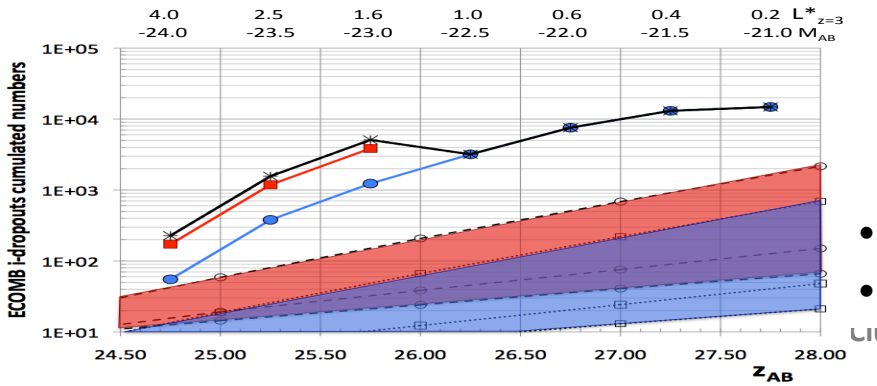


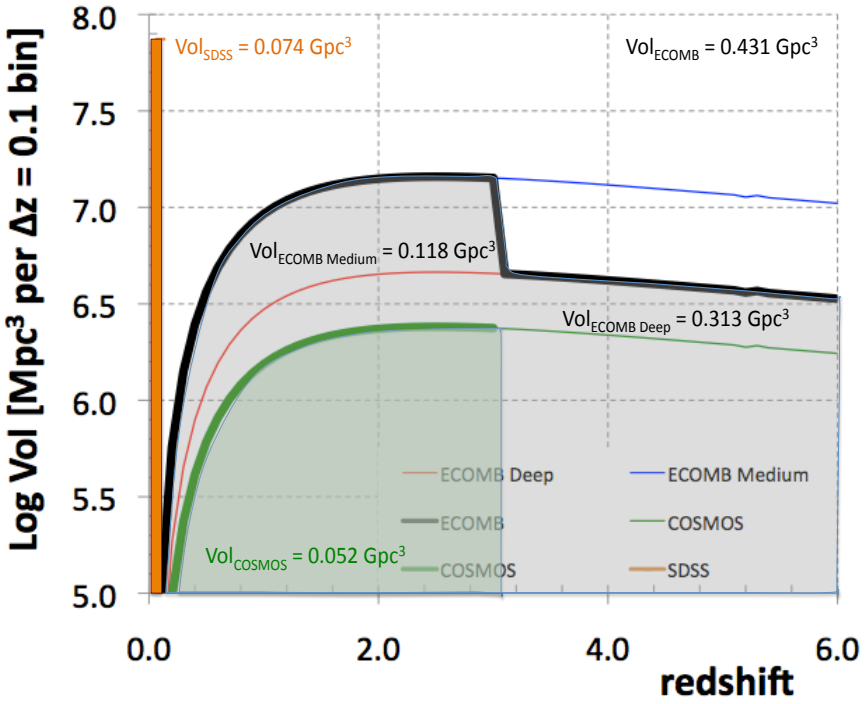
3. What's next in terms of wide-field observing facilities?

CFHT - `IMAKA (~2017): 0.3'' angular resolution over 0.7 deg^2 (GLAO) at z_{AB} = 27 - 28

ECOMB	Filters	Surface (deg2)	Exposure time (hours, 5σ)	Exposure time (hours, 5σ)	Exposure time (hours, 5σ)
Deep	grizY	2.4 × 1.6 = 3.84	375	2492	3115
Deep	12 medium bands	2.4 × 1.6 = 3.84	2117		
Medium	grizY	25 × 0.8 × 0.8 = 16	94	623	
Medium	12 medium bands	26 × 0.8 × 0.8 = 16	529		







- several 1000 z ~ 6 LBGs
- several tens or hundreds z ~ 6 quasars



Mercigale

A few more information to wrap up



- Present version: http://www.oamp.fr/cigale/
  provides best fit and Bayesian results
- Markov Chain Monte Carlo Approach (CIGALEMC) Serra et al., arXiv: 1103.3269, subm. to ApJ) to come soon