Characterizing the Stellar Populations of IR-bright galaxies at interm-z

An auto-consistent analysis of the UV-to-FIR SED

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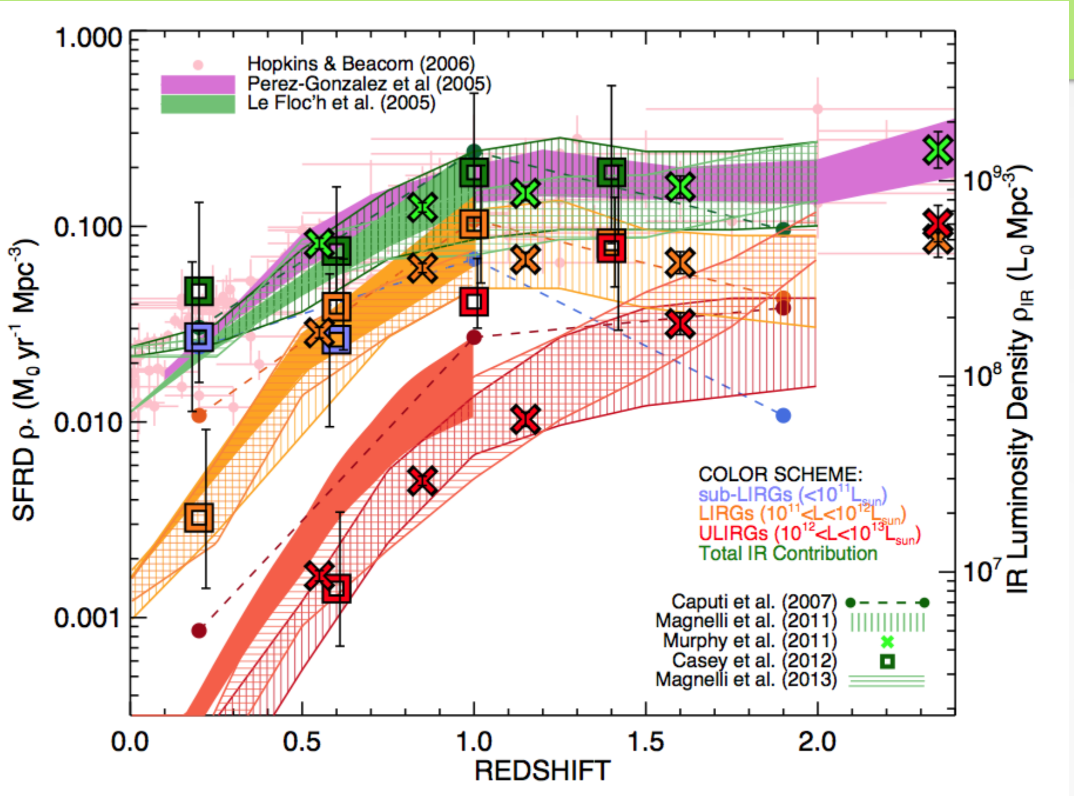
2nd SHARDS team meeting, May 2015

Introduction

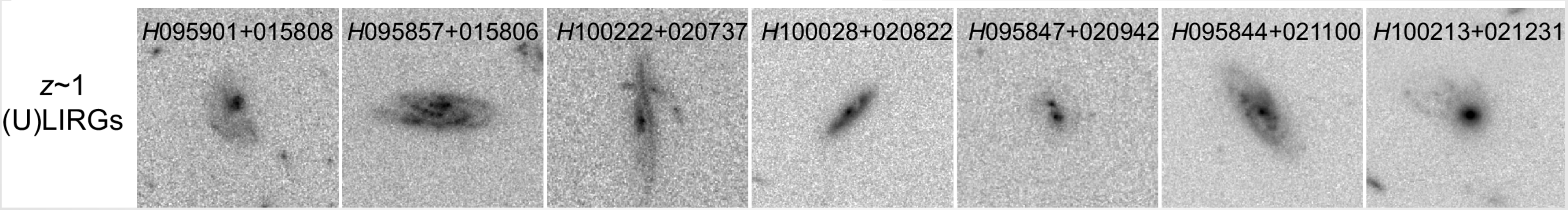


(U)LIRGS → L(8–1000 μm)

$L_{TIR} > 10^{11} L_{\odot}$ ($10^{12} L_{\odot}$)

SFRD @ z > 1

Casey et al. (2014)

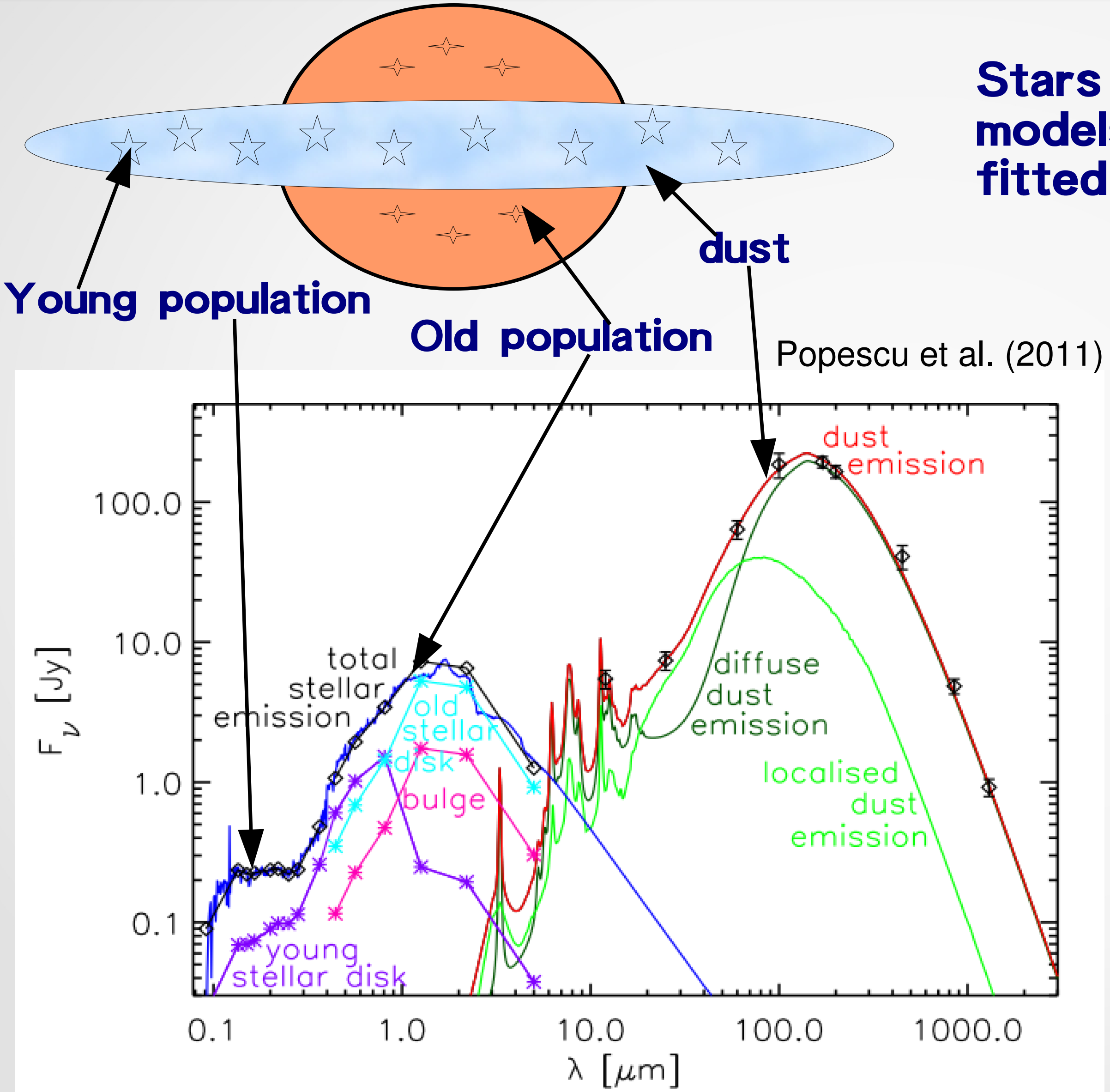


Chao-Ling et al. (2014)

GOALS:

- **Estimate accurate A(V) values in U(LIRGS)**
- **Improve determination of SFRs and $M_{\star}$s**

Introduction



Popescu et al. (2011)

Stars and dust models created and fitted separately

Auto-consistent analysis of UV-to-FIR SED

absorbed energy from the stars re-emitted by the dust

FIR prior:

L_{TIR} constrains A(V)

energy consevation

Two codes Auto-consistent modelling:

SYNTHESIZER Pérez-González et al. (2003,2008)

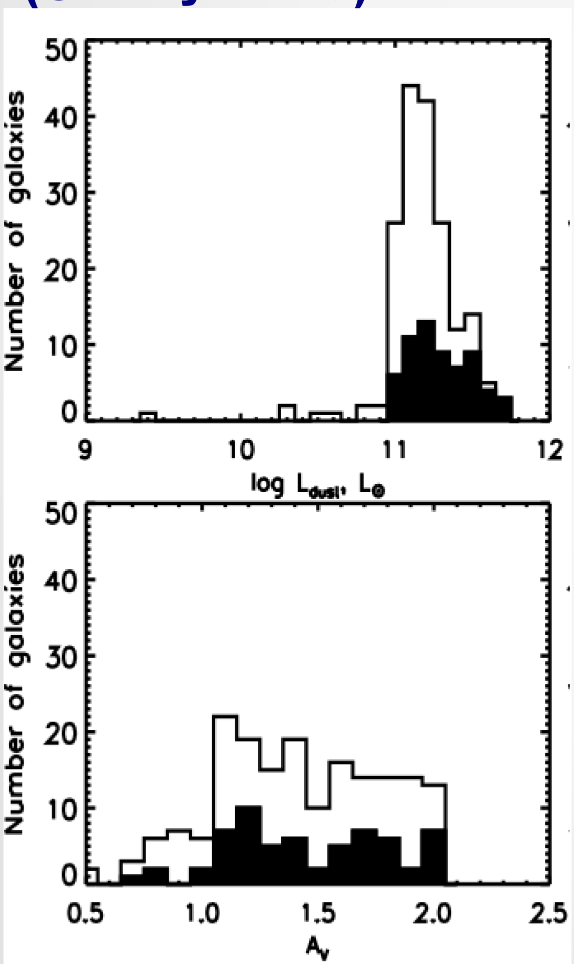
CIGALE Noll et al. (2009)

Introduction

Age-dust degeneracy

Young, dusty SP can have UV/Opt/NIR SED similar to a not so young, not so dusty SP

Broadband UV-NIR data don't constrain A(λ) → spectroscopy, FIR data (Conroy 2013)



Giovannoli et al. (2011)

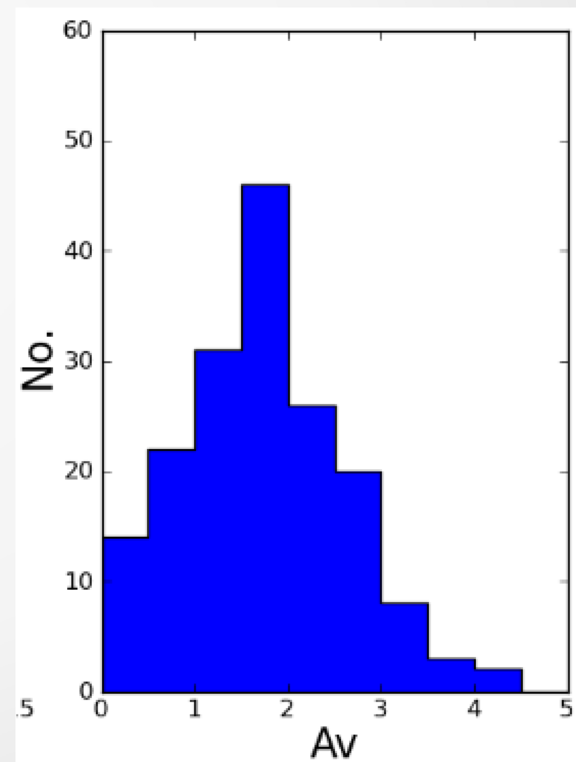
LIRGs a z~0.7 CDFS

FIR → 24, 70 μm

auto-consistent UV-to-FIR SED-fitting

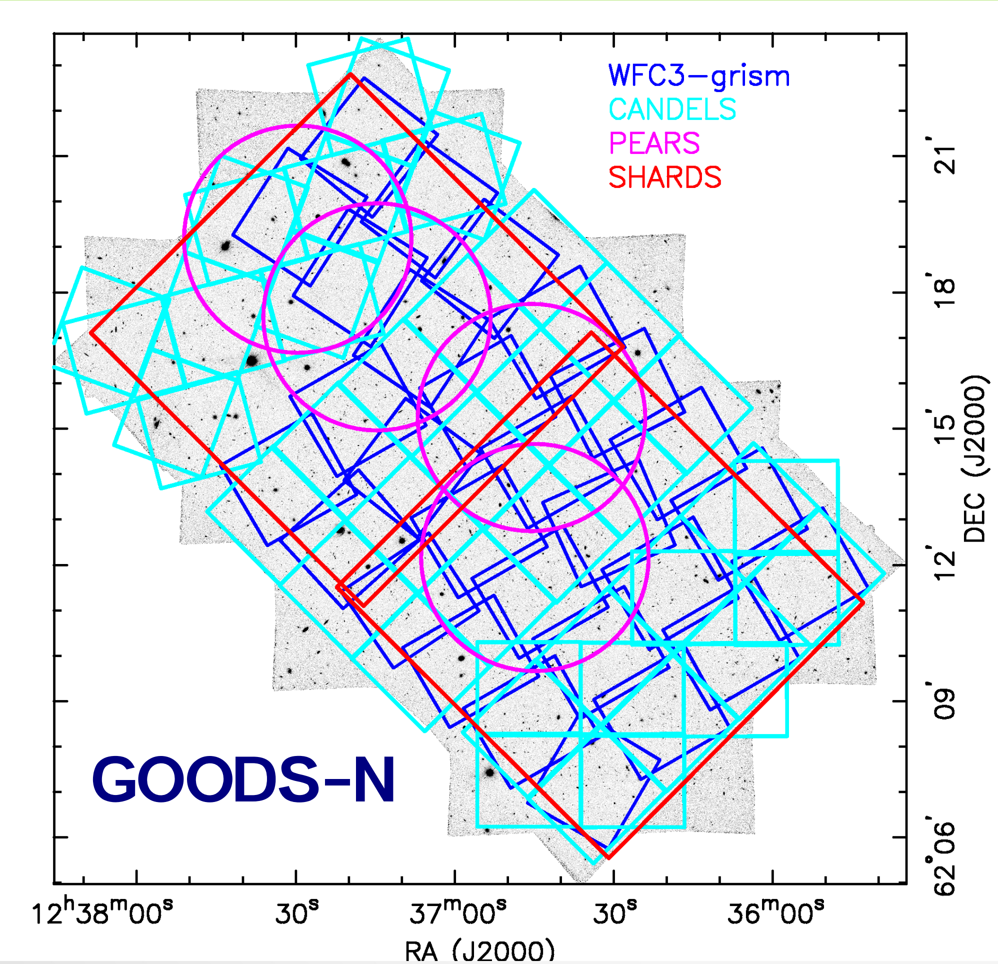
González-Delgado (2011)

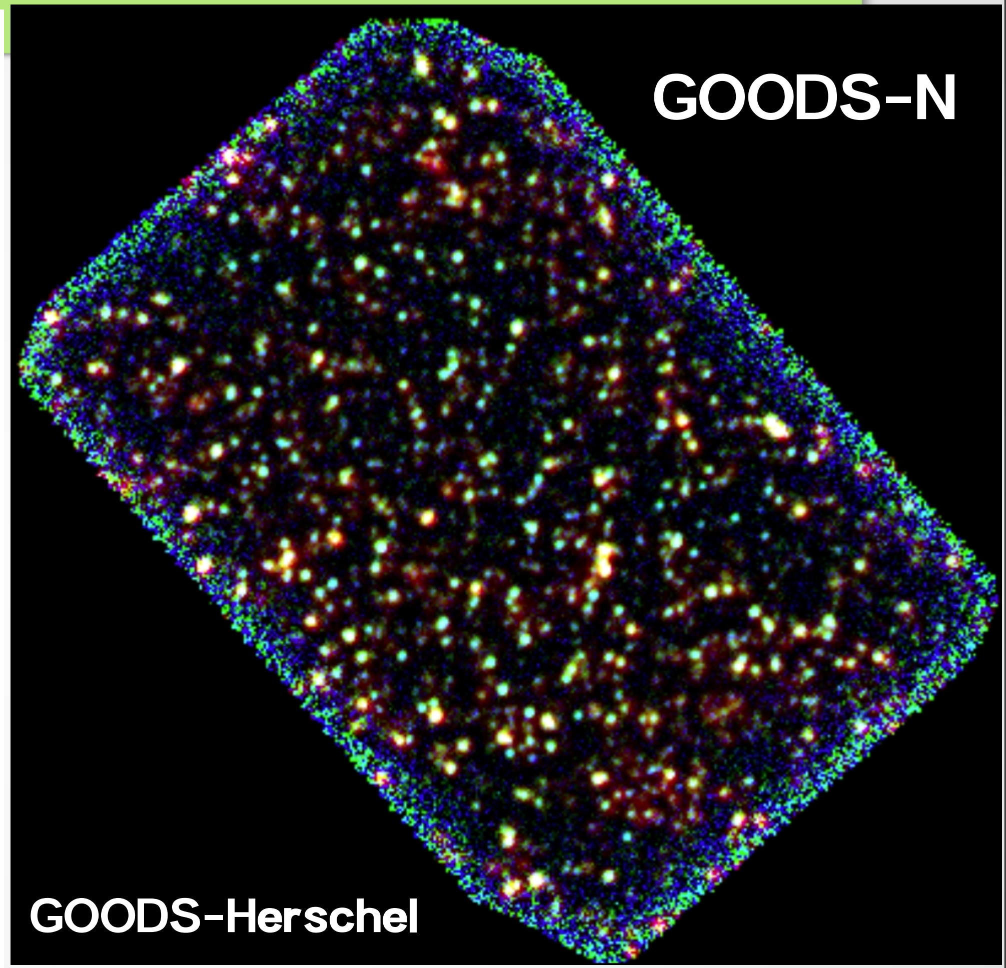
local LIRG sample spectroscopic data



Ingredients

Photometry





Pérez-González et al. (2013)

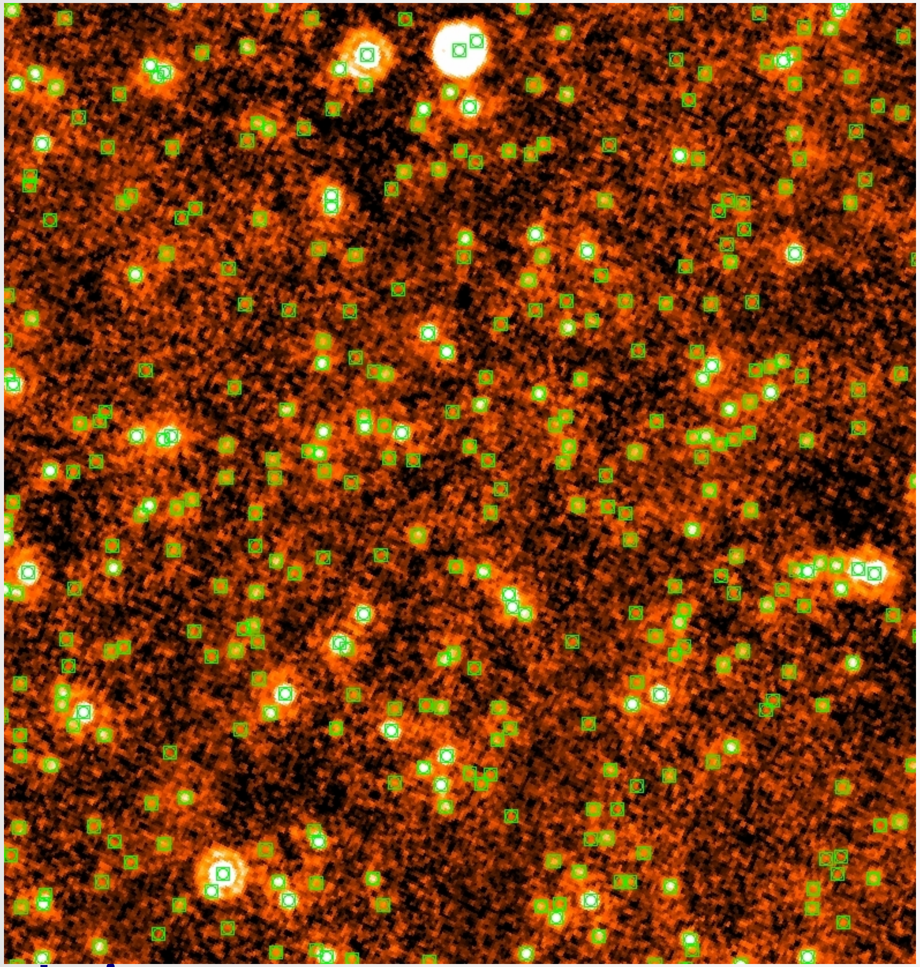
Elbaz et al. (2011)

Substantial wavelenght coverage: SHARDS 24 MB fil. 500-950nm reaching 26.5 AB HST (ACS, WFC3; PEARS). CANDELS data. Deepest IRAC (3.6<26 mag), MIPS (S_{24}>30 μJy), PACS (S_{100}>1mJy, S_{160}>3mJy), SPIRE (S_{250}>7mJy, S_{350}>8mJy, S_{500}~20mJy)

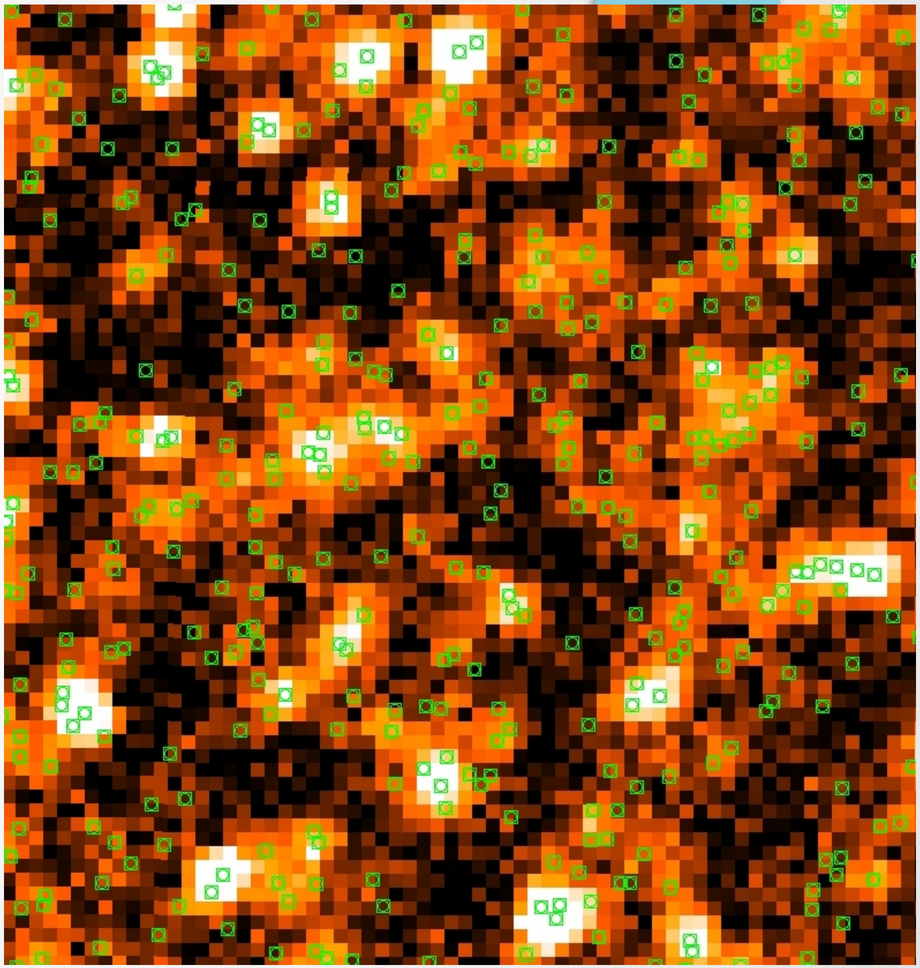
Ingredients FIR → MIPS 24+70 and 2 Herschel bands

Reduction and Cataloging:

MIPS 24



SPIRE 250



Cataloging:

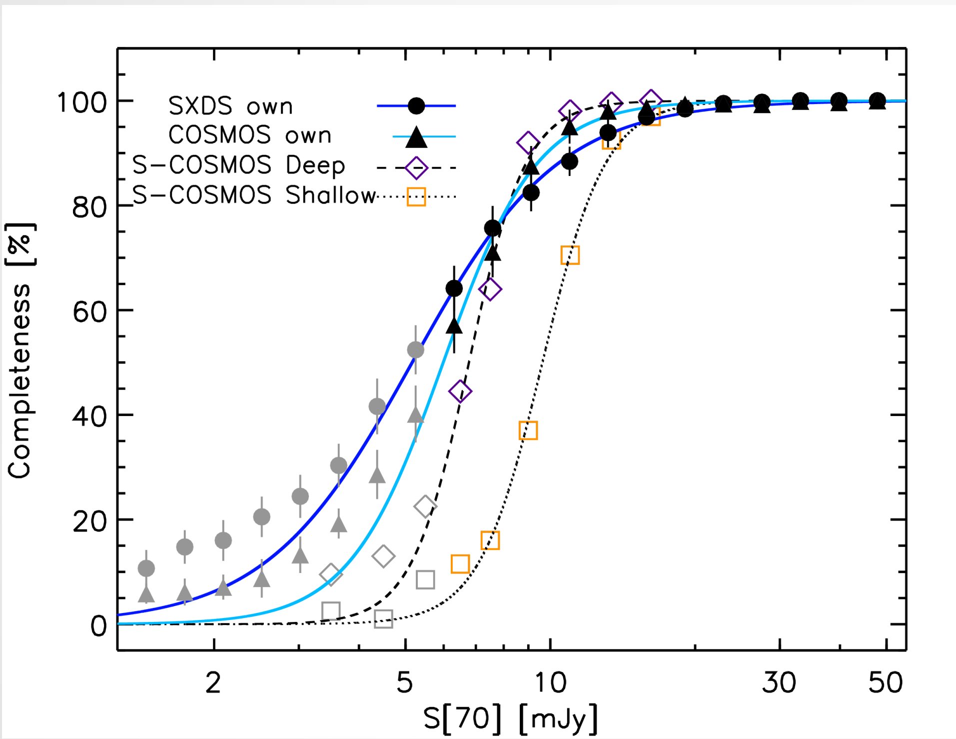
PSF fitting for high confidence direct detection + purged priors

(Peréz-González et al. 2010)

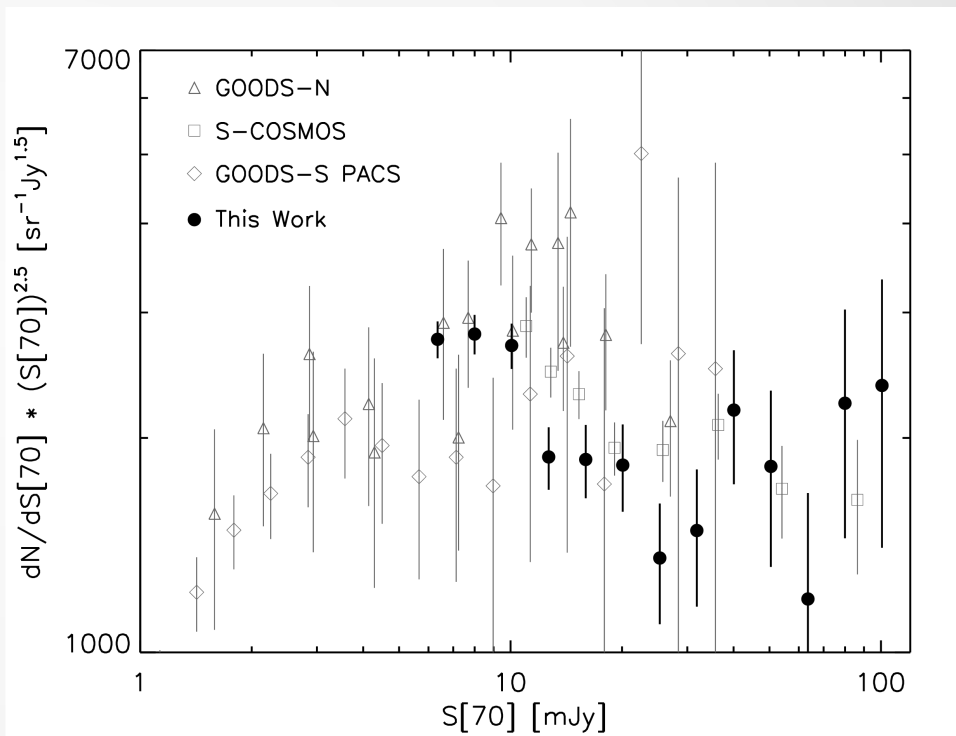
Ingredients
Reduction and Cataloging:

FIR → MIPS 24+70 and 2 Herschel bands

MIPS 70



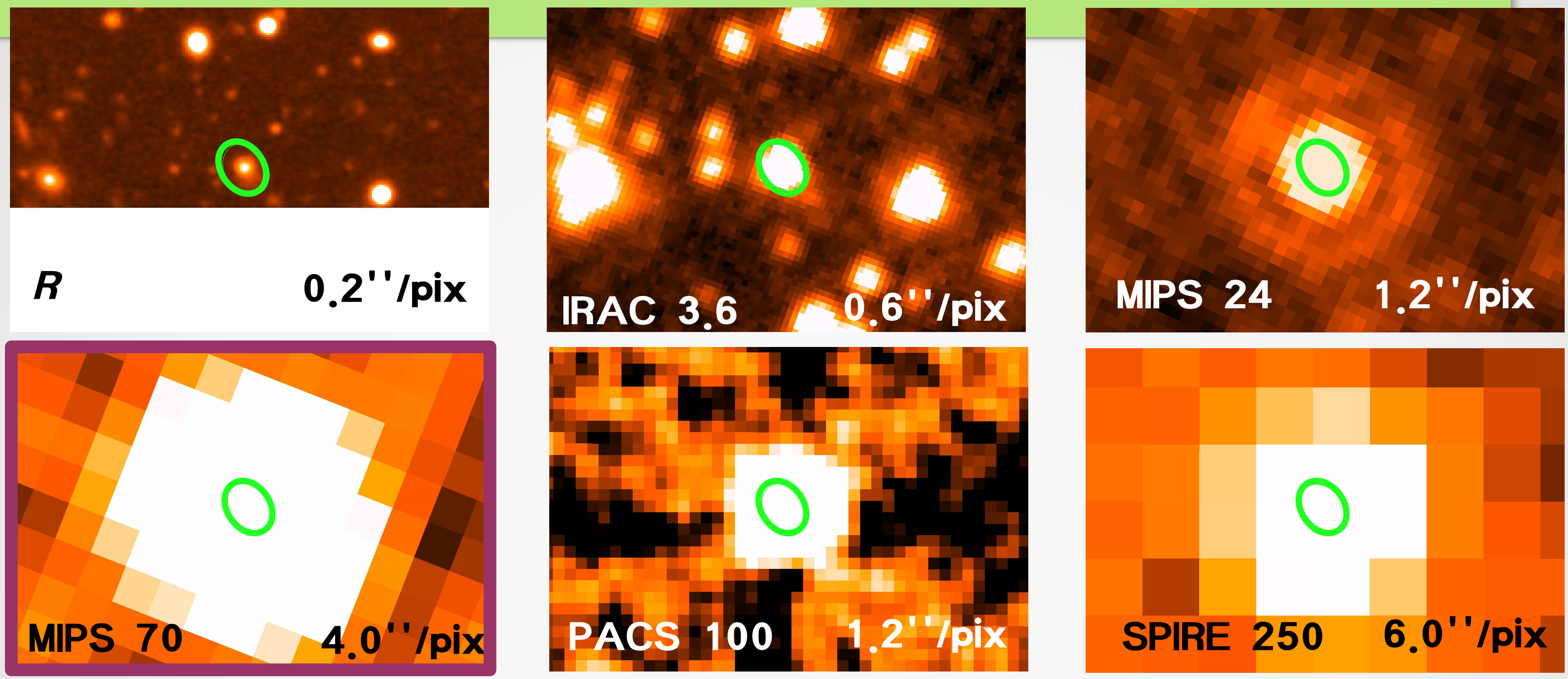
Completeness Corrections



Number Counts

Ingredients

Merged Catalogs

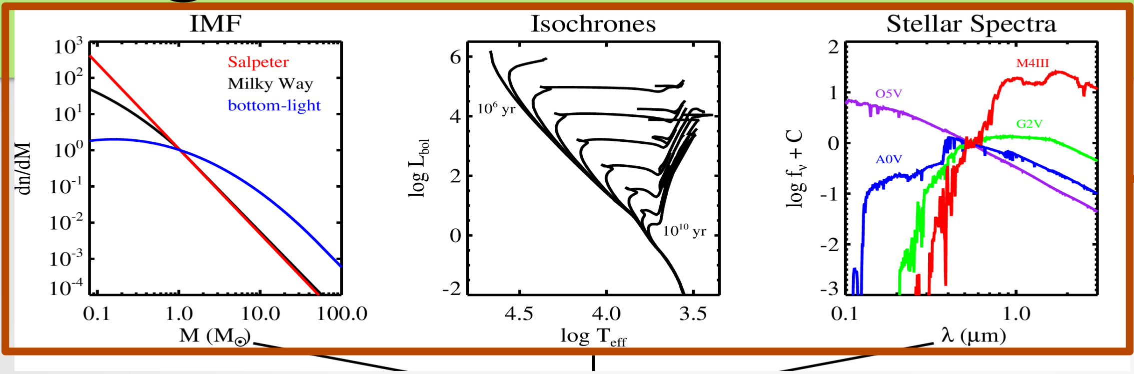


SXDS broadband data

- **MIPS 70 Selection. Search for *R* counterpart in 4'' radius. Then optical/NIR and IRAC in 1.5'', MIPS 24 and PACS 100 in 2.5'', 160 in 3.5'', SPIRE 250 in 6'', 350 in 9'' and 500 in 12''** (Pérez-González et al. 2008; Rainbow Software)
- **Spec-z if available, Photo-z's EAZY** (Brammer et al. 2008)
- **19 (U)LIRGs with secure optical counterpart checked visually 0.6 < z < 1.3**

Ingredients

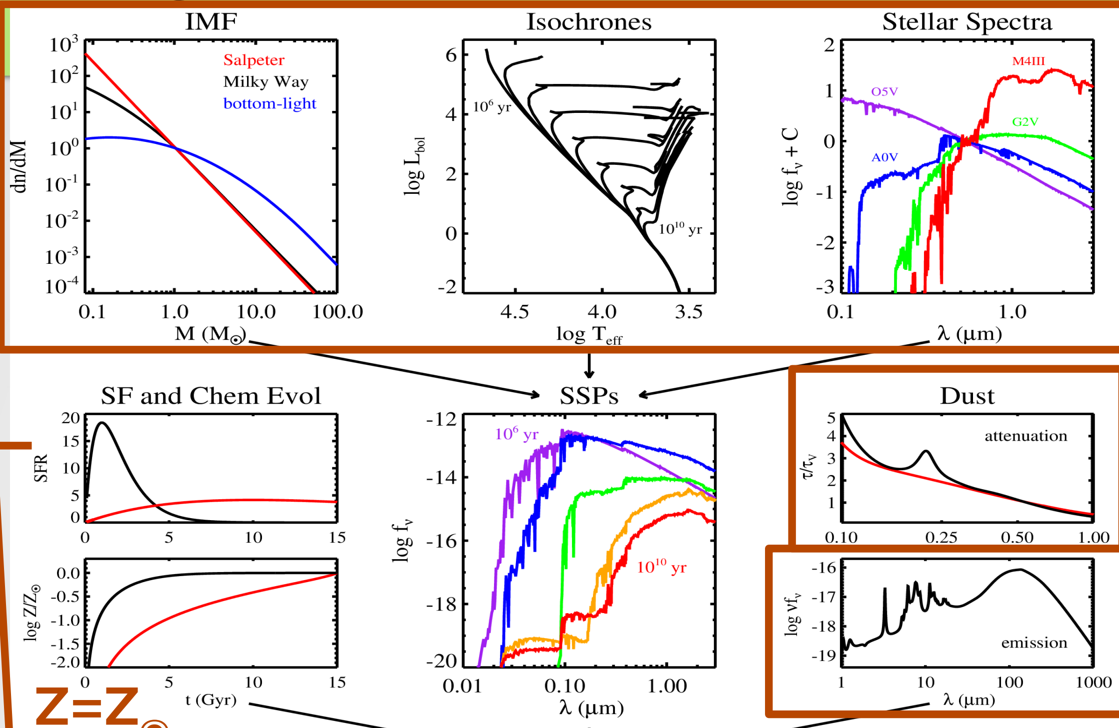
SPS+dust models



Maraston (2005) models
IMF: Salpeter (1955)

Ingredients

SPS+dust models



Z=Z$_{\odot}$

Maraston (2005) models
IMF: Salpeter (1955)

Calzetti et al. (2000)

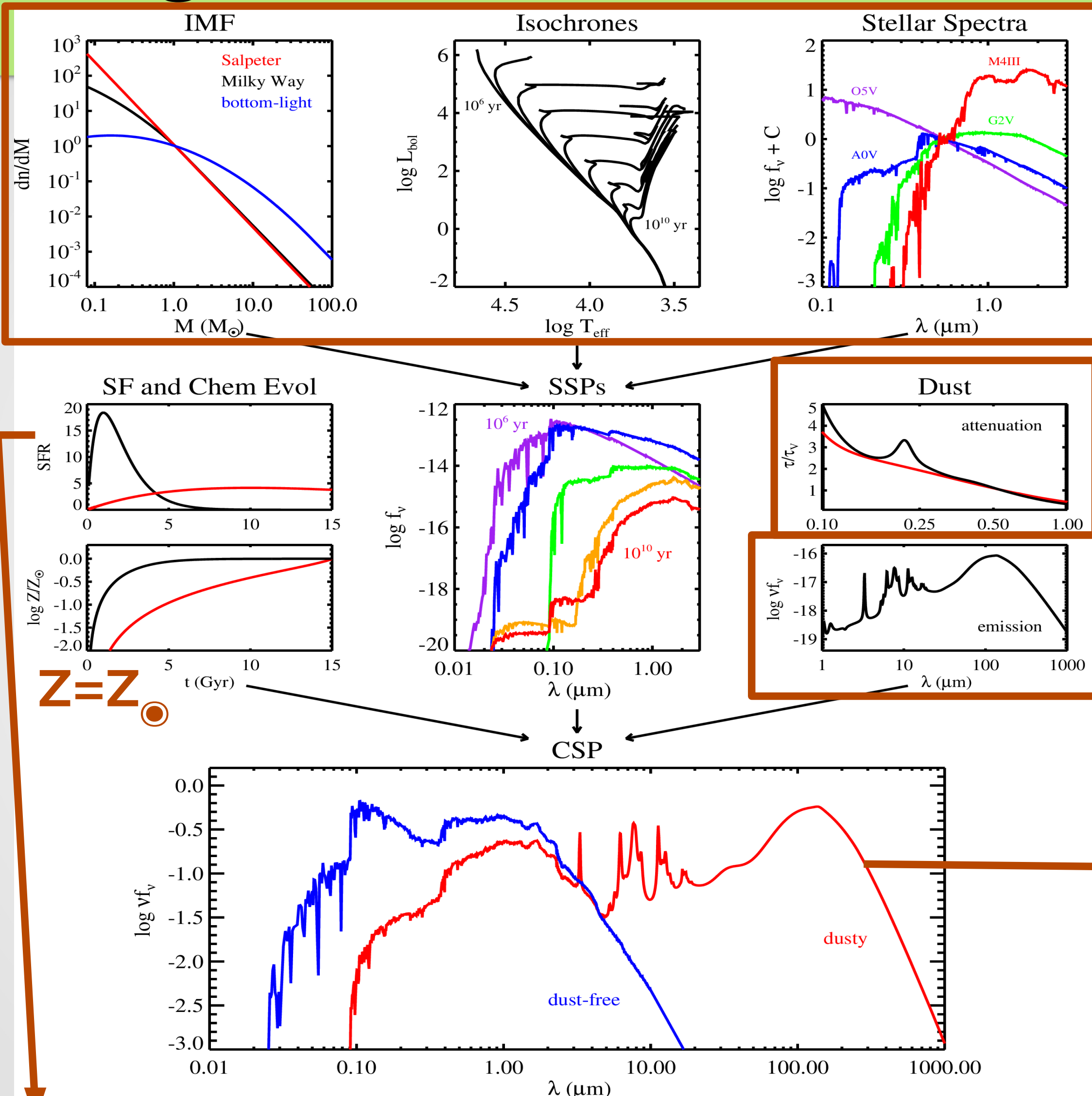
Chary & Elbaz (2001),
Dale & Helou (2002),
Rieke et al. (2009)

$$b = M_{you}/M_{*}$$

$$SFR(t) = \alpha_{old} \cdot e^{-\frac{t}{\tau_{old}}} \cdot H[t] + \alpha_{you} \cdot e^{-\frac{[t-(t_{old}-t_{you})]}{\tau_{you}}} \cdot H[t-(t_{old}-t_{you})]$$

Ingredients

SPS+dust models



$Z=Z_\odot$

Maraston (2005) models
IMF: Salpeter (1955)

Calzetti et al. (2000)

Chary & Elbaz (2001),
Dale & Helou (2002),
Rieke et al. (2009)

SYNTHESIZER (MC simulations)
CIGALE (Bayesian)

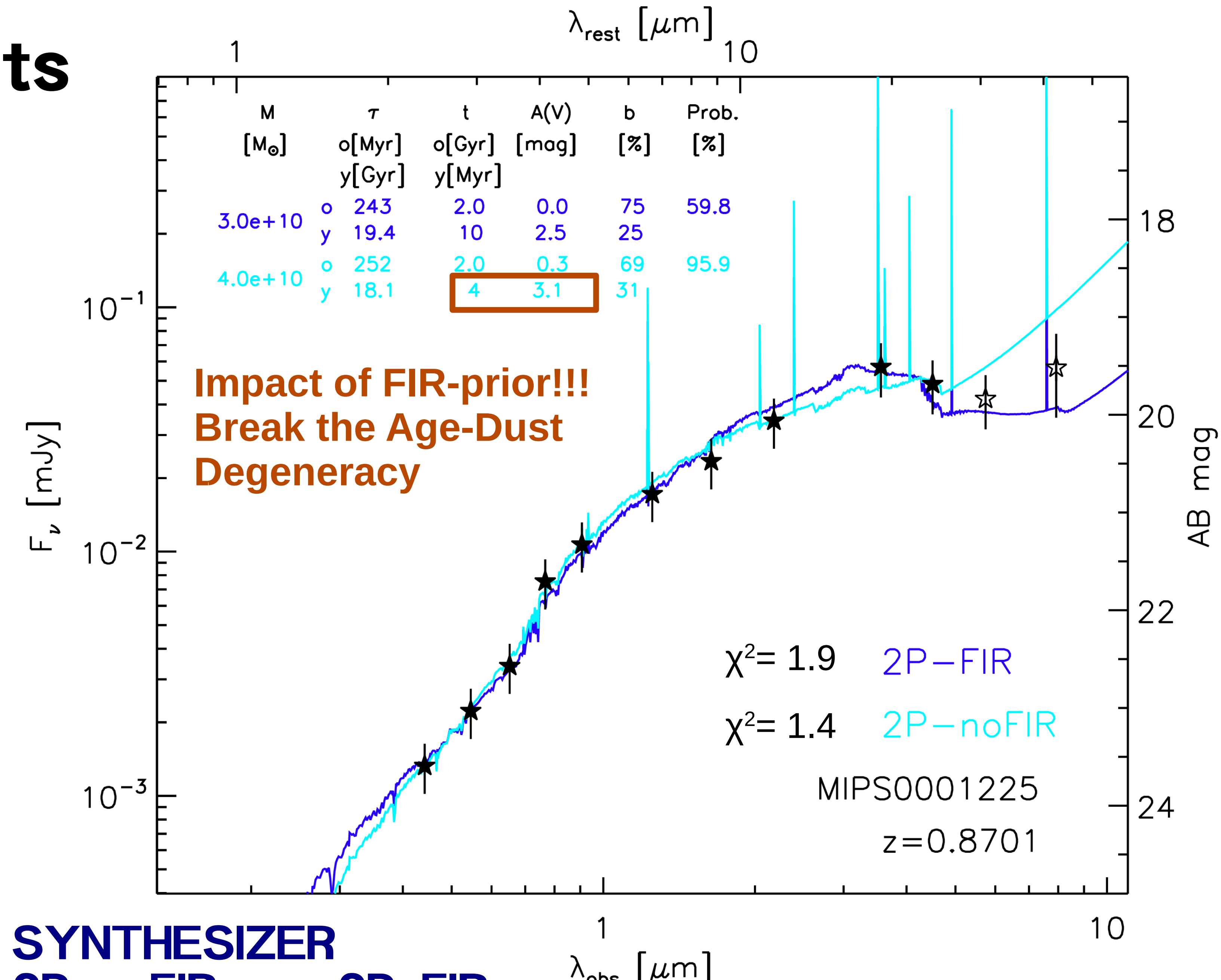
Conroy (2013)

$$b = M_{you}/M_{*}$$

$$SFR(t) = \alpha_{old} \cdot e^{-\frac{t}{\tau_{old}}} \cdot H[t] + \alpha_{you} \cdot e^{-\frac{[t-(t_{old}-t_{you})]}{\tau_{you}}} \cdot H[t-(t_{old}-t_{you})]$$

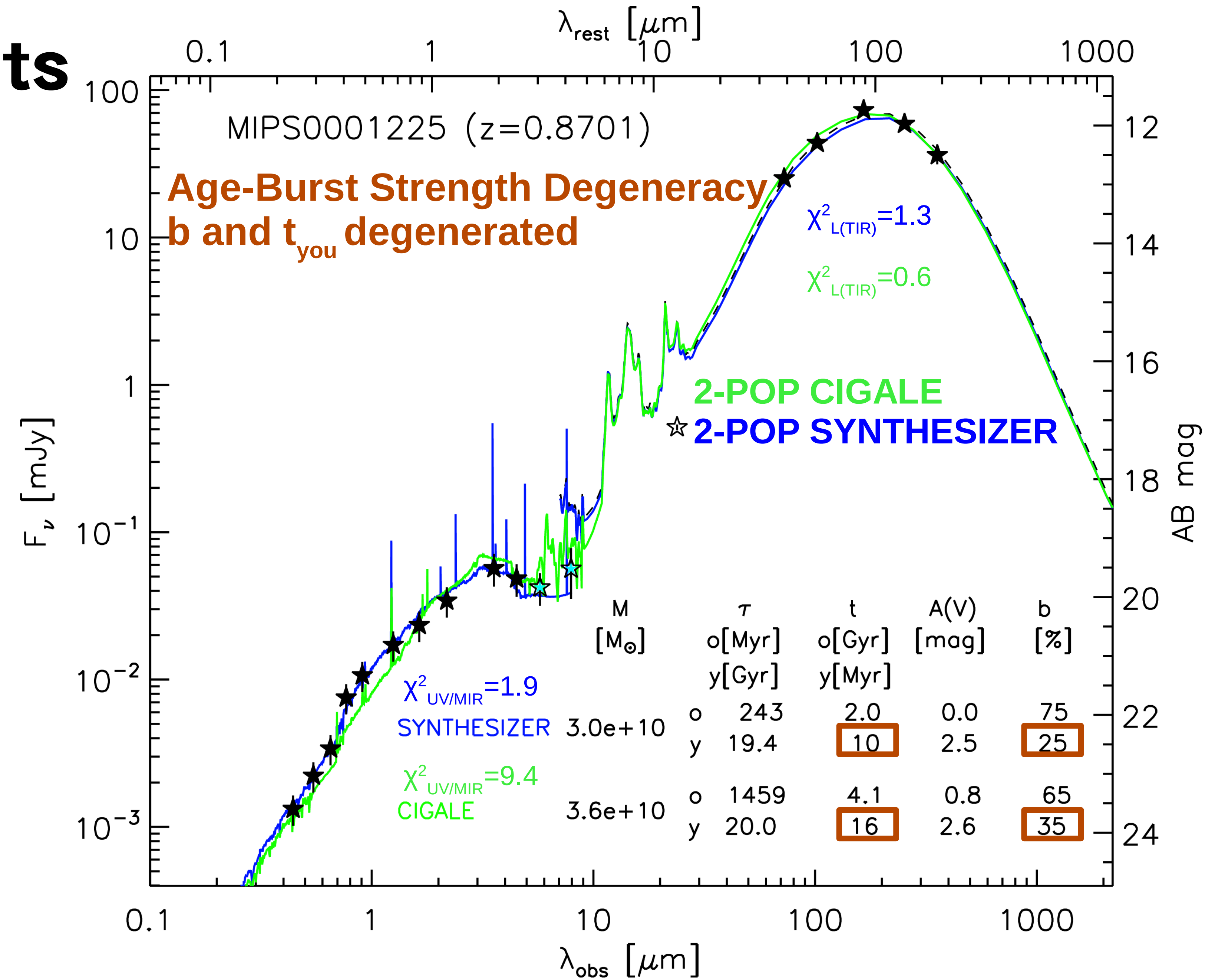
Results

Fits:



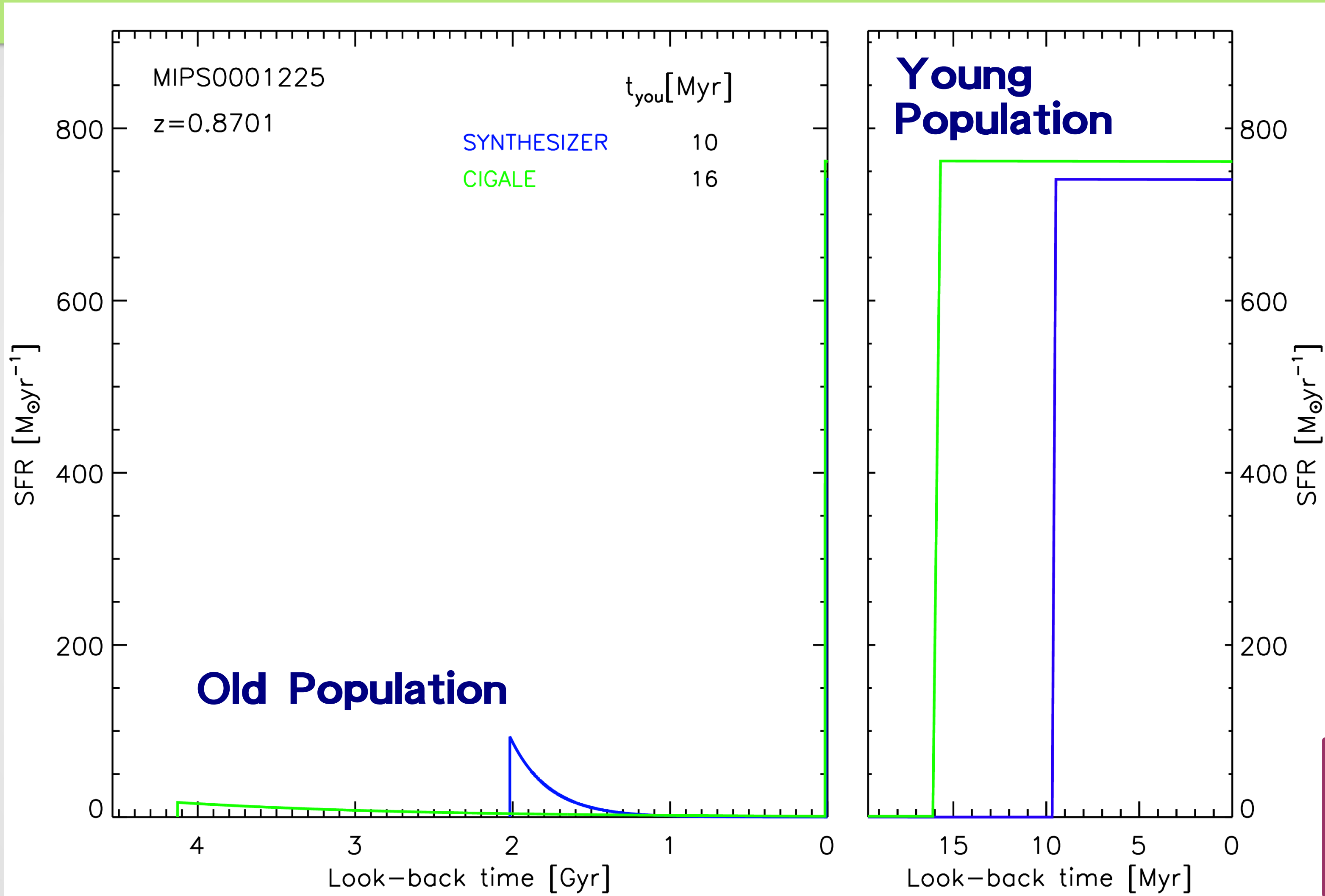
SYNTHESIZER
2P-noFIR vs. 2P-FIR

Results Fits:



Results

SFHs:



Ages

t_{CIGALE} > t_{SYNTH}

CIGALE finds t_{you}'s ~3 times larger than SYNTH, and t_{old}'s ~1.5 larger than SYNTH

$M_{\star}$, A(V)

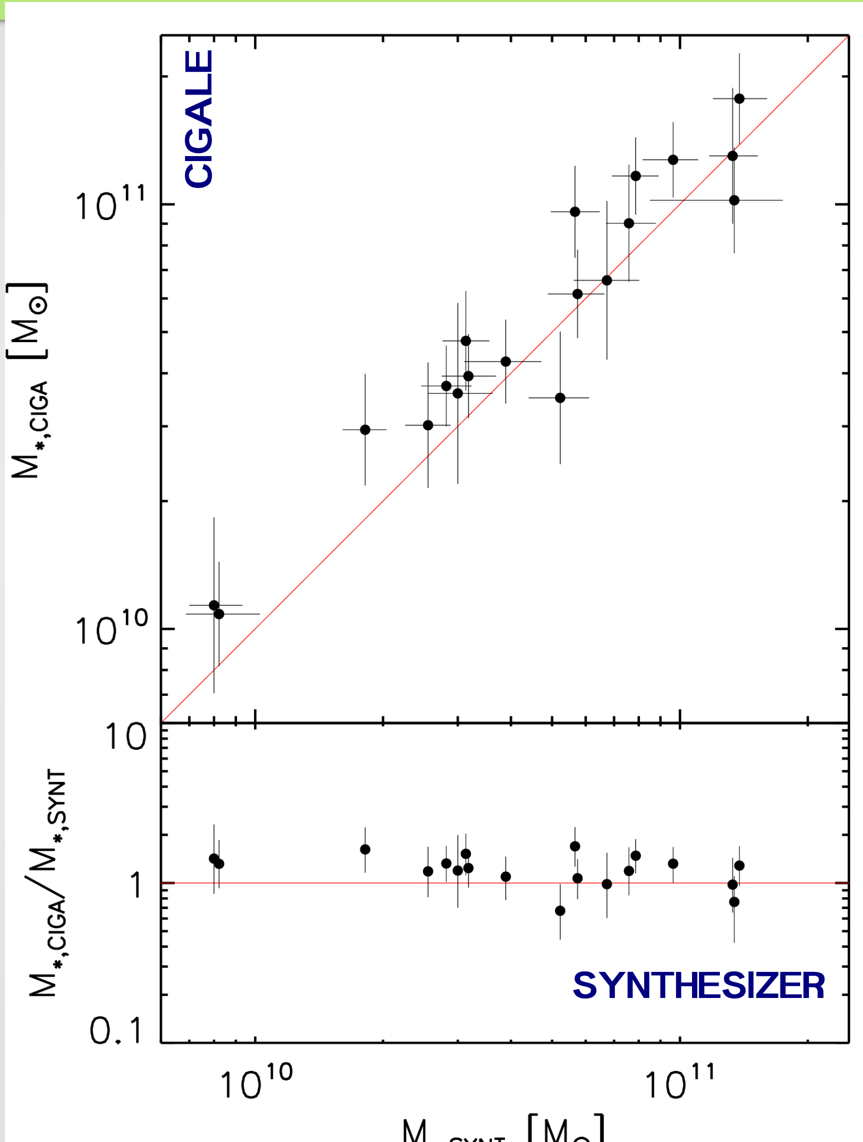
Both codes get similar $M_{\star}$ and $A(V)_{you}$

SFHs characterized by a recent burst overlapped to an evolved SP.
The YP dominates the recent SFR.
The OP contributes with stellar mass.

Results

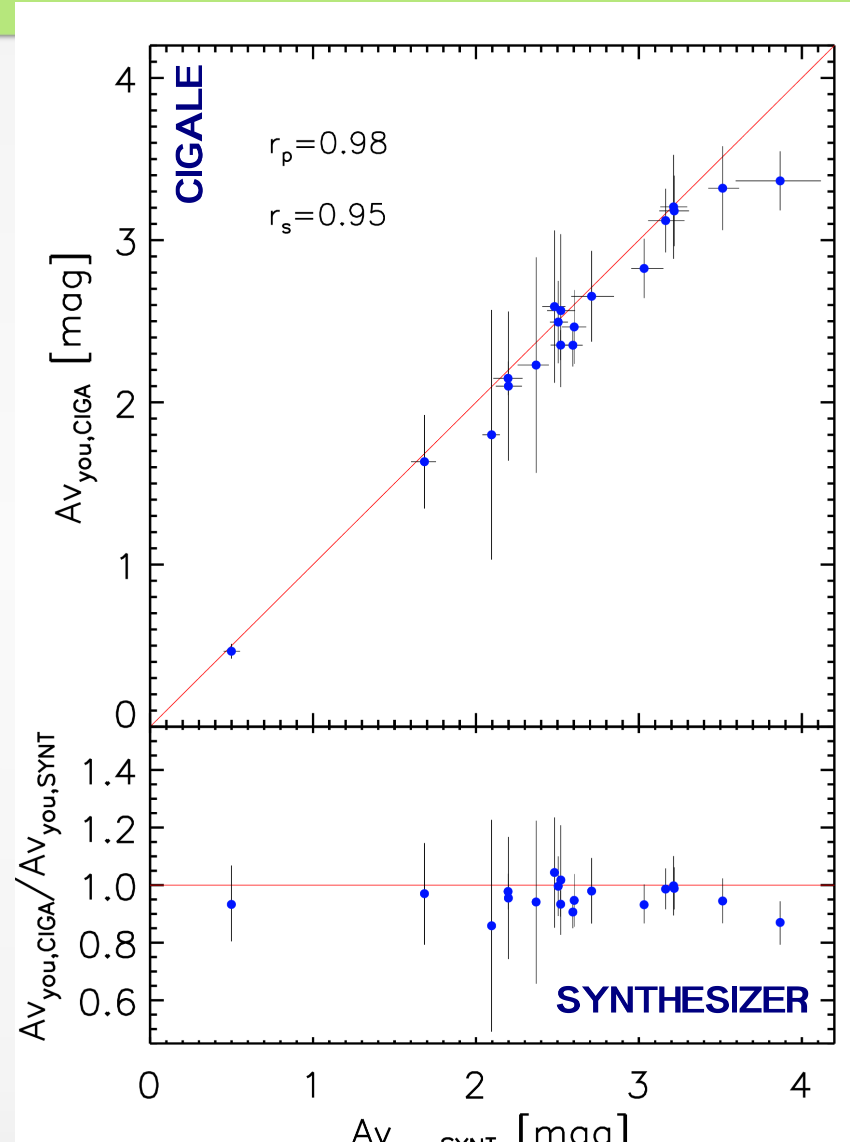
$M_\star$'s and $A(V)_{you}$'s

Similar $M_\star$ with $M_{\star,CIGA} \sim 1.5 M_{\star,SYNTH}$



$8 \times 10^9 < M_\star/M_\odot < 2 \times 10^{11}$

Similar $A(V)_{you}$ values



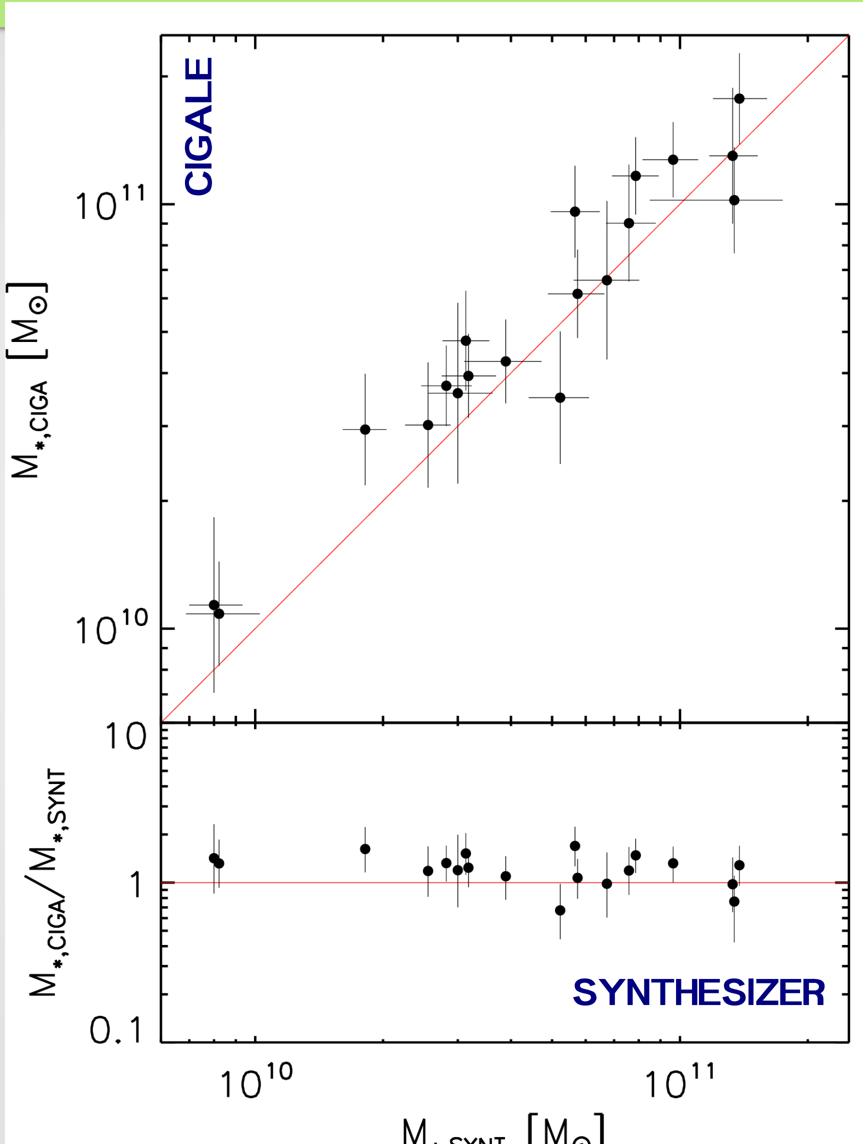
$0.5 < A(V)_{you} < 3.9$ mag, 89%>2 mag

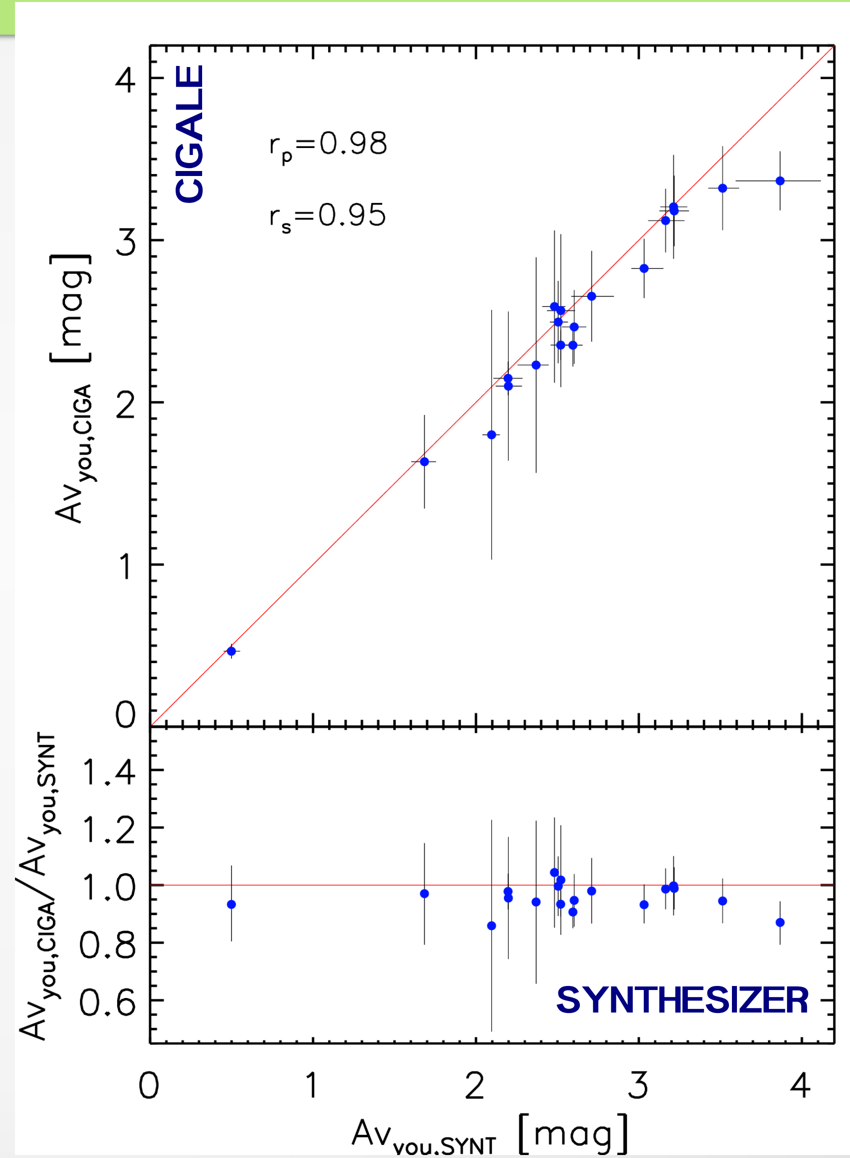
Results

$M_\star$'s and $A(V)_{you}$'s

Similar $M_\star$ with $M_{\star,CIGA} \sim 1.5 M_{\star,SYNTH}$

Similar $A(V)_{you}$ values



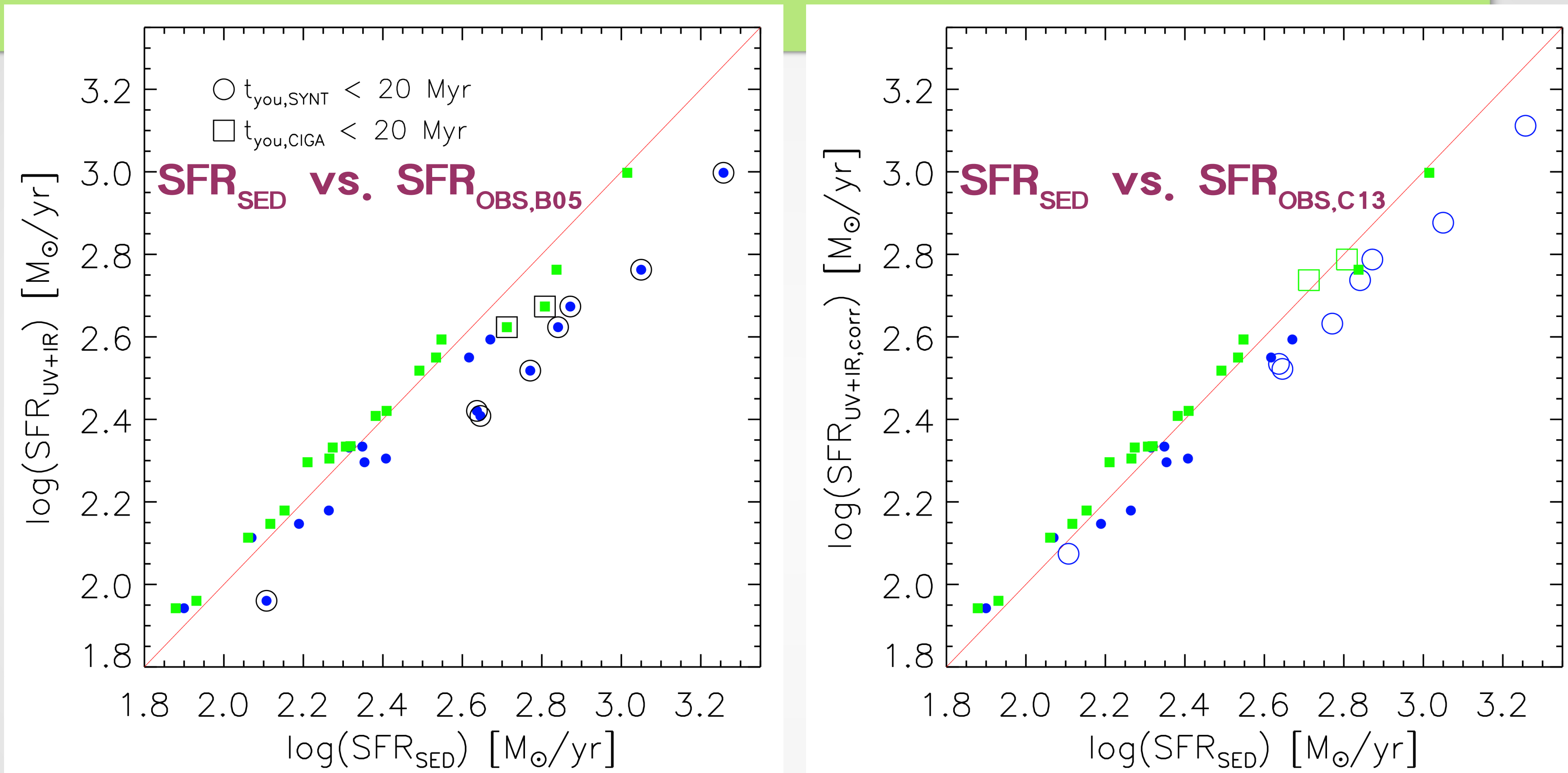


- **Consistent determination of $M_\star$s**
- **Estimate accurate A(V) values in U(LIRGS)**

$8 \times 10^9 < M_\star/M_\odot < 2 \times 10^{11}$

$0.5 < A(V)_{you} < 3.9$ mag, 89%>2

Results SFR_{SED} vs. SFR_{OBS}



$$SFR_{UV+IR}(M_\odot/yr) = 1.8\times10^{-10}[3.3L(0.28)+L(TIR)]/L_\odot$$

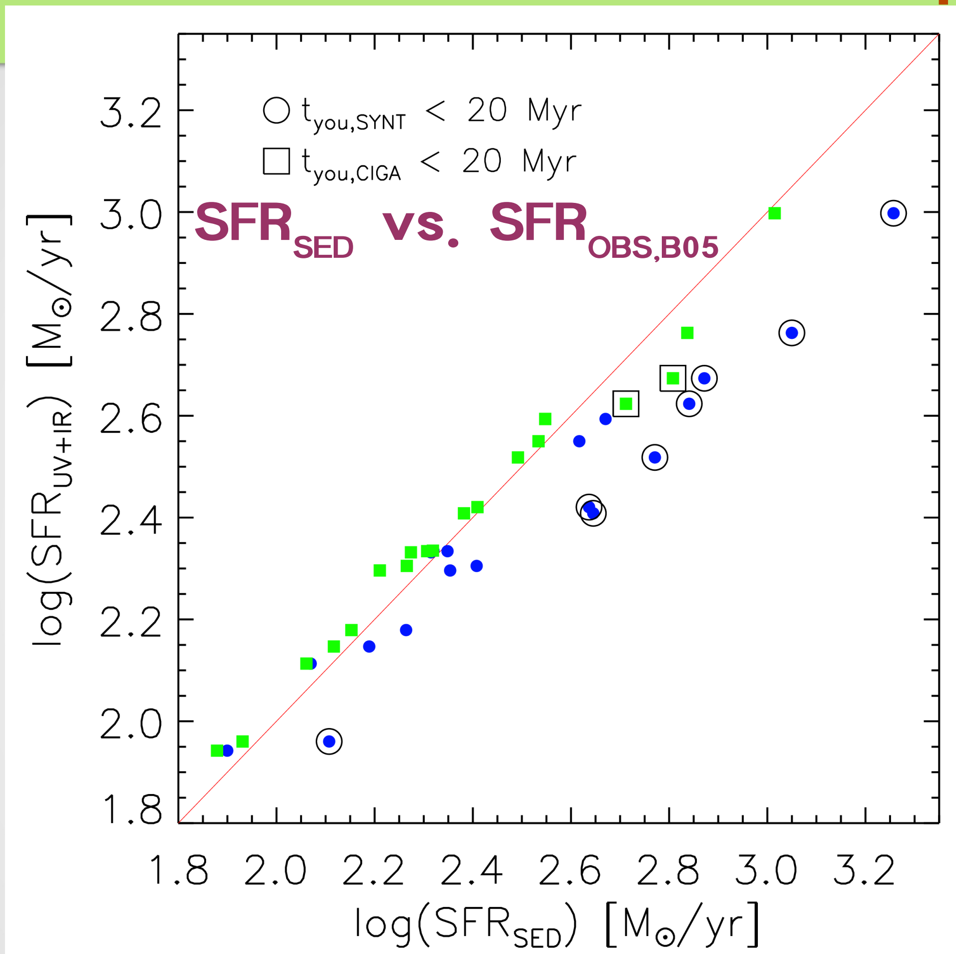
Kennicutt (1998), Bell et al. (2005). Timescale 100 Myr

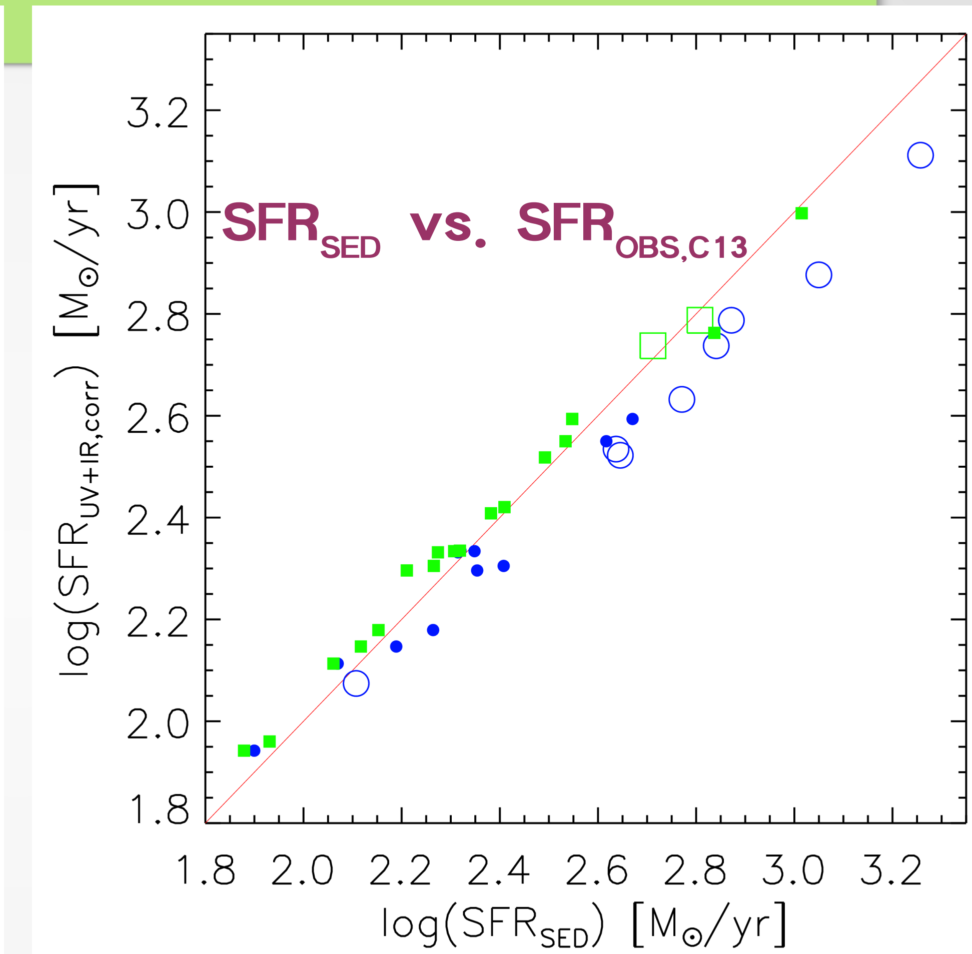
$$SFR_{UV+IR,corr}(M_\odot/yr) = 2.3\times10^{-10}[3.3L(0.28)+L(TIR)]/L_\odot$$

Calzetti (2013). Timescale 10 Myr

Results

- **Improve determination of SFRs**





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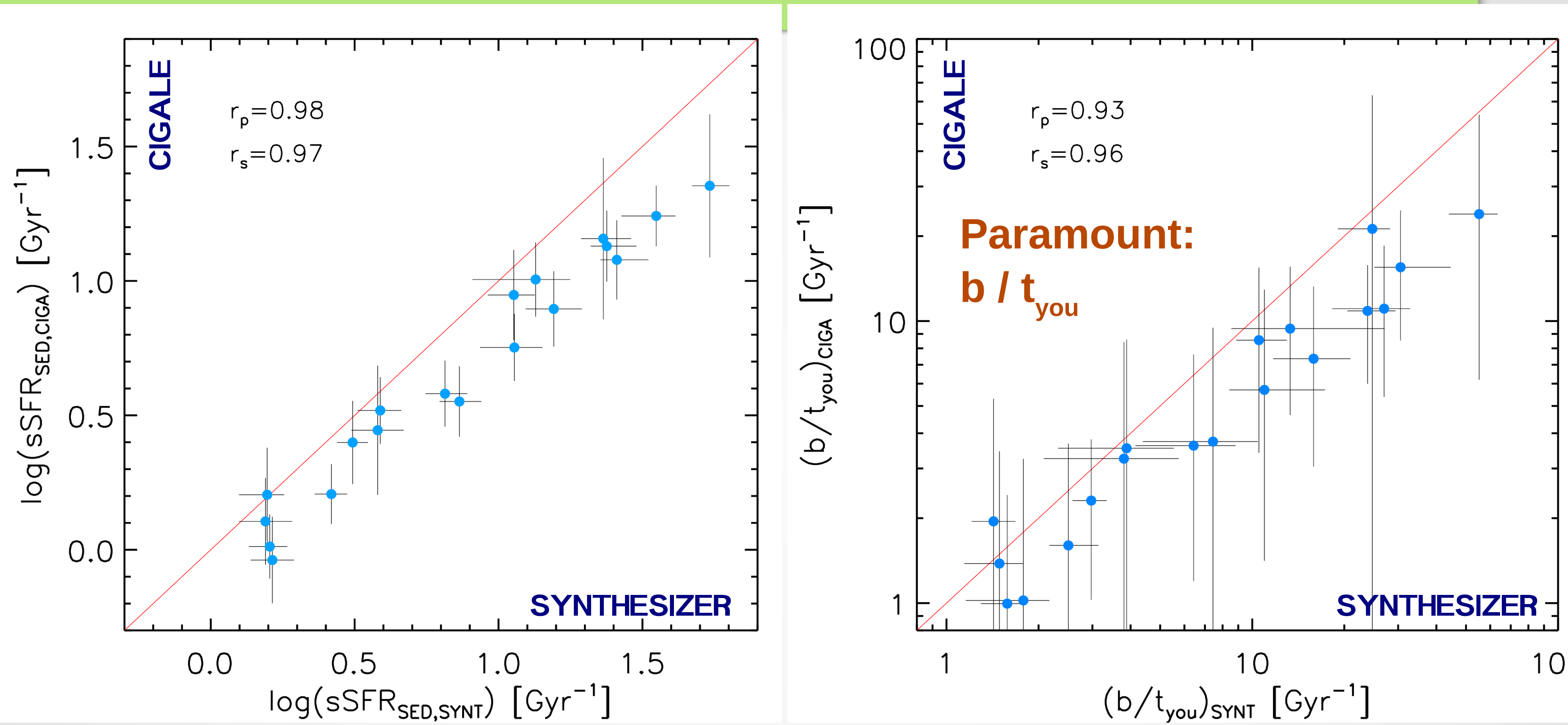
Calzetti (2013). Timescale 10 Myr

Results

sSFRs:



$0.9 < sSFR_{SED} < 51\ Gyr^{-1}$

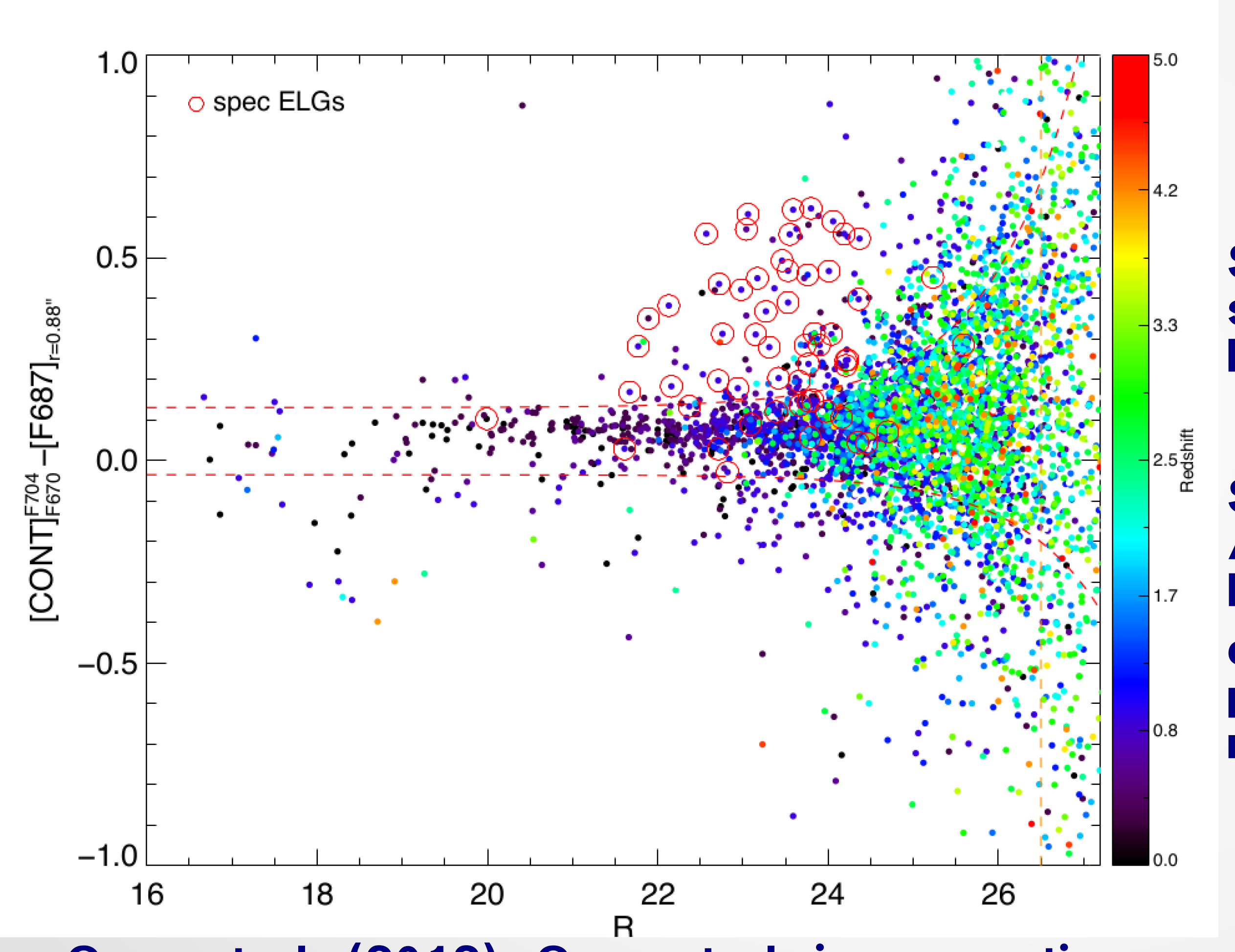
$$SFR_{SED} \simeq SFR_{SED,you} \simeq \frac{M_{*,you}}{t_{you}} = \frac{M_* \cdot b}{t_{you}}$$

$$sSFR_{SED} = \frac{SFR_{SED}}{M_*} \simeq \frac{b}{t_{you}}$$

SHARDS

Emission Line Galaxies (ELGs)

SHARDS 24 MB fil. 500-950nm

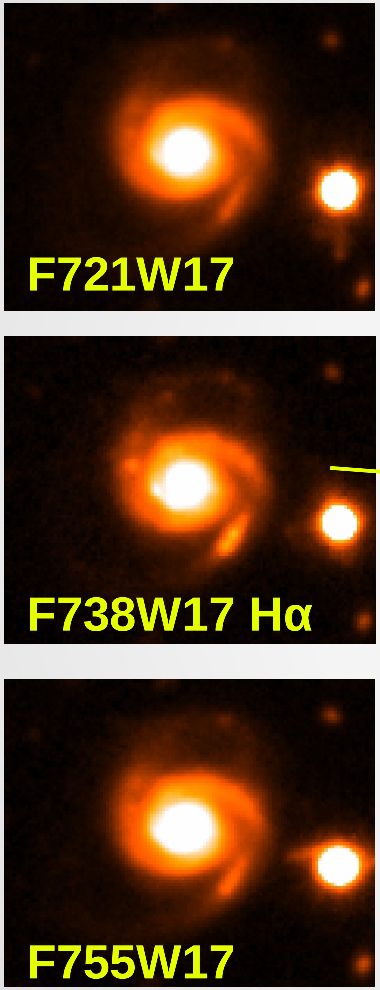


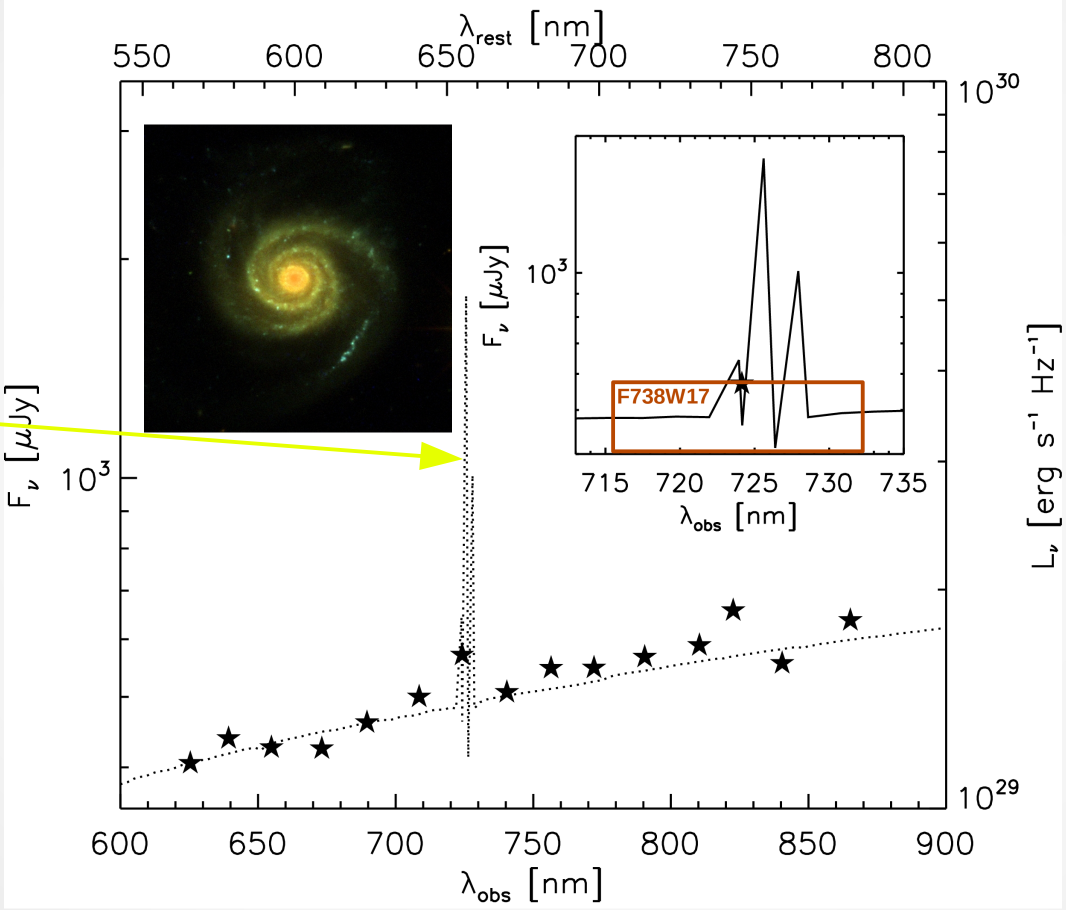
Cava et al. (2012), Cava et al. in preparation

SHARDS data is useful to select ELGs, and measure EWs values.

SHARDS EL fluxes and Absorption indices + accurate L_{TIR} → improvements in estimations stellar populations parameters for galaxies at mid z

SHARDS





FIR data → Spitzer + GOODS-Herschel

accurate L_{TIR} constrains A(V)

Analyze the extinction properties nearby galaxies

Nearby galaxy in GOODS-N showing a fitted SPS model with Hα

Conclusions

- 2-POP models with FIR prior are needed for breaking the Age-Dust degeneracy and getting $M_{\star}$ in IR-bright galaxies
- classic $SFR_{UV+IR,B05}$ can differ in a factor ~2 from SFR_{SED}, if t_{you}<20 Myr and SFR_{you}~const. When $SFR_{UV+IR,CAL13}$ (ts=10 Myr) is used, we get a better agreement
- There are degeneracies between b and t_{you} i.e., a massive burst of SF with older age has a similar emission than a less massive burst with younger age (between a factor~2)
- SHARDS data + Self-consistent modelling → Better determination of stellar properties of IR-bright galaxies

THE END