COSMIC STAR FORMATION
THE RADIO LOW FREQUENCY WINDOW

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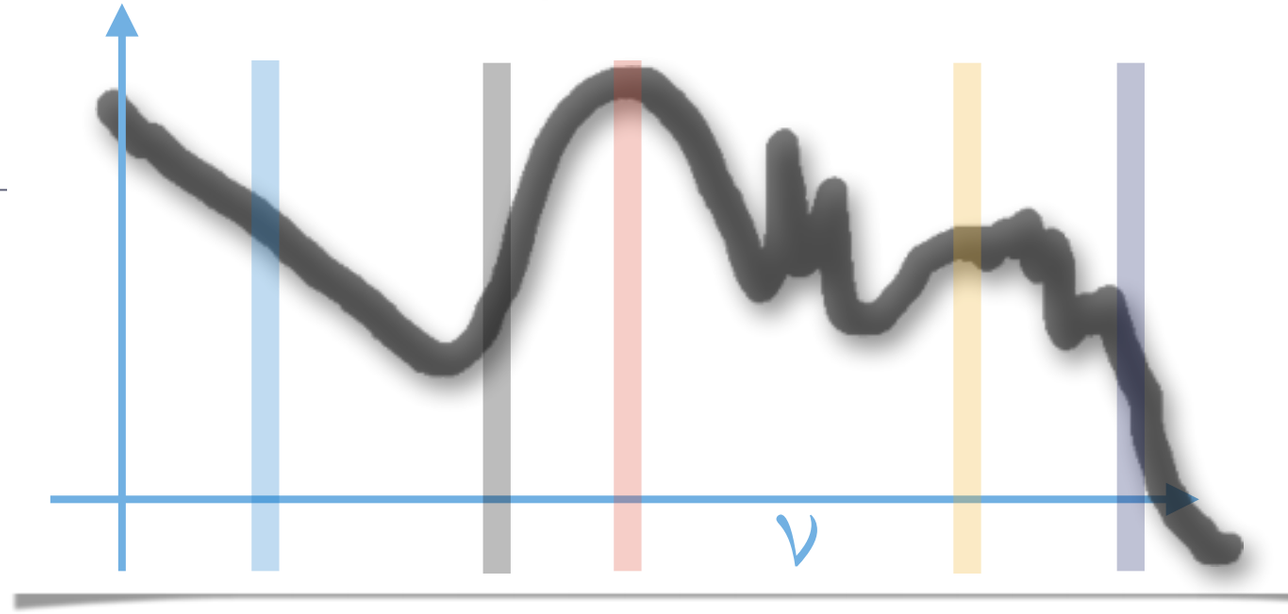
1.
INTRODUCTION

INTRO: HIGHz STAR FORMATION



sub-mm

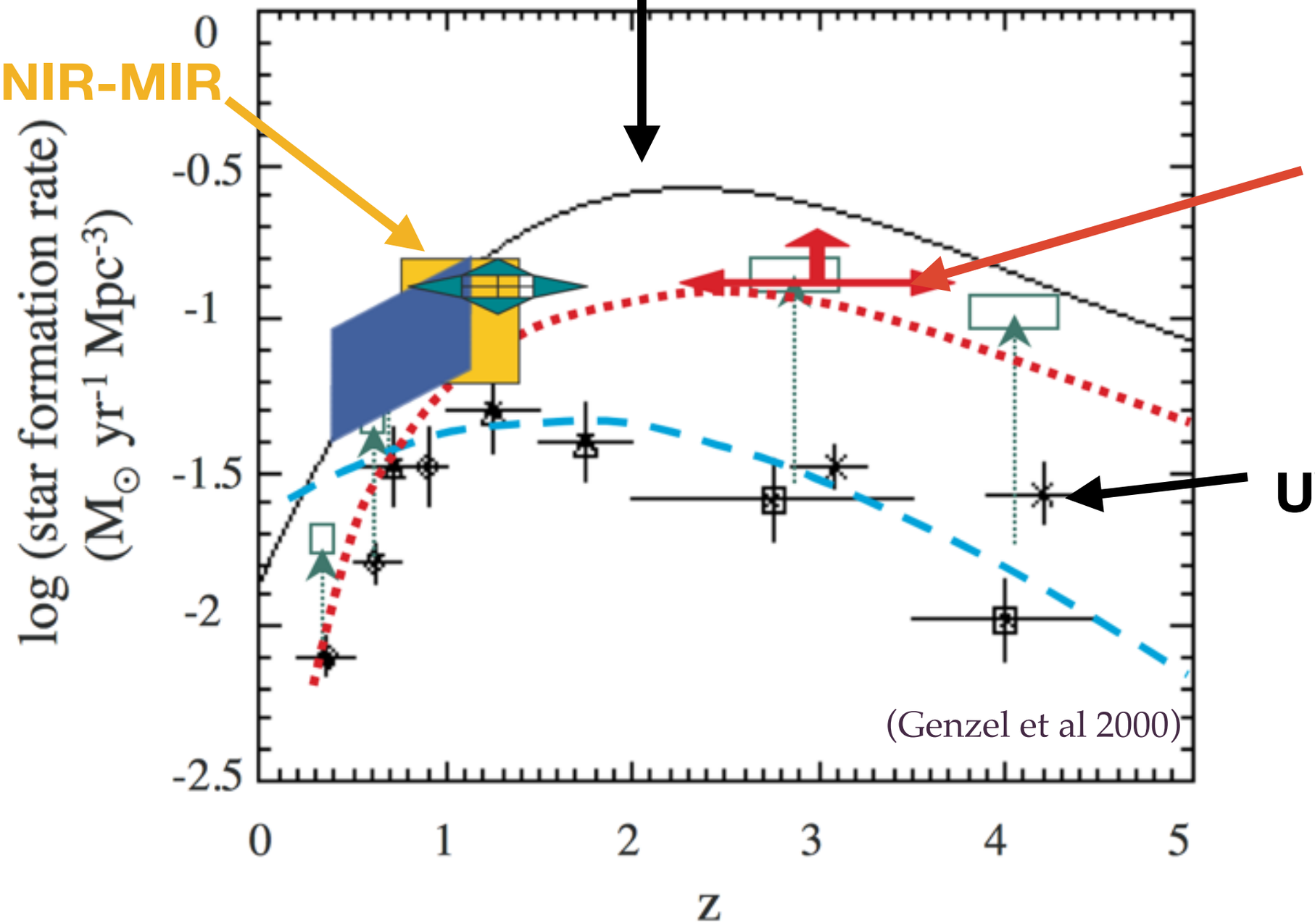
NIR-MIR

FIR

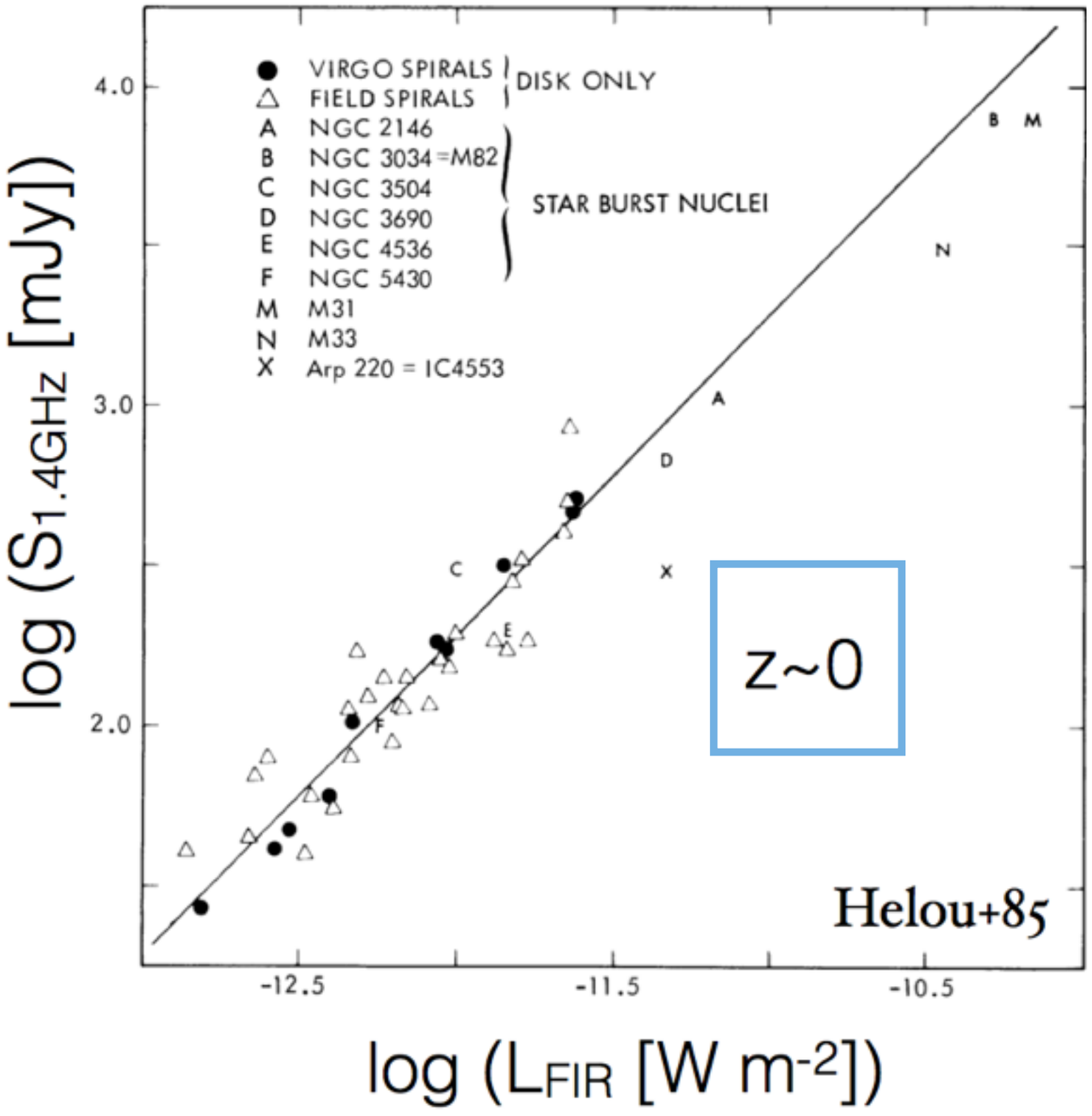
RADIO

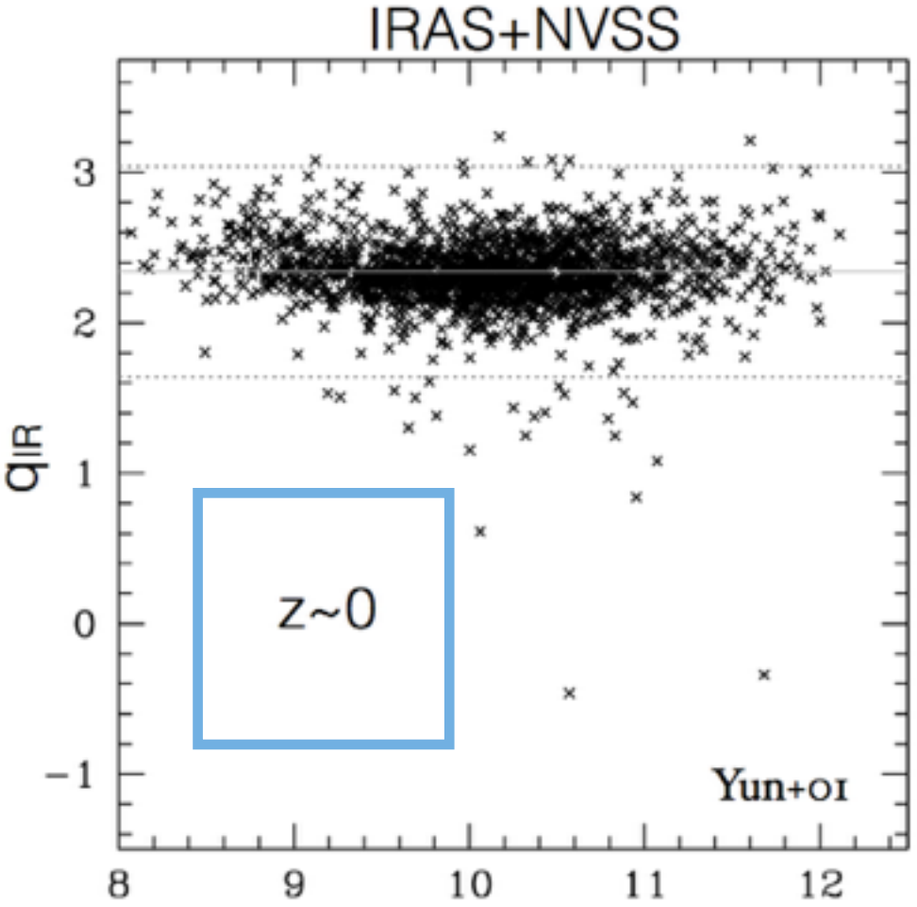
LOFAR

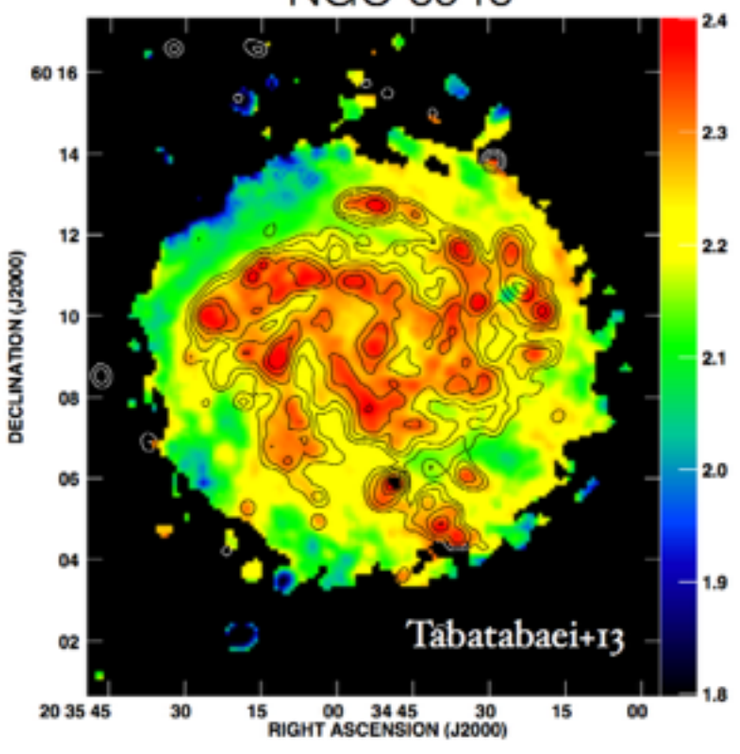
UV



INTRO: FIR - RADIO CORRELATION







qFIR + contours(Free-Free)

INTRO: RADIO SPECTRUM

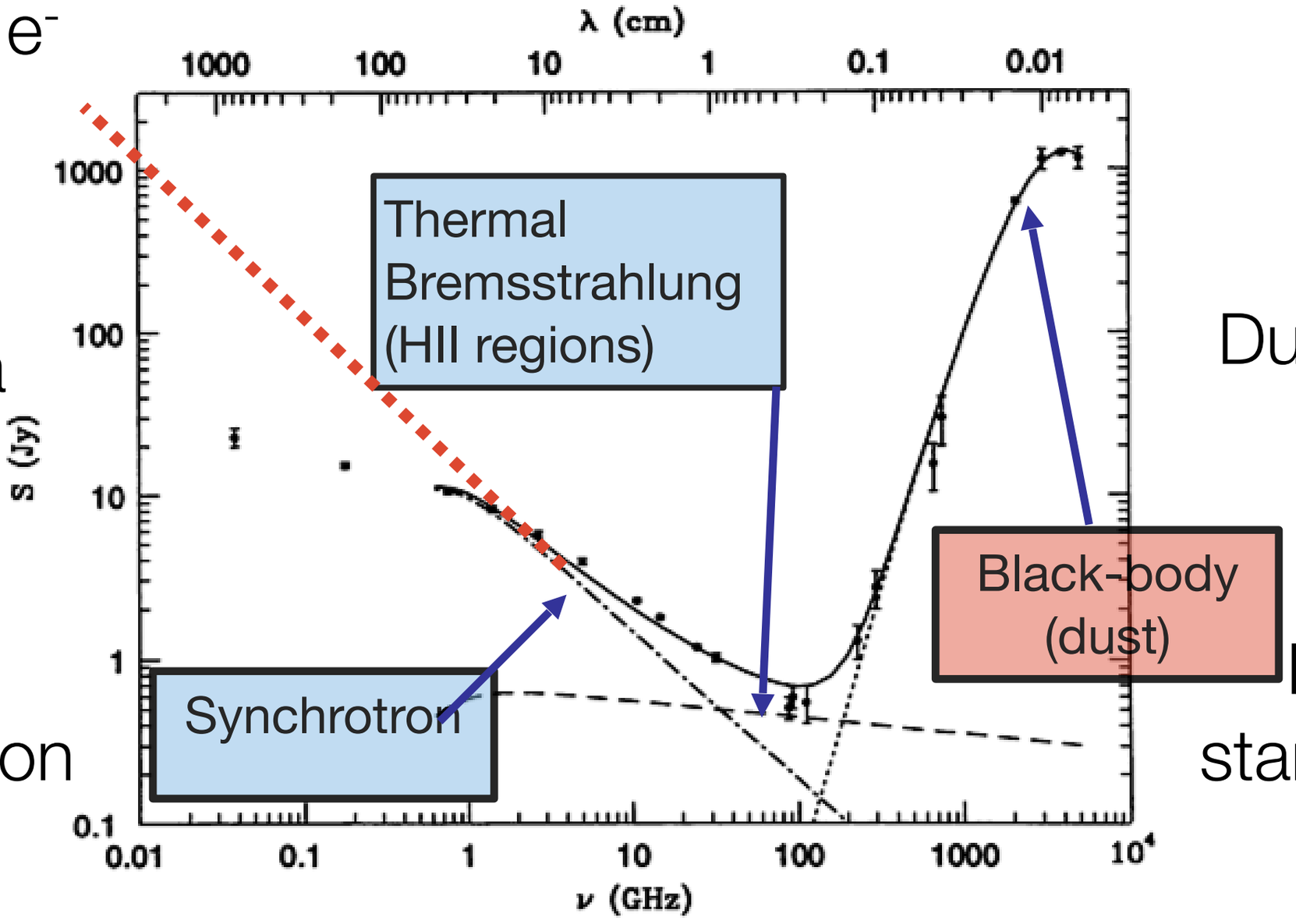
Relativistic e^-
+ B-field

⬆

Supernova
shocks

⬆

Massive
star formation



Dust heating

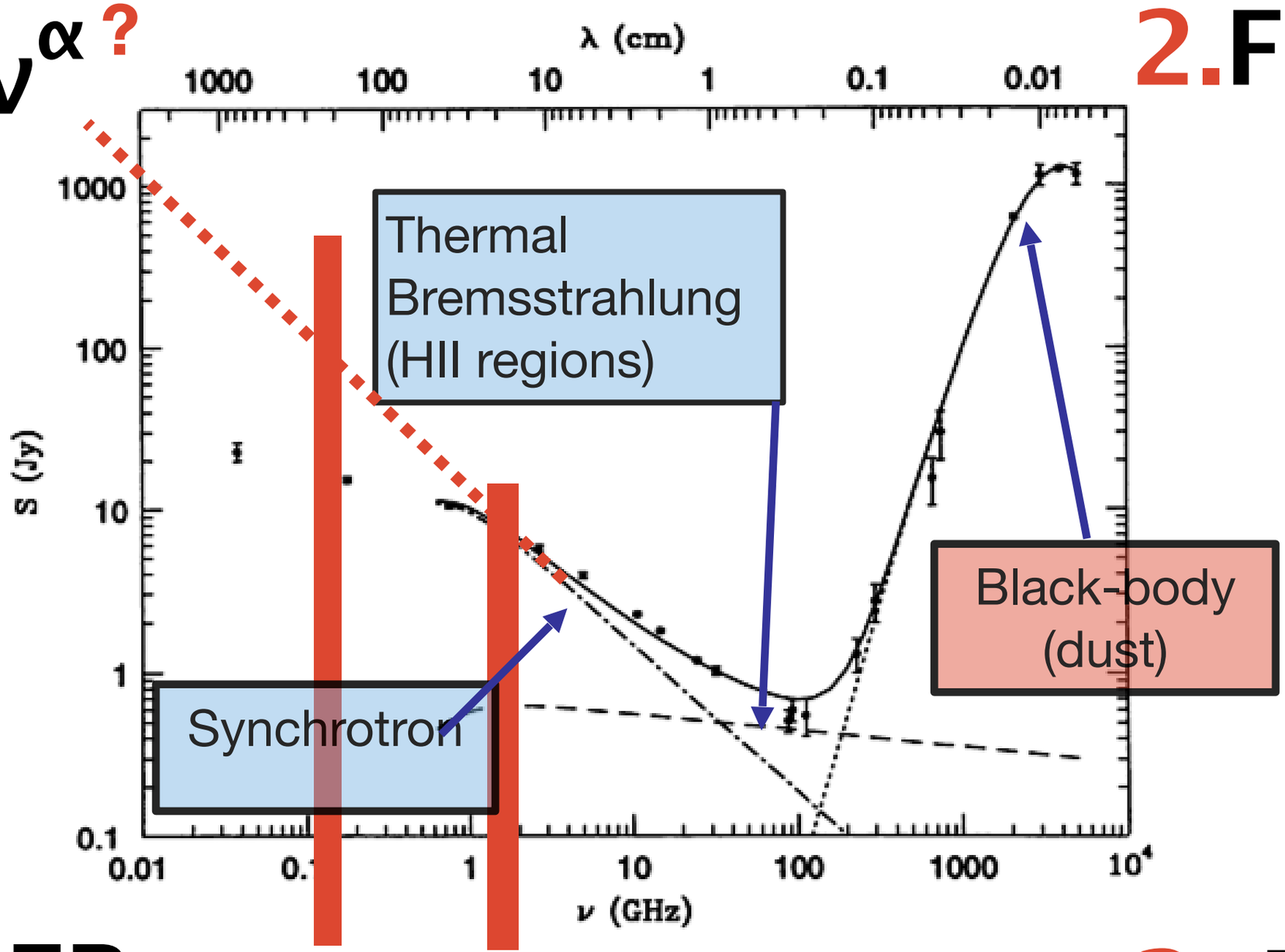
⬆

Massive
star formation

INTRO: MAIN QUESTIONS

1. $F \propto \nu^{\alpha}$ **?**

2.FRC **LOFAR** **150 MHz**



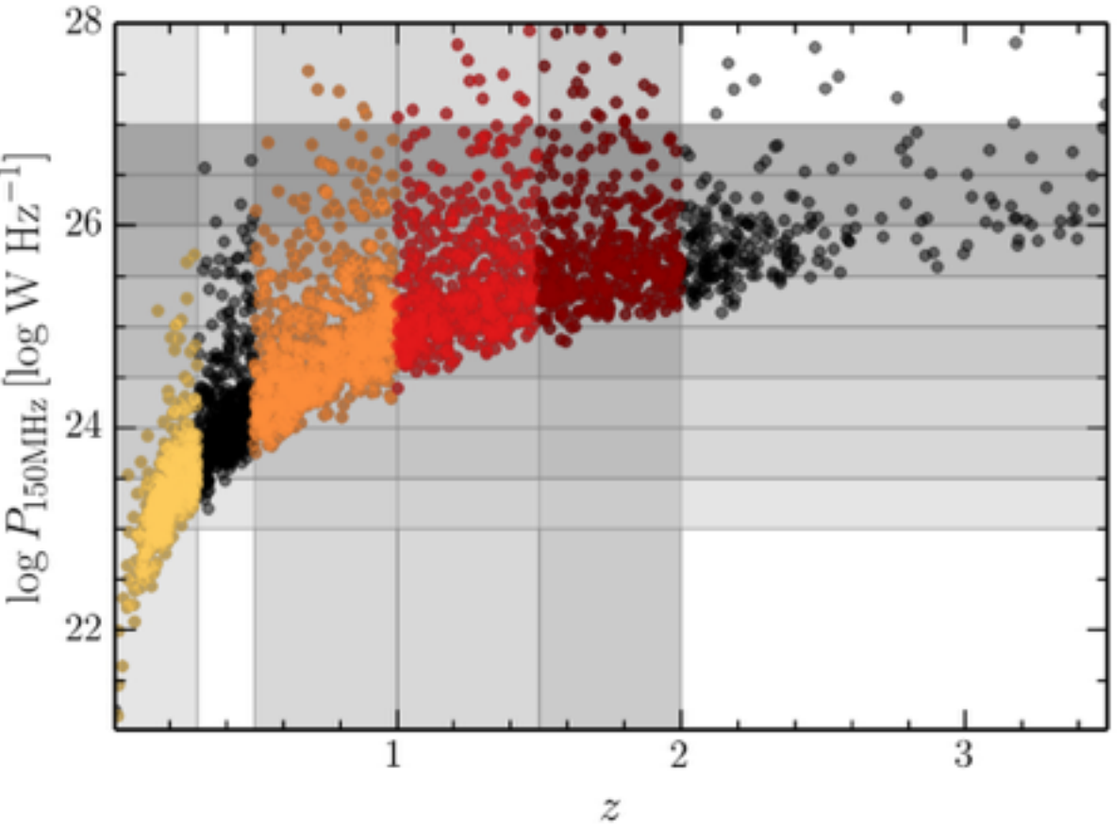
4. **SFR** **LOFAR** **150 MHz** **1.4 GHz**

3. **FRC⇢z**

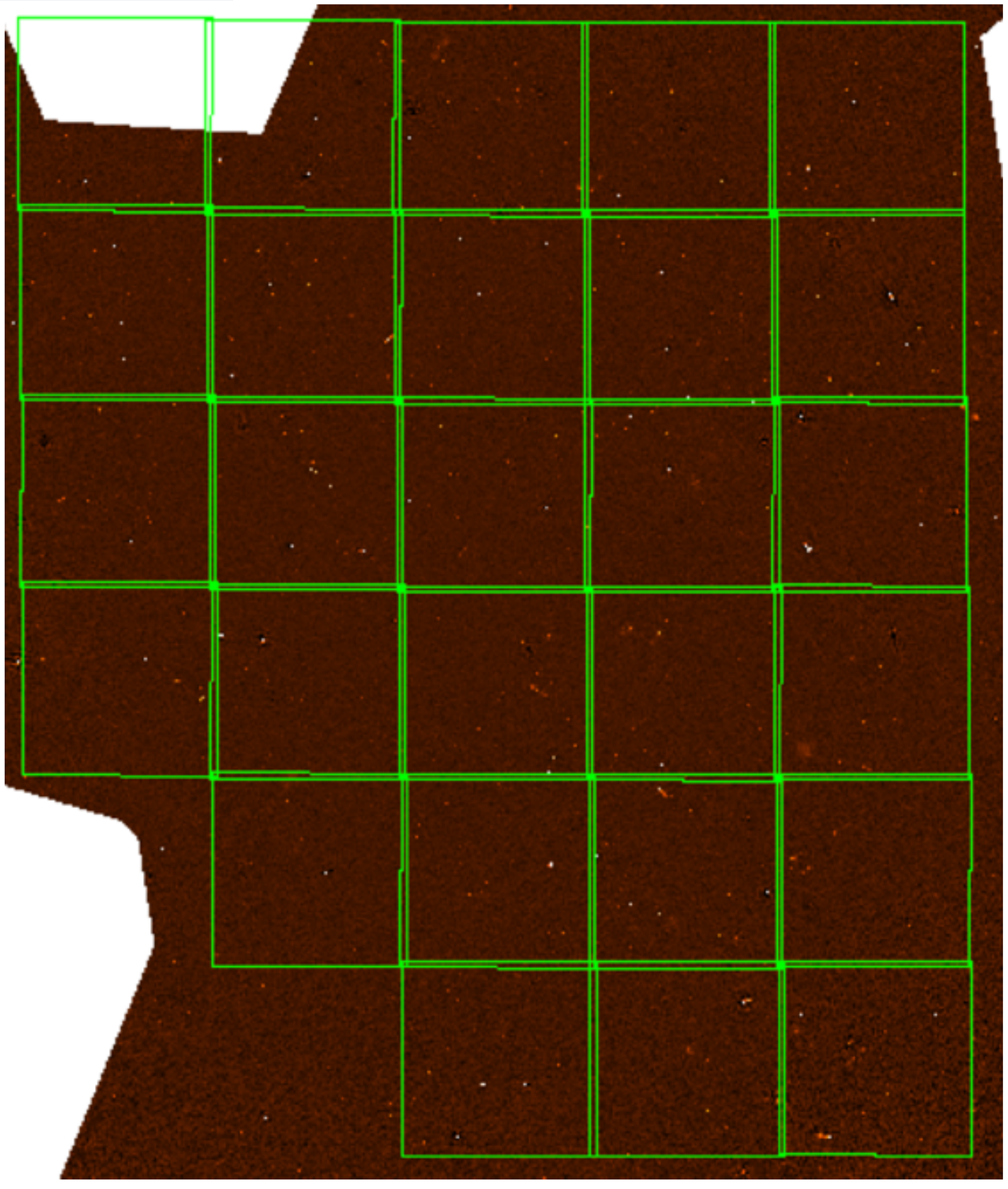
2.
SAMPLE

SAMPLE: Bootes field

Wendy Williams+(in prep)



- rms ~ 135 μJy
- resolution: ~ 5″

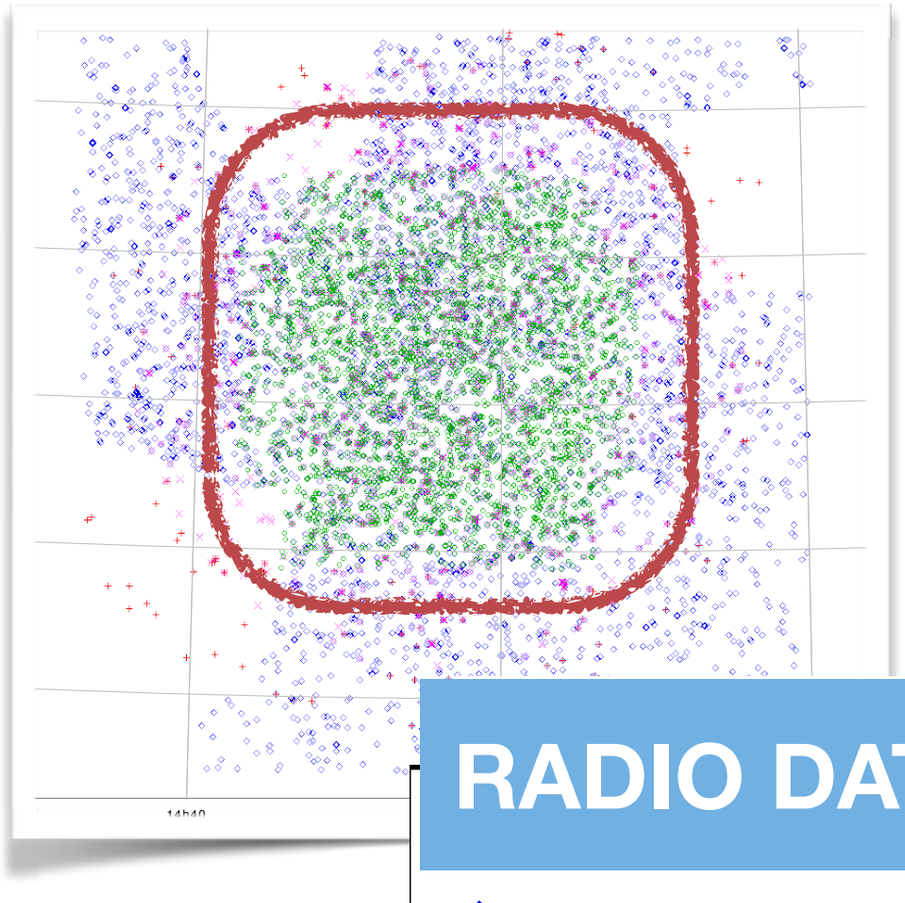


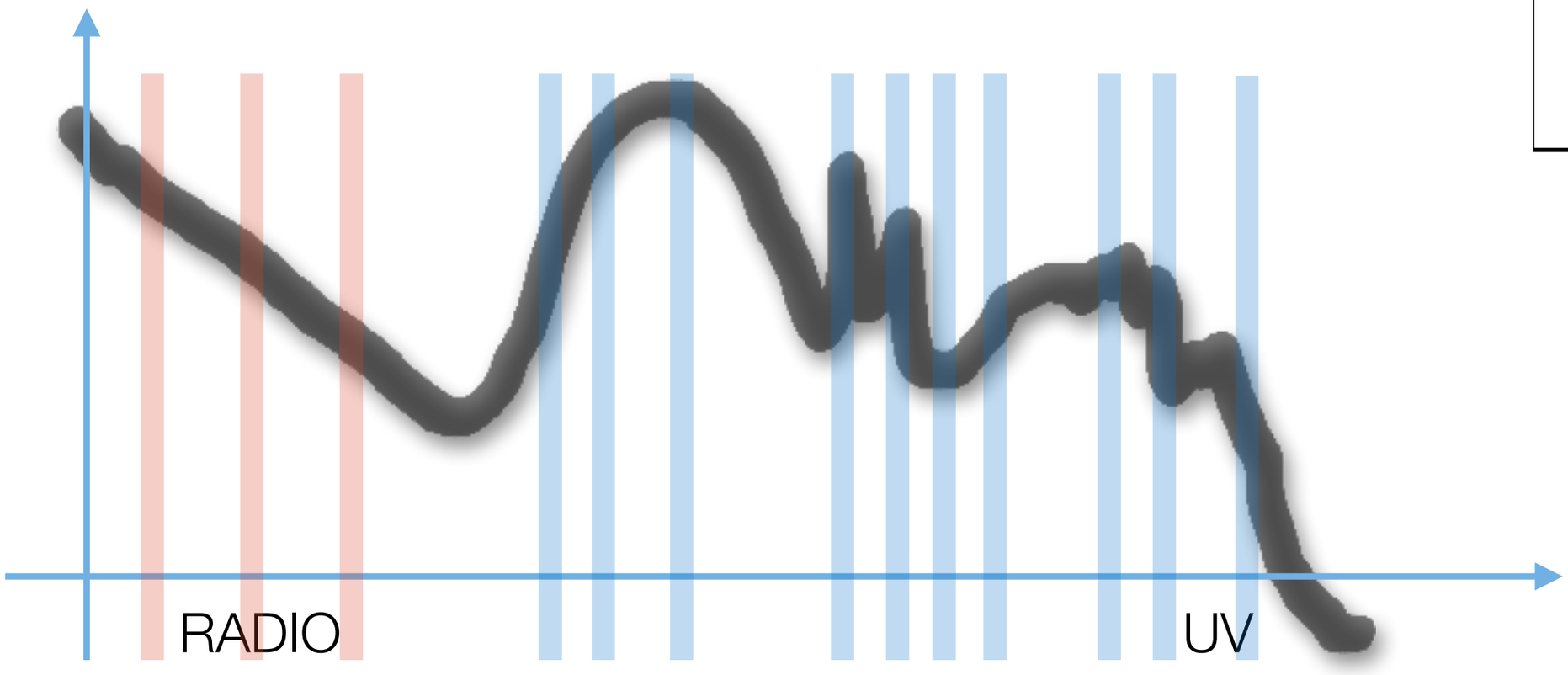
SAMPLE: DATA

- **Large part of Böotes field : 5 deg2**
- **Rich multiwavelength coverage**

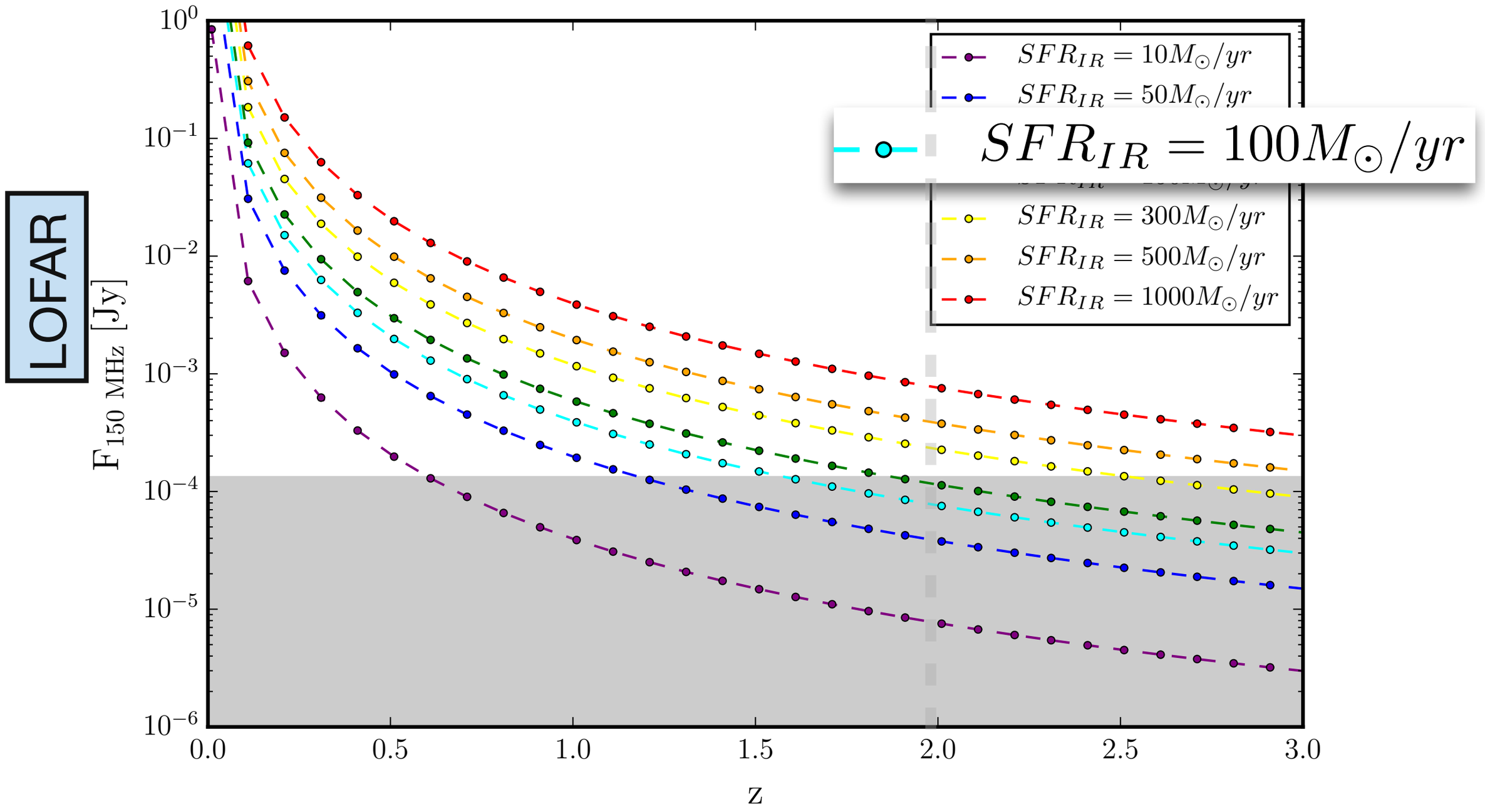
SELECTION:

- **I-band and LOFAR 150 MHz**



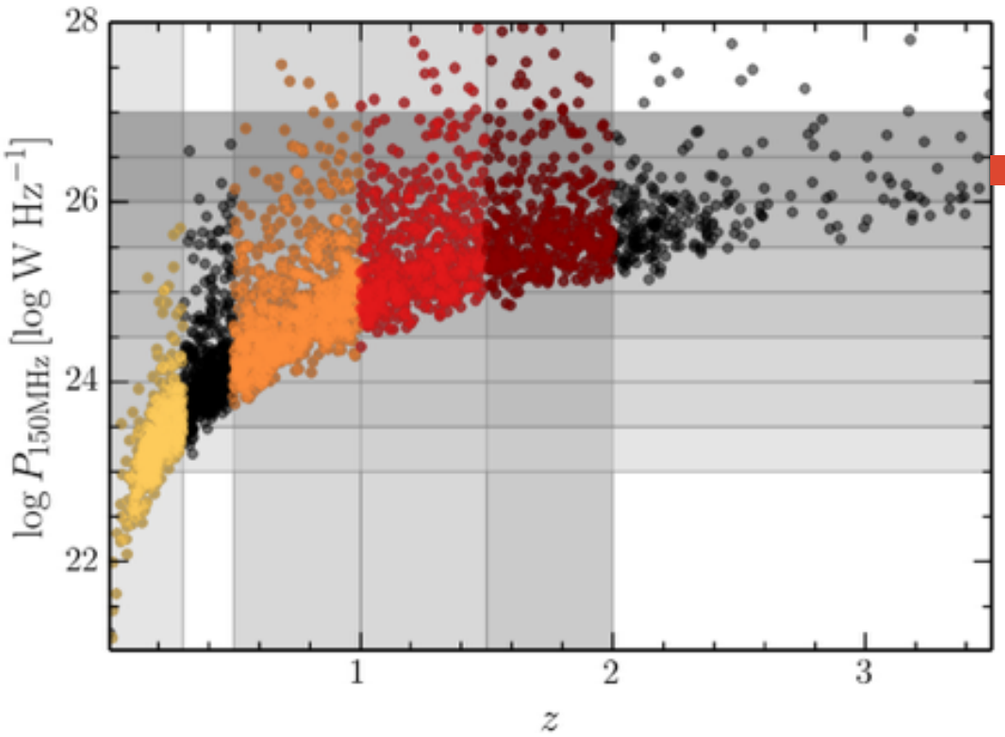


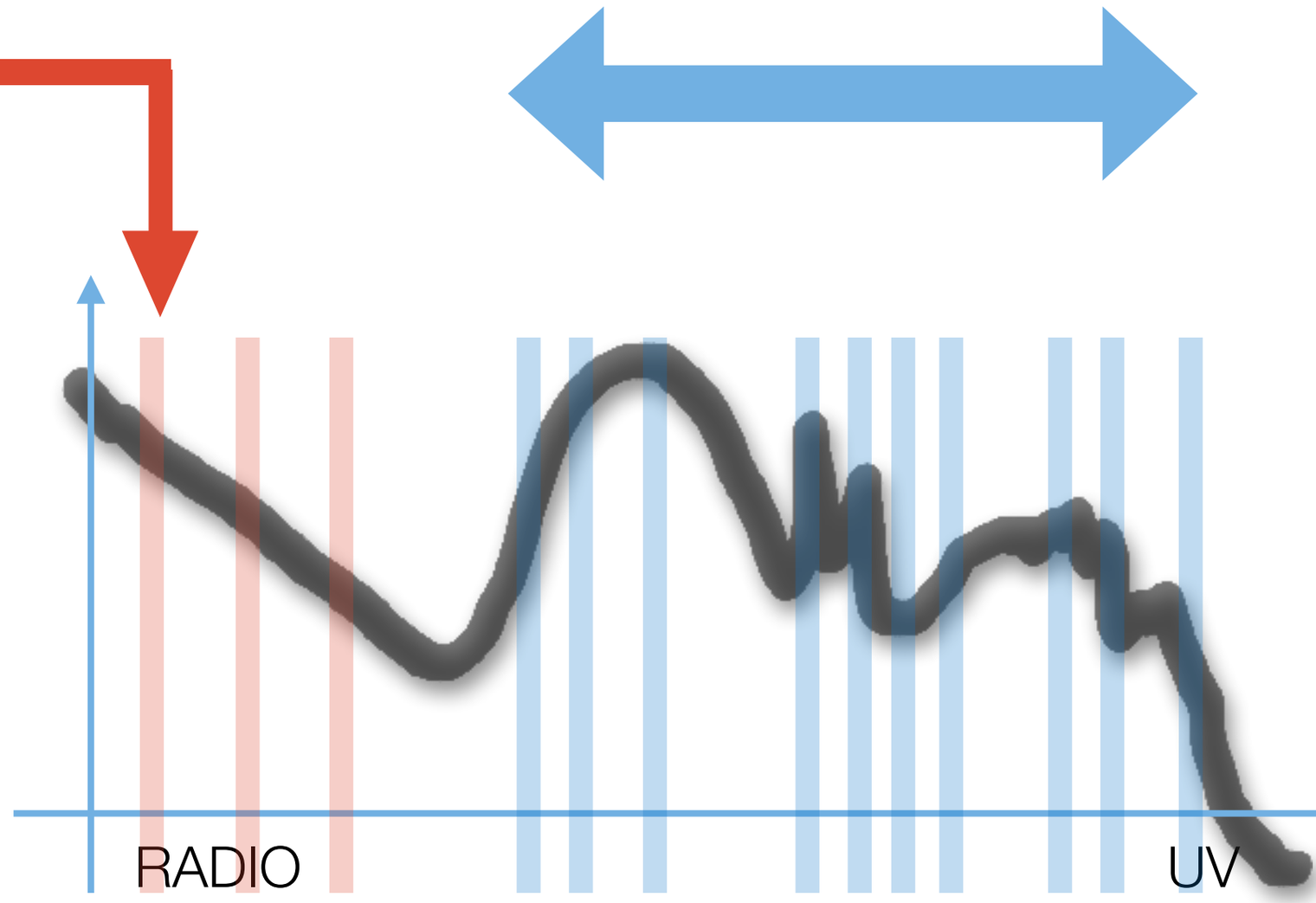
SAMPLE: SELECTION BIASES?



- **We are studying the most star-forming monsters!**

SAMPLE: SELECTION BIASES?



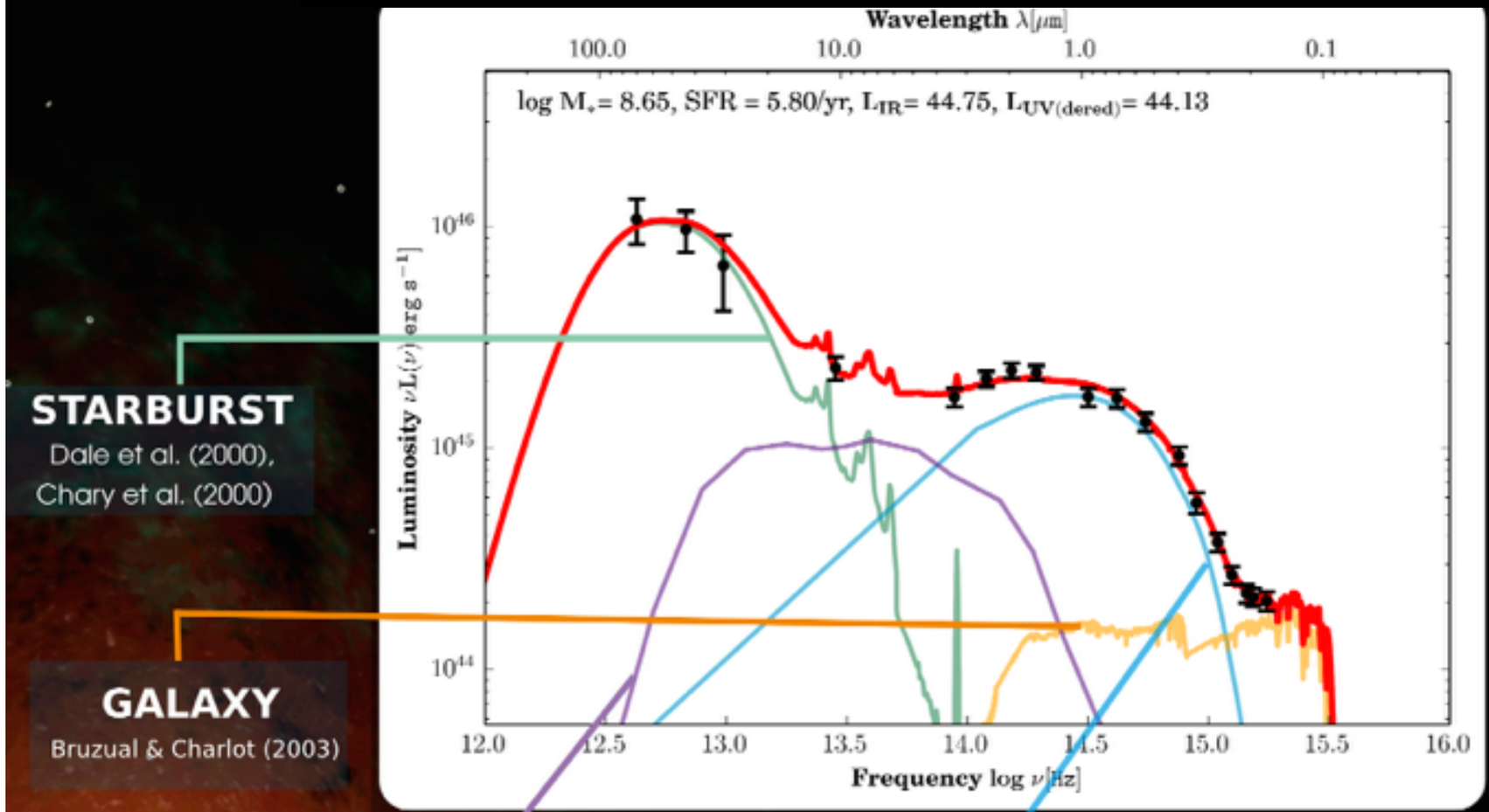


SAMPLE: DATA

- Bayesian SED-fitting with MCMC for AGN and galaxies:
- Degeneracies and correlations are taken into account.

AGN*fitter*

MCMC SED fitting
of AGN and Galaxies

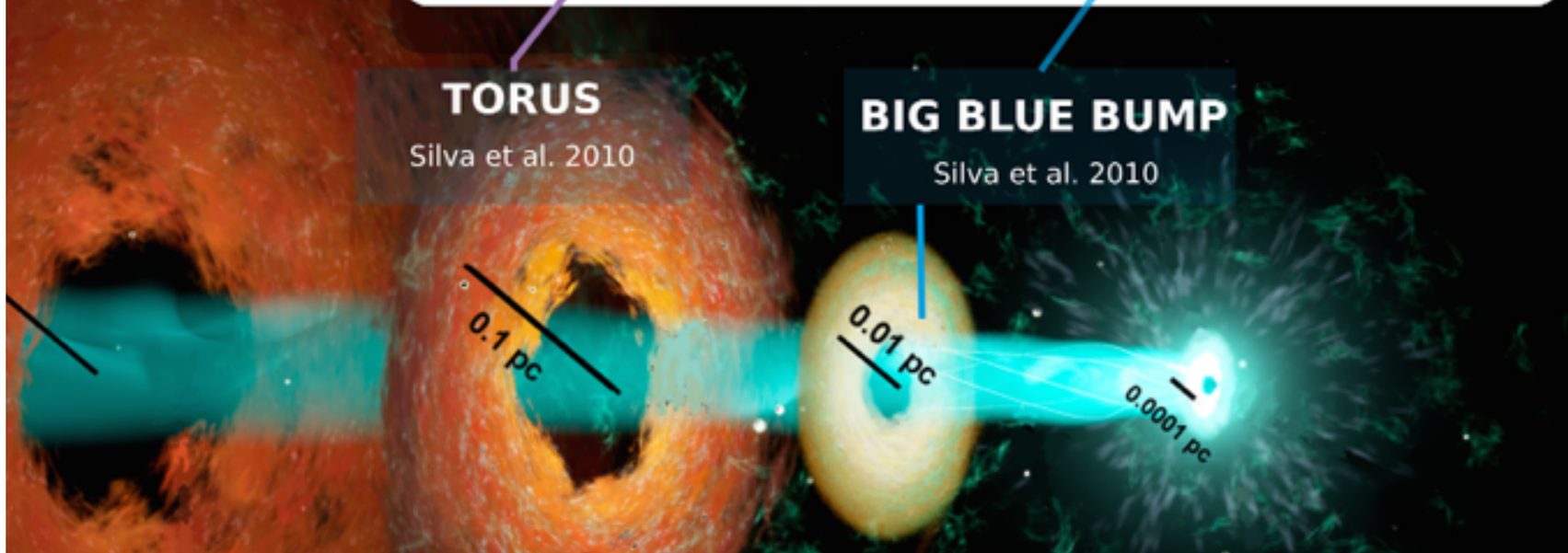


STARBURST
Dale et al. (2000),
Chary et al. (2000)

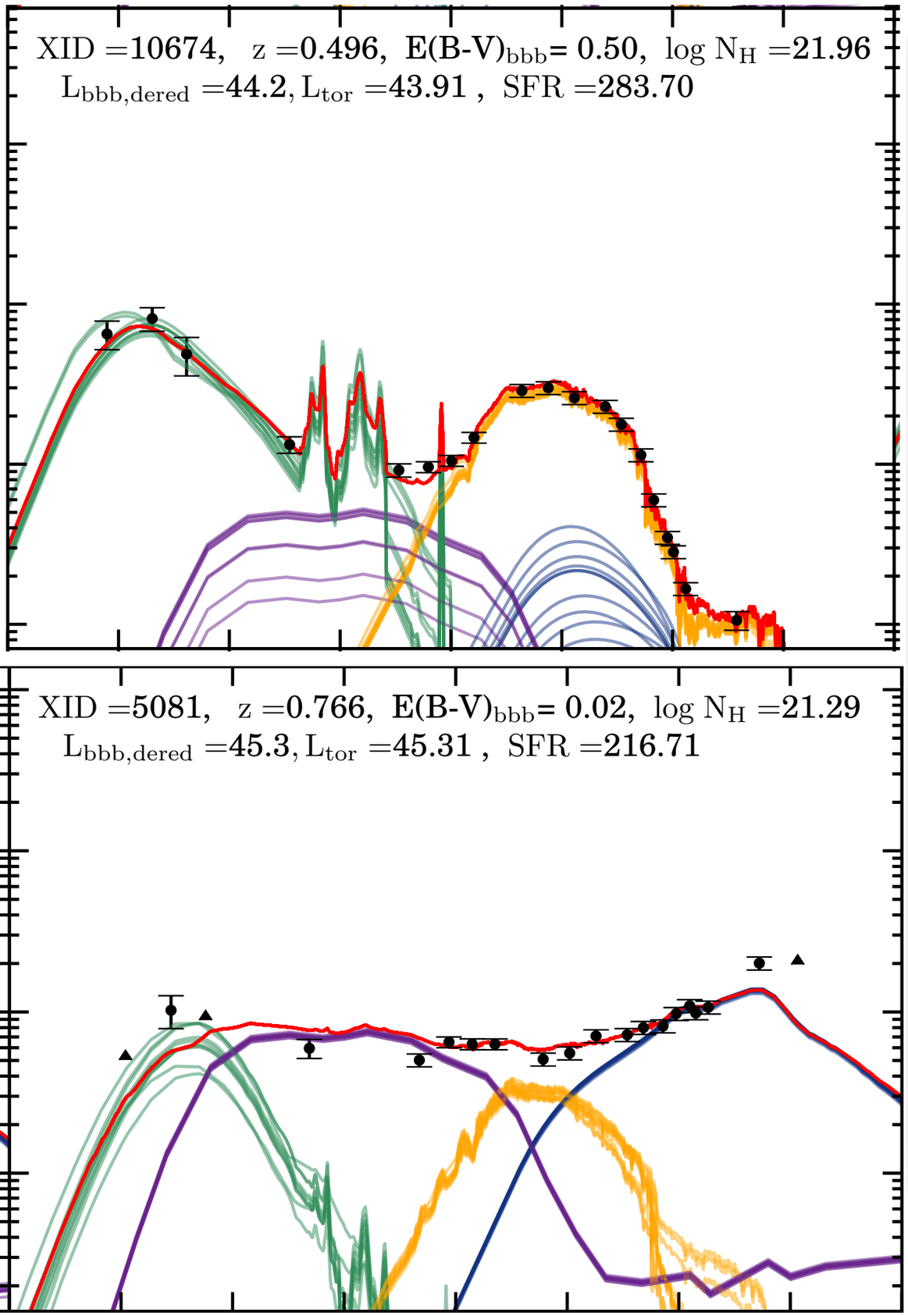
GALAXY
Bruzual & Charlot (2003)

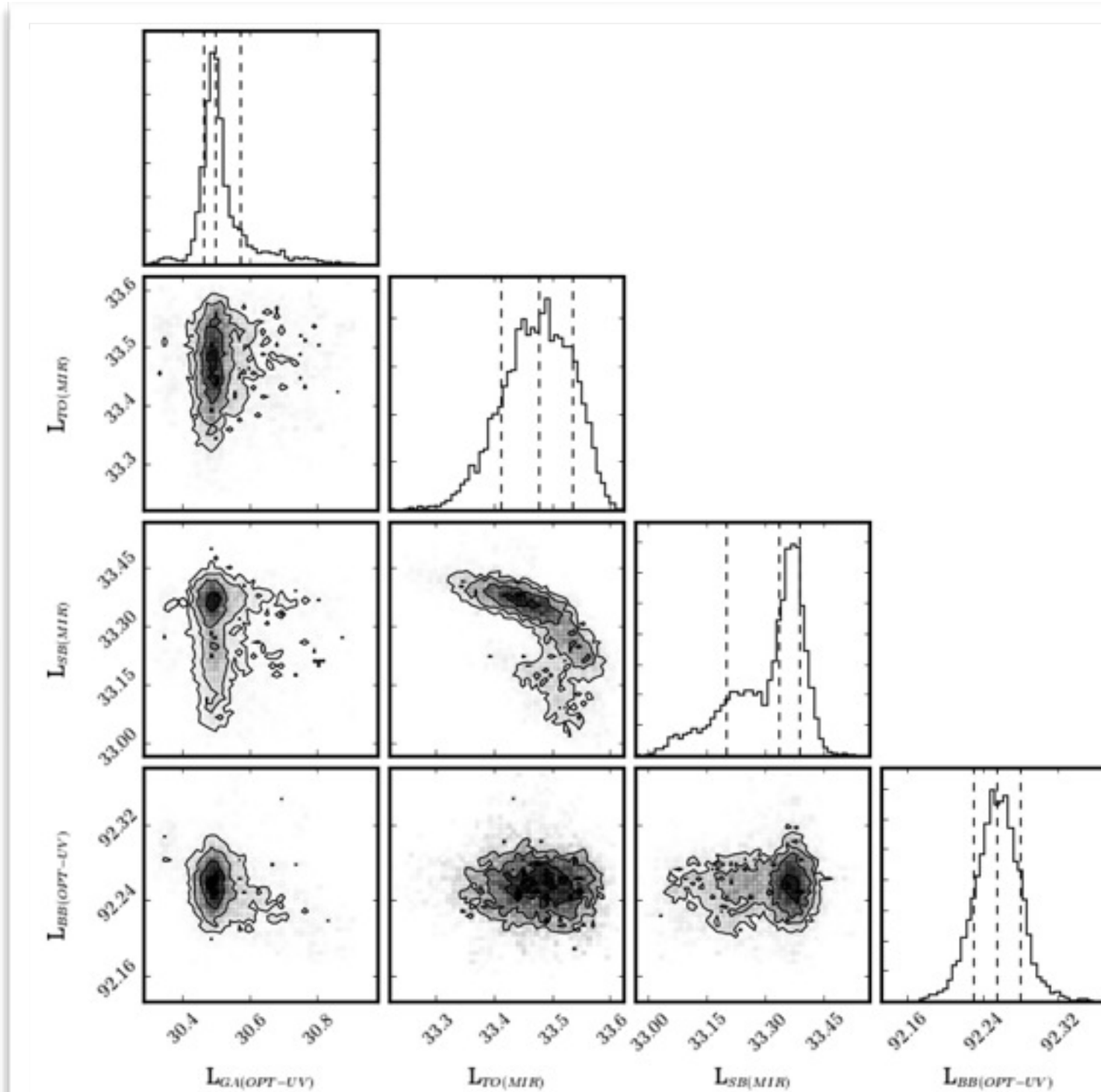
TORUS
Silva et al. 2010

BIG BLUE BUMP
Silva et al. 2010



SAMPLE: SELECTION SED-fitting





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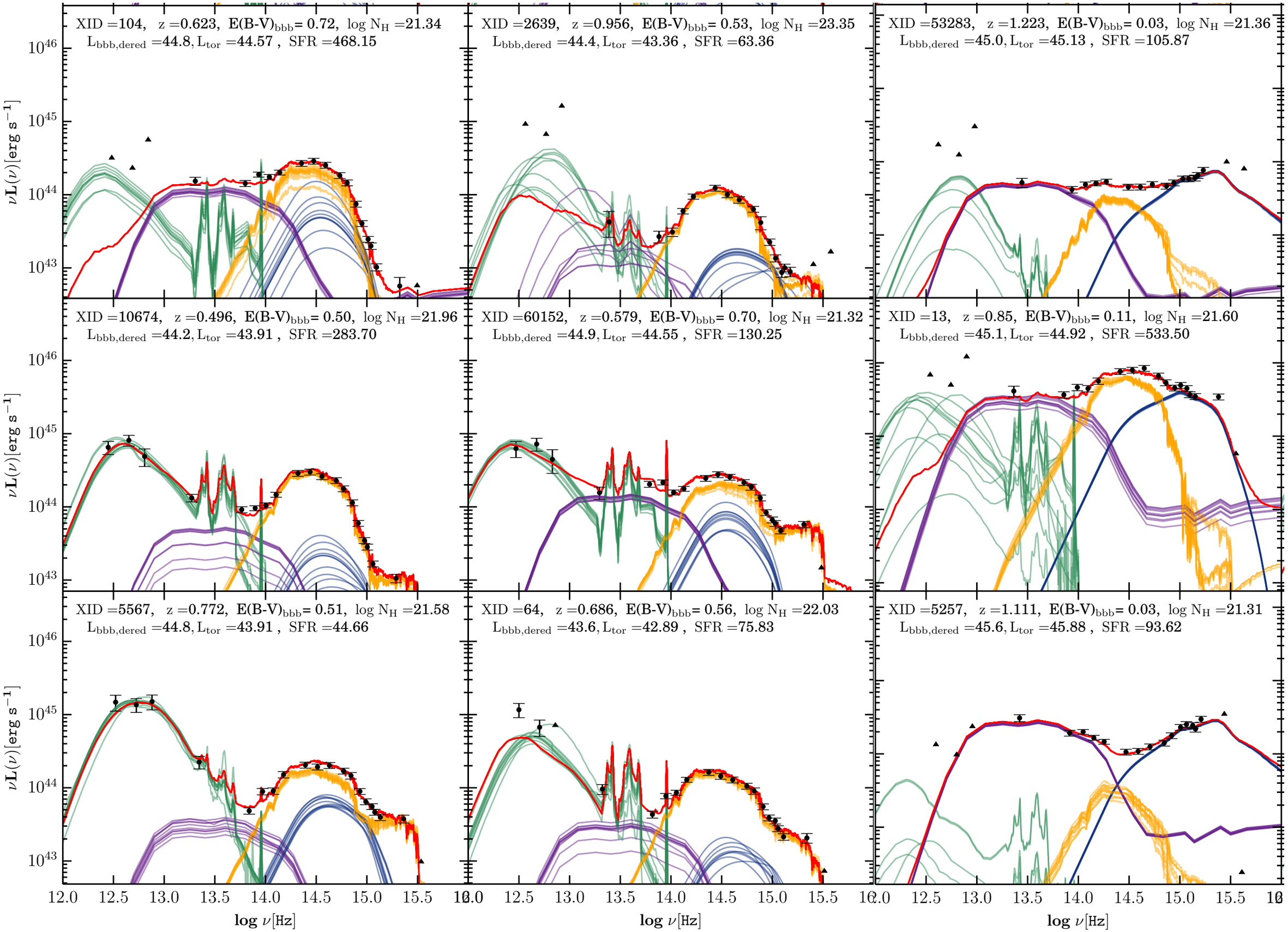
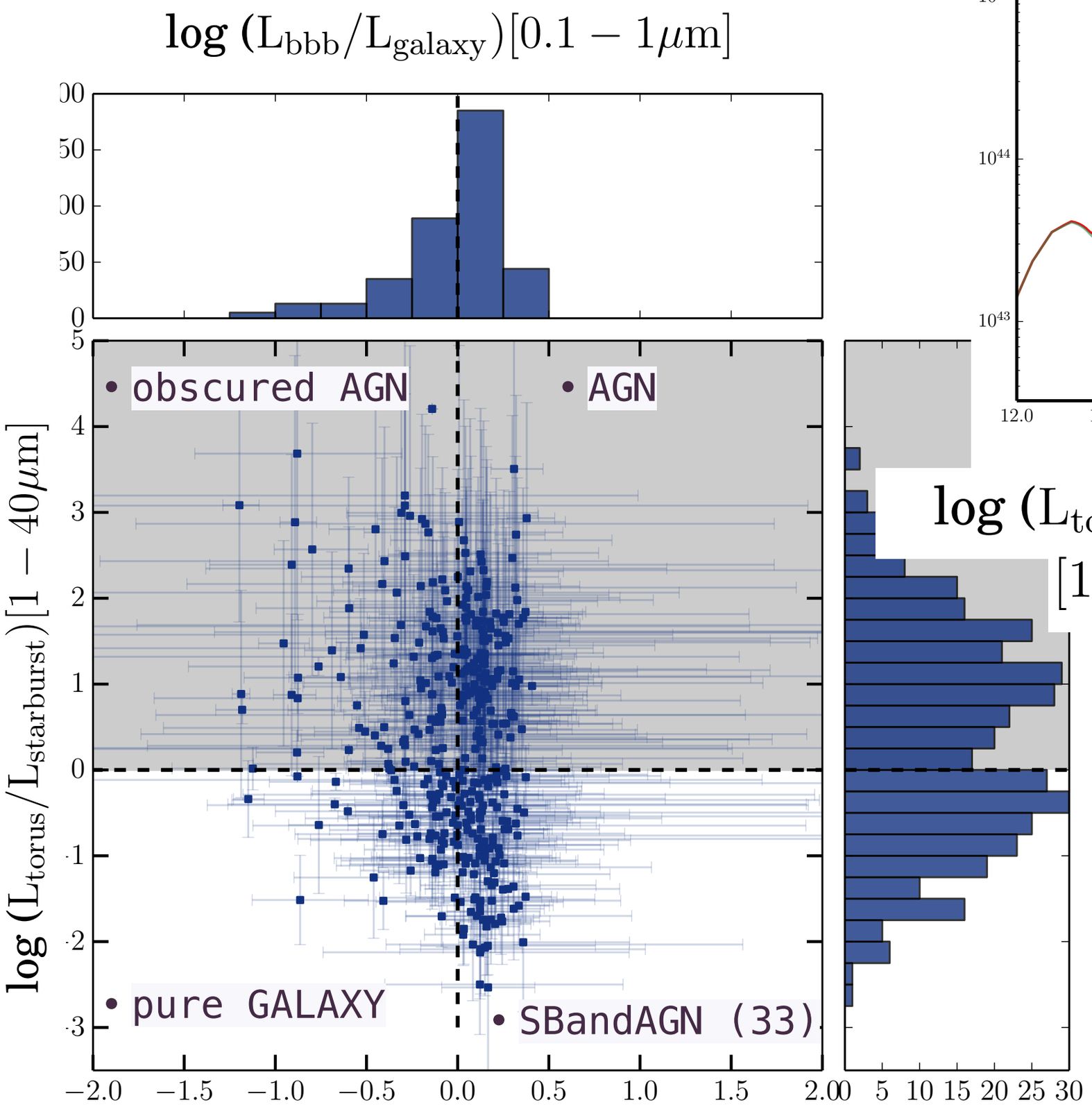
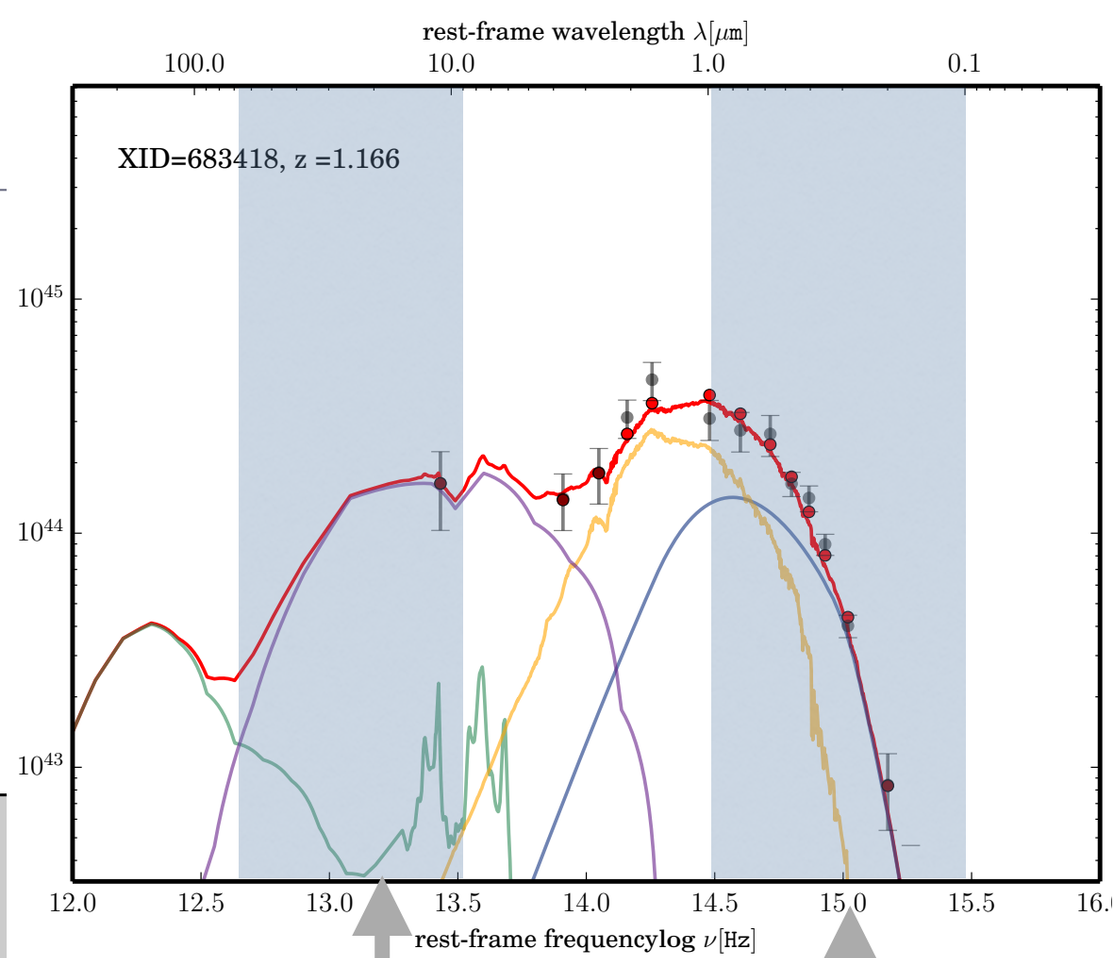


SAMPLE: SELECTION SED-fitting

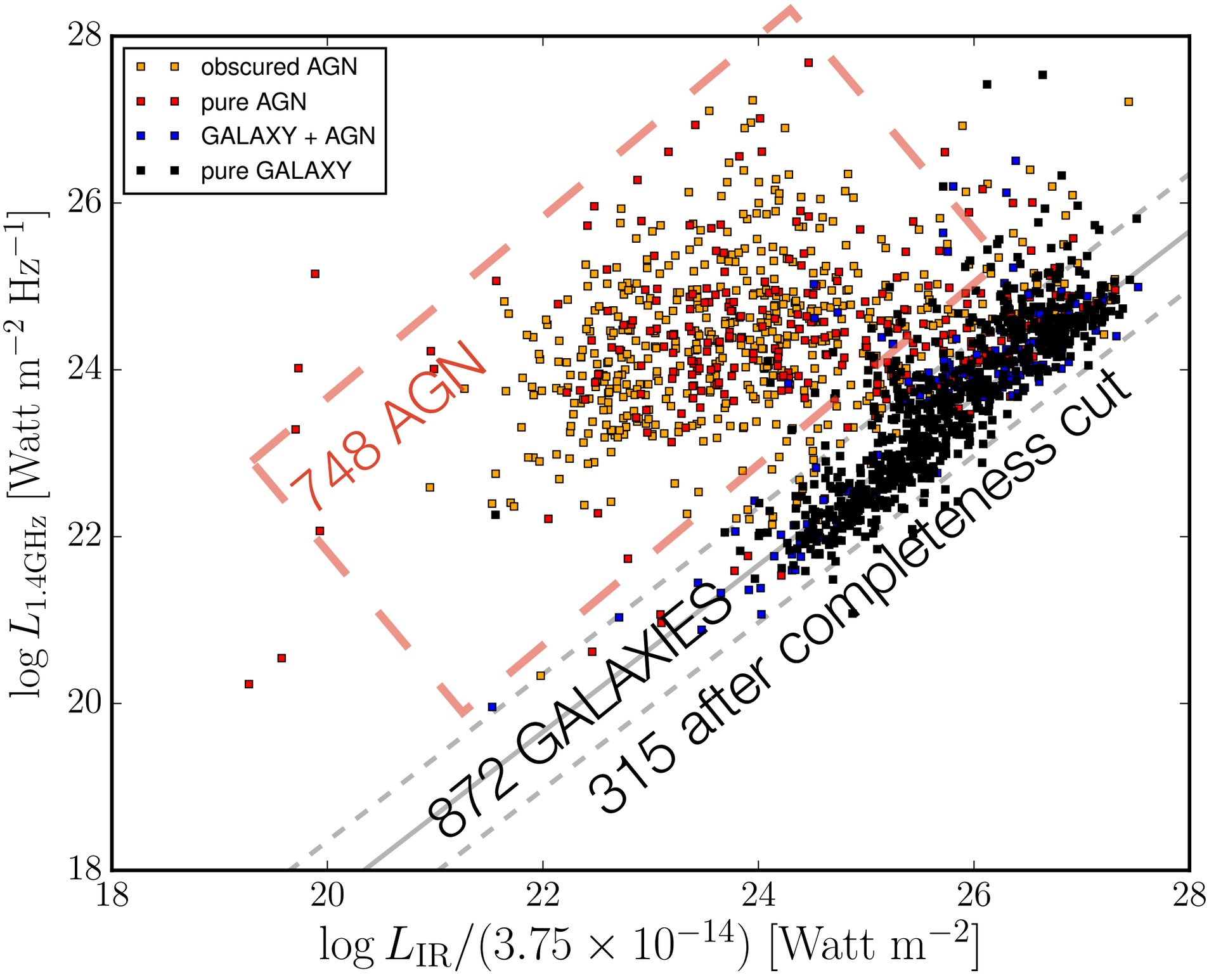




log (L_torus/L_starburst) [1 − 40μm]

log (L_bbb/L_galaxy) [0.1 − 1μm]

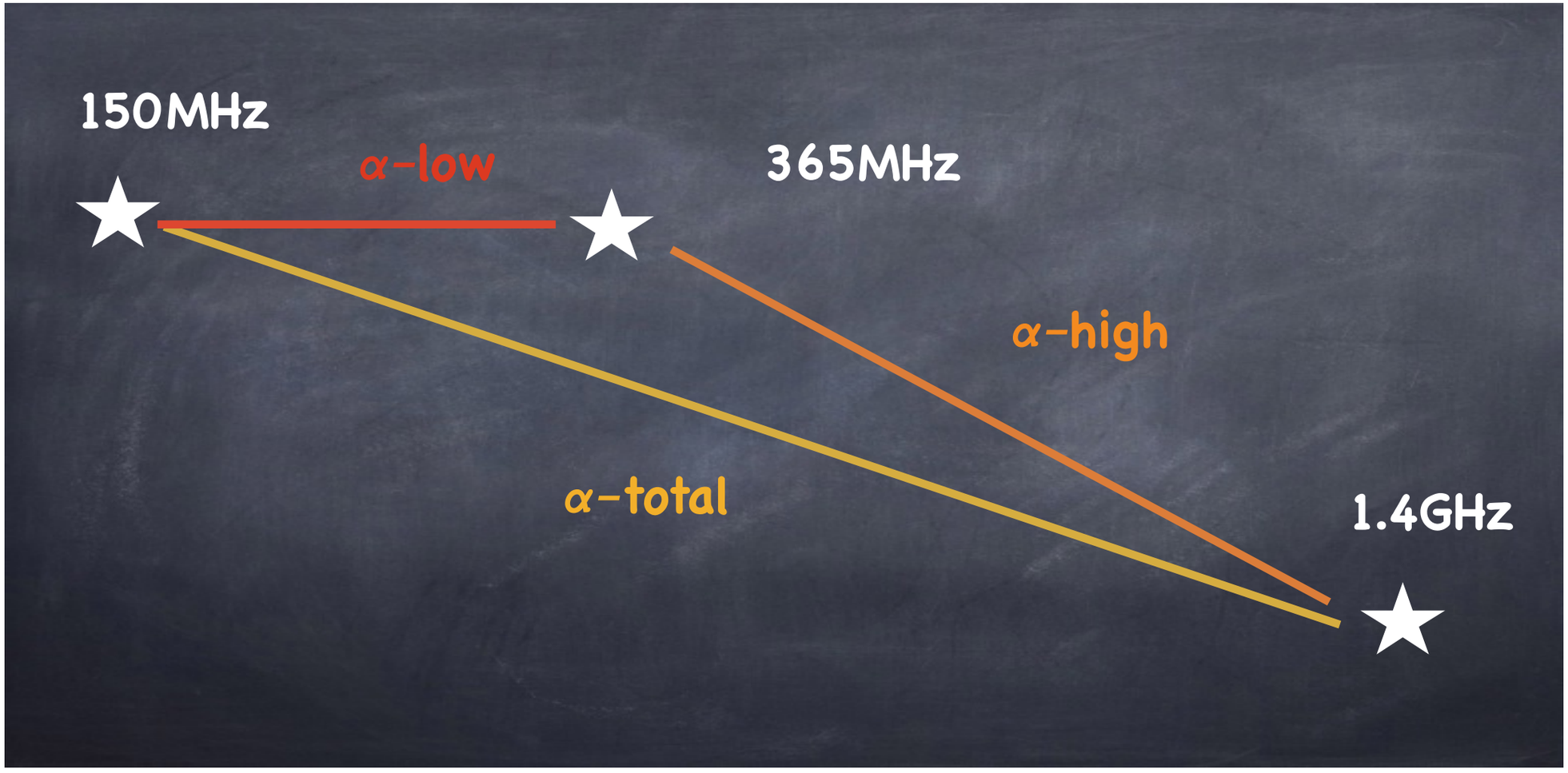
SAMPLE: SELECTION THROUGH SED-fitting



3.
RADIO CONTINUUM OF STARBURSTS

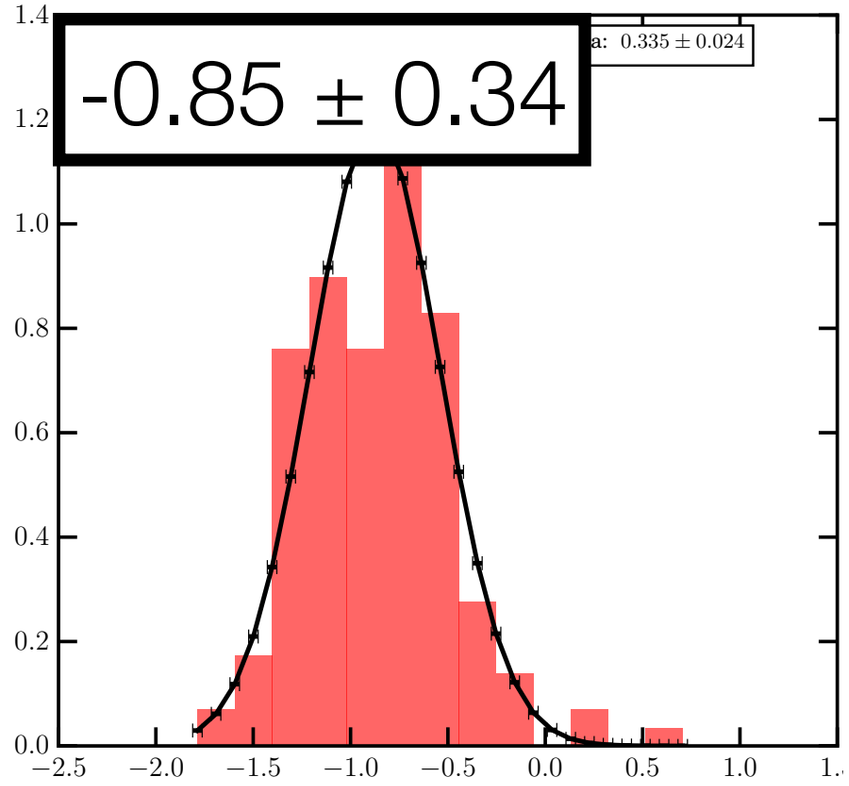
RADIO CONTINUUM

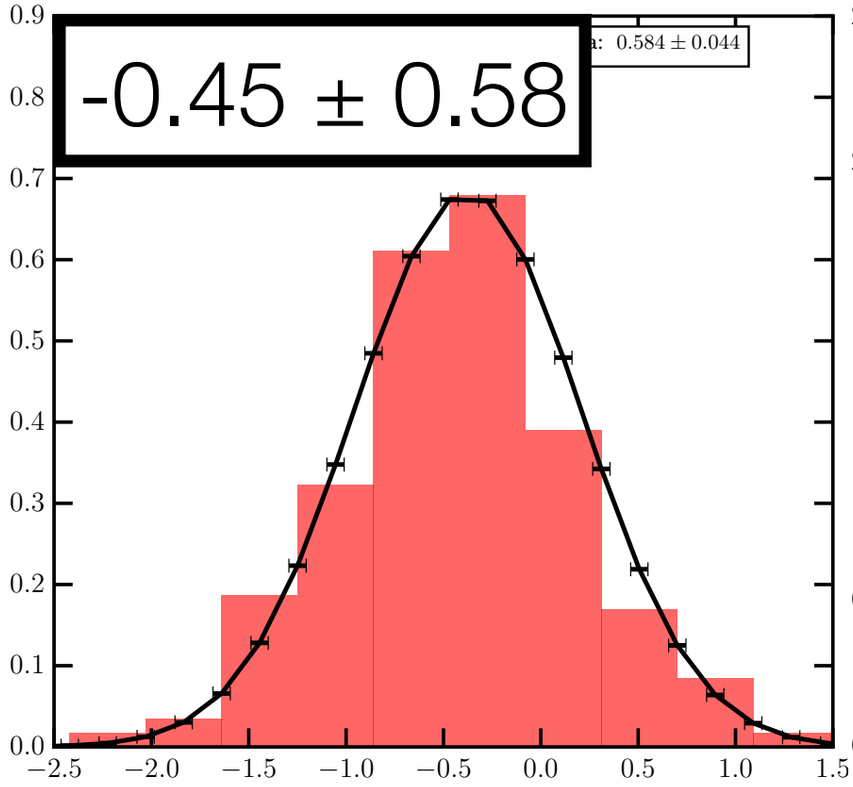
IS THE SPECTRAL INDEX CONSTANT?

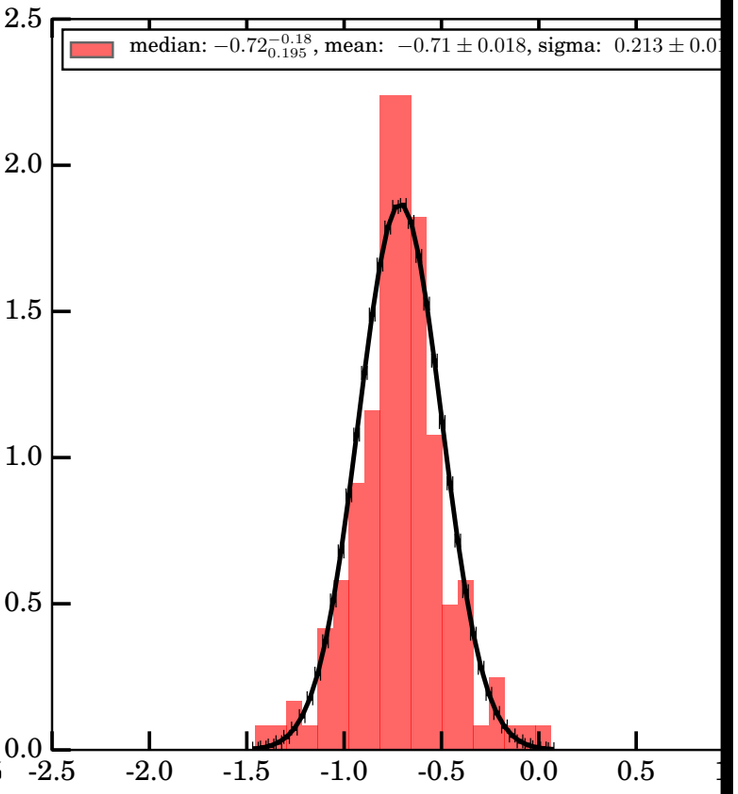


Canonical value,
mostly observed in α-high
α = - 0.8

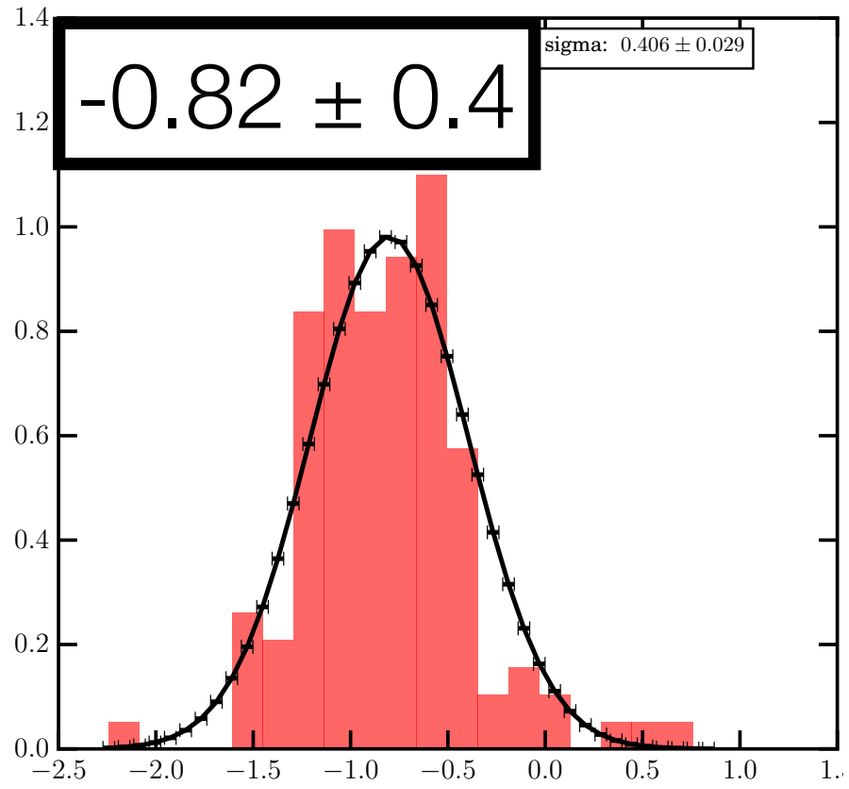
STARBURST

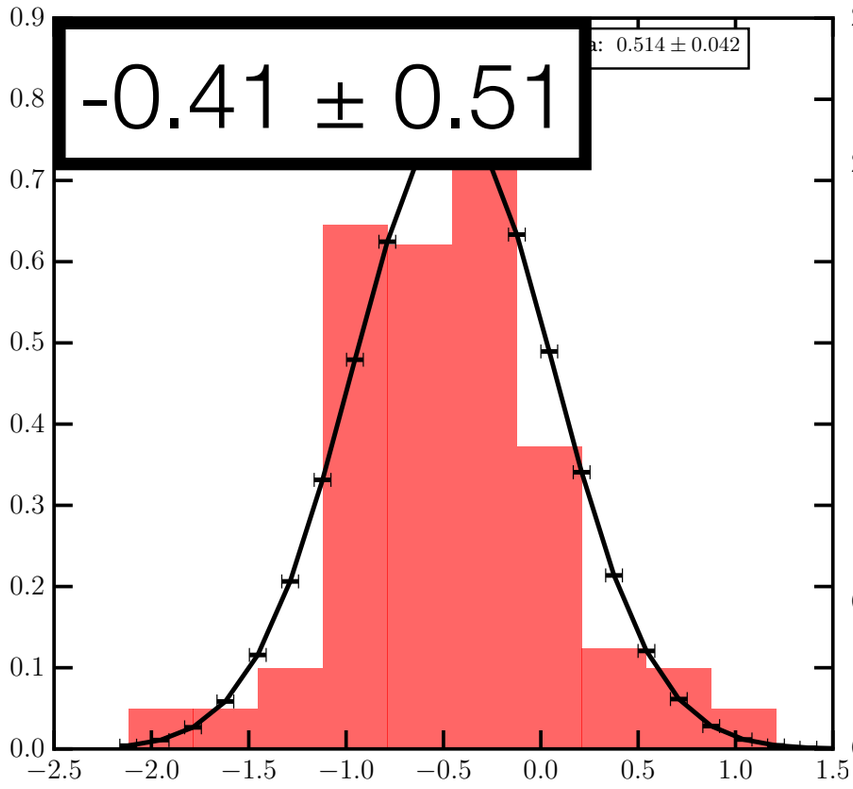


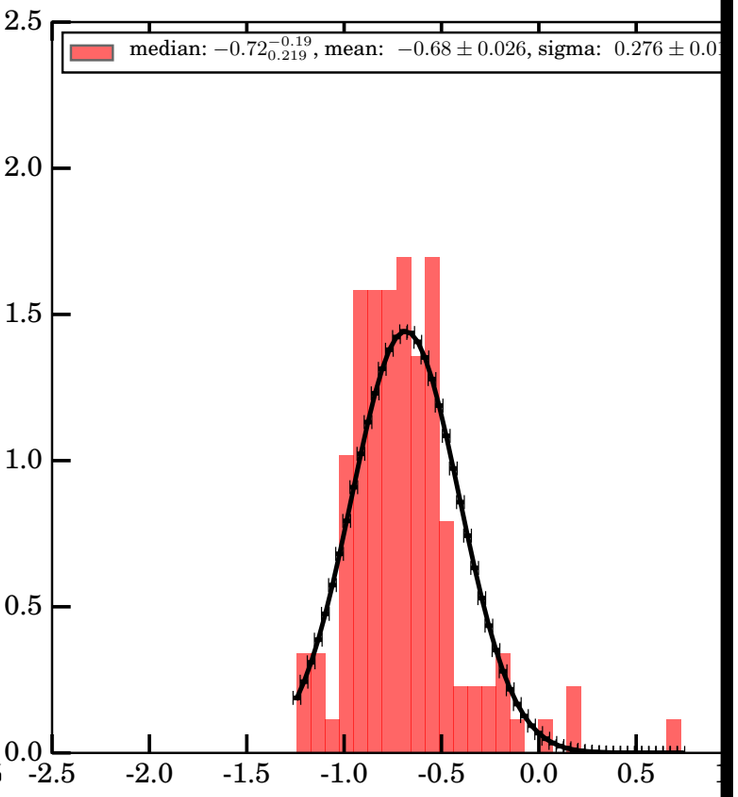




low-z



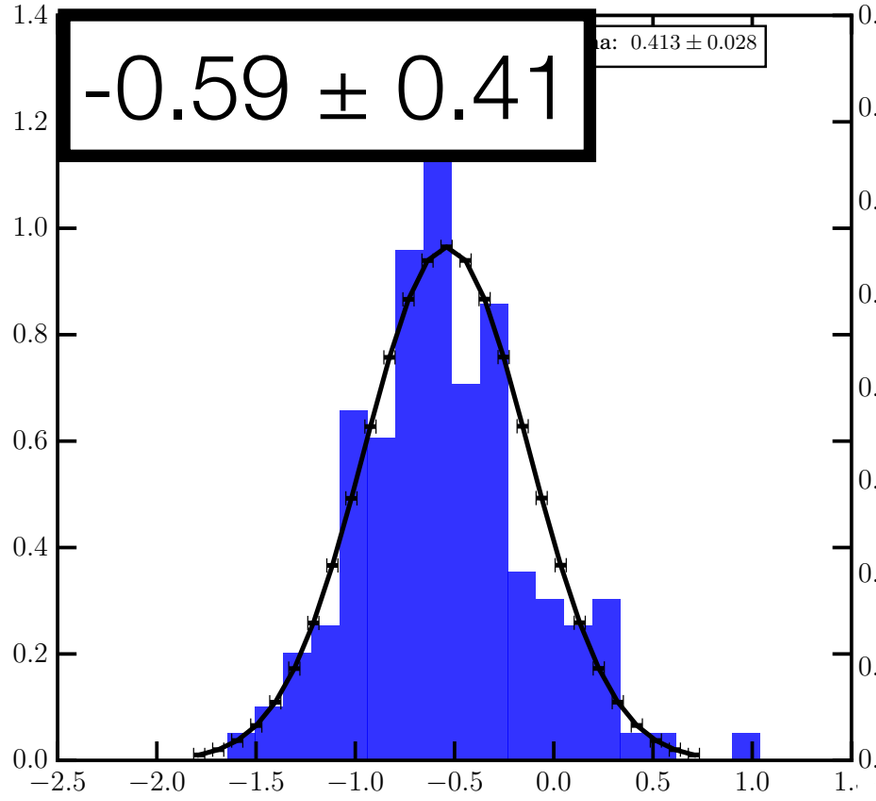




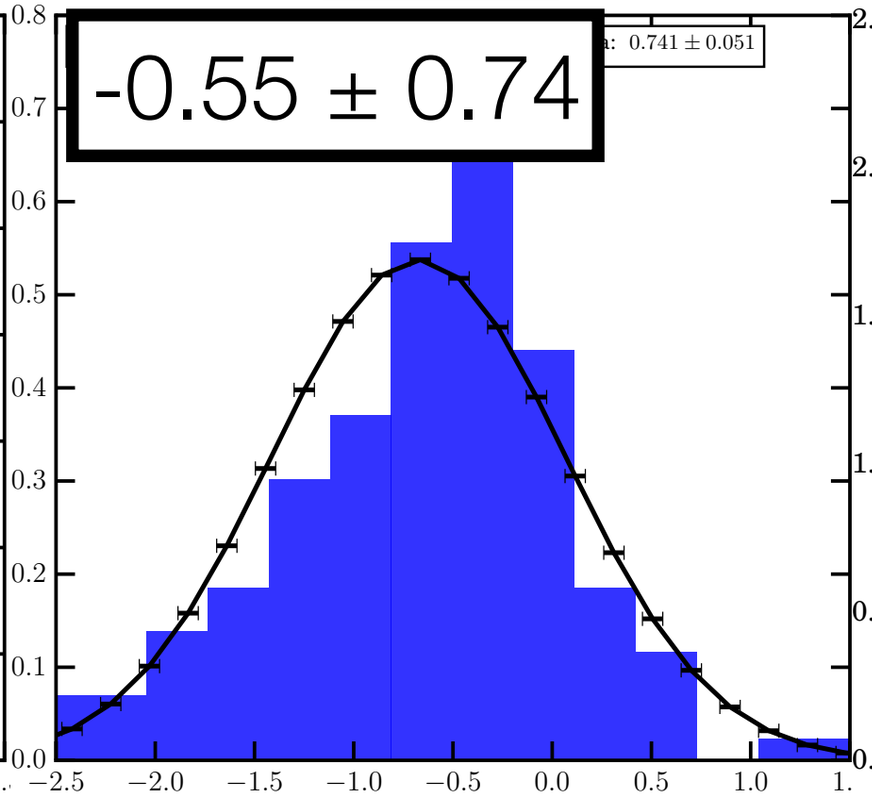
high-z

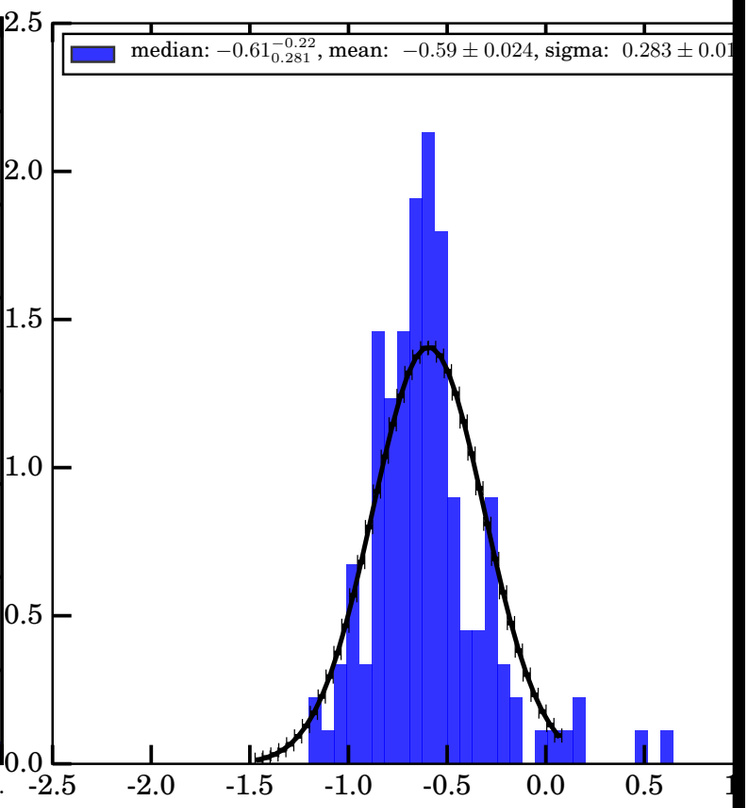
AGN

-0.59 ± 0.41



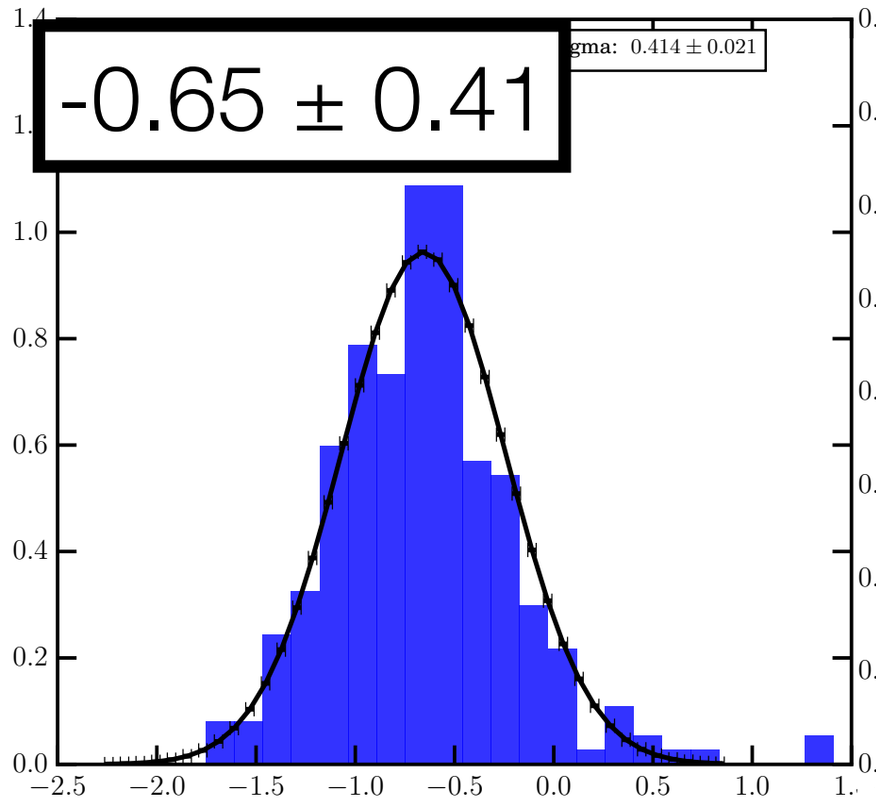
-0.55 ± 0.74



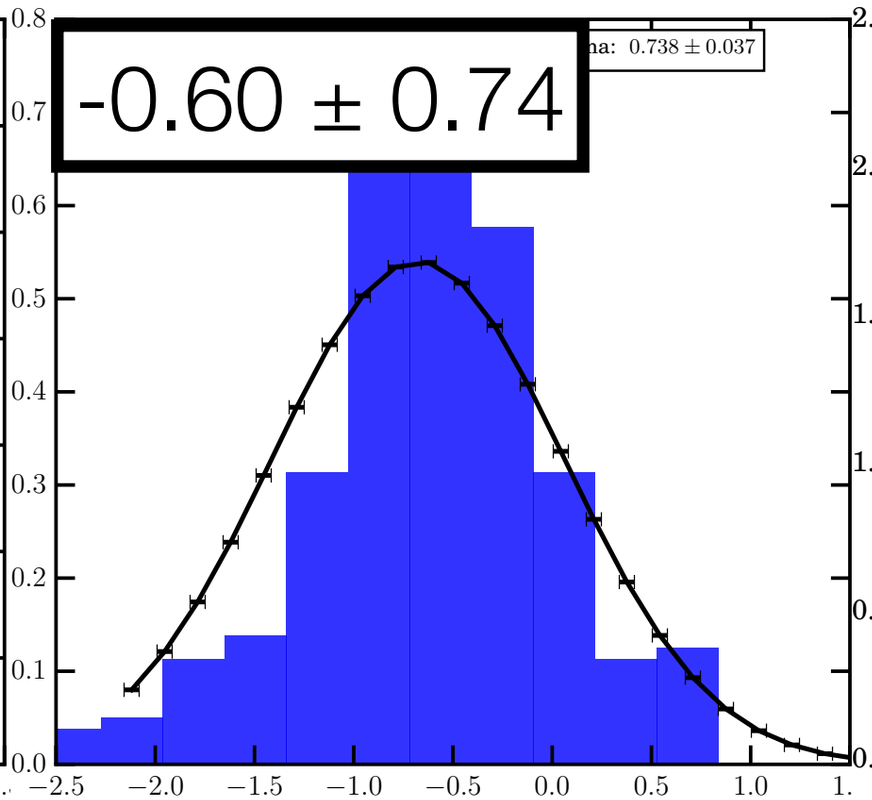


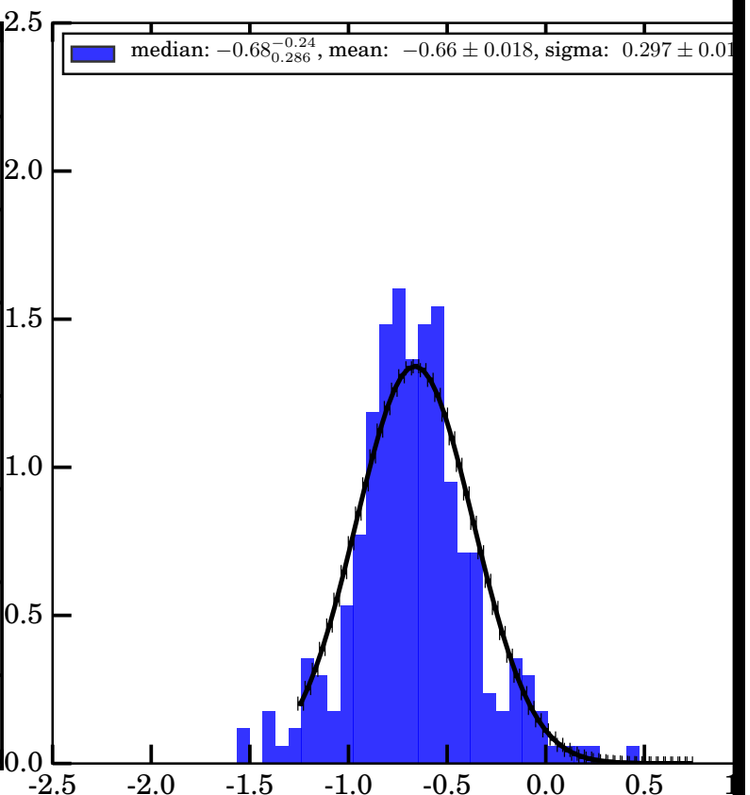
low-z

-0.65 ± 0.41



-0.60 ± 0.74





high-z

4.
FIR-RADIO CORRELATION OF STARBURSTS

$$q \equiv \log\left(\frac{\mathrm{FIR}}{3.75 \times 10^{12}\ \mathrm{W\ m^{-2}}}\right) - \log\left(\frac{S_{1.4\ \mathrm{GHz}}}{\mathrm{W\ m^{-2}\ Hz^{-1}}}\right)$$

FIR-RADIO CORRELATION

z- evolutior

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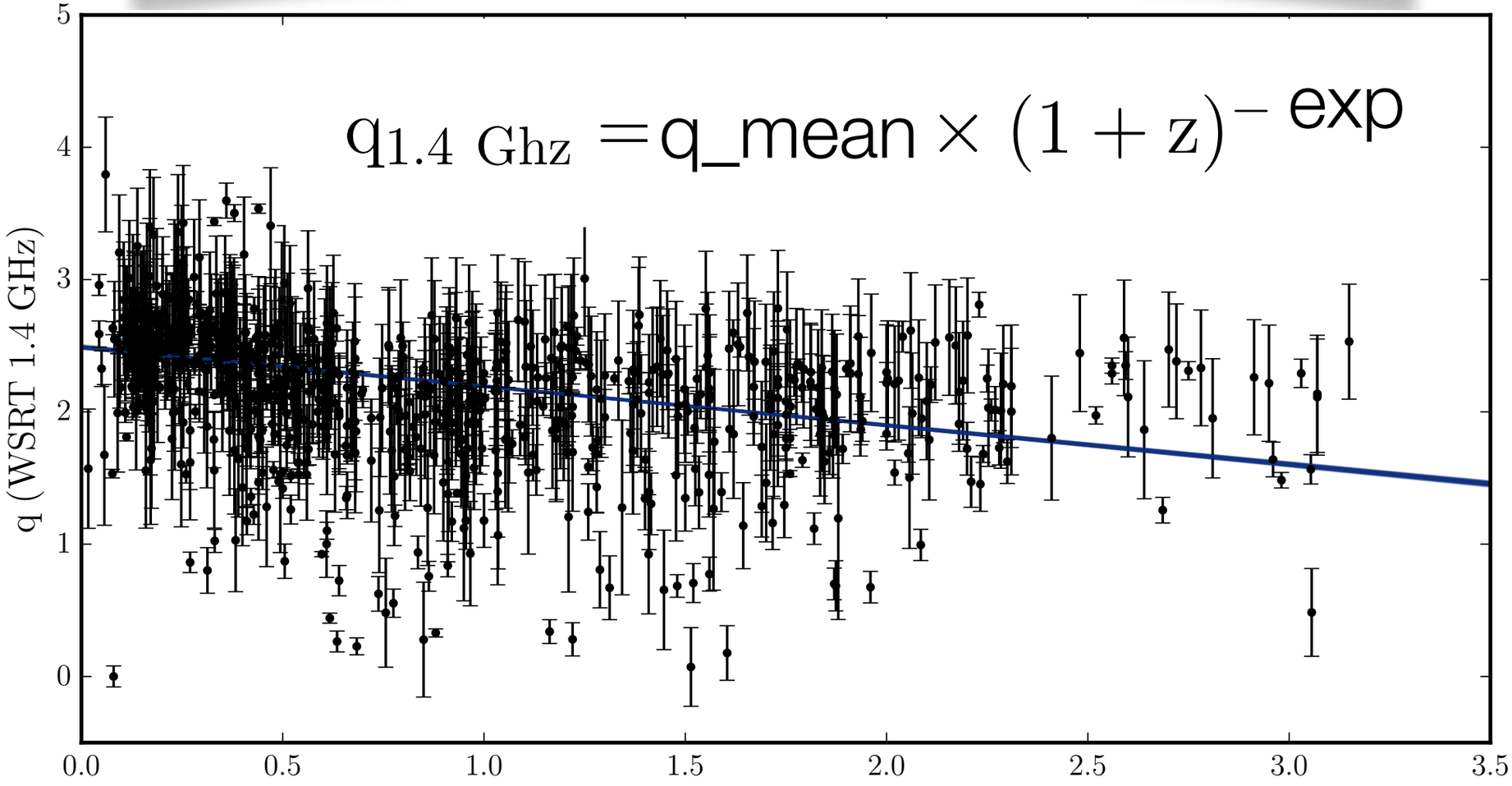


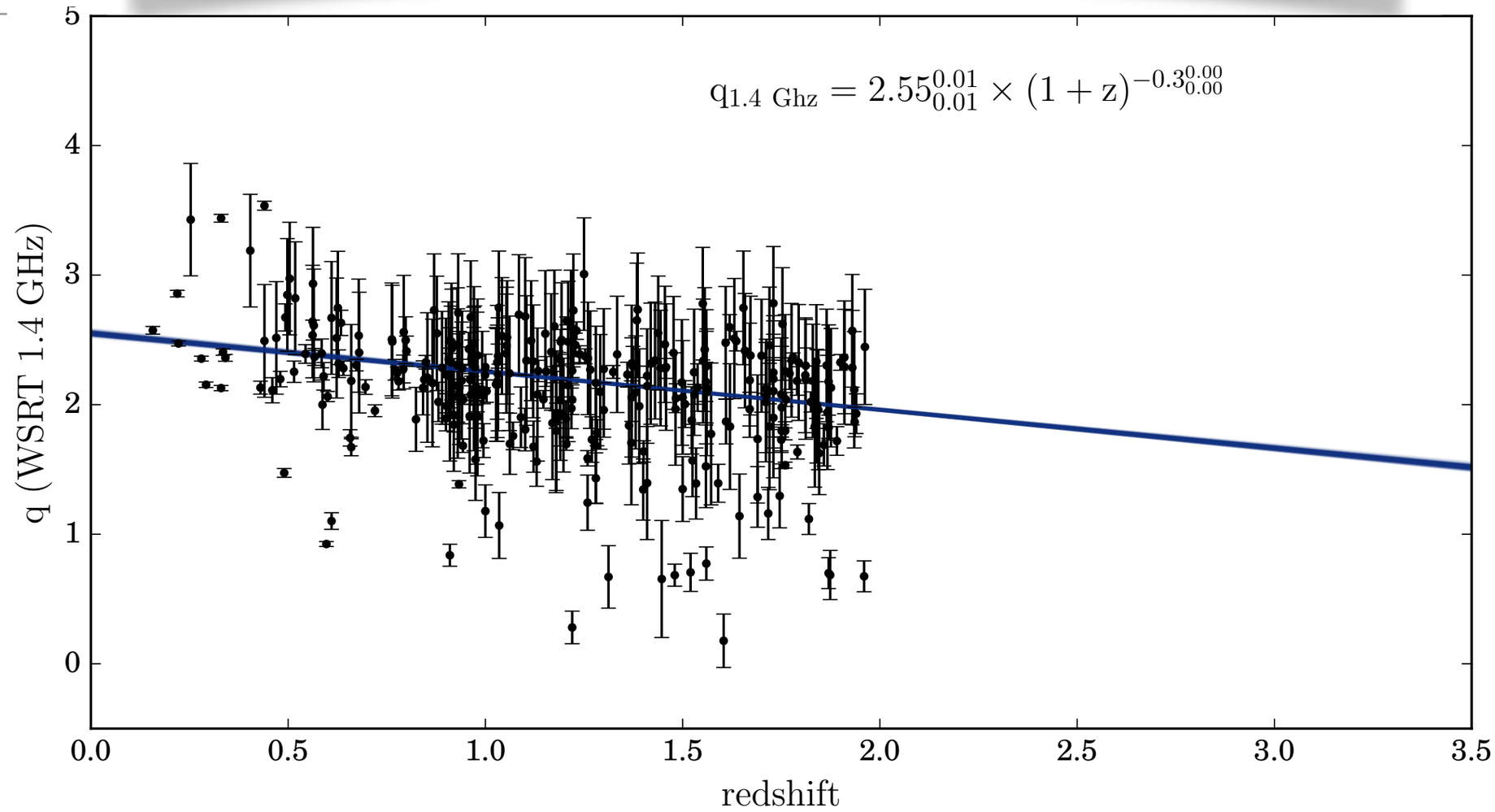
3.

- **q ~ 2.5±0.05**
- **FIR-radio (1.4GHz) correlation evolves with redshift as ~(1+z)$^{-0.3}$**
- Evolution of ISM properties with z
- Possible biased due to selection?

FIR-RADIO CORRELATION

z- evolution

$$q \equiv \log\left(\frac{\mathrm{FIR}}{3.75 \times 10^{12}\ \mathrm{W\ m^{-2}}}\right) - \log\left(\frac{S_{1.4\ \mathrm{GHz}}}{\mathrm{W\ m^{-2}\ Hz^{-1}}}\right)$$



3.

- **q ~ 2.5±0.05**
- **FIR-radio (1.4GHz) correlation evolves with redshift as ~$(1+z)^{-0.3}$**
- Evolution of ISM properties with z
- Only complete SFR bins: Evolution still holds

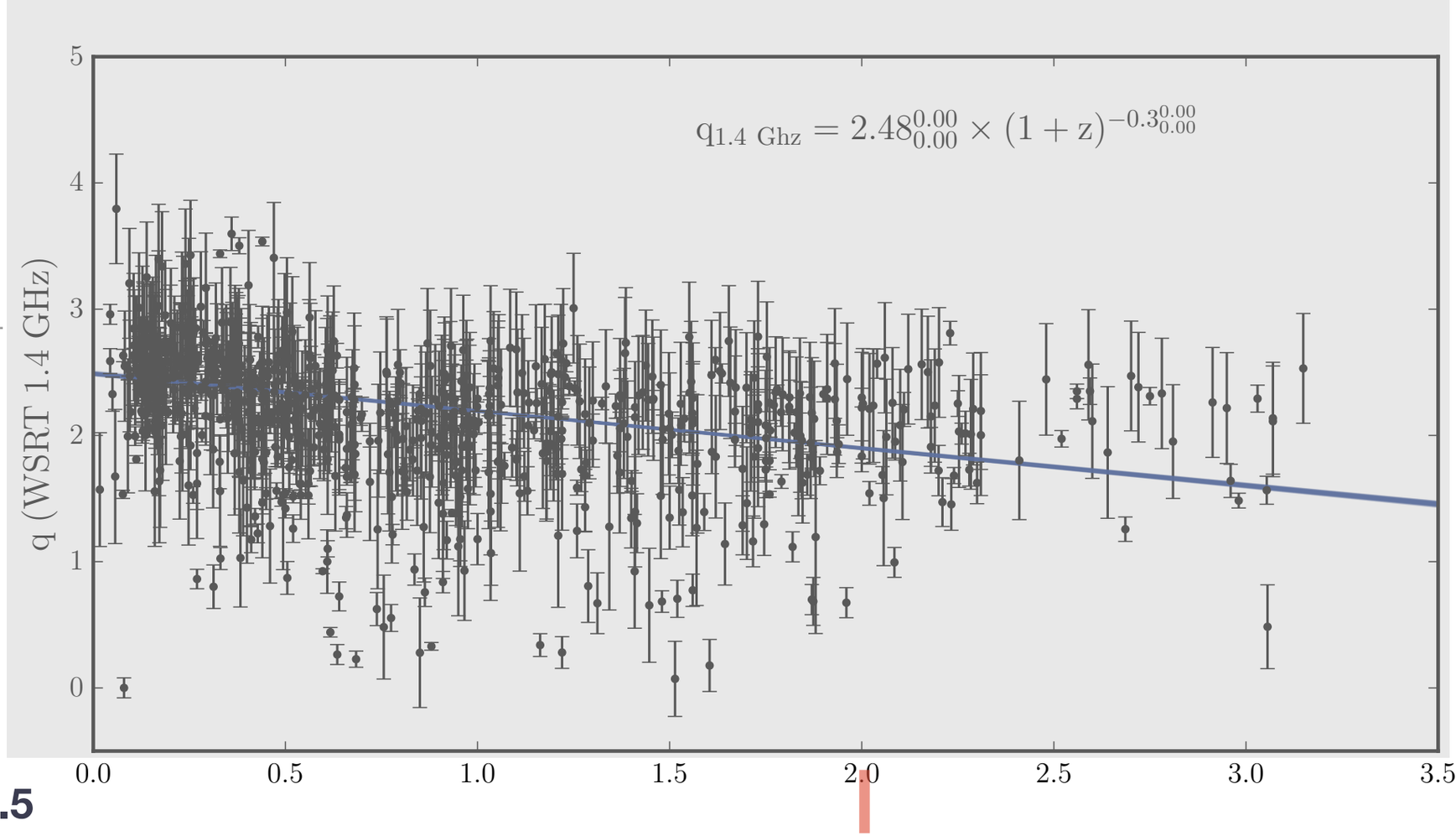
FIR-RADIO CORRELATION

z- evolution

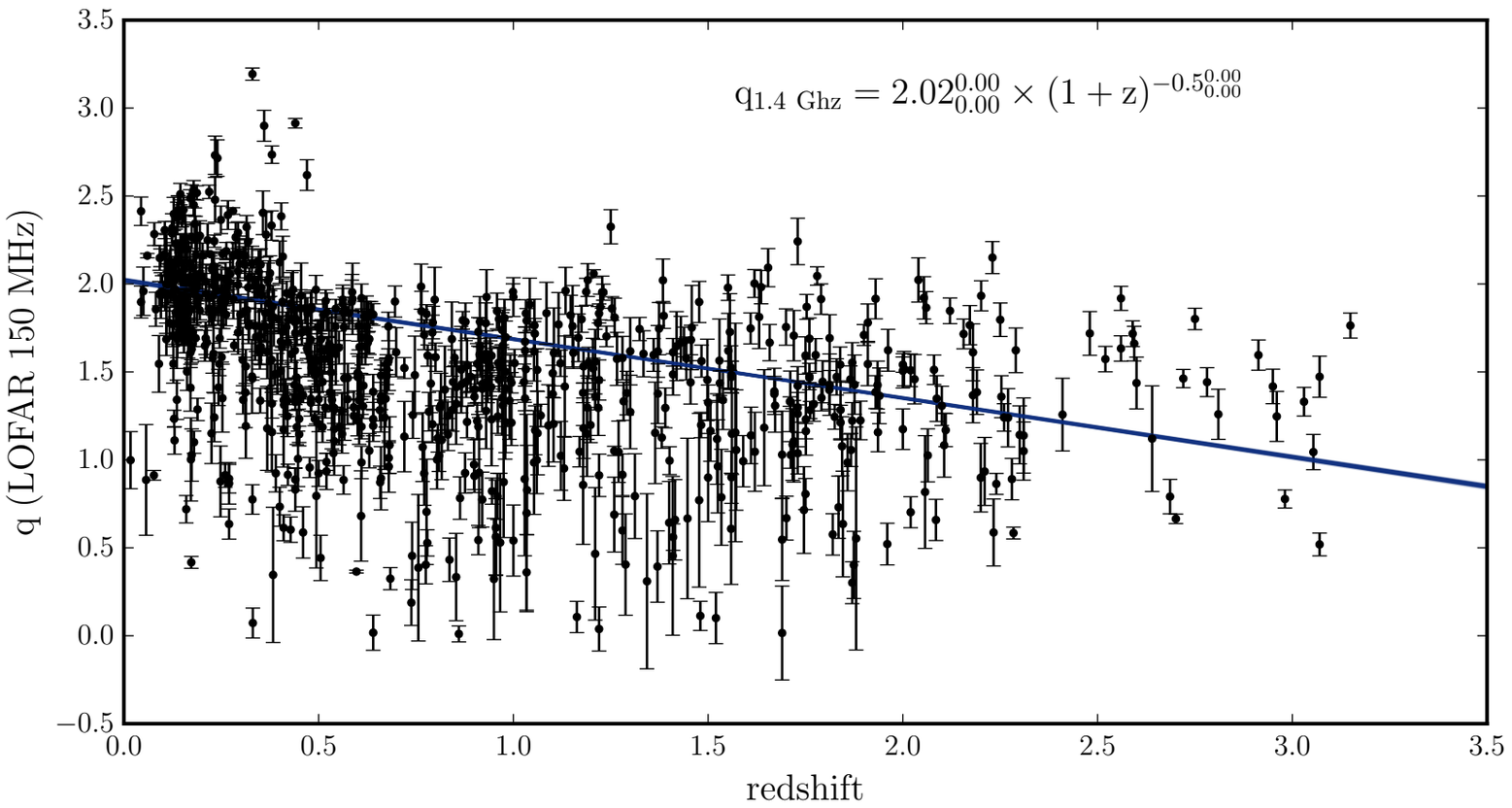
4.

- **FIR-radio (150MHz) correlation:**

$q \sim 2.0 \pm 0.02 \times (1+z)^{-0.5}$



- FRC LOFAR presents larger scatter
  - sensitivity
  - curvature



RADIO CONTINUUM

EMPIRICAL SFR ESTIMATION with LOFAR

- Assuming FIR-RADIO$_{1.4GHz}$ correlation holds for z :

$$SFR_{1.4GHz} = 6.35e\text{-}29 \times (L_{1.4GHz}/ergs\ s^{-1}\ Hz^{-1})$$

(Murphy+11)

$$L_{1.4GHz} = L_{150MHz} \times (150/1400)^{-0.8}$$

$$SFR_{150MHz} = 3.79e\text{-}28 \times (L_{150MHz}/ergs\ s^{-1}\ Hz^{-1})$$

- Our observations:

$SFR_{150MHz} = 1.45e\text{-}29 \times (L_{150MHz}/ergs\ s^{-1}\ Hz^{-1})$ at z~0

$SFR_{150MHz} = 0.21e\text{-}29 \times (L_{150MHz}/ergs\ s^{-1}\ Hz^{-1})$ at z~2

5.
CONCLUSIONS

CONCLUSIONS

LOFAR selection + multiwavelength GALAXY classification:

1. The radio continuum of starbursts is not as simple as a power law!

2. FIR-radio (1.4GHz) and (150 MHz) correlation evolves with redshift as $\sim(1+z)^{-0.3}$

3. Assumptions would imply an overestimation of >1 order of magnitude in SFR_150MHz