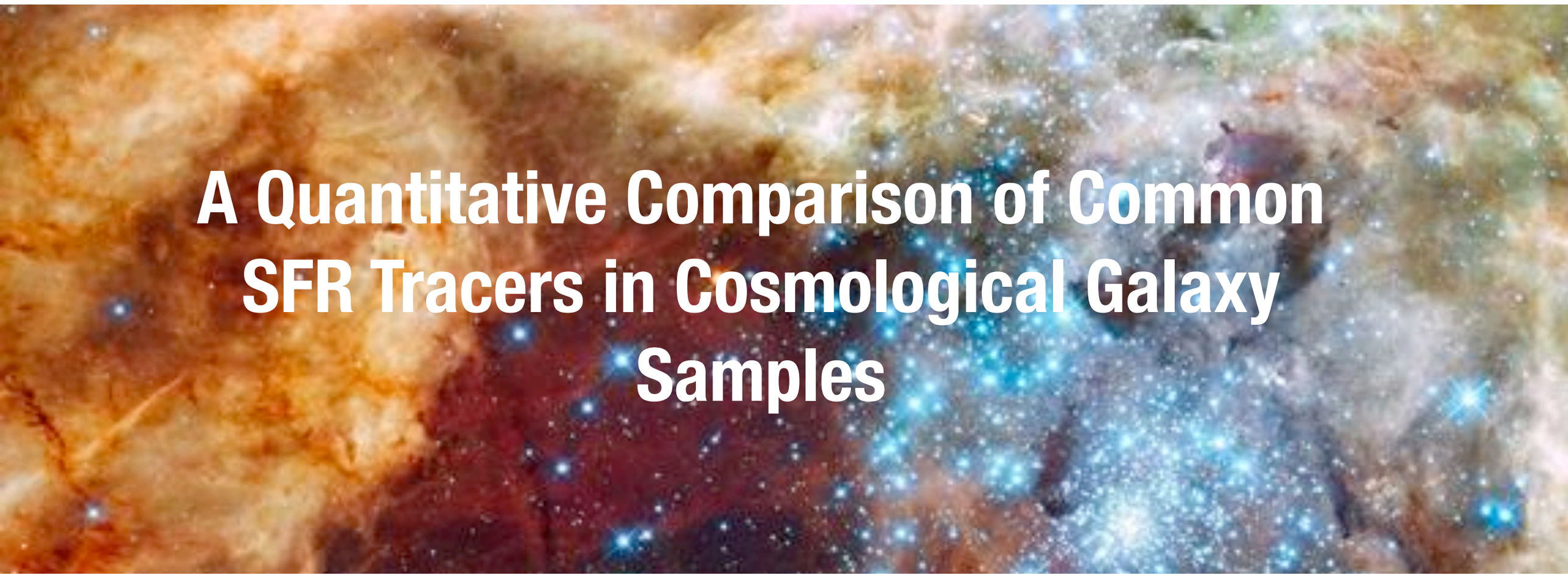
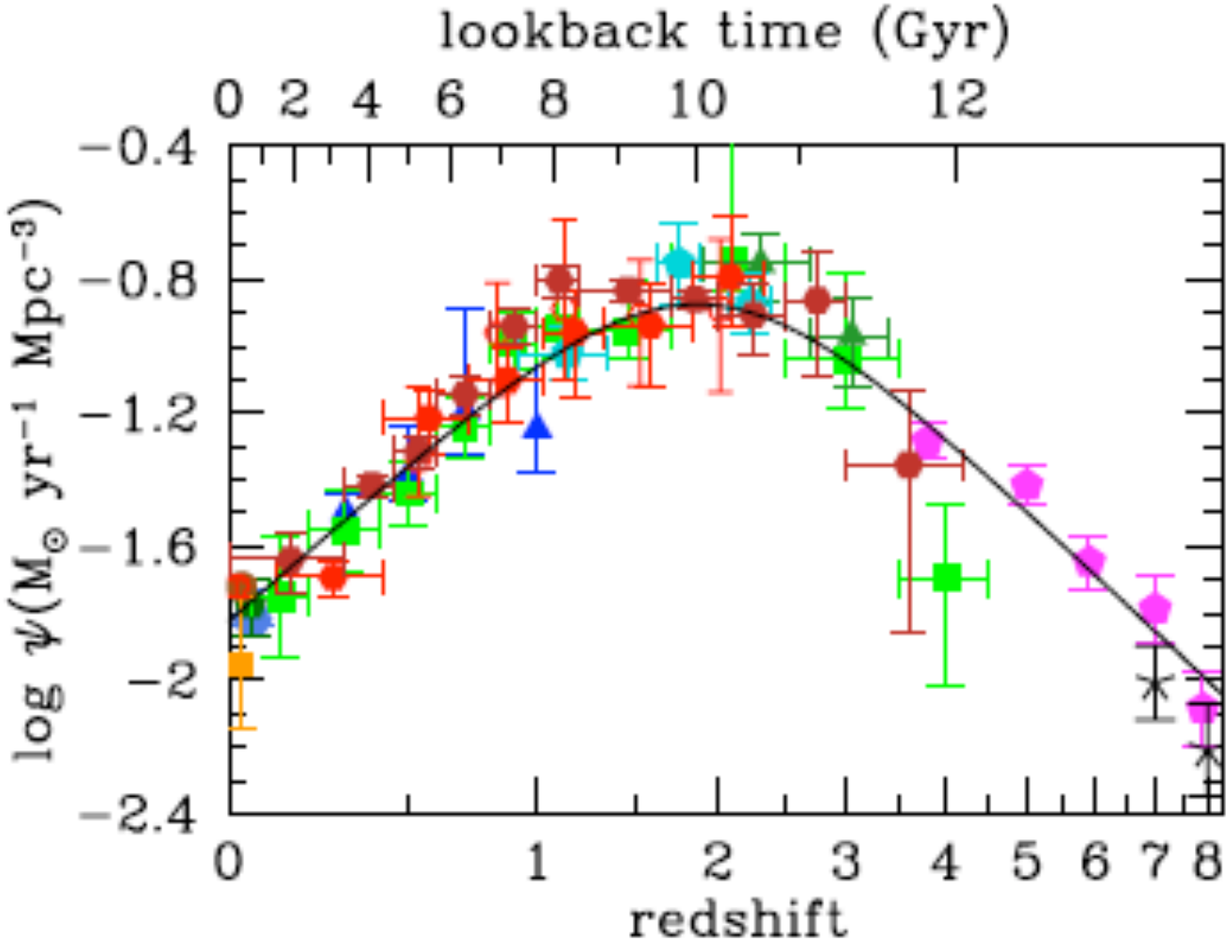


A Quantitative Comparison of Common SFR Tracers in Cosmological Galaxy Samples

Emer Brady (MPIA, Heidelberg)

E.Schinnerer (MPIA), B. Groves (ANU, Canberra), A. Karim (AIfA, Bonn), B. Magnelli (AIfA, Bonn). M. Sargent (Sussex)

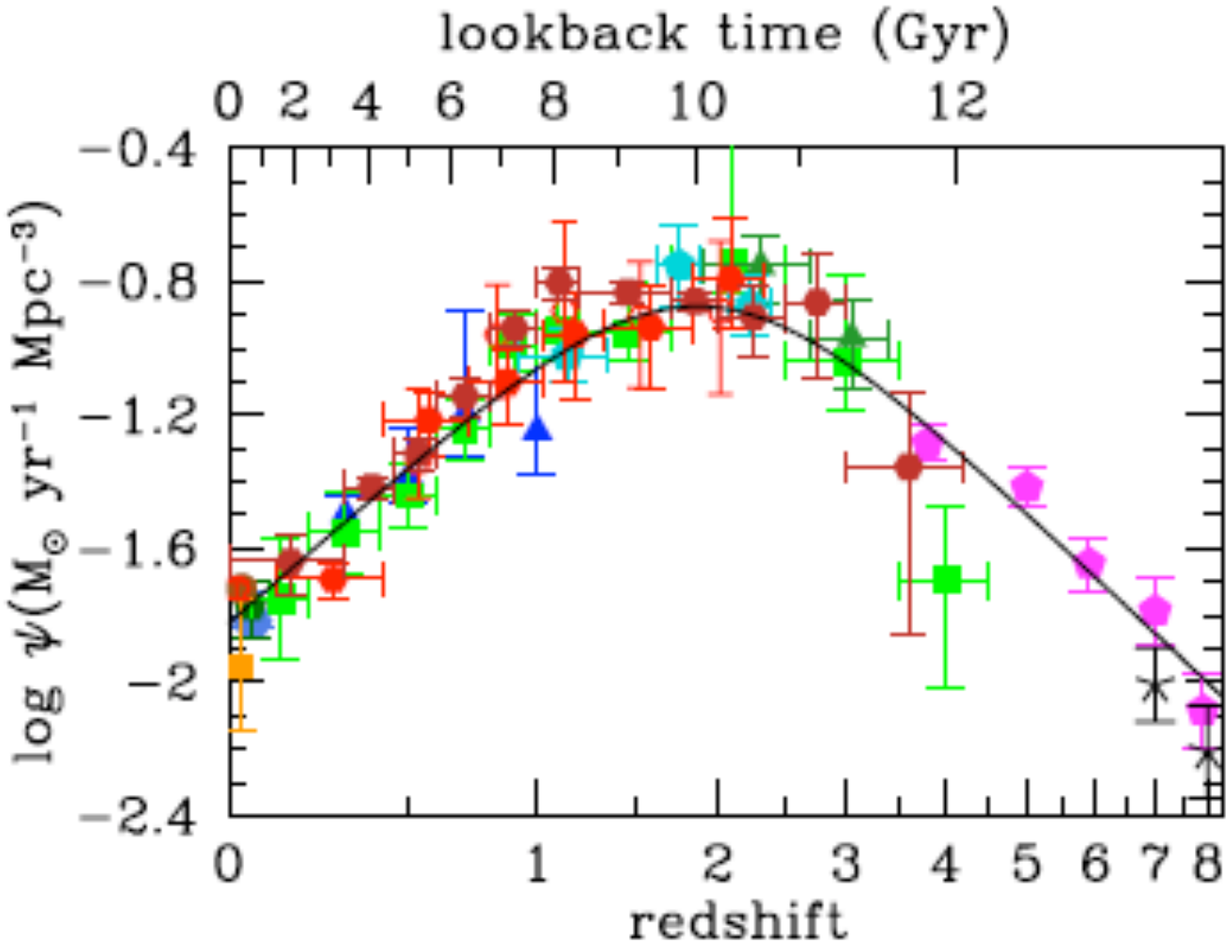
SFRD



Madau +Dickinson 2014

SFRD

Do SFR tracers exhibit systematic biases?

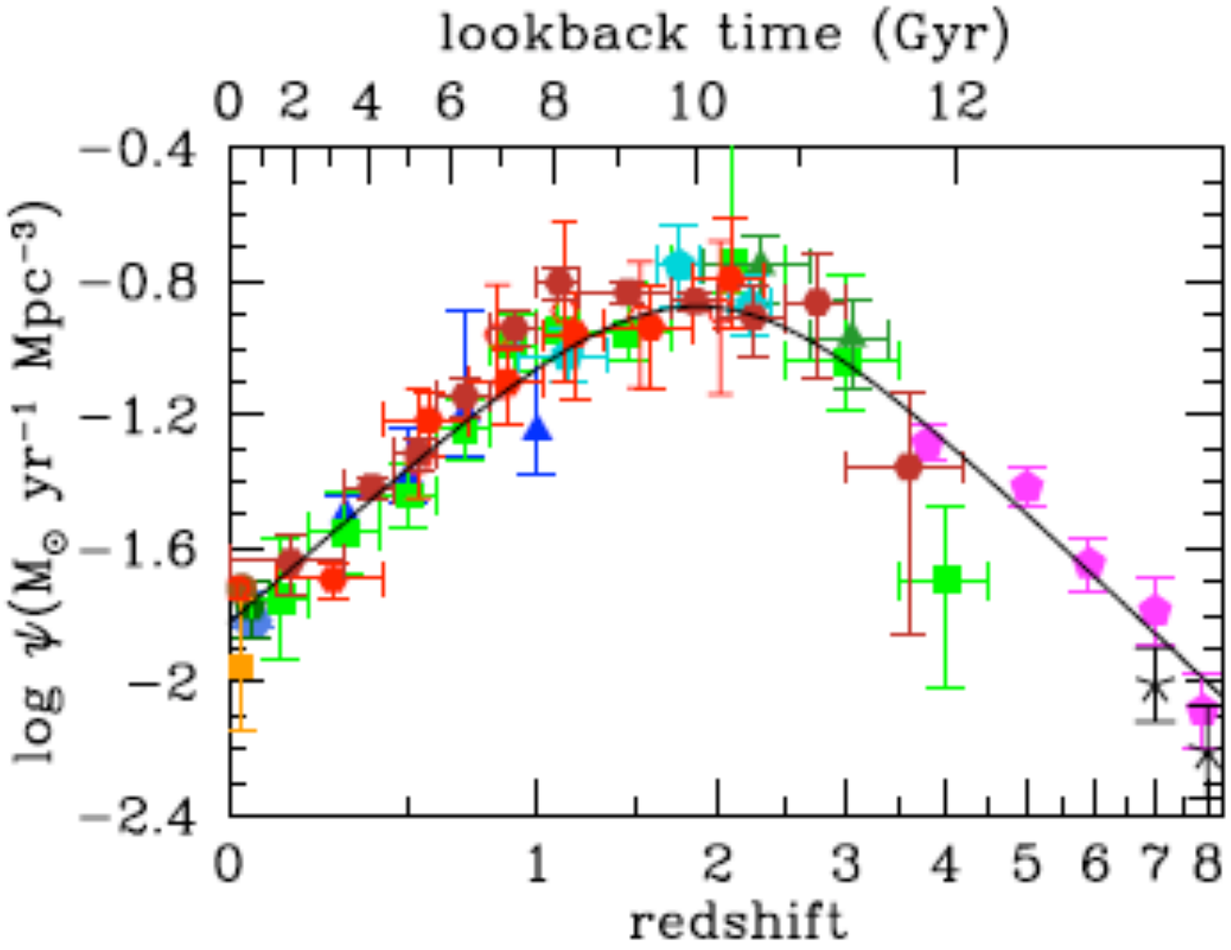


Madau +Dickinson 2014

SFRD

Do SFR tracers exhibit systematic biases?

How/do they evolve with z?



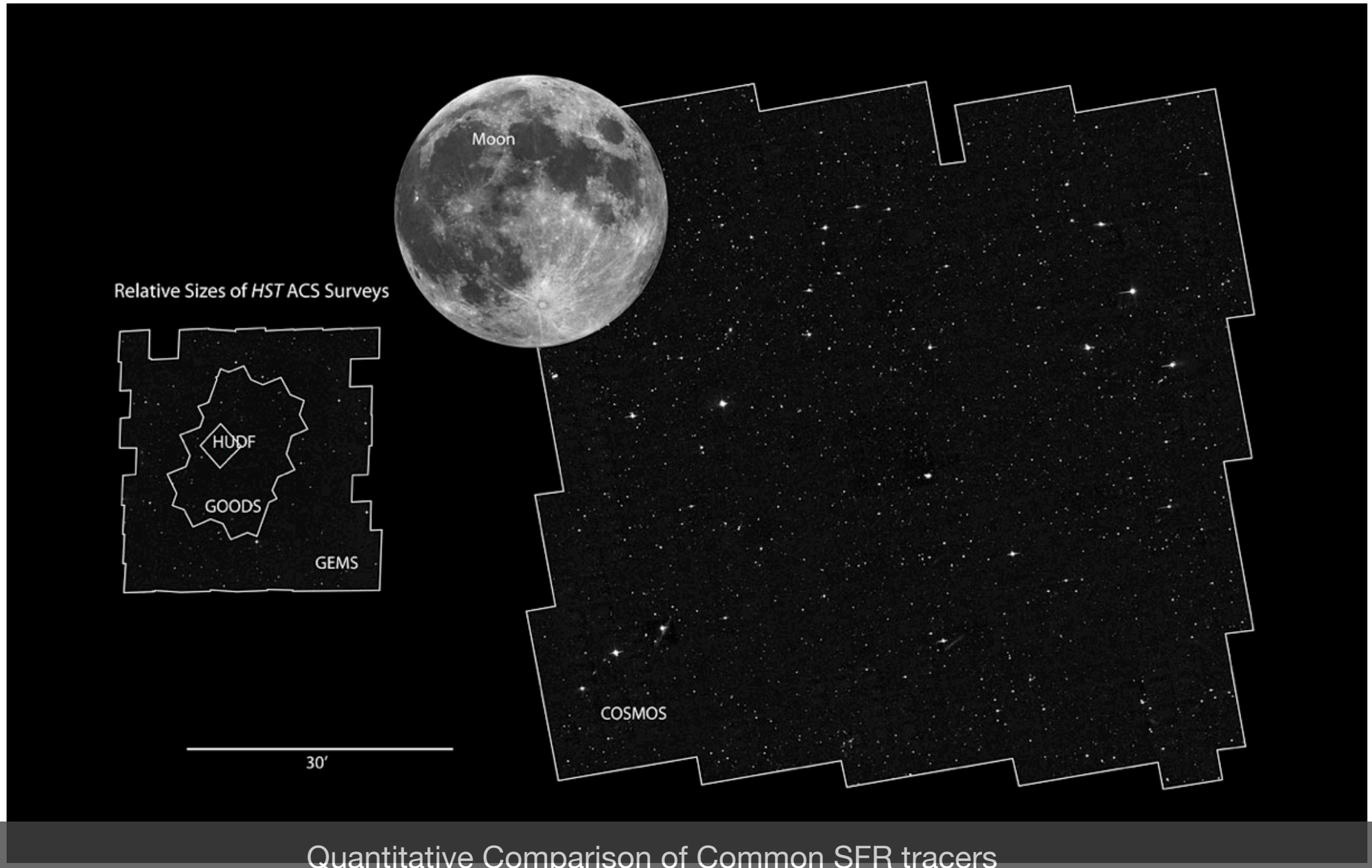
Madau +Dickinson 2014

Radio-based SFR comparison sample

PI:N.Scoville **COSMOS** 2 sq deg, equatorial

Coverage by: VLA, Spitzer, Herschel, GALEX, Subaru,.....

Spectroscopic and photometric z for~2 million objects



Radio-based SFR comparison sample

Radio: 1.4GHz deep; Schinnerer et al. (2010)
2864 sources to 5sig=50uJy

Photo-z: Laigle, Mc Cracken et al. (in prep); 1.2 mil
z_{phot} following Ilbert et al. 2013
Optical and UV from Capak et al. 2007
YJHK of UVISTA DR2, SPLASH photometry

100um: PEP DR1 24um priors (Lutz et al. 2011),3sig=4.5mJy
24um: MIPS (Le F'loch et al. 2009), 3sig=45uJy

Lines: zCOSMOS 20k bright; Lilly ey al. 2009

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772 galaxies: good z_{phot}, single component radio source, 24um and 100um detections

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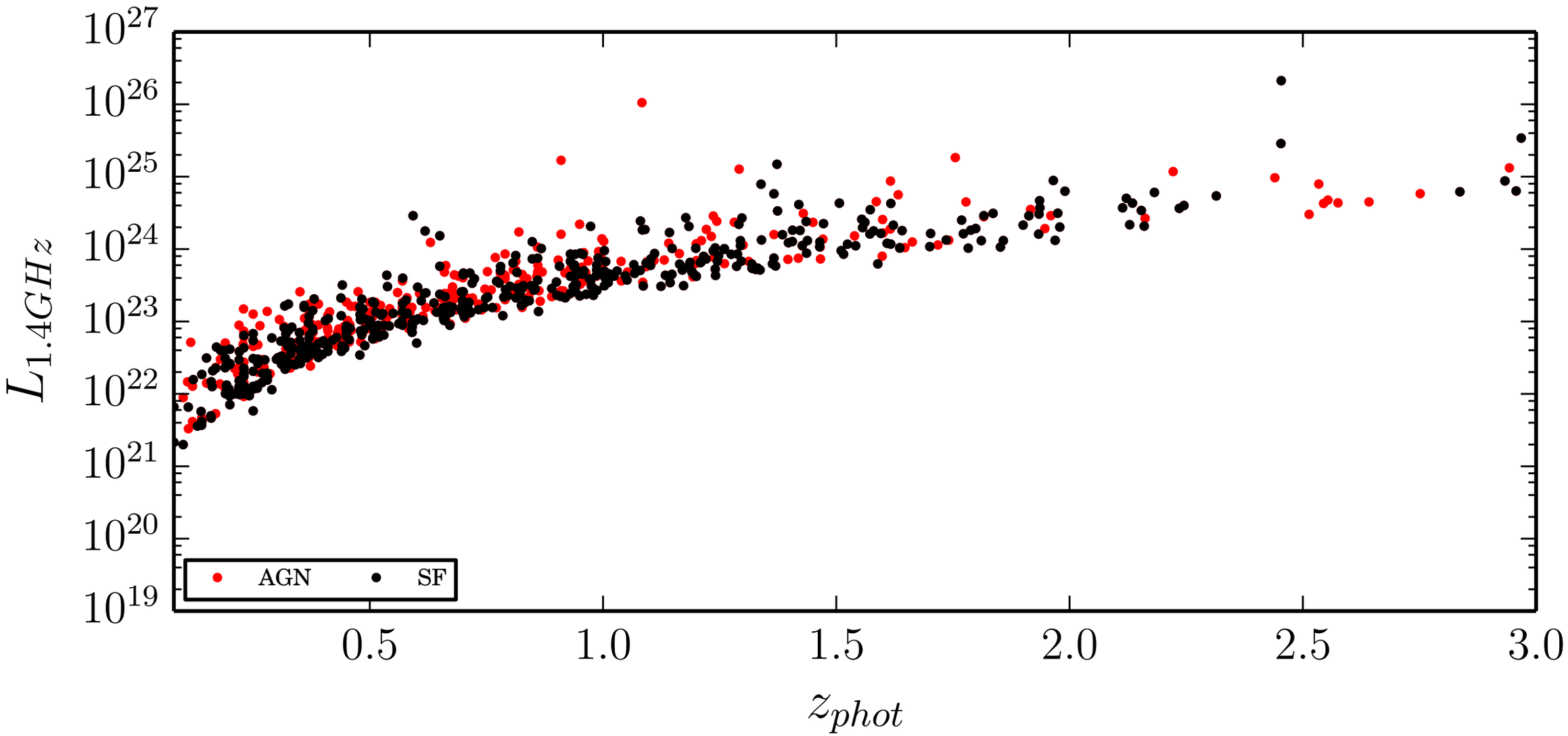
Lines: zCOSMOS 20k bright; Lilly ey al. 2009

Radio-based SFR comparison sample

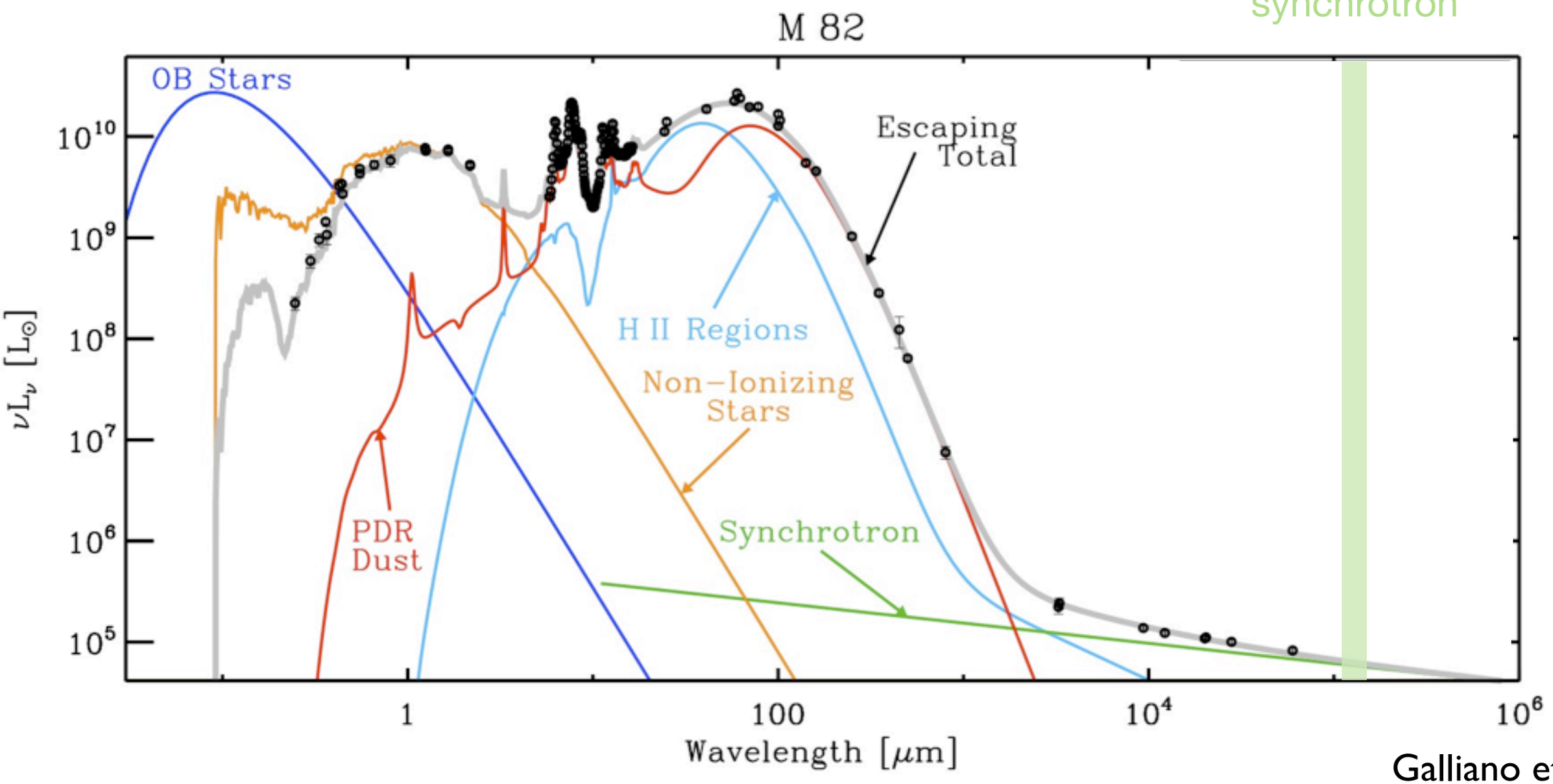
AGN selection: 473 star forming



AGN megacatalogue: Brusa et al. (XMM, zCOSMOS NL+BL, IRAC, Radio P1)
Chandra legacy catalogue: Civano et al. 2015

Tracers

1.4GHz non-thermal synchrotron



Galliano et al.

Tracers

24um and 100um
warm dust emission

1.4GHz non-thermal
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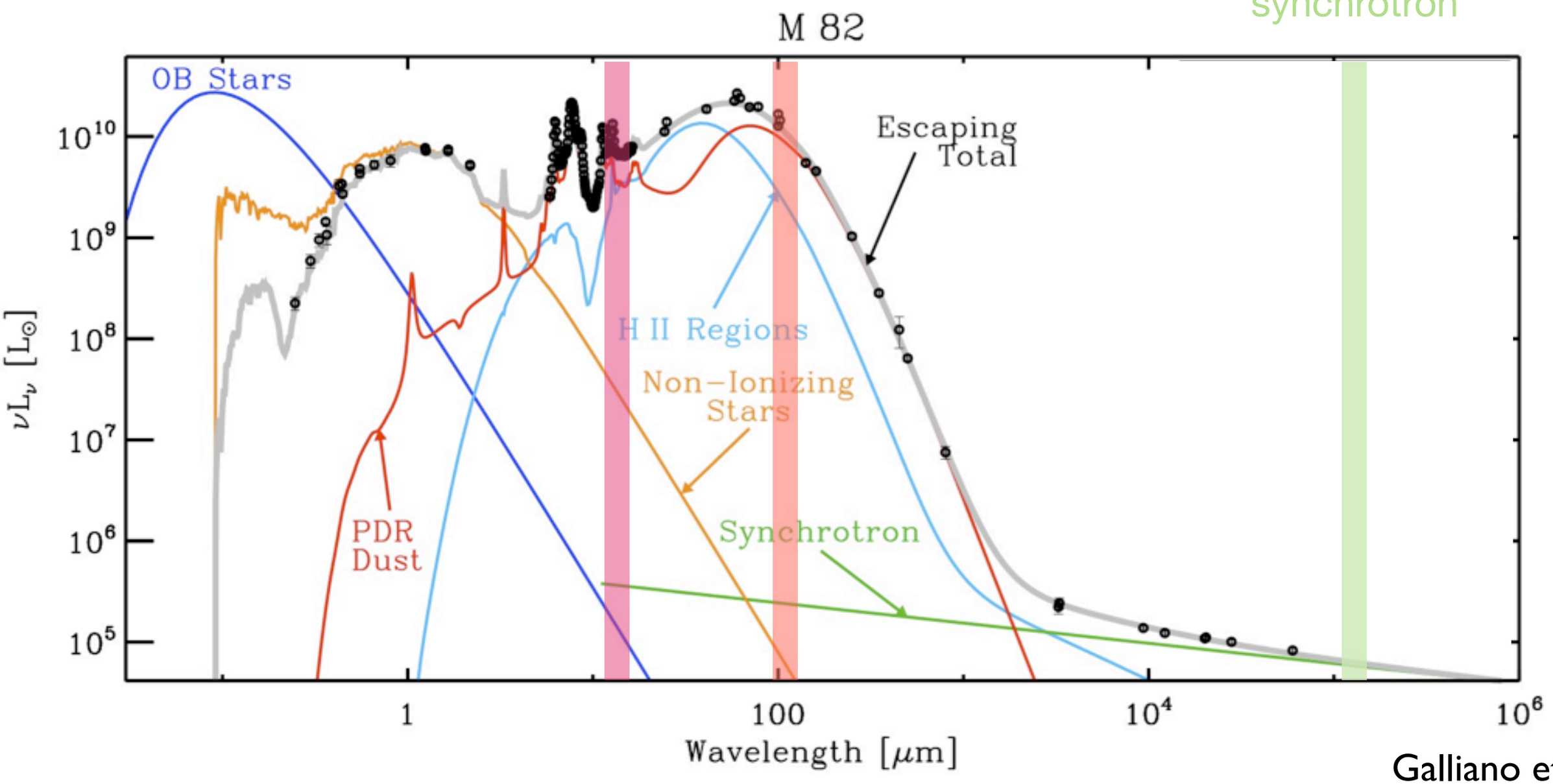

Galliano et al.

Tracers

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Ha

1.4GHz non-thermal
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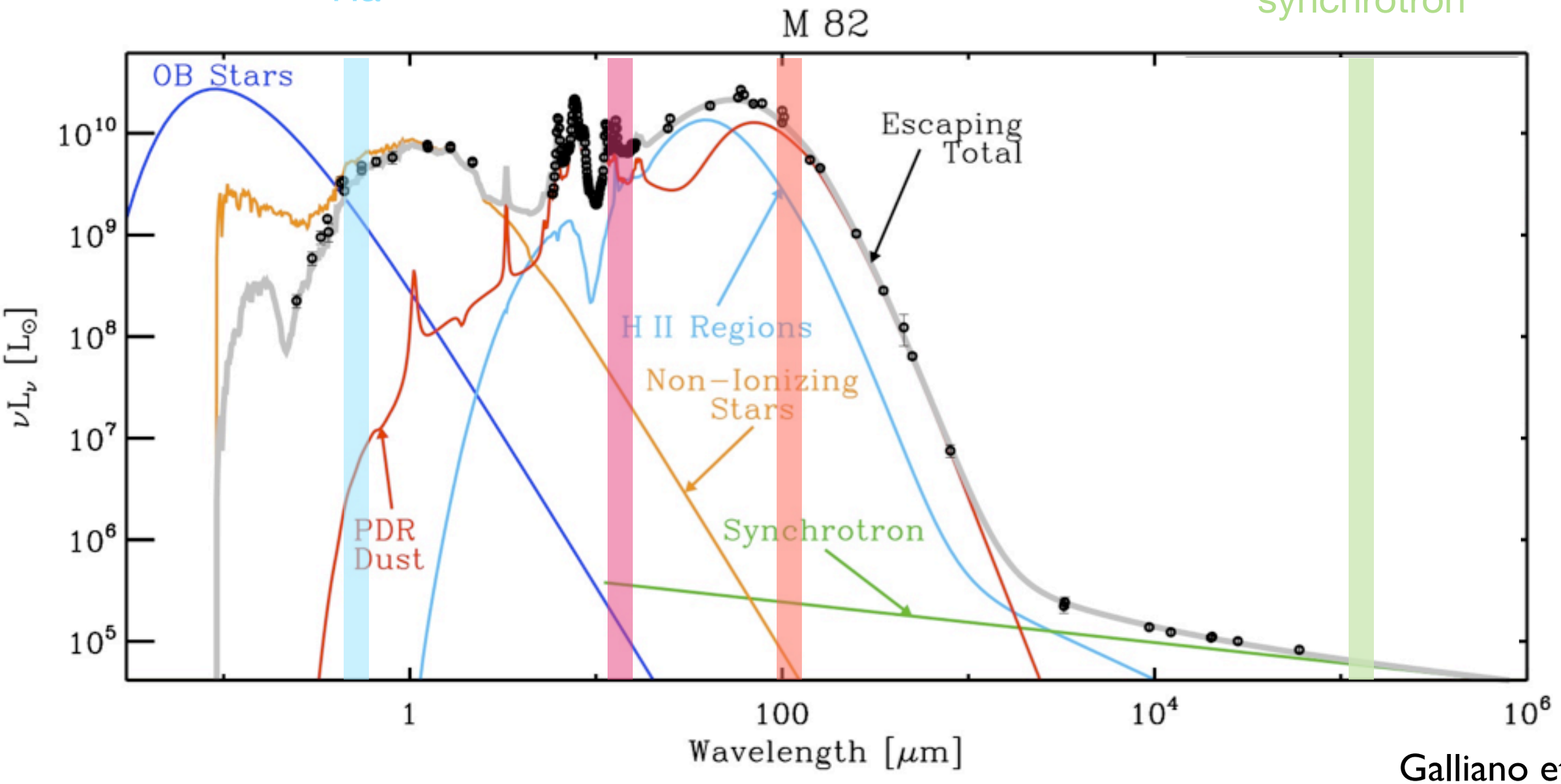


Galliano et al.

Tracers: Caveats

AGN contamination: Radio, IR, UV ✓

K-correction (templates): IR, UV

Dust attenuation: UV

Resolution: IR

Tracers: Prescription

Murphy et al. 2011

Self consistent calibration

Local study

Starburst 99

Kroupa IMF

Continuous SFR on 100 Myr timescales

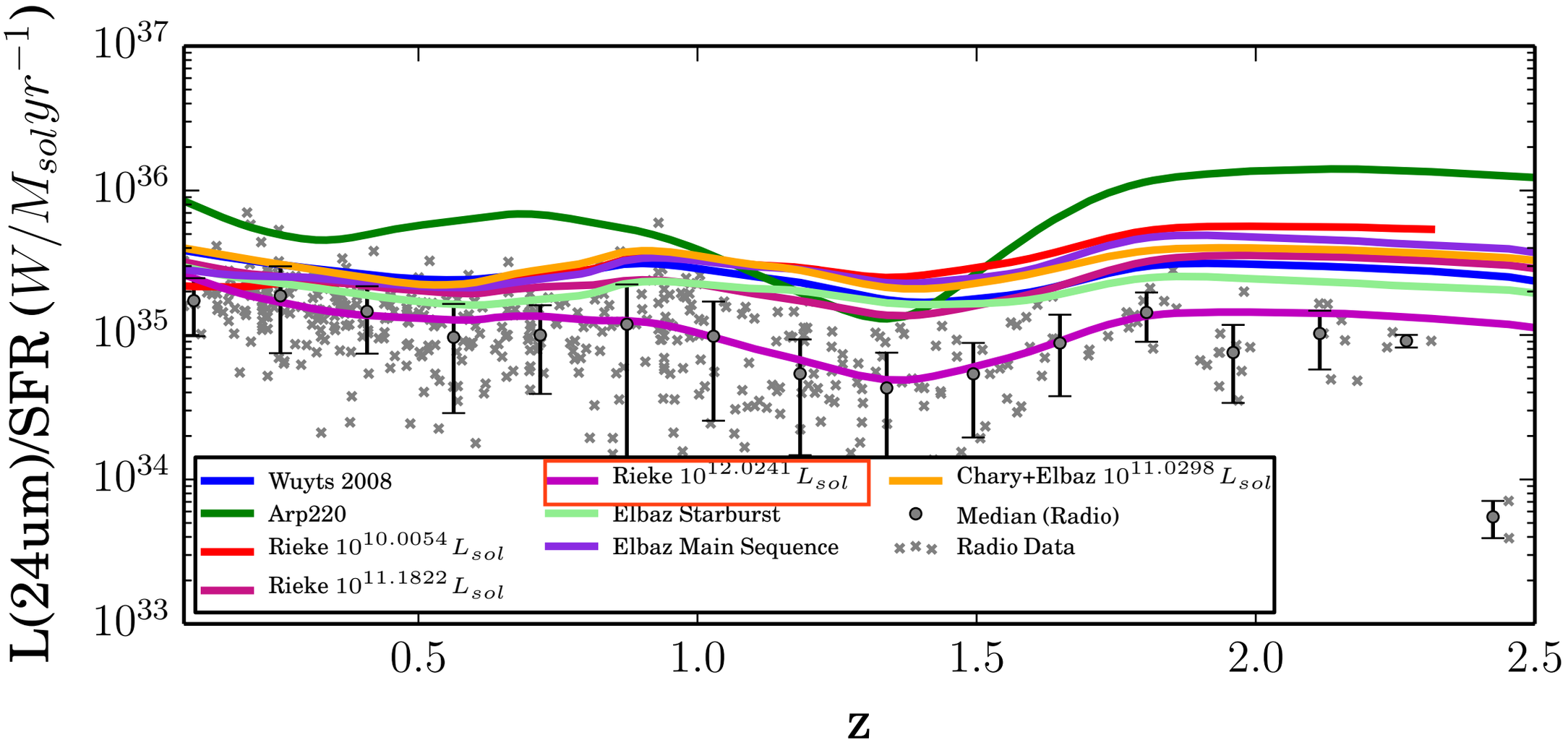
Radio-IR q= 2.64 +/- 0.26

1.4GHz-TIR comparison

<u>For a set of commonly used templates:</u>

Normalise SED with MIPS 24um or PACS 100um

Integrate 8um-1000um for TIR luminosity



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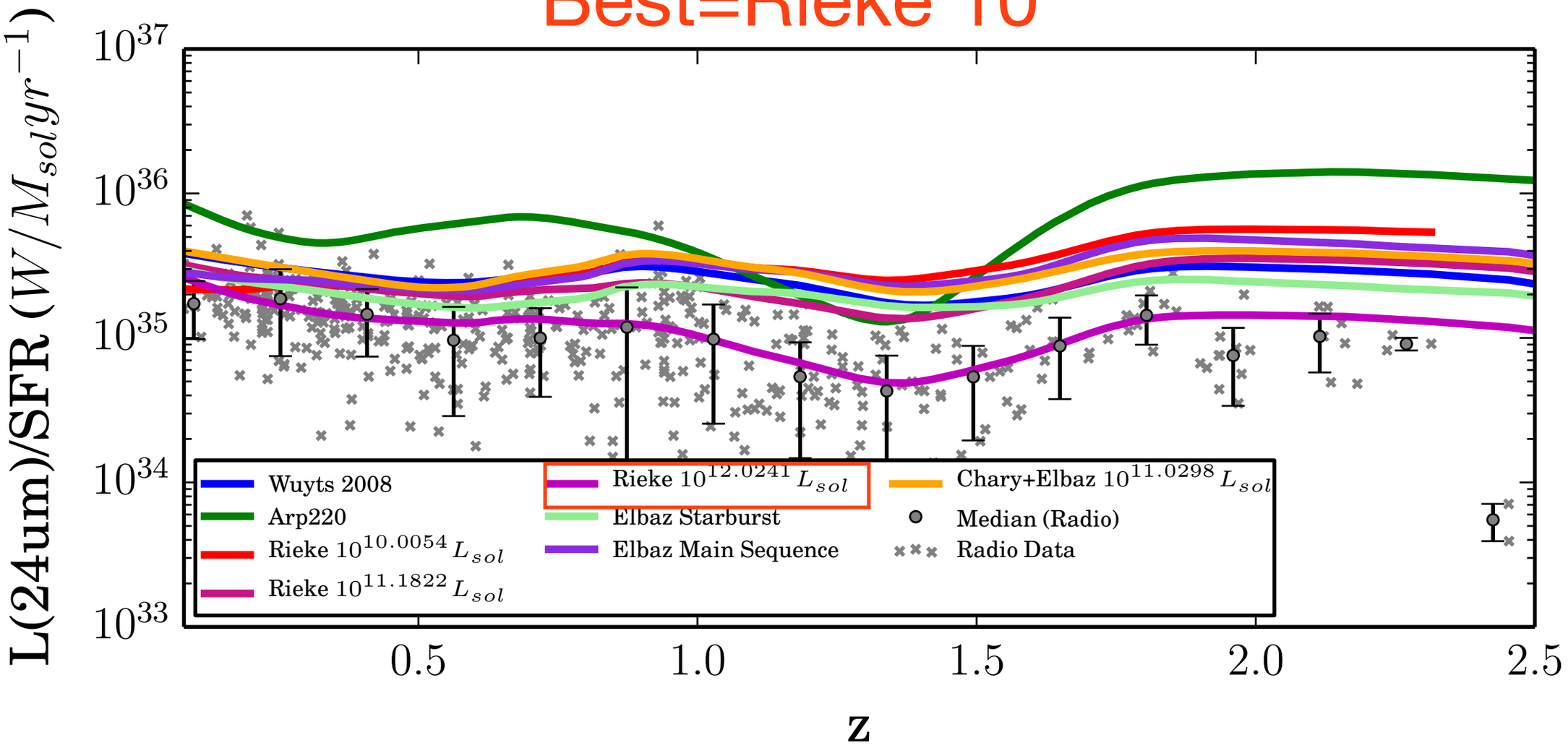
Best=Rieke 10 $^{12.0241}$



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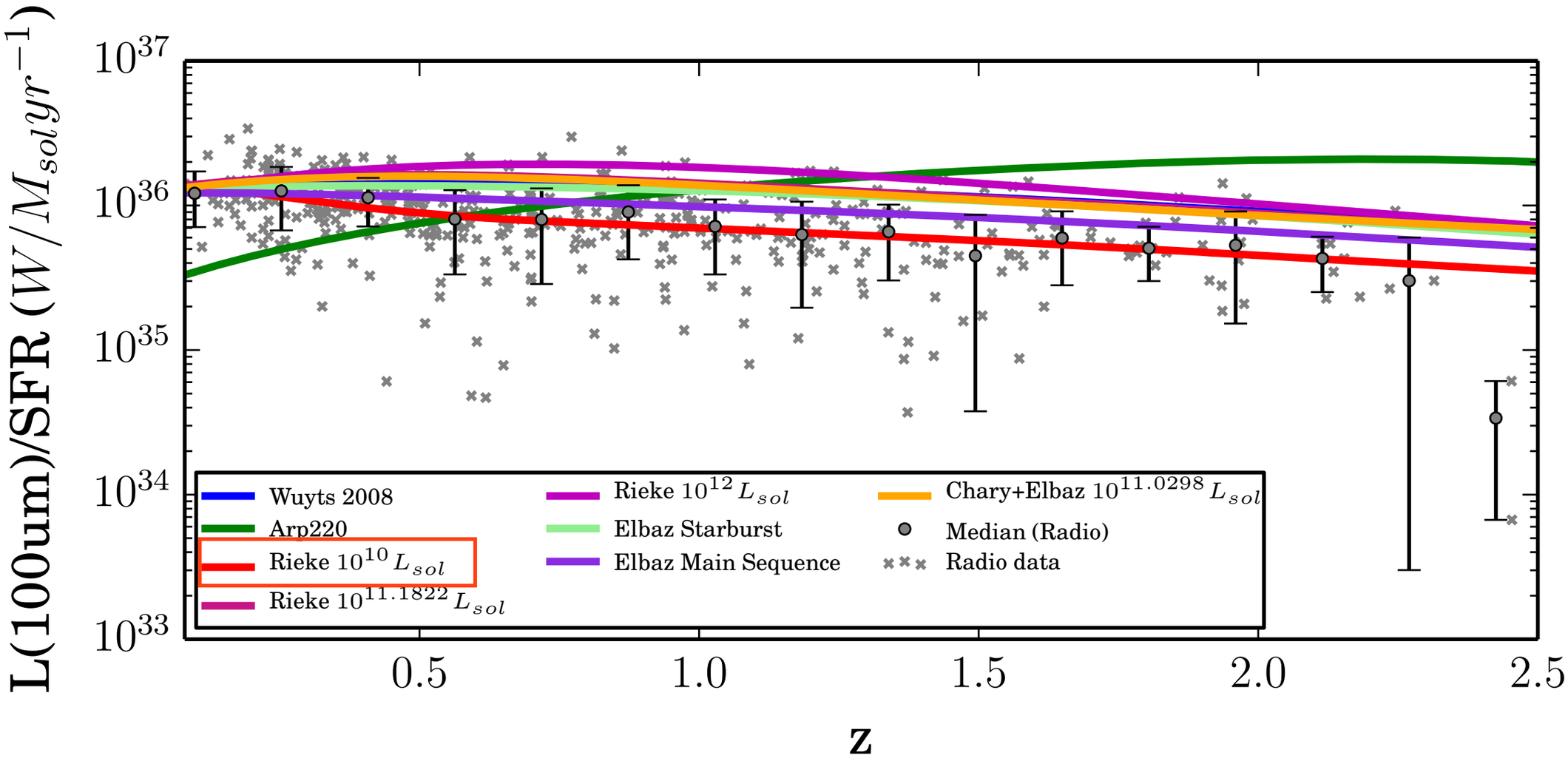

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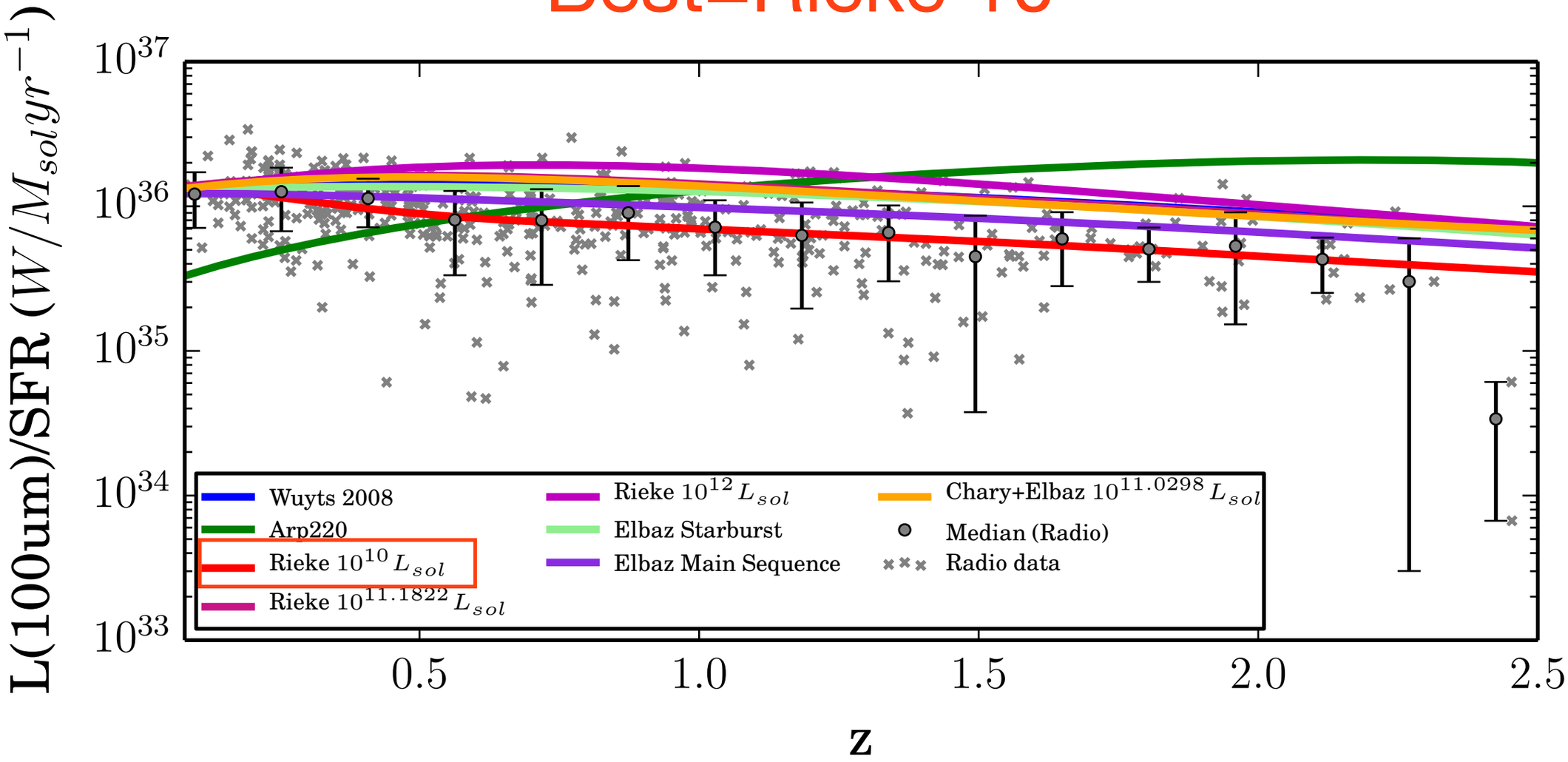

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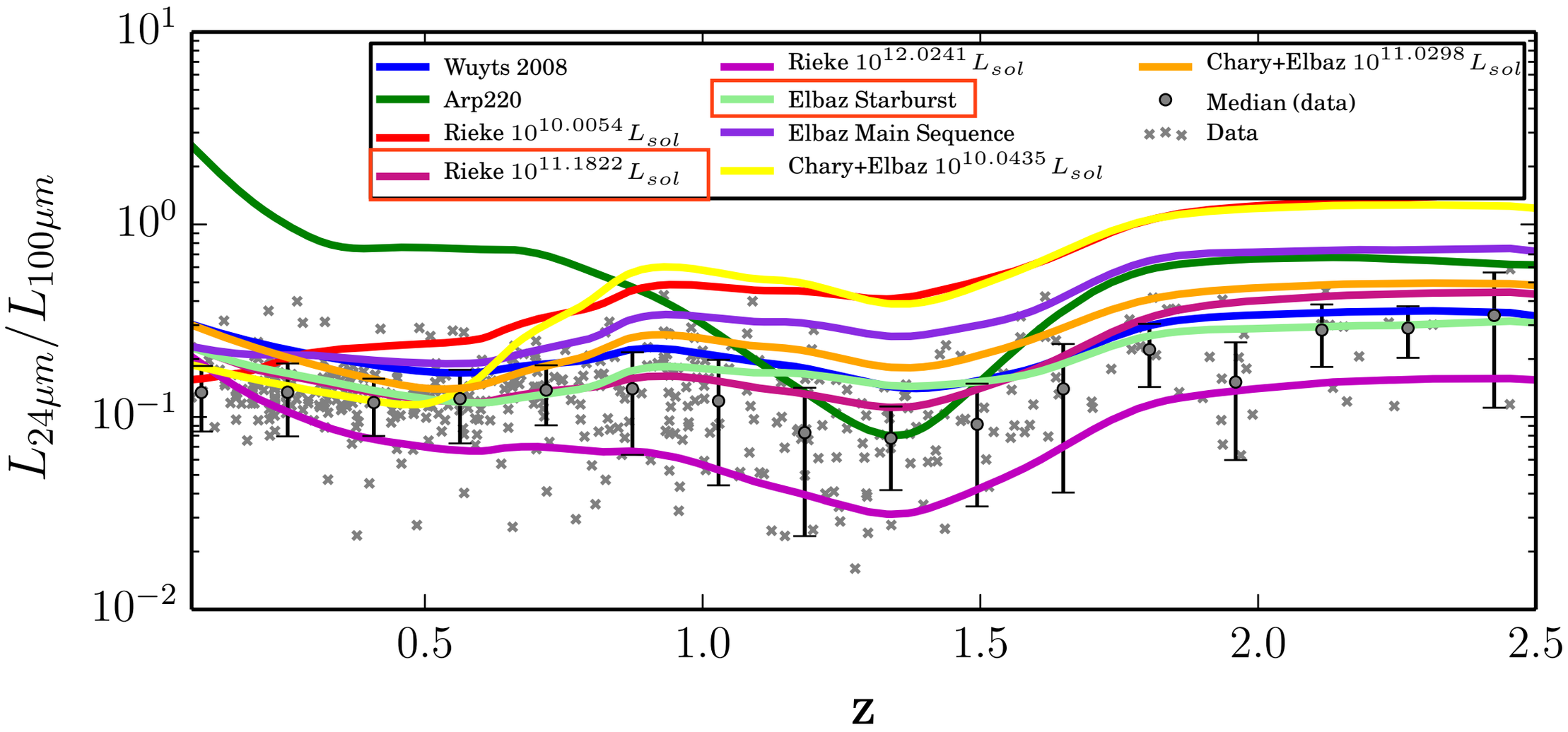

1.4GHz-TIR comparison

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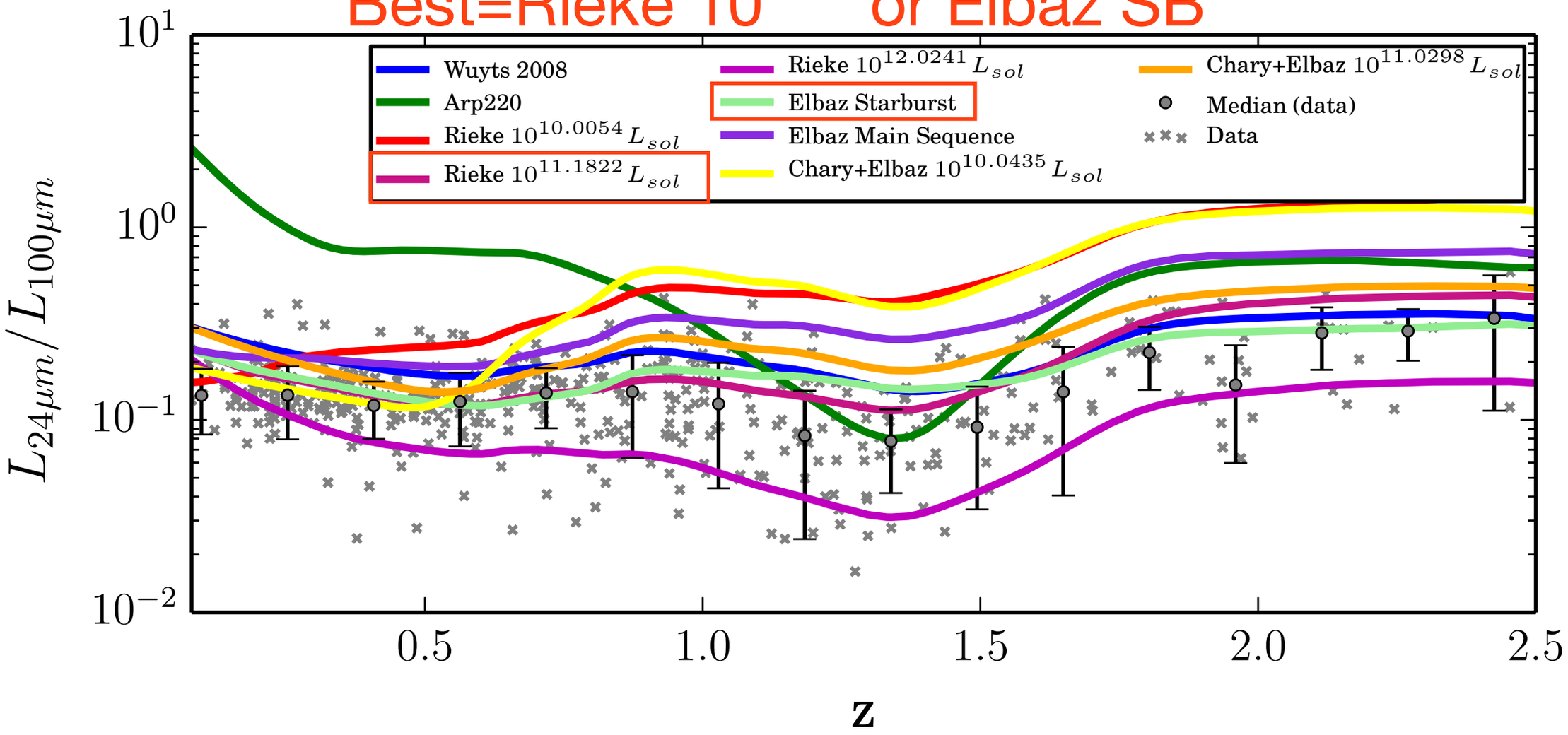
Best=Rieke $10^{11.1822}$ or Elbaz SB



Origin of disagreement

Local template not working with blind application of Murphy et al. 2011 for radio-selected sample

$$q_{\rm IR} \equiv \log\left(\frac{L_{\rm IR}}{3.75\times10^{12}L_{1.4\,\rm GHz}}\right).$$

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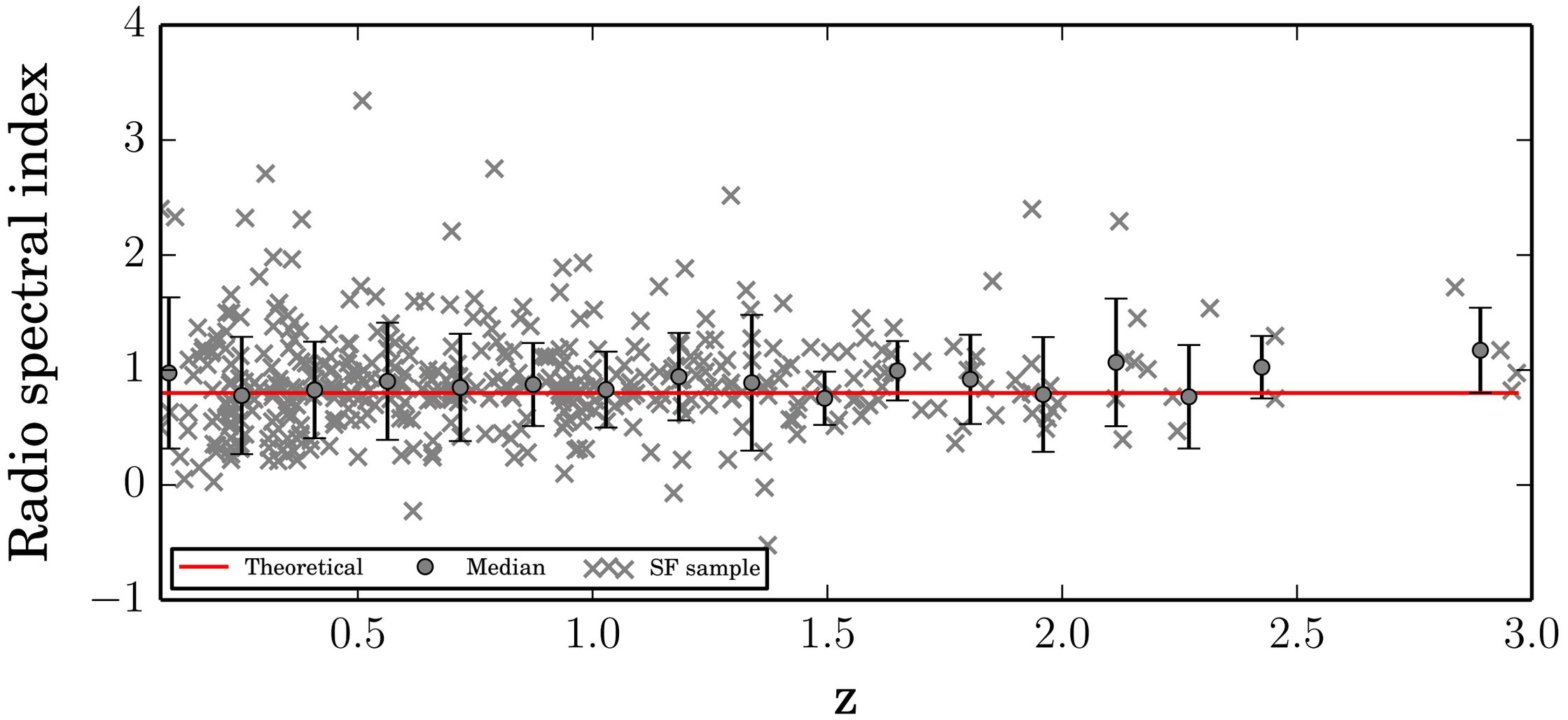
SED TIR underestimating or radio luminosity overestimated?

Origin of disagreement: Radio spectral index

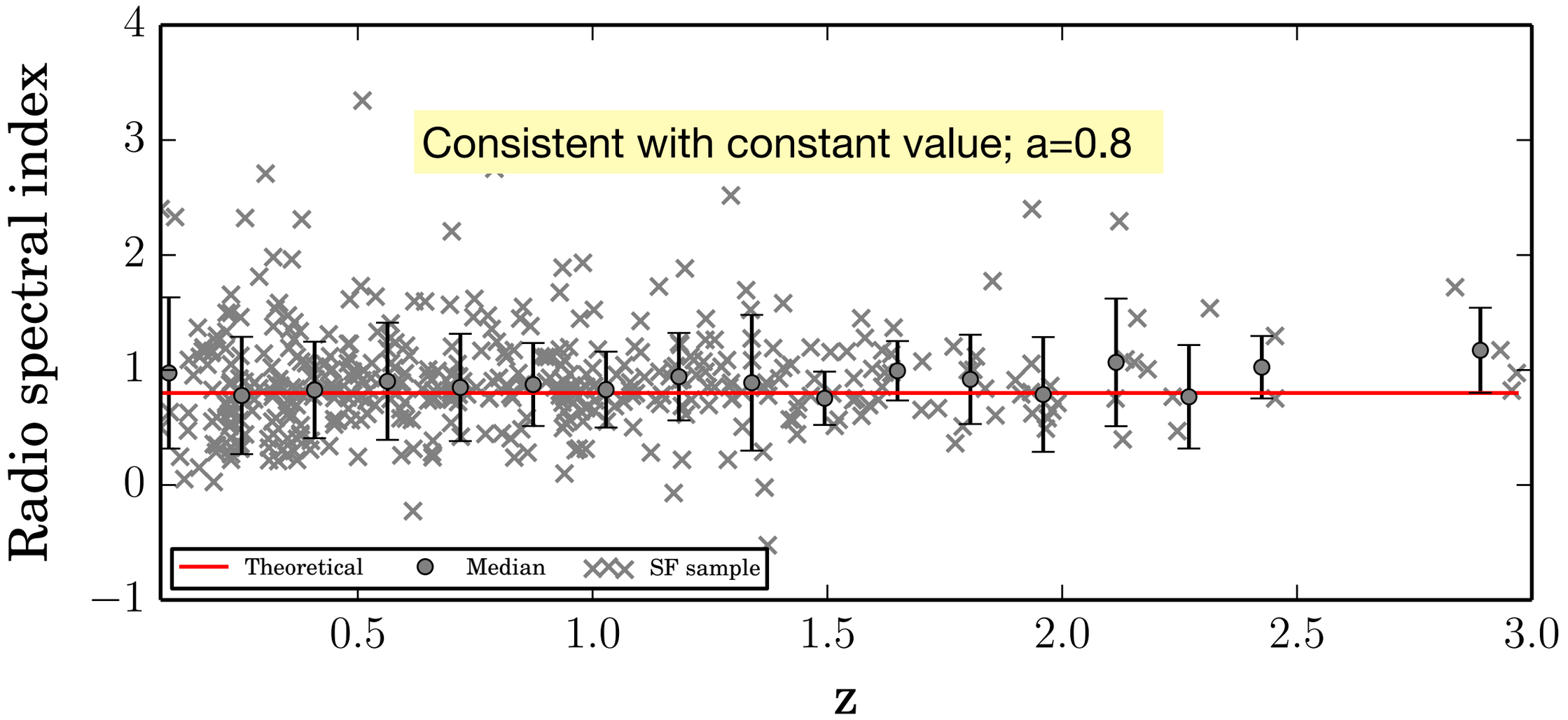
Radio spectral index varies?



3GHz-1.4GHz slope: 3GHz VLA data *preliminary* - provided by M. Novak

Origin of disagreement: Radio spectral index

Radio spectral index varies?



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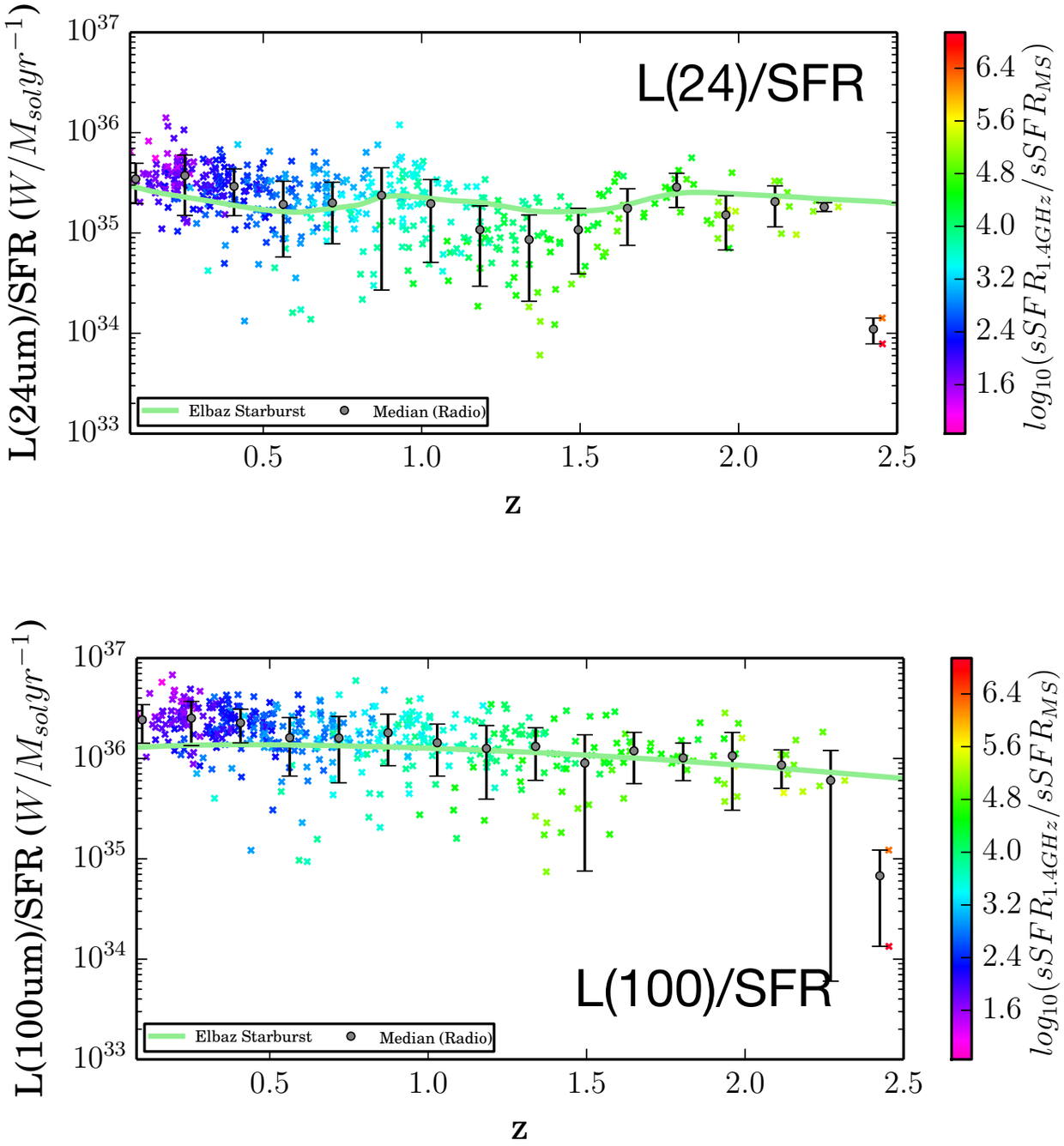
Origin of disagreement: TIR-radio ratio



$$q_{\rm FIR}(z) = (2.35 \pm 0.08) \times (1+z)^{-0.12\pm0.04}$$

q=2.35 (Yun et al. 2001) shows better agreement

q(z) of Magnelli et al. 2014 (not seen by Pannella et al. 2011) weak and values consistent with usual 2.35

Elbaz starburst

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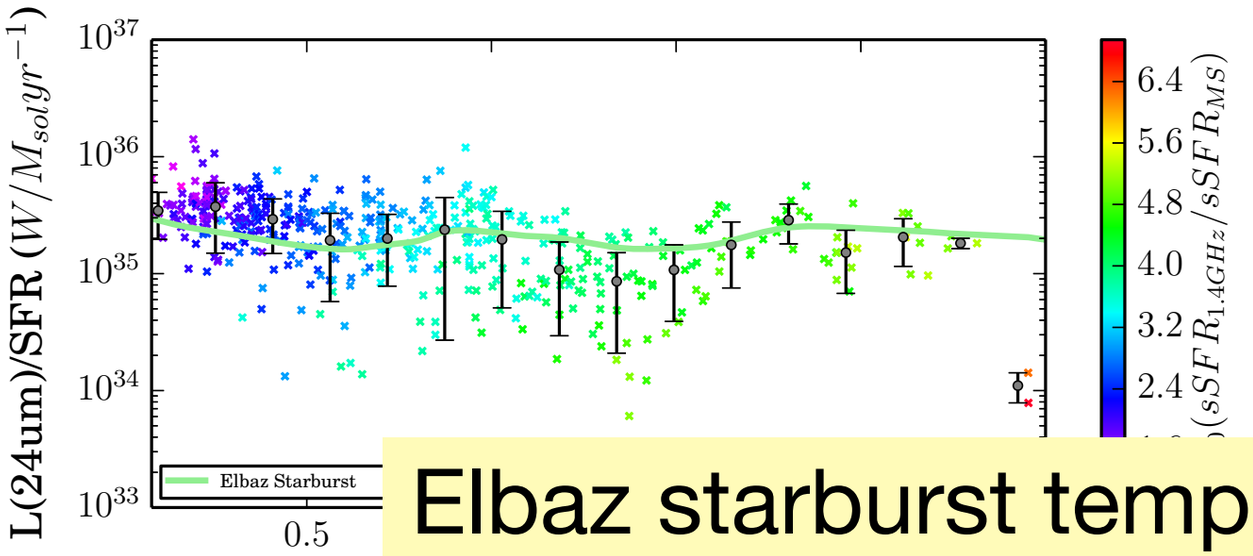

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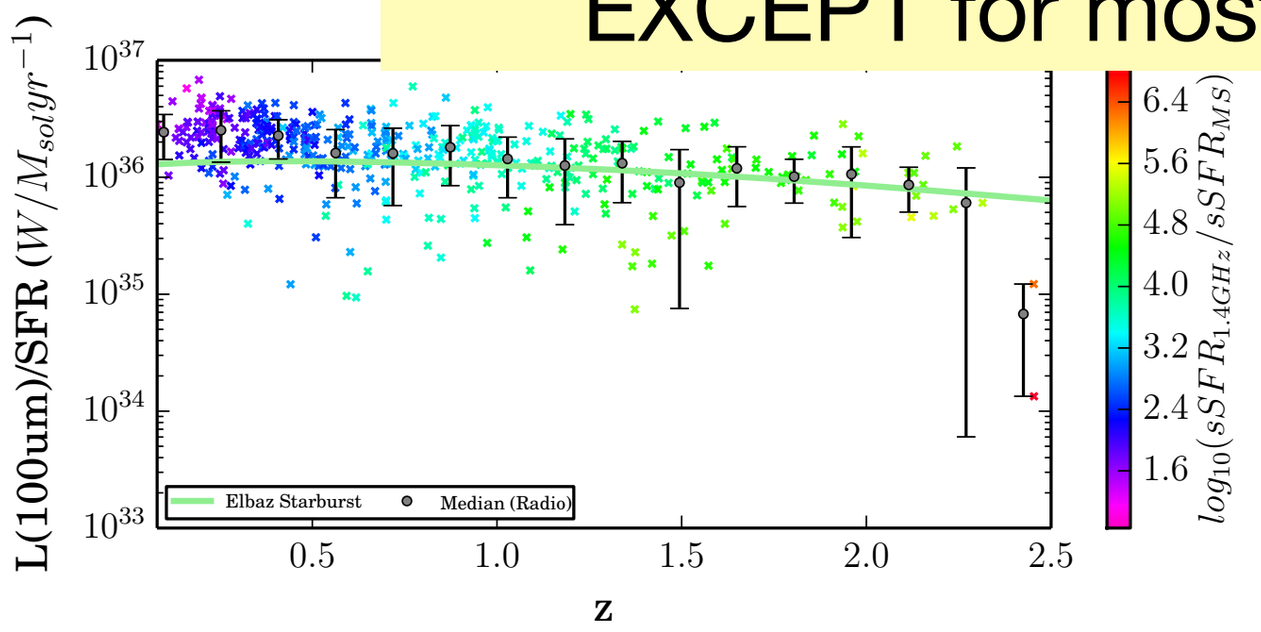
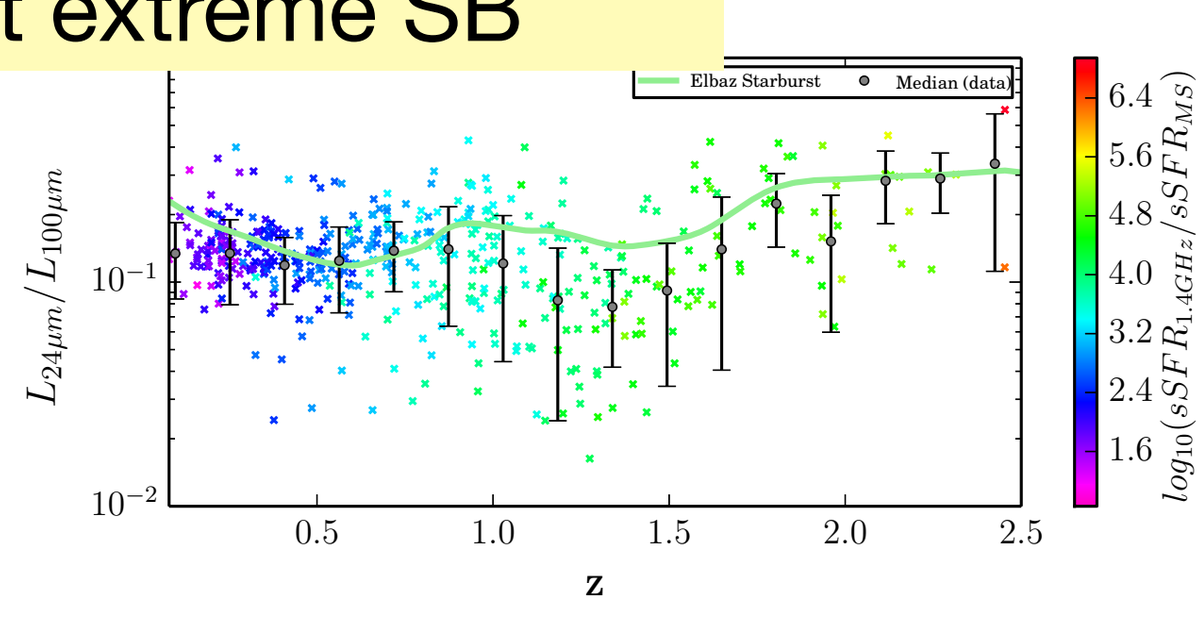
Elbaz starburst template: SFR TIR and SRF radio agree to within errors EXCEPT for most extreme SB





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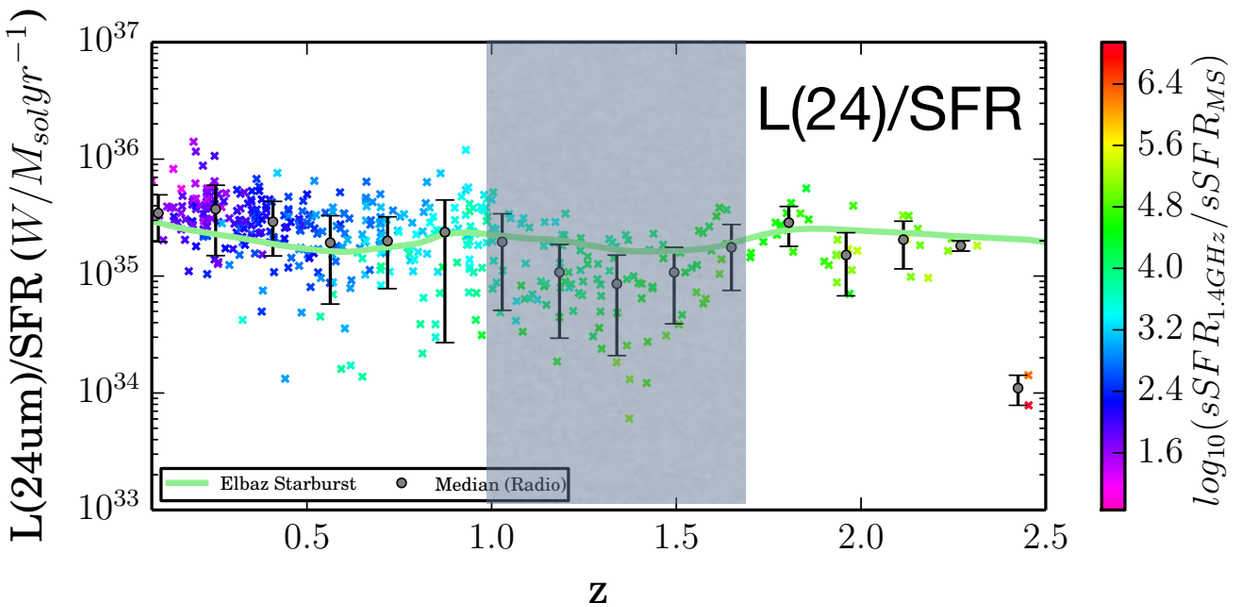

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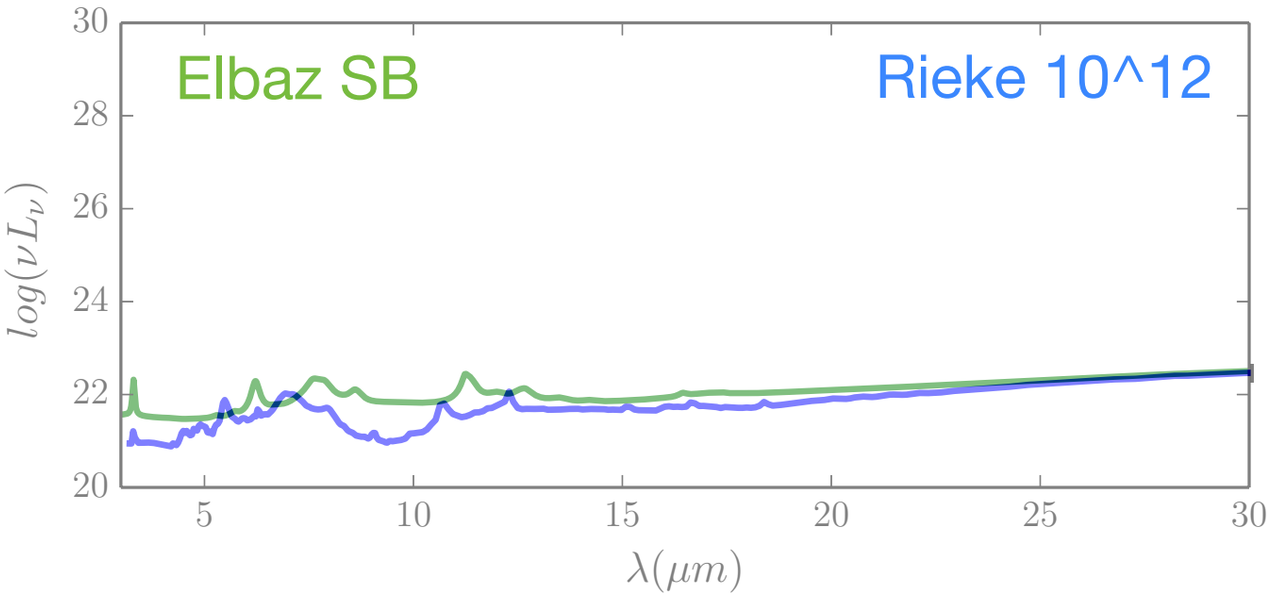
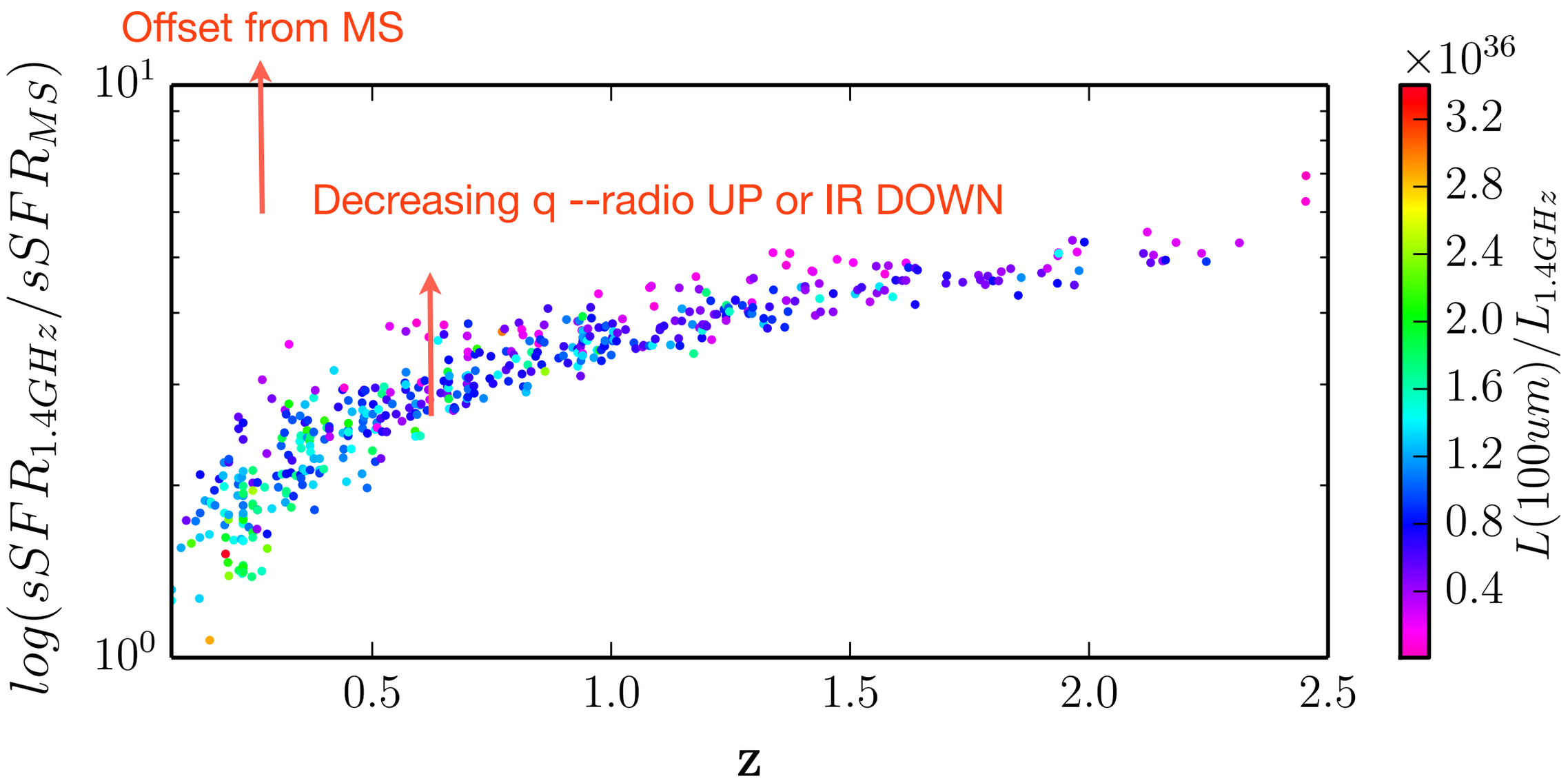


PAH of 10^12 (ULIRG) Rieke a better match than Elbaz local SB

Evolution of q with MS offset

Or for universal IR SED q must evolve



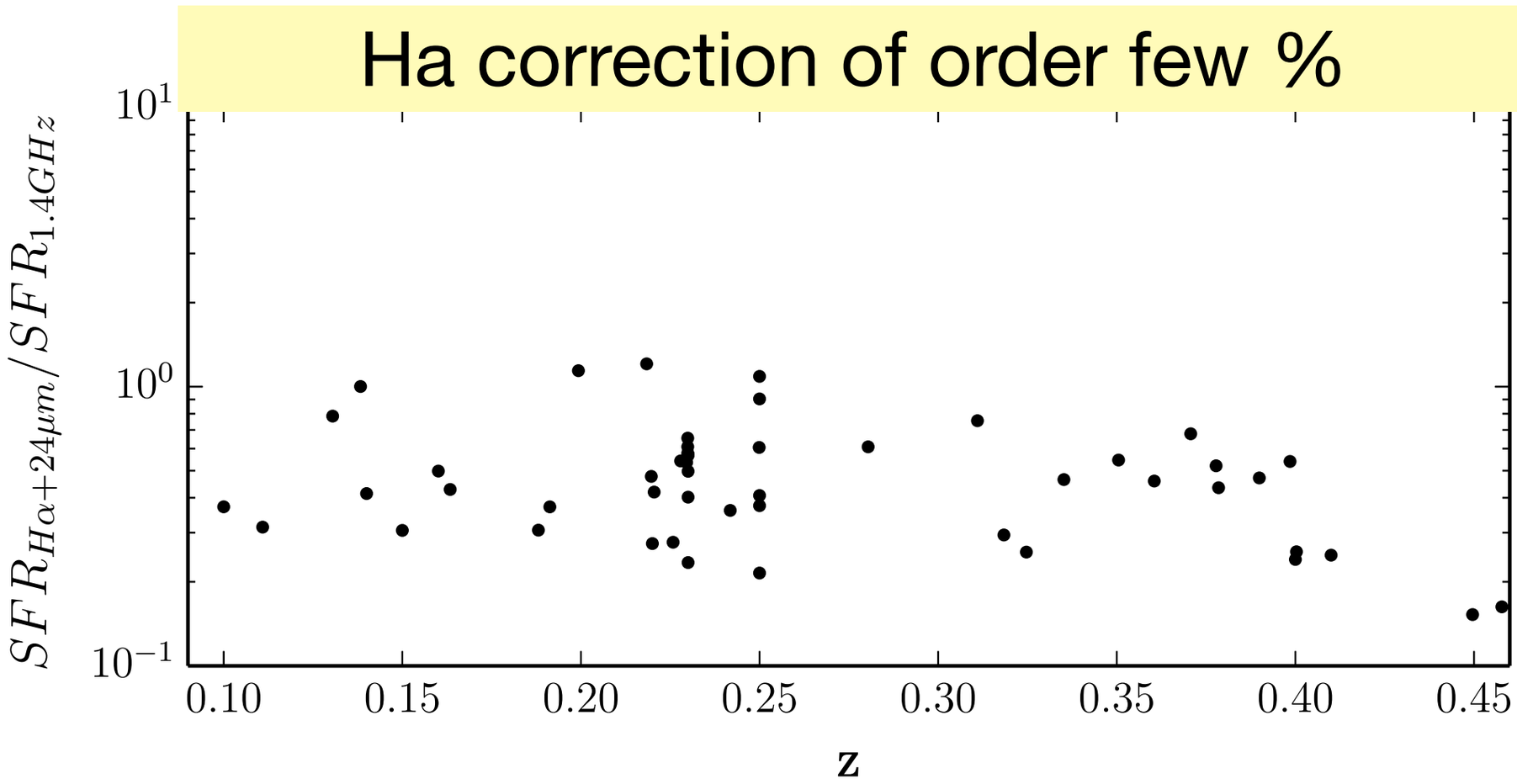
Evolution as proposed by Magnelli et al. 2014

Hybrid monochromatic tracer

Warm dust should be better measure of instantaneous SFR than TIR? (Helou et al. 2004): 24um

Use observed Ha + 24um correction (Elbaz SB template)

Ha correction of order few %



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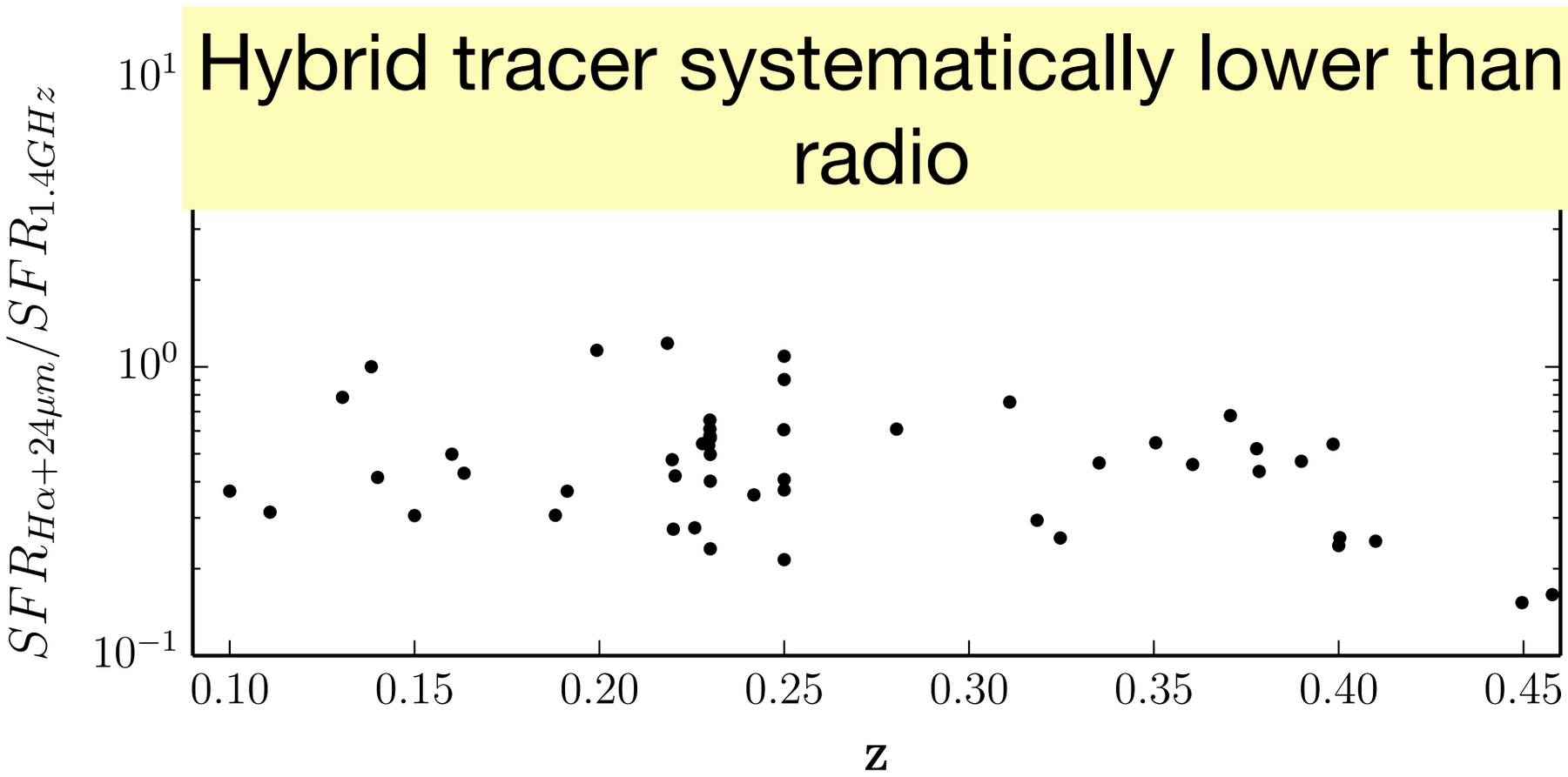
Hybrid tracer systematically lower than radio



Take home messages

Careful of SED choice for your sample: Here prefer cooler dust and SB PAH

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More off main sequence -- less secure. Introduce z variation in SFR depending on relative numbers of more extreme SB in sample bins

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Ha corrected tracer systematically lower than radio and decreasing with z

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Ha corrected tracer systematically lower than radio and decreasing with z

Overall radio non thermal continuum seems to have fewer problems for flux limited samples off main sequence