The Evolution of the IR-Radio Relation

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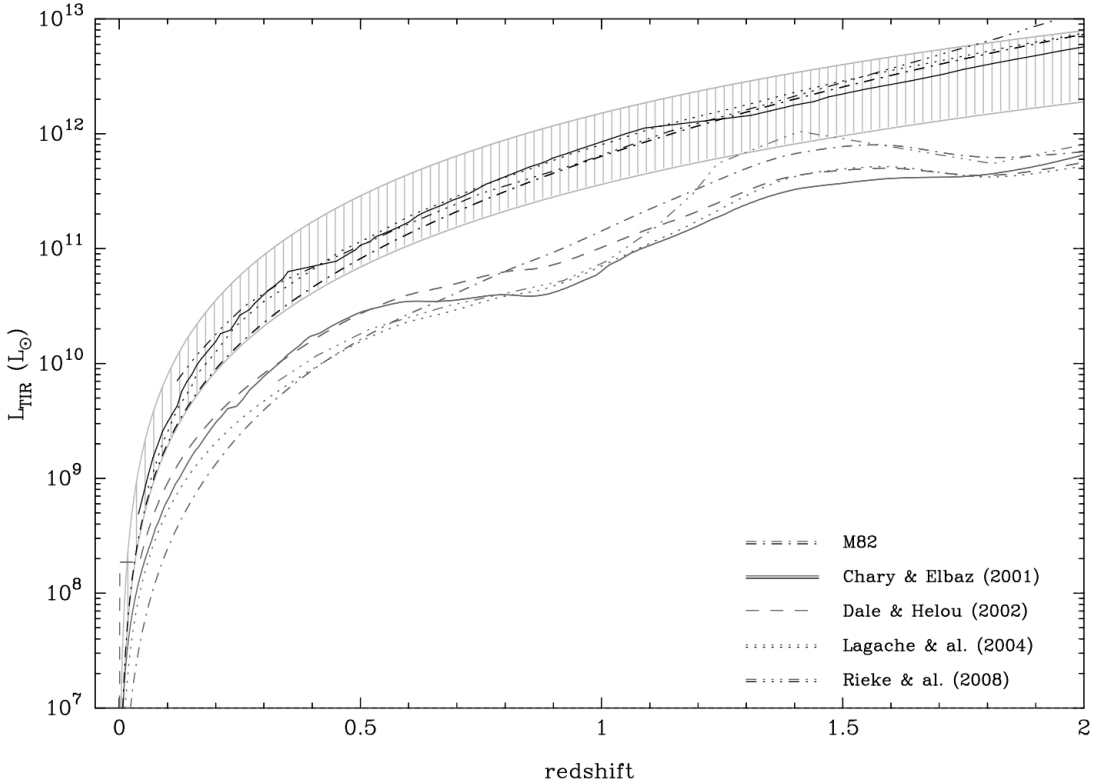
Sample Definition



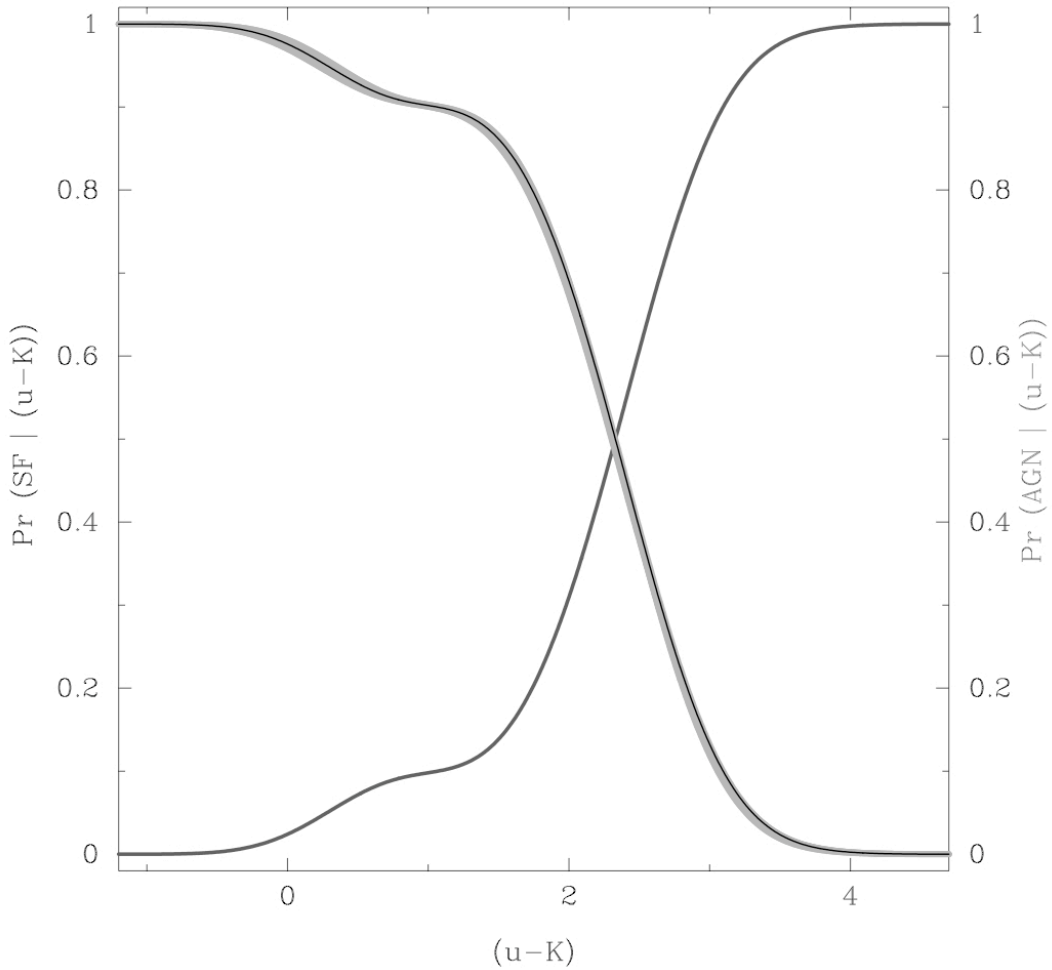
Catalogs:

- 1.4 GHz (σ~12 μJy; FWHM~2.5")
- 24 μm (σ~18 μJy; FWHM~5.8")
- 70 μm (σ~1.7 mJy; FWHM~18.6")
- photometry/(AGN-) photo-z & spec-z catalogs

IR/radio counterparts:
- band merging of 3σ source catalogs
- removal of ambiguous matches (due to either position or varying FWHM)

→ Define both a radio- and an IR- (24 μm) selected sample (~2500 objects; restricted to a similar range of L_{TIR})

SF & AGN systems

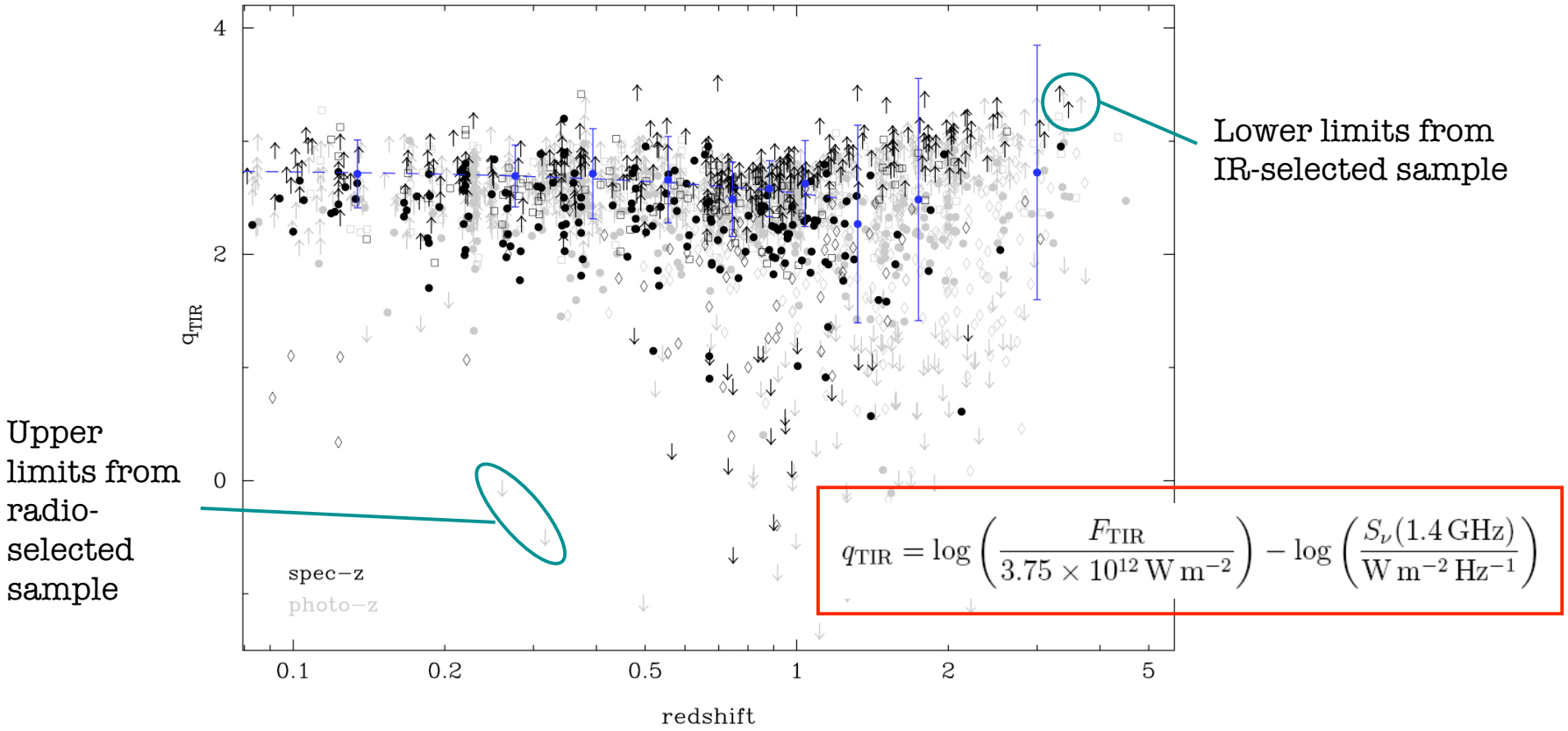


Separate star forming (SF) from AGN systems using rest frame optical colours (cf. Smolčić & al., 2008):

- COSMOS multi-λ photometry fitted with ZEBRA
- relate r.f. (u-K) to colour P1 of Smolčić & al.
- probability distribution:
  Pr (SF | (u-K))
- classify as SF if Pr (SF) > 50% (i.e. if (u-K)<2.36)

Evolution of the IR/Radio Ratio q

- combined IR- & radio-selected sample
- TIR luminosities ($L_{8\text{-}1000\,\mu m}$) from SED fitting (24 & 70 μm flux constraint)

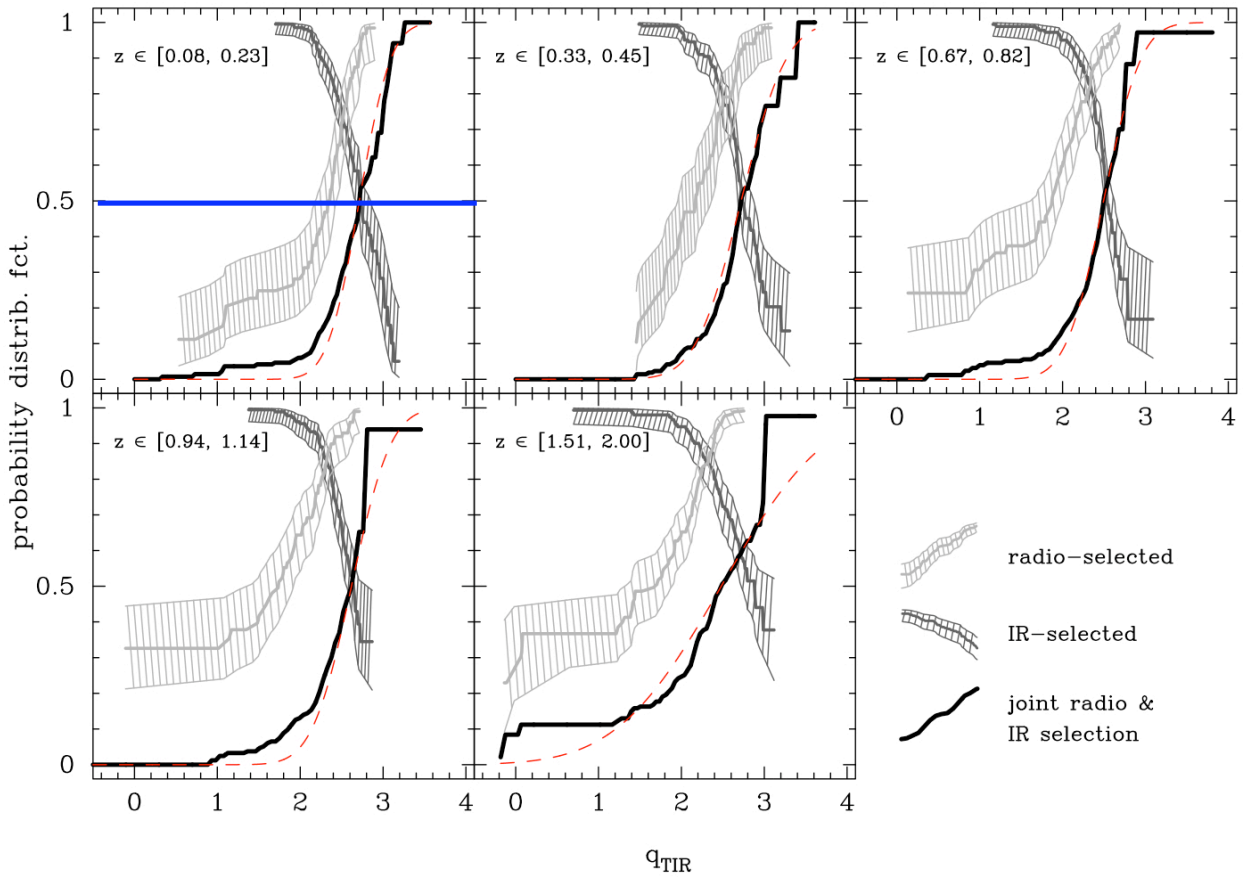


→ No significant change in median TIR/radio ratio out to z~1-1.5

(same applies to K-corrected monochromatic flux ratios q_{24} & q_{70})

Applying Survival Analysis...

Maximum likelihood approach to solving for the underlying distribution of q in the presence of both limits & well-defined measurements. (cf. Feigelson et al., 1985; Schmitt et al., 1993)



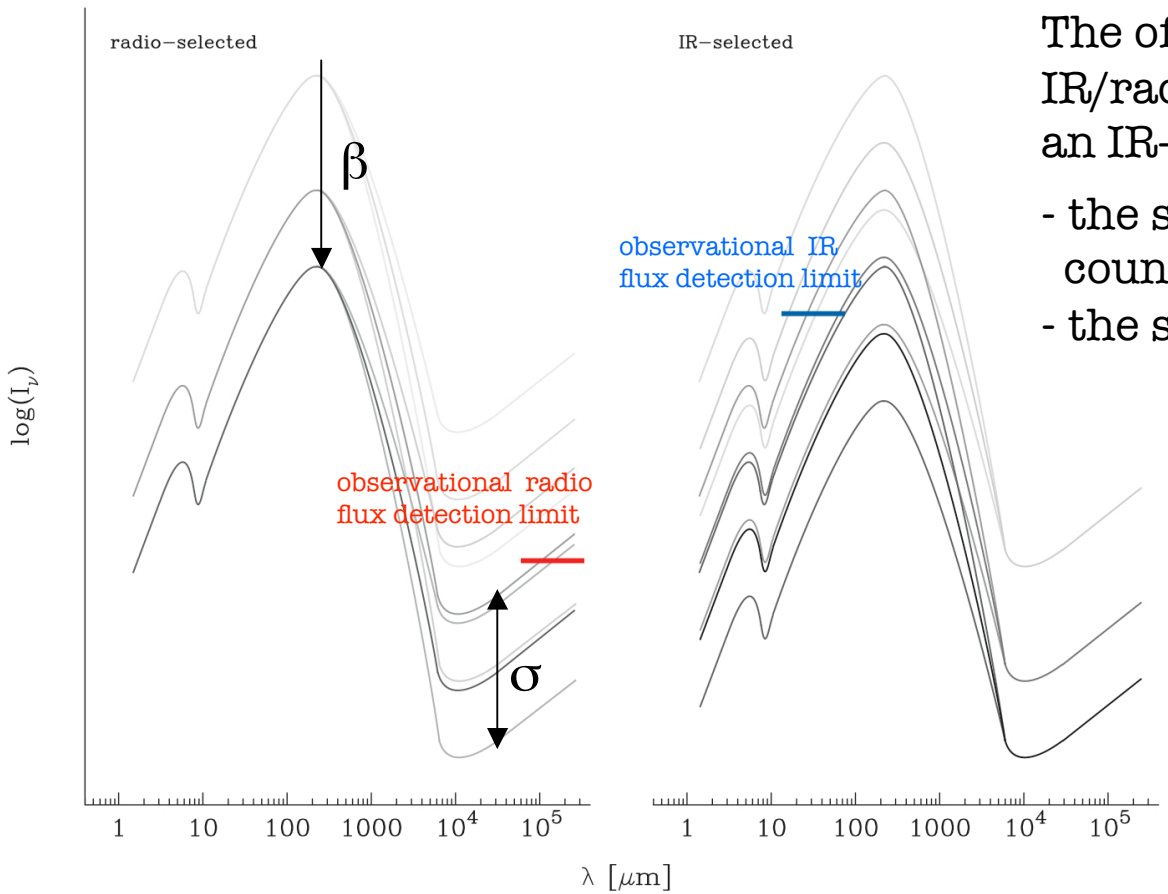
- Offset between IR- & radio selected sample +/- as expected

  (see additional slide in on-line version)

- Consistent with local IR/radio relation & previous results derived with IR-/radio-selected samples

  (e.g., Appleton & al., 2004; Ibar et al., 2008; Rieke & al., 2008)

Note on selection bias



The offset Δq_{bias} in the average IR/radio properties of an IR- and an IR-selected sample depends on:

- the slope, β, of the source counts; $dN/dS \sim S^{-\beta}$
- the scatter of the relation, σ

Analytically:

$$\Delta q_{\mathrm{bias}} = \ln(10)\,[\beta-1]\,\sigma^2$$

Example: if β=2.5 (Euclidean src. counts); σ~0.3

→ $\Delta q_{\mathrm{bias}} \sim 0.3$

$$\boxed{\overline{q}_{\text{IR-sel.}} > \overline{q}_{\text{radio-sel.}}}$$

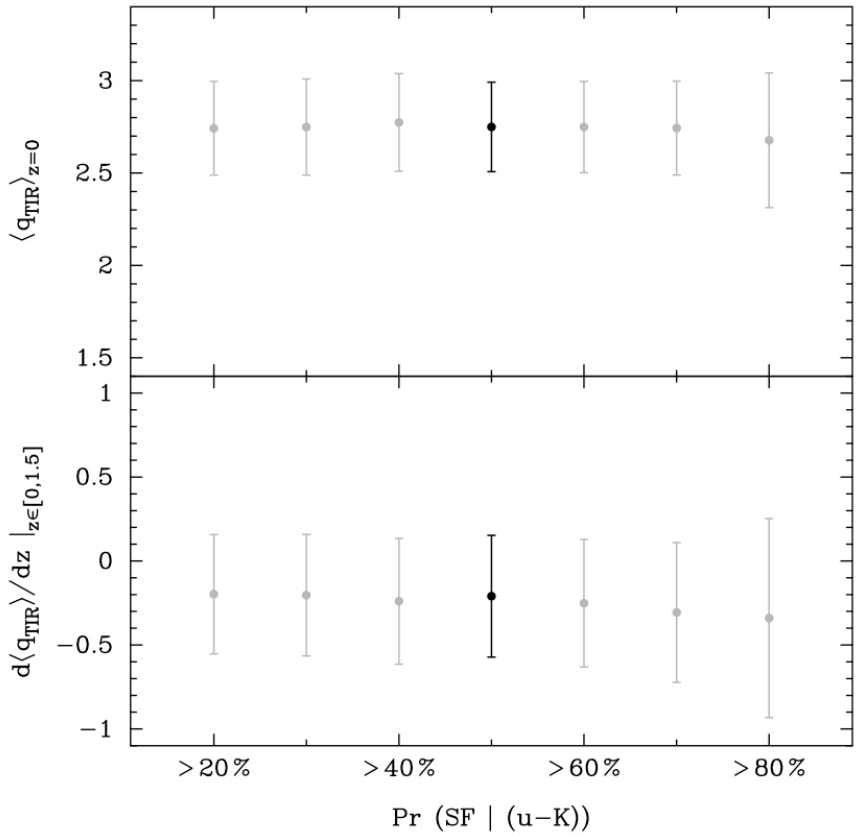
At successively fainter bolometric fluxes radio-selected samples contain ever fewer sources with a steep IR-radio slope; IR-selection works vice-versa (see figure on this slide).

Dependence on SF threshold?

Negligible variations in the zero point & evolutionary slope of the median IR/radio ratio...

... if the selection threshold for SF systems is chosen more conservatively,

... or even if a significant fraction of AGN are included.



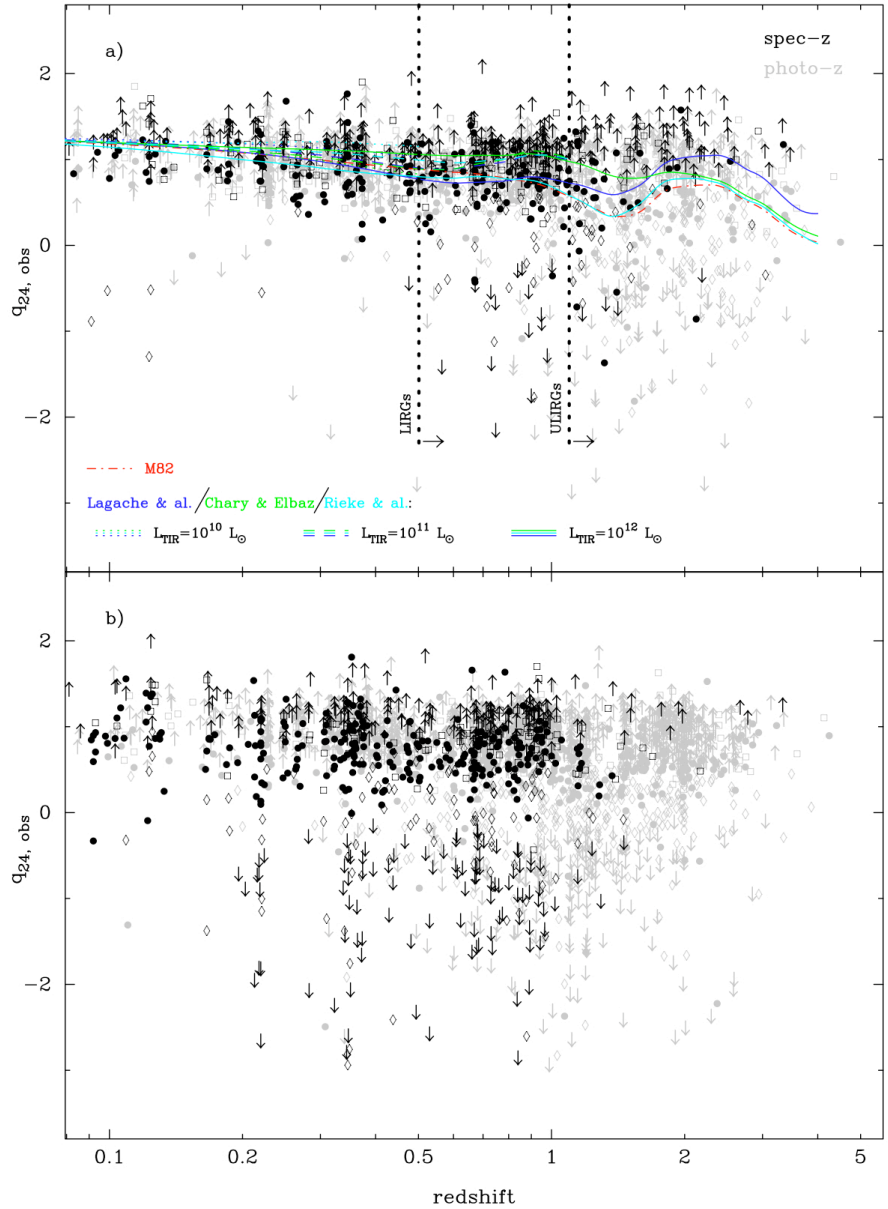
→ A considerable number of radio-quiet AGN are present in the sample, ...

AGN following the relation

Observed 24um/radio flux ratios:

star forming:

AGN:



... radio-quiet AGN which follow the same IR/radio relation as SF objects.

Summary

Methods: - study of both an IR- and a radio-selected sample (and their union)

- survival analysis

- accurate IR fluxes/luminosities due to 24 & 70 μm constraint

Results: - analysis confirms expected shifts as a function of the selection band/seems to reconcile disagreements in literature (e.g., Appleton & al., 2004; Ibar et al., 2008; Rieke & al., 2008)

(*However, discrepancies persist in radio stacks of IR-selected objects!*)

- constancy of average IR/radio properties out to z~1-1.5 confirmed with a sample 10 times larger than previously available

- at high z evolution is increasingly uncertain but consistent with an unchanged IR-radio relation -> need Herschel/EVLA

- numerous (radio-quiet) AGN hosts follow the IR-radio relation of star forming systems (cf. Sopp & al ., 1991; Roy & al., 1998)

- to come soon: search for variations of average IR/radio properties as a function of environment at high z (E. Murphy)