The PEP Survey: Infrared Properties of radio-selected AGN

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Credits for image: Hi-GAL

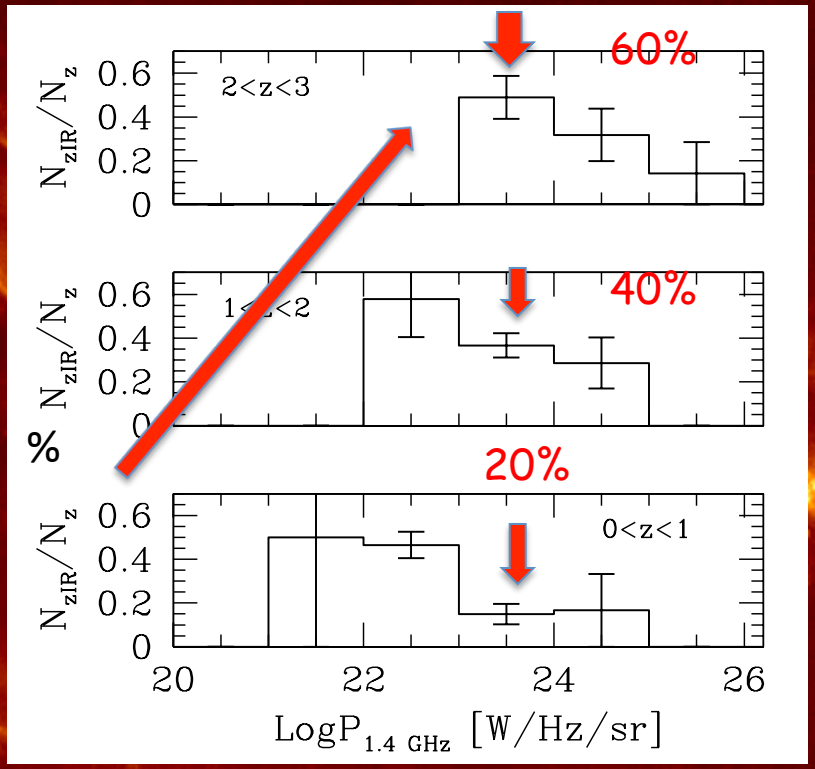
Scientific rationale and outline

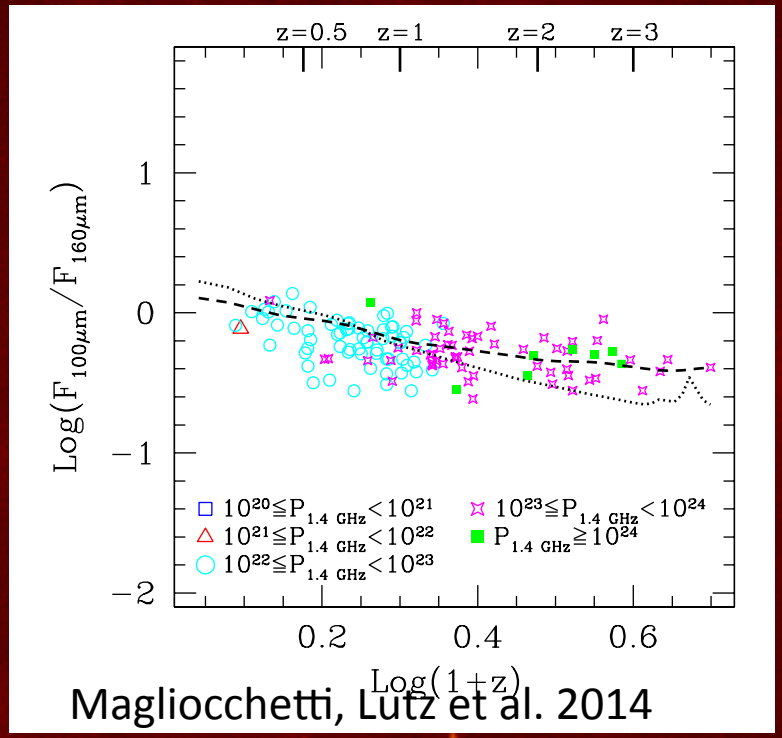
Almost general consensus on AGN selected in various bands (from optical to X-ray) to be hosts of star-forming activity.
Question: does it also hold for radio-selected AGN (generally expected to reside in "red and dead" galaxies)?

Aim: provide analysis of FIR properties of radio-selected AGN of *all* radio luminosities and at *all* redshifts.

Method: adopt criterion for selecting AGN based on *radio-luminosity alone*
Apply it to the COSMOS-VLA sample of 1.4GHz-selected objects.
FIR fluxes from the PACS Evolutionary Probe (PEP, P.I. D.Lutz) survey performed with the PACS instrument onboard Herschel.

Short answer: radio activity *does not* prevent star formation, especially at high z.
Caution when associating radio sources to 'dead' ellipticals (radio mode) as strong function of z!

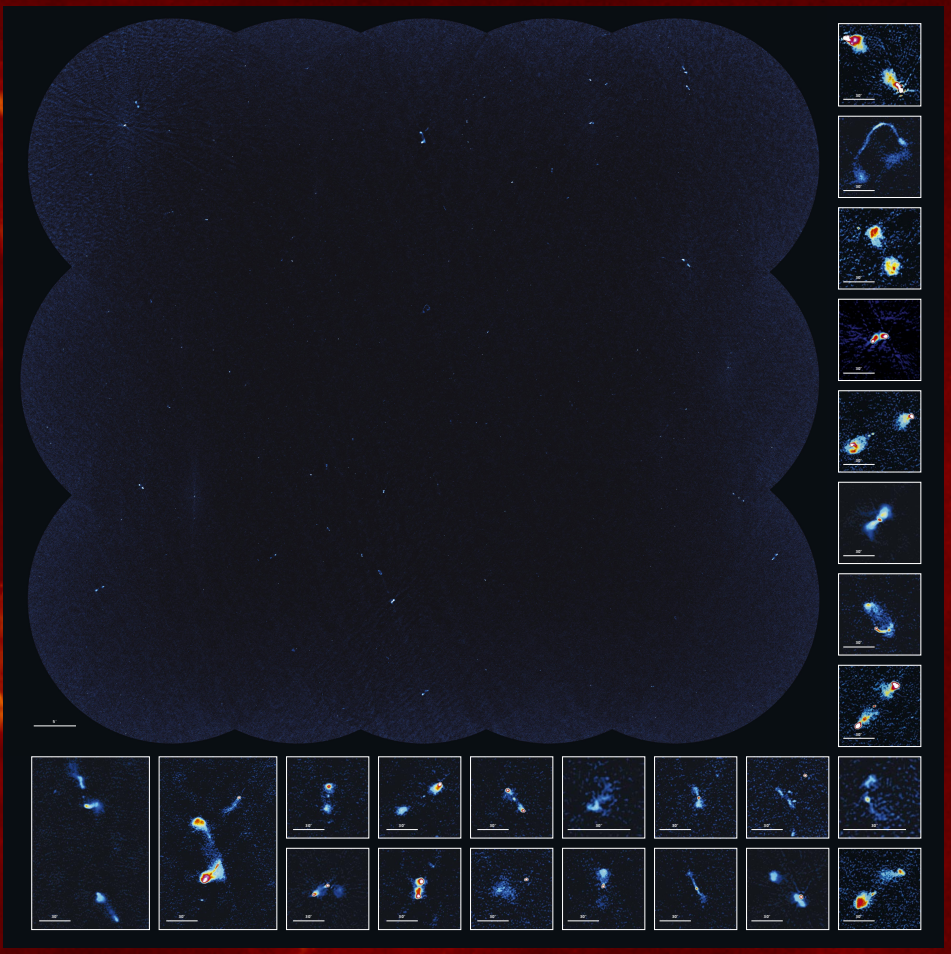




Magliocchetti, Lutz et al. 2014

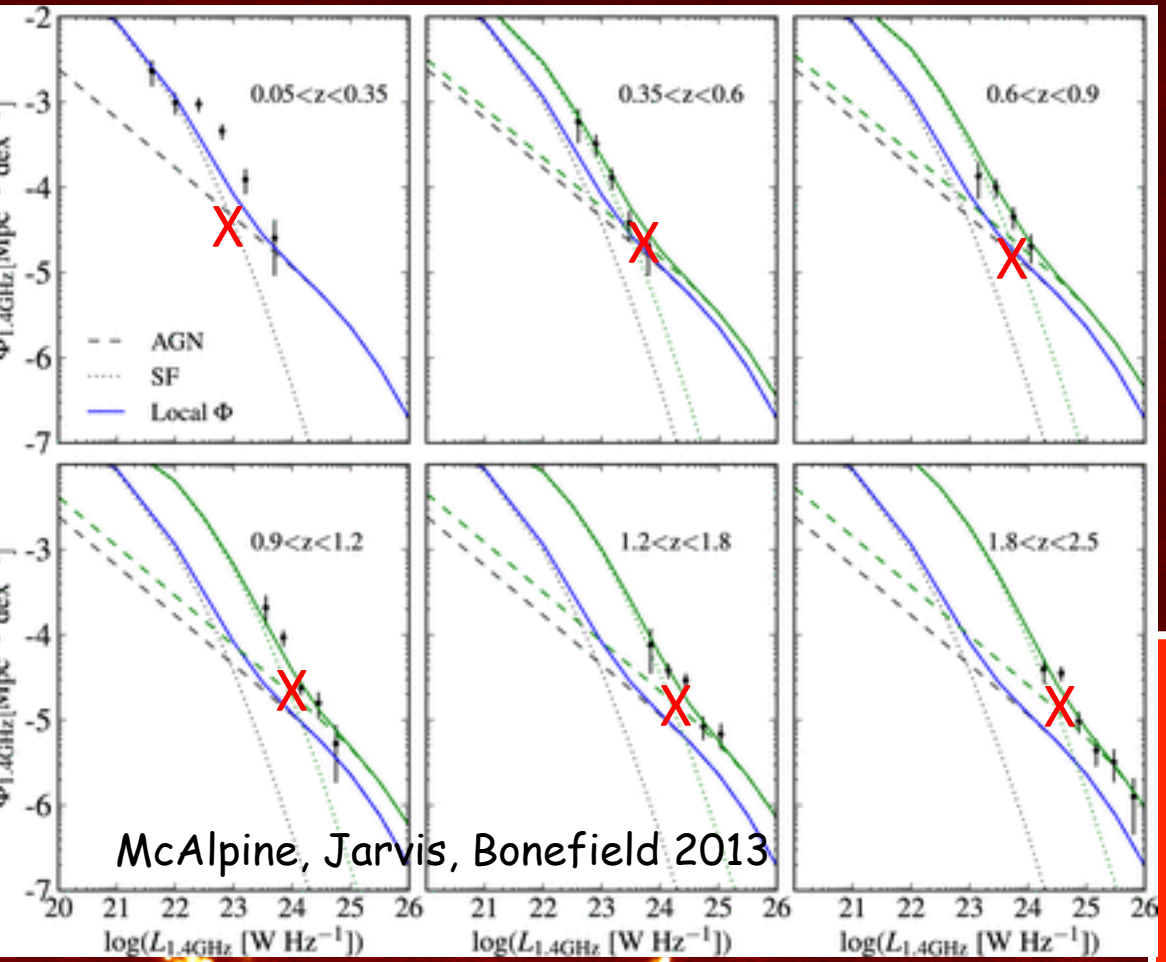
Powerful radio sources are more likely to be FIR emitters at earlier epochs FIR emission entirely due to star-forming processes

COSMOS-VLA @ 1.4 GHz
(Schinnerer+ 2004; 2007; Bondi+2008)



COSMOS-Herschel
(Lutz+2011)

The Origin of FIR emission in radio-selected AGN: criteria for AGN selection in radio surveys

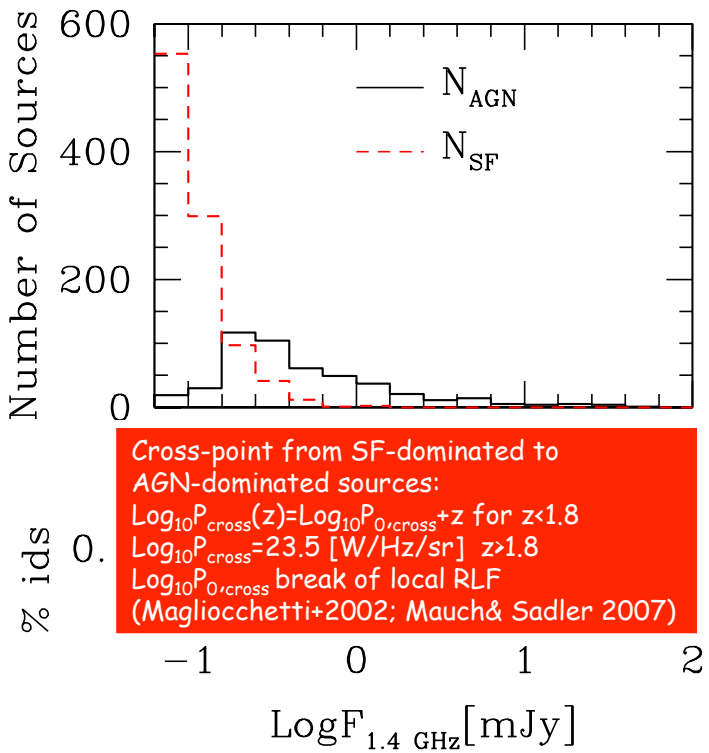


Radio data from VLA-VIRMOS (Bondi+ 2003). 1 deg^2 complete to 100mJy: 1054 sources

10-band photometry via VIDEO (Jarvis+2013) and CFHTLS (Ilbert+ 2006) for 942 sources (91%).
Photo-z with s~0.025 accuracy (s~0.10 for QSOs above z~0.22) + SED analysis of source type

From McAlpine+13 RLF z evolution of cross-point from SF-dominated to AGN-dominated sources:
$Log_{10}P_{cross}(z)=Log_{10}P_{0,cross}+z$ for $z<1.8$
$Log_{10}P_{cross}=23.5$ [W/Hz/sr] $z>1.8$
$Log_{10}P_{0,cross}$ break of local RLF
(Magliocchetti+2002; Mauch& Sadler 2007)

The Origin of FIR emission in radio-selected AGN: VLA-COSMOS (radio+FIR) sample



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$\mathrm{Log}_{10}P_{0,cross}$ break of local RLF
(Magliocchetti+2002; Mauch& Sadler 2007)

Radio data from VLA-COSMOS (Bondi+ 2008). 2 deg^2 complete to 60mJy: 2382 sources.

Redshifts from Ilbert+ 2013
1537 radio sources with z (65%) independent of radio flux.

1026 sources (67%) SF.
Majority SF $F_{1.4GH}<0.4$ mJy
482 sources (32%) AGN.
Majority AGN $F_{1.4GH}>0.4$ mJy.

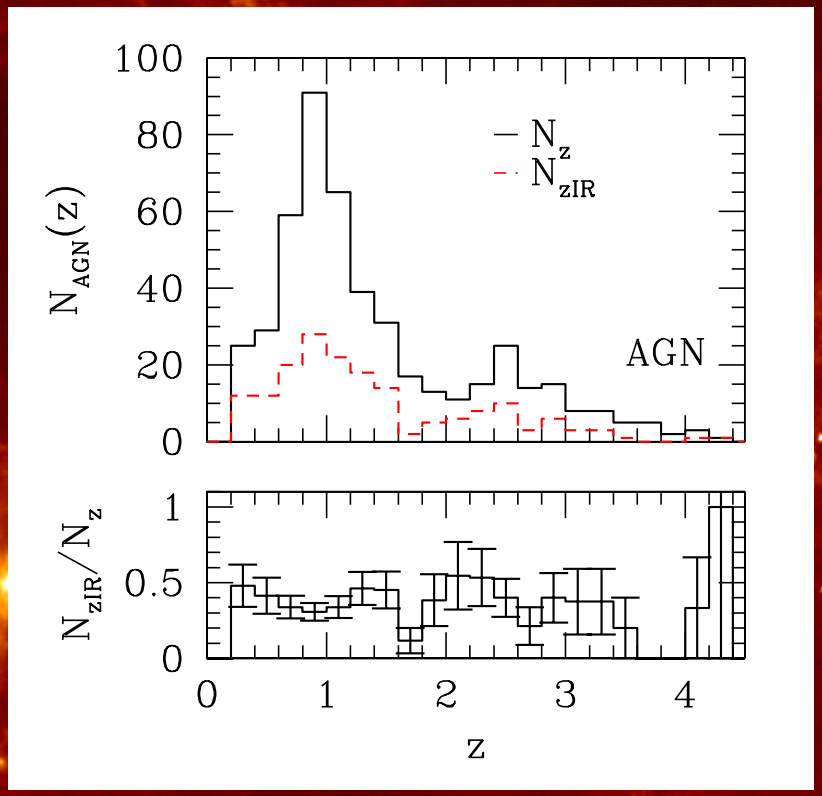
FIR fluxes from PEP Survey (Lutz+2011) down to ~4 mJy (@100mm to 4″) and 7 mJy (@ 160mm to 5″).

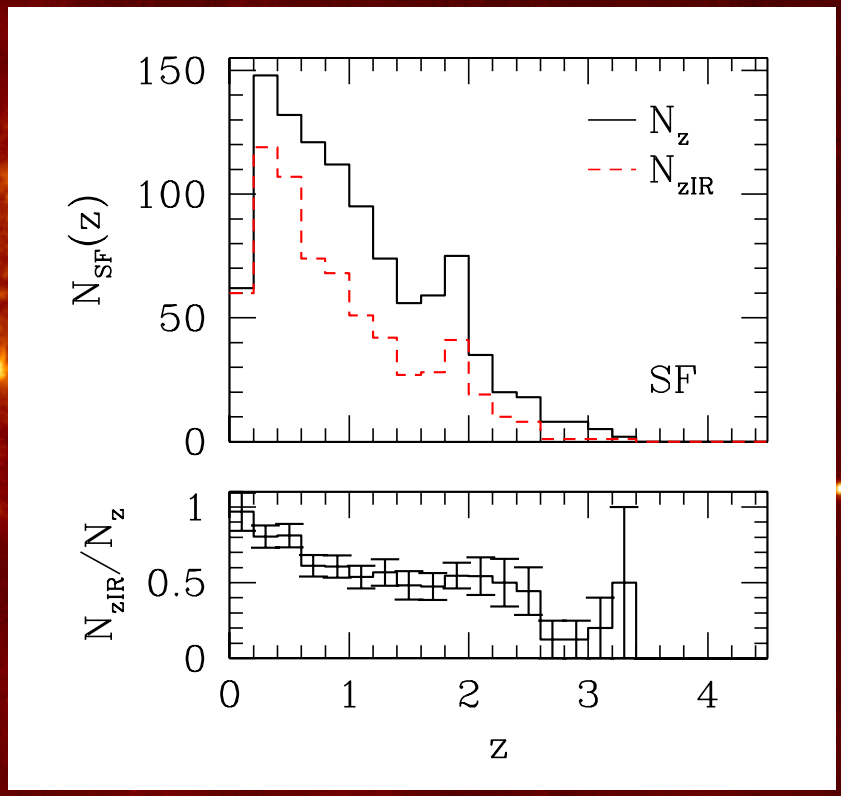
FIR ids →

-657 SF have counterpart in PEP catalogues. Dependent on RF.
-175 (36%) AGN. No dependence on radio flux up to F~3 mJy.

The Origin of FIR emission in radio-selected AGN: redshift distributions

-$F_{1.4GHz}$>0.06 mJy →P_{min}<P_{cnoss} [W/Hz/sr] for z<3.5→ VLA-COSMOS AGN sample *complete* in radio for *all z<3.5*!

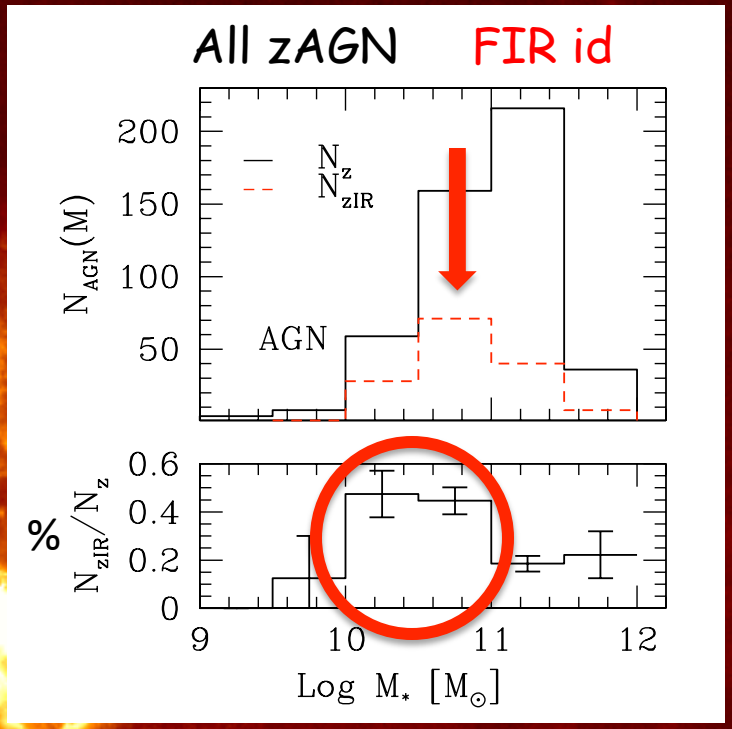


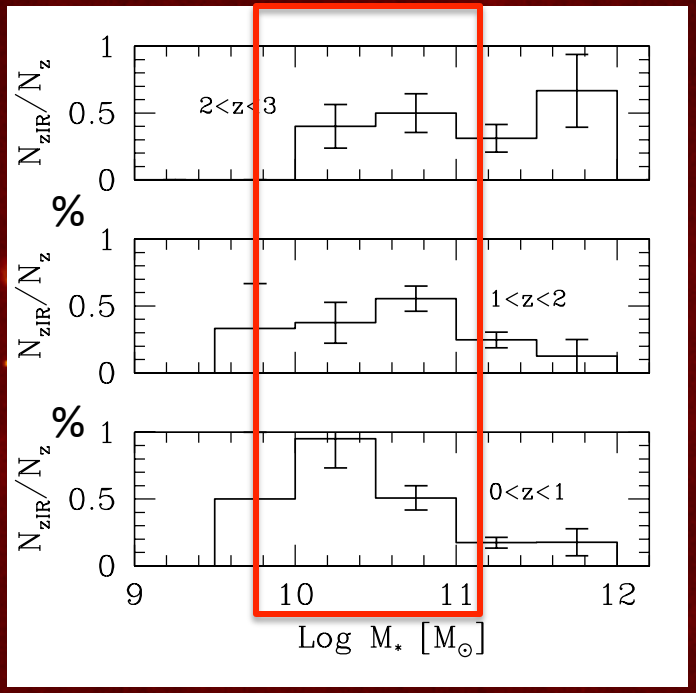


-NO dependence of FIR id success rate on z for AGN family
-FIR-id AGN same (rescaled) N(z) distribution wit marked peaks @ z~1 and z~2.5

Id-rate of SF galaxies monotonically decreases with z (incomplete sample)

The Origin of FIR emission in radio-selected AGN: information from stellar mass M_*



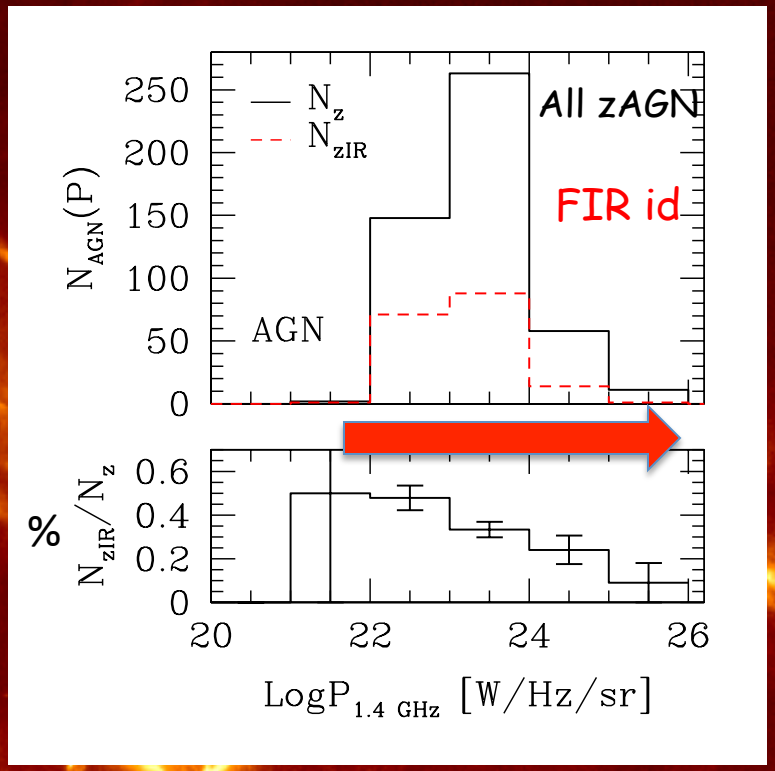


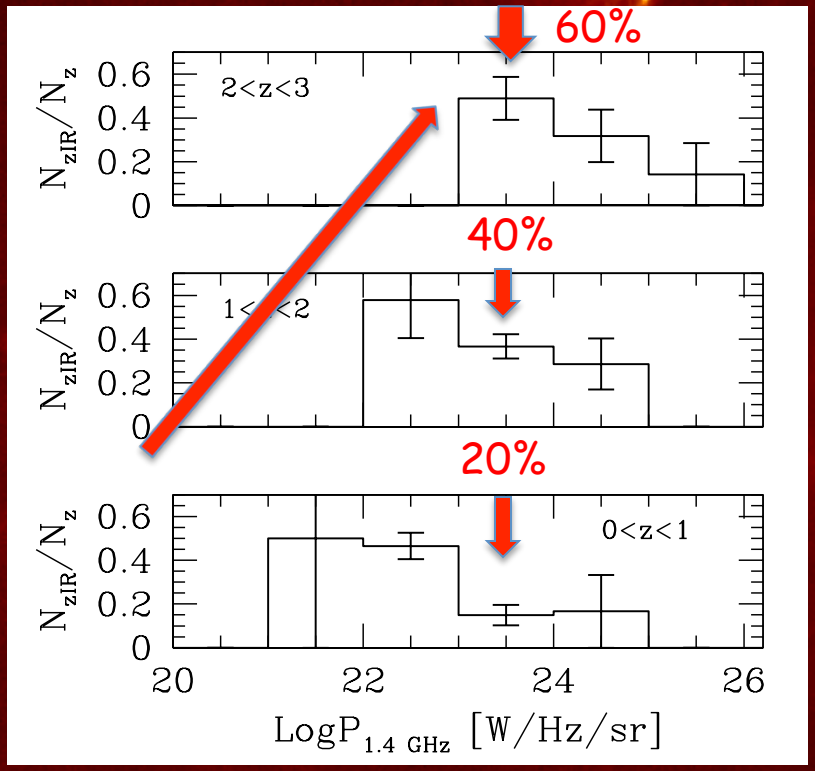
-FIR-id AGN smaller masses than whole radio-selected AGN population

-Preferential mass scale M_*~10^{10}-10^{11} M_{sun} maximizes chances for FIR emission

-Only true for z<2

The Origin of FIR emission in radio-selected AGN: information from radio luminosity $P_{1.4GHz}$

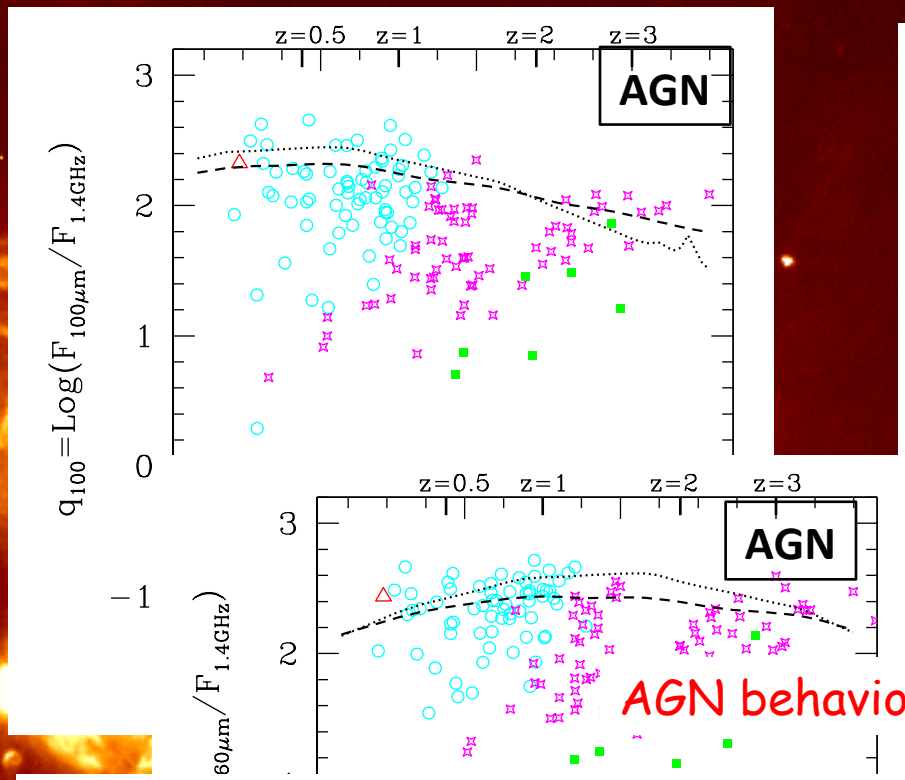


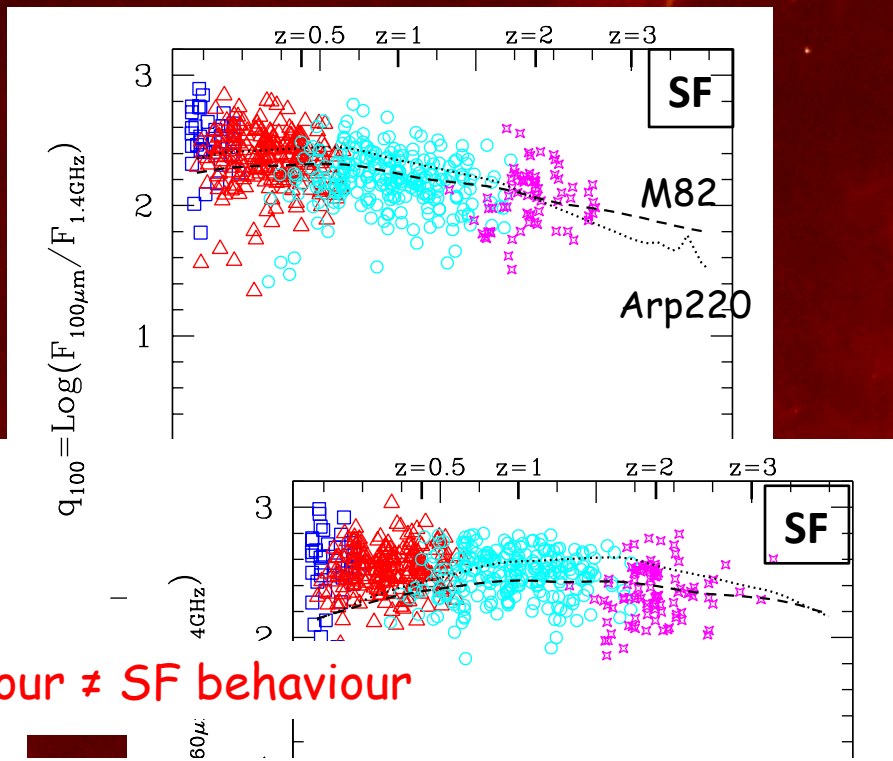


- As expected number of FIR emitters decreases with increasing radio luminosities
- Drop shifts to higher radio luminosities at higher zs

Powerful radio sources are more likely to be FIR emitters at earlier epochs

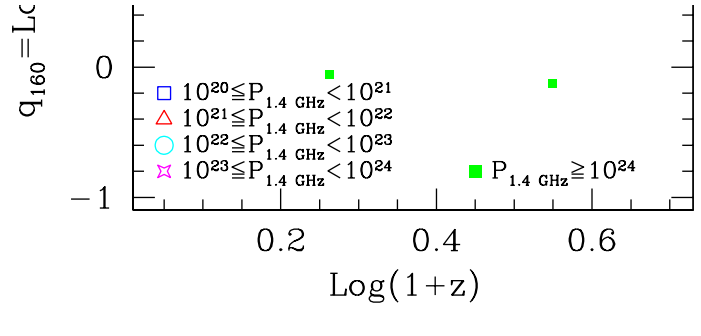
The Origin of FIR emission in radio-selected AGN: information from q_{100} and q_{160} for AGN and SF of given P

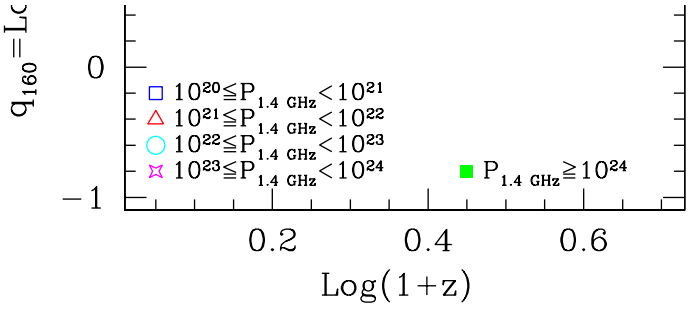




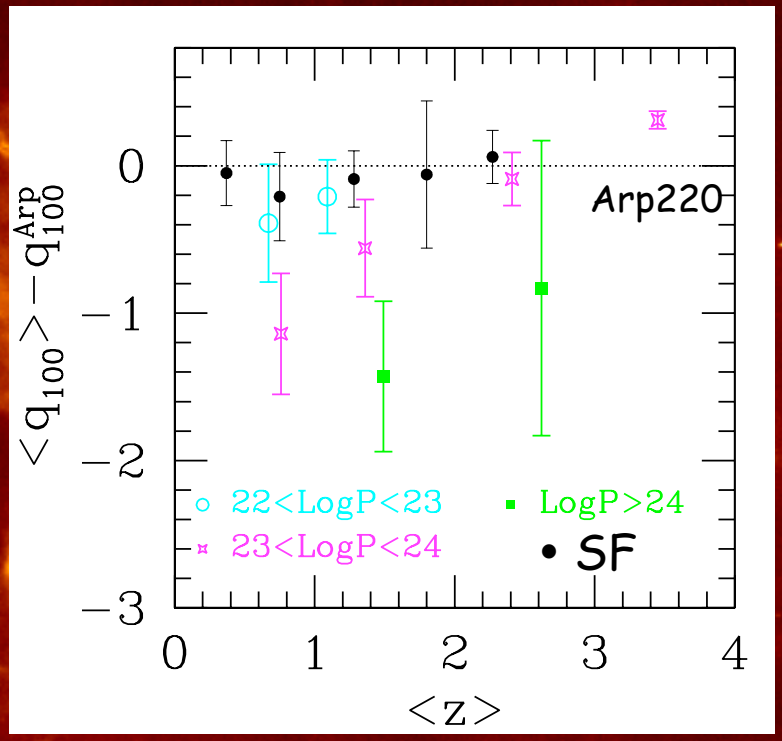
AGN behaviour ≠ SF behaviour

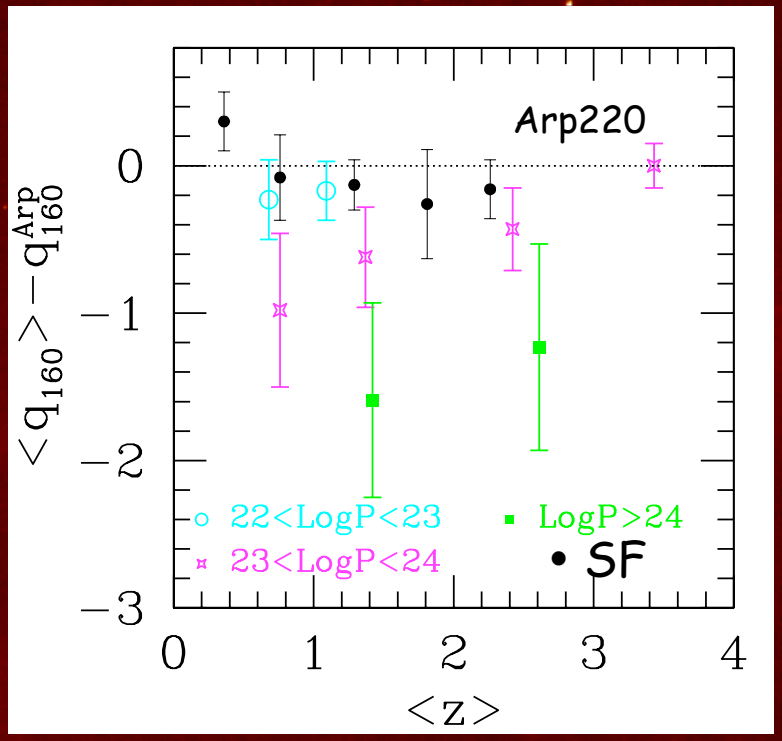
Trend for AGN SEDs to approach those of Arp220 and M82 at earlier epochs





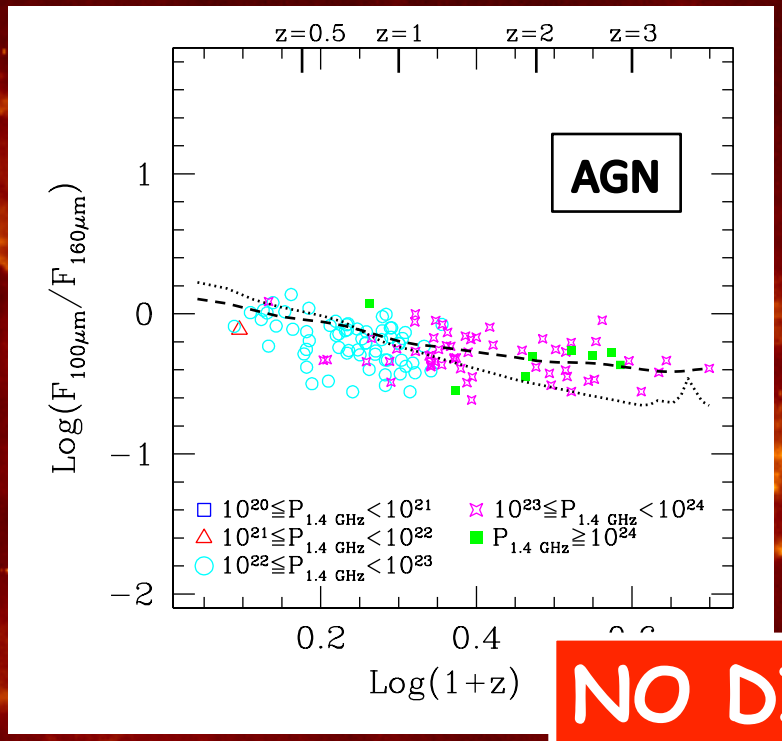
The Origin of FIR emission in radio-selected AGN: information from q_{100} and q_{160} for AGN and SF of given P

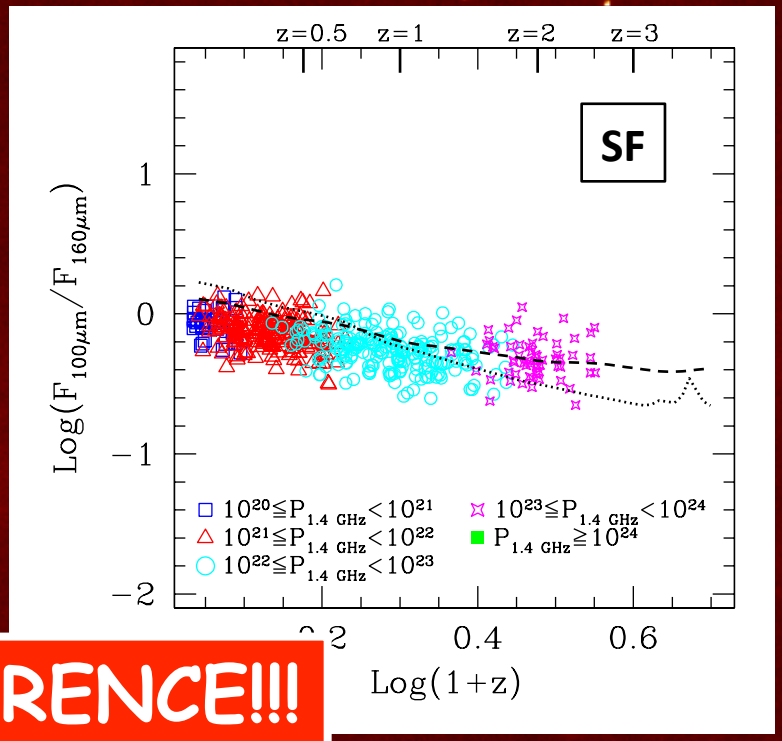




SF follow Arp220 SED at all z and P.
AGN FIR-to-radio approaches Arp220 at earlier epochs at *all* P.
Analysis performed at fixed P → enhancement of FIR activity with z

The Origin of FIR emission in radio-selected AGN: information from FIR fluxes of AGN and SF of given P





NO DIFFERENCE!!!

Irrespective of radio activity and z FIR emission in radio-selected AGN indistinguishable from that produced by star-forming galaxies →

→ FIR entirely due to star forming processes within AGN host

CONCLUSIONS

Complete catalogue (up to z=3.5) of 482 radio-selected AGN from COSMOS-VLA.
175 (i.e. 36%) with counterpart in the PEP survey either at 100 or at 160 mm.
No redshift dependence of FIR ids.

Probability for FIR emission strong function of P and z.
More powerful sources more likely FIR emitters at higher z.
$P_{1.4GHz}$~ 10^{23}-10^{24} W/Hz/sr from ~10% at z<1 to ~60% at z=[2-3].

Above phenomenon due to enhancement of FIR activity with z in AGN of all P.

Typical mass M_*~[10^{10}-10^{11}] M_{sun} for FIR emission (up to 60%, only for z<2). Why??

FIR emission in radio-selected AGN same origin of FIR emission in SF galaxies: SF activity within host galaxy.

Radio signal from radio-selected AGN especially at high z most likely due to superposition of AGN accretion and SF activity