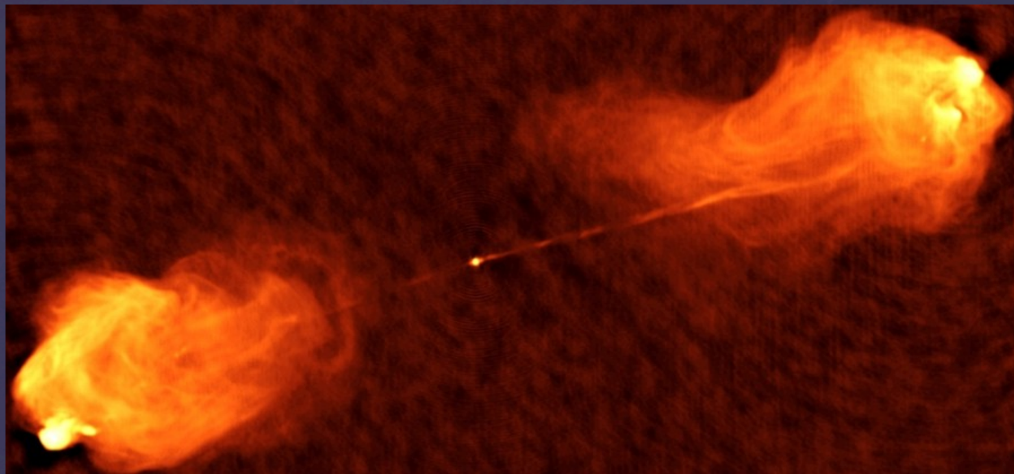
HOSTS AND ENVIROMENTS OF RADIO-ACTIVE AGN

Manuela Magliocchetti
IAPS-INAF

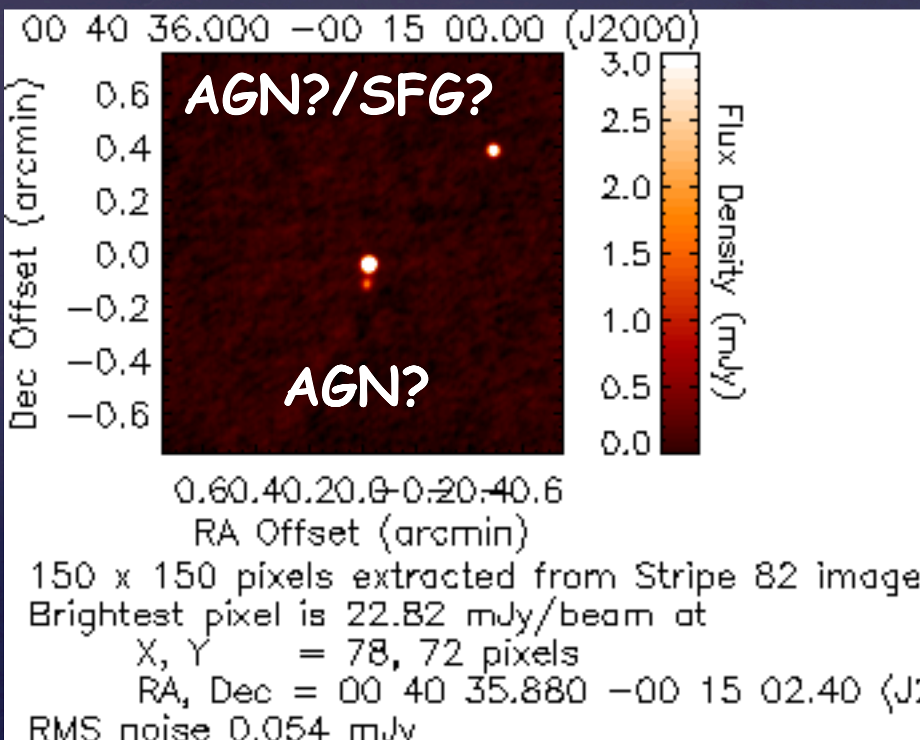
P.Popesso – M. Brusa – M.Salvato

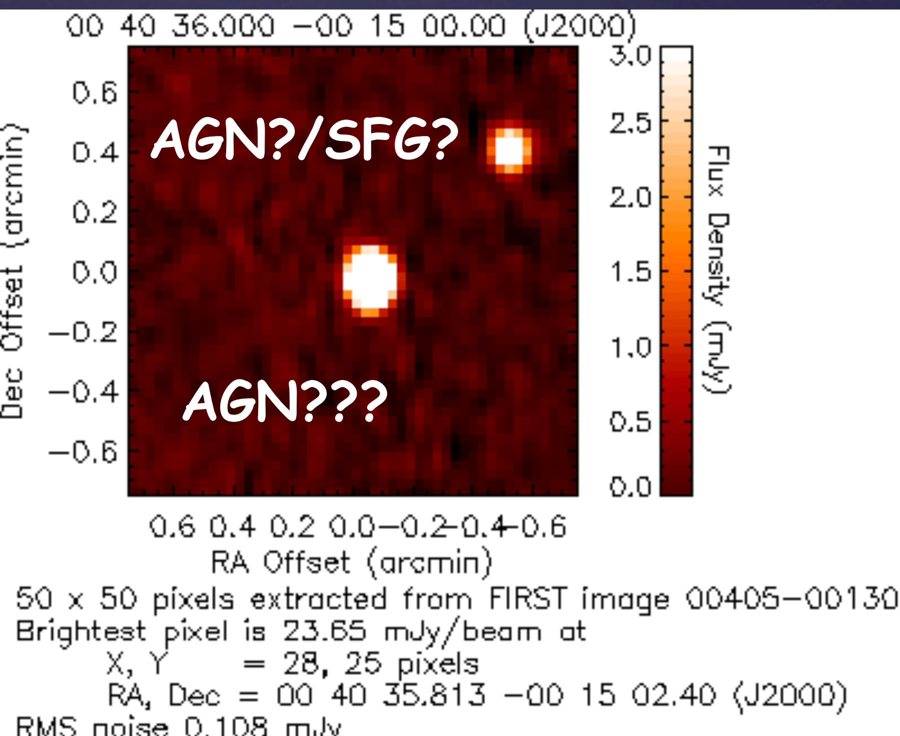
(Magliocchetti+2014;2016,2017, 2018a,2018b)

RADIO-EMITTING AGN OR STAR-FORMING GALAXY?



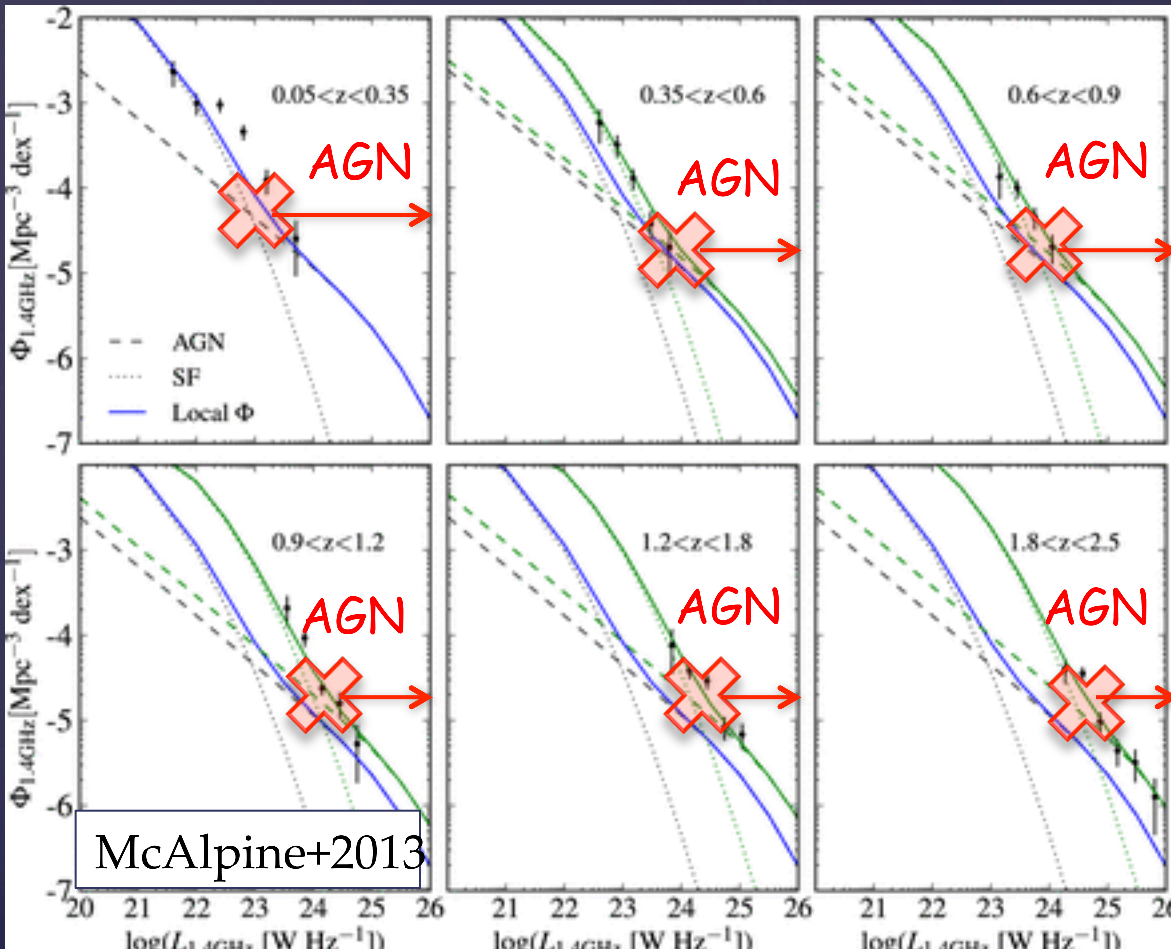
AGN!!





CRITERIA FOR AGN/SF DIVISION IN RADIO SURVEYS

(Magliocchetti+2014;2016,2017,2018a,2018b)



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

From McAlpine+13 RLF z evolution of cross-point from SF-dominated to AGN-dominated sources:

$Log_{10}P_{cross}(z)=Log_{10}P_{0,cross}+z$ @ z<1.8

$Log_{10}P_{cross}=23.5$ [W/Hz/sr] @ z>1.8

$P_{0,cross}$ break of local SF RLF (Magliocchetti+2002; Mauch& Sadler 2007)

AGN all sources with $P(z)>P_{cross}(z)$

SF all sources with $P(z)<P_{cross}(z)$ [N.B. also includes RQQ]

FIELD AND DATA SELECTION

A) COSMOS-VLA Survey (Bondi+2008)

Ntot ($F_{1.4GHz}$>60μJy): 2382
Nz($F_{1.4GHz}$>60μJy)=2123 (90%)

NAGN=704 (272 FIR) -- shallower in radio/FIR but wider area

B) GOODS-N + GOODS-S (Morrison+2010; Miller+2013)

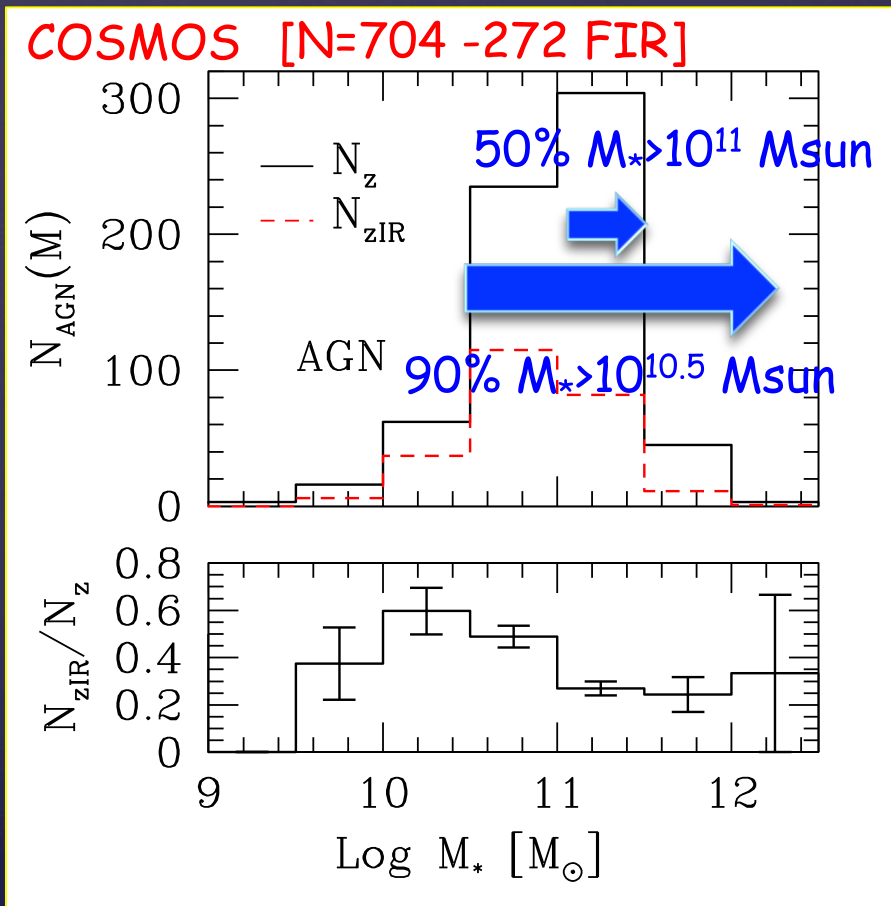
Ntot ($F_{1.4GHz}$>20μJy): 401 + 142
Nz($F_{1.4GHz}$>20μJy): 267 + 114 (≈75%)

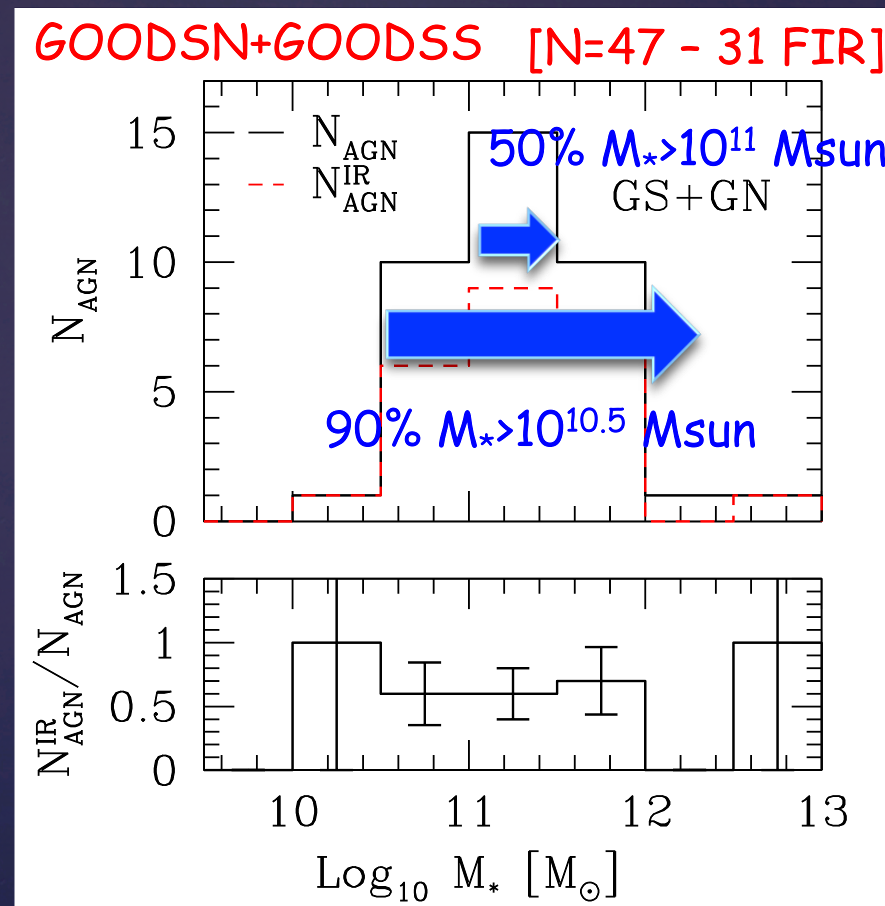
NAGN=32+15 (23+8 FIR)-- deeper in radio/FIR but smaller area

N.B. All samples complete up to z~ 3.5
Success-rate independent of radio flux (up to ~ 3 mJy) and redshift

STELLAR MASSES OF RADIO-AGN HOSTS

90% have $M_* > 10^{10}$ Msun. 50% $M_* > 10^{11}$ Msun

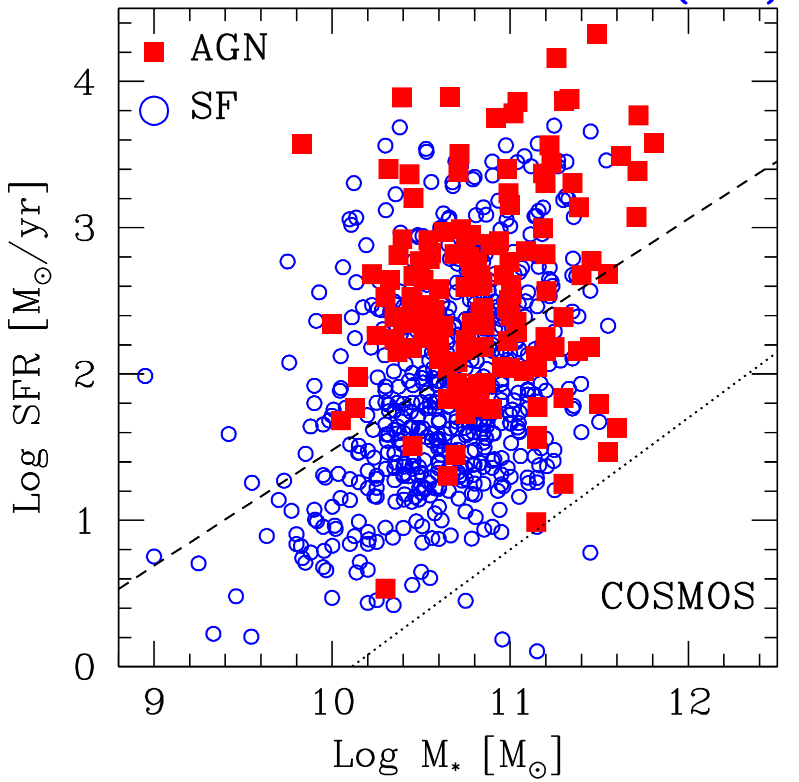




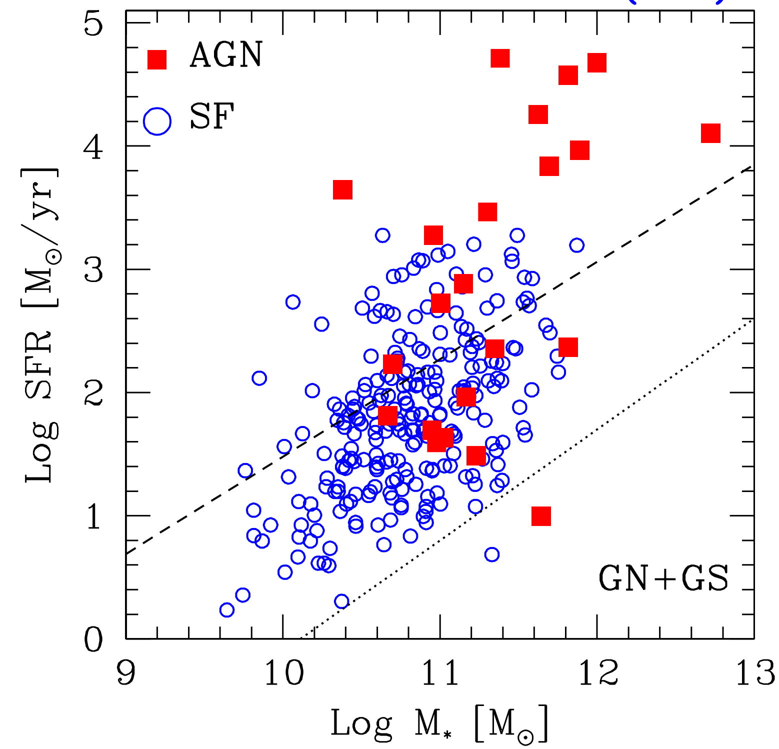
HOSTS OF RADIO AGN EXTREMELY MASSIVE GALAXIES AT ALL REDSHIFTS

STAR-FORMING ACTIVITY WIHIN RADIO-AGN HOSTS

COSMOS AGN WITH FIR ACTIVITY (38%)

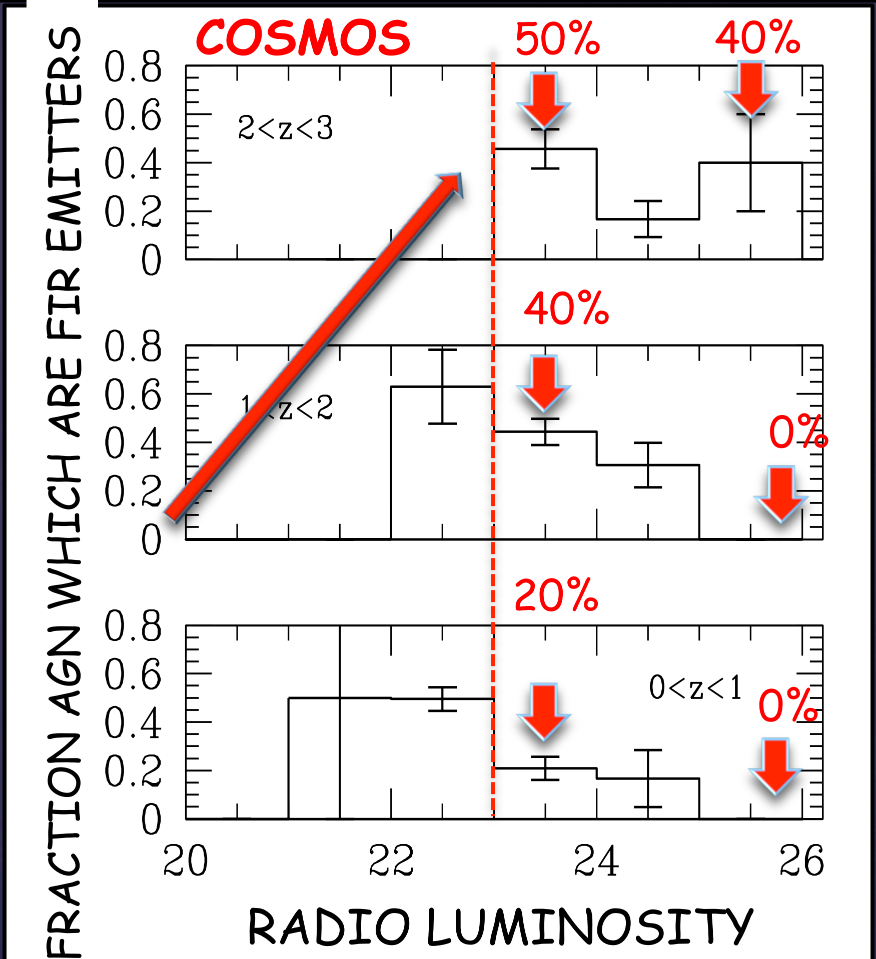


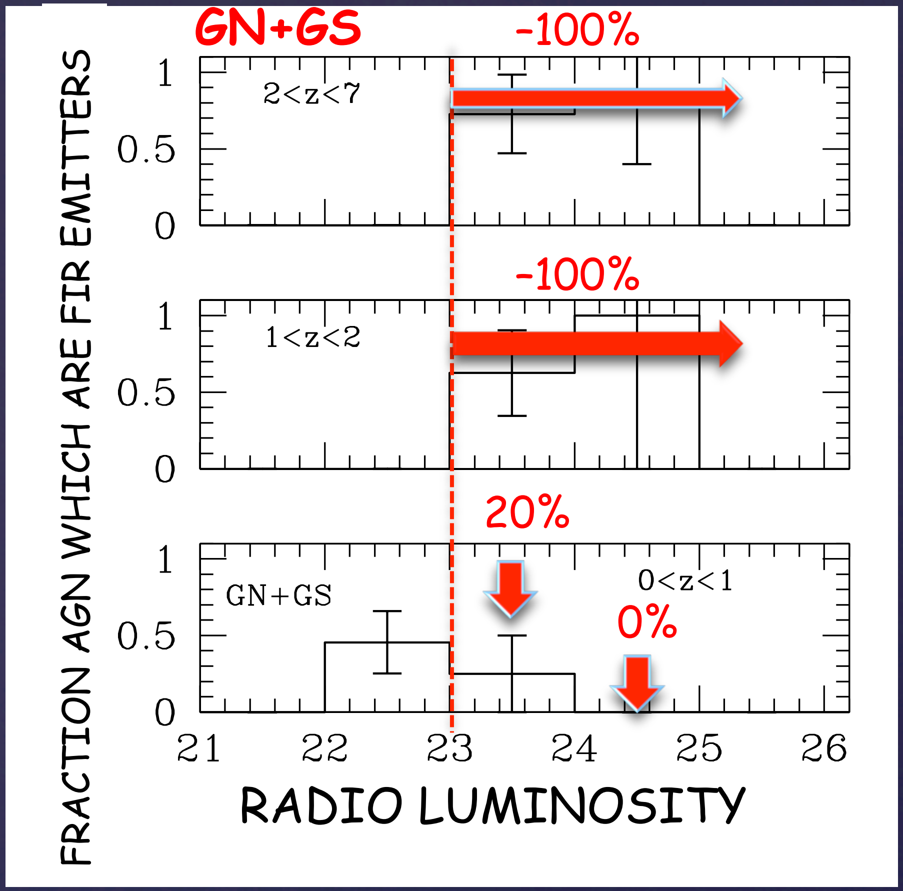
GN+GS AGN WITH FIR ACTIVITY (66%)



HOSTS OF RADIO EMITTING AGN NOT ONLY VERY MASSIVE BUT SITES OF INTENSE STAR FORMATION ACTIVITY, PARTICULARLY AT z>1

Fraction of FIR emitters amongst radio-selected AGN as a function of radio luminosity at different cosmological epochs





Powerful radio AGN are more likely associated to ongoing star-formation at earlier epochs. ~100% at z>1 for deep enough FIR surveys. NO SIGN OF NEGATIVE FEEDBACK only present for z<1 and only for radio-bright sources

WHAT HAVE WE LEARNED SO FAR?

1) Radio-emitting AGN are hosted by very massive galaxies at all z

2) Most of them are in the process of forming stars at very high rates

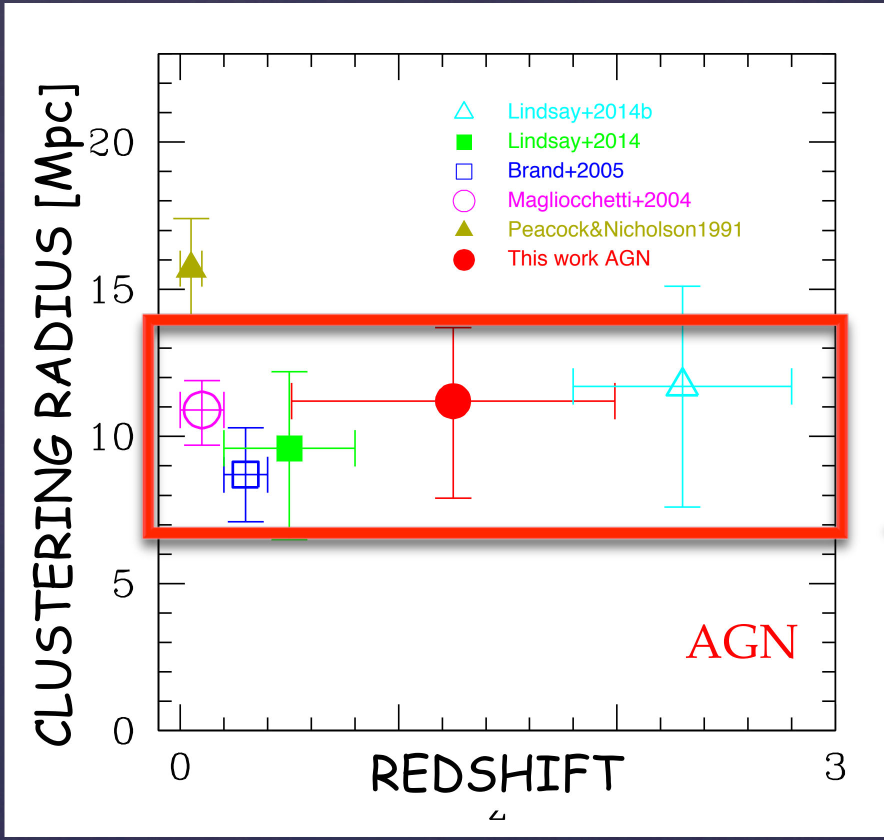
3) Such star-forming activity much more intense in the past. Deepest FIR surveys show that ~100% of high (z>~1) redshift radio-active AGN are associated to SF events
→ NO (negative) AGN-to-SF FEEDBACK at those z

4) Feedback only present in the z>1 universe and for mainly for sources which are radio-powerful

AND WHAT ABOUT AGN LARGE-SCALE ENVIRONMENT?

Investigate spatial distribution via 2ptCF and direct pinpoint on known structures (COSMOS)

CLUSTERING ANALYSIS: COMPARISON OF AGN RESULTS WITH LITERATURE



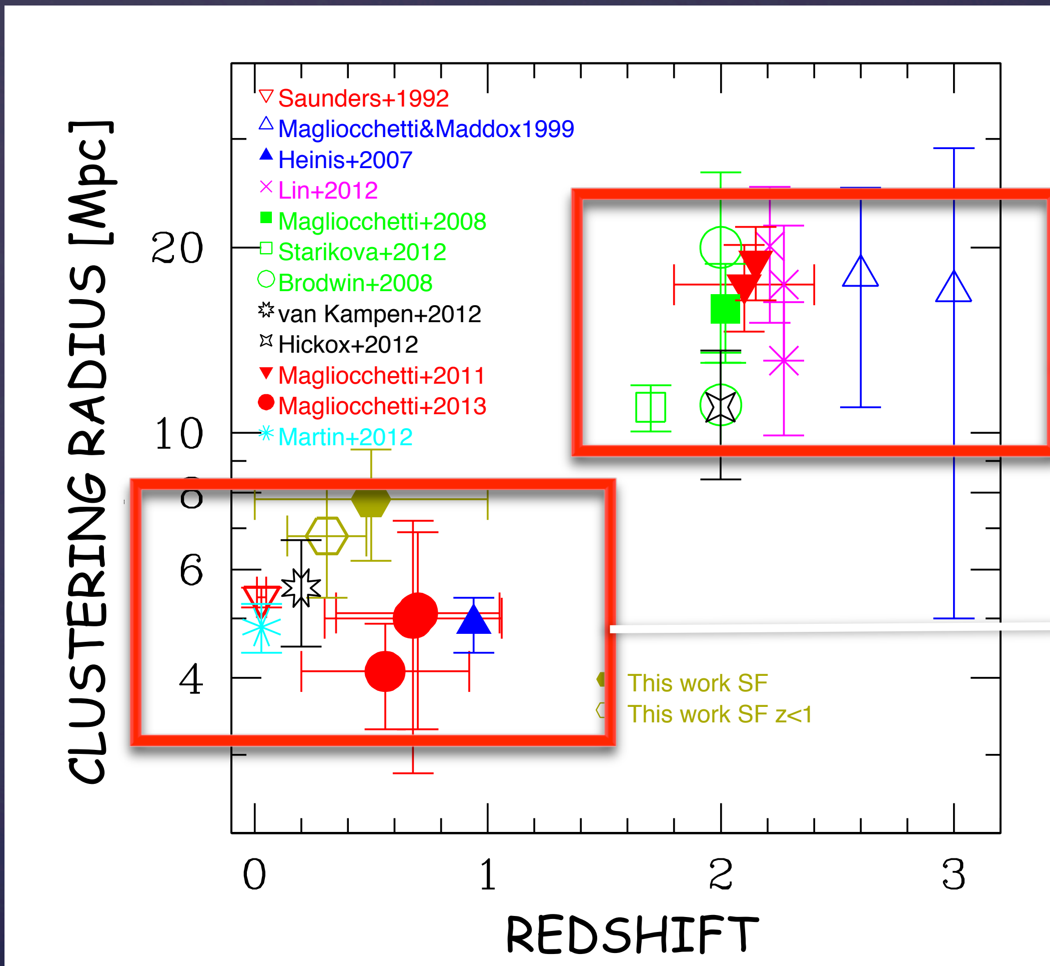
Peacock& Nicholson 1991
F>500 mJy - z<0.1
Magliocchetti+2004 -- 2dF+FIRST
F>1 mJy (AGN) -- <z>=0.1
Brand+2005 -- Texas-Oxford+NVSS
F>3 mJy -- <z>=0.3
Lindsay+2014 - GAMA+FIRST
F>1mJy -- <z>=0.5
Lindsay+2014b - VLA-VIRMOS
F>0.09 mJy -- <z>0=2.2
Magliocchetti+2016 - VLA-COSMOS
F>0.15 mJy -- <z>=1.3

$M^{HALO}_{MIN} \approx 10^{13.5}\ M_{sun}$
(groups-to-clusters of galaxies)

Except for P&N excellent agreement amongst different results →
→ INDEPENDENCE OF AGN CLUSTERING PROPERTIES ON
1) REDSHIFT and 2) RADIO LUMINOSITY (P<~ $10^{24.5-25}$ W/Hz)

RADIO-ACTIVE AGN RESIDE WITHIN THE SAME STRUCTURES AT ALL RADIO LUMINOSITIES <~$10^{24.5-25}$ W/Hz. NO EVOLUTION IN PROPERTIES DURING COSMIC EPOCHS AT LEAST SINCE z~3! NO DOWNSIZING

CLUSTERING ANALYSIS: COMPARISONS OF SF RESULTS WITH LITERATURE



Adapted from Magliocchetti+2014

Red: 60mm RF selection
Blue: UV selection
Magenta: BzK selection
Green: 24mm selection
Black: 250mm (RF) selection
Cyan: HI selection
Gold: radio-SF selection (this work)

$M^{HALO}_{MIN} \approx 10^{13.5}\ M_{sun}$

$M^{HALO}_{MIN} \approx 10^{11.5}\ M_{sun}$

Peculiar trend of SF clustering.
Jump in the clustering properties beyond z>1.5.
At variance with AGN
SF hosted by very massive structures only z>1.5

DOWNSIZING

RELATIONSHIP BETWEEN DARK AND LUMINOUS MATTER IN AGN

M_{min} from clustering ----- M_* from Laigle+2016 catalogue

$\langle M_* \rangle / M_{min} < 10^{-2.7}$ relatively small stellar content (large uncertainties)

DURATION OF RADIO-ACTIVE AGN PHASE

Comparison of observed space density of AGN with that expected for dark matter haloes more massive than M_{min} (from clustering results)

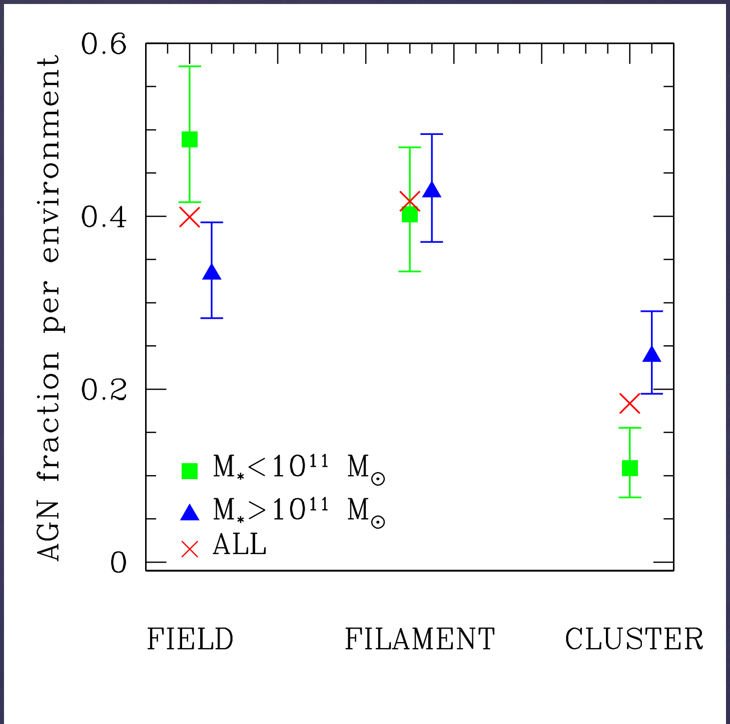
Fraction of haloes with $M_{min} > 10^{13.6} M_{sun}$ host of a radio-active AGN = 0.4
→ about one in two haloes observed to host radio-AGN (a lot!!)

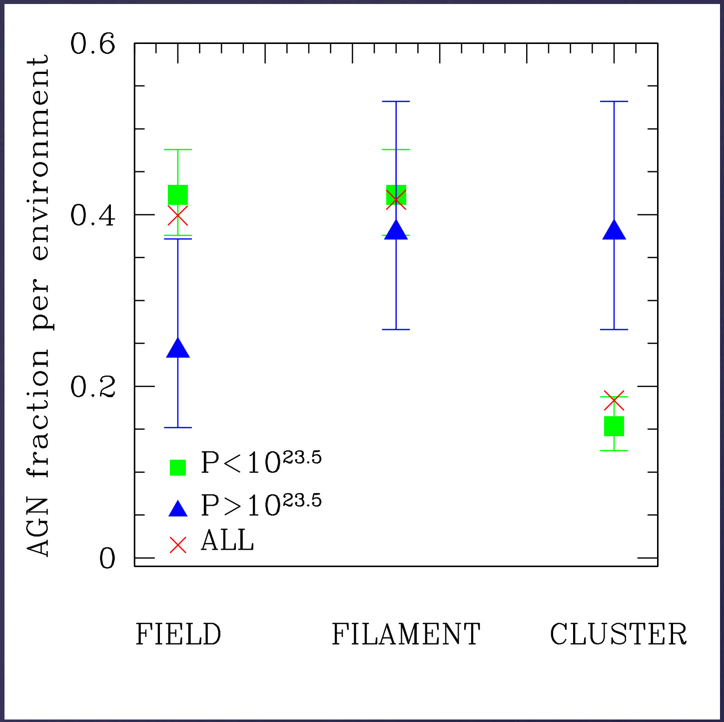
If we assume every halo with $M_{halo} > M_{min}$ hosts a black hole that at some point becomes radio-active we derive life-time of radio phase t=1 Gyr

t>>a few x10 Myr for radio-bright phase (Blundell & Rawlings 1999) →
Radio active phase is recurrent phenomenon

DEPENDENCE OF ENVIRONMENTAL PROPERTIES ON AGN-GALAXY PHYSICS

(218 radio-AGN z<1.2 on COSMOS field. Environments from Darvish+2017)





More massive radio-AGN prefer denser environments
(not only mass-segregation effect. Ask me!)

Most radio-powerful - P>~$10^{24.6}$ W/Hz - AGN prefer denser environments

(cf Peacock & Nicholson clustering results)

CONCLUSIONS

1) Radio-emitting AGN are hosted by very massive galaxies at all z

2) Most of them are in the process of forming stars at very high rates especially in the past.
   Deepest FIR surveys show that ~100% of z>~1 radio-AGN are associated to SF events → NO (negative) AGN-to-SF FEEDBACK at those z
   Feedback only present in the z<1 universe and mainly for sources which are radio-powerful

3) Hosted by DM halos of masses $>10^{13.5}$ M_{sun} (groups-to-clusters of galaxies)
   Radio-AGN environmental properties do not depend on radio luminosity (at least up to $P\sim10^{24.5-25}$ W/Hz) and do not evolve with cosmic epoch

4) Stellar content relatively small $\langle M_* \rangle / M^{HALO} < 10^{-2.7}$

5) From comparison of densities 1 out of 2 massive halos host of radio-AGN
   → $\tau\sim$ **1Gyr** → **Radio-active phase recurrent phenomenon**

6) Dependence of environmental properties on stellar content/AGN emission at different λ/radio luminosity (only for very bright sources)
   Connection between sub-pc up to Mpc behaviours?