Quasars at all cosmic epochs
Padova, April 3rd, 2017

The deepest view of radio AGN in COSMOS:
a two-fold population (arxiv:1703.09720)

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On behalf of:
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The 3 GHz VLA-COSMOS survey

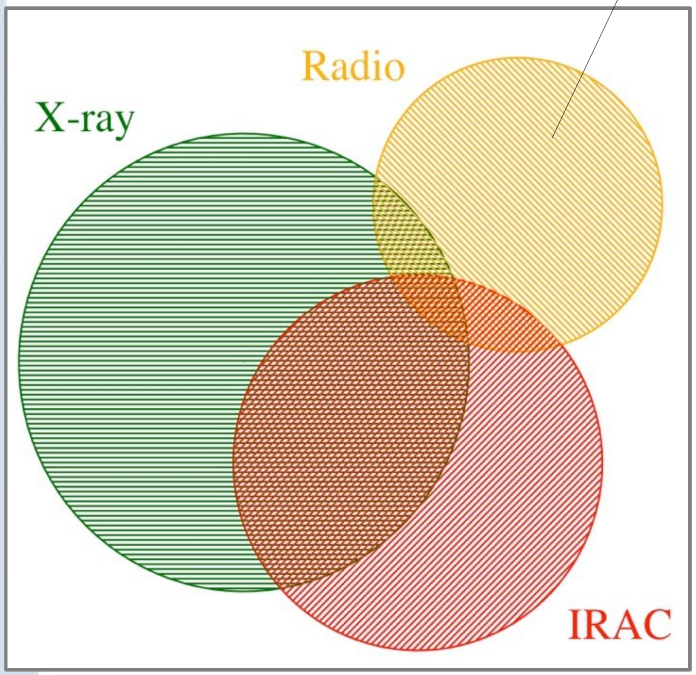
(last week on astro-ph)

- **1. Smolcic et al. (2017a):** *Source catalog and data release* **(arXiv:1703.09713)**
- **2. Smolcic, Delvecchio et al. (2017a):** *Multiwavelength counterpart catalog* **(arXiv:1703.09719)**
- **3. Delvecchio et al. (2017):** *AGN and host-galaxy properties out to z~5* **(arXiv:1703.09720)**
- **4. Delhaize, Smolcic, Delvecchio et al. (2017):** *The IRRC of star-forming galaxies out to z~5* **(arXiv:1703.09723)**
- **5. Novak et al. (2017):** *Cosmic star formation history since z~5* **(arXiv:1703.09724)**

THAT'S ALL PUBLIC!
(IPAC/IRSA database)

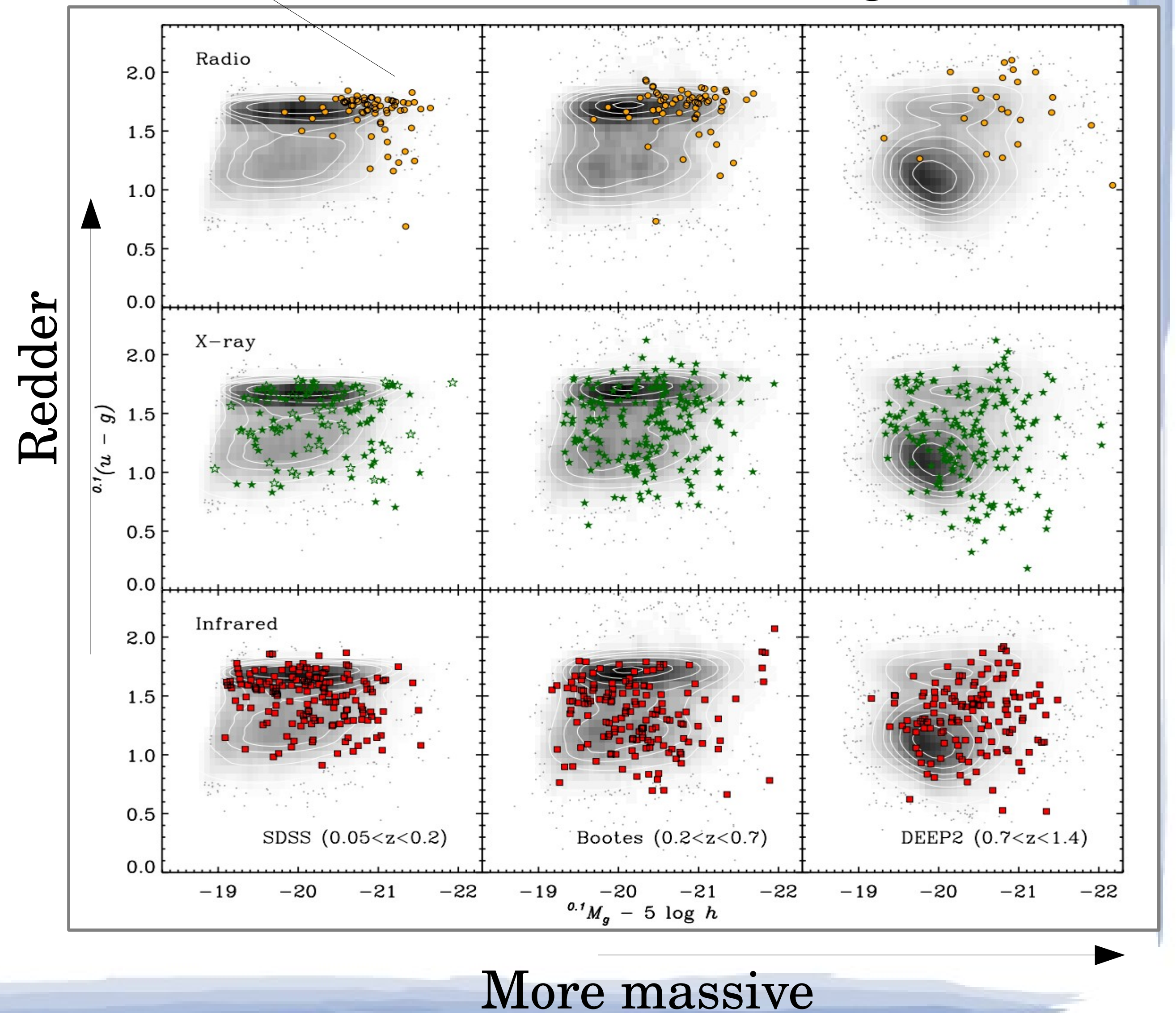
Radio (bright) AGN are special

$L_{1.4} > 10^{24.8}$ W/Hz

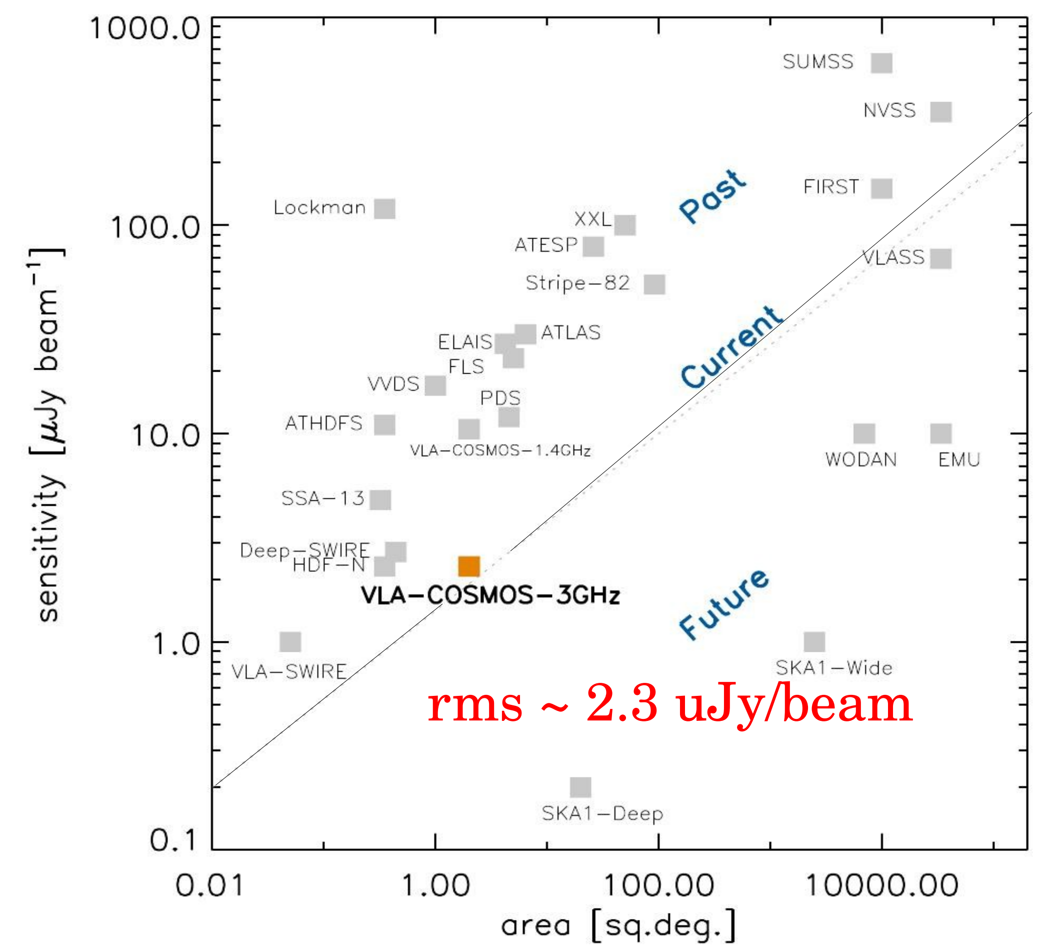


Hickox et al. (2009)

Goulding et al. (2014)



Going deeper and towards high-z: The 3 GHz VLA-COSMOS survey



- 10,830 radio sources selected at 3 GHz (10 cm) down to an unprecedented sensitivity over 2.6 deg^2 of the COSMOS field (Smolčić et al. 2017a)
- ~90% have optical/NIR counterpart in the COSMOS2015 catalog (Smolčić, Delvecchio et al. 2017b).
- Accurate redshifts and opt-mm photometry (>30 bands) from the COSMOS2015 catalogue (Laigle et al., 2016)

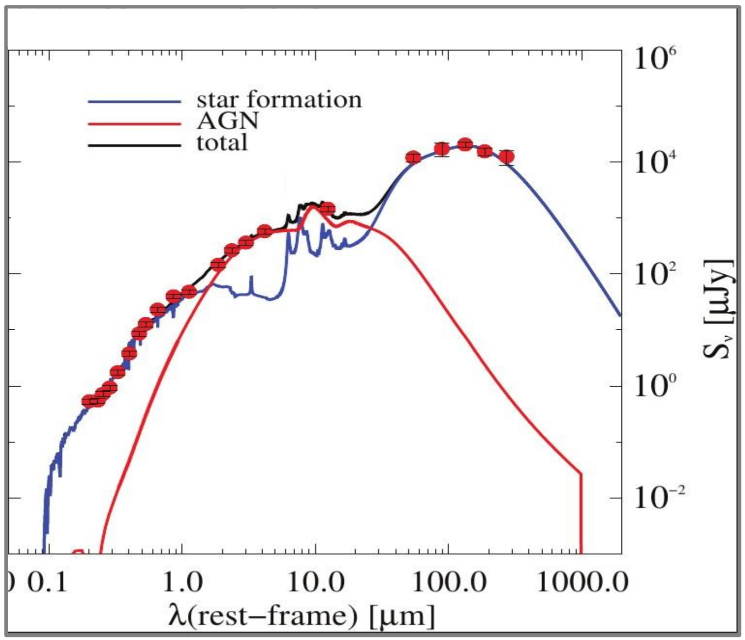
FINAL SAMPLE:
7,729
radio sources + multi-λ

erc

PI: V. Smolčić

Hunting for radio AGN

Moderate-to-high radiative luminosity AGN (**HLAGN**) ~ 21%

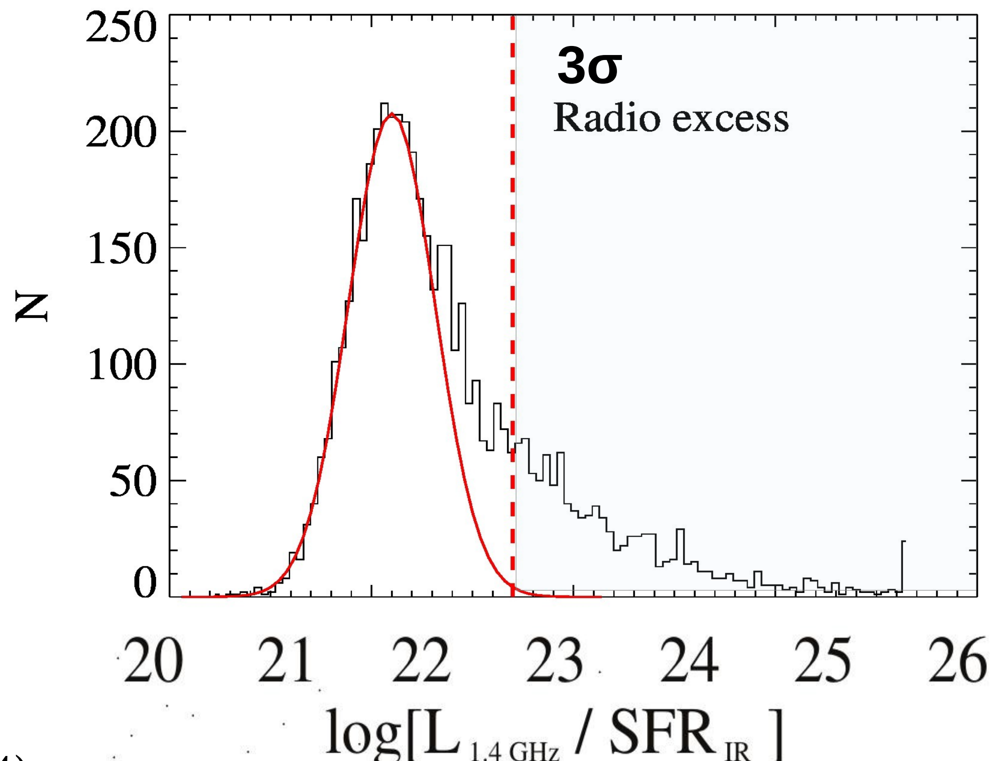


- 1) **Lx > 10^{42} erg/s** (e.g. Szokoly et al. 2004)
- 2) **Mid-IR** colour-colour diagram (Donley et al. 2012)
- 3) **SED-fitting** decomposition

SED3fit (Berta et al. 2013)

http://cosmos.astro.caltech.edu/page/other-tools

Low-to-moderate radiative luminosity AGN (**MLAGN**) ~ 17%



Not X-ray/MIR/SED AGN

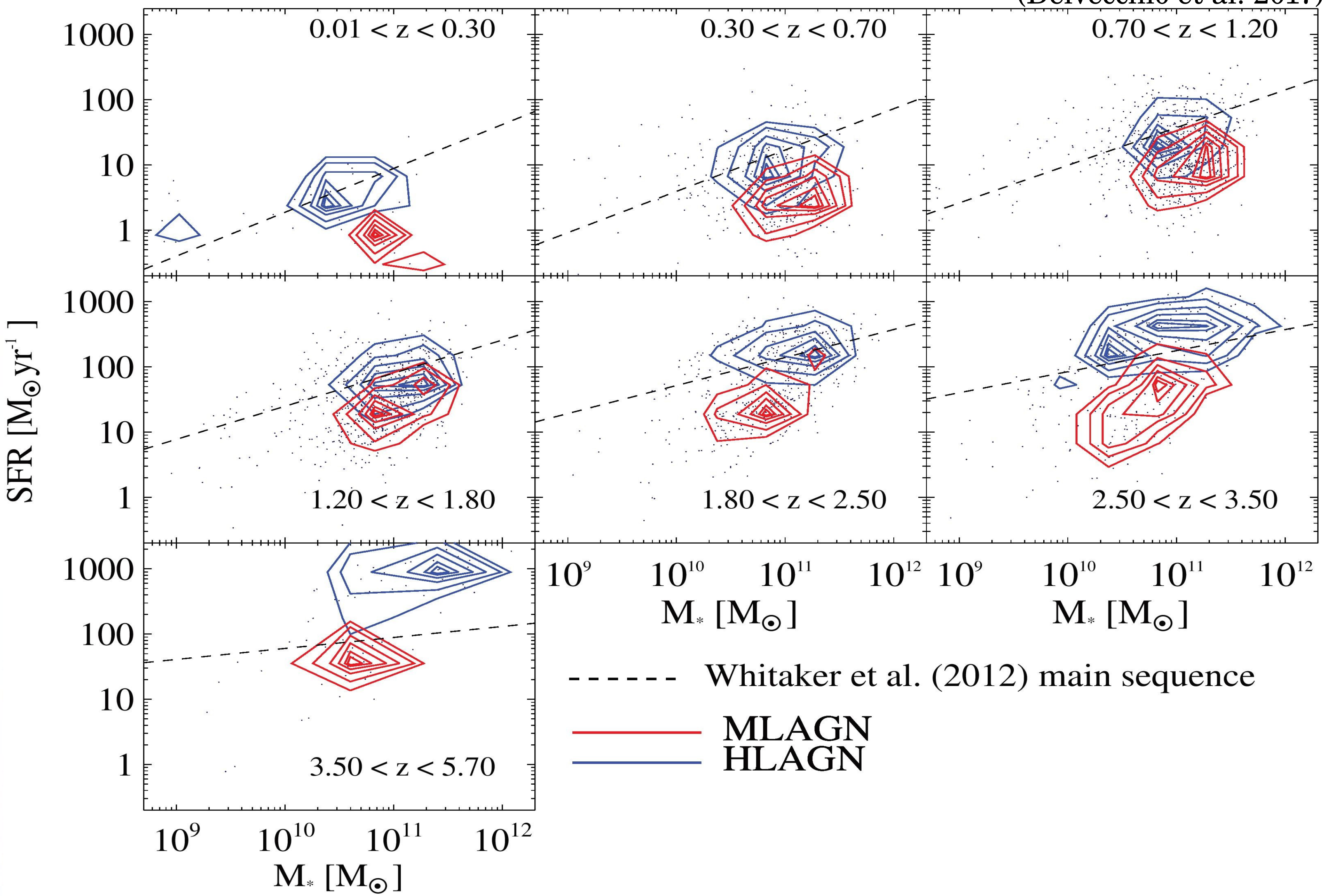
+

>3σ Radio-excess

(Delvecchio et al. 2017, see also Del Moro et al. 2013)

The SFR-M* plane of Radio AGN hosts

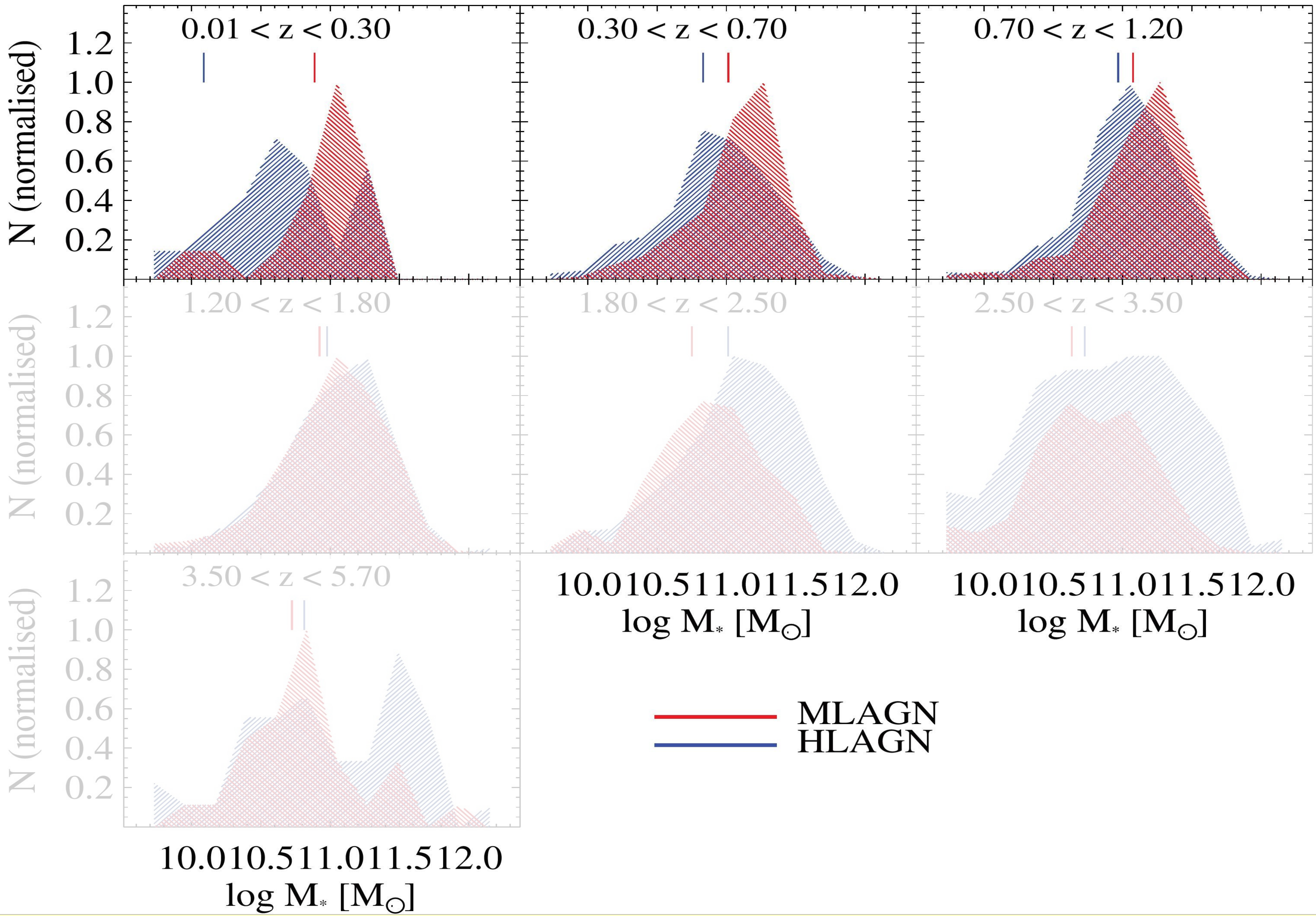
(Delvecchio et al. 2017)



HLAGN lie around the main sequence (e.g. Hickox et al. 2009; Bonzini et al. 2013, 2015)
MLAGN reside systematically below the MS (Best & Heckman 2012; Heckman et al. 2014)

Stellar mass distributions

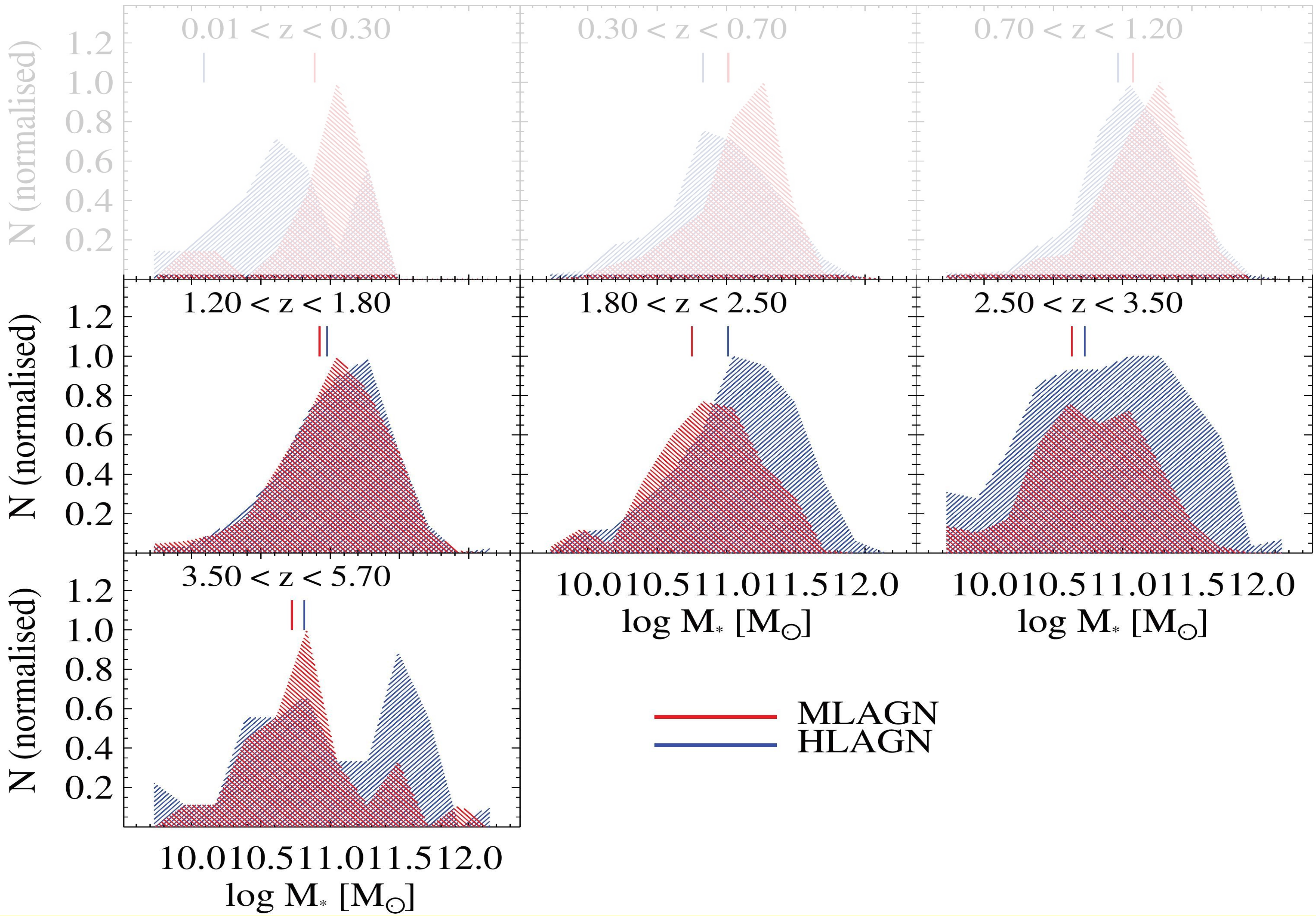
(Delvecchio et al. 2017)



z<1: HLAGN typically hosted in less massive galaxies than MLAGN

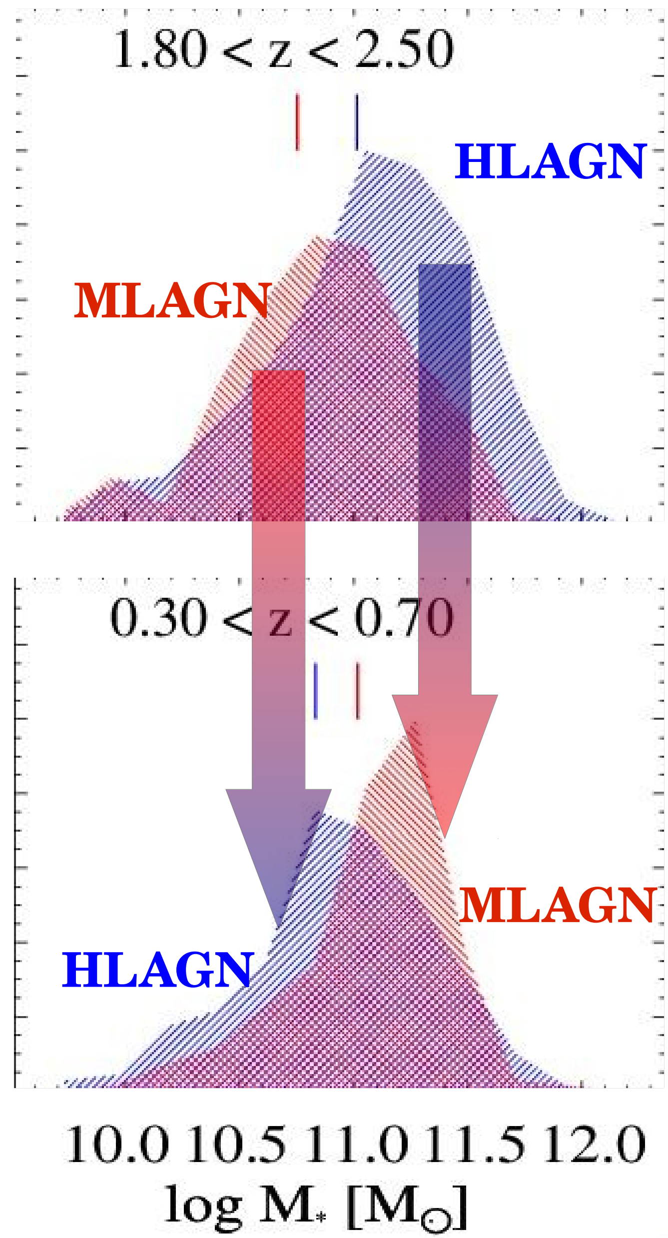
Stellar mass distributions

(Delvecchio et al. 2017)



z=1.5: similar M* distributions. At z=2 we observe a possible reversal (**6σ**) of the M* behaviour: the most massive galaxies host HLAGN

Hint of "downsizing"?



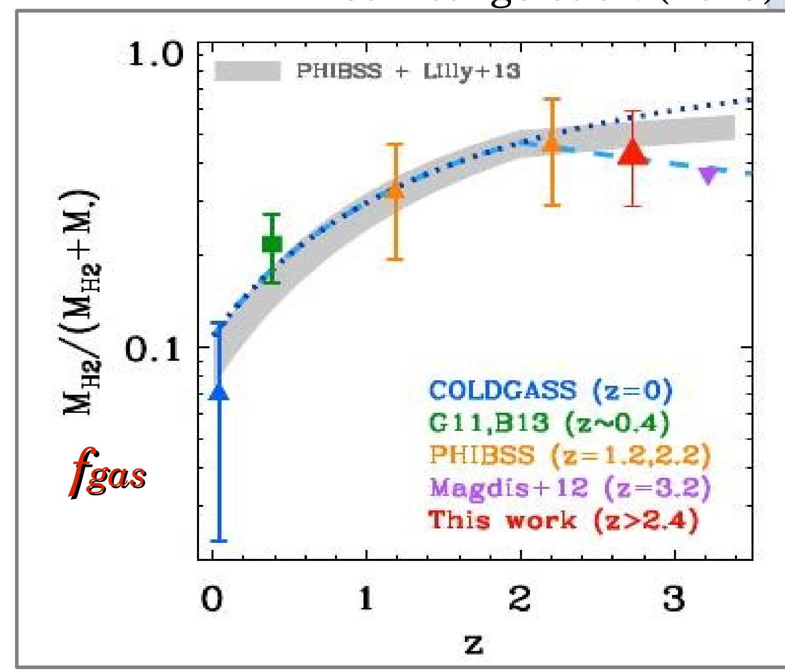
z=2

t

z=0.5

The most massive galaxies are very gas rich, and trigger radiative AGN activity (HLAGN)

Saintonge et al. (2013)



At later times, AGN activity fades: massive galaxies host MLAGN. HLAGN in less massive systems

Radio AGN host-galaxies follow two pathways

↕

AGN dichotomy?

Two-fold galaxies ⟷ AGN dichotomy?

Lx / Lradio

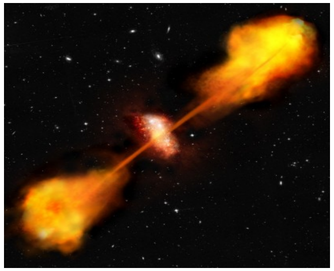
radiative-to-mechanical AGN power

- Is there an AGN dichotomy?
- Does it evolve with redshift?
- Are HLAGN and MLAGN the high-z analogs of HERGs/LERGs?

HLAGN?

Radiatively inefficient

MLAGN?



Radiatively efficient

Lx / M* ~ *Specific BHAR* ~ *Eddington ratio*

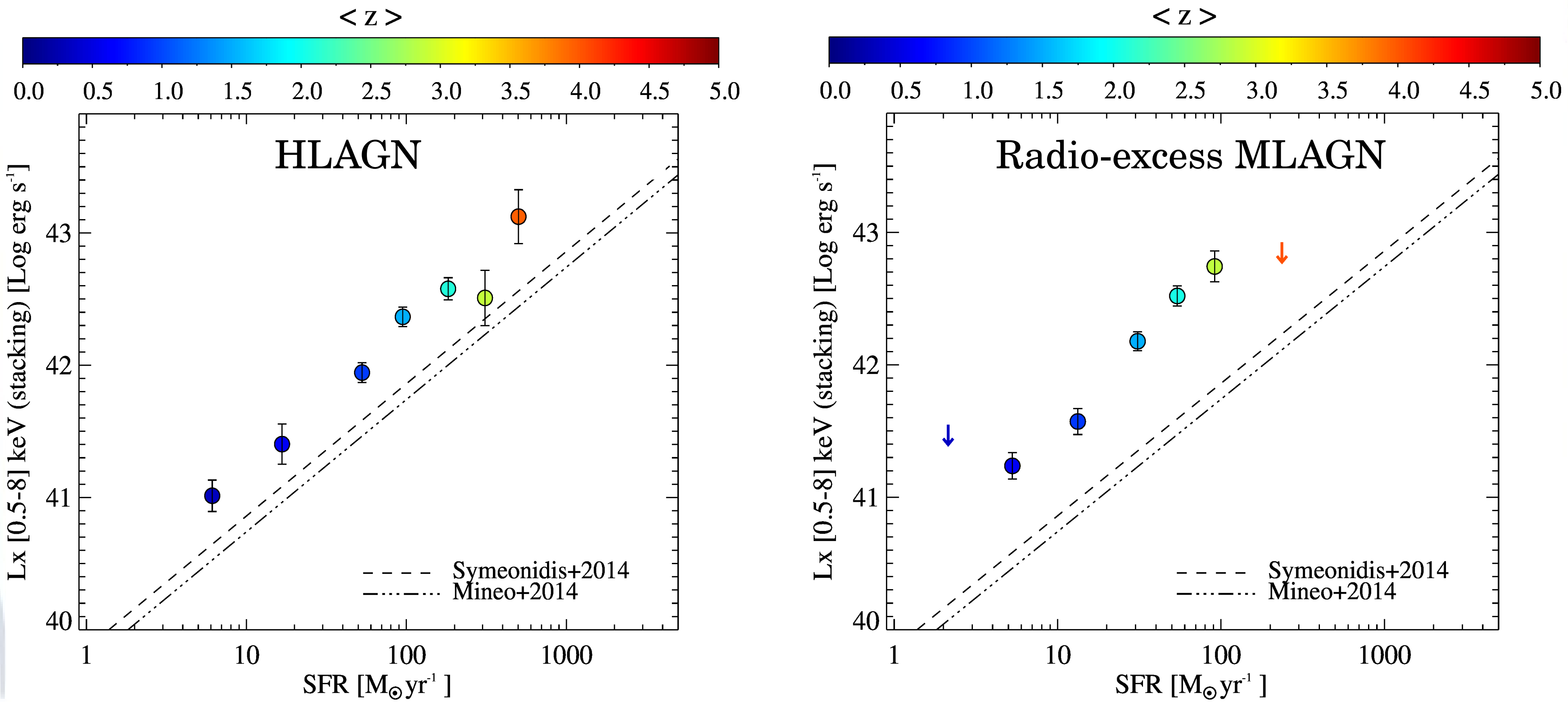
Exploring the physical nature of AGN activity in HLAGN vs MLAGN out to z~5: a combined radio & X-ray approach

X-ray stacking of HLAGN vs MLAGN

- X-ray stacking tool CSTACK*
- Stacking Chandra images of X-ray undetected sources, binned in class and redshift

→

- >2σ detection at almost all redshifts
- Excess in X-ray emission due to AGN



* http://lambic.astrosen.unam.mx/cstack/ (developed by T. Miyaji)

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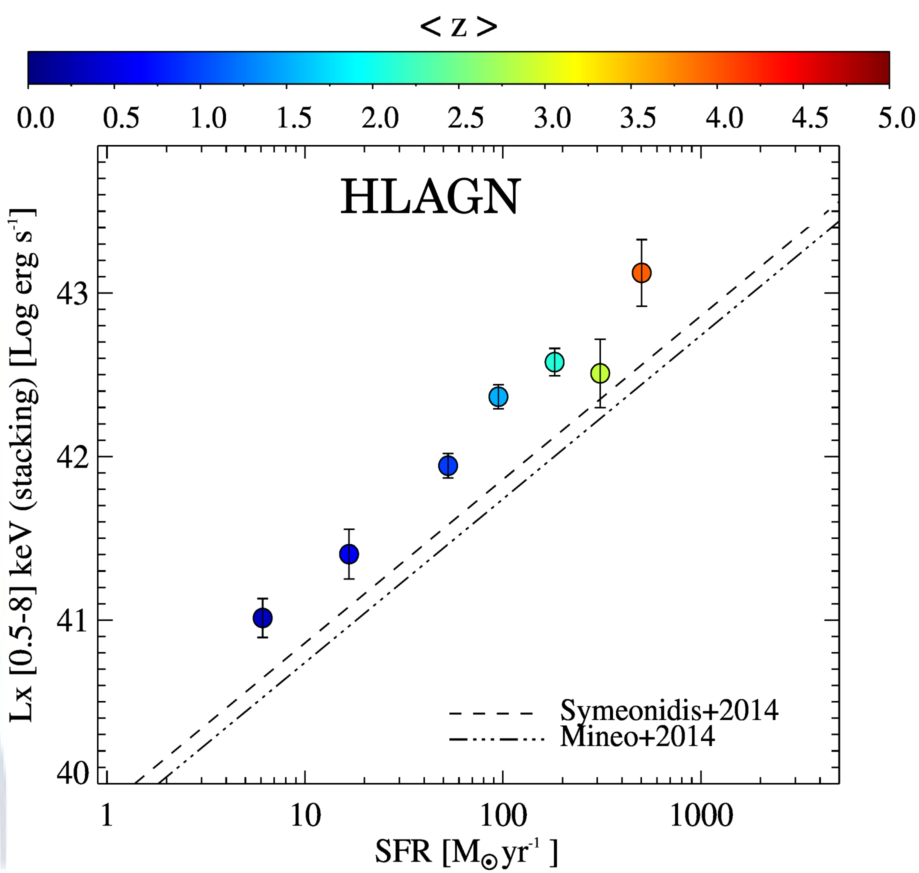
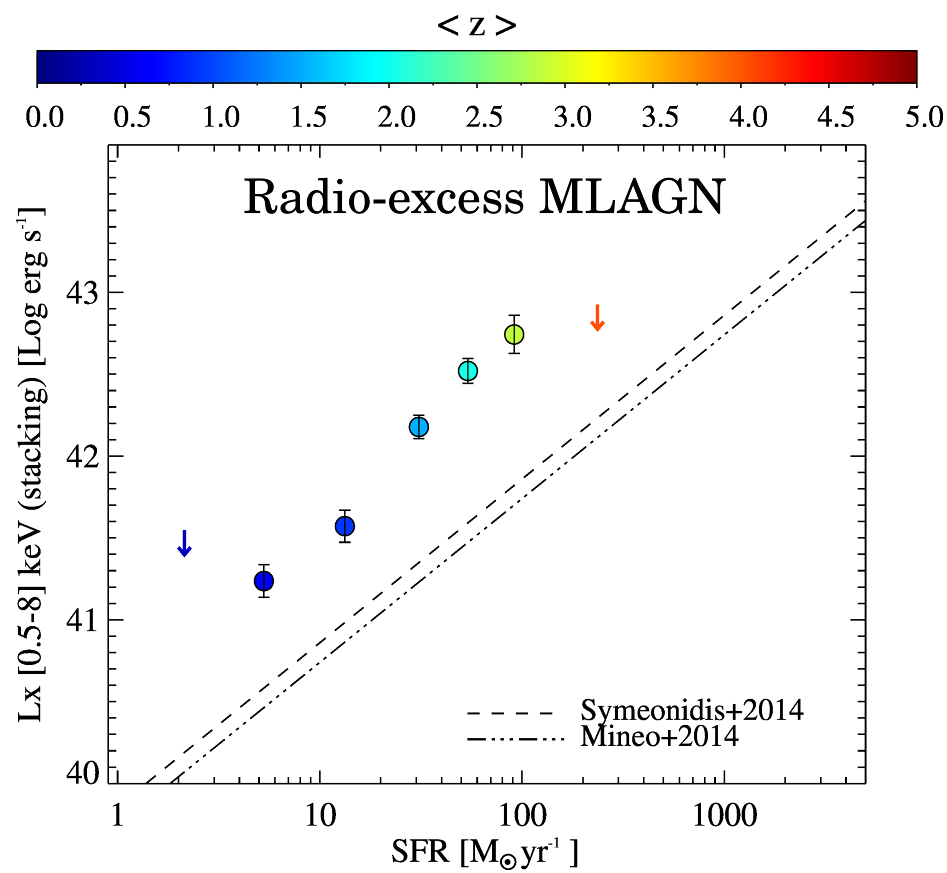
- >2σ detection at almost all redshifts
- Excess in X-ray emission due to AGN
- From Lx(AGN) to Lbol(AGN) (Lusso+2012)
- From Lbol(AGN) to Eddington ratio via M^*/M_{BH} = 500 (Häring & Rix 2004)





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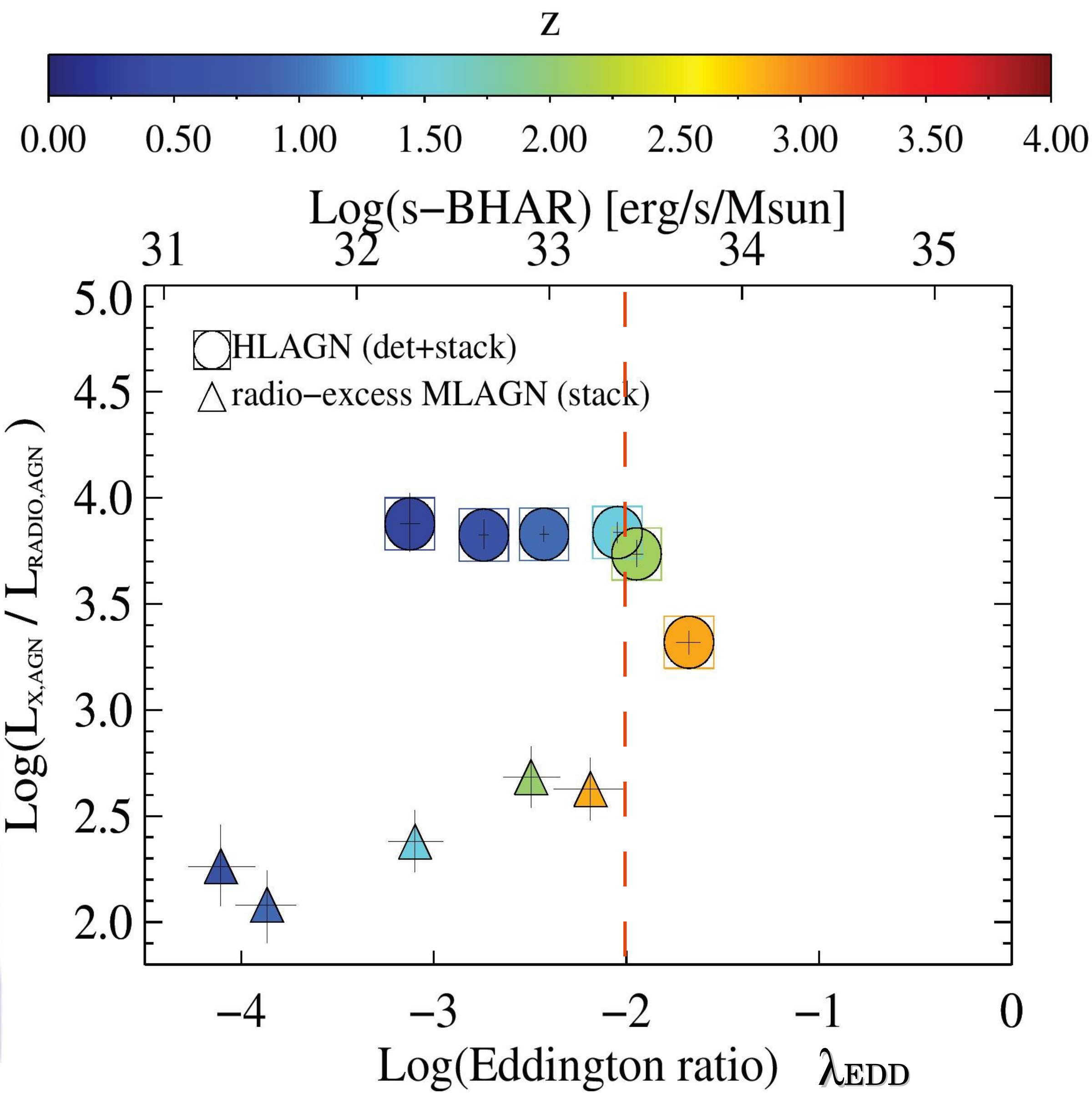
The *Eddington ratio* – vs – *Lx / Lradio* plot

(Delvecchio et al. in prep.)



- The full HLAGN population displays higher λ_{EDD} than MLAGN (Padovani et al. 2015)
- Radio-excess MLAGN display *radiatively-inefficient* accretion (Best & Heckman 2012; Heckman et al. 2014)

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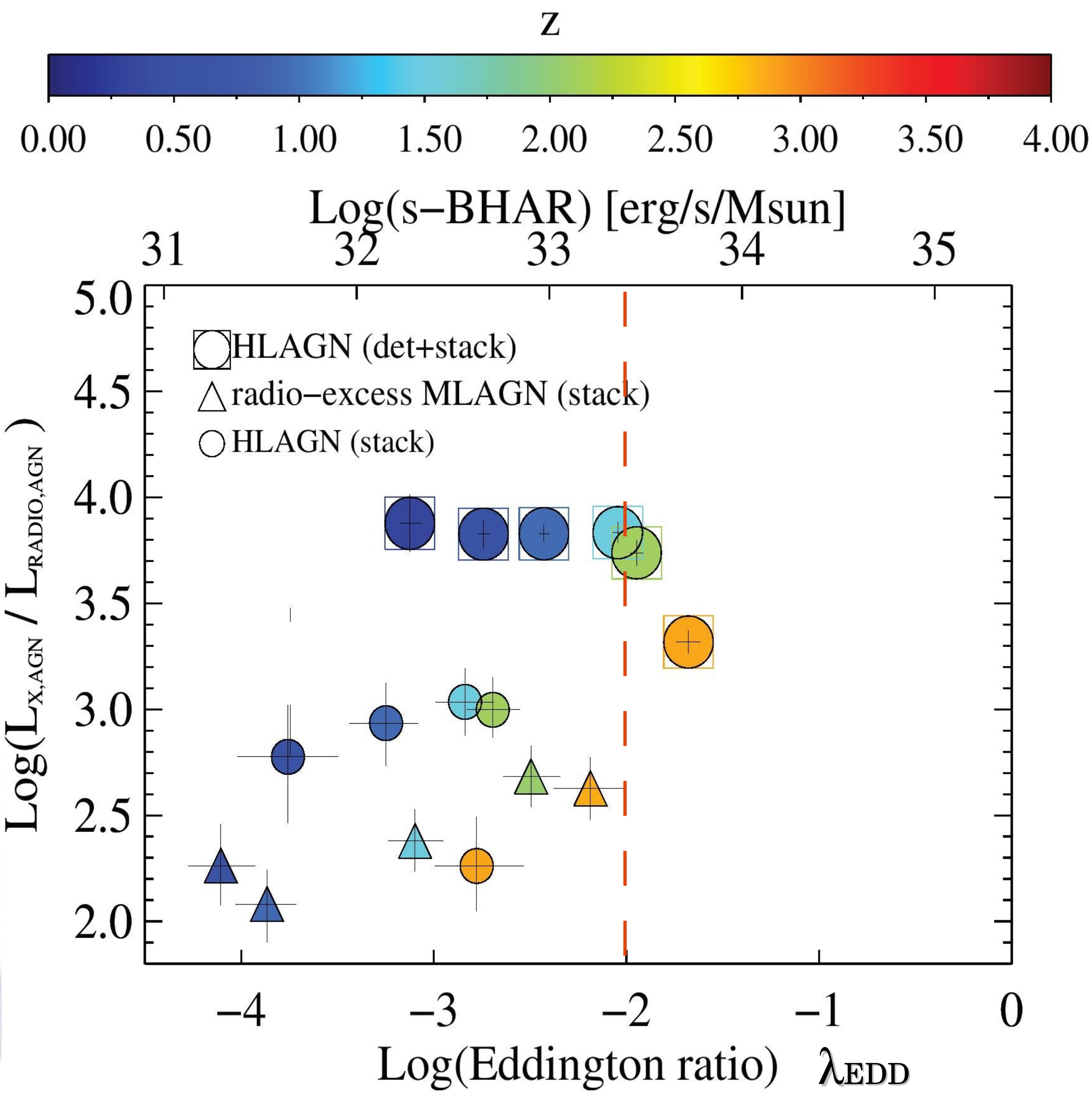

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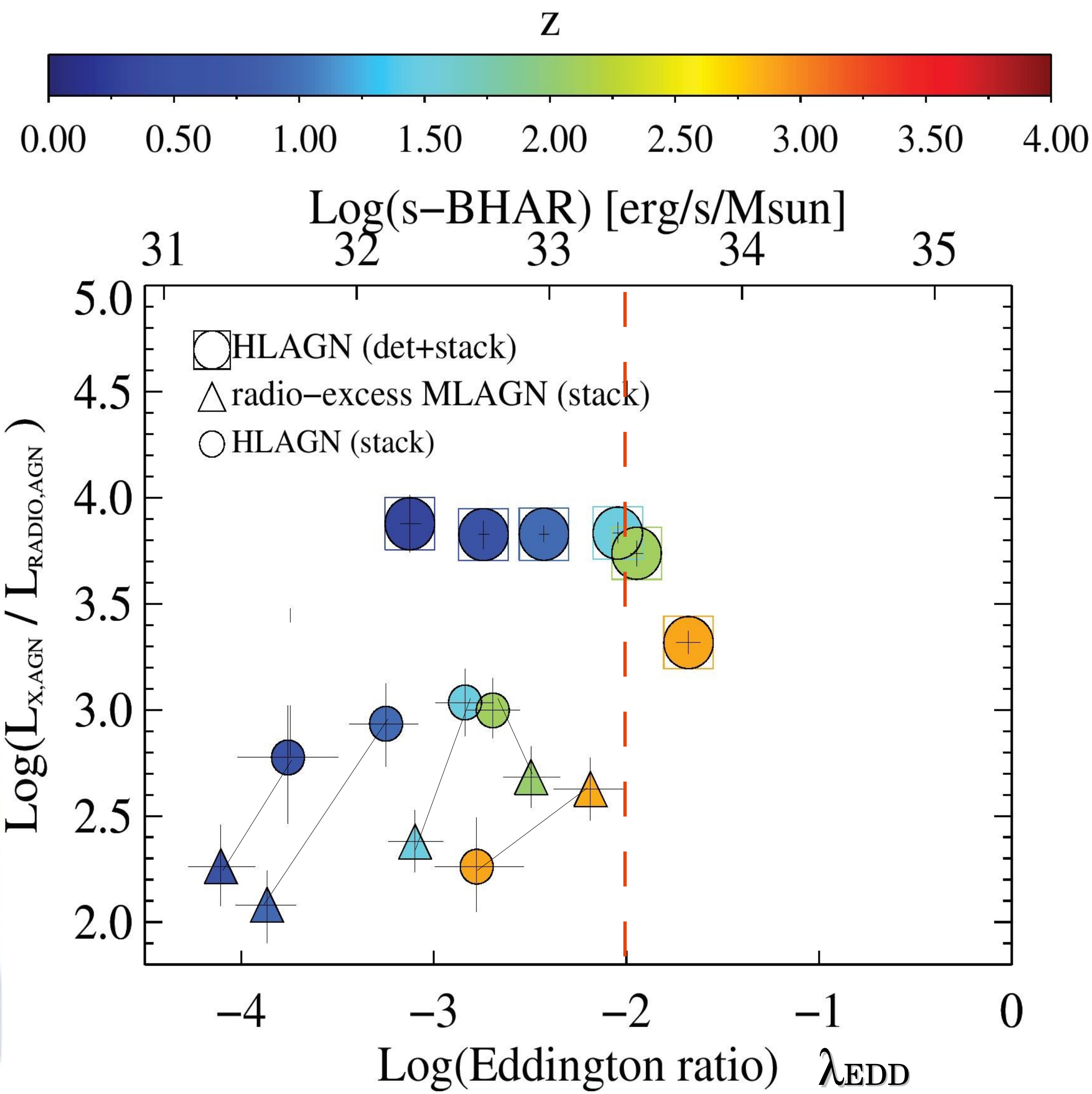

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At moderate $L_{x,AGN}$ (from stacking) we observe:

- (z<1)

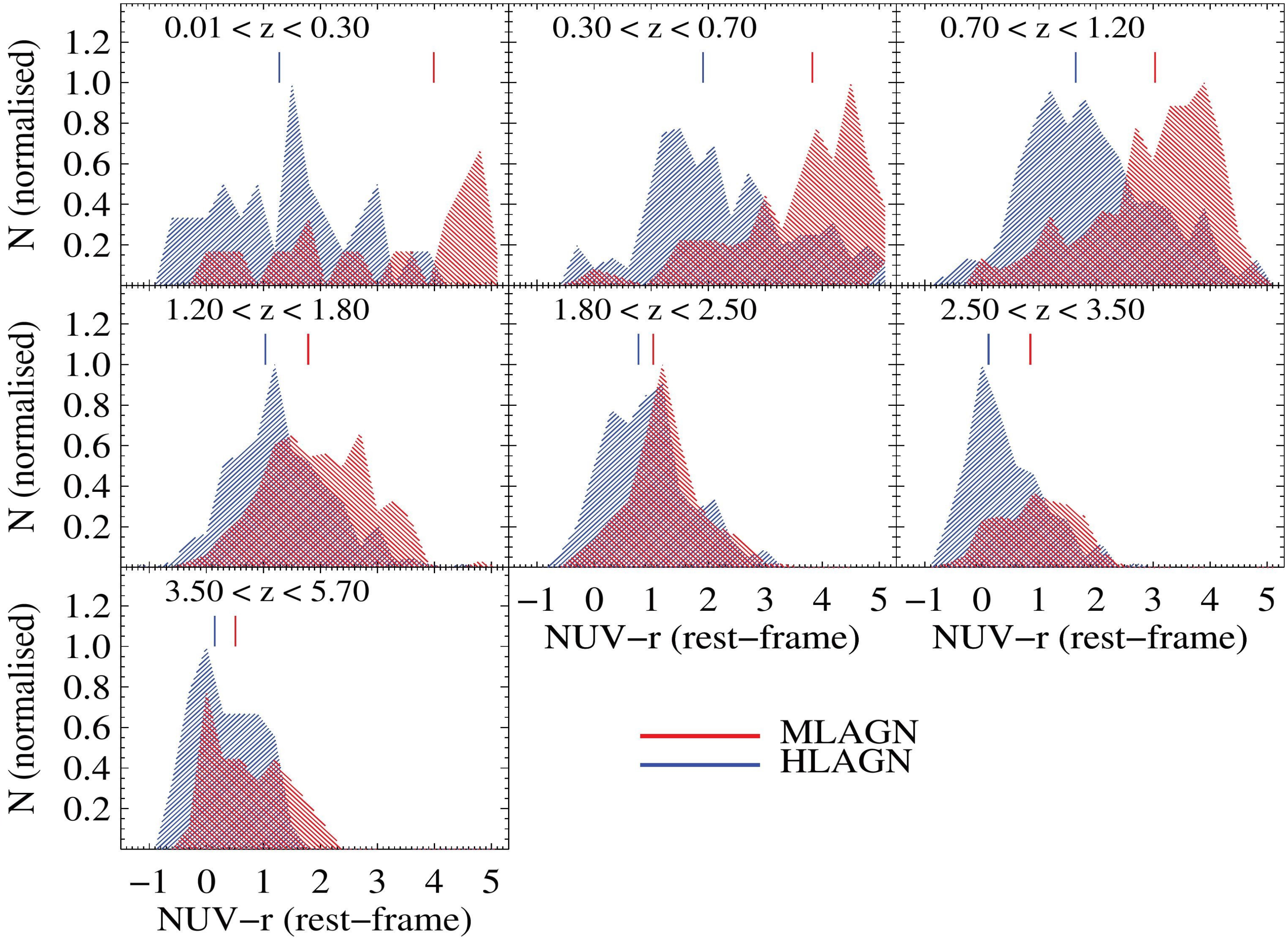
λ_{EDD} (HLAGN) > λ_{EDD} (MLAGN)

- (z>1)

λ_{EDD} (HLAGN) ~ λ_{EDD} (MLAGN)

Eddington ratio ⟷? galaxy colour

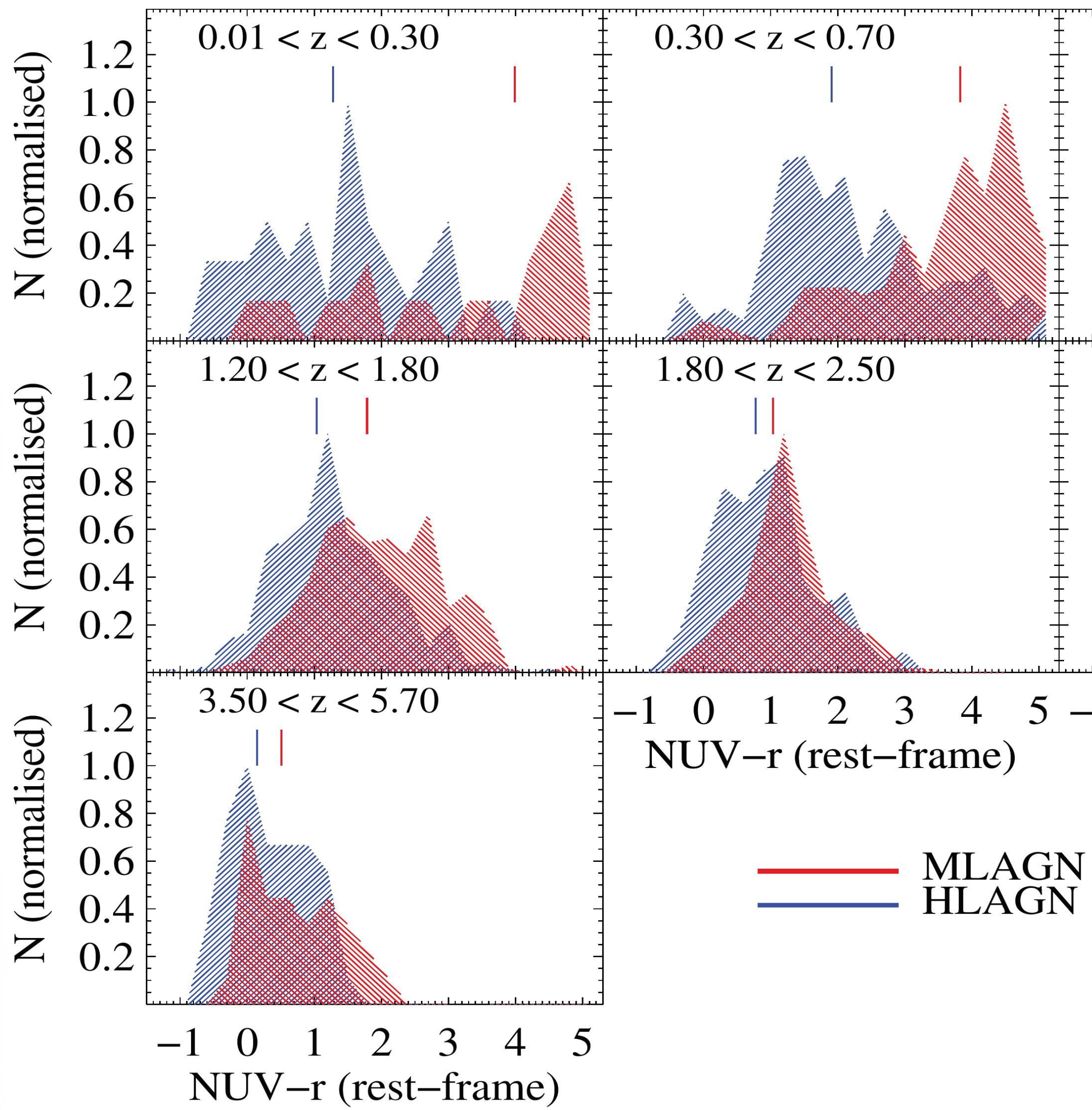
(Delvecchio et al. 2017)



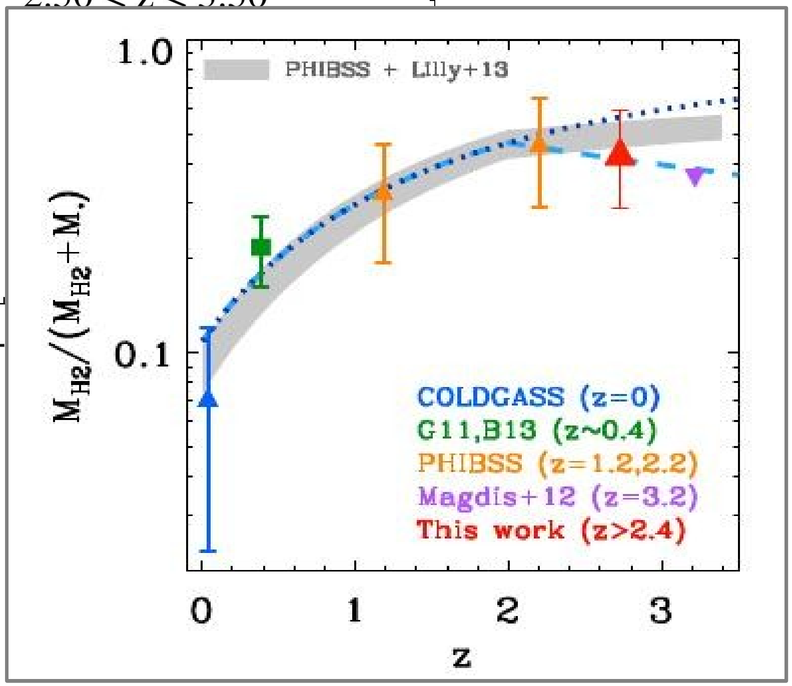
HLAGN lie in blue/green galaxies, MLAGN lie in red/green galaxies.
Their overlap increases towards higher redshifts (i.e. less red galaxies)

Eddington ratio ⟷ galaxy colour

(Delvecchio et al. 2017)



? f_{gas}

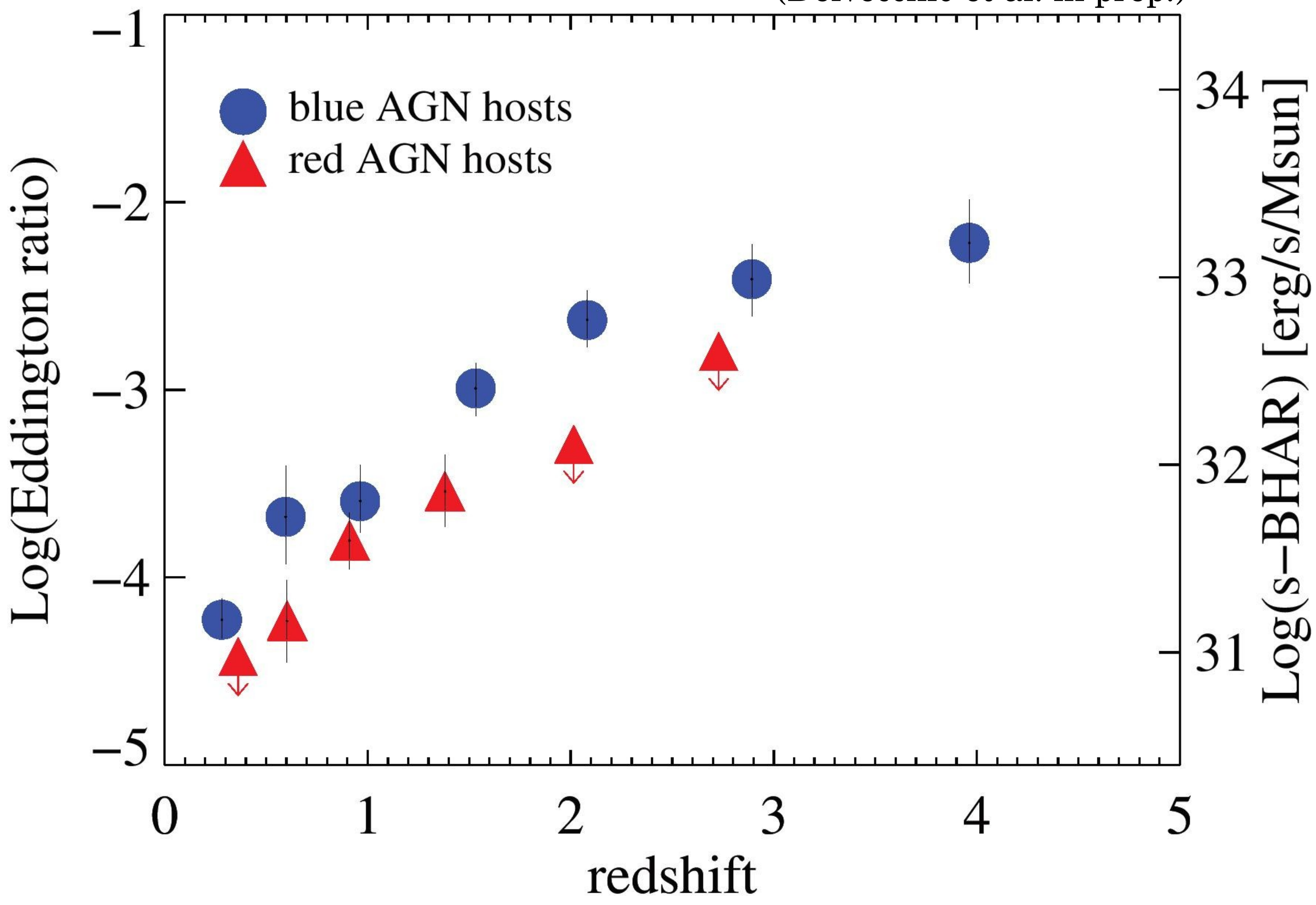


Saintonge et al. (2013)

Evolution of the gas fraction and optical colours in galaxies might be tied to the AGN Eddington ratio: common fuelling?

Stacking blue vs red AGN hosts

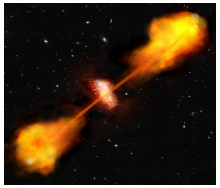
(Delvecchio et al. in prep.)



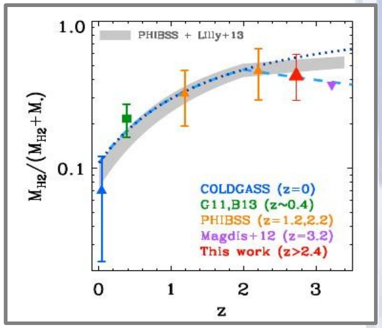
Blue AGN hosts display higher Eddington ratios than red AGN hosts at *all* redshifts (e.g. Bernhard et al. 2016; Aird et al. 2017)

Take-home messages

Studying radio AGN in the low-luminosity regime
reveals a two-fold population:
HLAGN (X-ray/MIR/SED) vs MLAGN (radio-excess)



The observed trends of M* and Eddington ratio
are plausible in the context of the evolution
of the cold gas content (common fuelling?)



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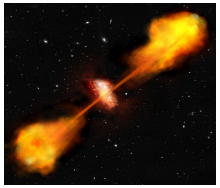

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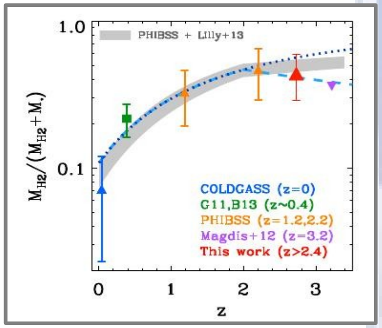

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Thank you!