Large-scale clustering measurements of broad-line AGN at low redshifts

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SDSS DR7

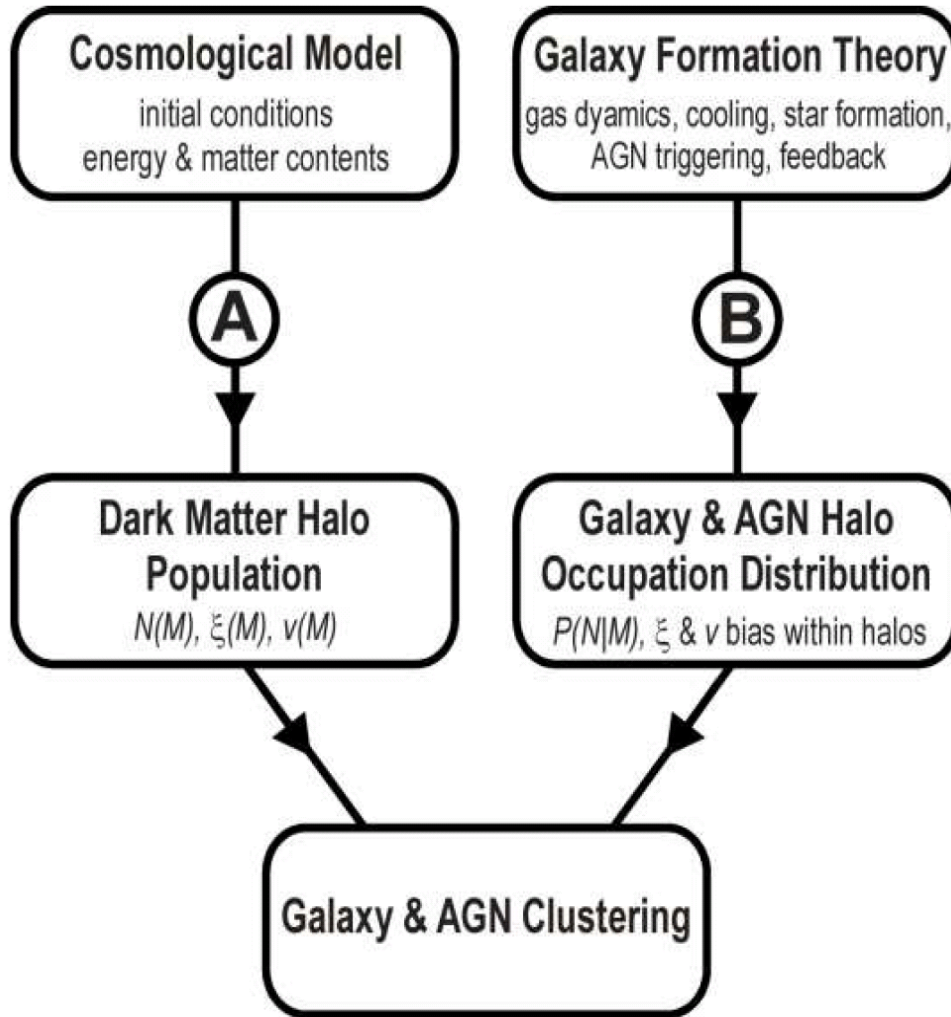Miguel A. Aragon (JHU)
Mark Subbarao (Adler P.)
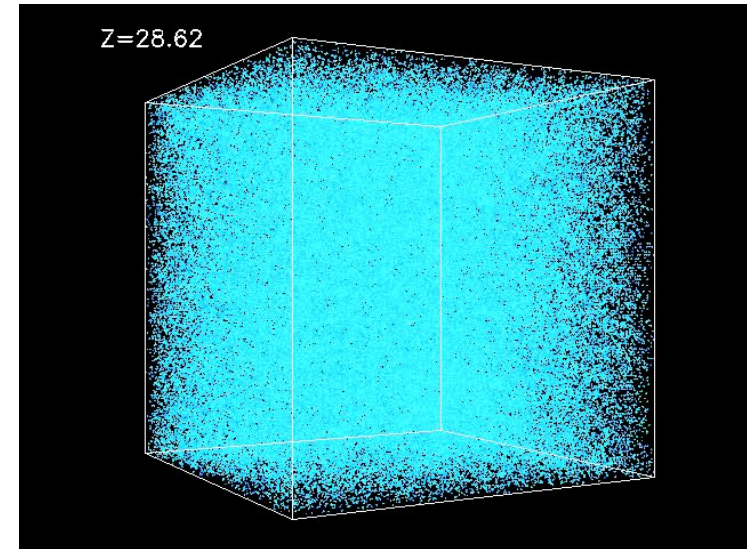Alex Szalay (JHU)

What drives clustering?

Z=28.62

National Center for Supercomputer Applications(Kravtsov & Klypin)

2) Galaxy distribution within DMHs


Cosmological Model
initial conditions
energy & matter contents

Galaxy Formation Theory
gas dyamics, cooling, star formation,
AGN triggering, feedback

(A)

(B)

Dark Matter Halo Population
$N(M)$, $\xi(M)$, $v(M)$

Galaxy & AGN Halo Occupation Distribution
$P(N|M)$, ξ & v bias within halos

Galaxy & AGN Clustering

Based on Zheng & Weinberg 2007, Weinberg 2002

tracer set **cross-correlation function** **AGN**

$$\xi_{ACF(AGN)} = \xi^2_{CCF(AGN\text{-}Galaxies)} / \xi_{ACF(Galaxies)}$$

number of pairs

distance r in Mpc

Credits: SDSS
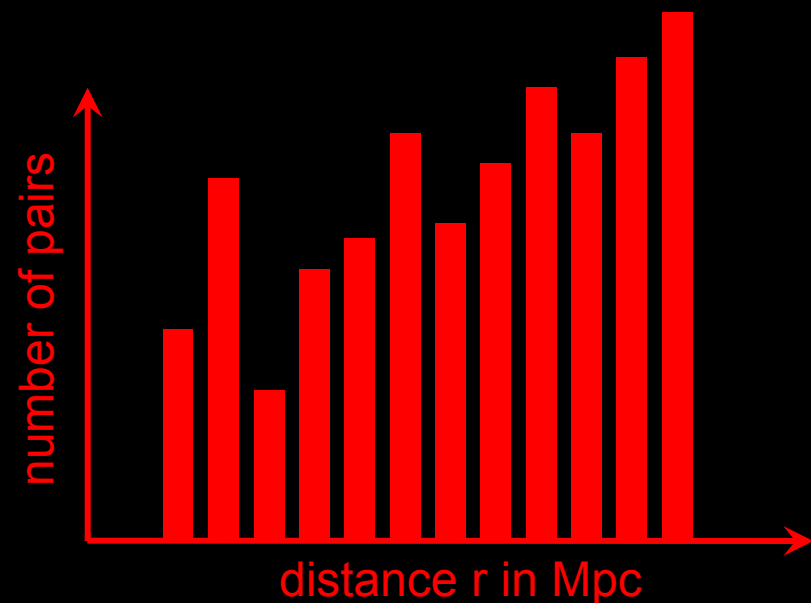
broad-line AGN samples

X-ray selected
(ROSAT All-Sky Survey)

Krumpe et al. (2010)

ROSAT
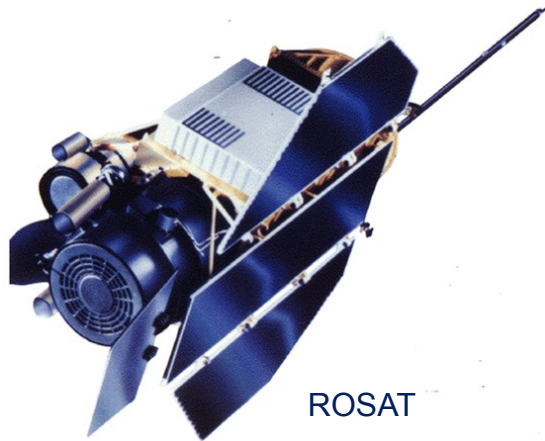
- still the most sensitive all-sky
  (soft) X-ray survey (Voges et al. 1999)

- 6224 broad-line AGN
  with spectroscopic redshifts
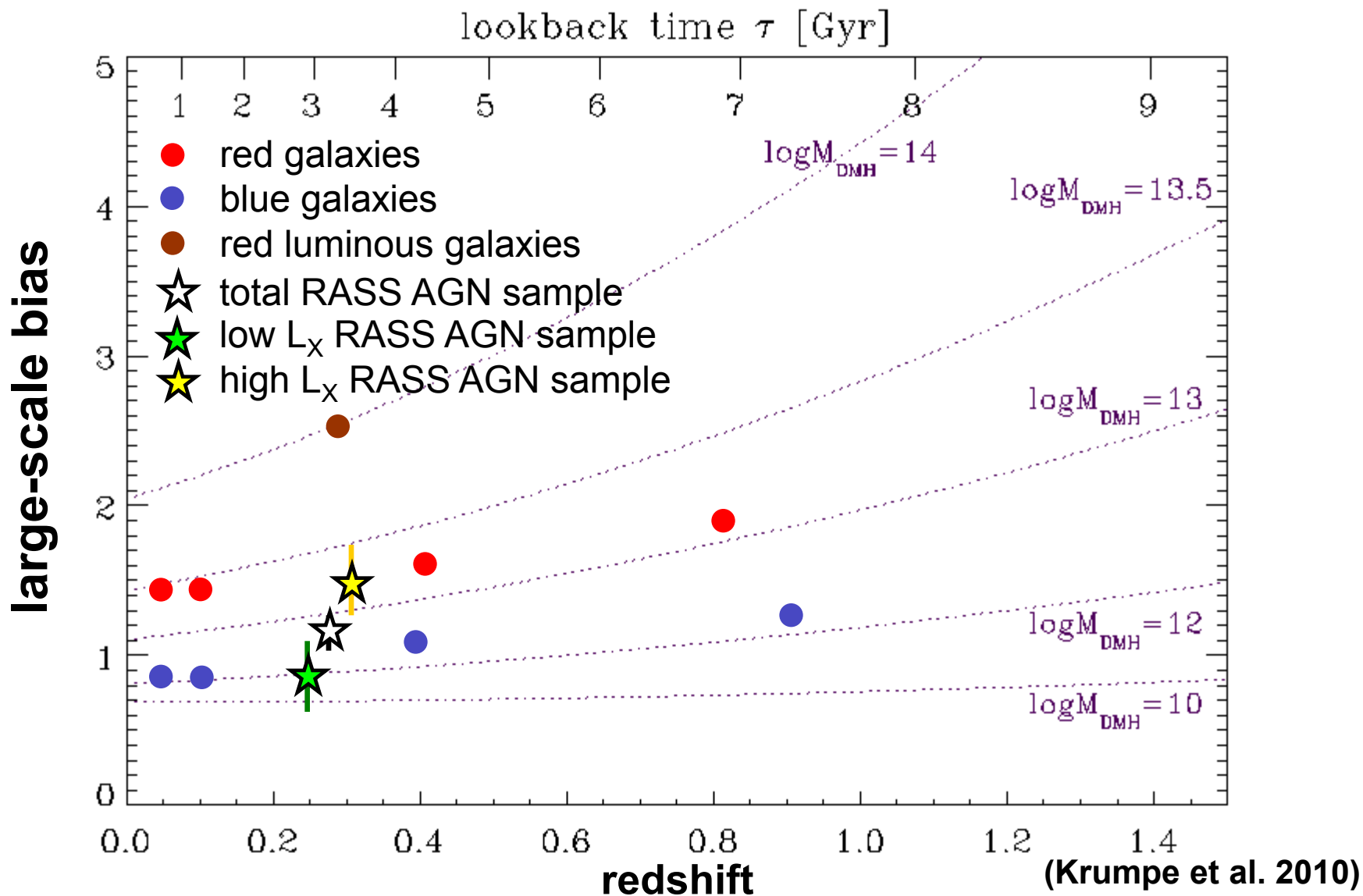 from SDSS (Anderson et al. 2003, 2007)

optically-selected
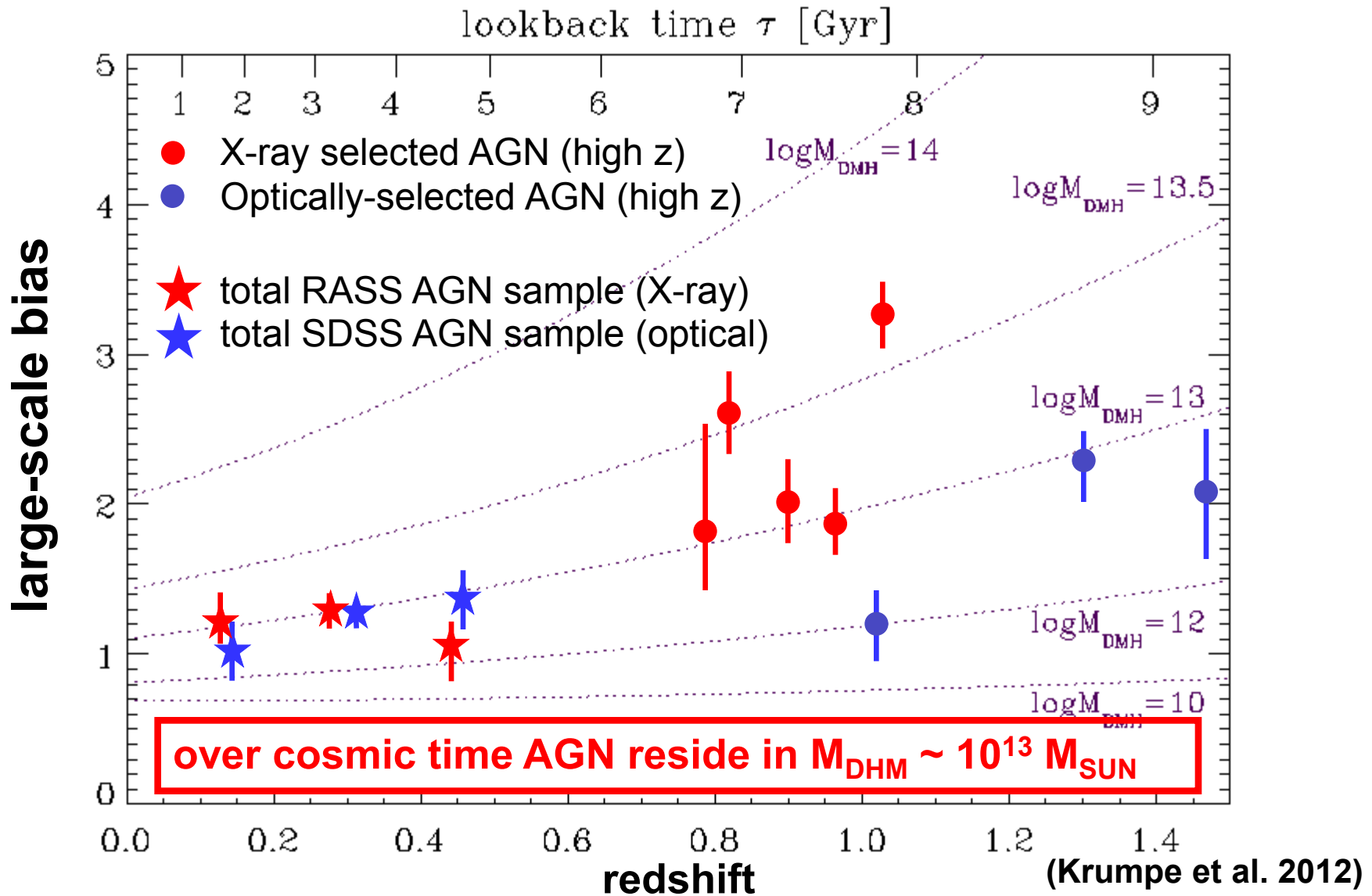## (SDSS)

Krumpe et al. (2012)

SDSS

- at least one broad emission line
  (FWHM > 1000 km s^{-1})

- M_i < -22 mag, i > ~15 mag

(Krumpe et al. 2010)

(Krumpe et al. 2012)

Origin of the L_X dependence of the broad-line AGN clustering strengths at low z

Krumpe et al. 2015, ApJ accepted, soon on astro-ph

# L_X dependence of the AGN clustering strength

Krumpe et al. (2010):

more X-ray luminous AGN cluster more strongly

(higher M_{DMH}) than lower-luminosity counterparts

X-ray luminosity depends on physical properties:

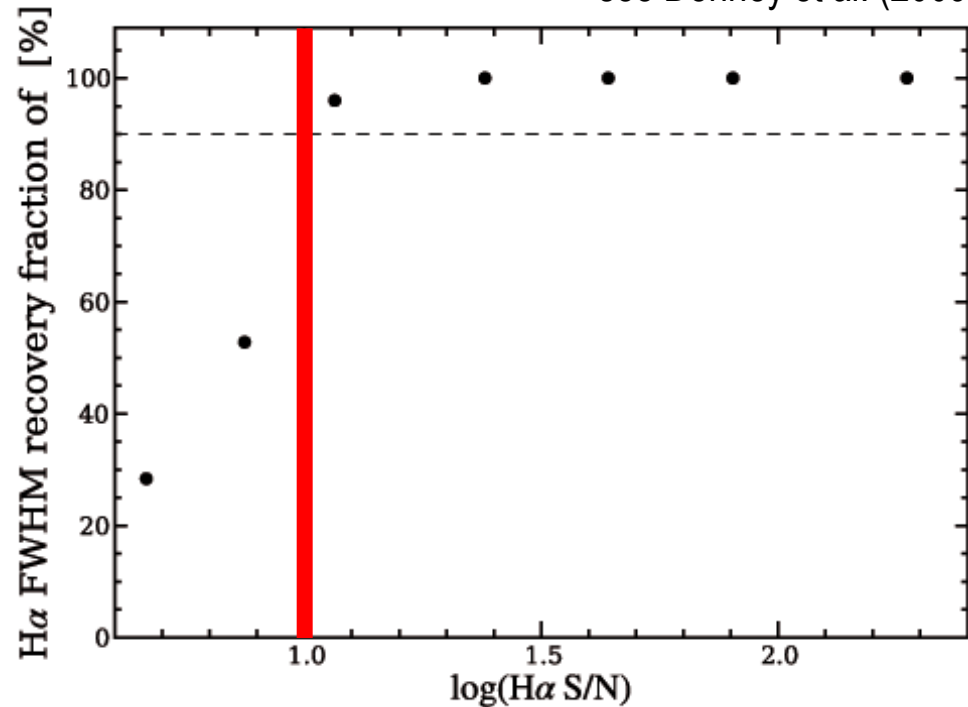**black hole mass (M_{BH}) and accretion rate relative to Eddington (L/L_{EDD})**

explore physical origin of clustering dependence
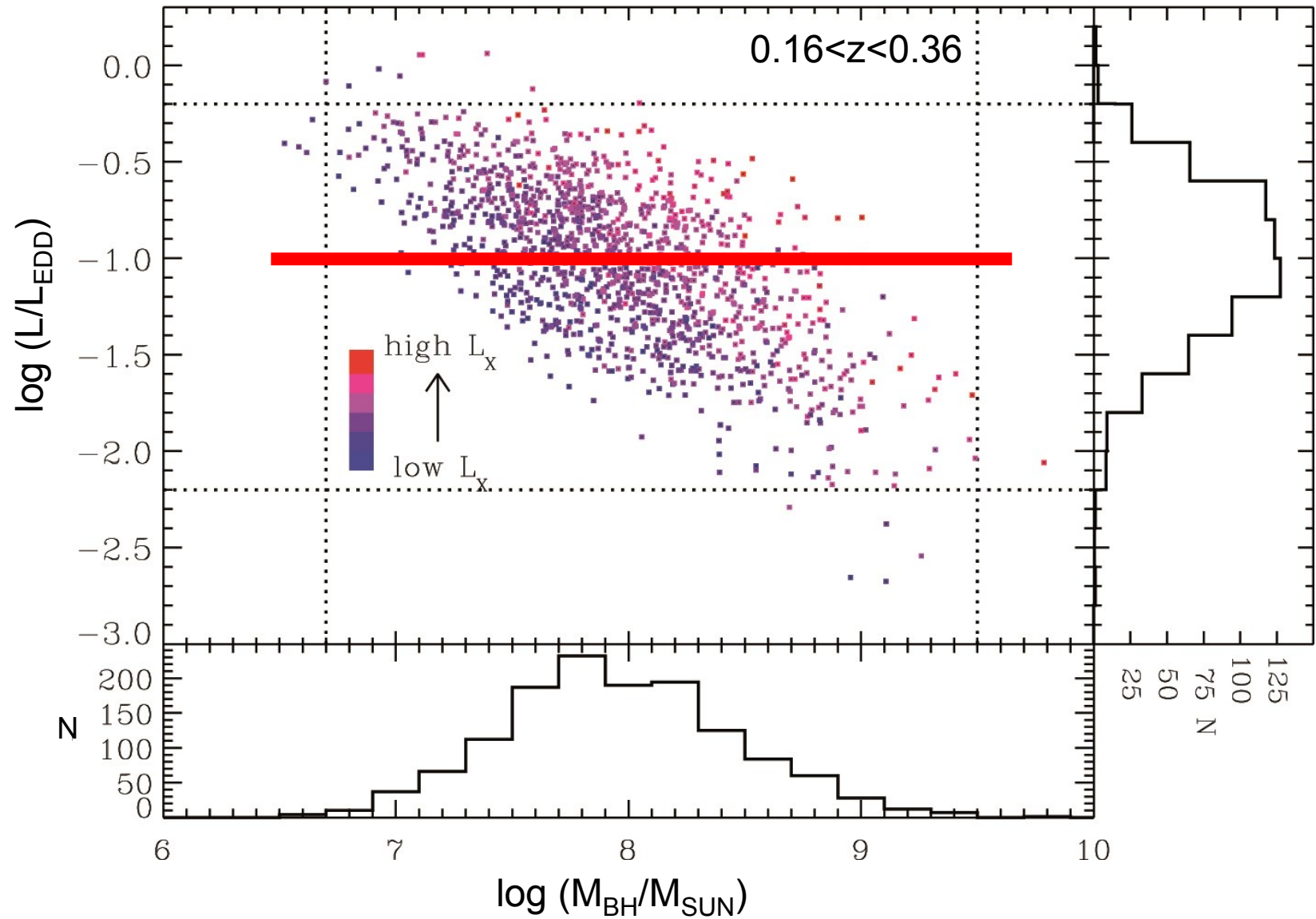**$\Rightarrow$ caused by M_{BH} or/and L/L_{EDD}?**

Determine M_{BH} from SDSS spectra
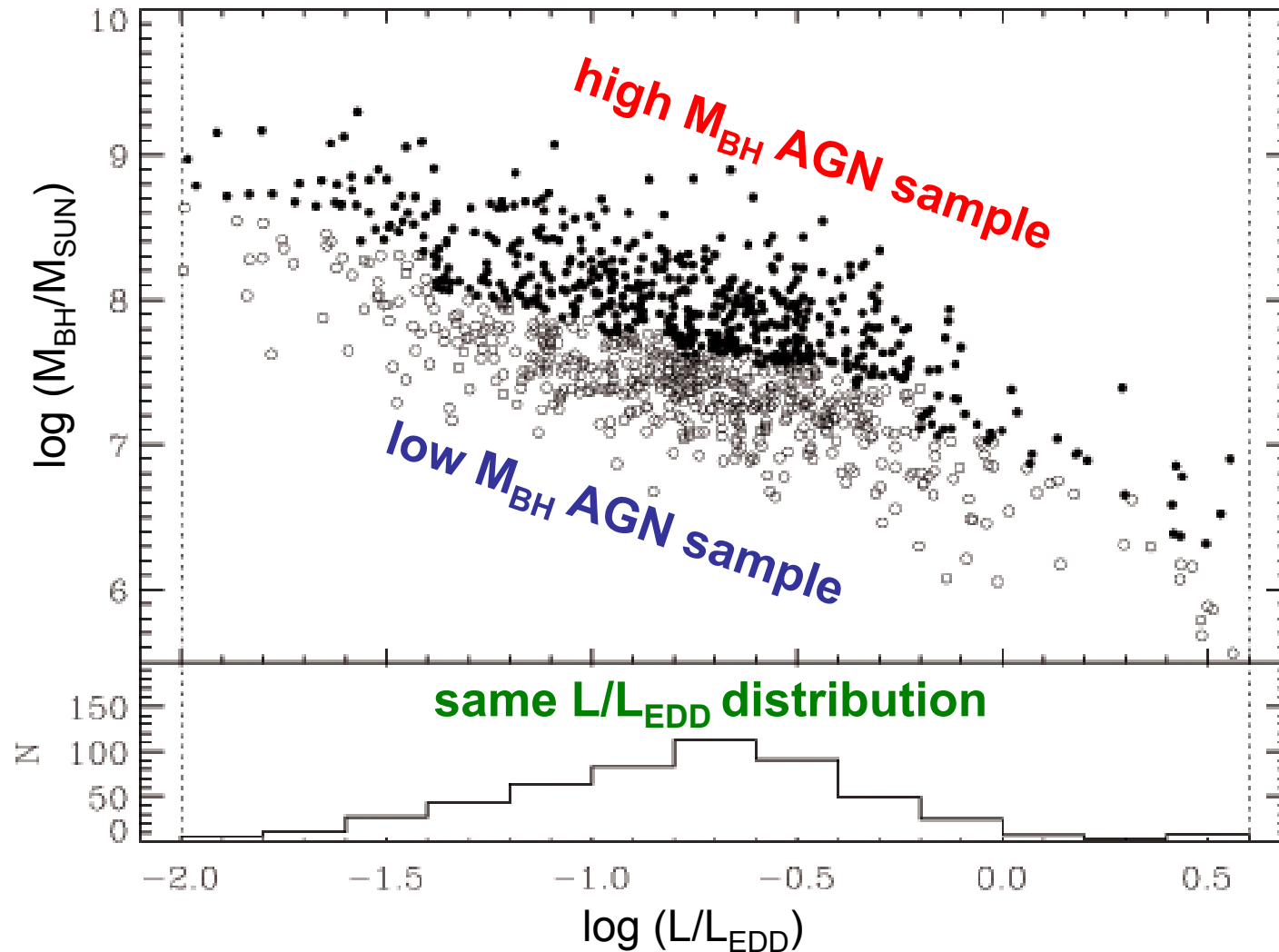
Hα bandpass
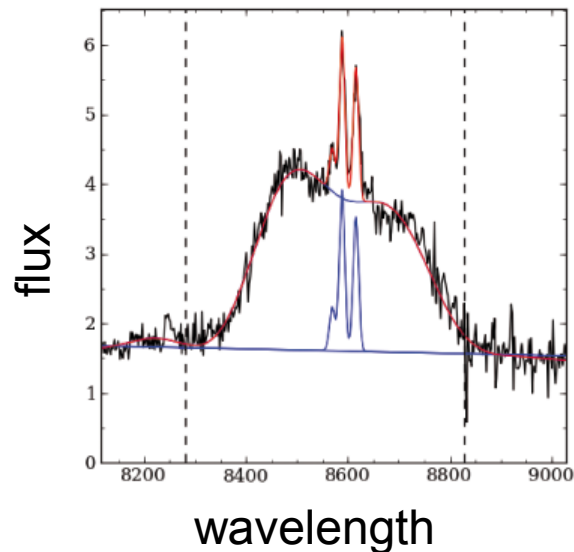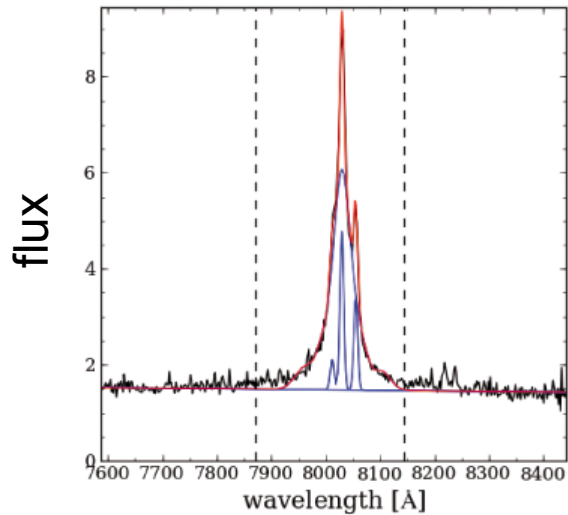
see Denney et al. (2009)

fit the Hα line profile
$\Rightarrow$ determine Hα-FWHM & $L_{H\alpha}$
$\Rightarrow$ estimate M_{BH} and L/L_{EDD}

# M$_{BH}$ - L/L$_{EDD}$ plane

Unbiased split distributions
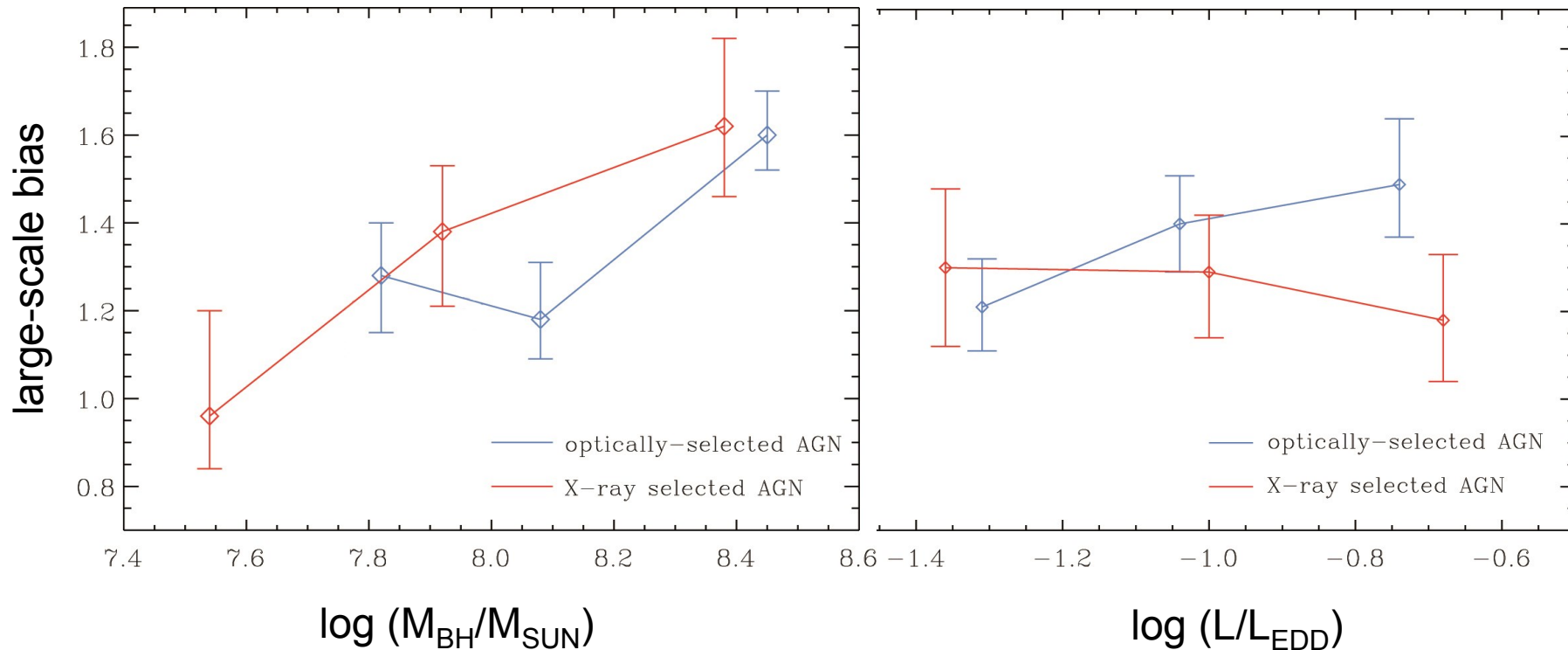
Results

L_X dependence of clustering due to M_{BH} dependence (and not L/L_{EDD})
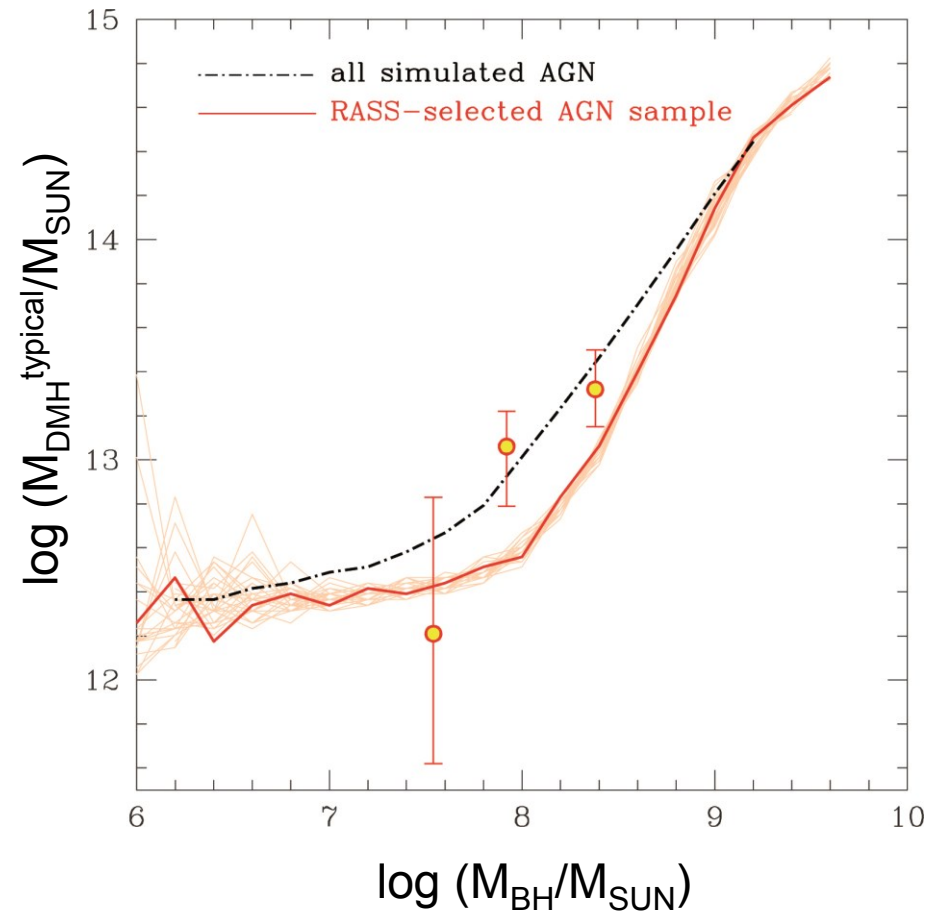
Is this result due to selection effects?
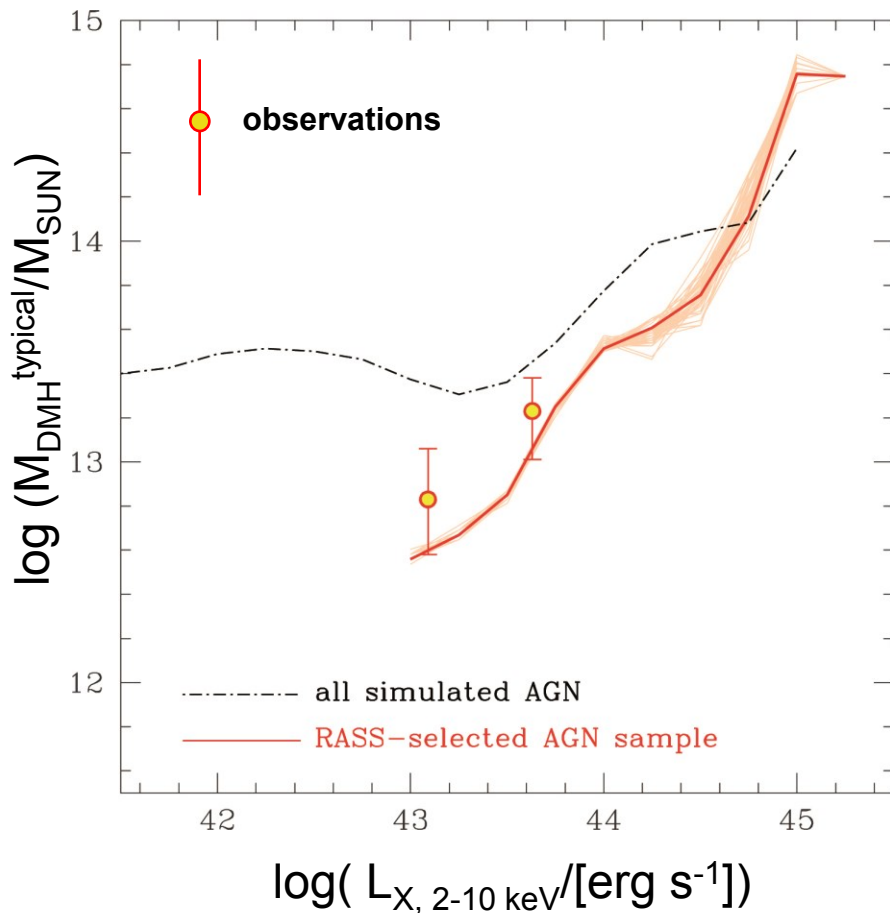
semi-analytic cosmological simulations (GALFORM)
that include SMBH physics (Fanidakis et al. 2011, 2012, 2013)

1) **all simulated AGN sample**:
   accreting SMBH with
   $L_{X,2\text{-}10\ keV} > 10^{41.5}$ erg s^{-1}

2) **simulated RASS-selected AGN**:
   out of 1) only objects with:
   - f_X high enough to be detected
   - soft X-ray selected
   - $\log (L/L_{EDD}) > -2$
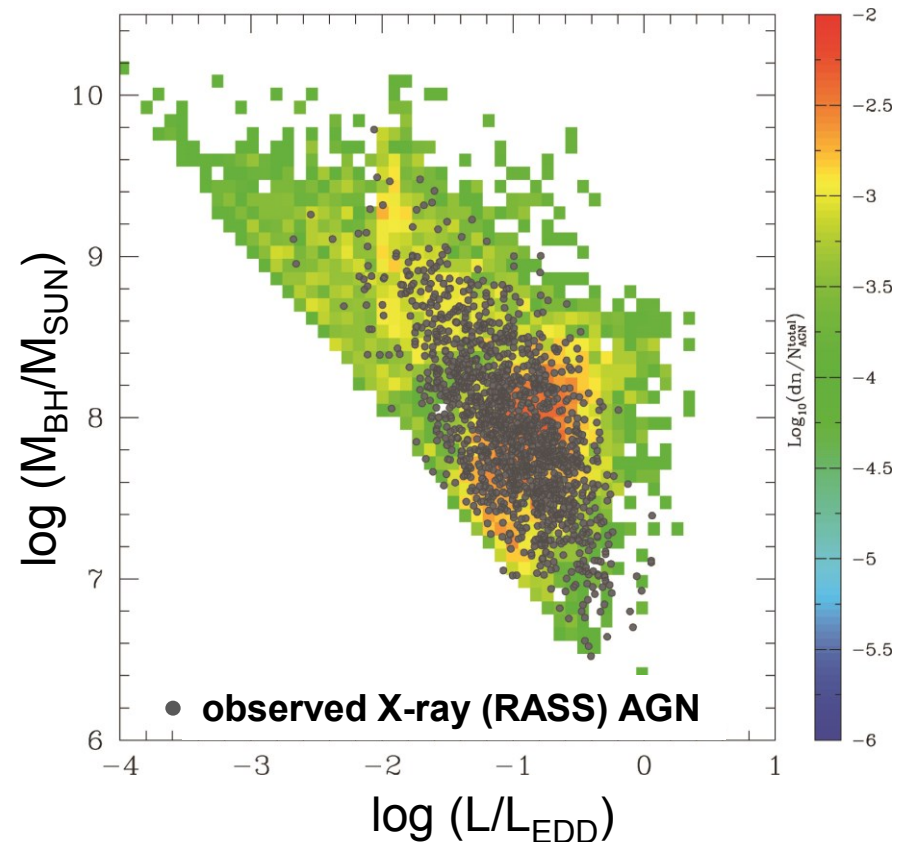
Comparison: simulations vs observations

Consequences

at the luminosity and redshift range studied:

(broad-line AGN; $L_X \sim 10^{43}$-10^{45} erg s^{-1}; $0.16 < z < 0.36$)

no correlation with L/L_{EDD}:

higher densities of galaxies/larger DMH masses
do NOT cause more accretion of matter

correlation with M_{BH}:

more massive accreting black holes
reside in more massive DMHs

more consequences and details given in Krumpe et al. 2015, ApJ, accepted

Conclusions

• **we accurately measure the clustering of X-ray and optically selected AGN at low redshift through CCFs** (Krumpe et al. 2010, 2012)

Broad-line, luminous AGN (z=0.07-0.5):

• no statistically convincing difference between:
X-ray, optically selected, radio-quiet AGN

• weak L_X dependence of the clustering strength

L_X dependence of the clustering strength due to dependence on M_{BH}
$\Rightarrow$ more massive SMBH reside in more massive DMH
$\Rightarrow$ more luminous AGN do not require denser galaxy environments
(Krumpe et al. 2015, ApJ accepted, soon on astro-ph)