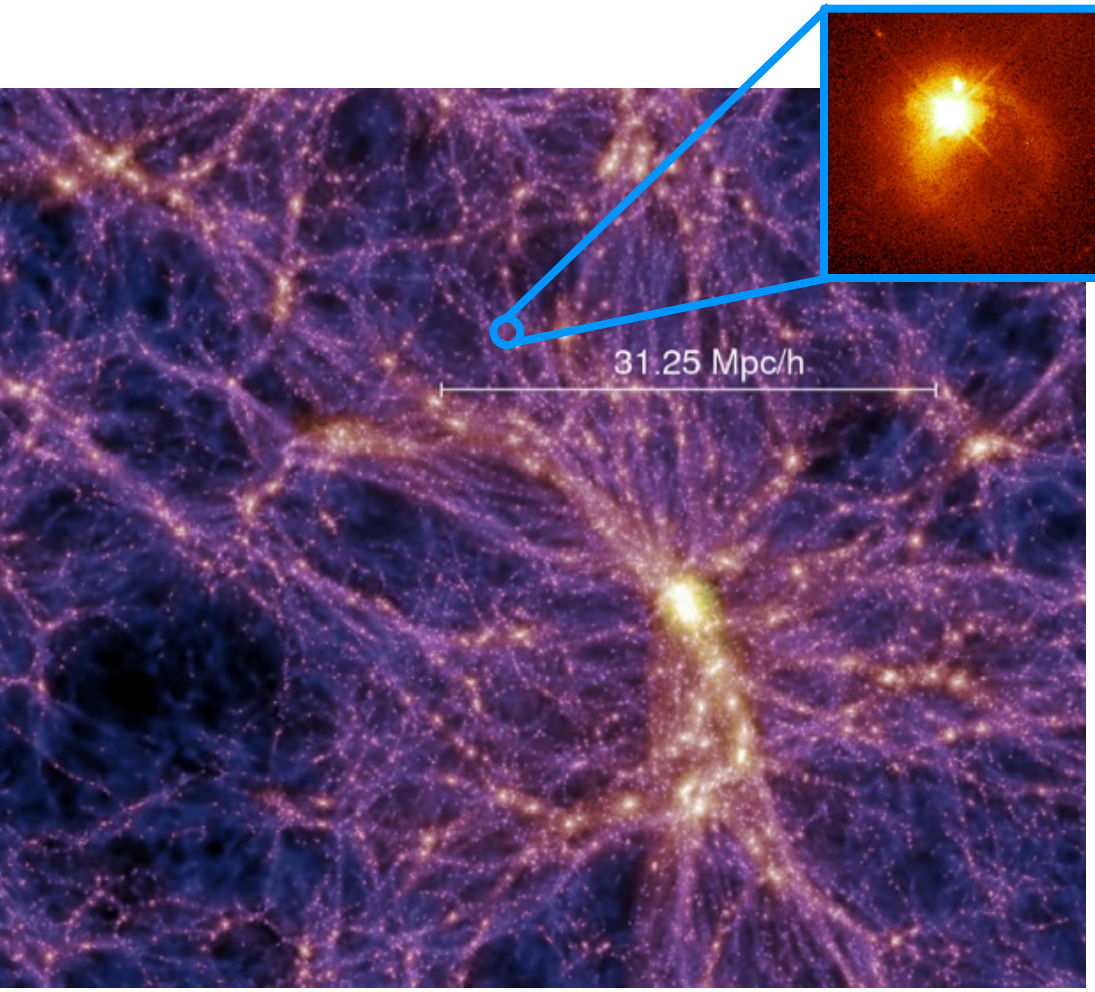
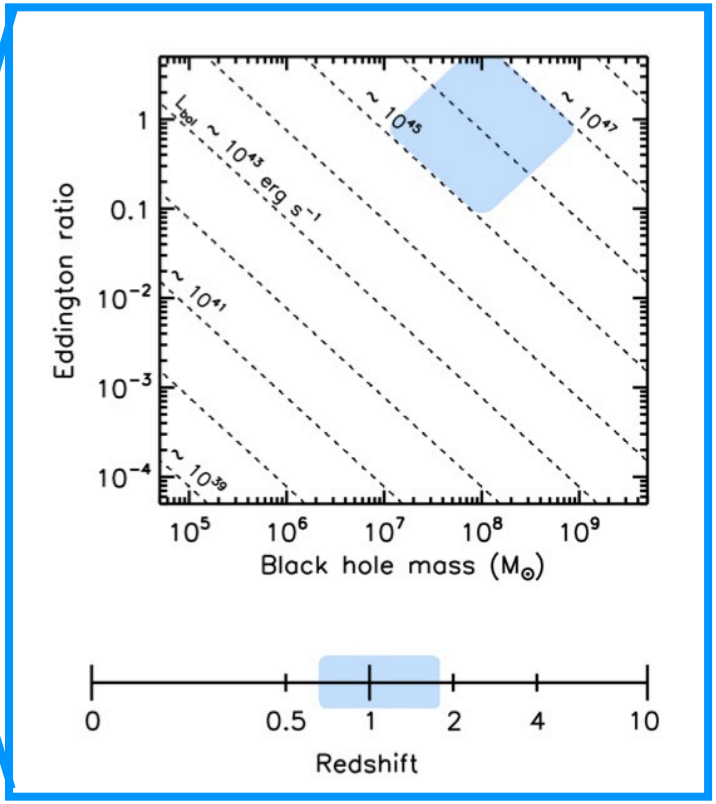
Clustering of obscured and unobscured quasars





Ryan C. Hickox

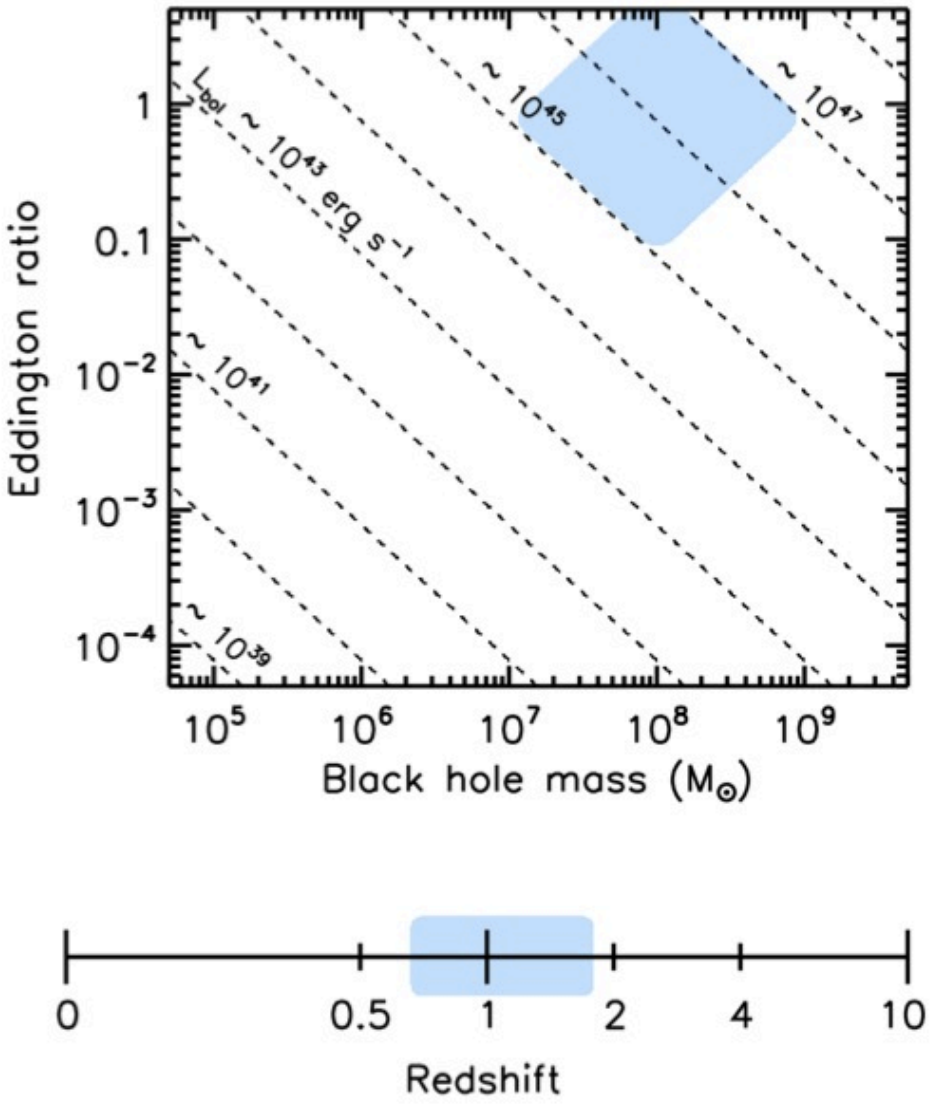
Durham University

with Adam Myers (University of Illinois)

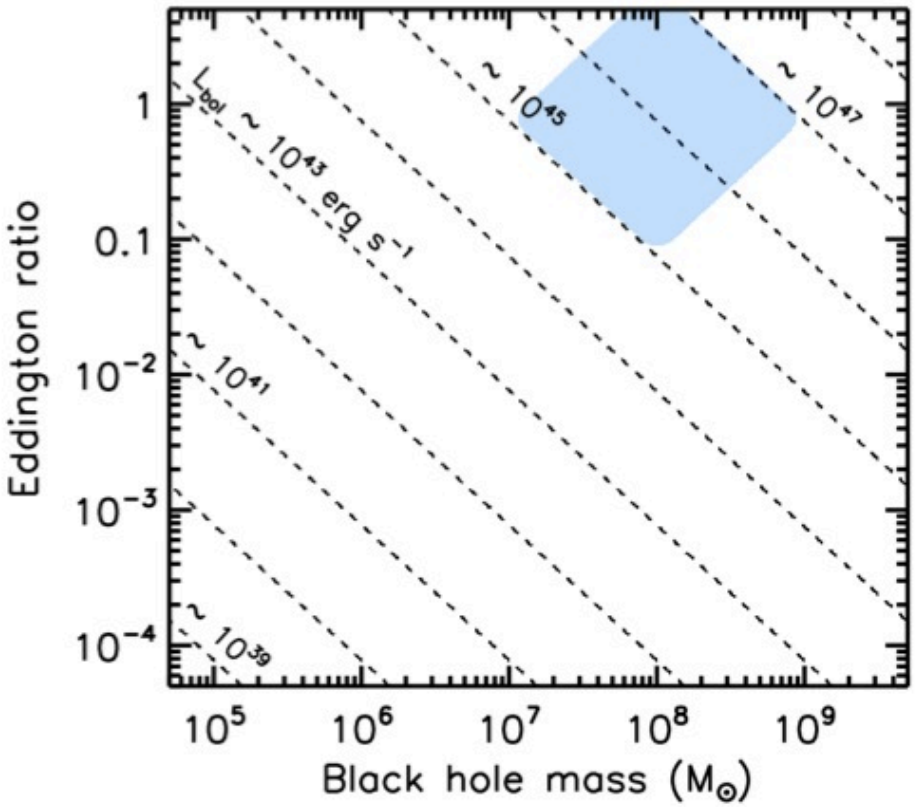
and the Bootes Survey Collaboration

What Drives the Growth of Black Holes?

28 July 2010


Eddington ratio
1
0.1
10^{-2}
10^{-3}
10^{-4}
$L_{bol} \sim 10^{43}$ erg s^{-1}
$\sim 10^{41}$
$\sim 10^{39}$
$\sim 10^{45}$
$\sim 10^{47}$
10^5
10^6
10^7
10^8
10^9
Black hole mass ($M_\odot$)

0
0.5
1
2
4
10
Redshift


Eddington ratio
1
0.1
10^{-2}
10^{-3}
10^{-4}
$L_{bol} \sim 10^{43}$ erg s^{-1}
$\sim 10^{45}$
$\sim 10^{47}$
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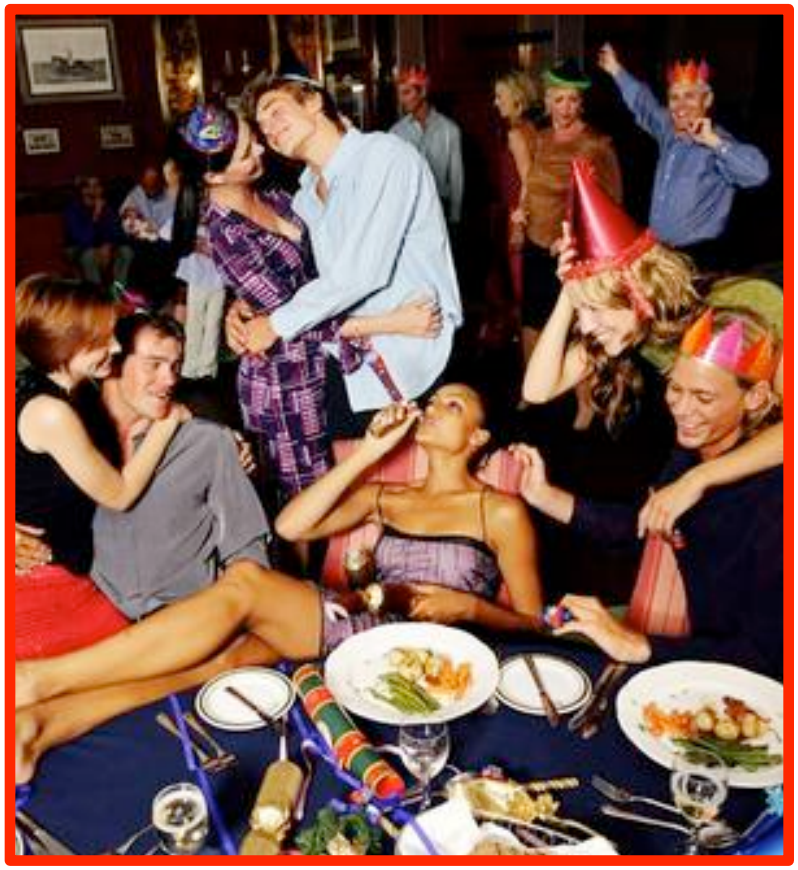
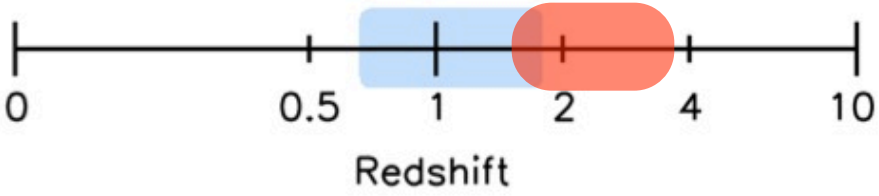
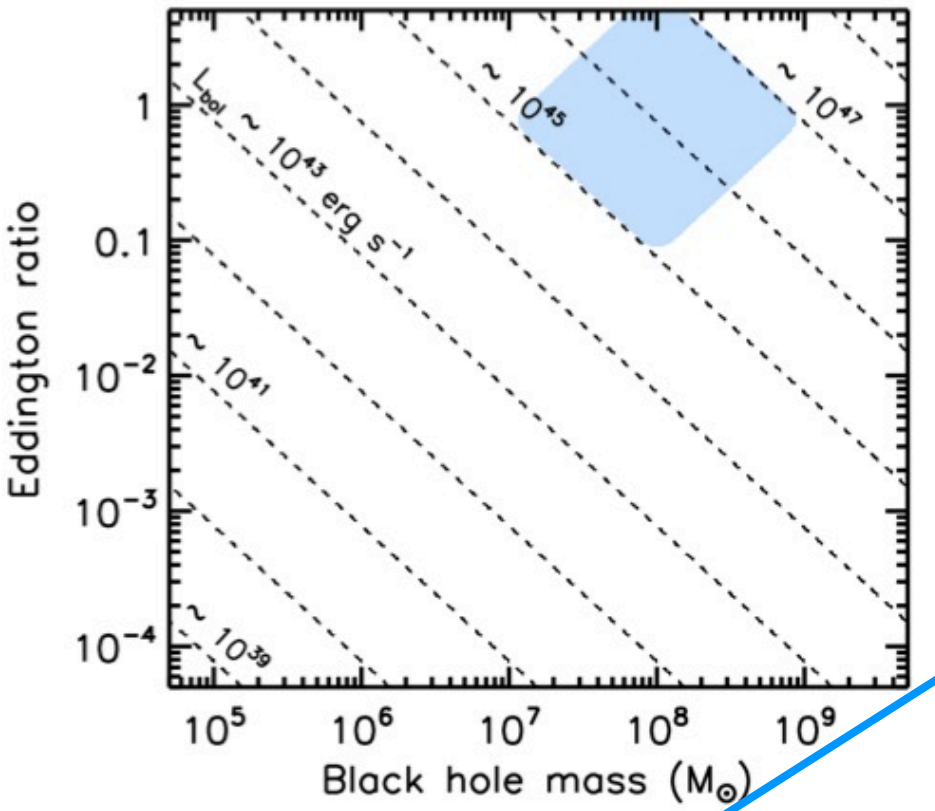
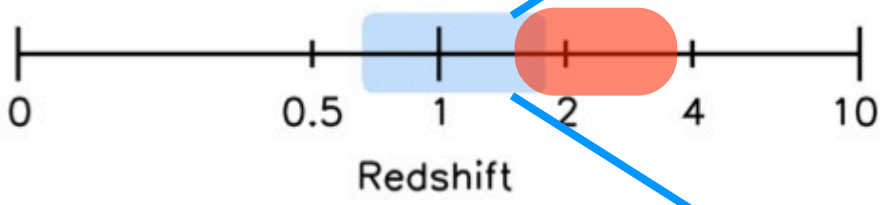
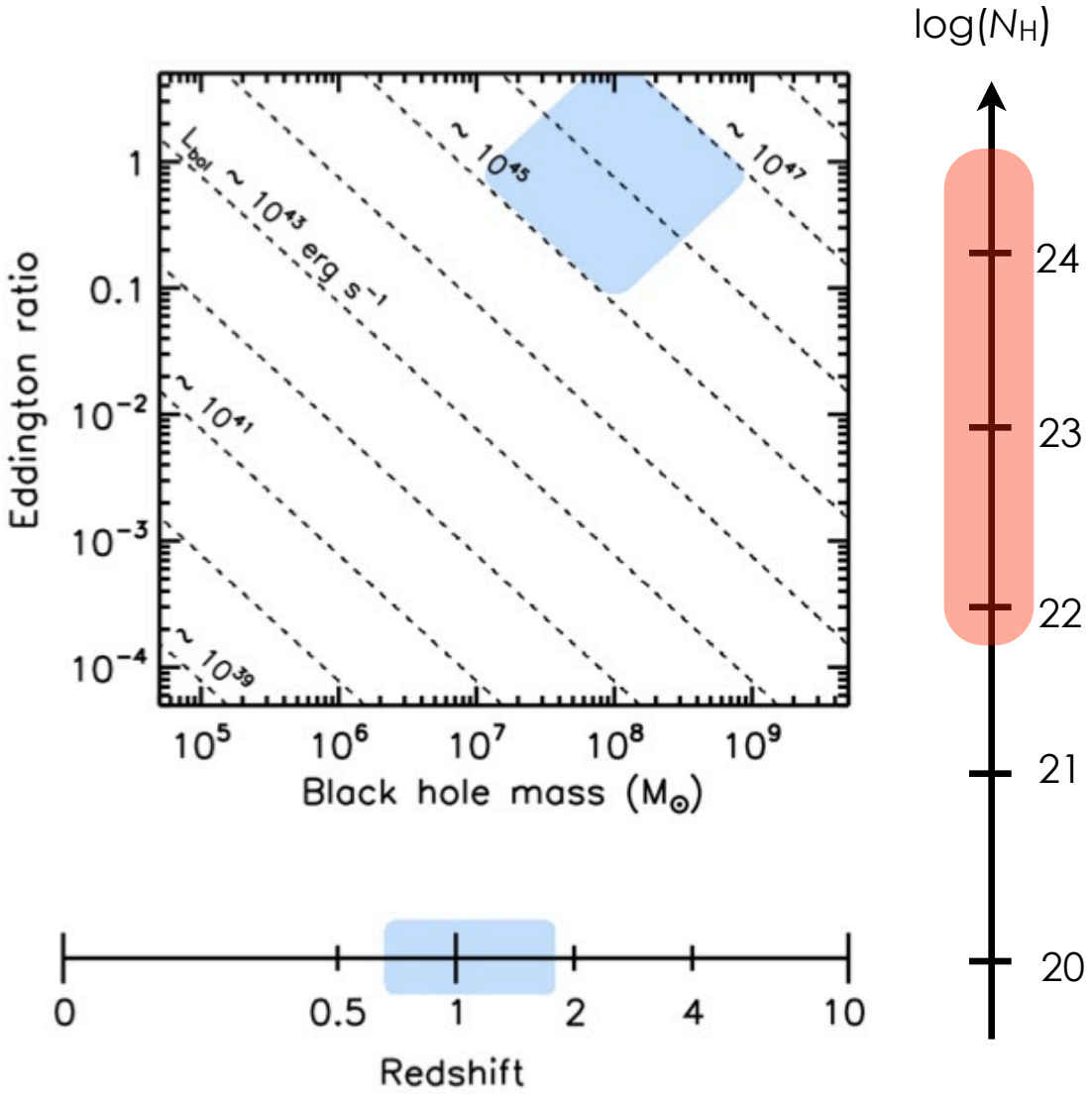
10^5
10^6
10^7
10^8
10^9
Black hole mass ($M_\odot$)




0
0.5
1
2
4
10
Redshift


Eddington ratio
1
0.1
10^{-2}
10^{-3}
10^{-4}
$L_{bol} \sim 10^{43}$ erg s^{-1}
$\sim 10^{45}$
$\sim 10^{47}$
$\sim 10^{41}$
$\sim 10^{39}$
10^5
10^6
10^7
10^8
10^9
Black hole mass ($M_\odot$)


0
0.5
1
2
4
10
Redshift



2.3 Emma Bradshaw
The environments of AGN at high redshift

2.5 Andrea Comastri
Heavily obscured AGN in the deep XMM survey in the CDFS

2.15 Somak Raychaudhury
AGN activity vs. host and environment

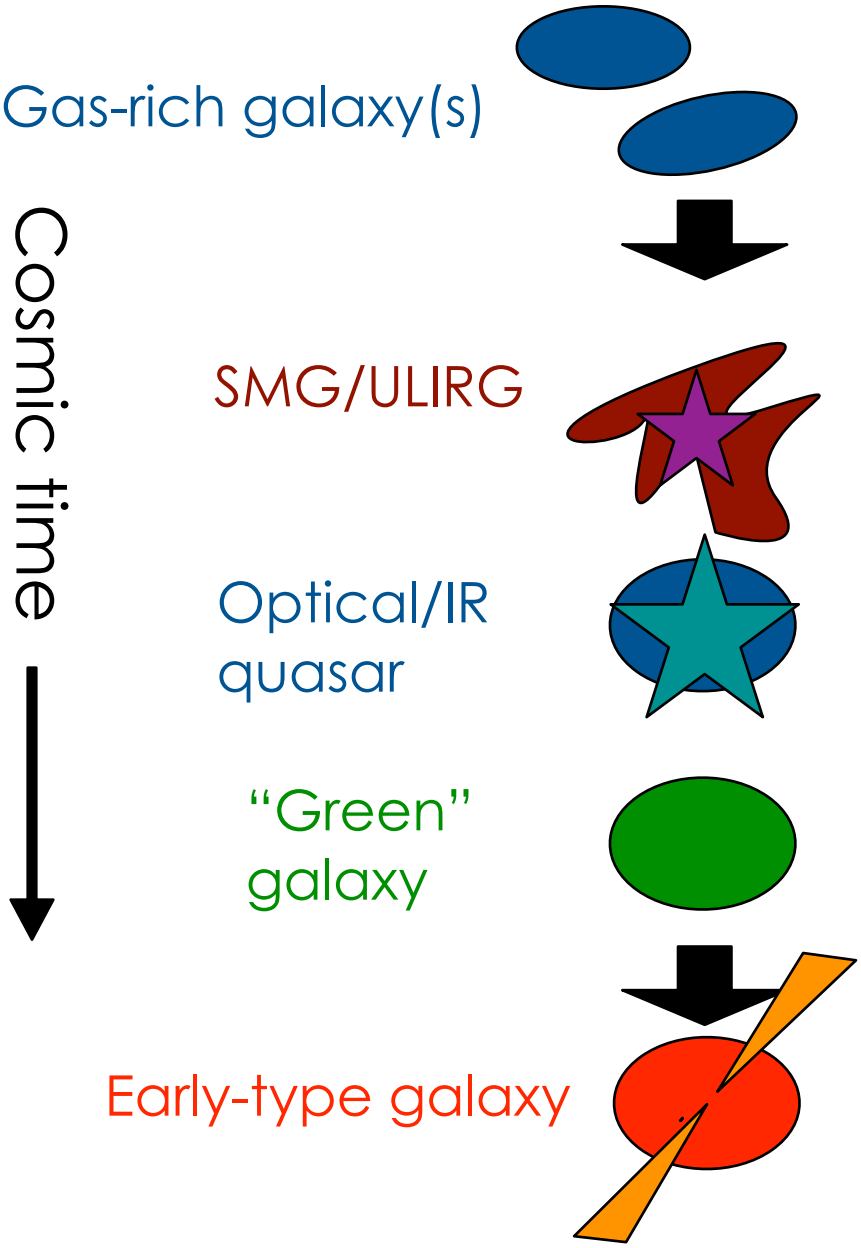
2.16 Aneta Siemigniowska
Cluster-quasar bound: 3C186, a QSO in a massive cluster at high z

3.6 Heidi Lietzen
Large scale environments of nearby quasars

3.9 Ezequiel Treister
Host galaxy mergers and growth of SMBH in QSOs

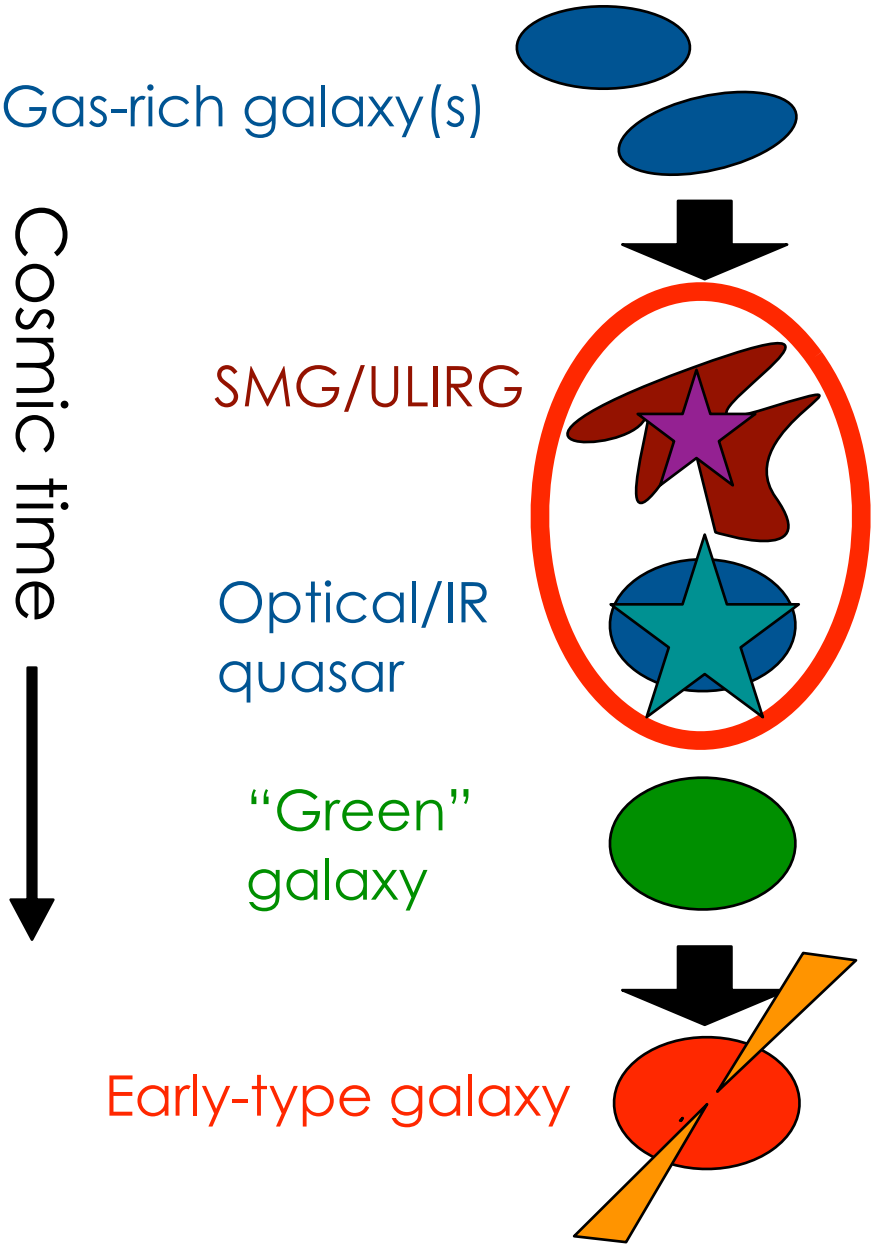
4.3 Marcella Brusa
Feedback in action in a z~1.6 XMM-COSMOS

Cartoon of massive galaxy evolution



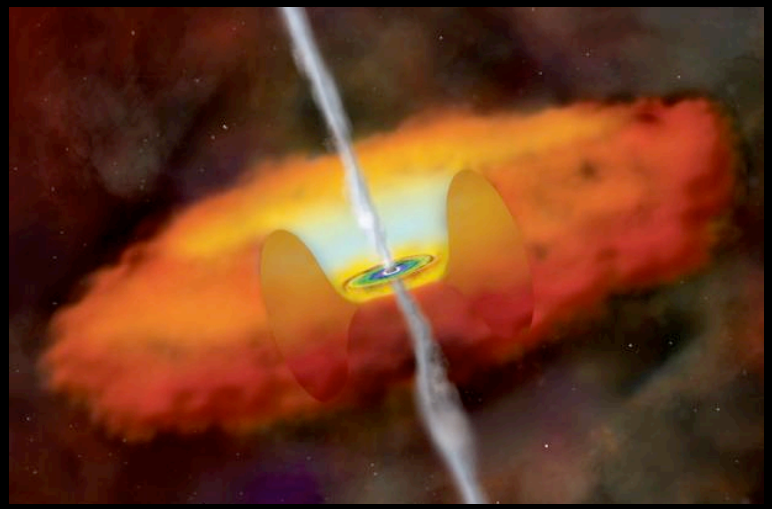
a la Sanders et al. (1988)
see Hickox et al. (2009)

Cartoon of massive galaxy evolution



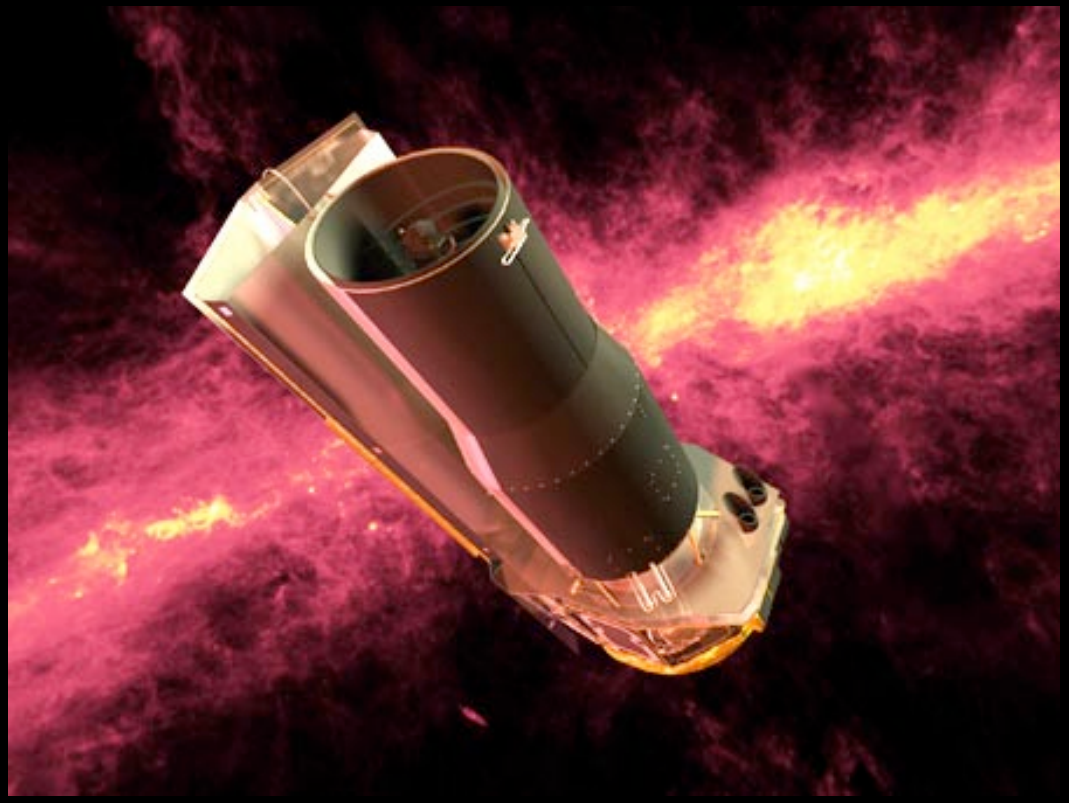
a la Sanders et al. (1988)
see Hickox et al. (2009)

Unobscured (QSO1)



?

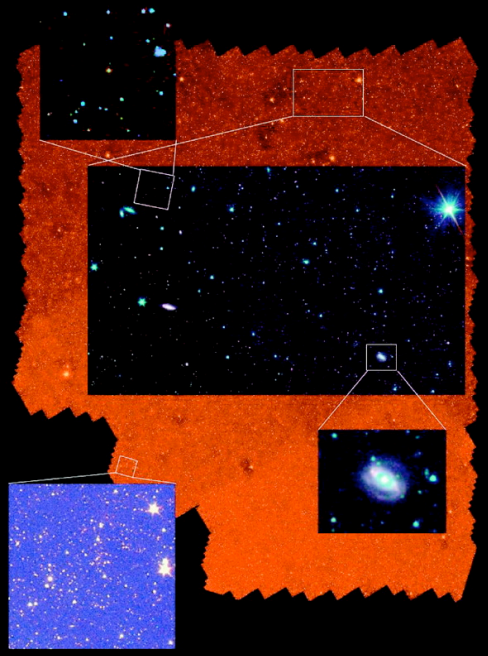
Obscured
(QSO2)

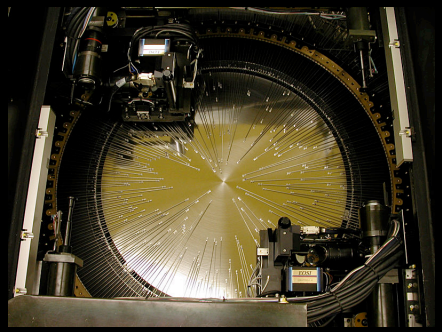


Can find large populations of obscured quasars with *Spitzer*!

(e.g., Lacy et al. 2004, Stern et al. 2005, Rowan-Robinson et al. 2005, Martinez-Sansigre et al. 2006, 2008, Polletta et al. 2006, 2008, **Hickox et al. 2007**, Donley et al. 2007, 2008, Alexander et al. 2008)

The 9 deg^2 Boötes survey





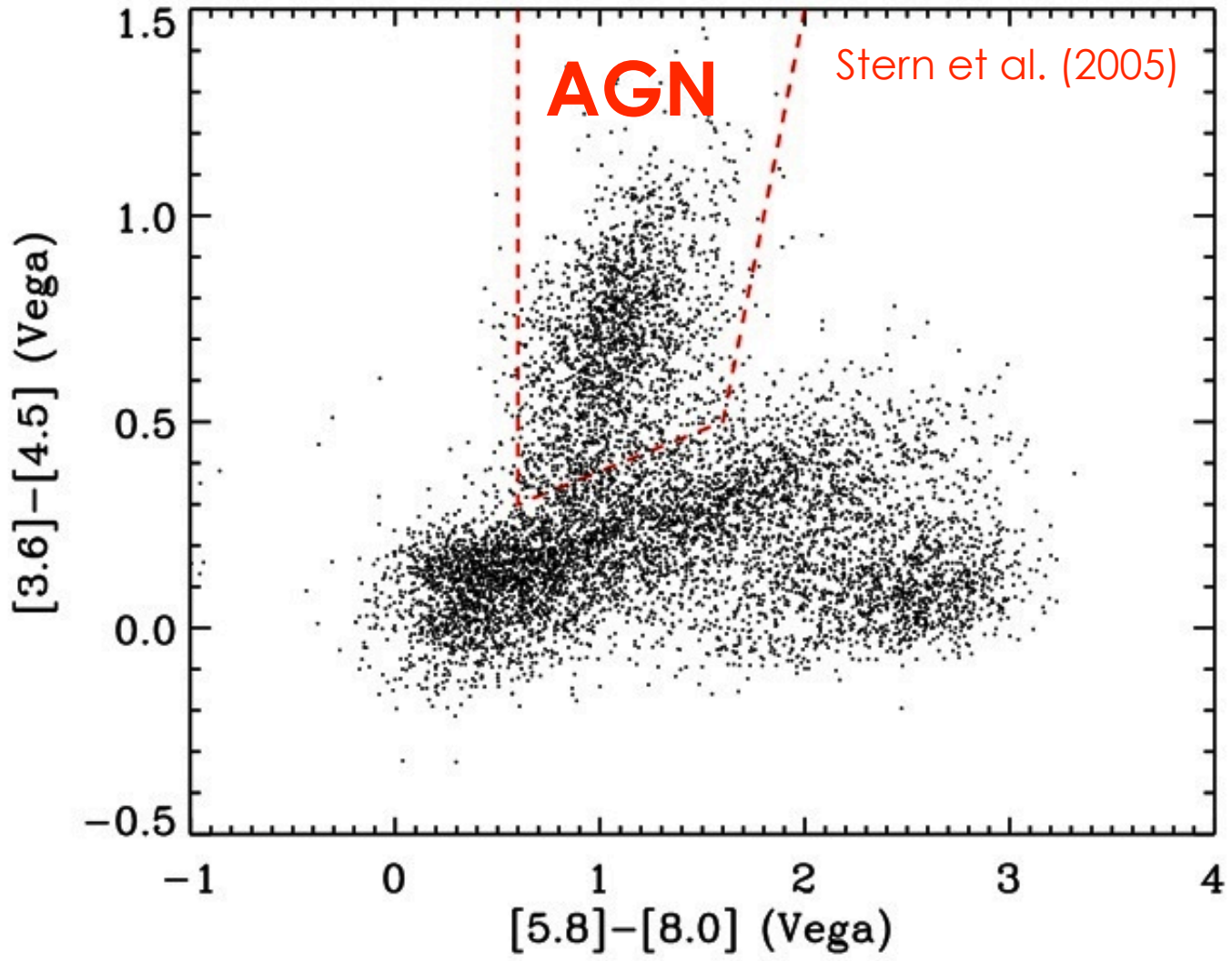
Chandra (CfA)
C. Jones
W. Forman
S. Murray
A. Kenter
R. Narayan

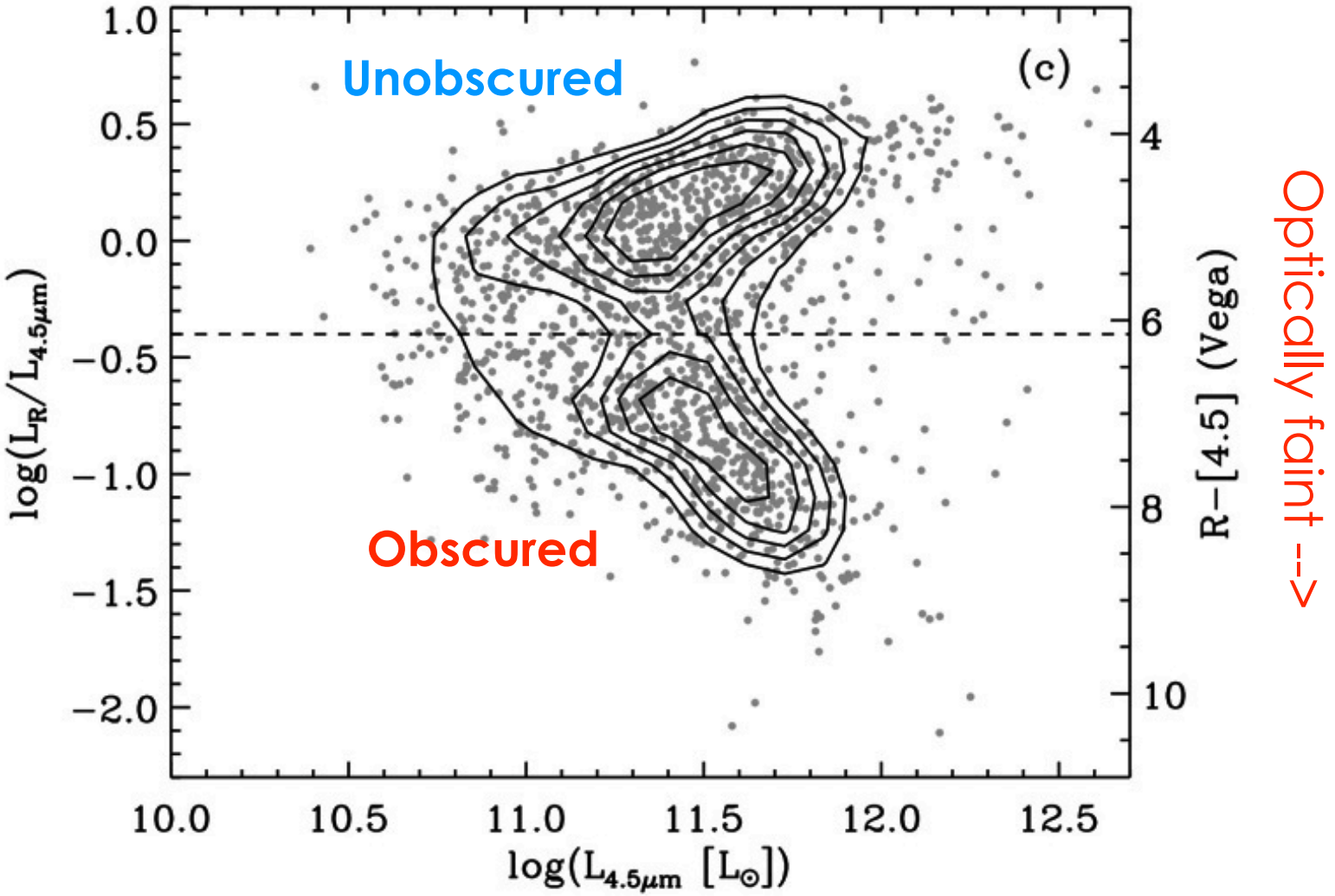
Optical photometry (NOAO/etc.)
B. Januzzi
A. Dey
K. Brand
M. Brown
and the NDWFS Team

Spitzer IRAC (JPL/Caltech/CfA)
P. Eisenhardt
M. Brodwin
V. Gorjian
D. Stern
M. Pahre
and the IRAC Shallow Survey Team

Optical spectroscopy (OSU/Arizona/CfA)
K. Kochanek
D. Eisenstein
R. Cool
N. Caldwell
and the AGES Team

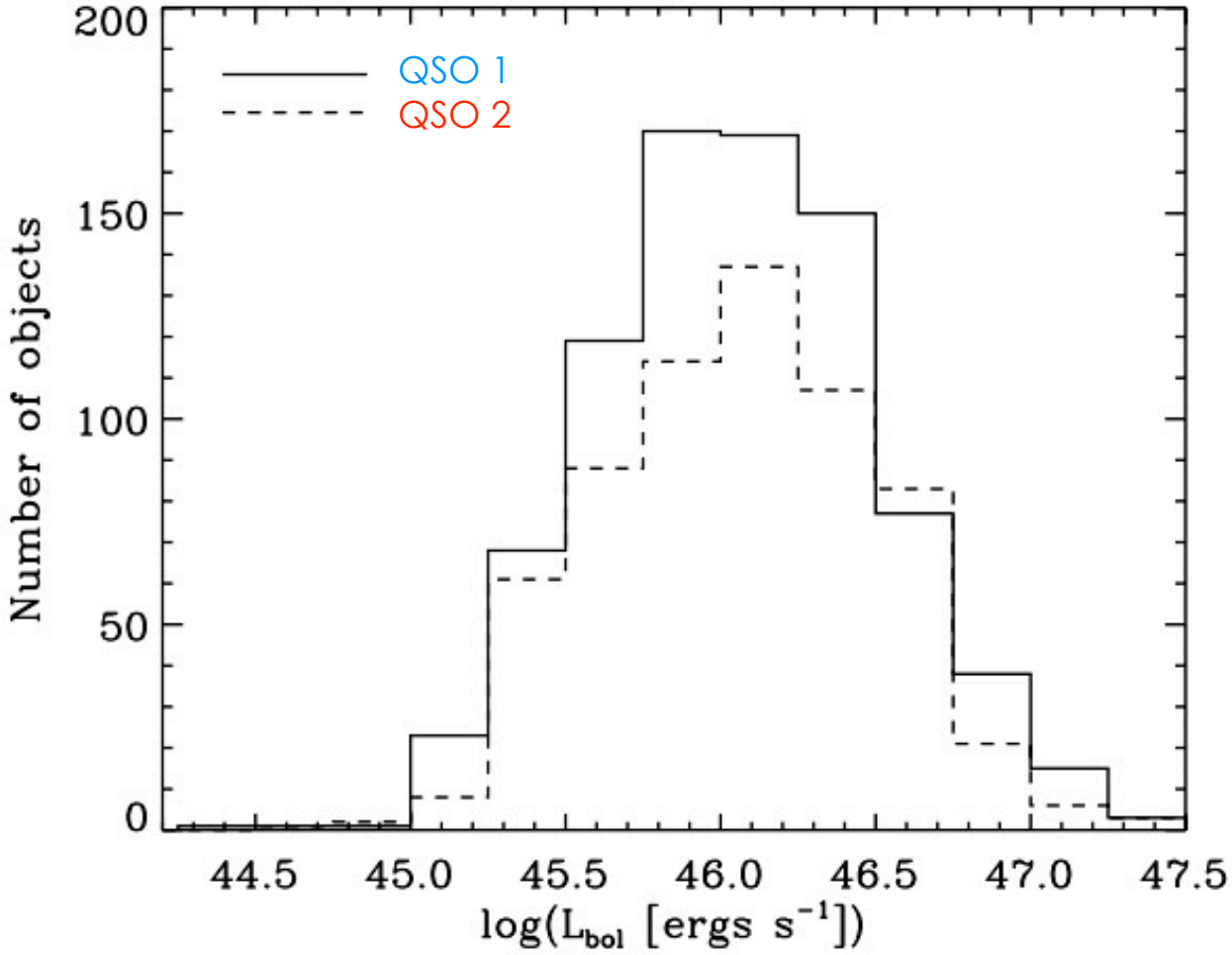
IRAC color-color selection





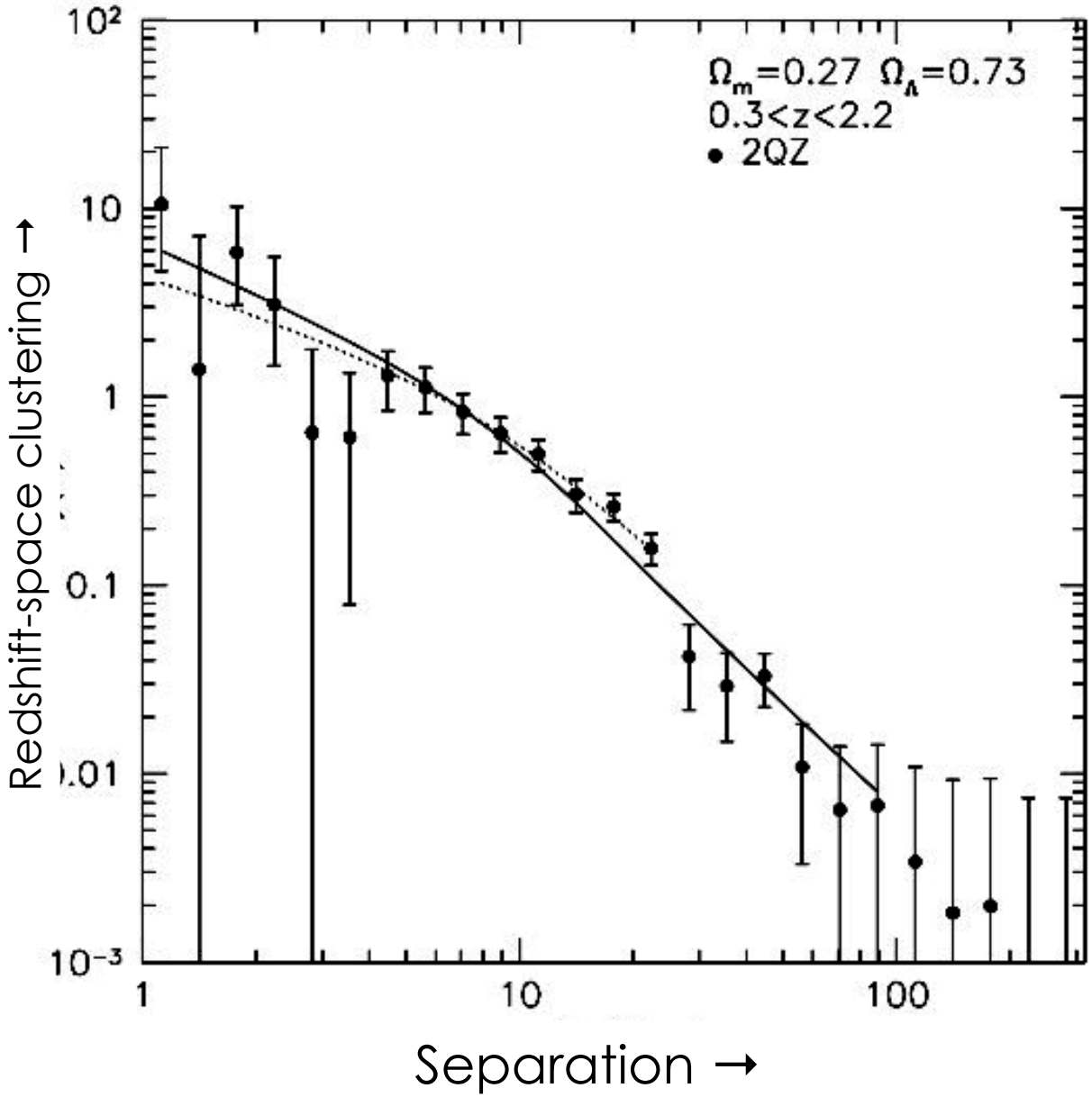
Hickox et al. (2007)

A matched sample of obscured and unobscured quasars

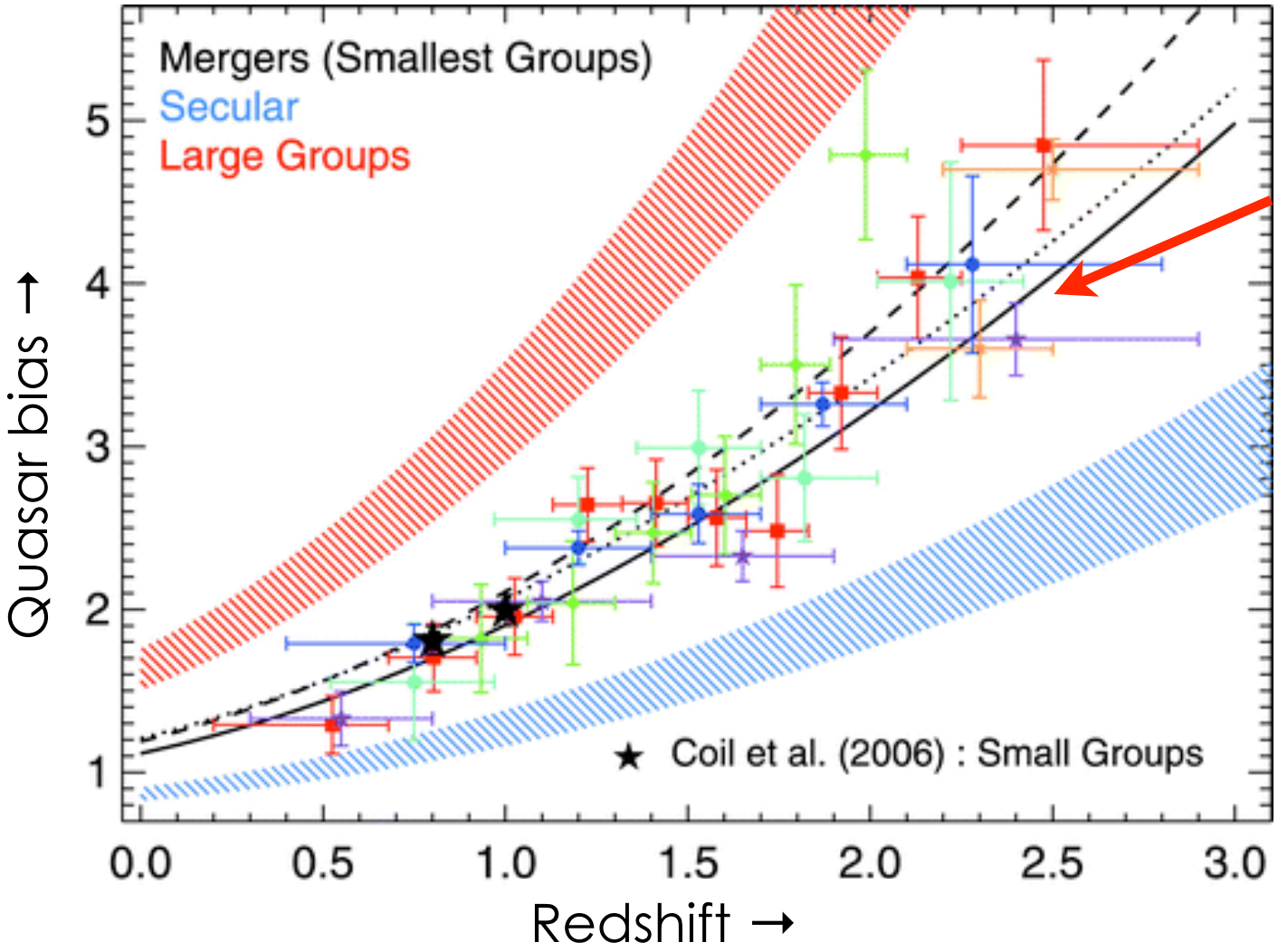


QSO autocorrelation

Croom et al. (2005) [2QZ]



Optical quasars: large-scale clustering



constant M_{halo}

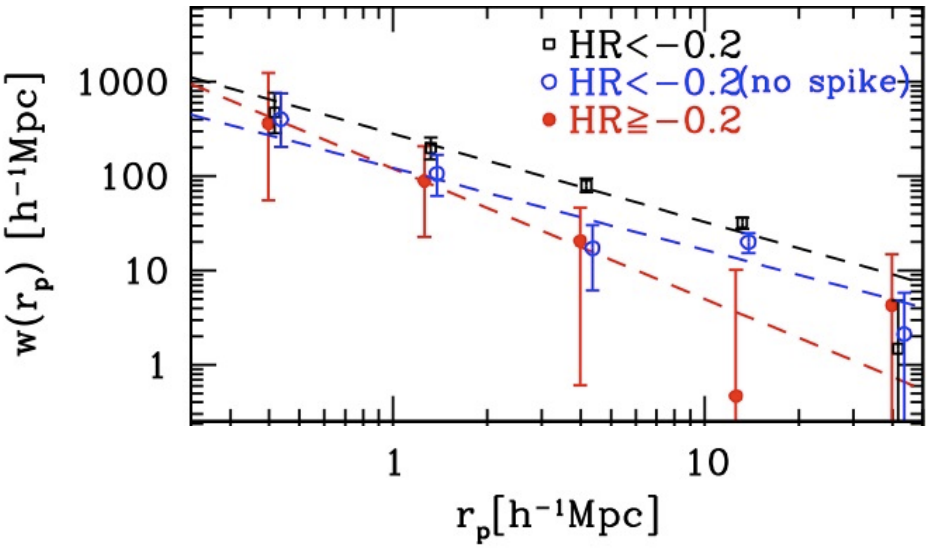
~ 3 x 10^{12} h^{-1} $M_\odot$

"small group" scale (e.g., several previous talks)

Hopkins et al. (2008)

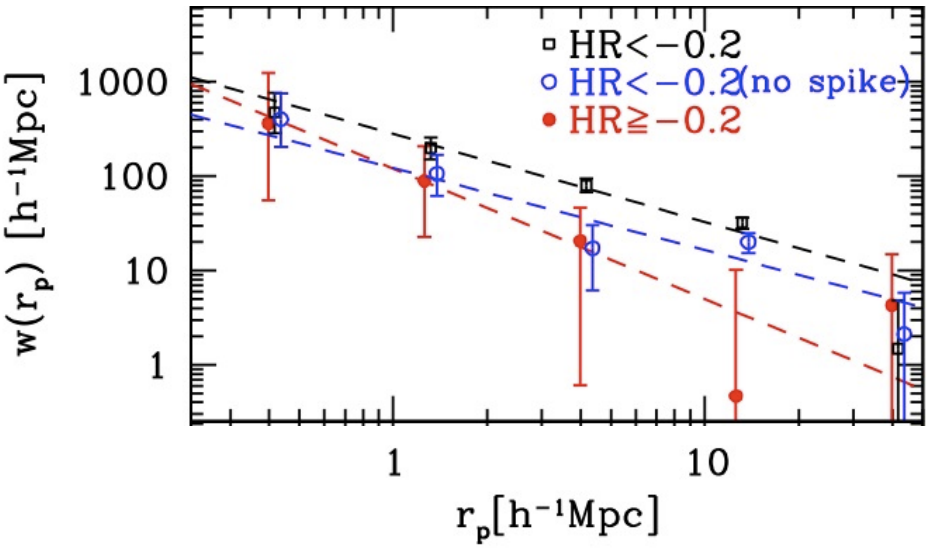
Is there any difference in clustering between obscured and unobscured quasars?

but...



NO significant difference between obscured and unboscured X-ray AGN

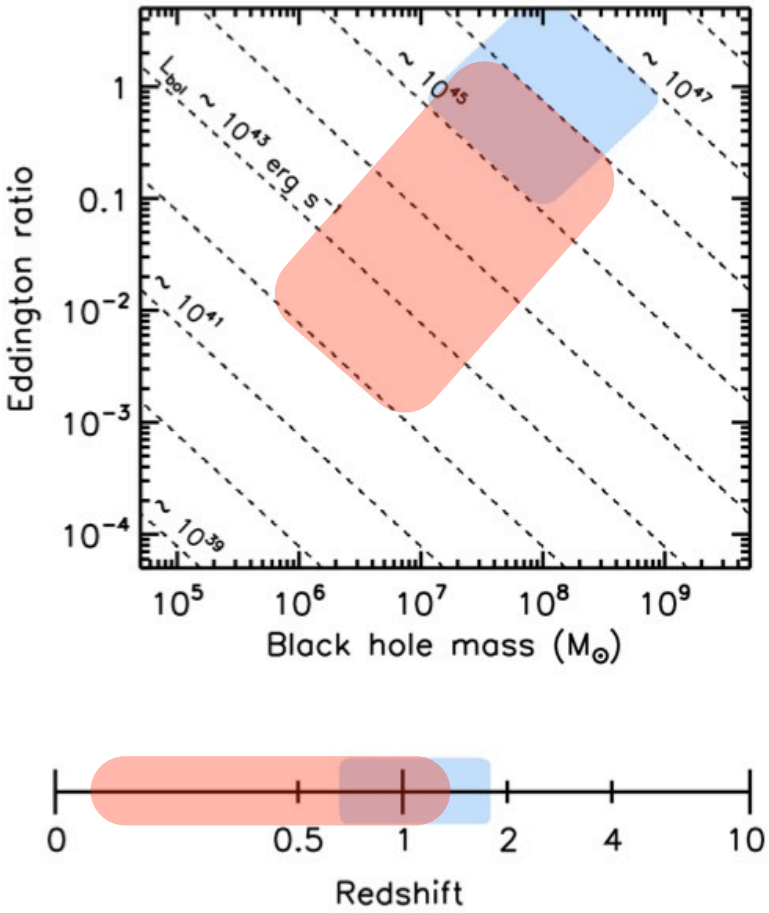
(Gilli et al. 2009, see also Gandhi et al. 2006)



NO significant difference between obscured and unboscured X-ray AGN

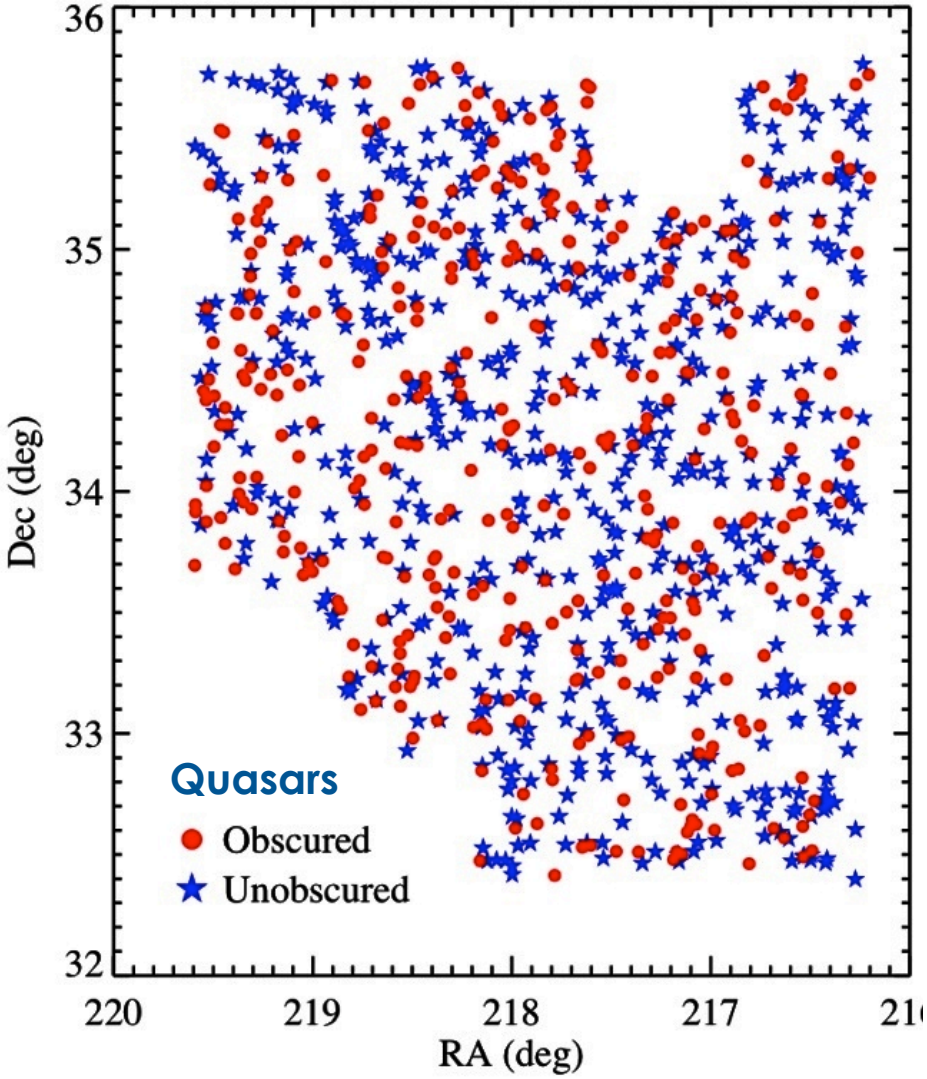
(Gilli et al. 2009, see also Gandhi et al. 2006)

but...

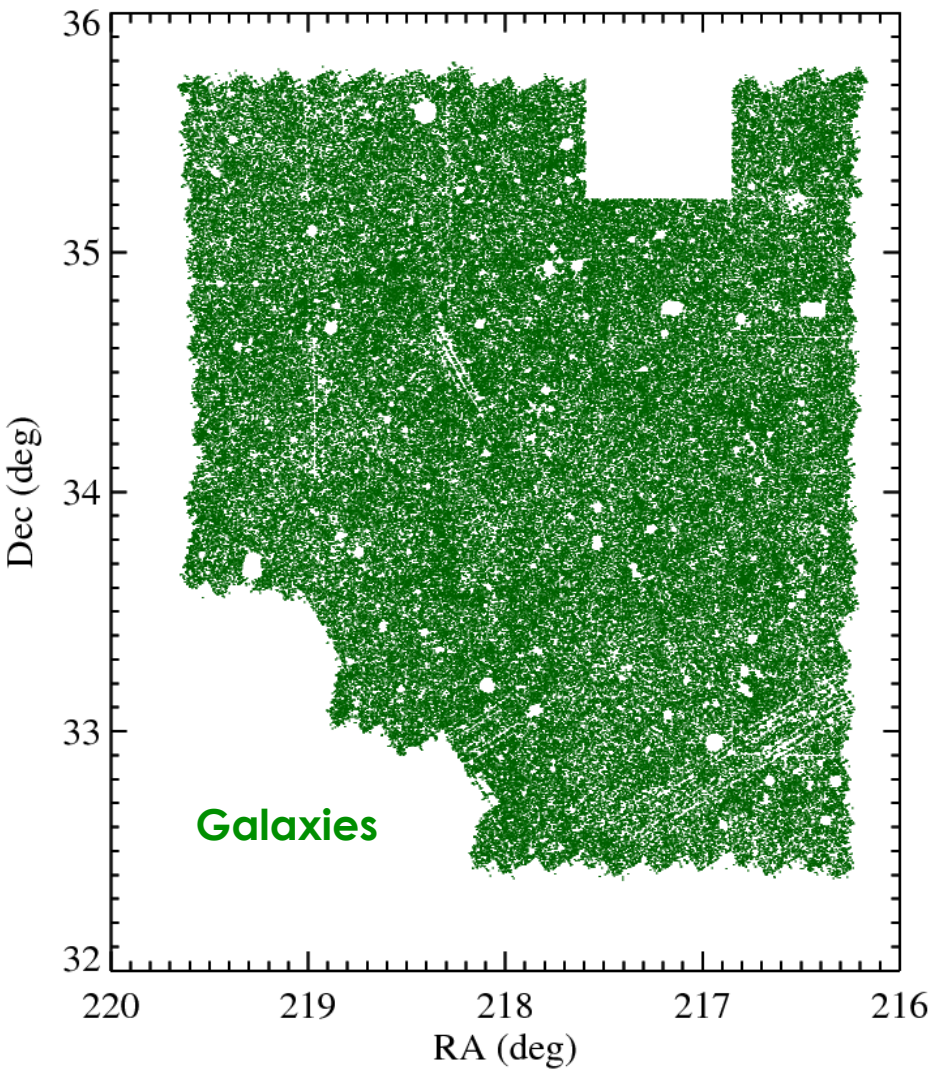


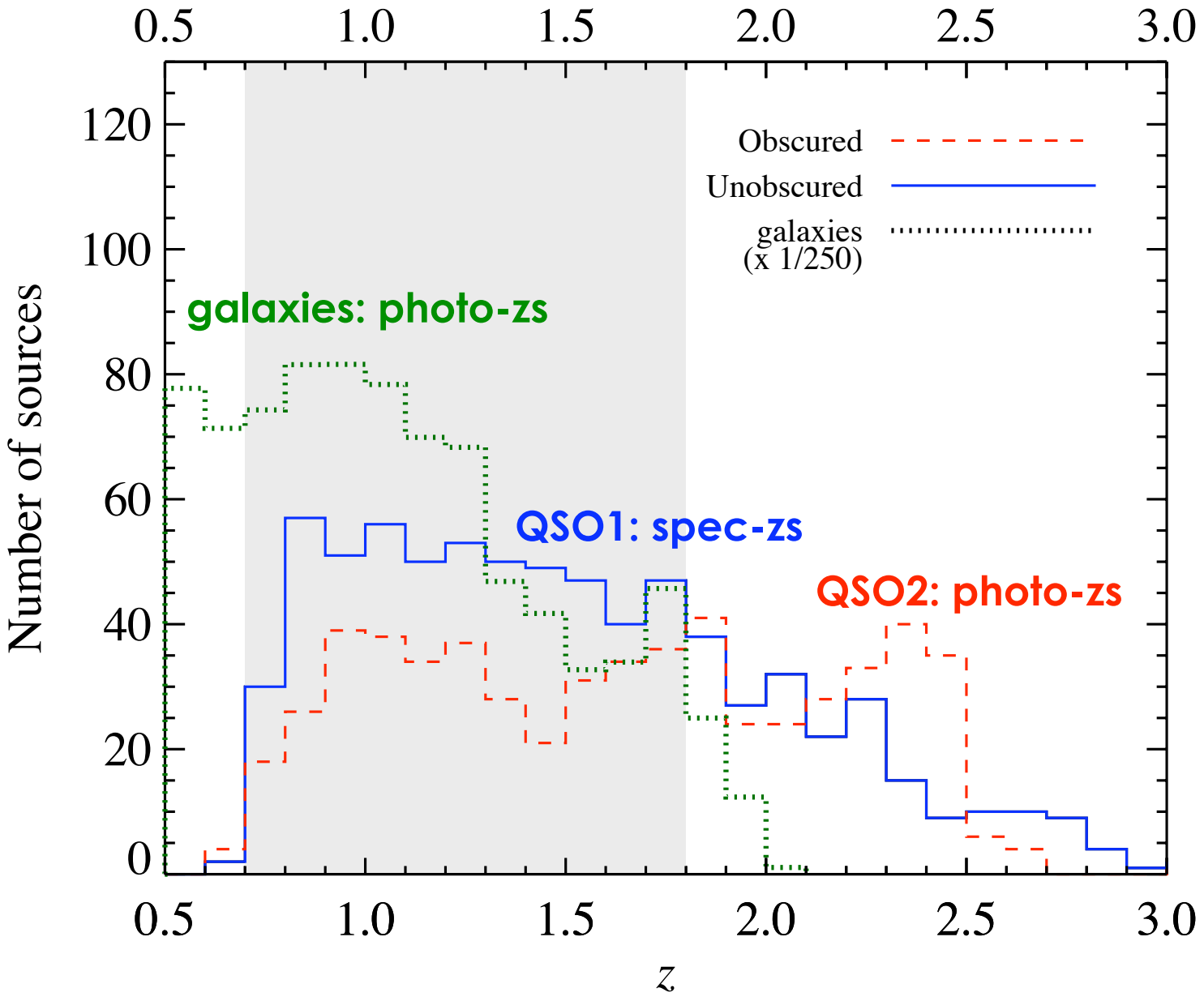
Infrared-selected quasars

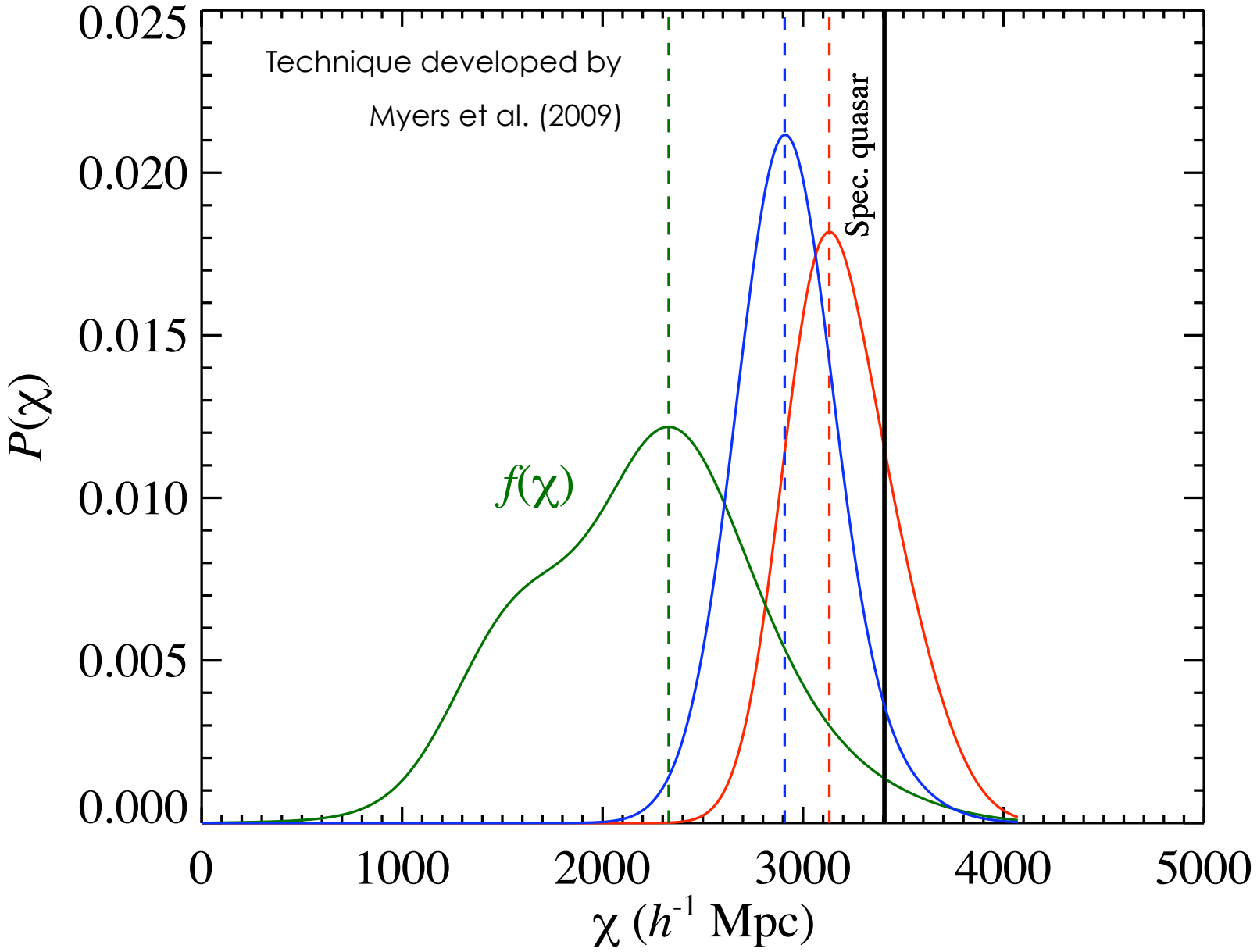
Hickox et al. (2007)

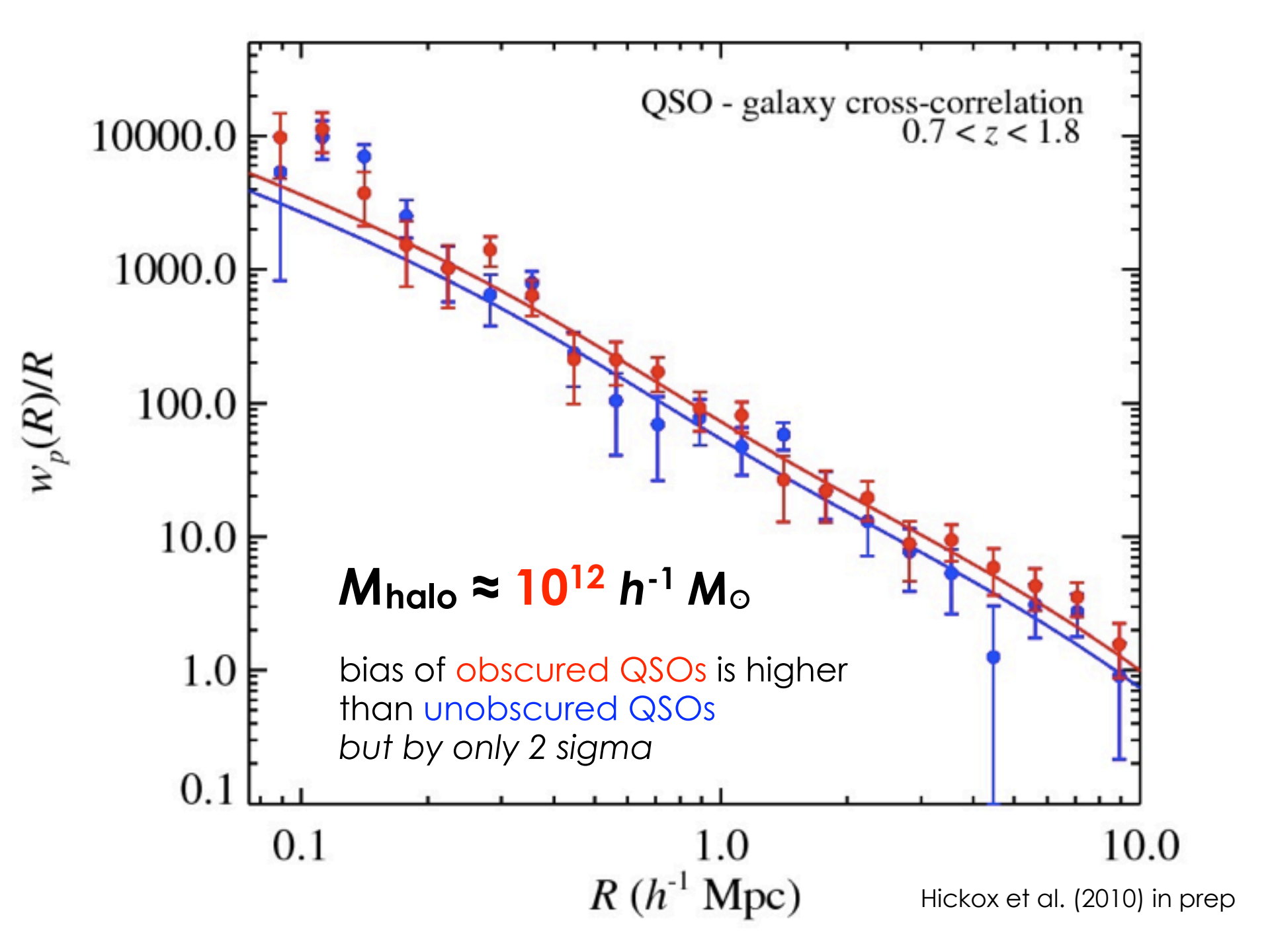


Brodwin et al. (2006)



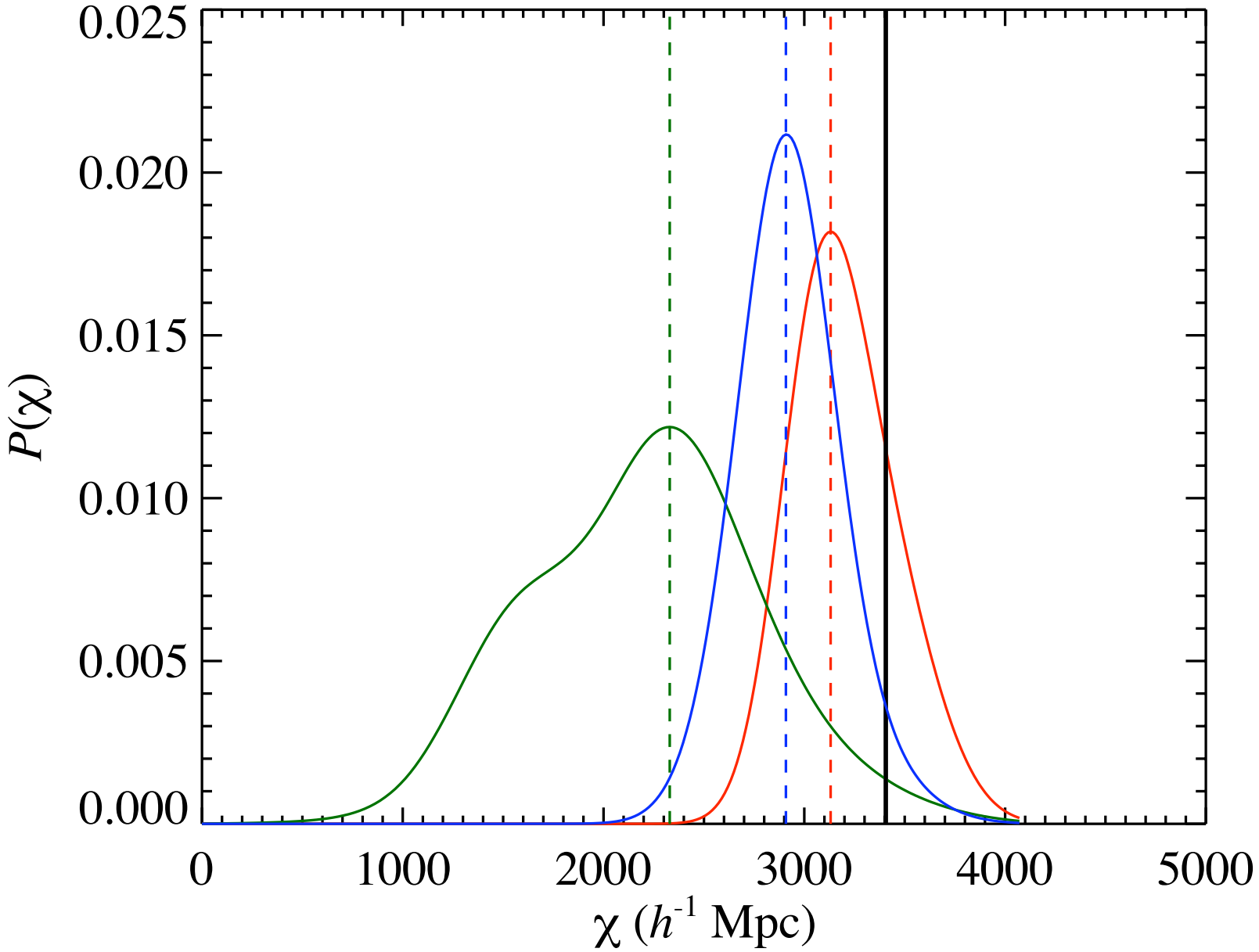

0.5
1.0
1.5
2.0
2.5
3.0
120
100
80
60
40
20
0
Number of sources
z
Obscured
Unobscured
galaxies
(x 1/250)
galaxies: photo-zs
QSO1: spec-zs
QSO2: photo-zs


Technique developed by
Myers et al. (2009)
Spec. quasar
$f(\chi)$
$P(\chi)$
0.025
0.020
0.015
0.010
0.005
0.000
0
1000
2000
3000
4000
5000
χ (h^{-1} Mpc)

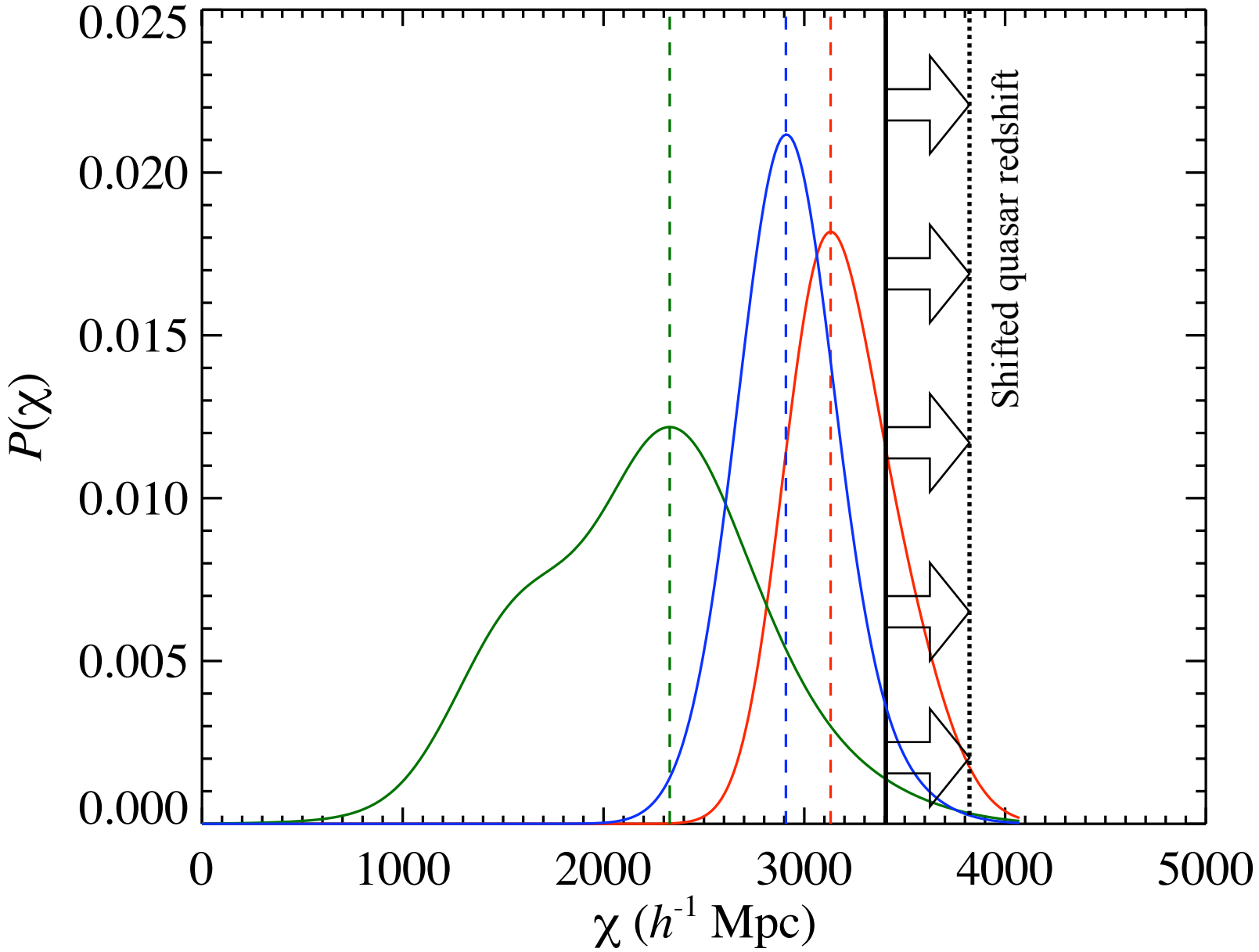


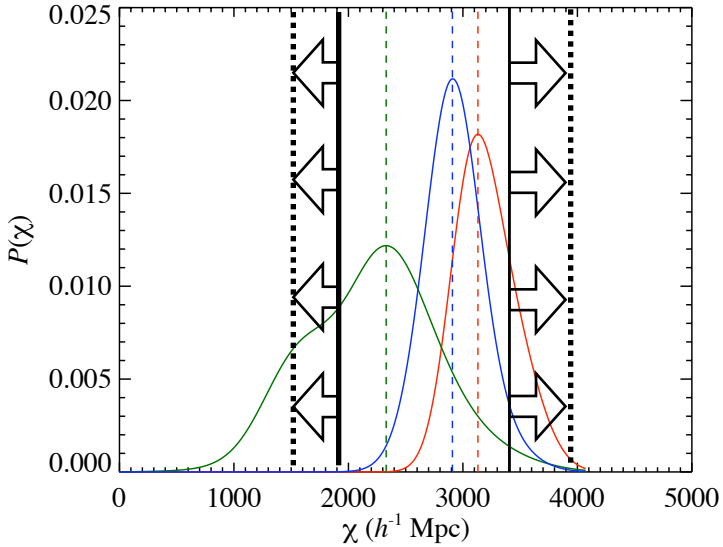
Hickox et al. (2010) in prep

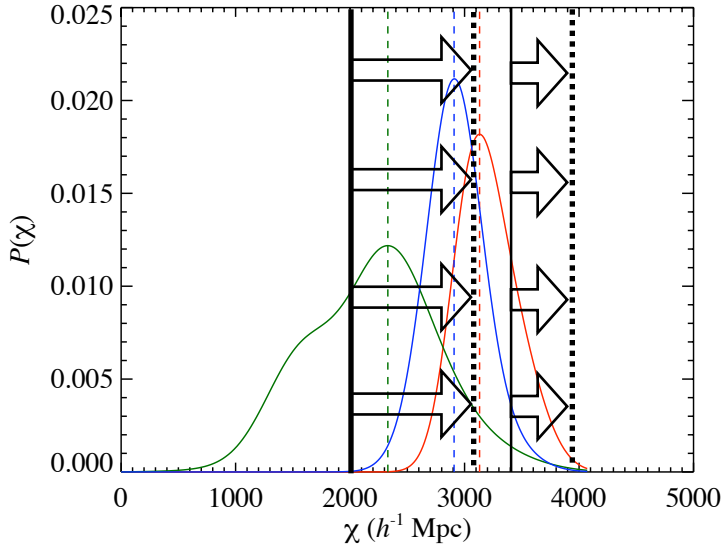
Check photo-zs by smearing quasars in redshift

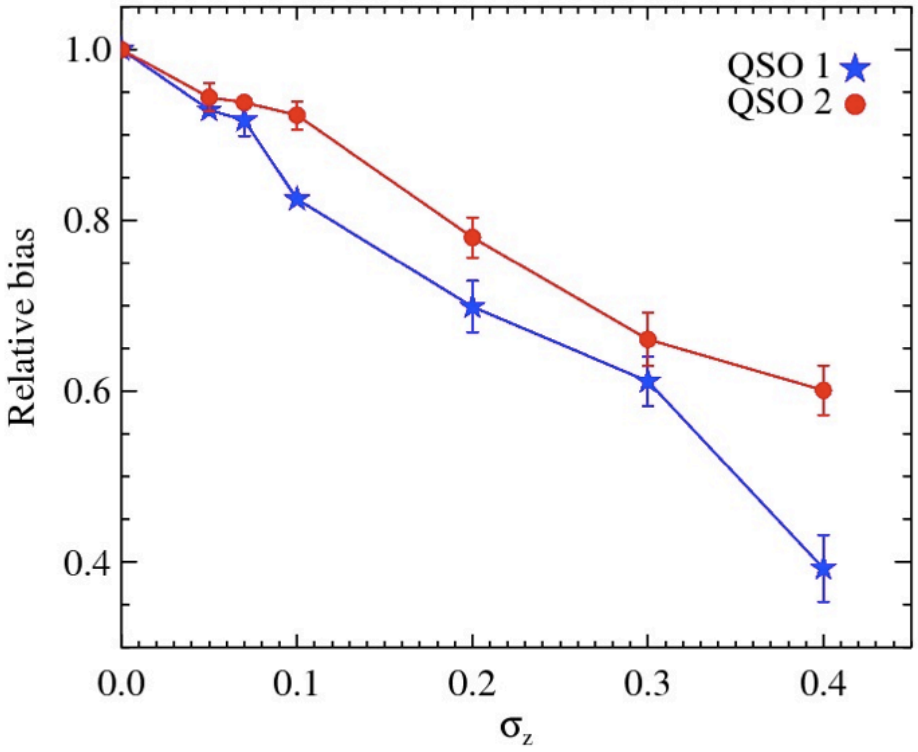


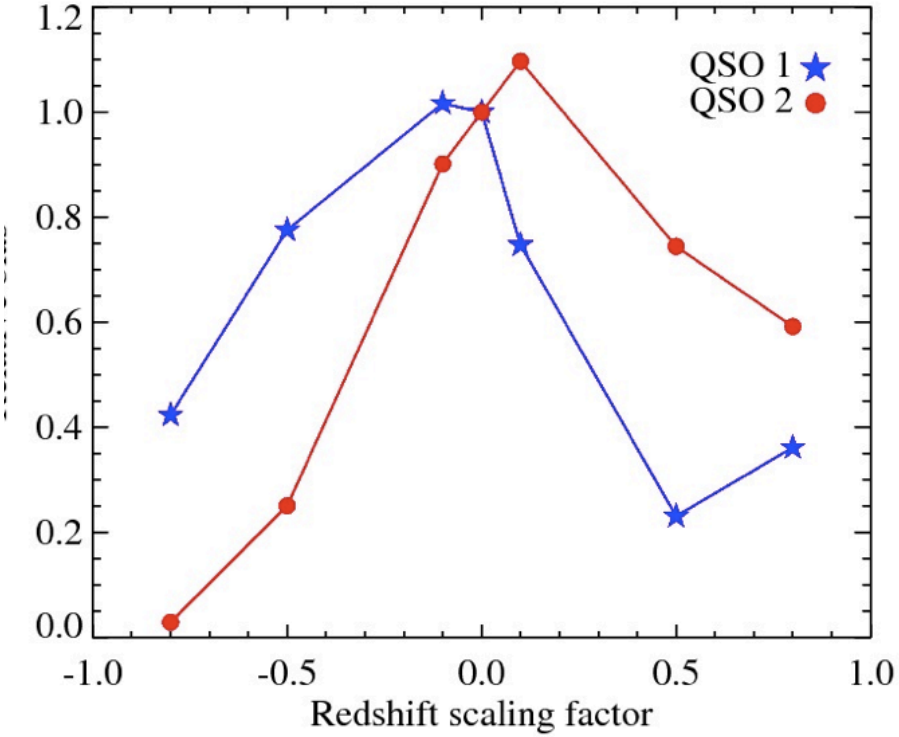
Check photo-zs by smearing quasars in redshift

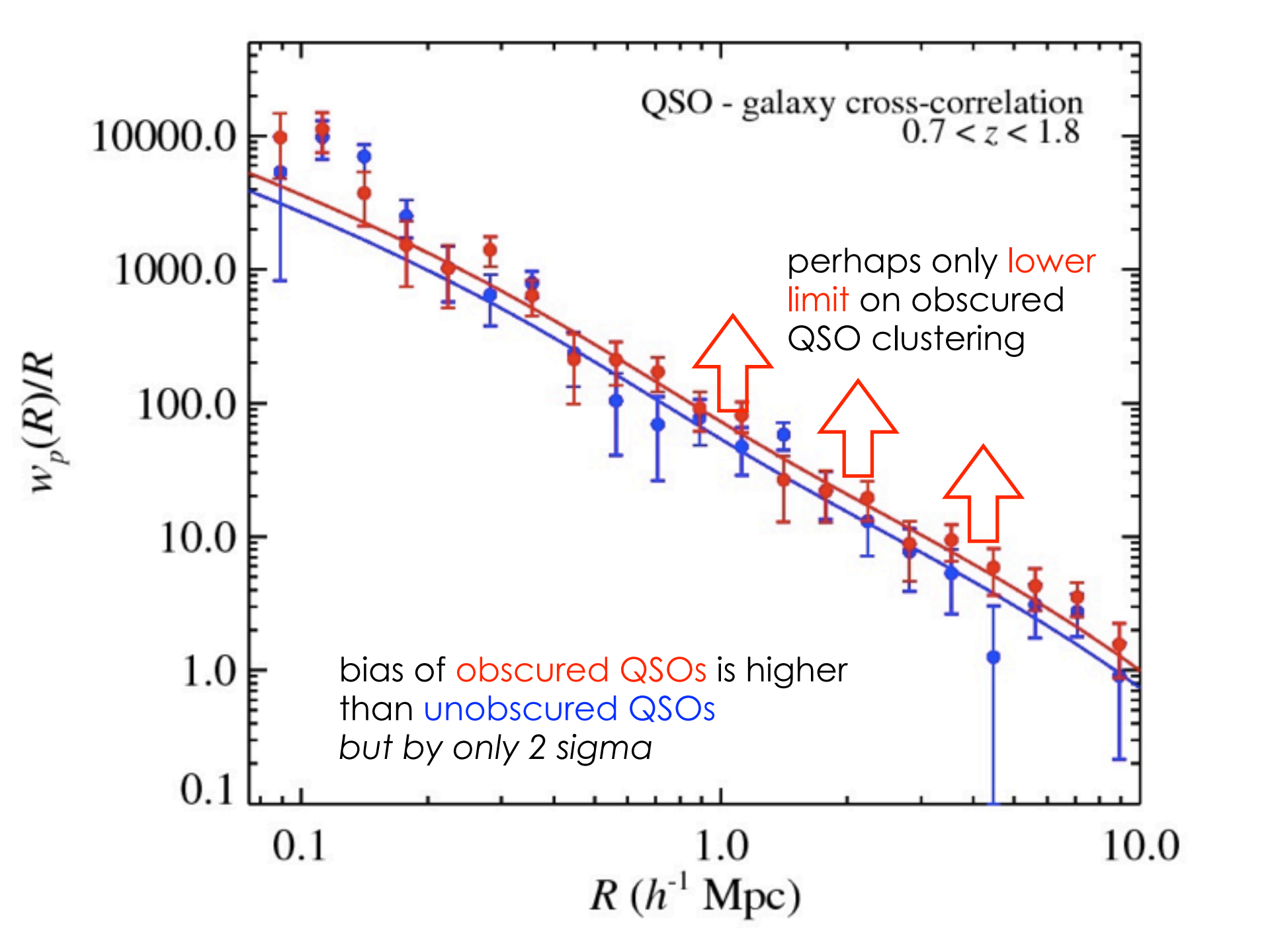


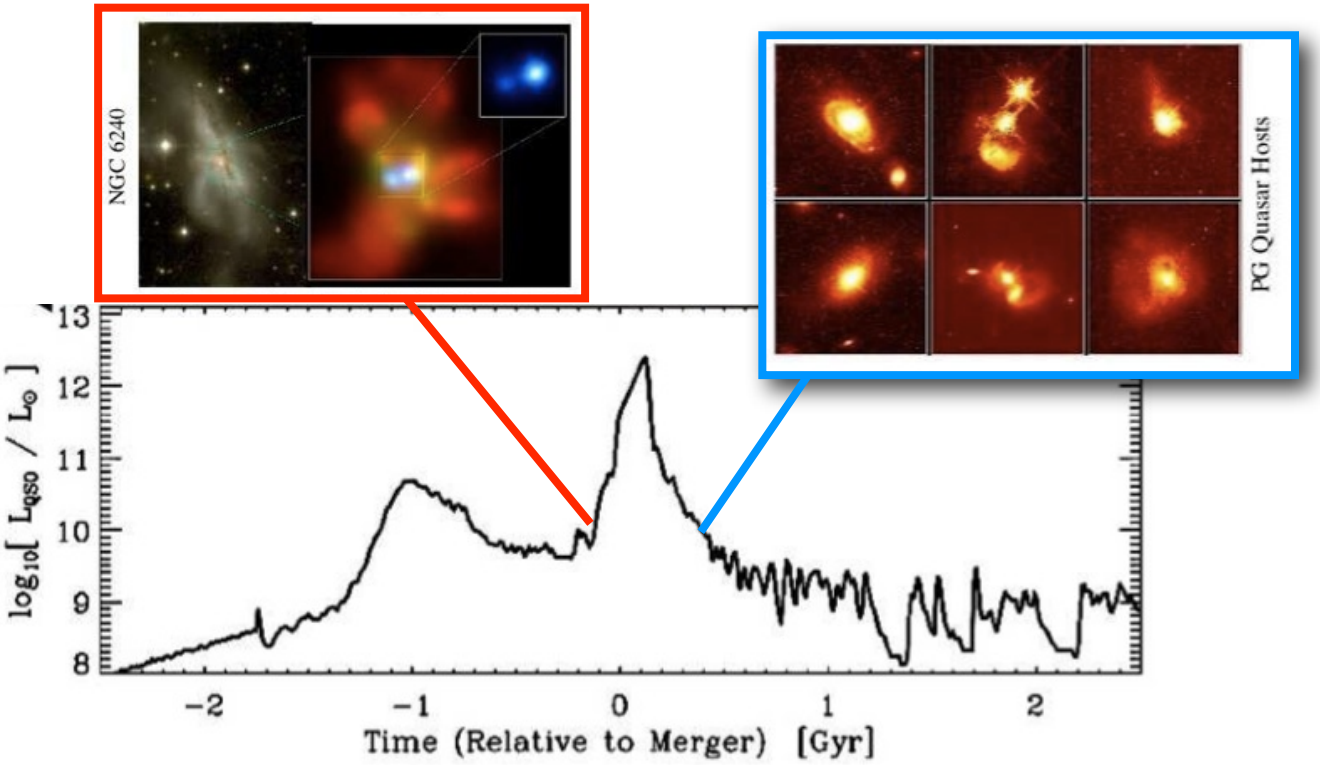

0.025
0.020
0.015
0.010
0.005
0.000
P(χ)
0
1000
2000
3000
4000
5000
χ (h-1 Mpc)


0.025
0.020
0.015
0.010
0.005
0.000
P(χ)
0
1000
2000
3000
4000
5000
χ (h-1 Mpc)


QSO 1
QSO 2
Relative bias
1.0
0.8
0.6
0.4
0.0
0.1
0.2
0.3
0.4
σz


QSO 1
QSO 2
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-1.0
-0.5
0.0
0.5
1.0
Redshift scaling factor


QSO - galaxy cross-correlation
0.7 < z < 1.8
perhaps only lower limit on obscured QSO clustering
bias of obscured QSOs is higher than unobscured QSOs
but by only 2 sigma
10000.0
1000.0
100.0
10.0
1.0
0.1
0.1
1.0
10.0
$w_p(R)/R$
R (h^{-1} Mpc)

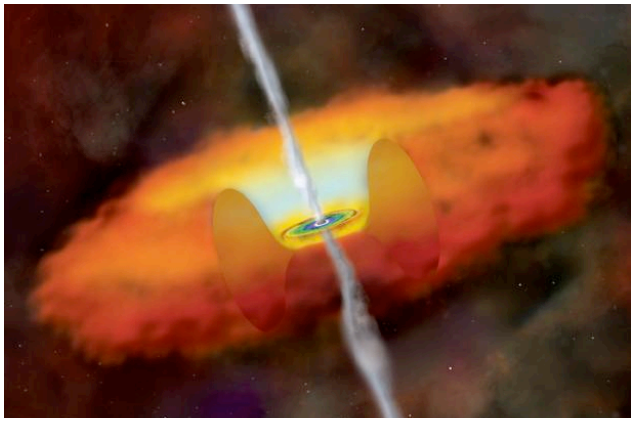


Black hole mass →

Hopkins et al. 2008

?

Accretion geometry / torus height depend on halo mass?

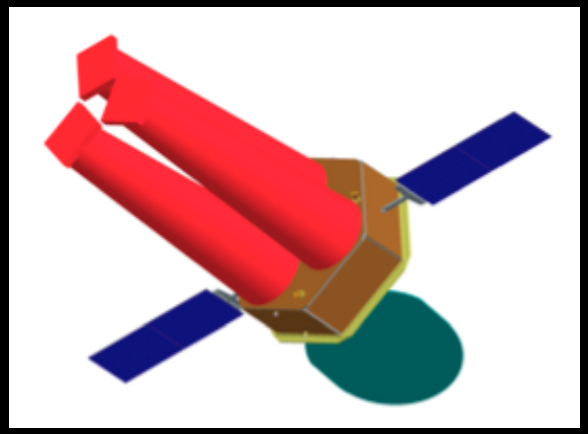


Summary

1. With Spitzer we obtain equivalent (large) samples of obscured and unobscured quasars at $z \gtrsim 1$.

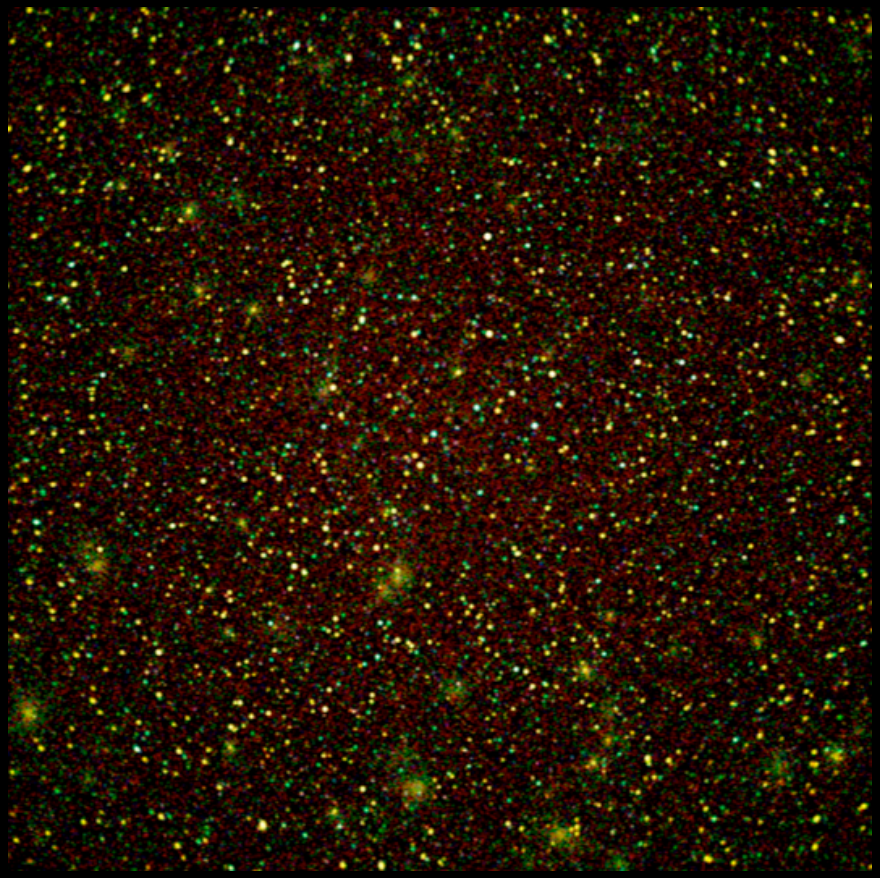
2. Obscured and unobscured quasars are found in similar large-scale environments, although there are hints of stronger clustering for obscured quasars.

Wide-Field X-ray Telescope (WFXT)



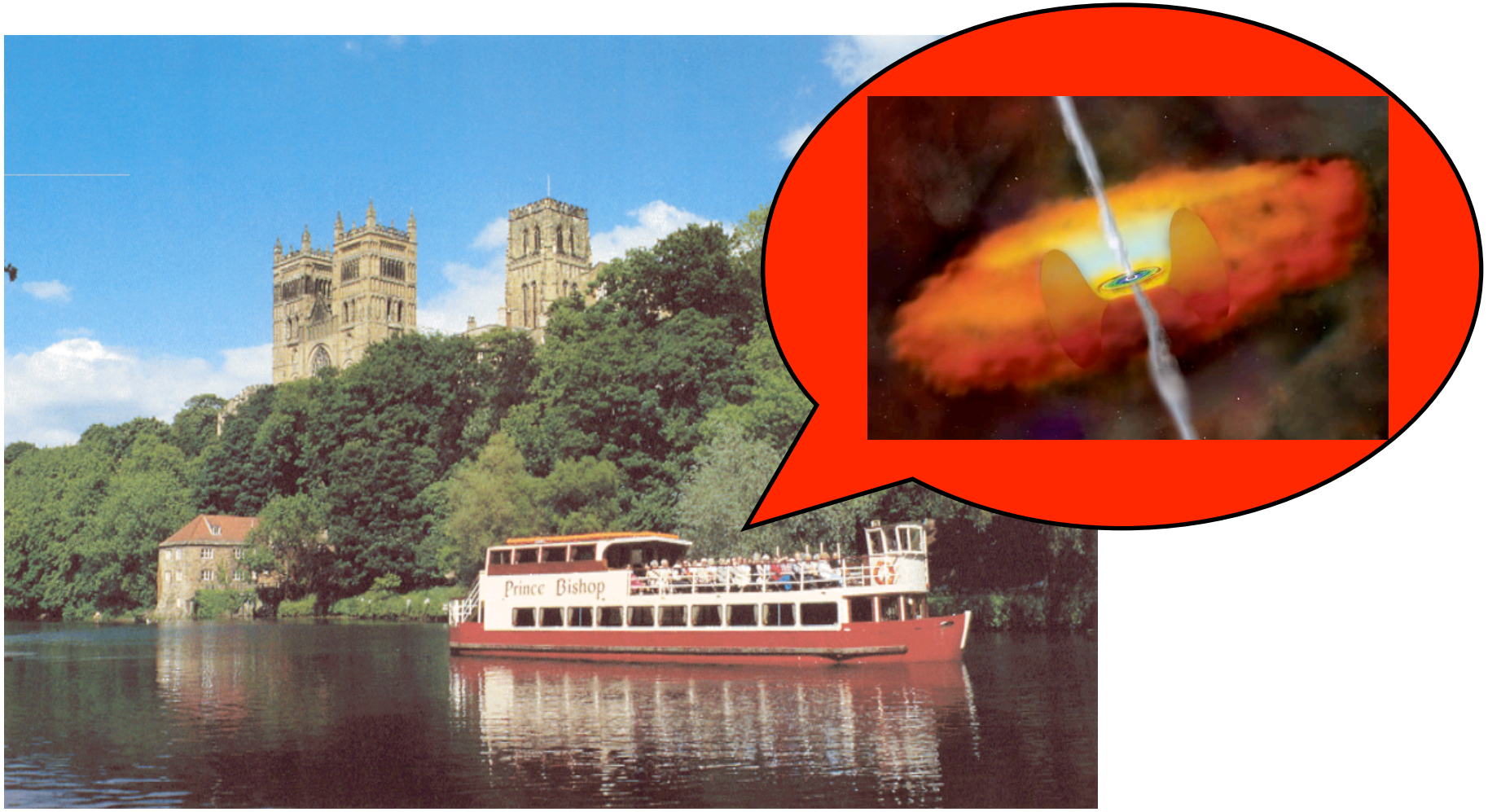
Large-area survey mission (0.1-6 keV)

Will detect and characterize **tens of millions of AGN**. Similar studies for AGN evolution as SDSS has enabled for galaxies.



Simulated 1 deg^2 WFXT image

http://wfxt.pha.jhu.edu


Prince Bishop