Obscured AGN in Clusters of Galaxies

Paul Martini

The Ohio State University

Collaborators

Carnegie:

    John Mulchaey

    Dan Kelson

    Alex Athey

Leiden:

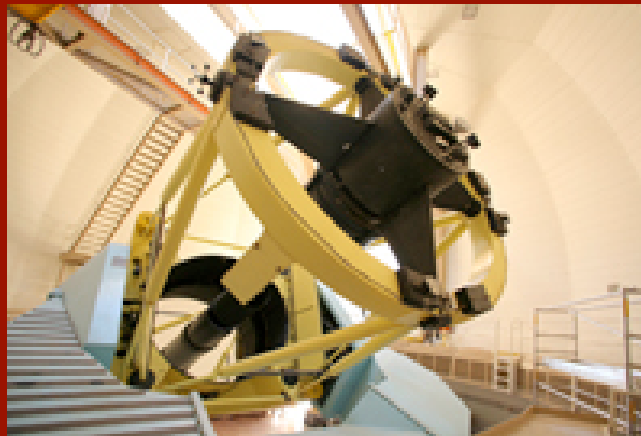   Kim-Vy Tran

The Ohio State University:

    Jason Eastman

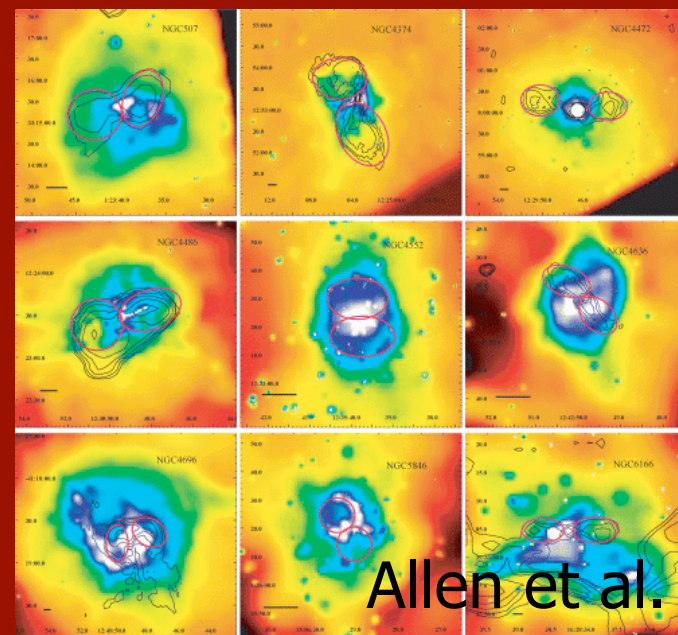   Greg Sivakoff

Harvard-Smithsonian CfA:

    Eunhyeuk Kim

Outline

High AGN fraction in clusters of galaxies
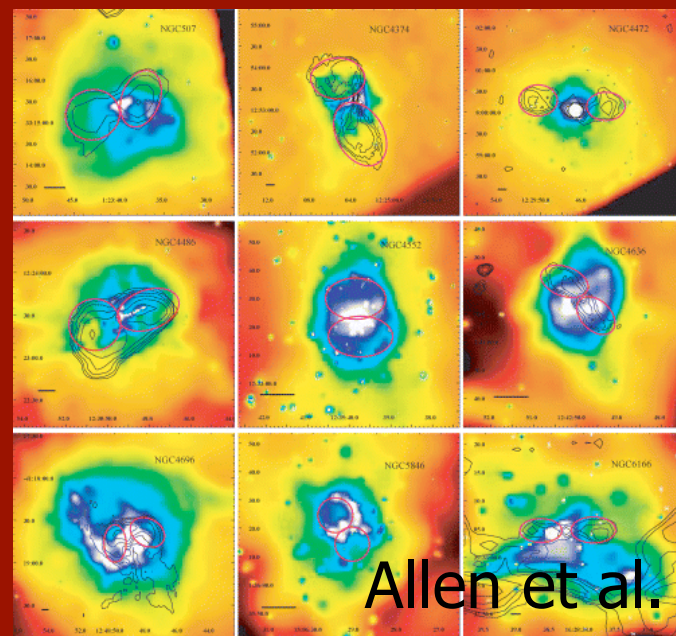
Increase in the cluster AGN fraction with redshift

Fabian et al.

Allen et al.

Outline

High AGN fraction in clusters of galaxies

Increase in the cluster AGN fraction with redshift
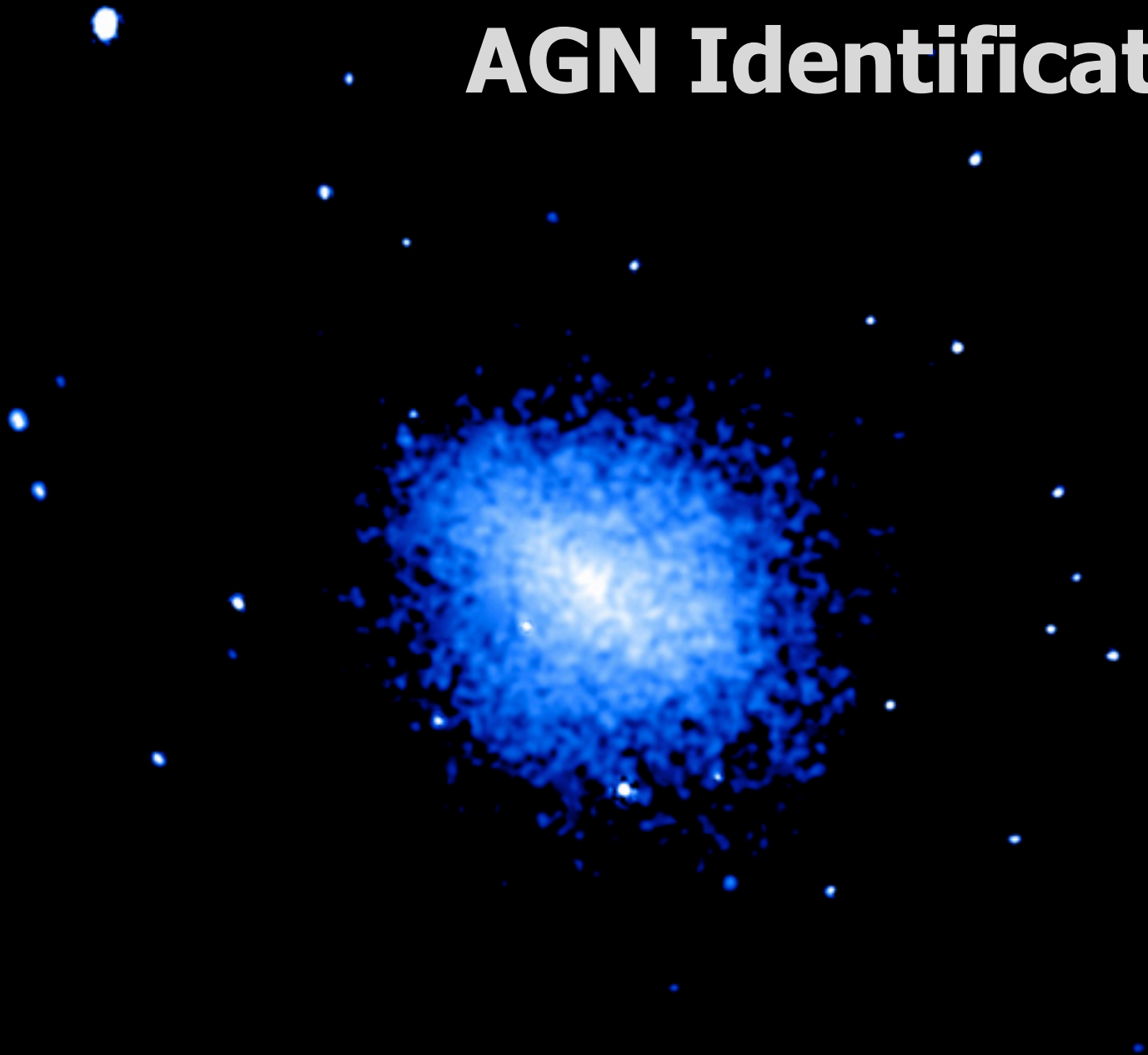

Fabian et al.

Motivations

AGN feedback on galaxy clusters and cluster galaxies
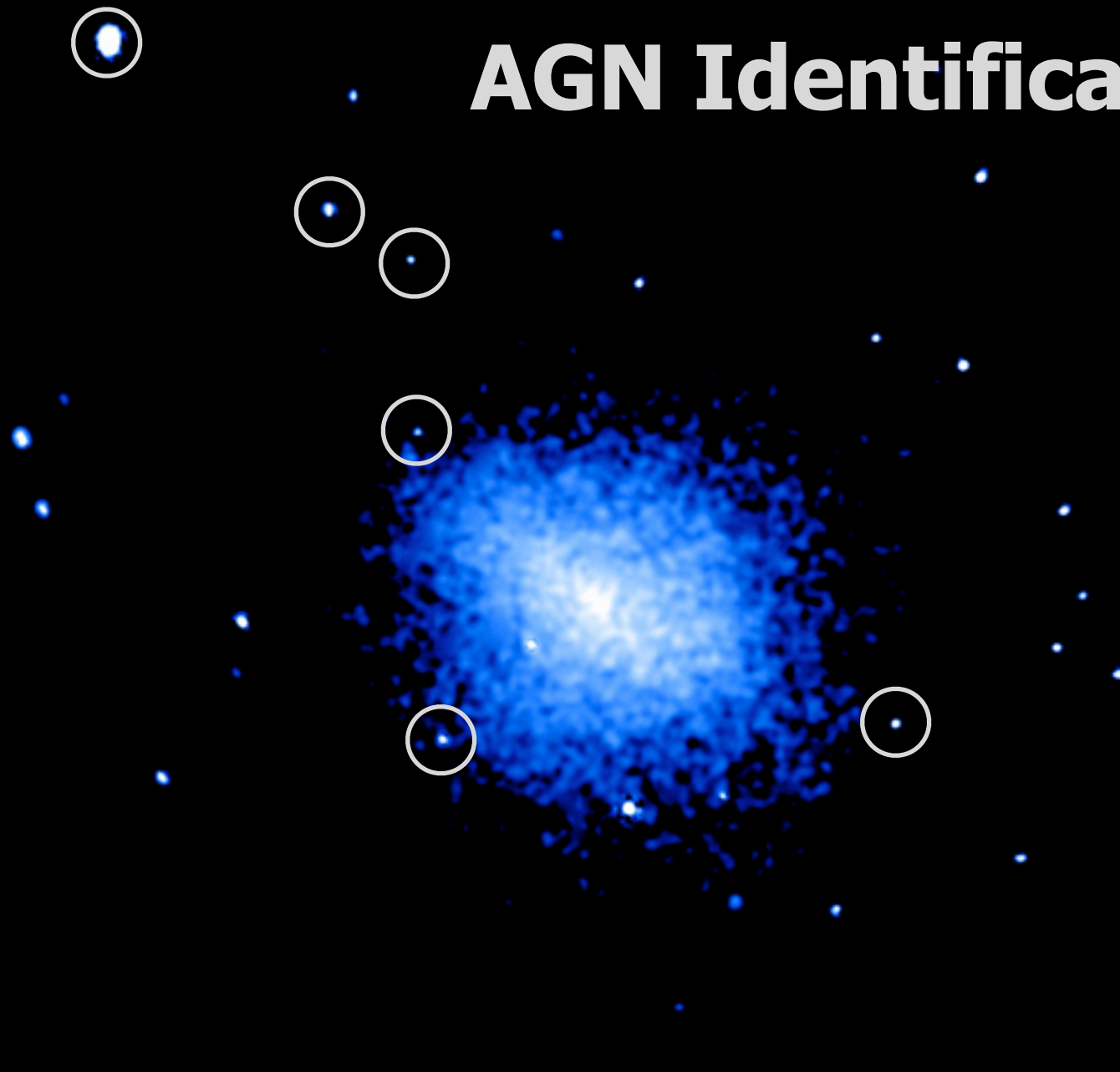
Do AGN preheat the intracluster medium?

Allen et al.

AGN Identification

Martini et al. (2002)

AGN Identification
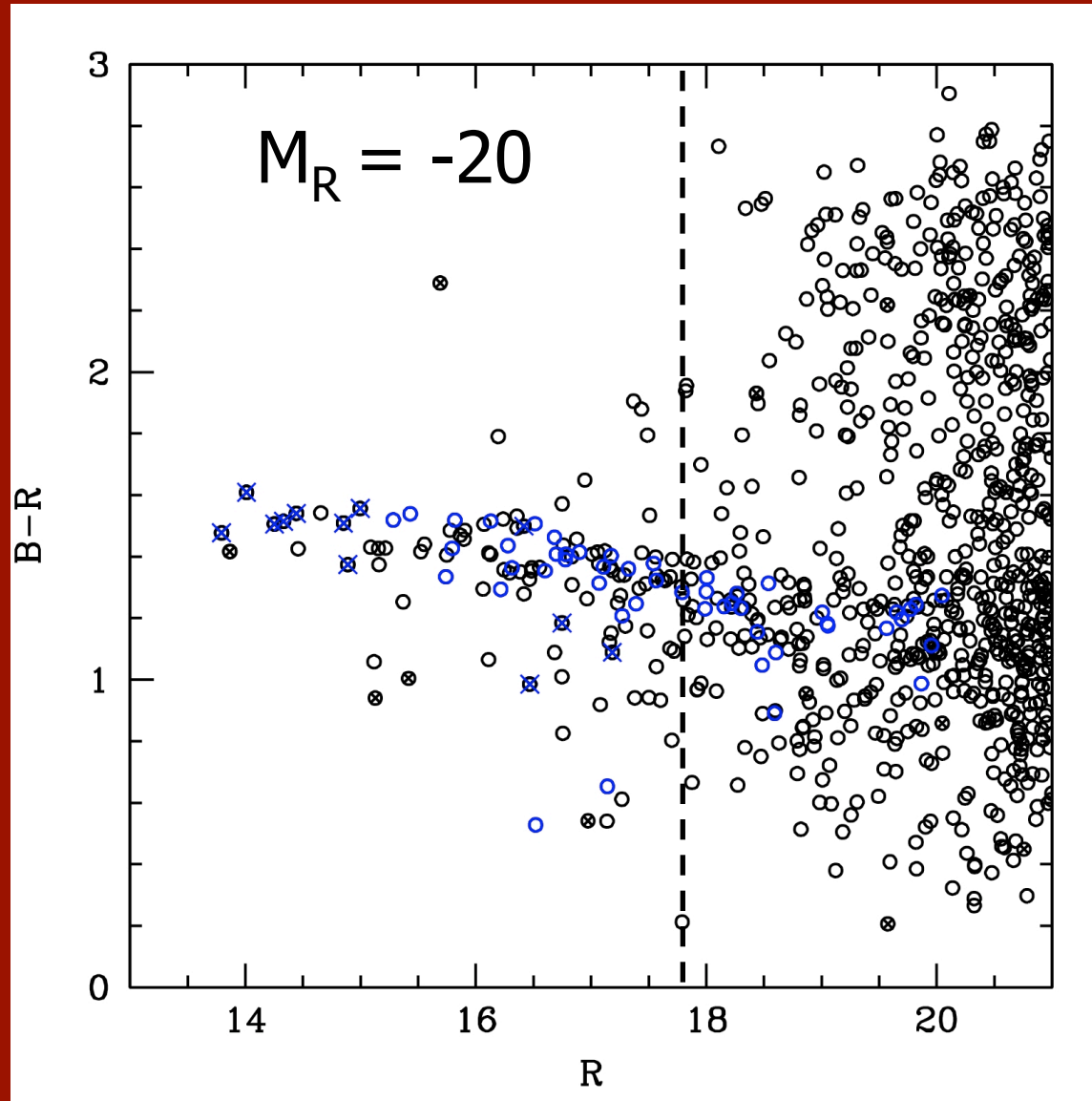
Abell 2104 X—ray Sources
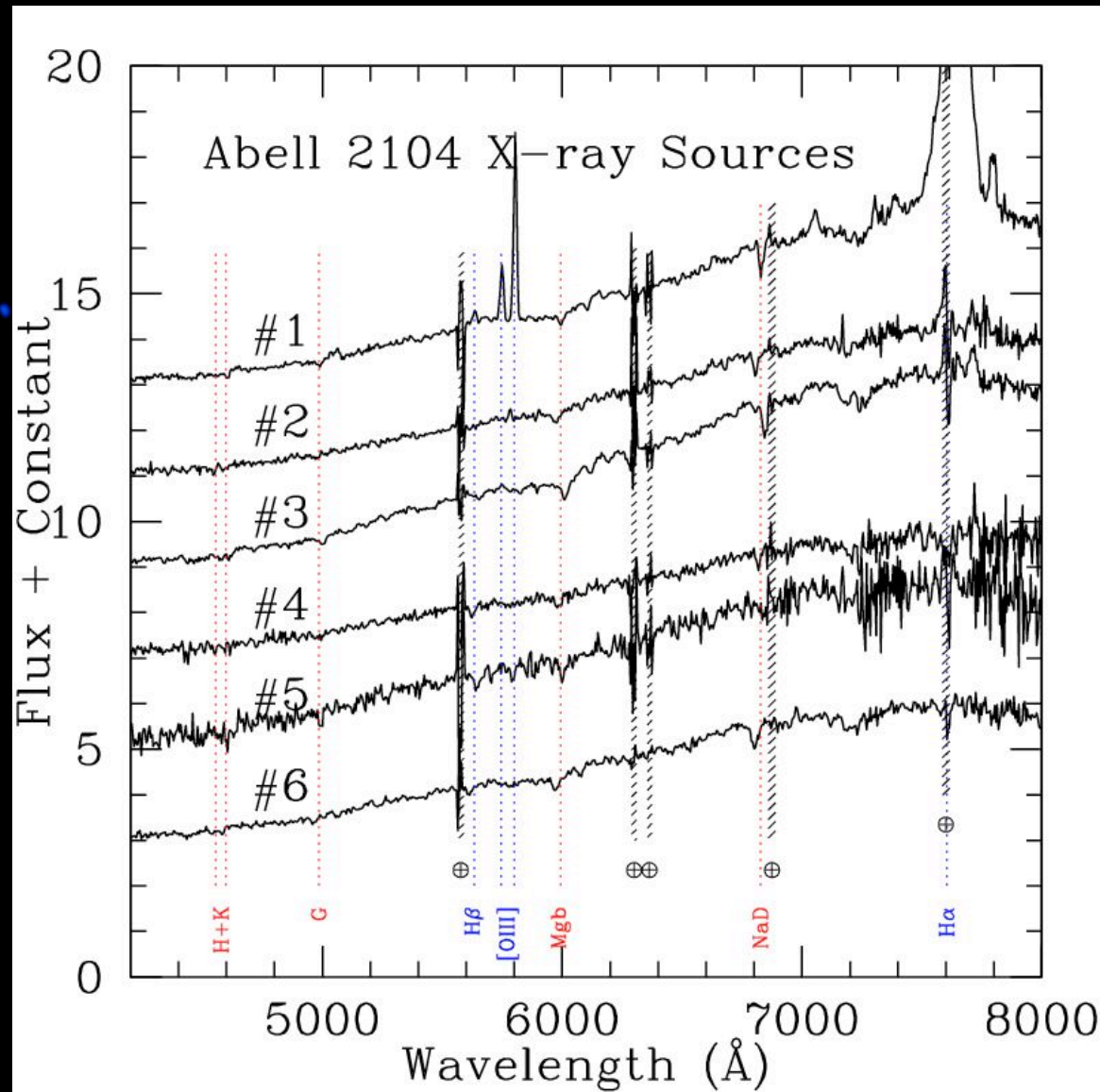
AGN Classification

40 X-ray sources in 8 clusters with 0.06 < z < 0.3
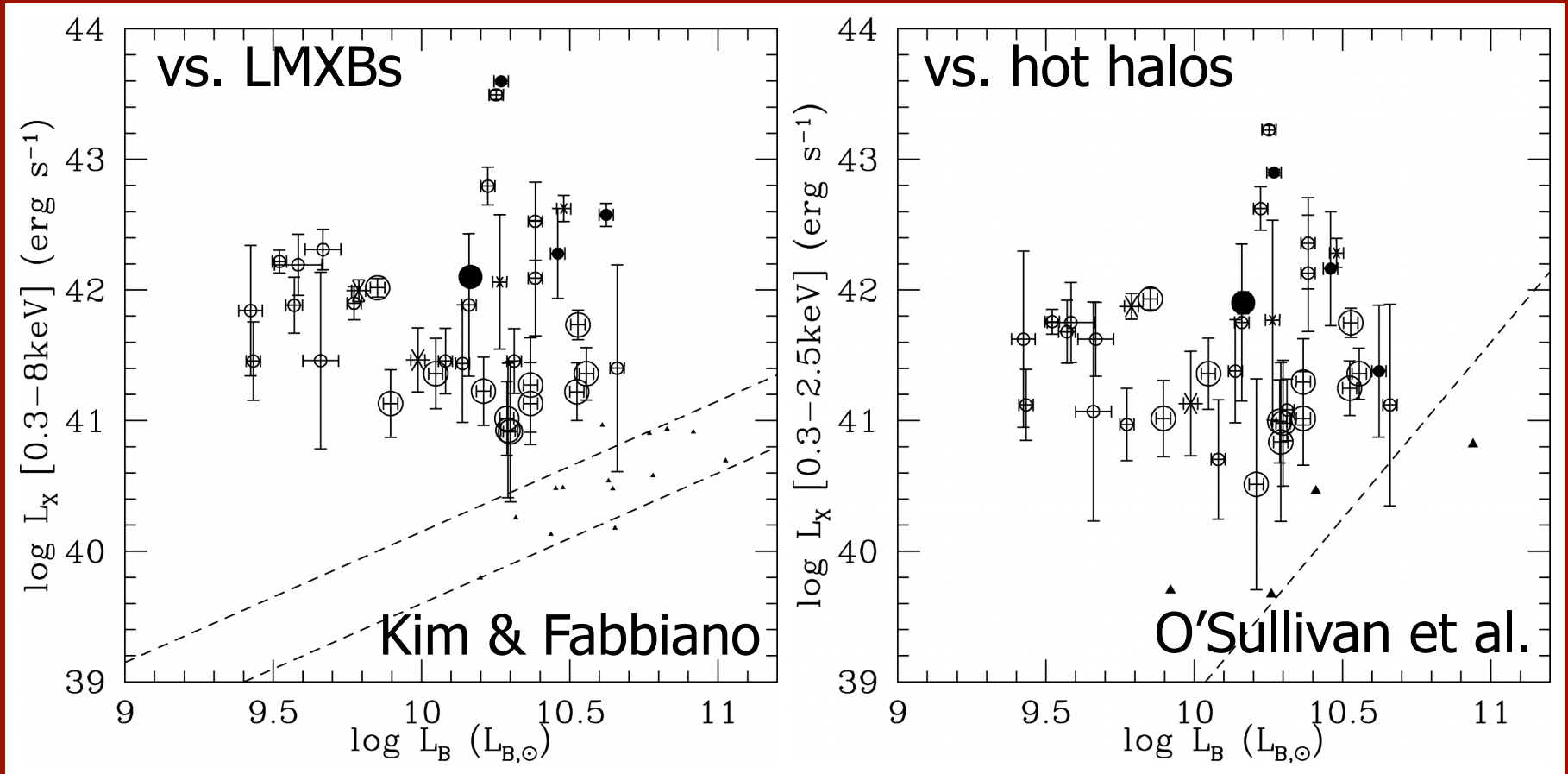
35 are classified as AGN
Only 4 show spectral signatures

Martini et al. (2006)

AGN Fraction Measurement

AGN Fraction Measurement

$$f_A = \frac{N_X (L > L_X;\ M_R < -20)}{N_{gal} (M_R < -20)}$$

AGN Fraction Measurement

$$f_A = \frac{N_X (L > L_X;\ M_R < -20)}{N_{gal} (M_R < -20)}$$

We have observed 8 clusters with $0.06 < z < 0.3$
In ~1400 cluster galaxies with $M_R < -20$:

35 have $L_X > 10^{41}$ for $f_A = 5\%$

1 has $L_{X,H} > 10^{43}$ for $f_A = 0.07\%$

Martini et al. (2007)

Cluster AGN Evolution

Cluster AGN Evolution

Comparison of 8 low redshift (z~0.2) and
4 high-redshift (z~0.6) clusters

Cluster AGN Evolution

Comparison of 8 low redshift (z~0.2) and
4 high-redshift (z~0.6) clusters
Low-z clusters have 1 AGN above $L_{X,H} > 10^{43}$
and 2 above $L_{X,H} > 10^{42}$ erg/s

Cluster AGN Evolution

Comparison of 8 low redshift (z~0.2) and 4 high-redshift (z~0.6) clusters

Low-z clusters have 1 AGN above $L_{X,H} > 10^{43}$ and 2 above $L_{X,H} > 10^{42}$ erg/s

High-z clusters have 8 AGN above $L_{X,H} > 10^{43}$ AGN and (three deepest) 7 $L_{X,H} > 10^{42}$ AGN

Cluster AGN Evolution

Comparison of 8 low redshift (z~0.2) and 4 high-redshift (z~0.6) clusters

Low-z clusters have 1 AGN above $L_{X,H} > 10^{43}$ and 2 above $L_{X,H} > 10^{42}$ erg/s

High-z clusters have 8 AGN above $L_{X,H} > 10^{43}$ AGN and (three deepest) 7 $L_{X,H} > 10^{42}$ AGN

Cluster AGN Evolution

Comparison of 8 low redshift (z~0.2) and 4 high-redshift (z~0.6) clusters

Low-z clusters have 1 AGN above $L_{X,H} > 10^{43}$ and 2 above $L_{X,H} > 10^{42}$ erg/s

High-z clusters have 8 AGN above $L_{X,H} > 10^{43}$ AGN and (three deepest) 7 $L_{X,H} > 10^{42}$ AGN

Note: High-redshift cluster data are only sensitive to $L_{X,H} >$ few x 10^{42} or 10^{43} erg/s

Cluster AGN Evolution

Comparison of 8 low redshift (z~0.2) and 4 high-redshift (z~0.6) clusters

Low-z clusters have 1 AGN above $L_{X,H} > 10^{43}$ and 2 above $L_{X,H} > 10^{42}$ erg/s

High-z clusters have 8 AGN above $L_{X,H} > 10^{43}$ AGN and (three deepest) 7 $L_{X,H} > 10^{42}$ AGN

Note: High-redshift cluster data are only sensitive to $L_{X,H} >$ few x 10^{42} or 10^{43} erg/s

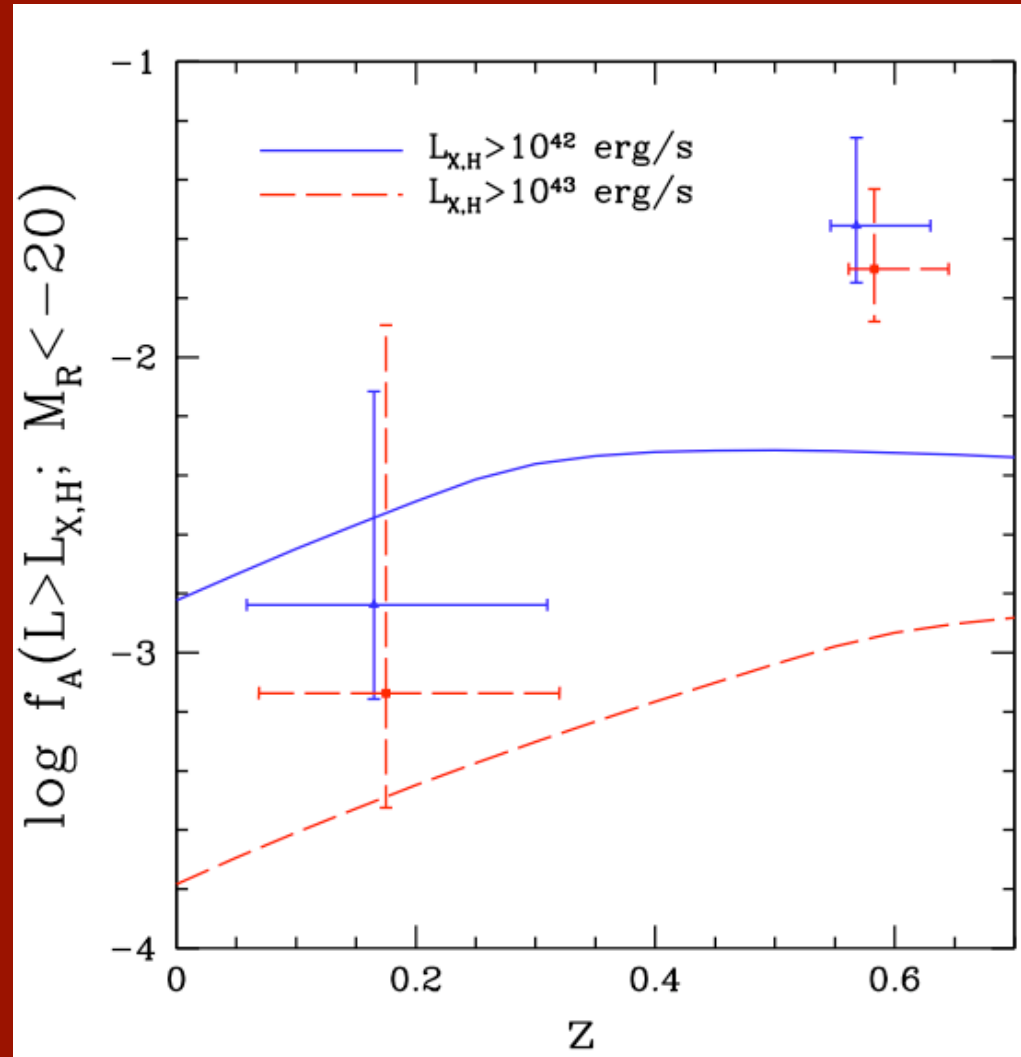Low-redshift data are about an order of magnitude more sensitive

An AGN Butcher-Oemler Effect
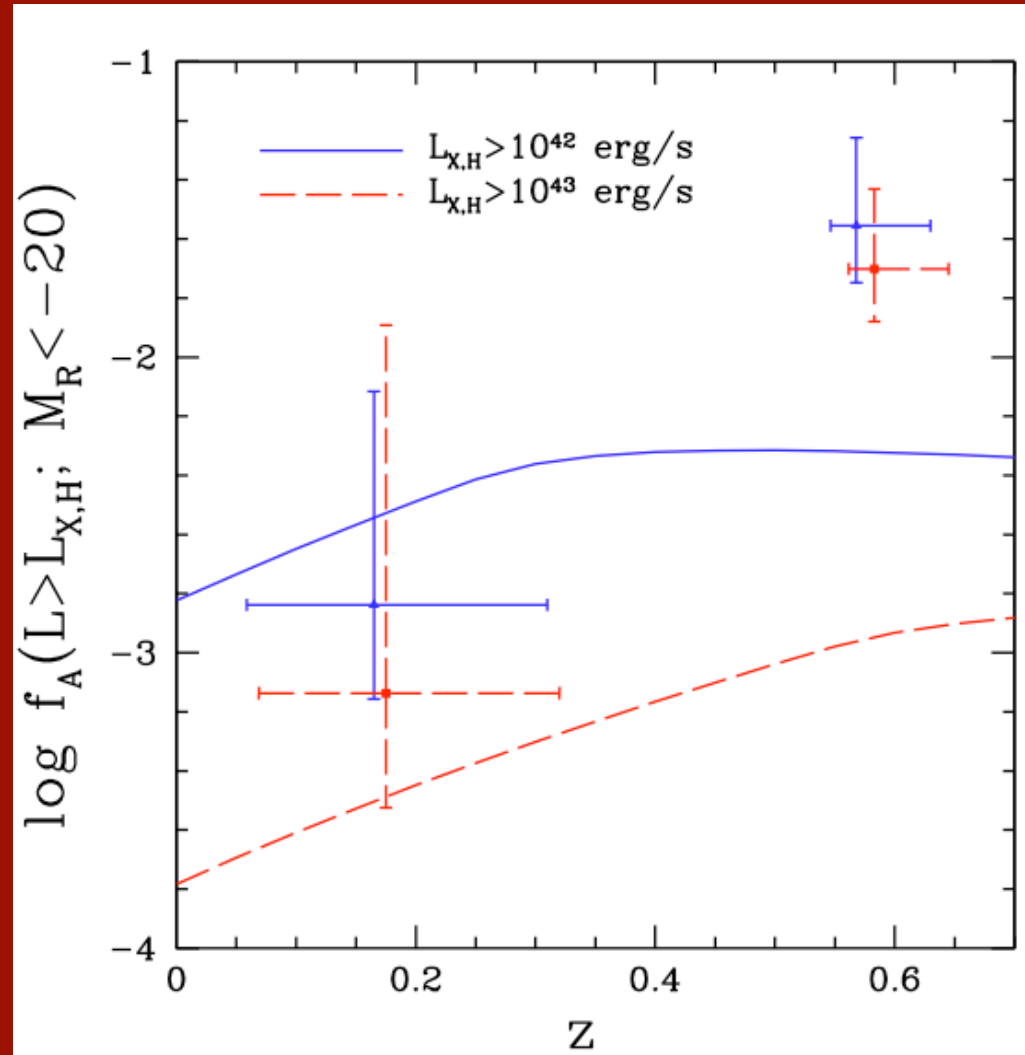
Eastman, Martini, et al. (2007) - see today's astro-ph

An AGN Butcher-Oemler Effect

Factor of ~20x
    increase in the
    cluster AGN fraction

Eastman, Martini, et al. (2007) - see today's astro-ph

An AGN Butcher-Oemler Effect

Factor of ~20x increase in the cluster AGN fraction
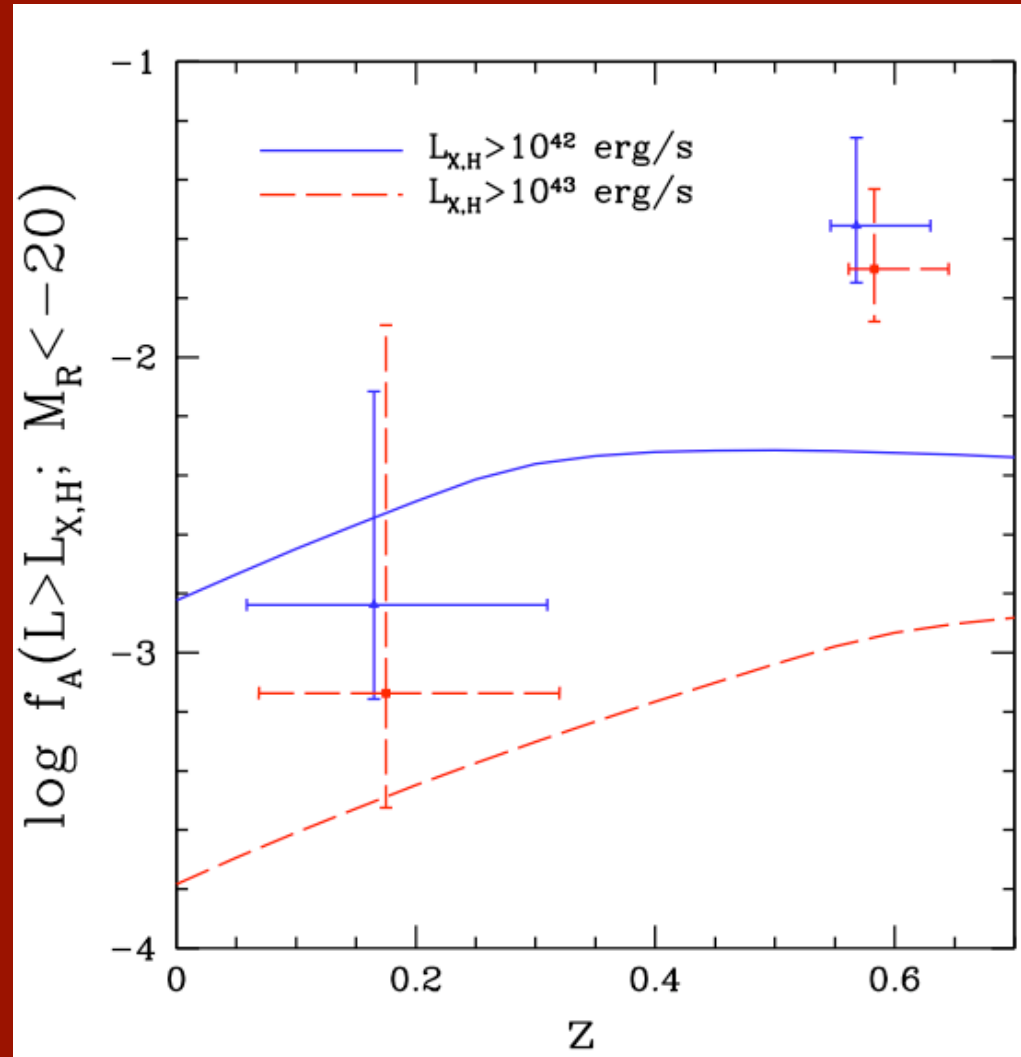
Evidence for an AGN Butcher-Oemler Effect

Eastman, Martini, et al. (2007) - see today's astro-ph

An AGN Butcher-Oemler Effect

Factor of ~20x increase in the cluster AGN fraction

Evidence for an AGN Butcher-Oemler Effect

More pronounced than the field evolution from Ueda et al.
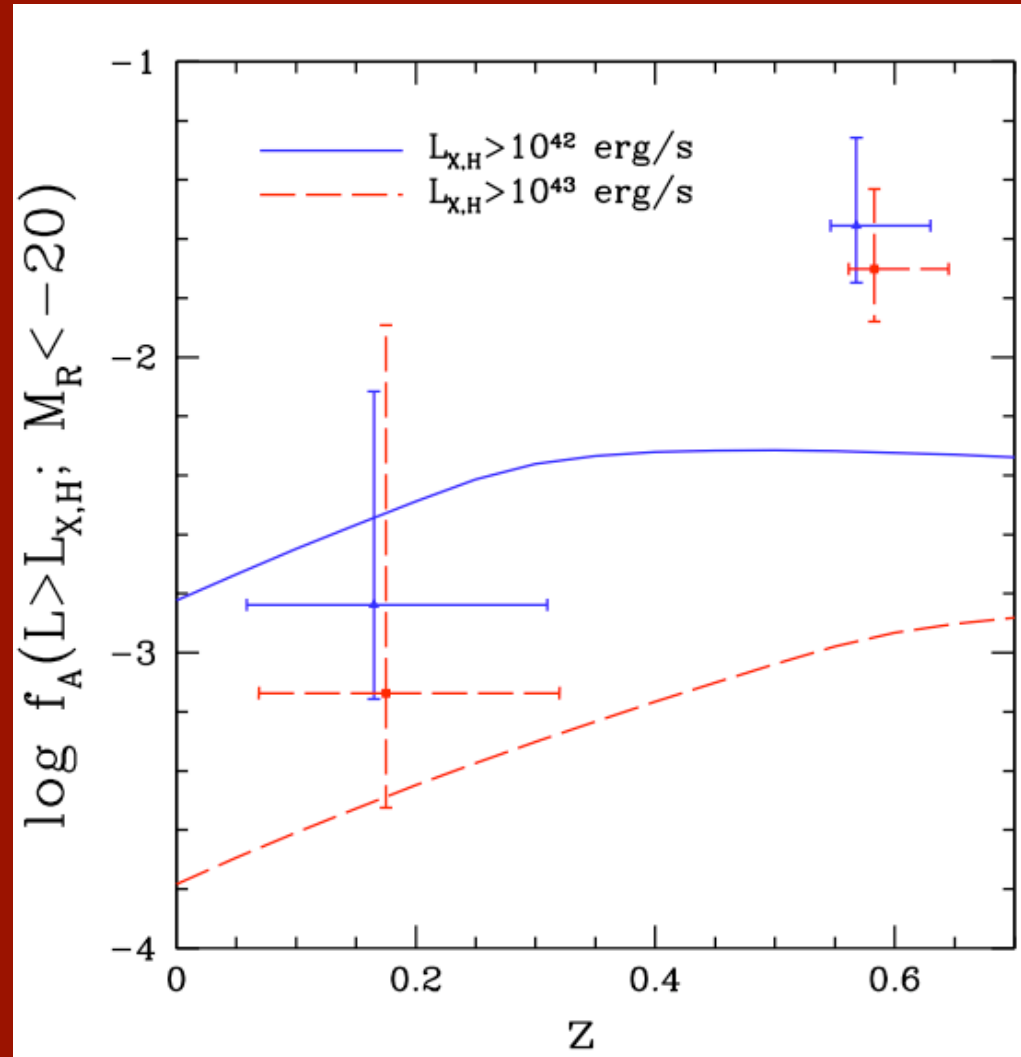

Eastman, Martini, et al. (2007) - see today's astro-ph

An AGN Butcher-Oemler Effect

Factor of ~20x increase in the cluster AGN fraction

Evidence for an AGN Butcher-Oemler Effect

More pronounced than the field evolution from Ueda et al.

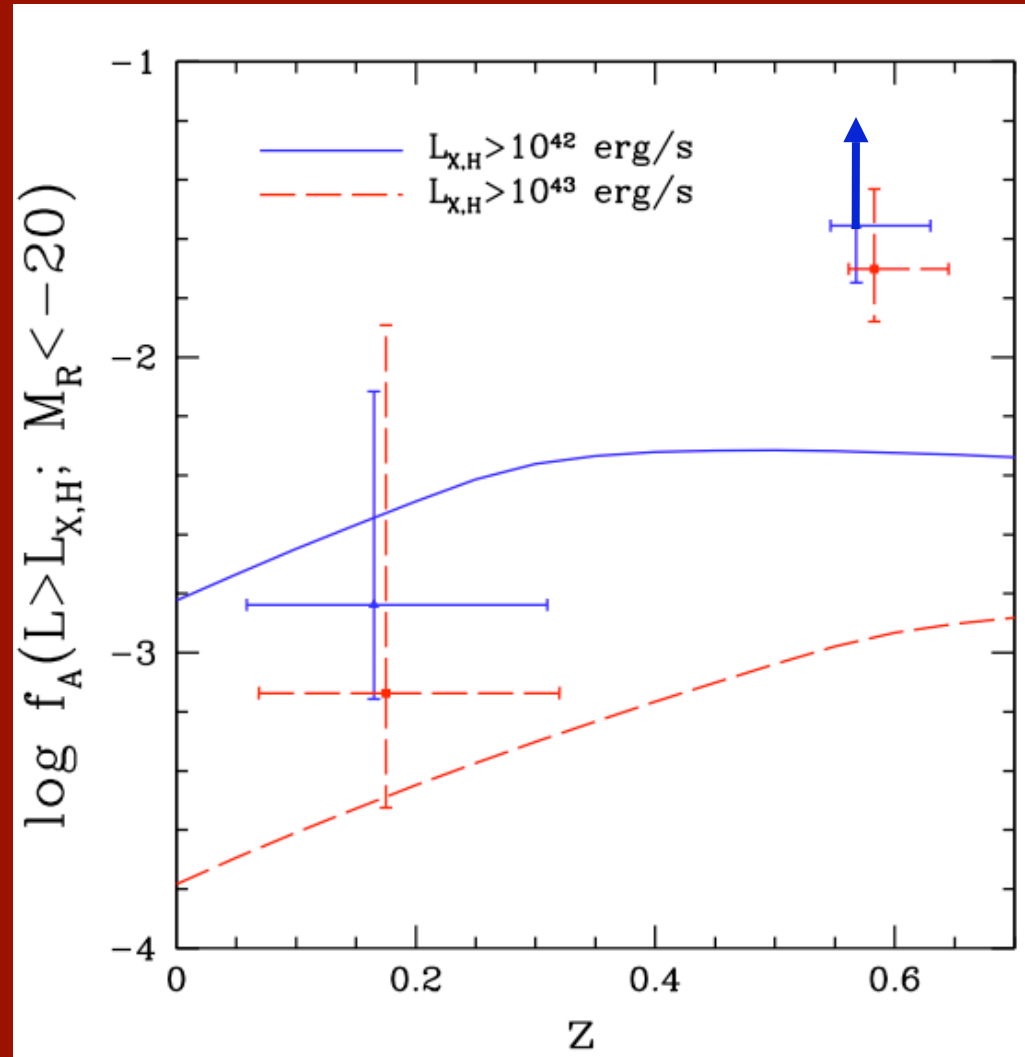Due to systematics, this is likely an underestimate

Eastman, Martini, et al. (2007) - see today's astro-ph

Summary

More cluster AGN than expected

- Few show visible-wavelength signatures
- Intrinsically weak or obscured?

Evidence for an AGN Butcher-Oemler Effect

- Higher cluster AGN fraction at high z
- More rapid increase than field AGN

Summary

More cluster AGN than expected

- Few show visible-wavelength signatures
- Intrinsically weak or obscured? YES

Evidence for an AGN Butcher-Oemler Effect

- Higher cluster AGN fraction at high z
- More rapid increase than field AGN