Eddington Ratio Distribution of X-ray selected Broad-line AGNs at 1.0<z<2.2

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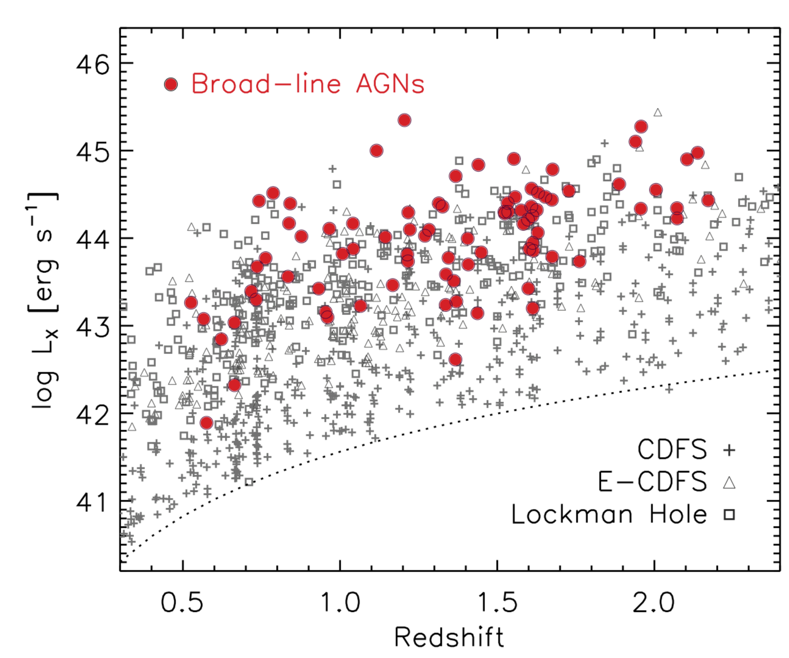
ABSTRACT

We investigate the Eddington ratio distribution of X-ray selected broad-line AGNs in the redshift range 1.0<z<2.2, where the number density of AGNs peaks. Combining the optical and Subaru/FMOS NIR spectroscopy, we estimate black hole masses for broad-line AGNs in the *Chandra* Deep Field-South (CDF-S), Extended *Chandra* Deep Field-South (E-CDF-S), and the *XMM-Newton* Lockman Hole (XMM-LH) surveys. AGNs with similar black hole masses show a broad range of AGN bolometric luminosities, indicating that the accretion rate of black holes is widely distributed. We find that a substantial fraction of massive black holes accreting significantly below the Eddington limit at z < 2, in contrast to what is generally found for luminous AGNs at high redshift. Our analysis of observational selection biases indicates that the "AGN cosmic downsizing" phenomenon can be simply explained by the strong evolution of the co-moving number density at the bright end of the AGN luminosity function, together with the corresponding selection effects, but it might need to consider a correlation between the AGN luminosity and the accretion rate of black holes in order to understand low-luminosity AGNs with low accretion rates. Therefore, the observed downsizing trend can be interpreted as massive black holes with low accretion rates, which are relatively fainter than less massive black holes with efficient accretion.

AGN Sample

We select a sample of AGNs based on X-ray observations in the *Chandra* Deep Field-South (CDF-S), Extended CDF-S (E-CDF-S), and *XMM-Newton* Lockman Hole (XMM-LH) fields. We utilize public X-ray point source catalogs for these 3 X-ray surveys.



1. 4Ms CDF-S (Xue et al. 2011)
2. E-CDF-S (Lehmer et al. 2005; Silverman et al. 2010)
3. XMM-LH (Brunner et al. 2008; Fotopoulou et al. 2012)

Figure shows the absorption-corrected 0.5-8 keV X-ray luminosity versus spectroscopic or photometric redshift from the X-ray surveys.

Subaru/FMOS NIR Spectroscopic Observations

We performed near-infrared (NIR) spectroscopic observations for the AGN sources with the FMOS high-resolution spectrographs on the Subaru telescope.

+ Mar 25-26, 2012 (J-long, H-long)
+ Dec 29-30, 2012 (H-short, H-long)
+ Feb 23-24, 2013 (H-short)
+ Oct 23-24, 2013 (H-short, H-long)

The primary targets are
+ X-ray selected AGNs in the CDF-S, E-CDF-S, and XMM-LH fields
+ Either spectroscopic or photometric redshifts in the range 1.0<z<2.2

Black hole mass Estimation

We measure the properties of broad emission lines present in optical and NIR spectra to derive single-epoch virial black hole mass of broad-line AGNs. We perform a fit to the emission lines with the combination of
+ a power-law continuum ($f_\lambda \propto \lambda^{-\alpha}$)
+ narrow line components (Hα, Hβ)
+ broad line components
+ FeII emission components (MgII)

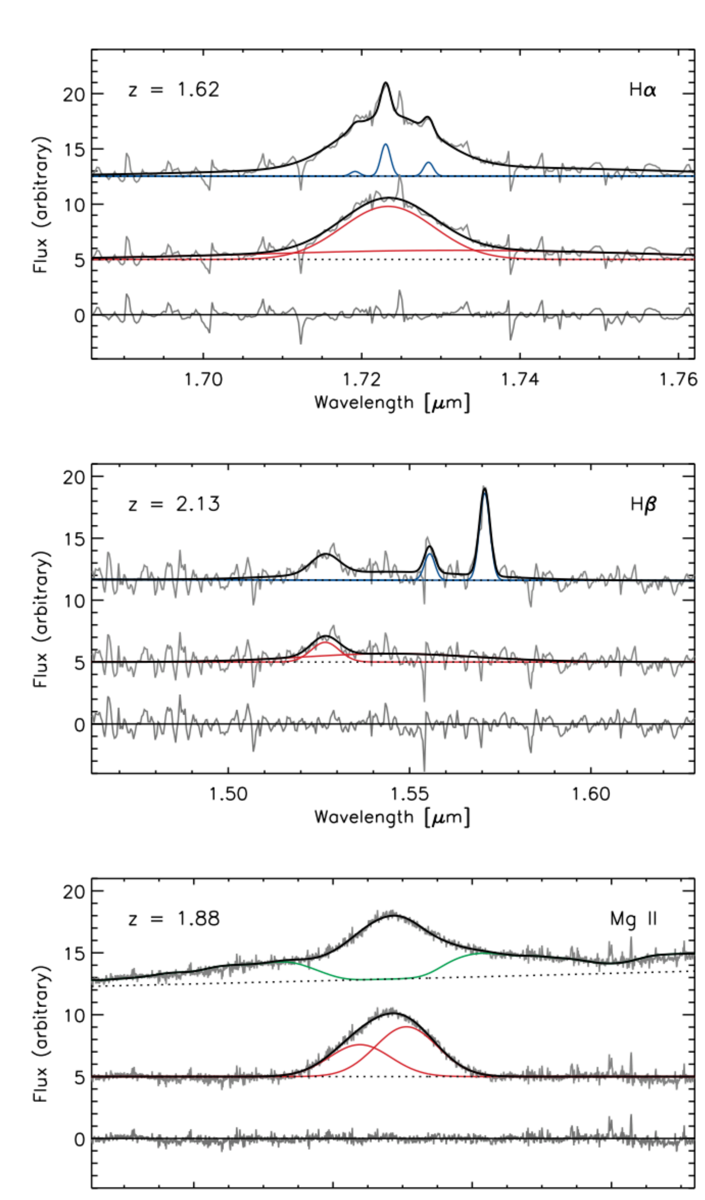


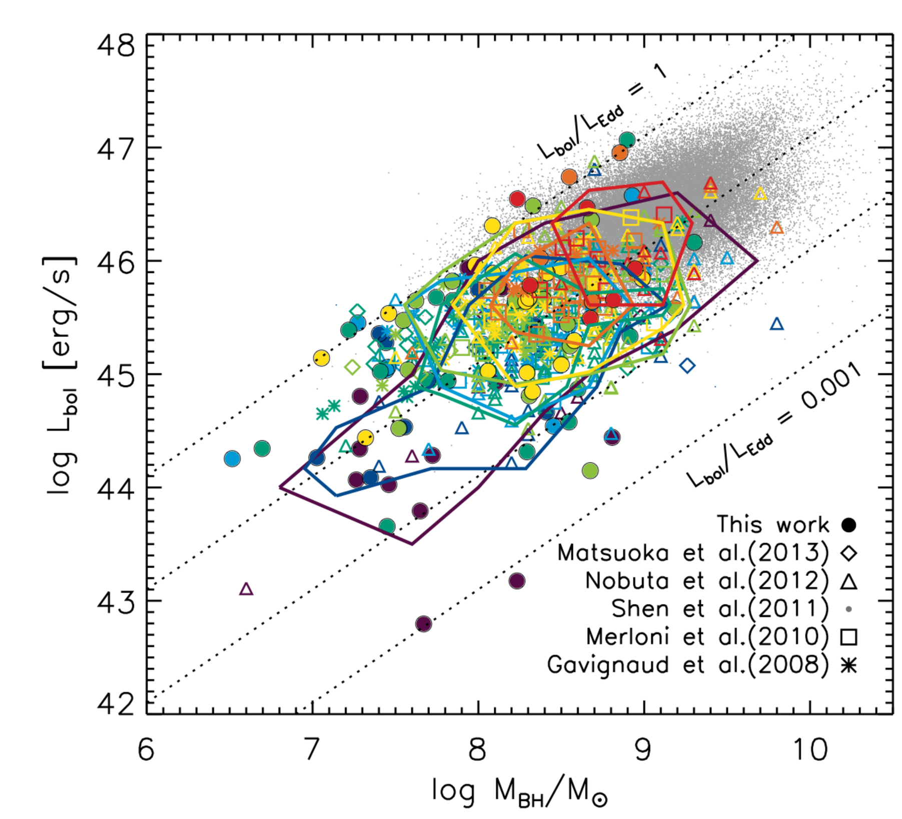
Figure shows examples of broad-line fits for Hα, Hβ, and MgII emission lines at z=1.62, 2.13, and 1.88, respectively.

We calculate black hole masses from the FWHM and the luminosity of the sum of the broad line components.

1. Hα and Hβ (Greene & Ho 2005)
2. MgII (McLure & Dunlop 2004)

Eddington ratio Distribution

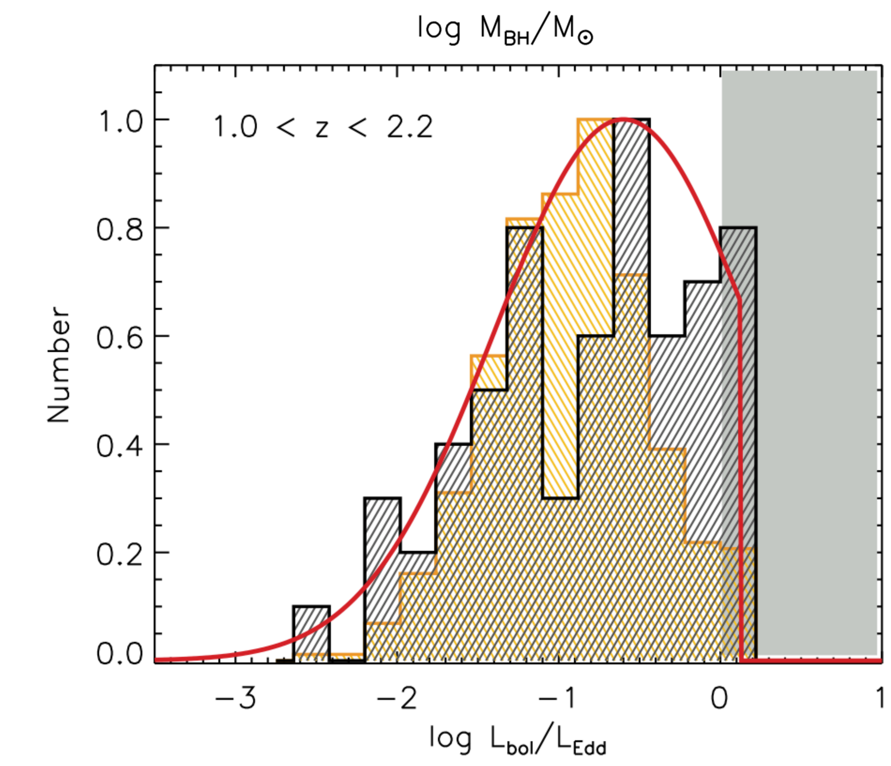
We show AGN bolometric luminosity versus black hole mass for our sample of broad-line AGNs, together with published observations in the different redshift bins.



+ AGNs with similar black hole masses show a broad range of bolometric luminosities, indicating that **the accretion rate of black holes is widely distributed.**

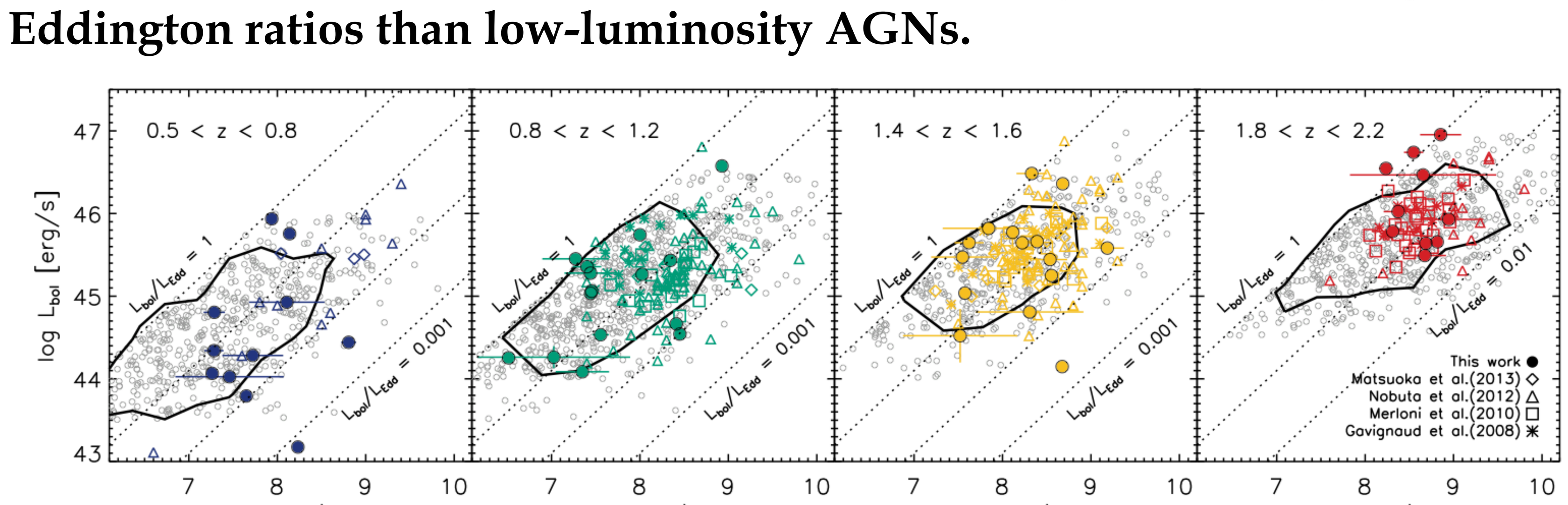
+ The distribution of Eddington ratios peaks at log L_{bol}/L_{edd}~ -1 with an extended tail towards low Eddington ratios, down to -3. Black and yellow histograms represent our sample of AGNs and that with the published observations from the literature, respectively.

+ A log-normal fit with a peak of -0.6 and a dispersion of 0.8 dex.



Analysis of Selection Biases

We construct Monte Carlo simulations to make artificial datasets, which are affected by the same selection effects. Figure shows the comparison of the simulated data sets (grey) with the observed AGNs (color) for each redshift bin.
+ For low-luminosity AGNs with high Eddington ratios, the simulations systematically predict a larger number of objects, than those observed.
+ There might be a dependence of AGN luminosities on the Eddington ratios in the sense that **luminous AGNs appear to have systematically higher Eddington ratios than low-luminosity AGNs.**



Summary

We present the Eddington ratio distribution of X-ray selected broad-line AGNs in the CDF-S, E-CDF-S, and the XMM-LH surveys. Our sample of broad-line AGNs spans the bolometric luminosity range $L_{bol} \sim 10^{43.5\text{-}47}$ erg/s, and the black hole mass range $M_{BH} \sim 10^{6.5\text{-}9.5}$ $M_\odot$ with a broad range of Eddington ratio L_{bol}/L_{Edd}~0.001-1.