The Suzaku view of highly-ionised outflows in AGN

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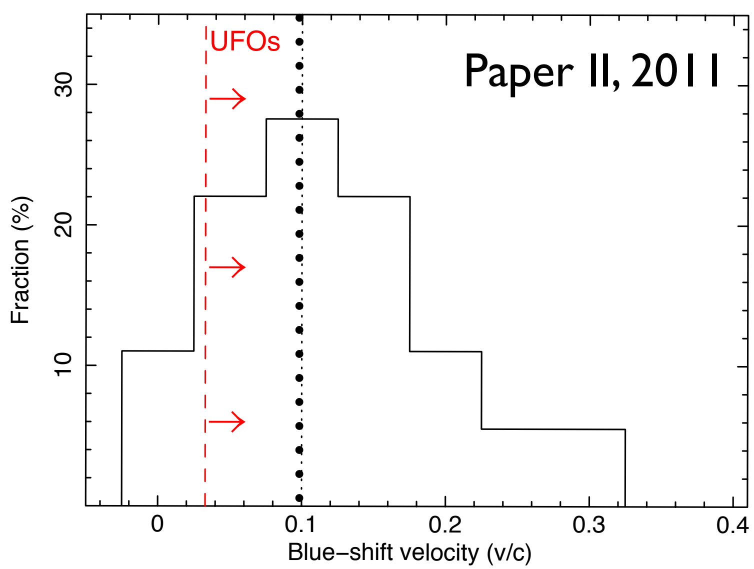
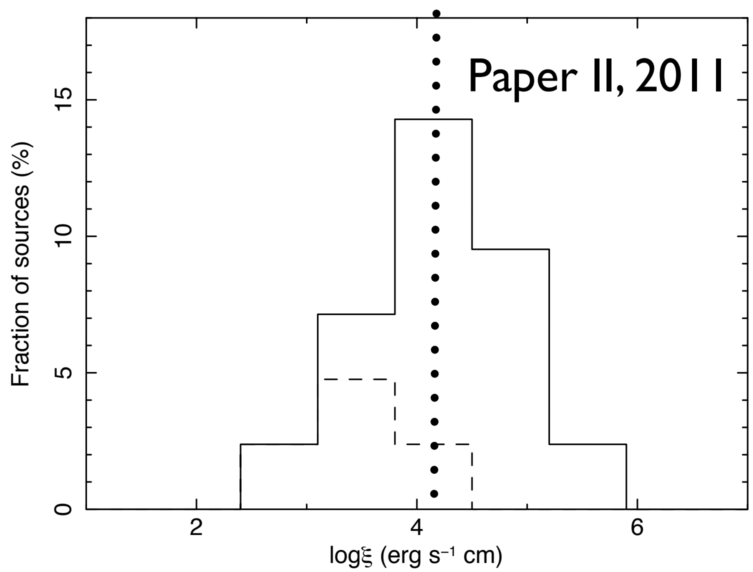
XMM Sample - Recap

- Previous study with XMM found ~40% of local (z<0.1) AGN have blue-shifted narrow Fe K absorption (Tombesi et al. 2010, 2011)
- Absorbers distributed over a range of parameters (N_H, logξ, V_{out}) but peak parameters: N_H~10^{23} cm^{-2}, logξ~4.0, V_{out}~0.1c





The *Suzaku* Sample:

- Consists of all available pointed AGN spectra in *Suzaku* archive which:
  - ❖ Have **total** net exposures >50ks
  - ❖ Not Blazars/BL Lac
  - ❖ Not Compton Thick TypeII (i.e. $N_H < 10^{24}$ cm^{-2})
  - ❖ Minimum 2-10 keV counts >10k

- All spectra parameterised utilising the ***full 0.6-50.0 keV Suzaku bandpass***:
  - ❖ S.C. modelling of Reflection/FeKa with reflionx (ξ~1)
  - ❖ Soft X-ray warm absorption modelled with XSTAR.
  - ❖ Soft-excess fit with *bbody* as necessary

- Sample is growing: observations added as they become public.

- Currently: 59 spectra of 45 objects fit and tested for Fe K absorp.

The *Suzaku* Sample:

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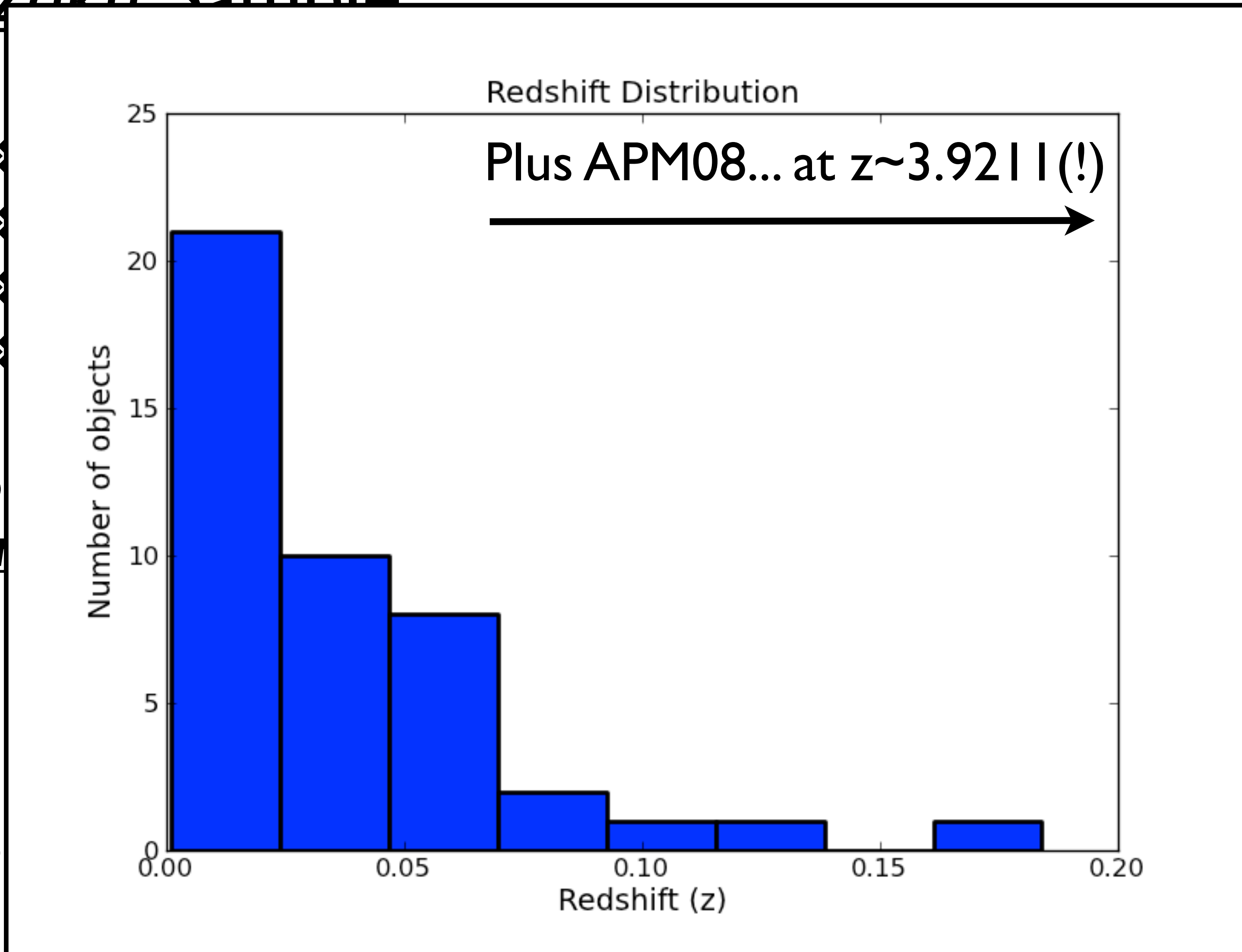


- Currently: 59 spectra of 45 objects fit and tested for Fe K absorp.

Assessing Fe K absorption

- For a manually fit continuum model, perform a search for Fe K absorption using both contour plots and by-eye Gaussian fitting. (similar to Tombesi et al.)

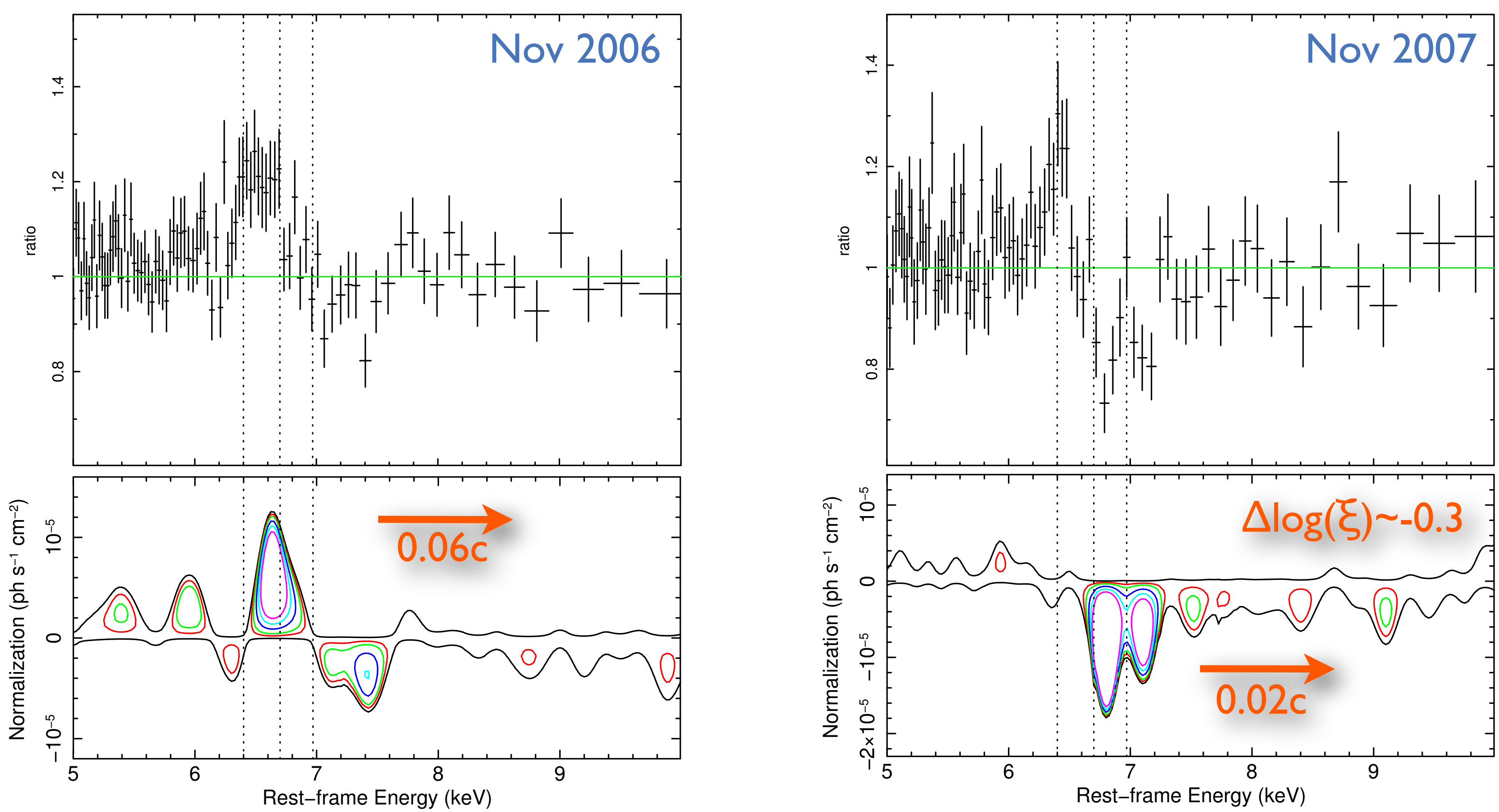
- Detailed Montecarlo simulations performed for all spectra with suspected absorption lines with $\Delta\chi^2$[dof]>9.21[2] (99%)
  - Gaussian stepped every 25 eV over entire Fe K band (5-9.5 keV) in 1000 simulated spectra (180,000 fits per spectrum)
  - ***Samples probability of random lines to the nearest 0.1%***
  - Time consuming, still being run (>week per spectrum)
  - Spectra with least significant lines Montecarlo'd first (8/9 >99.5%)

- Spectral parameters taken from Gaussian fit, and XSTAR modelling.

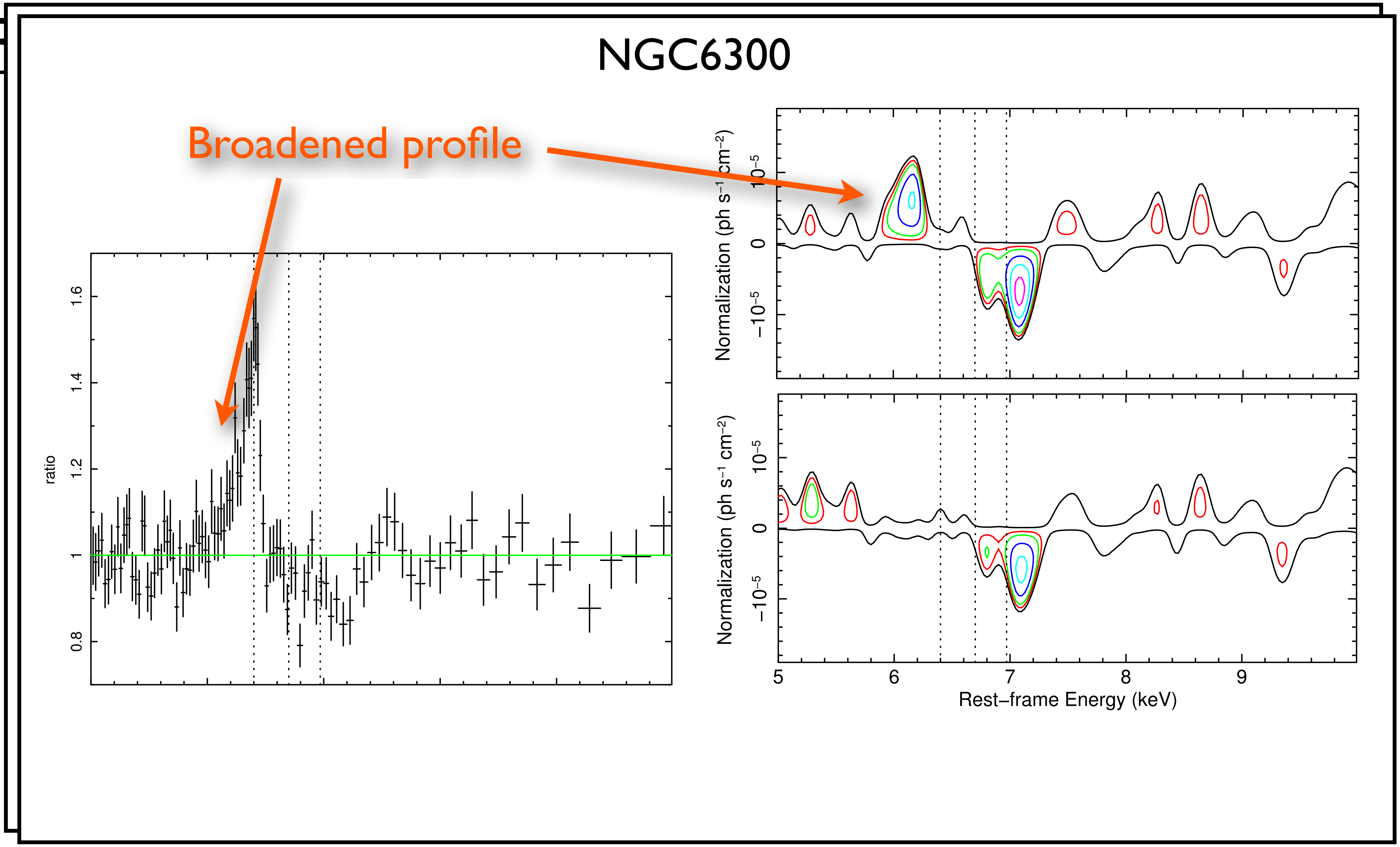
Results & Examples

- **16/45 objects** found to have significant Fe K absorption in **21/59 fitted spectra** (~36%)
- Four objects with Fe K absorption. in >1 obs, w/ evidence for variability (e.g. PDS456, Mrk766, NGC3227)

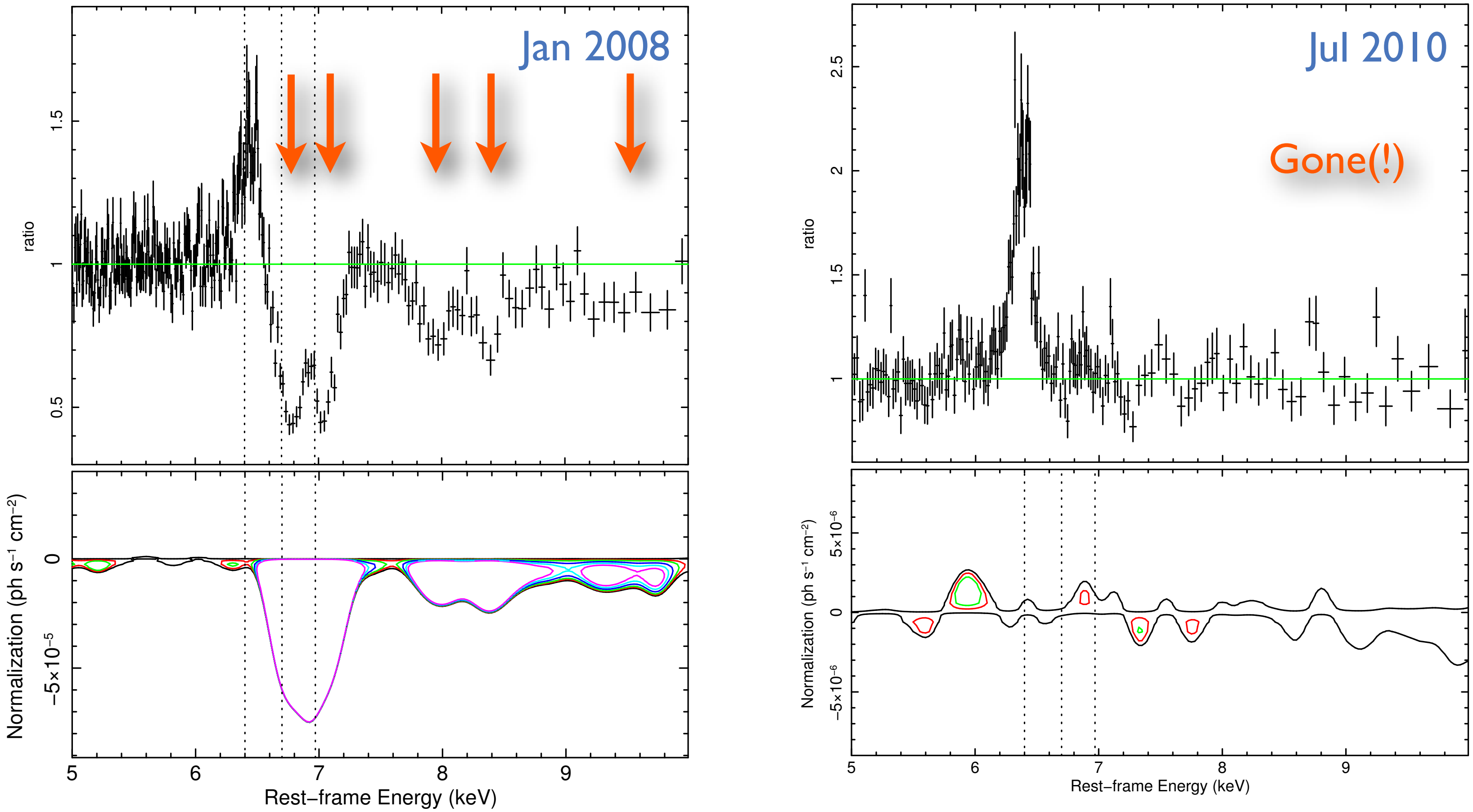
Mrk 766



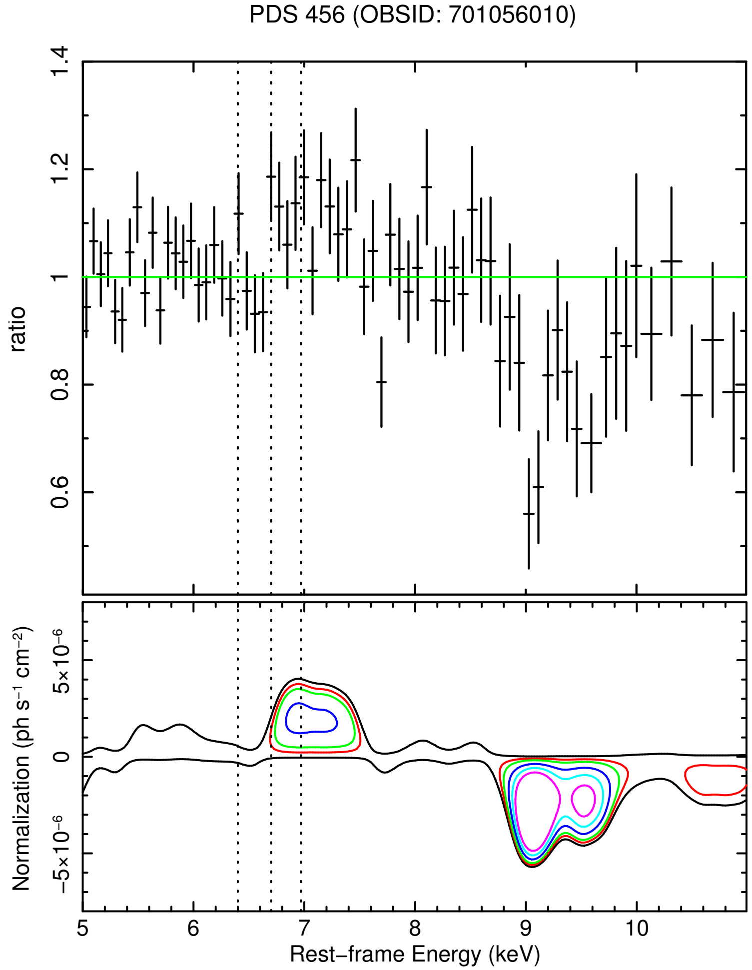
Nov 2006
ratio
1.4
1.2
1
0.8
Normalization (ph s⁻¹ cm⁻²)
10⁻⁵
0
−10⁻⁵
0.06c
5
6
7
8
9
Rest−frame Energy (keV)
Nov 2007
ratio
1.4
1.2
1
0.8
Δlog(ξ)~-0.3
0.02c
−10⁻⁵
−2×10⁻⁵
Rest−frame Energy (keV)


NGC6300
Broadened profile
ratio
1.6
1.4
1.2
1
0.8
Normalization (ph s^{-1} cm^{-2})
10^{-5}
0
-10^{-5}
5
6
7
8
9
Rest−frame Energy (keV)

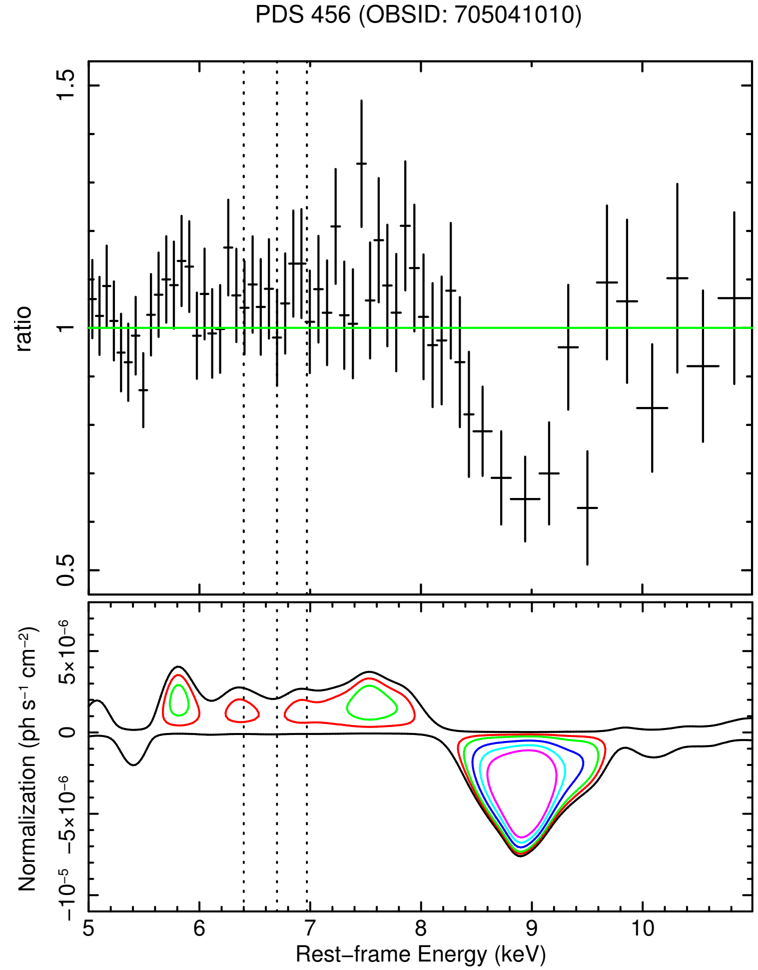
NGC1365


Jan 2008
ratio
0.5
1
1.5
Normalization (ph s⁻¹ cm⁻²)
0
−5×10⁻⁵
5
6
7
8
9
Rest−frame Energy (keV)
Jul 2010
Gone(!)
ratio
1
1.5
2
2.5
Normalization (ph s⁻¹ cm⁻²)
5×10⁻⁶
0
−5×10⁻⁶
Rest−frame Energy (keV)

PDS456



PDS 456 (OBSID: 701056010)
ratio
1.4
1.2
1
0.8
0.6
Normalization (ph s⁻¹ cm⁻²)
5×10⁻⁶
0
−5×10⁻⁶
5
6
7
8
9
10
Rest−frame Energy (keV)



PDS 456 (OBSID: 705041010)
ratio
1.5
1
0.5
Normalization (ph s⁻¹ cm⁻²)
5×10⁻⁶
0
−5×10⁻⁶
−10⁻⁵
5
6
7
8
9
10
Rest−frame Energy (keV)

Results & Examples

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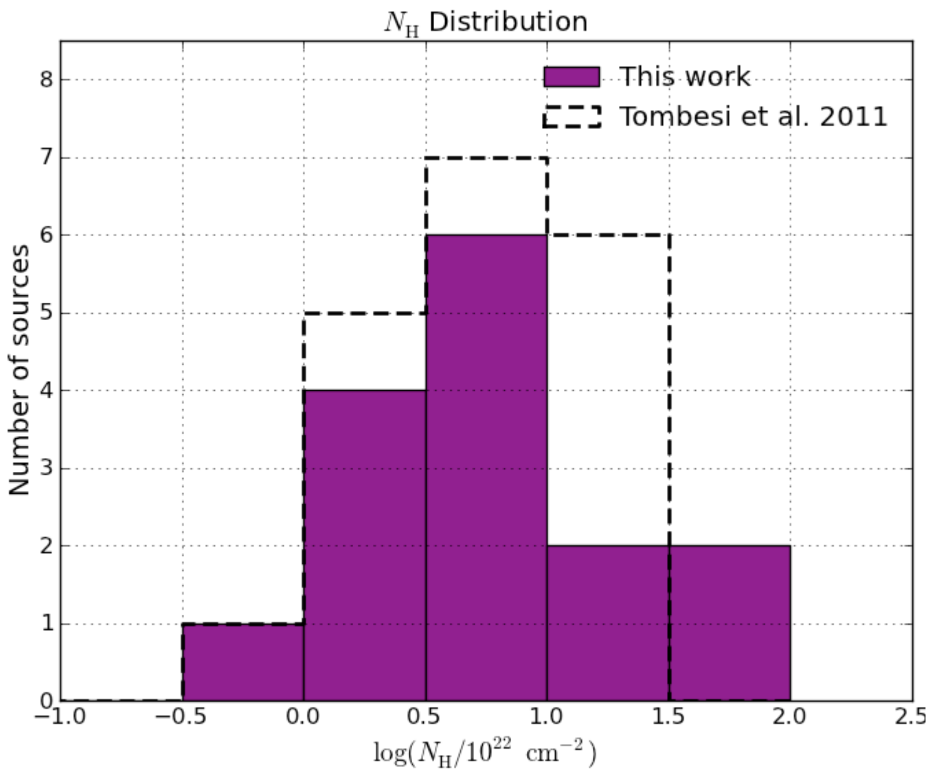
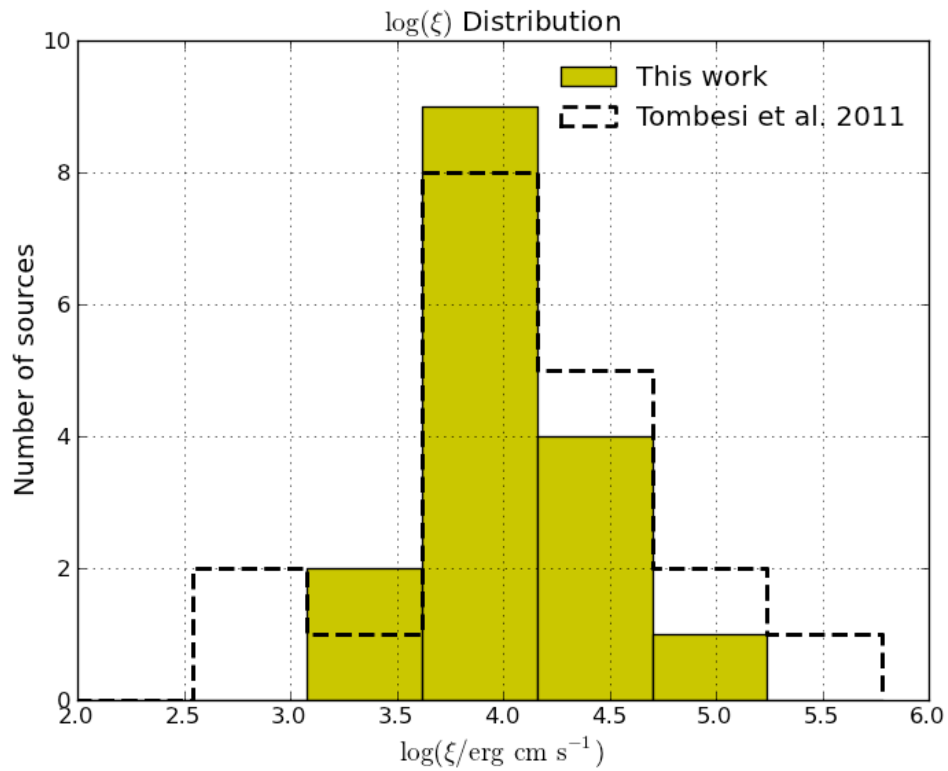
Lines	No. of Objects
Fe XXV+Fe XXVI (same V_{out})	6
Fe <XXV	2
Fe XXVI only	6
Multi V_{out} systems	2
	16

Absorber properties

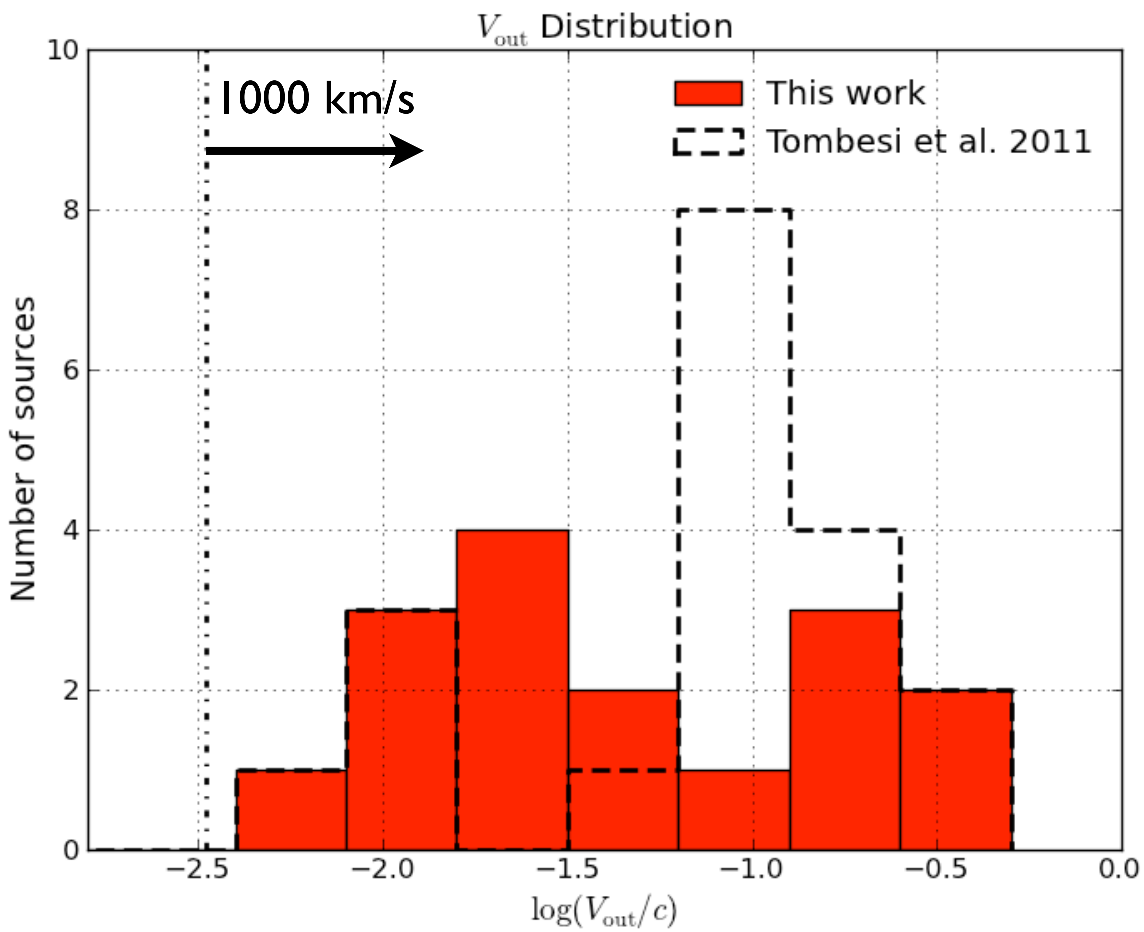




$\langle N_H, \mathrm{Suzaku} \rangle \approx 1\mathrm{e}23\ \mathrm{cm}^{-2}$
$\langle N_H, \mathrm{XMM} \rangle \approx 9\mathrm{e}22\ \mathrm{cm}^{-2}$

$\langle \log\xi, \mathrm{Suzaku} \rangle \approx 4.2$
$\langle \log\xi, \mathrm{XMM} \rangle \approx 4.5$

Absorber properties



$<V_{out,Suzaku}> \approx 0.11c$
$<V_{out,XMM}> \approx 0.09c$

Mean Energetics

Mass outflow rate: $$\dot{M}_{\rm out} = 4\pi b \left(\frac{L_{\rm ion}}{\xi}\right) m_{\rm p} V_{\rm out}$$

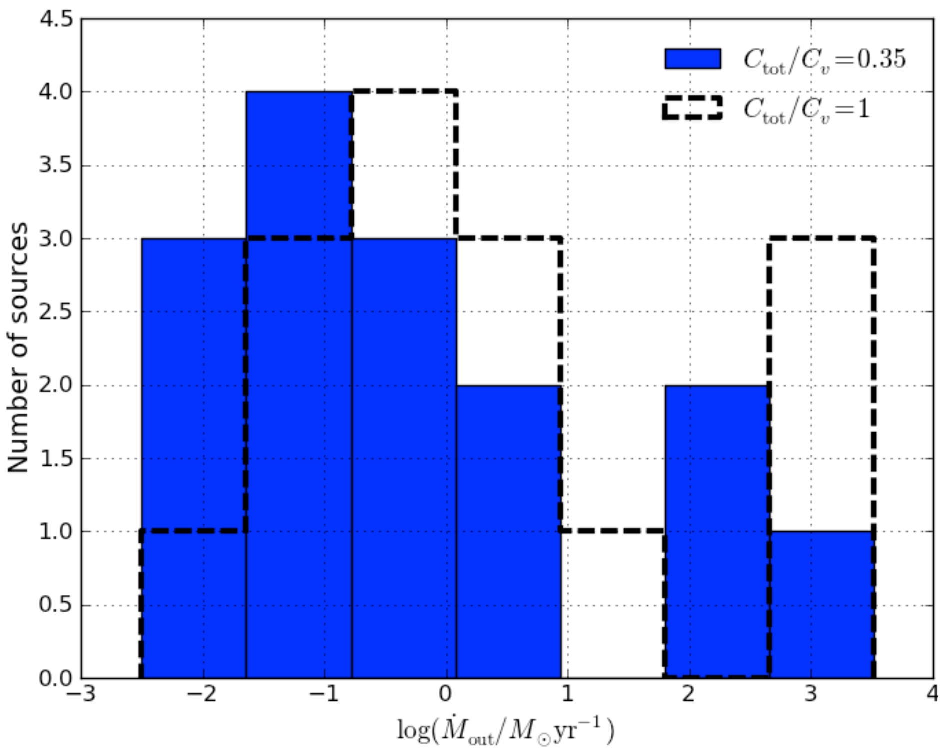
Eddington rate: $$\dot{M}_{\rm Edd} = \frac{4\pi M_{\rm BH} m_p}{\sigma_T}\left(\frac{1}{\eta c}\right)$$

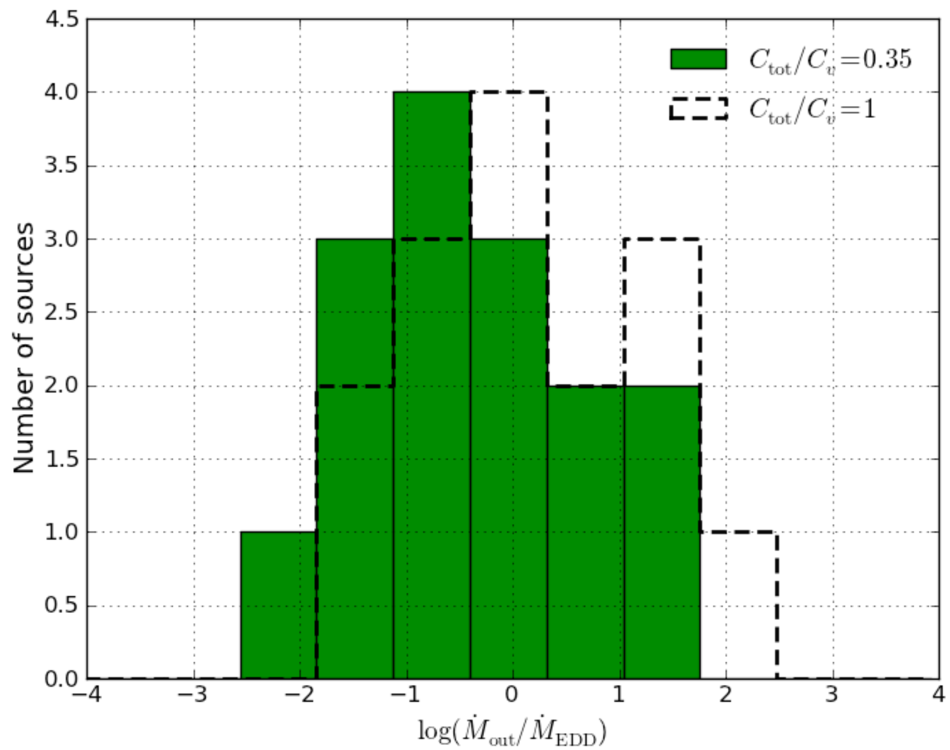
M_{BH} from literature
assumed 5% efficiency

Assume $M_{out} \lesssim M_{Edd}$

- M_{Edd} more robust upper limit
- Avoid uncertainty with L_{bol} corrections/estimates
- Get useful mean upper limits

Mean Energetics





$\langle M_{out} \rangle \sim 200$ Msun/yr

$\langle M_{out}/M_{Edd} \rangle \sim 5$

On average, $C_v < \sim 0.2$ for $C_f \sim 0.35$ and efficiency of 5%

Conclusions & Summary

- ***Independent*** studies with Suzaku and XMM both find blue-shifted Fe K absorption in ~35-40% of AGN.

- Absorber parameters (N_H, $\log\xi$) are in very good agreement. V_{out} differs in distribution, likely due to detector differences (e.g. effective area/energy resolution), but we find a similar $<V_{out}>\sim 0.1c$

- Taking M_{edd} as robust estimate for M_{acc}(max), we find that, on average, wind "clumpyness" of the order of $C_v\sim 20\%$ (or higher if $M_{out}/M_{edd}>1$ permitted)