Constraining Black Hole Spin in AGN with *Suzaku*

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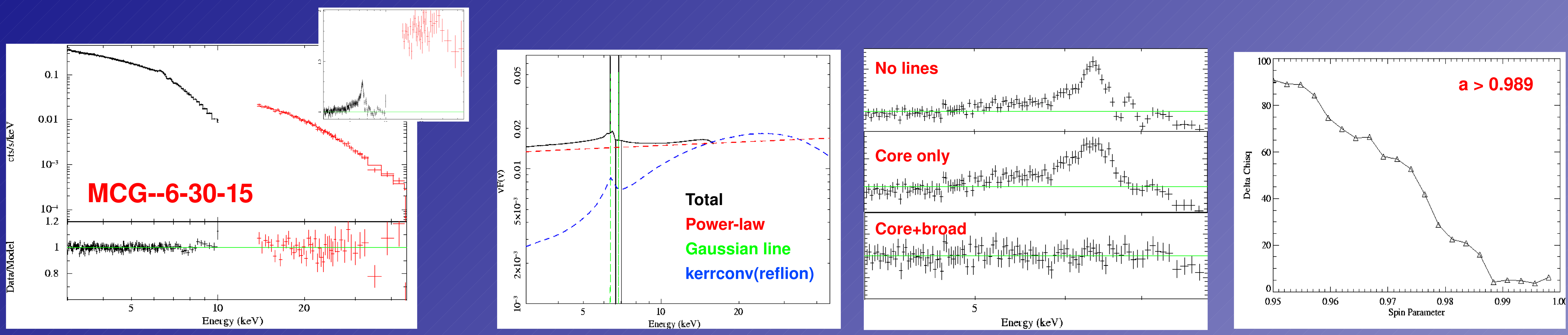
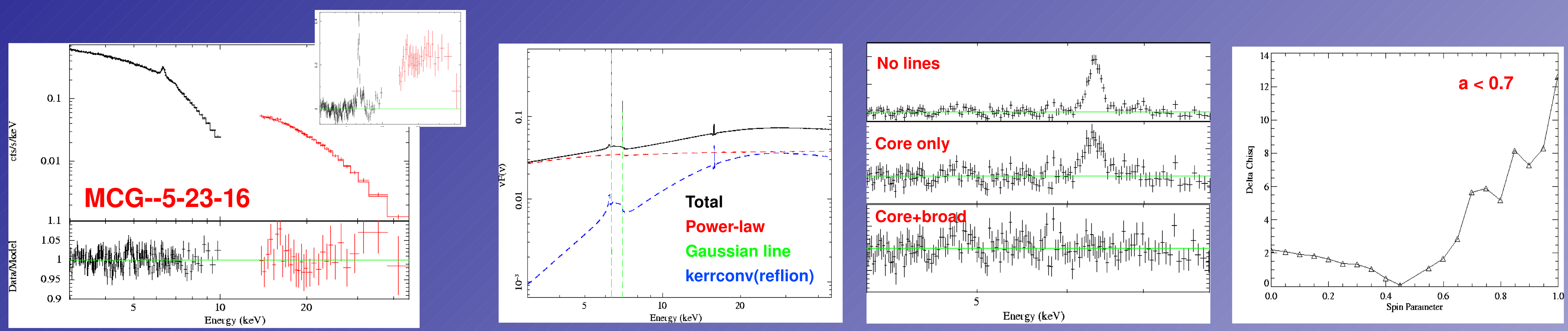
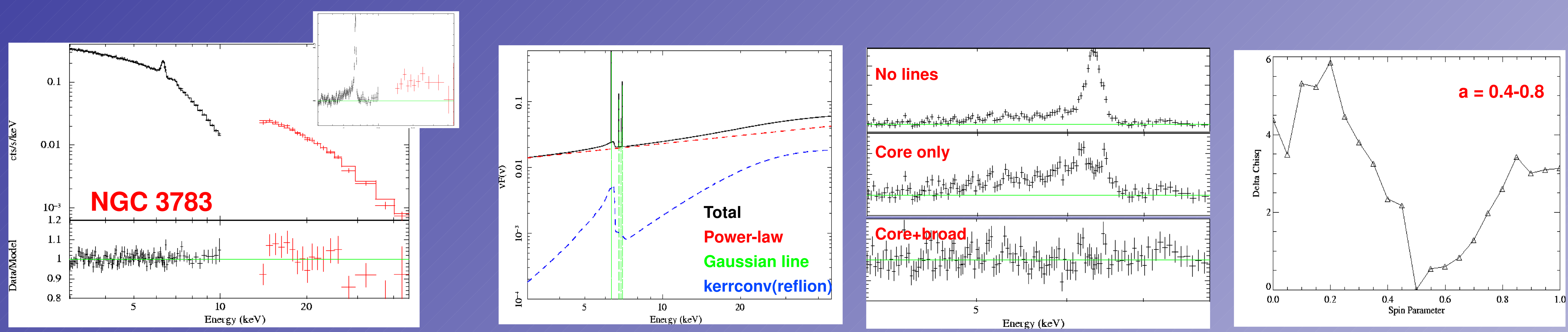
Introduction: Relativistically broad iron lines in AGN act as a powerful diagnostic probe of the inner accretion flow onto supermassive black holes, allowing observers to test the predictions of General Relativity in the strong-field limit. The extent of the broadening seen in the red wing of the Fe-Kα line, in particular, enables us to place a lower limit on black hole spin in a given source. X-ray instruments with large collecting areas and broad bandpasses such as *Suzaku* are now allowing us to obtain high-resolution spectra of the Fe-Kα line region in many AGN. I present black hole spin constraints from a *Suzaku* archive survey of five AGN with broad iron lines. Each of the data sets employs XIS and HXD/PIN data, and has been reprocessed using the latest version of the calibration. Black hole spin constraints were derived from spectral fitting using the *kerrconv* model (Brenneman & Reynolds 2006) applied to the ionized disk reflection spectrum of Ross & Fabian (2005).



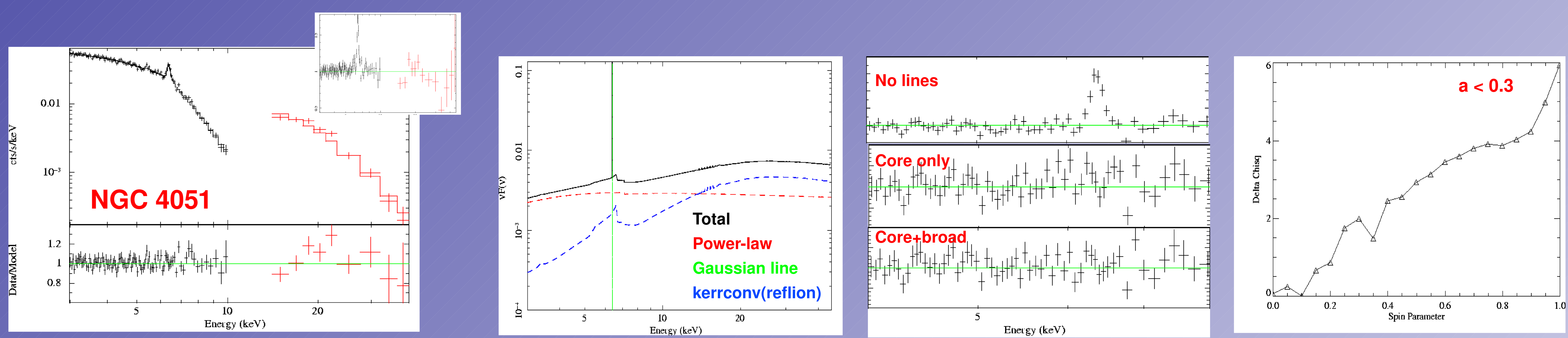
Left to right: The best-fit (inset: residuals to a power-law fit) 3-45 keV spectrum of MCG—6-30-15; the model components; Fe-K line residuals from a power-law, power-law+narrow core and power-law+narrow core+relativistic disk spectrum fit; change in global goodness-of-fit with black hole spin.



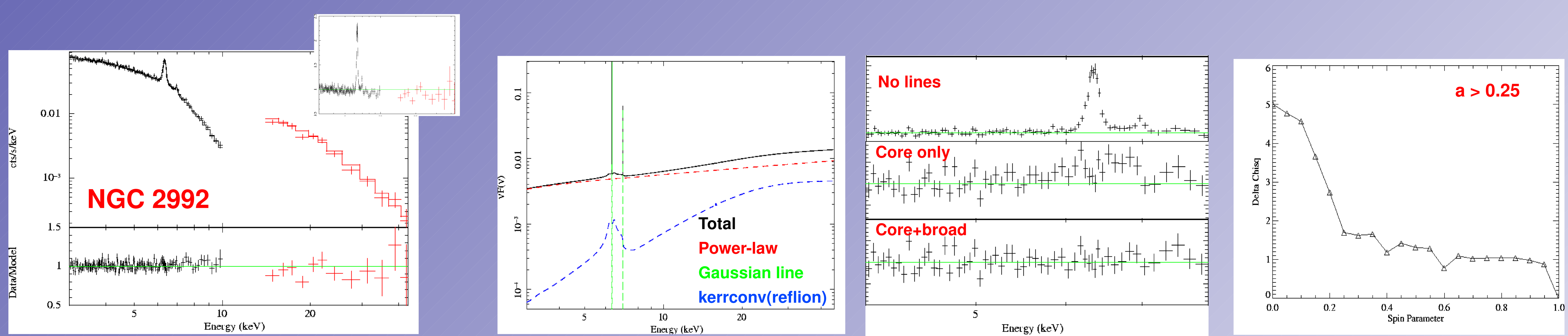
Left to right: Same as above, this time for MCG—5-23-16. Though there is evidence for a broad line component, the broad line is neither as strong nor as broad as that of MCG—6-30-15.



Left to right: Plots for NGC 3783. Again, a broad line is present, although the amount of reflection is diminished in the Compton hump.



Left to right: Plots for NGC 4051. In this case, only marginal evidence for a Compton Hump is seen, and although a broad line is statistically wanted by the fit, the narrow core is the dominant component of the line.



Left to right: Plots for NGC 2992. In this case, no evidence for a Compton Hump exists in the data, although a broad line is statistically wanted by the fit. Because both components are thought to arise from the same physical process, this result is puzzling.

AGN	a (cJ/GM^2)	r_{min} (r_g)	Incl (°)	$\Delta\chi^2/\Delta$d.o.f. (with smearing)
MCG—6-30-15	> 0.989	1.66-1.67	28-29	-1026/-6
MCG—5-23-16	< 0.7	3.15-7.46	42-43	-72/-5
NGC 3783	0.4-0.8	3.40-3.75	21-24	-115/-4
NGC 4051	< 0.3	18-22	27-28	-15/-4
NGC 2992	> 0.25*	< 5.16*	30-60*	-23/-6*

* NGC 2992 results are preliminary: error analysis is ongoing.

Conclusions: Our sample of AGN above shows a wide range in black hole spin. The best results are obtained for sources which have a higher number of photons in the spectrum as well as a strong Fe-Kα line with robust evidence of relativistic broadening by the accretion disk. The presence of a Compton reflection hump in the data allows us to better constrain the reflection parameters of the disk, enabling better limits to be placed on black hole spin. Three of our five sources show robust evidence for the reflection hump in their HXD/PIN spectra, and, not coincidentally, are also the three sources in which the greatest effects from the disk are seen. Relativistic smearing of the spectrum by the black hole is also most significant in these cases, and leads to the best constraints on black hole spin. Both NGC 4051 and NGC 2992 do *not* display Compton reflection above 10 keV, yet both sources show evidence of a relativistically broadened Fe-Kα line reflected from the disk. Perhaps there is a different origin for the broad Fe-Kα line in these two sources, such as a wind from the disk, a truncated inner disk, or a yet more exotic phenomenon.