Multi-Time Scale Spectral Monitoring of Seyferts with RXTE

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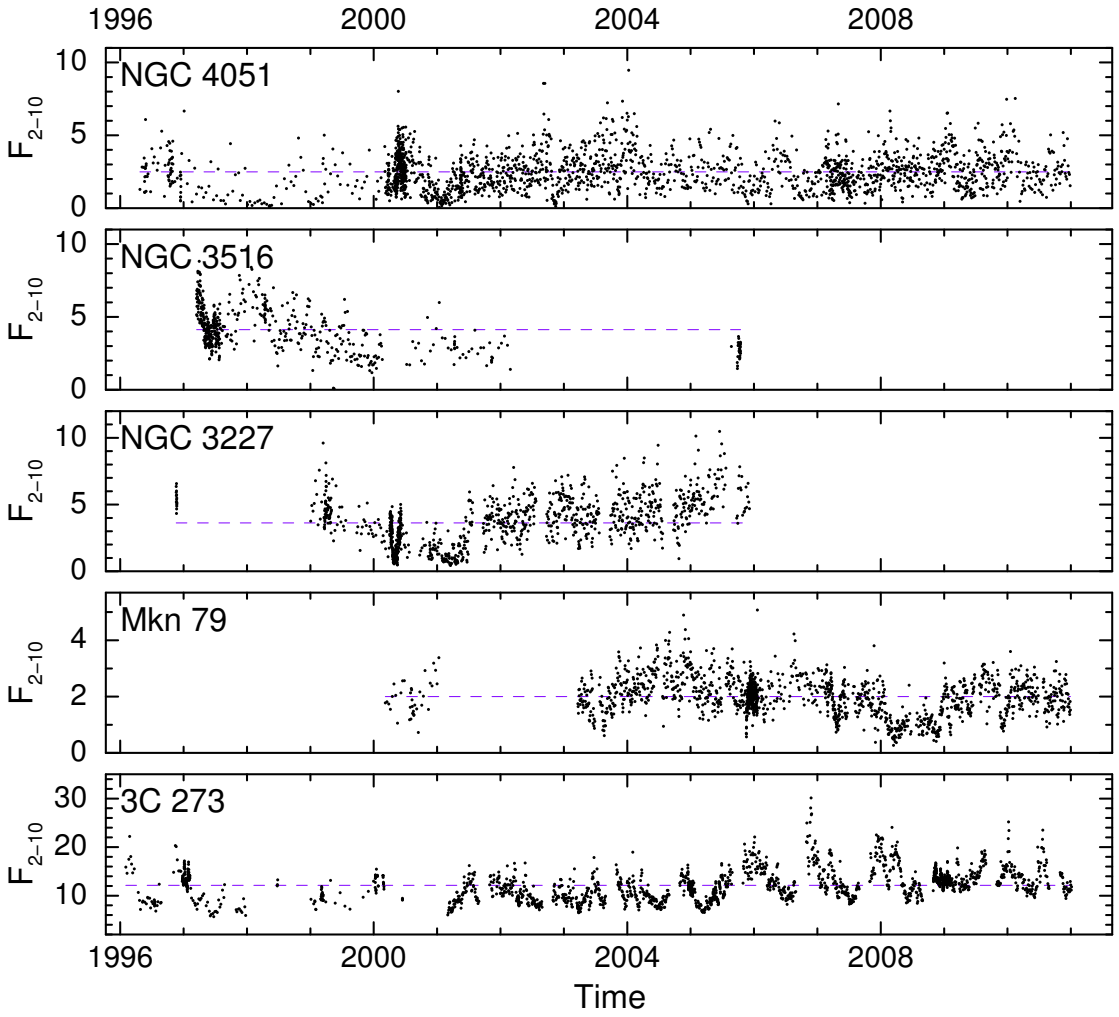
Karl Remeis Observatory, Bamberg, & ECAP


Karl Remeis Sternwarte

RXTE's Legacy: The AGN Variability Database



	Sy1	Sy2	Blzr
# Visited	57	47	51
# Monitored	39	15	45
Tot. Mon. (obj · yr)	152.5	39.6	68.6

- Average flux & typical flux range for each object

Time scales of months–years are interesting for AGN!

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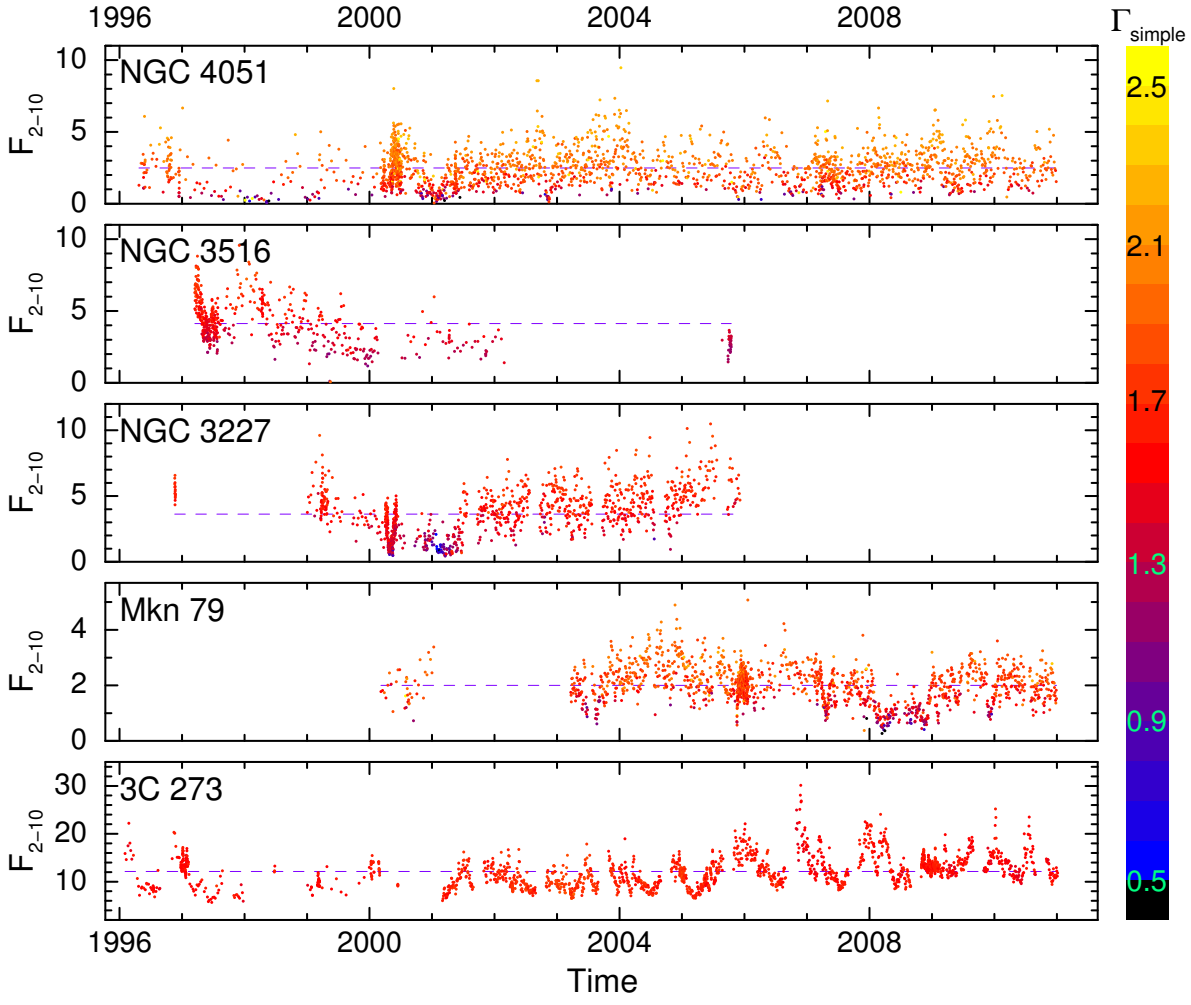

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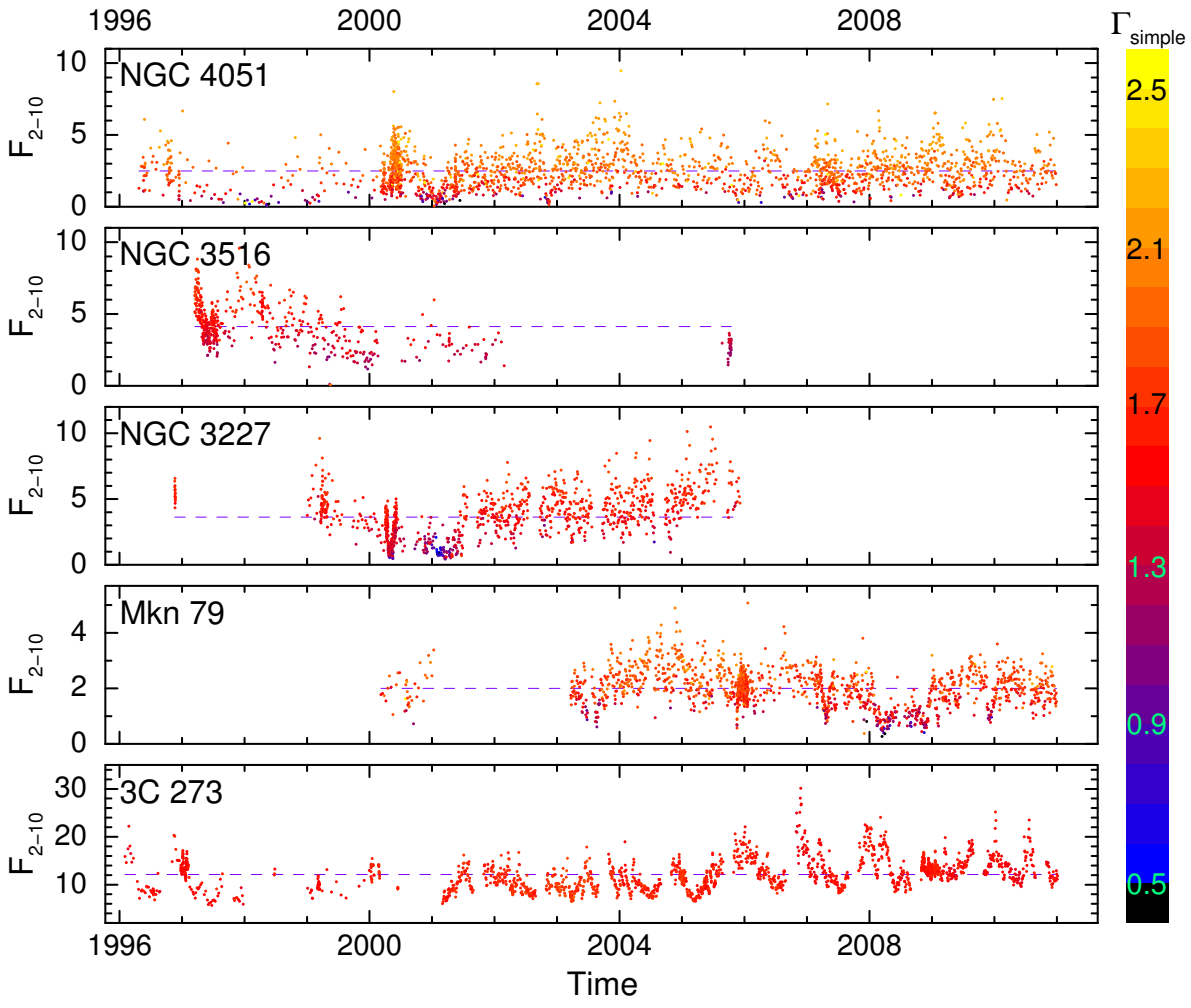

- Long-term avg. spectral properties (Rivers et al. 2011a; **SEE POSTER!**)

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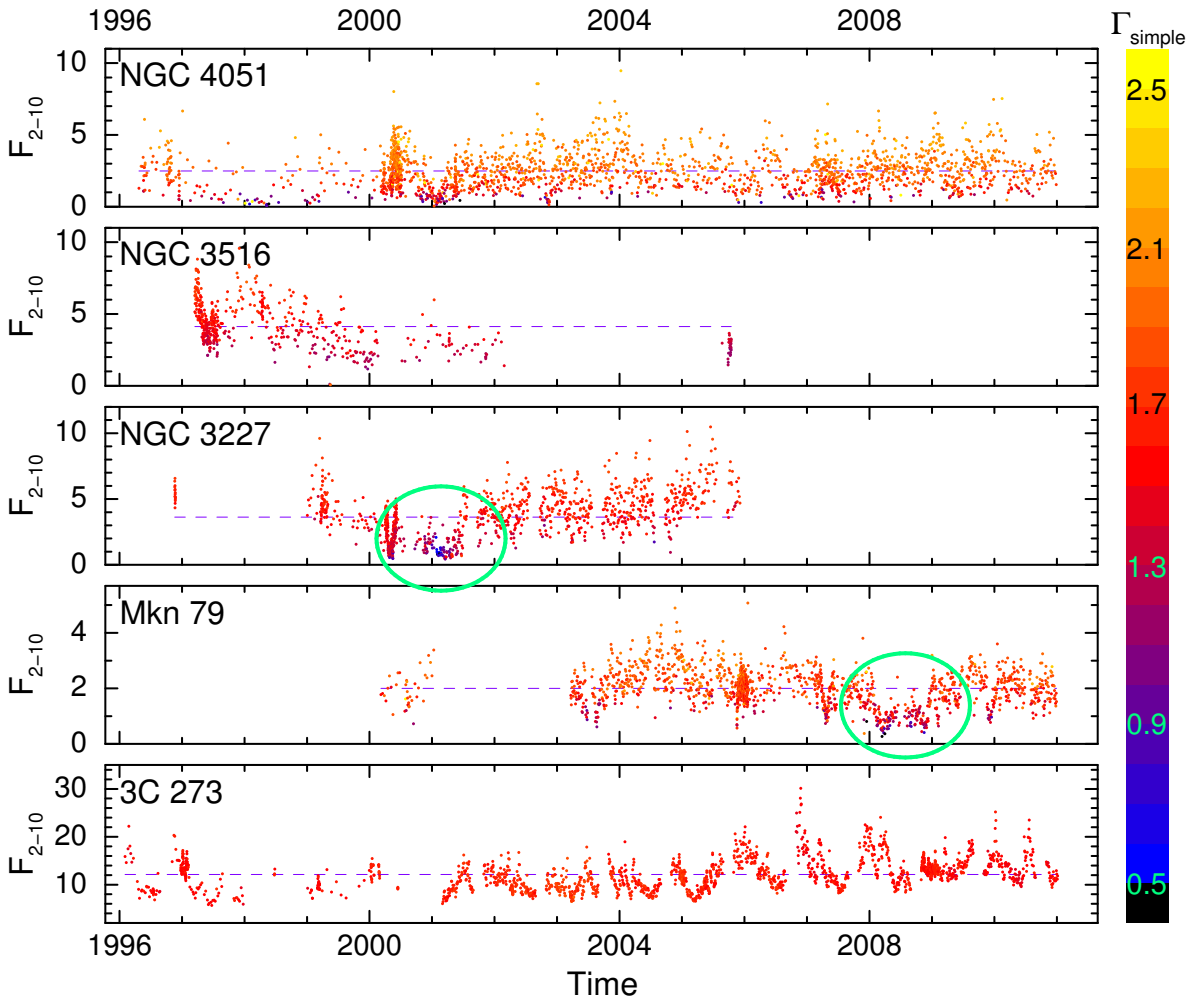

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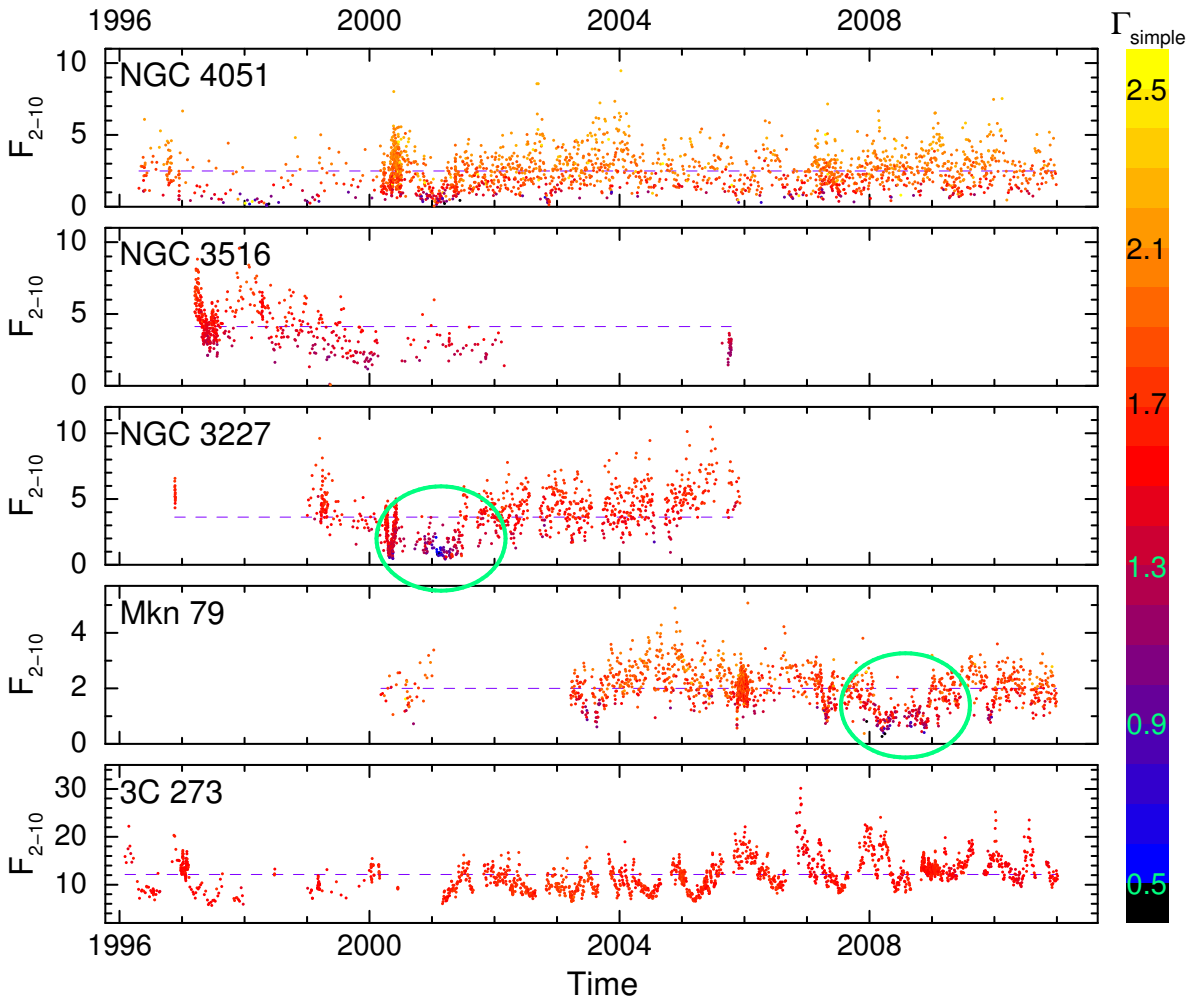

- Long-term avg. spectral properties (Rivers et al. 2011a; **SEE POSTER!**)
- **Monitoring** $\rightarrow \Gamma(t)$, $I_{\mathrm{FeK}\alpha}(t)$, $N_{\mathrm{H}}(t)$

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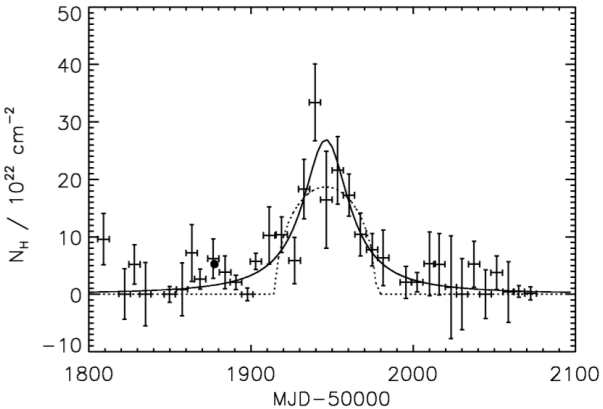
Variability in Line of Sight Absorbers

- Variations in X-ray absorbing columns in *both* Sy 1s & 2s, on time scales of hours–years (Risaliti+ 2002, Puccetti+ 2007, Turner+ 2008)



Lamer+ '03: NGC 3227: 3-month eclipse, 2000–1

$N_{\rm H}$ monitoring with RXTE: complementary to short-term results

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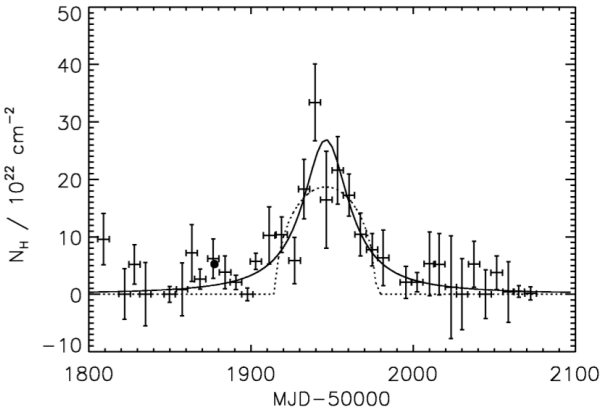

Lamer+ '03: NGC 3227:
3-month eclipse, 2000–1
$\Delta N_{\rm H} = 3 \times 10^{23}$ cm^{-2}
$R \sim 10 - 100$ lt.-days
BLR cloud likely

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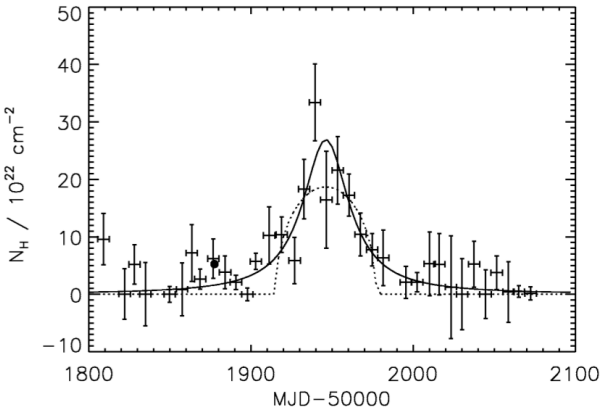

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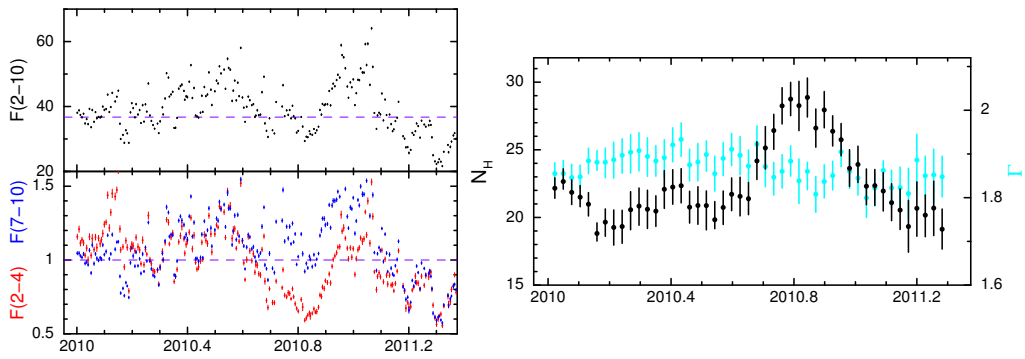

Rivers+ '11b: Cen A
6-month eclipse, 2010–1

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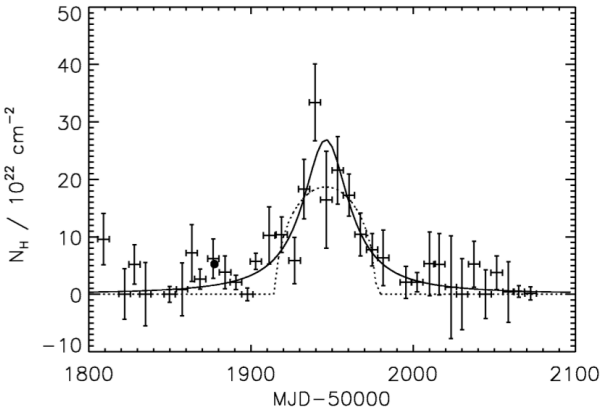

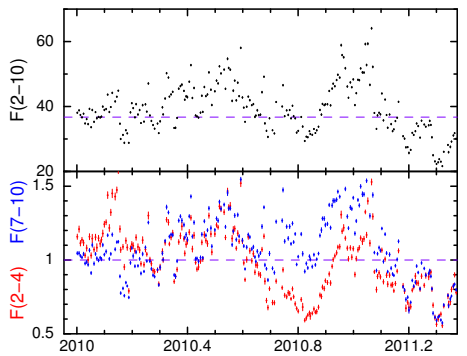

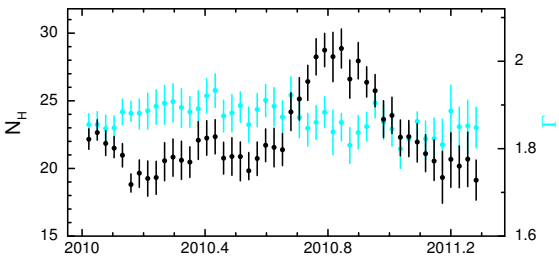

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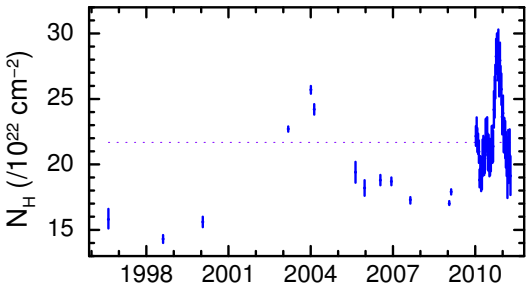
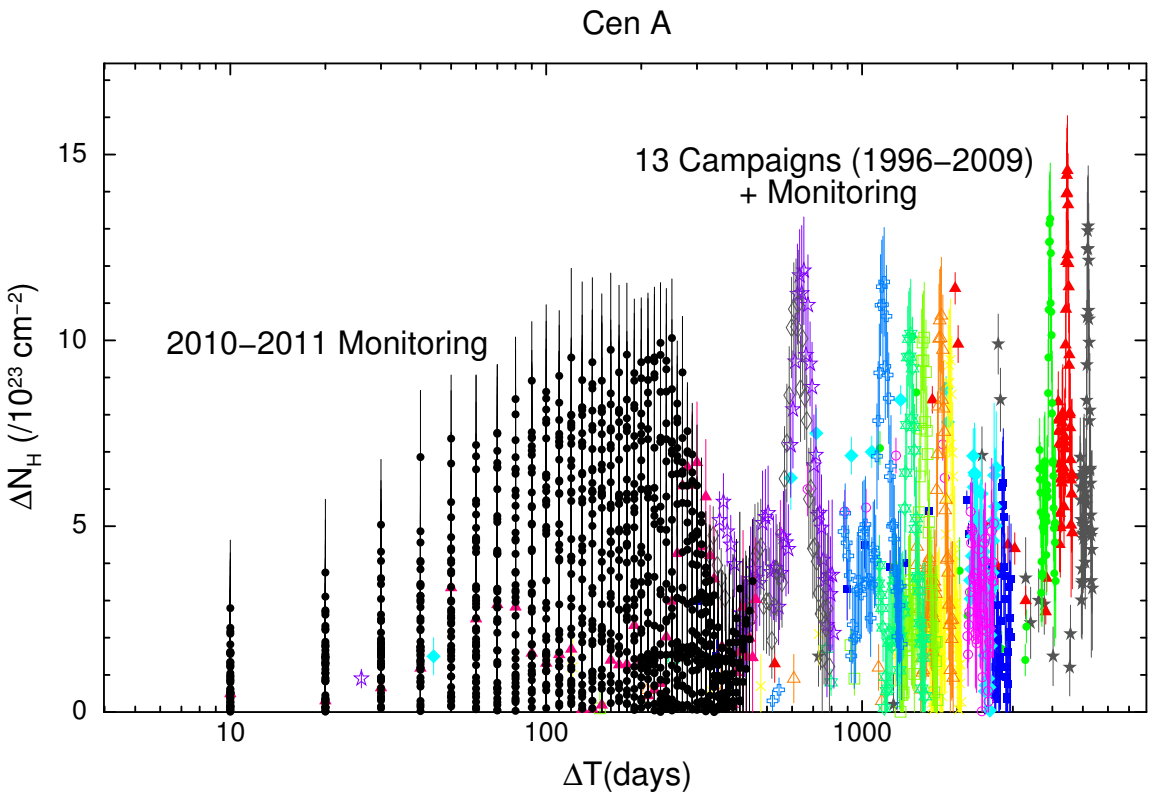
$R \sim 10 - 100$ lt.-days
BLR cloud likely

Rivers+ '11b: Cen A
6-month eclipse, 2010–1
$\Delta N_{\rm H} = 8 \times 10^{22}$ cm^{-2}
$R \sim 0.1 - 0.3$ pc
Torus cloud likely

$N_{\rm H}$ monitoring with RXTE: complementary to short-term results

Absorption Variability in Cen A: From weeks to a decade





(monitoring of Cen A on even longer timescales would be ideal....)

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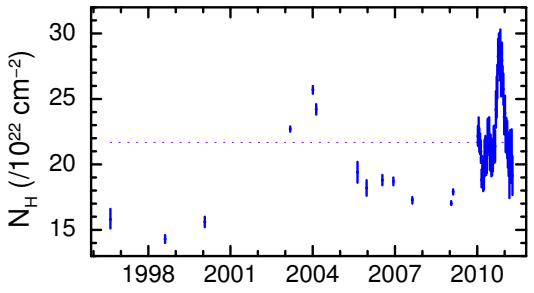

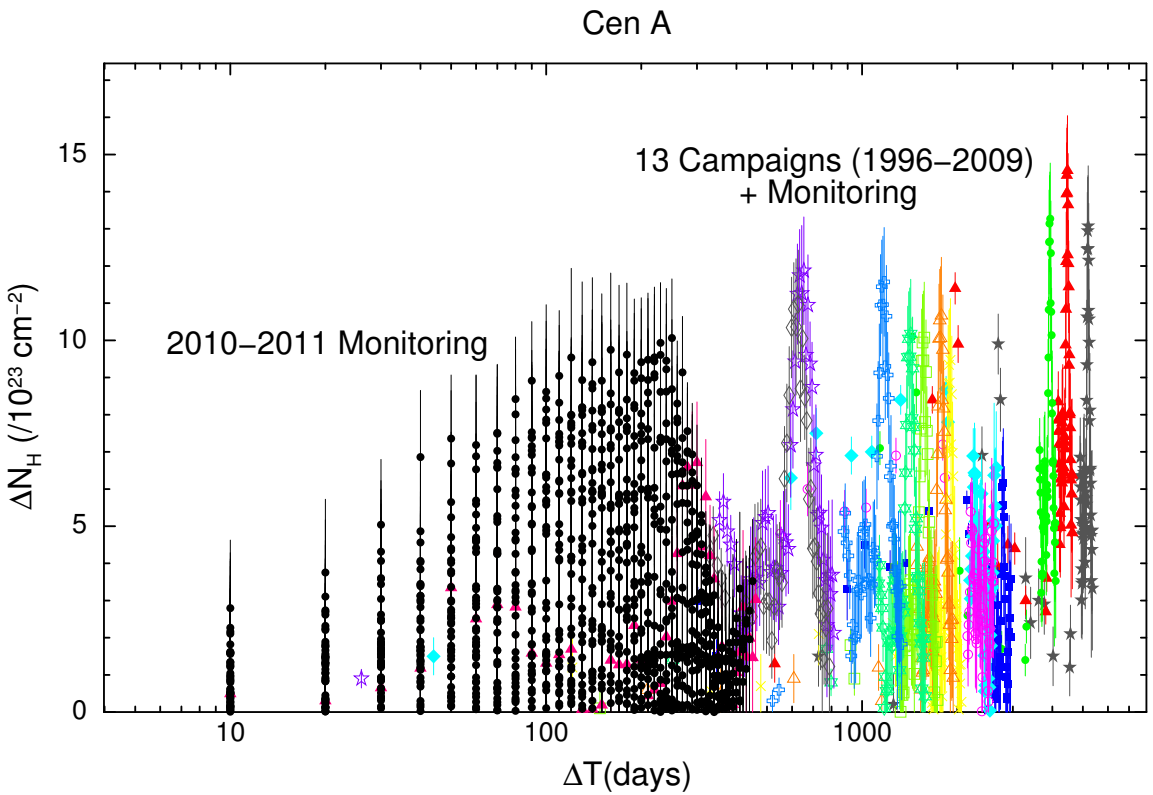

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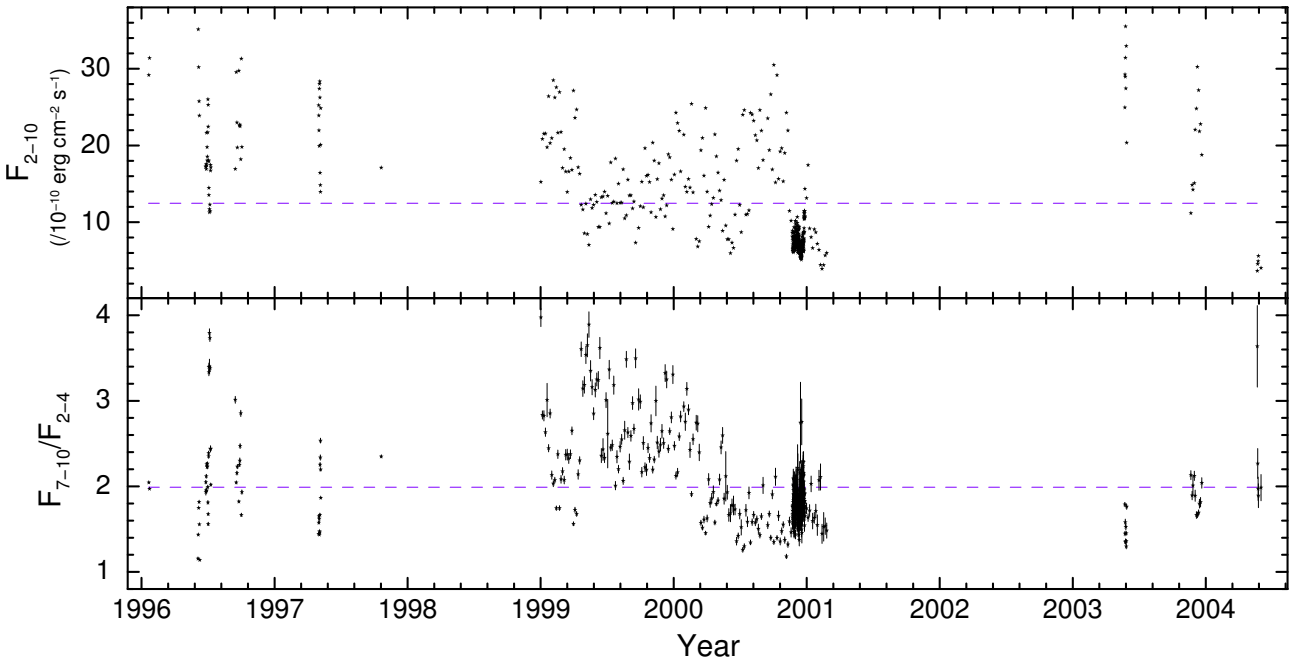
ALSO: NGC 6300 changed from C-thick to C-thin over 2.5 years (Leighly et al. 1999, 2000 & Guainazzi et al. 2002)

RXTE Spectral Monitoring of NGC 4151, 1996–2004



NGC 4151: Complex, absorbed X-ray spectrum (e.g., full-covering + partial-coverer):

Can variations in absorption explain the observed trends in Hardness Ratio?

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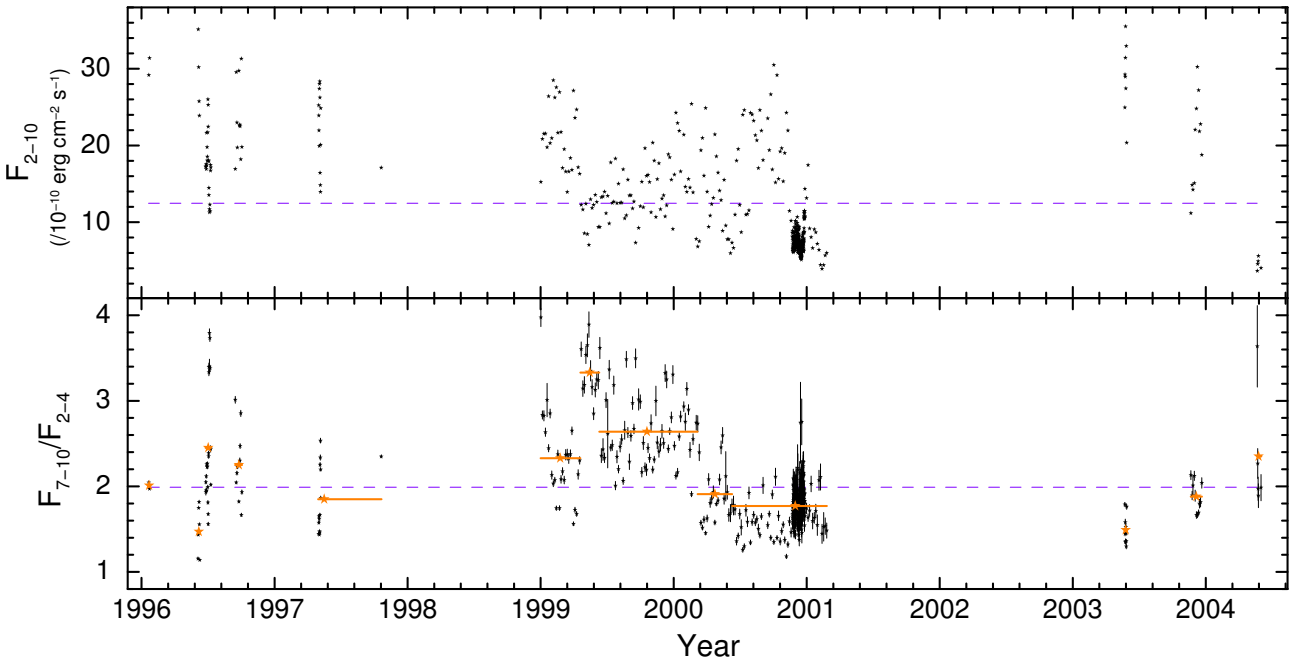

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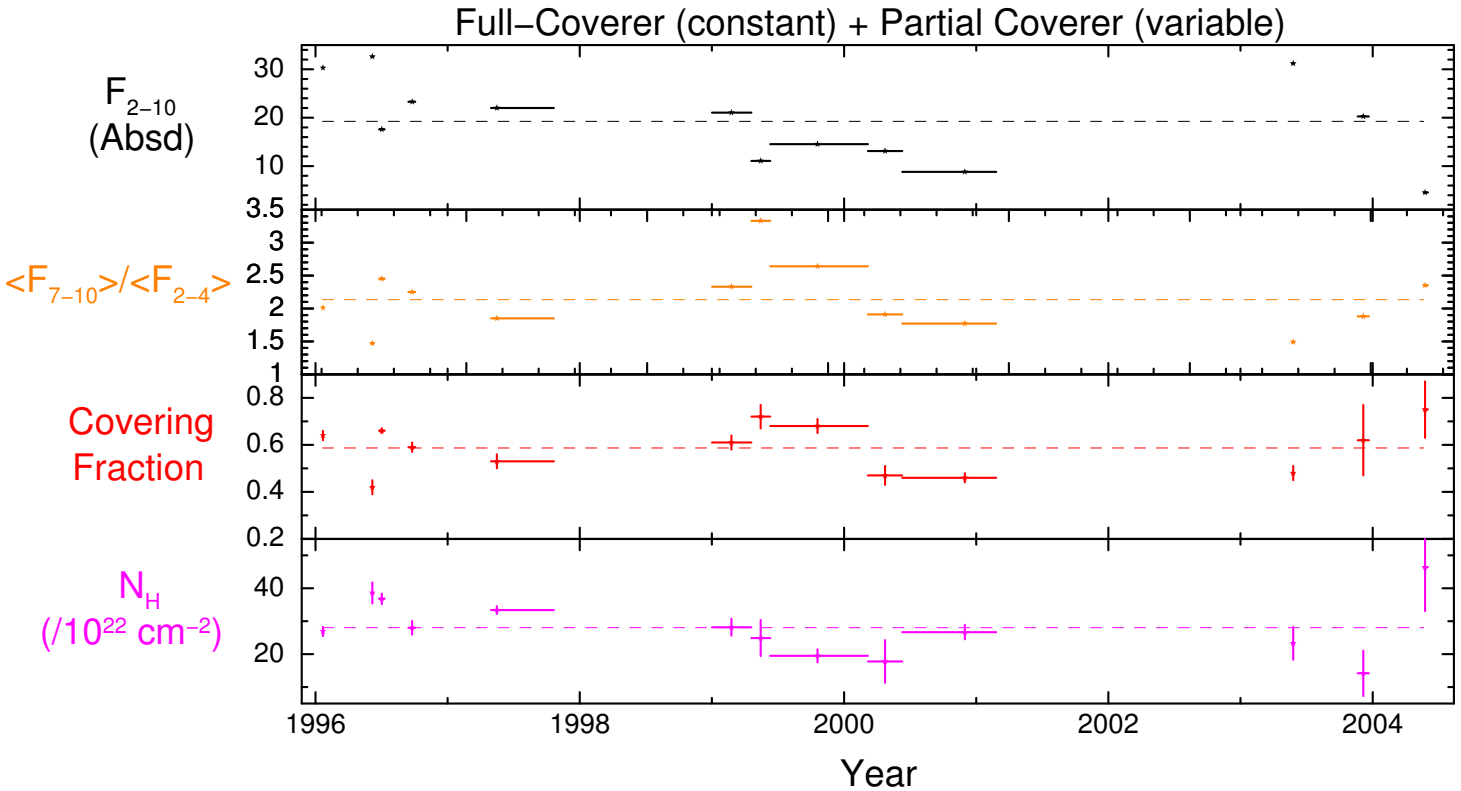
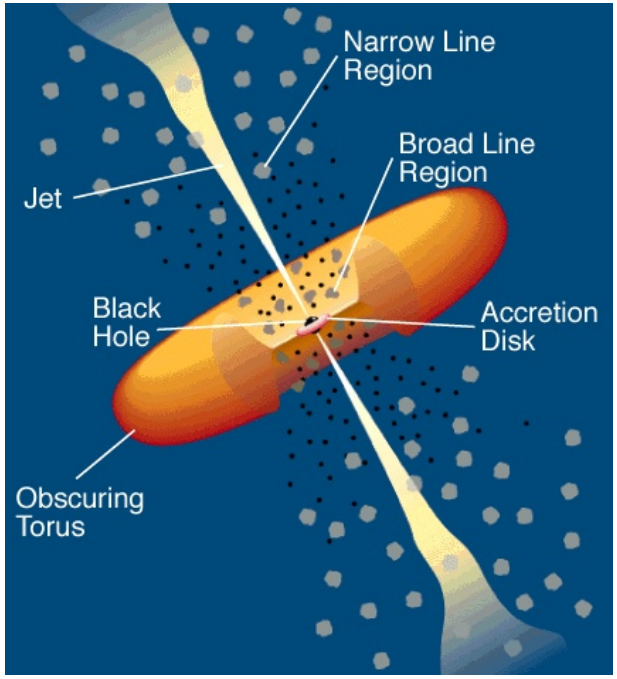


Markowitz et al., in prep.: Yes: Changes in covering fraction of partial coverer drive Hardness Ratio trends (consistent with DeRosa et al. 2007, 5 BeppoSAX observations)

Clumpy torus models



(Urry & Padovani 1995)

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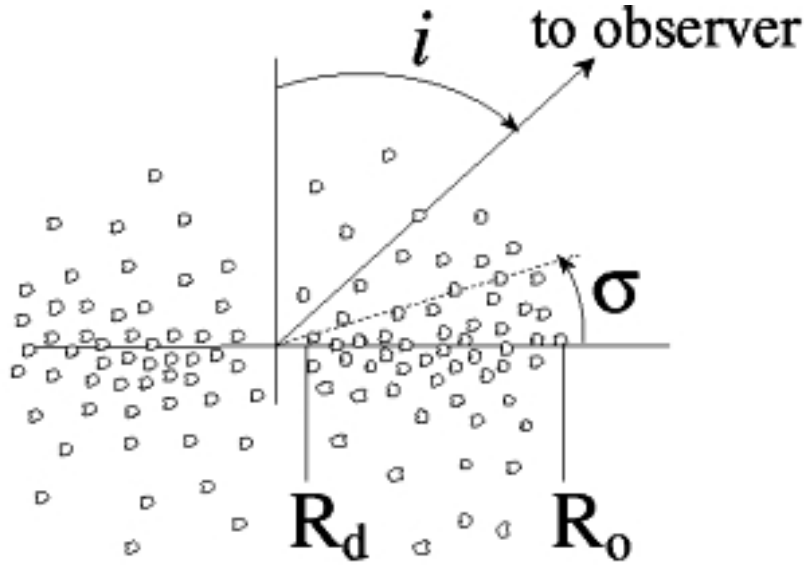
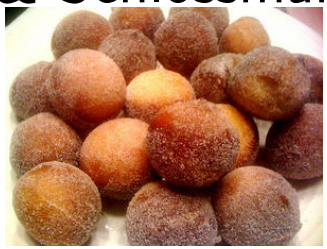
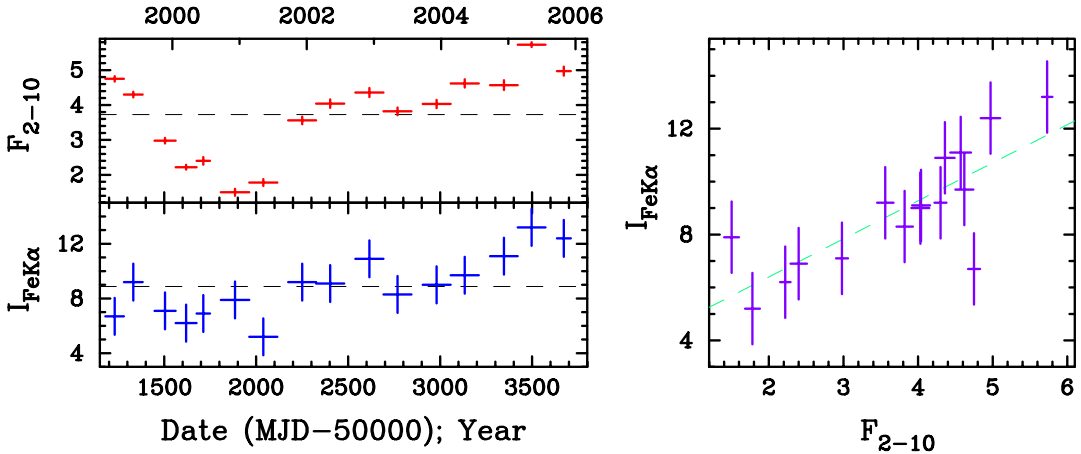


e.g., Nenvoka et al. 2002, 2008; Elitzur & Schlossmann 2006

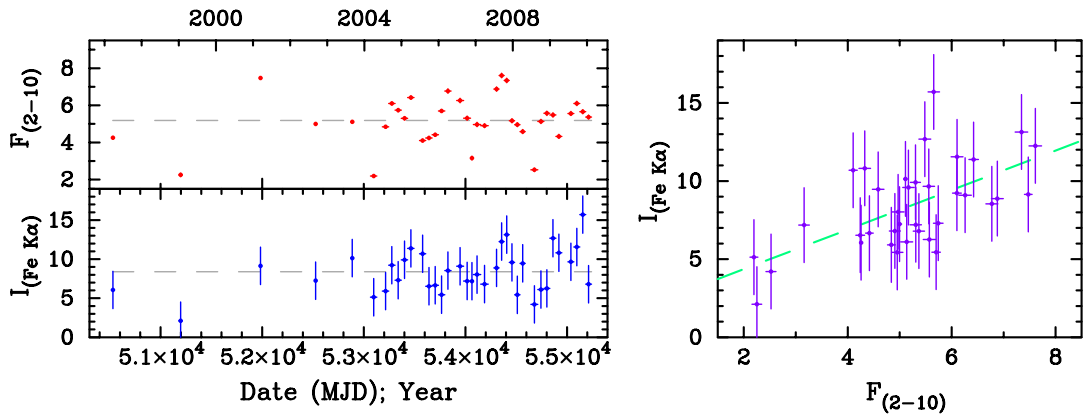


Reverberation Mapping with the Fe Kα Line

NGC 3227 (Markowitz et al. 2009)



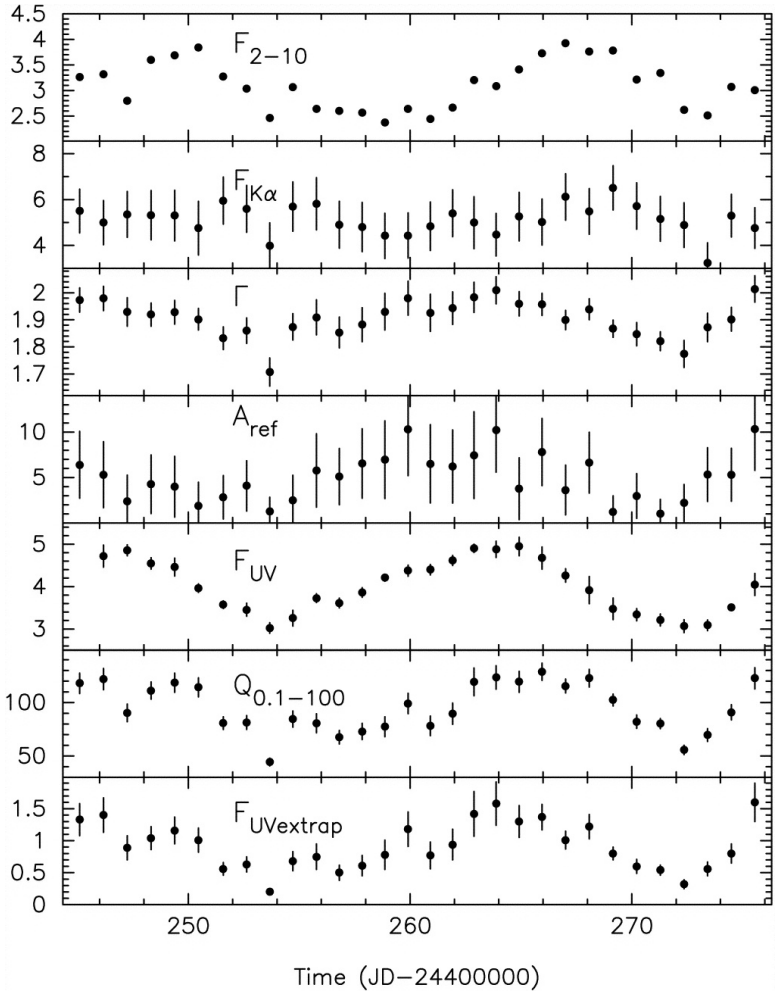
3C 111 (Chatterjee et al. 2011)



50%/80% of line flux responds to continuum variations; variable portion of line originates in gas $< 700/< 60$ light-days from central engine

(Related: see also: Markowitz, Edelson & Vaughan 2003; Vaughan & Edelson 2001; Nandra et al. 2000)

Coronal Power Law Component

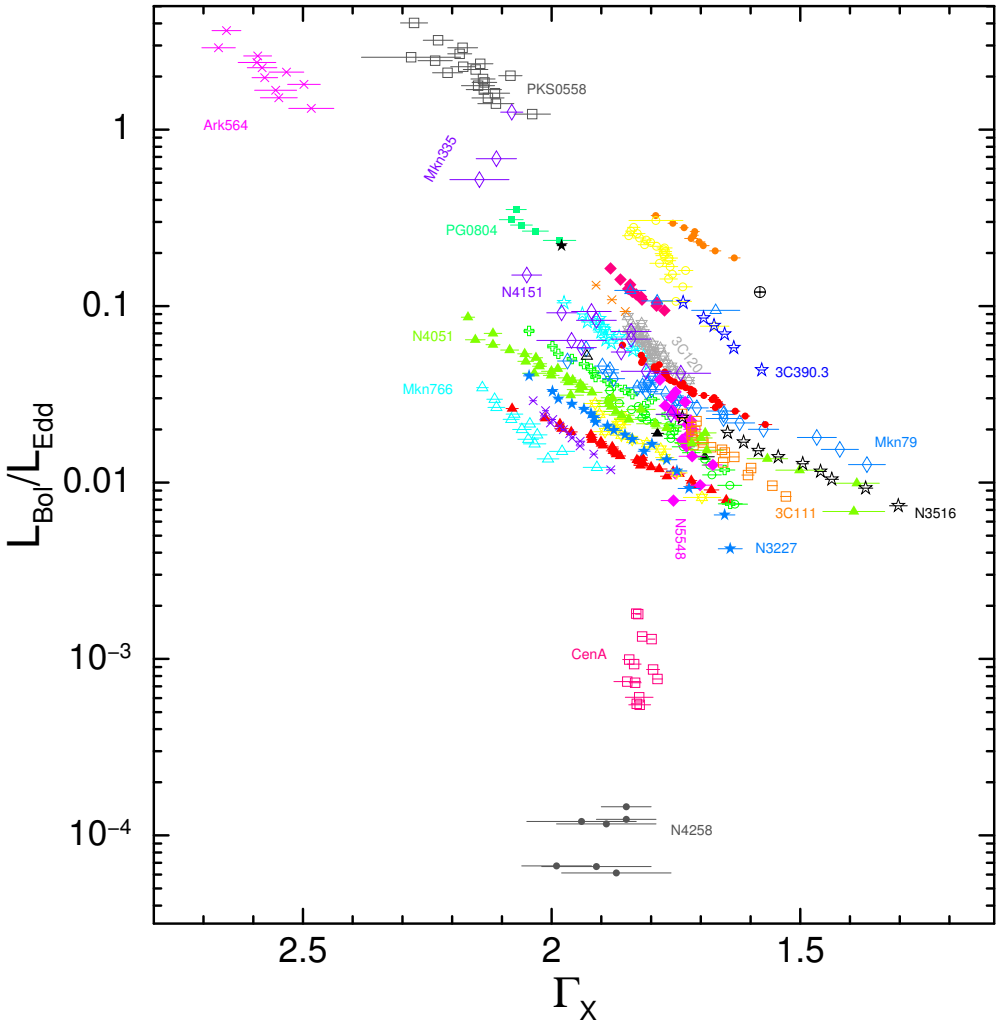


Nandra et al. (2000), 32-day RXTE+IUE campaign on NGC 7469:

- **Γ_X & F_{UV} correlated**
- Consistent with Comptonization in a corona
- But also supports thermal reprocessing of SX/EUV photons into UV continuum photons

(Related: see also: Chiang et al. 2000, RXTE+ASCA+EUVE campaign on NGC 5548)

Coronal Power Law Component: Links to accretion in GBHs?



- For most X-ray-bright, nearby Seyferts: Power-law softens as flux increases (e.g., Papadakis et al. 2002)
- FUTURE: Need to access more LLAGN/ lower-$\dot{m}$ sources (which are more slowly variable)

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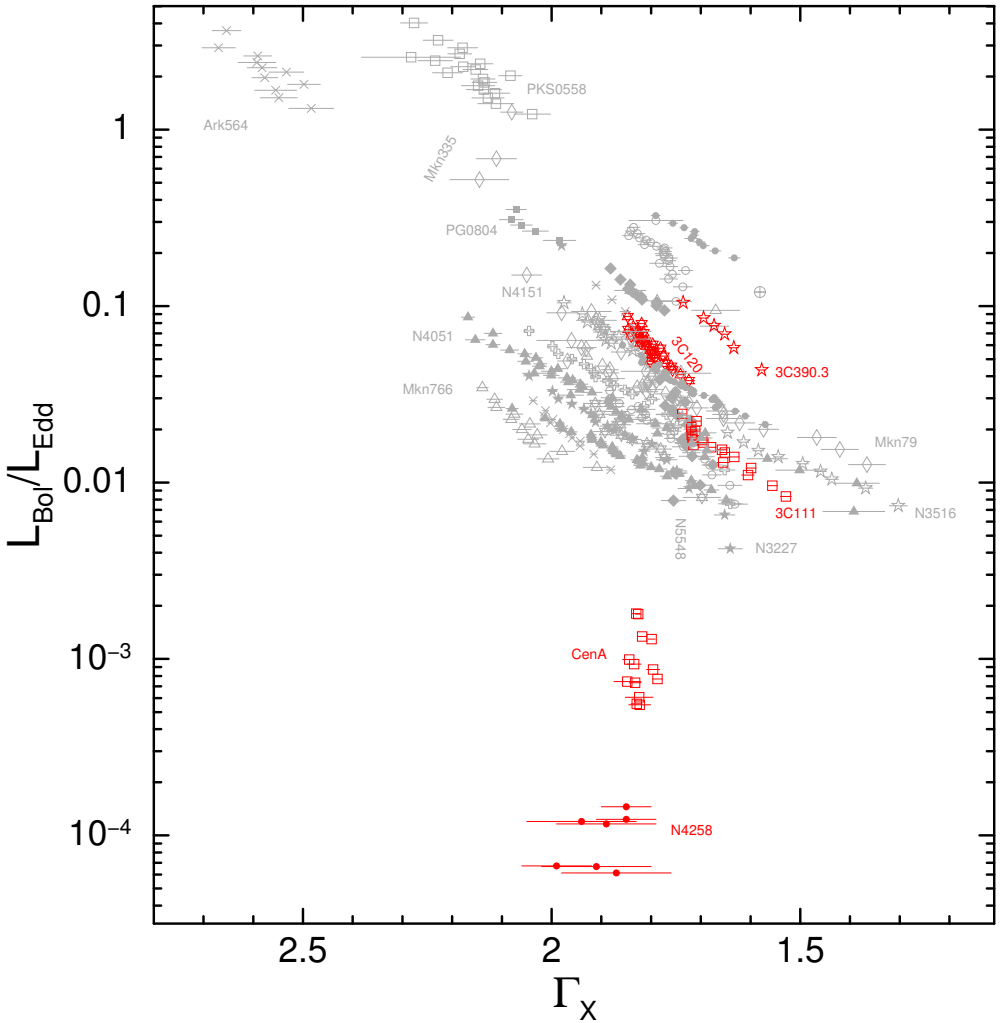

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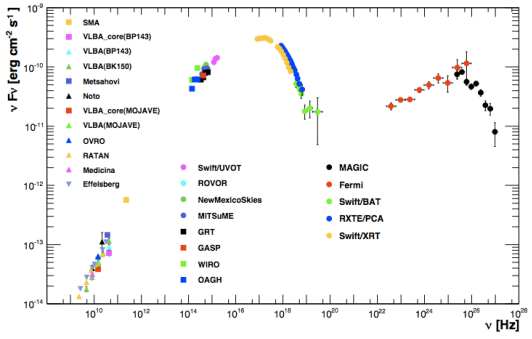
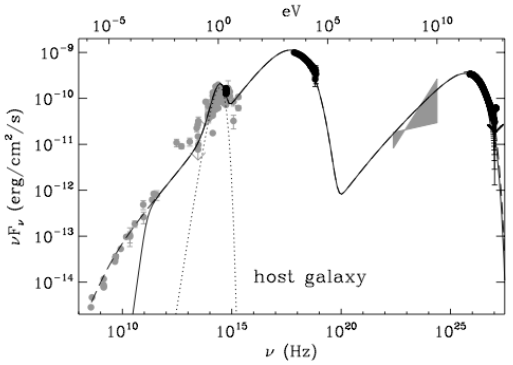
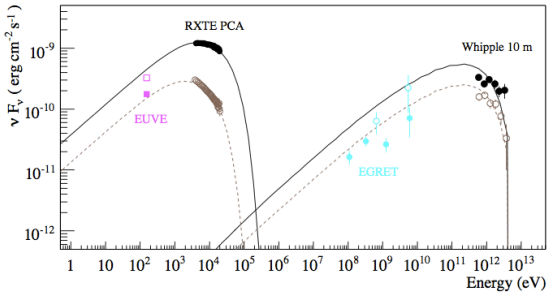
Constraints on Blazar Jet Emission Models



(Abdo et al. 2011)



(Giebels et al. 2007)

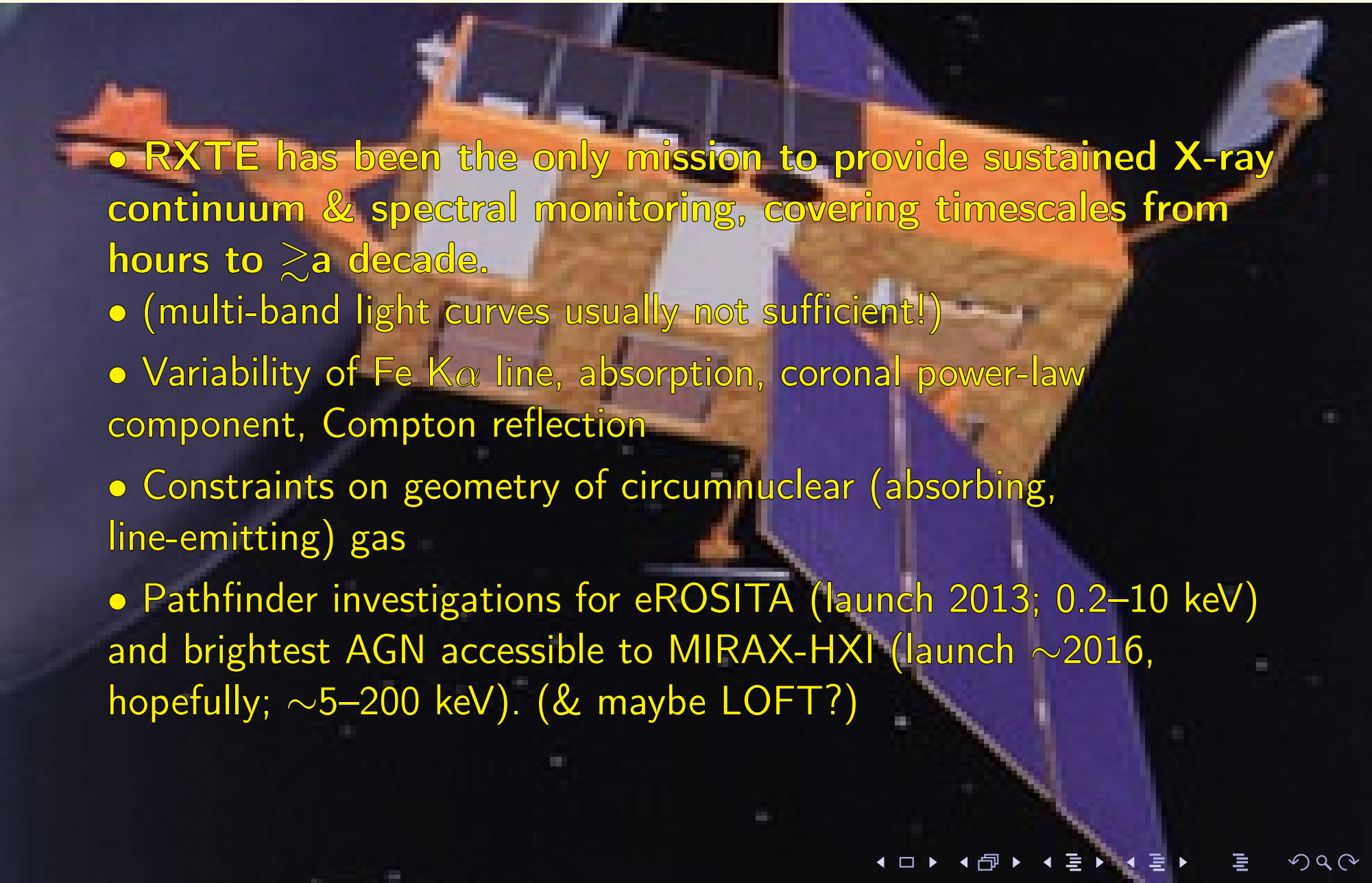


(Grube 2007)

- RXTE's flexible scheduling $\rightarrow$ participation in many ToO campaigns on flaring blazars

- RXTE spectral monitoring $\rightarrow$ better model SED(t) $\rightarrow$ constrain models of particle acceleration, jet emission

Summary



- **RXTE has been the only mission to provide sustained X-ray continuum & spectral monitoring, covering timescales from hours to $\gtrsim$a decade.**
- (multi-band light curves usually not sufficient!)
- Variability of Fe Kα line, absorption, coronal power-law component, Compton reflection
- Constraints on geometry of circumnuclear (absorbing, line-emitting) gas
- Pathfinder investigations for eROSITA (launch 2013; 0.2–10 keV) and brightest AGN accessible to MIRAX-HXI (launch $\sim$2016, hopefully; $\sim$5–200 keV). (& maybe LOFT?)

References & Back-up Slides

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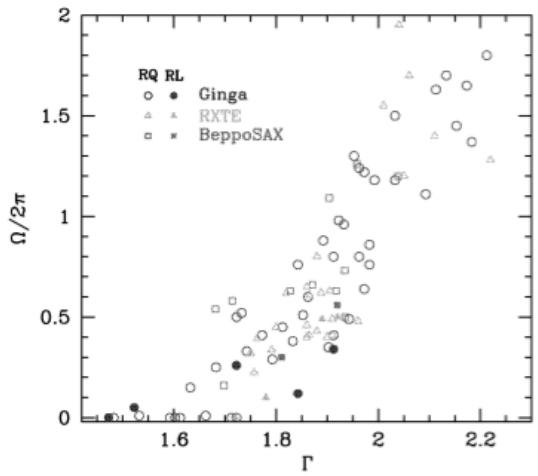
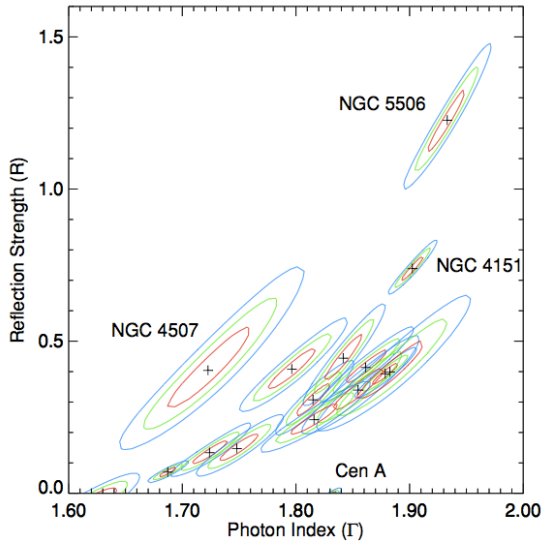
$R - \Gamma$ Correlation

Global correlations and correlation within individual objects:

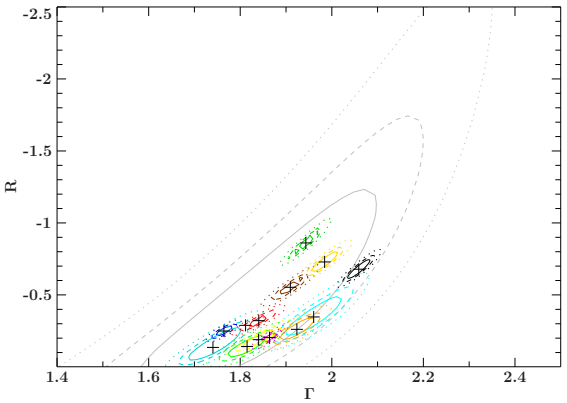


Zdziarksi et al. (2003)



Rivers et al. (2011)

PCA+HEXTE



Markowitz et al., in prep.

NGC 4151; PCA

- Other examples: Chiang et al. (2000); Zdziarski et al. (1999, Ginga)
- CAUTIONS: See Vaughan & Edelson (2001) and Nandra et al. (2000), and run those Monte Carlo sims!