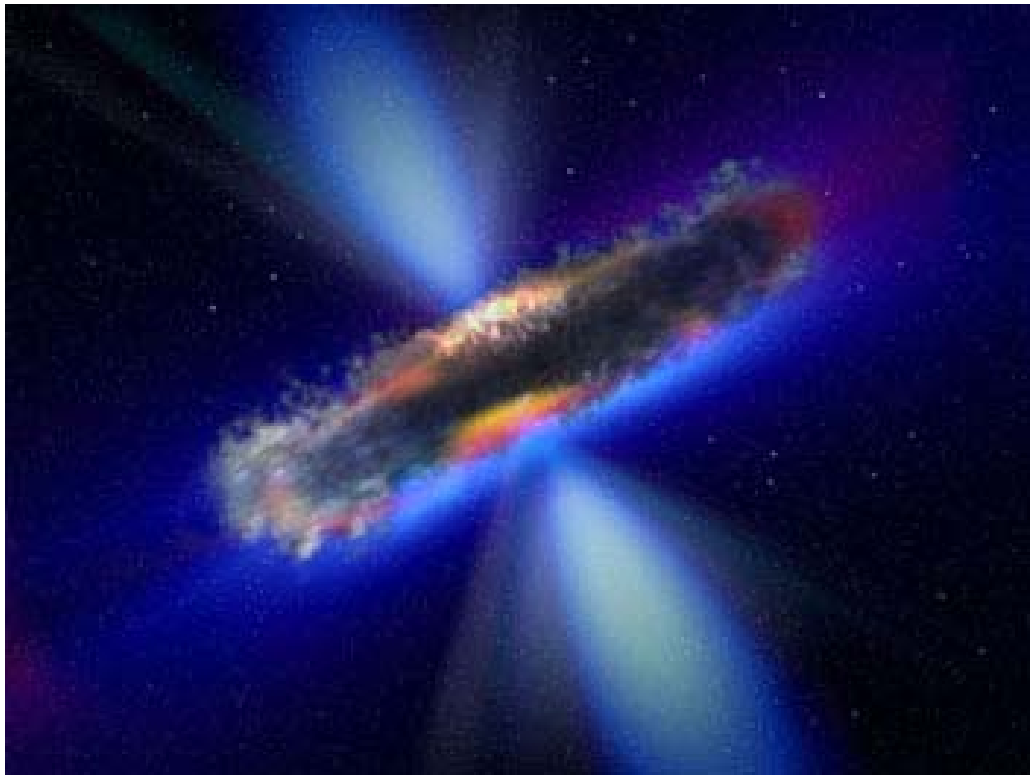
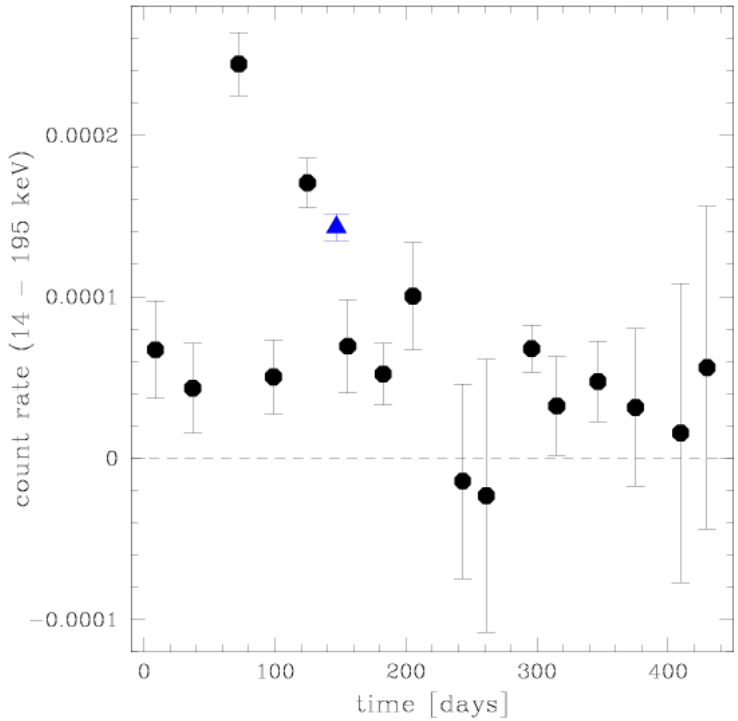
The Dichotomy of Seyfert Galaxies at Hardest X-rays





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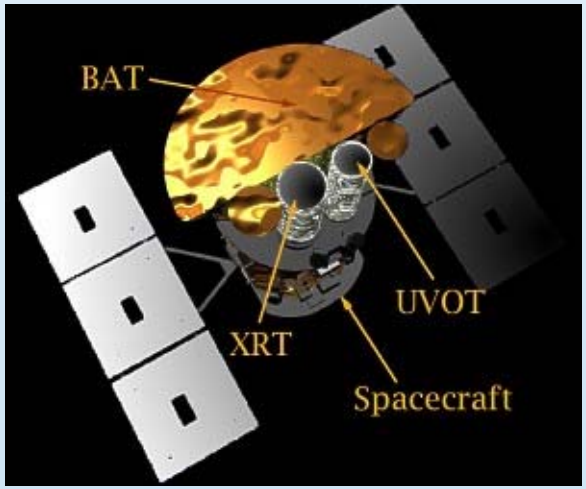
COSPAR 2008, July 2008

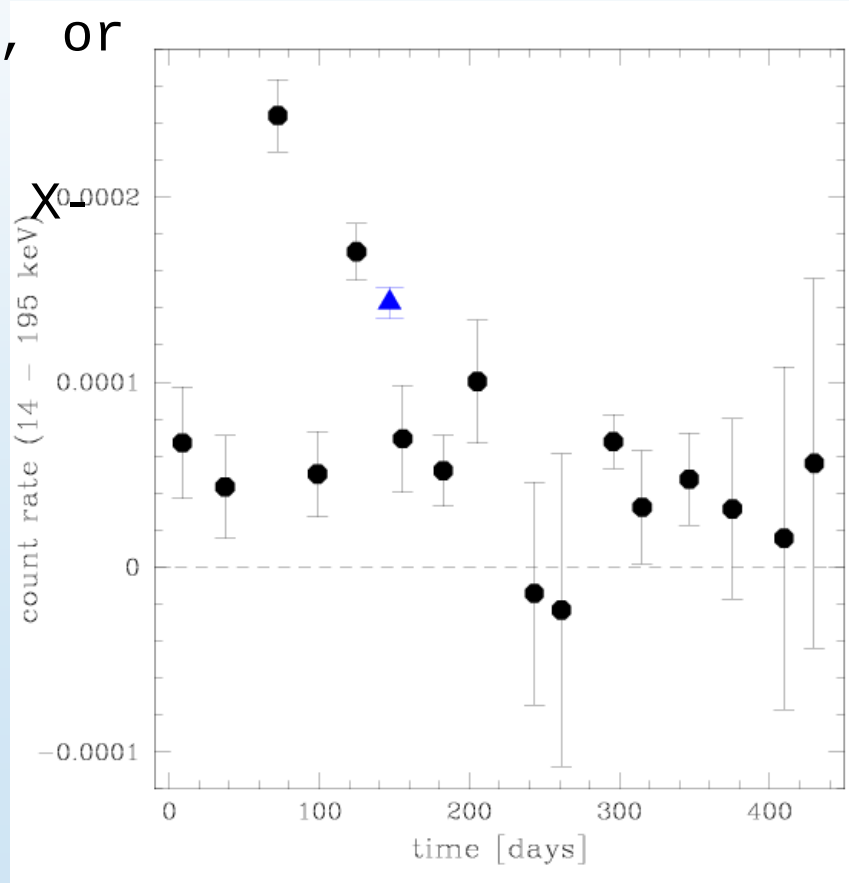
Overview

- **Differences of Seyfert type AGN ?**
- **Variability of AGN at hardest X-rays**
- **Swift/BAT detected AGN in the 9 month survey**
- **Variability analysis**
- **Maximum Likelihood approach**
- **variability as function of Lx and Eddington ratio**
- **other parameters as a function of the hard X-ray spectrum?**
- **Future work**

Scientific goals

- On what time scales do AGN show variability above 15 keV ?
- Does variability depend on source type, on intrinsic absorption, or on spectral shape ?
- What processes drive the hard X-ray variability?





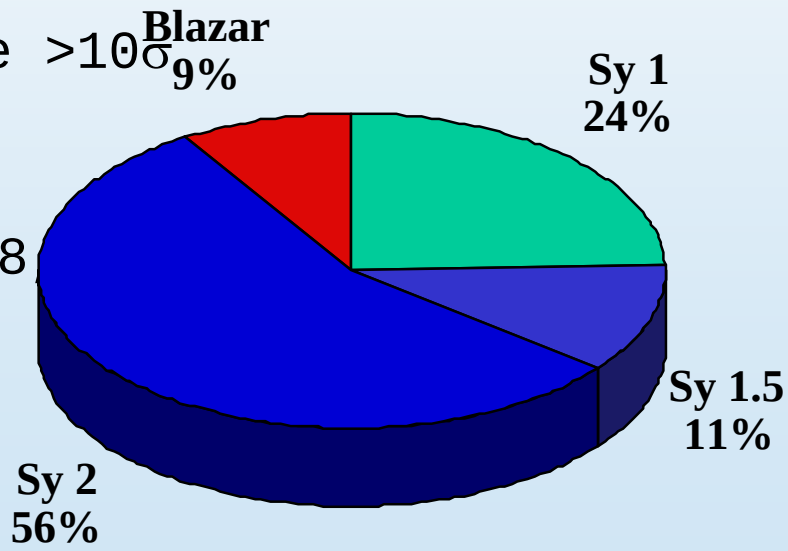
NGC 2992; Beckmann, Gehrels & Tueller (2007)

Swift/BAT 9 month survey

- First 9 months of survey, starting December 2004
- 15 - 195 keV count rates
- 408 sources with significance >5σ
- 160 AGN (w/o unid. sources)
- 44 AGN with significance >10σ
- Swift/BAT AGN paper by

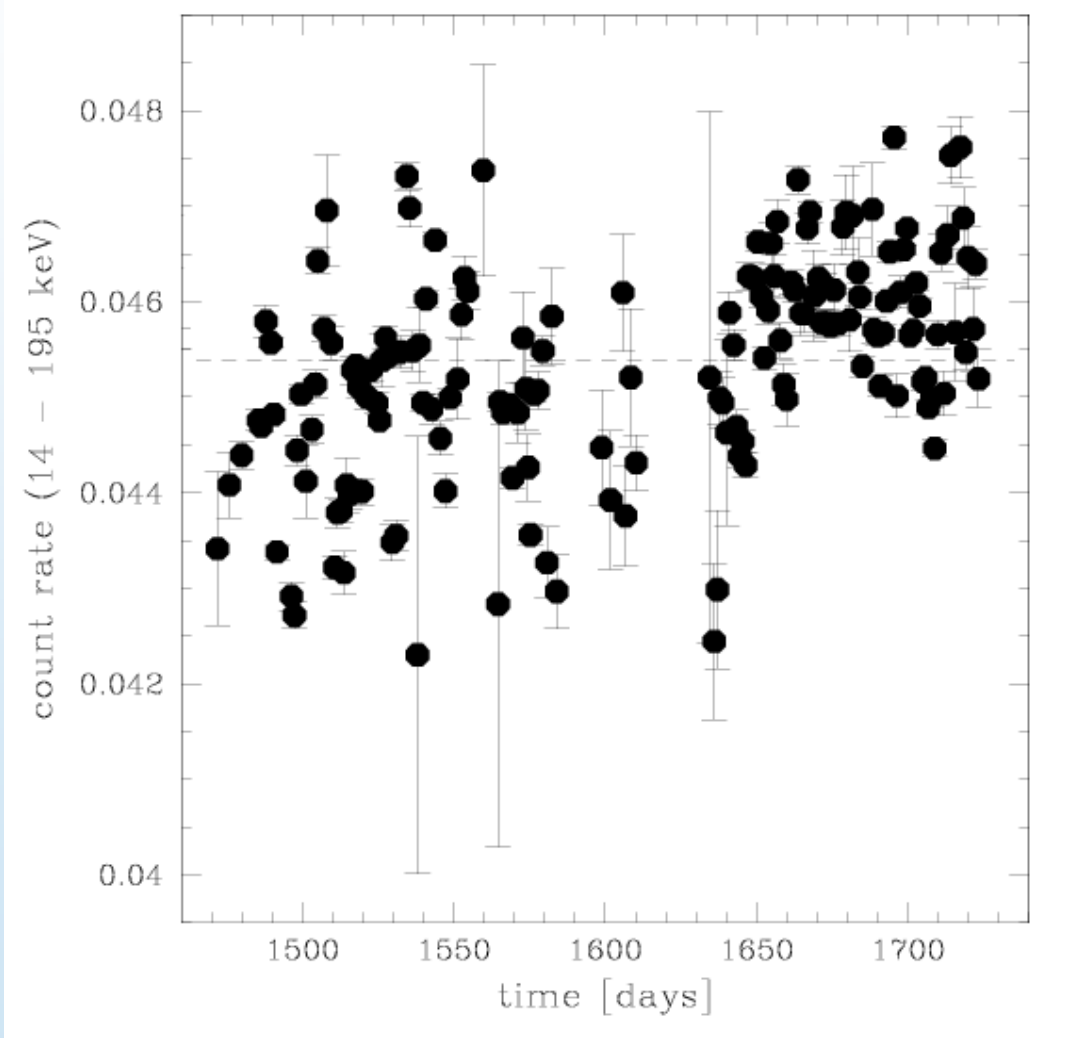
  Jack Tueller et al. 2008

  arXiv:0711.4130



Variability

χ^2 test - only for correct errors (systematic error?



Crab lightcurve from Swift/BAT 9 month

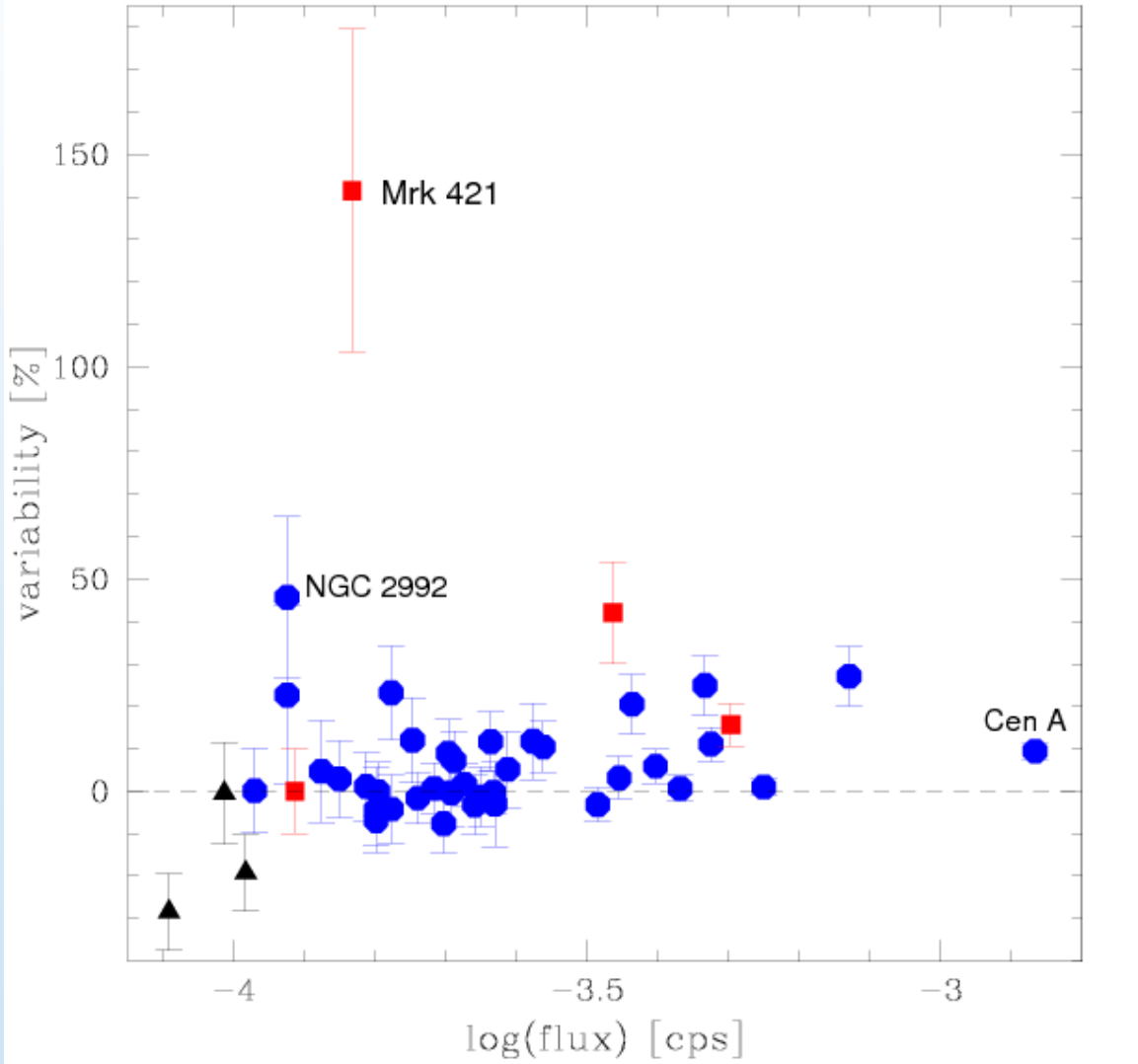
Maximum Likelihood estimator

- Variance has two components: noise and intrinsic variability σ_Q
- Assume that the intrinsic variability is constant
- For Gaussian statistics we can determine the probability density for obtaining the N measurements (x_i, σ_i)
- This can be solved iteratively (see χ^2 form (see Almaini, for details)

$$\sum_{i=1}^{N} \frac{(x_i - \bar{x})^2 - (\sigma_i^2 + \sigma_Q^2)}{(\sigma_i^2 + \sigma_Q^2)^2} = 0$$

Maximum Likelihood estimator

The variability is not a function of source flux



Blazars in red

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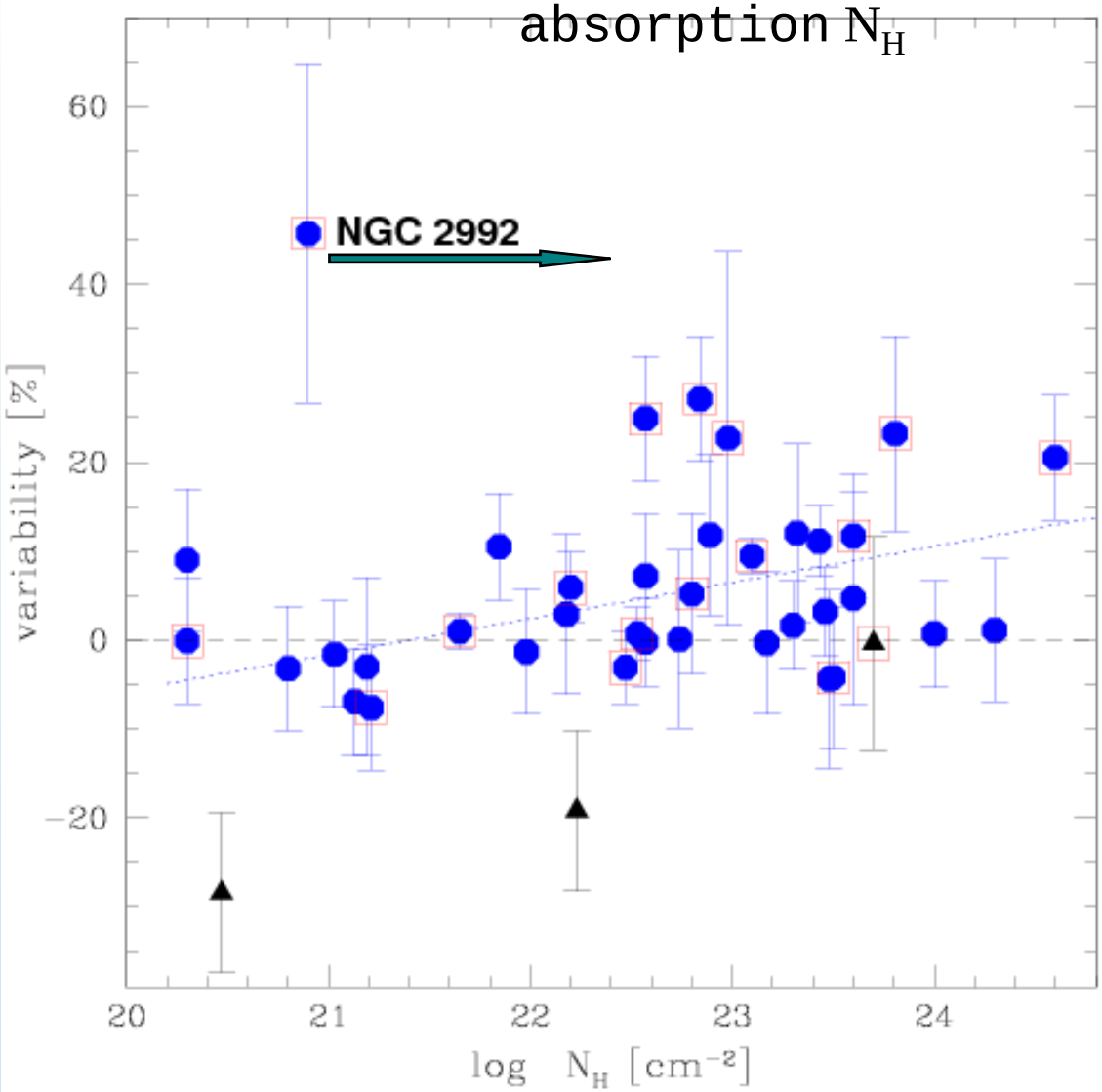
Variability

Variability seems to be a function of intrinsic absorption N_H

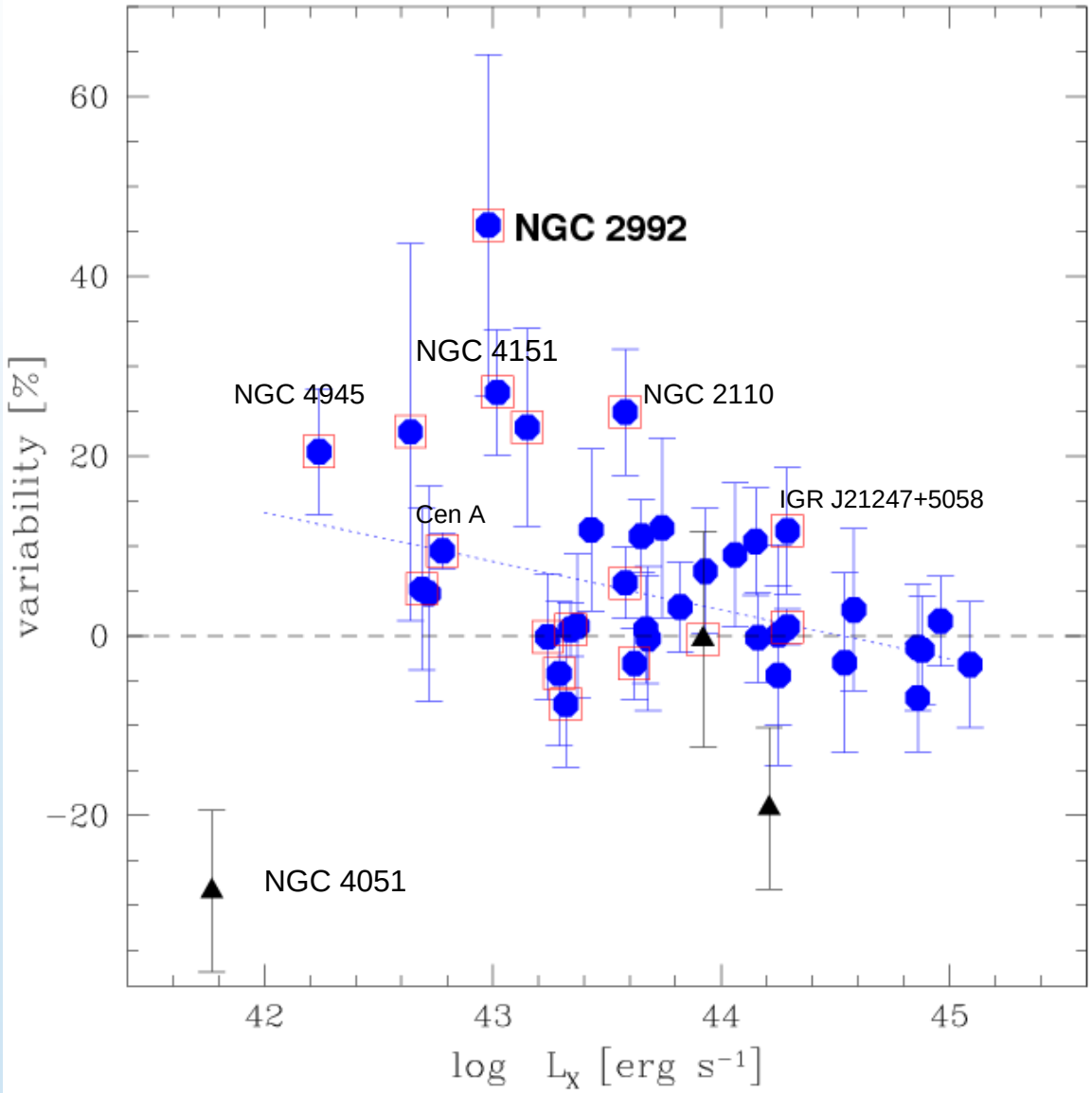


Blazars excluded

Red squares: variable according to structure function analysis

Black triangles: three lowest

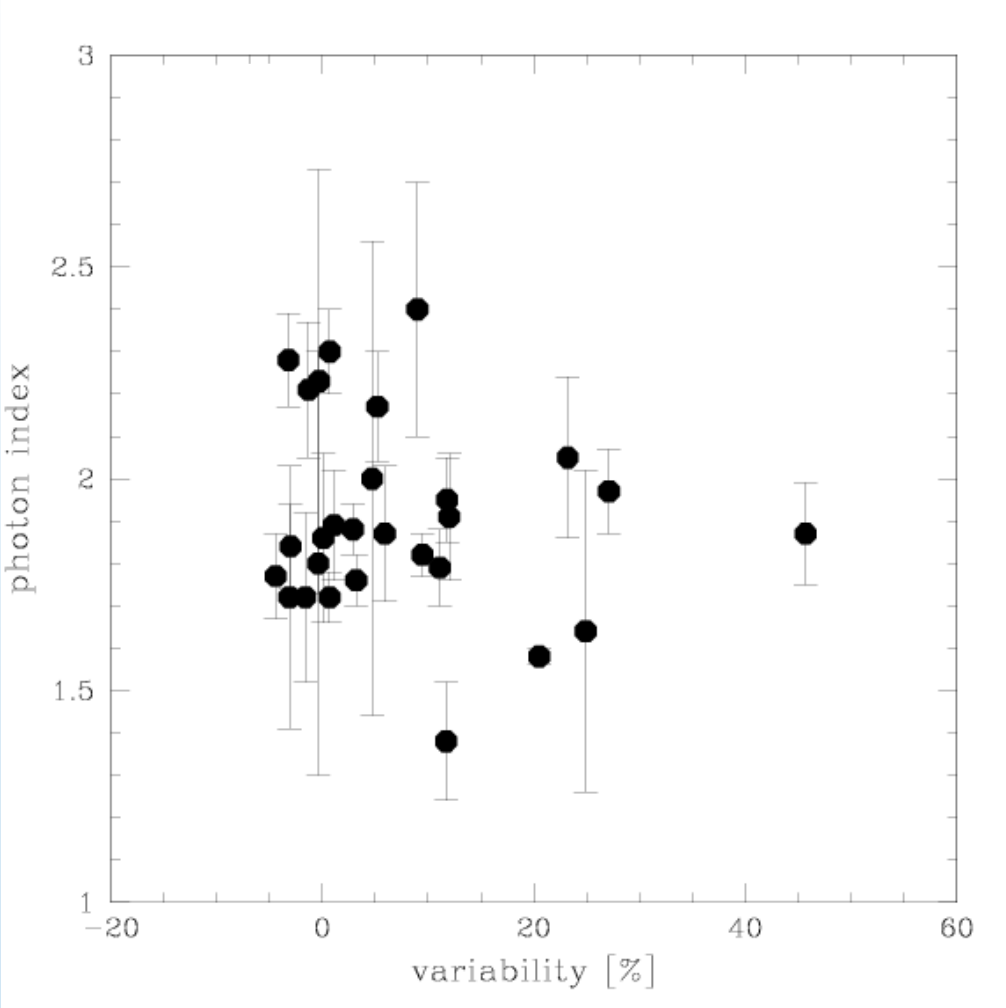
Variability vs. Luminosity



Blazars excluded

Red squares: variable according to structure function analysis

Photon index vs. variability



Photon indices from INTEGRAL IBIS/ISGRI

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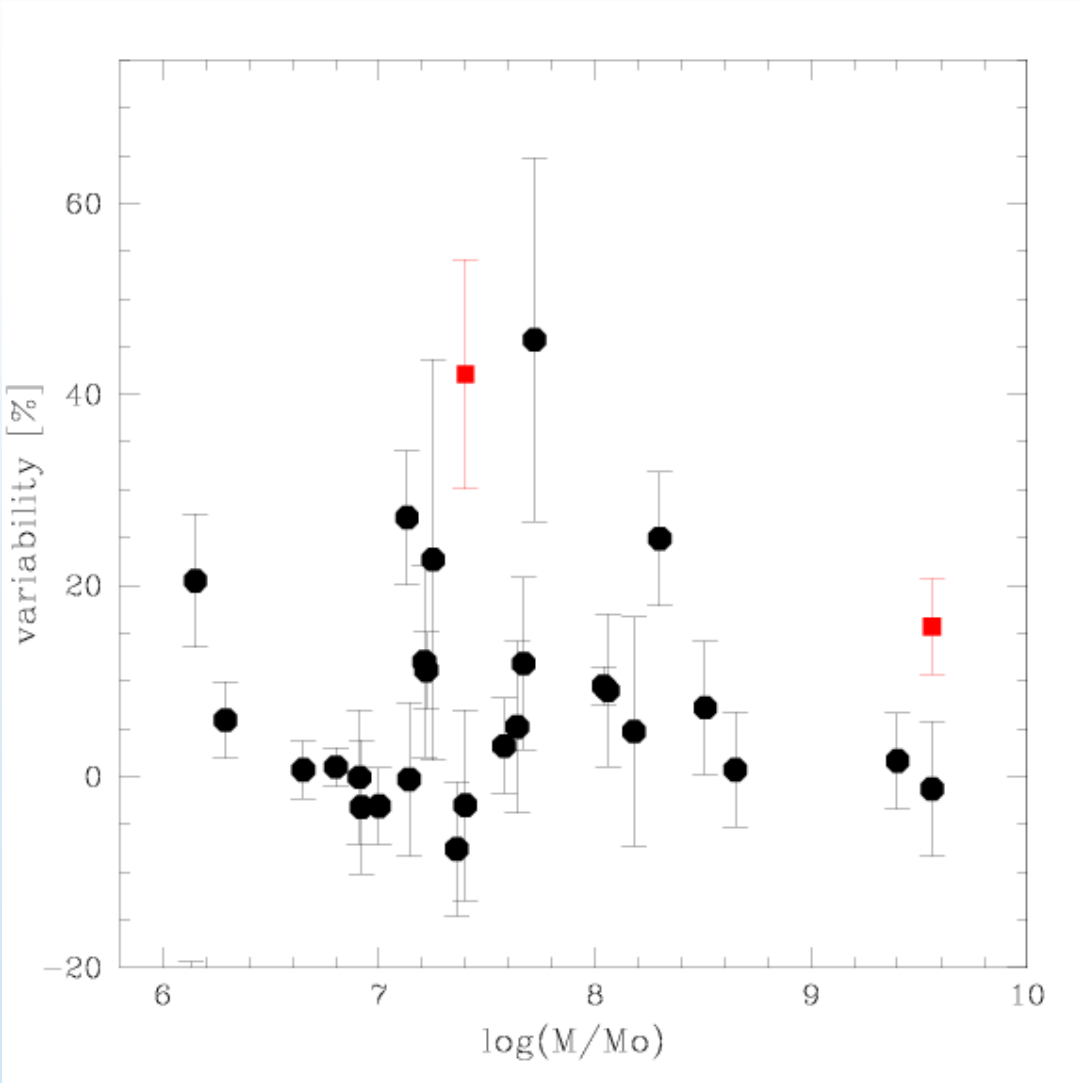
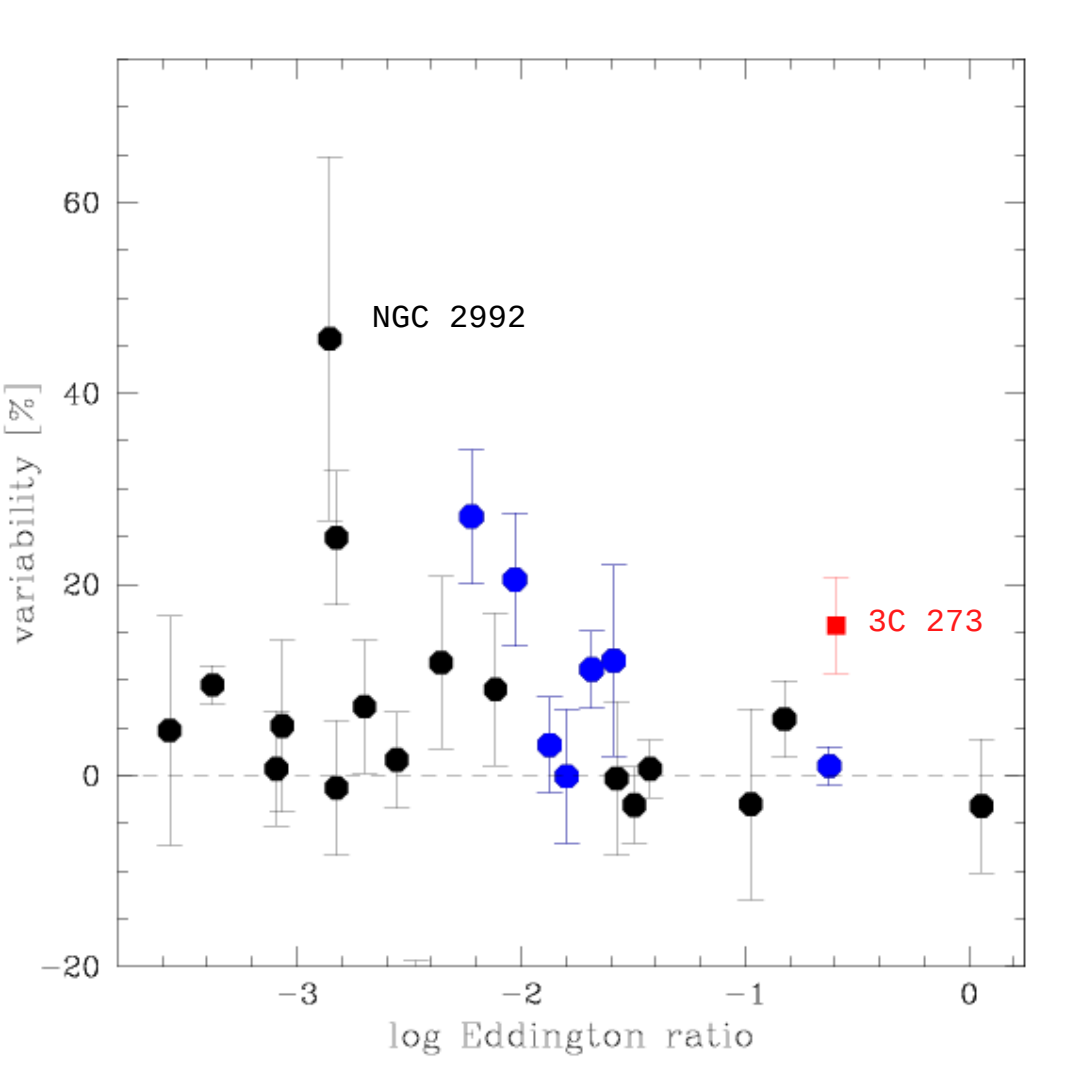
Variability vs. black hole mass



Blazars in red

Black hole masses from Woo & Urry and references therein

Variability vs. Eddington rati



Blue: sources showing a cut-off in INTEGRAL IBIS/ISGRI spectra

Results

- 44 brightest Swift/BAT AGN
- 30% of Seyfert type AGN exhibit variability
- strong variability seen in blazars
- 15% show >20% variability in maximum likelihood estimator
- type 1 objects seem to be less variable than type 2
- probably a function of luminosity / Eddington ratio:
- variable objects are the ones with Lx < 10^{44} erg sec^{-1} and with Eddington ratio < 1%
- seen previously at soft X-rays, optical, UV

Future Work

- underlying physical process
- are absorbed/unabsorbed sources intrinsically different?
- what role does the mass / Eddington ratio play ?
- use of INTEGRAL combined JEM-X, IBIS ISGRI/PICsIT and SPI spectra for the brightest ~150 AGN

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Dichotomy ?

Seyfert 1/Seyfert 2 galaxies show no differences
hardest X-rays
(except for spectral slope?)