Constraining Key Coronal Parameters of Black Holes via X-ray Reflection Spectroscopy

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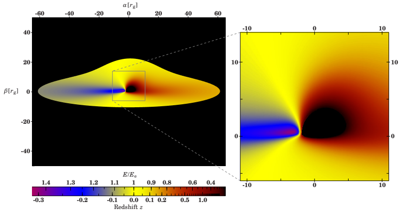
Modeling Relativistic Reflection: RELXILL

RELXILL: Relativistic reflection model that combines detailed reflection spectra from **xillver** (García & Kallman 2010), with the **relline** relativistic blurring code (Dauser et al. 2010).



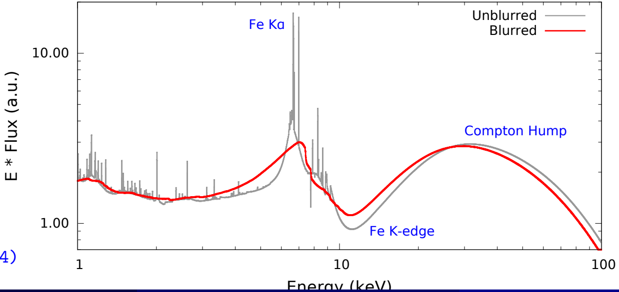
Model Parameters

a: Black hole spin, R_{in}: Disk's inner edge

i: Inclination, ϵ: Emissivity index

R_f: Reflection fraction, Γ: Power-law index

E_{cut}: High-energy cutoff, A_{Fe}: Fe abundance



(García+Dauser+14)

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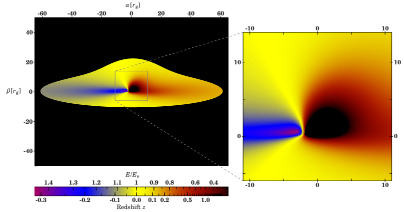

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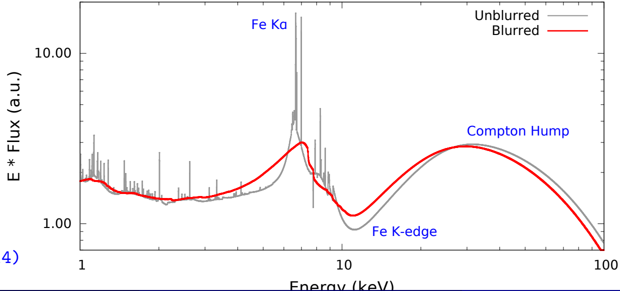


(García+Dauser+14)

Coronal Parameters

In the standard picture, the continuum power law spectrum is generated in a hot corona by Compton up-scattering of thermal UV disk photons:

$$\boxed{\Gamma = -\frac{1}{2} + \sqrt{\frac{9}{4} + \frac{1}{\theta_e \tau_e (1 + \tau_e/3)}}}$$

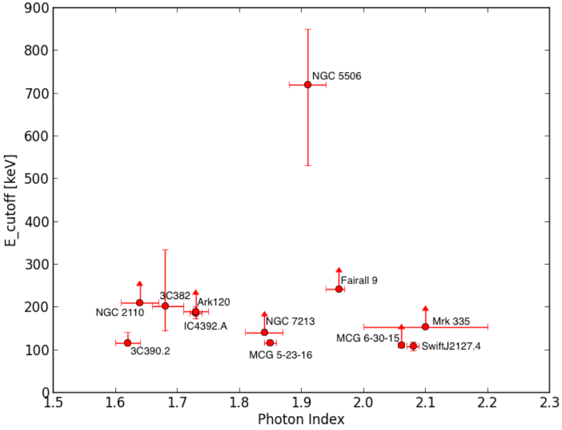
where $\theta_e = kT_e/m_e c^2$ and $m_e c^2 = 511$ keV is the electron rest mass (Lightman+Zdziarski 1987).

In practice:

$$\boxed{E_{\rm cut} \sim 2 - 3kT_e}$$

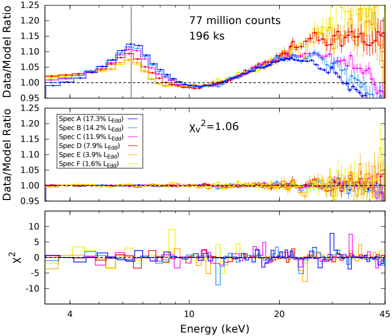
Observational Evidence

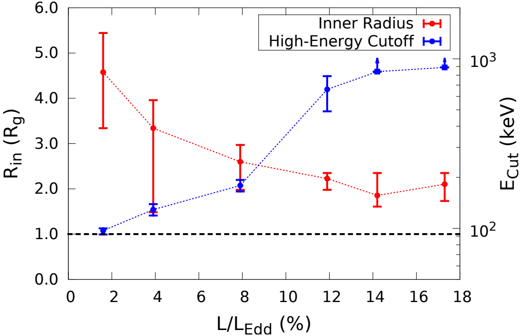
(A. Marinucci's talk, also A. Fabian, C. Reynolds, etc...)



Also, $E_{\rm cut} > 600$ keV for NGC 4151 (Keck+15)

Also in GX 339–4!



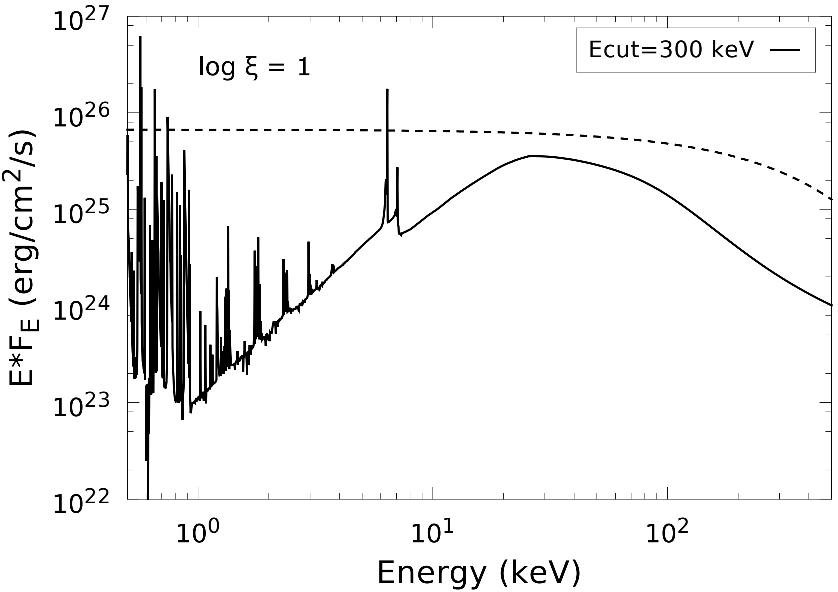


PCA RXTE observations of **GX 339–4** in the hard state for 6 different luminosities

$E_{\rm cut} > 890$ at $\sim 17\% L_{\rm Edd}$

García+15 (arXiv:150503607G)

Including the Cutoff



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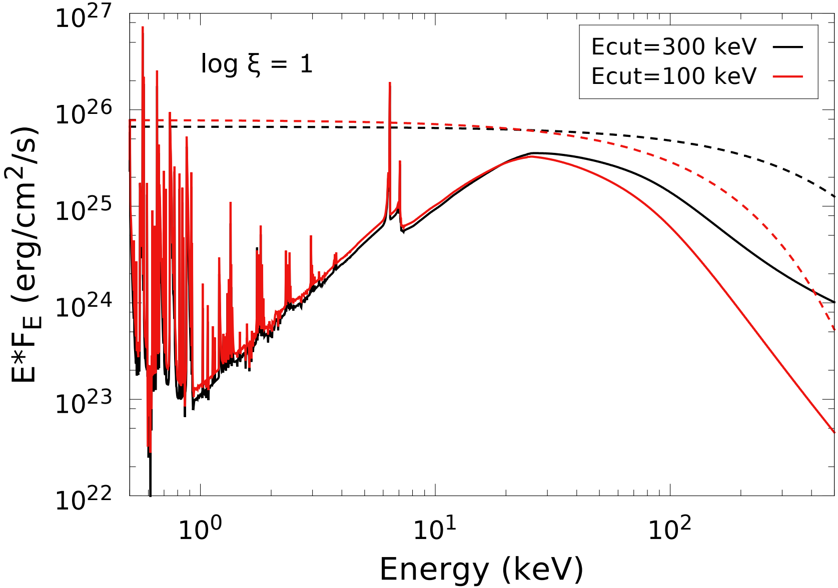

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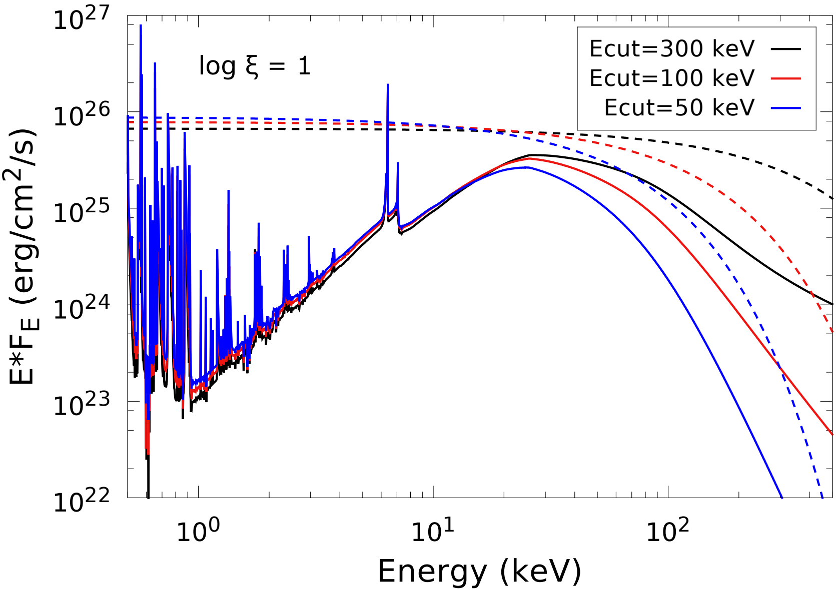
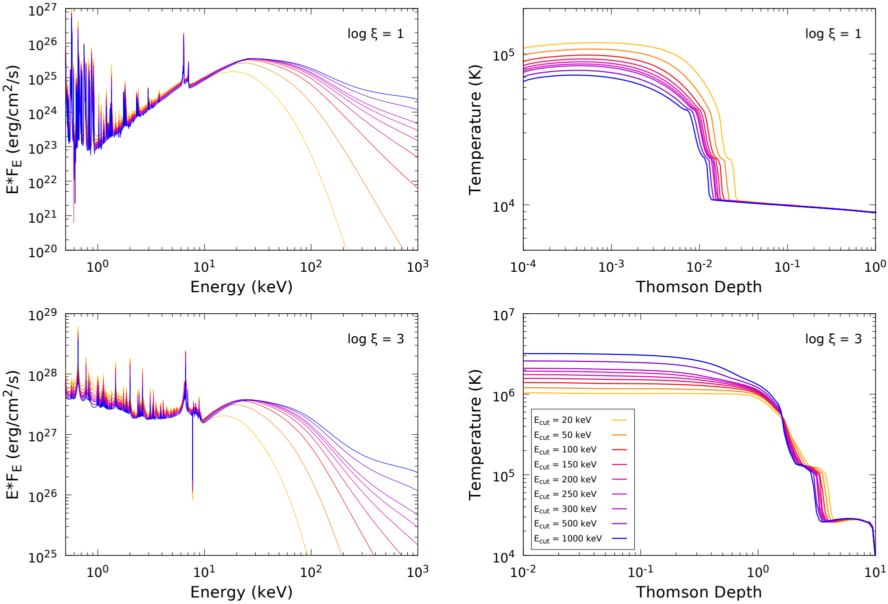
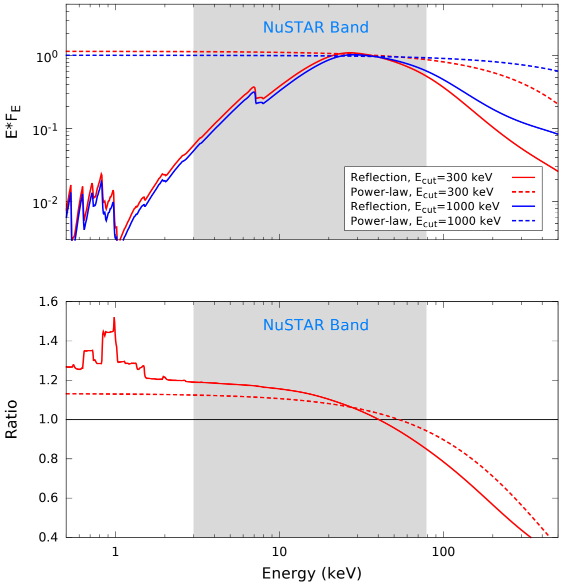


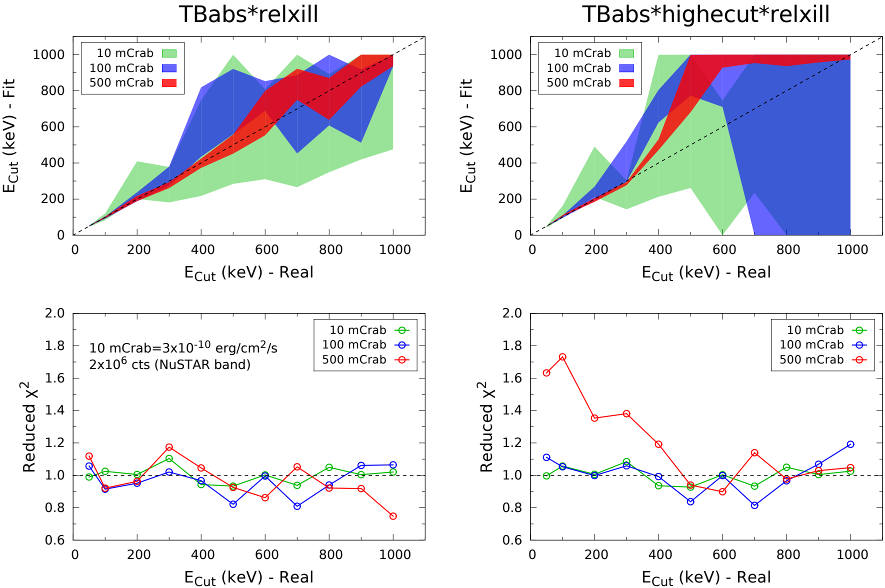
Effects on the Reflection Spectrum (no GR)



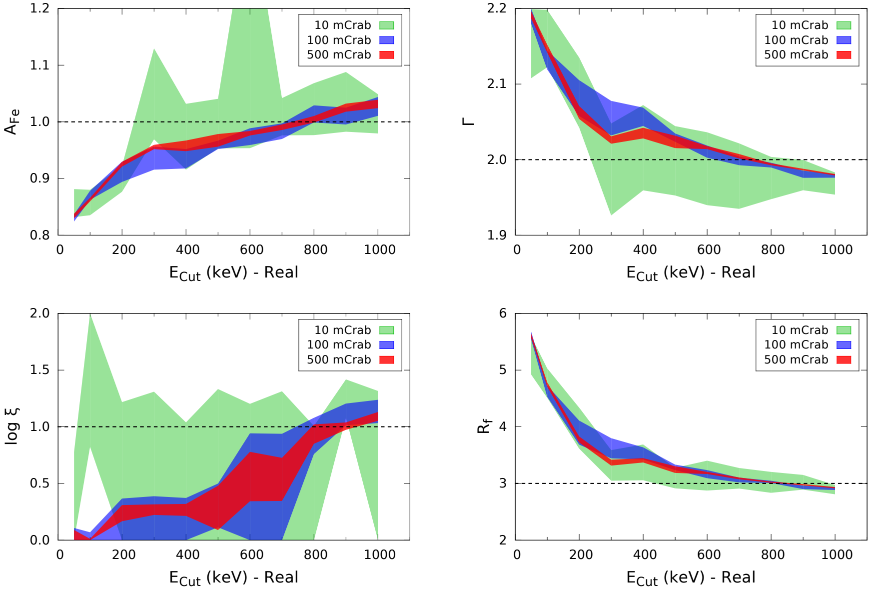
Reflection in the NuSTAR band (with GR)



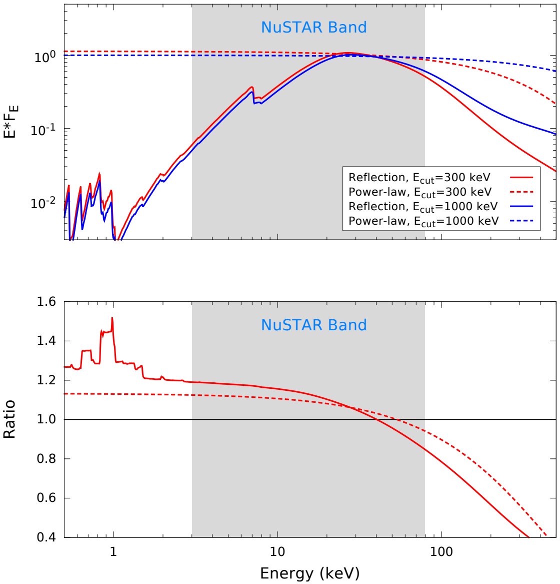
NuSTAR Simulations (100 ks)



Model Parameters: TBabs*highecut*relxill



Including Low-Energy Data



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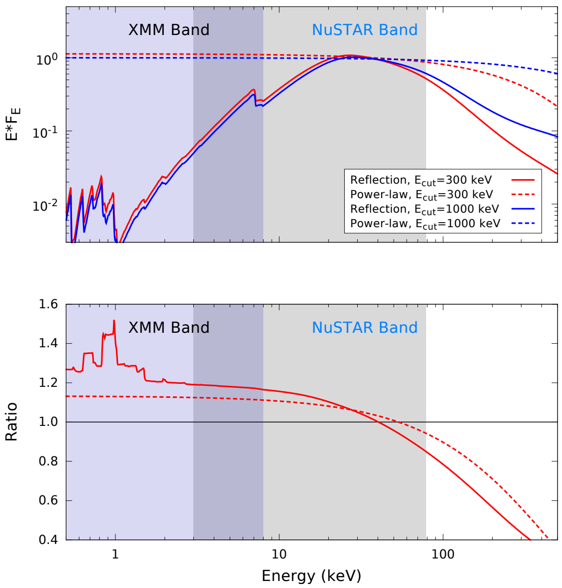

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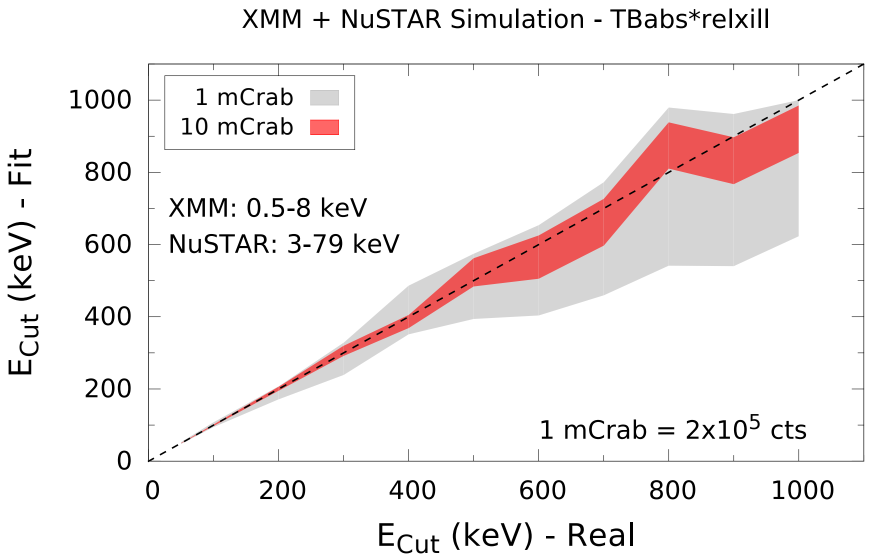
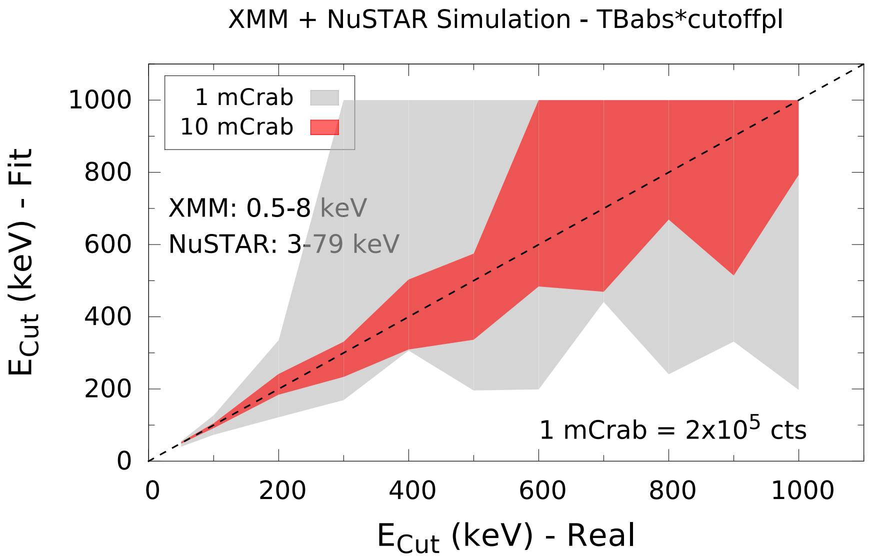


Only using a Cutoff-Powerlaw (i.e. No Reflection!)



Conclusions

- In constraining E_{Cut}, misleading results are obtained if only the power-law continuum is modeled. It is therefore essential to employ a detailed and accurate model of the reflection spectrum, which includes E_{Cut} as a fit parameter.
- Because the cutoff energy most strongly affects the low-energy part of the reflection spectrum, to obtain useful constraints on E_{Cut} for AGN it is crucial to combine NuSTAR data with low-energy (e.g., XMM-Newton or Suzaku) data.
- Fitting for E_{Cut} could have important implications in the understanding of the soft-energy emission.