A *Suzaku*, *NuSTAR*, and *XMM-Newton* view on variable absorption and relativistic reflection in NGC 4151

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FAKULTÄT

NGC 4151 - Source Properties

- Well-studied nearby Seyfert 1.5
- Brightest radio-quiet Seyfert $< 10\,\mathrm{keV}$
- Non-variable soft emission from extended, photo-/collisionally ionized environment (e.g., Ogle et al., 2000; Yang et al., 2001; Schurch et al., 2004; Wang et al., 2011a,b,c)
- Strongly variable hard X-ray spectrum (e.g., Caballero-Garcia et al., 2012)
- Strongly variable neutral absorbers (days to years) (e.g., Holt et al., 1980; Yaqoob et al., 1989; Yaqoob et al., 1991; Schurch et al., 2002; Puccetti et al., 2007; de Rosa et al., 2007; Wang et al., 2010)
- Seyfert 1 properties: variability, broad Fe Kα line (e.g., Yaqoob et al., 1995; Zdziarski et al., 2002; Keck et al., 2015)

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Our aim: symbiosis of **strong gravity** and **variable absorption** in NGC 4151

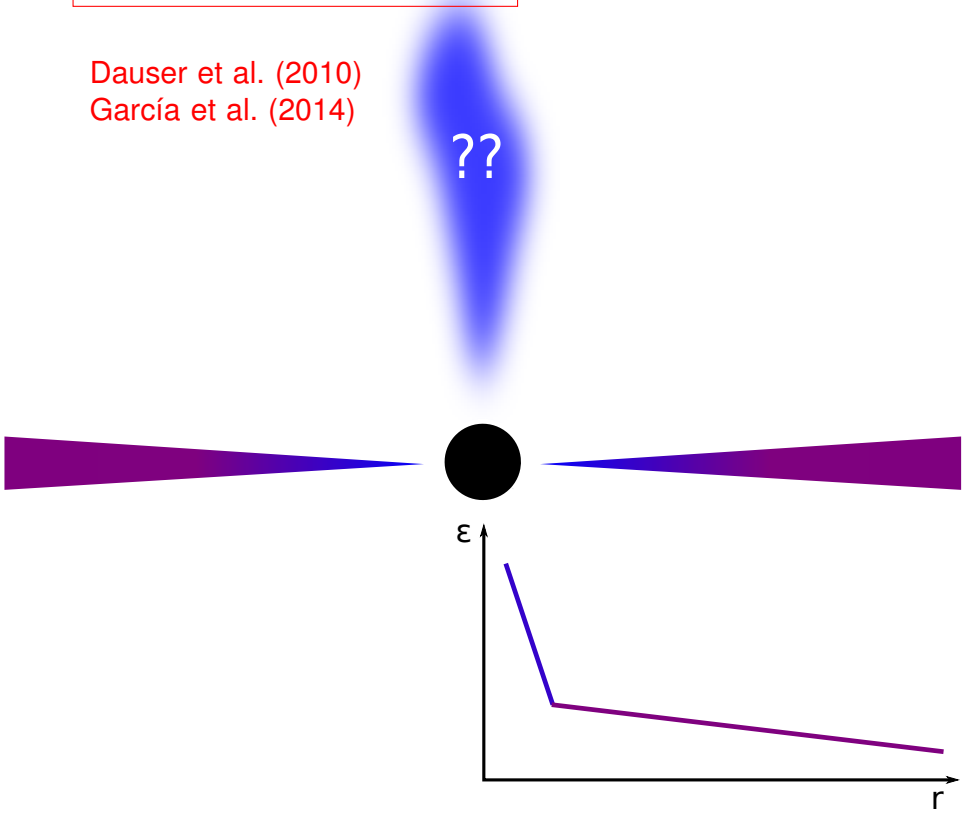
(compare width NGC 1365: Risaliti et al. 2009a, 2013; Brenneman et al. 2013; Walton et al. 2014)

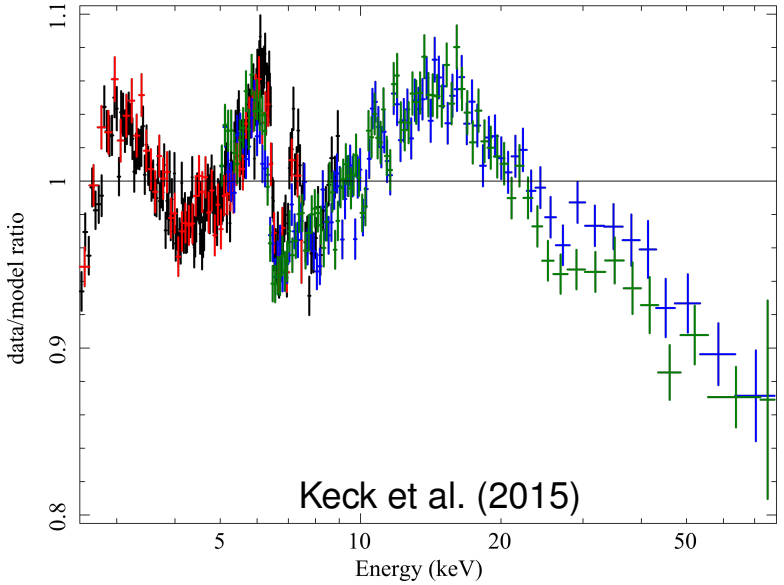
$\Rightarrow$ **Beuchert et al., 2017 (arXiv:1703.10856)**

Inner-Disk Reflection

`xillver*relconv`

Dauser et al. (2010)
García et al. (2014)





Inner-Disk Reflection

`relxilllp_Cp`

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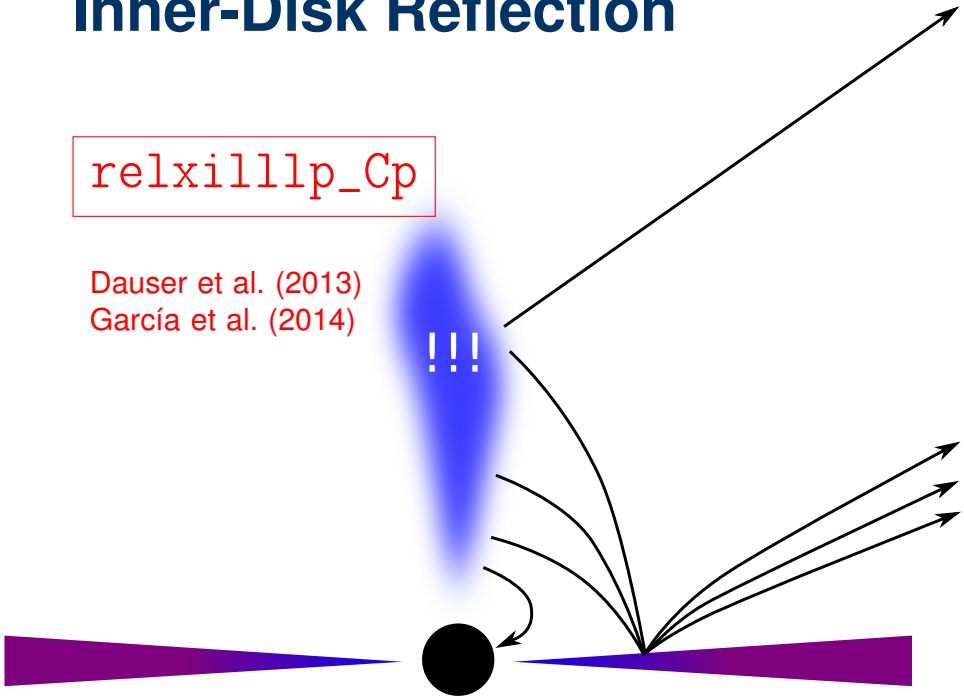
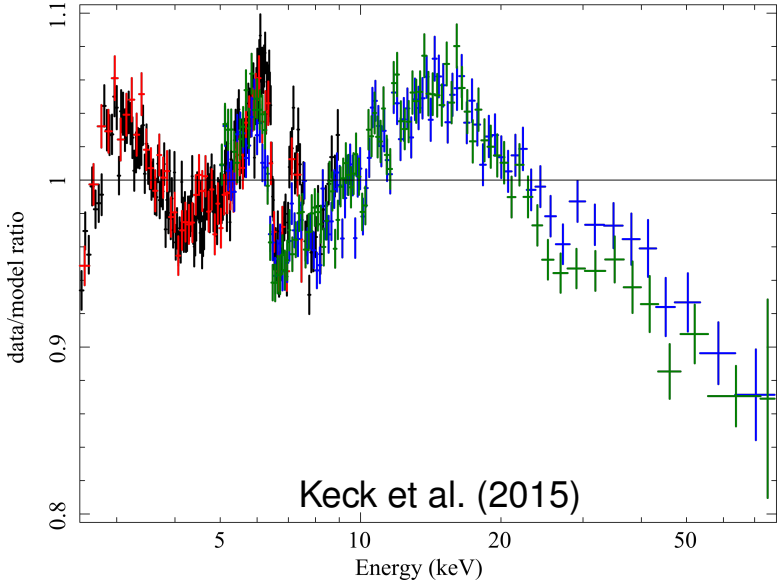


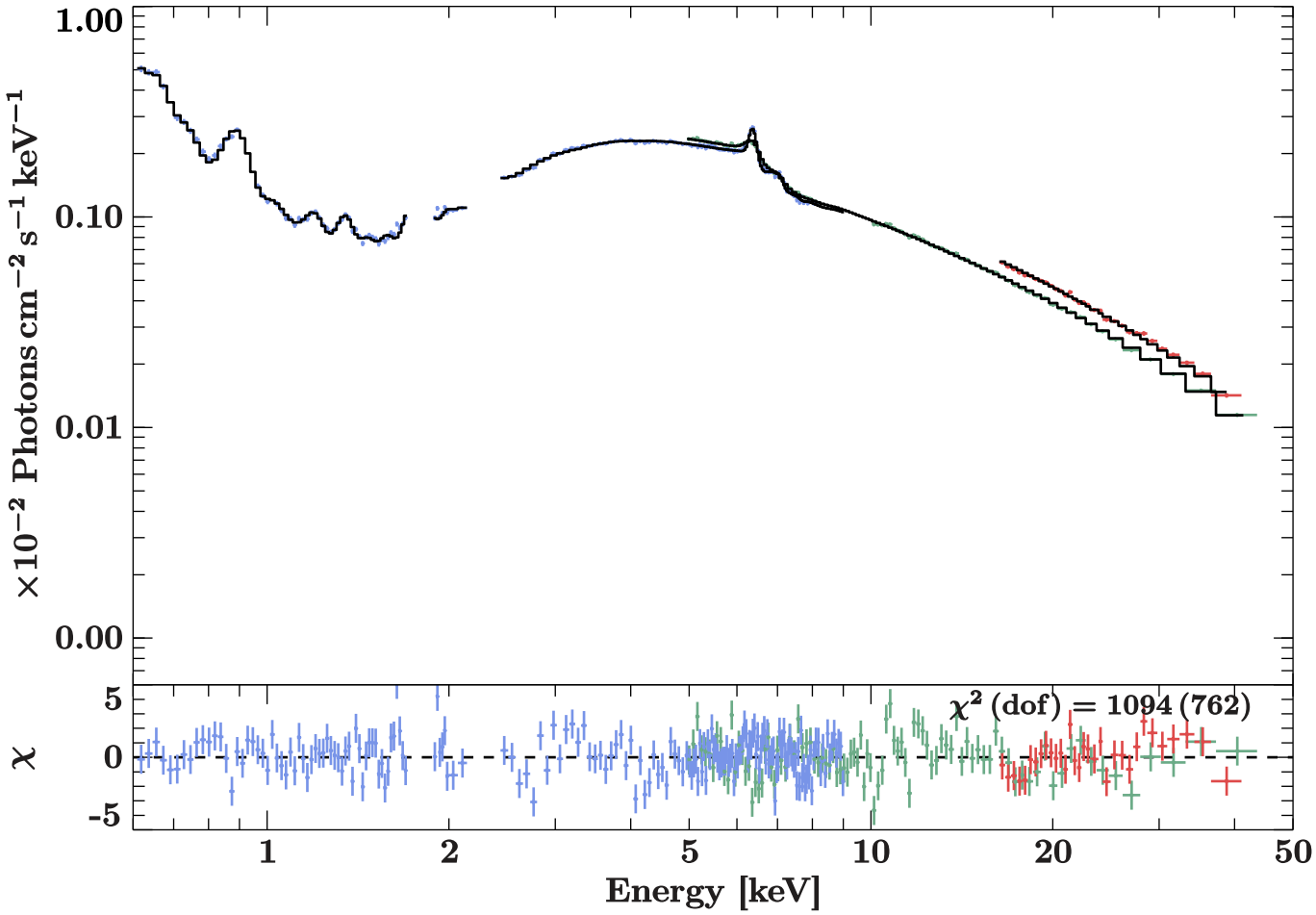


Observed emissivity profiles self-consistently explained in lamp-post geometry

see also: Svoboda et al. (2012) and refs. therein

poster J10 by Marco Fink et al.
talk by T. Dauser at 18:15

Establishing a Baseline Model



Beuchert et al., 2017 (arXiv:1703.10856)

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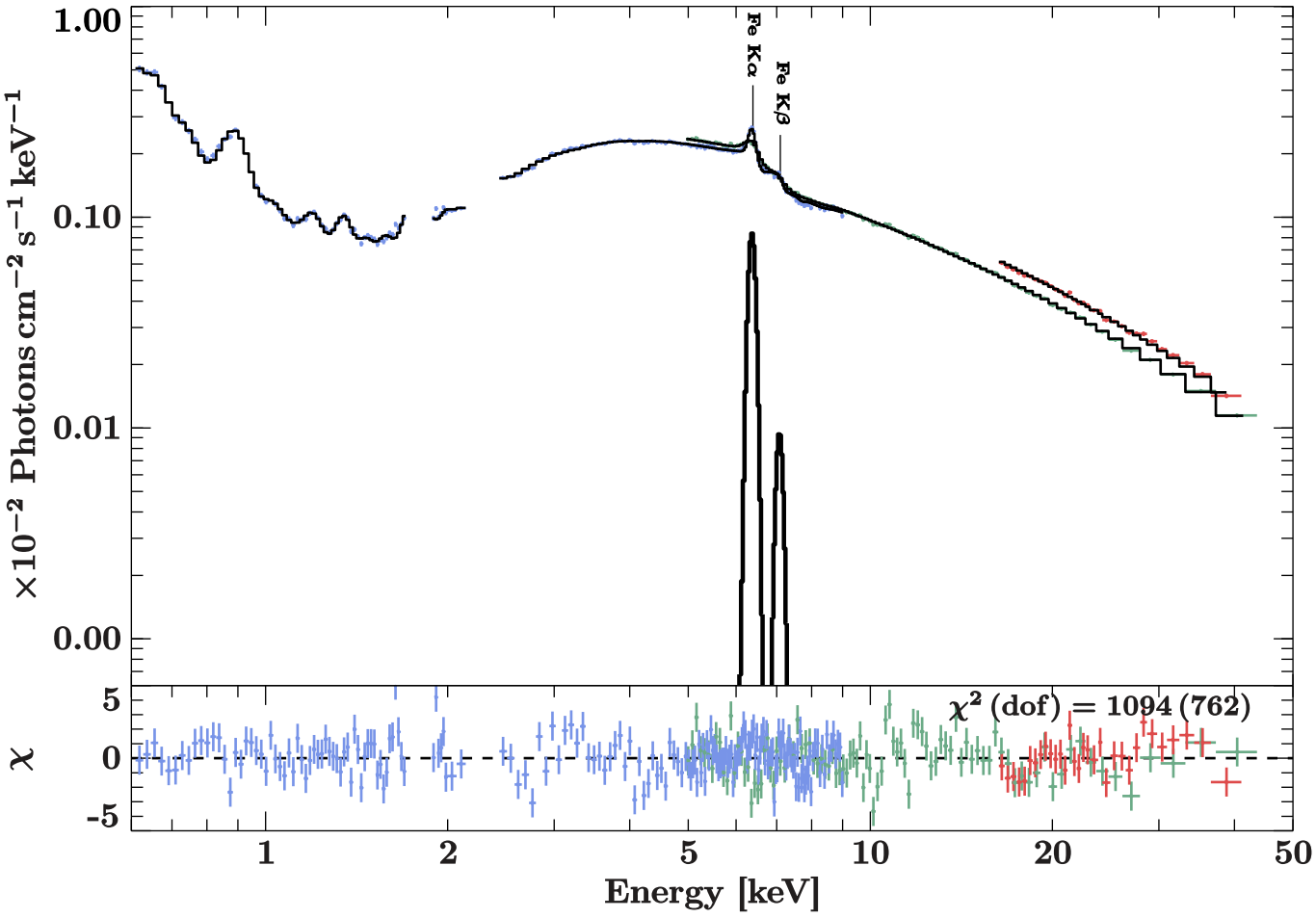

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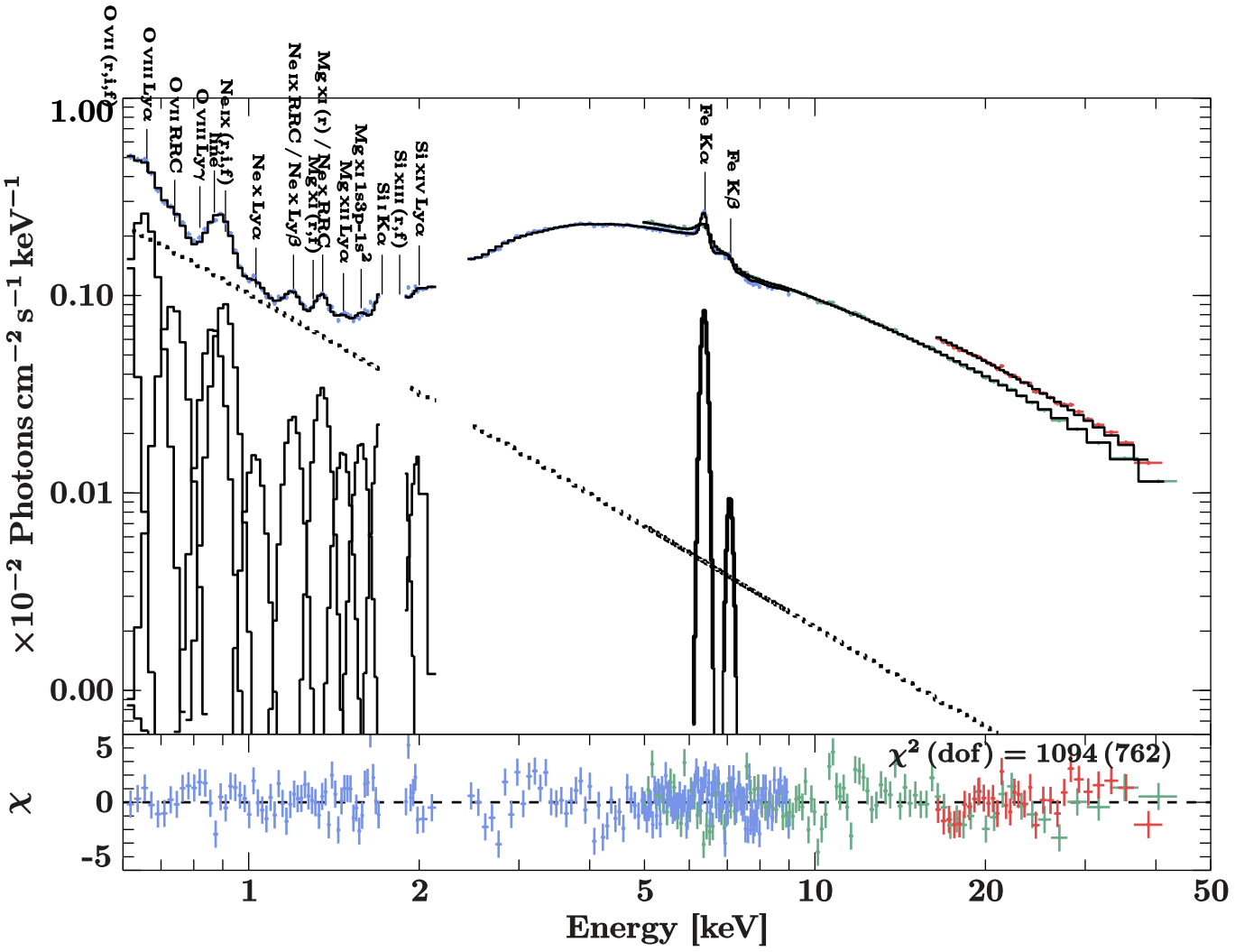

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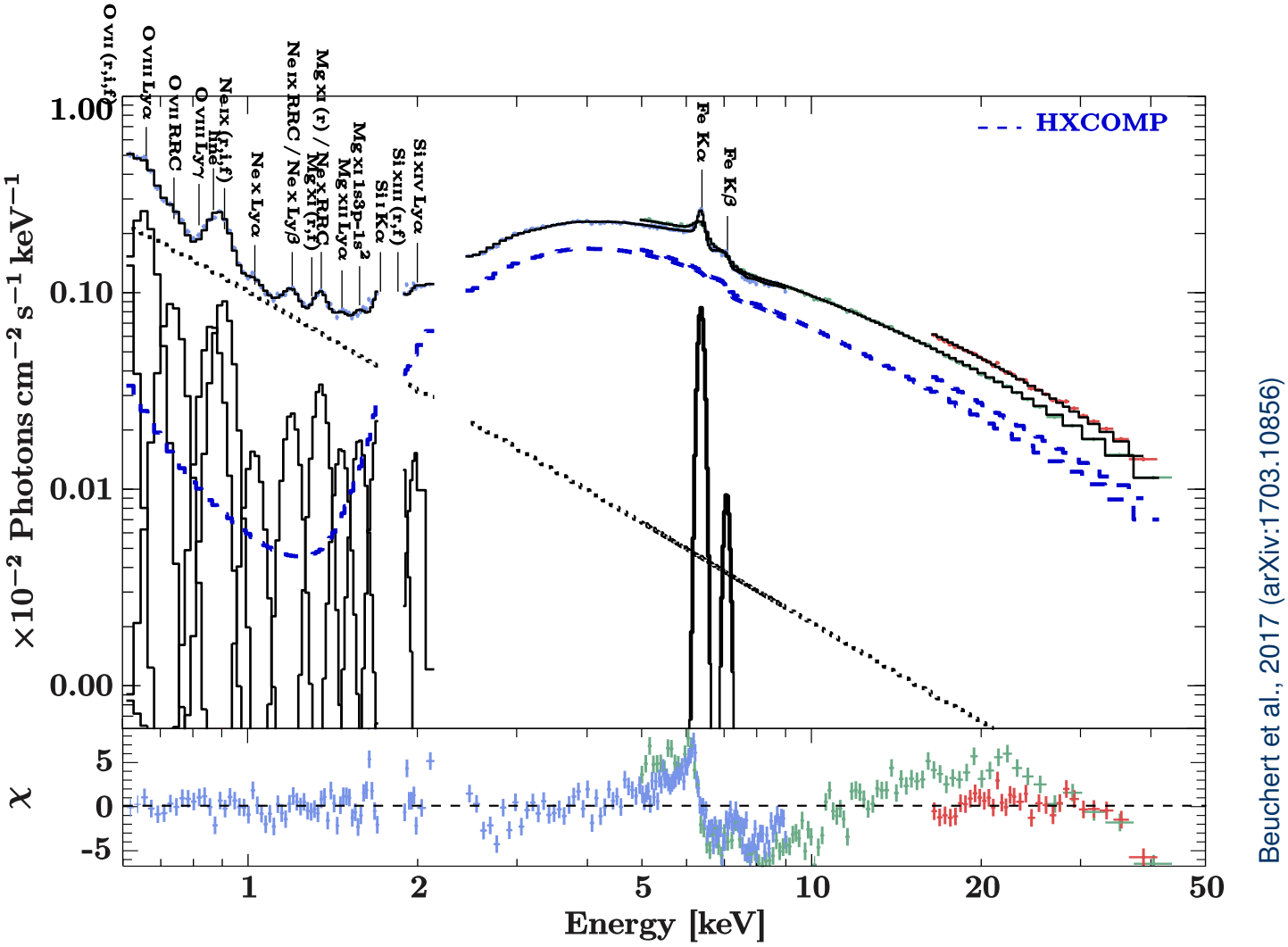

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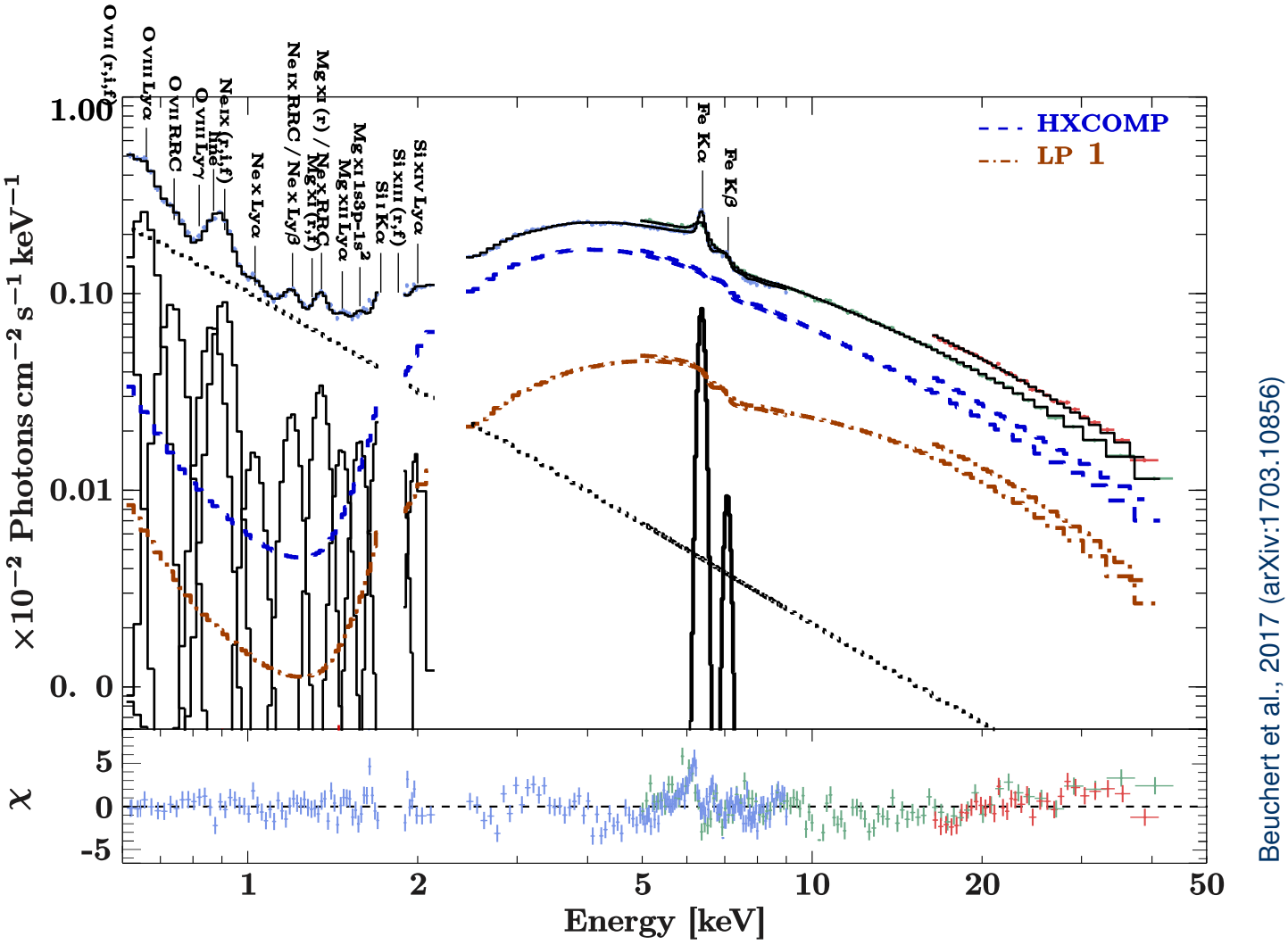

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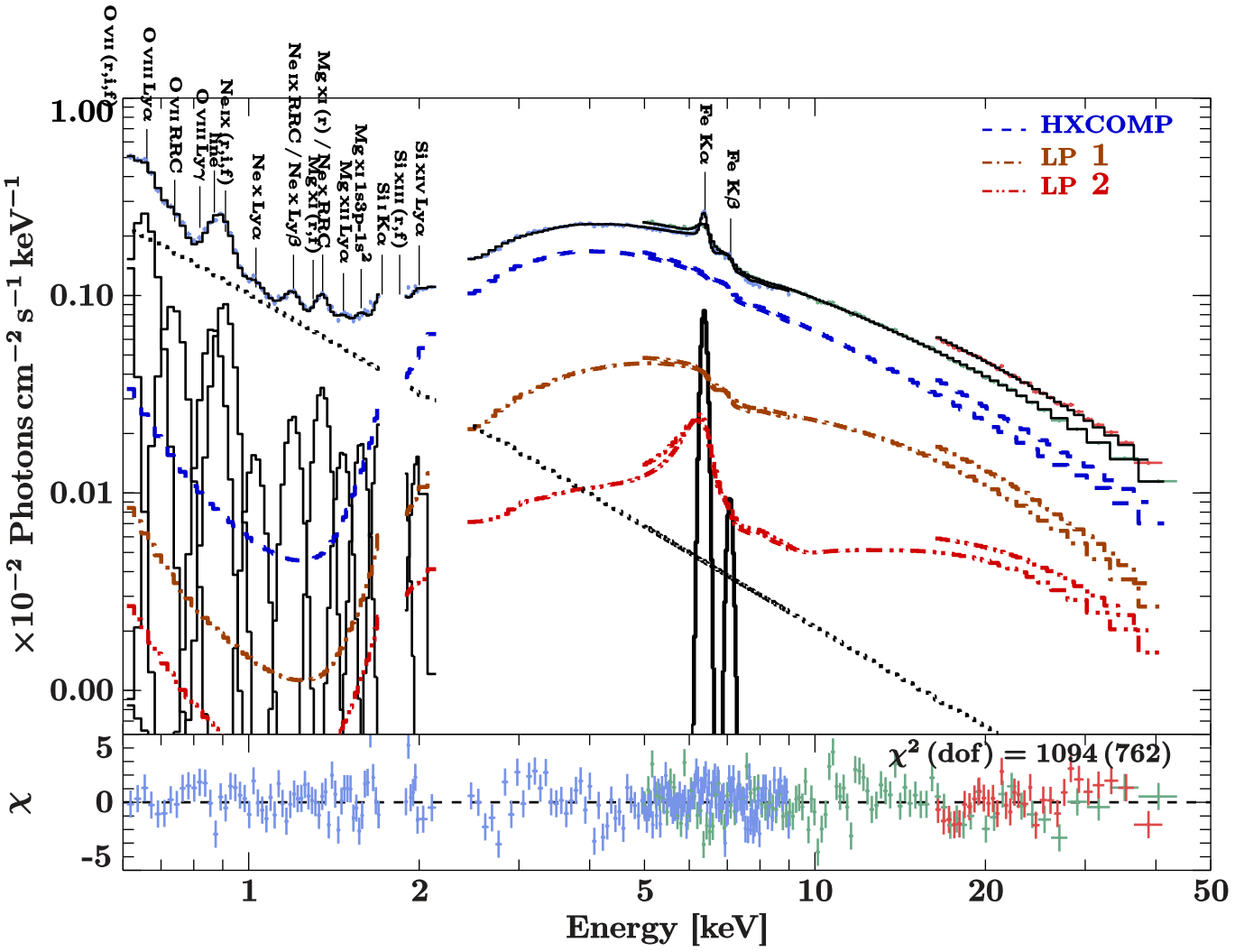
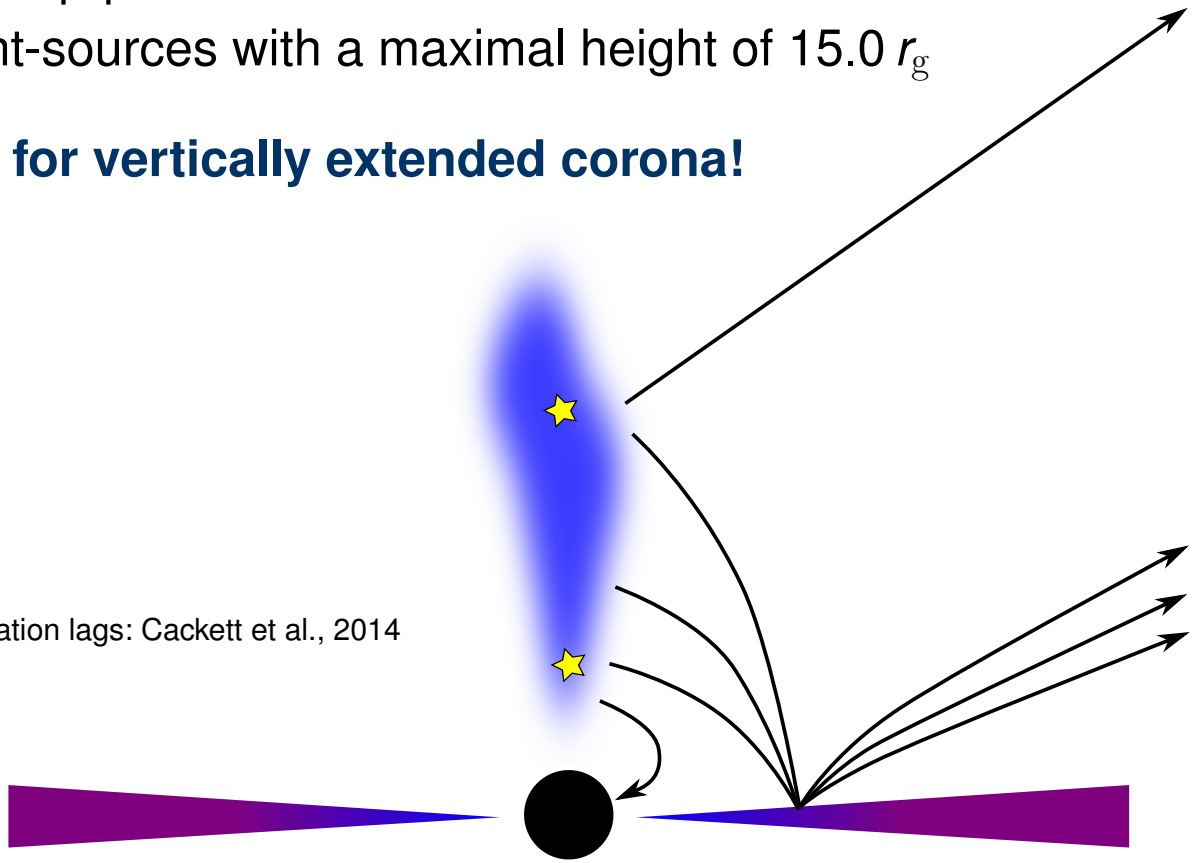


Beuchert et al., 2017 (arXiv:1703.10856)

Establishing a Baseline Model

- Self-consistent lamp-post solution works well
- Require two point-sources with a maximal height of 15.0 r_g

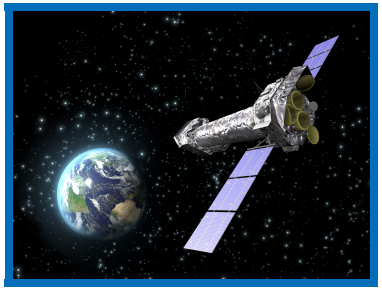
Strong arguments for vertically extended corona!

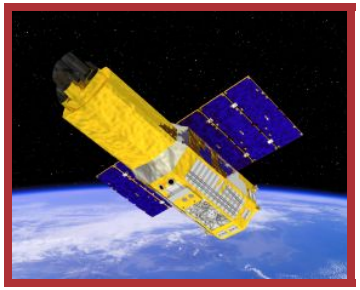


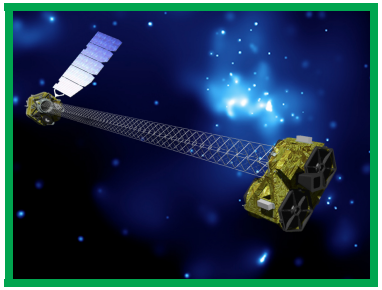
consistent with reverberation lags: Cackett et al., 2014

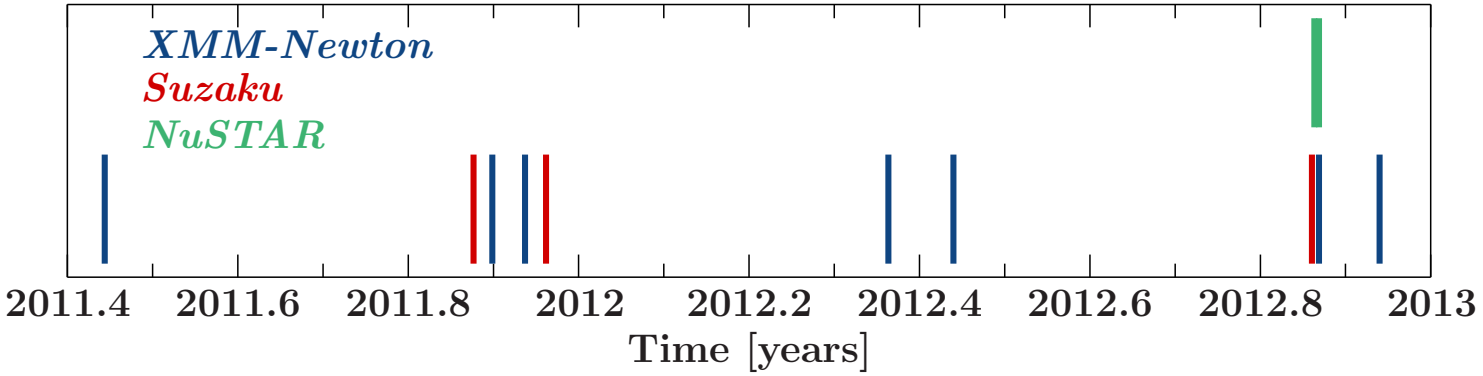
Time-Resolved Spectroscopy

Beuchert et al., 2017 (arXiv:1703.10856)









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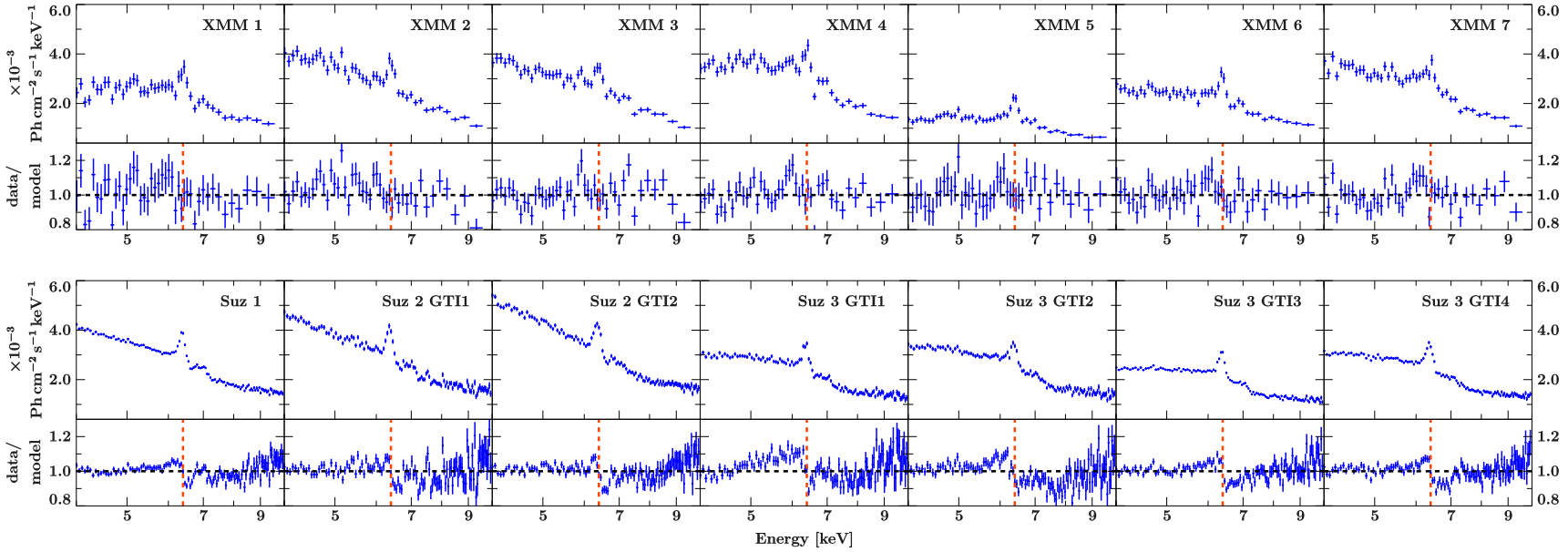
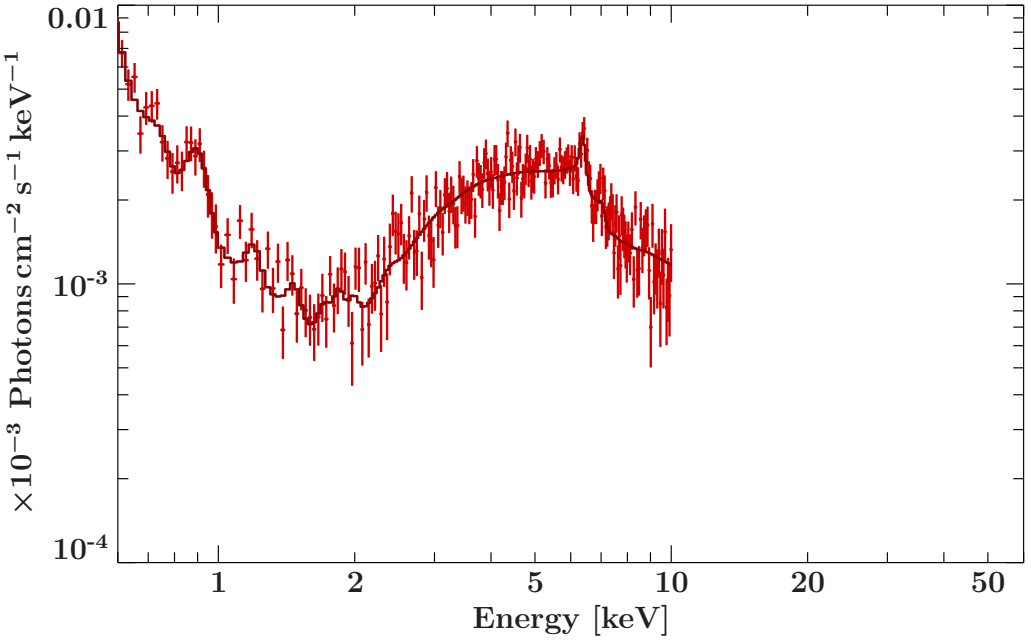
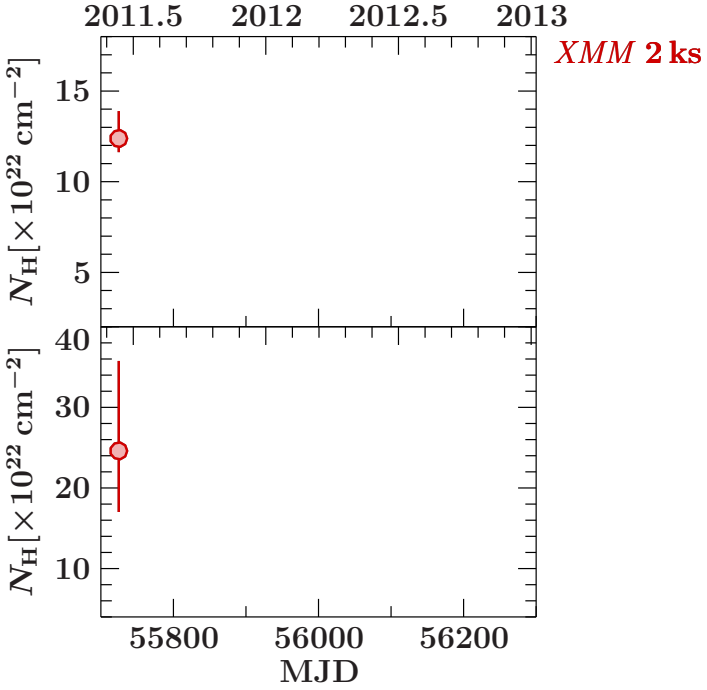


Beuchert et al., 2017 (arXiv:1703.10856)

- Blurred Fe K α feature visible in nearly all observations
- **Apply baseline model to all spectra**
- Major free parameters: $N_{\mathrm{H},1}$, $N_{\mathrm{H},1}$, incident flux

Time-Resolved Spectroscopy





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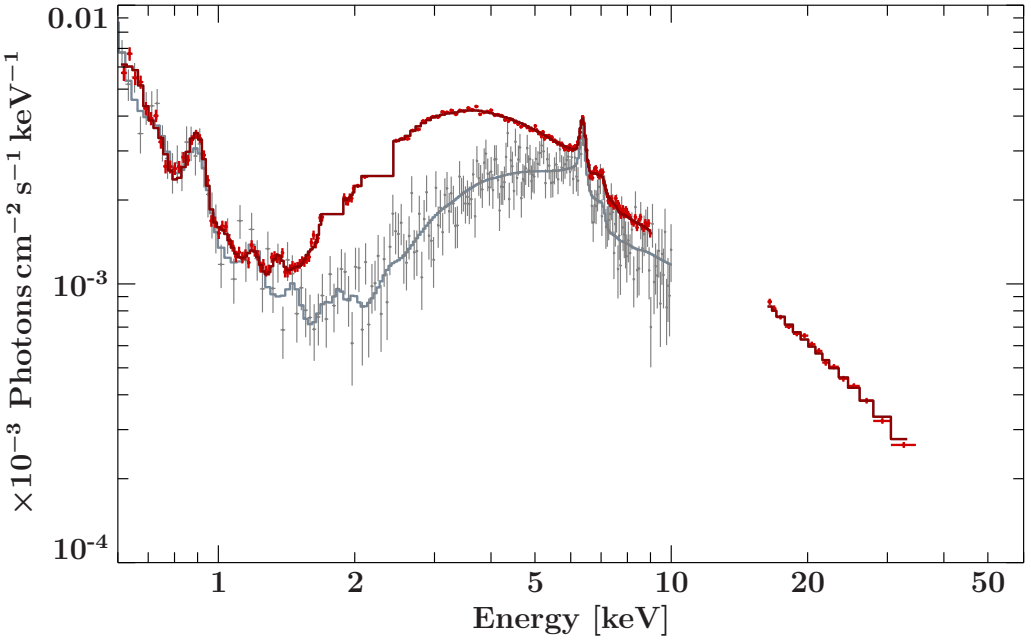

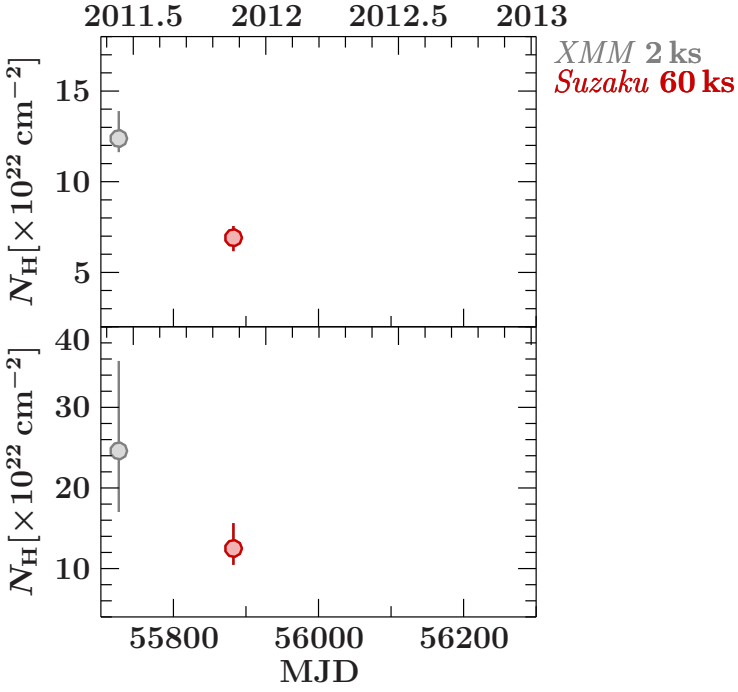

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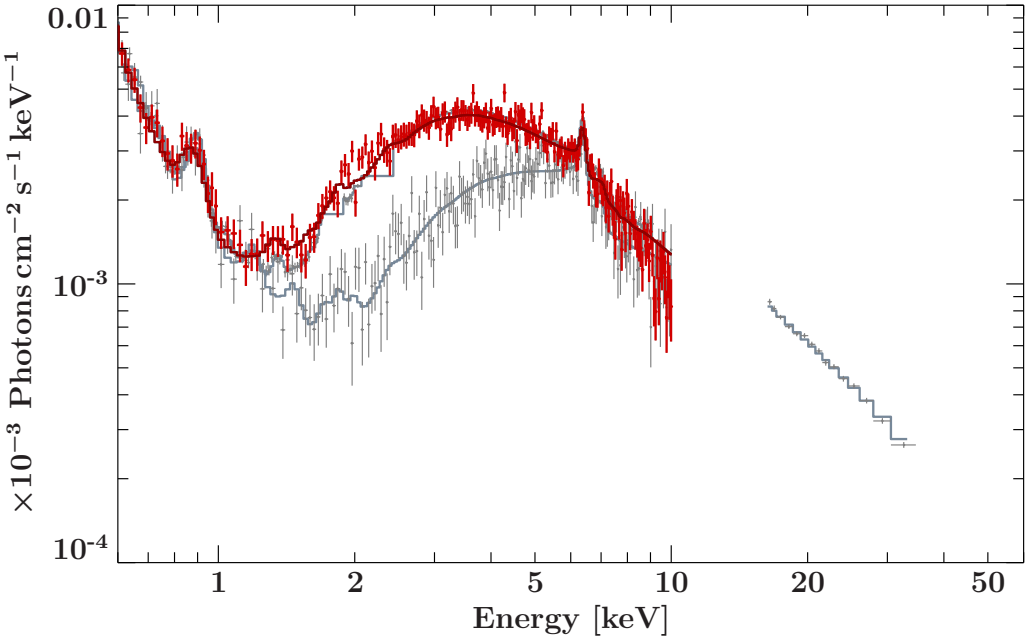

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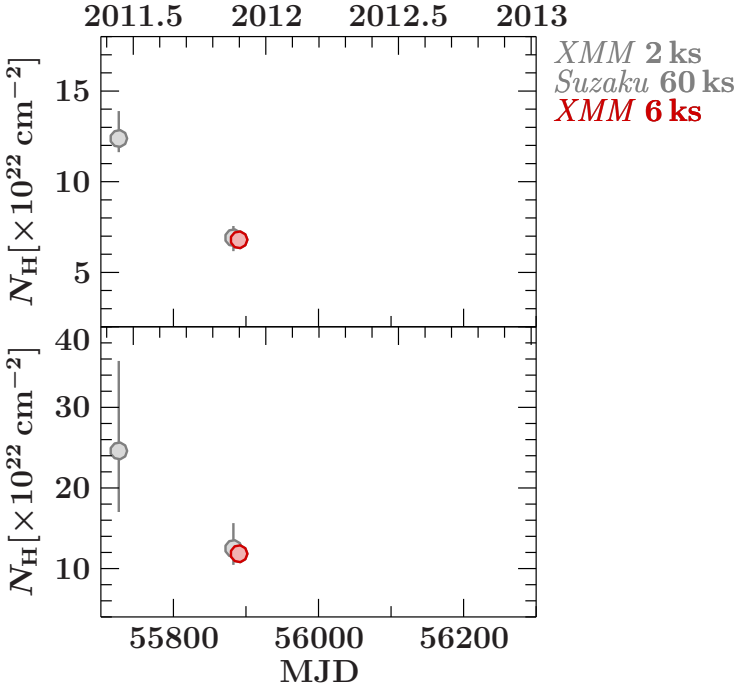

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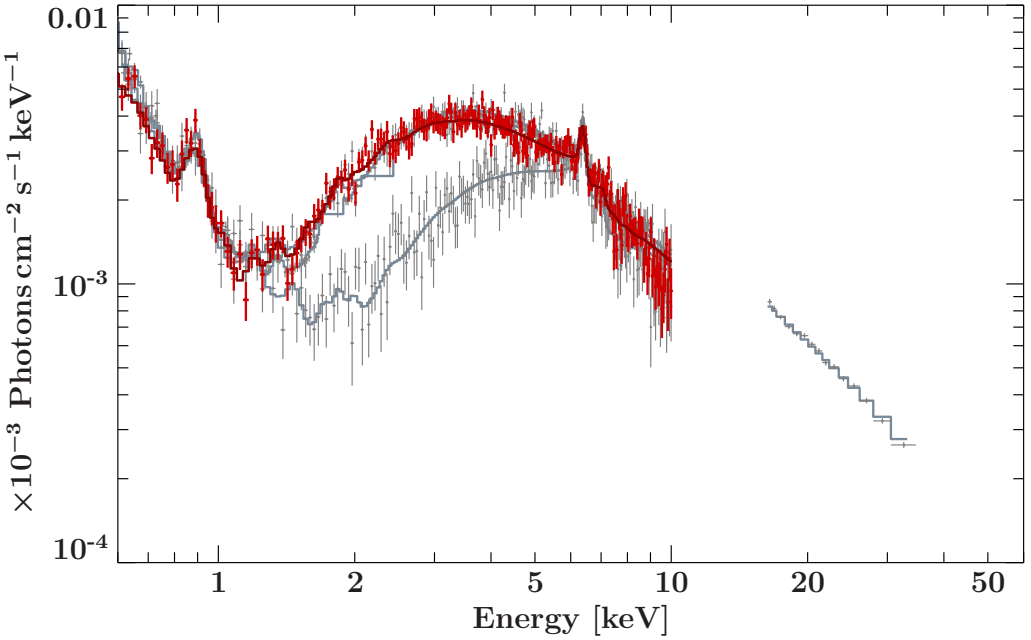

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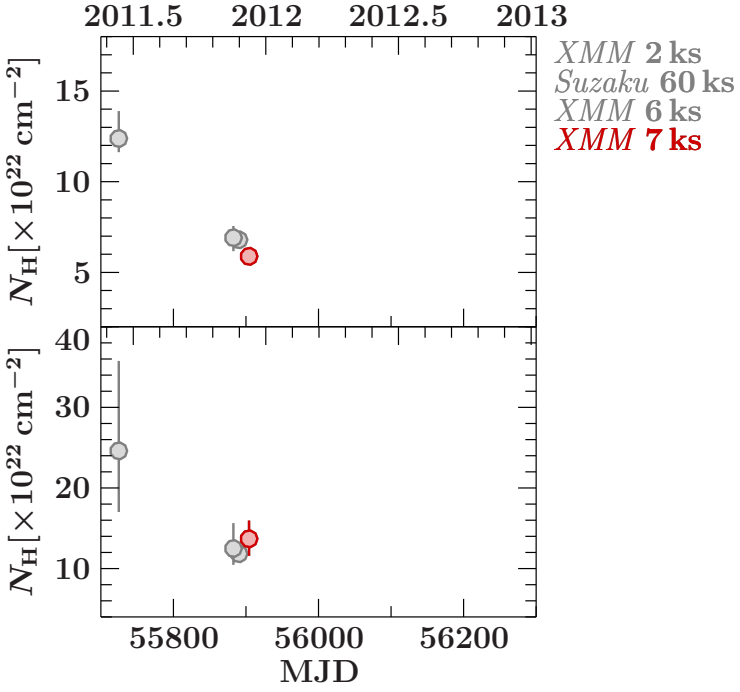

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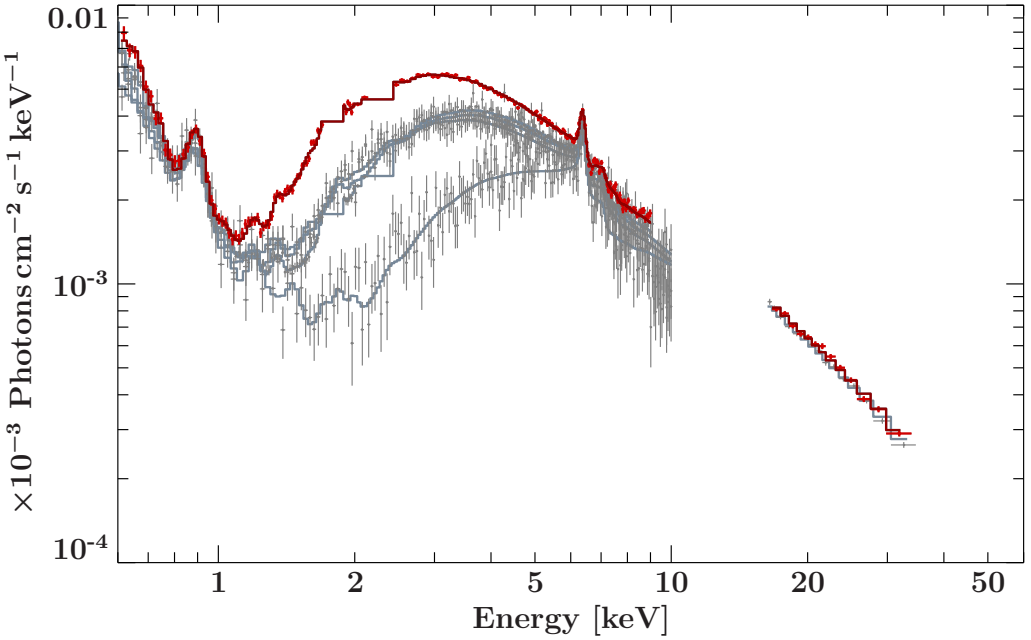

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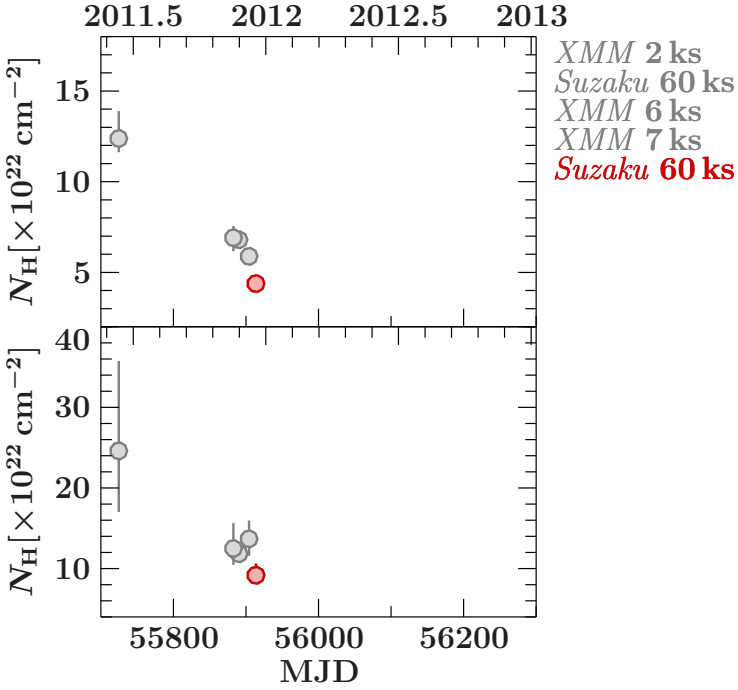

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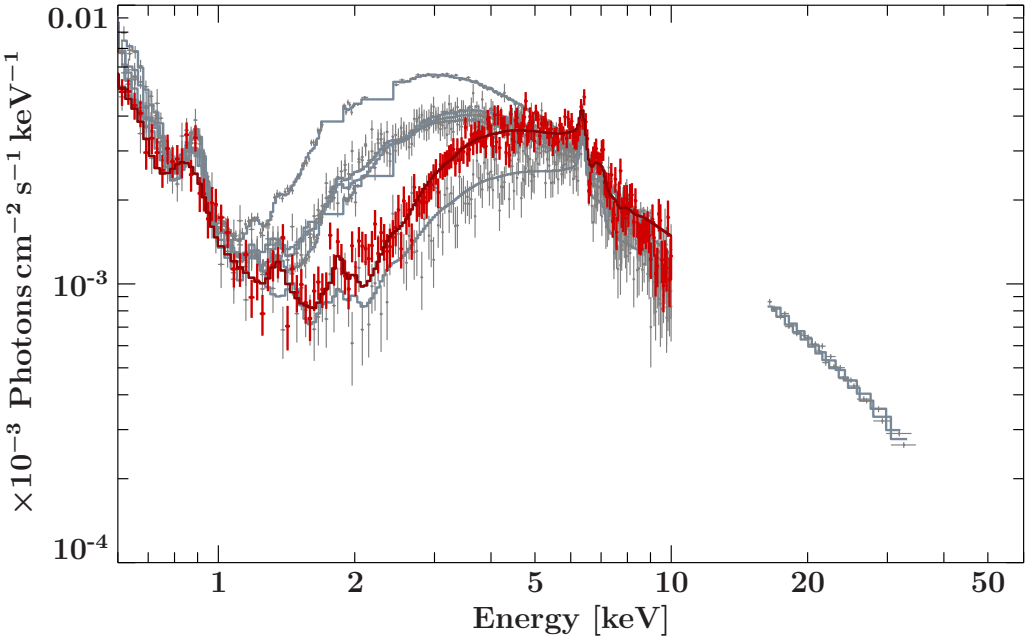

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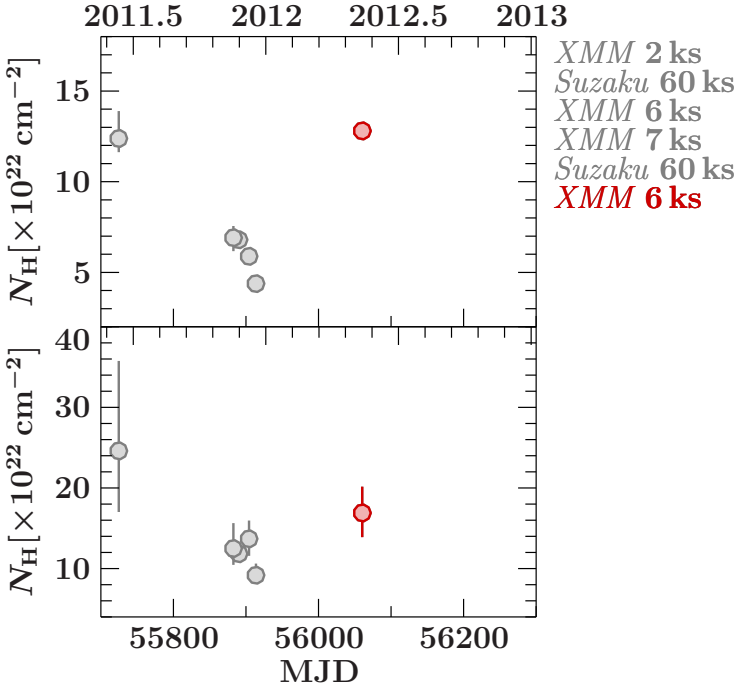

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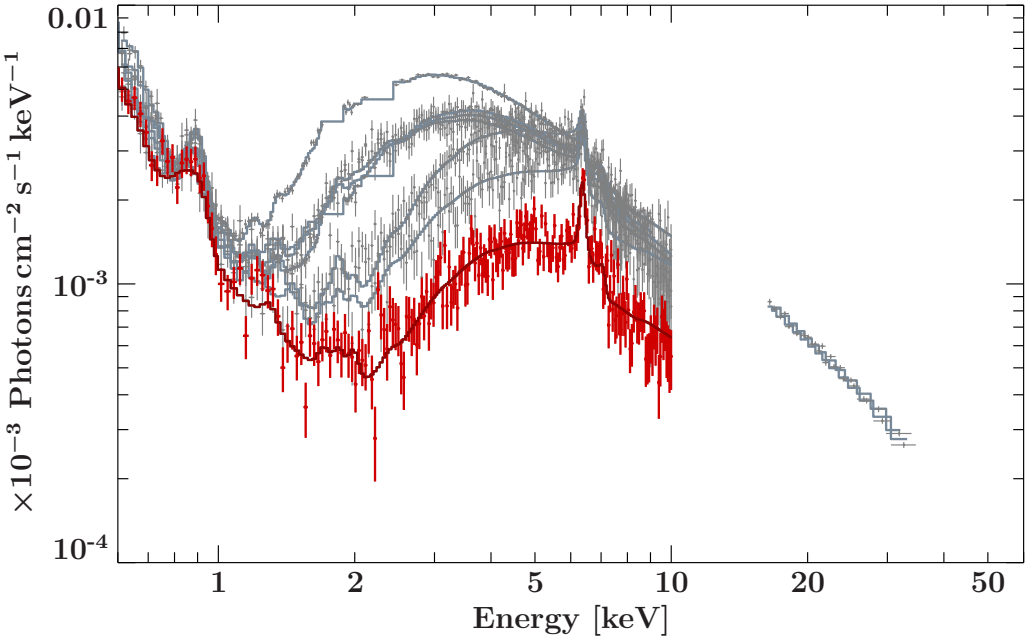

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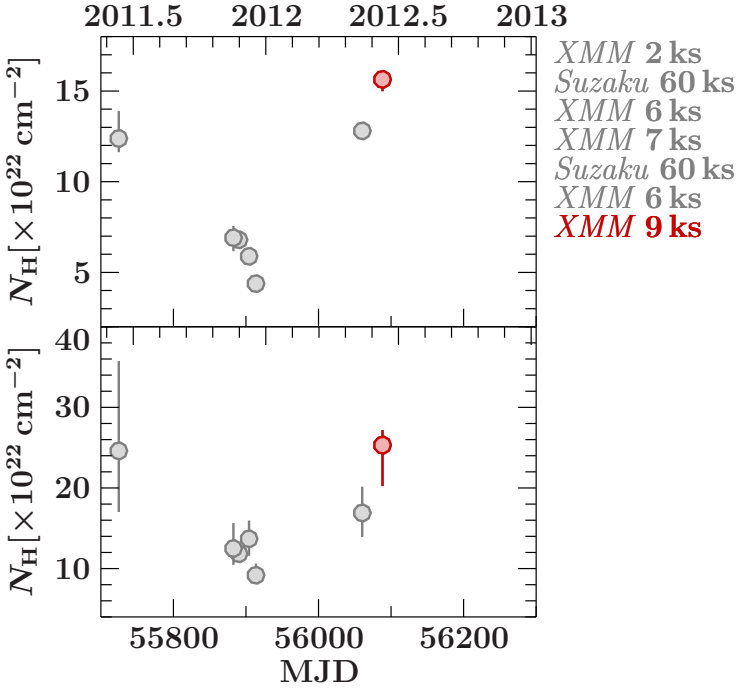

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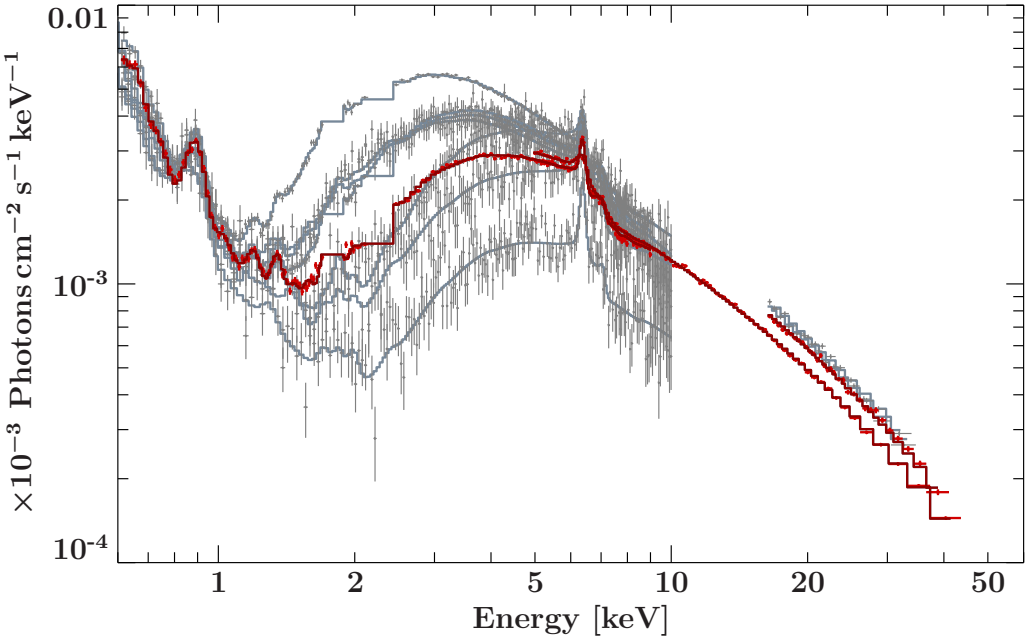

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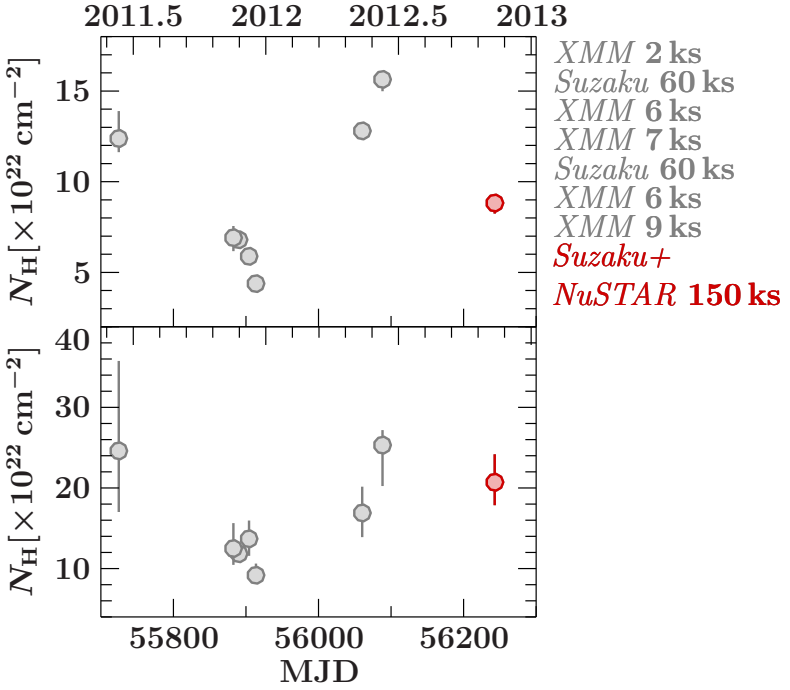

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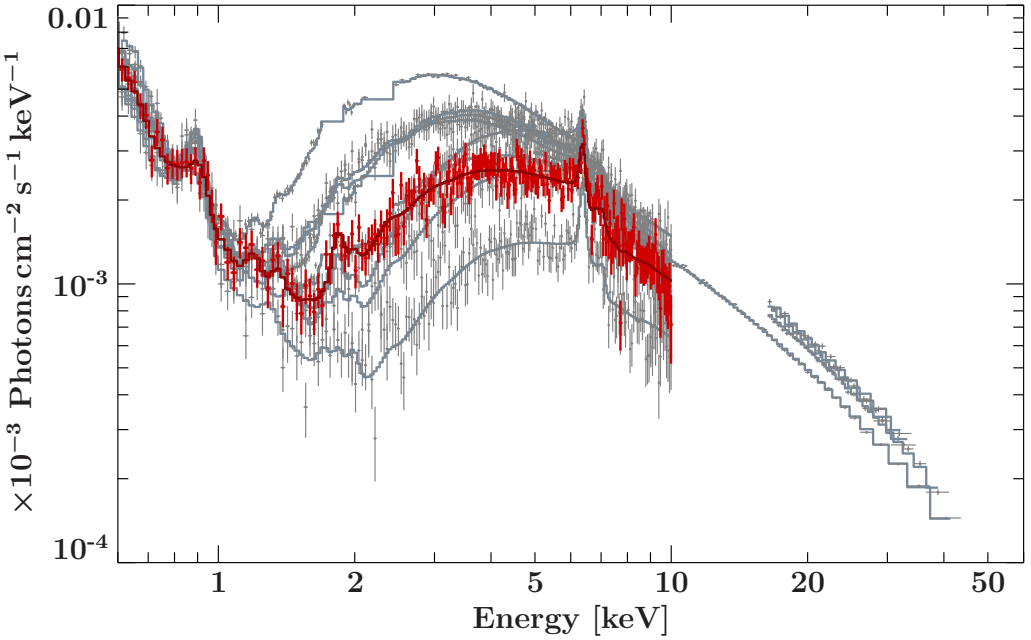

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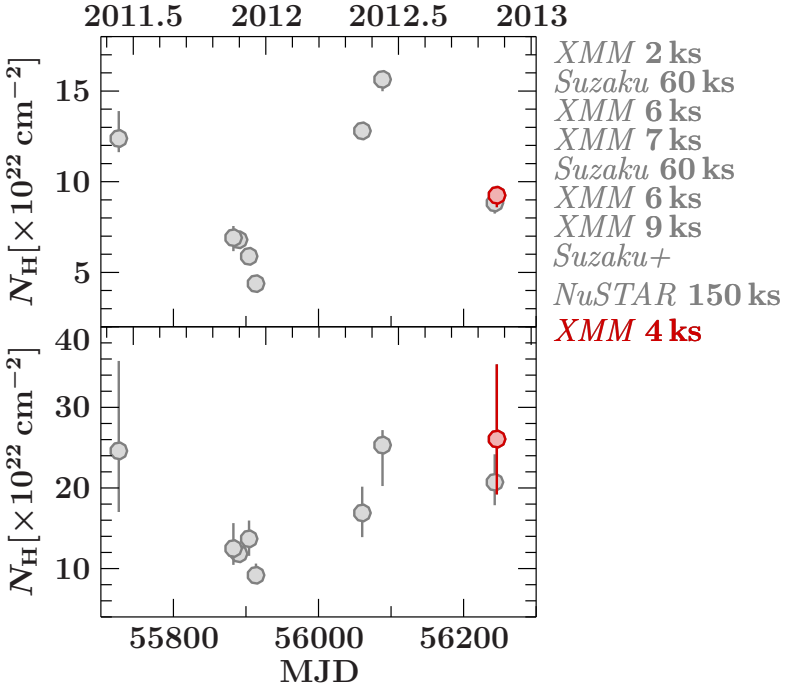

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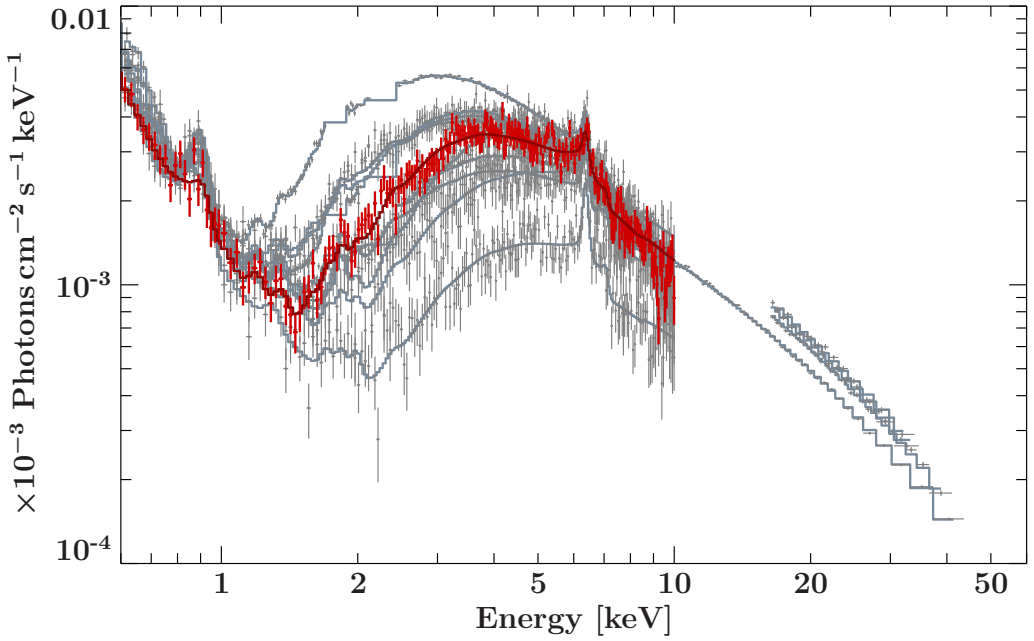
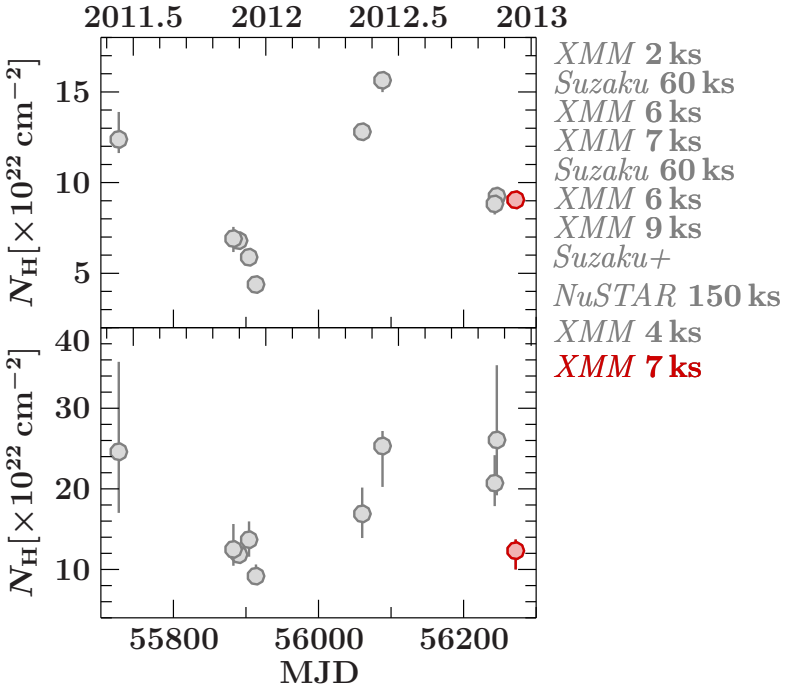




Variability of . . .

absorption (months–years)

incident flux

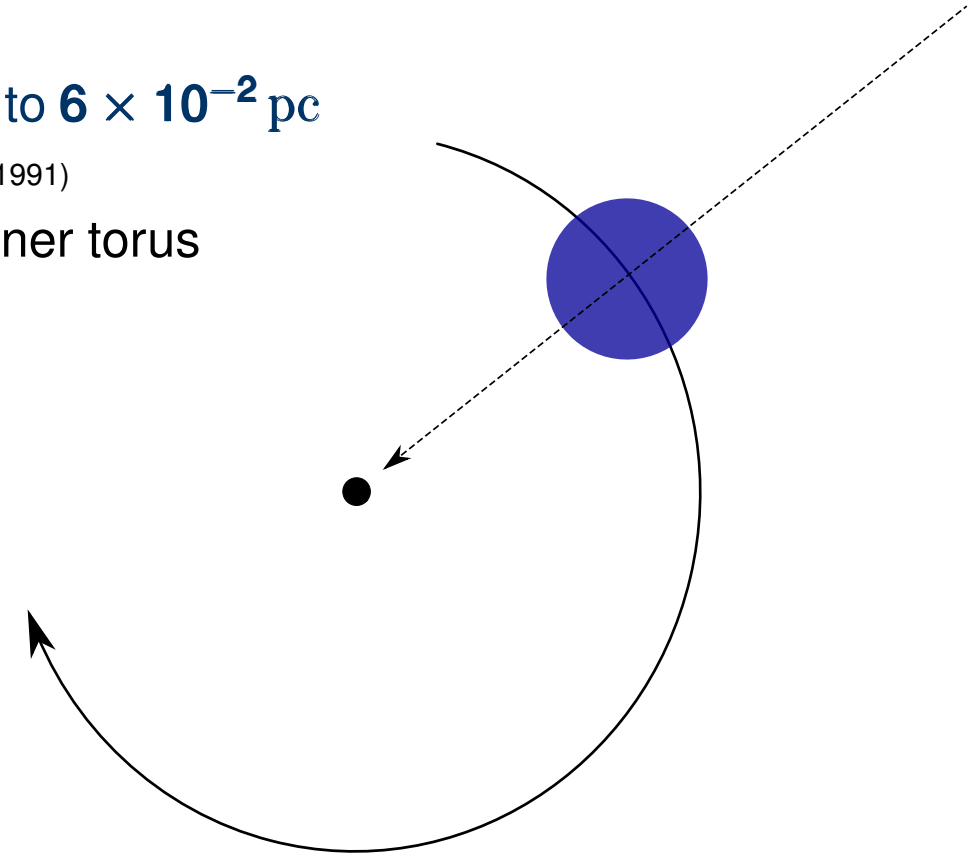
Lack of strong variability for . . .

soft emission

Constraining the Absorber Distance

- Assume Keplerian motion of distinct cloud
- Dynamical time-scale Δt : days to years
- distance $R \propto M_{\mathrm{BH}}\, n_{\mathrm{H}}^{2}\, N_{\mathrm{H}}^{-2}\, \Delta t^{2}$
- for $\Delta t = 2\,\mathrm{days}$: $\boldsymbol{R \sim 6 \times 10^{-4}}$ **to** $\boldsymbol{6 \times 10^{-2}\,\mathrm{pc}}$

  Compare: $R_{\mathrm{BLR}} \sim 8 \times 10^{-3}\,\mathrm{pc}$ (Maoz et al., 1991)
- for $\Delta t \sim \mathrm{years}$: outer BLR or inner torus



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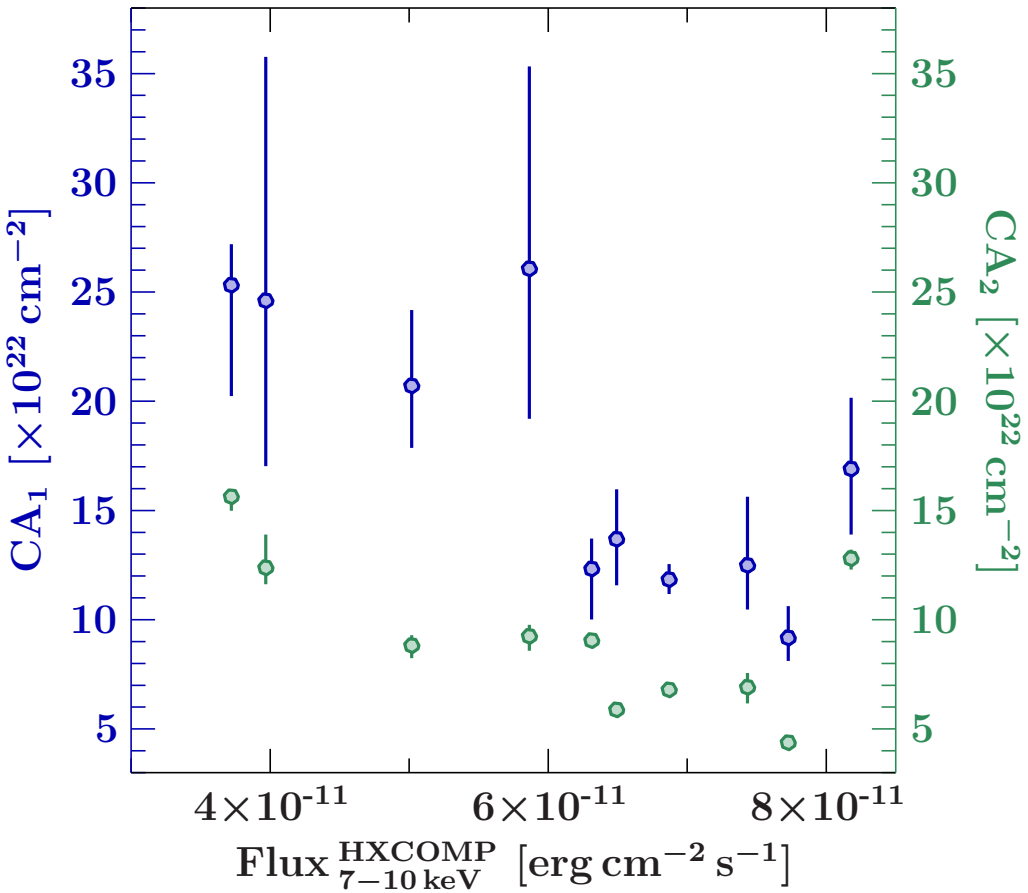
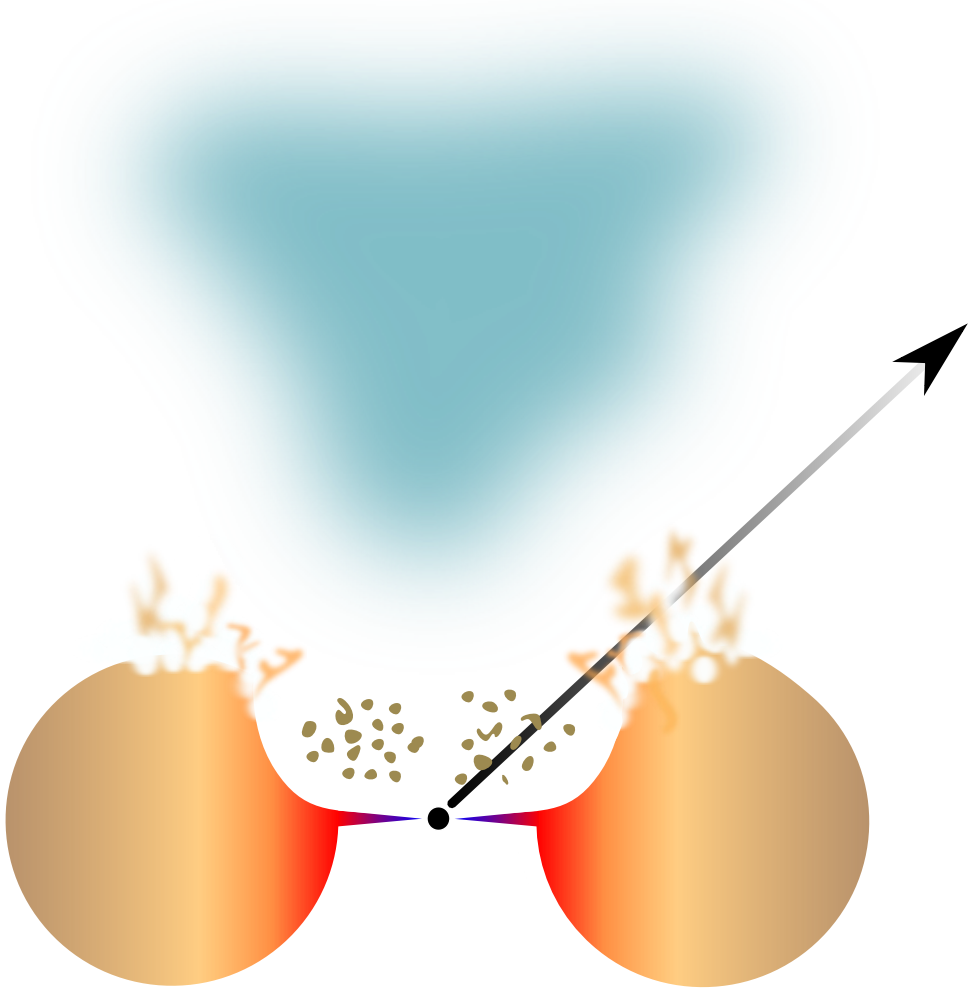


Is the absorbing structure . . .

- clumpy/filamentary?
- radiatively driven?
- changing its ionization state with changing irradiation?

see also: Couto et al., 2016



see also, e.g., Markowitz et al., 2014; Miniutti et al., 2014; Beuchert et al., 2015; Svoboda et al., 2015; Sanfrutos et al., 2016

Conclusions

- Disentangled **complex absorbers** from **relativistically blurred reflection**
- Self-consistent double-lamp-post solution
- Strong arguments for a coherent and vertically extended X-ray source
- Absorption variability on timescales from days to years
- Dynamic BLR or radiatively driven structures