“Quasars for the Impatient”

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thanks to: Ed Cackett, Andy Fabian, Luigi Gallo, Chris Reynolds, Rubens Reis

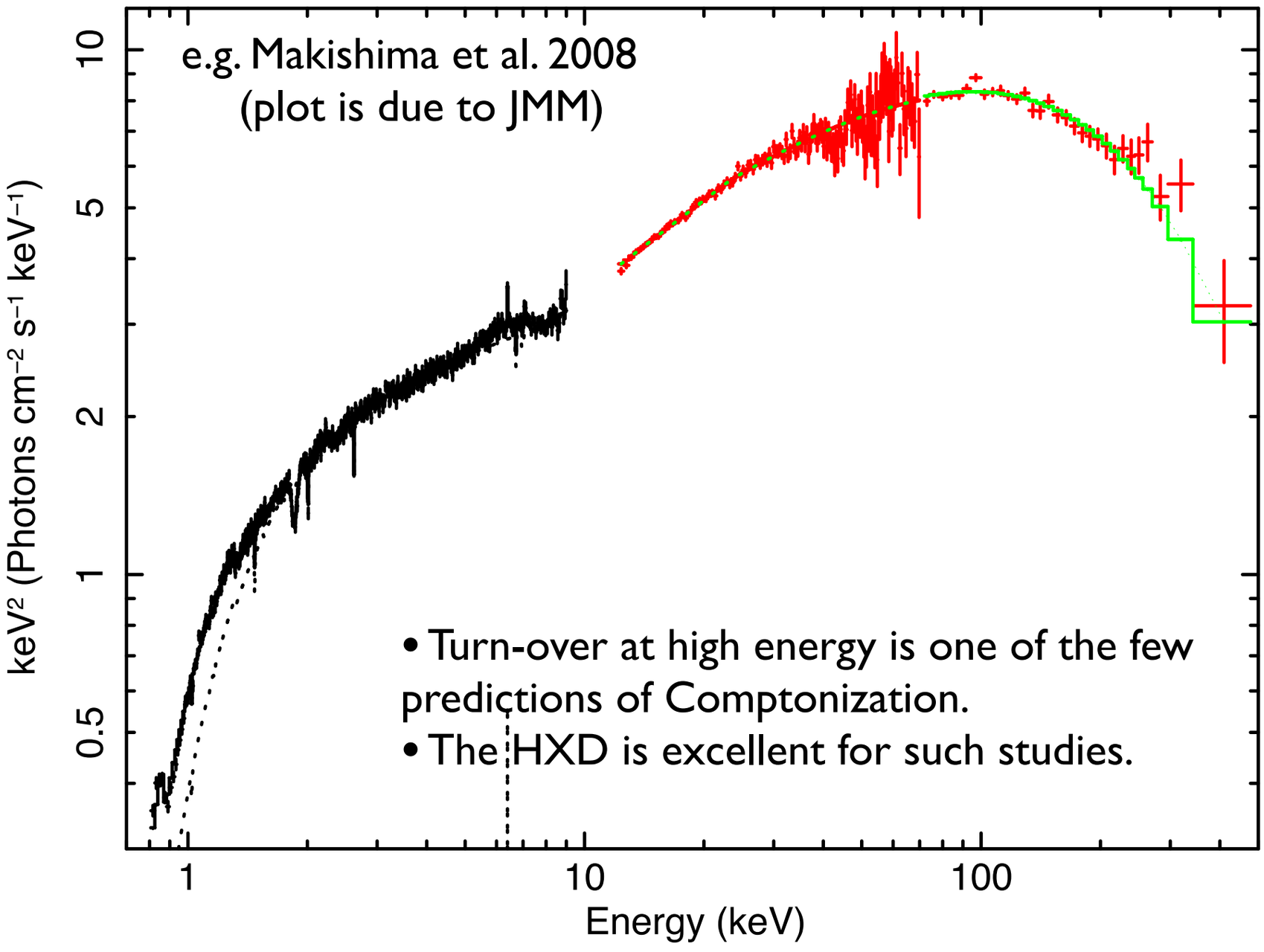
3 Outstanding Issues

- The nature of hard X-ray emission.
- Accretion flow evolution with m-dot.
- Distribution and origin of black hole spins.

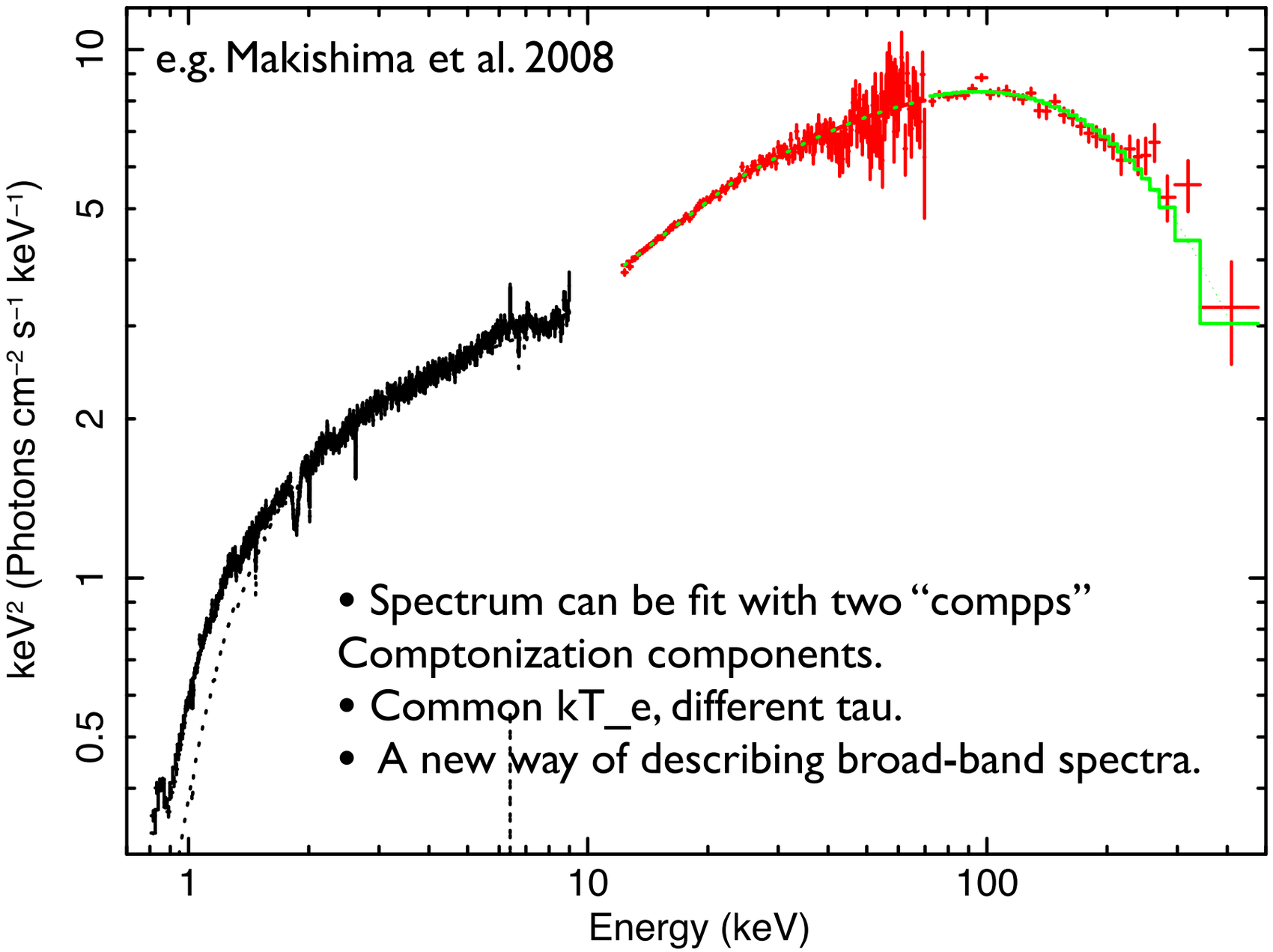
Hard X-ray Emission

- Thermal Comptonization?
- Non-thermal Comptonization?
- Both?!
- Synchrotron?
- Synchrotron self-Comptonization?

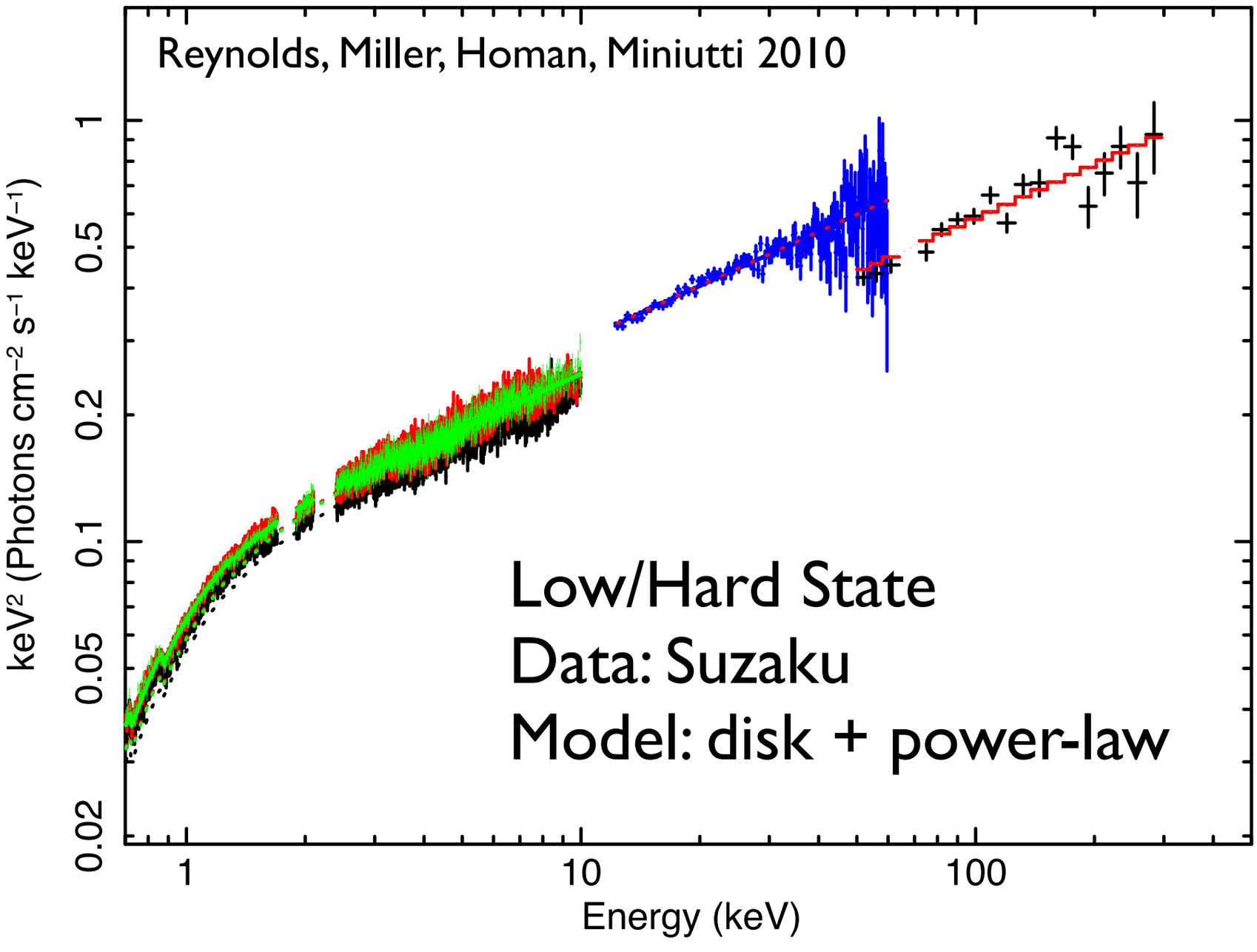
Turn-over in Cyg X-1



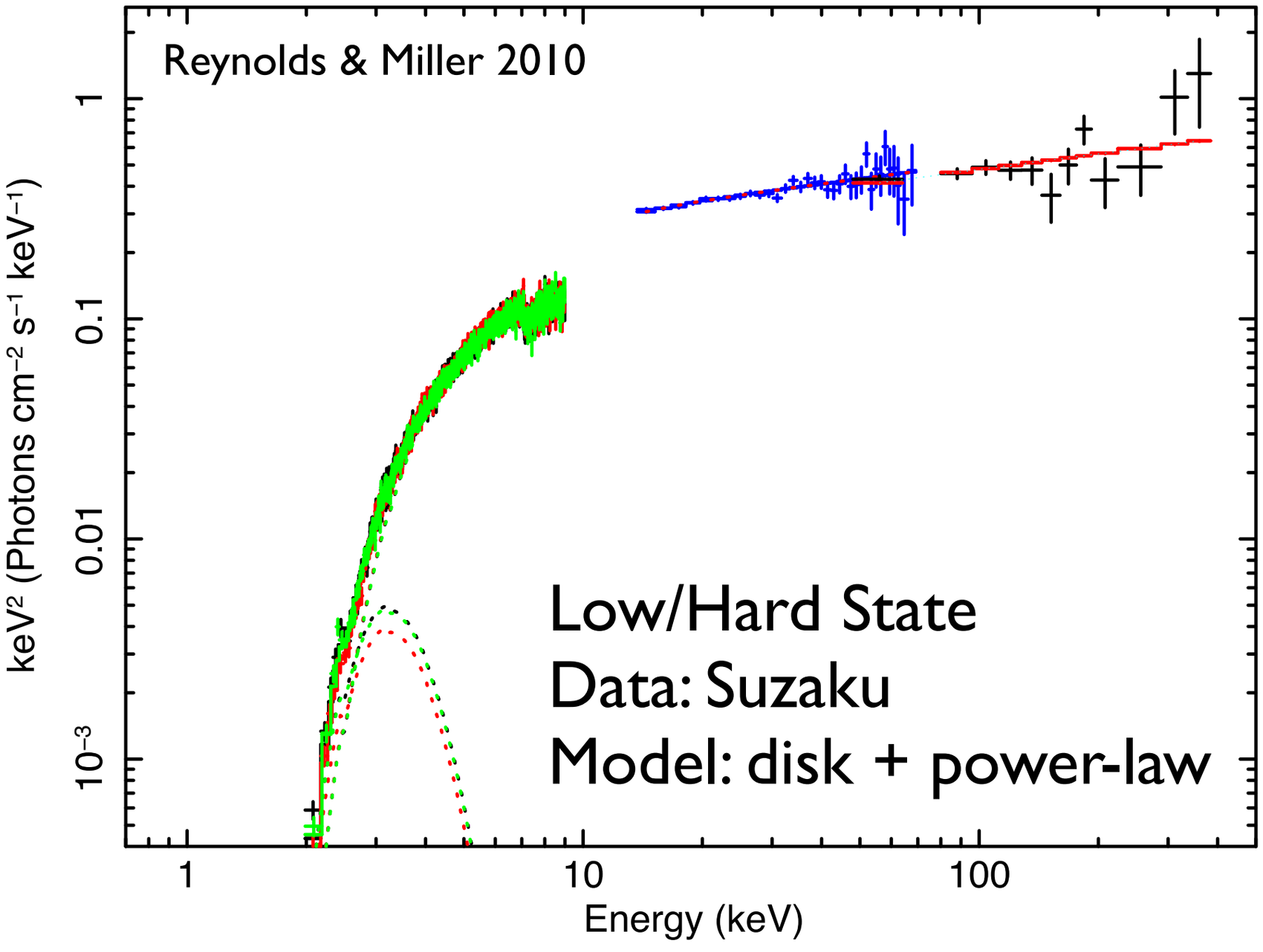
Cyg X-1: complex?



Swift J1753.5



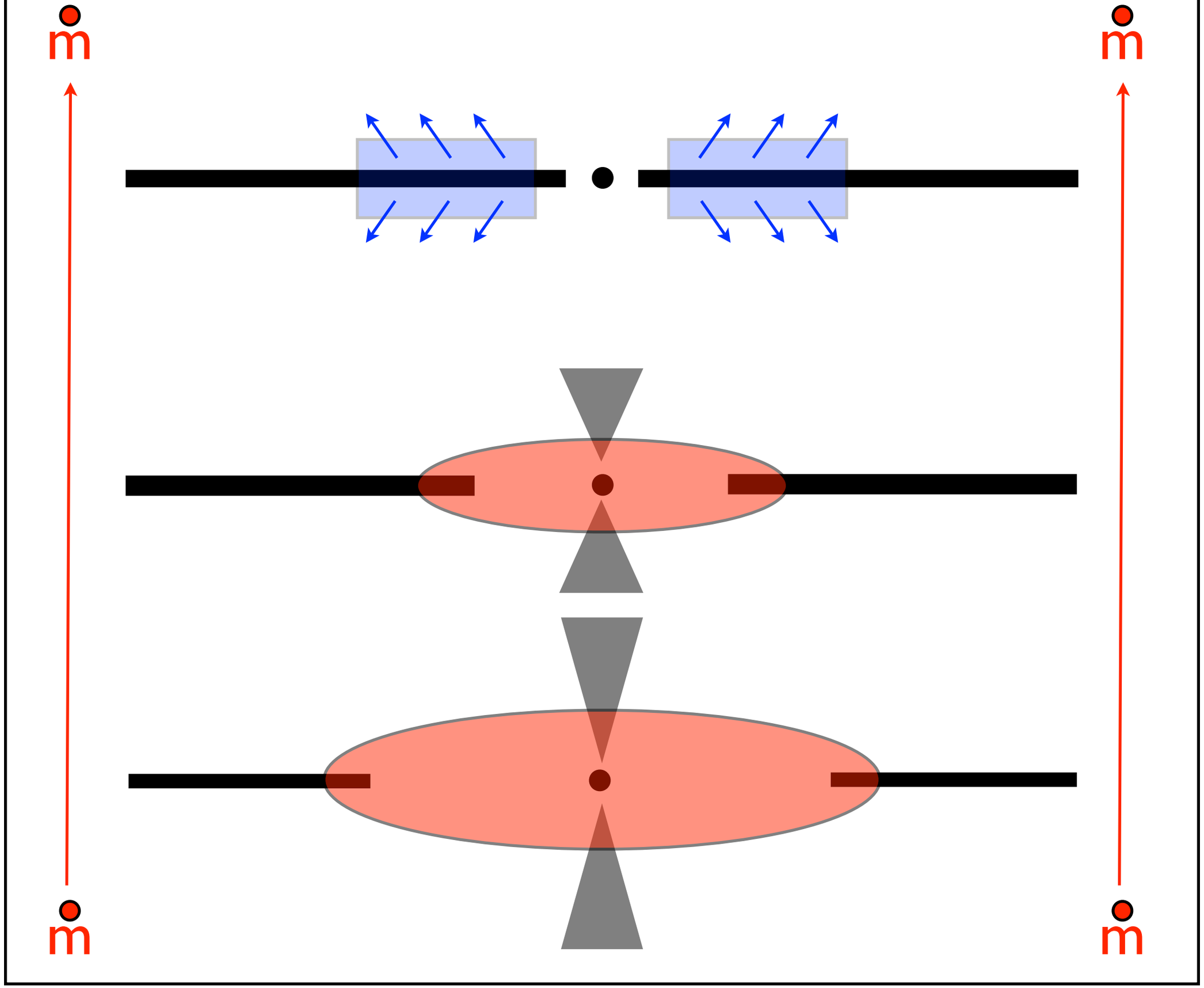
IE 1740.7-2942



Hard X-ray Production

- Thermal or hybrid Comptonization is at work in some sources, e.g. Cygnus X-1.
- Other sources do not show the same signatures. They may require different or additional mechanisms.
- Different sorts of hard states hinted at by Coriat et al. based on X+R observations.

Geometry and m-dot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Diagnostics of R_{in}

- <u>Iron Lines:</u>

  + Use FWHM to constrain R_{in}

  - emissivity ... but you can fit for this

- <u>Disk Continua:</u>

  + Use flux to constrain R_{in}

  - mass, distance, hard component, detector

Truncation Criteria

- Strong:

  - rule-out Fe K line (EW = 60 eV), *and*

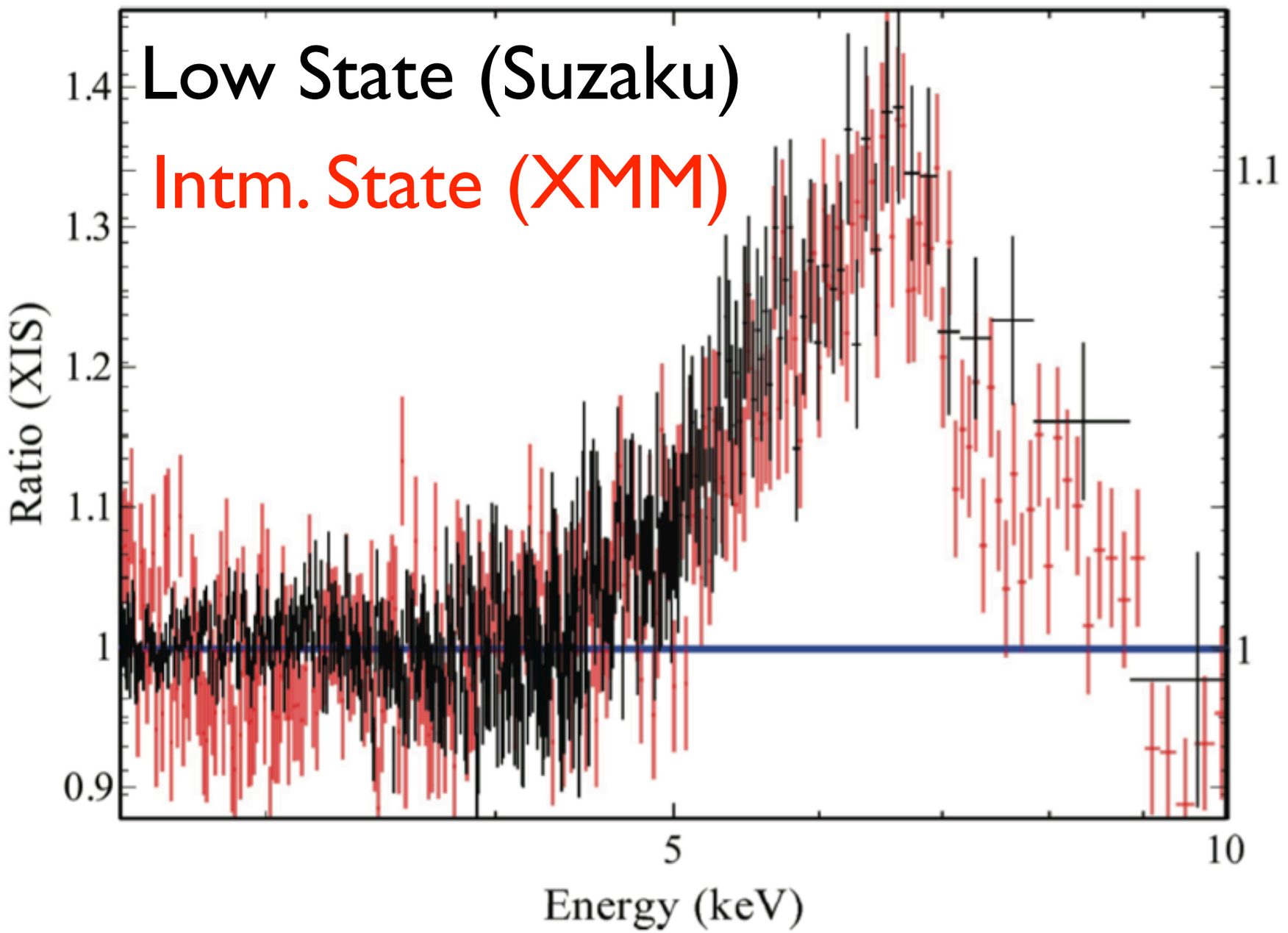
  - significant departure from $L \sim T^4$

- Weak:

  - only one of the above

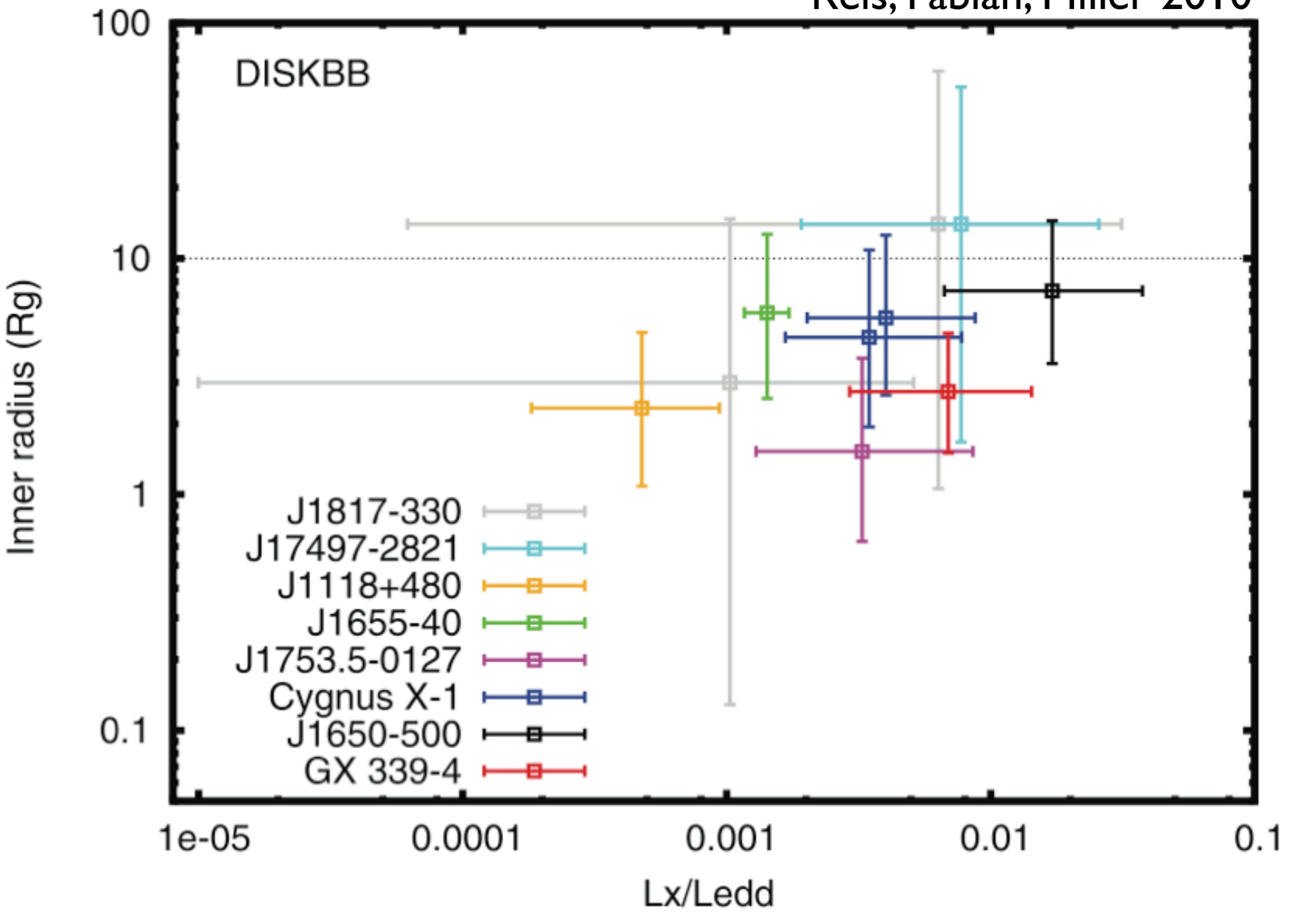
XTE J1752-223

Reis et al. 2010



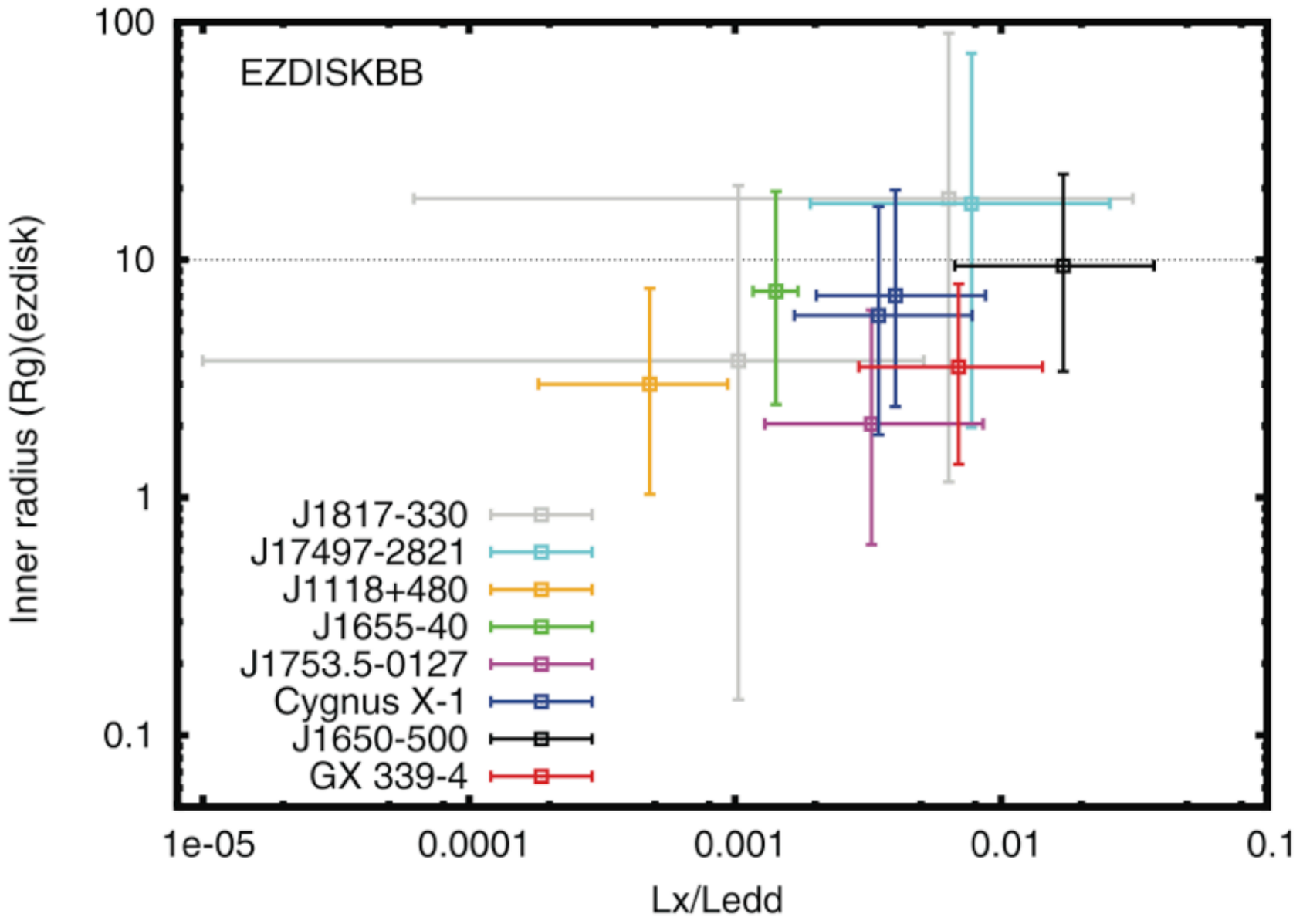
Disks at Low L/L_{Edd}

Reis, Fabian, Miller 2010

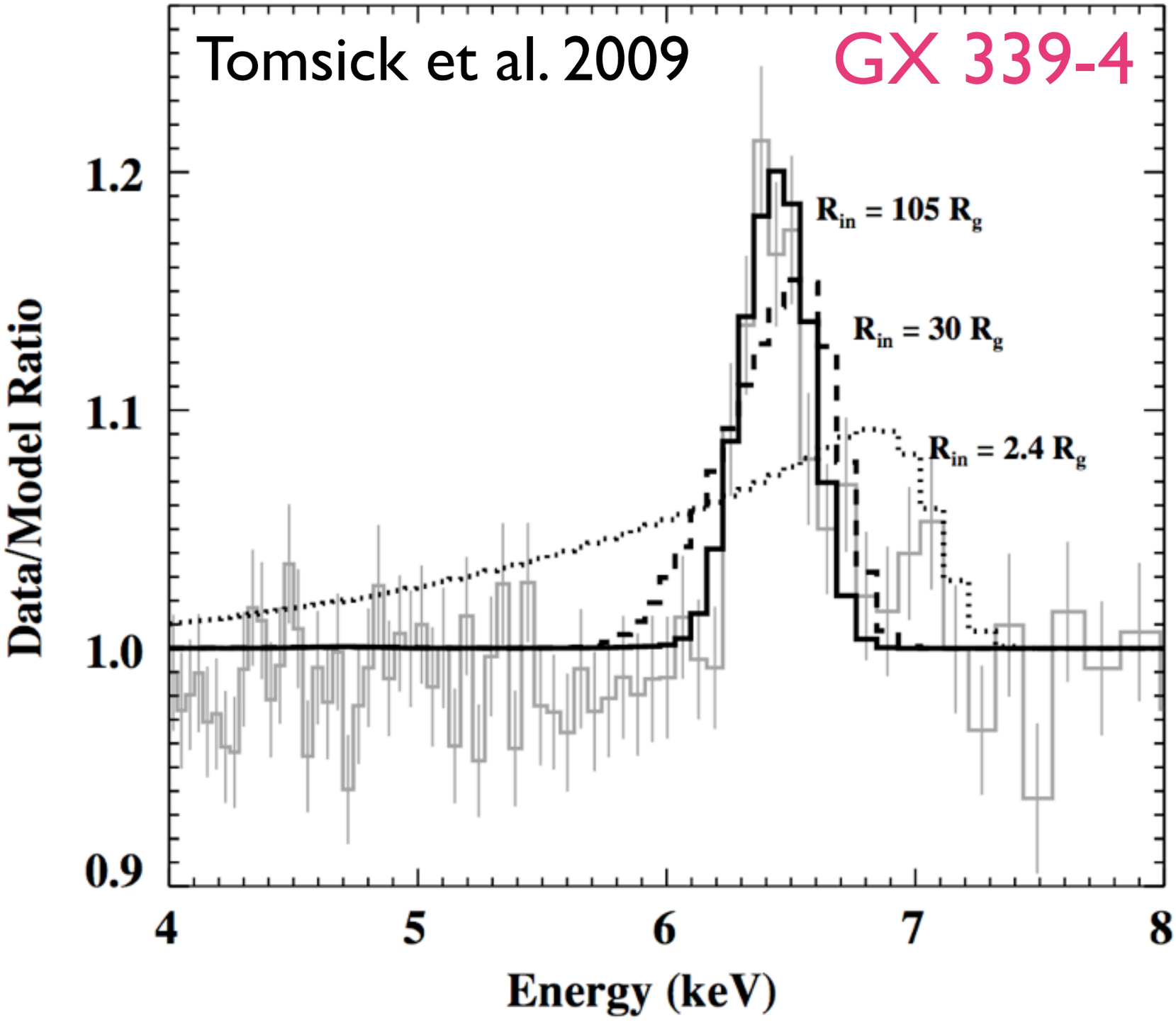


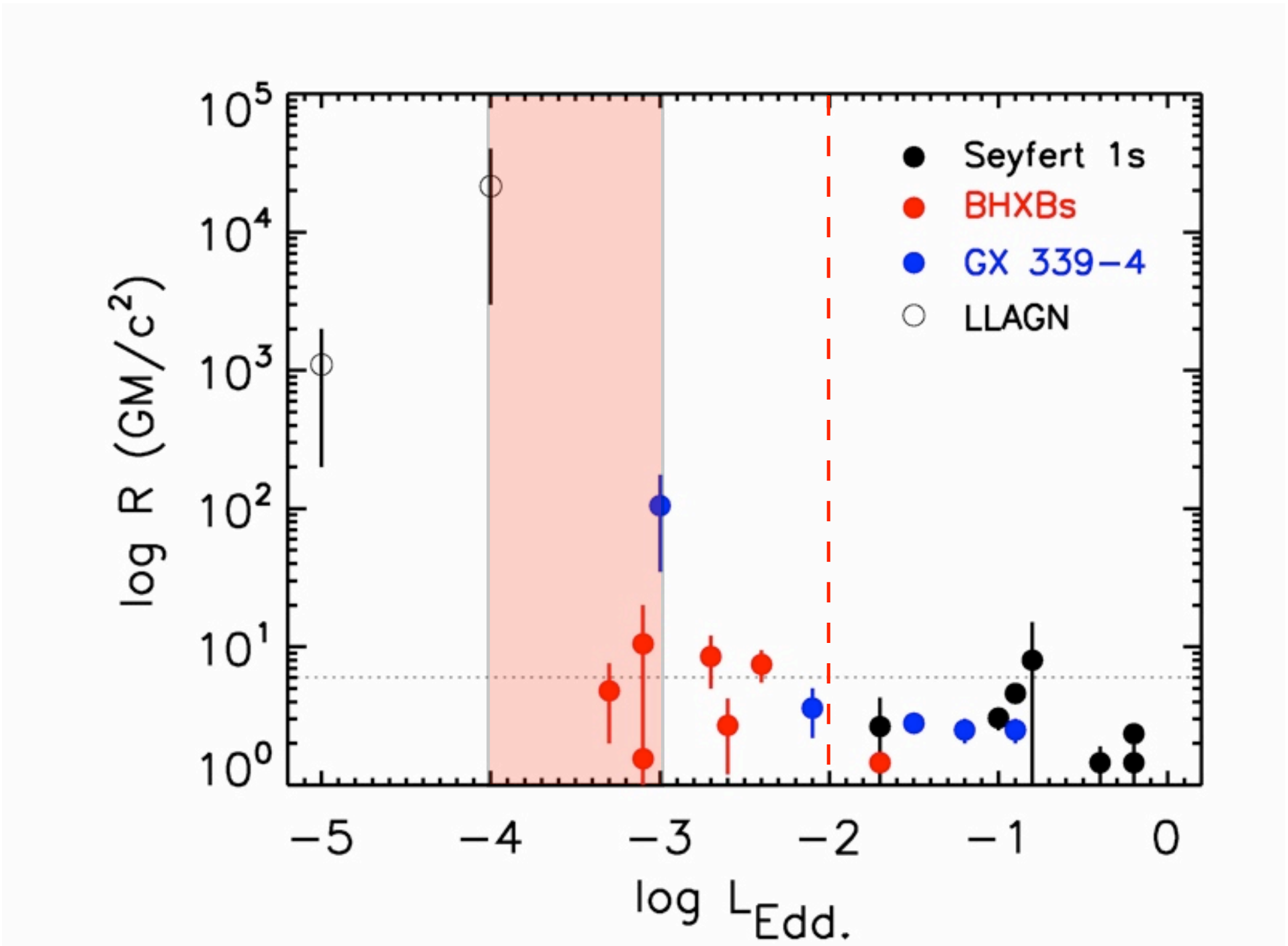
Systematic Study

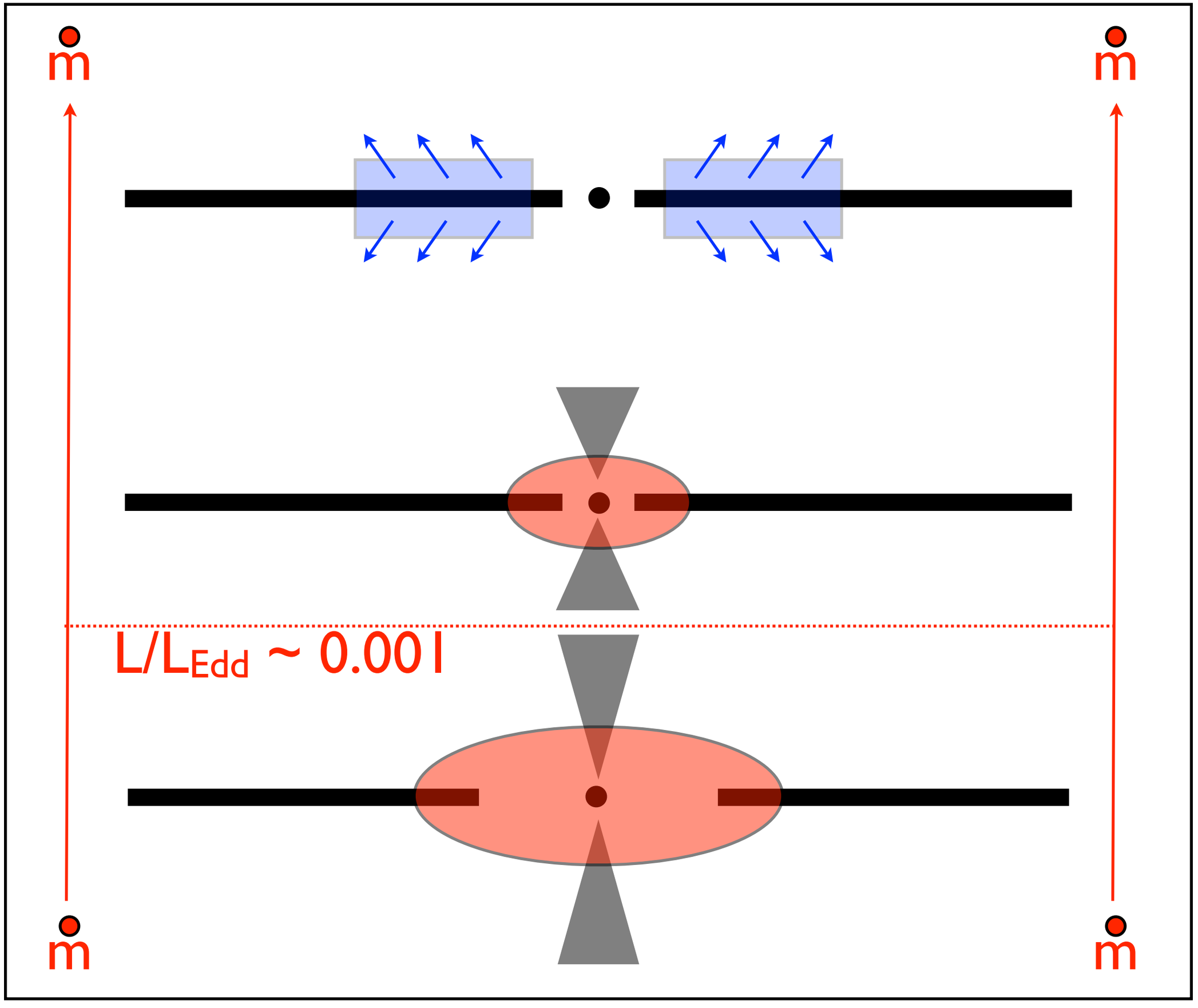
Reis, Fabian, Miller 2010



Truncation ... at last




Seyfert 1s
BHXBs
GX 339−4
LLAGN
log R (GM/c²)
log L_Edd.
10⁵
10⁴
10³
10²
10¹
10⁰
−5
−4
−3
−2
−1
0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L/LEdd ~ 0.001
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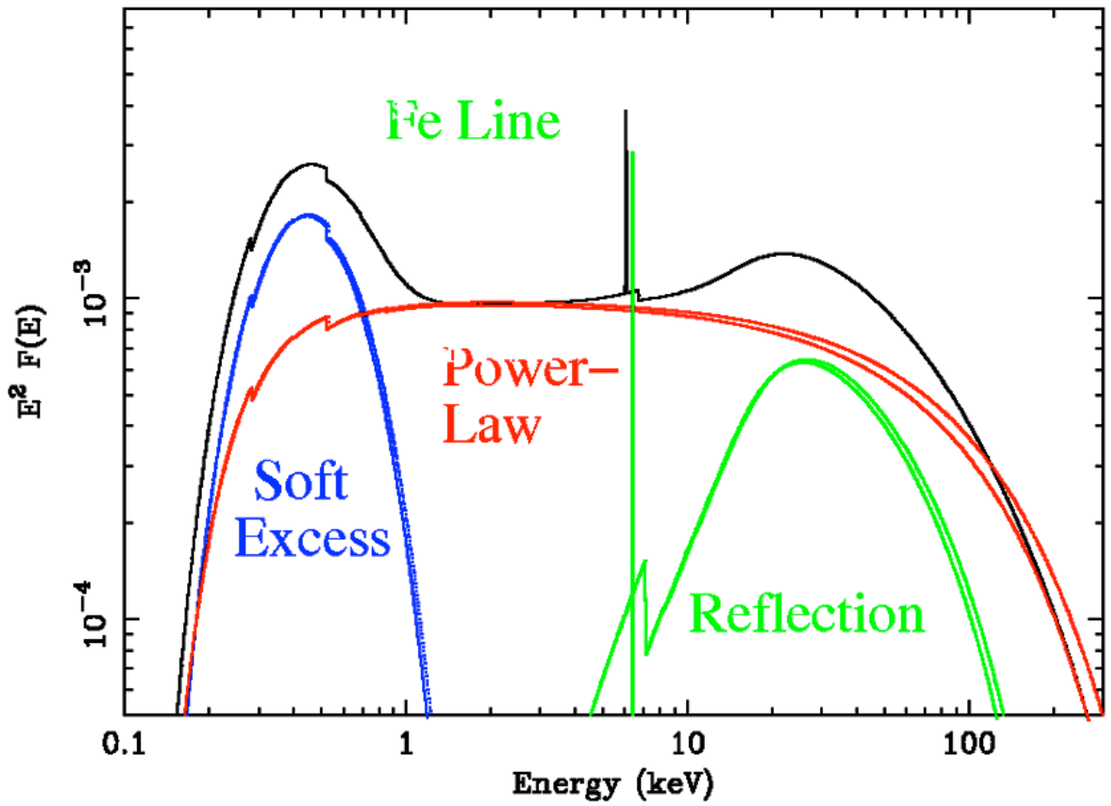
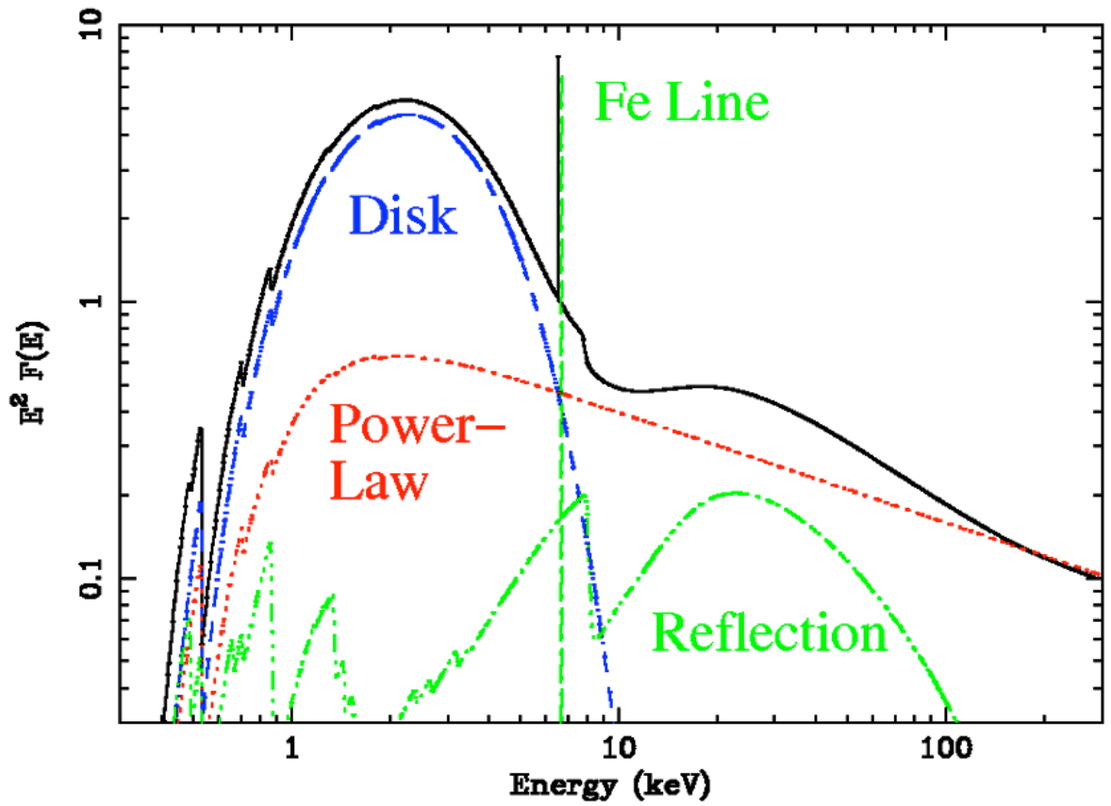
Similar Spectra

Seyfert-1 AGN

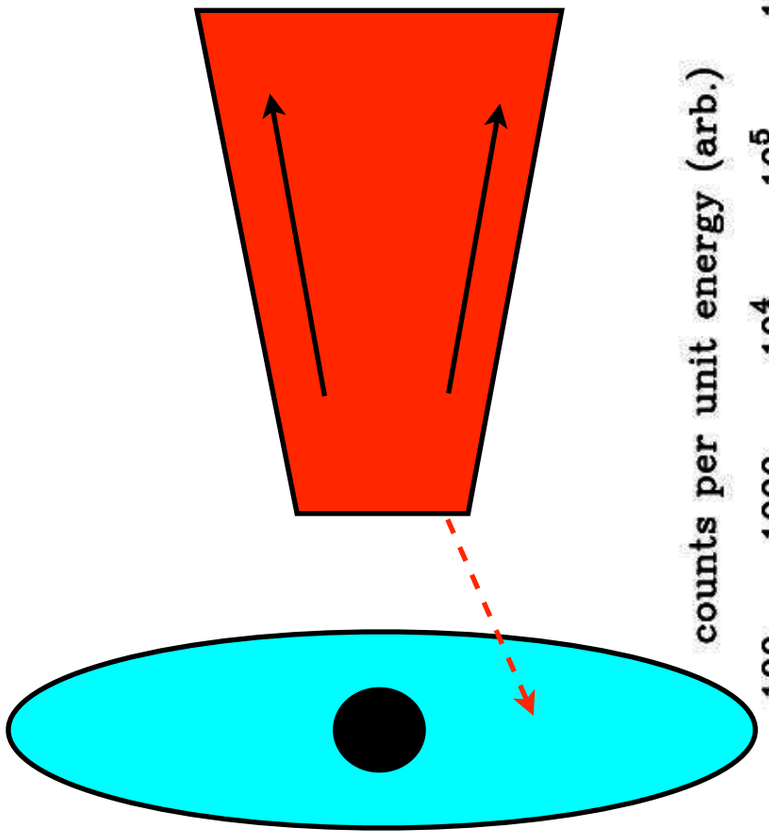


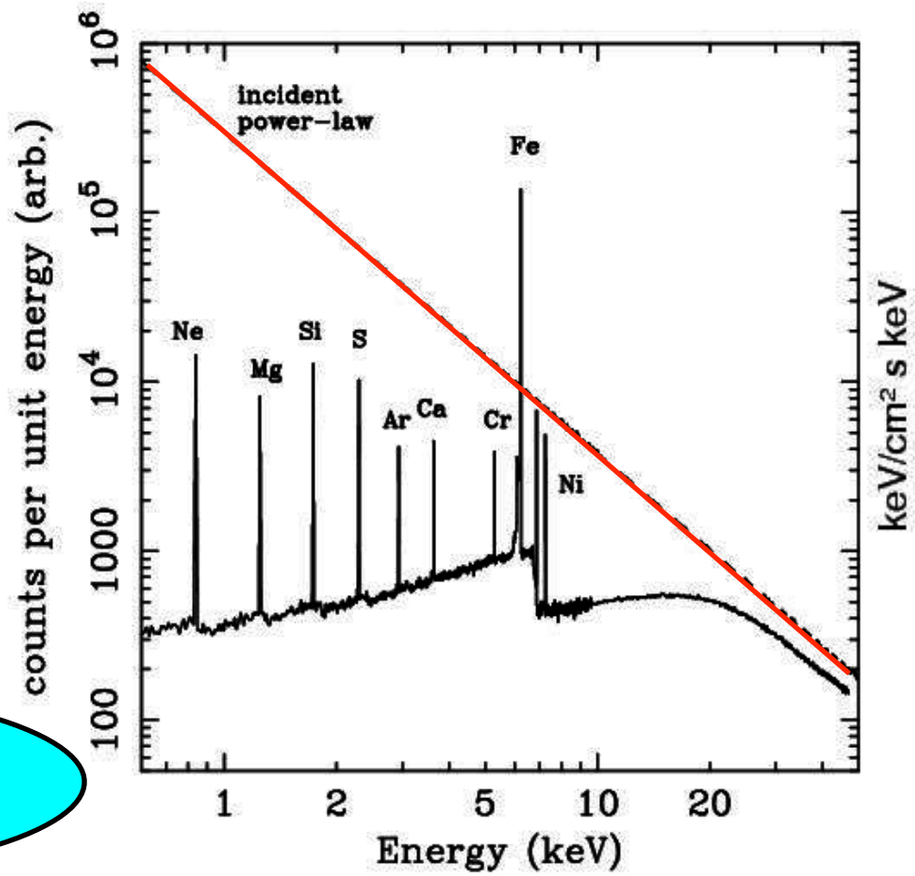
Stellar-mass black hole

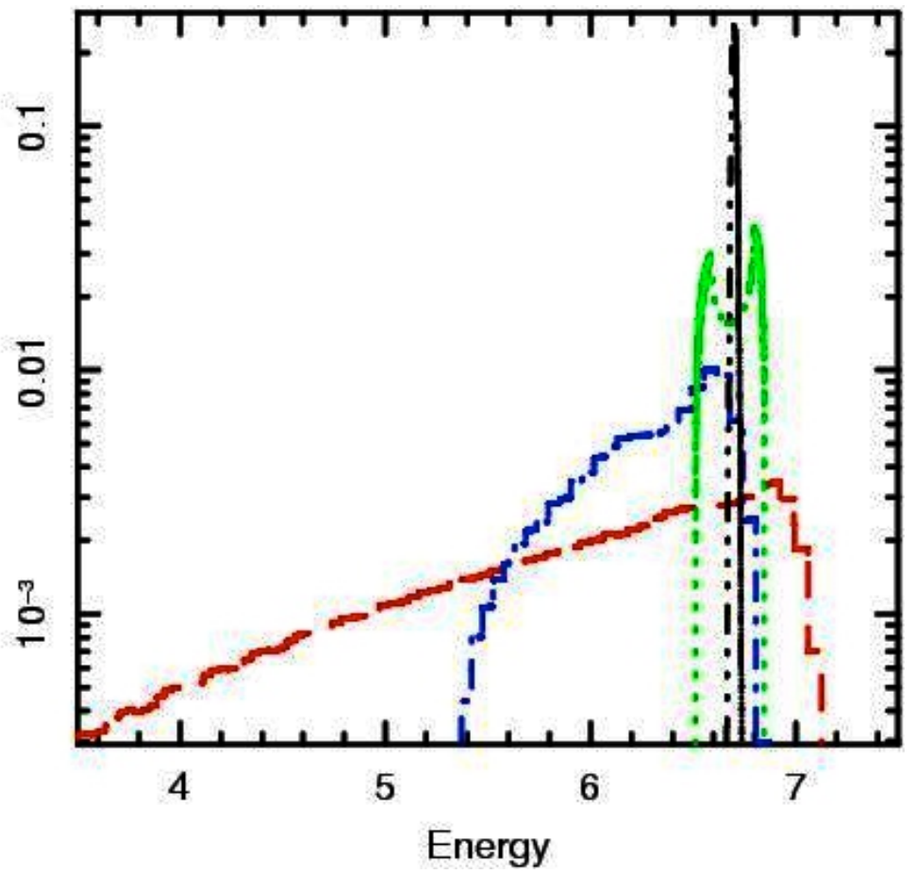


- The continuum in stellar-mass BHs is rather simple.
- Any "warm absorber" < 0.01 of Sy1s (N_OVIII).
- Not plausibly due to partial covering absorbers.

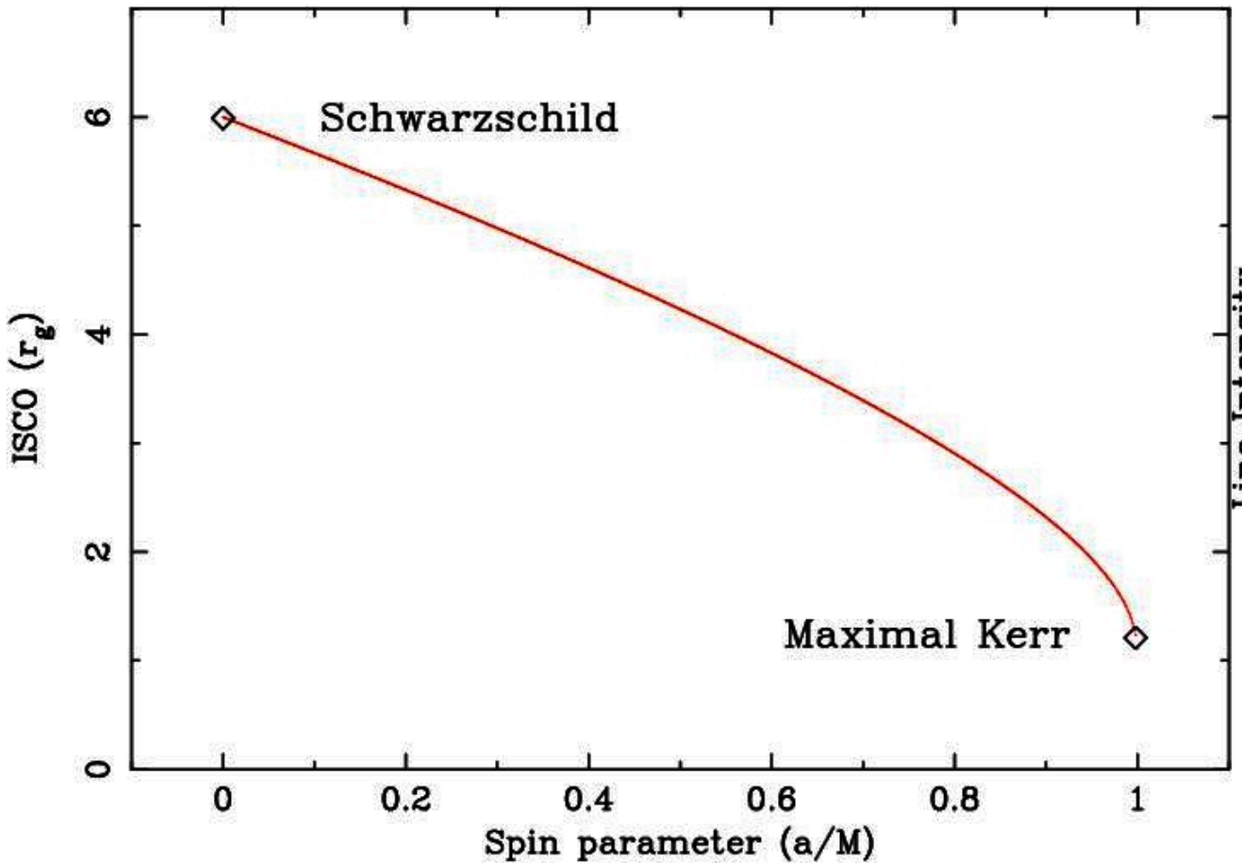
X-ray Disk Lines

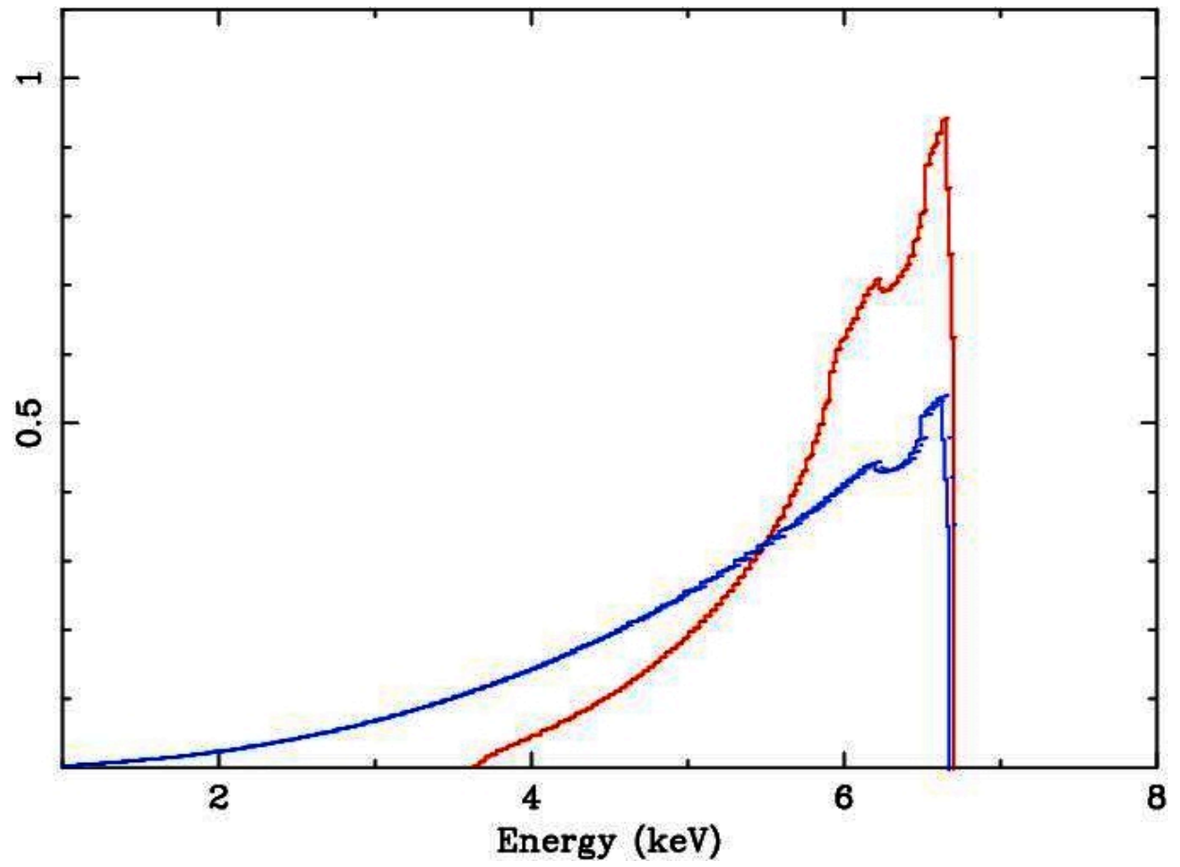






X-ray Disk Lines

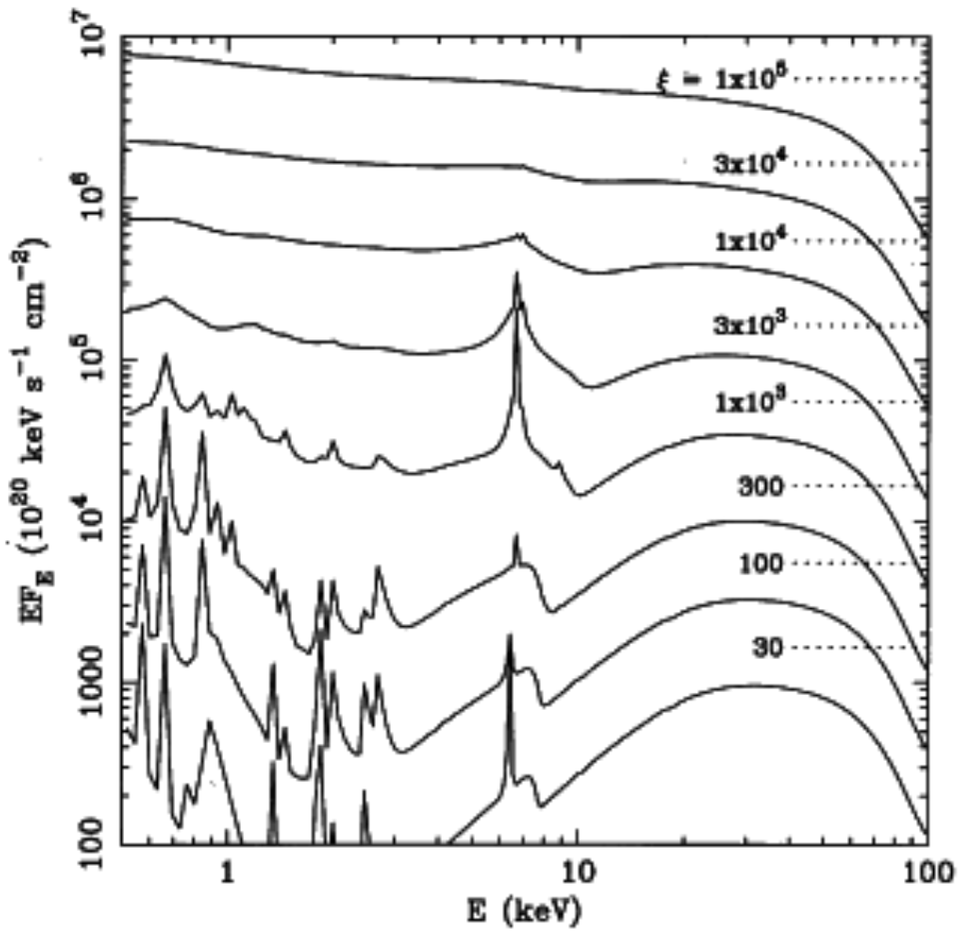




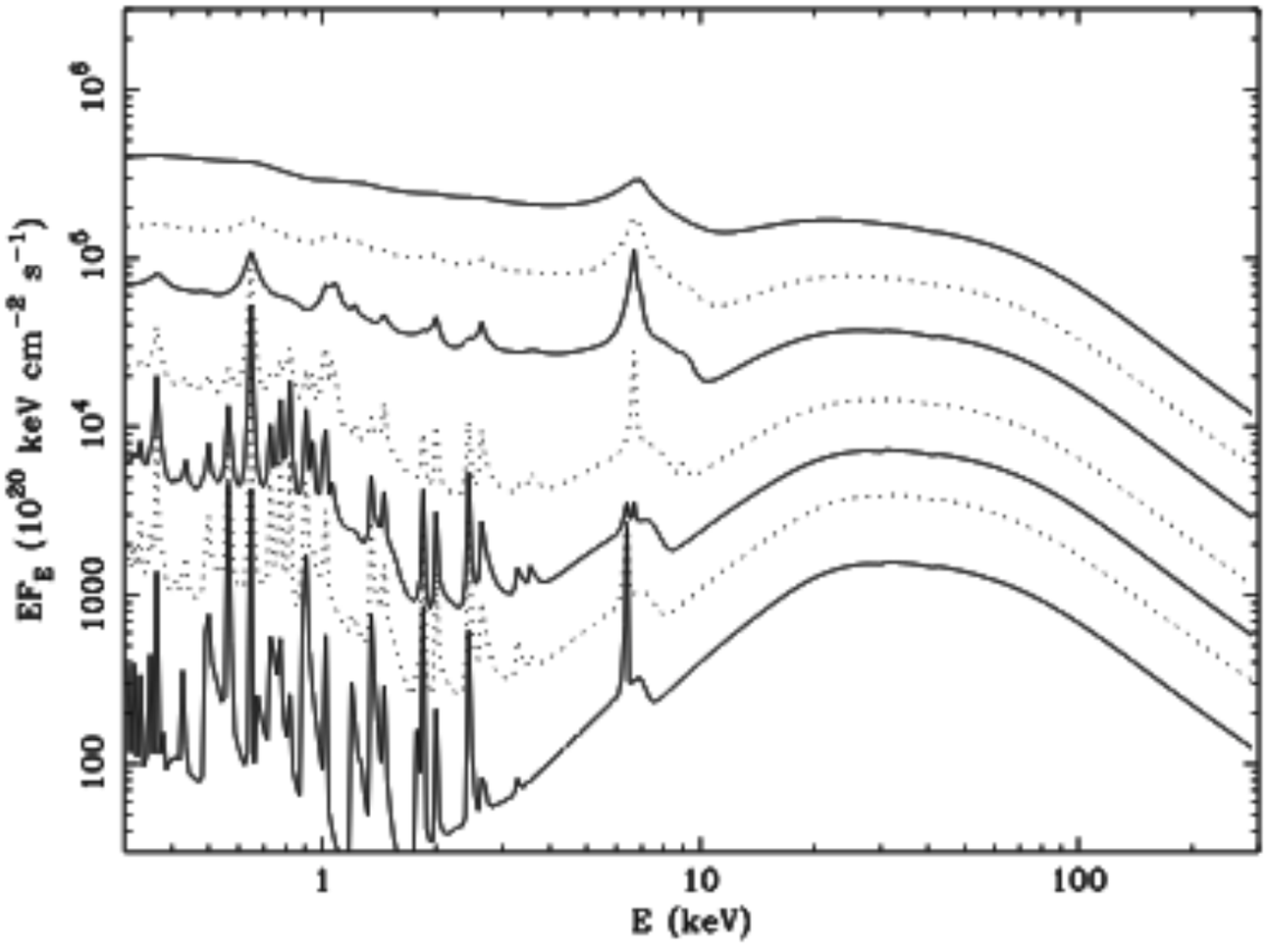
Ray tracing --> line profiles.
Diskline (a=0), Laor (a=0.998).
4 models where spin is variable

X-ray Disk Reflection

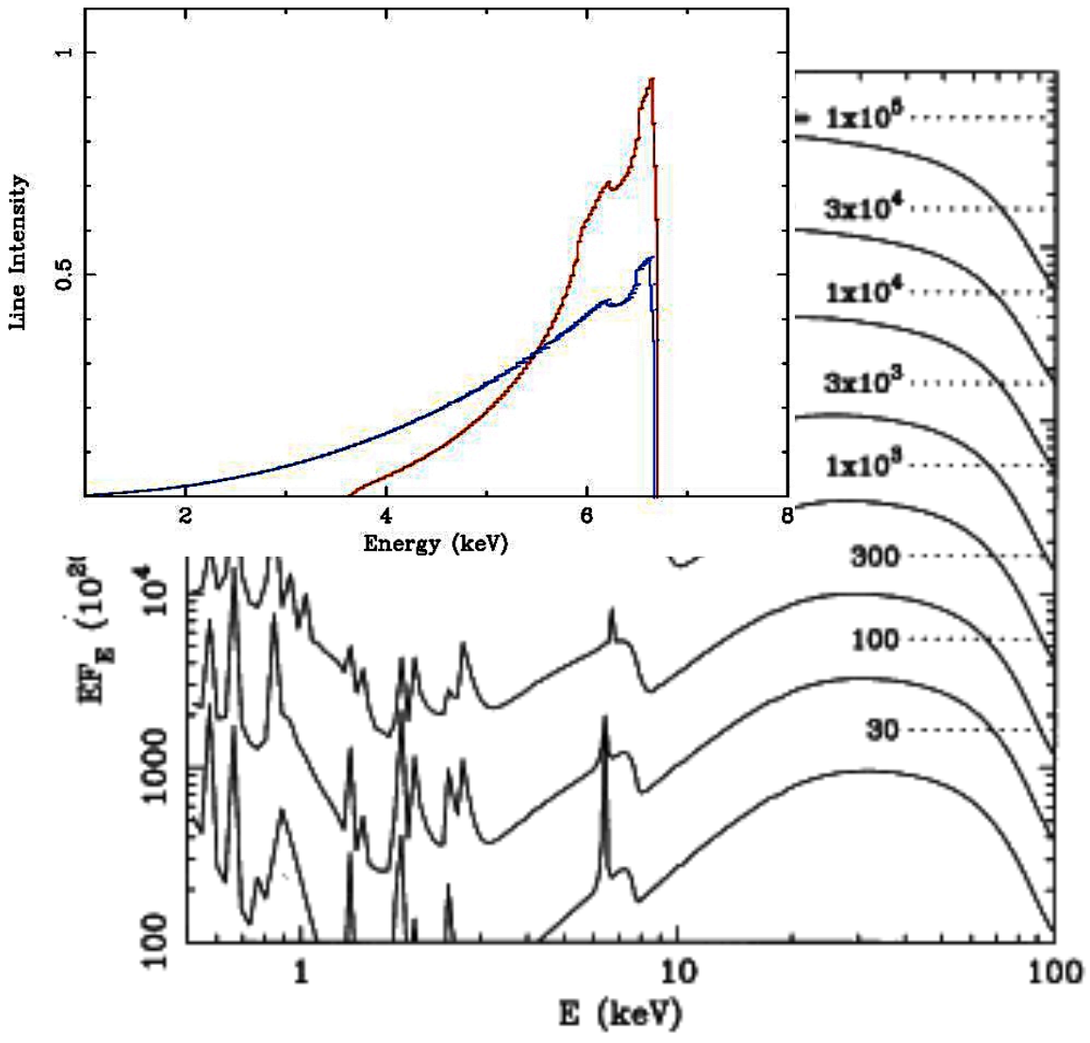
Ross & Fabian 93



Ross & Fabian 07



Reflection must be *blurred*



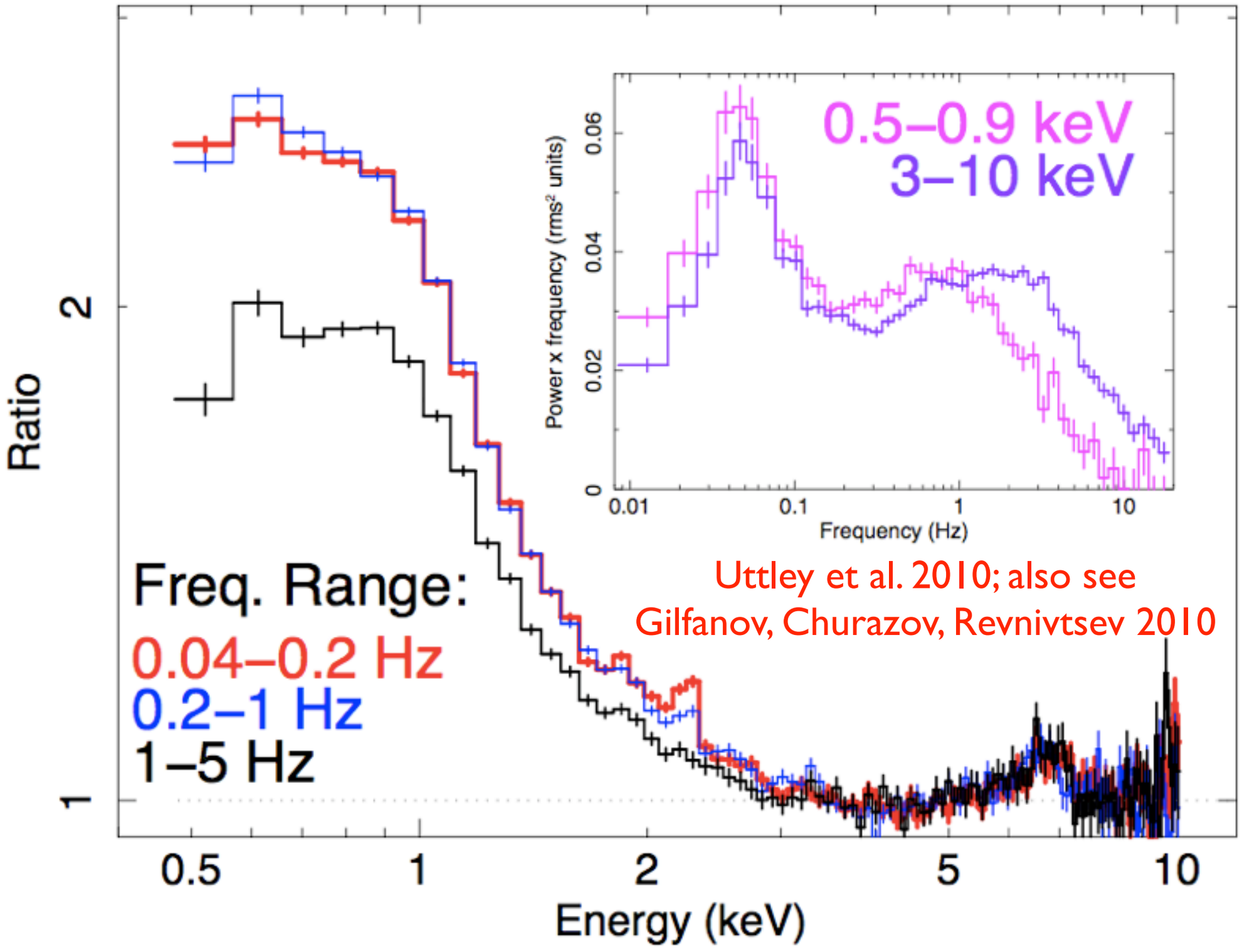
- Fe K lines & disk reflection *are one and the same.*

- Reflection spectra are calculated in the disk frame.

- Must change frames to see what it looks like at infinity. -> *convolve with line function.*

- Ross, Fabian, Brandt 1996; Zycki & Done 1999

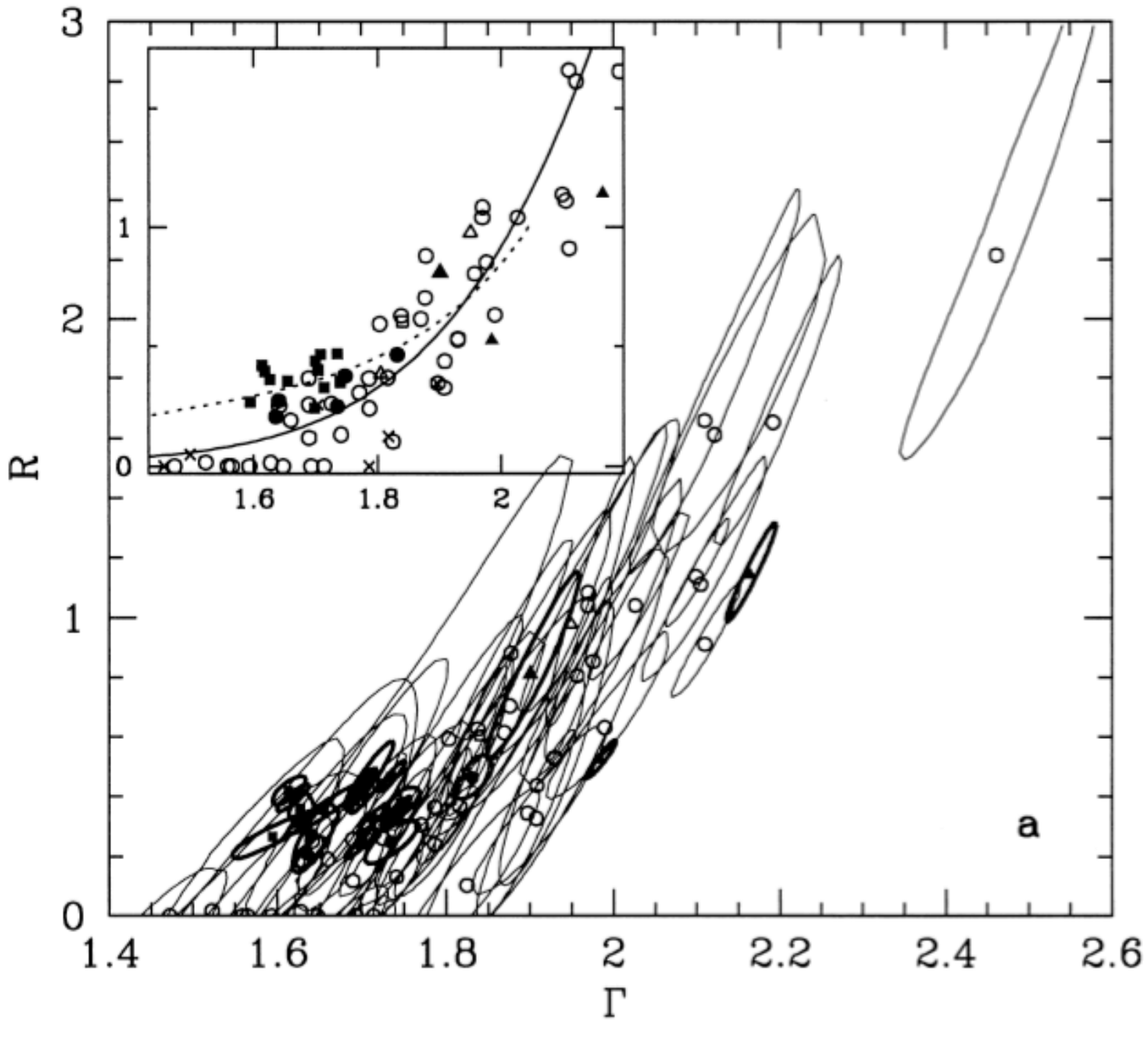
Lags in FCS of GX 339-4



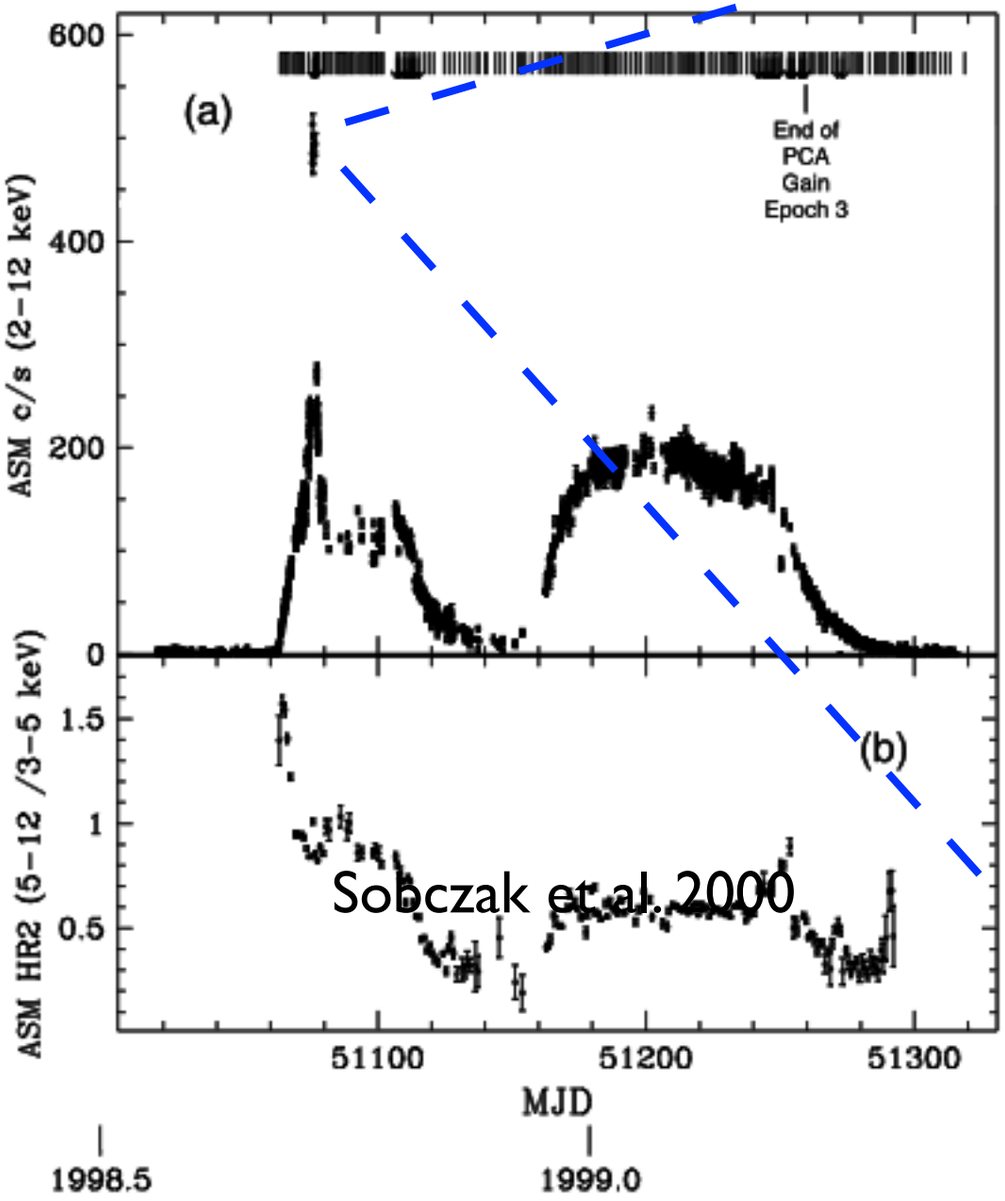
Uttley et al. 2010; also see
Gilfanov, Churazov, Revnivtsev 2010

R-Gamma Correlation

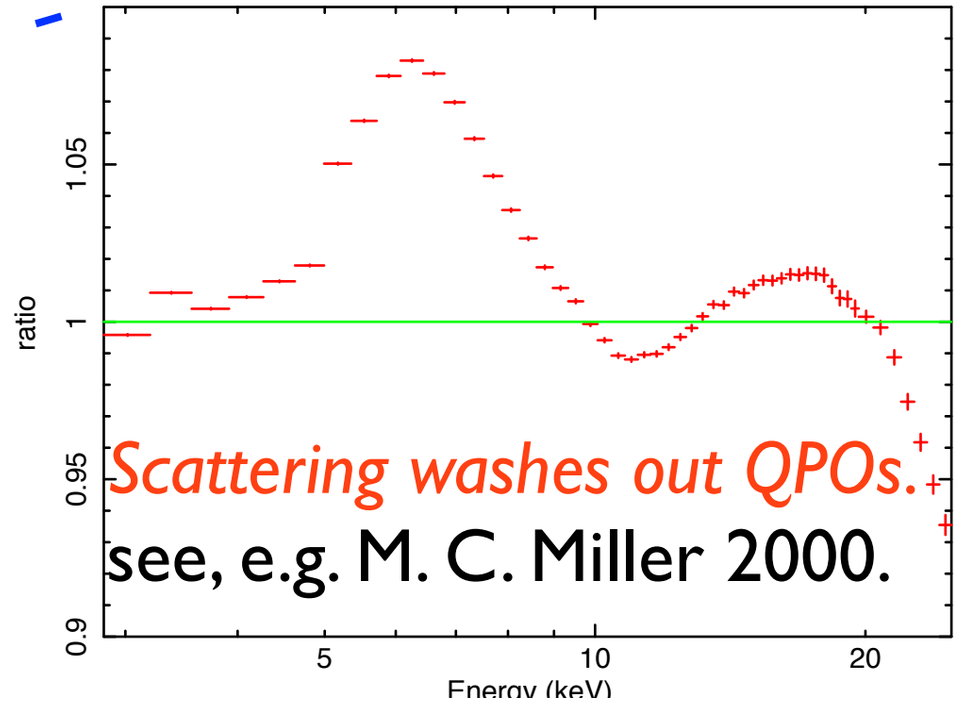
Zdziarski, Lubinski, Smith 1999



XTE J1550-564 in 1998/1999

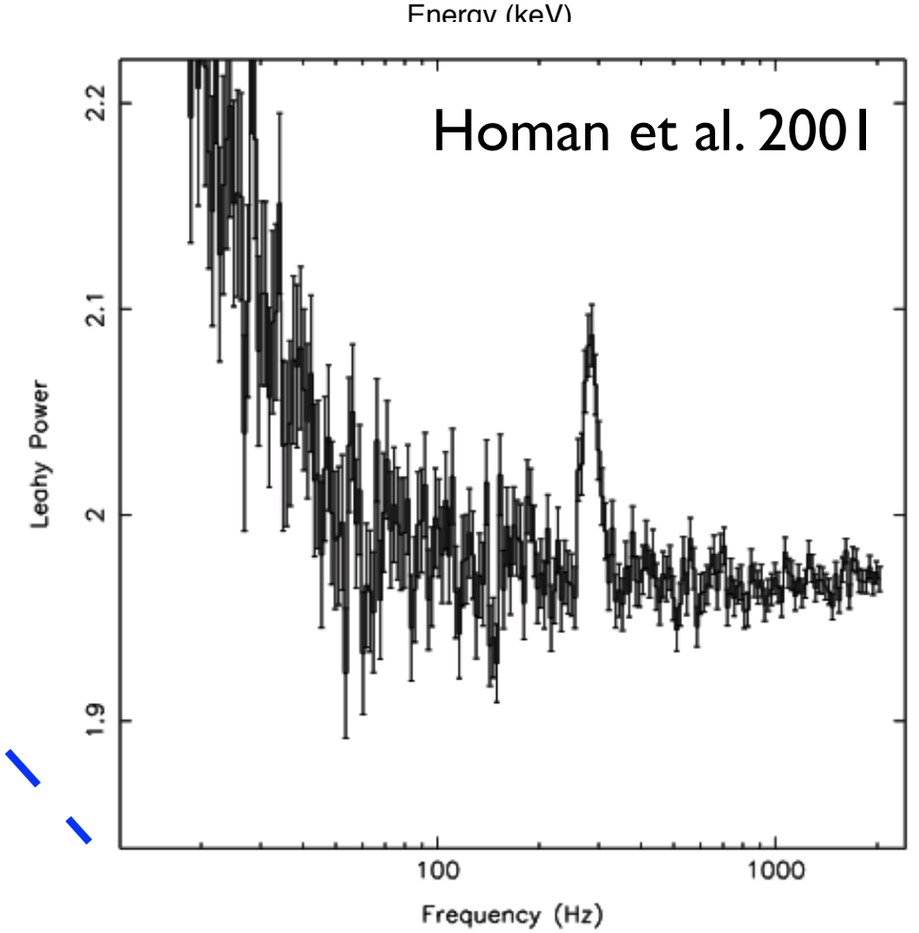


Sobczak et al. 2000



Scattering washes out QPOs.

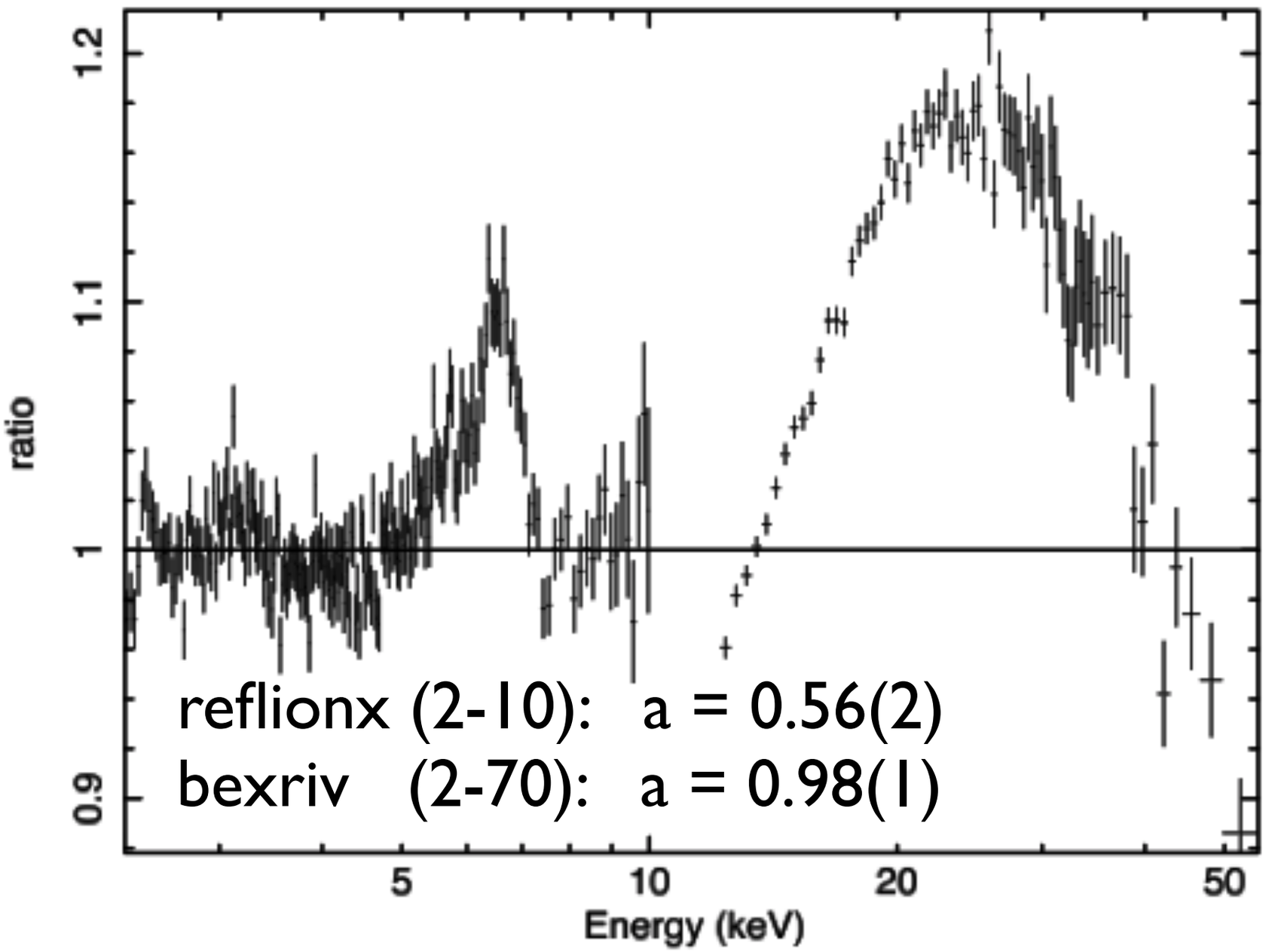
see, e.g. M. C. Miller 2000.



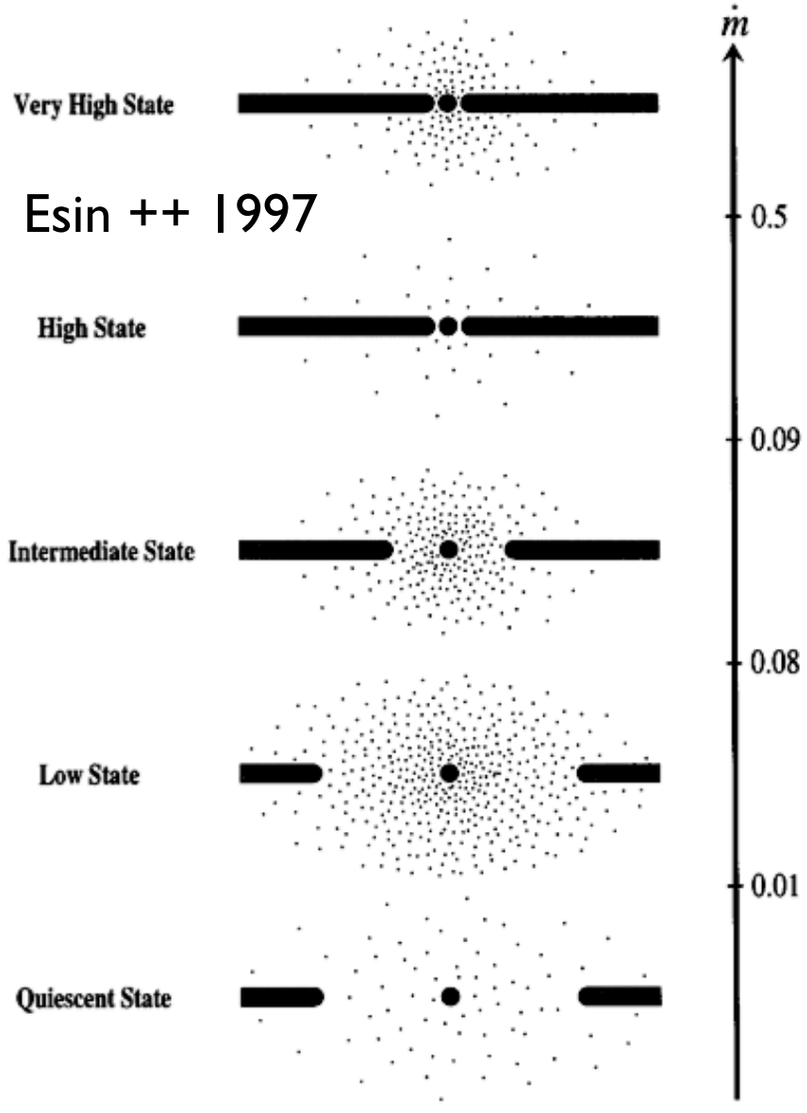
Homan et al. 2001

GRS 1915+105

Blum et al. 2009

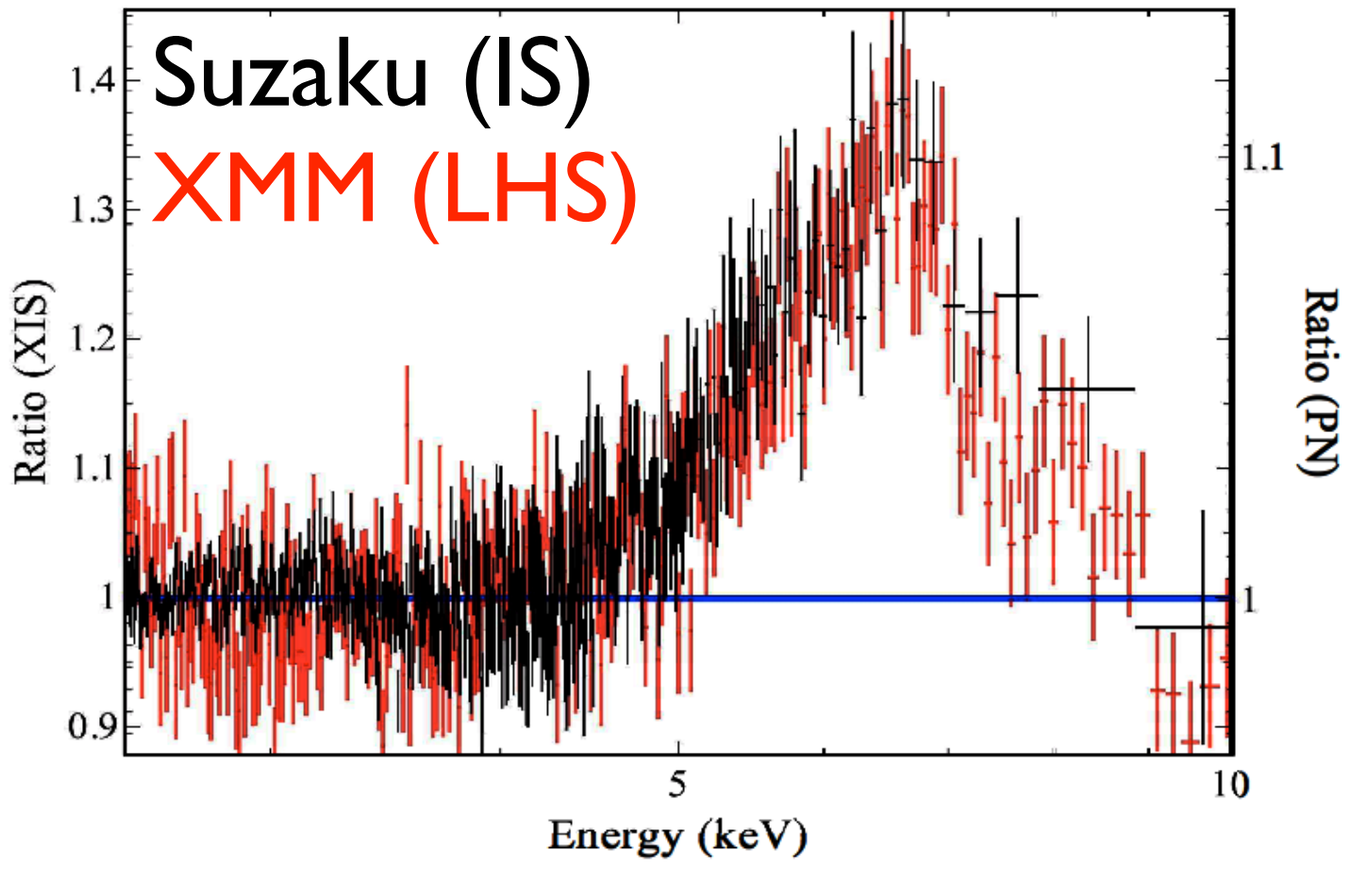


Spin in XTE J1752-223



Esin ++ 1997

Reis et al. 2011



Intermediate State (Suzaku), low/hard state (XMM).

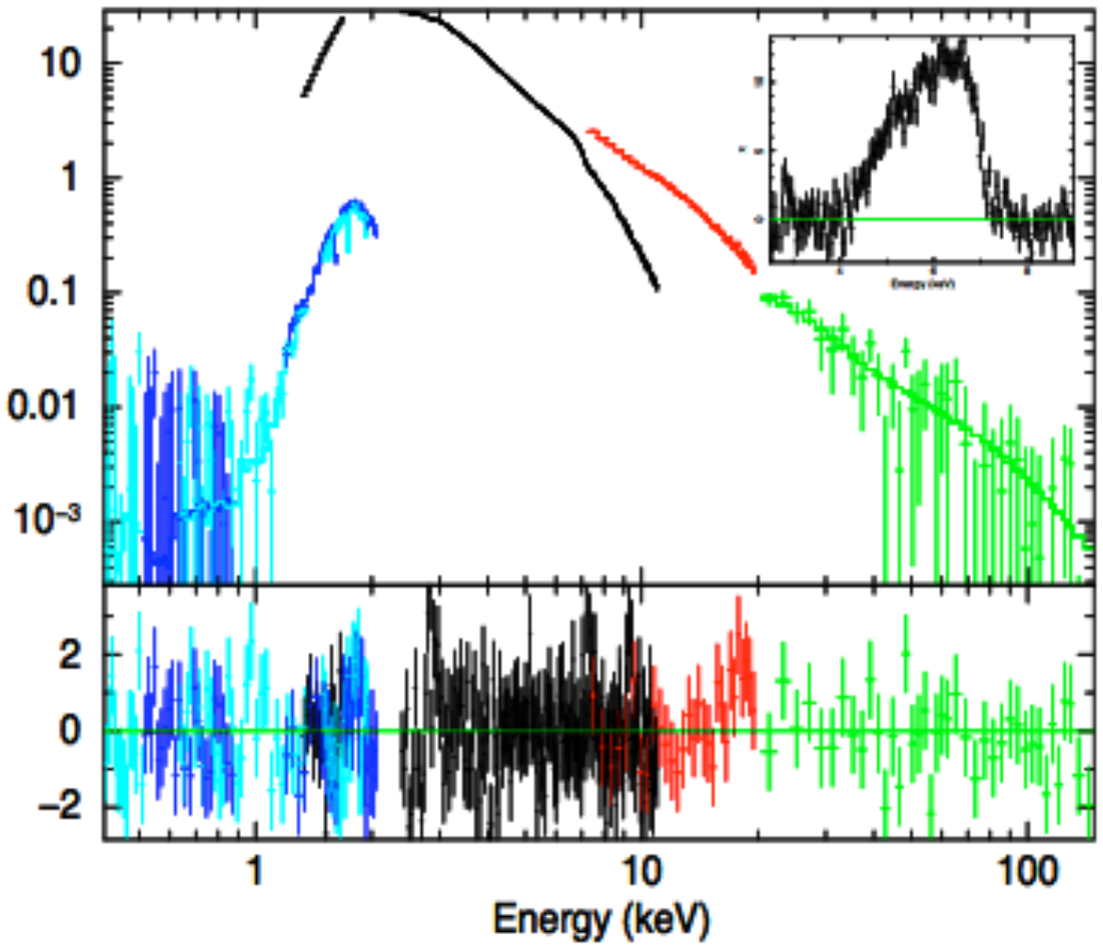
Blurred reflection fits: a/M = 0.52 +/- 0.11.

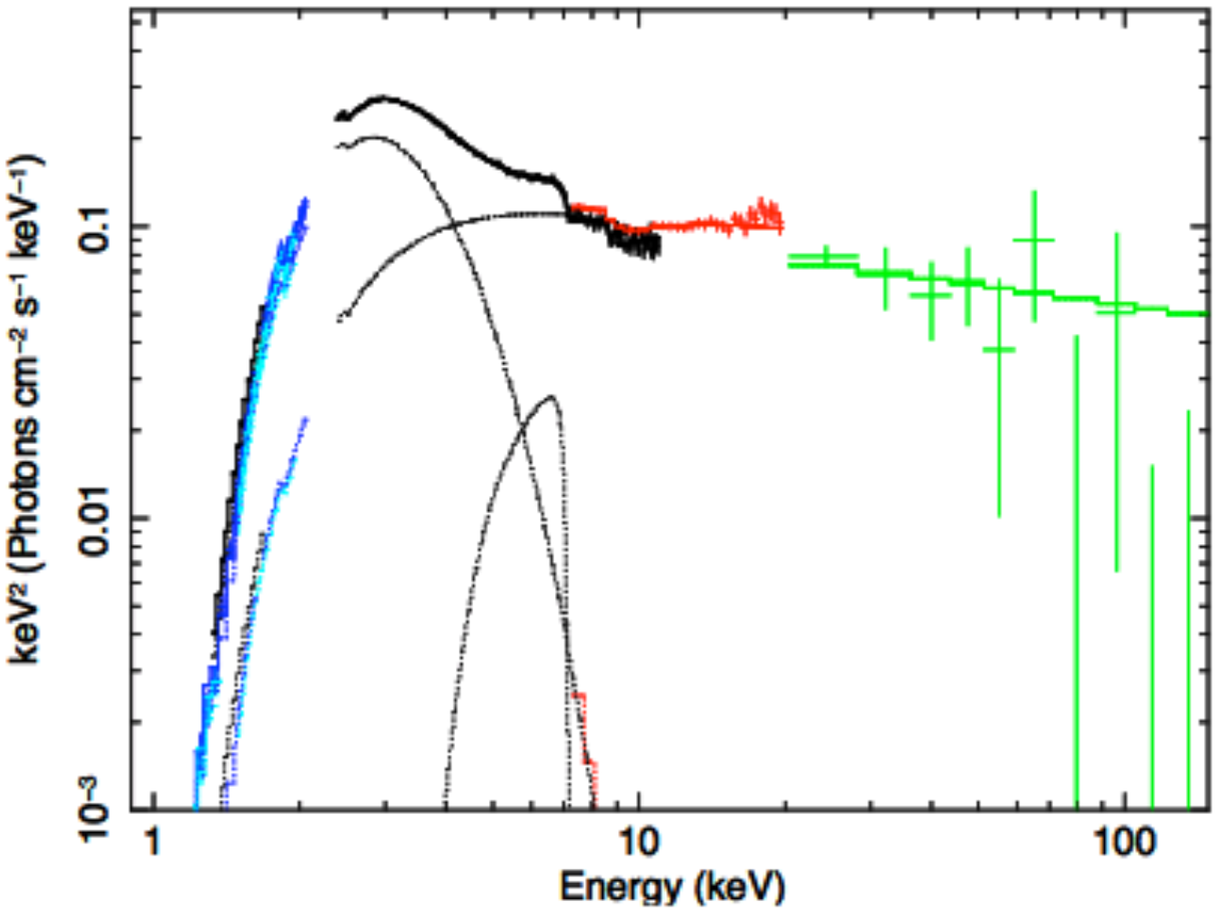
Strong implications for accretion flow models.

Spin in XTE J1652-453

XMM-Newton

Hiemstra et al. 2010

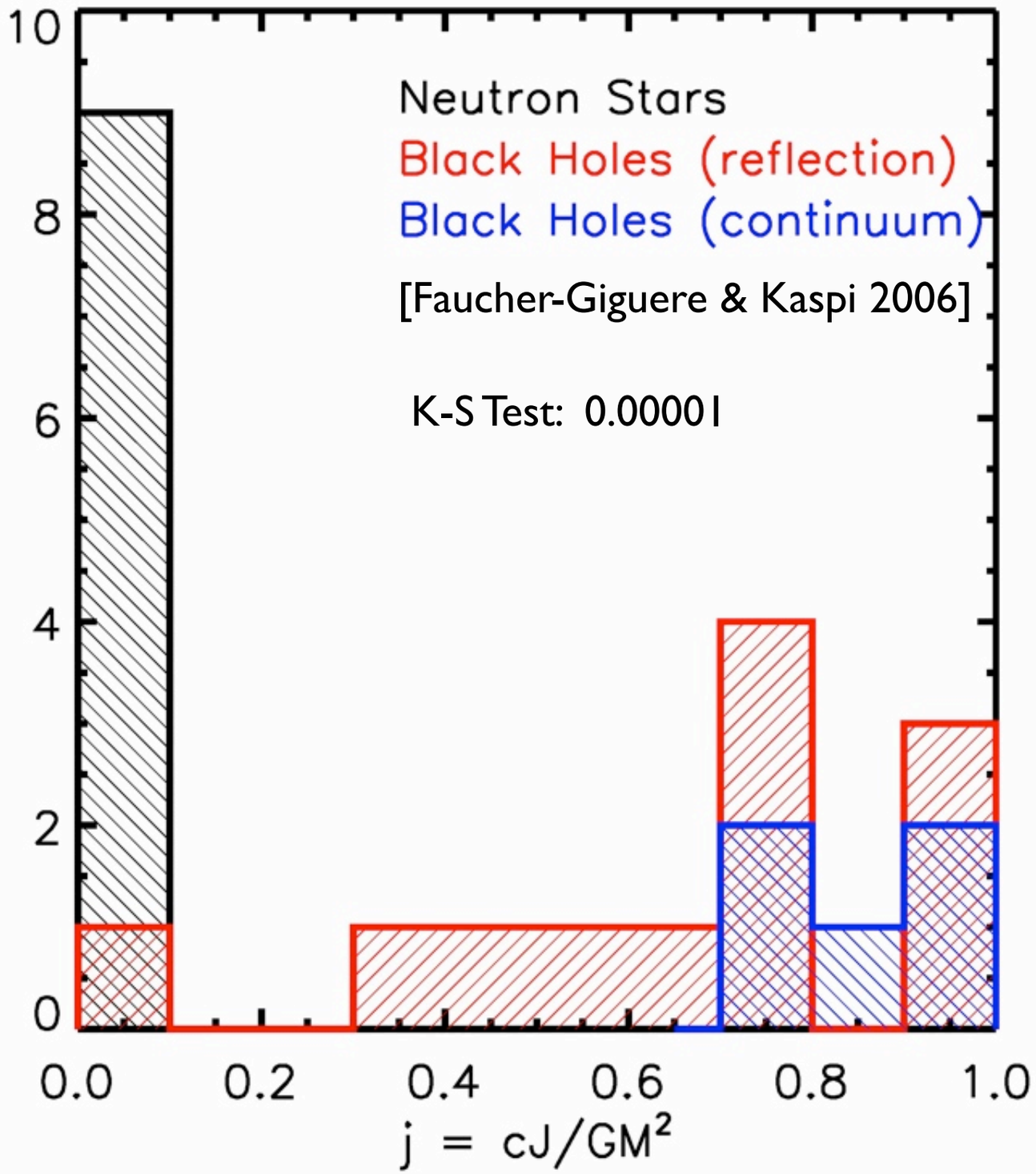




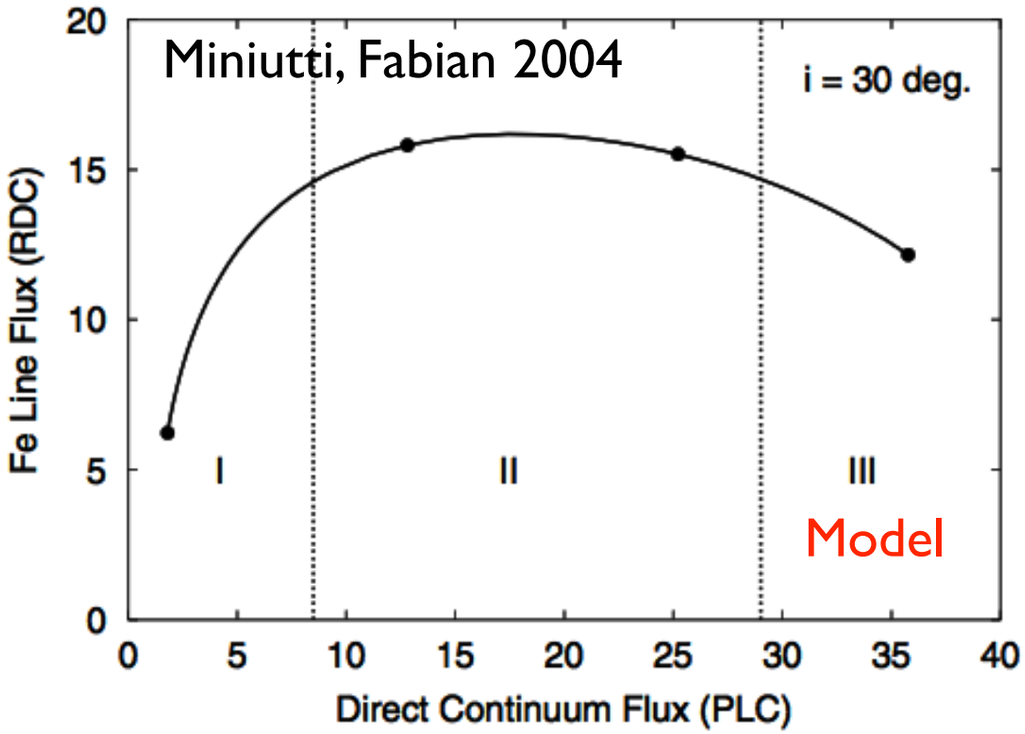
XTE J1652-453 observed in an Intermediate State.

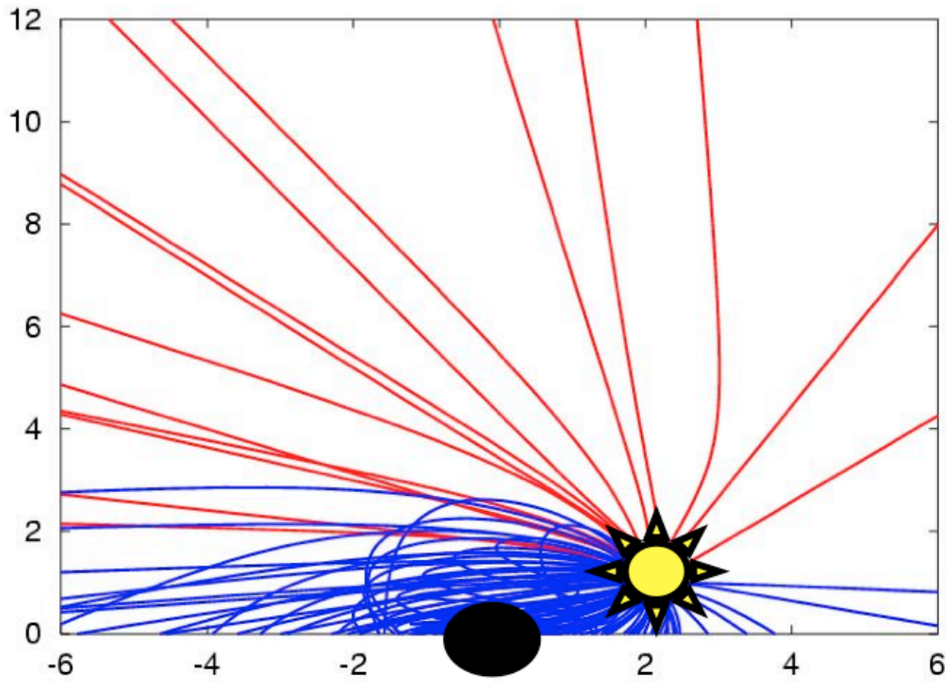
Blurred reflection fits: a/M = 0.45 +/- 0.02.

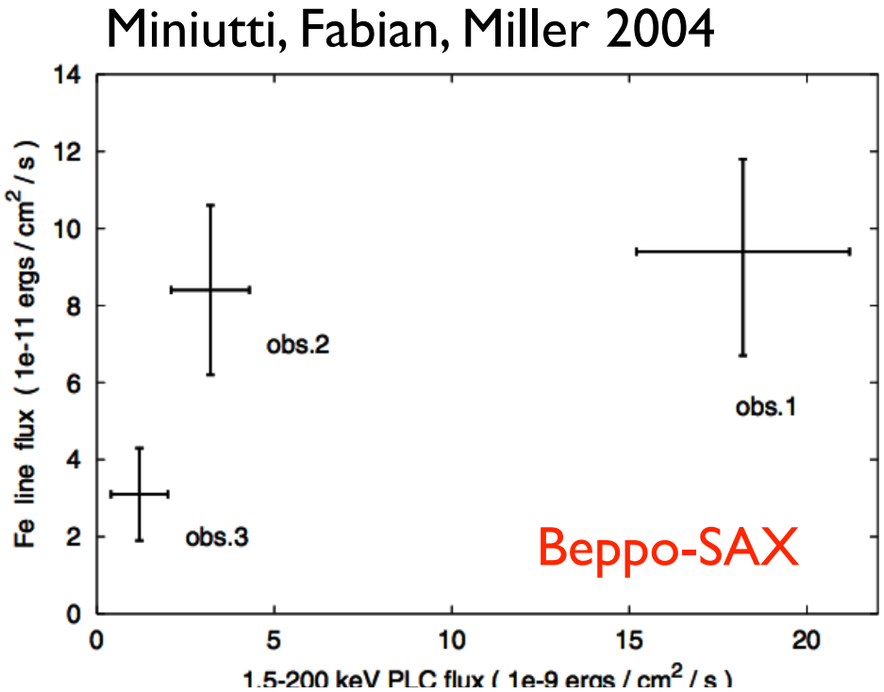
Miller, Miller, Reynolds 2010

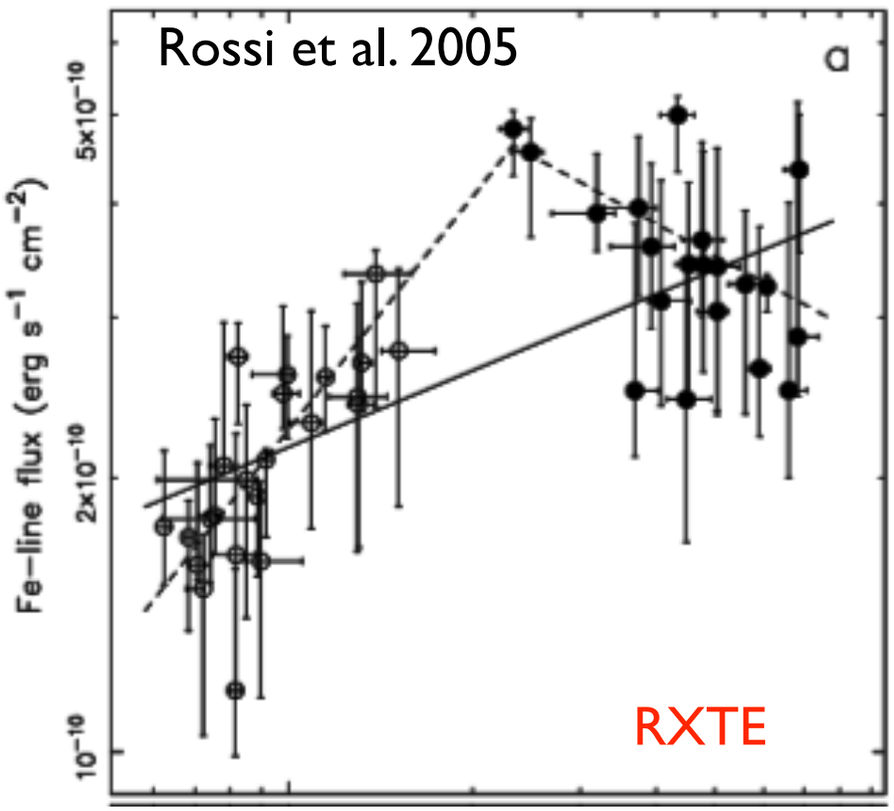


XTE J1650: Light Bending?









Looking ahead

- Suzaku, Astro-H can continue to measure spins ... double number of measurements?
- ... can make excellent tests of light bending.
- ... can test whether or not disks always truncate at 0.001 Eddington. Is Eddington fraction the only determinant?
- ... can continue to enhance our understanding of hard X-ray production in black holes across the mass scale.