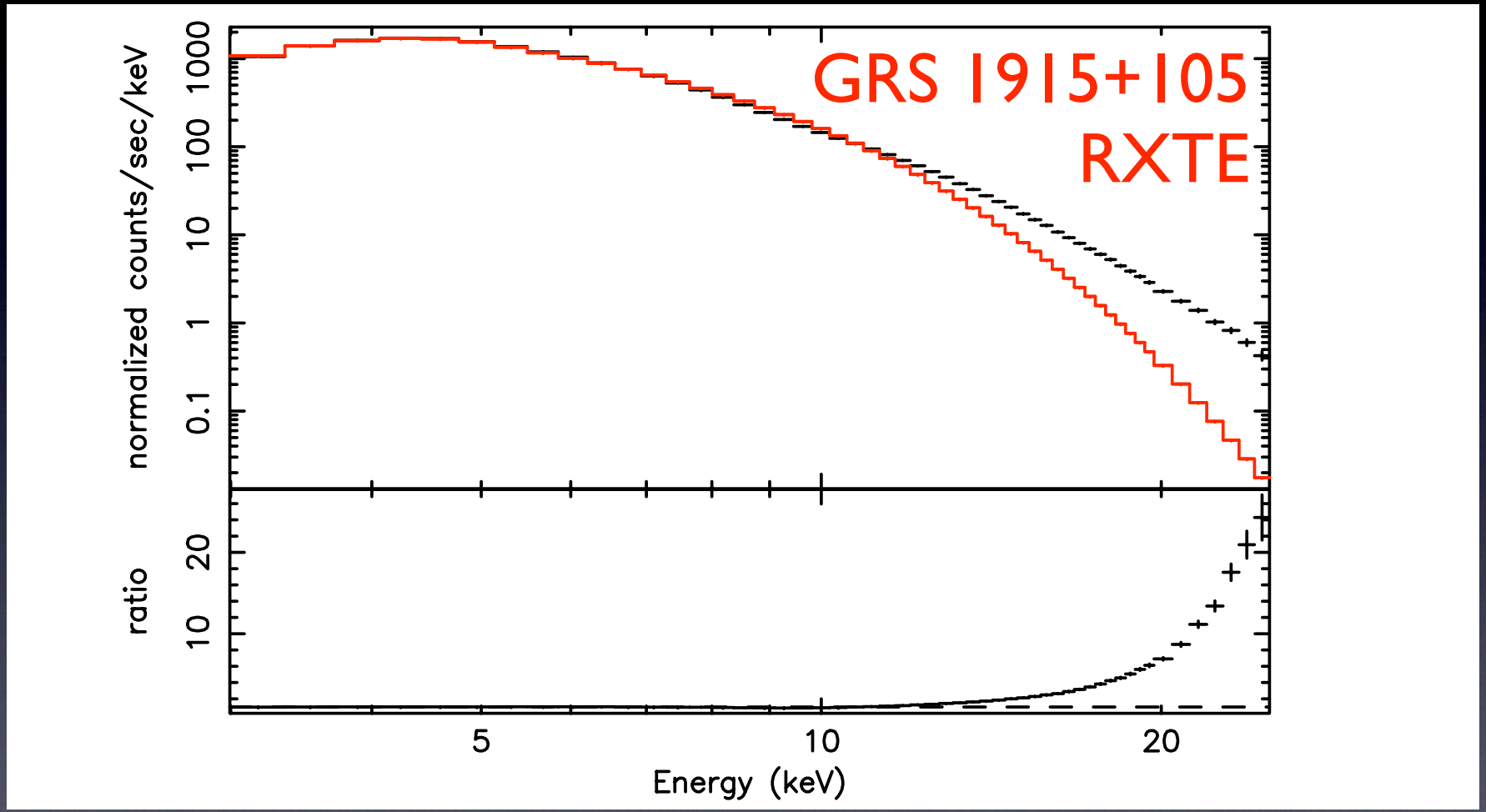
Relativistic Iron Lines in Black Holes and Neutron Stars

Jon Miller (Univ. Michigan)
Cackett, Fabian, Reynolds
Homan, van der Klis, Rupen, Steeghs, Wijnands

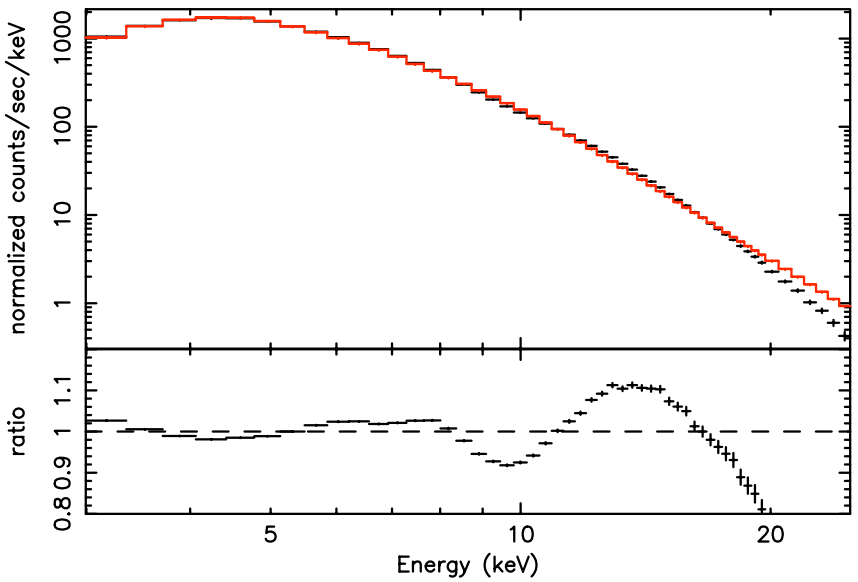
The disk continuum



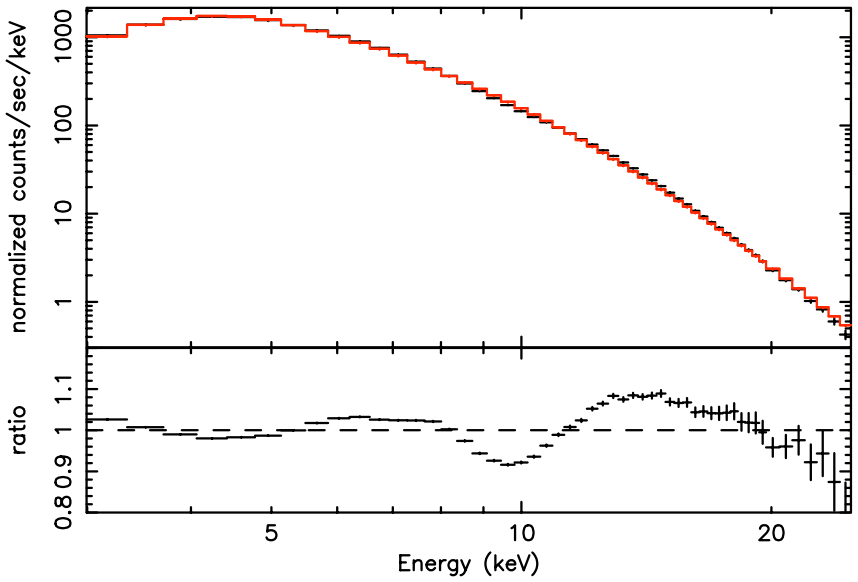
McClintock et al. 2006: a = 0.98 in GRS 1915+105

A Harder Look at the Continuum

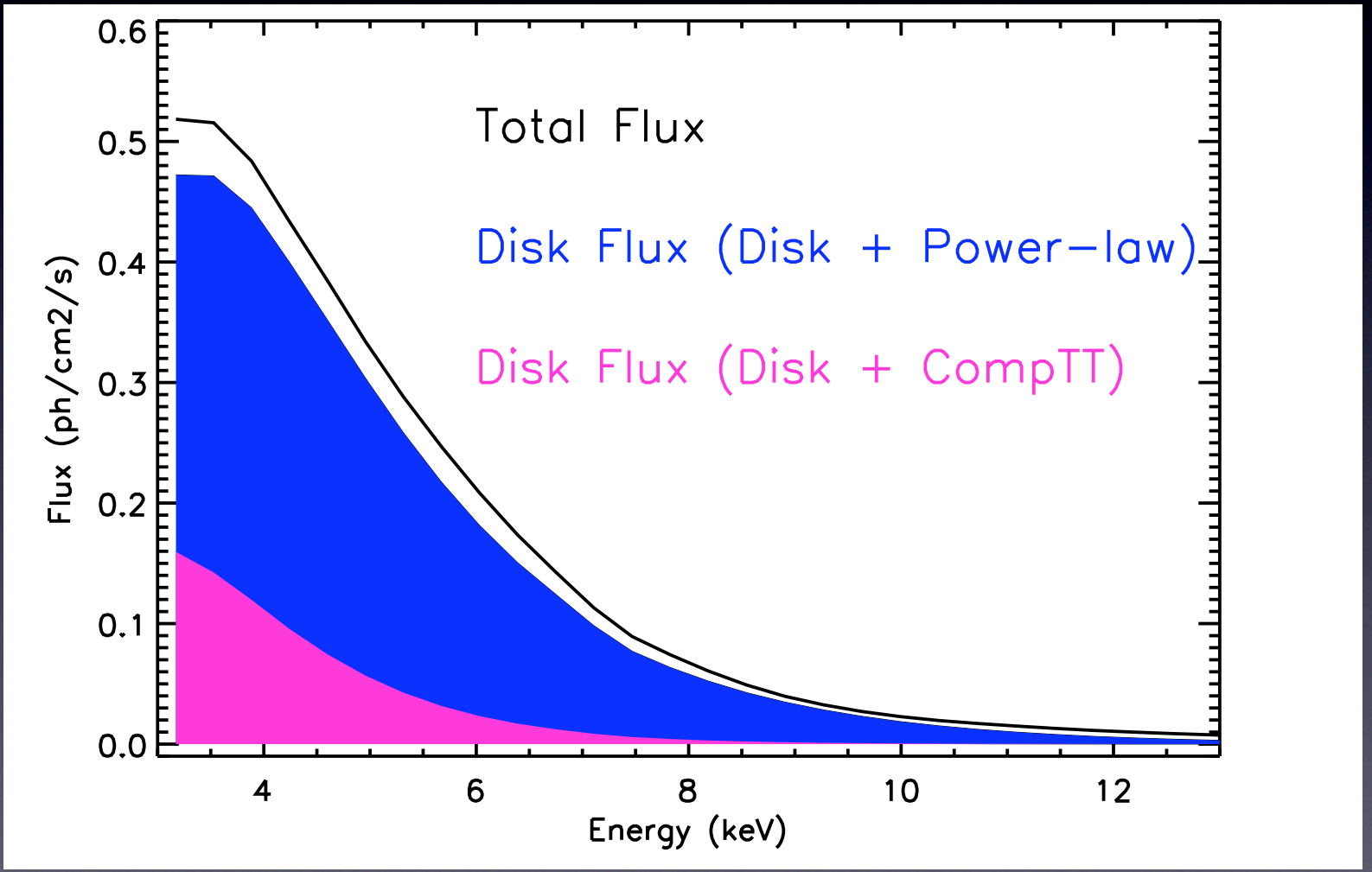
Diskbb + Power-law



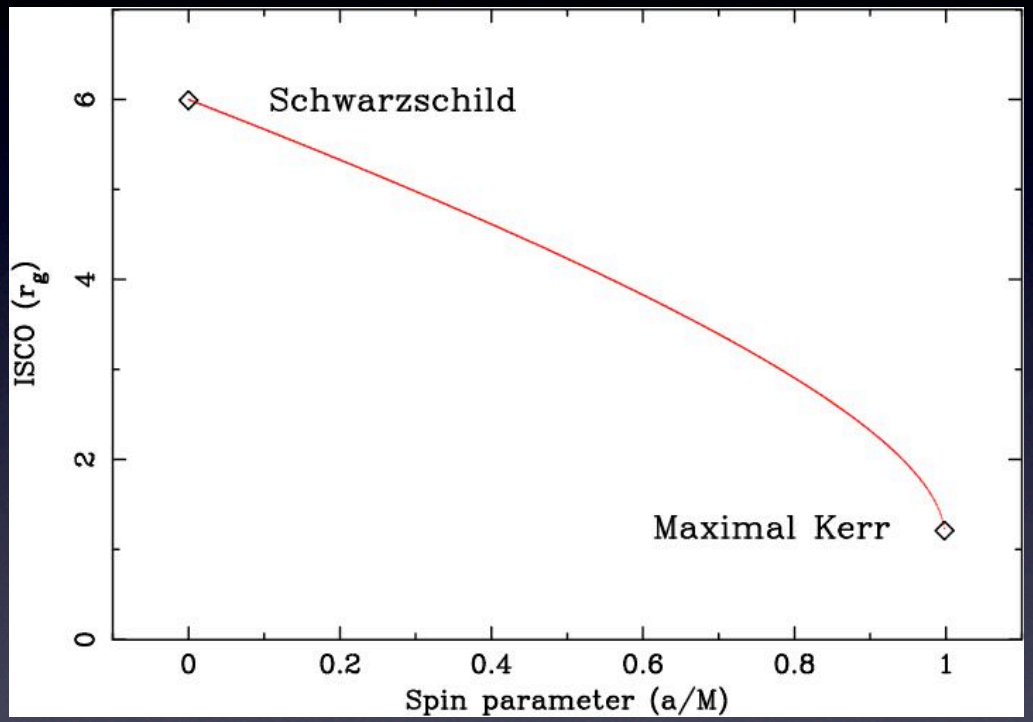
Diskbb + CompTT

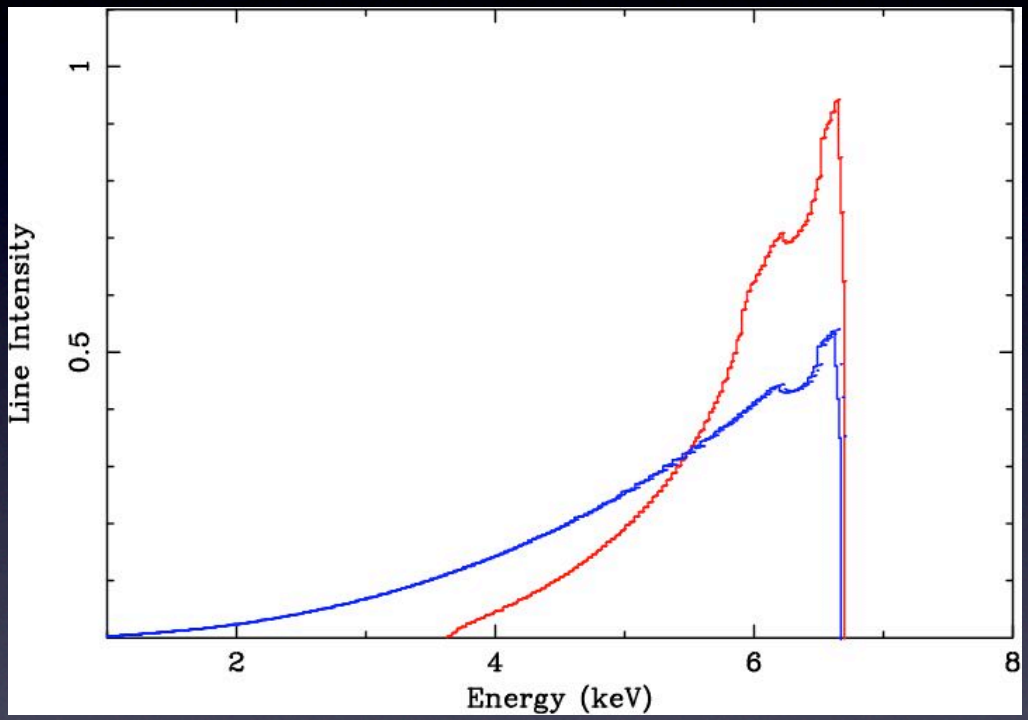


High radius (spin) precision is impossible with disk continua

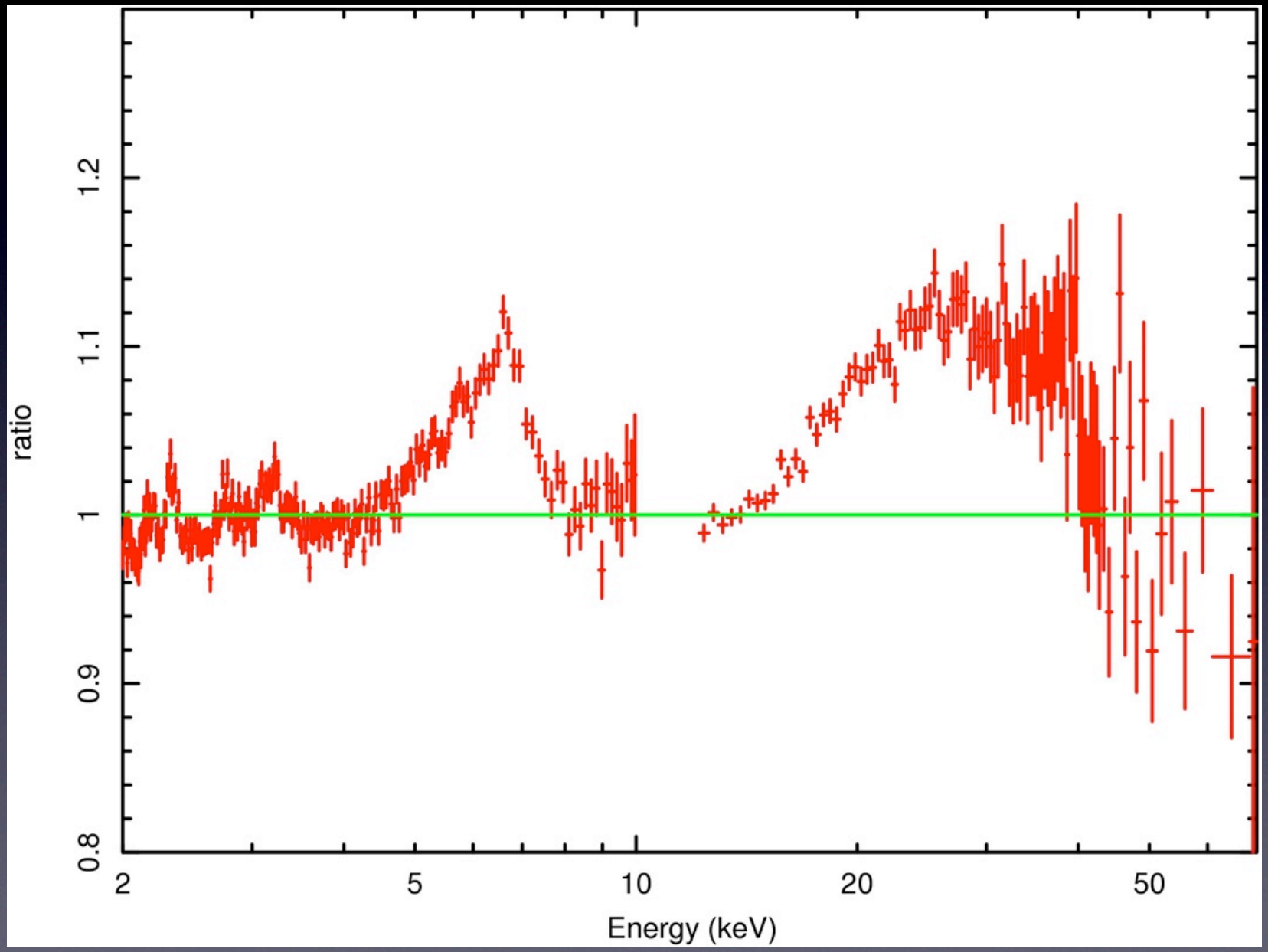


X-ray Disk Lines



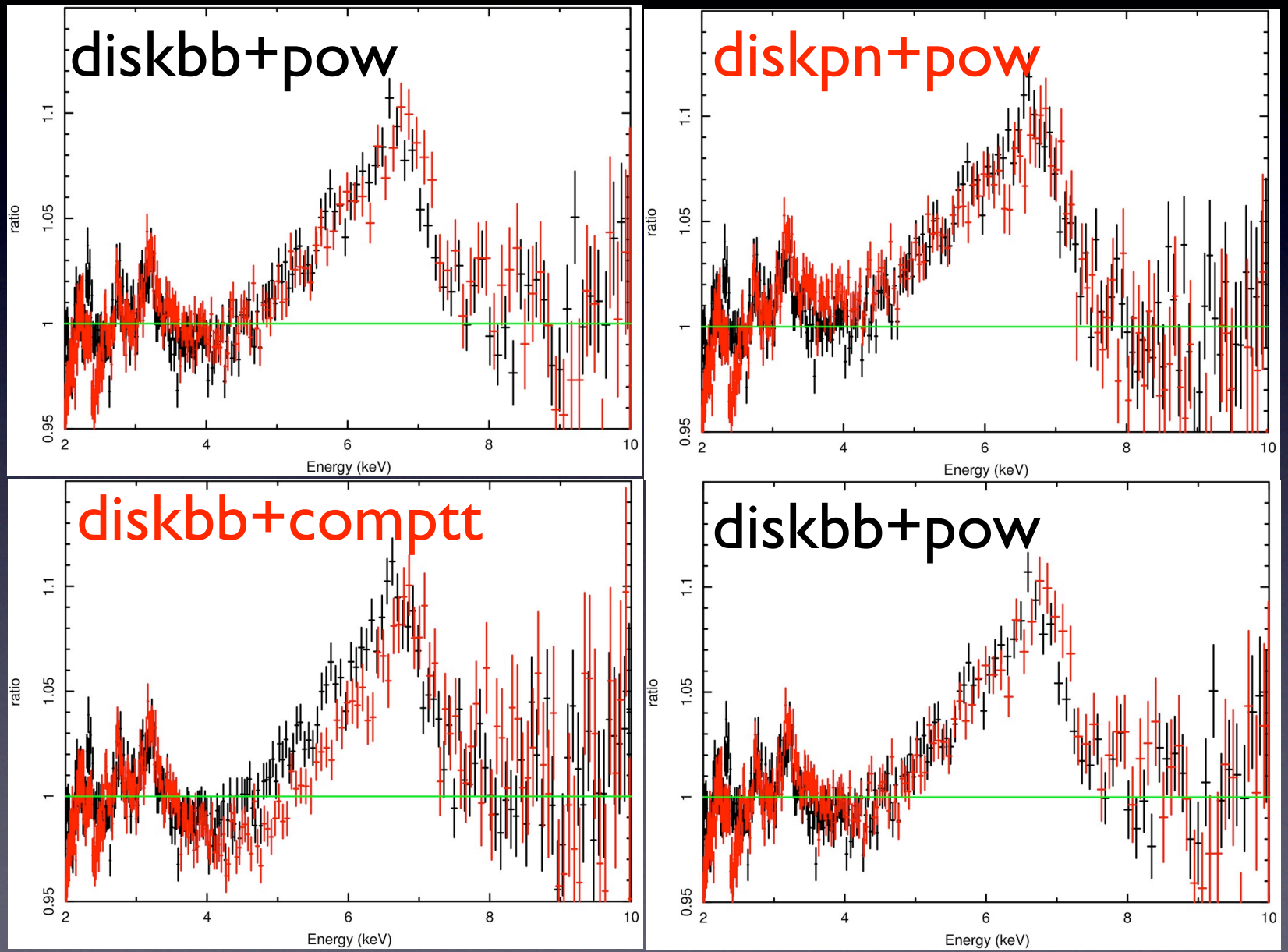


Suzaku: GX 339-4



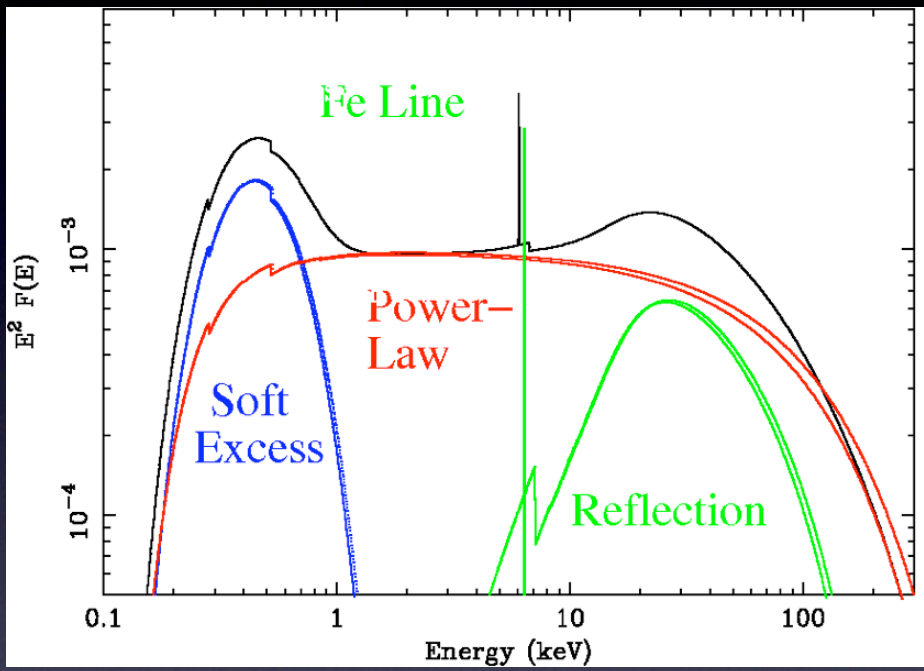
Suzaku: GX 339-4

Miller et al. 2008

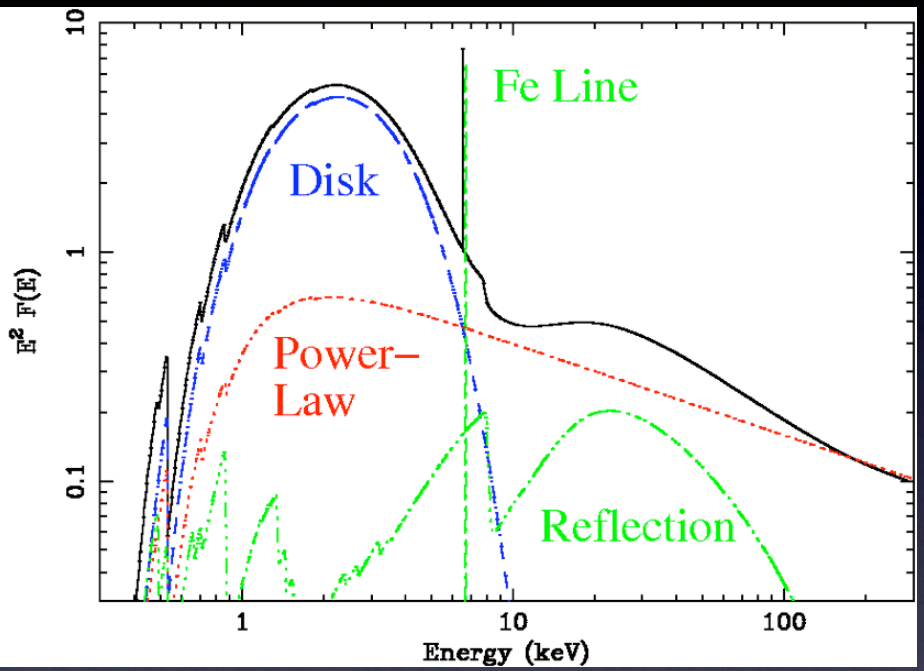


X-ray Spectra

Seyfert-1 AGN

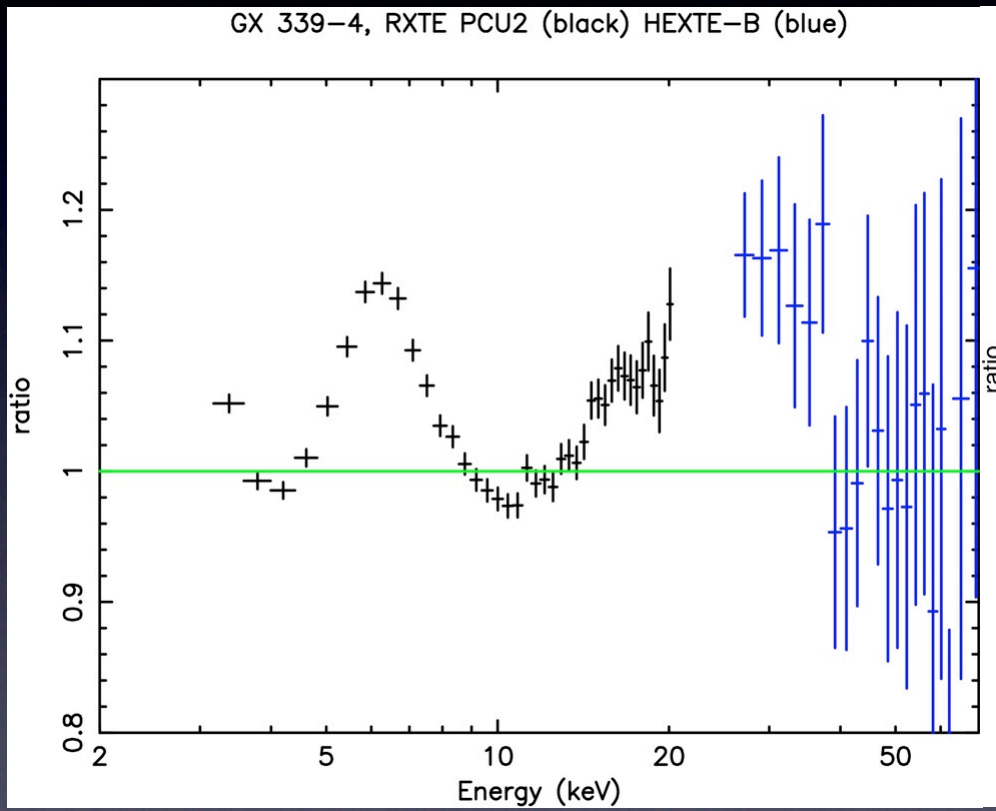


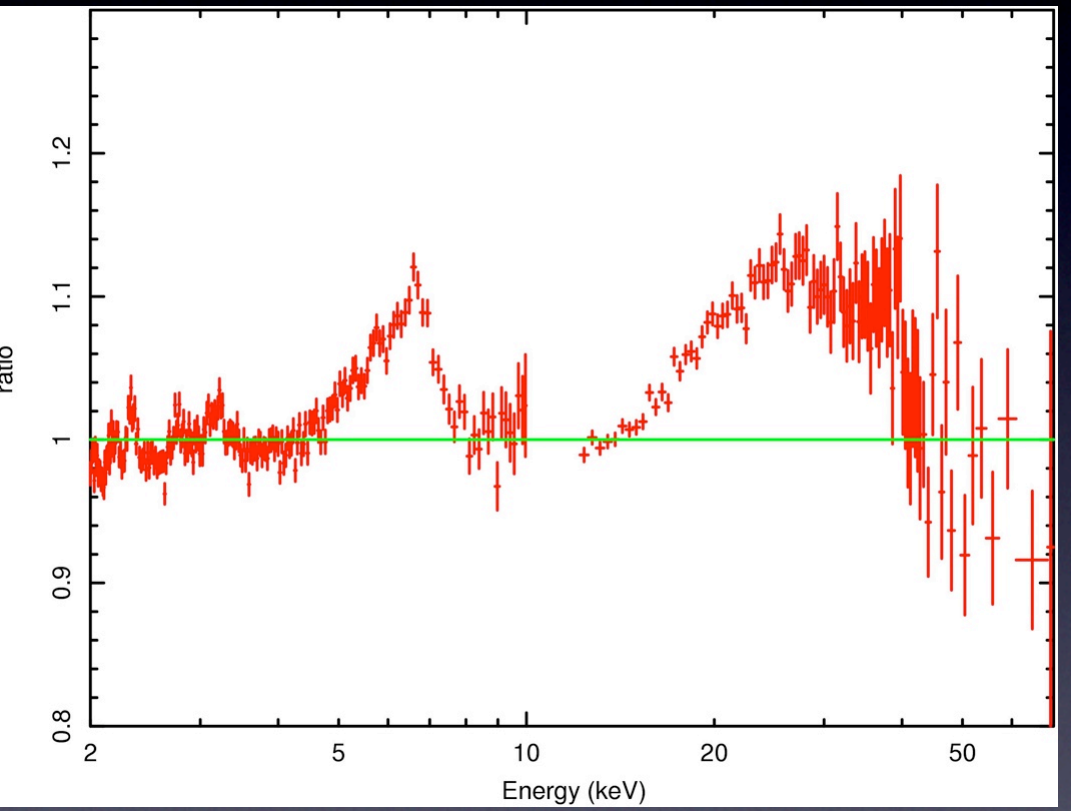
Stellar-mass black hole

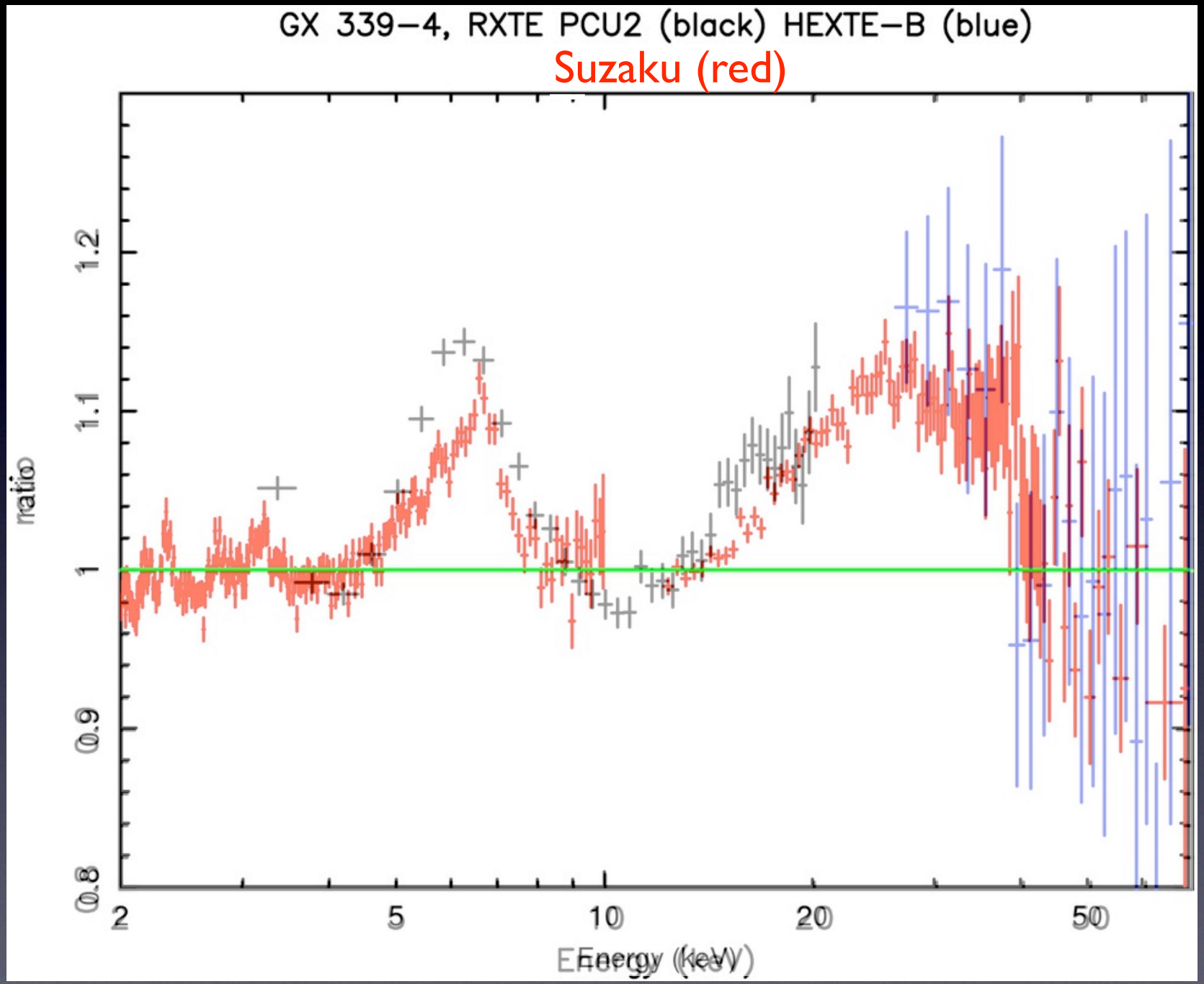


- The continuum in stellar-mass BHs is rather simple.
- No warm absorber (no means N_OVIII 10^-2 less).

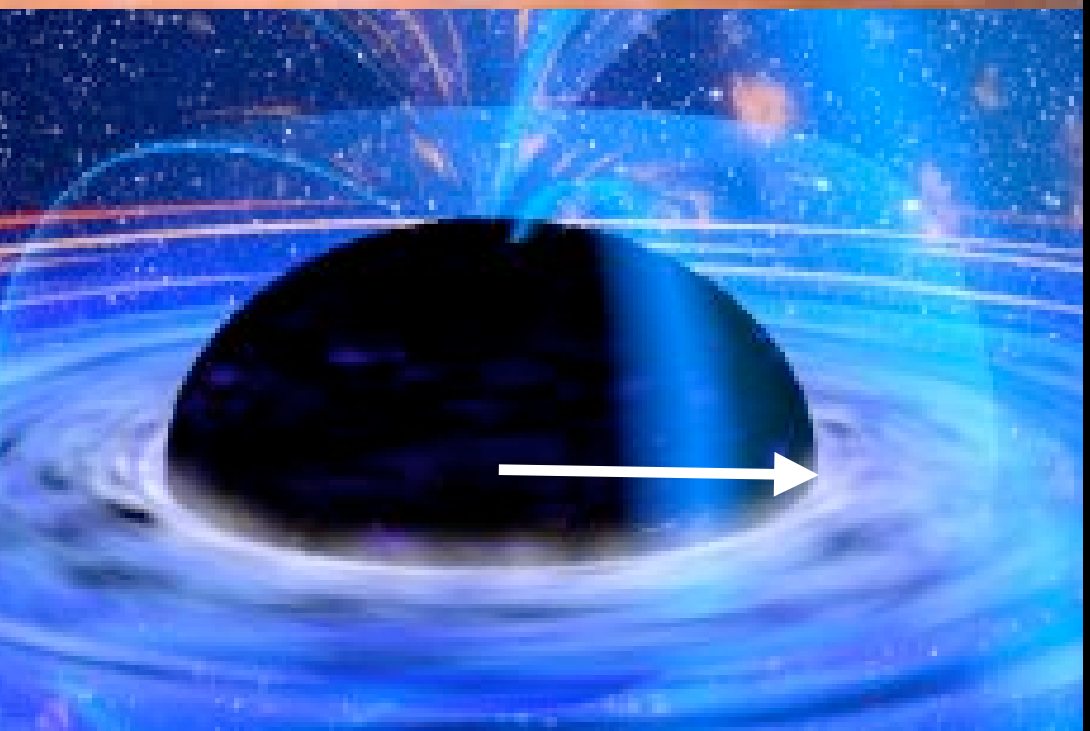
Suzaku: Reflection Machine






GX 339−4, RXTE PCU2 (black) HEXTE−B (blue)
Suzaku (red)
ratio
0.8
0.9
1
1.1
1.2
2
5
10
20
50
Energy (keV)

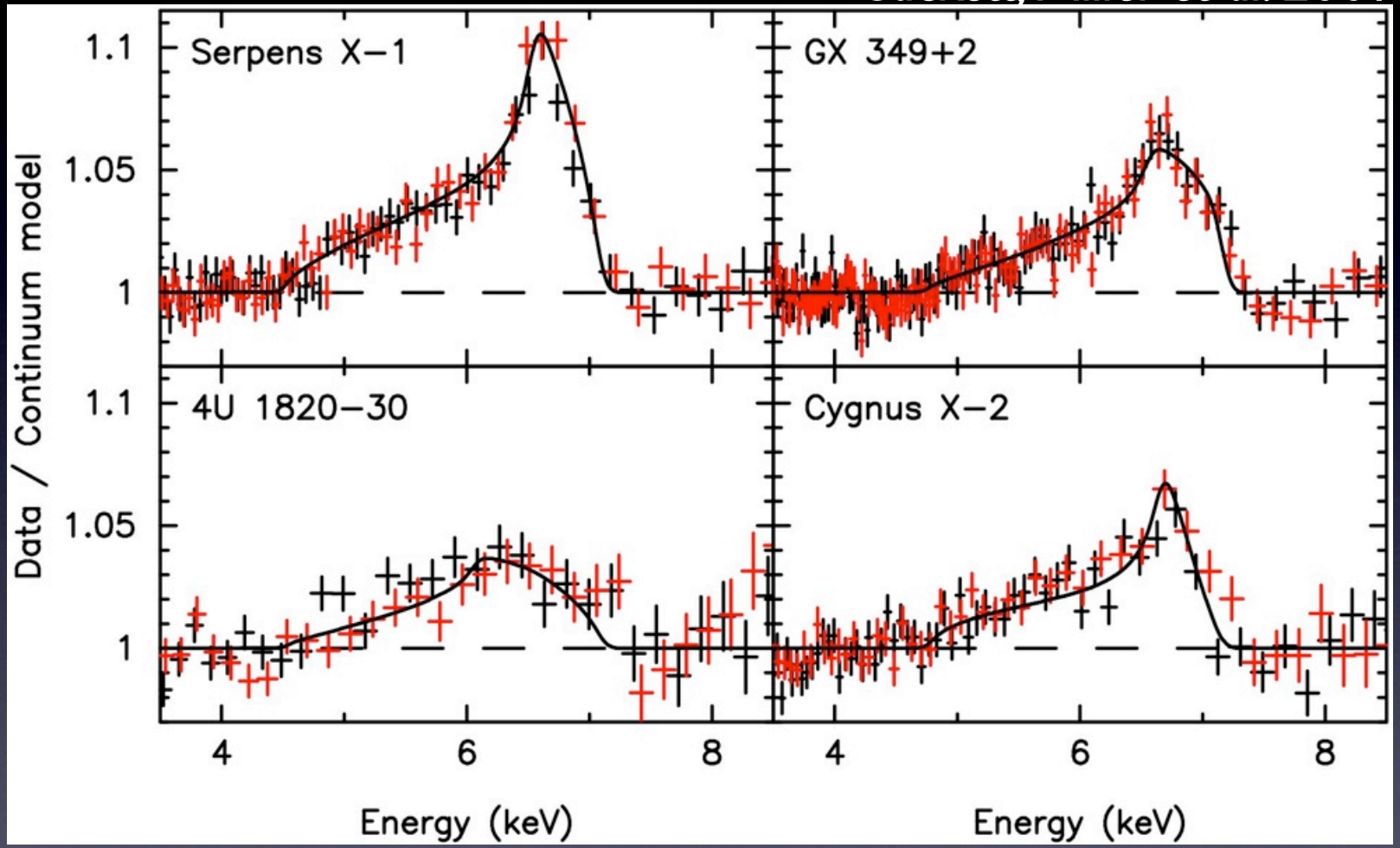
A 1.4 Msun neutron star with a radius of 10 km is about 4.5 times GM/c^2.



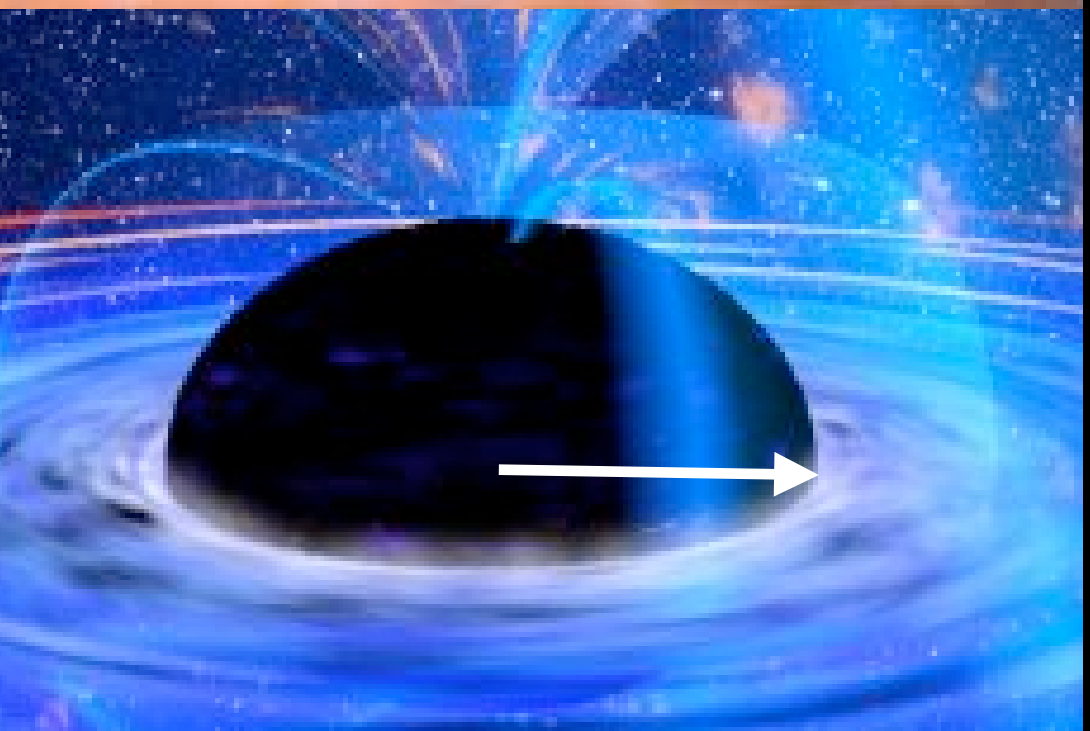
This is very similar to the 6 GM/c^2 ISCO expected for a=0 black holes.

Relativistic lines in neutron stars!

Cackett, Miller et al. 2007



r* < 14-16 km



Interesting corollary:

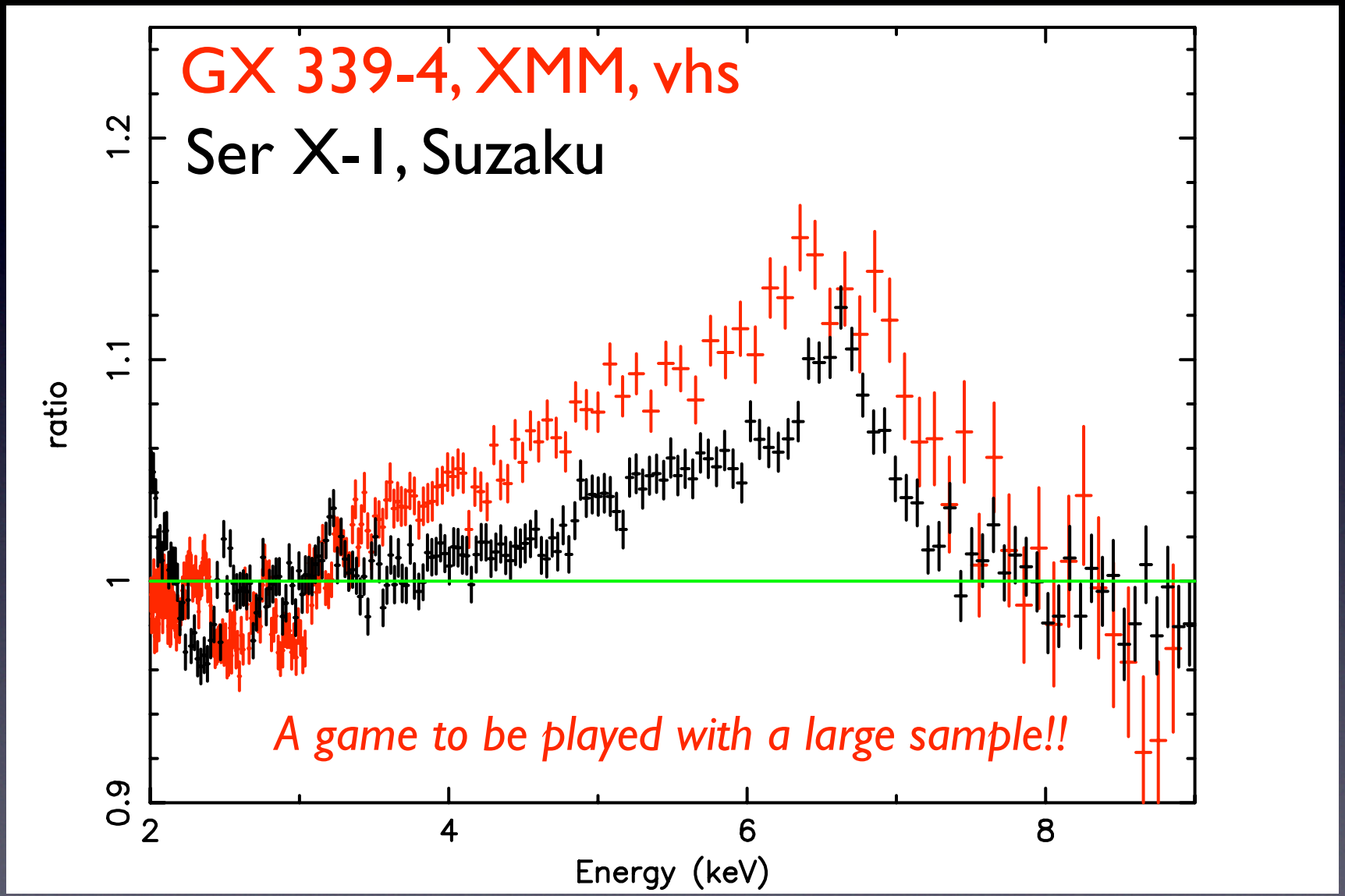
2.0 Msun NS
--> 3.3 GM/c^2

3.0 Msun NS
--> 2.2 GM/c^2

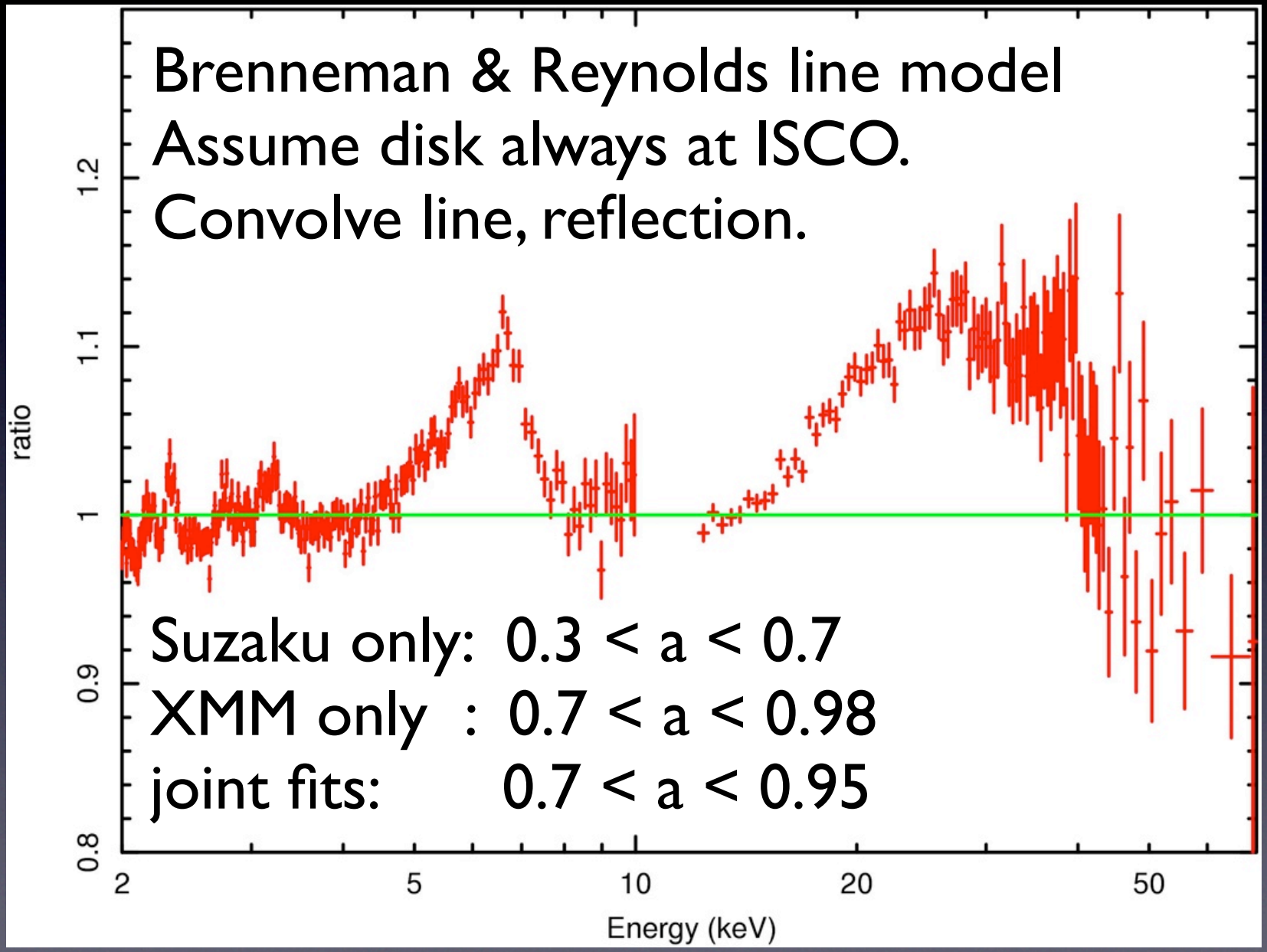
Massive neutron stars start to look like spinning black holes.

Indirect masses?

GX 339-4 and Serpens X-1



Toward spin in GX 339-4



Challenge

5-10 new + 5-10 known black hole transients.

3 observations of 10 outbursts, 50 ksec each.

→ *1.5 Msec for 15 black hole spin constraints.*

12 persistent + 4 transient neutron star binaries.

3 observations of each source at 50 ksec.

→ *2.4 Msec for 16 stellar radius limits.*

→ 5% of total time in a 10 year mission.

More Challenges

- Are disk lines present in BH high/soft states?
- Can we reveal the corona with reflection?
- At what L_X/L_Edd do lines disappear?

- Can we see the 20-30 keV hump in a NS?
- How do lines vary through a Z/atoll track?
- How many masses can we get? (Cackett)

Summary

- Suzaku is ideal for the study of disk reflection in Galactic black holes and neutron stars.
- Relativistic lines in neutron stars have been clearly revealed, can constrain radii (Cackett).
- With broad-band spectra and new models, the time has arrived for BH spin constraints.
- *Meaningful samples only require 5% in 10 yrs.*

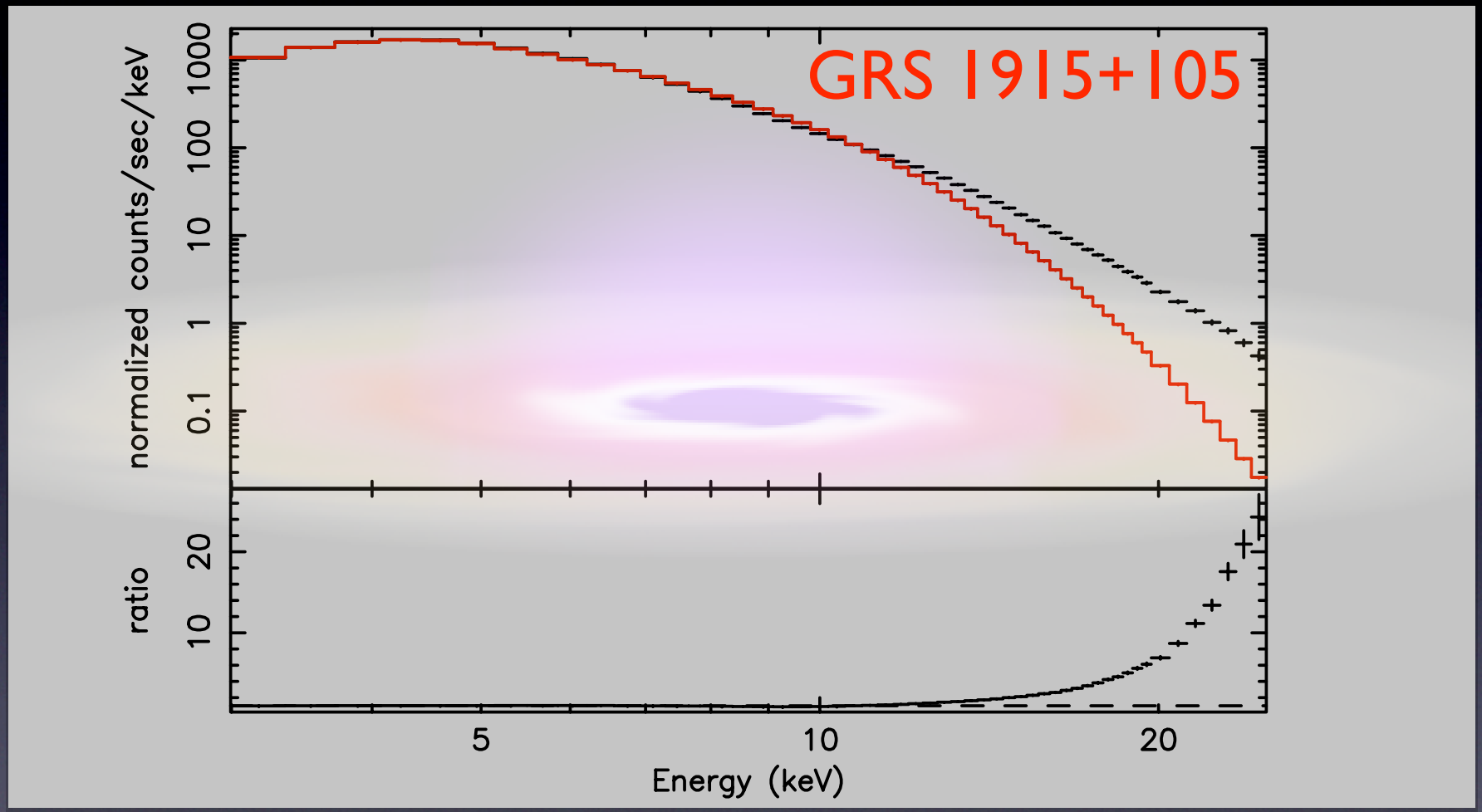
Additional Slides

Iron lines are the worst way to reveal compact objects ... apart from all the others.

Winston Churchill*

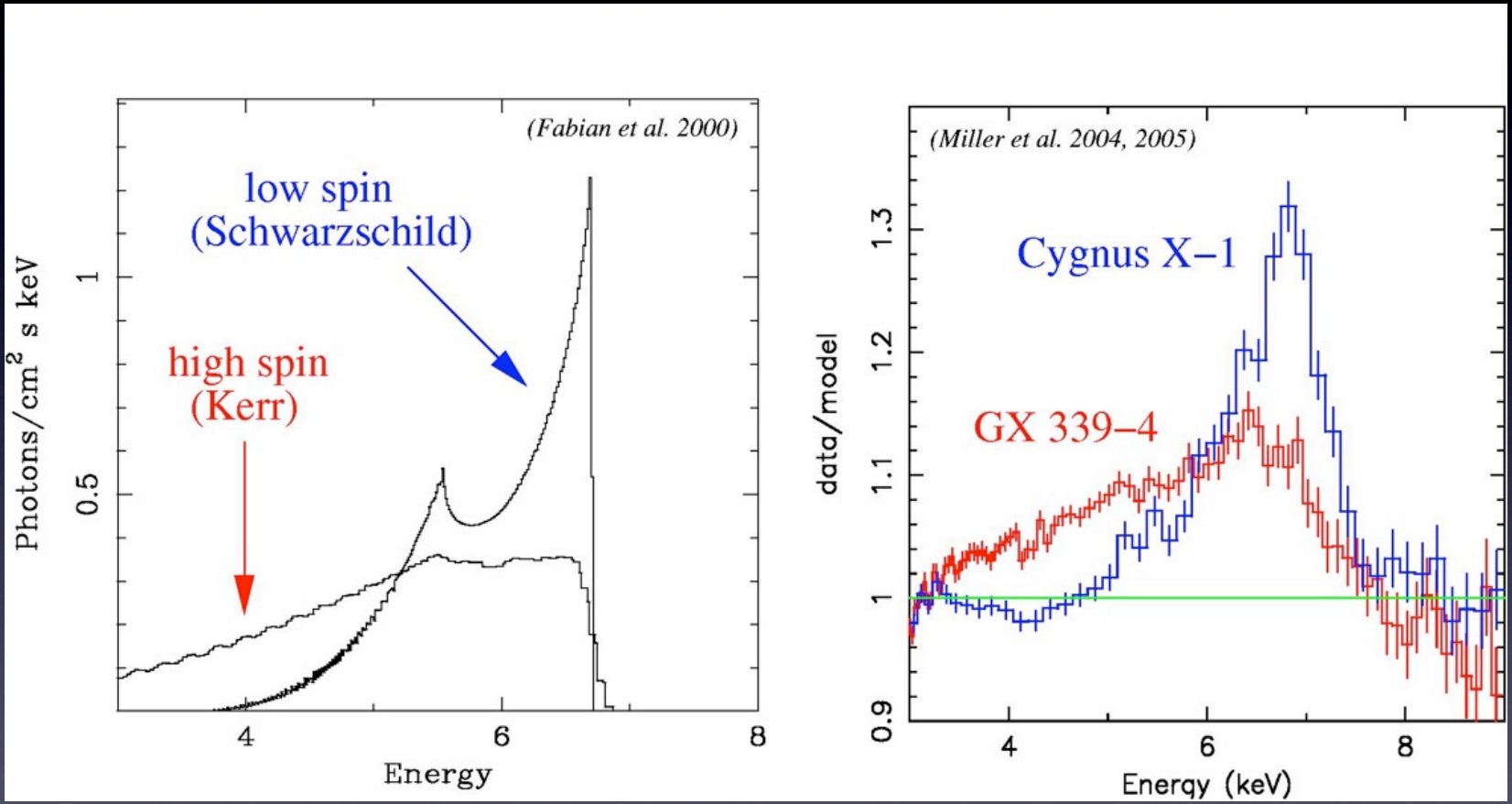
* not so much

The disk continuum

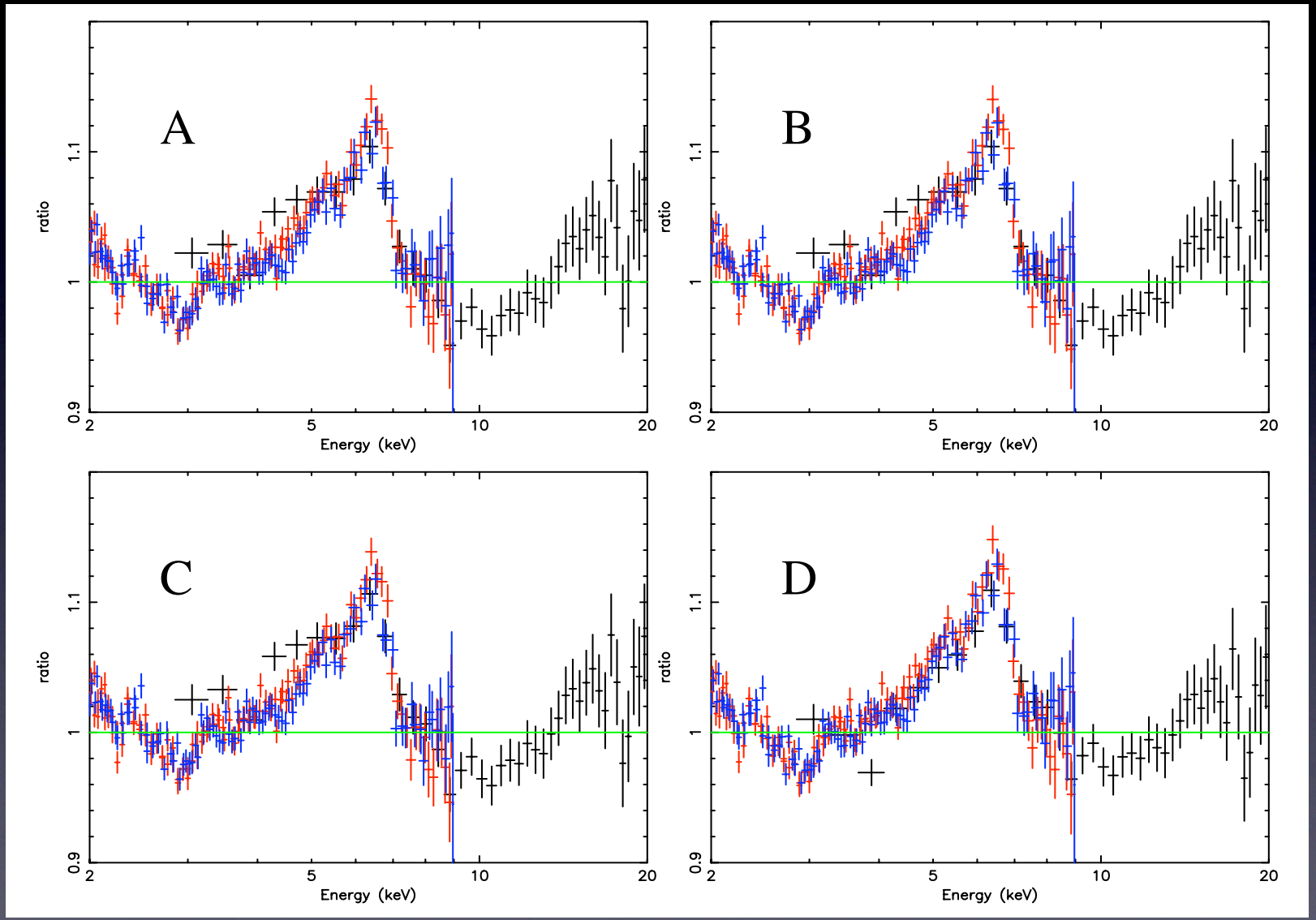


McClintock et al. 2006: a = 0.98 in GRS 1915+105

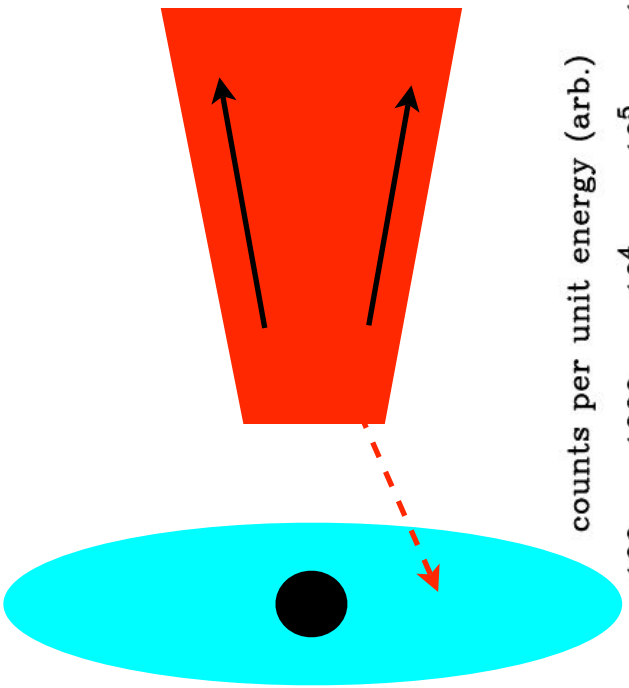
X-ray Disk Lines

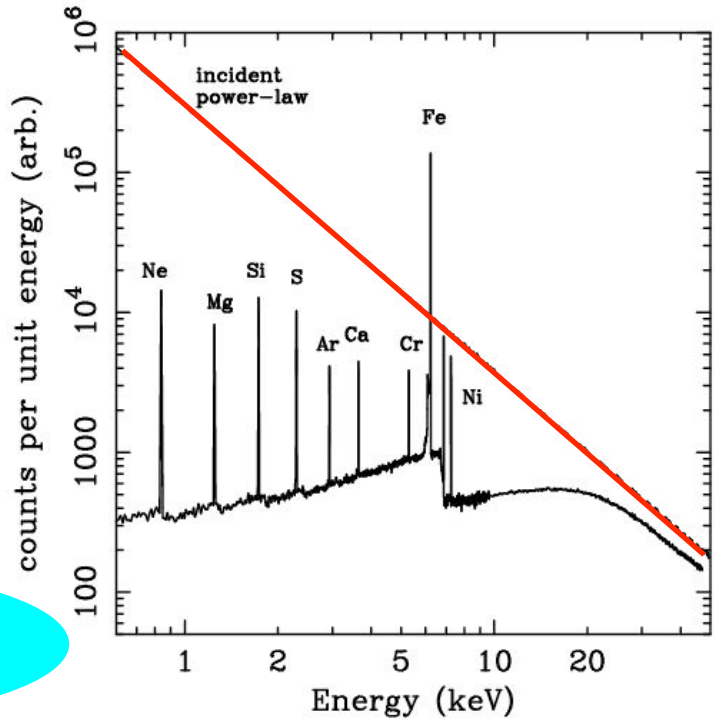


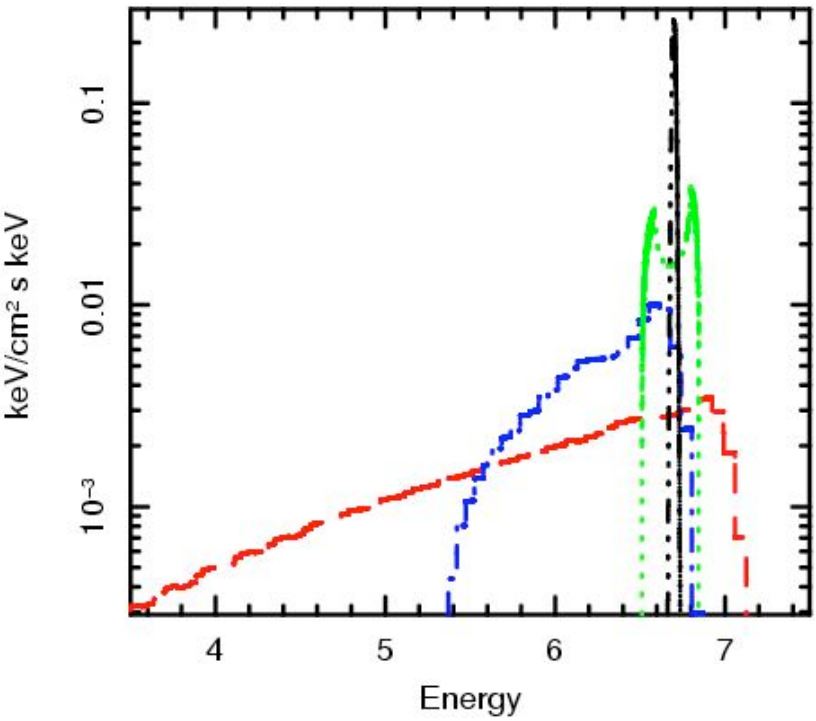
Continuum *In*-dependence



X-ray Disk Lines







GX 339-4 and Serpens X-1