Suzaku Future Impact: Compact & Stellar Objects

Günther Hasinger (MPE)

12.12.2007, San Diego

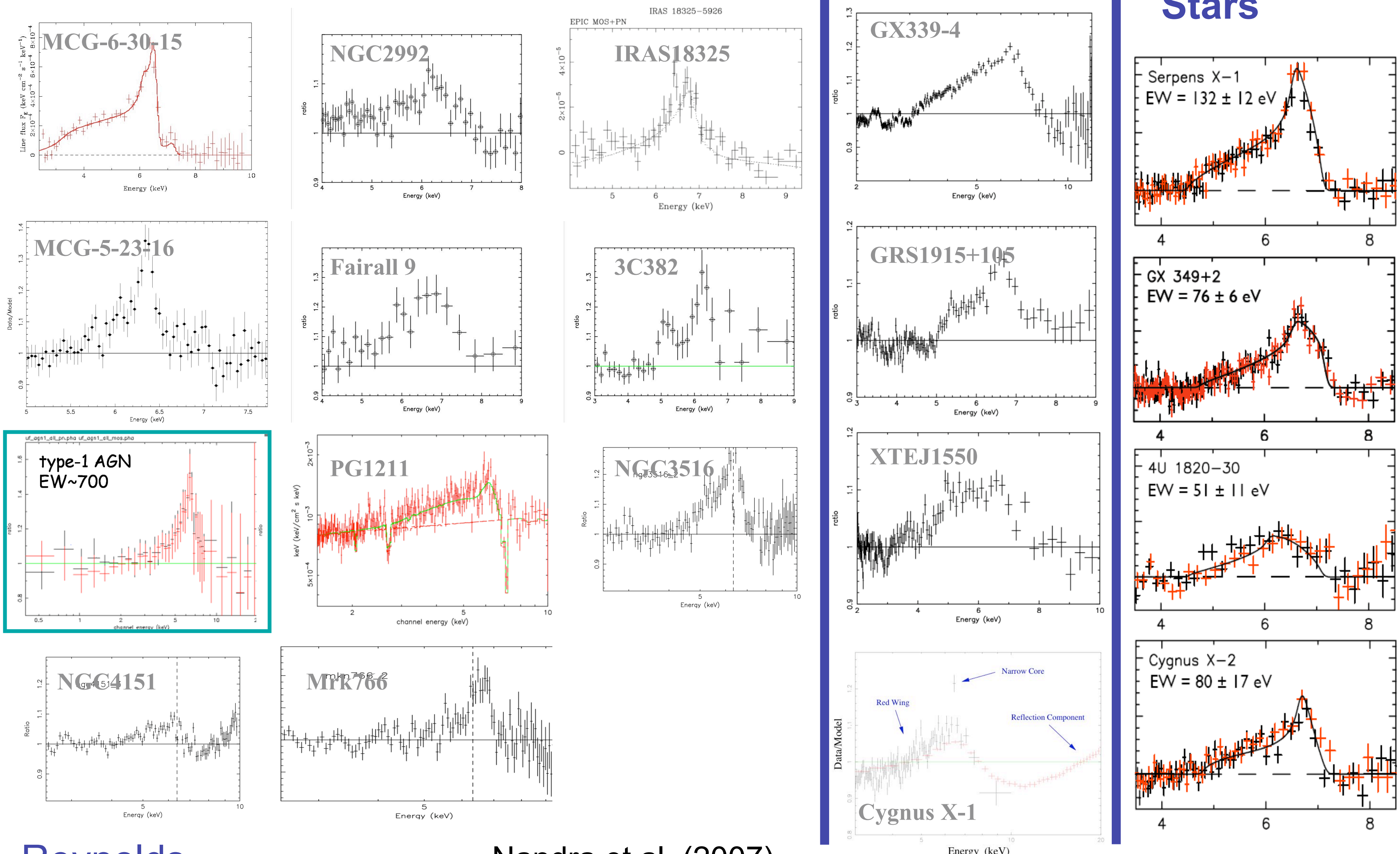
Iron Lines !

Gallery of broad iron lines from XMM Suzaku

Active Galactic Nuclei

Stellar BH

Neutron Stars

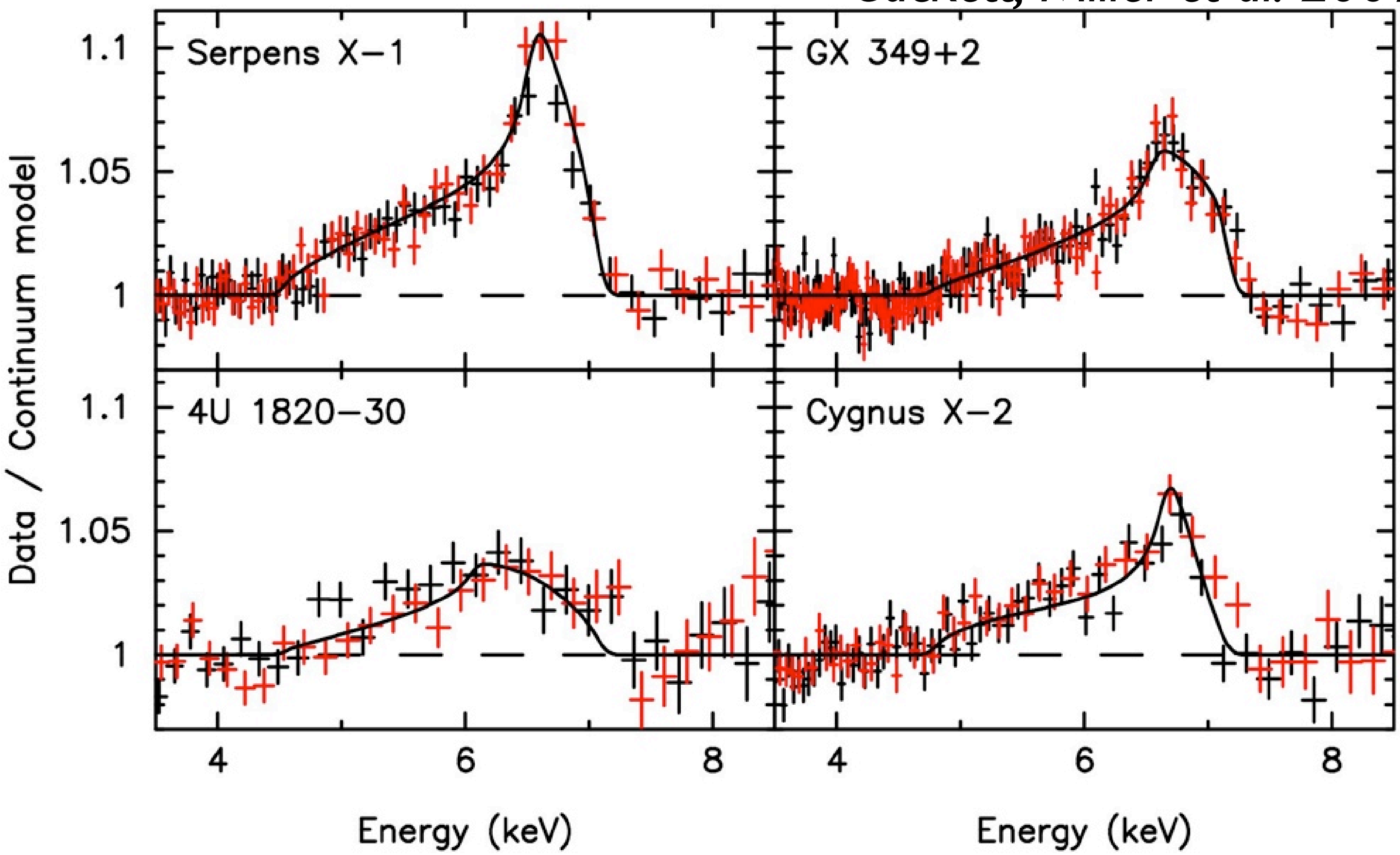


Reynolds

Nandra et al. (2007)

Relativistic lines in neutron stars!

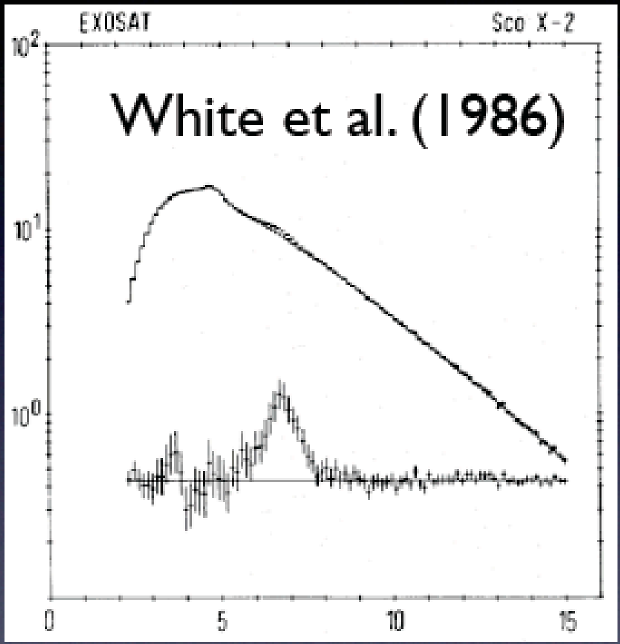
Cackett, Miller et al. 2007



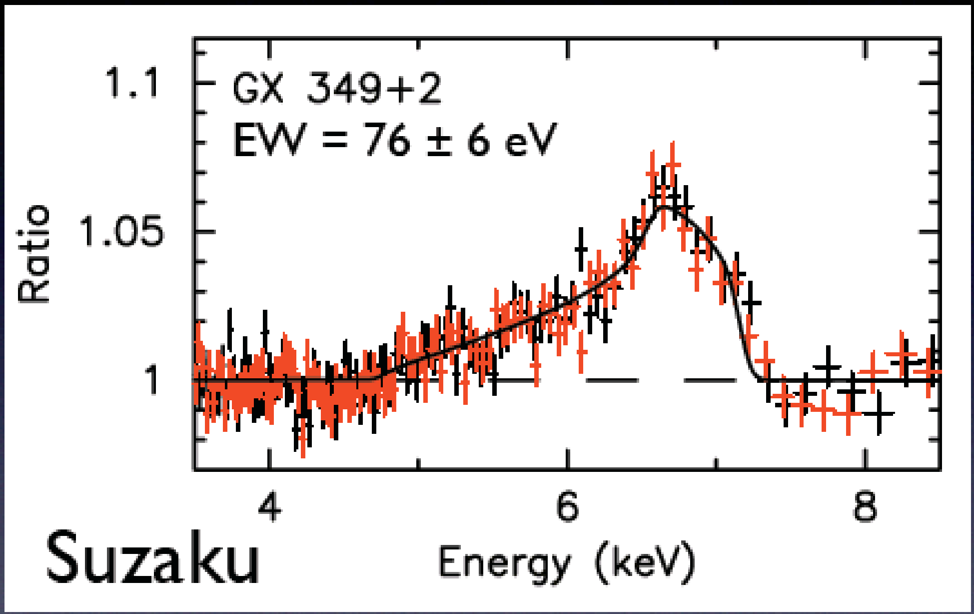
r* < 14-16 km

Miller

GX 349+2 (Sco X-2)



Energy (keV)



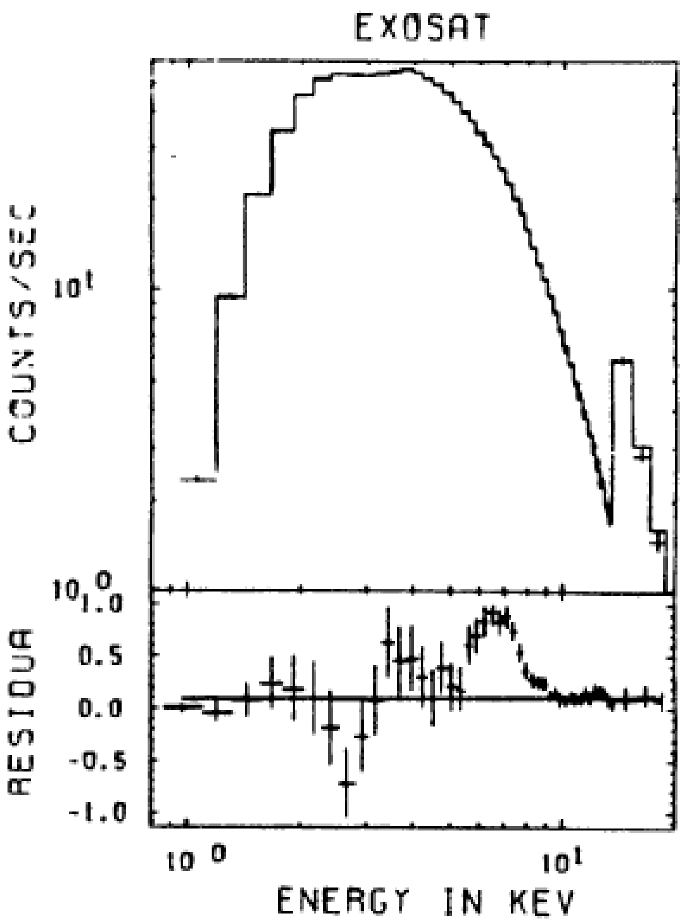
Cackett et al. (2007)

- R_{in} = 8.0 ± 0.4 R_G (where $R_G = GM/c^2$)
- Corresponds to 16.5 ± 0.8 km for 1.4 $M_\odot$ NS

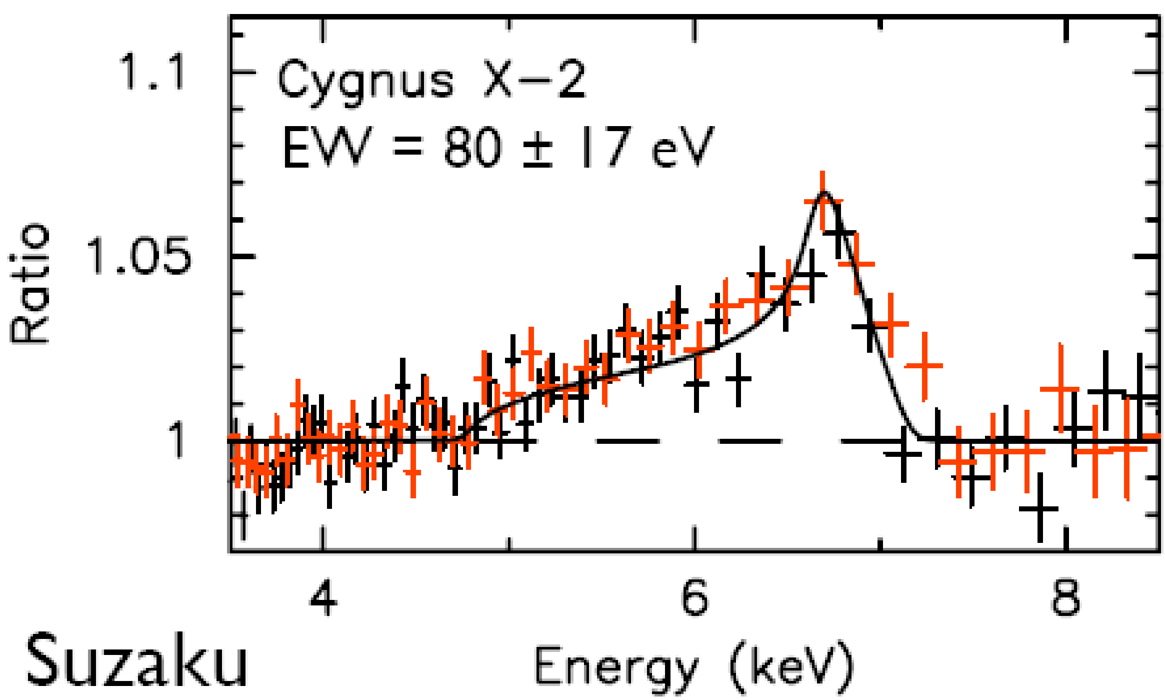
Cackett

Cygnus X-2

Hasinger et al., 1985
(EXOSAT PV observation)



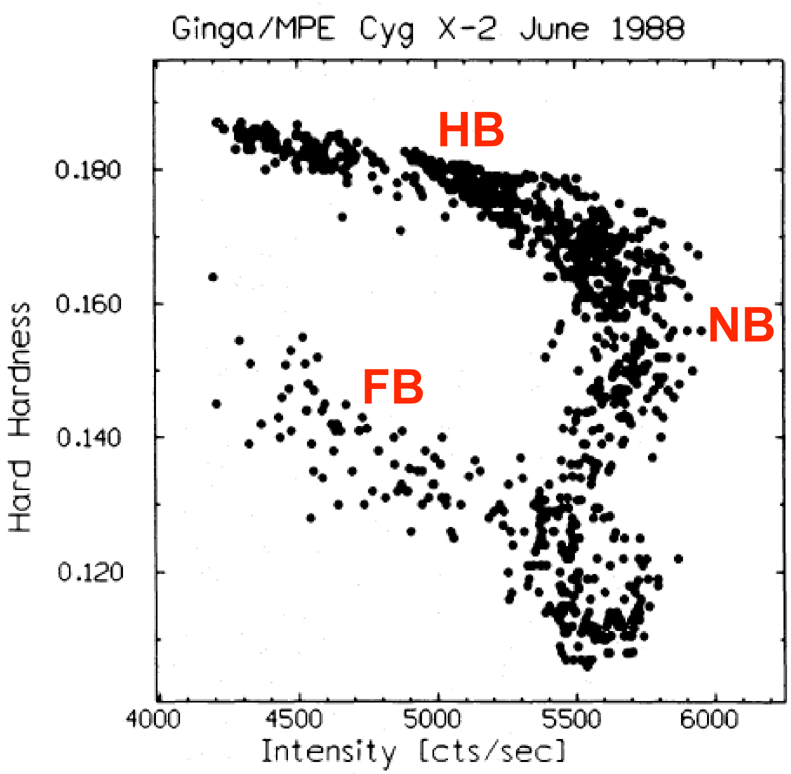
Cackett et al., 2007 Suzaku)

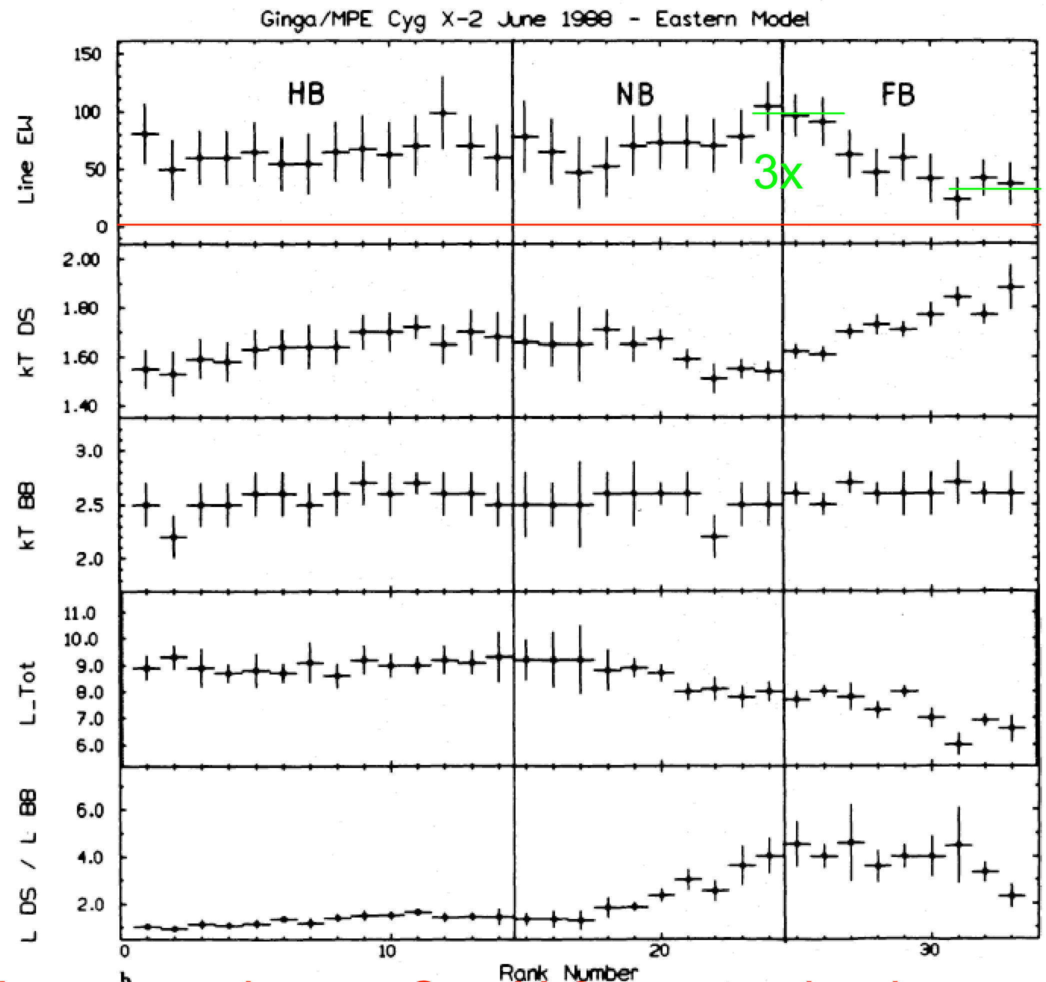


Cyg X-2: Ginga observations

2 x 4 days continuous observations of Cyg X-2 in June and October 1988.

Hasinger, van der Klis, Ebisawa, Dotani & Mitsuda 1990

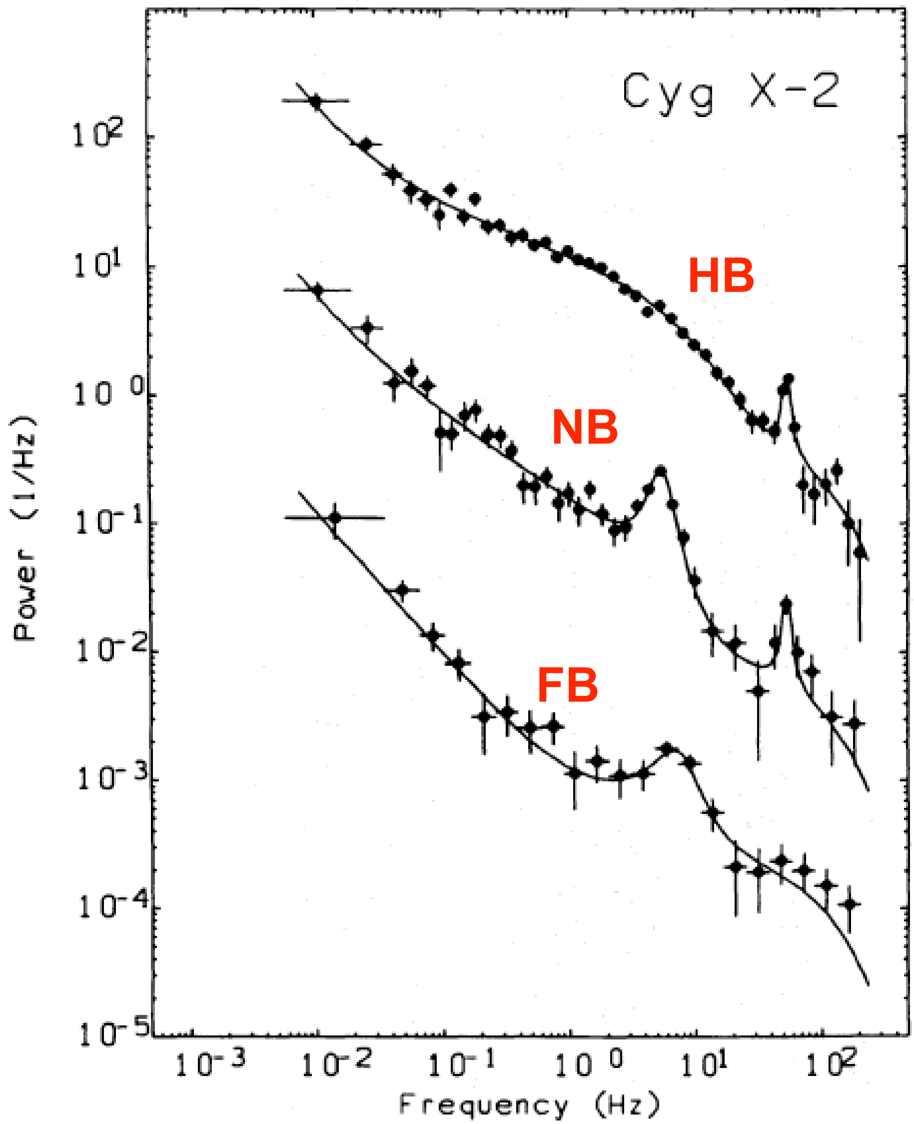




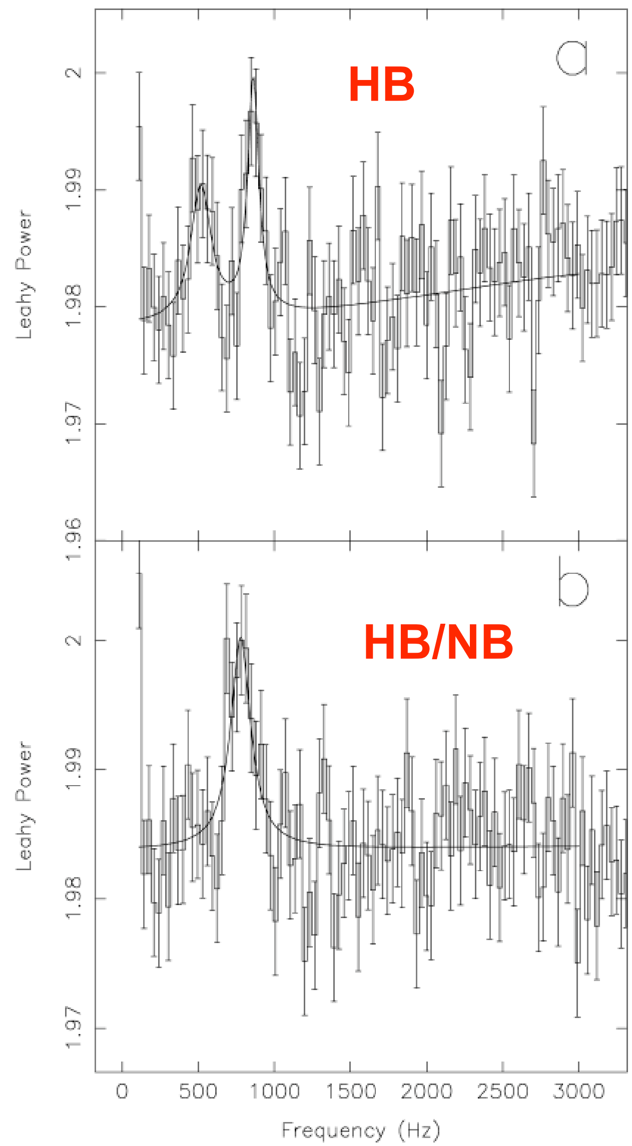
➔ Do a massive Suzaku observing campaign on Cyg X-2, comparing iron line with z-state and QPO

QPO in Cyg X-2

HB-NB-FB QPO (GINGA, Hasinger et al., 1990)

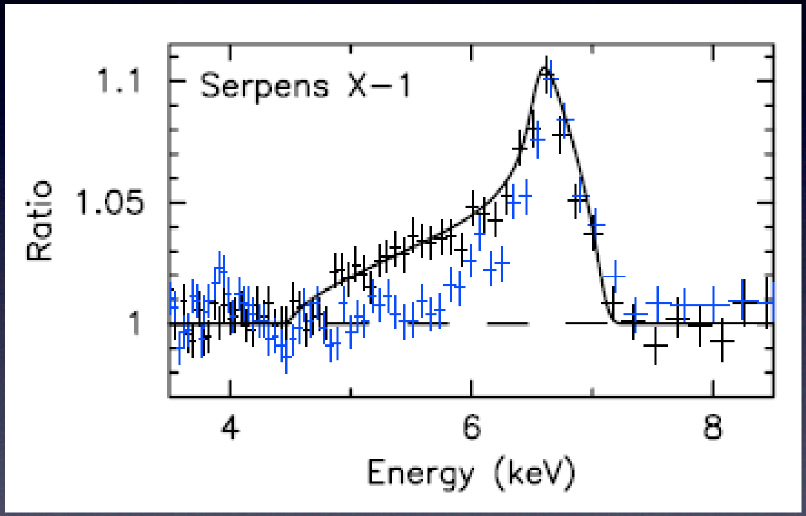


kHz QPO (RXTE, Wijnands et al. 1998)



Comparison with XMM

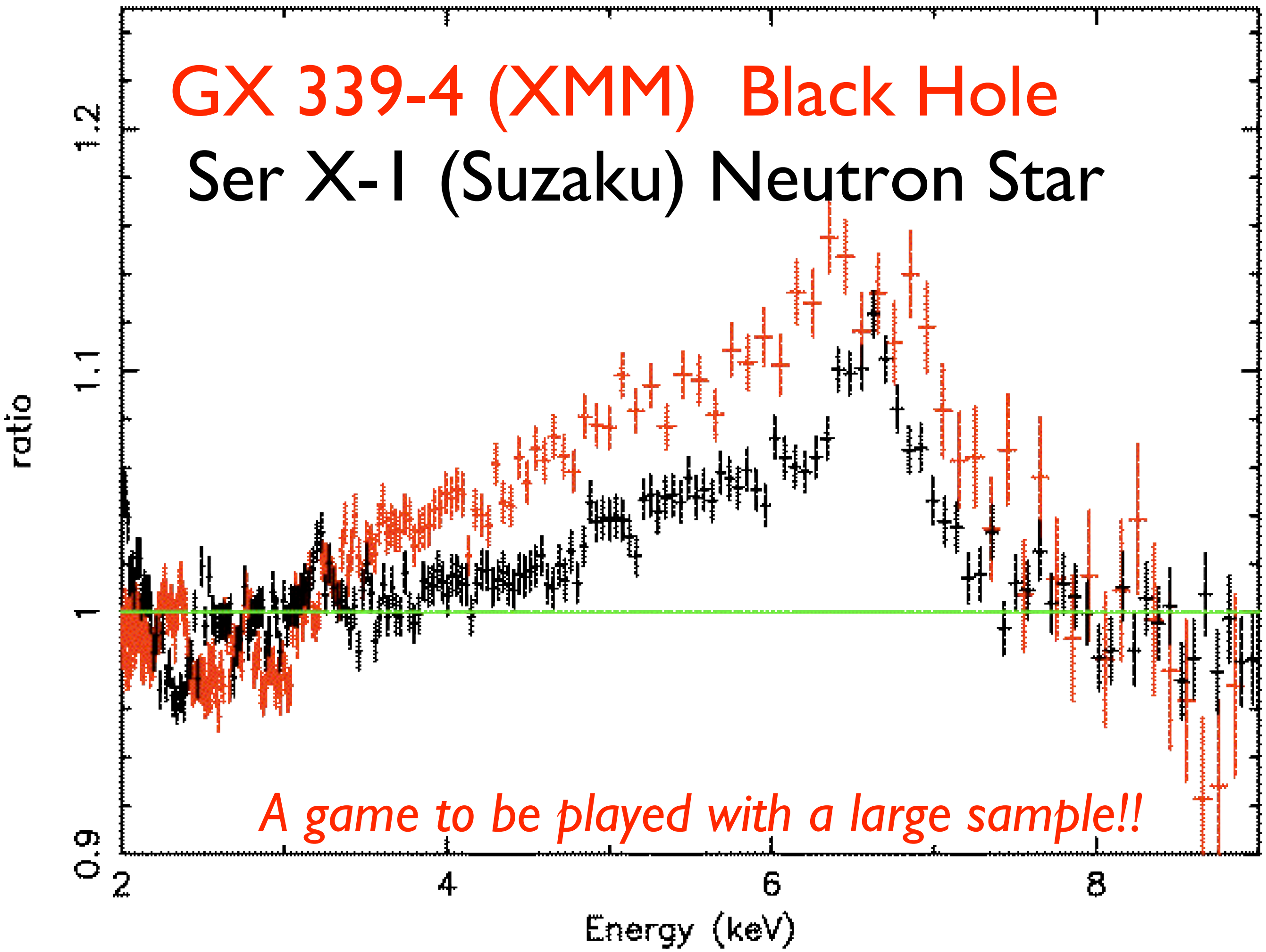
- Asymmetric Ser X-1 line also observed by Bhattacharyya & Strohmayer (2007) with *XMM-Newton*
- Similar profile, though some evidence for variablility - needs further study



Blue - XMM
Black - Suzaku

Cackett

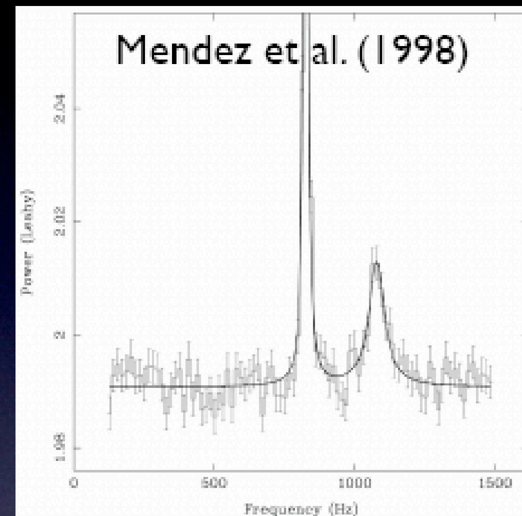
GX 339-4 and Serpens X-1

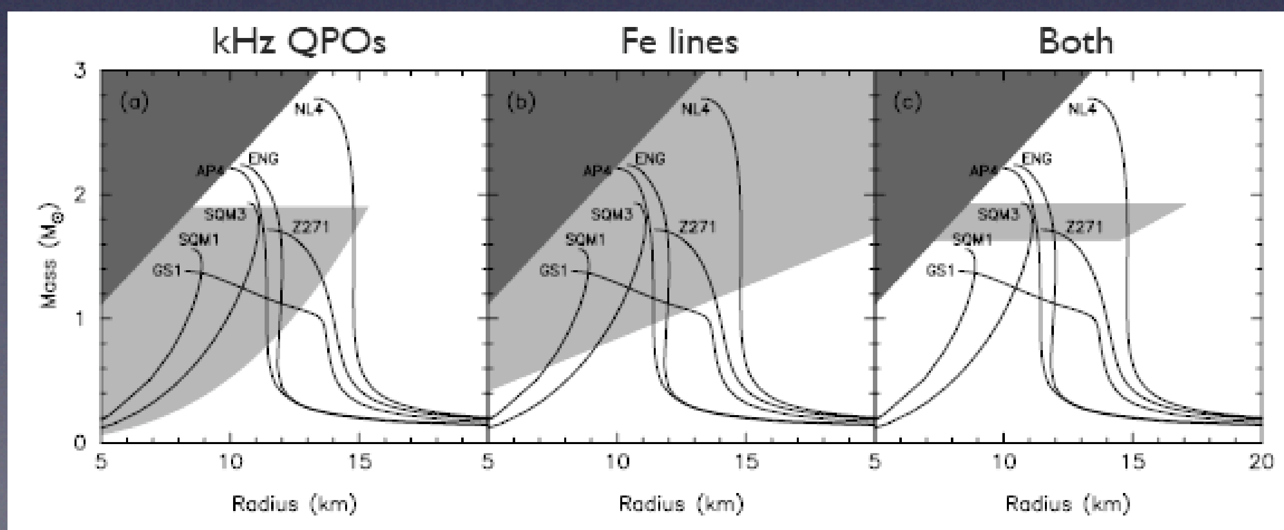


Miller

Getting NS mass using kHz QPOs

- If upper kHz QPO is orbital frequency then $\nu \sim (GM/R^3)^{1/2}$
- We get velocity in disk from iron lines: $v = (GM/R)^{1/2}$
- Combining both we can measure NS mass: $M = v^3 / 2\pi G\nu$





Cackett

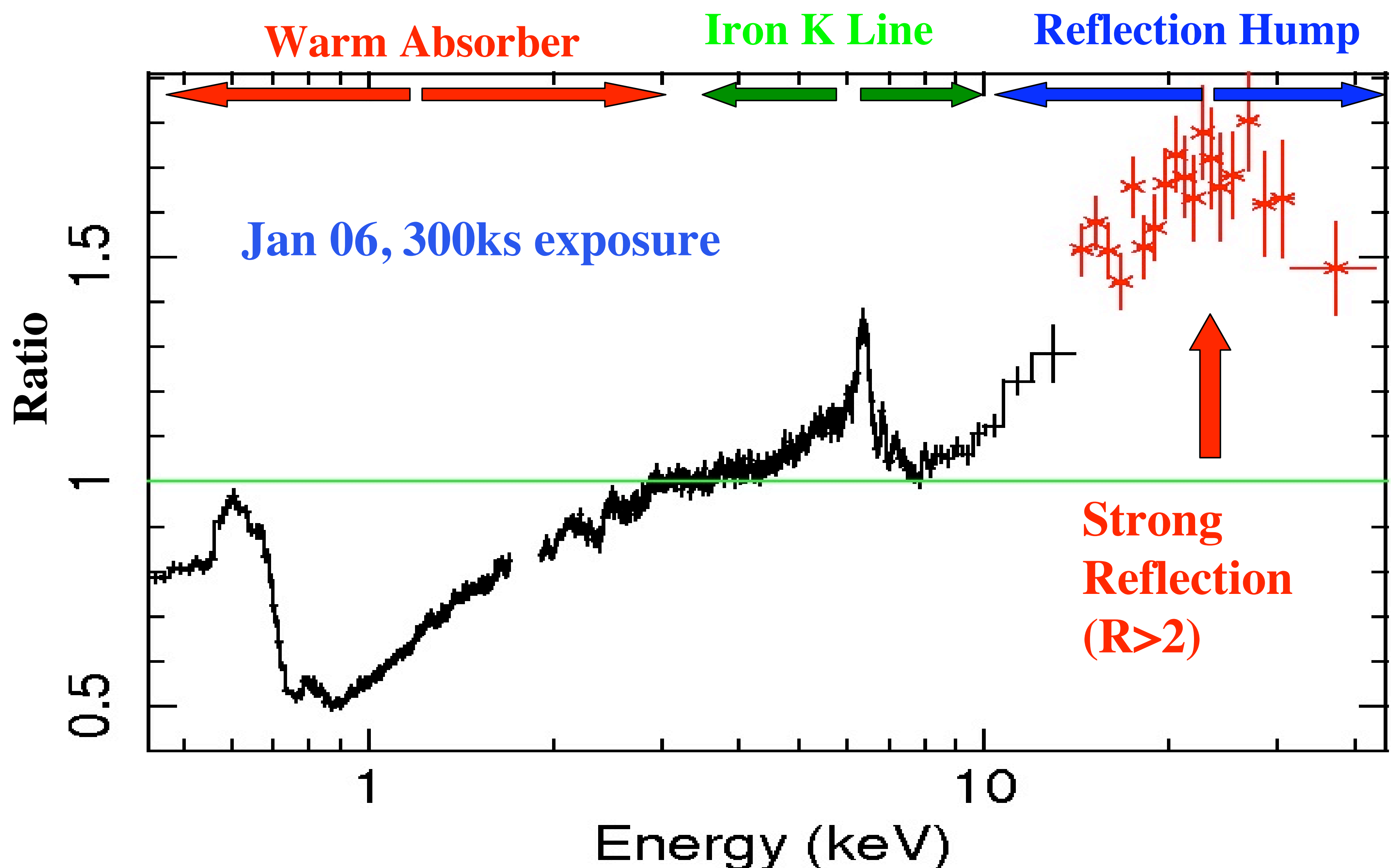
Recommendation

Observe 1-2 NS sources for a long time, e.g. one Atoll, one Z-source

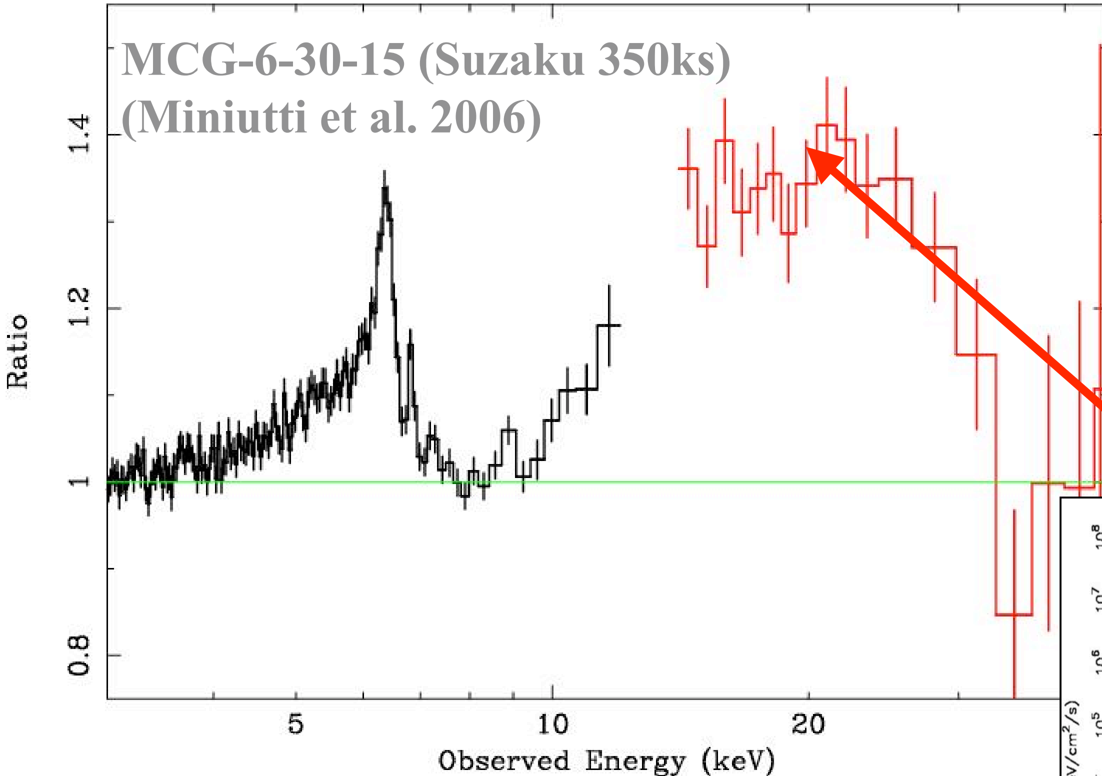
(~1 Msec observations)

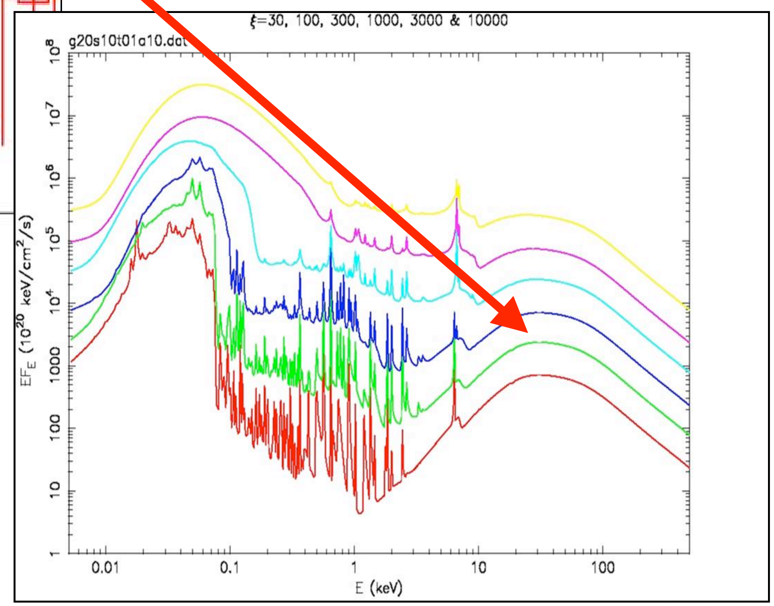
Relativistic Smearing
vs.
Absorption

Broad-band Suzaku Observations reveal the relativistic line/disk reflection in MCG -6-30-15 (Miniutti et al. 2007, PASJ)



A : Confirming the disk-reflection paradigm

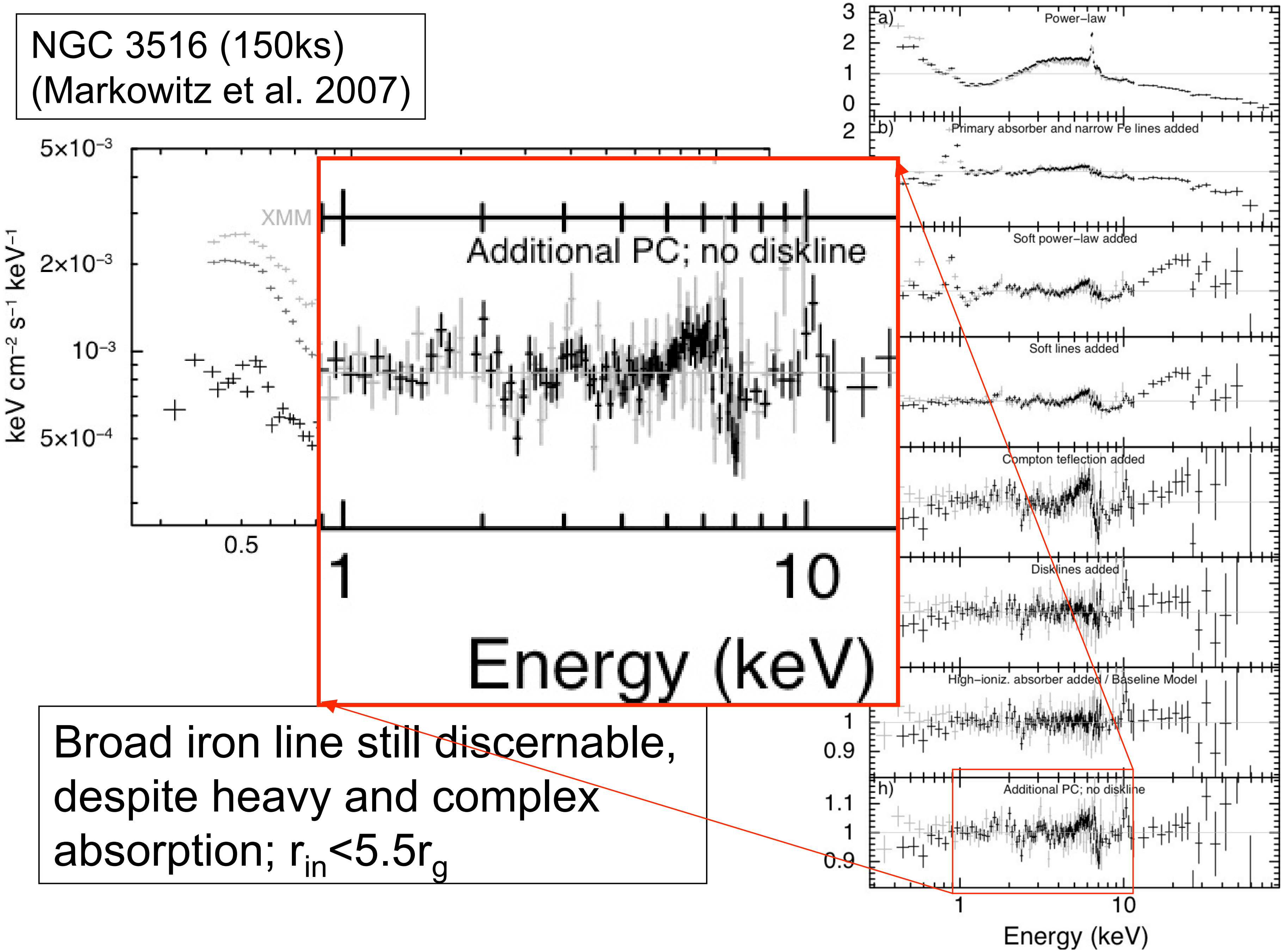




Broad-band coverage allows iron line and reflection "bump" to be observed… powerful constraint on alternative models

Reynolds

NGC 3516 (150ks)
(Markowitz et al. 2007)

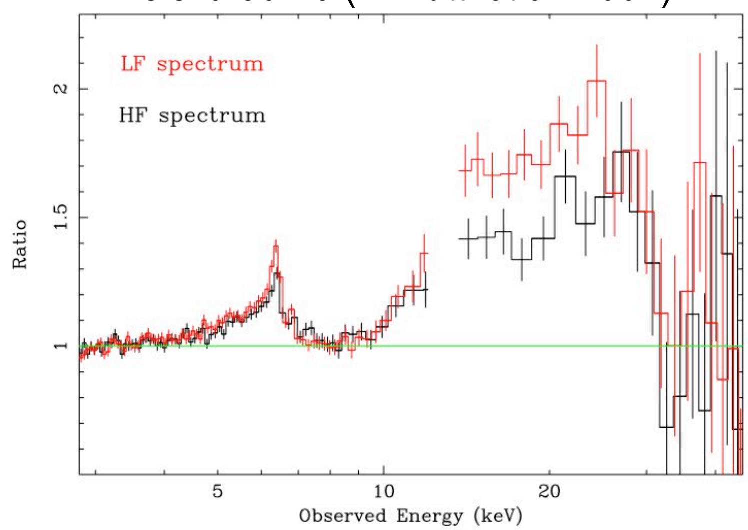


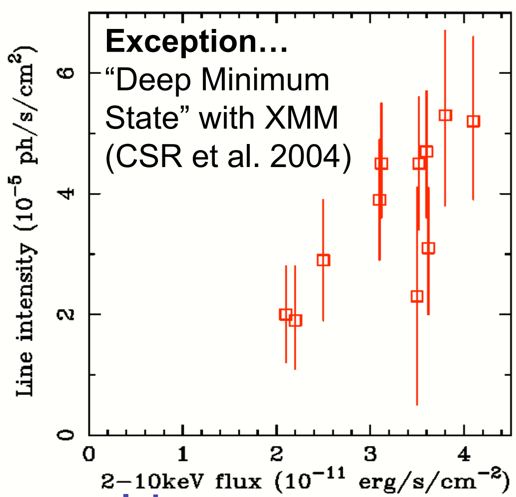
Broad iron line still discernable, despite heavy and complex absorption; $r_{in}<5.5r_g$

Reynolds

C: Variability of the disk reflection

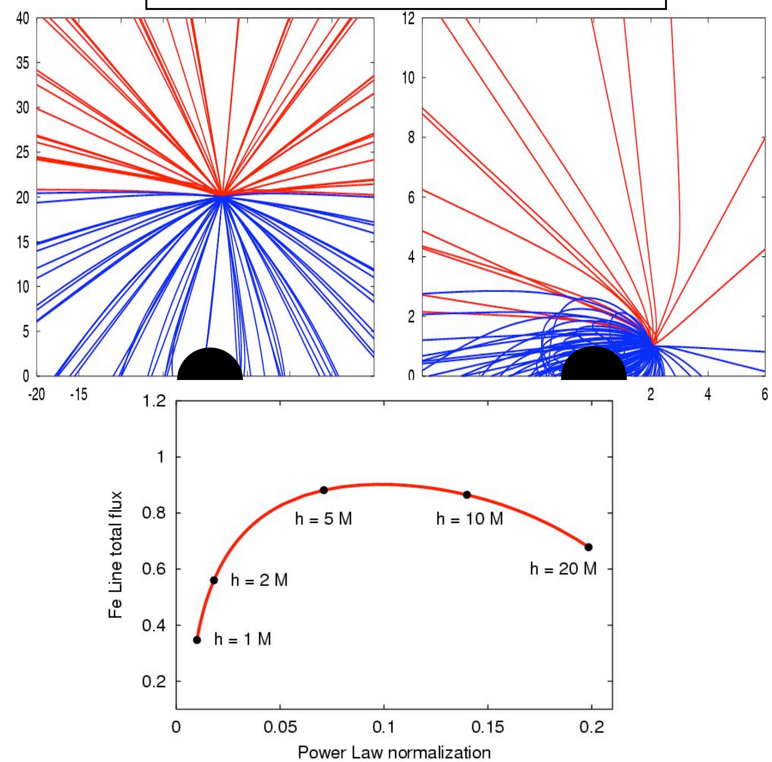
MCG-6-30-15 (Miniutti et al. 2007)





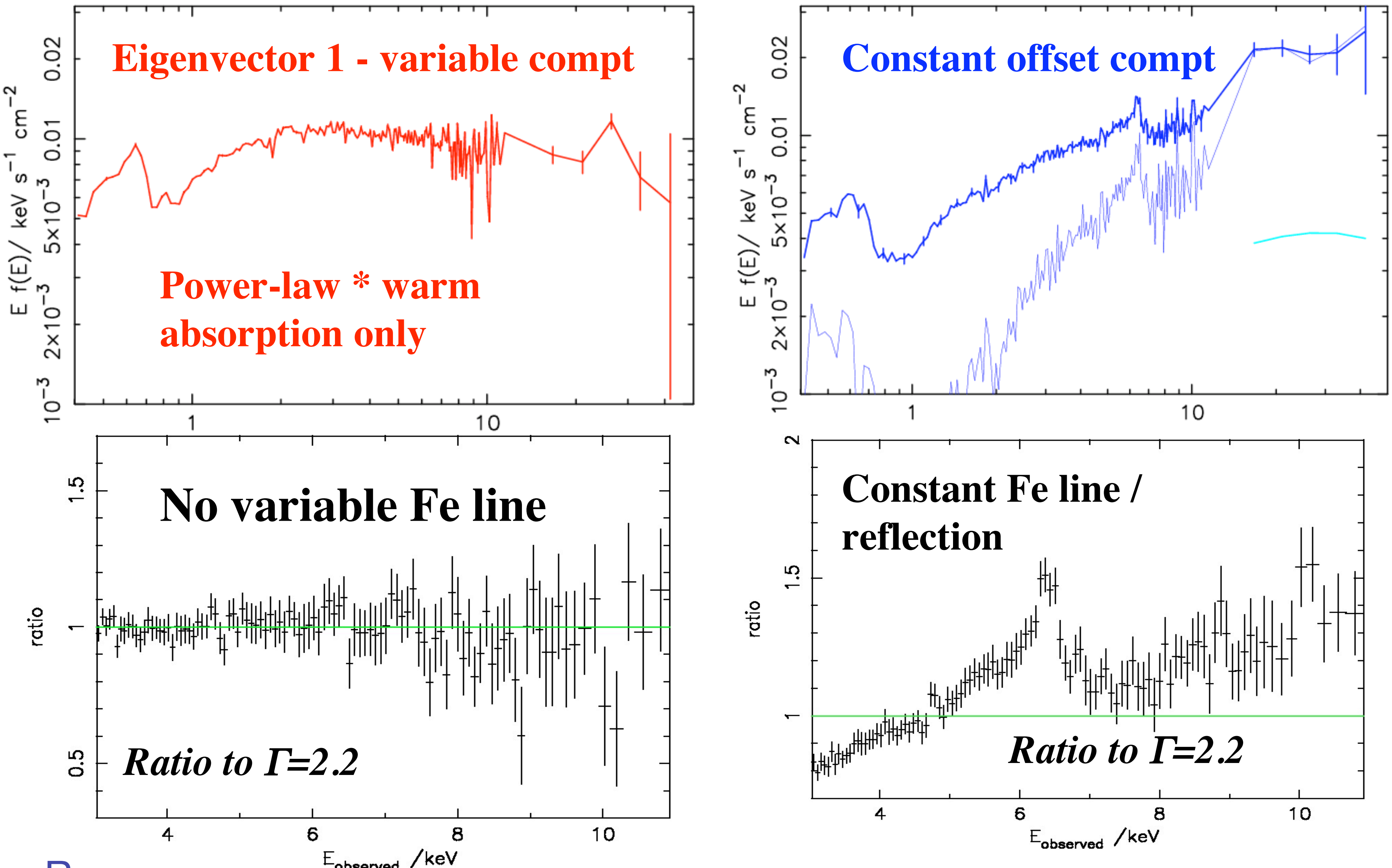
MCG-6-30-15 : Both iron line **and reflection** hump unresponsive to continuum changes… **contrary to naïve expectation**

Light-bending model Miniutti & Fabian (2004)



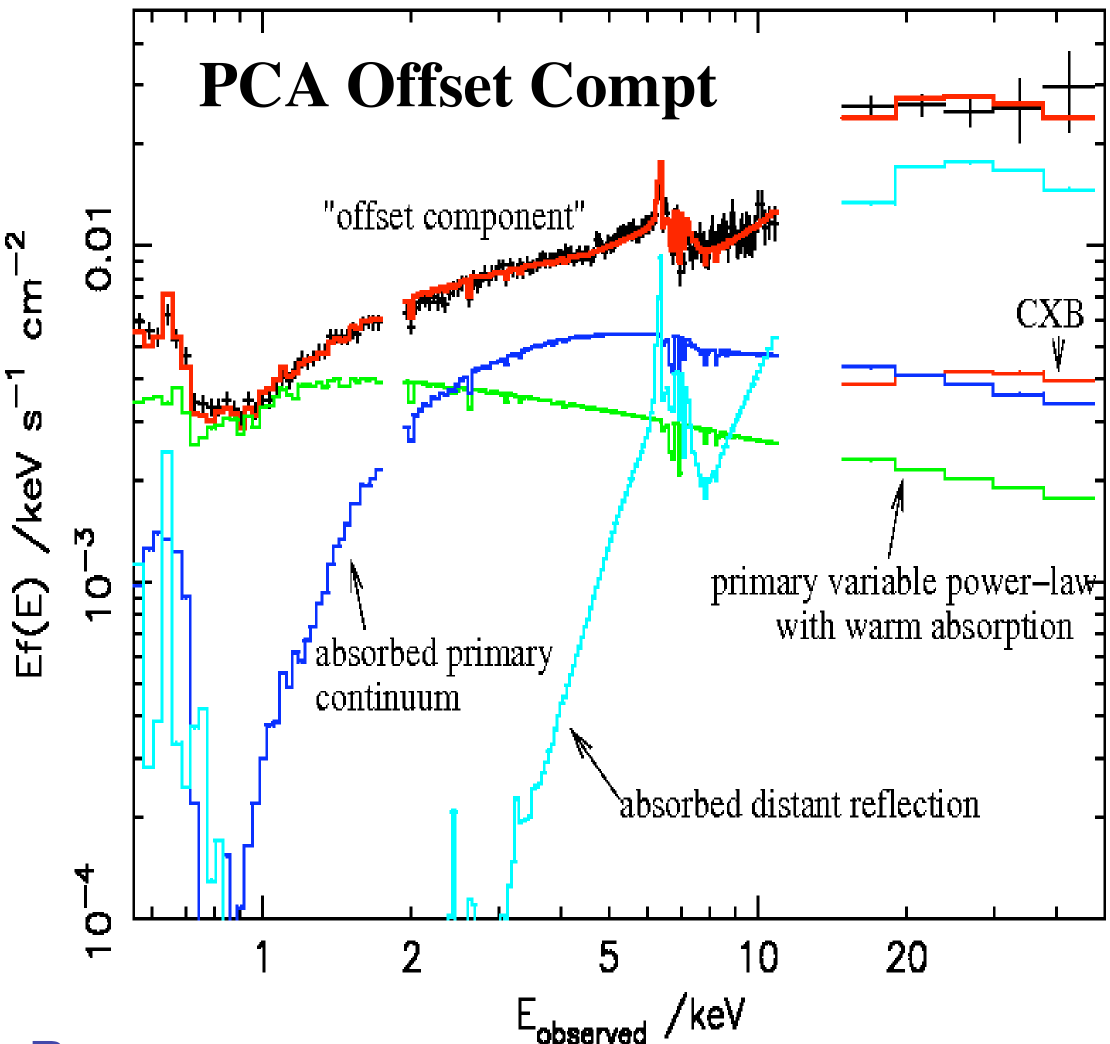
Reynolds

PCA deconstruction of MCG -6-30-15 with Suzaku (see L. Miller poster)



Reeves

An Alternative to Light-Bending in MCG -6-30-15? (L. Miller poster)



Model consists of:-

"distant" absorbed reflector (R=1-1.5)

intrinsically variable power-law (with warm absorber).

Partially covered absorbed power-law.

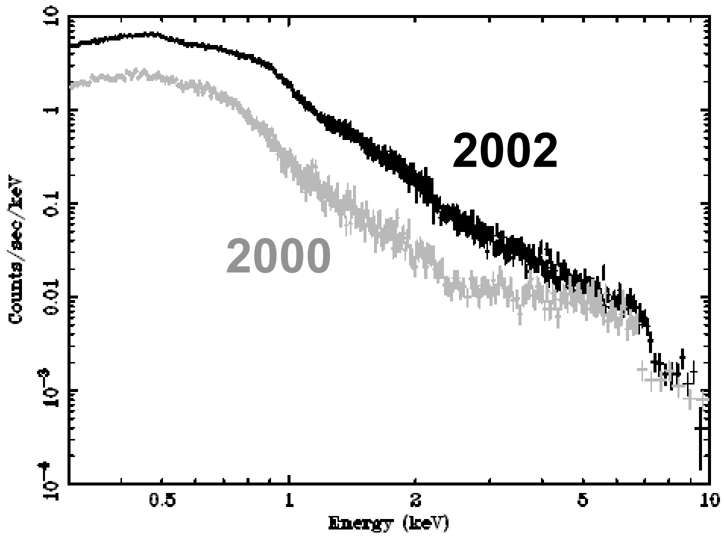
Excellent fit statistic in broad-band Suzaku/XMM datasets.

Reproduces absorption in Chandra/HETG, XMM/RGS

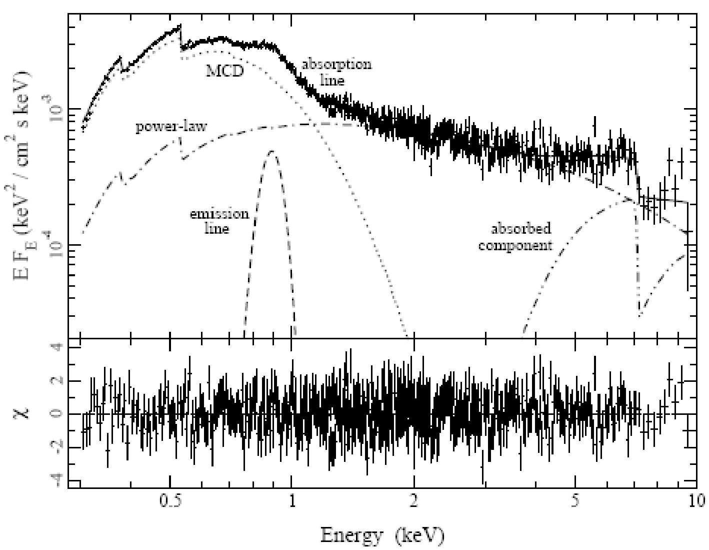
Reeves

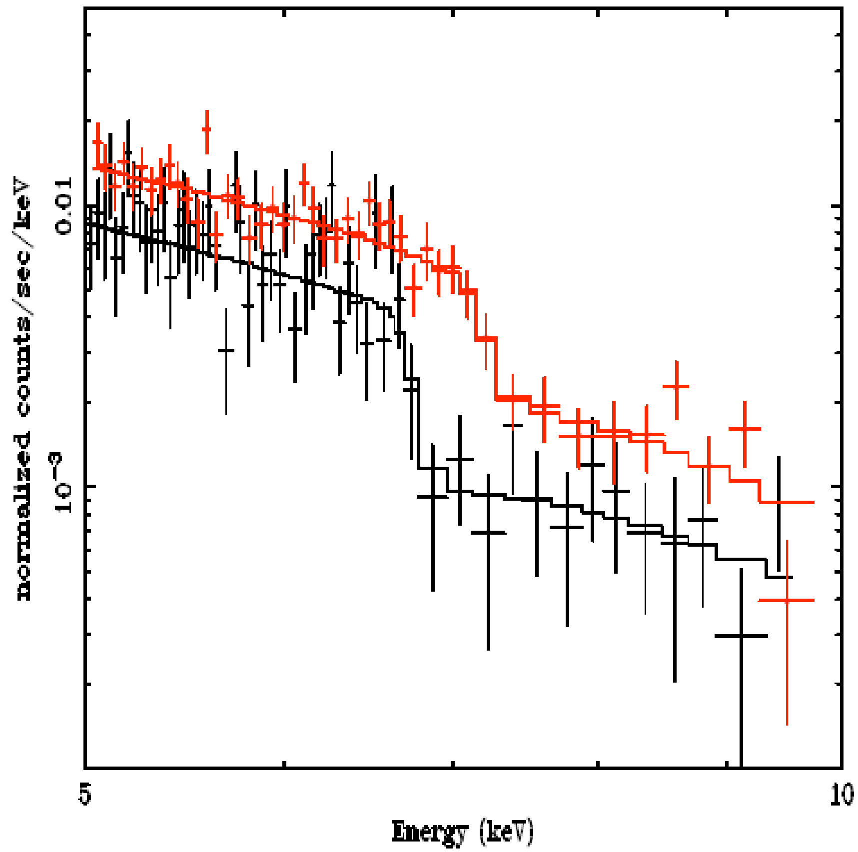
Long-term Changes in NLS1

Gallo,Tanaka,Boller,Fabian, Vaughan & Brandt, 2004

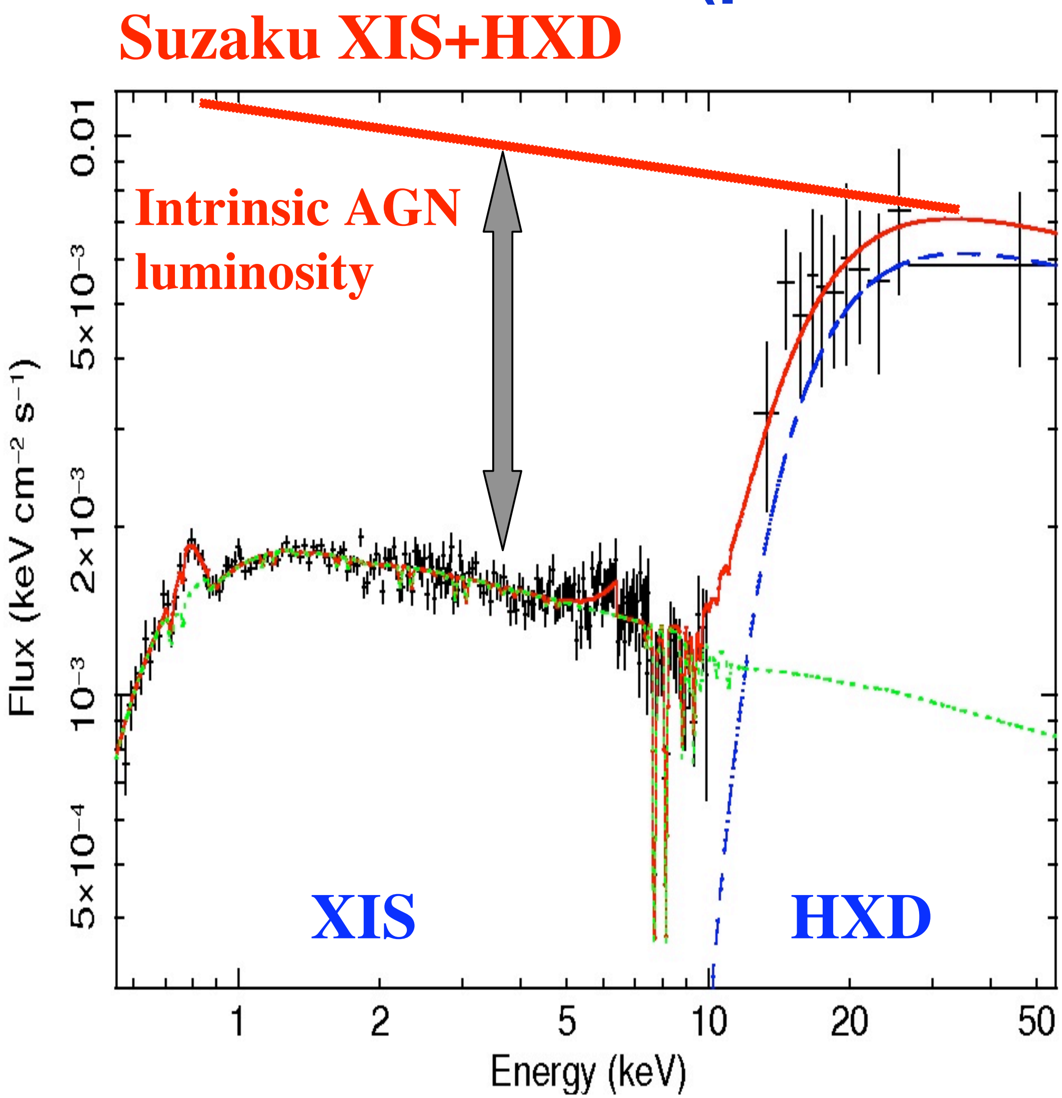


Two XMM-Newton observations of 1H 0707-495 show dramatic change around the iron edge. Can both be fit equally well with partial covering and (huge) relativistic disc line.





A Surprise from PDS 456
(preliminary!)



Optical type I AGN - but looks like a type II AGN in X-rays!

The hard X-ray data (above 10 keV) show a large x8 excess of flux.

Strongly absorbed ($N_H > 10^{24} cm^{-2}$) emission emerges above 10 keV.

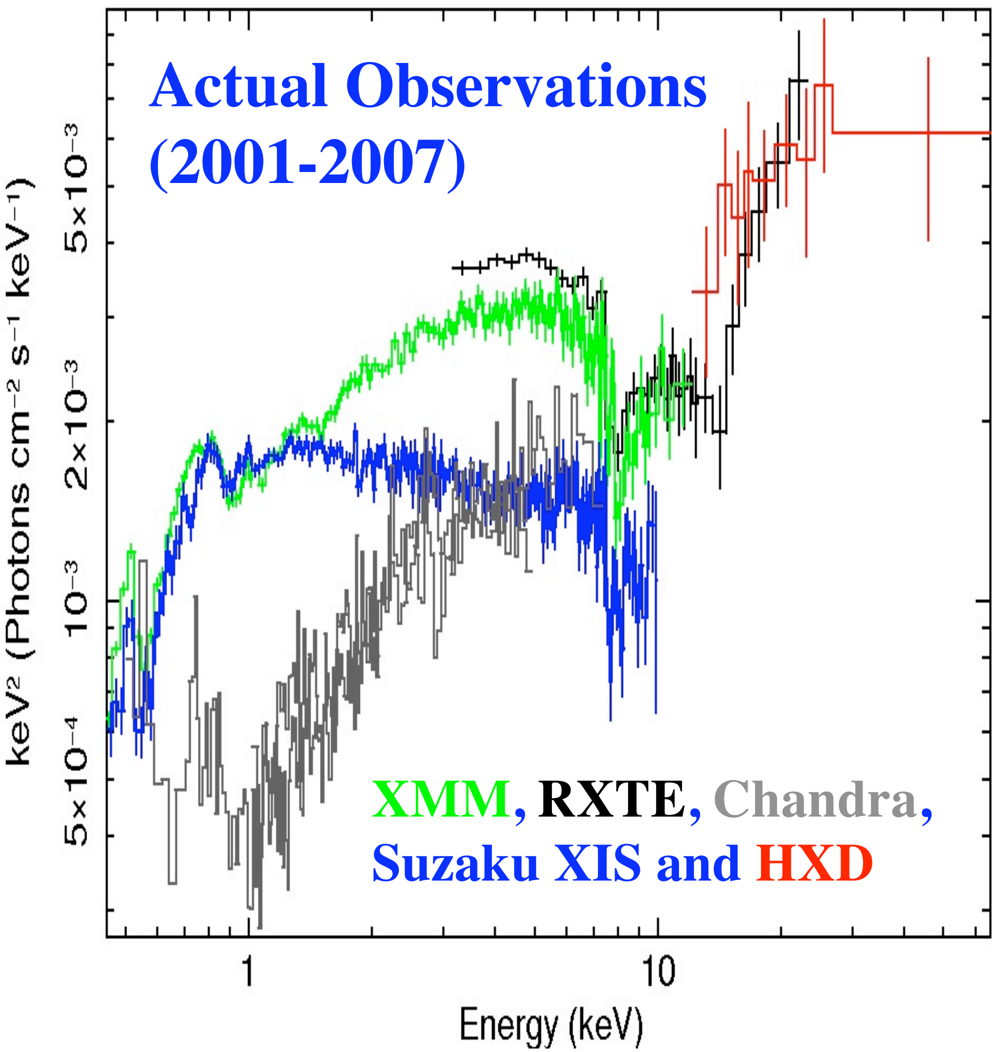
Absorber must be located ***close to black hole*** (well within BLR) to ***partially cover*** X-ray source

Or more exotic - a binary black hole (e.g. NGC 6240)?

Intrinsic X-ray luminosity much higher than is apparent($L_{2-10} = 10^{46}$ erg s^{-1}, cf $L_{bol} = 10^{47}$ erg s^{-1})

Reeves

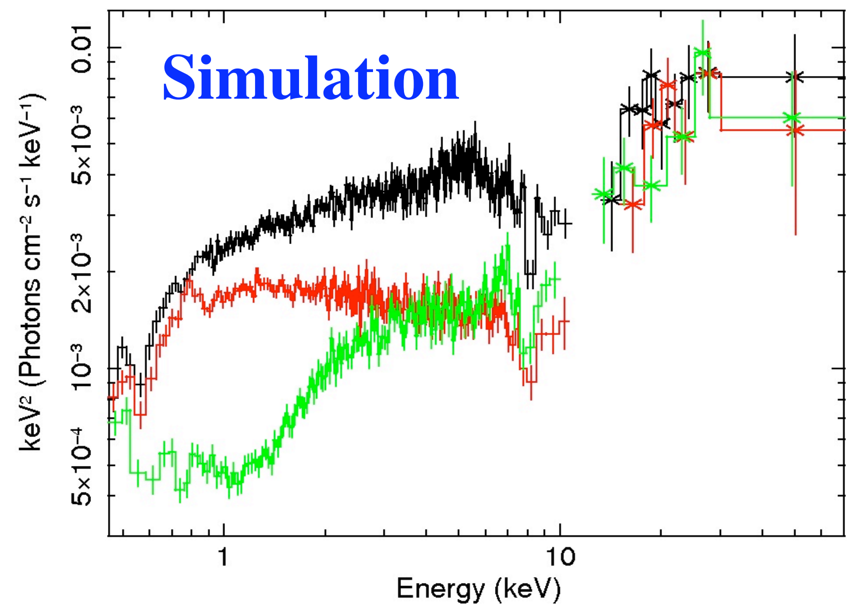
Can the spectral variability in PDS 456 be explained by variable absorption?



Can rapid variations in the large (10^{24} cm^{-2}) absorbing column (e.g. covering fraction) account for the spectral var in PDS 456?

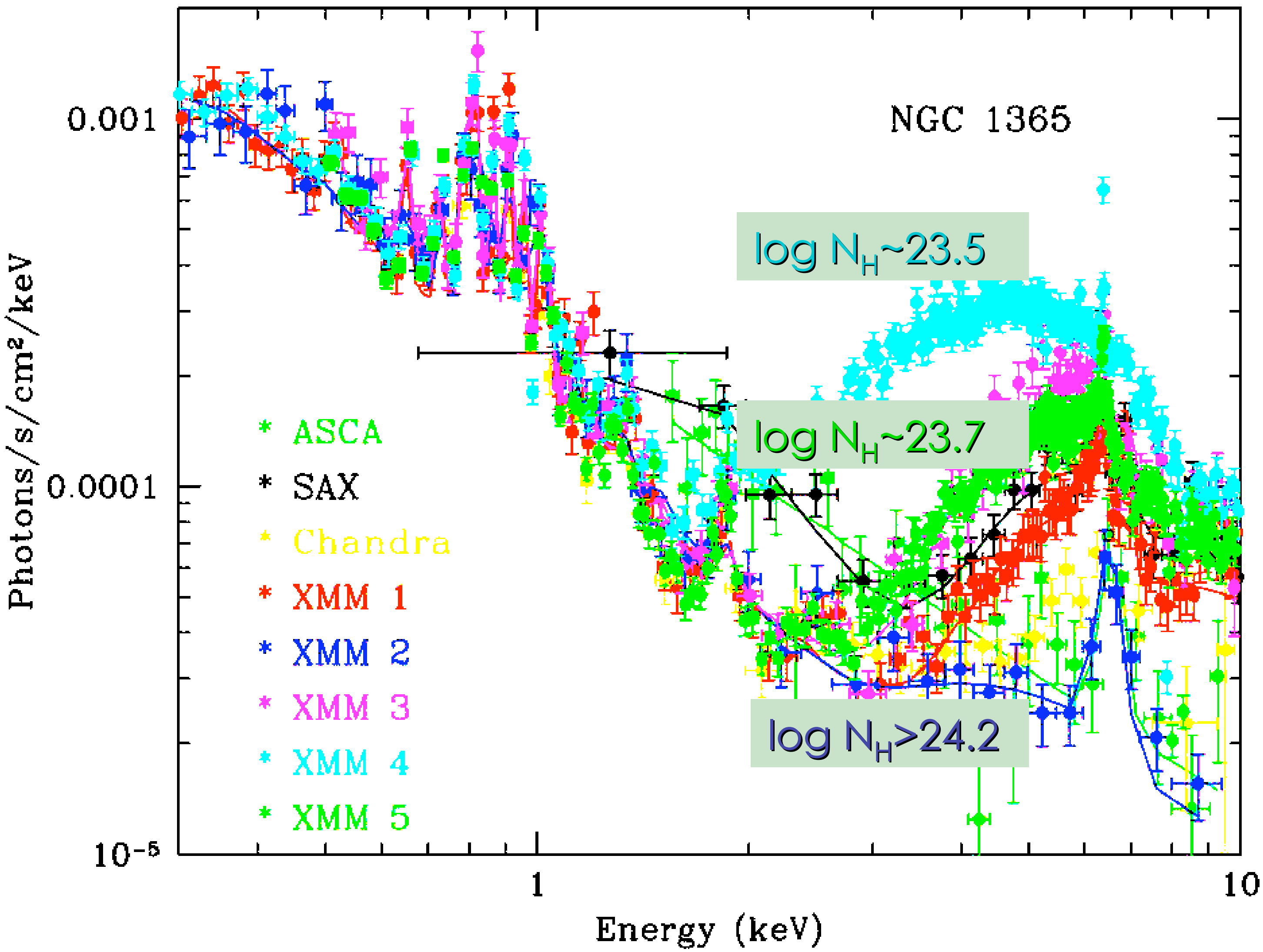
Prediction is for ***least variability*** in the hard X-ray band (i.e. 10 keV).

Absorbing clouds must be compact (few Rg) and close to source (e.g. bricks or a clumpy outflow?)



Reeves

NGC1365: Compton thick/Thin



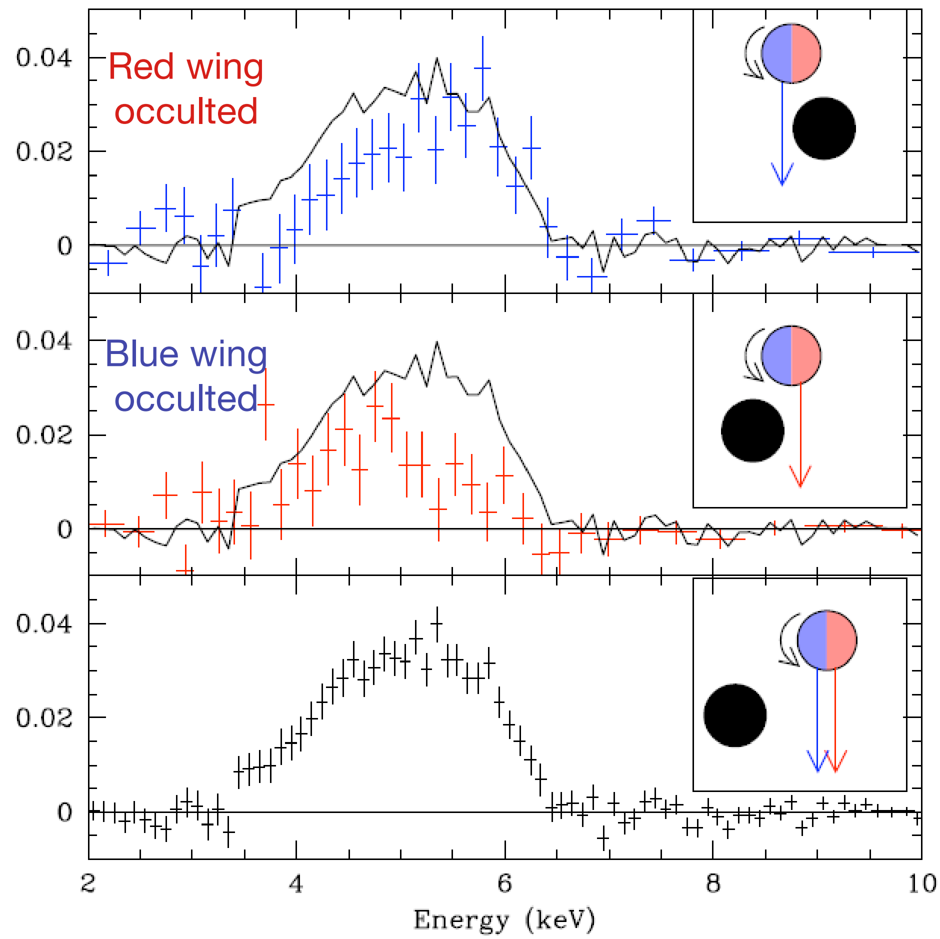
Elvis

<30 R_S Tomography of Fe-K Continuum

Reynolds, Risaliti, Elvis, ...

Prospects:

- apply Binary physics
- Ingress, egress successively cover/uncover red-/blue-shifted Fe-K
- *Establish rotation, z(R)*
- Goal of Suzaku Cycle 3 proposal



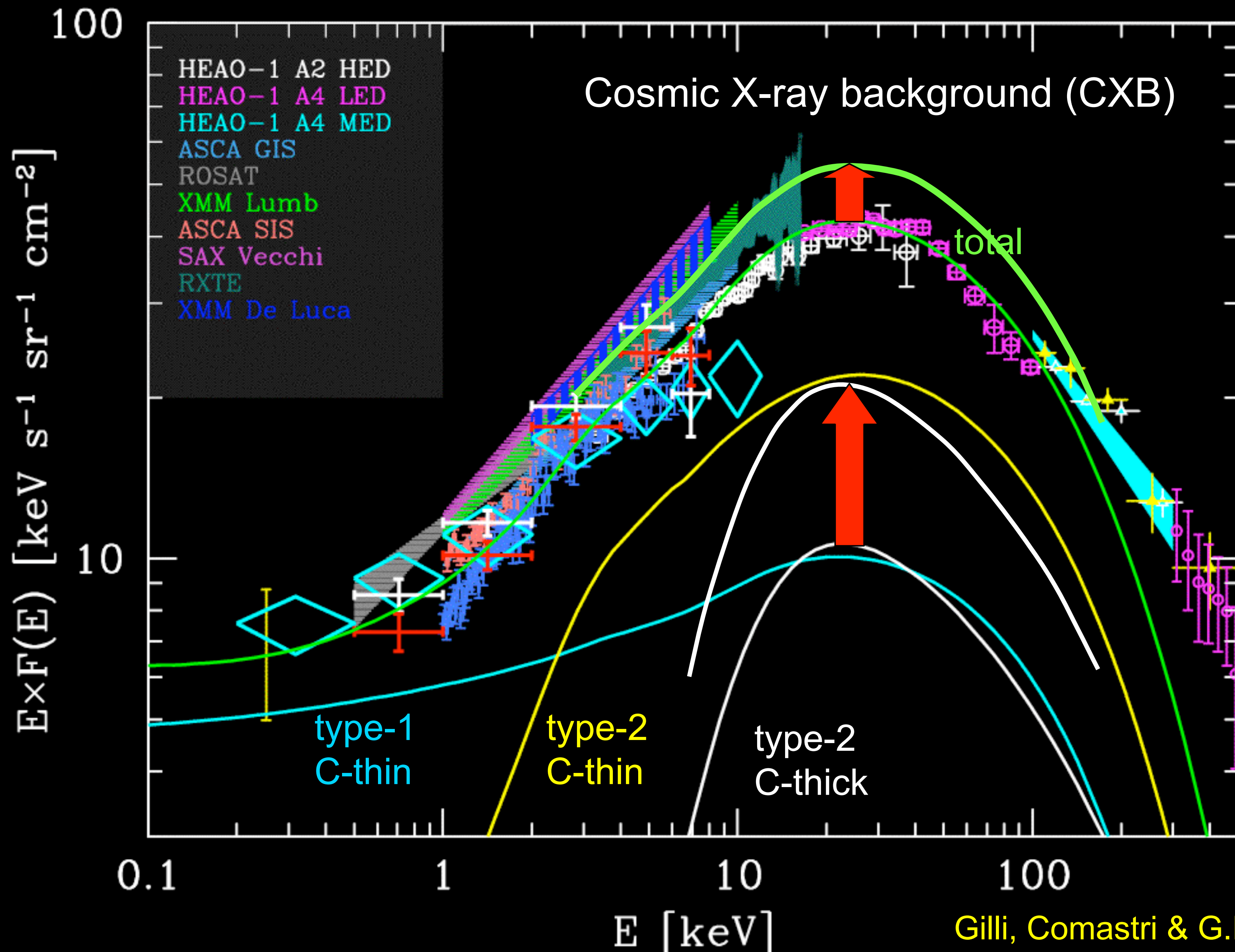
Recommendation

Beat a few strongly time variable AGN to death

(~1 Msec observations)

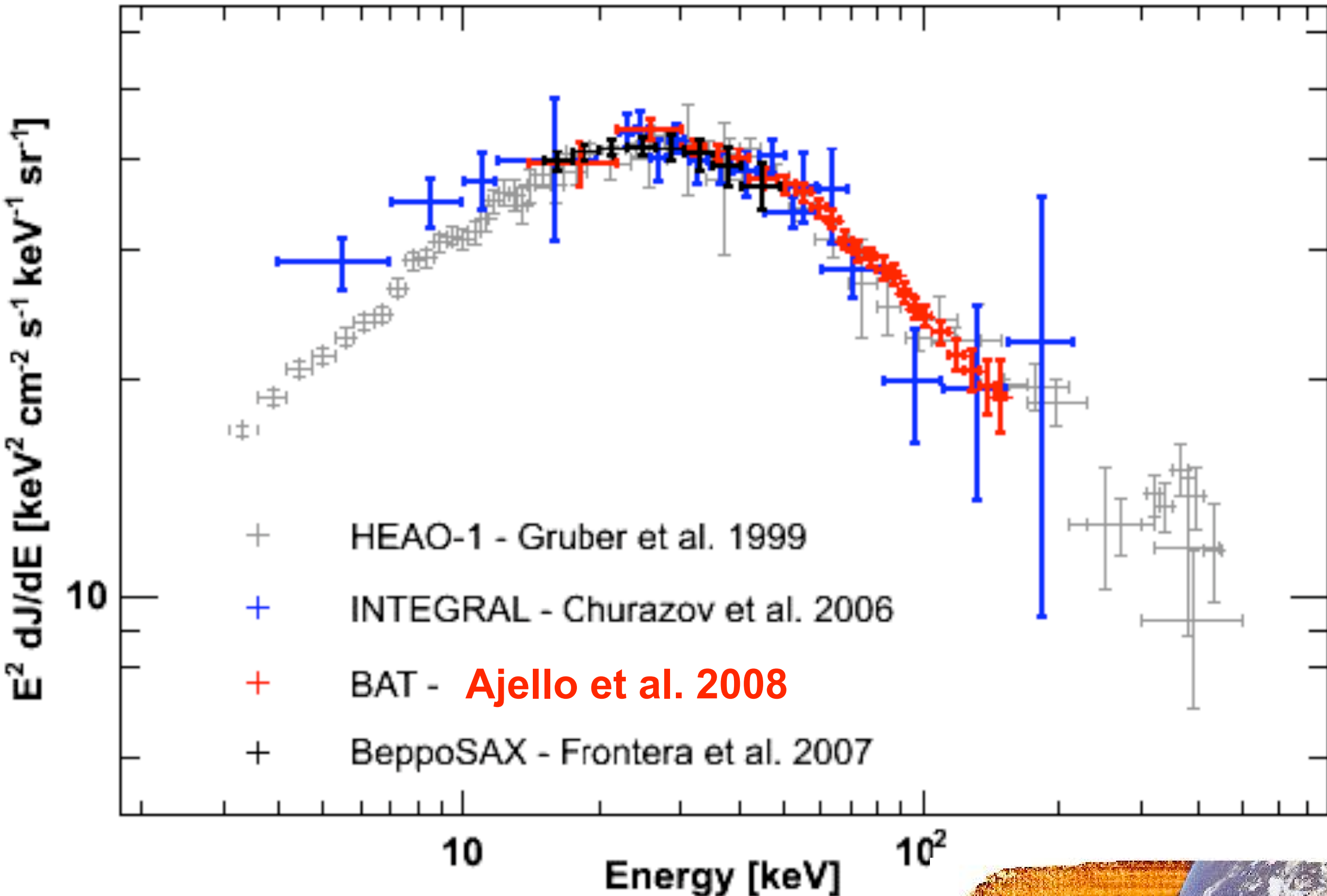
Compton-thin and Compton-thick absorption

Recent CXB Population Synthesis Model



Gilli, Comastri & G.H., 2007

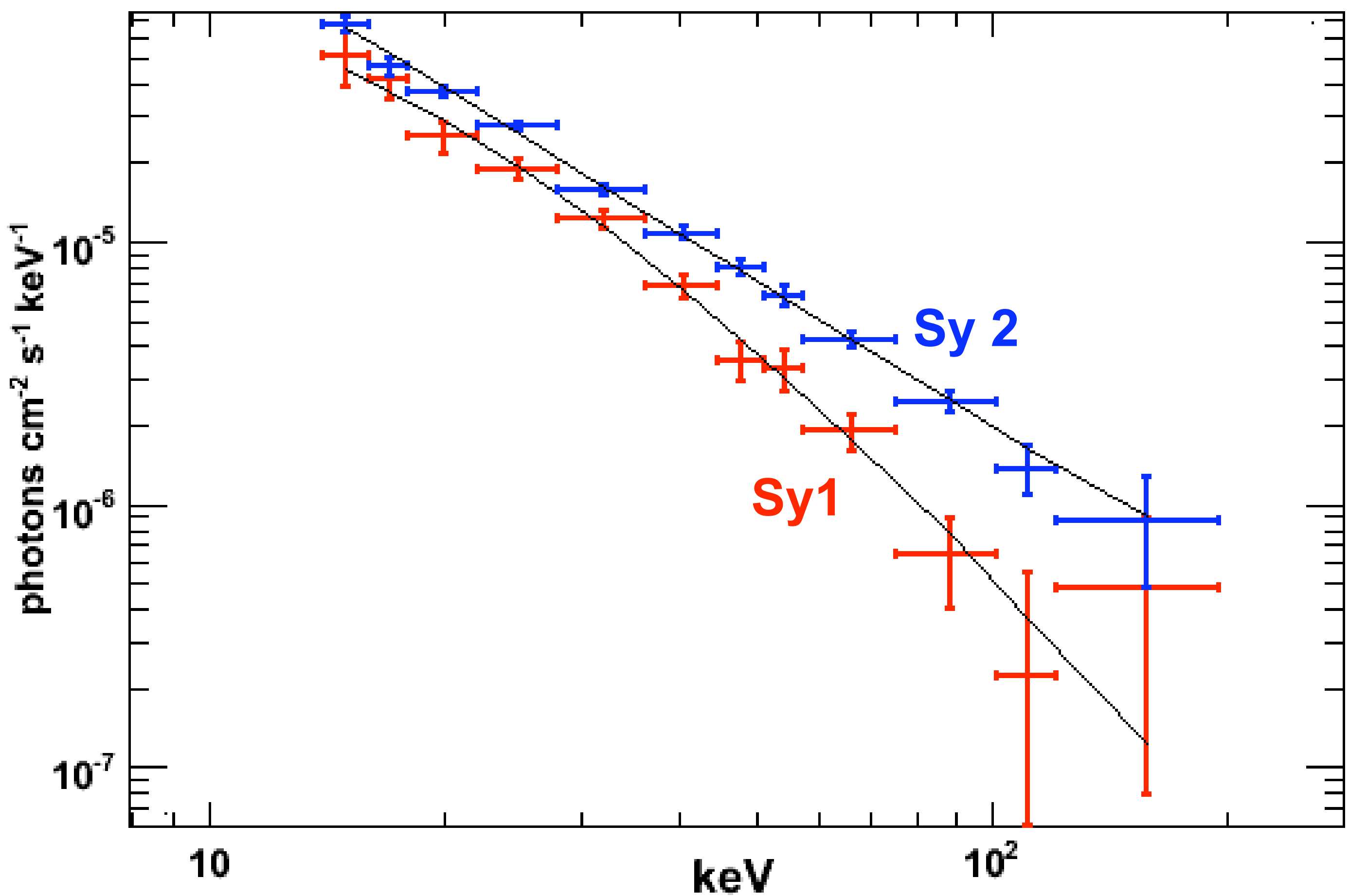
New results on X-ray Background



All data normalized to the same Crab spectrum.
HEAO-1 was right all along. Congratulations!
Swift-BAT now has highest quality spectrum (20-100 keV)

What is going on with imaging XRB measurements ???

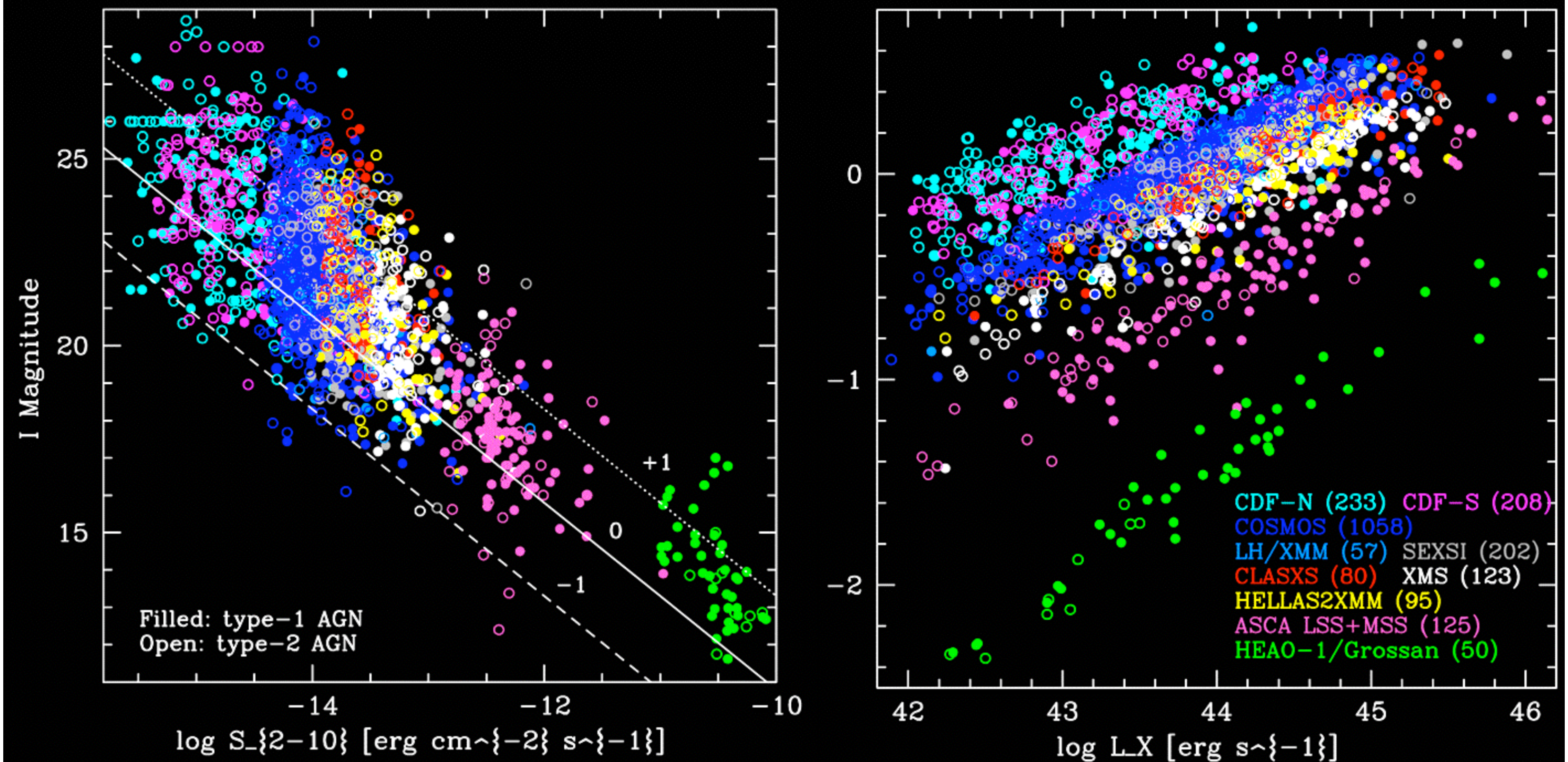
Swift BAT Stacks of Seyferts



Ajello et al., 2007: Sy2 are harder than Sy1 and the cutoff energy seems to be different (c.f. Mushotzky's talk)

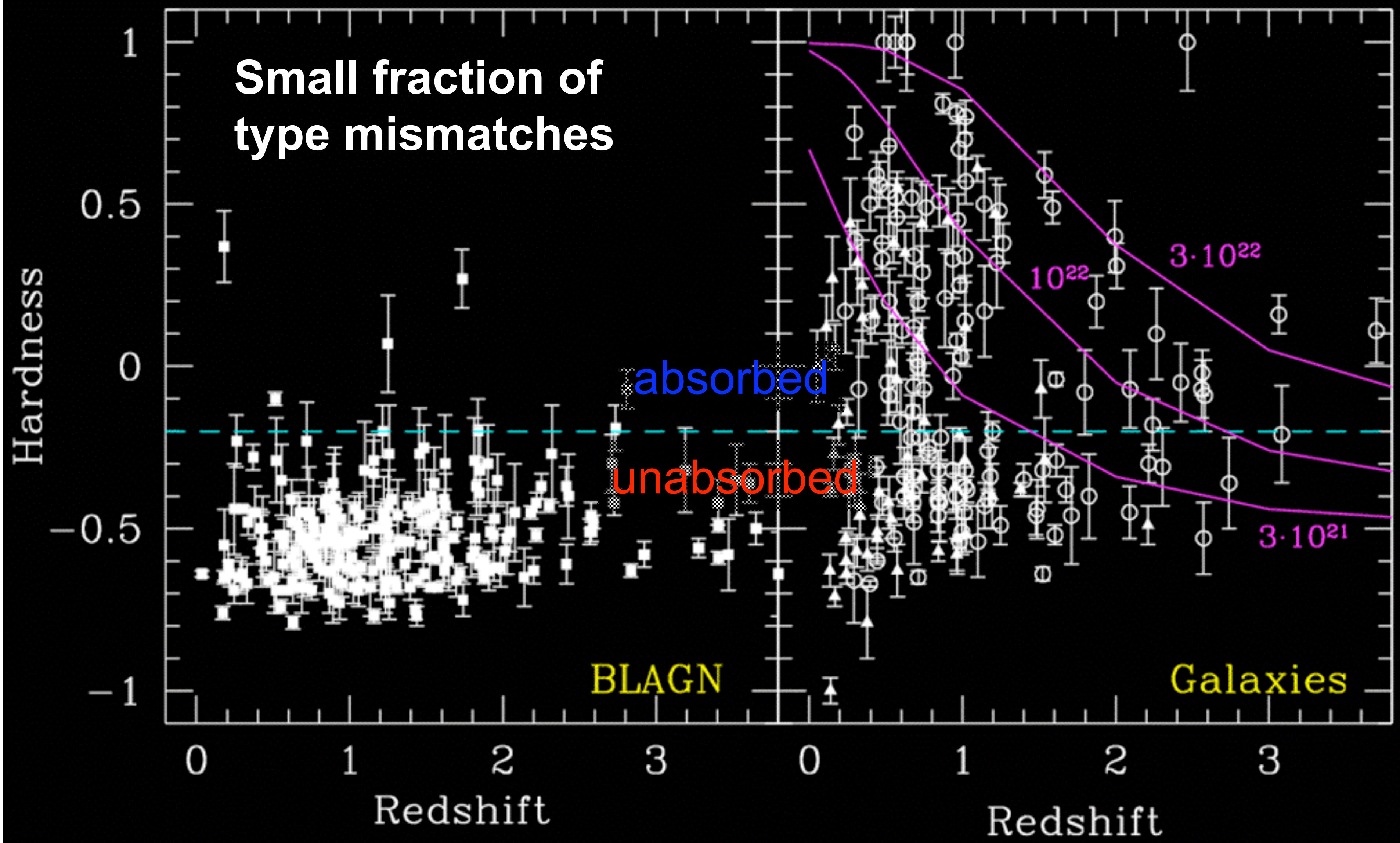
Need to include this into XRB models to fit data above 50 keV !

Huge 2-10 keV AGN sample Including COSMOS (~2200 AGN)



Filled circles: AGN-1
Open circles: AGN-2

Type1/Type2 Discrimination

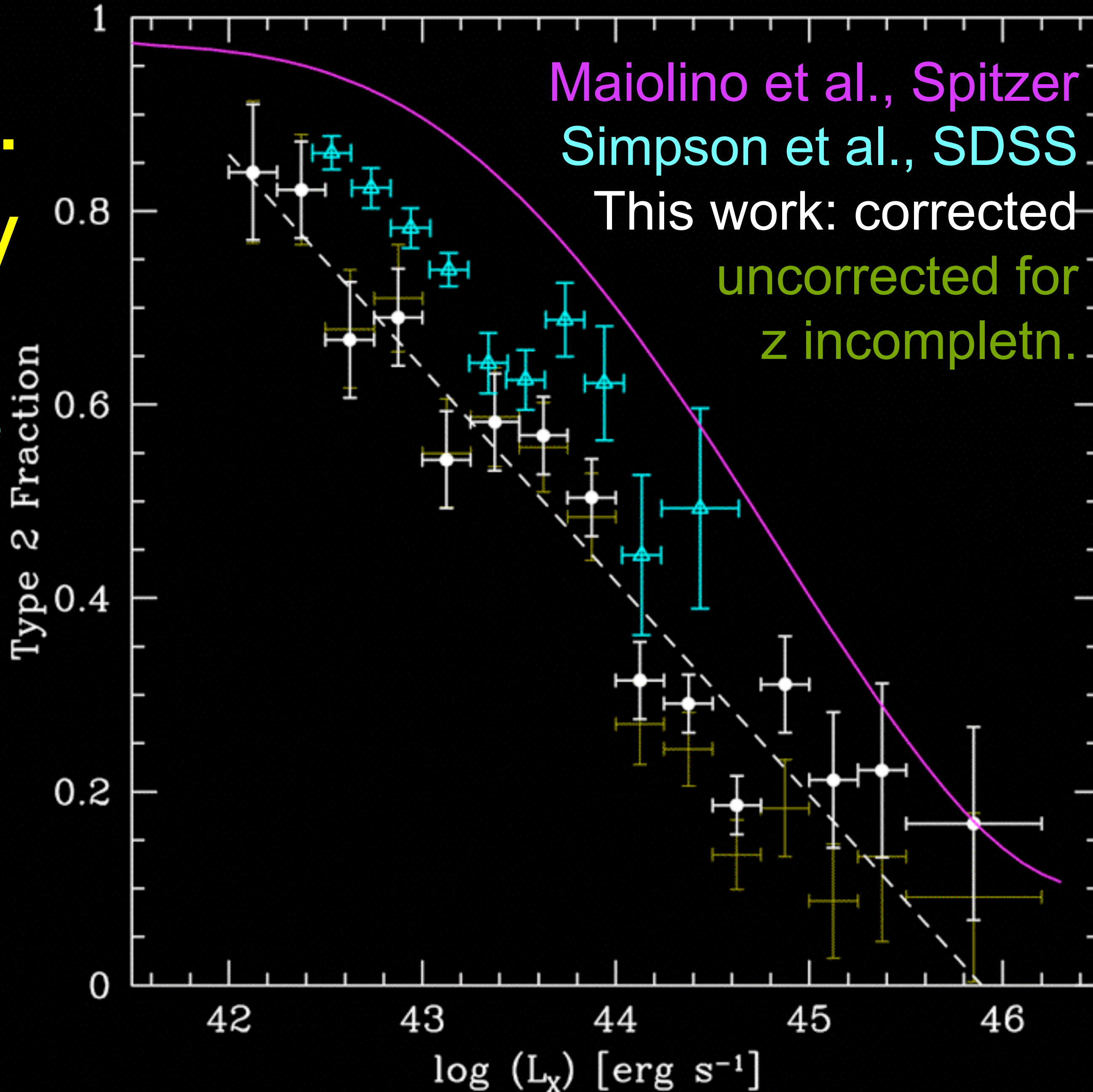


Type-2 fraction vs. Luminosity

Clear trend of less absorption for more luminous AGN in different samples

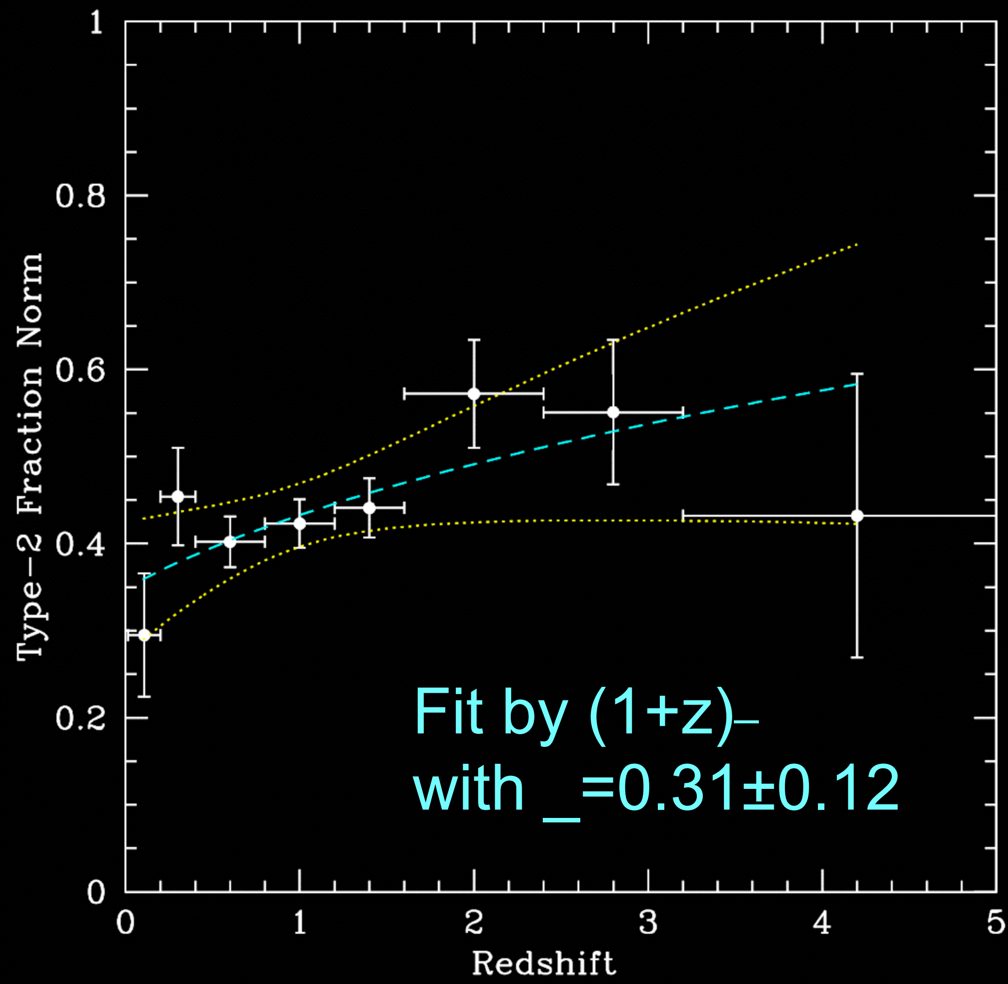
➔ High-luminosity AGN can clean out their environment

➔ Break-down of the strong unified AGN model



G. Hasinger (2008)

Evolution of type-2 normalization

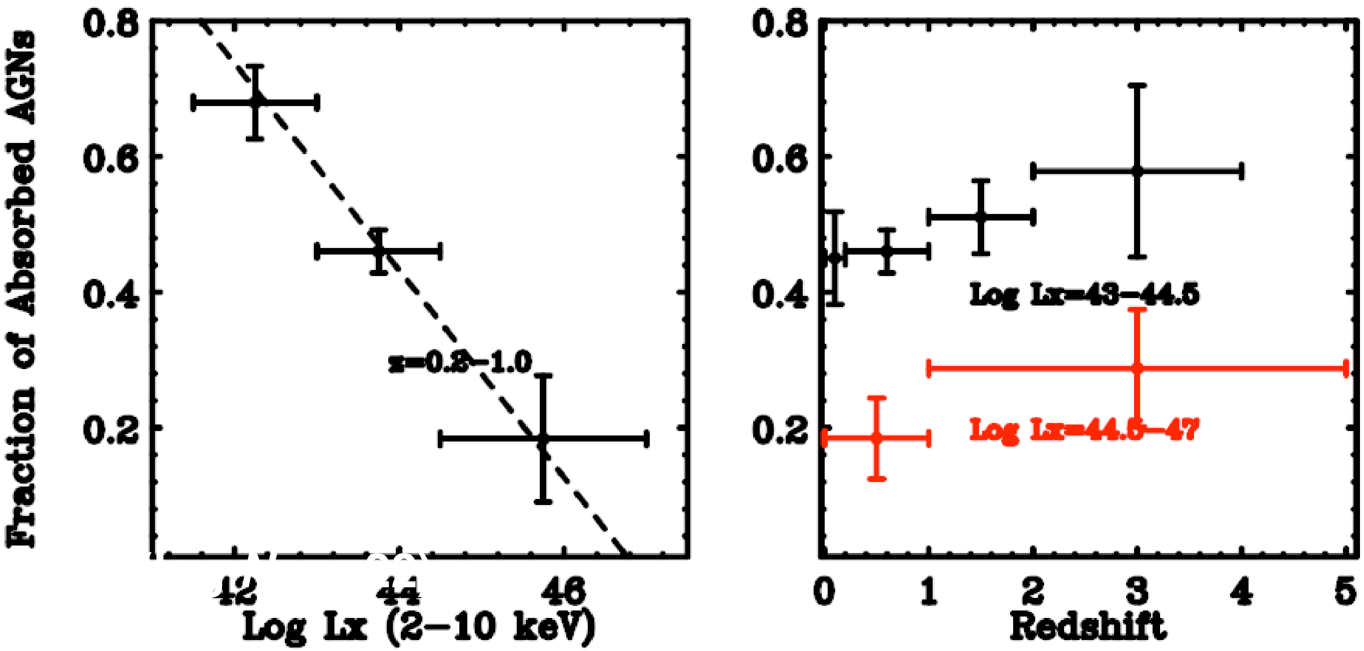


Formally consistent with Treister & Urry 2006, but only a 2.5 _ effect, i.e. not significant. Also consistent with constant.

See also Ueda talk!

(2) Fraction of Absorbed AGNs

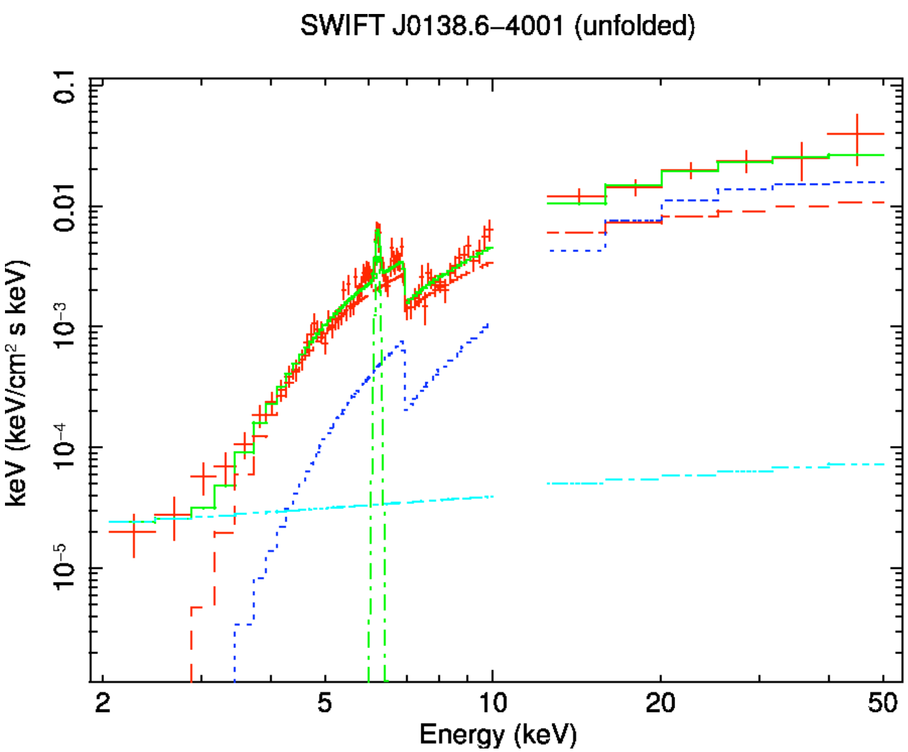
- Our present analysis: *Fx*(2-10 keV) > 3e-15 cgs
  - Swift/BAT 3 months Catalog (Markwardt+ 2005)
  - ASCA LSS/MSS
  - CLASXS
  - XMM Hard Bright Sample (Caccianiga+ 04)
  - XMM Lockman Hole 800 ks (Hasinger+01, Matteos+05)
  - CDFS + XMM 400 ks (Giacconi+02, Streblyanska+08)
- Redshift dependence is not significant, but plausible: if true indicative of higher fraction of Compton thick AGNs at early universe?

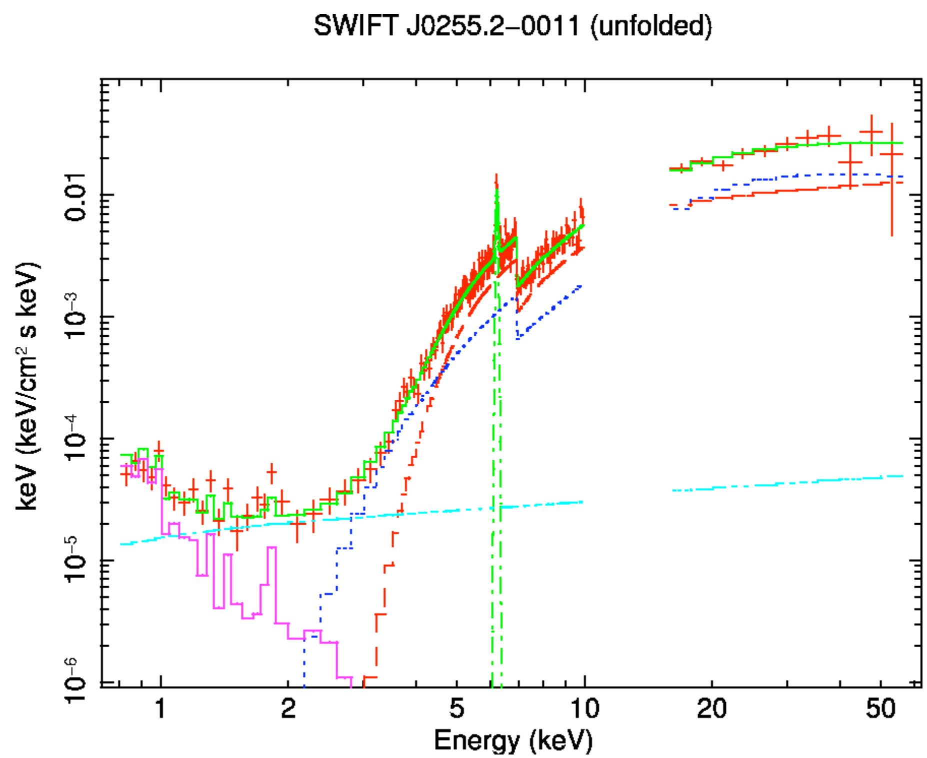


Elvis

New Type: Other Examples

- Log N_H~23.8 cm^{-2}, very small scattering (*S*<0.3%) and strong reflection (R>1)
- More in Mushotzky's talk



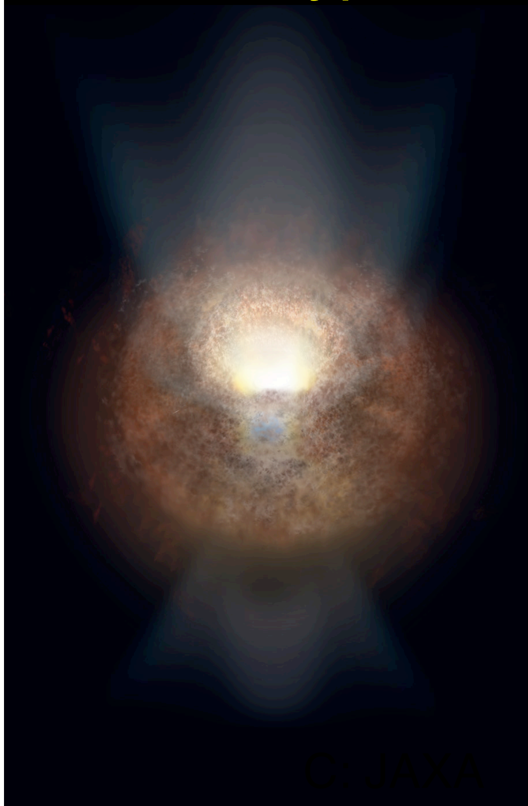


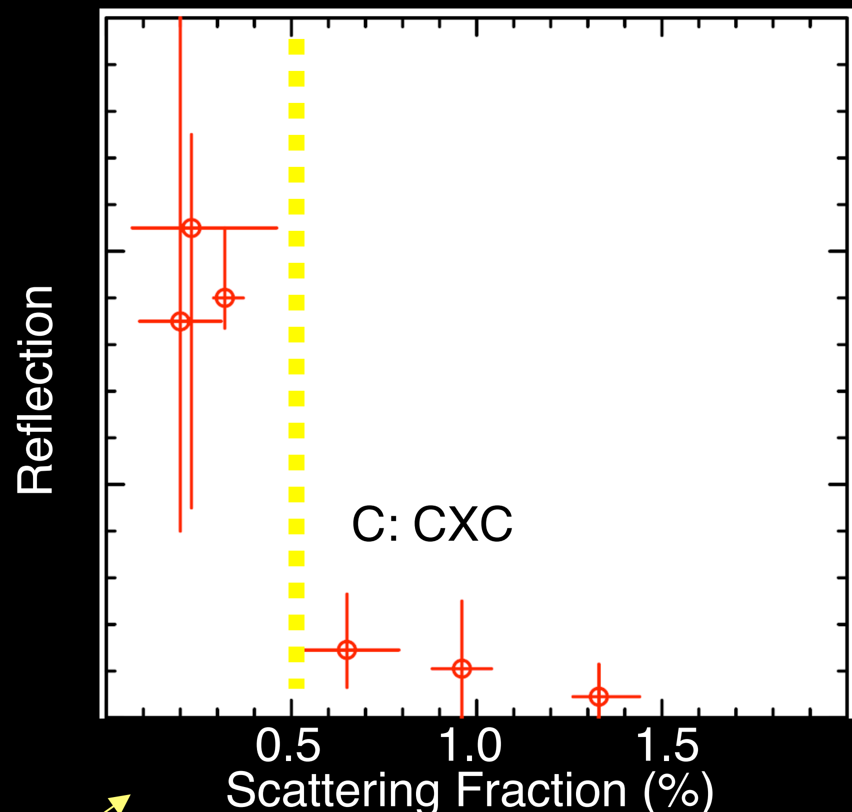
Ueda

Eguchi (2008)

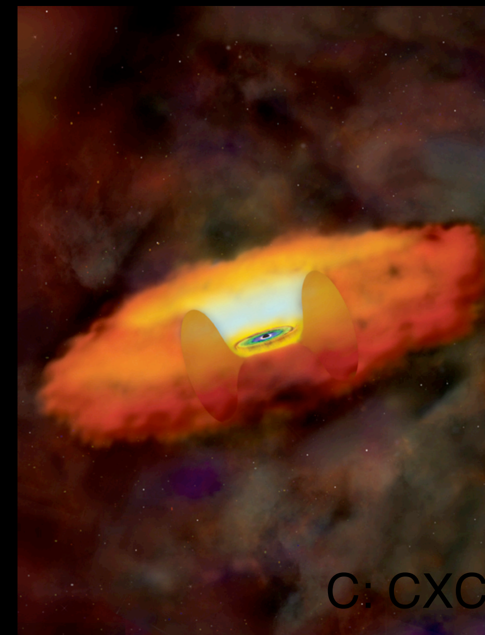
Two types?

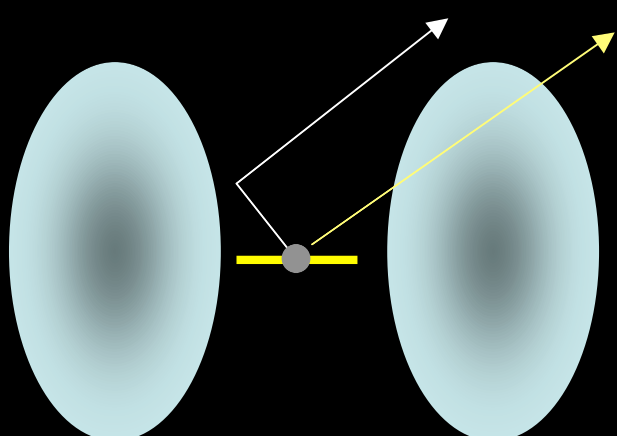
New Type

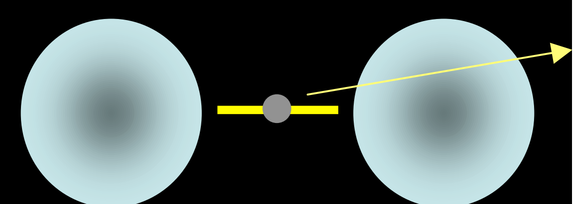




Old Type







Ueda

Recommendation

Study systematically a larger sample of Swift BAT sources to pin down reflection and scattering

These two parameters strongly beat with the fraction of Compton-thick sources

Thank you very much!

And apologies to all the wonderful Suzaku results I was not able to mention in my talk