X-ray signatures of circumnuclear gas in AGN

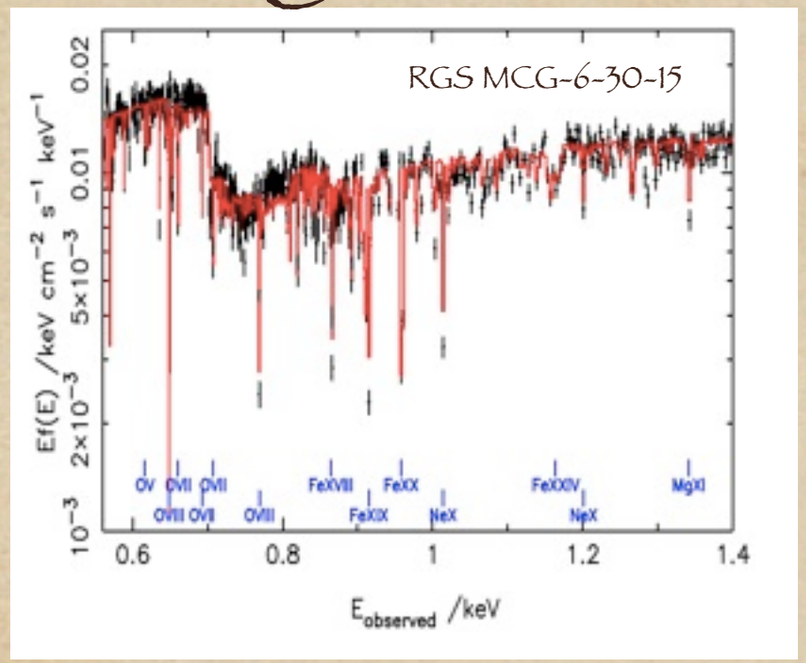
Jane Turner UMBC

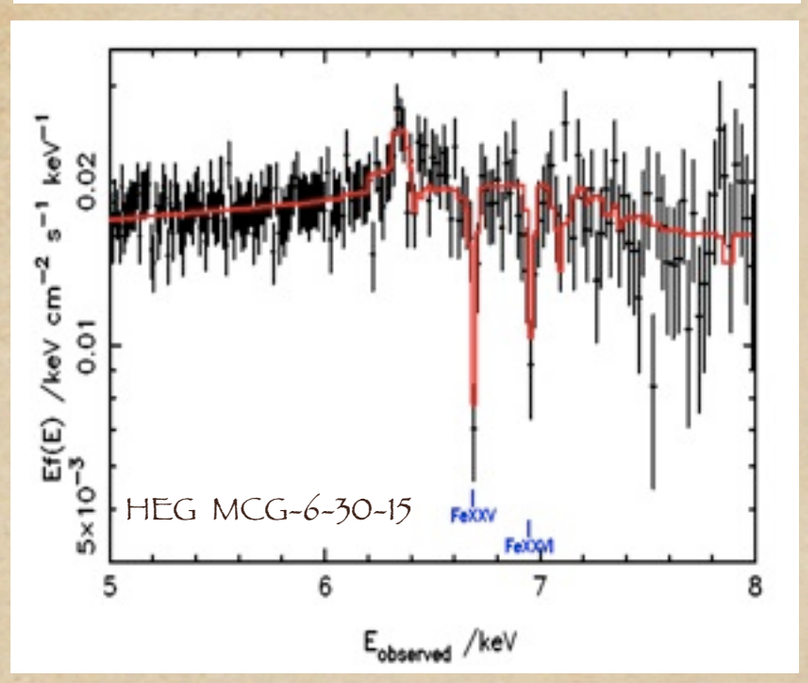
Lance Miller (Oxford)
James Reeves (Keele)
Stuart Sim (MPA)
Steve Kraemer (Catholic)
Andrew Lobban (Keele)
Mike Crenshaw (Georgia)
Valentina Braito (Leicester)
Knox Long (STScI)
Malachi Tatum (UMBC)

Overview

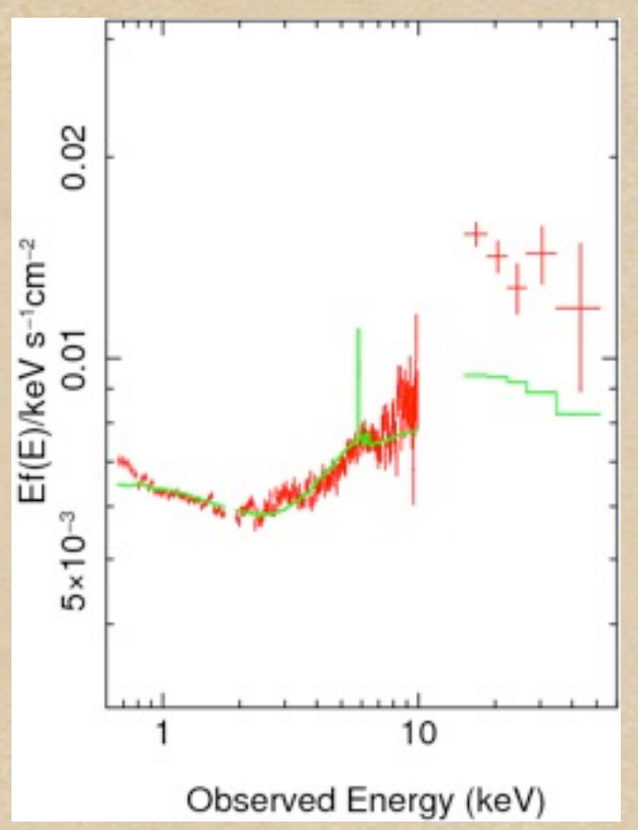
- X-ray observational results
- A model for observed X-ray properties
- Model predictions
- What can we learn about NLSy1s

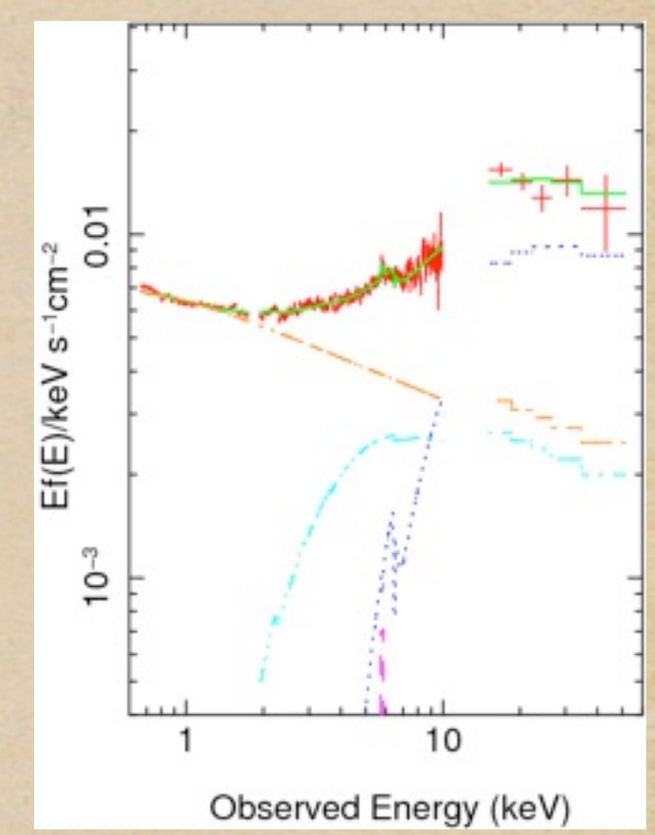
Signatures of circumnuclear gas





Miller, Turner & Reeves 2008





Compton-thick gas partially covering source
1H0419-577 (Turner et al 2009)

Also: PDS 456 (Reeves et al 2009)

High flux above 10 keV:
NGC 4051 (Terashima et al 2009)
MCG-6-30-15 (Ballantyne et al '03, Miniutti et al '07)
Mrk 335 (Larsson et al '08)

X-ray signatures of circumnuclear gas

Intrinsic X-ray absorbers, most nearby AGN (Blustin et al 2005, McKernan et al 2007)

Discrete absorption lines show:

Sources show multiple X-ray zones
X-ray gas covers ~6 orders mag in ξ
Columns range 10^{20} - few x 10^{24} cm^{-2}

Hard-band data show columns > 10^{25} cm^{-2} in play

Absorption is outflowing:

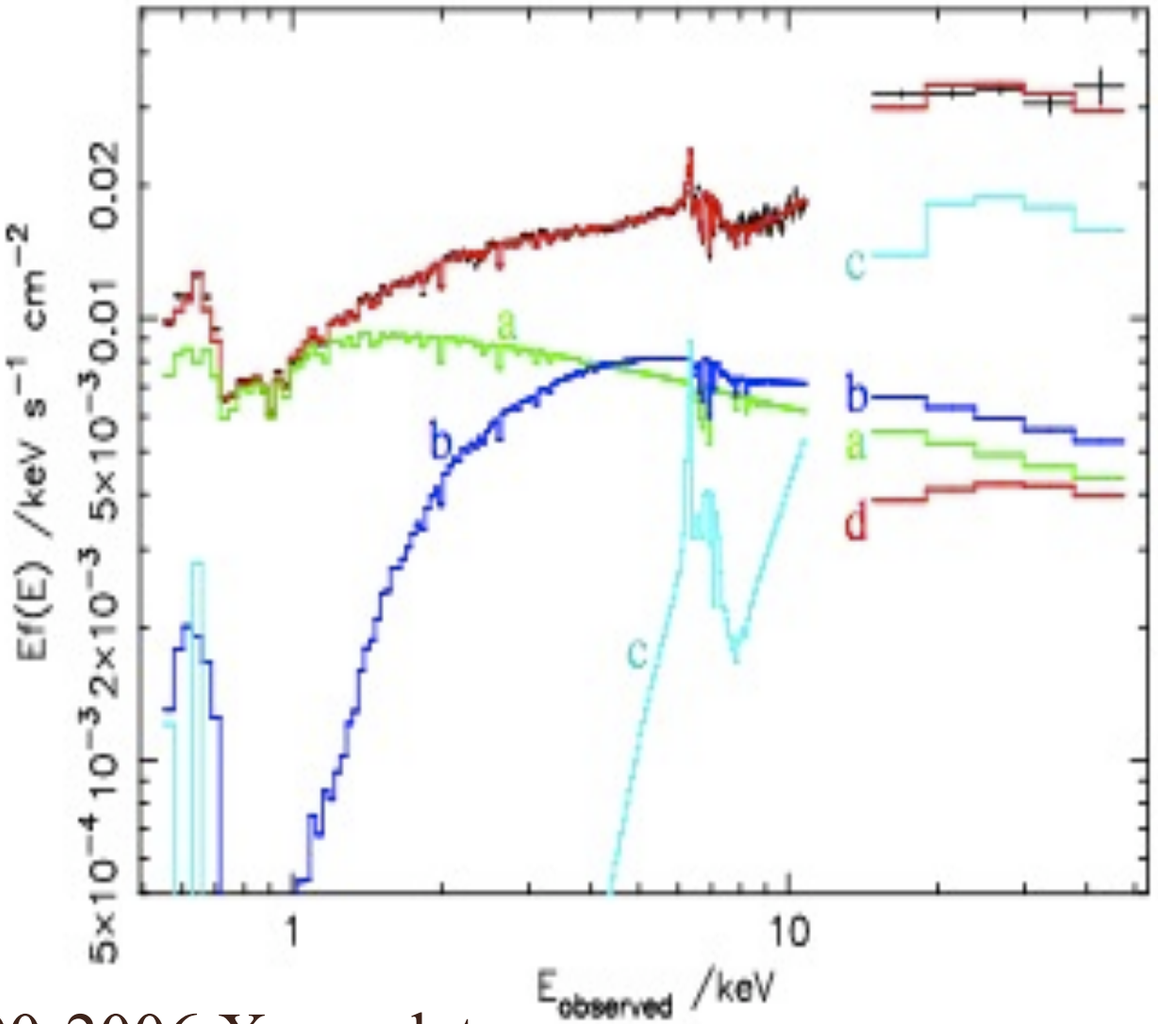
few hundred - few thousand km/s for low N_H/ξ zones,
few thousand - tens of thousands of km/s for highest N_H/ξ zones (Tombesi et al 2010)

Natural extension of UV partial-covering absorber complex
cf BAL QSOs

Outflow may transport significant energy, e.g. Pounds et al 2008 (PG1211+143), Reeves et al 2009 (PDS 456)

Winds inevitable for sources accreting at high fraction of Eddington (King 2010)

No source whose X-ray properties cannot be explained with absorption models



2000-2006 X-ray data

Absorption Models fit MCG -6-30-15 (Miller et al. 2008)

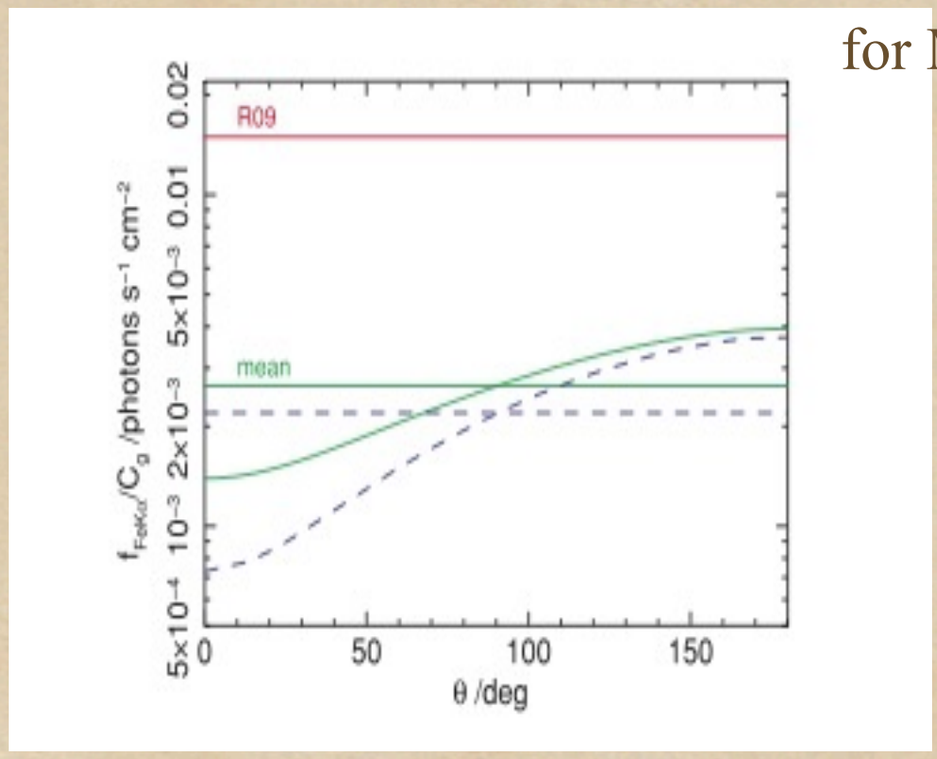
- **PL absorbed by low column complex**
- PC PL absorbed by 4E22
  - High state 50% covered
  - Low state, almost entirely covered
- **Reflection**

Fe line strength from absorber

Observed neutral Fe line <u>does not</u> rule out absorption models

Ionized PC-absorber, may produce little observable Fe K emission (e.g. Yaqoob & Murphy 2009, Miller et al 2009)

C_g(M09)~ 0.45 for MCG-6-30-15

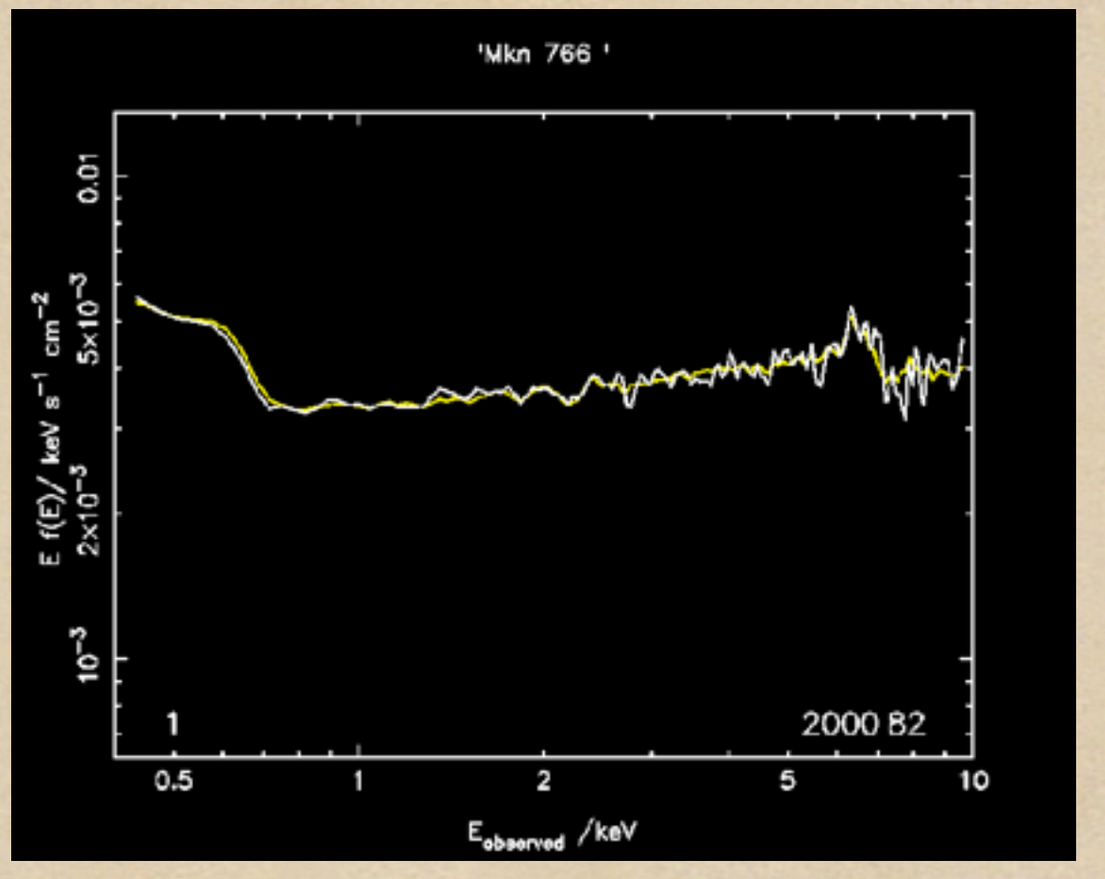


Fe Kα flux as function of viewing angle

Reynolds et al ’09 - assumed all photons abs by Fe K bound-free transition

Miller et al 2009 & Yaqoob & Murphy - must consider all sources of opacity and cannot ignore line self-absorption with τ~3.5 at Fe Kα

Spectral Variability



Mrk 766
Miller,et al '07,
Turner et al '07

Deep Fe K edge

Fe XXV, XXVI outflow
13,000 km/s

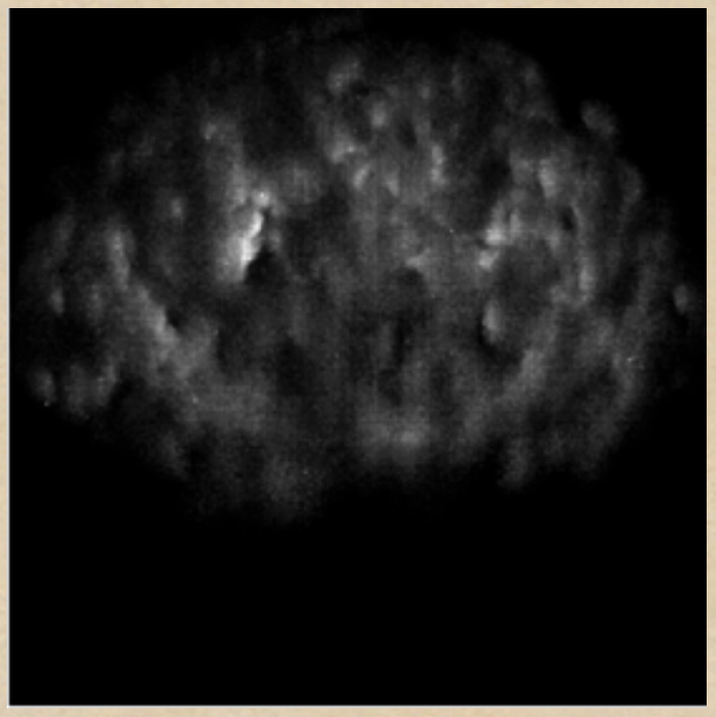
Likely variable covering and/or scattering from disk wind

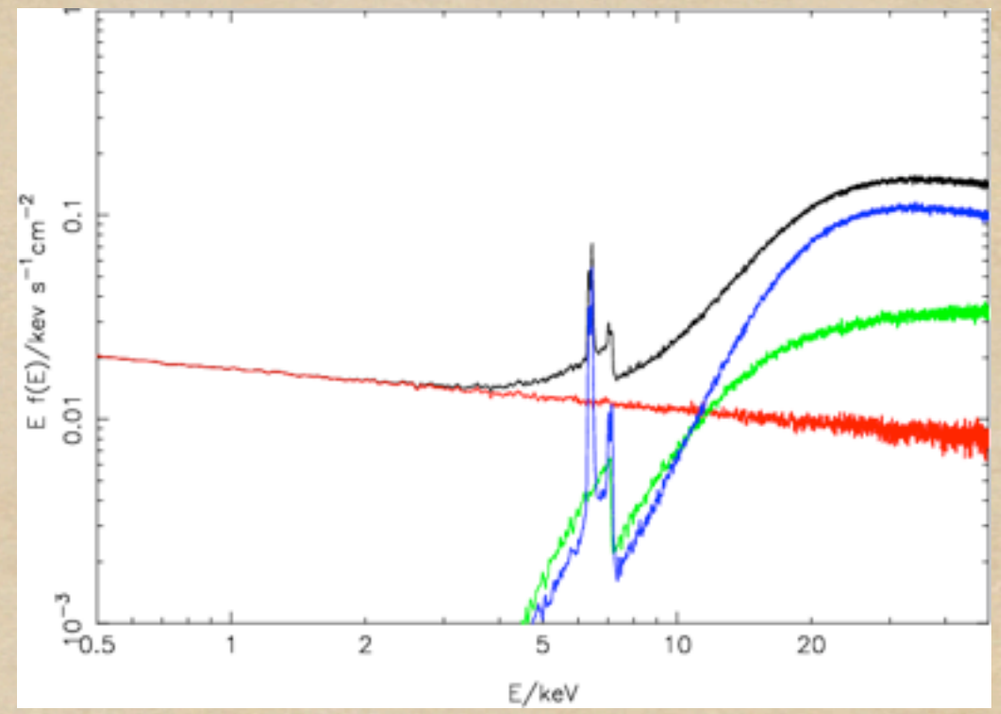
Variable covering by large columns in

Mrk 766	0-60% (Miller et al '07, Turner et al '07)
NGC 3516	30-70% (Turner PDS et al '08)
MCG-6-30-15	50-100% (Miller et al '08)

Supported by Risaliti et al 2009a, 2009b - evidence for obscuration/de-obscuration in NGC 1365

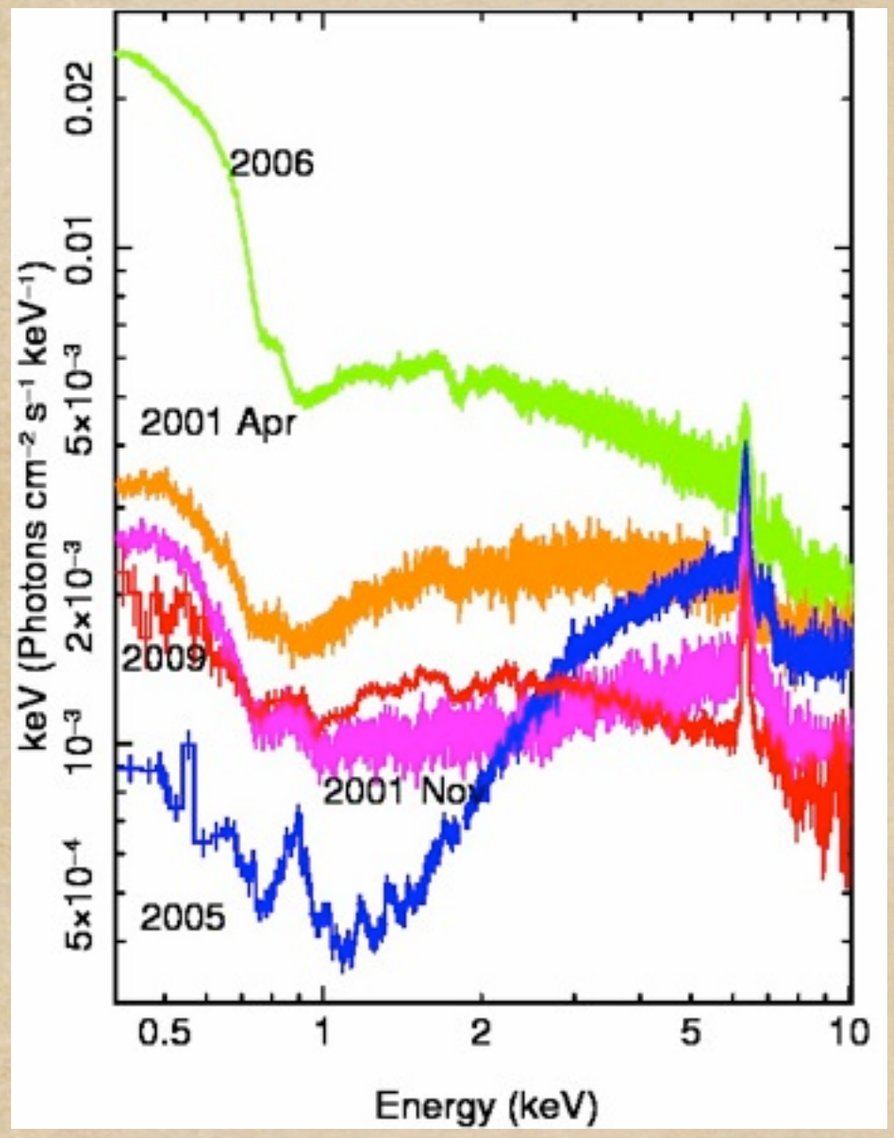
Spectral Variability



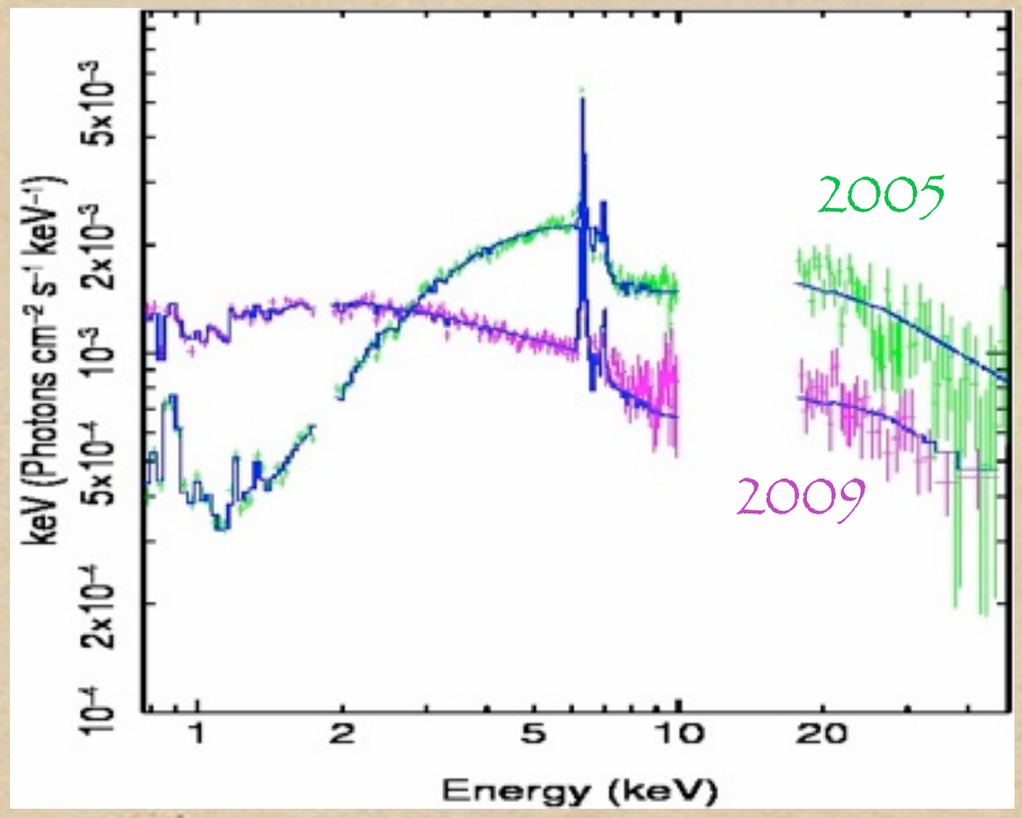


Expect flux and spectral variability from absorption changes

Absorber changes in NGC 3516



Markowitz et al 08, Turner et al 08, Turner et al 2010 in prep

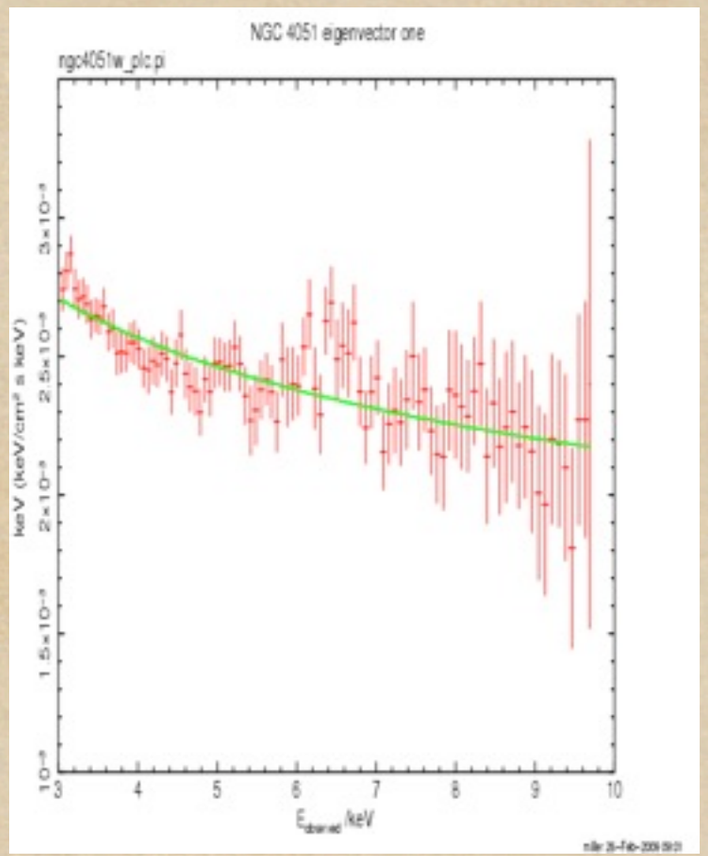


Not a simple ξ change (cf Mehdipour et al 2010)

Need covering changes - such may also explain flux variability

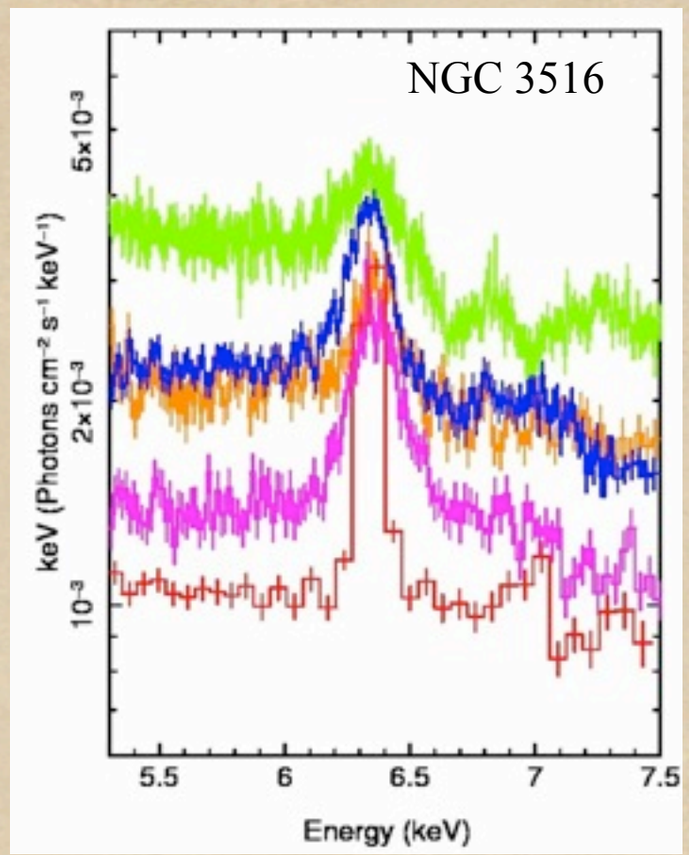
PIN-band variability may be from passage of Compton-thick clumps of gas

Broad Fe lines in Seyferts

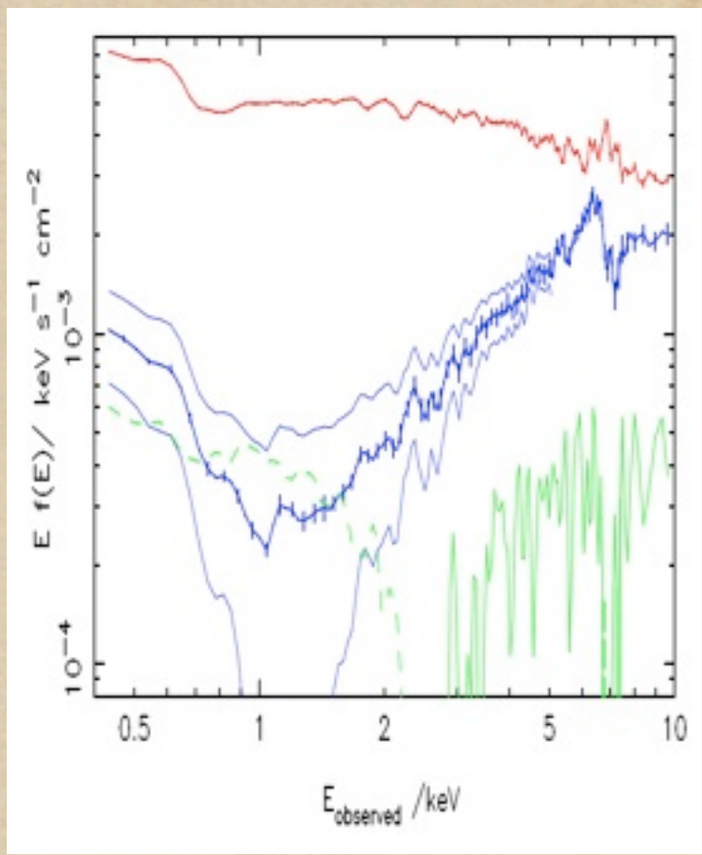


NGC 4051 variable component

Miller et al 2010



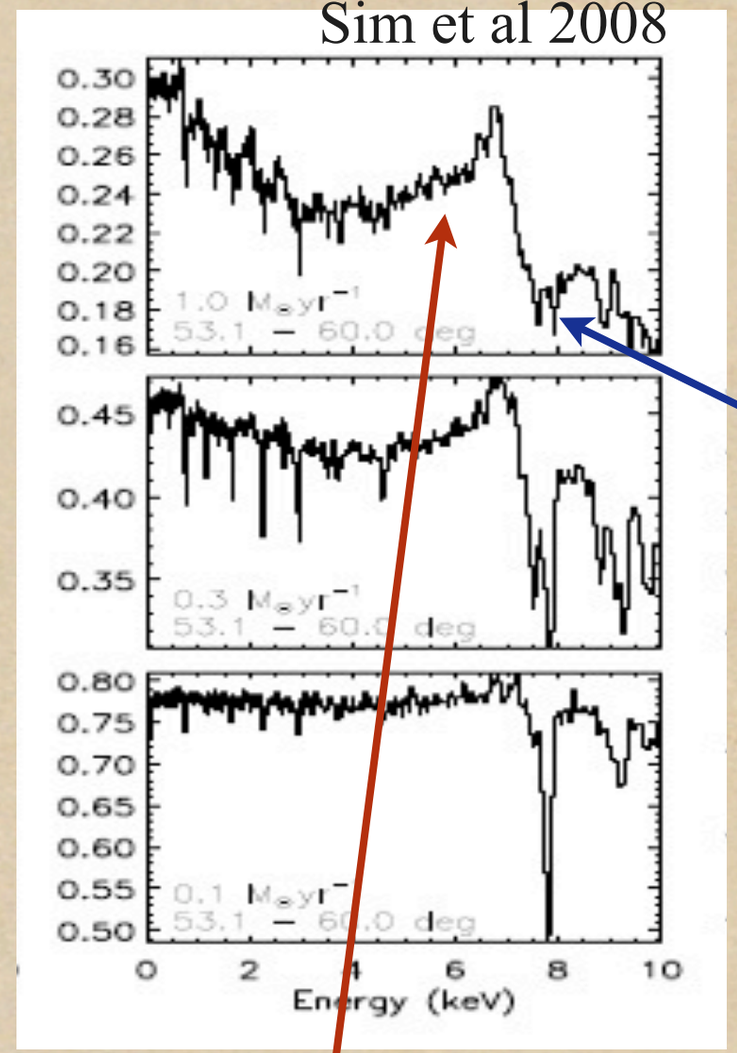
Turner et al 2010

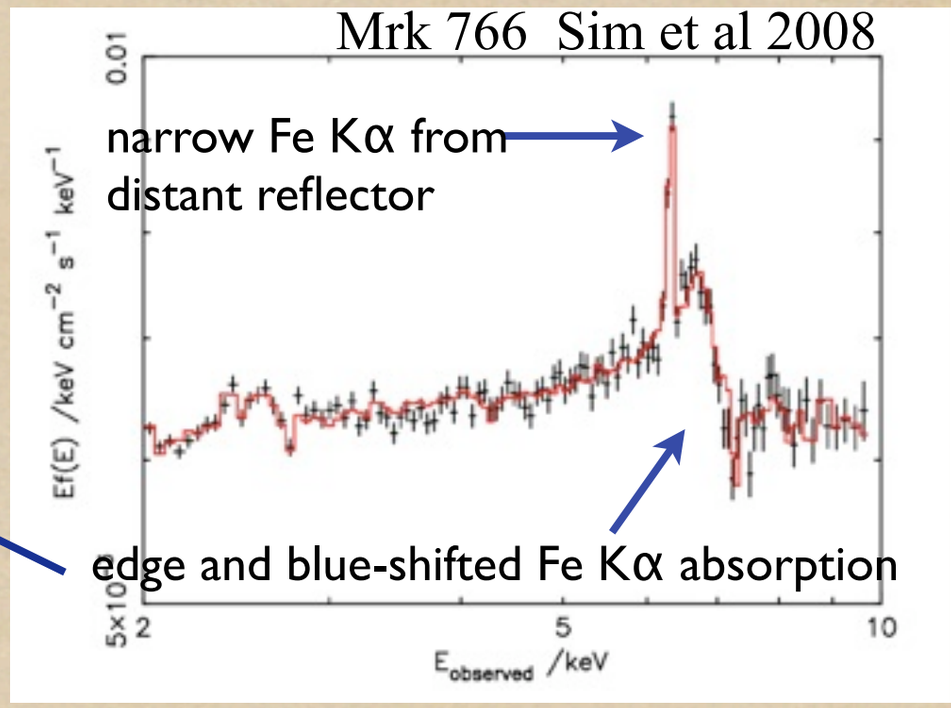


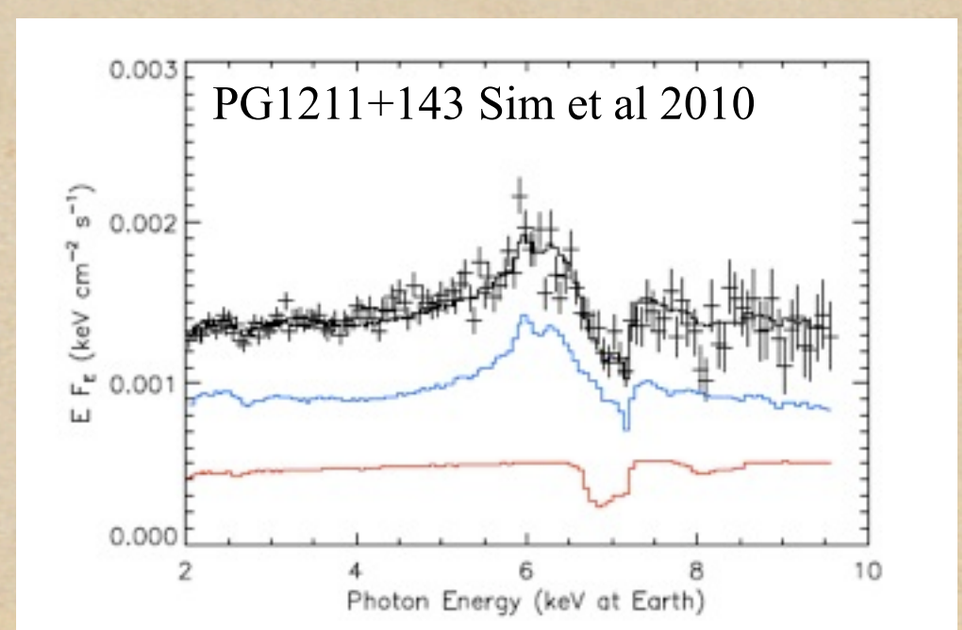
Mrk 766 Miller et al 2006

Modest broad components evident after absorption modeled (also see Guainazzi et al 2010, Patrick et al 2010)

Compton-thick wind models



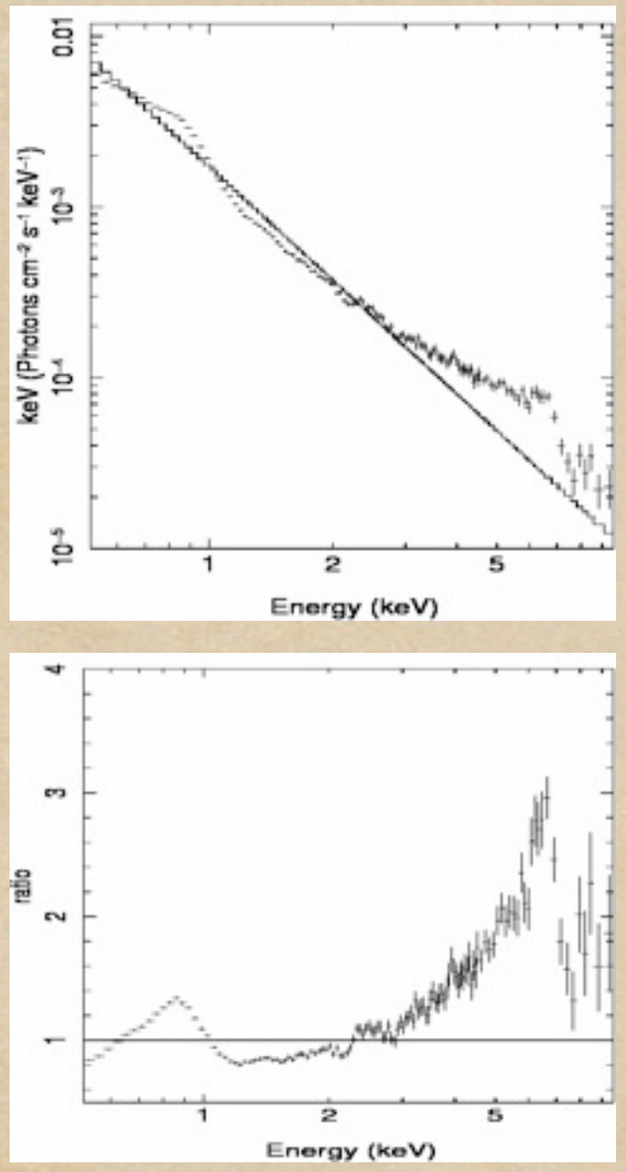




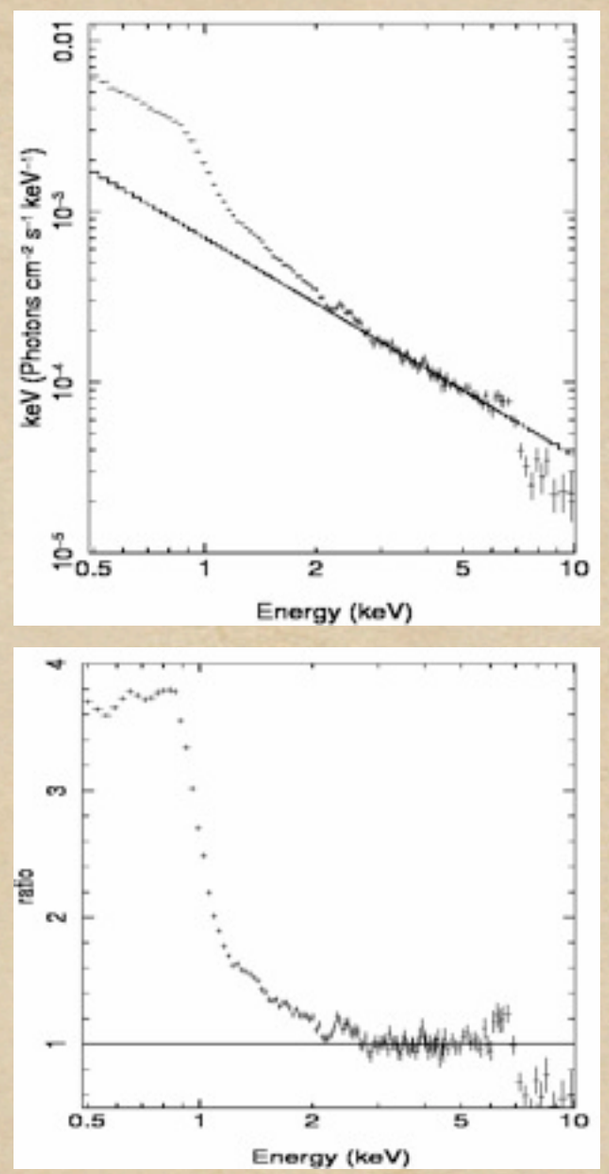
"red wing" produced by scattering and absorption - not by GR effects!

*The outflow **detected** in absorption lines predicts (modestly) broadened Fe K emission line*

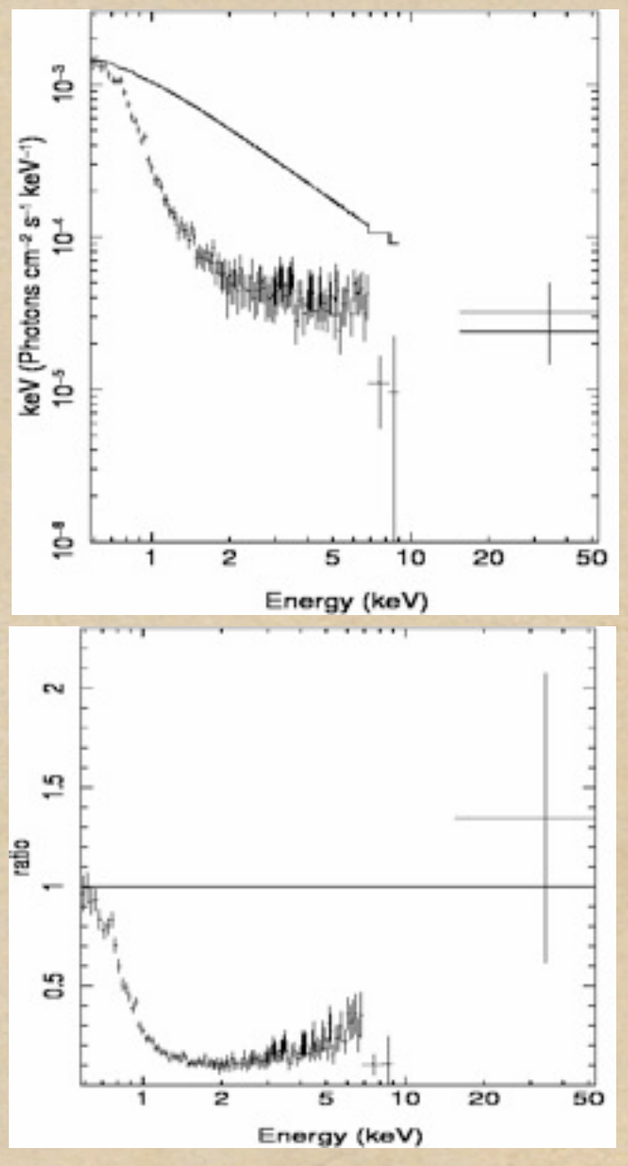
A note on extreme sources ... 1H0707-495



Ratio to PL 0.5 -10 keV



Ratio to PL 2.0-5.0 keV



True continuum?

Summary

- *Clear* evidence for outflowing X-ray absorber complex in AGN tracing columns 10^{20} - 10^{25} cm^{-2} ionized gas
- Natural extension of partial-covering UV gas
- We are not seeing a naked accretion disk, circumnuclear gas exists at tens - hundreds of r_g
- Absorption models explain spectral and timing properties with covering changes and reverberation (see L. Miller talk)
- Compton-thick wind/reverberation models look promising to explain even the most complex sources - **NLSy1s**
- Consider the extreme properties of NLSy1s in the context of absorption models (smaller scale size for the system and/or viewing angle)