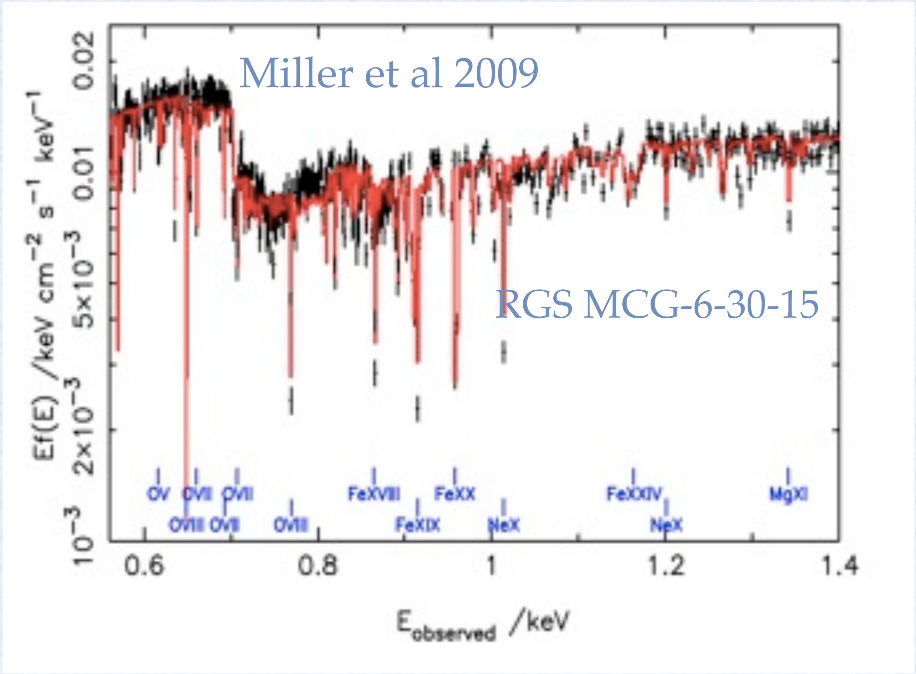
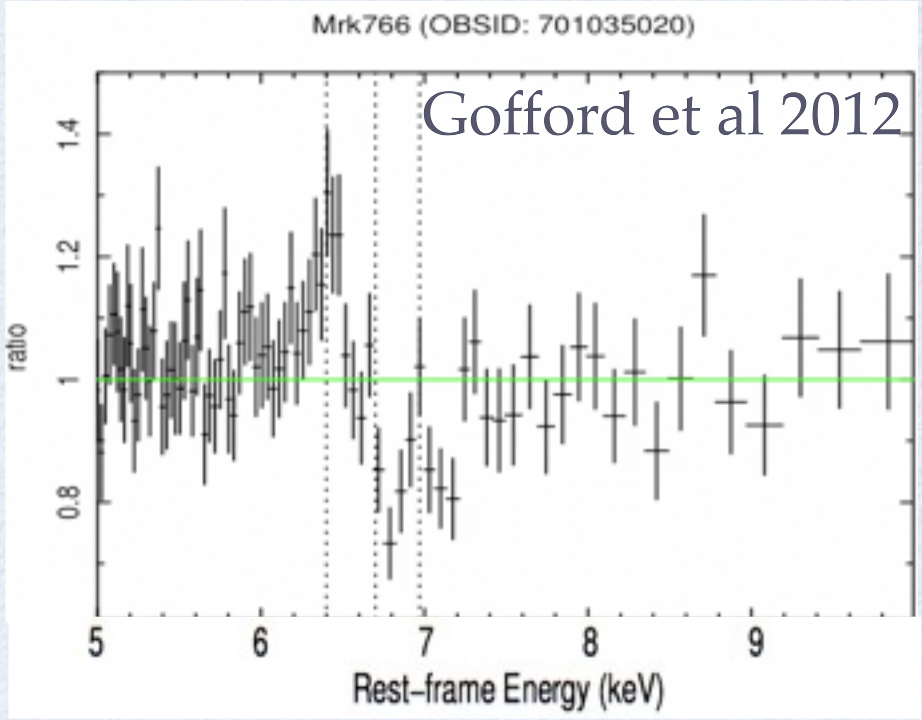
Jane Turner UMBC

The Importance of Nuclear Winds in Shaping the X-ray properties of AGN

Collaborators:
Lance Miller (Oxford)
Malachi Tatum (NASA/GSFC)
James Reeves (Keele)
Matthew Clayton (Oxford)

X-ray signatures: broad range of N_H, ξ



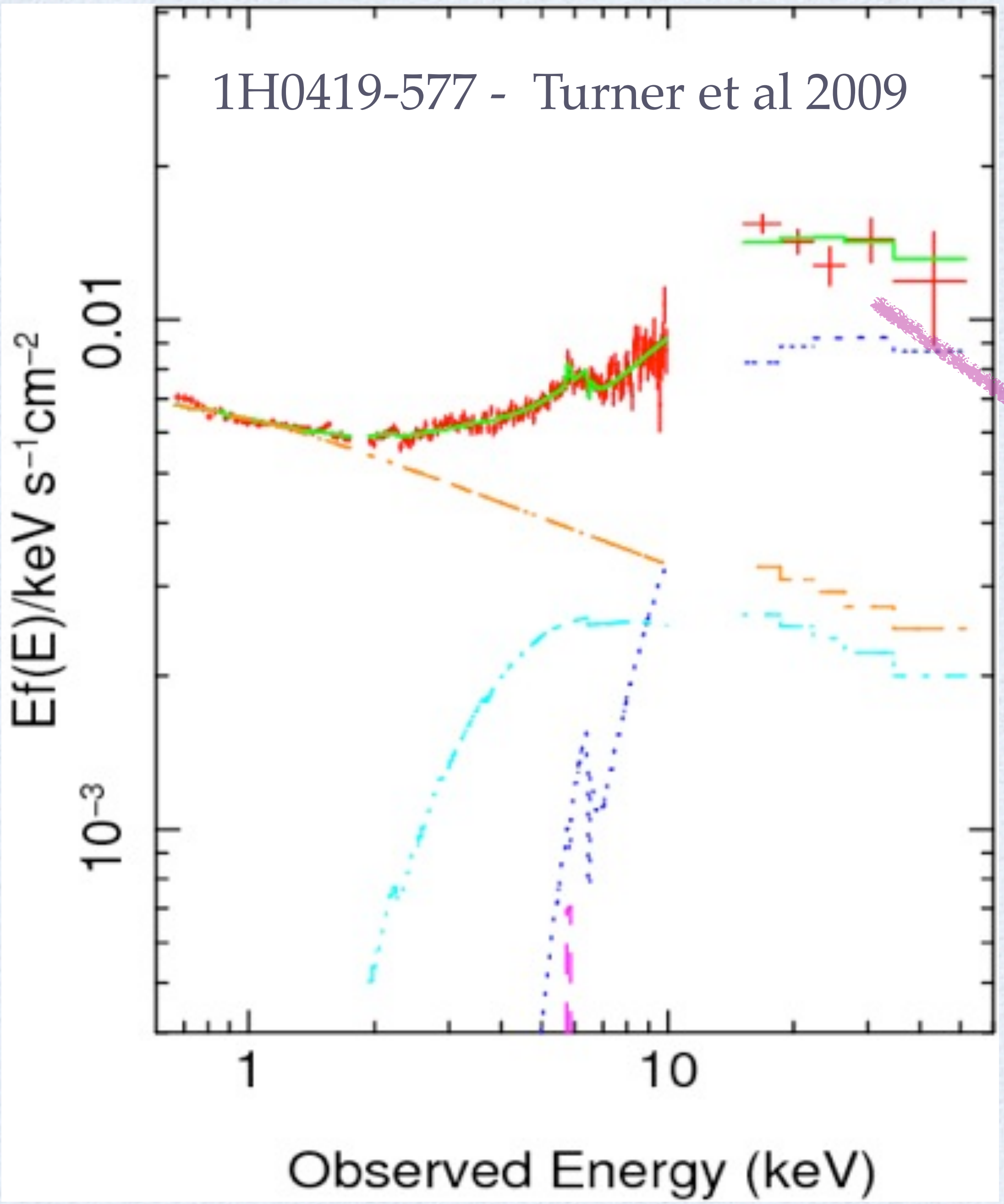


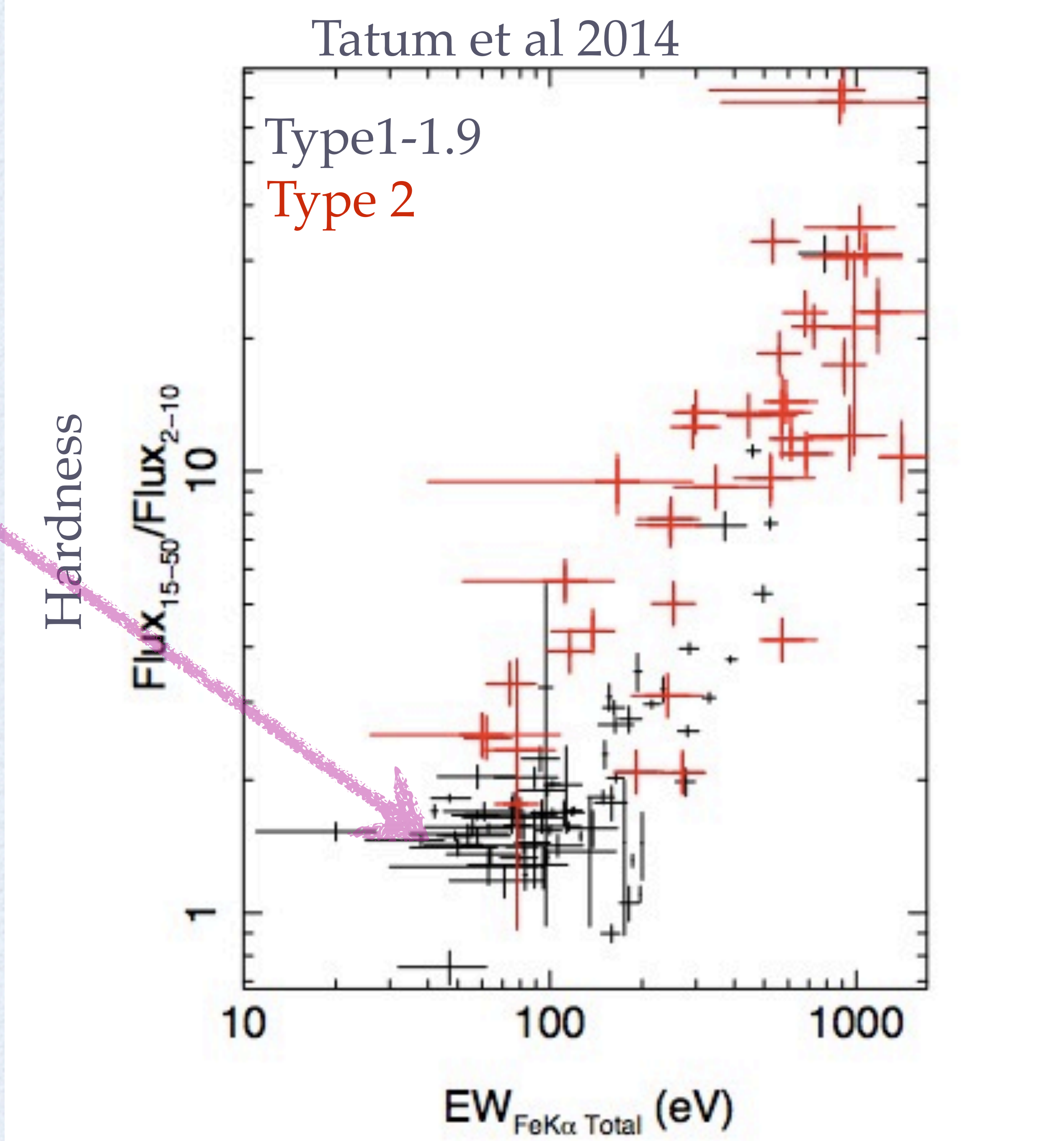
Outflow hundreds-thousands km/s for low ξ , N_H zones (e.g. Blustin et al 2005, McKernan et al 2007)

Tens of thousands km/s - fraction of c for high ξ N_H zones (e.g. Tombesi et al 2010)

Wind inevitable if accreting at high fraction of Eddington (King & Pounds 2003, King 2010)

Suzaku study of hard spectral form

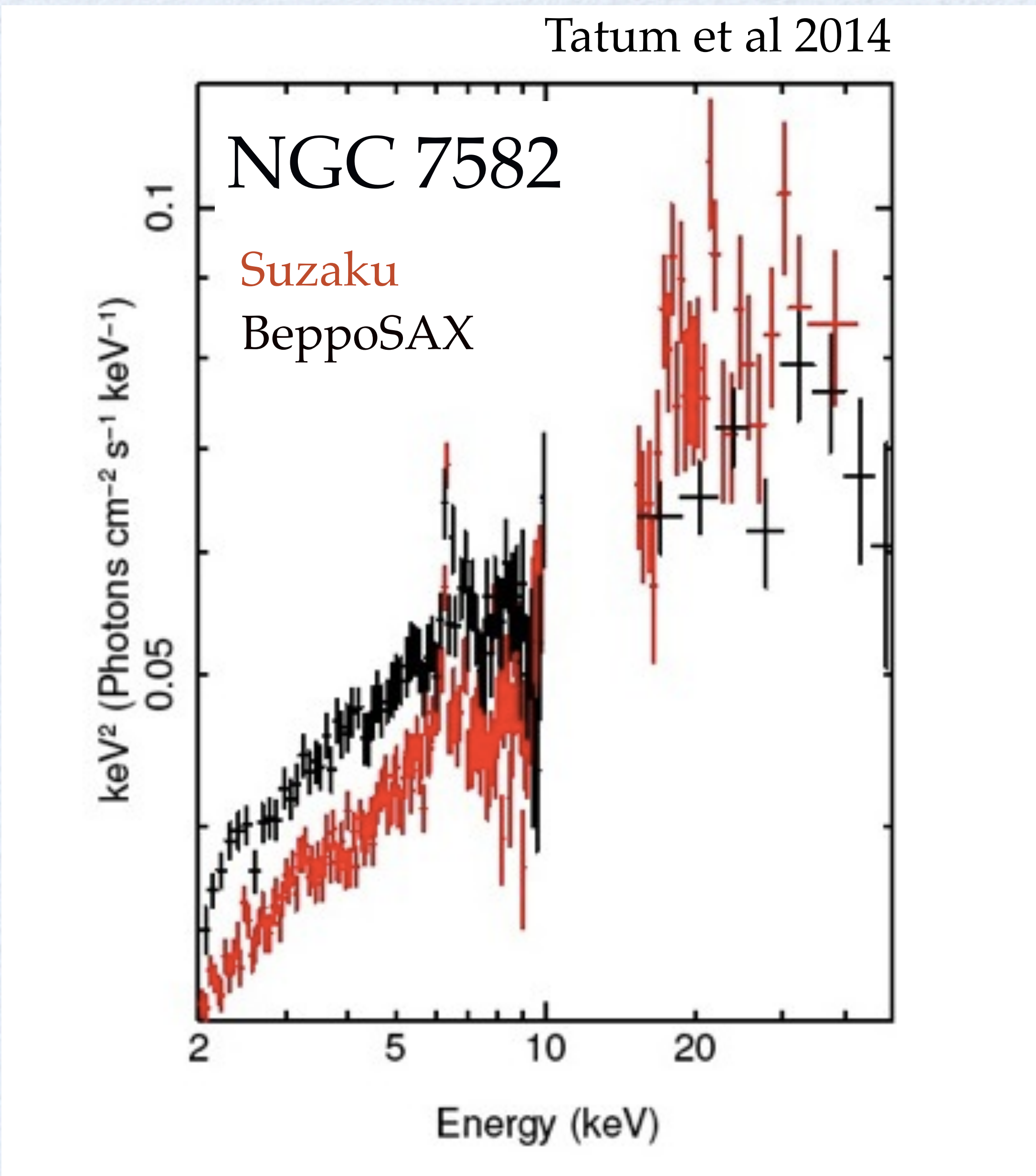


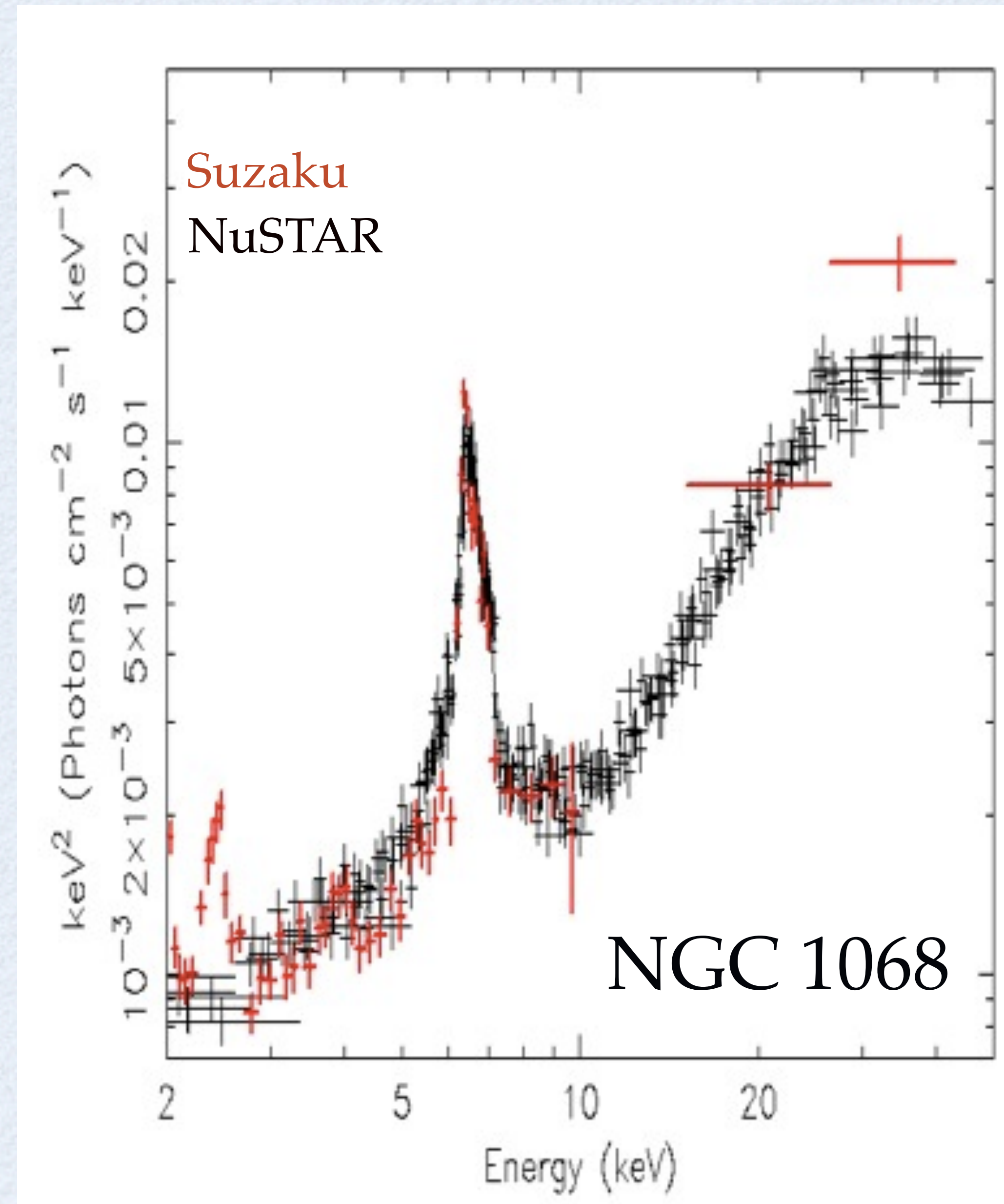


Hard component- partial-covering Compton-thick gas type I AGN

Tatum et al (2013, 2014) - hard excess ubiquitous in local Seyferts

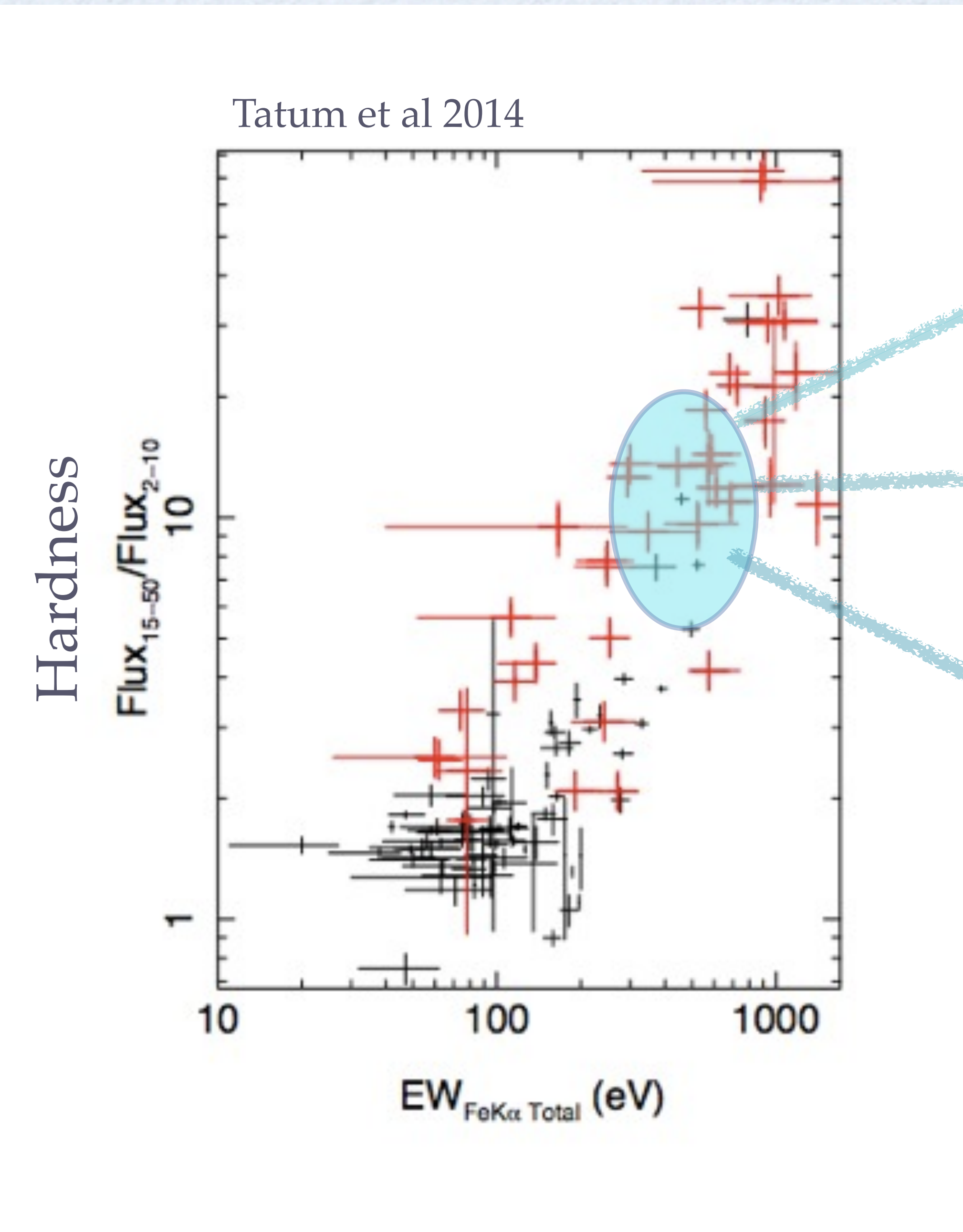
Comparisons

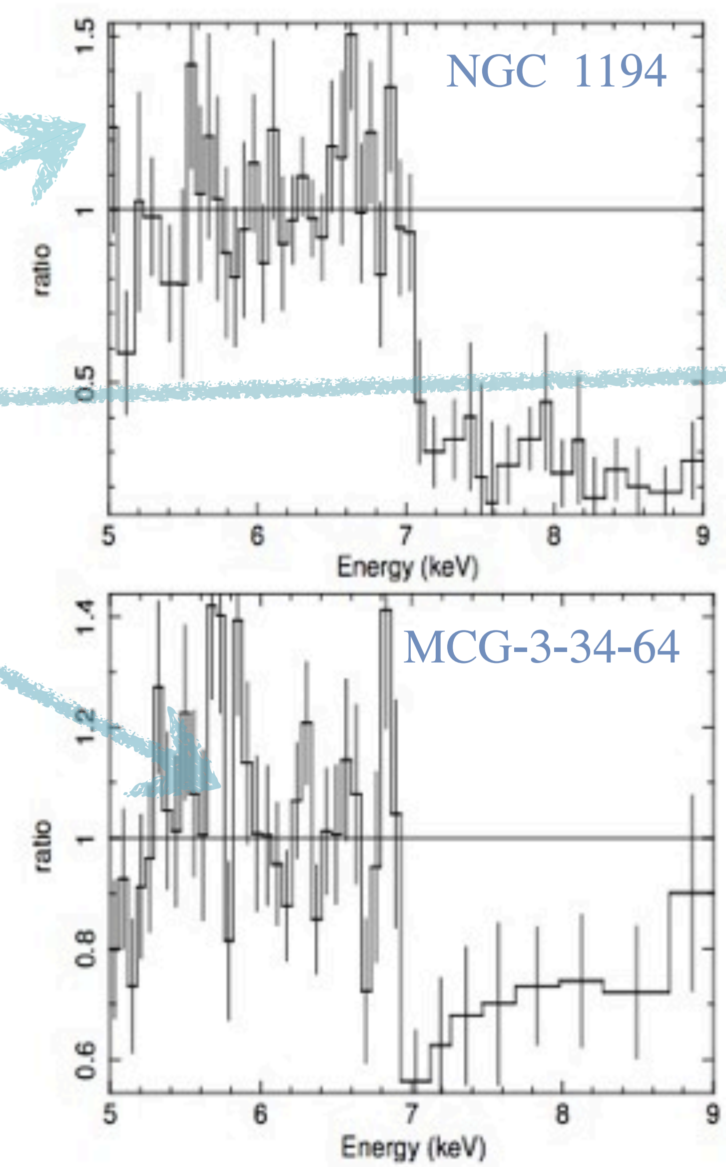




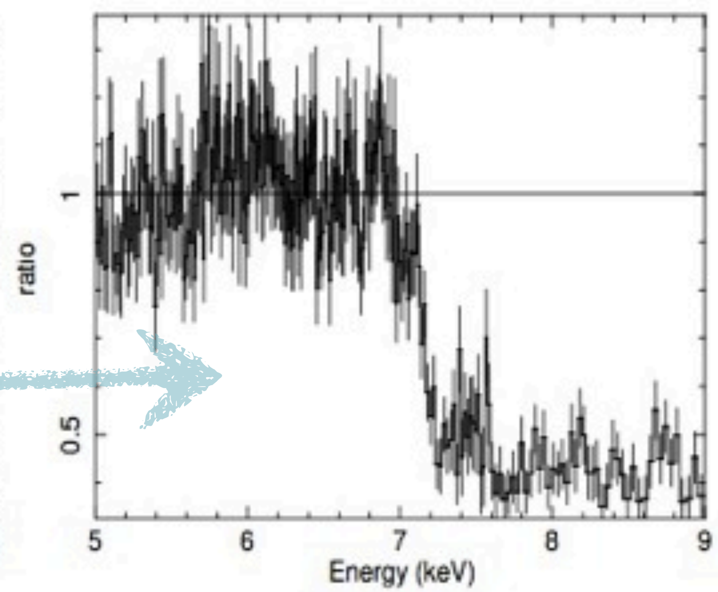
Hardness ratios from Tatum et al 2012 and Dadina et al 07 consistent for the local AGN population

Sharp Fe K edges



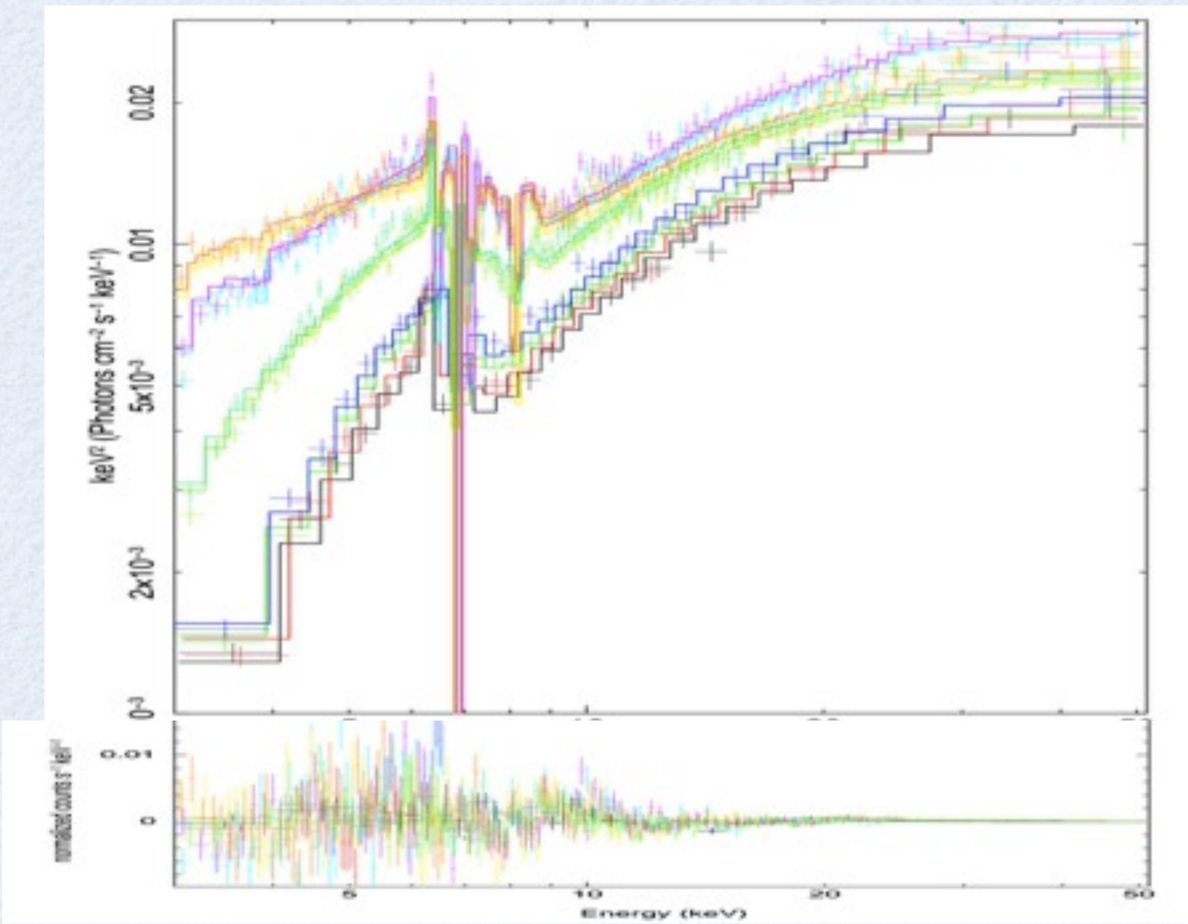


NGC 1365 2010 PIN data show very hard excess - absorption!



Sharp edges - hardness not predominantly from GR blurred component (Tatum et al 2013)

NGC 1365

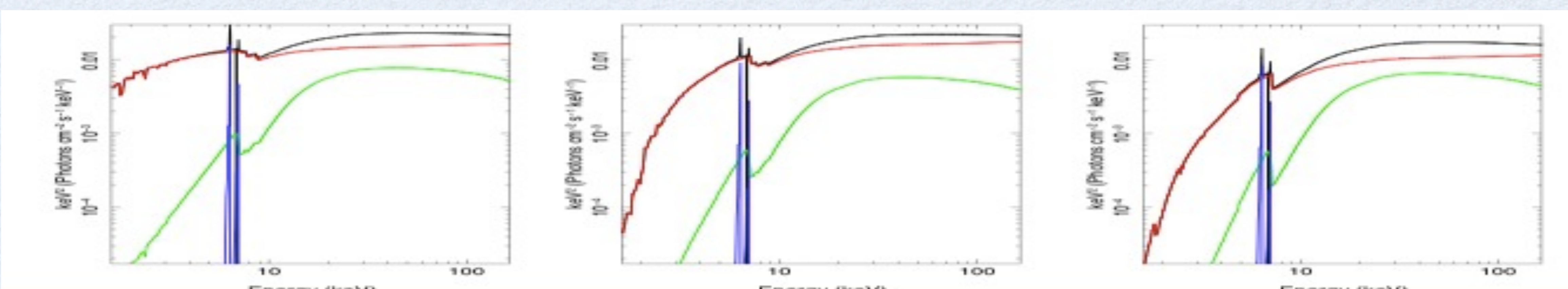


Tatum et al 2014b *in prep*
5 NuSTAR epochs fit simultaneously using both mirrors

Model MYTorus (N_H=2E24, ϴ= 60^o) plus *xstar* zone with variable ξ and N_H

$\chi^2_{r} \sim 1.1$

~ 5 months separating extremes



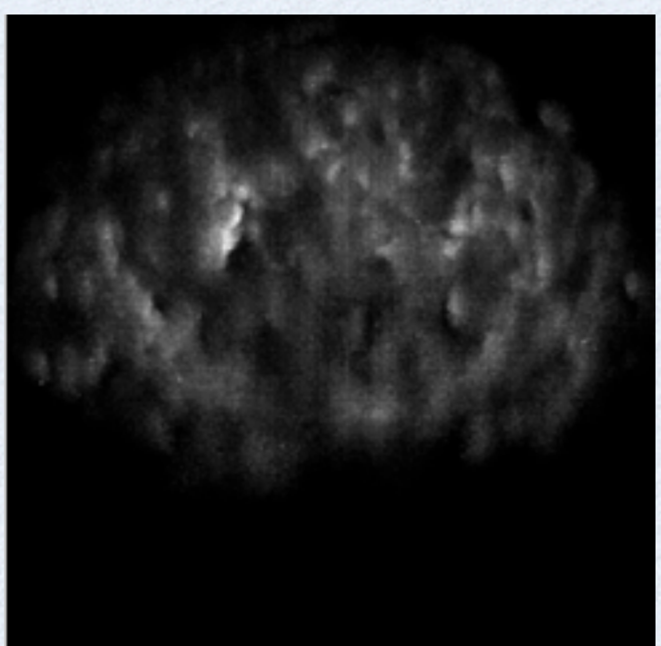
Compton Thick Wind

MCRT - high global covering, clumpy gas atmosphere, partially covering the source (cf Nandra & George '94, aka 'Blob')

MCRT accounts for scattering of photons between clouds

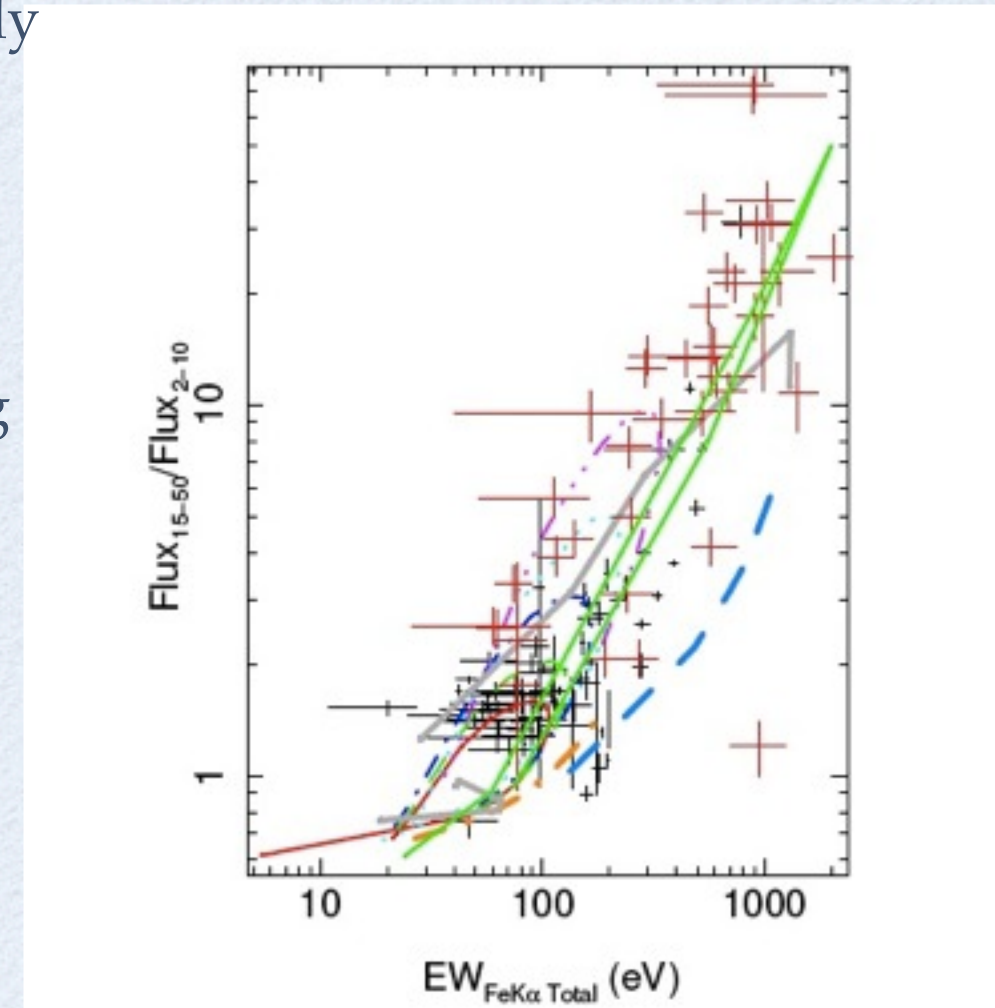
System scale-free - i.e. the scale can be set to anything, keeping N_H through each cloud invariant get same results - hence we never specify size of clouds in cm nor gas density in cm^{-3}

Instead specify shell inner (Rmin) and outer (Rmax) radii in terms of cloud radii



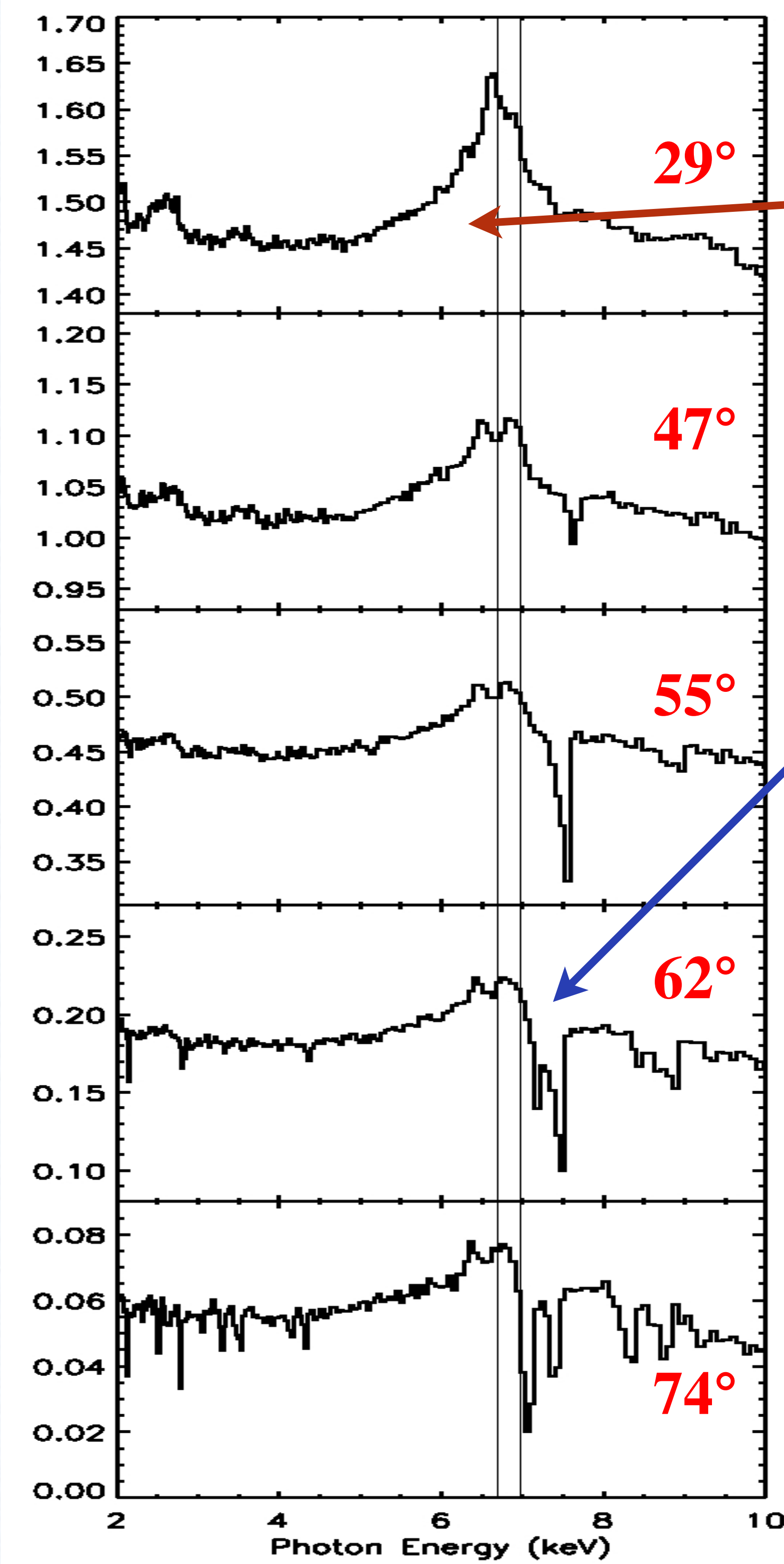
Rmin, Rmax control covering fraction of atmosphere

Initially, spectra for each atmosphere parameter averaged over large solid angle of sight-lines



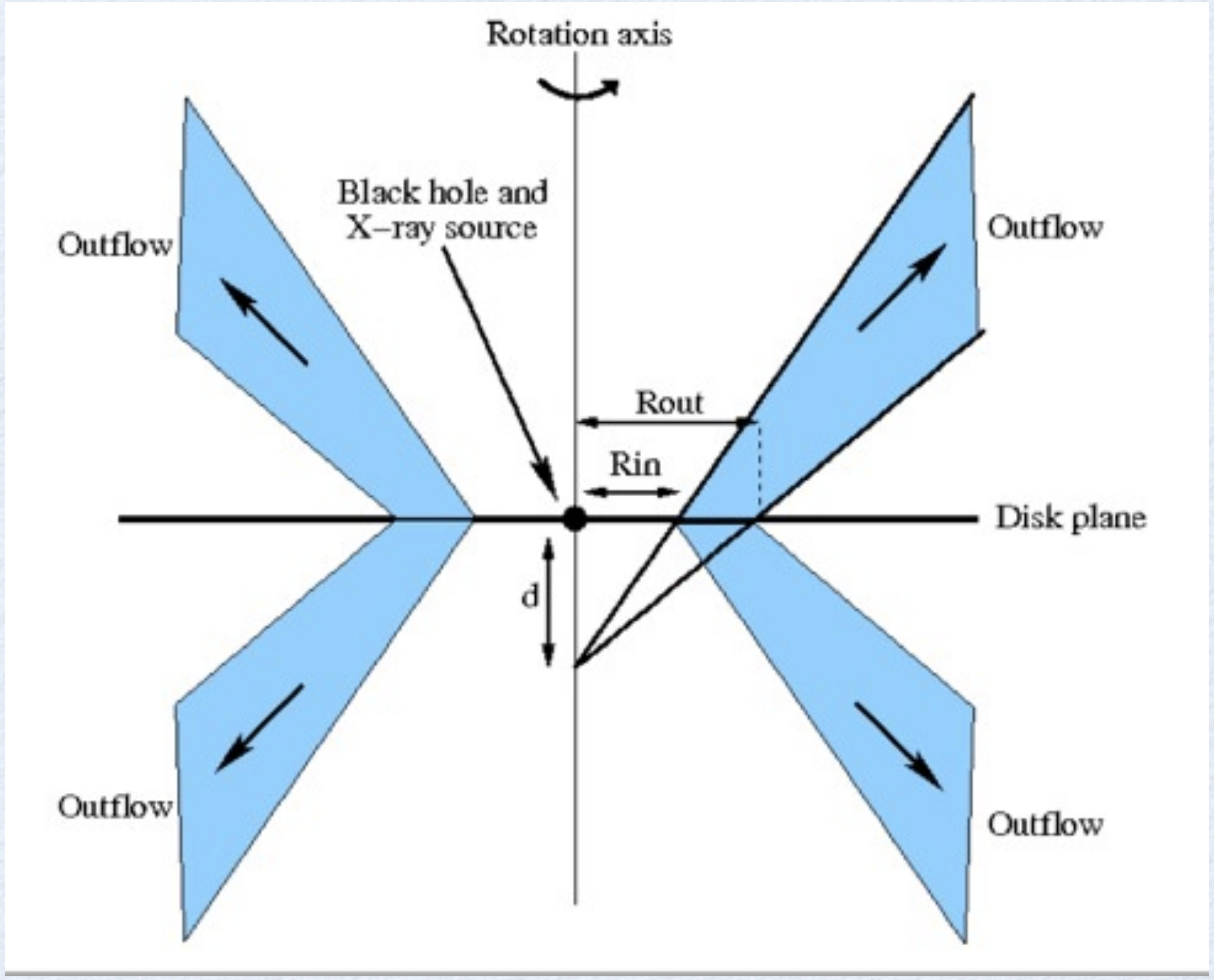
MCRT good fit to ~80% of sample, with different N_H, filling factor flows,1000 clouds within 10-20 cloud radii   Tatum et al 2013, 2014

Other signatures of a Compton-thick Wind



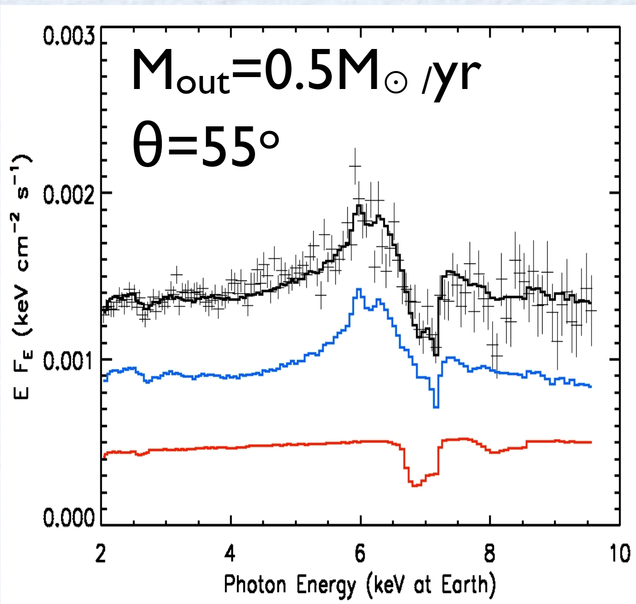
Broadened Fe Kα line from scattering and absorption in high velocity gas - not GR effects

Edge and blue-shifted Fe absorption lines

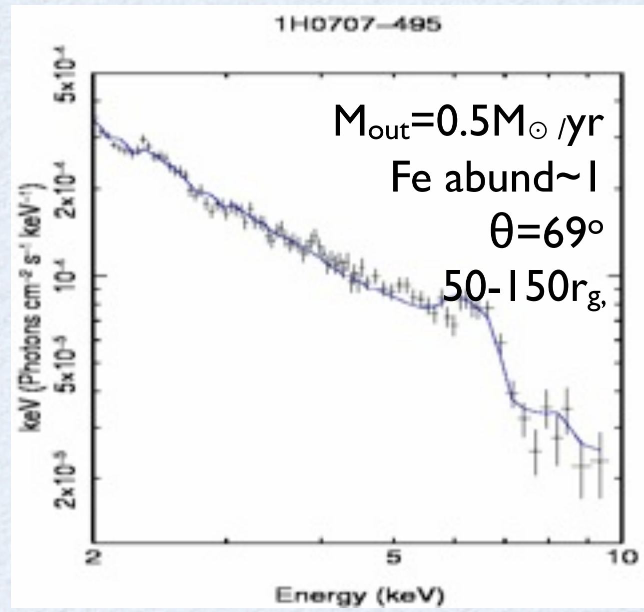


Sim et al. (2008, 2010 a,b, 2012)

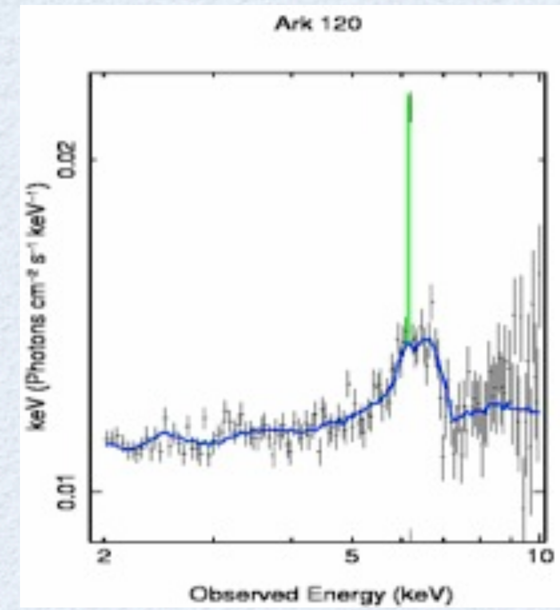
CT wind predicts broad Fe Kα



PG1211+143, Sim et al 2010



1H0707-495



Ark 120, Tatum et al 2012

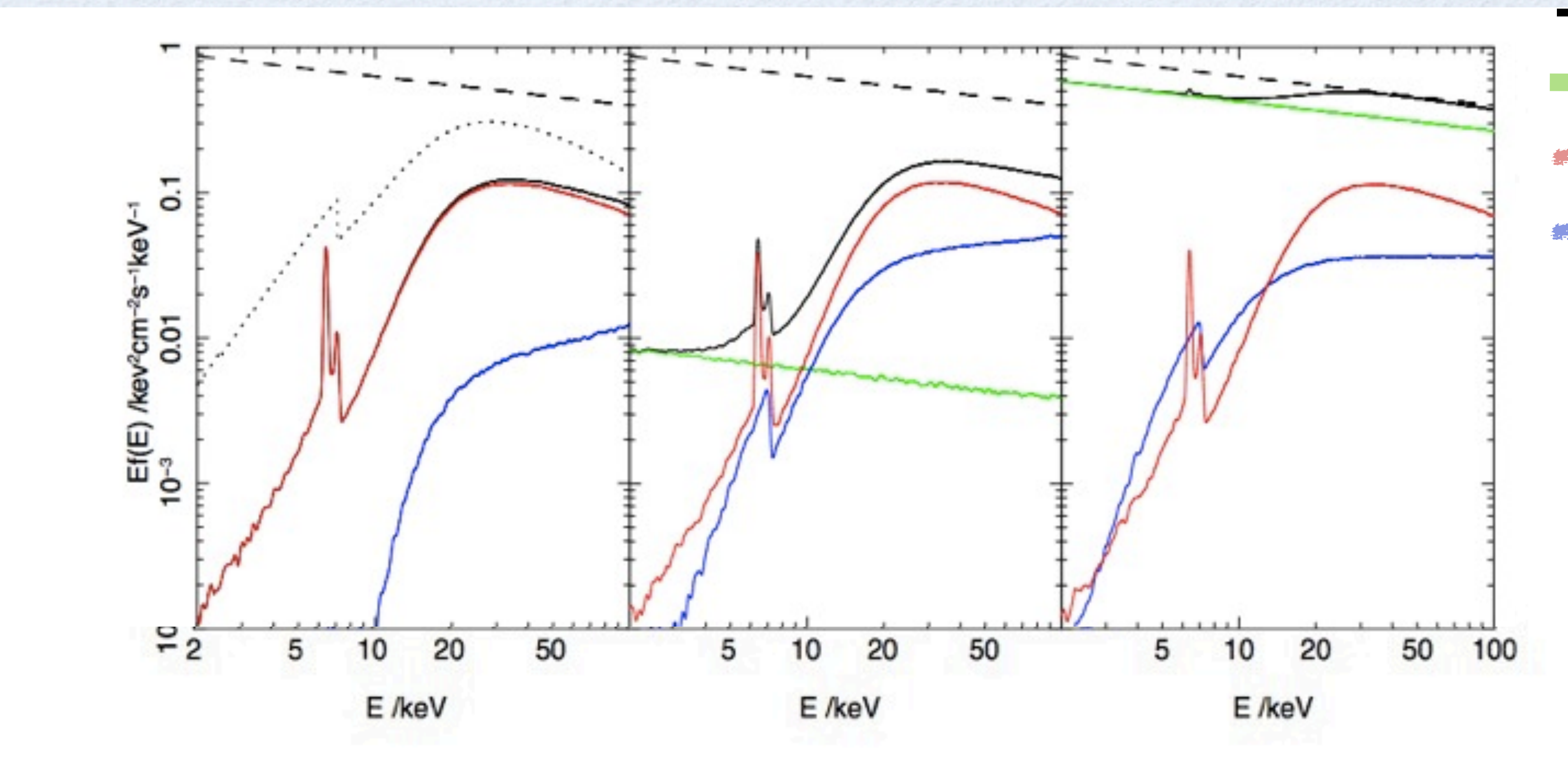
Broad Fe Kα emission produced in CT wind (Sim et al 2008 2010a,b), outflow rates ~ 1$M_\odot$/yr

Radii tens - hundreds of r_g consistent with estimates from reverberation mapping within X-ray band, e.g. NGC 4051 (L. Miller et al 2010)

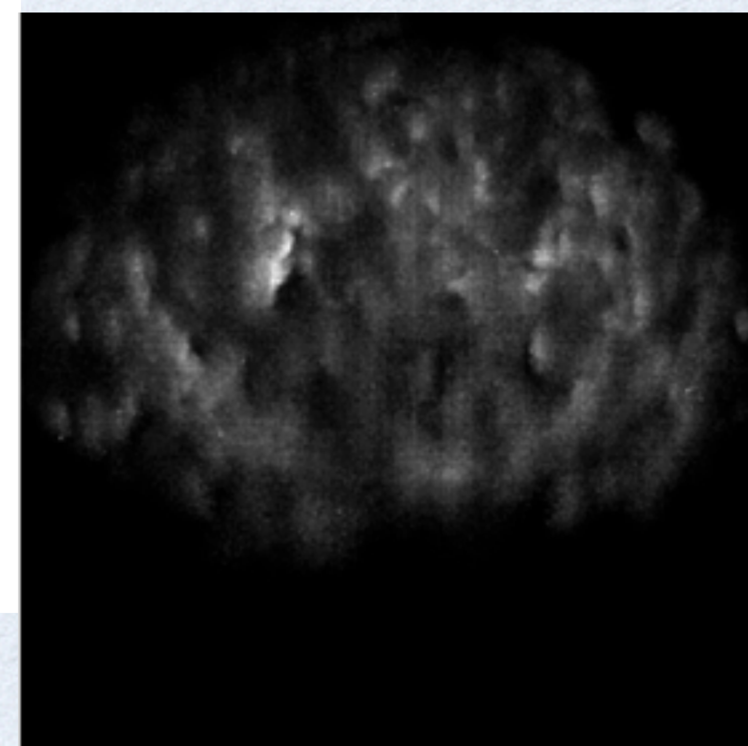
MCRT - spectral variability -single AGN

Miller & Turner 2013 - accumulated spectra over small sets of sight-lines (solid angled equal to that subtended by a cloud at Rmax)

$n_0 = 1.5\times10^{24}$ cm^{-2} mean column density through a single cloud, solar abundance, $\Gamma = 2.2$, shell 10-20 cloud radii, cloud number density $\propto \sin\boldsymbol{\theta}$



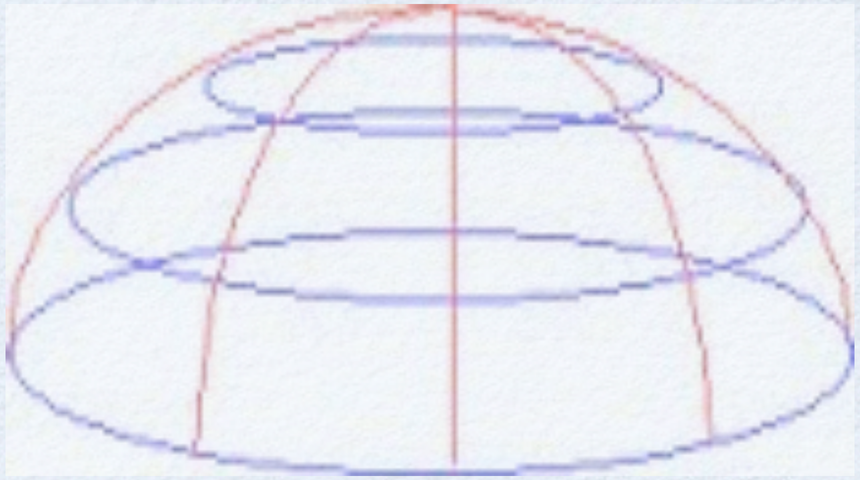
------ incident continuum
unabsorbed continuum
scattered light
transmitted continuum



Spectral variations evident as a function of azimuthal angle, for a single atmosphere

MCRT - Unification of Local AGN

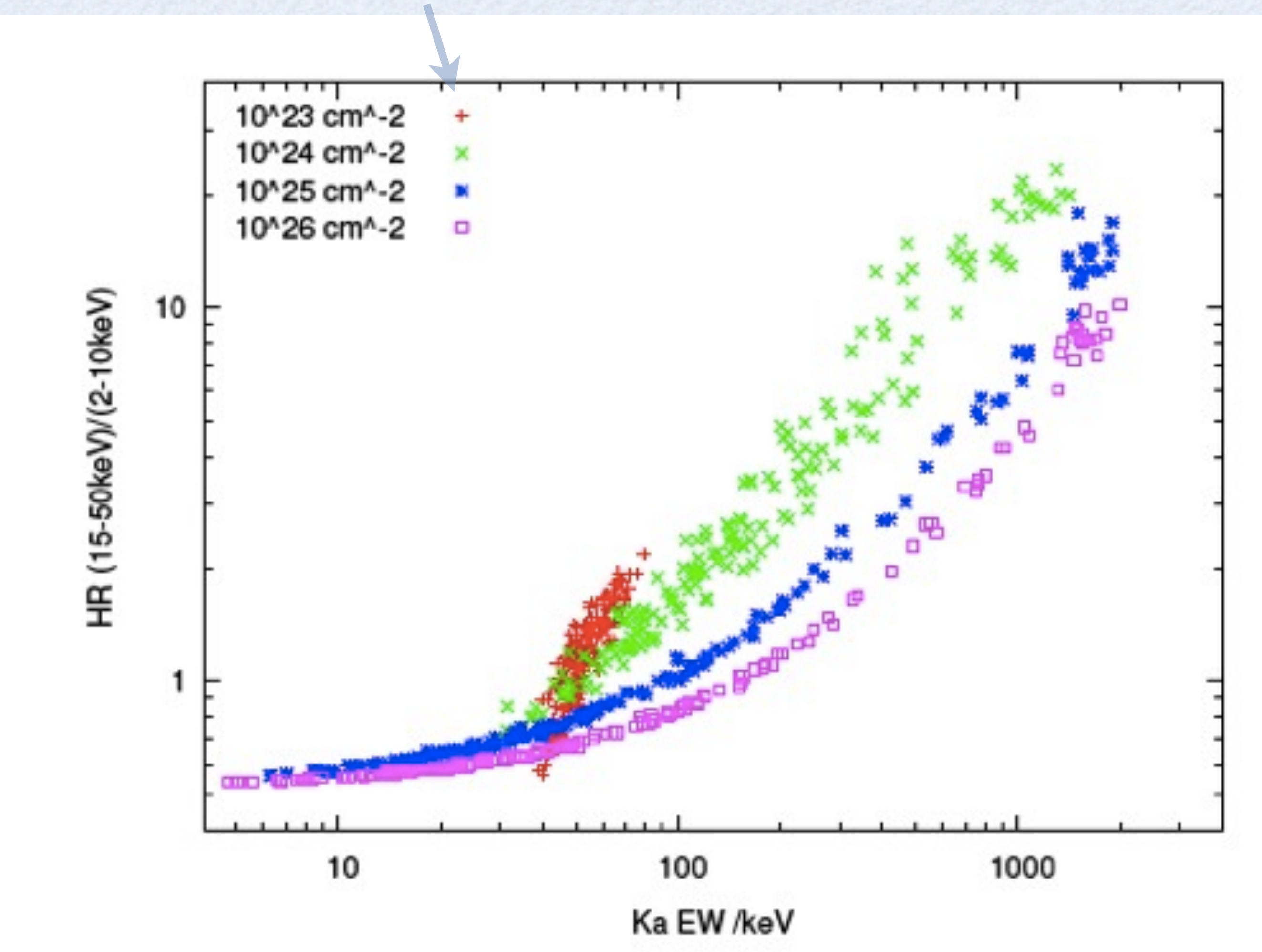
Extend Miller & Turner (2013) sims - test whether a single atmosphere can account for the local AGN population



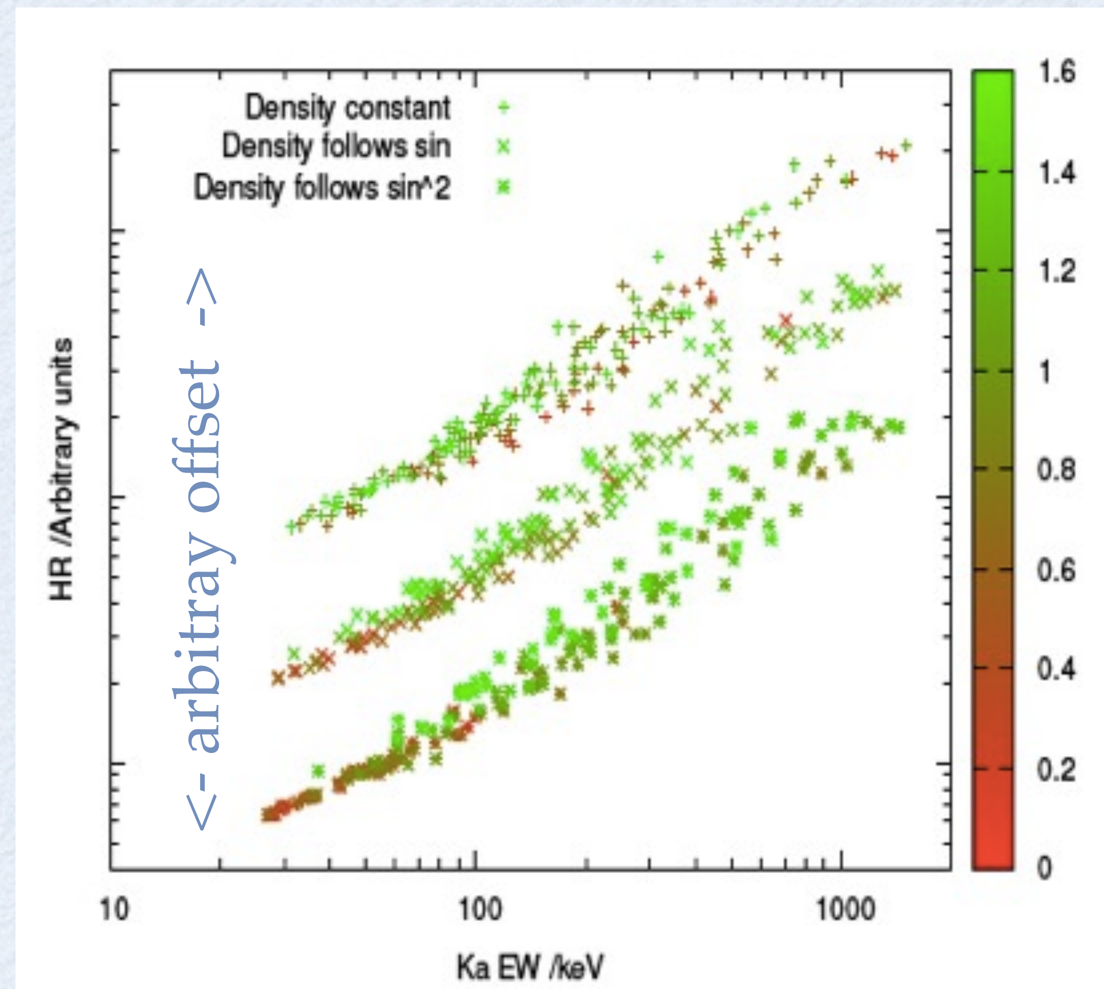
~5^{o}x5^o segments - large enough to give PC in majority of sight-lines - small enough to get variations between sight-lines

Sampling a single atmosphere

mean column density
through a single cloud



Rmax=20, 1000 clouds, small samples
of solid angle, cloud density constant

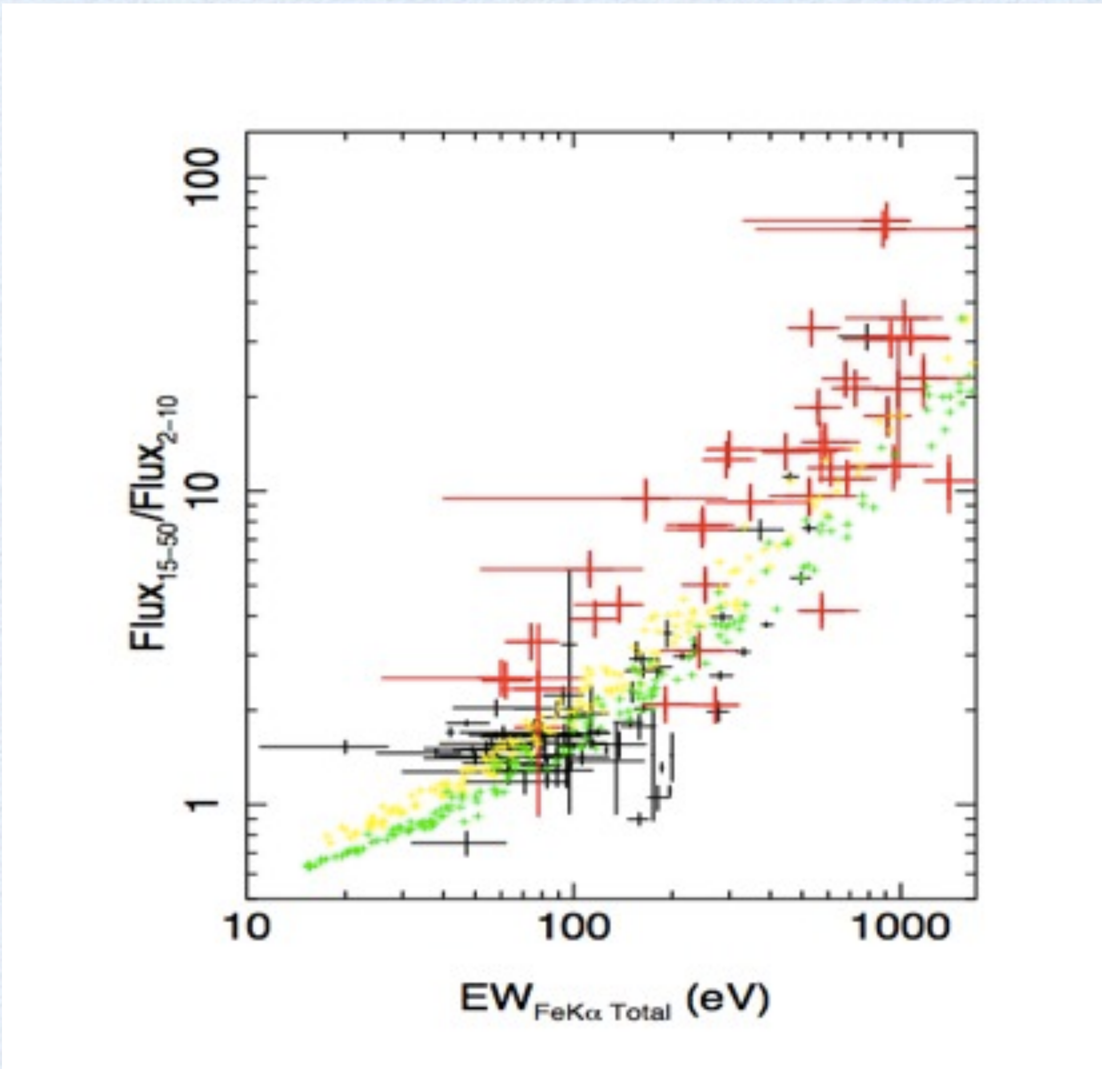


polar angle of sightline, radians

Viewing angle dependences for different
degrees of anisotropy of cloud distribution

Clayton, p.comm

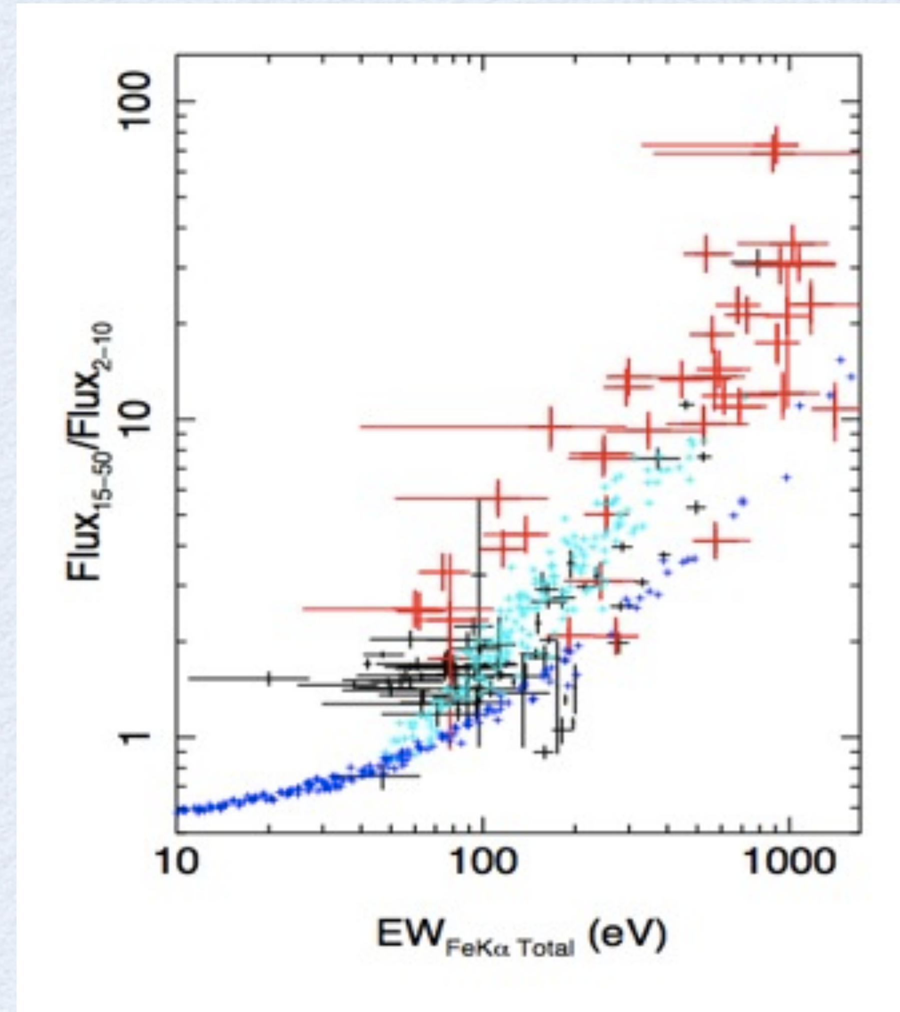
Single atmosphere



$n_0=2x10^{24}$ cm^{-2}
Γ=2.2, 10 - 20 cloud radii

+ cloud density constant

+ $\sin^2\theta$

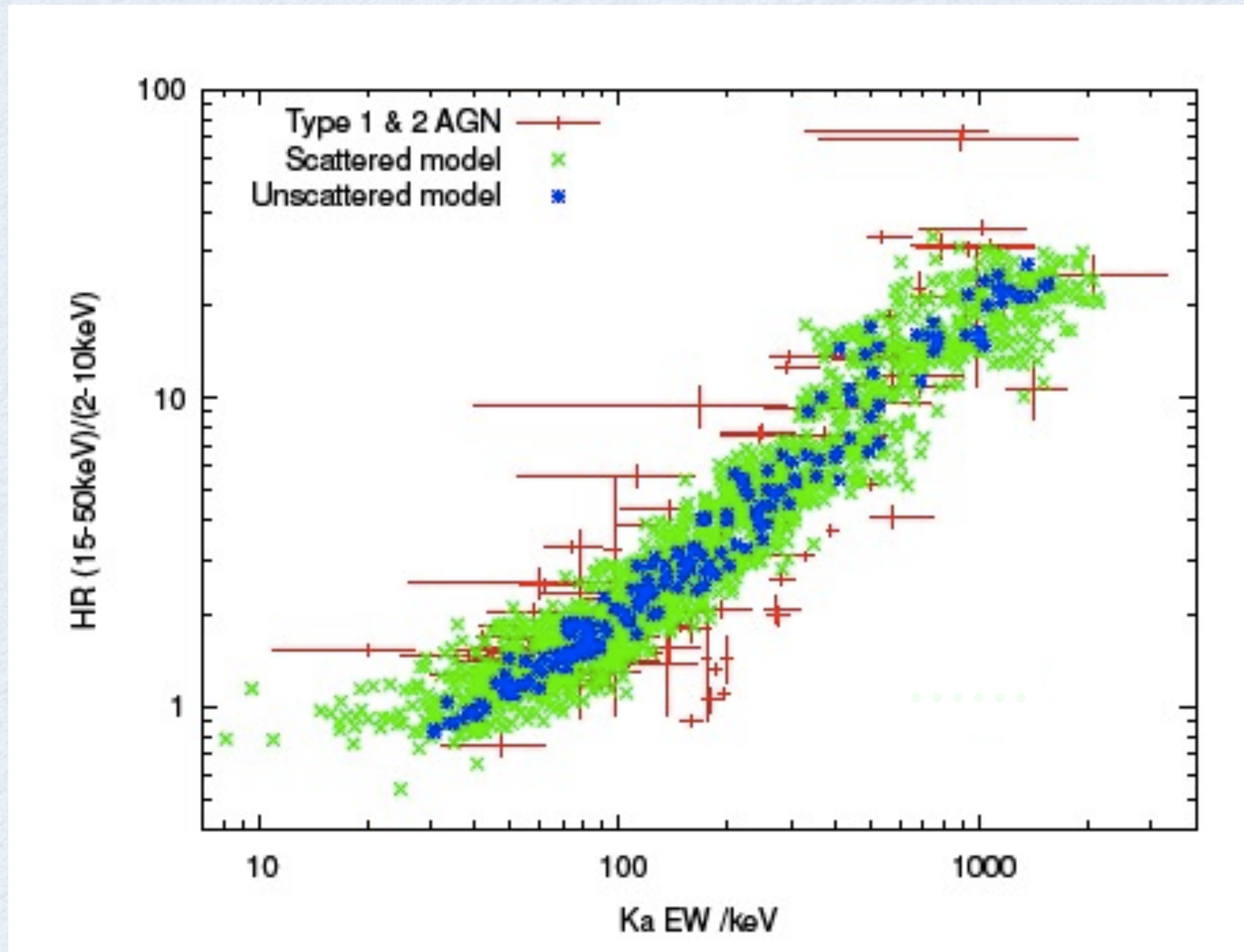


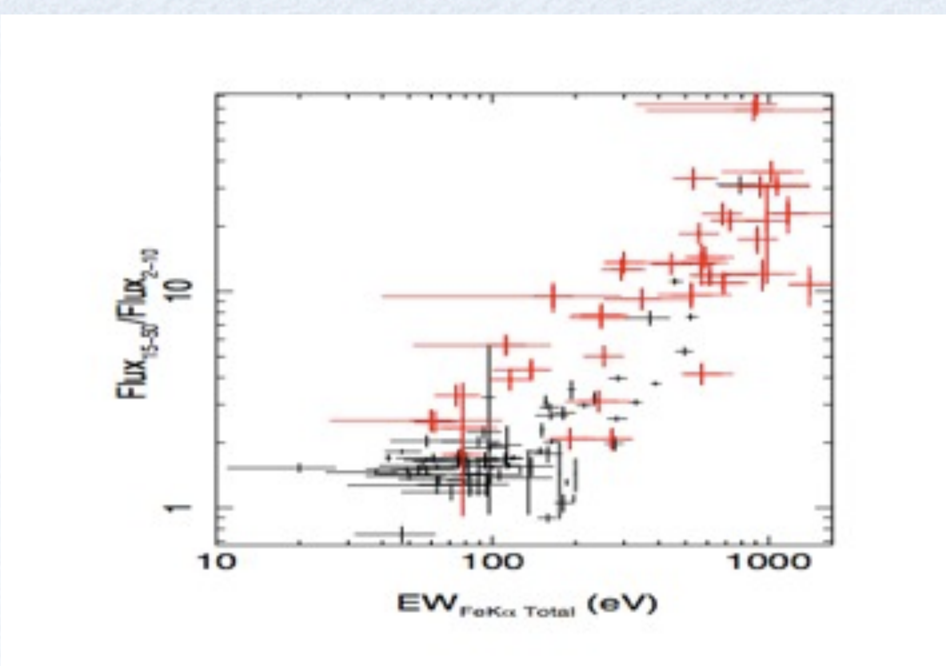
$n_0=5x10^{23}$ cm^{-2}, $1x10^{25}$ cm^{-2}
Γ=2.2, 10 - 20 cloud radii
cloud density constant

Tatum et al 2014

Errors on the model

- $n_0 = 10^{24}$ cm^{-2}
- ...including simulated experimental errors





Clayton, p.comm

Summary

- Not seeing naked disk - X-rays reprocessed by wind with high N_H, global covering
- Smooth transition of reprocessor properties across local population
- Clumpy Compton thick wind explain, to first order, local AGN X-ray spectra and spectral variability with varying views through an anisotropic atmosphere
- Compton-thick absorber not previously recognized as ubiquitous AGN - crucial for understanding, accretion process, the AGN energy budget, feedback and CXB