AGN Observations with Suzaku

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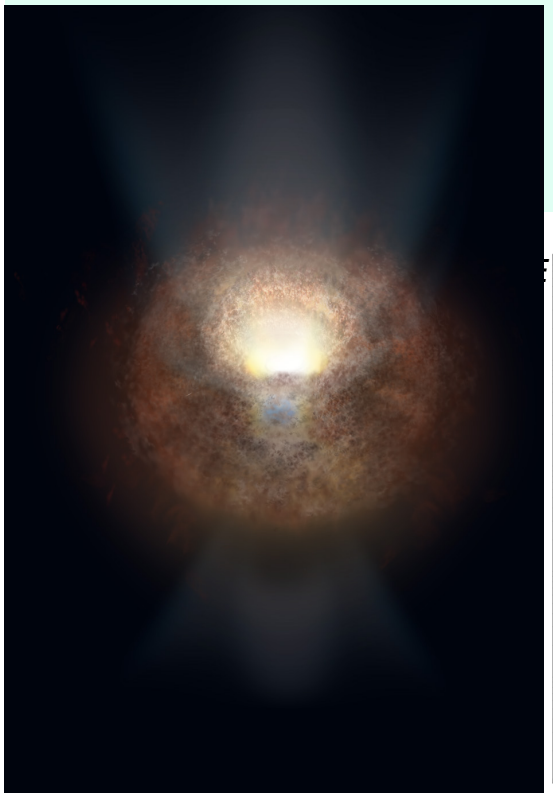
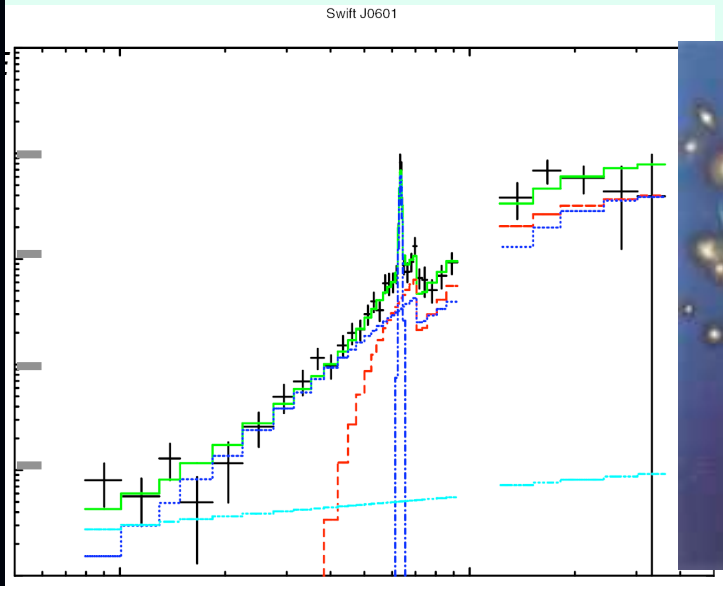


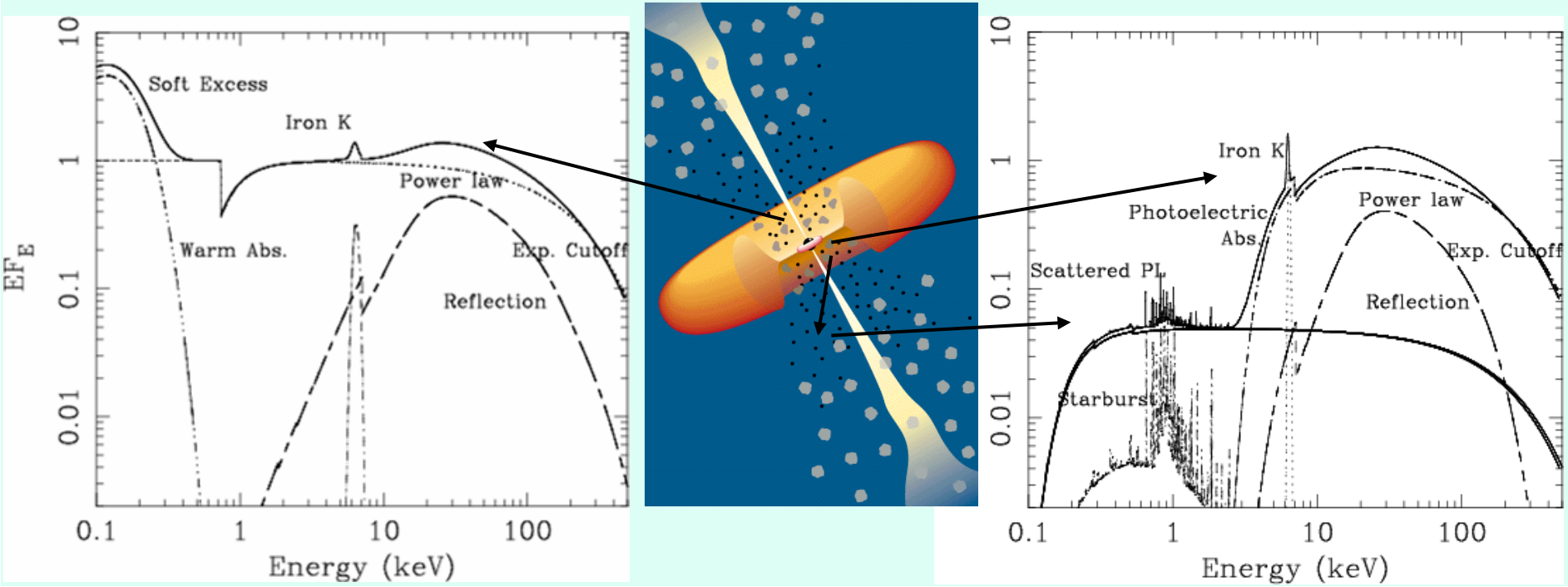


Introduction: Suzaku Observations of AGNs

Broad band coverage

+ High sensitivity at hard X-rays

Decomposing multiple components



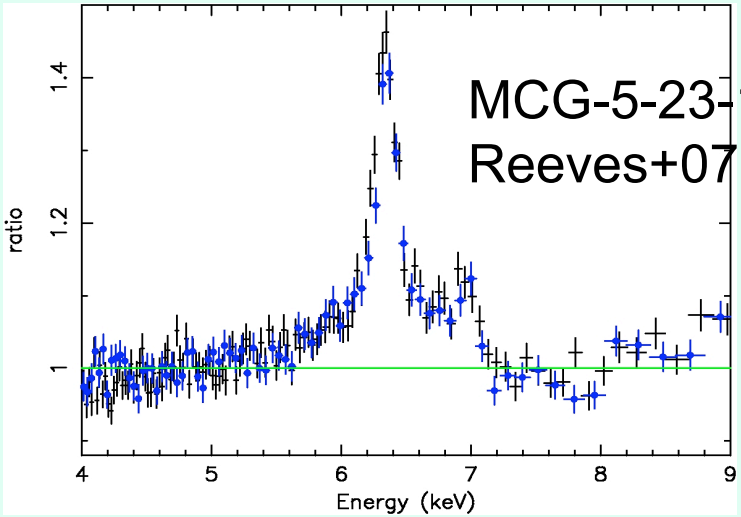
Contents

1. Unobscured AGN
   - Fe-K Line Profile and Variability
2. Obscured AGNs
   - Optically and X-ray selected samples
     - Structure
     - Evolution

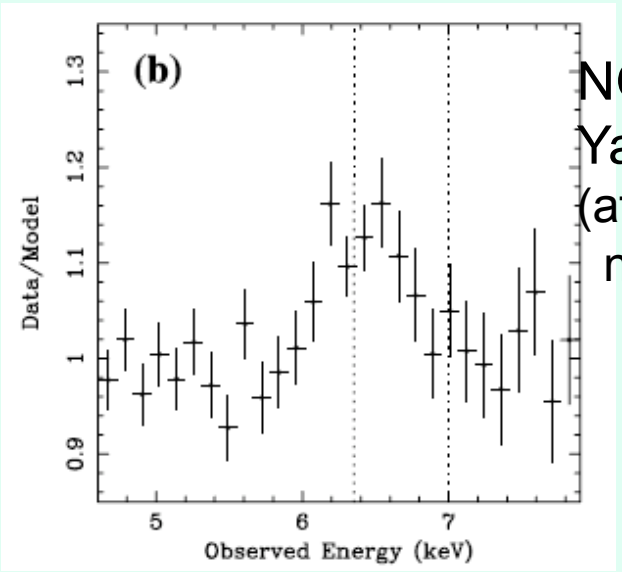
1. Unobscured AGN

Fe-K Line Profile and Variability

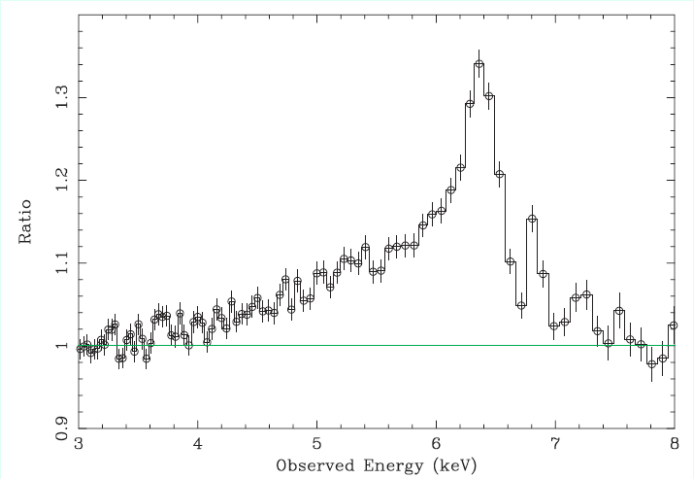
Fe-K Lines



MCG-5-23-16
Reeves+07



NGC 2992
Yaqoob+07
(after subtracting
narrow comp.)



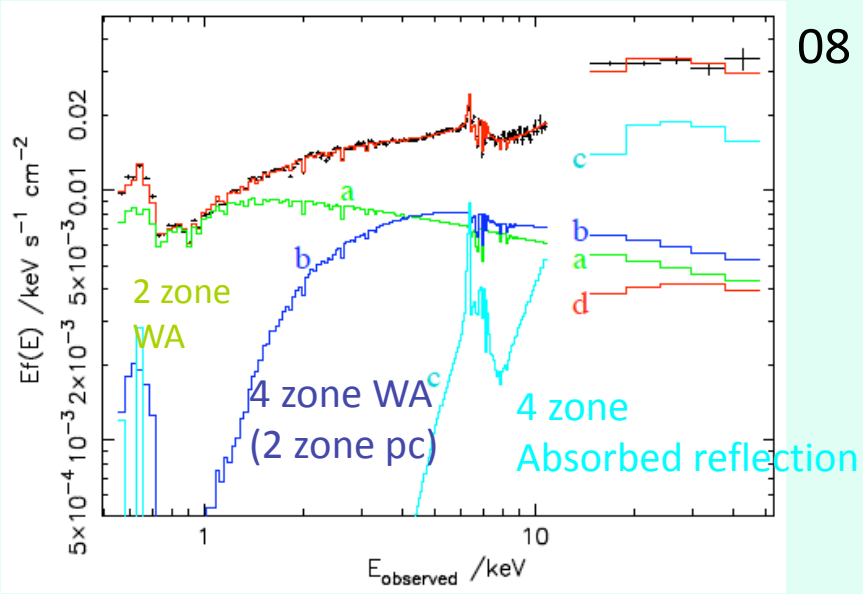
MCG-6-30-15
Miniutti+07

MCG-6-30-15:
WA + broad line modeling

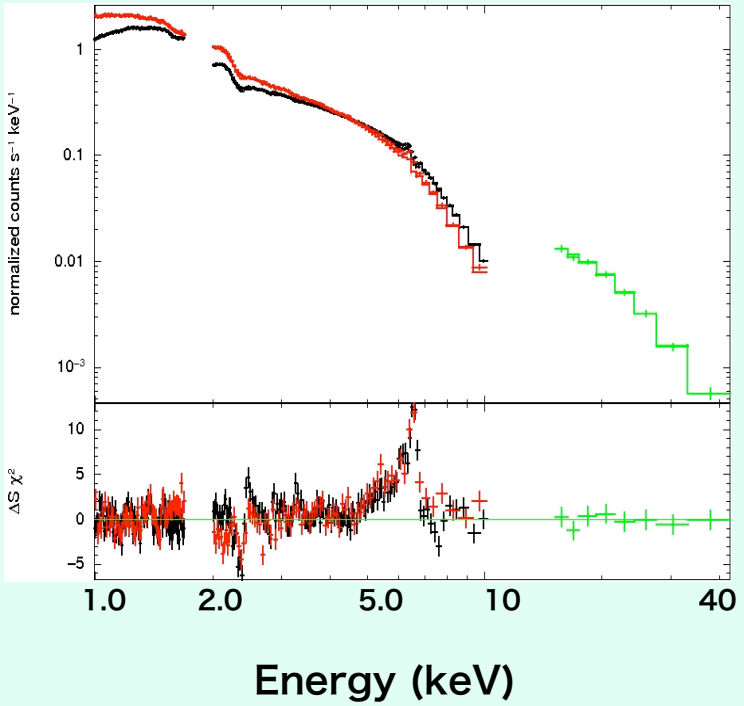
WAs + continuum modeling affects Fe line parameters

5WAs (2/5 partially covered)
relativistic broadening not required

L. Miller+ 08



4WAs
+ diskline (Rin=3Rs)
+ smeared reflection



See also Reynolds+09, L. Miller+09

Support for Broad Line

(1) Broad line in ``clean'' spectrum

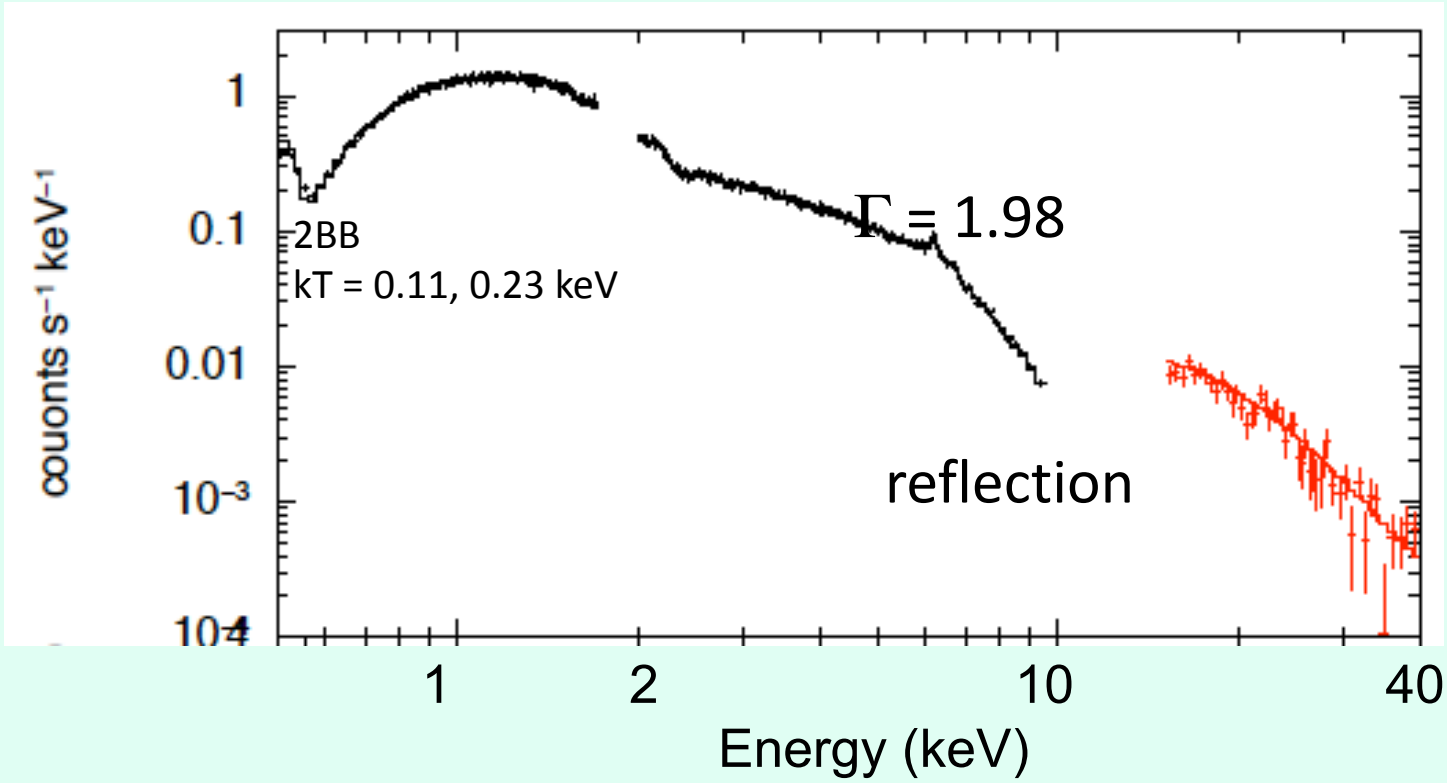
(2) Short term variability of Fe line

Ark 120: Bright Seyfert 1
No Warm Absorber

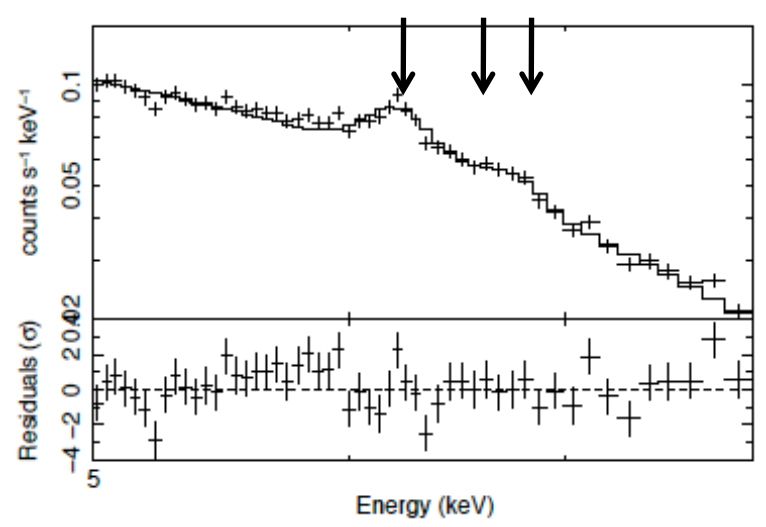
No strong WA features above 0.7 keV

-> clean continuum

Suzaku 100 ks



Ark 120 Fe line profile



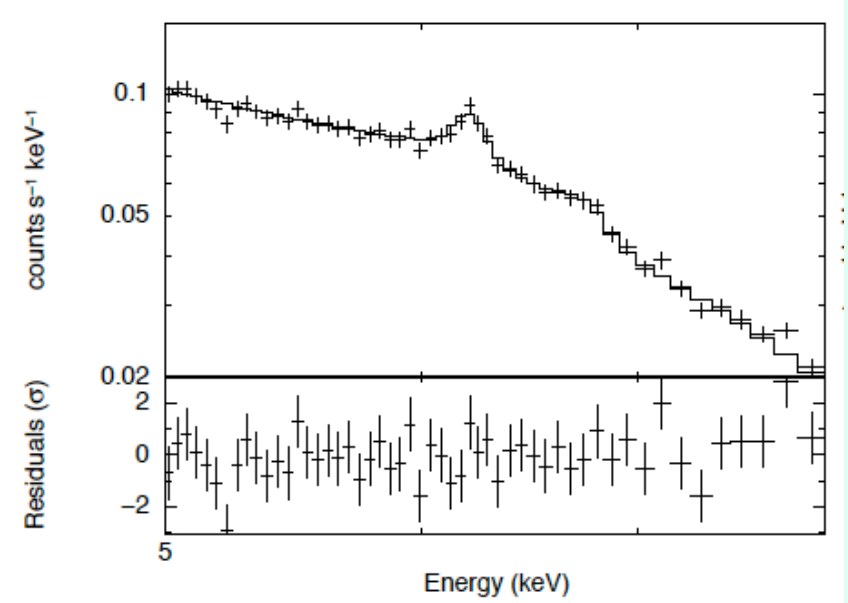
3 Gaussians

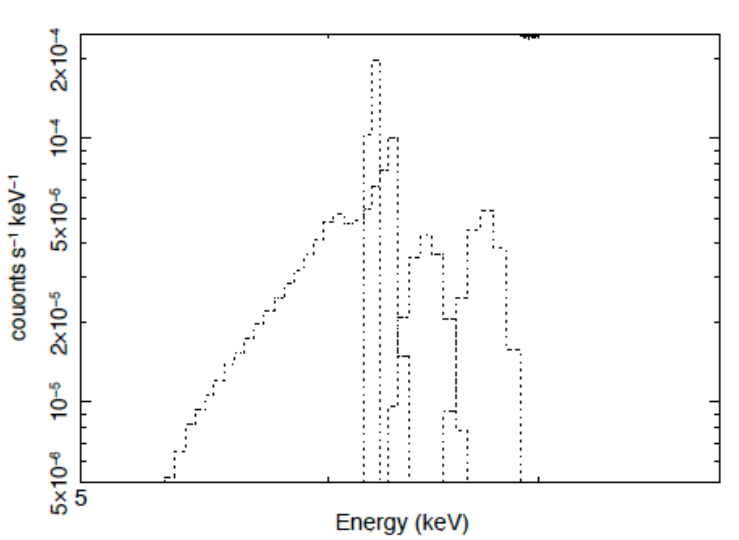
-> systematic residuals at < 6keV

Diskline + 3 Gaussians

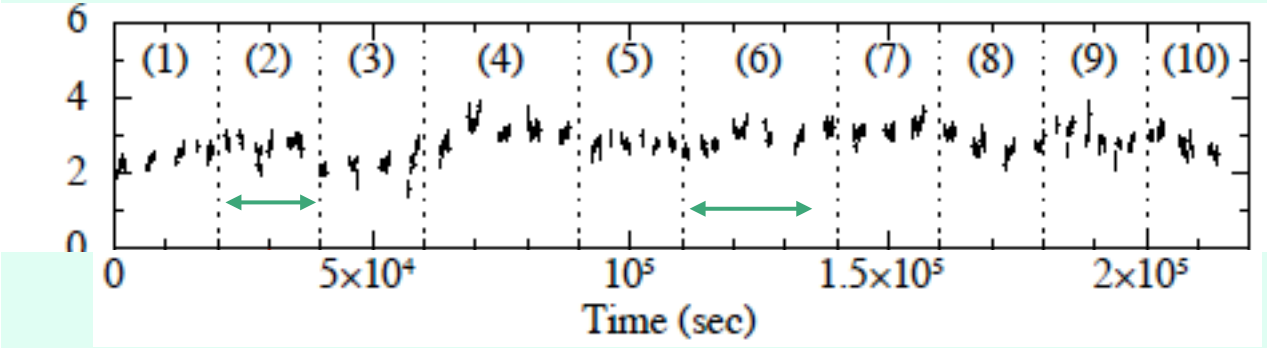
PL + smeared reflection

Rin = 19rg, rout = 310rg, i=20°, EW=100 eV



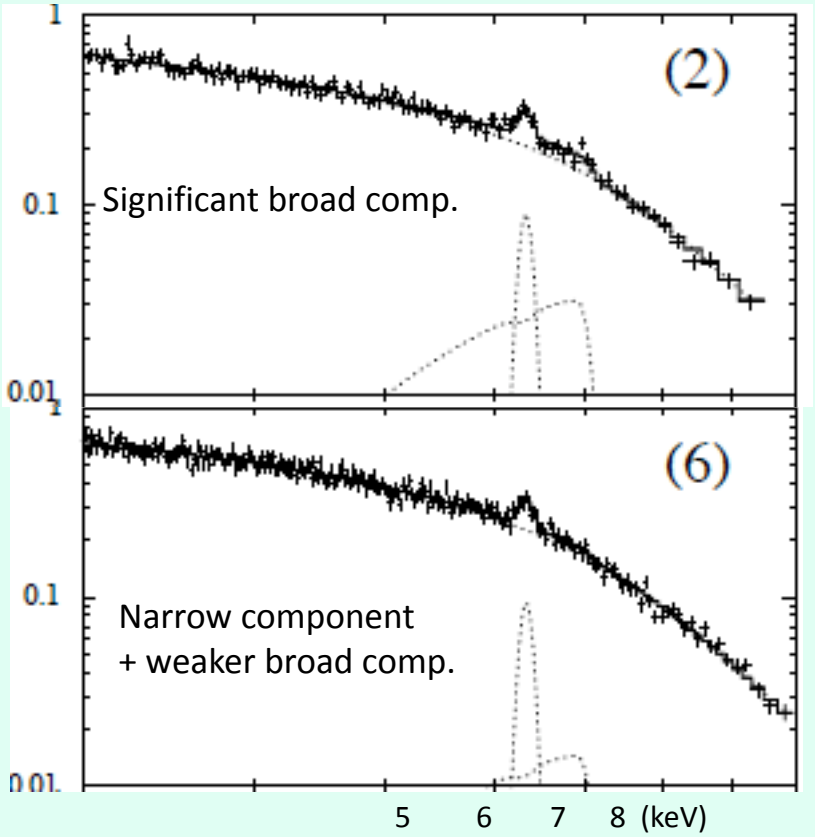


Fe Line: Short term variability

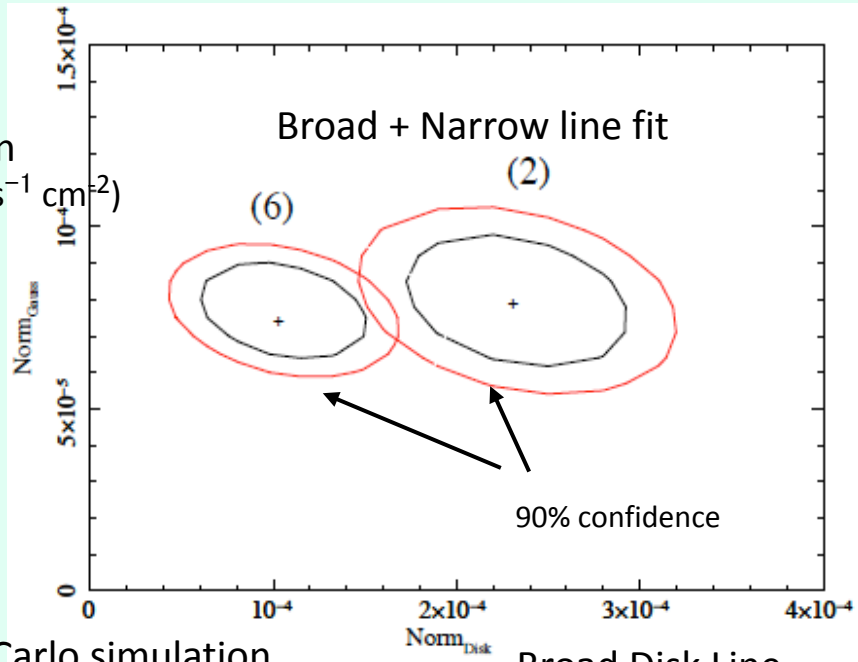


MCG-5-23-16
H. Inoue, Ph.D. thesis

Variable on time scales of
20-30 ksec



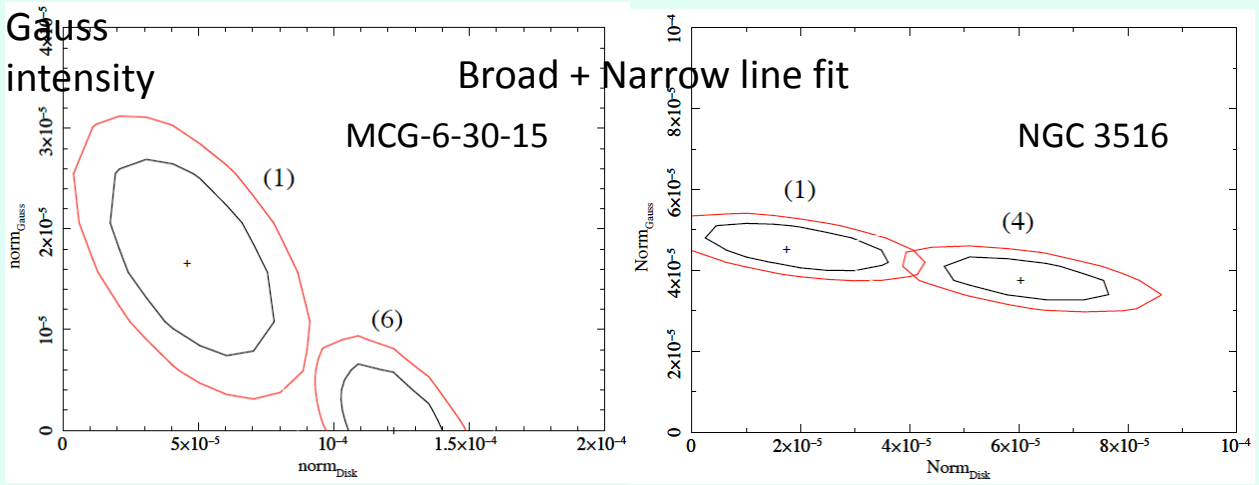
Narrow Gaussian
(photon s^{-1} cm^{-2})



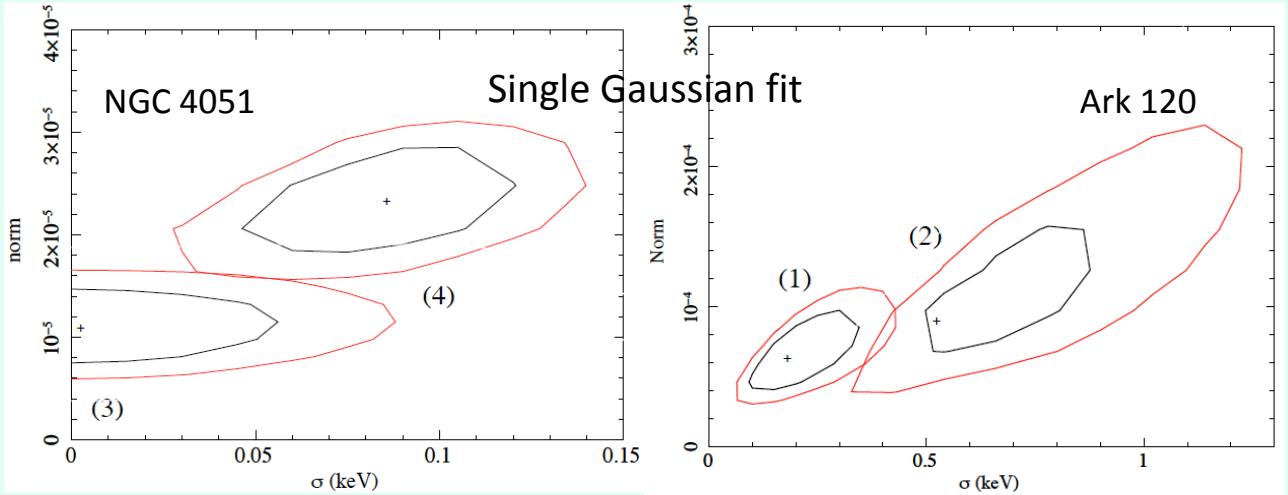
Monte-Carlo simulation
-- significant at > 99.9% conf.

Broad Disk Line
(photon s^{-1} cm^{-2})

Fe Line: Short term variability



Disk line intensity



Gaussian sigma (keV)

Fe line variable on timescales of <30 ksec

R<100Rs for $M_{BH}=3x10^7 Msolar$

At least part of the line comes from inner part of acc. disk

XMM results talk by Ponti

2. Obscured AGN

Broadband Spectra

Structure

Evolution

The Sample

(1) [OIII]λ5007 selected sample

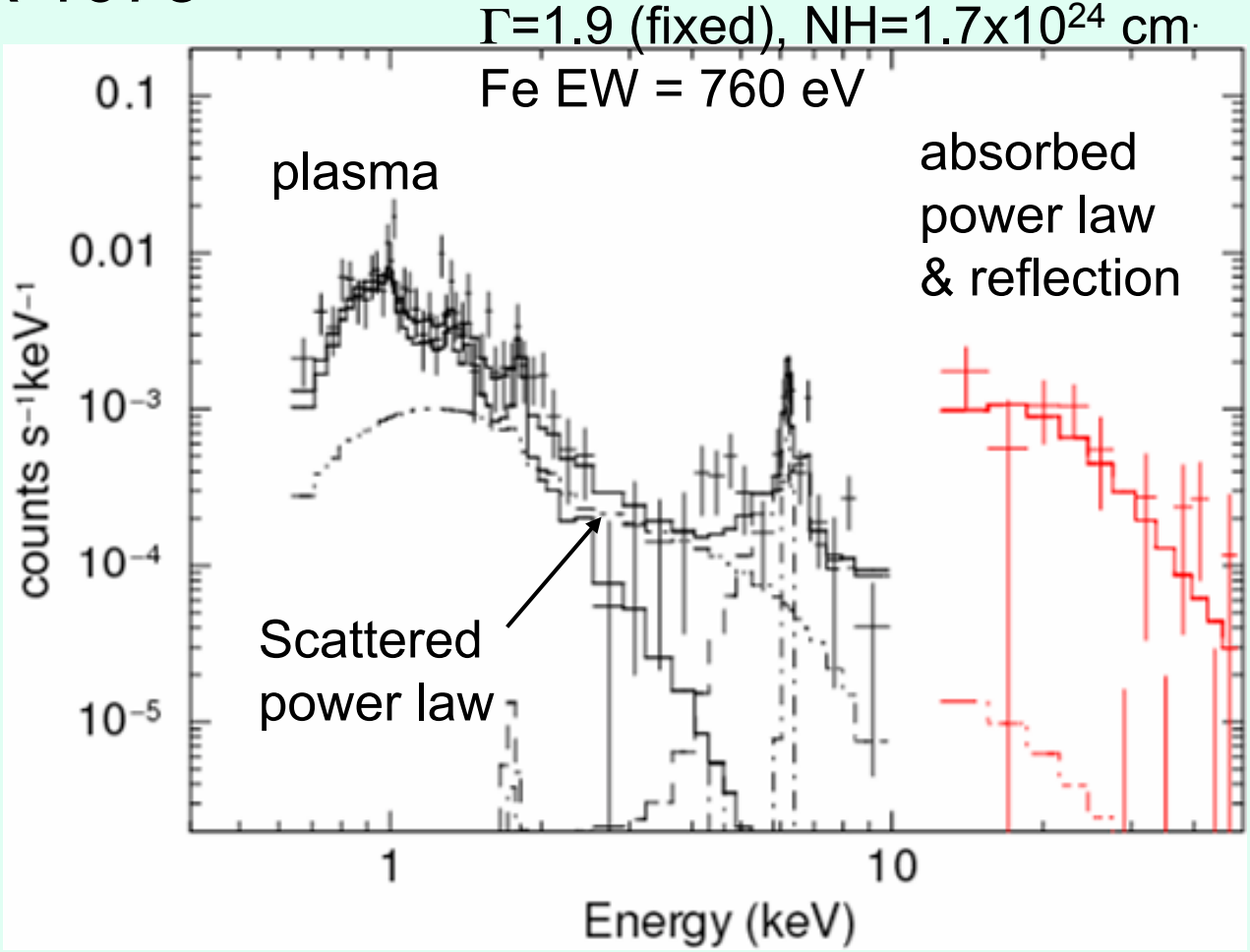
- Indicator of ``intrinsic'' luminosity
  (Caveats discussed later)
- Risaliti+99 (Seyfert 1.8-2, BT<13.4; Revised Shapley Ames catalog)
- 12 objects (Large N_H, ambiguous previous measurement)
  Complete to [OIII] ranking #36, if combined with past obs.

(2) Hard X-ray selected AGNs

- Swift BAT AGNs (Markwardt+05, Tueller+08)
  → Talk by R. Mushotzky, L. Winter
- XMM serendipitous source catalogue + XMM archives

[OIII]λ5007 Selected Obscured AGNs

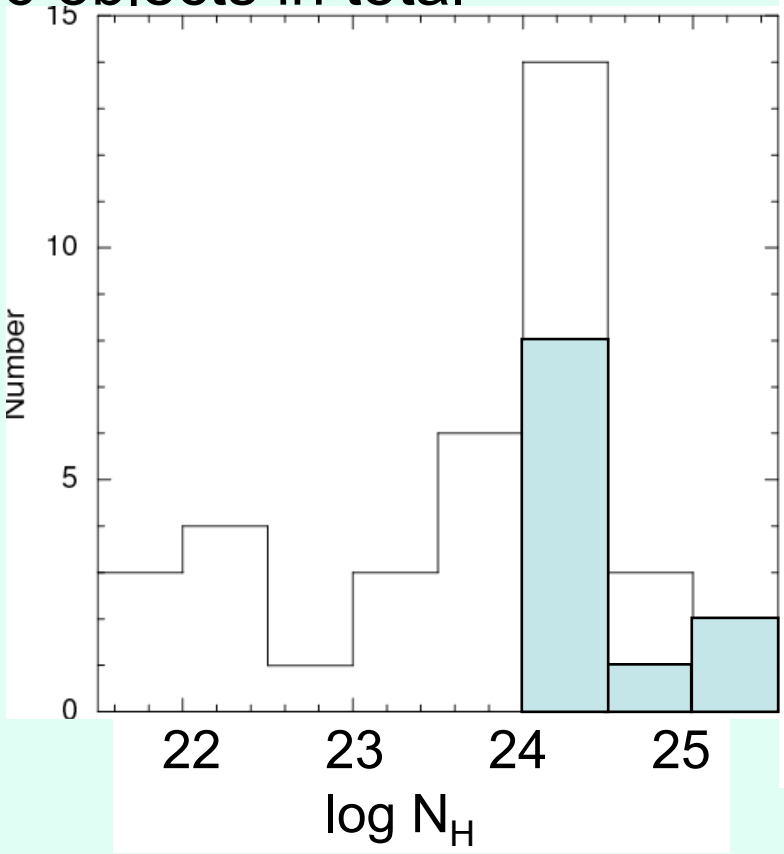
Mrk 1073



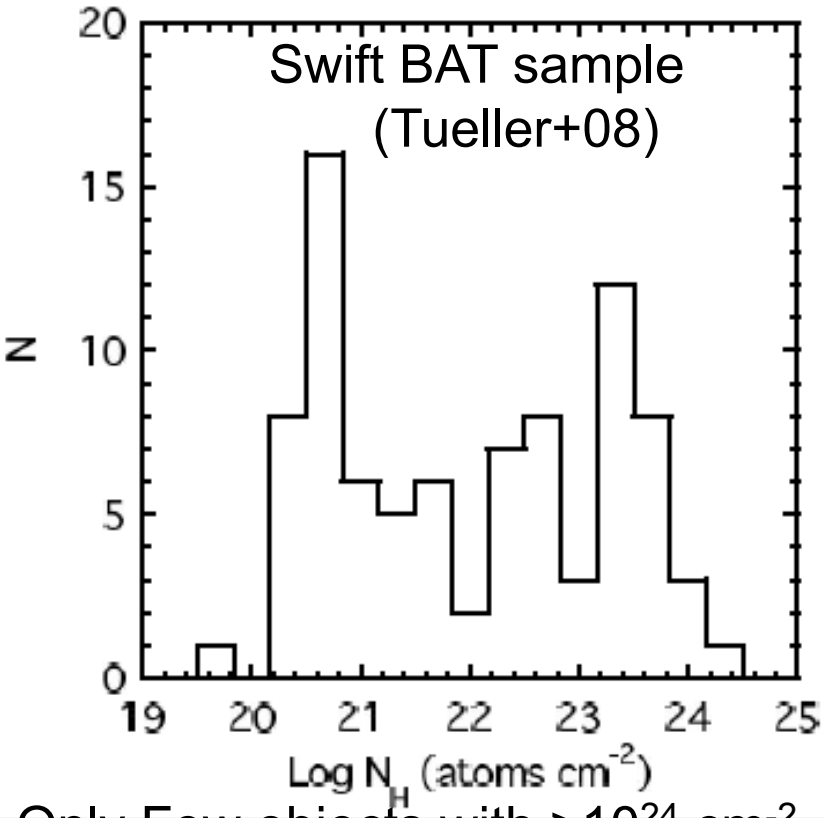
N_H Distribution

12 Suzaku observations + literature

36 objects in total



Shaded: Lower limit

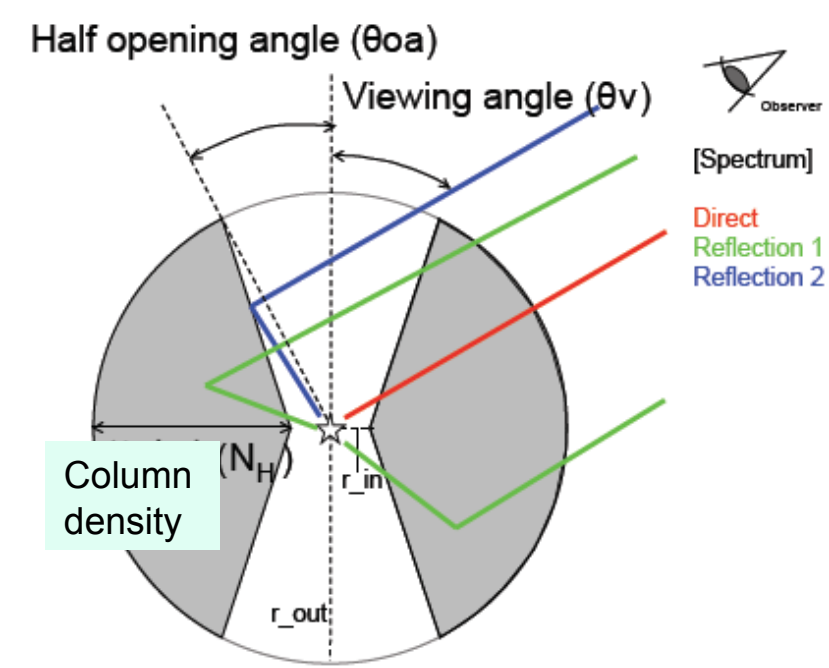


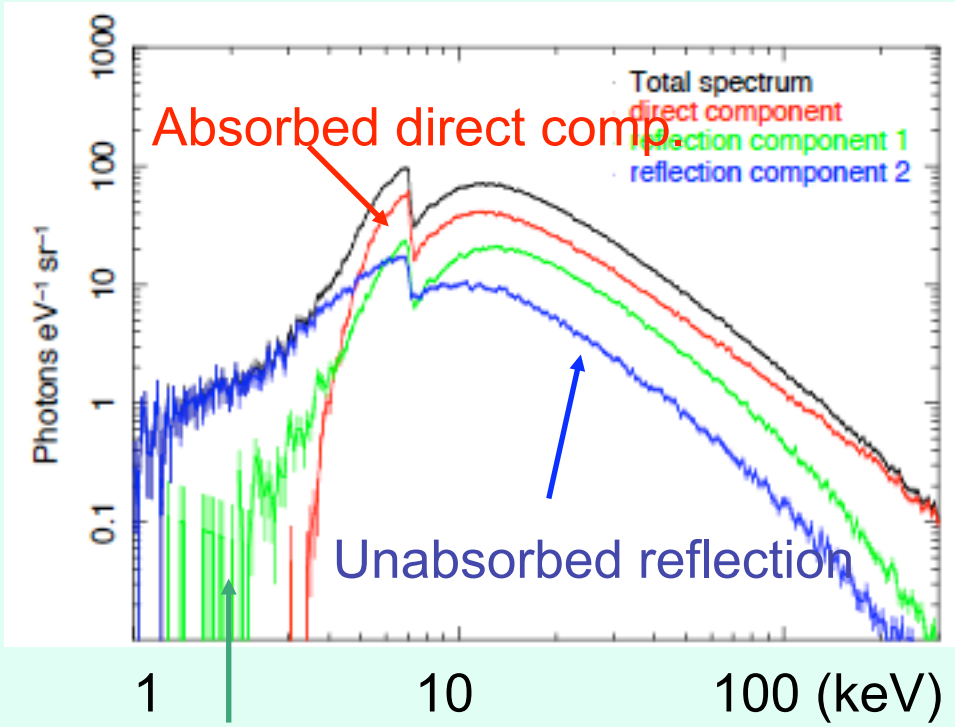
Only Few objects with $>10^{24}$ cm^{-2}

Hard X-ray selection biased against $>10^{24}$ cm^{-2}

Structure of Obscuring Matter: Monte-Carlo Simulation

Ikeda+09, ApJ



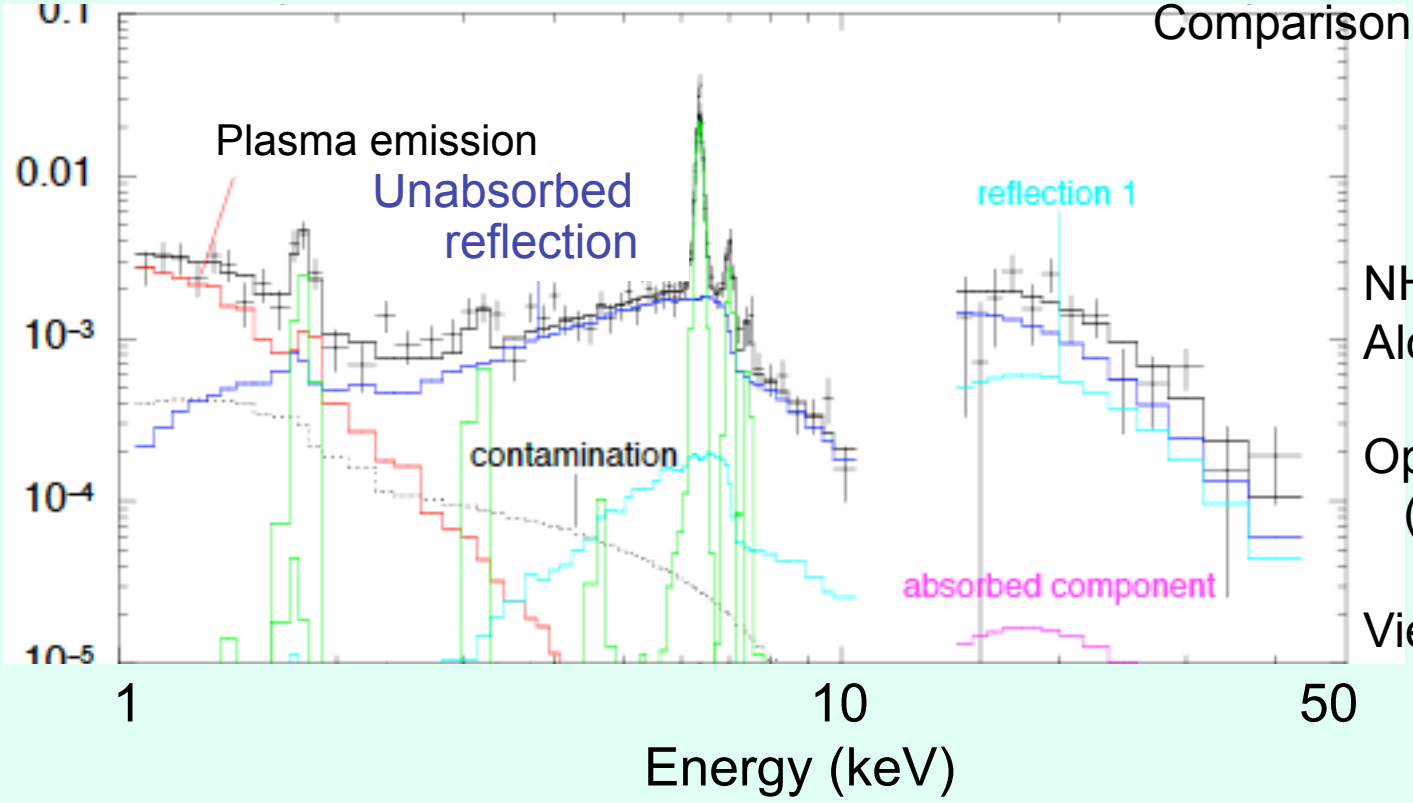


These three components depend on viewing angle, opening angle

→ Geometry can be constrained from spectral shape

Obscuring Matter in NGC 2273

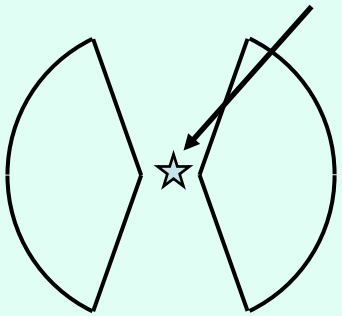
Awaki+09, PASJ
Comparison with Monte-Carlo



NH = 5.4×10^{24} cm^{-2}
Along equatorial plane

Opening angle~40 deg
(unconstrained)

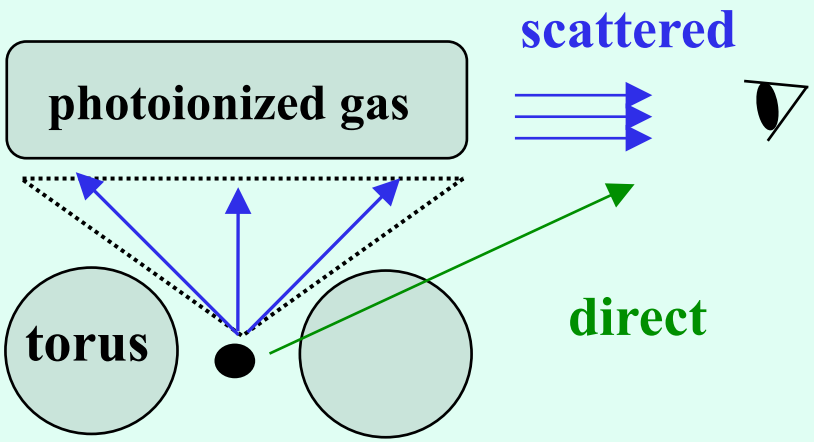
View angle
- Opening angle
~3 deg



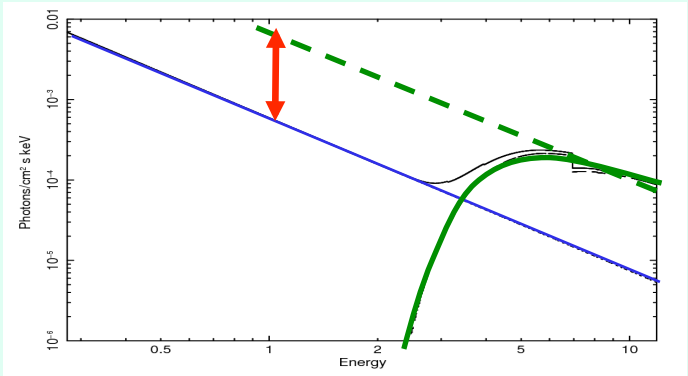
Unabsorbed reflection from the other side of the inner wall visible

Soft Component

- Soft comp: photoionized gas or thermal gas in hosts (starforming activity)
  - Chandra/XMM grating observations
    - photoionized (or photon statistics limited) (e.g., Guainazzi+07)
- Scattered comp…. indicator of ``torus'' geometry



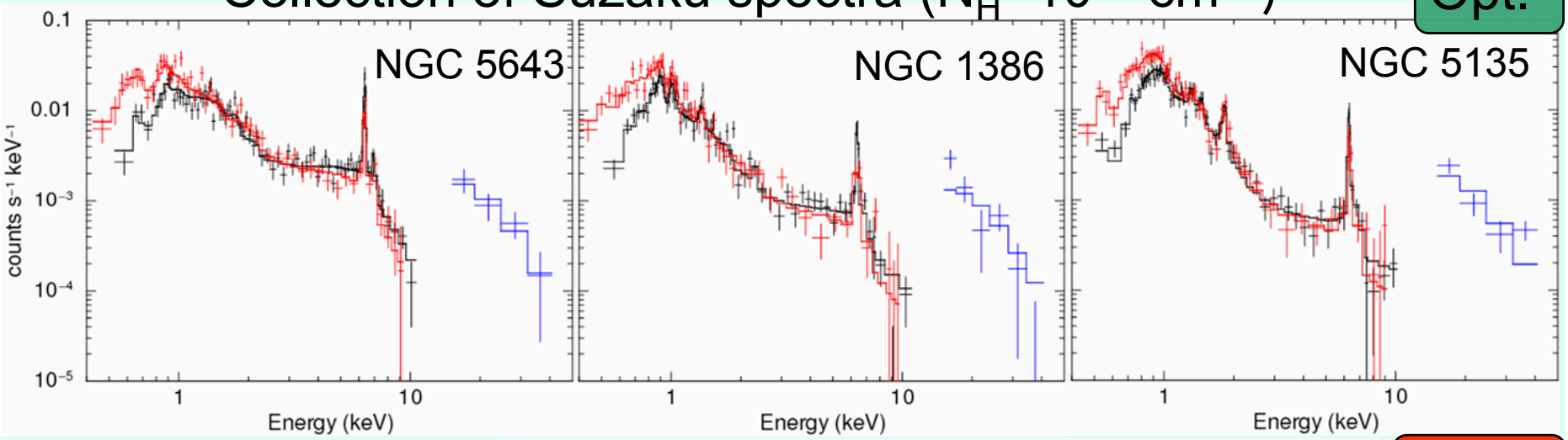
f_{scat} = scattered / direct
= $\tau\ \Delta\Omega / 4\pi$



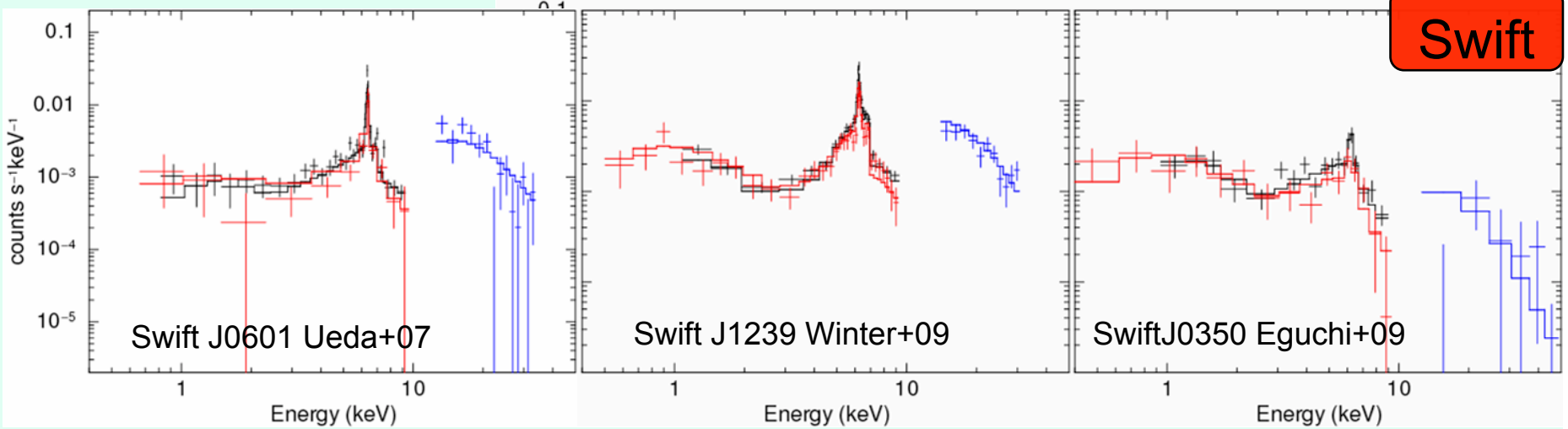
Soft Component: opt. vs Swift sample

Collection of Suzaku spectra (N_H~10^{24} cm^{-2})

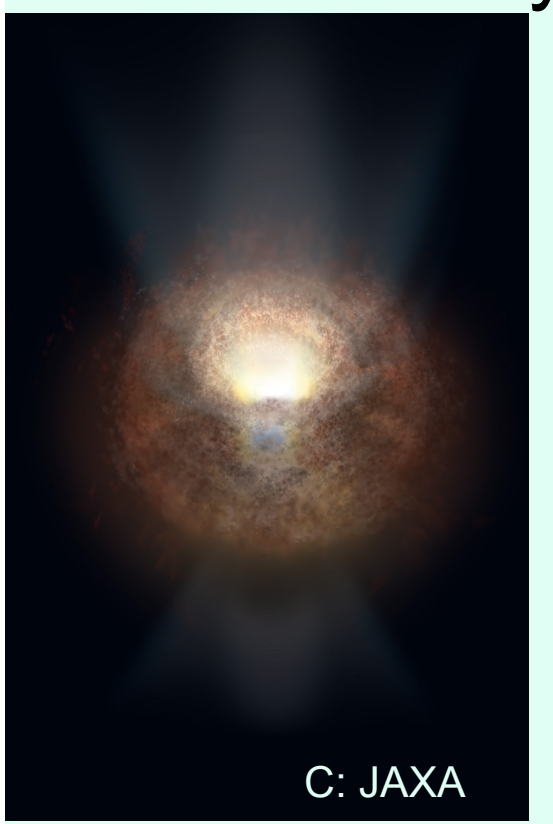
Opt.



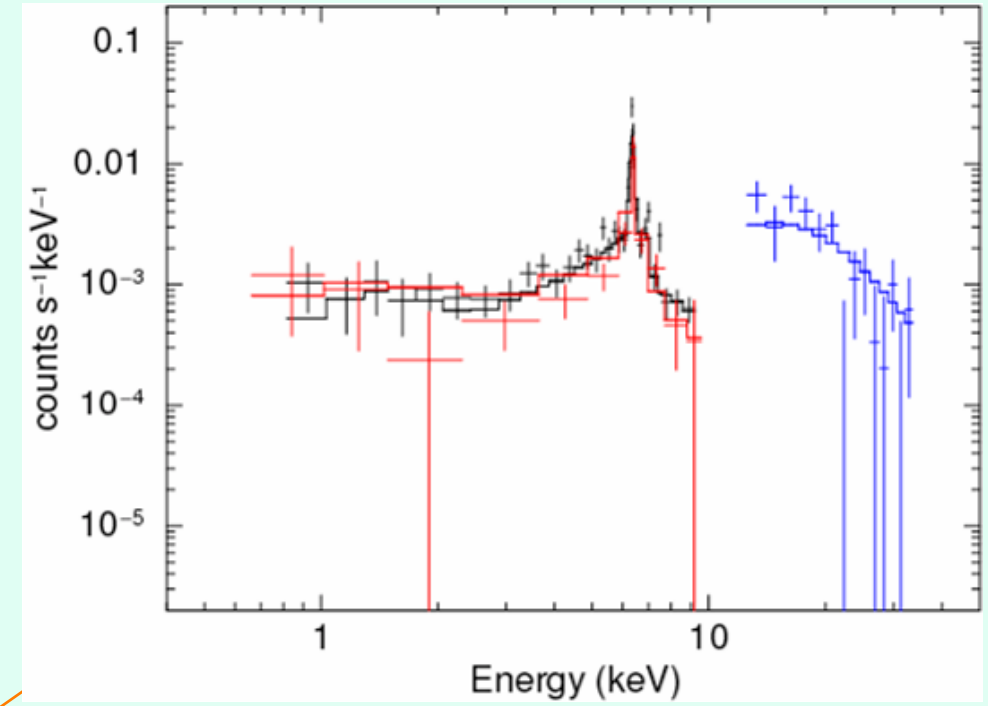
Swift



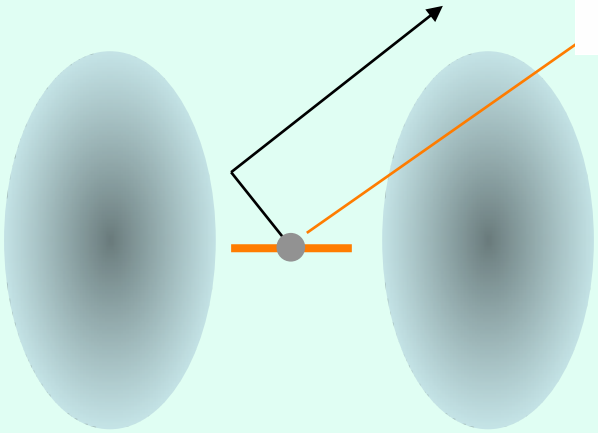
X-ray Selected Obscured AGNs



Swift J0601 Ueda+07



Swift



Very weak scattering compont

``New Type'':

Obscured by geometrically thick torus

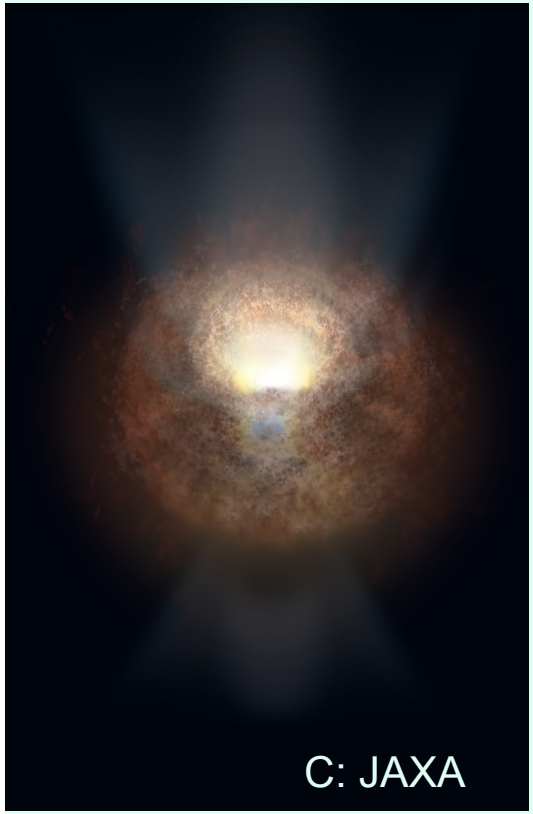
Extremely large NH if viewd from edge-on

Many buried AGN predicted

X-ray Selected Obscured AGNs

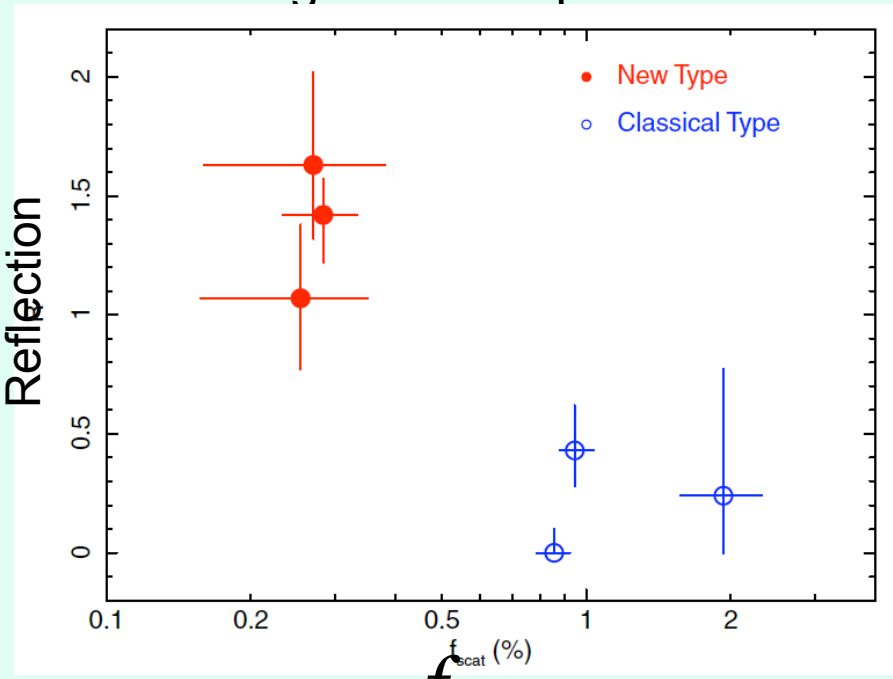
Swift

New Type



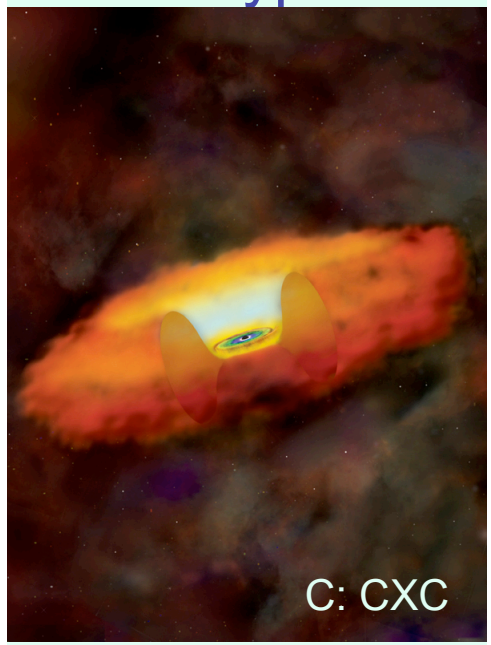
Suzaku observations of six Swift BAT AGNs

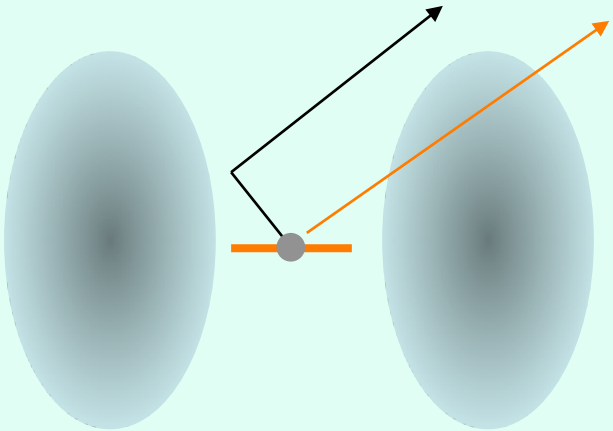
Eguchi+09 ApJ

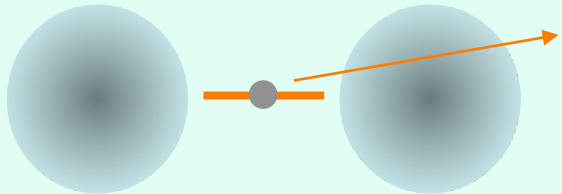


f_{scat}

Old Type







New Sample of Obscured AGNs: XMM sample

Noguchi, YT+, ApJ, submitted
Poster Noguchi

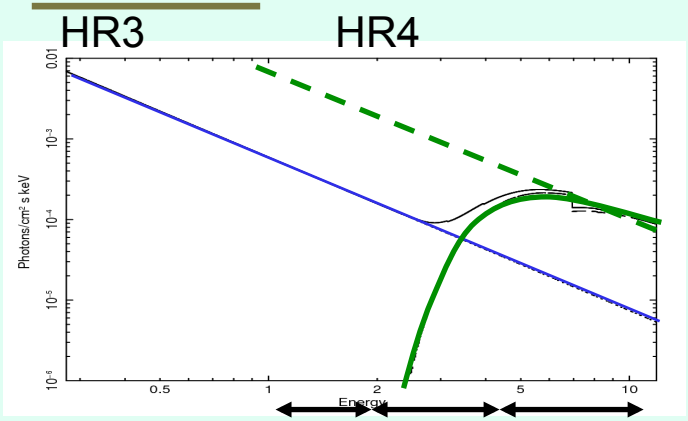
2nd XMM Serendipitous Source Catalogue

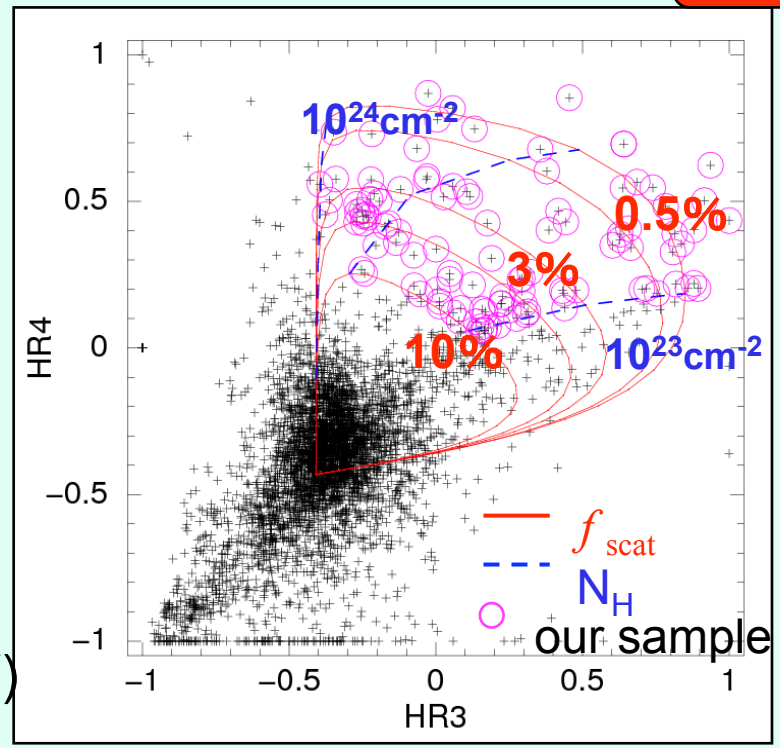
XMM

246897 sources

Hardness selection

1-2, 2-4.5, 4.5-12 keV





38 bright objects selected

log N_H 23-24, f_{scat} <10%

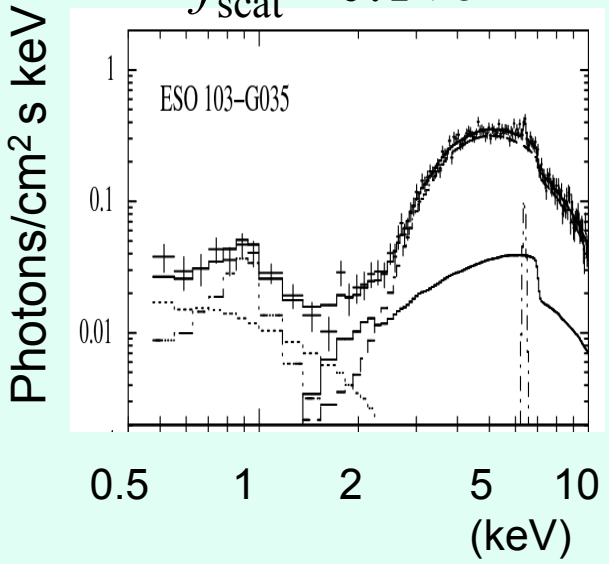
XMM (+ some Suzaku) spectra analyzed

Examples

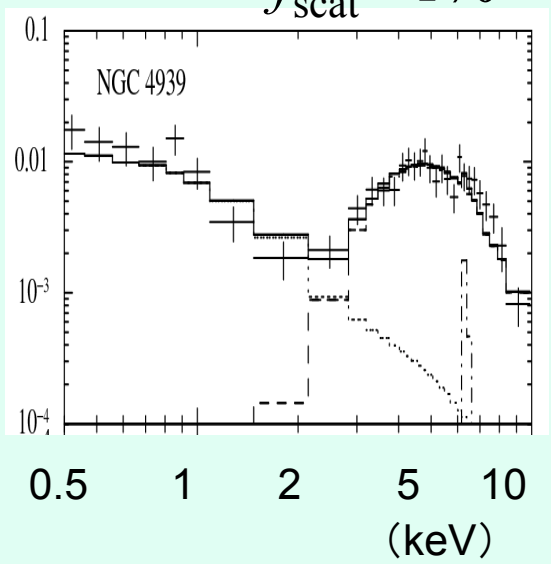
XMM

f_{scat}= F(0.5-2) / F(2-10) (absorption corrected)

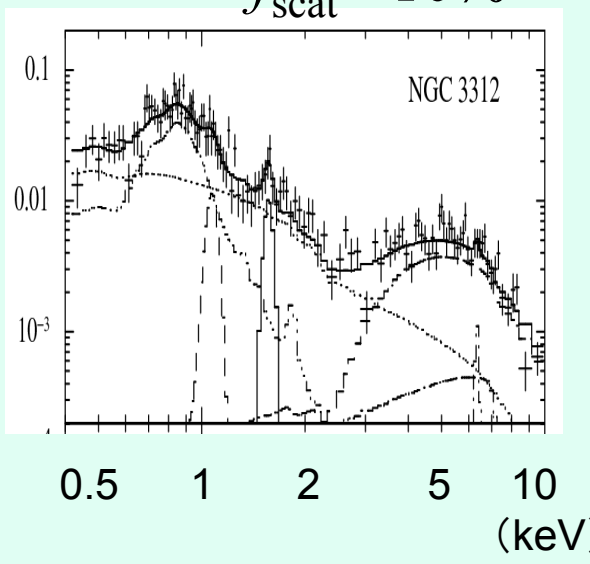
f_{scat}= 0.1%

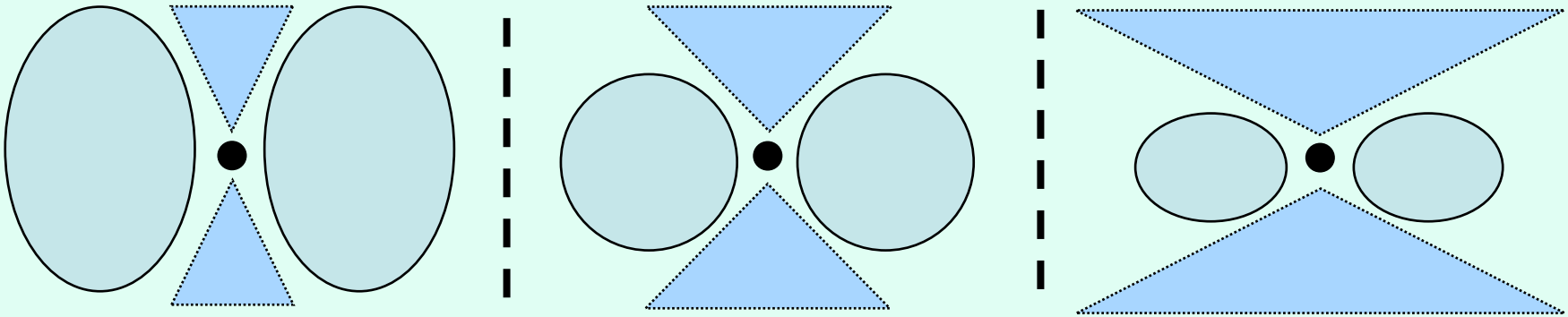


f_{scat}= 1%

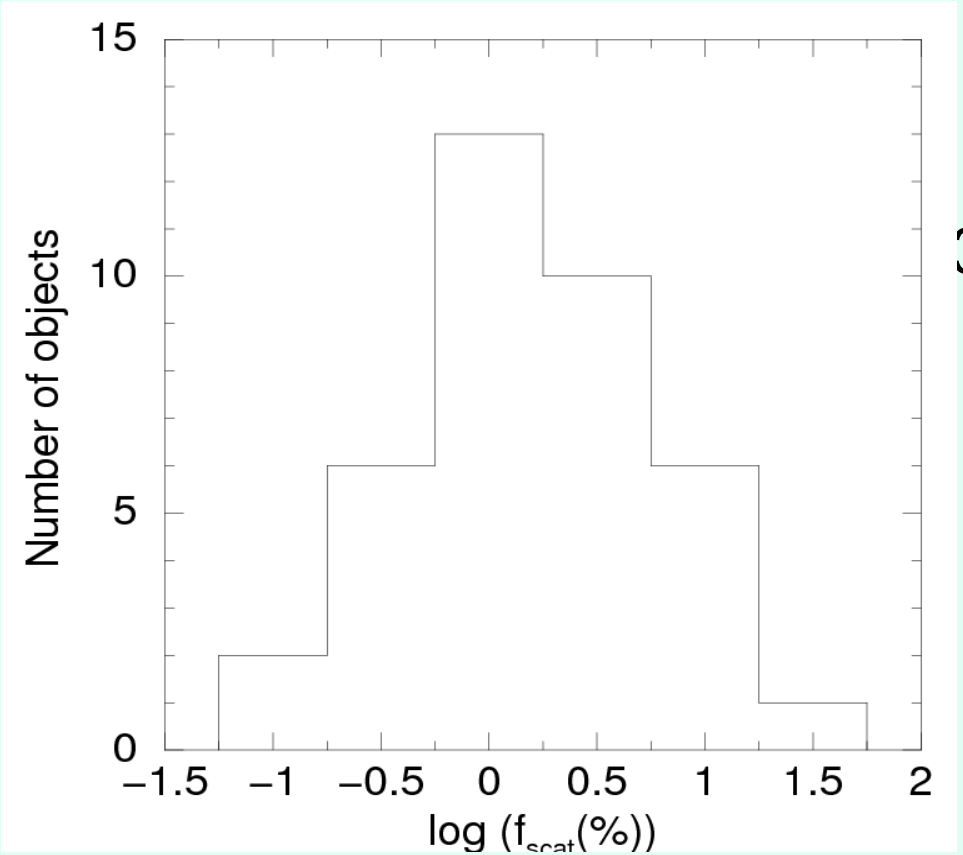


f_{scat}= 10%





Distribution of $f_{\rm scat}$



XMM

38 objects

covering wide range of $f_{\rm scat}$ (0.1-10 %)

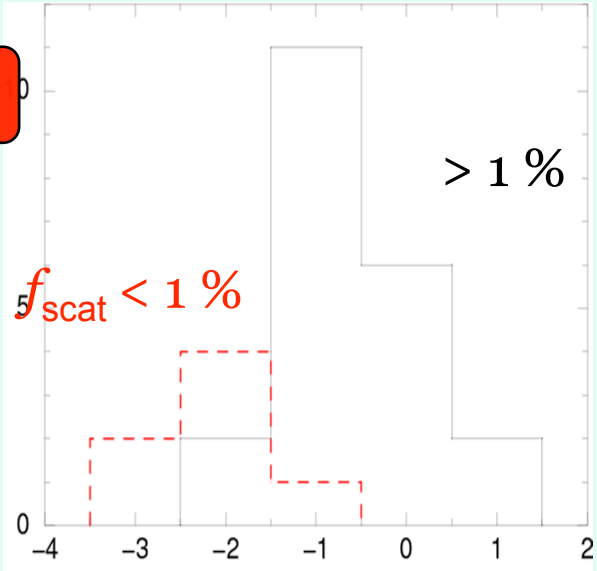
0.1 1 10 $f_{\rm scat}$ (%)

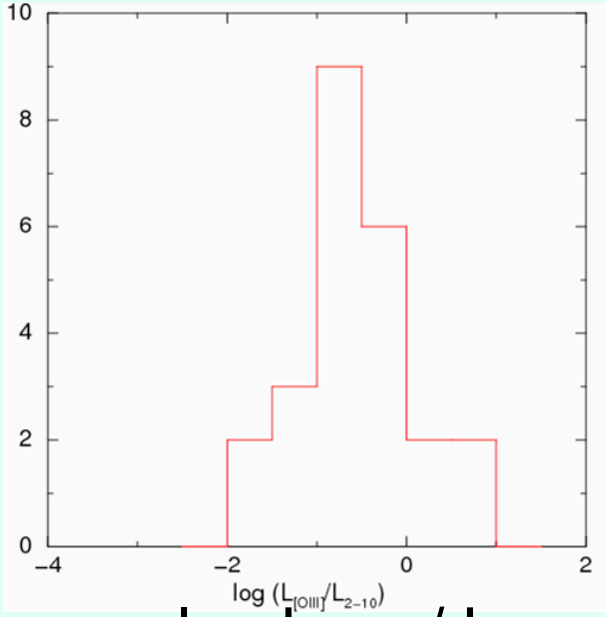
$L_{[OIII]}/L_{2\text{-}10}$ vs f_{scat}

[OIII] optical narrow line photoionization in the opening part of absorber

→ $L_{[OIII]}/L_{2\text{-}10}$ - f_{scat} correlation

XMM





log $L_{[OIII]}$ / $L_{2\text{-}10}$

Opt.

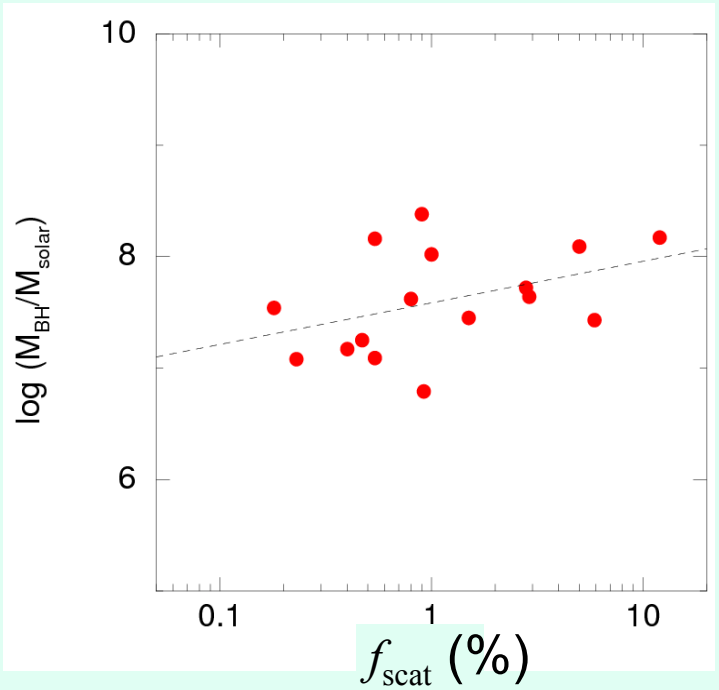
Optical emission-line selection:
biased against objects with small opening angle

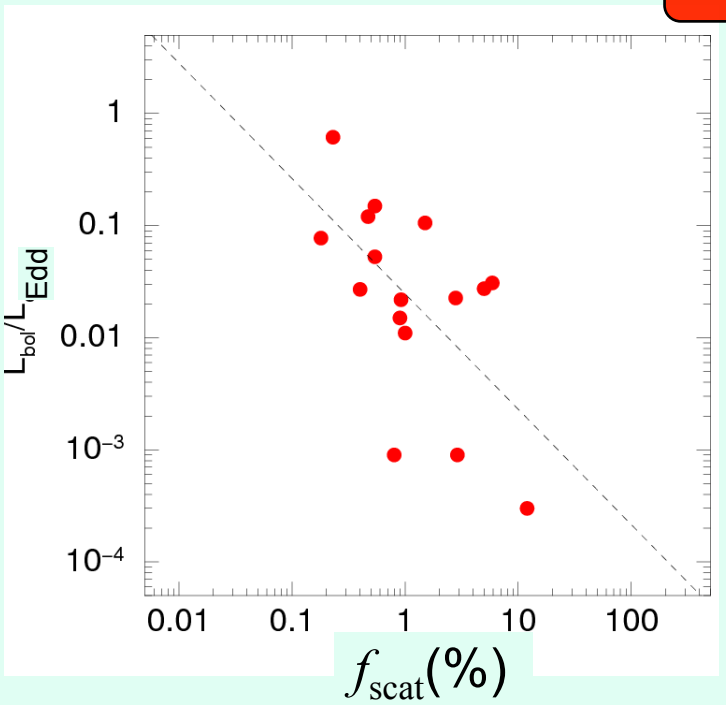
Ueda+07 prediction

Poster Noguchi+ (XMM sample)

BH mass and Eddington Ratio

XMM



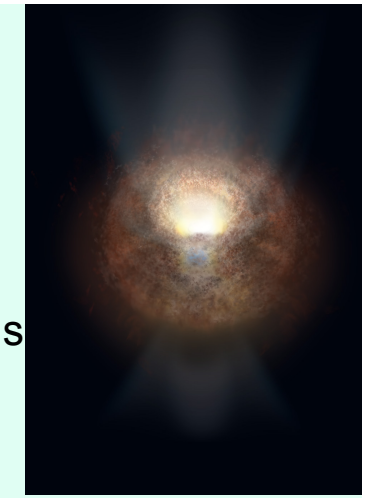


M_{BH} vs f_{scat}:
very weak?/no correlation
``Torus'' scale height not strongly affected by M_{BH}

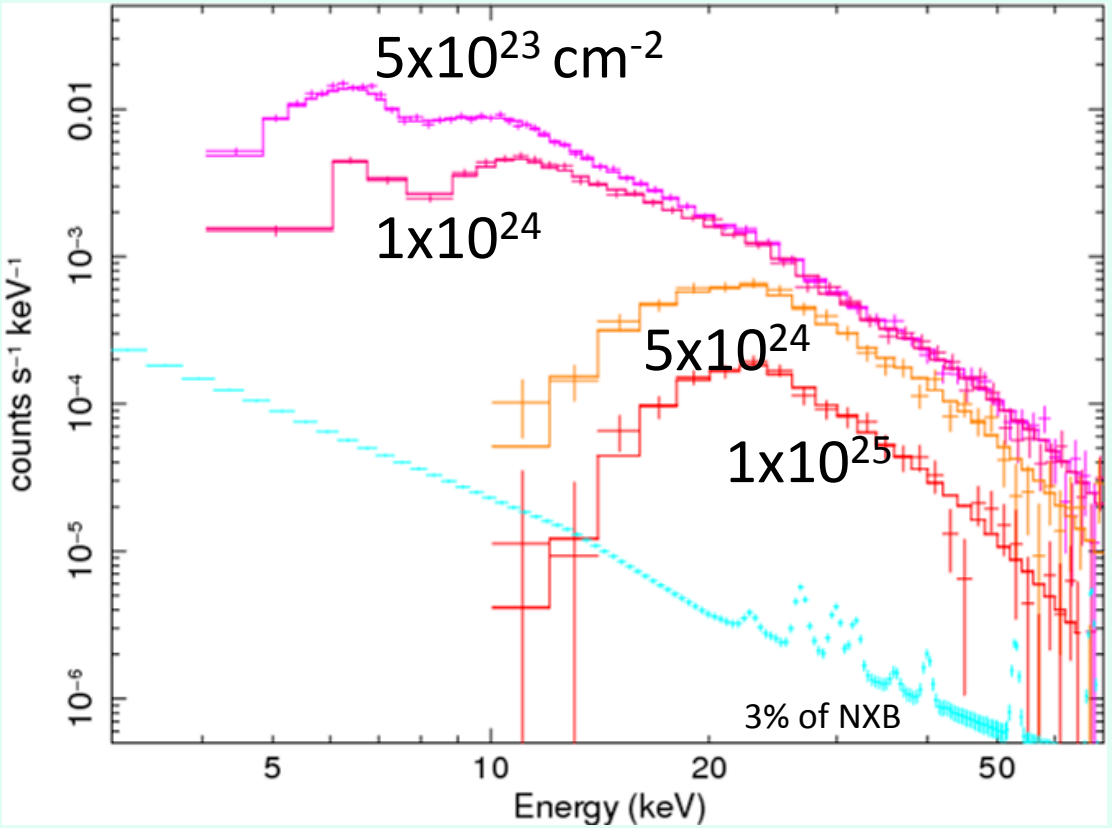
Eddington ratio vs f_{scat}:
weak anti-correlation
Obscuring matter
- reservoir of mass fuel?

Growing phase of BH might be obscured by geometrically thick torus.

Astro-H Observation of VERY Compton-thick AGN



NEW type AGN: Swift J0601: NH~1x10^{24} cm^{-2}; F2-10(intrinsic) = 1x10^{-11} cgs
Assumption: log NH = 25 if viewed from edge-on
photon index1.9; No reflection component.



Astro-H HXT+HXI

100 ksec

(300 ksec for 1x10^{25})

Scattered emission and Fe line not included.

Buried very Compton thick AGN detectable at >10 keV.

Summary

- Broad band spectra with Suzaku: ---Powerful to decompose spectral components (Broad line, reflection, NH, and intrinsic Lx)
- Broad red wing and short term variability of Fe-K support the presence of line from inner acc. Disk
- Scale height of obscuring matter might be related to Eddington ratio or fueling: --- Obscured population is important to pursue growing phase of BH
- Astro-H capable to detect very C-thick population in the local Universe, which cannot be detected with current selection techniques