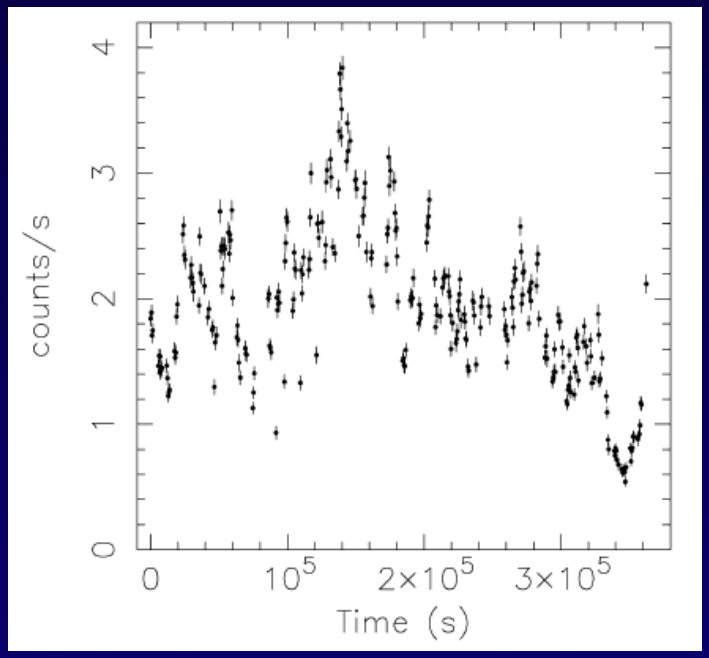
X-ray Light Curve Simulations of Clumpy-Torus Models

Yuichi Terashima
Ehime U.

Outline

1. X-ray Variability
2. Light Curve Simulation — Assumptions
3. X-ray Spectrum
4. Light Curves
5. N_H Distribution
6. Power Spectrum

1. X-ray Variability



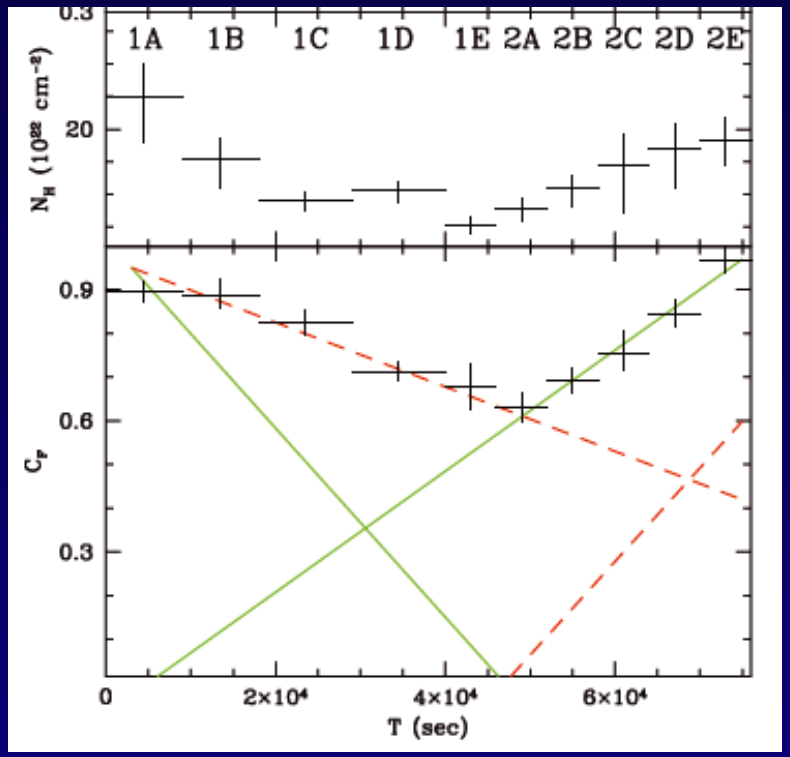
McKernan & Yaqoob 98
MCG-6-30-15

- Intrinsic to primary X-ray source energy release in accretion disk / change in accretion rate
- Variable absorption
  - X-ray variability caused by clumpy absorbers

Importance of partial covering

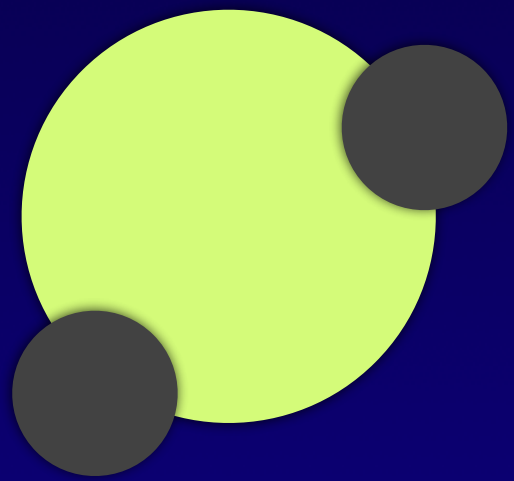
N_H

Covering Fraction (CF)



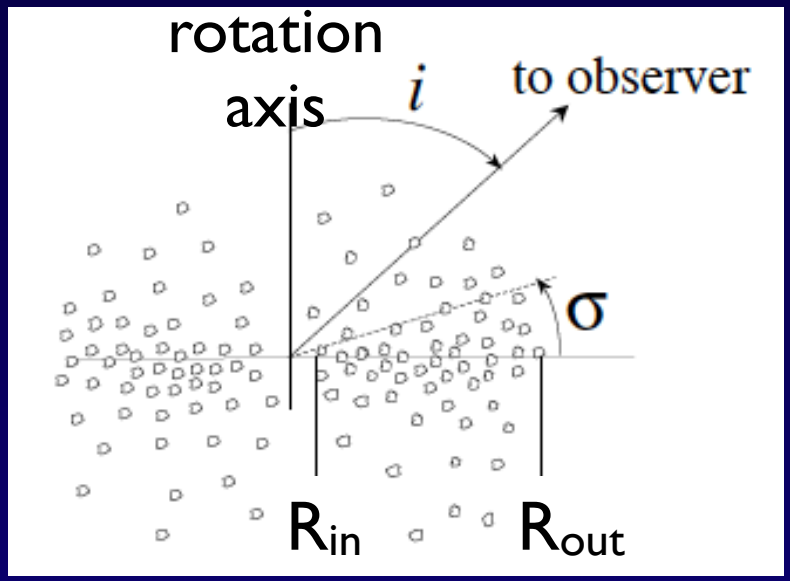
Mrk 766
Risaliti+11

Extended X-ray source
Rx~10Rg



Clumpy absorbers of similar size Rc

2. Light Curve Simulaion: Assumptions



Nenkova+08 geometry

$N(\theta) \propto$ Gaussian

sigma=20 deg

radial dependence r^{-2}

R_{out} = 2 pc

Keplerian rotation

i=70 deg, 10^7Msolar

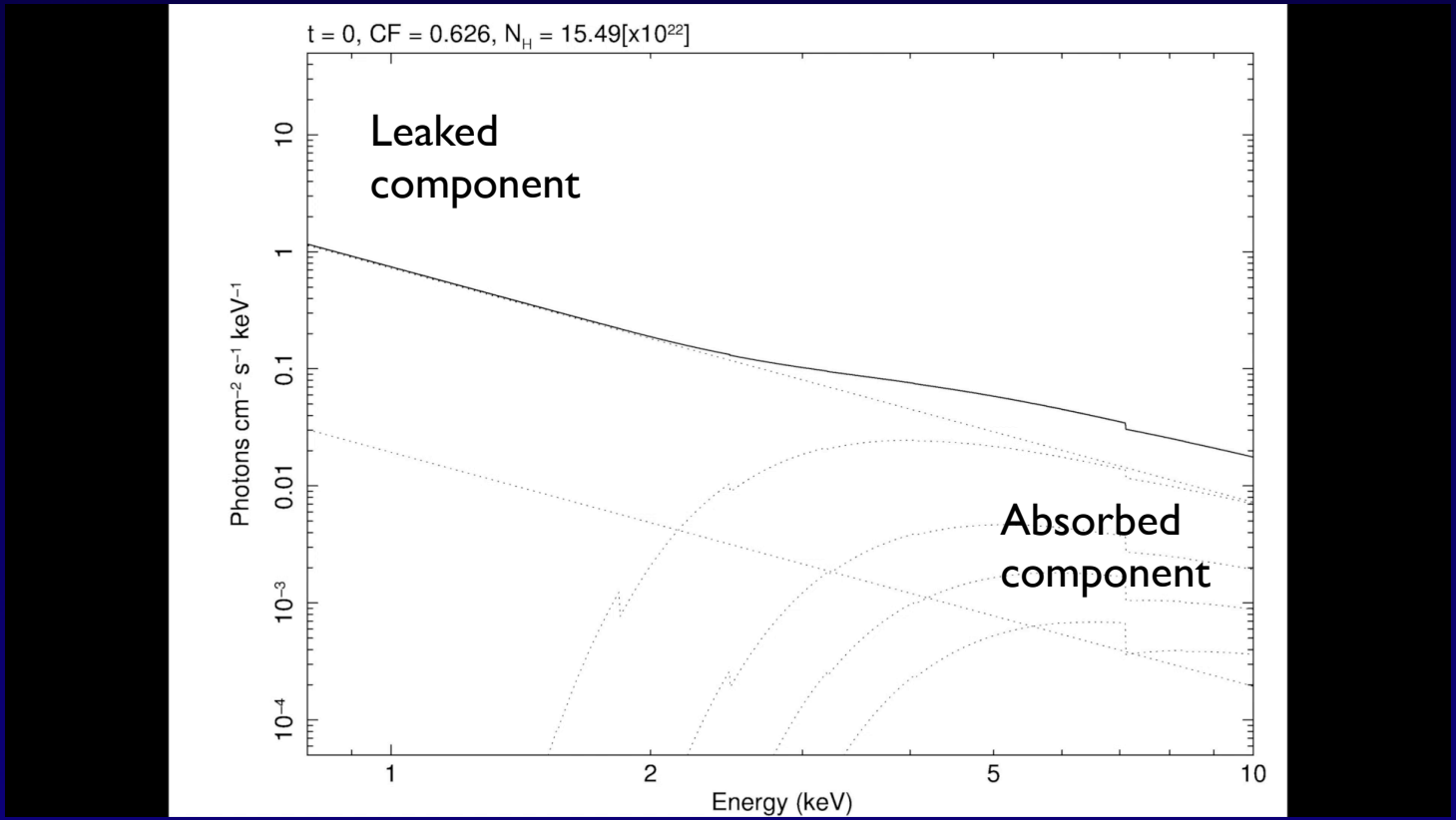
neutral absorber

Only transmitted emission is calculated

Scattering / time lag are ignored

ok if absorption is Compton-thin

3. X-ray Spectrum

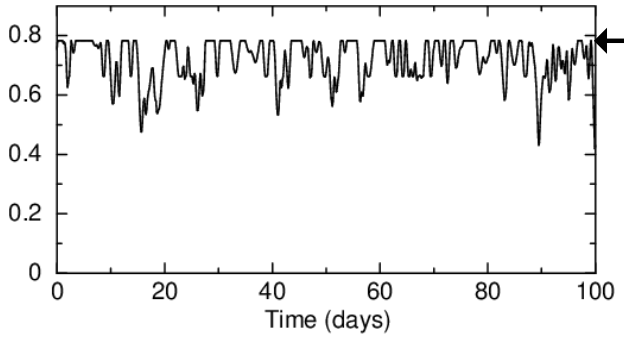


time step = 1 day

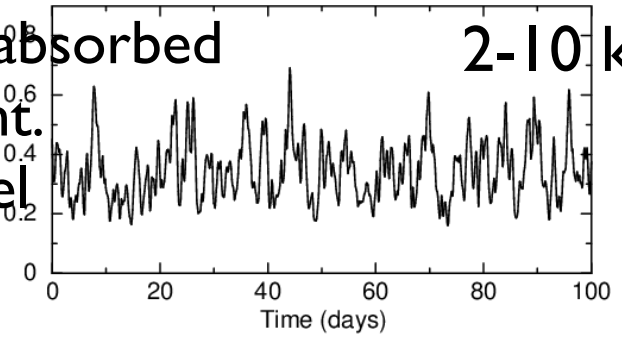
<N>=14

4. Light Curves

Count rate



← unabsorbed cont. level



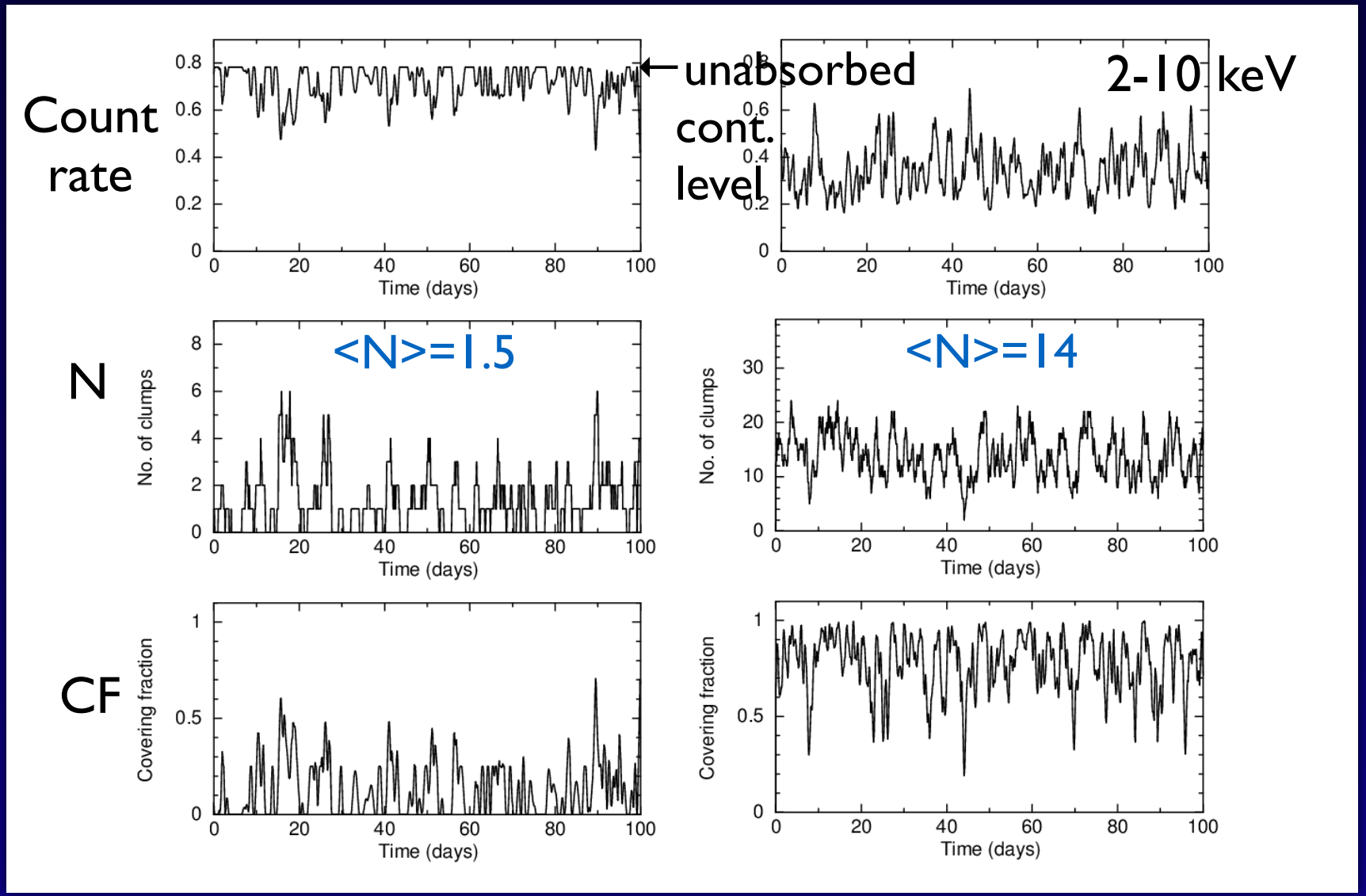
2-10 keV

<N>=1.5

<N>=14

Rc/Rx=0.5

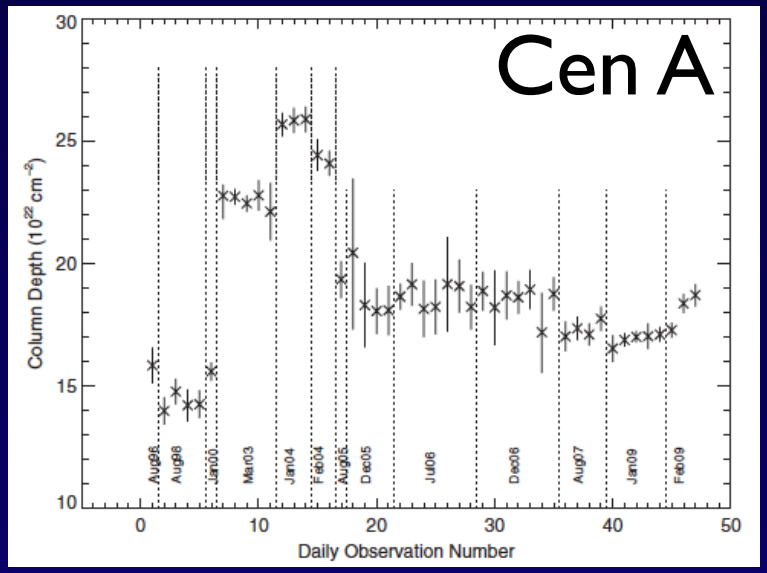
4. Light Curves

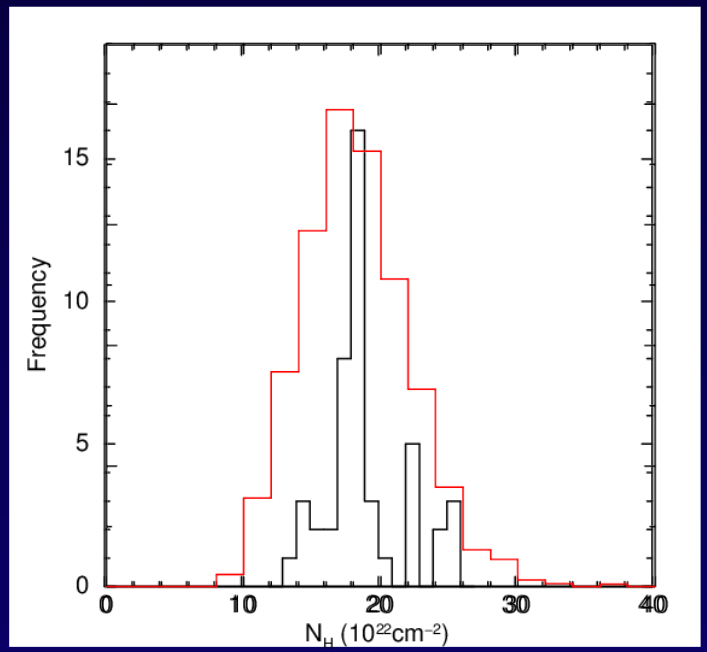


Rc/Rx=0.5

<N> determines behavior

5. N_H Variability



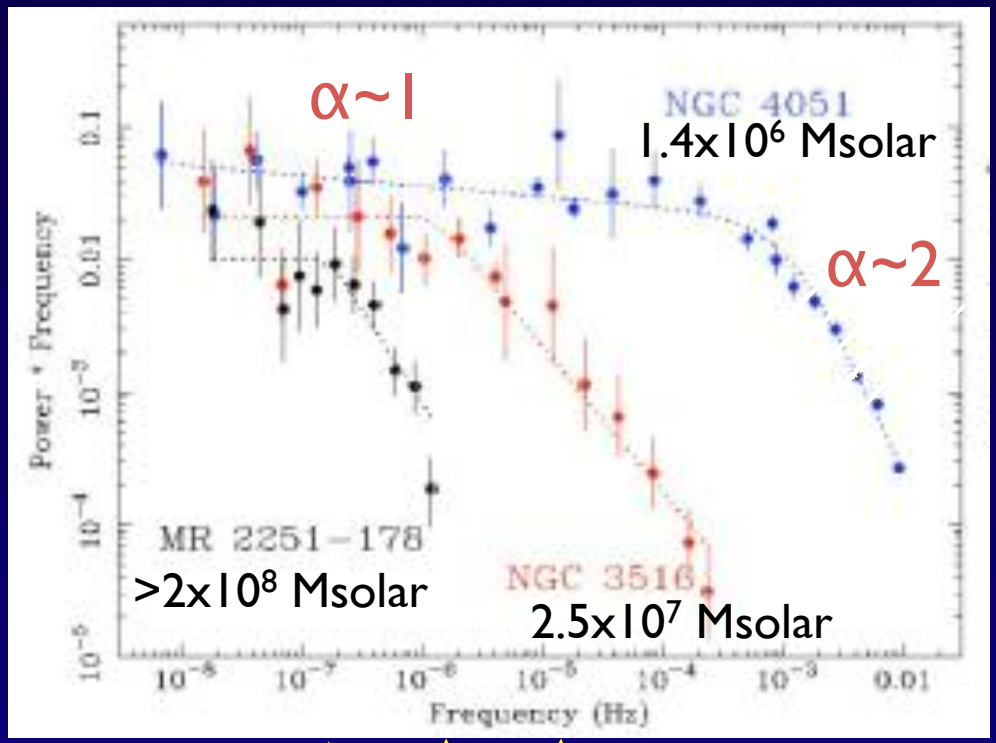


47 daily N_H measurements
in ~5000 days
(Rothchild+11)

Black: Observation
Red: <N>=32
$N_H = 5 \times 10^{22}$ cm^{-2}/cloud

6. Power Spectrum

$f\,P(f)$ $P(f) \propto f^{-\alpha}$



Break time T_B
hours to 100 days
scales with M_{BH} (& L/LEdd)

f (Hz)

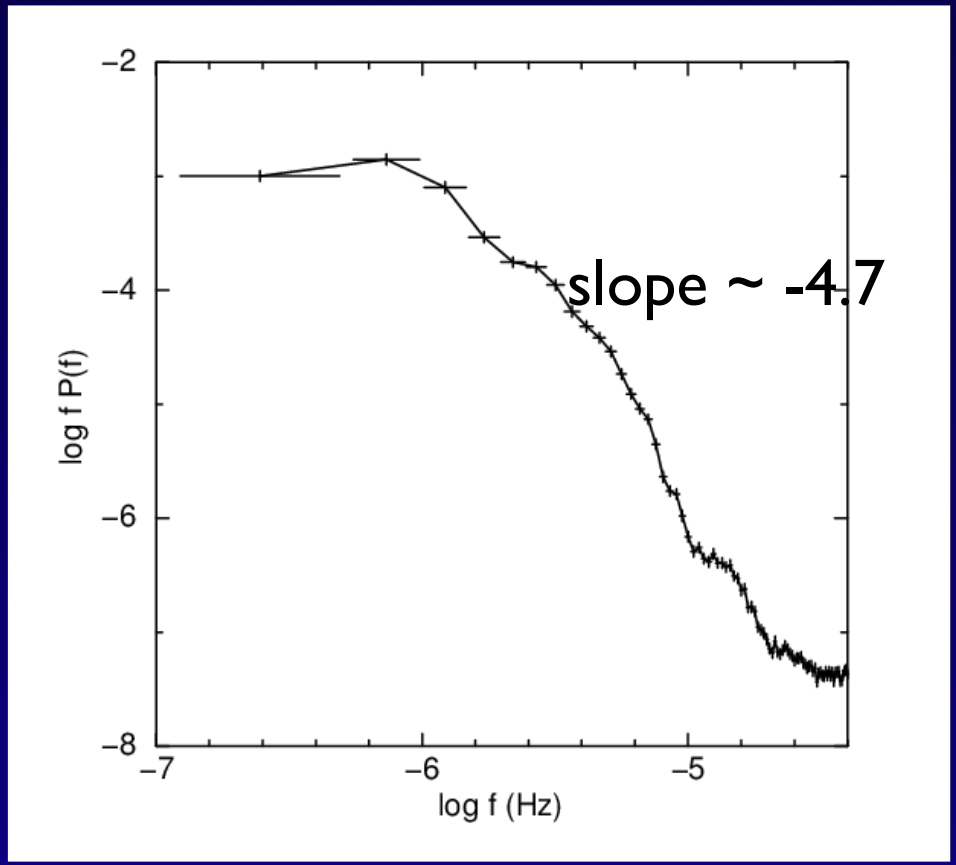
100 10 1 (days)

Utlley 07

6. Power Spectrum

$$P(f) \propto f^{-\alpha}$$

$f\,P(f)$



Rin = 0.1 pc
Rout = 2 pc
``torus'' scale

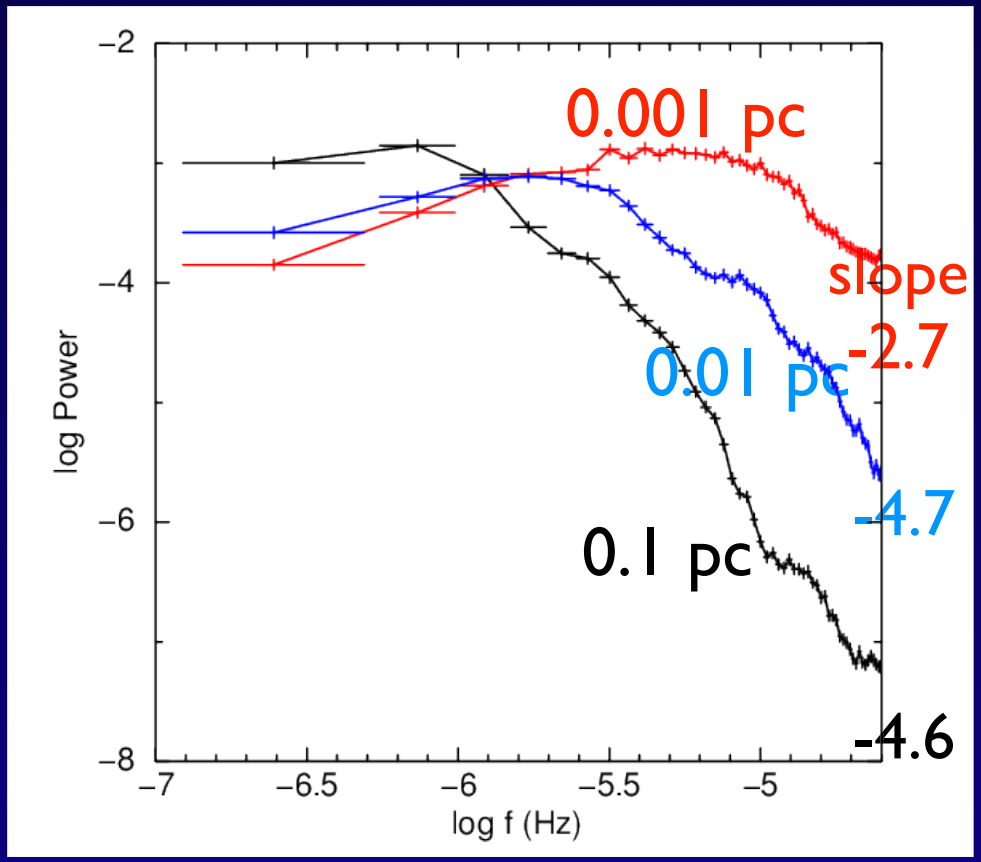
much steeper than observed slope (~2)

deficit of higher frequency component

$M_{BH} = 10^7$ Msolar
Rc/Rx = 0.2

Power Spectrum
Rin dependence

$f\,P(f)$



smaller Rin
→more power
at higher freq

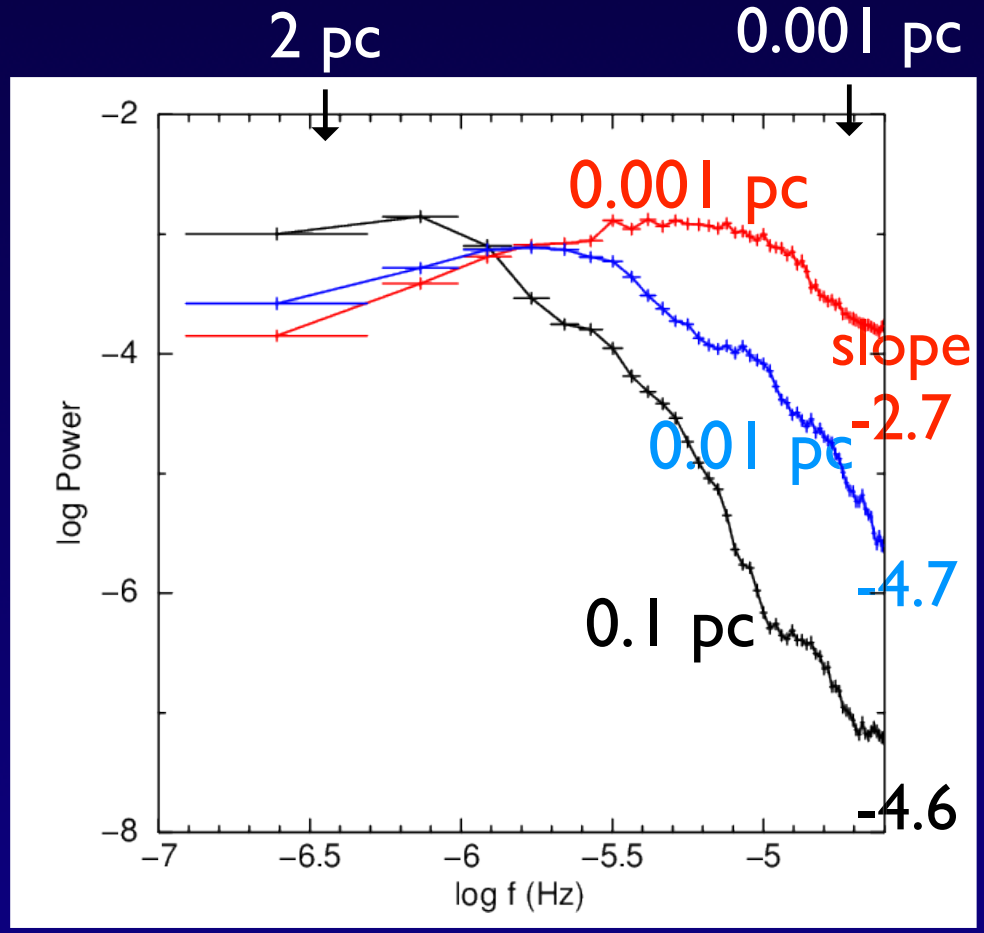
still need more
power at high freq

presence of src. of
more rapid var.
near BH

Rout = 2 pc
10^7Msolar
Rc/Rx = 0.2

Power Spectrum
Rin dependence

f P(f)



crossing time scale of Rx + Rc
(beginning of ingress to end of egress)

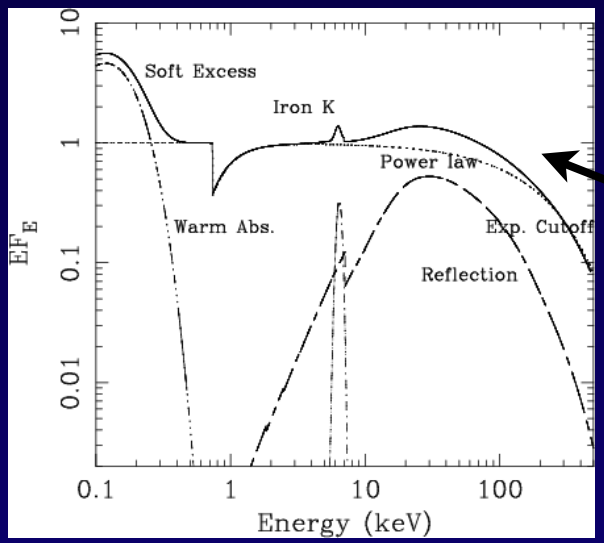
Rout = 2 pc
10^7Msolar
Rc/Rx = 0.2

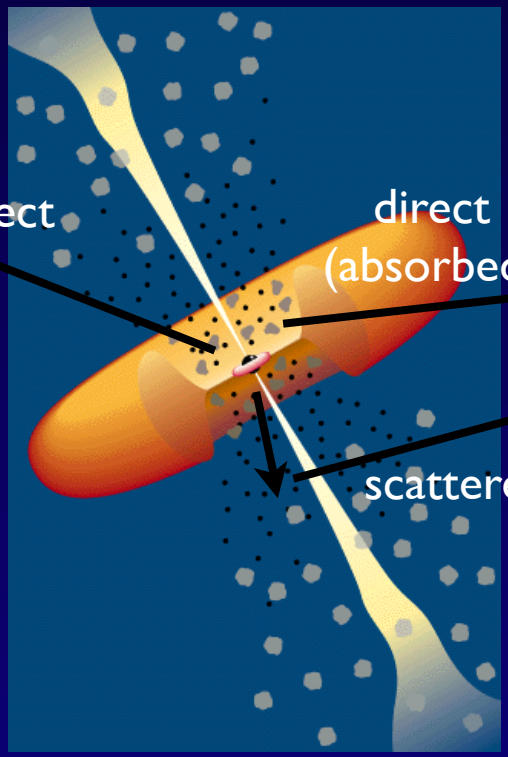
Summary

- Random X-ray variation can be made by clumpy absorbers
- <N> is essential to determine behavior
- >50 N_H measurements constain <N>
  - larger sample required to solve degeneracy sigma and i
- Crossing-time scales determine board peak of PSD
- Deficit of high frequency comp. suggests the presence of proseses generating rapid variability

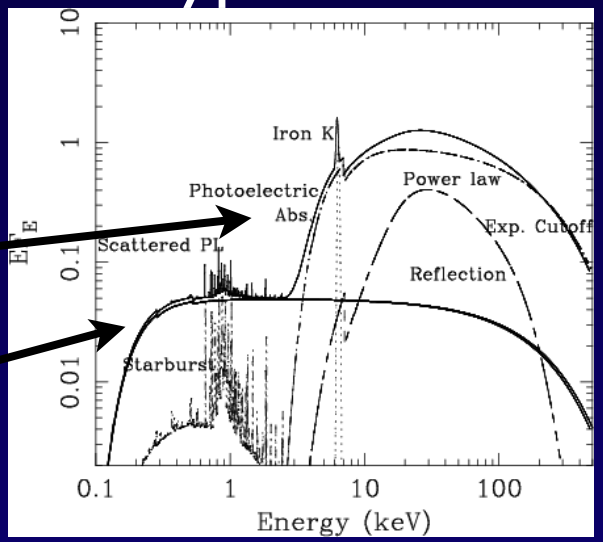
2. X-ray Spectral Components in Seyferts

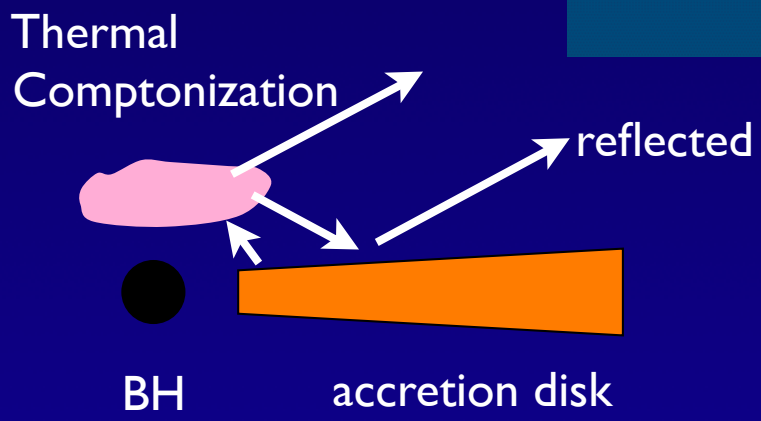
Type 1





Type 2



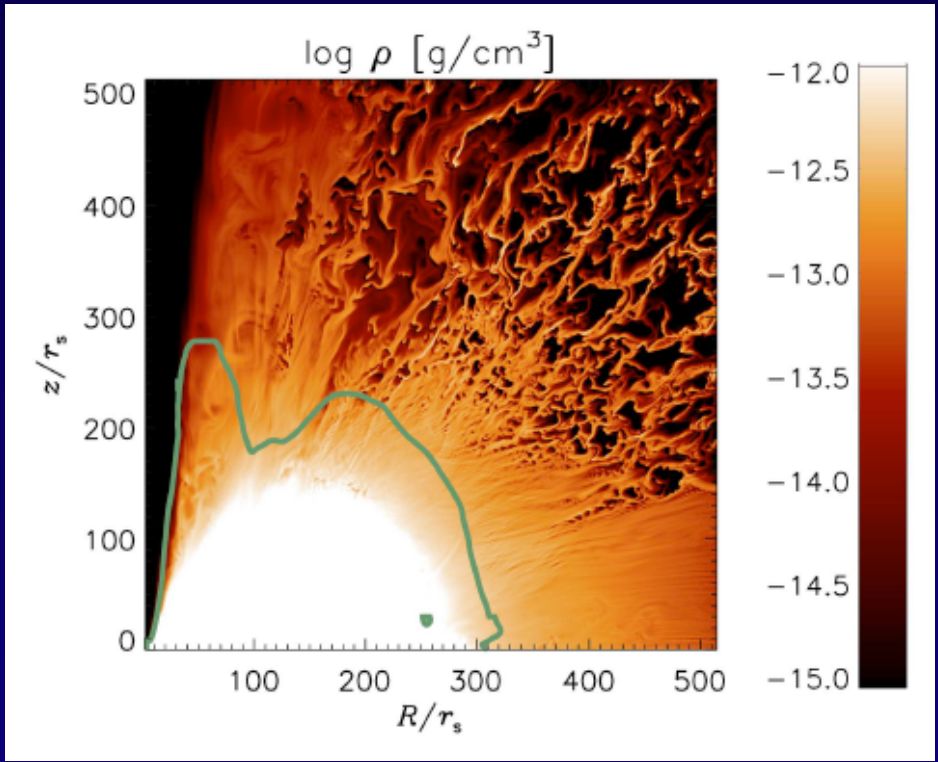


Decomposition
by broadband spectroscopy
+ spectral variability

Clumpy Outflow

2D RMHD simulation of
Supercritical accretion flow around a 10^8 Msolar BH

Takeuchi+13



- Clumpy structure is formed.
- Such clumps could partially obscure the central X-ray source.

Covering faction can be measured by high resolution spectroscopy.