

# AGN (accretion & ejection) Physics:



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## Plan of the Lectures

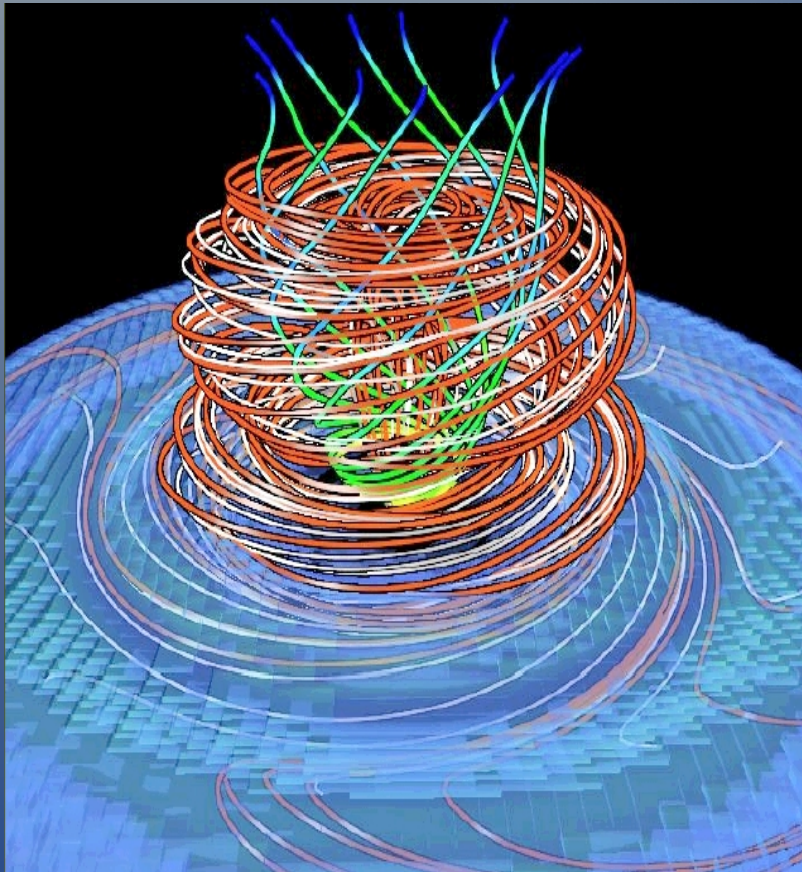
- (I) General framework
  - Paradigm(s)
  - The 2 “Unknowns”
  - The 3 “Known” (models + basic physics)
- (II) The 2 contenders
  - Relativistic reflection (=accretion)
  - Relativistic absorption (=ejection)

These lectures are “complementary” to others on evolution of AGNs, and on high energy detectors as well.

Goal of the lectures: Give introductory informations on general “models” of AGNs, and in particular on reflection vs absorption hypothesis in RQAGNs

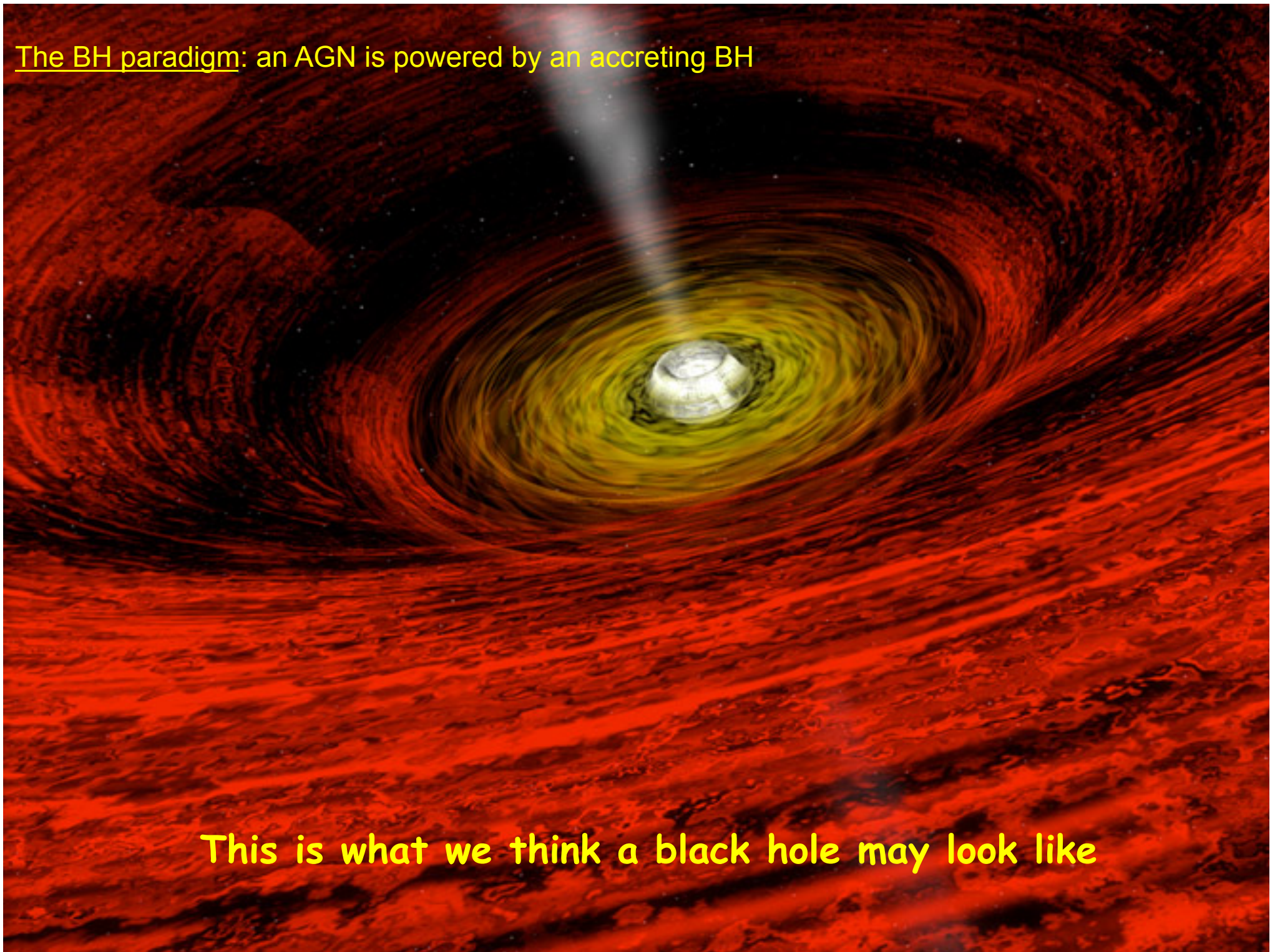
### Bibliography:

- A. Mueller, PhD Thesis, Heidelberg, 2004
  - C. Done, Lectures, August 2010, arXiv:1008.2287v1
- Give a panorama on theoretical models+spectral physics for AGNs&BHs



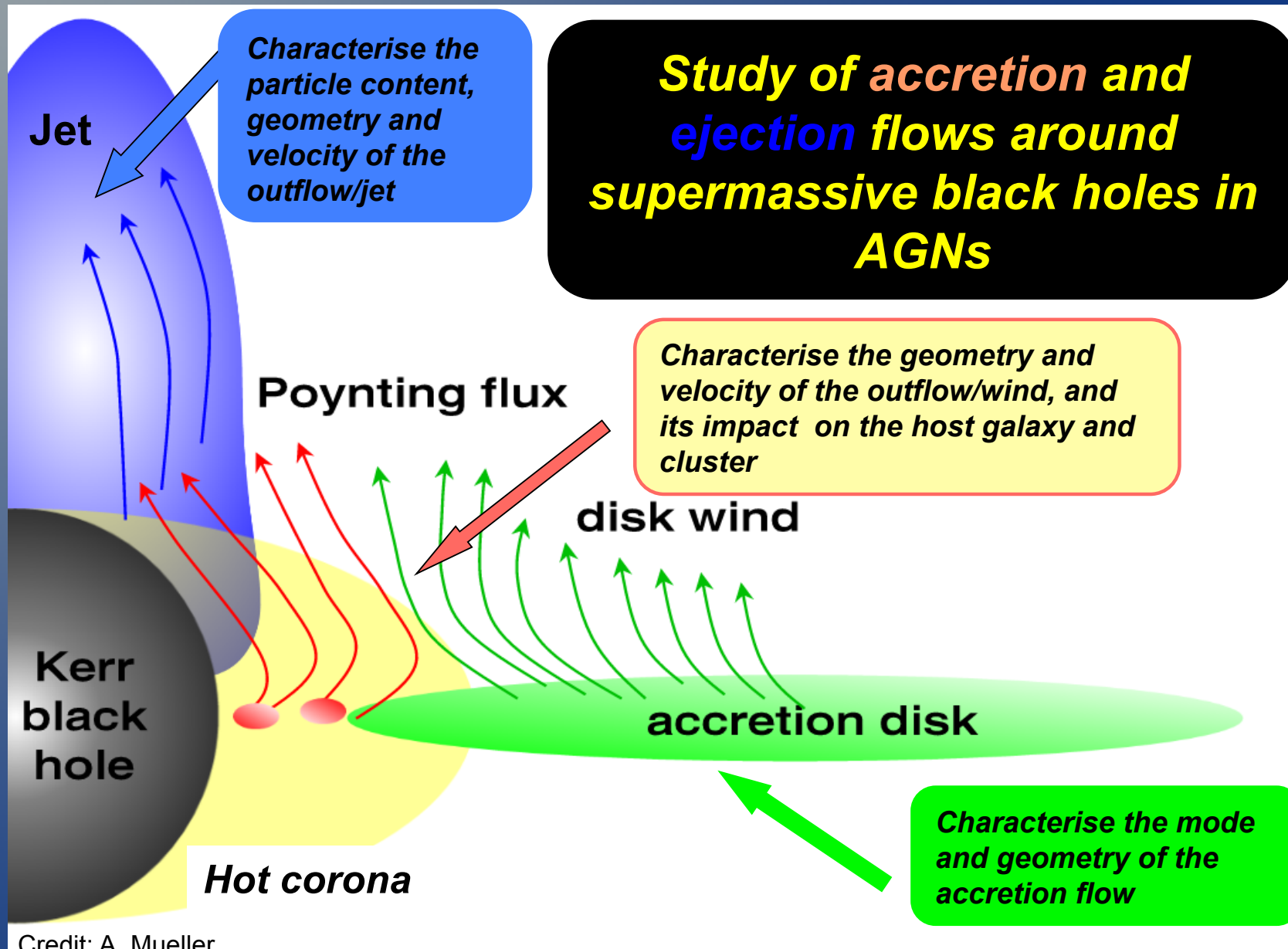


The BH paradigm: an AGN is powered by an accreting BH



This is what we think a black hole may look like

# The „Unknowns“ or the Open issues

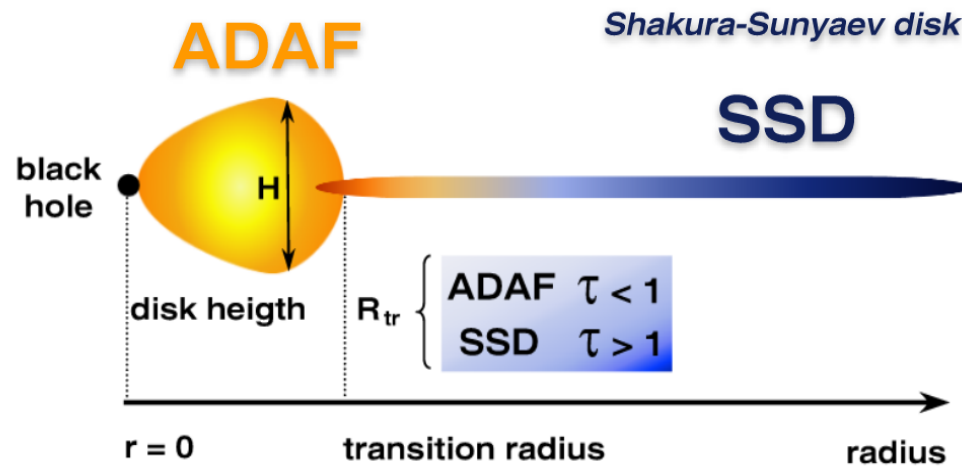




# First major “Unknown”: The type of accretion flow

We don't know exactly the accretion mode/type (SAD, ADAF, RIAF, CDAF, etc.)...

*advection-dominated accretion flow*

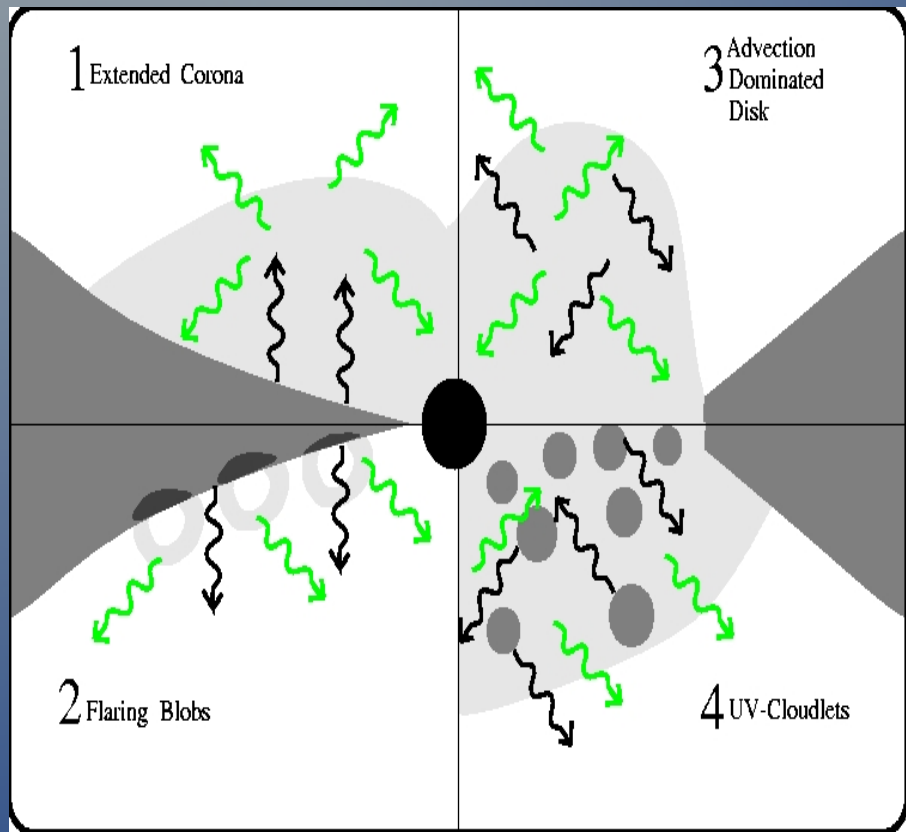


(Müller, '04)

- Shakura–Sunyaev disk (SSD) or equivalently standard accretion disk (SAD)
- advection–dominated accretion flow (ADAF)
- radiatively–inefficient accretion flow (RIAF)
- convection–dominated accretion flow (CDAF)
- slim disk
- truncated disk – advective tori (TDAT)
- non–radiative accretion flow (NRAF)



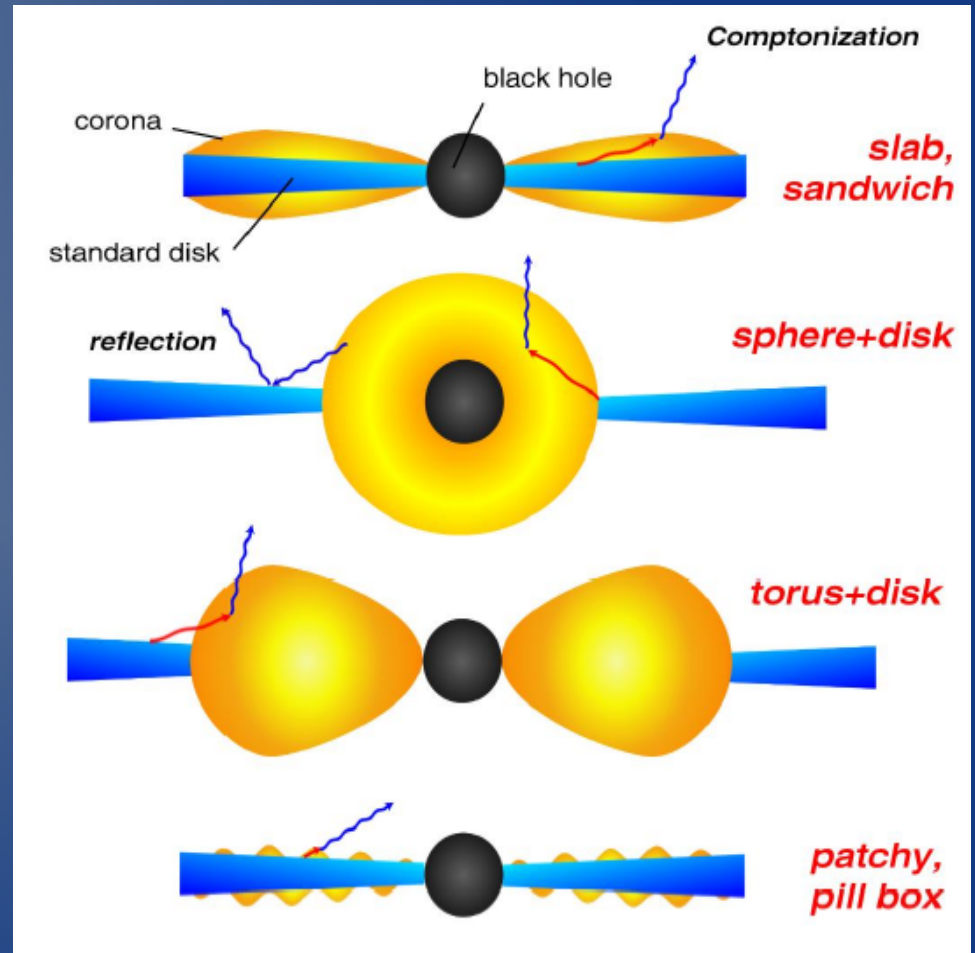
# Second major "Unknown": The disk-corona geometry



Lamp-post model

Patchy corona model

(Haardt '96)



Muller '04

## The 3 “Knowns”...or the AGN “Models”

BH paradigm + assumptions on geometry + emission mechanisms (physics) + Multi- $\nu$  observations  
**= AGN “Model”**

The TWO major RQ AGN models are:

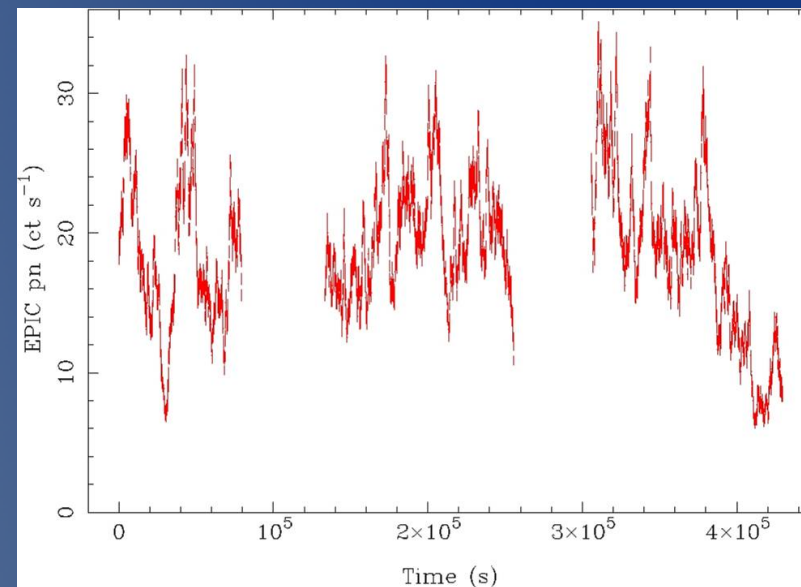
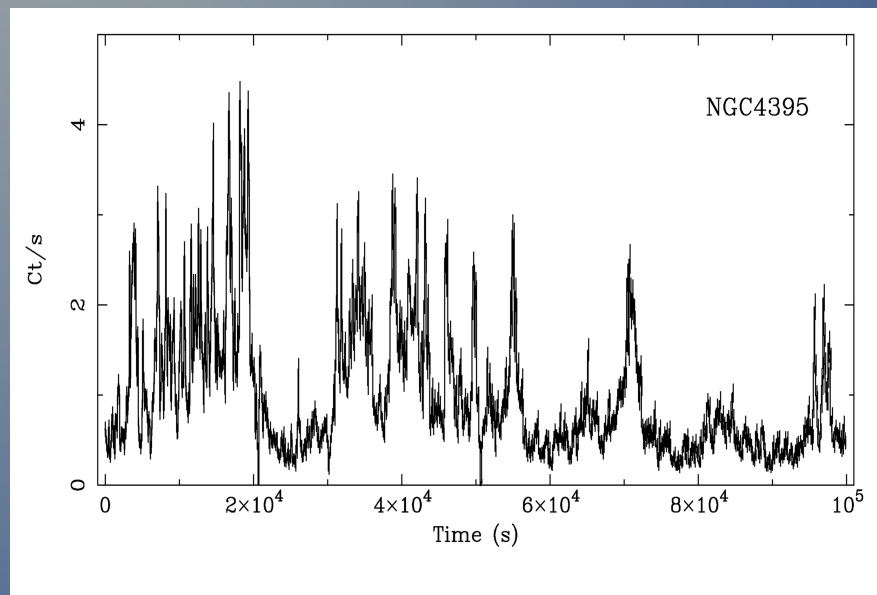
- 1: **2-Phases model** (for Radio Quiet AGNs)
- 2: **Inefficient model** (for Low Luminosity AGNs .. also RL)



# Model 1

The 2-phases  
(efficient) model  
(RQAGNs)

## Model I (RQ AGN): X-ray observations - Lightcurves



$\Delta L \sim L \sim \text{up to } 10^{44} \text{ erg/s}$

Light curves

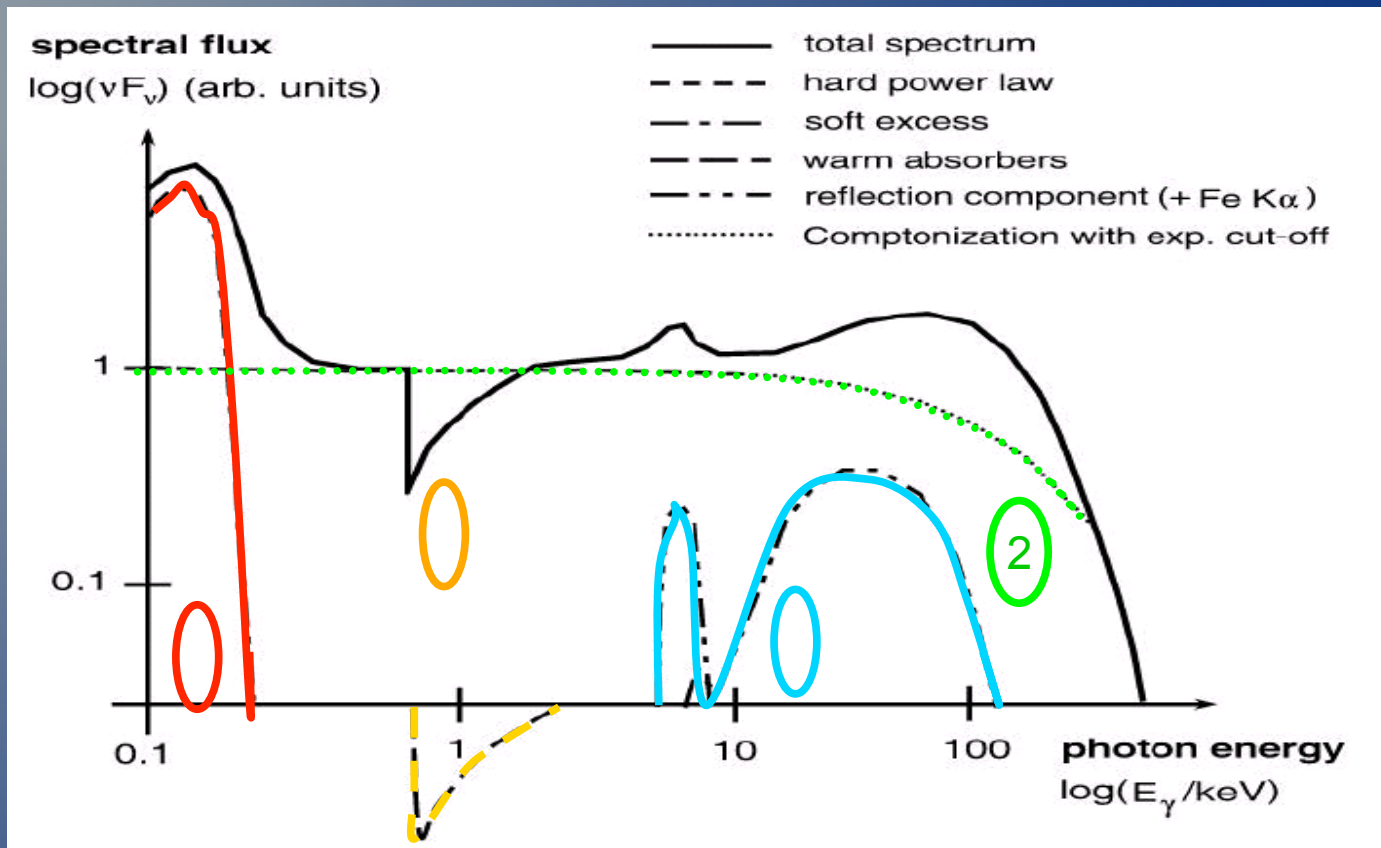


N.B:  $\Delta t \sim 50 \text{ s}$  corresponds to  $1 R_g$  for  $M = 10^7 M_{\text{sol}}$   
( $\tau \sim R_g/c \sim GM/c^3 \sim 50 M_7 \text{ s}$ )

Implies most of radiation from innermost regions



## Model I (RQ AGN): X-ray observations - typical spectra

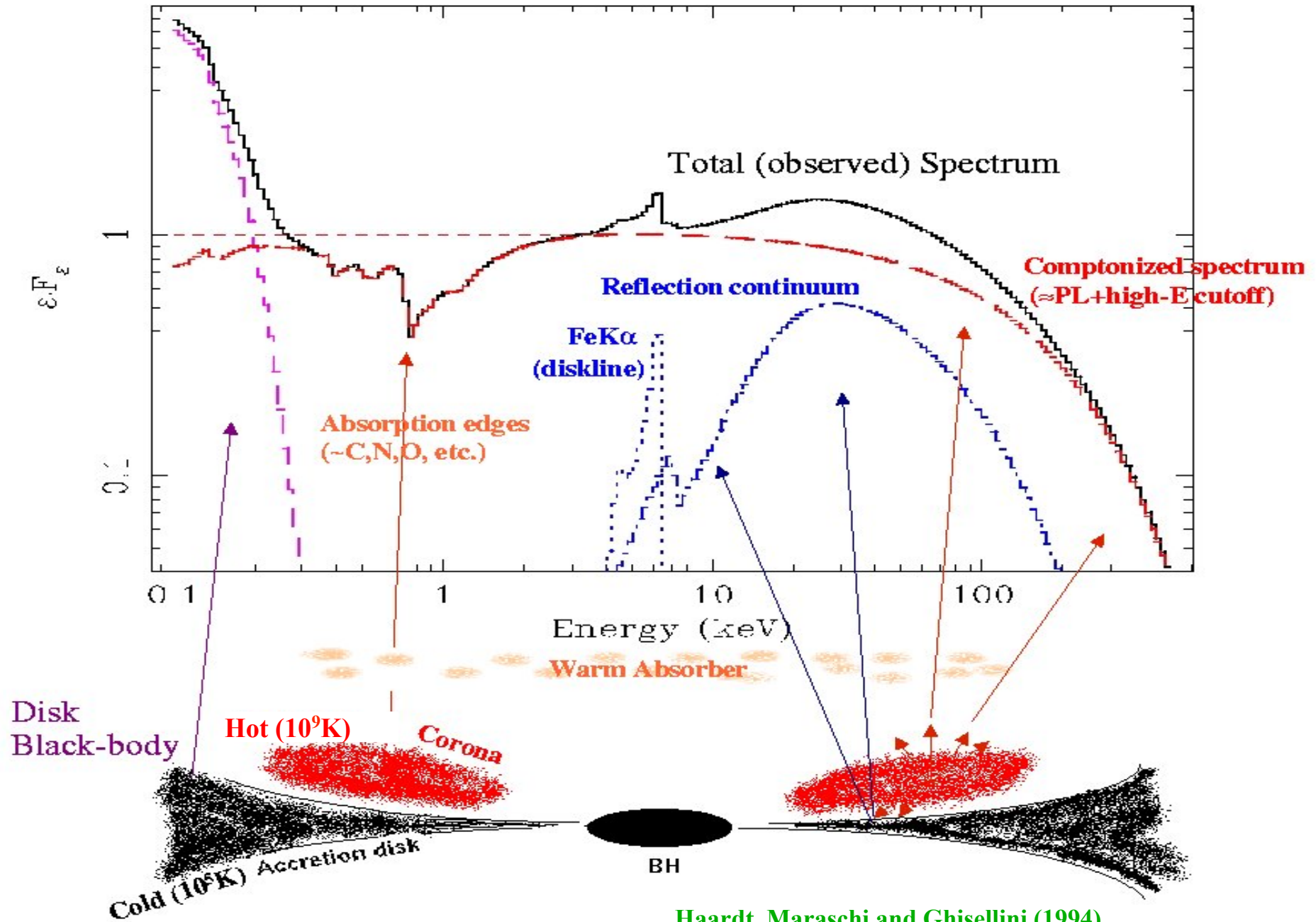


➔ (At least) 4 major spectral components:

1. Soft excess (Black body)
2. Power-law Component (Thermal Comptonization)
3. Reflection component (Fluorescence Lines + Compton hump)
4. Warm absorber (photoelectric absorption)

# Typical X-ray Spectrum of a Seyfert 1 Galaxy

↔ Standard two-phase Comptonization model



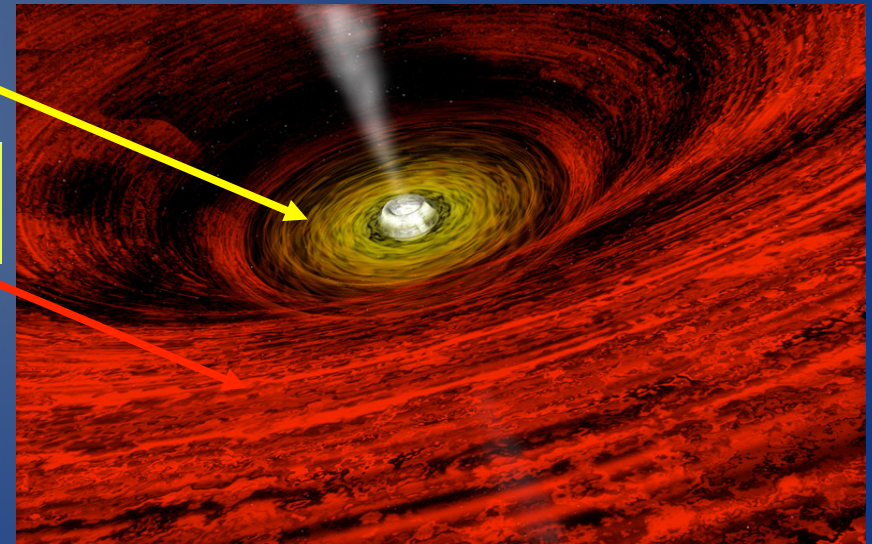
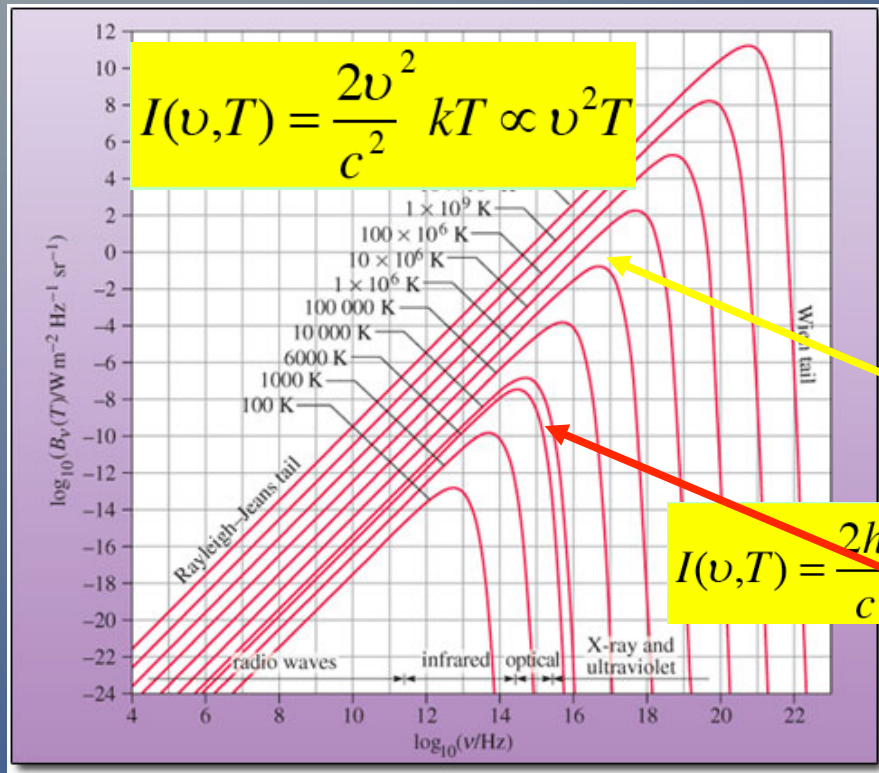
Haardt, Maraschi and Ghisellini (1994)



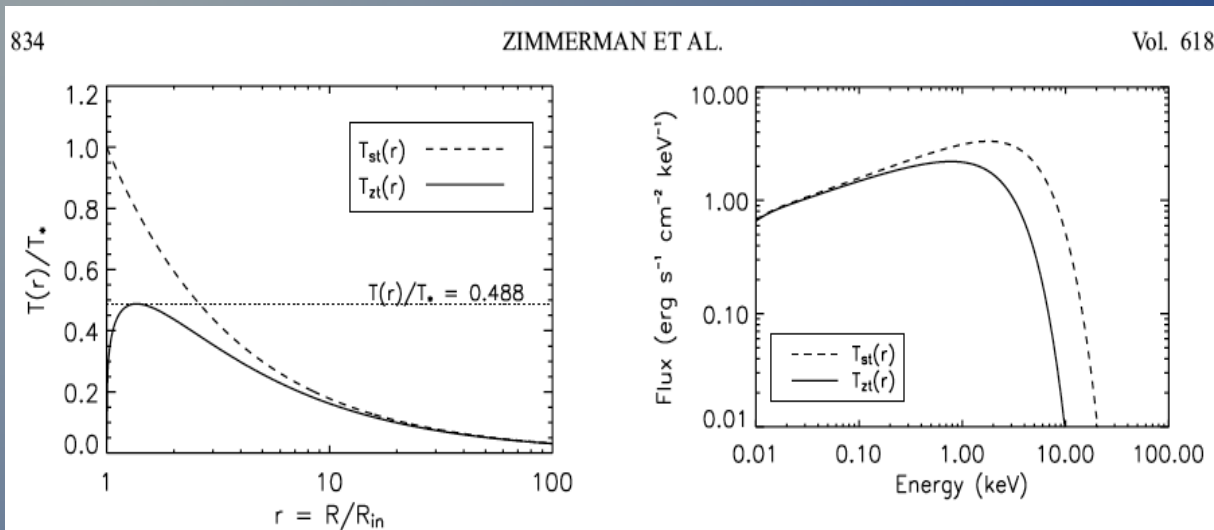
# 1- Black Body emission from accretion disk

Planck radiation law:

$$I(\nu, T) = \frac{2h\nu^3}{c^2} \frac{1}{e^{h\nu/kT} - 1}$$



# 1- Black Body emission from accretion disk



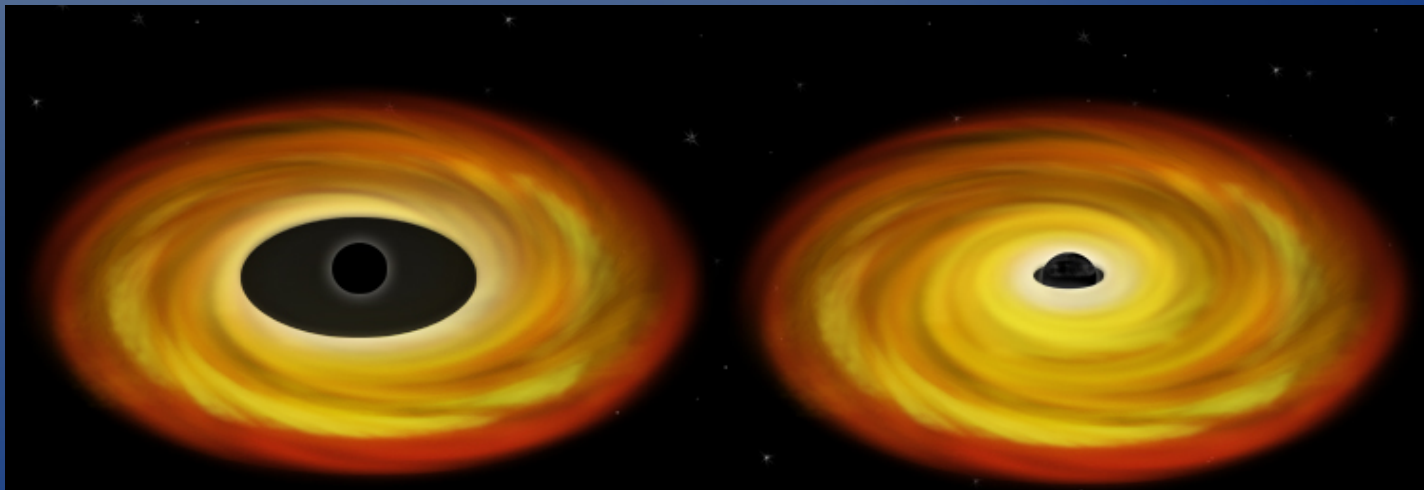
Multi-temperature disk black-body emission (see also “big blue bump”)

n.N.B.: in SADthin disk:

$$L_{\text{acc}} \sim 0.1 \dot{M} c^2$$

$$kT \sim 10 \left( \frac{M_{\text{BH}}}{10^8 M_\odot} \right)^{-1/4} \left( \frac{\dot{M}}{\dot{M}_{\text{Edd}}} \right)^{1/4} \text{ eV}$$

N.B: Another important consequence/application: Innermost Stable Circular Orbit (ISCO) depends on BH spin ( $a_*$ )



$$a_* = 0$$

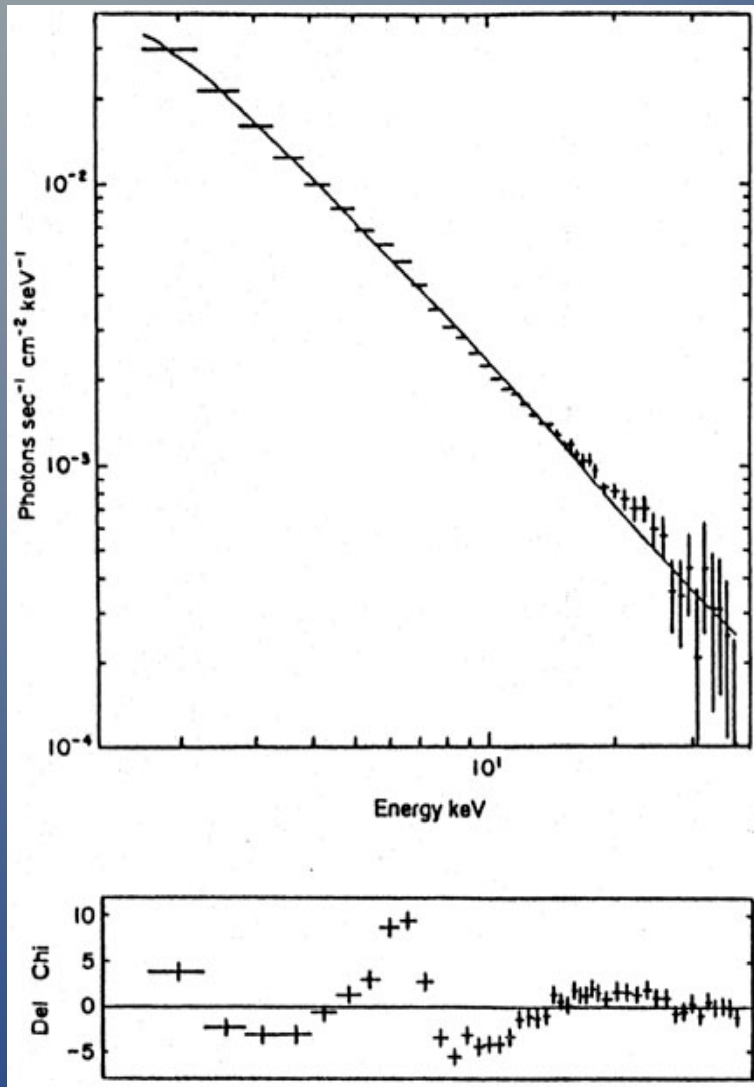
$$R_{\text{ISCO}} = 6MG/c^2 = 90 \text{ km}$$

$$a_* = 1$$

$$R_{\text{ISCO}} = 1MG/c^2 = 15 \text{ km}$$

(for  $M = 10 M_\odot$ )

# Power-law spectra: an universal law $\Gamma=1.7$ ?



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consistent with a mean  $\alpha$  of  $0.55 \pm 0.04$  for the hard X-ray slope, constant over variations of an order of magnitude in flux.

(iii) 3C273 is by far the most luminous source in our sample and may represent one extreme of the Seyfert phenomenon. Numerous observations with *EXOSAT* and previous X-ray satellites have shown 3C273 to have a flat spectrum, the observation reanalysed here giving  $\alpha = 0.53^{+0.06}_{-0.11}$ .

(iv) Akn 120 is another bright Seyfert with a well-constrained *EXOSAT* spectrum. The ME data alone showed a slope of  $\alpha = 1.10^{+0.23}_{-0.16}$ , significantly steeper than the mean  $\alpha$  for the sample. Addition of the LE data confirmed the steep slope as  $\alpha = 1.19 \pm 0.08$ . A previous *Einstein* observation of Akn 120 revealed a steep slope consistent with our result (Urry *et al.* 1987).

Fig. 6(a) shows  $\alpha$  versus log of the 2–10 keV luminosity for the ME data and Fig. 6(b) shows the same for the ME + LE data, where error bars on  $\alpha$  cover the 90 per cent confidence range

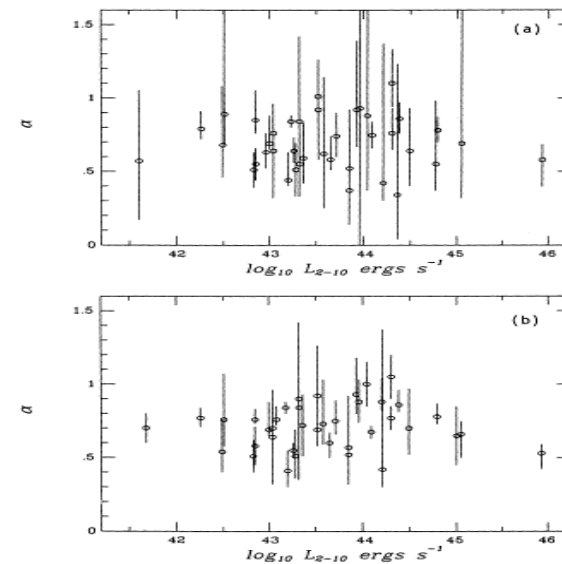


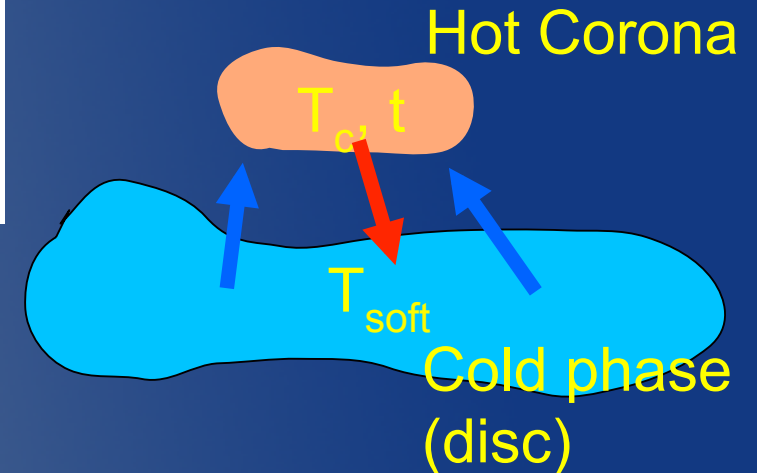
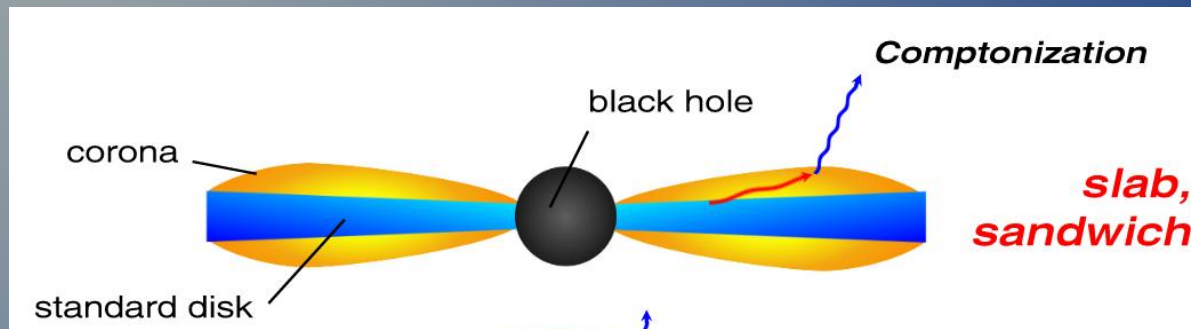
Figure 6. Energy index,  $\alpha$ , versus 2–10 keV luminosity (absorption corrected). Only hard X-ray components are plotted for (a) the ME data and (b) the ME + LE data.

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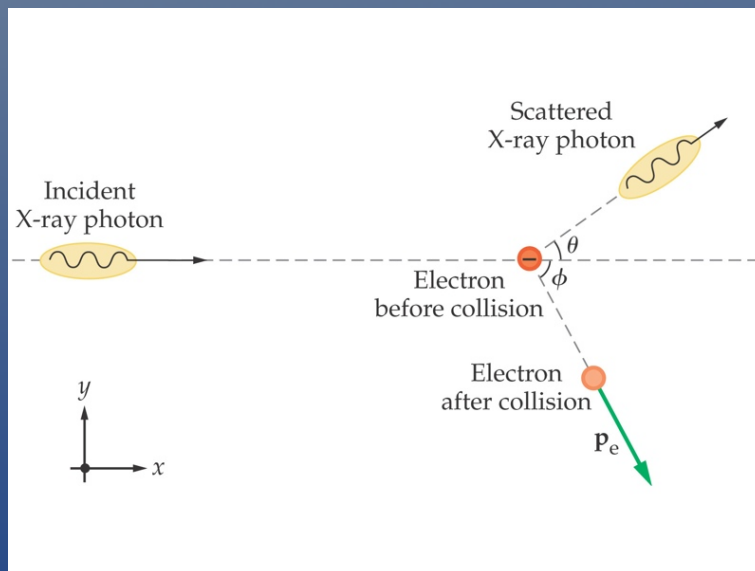
Nandra & Pounds 1994

Turner & Pounds 1989

## II - Power-law (Thermal Comptonization from the corona)



Thermal Comptonization from thermal electrons plasma with  $kT$  and optical depth  $\tau$



If electron at rest:

$$\Delta E = E' - E$$

$$\simeq -\frac{E^2}{m_e c^2} (1 - \cos \theta)$$

For non-stationary electron:

$$\Delta E < 0 \rightarrow \text{Compton}$$

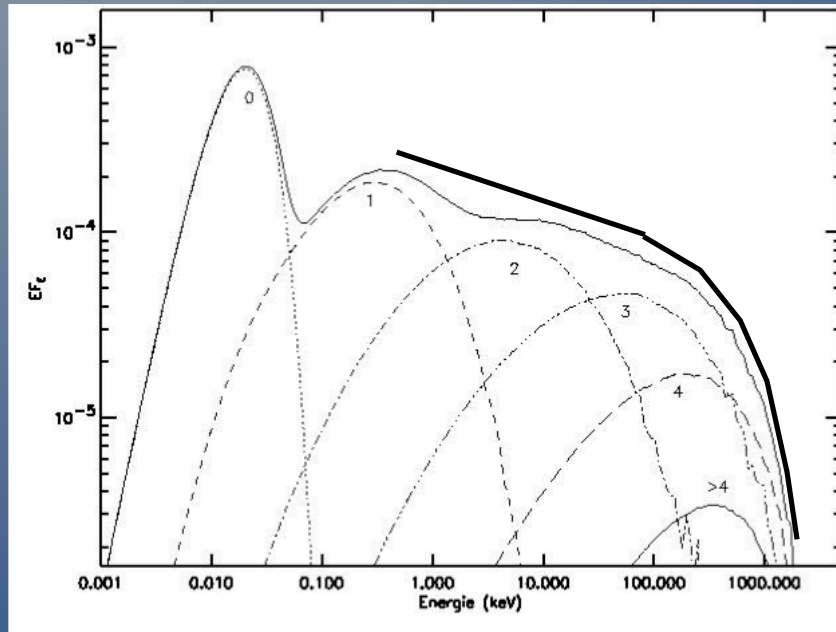
$$\Delta E > 0 \rightarrow \text{Inverse Compton}$$



## II - Power-law (Thermal Comptonization from the corona)

$$f_{\epsilon}(\epsilon) d\epsilon = \sqrt{\frac{1}{\pi \epsilon kT}} \exp\left[\frac{-\epsilon}{kT}\right] d\epsilon$$

Maxwellian Distribution of electron energies  
 $\Rightarrow$  produce power-law + high energy cut-off

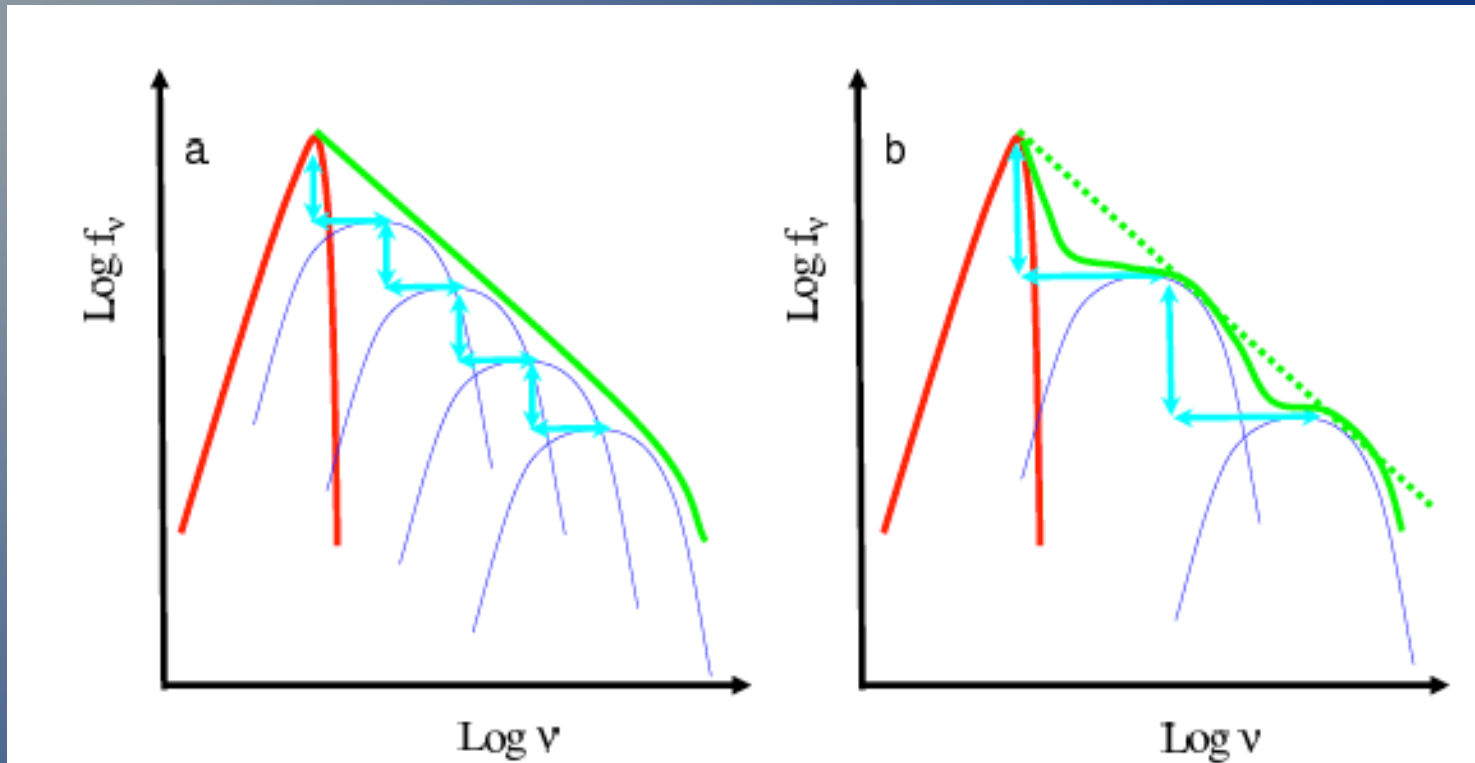


$$F_E \propto E^{-\Gamma(kT, \tau)} \exp\left(-\frac{E}{E_c(kT, \tau)}\right)$$

$$\left\{ \begin{array}{l} \Gamma \propto \left(\frac{L_{heat}}{L_{cool}}\right)^{-\delta} \propto f(kT, \tau) \\ E_c \simeq kT \end{array} \right.$$

$\Gamma(kT, \tau) \Rightarrow$  Spectral degeneration since different  $(kT, \tau)$   
 can yield same  $\Gamma$

## II - Power-law (Thermal Comptonization from the corona)

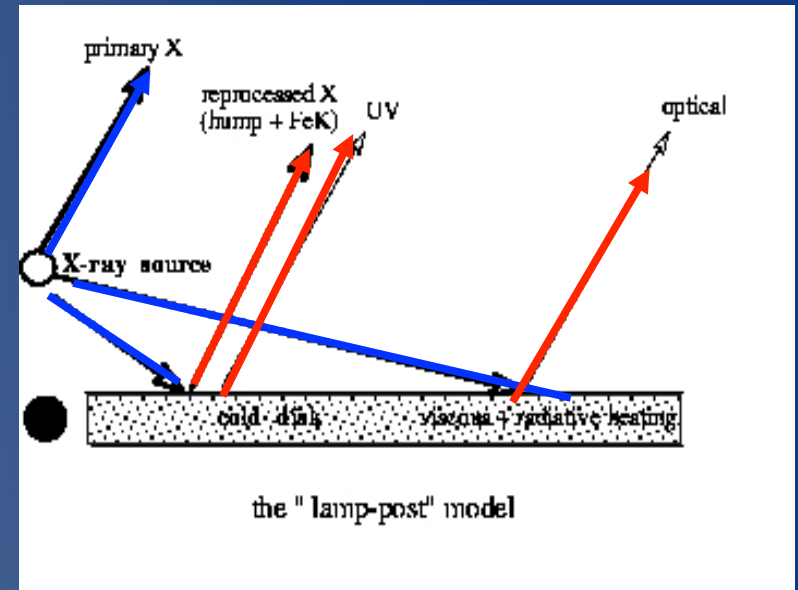
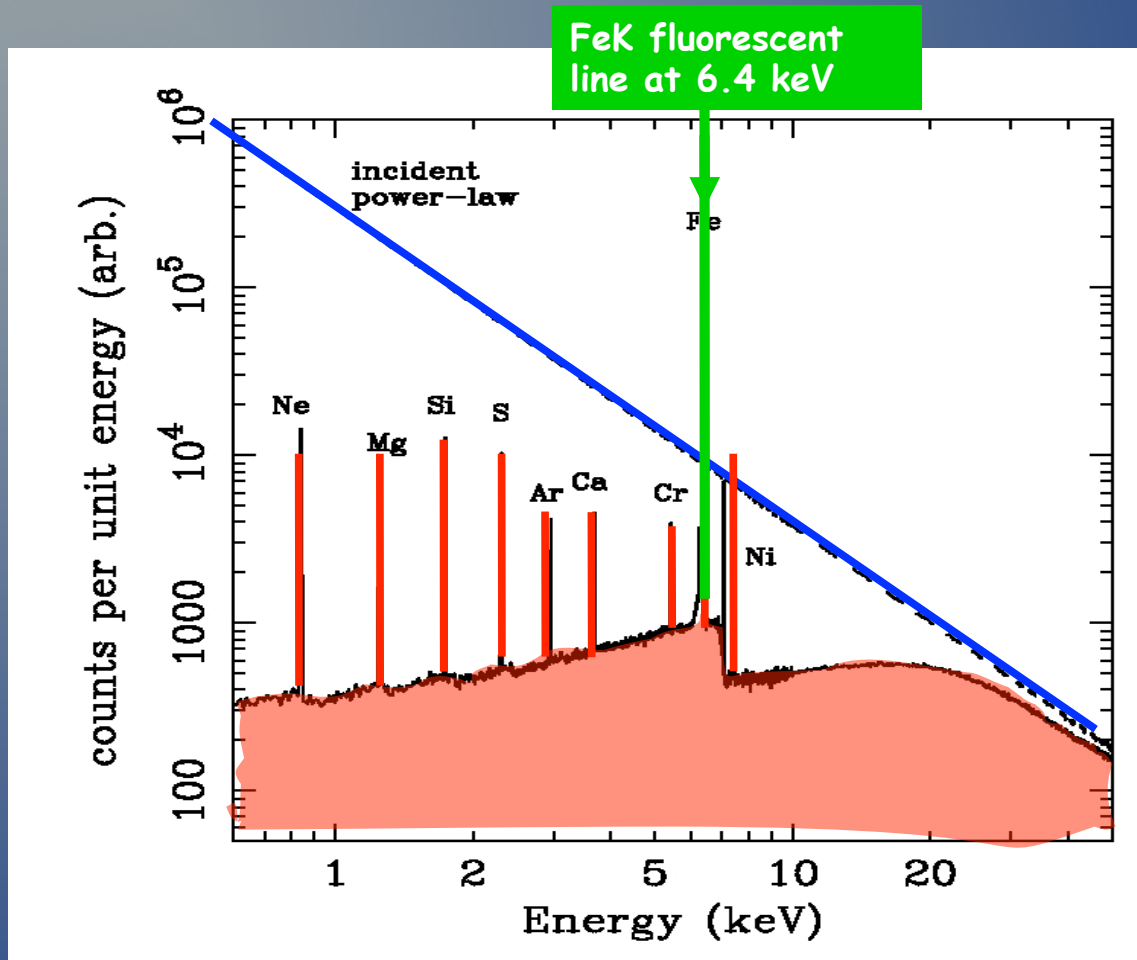


$$\Theta = kT_e/m_e c^2$$

$$\epsilon_{out,1} = (1 + 4\Theta)\epsilon_{in}$$

$$\log f(\epsilon) \propto \ln(1/\tau)/\ln(1 + 4\Theta) \text{ i.e. } f(\epsilon) \propto \epsilon^{-\alpha} \text{ with } \alpha = \ln \tau / \ln(1 + 4\Theta)$$

# III - Reflection component (line + continuum)



(e.g. Reynolds et al. '94)

$\propto$  Inclination

$\propto \Omega/2\pi$  (coverage, isotropy)

$\propto Ab$

Major modifications expected:

a) Ionization effects

b) Relativistic effects

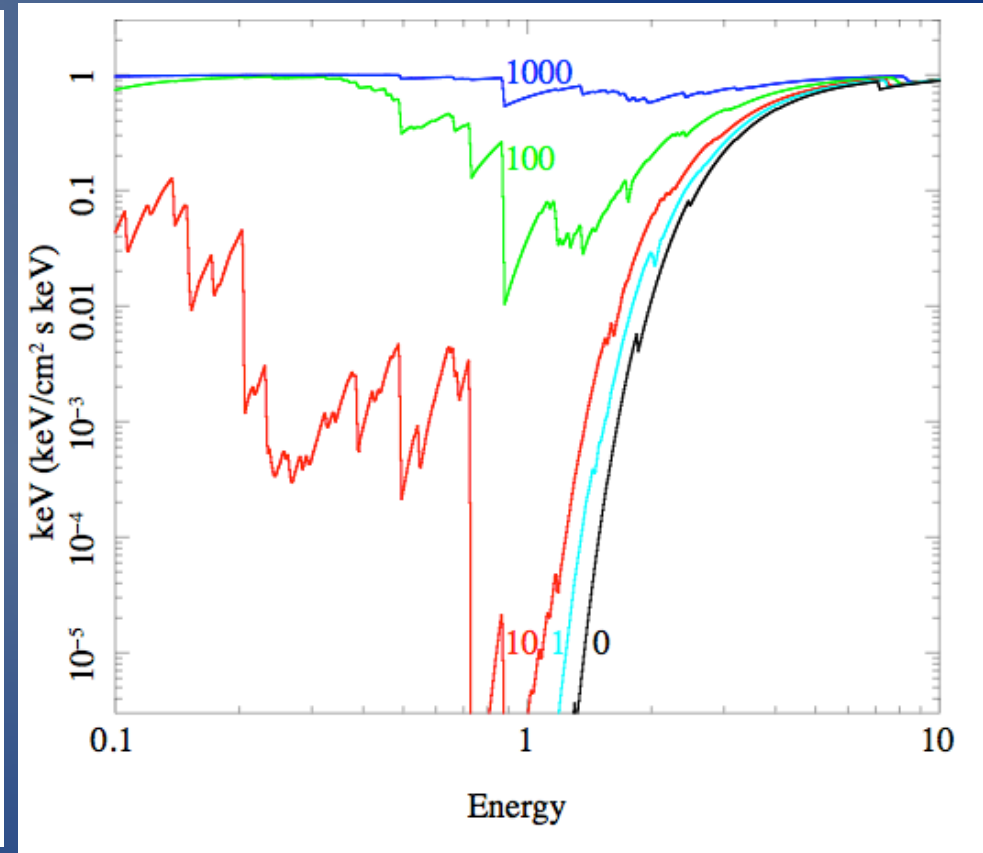
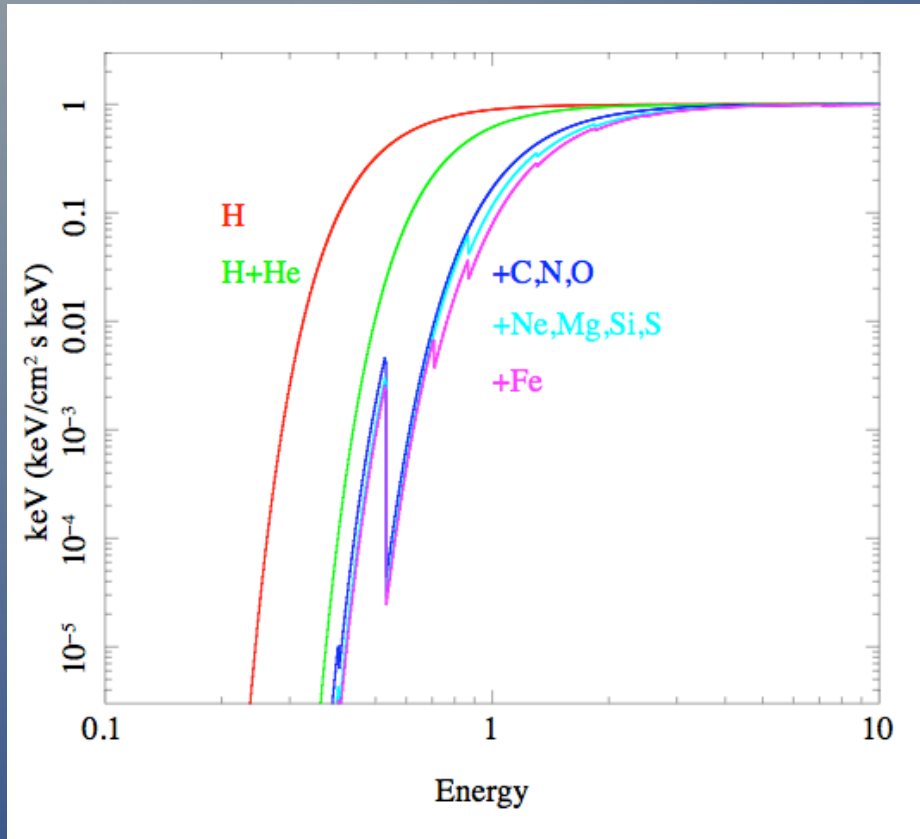
or a combination of both...

# IV - absorption along the line of sight

## Photoelectric absorption

Neutral

Ionized ( $\xi_i = L/nR^{**2}$ )





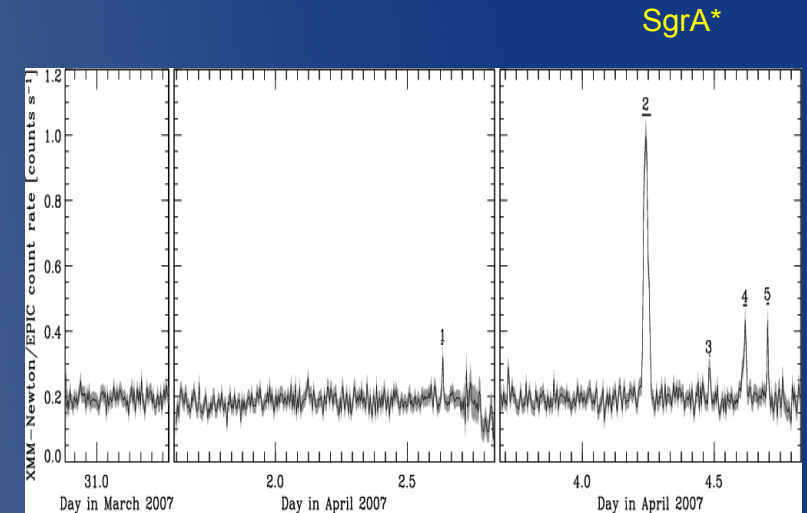
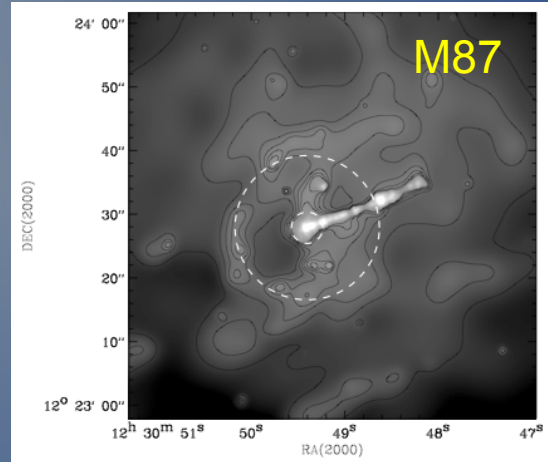
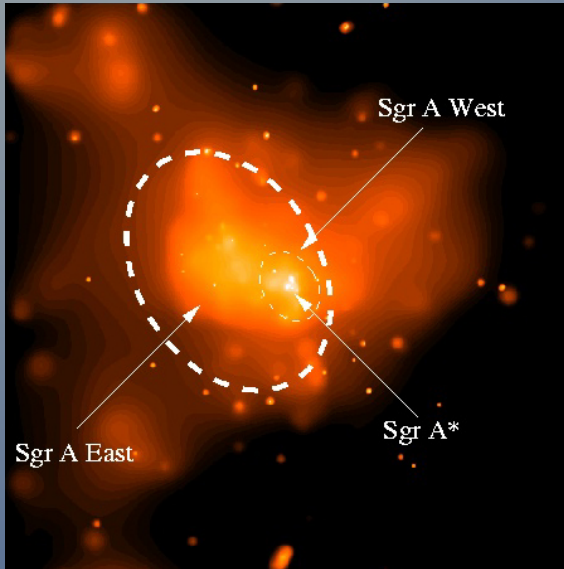
## Model 2

The radiatively  
inefficient model  
(LLAGNs)

# Modello II (LL AGN): X-ray observations - Images and Lightcurves

SgrA\*

## Images + Lightcurves



Low-L and diffuse X-ray source

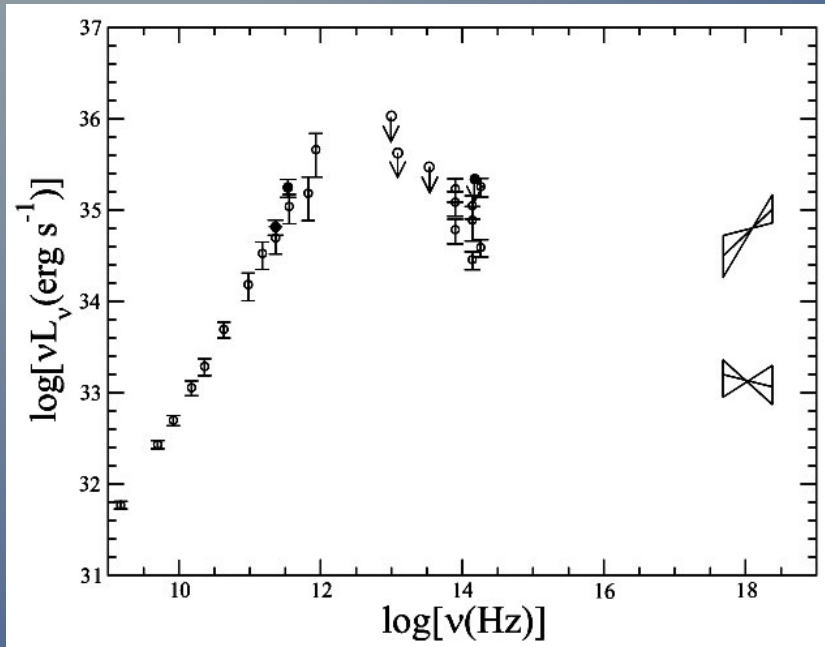


N.B:  $\Delta t \sim 50$  s corresponds to  $1 R_g$  per  $M = 10^7 M_\odot$   
( $\tau \sim R_g/c \sim GM/c^3 \sim 50 M_7 s$ )

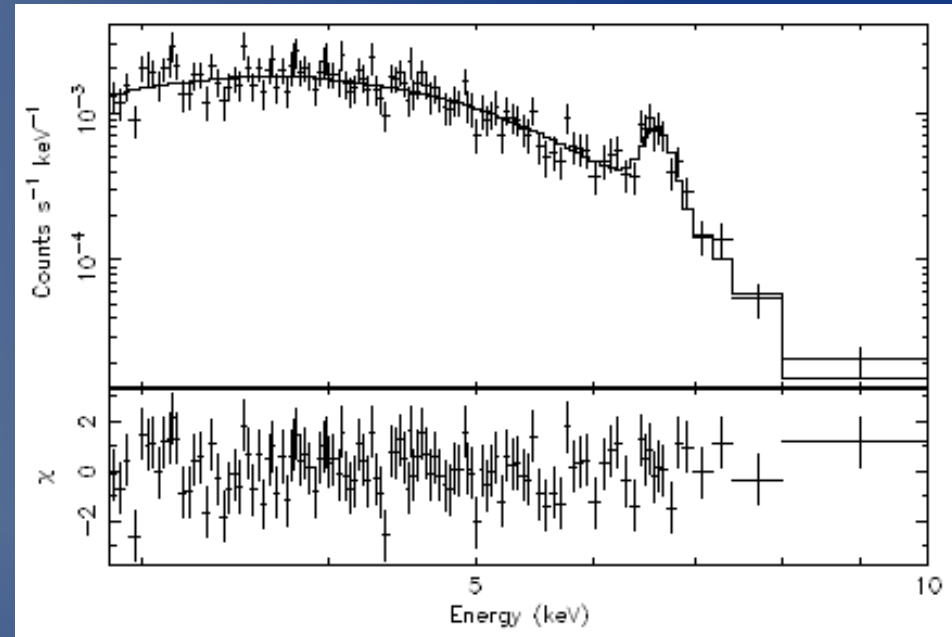
Low-L, likely diffused emission  
+ isolated flares (otherwise quiescent)

## Model II (LL AGN): X-ray observations - Typical Spectra

### Spectra:



$L_x \sim 2 \times 10^{33} \text{ erg/s} < 10^{-11} L_{\text{Edd}}$



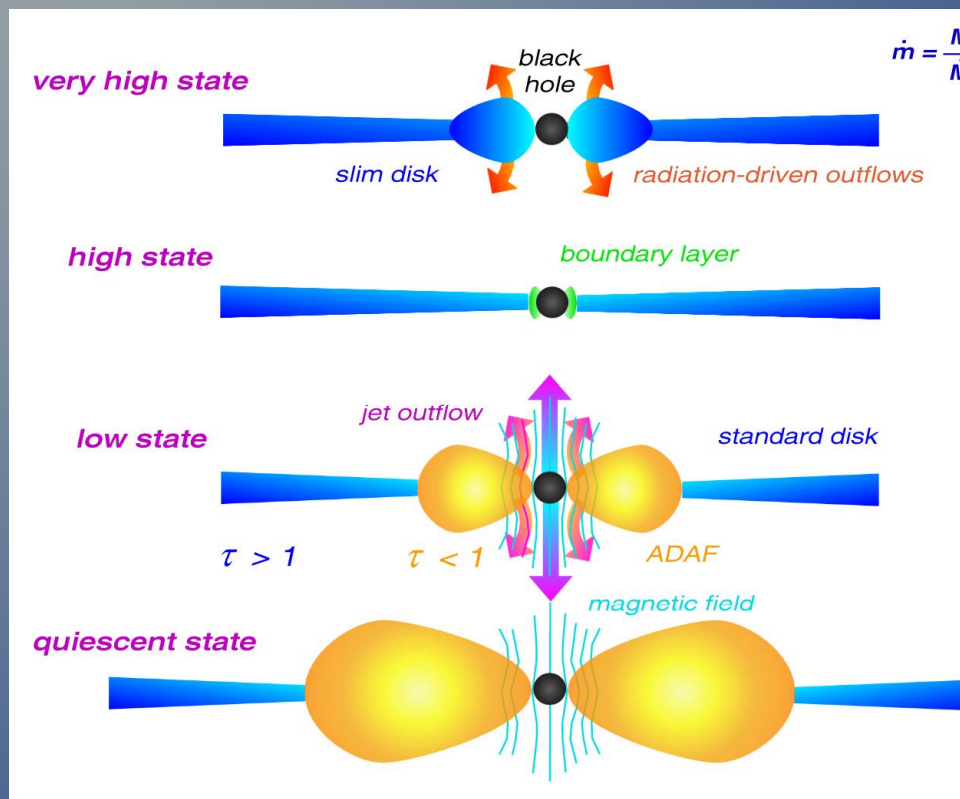
Bremsstrahlung Thermal-like quiescent spectrum



(At least) 2 major spectral components:

1. Synchrotron emission
2. Bremsstrahlung (+ power-laws during flares)

## Model II (LL AGN):



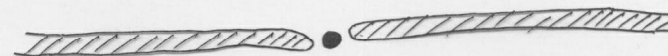
### Simil-ADAFs:

- advection-dominated accretion flow (ADAF)
- radiatively-inefficient accretion flow (RIAF)
- convection-dominated accretion flow (CDAF)
- slim disk
- truncated disk - advective tori (TDAT)
- non-radiative accretion flow (NRAF)

Two types of accretion flows onto a black hole

**Normal thin disk** - for high mass accretion rate

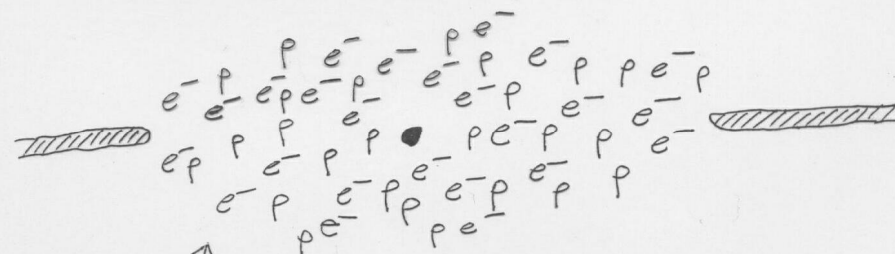
(side view)



- geometrically thin, optically thick accretion disk
- disk efficiently radiates the gravitational potential energy lost as matter spirals inward

**ADAF** - for low mass accretion rate

(side view)



- geometrically thick, optically thin ADAF
- $p$  Temperature much higher than  $e^-$  temperature
- matter inefficient at radiating the lost grav. pot. energy - it appears as thermal motions and is advected into black hole

From N. Brandt (I think)

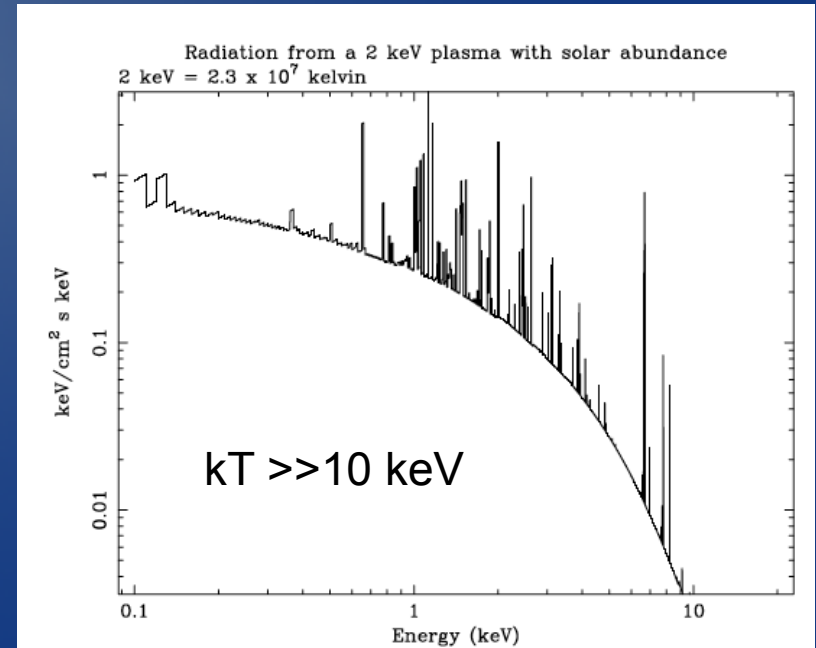
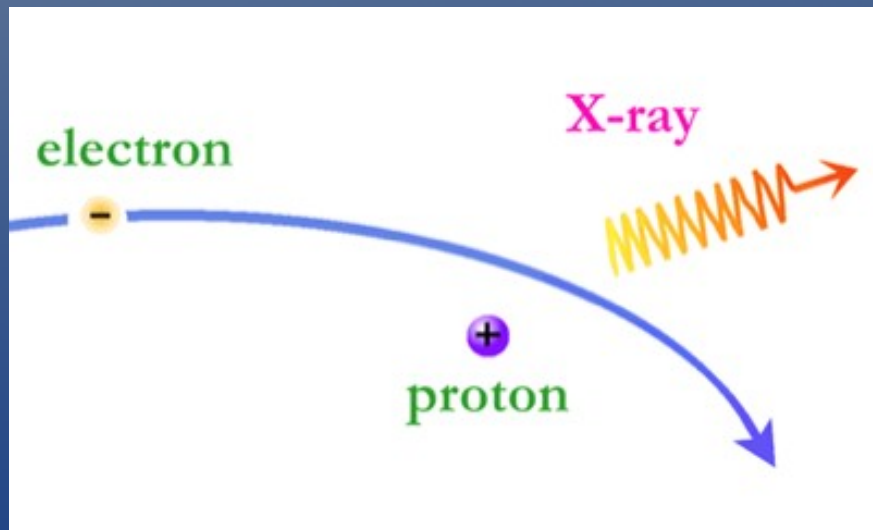


## Modello II (LL AGN): ADAFs model

Synchrotron  
(non-thermal emission)

Lorentz Force

+ Thermal Bremsstrahlung from  
a very hot, optically thin,  
geometrically thick flow



# Summary

After introducing the BH and AGN paradigm, we have reviewed 3 major “models” of AGN:

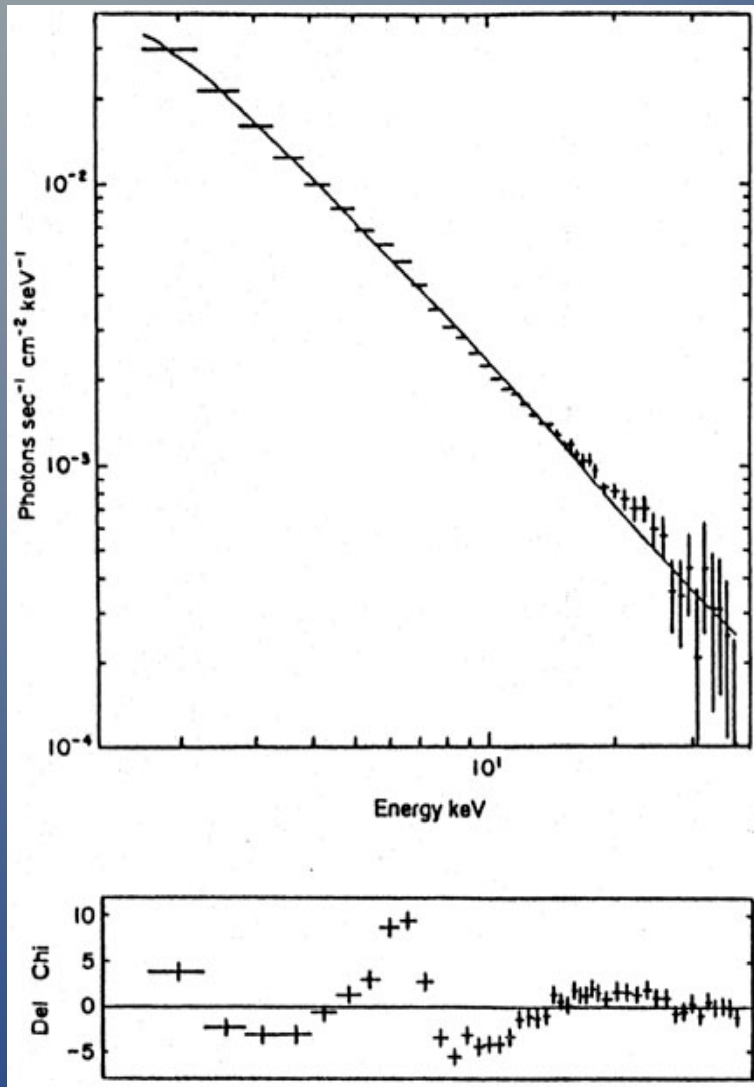
## Model I: 2-phase model (radio-quiet AGNs)

1. Multi-T black-body emission (soft-excess)
2. Thermal Comptonization (power-law)
3. Reflection (FeK line + Compton hump)
4. Absorption (ionized, partially covering, etc.)

## Model II: Inefficient model (LLAGNs)

- ~~1. Synchrotron~~
2. Bremsstrahlung (thermal)

# Power-law spectra: an universal law $\Gamma=1.7$ ?



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consistent with a mean  $\alpha$  of  $0.55 \pm 0.04$  for the hard X-ray slope, constant over variations of an order of magnitude in flux.

(iii) 3C273 is by far the most luminous source in our sample and may represent one extreme of the Seyfert phenomenon. Numerous observations with *EXOSAT* and previous X-ray satellites have shown 3C273 to have a flat spectrum, the observation reanalysed here giving  $\alpha = 0.53^{+0.06}_{-0.11}$ .

(iv) Akn 120 is another bright Seyfert with a well-constrained *EXOSAT* spectrum. The ME data alone showed a slope of  $\alpha = 1.10^{+0.23}_{-0.16}$ , significantly steeper than the mean  $\alpha$  for the sample. Addition of the LE data confirmed the steep slope as  $\alpha = 1.19 \pm 0.08$ . A previous *Einstein* observation of Akn 120 revealed a steep slope consistent with our result (Urry *et al.* 1987).

Fig. 6(a) shows  $\alpha$  versus log of the 2–10 keV luminosity for the ME data and Fig. 6(b) shows the same for the ME + LE data, where error bars on  $\alpha$  cover the 90 per cent confidence range

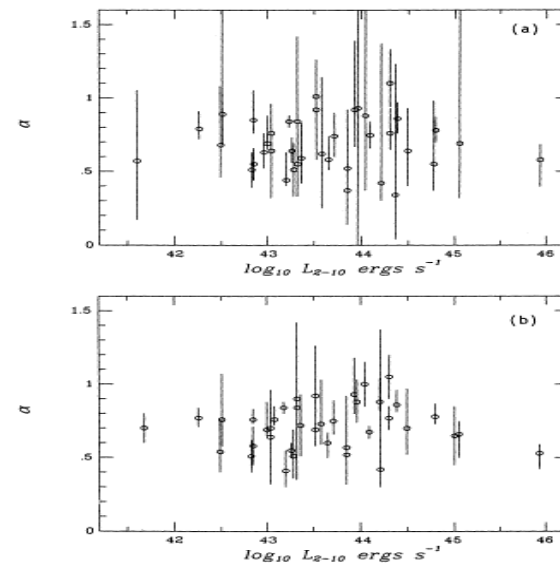


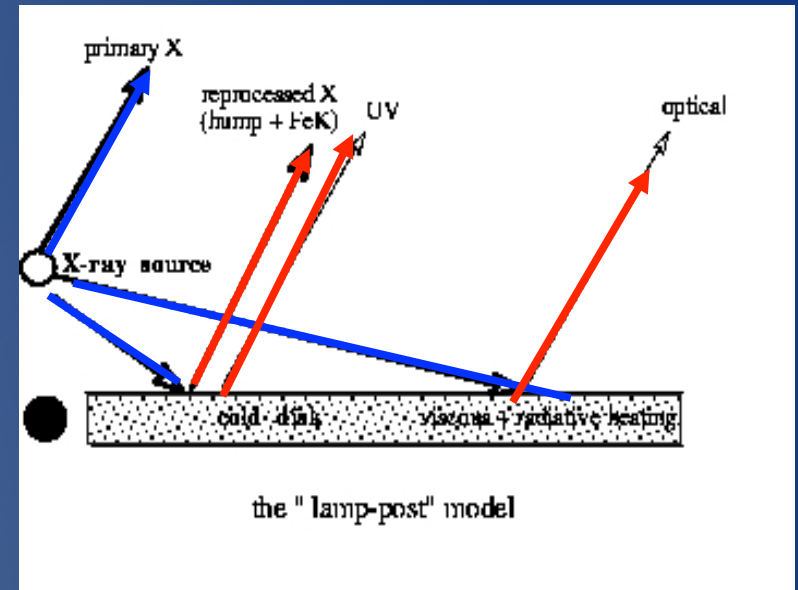
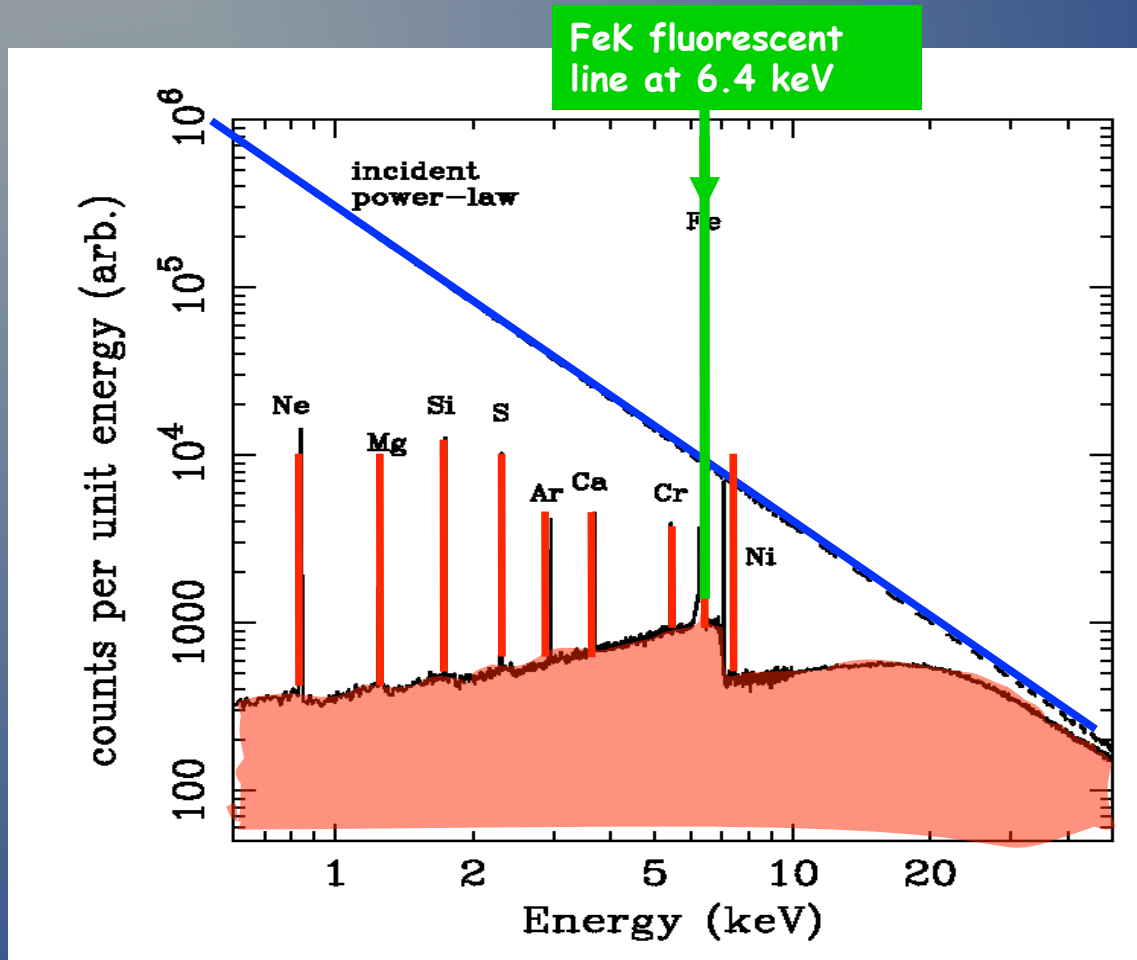
Figure 6. Energy index,  $\alpha$ , versus 2–10 keV luminosity (absorption corrected). Only hard X-ray components are plotted for (a) the ME data and (b) the ME + LE data.

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Nandra & Pounds 1994

Turner & Pounds 1989

# III - Reflection component (line + continuum)



(e.g. Reynolds et al. '94)

$\propto$  Inclination

$\propto \Omega/2\pi$  (coverage, isotropy)

$\propto Ab$

Major modifications expected:

a) Ionization effects

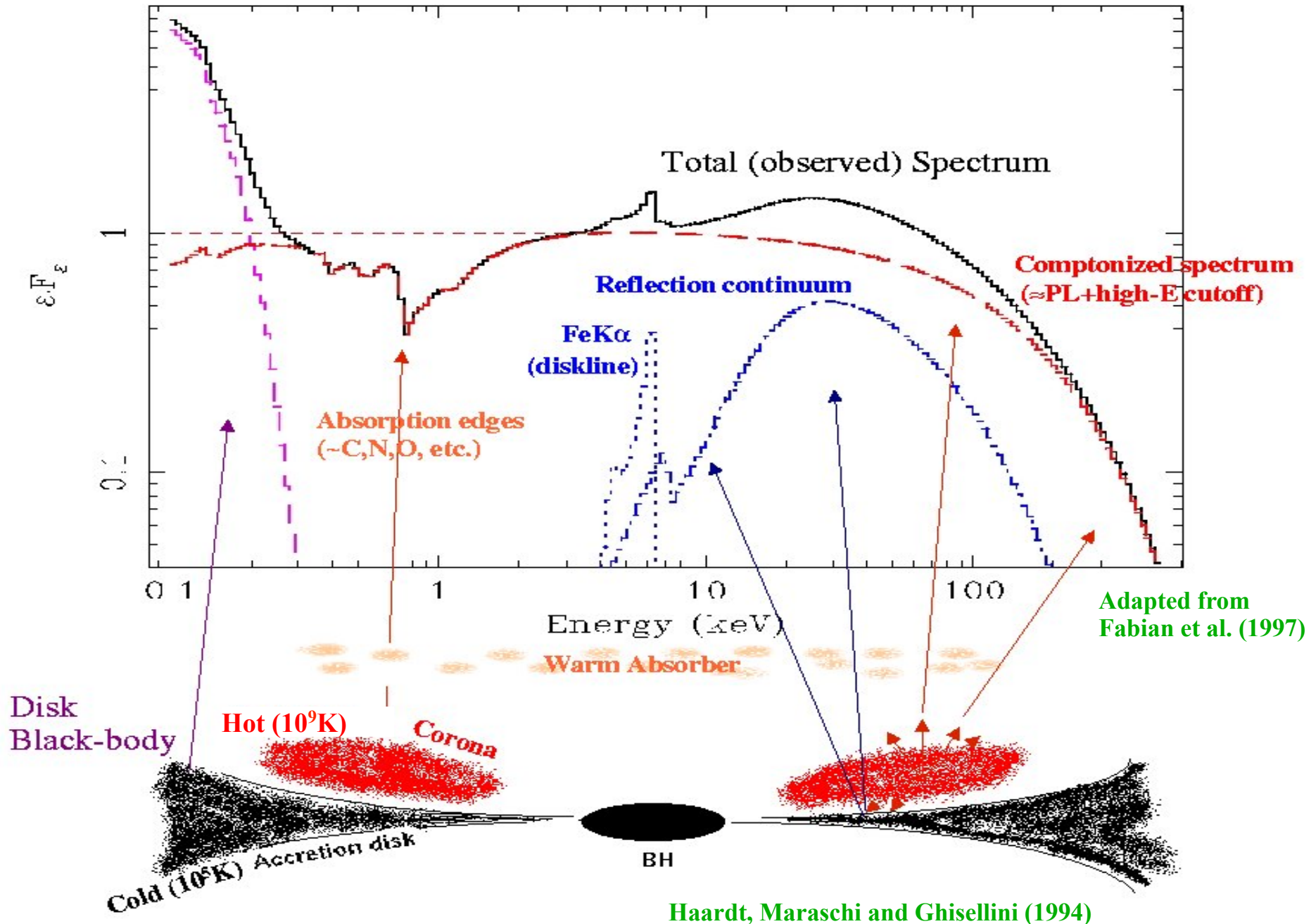
b) Relativistic effects

or a combination of both...



Reflection(s)  
(i.e. accretion)

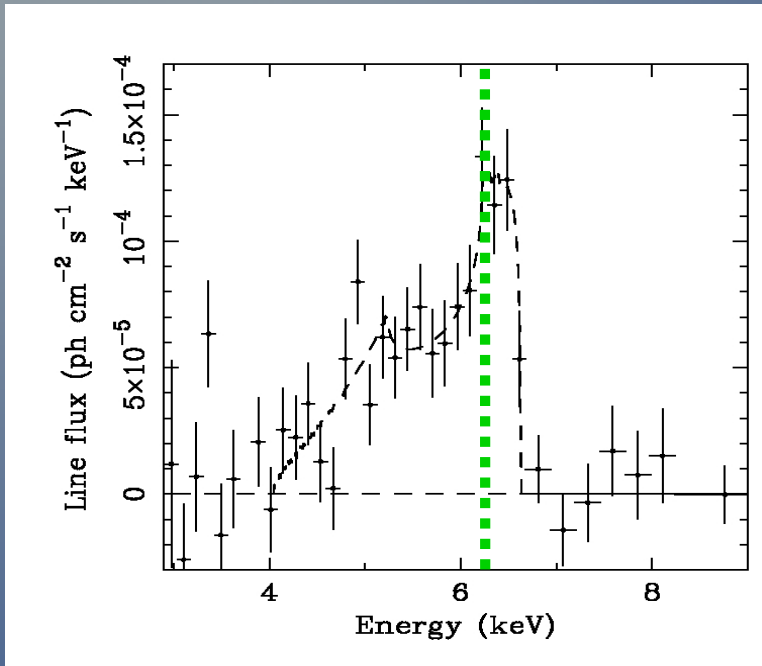
# Typical X-ray Spectrum of a Seyfert 1 Galaxy ↔ Standard two-phase Comptonization model



# Reflection: Observations

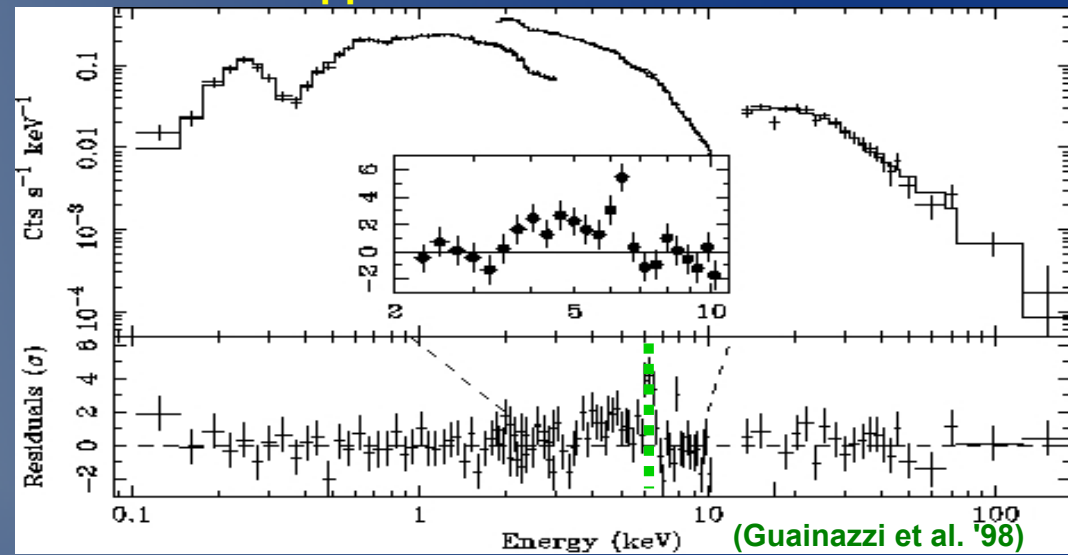
Pre-Chandra & XMM-Newton

ASCA obs. of Sey1 MCG-6-30-15



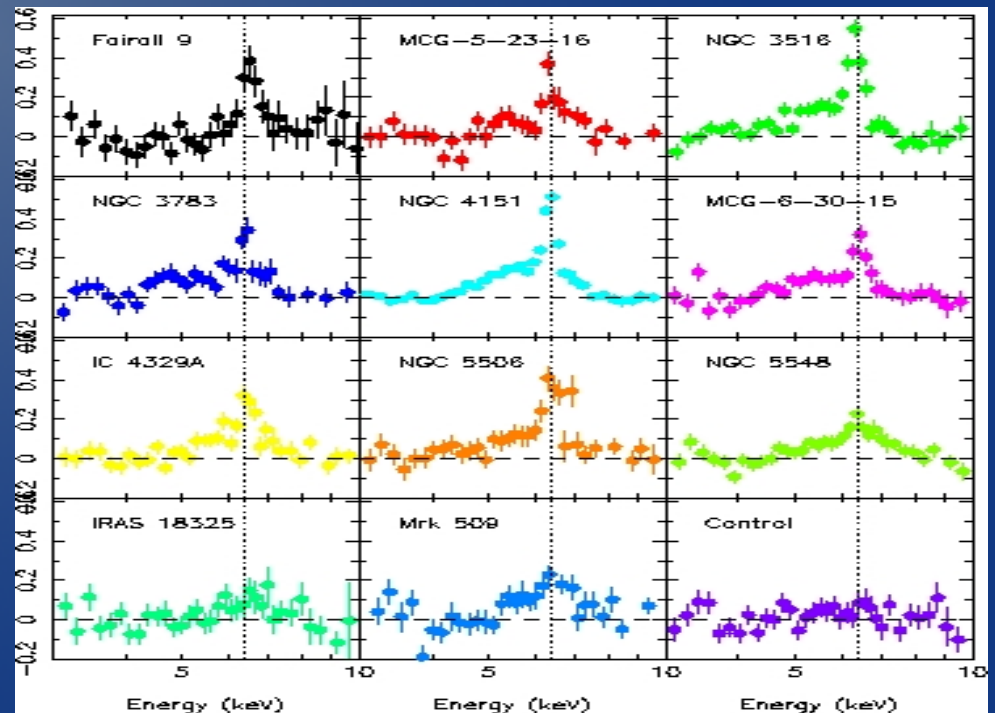
(Tanaka et al. '95)

BeppoSAX obs. of MCG-6-30-15



(Guainazzi et al. '98)

ASCA ---> Broad (relativistic) lines are common, and ubiquitous (?) in Seyfert1s!

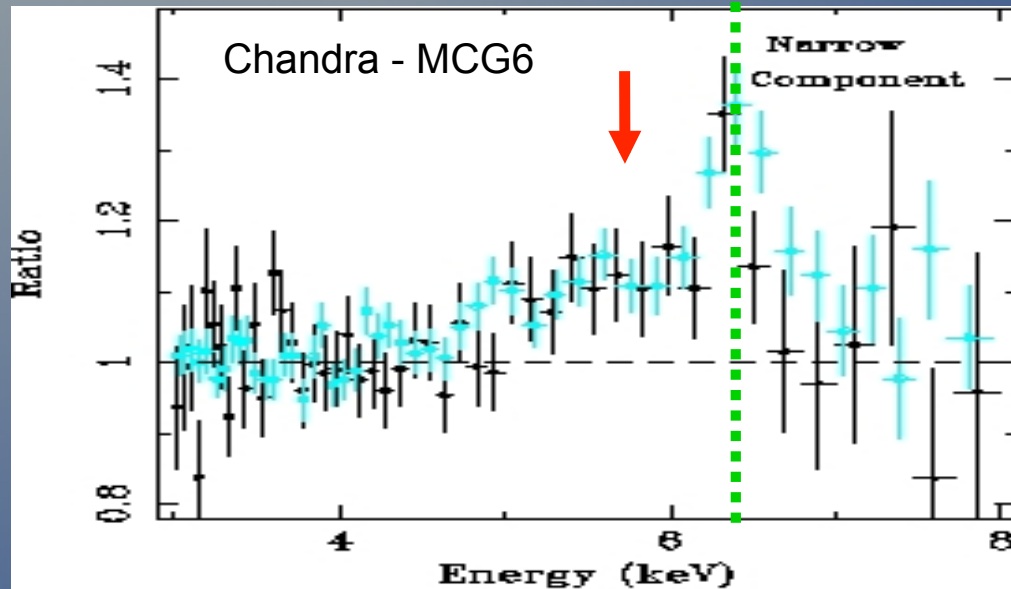


(Nandra et al. '98)

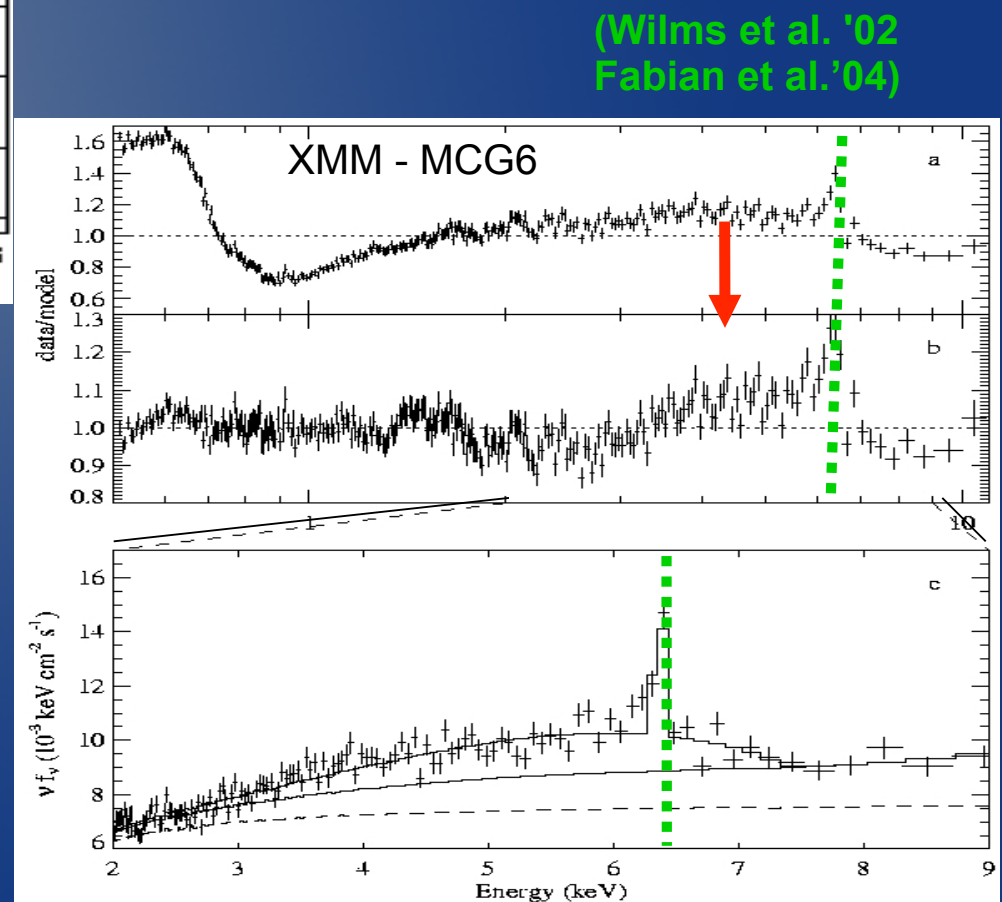
# Reflection: Observations

Post-Chandra & XMM-Newton

Yes, we see broad lines indeed!

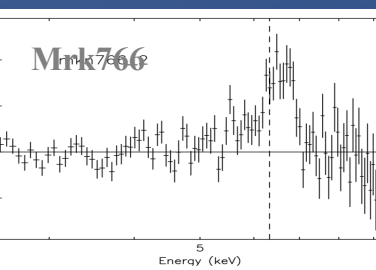
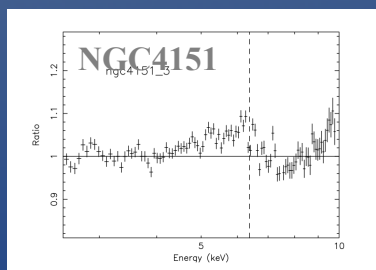
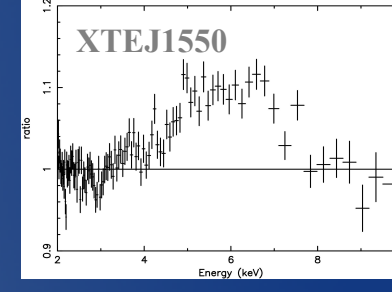
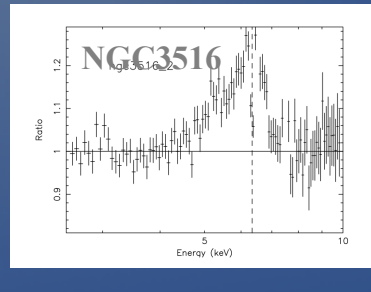
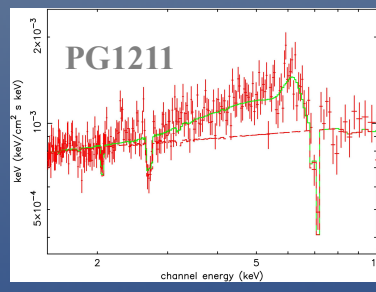
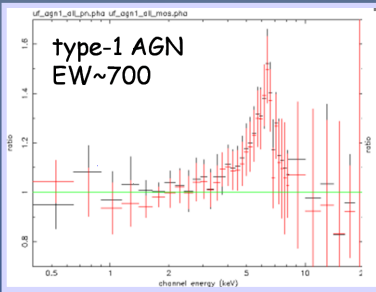
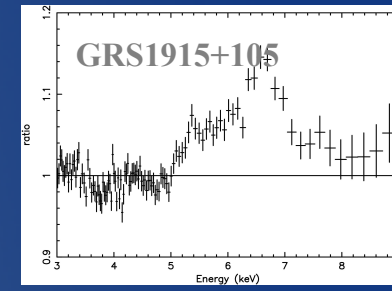
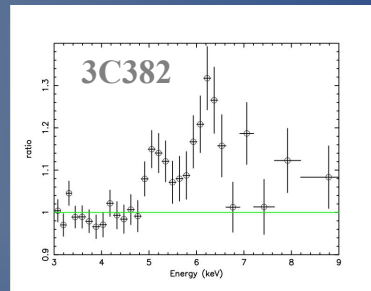
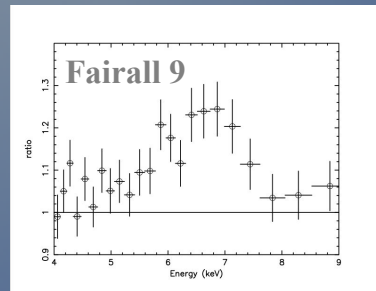
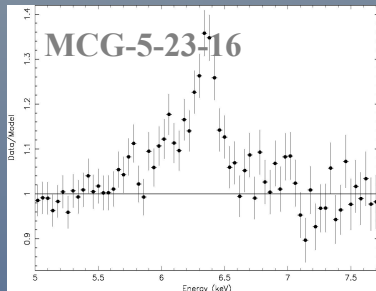
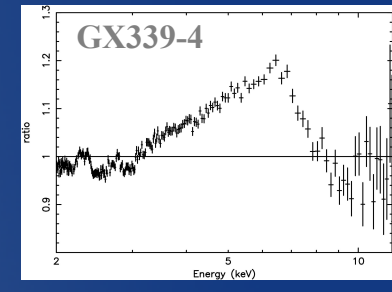
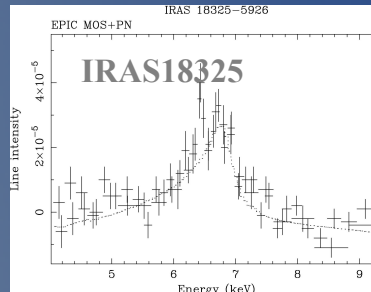
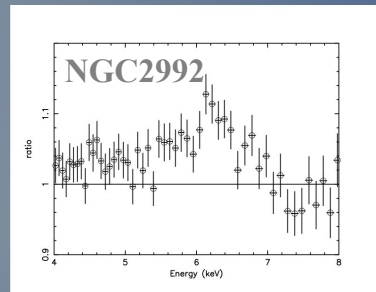
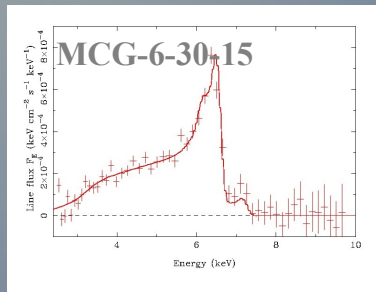


(Lee et al. '02)

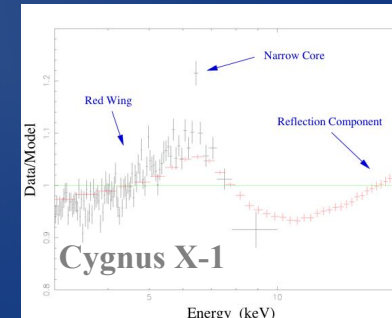


Origin in innermost regions of accretion disk

# Reflection: Re-affirmed importance of broad iron lines



Similar line profiles from stellar-mass and super-massive black hole systems... demonstrates insensitivity of line profile to mass



Nandra et al., 2007,  
De La Calle et al., 2010

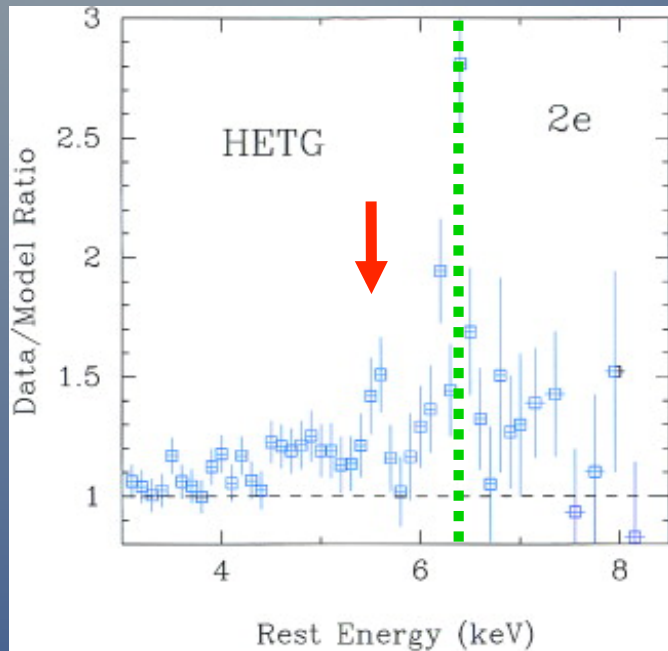


# Reflection: Observations

Post-Chandra & XMM-Newton

Also some narrow redshifted lines...

Chandra – NGC3516



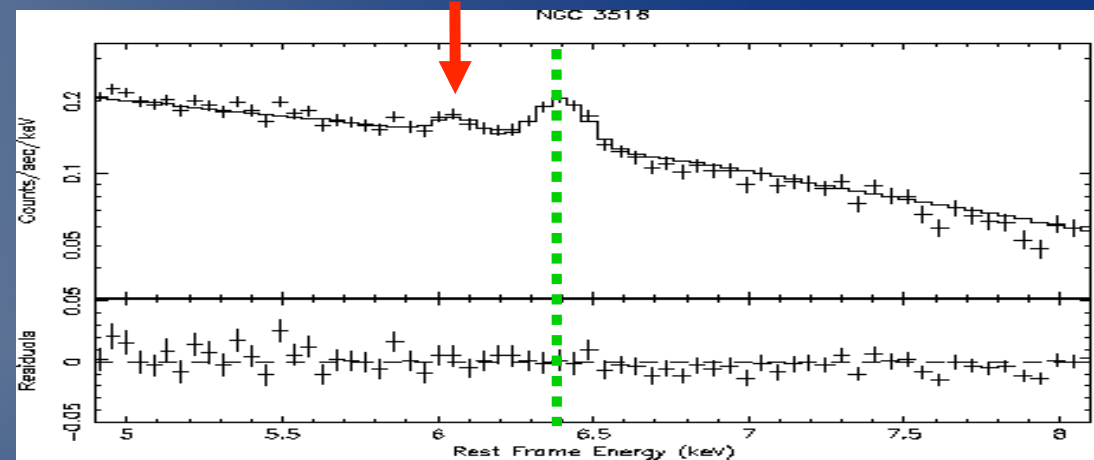
(Turner et al. '02)



Origin in innermost regions of accretion disk+ blob-like structure (or inflowing blobs?)

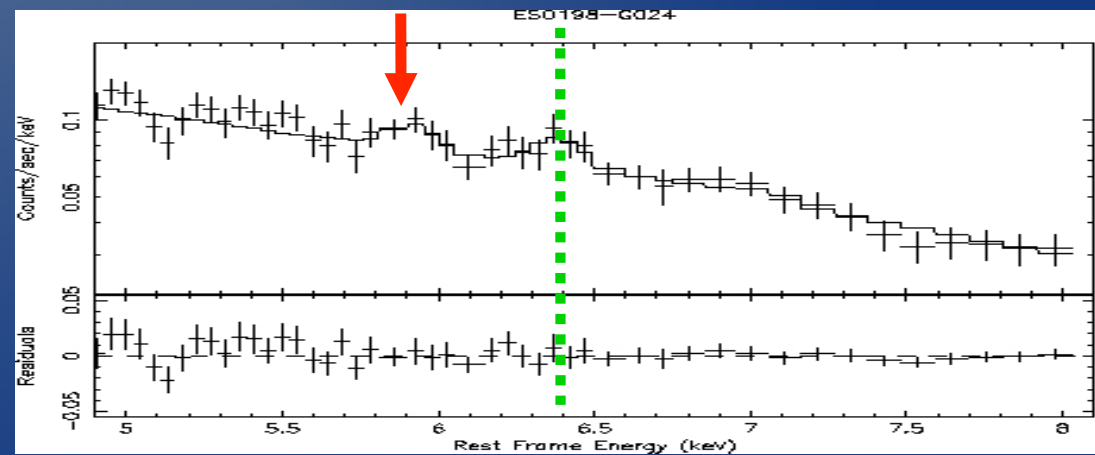
Dovciak et al., 2004

XMM – NGC3516



Bianchi et al., 2004

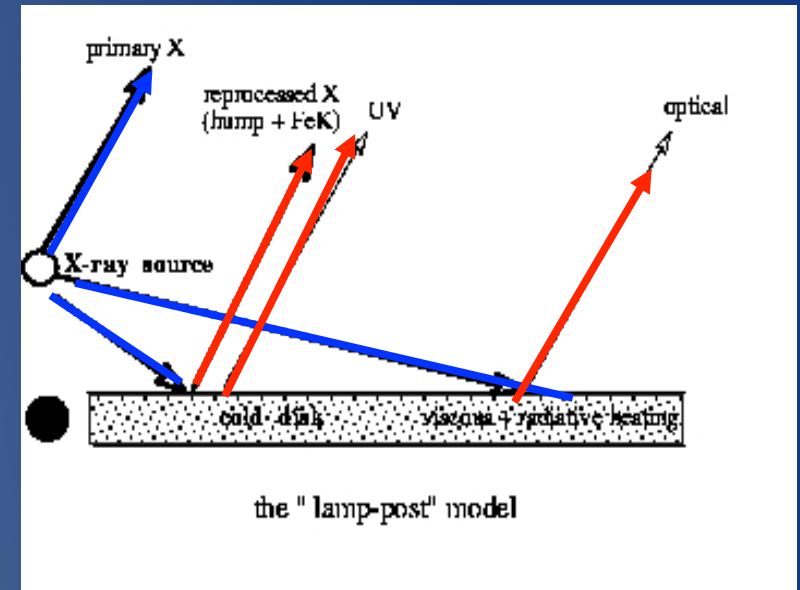
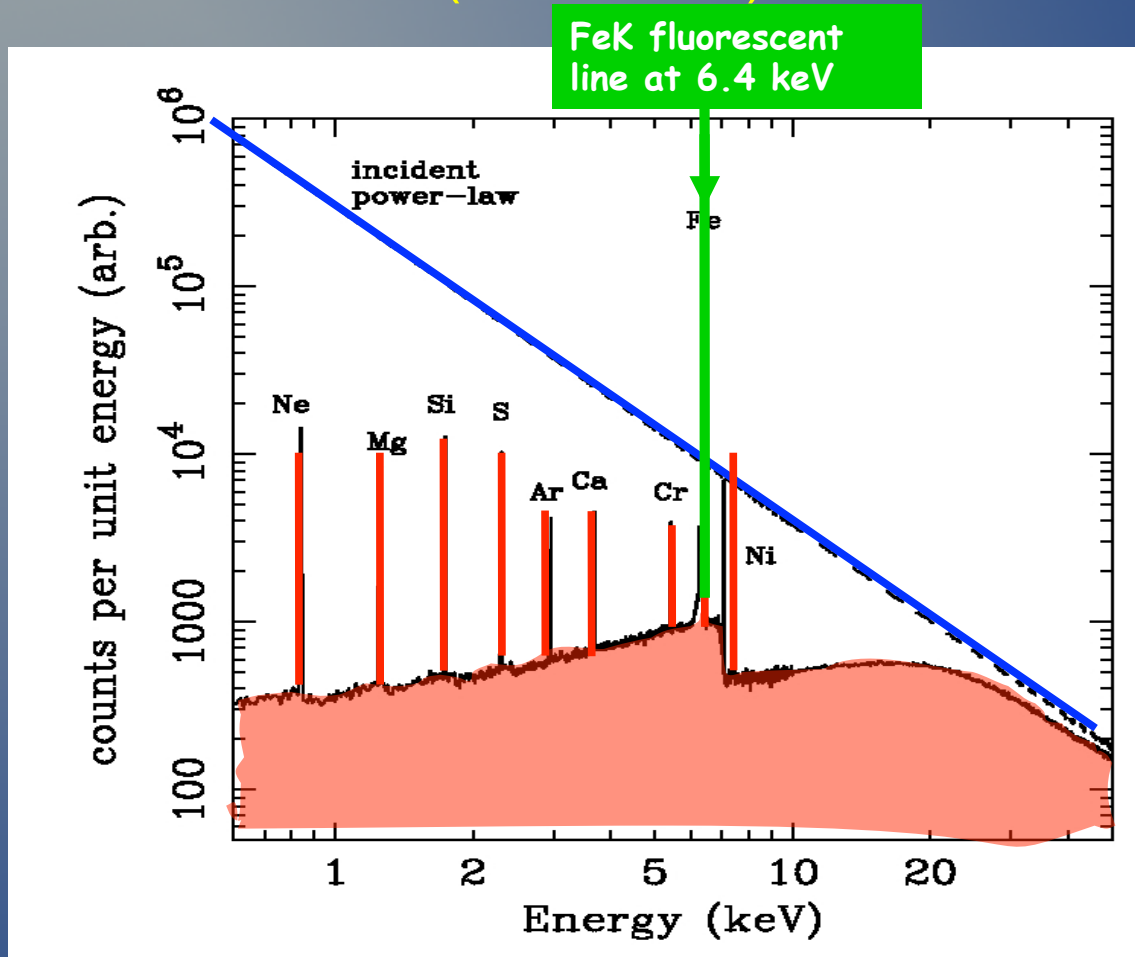
XMM – ESO198-G024



Guainazzi et al., 2003

## Reflection: Interpretation

We understand (theoretical) reflection models... don't we? ;-)



(e.g. Reynolds et al. '94)

$\propto$  Inclination

$\propto$   $\Omega/2\pi$  (coverage, isotropy)

$\propto$  **Ab**

Major modifications expected:

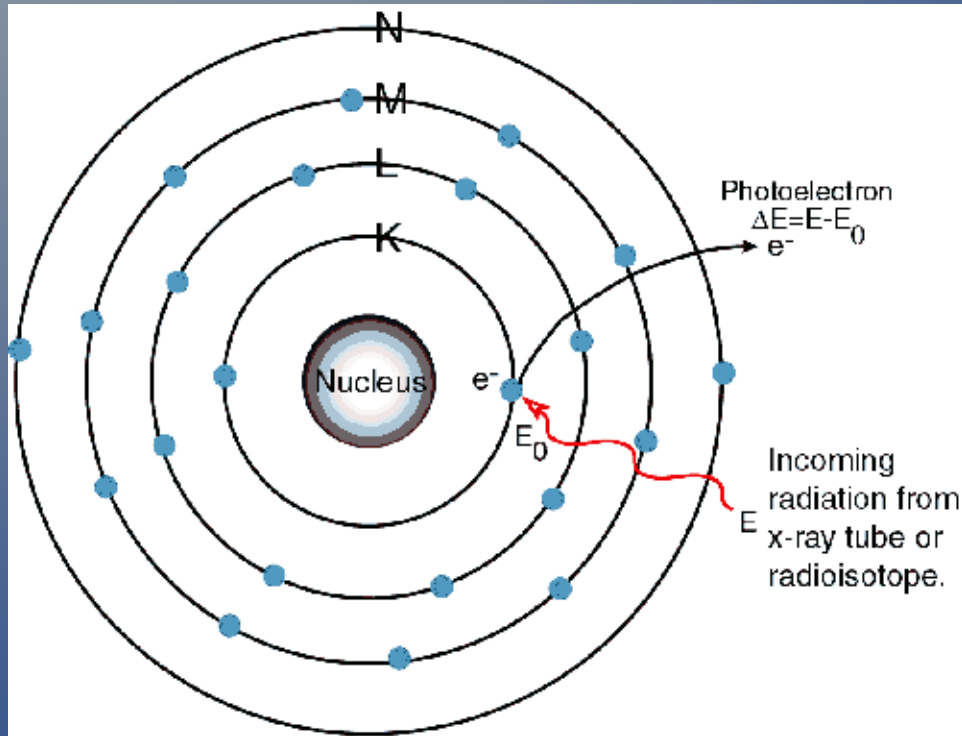
a) Ionization effects

b) Relativistic effects

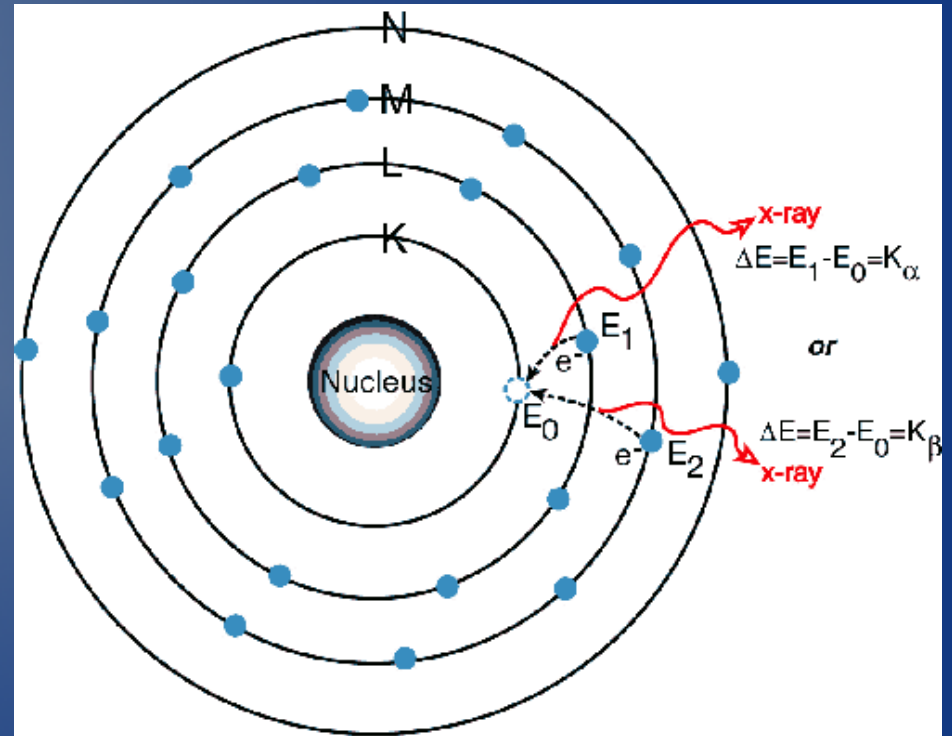
or a combination of both...

# Reflection: (Fe) Fluorescence Line

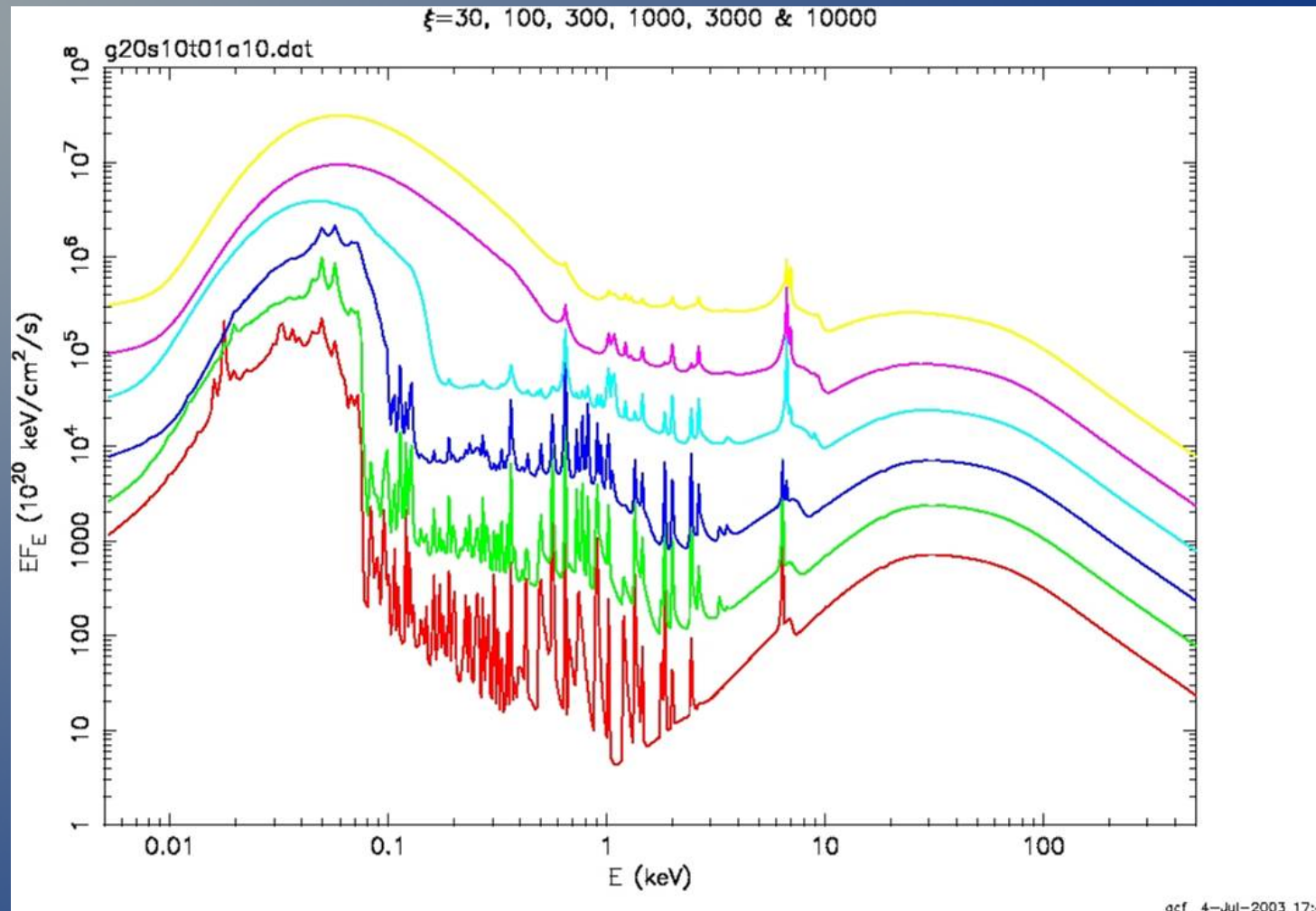
## Photoelectric Absorption



## Fluorescence (+ Auger for 60%)



## Reflection: A- Ionization effects



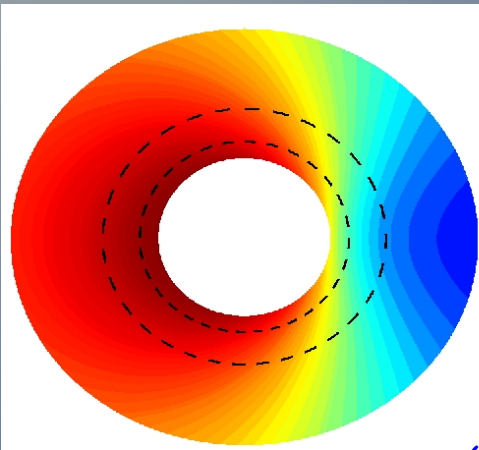
Major variations:

- 1) FeK energy ( $\uparrow$ )
- 2) FeK intensity ( $\downarrow, \uparrow, \downarrow$ )
- 3) Soft lines intensity/energy ( $\uparrow, \downarrow$ )

$$\xi = L/nR^2$$

Ballantyne & Fabian '02, Ross & Fabian '93, '05,  
Young+, Nayakshin+, Ballantyne+, Rozanska+, Dumont+

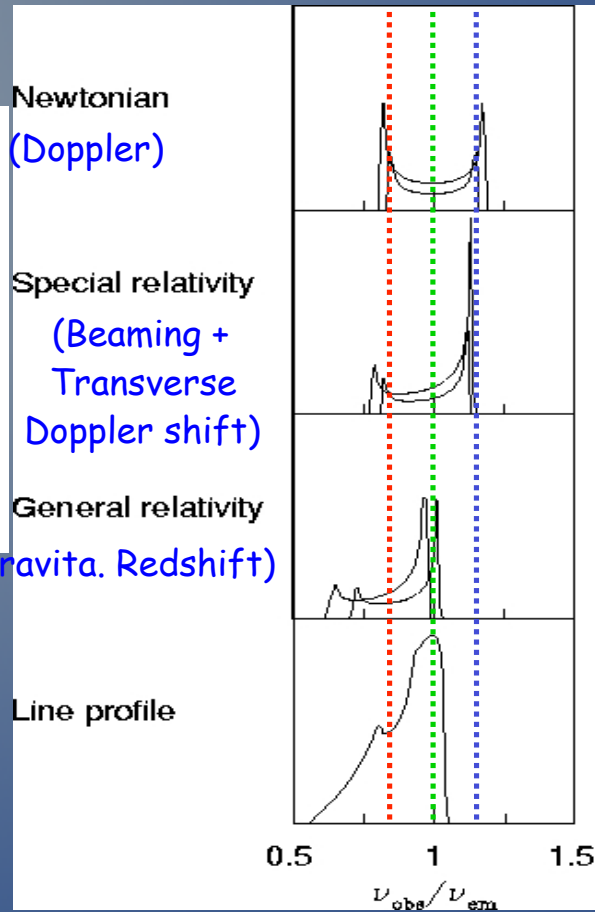
# Reflection: B - Relativistic effects



Newtonian  
(Doppler)

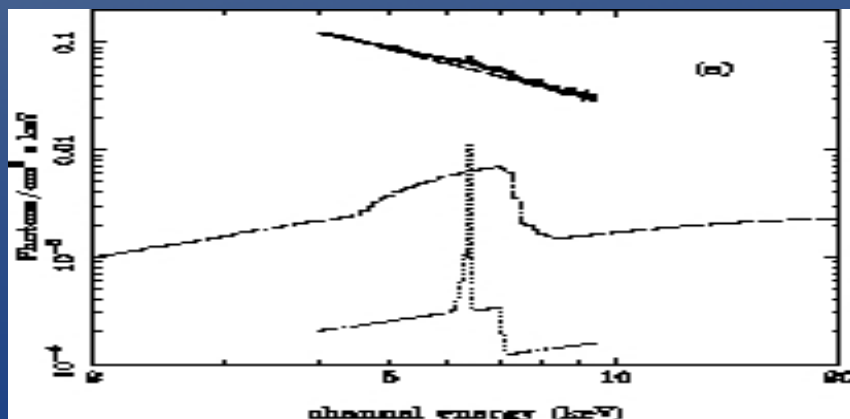
Special relativity  
(Beaming +  
Transverse  
Doppler shift)

General relativity  
(Gravita. Redshift)

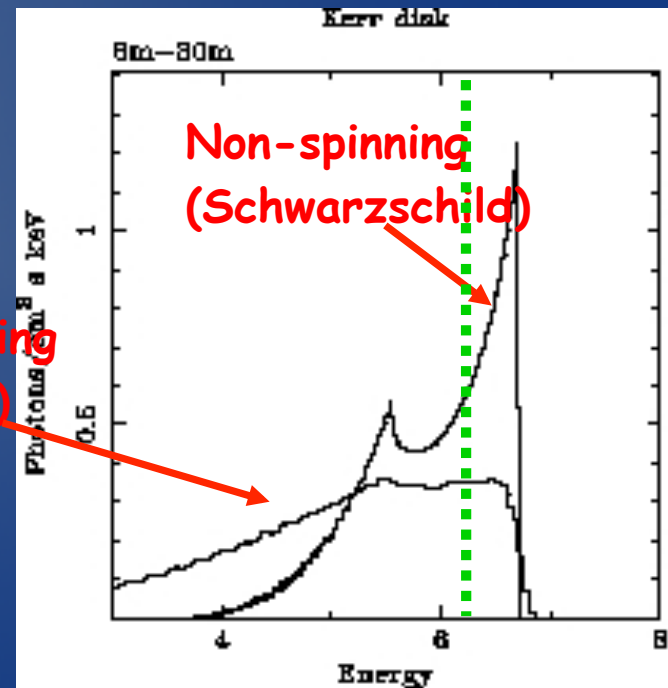
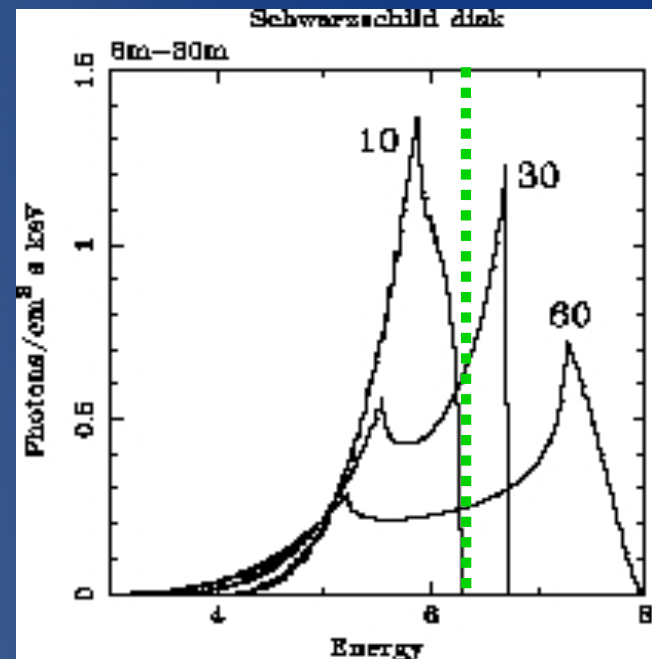


(e.g., Fabian et al. '89)

N.B: Not only relativistic lines, but also reflection continuum...



(Done & Zycki, '98)



(Fabian et al. '00)



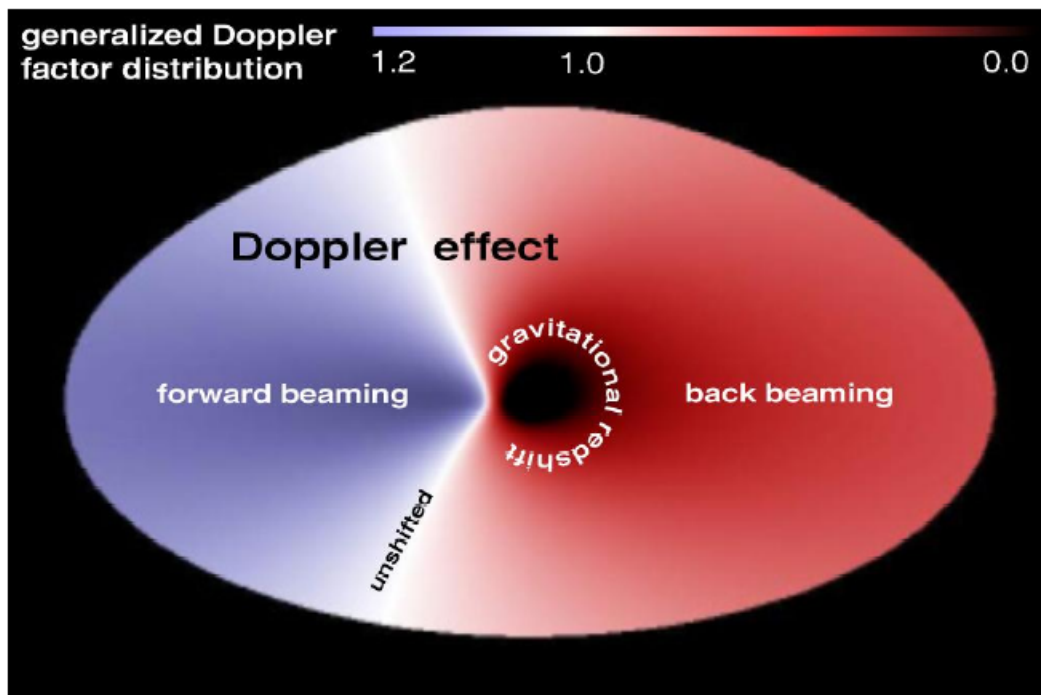


Figure 6.2: Simulated disk image around a central Kerr black hole color-coded in the generalized Doppler factor  $g$ . The distribution illustrates redshift  $g < 1$  (*black to red*), no shift  $g = 1$  (*white*) and blueshift  $g > 1$  (*blue*). Regions of Doppler effect, beaming and gravitational redshift are marked. The inclination angle amounts  $i = 60^\circ$ .

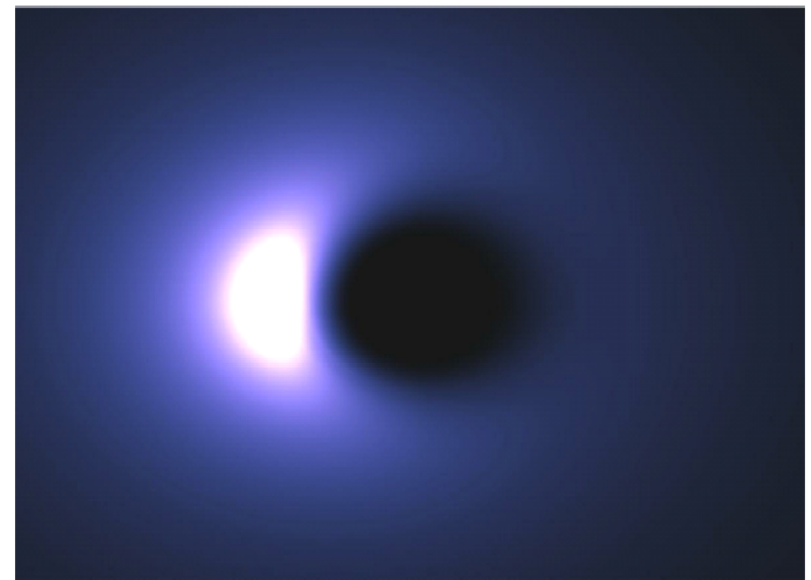
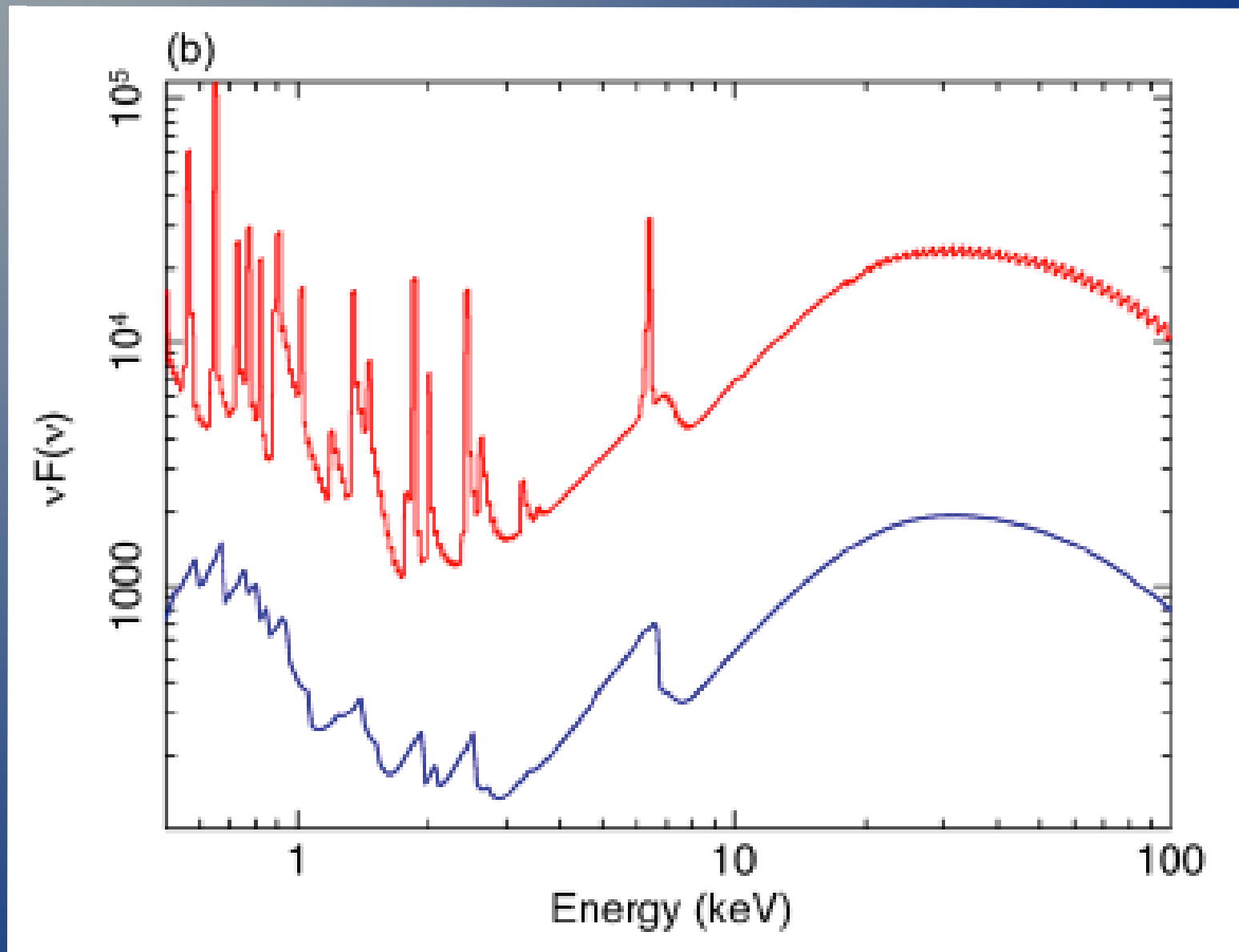
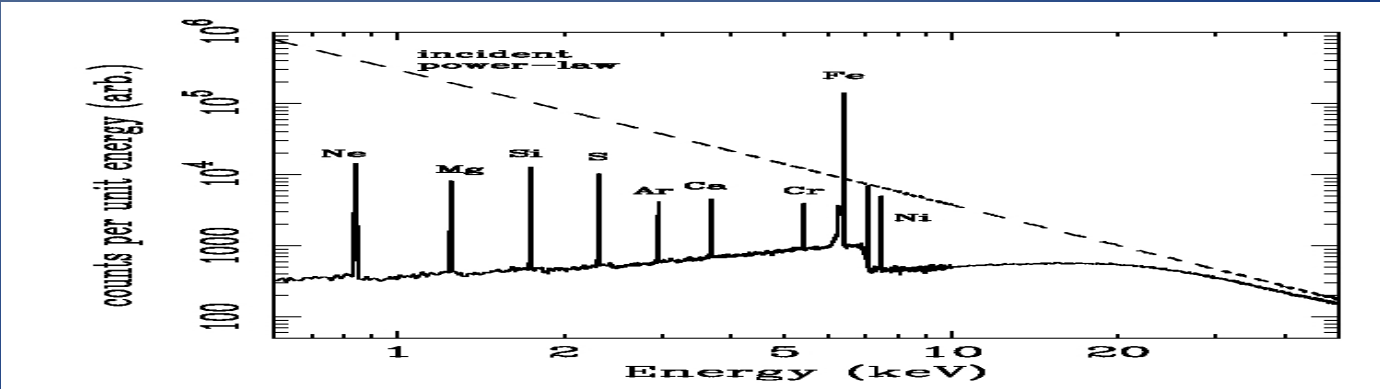
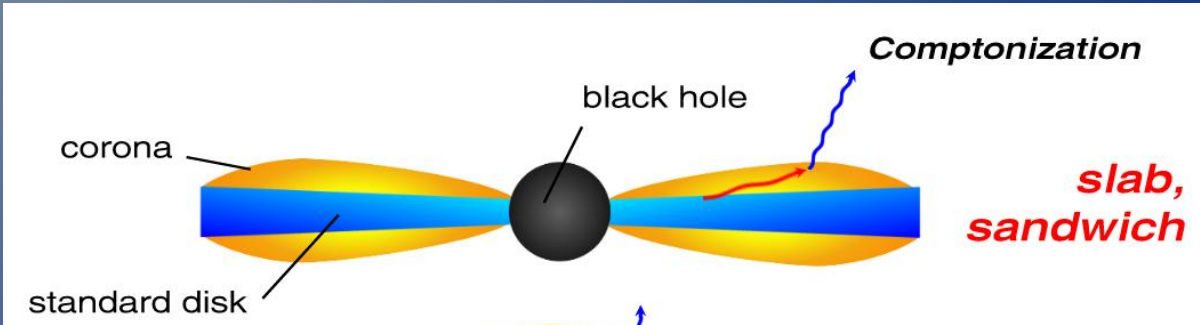
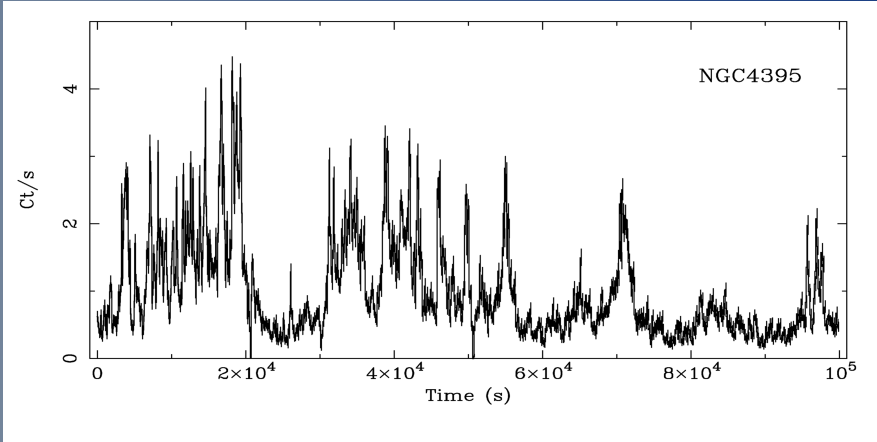


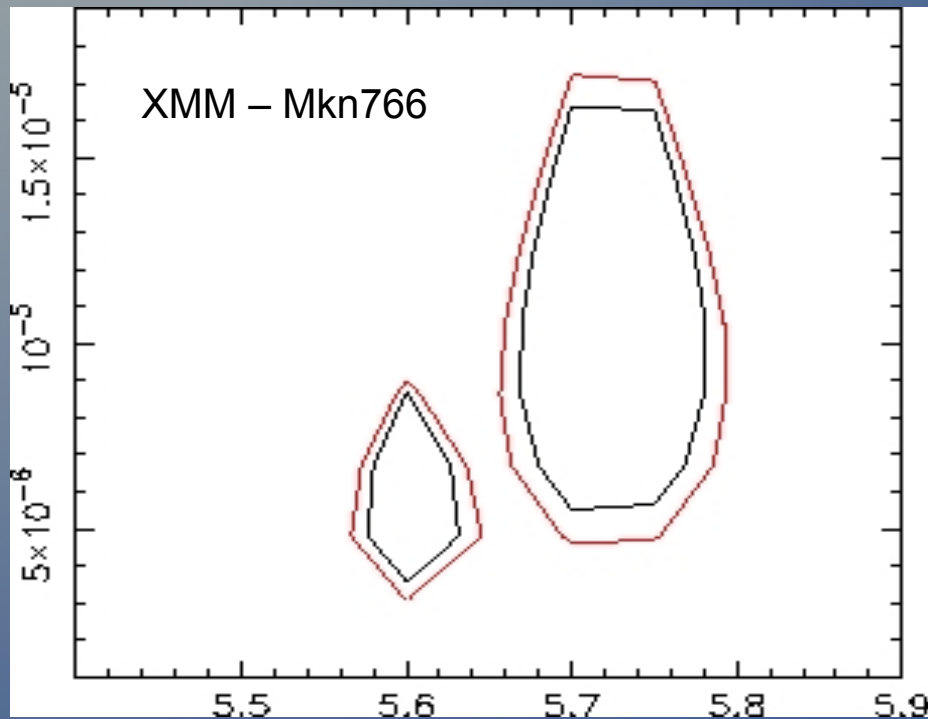
Figure 6.3: Simulated appearance of a uniformly luminous standard disk around a central Kerr black hole,  $a \simeq 1$ . The emission is color-coded and scaled to its maximum value (*white*). The disk is intermediately inclined to  $i = 40^\circ$ . The forward beaming spot of the counterclockwise rotating disk is clearly seen on the left whereas the right side exhibits suppressed emission due to back beaming. The black hole is hidden at the Great Black Spot in the center of the image.

## Reflection: C - Ionization + relativistic effects

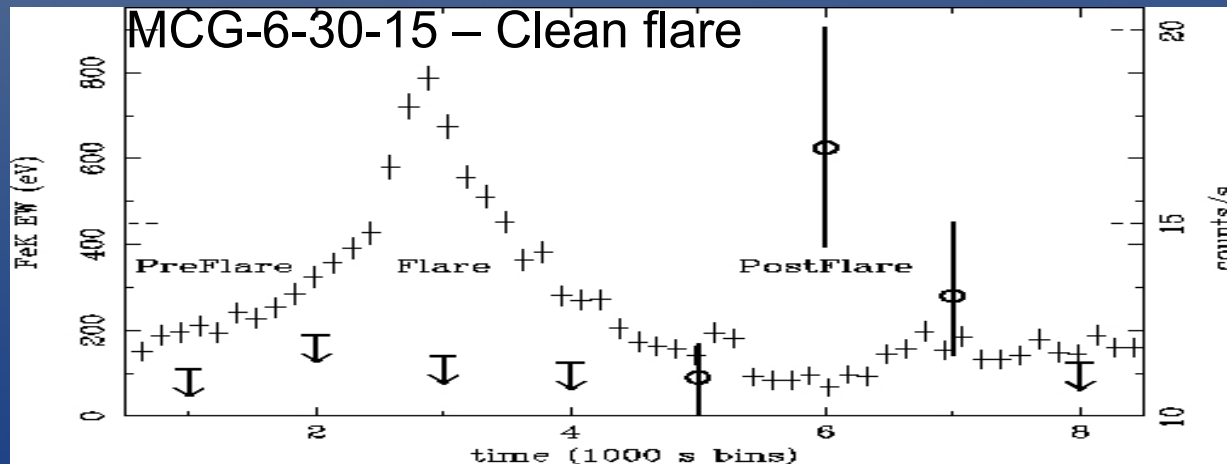
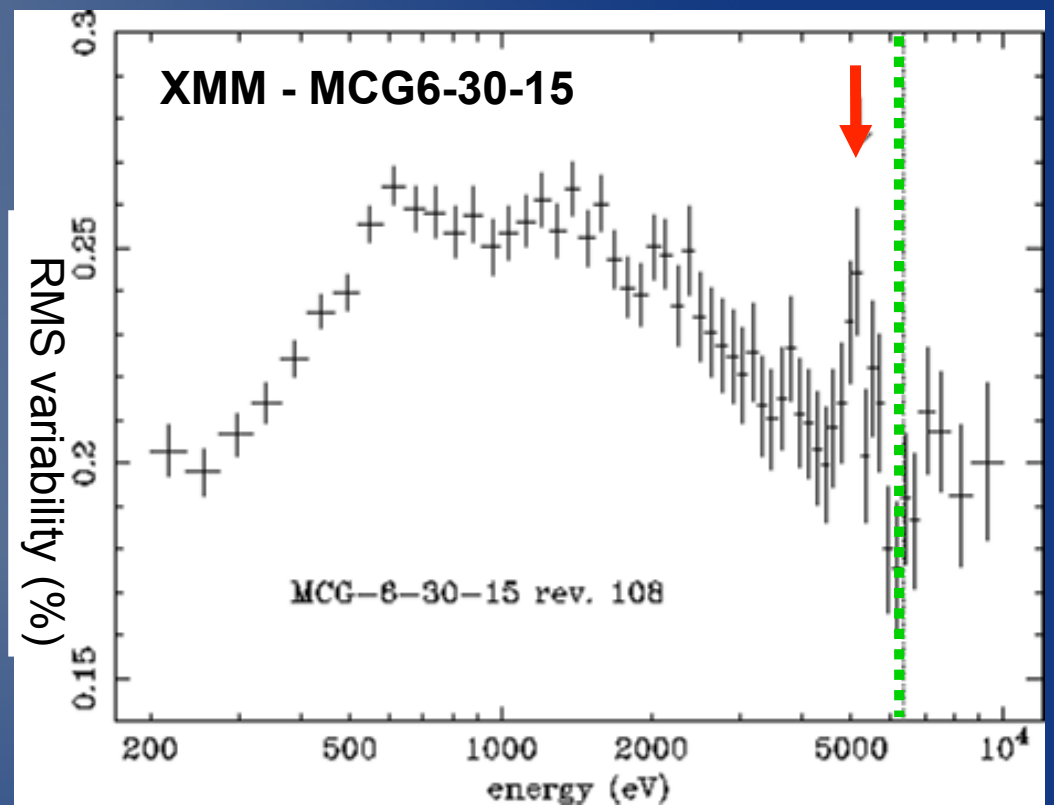




...other independent evidence of FeK line variability...



Turner et al., 2003

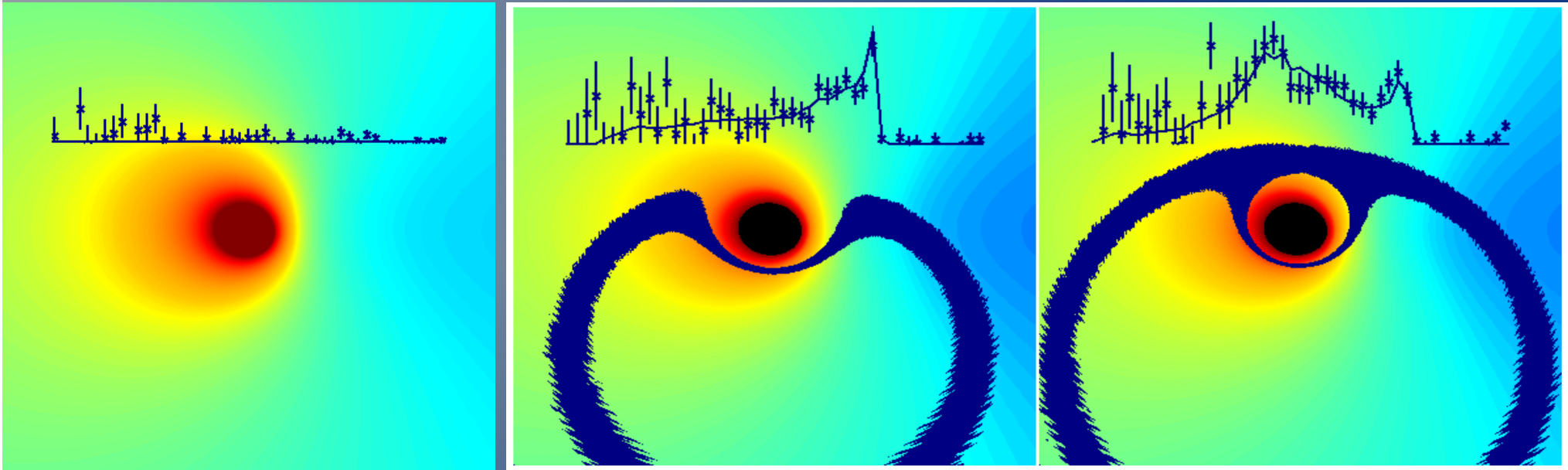


Ponti et al., 2004, (and INAF press-release)

Origin in innermost regions of accretion disk

# Reflection: Reverberation mapping - simulation

...The idea would be to perform FeK (disk)line reverberation/echo mapping...

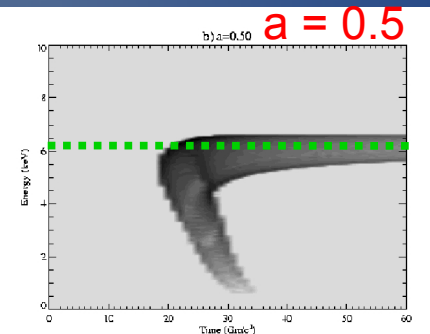
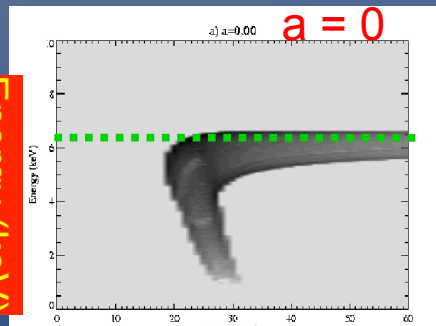


Transfer function  
for a single flare:

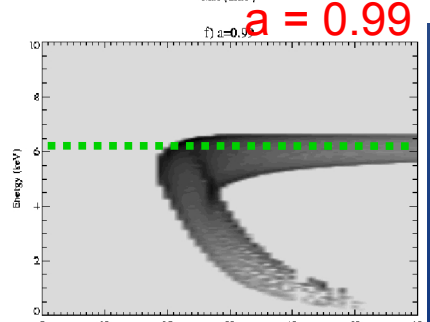
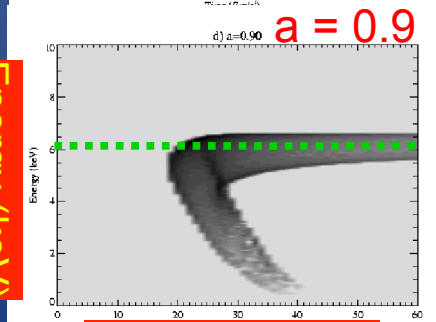


M and a !

Energy (keV)  
2  
6



Energy (keV)  
2  
6



Time (500 s/bin)

(Reynolds '00)

(But see also:  
Stella '90,  
Matt & Perola '92,  
Campana & Stella '93)

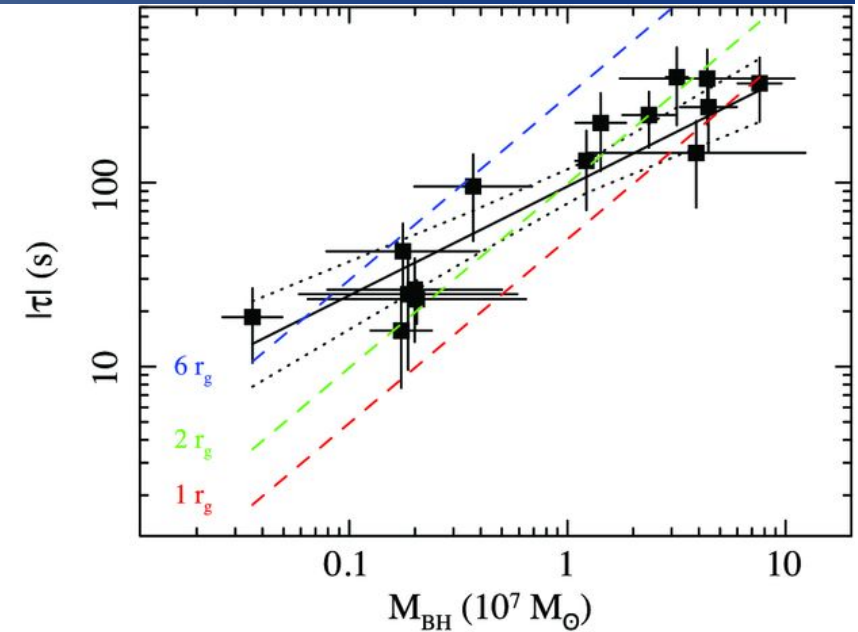
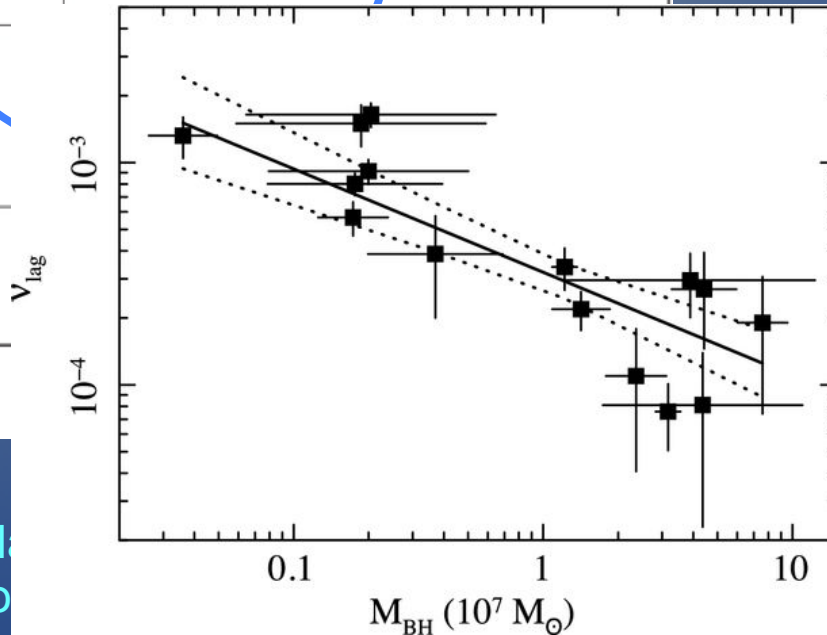
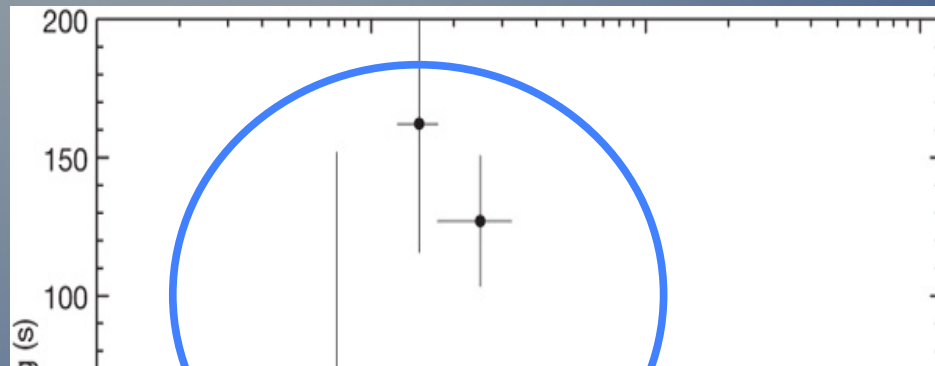
(Young & Reynolds, '01)



# Reflection: Reverberation mapping - real data

Lags in frequency space

1H0707



De Marco et al. 2013

Hard lags  
⇒ From

Soft lags on short time-scales  
⇒ From FeL reverberation, 25s light travel time corresponds to  $2 R_g$

Absorption(s)  
(i.e. ejection)

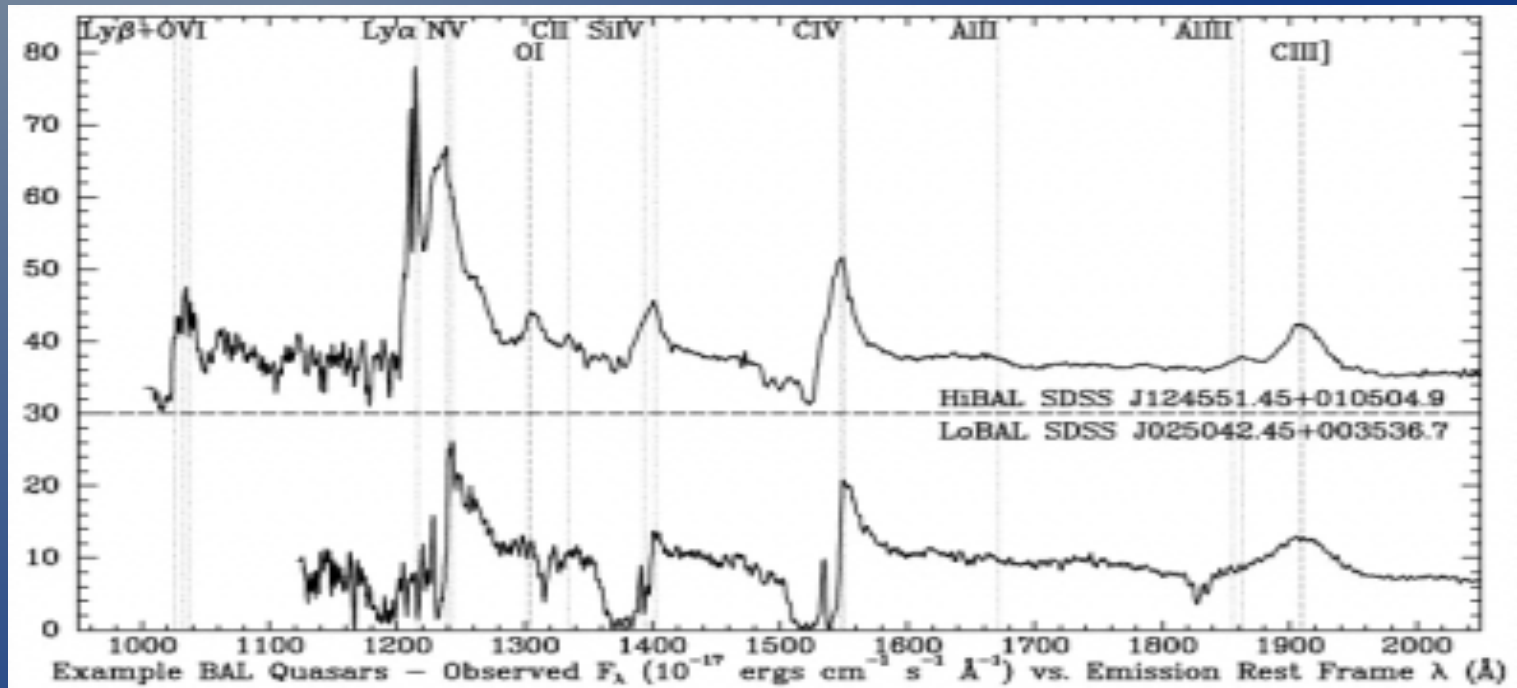
## Absorption: BAL QSOs

Evidence of absorbers along the line of sight to AGNs

...known/seen since long ago

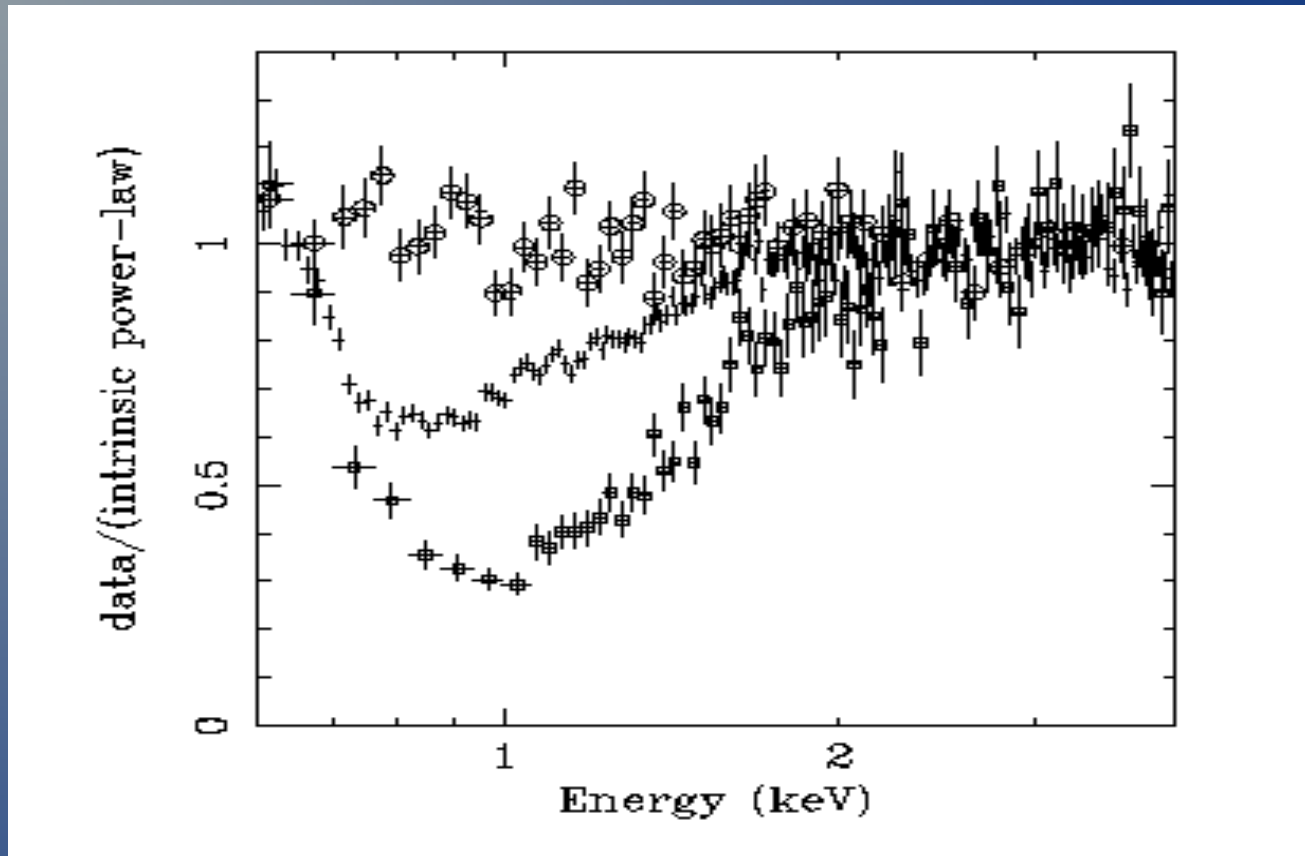
Fast ( $v$  up to  $\sim 50000$  km/s) winds in

BAL QSOs ( $\sim 20\%$  of all QSOs)



Weymann et al., '91;  
Reichards et al., '03

Most (>50%) Seyfert 1 galaxies exhibit Warm Absorbers



Reynolds et al. '97  
Georges et al. '97

➔ Clear since years that warm absorbers must be dynamically important (radiatively driven outflow located in BLR and NLR)

Open Problem: Characterisation of warm absorber? (cov. Factor, ion. state, mass/energy outflow, etc. )

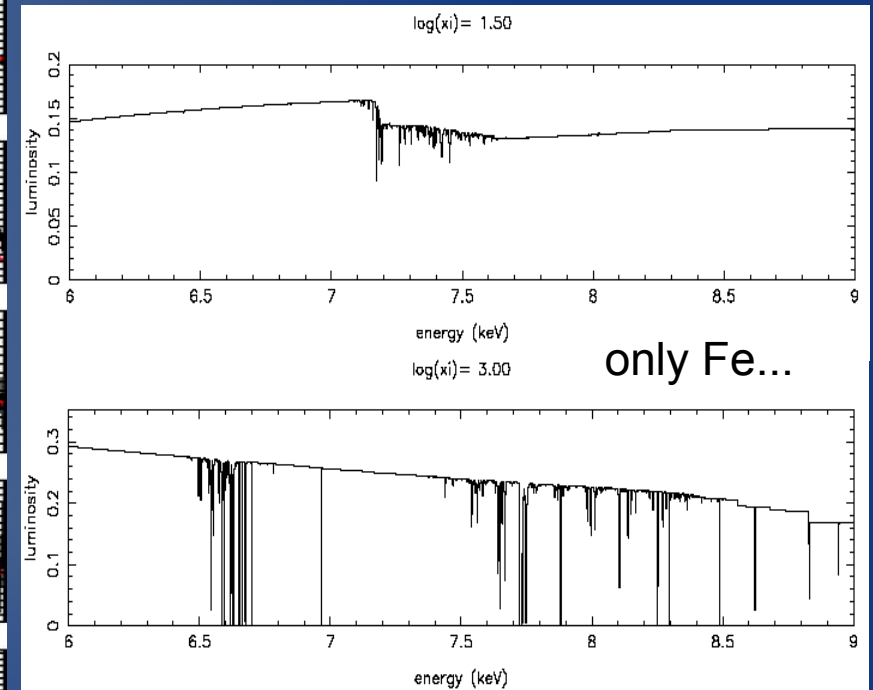
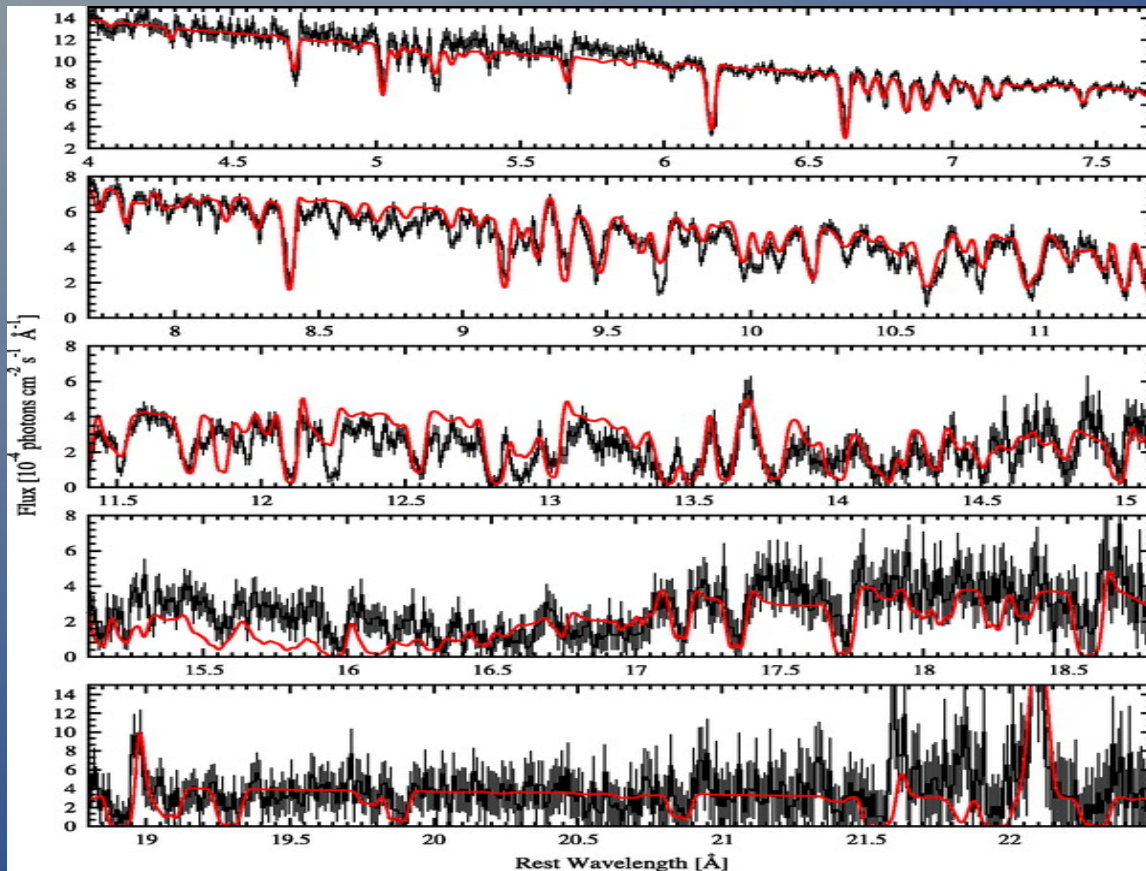
# Absorption: warm absorbers

Post-Chandra & XMM-Newton

Many more details from Chandra gratings

NGC3783 Exp=900 ks

Consistent with models which predict many absorption features



Kallman et al. '05

Kaspi et al. '01  
Netzer et al. '02  
Georges et al. '03

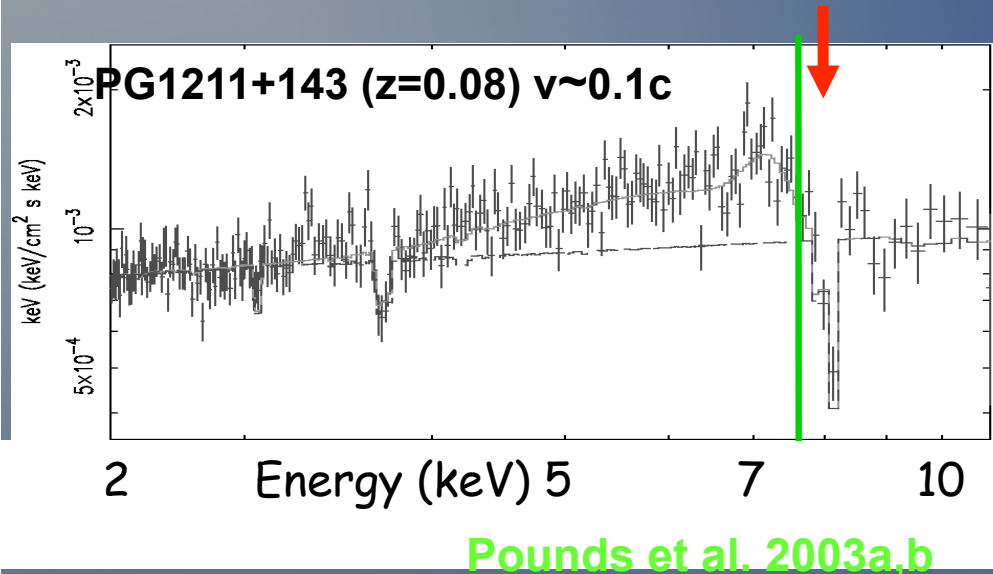


Clear now that often multiple ionization & kinetic components: outflows with ~100-1000 km/s



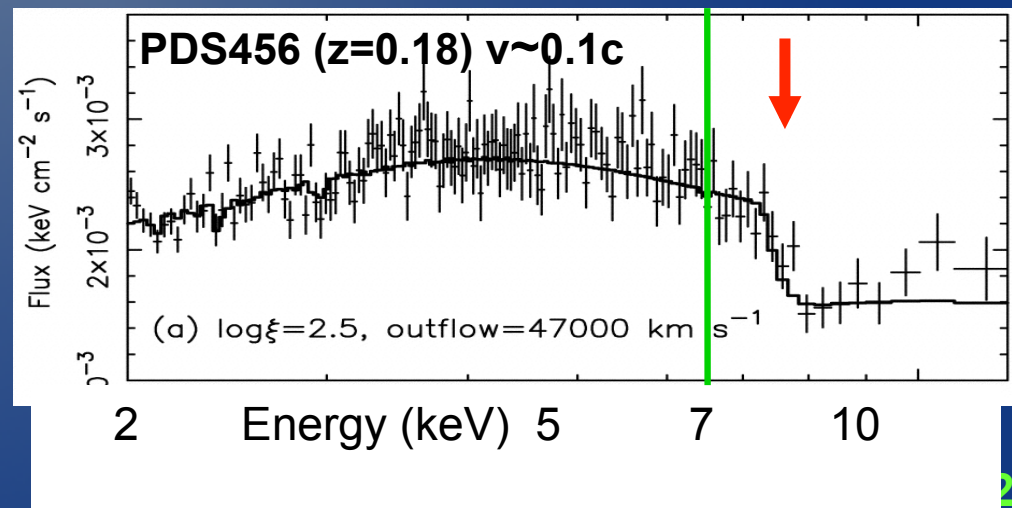
# Absorption: UFOs

New and unexpected results from Chandra and XMM-Newton observations



Blue-shifted absorption lines/edges – **High-v**

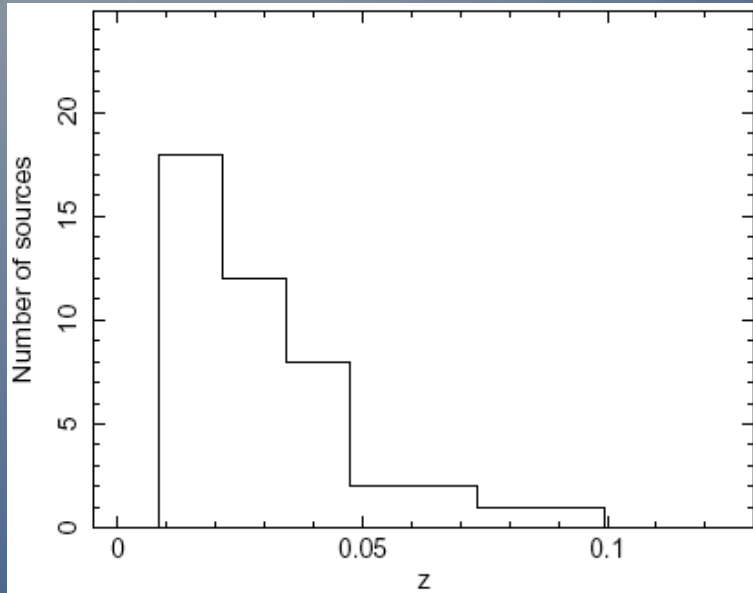
(If) interpreted as K $\alpha$  resonant absorption by Fe XXV (6.70 keV) or FeXXVI (6.96 keV)



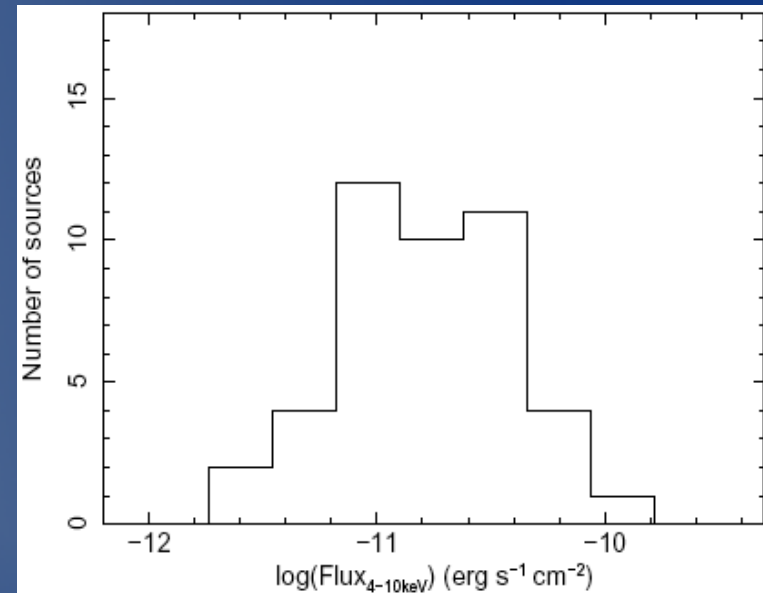
⇒ massive, **high velocity** and highly ionized outflows in several RQ AGNs/QSOs  
Mass outflow rate: comparable to Edd. Acc. rate ( $\sim M_{\odot}$ /yr); velocity  $\sim 0.1-0.2 c$

## Absorption: UFOs

Tombesi et al. (2010) analysed in a systematic and uniform way, a (almost) complete sample of nearby, X-ray bright, radio-quiet AGNs



z distribution of sources

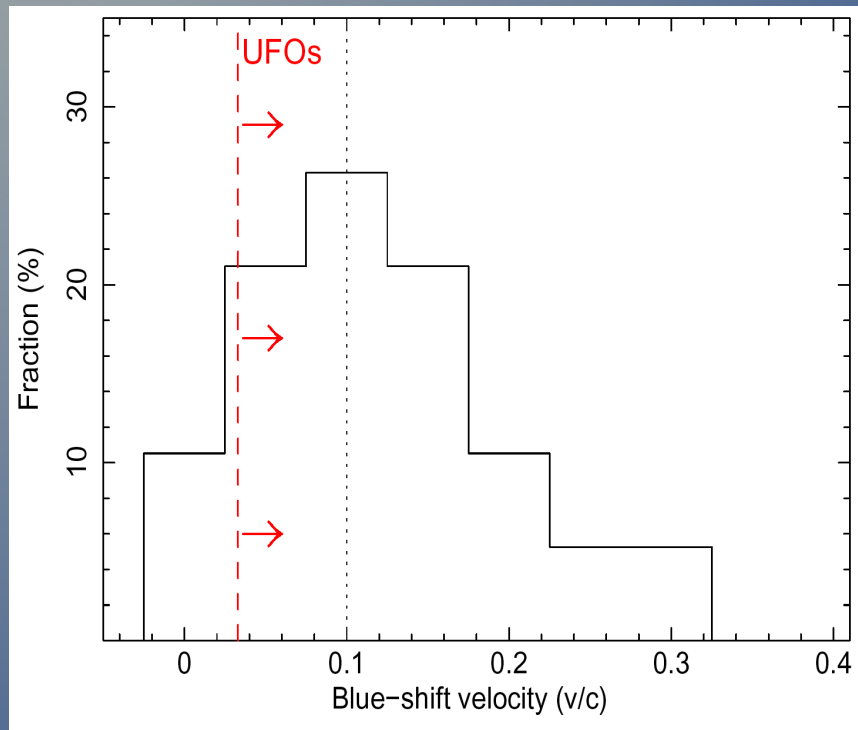


4-10keV fluxes

- Selection of all NLSy1, Sy1 and Sy2 in RXTE All-Sky Slew Survey Catalog (XSS; Revnivtsev et al. 2004)
- Cross-correlation with XMM-Newton Accepted Targets Catalog
- 44 objects for 104 pointed XMM-Newton observations
- Local ( $z < 0.1$ )
- X-ray bright ( $F_{4-10\text{keV}} = 10^{-12} - 10^{-10} \text{ erg s}^{-1} \text{ cm}^{-2}$ )

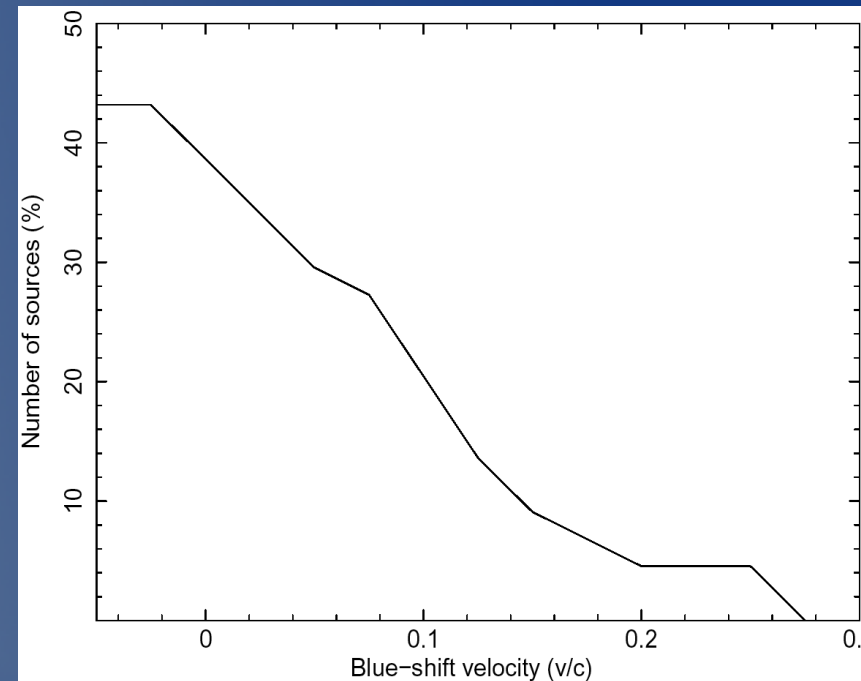
## Absorption: UFOs

Main result: UFOs (Ultra-Fast Outflows) are confirmed and are quite common



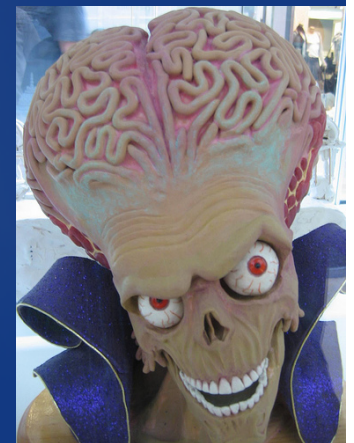
Blue-shift velocity distribution

- 36 absorption lines detected in all 104 XMM observations
- Identified with FeXXV and FeXXVI K-shell resonant absorption
- 19/44 objects with absorption lines ( $\approx 43\%$ )
- 17/44 objects with blue-shifted absorption lines (lower limit  $\approx 39\%$ , can reach a maximum of  $\approx 60\%$ )
- 11/44 objects with outflow velocity  $> 0.1c$  ( $\approx 25\%$ )
- Blue-shift velocity distribution  $\sim 0-0.3c$ , peak  $\sim 0.1c$
- Average outflow velocity  $0.110 \pm 0.004 c$



Cumulative velocity distribution

**Tombesi et al. 2010a**  
**(The UFO's hunters**  
**commander in chief)**

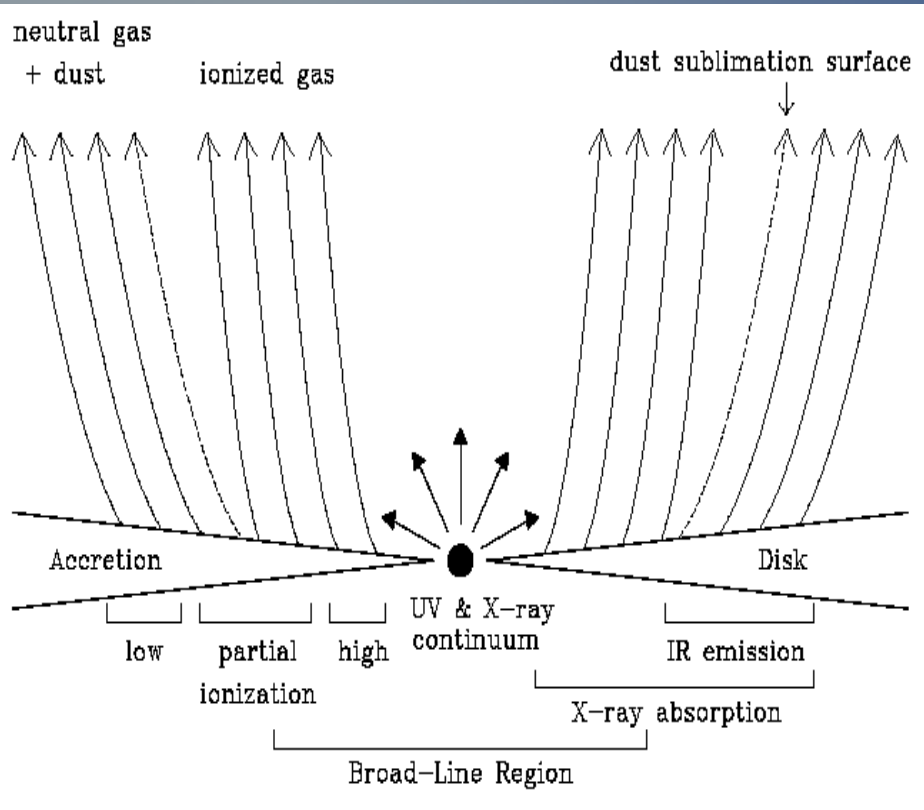


## Absorption: Results on UFOs

- estimated distances  $r < 0.01 - 0.1 \text{ pc}$  ( $< 10^2 - 10^5 r_s$ )  
(accretion disk winds? e.g. Elvis 2000; King & Pounds 2003)
  - Often  $v_{\text{out}} > v_{\text{esc}}$ , but not always, material shall fall back sometimes? (“aborted jet”? e.g. Ghisellini et al. 2004, Dadina et al. 2005)
  - variability time scales  $t \sim 1 \text{ day} - 1 \text{ year}$
  - $L_{\text{bol}}/L_{\text{Edd}} \sim 0.1 - 1$
  - $M_{\text{out}}/M_{\text{acc}} \sim 0.1 - 1$
  - $E_k \sim 10^{44} - 10^{45} \text{ erg s}^{-1} \sim 0.1 L_{\text{bol}}$
- (last two estimates depend on covering fraction C)
- Acceleration mechanism? Line, magnetically or momentum driven?

# Absorption: Interpretation - Three main wind dynamical models

## i) Thermally driven winds from BLR or torus

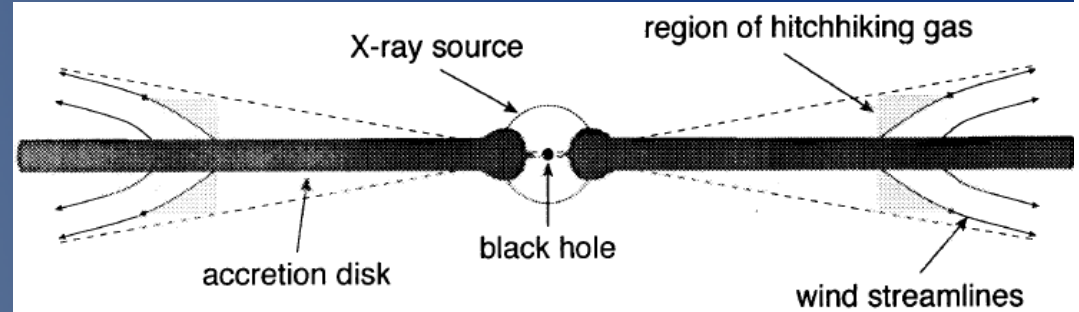


Balsara & Krolik, '93; Woods et al. '96

i)  $\Rightarrow$  Large  $R$ , low  $v$

ii) and iii)  $\Rightarrow$  Low  $R$  and large  $v$

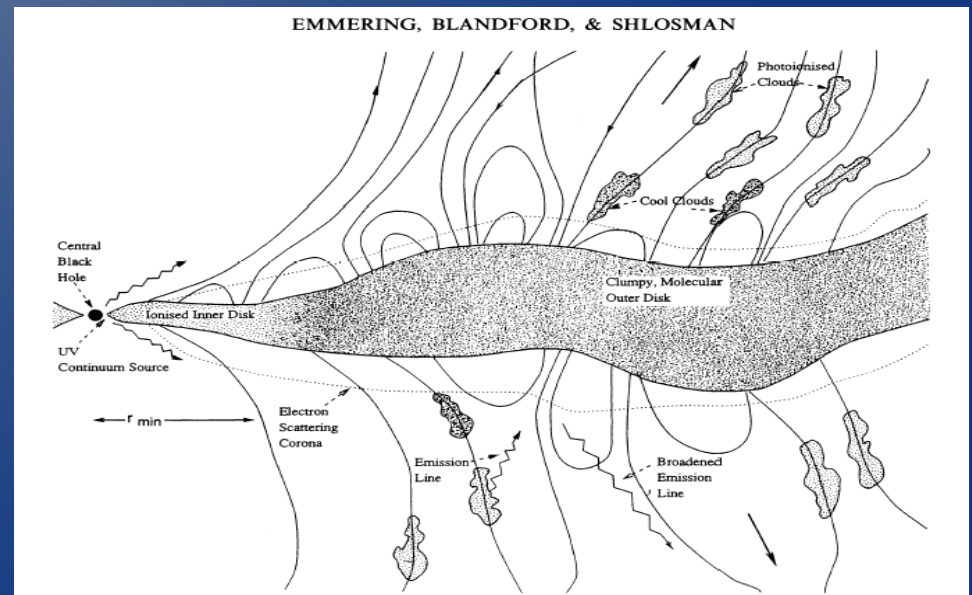
## ii) Radiative-driven wind from accretion disk



Murray et al. '95, Proga et al. '00

...and/or...

## iii) Magnetically driven winds from accretion disk



Emmering, Blandford & Shlosman, '92; Kato et al. '03



## Absorption: Final impact - An open issue

- ü  $N_w$  ( $\text{cm}^{-2}$ )
- ü Location ( $R$ ,  $\Delta R$ )
- ü Ionization state ( $\xi$ )
- ü Velocity
- ü Covering factor
- ü Frequency in AGNs

Fundamental to:

- PHYSICS of accelerated and accreted flows (winds?, blobs?, etc.), i.e. understand how BHs accelerate earth-like quantities of gas to relativistic velocities
- COSMOLOGY: i.e. estimate the mass outflow rate, thus the impact of AGN outflows on ISM and IGM enrichment and heating!

Elvis et al. '00, Crenshaw et al. '03, King et al. '03, Chartas et al. '03,  
Yaqoob et al. '05, Blustin et al. '05, Risaliti et al. '05, Krongold et al. '07

Current estimates have order of magnitude uncertainties, they go from:

$dM/dt$  ( $\propto L_{\text{kin}}$ ) few % to several times  $dM_{\text{acc}}/dt$  ( $\propto L_{\text{edd}}$ )

**This is a fundamental (open) issue**

# Reflection vs. Absorption? conclusions

- Reflection hypothesis is robust and its predictions are consistent with all existing data.
- Nevertheless, absorption **is** present and potentially very complex.
- Both phenomena are interesting because probe “extreme” (inflow/outflow) conditions.

Disentangling between the two requires the combination of:

High throughput @ 6 keV  
and  
calorimeter-type energy resolution  
(future telescopes...)

## Conclusions & Summary

**Goal of the lectures:** Give introductory informations on general “models” of AGNs, and in particular on reflection vs absorption hypothesis in RQAGNs

We have reviewed basic physics with basic assumptions for 3 major “models” of AGN

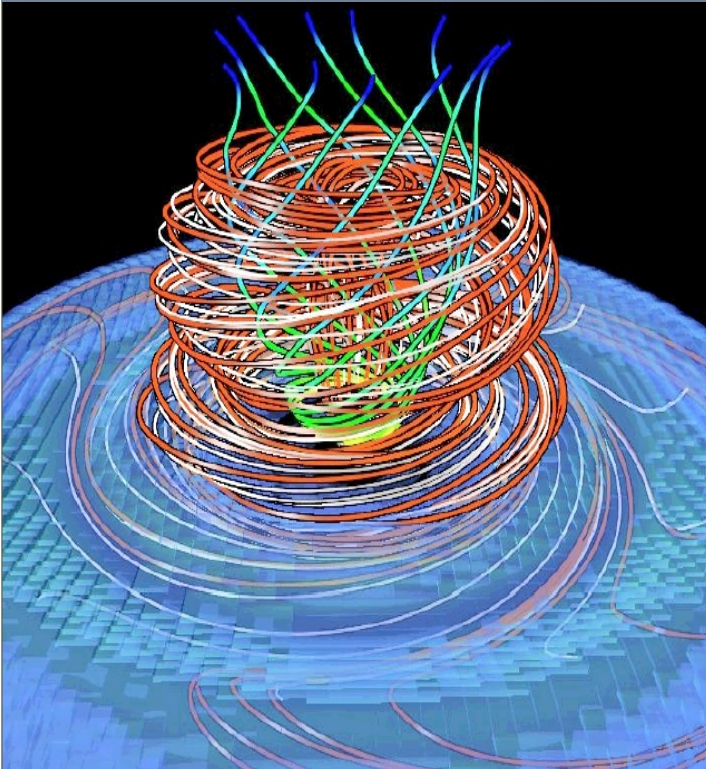
- 1- The 2-Phases model (RQAGNs)
- 2- The Inefficient model (LLAGNs)
- 3- The Jet model (RLAGNs)

We have focused on 1, and address the reflection vs. absorption hypothesis to explain the X-ray spectra of RQAGNs

**Not a “mere” fitting exercise but major physical differences in the two hypothesis:**

**Relativistic Reflection:** Produced within few ( $<10$ )  $R_g$  and carries information on BH spin and mass

**(Very) Complex Absorption:** Produced farther at 100s  $R_g$  and carries information on wind/jet base



**This is the END....**

**Questions**

