

**From SED to line suppression:  
Probing the physics of the X-ray-weak  
WLQ SDSS J101353.45+492758.1**



**Laetitia Gibaud  
Dr. Marek Nikołajuk**



# Talk outline

Quasars & weak-emission-line quasars

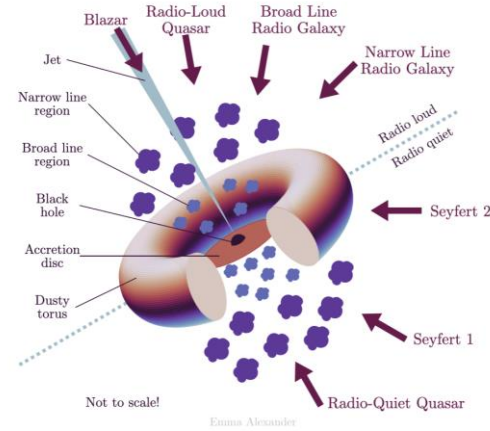
The target: SDSS J101353.45+492758.1

The continuum fitting

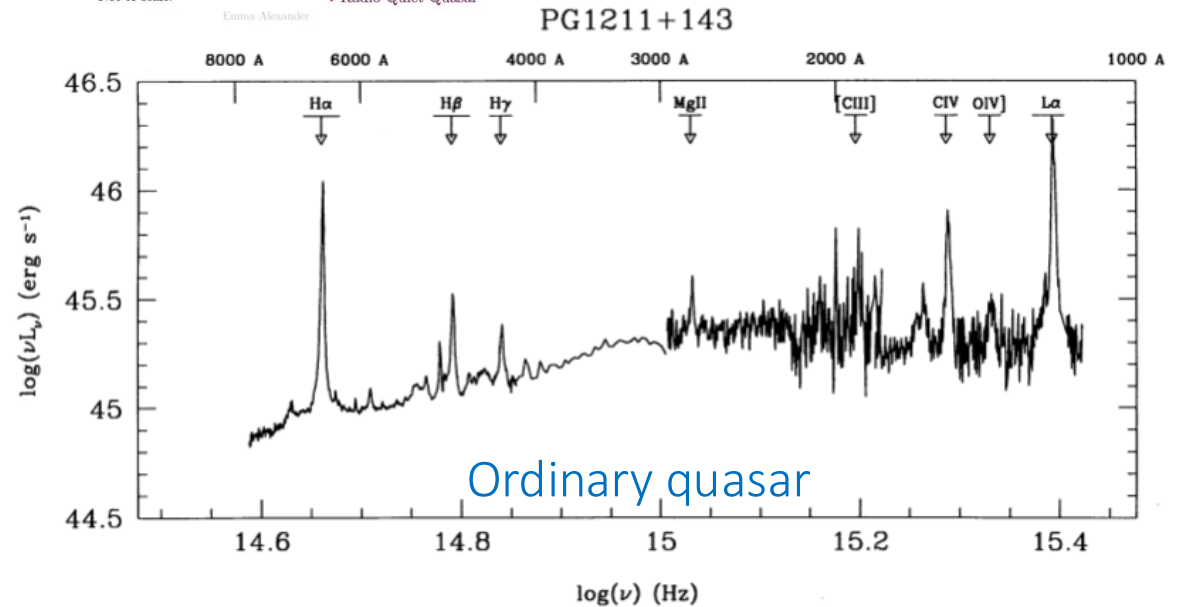
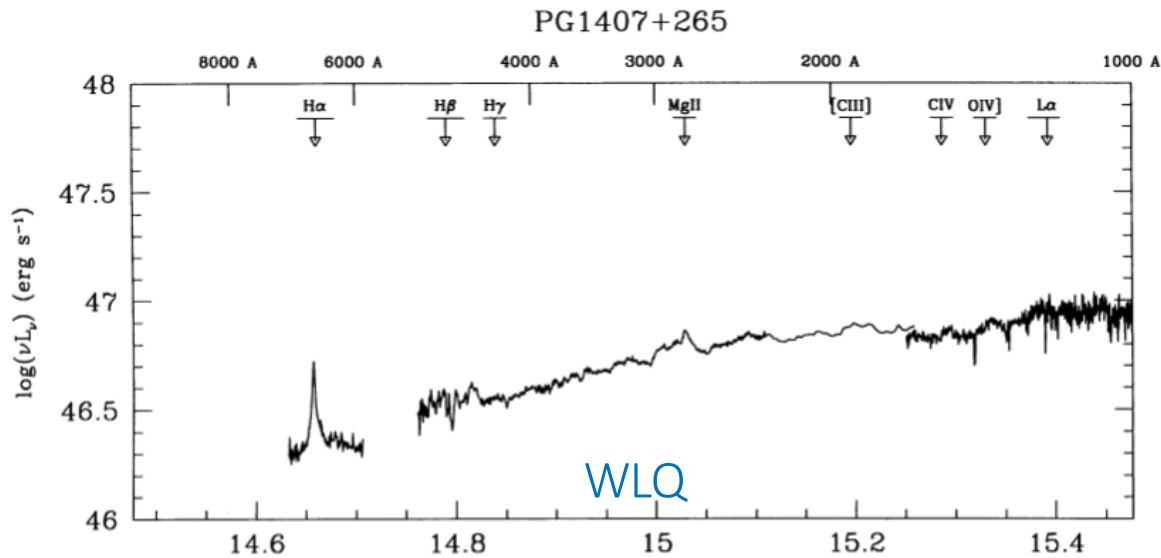
The Cloudy exploration

# Quasars & weak-emission-line quasars

Quasars with unusually weak emission lines  
 => Challenge standard BLR/accretion paradigms



Adapted from Urry & Padovani 1995

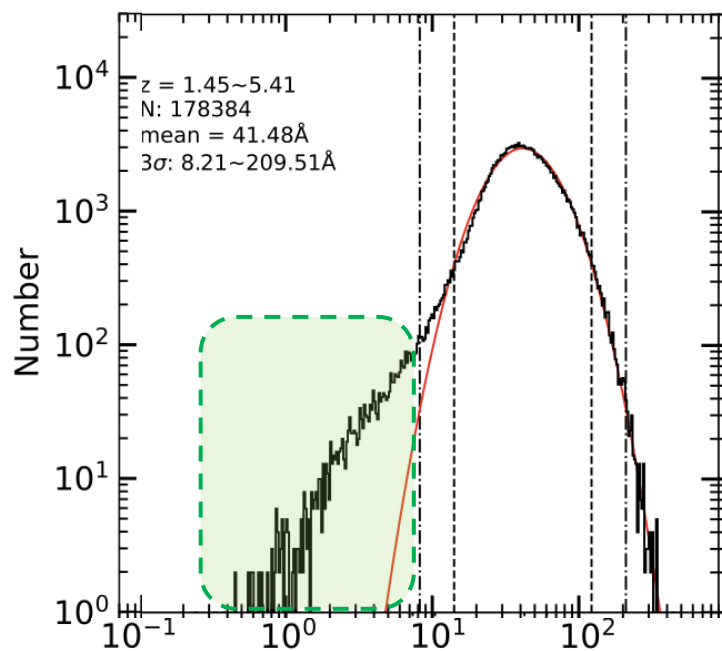


McDowell et al. 1995

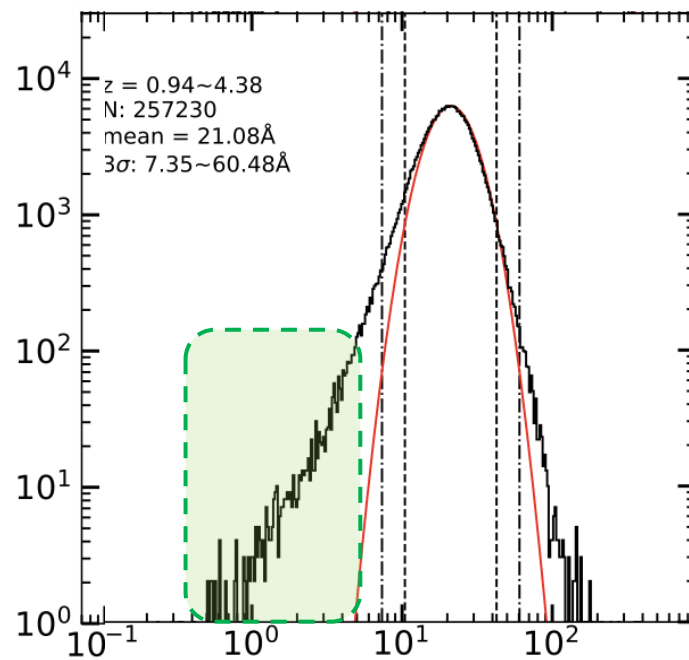
# Why should we care about WLQs?

EW distribution of high and low ionization lines from Cheng et al. 2025

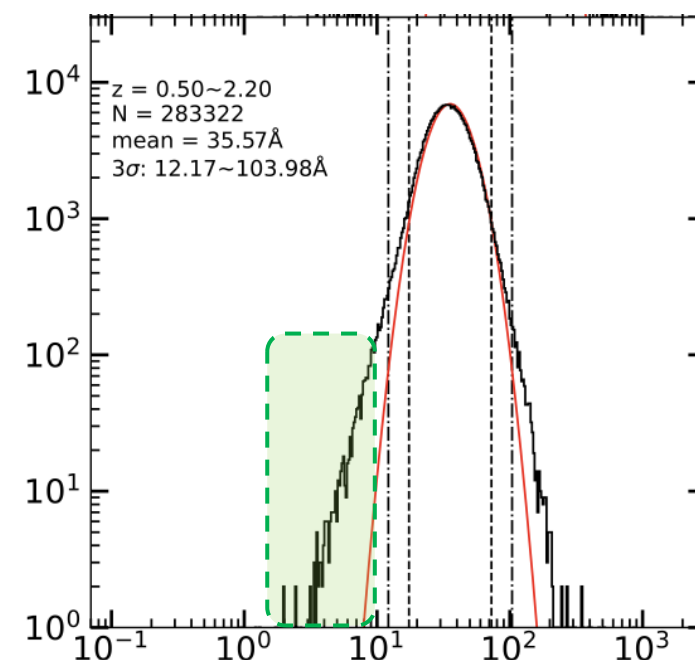
C IV  $\lambda 1549$  EW( $\text{\AA}$ )



C III]  $\lambda 1909$  EW( $\text{\AA}$ )



Mg II  $\lambda 2798$  EW( $\text{\AA}$ )



# A few possible explanations



Anemic or underdeveloped BLR and/or evolutionary effects



Super-Eddington accretion



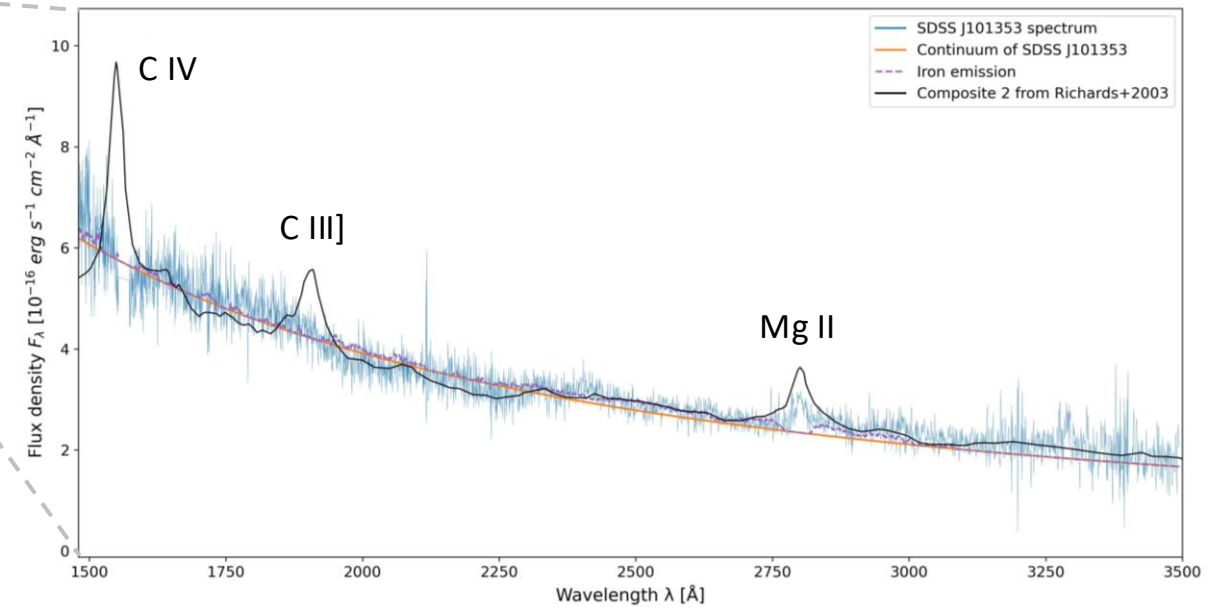
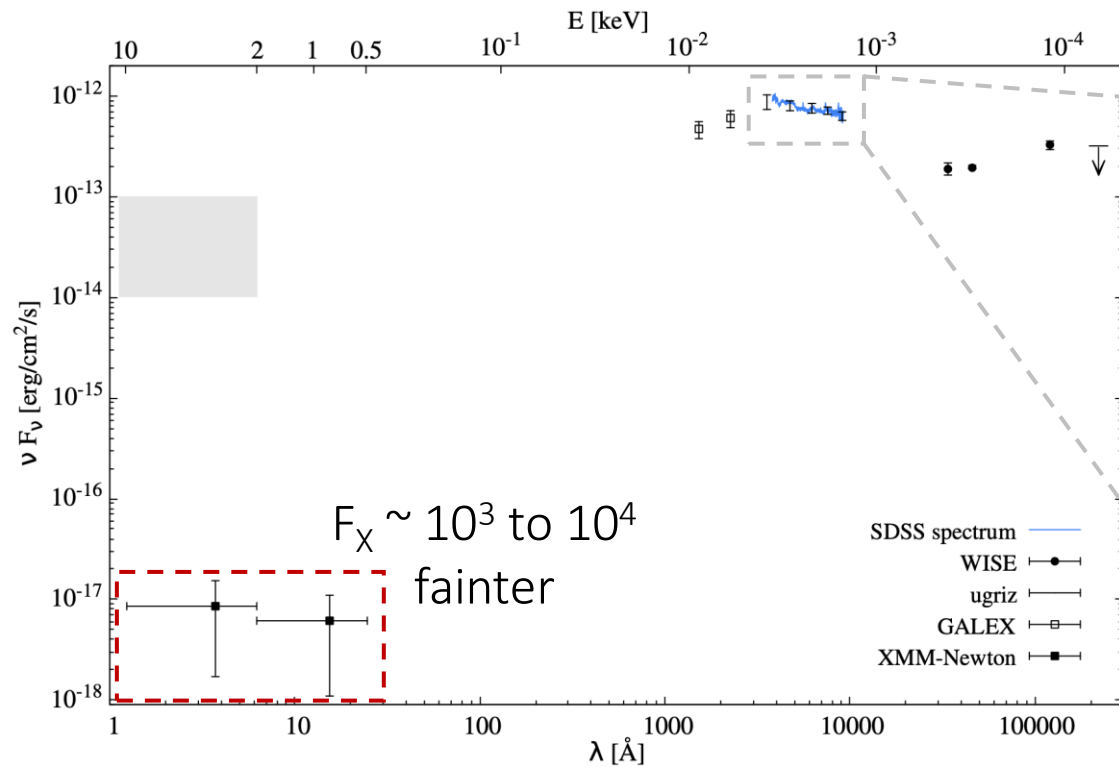
Shielding gas

# The target: SDSS J101353.45+492758.1

$z = 1.64$  ;  $D = 4691.20$  Mpc

$L = 1.06 \times 10^{46}$  erg/s

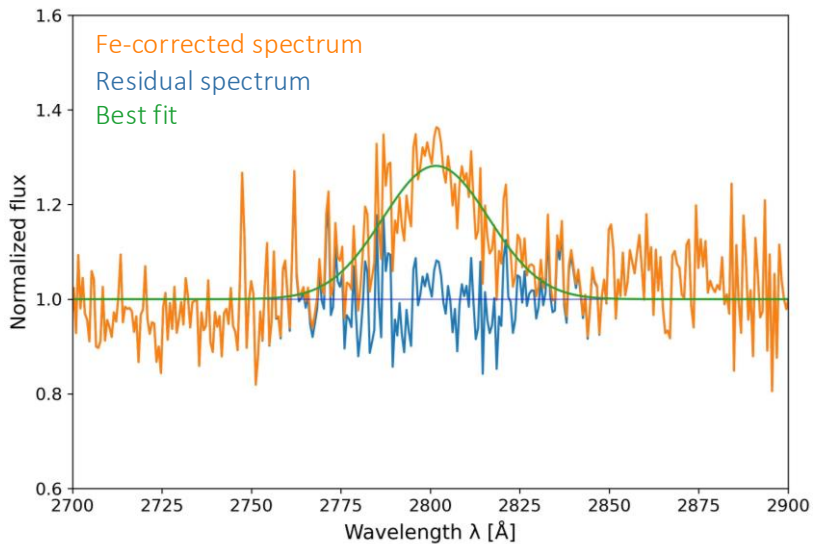
$L_{\chi(0.5-10 \text{ keV})} = 2.25 \times 10^{41}$  erg/s (Young et al. 2009)



# Mg II emission line

Key ideas:

- Extraction of emission line information
- BH's parameters determination as baseline for fitting process



Rest-frame Mg II properties of SDSS J101353

$\lambda$ ( $\text{\AA}$ )	FWHM ( $\text{km s}^{-1}$ )	REW ( $\text{\AA}$ )
$2801.63 \pm 0.90$	$3875.13 \pm 250.99$	$10.89 \pm 0.57$



$$M_{\text{SMBH}} = 10^{6.86} \left[ \frac{\text{FWHM}(\text{Mg II})}{1000 \text{ km/s}} \right]^2 \left[ \frac{\lambda L_{\lambda}(3000 \text{ \AA})}{10^{44} \text{ erg/s}} \right]^{0.5} \quad (\text{Vestergaard \& Osmer 2009})$$

$$\dot{m} = \frac{L_{\text{bol}}}{L_{\text{Edd}}} \quad \text{with} \quad L_{\text{Edd}} = 1.25 \times 10^{38} \text{ erg s}^{-1} (\text{M}/\text{M}_{\odot})$$

RESULTS:

- $M_{\text{SMBH}} = (4.95 \pm 0.64) \times 10^8 M_{\odot}$
- $\dot{m} = 0.17$



Estimations susceptible to bias!  
Marculewicz & Nikolajuk (2020)

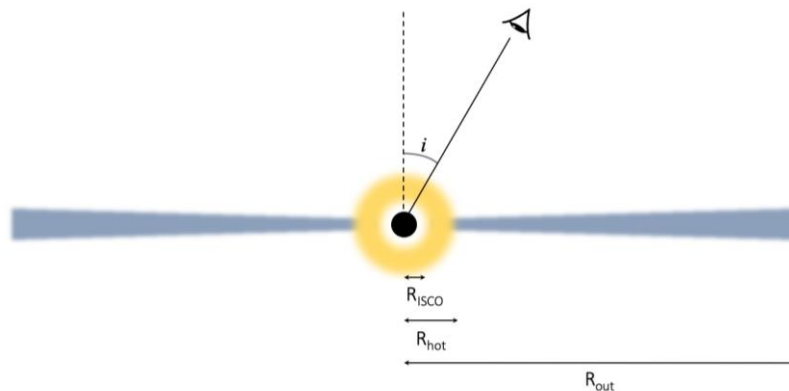
# The continuum fitting

## Models to explore the geometry

### Model 1

A simple geometry:

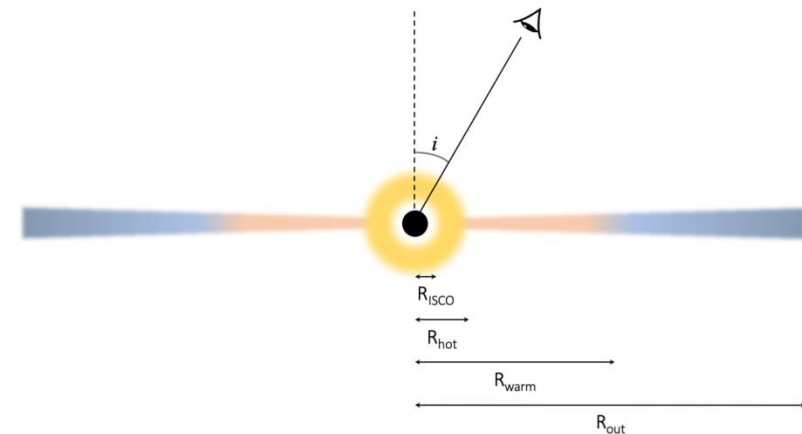
- relativistic thin disk (**kerrbb**, Li et al. 2005)
- power law
- starlight component (Polletta et al. 2007)
- torus component



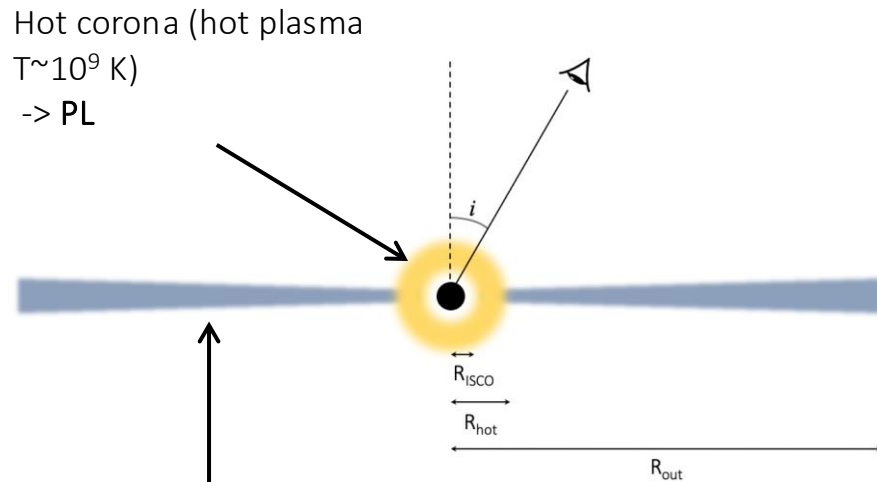
### Model 2

A more complex geometry:

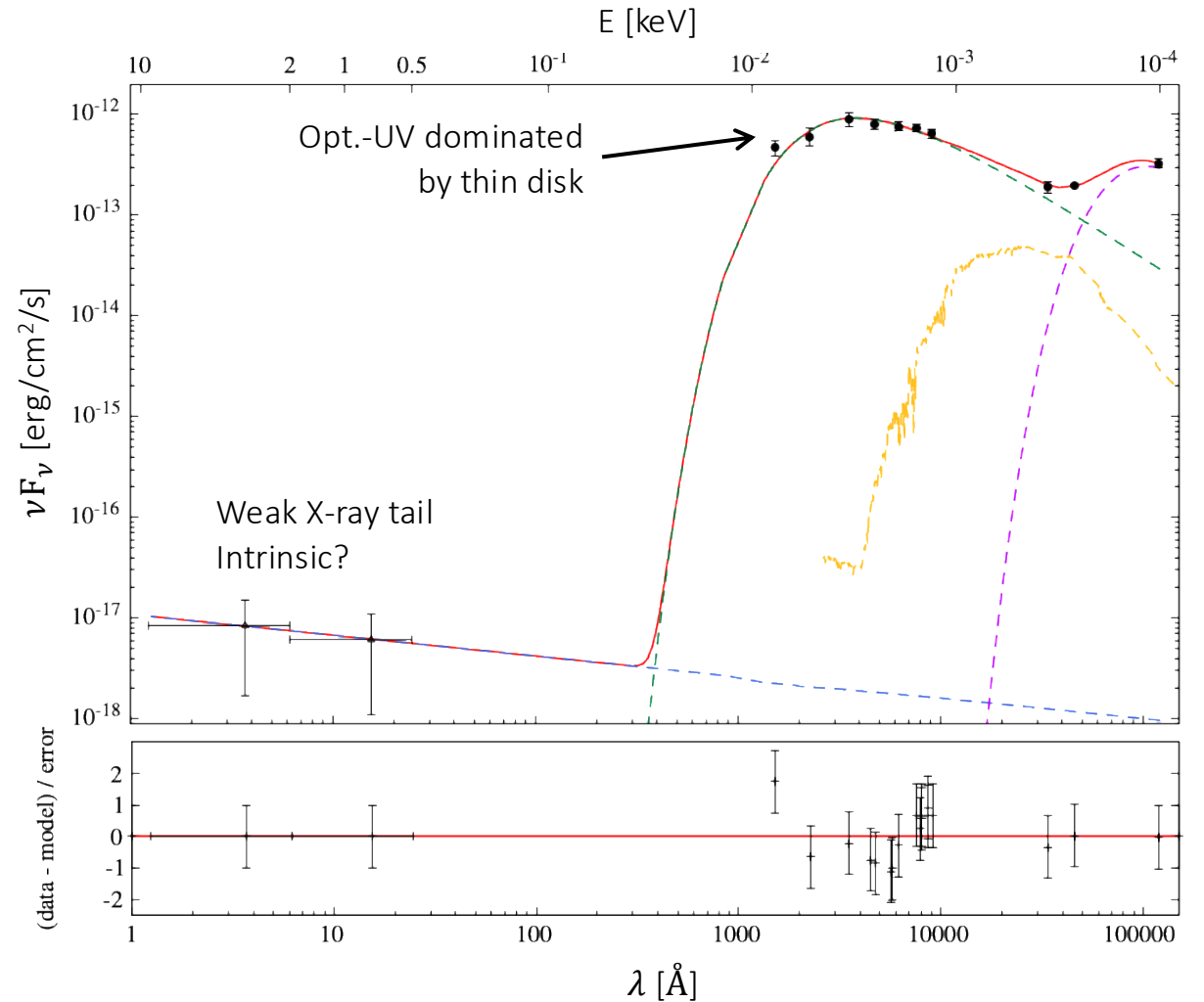
- accretion disk + warm Comptonization region (**relagn**, Hagen & Done 2023)
- starlight component (Polletta et al. 2007)
- torus component



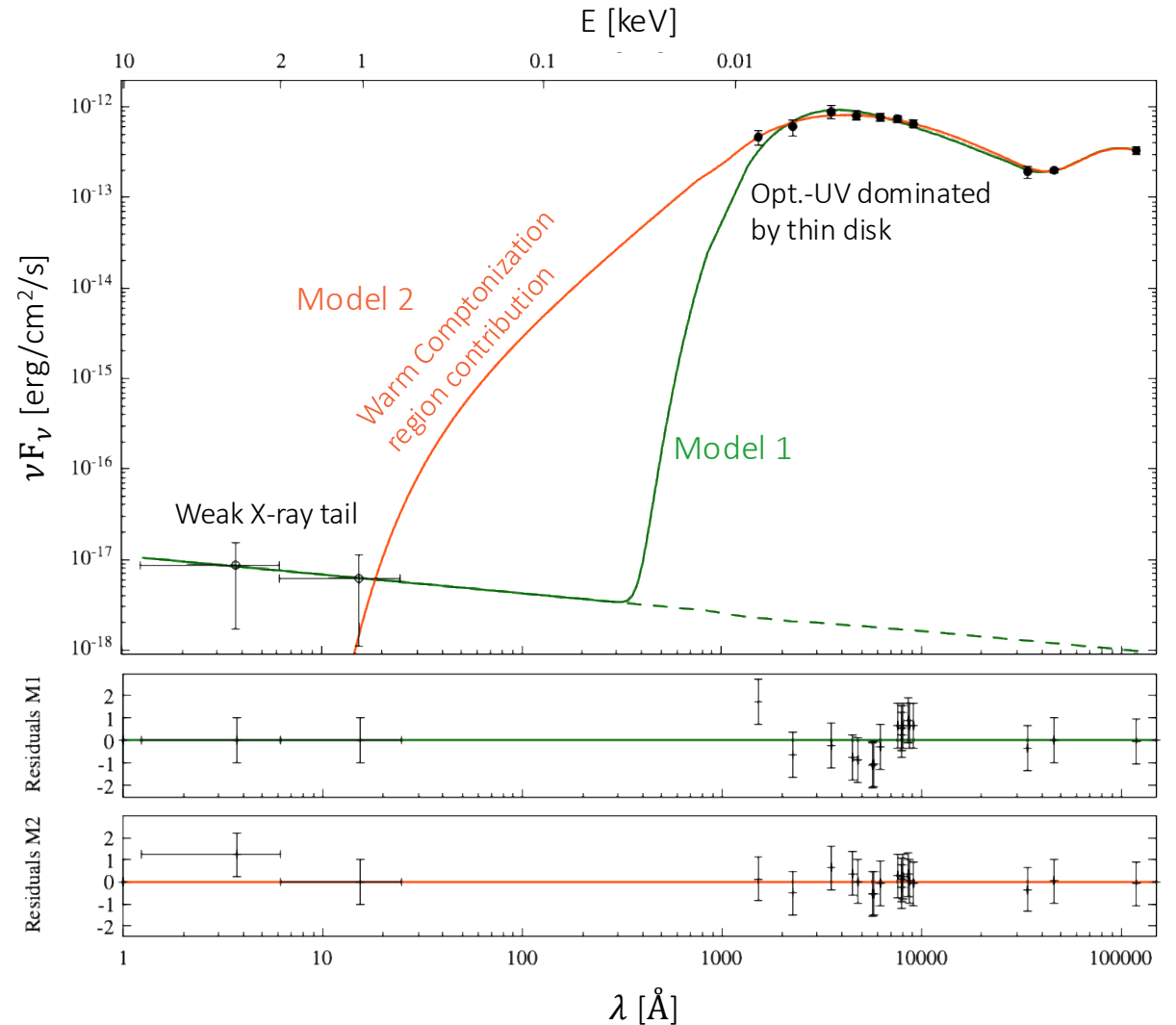
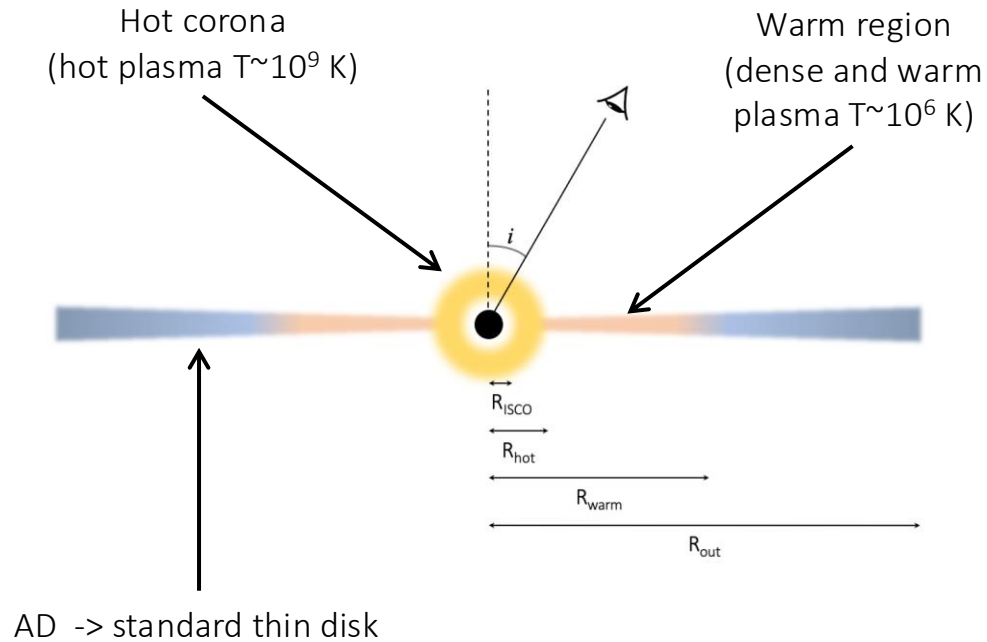
# Broadband SED fit assuming a simple geometry: model 1



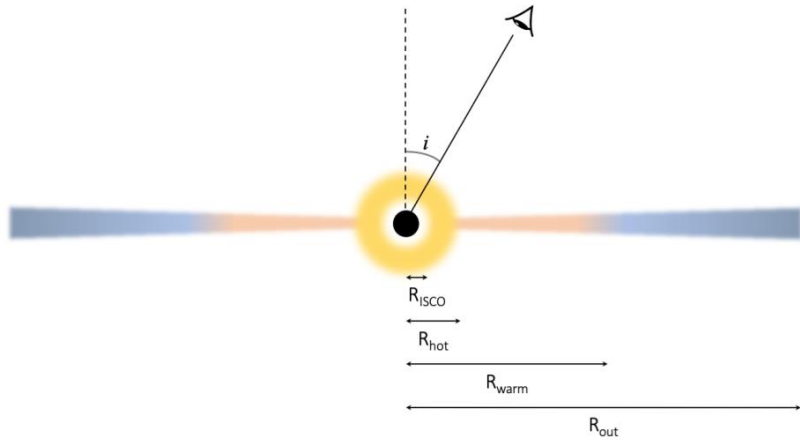
AD + compact weak hot corona



# Broadband SED fit assuming a complex geometry: model 2



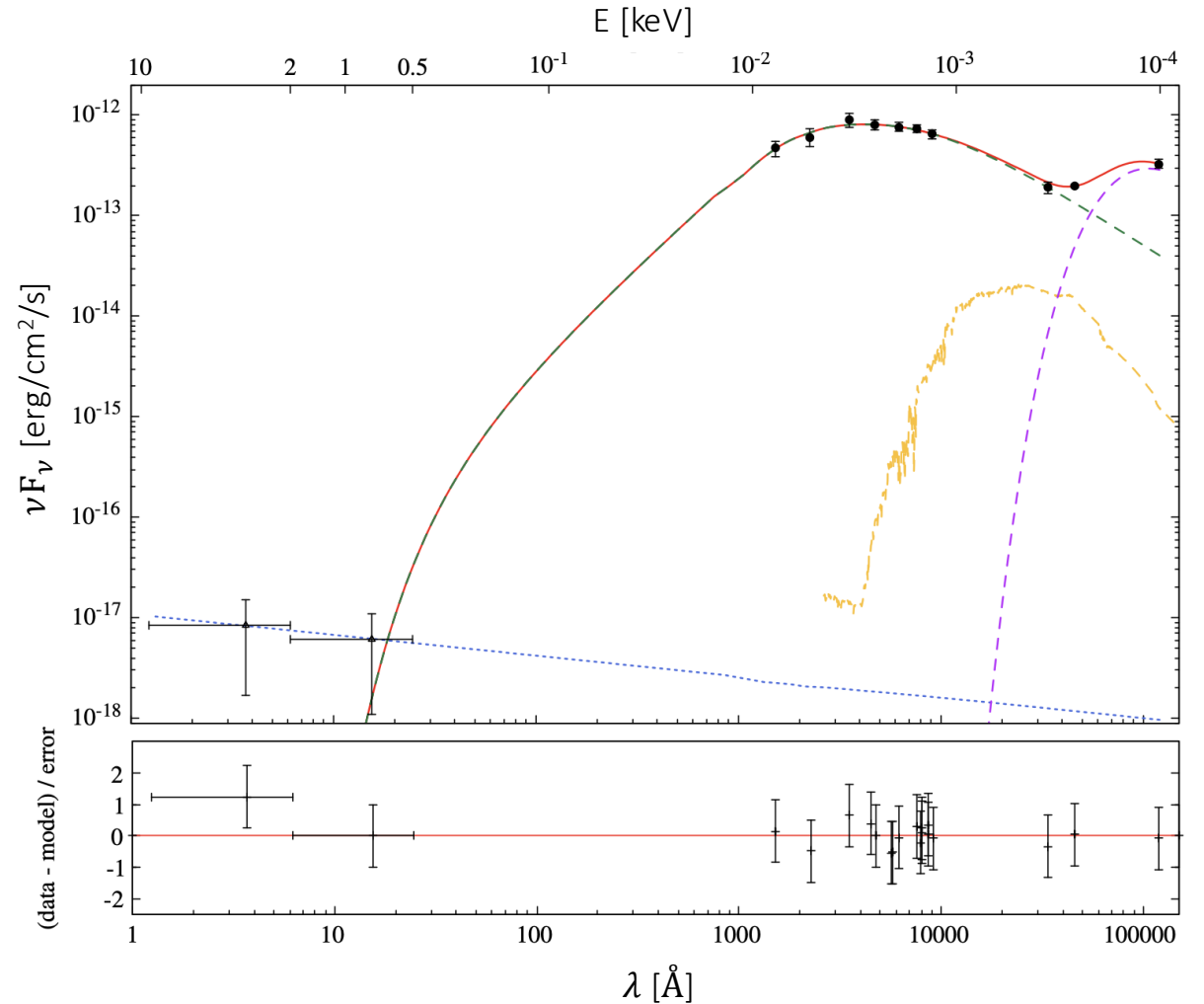
# Broadband SED fit assuming a complex geometry: model 2



Warm region parameters:

- $kT_{e,warm} \approx 0.19^{+0.06}_{-0.09}$  keV
- $\Gamma_{warm} \approx 3.83^{+0.47}_{-0.19}$
- $R_{warm} \approx 34^{+10}_{-7}$  Rg

Consistent with an optically thick warm corona



# Fitting results

Gibaud et al. 2026

Model	$M_{\text{BH}}$ ( $10^9 M_{\odot}$ )	$\dot{m}^a$	$\Gamma_{\text{hot}}^b$	$\Gamma_{\text{warm}}^c$	Starlight ( $10^{-17}$ )	$kT_{\text{e,torus}}$ (K)	$\chi^2/\text{d.o.f.}$
Model 1	$2.05^{+0.37}_{-0.30}$	$0.087^{+0.005}_{-0.006}$	$1.8 \pm 0.8$	–	$5.18 \pm 3.93$	$934.16 \pm 98.64$	10.31/13
Model 2	$1.90^{+0.28}_{-0.26}$	$0.155^{+0.027}_{-0.025}$	1.8 fixed	$3.83^{+0.47}_{-0.19}$	$1.83 \pm 0.87$	$913.27 \pm 30.18$	3.69/12

**Notes.** Model 1a: kerrbb + power law. Model 1b: accretion disk + compact weak hot corona using relagn. Model 2: warm region contribution to Model 1b using relagn. <sup>a</sup>Accretion rate  $\dot{m} = \dot{M}/\dot{M}_{\text{Edd}}$ . <sup>b</sup>Photon-index in the 1–10 keV energy range. <sup>c</sup>Photon-index in the 0.1–1 keV energy range.

Massive BH  
Moderate  
accretion rate

Hot  
corona

Warm  
corona

Typical hot thermal dust  
emission in WLQs ranges  
from 870 K to 1240 K  
according to Diamond-  
Stanic et al. (2009).

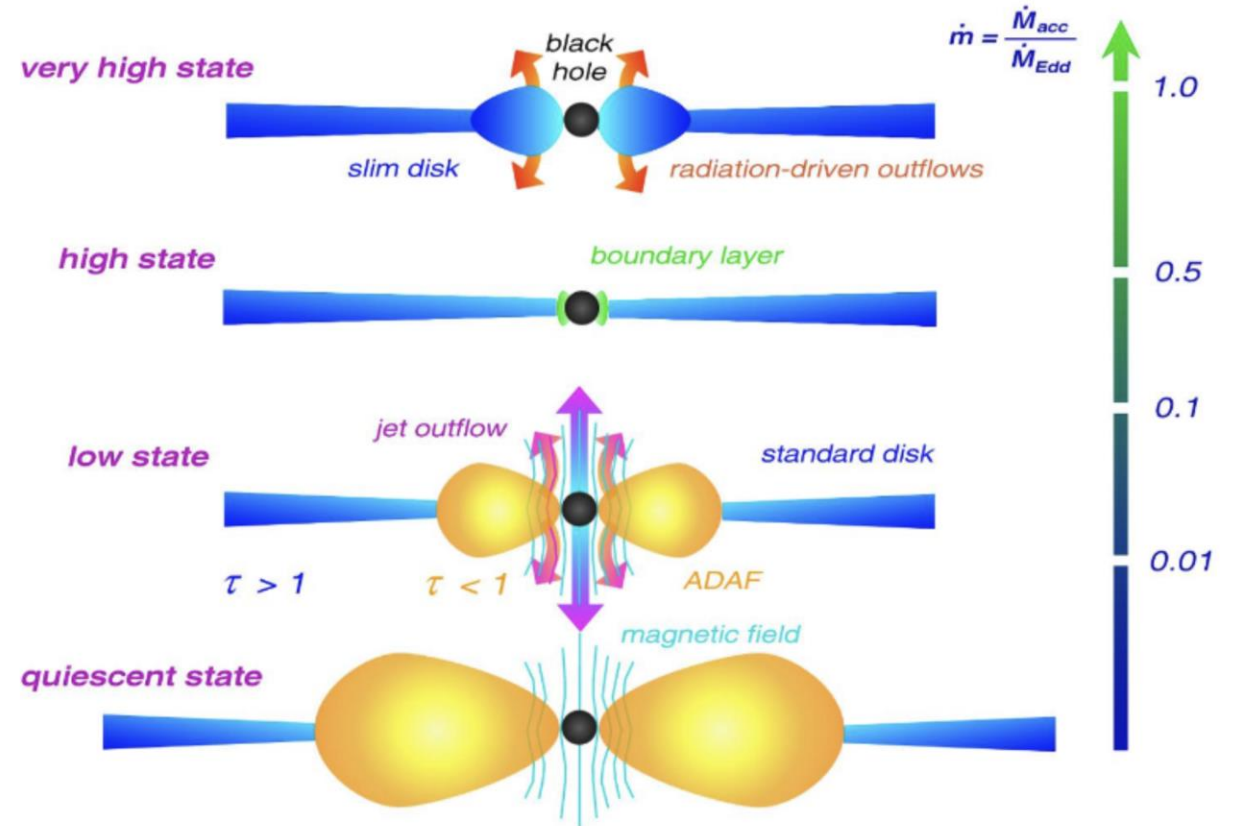
# Proposed interpretations

Ultrasoft state in XRBs:

- High Edd. accretion rate ( $\sim 1.0$ )
- Thermal disk fraction  $> 80\text{-}90\%$  of the tot. flux
- Weak hot corona
- Radio quenched

Spectral state in SDSS J101353:

- **does not require** super-Eddington accretion
- has an intrinsically **weak hot corona** => may represent an AGN analogue of the **ultrasoft state** observed in XRBs, but with a smaller accretion rate



Credit: Muller 2004

# The Cloudy exploration

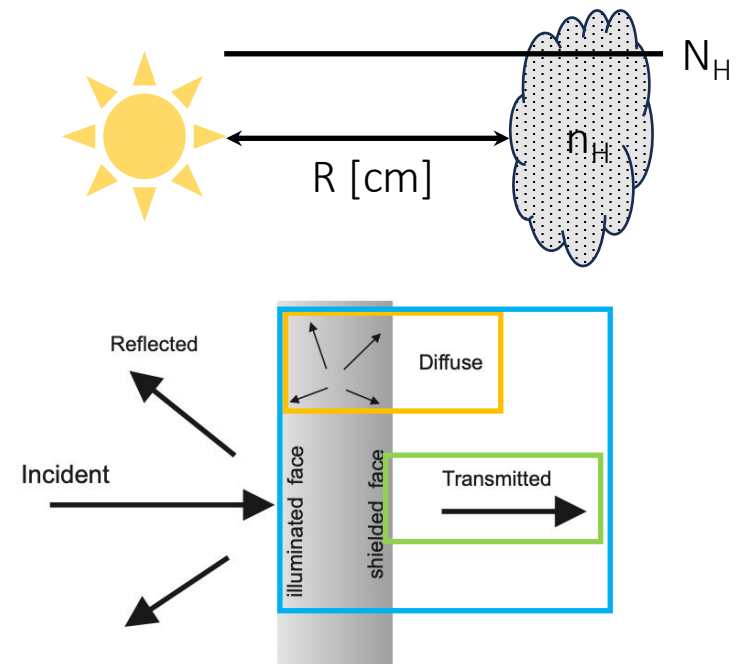
Photoionization simulations performed with Cloudy code (e.g., Chatzikos et al. 2023)

Key idea:

- Understand & reconstruct the emission-line weakness

Methodology:

- Input SEDs from models 1 & 2
- Run grid of simulations assuming a **single BLR cloud**, over:
  - Column densities, from  $10^{22}$  to  $10^{24}$   $\text{cm}^{-2}$  (dex 1)
  - H densities, from  $10^9$  to  $10^{12}$   $\text{cm}^{-3}$  (dex 1)
  - Distances from the central engine, from  $10^{14}$  to  $10^{21}$  cm (dex 0.5)

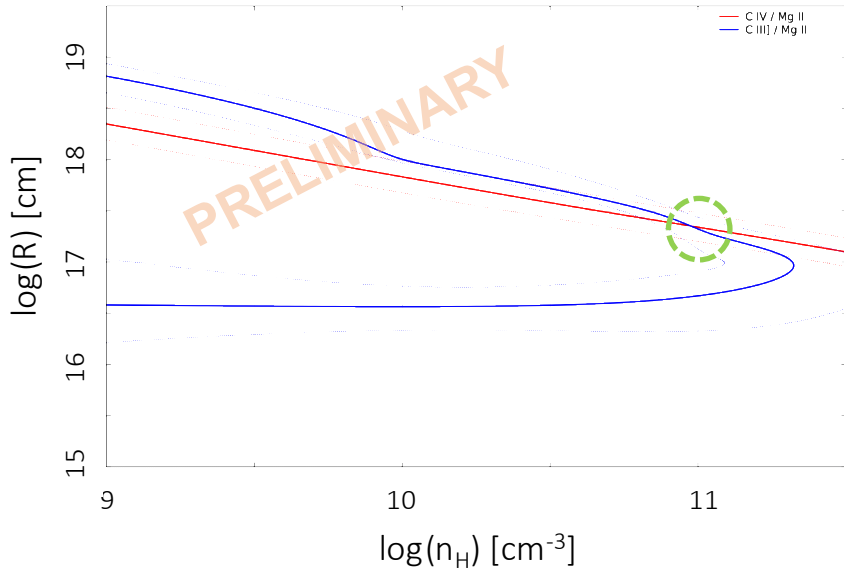


Source: Hazy documentation

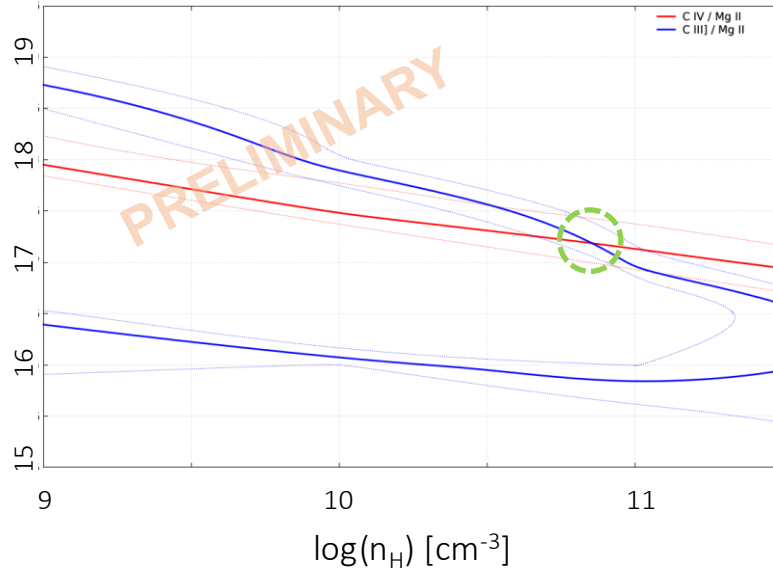
# Luminosity ratios for **model 1**

— C IV / Mg II  
— C III] / Mg II

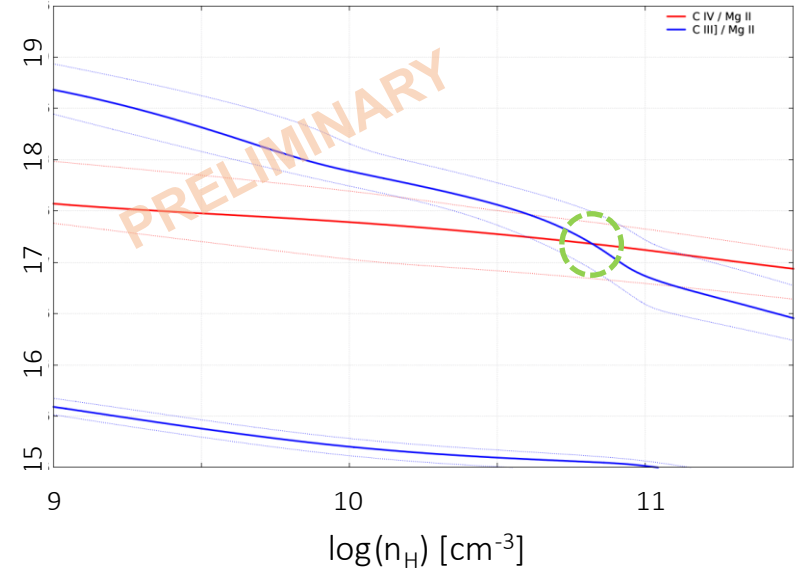
$\log(N_H) = 22 \text{ [cm}^{-2}\text{]}$



$\log(N_H) = 23 \text{ [cm}^{-2}\text{]}$



$\log(N_H) = 24 \text{ [cm}^{-2}\text{]}$

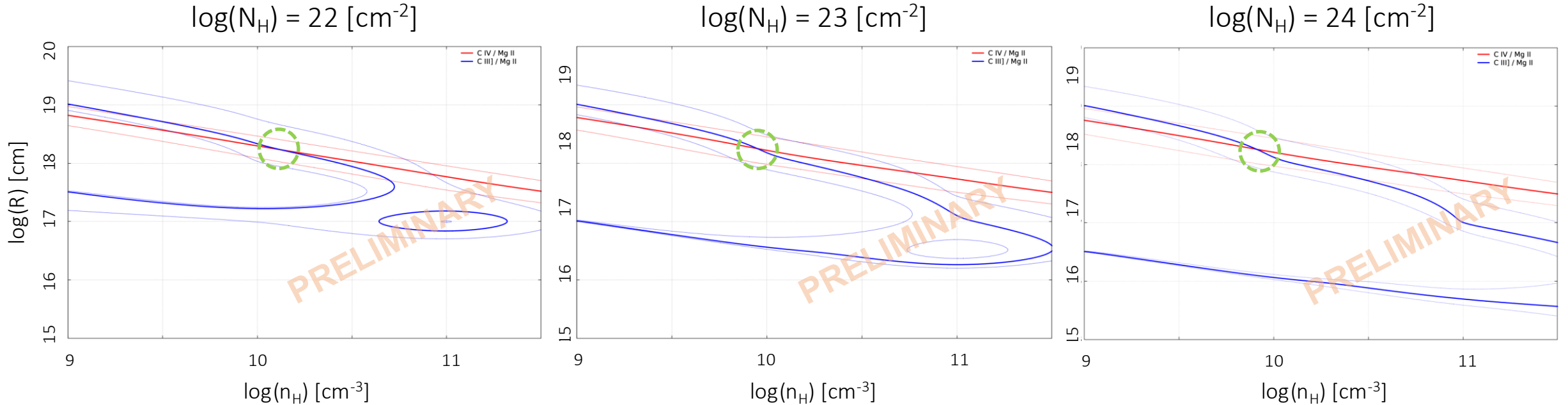


The 2 luminosity ratios agree with a narrow parameter range:

- $\log(n_H) \approx 10.9 \text{ [cm}^{-3}\text{]}$
- $\log(R) \approx 17.2 \text{ [cm]}$

# Luminosity ratios for **model 2**

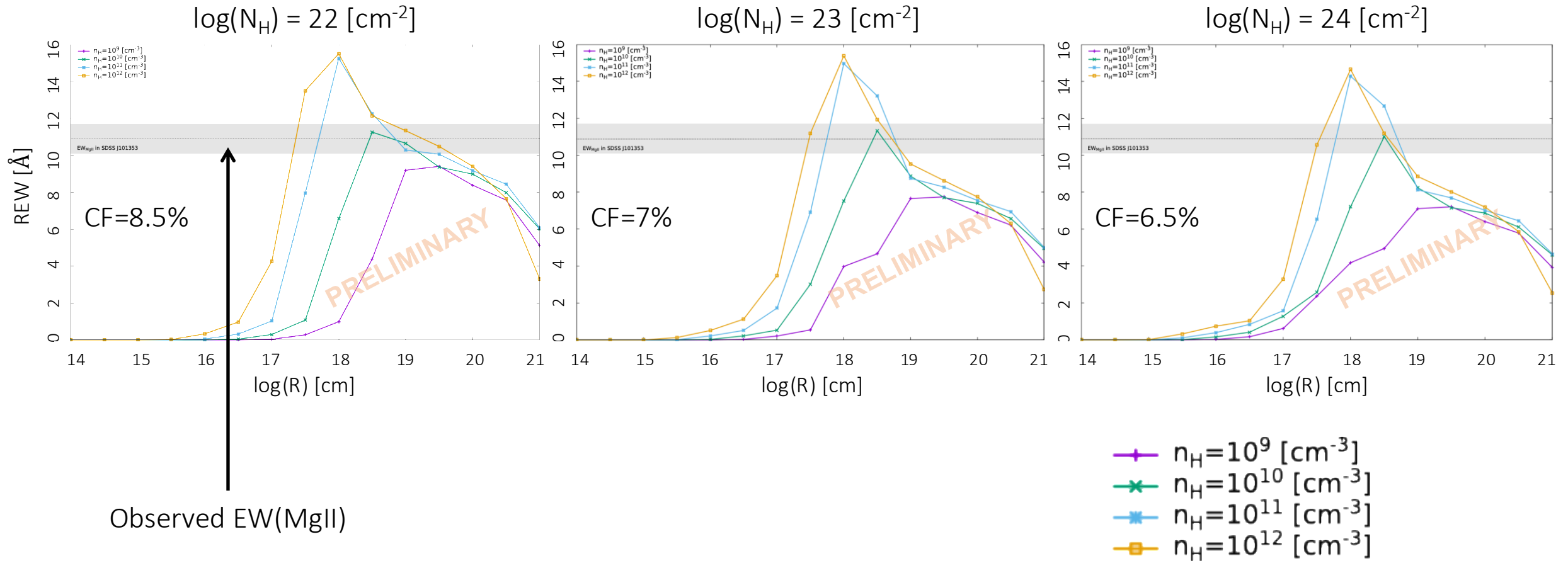
— C IV / Mg II  
— C III] / Mg II



The 2 luminosity ratios agree with a narrow parameter range:

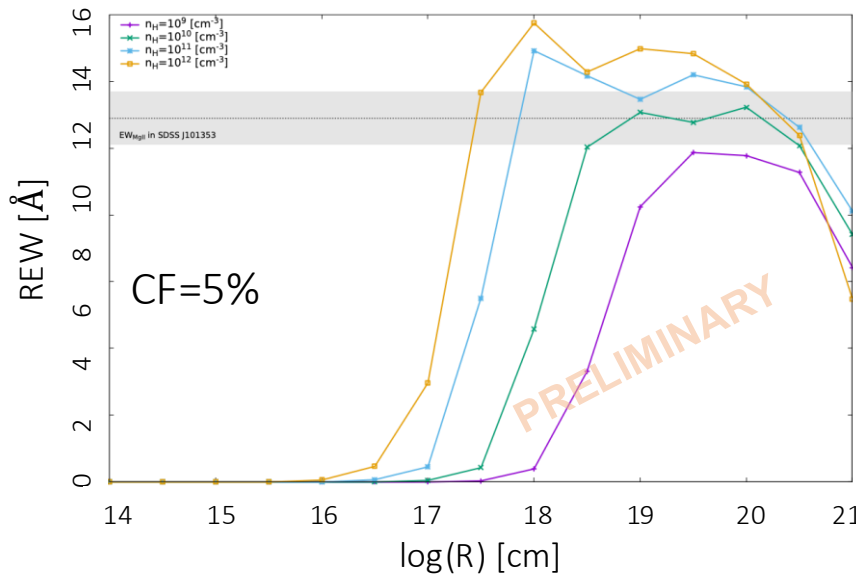
- $\log(n_H) \approx 10.0$  [cm<sup>-3</sup>]
- $\log(R) \approx 18.2$  [cm]

# EW of MgII emission line for **model 1**

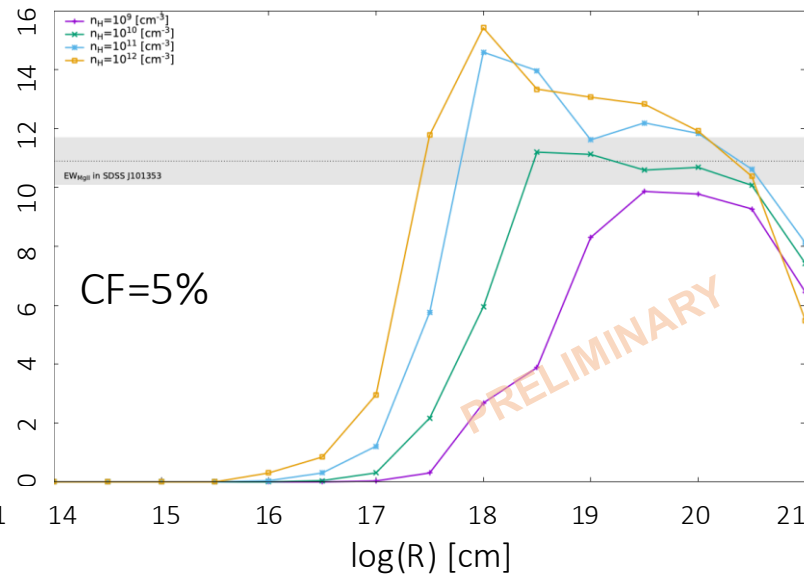


# EW of MgII emission line for **model 2**

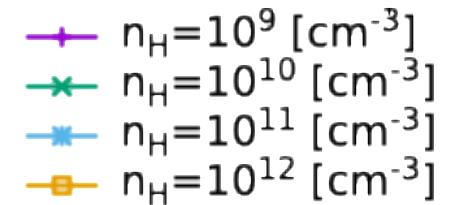
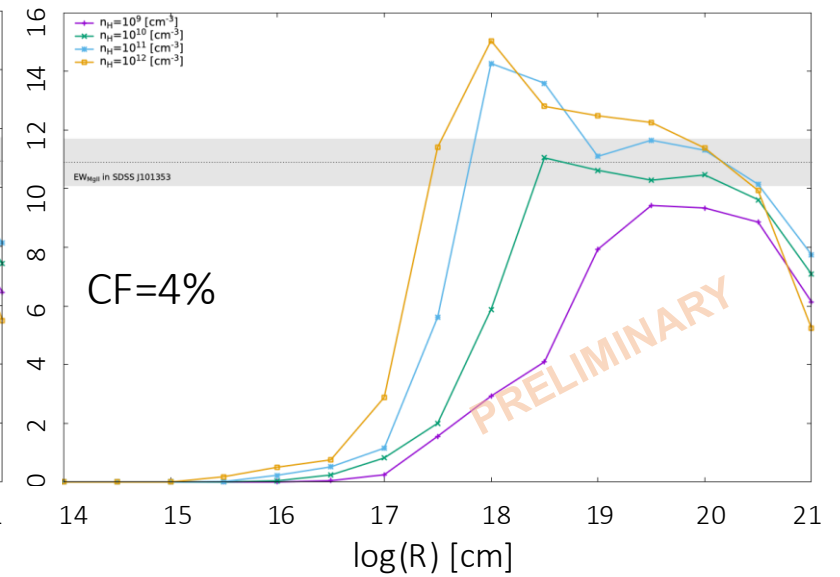
$\log(N_H) = 22 \text{ [cm}^{-2}\text{]}$



$\log(N_H) = 23 \text{ [cm}^{-2}\text{]}$



$\log(N_H) = 24 \text{ [cm}^{-2}\text{]}$



# Conclusions

- Both models yield consistent BH parameters:  $M_{\text{BH}} \approx 2 \times 10^9 M_{\odot}$  and  $\dot{m} \approx 0.1$   
=> SDSS J101353 does not accrete at super-Eddington rate
- Inefficient or compact hot corona, evidence of a warm corona (model 2)
- The ultrasoft-state interpretation provides a physically plausible explanation that naturally accounts for the observed SED

## From photoionization simulations:

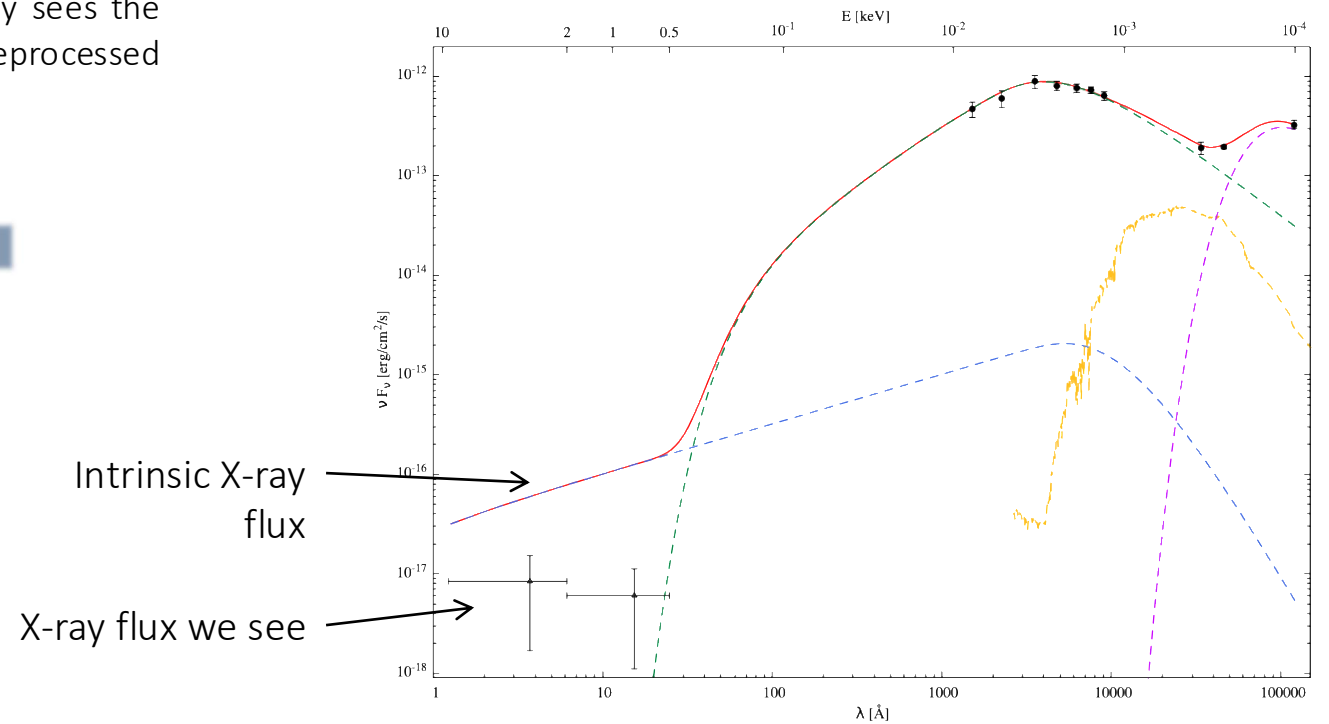
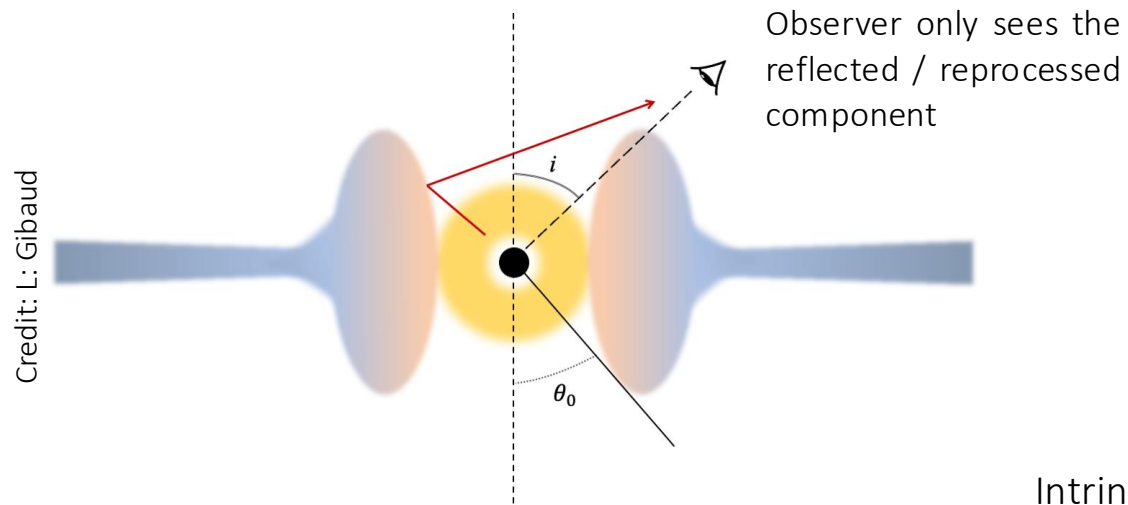
- From simulations of a single cloud model: the BLR is located around  $10^{17}$  to  $10^{18}$  cm from the central engine
- To reproduce the observed EW of Mg II line, a small covering factor is required

**THANK YOU!**



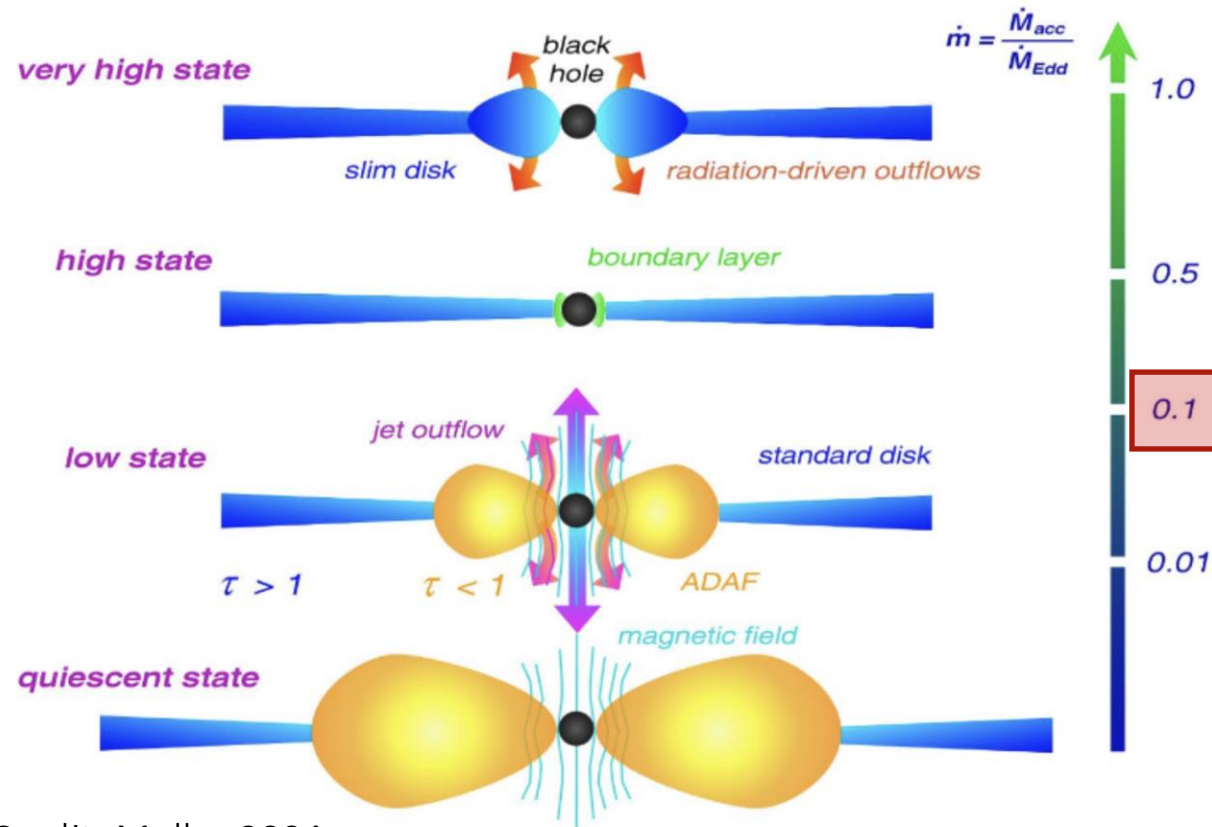
# The obscuration scenario

An alternative explanation for the X-ray weakness in SDSS J101353 is that the observed hard X-ray spectrum does not represent the intrinsic coronal emission, but rather its **reflection** from **obscuring material** along the line of sight.



# The accretion regime

X-ray binaries analogy



High/soft state

- Standard accretion disk dominates => thermalized disk emission (soft X-rays, UV)
- Suppressed jets

Low/hard state

- Prominent hot corona => hard X-ray emission
- Hot inner flow
- Jets

Credit: Muller 2004