# On the Origin of The Soft X-ray Excess in Radio Quiet AGNs

P.O. Petrucci
Ursini, Cappi, Bianchi, Matt, DeRosa, Malzac, Henri

XMM the next Decade. Madrid. 9-11 May 2016

# Context

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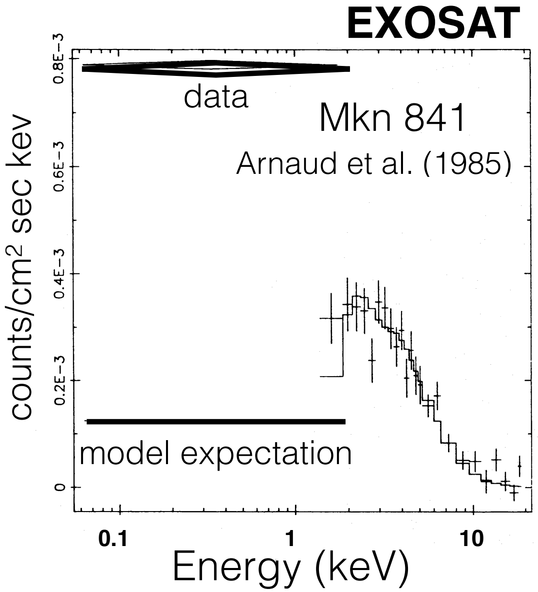
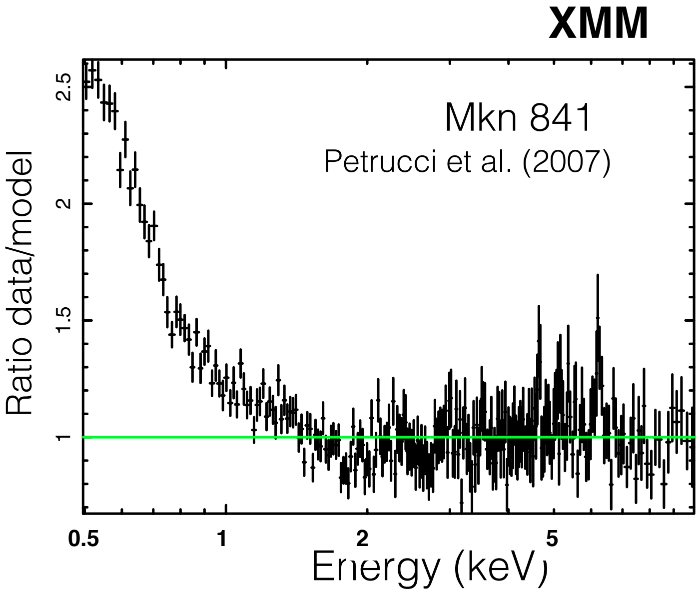
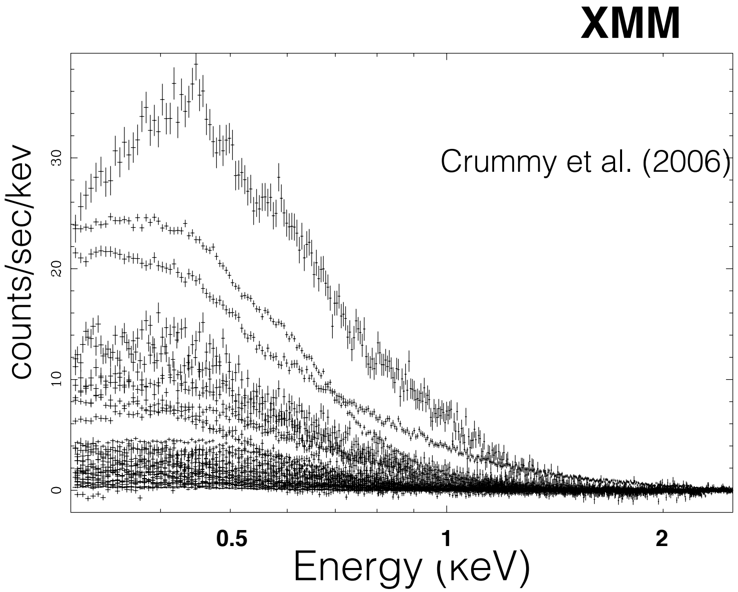
- Known since the 80s’ (Arnaud et al. 1985, Singh et al. 1985)







# Context

- Soft excess: excess of flux below 1-2 keV compared to the extrapolation of the 2-10 keV power law

- Known since the 80s' (Arnaud et al. 1985, Singh et al. 1985)

- Detected in more than 50% of Sy 1 galaxies (e.g. Halpern 1984; Turner & Pounds 1989, Piconcelli et al. 2005, Bianchi et al. 2009, Scott et al. 2012)

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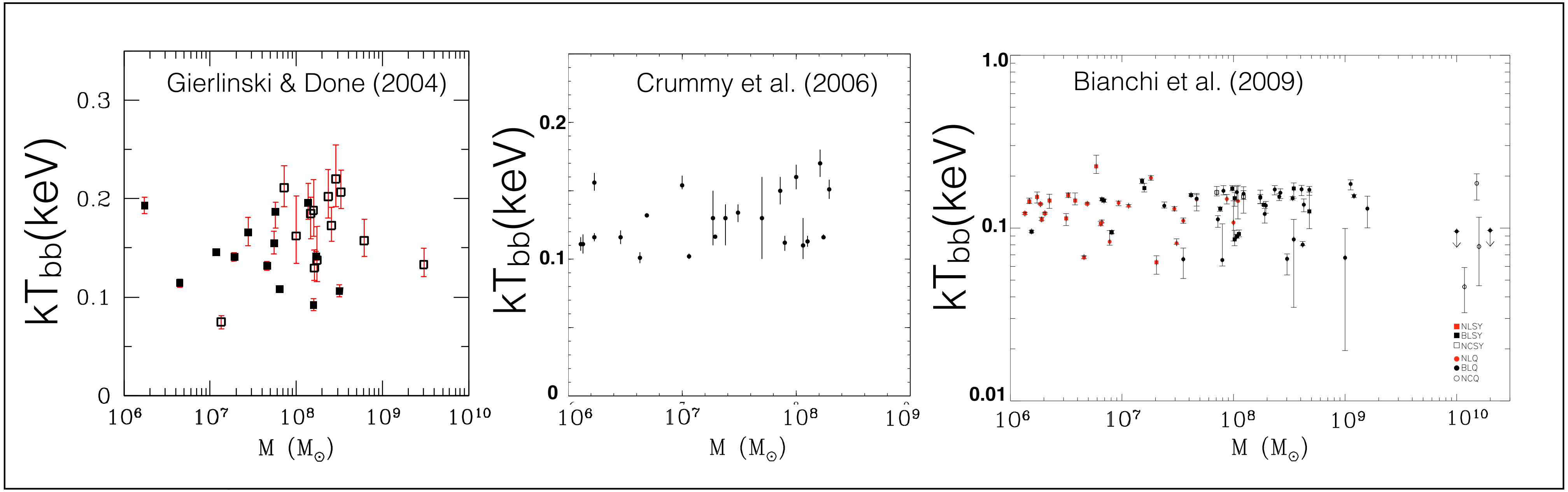
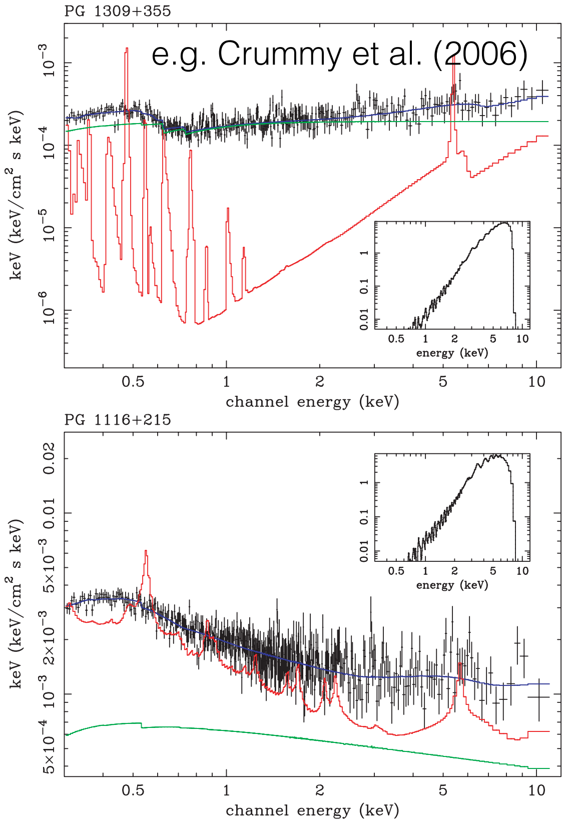


- With a « universal » spectral shape (e.g. Walter & Fink 1993, Gierlisnki & Done 2004, Crummy et al. 2006, Bianchi et al. 2009)

# Modeling

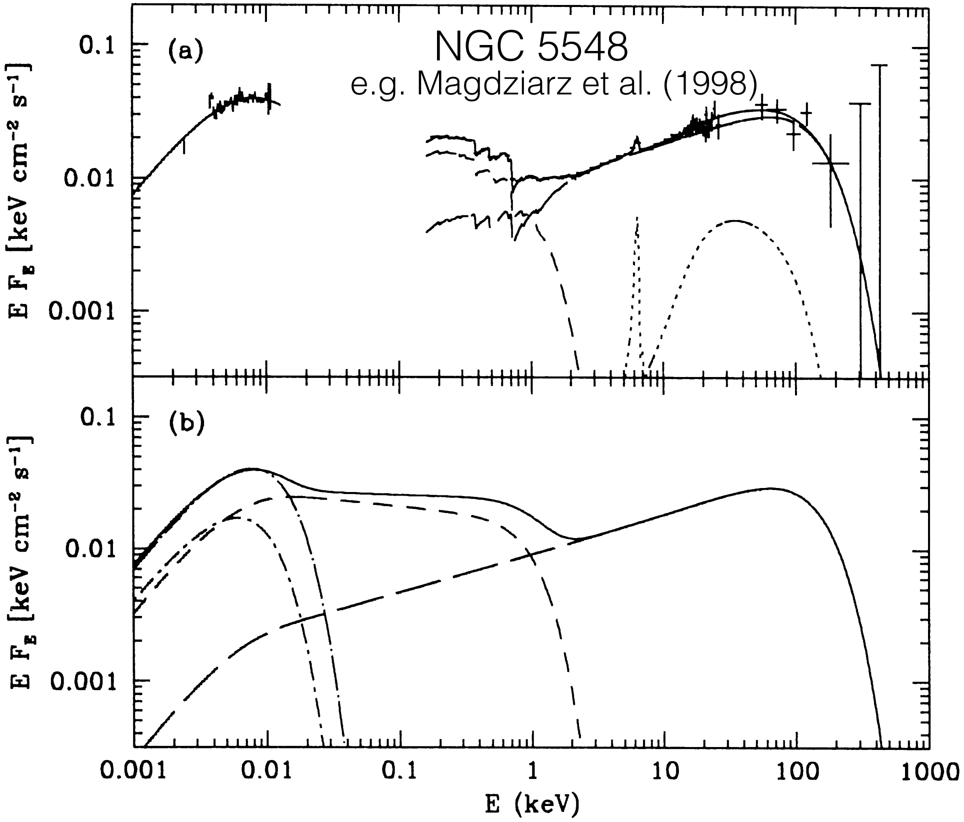
- Two main models proposed yet…

Blurred ionized reflection



e.g. Crummy et al. (2006)

Thermal Comptonisation



NGC 5548

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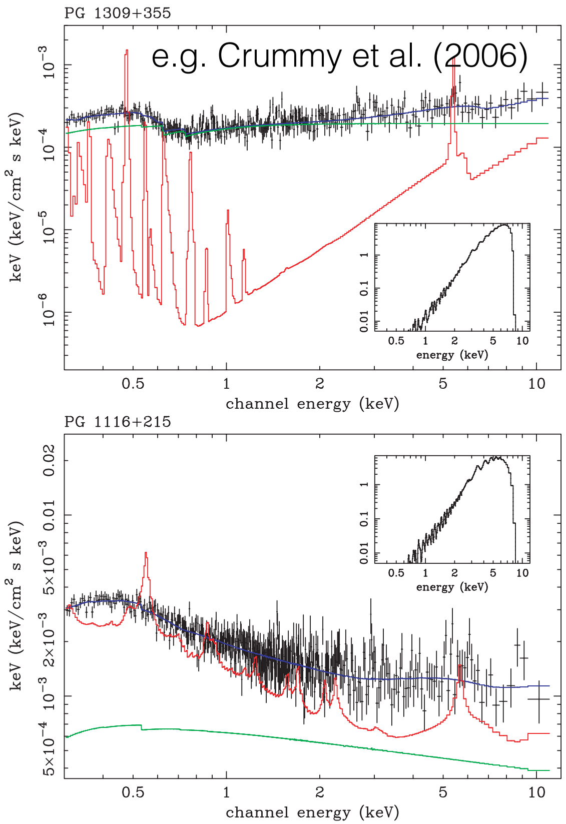
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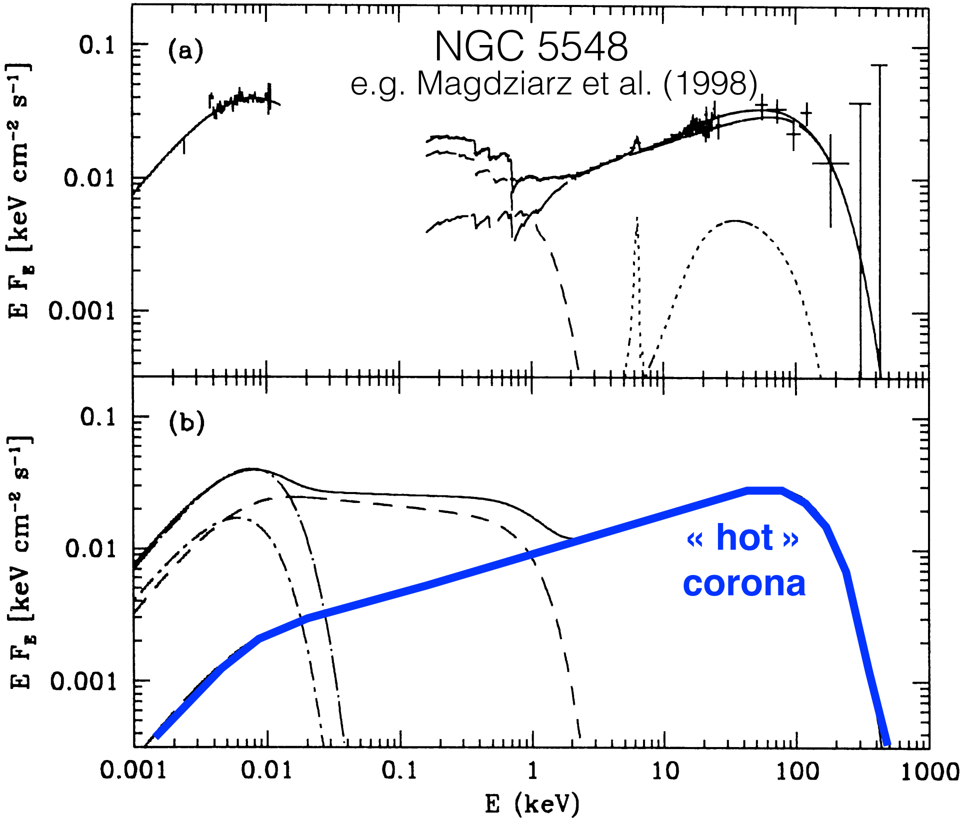
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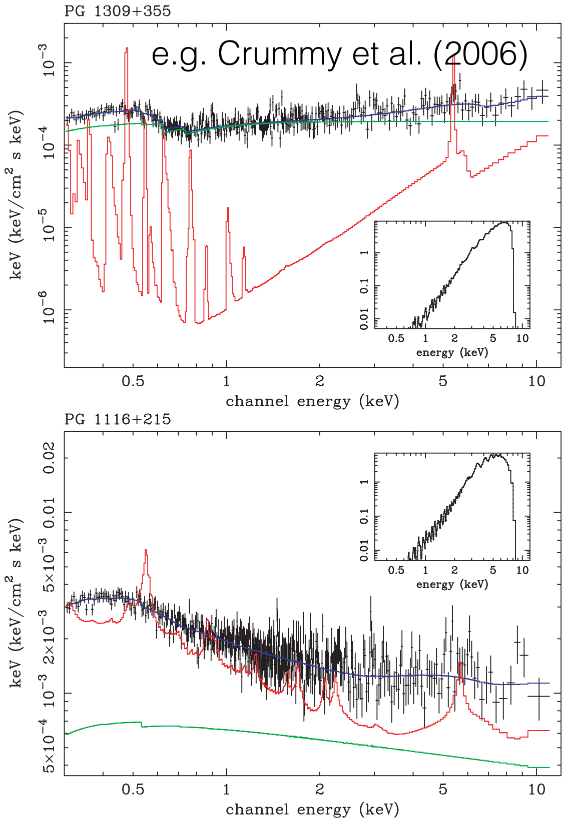
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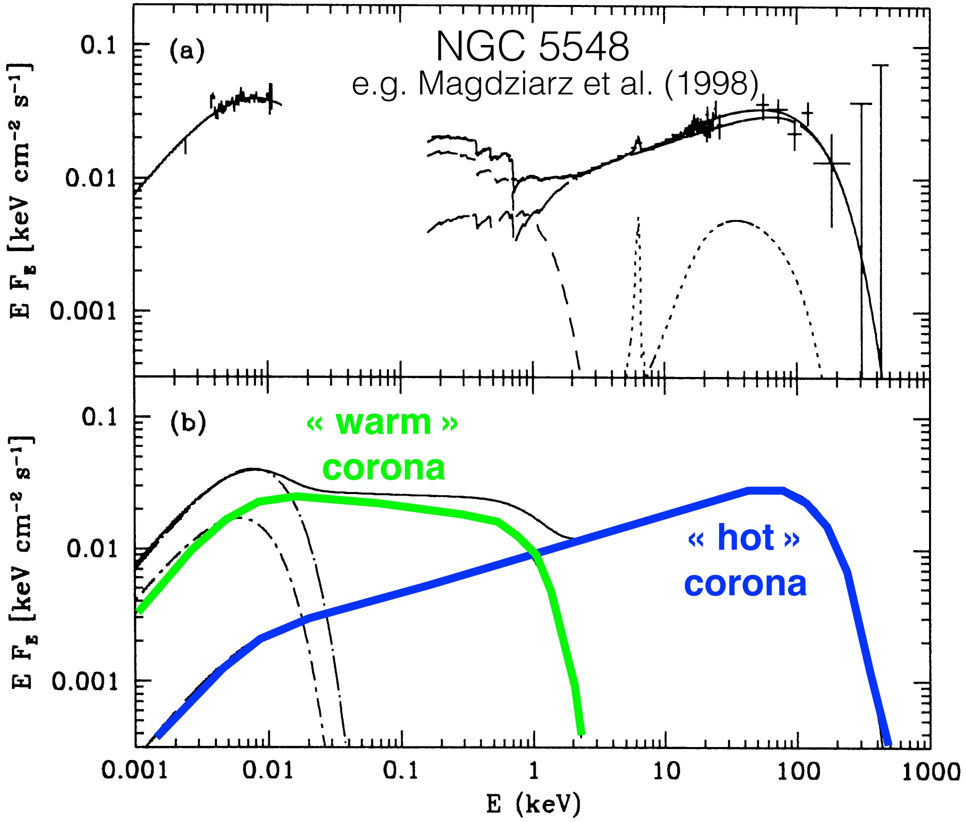
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« warm » corona

« hot » corona

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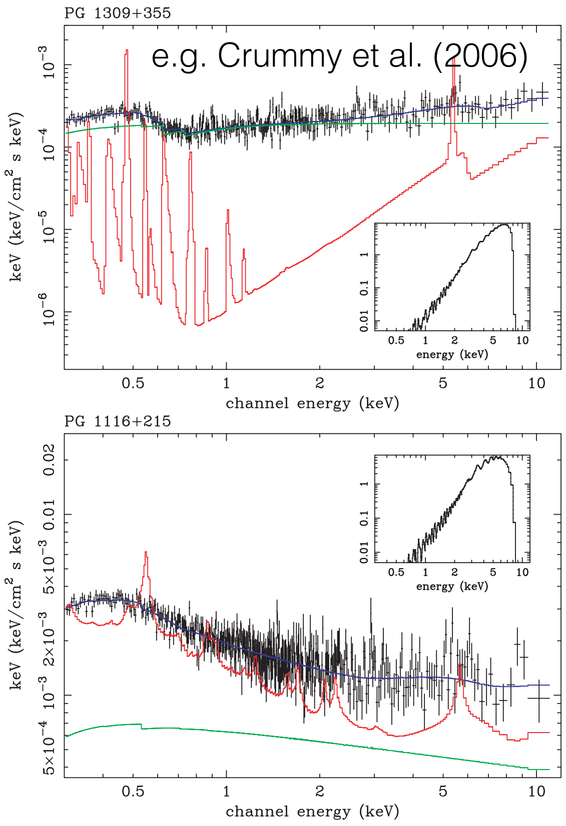

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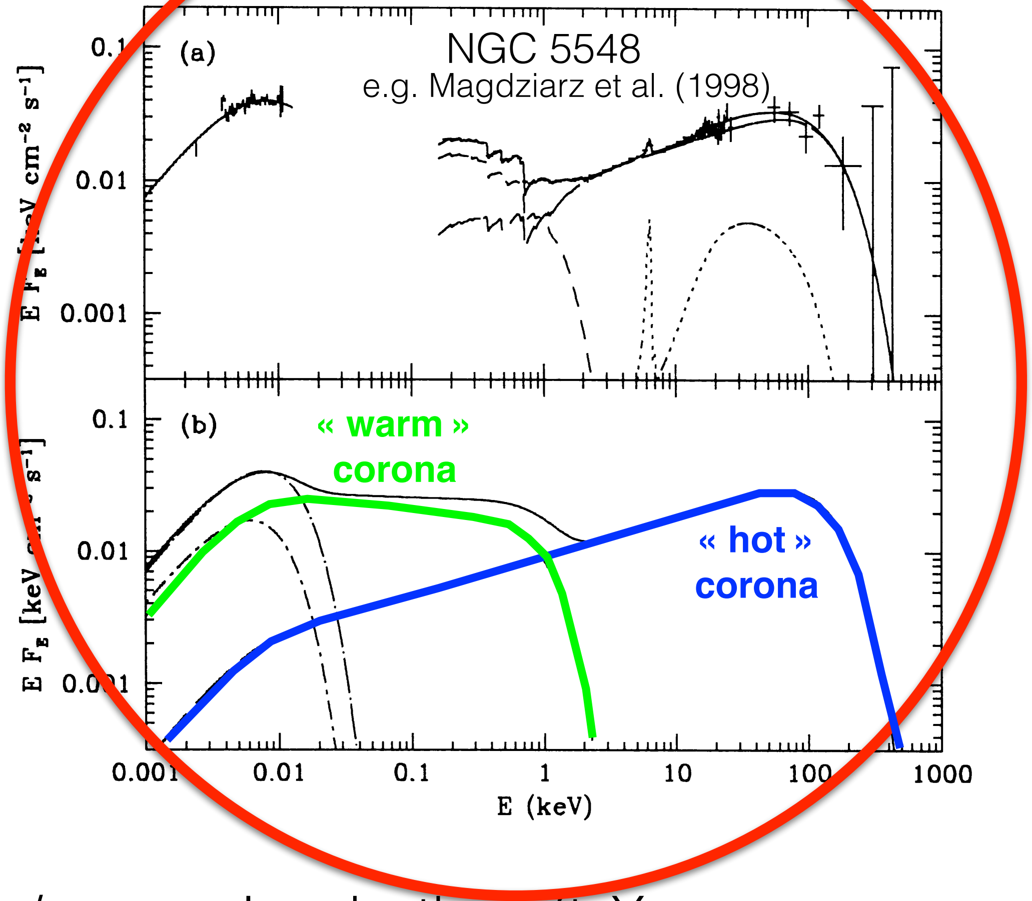

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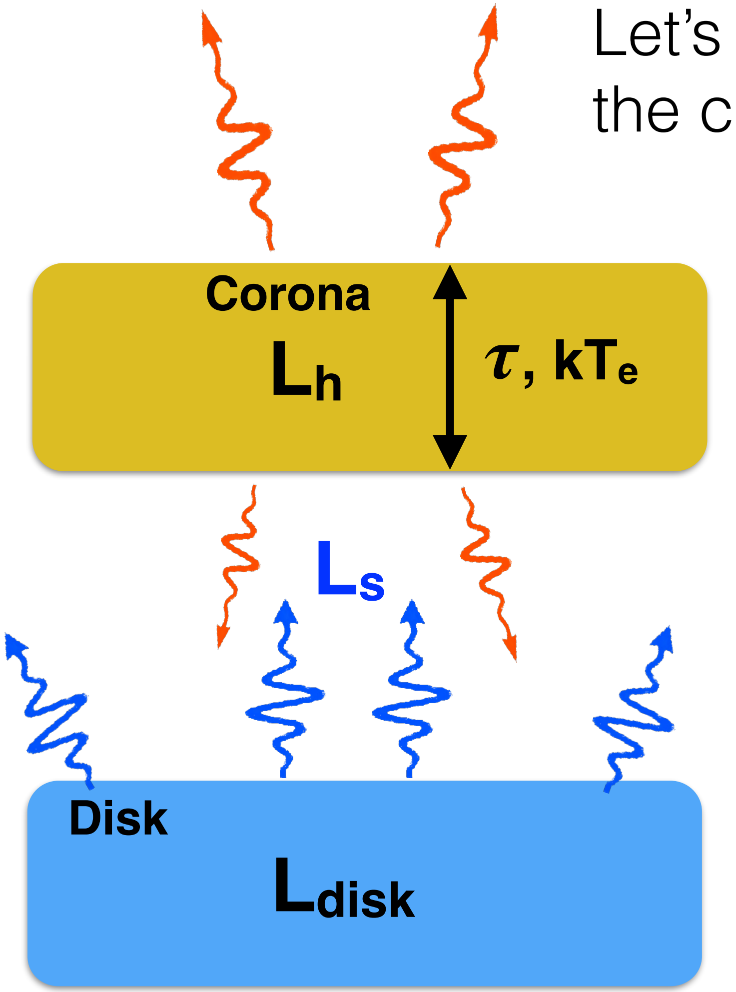
# Thermal Comptonisation

## Two-phases Radiative Equilibrium



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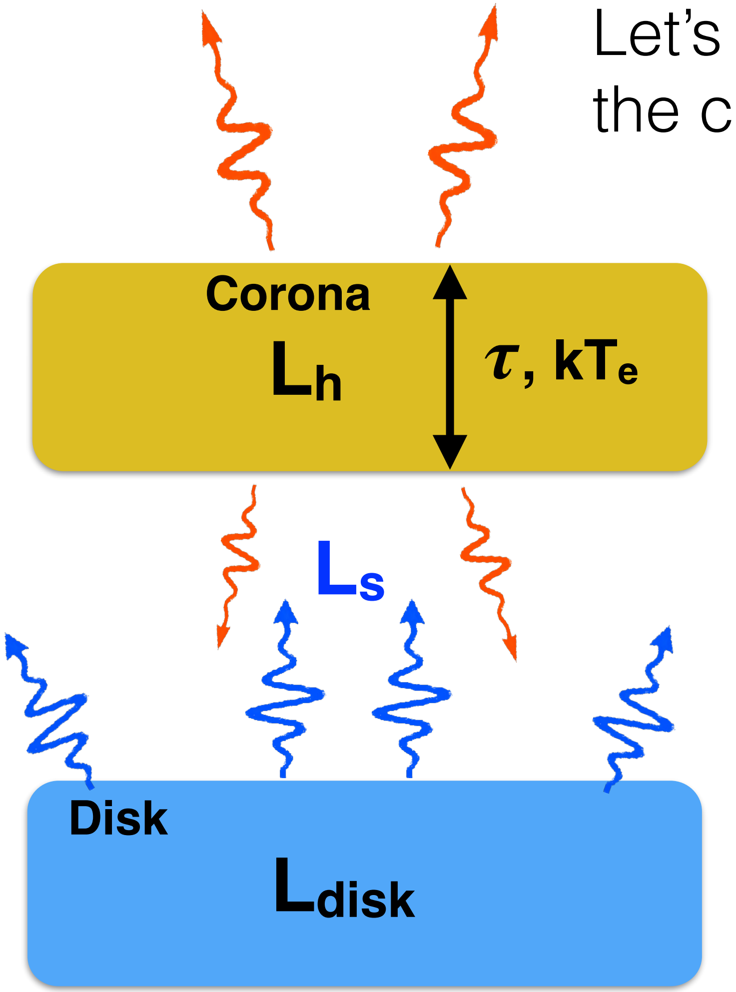

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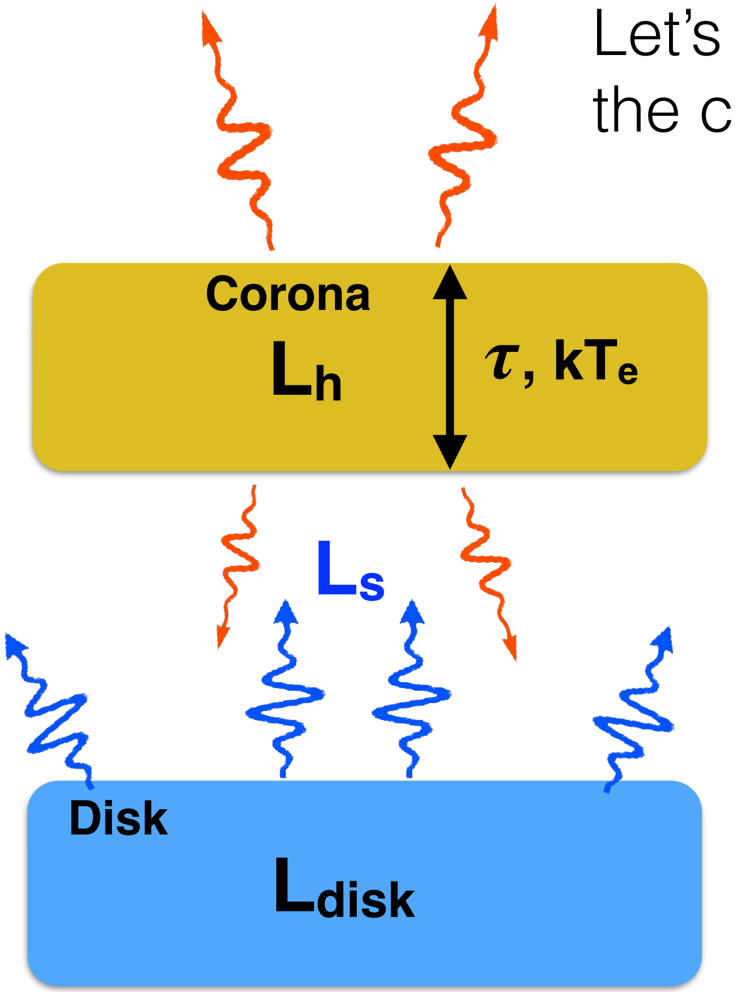

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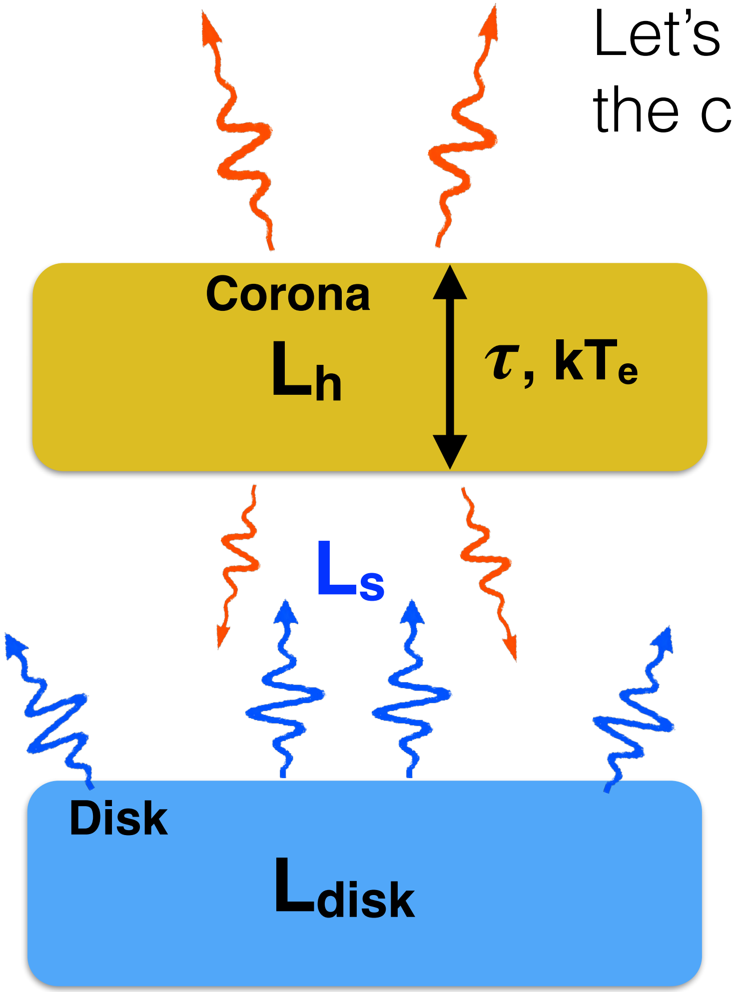

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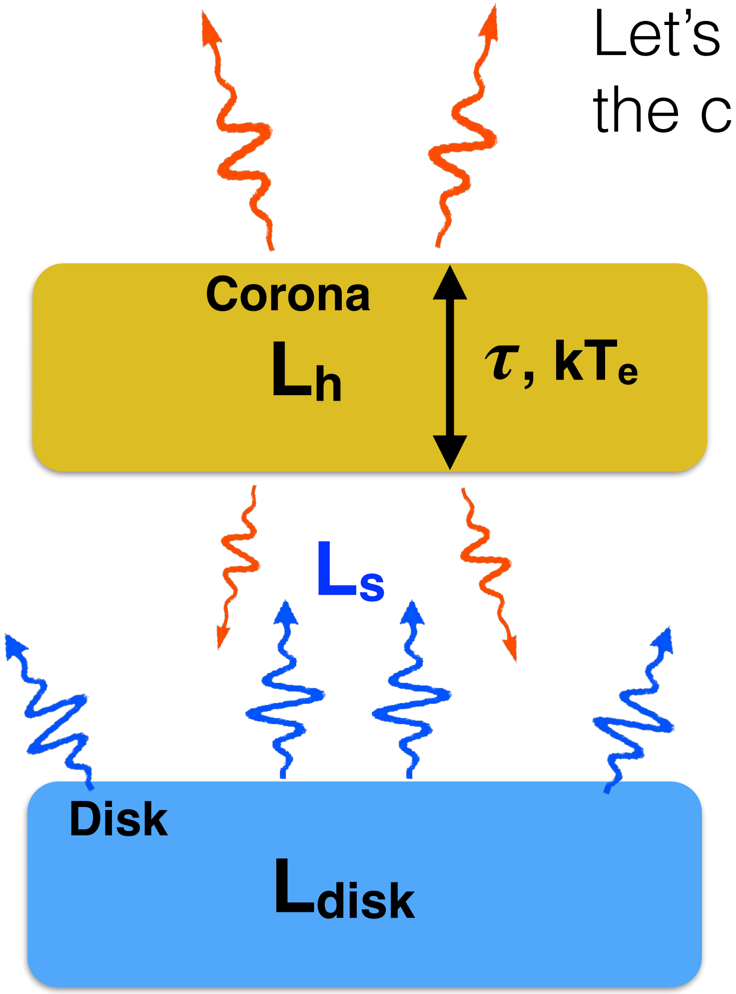

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soft photons crossing the corona **without being scattered**

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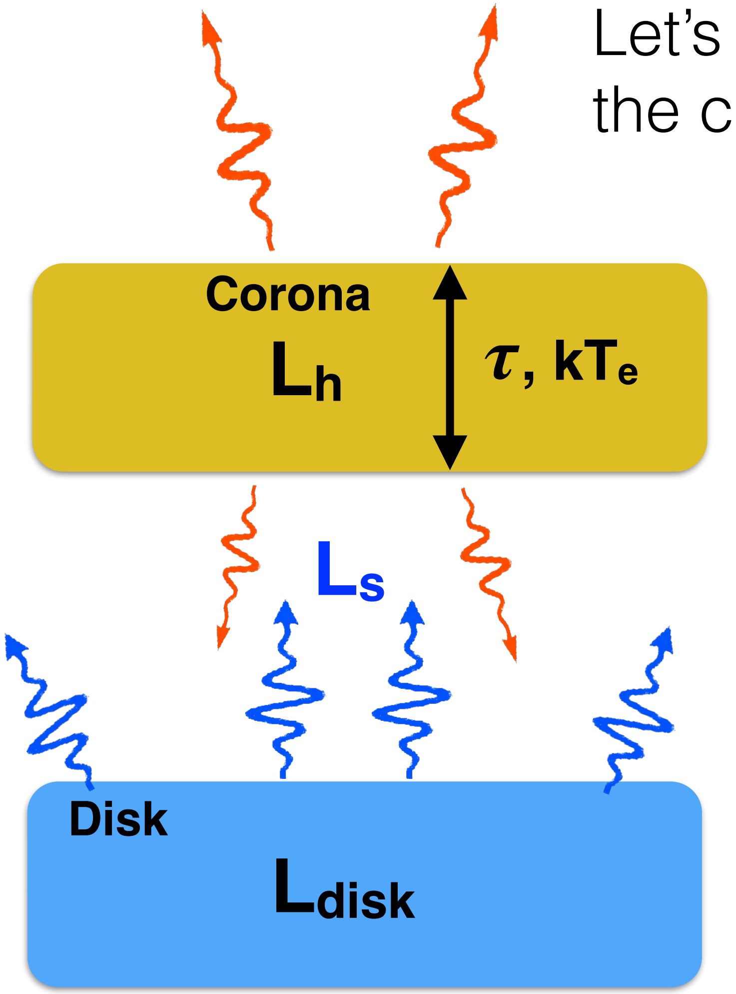

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soft photons crossing the corona **without being scattered**

soft photons entering the corona **being scattered upward**

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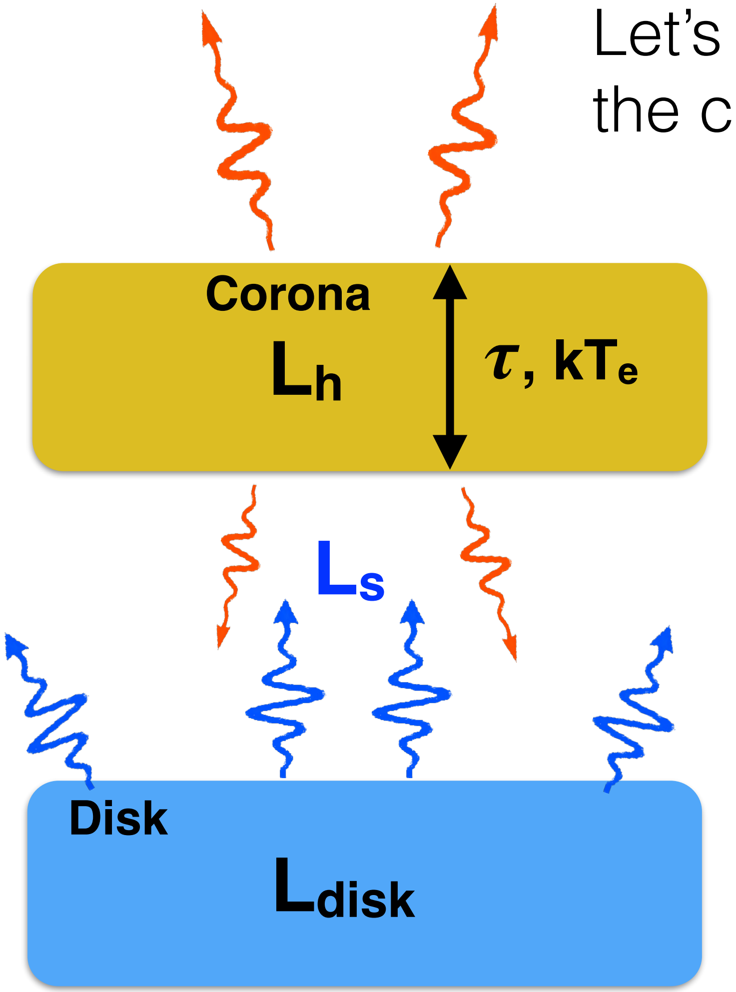

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soft photons entering the corona **being scattered downward**

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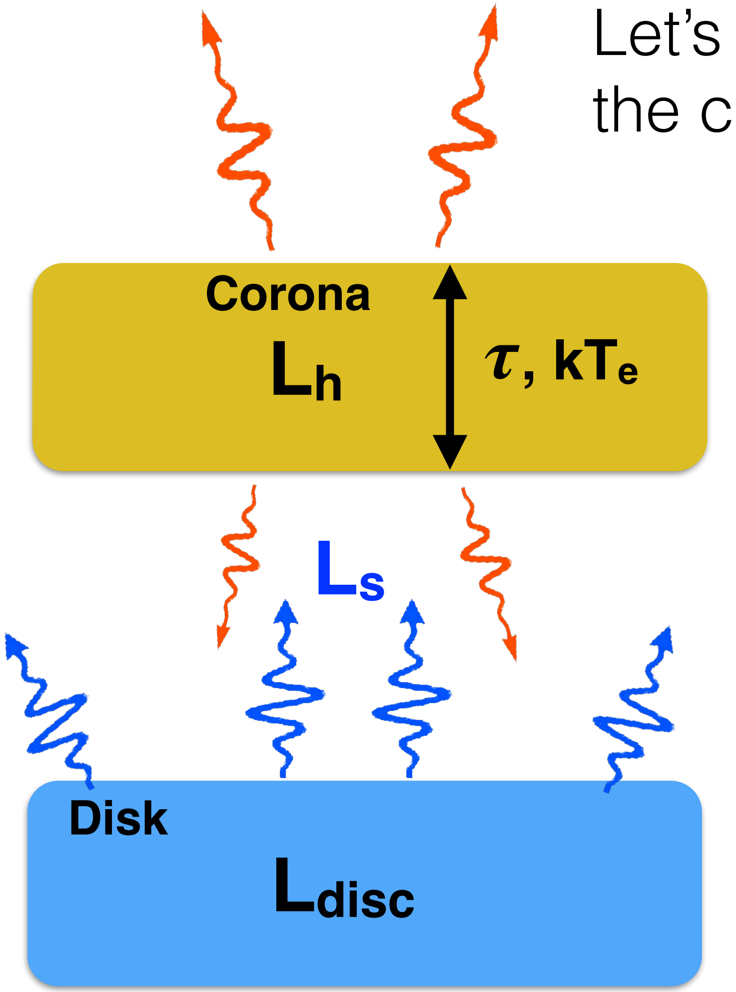

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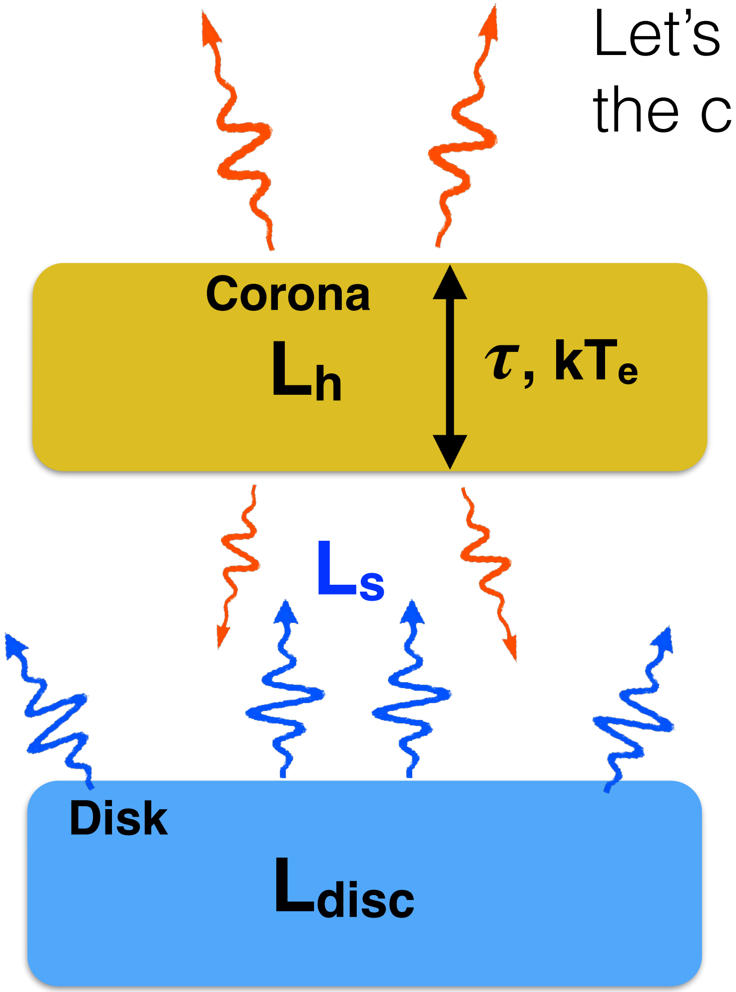

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Constrains:

➔ $L_{obs} = L_{s,up} + L_{h,up}$

➔ $L_s \leq L_{disc} = \underbrace{L_{h,down} + L_{s,down}}_{reprocessing} + L_{disc,intr}$

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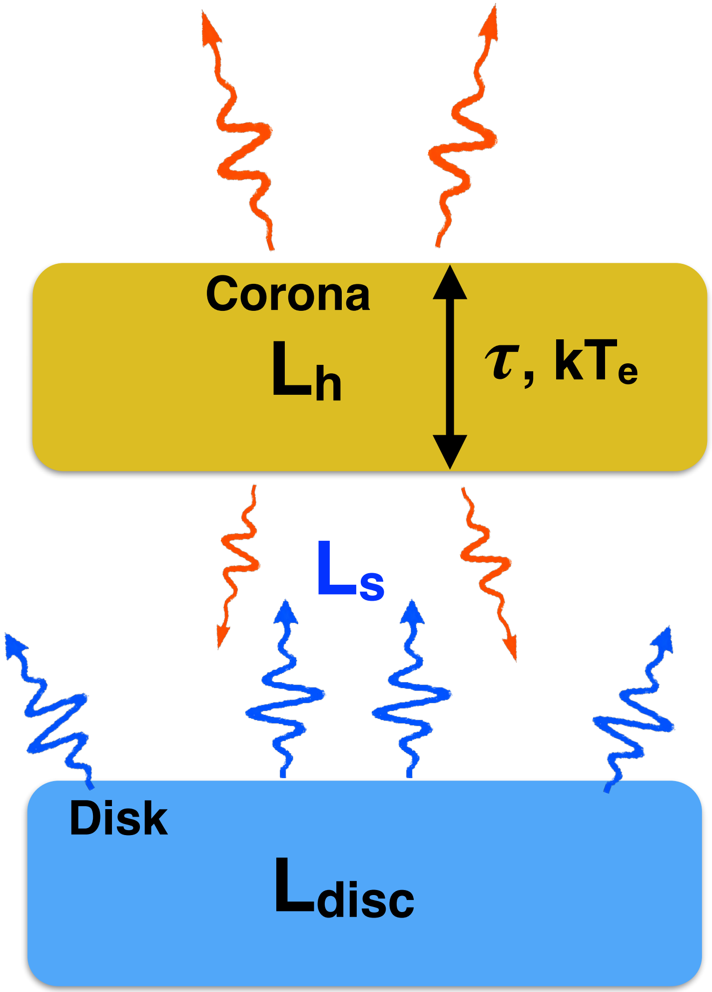

We can deduce a lower limits of the disc intrinsic emission from our best fits:

$$\boxed{\frac{L_{disc,intr}}{L_s} \geq 1 + e^{-\tau} - \frac{L_{obs}}{L_s} = \left.\frac{L_{disc,intr}}{L_s}\right|_{min}}$$

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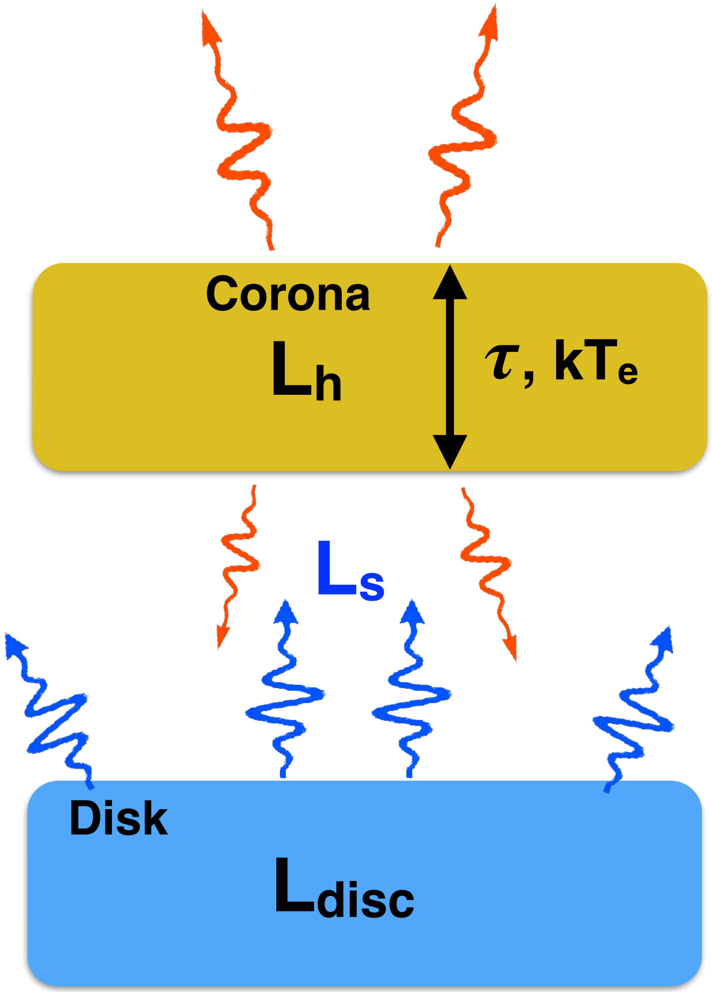

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Examples:

No intrinsic disc emission and $\tau$ <<1

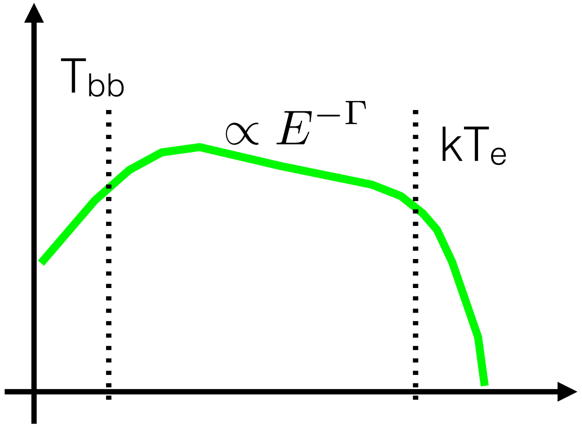
➔ $L_{obs}/L_s$=2 (Haardt & Maraschi 1993)

No intrinsic disc emission and $\tau$ >>1

➔ $L_{obs}/L_s$=1

# Numerical estimates of $\left.\frac{L_{disc,intr}}{L_s}\right|_{min}$

1. Warm corona model: nthcomp in XSPEC. Model parameters: $\mathbf{\Gamma}$, $kT_e$,$T_{bb}$
2. Choose $T_{bb}$ (e.g. 3 eV), vary $\mathbf{\Gamma}$ and $kT_e$



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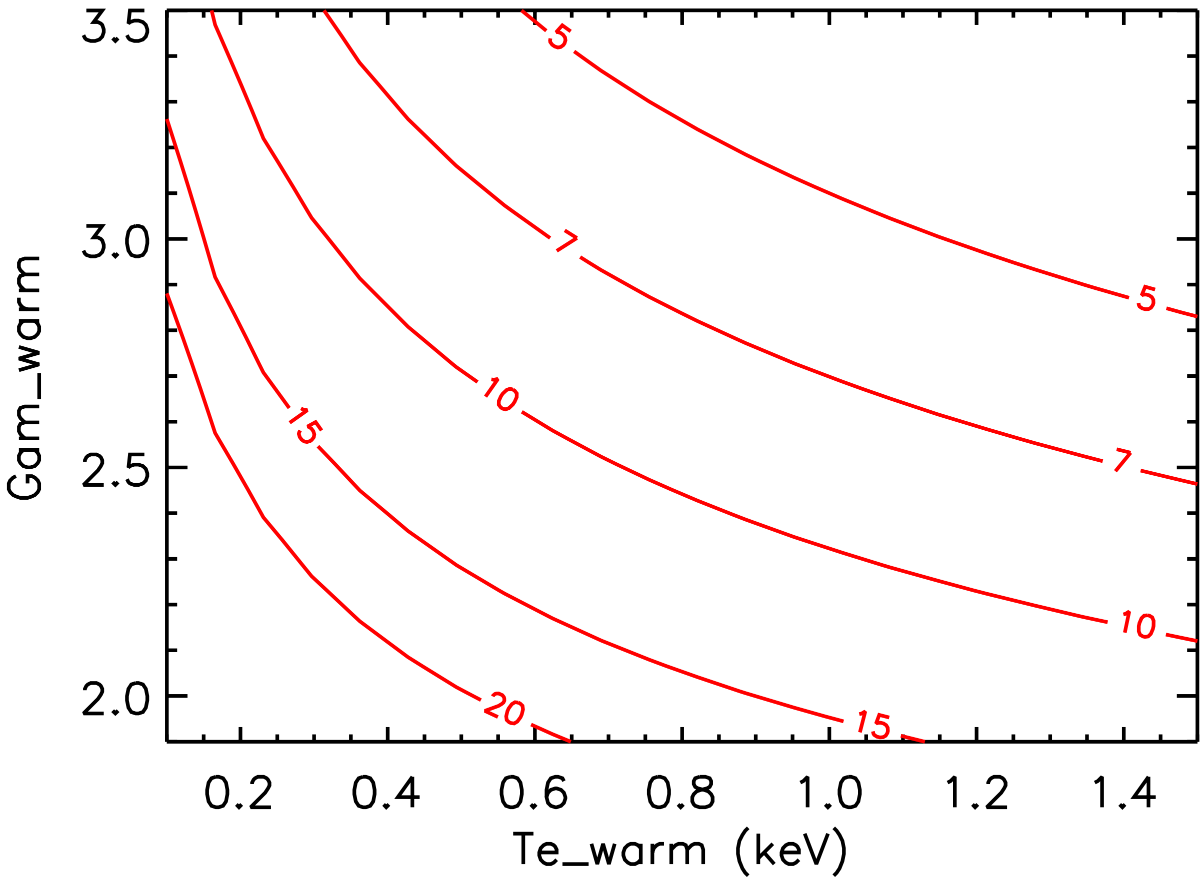

$\boldsymbol{\tau}$ contours

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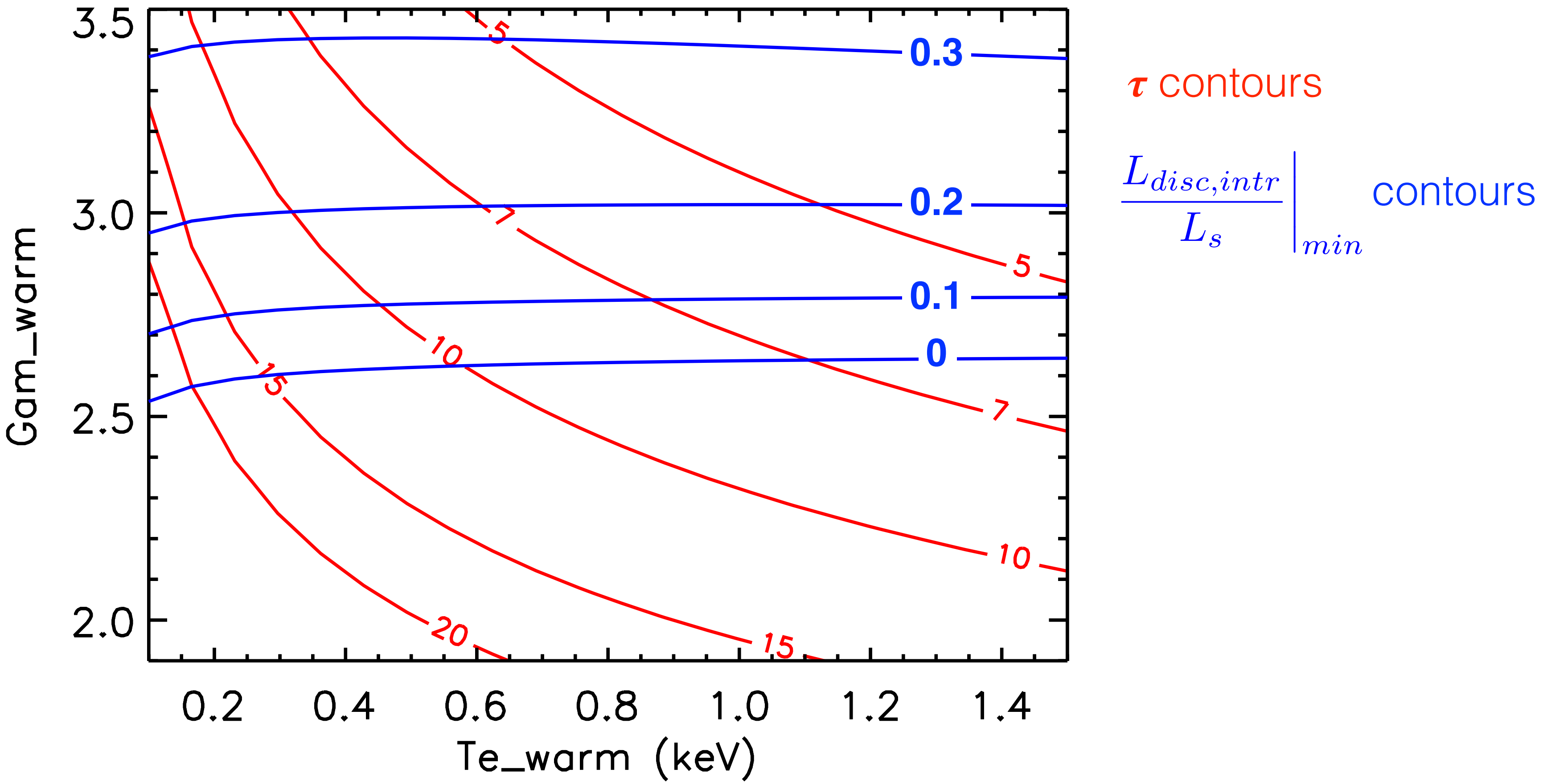

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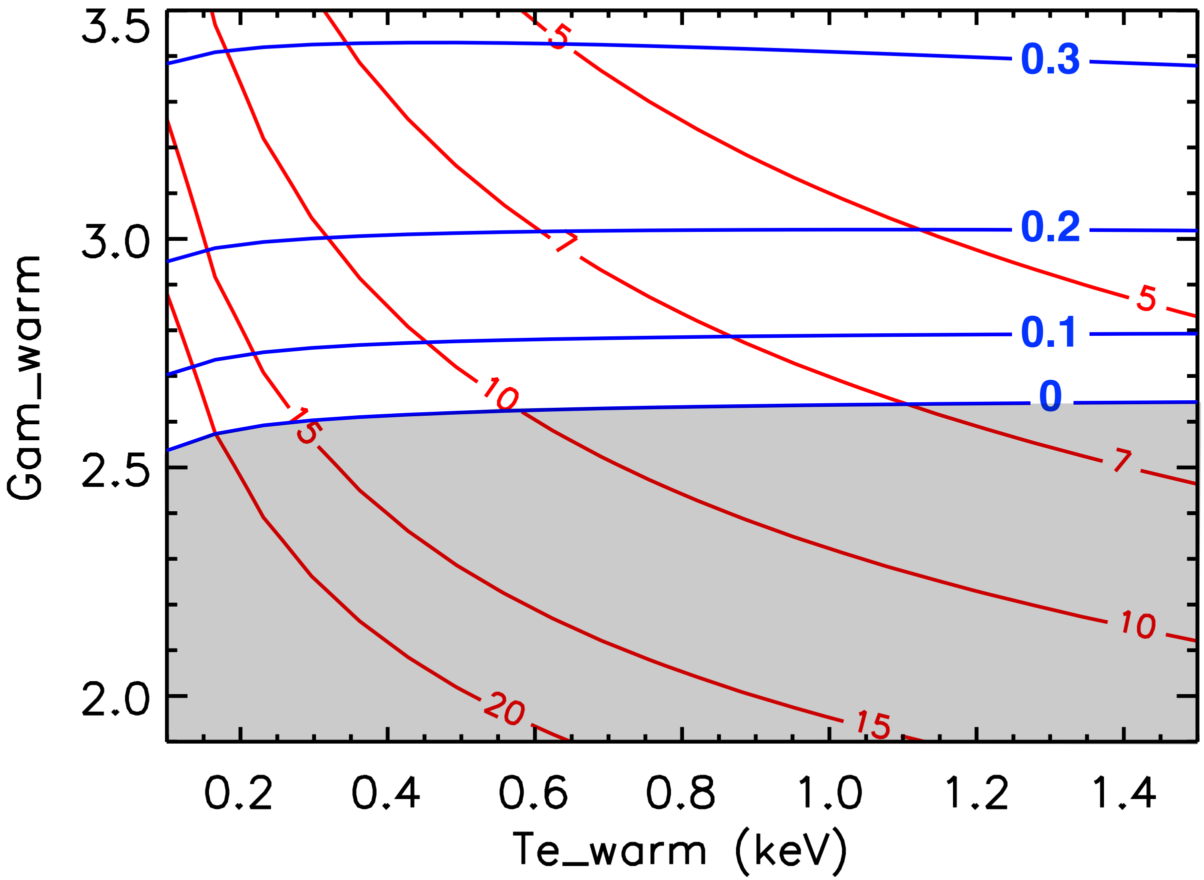


$\tau$ contours

$\left.\frac{L_{disc,intr}}{L_s}\right|_{min}$ contours

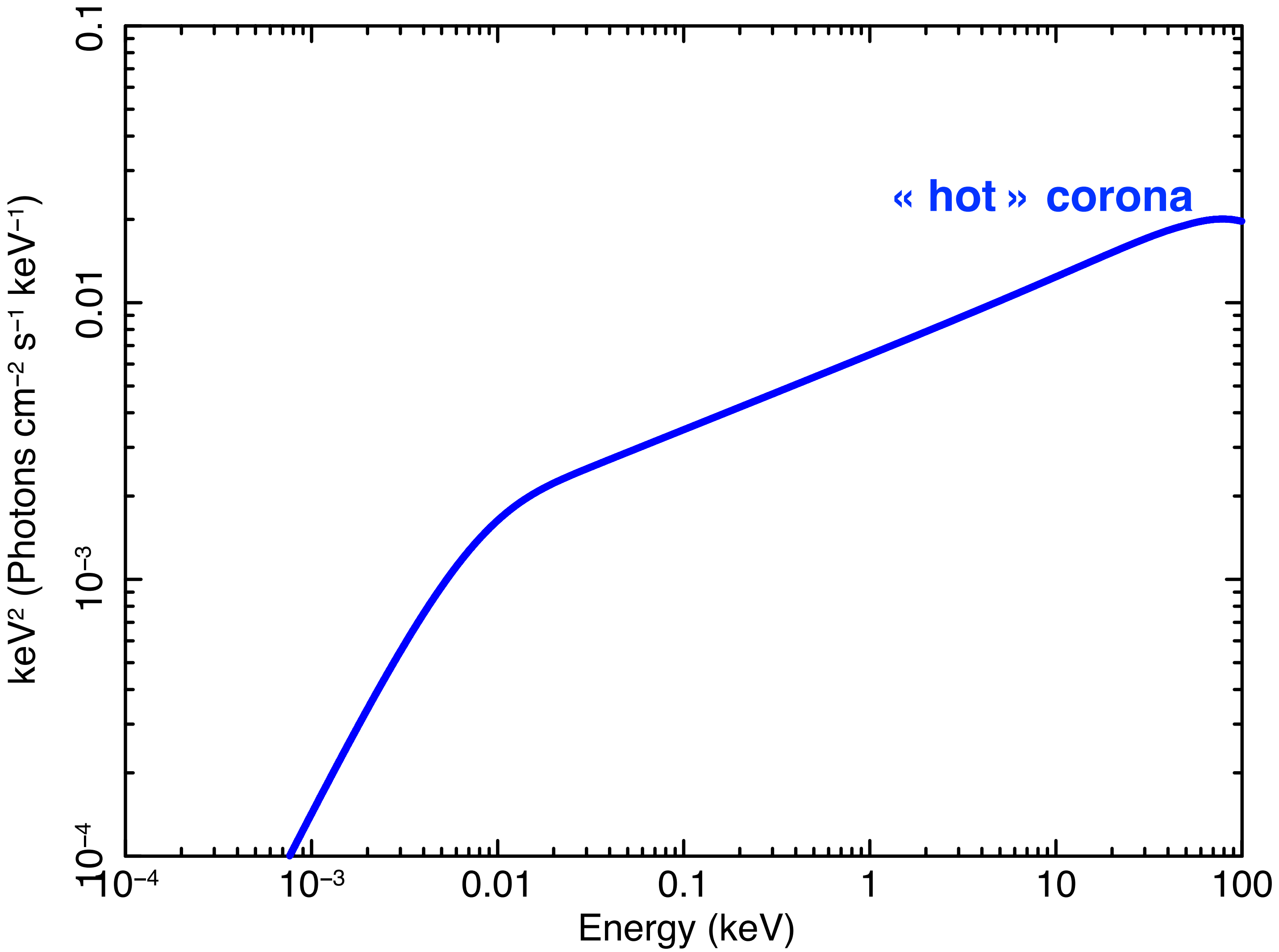
$L_s < L_{disc}$
patchy warm
corona

# Sample

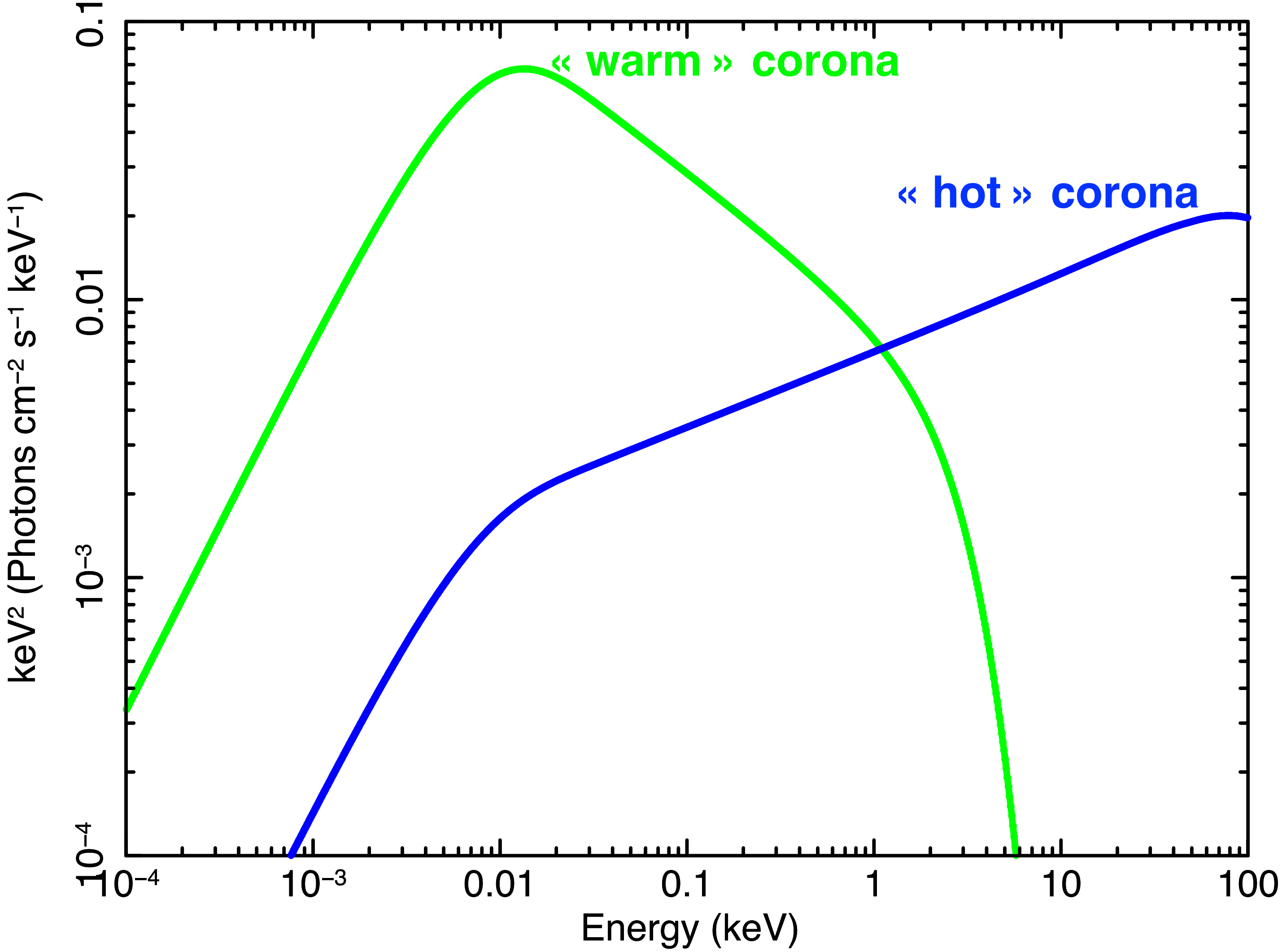
- In the CAIXA catalogue (XMM archive, Bianchi et al. 2009 + new sources)
- With more than 3 observations
- With more than 3 OM filters
- Low Nh (< $10^{22}$ cm$^{2}$), weak WA

**Mkn 509, Mkn 883, Mkn 279, PG1116+215, PG1114+445**, Mkn 335, NGC 7469, 1H0707-495, H0557-385, Mkn766, PG1211+143, Q2251-178

# Model


« hot » corona
keV² (Photons cm⁻² s⁻¹ keV⁻¹)
0.1
0.01
10⁻³
10⁻⁴
10⁻⁴
10⁻³
0.01
0.1
1
10
100
Energy (keV)

# Model


« warm » corona
« hot » corona
keV² (Photons cm⁻² s⁻¹ keV⁻¹)
0.1
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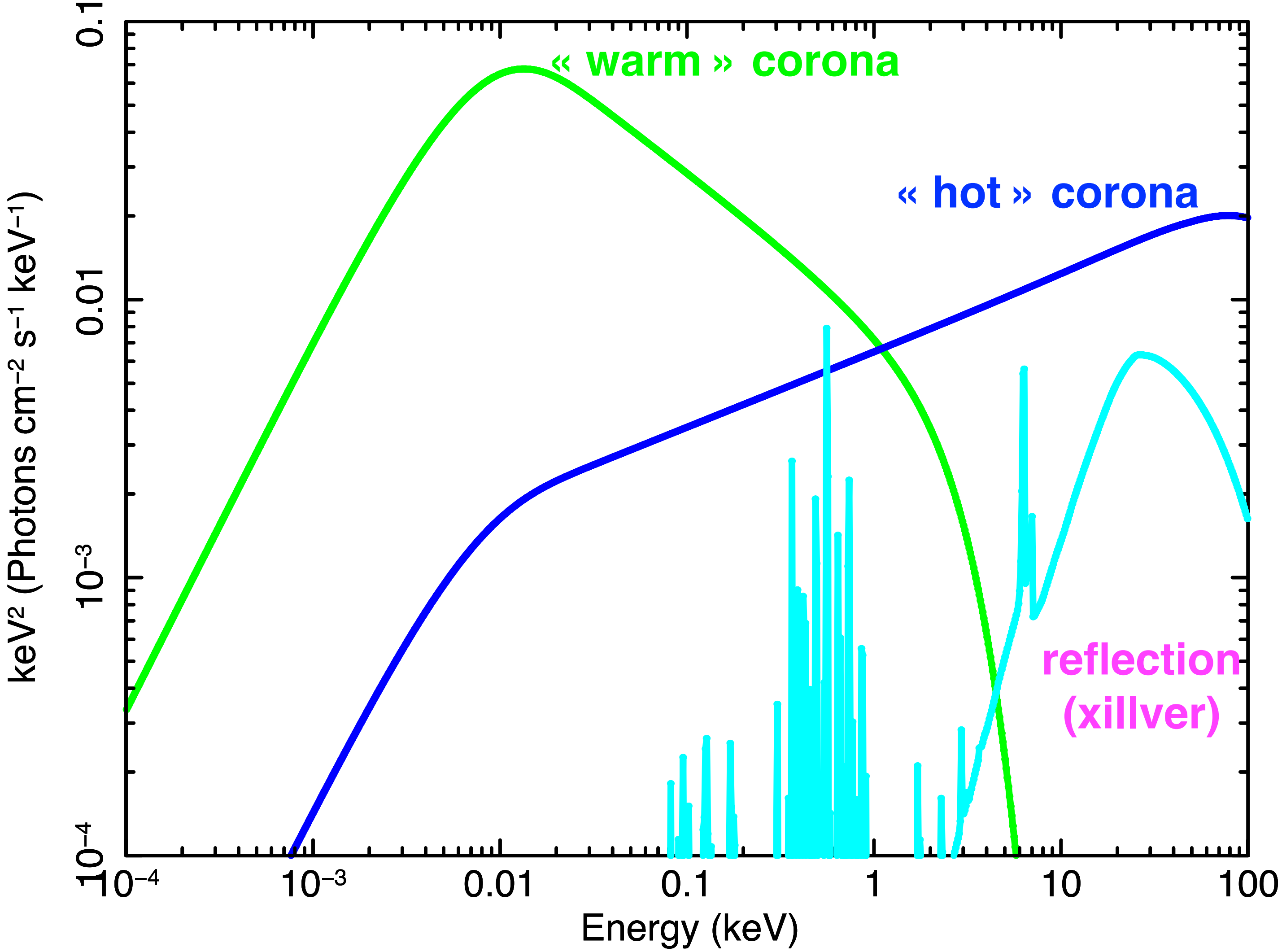
« warm » corona
« hot » corona
reflection
(xillver)
keV² (Photons cm⁻² s⁻¹ keV⁻¹)
Energy (keV)
0.1
0.01
10⁻³
10⁻⁴
10⁻⁴
10⁻³
0.01
0.1
1
10
100

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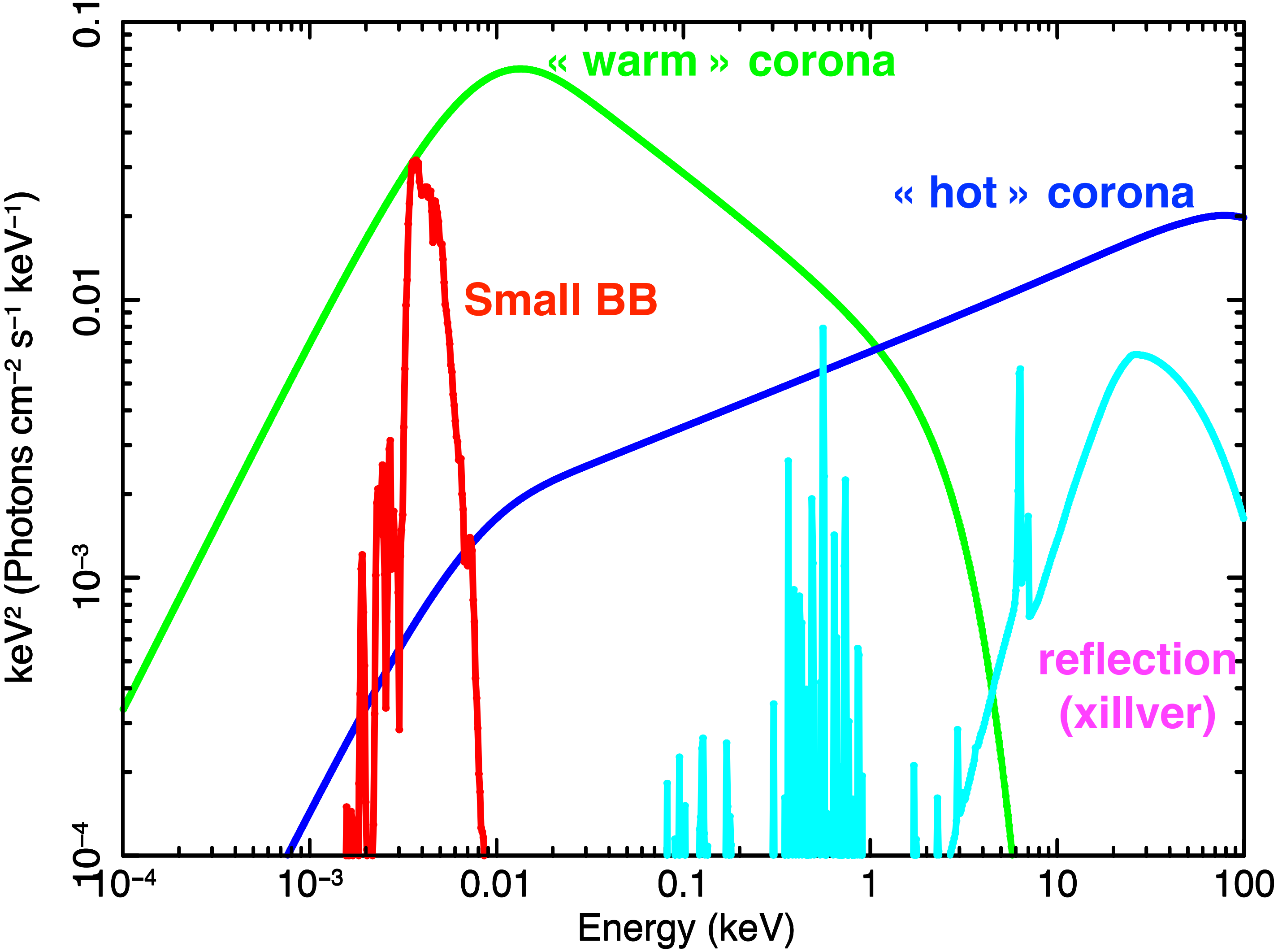
« warm » corona
« hot » corona
Small BB
reflection
(xillver)
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0.1
0.01
10⁻³
10⁻⁴
10⁻⁴
10⁻³
0.01
0.1
1
10
100
Energy (keV)

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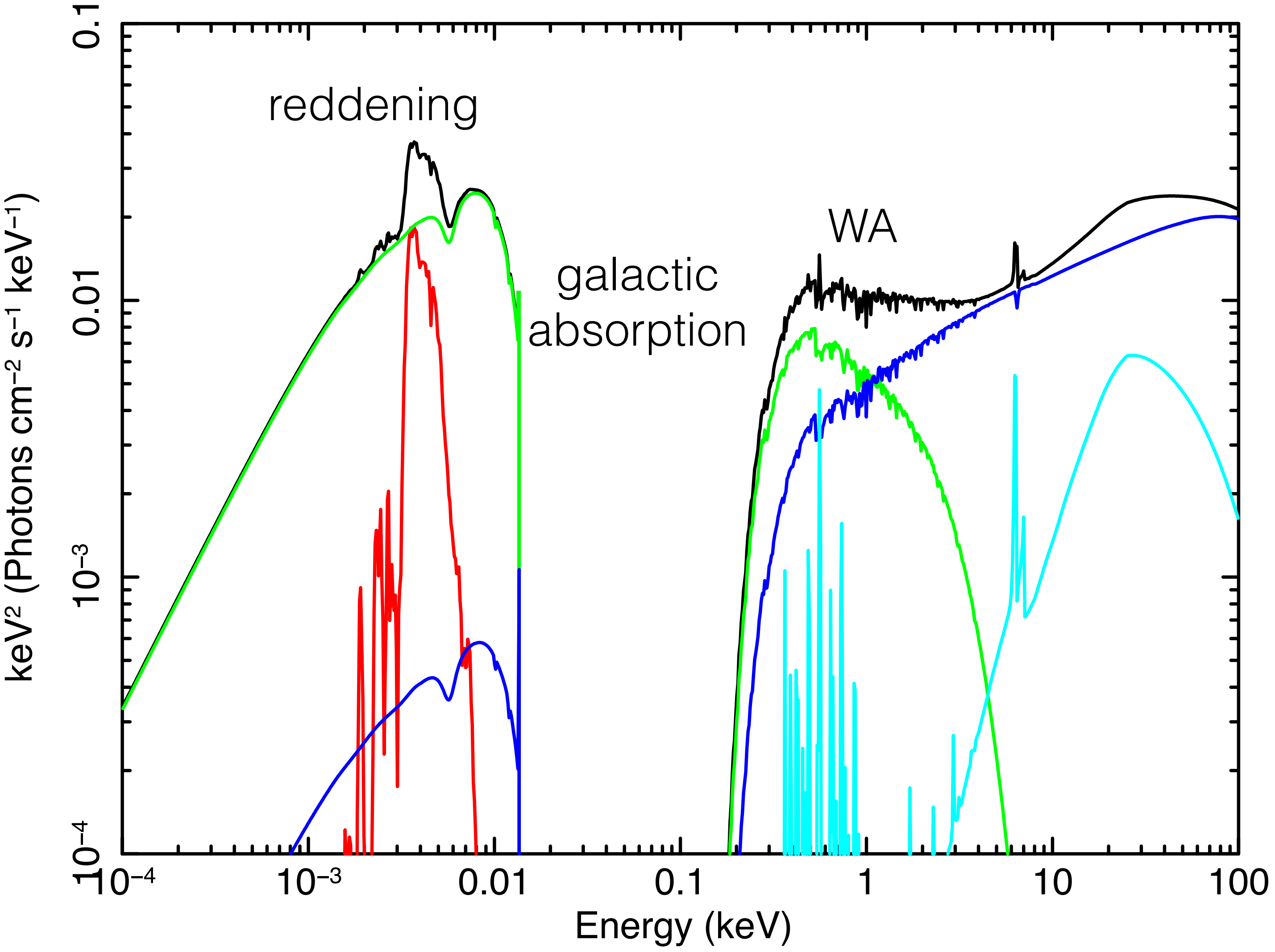
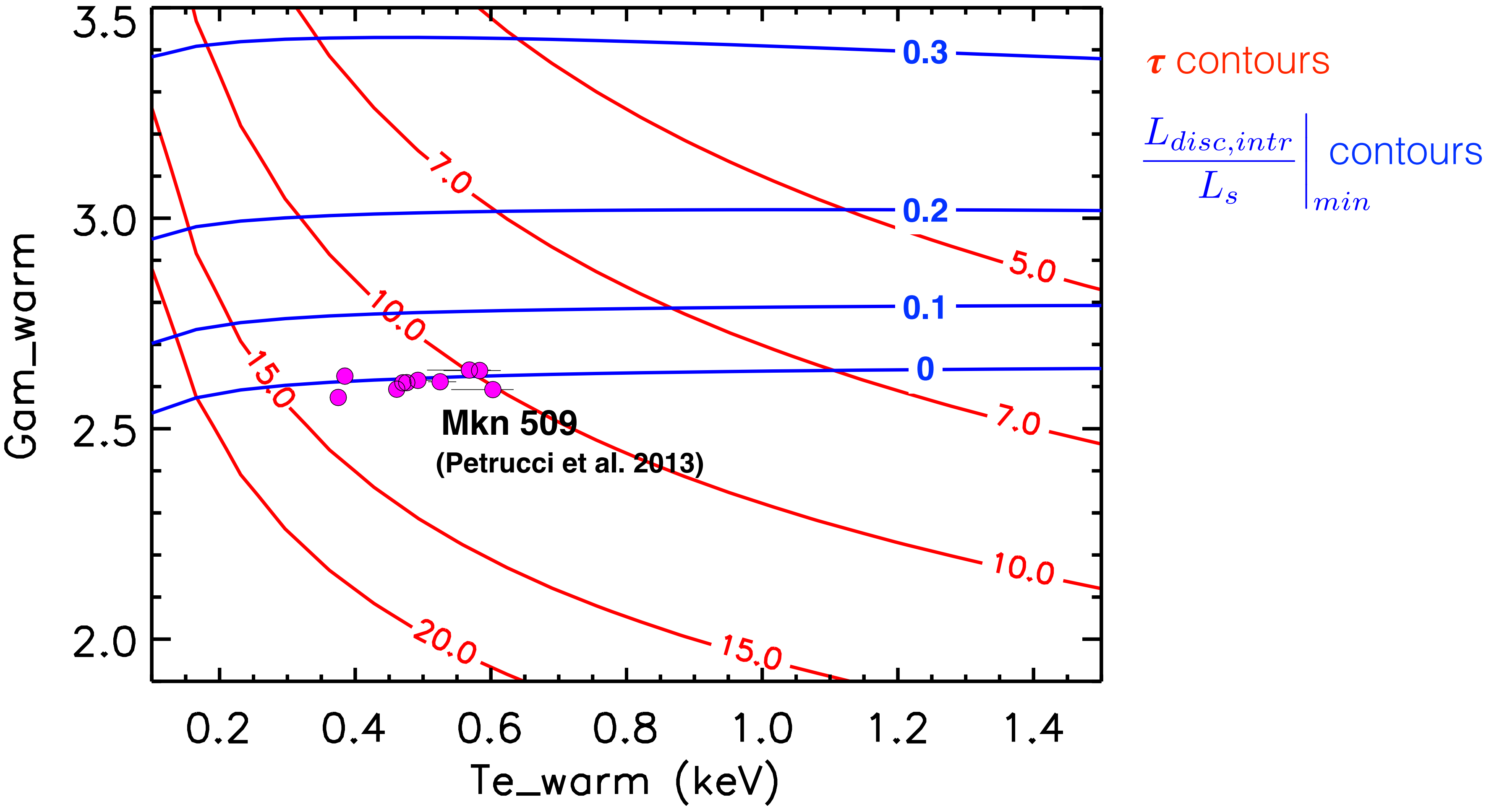

reddening
galactic
absorption
WA
keV² (Photons cm⁻² s⁻¹ keV⁻¹)
0.1
0.01
10⁻³
10⁻⁴
10⁻⁴
10⁻³
0.01
0.1
1
10
100
Energy (keV)

# Results (preliminary)



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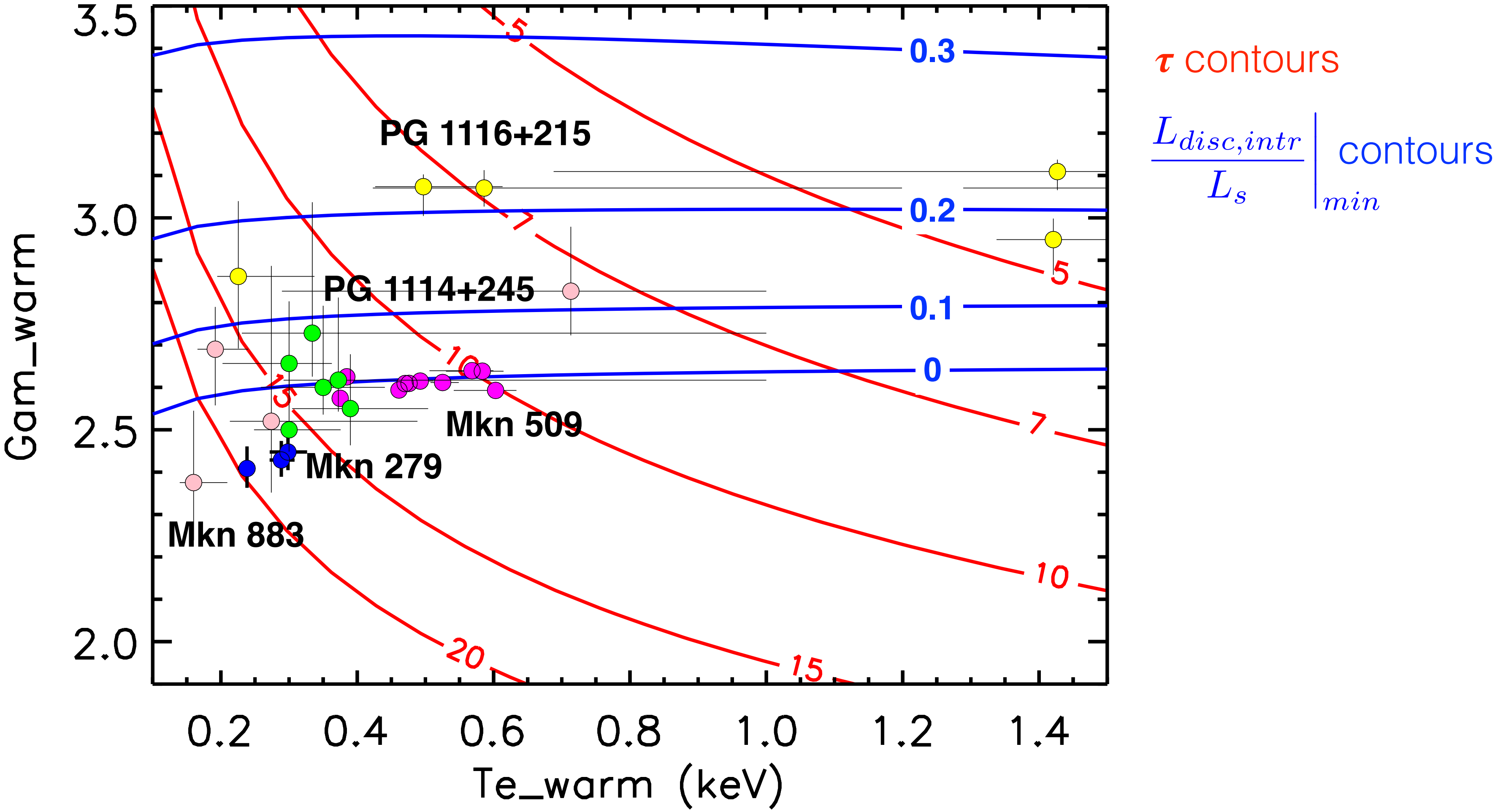

The sample agrees with low or even no disc intrinsic emission !

# Conclusions

- A two-corona model (a **warm** ~1 keV, optically thick $\boldsymbol{\tau}$~10 and a **hot** ~100 keV, optically thin $\boldsymbol{\tau}$~1) reproduce well the UV-X-ray spectrum of our sample
- The warm corona explaining the UV-Soft X-ray excess agrees with **a slab geometry** above the accretion disc
- **MOST** of the accretion power is **released in the warm corona** (illumination? Turbulence?)
- The warm corona could be the **disc upper layers** (Janiuk et al. 2001, Czerny et al. 2003, Rozanska et al. 2015)

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Thanks!