

MoCA: a Monte Carlo code for Accretion

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many thanks for the help also to: Michal Dovciak, René Goosmann
and Michal Bursa

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Outline

- scientific motivation
 - the model
 - the code
 - preliminary results (just the spectra)
 - future developments & applications
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Scientific motivation

MoCA is a fully special relativistic code for studying the spectrum and the polarization signal in accreting sources

Why polarimetry?

Since the birth of X-ray astronomy, **spectral, spatial and timing observation** improved dramatically, procuring a wealth of information on the majority of the classes of the celestial sources. Polarimetry, instead, remained basically unprobed. X-ray polarimetry promises to provide additional information procuring **two new observable quantities**, the degree and the angle of polarization. [*Enrico Costa*]

The poster is titled "THE COMING OF AGE OF X-RAY POLARIMETRY" in large yellow letters at the top. Below the title, it specifies the dates "APRIL 27-30, 2009" and the location "CENTER FOR AMERICAN STUDIES, ROME, ITALY". The background features a collage of astronomical images, including a galaxy and a cluster of stars. On the left side, there are logos for "INAF", "MoCA", "INAF", "INAF", and "INAF". The central part of the poster lists "Topics" under two sub-headings: "Theory" and "Instruments". The "Theory" section includes: "Low magnetized NS and WD", "Tata flux reversals: AGN B", "Radio pulsars and FRX", "Highly magnetized NS", "GRB", "Strong gravit*", and "AGN B". The "Instruments" section includes: "PHP", "Scattering", and "Irispa". On the right side, the "Scientific Organizing Committee" is listed with names: R. Fallickini, P. Bianziford, E. Costa, G. Inzer, K. Ingeles, R. Gaaret, G. Garas, G. Matt, M. McCannell, S. Non Zhang, D. Faval, G. Rando, J. Roulonon, A. Santonino, E. Silver, R. Sunayev, J. Swank, G. Tagliarini, E. Waxman, and M. Weisskopf. At the bottom, the "Local Organizing Committee" is listed: G. Arcizola, S. Di Cosimo, R. Milul, R. Nulari. A URL "http://npo.issia.cnr.it/2009/09/" is at the very bottom.

...unfortunately ALL the large and medium missions with an X-ray polarimeter on board have been cancelled or unselected.

the model

- the corona -

SPHERICAL corona parameters

$$R_{\text{Cin}} = 6 \text{ rg}$$

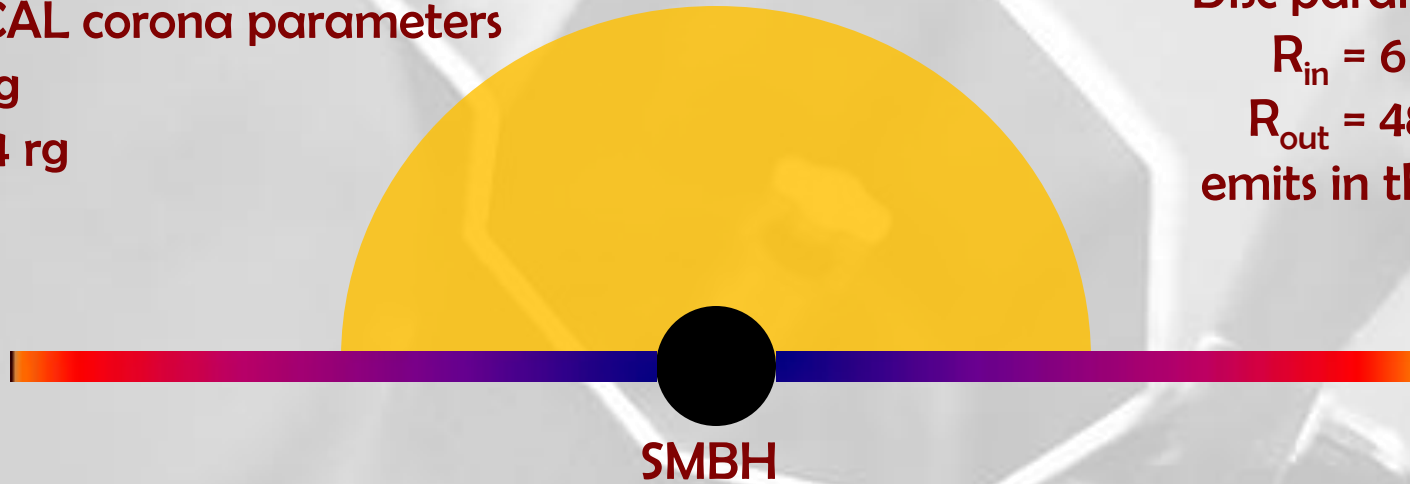
$$R_{\text{Cout}} = 24 \text{ rg}$$

Disc parameters

$$R_{\text{in}} = 6 \text{ rg}$$

$$R_{\text{out}} = 48 \text{ rg}$$

emits in the UV



SLABBY corona parameters

$$H_{\text{C}} = 6 \text{ rg}$$

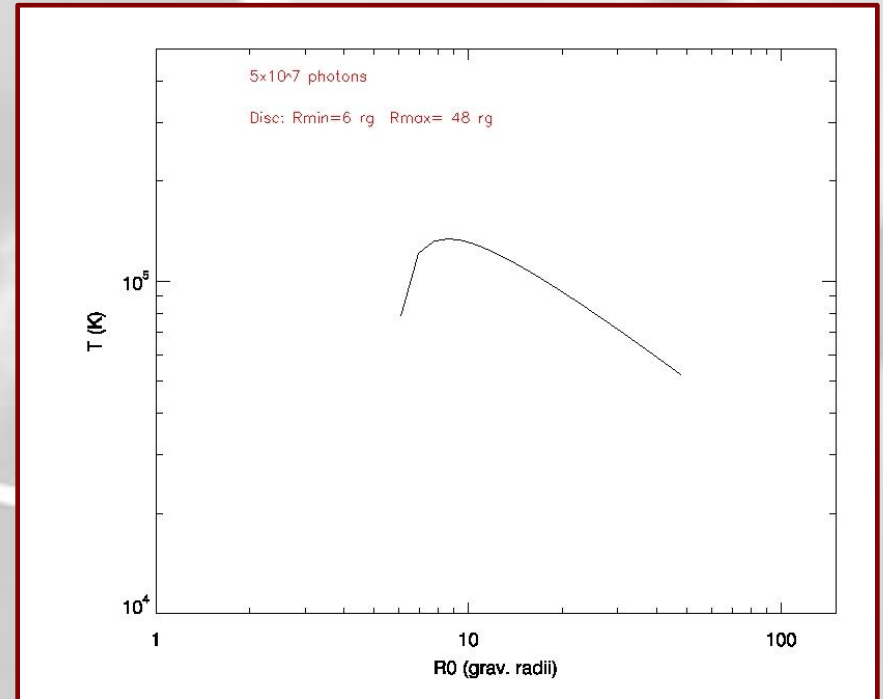
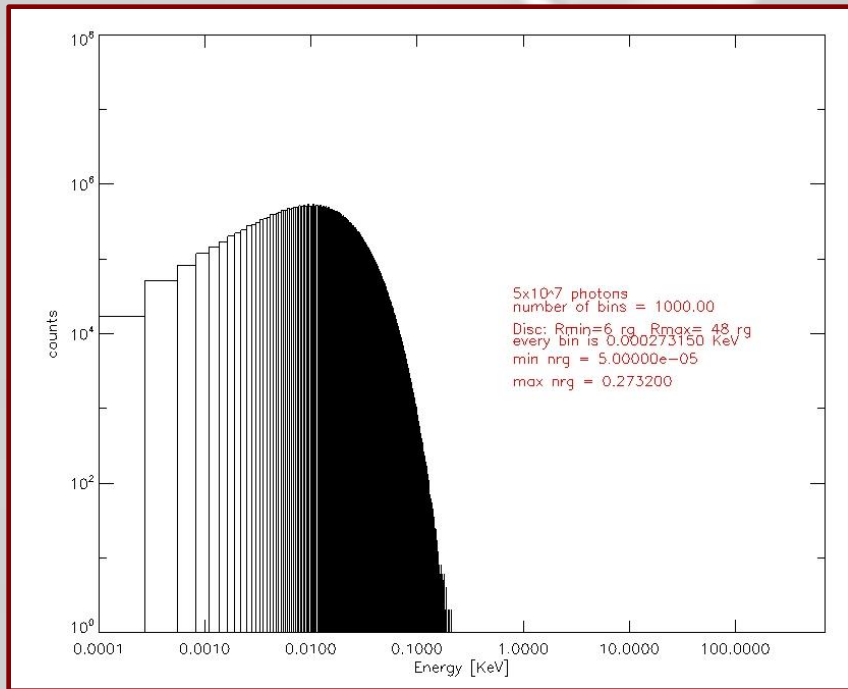
$$L_{\text{C}} = 48 \text{ rg}$$



the model

- the emission -

- emission from the disc (MTBB)



for both the geometries the thermal energy of the corona is $kT = 100$ KeV

- Iron line @ 6.4 KeV (unpolarized)

for both the geometries the thermal energy of the corona is $kT = 2,5,8$ KeV

the code

The code is written in IDL, an interactive and vectorized language, and it's modular, fully special relativistic, **and extremely time consuming!!**

The approach is to follow every photon during its journey from the disc to the observer, switching between the RF of the Disc and the RF of the electron

INPUT: seed photon = $\{ R_o, \theta_d(=90^\circ), \varphi_d, K_d(h\nu_d) \}$

$$K_{d,t} = \frac{2\pi\nu_d}{c}$$

$$K_{d,x} = K_{d\{0\}} \sin(\Theta_d) \cos(\Phi_d)$$

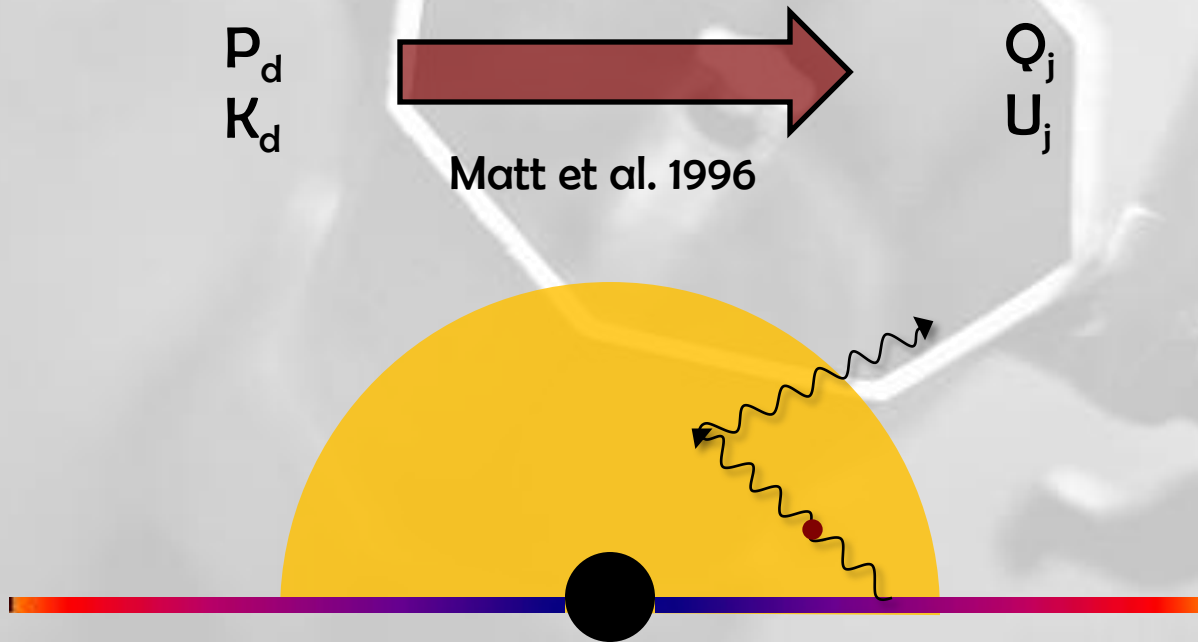
$$K_{d,y} = K_{d\{0\}} \sin(\Theta_d) \sin(\Phi_d)$$

$$K_{d,z} = K_{d\{0\}} \cos(\Theta_d)$$

- emissivity law weighted both on $\sigma_{SB} T_D$ and on $R_o dR$ (for disc emission)
- limb darkening on Θ_d

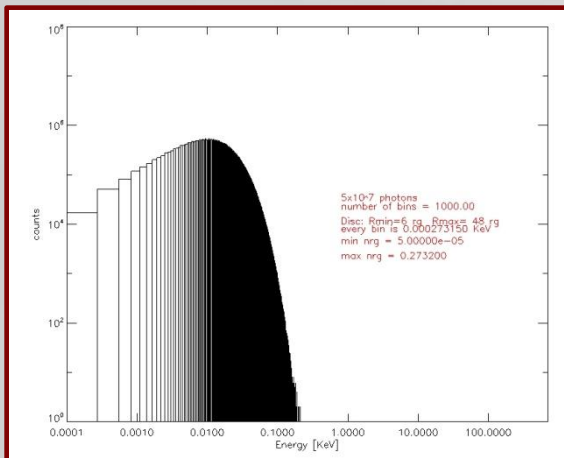
the code

The P_d vector (electric field) of the seed photon is randomly chosen on the polarization plane for unpolarized radiation OR linearly polarized (up to 11%) on the direction parallel to the plane of the disc (Chandrasekhar, 1960).



OUTPUT: $h\nu, \Theta, \Phi, Q_j, U_j, \#sc$

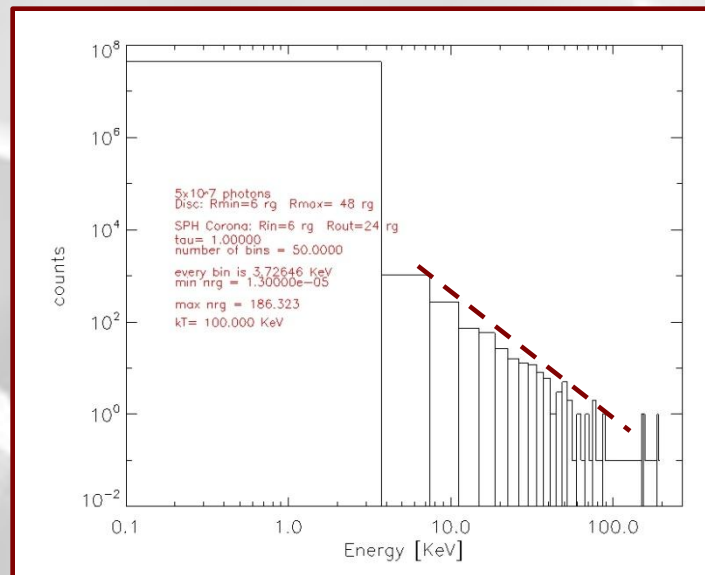
the spectra



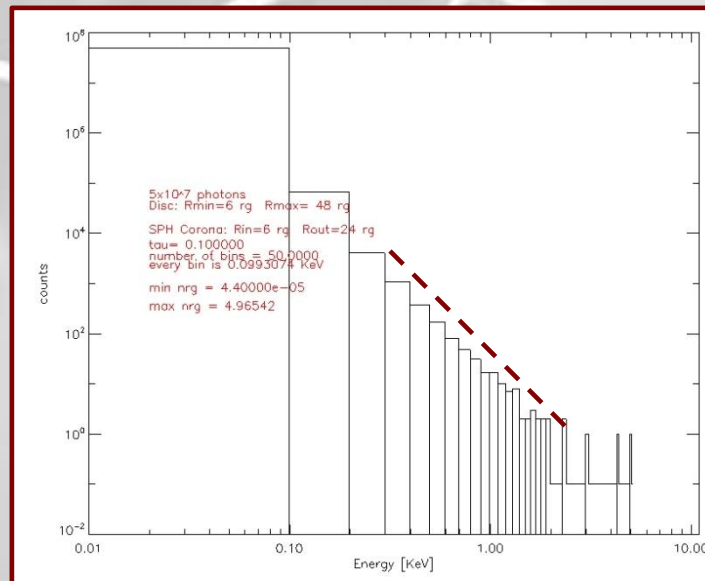
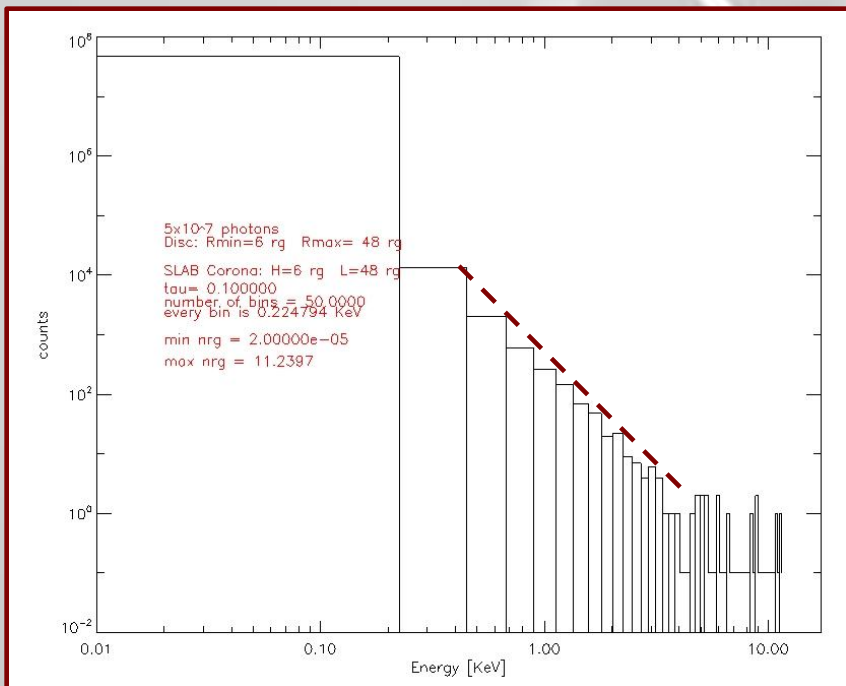
SLAB, $\tau = 0.1$

$kT = 100$ KeV
 5×10^7 photons

SPHERE, $\tau = 1$



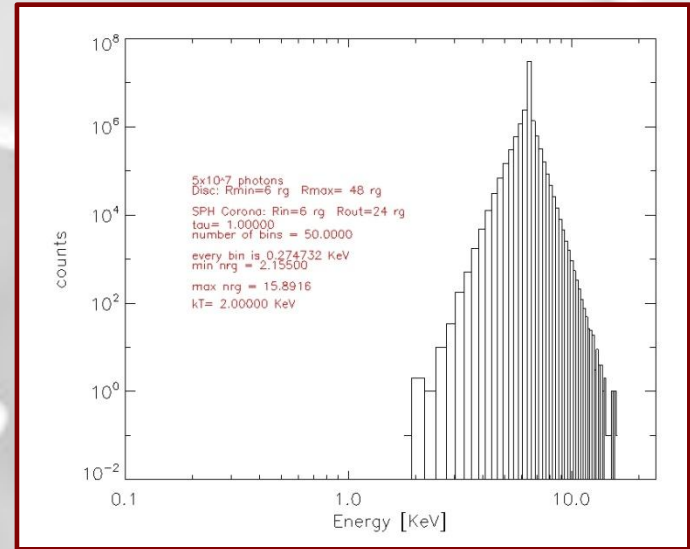
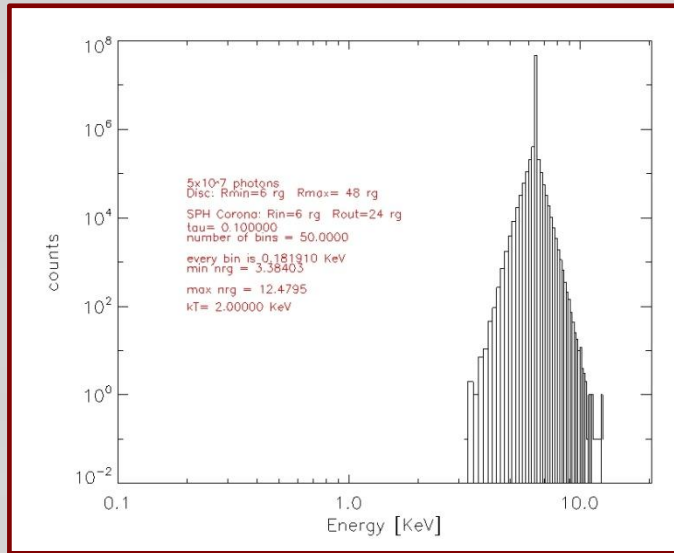
SPHERE, $\tau = 0.1$



the spectra

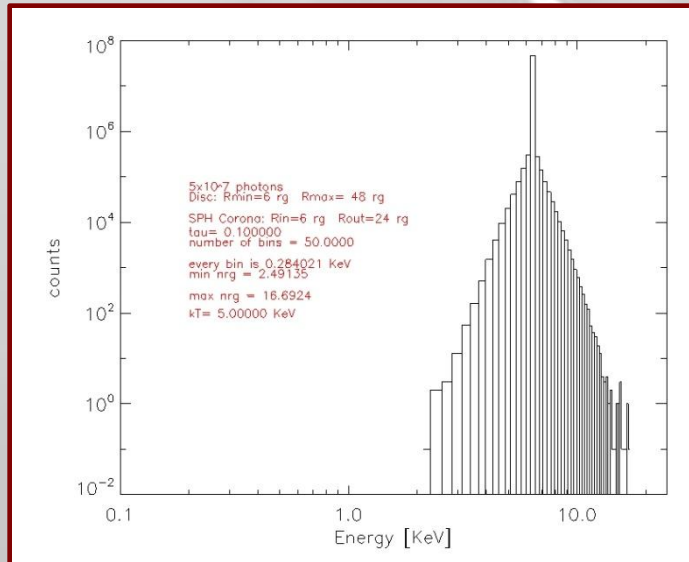
$kT = 2 \text{ KeV}$

$\tau = 0.1$



$kT = 5 \text{ KeV}$

$\tau = 0.1$



$kT = 2 \text{ KeV}$

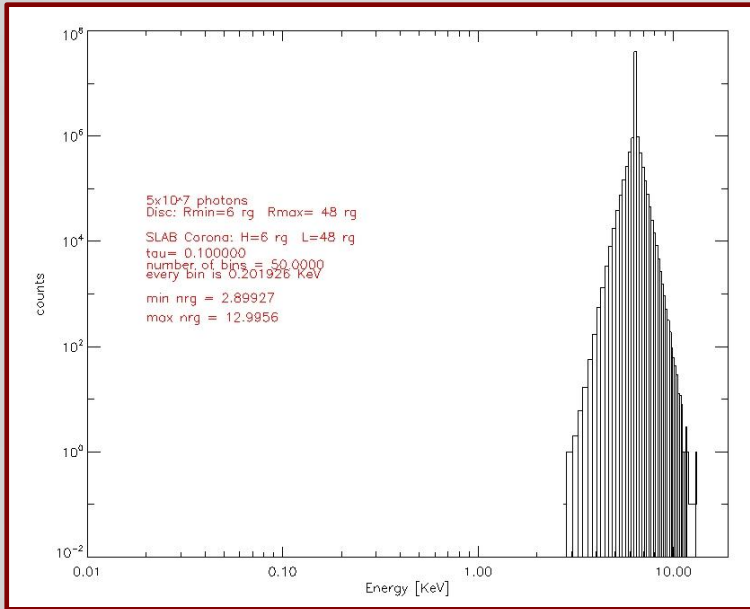
$\tau = 1$

input energy = 6.4 KeV
(unpolarized)

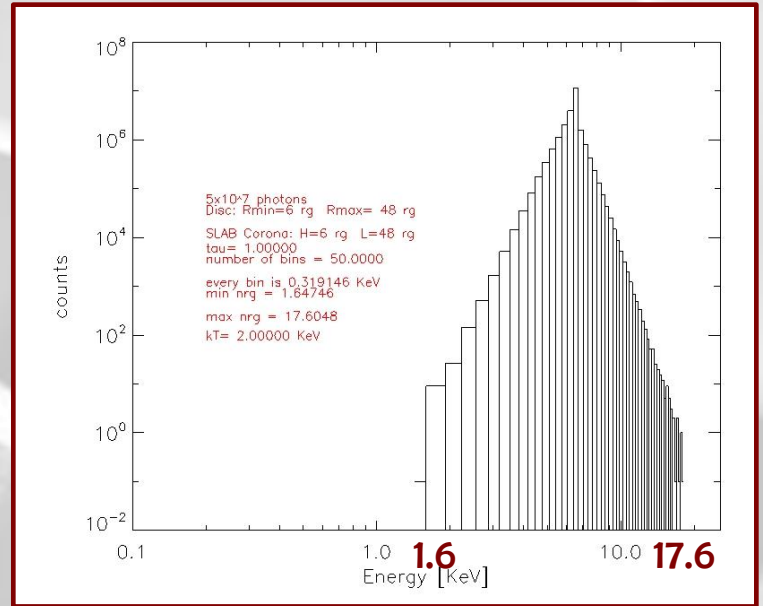
SPHERICAL corona

the spectra

$kT = 2 \text{ KeV}$
 $\tau = 0.1$



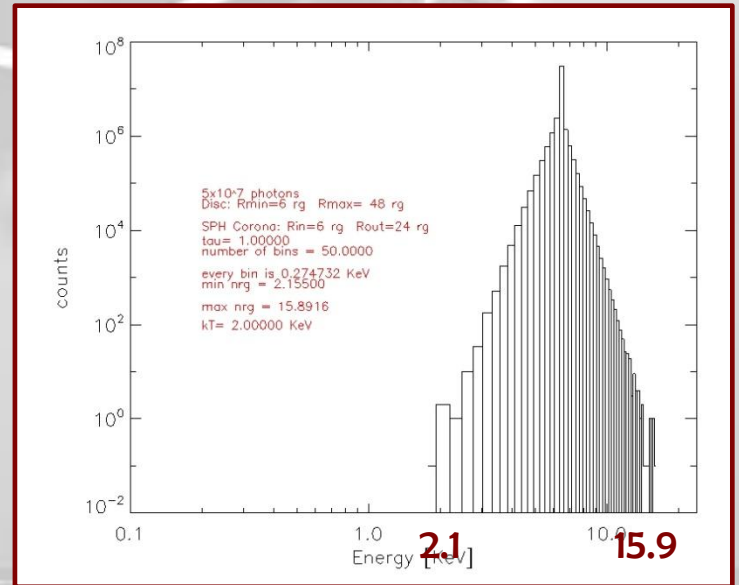
$kT = 2 \text{ KeV}$
 $\tau = 1$



input energy = 6.4 KeV
 (unpolarized)

SLAB corona

SPHERE
 $kT = 2 \text{ KeV}$
 $\tau = 1$



future developments & applications

- increase the statistics!!
- include GR (Michal Bursa ray tracing routine)
- include reflection
- apply the code to the iron line case to discriminate between a scattering or a relativistic broadening in NS