MoCA: a Monte Carlo code for accretion in Astrophysics

- the Iron Kα line polarization case -

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[2] University of Rome“Roma Tre”
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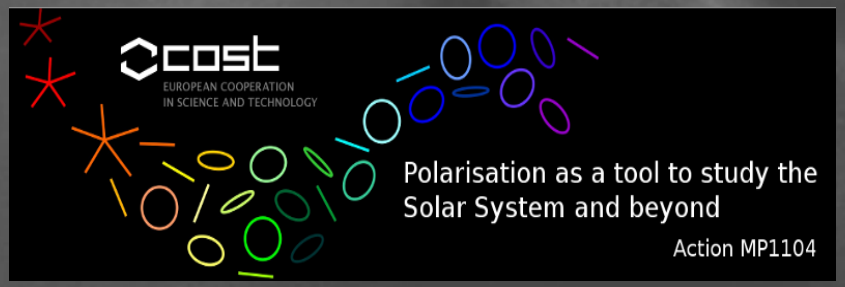


9th Serbian Conference on Spectrtal Line Shapes in Astrophysics
Banja Koviljaca, Serbia, May 13-17, 2013

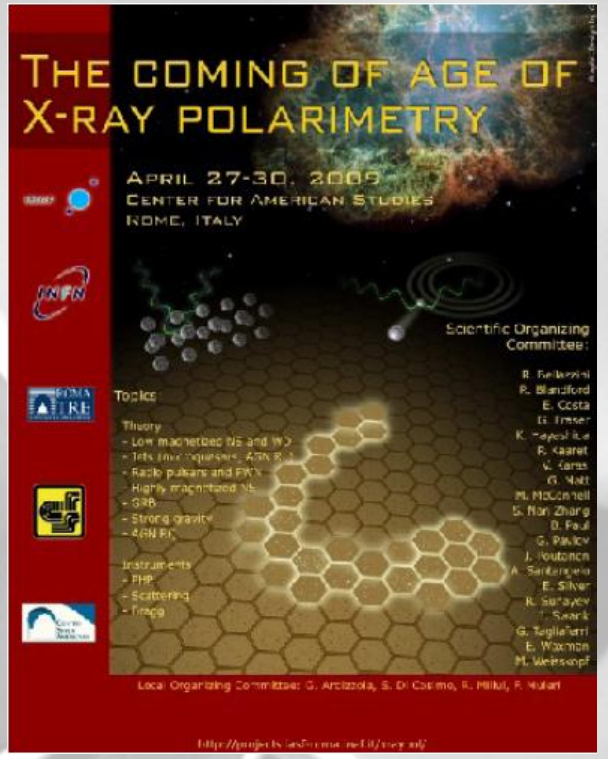
Outline

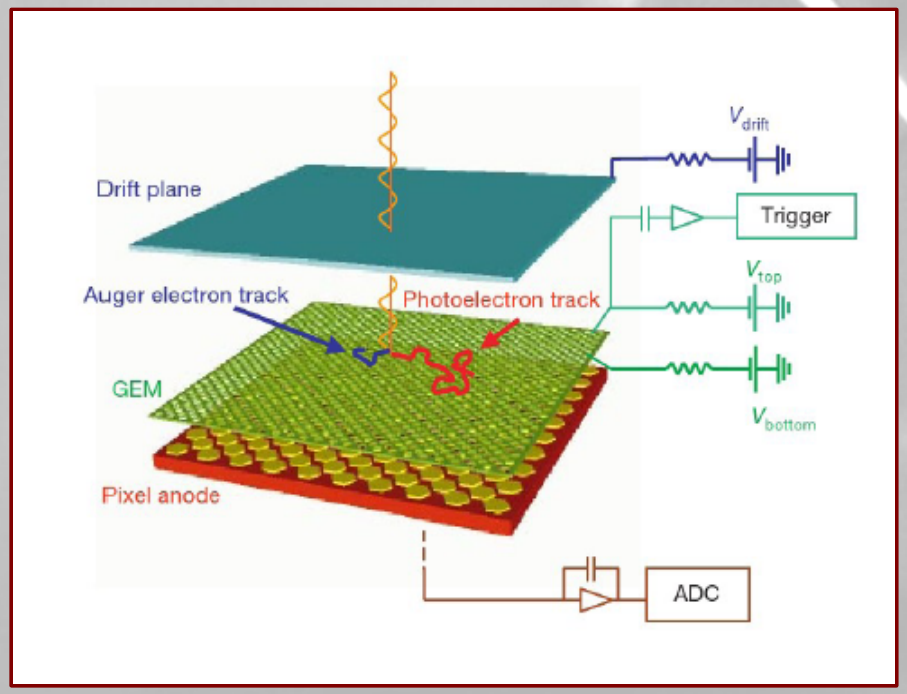
- Scientific Motivation & Introduction
- The code
- The model
- Preliminary results
- Conclusions & Future developments

Scientific Motivation

Why X-ray 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.



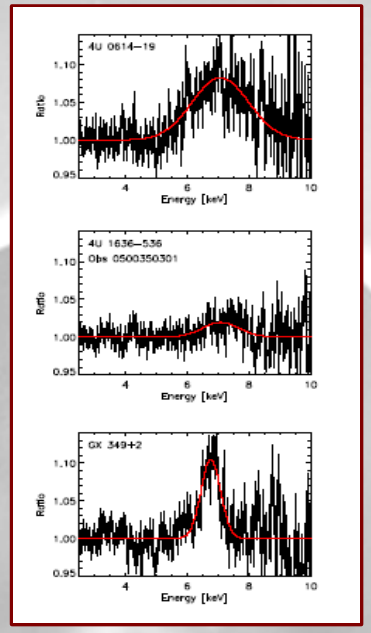


...but then **ALL** the missions with an X-ray polarimeter onboard have been canceled or have not been selected!!

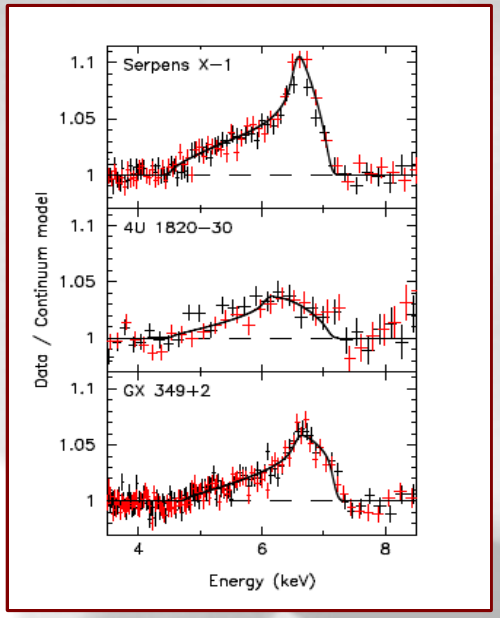
- IXO (XEUS)
- NHXM
- GEMS
- XIPE

Introduction

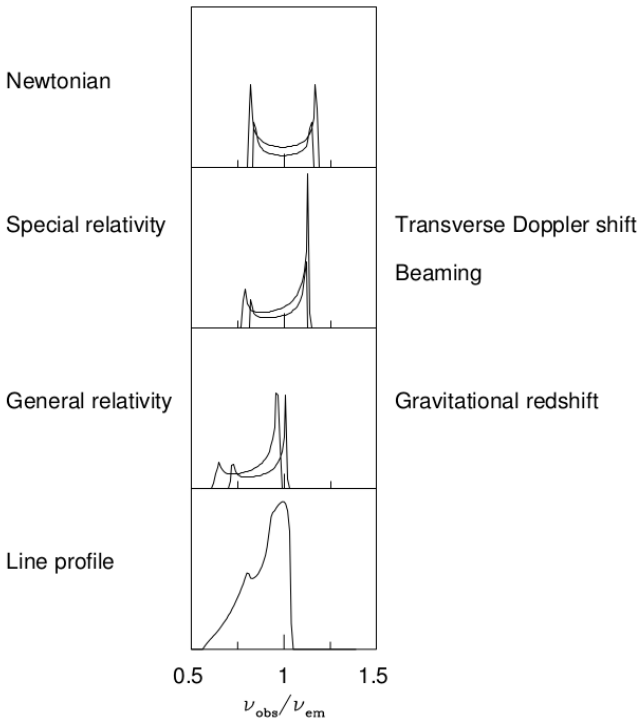
LMXRB



NS Iron lines seen by XMM



NS Iron lines seen by Suzaku

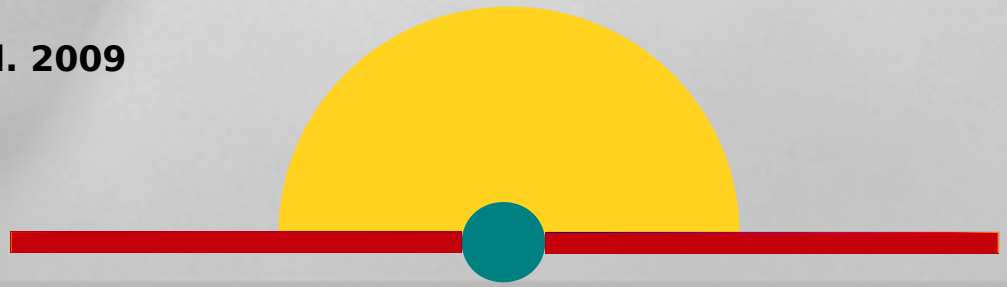


Relativistic broadening (Fabian 2006)

Multiple Compton scattering (Ng et al. 2010)

Cackett et al. 2008

Di Salvo et al. 2009



The code

The code is written in **IDL**, an interactive and vectorized language, and it is:

- **modular** (with minor modifications can be applied to different astrophysical situations)

- **fully special relativistic** (Klein-Nishina cross-section for scattering, Juttner distribution for electrons in the corona,...)

The approach is to follow every photon during its journey from the disc to the observer.

INPUTS: coordinates {R, theta, phi}, direction {Theta_i, Phi_i}, energy, (polarization)

OUTPUTS: direction {Theta_f, Phi_f}, energy, # of scatterings, Stokes parameters {Q, U}

$$\Pi = \left(\frac{\sqrt{Q^2 + U^2}}{I}\right)$$

$$\psi = \frac{1}{2}\tan^{-1}\left(\frac{U}{Q}\right)$$

SCATTERING LOOP

Extract an electron → BOOST to the electron → KN cross-sec

↓

MFP → (scattering) → ANTIBOOST to the disc

↑

The model

The emission

- Monochromatic seed photons @ 6.4 keV
- isotropic
- unpolarized (i.e. randomly polarized)

$5x10^7$ seed photons

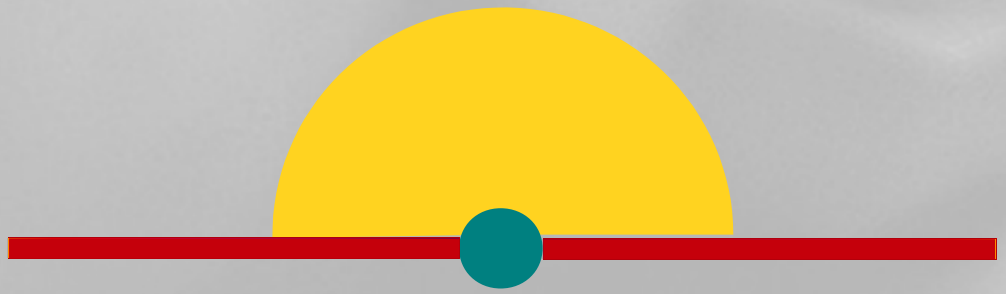
The corona

Spherical:
R_{in} = 6 rg
R_{out} = 24 rg

Slabby:
R_{in} = 6rg
R_{out} = 48 rg

Optical depths (tau) = 0.1 & 1
kT = 2 keV

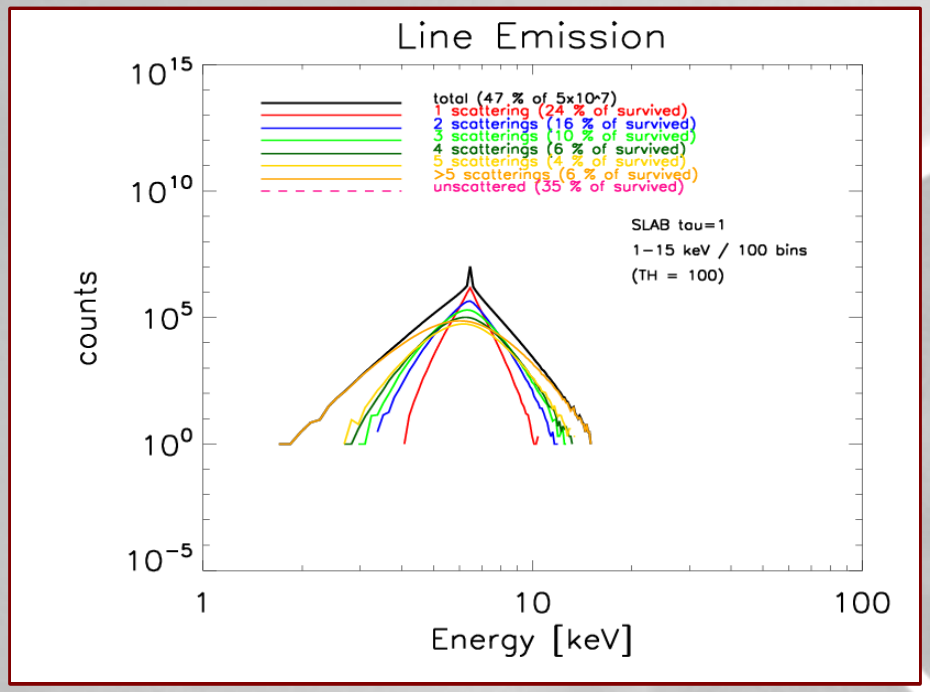
RAY TRACING ROUTINE NOT INCLUDED
REFLECTION NOT YET IMPLEMENTED



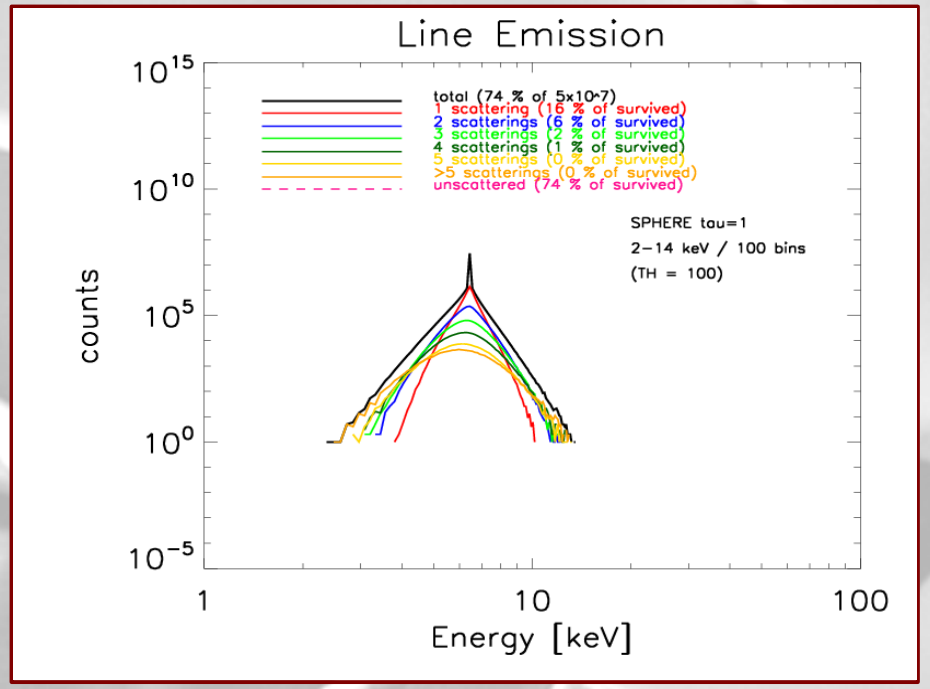
Results

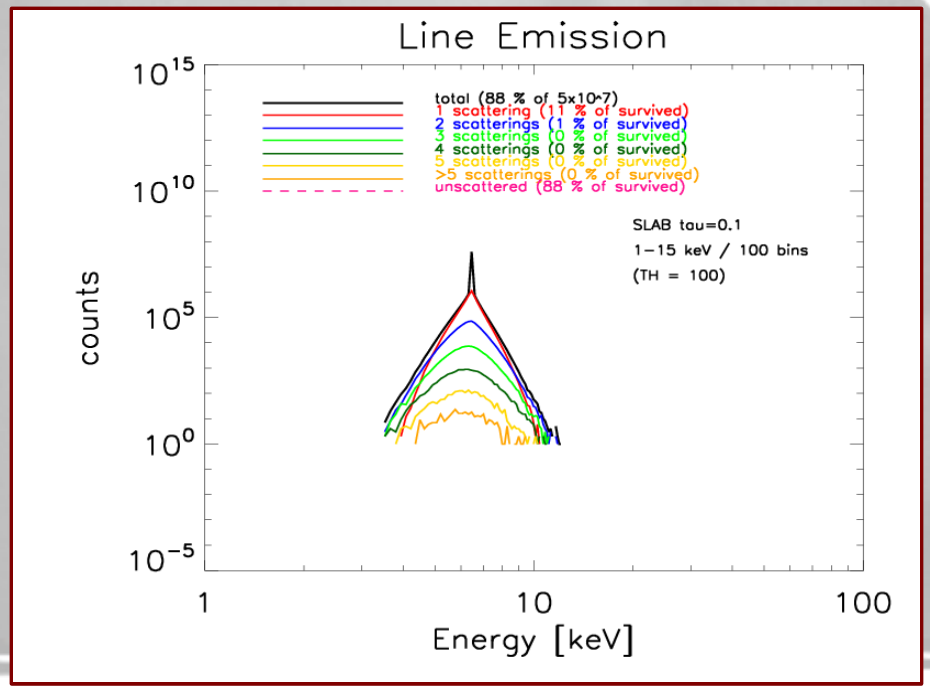
- the spectra -

SLAB | **SPHERE**

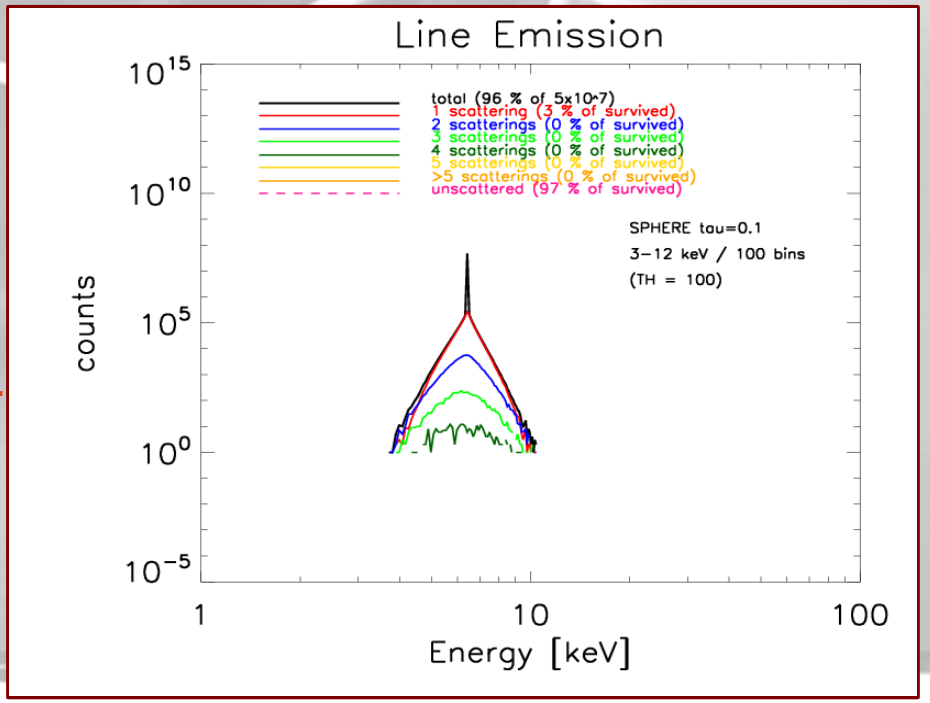


tau = 1





tau = 0.1



Results

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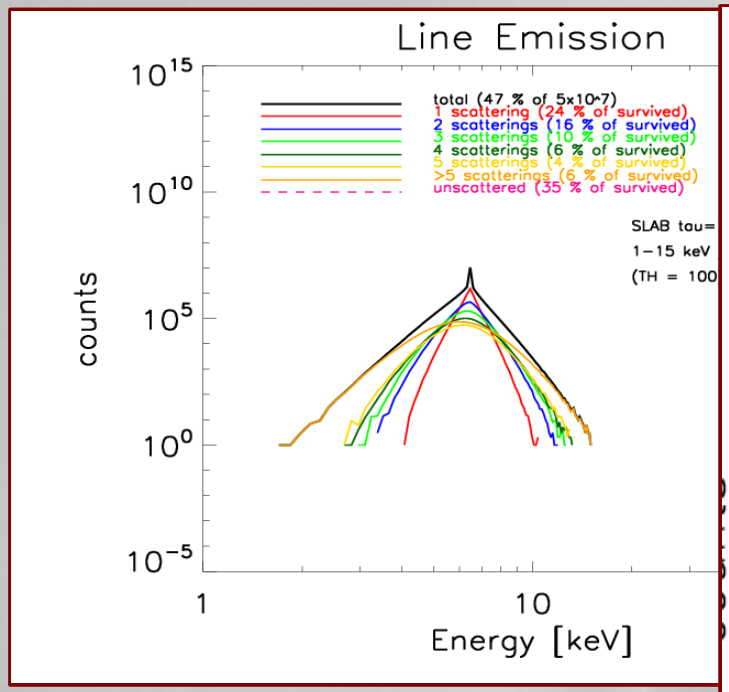
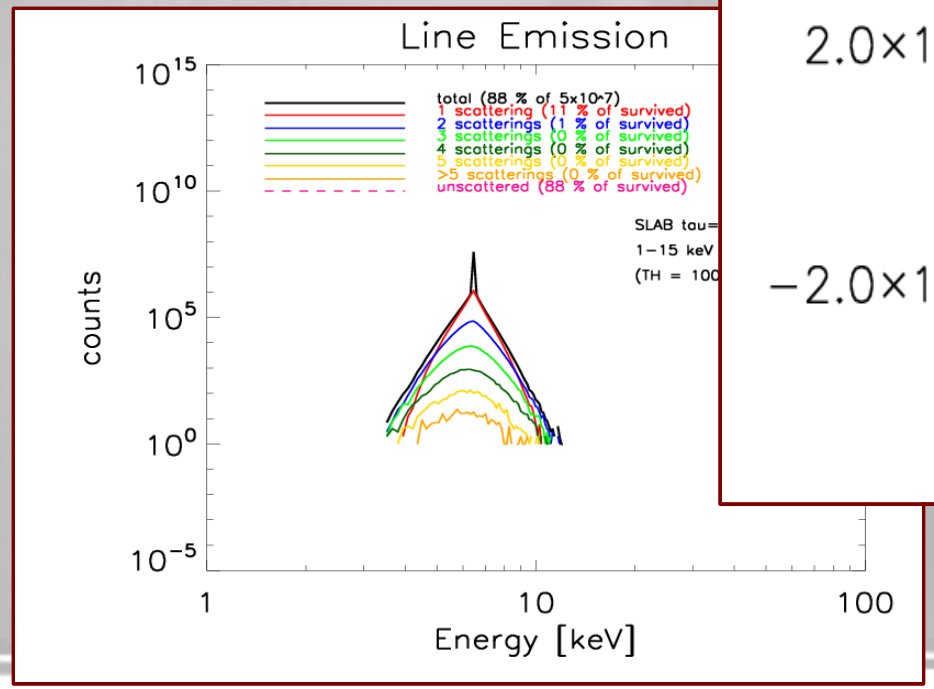
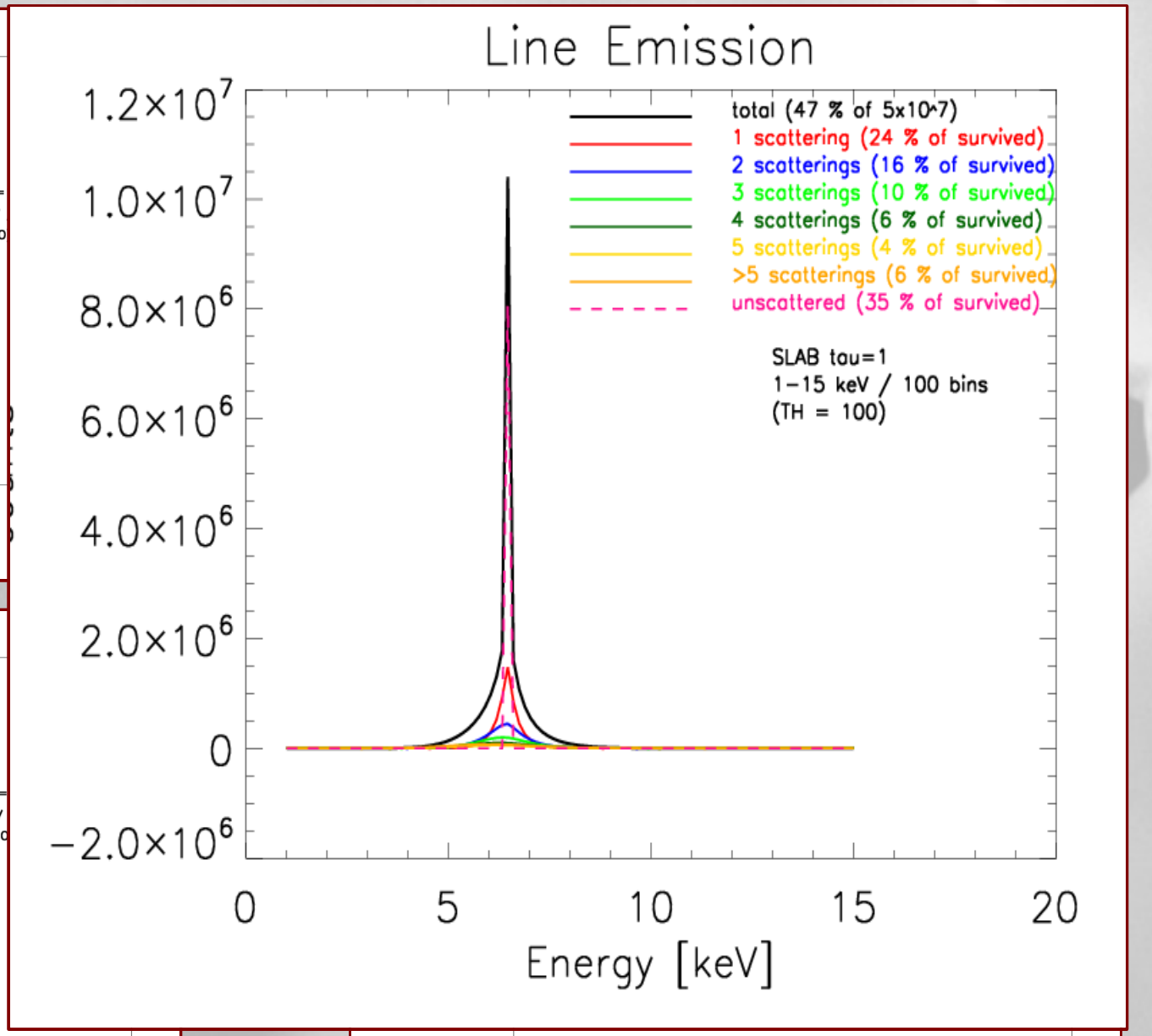


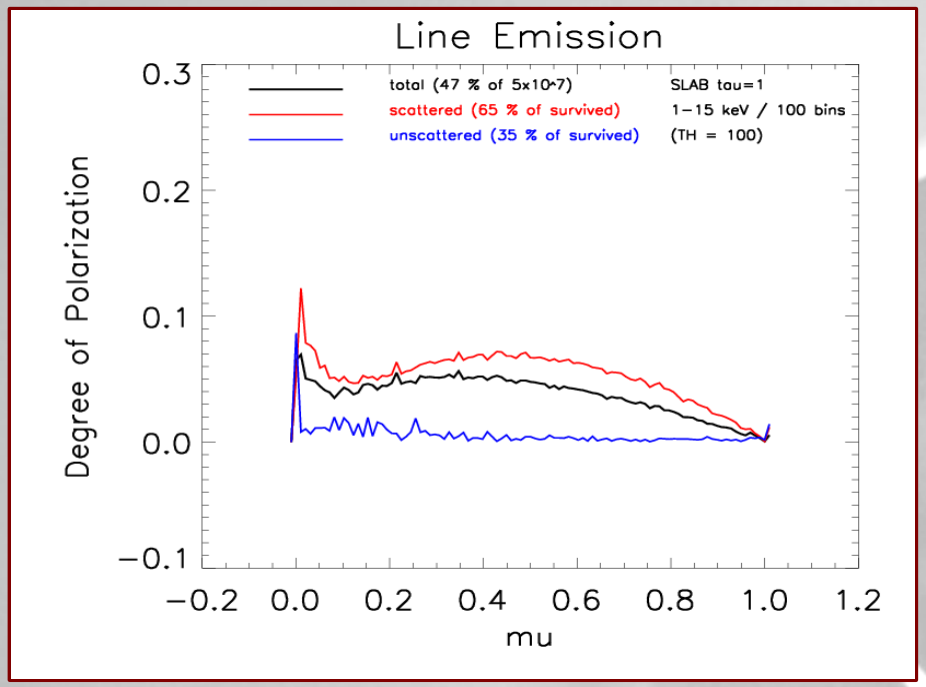


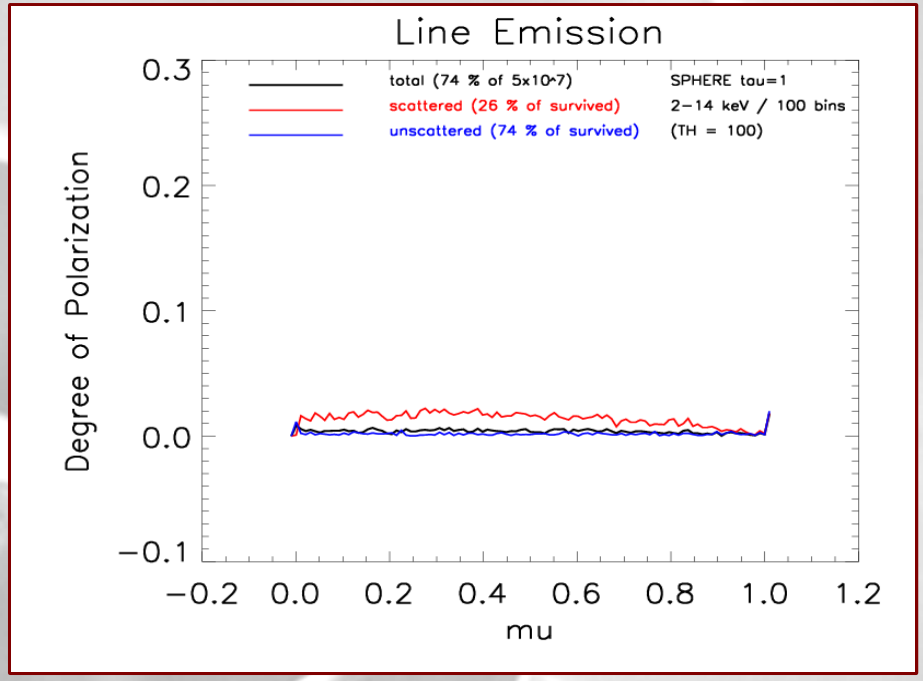


Results

- The polarization degree -

SLAB | **SPHERE**

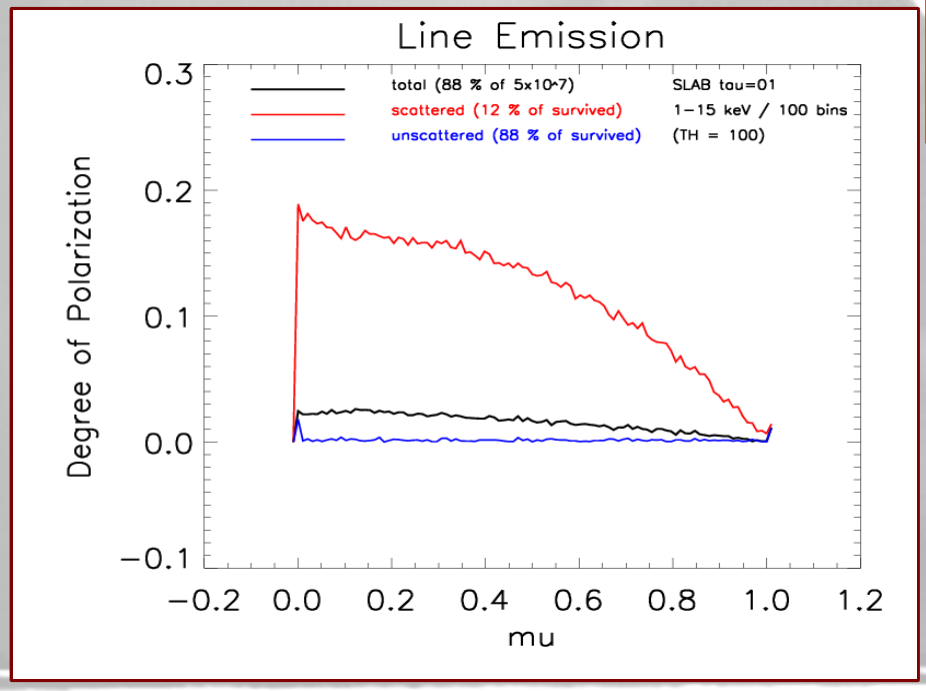




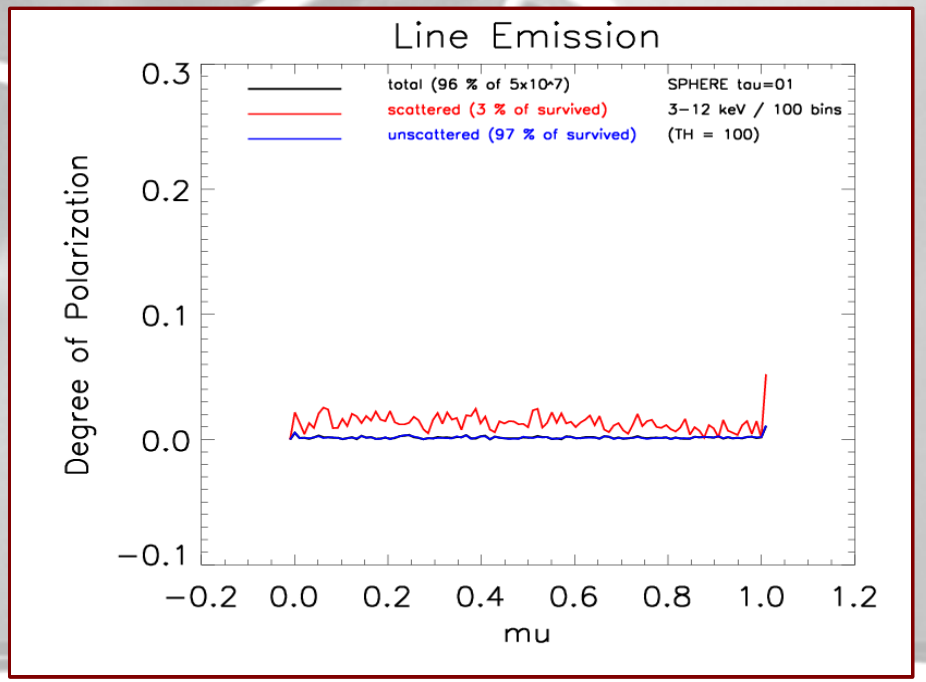
tau = 1

binned in mu

(angle of view)



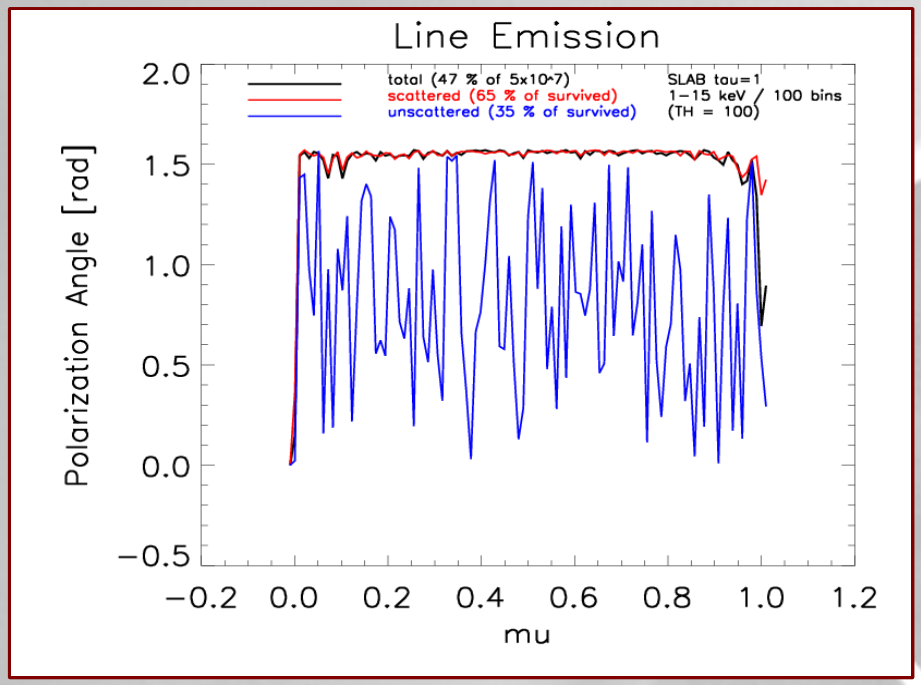
tau = 0.1

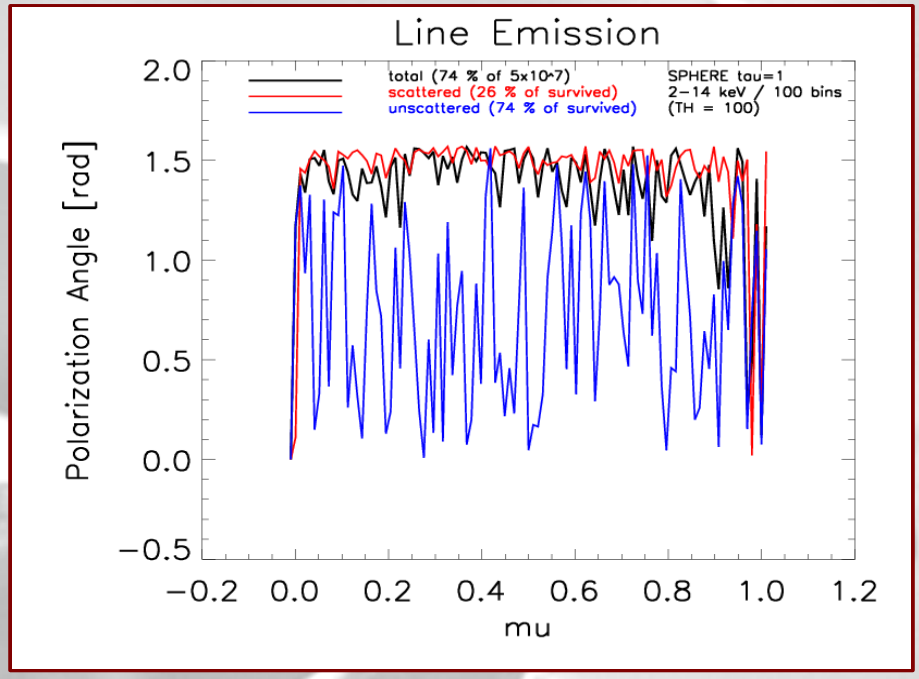


Results

- The polarization angle -

SLAB **SPHERE**

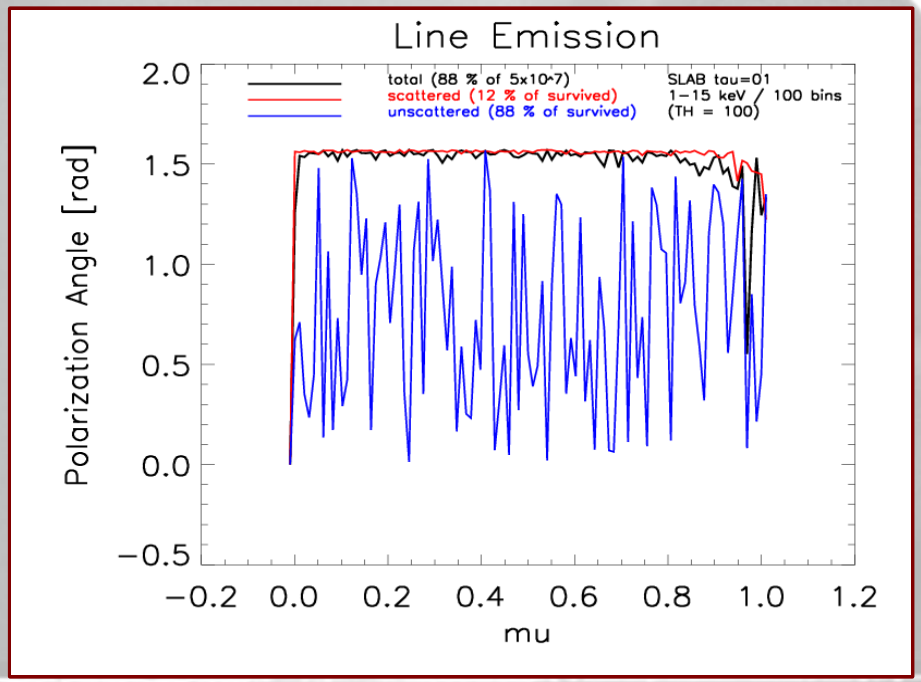




tau = 1

binned in mu

(angle of view)



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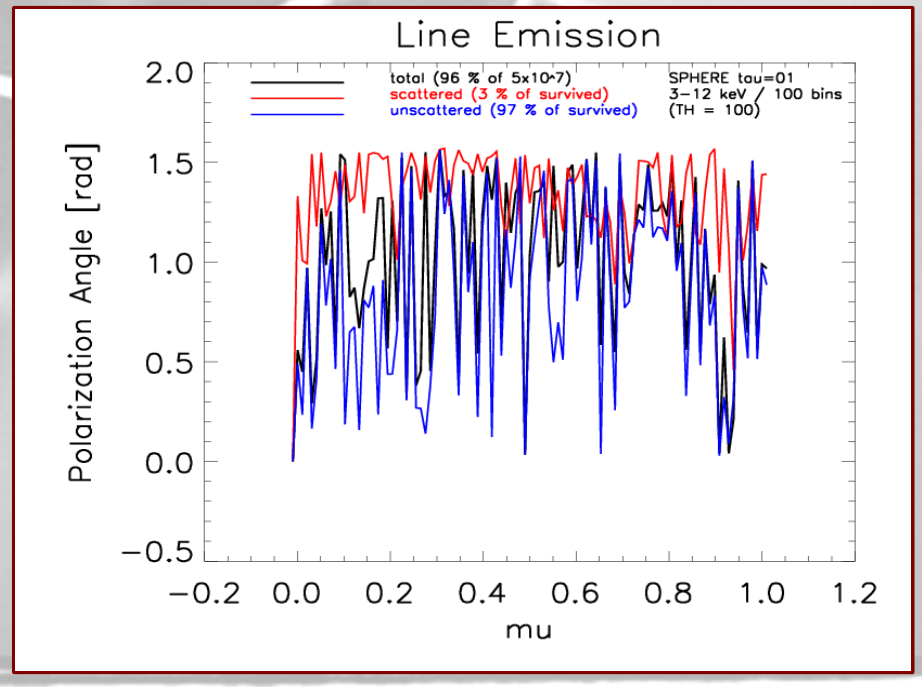
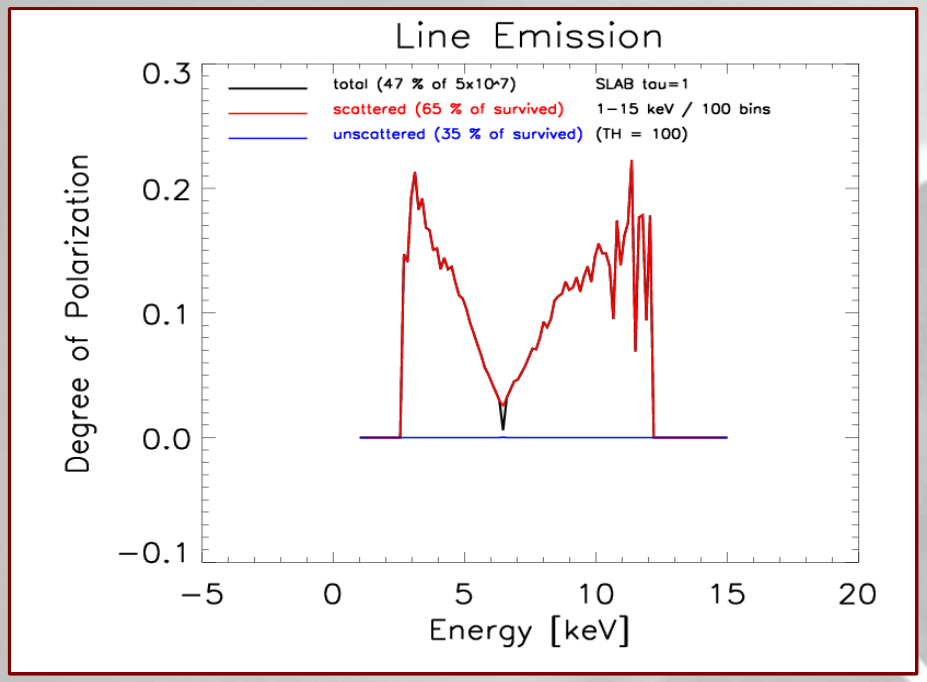
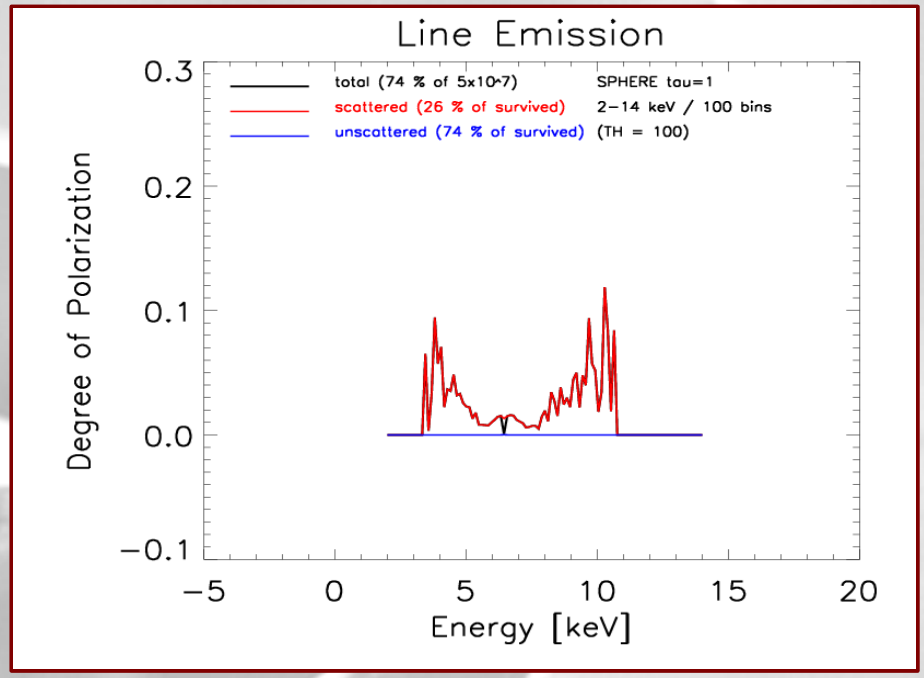


Results

- The polarization degree -

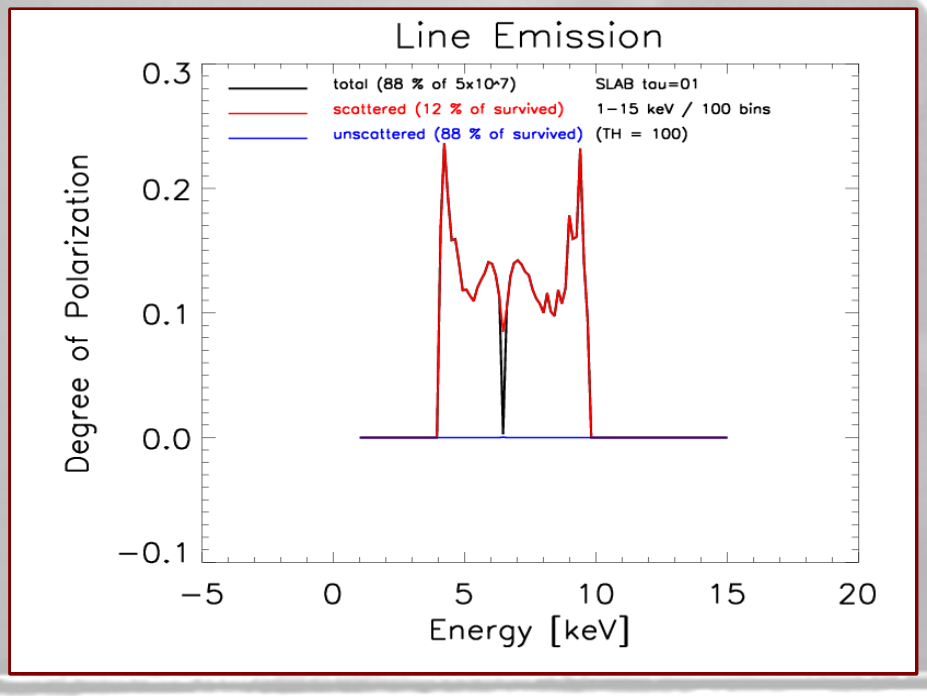
SLAB **SPHERE**

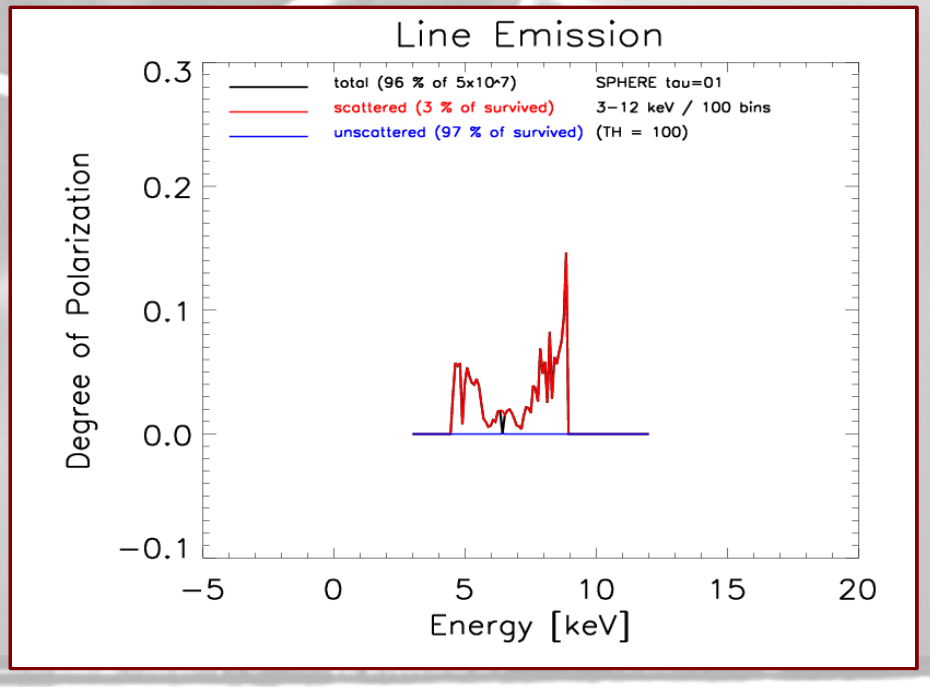




tau = 1

binned in energy



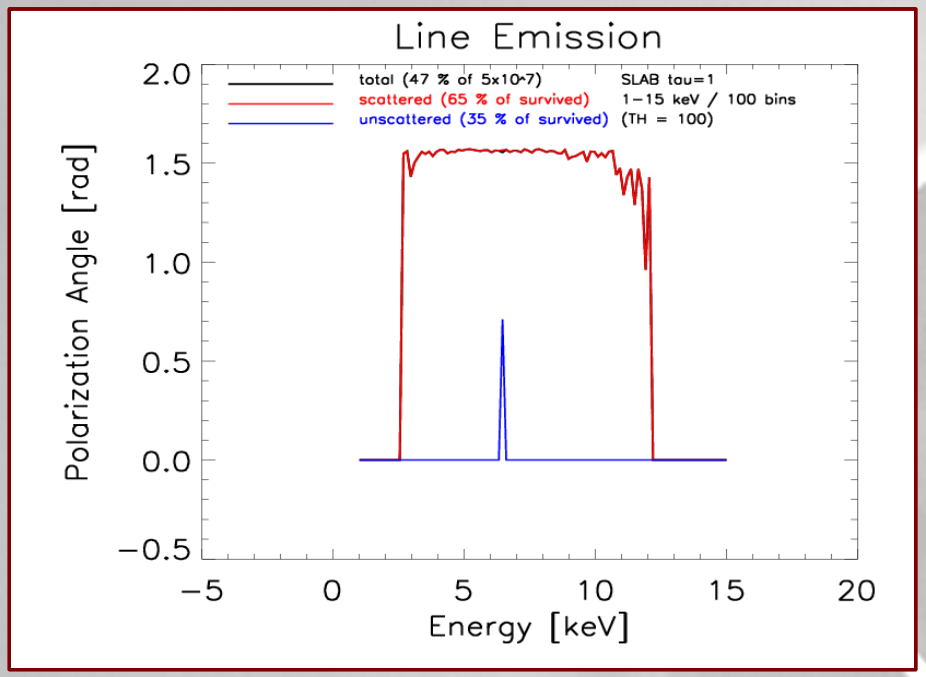


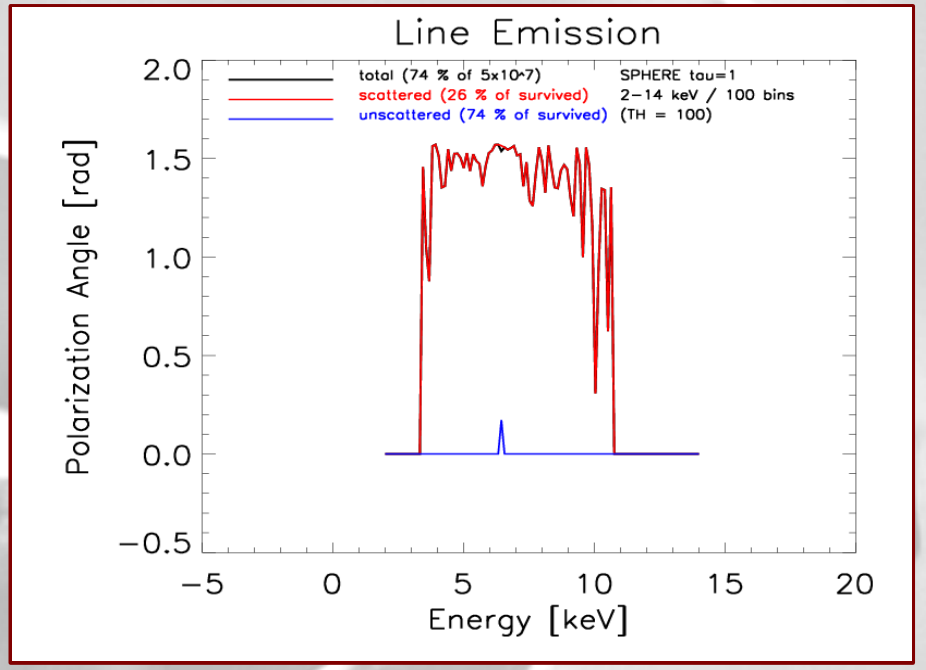
tau = 0.1

Results

- The polarization angle -

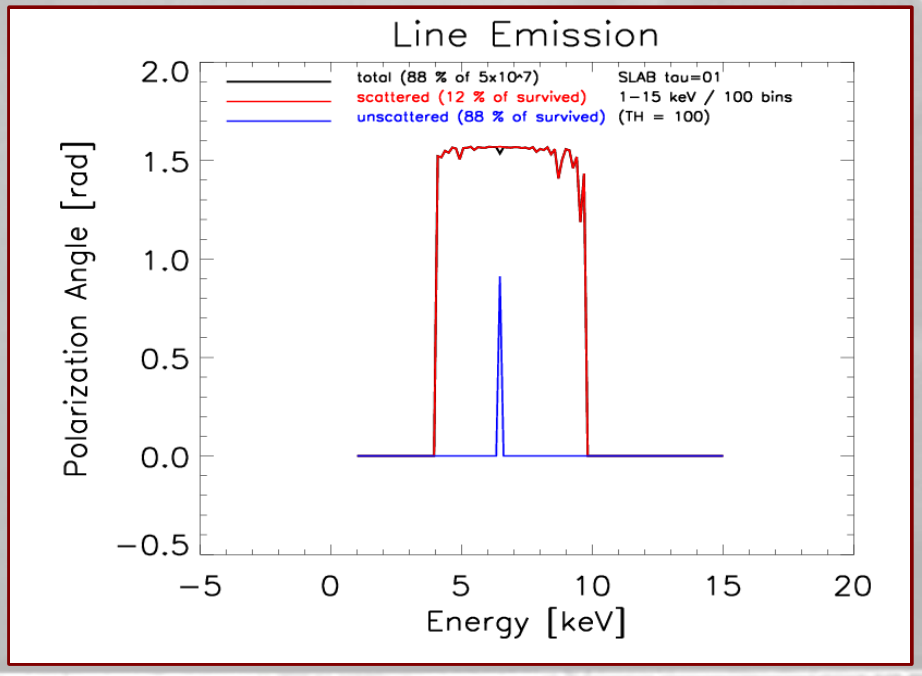
SLAB **SPHERE**





tau = 1

binned in energy



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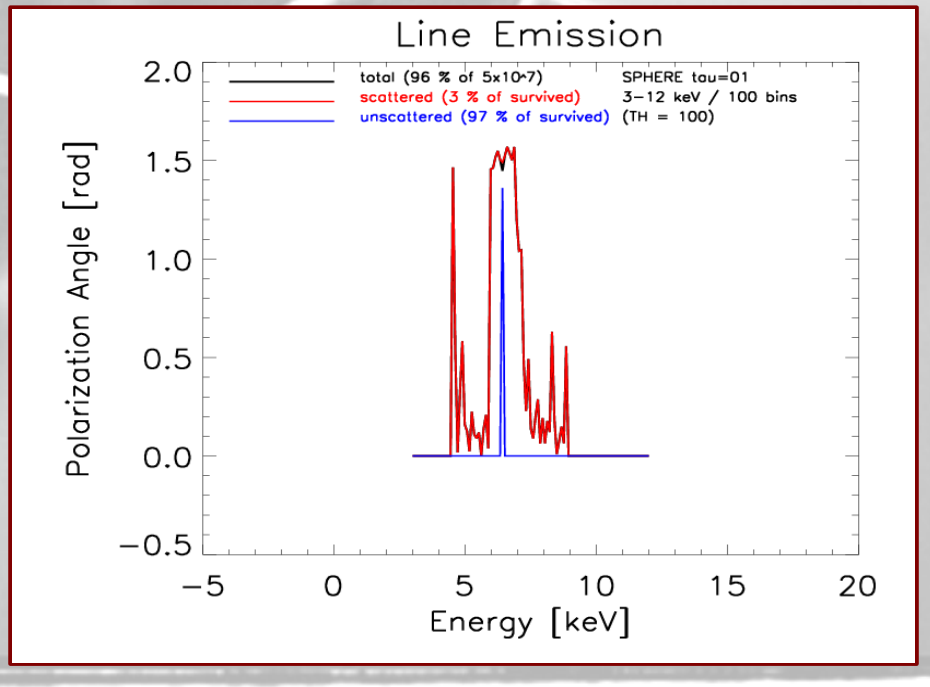

Conclusions & Future developments

The Iron line

The line profile does not appear qualitatively broadened by multiple Compton scattering for any tested geometry.
However, in the best scenario, the line flux can be significantly linearly polarized along the direction perpendicular to the plane of the disc.

Things to do

- add reflection
- add rotation to the disc
- makes the code faster (especially for the ray-tracing routine)

Capabilities

X-rays polarimetric spectral, spatial and timing analysis in a fully relativistic context