Modeling relativistic X-ray polarization signals in AGN

(with MoCA)

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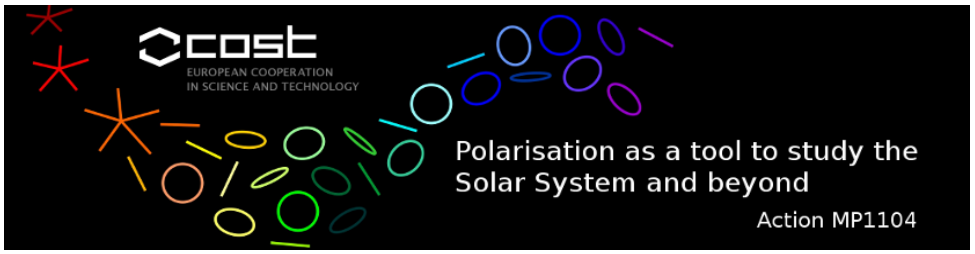
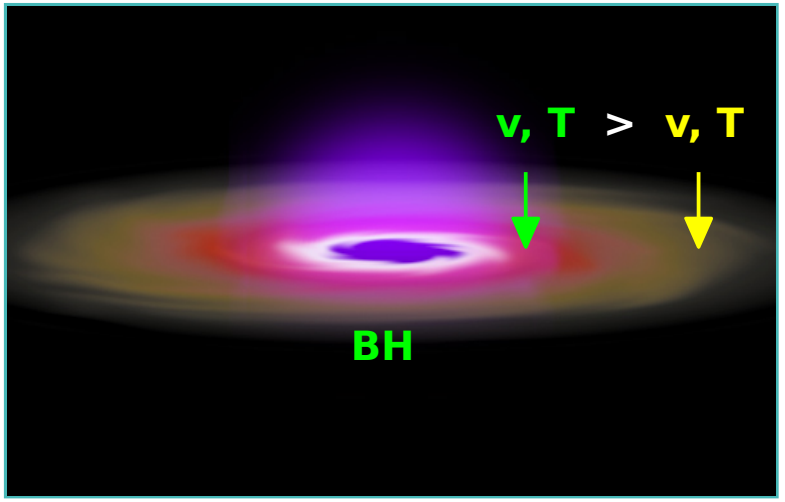


The 2nd COST workshop on Polarization and Active Galactic Nuclei
11-12 May 2015, Strasbourg

Outline

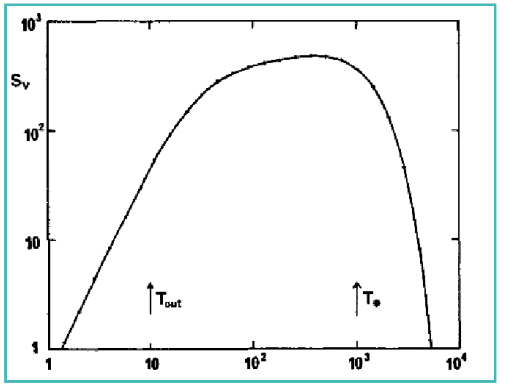
- A brief introduction
- Description of the model and the code
- Some results on AGN
- Conclusion, future work and observational perspectives

A Brief Introduction



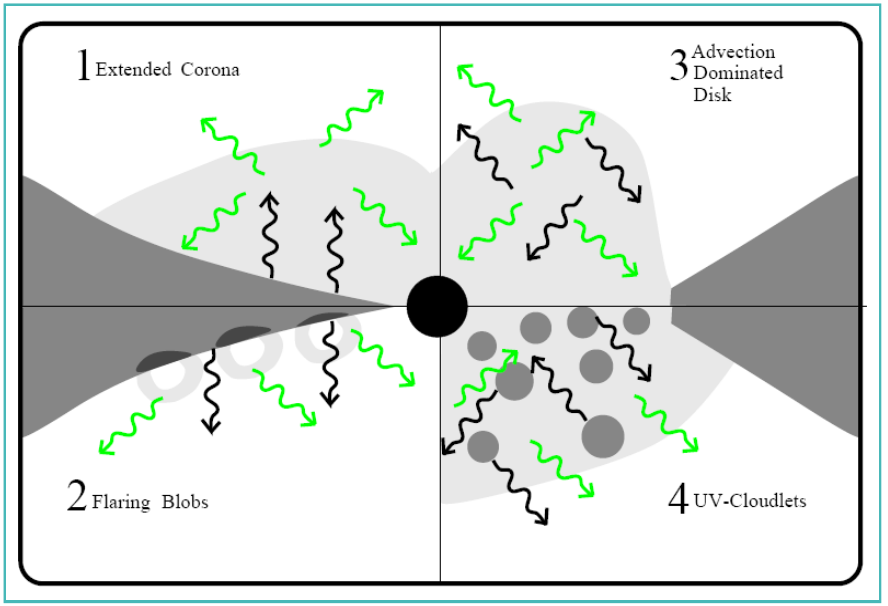
Steady, geometrically thin & optically thick disc
(Shakura-Sunyaev 1973)

Multi-temperature BB emission

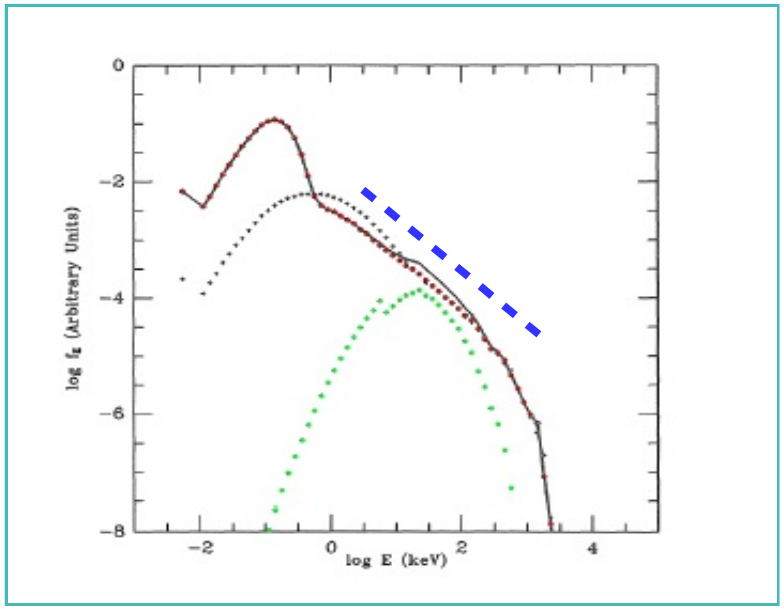


Galactic BHs (10 $M_\odot$) → soft X-rays
SMBHs (10^8 $M_\odot$) → UV

Comptonization by relativistic (thermal) electrons



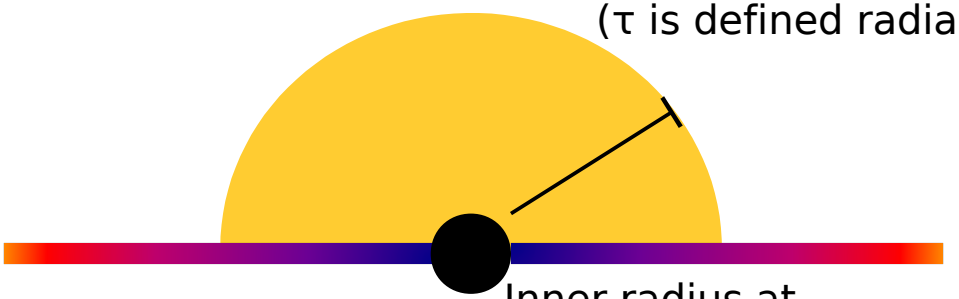
The parameters of the corona are
basically unknown !



Two-phase disc (Haardt-Maraschi 1991)

Description of the model

HEMISPHERICAL corona

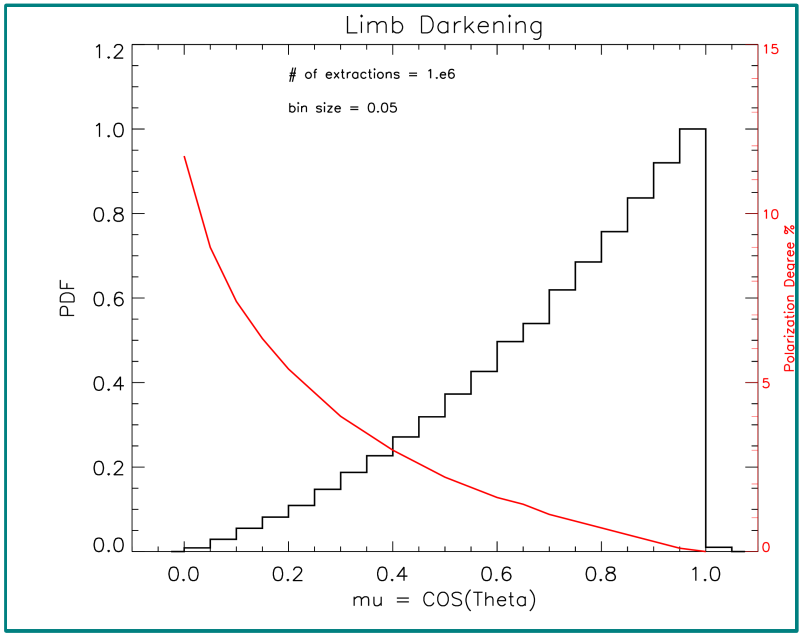


Schwarzschild SMBH
(10^8 M_{sun})

SLAB corona

Seed photons:

- limb darkening
- **horizontal (i.e. 0°) polarization**



(Chandrasekhar 1960)

Corona parameters:

- thermal energy (kT = 100 keV)
- optical depth (τ = **0.1**, **1**)

Description of the code

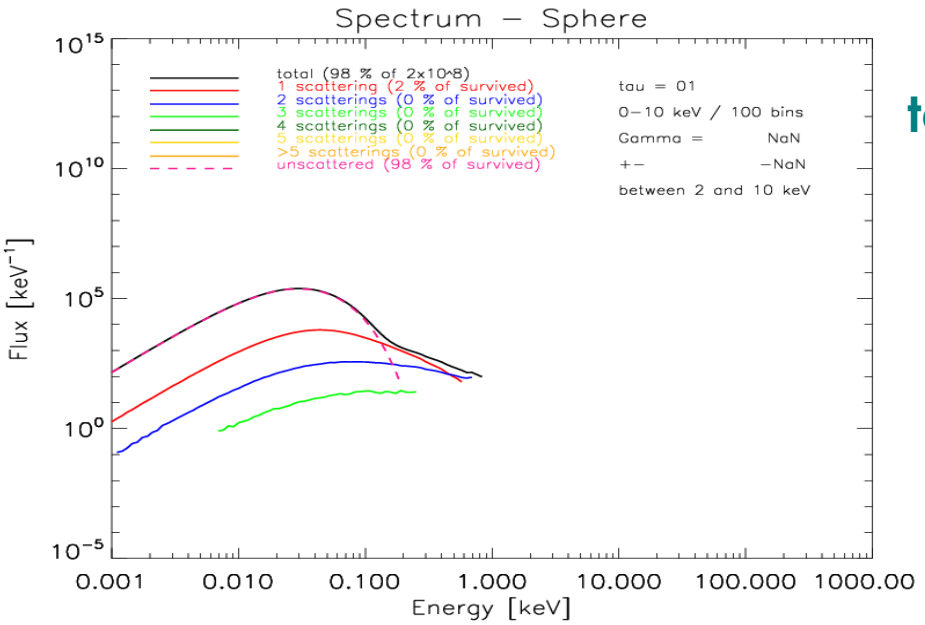
MoCA: a Monte Carlo code for Comptonization in Astrophysics

Main feature:

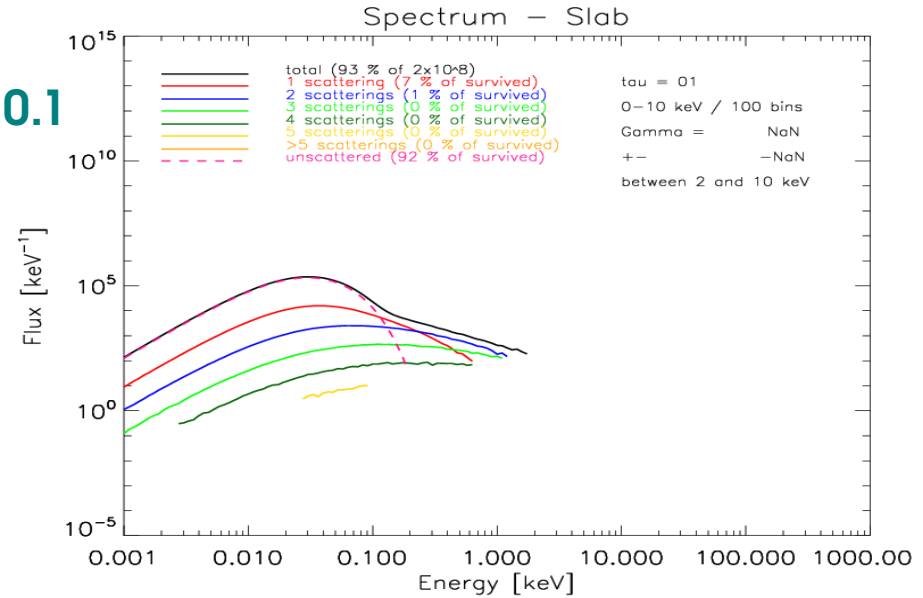
- Fully special relativistic (K-N cross-section, Maxwell-Juttner distribution) – GR will be included soon!
- Modular (different corona geometries and compact object)
- Include polarization

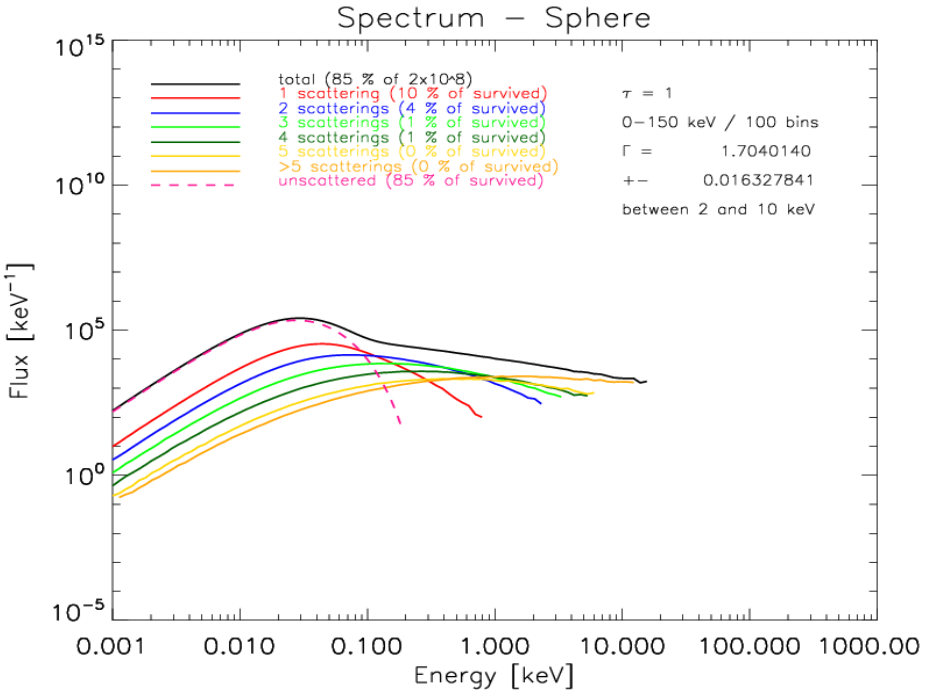
Result

- the spectra -

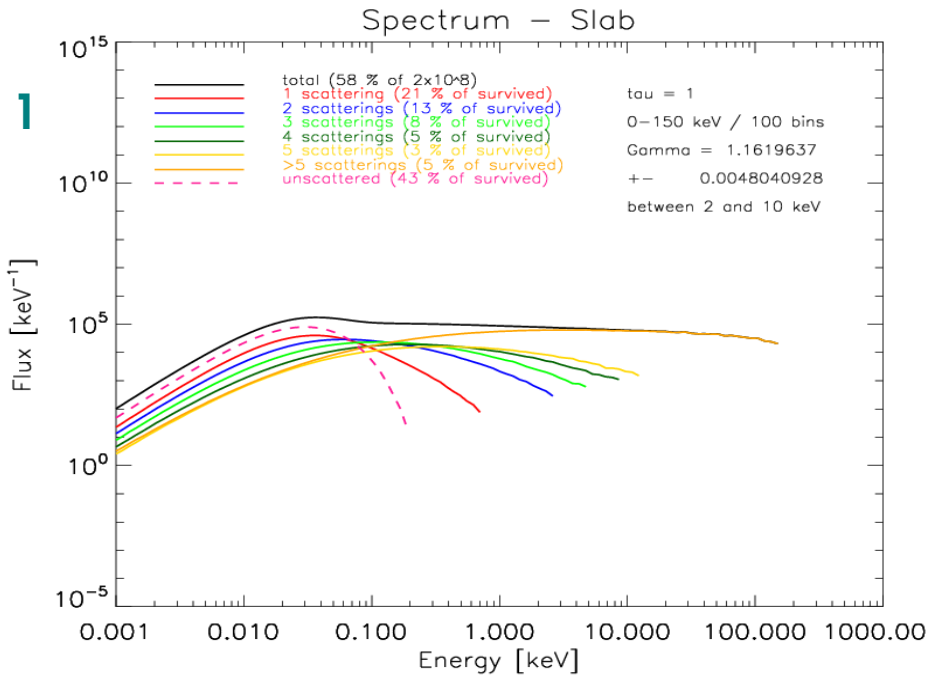


tau = 0.1



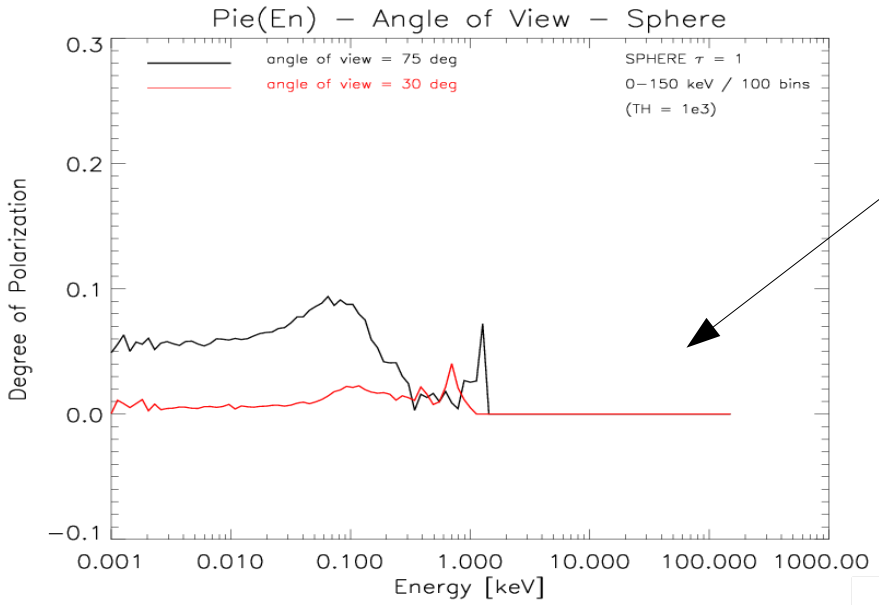


tau = 1



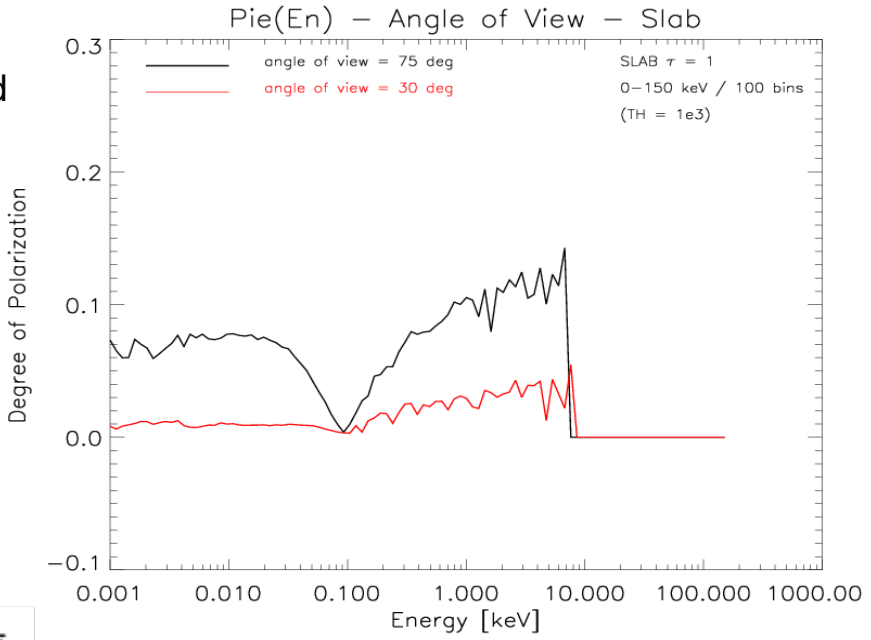
Result
- the polarization -

Sphere / tau = 1



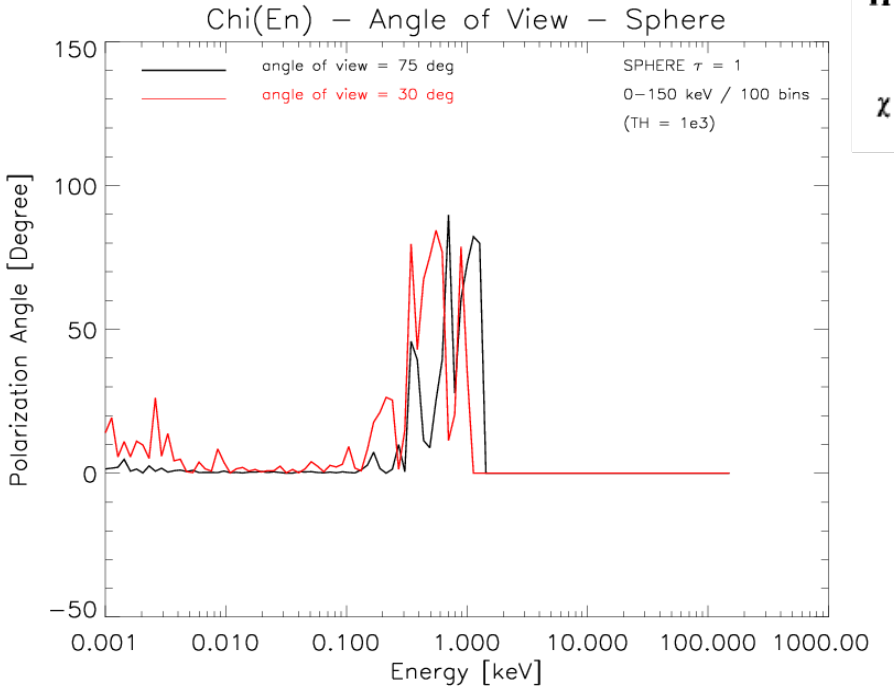
Treshold effect

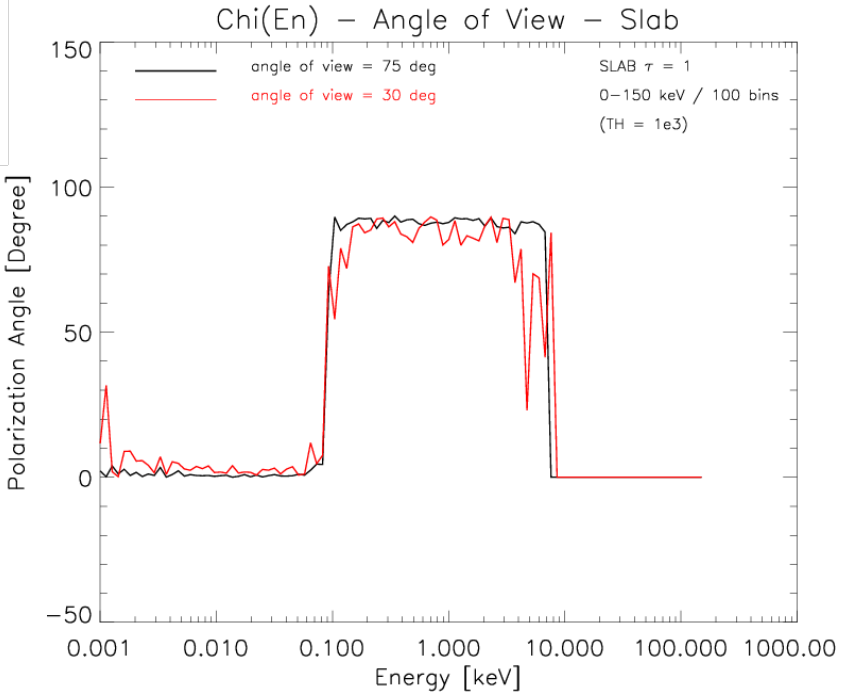
Slab / tau = 1



$$\Pi = \frac{\sqrt{Q^2 + U^2}}{I},$$

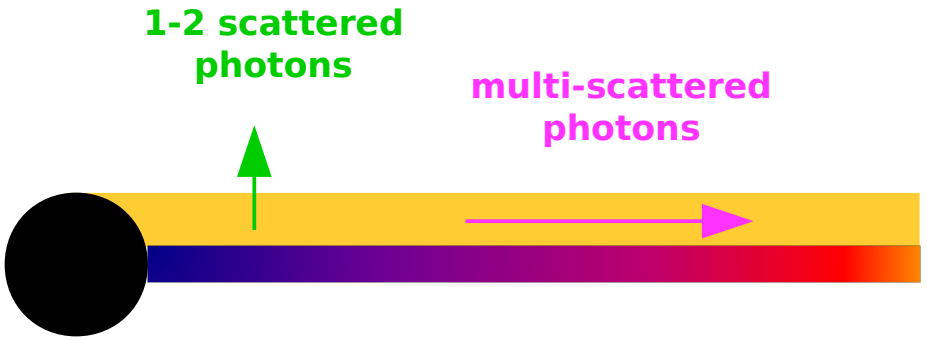
$$\chi = \frac{1}{2}\arctan\frac{U}{Q}.$$

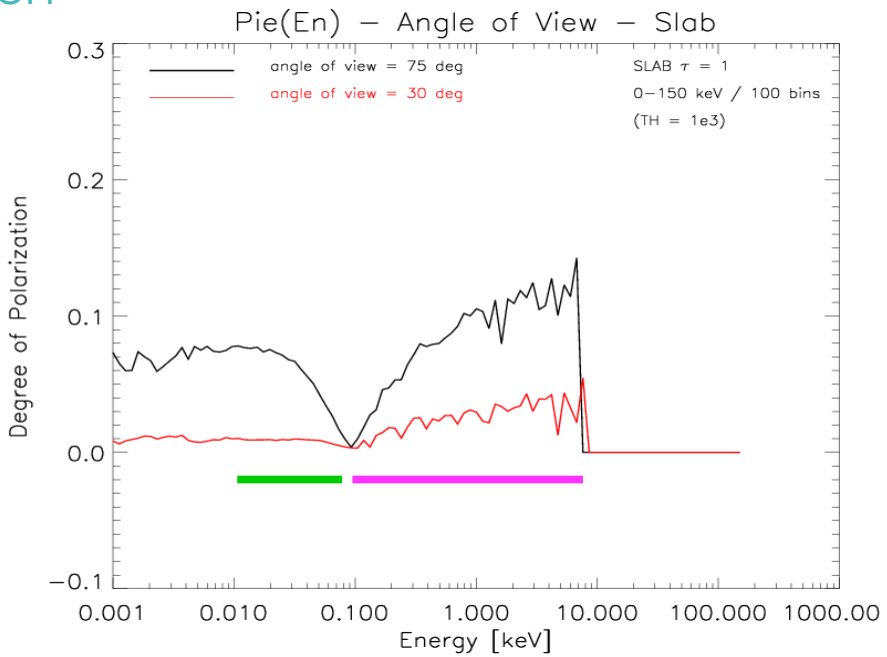


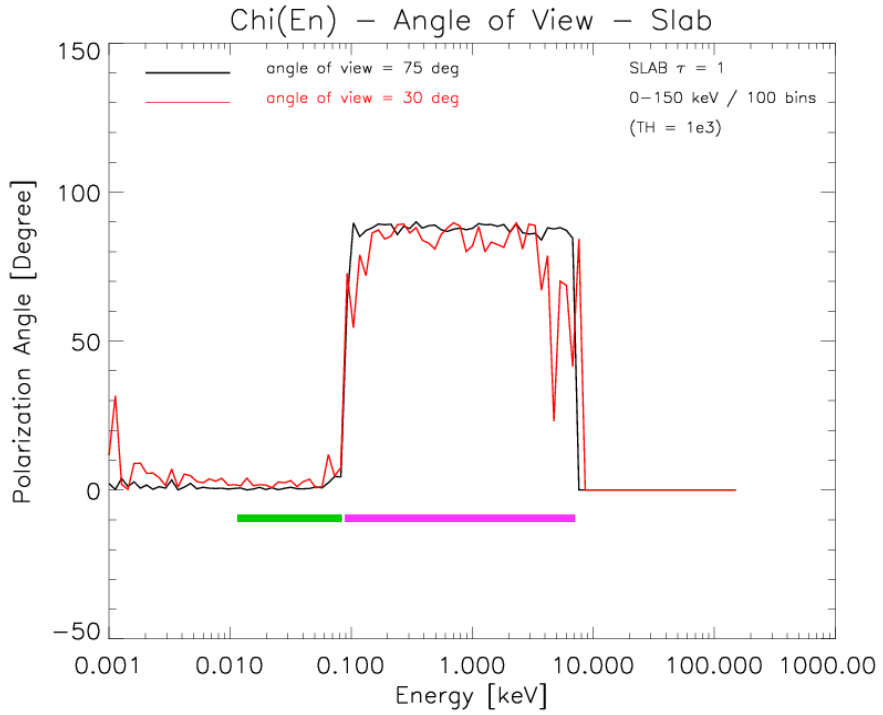


Result
- the polarization -

SLAB
τ = 1

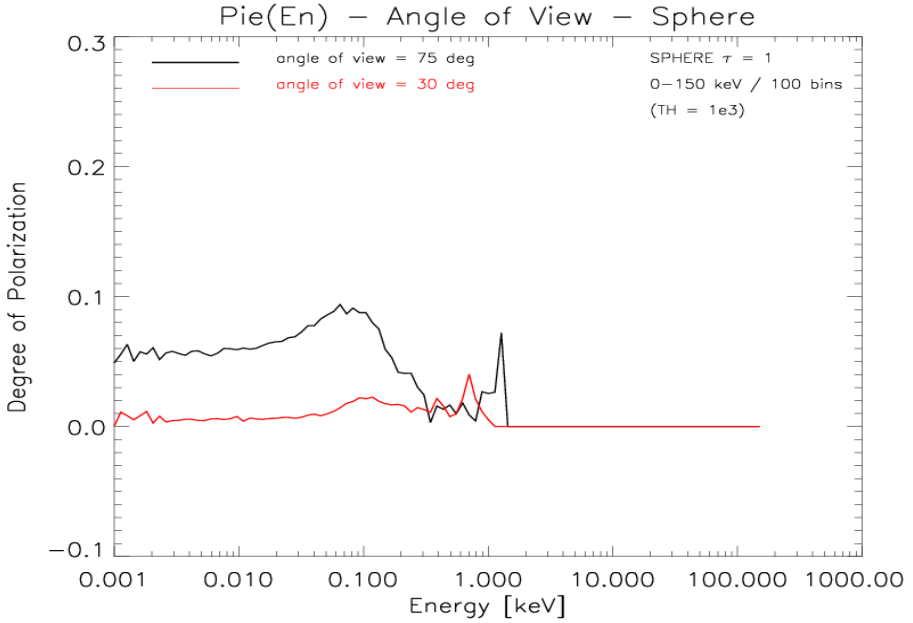


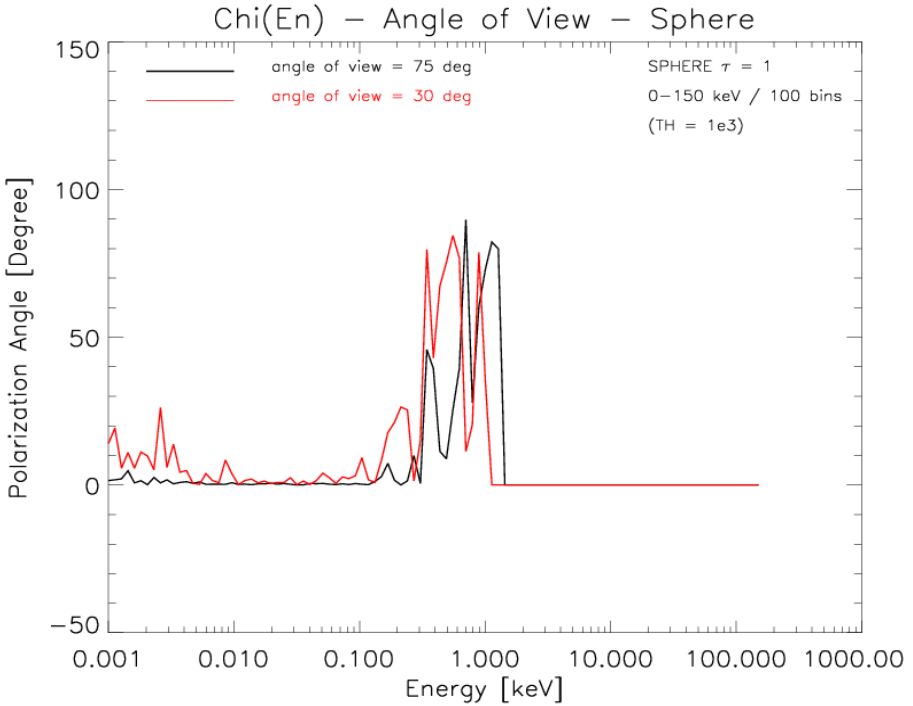


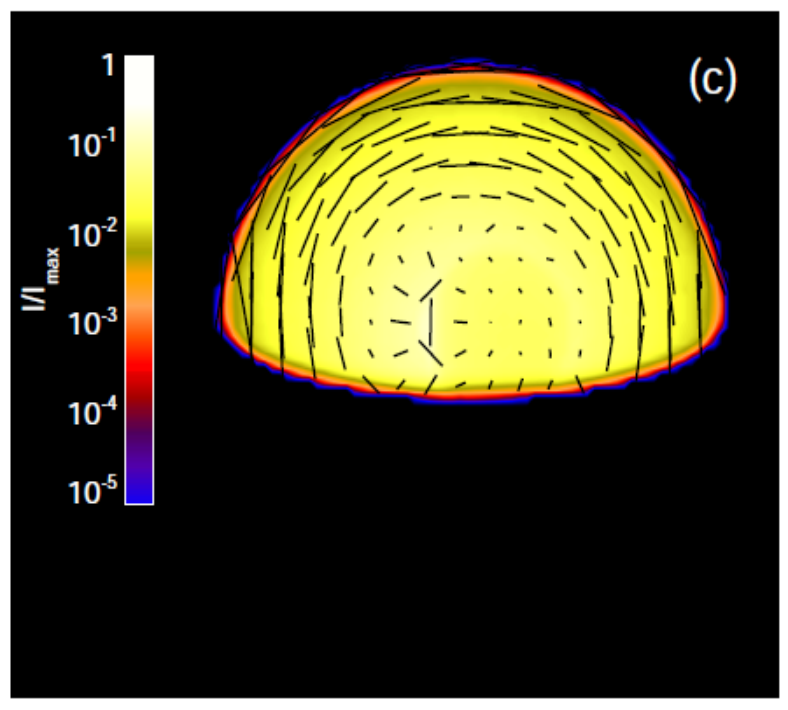


Result
- the polarization -

SPHERE
τ = 1







(picture from Schnittman+ 2009)

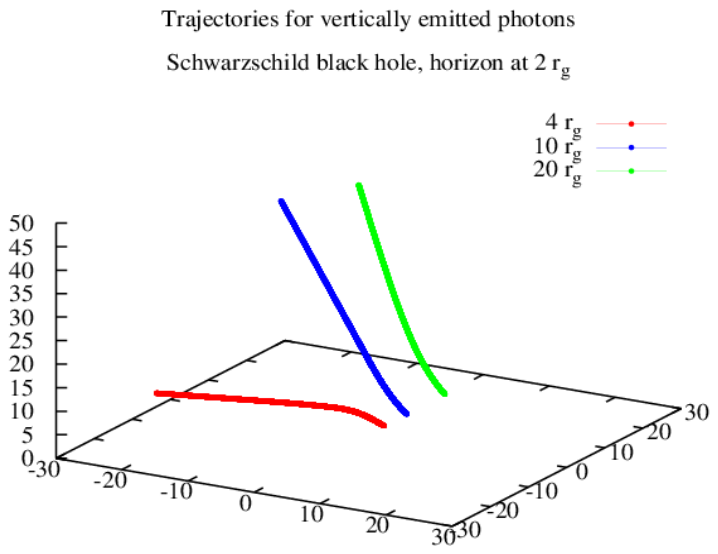
Conclusion

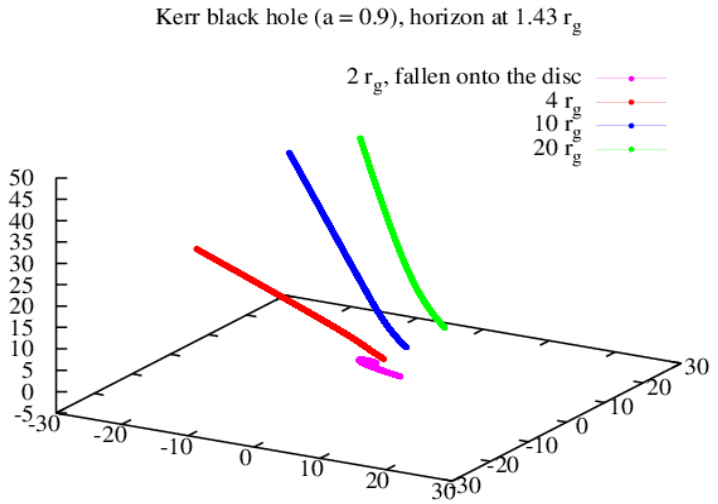
- Polarized x-ray radiation is expected in AGN due to Comptonization and can reach ~10% of observed flux in the best scenario (without GR effects)

- Polarimetry offers 2 new independent observables which are complementary to specral analysis

- These observables are extremely sensitive to geometry & angle of view

Future Work

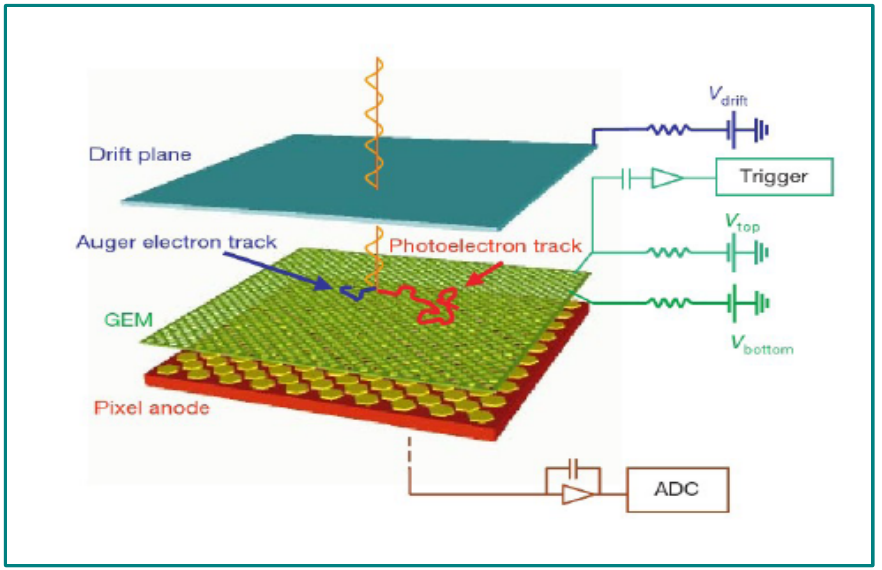




- Include GR
- Even more flexibility (turn on/off GR and polarization)

Light bending de-polarizes polarized radiation (and polarizes unpolarized radiation)

Observational Perspectives
...none yet



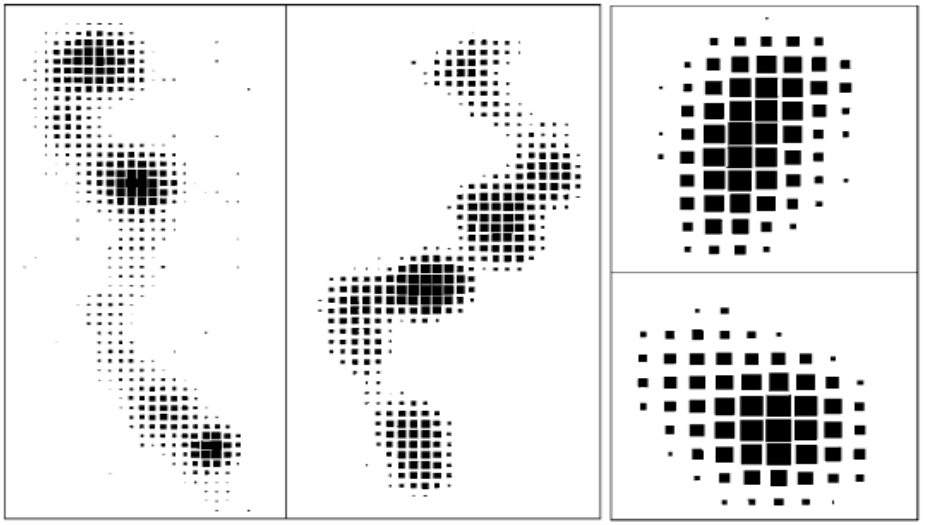


Fig. 3. Track images from 20 keV X-rays (left) and 4.5 keV X-rays (right).

Costa et al. (2001), Bellazzini et al.(2009), Muleri et al. (2009), Soffitta et al. (2012 - 2013)

...but the technology is ready and well tested (yesterday's talk by Paolo Soffitta on XIPE / IXPE)