# X-ray polarization in the lamp-post geometry of the compact corona illuminating a black-hole accretion disc in AGN


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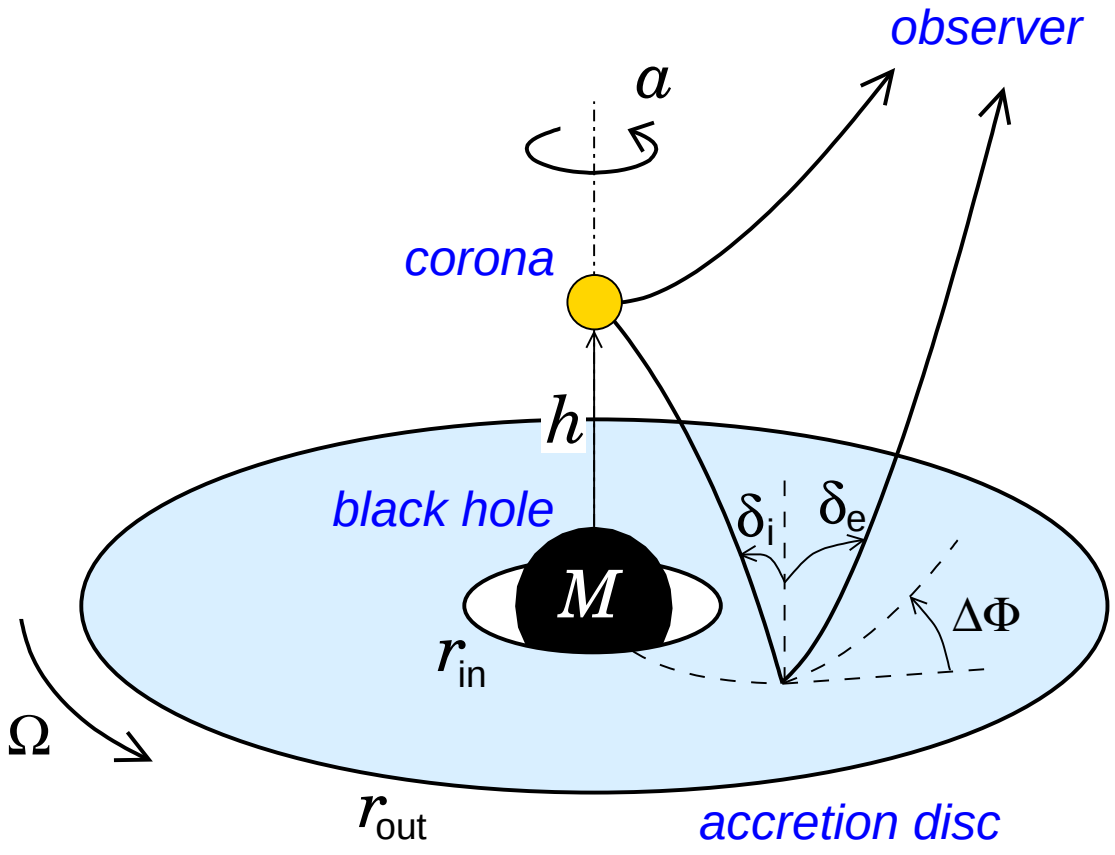
# Motivation

- light bending scenario to explain variability in continuum versus line flux (e.g. Miniutti & Fabian, 2004)
- X-ray continuum variability and microlensing suggests the X-ray emitting regions $\lesssim 10\, r_{\rm g}$
- polarization in reflection in non-axisymmetric geometry should be significant
- resolve the reflection versus absorption dispute for origin of the AGN X-ray spectral shape in 2–10 keV range (Marin et al, 2012)
- new polarimetric detectors for next generation X-ray missions have been developed and proposed (XEUS, IXO, NHXM, GEMS, XIPE, ???)

# Scheme of the geometry

Matt (1993)

Dovčiak, Muleri, Goosmann, Karas & Matt (2011)



# Stokes parameters

Stokes parameters at infinity:

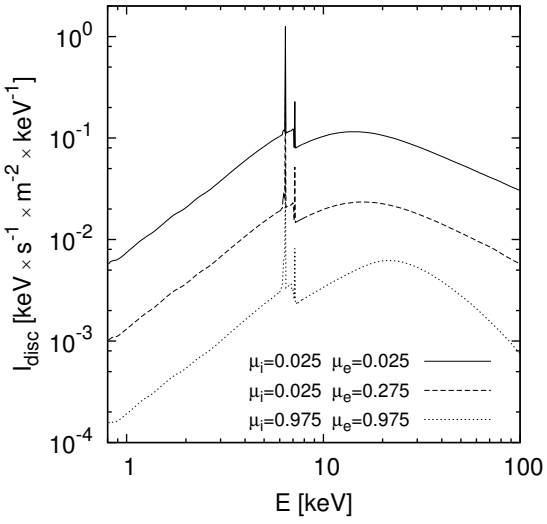
$$\Delta I(E) = \int_\Sigma \mathrm{d}S\; G\; I_{\rm loc}(E/g) \qquad G = g^3\,\ell\,\mu_{\rm e}$$

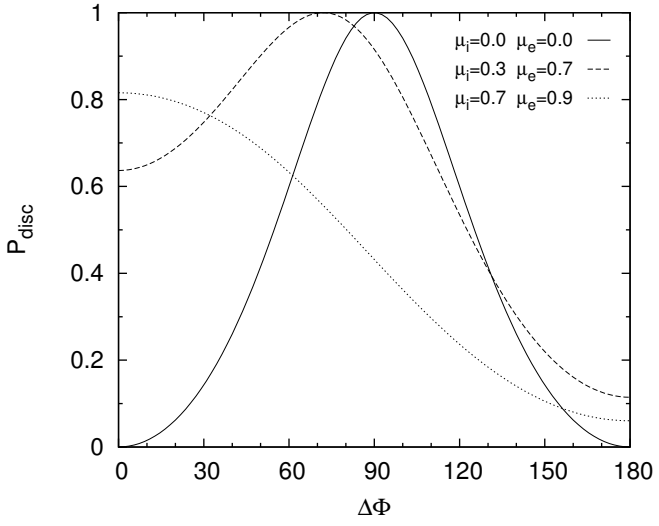
$$\Delta Q(E) = \int_\Sigma \mathrm{d}S\; G\; P_{\rm loc}(E/g)\; I_{\rm loc}(E/g)\; \cos 2[\chi_{\rm loc}(E/g) + \psi]$$

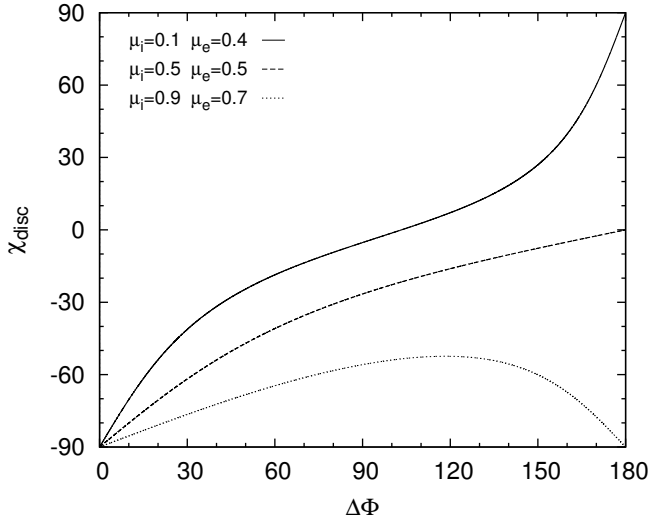
$$\Delta U(E) = \int_\Sigma \mathrm{d}S\; G\; P_{\rm loc}(E/g)\; I_{\rm loc}(E/g)\; \sin 2[\chi_{\rm loc}(E/g) + \psi]$$

$\rightarrow$ $I_{\rm loc}$, $P_{\rm loc}$ and $\chi_{\rm loc}$ depend on local geometry of scattering

# Local emission



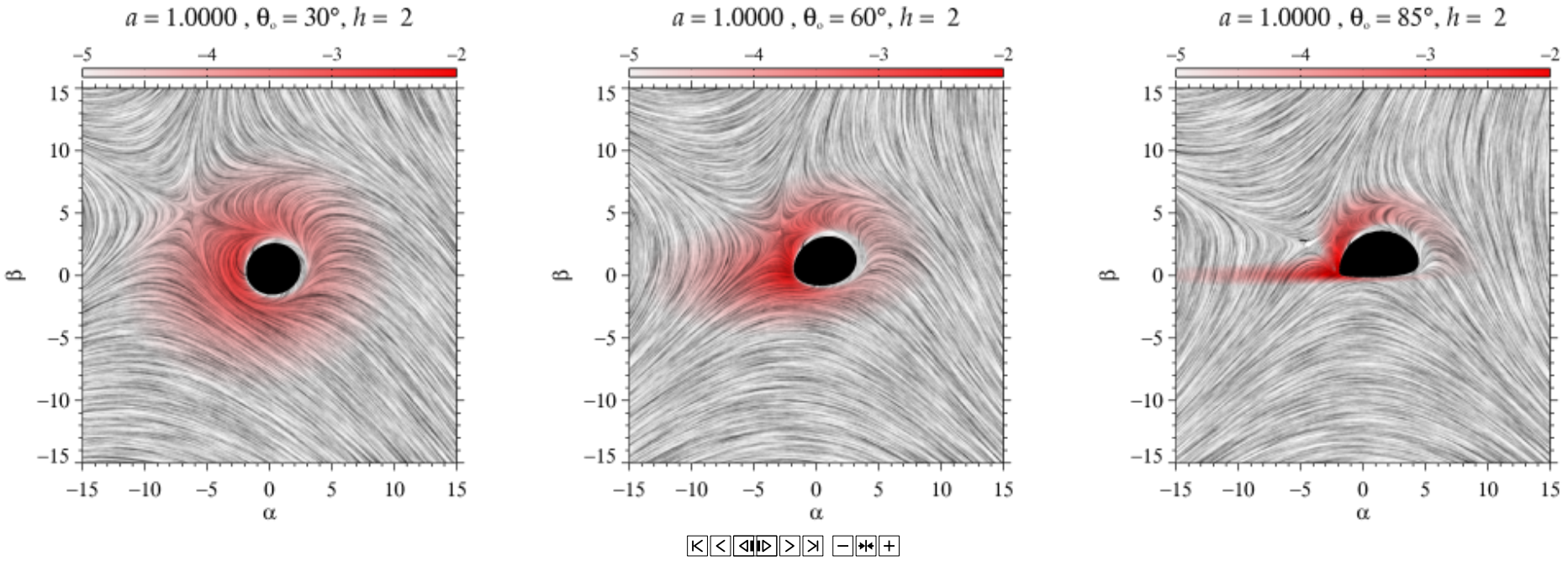



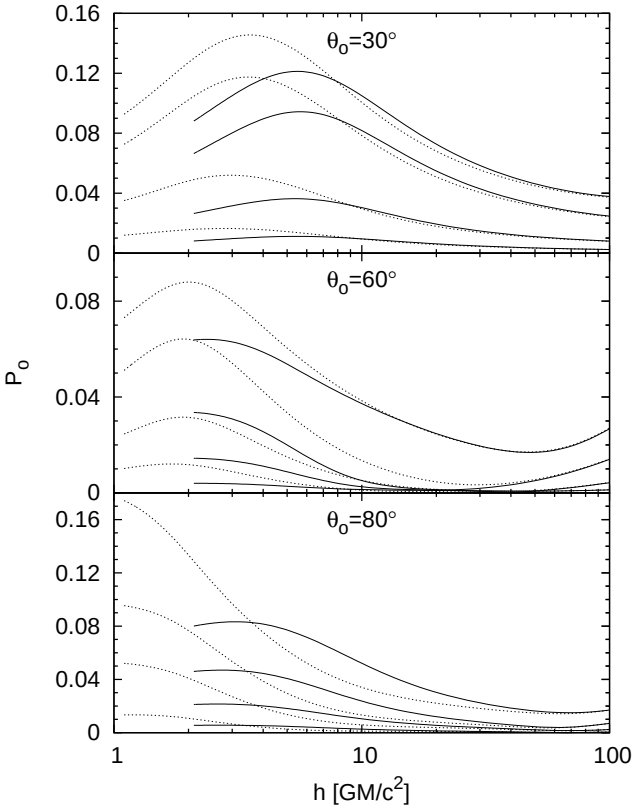

- flux — multiple Compton scattering and K$\alpha$, K$\beta$ fluorescence (code `NOAR`)
- polarization — Chandrasekhar (1960)

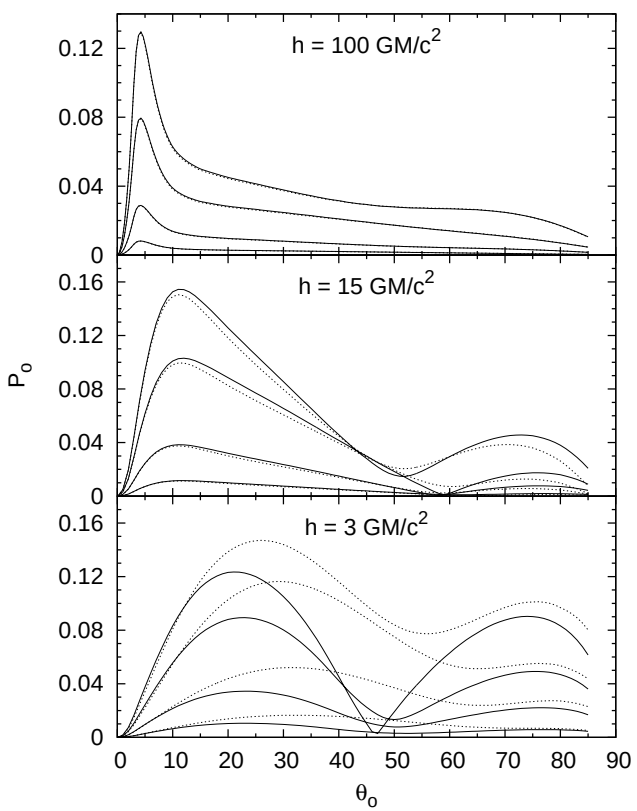
# Polarization at infinity

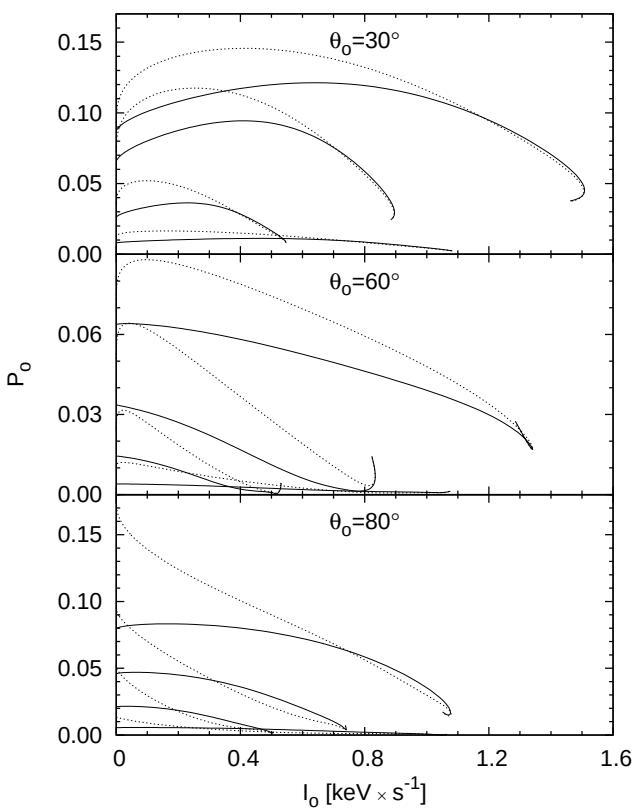
- → importance of the local polarization properties
- → geometry of scattering (incident, emission and relative azimuthal angles)
- → source height, observer inclination and black hole spin
- → formation of additional depolarizing critical points
- → illumination pattern depends on height of the source



# Polarization degree



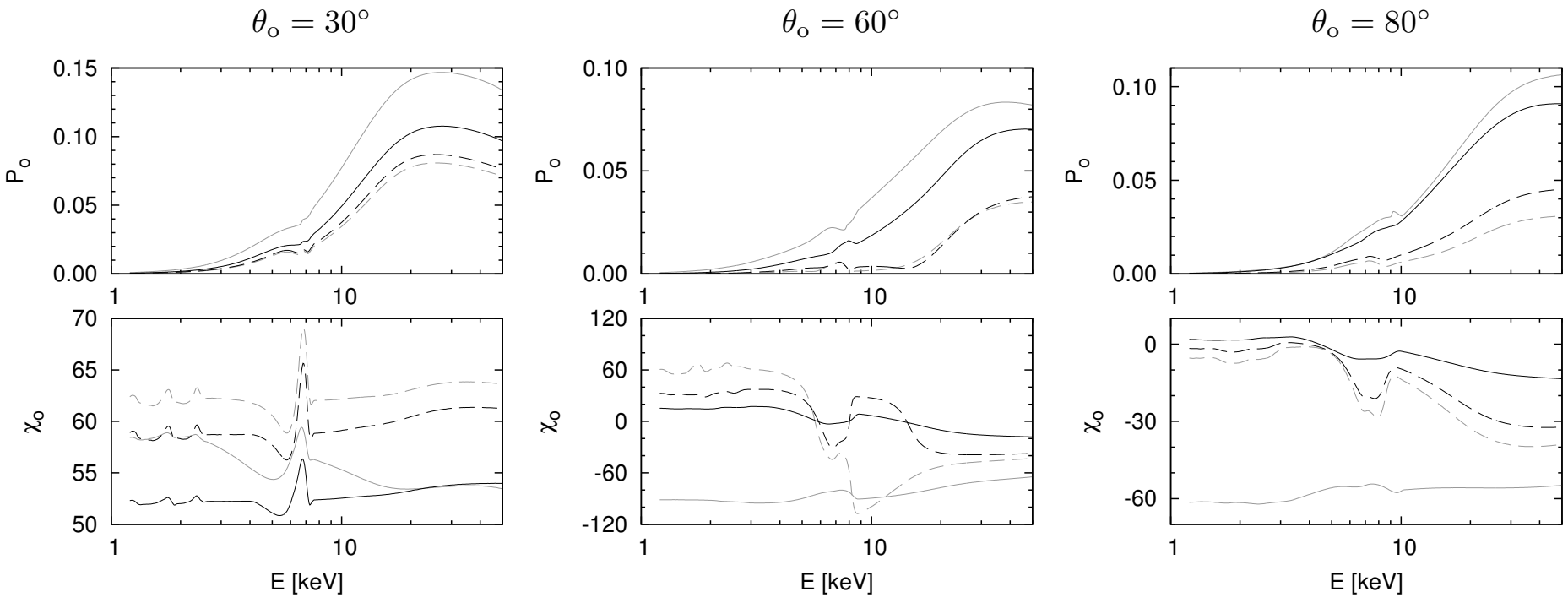




Energy bands: 20 – 50 keV
10 – 20 keV
6 – 10 keV
2 – 6 keV

dotted → extreme Kerr black hole (a=1)

solid → Schwarzschild black hole (a=0)

# Polarization of the total radiation



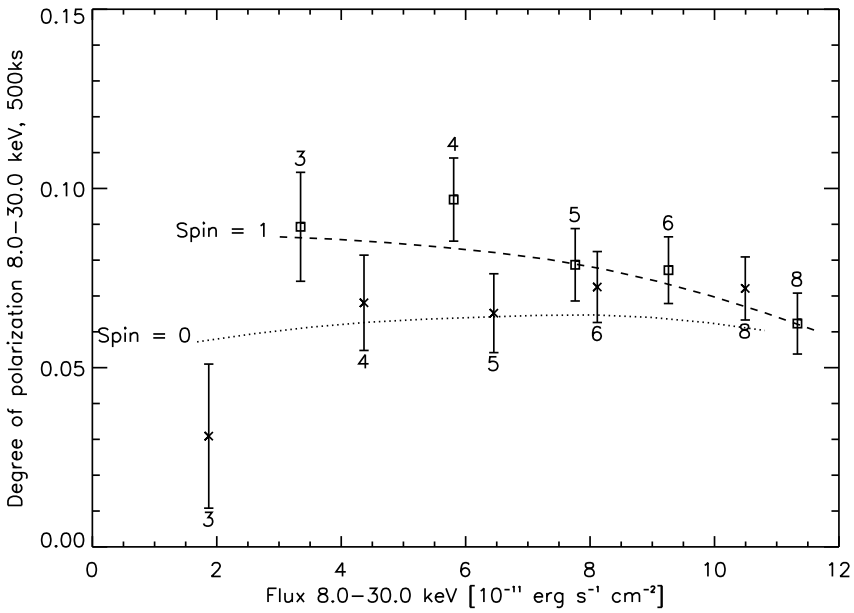

black → Schwarzschild black hole (a=0)

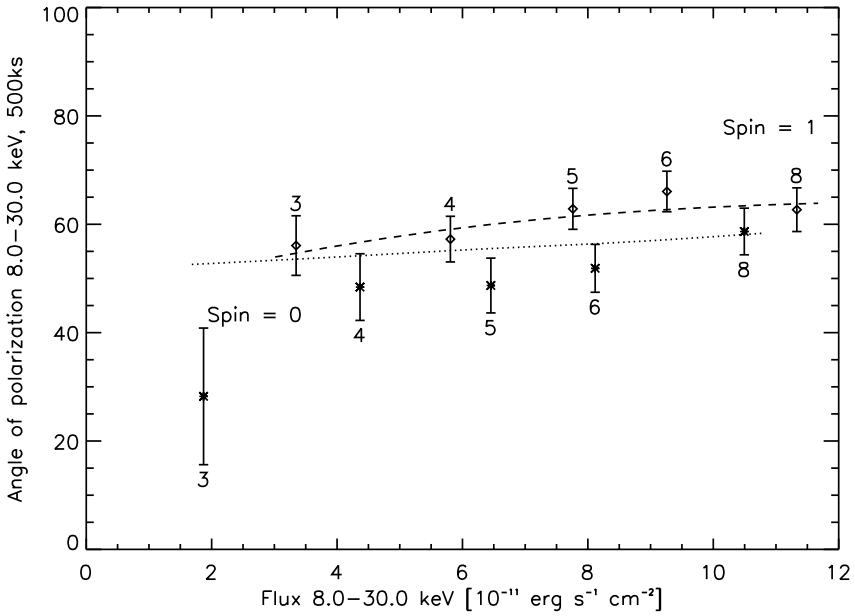
grey → extreme Kerr black hole (a=1)

solid → h = 3 GM/c$^2$

dashed → h = 15 GM/c$^2$

# Simulations — MCG-6-30-15




- dashed lines – extreme Kerr black hole ($a = 1$)
- dotted lines – Schwarzschild black hole ($a = 0$)

Assumptions:

- polarimeter on-board NHXM (i.e. medium sized mission)
- observing time – 500 ks
- energy range 8–30 keV

# Conclusions

Polarization degree is the highest

- at the Compton hump energies (10–50 keV)
- small inclination angles (5°–30°)
- small heights of the primary source (below 10 $GM/c^2$)
- large spin of the black hole