ON THE POLARISATION SIGNAL PRODUCED BY COMPTONIZATION IN ACCRETING SOURCES

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STRONGGRAVITY

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OUTLINE

- Scientific motivation
- MoCA in a nutshell
- The polarisation signal representation
- Polarisation signal in AGN
- Polarisation signal in BHBs
- Conclusions

Scientific Motivation

We can safely say that at least 90% of astronomy is made using photons.
However in X-ray we only use 2 observables out of three:

energy (spectral analysis)
time (timing analysis of variability)
but no polarisation

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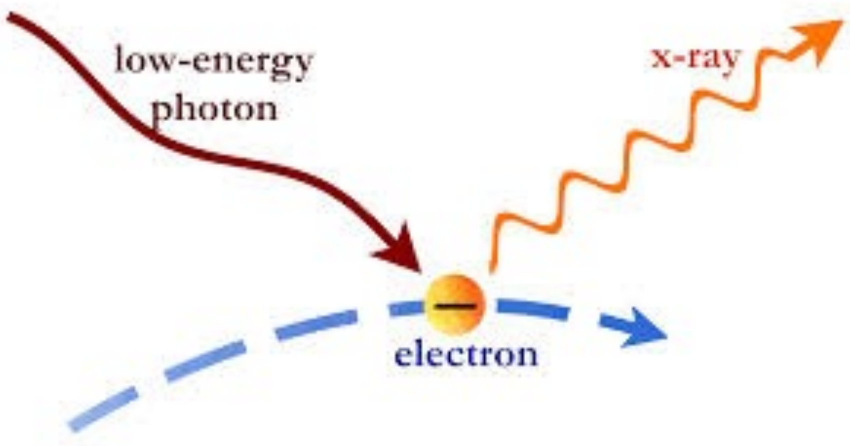
The X-ray spectrum observed in accreting sources is believed to be produced by Comptonization of soft photons coming from the disc by an hot corona of electrons whose geometry is still unknown.



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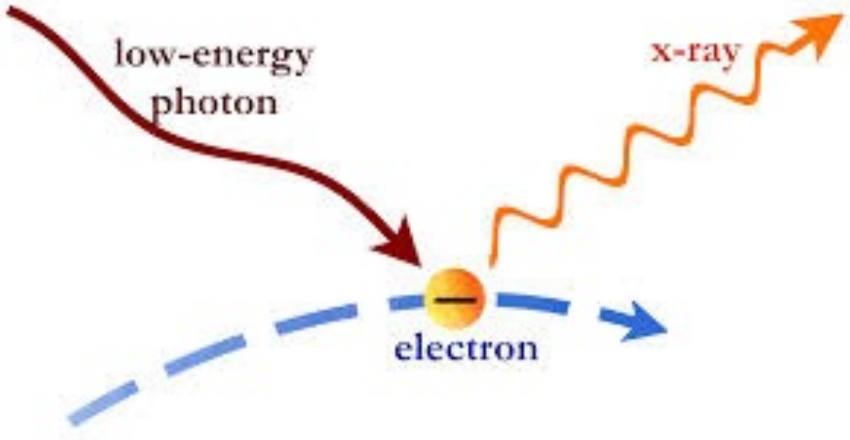


Inverse Compton, as any scattering process, should produce radiation linearly polarised perpendicularly to the plane of scattering, reflecting the geometry of the scattering material.

The polarisation signal will be stronger as the material is more asymmetric and/or as it is seen from a line of sight maximising its asymmetry.

X-ray polarisation analysis, together with spectroscopical analysis, has the potential to constrain the inclination of the system and the geometry of the corona

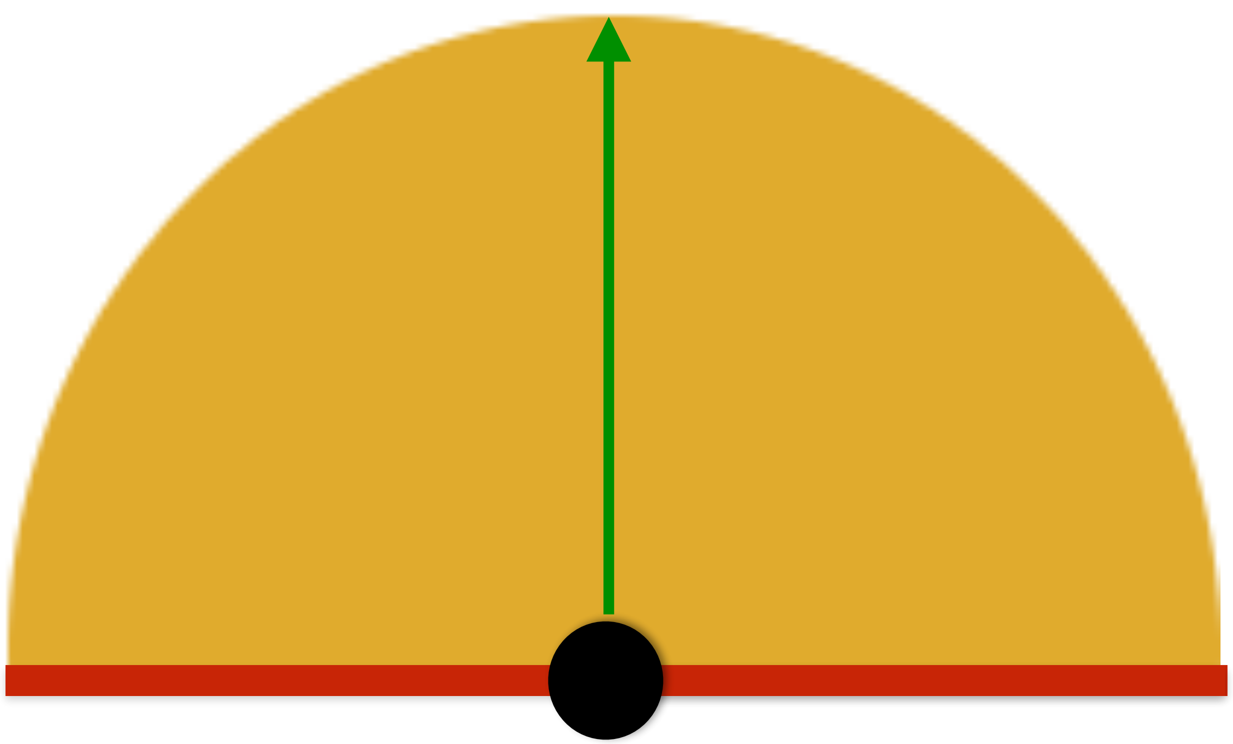
MOCA IN A NUTSHELL

For these reasons we developed MoCA: a Monte Carlo code for Comptonization in Astrophysics
(Tamborra et al. in prep.)

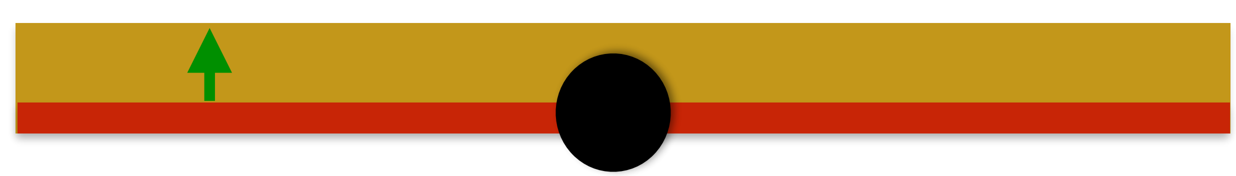
MoCA works in a fully special relativistic scenario (and soon with GR as well), it includes quantum effects (i.e. Klein-Nishina cross-section), it is modular and it works with single photons without any particular approximation or limitation.

For the corona we implemented the two geometries sketched below

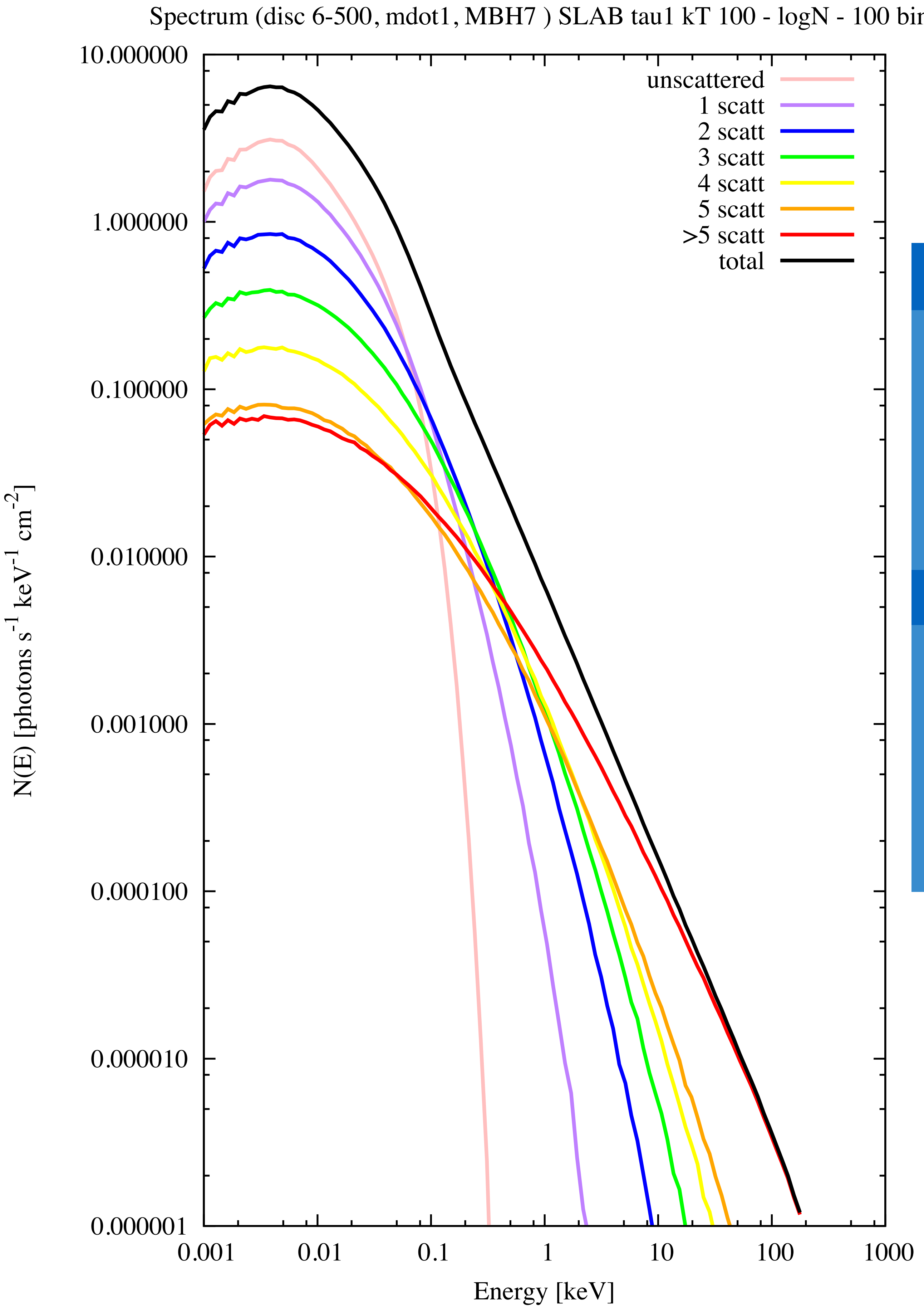
SPHERE



SLAB

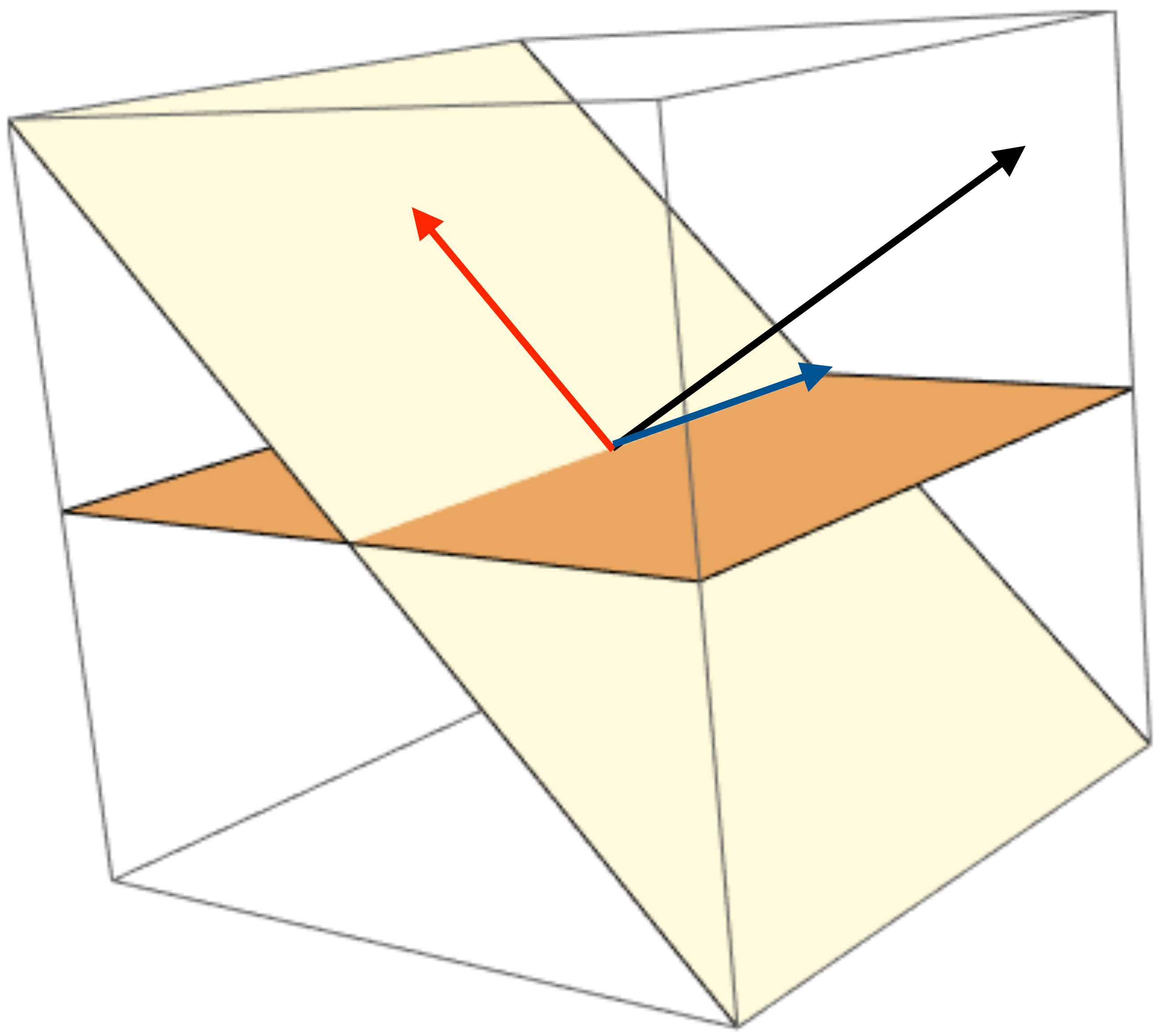


Spectra in MoCA



geom tau-kT	MoCA	compPS
SLAB 1-100	-1.63	-1.61
SLAB 0.5-100	-1.95	-1.97
SLAB 1-50	-2.31	-2.08
SLAB 0.5-50	-2.79	-2.50
SPHERE 1-100	-1.95	-1.96
SPHERE 0.5-100	-2.28	-2.38
SPHERE 1-50	-2.57	-2.59
SPHERE 0.5-50	-3.29	-3.20

Polarisation Signal in MOCA



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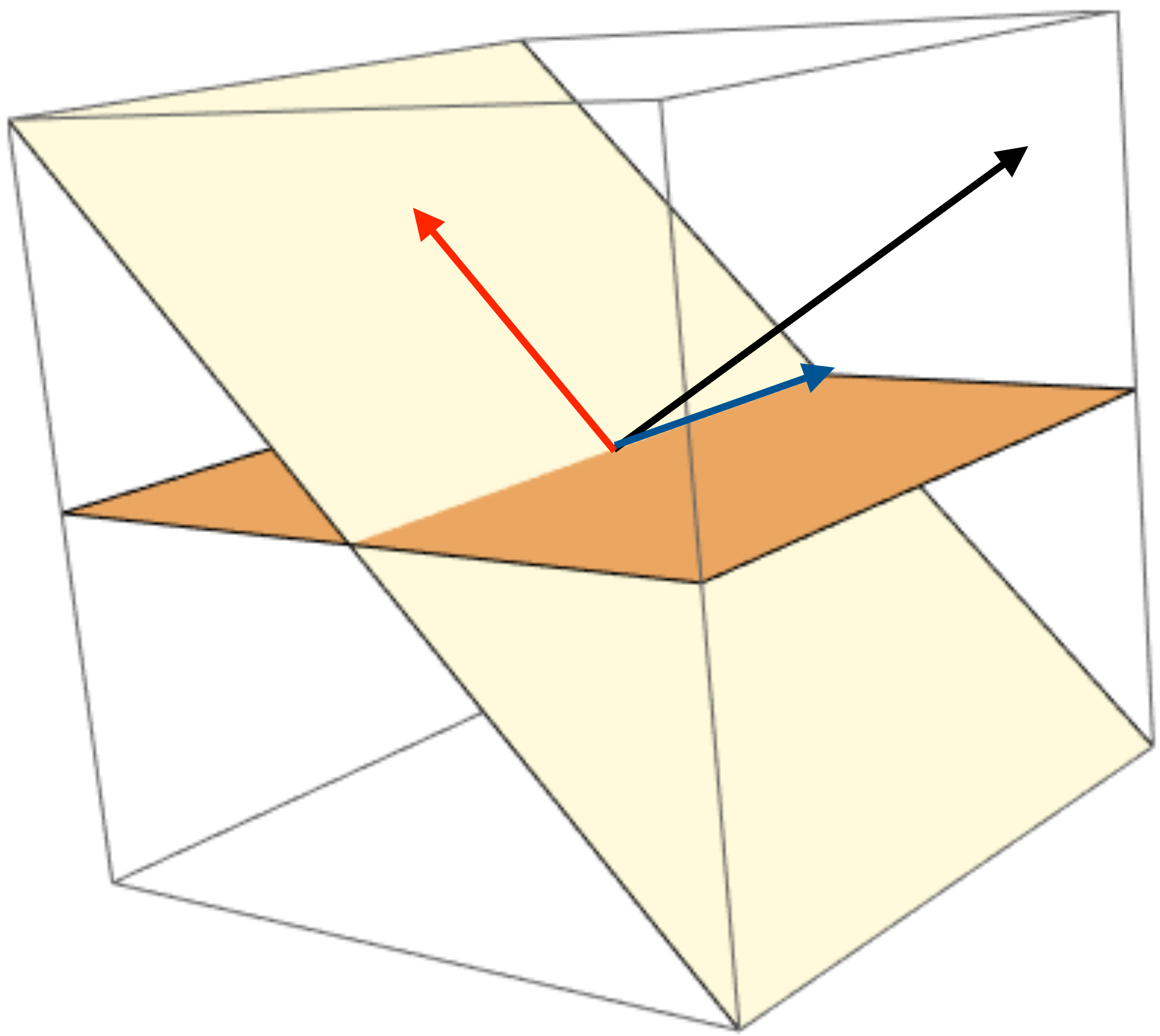
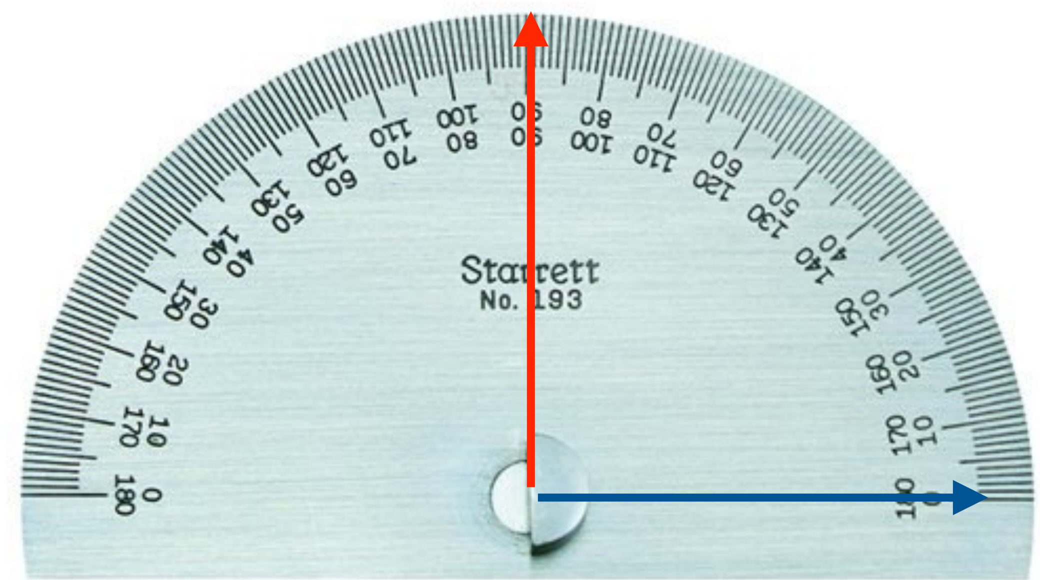
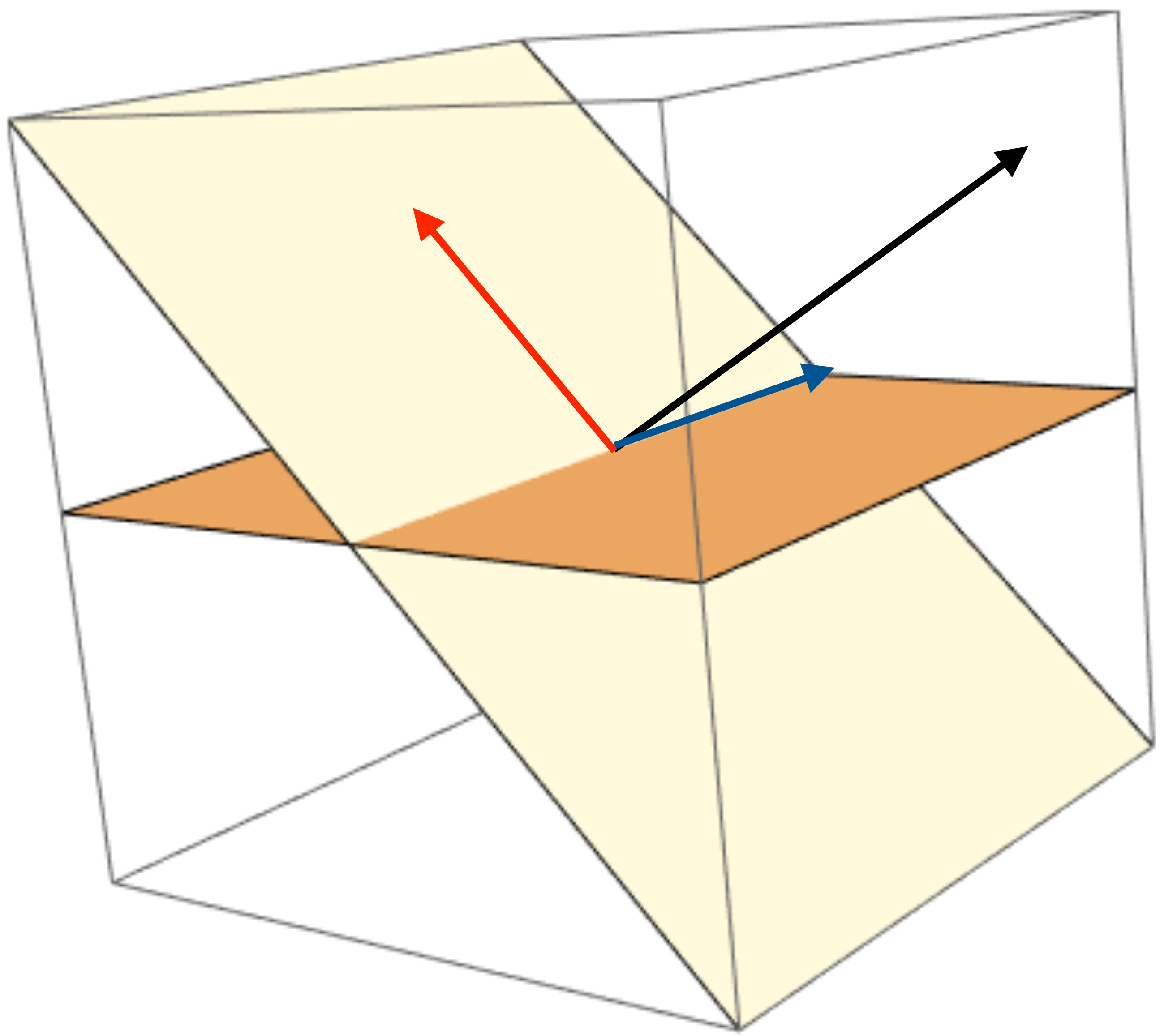
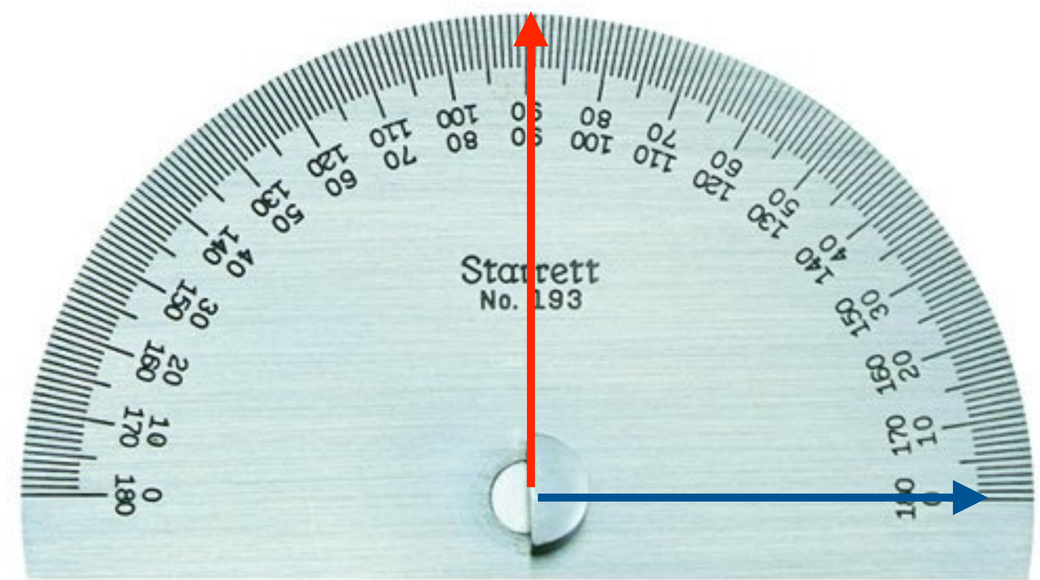
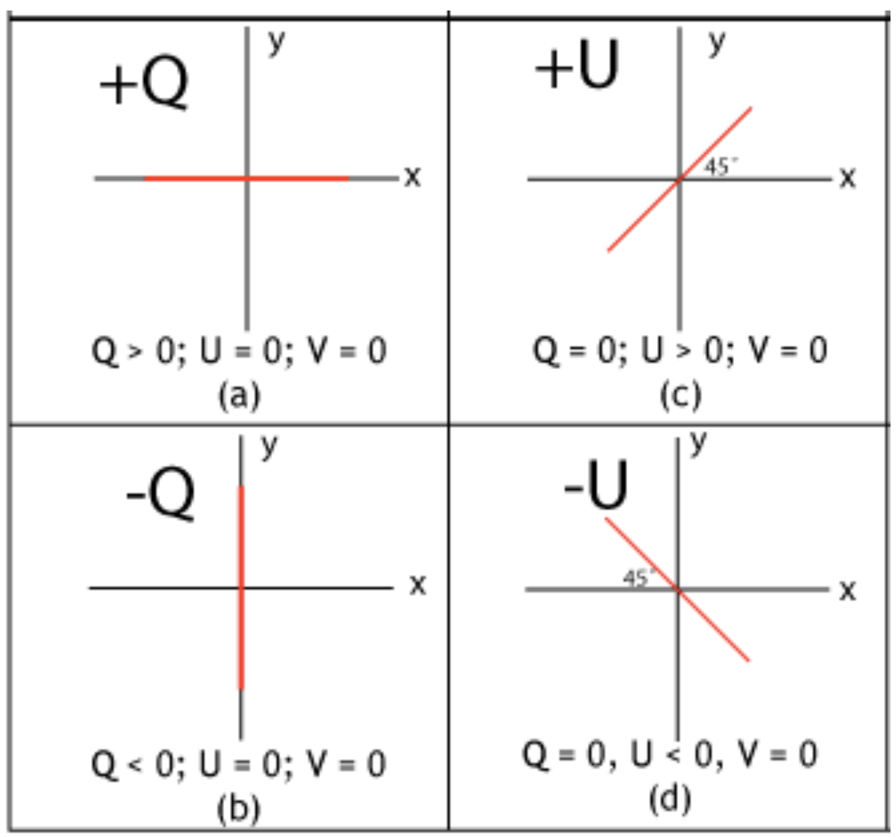




POLARISATION SIGNAL IN MOCA







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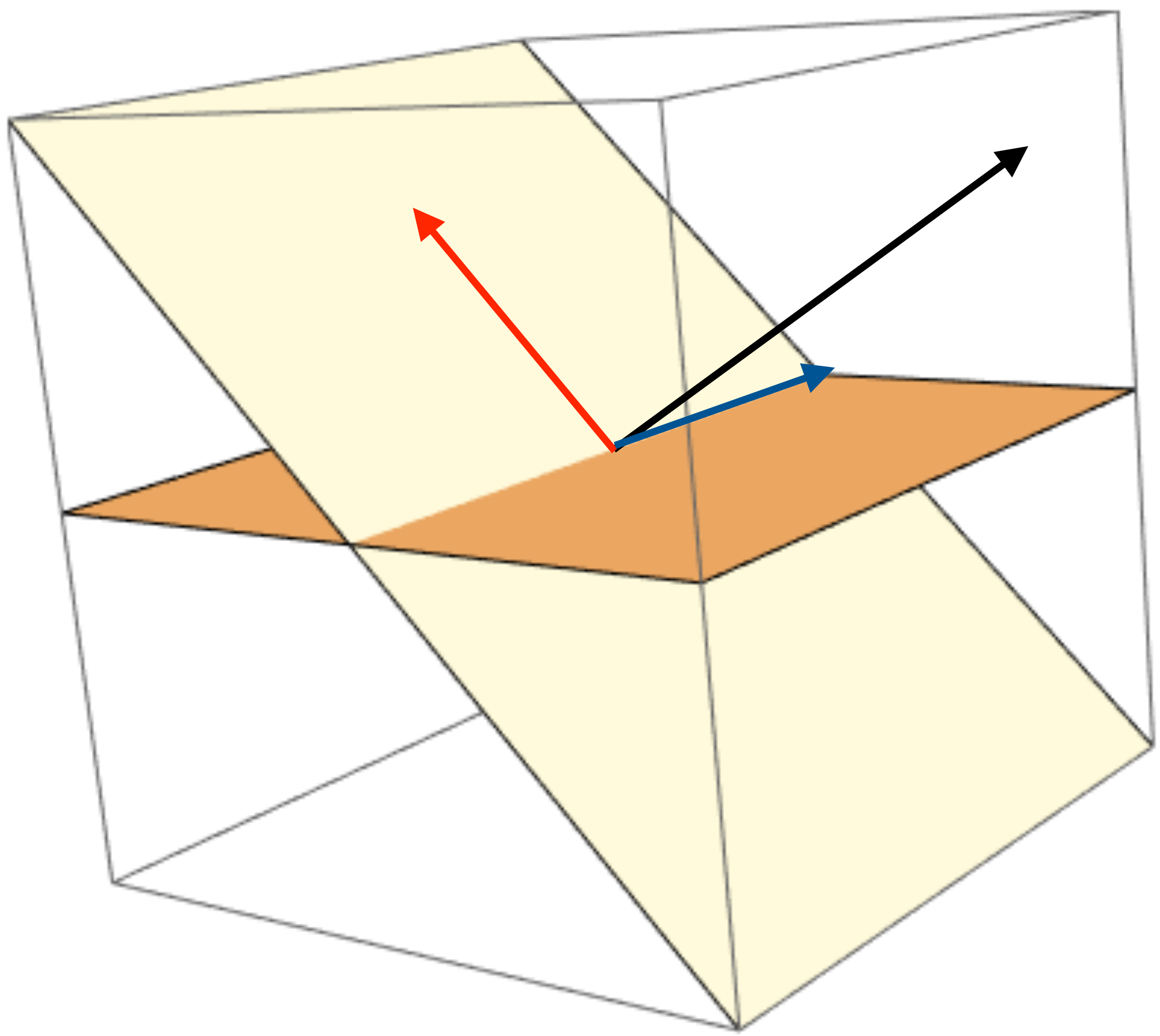
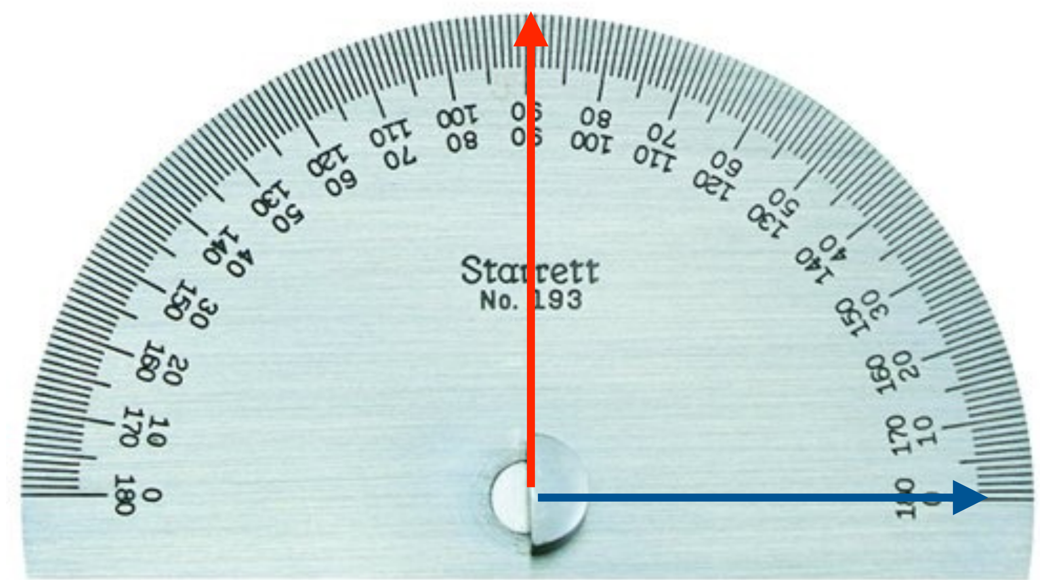
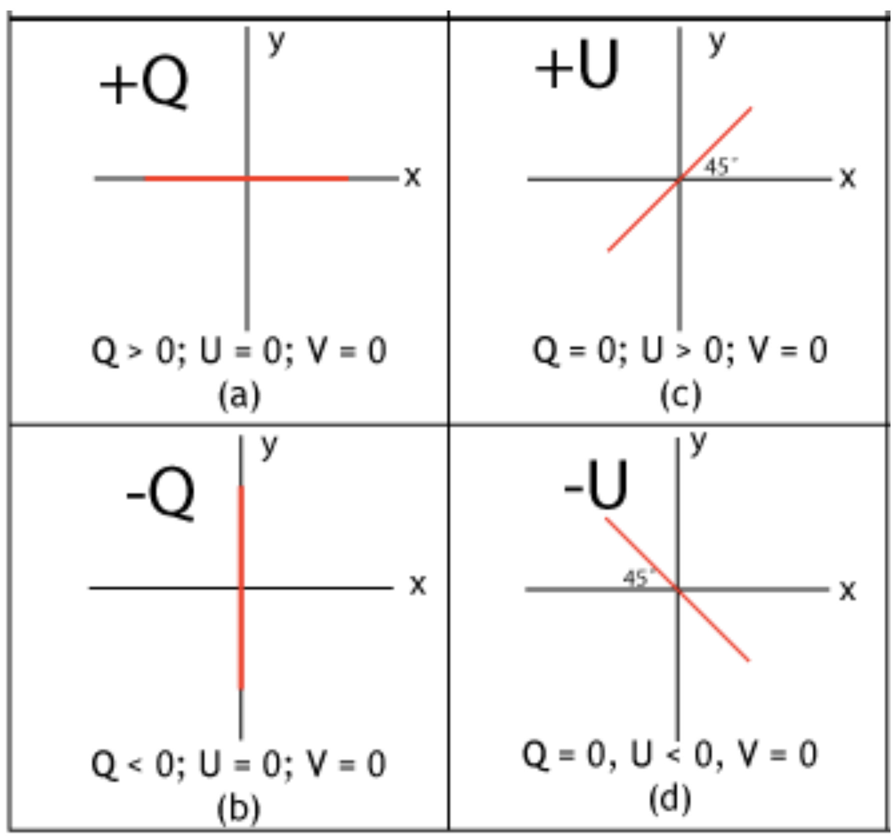


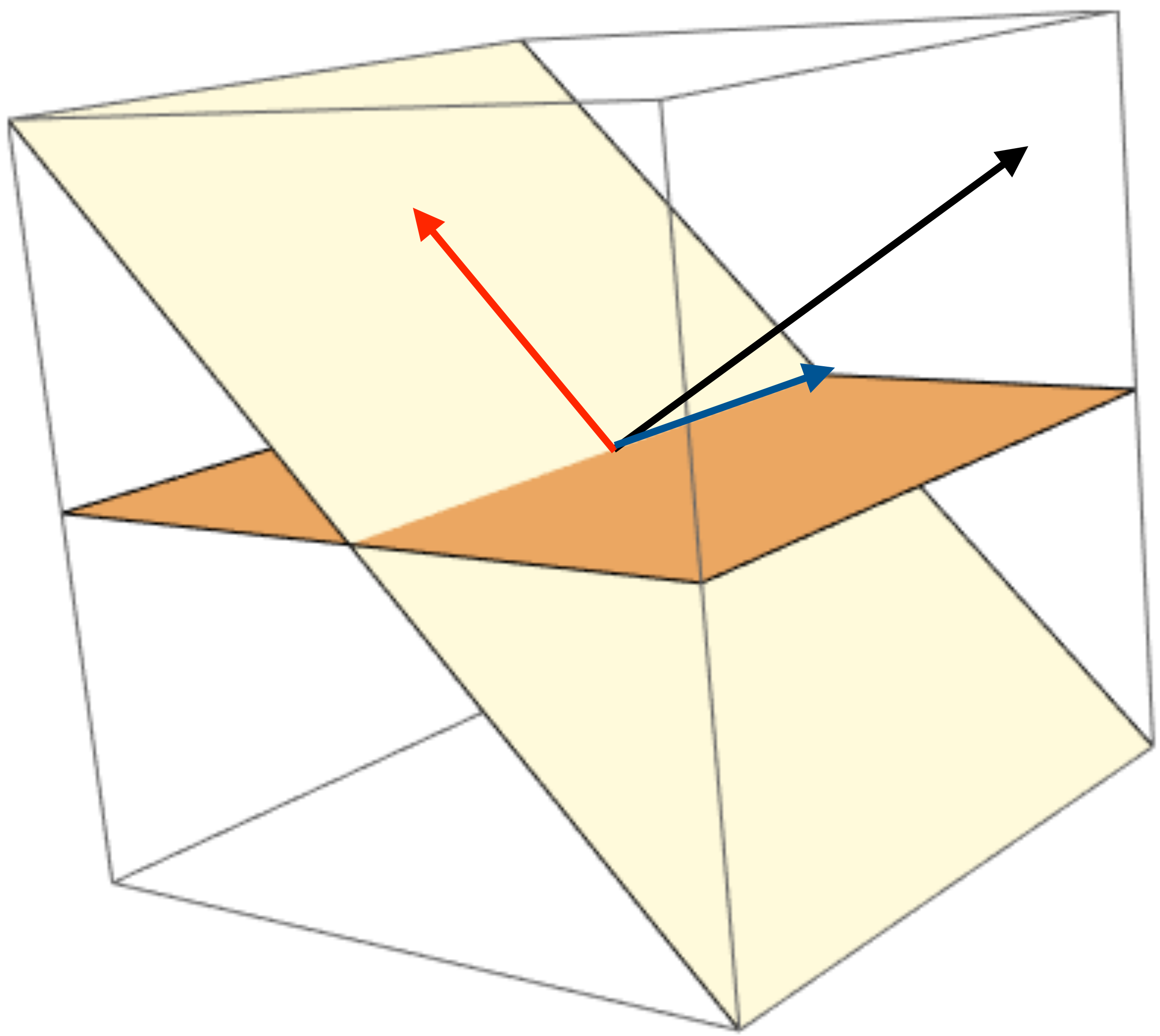


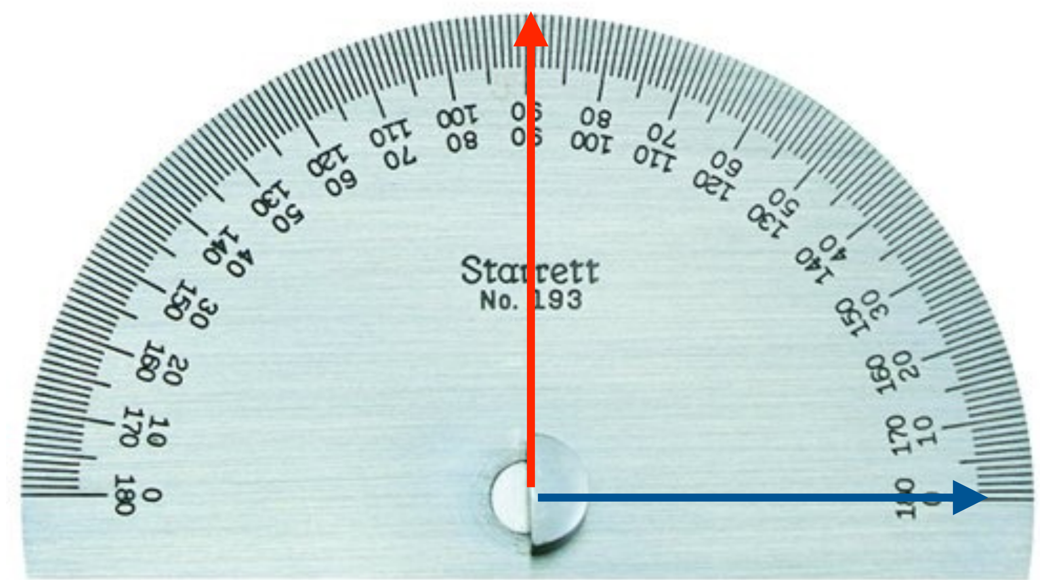


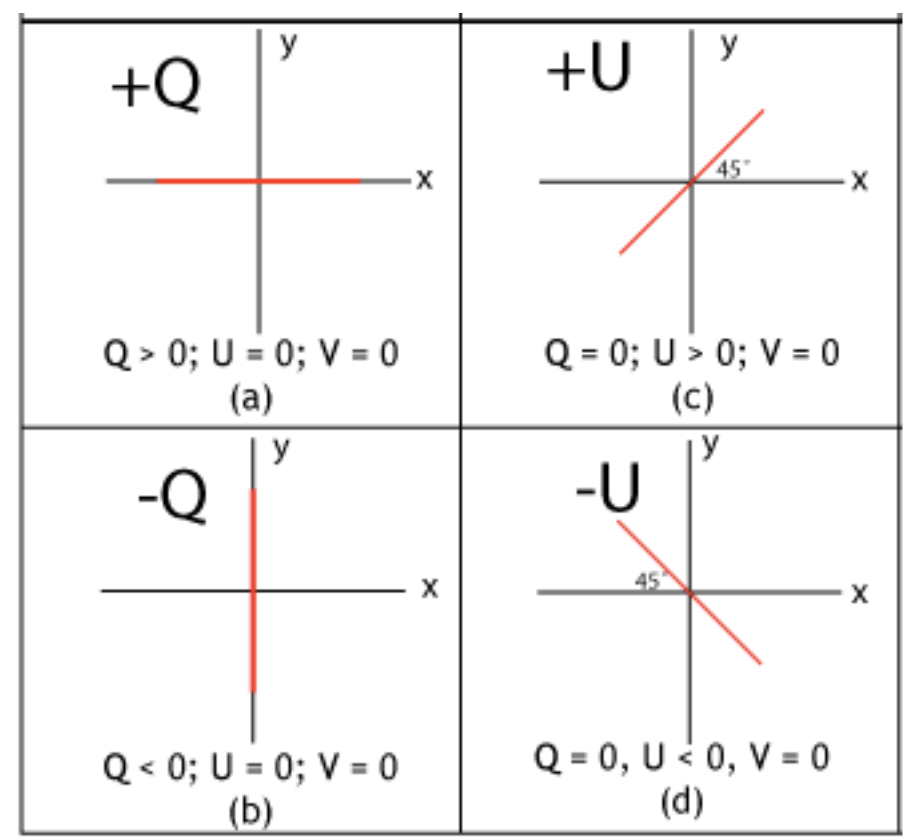
$$\Pi = \frac{\sqrt{Q^2 + U^2}}{I}$$

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

POLARISATION SIGNAL IN MOCA







if U~0,

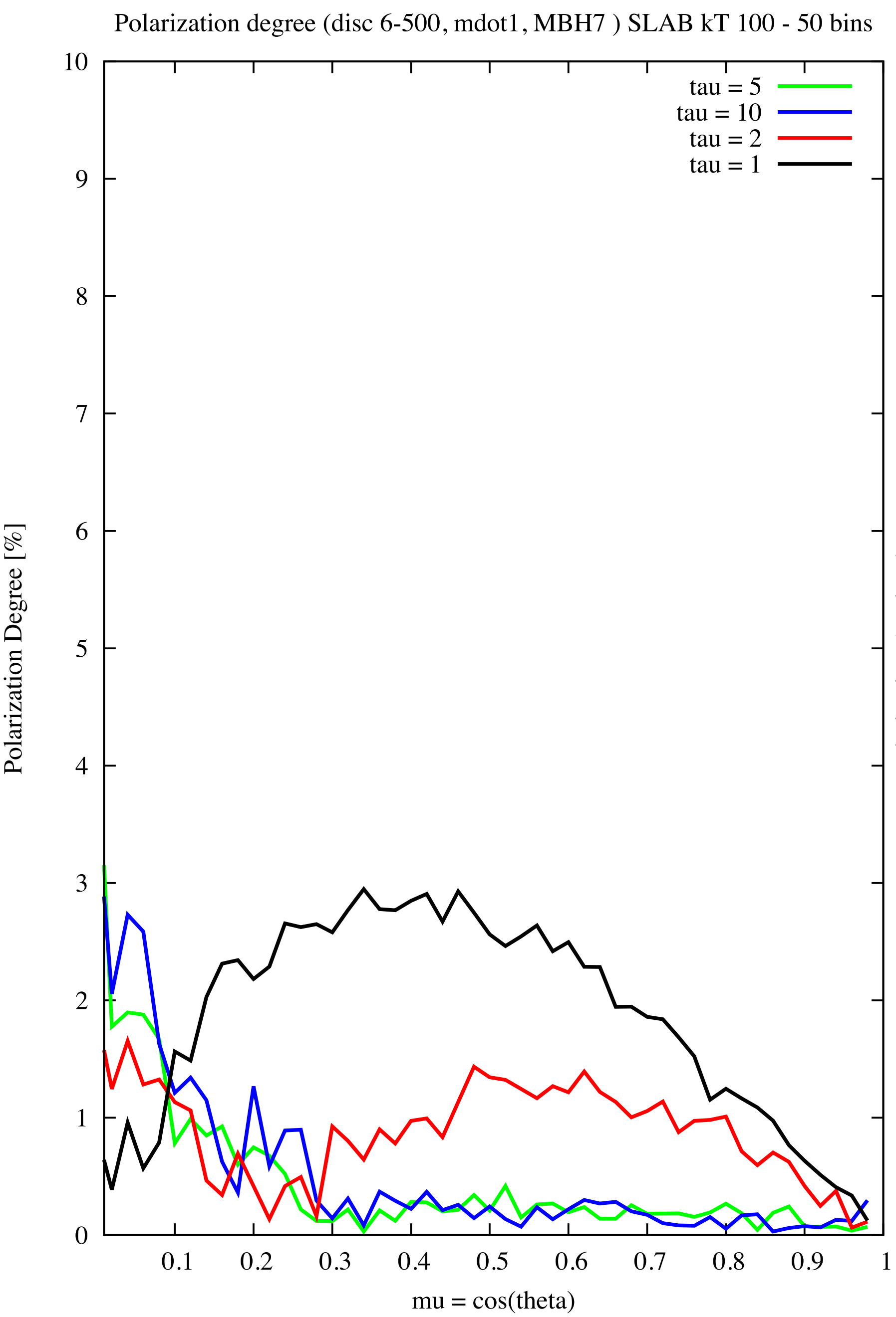
$$\Pi = Q / I$$

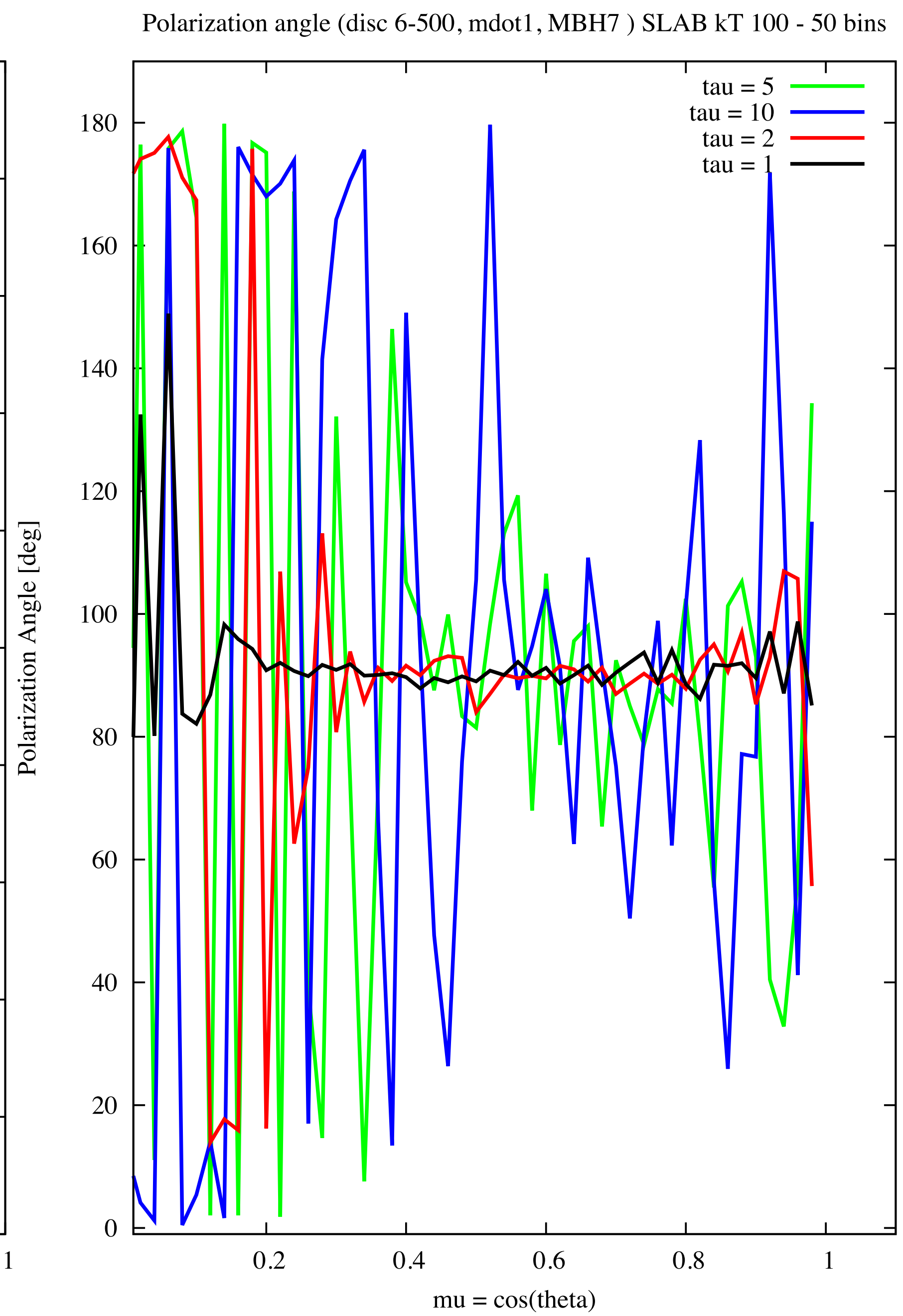
the sign of Q representing the angle of polarisation

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

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

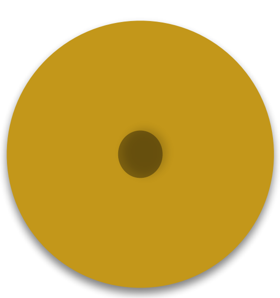
POLARISATION SIGNAL REPRESENTATION



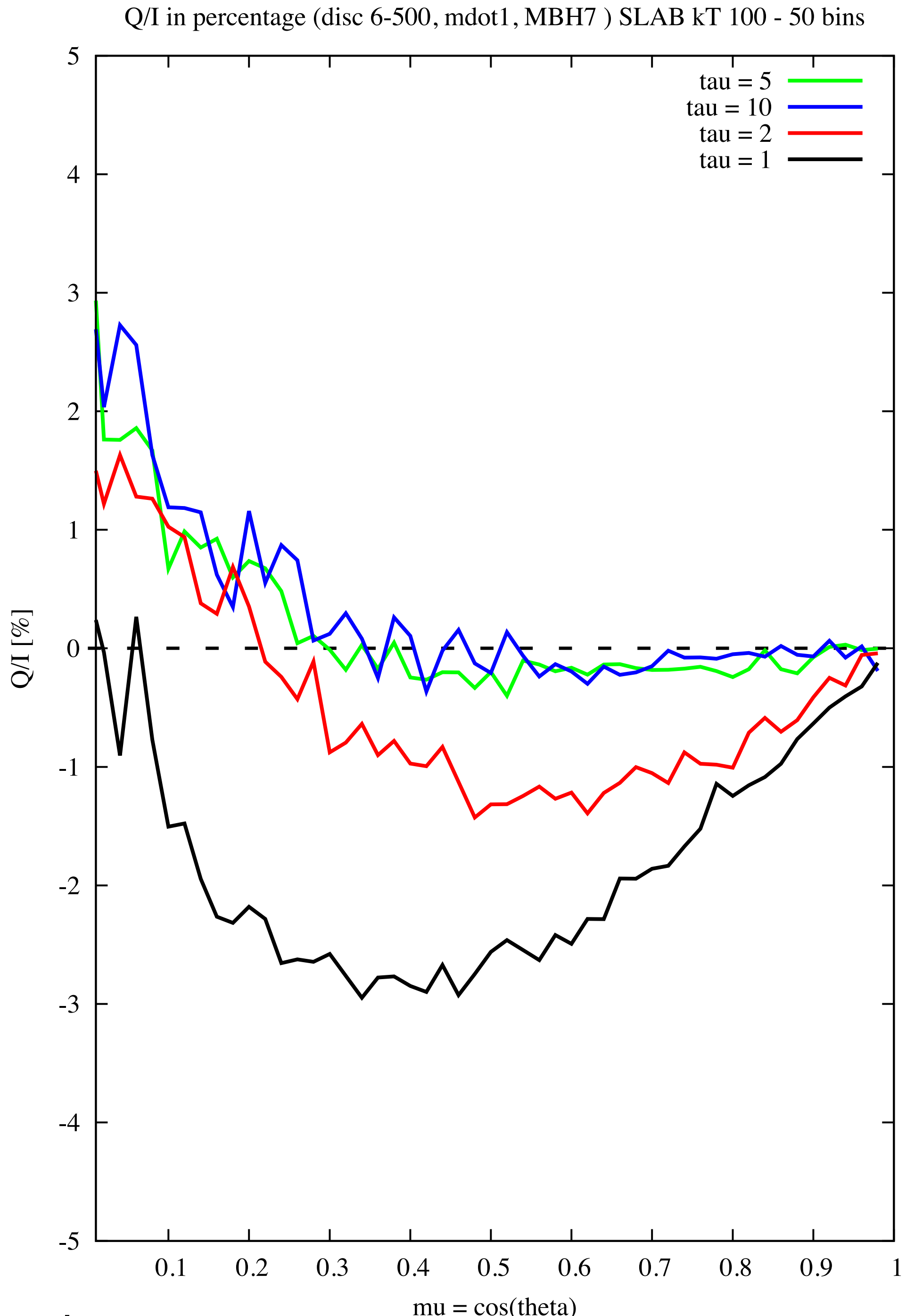


edge-on

face-on

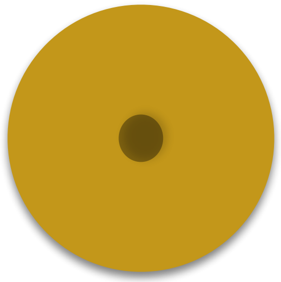


Polarisation signal representation



edge-on

face-on



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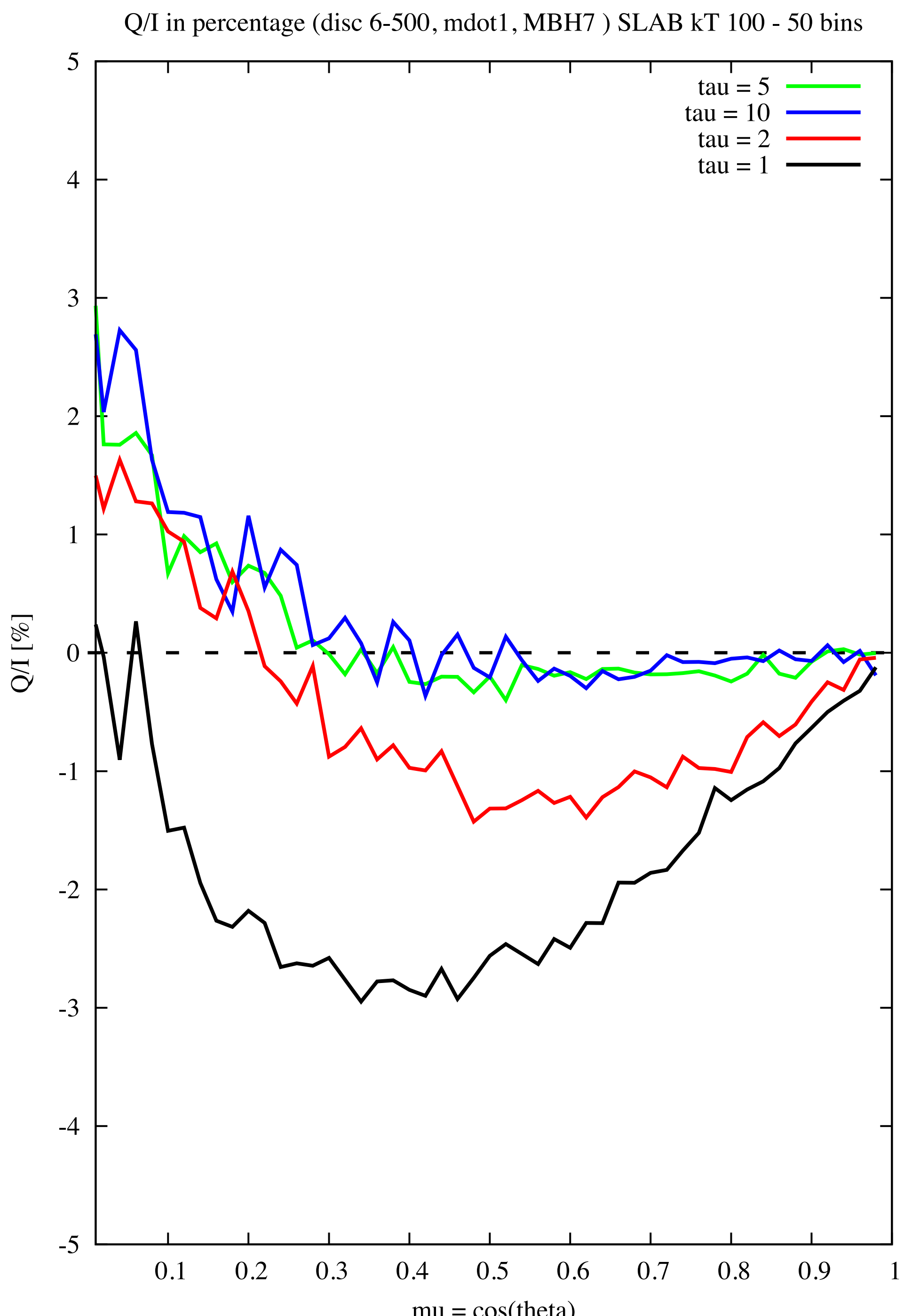
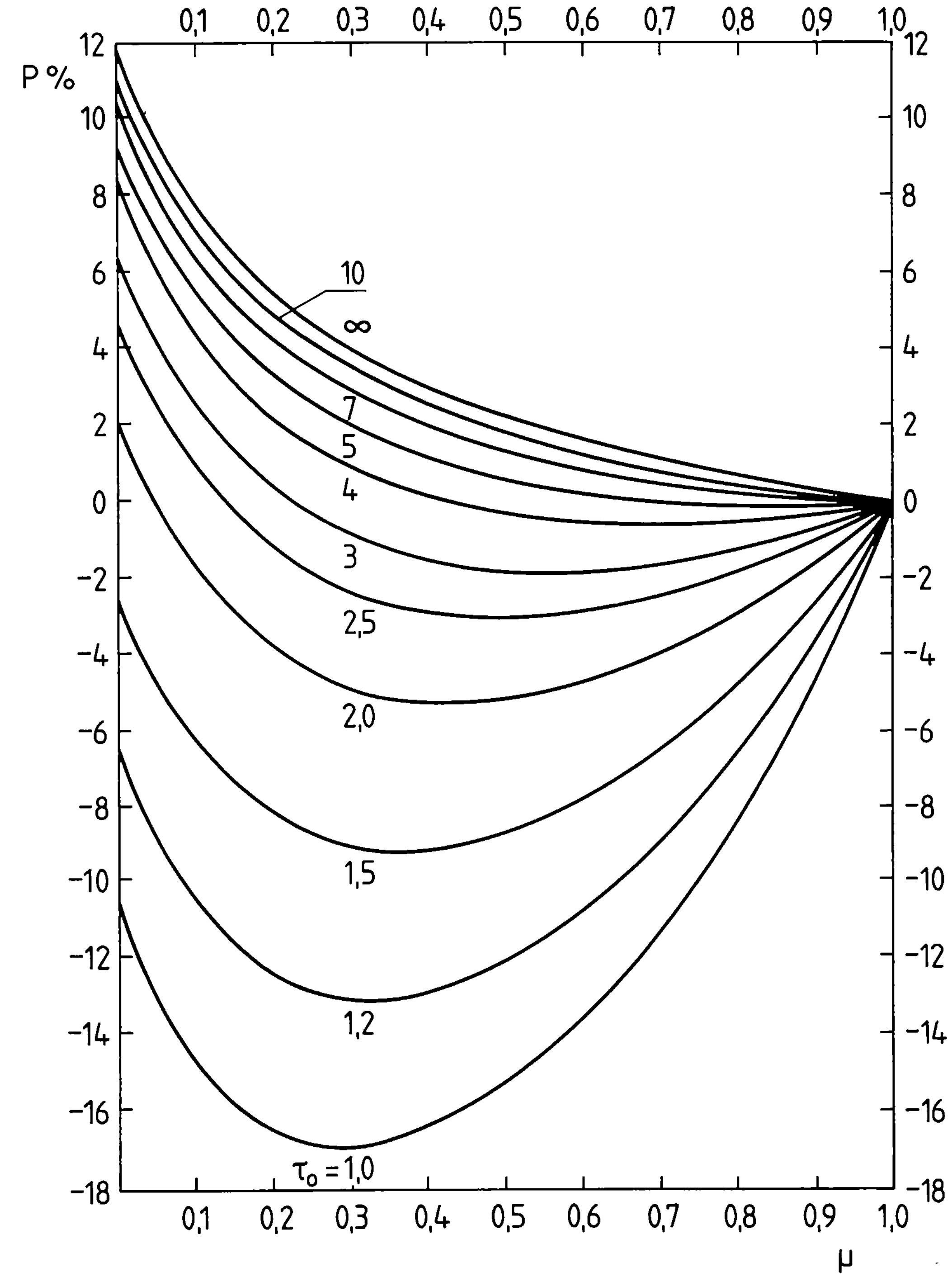
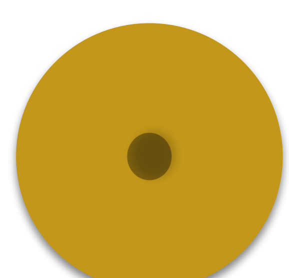




edge-on

face-on

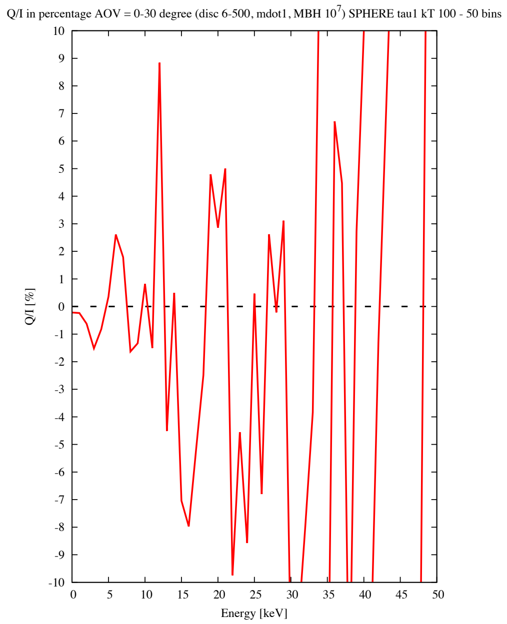
Sunyaev-Titarchuk 85



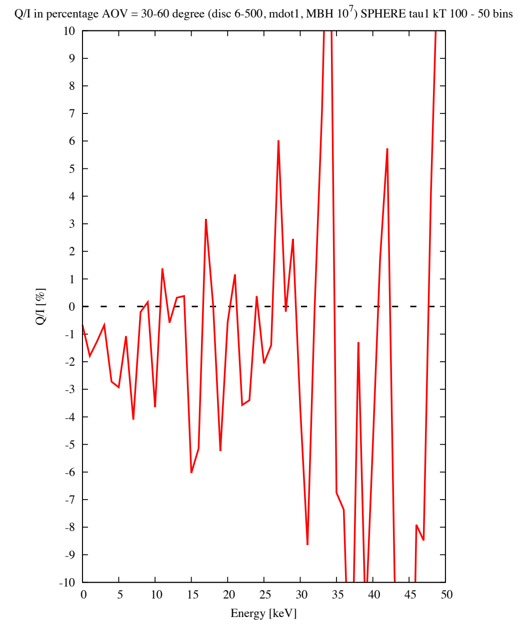
SPHERE tau = 1, kT = 100 keV

SLAB tau = 1, kT = 100 keV

LOS = 0°-30°



LOS = 30°-60°



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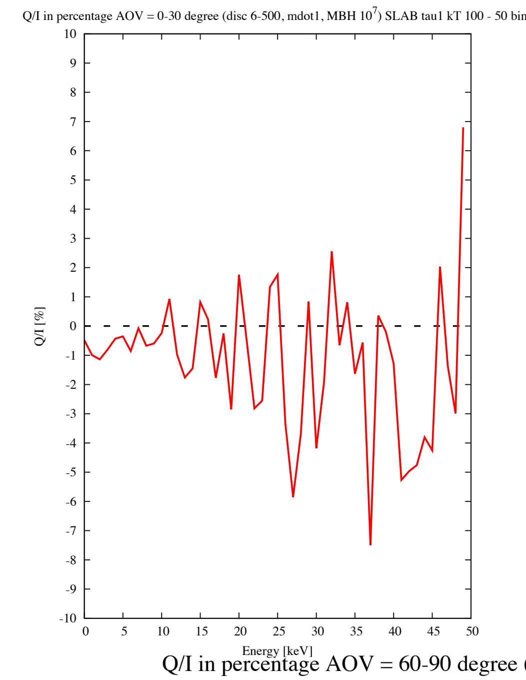

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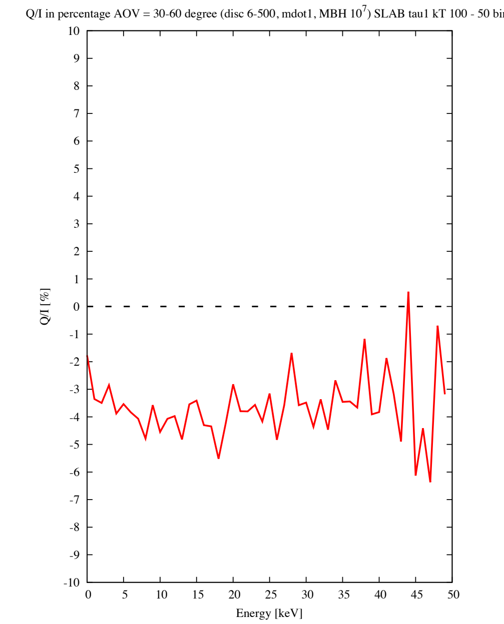
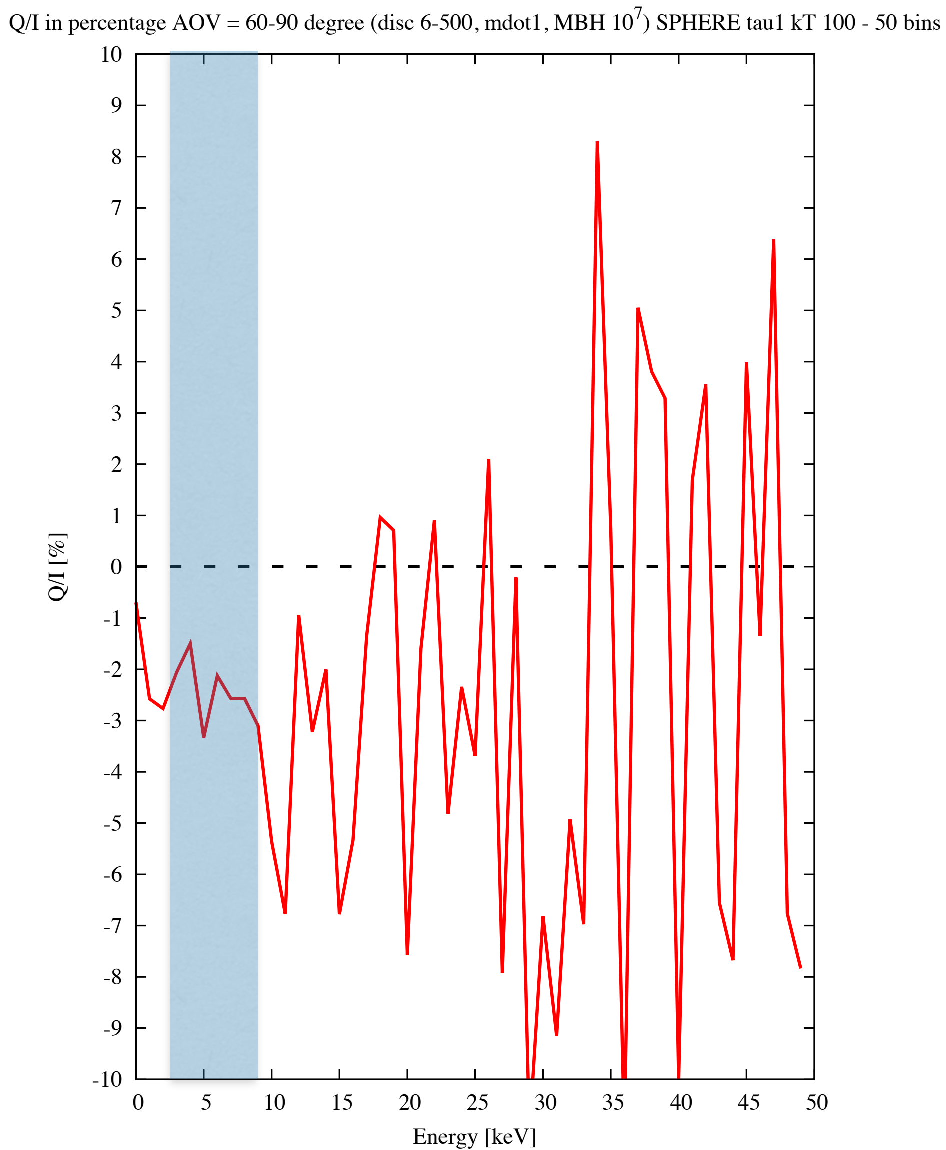
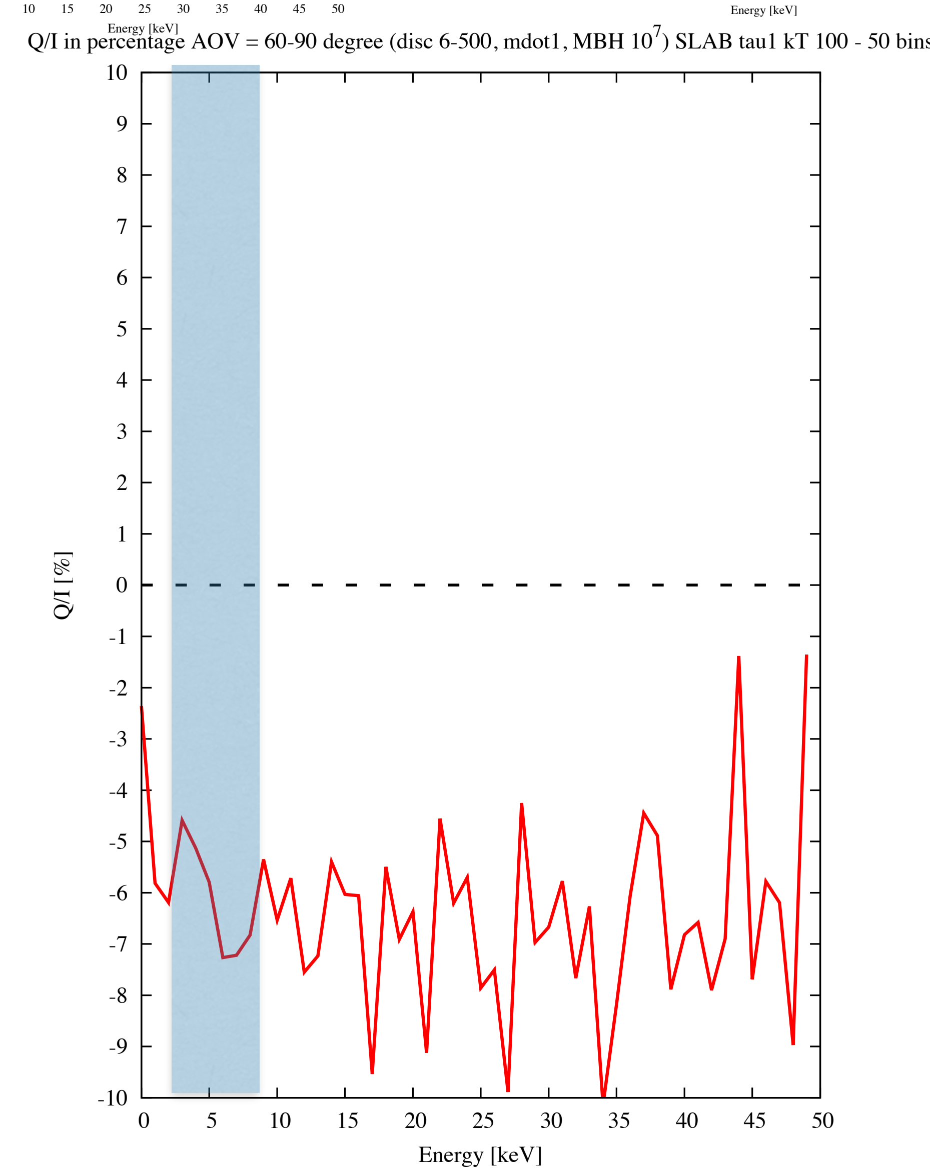




LOS = 60°-90°



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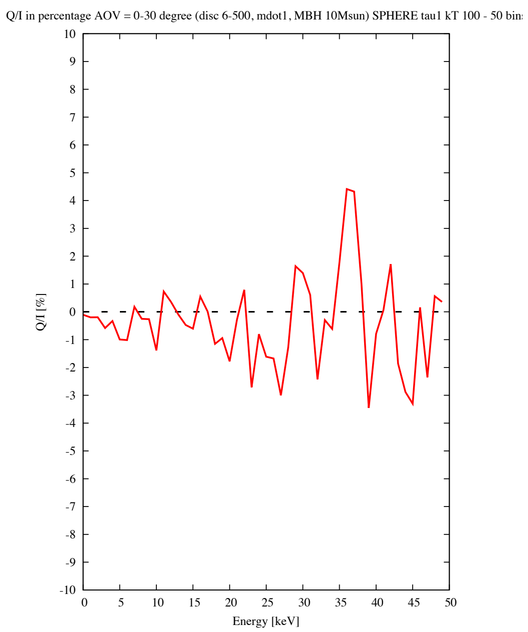
SLAB tau = 1, kT = 100 keV

BHB

LOS = 0°-30°



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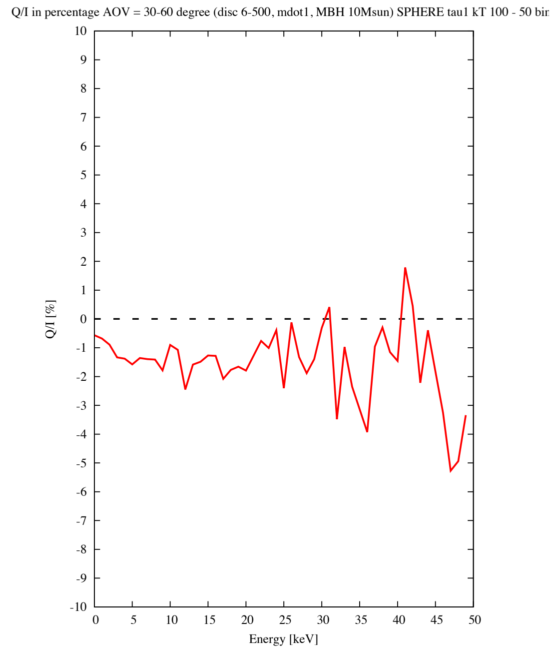
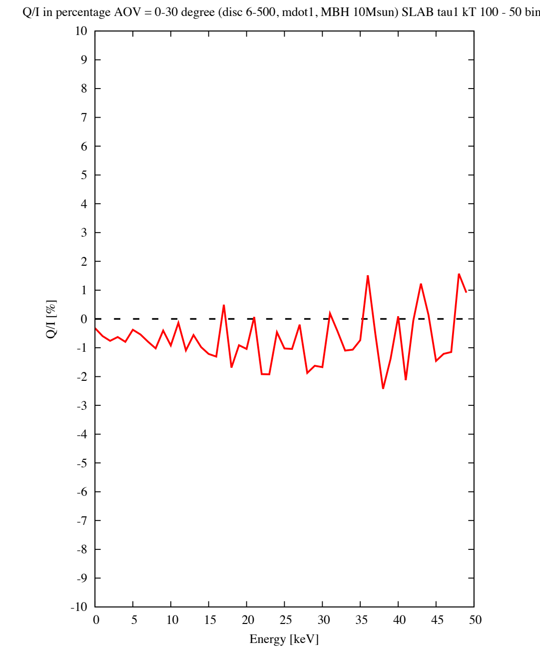


LOS = 0°-30°



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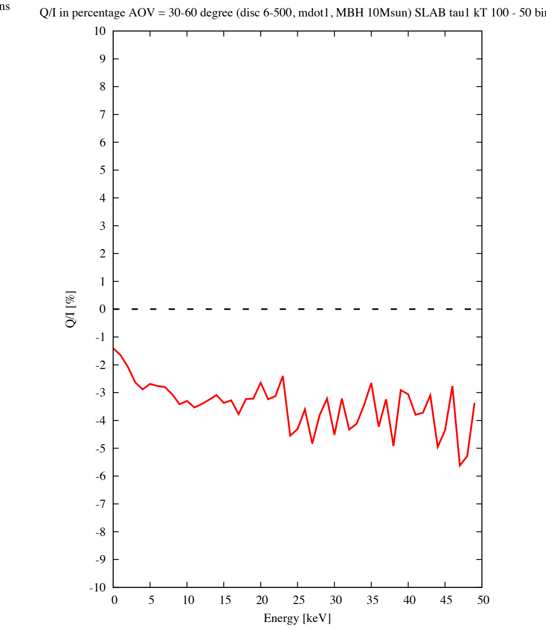

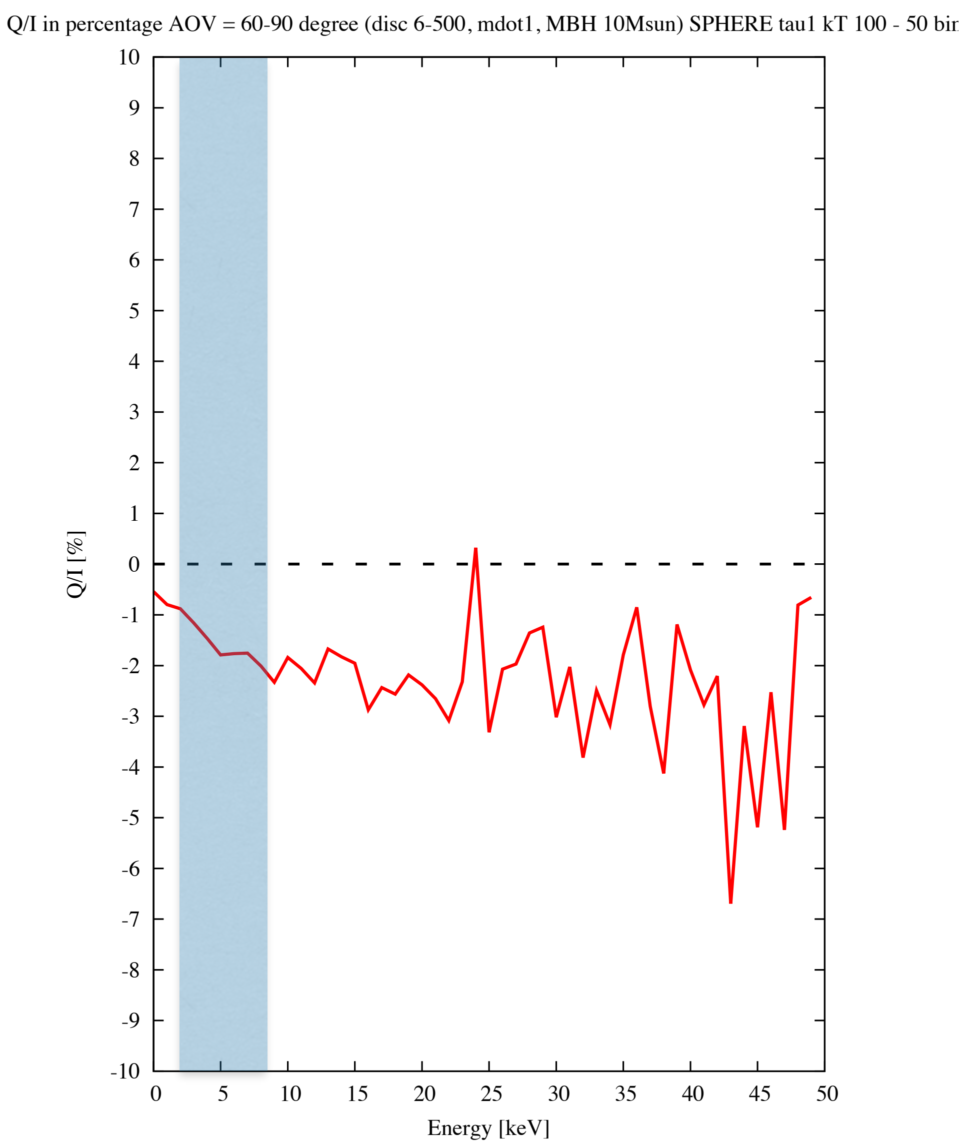

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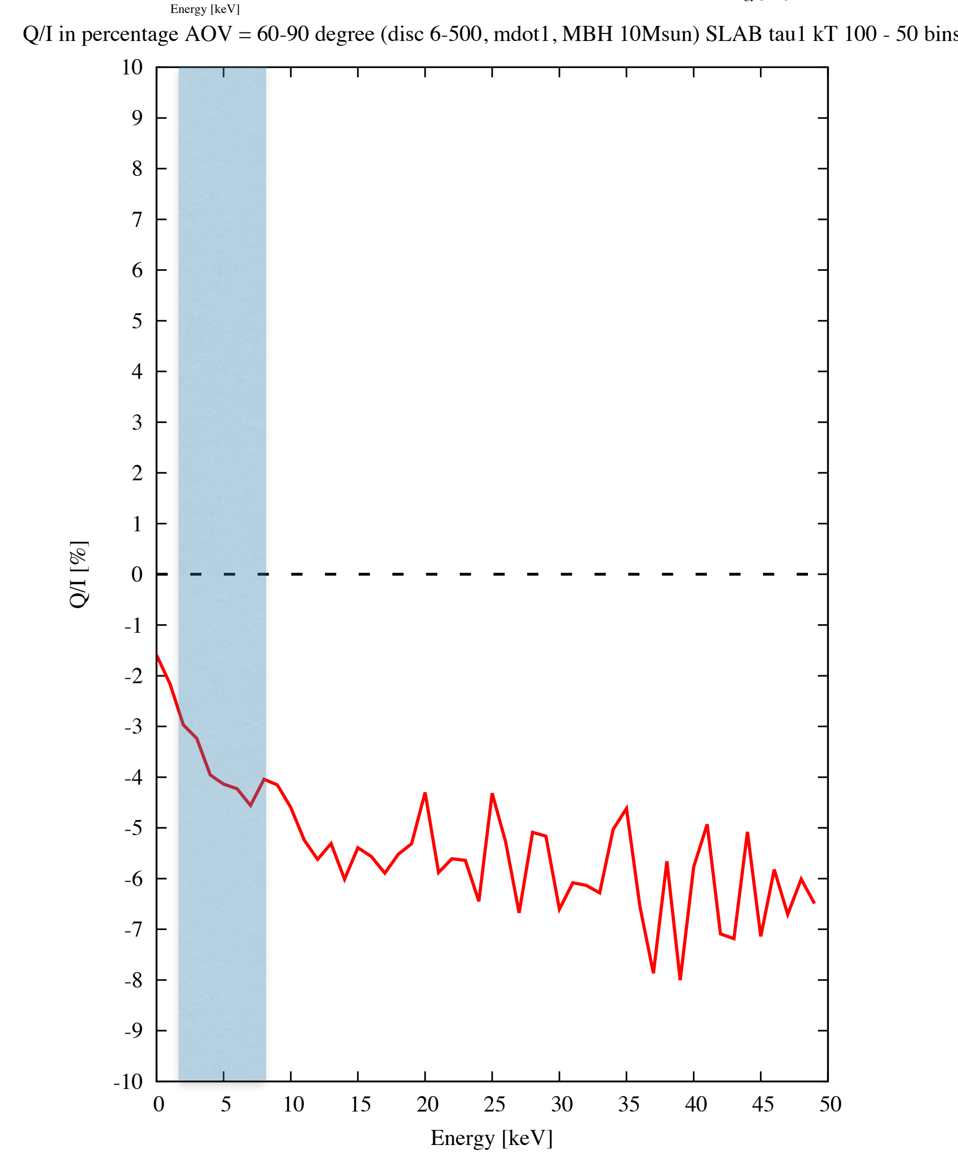

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BHB

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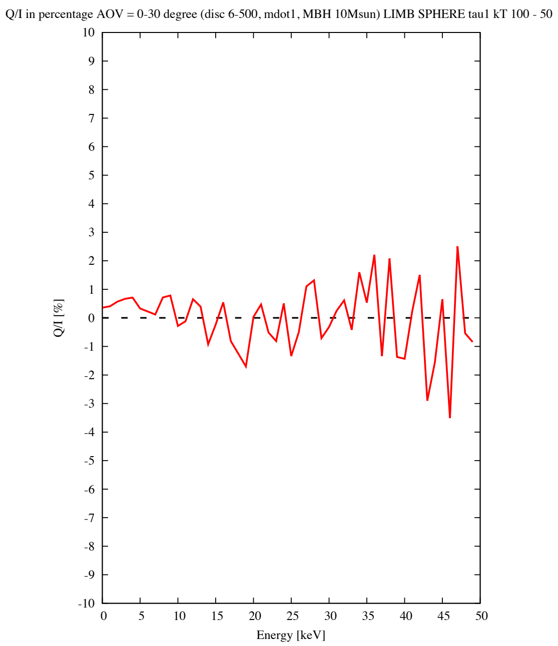
LIMB

LOS = 0°-30°



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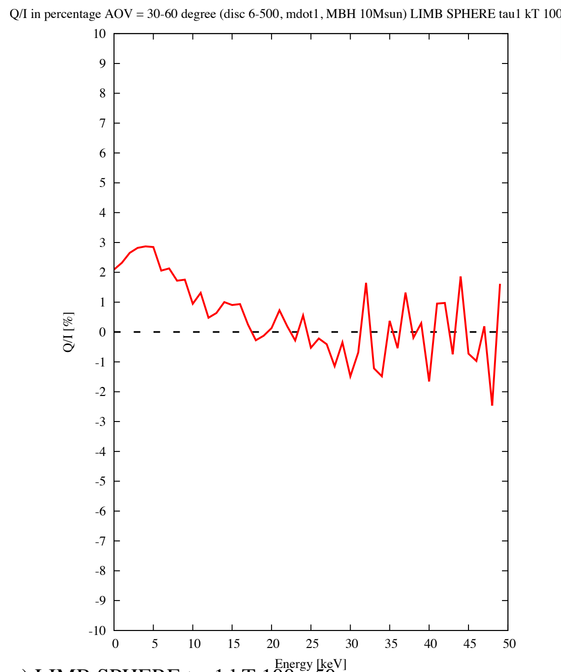

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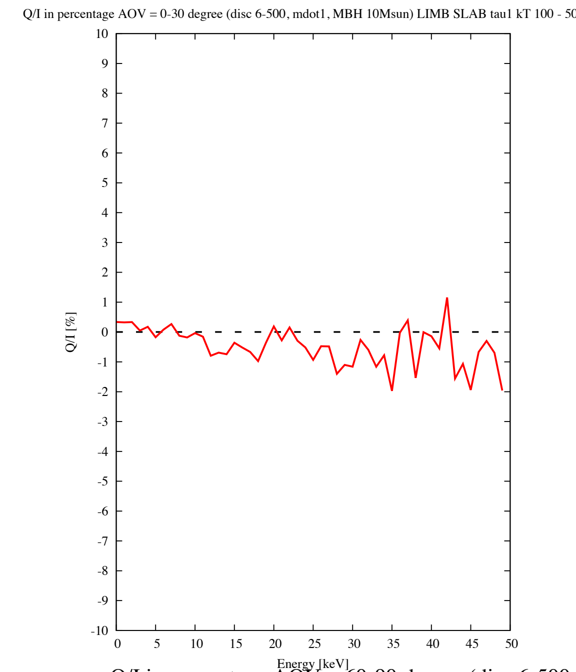

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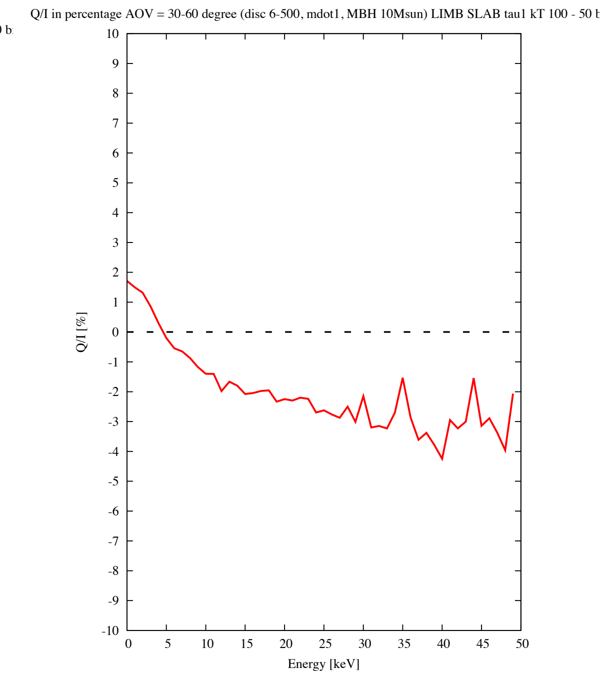

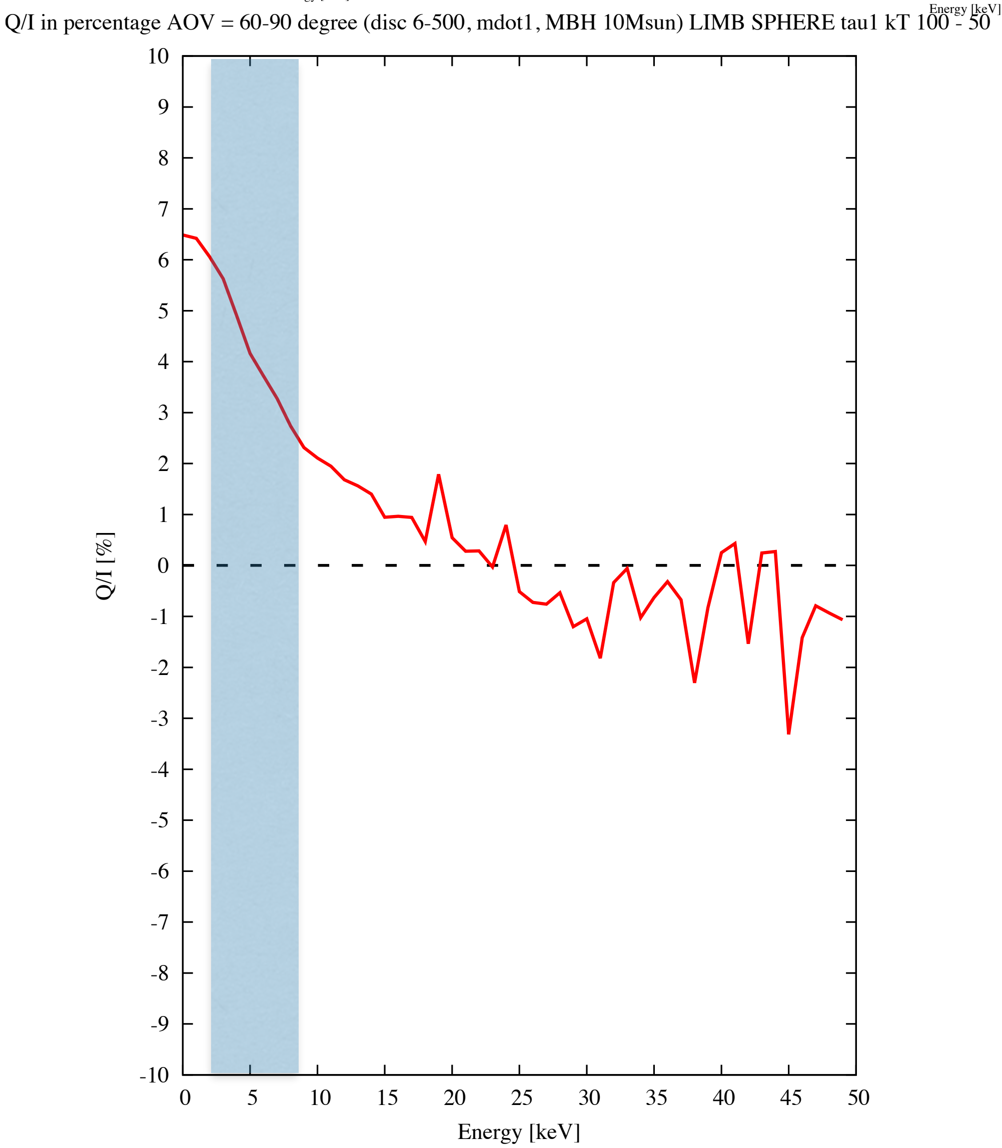

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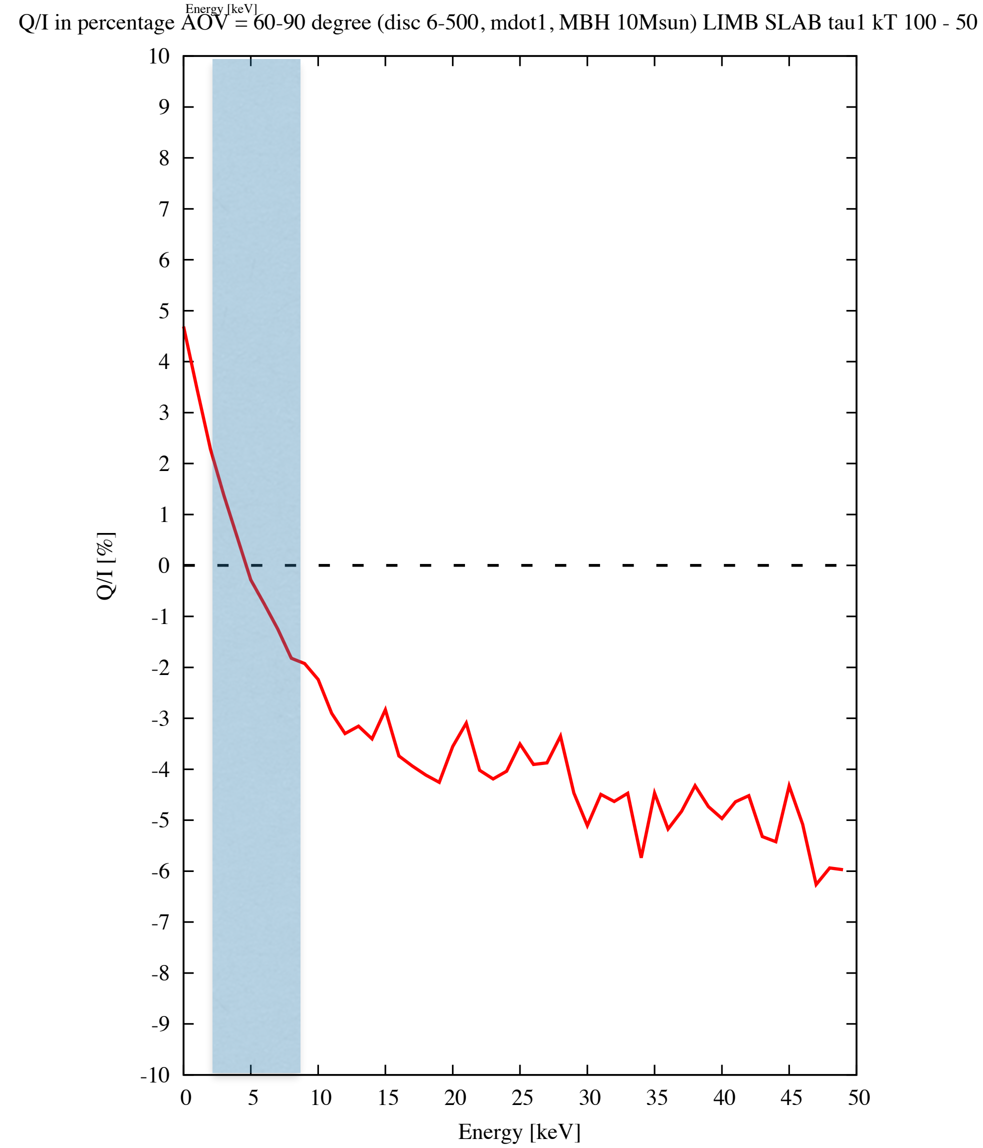
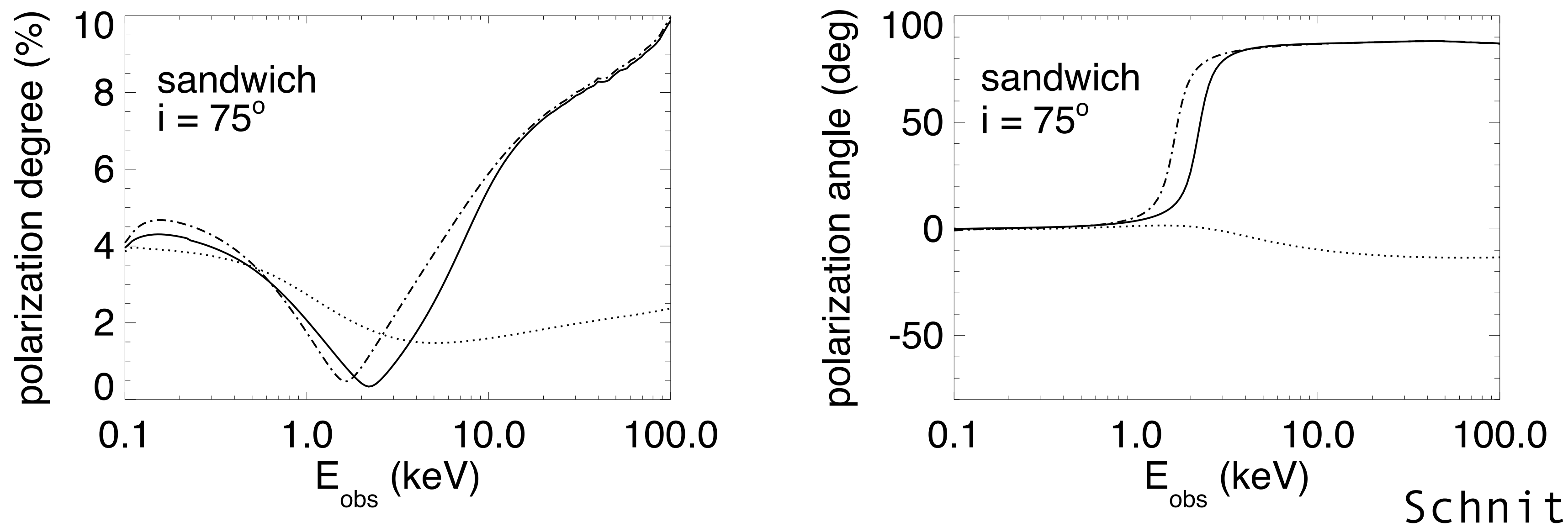
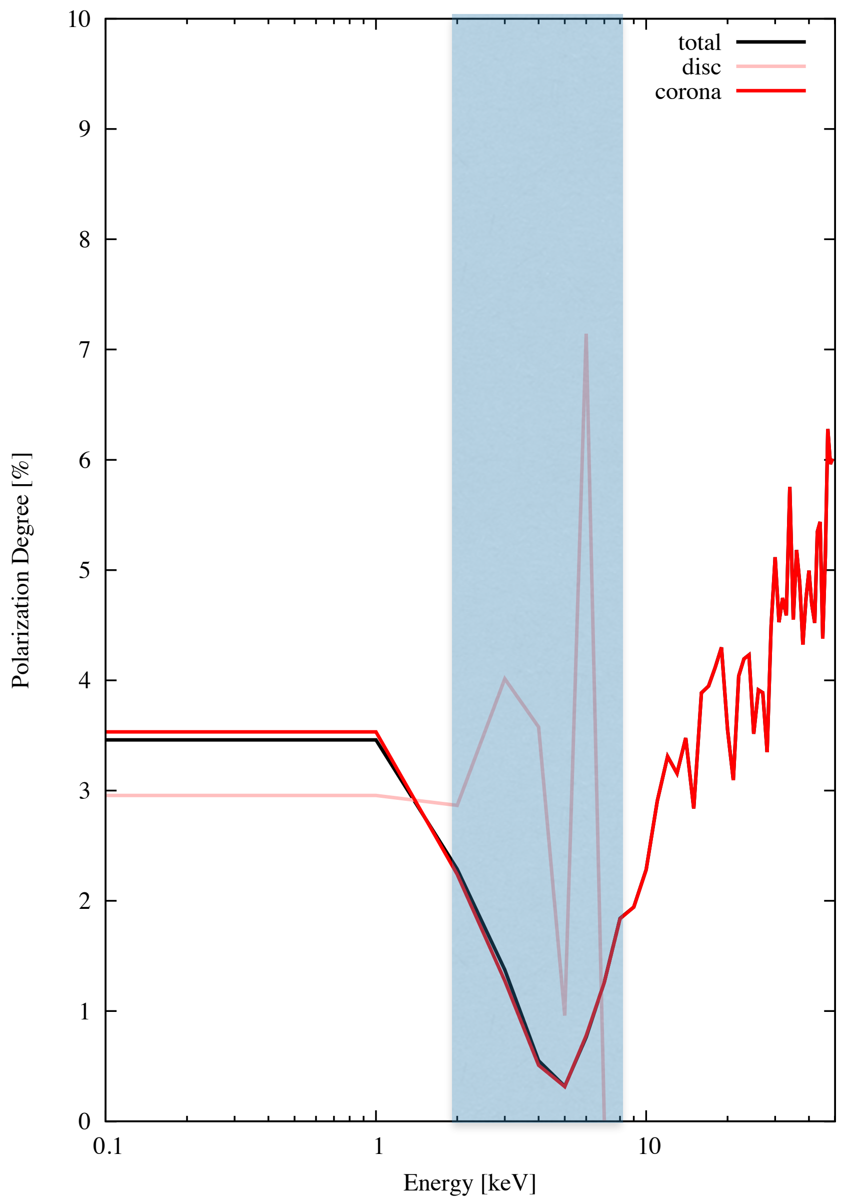


BHB 10 Msun - LIMB SLAB tau = 1, kT = 100 keV



Schnittman-Krolik 09

Polarization degree, AOV=60-90 degree (disc 6-500, mdot1, MBH 10Msun) SLAB LIMB tau1 kT 100 - 50



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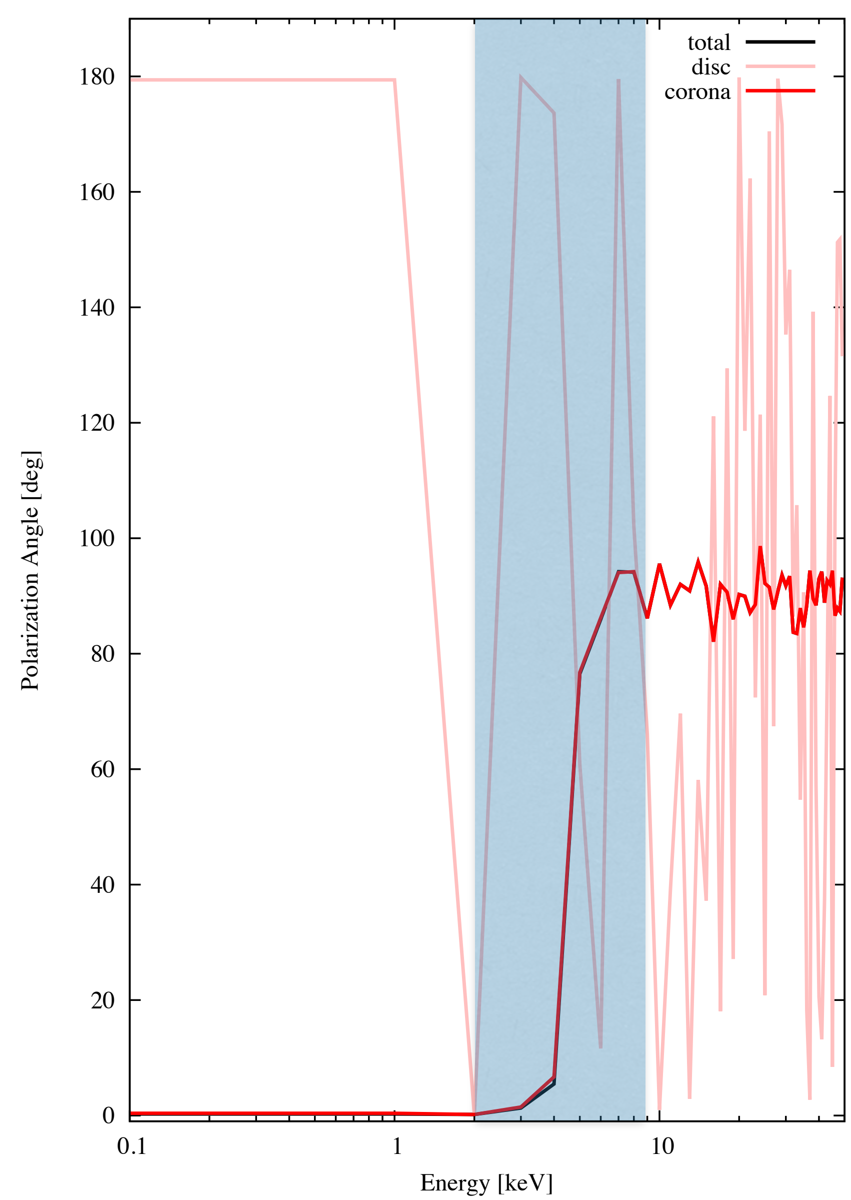

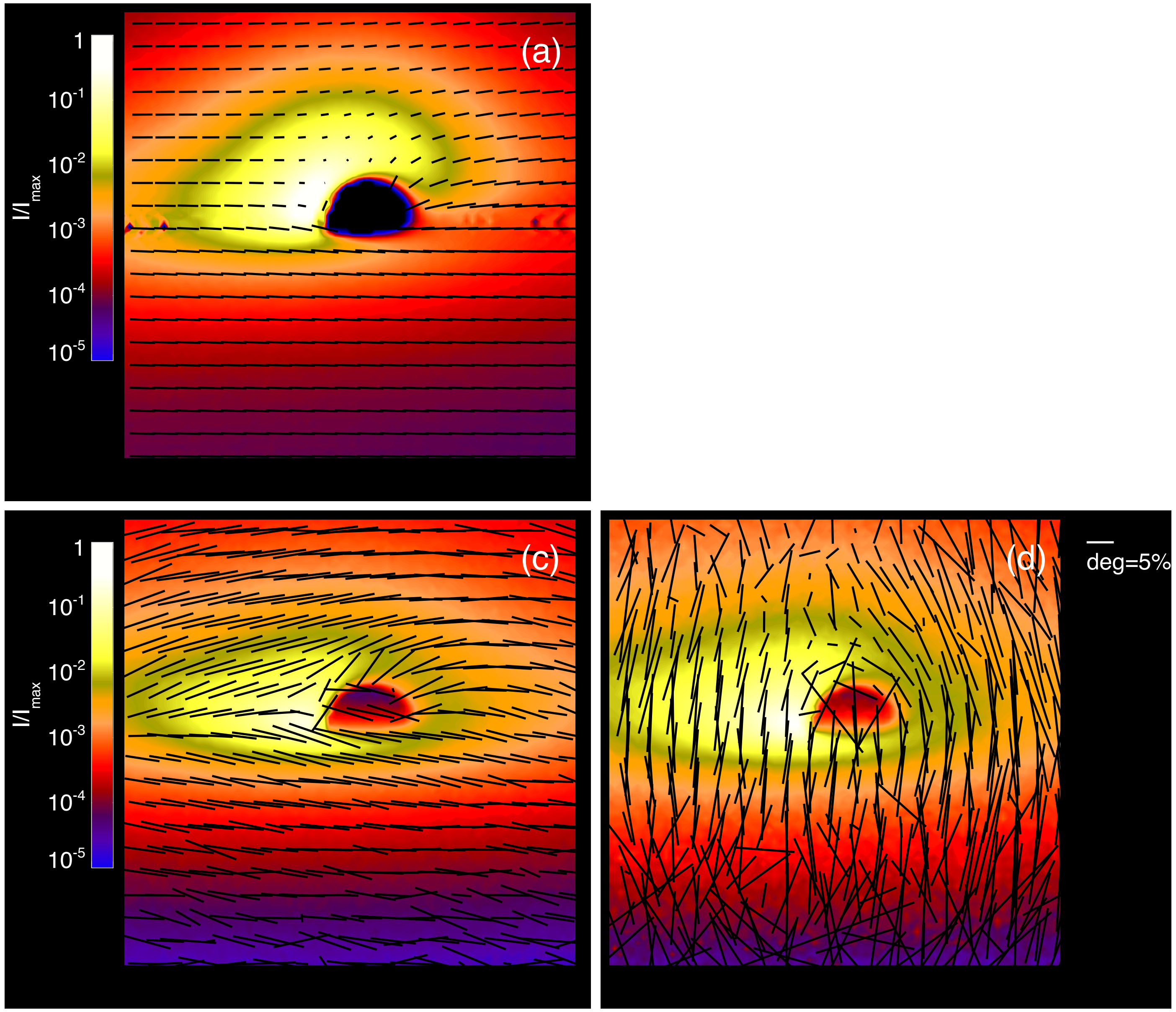

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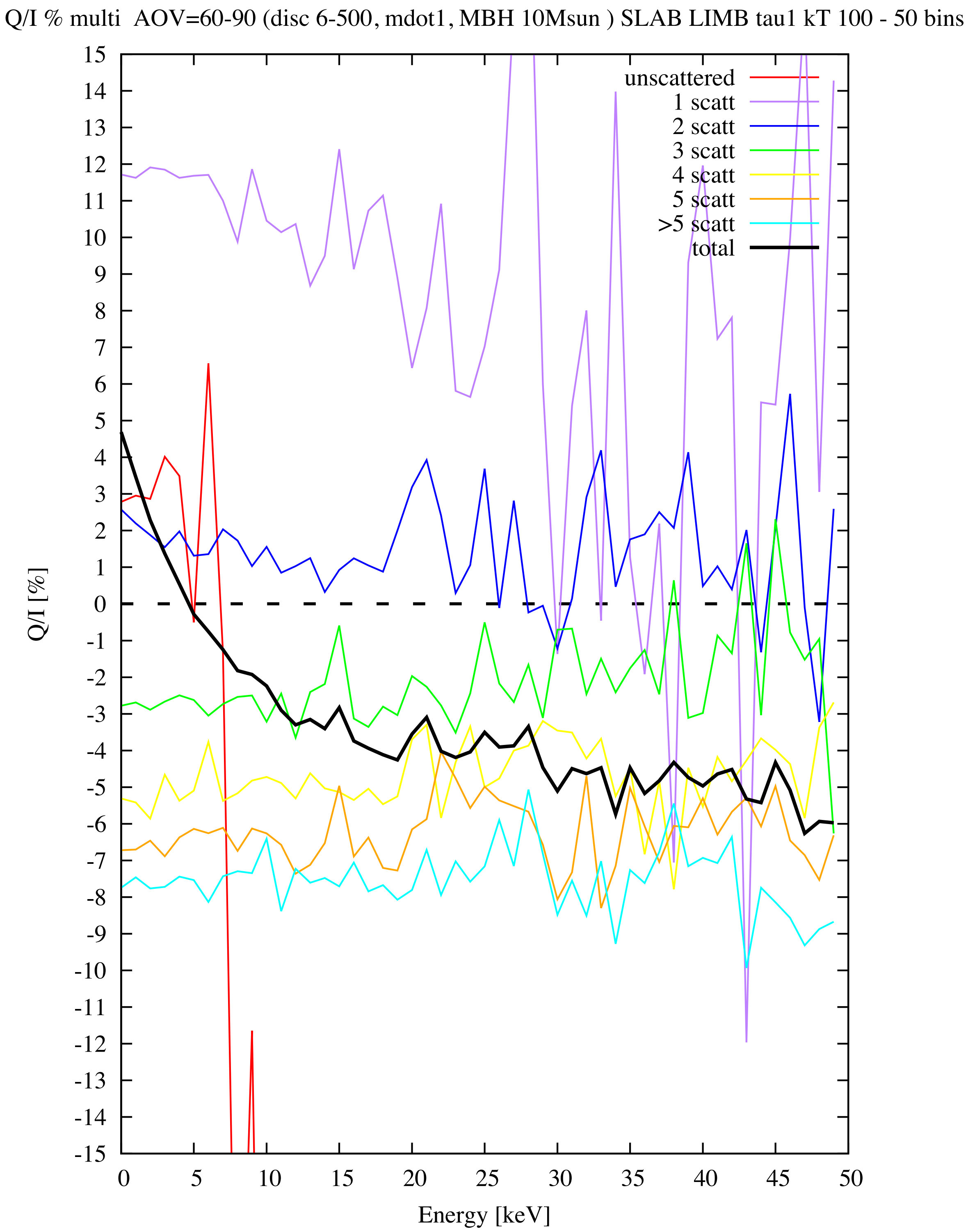
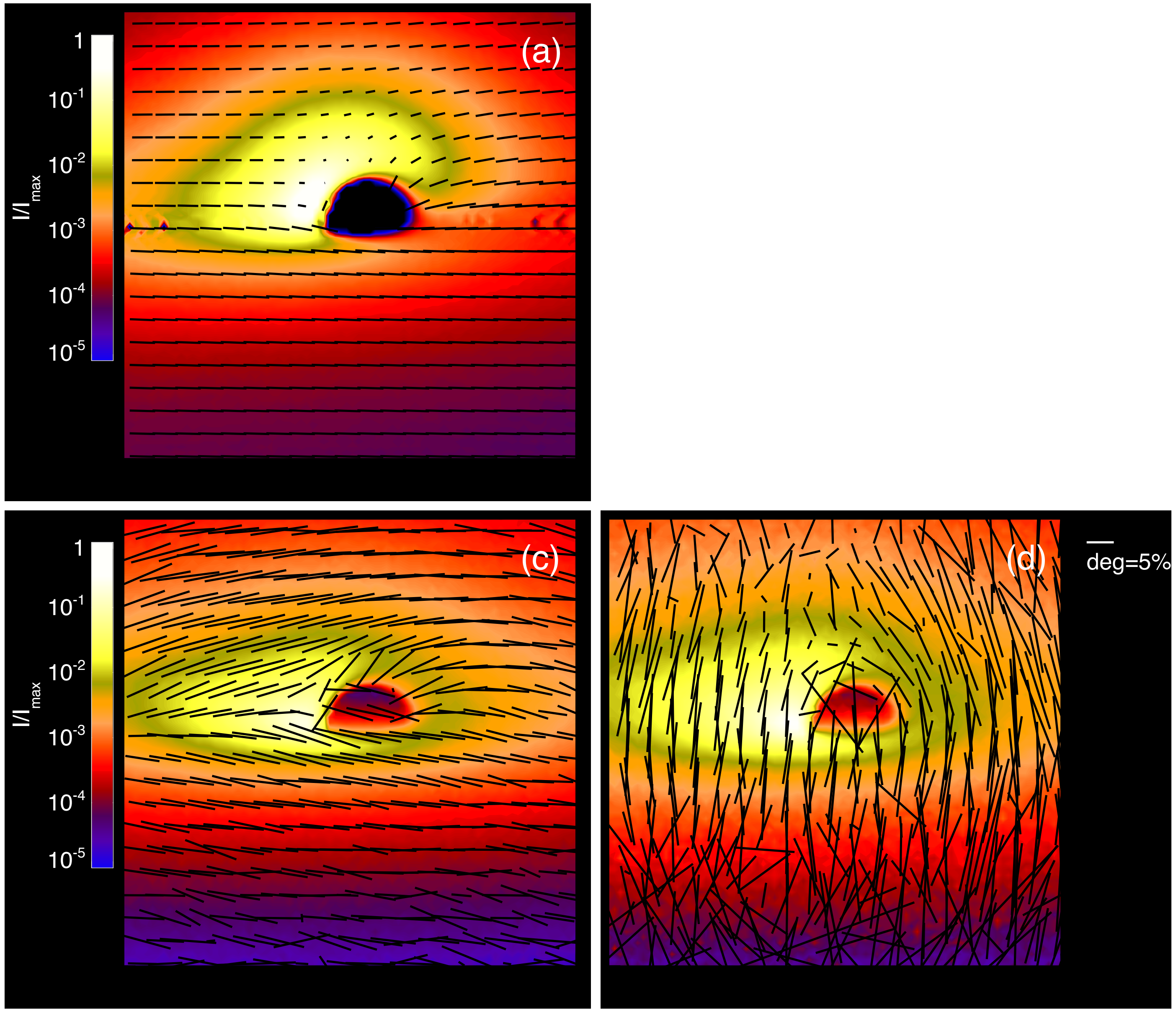
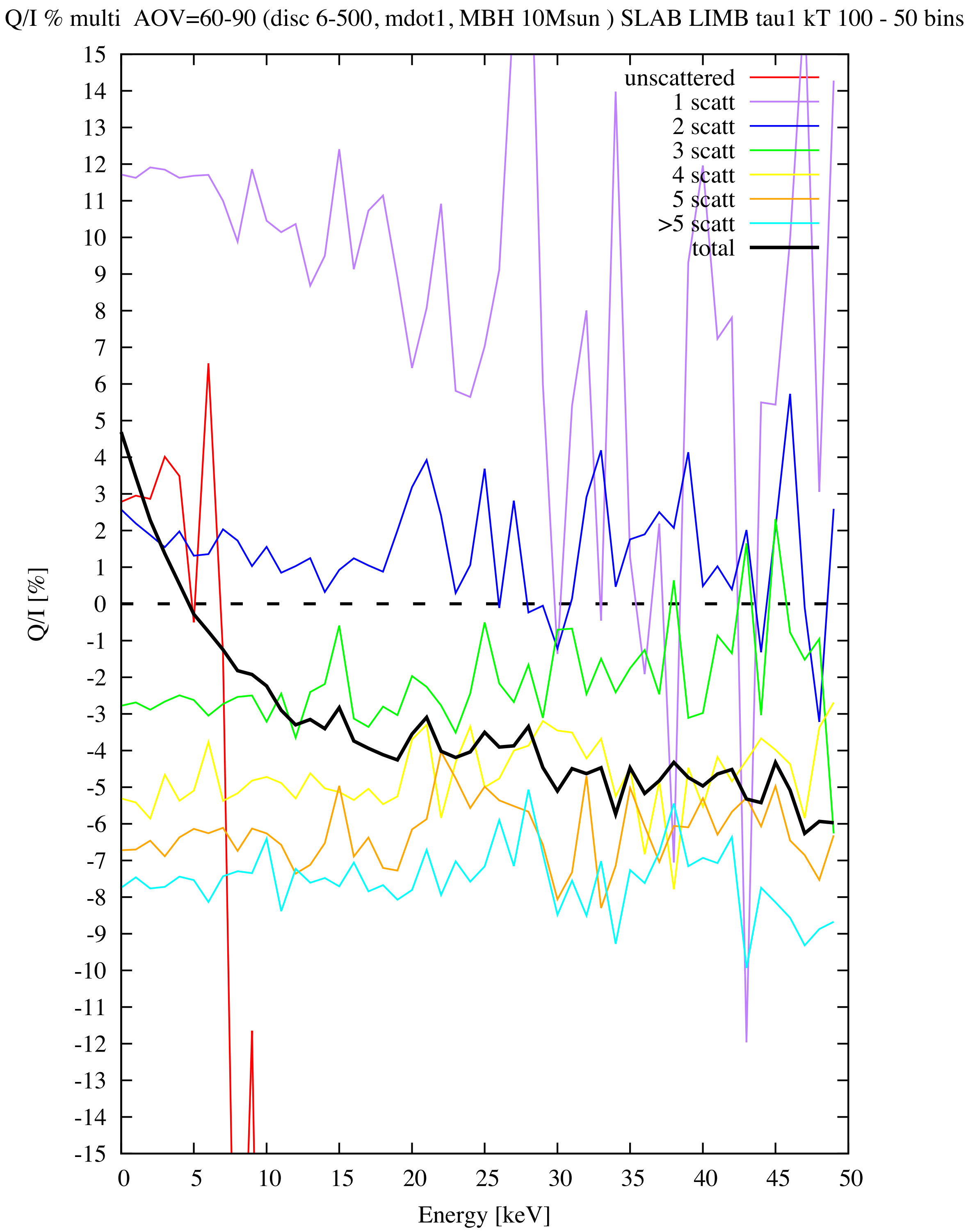
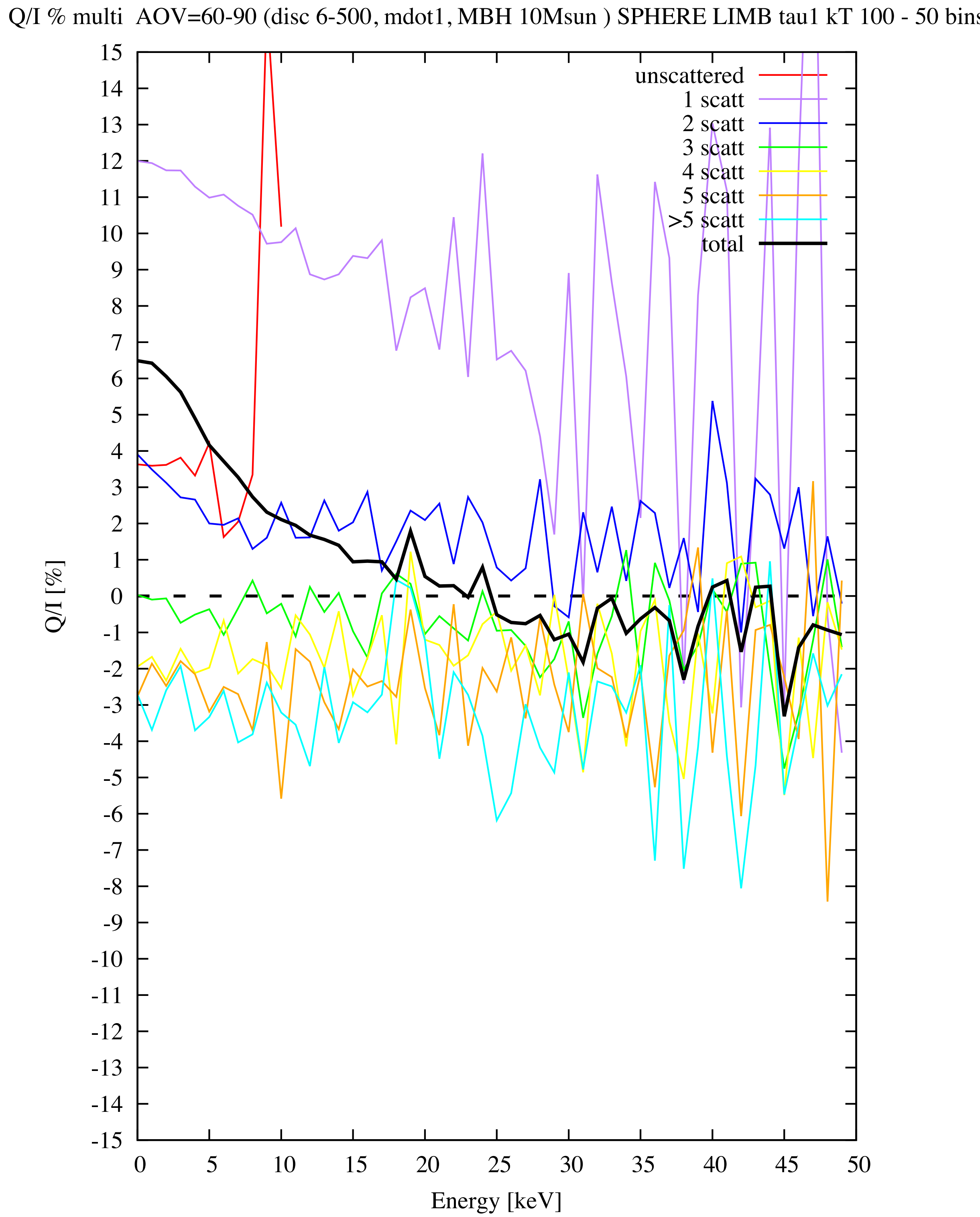




Schnittman-Krolik 09

BHB LIMB SLAB tau = 1, kT = 100 keV BHB LIMB SPHERE tau = 1, kT = 100 keV





CONCLUSIONS

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The intensity of the signal is an indicator of the “asphericity" of the scattering material and it can put constraints on the geometry of the corona.

For both AGN and BHBs the polarisation in the case of spherical corona do not exceed ~3% while for the slab it is ~7-8%

(see Alessia Tortosa et al. poster on NuStar sources!)

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For BHBs we can even see if the accretion disc is optically thick or not (by observing limb darkening polarisation) and, if it is the case and we are lucky enough to see the tilt in the PA, we can infer even more information on the disc (i.e.g. if it is truncated or it extends up to the ISCO).

And all of this was just for tau = 1!