X-ray polarization
as a tool to understand coronae in accreting sources

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collaborators:
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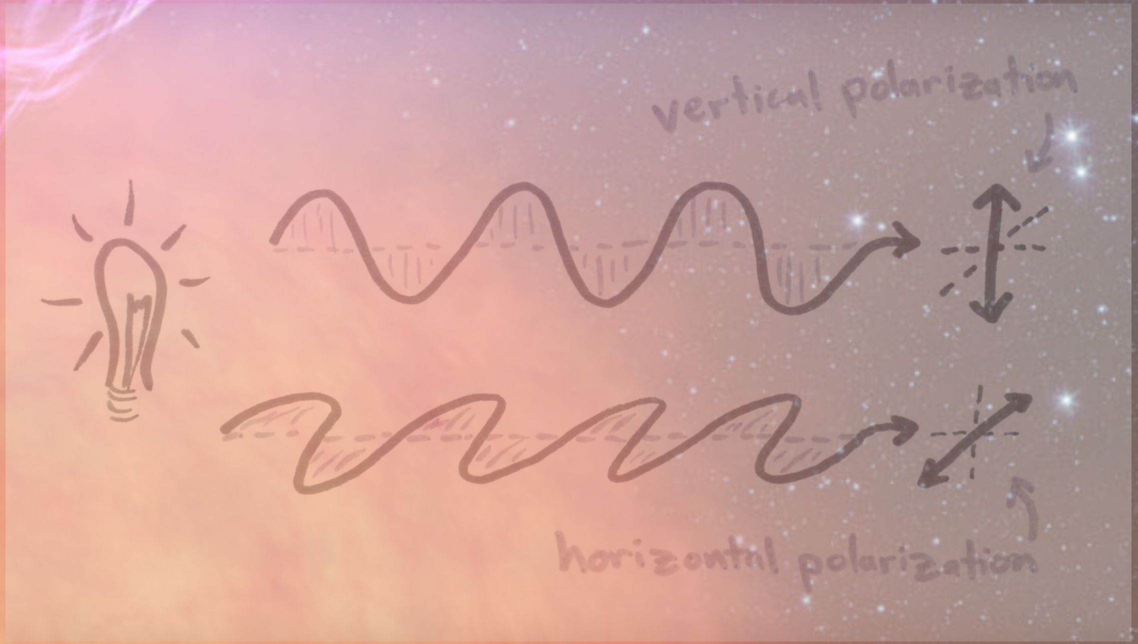

AXRO - International workshop on Astronomical X-Ray Optics - Prague, 7th/12/2017

STRONGGRAVITY
EU FP7-SPACE research project 312789
2013 - 2017

Astronomický ústav AV ČR
asu

An extremely brief introduction

Accretion alone produce a MTBB peaked
at UV for SMBH and soft X-rays for galactic BH

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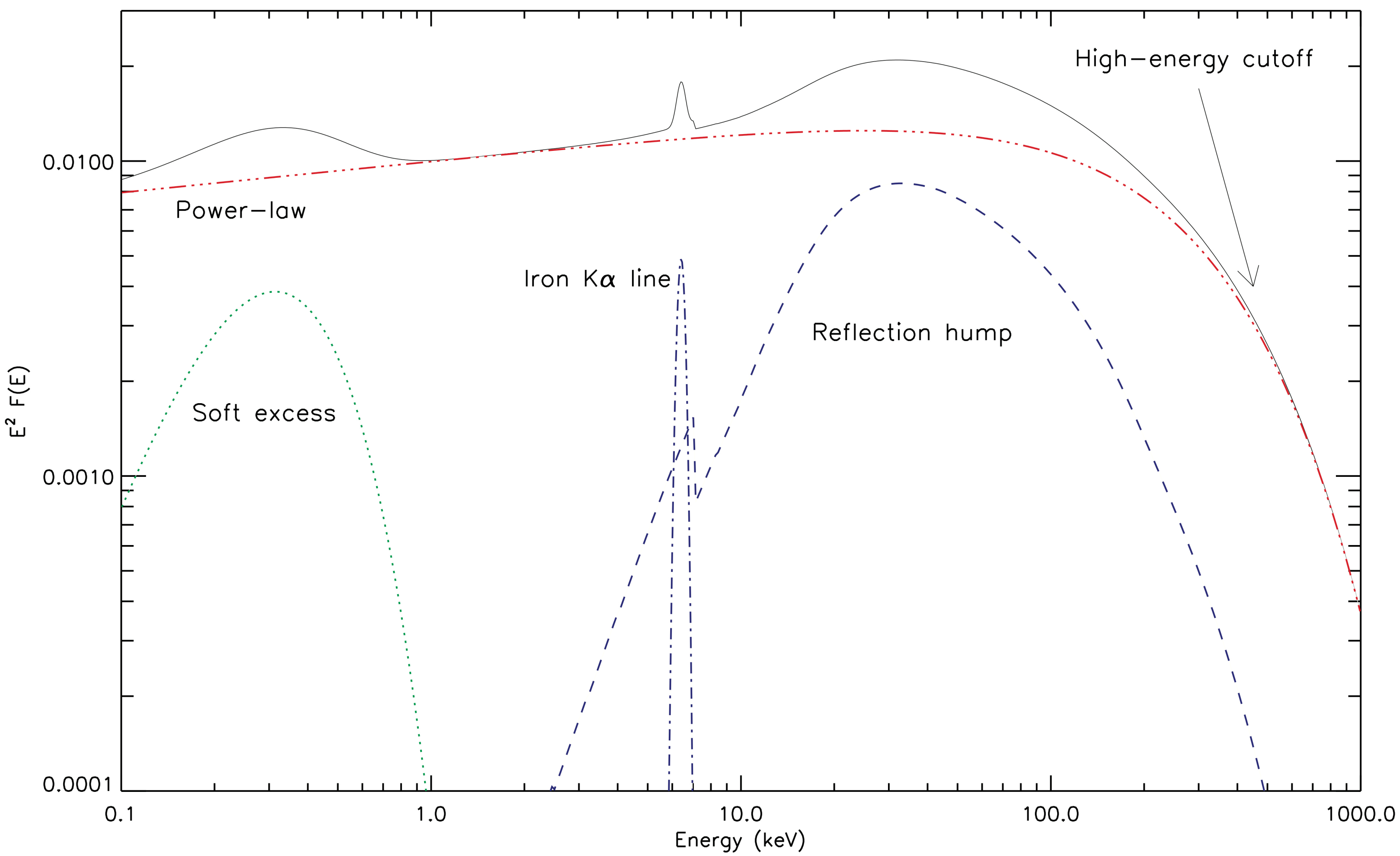

(from Ricci et al. 2011)

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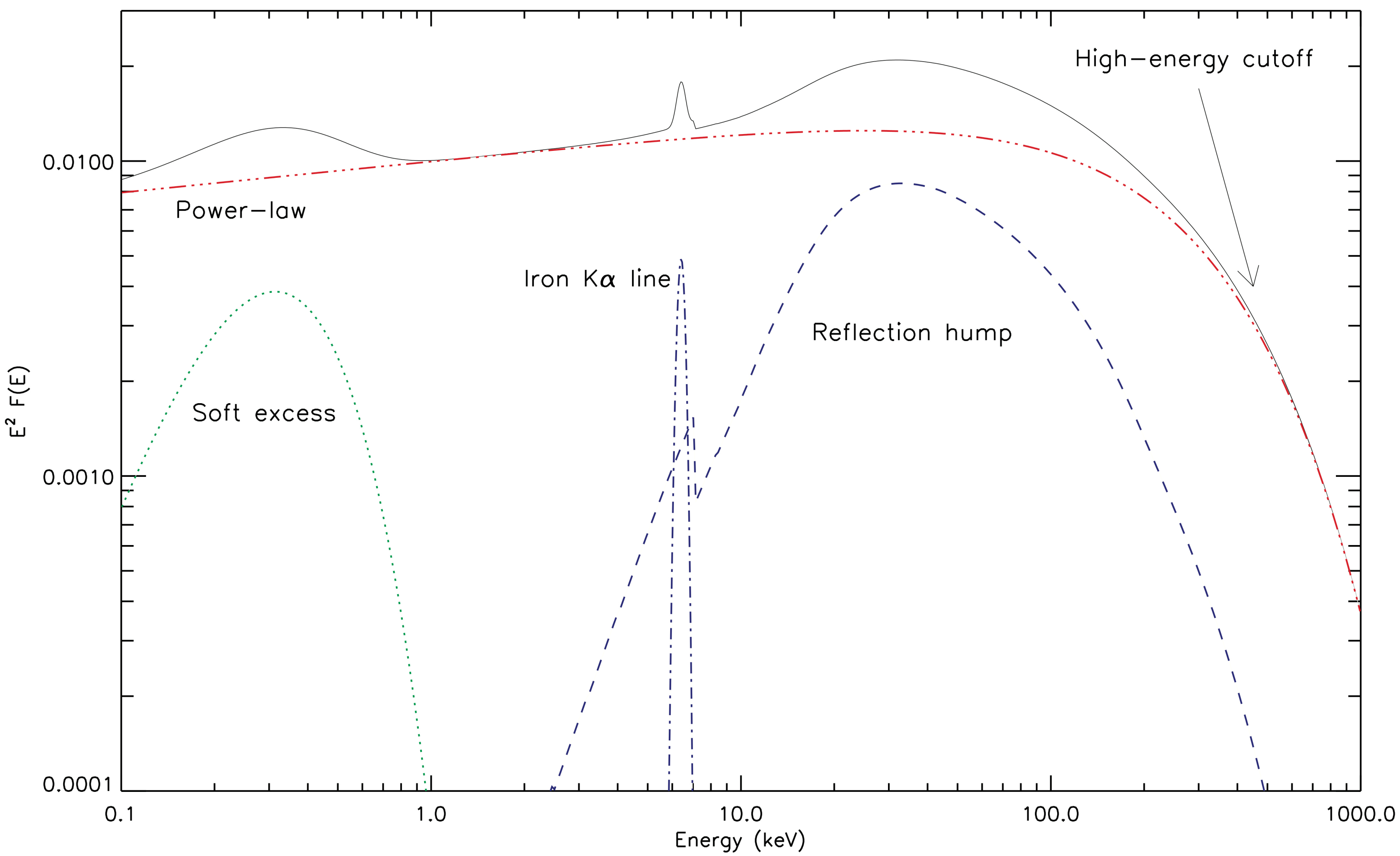

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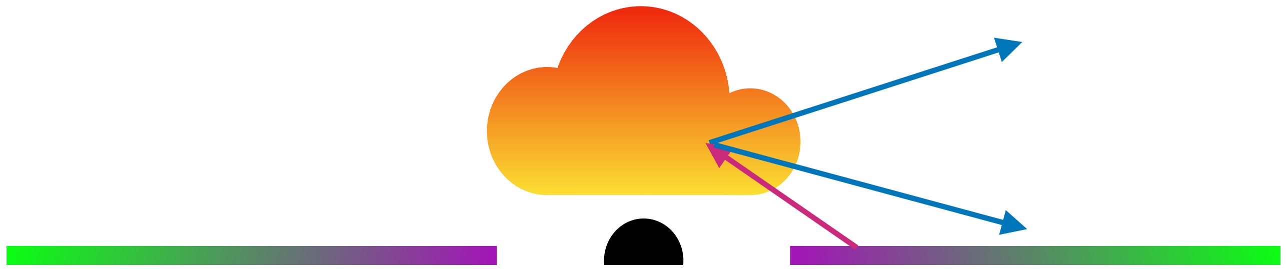

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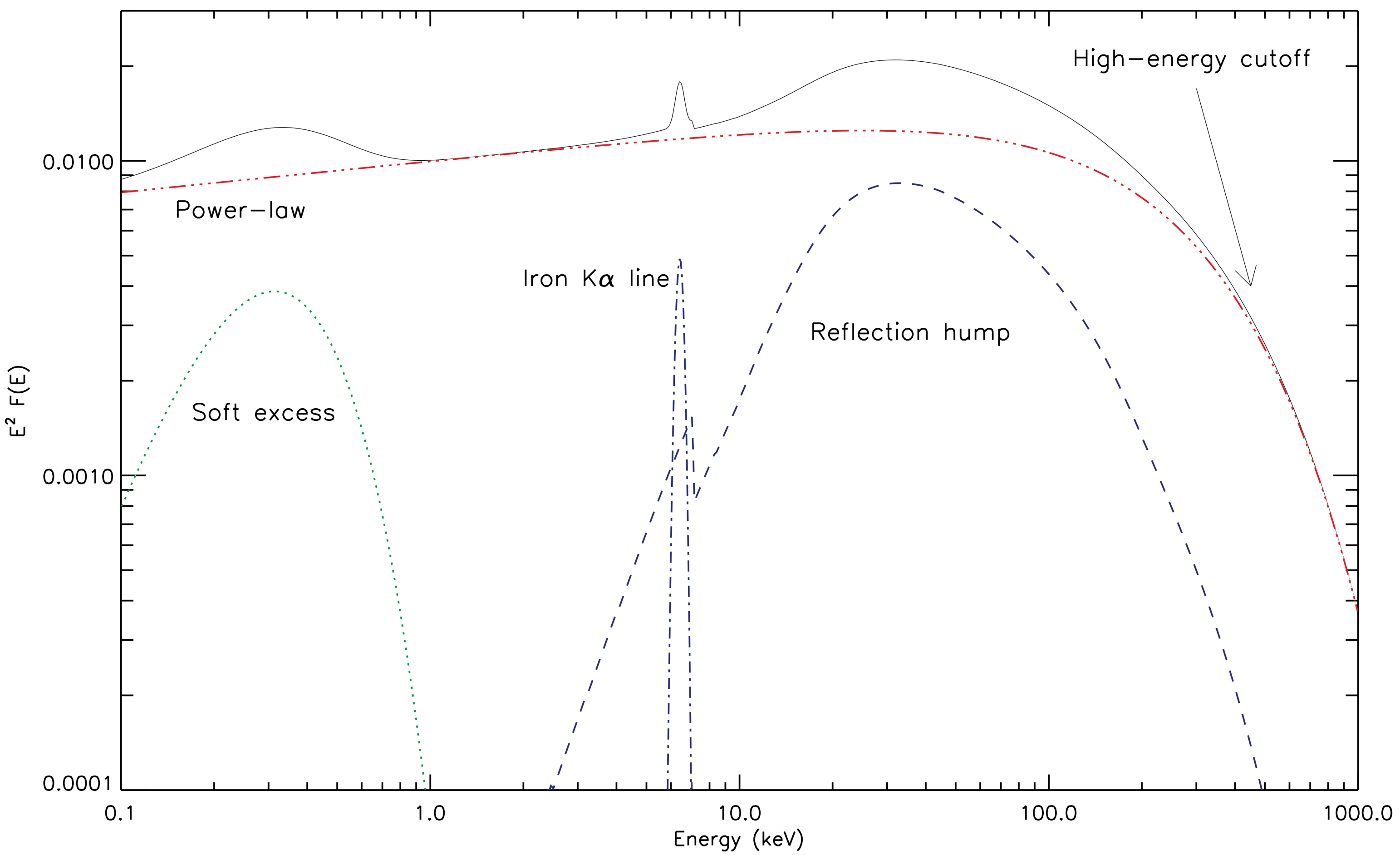

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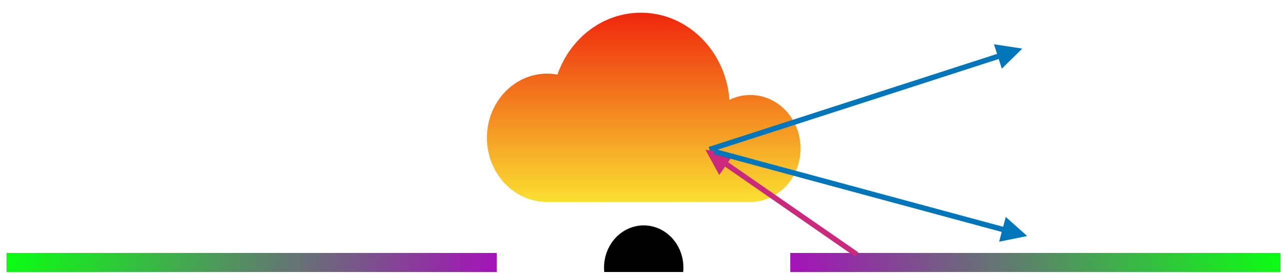

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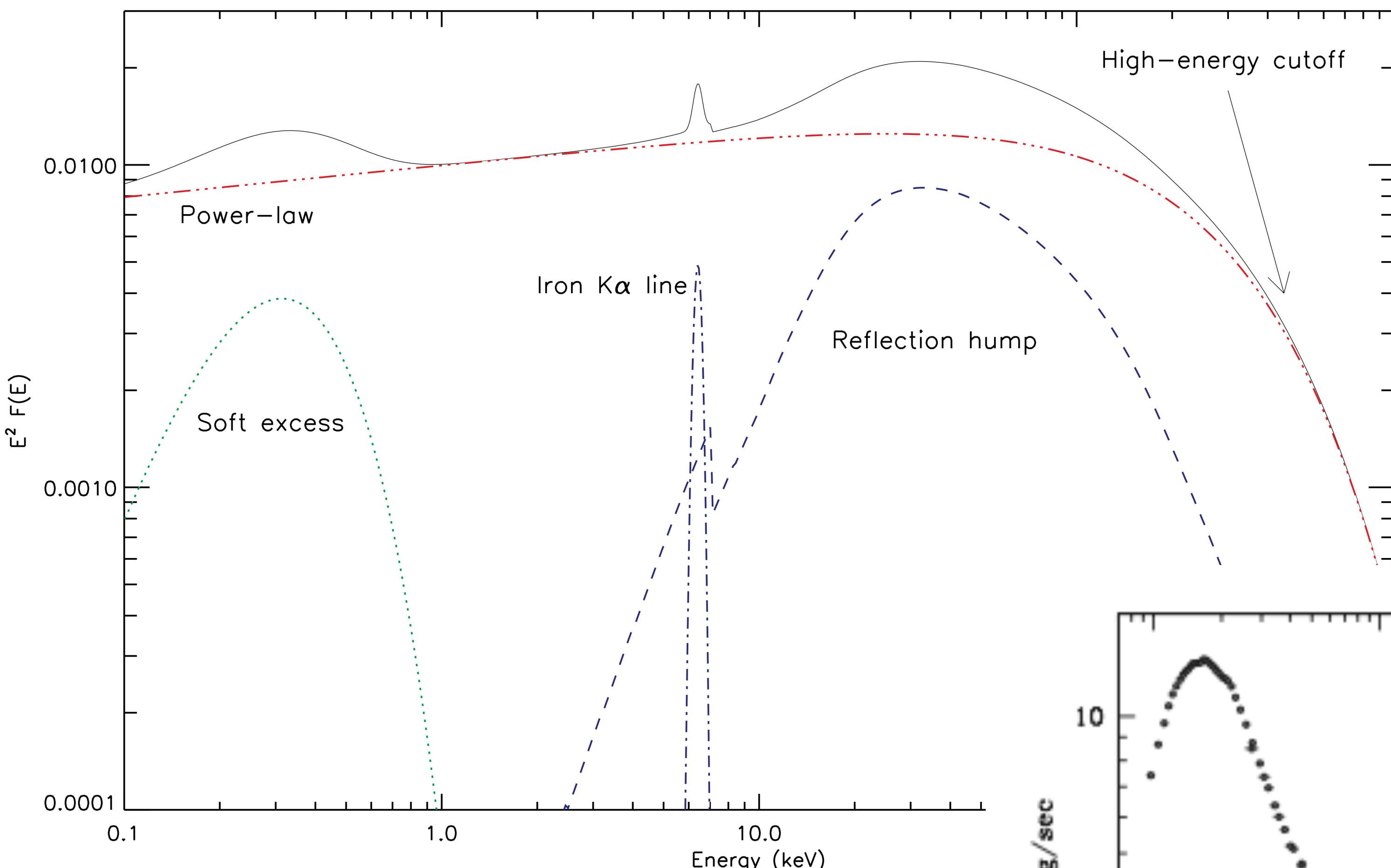

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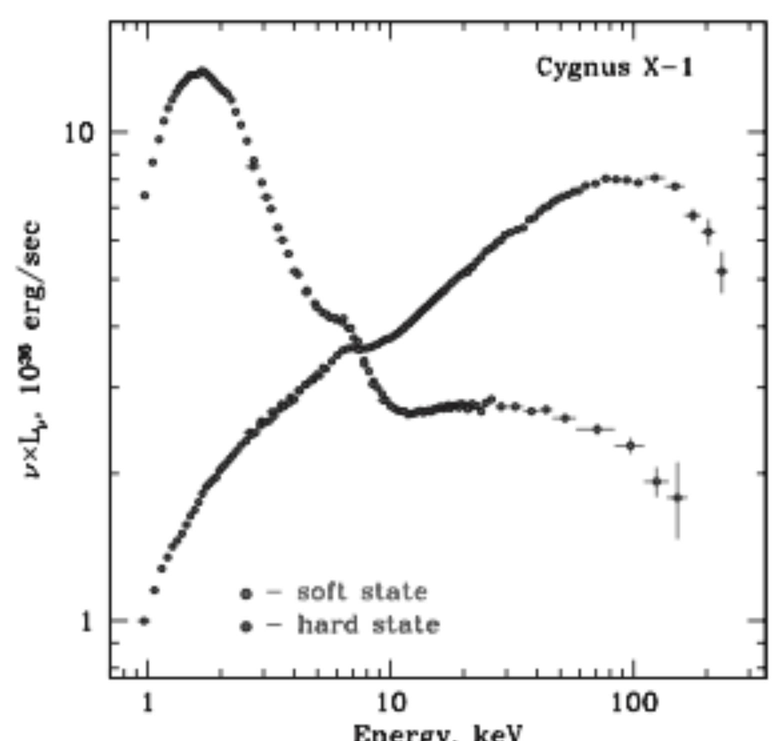
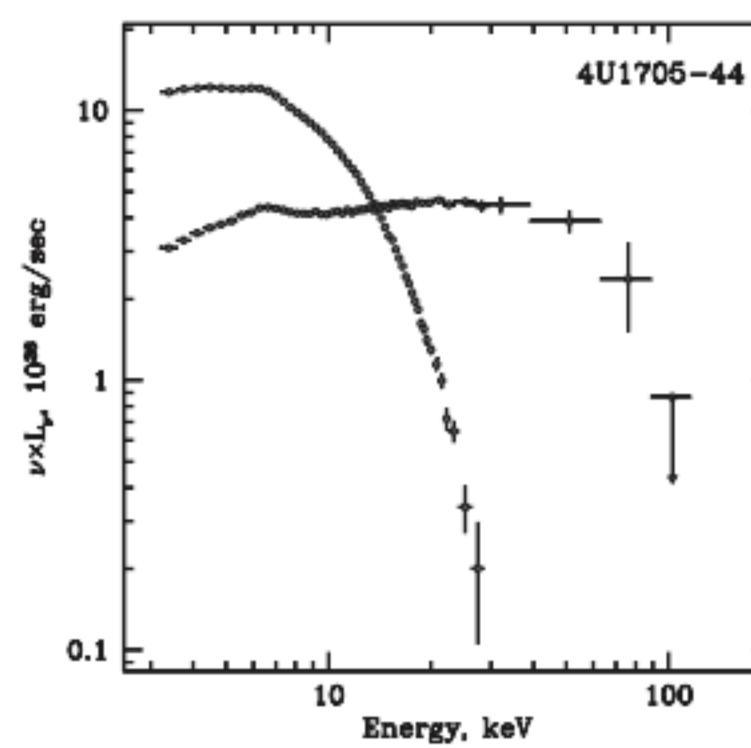




(from Gilfanov et al. 2000)

MoCA in a nutshell

MoCA: a Monte Carlo code for Comptonization in Astrophysics

- single-photon source-to-observer class (Fortran2003)

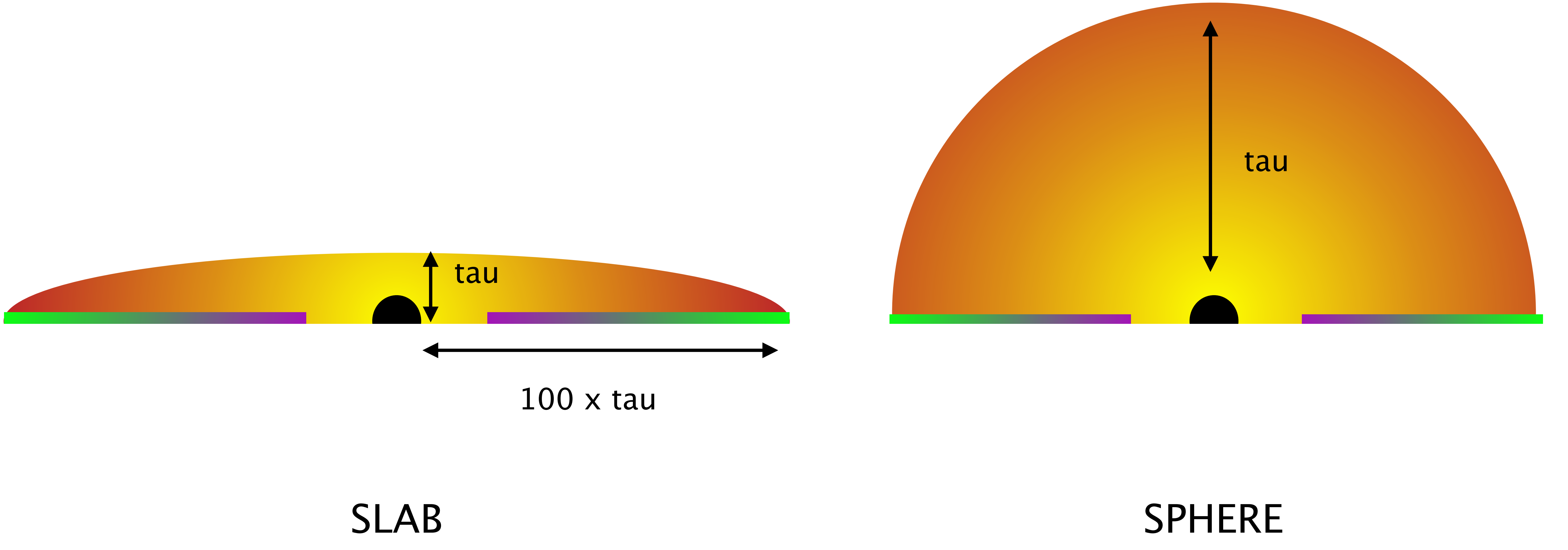
- complete special relativistic and quantum treatment of Comptonization
(Maxwell-Juttner distribution, KN cross-section & scattering angle distribution)

- complete GR description of the process
(N-T disk, ray-tracing (M.Bursa routine), parallel transport of P vector)

- parallelisation & interoperability with C

- modular and easily customisable

Geometries in this talk



source parameters

MBH = 10 Msun
mdot = 0.1 (Edd)

a = 0 / 0.998
limb darkening ON/OFF

corona parameters

kT = 100 keV

geometry SLAB/SPHERE
tau = 0.5/1/2

source parameters

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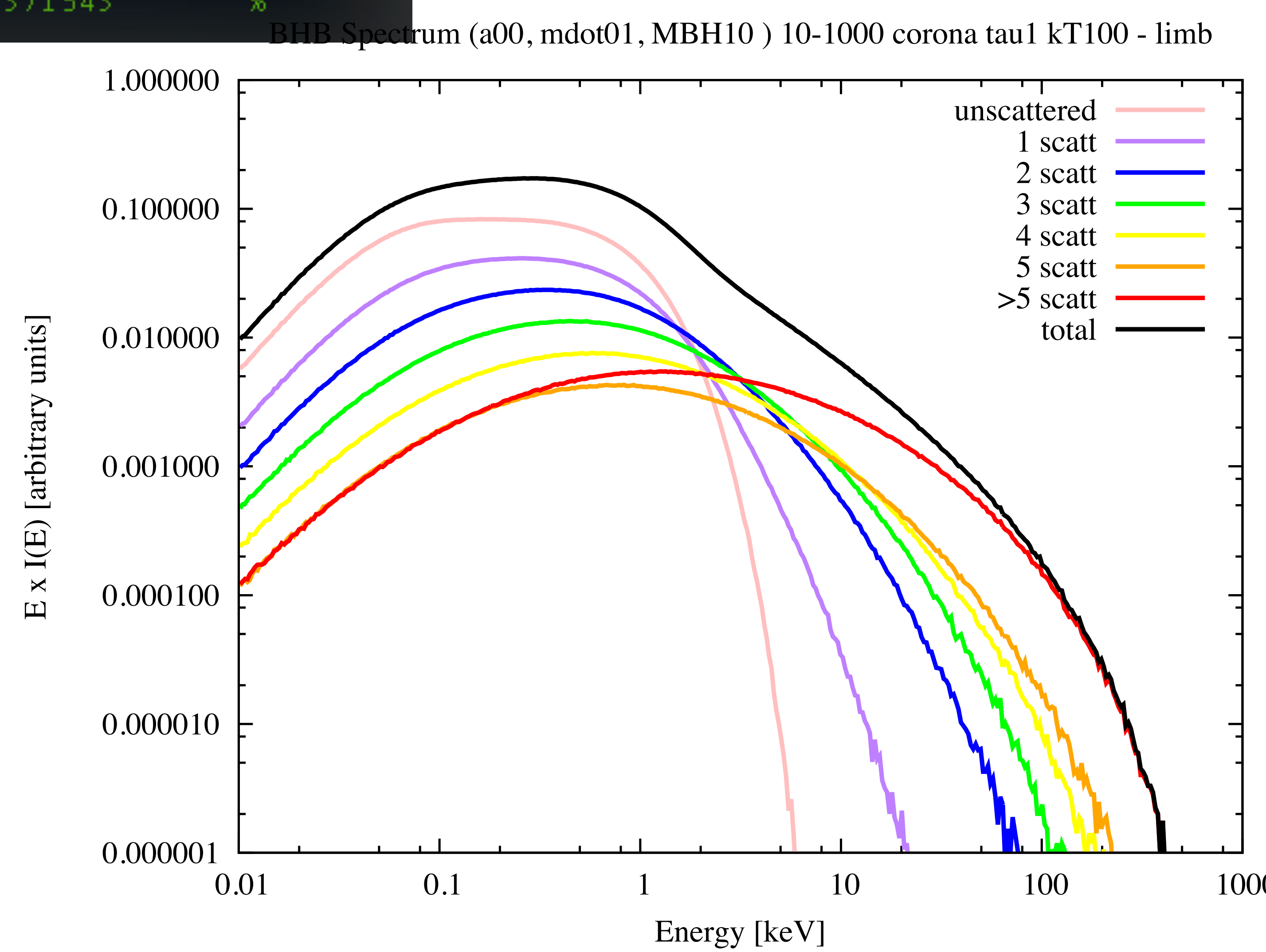
a = 0 / 0.998
limb darkening ON/OFF

corona parameters

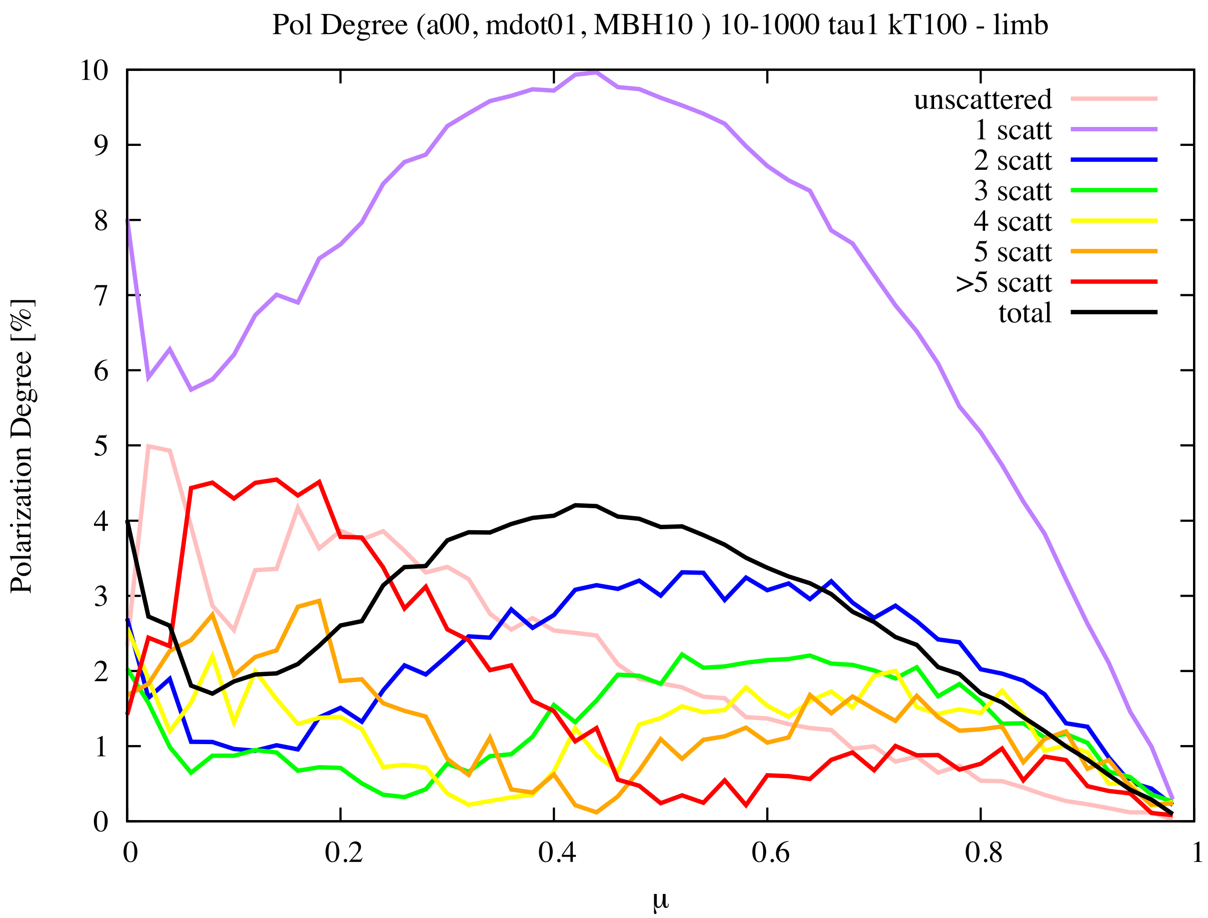
kT = 100 keV

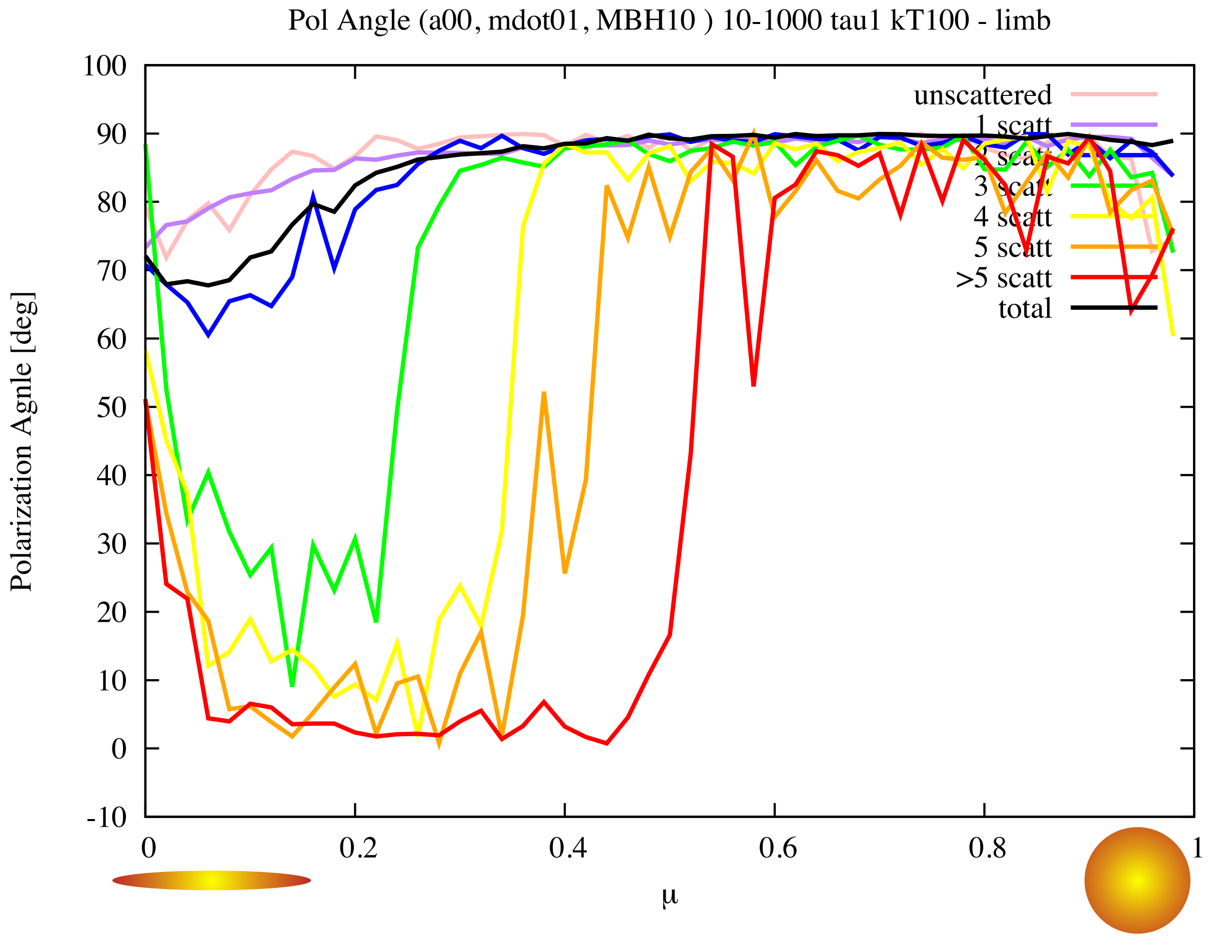
geometry SLAB/SPHERE
tau = 0.5/1/2

```
photons BH   =    0.0000000000000000       %
photons disc  =    40.079922177797634       %
photons escaped  =    59.920077822202366       %
    - photons escaped without scatterings =    45.703730106526983       %
    - photons escaped 1 scattering =    21.811584536367246       %
    - photons escaped 2 scattering =    13.132952453387409       %
    - photons escaped 3 scattering =    7.9157220790942784       %
    - photons escaped 4 scattering =    4.7218875253750205       %
    - photons escaped 5 scattering =    2.7920075188119124       %
    - photons escaped >5 scattering =    3.9221157804371543       %
```



a0 limb / SLAB tau1





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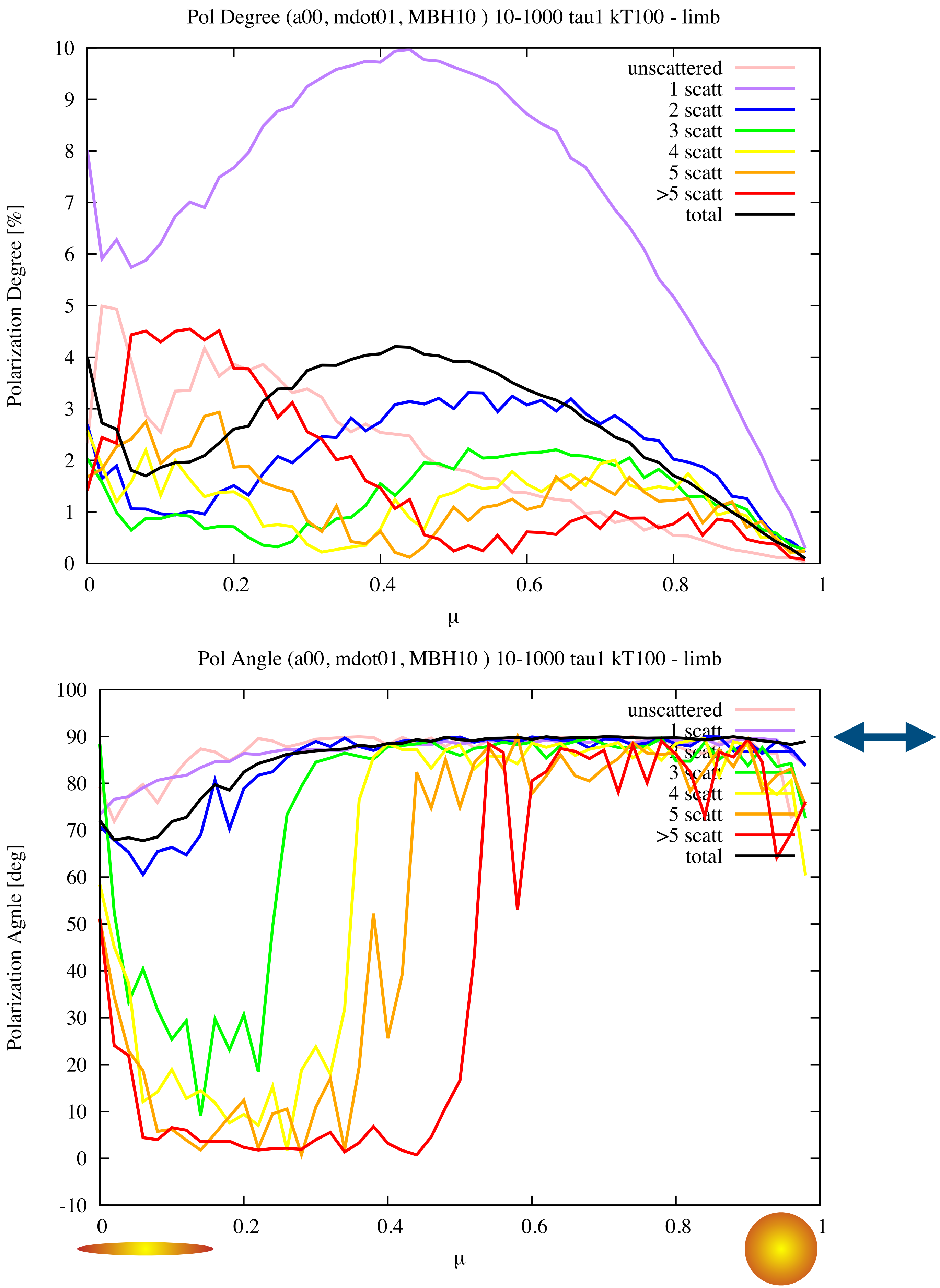
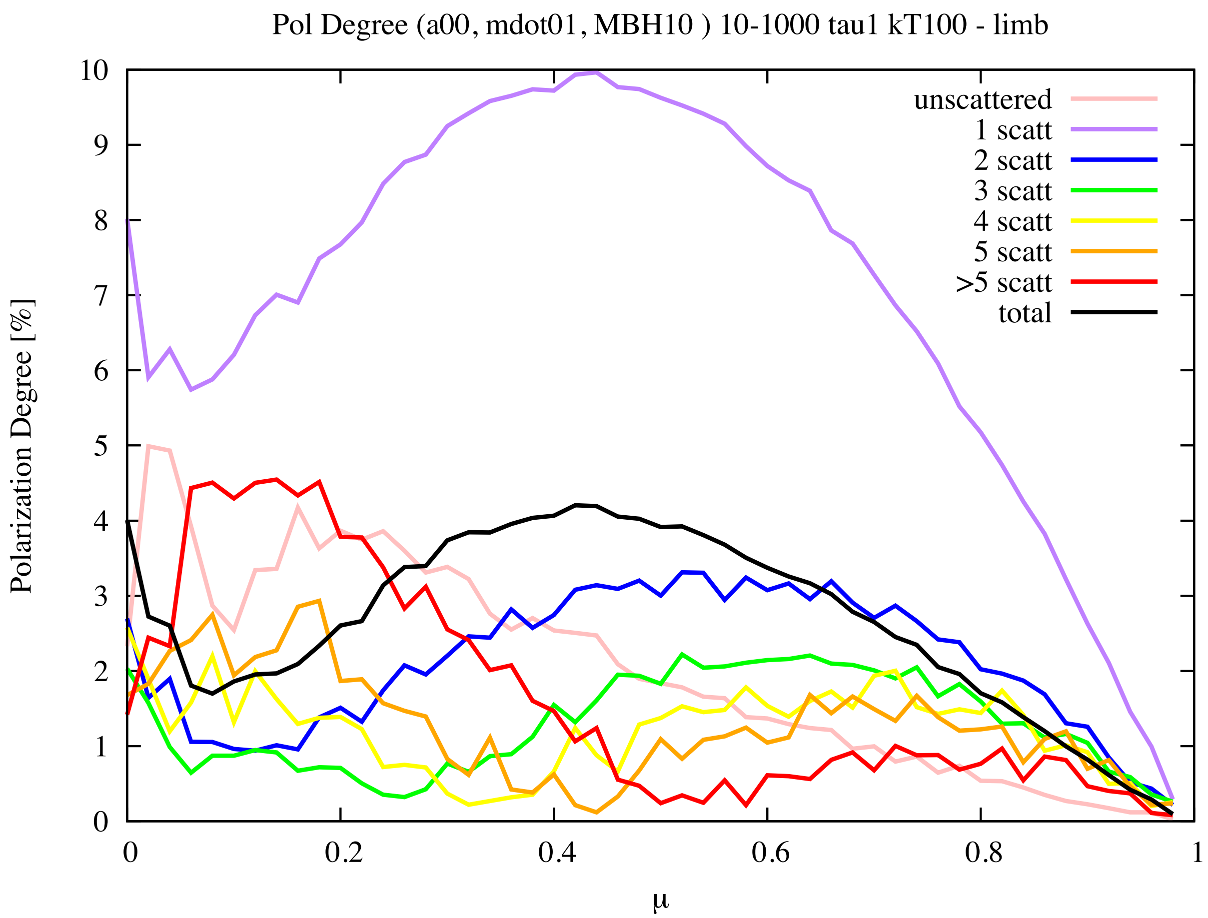
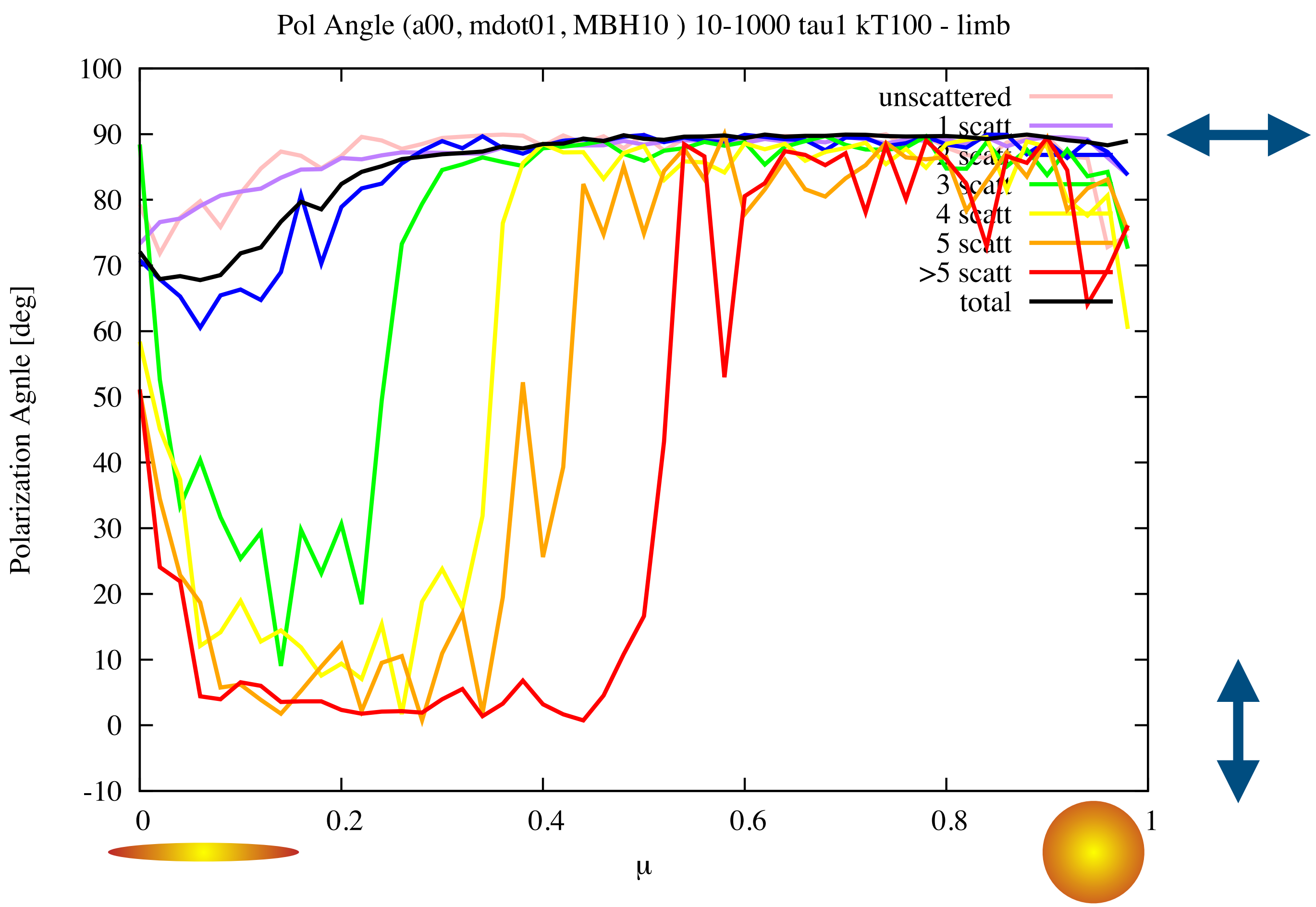


a0 limb / SLAB tau1





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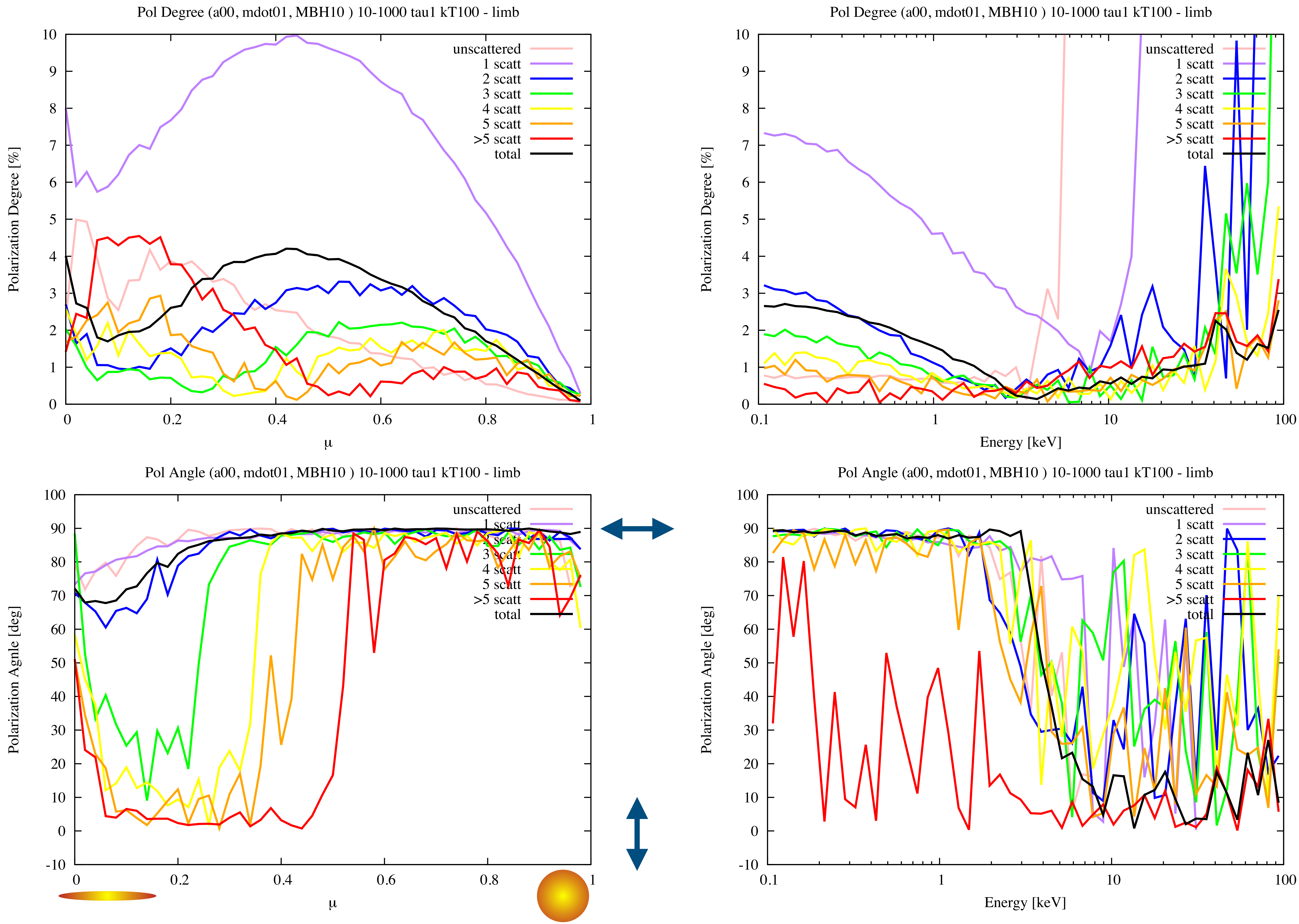
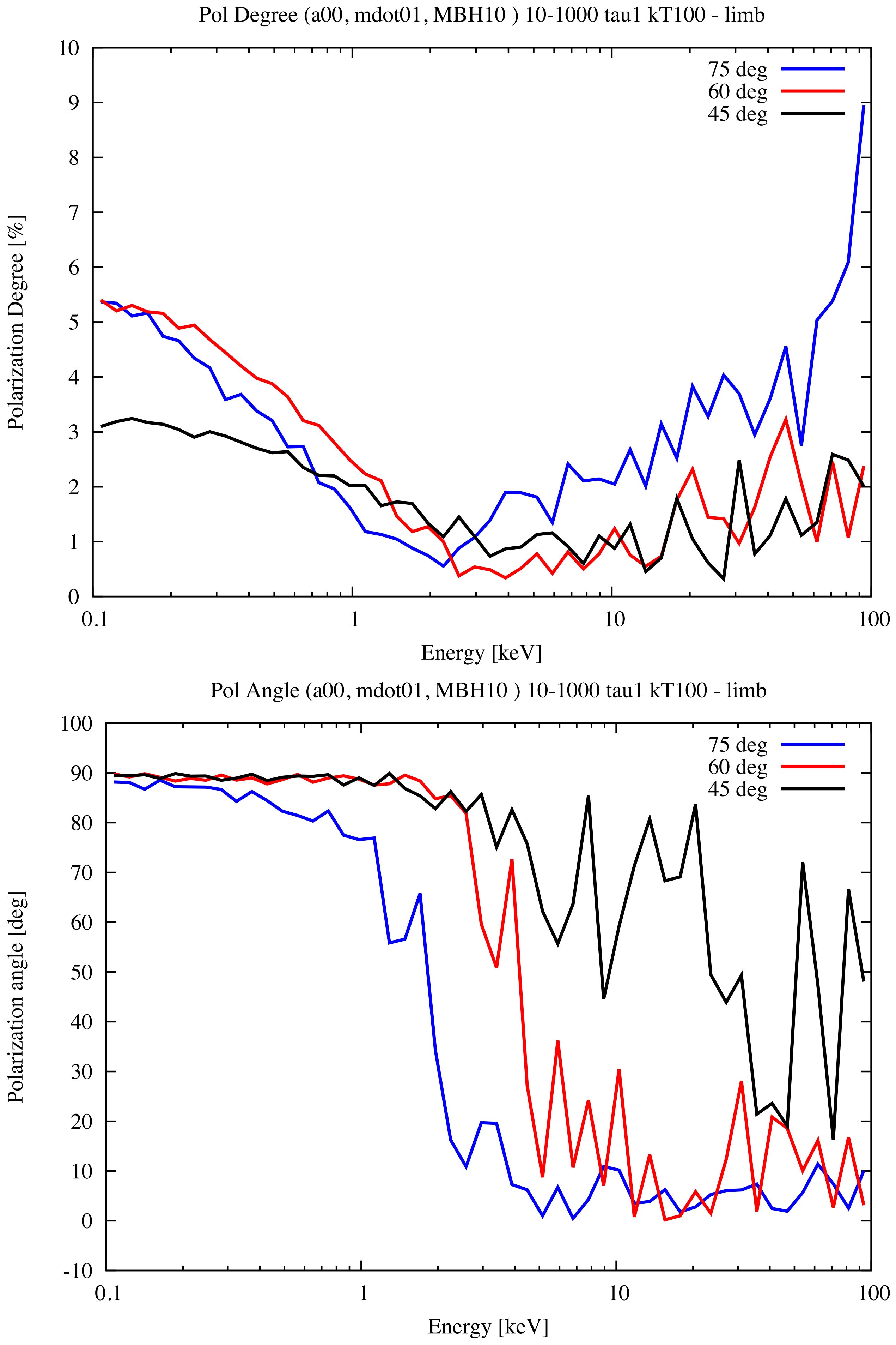
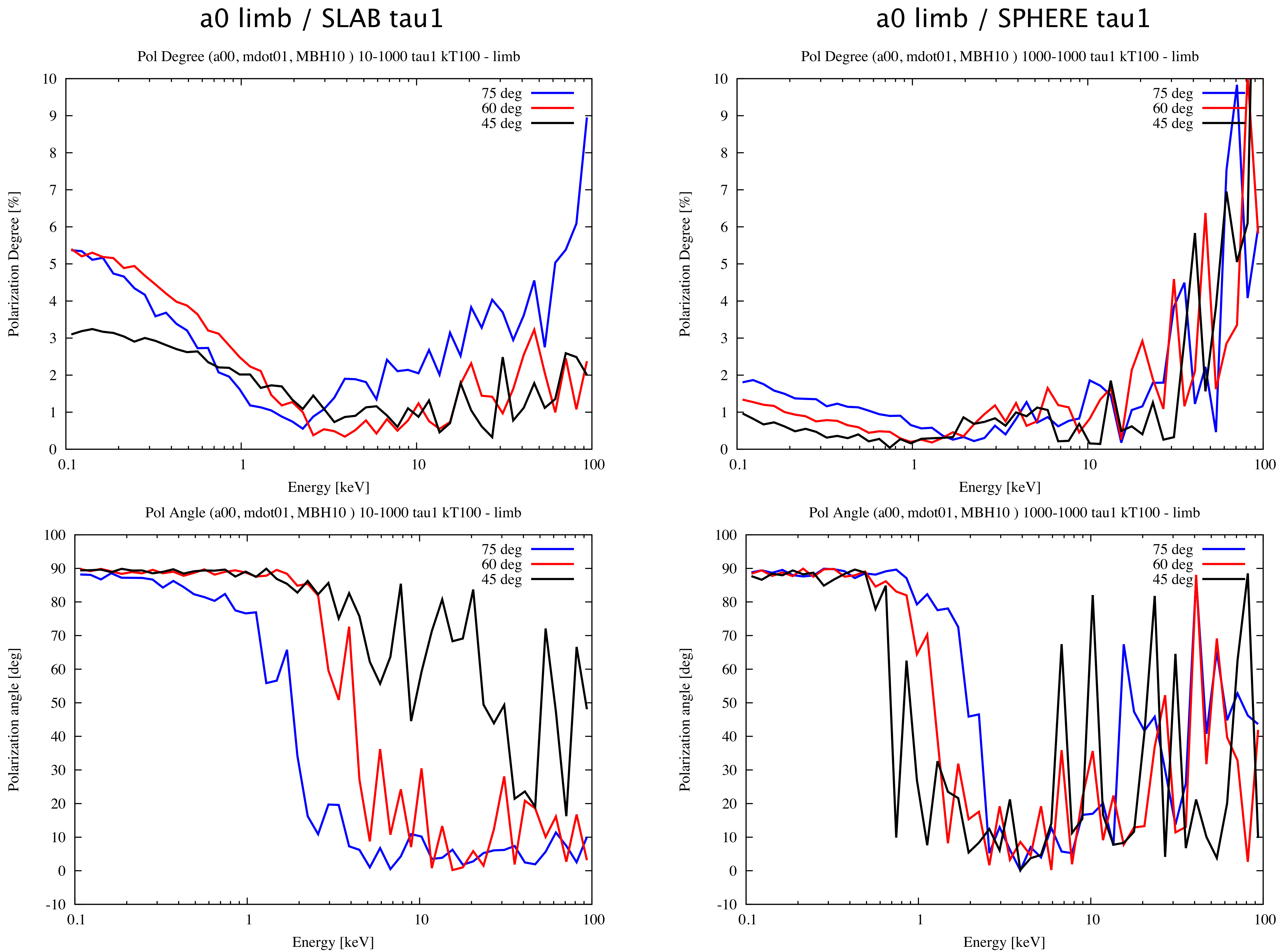
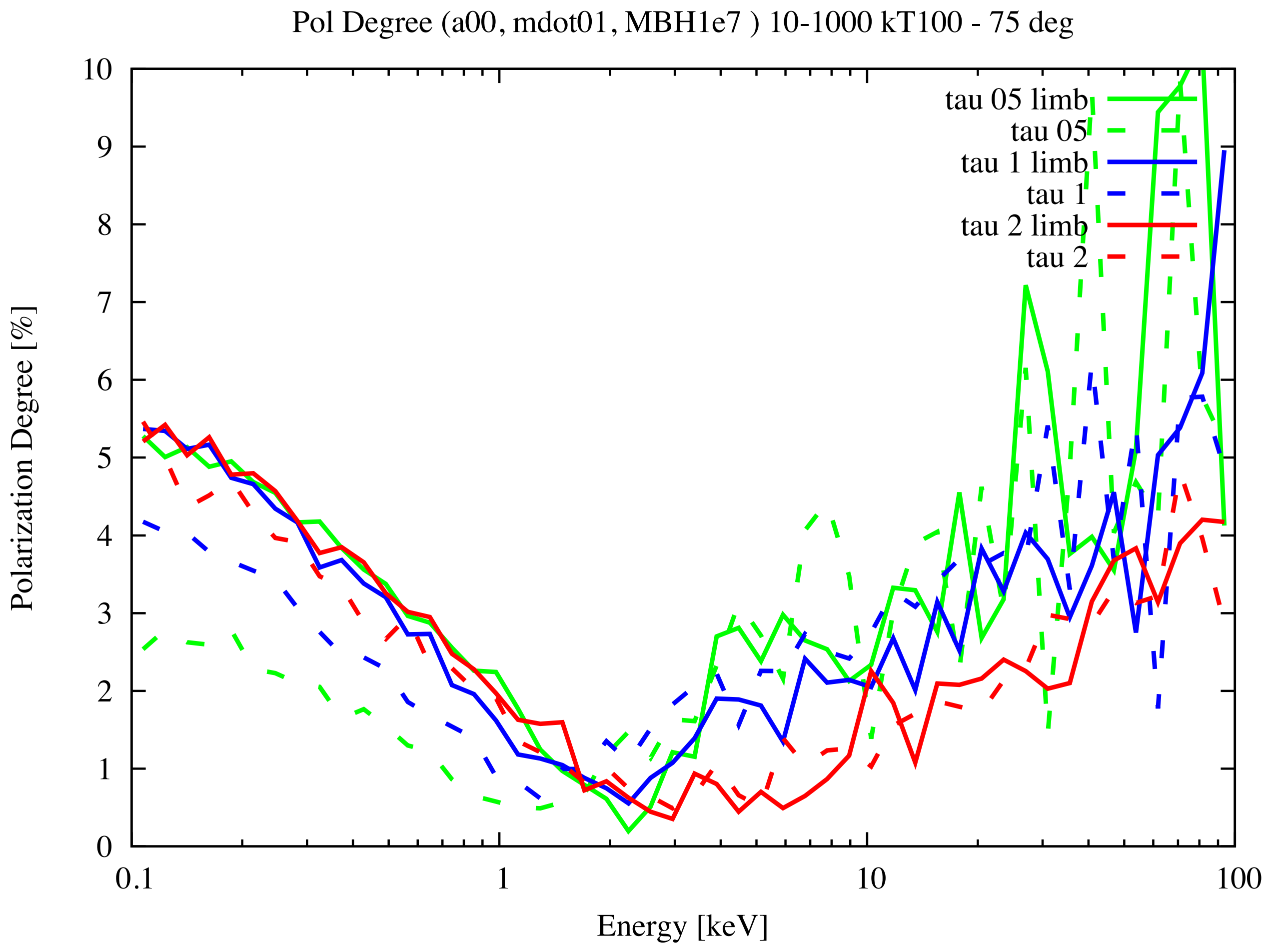


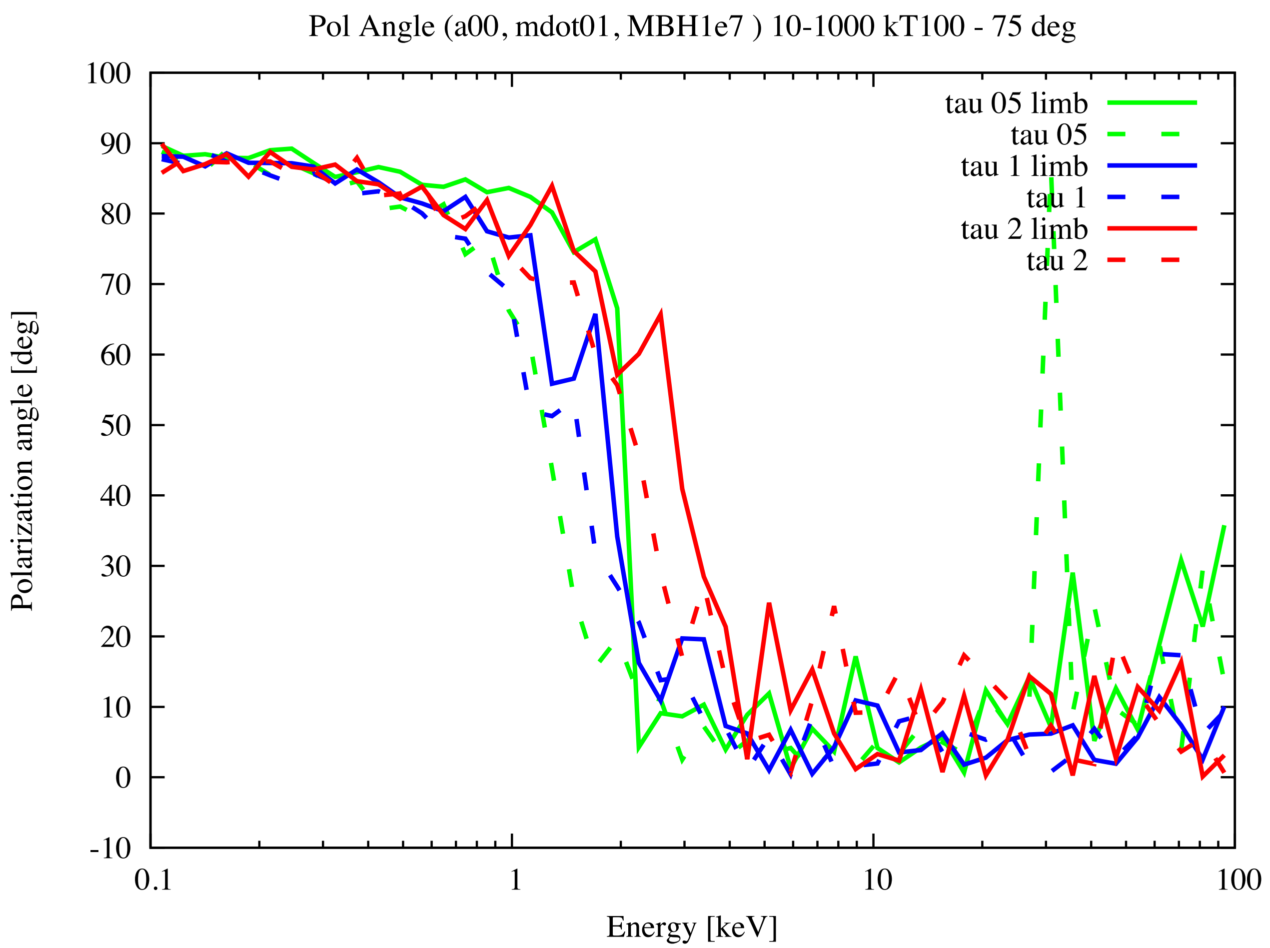
a0 limb / SLAB tau1




a0 limb / SLAB tau1
a0 limb / SPHERE tau1
Pol Degree (a00, mdot01, MBH10) 10-1000 tau1 kT100 - limb
Pol Degree (a00, mdot01, MBH10) 1000-1000 tau1 kT100 - limb
Pol Angle (a00, mdot01, MBH10) 10-1000 tau1 kT100 - limb
Pol Angle (a00, mdot01, MBH10) 1000-1000 tau1 kT100 - limb
75 deg
60 deg
45 deg
Polarization Degree [%]
Polarization angle [deg]
Energy [keV]
0.1
1
10
100

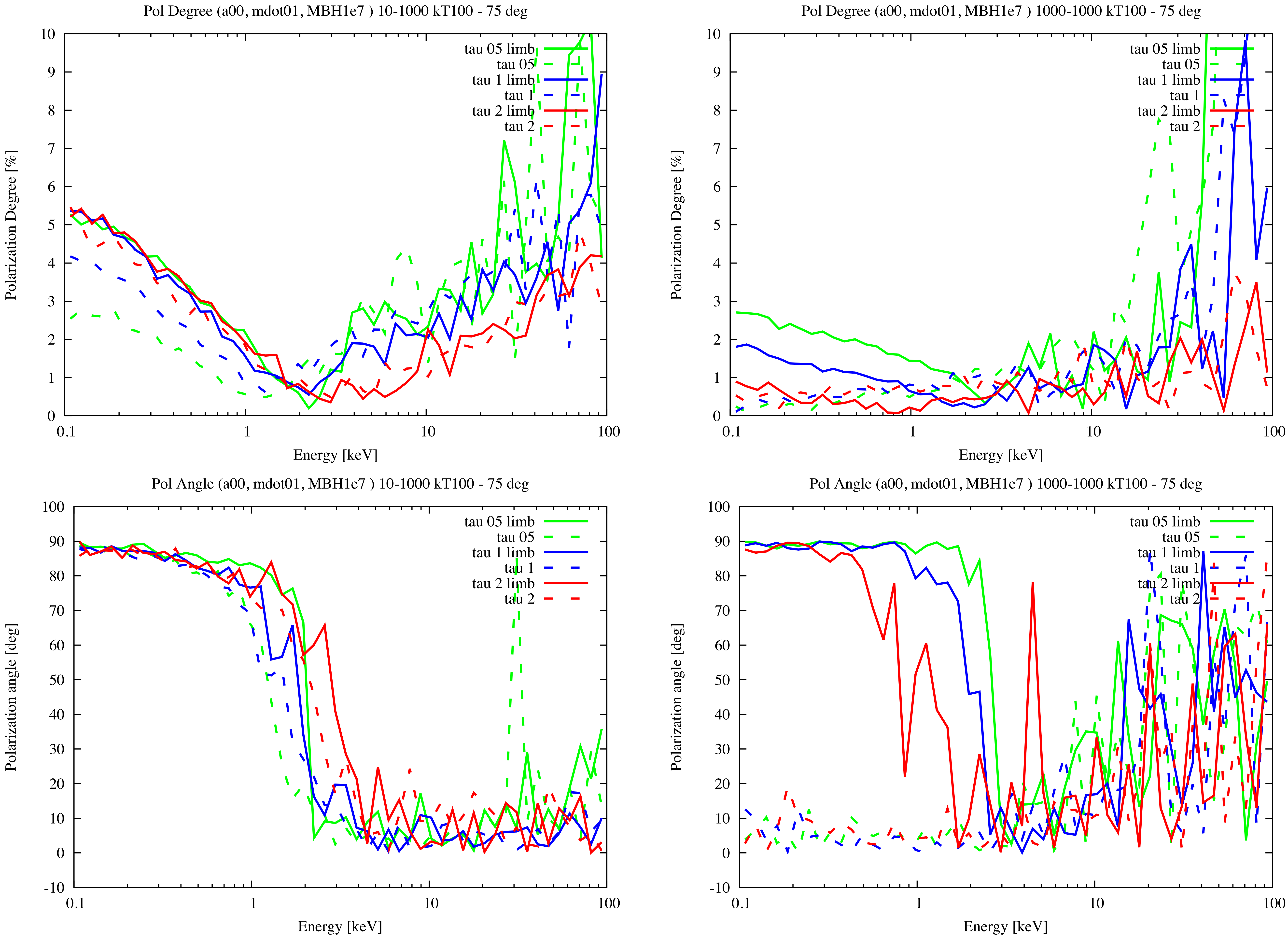
SLAB a0 - tau 05/1/2 - limb ON/OFF



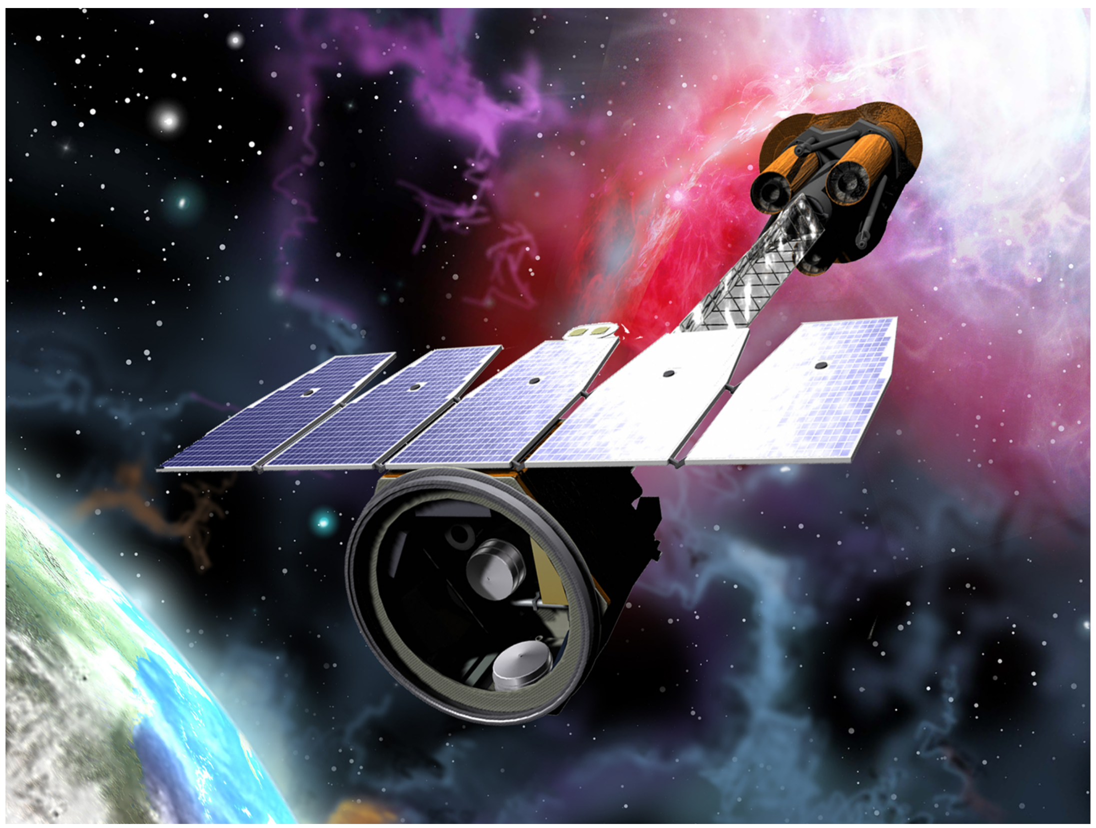


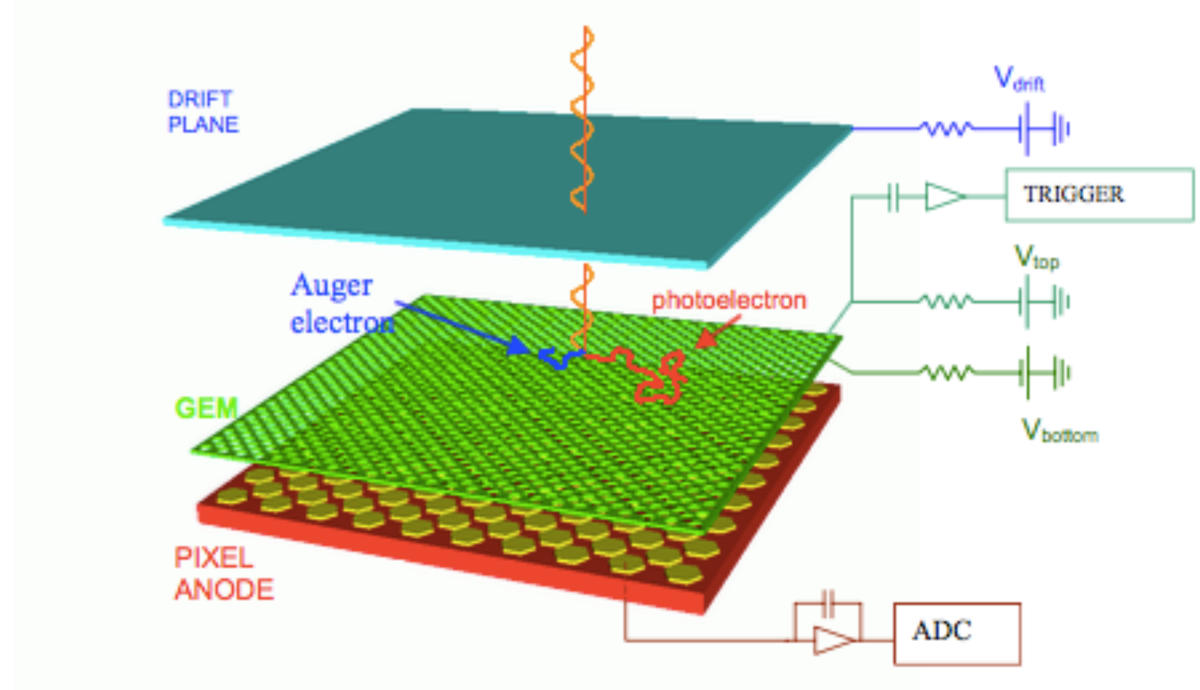
SLAB a0 – tau 05/1/2 – limb ON/OFF

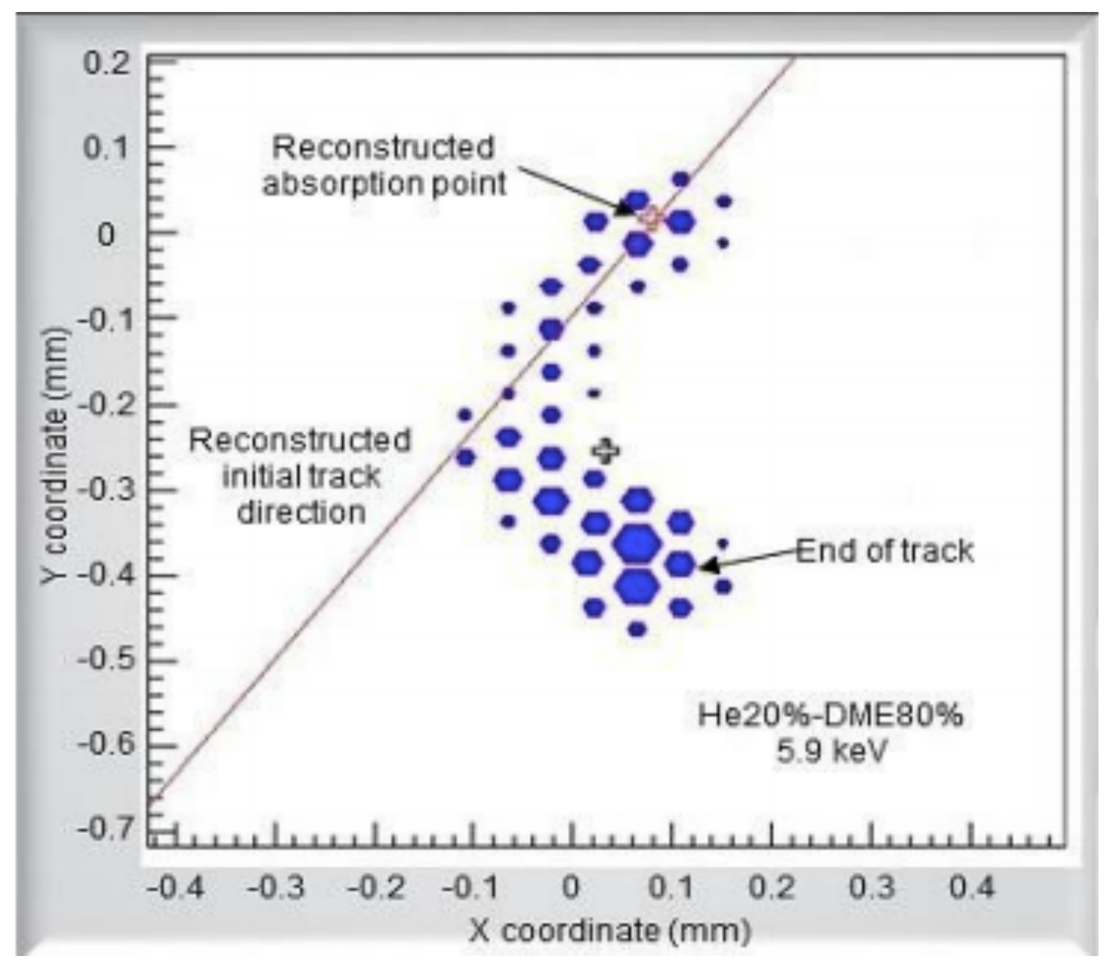
SPHERE a0 – tau 05/1/2 – limb ON/OFF



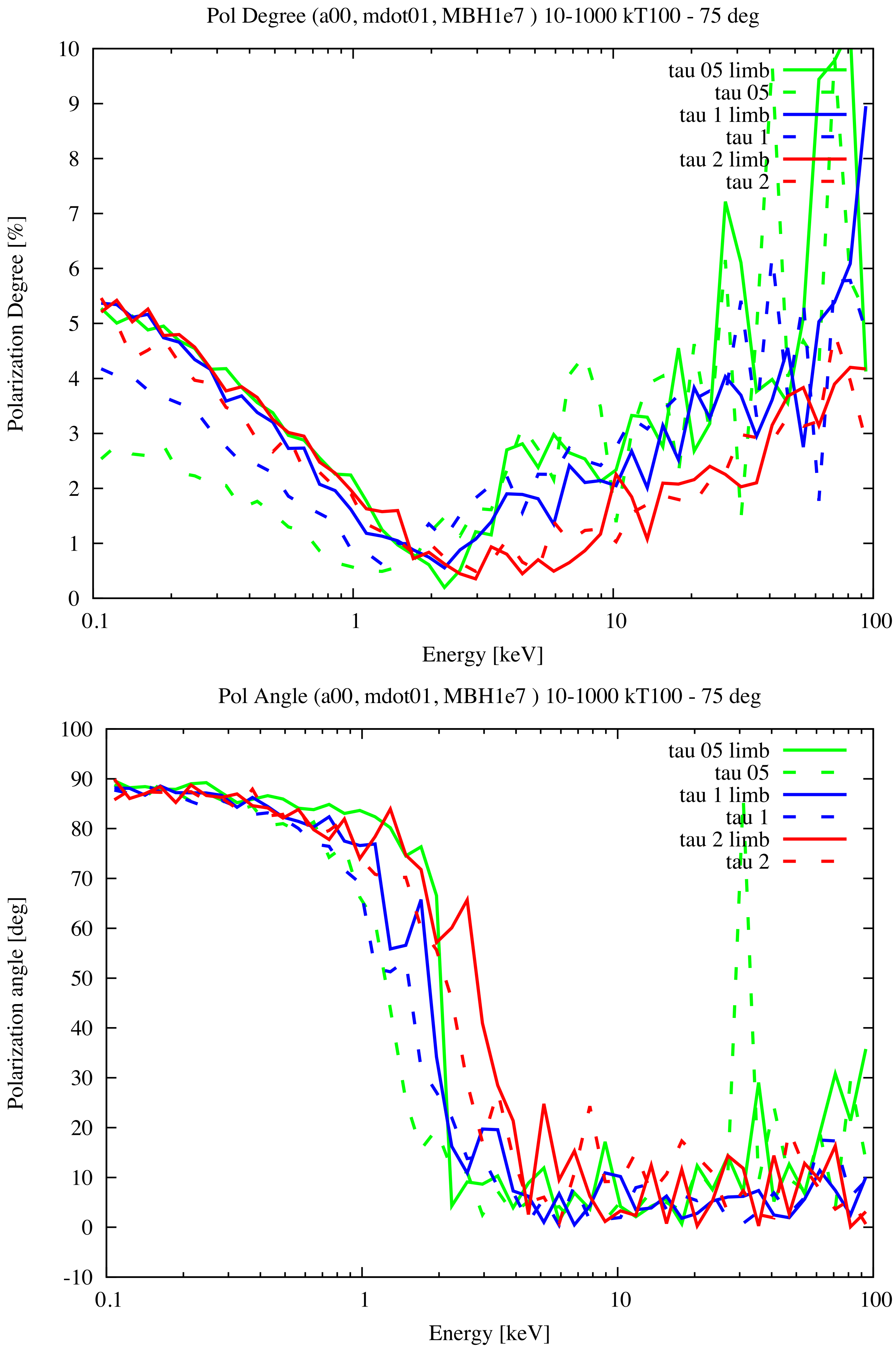
Stephen O'Dell talk on IXPE



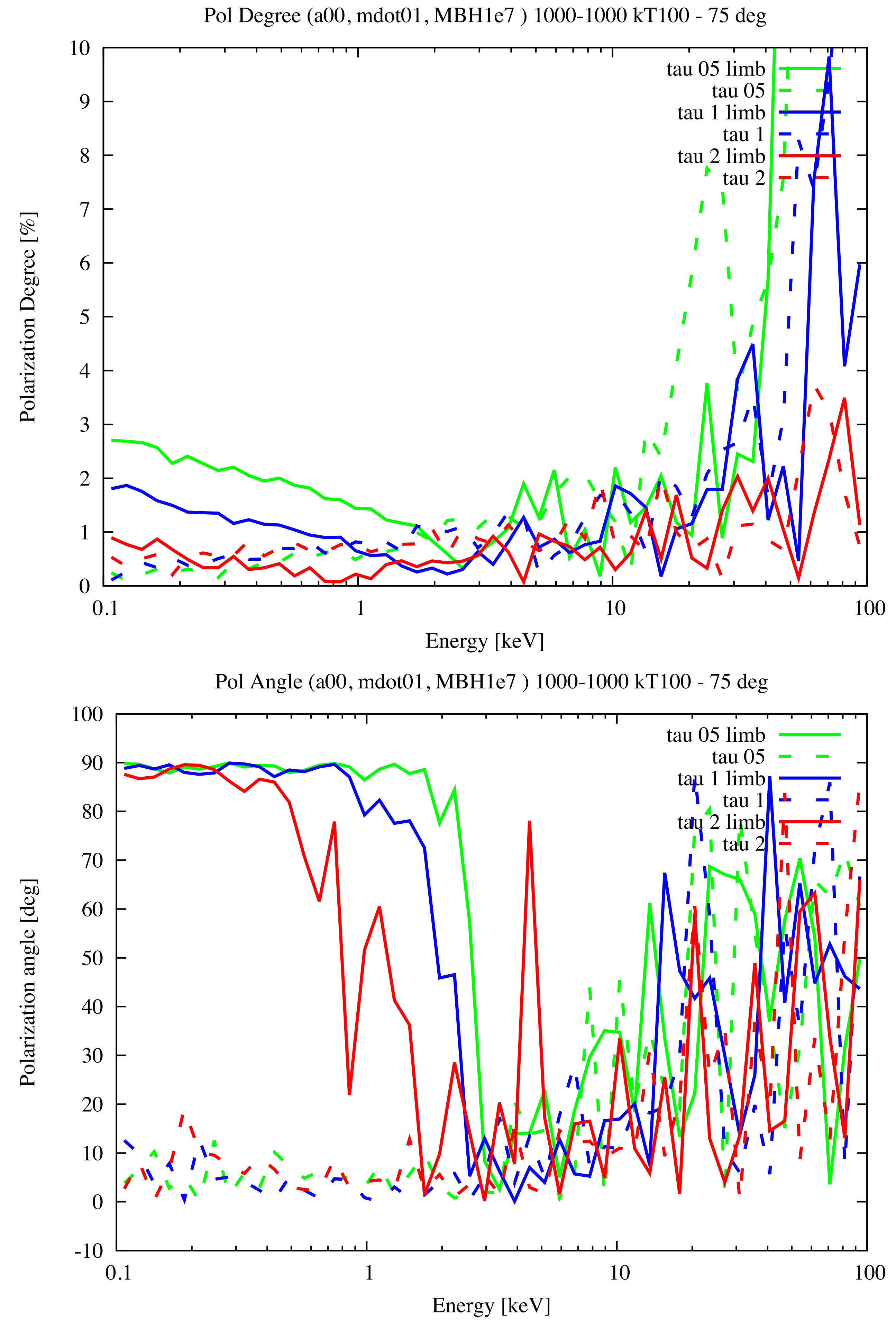


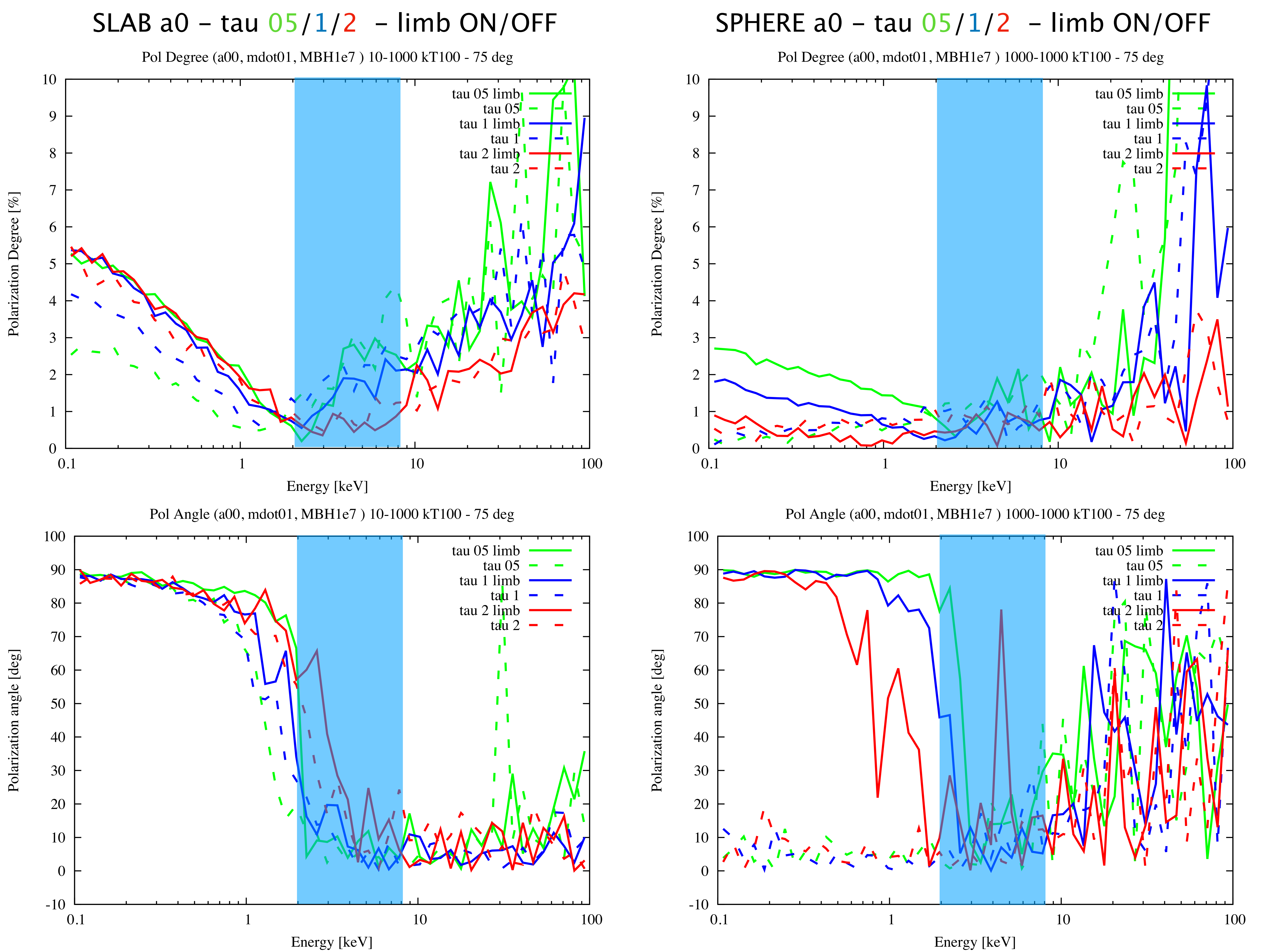


SLAB a0 - tau 05/1/2 - limb ON/OFF

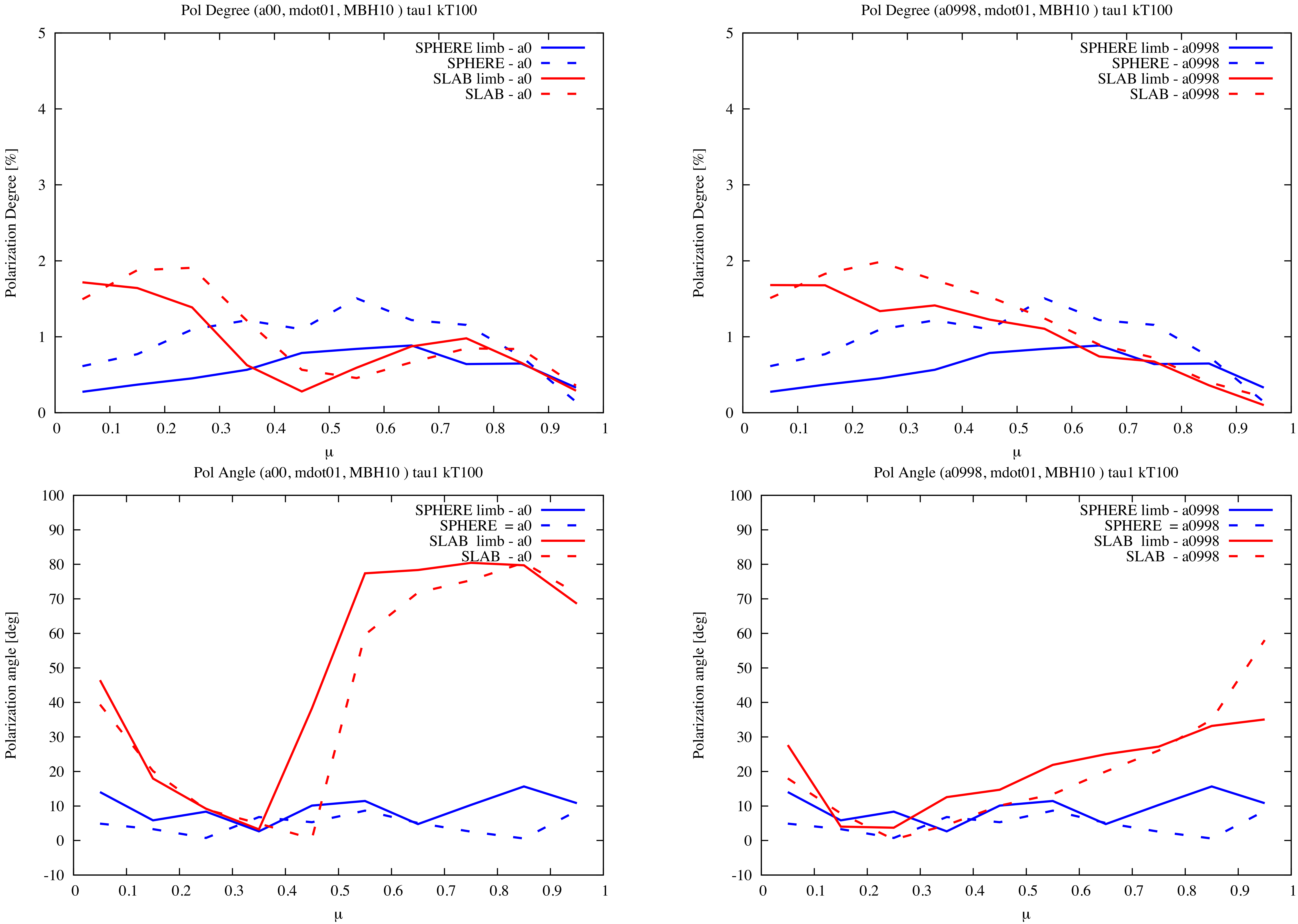


SPHERE a0 - tau 05/1/2 - limb ON/OFF




SLAB a0 - tau 05/1/2 - limb ON/OFF
SPHERE a0 - tau 05/1/2 - limb ON/OFF
Pol Degree (a00, mdot01, MBH1e7) 10-1000 kT100 - 75 deg
Pol Degree (a00, mdot01, MBH1e7) 1000-1000 kT100 - 75 deg
Pol Angle (a00, mdot01, MBH1e7) 10-1000 kT100 - 75 deg
Pol Angle (a00, mdot01, MBH1e7) 1000-1000 kT100 - 75 deg
Polarization Degree [%]
Polarization angle [deg]
Energy [keV]
tau 05 limb
tau 05
tau 1 limb
tau 1
tau 2 limb
tau 2

a0 tau 1 a0998

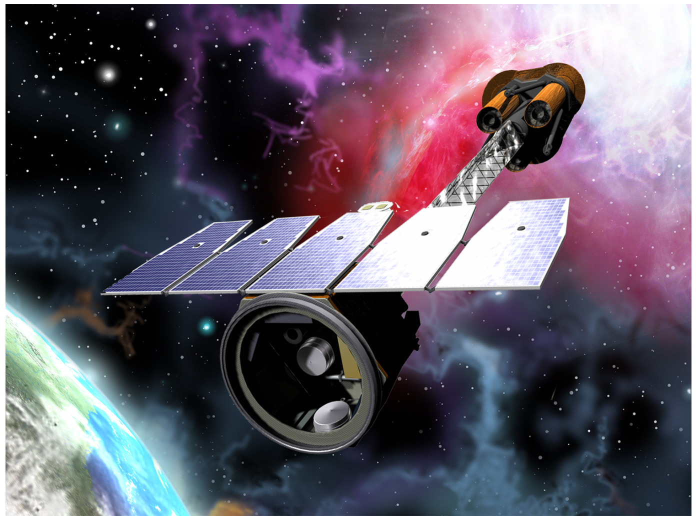


Conclusions & Future Developments

X-ray polarization has the potential to discriminate (certain) geometries even w/o exploiting the spectral capabilities of future polarimeters (IXPE, eXTP)

If the data will be very good it has the potential to constrain even more parameters such as the spin of the BH, for example

Waiting for 2021…



- Develop more realistic models and explore more of the parameters space (e.g. reflection from the disc, compact corona, double corona, non-thermal electrons,..)

- Apply MoCA to different interesting astrophysical case of study (magnetic-field induced polarization, i.e. GRB, jets)