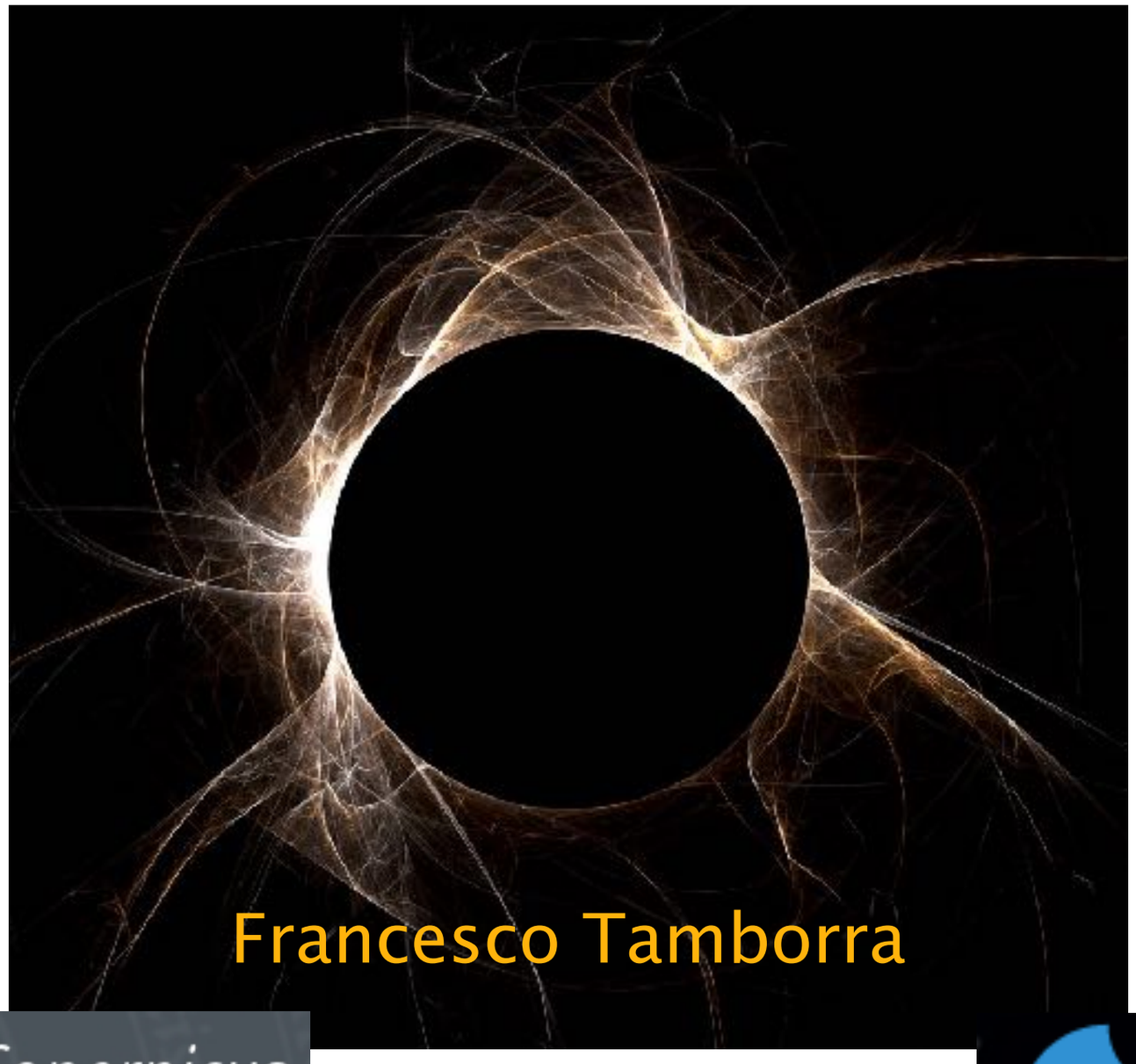
On the size and geometry of coronae in BHBs

a spectral(-timing) preview with MoCA



Francesco Tamborra

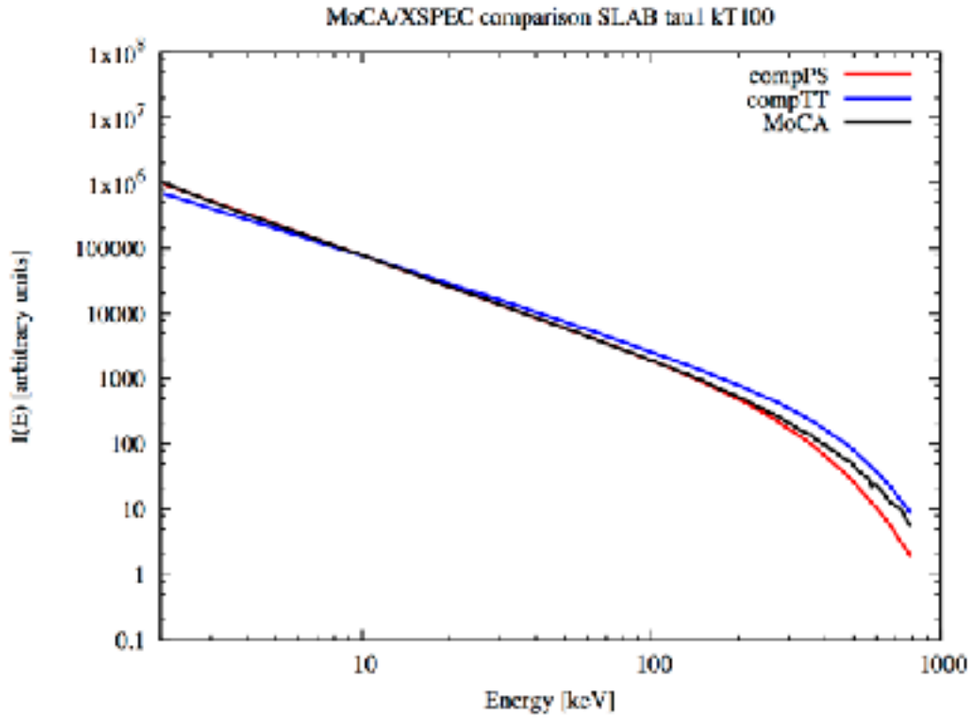
Nicolaus Copernicus Astronomical Center of the Polish Academy of Sciences

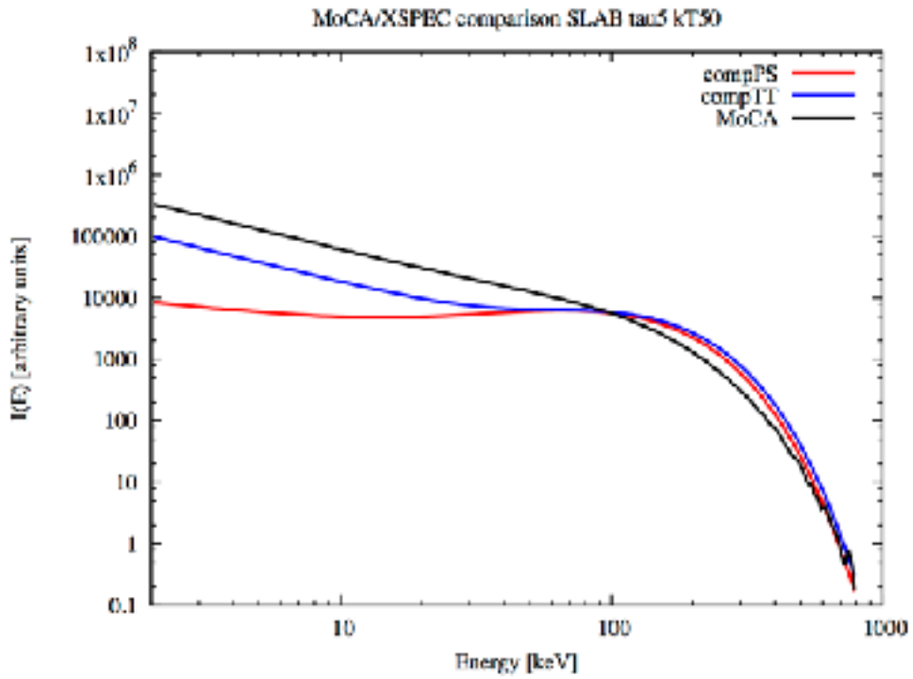
asu Astronomický ústav AV ČR

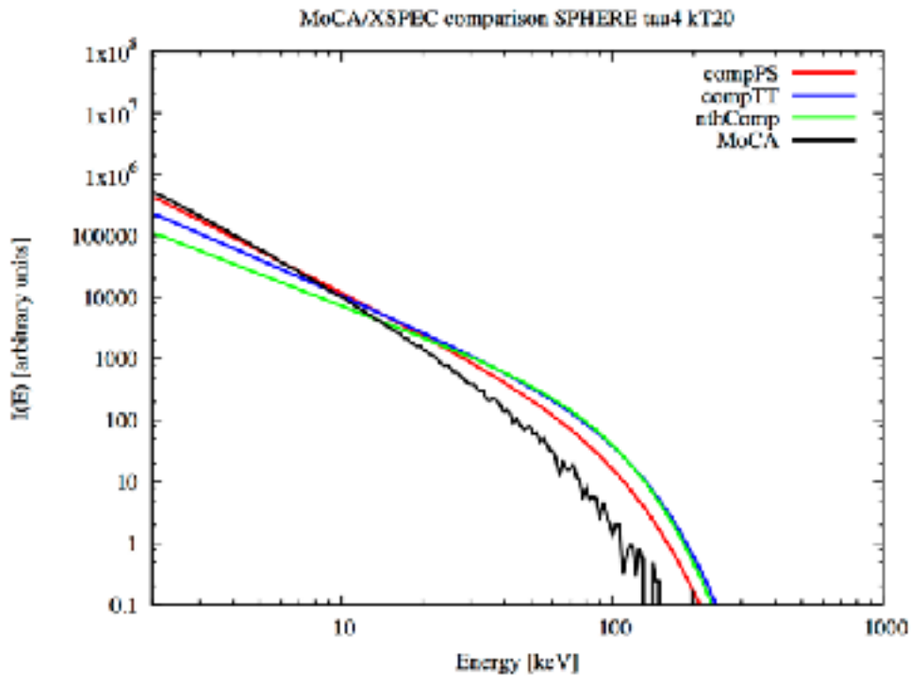
9th Fero meeting, 23-25 May 2018 - Heraklion

MoCA: a Monte Carlo code for Comptonization in Astrophysics

- uses a single photon approach
- accurately treats Comptonization process using Klein-Nishina cross-section and scattering angle distribution
- includes polarization (see Giorgio's talk)

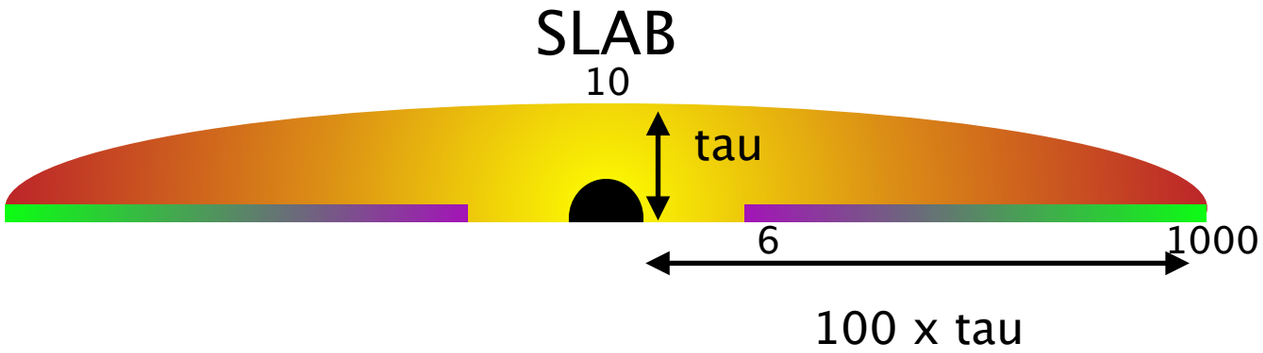




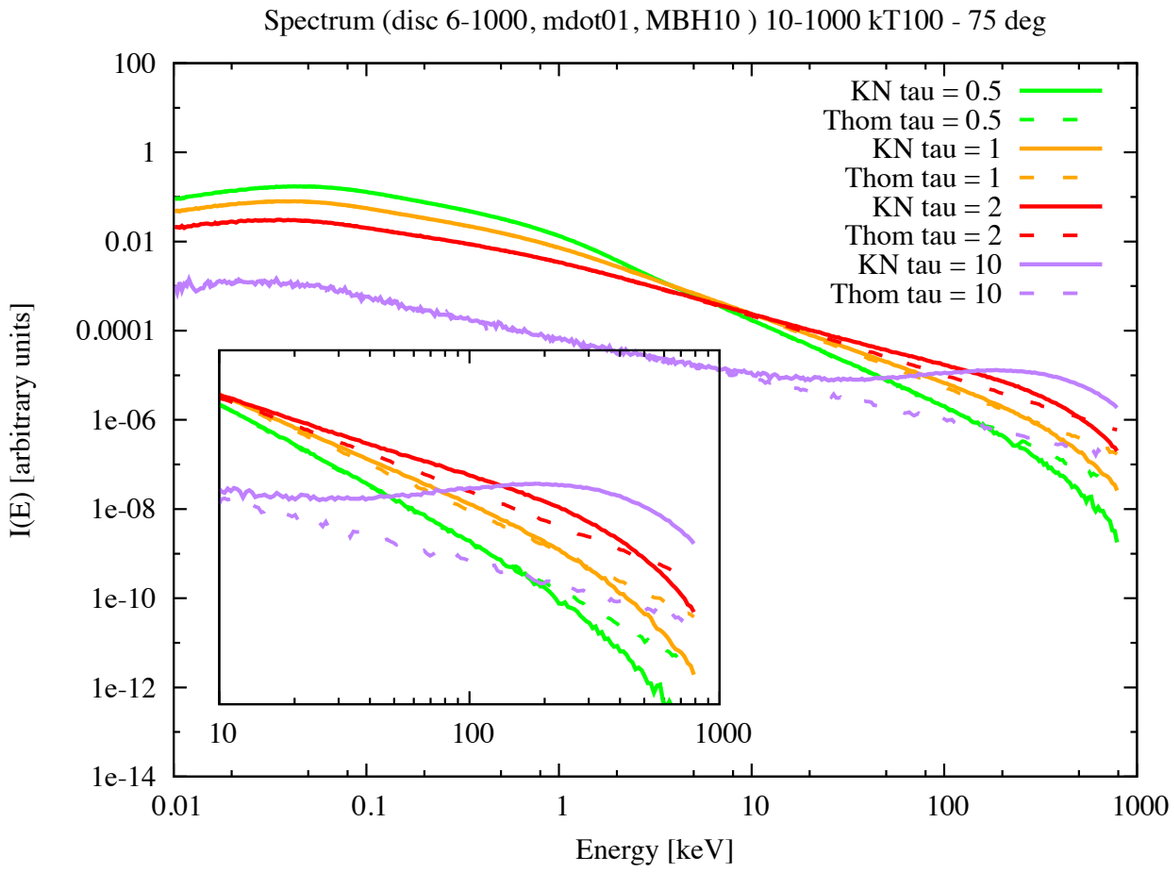


See Riccardo's talk (next one) for more !

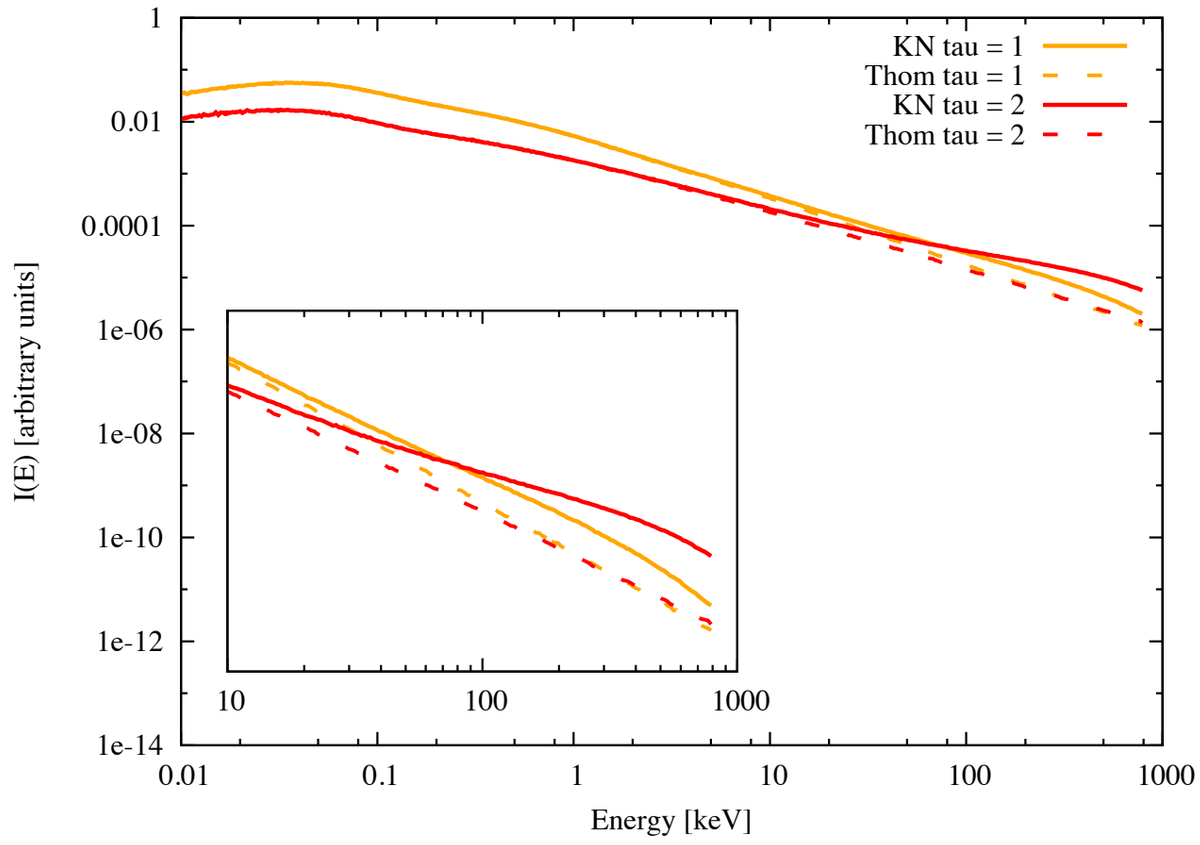
Extended coronae without GR
what we learned so far



kT = 100 keV



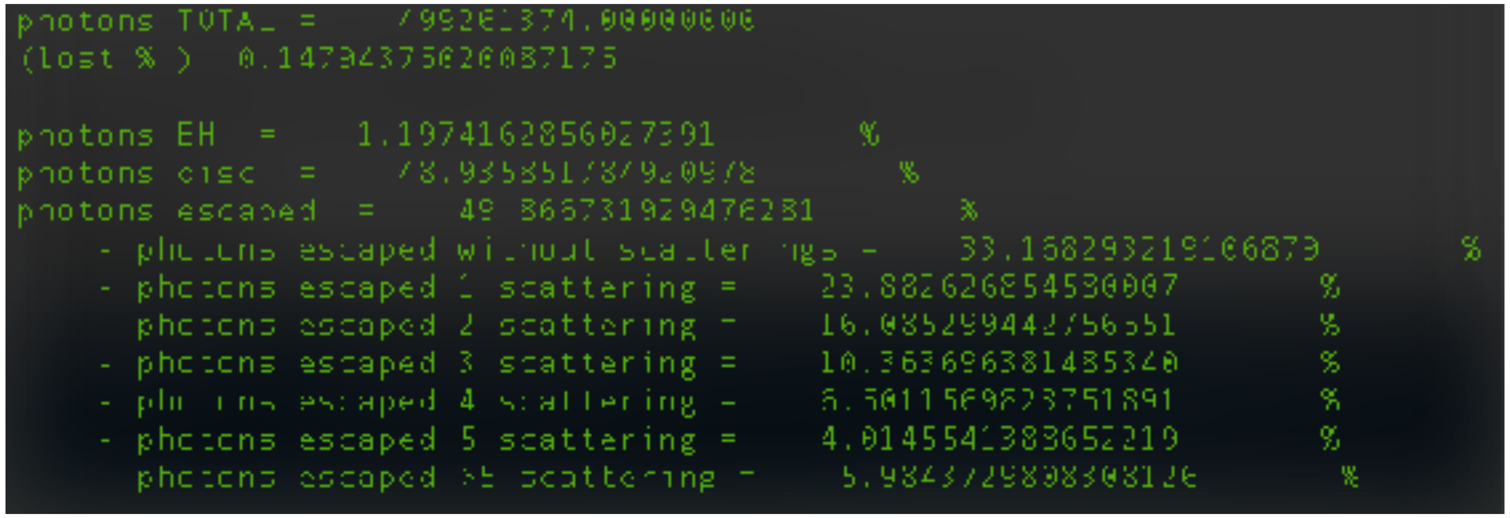
kT = 200 keV



K-N is relevant even below 100 keV and naturally produce the curvature at higher energies

Extended coronae: GR effects

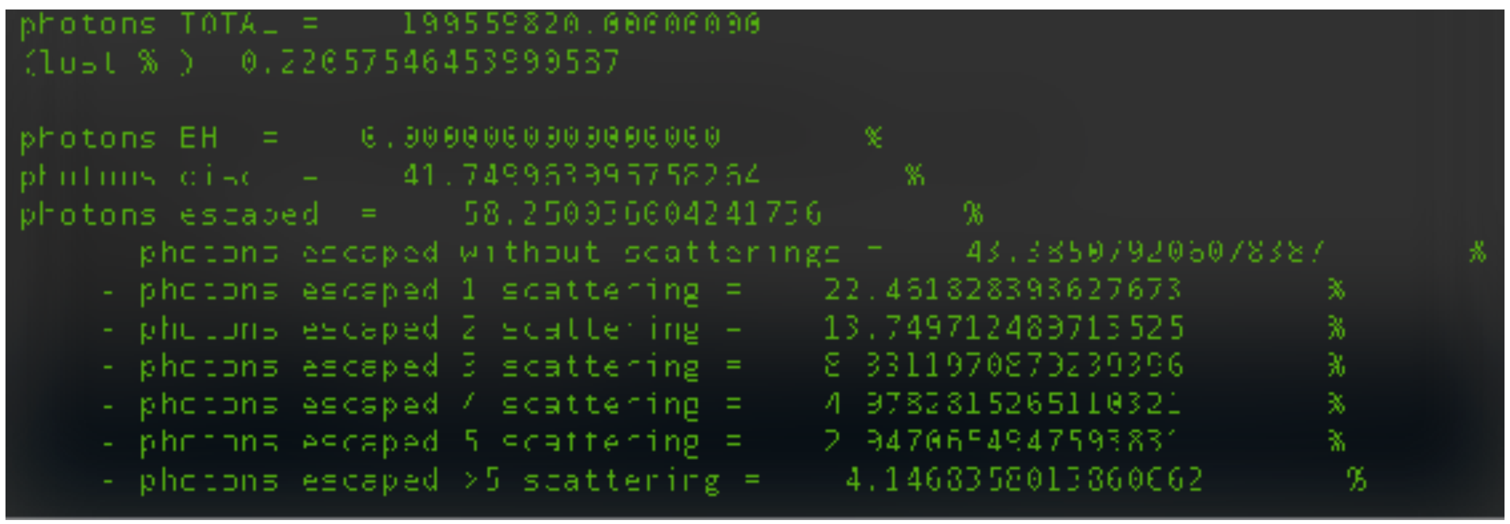
NO GR



```
photons TOTAL =     79921374.00000000
(lost % )  0.14734375026087175

photons EH  =     1.1974162856027391        %
photons disc  =     78.935851787920978        %
photons escaped  =     49.866731929476281        %
    - photons escaped without scatterings =     33.168293219166873        %
    - photons escaped 1 scattering =     23.882626854530007        %
      photons escaped 2 scattering =     16.035299442756551        %
    - photons escaped 3 scattering =     10.363696381485340        %
    - photons escaped 4 scattering =     6.5011569823751891        %
    - photons escaped 5 scattering =     4.0145541383652219        %
      photons escaped >5 scattering =     5.9843729898308126        %
```

GR, a=0



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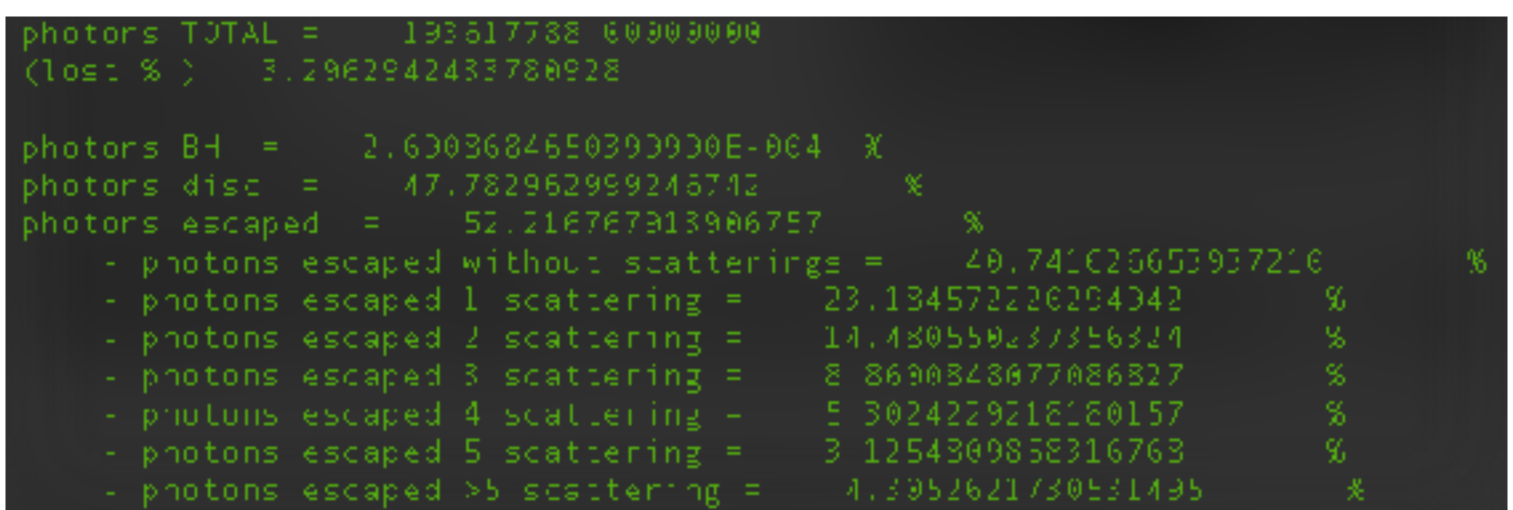
photons TOTAL =     199559820.00000000
(lost % )  0.22657546453999537

photons EH  =     0.0000000000000000        %
photons disc  =     41.749963995758264        %
photons escaped  =     58.250036004241736        %
      photons escaped without scatterings =     43.385079206078387        %
    - photons escaped 1 scattering =     22.451328393627673        %
    - photons escaped 2 scattering =     13.749712483713525        %
    - photons escaped 3 scattering =     8.3311970873230396        %
    - photons escaped 4 scattering =     4.9782815265110321        %
    - photons escaped 5 scattering =     2.9470654947599383        %
    - photons escaped >5 scattering =     4.1468358013360662        %
```

GR, a=0.998



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photons TOTAL =     193617738.00000000
(lost % )   3.2962942433780928

photons BH  =     2.6303684650393930E-004  %
photons disc  =     47.782962999246742        %
photons escaped  =     52.216767313906757        %
    - photons escaped without scatterings =     40.741625653937216        %
    - photons escaped 1 scattering =     23.134572226204342        %
    - photons escaped 2 scattering =     14.480550237356324        %
    - photons escaped 3 scattering =     8.8690834307708327        %
    - photons escaped 4 scattering =     5.3024229216160157        %
    - photons escaped 5 scattering =     3.1254309858316763        %
    - photons escaped >5 scattering =     4.3952621730531435        %
```
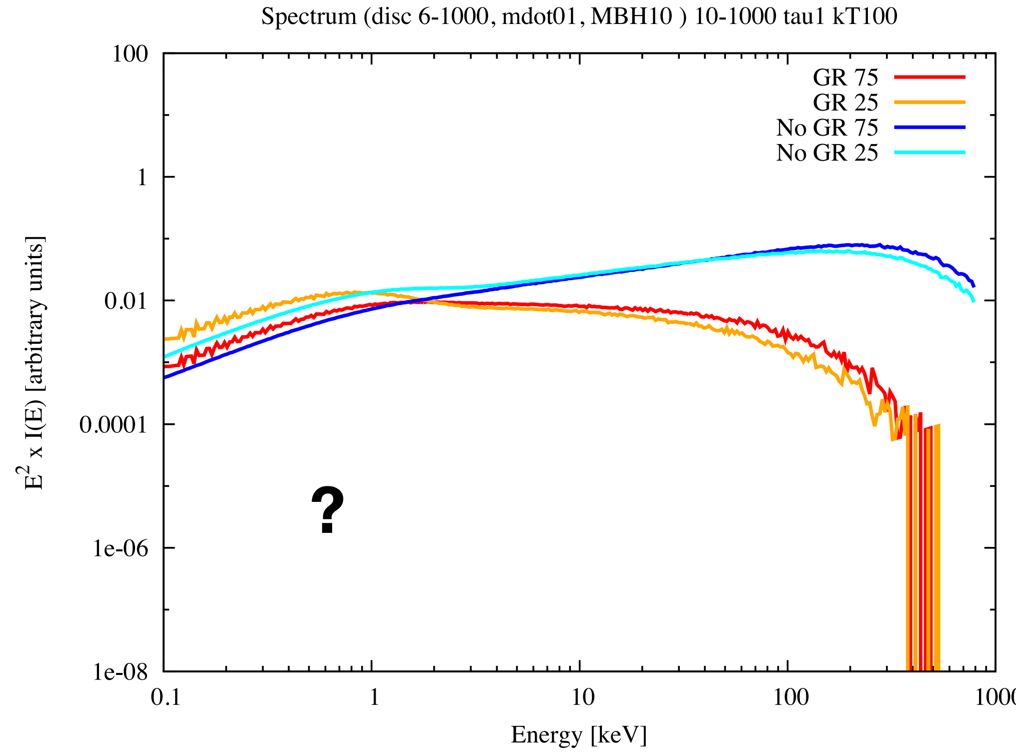
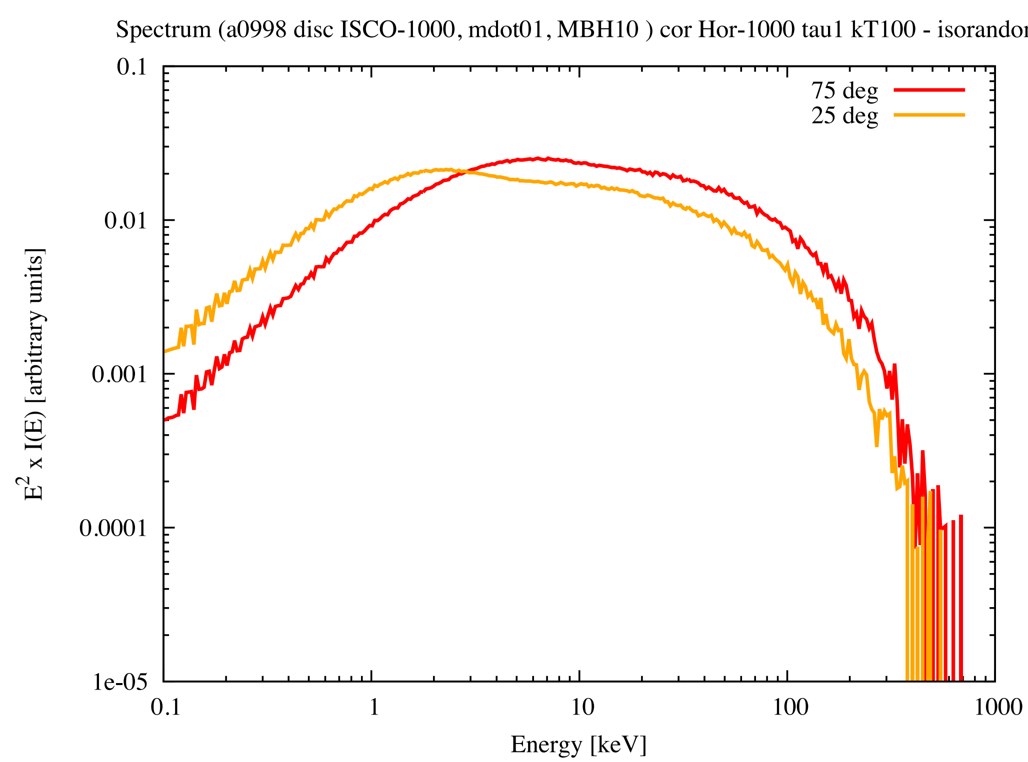

tau = 1, kT = 100 keV

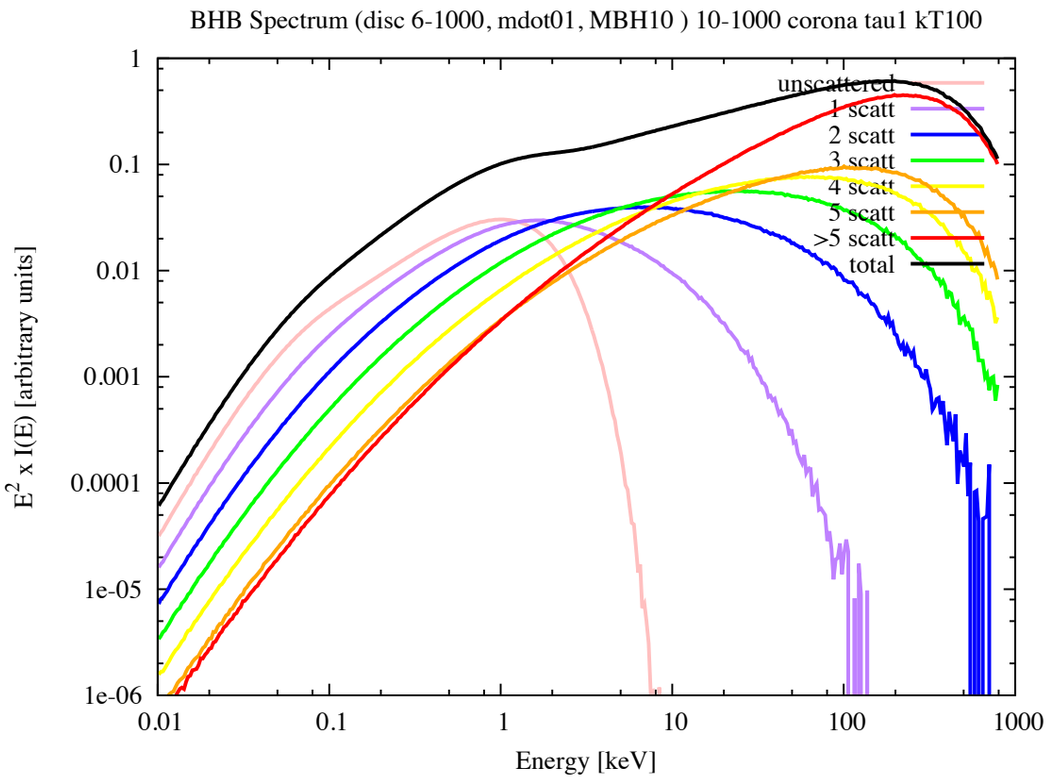




extended slab

a=0 , isoran

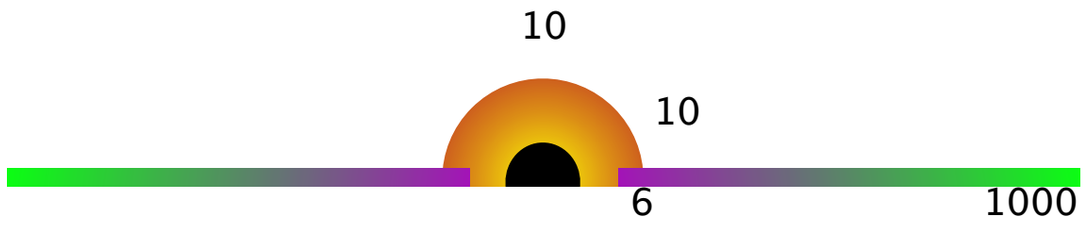
a=0998 , isoran

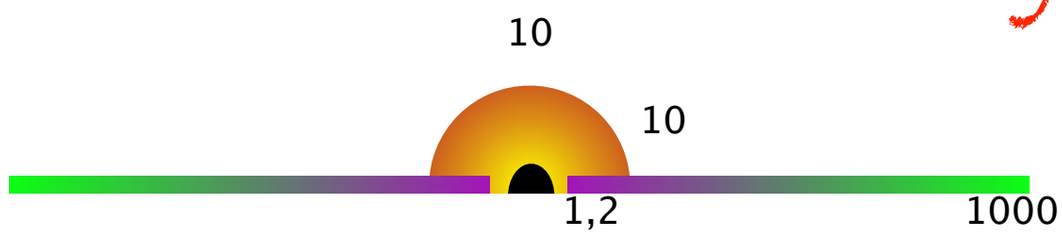


no GR

“SOFT”

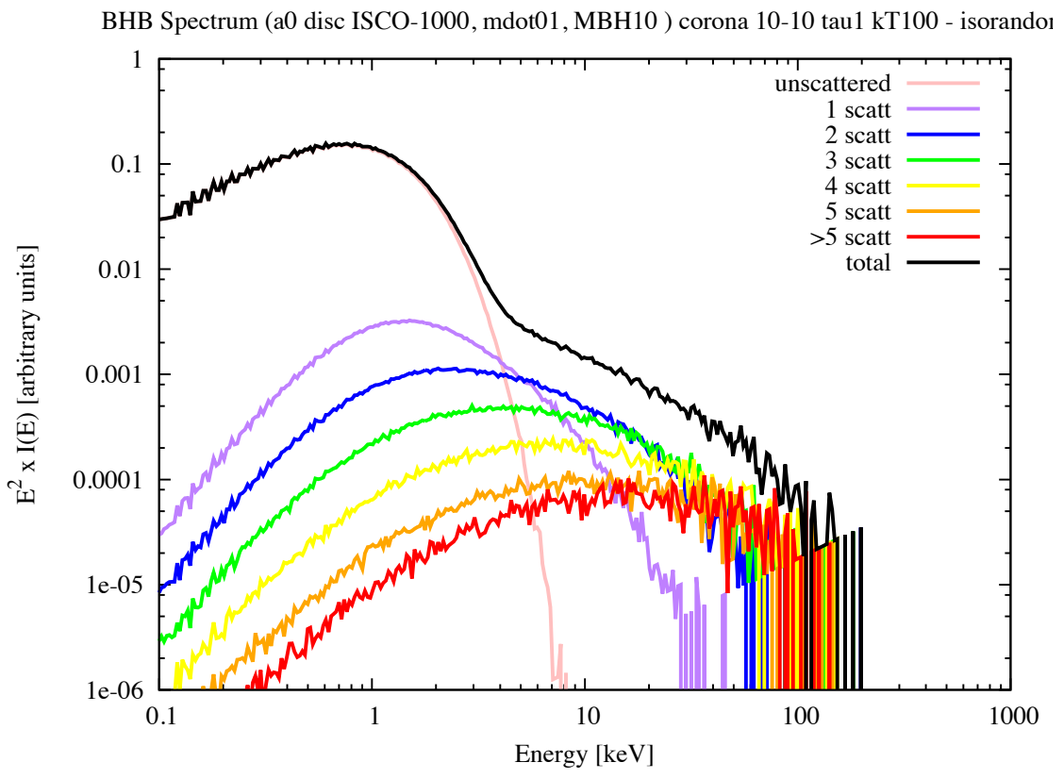
Preliminary

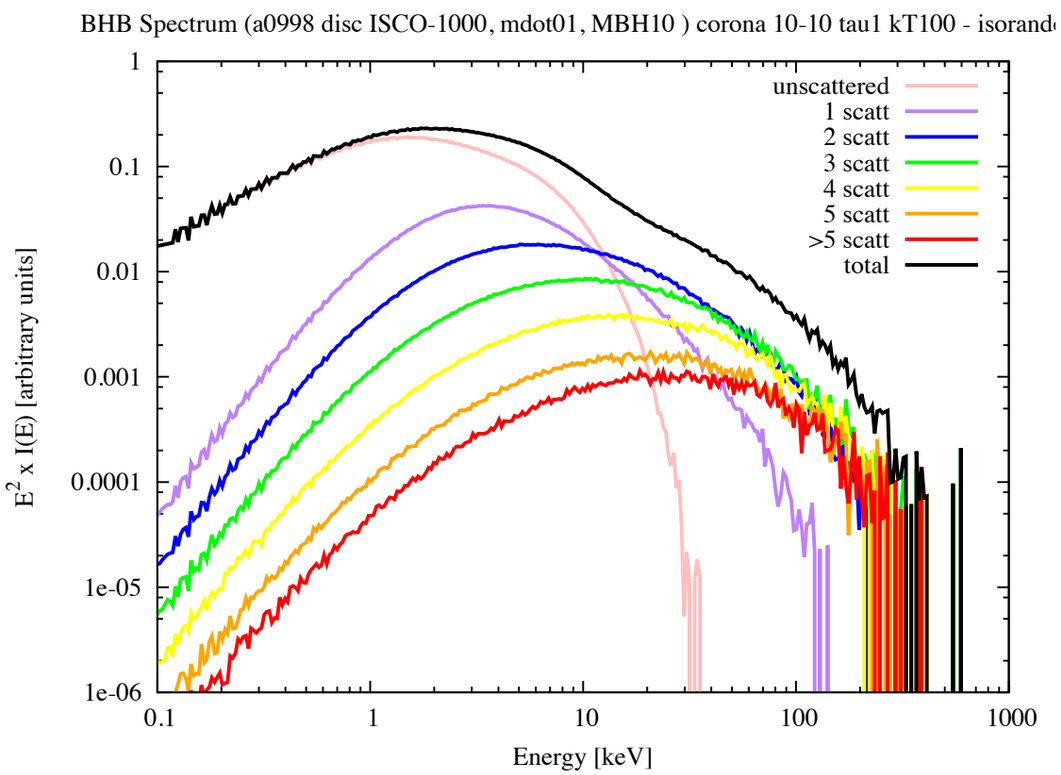




a=0

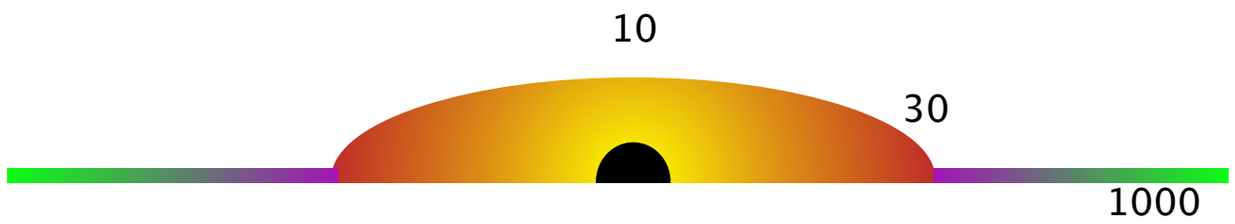
a=0.998



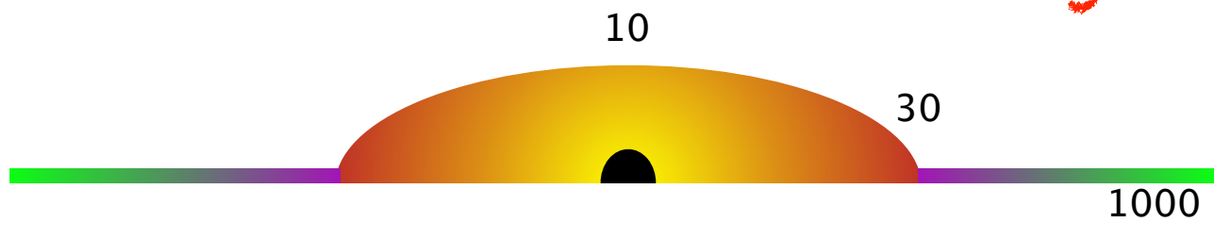


“HARD”, no overlap

Preliminary



a=0



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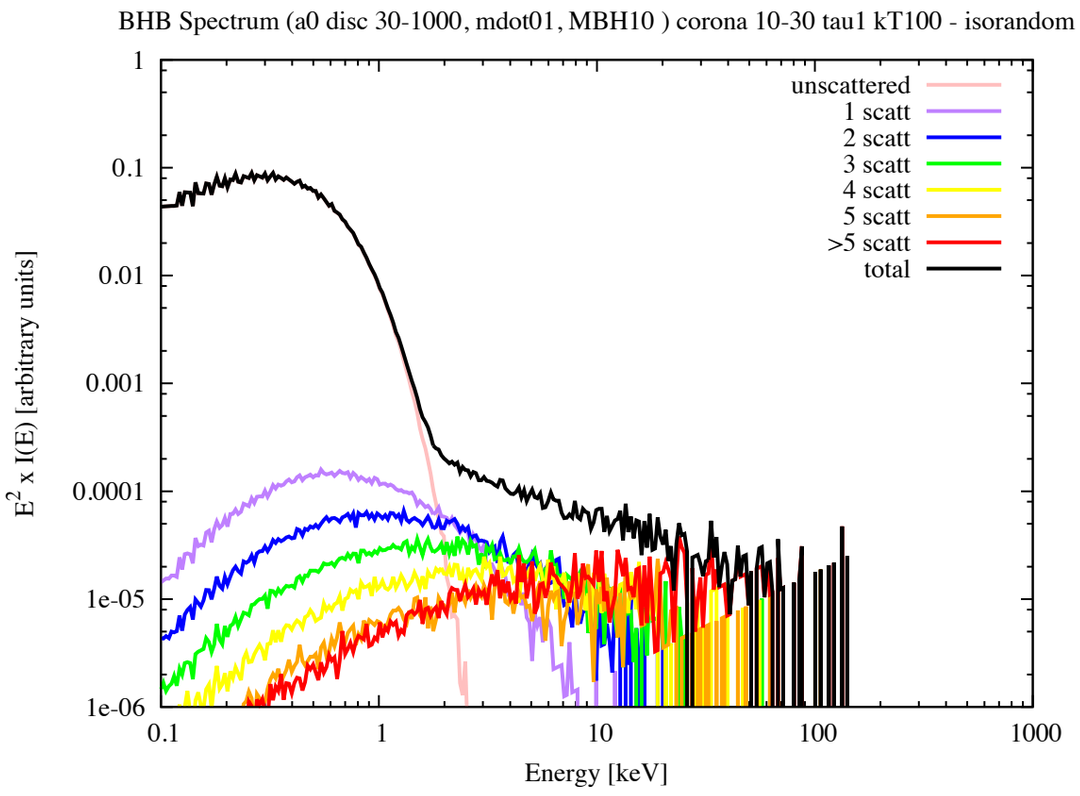
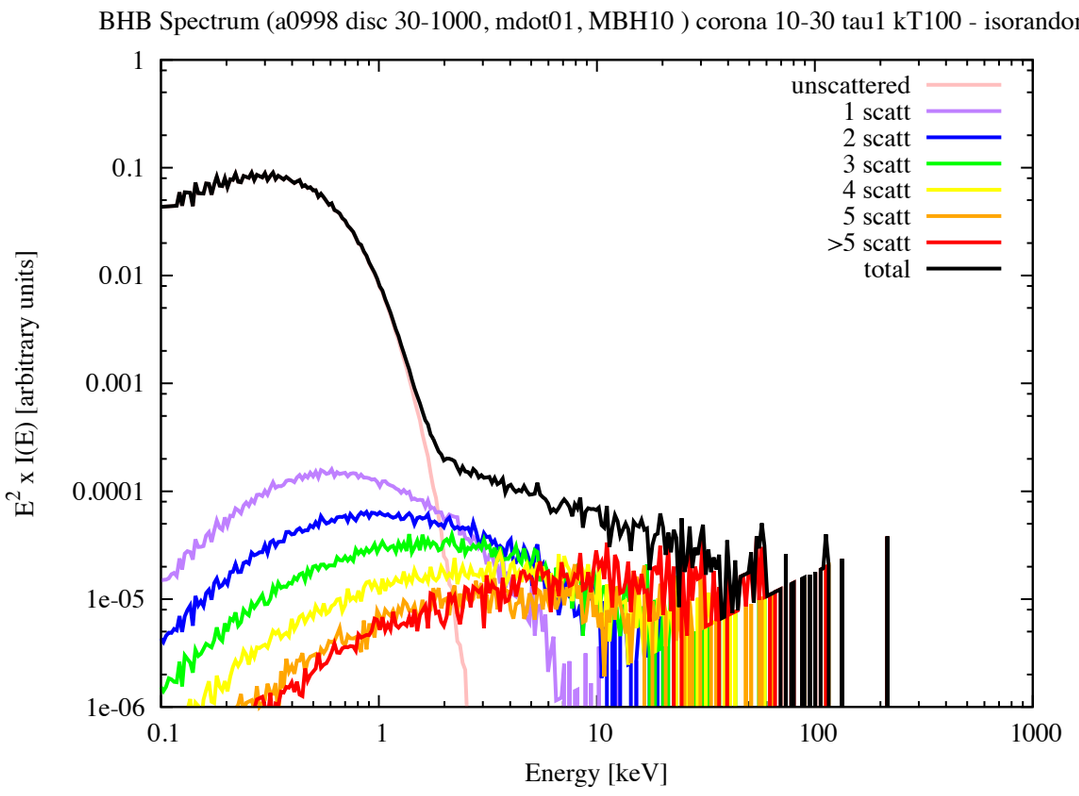
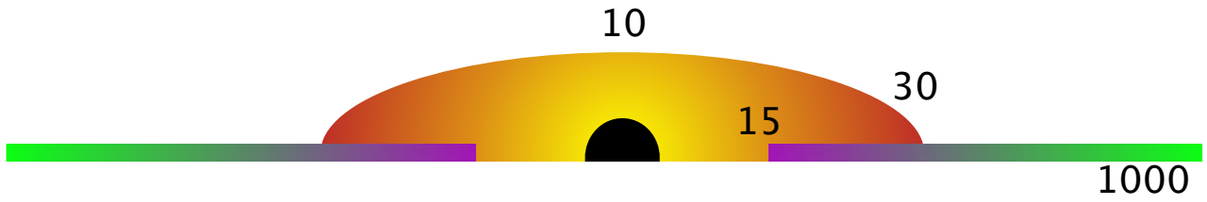
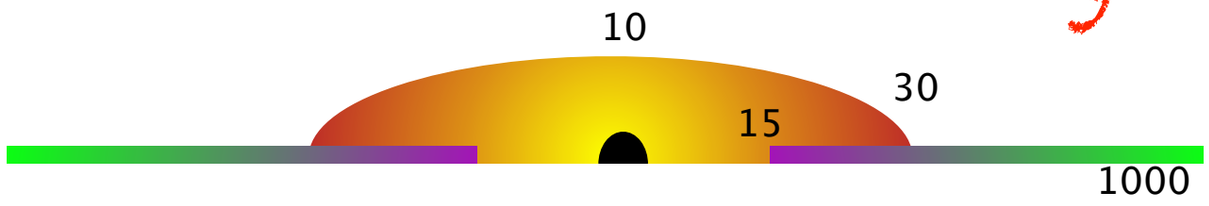




HARD, overlap



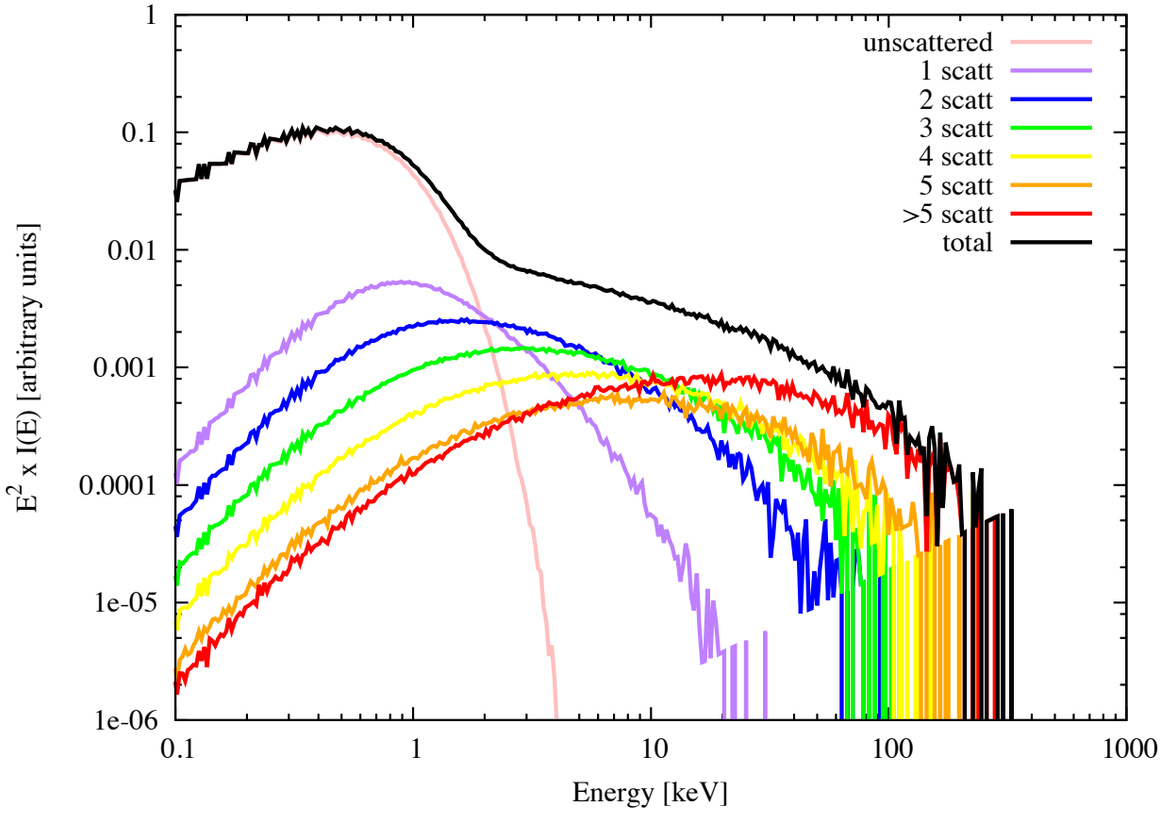
a=0



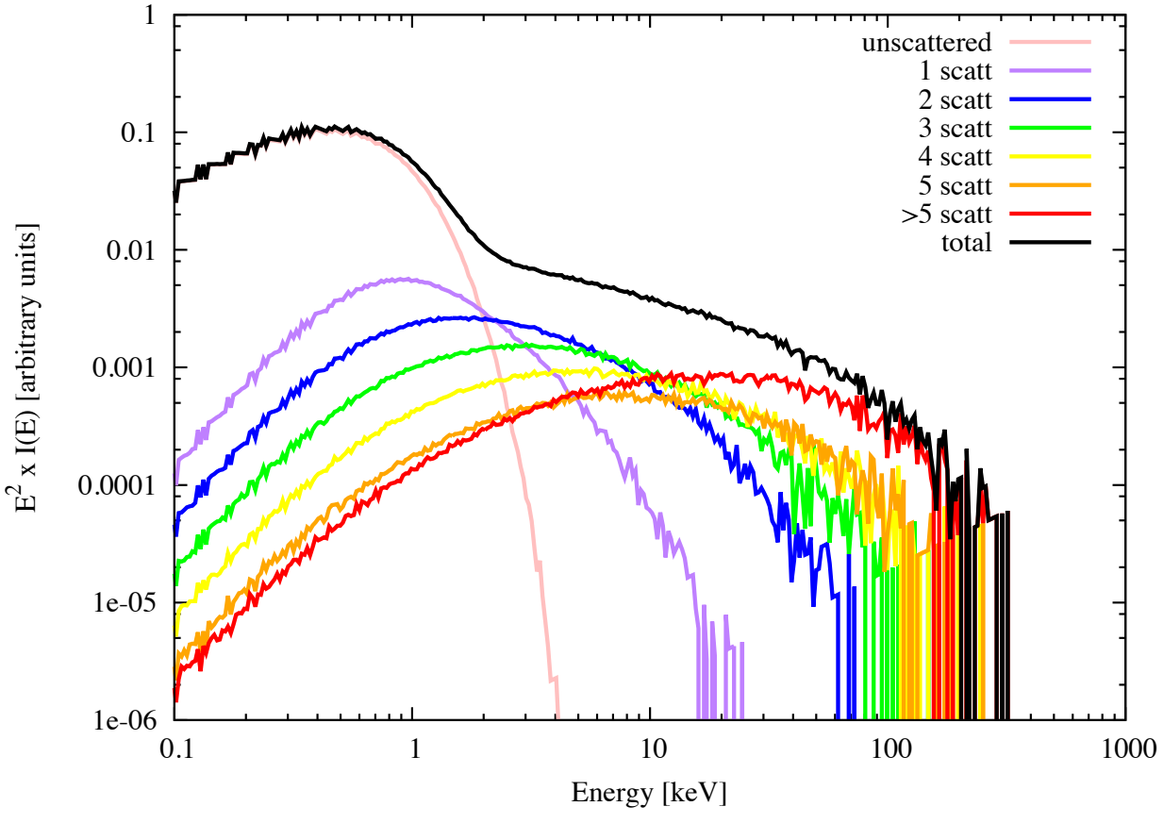
a=0.998

Preliminary

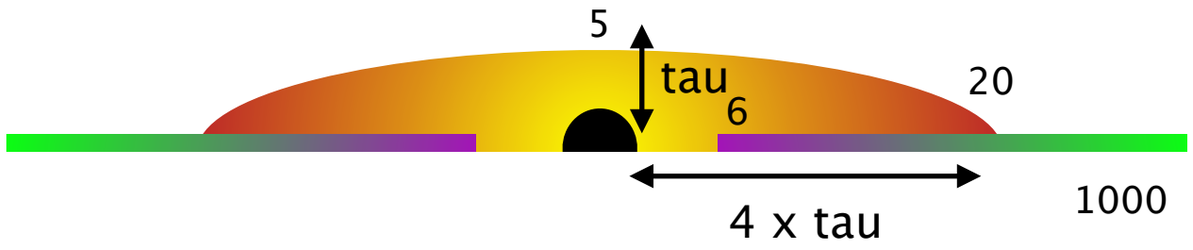
BHB Spectrum (a0 disc 15-1000, mdot01, MBH10) corona 10-30 tau1 kT100 - isorandom



BHB Spectrum (a0998 disc 15-1000, mdot01, MBH10) corona 10-30 tau1 kT100 - isorandor

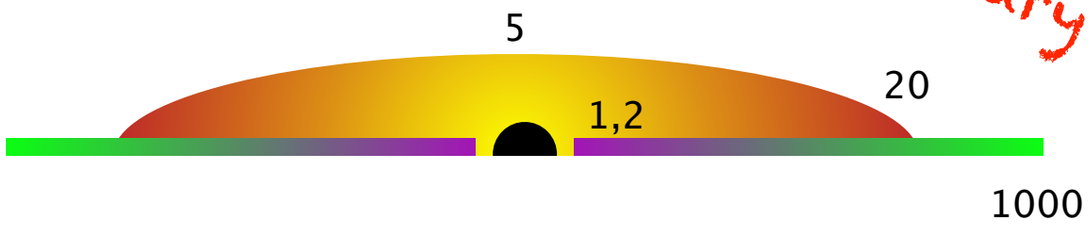


“Compact” spheroid

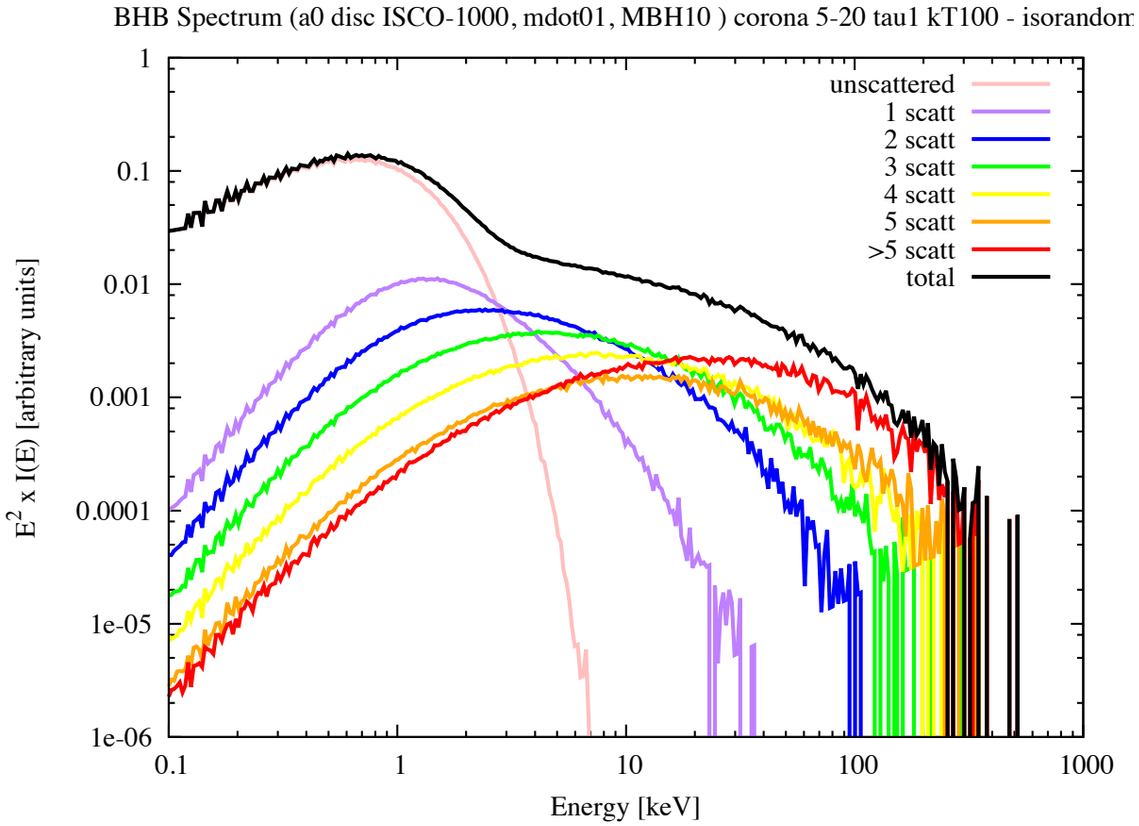


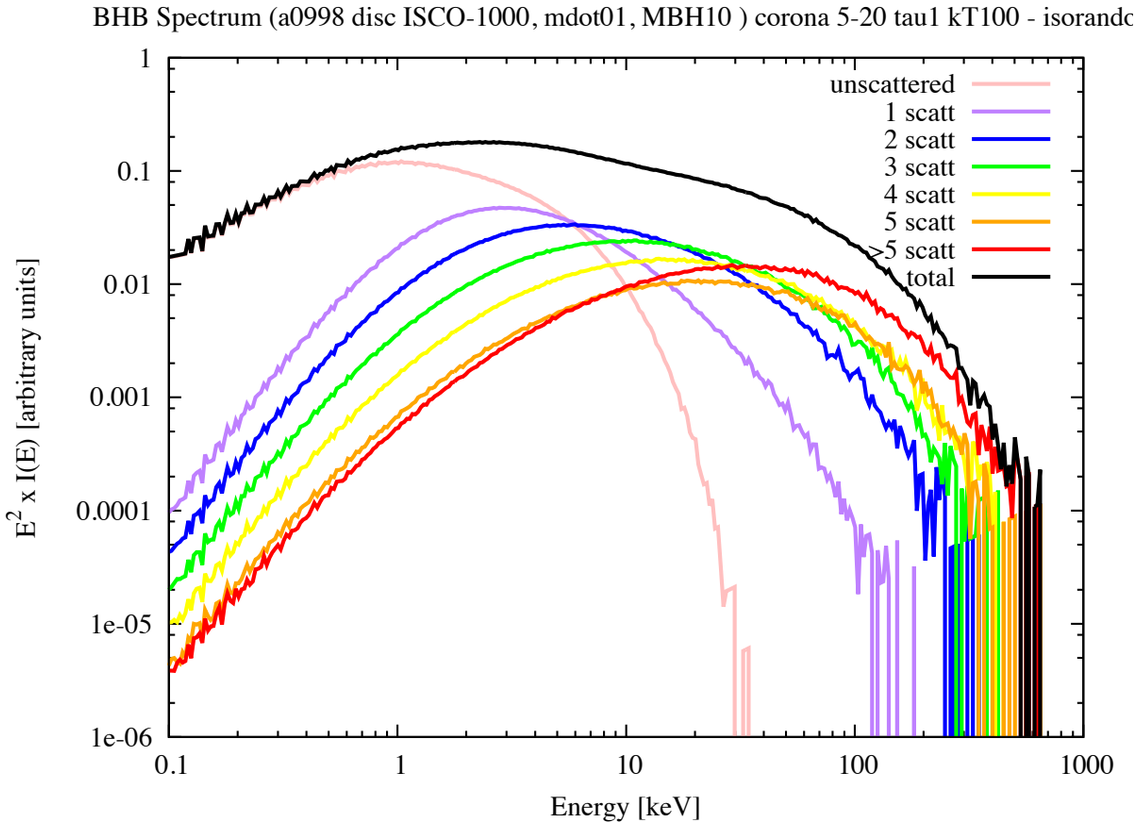
a=0

Preliminary

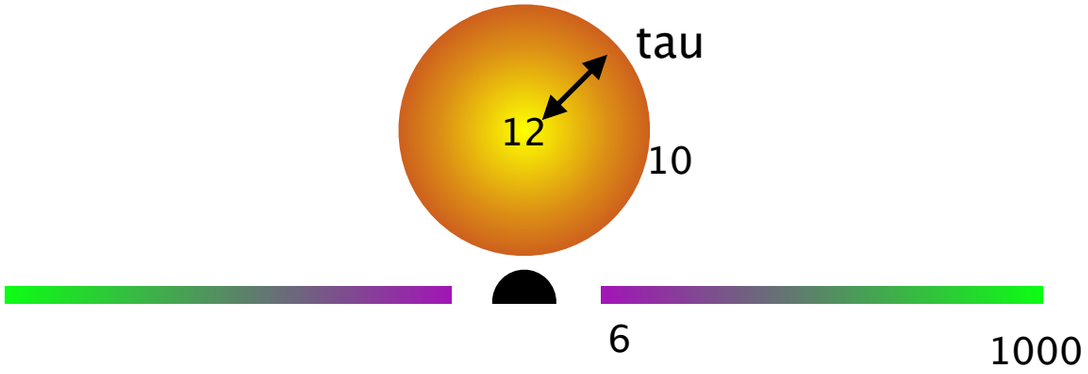


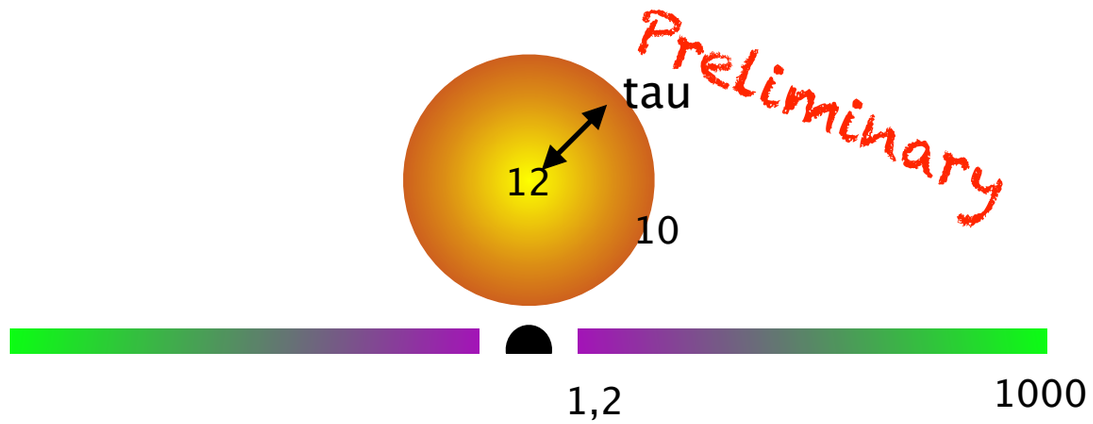
a=0.998





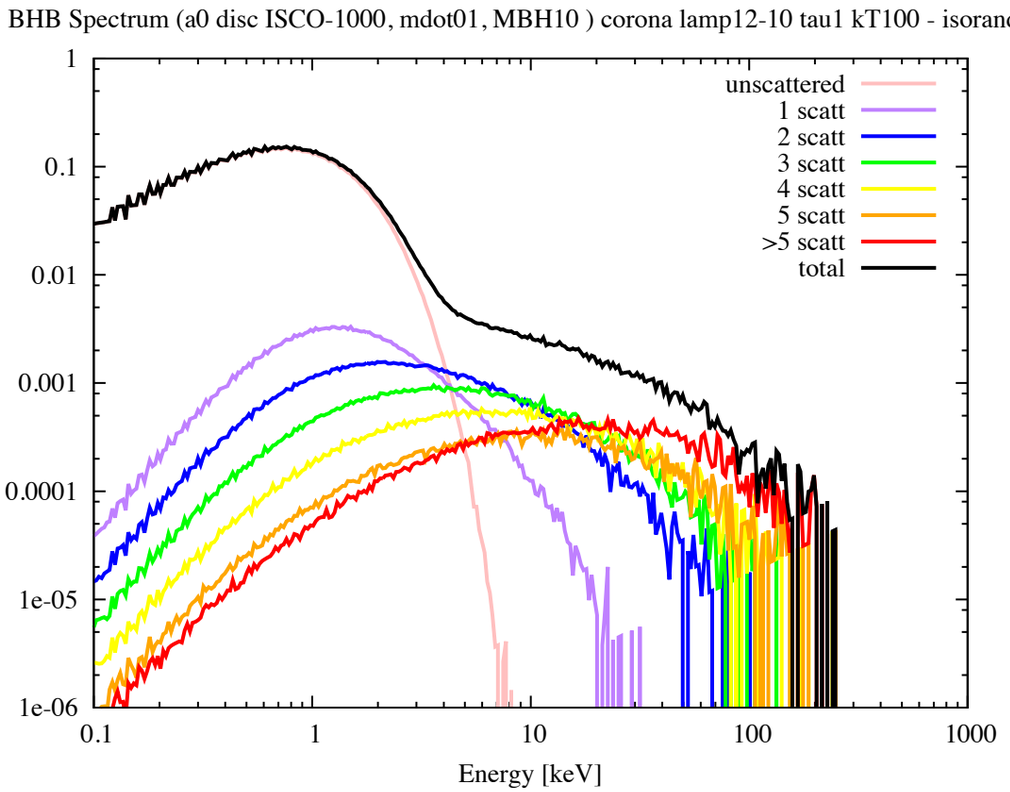
lamp-post

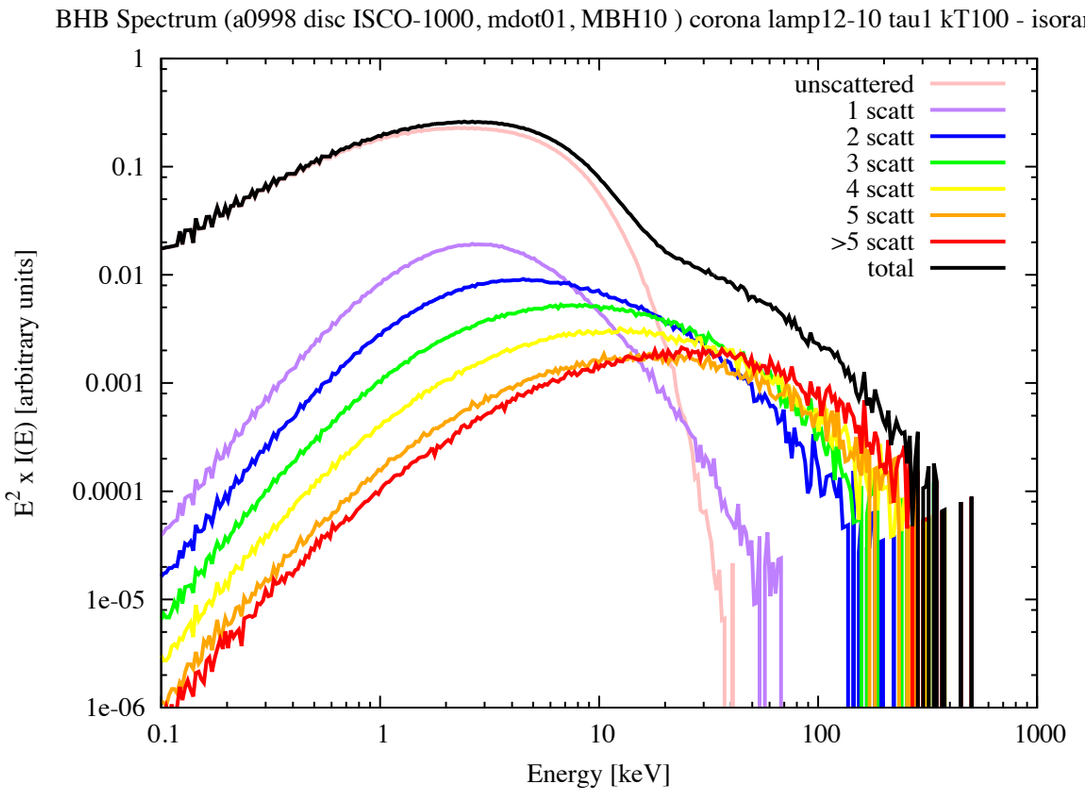




a=0

a=0.998





The response in time of Comptonization

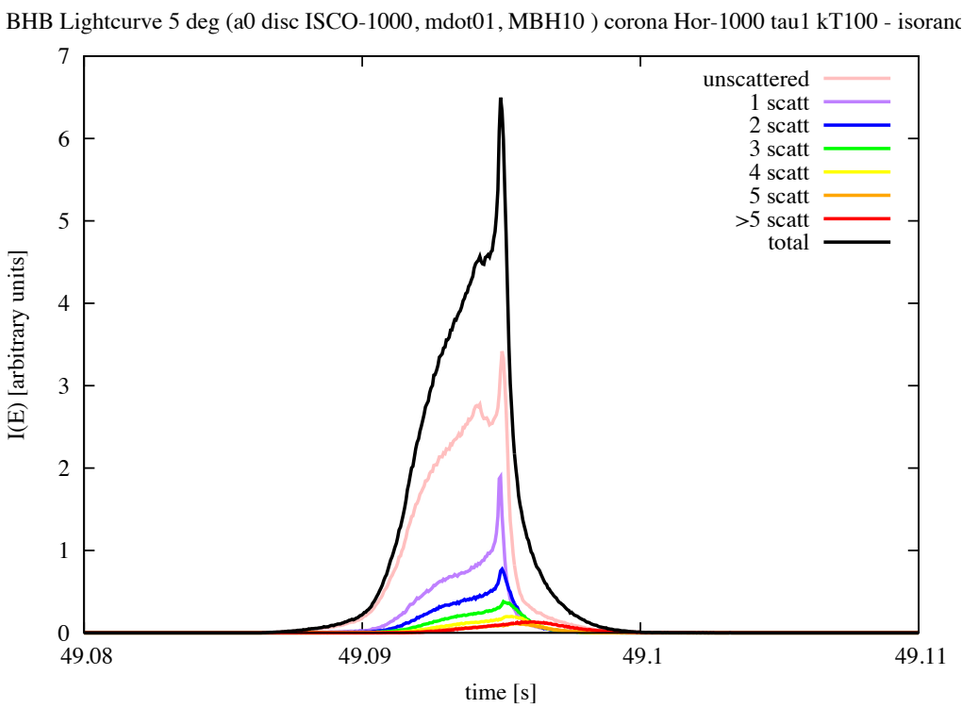
extended slab

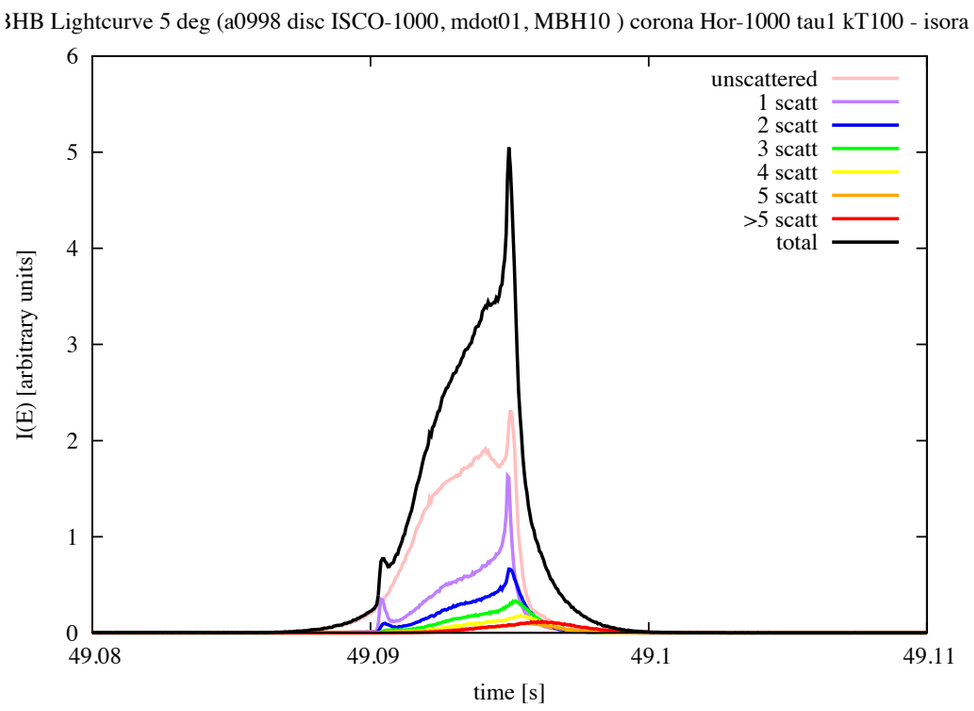
Extremely preliminary

a=0

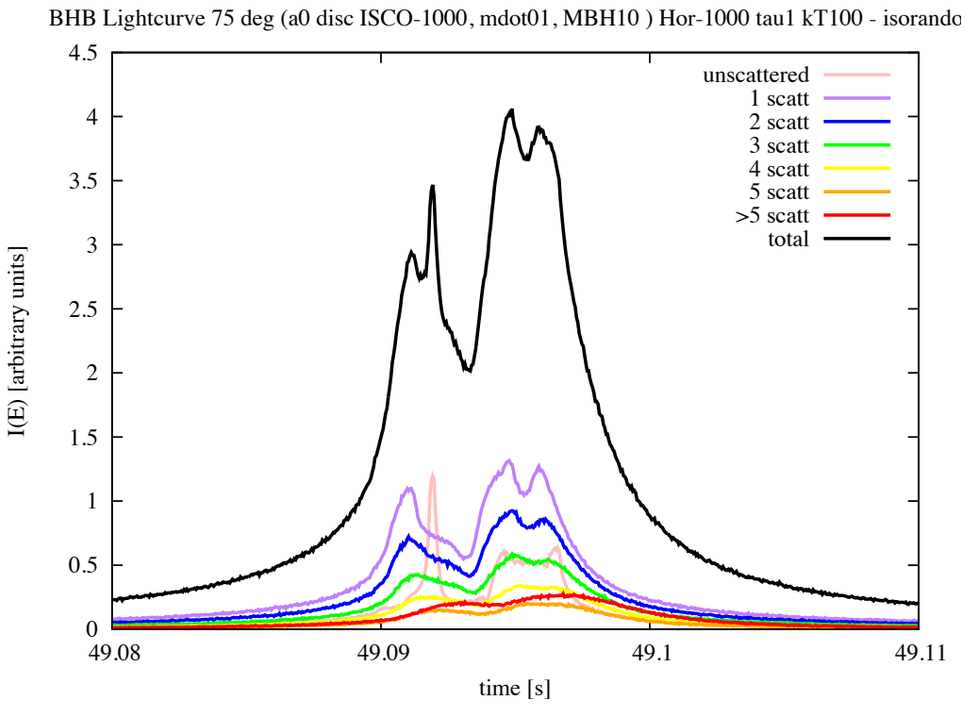
a=0.998

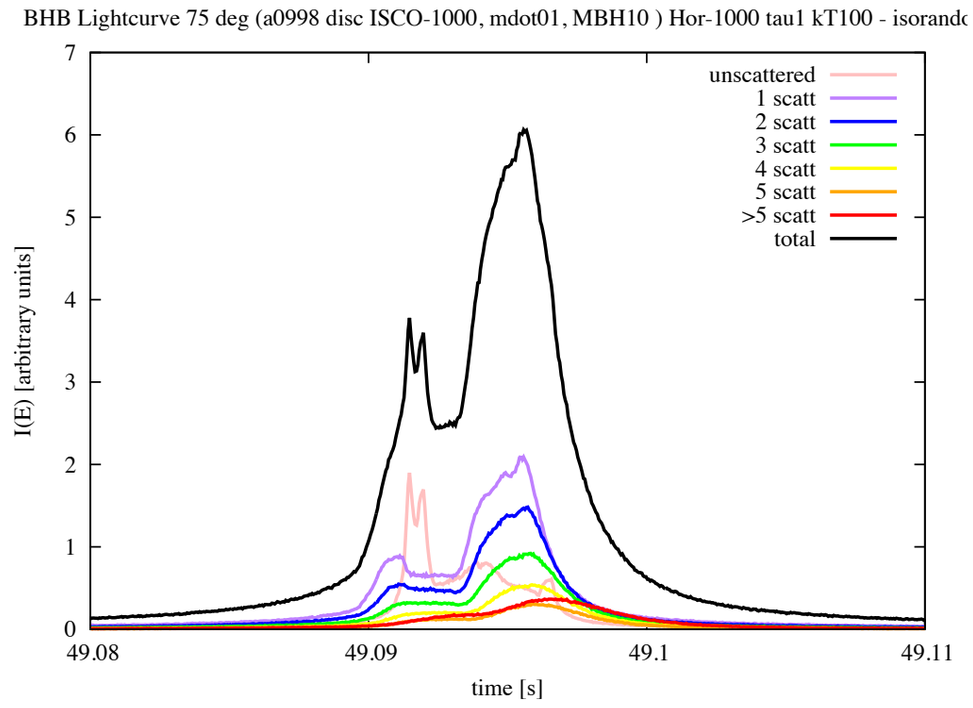
5 deg





75 deg





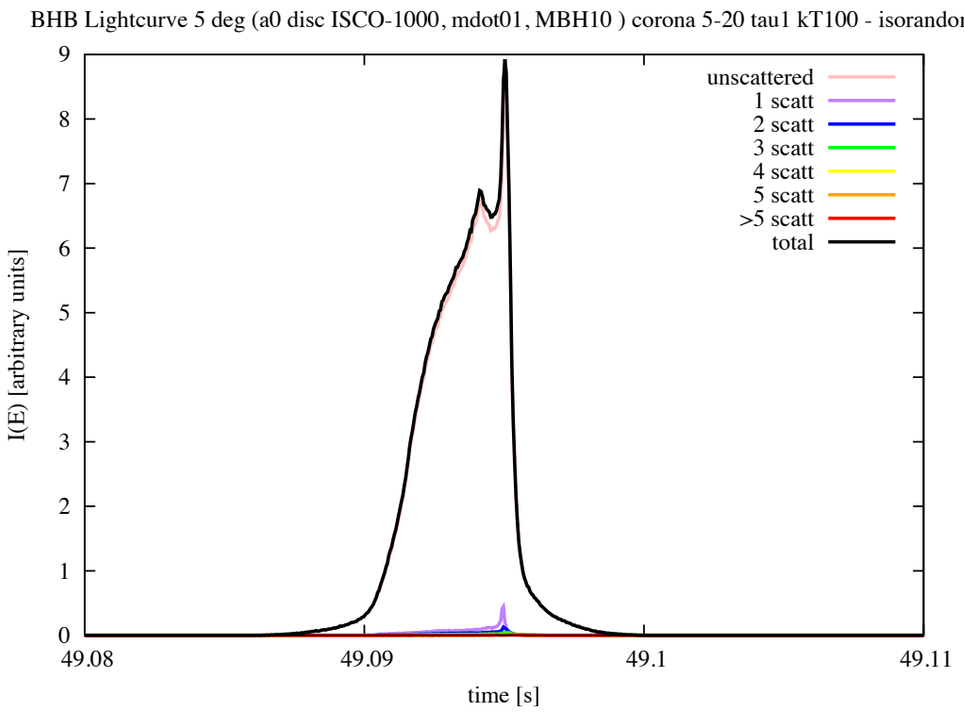
compact spheroid

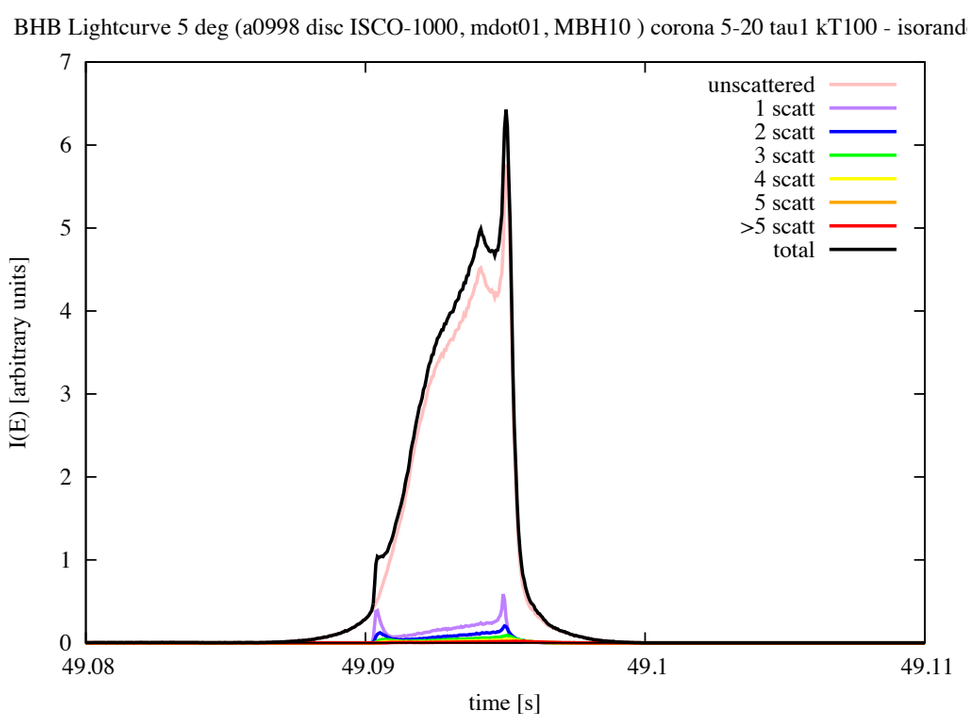
Extremely preliminary

a=0

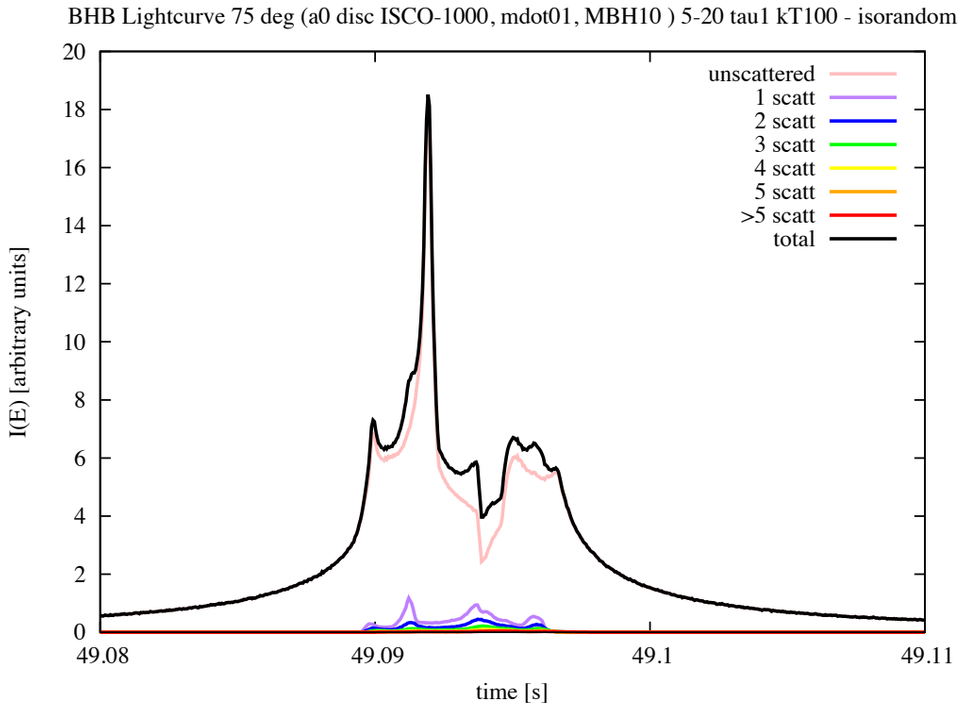
a=0.998

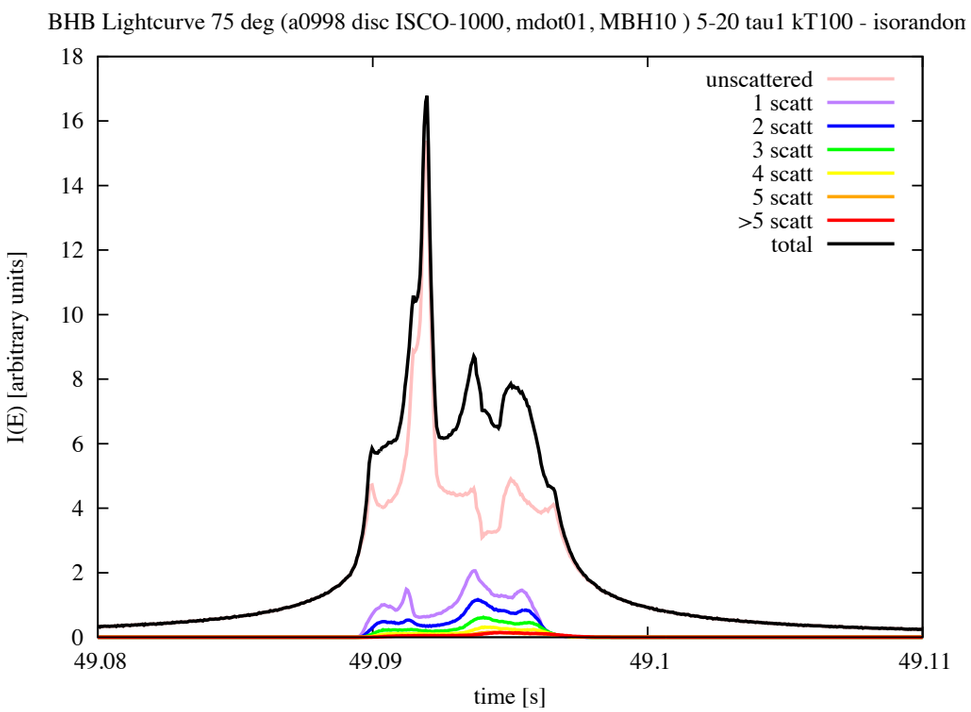
5 deg





75 deg

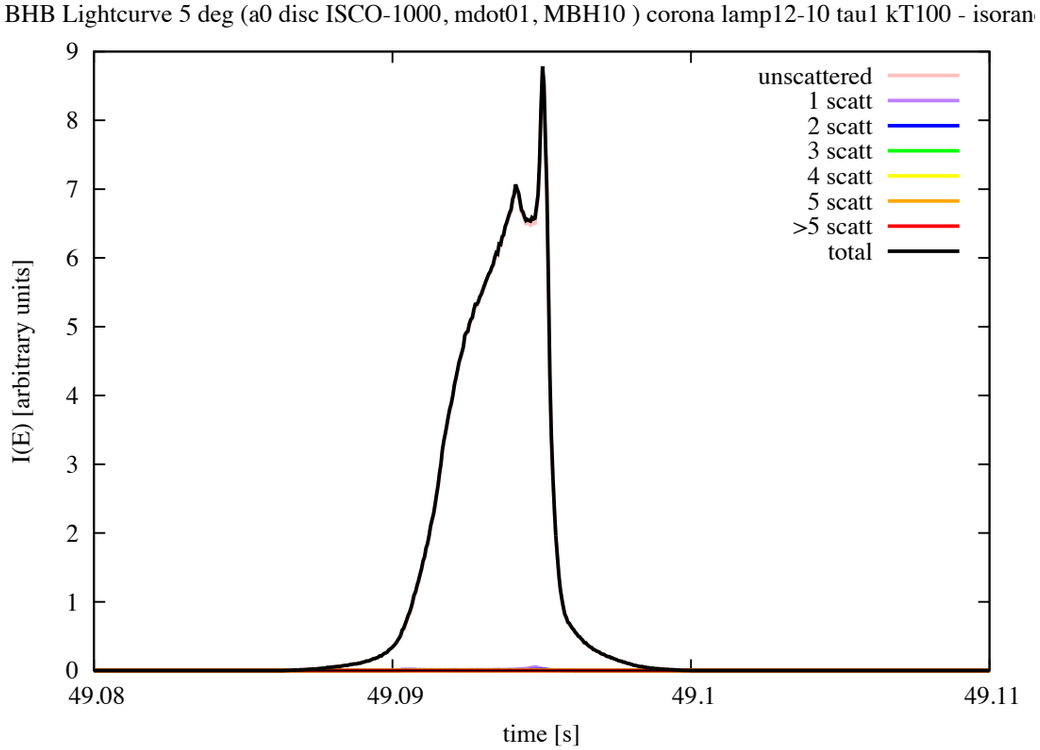




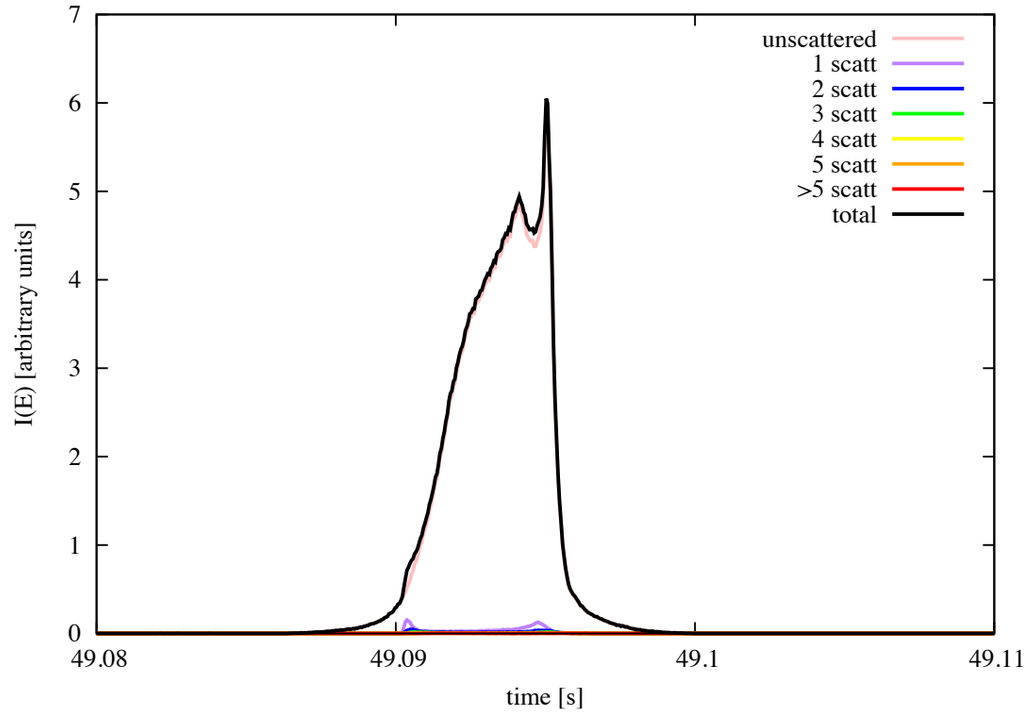
lamp-post

Extremely preliminary

a=0

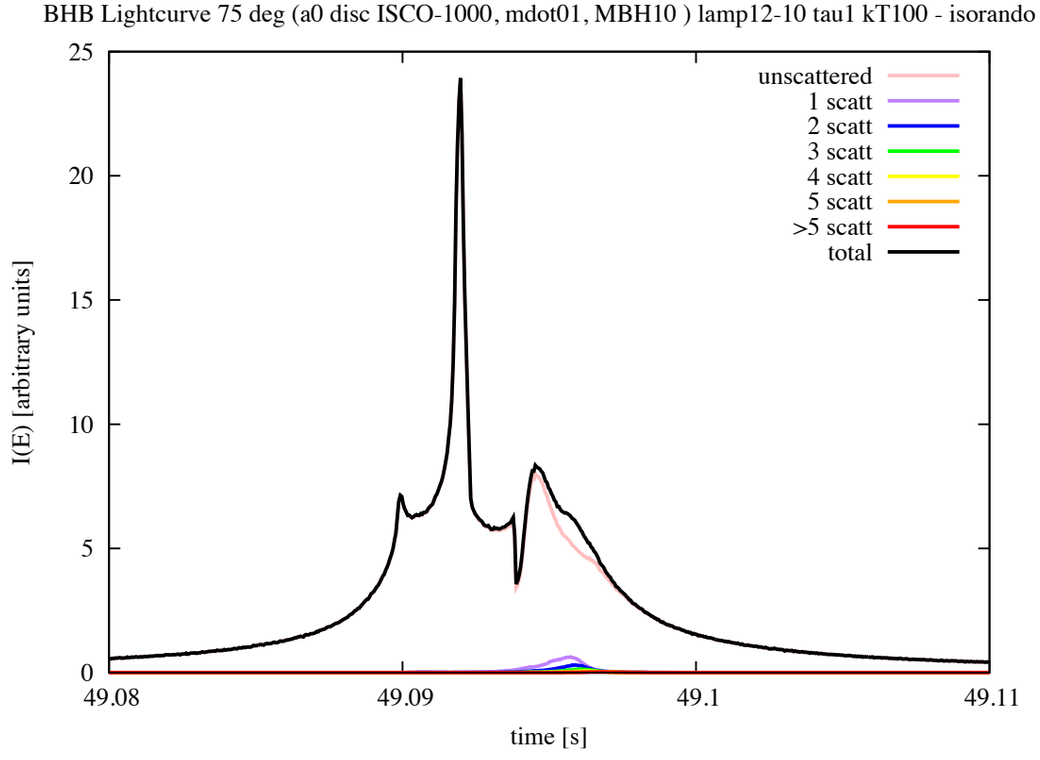


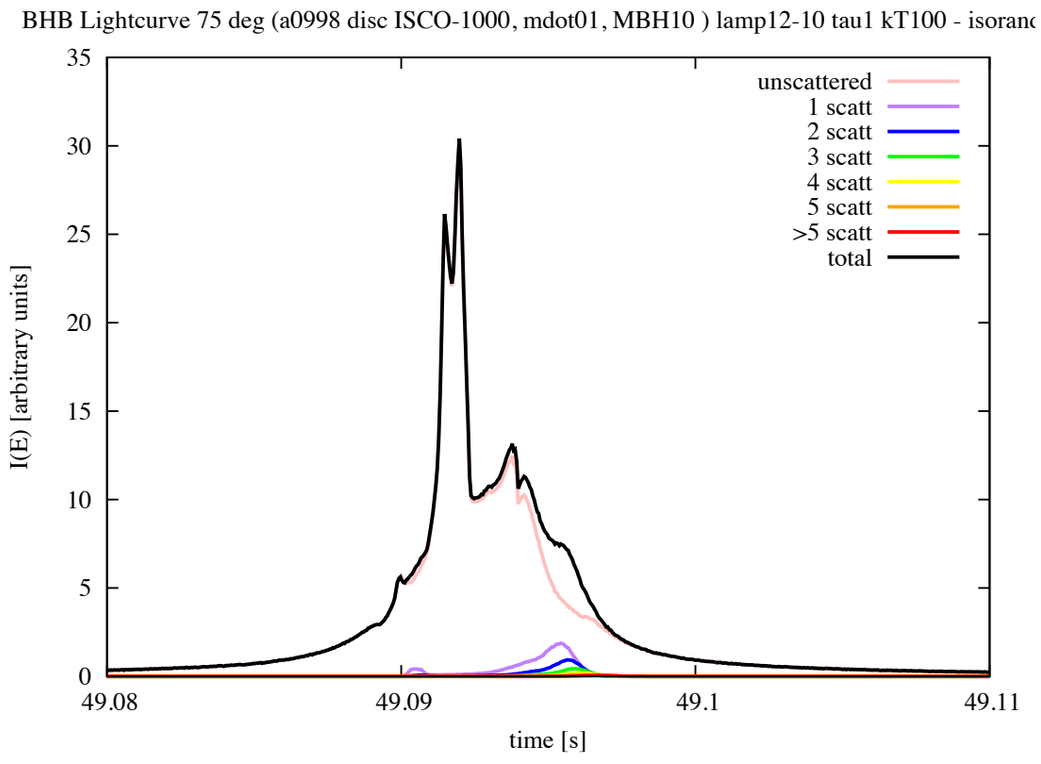
a=0.998



5 deg

75 deg





Conclusions

- with GR we have much softer spectra than expected
- soft/hard state in BHBs seems to be more related to the overlap of disc/corona rather than disc/corona parameters themselves.
- a compact spheroid Comptonizes more than a compact lamp-post with the same volume. More testing and exploration of the parameters space is required (i.e. minimum size of the lamp-post).
- time response due to Comptonization only is really complicated. Disc emission alone is already really complex. (We need to divide in energy bands)

Thanks for your attention