Effect of initial state on thermal photon production in heavy ion collisions

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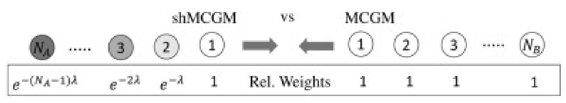
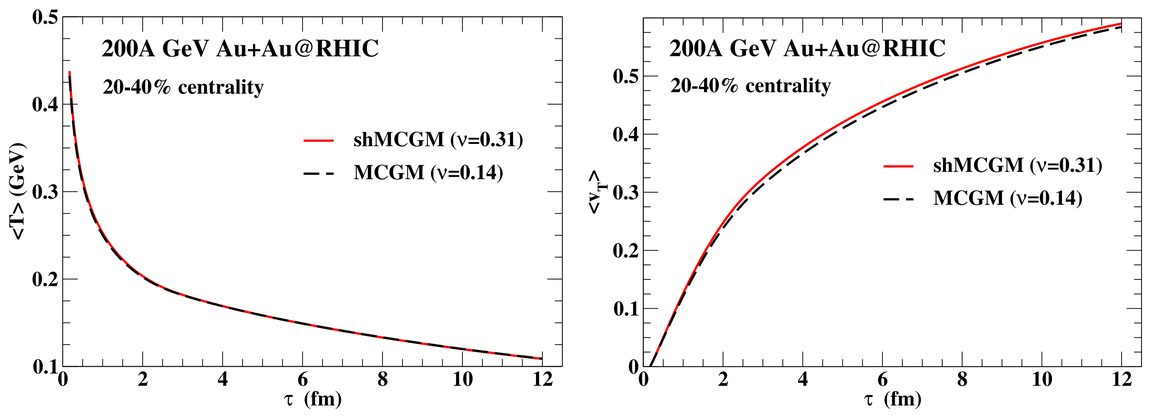
Effect of initial-state nucleon shadowing

In the Monte Carlo Glauber Model (MCGM), the sources for the initial energy depositions can be of two types : (a) participants and (b) binary collisions. The weight given to each participant (or binary collision) source is identical and independent of its position. Unlike MCGM, in the shadowed Monte Carlo Glauber Model (shMCGM) [1], these sources have position-dependent weights due to 'nucleon shadowing'.

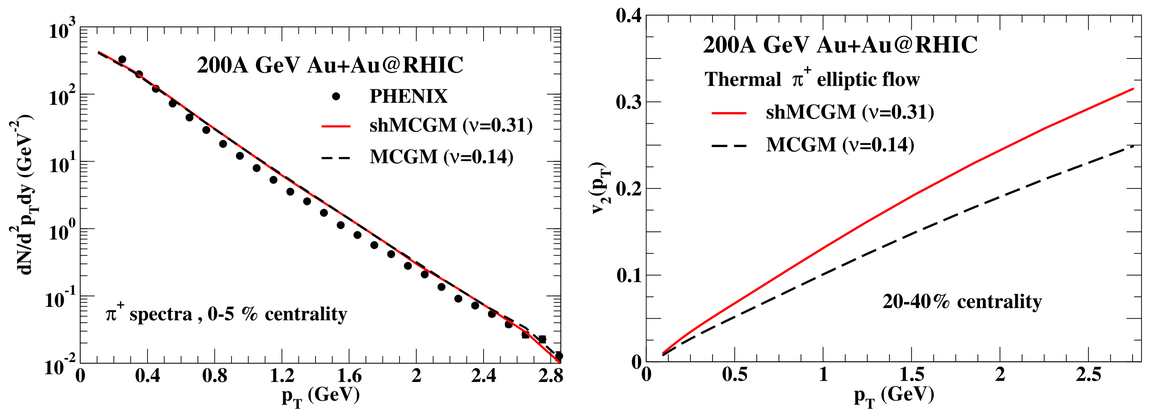


The relative weight factors of each nucleon in a row for Monte-Carlo Glauber and Shadowed Monte-Carlo Glauber [1].

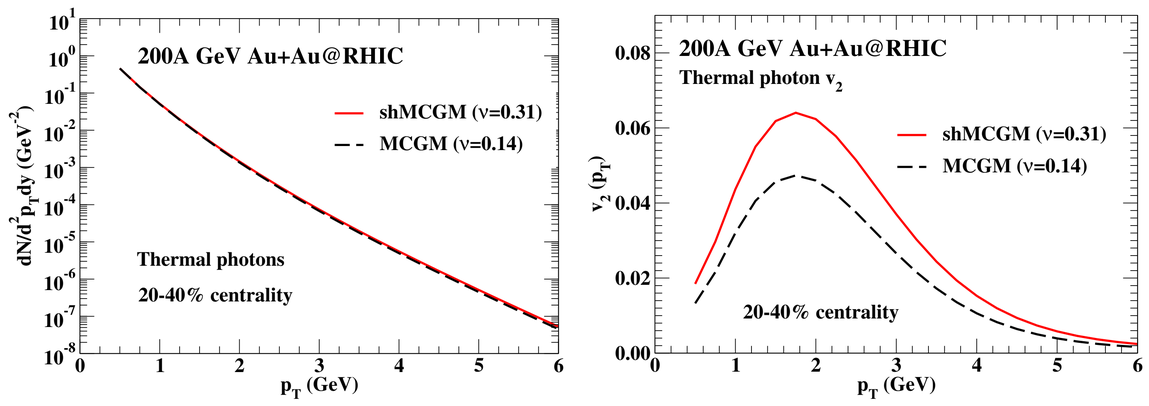
shMCGM has been successful in reproducing the anti-correlation between $\frac{dN_{ch}}{dy}|_{y=0}$ and elliptic flow coefficient (v_2) for most central U+U collisions and the eccentricity distributions for the mid-central Au+Au and U+U collisions [1]. Results in the following show effects of the 'nucleon shadowing' in thermal photon spectra and v_2 for mid-central Au+Au collisions. Our study involves boost-invariant ideal hydrodynamic framework with initial-state averaged smooth profile for both the MCGM and shMCGM cases and we use QGP and hadronic photon rates from the references [2] and [3] respectively to evaluate the photon production.



A similar evolution of average temperature is observed for both the MCGM and shMCGM. However, we see slightly faster expansion in the case of shMCGM.



The inclusion of shadowing does not affect the hadron spectra. However, elliptic flow coefficient (v_2) is getting significantly enhanced due to shadowing.



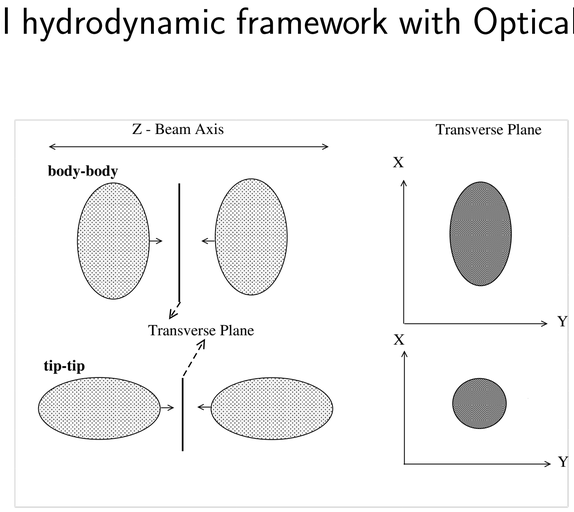
The thermal photon spectra for shMCGM and MCGM are similar. However, the peak value of thermal photon v_2 increases about 36% ($p_T \simeq 2.4\ GeV$). At the same p_T, the increment in v_2 for π^+ is about 29%. Therefore, we see that the effect of shadowing on thermal photon v_2 is larger compared to the v_2 of thermal π^+. We observe similar behaviour at the LHC energy as well [4].

Therefore, a complete calculation considering initial-state shadowing in event-by-event fluctuating initial conditions would be useful to understand the v_2 of photons better.

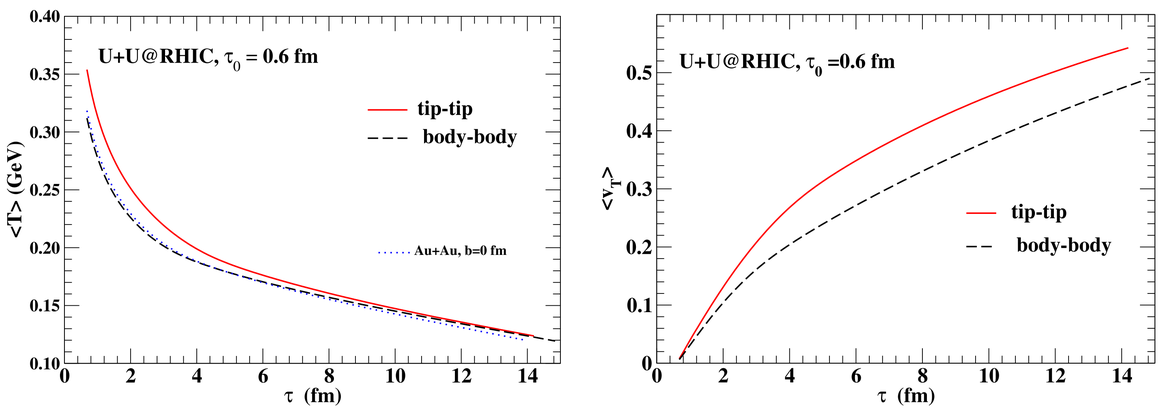
References:
[1] S. Chatterjee *et. al. Physics Letters B* **758**, 269–273(2016). [2] P. Arnold *et.al*, JHEP **0112**, 009 (2001). [3] S. Turbide *et.al*, Phys. Rev. C **69**, 014903 (2004). [4] P. Dasgupta *et.al*, Phys. Rev. C **97**, 034902 (2018).

Effect of deformed initial geometry

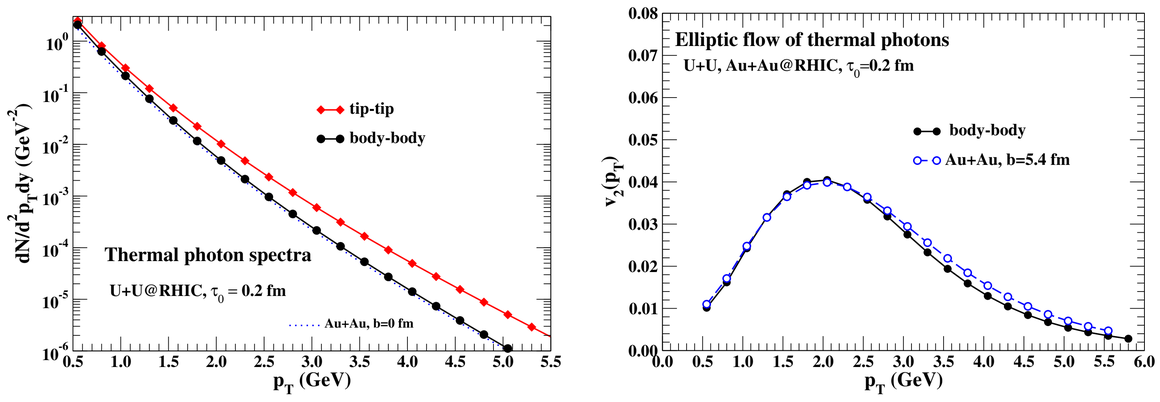
Uranium (^{238}U) nucleus has a non-spherical prolate shape which can lead to different collision geometries and energy depositions even for the most central collisions of uranium nuclei. We consider two extreme cases (in terms of multiplicity) of full overlap collision of uranium nuclei, i.e tip-tip and body-body. The following results show the sensitivity of thermal photon spectrum and flow observable v_2 on these two different collision geometries. Our study involves boost-invariant ideal hydrodynamic framework with Optical Glauber initial profile [1,2].



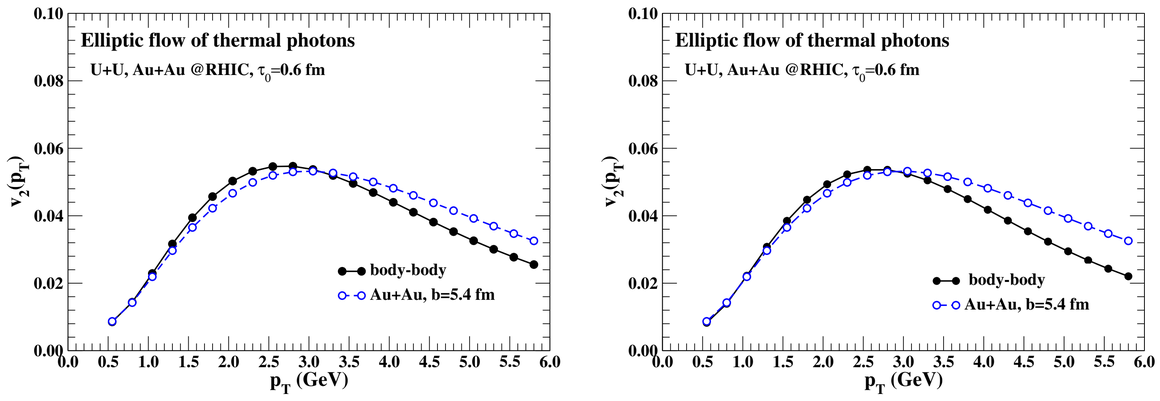
Schematic of tip-tip and body-body collision of full- overlap uranium nuclei [2].



Initial average temperature for tip-tip collision is about 12% higher than body-body collision. As a consequence, tip-tip collision produces much larger v_T compared to the body-body collision [2].



Tip-tip and body-body configurations have different slopes in thermal photon spectra. High p_T thermal photons are produced larger in number for the tip-tip collision than the body-body collision. Whereas, production of thermal photons at low p_T are close to each other. We obtain a large amount of thermal photon v_2 for body-body collision. The v_2 for tip-tip collisions is zero as there is no initial spatial anisotropy present in the system.



Similar qualitative nature of spectra and v_2 are observed for two different initial thermalization time and energy distributions (from two and one compnent Glauber Model). We see that photon v_2 calculated at $b = 5.4$ fm from 200A GeV Au + Au collisions at RHIC is comparable to the v_2 from body-body U + U collisions [2]. Comparison of photon v_2 from mid-central Au + Au collisions at RHIC would be valuable to understand the photon-v_2 puzzle.

References : [1] U. Heinz *et. al. Phys. Rev. Lett.* **94**, 132301(2005). [2] P. Dasgupta *et.al*, Phys. Rev. C **95**, 064907 (2017).

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