Update on direct photon simulations at NICA energies

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What's new

- More data simulated (0<b<9 fm)
- Energies: 11 GeV, 4.9 GeV(c.m.s)
- Answer from prof. Marcus Bleicher (granted permission for UrQMD code usage for direct photon studies). Also he send us a link to his work with simulations for FAIR energies (2-35 AGeV). We compare now with them our results.
- Reference: Phys. Rev. C 93, 054901 (2016)

Photon and dilepton production at the Facility for Antiproton and Ion Research and the beam energy scan program at the Relativistic Heavy-Ion Collider using coarse-grained microscopic transport simulations

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(Dated: May 2, 2016)

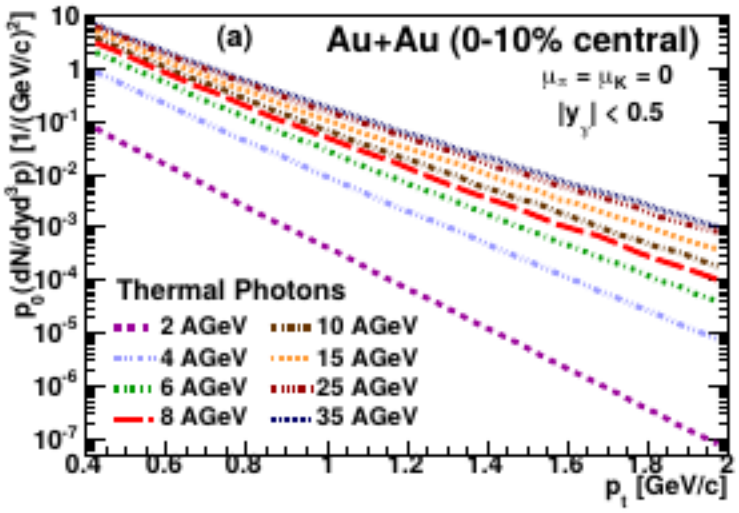
We present calculations of dilepton and photon spectra for the energy range $E_{\rm lab} = 2 - 35\,A$GeV which will be available for the Compressed Baryonic Matter (CBM) experiment at the future Facility for Anti-Proton and Ion Research (FAIR). The same energy regime will also be covered by phase II of the Beam Energy Scan at the Relativistic Heavy-Ion Collider (RHIC-BES). Coarse-grained dynamics from microscopic transport calculations of the Ultra-relativistic Quantum Molecular Dynamics (UrQMD) model is used to determine temperature and chemical potentials, which allows for the use of dilepton and photon-emission rates from equilibrium quantum-field theory calculations. The results indicate that non-equilibrium effects, the presence of baryonic matter and the creation of a deconfined phase might show up in specific manners in the measurable dilepton invariant mass spectra and in the photon transverse momentum spectra. However, as the many influences are difficult to disentangle, we argue that the challenge for future measurements of electromagnetic probes will be to provide a high precision with uncertainties much lower than in previous experiments. Furthermore, a systematic study of the whole energy range covered by CBM at FAIR and RHIC-BES is necessary to discriminate between different effects, which influence the spectra, and to identify possible signatures of a phase transition.

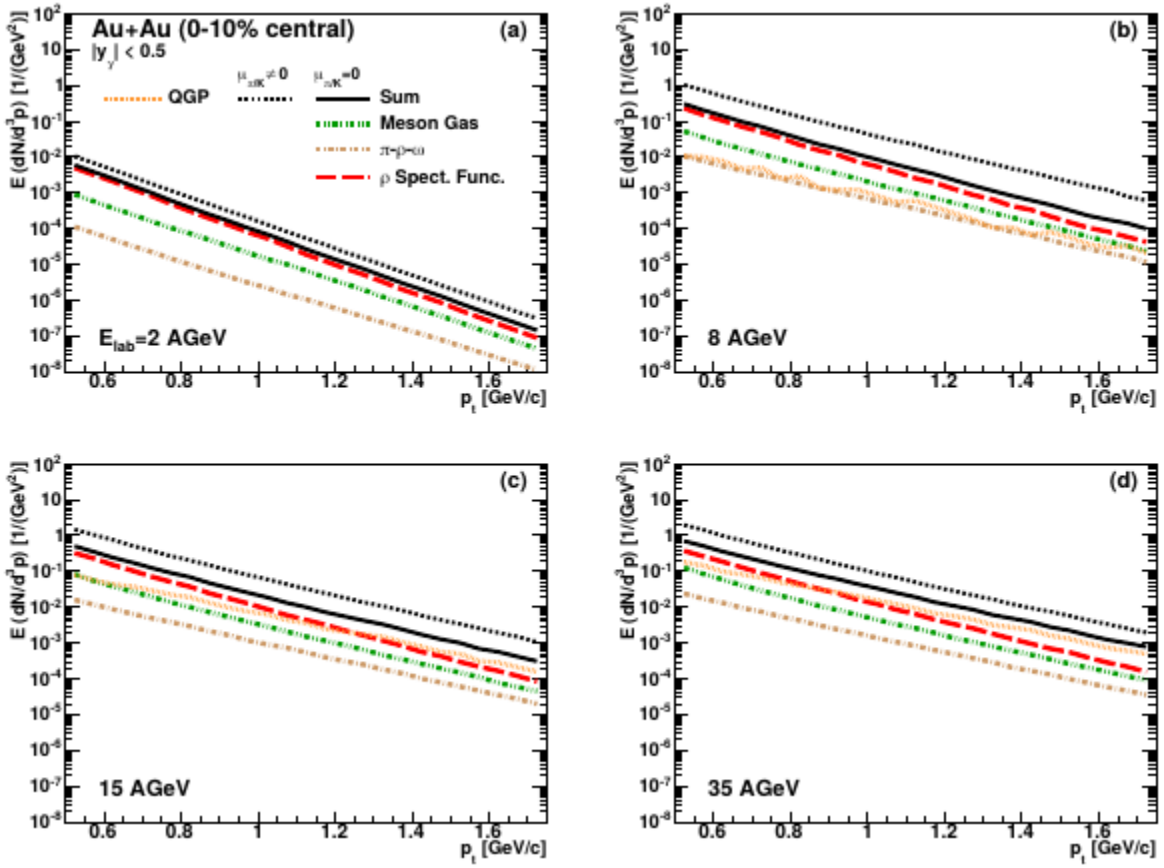
PACS numbers: 25.75.Cj, 24.10.Lx
Keywords: Dilepton & photon production, Monte Carlo simulations

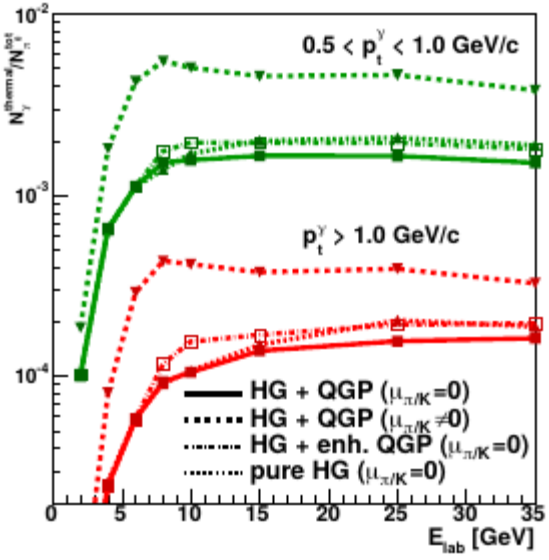
Short overview of this work

- Similar to previous work with simulations for WA98 (Phys.Rev.C81:044904,2010), also based on AMY rates from QGP and Turbide, Rapp, Gale rates from HG.
- HG EOS (not BagModel!)
- Discussions on non-equilibrium dynamics (additional contribution from hadrons)

Why fig. 8 and 11 show different results???



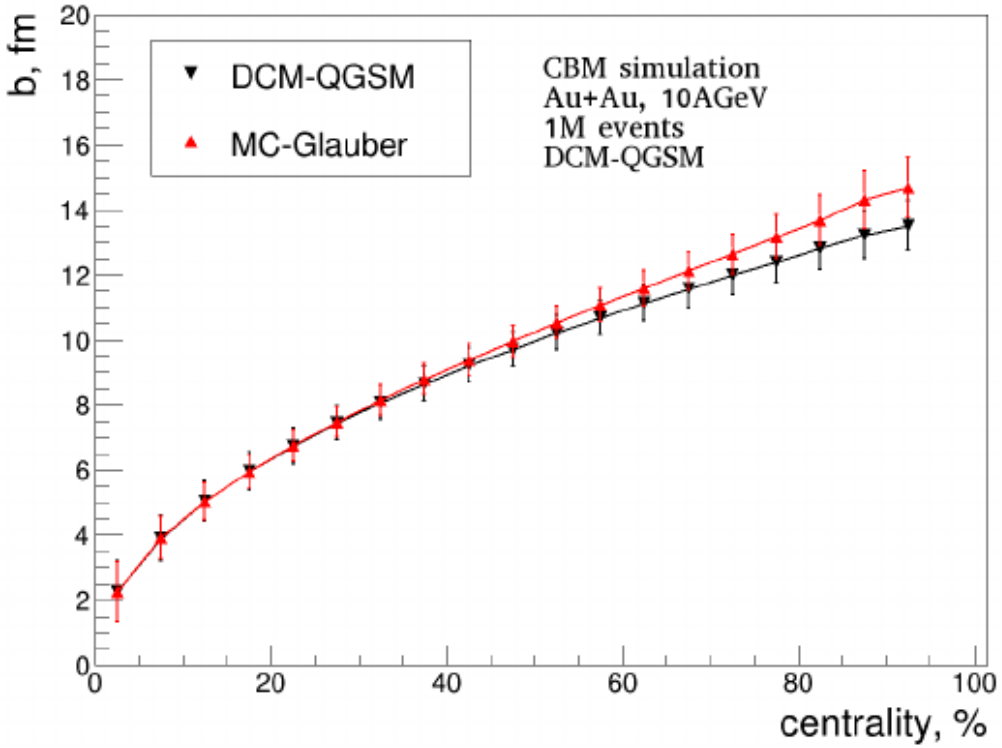




Interesting results on $\gamma/\pi 0$ dependence on energy

Centrality

- Centrality intervals approximately taken as in CBM studies. Do we have similar for NICA?
- b<4.5 fm → 0-10% centrality
- 6<b<9 fm → 20-40% centrality



V. Klochkov, I. Selyuzhenkov
2017 J. Phys.: Conf. Ser. 798 012059

Simulation setup

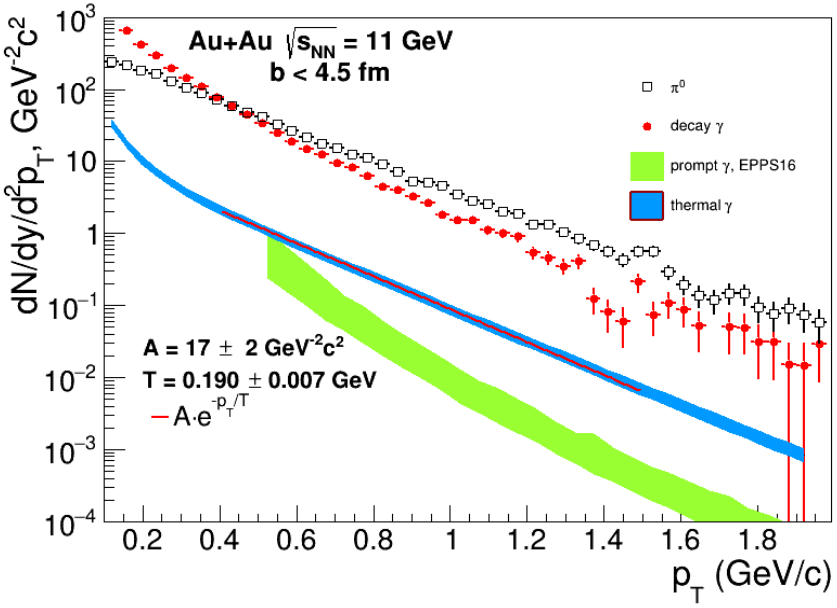
- 1000 events for **11 GeV**, 2000 events for 5 GeV
- **Imp -9**
- Tim 30 30 (to exit if simulation takes too long, maybe can increase)
- 1 event per job
- Bag model EOS
- Each job produce final particles (f14 file) and hydro output (modified fort.21). Can compare them event by event!

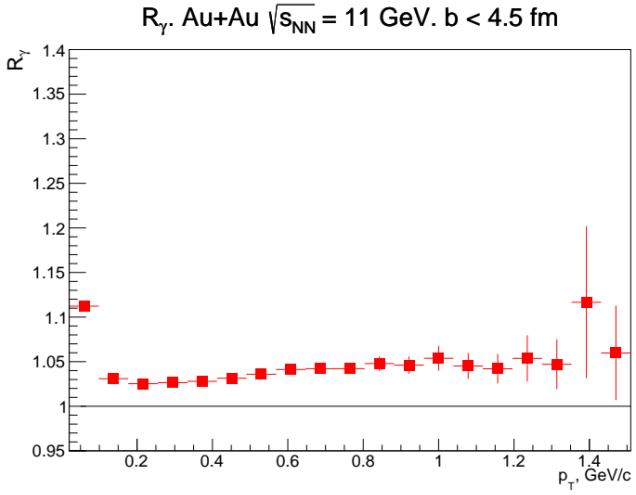
- Prompt direct photons simulated by D.Peresunko using JetPHOX package. Scaling by Number of binary collisions with values taken from LHC calculations by D. D'Enterria. Do we have Nbc calculations for NICA?
- Details in previous talks

Calculations at $\sqrt{s_{NN}}$ = 11 GeV

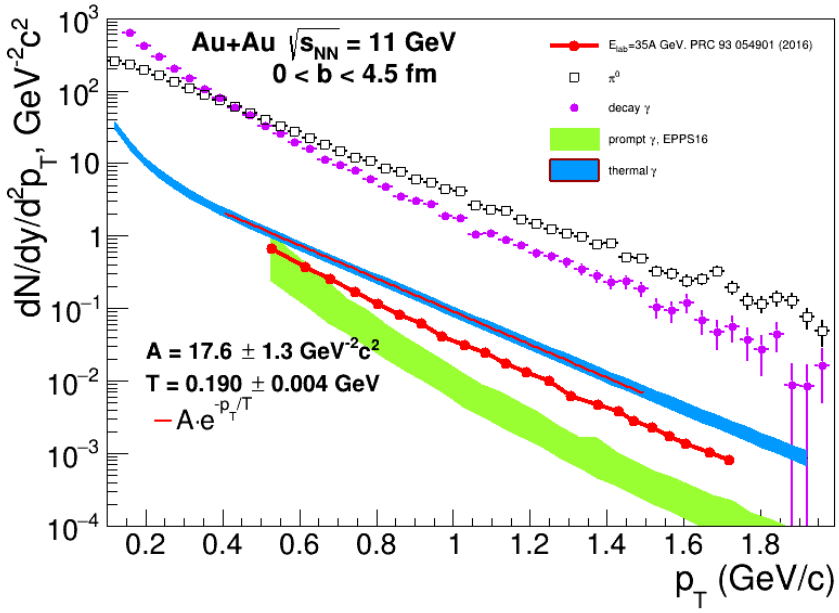
- New results have smaller errors due to statistics increase.
- R_γ is ~ 5% at 1 GeV/c (for b<4.5).
- Comparison to Elab=35A GeV – results consistent.

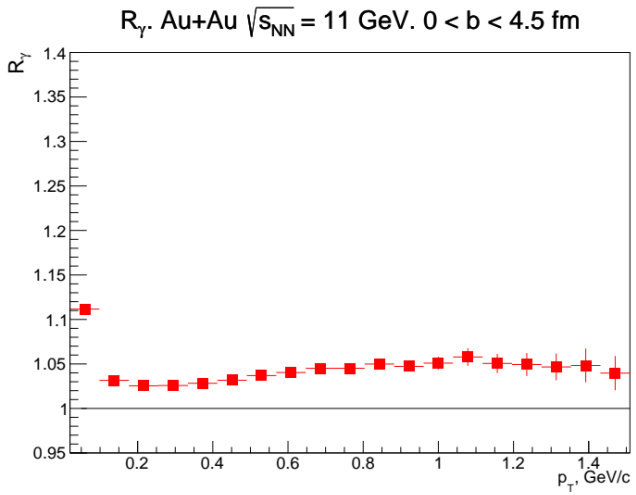
b<4.5 fm Previous!





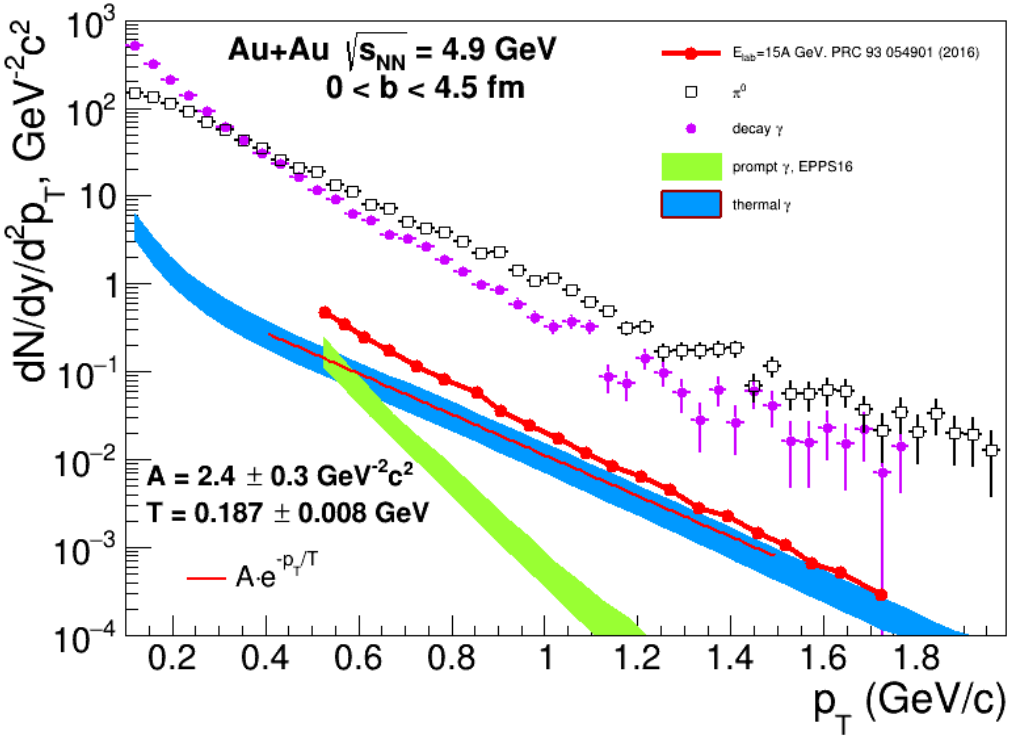
b<4.5 fm New!

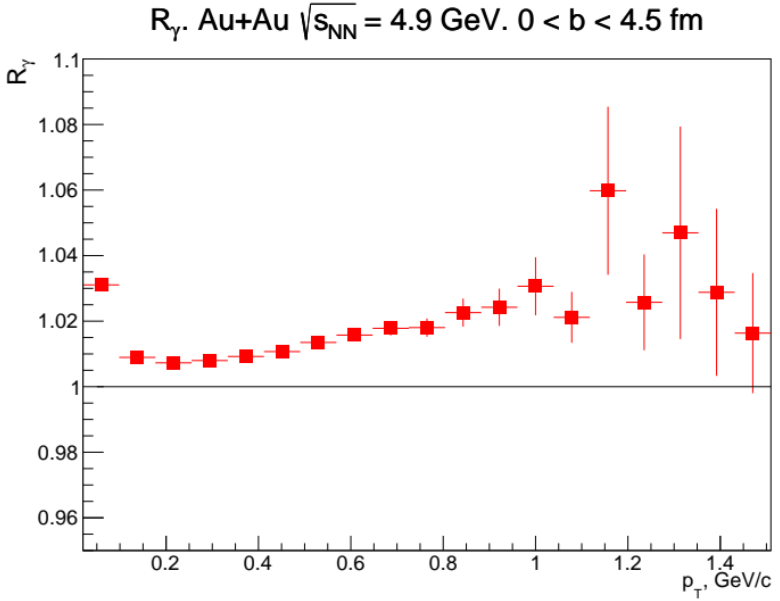




Calculations at $\sqrt{s_{NN}} = 4.9$ GeV

- R_γ is ~ 2% at $p_T < 1$ GeV/c (for b<4.5).
- Comparison to Elab=15A GeV – results consistent.

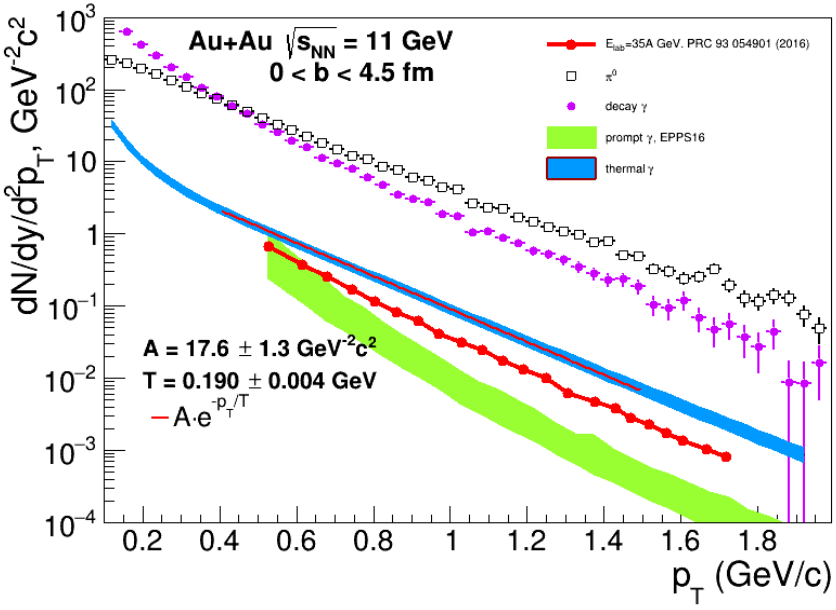




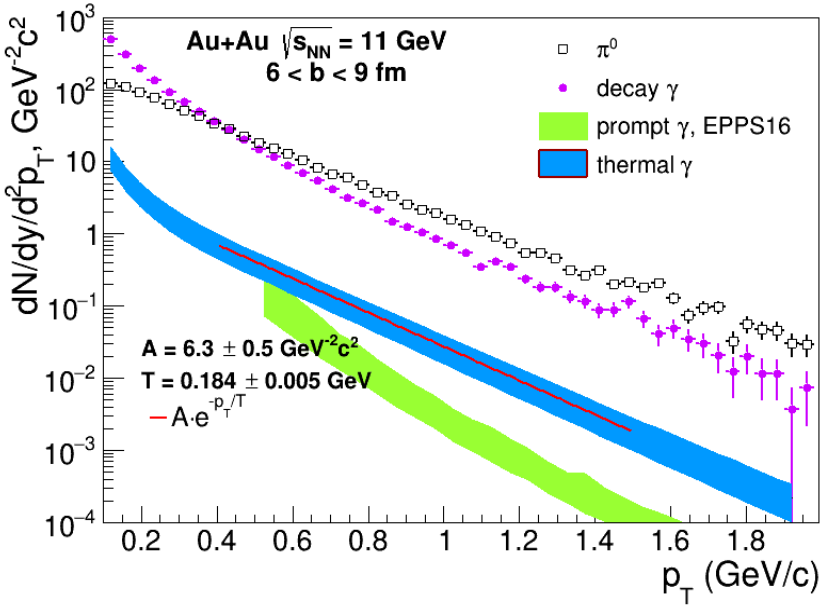
Centrality dependence at 11 GeV

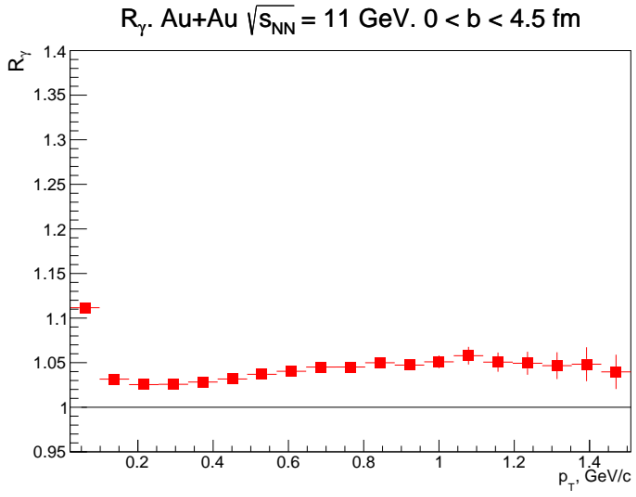
- Compare 0-10% and 20-40%
- Yield smaller by ~ 3 times.
- R_γ for 20-40% is about 2-3%. Much larger event-by-event fluctuations

b<4.5 fm

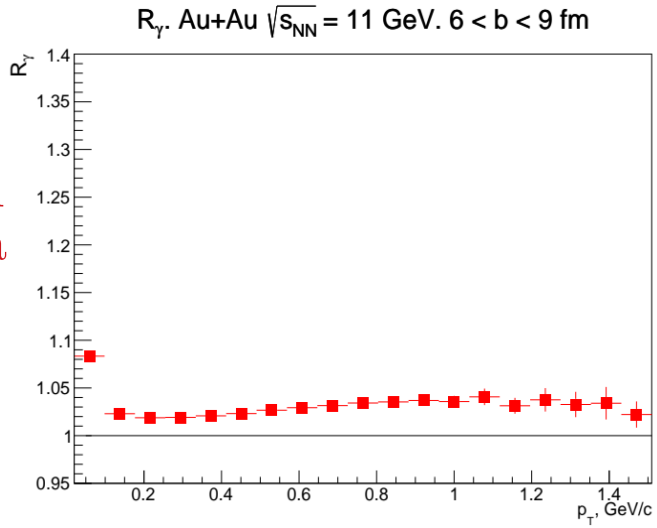


6<b<9 fm





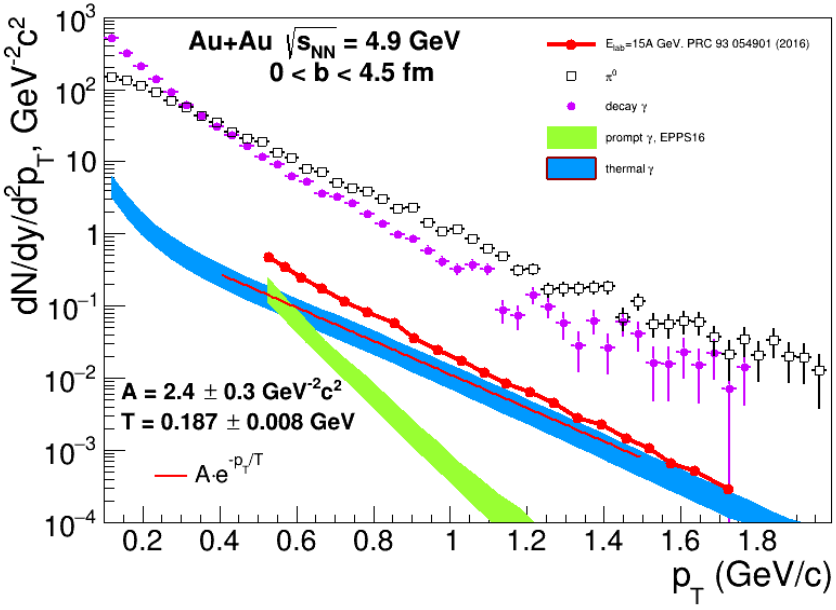
Note: R_γ doesn't contain prompt gamma contribution

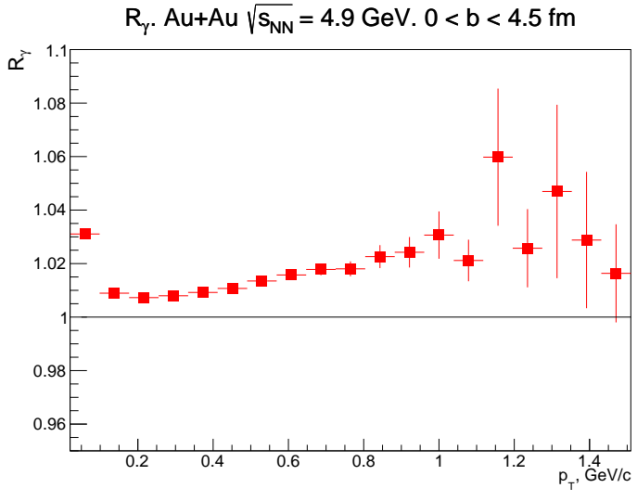


Centrality dependence at 4.9 GeV

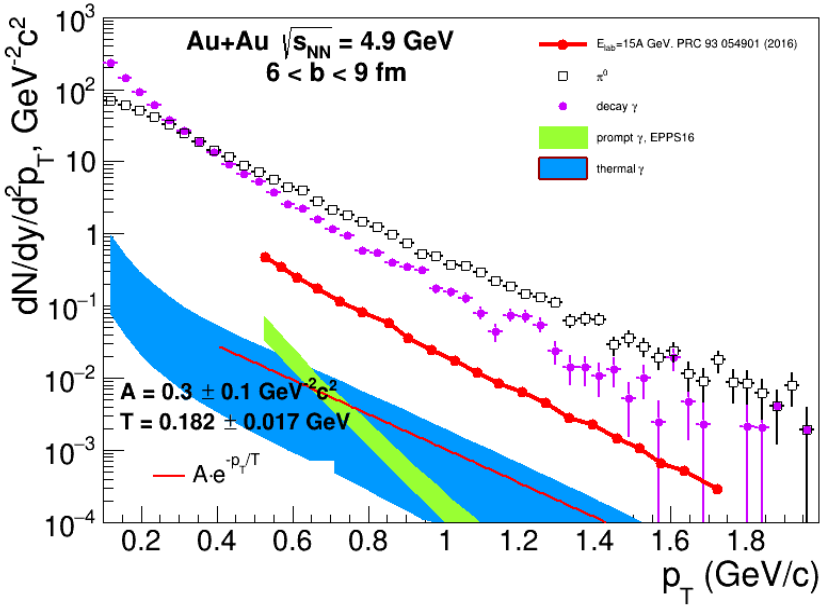
- Compare 0-10% and 20-40%
- Yield smaller by ~ 10 times.
- R_γ for 20-40% centrality is below 1%.

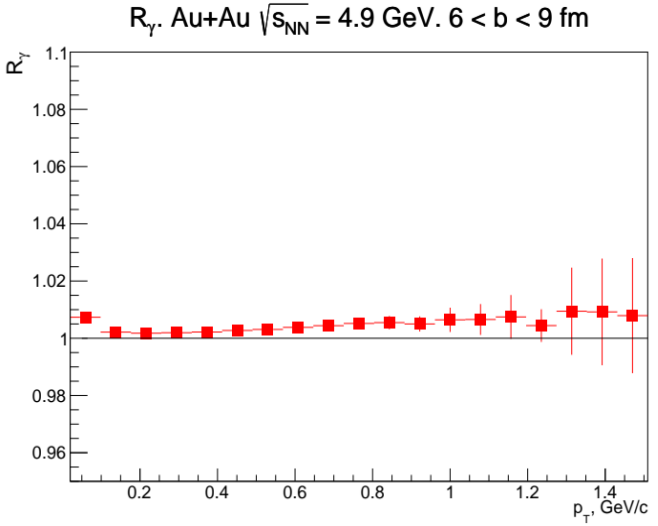
b<4.5 fm





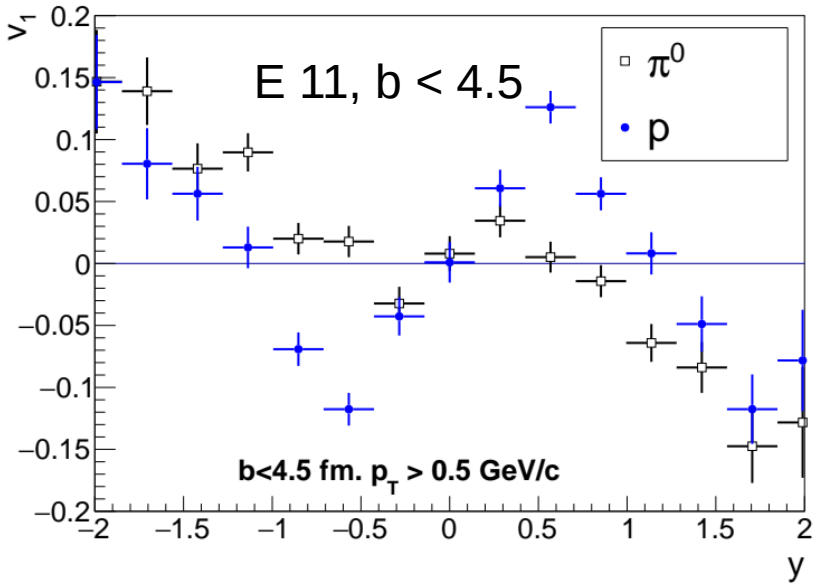
6<b<9 fm

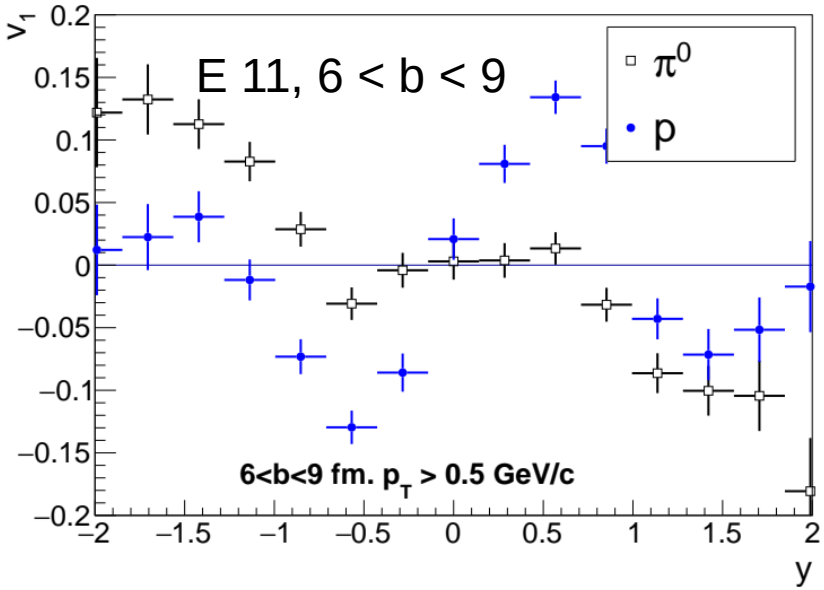


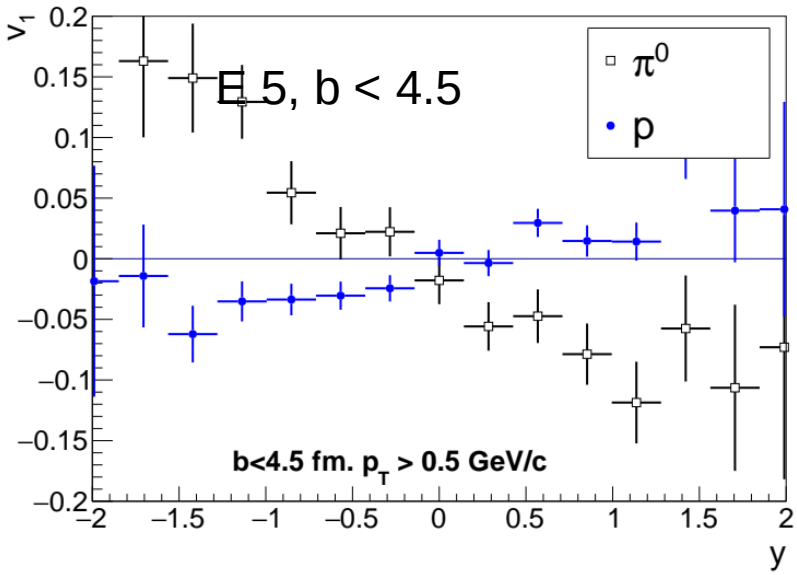


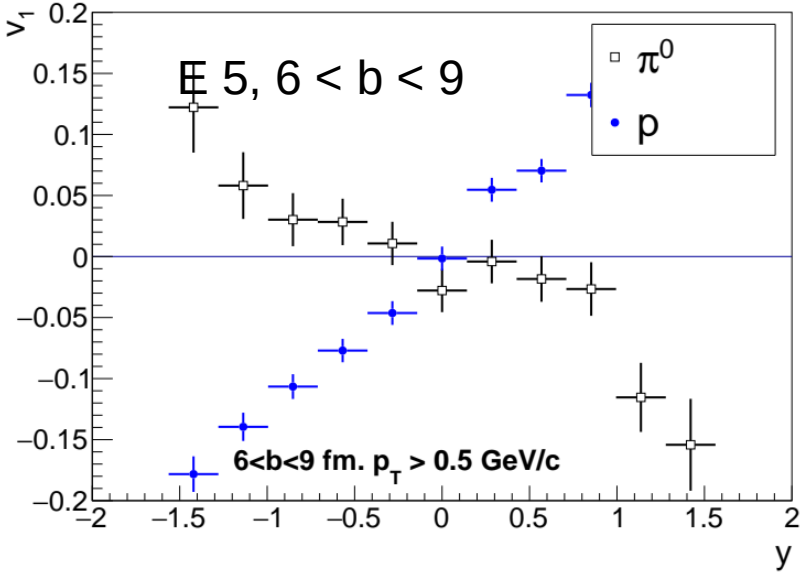
Directed flow of hadrons

- $v_n = \langle \cos(n\varphi_i) \rangle$
- $p_T > 0.5$ GeV/c
- Compare different energy and centrality. Strange behavior at 11 GeV not understood



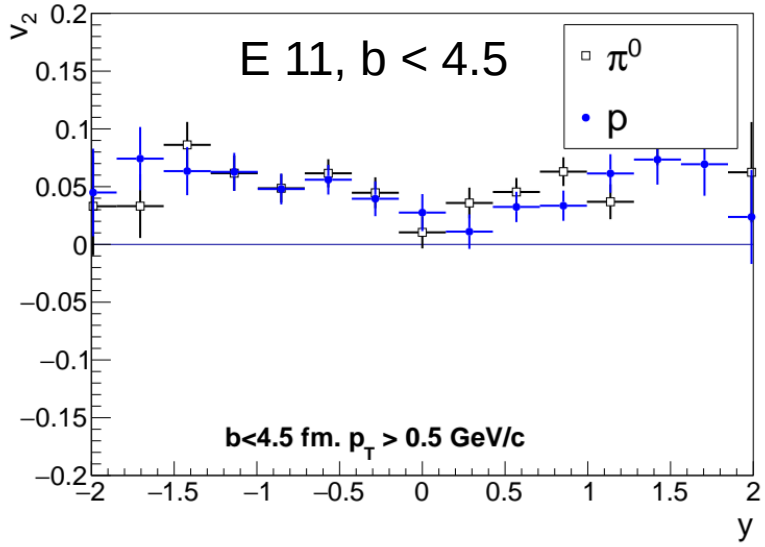


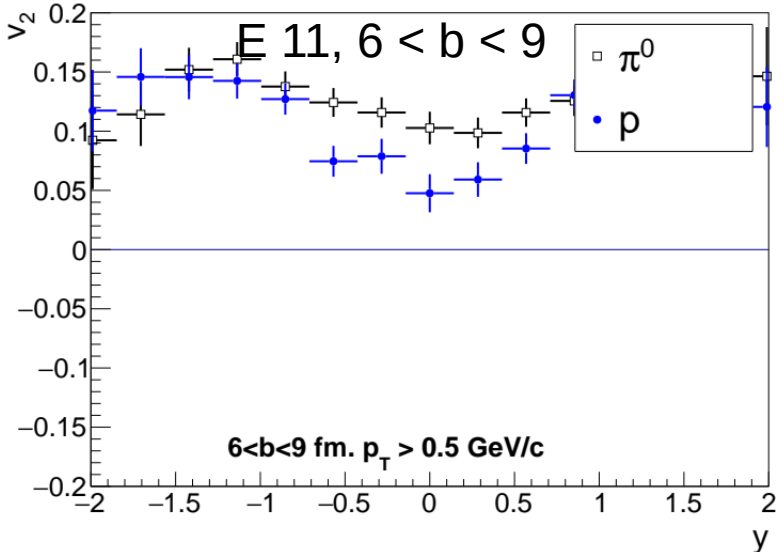


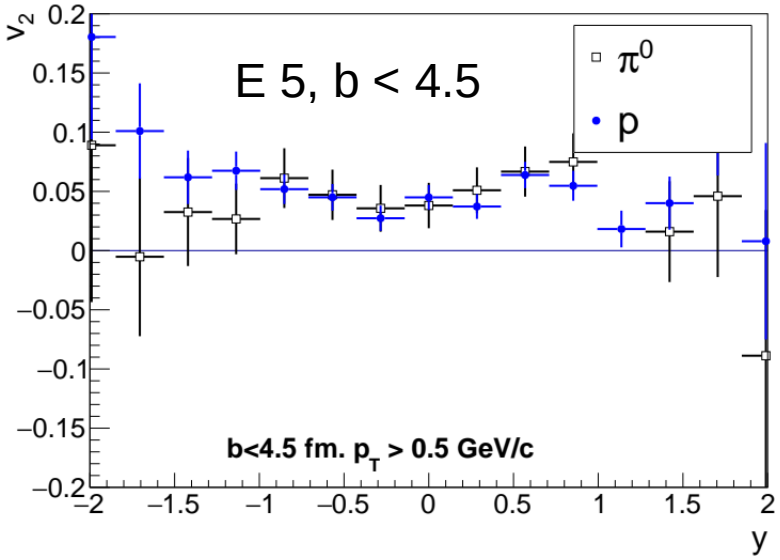


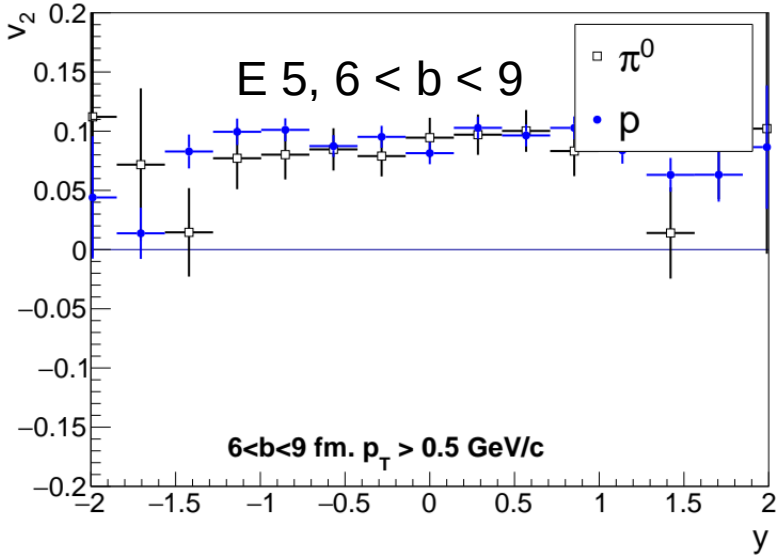
Elliptic flow of hadrons

- $v_n = \langle \cos(n\varphi_i) \rangle$
- $p_T > 0.5$ GeV/c
- Compare different energy and centrality



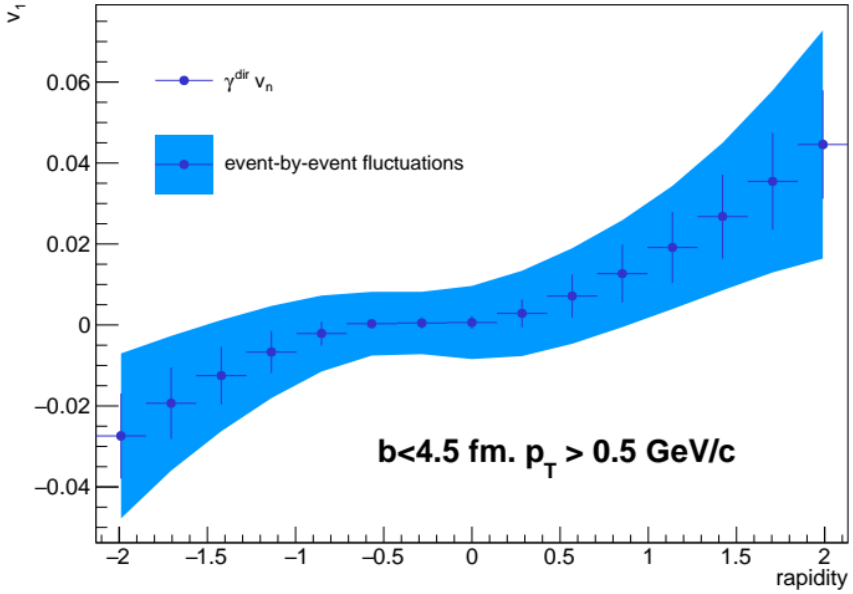


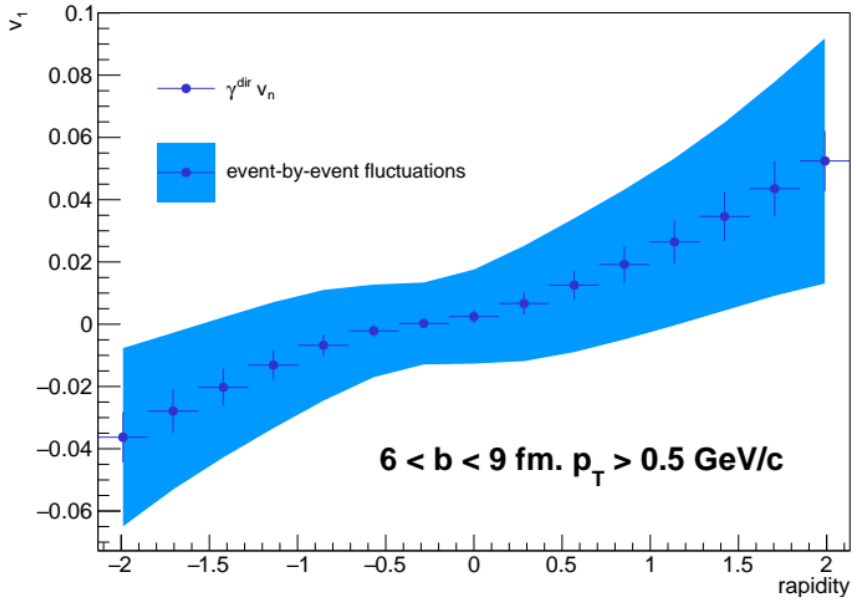


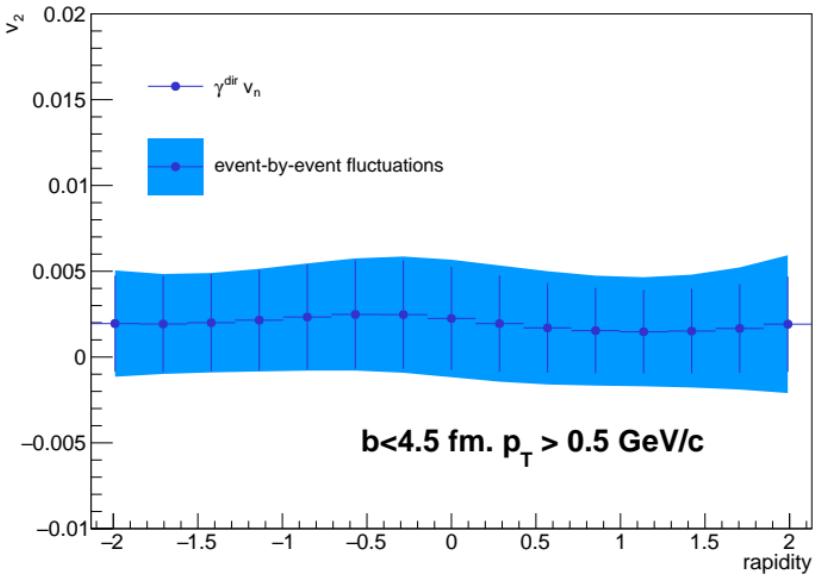


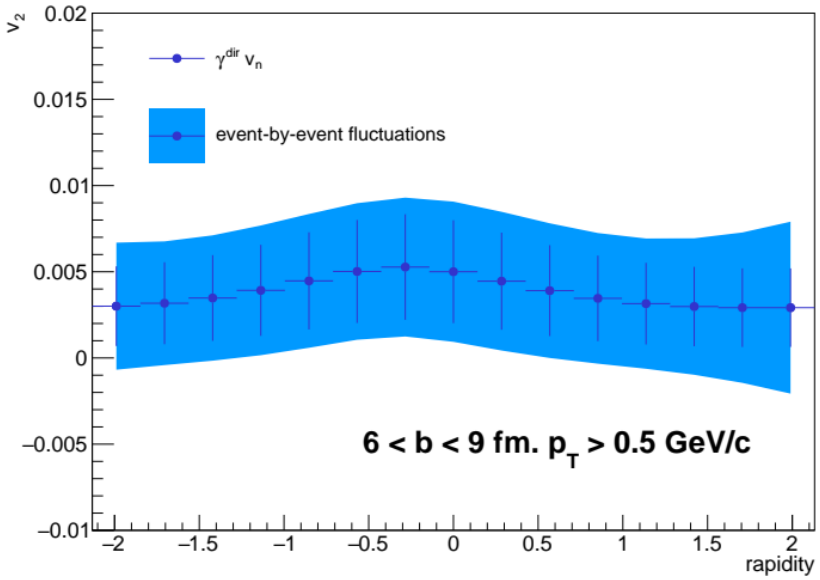
Directed and elliptic flow of direct gamma (11 GeV)

- Results for $p_T > 0.5$ GeV/c (sum of v_n bins weighted with fit to spectrum).
- v_1 slope positive – like for protons
- Magnitude (v_1 about 1-2% at y=1) is 3-5 times smaller than hadrons









Conclusions

- Direct photon yield studies are ongoing. New calculations:
  - More statistics added;
  - Results for 5 GeV added
  - Comparison to PRC 93 054901 done, similar yields

- Collective flow studies ongoing (model data).
  - p_T cut for gamma flow is made consistent with cut for hadrons
  - About 2% directed flow at 1 GeV for p_T>500 MeV is obtained for central Au-Au collisions at 11 GeV