Constraining Particle Production Mechanisms in Au-Au Collisions at RHIC Energies using A Multiphase Transport Model

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1. Abstract

We study the production of pions, kaons, and (anti-) protons in A Multi Phase Transport (AMPT) Model in Au+Au collisions at $\sqrt{s_{NN}}$ = 7.7, 27, and 200 GeV. We present the centrality and energy dependence of various bulk observables such as invariant yields as a function of transverse momentum p_T, particle yields dN/dy, average transverse momentum $\langle p_T \rangle$ and various particle ratios, and compare them with experimental data. Both default and string melting (SM) versions of the AMPT model are used with three different sets of initial conditions. We observe that neither the default nor the SM model could consistently describe the centrality dependence of all observables at the above energies with any one set of initial conditions. The energy dependence behavior of the experimental observables for 0–5% central collisions is in general better described by the default AMPT model using the default HIJING parameters for Lund string fragmentation and 3mb parton scattering cross-section.

2. The AMPT model

- A Multi Phase Transport (AMPT) model is a hybrid transport model with four main components:
  - Initial conditions
  - Partonic interactions
  - Hadronization
  - Hadronic interactions
- Two versions:
  - Default - only minijet partons take part in ZPC, recombine with parent strings and hadronized by Lund string fragmentation.
  - String Melting (SM) - strings are completely converted to partons hence parton density is more in ZPC; hadronization by quark coalescence.
- The following parameters are used for this study:

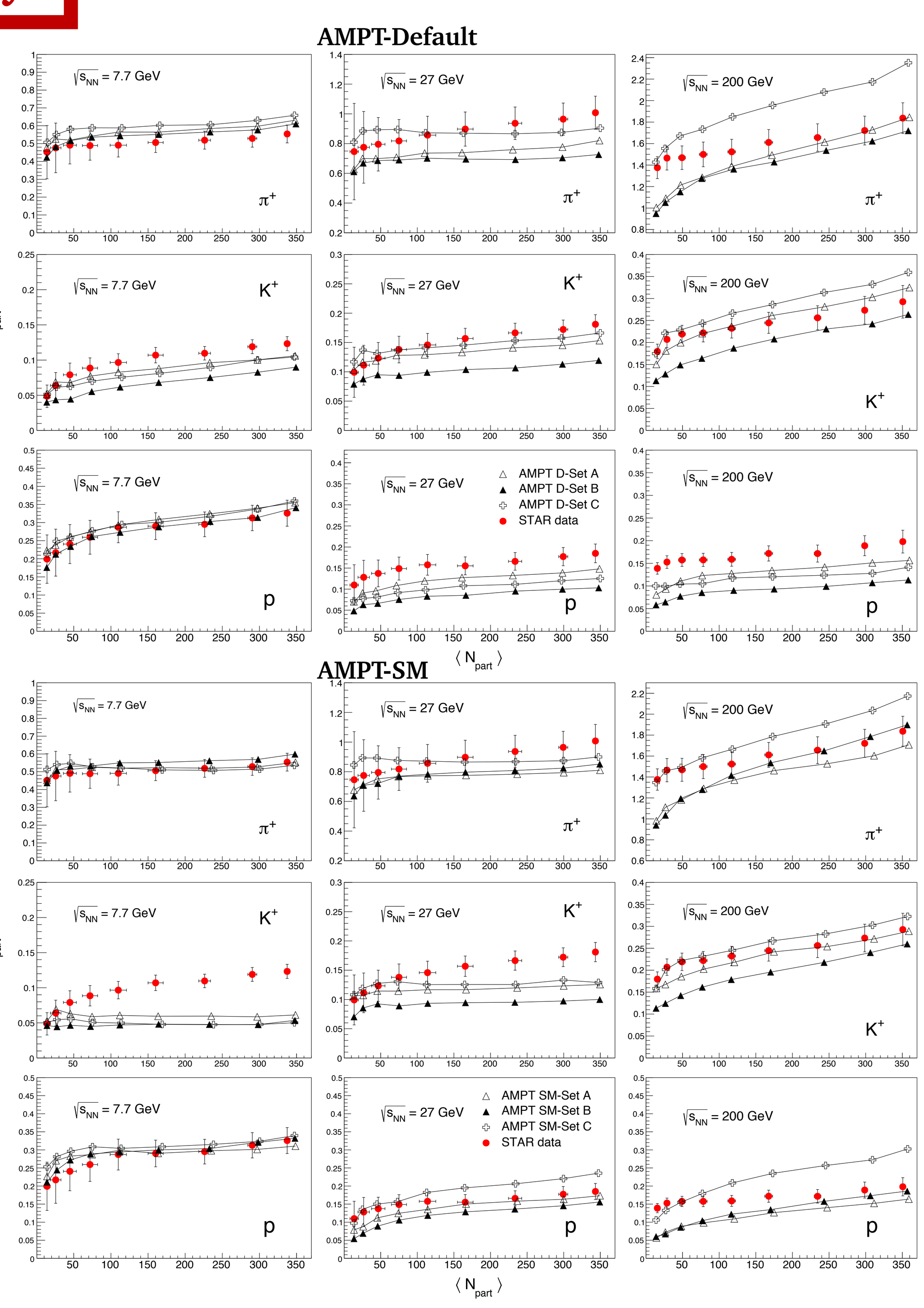
Set	Cross-section (σ)	a	b (GeV^{-2})	α_s	μ (fm^{-1})
Set A	3 mb	0.55	0.15	0.33	2.265
Set B	1.5 mb	0.5	0.9	0.33	3.2
Set C	10 mb	2.2	0.5	0.47	1.8

α_s: strong coupling constant, μ: Debye screening mass in partonic matter; a and b: Lund's string fragmentation parameters.

- Around 20k events are generated for each set at all energies using both versions of AMPT. p_T spectra, dN/dy, <p_T>, and particle ratios are obtained.

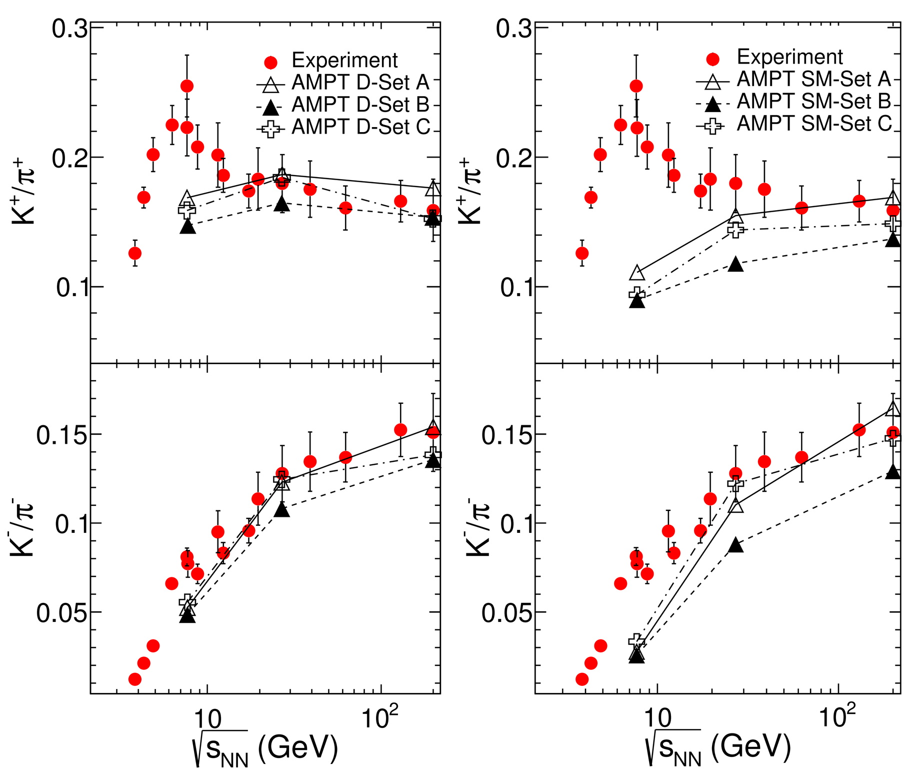
3.1 Results: dN/dy

- **Pions:** Set C in SM version describe yield for $\sqrt{s_{NN}} \leq 27$ GeV. At 200 GeV yield is constrained between set A and C at all $\langle N_{part} \rangle$ for both versions of AMPT.
- **Kaons:** Models underestimate the yields at 7.7 GeV for both versions; default version explains the kaon yield at 27 GeV with set C and at 200 GeV with set A; SM version explains 200 GeV with set C.
- **Protons:** Yield at 7.7 GeV is explained by all sets with both versions; at 27 GeV by set A with SM model; At 200 GeV proton yield is constrained between set B and C with SM version.



In general, set C parameters corresponding to largest a = 2.2 give higher yields while set B corresponding to smallest a = 0.5 give smaller yields as expected.

3.2 Results: Energy dependence of particle ratios



K^+/π^+: Default AMPT model is consistent with data for all three sets at 27 and 200 GeV. At 7.7 GeV, all the three sets under-predict the ratio significantly. However, set A parameters are closest to the data. Comparing between default and SM, the default set A describes the energy dependence better.

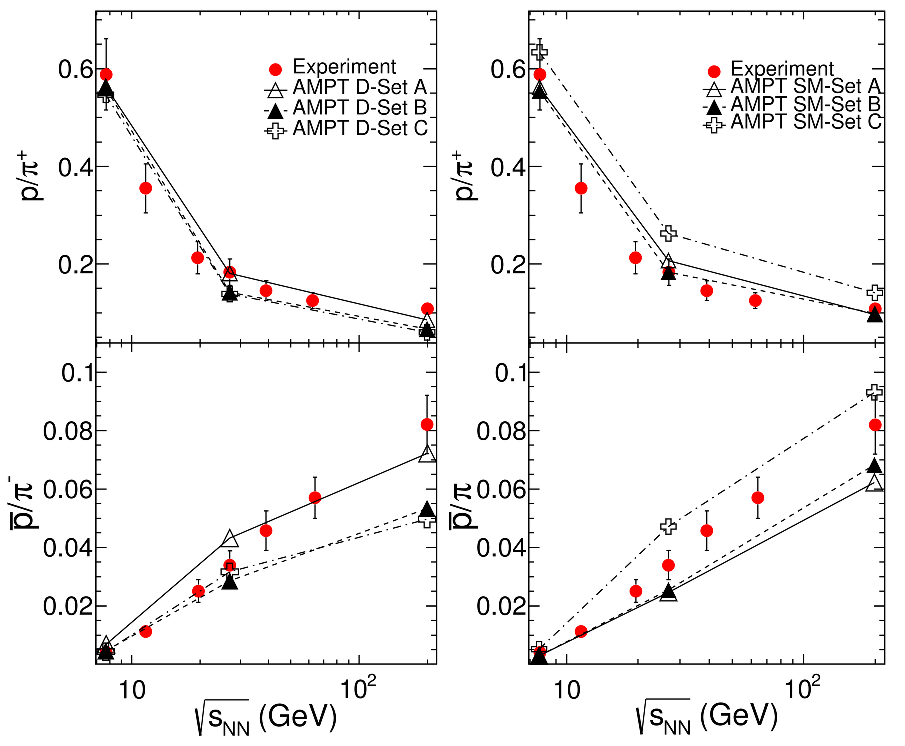
K^-/π^-: At 200 GeV is described by all three sets of the default and SM model. At 27 GeV, set A and C are consistent with the data. At 7.7 GeV, the ratio is again under-predicted by both the versions. The default model is in relatively close agreement with data at lower energies.

We observe that the strangeness (kaon) production at $\sqrt{s_{NN}}$ = 7.7 GeV is not explained by the AMPT model.

p/π^+: In the default model, the set A parameters seem to describe the ratio better at the three energies. In the SM model, both sets A and B describe the data at the three energies.

$\bar{p}/\pi^-$: Default AMPT set A describes the ratio at 7.7 and 200 GeV, while set B and C describe it at 7.7 and 27 GeV. Overall, the set A parameters are closest to the data. For SM model, the set C parameters describe the ratio at 7.7 and 200 GeV, while sets B and C only describe the data at 7.7 GeV.

We observe that the default AMPT model with set A parameters works better than SM model.



4. Summary & Conclusions

- The particle production using AMPT model, both default and string melting, is studied at three different RHIC energies and for various centralities with three sets of different input conditions to the AMPT.
- Neither the default nor the SM model could consistently describe the centrality dependence of the observables studied.
- Energy dependence of observables in 0-5% central collisions is in general better described by the default AMPT model using the default HIJING parameters for Lund string fragmentation and 3mb cross-section (Set A).
- At 7.7 GeV, the strange particle production is not well explained by the AMPT model.
- These comparisons will provide help in constraining the models in a better way.

5. References

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6. Acknowledgement

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