Reconstructed jets within the partonic transport model BAMPS

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H-QM Helmholtz Research School Quark Matter Studies

Abstract

The momentum imbalance A_J of reconstructed jets is studied for parton showers traversing central heavy-ion collisions with $\sqrt{s_{NN}} = 2.76$ TeV at LHC by employing the partonic transport model *Boltzmann Approach of Multi–Parton Scatterings* (BAMPS) [1].

The model: BAMPS

BAMPS [2, 3] simulates the full 3+1D evolution of the QGP by solving the relativistic Boltzmann equation,

$$\left(\frac{\partial}{\partial t} + \frac{\mathbf{p}_i}{E_i}\frac{\partial}{\partial \mathbf{r}}\right) f_i(\mathbf{r}, \mathbf{p}_i, t) = \mathcal{C}_i^{2\to 2} + \mathcal{C}_i^{2\leftrightarrow 3} + \dots ,$$

for on-shell partons and pQCD interactions. Therefore it uses $2 \to 2$ as well as $2 \leftrightarrow 3$ scattering processes of gluons as well as light quarks while employing stochastic interactions together with a test-particles ansatz [2, 3, 4, 5]. By doing so, it permits the investigation of bulk and high-p_t phenomena in a common framework.

For studying jets within BAMPS, we employ the improved Gunion-Bertsch (GB) matrix element [6], a running coupling, and a cutoff function $|\mathcal{M}_{23}| \propto \theta\left(\lambda - X_{\text{LPM}}\,\tau\right)$ modeling the Landau-Pomeranchuk-Migdal (LPM) effect. The factor X_{LPM} thereby controls effectively the magnitude of suppression of gluon emissions resulting from multiple coherent in-medium scatterings.

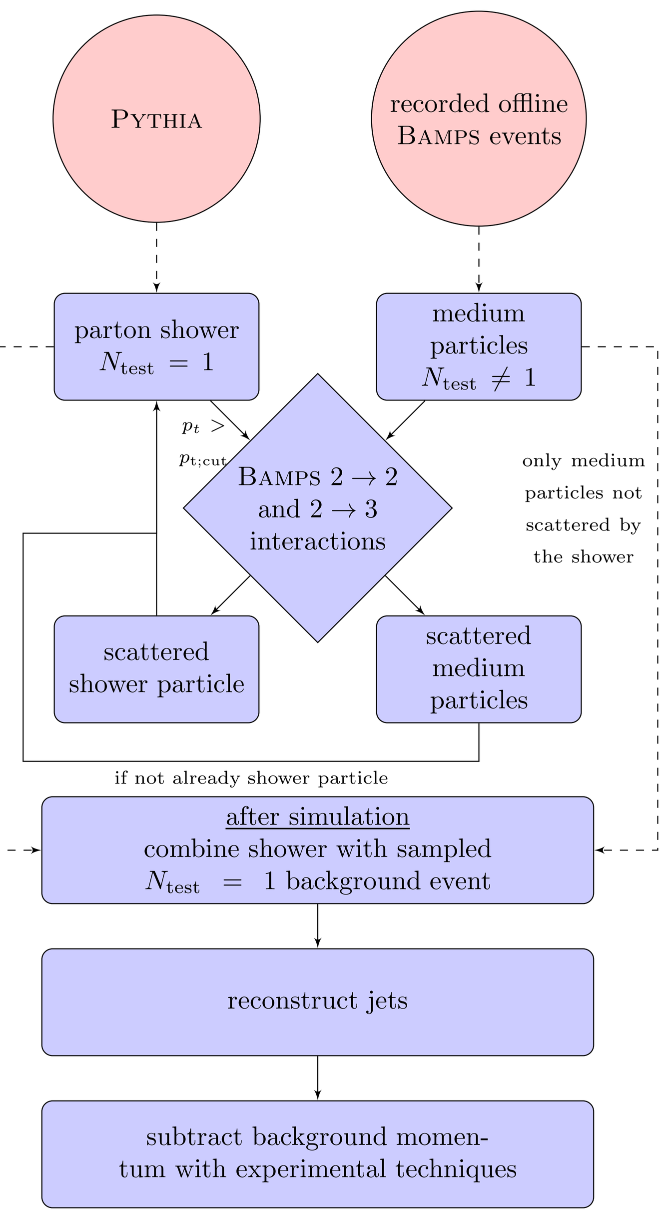
Momentum imbalance A_J in BAMPS

An observable for investigating the momentum loss of high p_t back-to-back di-jets within a heavy-ion collision is the momentum imbalance

$$A_J = \frac{p_{t;1} - p_{t;2}}{p_{t;1} + p_{t;2}},$$

where $p_{t;1}$ and $p_{t;2}$ are the reconstructed transverse momenta of the leading and subleading jet.

Based on studies by CMS [7], jets are reconstructed with the "anti-k_t"-algorithm with $R = 0.3$ provided by "FastJet" [8]. All experimental trigger conditions are applied. For subtracting the underlying background medium the "CMS noise/pedestal" subtraction method is employed. Detector effects are effectively modeled by a Gaussian smearing of the leading/subleading jet momenta based on p+p A_J data.



The work-flow for simulating reconstructed jets within BAMPS consists of initial conditions modeled by partonic PYTHIA events followed by the in-medium evolution within BAMPS. After correcting for the employed test-particle number, jets are reconstructed based on full heavy-ion events and their background momenta are subtracted.

Influence of in-medium scatterings on A_J

While considering the recoiled medium partons, the momentum loss of jets within BAMPS caused by partonic medium scatterings leads to a momentum imbalance A_J, that is, after subtracting the background, in agreement with experimental data for $X_{\text{LPM}} = 0.3$. This is consistent with studies of R_{AA} within BAMPS that also show a good agreement with experimental data for $X_{\text{LPM}} = 0.3$ [9].

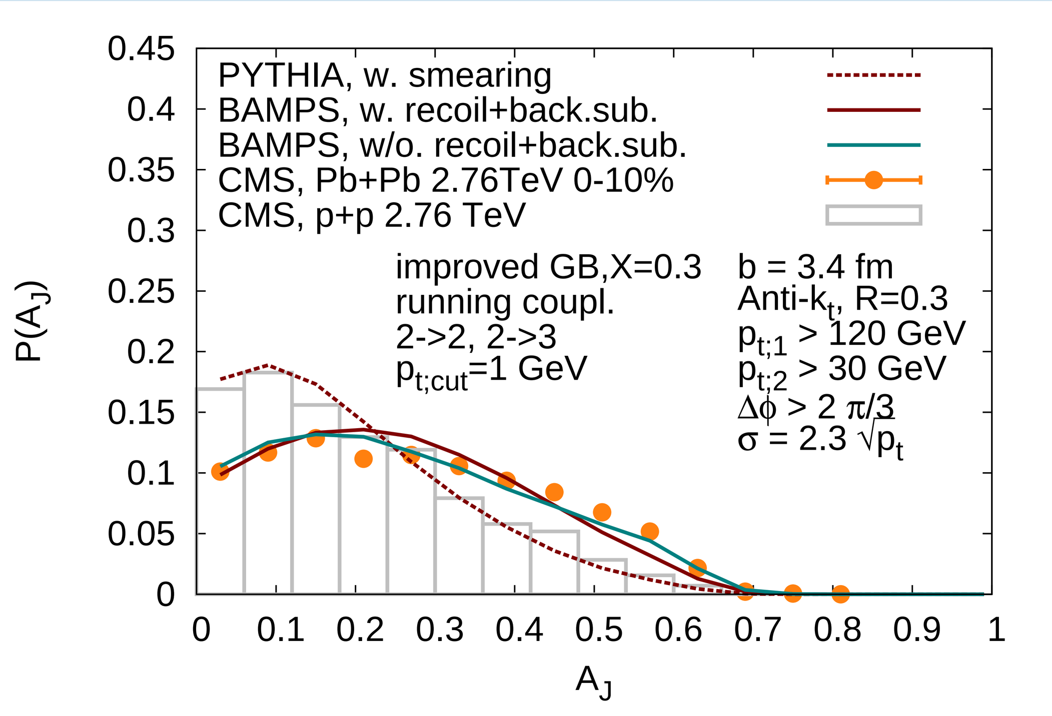


Figure 1: A_J for 0-10% Pb+Pb collisions with $\sqrt{s}$ =2.76 TeV calculated by BAMPS in comparison with CMS data [7].

The applied experimental background subtraction successfully moderates the influence of recoiled medium partons on the momentum imbalance.

Momentum loss of jets within the QGP

The enhancement of imbalanced events is caused by an interplay between a momentum loss of the subleading jet and a triggering on less modified leading jets.

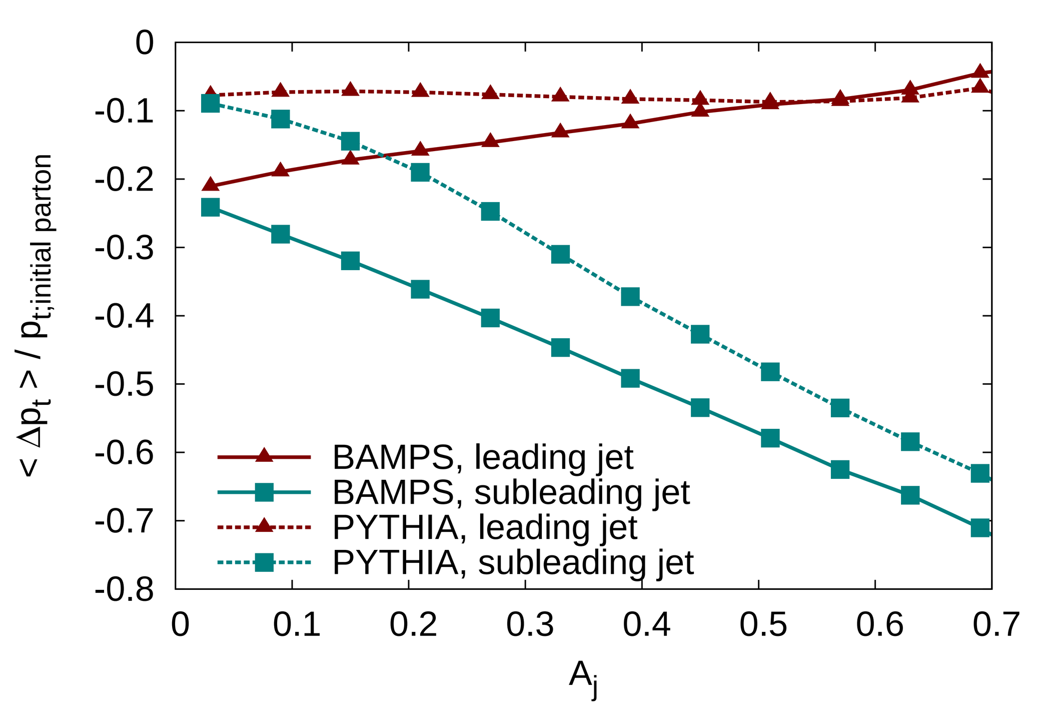


Figure 2: Average momentum loss of the unsmeared reconstructed jets compared to the initial shower initiating parton depending on the momentum imbalance A_J. Same setup and parameters as in Fig. 1 are used.

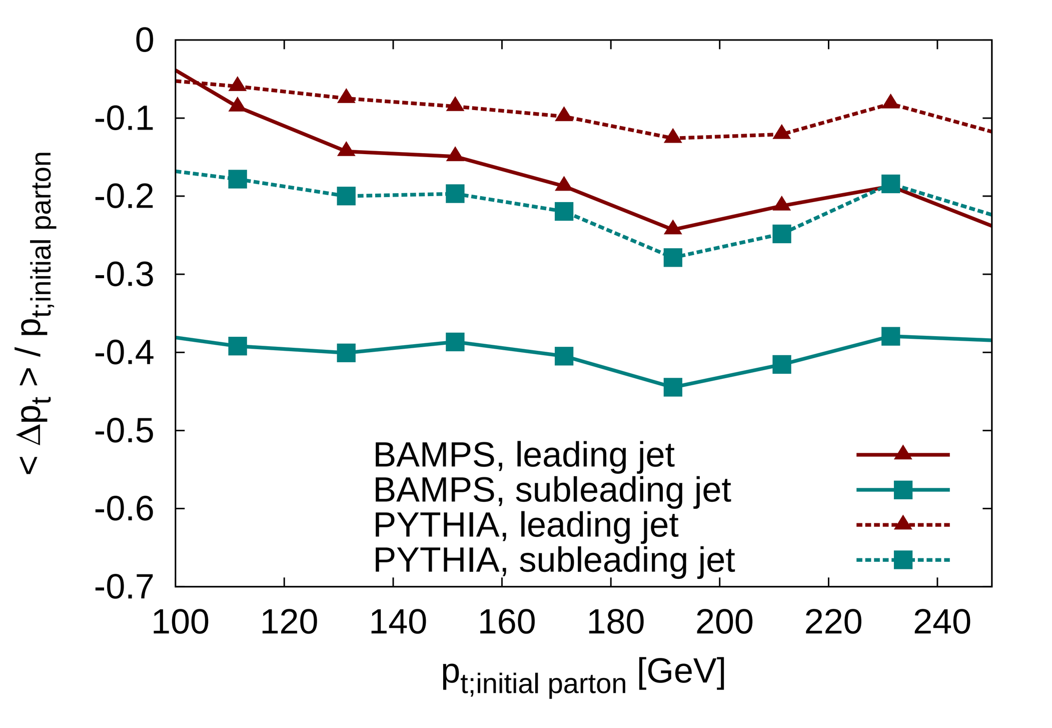


Figure 3: Average momentum loss of the unsmeared leading/subleading jet compared to the initial shower initiating parton depending on the initial parton momentum. Same setup and parameters as in Fig. 1 are used.

The dependence of A_J on the underlying different in-medium path lengths of the initial parton pair is investigated. The A_J distributions in bins of the length imbalance parameter L_i [1], defined as

$$L_i = \frac{L_{\text{long}} - L_{\text{short}}}{L_{\text{long}} + L_{\text{short}}},$$

show no correlation between the imbalance in momentum and the underlying path length.

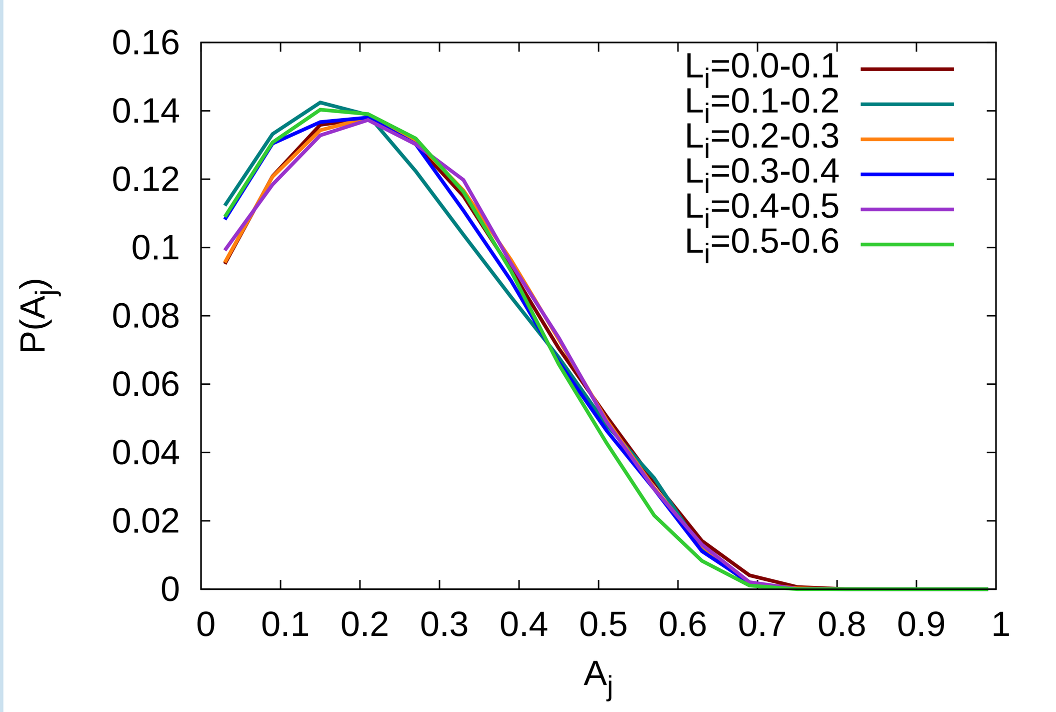


Figure 4: Momentum imbalance distribution A_J in bins of the length imbalance L_i. Same setup and parameters as in Fig. 1 are used.

More relevant for the final momentum imbalance is the momentum imbalance before traversing the medium $A_{\text{j;PYTHIA}}$.

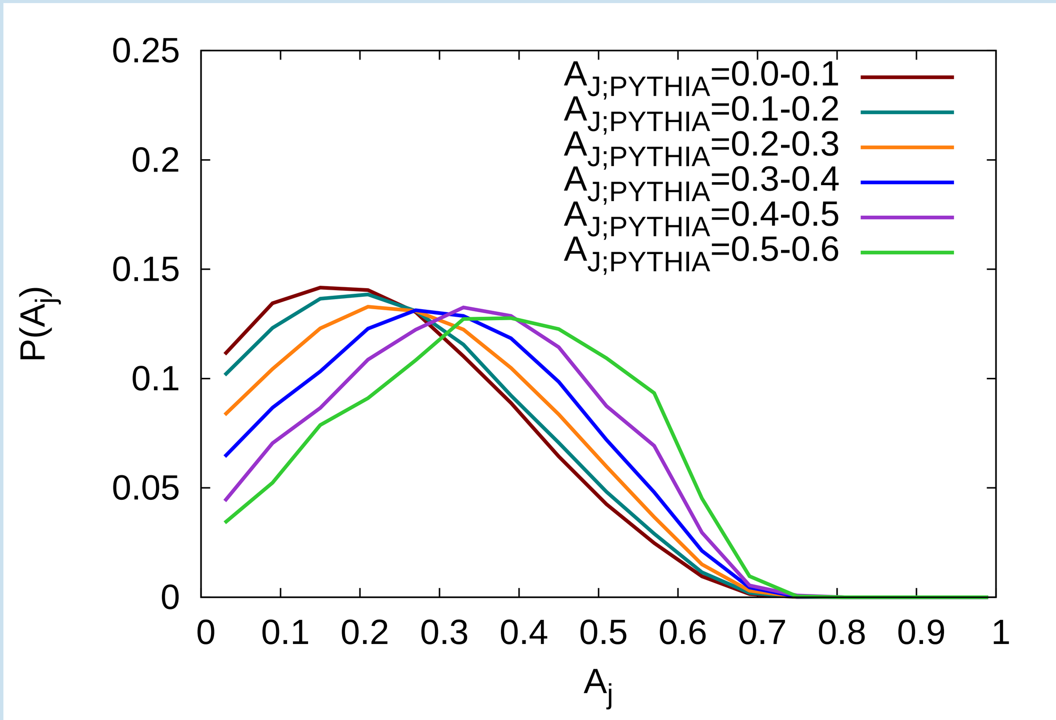


Figure 5: Momentum imbalance distribution A_J in bins of the momentum imbalance of the same event without medium modification $A_{\text{j;PYTHIA}}$. Same setup and parameters as in Fig. 1 are used.

Conclusions

The momentum loss of reconstructed di-jets has been studied with the pQCD based transport model BAMPS while employing an improved GB matrix element, a running coupling and an effective LPM cutoff. The momentum imbalance A_J is explained by the partonic momentum loss within BAMPS together with detector effects and an experimental background subtraction. For investigating the sensitivity of R_{AA} and A_J on the factor X_{LPM}, a stochastical implementation of the LPM effect is in progress.

References

[1] F. Senzel, O. Fochler, J. Uphoff, Z. Xu, and C. Greiner, (2013), arXiv:1309.1657.
[2] Z. Xu and C. Greiner, Phys. Rev. C **71** (2005), arXiv:hep-ph/0406278.
[3] Z. Xu and C. Greiner, Phys.Rev.Lett. **100** (2008), arXiv:0710.5719.
[4] O. Fochler, Z. Xu, and C. Greiner, Phys.Rev. **C82** (2010), arXiv:1003.4380.
[5] O. Fochler, J. Uphoff, Z. Xu, and C. Greiner, J.Phys.G **G38** (2011), arXiv:1107.0130.
[6] O. Fochler, J. Uphoff, Z. Xu, and C. Greiner, Phys.Rev. **D88**, 014018 (2013), arXiv:1302.5250.
[7] CMS Collaboration, Phys.Lett. **B712**, 176 (2012), arXiv:1202.5022.
[8] M. Cacciari, G. P. Salam, and G. Soyez, (2011), arXiv:1111.6097.
[9] J. Uphoff *et al.*, (2014), arXiv:1401.1364.

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