PYTHIA8 IS READY FOR HEAVY-ION PHYSICS

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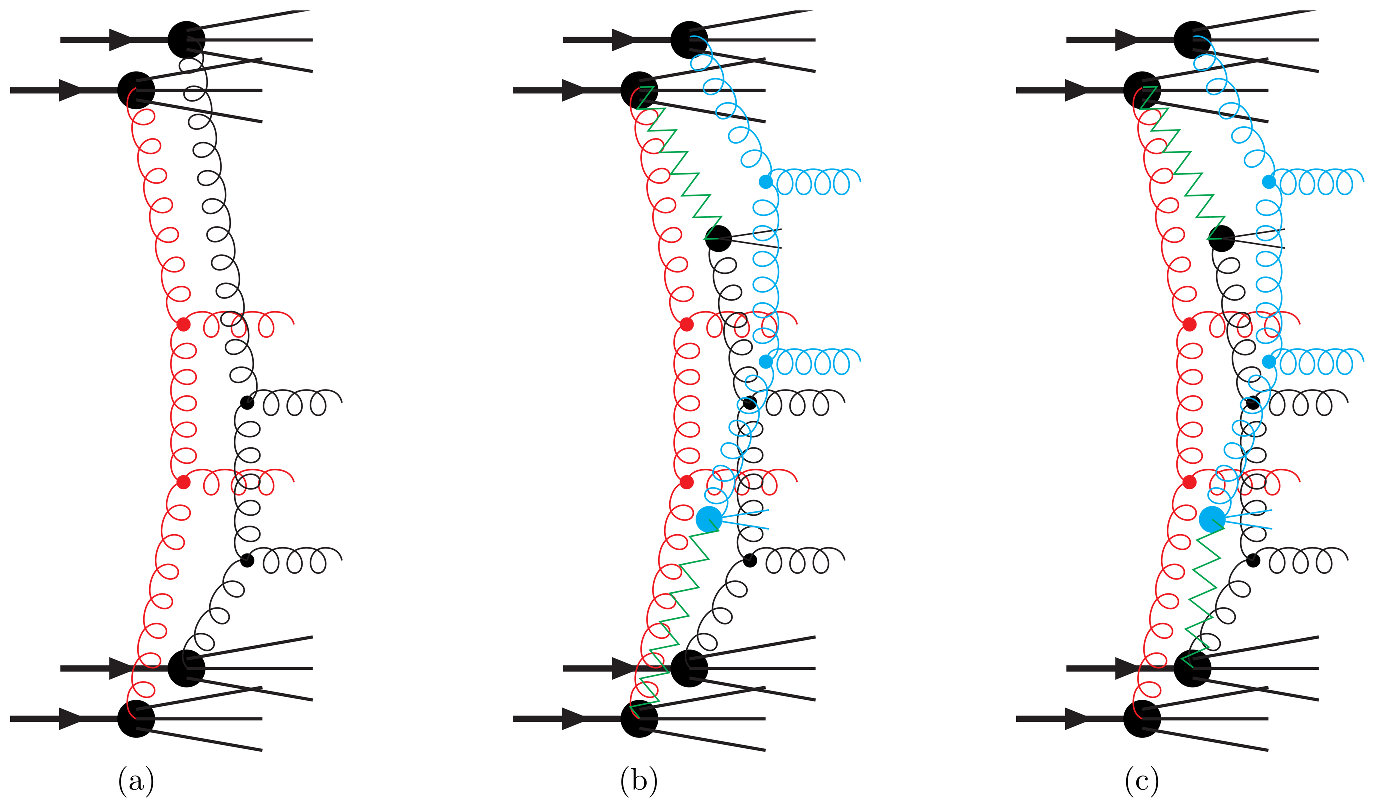
Abstract

We have formulated a new model for collisions with nuclei, called Angantyr, which is now included in the Pythia8 event generator. The model is inspired by the old Fritiof model, but also includes effects of multiple (semi-hard) partonic interactions. It uses a Glauber model to calculate the number of wounded nucleons, that includes fluctuations in the NN interaction to separate non-diffractive from diffractively excited nucleons. The MC simulates final states without assuming a thermalized plasma. Hence, in this manner we are providing an event generator to be used to simulate events from pp, pA and AA with the same underlying physics approach. Collective effects due to high string densities are not included in a present version, but will be added in a future work.

Overview

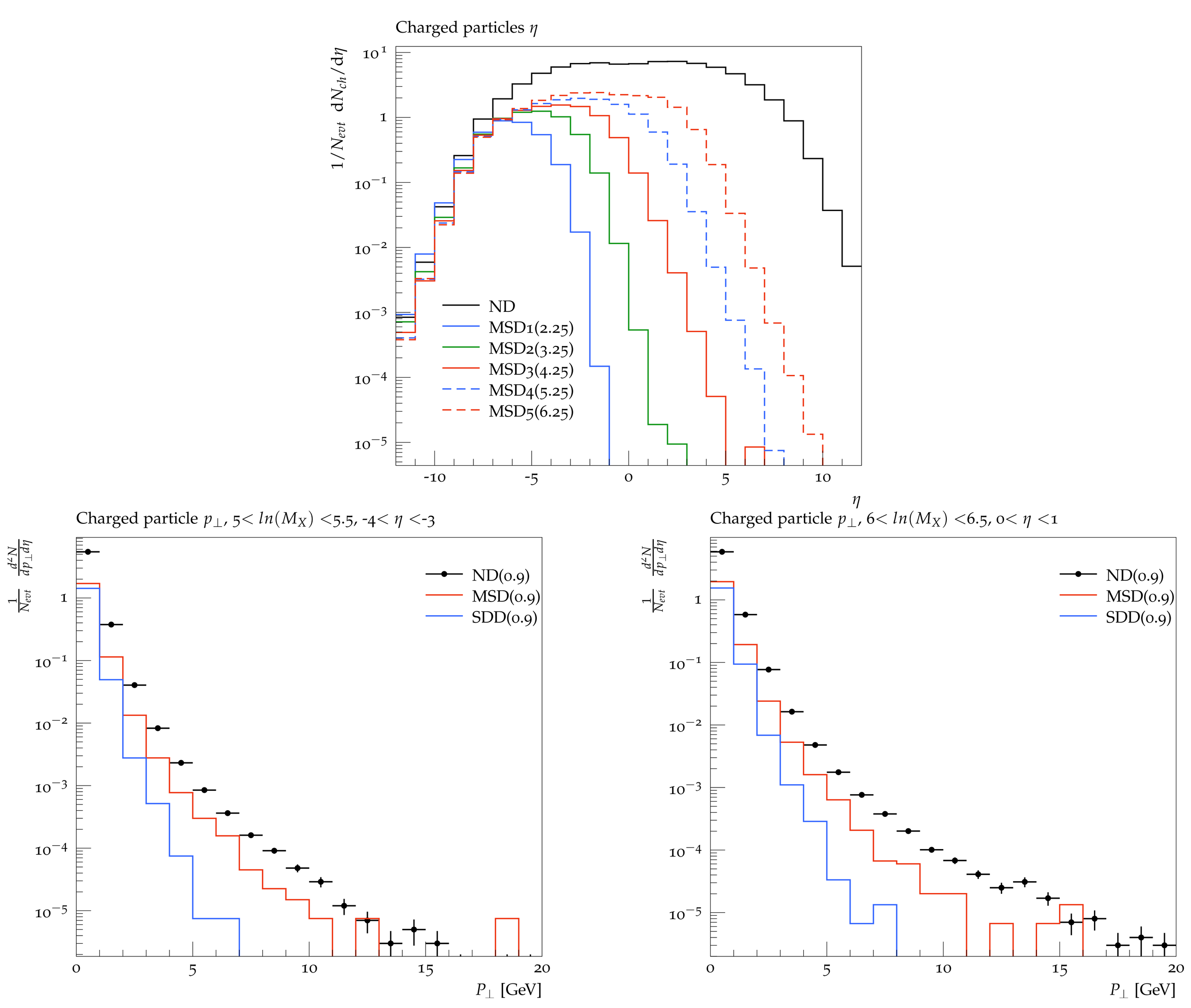
Objective: Build an event generator model based on the underlying physics of pp collisions for the heavy-ion(HI) interaction.
Question: Can we simulate pp, pA and AA collision events without formation of thermalized plasma?
Available: Fritiof model, Glauber formalism and PYTHIA 8 framework.
Method: Generate wounded nucleons using the Glauber and Good-Walker formalism [1], then with PYTHIA 8 machinery generate nucleon-nucleon sub-events and stack them appropriately to obtain heavy-ion final states.
Model feature 1: Diffractive excitations of projectile and target nucleons are included in the model.
Model feature 2: Non-diffractive secondary collisions are treated with appropriate modifications of single diffraction in the model.
Model feature 3: Current version can be used to study non-collective behaviour of observables sensitive to collective phenomena.

Secondary non-diffractive collisions in AA collisions



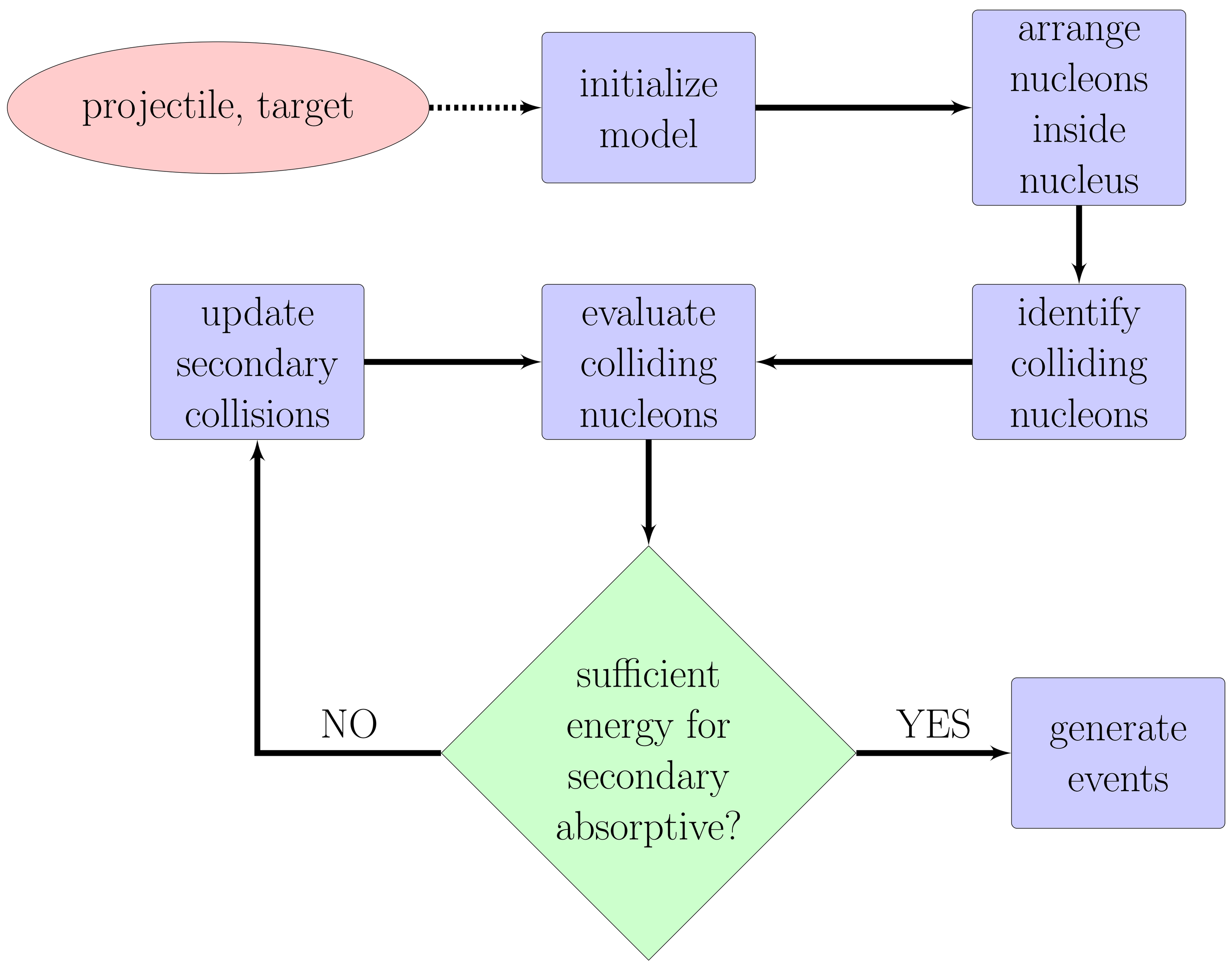
A schematic representation of MPI between two projectiles and targets a) two separate nucleon-nucleon collisions, b) and c) one primary interaction and two secondary interactions between projectile and target nucleons in an AA collision.

The modified single diffraction



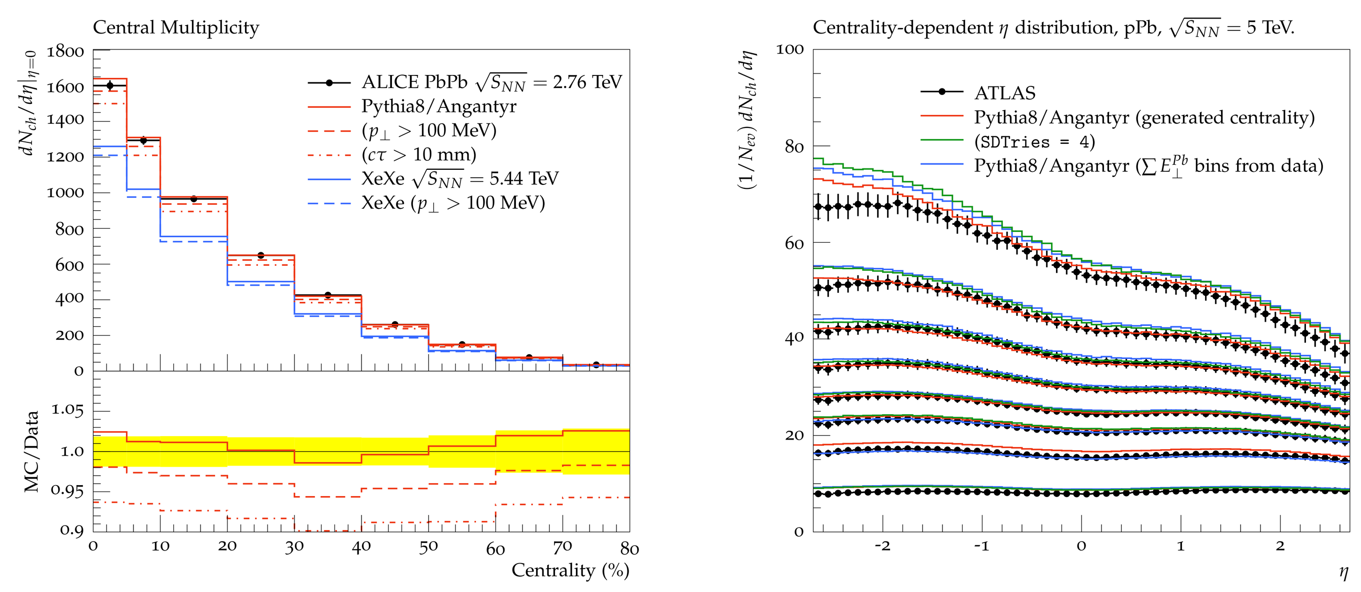
Top: Charged particle multiplicity for different $< ln(M_X) >$ (numbers in brackets) of modified single diffraction compared with non-diffractive. **Bottom**: P_t distributions of charged particles in modified single diffraction (red line) and PYTHIA 8 default single diffraction (blue line), compared with non-diffractive events for a specific impact parameter (b=0.9) and for two different diffractive mass ranges and psuedo-rapidity bins.

The Angantyr model in nut-shell



This schematic diagram outlines key steps performed before pA and AA final state generation through Angantyr model.

Comparison to data



Left:(Preliminary) Comparison of average charged multiplicity in central pseudo-rapidity bin(red lines) with PbPb collision ALICE data [2] and a prediction for charged multiplicity in central pseudo-rapidity for XeXe collision(blue lines) for different centrality.
Right:(Preliminary) Angantyr generated average charged multiplicity is compared with pPb data from ATLAS [3]. The effect of retrying to add secondary sub-events; failed due to energy-momentum conservation, in the Angantyr model is shown by green line.

Conclusions and outlook

A model for heavy-ion collisions has been developed using the PYTHIA 8 framework. Secondary non-diffractive sub collisions are modeled using modified single diffractive events. The model generated centrality and multiplicity distributions are in reasonable agreement with experimental data. Angantyr cannot reproduce elliptic flow and jet quenching in its current version.
Further studies include implementation of string shoving and rope hadronizaton to provide a description of flow like behavior.

References

[1] M.L. Good, W.D. Walker, Phys.Rev. 120 (1960) 1857-1860
[2] ALICE Collaboration (Kenneth Aamodt (Bergen U.) et al.), Phys.Rev.Lett. 106 (2011) 032301
[3] ATLAS collaboration(Georges Aad (Marseille, CPPM) et al.), Eur.Phys.J. C76 (2016) no.4, 199