Deep learning predicted elliptic flow of identified particles in heavy-ion collisions at the RHIC and LHC energies

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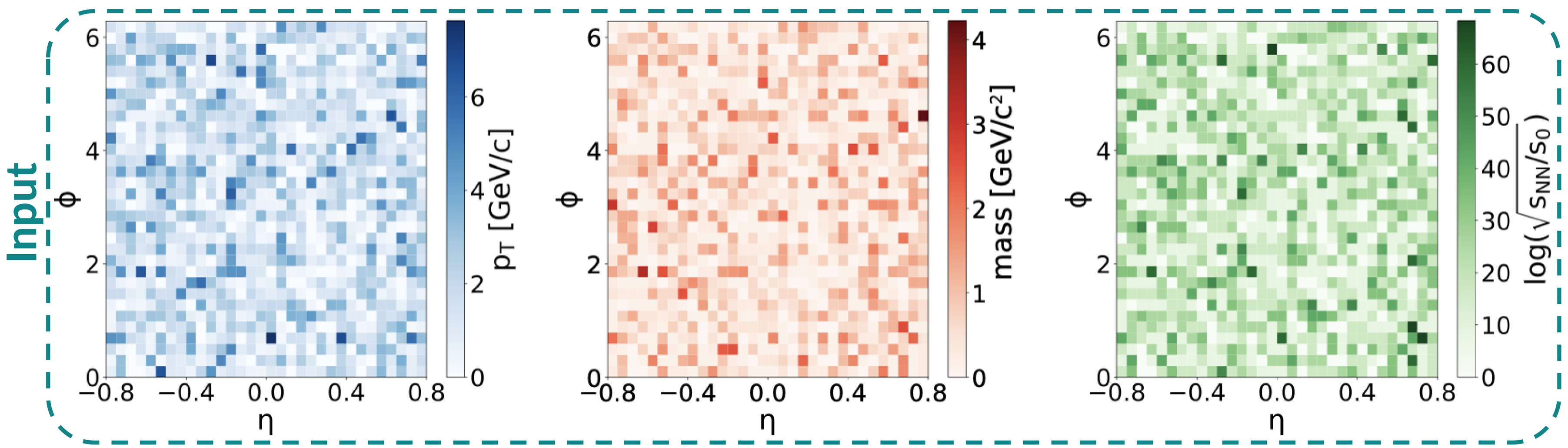
1. Introduction

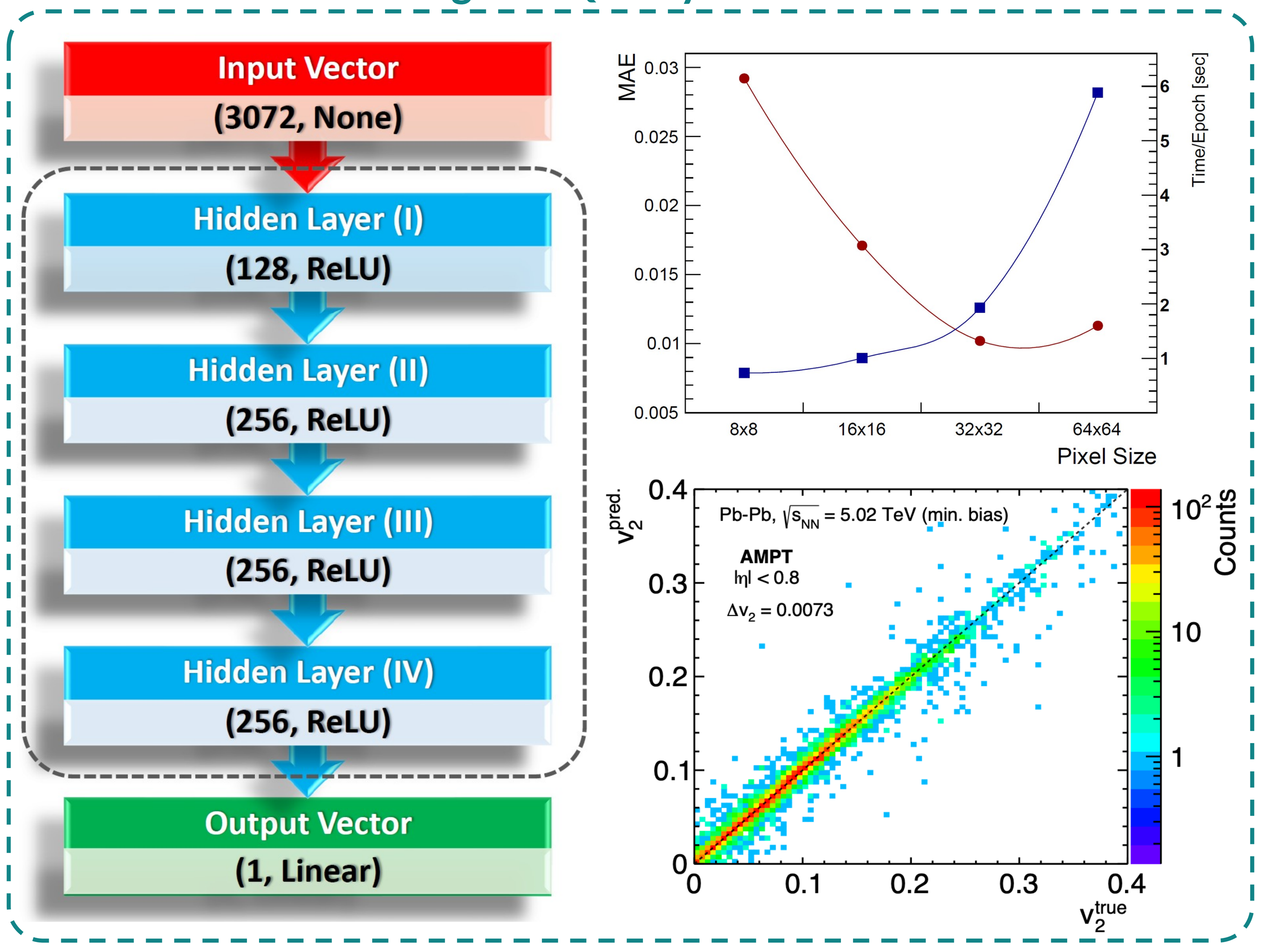
- Transverse collective flow is a crucial observable in studying the properties of quark-gluon plasma
- Collective flow is anisotropic and depends on the equation of state and transport coefficients of the system
- Anisotropic flow develops in the early partonic phase, evolves through relativistic hydrodynamics, and later gets influenced by hadronic phase interactions
- **First deep learning-based estimator for elliptic flow (v_2)**



- Trained on final-state freeze-out surface, learns from multiparticle production dynamics and correlations to estimate any physical observable of interest

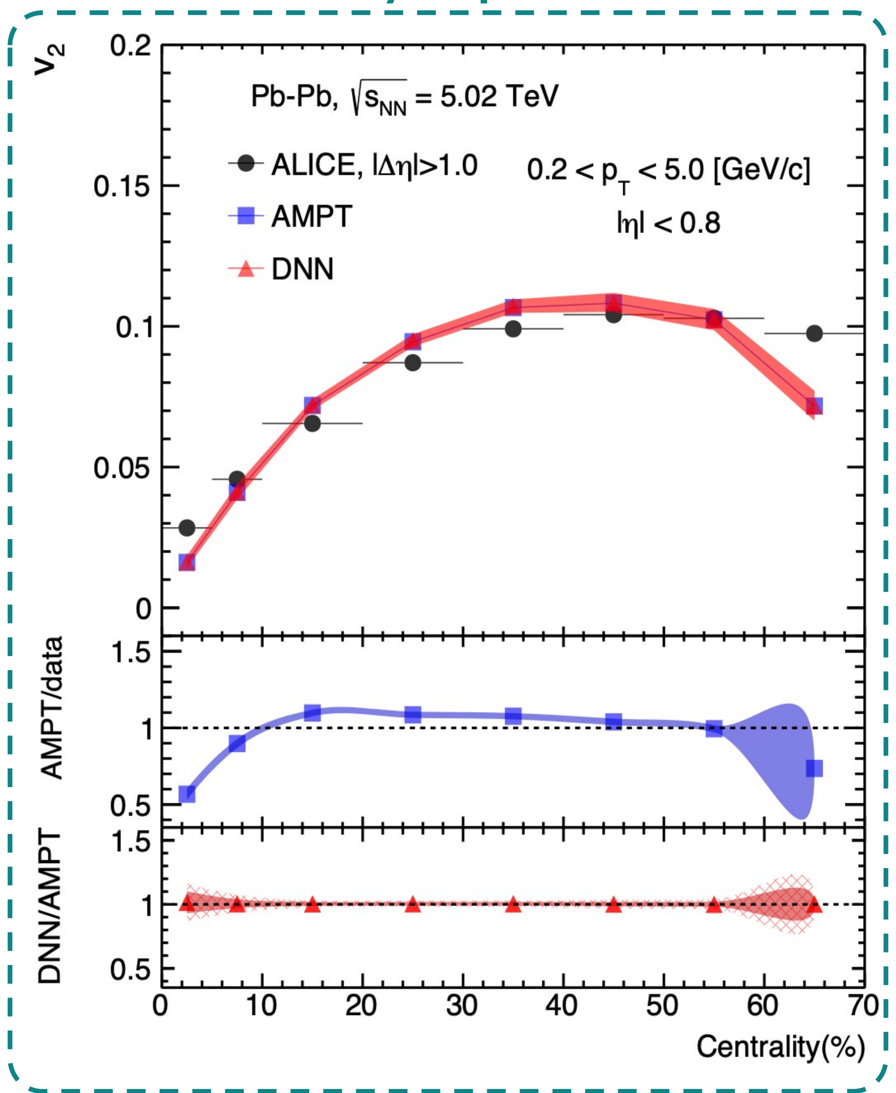
2. Deep learning estimator

Training and Quality Assurance



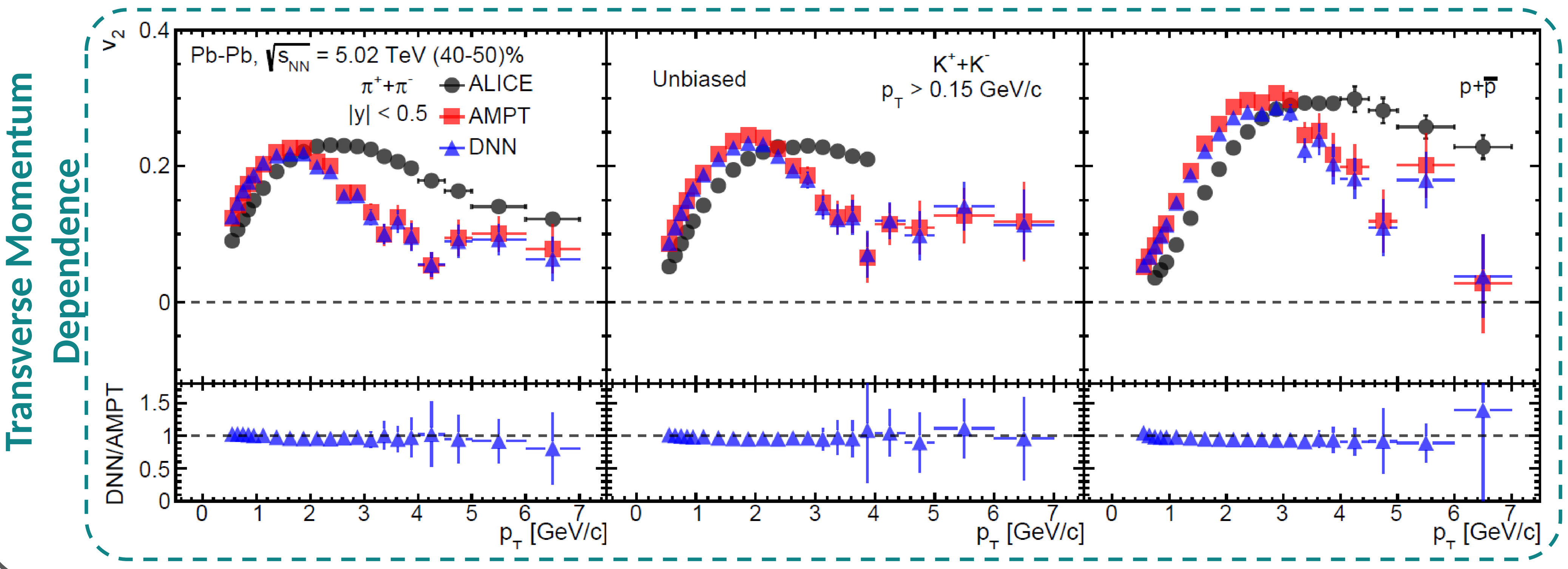
- surface as input
- Weights: , mass, and energy
- Training on Pb-Pb collisions, TeV (min. bias) simulated with AMPT
- Optimizer: `adam`, Loss: `mse`
- Choice of pixel size optimized with `MSE` and training `time/epoch`
- Overfitting rejection through `EarlyStopping` callback
- Noisy simulation for systematics

Centrality Dependence

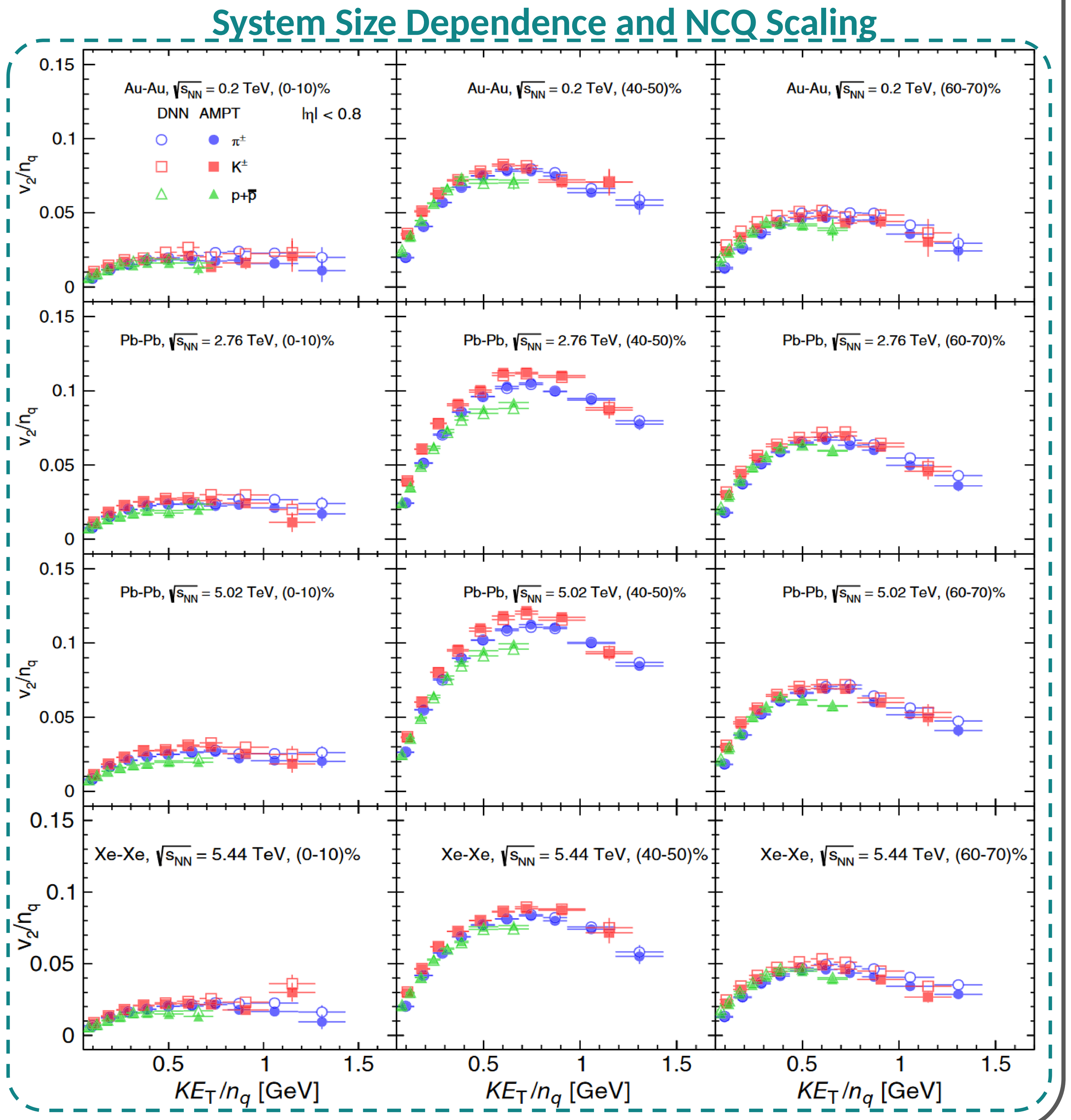


3. Results

- Predictions are obtained for the collision centrality, energy, system size, particle species, and transverse momentum dependence of elliptic flow
- The number-of-constituent-quark scaling behavior across different collision systems at different energies is also predicted by this estimator
- AMPT explains the data to a reasonable extent from low- to intermediate-but deviates for GeV/c
- Model and estimation technique dependency on training



System Size Dependence and NCQ Scaling



4. Summary

- Particle kinematics information at freeze-out as input
- Event-by-event predictions for the flow coefficient
- Centrality, , and meson-baryon dependent predictions
- Applicable to both RHIC and LHC energies
- Scalable model, can be extended to other physical observables in heavy-ion collisions
- Faster and more efficient prediction
- Robust to noisy simulation

Based on:

1. N. Mallick, S. Prasad, A. N. Mishra, R. Sahoo, and G. G. Barnaföldi, Phys.Rev.D 105, 114022 (2022).
2. N. Mallick, S. Prasad, A. N. Mishra, R. Sahoo, and G. G. Barnaföldi, Phys.Rev.D 107, 094001 (2023).

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