A Deep Learning Based Estimator for Elliptic Flow in Heavy ion Collisions

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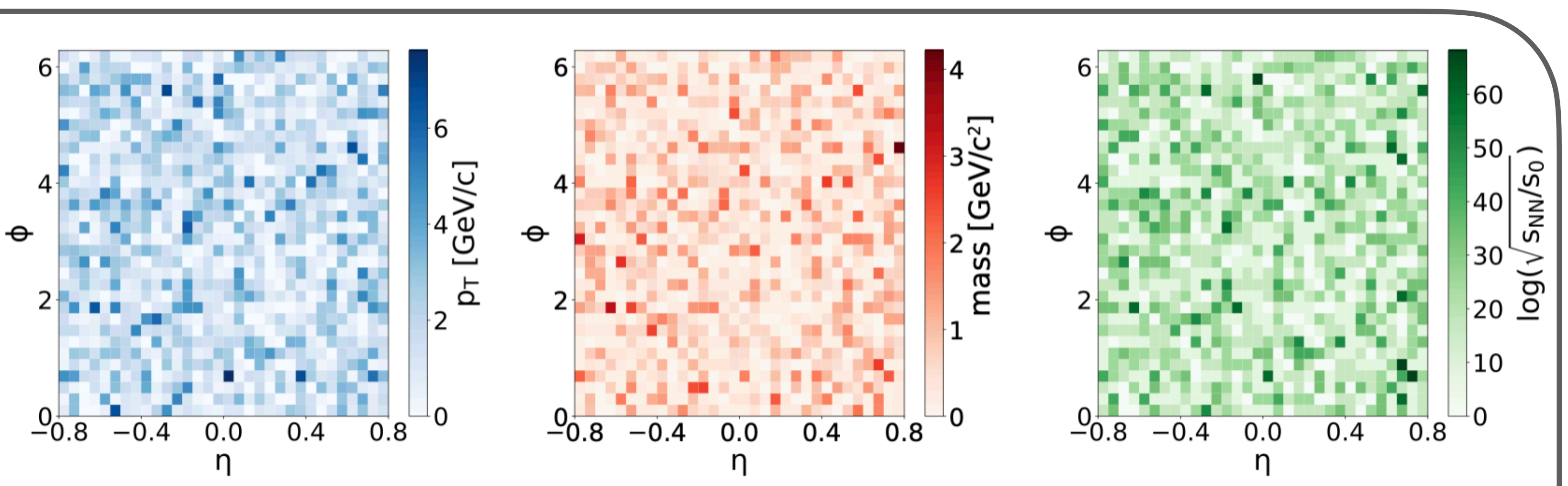
1. Introduction

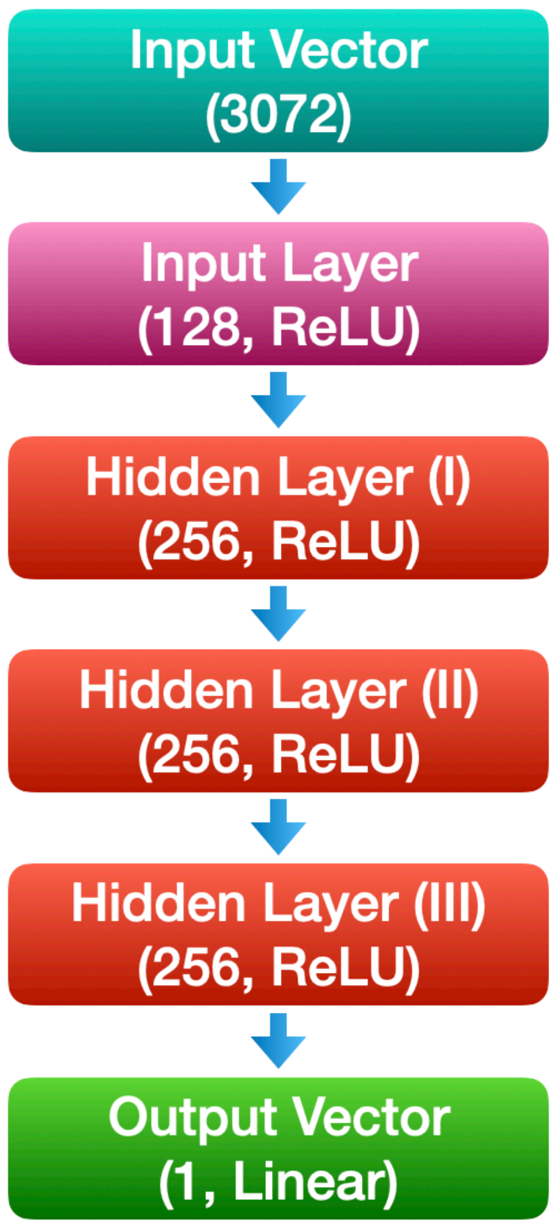
- Transverse collective flow is an important observable in studying Quark-Gluon Plasma (QGP) [1]
- Heavy-ion collisions observe significant elliptic flow (v_2) [2]
- Estimation of reaction plane angle (ψ_R) is non-trivial [3]
- Deep Neural Networks are well suited for mapping complex nonlinear functions [4]



$$v_n = \langle \cos[n(\phi - \psi_R)] \rangle$$

First Deep Learning based estimator for elliptic flow [5]

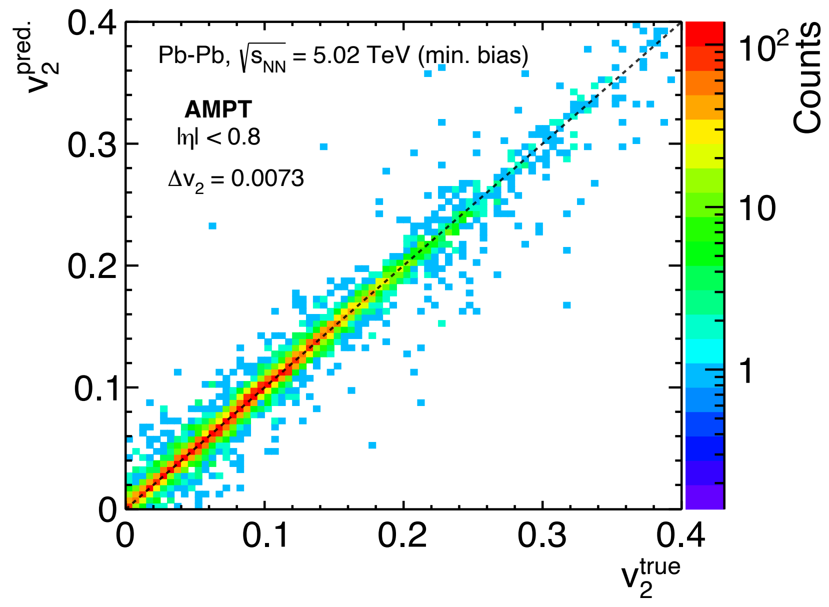
2. Deep Learning Estimator

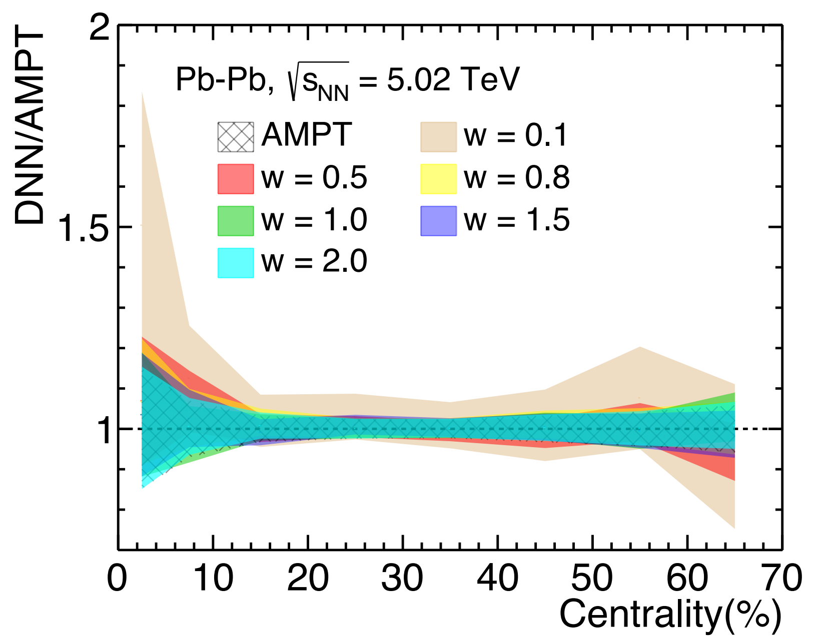


- $(\eta - \phi)$ space as the primary input space
- p_T, mass, and an energy term as the secondary inputs
- 32×32 bins each, three such input layers
- Training with Pb-Pb collisions, $\sqrt{s_{NN}} = 5.02$ minimum bias events, simulated with a multiphase transport model (AMPT)
- Early stopping callback to ensure minimal overfitting
- Mean Absolute Error ($\Delta v_2 = 0.0073$) on 10K testing data
- For i^{th} event, and j^{th} feature, the feature value

  $F_{i,j} \leftarrow F_{i,j} + X_{i,j}/w$, where $X_{i,j} \in (-\sigma_j, \sigma_j)$.

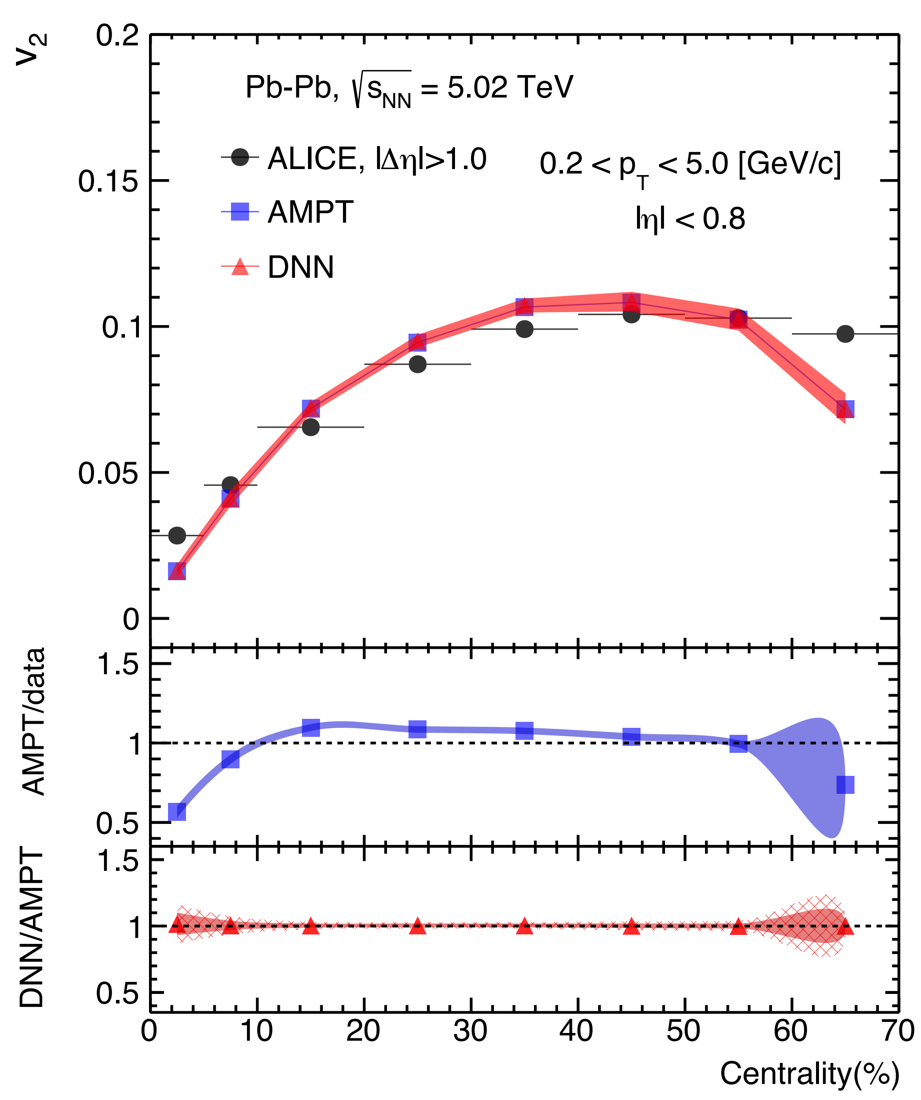
  σ_j = standard deviation, w = noise parameter

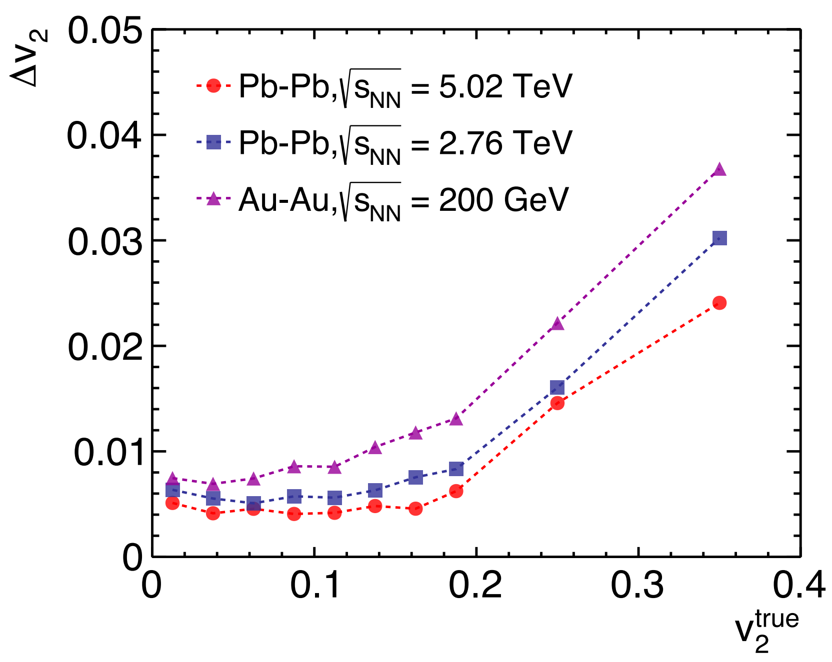




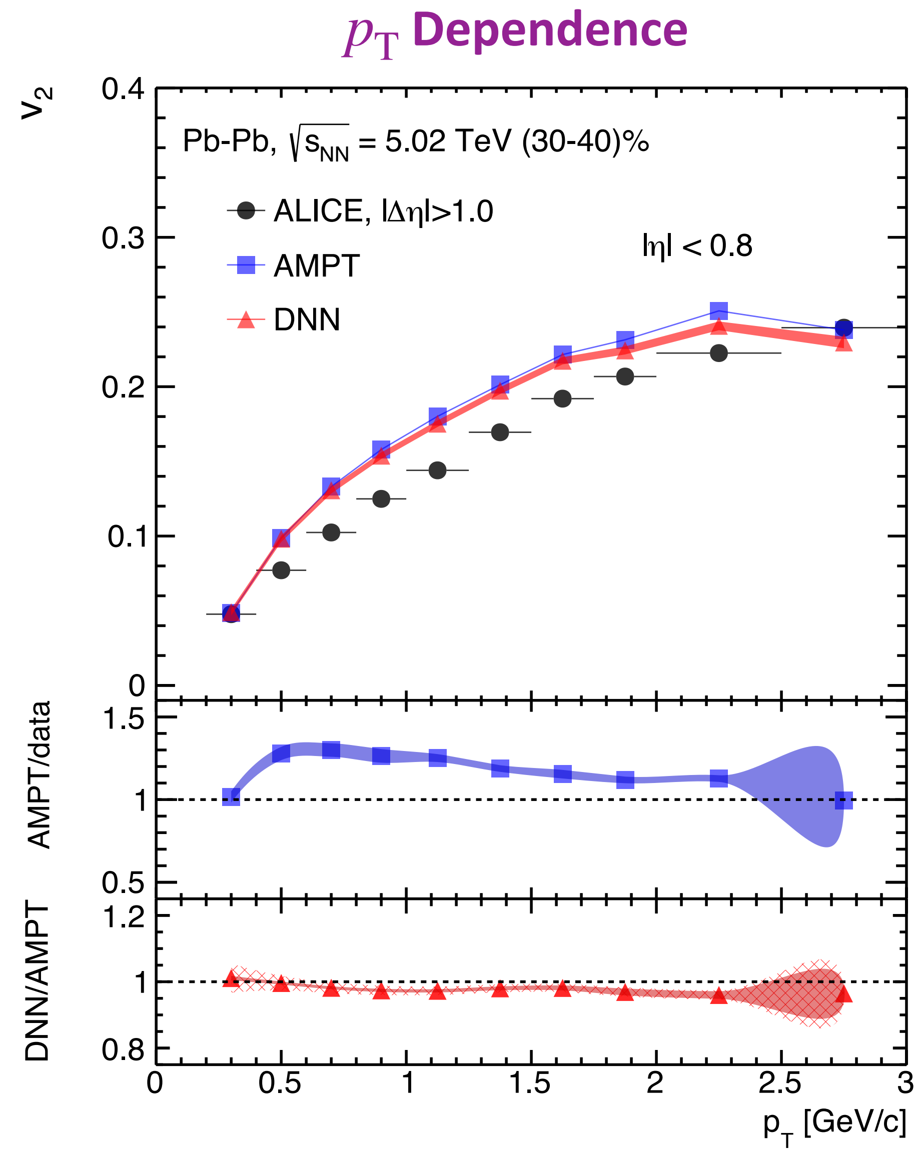
3. Results

Centrality Dependence





p_T Dependence



- From minimum bias training to estimation of centrality and p_T dependence of v_2
- Comparison of prediction with simulation and experimental results
- Estimation of v_2 for different collision systems

4. Summary

- Final state particle kinematic information as input
- Estimator preserves the centrality, and p_T dependence of v_2
- Excellent prediction accuracy against noisy simulation
- Applicable to both RHIC and LHC energy
- v_2 for identified particles, and n_q scaling under study

References

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