Estimating elliptic flow coefficient in heavy ion collisions using deep learning

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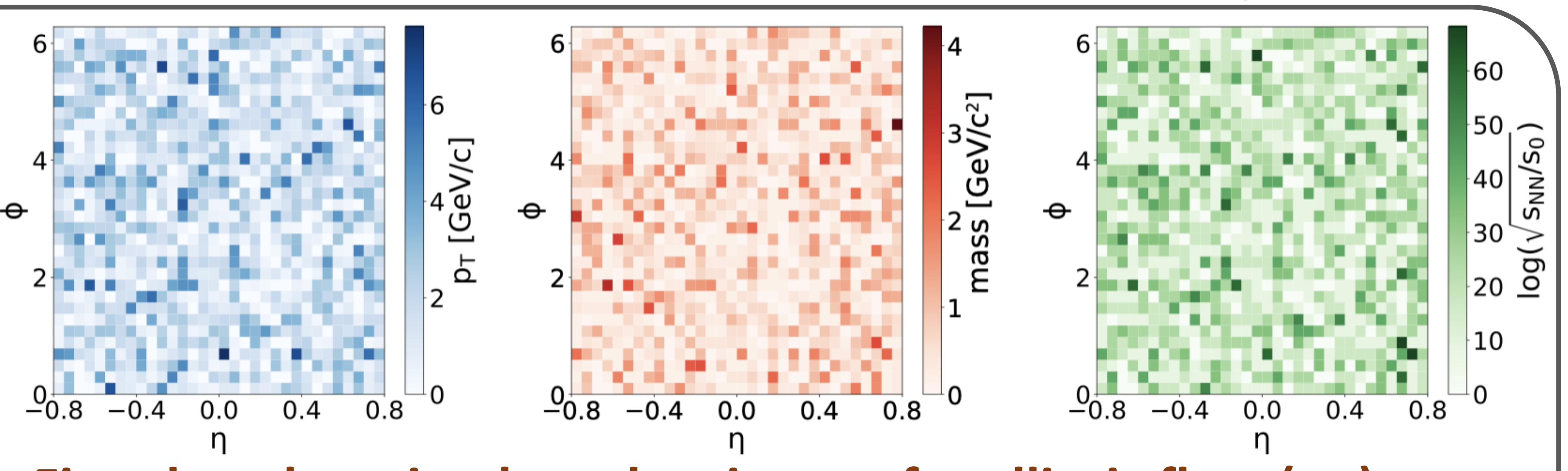
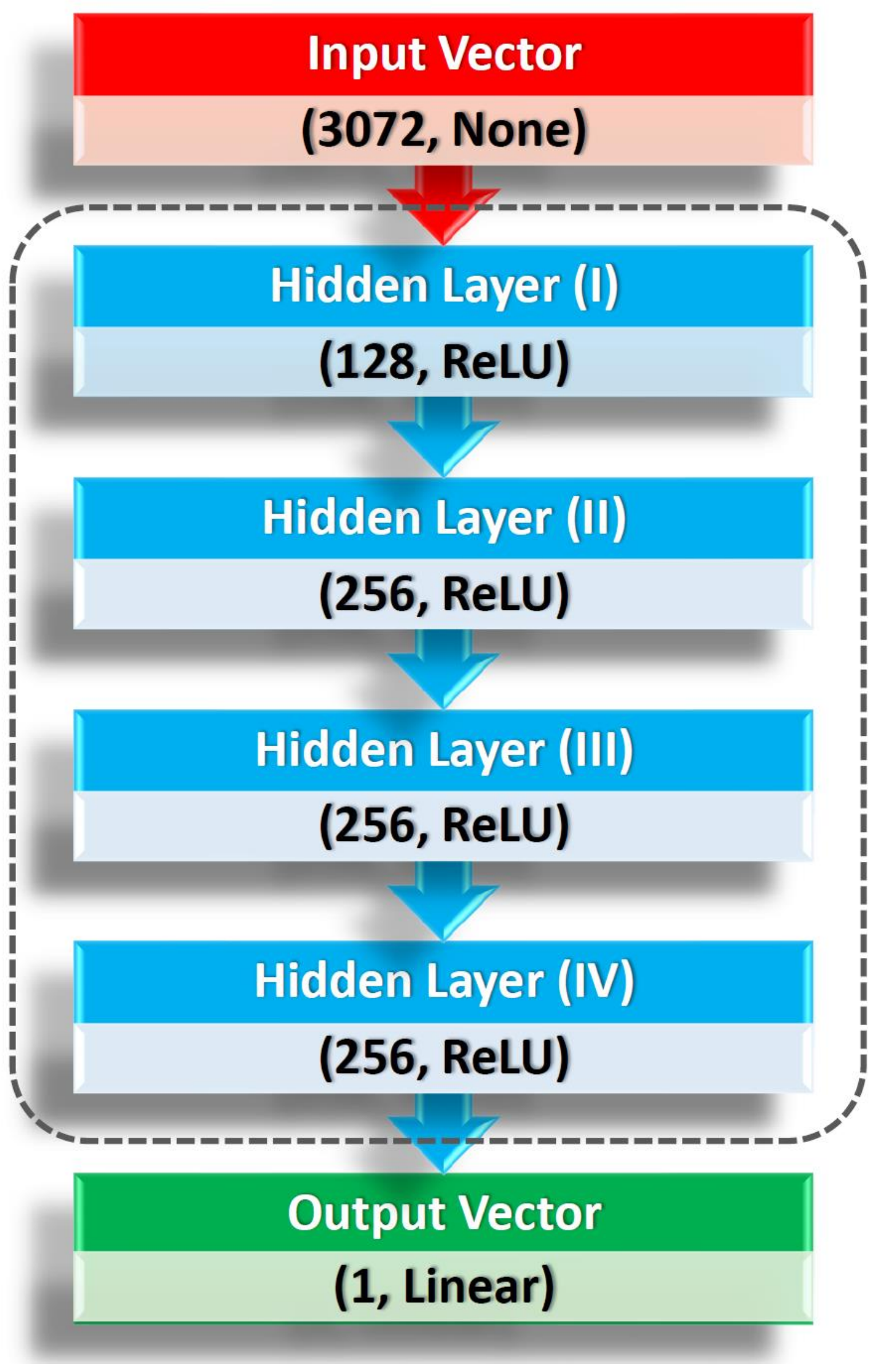
1. Introduction

- Transverse collective flow is a crucial observable in studying the properties of quark-gluon plasma (QGP)
- Collective flow is anisotropic and depends on the equation of state and transport coefficients of the system
- Anisotropic flow appears to be developed in the early partonic phase, evolves through relativistic hydrodynamics, and later gets influenced by hadronic rescatterings

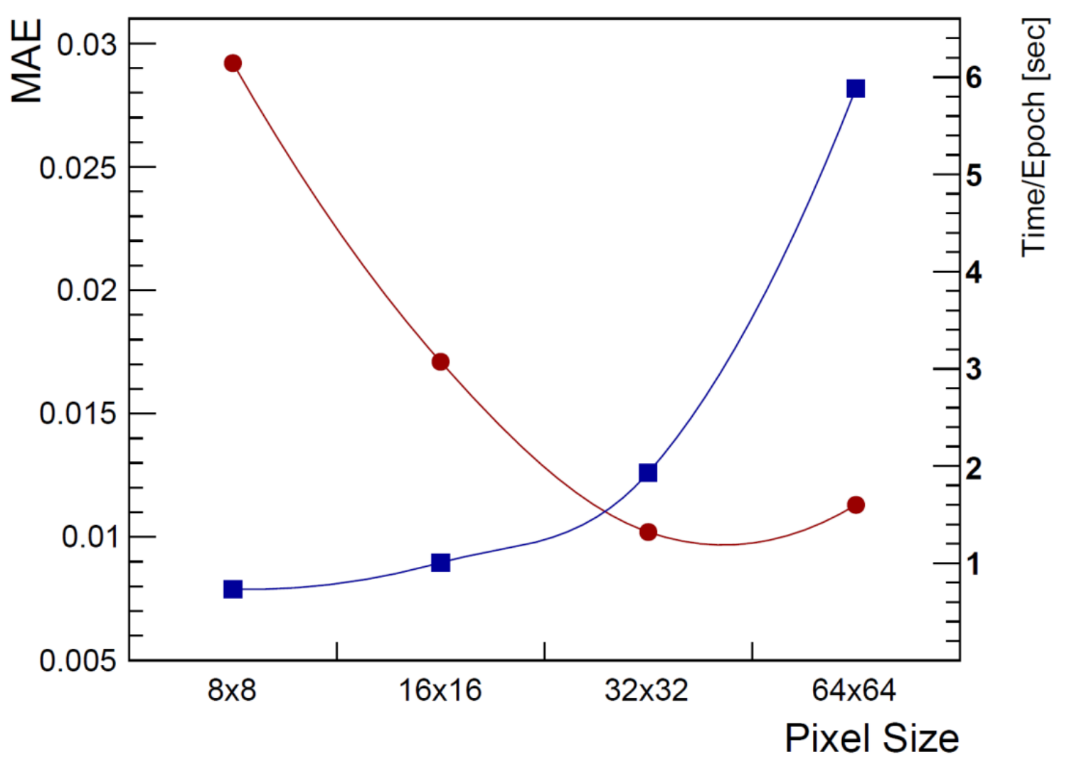


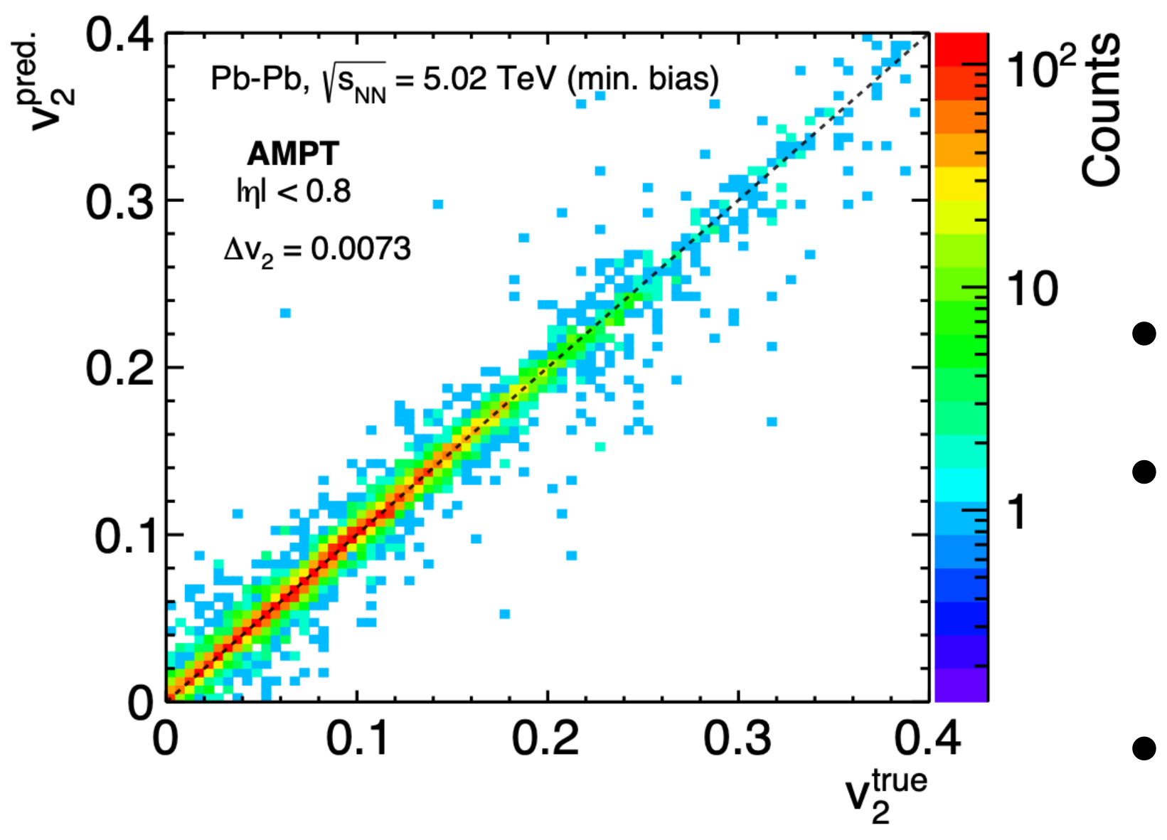
- **First deep learning-based estimator for elliptic flow (v_2)**
- Machine learning model to learn from multiparticle production dynamics and its correlation to estimate any physical observable of interest

2. Deep learning estimator

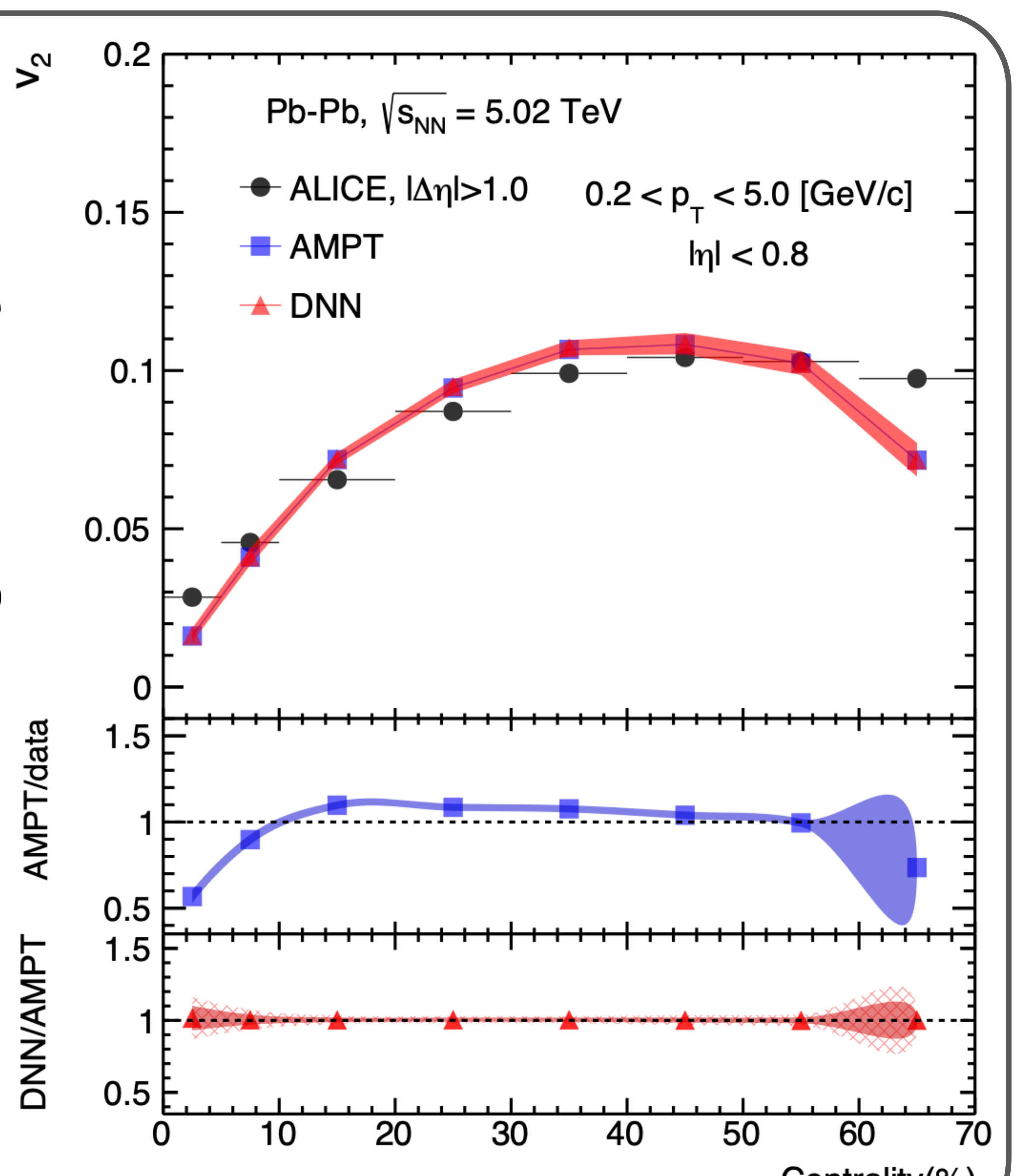


Input Vector
(3072, None)
Hidden Layer (I)
(128, ReLU)
Hidden Layer (II)
(256, ReLU)
Hidden Layer (III)
(256, ReLU)
Hidden Layer (IV)
(256, ReLU)
Output Vector
(1, Linear)



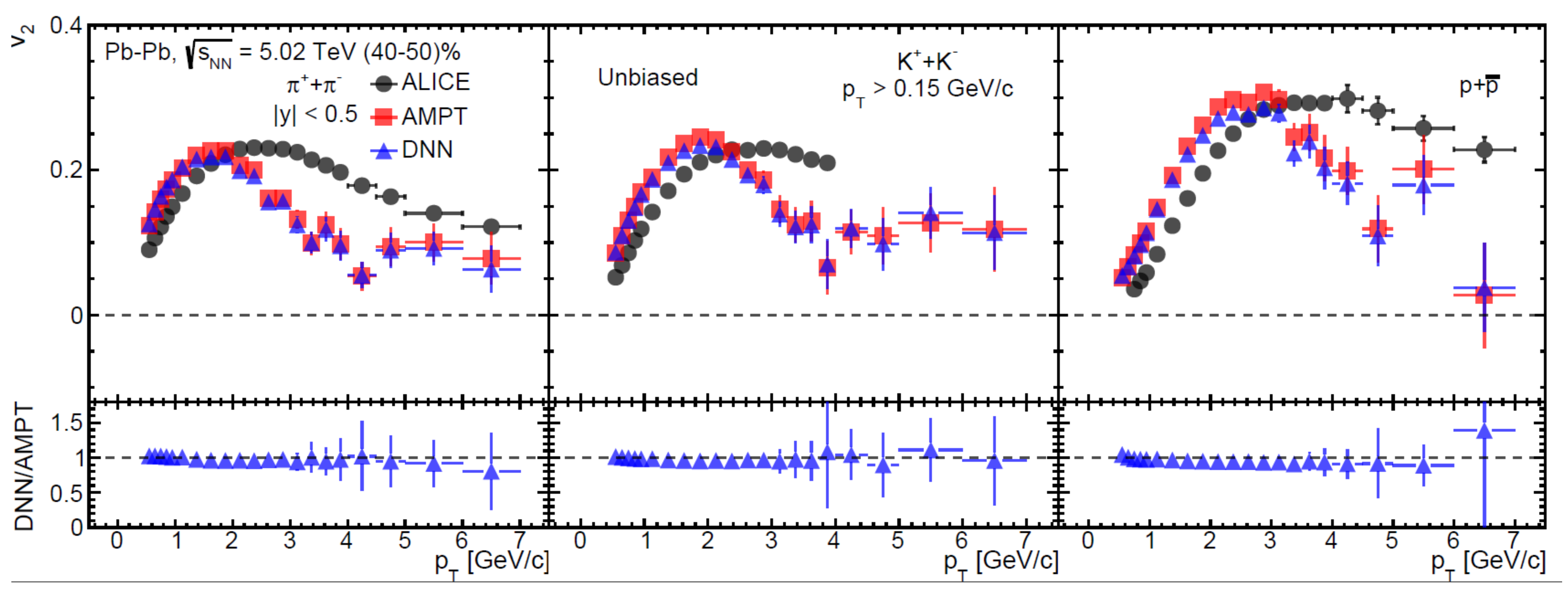


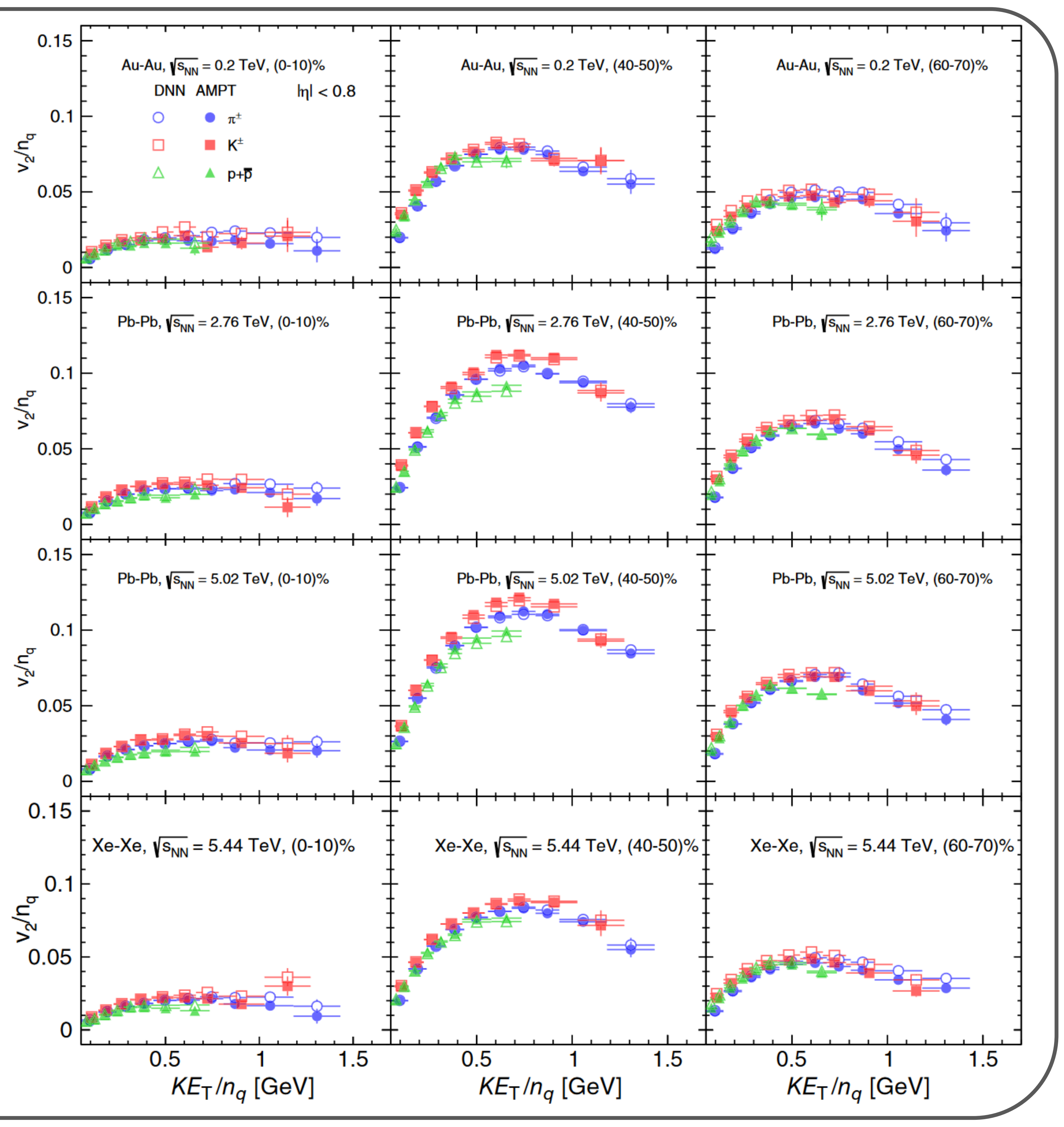
- $(\eta - \phi)$ as primary input space
- p_T , mass, and energy as the secondary input
- 32×32 pixels, three such layers
- Training with minimum bias Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV from AMPT
- Optimizer: *adam*, Loss: *mse*
- Network consists of four hidden layers (*128-256-256-256* nodes)
- *ReLU* activation for hidden layers



3. Results

- Predictions are obtained for the collision centrality, energy, system size, particle mass, 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 the DNN
- AMPT explains the data to a reasonable extent from low-p_T to intermediate-p_T but deviates for high-p_T





4. Summary

- Final state particle kinematics information are used as input
- Event-by-event predictions for elliptic flow are obtained
- DNN preserves the centrality, p_T , energy, and meson-baryon dependent behavior of elliptic flow
- Applicable to RHIC and LHC energies
- Faster and more efficient prediction as compared to the conventional methods

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).

52nd International Symposium on Multiparticle Dynamics
21-26 Aug, 2023
Károly Róbert Campus of MATE in Gyöngyös, Hungary

Flash talk and poster presented by Mr. Neelkamal Mallick [Neelkamal.Mallick@cern.ch]

This work is supported by SR/MF/PS-02/2021-IITI (E-37123) , NKFIK OTKA K135515