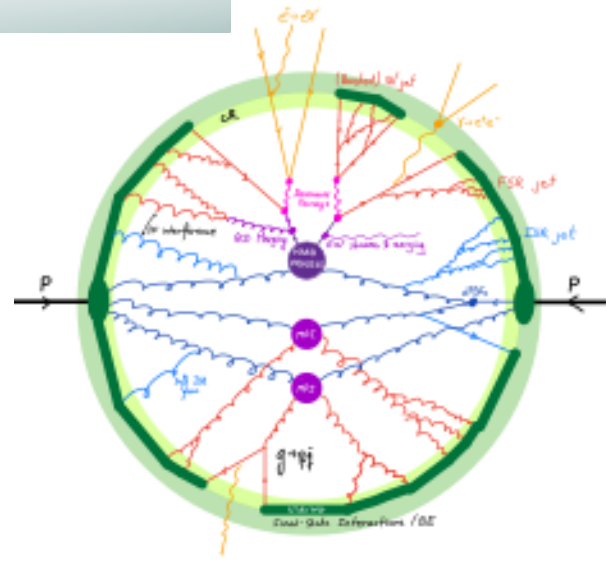
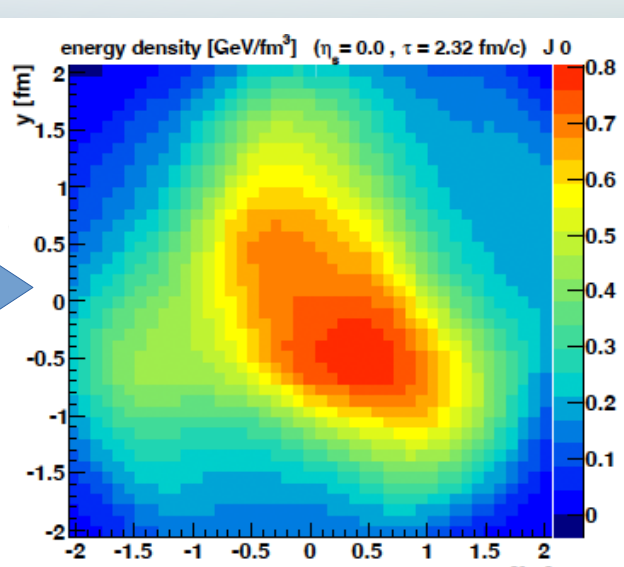
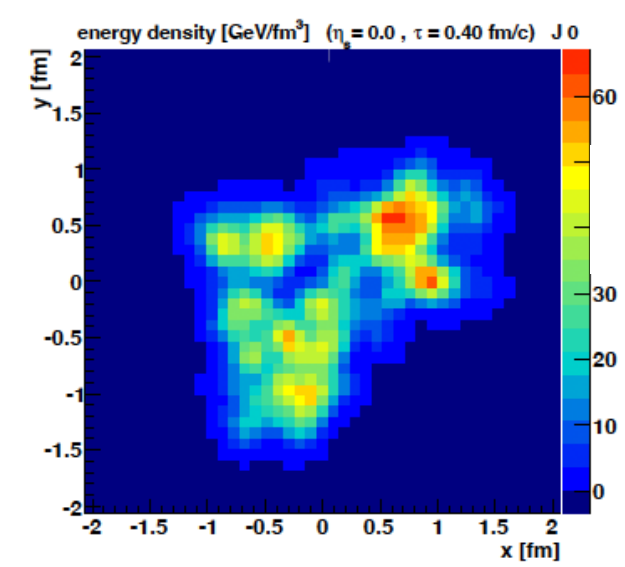


## Introduction

- Collective effects in small collision systems similar to those in heavy ions collisions
  - Initial state effects (Color Glass Condensate Glasma, color-field domains)
  - Final state effects (hydrodynamics, parton escape)

What is the origin of these collective effects?

## Models

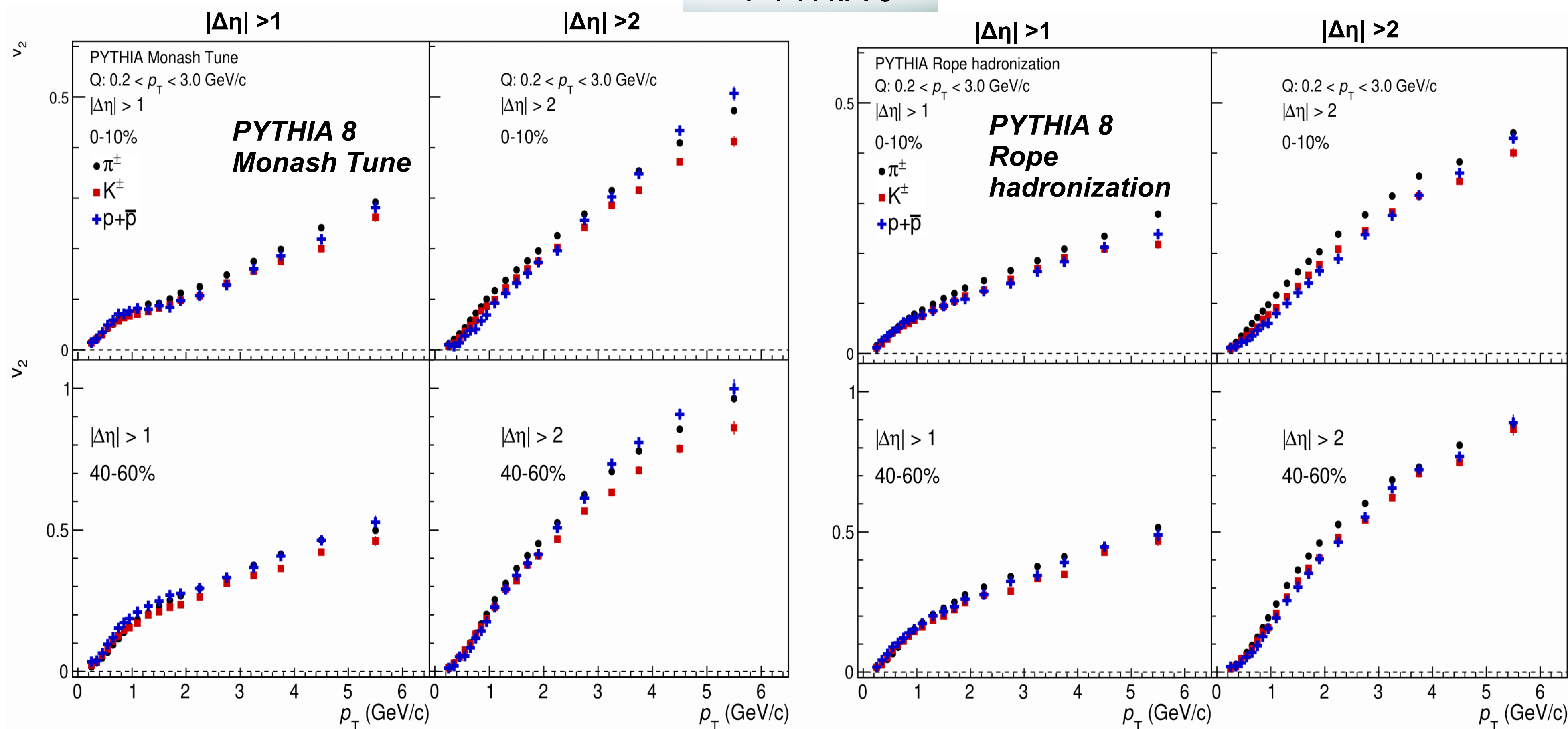


- Macroscopic model: EPOS4<sup>[4]</sup>
- Core-corona model with statistical hadronization
  - Collective effects from hydrodynamical evolution of the medium

- Microscopic model: PYTHIA 8<sup>[5,6]</sup>
- QCD strings with LUND fragmentation
  - Collective effects from new processes
    - Color reconnection, rope hadronization

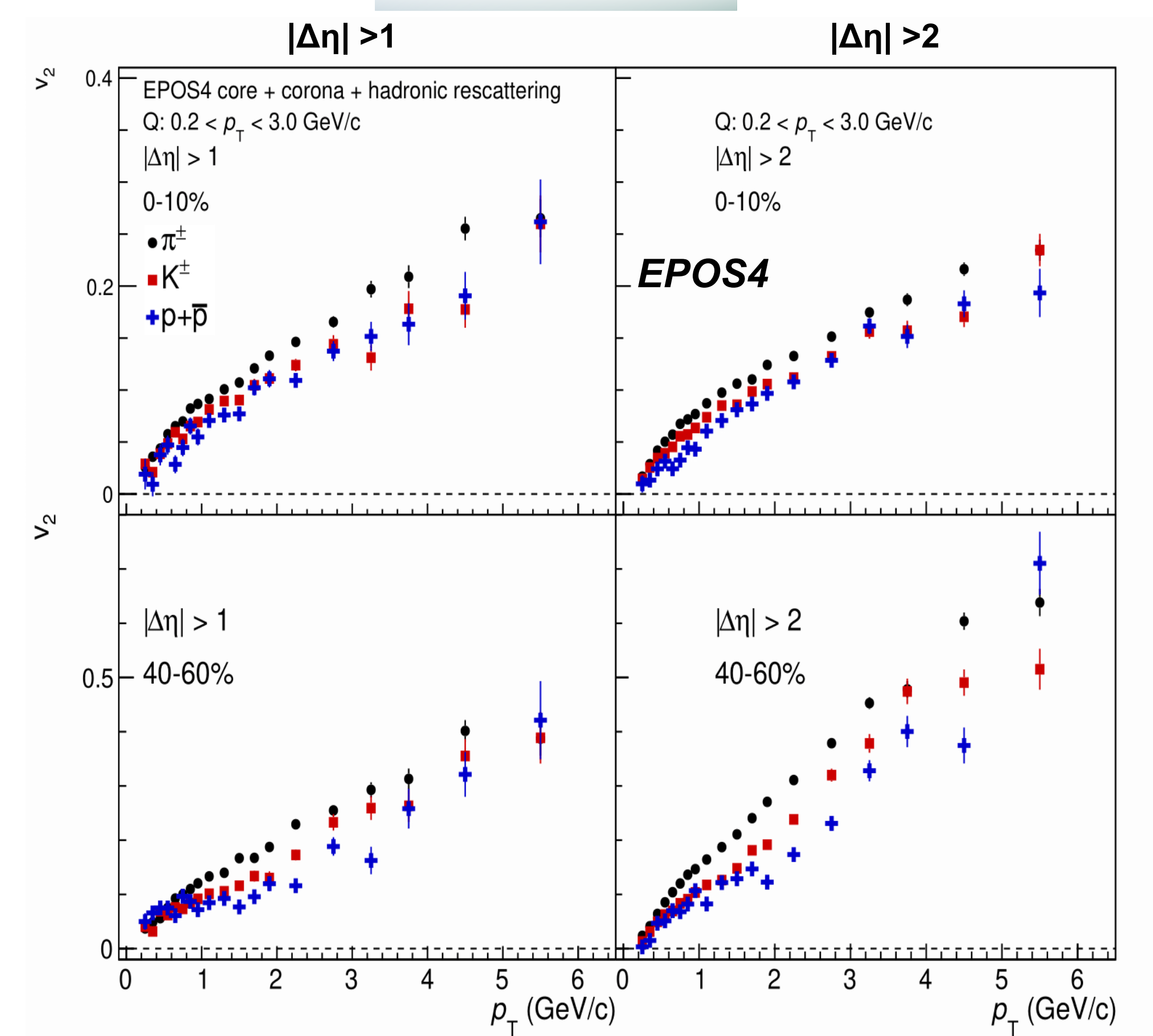
## Results

### PYTHIA 8



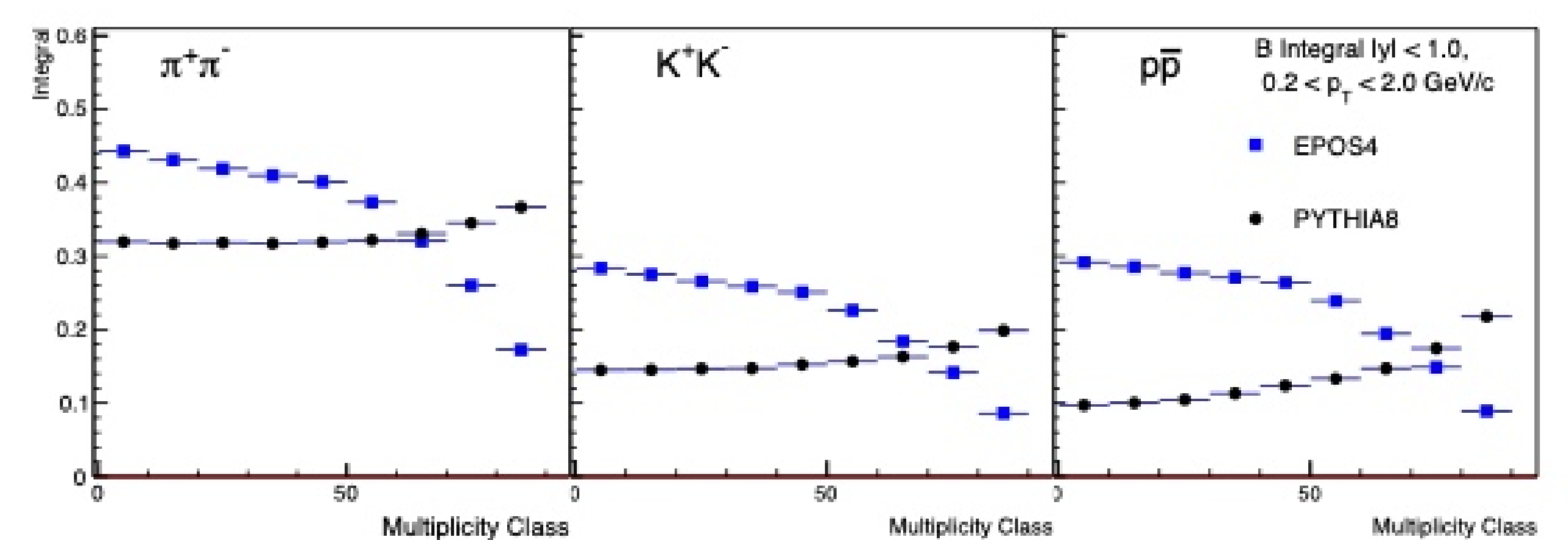
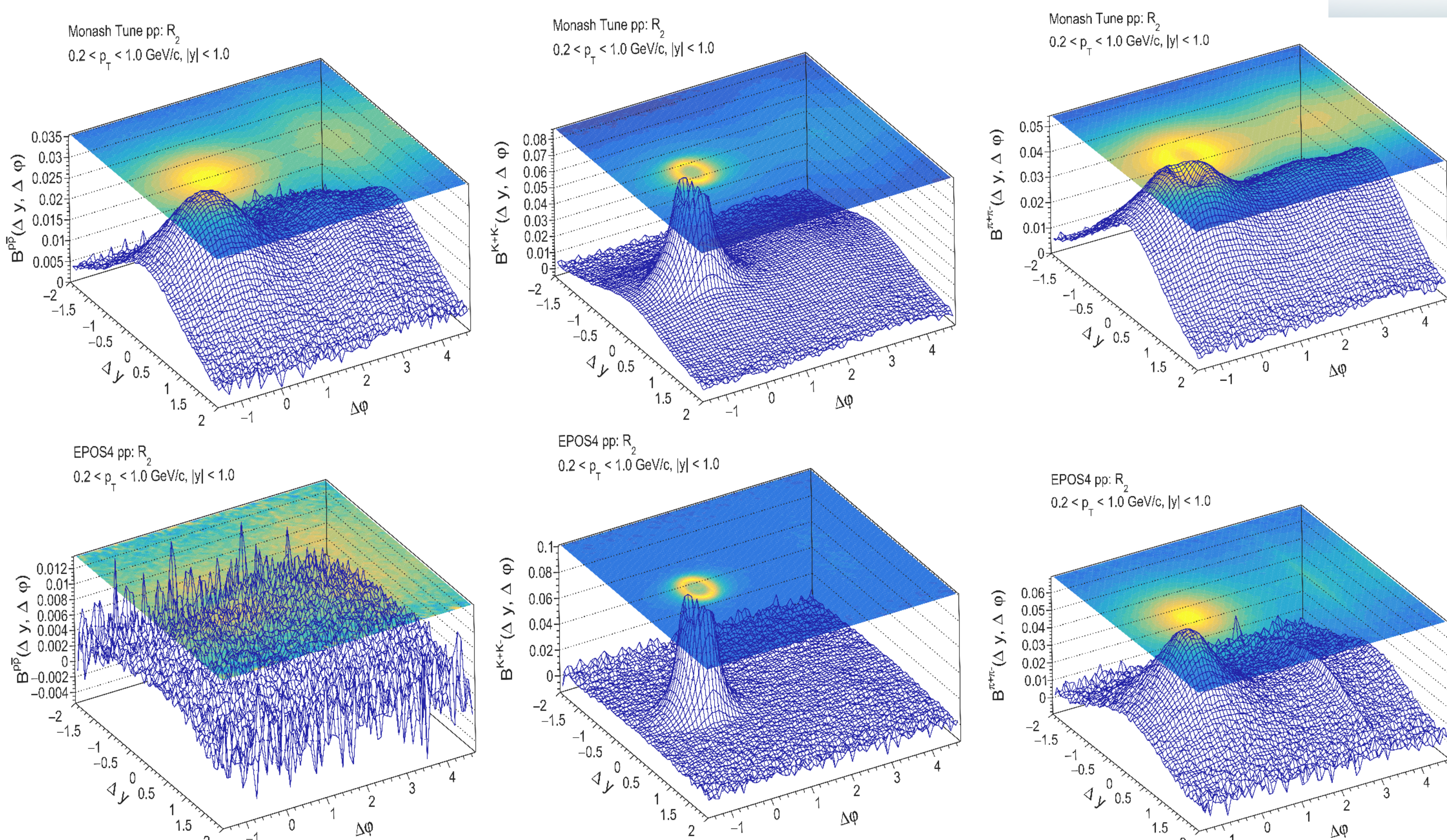
- Similar qualitatively behavior as seen in data for  $|\Delta\eta| > 2$
- Low  $p_T$ : mass ordering (i.e., heavier particles have a smaller  $v_2$  than lighter particles at the same  $p_T$ )
- Intermediate  $p_T$ : crossing between meson and baryon  $v_2$ 
  - No particle-type grouping
- Differences between MONASH tune and Rope hadronization
- Evolution with multiplicity classes

### EPOS4



- Similar qualitatively behavior as seen in data for  $|\Delta\eta| > 1$  and  $|\Delta\eta| > 2$ 
  - No crossing between mesons and baryons  $v_2$
- Different trends then seen in PYTHIA 8
- Evolution with multiplicity classes

## Balance Function (BF)



- Differences between PYTHIA 8 and EPOS 4
  - Different particle production mechanisms
- Different evolution of BF integrals between EPOS4 and PYTHIA 8
  - Strong constraints for particle production mechanism

## Summary

- Investigate collective effects in EPOS4 and PYTHIA 8 simulations
  - Mass ordering for  $v_2$  when a large  $|\Delta\eta|$  gap is employed
  - Particle production is different in models
  - Strong constrains for particle production mechanism from BF calculation

### References:

- [1] ALICE Collaboration
- [2] CMS, JHEP 1009 (2010) 091
- [3] ATLAS, PRC 96 (2017) 024908
- [4] K. Werner, arXiv: 2306.10277
- [5] Figure by P. Skands
- [6] C. Bierlich et al., arXiv: 2203.11601
- [7] S. Voloshin et al., arXiv:0809.2949
- [8] C. Pruneau et al., arXiv: 2209.10420