Flattenicity as centrality estimator in p-Pb collisions simulated with PYTHIA/Angantyr

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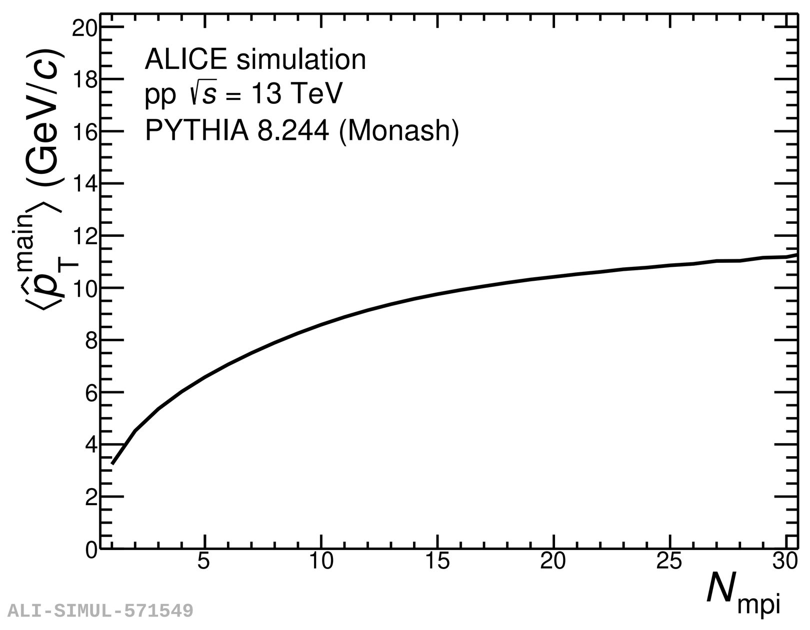
Motivation

Small-system collectivity: large amount of soft-QCD results but origin **not yet understood**

- **High-multiplicity collisions** measured at forward pseudorapidities $\leftrightarrow$ **jet bias** from local multiplicity fluctuations

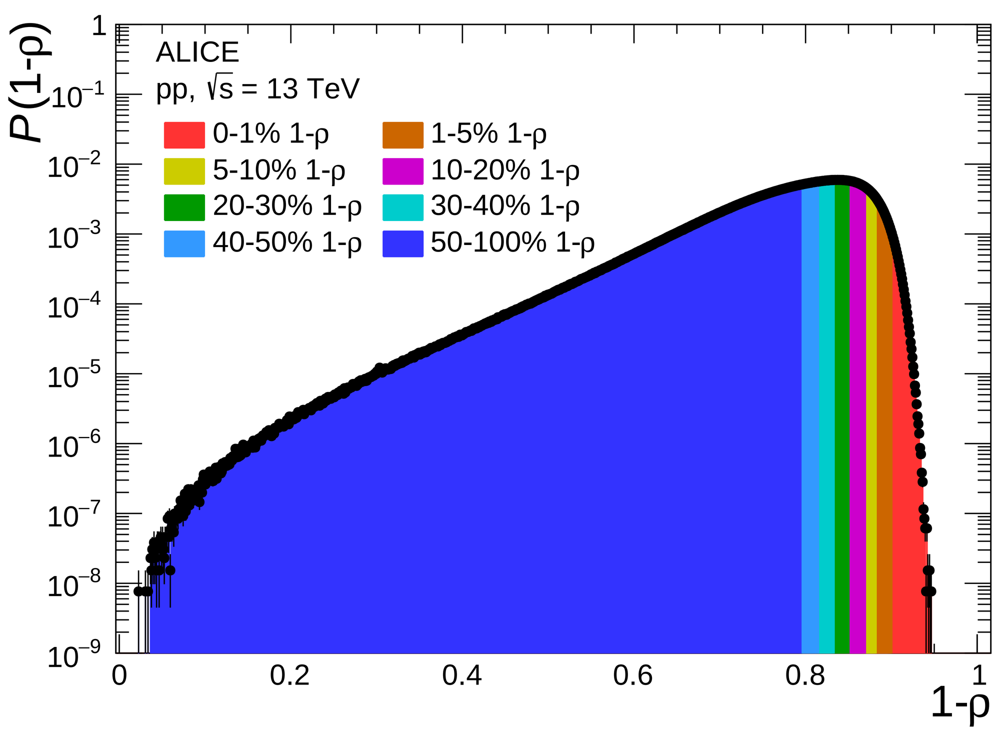


- **Correlation** between **multiparton interactions (MPI)** and the **hardness of the collision**: the larger the number of MPIs (colls. with small impact parameters), the larger the likelihood of producing a harder parton-parton scattering

Objectives

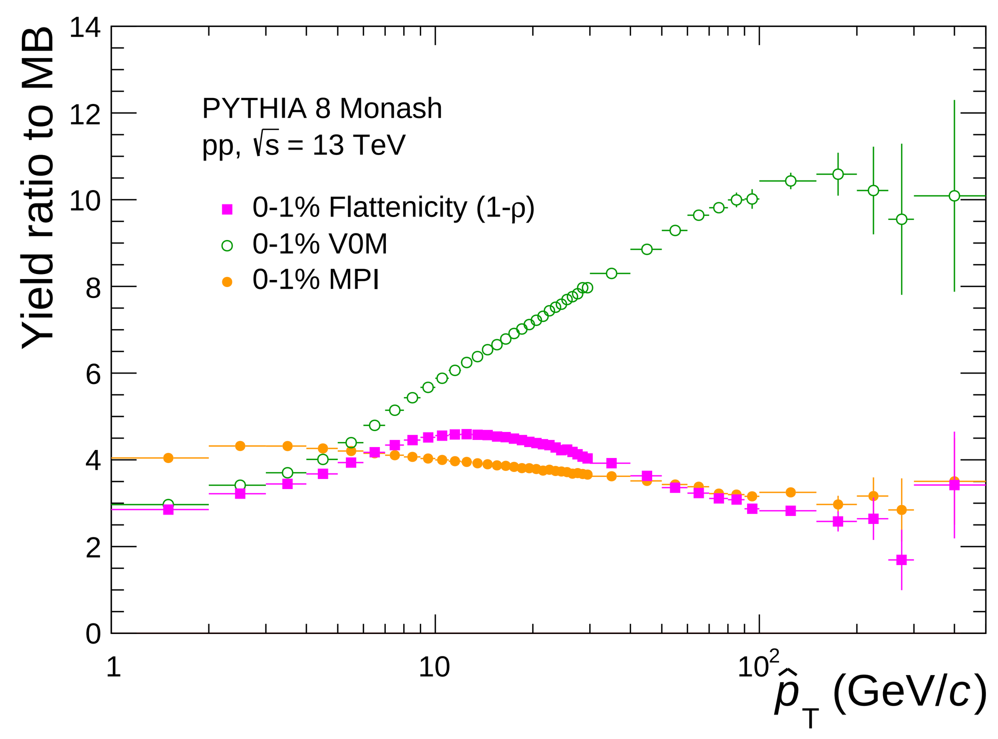
- Usage of **novel event activity classifier flattenicity** with sensitivity to MPIs [1,2]
- Proposal ofxx **an alternative** (less biased) **centrality estimator for p-A** collisions [3]

Charged-particle flattenicity



$$\rho = \frac{\sqrt{\sum_{i=1}^{64} (N_{ch}^{cell,i} - \langle N_{ch}^{cell} \rangle)^2 / N_{cell}^2}}{\langle N_{ch}^{cell} \rangle} \quad (1)$$

- **Event-by-event measurement of multiplicity** of primary charged particles ($N_{ch}^{cell,i}$) in each cell i **of a forward detector (V0M of ALICE)**
- **High flattenicity:** $1-\rho \to 0$: low-multiplicity events with few MPIs ("soft" pp collisions) $\Rightarrow$ low number of high-p_T hadrons
- **Low flattenicity:** $1-\rho \to 1$: high-multiplicity events (large event activity) $\Rightarrow$ large number of MPIs $\Rightarrow$ multijet topologies
- $P(1-\rho)$ probability distribution: divided into percentiles $\to$ define event activity classes



Flattenicity as centrality estimator

Test the sensitivity of flattenicity to the impact parameter of the collision

Centrality estimators in p-A

- **Midrapidity** multiplicity (**CL1**) [4]: the **largest bias** towards hard pp collisions
- **Forward** multiplicity (**V0M**): reduced autocorrelation bias w.r.t. CL1
- **Flattenicity: reduced bias w.r.t. V0M**

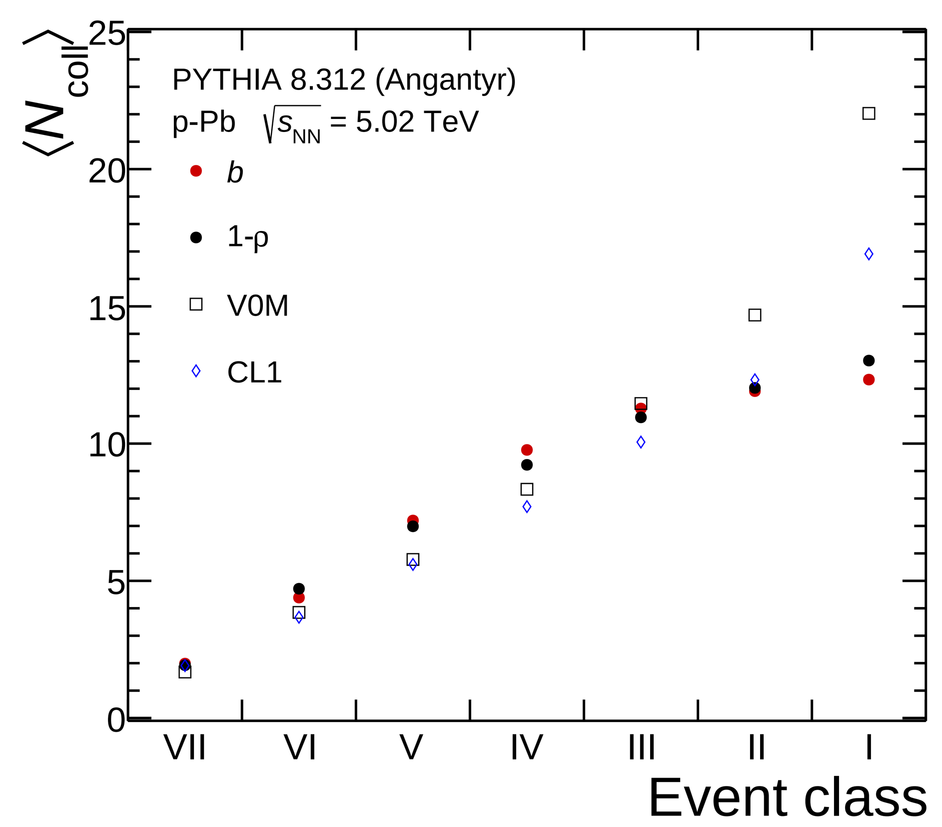
p-A in PYTHIA/Angantyr

- **Angantyr** [5]: pp dynamics $\to$ **collisions of nuclei** without ropes and string shoving
- Participant nucleons: (1) Glauber model + Gribov correction, (2) Color-reconnection (CR) only applied for individual NN coll.

Used event classifiers	Symbol	Pseudorapidity (η) coverage	φ information
Midrapidity multiplicity	CL1	$-0.3 < \eta < 0.3$	not used
Forward multiplicity	V0M	$-3.7 < \eta_{lab} < -1.7$ and $2.8 < \eta_{lab} < 5.1$	not used
Flattenicity	1-ρ	$-3.7 < \eta_{lab} < -1.7$ and $2.8 < \eta_{lab} < 5.1$	used

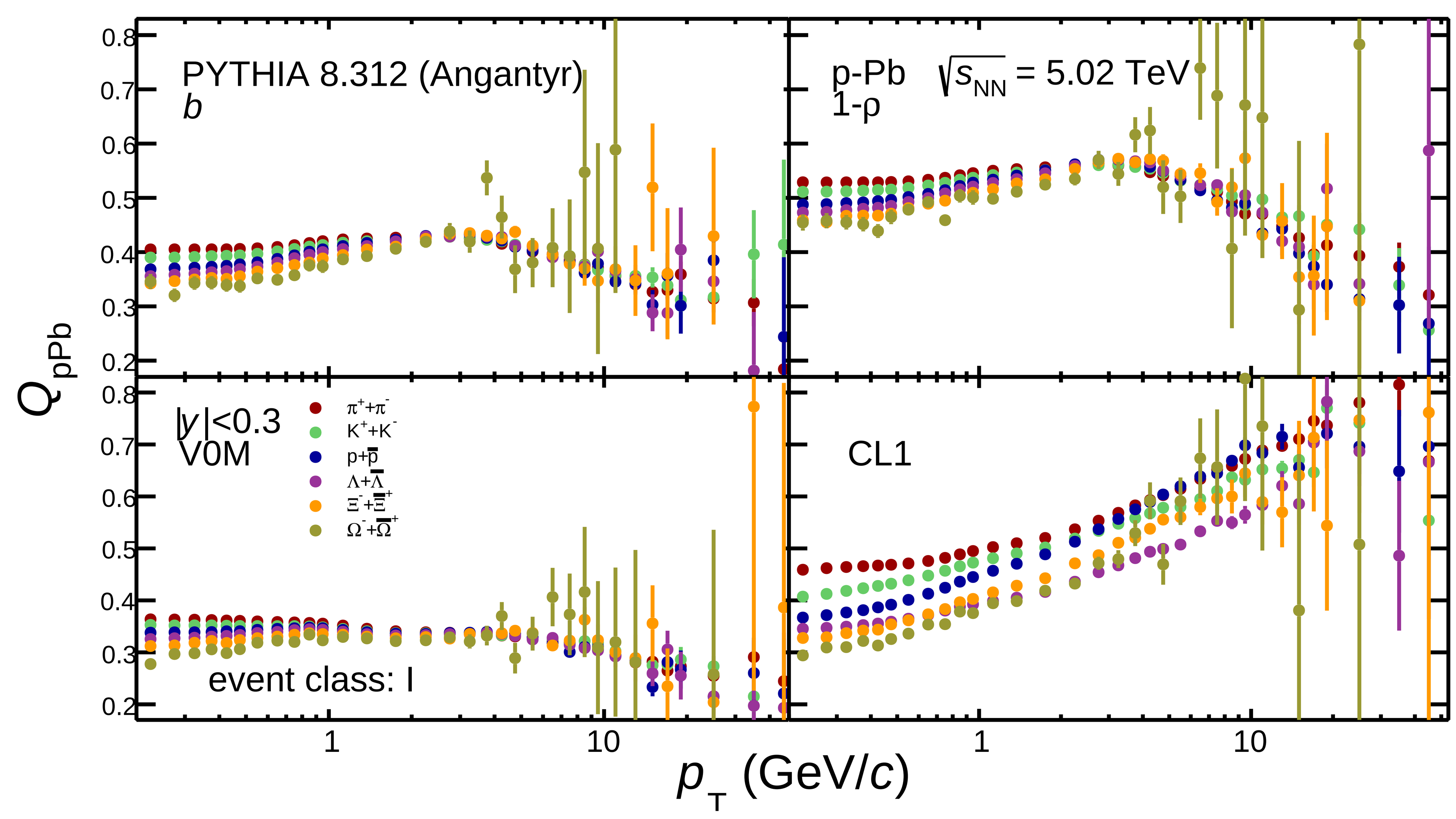
$\langle N_{coll} \rangle$ for event activity estimators

- Average number of **binary nucleon–nucleon collisions** $N_{coll} = N_{part} - 1$ obtained **from PYTHIA/Angantyr**
- **Seven centrality classes** are defined:
  - lowest multimplicity class: VII, $\langle dN_\pi/dy \rangle \approx 3$
  - highest multiplicity class: I, $\langle dN_\pi/dy \rangle \approx 46$
- V0M- and CL1-based estimators:
  - weak correlation with impact parameter
  - ensitivity to N_{part} fluctuations
- **High-multiplicity classes:** $\langle N_{coll} \rangle(b) \approx \langle N_{coll} \rangle (1-\rho)$



Results and discussion

- PYTHIA/Angantyr 8.312: N_{coll}-**scaling** of high-p_T yields **not reproduced**, **yet** we want to see how centrality estimators bias the p_T spectral shapes
- **Quantify spectral shapes**: $Q_{pPb}(p_T) = (dN^{pPb}/dp_T)/(\langle N_{coll} \rangle dN^{pp}/dp_T)$
- Particle species dependent analysis for the most central (class I) p–Pb collisions (see Figure below)



- $Q_{pPb}(p_T)$: **strong mass dependence and bump structure** at intermediate p_T when centrality event **selection** is based on impact parameter or **flattenicity**
- No bump structure observed for V0M and CL1 estimators: affected by biases towards hard physics

Take-home message

Flattenicity is a novel event activity estimator that controls the biases in high-multiplicity events

References and Acknowledgment

[1] ALICE Coll., Phys.Rev.D 111 (2025) 1, 012010, [2] Ortiz, A. et al., Phys.Rev.D 107 (2023) 7, 076012, [3] Ortiz, A. et al., J.Phys.G 51 (2024) 12, 125003, [4] ALICE Coll., Phys.Rev.C 91 (2015) 6, 064905, [5] Bierlich, C. et al., JHEP 10 (2018) 134

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