Event Shape Sorting

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1. Motivation

In ultra-relativistic heavy-ion collisions each event evolves from different intial conditions. This leads to anisotropies in the final distributions of hadrons.

Experimental results should be compared to theoretical simulations. Do we simulate the same evolution as the real events undergo?

Some information may get lost if we average hadron distributions over events with fluctuating anisotropies.

Can we select events from the experimental sample which are similar and were likely to undergo similar evolution?

A method already on the market: Event Shape Engineering (ESE) [1]. ESE selects events according to a chosen variable. How does one know that the chosen variable for ESE is relevant?

Our new method: Event Shape Sorting (ESS) [2] creates order in a set of events in such a way, that events which end up close to each other have similar shape.

Event shape sorting thus allows to select samples of similar events.

2. How the method works

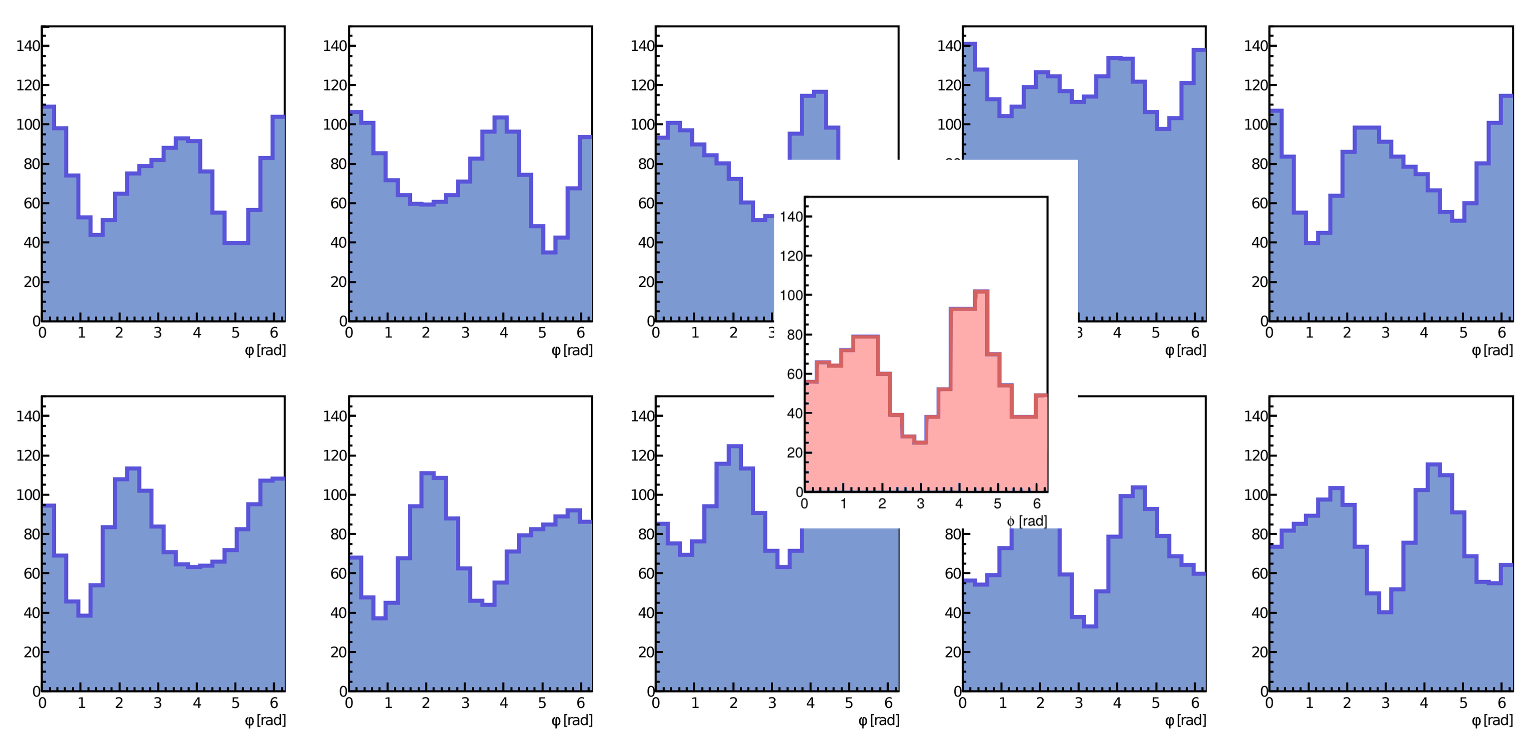
We apply the method to histograms of azimuthal angles of hadron momenta.

The algorithm:

1) (Rotate the events appropriately)
2) Sort your events as you wish (actually, the initial sorting has no influence on the final result)
3) Divide sorted events into quantiles (we'll do deciles)
4) Determine average histograms in each quantiles
5) For each event *i* calculate Bayesian probability $P(i|\mu)$ that it belongs to quantile μ.
6) For each event calculate average $\bar{\mu}_i = \sum_{\mu=1}^{10} \mu\, P(i|\mu)$
7) Sort events according to their values of $\bar{\mu}_i$
8) If order of events changed, return to 3. Otherwise sorting converged.

Illustration of point 5):

To which event bin is the selected event (in red) most likely to belong?



Result of the algorithm: sorted events

One can compare the ordering with the values of parameters like v_2, v_3, q_n etc. in each event.

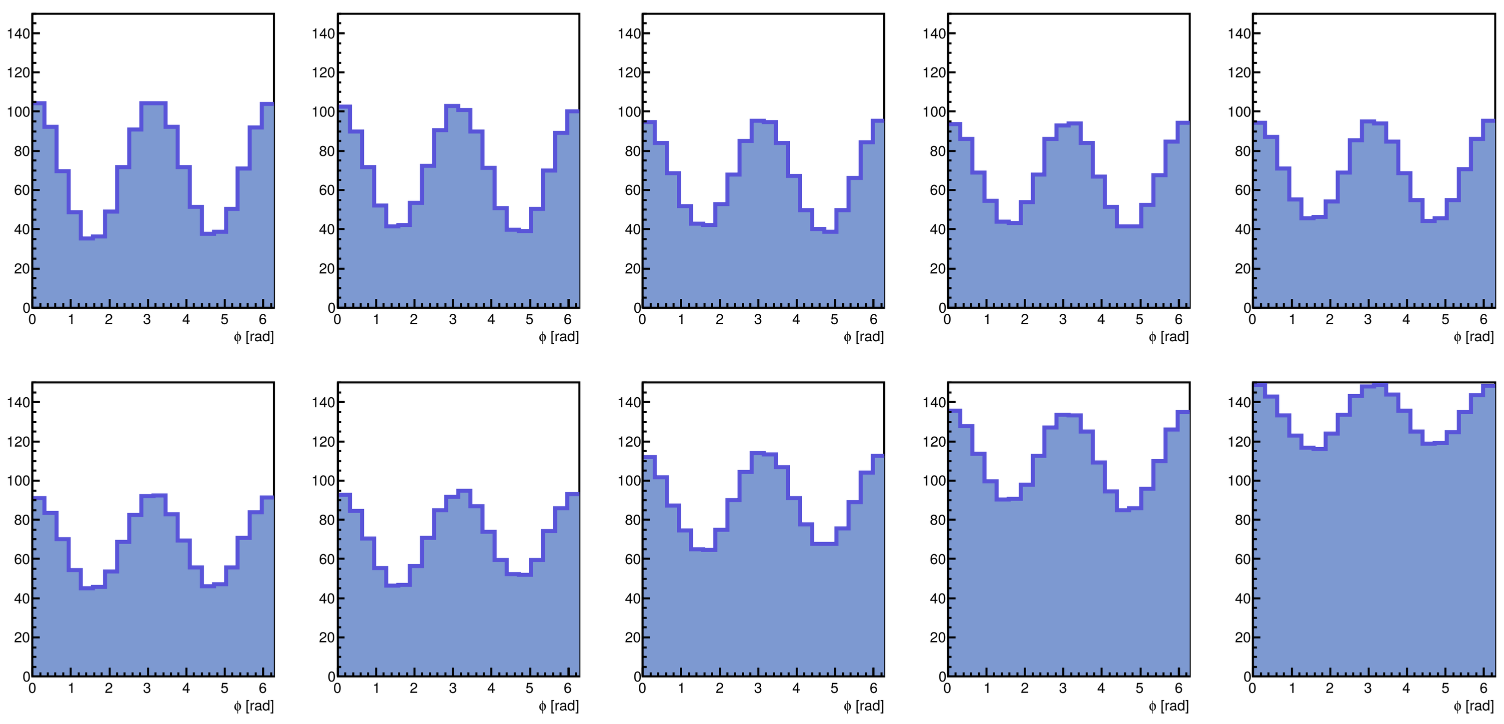
The method is based on works published in [3,4]

3. Method check with a toy model

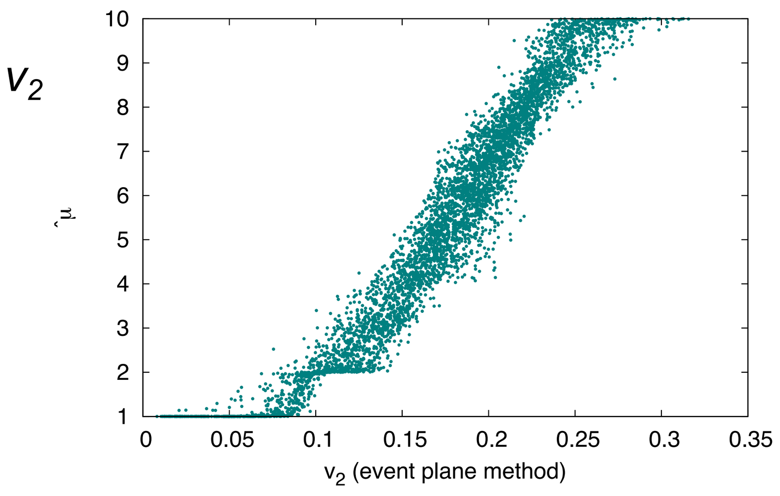
Monte-Carlo-generated events with only elliptic flow anisotropy which varies together with the multiplicity: $v_2 = aM^2 + bM + c$ (fluctuations are added on top of this dependence).

The method reliably sorts the events according to their elliptic flow.

Illustration of average histograms of the event bins:



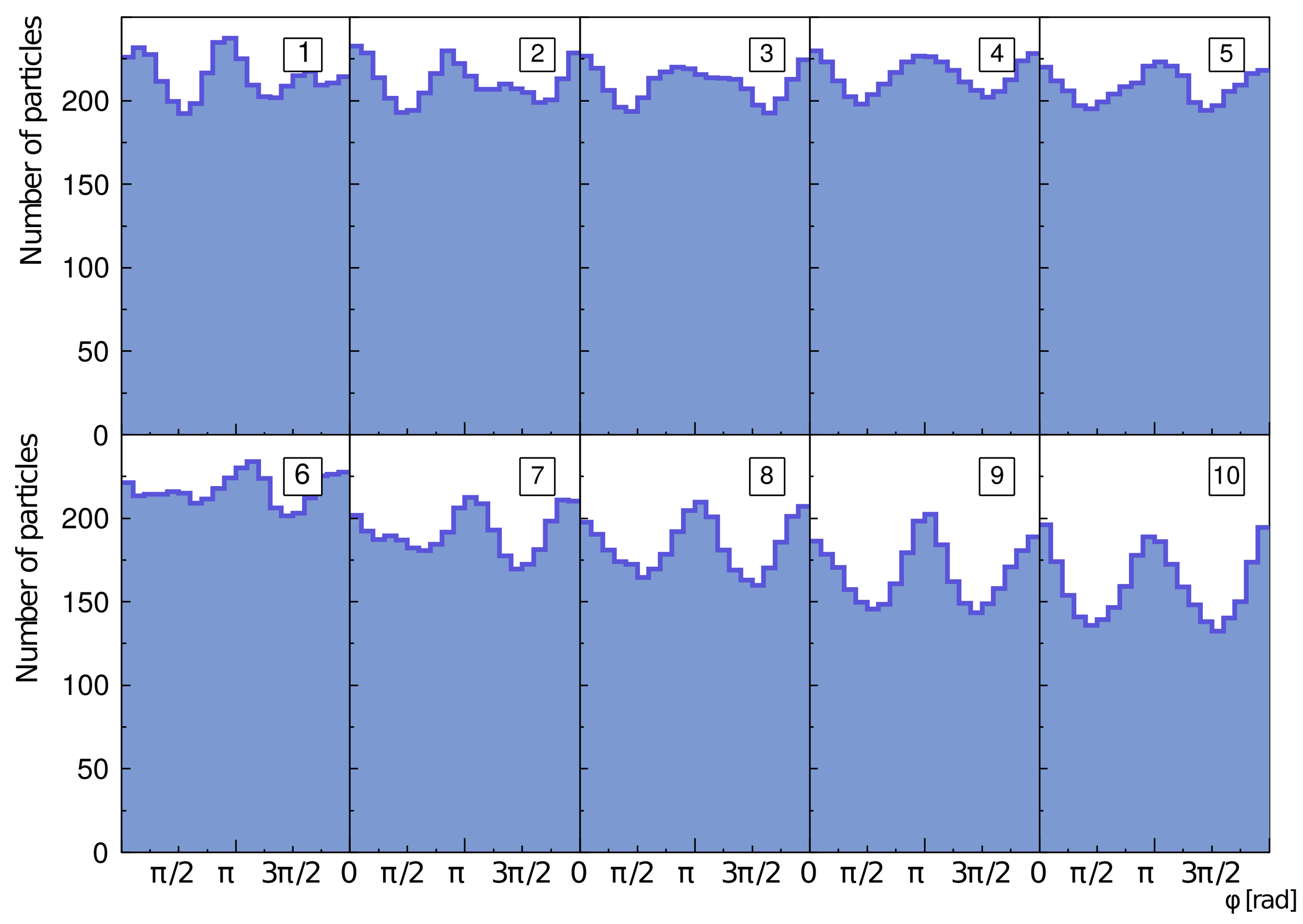
Correlation of the sorting variable with v_2



4. Application to AMPT events

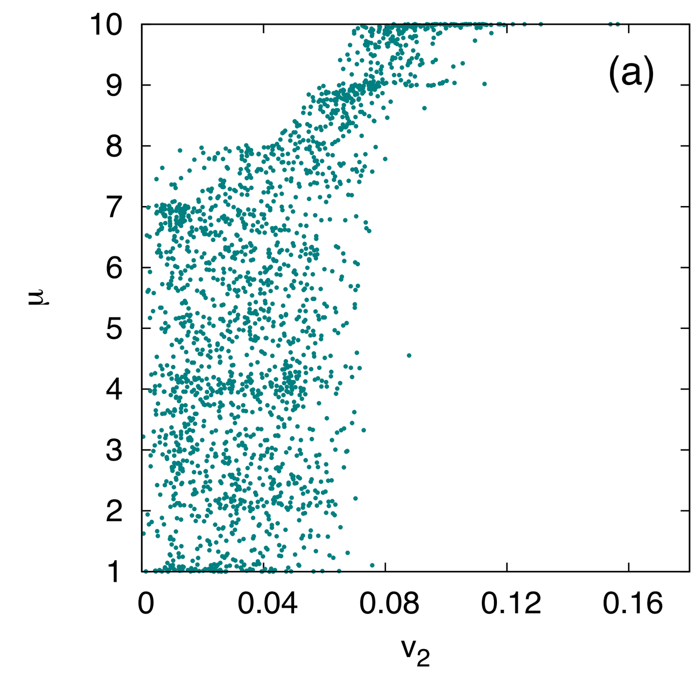
Simulated 2000 Pb+Pb events at $\sqrt{s_{NN}}$ = 2.76 TeV with the help of the AMPT transport code [5]. The centrality was selected 0-20%.

Average histograms for the event bins:



Plotted on the right-hand side: correlation between sorting variable $\bar{\mu}$ and the elliptic flow v_2 within the event.

There is correlation between the sorting and the elliptic flow. However, for not extremely high values of the elliptic flow the overall shape of the histograms results from some more complicated interplay of many features.



5. Conclusions

Event shape sorting can help to select events with similar shapes for more exclusive studies.

Possible applications:

- More dedicated theory vs. experiment comparison, because ESS allows to select events with specific evolution and this reduces the need to average over a large number of event also in case of simulation.
- Better background construction for correlation studies, because one could use the mixed-events technique for event with very similar single-particle distributions.
- One could try single-event femtoscopy, because the method allows to construct mixed-events background from similar events.
- …

References

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[5] Z.-W. Lin *et al.*, Phys. Rev. C **72** (2005) 064901