Review - Laszlo Gyulai

Balázs Ujvári

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1 Thesis

In small collision systems quark-gluon plasma (QGP) is not expected to create, because of the lower energy, temperature and density of the system. Altough LHC and RHIC experiments are measured QGP-like collective behaviour in small systems, there are other theories can explain the observations. Mainstream reasons for the similarities are the vacuum QCD processes at the soft-hard boundary, like mini-jets or multiple-parton interaction. The heavy-flavour jets can help us, since their fragmentation differ from the light-flavour jets, to understand of the nature of the underlying events. Laszlo used heavy-flavour production in small and large systems to answer these questions. His paper shows a very diverse work, covering simulation, ALICE measurements and comparisons of further measurements.

1.1 Introduction, Experiments

After raising the main questions, we got a substantial theoretical and experimental summary. These chapters introduce the candidate's work in a logical and goal-oriented way. He write about the PYTHIA 8 event generator, widely used Monte-Carlo methods, with different parameter sets these results (together with the GEANT simulations), can be compared with the data and the underlying mechanisms can be understood. Experienced users (Laszlo achieved this level with his work) of these simulations can also develop the analysis strategies and detector design for the future detectors and collaborations.

1.2 PYTHIA heavy-flavour

In the chapter 3 PYTHIA was used with different parametrizations, compared to ALICE analysis results. Events were triggered with hadrons and jets, R_T was measured and at it was shown, in the transverse region the p_T distribution is flat above 5 and 10 GeV, depending on trigger mode and the heavy-flavour hadron production in the transverse region is strongly influenced by the underlying event. Laszlo suggested the jet trigger to determine the direction of leading particle and calculate the R_T based on it and showed, the heavy-flavour production depend on underlying events in PYTHIA. With this method the simulations and the measurements (even at different experiments) can be comparable and the nature of the underlying event can be understood.

1.3 ALICE heavy-flavour

In the ALICE Run2 MB dataset Laszlo reconstructed the D^0 mesons via the kaon+pion decay channels with several topological selection criterias. The topology of the D^0 is correct, extracted the raw yield by fitting the invariant mass in p_T intervals. Calculated the acceptance and efficiency, did the corrections. The systematics uncertainties is very detailed, they comply with the methodology of the ALICE experiment. The results are well understood and I consider them important for ALICE collaboration and for the particle physics too.

1.4 Tsallis thermometer

The candidate worked on the production of the light- and heavy-flavour hadrons within the Tsallis Pareto framework. He used huge amount of result from different experiments and was able to show, the scaling of D mesons are differ from light-flavour and strange hadrons. The heavy-flavour hadrons' parameters (T_{eq}, q_{eq}) are higher, which means these hadrons give us information about the earlier stages of their formation. He analysed different types of hadrons, measured by ALICE and determined the Tsallis parameters. Baryon have a bit lower T_{eq} than mesons and no ordering of q_{eq} was found with the meson masses.

2 General remarks

The dissertation is well-edited, compact and the figures and text are consistent. Literature is thoroughly analysed and used, and the independent work is well distinguished. At the beginning of the work (around page 16) a PDG list of the the mesons you used would be welcome, with the mass, lifetime, decay channels and probabilities.

3 Questions

1. Can your PYTHIA simulations explain the azimuthal particle correlations (CMS, Fig. 1.9), elliptic flow (ALICE, Fig 1.10) and the ratios of the yield like K^0_S... to pion (ALICE), you listed in page 12?

2. To avoid auto-correlation effects is it the only solution (pseudorapidity and azimuth gap) or are there any statistical method without a gap to increase the statistics?

3. What is the p_T distribution of the leading particle, why Fig. 2.9 stops at 40 GeV? Does ALICE have statistics till 50? For Run 3 will you expect wider range for this plot?

4. Page 34: "According to simulations, R_T is strongly correlated to MPI in a collision [59], therefore measuring it will indirectly classify events by MPI." In this paper we can see huge differences between MC simulations. How strongly can correlate R_T and the MPI? Are there any other papers? Can this relationship be quantified?

5. Page 43: For charged-hadron trigger events were generated and the average N_{trans} is calculated, for jet-triggered events it was only assumed this number is same (I also think this is close, but perhaps not 7.426), why did you not calculate it in the same way? The Fig 3.3 shows small differences between the two triggers.

6. If we use different trigger threshold (for example: $p_T^{leading} > 8$ GeV) will it change the Fig 3.4?

7. 1% of the Run 2 MB events has $p_T^{leading} > 5$ GeV particle, are there any triggers prefer at least one high-p_T track in the event?

8. Table 4.4. sometimes the parameters change with $p_T^{D^0}$, how can you calculate the systematical uncertainties in this case?

9. Page 66: When you calculated the acceptance-times-efficiency did you try to use 2D matrix to take into account the bin-by-bin migration in p_T too? As you did for R_T later.

10. Page 77, Feed-down systematic uncertainty. It was mentioned that it's a standard method as in publication 98. If I look at the 98 Table 1, and compare to your Table 4.7 (the p_T bins are different) the uncertainty from feed-down in your case seems to be much larger. Is it a bin or $\sqrt{s}$ issue or something else?

11. Fig 4.17 You said at the beginning, that Monash tune does not describe well the heavy-flavour correctly, in this plot, in the 2-4 GeV interval the Monash is closer to the data than the CR-BLC Mode 2 tune, what is the reason?

12. Page 89: "This behaviour may be explained by the fact that..." Page 94: "...hinting at later formation times for baryons..." What is needed to prove this?

4 Summary

I accept this thesis as worthy of a PhD degree. My assessment: **summa cum laude**.

Debrecen, 2025.05.05. Ujvári Balázs