Opponent‘s assessment of diploma thesis

Thesis title: Study of Upsilon meson production dependence on charged-particle multiplicity in pp collisions with the STAR experiment
Author: Bc. Jakub Češka
Opponent: Mgr. Martin Rybář, Ph.D.

Thesis assessment

The subject of the diploma thesis of Bc. Jakub Ceska is the study of Upsilon meson production dependence on charged-particle multiplicity in pp collisions with the STAR experiment. This study aims to improve our understanding of quarkonia (bound states of quark and antiquark of the same flavor) production, and it is also essential for the interpretation of quarkonia measurements in heavy-ion collisions.

The thesis is logically divided into seven chapters and a short introduction and conclusion. The number of factual errors is minimal; the work is very good in terms of graphics and language. The thesis is written in very good English, which will facilitate the use of the results obtained in the STAR collaboration. The number of typos and grammar errors is reasonable given the length of the text.

The first introductory chapters contain a very well-written summary of the standard model (Chapter 1), an overview of quarkonia physics, and recent results on quarkonia measurements (Chapters 2 and 3). This part of the thesis is extensive but very clear, which confirms
the author's good knowledge of the physics bacground. Chapter 4 discusses the RHIC accelerator and STAR detector with a focus on subdetectors used for the data analysis. In these chapters, I was missing some definitions of the kinematical quantities and coordination system. This would naturally fit the first chapter with the title "Relativistic hadron collisions," which includes only a summary of the standard model. Also, since the work is focused on the dependence of Upsilon production on the charged-particle multiplicity, I would expect a discussion of two recent LHC results: "Investigation into the event-activity dependence of Y(nS) relative production in proton-proton collisions at 7 TeV" (arXiv:2007.04277v3) by CMS and "Correlation of Y meson production with the underlying event in pp collisions measured by the ATLAS" (ATLAS-CONF-2022-023).

The author's study is concentrated in Chapters 5, 6, and 7. Firstly, the author simulated the production of Upsilon meson states in pp collisions and focused on the role of various production mechanisms of different Upsilon states and the correlation of the production with the total charged-particle multiplicity. The simulations from PYTHIA are compared with the STAR measurements showing a significant discrepancy between model and data at higher multiplicities.

Chapter 6 then describes the experimental analysis of extraction Upsilon signal in pp collisions collected by STAR detector. A significant part of the work is devoted to discussing the optimization of electron identification and event selection. Unfortunately, the work could not be fully completed due to missing information in the centrally produced datasets by the STAR collaboration. However, the author contributed to fixing this issue and presented a preliminary performance study with updated data.

Despite the above comments, it is clear that the author has done a non-trivial amount of work and obtained important results that can be further used. Thus, the present thesis meets the demands placed on the diploma thesis, and I recommend it to be rated as excellent, with grade A.

Questions for the discussion:

- I would appreciate more detailed information about the Pythia simulation: what is the exact version? Is there some parameter tuning used? What is the PDF?
- Would there be a significant benefit (statistic, background) from including also dimuon decay channel in the analysis of the data?
- Do you understand the significant increase in the Upsilon yield dependence in the highest interval of normalized multiplicity in simulations? It might be interesting to do the study with finner binning (not required now).
- Fig 6.1 suggest a total of ~1.5x10^9 events, while the text mentions 2.9x10^9 events. Why is that difference?
- I found it surprising that there is no good run list for the dataset from 2017. Do you expect that to be ready soon?
- Is the nHitsFit cut also dependent on pseudorapidity? If yes, is it just redundant to the nHitsRatio?
- Do you have some estimation of efficiency and purity for the existing electron ID?
- Do you understand the structures in Fig 6.14?
- I found the way of dealing with the background contribution to the dielectron invariant mass non standard. Typically, both the signal and background are estimated using fitting to the opposite sign distribution. The same sign is sometimes used only to check the background shape. The overall normalization is expected to be different for the same and opposite sign due to various processes that contribute to them. Was this method used also for previous STAR measurements?

V Praze dne 30.5.2022

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