COMENIUS UNIVERSITY BRATISLAVA
FACULTY OF MATHEMATICS, PHYSICS AND INFORMATIC
Department of nuclear physics and biophysics
Mlynská dolina F2, 842 48 Bratislava

doc. Mgr. Michal Mereš, PhD.
Department of nuclear physics and biophysics
FMPhI UK
Mlynská dolina F2,
842 48 Bratislava

In Bratislava, 25.8.2024

Review of dissertation thesis of student M.Sc. Santu Mondal.

Dissertation thesis with name: “Processes involving top quarks in proton-proton and proton-lead collision” reports the search for $t\bar{t}H$ production in multilepton final states using proton-proton collisions at a centre-of-mass energy of $\sqrt{s}$ = 13 TeV and the observation of top-quark pair production in proton-lead collisions in the ATLAS experiment using of p+Pb data collected at $\sqrt{s_{NN}}$ = 8.16 TeV.

The work is written clearly in English, with only a very small number of grammatical errors and typos, which, however, do not reduce the intelligibility of the text. On the formal side the author sometimes uses the label of elementary particles on contrary to conventions and uses additional information which are not needed - for example: labels for particles as proton and quarks should be written in regular not capital, extra notation “per nucleon pair” after $\sqrt{s_{NN}}$.

In the theoretical part of this thesis with name “Theoretical motivation” the author defined the standard model of particle physic and described top quark production its cross-section measurements. In several places the author mentioned that top quarks will serve as a distinctive tool for assessing the properties of the strongly interacting quark-gluon plasma (QGP) for a reference of ultra-relativistic Pb+Pb or p+Pb collisions at the LHC respectively. So top quark production as signature of quark-gluon plasma is also a very important part of theoretic motivation and could have been given more attention and not only reference to publication [180] in introduction to chapter 5. Could you, within the discussion, enplane why the production of top quarks in pp should be different from production in heavy ion collisions?

In the next chapter of the theoretical part, the author characterizes the LHC accelerator and ATLAS experiment and its subdetectors, which were used in the data analysis itself. He further describes very important physical properties of particle accelerators as a luminosity and coordinate systems of detectors. At the end of this chapter the trigger system is briefly introduced.

In the first practical part the eigenvector decomposition study related to b-tagging pseudo-continuous data-based calibration is performed. This section describes the different algorithms used for b-jet identification and the evaluation of their performance in simulation. Author is showing many variation of a cut at different values in different tagging algorithms. To maximize b-tagging performance, the results of the low-level algorithms are combined using multivariate classifiers. The

b-jet identification strategy integrates the results of low-level algorithms with high-level multivariate classifiers. The study shows that even coarsely binned tagweight distributions are sufficient to achieve most of the expected improvements. Regarding to this study I would like to ask if these insights led to changes in tagging algorithms itself or were used only for separate tool serves as a basis for investigating pseudo-continuous scale factors for EV decomposition and smoothing of pseudo-continuous calibrations?

The second practical part of this work describes the search for $t\bar{t}H$ production in multilepton final states, outlines the general technique of multilepton analysis for $t\bar{t}H$ and provides a detailed description of the estimation of fake leptons in the 2lSS1τ_{had} final state. Six final states, categorized by charged-lepton number and flavor, and 25 event categories are defined to simultaneously detect the $t\bar{t}H$ signal and limit significant backgrounds. The $t\bar{t}W$ background formalization is not constrained in the statistical analysis, resulting in a higher-than-expected normalization. An excess of events consistent with $t\bar{t}H$ production is observed. Author states that the observed production cross section $\sigma_{t\bar{t}H}$ is in in agreement with the Standard Model prediction, with a significance of 3.1 standard deviations. I would like to ask if there are not more experimental results to compare measurements of $\sigma_{t\bar{t}H}$?

The last practical part is very interesting, because using the ATLAS experiment for a measurement of top-quark pair production in p+Pb collisions at the $\sqrt{s_{NN}}$ = 8.16 TeV. This is the first observation of top quark pair production in the dilepton channel in proton-lead collisions. Top-quark pairs are observed in the individual l+jets and dilepton channels with electrons and muons in the final state. The high precision was achieved by using a tagging technique to distinguish b-quark jets and more comprehensive lepton selection criteria. The measured cross-section is found to be in good agreement with the previous measurement and SM predictions. But, It would be fine also to compare measure of top-quark par production cross section in p+Pb collisions at the $\sqrt{s_{NN}}$ = 8.16 TeV with measurements for the same dilepton channel in other collisions system to valid the hypotheses of QGP. Is possible to do it?

The thesis of M.Sc. Santu Mondal met with goals state of his thesis and he fulfilled all requirements for a dissertation thesis. I would suggest giving classification level **A** and after answer to my question to accept her dissertation thesis.

doc. Mgr. Michal Mereš PhD.
Opponent of thesis