REFEREE REPORT ON DOCTORAL THESIS

(OPONENTSKÝ POSUDEK NA DOKTORSKOU DISERTACI)

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Study of b-quark Prosesses using the ATLAS Detector

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Ing. Radek Novotný from Czech Technical University in Prague,

Faculty of Nuclear Science and Physical Engineering Department of Physics, elaborated during the Academic year 2019 – 2020 his Doctoral thesis: "Study of b-quark Processes Using the ATLAS Detector" under the Supervisor - prom. fyz. Václav Vrba, CSc., from Czech Technical University in Prague, Faculty of Nuclear Science and Physical Engineering, Department of Physics and Supervisor specialist - Ing. Michal Marčisovský, PhD., from the Institute of Physics of the Czech Academy of Sciences.

The Doctoral thesis is rather big. It contains more, than 160 pages. It is divided into 11 chapters that are writing very clear with many formulas and lot of figures. At the beginning the Theoretical Background chapter dealing with Standard Model, Symmetries and CPT Theorem, Week and Strong Interactions is present. The next chapter deals with Physics of the neutral B-mesons. Following two chapter themes are oriented to the description of The Large Hadron Collider and ATLAS Detector, where the experiment was performed. Then follows the chapters, which make clear the methods of ATLAS Software and Computing Tools and the chapter describing the Beauty Physics at ATLAS experiment. In the last three chapters is described the study of the problems of physics solved in the thesis by the author. On the end-chapter the Conclusions follows.

- **At the beginning, it is necessary to say, that the B-Physics theme belongs to the one of the most interested theme, which is since the longtime studied in our physics branch from various view of experiment or theory.**

The Doctoral thesis focuses on three topics related to the CP – violation measurement in the $B^0_S \rightarrow J/\psi(\mu^+ \mu^-)\, \Phi(K^+K^-)$ decay channel, studied in B-Physics working group at the ATLAS experiment in CERN Geneve. The study enables the possibility to look for physics valide beyond of Standard Model. Only few experiments can be successfull in this region. Here, in the leadership of the analysis group is since the long time busy one of the physicist - Mrs. Dr. M. Smižanská, (promoted in a group of elecronic experiments of Particle physics departement, Institute of Physics, Czech Academy of Sciences in Prague).

The main objective of the thesis - first analysis of the thesis - is performed in pp collisions at the centre-of-mass energy collected by the ATLAS experiment - $\sqrt{s}$ = 13 TeV. The integrated luminosity was 80. 5fb^{-1}. The analysis measured CP- violation phase Φ_s in $B^0_S \rightarrow J/\psi\, \Phi$ decay channel. The same measurements have been provided in former time on ATLAS at centre-of-mass energy $\sqrt{s}$ = 7 and 8 TeV. The three results are statistically combined. All measurements agree with the Standard Model Predictions.

In the chapter are the information about Data and MC samples, Reconstruction and Candidate Selection, Maximum Likelihood Fit, Flavour Tagging, Systematic Uncertainty Studies and finally Results. Combination with ATLAS Run 1 Results is also mentioned together with Outlook for Run 2 Measurement. The chapter contains 29 figures, in one of them at the end is interesting comparison of the results from several experiments – ATLAS, CMS and LHCb in pp collisions in CERN and in $p\bar{p}$ collisions CDF at TEVATRON in FERMILAB, USA.

The second analysis is a measurement of $B^{\pm} \rightarrow J/\psi\, K^{\pm}$ and $B^0_d \rightarrow J/\psi\, K^{*0}$ lifetimes. It serves as a benchmark measurement to validate the precision of the lifetime corrections applied on the B^0_s events and the performance of the B-Physics triggers. The chapter describes Data Samples, Reconstruction and Candidate Selection, then Fitting Procedure, Mass-Lifetime Monitoring, Precise Lifetime Measurement and finally Summary. The chapter contains several figures, where the interesting comparison of the results from ATLAS, CMS, LHCb and CDF are presented.

The last analysis of the thesis is devoted to the search for a structure in the $B^0_s\,\pi^{\pm}$ invariant mass spectrum, particularly the search for the tetra-quark candidate – the resonance X(5568). It was announced in experiment DØ in FERMILAB several years ago in $p\bar{p}$ collisions. The exotic state could be explain as a four quark state (b,s,u,d) and could be important for understanding of the production mechanism of multiquark objects. The X(5568) resonance was then investigated in in pp collisions at LHCb, CMS and in $p\bar{p}$ collisions at CDF experiment in FERMILAB. Up to now - no statistically significant signal was observed – therefore only upper limit on the number of signal events N(X) and others has been measured. The ATLAS result obtained in parallel to the above mentioned measurements is consistent with the results from the other LHC experiments. The chapter describes the analysis - Data and Candidate Selection, Fit to Data, Setting Upper Limits and Summary.

This measurement was useful test of sensitivity of the ATLAS detector, because the other LHC experiments were performing the same measurements. The ATLAS proved its capability to perform such search and provide consistent results with other experiments.

Ing. Radek Novotný has presented also several ATLAS reports on International conferences and in other places.

From the above facts it is possible to write:

- The Doctoral thesis is written in very clear system of text, formulas, equations, tables and figures. It proves of very good using methods of the given material.

- I am sure that the thesis totally fulfilled his purpose. The study theme is very actual.

- The results described in the thesis shows about the big contribution of the author to their scientific value.

On the basis of about facts I am recommending to the Committee for Doctoral thesis of the FJFI ČVUT to agree with the results of the Doctoral thesis of Ing. Radek Novotný. which fulfill all necessities needed to obtain him Ph.D title.

doc. RNDr. Ing. Jan Hladký, DrSc.

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