

Dear members of the Scientific Jury,

Regarding the defence by the student Elton Shumka of his PhD thesis in Experimental Particle Physics at the University of Sofia “St. Kliment Ohridski”, we would like to inform the Scientific Jury that Elton Shumka participated actively in the “Precision measurement of CP-violation in  $B_s^0 \rightarrow J/\psi\phi(1020)$  decays using Run2 data” analysis (BPH-23-004), providing essential contributions.

Elton Shumka joined the analysis group at the beginning of his PhD studies in 2021, and remained actively involved until the final stages of the analysis. The following is a list of his main contributions in this physics analysis:

- Development of an algorithm for the estimation of the angular efficiency function in  $B_s^0 \rightarrow J/\psi\phi(1020)$  decays with the use of the Kernel Density Estimate method, enhanced by Fast Fourier Transform. The algorithm was applied to obtain the CMS detector's angular efficiency, a crucial step in the angular analysis of the  $B_s^0 \rightarrow J/\psi\phi(1020)$  decay's final state.
- Development of a novel procedure for the per-event reweighting of Monte-Carlo samples used in the study of  $B_s^0 \rightarrow J/\psi\phi(1020)$  decays. It was implemented via a Machine Learning approach based on Boosted Decision Trees and served to correct for the inherent mismodelling present in the MC samples.
- Implementation of a procedure for the estimation of the background contribution in  $B_s^0 \rightarrow J/\psi\phi(1020)$  decays, originating from  $\Lambda_b \rightarrow J/\psi K_p$ , was implemented. The bootstrap method was used to account for bias introduced by the employment of Random Number Generators. The obtained result served to make a decision on whether this contribution is to be explicitly included in the fit model.
- The algorithms and methods listed above were successfully applied to enhance the precision measurement of CP violation performed in the  $B_s^0 \rightarrow J/\psi\phi(1020)$  decay channel. The analysis yielded the first evidence for the studied channel (with a certainty of 3.2 standard deviations) of CP-violation in the interference between mixing and decay.

The analysis resulted in a paper, titled “Measurement of time-dependent CP violation in  $B_s^0 \rightarrow J/\psi\phi(1020)$  decays with the CMS detector”, to be published in Physical Review Letters.

Sincerely,

  
CMS BPH Group conveners

Dmytro  
Kovalskyi