Review

of Master's thesis of Viktoriia Lysenko, a student of the study programme Nuclear and particle physics, elaborated on the topic:

Efficiency and accuracy of time-of-flight detector measurements in the ATLAS experiment and di-photon vertex reconstruction for the search for an axion-like particle in data from LHC Run-3

Submitted work deal with data taken by the AFP detector installed in the forward region of the detector ATLAS at CERN laboratories. A special attention was devoted to the time-of-flight subdetector (ToF) which could help with background rejection in the physics studies of di-photon interactions related to existence of so-called Axion-like particles (ALPs). These particles are considered as candidates for particles that make up missing dark matter. The performance of the ToF detector was the main topic. The performance analysis was done upon two dedicated runs of the newest Run-3 data from 2022 hereby following up on the study by Karel Cerny made on Run-2 data. As the ToF detector was significantly redesigned in between, the study made by student were of increased interest and presented results are undoubtedly valuable.

She continuously presented ongoing status of her analysis during plenty of video-conference meetings where she got relevant feed-back from members of AFP collaboration. In the frame of this task, the student encountered processes and procedures existing in the ATLAS collaboration, she learned how the AFP detector works, and she gained experience with the ROOT analysis tool.

Structure of thesis

The thesis is divided into seven chapters starting with Introduction and ending with Conclusions. There is an Appendix section with links to codes and full set of histograms generated in frame of this work. The Introduction is devoted to the physics motivation based on central exclusive di-photon production assuming an axion-like particle and how the AFP detector could contribute to such physics studies on the ATLAS detector. It also includes an introduction to the detector ATLAS. The second chapter describes at glance the ATLAS and AFP detectors including AFP's ToF detectors in more details. Third chapter deals with the timing resolution and efficiency of the ToF detector using Run-3 data. A special part is devoted to the topic of calibration of the HPTDC unit. The chapter four is about vertex reconstruction with the ToF. This includes calculations of time delay coefficients and that of the whole timing resolution of the AFP ToF

detectors using information from the ATLAS beam spot monitor. The fifth chapter describes di-photon vertex reconstruction process using data from the Run-3. The sixth chapter discusses eventual future applications on the search of the Axion-like particles using the ToF detector.

The thesis structure is properly straightforward and includes a necessary physics motivation.

There are 25 references, of which 18 were properly cited articles, 3 references probably with a restricted access (internal notes), two links to a source file in C++ language, one link to a software tool, and one reference to an oral presentation by student.

Topic elaboration

As mentioned above, the topic itself is important for the AFP community and thus this work is appropriately valuable in general. Selected topics are highly relevant, and they were properly addressed. This is mainly the case of measurements of the timing resolutions and efficiencies of all trains including discussion of the known problem with the double peak's artefacts in some channels. This issue is still not properly recognized. I would also highlight the efficiency summary plot in Figure 3.46 made of all available data in 2022. There is just typo in the picture label (there should be term X-axis instead of Y-axis when discussing meaning of labels). ToF vertex reconstruction is naturally the most prominent subject in ToF. It was addressed as needed with all the steps proposed in previous work by Karel Cerny. Concerning the di-photon vertex analysis, student just briefly discussed her results on data from 2022 referring her previous work for more details.

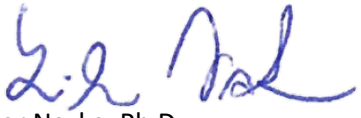
Questions

1. Section 3.2.2 (HPTDC calibration). I don't understand the shift in HPTDC bins positions. The presented explanation is not sufficient or to short in my opinion. Can you give more descriptive view how influence of positions or widths of bins result in such shifts?
2. Section 3.2.2 (HPTDC calibration). Comparing Figures 3.18 and 3.22, the distribution of the main gaussian profile narrowed and statistics dropped in half after application of presented likelihood cleaning procedure. Possible contributions by other gaussian distributions seems to be avoided. Can you consider a better algorithm for classification of events among all three distributions?
3. Appendix B.1, Figure 4. Looking at the picture, it seems the Train 3 mostly suffer from the existence of double peak effect instead of the Train 2 as declared in the section 3.2.1. Please comment on this.

Final assessment

I rate the submitted work positively. The author of the thesis got expertise in analysis of data in the leading ATLAS experiment. She obtained results demanding for the AFP collaboration and this thesis would be a valuable reference in further applications.

Suggested grade: A (excellent).



In Olomouc, September 13, 2023

Libor Nozka, Ph.D.

Palacky University in Olomouc, Faculty of Sciences