Testing Real Time Analysis at LHCb

Nazar Semkiv[1]
[1]Taras Shevchenko National University of Kyiv, Ukraine

Introduction

The LHCb detector [1] is the first experiment at the LHC to have a triggerless read-out. This means that track reconstruction algorithms run over the entire detector readout at a rate of 40 Tb/s. Machine learning algorithms used with real-time calibration and alignment reduce this rate to 12 Gb/s. This new trigger system, referred to as Real Time Analysis, ran for the first time in 2022. However, the performance of said system is yet to be extensively validated. This project will use 2022 data to test and compare the different machine learning algorithms used to select events, in addition to probing the performance of this new detector more generally. There may also be the possibility to incorporate 2023 data.

Project proposal

The student will first develop a BDT-based machine learning algorithm to cleanly select $B^+ \to K^+\mu^+\mu^-$ and $B^0 \to K^{*0}\mu^+\mu^-$ decay candidates in 2022 data. Statistical subtraction techniques combined with likelihood estimations will be used to remove any remaining background contamination. The decay properties of these channels, depending on which machine learning algorithm was employed in the trigger, will then be compared and their agreement with simulated events examined. If needed, the existing trigger algorithms may be altered and improved.

If time allows, the student will also have a first look at the angular distributions of the calibration channels being studied. Understanding such angular distributions are vital to the LHCb physics program.

In summary, this project will perform vital work assessing the performance of the new trigger-paradigm at LHCb.

Timeline

The project work will be arranged for 12 weeks starting from June 26th to September 15th under the supervision of Michele Atzeni and Prof. Dr. Eluned Anne Smith (Laboratory for Nuclear Science, MIT).

Weeks 1-2 Familiarize with the idea behind the project, learn the use of virtual environments, bash and python scripting, with focus on the statistical analysis libraries such as RooFit[2] or zfit[3].

Weeks 3-4 Development of machine learning techniques such as BDT or neural networks to increase the purity of the signal events in data.

Weeks 5-6

First fits to the reconstructed invariants mass of the B meson candidates and familiarization with sPlot[4] technique.

Weeks 7-8 Data-simulation comparisons and comparisons across candidates selected with different trigger lines.

Weeks 9-10 Parametrization of the distortion caused by selections to the angular observables of the two channels of interest.

Weeks 11-12 First angular fits to the 2022 data.

References

[1] R. Aaij *et al.* [LHCb], [arXiv:2305.10515 [hep-ex]].

[2] W. Verkerke and D. P. Kirkby, eConf **C0303241** (2003), MOLT007 [arXiv:physics/0306116 [physics]].

[3] J. Eschle, A. Puig Navarro, R. Silva Coutinho and N. Serra, doi:10.1016/j.softx.2020.100508 [arXiv:1910.13429 [physics.data-an]].

[4] M. Pivk and F. R. Le Diberder, Nucl. Instrum. Meth. A **555** (2005), 356-369 doi:10.1016/j.nima.2005.08.106 [arXiv:physics/0402083 [physics.data-an]].