Akademia Górniczo-Hutnicza
im. Stanisława Staszica w Krakowie

AGH Szkoła Doktorska AGH

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Krakow, 3.06.2025
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94111513881
Numer PESEL lub numer paszportu
PESEL or Passport number:

Physical Sciences
Dyscyplina naukowa lub dziedzina naukowa
Scientific discipline or field of science

Summary of Thesis

Large Hadron Collider (LHC) is the world's largest and highest-energy particle collider. LHCb is one of the four major experiments at the Large Hadron Collider (CERN). The LHCb experiment has been designed to study CP violation in beauty and charm hadrons, discovering exotic states, with a broad program covering also QCD, searches for long-lived particles, and dark matter.

This thesis concerns a few topics revolving around a common issue related to radiation damage in silicon sensors in one of the LHCb subdetectors, the Vertex Locator (VELO). The analysis is performed with the use of various samples: particles generated in proton-proton collisions at LHC energies with a stand-alone particle generator, events obtained in the simulation within the LHCb detector, a real minimum-bias sample collected in 2018 by LHCb, and finally, special detector data registered in the LHCb VELO in 2024.

The current state-of-the-art method of monitoring and predicting radiation damage is based on simulation. There are different physics models used in generators, and the simulated particle fluence varies between generators, especially when considering low- momentum particles emitted at high rapidity. Therefore, this project's first part deals with comparing general-purpose event generators, Pythia and Herwig, with special attention to parameters describing multiple parton interactions. A comparison of both event generators with respect to LHCb data is also mentioned.

Since the increase in LHC energy, more discrepancies between data and simulation have been observed among experiments, which gave rise to the necessity of an update in the generators' parameters. Therefore, the second task of this thesis focuses on tuning the campaign of the event generators, detailing the methodology and the software tools developed for tuning, such as Rivet and Professor. These are employed for estimating the optimal parameter values of the event

generators predominantly used at LHCb. The tuning results indicate the necessity for further refinements to enhance agreement with experimental observations at 13 TeV.

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The third section in this project takes into account the minimum-bias LHCb experimental data from Run 2 (Run 3 data were not available during this time). The main purpose of this analysis was to check whether one can use reconstructed and identified charged hadrons to obtain a reliable prediction for the current level of radiation damage in the VELO sensors.
This analysis uses data from proton-proton collisions at a centre of mass energy of 13 TeV taken during runs of the LHC in 2018, highlighting discrepancies between data and MC predictions. This study explores the sources of these differences by analysing particle multiplicities and identifying regions where MC models require improvements to better describe the data.

The last stage of the work describes an attempt to determine the particle fluence map in the new pixel detector VELO based on signals from individual sensors. Special samples of detector data collected in the summer of 2024, in the first months when all subdetectors of the modernised LHCb experiment were included for the data taking.

Sabin 03/06/2025

Signature and Date (Author)