Semester Report – 1st Semester

by **Ozgur Durmus** (odurmus@student.elte.hu)

PhD program: Particle Physics and Astronomy

Supervisor: Biplab Dey

PhD Thesis Title: Probing the Dark Sector at the CODEX-b and LHCb experiments

Introduction

Almost all the observed phenomena in high energy physics can be explained by the well-established Standard Model (SM). One of the predictions of the SM, the Higgs boson, was discovered in 2012 at the LHC at CERN. After the discovery, the focus of the experimentalists shifted towards beyond the Standard Model (BSM) theories to explain the phenomena such as dark matter, dark energy, matter-antimatter asymmetry and so on. Many extensions of BSM features so-called Dark Sector (DS), unobserved quantum fields and their corresponding particles. One natural way to probe DS is to investigate BSM Long Lived Particles (LLPs). General purpose detectors at LHC (ATLAS, CMS, LHCb, ALICE) are looking for BSM physics in many ways, one of which is to look for BSM LLPs. Moreover, there is a well-motivated need for new detectors to look for new physics. LLPs are likely to decay outside the detector volume. A new detector, CODEX-b, is dedicated to detecting LLPs traveling in transverse direction to the beam axis. A prototype detector for proof of concept, called CODEX-ß is being produced, as part of an R&D project for the LHCb experiment.

Description of research work carried out in current semester

This semester I have started working on CODEX-b simulation software. This part of the research was mainly focused on integrating CODEX-b software to the LHCb software, using the existing tools and frameworks. I have adapted the existing tracker used to get information on the particles that hit the detector, to have information on their parent-particles, grandparent-particles and so on...

To detect LLPs in LHCb volume, we plan to detect muons that are produced after magnet section of the LHCb detector, just before the muon station. To do that, we need to find muon tracks that originated before muon station. I've been developing an algorithm to do that throughout the semester. I need to use several different software frameworks. Gauss-on-Gaussino to generate and simulate Monte Carlo (MC) events, Boole to digitize the output from Gauss, Moore which is the High-Level Trigger (HLT) application of LHCb. Finally, Allen, which is an LHCb HLT1 application on graphics processing units (GPUs). This semester, I reached the point to use Allen,

which means I have been using Gauss, Boole and Moore. The next step will be implementing Allen.

I also performed monitoring duties for LHCb Data Quality Computing and Software (DQCS) throughout the semester. They were done online, from Budapest. Other than DQCS shifter role, I was involved in the Early Measurement Task Force (EMTF) to study and analyze the data taken on 2023. As part of the QCD, Electroweak and Exotica (QEE) working group, I studied the process of Axion-like particles decaying into two photons and the Drell-Yann process. I have reported my findings and suggestions for further studies to the EMTF. The results from all the groups are being collected and will become an internal note, with the possibility to become a paper.

Publications

As part of the LHCb collaboration, the following paper is published as a preprint.

Aaij, Roel, et al. "Study of $ B_c^+\rightarrow\chi_c\pi^+ $ decays." *arXiv preprint arXiv:2312.12987* (2023).

Studies in current semester

I took two courses at ELTE

- Artificial intelligence (complex exam preparatory) – (INFPHD606EN-N)
- Classical and Quantum Optimization – (FIZ/3/097)

Conferences in current semester

I presented the status of the CODEX-b experiment on the following conference:

- Brookhaven Forum 2023 Advancing Searches for New Physics – 05.10.2023 (English)

Awards

I am a Stipendium Hungaricum scholarship holder.