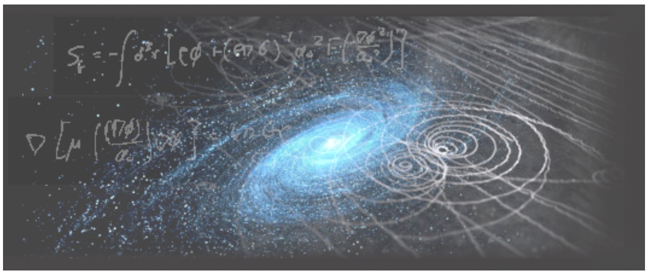

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Neural Network-based study on background for the Dark Leptonic Scalar model at NA64

The search for a particle candidate that could explain the origin of dark matter is a central goal in modern astro-particle physics. Numerous experiments employing various measurement strategies are being developed to try and understand this elusive phenomenon. The NA64 experiment situated at the CERN SPS is an active target experiment aiming to look for signatures like missing energies with hopes of finding signals that correspond to dark matter particles modelled to explain the physical process of kinetic mixing. The main purpose of this project is to study the background for a dark leptonic scalar model (DLS) using a highly accurate Monte Carlo simulation for the NA64 experiment. More precisely, the GEANT4 particle simulator was used for the NA64 experiment to simulate the results of the experimental setup used in 2023. The results of this was compared with the real data taken in 2023, and a first step was benchmarking the simulation which was done by using dimuon ($\mu\mu$) events. Furthermore, the simulation results were used as a means of perfecting the methods of event selection. The main source of background for DLS particle φ are $\mu\mu$ production, kaon κ and pion π decay. The main purpose of this thesis is to optimize the selection of events by using a Neural Network (NN), and evaluate its reliability. The background for the DLS φ was simulated and trained on a NN for selecting $\mu\mu$ events as a means of benchmarking the method. The selection of $\mu\mu$ using a trained NN is compared to traditional methods of selection, where an increase of 17 final events to 31 events is seen with the NN. A future study could be to simulate the DLS φ particles and train them on a NN to use for event selection. However, even if such a model exists, utilizing it for data selection is not straightforward. It is important to note that the trained NN model does not perform tasks beyond our capabilities; it simply aids in selecting data based on patterns learned from simulated data. The primary advantage of using a trained NN is its ability to identify complex selection criteria that may not be immediately apparent. However, the real challenges of using an NN arise during deeper sensitivity studies. By applying the NN to a small sample of unblinded data, we can carefully analyze its selection process, ensuring the use of an appropriate classification threshold and gaining a better understanding of the selection criteria. The ultimate goal is for the NN to assist in selecting data, which can then be individually examined to investigate potential dark matter discoveries.

Summary

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