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Study of Dark Matter at e+ e- collider using KISTI-5 supercomputer

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The Standard Model (SM) of particle physics is well established with the discovery of Higgs boson which is the last particle to be discovered in SM. Since SM can not give a description of dark matter, dark matter is barely known and under research through various method. The importance of computational science, which comprises theory, experiment and simulation in science, have been emerging in the field of high energy physics (HEP), especially, in searching for dark matter. Because the cross section of dark matter is very small compared to that of the Standard Model (SM), huge amount of calculation is required. Hence, to optimize Central Processing Unit (CPU) time is crucial to increase the efficiency of research in HEP.

We have studied the dark matter of the decay mode, e+ e- ⟶ mu+ mu- A'. The signal process is dark photon which couples only to heavy leptons. We focus on the case in which dark photon decays into two muons. Therefore, this is four muon final state. In this work, using MadGraph5 as a simulation tool kit, we have studied CPU time as well as cross section according to various parameters such as center of mass (CM) energy, dark photon (A') mass and coupling constant. The imported theoretical model in MadGraph5 is the Simplified Model which covers SM particles, dark matter and dark photon particles. We have studied background using the SM of e+ e- ⟶ mu+ mu- mu+ mu-. This result will be helpful for searching for dark matter at e+ e- collider of experiments such as Belle II, CEPC and ILC experiments.

To compare CPU time of calculation, we have used the KISTI-5 supercomputer [Nurion Knight Landing (KNL) and Skylake (SKL)] and the local Linux machine. Nurion KNL is equipped with processor Intel Xeon Phi 7250 and 68 cores per node. Nurion SKL is equipped with Intel Xeon 6148 and 40 cores per node. We have used one core or more cores to compare CPU time at machines. We have checked the optimization of the simulation tool kit by comparing the CPU time consumed for various physics modes. We have checked the physics simulation including MadGraph5 only and checked the full simulation including Pythia8, Delphes and MadAnanlysis5 as well as physics simulation. We have also checked efficiencies of parallel processing among the machines. The CPU time and the wall clock time of the KISTI-5 supercomputer and the local Linux machine with one or multiple cores have been studied for the optimization and parallelization with large number of cores of KISTI-5 supercomputer. The results will help to optimize HEP software using high performance computing (HPC).

Summary

We have studied the dark matter of the decay mode, e+ e- ⟶ mu+ mu- A'. The signal process is dark photon which couples only to heavy leptons. We focus on the case in which dark photon decays into two muons. In this work, using MadGraph5 as a simulation tool kit, we have studied CPU time as well as cross section according to various parameters such as center of mass (CM) energy, dark photon (A') mass and coupling constant. To compare CPU time of calculation, we have used the KISTI-5 supercomputer and the local Linux machine. The CPU time and the wall clock time of the KISTI-5 supercomputer and the local Linux machine with one or multiple cores have been studied for the optimization and parallelization with large number of cores of KISTI-5 supercomputer. The results will help to optimize HEP software using high performance computing (HPC).

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