Two methods for computation of the sensitivity region of the intensity frontier experiments

Authors: Volodymyr Gorkavenko[1], Yehor Kyselov[1]

[1]Department of Physics, Taras Shevchenko National University of Kyiv, Ukraine

Corresponding Author: *kiselev883@gmail.com*

The standard model is a remarkably consistent and complete quantum field theory. However, it fails to explain some fundamental problems such as the baryon asymmetry of the Universe, dark matter, and neutrino oscillations. Therefore SM is incomplete and requires an extension.

One possible approach is by adding new particles to the theory. There are two possible answers to the question "Why do we not observe particles of new physics in experiments?" The first answer is the following. The new particles are very heavy and can not be produced in modern accelerators like LHC. To detect them one has to build more powerful and more expensive accelerators. There is another possibility. The particles of new physics can be light particles that feebly interact with SM particles. The last case is very interesting for the experimental search of the new physics in the intensity frontier experiments just now. There are different choices of new renormalized interaction Lagrangian of particles of new physics with SM particles. It's called portals.

In order to detect them a lot of experiments were suggested. To know which one is best and relevant, a sensitivity region is built. This task is not trivial and may take a lot of time, so the question of the fastest and most precise method is crucial.

In this paper, we compare two approaches to computing the sensitivity region of the intensity frontier experiments. Namely, the analytical and Monte-Carlo based approach. We do it by computing the sensitivity region of the SHiP experiment for the detection of a GeV-scale singlet neutral scalar, produced in decays of B mesons [1, 2].

We decided to look at the scalar portal on the one hand due to the relative simplicity of this model. Monte-Carlo methods and analytical approach were implemented using *Wolfram* packages. Some calculations regarding data lists were done in *C++*.

Our analysis shows that both methods give approximately the same result, but take different times to compute. We conclude that in a case where the probability distribution function of the initial mesons is given in an analytical form, the analytical approach takes less time and is more suitable. If the distribution is given by a data list, Monte-Carlo method is more suitable and more accurate, but the analytical method allows us a faster estimate of the sensitivity region with a smaller, but good enough accuracy.

References

[1] Iryna Boiarska, Kyrylo Bondarenko, Alexey Boyarsky, Volodymyr Gorkavenko, Maksym Ovchynnikov, and Anastasia Sokolenko. Phenomenology of GeV-scale scalar portal. *JHEP*, 11:162, 2019.

[2] Iryna Boiarska, Kyrylo Bondarenko, Alexey Boyarsky, Maksym Ovchynnikov, Oleg Ruchayskiy, and Anastasia Sokolenko. Light scalar production from Higgs bosons and FASER 2. *JHEP*, 05:049, 2020.