# Statistical error for cosmic rays modulation evaluation by 1D model

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The propagation of cosmic rays through the heliosphere is solved for more than half a century by stochastic methods based on Ito's lemma. This work presents the estimation of statistical error of solution of Fokker – Plank equation by 1D forward stochastic differential equations method. The error dependence on simulation statistics and energy is presented for different combinations of input parameters. The 1% precision criterium in intensities and 1% criterium in standard deviation are defined as a function of solar wind velocity and diffusion coefficient value.

The wide-ranging availability of fast computers has brought significant advances in numerical modeling of solar modulation. In-situ observations have always been limited. So that numerical modeling plays an important role to broaden our understanding of solar modulation. In the view, that the image of Heliosphere, and our understanding of the heliosphere change and evolve dynamically in last decades more complex numerical models of solar modulation were developed in the past.

For comprehensive global numerical simulation of CR in heliosphere it is essential to have a sound transport theory, reliable numerical schemes with appropriate boundary conditions. These models also have some errors, as for example statistical errors. That why presented work focused on the study of statistical errors for this kind numerical modulations.

The CR spectra at 1 AU were evaluated in the F-p method for Yamada LIS spectra for the energy range from 0.001 to 100 GeV, for six sets of input parameters. To show statistical error dependence to the number of injected simulations, integrals for the whole energy range were evaluated. Standard deviation distribution with respect to the number of injected simulations was obtained from evaluated whole energy range normalized integrals. Linear fits of standard deviation in the range from 1000 to 10000 injected simulations were shown. Assuming that power law dependency fitted in range from 1000 to 10000 simulations could be extended to higher values of N, we could find a number of simulations needed to reach standard deviation 0.01 of spectrum integral. Fits parameters and number of simulations needed to reach standard deviation 0.01 for different combinations of input parameters were presented in table.

In conclusion, to reach the standard deviation of spectrum integral at level 10 percent, we need to inject approximately one or a couple of billion particles into the heliosphere. To reach standard deviation at level 1 percent, we need to inject approximately hundreds of billions of particles into the heliosphere.