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On GEANT-DIRAC multiple scattering in thin layers of DIRAC setup.

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Abstract

In DIRAC setup there are a lot of thin materials such as cathodes, anodes, wires, strips and so on. The GEANT3 program for Monte-Carlo simulation deals with REAL*4 numbers only and therefore for thin layers the rounding errors can be significant.

The aim of this work is to study of rounding error influence and to change, if need, the GEANT-DIRAC code to achieve a correct description of multiple scattering for thin layers in this program.

1 Results

We used the GEANT-DIRAC simulation program. The multiple scattering was analyzed for the following scatterers(detectors,layers): target, membrane of DIRAC channel, MDC, SFD, IH, membrane at entrance to magnet vacuum chamber, exit window of magnet vacuum chamber and all the drift chambers.

The target foil is the special case as its multiple scattering was measured precisely from DIRAC data([1]) and this scatterer was chosen as the reference sample in this work. For target foil(108 μ of Ni) we can operate the following information:

1. Its relative radiation length x/X_0=0.0076, where x - scatterer's thickness and X_0 - radiation length of this material.

2. The analytical formula for multiple scattering in this material which was obtained in [1].

3. The Moliere scattering which is used in GEANT(the Gaussian approximation is present there also but not used in this work).

The Gaussian approximation of multiple scattering angle(θ) in one projection

$$\theta_0 = \frac{0.0136GeV}{\beta cp}\sqrt{x/X_0}[1 + 0.038ln(x/X_0)], \quad (1)$$

where p is the particle momentum(in GeV/c), βc - its velocity. In GEANT-DIRAC we analyzed the distribution of $T = \theta p \beta c/0.0136$. For the Gaussian case it would mean that we estimate the value of $\sqrt{x/X_0}[1 + 0.038ln(x/X_0)]$. For the Moliere case, which we used, it's difficult to get the exact formula for T, certainly that the T can be written like $T = \sqrt{x/X_0} \times k$, where k is some function and it perhaps is close to 1.

The central peak of T distribution was fitted by Gaussian and the obtained value of σ was used to set the several intervals($\pm 5\sigma$,$\pm 13\sigma$ and $\pm 20\sigma$) of this distribution and for each interval the value of R.M.S. was obtained. The results are presented in Tab.1. We see that for target case and for interval $\pm 13\sigma$ the value of k is very close to 1. It can be noticed that if we use Gaussian approximation then for the target we would get $k = 0.8$. Hence our procedure implies that for each other scatterer we tune scatterer properties in a way to get that $RMS_T^2 = x/X_0$.

Table 1: The multiple scattering in some parts of DIRAC setup. The first column is the scatterer, the second - its value of x/X_0 calculated using only the thicknesses and X_0 of scatterer materials , 3th-5th is the value of RMS_T^2 for $\pm 5\sigma$,$\pm 13\sigma$ and $\pm 20\sigma$ intervals correspondingly. The last column is after some changes in the material description.

		RMS_T^2			
scatterer	x/X_0	$\pm 5\sigma$	$\pm 13\sigma$	$\pm 20\sigma$	$\pm 13\sigma$ final
target([1])	0.0076	0.0062	0.0074	0.0075	
target(Moliere)	0.0076	0.0062	0.00750	0.0080	
Channel membrane	0.00087	0.00053	0.00066	0.00071	0.00087
MDC	0.0130	0.0081	0.0097	0.0104	0.0130
SFD	0.0296	0.0255	0.0306	0.0351	
IH	0.0120	0.0094	0.0111	0.0120	0.0122
Magnet chamber membrane	0.00087	0.00053	0.00066	0.00071	0.00086
Al exit window	0.0083	0.0069	0.0082	0.0088	
DC1	0.00176	0.00137	0.00173	0.00186	
DC2	0.00094	0.00062	0.00081	0.00088	0.00092
DC3	0.00094	0.00062	0.00081	0.00088	0.00091
DC4	0.00135	0.00095	0.00121	0.00131	0.00134

We see that the angle of multiple scattering in GEANT-DIRAC is underestimated for some scatterers: MDC, IH, membranes, DC2, DC3 and DC4. The main reason is insufficient accuracy of REAL*4 in GEANT3 program. To get the more accurate description of scattering in these setup parts we made some changes in their material definition. In the MDC the density of gas was increased, in the IH the density of millipore was increased, in the drift chambers the thickness of cathodes was increased and the thickness of Mylar membranes was increased also. The results of this tuning are presented in last column of Tab.1.

References

[1] A.Dudarev, V.Kruglov, L.Kruglova, M.Nikitin [JINR] , DIRAC Note 2008-6.