Update in the Multiple Scattering description of the SFD detector in Geant-Dirac DIRAC NOTE 02-2016

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1 Introduction

The knowledge about multiple scattering is extremely important in DIRAC due to the nature of the events we are studying. The tracks of the atomic and Coulomb pairs are characterised by a very small opening angle, and the signal is extracted by comparing data and simulated events, thus a very detailed knowledge of the muliple scattering in data and simulation is needed.

This work is an update of the work presented in [1]. We assume that the two tracks of a prompt $\pi\pi$ pair originate from a single space point inside the target. The admixture of accidental pairs is subtracted. The tracks are firstly reconstructed using only the Downstream part of the detector and extrapolated to the target plane, in a second step the tracks are reconstructed in the upstream part of the detector, and a matching of the parameters upstream-downstream is performed.

Call $x_2(x_1)$ the $\pi^+(\pi^-)$ final track extrapolation to the target plane in the X and Y coordinates. The experimental error in the measurement of the tracks determines the width of the $\Delta x = x_2 - x_1$ and $\Delta y = y_2 - y_1$ which we call vertex resolution. We study the Vertex resolution as function of the total momentum of the track-pair. We can parametrise the distribution width of the two track impact points (in the target) as

$$\sigma^2_{\Delta x} = c_1^2 + \frac{ms_1^2}{(P_- \cdot \beta -)^2} + c_2^2 + \frac{ms_2^2}{(P_+ \cdot \beta +)^2}$$

here c_1 is the sigma (width) of the distribution of the x_1 coordinate for the part of the contribution that is momentum independent, $ms1$ defines a sigma of the part of the distribution that is momentum dependent.

c_2 and ms_2 have the same meaning but for positive particle. Let assume that $c_1 = c_2 = c$ and $ms_1 = ms_2 = ms$,

$$\sigma^2_{\Delta x} = 2 \cdot c^2 + \left(\frac{1}{(P_- \cdot \beta -)^2} + \frac{1}{(P_+ \cdot \beta +)^2}\right) \cdot ms^2$$

Therefore it is reasonable to use

$$Z = \frac{1}{(P_- \cdot \beta -)^2} + \frac{1}{(P_+ \cdot \beta +)^2}$$

and to fit $\sigma^2_{\Delta x}$ or the square of RMS of the Δx distribution for different value of the variable Z.

2 Event selection

The events selected for this analysis are $\pi\pi$ data and MC simulated data, the cuts applied on them are listed below:

- $|\Delta(t)_{VH}| < 0.3ns$
- 1 track per arm (DC)
- $|Q_x| < 4MeV$
- $|Q_y| < 4MeV$
- $|Q_l| < 22MeV$
- No electrons, cut applied on the N_2 Cherenkov amplitudes are $Ampl_{N_2^-} < 62$ $Ampl_{N_2^+} < 75$.
- No muons, cut applied $AND(Muonflag, 3) \neq 0$, this means that there is no hit in muon detector which corresponds to the reconstructed tracks.
- Events where the two tracks share the same SFD(x) or SFD(y) hits are eliminated.
- For the MonteCarlo events, the simulation of the background has been added, this has anyway a negligible influence on the ΔX and ΔY. Events have been weighted in order to reproduce the momentum $(p_\pi^+ + p_\pi^-)$ distribution shape in experimental data.
- For the Experimental data, accidentals events in the prompt window have been subtracted.

In the MC simulation after the study of O. Gortchakov reported in [2] and the one of A. Dudarev, M. Nikitin reported in [3] the density of the different constituents of the detectors were modified, in particular for the SFD X and Y plane as :

- Thickness of Cobex plane : $0.022cm$
- Thickness of Paint plane : $0.01465cm$
- The density of polystirene for SFD X and Y is reduced of a factor 0.829 to take into account of the measured thickness of the scintillator component in the SFD is $0.2072cm$ instead of $0.25cm$. (new factor $1.032 * 1.5398 * 0.967 * 0.657$ old factor $1.032 * 1.3047 * 0.973$ remember that 0.829/(1.3047*0.973)=0.653)
- The density of Cobex : $\rho_{Cobex} = 1.35 * 0.28g^{-3}$
- The density of Paint $\rho_{Paint} = 1.26 * 0.40g^{-3}$

for the W plane:

- Thickness of Cobex plane : $0.022cm$
- Thickness of Paint plane : $0.0284cm$
- The density of polistirene for SFDw is $1.032 * 1.5398 * 0.967$, the factor $1.5398 * 0.967$ has been introduced in order to take into acount the measurement done on the multiple scattering from Nikitin and Kruglov, reported in [4].

- The density of Cobex : $\rho_{Cobex} = 1.35g^{-3}$
- The density of Paint $\rho_{Paint} = 1.26g^{-3}$

Figures 1 and 2 show perfect agreement between data and MC for the X and Y planes. This method is not suitable for the W plane, there is too much uncertainty in the extrapolation from the W plane.

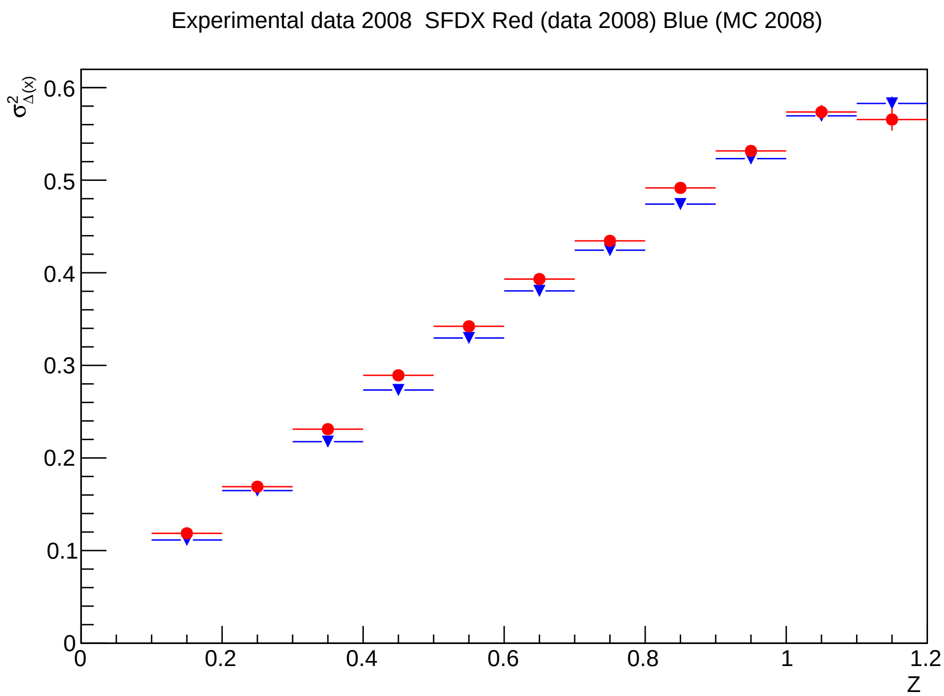

Figure 1: Vertex resolution as function of $Z = 1/(P_{-} \cdot \beta-)^2 + 1/(P_{+} \cdot \beta+)^2$ in SFD X

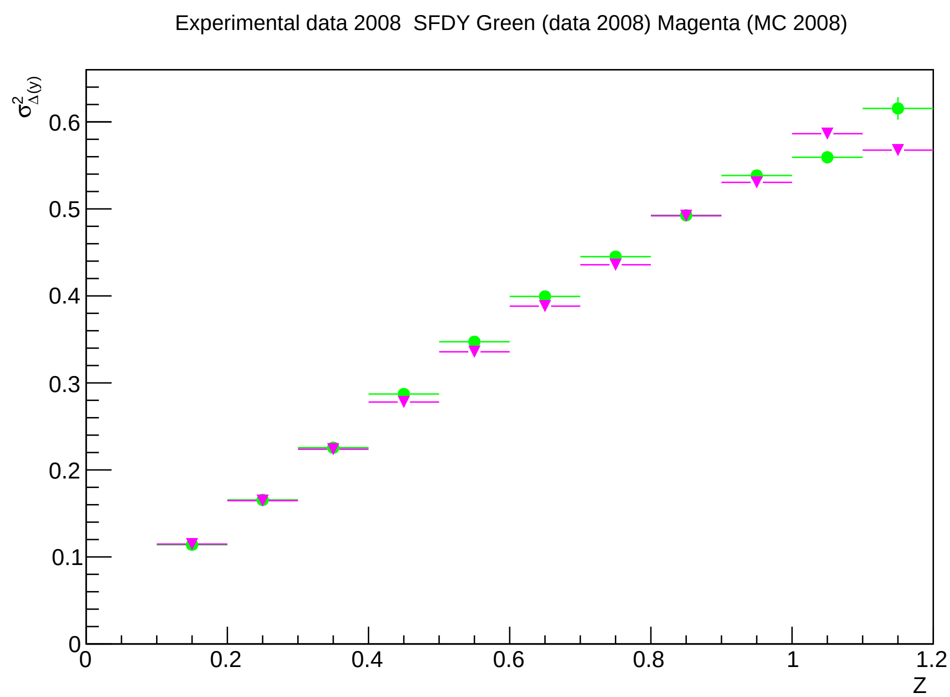

Figure 2: Vertex resolution as function of $Z = 1/(P_{-} \cdot \beta -)^2 + 1/(P_{+} \cdot \beta +)^2$ in SFD Y

References

[1] DIRAC-NOTE-2012-04 , Multiple scattering studies, A. Benelli [JINR, Zurich] and V. Yazkov [SINP, Moscow]

[2] DIRAC-NOTE-2014-01: On GEANT-DIRAC multiple scattering in thin layers of DIRAC setup, O. Gortchakov [JINR]

[3] DIRAC-NOTE-2012-09: Measurement of scatterers thickness, A. Dudarev, M. Nikitin [JINR]

[4] DIRAC-NOTE-2008-06 : Pion multiple Coulomb scattering in the DIRAC experiment (updated version), A. Dudarev, V. Kruglov, L. Kruglova, M. Nikitin [JINR]