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The description of forward permanent magnet of year 2012 run in the DIRAC software.

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1 Preface

For DIRAC setup run of 2011 the additional retractable permanent magnet was used. The software part of it was done in [1]. As during the run the field of this magnet was significantly degradated due the radiation the another magnet([2]) was used for the run of 2012 .

The last magnet induces the horizontal field in the gap between Be target and Pt foil. A magnet with bending power of 0.02 Tm is to shift the Q_Y value only for the pairs produced in Be target leaving practically unchanged this value for pairs produced in Pt foil. This magnet was installed in the vacuum target station just after the target and before the Pt foil where the atomic pairs are broken.

The distribution of this magnet field is used in GEANT-DIRAC and in ARIANE but in different forms. For GEANT-DIRAC the field should be present as three-dimensional polynomials(x,y,z) and the polynomials which used in ARIANE allow to calculate for a track its position(x and y) and angles(θ_x and θ_y) in the target(or in Pt foil) on dependence of this track position and its momentum at far end of this magnet field.

2 The field map.

The field map of needed size was obtained via calculation using the code([2]) for OPERA program. The calculated volume is equal: x from -2.0 to 2.0 cm, y from -2.0 to 4.0 cm and z from -20 to 20cm. For each coordinate the step was equal to 0.2cm.

3 The polynomials describing the field map.

In the GEANT-DIRAC the field of this magnet is needed to trace the charged particle coming from the target(or from the region around target) and this field is presented in the form of set of polynomials instead of map. To do it we divided the field volume into 216 subvolumes and in each one the simultaneous fit of all three field components was done.

A polynomial model([3]) of the field is designed such that the Maxwell's equations are satisfied. For this model of the field components we choose three polynomials, each in x, y and z of the same order. Taking terms with sum of powers less than or equal to N, we have a total of $(N+3)(N+2)(N+1)/2$ terms, being three times the number of combinations of i, j and k, if $i+j+k \leq N$ and i, j, k are integers ≥ 0.

Due to the constrains

$$\nabla \cdot B = 0, \qquad \nabla \times B = 0$$

the actual number of independent coefficients is $(N+2)^2 - 1$, which is lower than the number of of terms by a factor $(N+2)/2$. This method of fitting allows us to verify the precision of the field reconstruction.

The distributions of differences between the map values and the result of fit (δB_x,δB_y and δB_z) are shown on Fig.1. For the main component of the field, B_y, we have the σ is 2 Gauss.

4 The magnetic field polynomials for ARIANE.

The aim is to obtain the polynomials which are to use in ARIANE : to calculate $T_i(T_i = x$, y, $\tan(\theta_x)$, and $\tan(\theta_y))$ at the level of target as function of momentum, x, y, $\tan(\theta_x)$, and $\tan(\theta_y)$ at the level of magnetic field end(in z-direction; 20 cm after the magnet center). These calculations are needed generally for the case when we want to find for two particles their relative momentum and distance difference in the target.

The similar polynomials were determined also for the case when we need to calculate all these parameters at the level of Pt foil.

To obtain all of these polynomials we needed to simulate some number of particle tracks. This was done by GEANT-DIRAC program. The pions were taken in momentum interval from 1 to 10 GeV/c. The tracks were accepted if they passed through the vacuum membrane, at least four drift chambers, horizontal and vertical hodoscopes.

To approximate the each of these four parameters the length of polynomial was chosen between 33 and 36 for the case at target and between 6 and 16 for the case at Pt foil.

The results of fitting are shown on Fig.2-5. On Fig.2 the distributions of δx, δy, $\delta \tan(\theta_x)$ and $\delta \tan(\theta_y)$ for positive particles where the δ means the difference between the Monte-Carlo values and values calculated by fitting polynomials which determine the track position in the target on dependence of its position at the exit of magnet field and its momentum.

On Fig.3 is the same but for negative particles.

The Fig.4 and 5 are the same but for polynomials which determine the position of track at the level of Pt foil.

References

[1] O.Gorchakov [JINR], DIRAC Note 2007-17.

[2] A.Vorozhtsov [TE/MCS/MNC] , DIRAC Note 2012-2.

[3] H. Wind, Journal of Comp. Physics **2** (1968) 274.

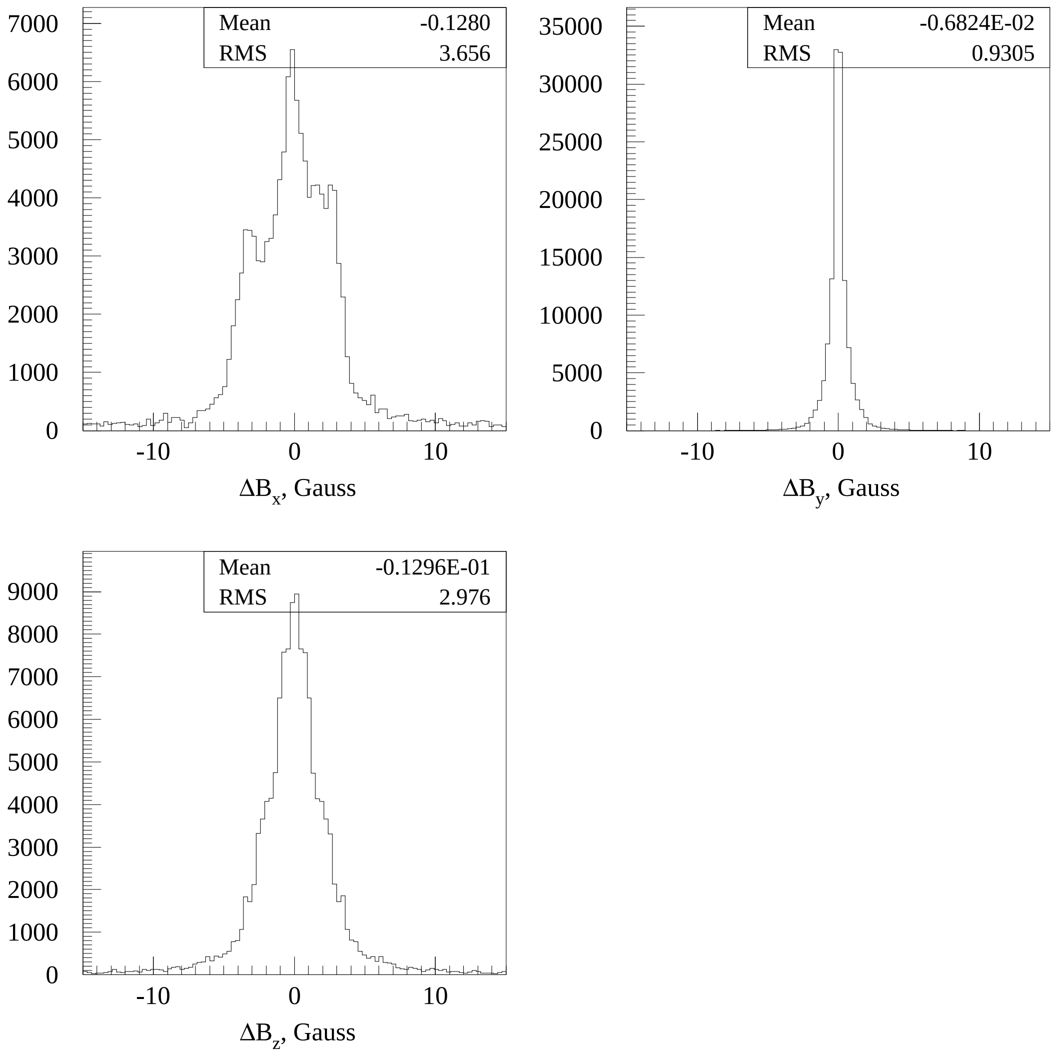

Figure 1: *The difference between calculated(OPERA) value of magnetic field and the fitted value.*

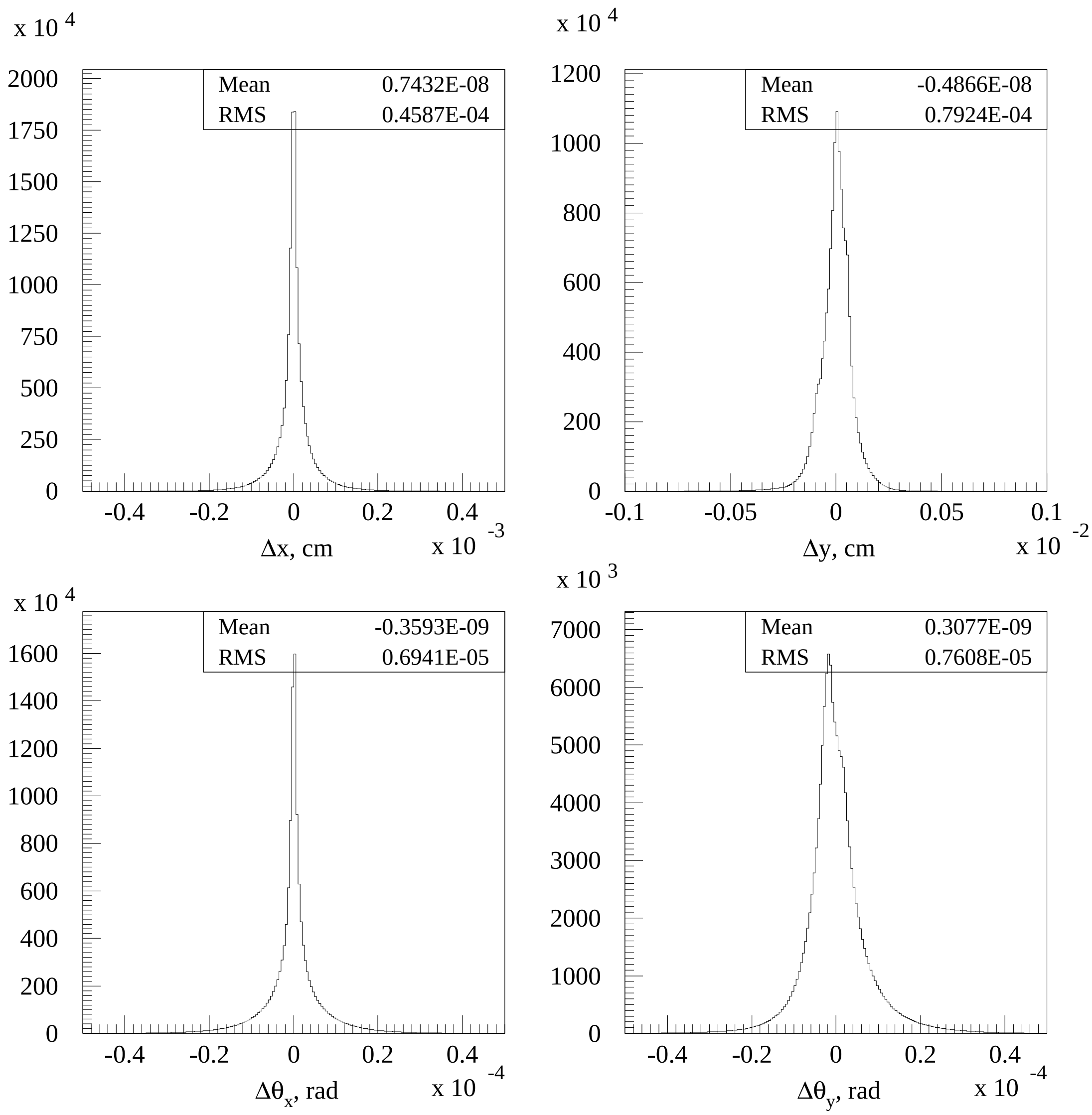

Figure 2: *Positive particles. The distributions of δx, δy, $\delta\tan(\theta_x)$ and $\delta\tan(\theta_y)$ where the δ means the difference between the Monte-Carlo values and values calculated by fitting polynomials which determine the track position in the target on dependence of its position at the exit of magnet field and its momentum.*

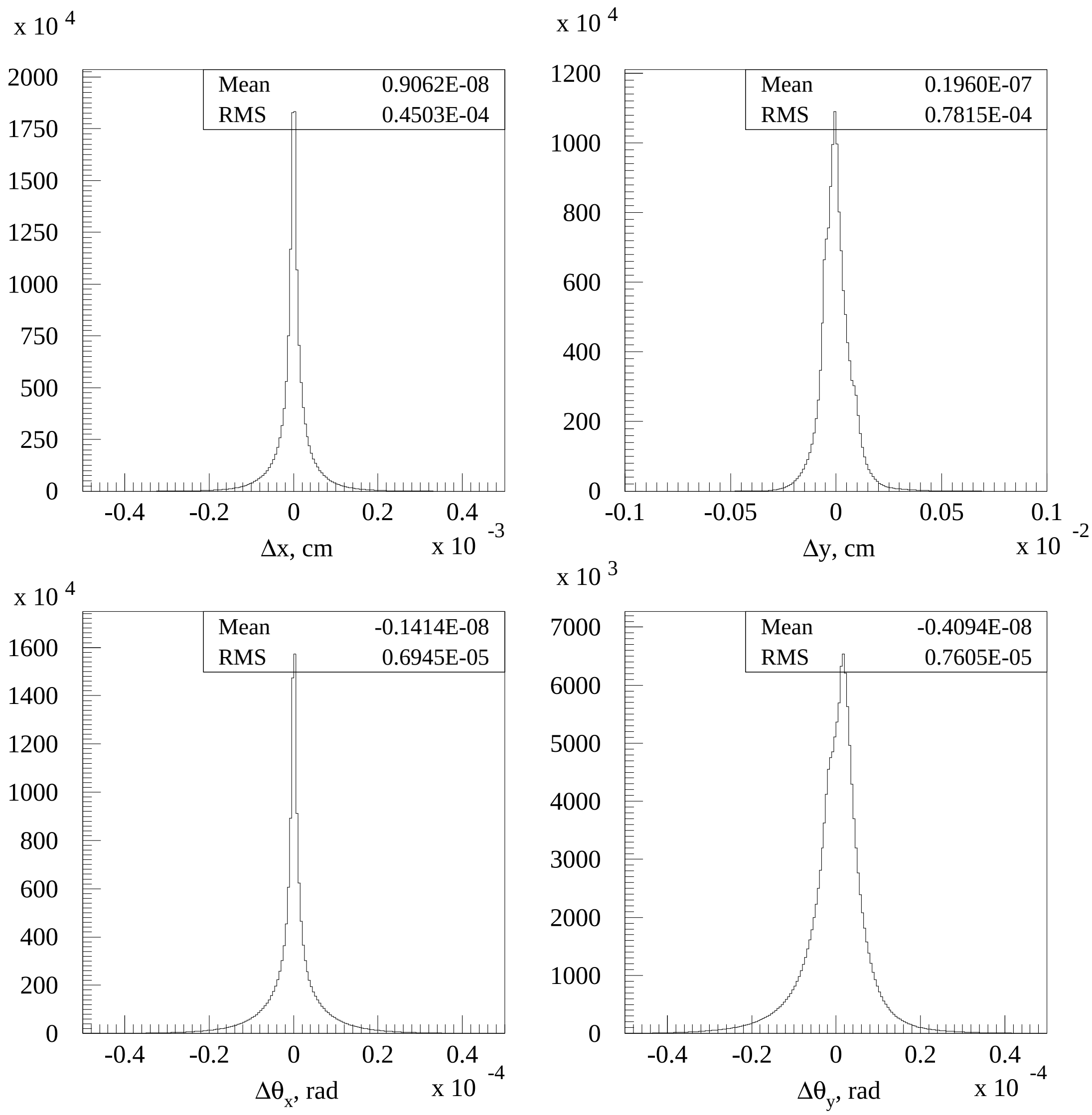

Figure 3: *Negative particles. The distributions of δx, δy, $\delta \tan(\theta_x)$ and $\delta \tan(\theta_y)$ where the δ means the difference between the Monte-Carlo values and values calculated by fitting polynomials which determine the track position in the target on dependence of its position at the exit of magnet field and its momentum.*

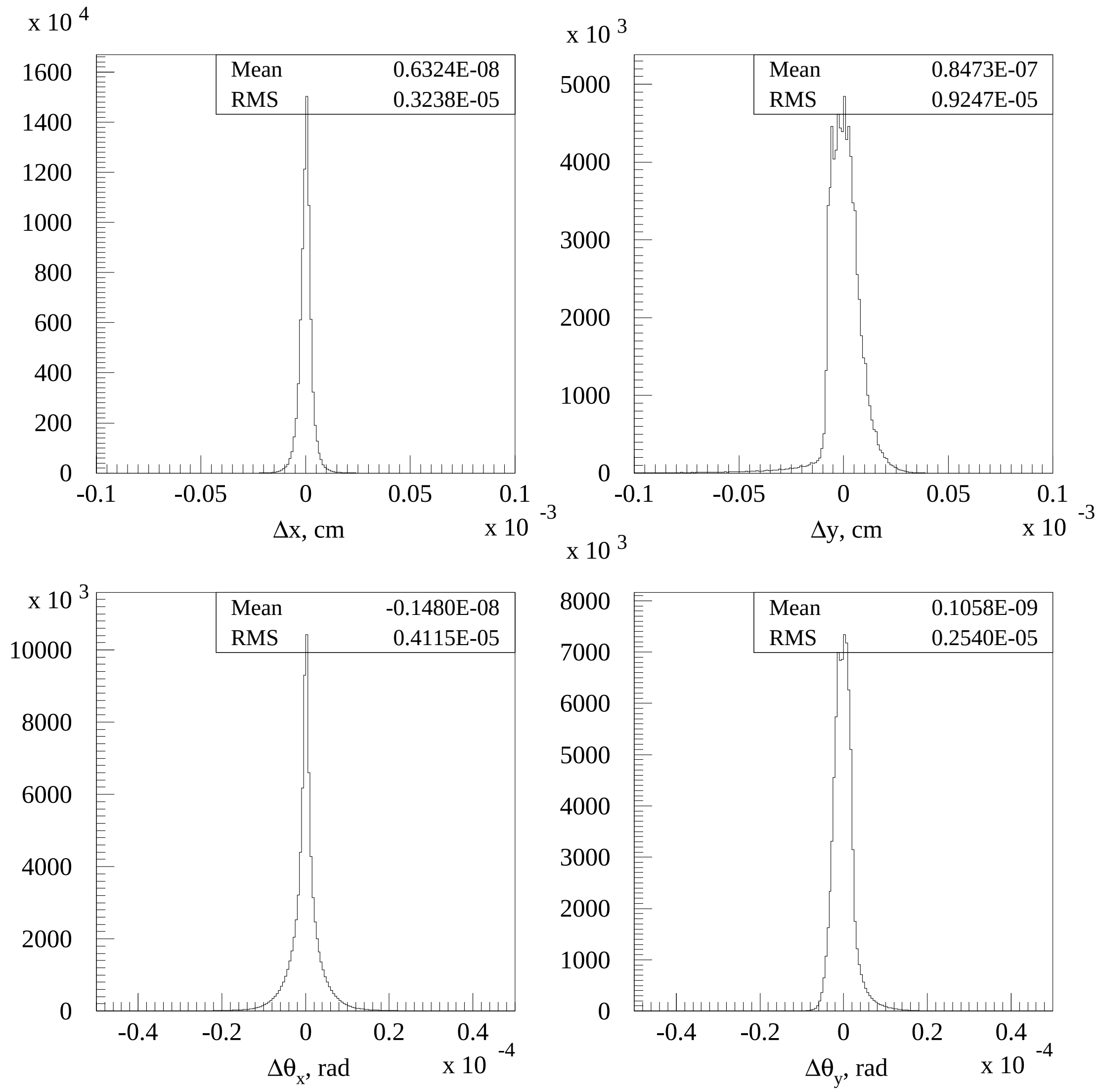

Figure 4: *Positive particles. The distributions of δx, δy, $\delta \tan(\theta_x)$ and $\delta \tan(\theta_y)$ where the δ means the difference between the Monte-Carlo values and values calculated by fitting polynomials which determine the track position in the Pt foil on dependence of its position at the exit of magnet field and its momentum.*

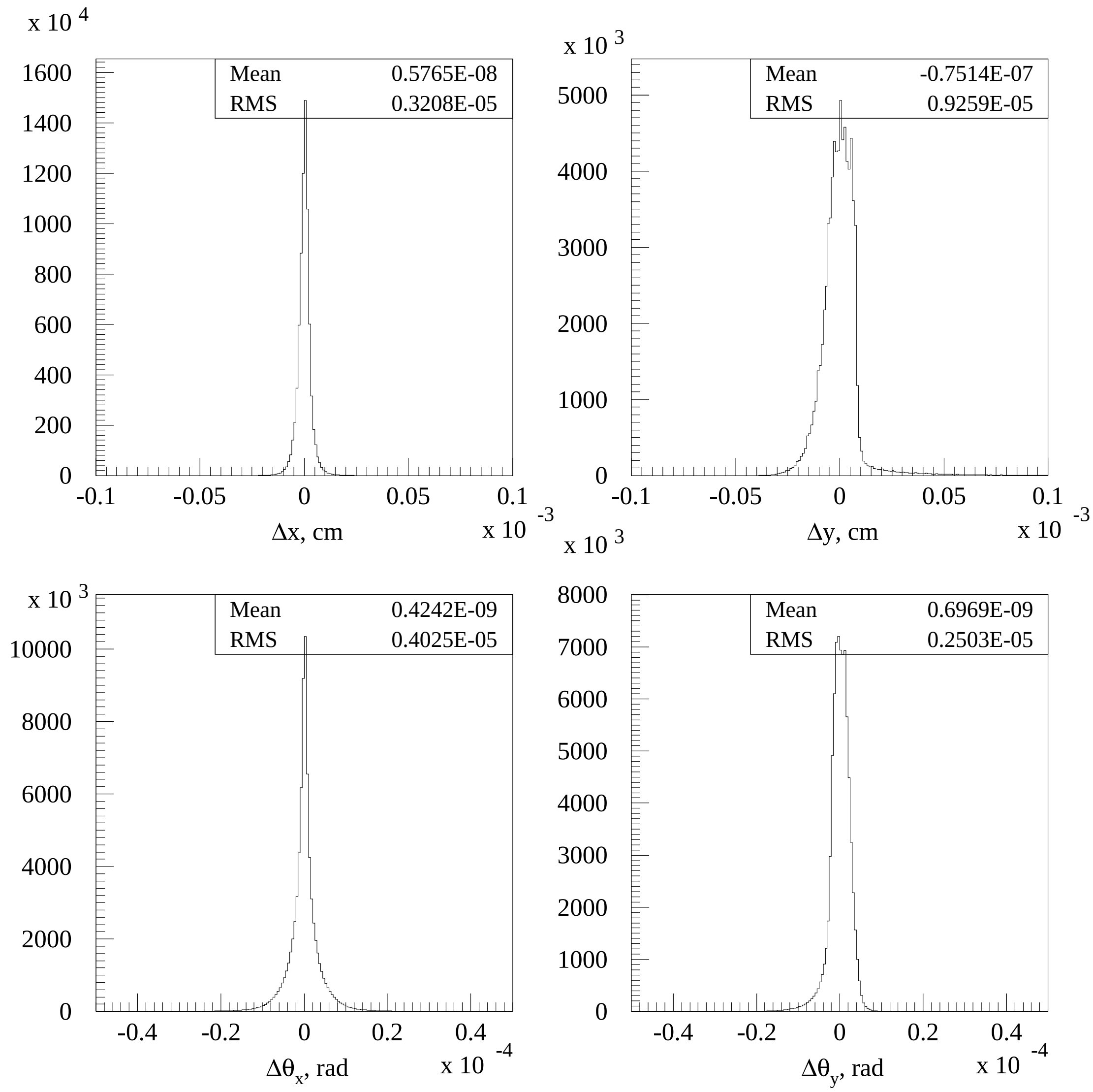

Figure 5: *Negative particles. The distributions of* δx, δy, $\delta \tan(\theta_x)$ *and* $\delta \tan(\theta_y)$ *where the* δ *means the difference between the Monte-Carlo values and values calculated by fitting polynomials which determine the track position in the Pt foil on dependence of its position at the exit of magnet field and its momentum.*