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On pions which go from long path decayed particles

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1 Preface

The aim of this work was to determine the space and kinematic properties and the contribution of pions which are produced at the decay of particles with long decay path. At first stage of this work we needed to prepare the corresponding pion pair generator - FRITIOF 6 was used for it.

The sources of pions were divided into four kinds:

1. Short-lived particles
2. Long-lived ones which decay in the target volume
3. Long-lived ones with decay path of several decimeters
4. Long-lived ones with decay path of several meters.

The second kind is presented mainly by η and $\eta\prime$, the third one - Λ and K^0_S, the fourth one - $K^{\pm}$ and K_L.

As FRITIOF can not simulate any decay path then for each event this was done by "hands" and the real shape of DIRAC channel was taken into account at that.

2 Results

Two last kinds have different distributions of their decay path(Fig. 1).

On Fig. 2 the two-dimensional plots, Y versus Z, of decay points of third and fourth kinds of pion sources are shown.

The properties of pions from each source which were used in the pion generator are the following:

1. the contribution of each pion source(1-4)
2. the decay path distributions (Fig. 1)
3. at the level of SFD plane the flux of pions depends on Y-coordinate
4. at the level of SFD plane the pion momentum distribution depends on Y-coordinate

5. the direction at which a pion of 3-th or 4-th kind enters the SFD plane differs from the vector which starts in the target and enters the same (X,Y) point on SFD plane. The corresponding values of σ_{θ_x} and σ_{θ_y} had been determined and used in the generator.

6. These values of σ_{θ_x} and σ_{θ_y} depend on pion momentum and corresponding decay path.

All of these items were used to prepare the generator of $\pi^+\pi^-$-pairs.

Some distributions which were obtained by this generator.

The contributions of each of these four kinds are shown on Fig.3 (for the pairs with pion momentum $1.5 < p < 5GeV/c$ and when each pion crosses SFD plane). The contribution of "channel" pairs is 11.4%. If we apply the cuts($|q_x| < 4MeV/c, |q_y| < 4MeV/c, |q_l| < 22.5MeV/c,$) then their contributions become like on Fig.4. The contribution of "channel" pairs is reduced to 8.5%. For pairs where at least one pion belongs to 3-th or 4-th kind we have the following distributions of δ_x and δ_y(Fig. 5).

The pairs from this generator were used as the input for GEANT-DIRAC and after analyzed by ARIANE. We have the following results.

On Fig. 6 the contributions of each source kind are presented. The contribution of "channel" pairs is 7.6%. The distributions of pion decay path are shown on Fig. 7.

The momentum distributions are slightly different for pions from target and pions from channel(Fig. 8).

The correlations between relative momentum of pair which it had at the creation(GEANT value) and reconstructed one are shown on Fig. 9(pairs from target) and 10(pairs from channel).

For the pairs from channel the distributions of δ_x and δ_y, initial ones(GEANT's) and reconstructed, are shown on Fig. 11 and 12.

The dependences of $\sigma_{x(y)}$ on pair momentum for reconstructed events are shown on Fig. 13.

ARIANE has the option which can switch off the usage all the forward detectors information and these our events were reconstructed in such way also. The correlation between relative momentum of pair which the pair had at the creation(GEANT value) and reconstructed one is shown on Fig. 14(pairs from target) and 15(pairs from channel).

On Fig. 16 the contribution of each source kind is presented. The contribution of "channel" pairs is the same 7.6%.

On Fig. 17 the distributions of Q_l for both versions of reconstruction(with upstream detectors information and without) are shown. For last case we have the number of pion pairs reconstructed is greater in 1.7.

For the full reconstruction version of ARIANE the comparison of distribution shapes of Q and Q_l for two types of pairs was done. First type of pion pairs is the pair when one pion belongs to 1-th kind and the second pion to the 2-th kind. The second type of pairs is the pair when the second pion belongs to 3-th or 4-th kind. These distributions and their ratios are shown on Fig. 18 and 19 and they exhibit non-flat behavior at small values of Q.

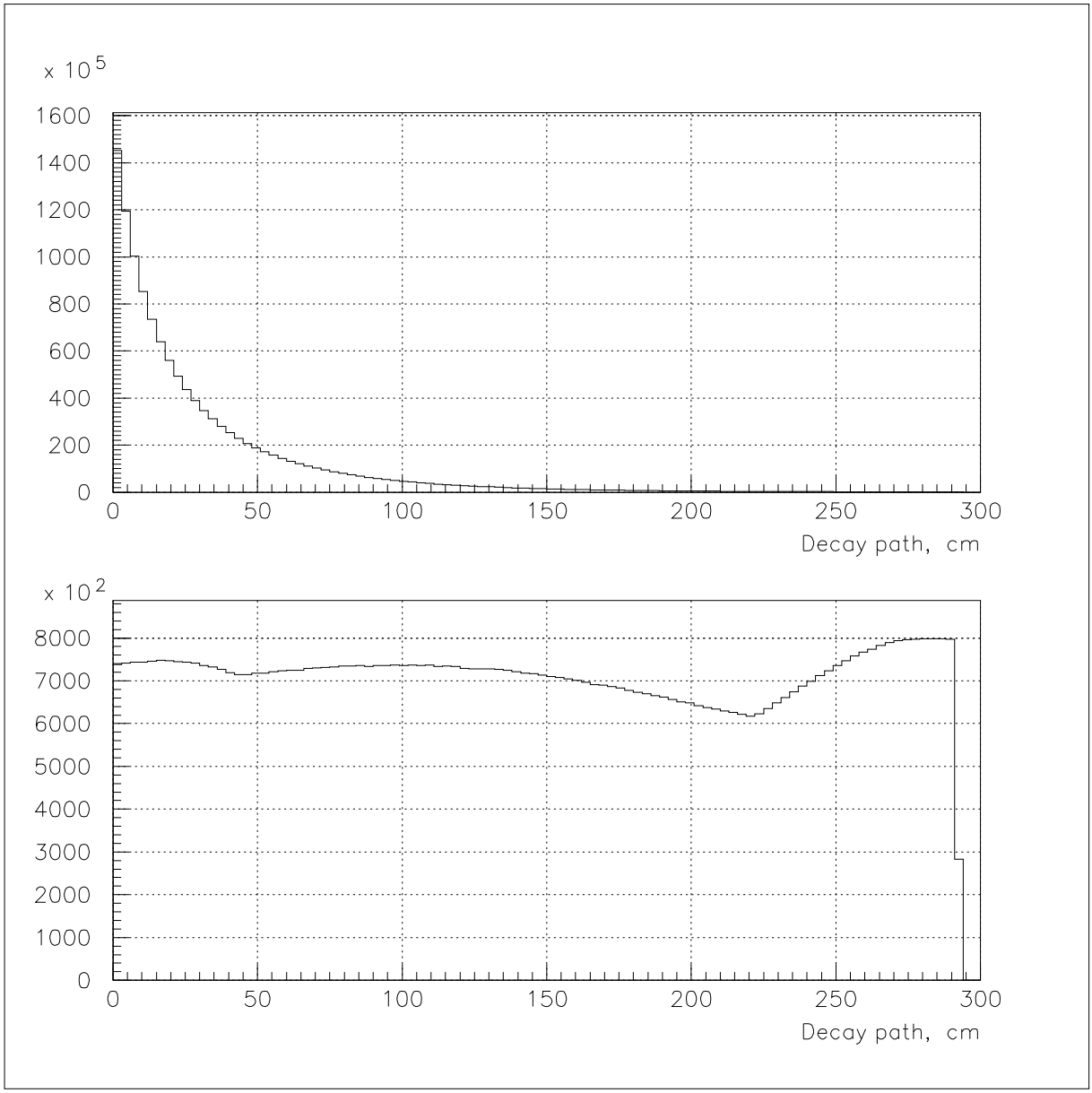

Figure 1: *The distributions of decay path for third (top) and fourth(bottom) kinds of pion sources.*

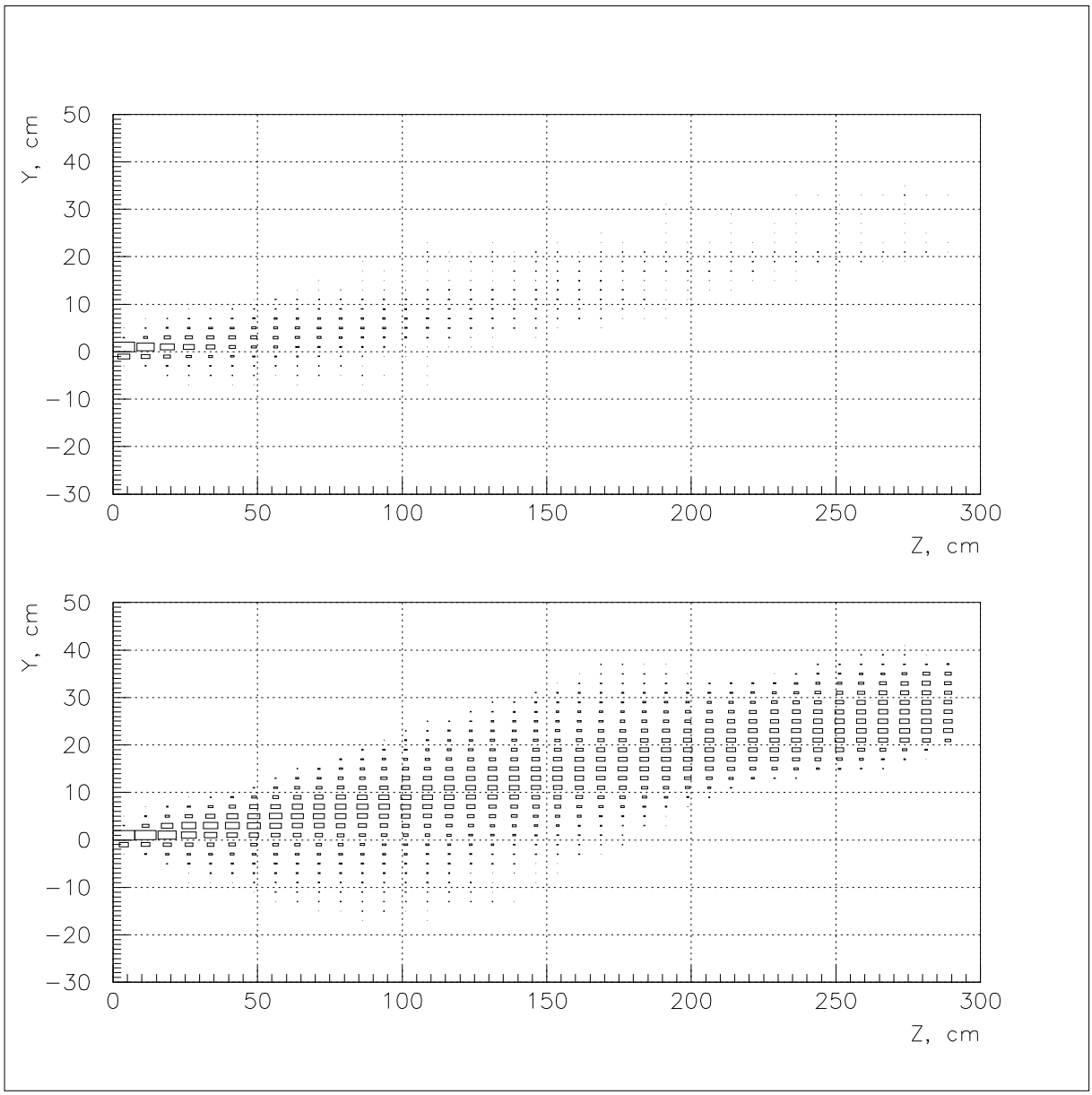

Figure 2: *The plots, Y versus Z, of decay points of third(top) and fourth kinds(bottom) of pion sources .*

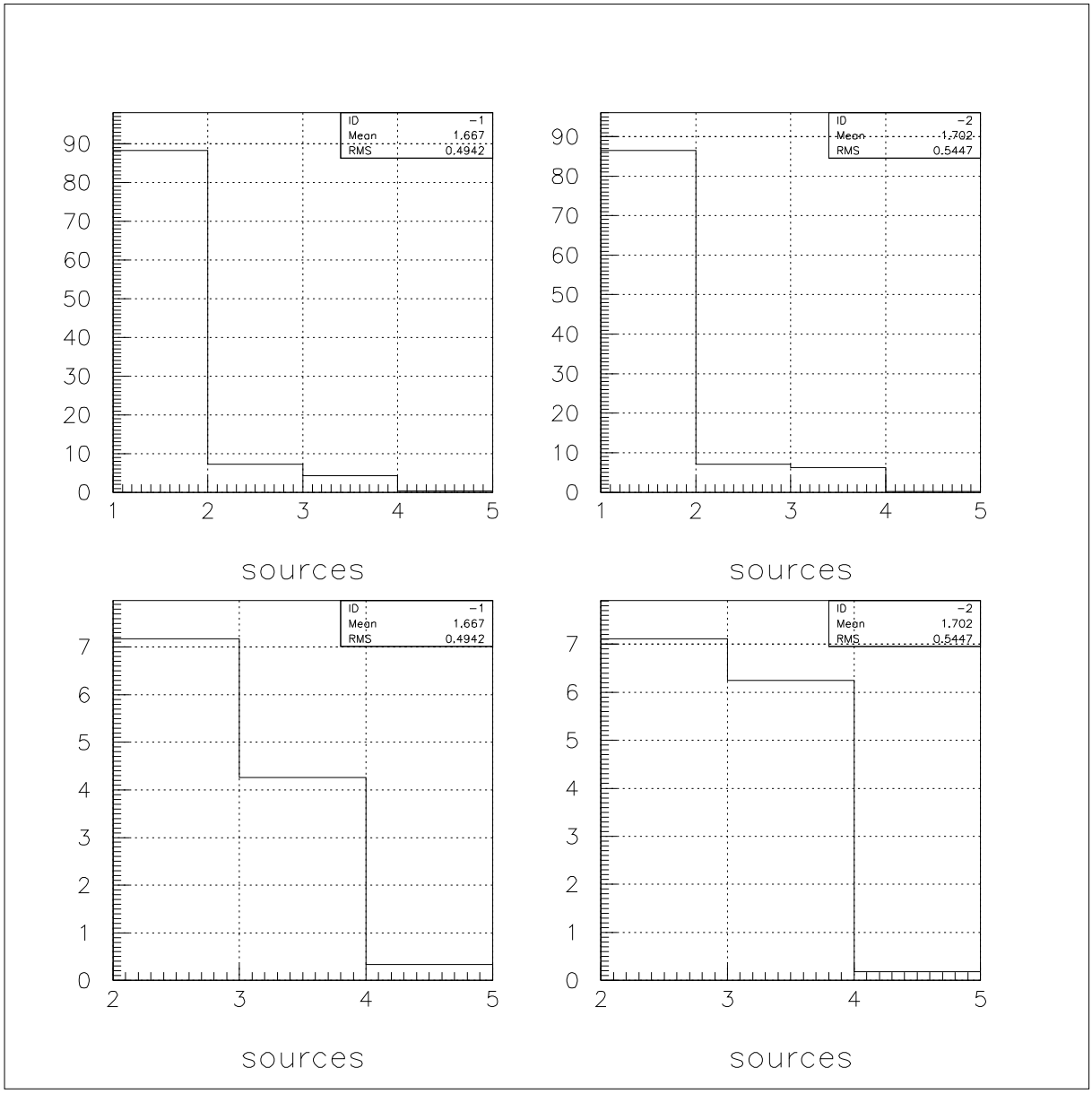

Figure 3: *The contributions of each of four kinds for the pairs with pion momentum* $1.5 < p < 5 GeV/c$ *and when each pion crosses SFD plane. Left -* π^+*, right -* π^-*.*

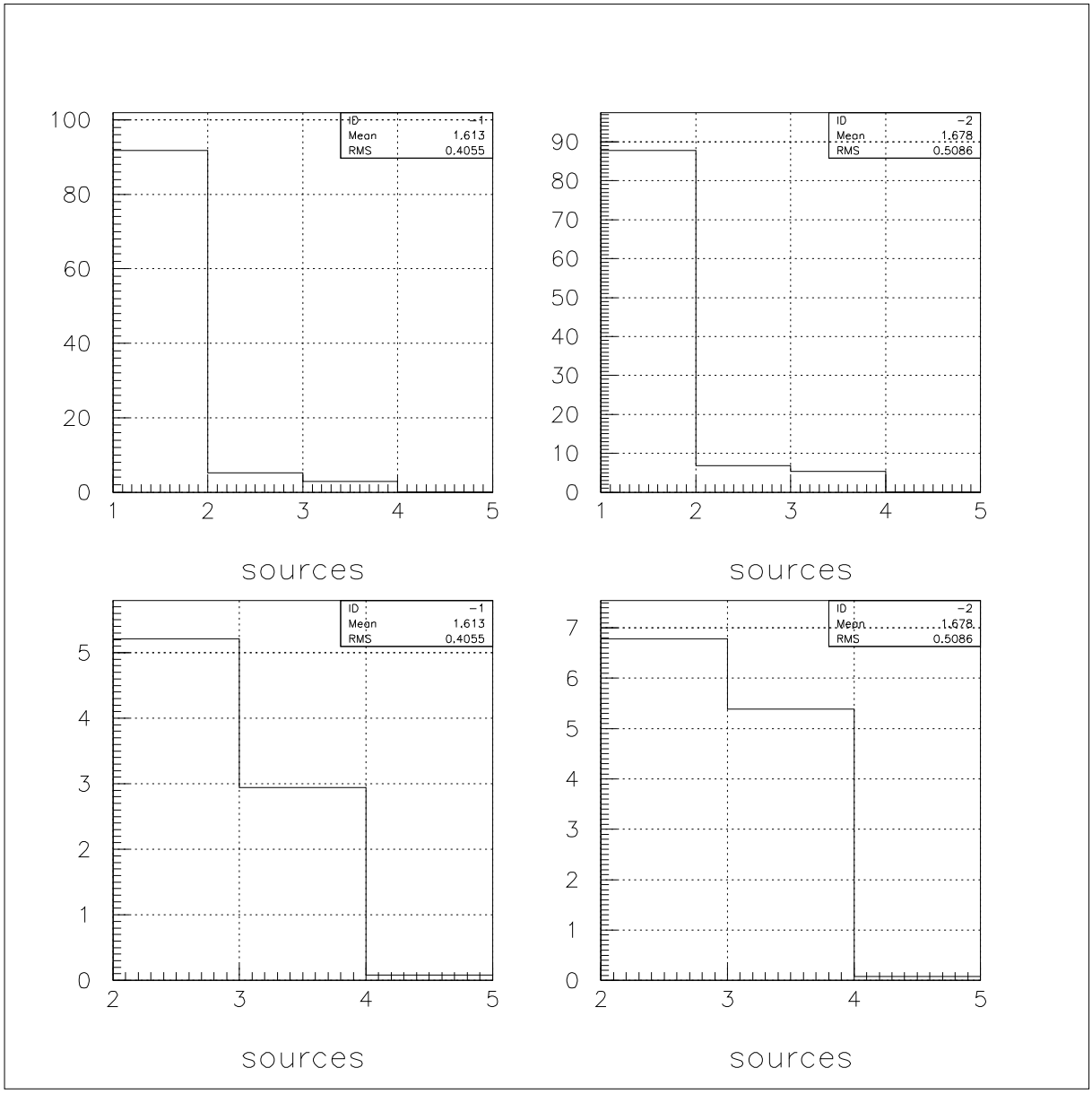

Figure 4: *The contributions of each of four kinds for the pairs with pion momentum* $1.5 < p < 5GeV/c$ *and when each pion crosses SFD plane and with the cuts* $|q_x| < 4MeV/c, |q_y| < 4MeV/c, |q_l| < 22.5MeV/c$*.Left -* π^+*, right -* π^-*.*

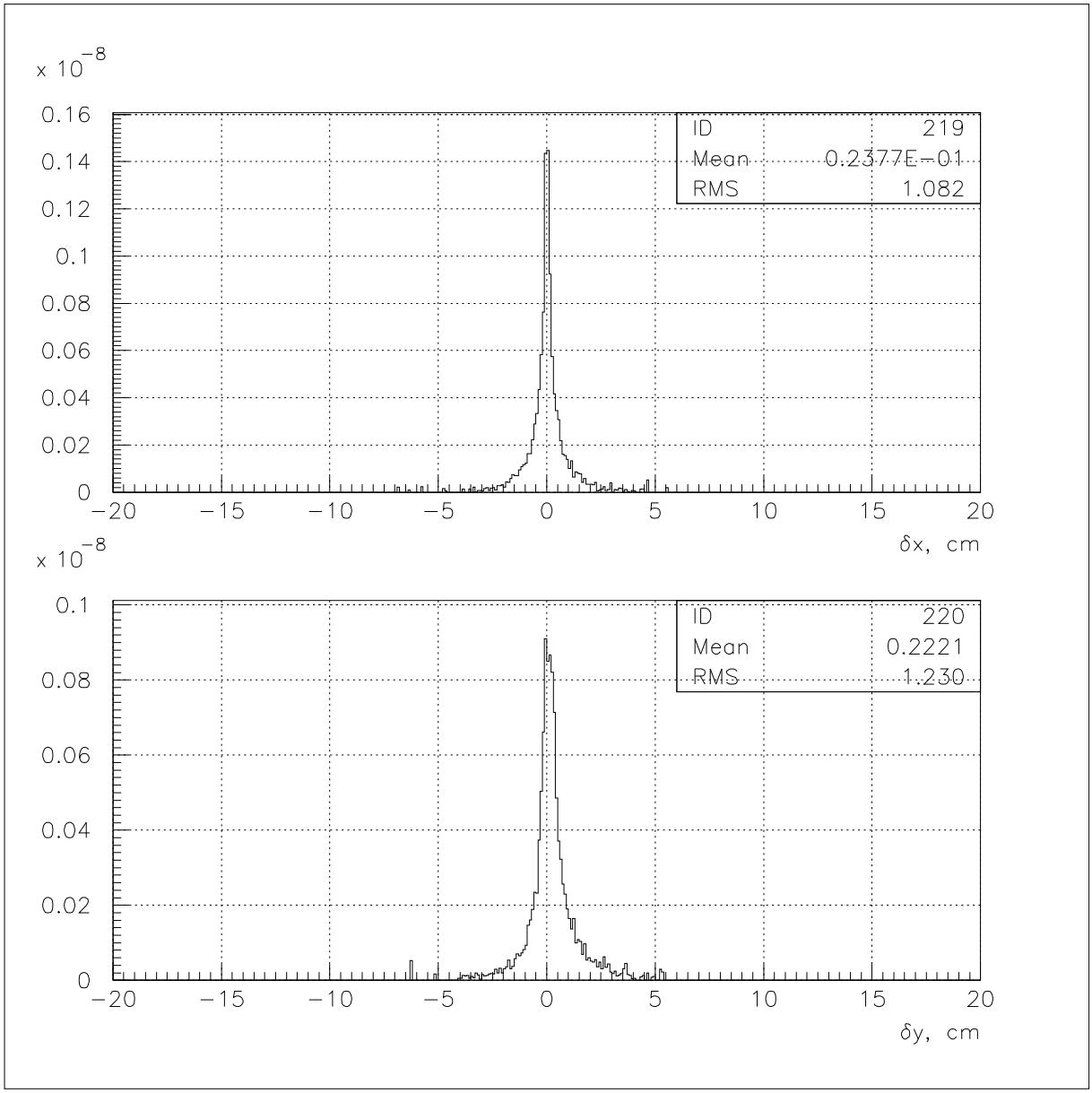

Figure 5: *The distributions of δ_x(top) and δ_y(bottom) for pairs where at least one pion belongs to 3-th or 4-th kind.*

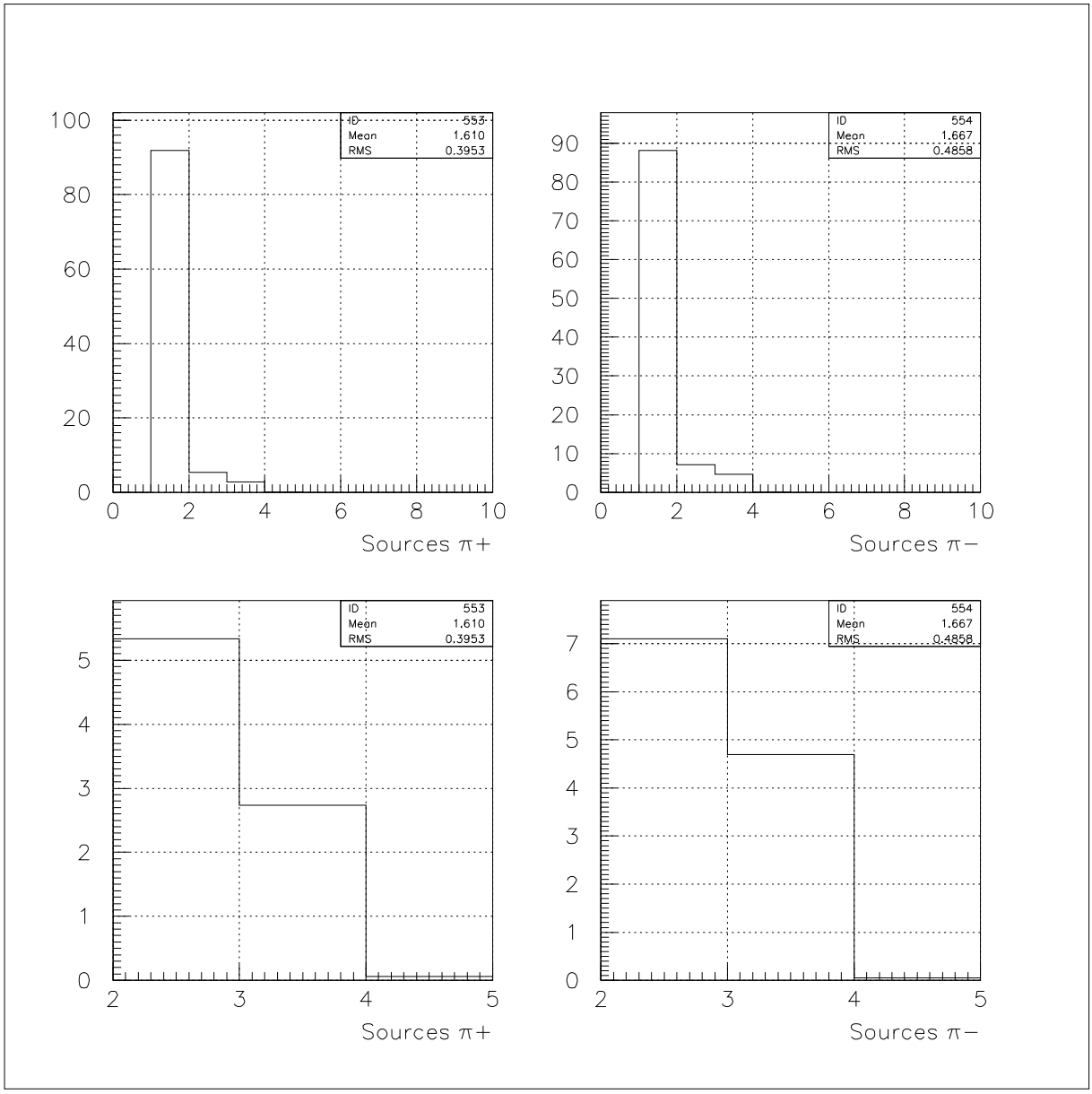

Figure 6: *The contribution of each pion source for reconstructed events.*

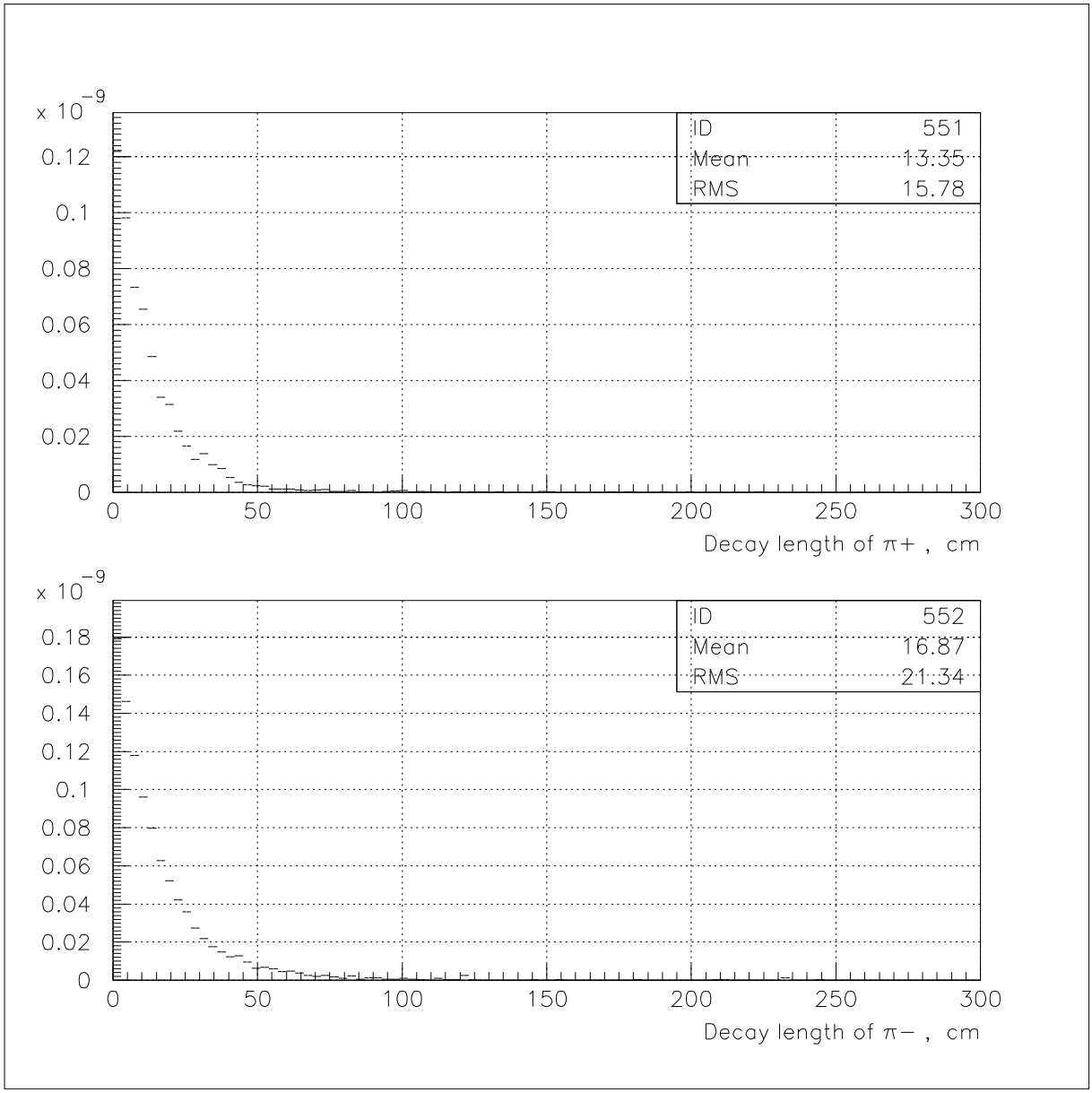

Figure 7: *The distributions of pions decay path for reconstructed events .*

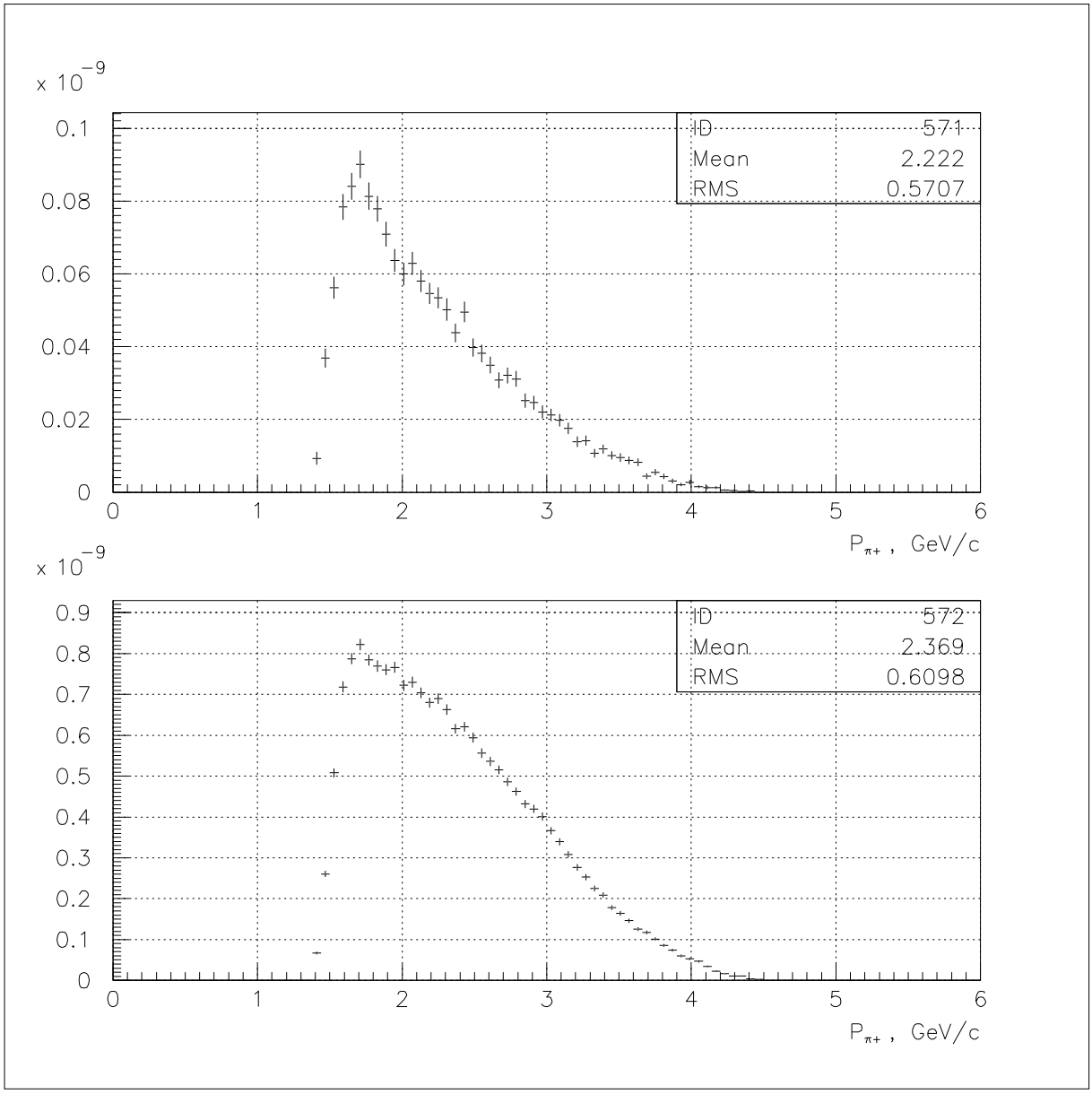

Figure 8: *The momentum distributions of π^+ from the target(top) and from the channel(bottom) for reconstructed events.*

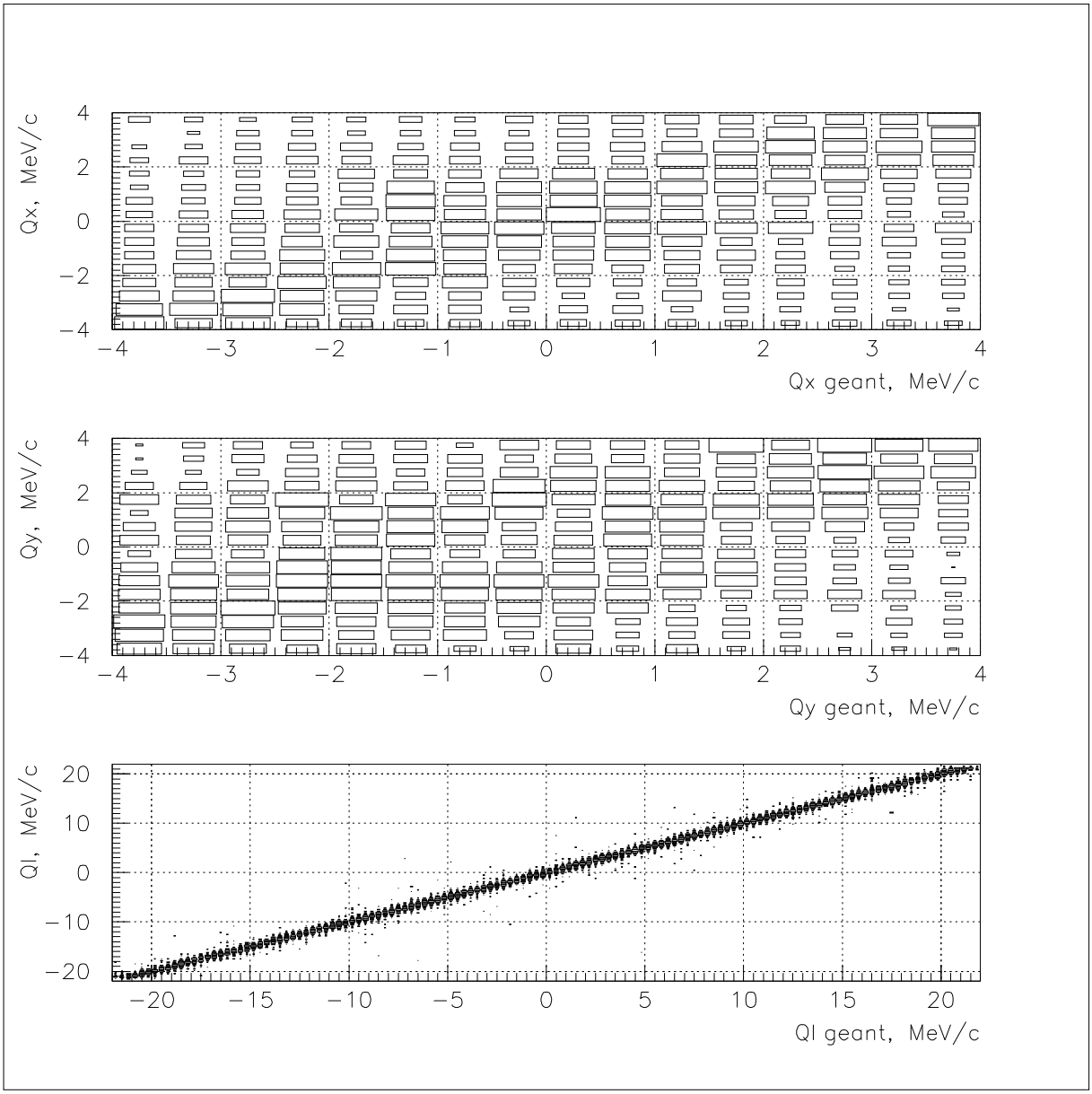

Figure 9: *The correlation between relative momentum of pair which it had at the creation(GEANT value) and reconstructed one for pairs from channel .*

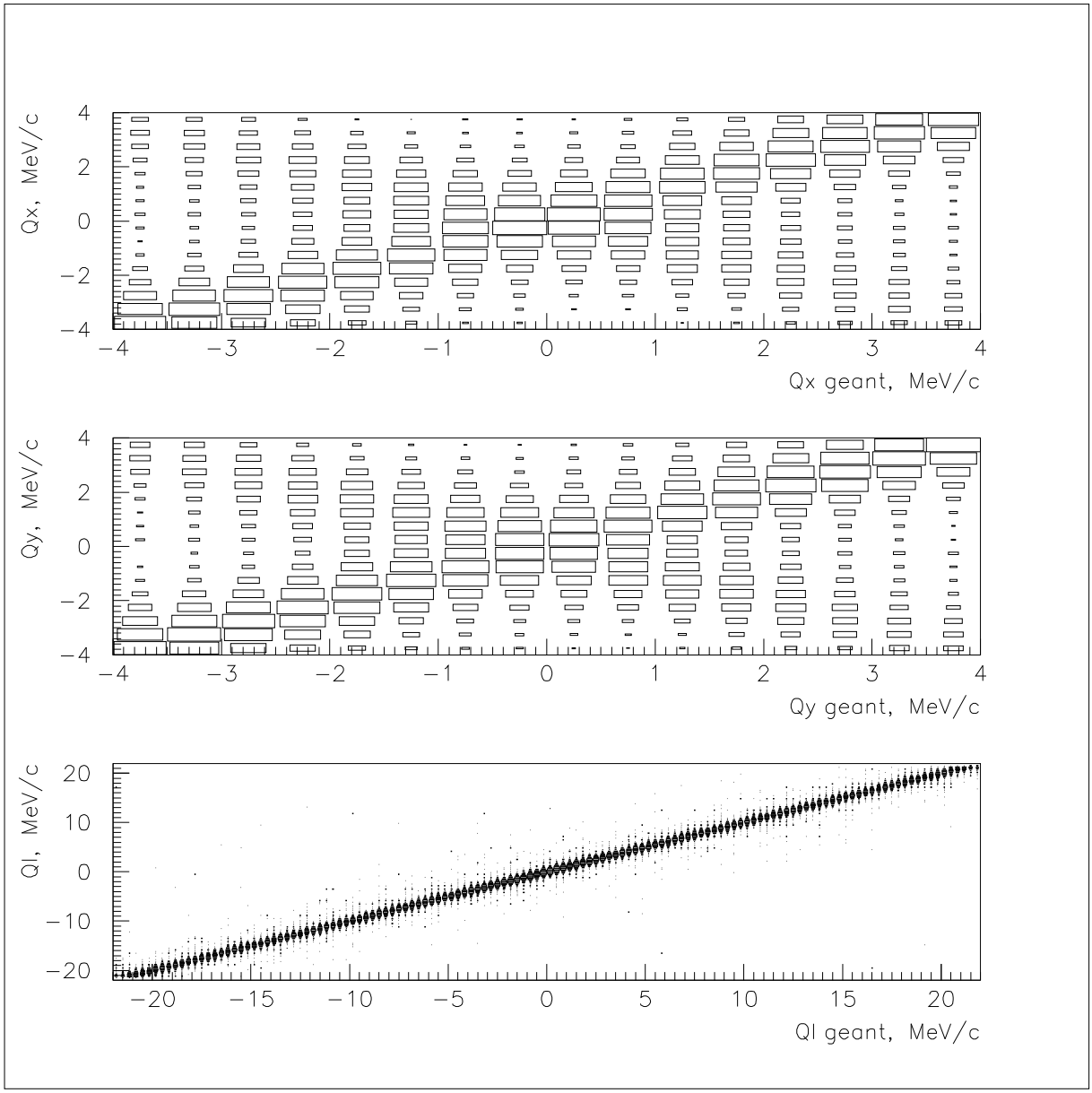

Figure 10: *The correlation between relative momentum of pair which it had at the creation(GEANT value) and reconstructed one for pairs from target .*

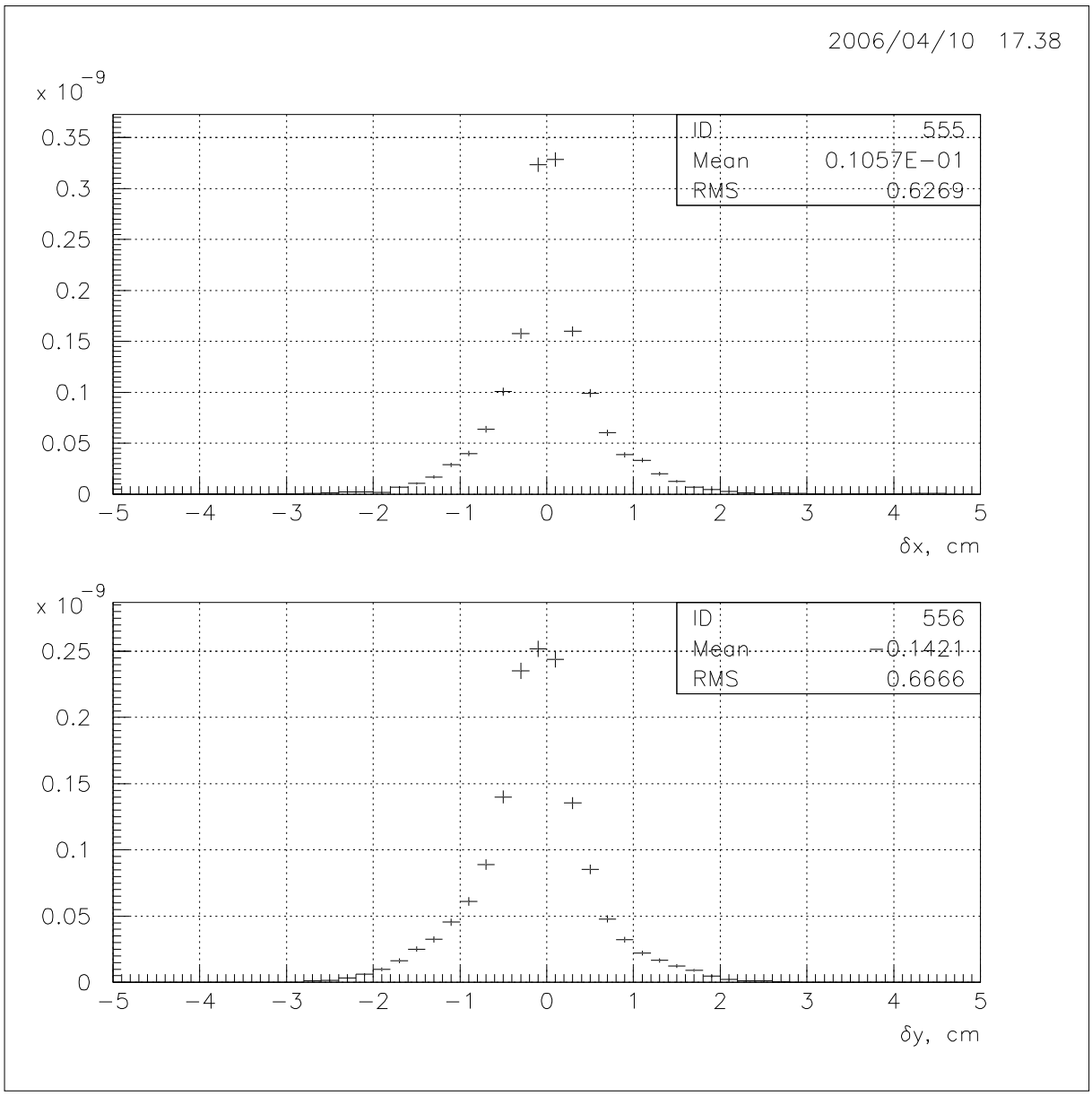

Figure 11: *The distributions of δ_x and δ_y for the pairs from channel for the reconstructed events. These values are initial, after the GEANT step .*

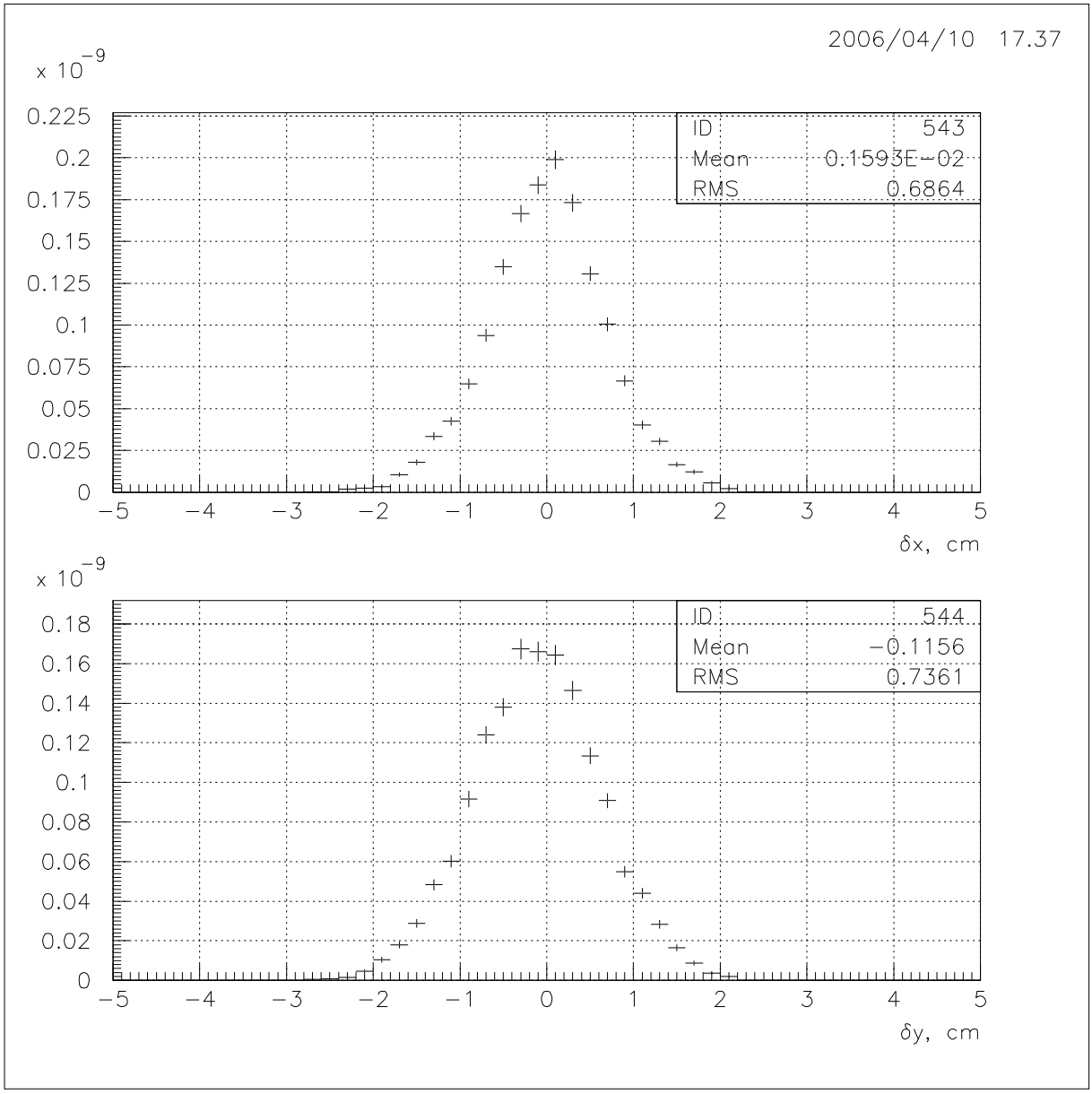

Figure 12: *The distributions of δ_x and δ_y for the pairs from channel for the reconstructed events. These values are reconstructed, after the ARIANE step .*

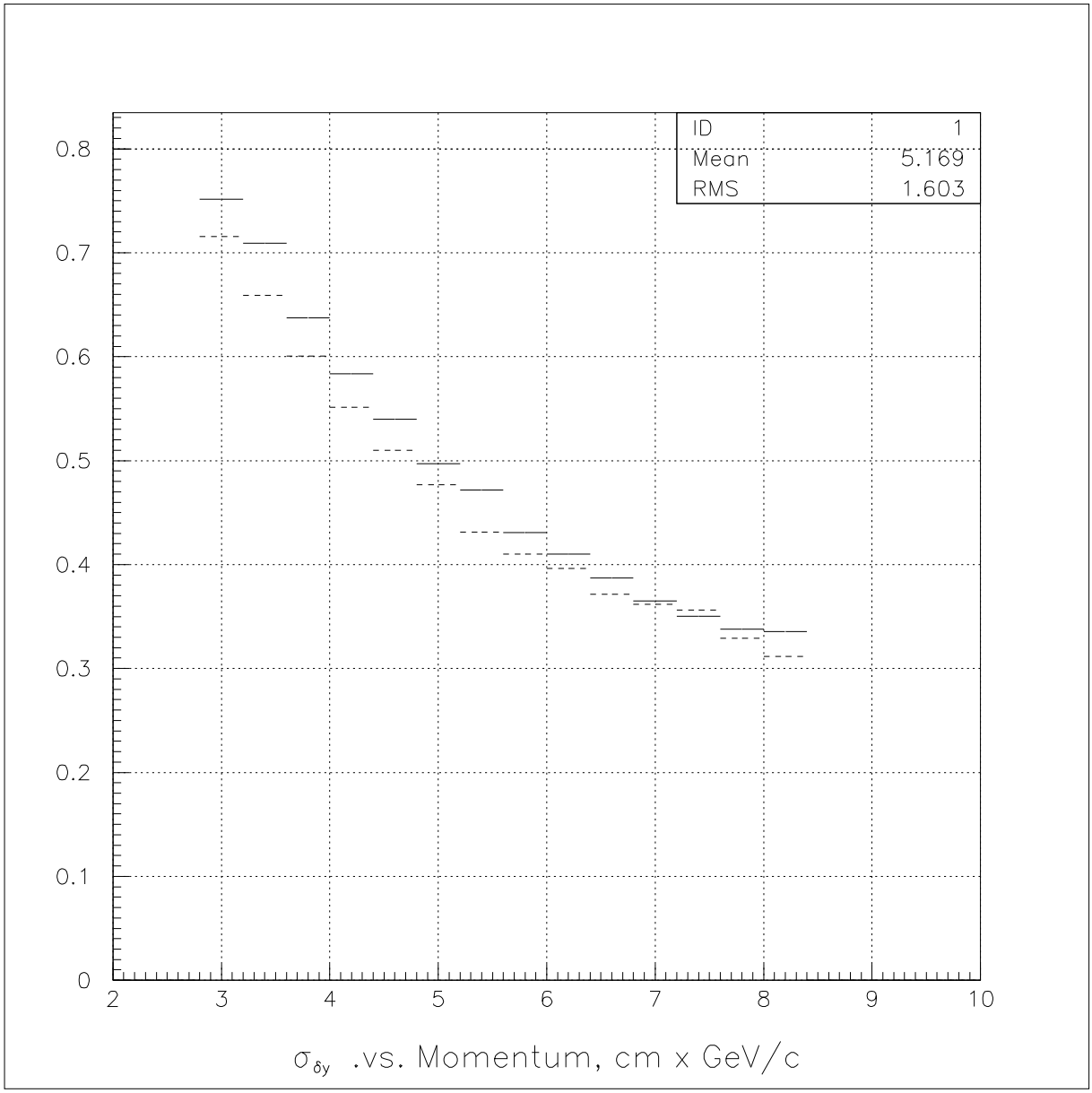

Figure 13: *The dependence of σ_x (dashed line) and σ_y on pair momentum for reconstructed events .*

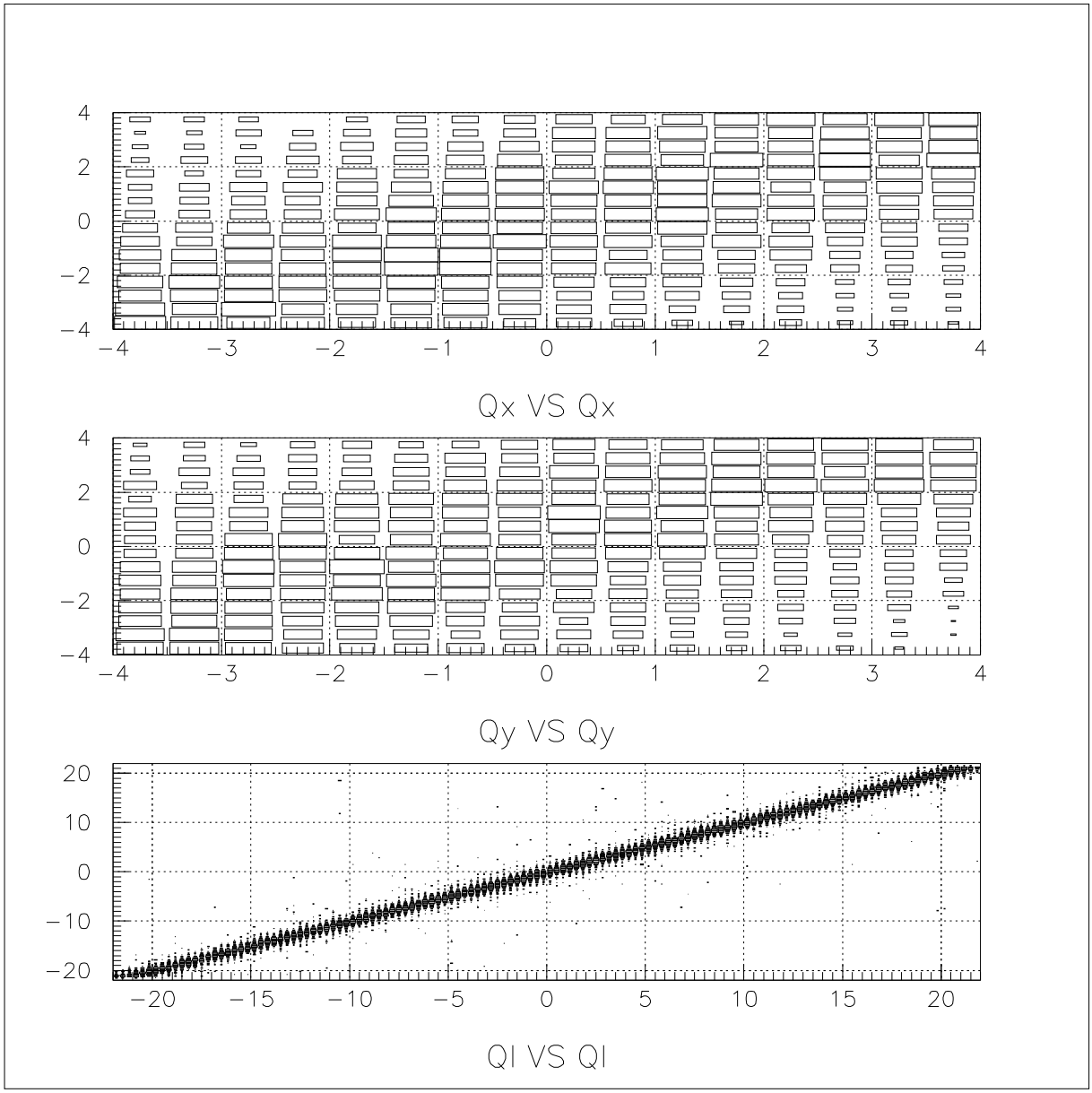

Figure 14: *The correlation between relative momentum of pair which it had at the creation(GEANT value) and reconstructed one for pairs from channel without using of forward detectors information .*

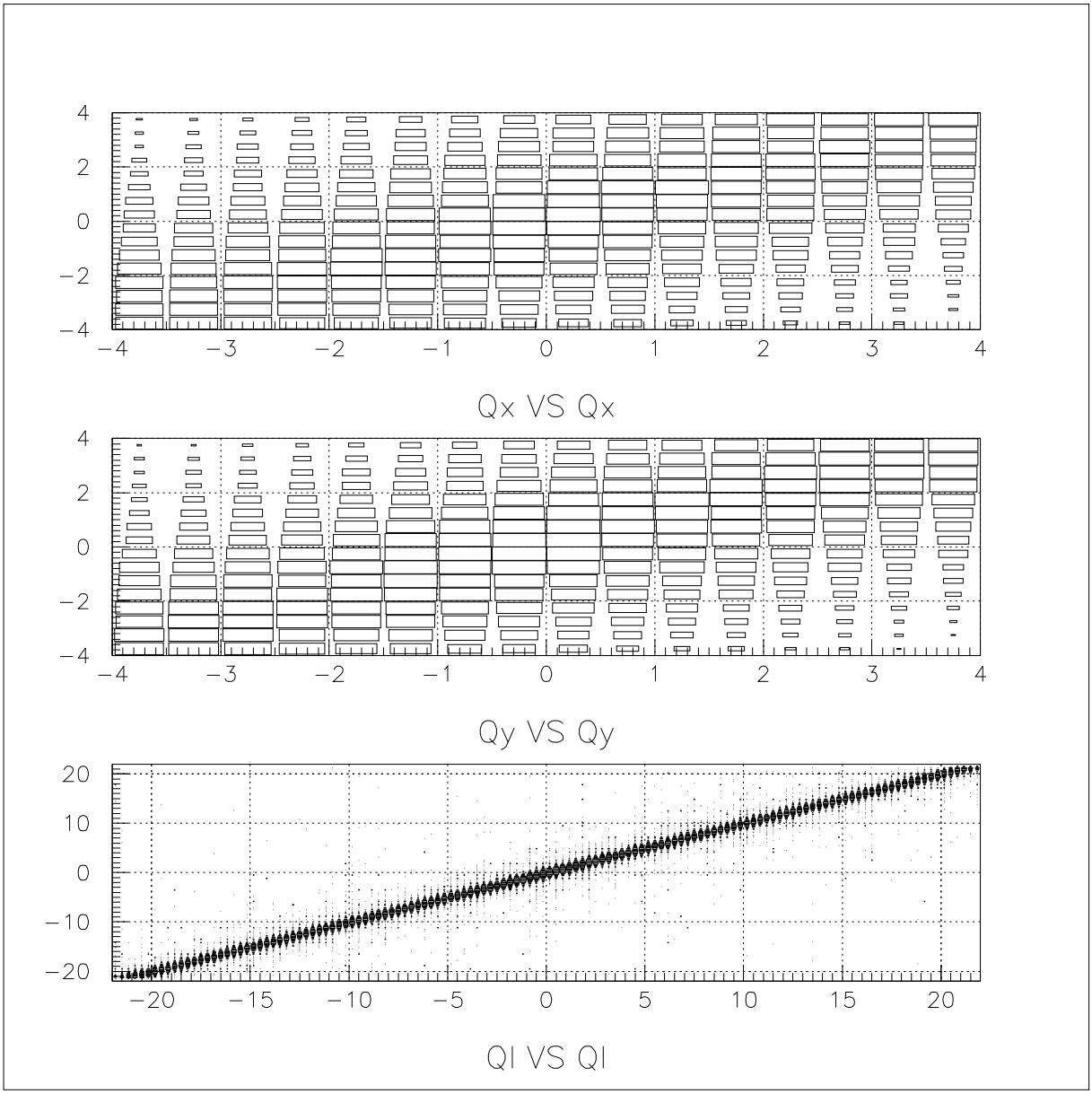

Figure 15: *The correlation between relative momentum of pair which it had at the creation(GEANT value) and reconstructed one for pairs from target without using of forward detectors information .*

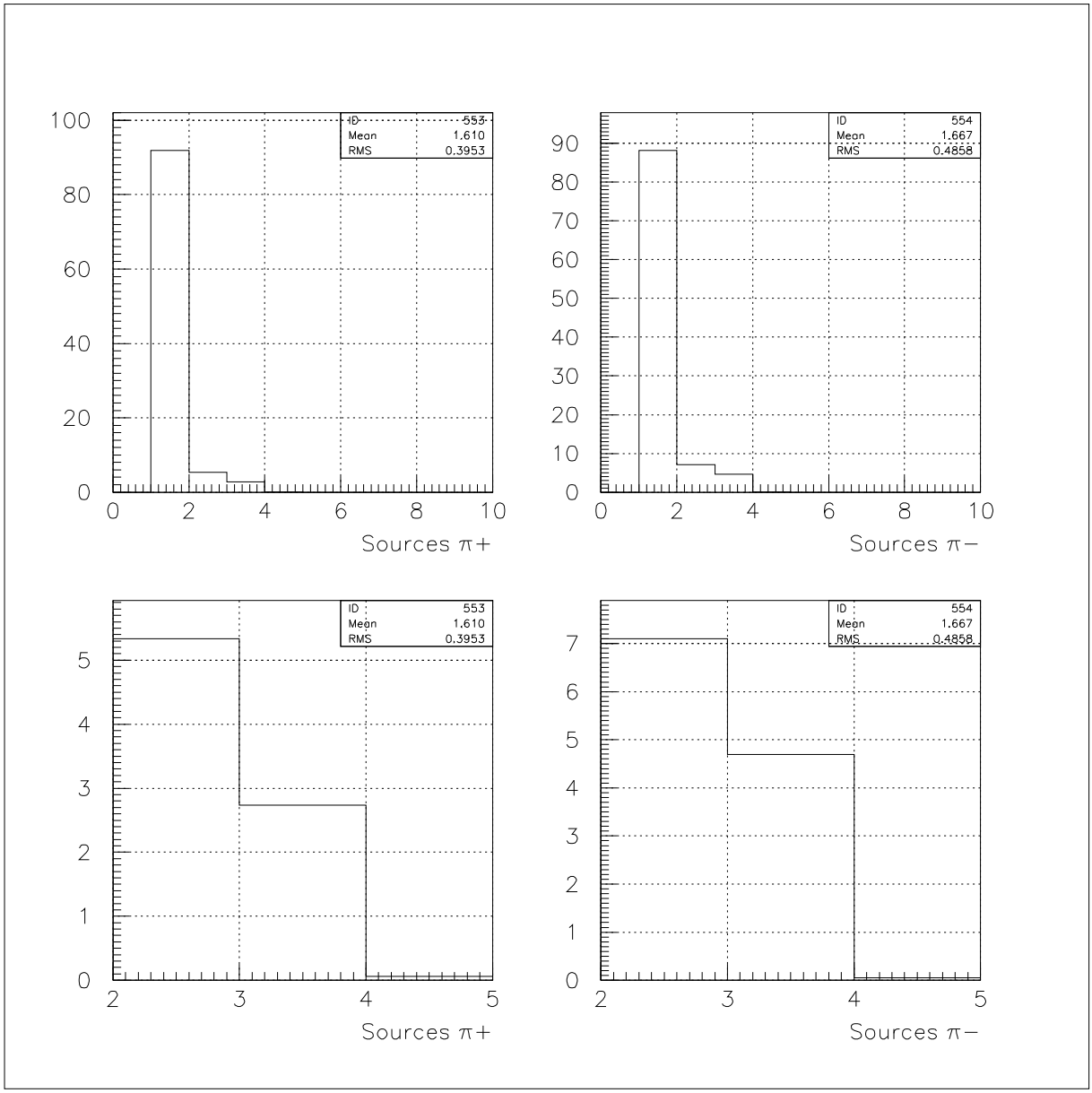

Figure 16: *The contribution of each pion source for the reconstructed events without using of forward detectors information .*

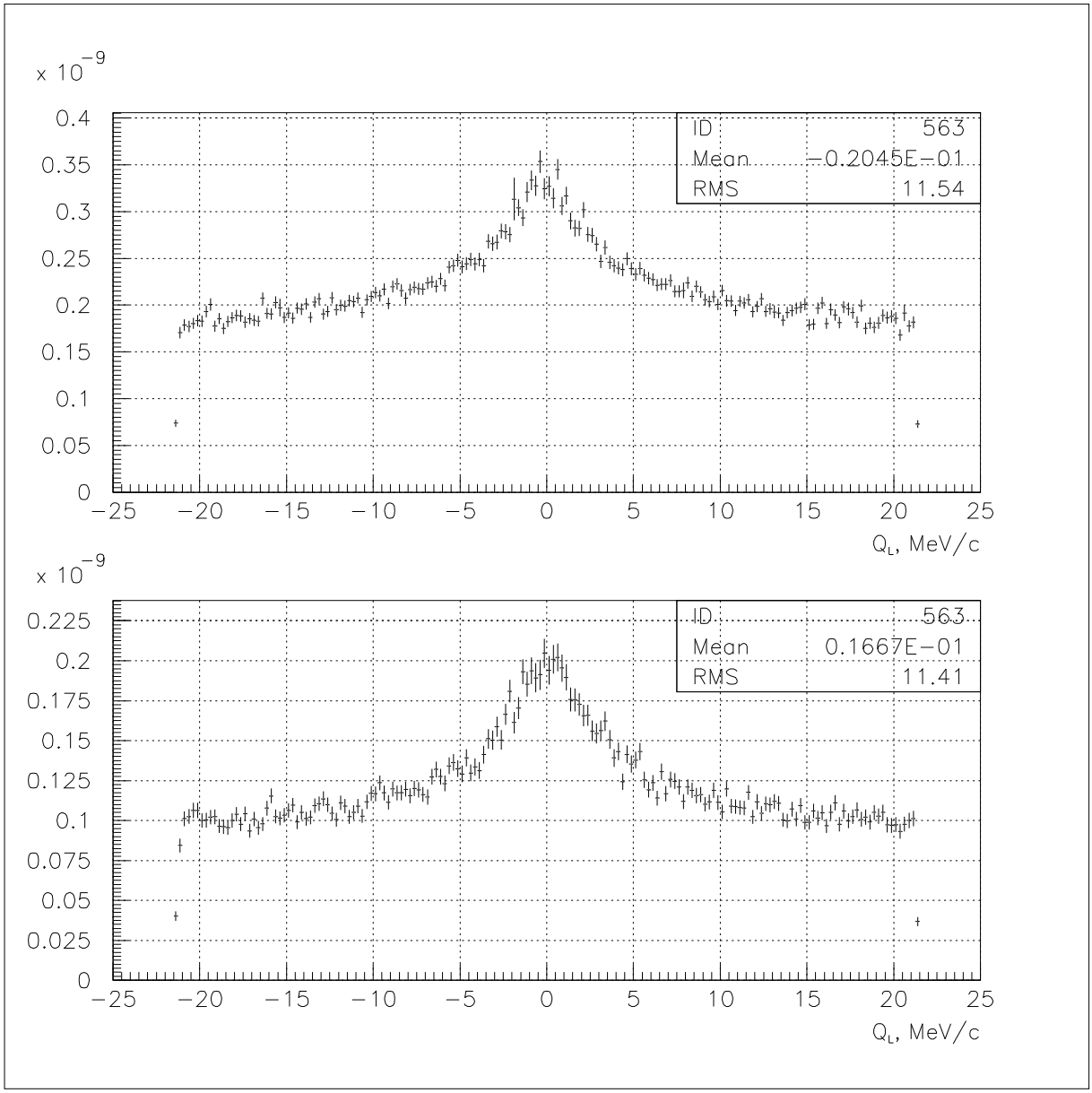

Figure 17: *The distributions of Q_l for both versions of reconstruction: with upstream detector information(bottom) and without one(top) without using of forward detectors information .*

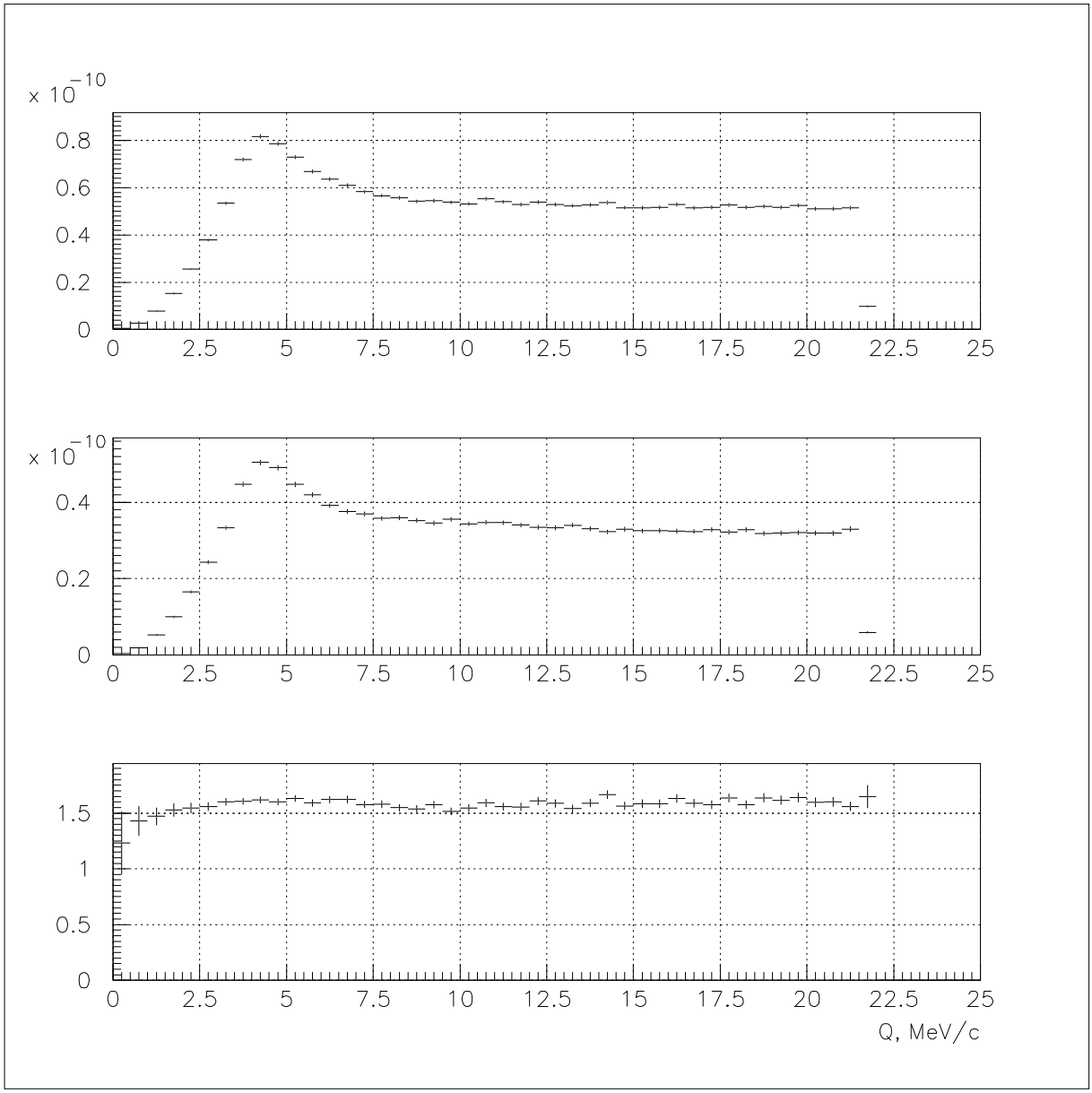

Figure 18: *The distributions of Q for pairs when one pion belongs to 1-th kind and the second pion to the 2-th kind(top), for pairs when one pion belongs to 1-th kind and the second pion to the 3-th or 4-th kind(middle) and their ratio(bottom) .*

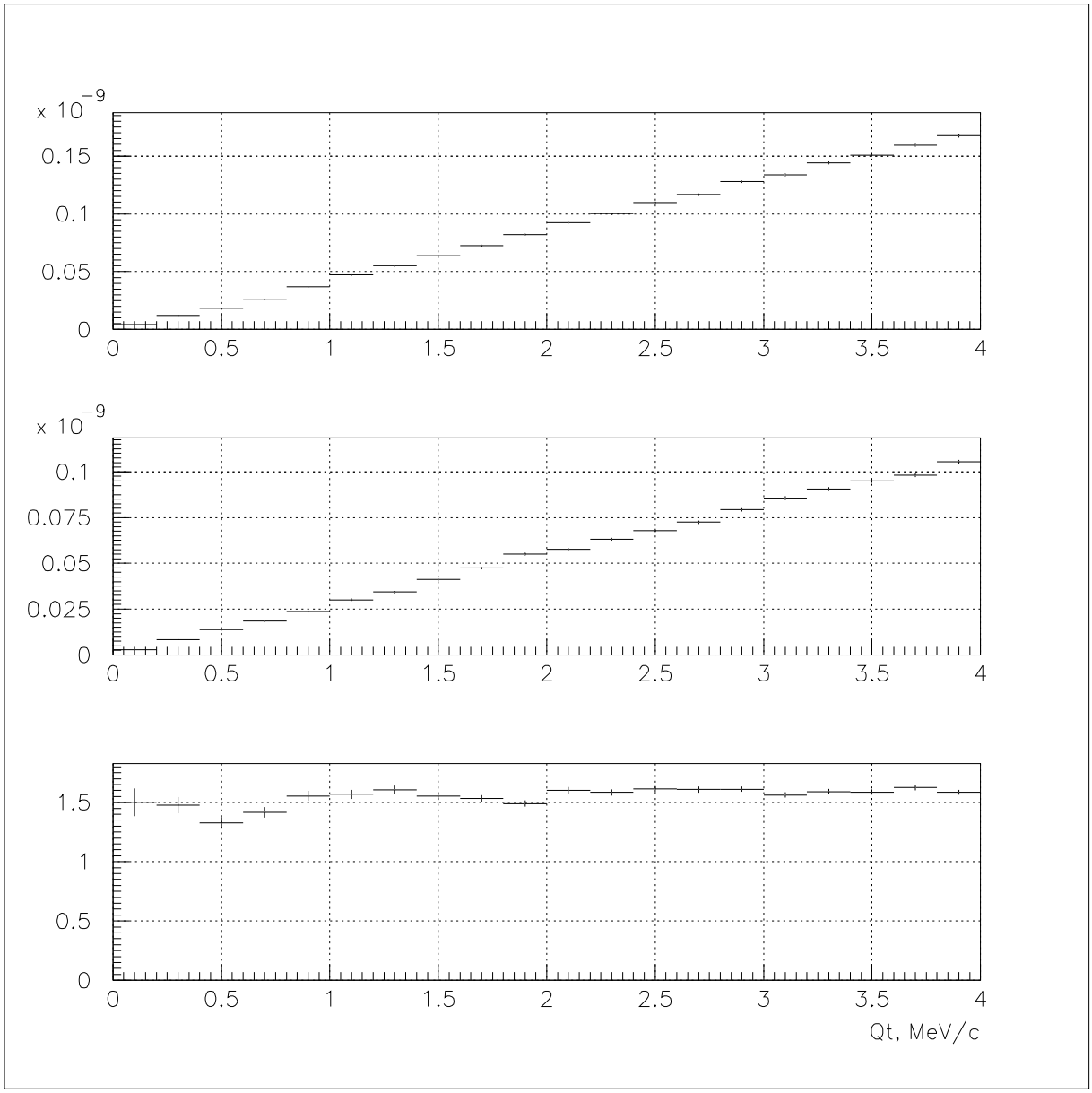

Figure 19: *The distributions of Q_t for pairs when one pion belongs to 1-th kind and the second pion to the 2-th kind(top), for pairs when one pion belongs to 1-th kind and the second pion to the 3-th or 4-th kind(middle) and their ratio(bottom) .*