EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

DIRAC Note 2005-20
10 November 2005

The implementation of new multiple scattering procedure into GEANT-DIRAC.

O.Gorchakov

GENEVA
2005

1 Simulation.

In the GEANT program the simulation of multiple scattering(MS) effects is done according to the Moliere distribution. Meanwhile in the DIRAC the experimental data were obtained which allow to get the parameters of pion multiple scattering process for some specific materials: for Nickel, Aluminum, MSGC plane material, SFD x-, y and w-planes materials. For each projection(X or Y) the angular MS distribution is described [1] by the function

$$f(x) = \sum_{i=1}^{3} \left(c_i \times \frac{1}{\sqrt{2\pi}\sigma_i} \exp\left(-\frac{x^2}{2\sigma_i^2} \right) \right) \quad \text{,where}$$
$$x = \theta_{projection} \times p, \qquad (1)$$
$$\theta_{projection} - \text{plane(X or Y) projected angle (rad)},$$
$$p - \text{total momentum (GeV/c)}.$$

The polar angle (θ) distribution, corresponded to the formula (1), is described by the function

$$F(X) = X \times \sum_{i=1}^{3} \left(c_i \times \frac{1}{2\pi\sigma_i^2} \exp\left(-\frac{X^2}{2\sigma_i^2} \right) \right) \quad \text{,where}$$
$$X = \theta \times p, \qquad (2)$$
$$\theta - \text{polar angle (rad)},$$
$$p - \text{total momentum (GeV/c)}.$$

The weighting coefficients (c_i) and Gaussian root-mean-square differences (σ_i), common for formulas (1) and (2), are given by

$$c_1 = \alpha_1 + \beta_1 \sqrt{\frac{l}{X_0^*}} \quad , \qquad \sigma_1 = \gamma_1 + \delta_1 \sqrt{\frac{l}{X_0^*}} \quad ,$$
$$c_2 = \alpha_2 + \beta_2 \sqrt{\frac{l}{X_0^*}} \quad , \qquad \sigma_2 = \gamma_2 + \delta_2 \sqrt{\frac{l}{X_0^*}} \quad , \qquad (3)$$
$$c_3 = 0.1 c_2 \quad , \qquad \sigma_3 = 2.75 \sigma_2 \quad .$$

For MSGC and SFD materials the values of β and δ are equal to zero. It means for these materials we don't use the dependence of MS angle on l. It leads to very small mistake as the θ angle at the level of these detectors is very small also.

The angular MS distributions can be simulated according to the first or second formulas. Only notice should be done - if we simulate angular distribution for each of two planes then these procedures must be correlated: if θ_x is generated for current event according, for example, to the second member of (1) then θ_y must be generated(with another random number) according to the same Gaussian. The choice of current Gaussian is done according to its weight(c_i). Otherwise, if both projections are simulated absolutely independently then the ϕ-angle distribution will not be flat.

2 Results.

As the new parameters of MS process were obtained only for some materials and these materials are presented in DIRAC setup in the form of very thin layers then the new MS procedure looks like this: when a pion enters one of these specific materials then the Moliere MS procedure is switched OFF, it means that a pion passes through this layer without MS but with all other physical interactions. When a pion leaves this layer then its space orientation is changed according to the formula (1) or (2)(we used the second one). When a pion passes through other materials then the GEANT Moliere procedure works.

The differences between these two procedures are presented in Fig. 1 - 5. On each picture two distributions are shown, upper one is for new MS procedure, lower one - for Moliere procedure. Each of them is fitted by Gaussian and the parameters of it are presented on the pictures. From these pictures it follows that new MS procedure gives more narrow angular distributions for Ni, Al and SFD w-plane materials. For SFD x- and y-plane materials the new MS procedure distributions are a bit wider. There are no differences for MSGC planes.

The influence of new MS procedure on Q_x-, Q_y-, Q_l- and $Q-$ distributions are shown in Fig. 6 - 9. Two Monte-Carlo samples are presented there . Both ones are $\pi^+\pi^-$-atomic pairs but one sample(solid line) was obtained with new MS procedure and the second one(dashed line) - with standard GEANT Moliere procedure. The main conclusion is that all of the distributions obtained with new procedure are a bit narrow than when we use Moliere MS procedure.

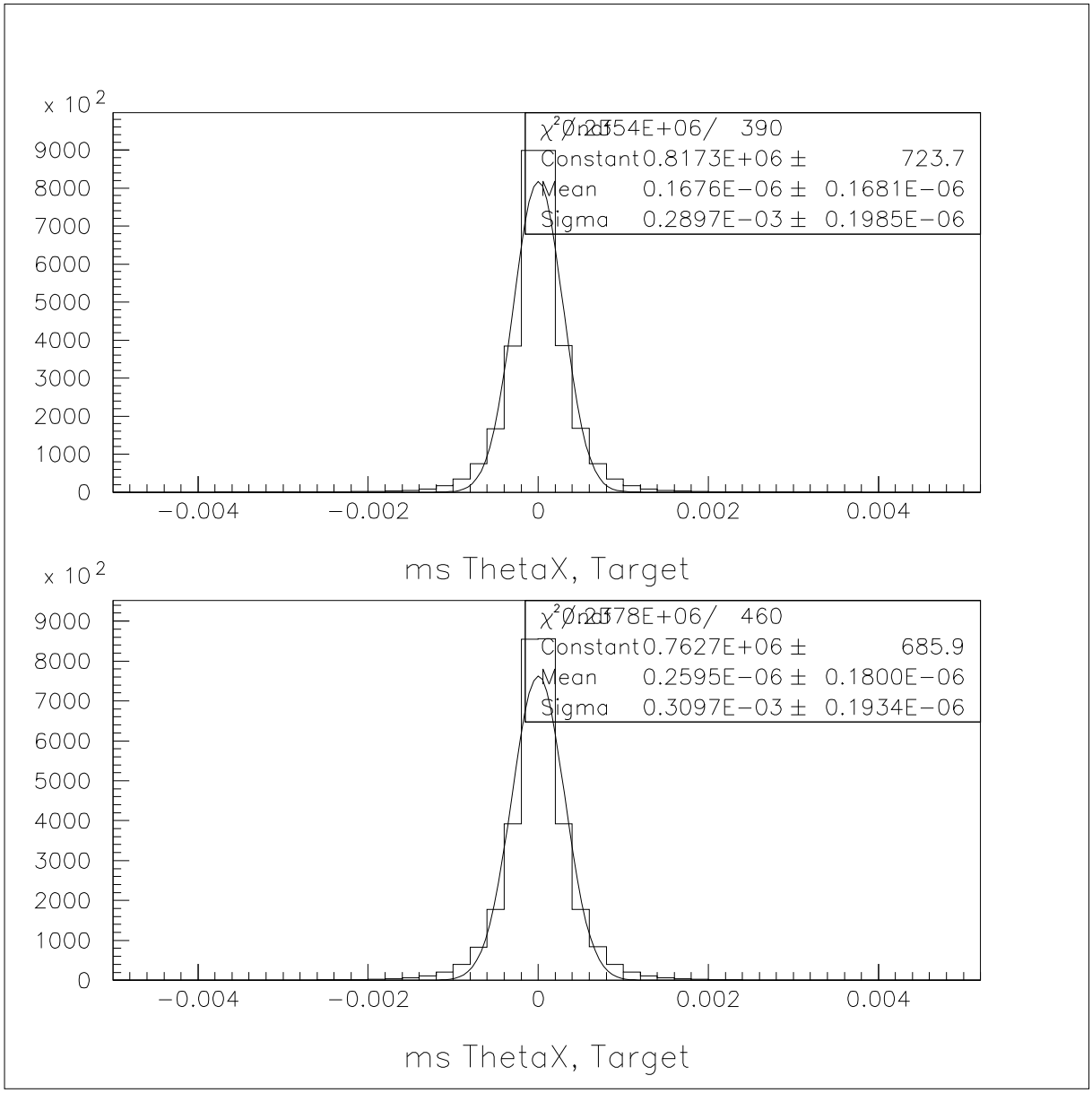

Figure 1: *The distribution of multiple scattering angle in X plane from new procedure(up) and from Moliere one(down) for Target.*

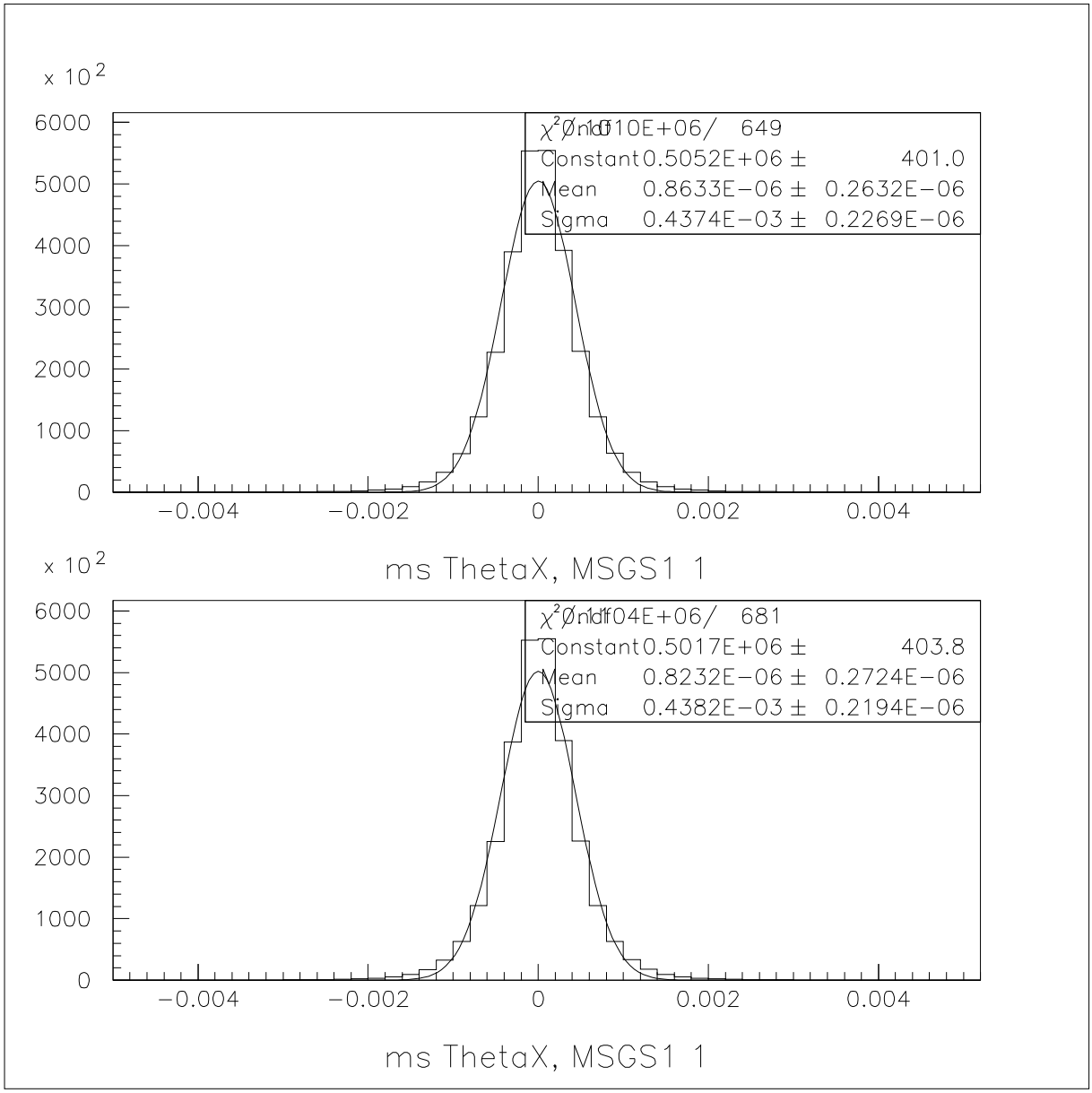

Figure 2: *The distribution of multiple scattering angle in X plane from new procedure(up) and from Moliere one(down) for MSGC1 plane.*

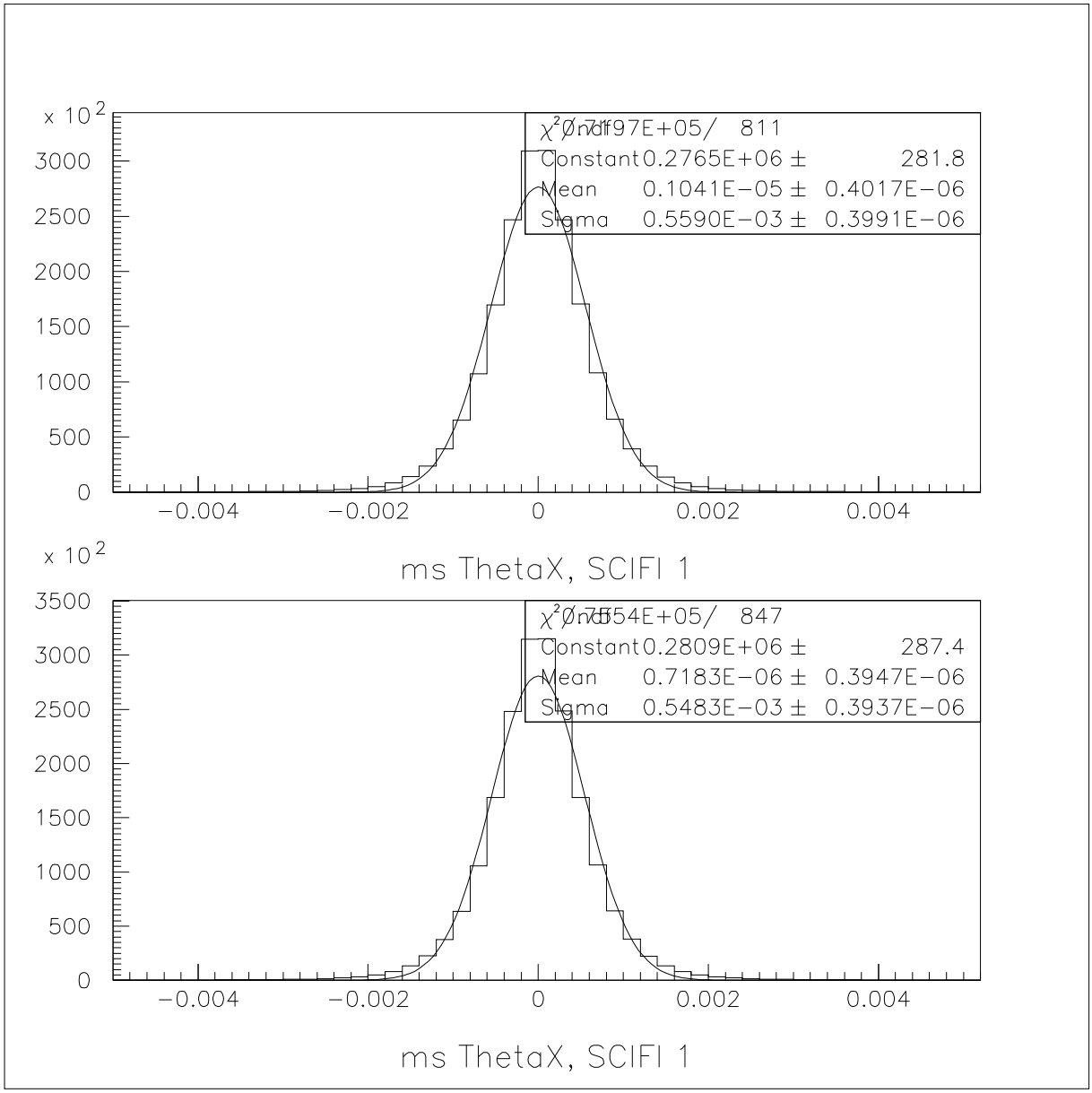

Figure 3: *The distribution of multiple scattering angle in X plane from new procedure(up) and from Moliere one(down) for SCIFI1 plane.*

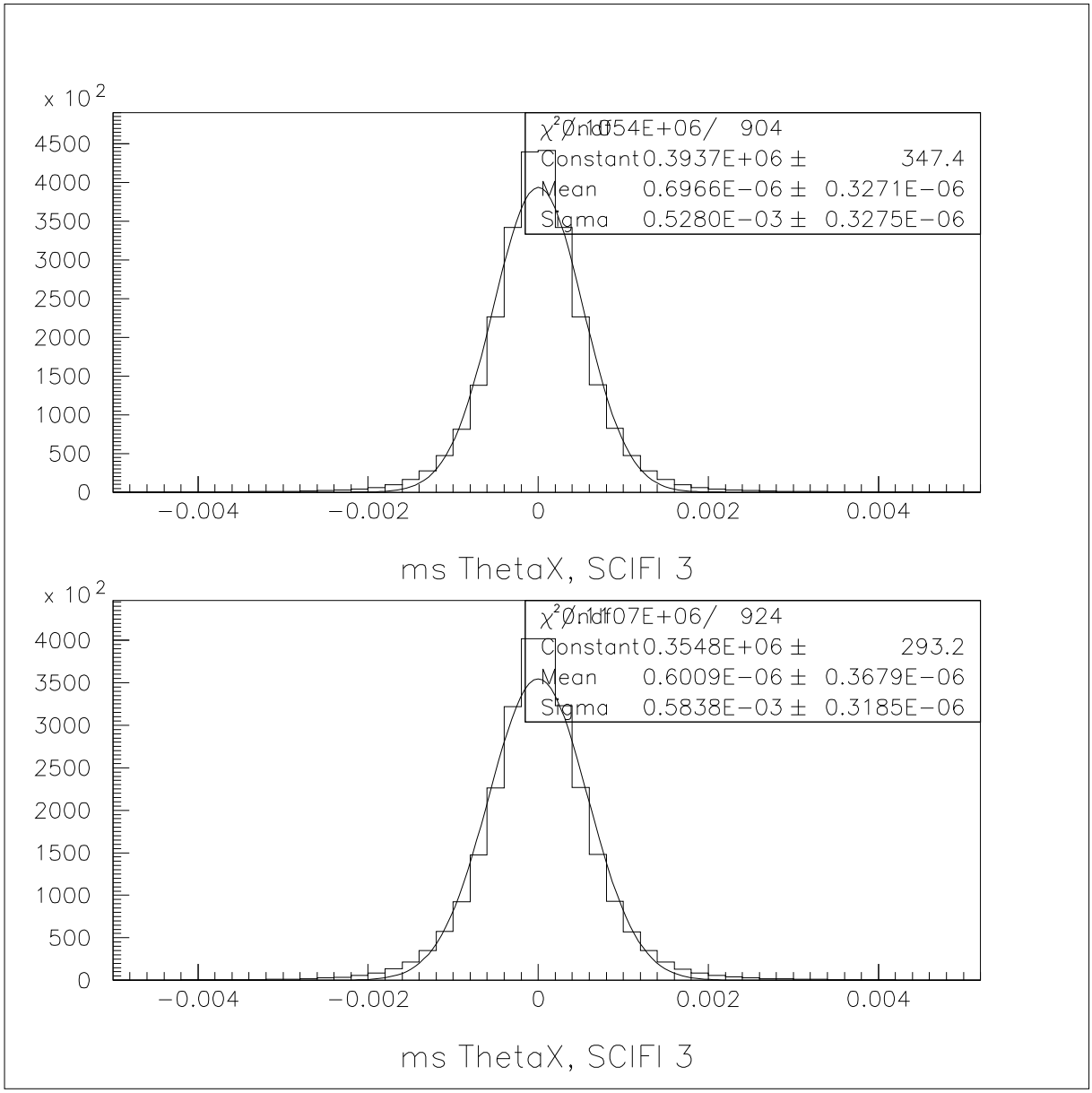

Figure 4: *The distribution of multiple scattering angle in X plane from new procedure(up) and from Moliere one(down) for SCIFI3 plane.*

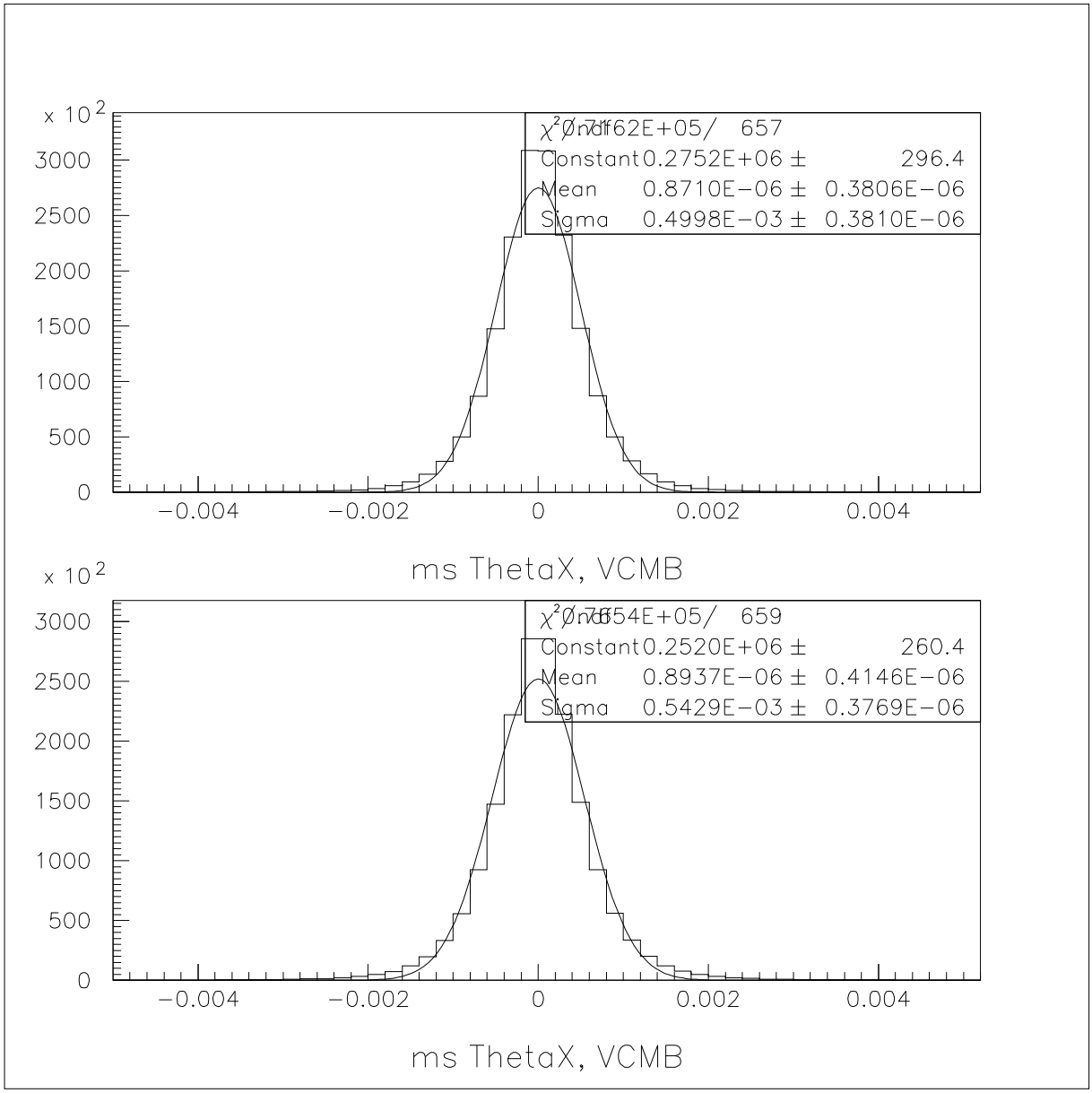

Figure 5: *The distribution of multiple scattering angle in X plane from new procedure(up) and from Moliere one(down) for vacuum membrane.*

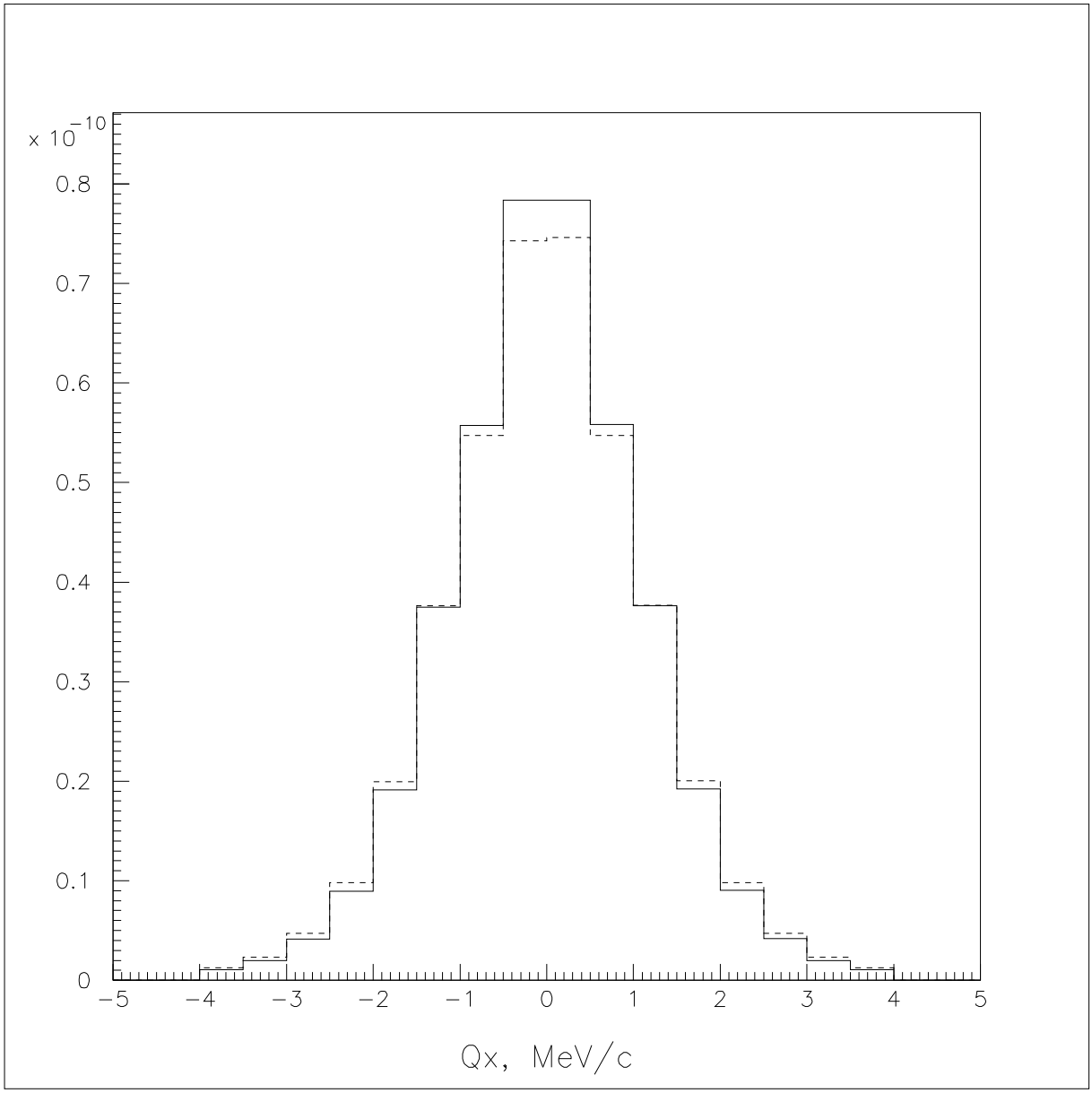

Figure 6: *The reconstructed Q_x-distribution of $\pi^+\pi^-$-atomic pairs for new MS procedure(solid) and for Moliere one(dashed).*

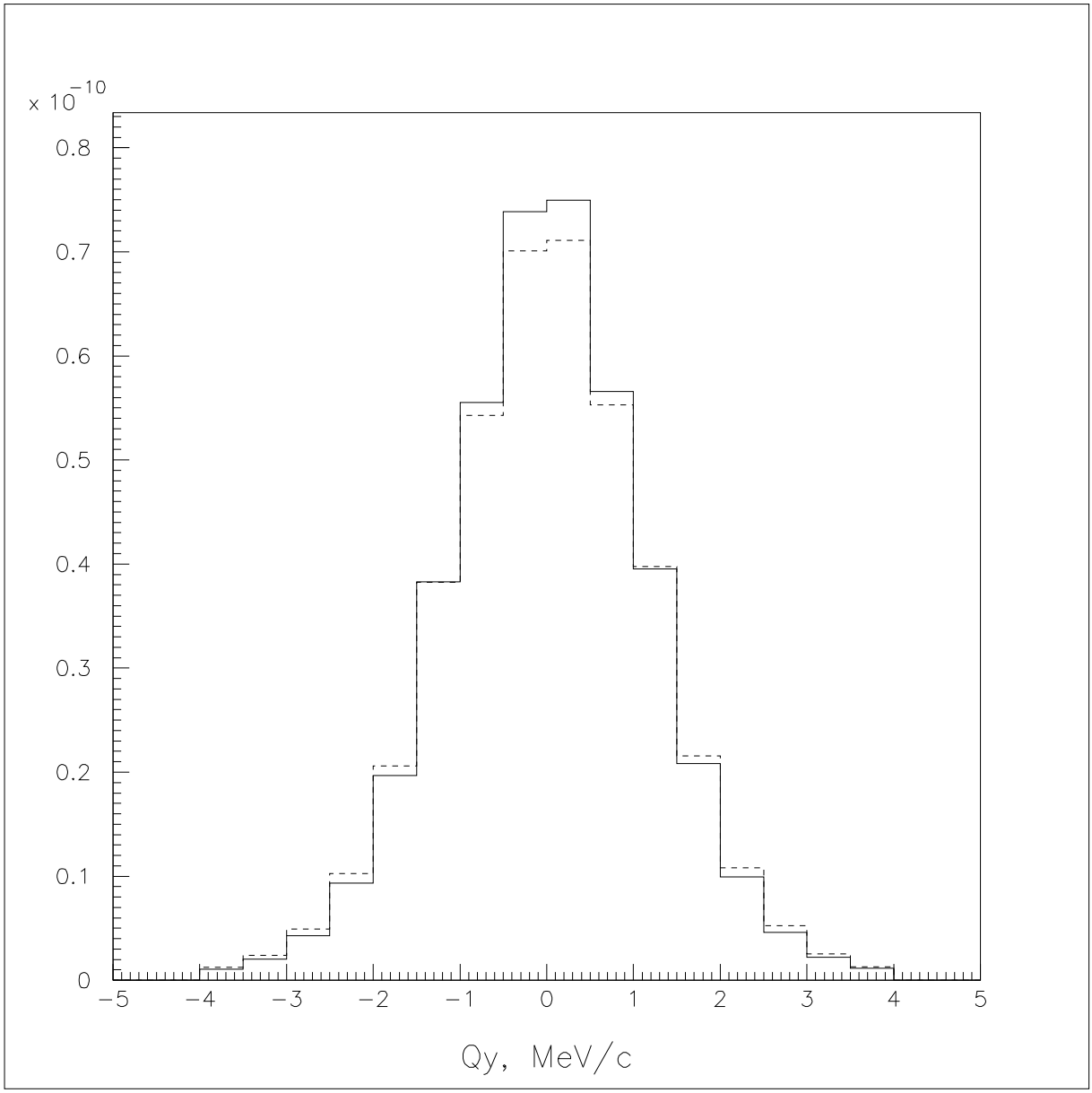

Figure 7: *The reconstructed Q_y-distribution of $\pi^+\pi^-$-atomic pairs for new MS procedure(solid) and for Moliere one(dashed).*

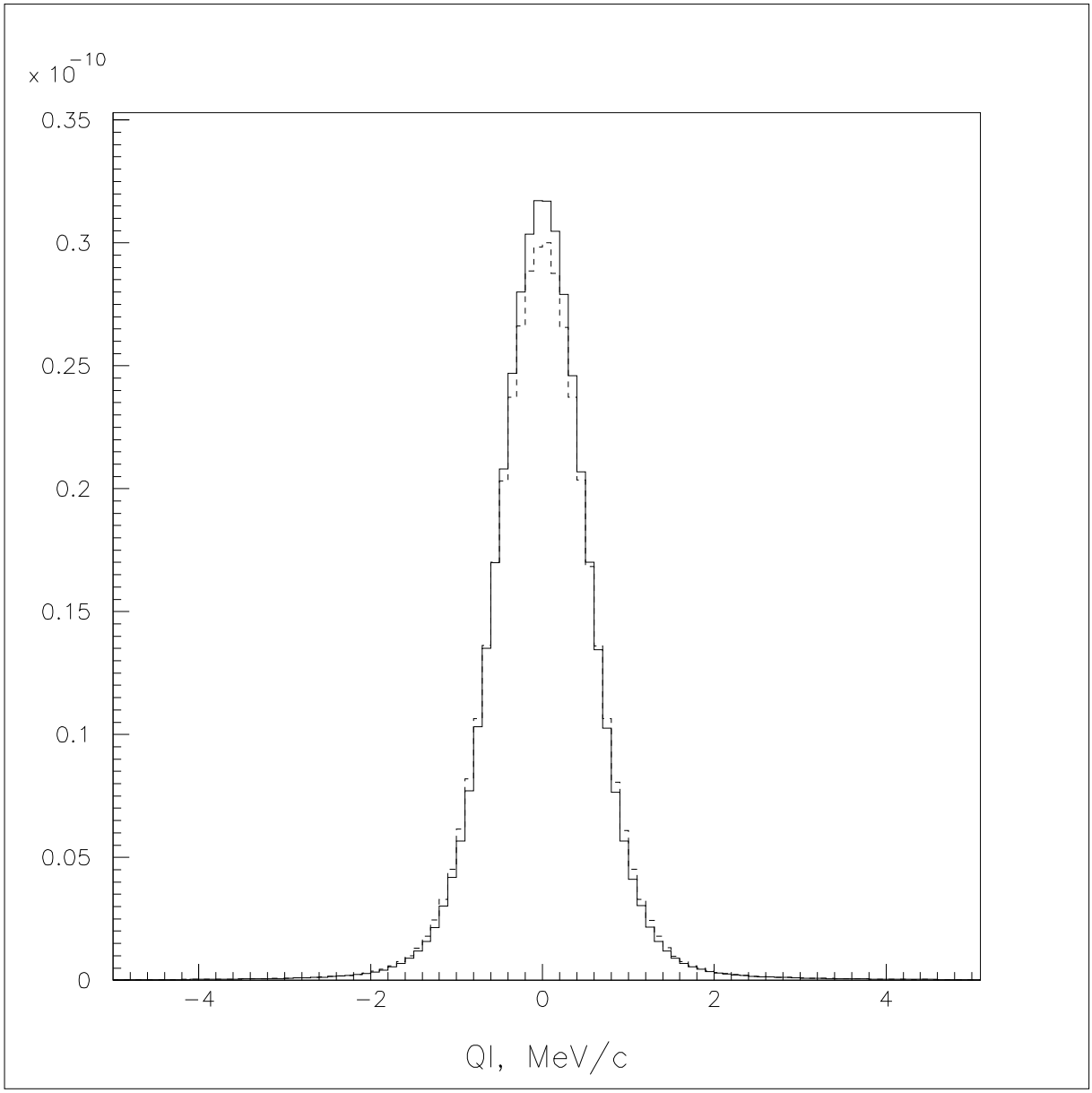

Figure 8: *The reconstructed Q_l-distribution of $\pi^+\pi^-$-atomic pairs for new MS procedure(solid) and for Moliere one(dashed).*

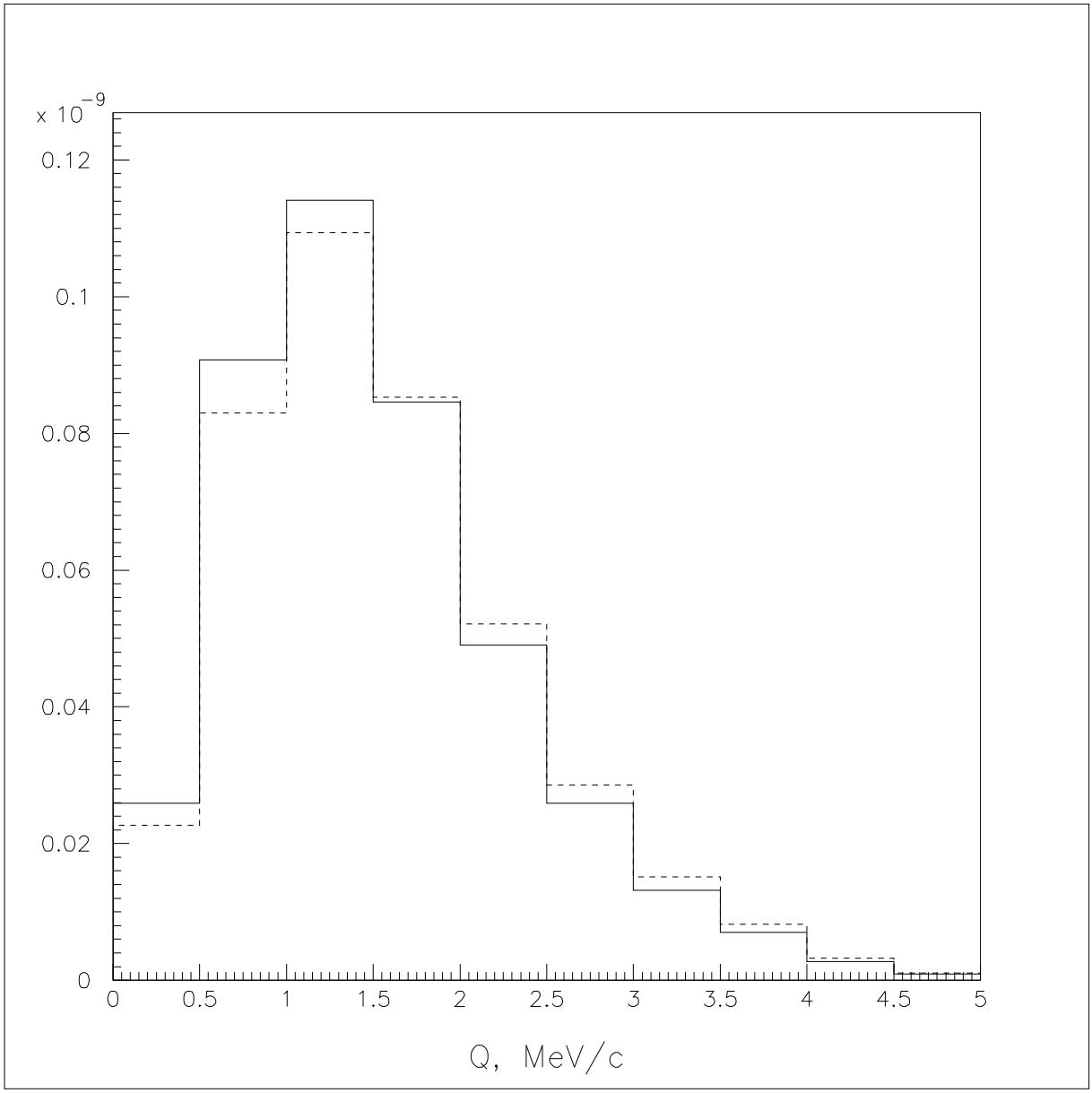

Figure 9: *The reconstructed Q-distribution of $\pi^+\pi^-$-atomic pairs for new MS procedure(solid) and for Moliere one(dashed).*

References

[1] A. Dudarev, V. Kruglov, L. Kruglova, M. Nikitin [JINR], DIRAC Note 2005-02.