EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

DIRAC Note 2007-17
November 23, 2007

The Lambda peak width difference of Monte-Carlo and real data is the one of sources of systematic error.

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GENEVA
2007

1 Preface

The aim of this work was to convert the difference of Lambda peak widths for Monte-Carlo(MC) and real data into the systematic error.

There were selected the proton-pion pairs with total momentum from 5.0 to 8.6 GeV/c. As the momentum distribution for MC and real data pairs are a bit different then the MC events were weighted to get the same momentum distribution as for real data. Also this momentum range was divided into three subintervals(5.-6.4-7.1-8.6GeV/c). For all of these subintervals and for whole interval the distributions of invariant mass(minus of $1.11GeV/c^2$) of proton and pion are shown on Fig. 1, for MC and real data. The real data distributions were fitted by the function which is the sum of Gaussian and polynomial of the third degree. The last one describes the background.

The used fitting procedure was the standard one - MINUIT. In the principle it is the problem for all the fitting procedures to obtain the most correct values of errors of parameters. As in our case the real data distributions have some background whereas the MC ones don't have it(it means that MC distributions have the tails which fall up to zero) and , in principle, this fact could influence on the result for fitting of MC distributions then the MC distributions were slightly modified to make the fitting conditions equal for both types of data: the proportional constant "background" was added to each MC distribution(the ration of peak/background must be the same for MC and real data). The MC data distributions were fitted therefore by the function which is the sum of Gaussian and a constant.

For all the events($5.0 \div 8.6GeV/c$) the ratio of sigmas(P3 parameter on the picture) of experimental distribution and MC one is equal to 1.06. One can see that the Gaussian function can not describe the lambda peaks well as for MC so for real data therefore another fitting procedure(suggested by V.Yazkov) was used also(Fig. 2): we decreased the bin width($new\ width = width/(1+R)$) of MC distribution(the abscissa axis on these pictures) and the resulting distribution was used to fit the real data one - the obtained values of χ^2 were plotted(the ordinate axis) as the function of R. Each distribution of χ^2 was fitted by second degree polynomial, the minimum value(χ^2_{min}) of it and its position (R_{min}) was determined; the abscesses of points of $\chi^2_{min} \pm 1$ give the error in R_{min}. These values of $1 + R_{min}$ and its error are shown on the picture too.

For all the events($5.0 \div 8.6GeV/c$) the values of $1 + R_{min}$ is equal to 1.059 ± 0.006. We can see that it is practically the same we obtained via the Gaussian sigmas ratio(1.06). The explanation of this fact is that the Lambda peaks of MC and real data belong to the same functional class - it can be seen on the Fig.5 and Fig.6. On the first one the ratio of experimental Lambda peak and fitted function(Gaussian plus polynomial) is shown, on the second one - the ration of experimental Lambda peak and MC distribution with decreased bin size(in $(1 + R_{min})$ times). We see that MC and real data distributions belong to the same functional class - they have the different widths only.

Certainly the reason that the MC and real data Lambda's distributions have the different widths arises from the differences between the magnetic field map we use and the real magnetic field of DIRAC spectrometric magnet. Now we have no information on what is this difference and we can convert this difference into the systematical error in such way: we apply additional smearing to the reconstructed momentum of pion and proton to make the MC Lambda peak width to be equal to the real data peak width. It can be seen from the Fig.2 that the value of this additional smearing does not practically depend on the Lambda momentum. It was found the smearing with weight of 1.0011(it means we apply the factor of 1+0.0011*Gaussian(0,1) to each of particle reconstructed momentum) makes both peak widths to be equal(Fig.3 and Fig.4).

Nevertheless if we are going to explain this Lambda peak difference as it is due, for example, to our poor knowledge of material thickness of forward detector then we can obtain how we must increase the current thickness of forward detectors to make both peak widths are equal. To get such result we must increase the forward detectors thickness in 1.64 times: on the Fig.7 the results, when we increased the forward detectors multiple scattering angle in 1.28 times, are shown - the MC widths are about to experimental ones. But the factor of 1.64 is too abnormal.

It can be proved by the fact that the widths of Δx and Δy distributions of π^+ and π^- at the level of the target for Monte-Carlo and real data are equal with the precision of 2%([1]). The calculations show that if we encrease the thickness of forward detectors in 1.1 times(Fig.8 and Fig.9) then the widths of Δx and Δy distributions for Monte-Carlo data became greater in 4%. It means that 2% in distributions widths correspond to 5% in forward detectors thickness. The values of 5% and 64% are too different.

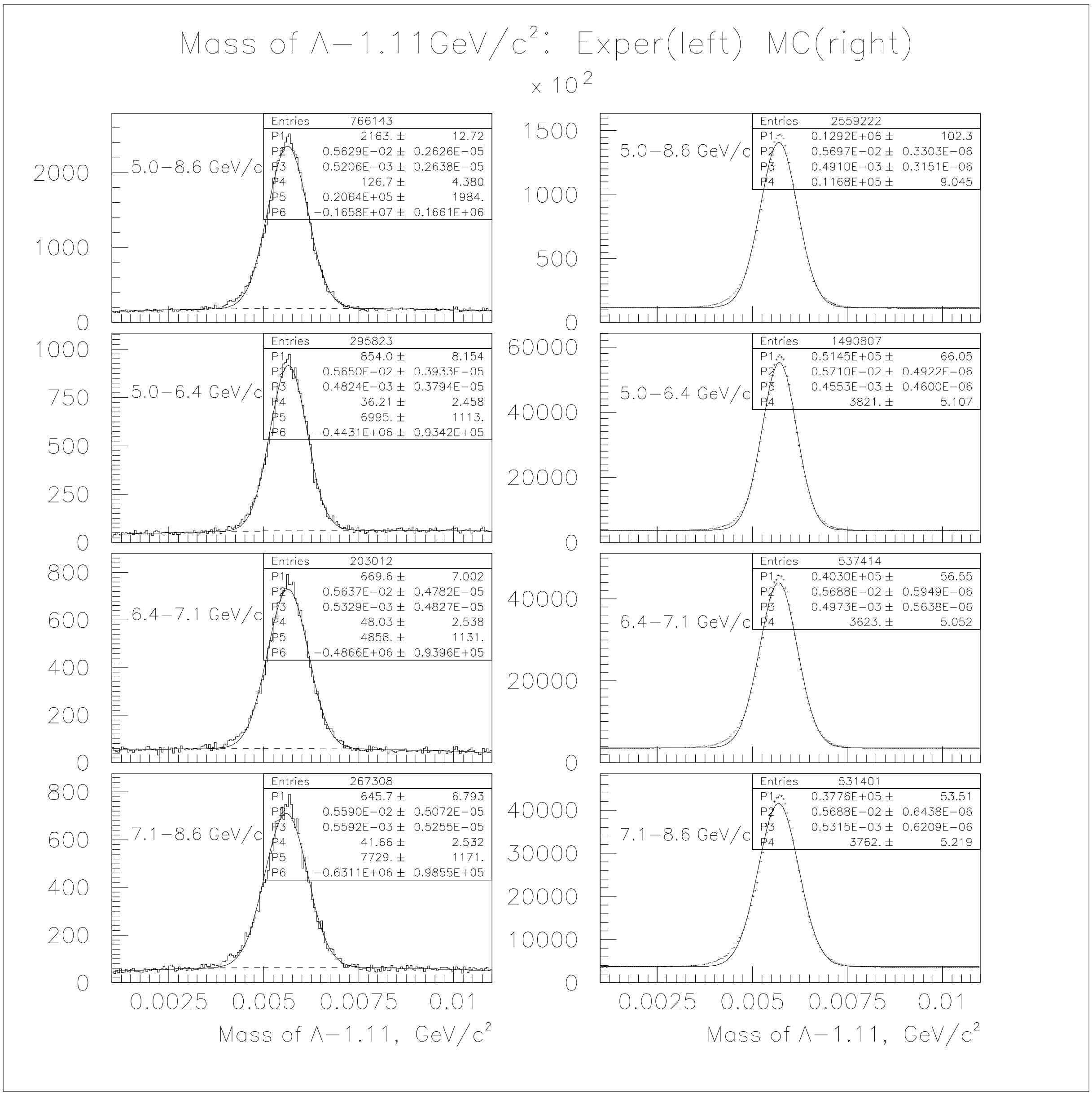

Figure 1: *MC and real data. The distributions of invariant mass of proton and pion for different intervals of lambda momentum. P2 - the center of Lambda peak, P3 - its Gaussian width.*

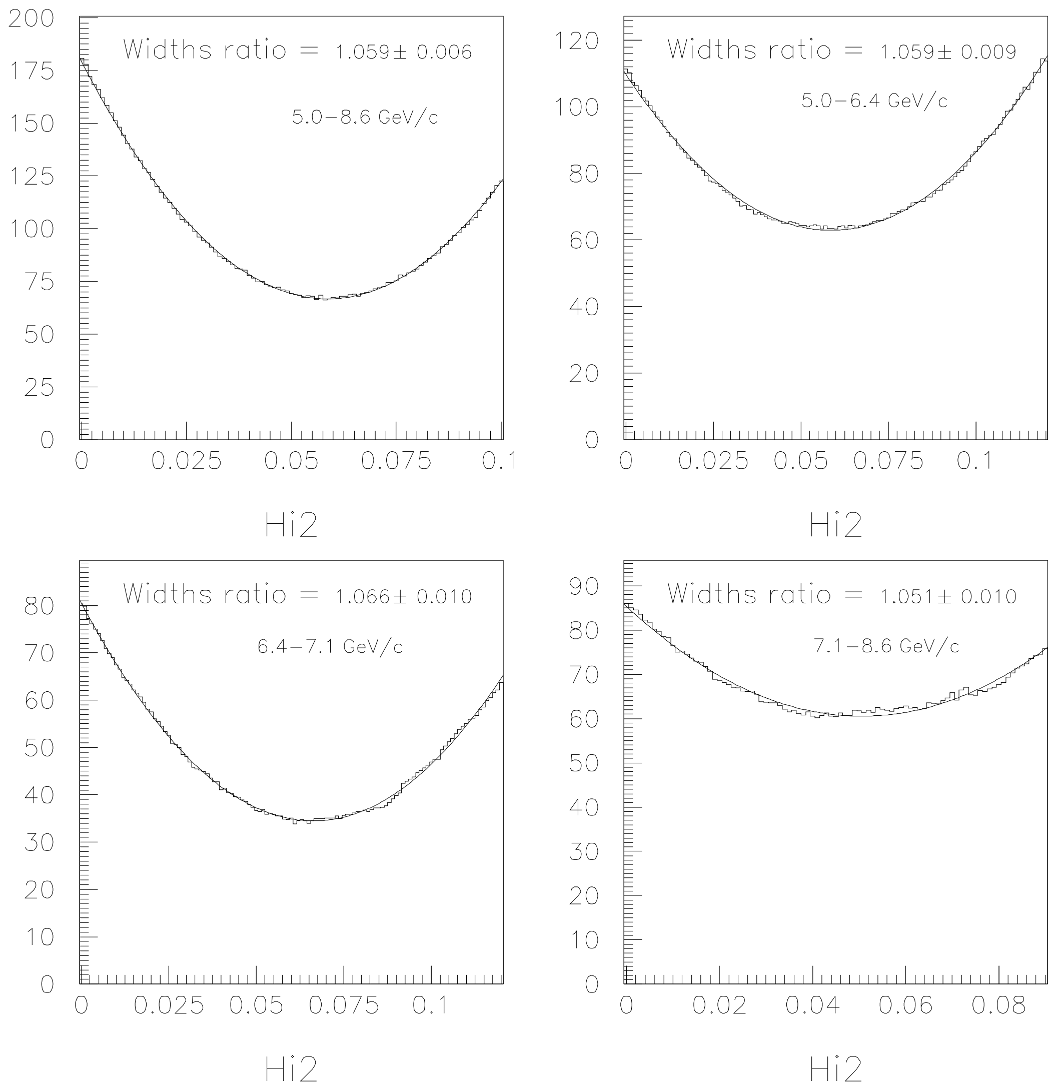

Figure 2: *The dependence of χ^2 which is the result of real data Lambda peak fitting by corresponding MC distribution on changing of MC distribution bin width for different intervals of lambda momentum. X-coordinate: R, where in $1+R$ times the MC bin width is decreased.*

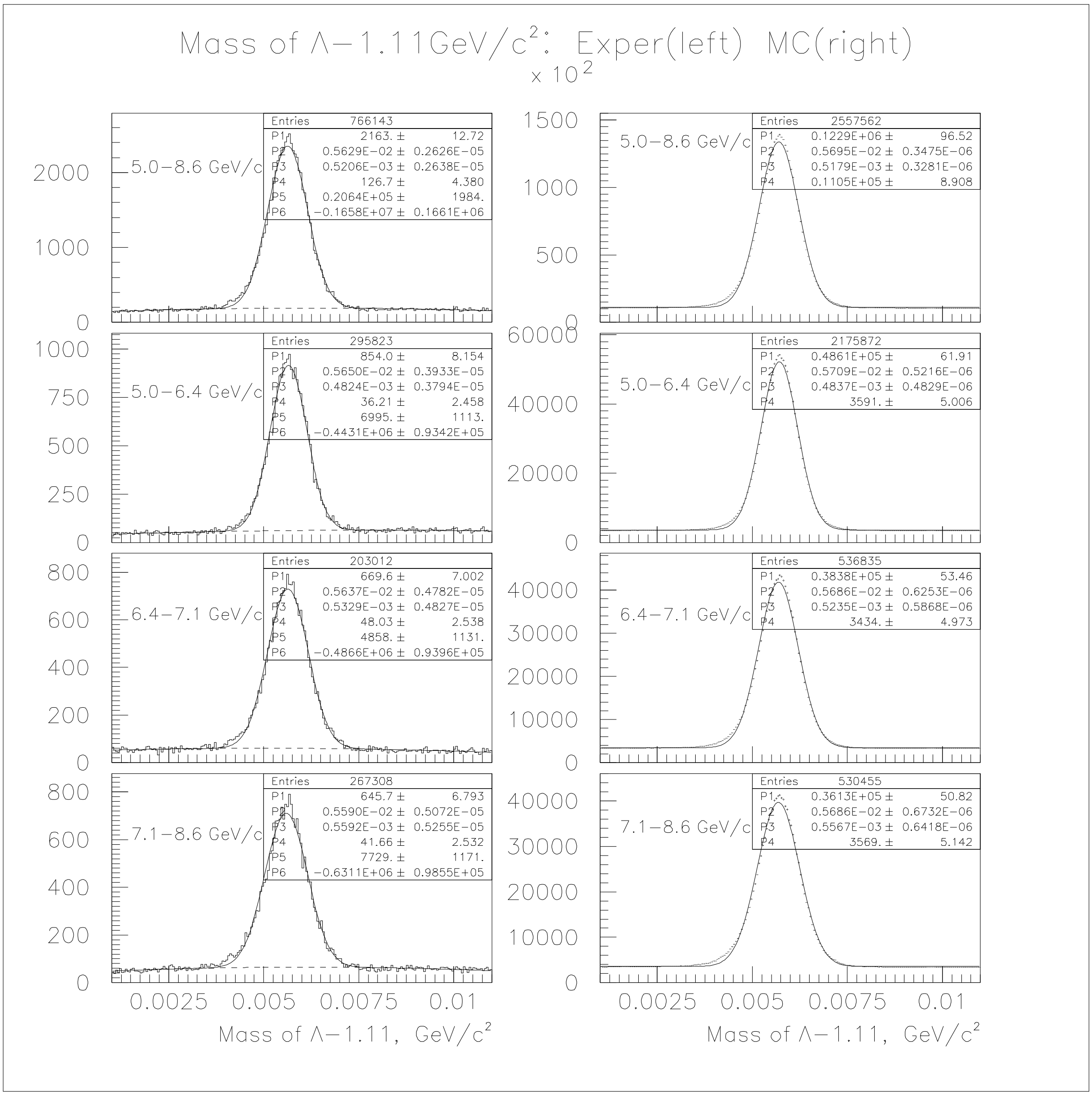

Figure 3: *MC and real data. The particle momentum of MC events were additionally smeared by:* $P_{new} = P * (1 + 0.0011 * Gaussian(0, 1))$. *The distributions of invariant mass of proton and pion for different intervals of lambda momentum. P2 - the center of Lambda peak, P3 - its Gaussian width.*

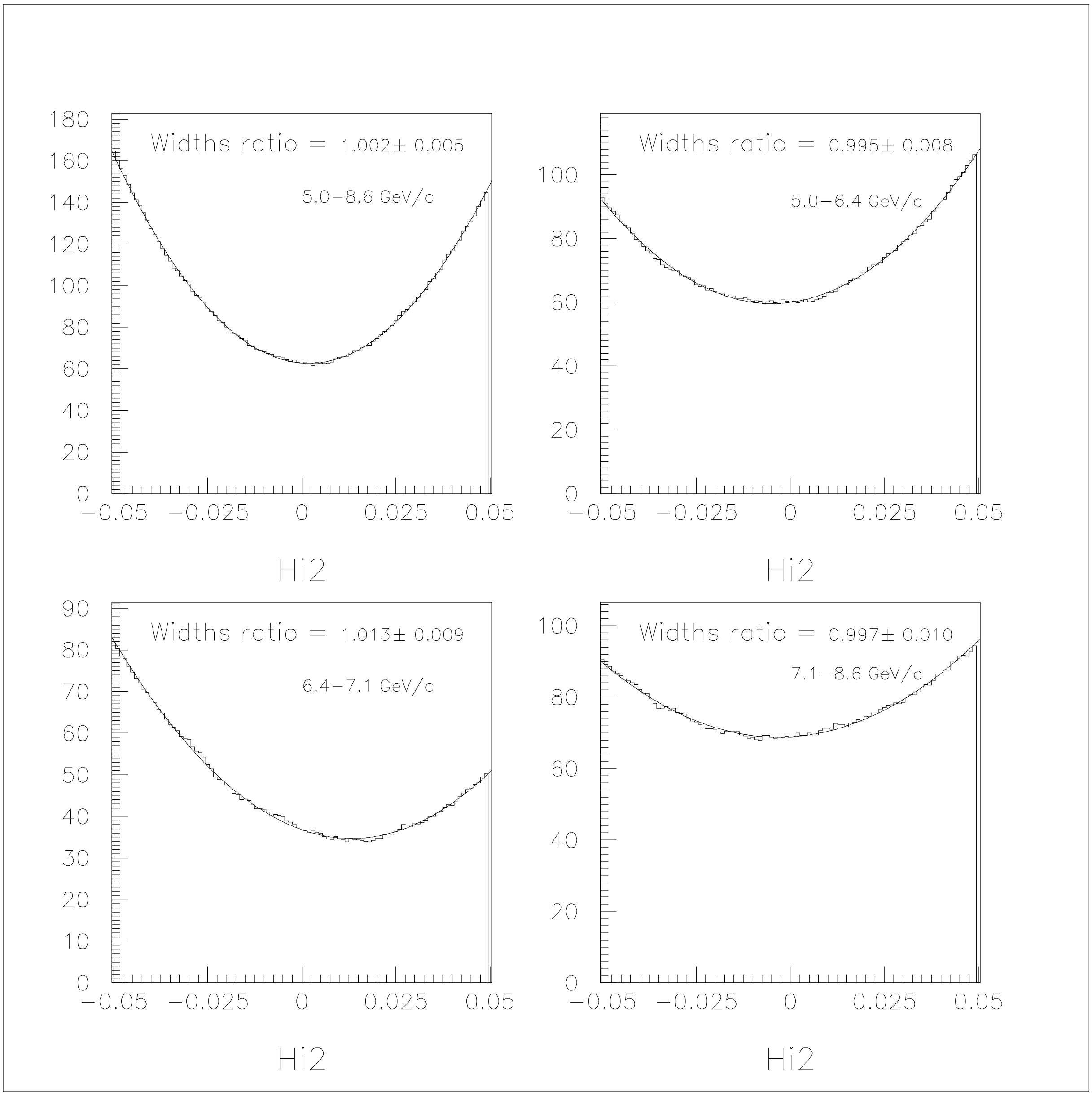

Figure 4: *The dependence of χ^2 which is the result of real data Lambda peak fitting by corresponding MC distribution on changing of MC distribution bin width for different intervals of lambda momentum. X-coordinate: R, where in $1 + R$ times the MC bin width is decreased. The particle momentum of MC events were additionally smeared by: $P_{new} = P * (1 + 0.0011 * Gaussian(0, 1))$.*

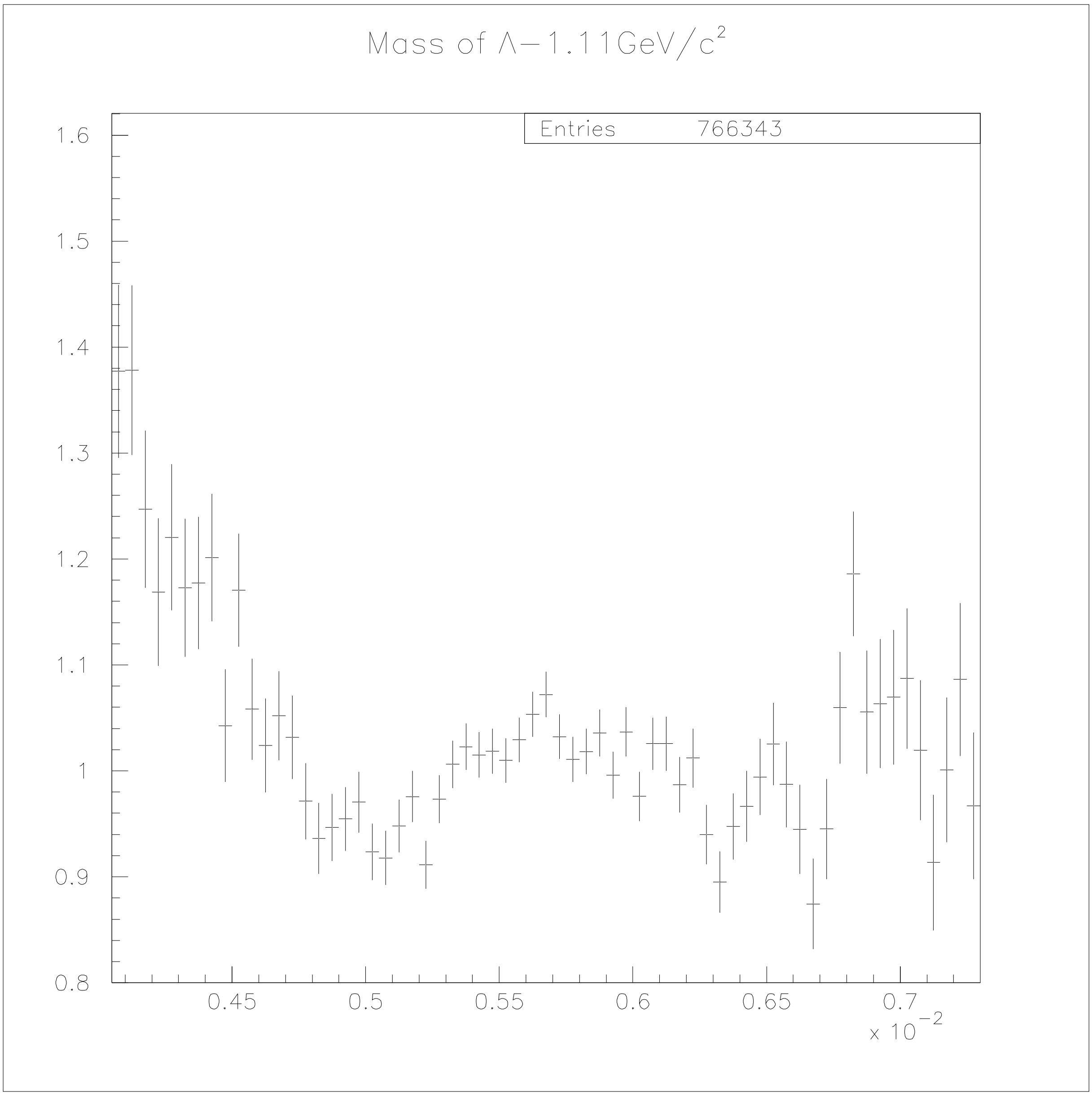

Figure 5: *The ratio of distribution of invariant mass of proton and pion for experimental data and of its fitted function(Gaussian plus polynomial) for all the events.*

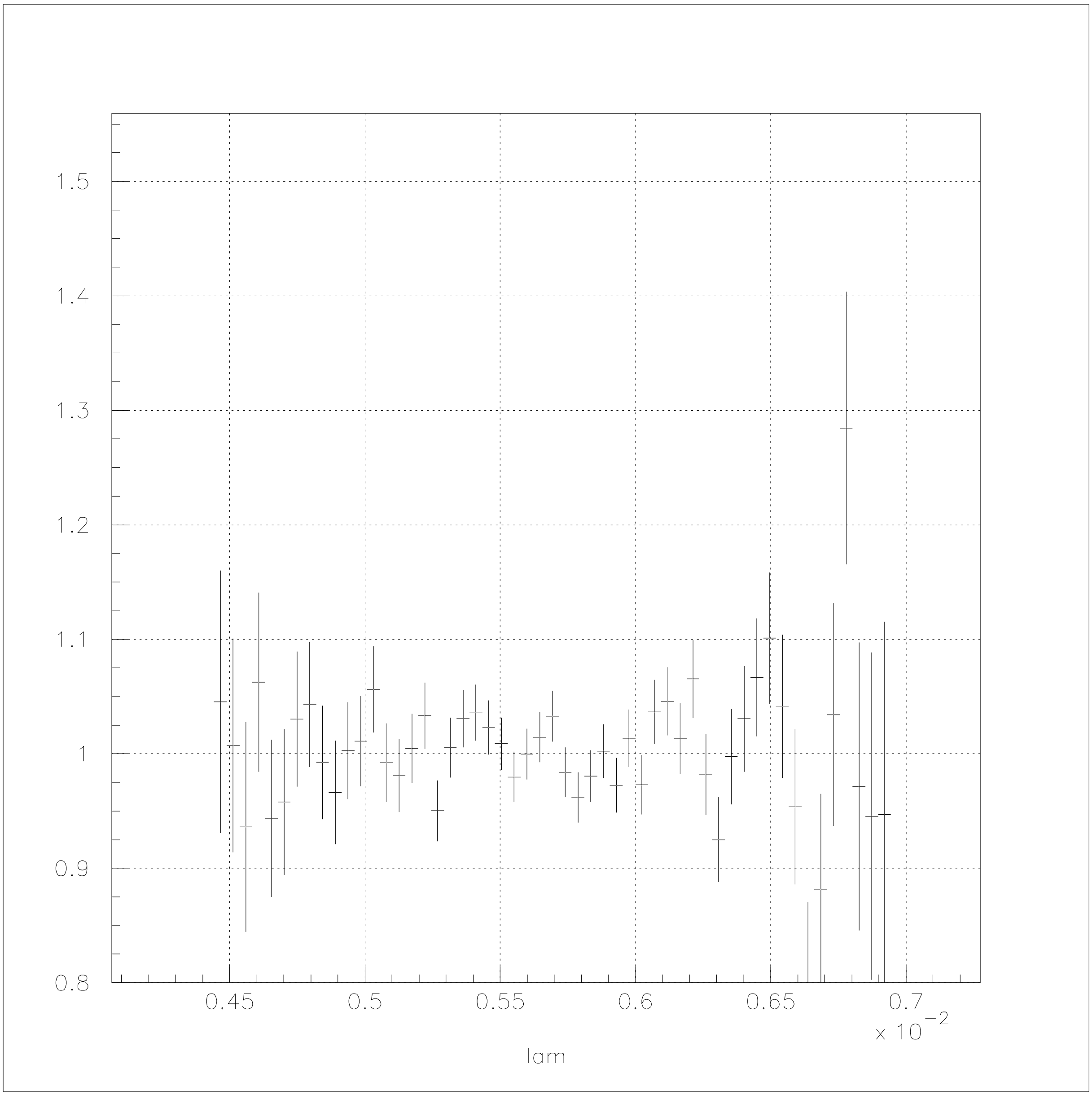

Figure 6: *The ratio of distribution of invariant mass of proton and pion of experimental data and of its fitted MC distribution for all the events. The last distribution is taken at* $R = R_{min}$.

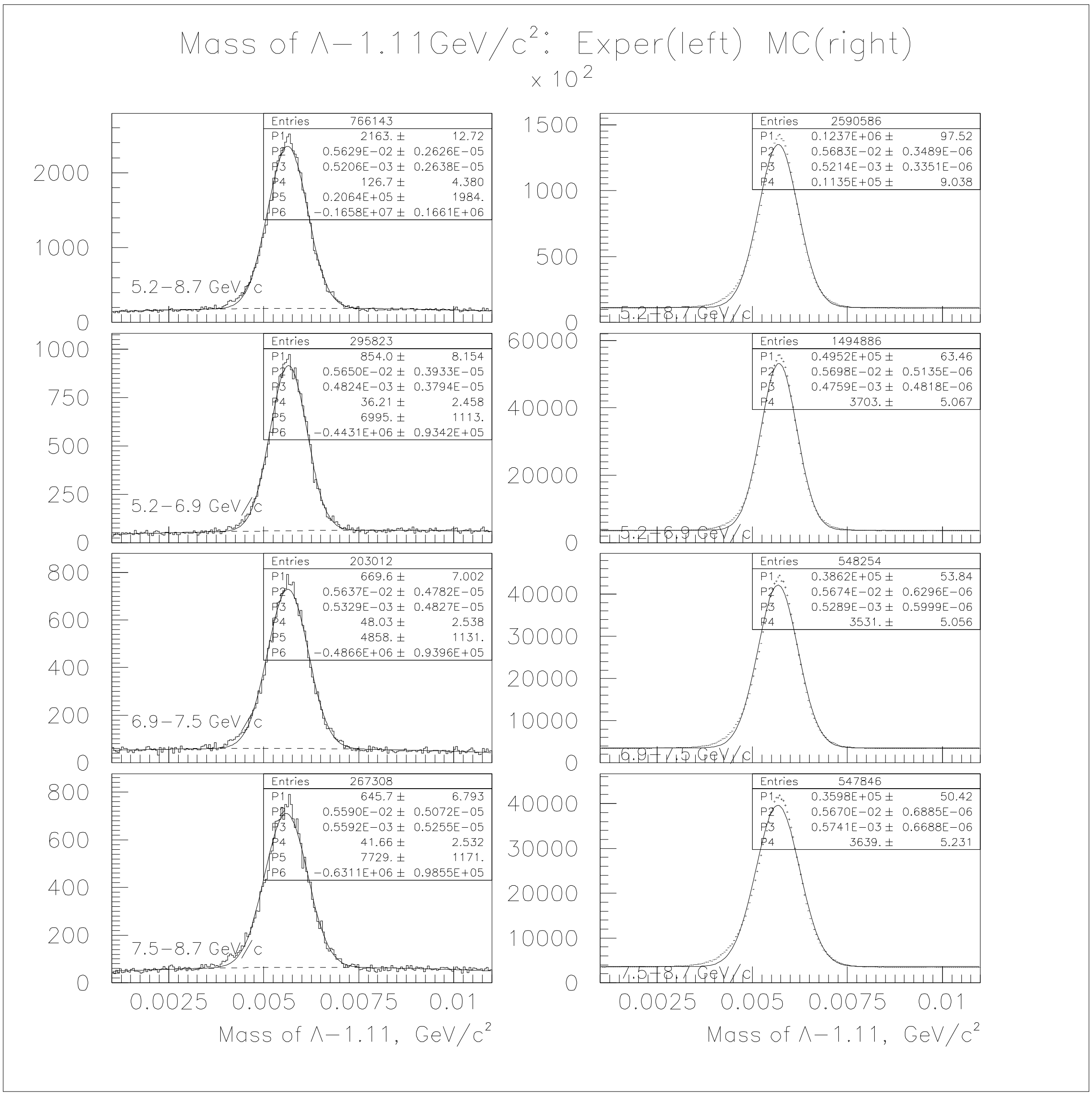

Figure 7: *MC and real data. The distributions of invariant mass of proton and pion for different intervals of lambda momentum. P2 - the center of Lambda peak, P3 - its Gaussian width. The thickness of the forward detectors materials was increased in 1.64 times.*

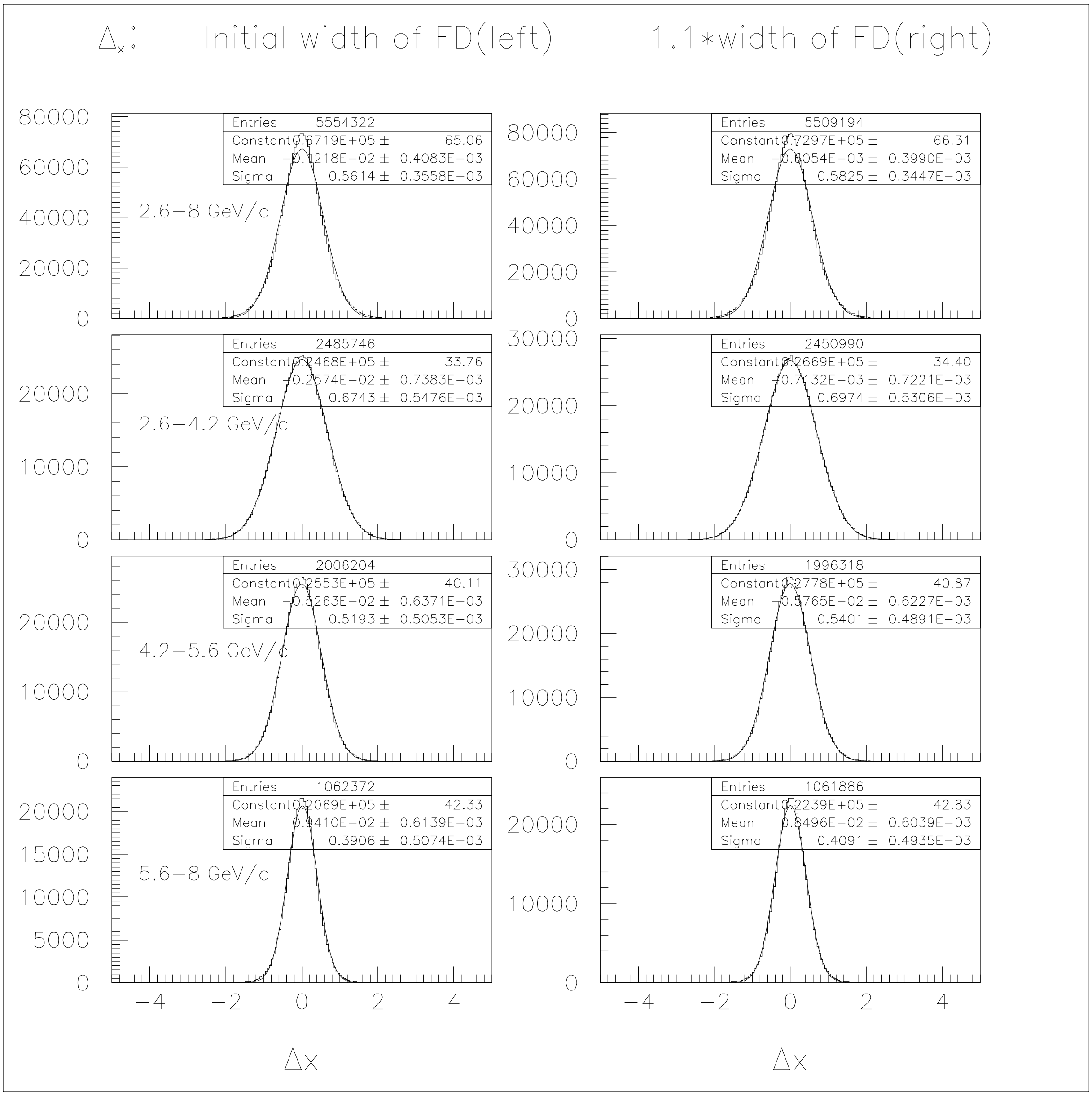

Figure 8: *MC data. The distributions of $\Delta x(cm)$ for π^+ and π^- at the level of the target for different intervals of pair momentum. Left pictures are for standard thickness of forward detectors materials, right ones - when their thickness was increased in 10%.*

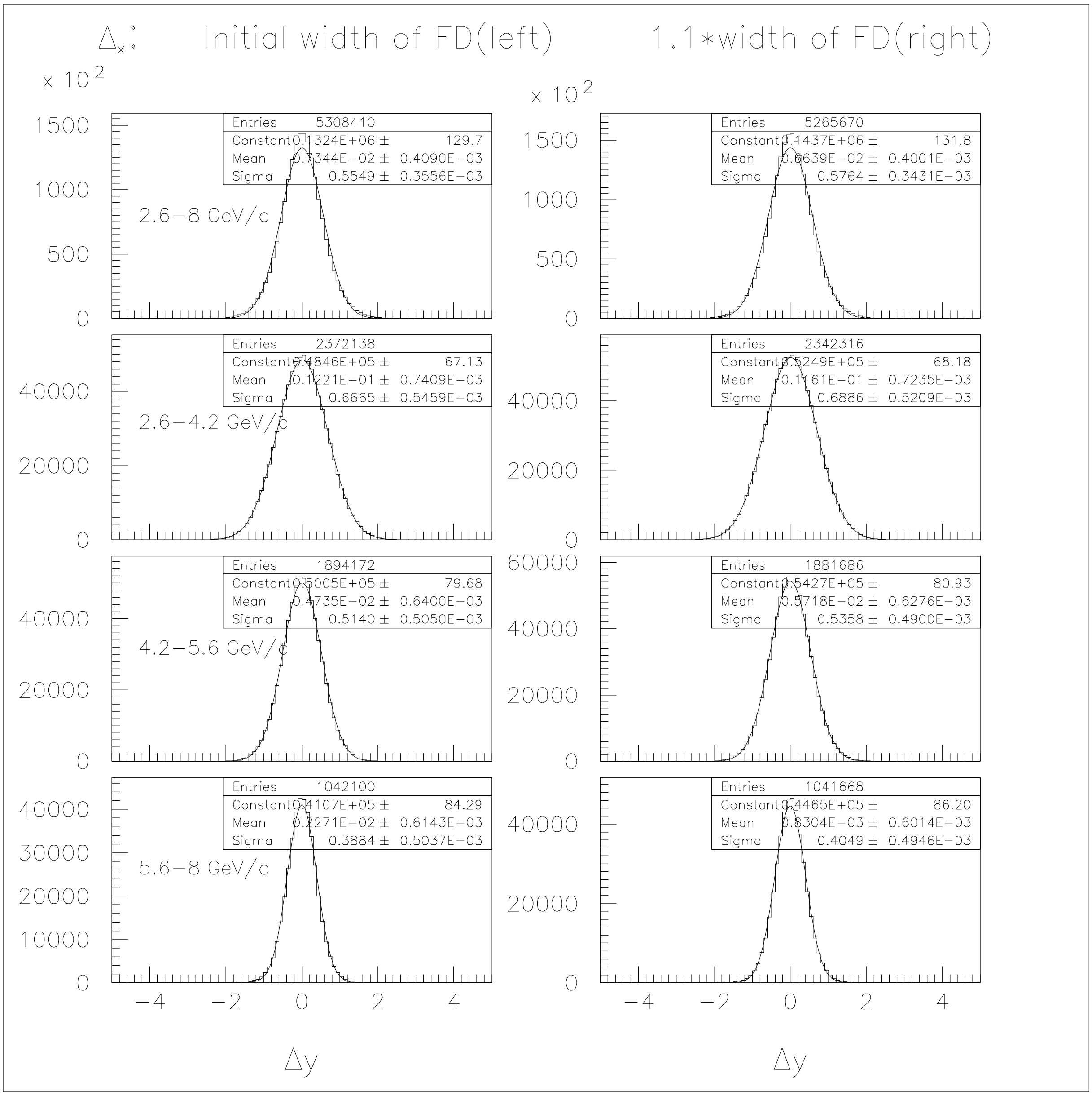

Figure 9: *MC data. The distributions of $\Delta y(cm)$ for π^+ and π^- at the level of the target for different intervals of pair momentum. Left pictures are for standard thickness of forward detectors materials, right ones - when their thickness was increased in 10%.*

References

[1] O.Gorchakov [JINR], DIRAC Note 2007-05.