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The behaviour of the BASEL extended tracking and the standard ARIANE tracking to $A_{2\pi}$ Monte Carlo data in the DIRAC experiment

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Abstract

This note describes the behavior of the BASEL extended DIRAC tracking and the standard ARIANE tracking package to simulated $A_{2\pi}$ Monte Carlo data. It illustrates the efficiencies of the two reconstruction methods, their relative error in the absolute momentum determination and the biases they introduce into the total and relative momentum determination.

1 Introduction

We describe the behavior of the BASEL extended DIRAC tracking[1] and the ARIANE tracking[2] to simulated $A_{2\pi}$ Monte Carlo data. The Monte Carlo data was created by an $A_{2\pi}$ generator using GEANT adapted to the DIRAC experiment. Both the BASEL extend tracking and the standard ARIANE tracking were used for the reconstruction.

First we compare the reconstruction efficiency of the two methods. Then the resulting total momentum P and relative momentum Q distributions from both tracking methods are compared to the input distributions. Further we look at possible biases in the x and y projection of Q as compared to the input.

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2 Monte Carlo

Conditions GEANT[3] adapted for DIRAC[4] was used as a Monte Carlo program. The $A_{2\pi}$ were generated with a specially prepared $A_{2\pi}$ generator[1]. GEANT was run with Gaussian multiple scattering and energy loss turned on.

GEANT input distributions The absolute and relative momenta of the $\pi^+\pi^-$ after break-up was written out just after the target. Figure 1 shows the relative momentum and its components. The multiple scattering in the target

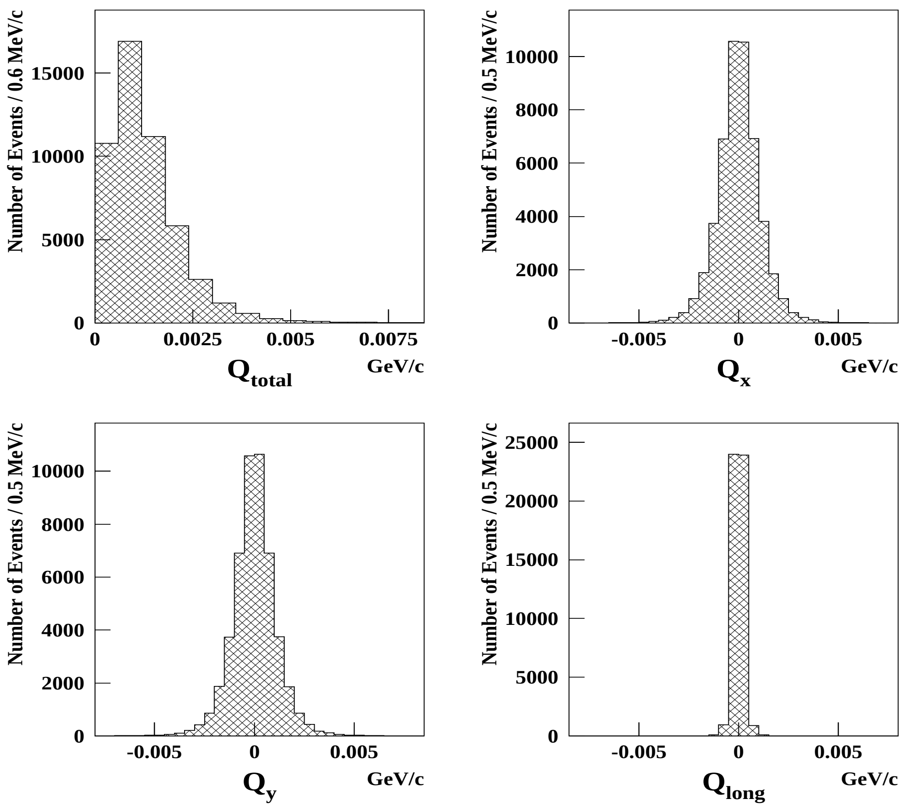

Figure 1: Relative momentum Q in [GeV/c] and its projection in GEANT just after the target.

widens the distribution mostly in x and y direction. All the projections are

[1]The $A_{2\pi}$ generator was created by C. Santamarina and can be found at /afs/cern.ch/user/d/diracww/public/offline/generator/

centered around zero. Their μ and σ in [MeV/c] obtained from a Gaussian fit are shown in table 1.

	μ	σ
Q_x	$1.0 \cdot 10^{-4}$	1.0
Q_y	$1.0 \cdot 10^{-2}$	1.0
Q_{long}	$1.0 \cdot 10^{-3}$	0.3

Table 1: The μ and σ in [MeV/c] of the Q projections just after the multiple scattering in the target in GEANT.

3 Reconstruction

Conditions For the reconstruction ARIANE was used, which includes the detector response simulation of the major detectors. The used detector simulation does not add noise. For the standard ARIANE analysis, the full vertex fit was used[2]. The MSGC were not included in the ARIANE tracking[3].

A trigger simulation of (T1$\pi^+\pi^-$Copl .and. DNA) was applied to the data.

The following study was performed using the BASEL SFDY determination for the BASEL tracking and the ARIANE determination for the ARIANE vertex fit[4].

Reconstruction efficiency From table 2 one can see that out of 50K input $A_{2\pi}$ around 34K are inside the fiducial volume of the detectors and are accepted by the trigger.

3.1 BASEL Reconstruction

Total Momentum P The reconstruction of the total momentum and its x, y and z projections were compared with the GEANT input data. The difference between the reconstruction and the input,

$$dP = P(BASEL) - P(GEANT)$$

	Events	%
Input to GEANT	50000	
Inside fiducial volume of the detectors and accepted by the trigger	33755	100%
BASEL tracking		
SFDY: BASEL.or.ARIANE	17223	51.0%
SFDY: BASEL only	17106	50.7%
ARIANE with vertex fit		
SFDY: ARIANE only	16694	49.5%

Table 2: Reconstruction efficiency of the two different tracking methods for a $A_{2\pi}$ sample. Both SFDY determination available were used according to the table. The rate reduction of a factor of two from 33755 to 17223 is mainly due to the DC tracking inefficiency.

can be seen in figure 2. dP_x and dP_y are both centered at zero with a σ of about 1 MeV/c. The lower two plots show dP_z and dP_{total}. One can see there the energy loss of the setup of about 7 MeV/c on average. The σ of the distributions are around 7 MeV/c. Running without energy loss centers the dP_{total} and dP_z around zero.

	μ	σ
dP_{total}	-6.8	7.3
dP_z	-6.8	7.3
dP_x	$+5.0 \cdot 10^{-3}$	1.0
dP_y	$-5.0 \cdot 10^{-3}$	1.0

Table 3: The μ and σ in [MeV/c] from a Gauss fit of the dP distributions from figure 2. Energy loss was turned on in GEANT.

Table 3 shows the μ and σ in [MeV/c] of the four distributions obtained by fitting a Gauss function to the data.

[2]This means that the options FullFitTrkVtx and UpVtxDCFit are both set to TRUE

[3]This means that the FF card SelMSGC was set to SelMSGC F F F F

[4]The two SFDY determination methods BASEL and ARIANE are described and compared in [1].

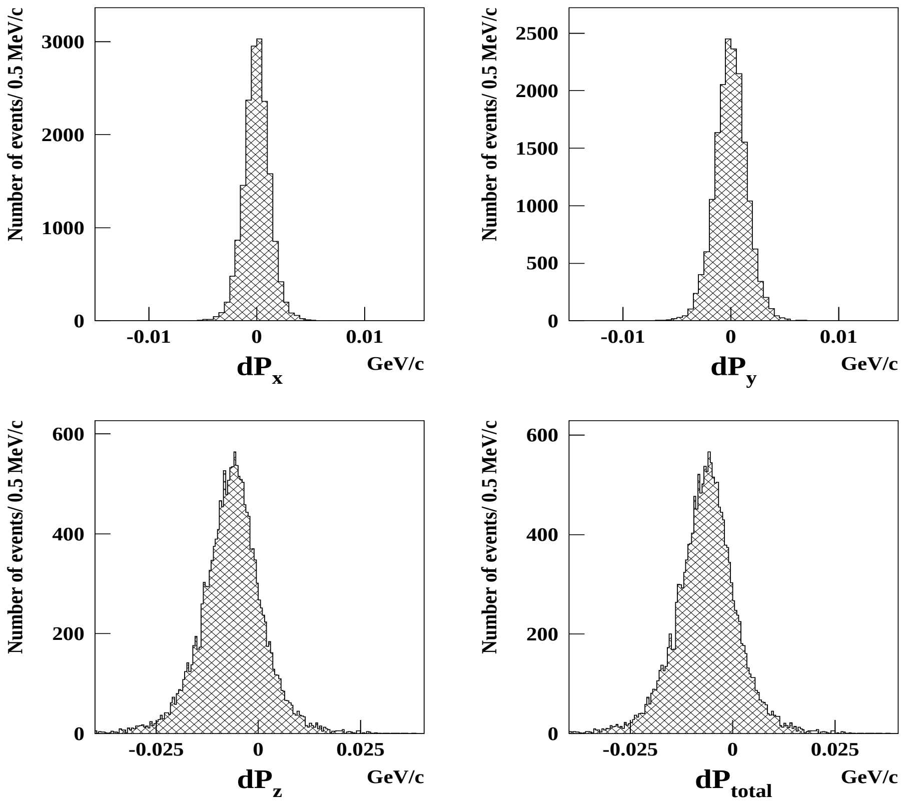

Figure 2: Difference dP of the total momentum P and its x,y and z projections in [GeV/c] between the BASEL reconstruction and GEANT.

Relative Momentum Q The Q distributions of the BASEL reconstruction and the corresponding GEANT input distributions are shown in figure 3 and 4 for events that were reconstructed only. The number of events for the GEANT distribution and the BASEL distribution are the same. Also the corresponding ratios BASEL/GEANT are plotted.

One can see in the Q_x and the Q_y plots that the reconstruction reproduces the input GEANT distribution very nicely for the regions $|Q_x| > 1.5$ MeV/c and $|Q_y| > 1.5$ MeV/c.

The region of smaller relative x and y momentum is influenced by the peak sensing algorithm of SFD which sometimes merges close-lying hits into one single hit. Such events will have only one hit fiber and hence will have a reconstructed relative momentum in x or y direction of about zero. This effect can clearly be seen for both plots in figure 3.

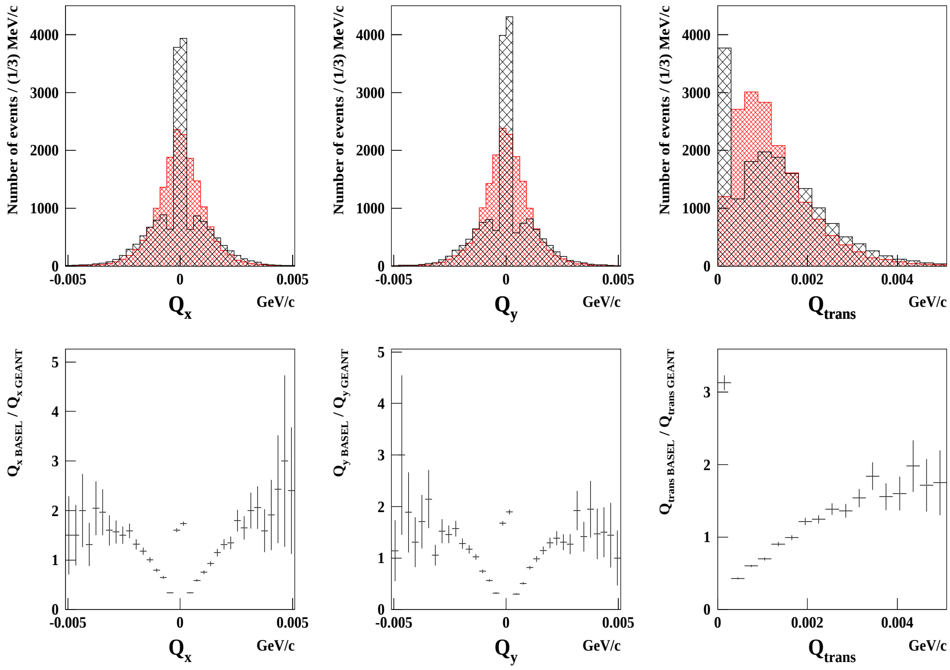

Figure 3: The relative momentum Q_x, Q_y and Q_{trans} in [GeV/c] for the BASEL reconstruction (black) and the true GEANT input(red) are plotted in the upper three plots. The lower three plots show the corresponding ratios $Q_{x\ BASEL}/Q_{x\ GEANT}$, $Q_{y\ BASEL}/Q_{y\ GEANT}$ and $Q_{trans\ BASEL}/Q_{trans\ GEANT}$.

Further one can see two dips around zero in the Q_x and Q_y distributions. These dips result from the removal of adjacent hit columns by the peak sensing algorithm. The fact that these dips are present in the Q_x and Q_y distribution implies that the relative momentum resolution in x and y direction is of the order of one SFD column. This would correspond to a relative error in Q_x and Q_y of

$$\sigma_{Q_x},\ \sigma_{Q_y}\ \ (\pi_{2.5\ \mathrm{GeV}}) = 0.37\ \mathrm{MeV/c} \tag{1}$$

The combined effects of the peak sensing algorithm on the Q_x and the Q_y distributions create a corresponding spike for Q_{trans} equals zero. The excess events are shifted from the region $Q_{trans} < 1.5$ MeV/c.

Figure 4 shows the Q_{long} and Q_{tot} of the BASEL reconstruction (black) and GEANT input (red). The reconstruction widens the Q_{long} distribution from $\sigma_{Ql(\mathrm{GEANT})} = 0.2$ MeV/c to $\sigma_{Ql(\mathrm{BASEL})} = 0.7$ MeV/c. This can be compared to the relative momentum resolution of the DIRAC spectrometer for

Q_{long} of $\sigma_{Ql(\Lambda)} = 0.6$ MeV/c[5].

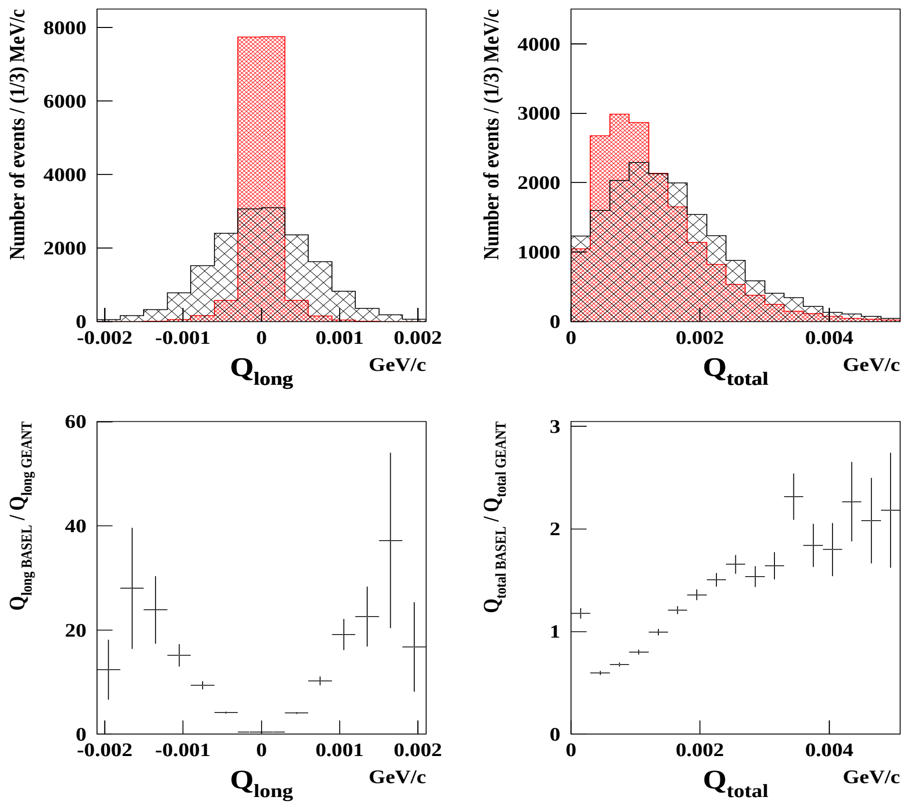

Figure 4: Relative momentum Q_{long} and Q_{total} in [GeV/c] for the BASEL reconstruction (black) and the true GEANT input(red) in the upper two plots. The lower two plots show the corresponding ratios.

The Q_{total} distribution widens accordingly, especially because a big part of the events have a transverse relative momentum close to zero. For such events Q_{long} becomes Q_{total}.

3.2 ARIANE Reconstruction

Total Momentum P The reconstruction of the total momentum and its x, y and z projections were compared with the GEANT input data. The differences

$$dP = P(ARIANE) - P(GEANT)$$

can be seen in the following figure 5. As for the BASEL tracking, figure 5

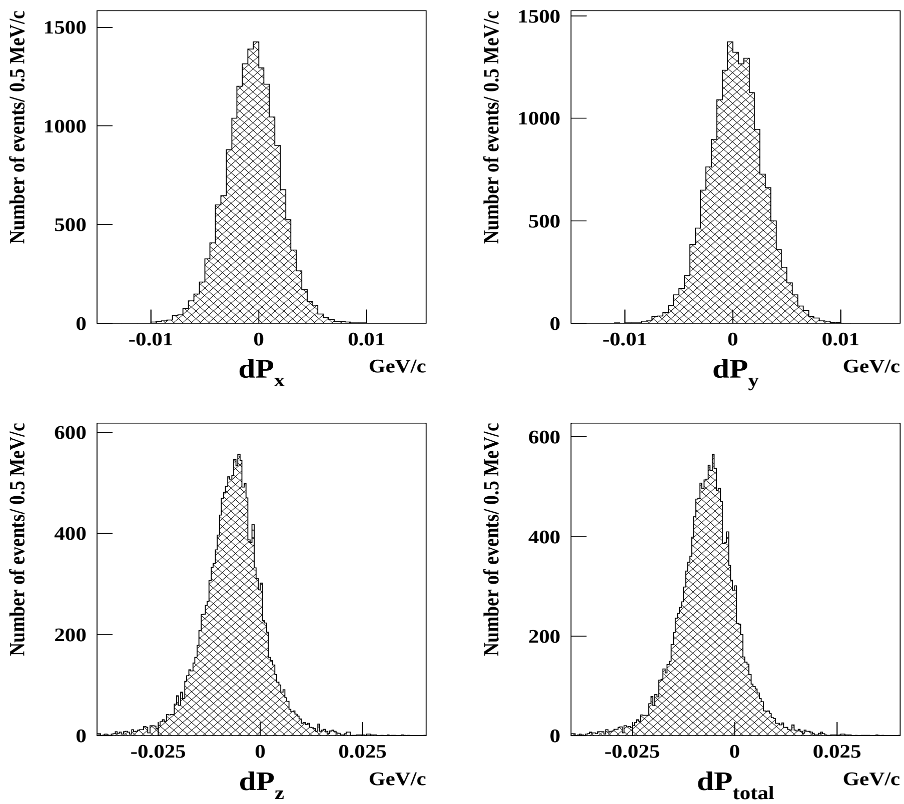

Figure 5: Difference of the total momentum dP and its x,y and z projections in [GeV/c] between the ARIANE reconstruction and GEANT.

shows the shift in the total momentum due to the energy loss of about 7 MeV/c.

Table 4 shows further that the dP_x and dP_y are slightly shifted. P_x is shifted by 0.5 MeV toward lower values, while P_y is shifted by 0.3 MeV toward higher values.

The sigmas of dP_x and dP_y are around 2.5 MeV/c which is 2.5 times more than for the BASEL tracking.

Relative Momentum Q The Q distributions of the ARIANE reconstruction and the corresponding GEANT input distributions are shown in figure 6 and 7 for events that were reconstructed only. The number of events for the GEANT distribution and the ARIANE distribution are the same.

The plots for Q_x and Q_y show that the algorithm shifts events up to 4

	μ	σ
dP_{total}	-7.0	7.1
dP_z	-7.0	7.1
dP_x	$-5.8 \cdot 10^{-1}$	2.5
dP_y	$+3.3 \cdot 10^{-1}$	2.6

Table 4: The μ and σ in [MeV/c] of the distributions of figure 5 showing the difference of the various momenta between GEANT and the ARIANE reconstruction.

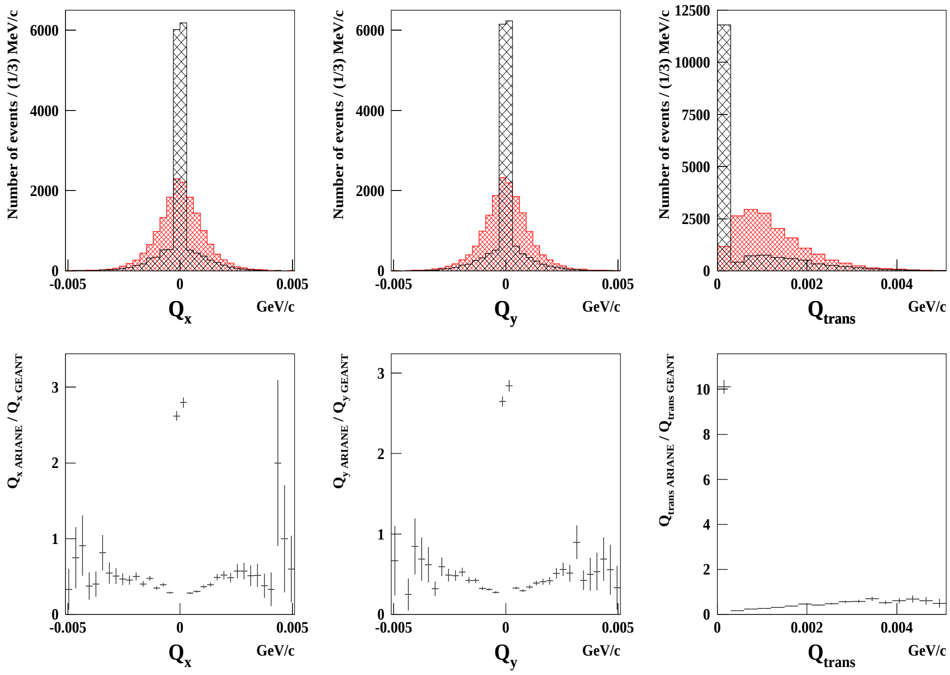

Figure 6: Relative momentum Q_x, Q_y and Q_{trans} in [GeV/c] for the ARIANE reconstruction (black) and the true GEANT input(red) for these events.

MeV/c into the spike at zero relative momentum. It also reduces the width of the input distributions. The resulting Q_{trans} shows a large enhancement for Q_{trans} equal zero.

The Q_{long} distribution in figure 7 has a sigma of $\sigma_{Ql(\text{ARIANE})} = 0.68$ MeV/c as compared to $\sigma_{Ql(\text{GEANT})} = 0.2$ MeV/c.

Q_{total} finally is dominated by the spike around zero in the Q_{trans} plot, so that a big fraction of events have very low total momentum.

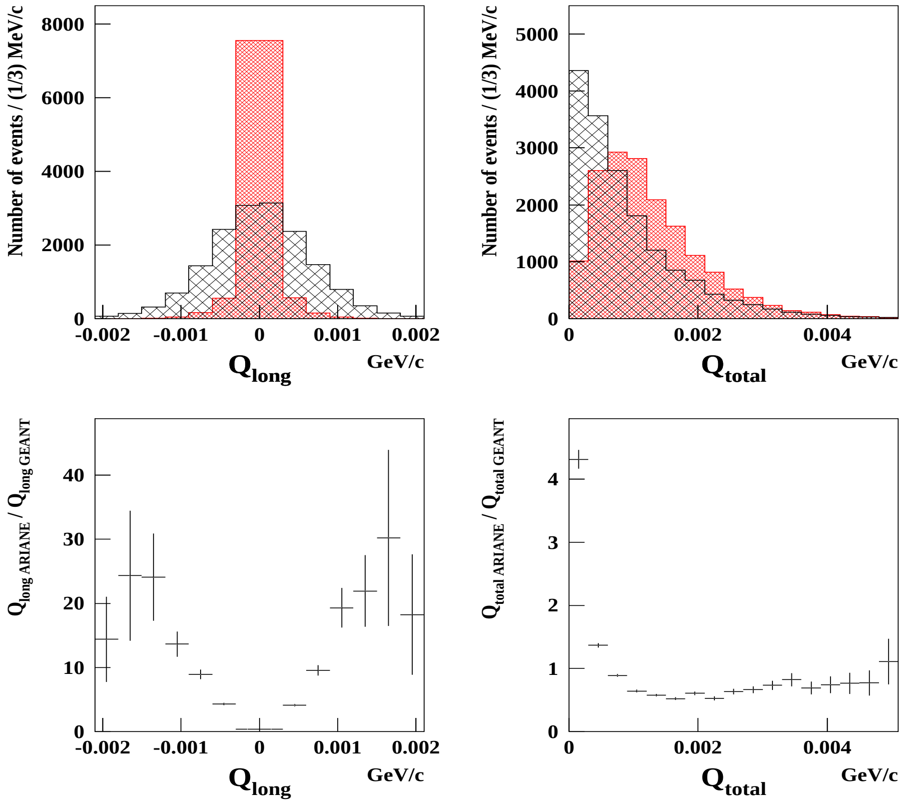

Figure 7: Relative momentum Q_{long} and Q_{total} in [GeV/c] for the ARIANE reconstruction (black) and the true GEANT input(red) for these events.

4 Conclusion

We compared the reconstructed total and relative momentum with the input GEANT data just after the target.

The relative momentum distribution Q_x, Q_y and Q_{long} of the Monte Carlo data are centered around zero with a $\sigma_{Qx} = \sigma_{Qy}$= 1 MeV/c and σ_{Ql}= 0.3 MeV/c. Q_{trans} and Q_{total} look accordingly.

For the reconstruction we used the standard version of ARIANE without the MSGC included performing a vertex fit and using the ARIANE SFD Y prediction method. For the BASEL extended DIRAC tracking we used the BASEL SFDY prediction method.

The reconstruction efficiency varies slightly with the chosen method. A combination of the two SFDY prediction methods would increase the ARI-

ANE efficiency by roughly 3% .

The relative error dP in the momentum determination is considerably smaller for the BASEL tracking ($\sigma_{dP_x} = \sigma_{dP_y} = 1$ MeV/c) than for the ARIANE tracking ($\sigma_{dP_x} = \sigma_{dP_y} = 2.5$ MeV/c). Also the ARIANE tracking seems to shift the P_x by 0.5 MeV/c toward lower values and the P_y 0.3 MeV/c toward higher values.

The relative momentum distributions of the BASEL tracking show for Q_x and Q_y a reconstruction over input ratio of roughly one for $|Q_x|, |Q_y| >$ 1.5 MeV/c. For smaller relative momenta values, the program reconstructs a peak around zero with a corresponding loss of events close to the peak. This is the effect of the peak sensing algorithm of the SFD, which merges close-lying hit fiber column into one single fiber column. The fact that one can see the same structure for Q_x than for the slab difference in SFD X leads to the conclusion that the relative momentum resolution for Q_x and Q_y is of the order of 0.4 MeV/c. The Q_{long} distribution of the reconstructed events is centered around zero with a sigma of about $\sigma_{Ql(\text{BASEL})}$= 0.7 MeV/c as compared to a sigma of $\sigma_{Ql(\text{GEANT})}$= 0.2 MeV/c. The Q_{total} distribution widens accordingly to the wider Q_{long} distribution.

The ARIANE tracking on the other hand shifts events with Q_x (Q_y) up to 4 MeV/c into the spike around zero. The ratio of reconstructed events over input events is around 0.5 for $|Q_x|, |Q_y| > 0.5$ MeV/c. The region with smaller relative momenta is also dominated by the peak sensing algorithm of SFD. The Q_{long} distribution with the ARIANE reconstruction is also centered around zero with a sigma of $\sigma_{Ql(\text{ARIANE})}$= 0.7 MeV/c. The reconstructed Q_{total} distribution is smaller than the input distribution which is due to the artificially small Q_x and Q_y distributions of the ARIANE reconstruction.

References

[1] C. Schuetz “Extended Tracking in the DIRAC experiment: A new SFD Y prediction and a new track finding and track fitting procedure using a Kalman filter”, (2001).

[2] ARIANE version 304-12.

[3] GEANT version 3.21.

[4] GEANT adapted for DIRAC version 2.61

[5] B. Adeva et al. “First Observation of πK Atom and its Lifetime Measurement” CERN/SPSC 2000-032, SPSC/P284 Add.2 (Aug 2000).