Two-track resolution of the E877 forward spectrometer

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The ability of the tracking system to reconstruct two tracks is a function of the separation between them (see Fig.1). Two tracks separated by less than some critical value look like one track. With increasing separation, the two-track efficiency saturates. Since the track separation is related to the relative momentum between the two particles, and since the described inefficiency does not occur for mixed pairs (i.e. pairs obtained taking particles from two different events), the two-particle correlation function are strongly affected. The result is a depletion of the correlation functions at low relative momentum Q for identical particles, and at a finite Q for non-identical ones.

The most obvious way to recover from this is to suppress in the true and in the mixed distributions all pairs with a separation below some critical value. The proper cut-off value can be guessed by looking at Fig.1. The choice can be optimized by comparing the correlation functions obtained with different cut values (Fig. 2).

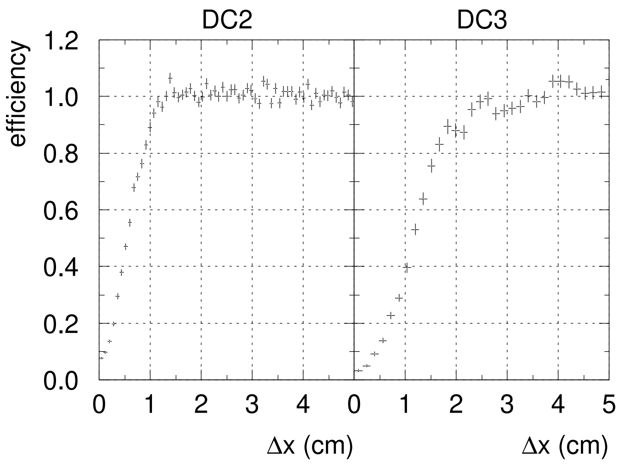

Figure 1: Two-track reconstruction efficiency as a function of the track separation in DC2 (left) and in DC3 (right) The histograms were obtained by dividing the $\pi^+\pi^-$ pair distribution (true) by the analogous distribution obtained from event mixing (mixed).

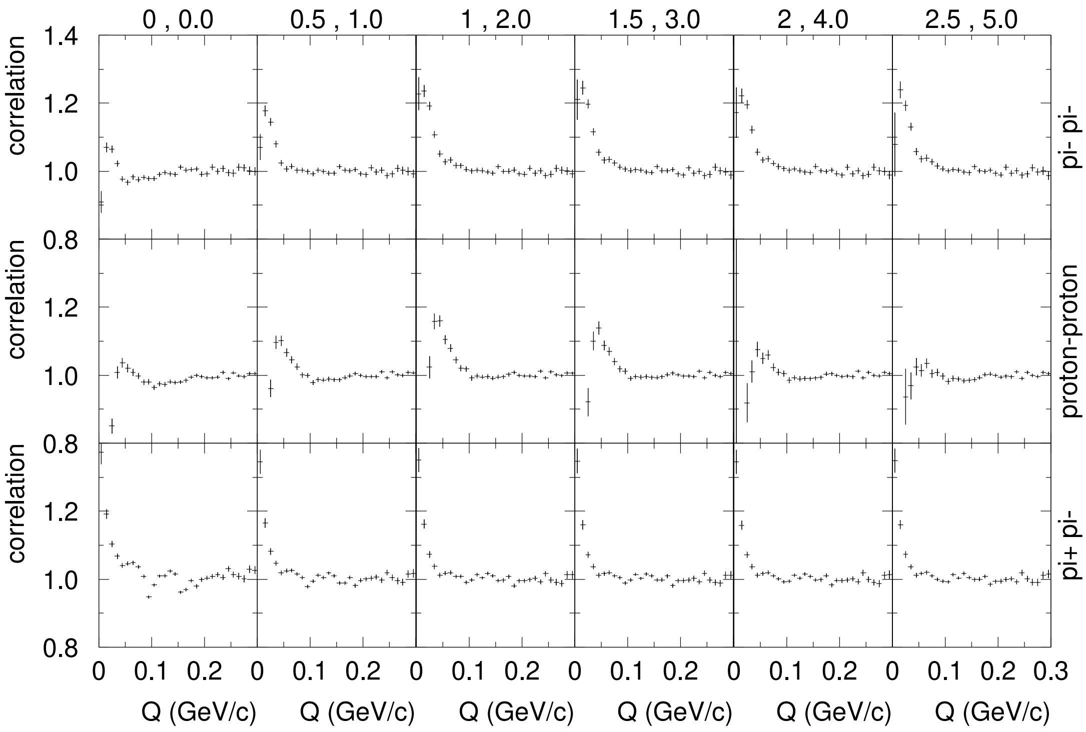

Figure 2: Correlation functions obtained with different cuts. The two numbers at the top of each column are the cuts, i.e. the required minimum separation (in centimeters) of the two tracks in DC2 and in DC3.

The cut should be set at the saturation point where the correlation function stops changing its shape with the changing cut.

Both Sergei Panitkin's two-proton 93 and 94, and my two-pion 93 analyses were done with DC2 cut of 1 cm and DC3 of 2 cm (as far as I know). This was enough to remove the major part of the the two-track resolution problem. However, a careful inspection of Fig. 2 indicates that the method was not perfect:

1. The peak of the two-proton correlation function at first rises with increasing two-track cut; this is fine. But then, starting from the DC2 cut of 1.0 cm, it goes down again; we never understood why.

2. The shape of the $\pi^+\pi^-$ correlation never becomes quite flat around Q = 0.1 GeV/c and Q = 0.16 GeV/c, corresponding to the track crossing in DC2 and DC3, respectively.

The latter point becomes even more visible in the multidimensional analysis, as shown in Fig. 3. The striking inefficiency at $q_{\rm out}$=–0.155 GeV/c, corresponding to two tracks crossing in DC3, cannot be removed by further increase of the cuts.

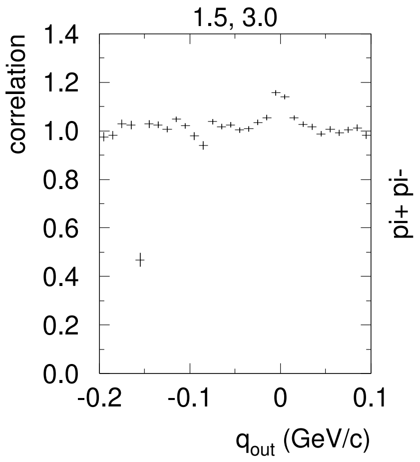

Figure 3: Projection of the three-dimensional $\pi^+\pi^-$ correlation on the $q_{\rm out}$ axis, for $|q_{\rm side}| < 30$ MeV/c and $|q_{\rm long}| < 30$ MeV/c. The DC2 cut of 1.5 cm and DC3 of 3.0 cm reduced but never entirely removed the inefficiency.

I traced backed the origin of the inefficiency in Fig. 3 to the fact that the relation between the separation Δx and the relative momentum Q is different for true and for mixed pairs. The reason for this is probably the variation of the horizontal beam angle from event to event. As a consequence, the relation between position and momentum is different for each event, and thus a cut on Δx corresponds to different Q-cuts for the true and the mixed distributions. The obvious solution is to cut not on the actual Δx but on a separation calculated from momentum. The correlations obtained using this cut are shown in Figs. 4 and 5. The problem is solved.

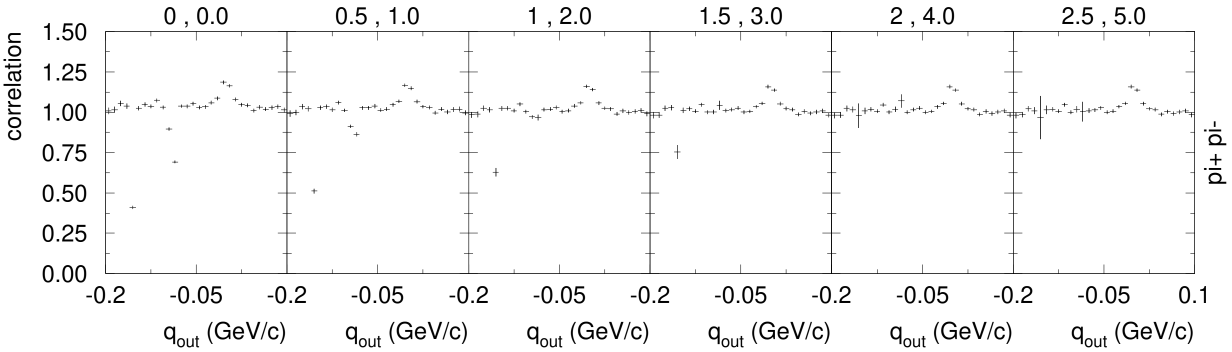

Figure 4: Projection of the three-dimensional $\pi^+\pi^-$ correlation on the $q_{\rm out}$ axis, for $|q_{\rm side}| < 30$ MeV/c and $|q_{\rm long}| < 30$ MeV/c. The cut was done on the separation calculated from momenta. The inefficiencies at $q_{\rm out}$=–0.155 and –0.090 GeV/c correspond to track crossing in DC3 and DC2, respectively.

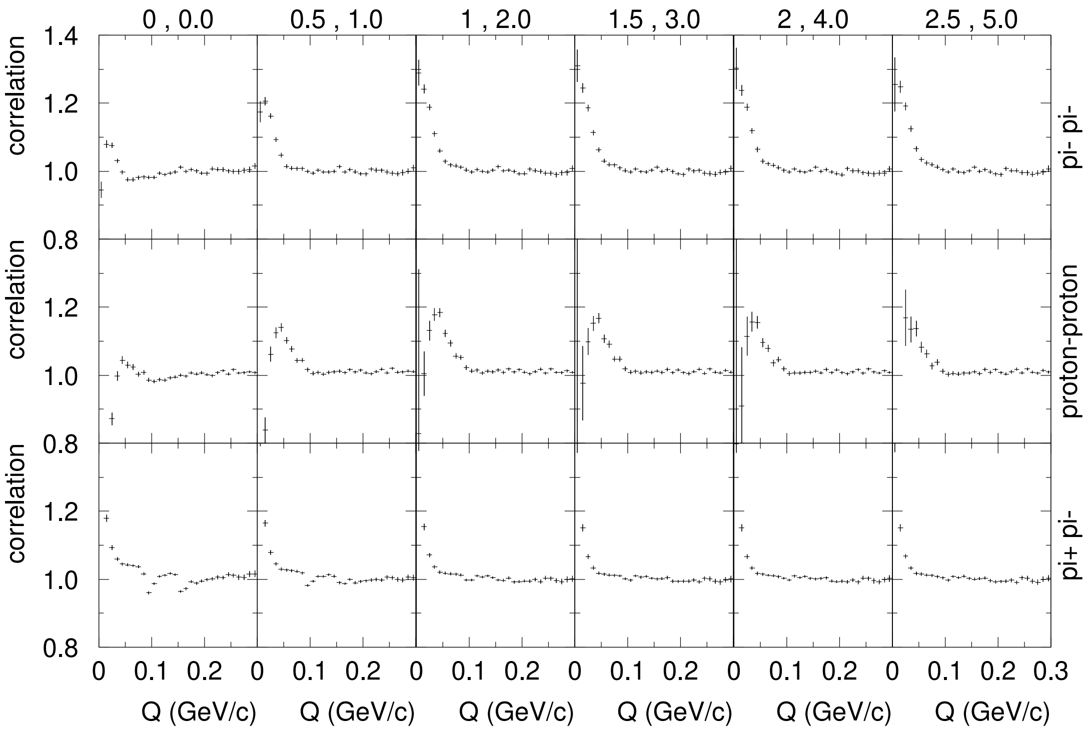

Figure 5: Correlation functions obtained with different values of the separation cut. The cut was done on the separation calculated from momenta.

Summarizing, the two track efficiency cuts should be imposed not on the measured two-track separation but on the separation calculated from the momenta. Concerning the value of the cut, safe numbers are 1.5 cm for DC2 and 4.0 cm for DC3. These numbers were deduced from the inspection of Fig. 4. The cuts for identical particles might be somewhat looser because the resolution for parallel tracks is somewhat better than for crossing ones. In any case, a DC2 cut of 1 cm and a DC3 cut of 2 cm are absolute minimum.