E877 Note # HD-96/08/15

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Occupancy correction. Method # $n+1$. or Where to put an extra dot on "i"? [a]

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ABSTRACT

I discuss a new approach to correction for tracking inefficiency in resolving close tracks, so called occupancy correction. The main advantage of the proposed method is the possibility to correct the data "on-line" during execution of step2 or directly in PAW (using column wise ntuples), without preliminary occupancy analysis of event sample under study.

[a] see T. Hemmick, selected works, Editors: TWP, et al., Volume *TRIVIAC*, Part: acceptance.f, Line 225; SB, 1996.

The reconstruction of close tracks is a difficult task as well as the evaluation of the tracking efficiency for this case. It is known that the problem appears when two tracks are separated in DC2 less then approximately 1 cm and/or in DC3 less than about 2 cm. As far as I know there exist a few approaches to correct for this inefficiency, so called occupancy corrections of different kinds. But all these approaches (to the best of my knowledge) require preliminary occupancy analysis for the particular event sample under study.

What complicates the problem that even for the same centrality the spectrometer occupancy depends on the orientation of the reaction plane. The mean number of reconstructed tracks varies about 20–30% depending on flow direction. It become important (especially for studies involving flow) the evaluation of the occupancy correction for many centrality regions as well as for different orientation of the reaction plane. I think that for such a case the method discussed below can be very useful.

The method consists of weighting of each track depending on the separation of this particular track with respect to all other tracks in the same event. Let us start for simplicity with only one drift chamber, DC2. At the beginning the weights for all tracks assigned to be 1. If the separation in the chamber of one particular track to any other track is less than 1 cm, the probability of it's reconstruction is low and the proper efficiency is strictly speaking unknown. The best solution in this case would be just to discard such track, or, in other words, assign for this track weight=0, or just multiply the "old" weight by 0. But somehow one should compensate this lost. For this purpose I define a double weight (=2) for the track if the separation to any other track is between 1 and 2 cm, or multiply the "old" weight by factor of 2. It is important to keep this multiplication by factor of 2 each time one finds another track in this region (see below). For all other cases the weight remains the same, weight=1. To keep the overal normalization constant the mean weight for each track has to be equal 1. Below I show that this is the case for the procedure described above under the assumption that the mean occupancy of tracks in the minimum separation "bin" is the same as in the bin of the same size adjacent to it. I denote the mean number of tracks in a bin as $\overline{n}$. The probability to find n tracks in the bin would be Poissonian:

$$p_n = \frac{(\overline{n})^n e^{-\overline{n}}}{n!}. \tag{1}$$

Then the mean weight $\langle w \rangle$ would be:

$$\langle w \rangle = e^{-\overline{n}} \sum_n p_n 2^n = 1, \tag{2}$$

where the factor in front of the sum reflects the probability not to find any track in the minimum separation region (when weight equals to zero).

The generalization of the method for the case of two chambers is straightforward, although not completely trivial. The first attempt would be just consider hits in DC2 and DC3 as complietely independet. In this case one should go through all tracks first in one chamber and then in the second chamber keeping the multiplication of the weight by factor of two (if track is found in the bin adjacent to minimum separation bin) or zero (if track is found in the minimum separation bin). How to take into account the correlation in hits in DC2 and DC3 I discuss at the end of the note.

I have simple Monte-Carlo code to test how the method works. In this Monte-Carlo code I have only (positive and negative) pions and protons. The rapidity distributions assumed to be Gaussian with widths 0.85 and 1.0 for protons and pions, respectively. Transverse momentum distributions was also assumed to be Gaussian. I have more or less realistic values for the collimator opening, the magnetic field, and the locations of DC2 and DC3 with the corresponding dead (beam) regions. The overall statistics (used for Figures below) is 40K events. The average number of tracks in the "spectrometer" is about 8.2.

The results of my study are presented in Figures 1–3. In the first Figure are shown the distirbutions in track relative separation in DC2 and DC3, as computed in this simple code. In Figures 2 and 3 I present the comparison of the original (not distorted by cuts on minimum separation in DC2 and DC3) distribution in p_x with the "reconstructed" one by applying the method discussed above. The minimum separation cuts applied in DC2 and DC3 are 1 and 2 cm, respectively. Dashed histogram shows the distribution after the minimum separation cuts. The lost of tracks due to "inefficiency" in resolving close tracks is about 50%.

Weight #2 in Figures 2 and 3 corresponds exactly to the one described in the text above, treating DC2 and DC3 hits as completely independent. The agreement of the "reconstructed" distribution with the original is rather good, although in some sence accidental, what becomes clear after more detailed analysis of the correlations in DC2 and DC3 hits. It appeares that the weight for some "trajectories" is overestimated and for some underestimated.

More carefull analysis of track "combinatorics" (hits in DC2 and DC3) gives following prescription for the weight calculation. I beleive it is clear from the FORTRAN code:

```
do i=1,ntrk
   weight(i)=1.
enddo
do i=1,ntrk
   do j=i+1,ntrk
      isep2=abs(x2m(i)-x2m(j))/minsep2
      isep3=abs(x3m(i)-x3m(j))/minsep3
      if(isep2*isep3.eq.0)then
         weight(i)=0.
         weight(j)=0.
      endif
      if(isep2*isep3.eq.1)then
         weight(i)=weight(i)*2.
         weight(j)=weight(j)*2.
      endif
      if(isep2*isep3.eq.2)then
         weight(i)=weight(i)*2.5
         weight(j)=weight(j)*2.5
      endif
      if(isep2*isep3.eq.3)then
         weight(i)=weight(i)*3.
         weight(j)=weight(j)*3.
      endif
      if(isep2*isep3.ge.4)then
         if(isep2.eq.1 .or. isep3.eq.1) then
            weight(i)=weight(i)*2.
            weight(j)=weight(j)*2.
         endif
      endif
   enddo
enddo
```

The results of the distribution "reconstruction" using the algorithm from this code are shown in Figures 2 and 3 by filled circles *weight #1*). I have looked also at the distributions of different particles. The agreement between the original and "reconstructed" distributions looks very similar to shown in Figures 2/3.

Note that there exist some freedom in the selection of proper weights. Different procedures could lead to slightly different results (mostly in the magnitude of fluctuations in the reconstructed distributions). For example one could use non flat shape of assigned weight, but keep the overall normalization (Eq. (2)) the same.

What is important in the method, that it looses and "recovers" tracks from the same kind of events, corresponding to the same spectrometer occupancy. It will be very interesting to check this approach in more sophisticated Monte Carlo used earlier for study of the occupancy correction.

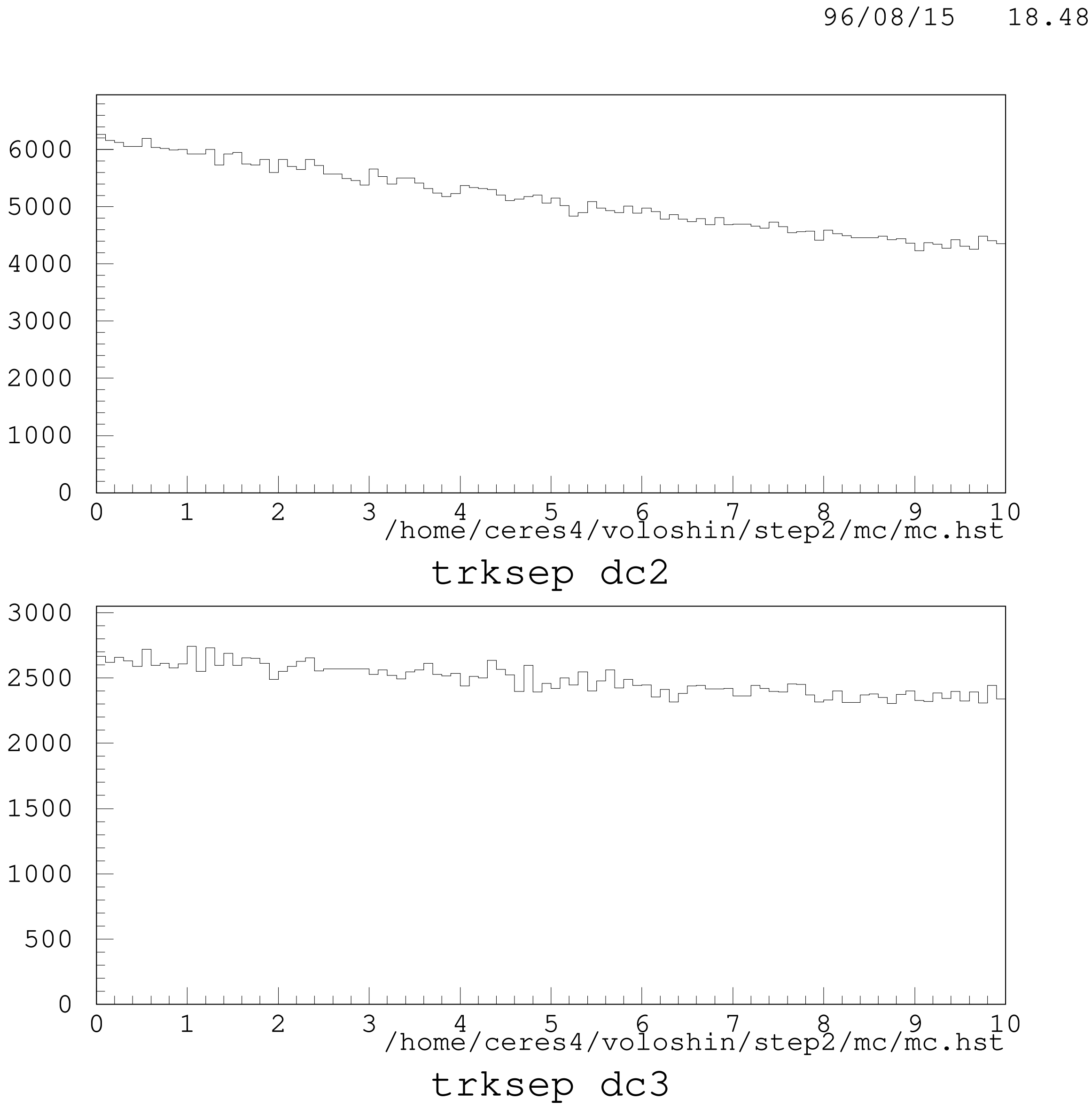

FIG. 1. The distribution in separation between tracks in DC2 and DC3.

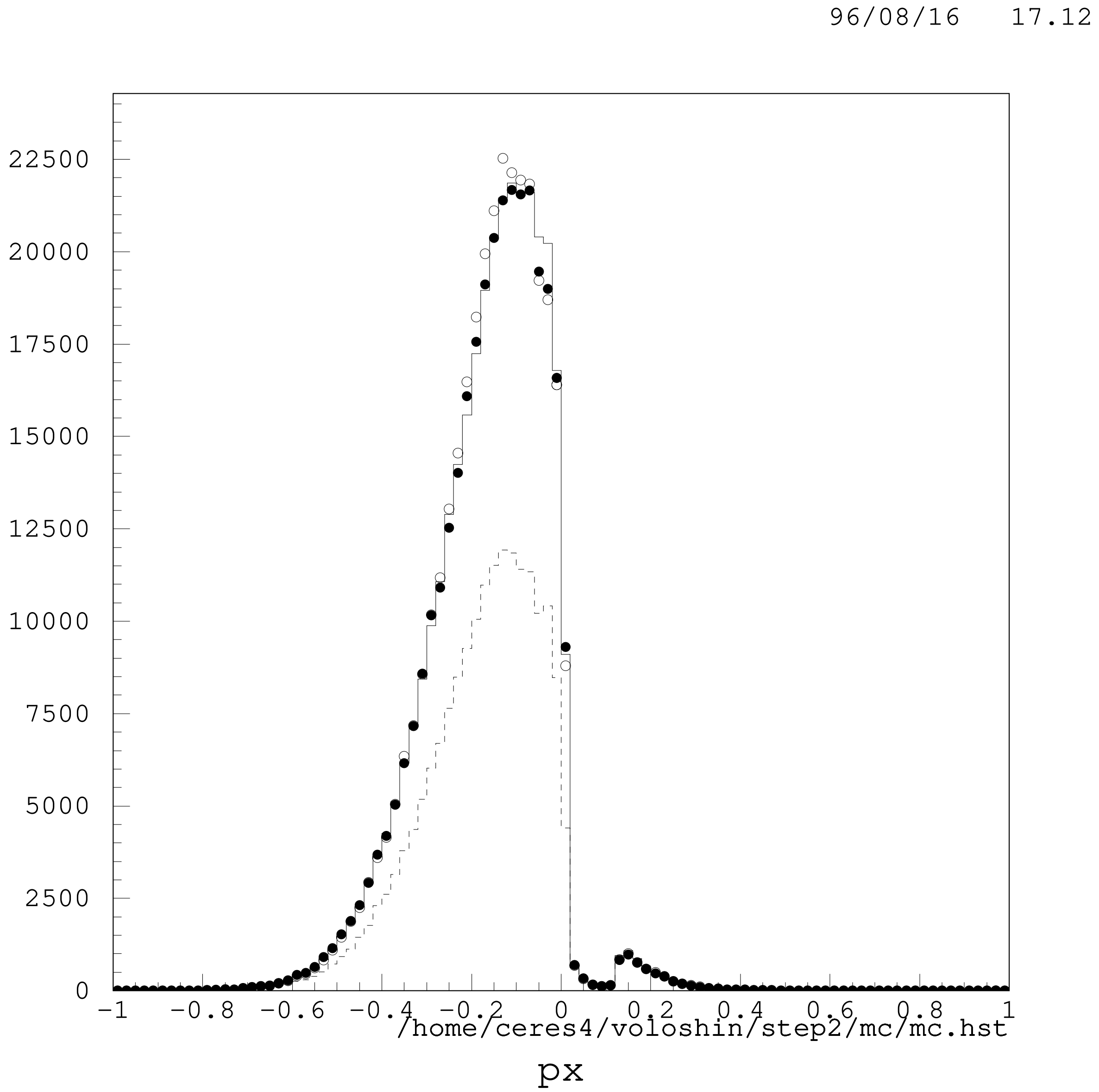

FIG. 2. Particle distribution in p_x. Solid histogram – input. Dashed histogram – the distribution after applying cuts on minimum separation in DC2 and DC3. Solid circles – the distribution, corrected using *weight #1*. Open circles – using *weight #2*.

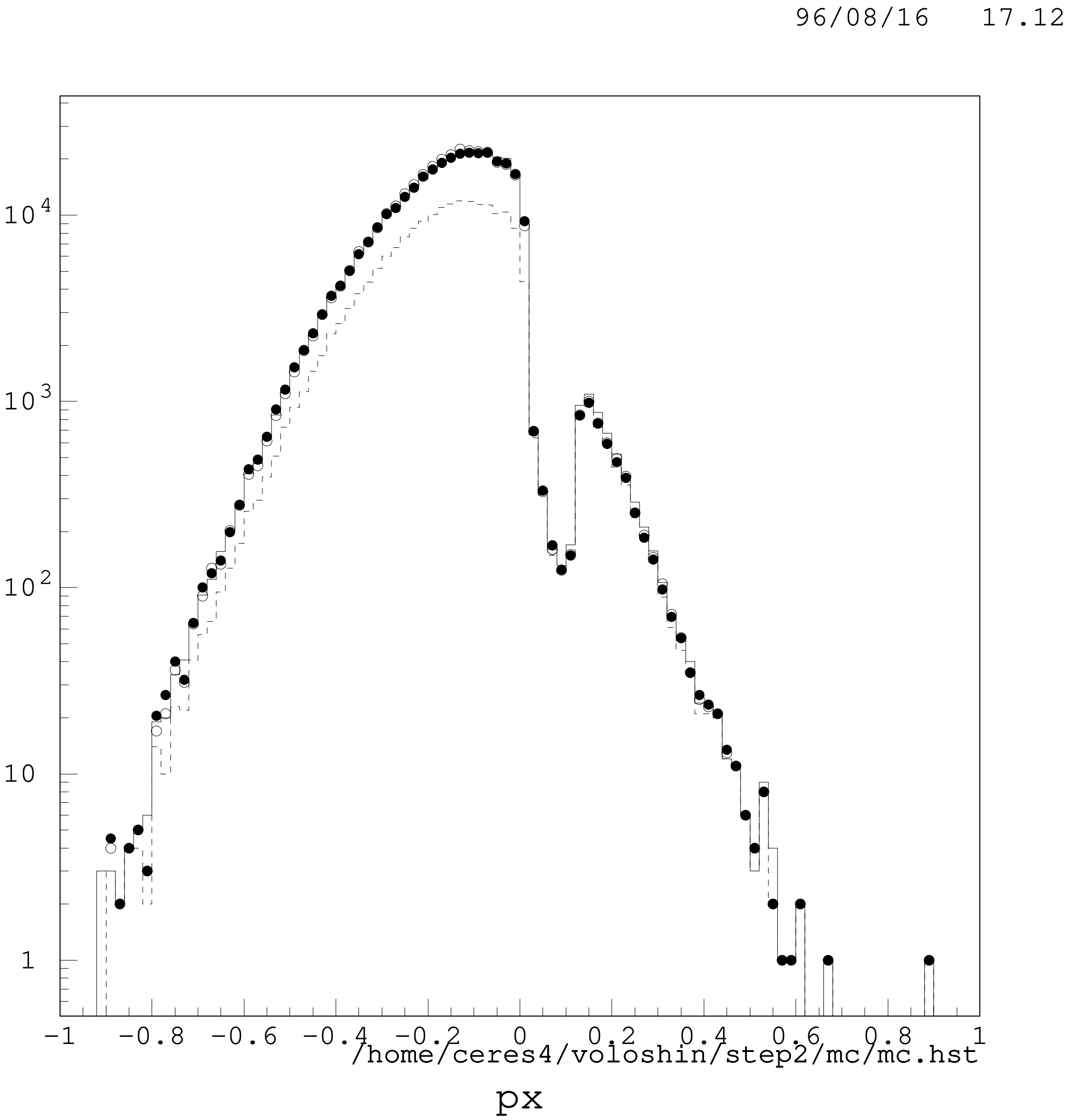

FIG. 3. The same as Figure 2 in log scale.