E949 K-037
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Experiment 949
Technical Note No. K-037

More accurate definition of target fiber coordinates.

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Abstract

Results of a more precise calibration of the target fiber positions are presented. In particular, the first update to the measurement of the Z dependence of the fiber locations since 1995 is reported. The particle track parameters from the UTC are obtained from the Pass2 ntuples for the kp21, kp22, km21 and km22 monitor triggers from the 2002 run and used for this calibration. While the Pass2 ntuple wasn't optimized for this problem, it appears adequate for obtaining the correction function for the X and Y coordinates of the center of each fiber as a function of the Z coordinate

$$\begin{pmatrix} \Delta X \\ \Delta Y \end{pmatrix} = \begin{pmatrix} 0.0056020 \pm 0.00008320 \\ 0.022910 \pm 0.000000015 \end{pmatrix} - \begin{pmatrix} 0.0008432 \pm 0.000023270 \\ 0.0107400 \pm 0.000000004 \end{pmatrix} \times \mathbf{Z} \qquad (1)$$

reducing the existing displacement of fibers by approximately a factor of 10 (in Y). These corrections $(\Delta X, \Delta Y)$ are subtracted from the raw values ($y_{new} = y_{old} - \Delta Y$). This implies that the downstream end of the target (+Z) is too XXX relative to the upstream end (-Z) in 2002. The slope Y/Z is about ∼50% larger than the 1995 value ($y_{new} = y_{old} + 0.0072 \times Z_\pi$).

1 Introduction

It is difficult to overestimate the importance of the most precise knowledge of the relative locations of all detectors in the experimental setup. The direct measurement, or survey, often isn't enough and is unavailable in some cases due to the construction of the experiment.

Every year in which the target was removed and replaced in the detector, a triplet of parameters was determined. These parameters are an average rotation, and shifts in X and Y, in order to align the target with the drift chamber. For 2002 data runs, the transformation equations are:

$$\begin{pmatrix} X' \\ Y' \end{pmatrix} = \begin{pmatrix} SIN(\theta) = -0.08520 & COS(\theta) = +0.99636 \\ -COS(\theta) = +0.99636 & SIN(\theta) = -0.08520 \end{pmatrix} \begin{pmatrix} X \\ Y \end{pmatrix} + \begin{pmatrix} \Delta X = +0.077 \\ \Delta Y = -0.330 \end{pmatrix} \qquad (2)$$

This corresponds to a 5° rotation.

In 1995, Jim Frank performed a detailed target alignment study in which displacements of the individual fibers from an assumed square grid was determined. This data forms the array *tg_p50.dat* which gives the positions of the individual 5 mm target fibers. In addition, Jim found that the target was tipped with respect to the beam line (z-axis). These tip parameters, as well as the individual fiber positions, have not been re-studied since then. All analyses of 1996–2002 data to this point have used these 1995 parameters. In this paper, our ability to study this and obtain a result for 2002 is presented.

Trigger type	Number of runs	Number of events	Events after all cuts
$K^+\pi^+21$	1465	194146	117219
$K^+\pi^+22$	1482	329514	231158
$K^+\mu^+21$	1459	1097640	735950
$K^+\mu^+22$	1459	1200076	785222
All above	—	2821376	1869549

Table 1: The data used in this analysis.

2 Experimental data

The monitor data from the 2002 data taking run has been used in this analysis.. Various aspects of the data set are summarized in Table 1, including the trigger types, runs, and number of events included in the present analyses. The events were required to have the variable ITGQUALT=0 and satisfied the following cuts:

$$\begin{aligned} npi\_tg &> 3 \\ radius &> 40.0cm \\ |xb4bm - tgx| &\leq 4.0cm \\ |yb4bm - tgy| &\leq 4.0cm \\ \text{The closest approach } D_0 &\leq 0.9cm \end{aligned}$$

where npi_tg is number of fibers hit by the pion or muon, the so called "pion fibers", radius is the UTC track radius, xb4bm and yb4bm are the x and y hit coordinates in the B4 counter, tgx and tgy are the x and y coordinates of the kaon decay point, D_0 is the distance of the closest approach of the UTC track to the "pion fibers".

3 Description of the method

The central part of the target consists of 413 fibers $0.5 \times 0.5 \times 310$ cm. The general features of the E949 fiber target are described in detail elsewhere [1]. To find the average displacement of these fibers the distance D_0 of the closest approach of the track after reconstruction by the UTC, so called "UTC track", to the "pion fibers", and the angle ϕ_0 of the tangent to the track at the point of the closest approach were used (see Fig. 1(a)). The D_0 is negative if the "pion fiber" is sitting inside of the particle trajectory circle. The scatter plot of D_0 versus ϕ_0 is presented in Fig. 1(b). The distribution of the average value, $< D0 >$, of the closest approach versus ϕ_0 is presented in Fig. 2(a) and is described by function:

$$< D_0 >= D_T \times COS(\phi_0 + \phi_T) + D_E \tag{3}$$

where the parameters have the following physical meaning:

- D_T is the value of average displacement of the "pion fibers"
- ϕ_T is the angle of the track tangent at the point of closest approach equal D_T, i.e. the direction of displacement vector aligned along the closest approach line
- D_E is the average displacement of "UTC track" due to pion energy loss in target fibers or track mis-reconstruction.

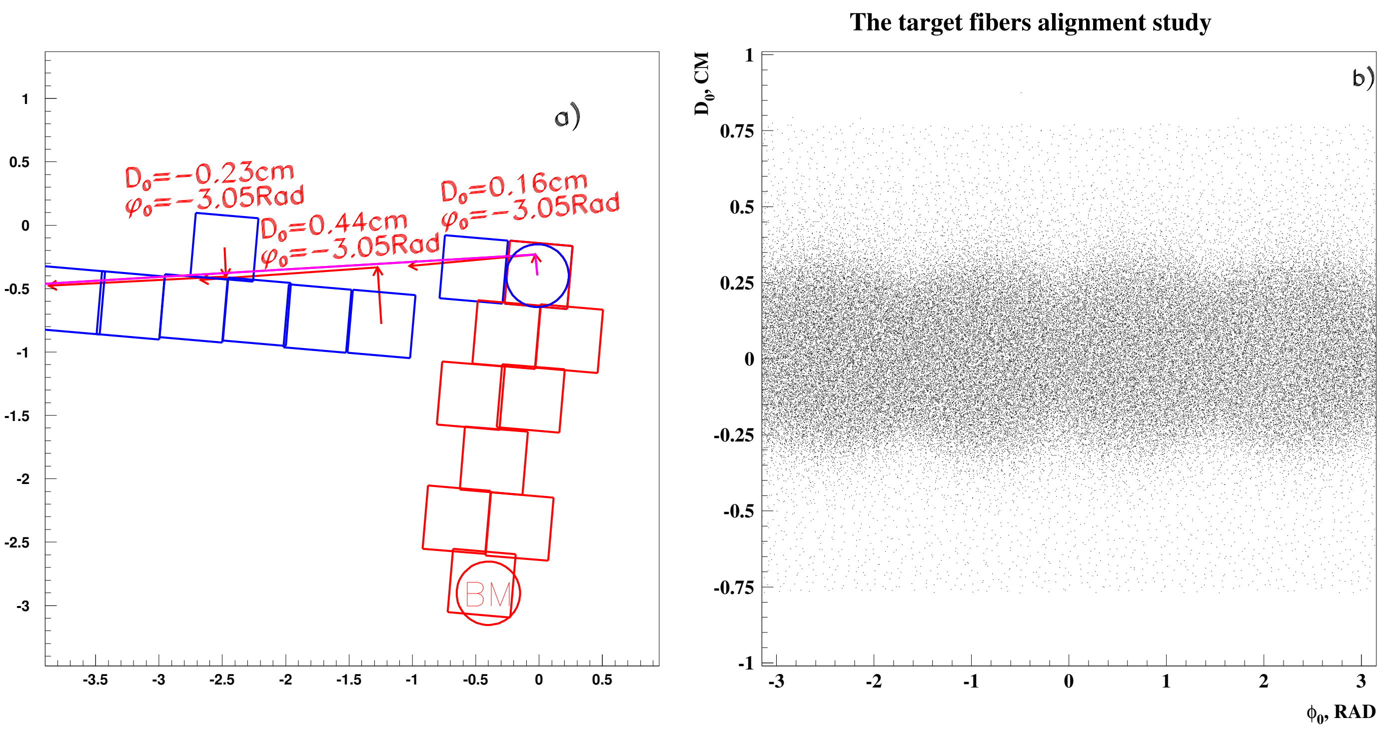

Figure 1: a) The target fibers and the UTC track, showing the distance of closest approach (D_0) and angle (ϕ_0) for each fiber and b) D_0 and ϕ_0 of the “kaon and pion fibers”

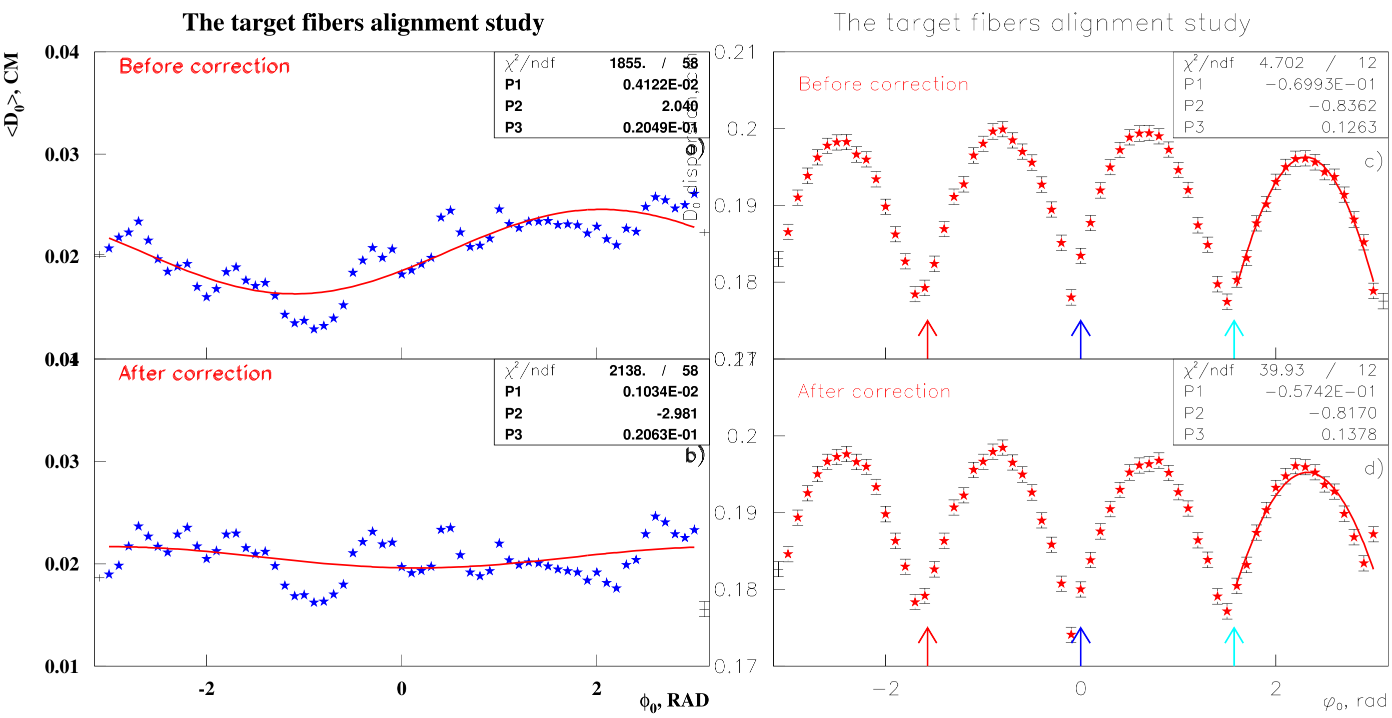

Figure 2: a) The average value and c) the dispersion of the closest approach, D_0, versus ϕ_0 before and b),d) after the Z correction described in this paper.

The dispersion of the closest approach D_0 is shown in Fig. 2(b). The structure of the dependence on ϕ_0 reflects the square form of fibers and shows a small (5°) rotation of the fibers around their own axis. All "pion fibers" in the events have Z coordinates between -10 cm and +13 cm. The data have been divided into 10 bins of equal statistics by their Z coordinate, as shown in Fig. 3, and the

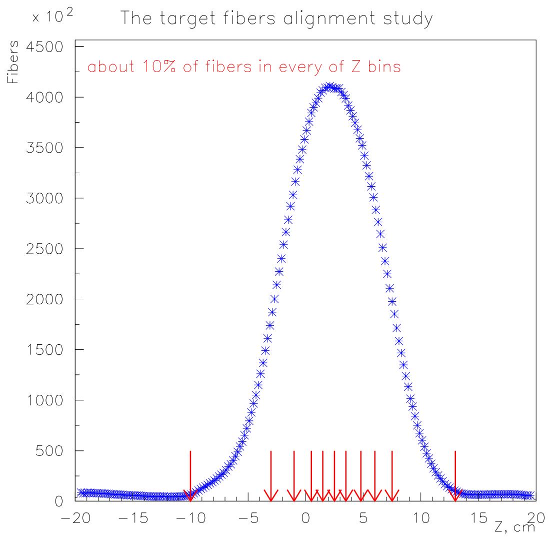

Figure 3: The Z distribution of the "pion fibers"

corresponding distribution of $< D_0 >$ versus ϕ_0 was made for every Z region and are presented in Fig. 4. After splitting D_T into the ΔX and ΔY displacement components as

$$
\begin{aligned}
\Delta X(Z) &= -D_T(Z) * SIN(\phi_T(Z)) \\
\Delta Y(Z) &= \quad D_T(Z) * COS(\phi_T(Z))
\end{aligned}
$$

the correction functions (dependent on Z) have been found by approximation of this set of data by a first degree polynomial.

$$
\begin{pmatrix} \Delta X \\ \Delta Y \end{pmatrix} = \begin{pmatrix} 0.0056020 \pm 0.00008320 \\ 0.022910 \pm 0.000000015 \end{pmatrix} - \begin{pmatrix} 0.0008432 \pm 0.000023270 \\ 0.0107400 \pm 0.000000004 \end{pmatrix} \times \mathbf{Z} \tag{4}
$$

The result is shown in Fig. 5(a,c). The corresponding function after the corrections have been applied are presented in Fig. 5(b,d)

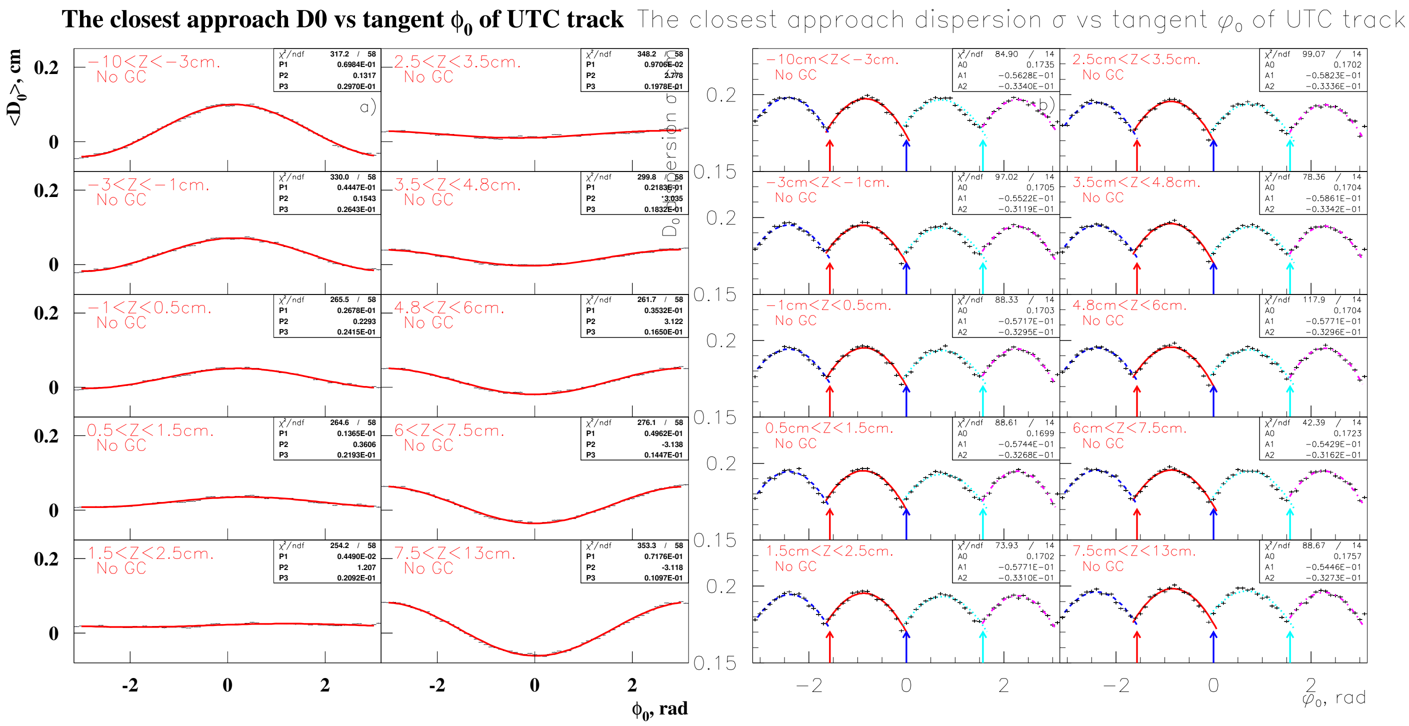

Figure 4: a) The average value and b) the dispersion of the closest approach, D_0, versus ϕ_0 in bins of different Z.

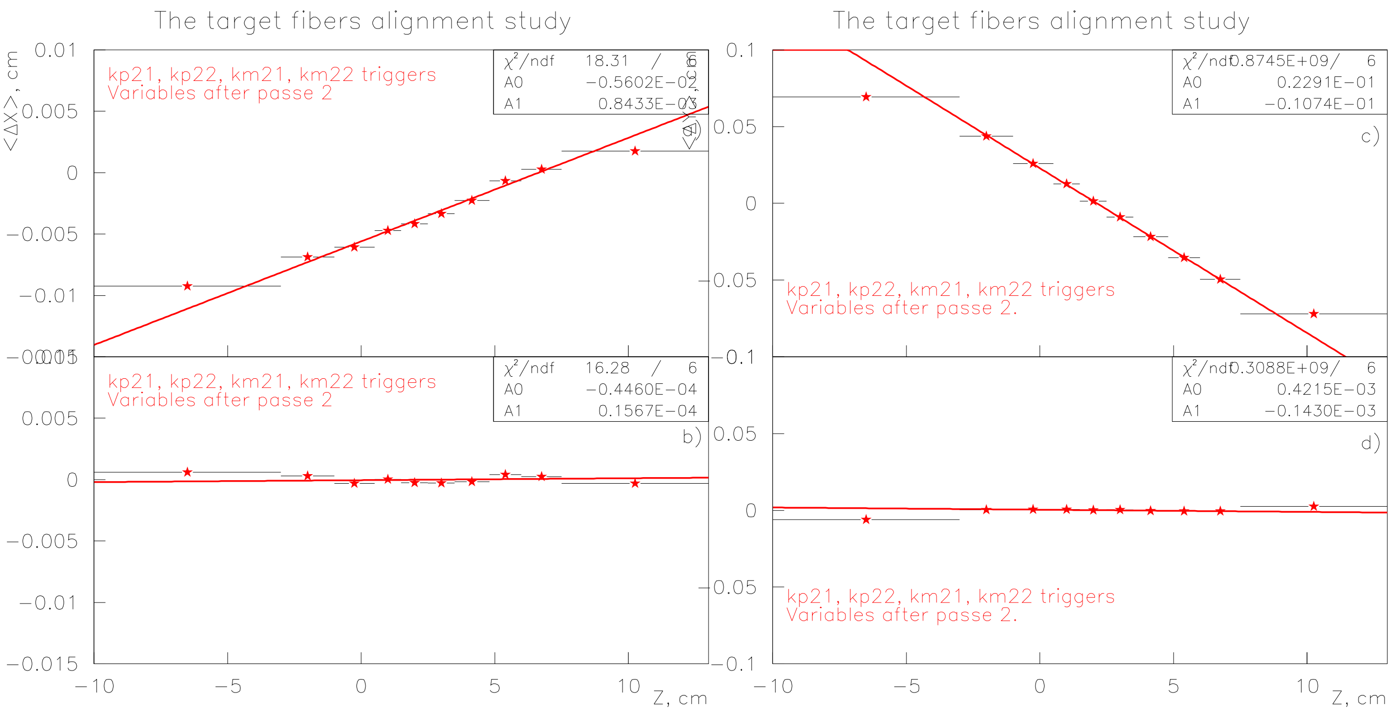

Figure 5: The correction functions for the fiber positions a) for the X coordinate c) for the Y coordinate. b) and d) are the corresponding functions after the Z correction.

4 Discussion of the results.

The result shows that the target fibers are primarily displaced in the vertical direction and in the fiducial volume of $-10 \leq Z \leq -13$ cm the target is “inclined XXXward” relative to the UTC by about 2 mm (from downstream to upstream). The displacement in the horizontal direction is negligible. The result of applying these corrections to the target fibers is shown in Fig. 2b),d) and in Fig. 6. It is easy to see that the overall displacement decreased by about a factor 10 (in Y) and

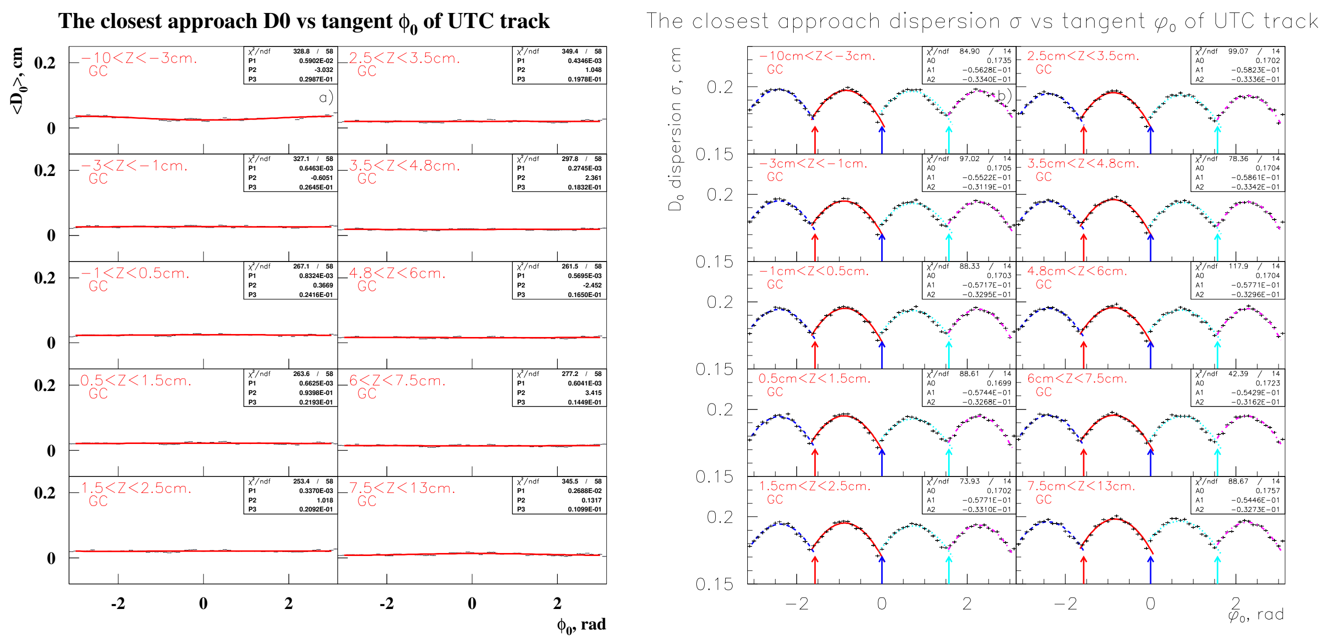

Figure 6: a) The average value and b) the dispersion of the closest approach, D_0, versus ϕ_0 in Z bins after Z-correction.

the precision of fiber’s location is now good enough and consistent with other detectors. It looks like further improvement of the “global” target fiber alignment is not useful.

5 Conclusions

The target fiber displacements as a function of the Z coordinate have been measured, with values reduced from ± 1 mm in the Y direction and from ± 0.1 mm in the X direction. These small displacements are unlikely to significantly affect the results of 2002 pnn1 data analysis, but have to be included in the reconstruction software tree to avoid any confusion and may have more significant impact on the upcoming 2002 pnn2 analysis.

The same procedure could be applied to every fiber separately but it will require significantly more data. Besides, some of the data (km22) are biased by the trigger for fibers located at the edge of target, rejecting all pions that go from the edge into target and out the other side, due to range requirements in RD/BVL. The individual fiber location calibrations should be next.

Some additional work to understand why the global ϕ rotation for 2002 still leaves each individual fiber rotated relative to the UTC is needed.

Acknowledgments

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References

[1] http://www.phy.bnl.gov/e949/detector/tracking/tt/