Correction to TOF Time and Resolution

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1 Motivation

TOF has been improved at BESII, the resolution is about 180ps(for electron). It can identificate particles well. The advantages of PID using TOF is obvious.

From the TOF and DEDX information ,and using the kinematic formula :

$$T_{exp} = \frac{L\sqrt{P^2 + m^2}}{0.3P}$$

We can get the time expectation T_{exp},and we can define χ :

$$\chi = \frac{T_{mea} - T_{exp}}{\sigma}$$

Where the σ is the resolution of particles.

The particle with the least χ^2 is assumed to be the correct one.

Using the define of χ, the distribution of χ should be N(0,1). But from studying , we found the distrubution is not real N(0,1)(see the Fig1) . The centre of the χ shift, which mean time offset. Furthermore, the resolution should depend on countour number, Z direction , Q value and even the momentum of particles. It will affct the identification efficiency, the most importance is it will increase the difference between MC data and real data, and it will cause more system error. So we need do some correction to TOF time and resolution.

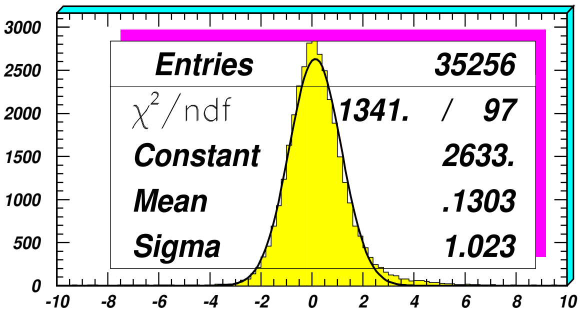


Fig1.χ Distribution of π

2 How to do the correction

• Sample selection

In order to study TOF well, we must select sample as pure as possible. Because we used the samples to study TOF, we did not use the TOF information when we select the samples. we only use the four-constraint kinematic fits, and the sample must come from a resonance decay.

♠ π sample

we select π from the decay cannel: $J/\psi \to \rho\pi \to \pi^+\pi^-\pi^0$

Cut condition are : $|m_{\pi^0} - 0.135| < 0.02GeV$, $|m_\rho - 0.78| < 0.15GeV$, $\chi^2_{\pi\pi\pi} < \chi^2_{kk\pi}$&$\chi^2_{\pi\pi\pi} < 15$

♠ K sample

We select K sample from the decay cannel: $J/\psi \to K^{*\pm}K^{\mp} \to K^{\pm}K^{\mp}\pi^0$

Cut condition are : $|m_{\pi^0} - 0.135| < 0.015GeV$, $|m_{k^*} - 0.892| < 0.1GeV$, $\chi^2_{kk\pi} < \chi^2_{\pi\pi\pi}$&$\chi^2_{kk\pi} < 15$

Because the K sample statisticis finite, and $J/\psi \to K^{*\pm}K^{\mp}$ only can give K with high momentun , we can select K from another cannel : $J/\psi \to \phi\pi\pi \to KK\pi\pi$.

Cut condition are: $|m_\phi - 1.19| < 0.01GeV$, $\chi^2_{KK\pi\pi} < \chi^2_{4\pi}$&$\chi^2_{KK\pi\pi} < \chi^2_{4K}$&$\chi^2_{KK\pi\pi} < 15$

• How to do the correction

♠ TOF resolution

a. Depend on counter numbers

We can get time offset $\Delta T = T_{mea} - T_{exp}$ of all particles hitting the same counter, and fit ΔT with Gaussian. then the σ is the resolution of the block of scintilator. From

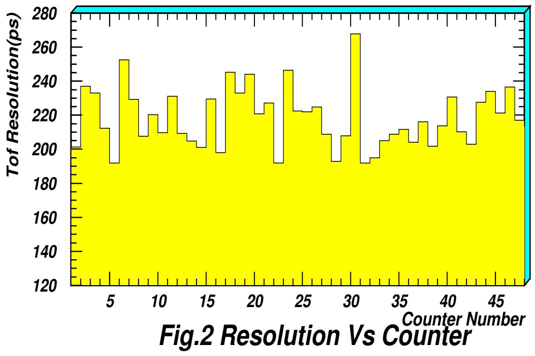


Fig.2 Resolution Vs Counter

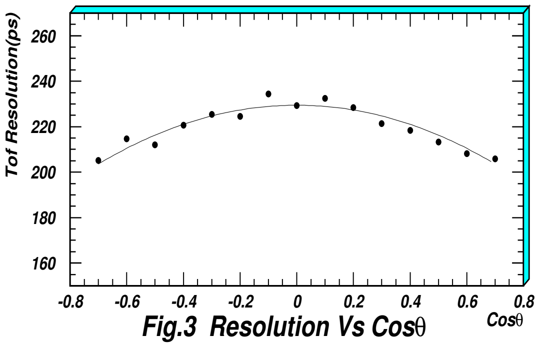


Fig.3 Resolution Vs Cosθ

the plot we can find resolution is much depend on counter number(see Fig.2).

b. Depend on $cos\theta$

We can divide $cos\theta$ into sevel slices , and get ΔT and resolution in a certian range. Then we can get the resolution vary with $cos\theta$(see Fig.3). We fitted the plot with the formula :

$$\sigma = P1 + P2 * \cos^2\theta$$

then we get:

$$\sigma = 229.5 - 52.7 * \cos^2\theta$$

c. Depend on momentum

We also studied resolution vary with momentum, from the plot we can see the resolution hardly depend on momentum(see Fig.4)

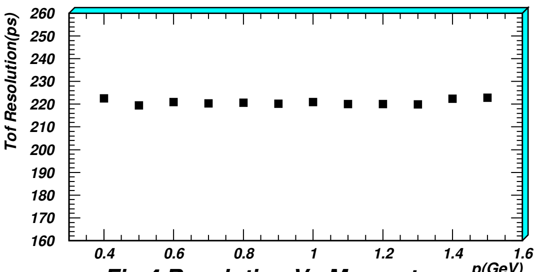


Fig.4 Resolution Vs Momentum

After we studied resolution vary with counter number, $cos\theta$ and monmentum, we have gotten the resolution depend on counter number and $cos\theta$, but it hardly depend on momentum. Finally we correct the resolution with the fomula:

$$\sigma = (P1 + P2 * \cos^2\theta) * \frac{\sigma_i}{\sigma_{tot}}$$

and the we get :

$$\sigma = (229.5 - 52.7 * \cos^2\theta) * \frac{\sigma_i}{223.2}$$

♠ Time offset

We already know χ is not real N(0,1) distribution. the centre shift, which mean time offset. So we will do some correction for TOF time.

a. Depend on $cos\theta$ and momentum

As studying resolution depend on $\cos\theta$, we dive momentum into several slices, and then dive $|cos\theta|$ into several slices when momentum is in each certian range. Then we can get time offset vary with $|cos\theta|$. From the plot(see Fig.5) when monentum is in a

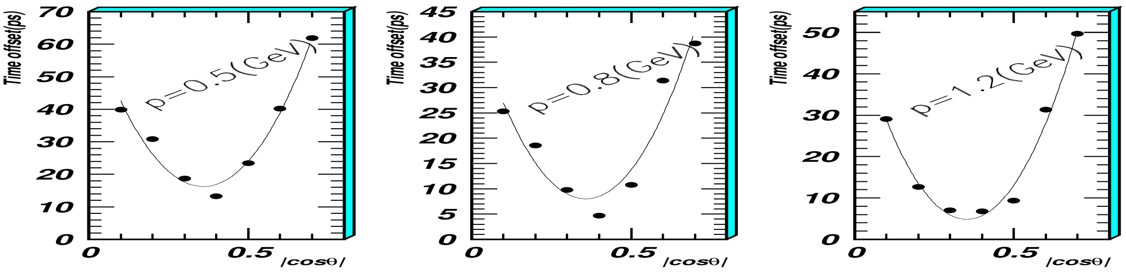


Fig.5 Time offset vary with |cosθ|

certian range, we can fit the time offet with formula:

$$\triangle T = A + B|\cos\theta| + C|\cos\theta|^2$$

Then we can get A,B,C vary with momentum(see Fig.6). and fit A,B,C with polynomial. Finialy we got the result:

$$\begin{aligned}\triangle T1 &= (148.3 - 216.8 * P + 117.3 * P**2) \\ &+ (-543.7 + 746.4 * P - 435.3 * P**2) * |\cos\theta| \\ &+ (750.3 - 1000.1 * P + 555.4 * P**2) * |\cos\theta|^2\end{aligned}$$

b. Depend on Q value

After studying time offset depending on $cos\theta$ and momentum, we difined $\triangle T2 = T_{mea} - T_{exp} - \triangle T1$, and found $\triangle T2$ also depend on Q value(see Fig.7). In order to reduce the dependence,we should do some correction to time. We also fit the plot with polynomial. Then we got:

$$\triangle T2 = -72.01 + 4704.4 * Q + 130110 * Q^2$$

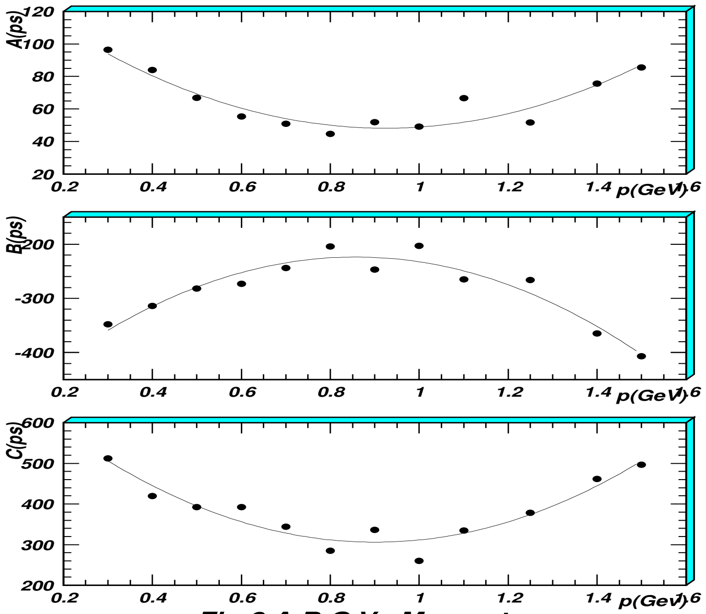


Fig.6 A B C Vs Momentum

The totle correction to time :

$$\triangle T = \triangle T1 + \triangle T2$$

After correct to time and resolution ,we defined χ again :

$$\chi = \frac{T_{mea} - T_{exp} - \triangle T}{\sigma}$$

where

$$\sigma = (229.5 - 52.7 * \cos^2\theta) * \frac{\sigma_i}{223.2}$$

Then we can get the distribution of χ, we can see χ is good N(0,1) distribution(see Fig.8).

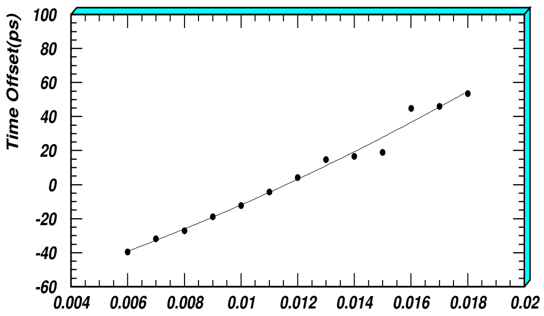


Fig.7 Time Offset vs Q value

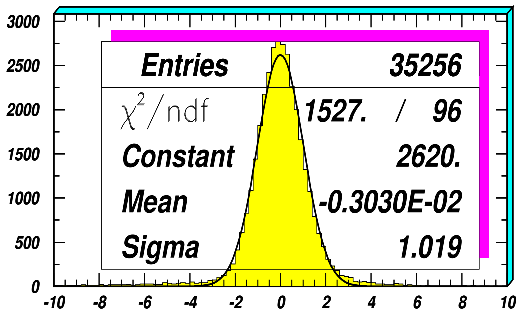


Fig.8 χ Distribution After Correction

♠ For Kaon

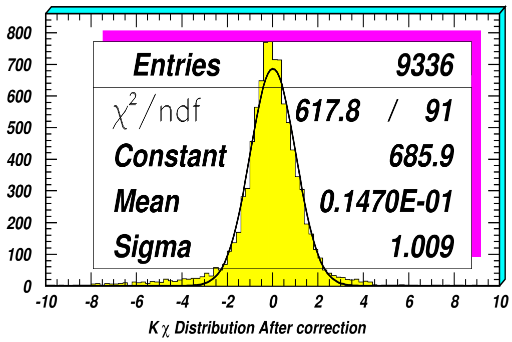
For kaon we do the same correction to time and resolution. We got :

$$\sigma = (223.91 - 31.57 * \cos^2\theta) * \frac{\sigma_i}{223.2}$$

$$\begin{aligned} \triangle T1 &= (298.3 - 405.2 * P + 158.9 * P * *2) \\ &+ (-77.79 - 491.5 * P + 357.1 * P * *2) * |\cos\theta| \\ &+ (32.82 + 1174 * P - 797.5 * P * *2) * |\cos\theta|^2 \end{aligned}$$

$$\triangle T2 = -39.6 + 1056 * Q + 99880 * Q^2$$

We can get the distribution of χ after correction, N(0,1) distribution reached.



3 PID using TOF

After do some correction for time and resolution of TOF, we finished the PID code using TOF information.

In the process, we defined χ value :

$$\chi = \frac{T_{mea} - T_{exp} - \triangle T}{\sigma}$$

Particle with the least χ^2 is assumed to the correct one.

The valuables used in the process:

Input : IITRK , The track # of the particle.

Output : A integer value.1 is for π ,2 or K ,3 for p

In order for users to use the process freely, we also define a common block in the file tofwgt.inc. It include some useful valuables such as weight, probabilaty, and relative weight between K and π.

4 Check the code

Finilly we can get the identicate efficiency for the K and $\pi(seeFig.10andFig.11)$. (Fig.12 show the relatibe probalilaty between K and π)

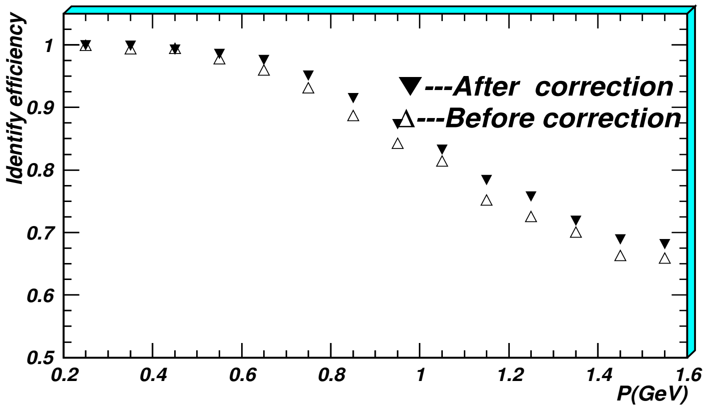


Fig.10 Identify Efficiency of π

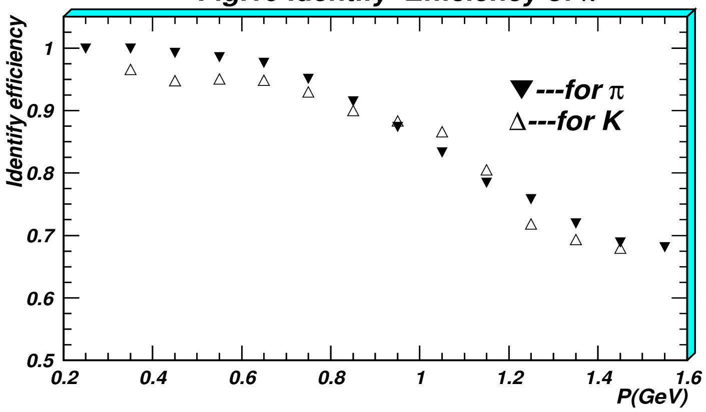


Fig.11 Identify Efficiency After correction

5 Conclusions

♠ What had done

We have studied TOF resolution vary with counter number , $cos\theta$, momentum, and time offset vary with momentum ,$cos\theta$ and Q value. we also have finished PID code using TOF imformation. Finally we gave the identication efficiency for K and π.

♠ How about the effect

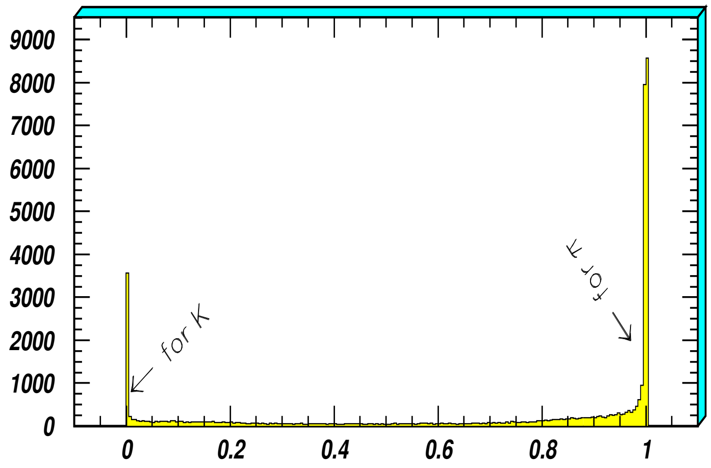


Fig.12 Relative Probability Between K and π

After the correction, we can see the χ distribution is N(0,1). The identication efficiency increased (about 3 percent in the high momentun range). The most importance is **the correction can minimise the difference between MC data and real data**. so the system error will reduce largely.

♠ What need to do next

We will do some correction for MC data. and we also can do some correction for proton, electron and muon. DEDX information also can be correct with J/ψ data, and then we can construct PID code with the information of TOF, DEDX, MUC and BSC.