Correction to BESⅡ TOF Time and Resolution

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August 8, 2001

- Motivation
- Sample Selection
- How to do the correction
- PID using TOF
- Check the code
- For M.C. data
- Compare M.C. data and real data
- Conclusion

1 Motivation

- **The Importance of TOF at BESΠ**

The BESΠ detector[1] is a large general purpose solenoidal detector at BEPC, the wide range of physics that can be studied requires the detector to have good momentum resolution and particle identification for charged tracks. there are two sub-detectors–TOF and dE/dX used to identify particles, especially for hadrons.

TOF has been upgraded at BESΠ, the resolution is about 180ps(forBhabha events). Comparing with BESI(330ps for Bhabha events), it has been improved much. The separation ability is greater than 3σ when the momentum is less than 0.8GeV for K/π, so BESΠ TOF can identify particles well.

- **TOF Calibration and Reconstruction**

When doing the TOF reconstruction, we must consider the effect of the transmiting time of the light in the scintillator, the 'time walk' when the pulse amplitude of PMT varies, the transit time of the photomultipliers and the different length of the cables. So we do the time correction for raw data. The corrected time is a function of pulse amplitude Q and hit point Z, including 10 terms[2] :

$$T^{offset} = T_0^{offset} + \frac{P_1 + P_2 * Z}{\sqrt{Q}} + (P_3 * Q + P_4 * Q^2 + P_5 * Q^3)$$
$$+ \frac{P_6}{1.157^2 + Z^2} + (P_7 * Z + P_8 * Z^2 + P_9 * Z^3) + P_{10}$$

Then the expected flight time of single end is:

$$T_{corr} = T_{raw} - T^{offset}$$

Since time is read out from both sides of the each counter, we can get two single times from both sides for a track. Then the measured time is the weighted means of the two single times[2]:

$$T_{meas} = \frac{T^1_{corr} * W_1 + T^2_{corr} * W_2}{W_1 + W_2}$$

$$W = A_1 + A_2 * Z + A_3 * Z^2$$

Where, Z is the hitted point. All the corrected parameters can be obtained by the calibration with electron selected from the Bhabha events.

- **PID using TOF and Particles Separation**

In order to identify particle using TOF, firstly we can get the momentum and the length of path from MDC. According to the kinematic formula :

$$T^i_{exp} = \frac{L\sqrt{P^2 + m_i^2}}{0.3P}$$

where, L is the path length of particle flights, P is the momentum of particle, m_i is the mass of particle i. we can get the expected time for each kinds of particles. the expected time T^i_{exp} is different from each other for a given momentum and path length. Next we define χ_i :

$$\chi_i = \frac{T_{mea} - T^i_{exp}}{\sigma},$$

where, T_{mea} is the measured time, T^i_{exp} is the expected time of particle i and σ is the time resolution. Then the particle with the least χ^2_i is assumed to be the correct one.

In order to describe the separated ability of TOF for particle A and particle B, the power of two particles seperation with TOF measurement is defined as:

$$SPRT = \frac{T_A - T_B}{\sigma_B}$$

here T_A and T_B are the flight times of particle A and particle B with the same path length , respectively, σ_B is the time resolution of particle B

- **The problems**

  According to the definition of χ, the distribution of χ should be a normal N(0,1) distribution for correct identified particles. However from the study we can see that χ is not a normal distribution especially for hadron samples as show in Fig.1, the mean of χ shifts, which means the measured time has systematic error and the σ does not equal to 1 reflect some problems in determination of the time resolution. The reason probably is that Bhabha events are used to do calibration, so the parameters of calibration can describe the behaviors of electrons well. However the behaviors of lepton and hadron are quite different in TOF, which results in the different pluse height and different energy loss in TOF, so the correction for the raw data when doing reconstruction does not fix well for each kinds of particles. Furthermore, the resoltion should depends on counter number, pulse amplitude and momentum. So the calibration parameters for bhabha events can not fix the hardons very well.

  Therefore, the corrections to TOF time and resolution are necessary to reduce the difference between the real data and MC data, to reduce the systematic error of the physics results and to inprove the identification efficiency.

2 Sample selection

In order to study TOF well ,we must get a sample as pure as possible. Since the samples will be used to study TOF, we must obey the following rules when selecting the samples:

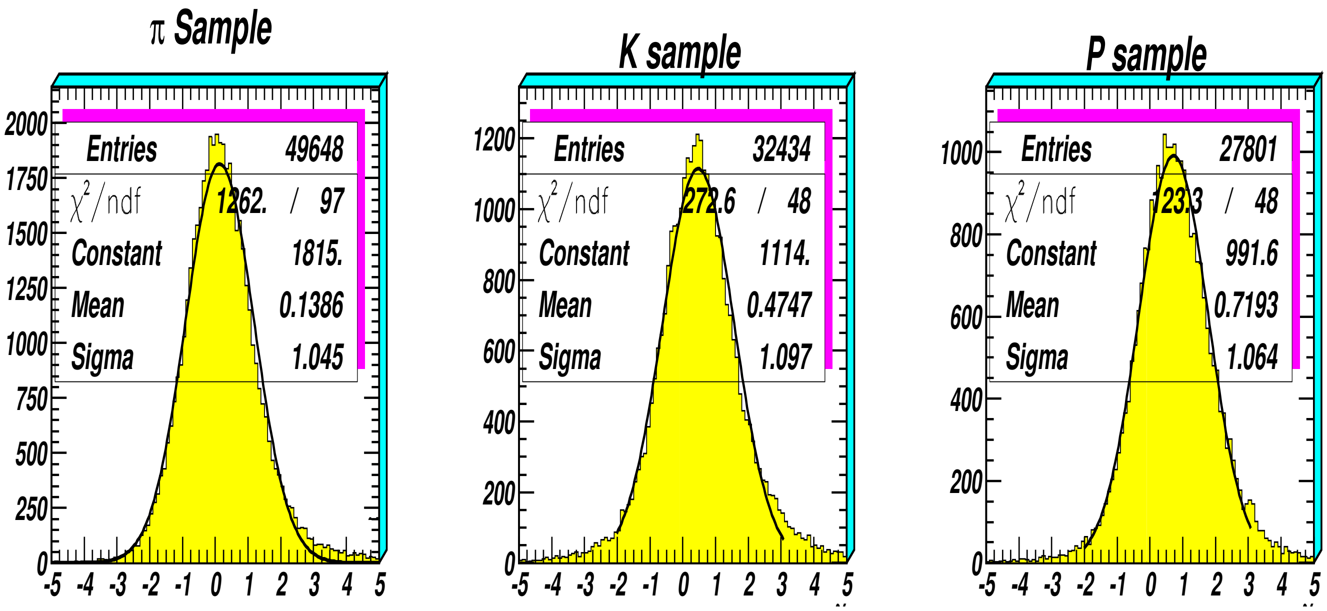

Figure 1: The χ distribution of π,k,p whout correction

1. Use dE/dX information to do PID.
2. Do not use TOF information .
3. Use the four-constraint kinematic fits .
4. Better that the samples come from the decay of a resonance.

- **π sample**

  We select π from the decay channel:

  $$J/\psi \to \rho\pi \to \pi^+\pi^-\pi^0$$

  Cut condition:

  1. $|M_{\pi^0} - 0.135| < 0.015GeV$
  2. $|M_{\rho^0} - 0.770| < 0.15GeV.or.|M_{\rho^+} - 0.770| < 0.15GeV.or.|M_{\rho^-} - 0.770| < 0.15GeV$
  3. $\chi_\pi < \chi_K.and.\chi_\pi < \chi_P.and.\chi_\pi < 15$

  Fig2. shows some plots of $J/\psi \to \rho\pi$

- **K sample**

  We select K sample from decay channels:

  $$J/\psi \to K^{*\pm}K^{\mp} \to K^{\pm}K^{\mp}\pi^0$$

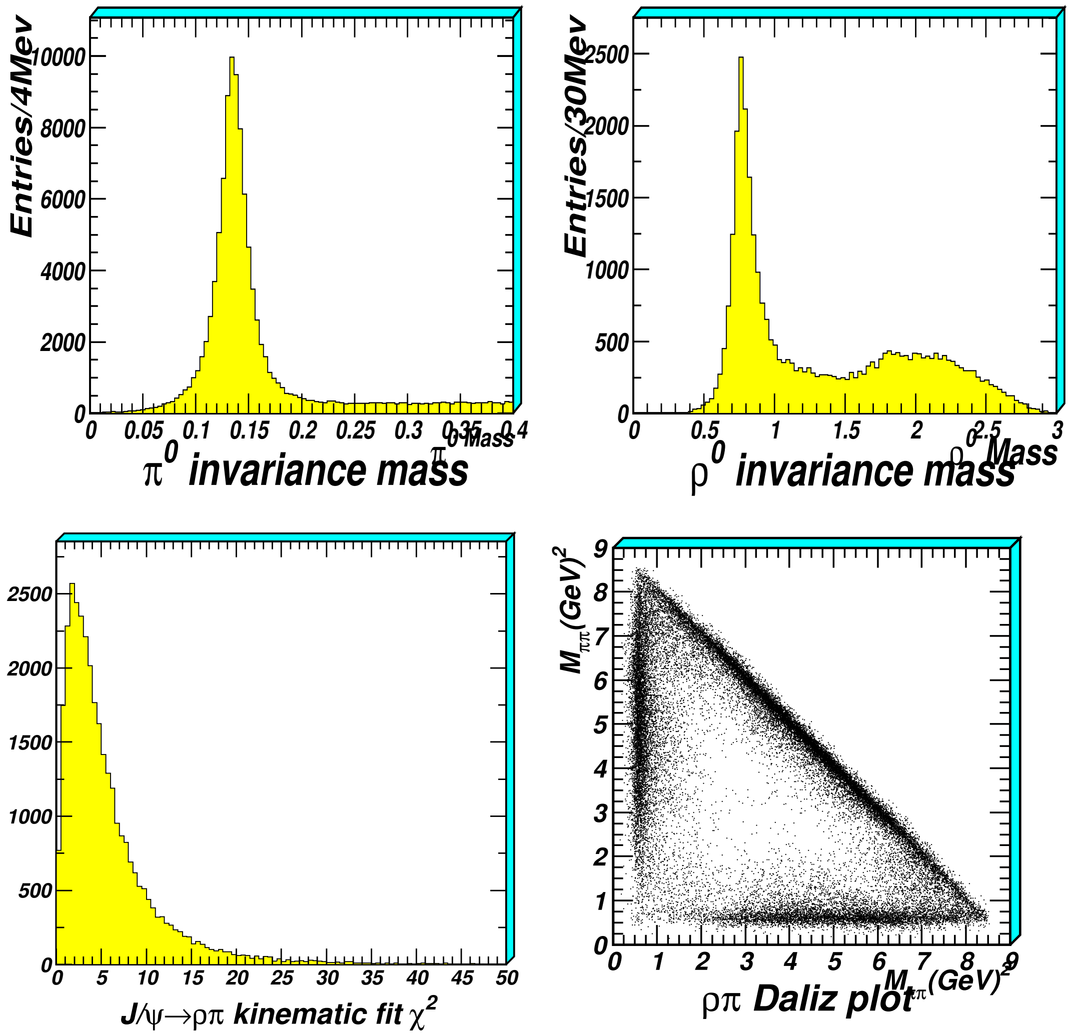

Figure 2: Some plots used in π sample selection

$$J/\psi \to K^{*\pm}K^{\mp} \to K^{\pm}K^{\mp}\eta$$

Cut condition:

1. $|M_{\pi^0} - 0.135| < 0.02GeV.or.|M_{\pi^0} - 0.547| < 0.03GeV$
2. $\chi_K < \chi_\pi.and.\chi_K < \chi_P.and.\chi_K < 15$
3. $|M_{K^{*+}} - 0.892| < 0.1GeV.or.|M_{K^{*-}} - 0.892| < 0.1GeV$

and

$$J/\psi \to \phi\pi\pi \to KK\pi\pi$$

Cut condition:

1. $\chi_{kk\pi\pi} < \chi_{4k}.and.\chi_{kk\pi\pi} < \chi_{4\pi}.and.\chi_{kk\pi\pi} < 15$
2. $|M_\phi - 1.019| < 0.01GeV$

Fig.3 shows some plots from $J/\psi \to K^{*\pm}K^{\mp}$ and $J/\psi \to \phi\pi\pi$.

- **p sample**

  We select K sample from the decay channel:

$$J/\psi \to \pi^0 p\bar{p}$$

$$J/\psi \to \eta p\bar{p}$$

Cut condition

1. $|M_{\gamma\gamma} - 0.135| < 0.03GeV.or.|M_{\gamma\gamma} - 0.547| < 0.04GeV$
2. $\chi_P < \chi_\pi.and.\chi_P < \chi_K.and.\chi_P < 15$

Fig.4 show some plots of cut conditions for p samples selection.

- **e and u sample**

  We select electrons from e and u from decay channel:

$$J/\psi \to \gamma e^+e^-$$

$$J/\psi \to e^+e^-$$

$$J/\psi \to u^+u^-$$

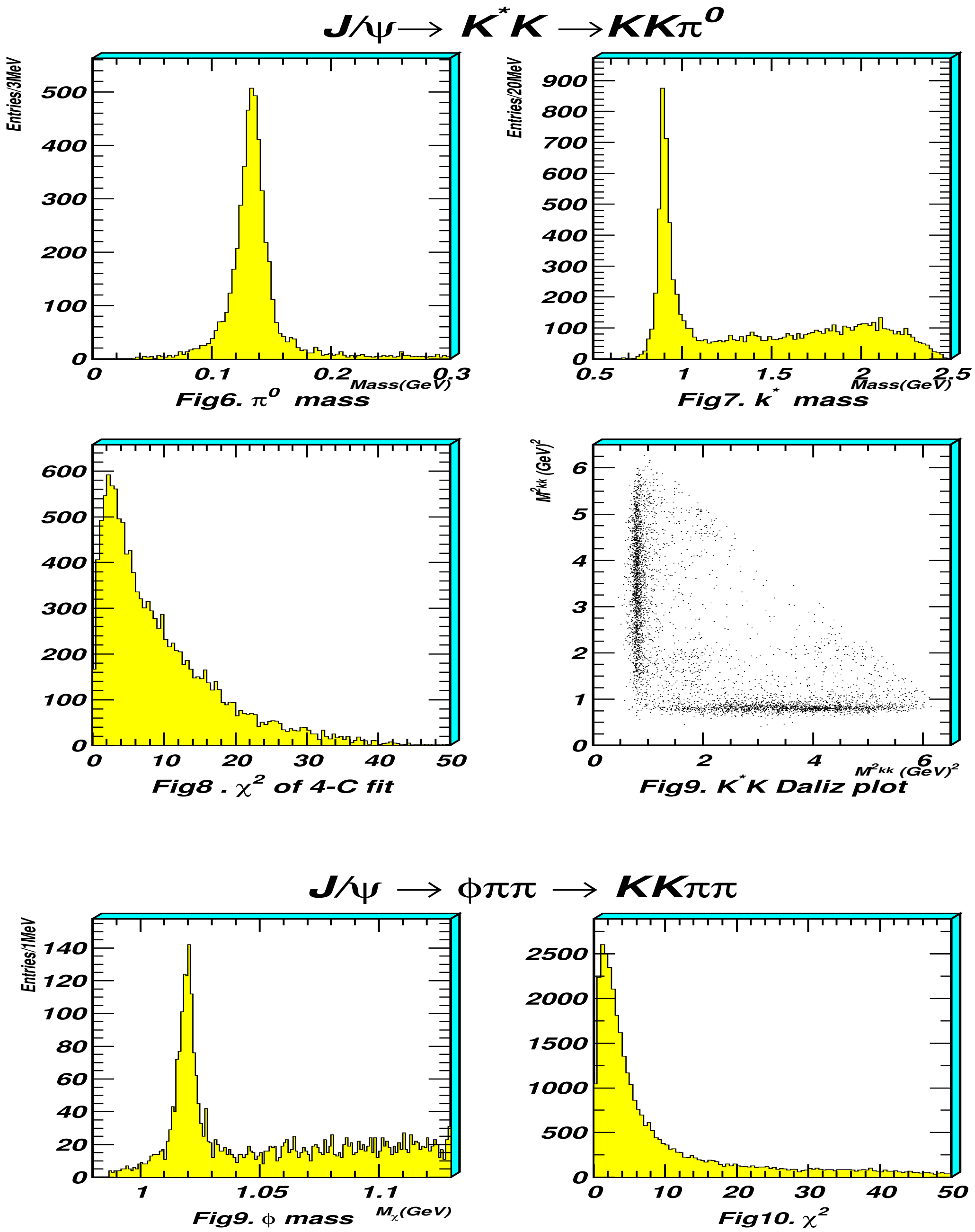

Figure 3: Some plots used in the K sample selection

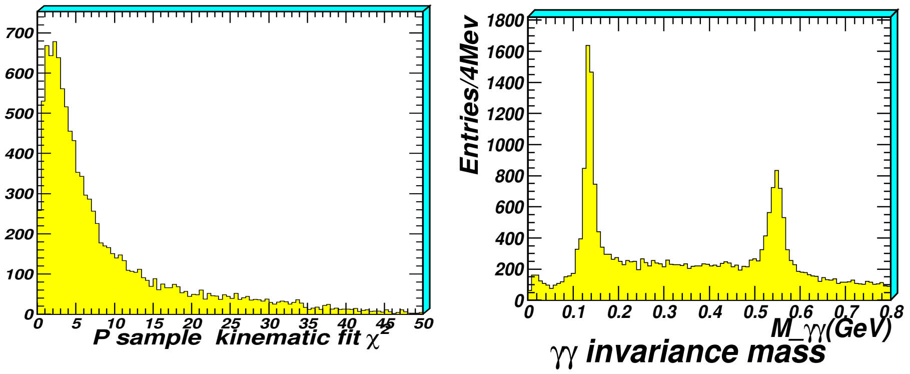

Figure 4: Some plots of cut condition for p sample selection

We select electrons and muons from BSC and Muon Counter respectively.

From the Dalitz plots and the invariant mass distribution of resonances, we can say that the samples are relatively pure.

3 How to do the correction

According to the definition of χ, the χ should be a normal distribution. But in fact, χ is not a normal distribution, the mean does not equal to 0 hints a systematic error in time measurement. The σ does not equal to 1 means resolution determanation have some problems. now we can study TOF time offset and resolution carefully, first we study time offset, then study resolution

- **Time Offset**

  Now we begin to study time offset, we define time offset as $\Delta T = T_{mea} - T_{exp}$. First we introduce how to get time offset briefly, according the defination of time offset , ΔT should be a gaussion distribution, we can get the ΔT distribution, fit the plot with gaussion function, then the mean is time offset.

  We can get time offset varying with cosθ, pulse amplitude Q and momentum for all kinds of particles(Fig.5,6).

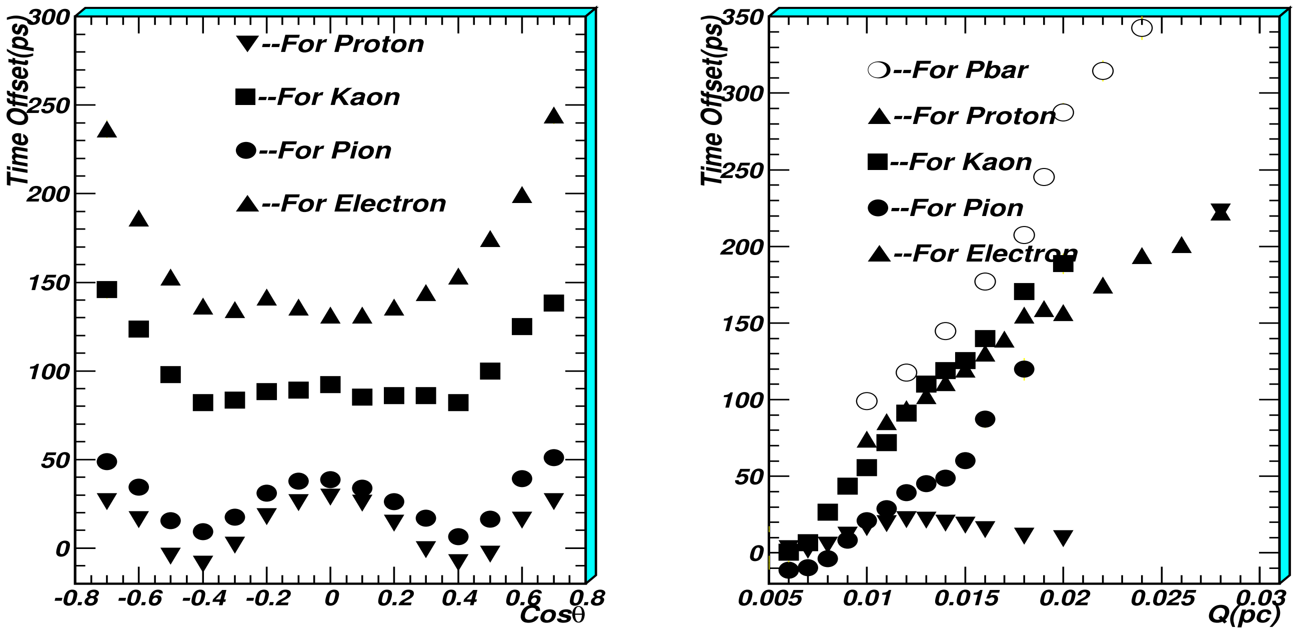

Figure 5: Time offset varying with $cos\theta$ and pulse amplitude without correction

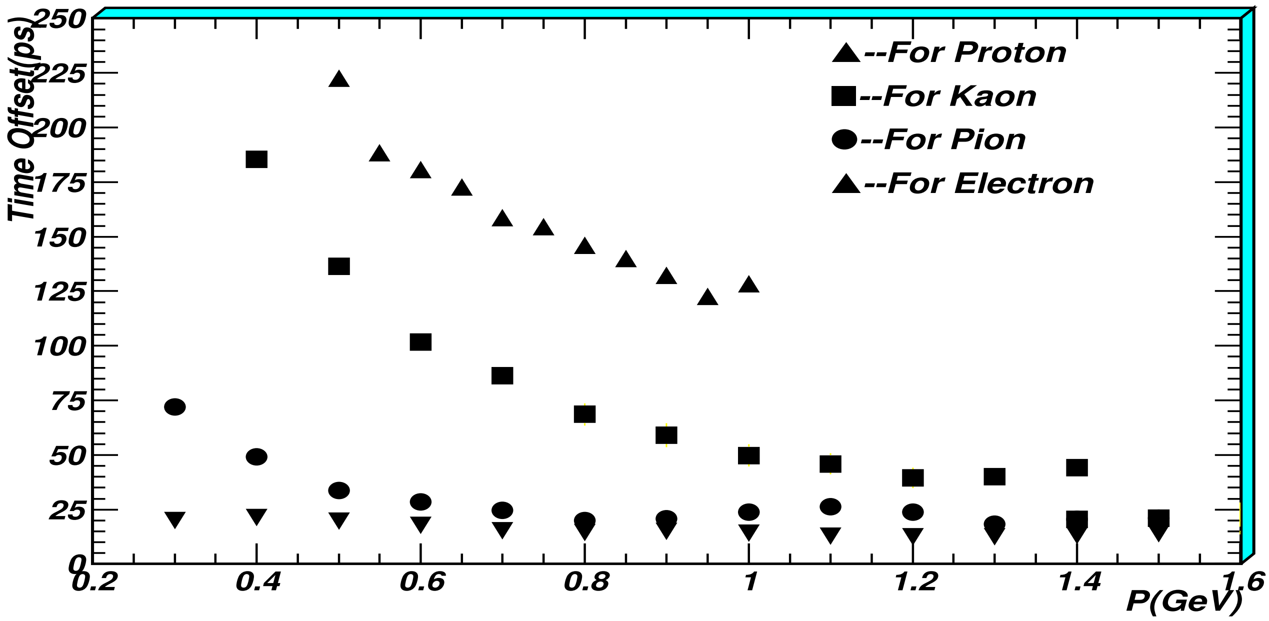

Figure 6: Time offset varying with momenta without correction

Due to different interation time and path length in TOF, the energy loss should be different when momentum or the direction of particle fight is different, so the pluse amplitude should depends on the momentum and $cos\theta$(Fig.7).

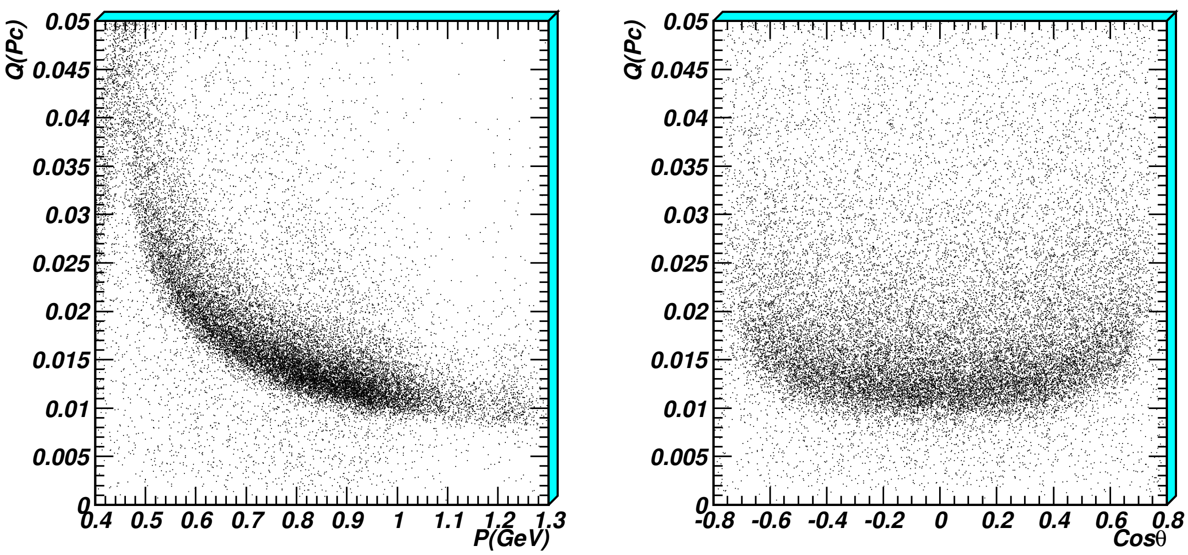

Figure 7: Pulse amplitude varying with momenta and $cos\theta$

From the above plots, we can see that :

1. The time offset depends on pulse amplitude, momentum and

$cos\theta$(Fig.5,6). Furthermore, the dependence is different for each kinds of particles. The behaviors in TOF is different for each kind of particle.

2. The time offset has oscillation when it varies with $cos\theta$ especially for electron and π, and the amplitude of oscillation is different for each kind of particle (Fig.5)
3. The pulse amplitude depends on momentum and $cos\theta$(Fig.7).
4. The behaviors of proton and antiproton in TOF are different, because the antiproton is antiparticle, and it will annihilate with materials in TOF.
5. The actions of lepton in TOF is better than hadrons except for oscillation, besause the calibration paramters are gotten from electron.

1. **Time offset oscillation**

   First we study the time offset oscillation when it varies with $cos\theta$ with electron sample. We can get the time offset as functions of momentum and pluse amplitude when $cos\theta$ in a small range(Fig.8) respectively. We can see the amplitude of time offset distribution is flat when $cos\theta$ is in a small range. Furthermore time offset is in different level when $cos\theta$ is in different small range. It means that the oscillation does not depend on momenta and pulse amplitude. We also can get the measured time and expected time as a function of $cos\theta$. Because electron momentum is about 1.5 GeV, the path of the electron in the MDC is almost straight, the measured time and expected time can be given by function $T = A/sin\theta$. we fit the expected time and measured time with the function, we can see that the expected time fitting is better than measured time fitting. We also subtract expected time fitting result from the expect time and measured time. then we can see time oscillation comes from the measured time(Fig.9). But we do not know the reasons of oscillation now.

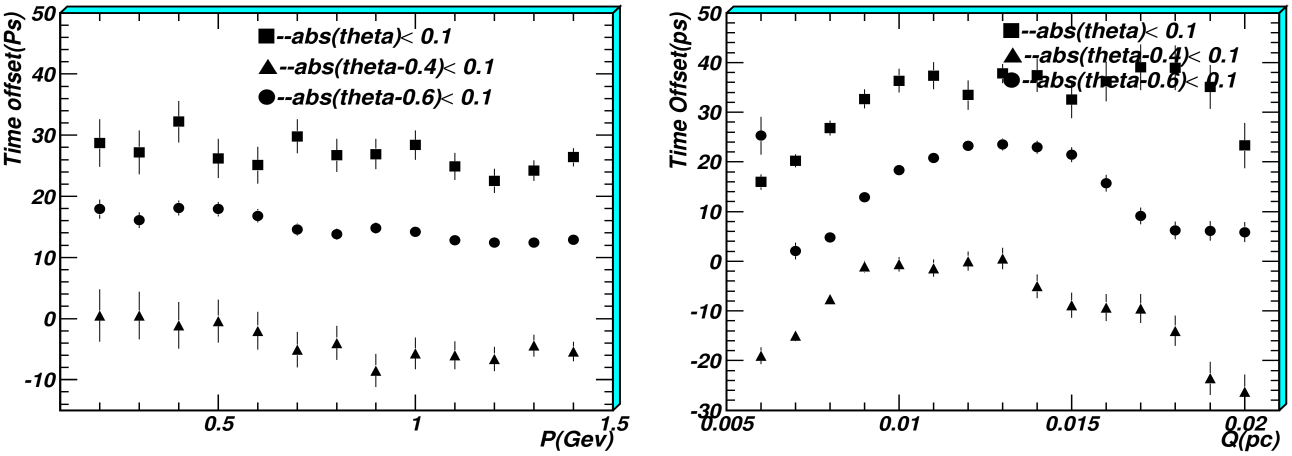

Figure 8: Time offset varying with momenta and Q value

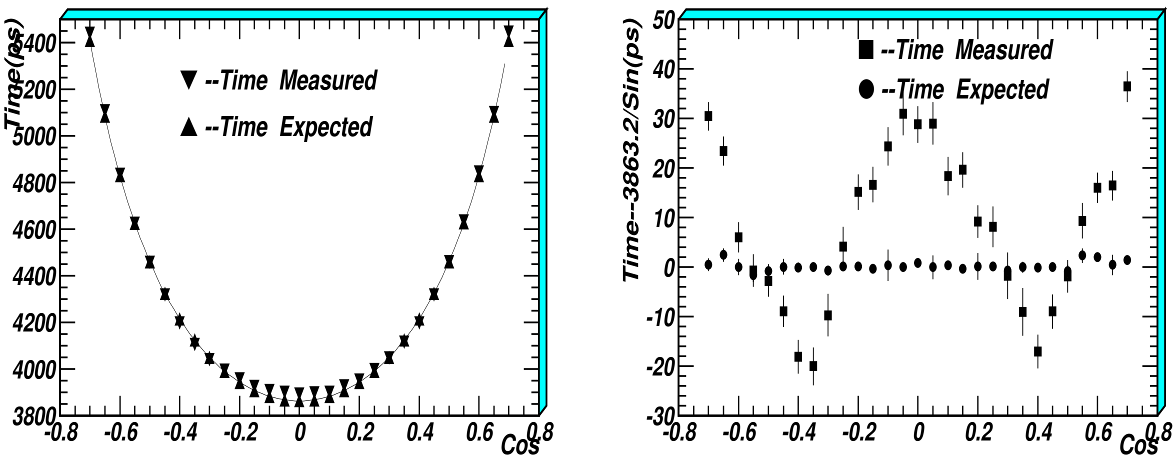

Figure 9: Time varying with $cos\theta$

We have known time offset depends on pulse amplitude, momentum and $cos\theta$, and the pulse amplitude depends on momentum and $cos\theta$. In order to derive the relation , we study time offset carefully with proton sample.

2. $cos\theta$ **dependence**

First we can study time offset varying with $cos\theta$ when the momenta and the pulse amplitude are in a small range(Fig.10(right)). From the plot we can see the amplitude of time offset distribution is flat when momentum and pulse amplitude is in a small range. we also can compare the time offset varying with momentum when the pulse amplitude in a small range but $cos\theta$ inside or outside $-0.3 - 0.3$ range(Fig.10(left)),Finally we get the time offset as a function of pulse amplitude when the momentum is in a small range and $cos\theta$ inside or outside $-0.3-0.3$ range(Fig.11). From the plots we see the time offset does not have too much different when it vary with momentum and pulse amplitude but $cos\theta$ inside or ouside $-0.3 - 0.3$, it means the $cos\theta$ dependence is not vary obvious.

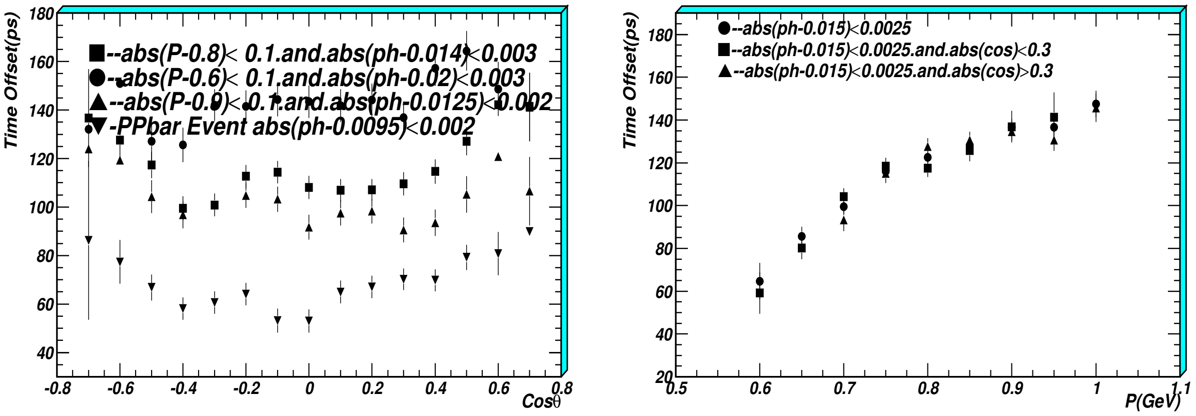

Figure 10: Time offset varying with $cos\theta$ and momenta of proton

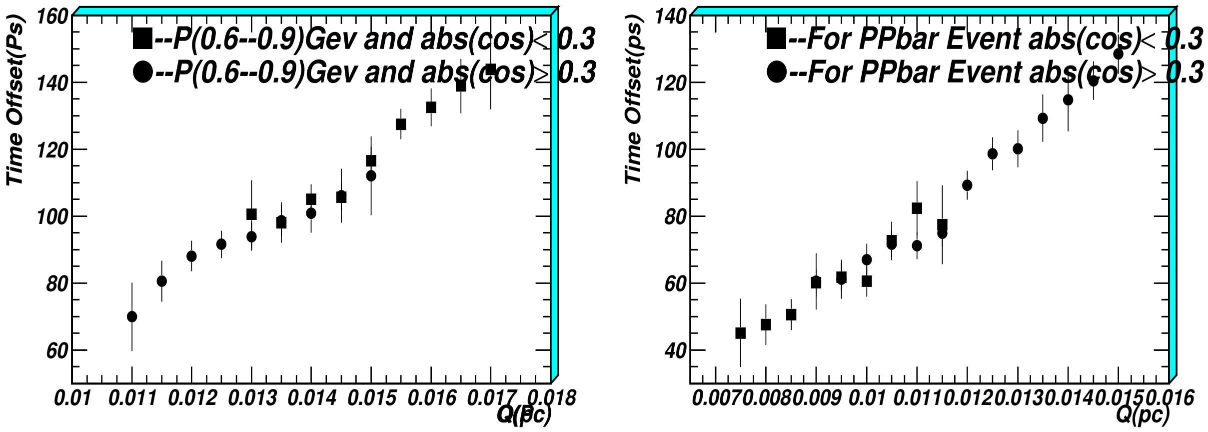

Figure 11: Time offset varying with pulse amplitude of proton sample

3. **Momenta dependence**

We also study the time offset varying with mometum when the pulse amplitude is in a small range(Fig.12).Then we can see time offset changed tendency is different when pulse amplitude is in all range and in a small range. It can be explained that the pulse amplitude dependence is much larger than momenta dependence, and the pulse amplitude depends on momenta, then the momenta dependence is coverd by pulse amplitude dependence when the pulse amplitude is in a all range.

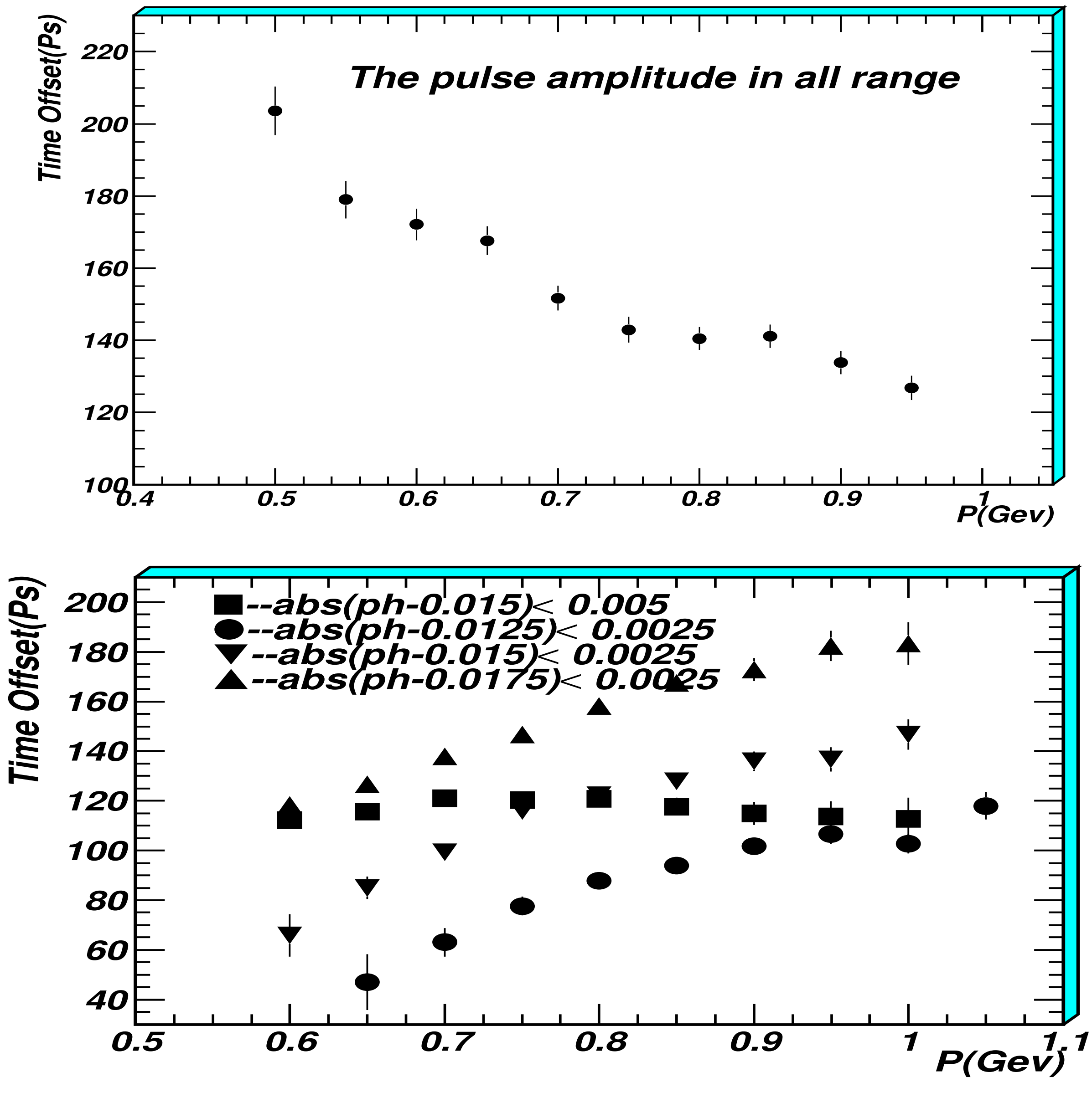

Figure 12: Time offset varying with momenta

4. **Pluse Amplitude dependence**

   We study the time offset varying with pulse amplitude (Fig.13). The slope of time offset varying pulse amplitude is big, which means the dependence of pulse amplitude is big. However we can not study it carefully due to the limited statistics.

5. **Time Correction**

   Comparing time offset dependence of pulse amplitude, $cos\theta$ and momentun, we can find the dependence of pulse amplitude is the largest, then is momentum dependence, , and $cos\theta$ dependence is the smallest. the pulse amplitude dependence is largest can be explained that the attenuate time in TOF is different for each kinds of particle, then the rising time of pulse wave is different for each kinds of particle, but we use Bhabha events to do calibration, the calibration parameters can fix the electrons well, but for other particles especial for hadrons, the time correction is not very exact during data reconstruction, also in the data reconstruction, pulse amplitude correction is the most main term for raw data, so the pulse amplitude dependence is the largest for time offset. We can do time correction step by step, firstly we do pulse amplitude correction, then do momentum correction, lastly we do $cos\theta$ correction. Because all the dependence is different for each kinds of particles, we do the correction for each kinds of particles respectively, also the dependence is different for proton and antiproton, so we do the correction for proton and antiproton respectively.

   (a) Do pulse amplitude correction.

      Firstly we do pulse amplitude correction,we can get the time offset varying with pulse amplitude for all kinds of particle(Fig.13), fit the plots with function $\triangle T1 = A + B *$

$EXP(-C*Q)$(Fig.13), where Q is pulse amplitude, and get the dependence between time offset and pulse amplitude.

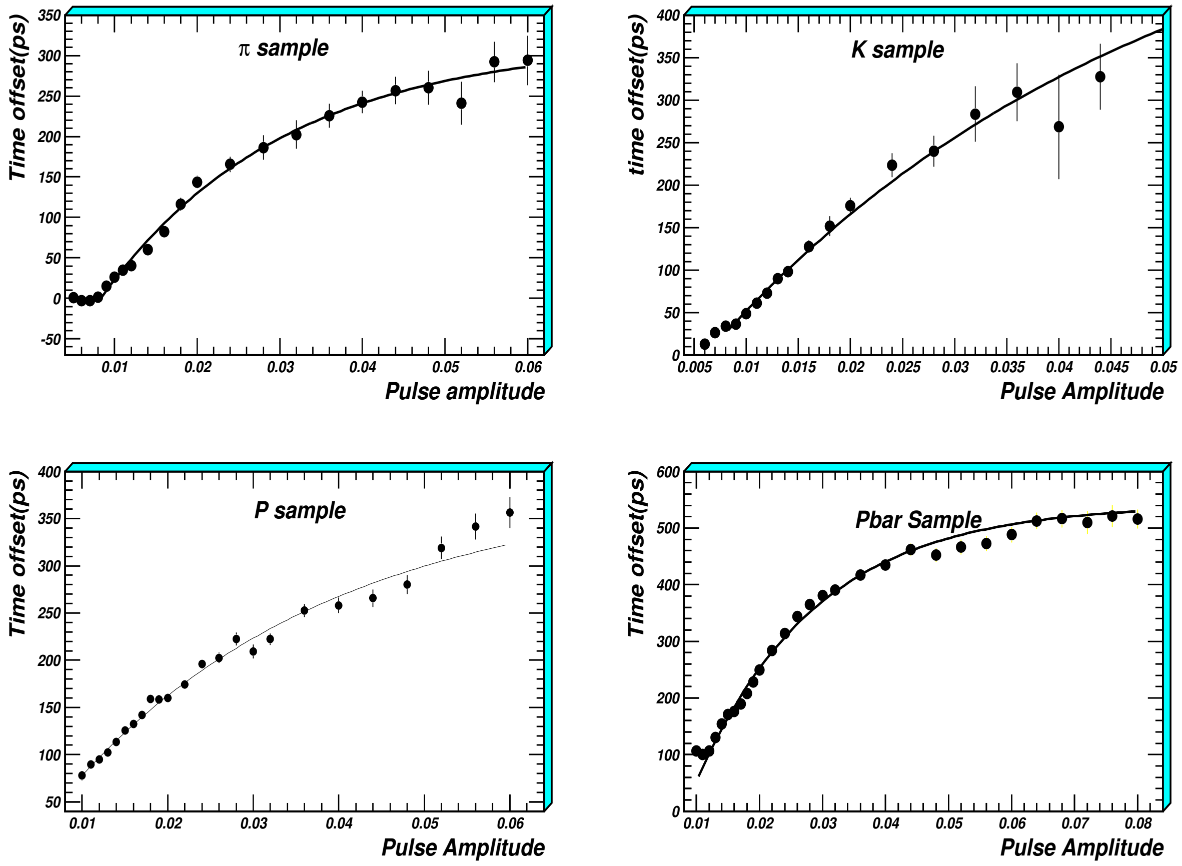

Figure 13: Time offset varying with pulse amplitude

(b) Do momenta correction.

secondly we can define $\triangle T2 = T_{mea} - T_{exp} - \triangle T1$ and get the $\triangle T2$ as a function of momentum(Fig.14). Fit the plots with function $T1 = A + B * EXP(-C * P)$, and get the dependence between momenta and time offset.

(c) Do $cos\theta$ correction.

Lastly we also can define $\triangle T3 = T_{mea} - T_{exp} - \triangle T1 - \triangle T2$. and get $\triangle T3$ varying with $cos\theta$(Fig.15) ,fit the plots with function $\triangle T3 = A + B * cos^2\theta + C * cos^4\theta$, and get the dependence between $\triangle T3$ and $cos\theta$.

After all the correction for time offset, Then the total

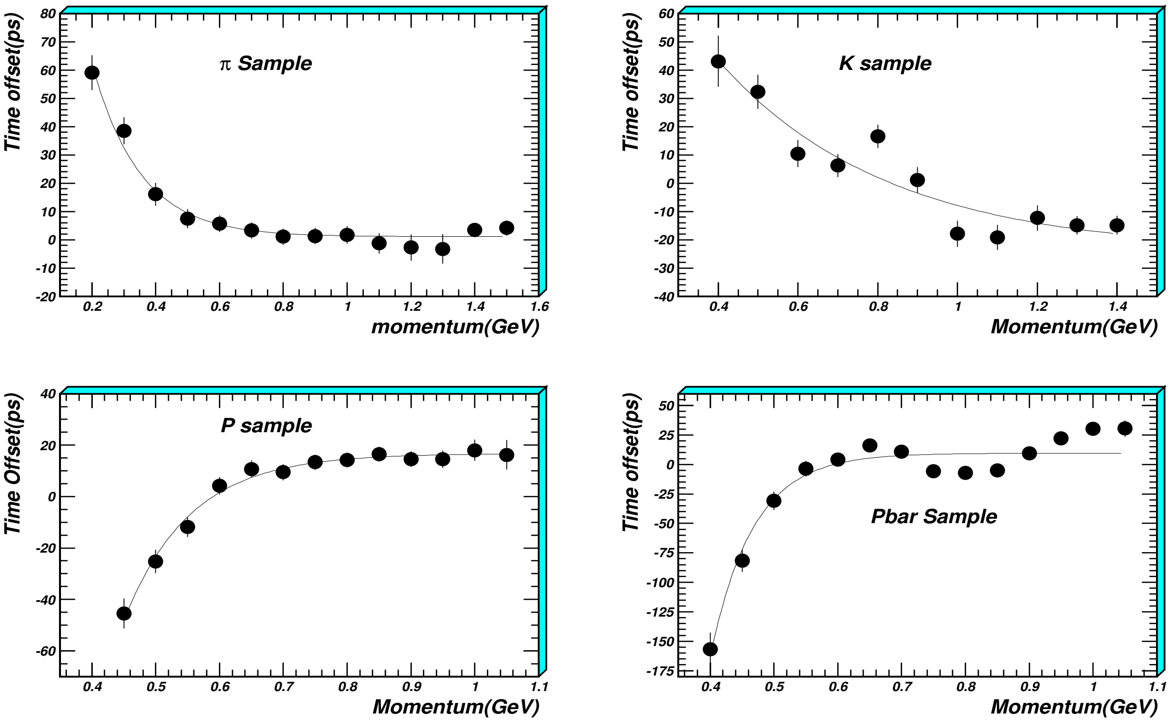

Figure 14: Time offset varying with momenta after pulse amplitude correction

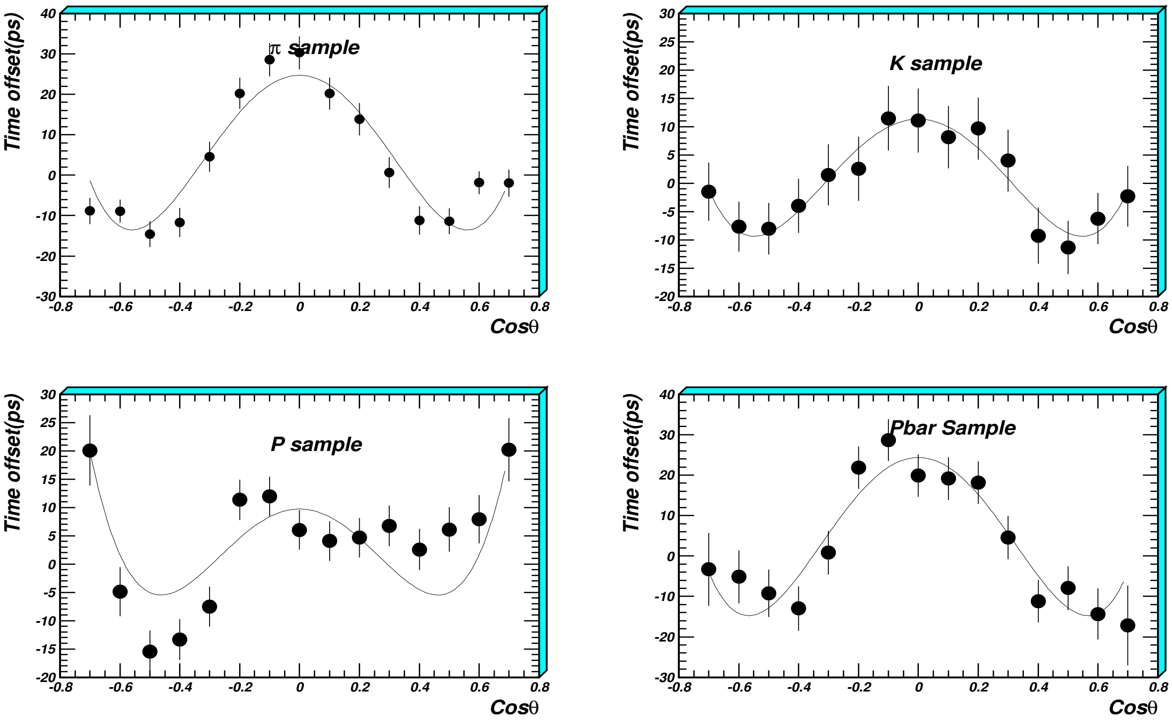

Figure 15: Time offset varying with Cosθ after momentum correction

time correction is

$$\triangle T_{tot} = \triangle T1 + \triangle T2 + \triangle T3$$

- **TOF resolution**

We known that the σ of χ does not equal to 1, which means some corrections need to be done to determine the time resolution. TOF is composed of 48 block scintillation counters, due to some differences of each scintillation counters, the resolution for each counter is different from each other. Time is read out by PMT, since PMT resolution depends on the number of photon, so the resolution should depend on pulse amplitude. After the particle hit TOF, the transing time of photon in TOF will be difference, then it will affect the TOF resolution, so the resolution will depend on $cos\theta$. Lastly due to the uncertain of path and momentum will contribute to TOF resolution, maybe TOF resolution will depend on momentum.

Now we introduce how to get the TOF resolution briefly. After doing all time offset correction, we can define $\Delta T = T_{meas} - T_{exp} - \Delta T_{tot}$, then the distribution of ΔT should be a gaussion distribution, fit ΔT with gaussion function, then σ is the resolution of TOF. Fig 16 show the resolution varying with pulse amplitude, cosθ, momentum and counter number for pion sample.

From the plots, we can see the resolution depend on counter number, pulse amplitude and $cos\theta$, but it does not depend on momentum. As time offset study, pulse amplitude will depend on $cos\theta$ and momentum, then all the elements combine together, so we should study the relation carefully.

We can get the resolution varying with pulse amplitude for electron sample(Fig.17(right)), Fig.17(left) show the resolution varying with cosθ for hadron sample and muon sample. Fig.18(right) show

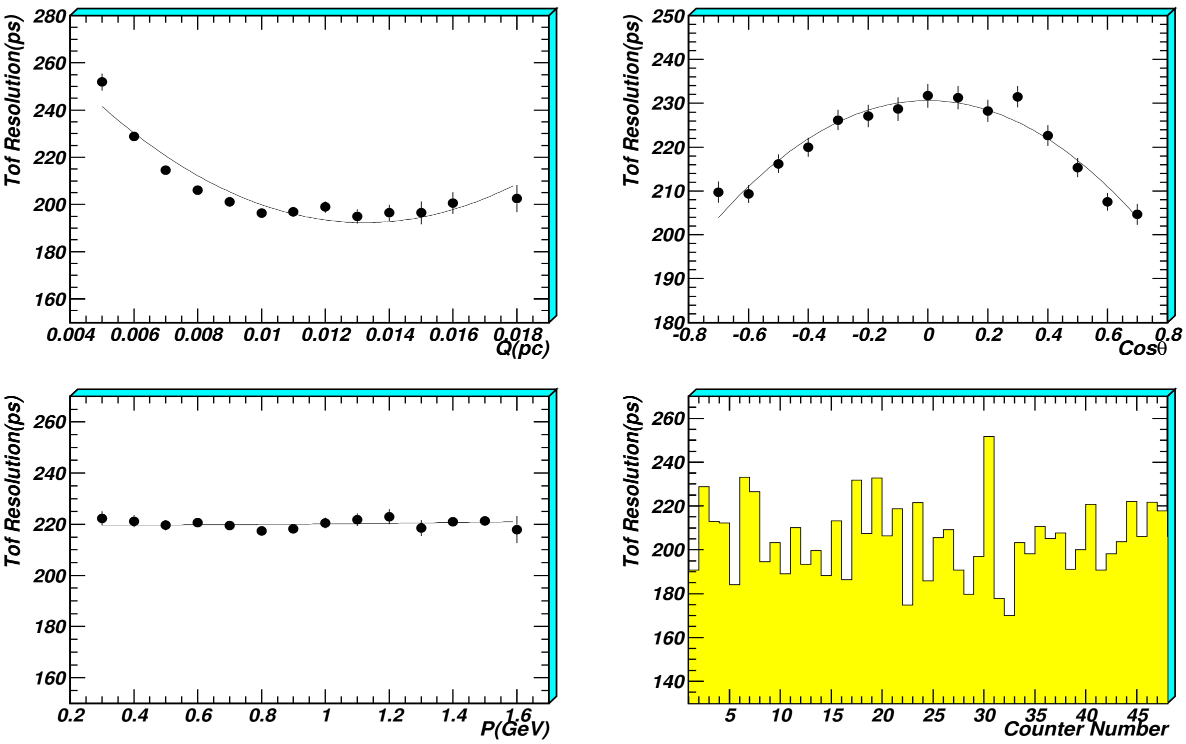

Figure 16: the resolution distribution for pion sample

the resolution varying with cosθ when the pluse amplitude in some range and in full range, from the plot we can see the resolution distribution is flat when the pulse amplitude in small range, also the resolution is in the different level when the pulse amplitude in the different range. Fig.18 left show the resolution vary with pulse amplitude when the cosθ is in small range, from the plot we can see the resolution distribution does not have much different when the cosθ in differnt range. From the above plots, we can get the dependence between resolution and pulse amplitude is much bigger than dependence between resolution and cosθ. So, when doing the resolution correction, firstly we can get the resolution as a function of pulse amplitude, sencondly we do cosθ correction, lastly we doing counter number correction. because the number of sample is limited, we can not study the resolution varying with momentum when pulse amplitude or cosθ in small range, so we do not do momentum correction for resolution, but we can check the result after doing all correction, we can find that it need not do momentum correction for resolution.

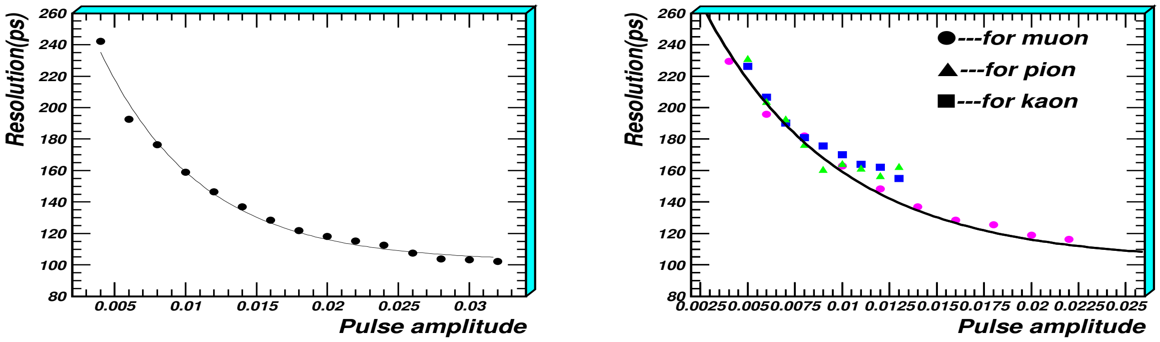

Figure 17: the T_{end} resolution distribution

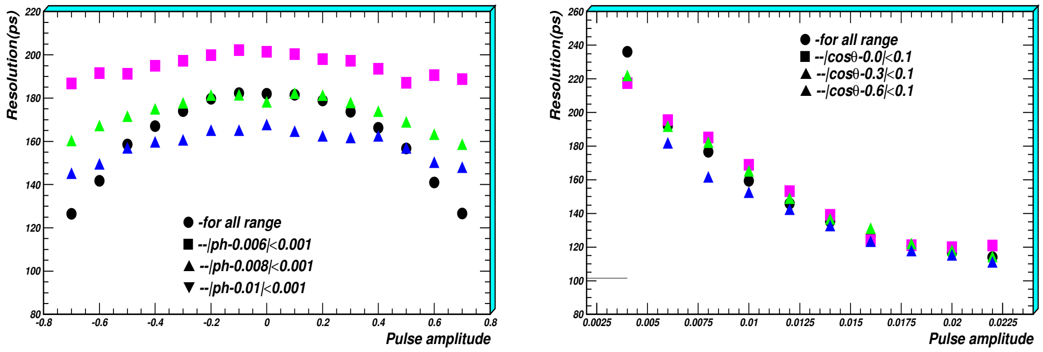

Figure 18: the T_{end} resolution varys with $cos\theta$

1. **Pulse amplitude dependence**

   We can get the resolution varying with pulse amplitude for all kinds of particle(Fig.19), fit the plot with fuction $\sigma_q = a + b * exp(-c * ph)$, where, ph is the pulse amplitude, and get resolution as a function of pulse amplitude.

2. **The $cos\theta$ correction**

   After get the resolution as a function of pulse amplitude, we define $\chi = \frac{T_{measure} - T_{exp} - \Delta T}{\sigma_q}$, fit χ with gaussion function, get the σ of χ varying with $\cos\theta$ for all kinds of particles, fit the plots with function $F_{cos} = a + b * cos^2\theta$, get the $cos\theta$ correction factors, then the resolution is $\sigma_{cos} = \sigma_q * F_{cos}$ after $cos\theta$ correction.

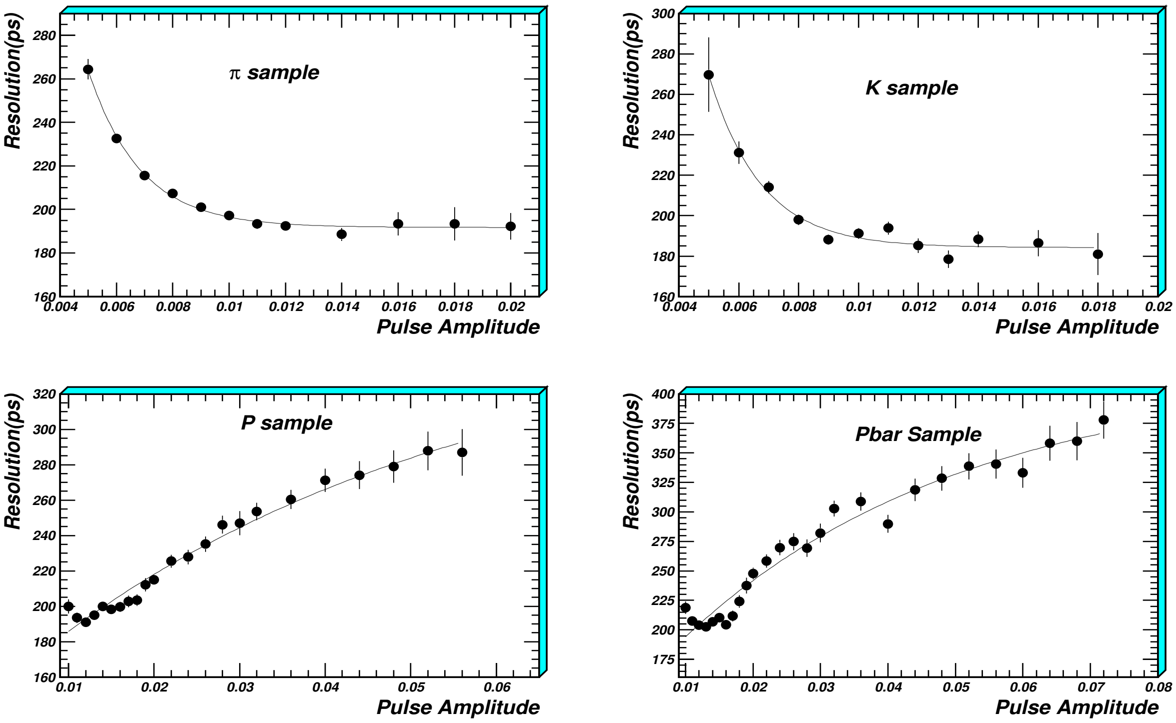

Figure 19: the resolution varys with pulse amplitude

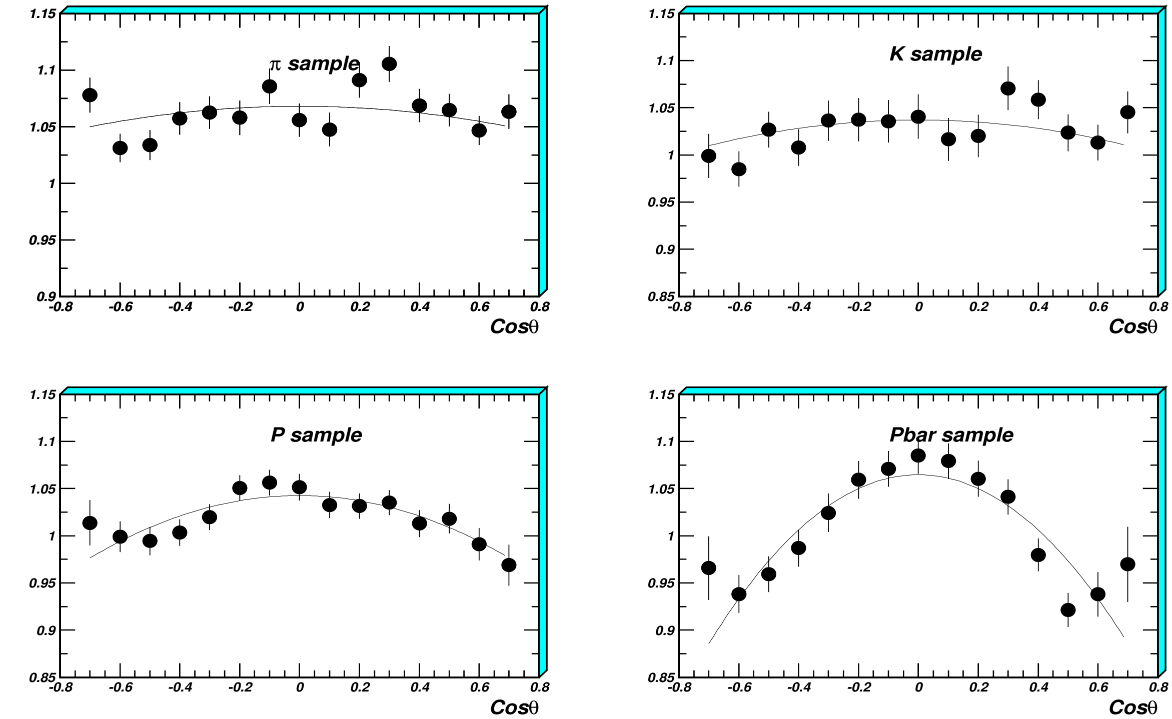

Figure 20: the resolutionvarys with $cos\theta$

3. **Counter numbers dependence**

After doing $cos\theta$ correction to resolution, we define $\chi = \frac{T_{measure}-T_{exp}-\Delta T}{\sigma_{cos}}$, ang get the σ of χ varying with counter number for all kinds of particles(Fig.21), then we can get the counter number rescolution correction factors F_i, then the resolution is $\sigma_{tot} = \sigma_q * F_{cos} * F_i$.

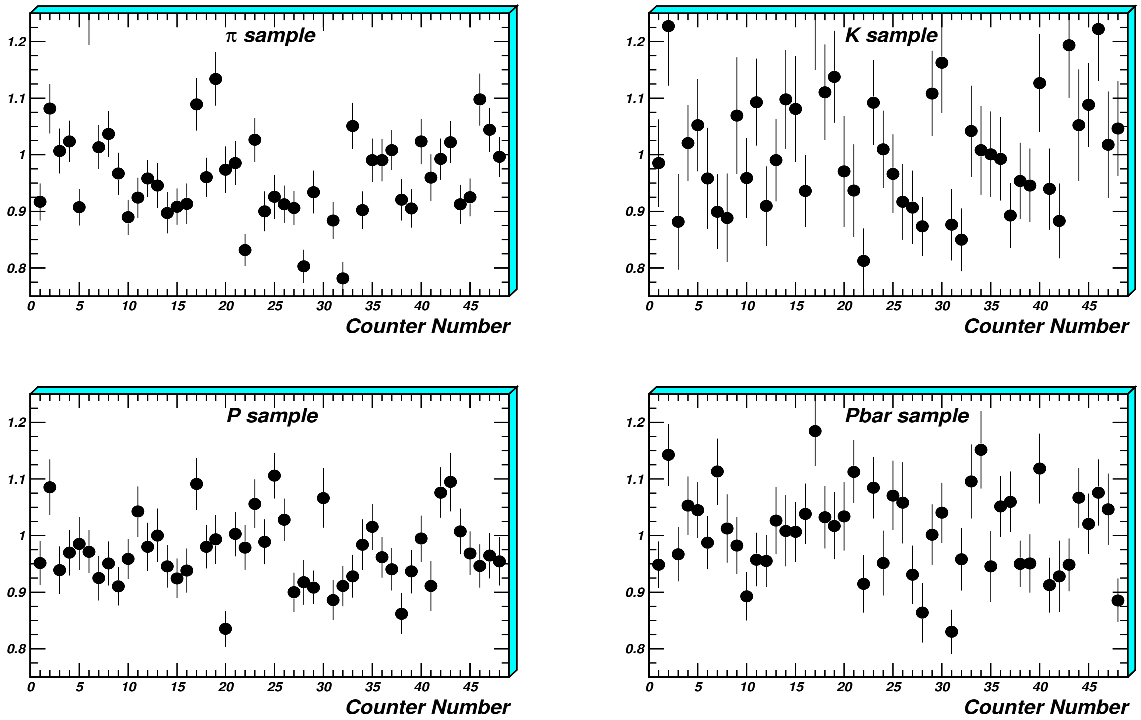

Figure 21: The resolution varys with Counter number

So the resolution depends on pulse amplitude, cosθ, and counter number:

$$\sigma = (A + B * exp(-C * ph)) * (D + E * cos^2\theta) * F_i$$

where ph is pulse amplitude of PMT.

- **Compare the data between first run set and second run set**

We have taken 50M J/ψ data between 1999-2000 and 2000-2001, now we can campare the time offset and resolution between 1999-2000 and 2000-2001 roughly with pion sample.

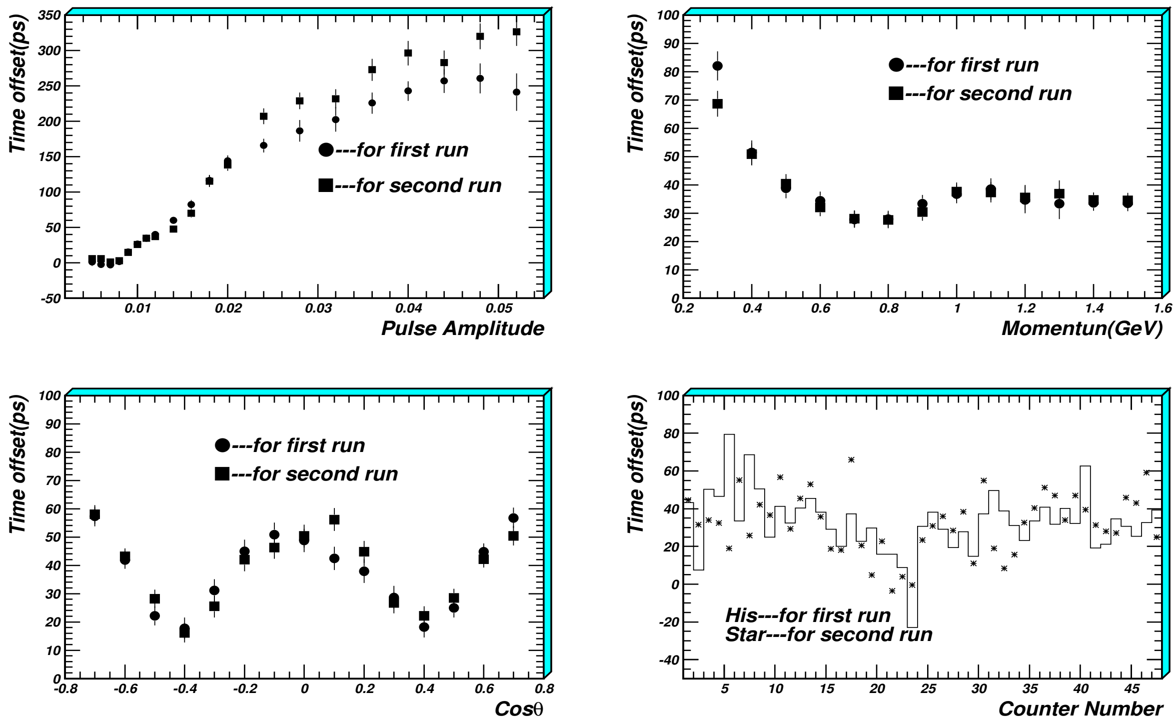

Figure 22: Compare the time offset between firest run and second run

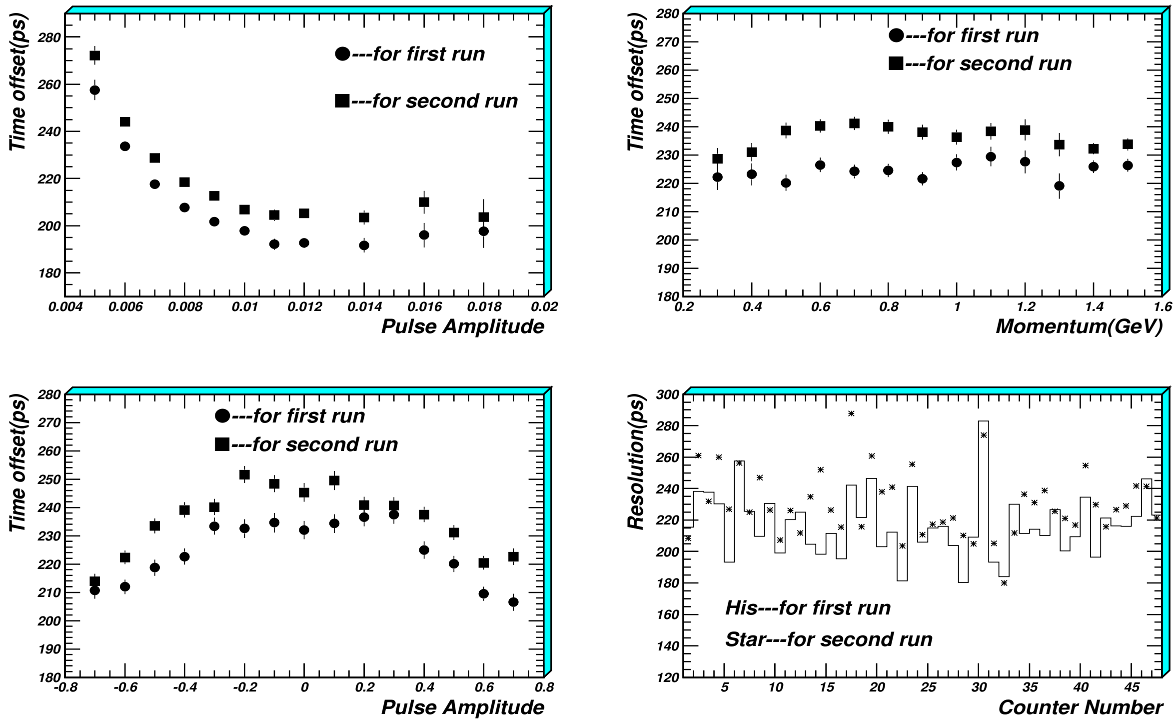

Figure 23: Compare the resolution between firest run and second run

From the compare, we can see the time offset do not have too much different between the first run set and second run set, but for the resolution, the first run set is better than the second run set. In order to do the correction well, we do the correction including time offset and resolution for two run set J/ψ data respectively.

4 PID using TOF

We have finished the code for particle ID using TOF information after corrections.

We defined χ value as:

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

Where $\triangle T$ is the correction of time. σ is the rescoultion after correction, it is a function of pulse amplitude, $cos\theta$ and counter number. Particle with the least χ^2 value is assumed to be the correct one.

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

5 Check the code

After all correction, now we can check the results.

First we check the time offset varying with pulse amplitude, momentum, $cos\theta$ and counter number for all kinds of particles

- Time offset varying with pulse amplitude.
- Time offset varying with momentum

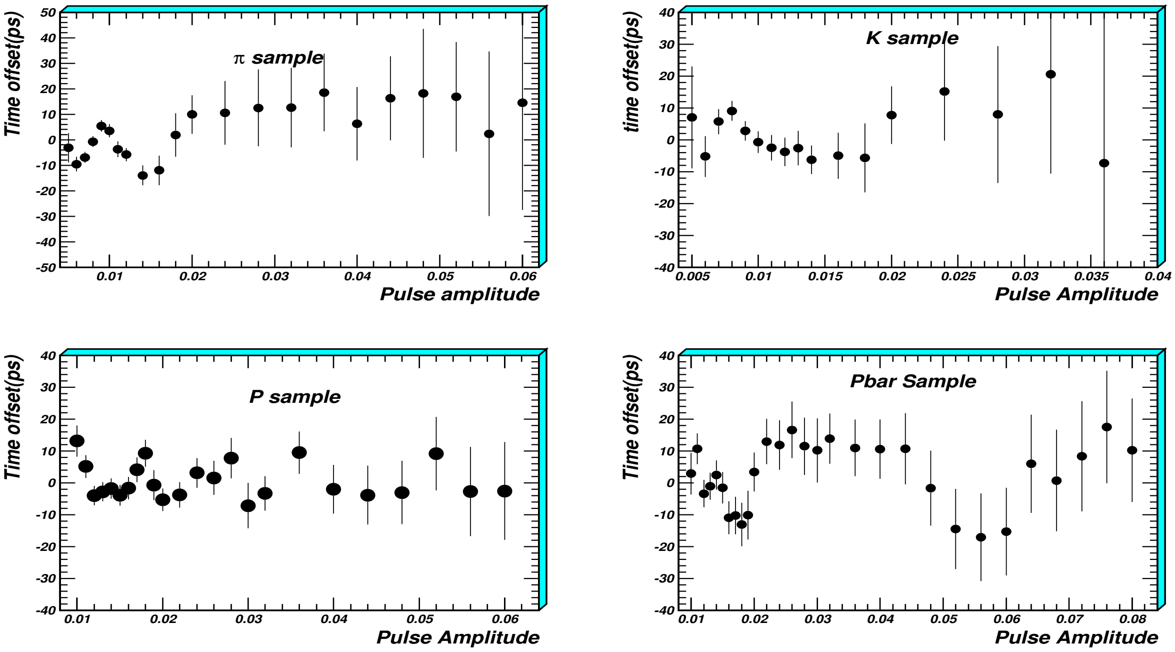

Figure 24: Time offset varying with pulse amplitude after correction

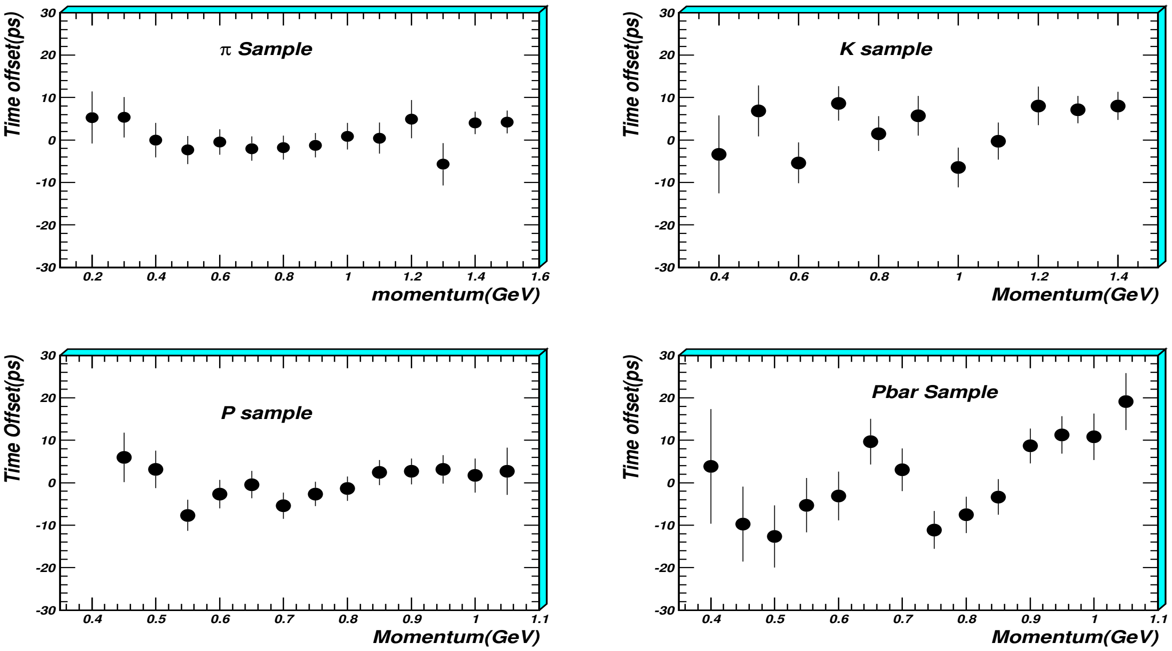

Figure 25: Time offset varying with momentum after correction

- Time offset varying with $cos\theta$
- time offset varying with counter number

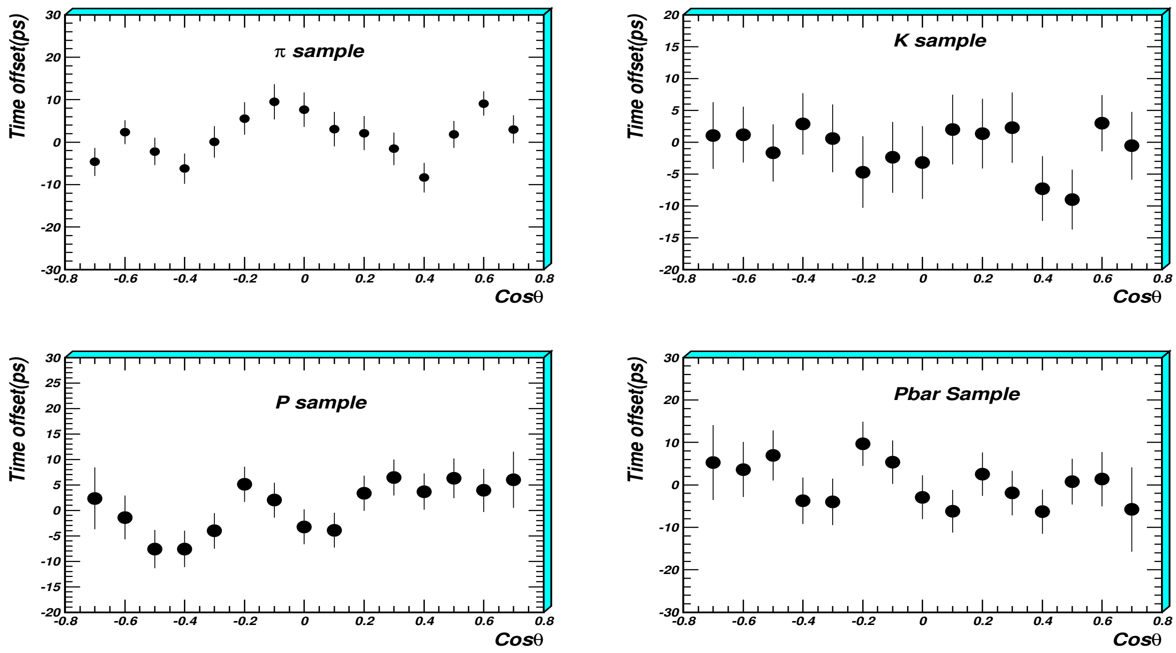

Figure 26: Time offset varying with $cos\theta$ after correction

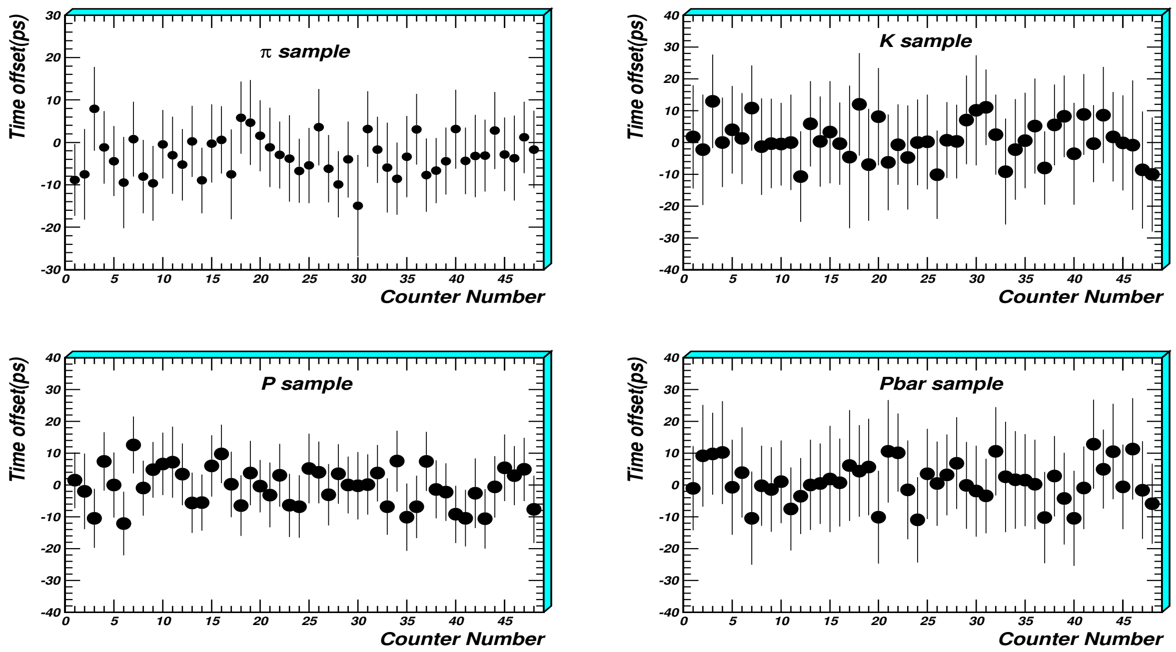

Figure 27: Time offset varying with counter number after correction

Fron the plots, we can see time offset is very close 0 when it vary with pulse amplitude, $\cos\theta$, momentum and counter number.

After the correction, χ should be a normal distribution. now we can check χ distribution after correction.

- The mean and σ of χ varying with pulse amplitude

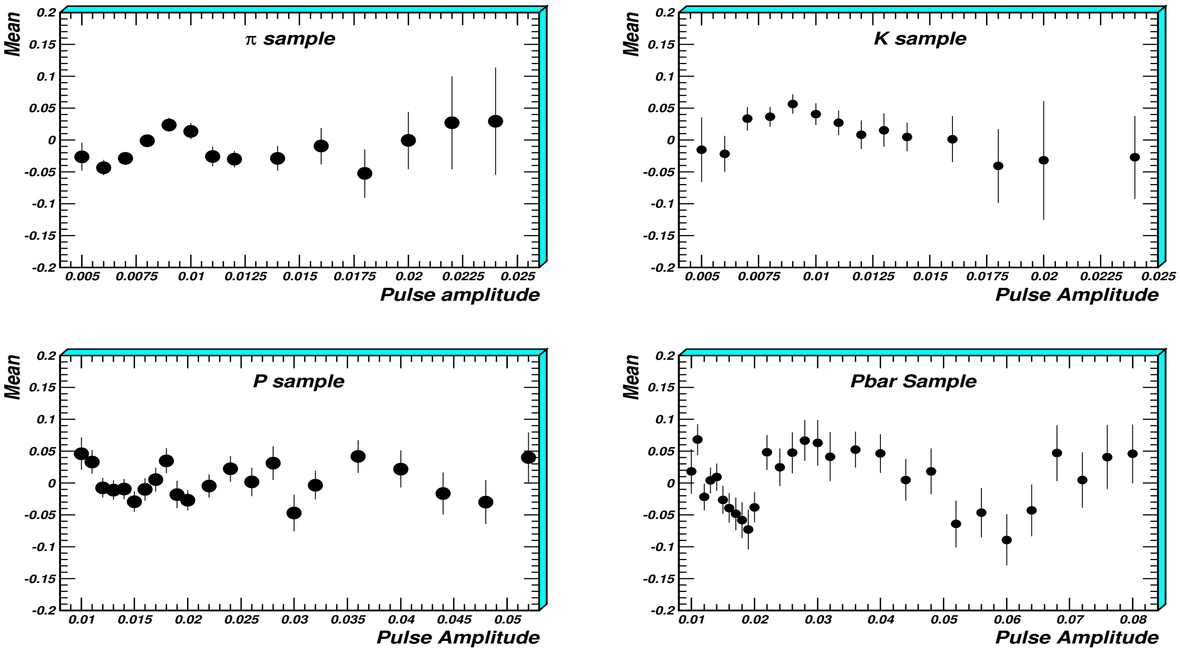

Figure 28: The mean of χ varying with pulse amplitude

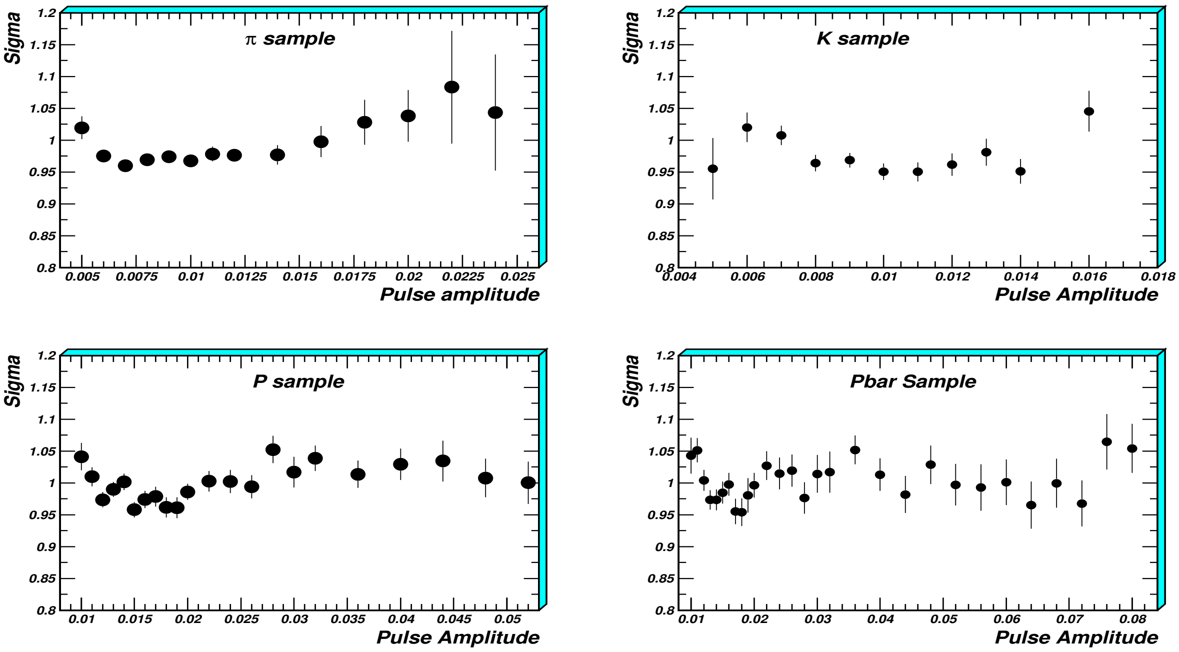

Figure 29: The sigma of χ varying with pulse amplitude

- The mean and σ of χ varying with momentum

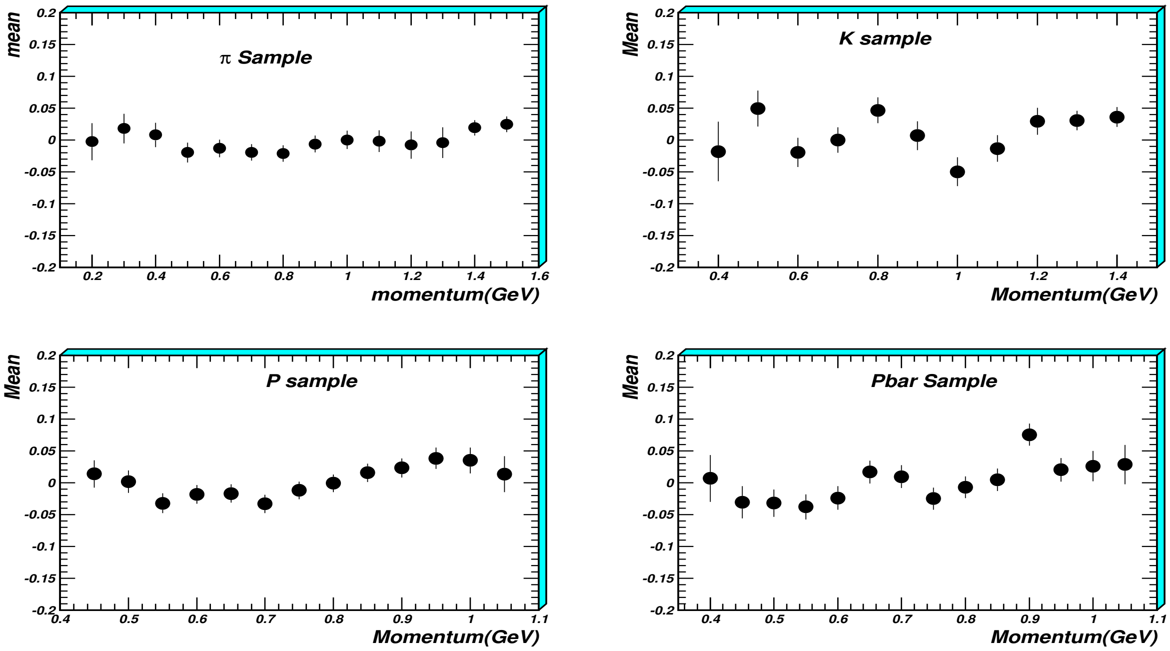

Figure 30: The mean of χ varying with momentum

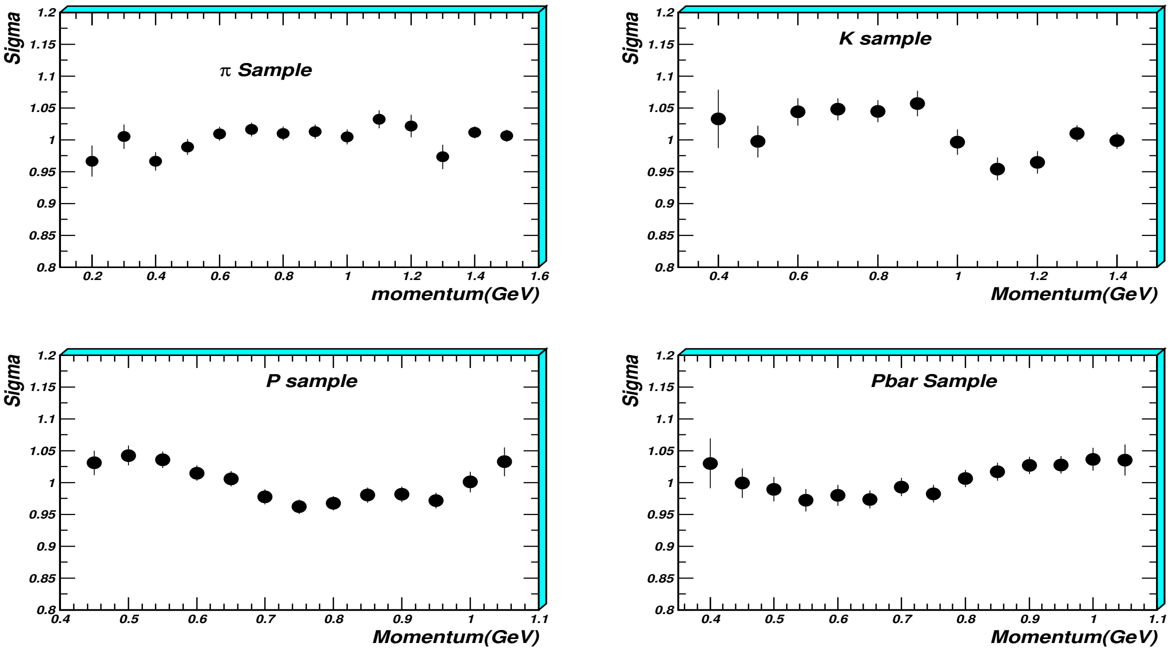

Figure 31: The sigma of χ varying with momentum

- The mean and σ of χ varying with $cos\theta$

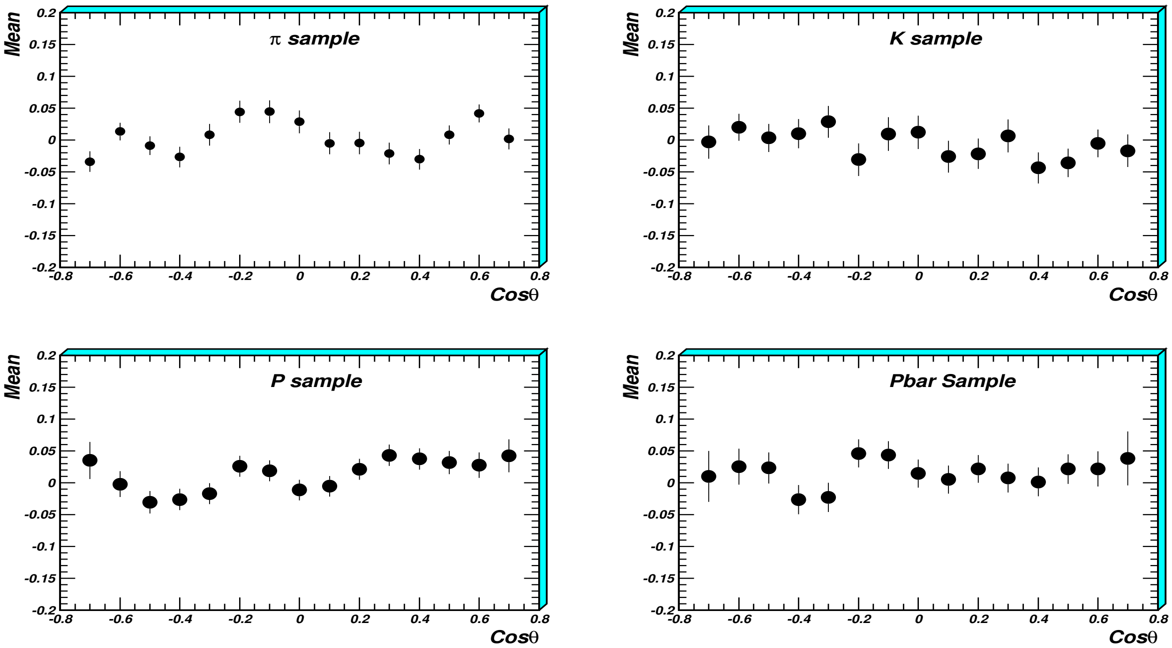

Figure 32: The mean of χ varying with $cos\theta$

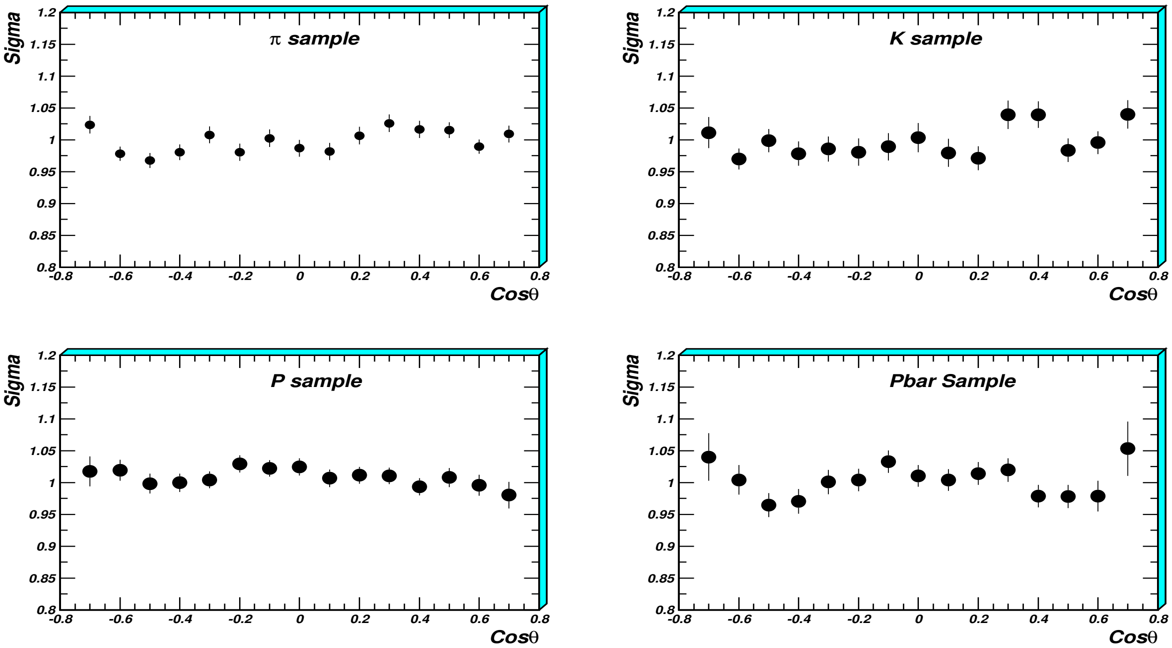

Figure 33: The sigma of χ varying with $cos\theta$

- The mean and σ of χ varying with counter number

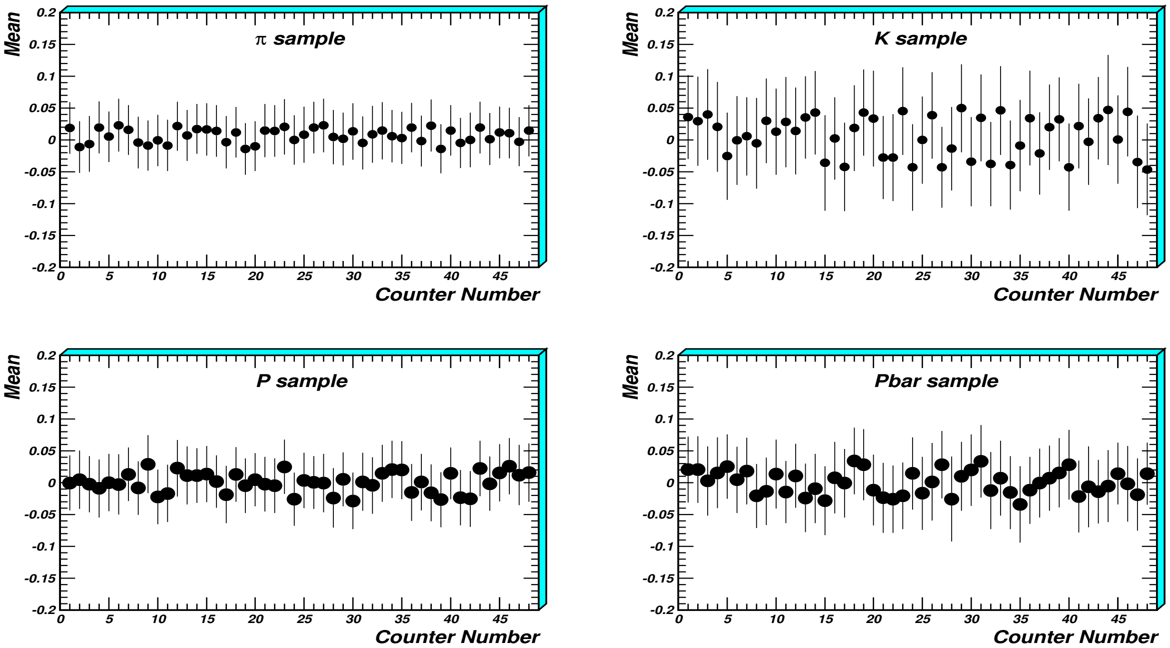

Figure 34: The mean of χ varying with counter number

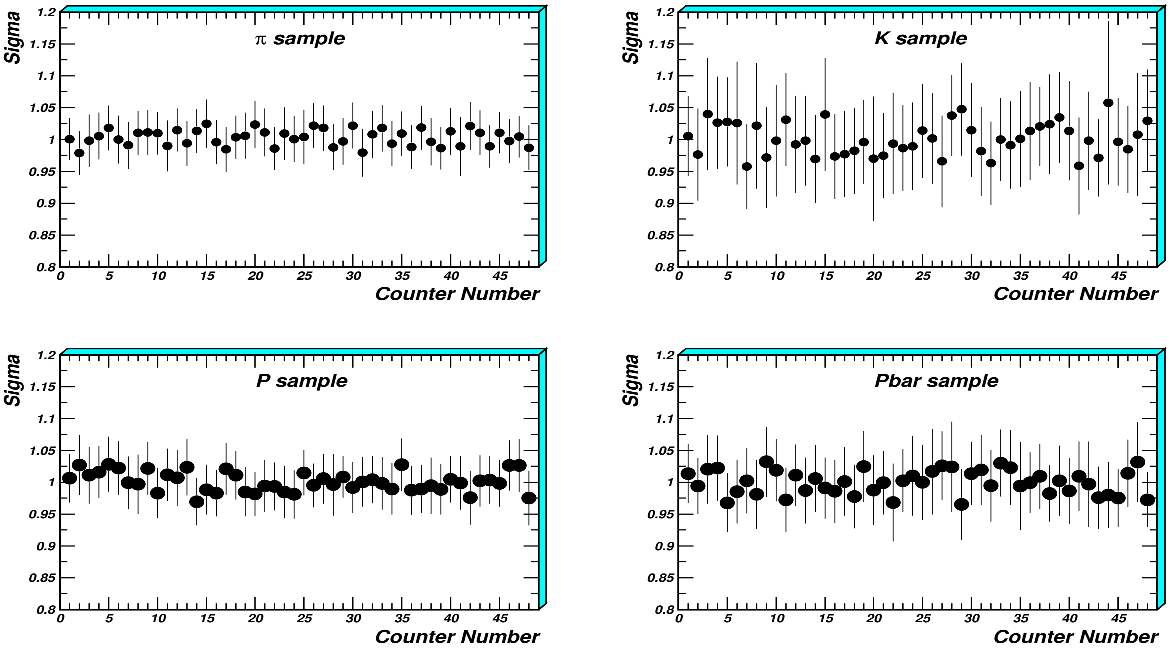

Figure 35: The sigma of χ varying with counter number

From the plots, we can see the χ is a better normal distribution when it vary with pulse amplitude, momentum, $cos\theta$ and counter number after correction.

Thirdly we should check the identification efficiency for the K and π. Fig.36 show π, K, P identification efficiency before and after correction respectively. From the plots we can see the identification efficiency are improve for k and π.

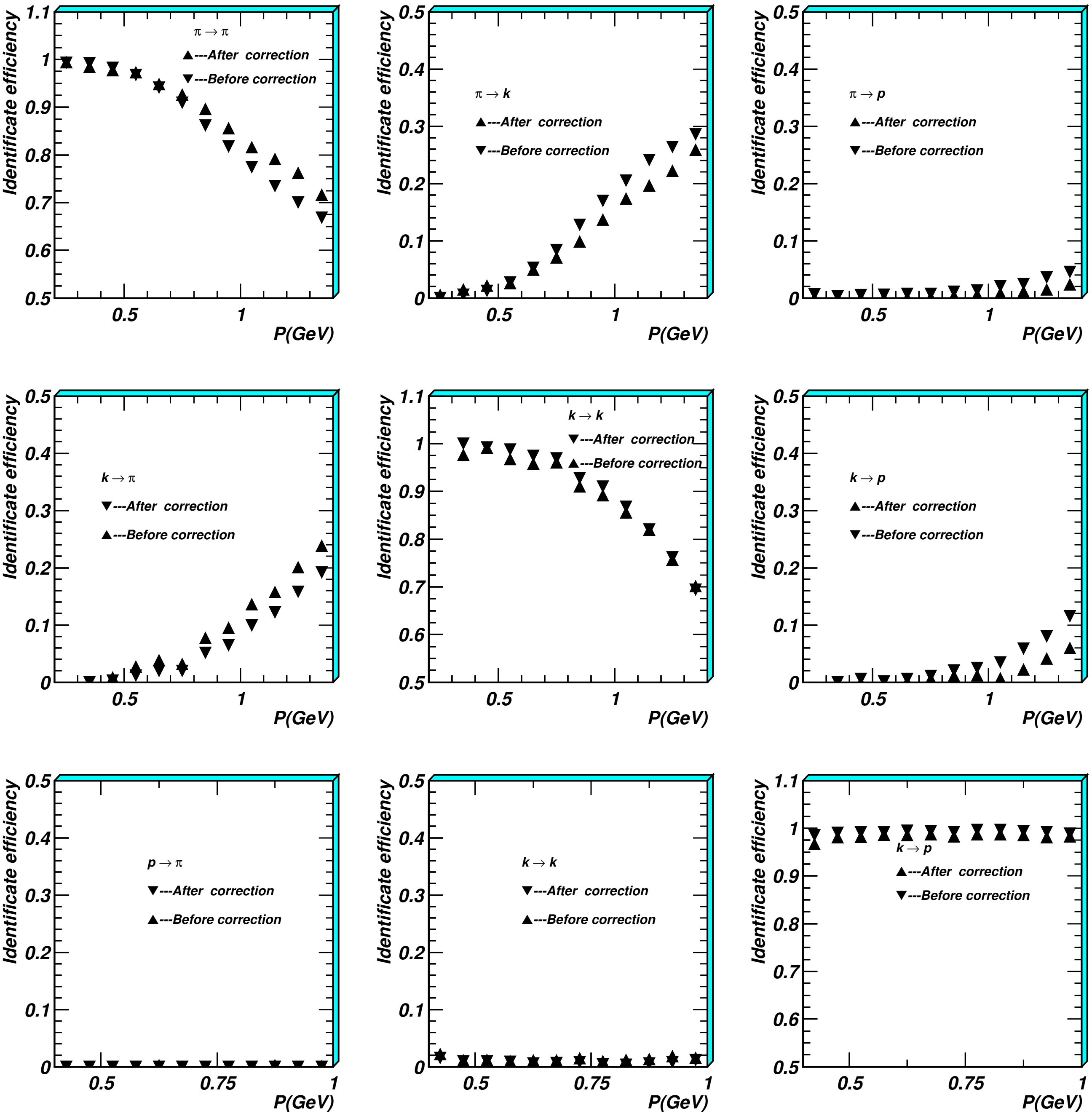

Figure 36: Identifycation efficiency

Fig.37 show β distribution of TOF as a function of momenta for π,K and p, Fig.38 shows the seperation ability for $\pi/K/p$, we can see the power of separation is greater than 3σ when the momenta less than 0.8GeV for K/π.

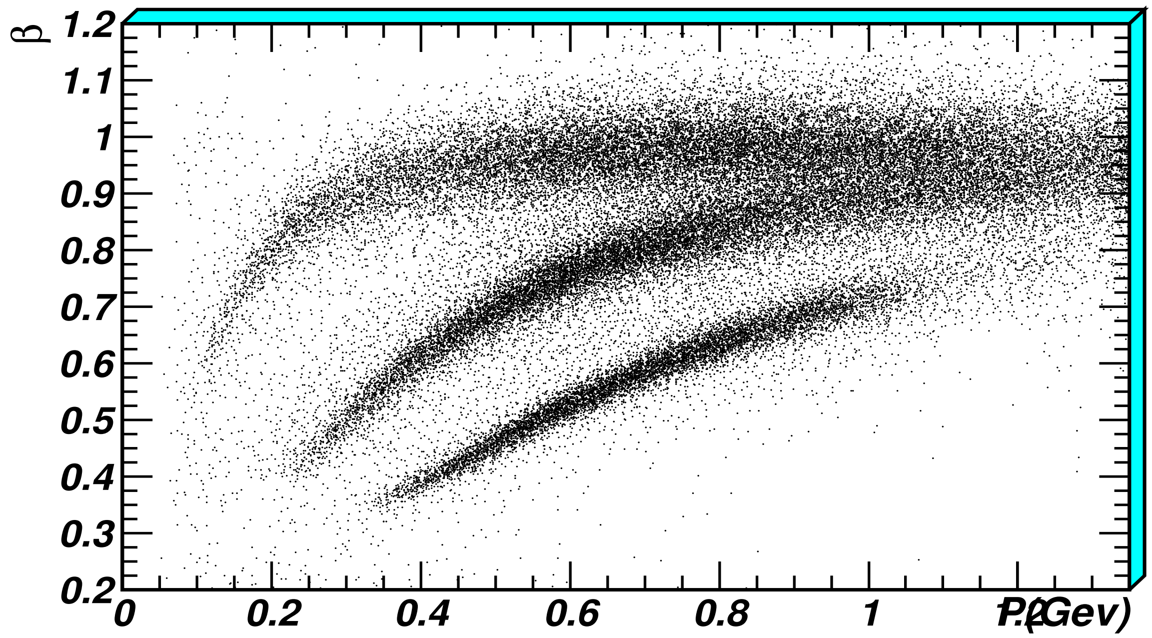

Figure 37: β distribution

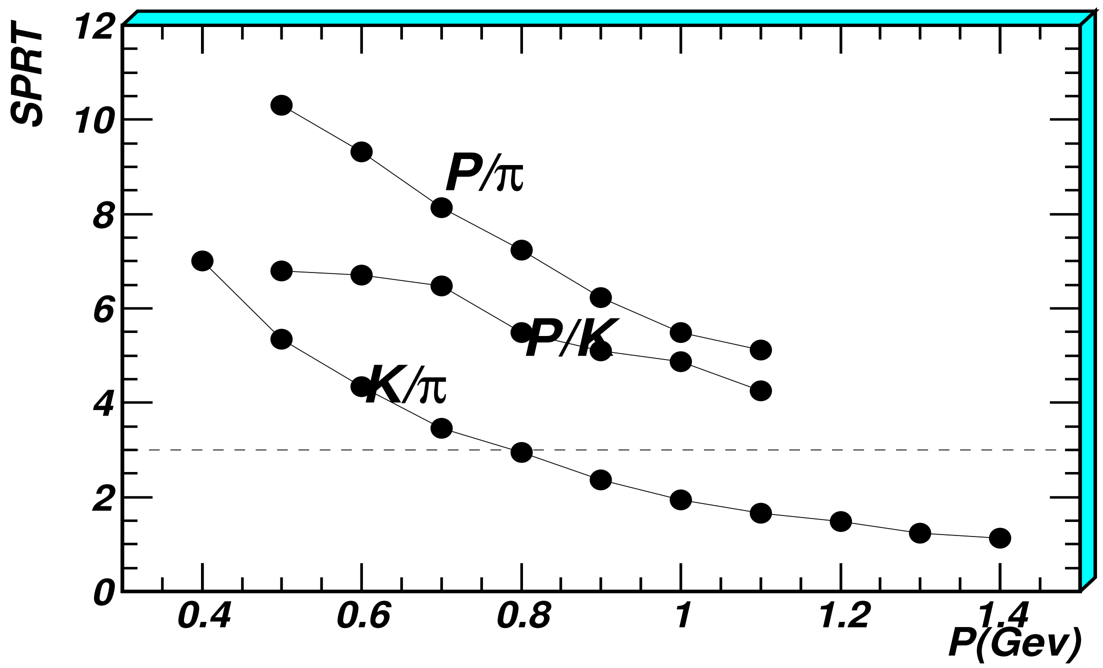

Figure 38: The separation ability

Fanilly we check the code from some J/ψ decay channel:

$$J/\psi \to \phi\pi\pi \to KK\pi\pi$$

$$J/\psi \to \omega KK \to \pi^+\pi^-\pi^0 kk$$

From the distribution of ϕ ,ω mass(Fig.22,Fig.23), we can see the select efficiency is increased after correction

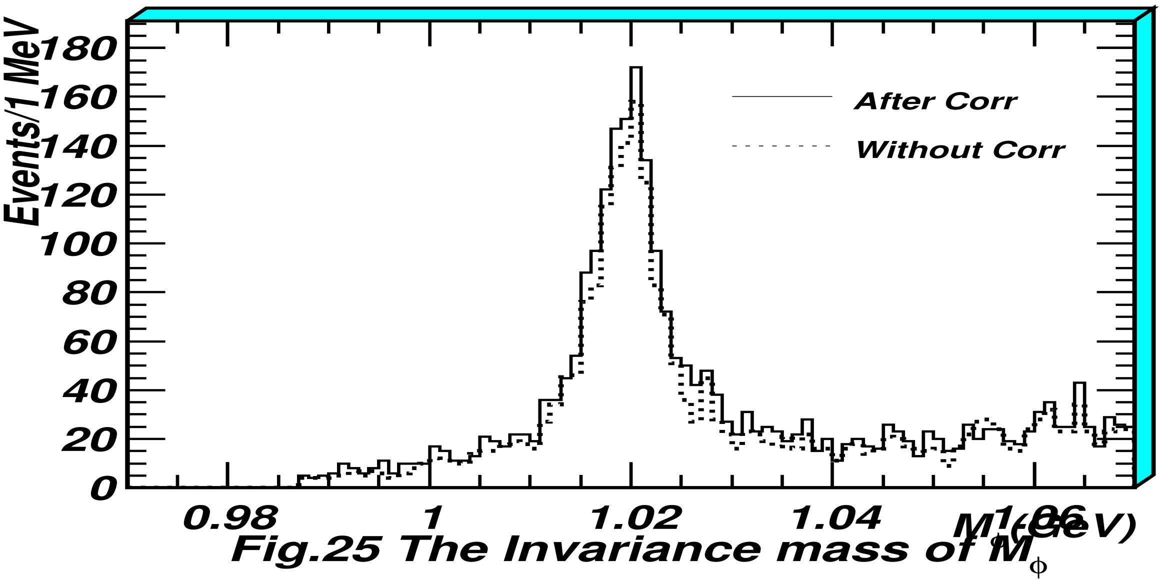

Figure 39: The invariance mass of ϕ

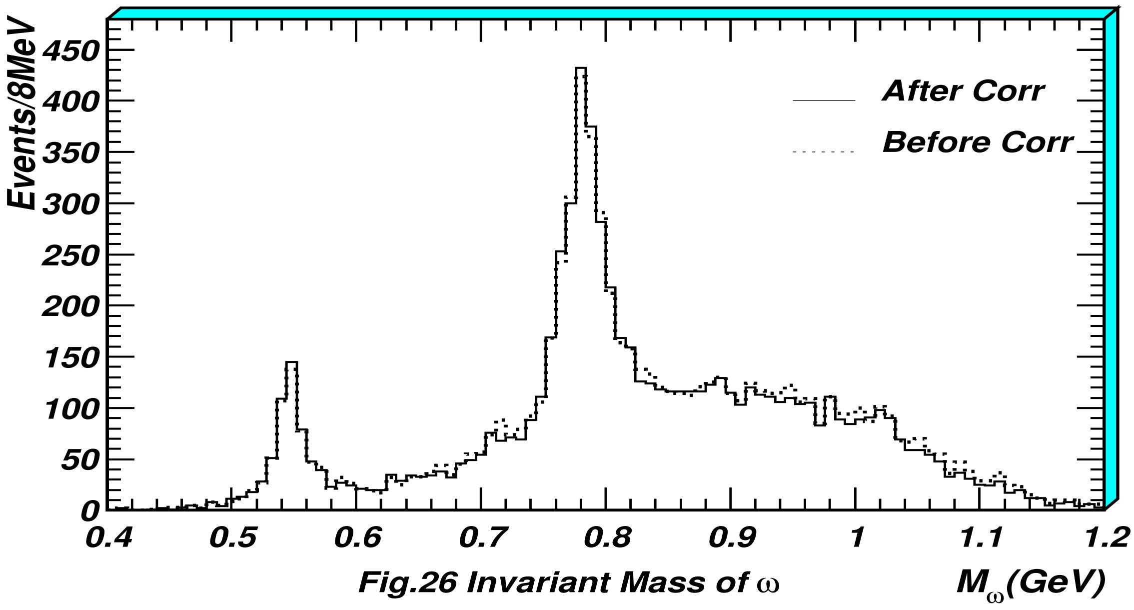

Figure 40: The invariance mass of ω

- 8 -

6 For M.C data

Inorder to reduce the difference between real data and M.C. data, we must do the same correction to M.C. data as the real data. We use HOWL generator to generate J/ψ decay channel:

$$J/\psi \to \pi^+\pi^-\pi^0$$

$$J/\psi \to k^+k^-\pi^0$$

$$J/\psi \to p^+p^-\pi^0$$

to get π,k,and p sample.

Of course the quality of M.C. data is better than the real data, Fig.41 show the time offset distribution as a function of momenta, pulse amplitude, $cos\theta$, and counter number. Fig.42 show the resolution distribution.

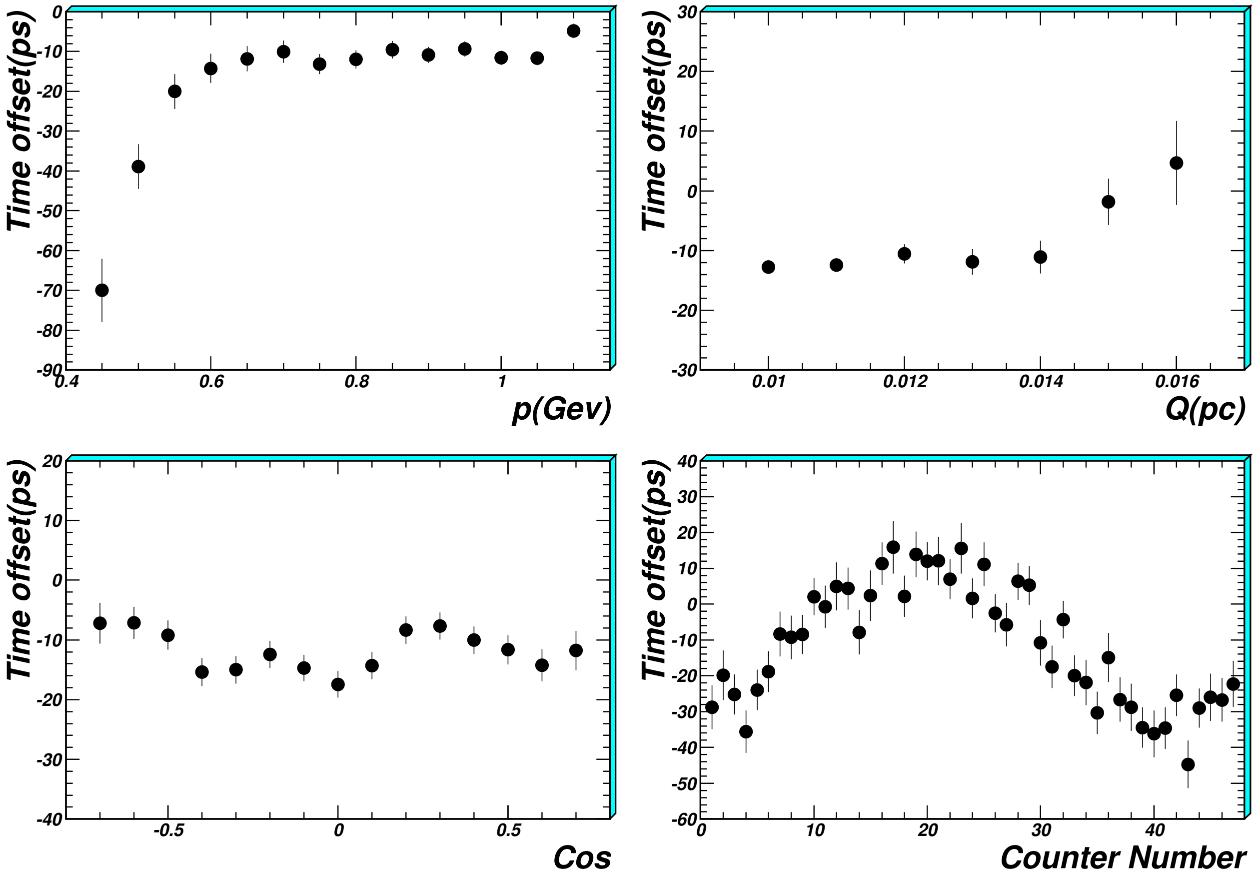

Figure 41: Time offset of M.C. data

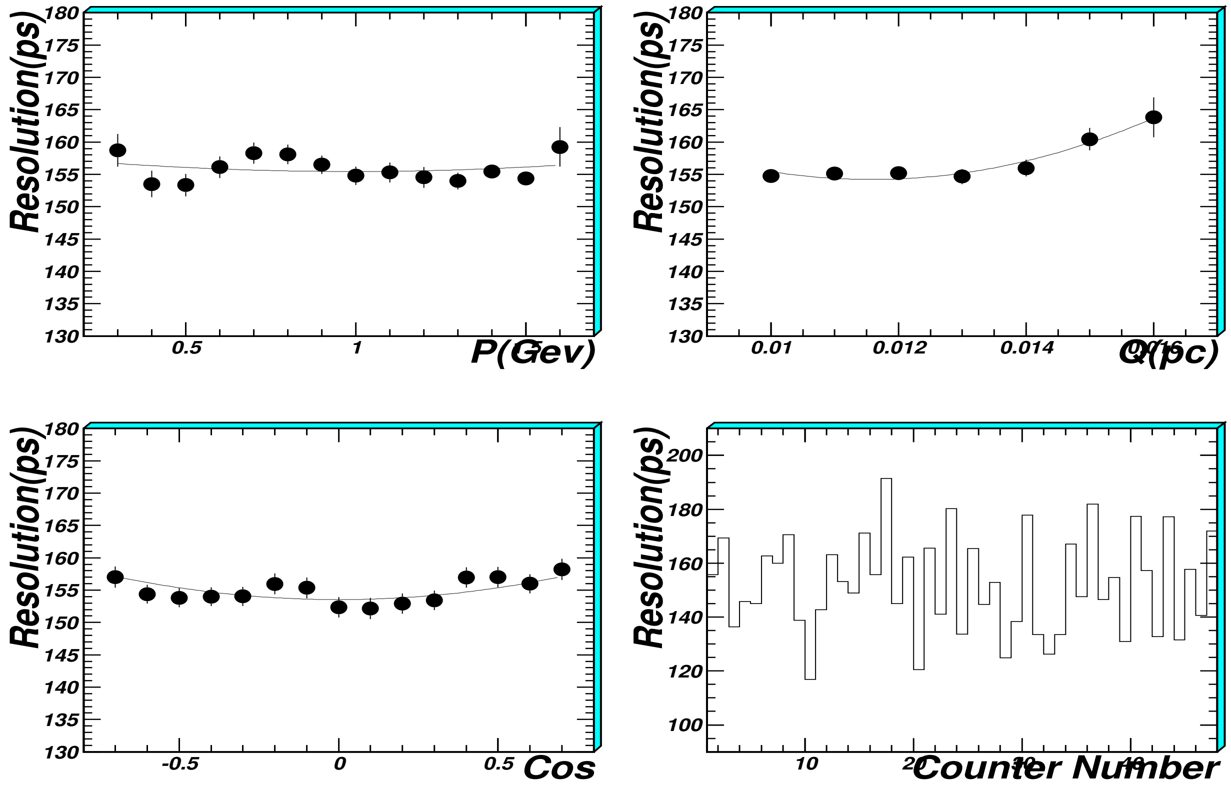

Figure 42: The TOF resolution of M.C. data

For the time offset ,we only do momenta correction . After do momentum correction we check the time offset varying with $cos\theta$,pulse amplitude. we found $\Delta T = T_{mea} - T_{exp} - \Delta T_p$ is very close 0(Fig.43).

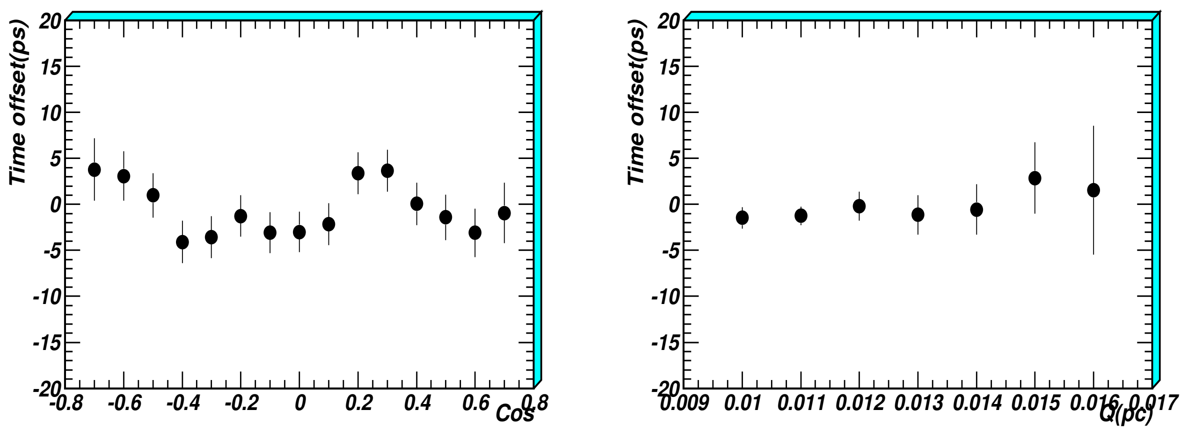

Figure 43: Time offset varying with $cos\theta$ and pulse amplitude after correction

For the resolution,we do the same correction as real data.

1. Get the resolution as a function of pulse amplitude
2. Do $cos\theta$ correction
3. Do counter number correction

Then we can get the resolution:

$$\sigma = (a + b * exp(c * ph)) * F_{cos} * F_i$$

$$F_{cos} = c + d * cos^2\theta$$

After the correction, we define χ as $\chi = \frac{T_{mea} - T_{exp} - \Delta T_p}{\sigma}$, and check χ varying with counter number, $cos\theta$, momenta and pulse amplitude, found it is a normal distribution(Fig.44, 45). Also we generate π sample using RHOPI generator and use the same correction result which are obtained from HOWL generator to check χ, and we find χ is a normal distribution when it varies with counter number,$cos\theta$, momentum and pulse amplitude. Therefore the correction of M.C. data is universal for each generator.

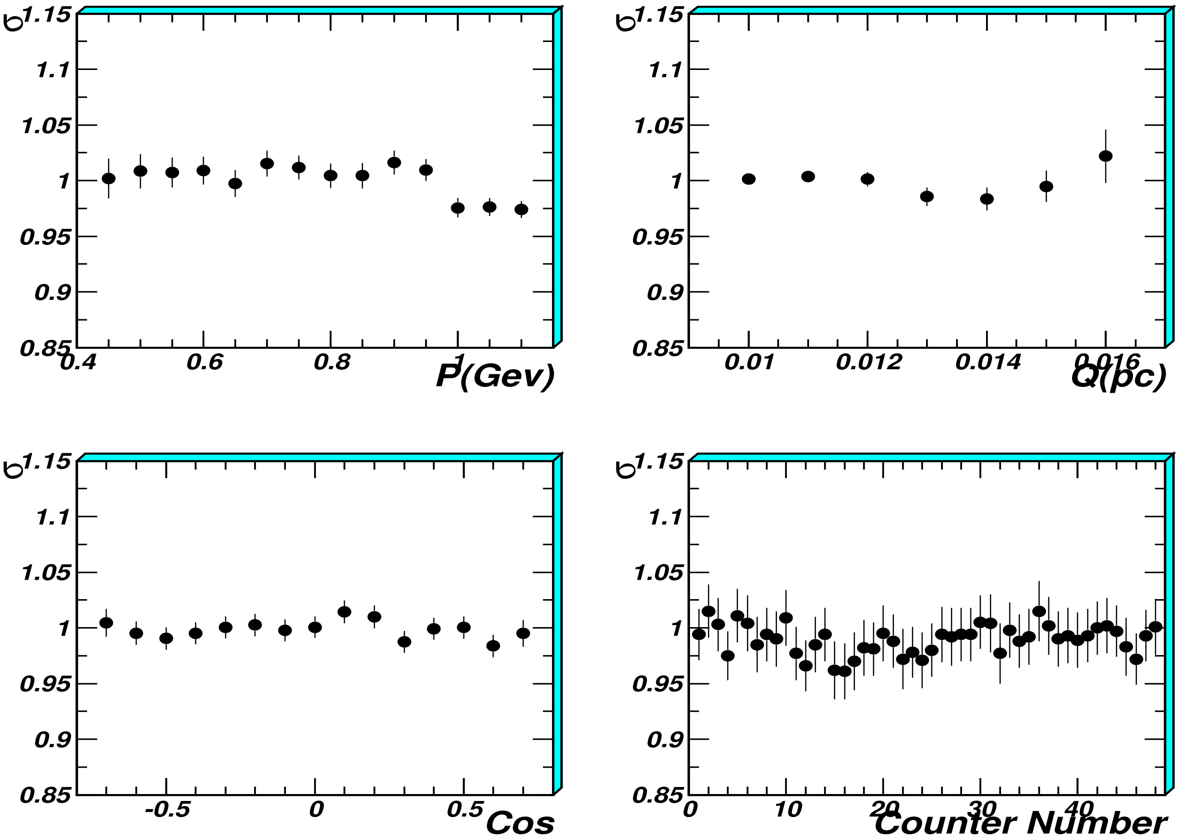

Figure 44: The σ of χ distribution of M.C. data after correction

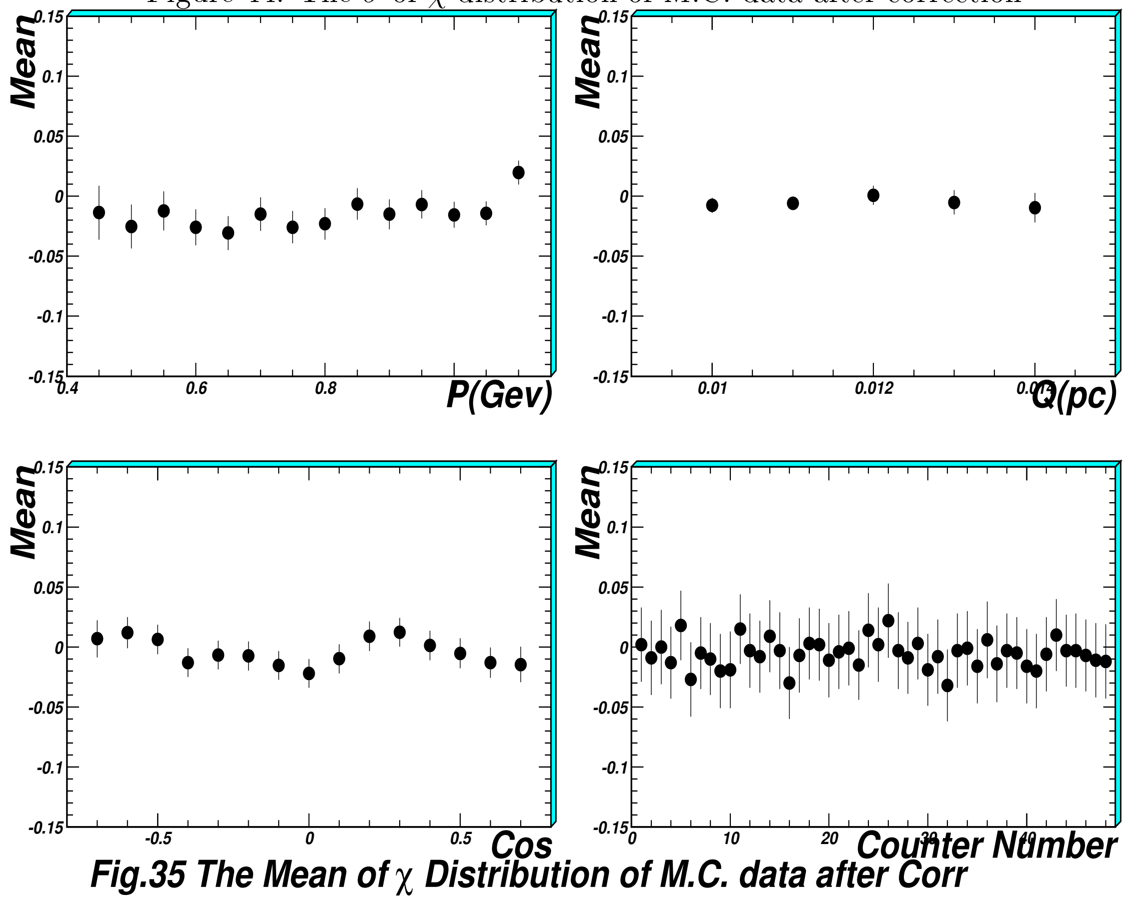

Figure 45: The mean of χ distribution of M.C. data after correction

7 Compare M.C. data and real data

After we do all the corrections to both real and M.C. data, the difference between real data and M.C data is reduced. But from our study, we find there are still some problems. Fig.46(left) show the data and M.C. resolution varying with counter number. one can see that the M.C. data resolution is smaller than real data. Also we study the resolution varying with $cos\theta$(Fig.46(right)), and found the slope of res-

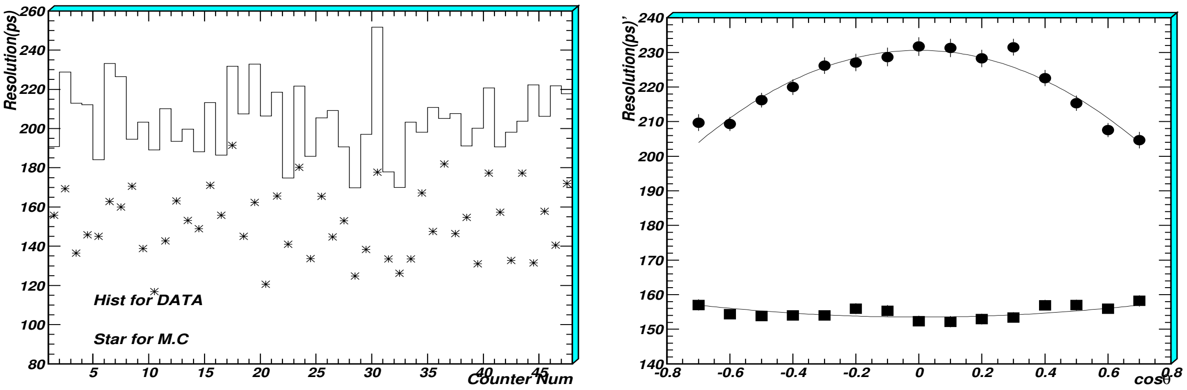

Figure 46: the resoltuion varying with counter number and $cos\theta$ of M.C data and real data

olution is very different between real data and M.C. data. Fig.47(left) and Fig.47(right) show the identification efficiency varying with momenta. We can see the M.C. identification efficiency is higher than real data, The reason is that the real data resolution is worse than that for M.C. data. This will make a systematic error.

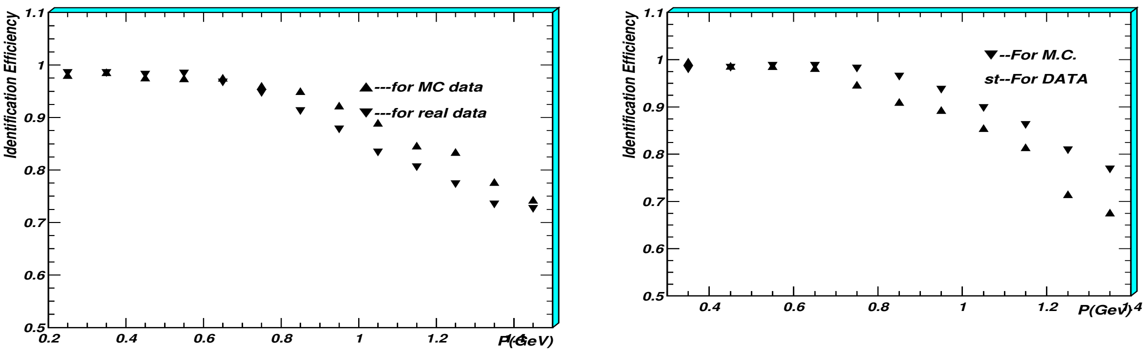

Figure 47: The identify efficiency of π(left) and k(right) sample

8 Conclusion

1. **What has been done**
   (a) Correction for TOF time and resolution for real data.
   (b) Correction for TOF time and resolution for M.C. data.
   (c) PID using TOF information code and check the code.
   (d) Give the identification efficiency.
2. **How about the effect**
   (a) The χ distribution is N(0,1) after correction .
   (b) The identification efficiency is increased for real data, and event select efficiency also is improved after correction.
   (c) The most important thing is that **the correction can minimize the difference between MC data and real data**, and the systematic error will be much reduced.
3. **The problem**
   (a) Why does the time offset oscillate when it varies with $cos\theta$
   (b) The resolution of M.C. data is better than real data. We should do some improvement of M.C. simulation.
   (c) We hope to get a set of same correction parameters universal for each kind of particle.
   (d) Can we do calibration with hadron such as proton????

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