Calibration of Main Drift Chamber

Jing Liu Zepu Mao
Div.1, IHEP, Beijing 100039, China

Jun.17 1998

1 Introduction

Offline calibration is an important part in data analysis process of high energy physics, events reconstruction is based on the constants obtained from it. We can boast that physical data analysis is nothing without good calbration constants of detectors.

All detectors of BES-II need a set of calbration constants,the calibration constants of MDC should be our first efforts because 1) it is indenpendent on other detectors, 2) calibration of other detectors (BSC and ESC,TOF,MOUN) dependenton the calibration and reconstruction of MDC.Drift chamber in BES-II need all of the following calibration constants: 1)T_0 , Zero time of every sense wires–RTAC(3216);2) Drift velocity of every layer–DFTVEL(2,40);3) Correction of drift time according to pulse height–QTCORT (2400);4) Correction of wire position–RLSHFT(2,3216);5) Status of every wires, dead or hotted.

The calibration of MDC is interesting because that it conceivablely differ with the BES-I convertional calibration,1)MDC of BES-II is a brand new detector to us, no initial calibration constants can be used, it need arduous work to calibrate. For BES-I convertional calibration, what we need to do is to improve existed calibration constants.2)We need carefully calibrate T_0 ,DFTVEL,QTCORT and RLSHFT from none to real value. We assign $T_0 = 500$, $DFTVEL = 5\mu m/0.1ns$,$QTCORT = 0$, $RLSHFT = 0$ as our initial constants.For BES-I convertional calibration, only T_0 need to be renewed every time, other constants can keep unchanged.3) The method for calibrating DFTVEL, QTCORT is a new one compared with BES-I calibration.

Before starting our calibration, we must define some variables and expressions which will be used later.(See Fig. 1) 1) D_F ,drift distance according to helix fit 2) $D_M = V(T - T_0 - T_0(Q))$,drift distance calculated by measured drift time 3) ΔD =D_F -D_M ,residue of drift distance(error of measurement),statistic of it will give us the space resolution. 4) ΔD_R and ΔD_L is residue when track pass though a wire from right or left.

By simple deducing, considering D_F affectted by errors of wire position, we can approximately get:

$$\begin{cases} \Delta D_L &= V_L \Delta T_0 + \Delta W + \Delta V_L T + V_L \Delta T_0(Q) \\ \Delta D_R &= V_R \Delta T_0 - \Delta W + \Delta V_R T + V_R \Delta T_0(Q) \end{cases} \quad (1)$$

in which, V_L and V_R is drift velocity at the left and right of sense wire, ΔW is wire position errors in ϕ direction, $\Delta T_0(Q)$ is pulse height correction to drift time.It shows that $\Delta D_{R(L)}$ was total contribution of constants we need to calibrate.

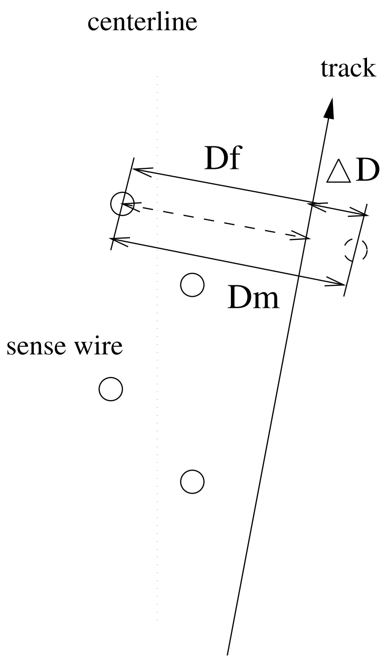

Figure 1: Defination of D_F ,D_M and ΔD

2 T_0 and wire position calibration

Start from equation (1), we can calibrate T_0 and wire position. Add(or substract) two expressions, omitting $\Delta T_0(Q)$ and notice $\Delta V_L + \Delta V_R \sim 0$ and $V_L \sim V_R \sim V$, finally we have:

$$\begin{cases} \Delta T_0 = \frac{\Delta D_L + \Delta D_R}{2V} \\ \Delta W = \frac{\Delta D_L + \Delta D_R}{2} \end{cases} \qquad (2)$$

So T_0 and wire position can be corrected by

$$T_0 = T_0 + \Delta T_0, \quad W = W + \Delta W \qquad (3)$$

ΔW is position correction in ϕ direction, we can obtain the position correction in $X - Y$ plane by simple calculation.

In our calibration process, we fill the left and right residue distributions of every sense wires in 2×3216 histograms first, take the mean value of every histograms as ΔD_L and ΔD_R to calculate ΔT_0 and ΔW , renew T_0 and wire position of every wire like equation (3), this is one time calibration of T_0 and wire position. After iterate like above several times, till ΔT_0 and ΔW will become small enough and keep unchanged , calibration for T_0 and wire position is finished.

Let's see what happened in our calibration process, Fig. 2 shows that residues(left and right) of a wire are improved during calibrating T_0 . Fig. 3 show that ΔT_0 change from very large to very small. Fig. 4 show change of ΔW .

3 Drift velocity calibration

After ΔT_0 and ΔW are calibrated(ΔT_0 and $\Delta W \sim 0$), ignore shift of $\Delta T_0(Q)$, use constants C to include the three, equation (1) becomes:

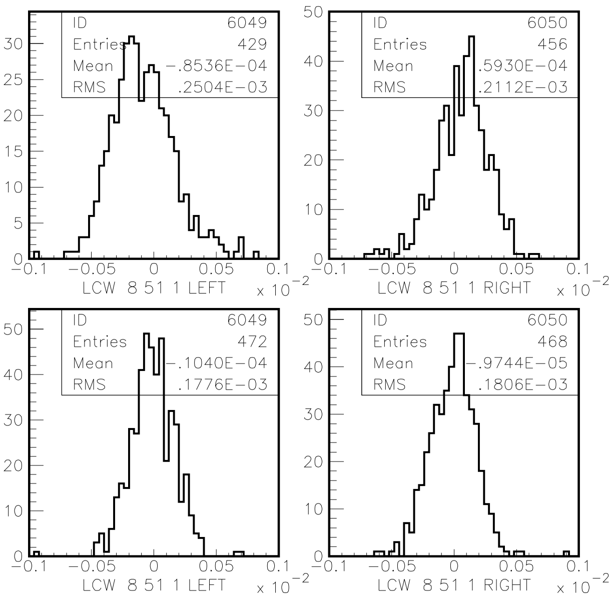

Figure 2: Residue are improved during calibration process

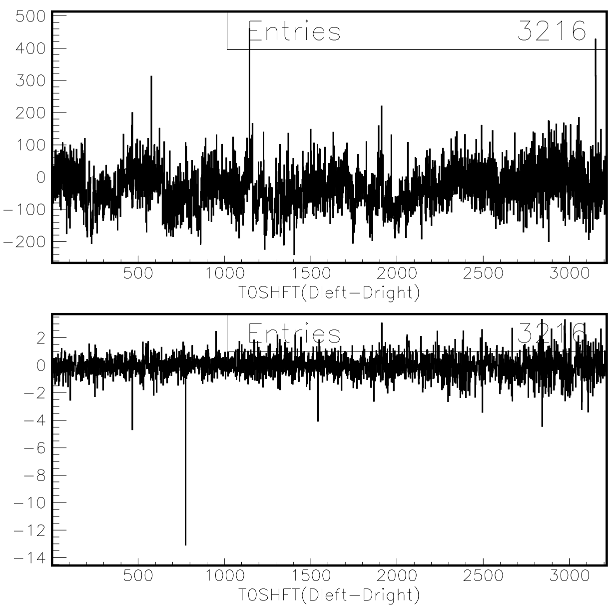

Figure 3: ΔT_0 become smaller

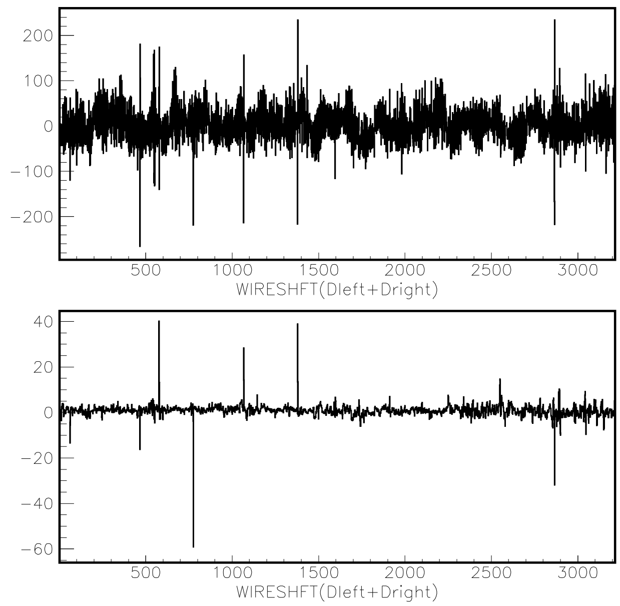

Figure 4: wireshift during calibration

$$\Delta D_{L(R)} = \Delta V_{L(R)} T + C \qquad (4)$$

for different drift time T, $\Delta D_{L(R)}$ can be calculated according to their linear relation. $\Delta V_{L(R)}$ can be reached by finding slope of the line and then drift velocity at the right or left side of sense wire can be corrected by

$$V_{R(L)} = V_{R(L)} + \Delta V_{R(L)} \qquad (5)$$

In our calibration process, we divided drift time T by 50 bins. Fill a two-dimension histograms of bin numbers(calculated by drift time) vs corresponding $\Delta D_{L(R)}$, fit histograms by line, the slope is $\Delta V_{L(R)}$,correct $V_{R(L)}$ according to equation (5). Iterate several times untill $\Delta V_{L(R)}$ becomes small enough, take $V_{R(L)}$ as our real value of last time.

We only calibrate the velocity in 40 layers, so 2×40 drift velocities are calibrated instead of calibration for every wires. Fig. 5 is $\Delta V_{L(R)}$ before and after calibration.

4 Q-T correction calibration

Still consider equation (1), as T_0 and ΔW , Dift velocity V are calibrated, the equation can become

$$\Delta D_L = V_L \Delta T_0(Q) + C1$$

$$\Delta D_R = V_R \Delta T_0(Q) + C2$$

So

$$\Delta T_0(Q) = \frac{\Delta D_L}{V_L} - \frac{\Delta D_R}{V_R} + C(6)$$

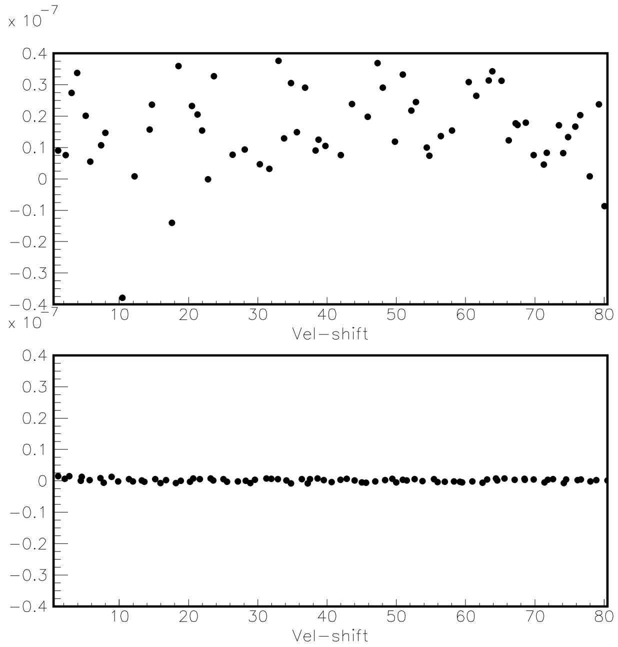

Figure 5: $\Delta V_{L(R)}$ shift duing calibration

For different Q, We can obtain $\Delta T_0(Q)$ and correct $T_0(Q)$. In our calibration process, we divide Q in 60 bins, and calibrate in 40 layers, so 40×60 calibration constants can be reached. Fig. 6 shows change of $\Delta T(Q)$ during calibration

5 Calibration process

Because all calibration constants are related each other (equation(1)), calibrating one constant will affect other constants. We solve this problem by arrange our calibration process like Fig. 7 What be used to judge when our calibration process should be terminated is the distribution of all above and momentum and residue distribution. Fig. 8 gives the momentum distribution before and after our calibration process, Fig. 9 gives residue distribution of layer 2 and 23.

6 Probelms unsolved

There still some problems unsolved in our calibration process

- T0OFFS, the online T zero for each run. Fig 10 is T_0 of every run from online. we noticed that it has about several TDC channels devaiation, which as large as our calibration errors. Consideration of the deviation of online T zero is desirable later.

- Velocity of near and far region should be carefully calibrated after all calibration constants are satisfied, not finished yet.

- wire position calibration is not very satisfied,why some wires need corrected so much?

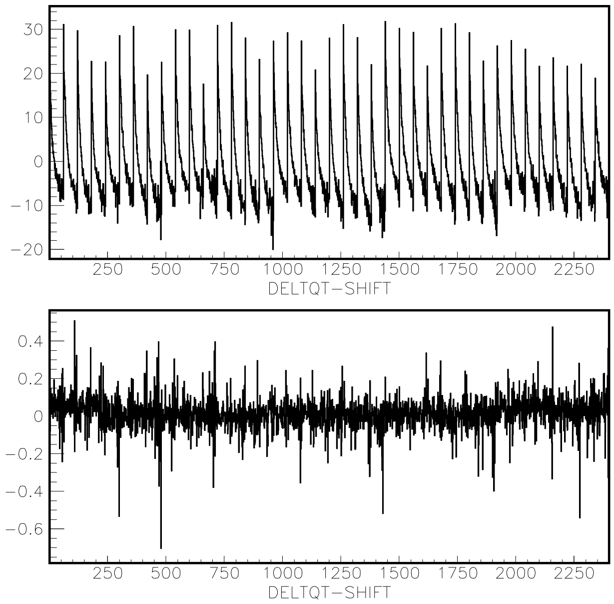

Figure 6: Qtshift during calibration

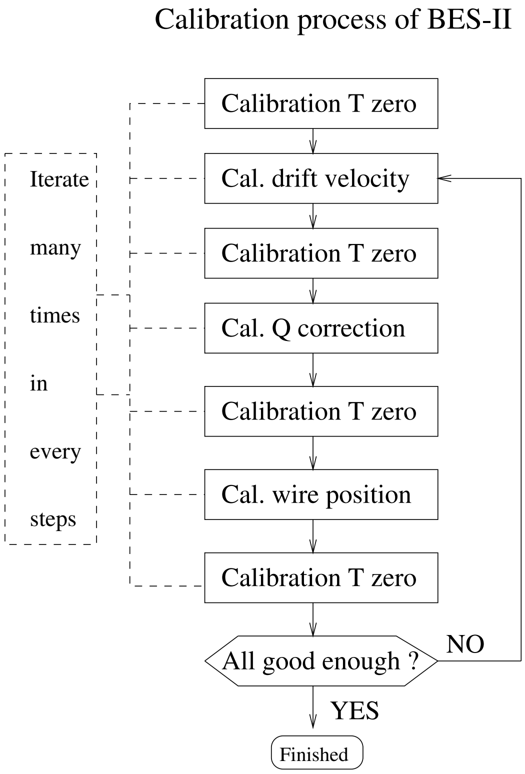

Figure 7: Calibration Process of BES-II

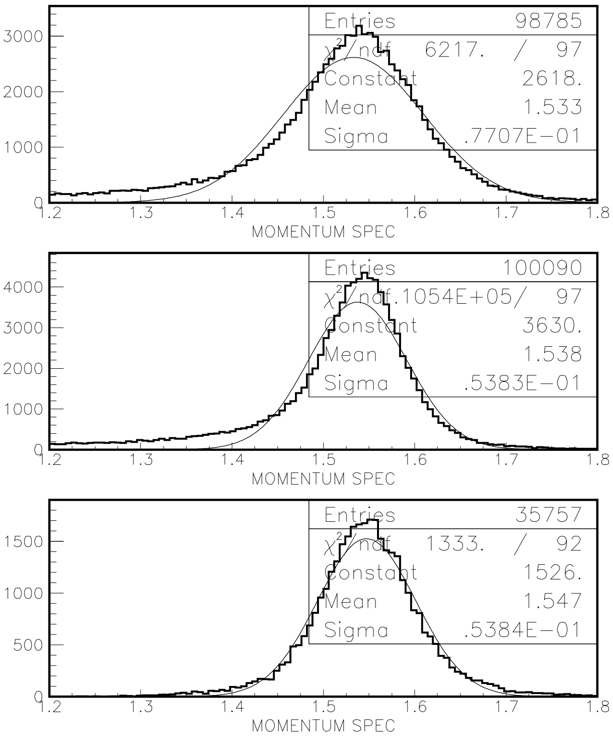

Figure 8: Momentum of Bhabha

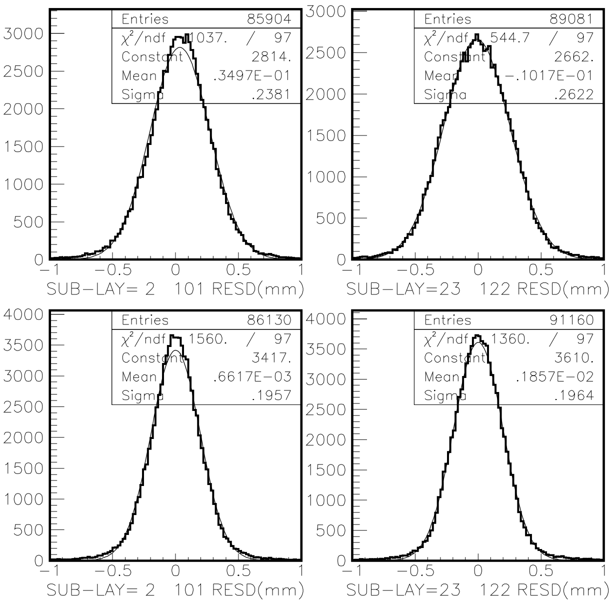

Figure 9: Residue of reconstruction

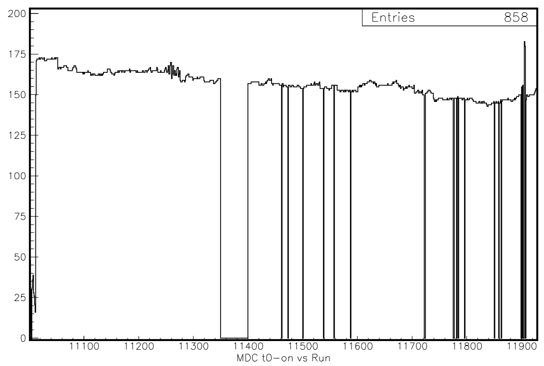

Figure 10: online-T_0 distribution

- T_0 needs study from T_0 distribution, why some T_0 is obviously larger(smaller) than average value?

7 Conclusion and comments

The calibration data we use is Bhabha from Run11000 to Run11150 of J/ψ data. Use the calibration constants to reconstruct all data, Fig. 8 gives momentum distribution of e^+e^- and $\mu^+\mu^-$, $\Delta P \sim$ 51MeV

- $\frac{\Delta P}{P} = 1.78\%\sqrt{1+p^2}$ Fig. 11 is final results.

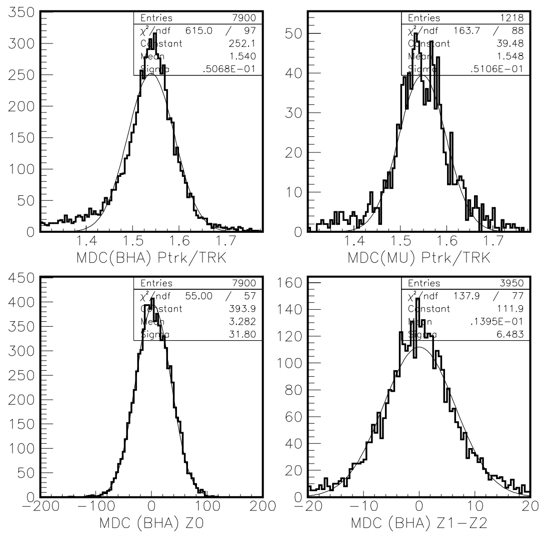

Figure 11: Results of reconstruction

- Space resolution is about 190μm $\sim$ 220μm from residue distribution.

- Fig 12 is distribution of θ and ϕ

- Fig. 12 is vertex of tracks. x,y,z

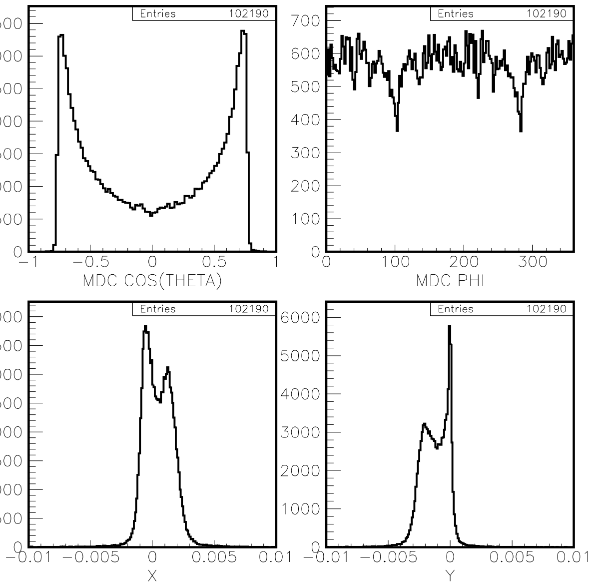

Figure 12: Results of reconstruction

After the calibration really finished, calibration for BES-II data later will be a simple thing, wire position, drift velocity and q-t correction will take as stable, so for bes-II new data, we just need calibration T_0 for several times, it is fast and a joyful thing!