Test Beam at IHEP,CAS

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Introduction

BEPC/BESⅡ will be upgraded as BEPCⅡ/ BESⅢ, it is necessary to do beam test for prototypes of sub-detectors to be used at BESⅢ. After two years of construction, the Test Beams E1， E2 and E3 have been established successfully based on BEPC LINAC at IHEP, CAS. In December 2003, technical appraisal approved the Test Beam work. The Test Beam has been operating smoothly, several experimental results have been obtained based on them. Also, the Test Beam is necessary to search for more applications.

E1, E2, E3 Beams

Among them, E1 is for Beijing Slow Positron Facility specially; E2 can be a primary electron or positron beam respectively, and it forms a secondary particle field as the E2 beam hit a fixed target; E3 is based on E2 and used offering a single particle beam of e / π^{-} or e^{+} / π^{+} / p respectively. The momentum of E3 beam can be adjusted continuously, that is available from 0.2 to 1.1GeV/c for $e^{\pm}$, 0.4 to 0.9GeV/c for $_{\mp}\nu$ and 0.5 to 1GeV/c for protons, with error < 1%. By means of MWPCs, spatial resolution of the hit position of an E3 beam particle is about 0.2 to 0.4 mm; counting rate of negative E3 beam can be adjusted up to about 3 – 4 per second.

BEPC LINAC outputs pulsed 1.3GeV/c electron or positron beam, each pulse is 2.5 ns wide, its repetition frequency is 12.5Hz; for electron beam, it is about 0.8 x 10^{11} electrons/second.

As an 1.3GeV/c electron/positron beam hit a fixed target, possible reactions to be happened at the target and afterwards are as follows:

1, electro-production or photo-production of π :

$e + p \leftarrow \pi^- + n + e$; $e + n \leftarrow \pi^o + p + e$; $e + p \leftarrow \pi^o + p + e$;

$\gamma + n \leftarrow {}^+\pi + p$; $\gamma + p \longrightarrow \pi^- + p$; $\gamma + p \leftarrow {}^+\pi + n$;

2, π production via resonance:

$$\gamma + n \rightarrow \begin{bmatrix} \Delta(1232) \\ N(1440) \\ N(1520) \end{bmatrix} \rightarrow N\pi, N\pi\pi;$$

3, μ production due to π decaying:

$$\pi \longrightarrow \mu + \nu_{\mu} \; , \; \pi^{o} \longrightarrow \gamma + \gamma \; ;$$

4, electromagnetic shower and so on;

So, the secondary particles will be γ , $e^{\pm}$, $\pi^{\pm}$, protons, neutrons and so on.

Figure 1 shows the layout of the Test Beams E1, E2 and E3.

We use quadruple magnets LQ1, LQ2 to collect those charged particles with production angle of about 15^{0} , use analytic magnets D1, D2 to select those charged particles with necessary sign and momentum, use Cherenkov counter to select electrons, scintillate counters to measure TOF. Then we make coincidence/veto for signals respectively from Cherenkov counter and scintillate counters to select/exclude electrons. During offline analysis, we separate pion/proton according to TOF. So, most particles can be identified.

Meanwhile, the intensity of the E3 beam has been reduced to less than 1/pulse, that means most non-empty pulses contain one particle, furthermore, we use MWPCs to exclude those pulses with more than 1 particles according to hit position and amplitude distribution to get “single particle beam” .

Momentum accuracy

Central momentum of the E3 beam can be represented as: $p_0(GeV/c) = 0.299792 \times B(Tesla) \times \rho(m)$; where B be the field of D2 magnet, ρ the radius of E3 beam bending in the field of D2. It can be calculated according to the formula: $\rho = L_{eff} \frac{1}{2Sin(\phi/2)}$; where L_{eff} the effective length of D2, ϕ the turning angle of E3 beam in the field of D2. In order to increase the momentum accuracy, we measure B, L_{eff} and ϕ many times to reduce the error, they are all at 10^{-4} now, and expected momentum error is 0.44% according to $\frac{\Delta P}{P_0} = \frac{\Delta B}{B} + \frac{\Delta L_{eff}}{L_{eff}} + \frac{\cos(\phi_0/2)}{\sin(\phi_0/2)} \frac{1}{2} \Delta\phi$.

We also made measurements many times to select the applied current for D1 to meet the momentum for D1 with that of D2 (the stability of power supply is better than $2*10^{-4}$).

Furthermore, we use an alternative way to confirm the momentum: measuring the TOF difference for an electron and a proton to calculate the momentum, and use Monte-Carlo simulation to correct TOF of proton, this is owing to its energy loss in air, the momentum difference obtained from these two ways(D2 field and TOF difference) is only 0.12%, so, the momentum error less than 1% is believable.

Fig.1, Layout of E1,E2,E3 beams

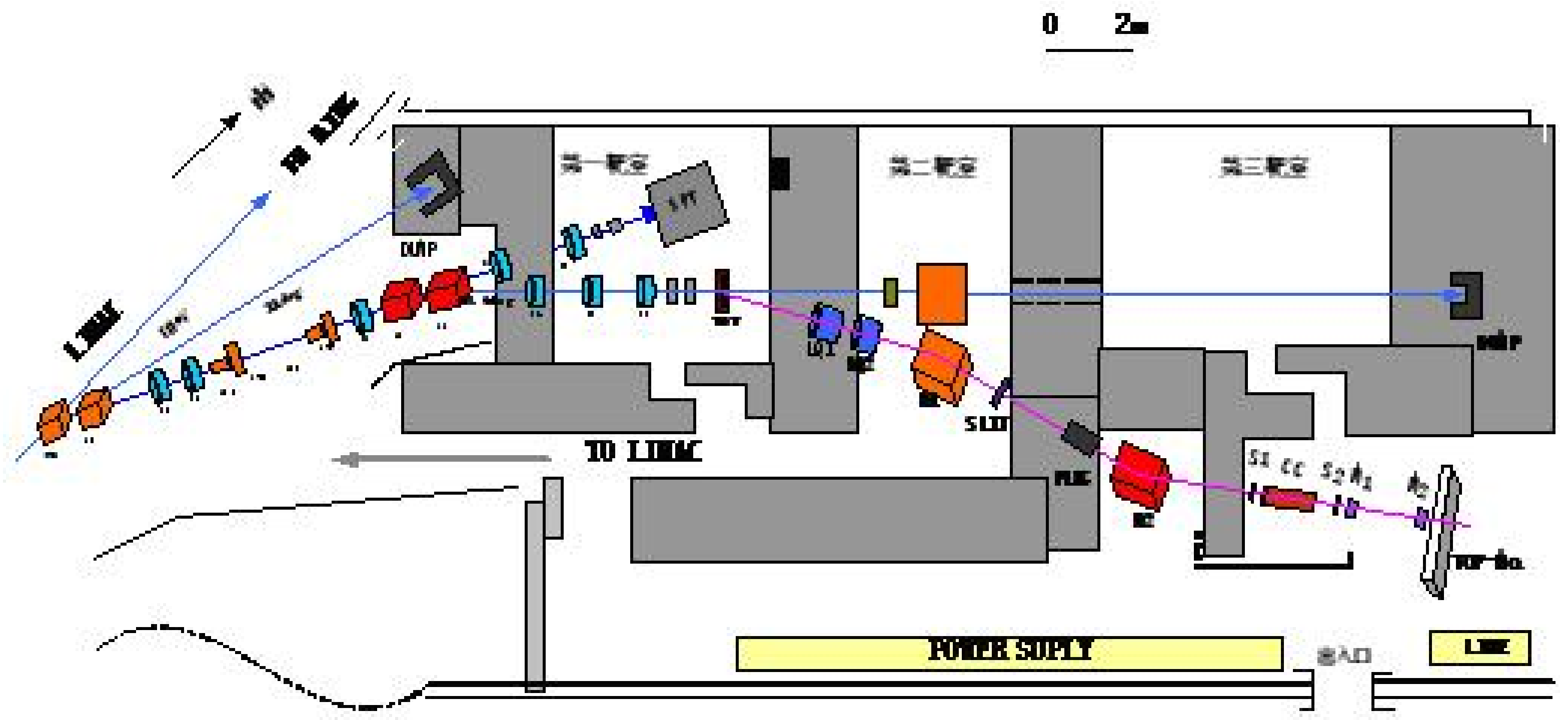


Fig.2, Beam spot of E2

Fig.3,MWPC, electronics and data acquisition system(in part)

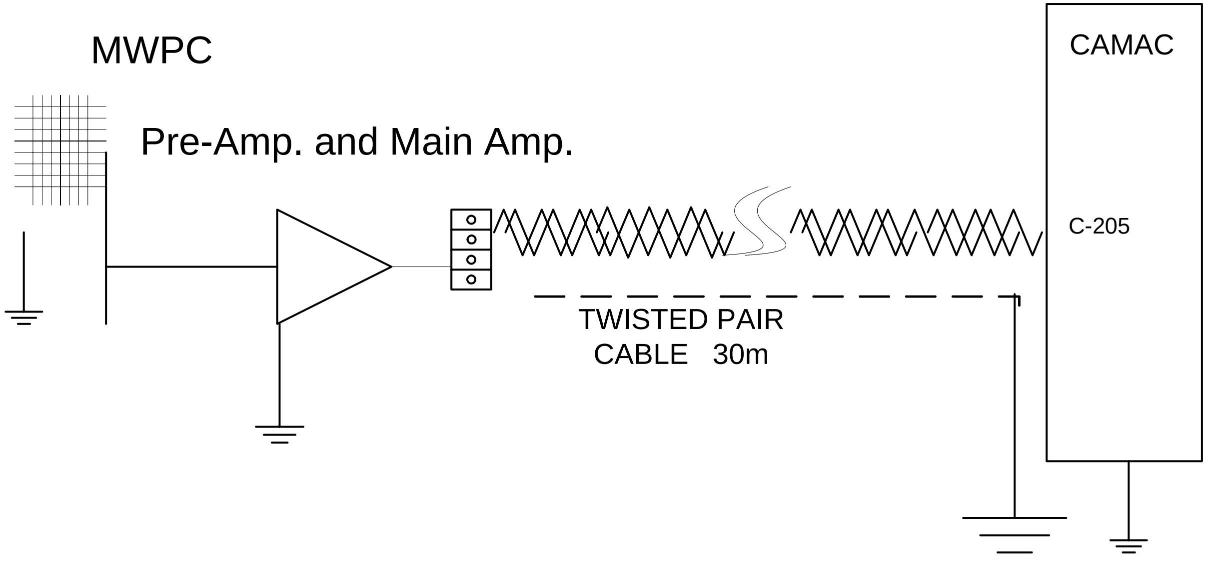


Fig.4, X distribution of hit positions in MWPC

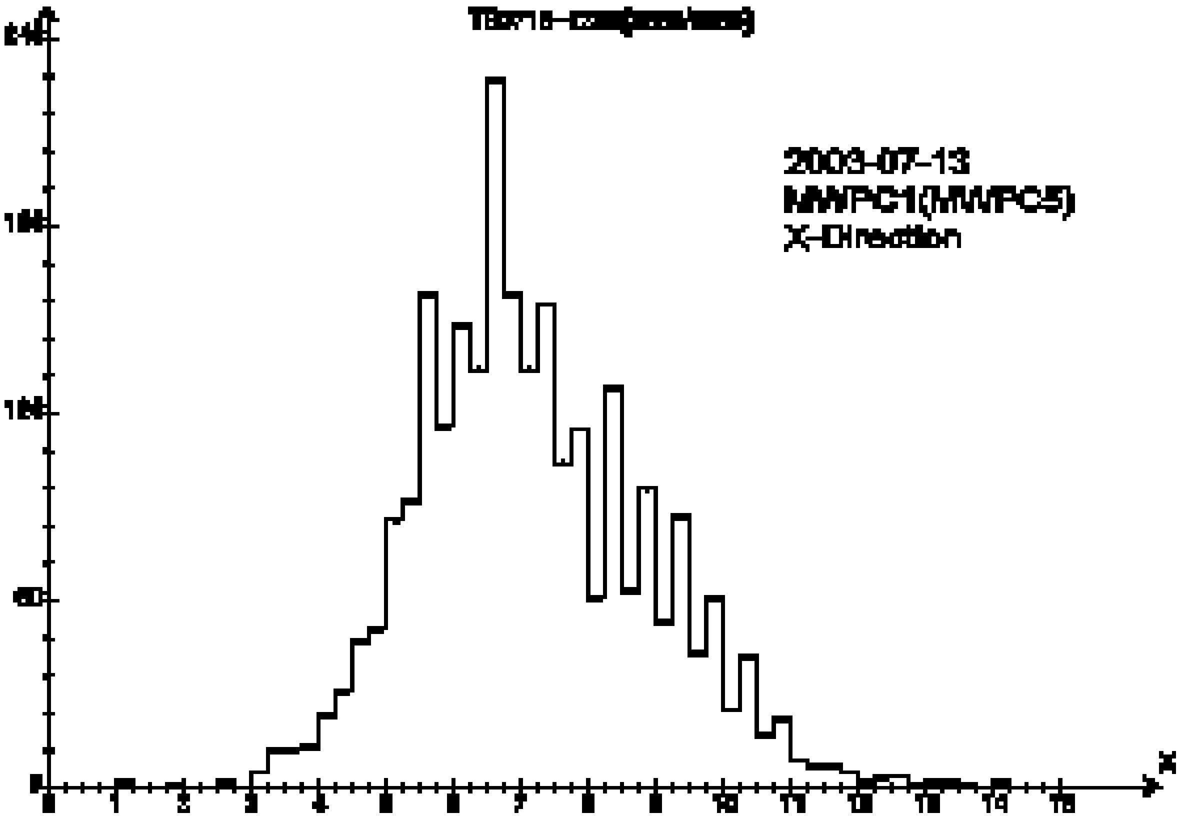


Fig.5, Y distribution of hit positions in MWPC

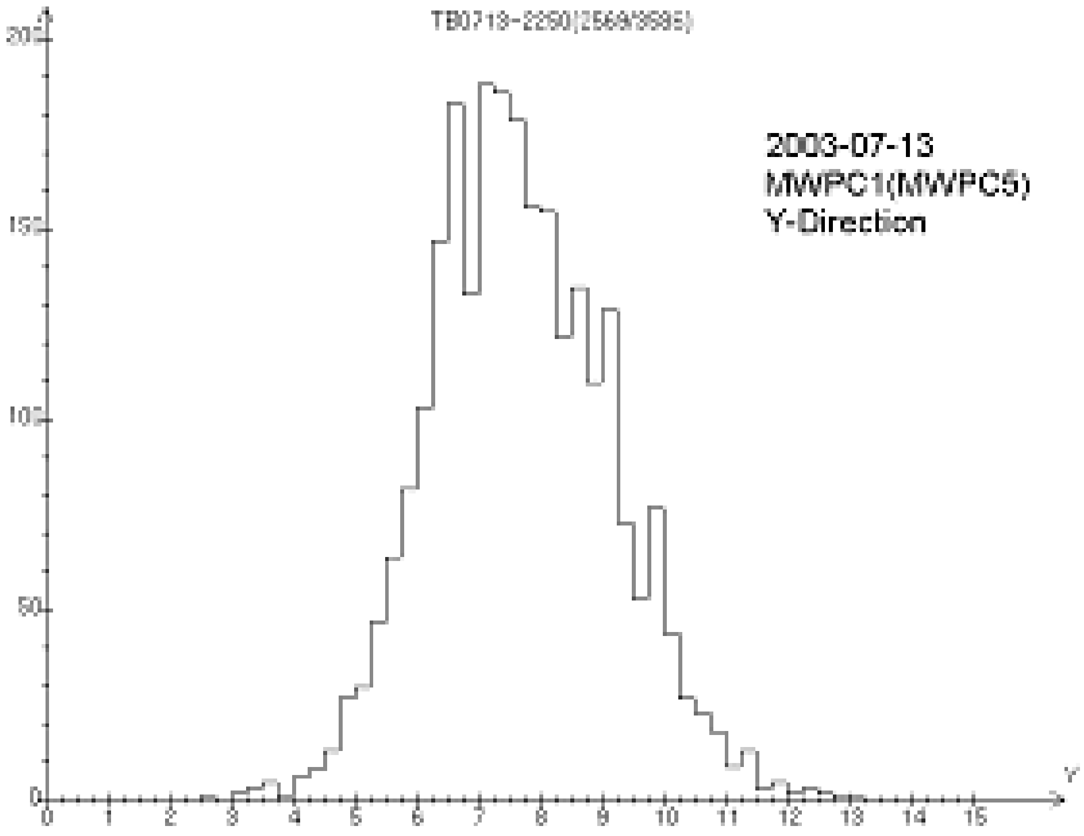


Fig.6,TOF of E3 beam 500MeV/c e^+, π^+, p

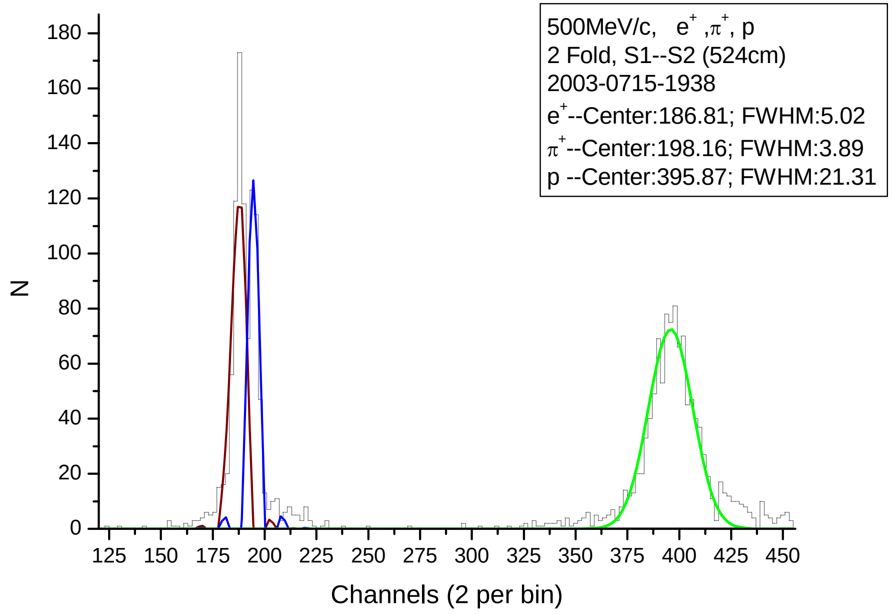


Fig.7, Amplitude distribution of MWPC outputs

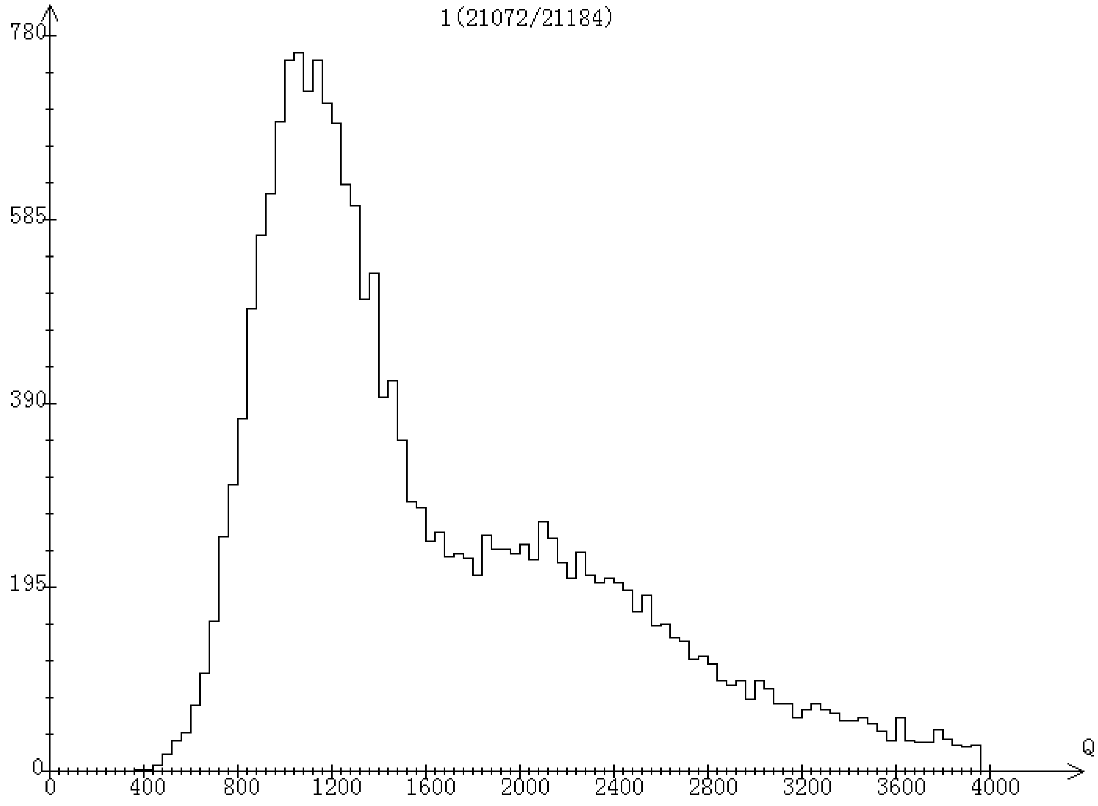


Fig.8, Amplitude vs. x, y coordinates of induced signals from MWPC cathode

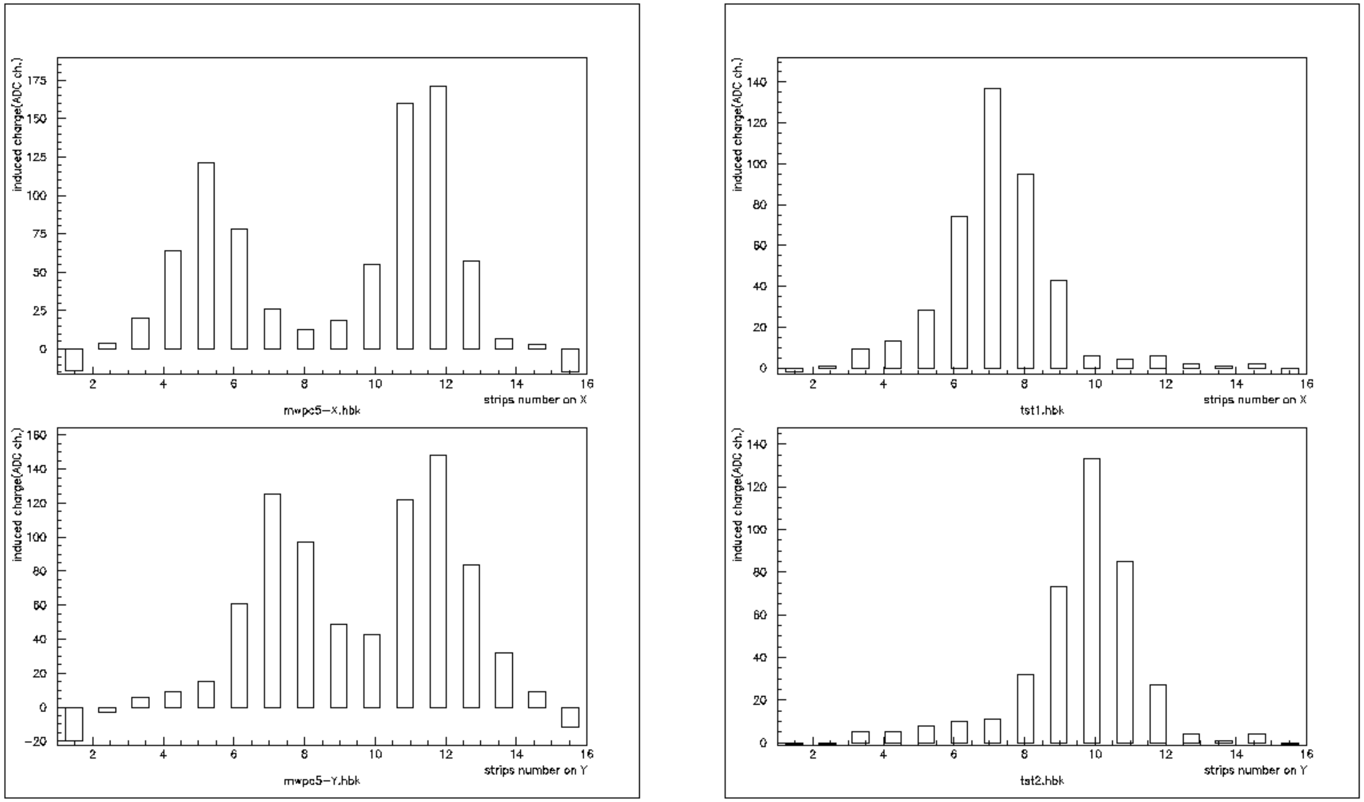


Fig.9,Residual distribution, calculated according to three hit positions in three MWPCs respectively due to an E3 particle passing through them, $2\sigma \approx 0.4mm$

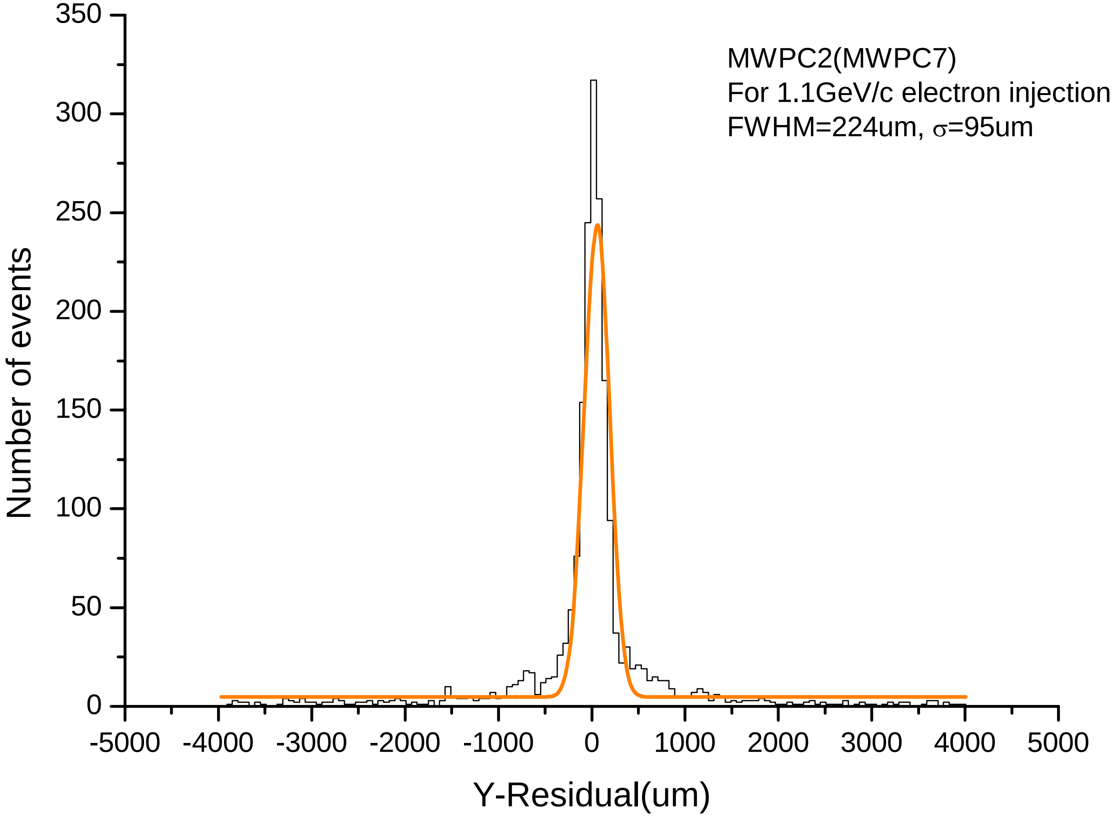
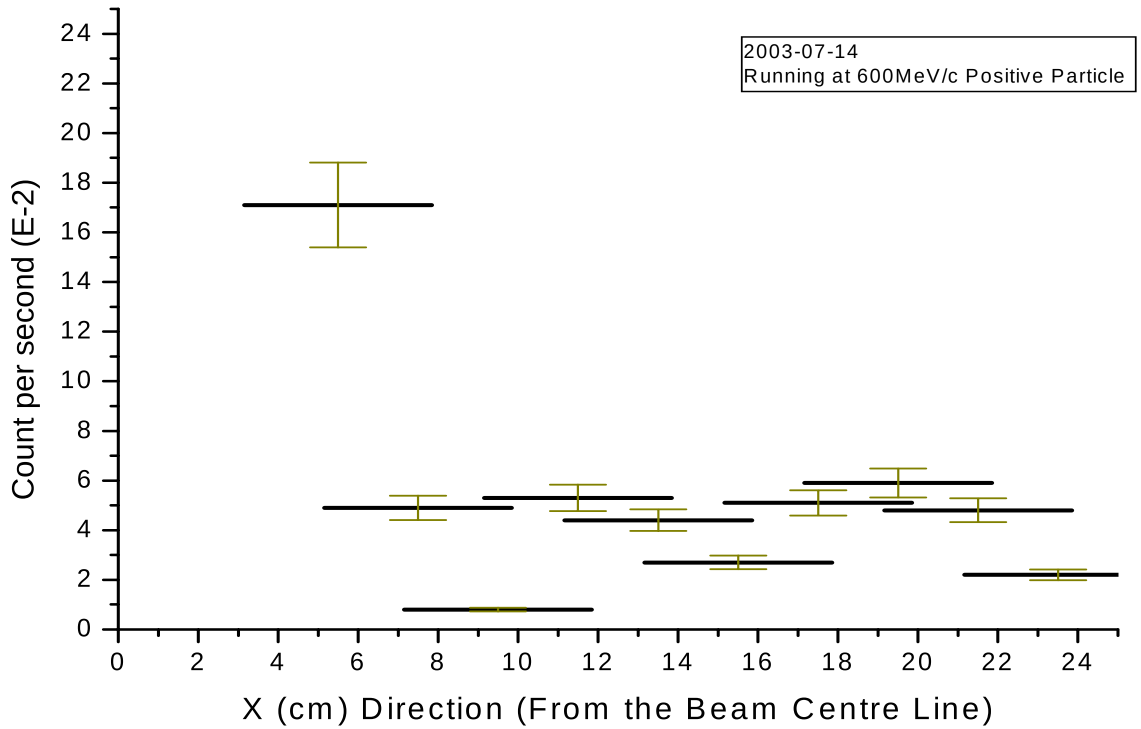


Fig.10, Dose rate in vicinity of E3 beam (E3 on)



Applications of the Test Beams

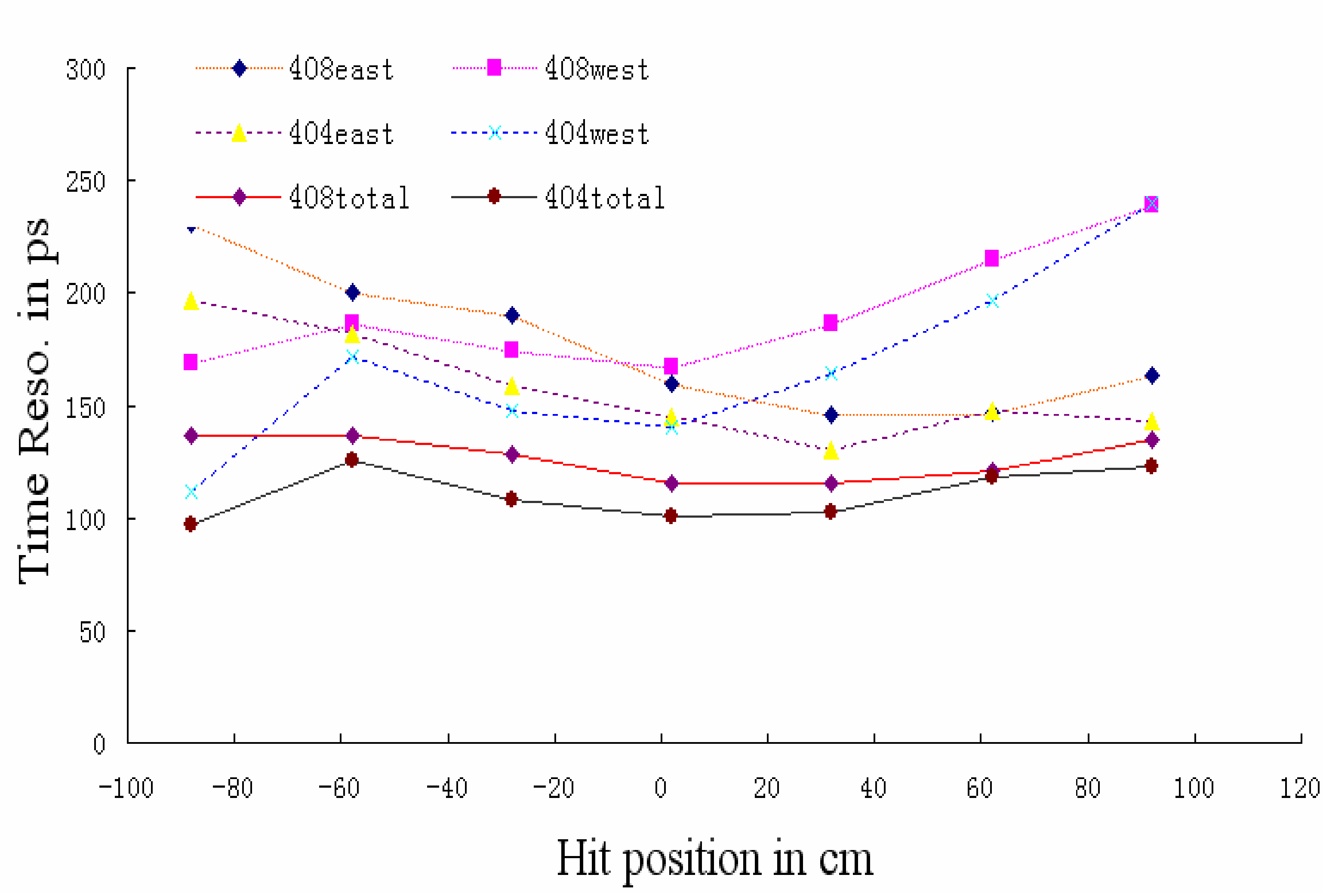
The Test Beams have been operating smoothly and several applications have been realized, such as:

BT001: Beam test for prototypes of barrel TOF counter to be used at BESⅢ, the Test Beam group together with BESⅢ-TOF group in the IHEP;

For example, we have obtained:

Scintillator	Attenuation length(cm)
BC408*4：	171.8±37.1
BC408*5：	217.5±66.56
BC408*6：	240.6±16.9
BC404*5：	288.7±55.2

Fig.11, Time Resolution vs. Hit Position
(very preliminary)



BT002: Beam test of prototypes of end-cup TOF counter to be used at BESIII, together with BESIII-TOF group in the University of Science and Technology of China (USTC);

BT003: Research of biological effect due to irradiation of wheat seeds in the secondary particle field formed by E2 beam. It is a cooperative research project together with the Chinese Academy of Agricultural Sciences, supported by the National Natural Foundation of Sciences of China.

BT004: Checkup of photo-emission of an E3 beam electron with certain momentum in a Cherenkov detector, compared with that of an E3 π with the same momentum;

BT005: Beam test of prototypes of CsI(Tl) electromagnetic calorimeter together with its preamplifier, cooperated with BESIII-ECAL group in the IHEP;

The total data acquisition for beam test of both barrel and end-cup TOF prototypes and for test of Beijing Slow Positron Facility has been accumulated to 662 hours in the first three months of 2004.

The available momentum region of the Test Beam E3 is supplementary to other test beams in the world. We hope that more institutions and collaborations can use the Test Beam.