A study of vertexing and tracking performance of JLC 3T detector

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Abstract. The tagging efficiencies of heavy quarks of JLC detector was studied using the topological finding algorithm. We also studied a momentum resolution and a missing mass resolution of the process $e^+e^- \to \mu^+\mu^- X$.

INTRODUCTION

The JLC group has recently proposed to increase the strength of the detector solenoid magnet from the original 2 Tesla [4] to 3 Tesla [2] to accommodate backgrounds in higher luminosity operation. Since detector geometry was modified, performances of tracking detectors were re-evaluated using Quick Simulator and JIM Full Simulator [1].

The JLC tracking system consists of three tracking detectors, VTX(Vertex Detector), IMT (Intermediate Tracker), and CDC(Central Drift Chamber). They are placed in 3 Tesla magnetic field. VTX consists of four layers of CCD at radii of 2.4, 3.6, 4.8 and 6.0 cm. The spatial resolution is 4μm each in $r\varphi$ and Z directions. The material thickness of them is 0.3% radiation length. IMT is 5 layers of silicon detectors at 9, 16, 23, 30 and 37 cm whose thicknesses are same as VTX. CDC is a jet chamber whose inner and outer radius is 45 and 155 cm, respectively. There are 50 radial sampling with spatial resolutions of 85μm and 3mm in $r\varphi$ and Z directions, respectively. The total length of CDC in Z direction is 310 cm and VTX and IMT covers $|\cos\theta| < 0.9$ region. The beam pipe of thickness 0.5% radiation length is place at radius of 2.0 cm. To improve the stability of the interaction point, we have a support tube of 5 mm thick CFRP between IMT and CDC.

VERTEXING PERFORMANCE

Using the Quick Simulator, performances of the topological vertexing and the mass tagging method was studied. The topological vertexing algorithm was devel-

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oped by SLD group [3]. In this method, a tube of probability is defined along a particle trajectory. Since the probability is high when trajectories overlap, such points are selected as vertices. When secondary or tertiary vertex is found, the p_t corrected mass (`MSPTM`) is calculated from the vertex mass (M_{vtx}) and the vertex momentum transverse to the flight direction of the vertex (P_T): `MSPTM`=$\sqrt{M_{vtx}^2 + P_T^2} + |P_T|$.

For the study, we generated quark pair events at Z pole. The events were clustered to two jets by using the JADE clustering algorithm. Y_{cut} were varied so as to clustered as two jets. When the production angle of the jet satisfied $|\cos\theta_{jet}| < 0.8$, the tagging method was applied and efficiencies and purities were studied.

The Fig. 1(A) shows a probability to find secondary vertices when $b\bar{b}$ events are generated. The efficiency was about 90% and flat for decay length greater than about 0.1 cm. The distribution of `MSPTM` is shown in Fig. 1(B) for jets whose secondary decay length is greater than 300 μm. We can see clear separation between b quark jets and c quark jets.

We tagged jets as b when the decay length was greater than 300 μm and M_{corr} was greater than the cut value. The purity and the efficiency of b tagging is shown in Fig. 1(C), which was obtained by changing the cut value from 1.0 GeV to 5.0 GeV. The open-square points are for the JLC 3T detector. For comparison, we defined a new geometry with an additional CCD layer at 1.2 cm and the beam pipe at 1.0 cm. The purity and the efficiency in that case is shown in the same figure. In this case, the requirement to the decay length was reduced to 150μm, thanks to the improved vertex resolution. As a result, the efficiency was increased about 10% for the selection of purity greater than 95%.

In the case of c tagging, we required the decay length to be greater than 150μm and `MSPTM` was between 0.55 GeV and the cut value, which is changed from 1.0 GeV to 5.0 GeV. The result is shown in the Fig. 1(D) for the case of the JLC detector and with the additional CCD layer. The c tag efficiency is about 30% with the purity of about 50% in the case of the JLC detector. Both the efficiency and the purity will be improved by using additional conditions such as vertex momentum, etc.

THE TRACKING PERFORMANCE

As tracking performances, we studied a momentum resolution and a missing mass resolution of $e^+e^- \to ZH$ process using the JIM Full simulator.

To study the momentum resolution, we generated a single μ track by JIM. Generated exact hits points were smeared by assumed resolution. Hit points were fitted by helix parameters separately for CDC and VTX. After moving a pivot of CDC helix parameter to that of VTX, taking into account energy losses and multiple scatterings, they were averaged with weights of error matrices to get a CDC-VTX combined helix parameter. This method does not require a cpu time consuming minimization procedure such as a kink fitting and reasonable results can

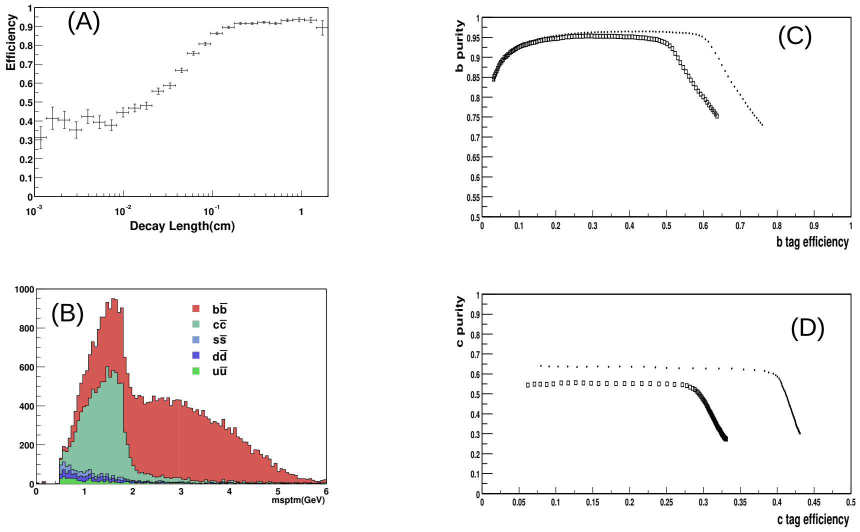

FIGURE 1. (A) The efficiency to find secondary vertices in b quark jets, (B) The p_t corrected secondary mass distribution for each quark, (C) b tag efficiency and purity for the JLC detector (open square) and for additional CCD layer at 1.2 cm (circle), (D) Same as (C) for c tag.

be obtained as multiple scatterings and energy losses in the material can be well approximated by Gaussian.

The p_t resolution and the impact parameter resolution as a function of p_t are shown in the paper [1] presented at the session of "Simulation Tools'. The p_t resolution was $0.9 \times 10^{-4} p_t$ at high momentum and the impact parameter resolution in $r\varphi$ plain was 25 μm at 1 GeV.

The missing mass resolution was also studied using a process $e^+e^- \to \mu^+\mu^- X$. This is a channel to search Higgs independently with its decay mode and a width of Higgs can be measured if it is large enough to be detected. For the study, we generated events using Helas [5]/Bases/Spring [6] libraries in PhysSim [1] package. The beamstrulung spectrum of JLC-I [4] X-band 300 GeV parameter with $\pm 0.5\%$ initial energy spread was included. The center-of-mass energy was 250 GeV.

The event was selected by requiring two good charged tracks (the number of sampling is equal to 50) whose invariant mass is between 80 to 100 GeV. The obtained the missing mass spectrum is shown in Fig. 2. The spectrum is fitted by the curve given by

$$F(m) = N_H \int F_H(m,t) \exp^{-\frac{t^2}{2\sigma^2}} dt + N_Z \cdot F_Z(m) \tag{1}$$

where $F_Z(m)$ is a scaled missing energy respect to Z($F_Z(m) = 1 - \frac{m - M_Z}{\sqrt{s} - M_Z}$), and $F_H(m,t)$ is that to Higgs ($F_H(m,t) = Max(0, 1 - \frac{m - M_H + t}{\sqrt{s} - M_H})$). From the fit, we obtained the missing mass resolution of 1.0 GeV. The main contribution to the width is the initial energy spread of $\pm 0.5\%$, but the resolution could be slightly improved to 0.9 GeV if the measurement is performed at 240 GeV.

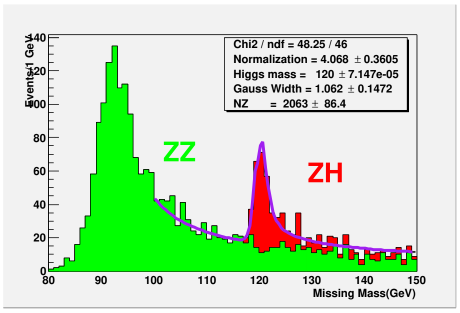

FIGURE 2. The missing mass spectrum of the two tracks for $e^+e^- \to ZH$ and ZZ processes.

SUMMARY

We have studied the vertexing performance of the JLC detector using Quick Simulator. By using the topological finding method and the p_t corrected vertex mass, we found that the efficiencies of b and c tagging are about 95% and 30% with purity of 95% and 50%, respectively. The efficiencies can be improved by 10 to 15% if an additional CCD layer is placed at the radius of 1.2 cm.

The missing mass resolution of the tracking system is also studied using the JIM Full simulator. By the combined fitting of VTX and CDC hit points, we obtained the momentum resolution (σ_{p_t}/p_t) of about $10^{-4}p_t$ at 100 GeV. The missing mass resolution for the process $e^+e^- \to ZH \to \mu^+\mu^-X$ is 0.9 GeV(σ) for the Higgs mass of 120 GeV at $\sqrt{s} = 240$ GeV.

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REFERENCES

1. Miyamoto, A., in these proceedings.
2. Sugimoto, Y., in these proceedings.
3. Jackson, D.J., *Nucl. Instr. Meth.* **A388**, 247 (1997)
4. JLC gruop, JLC-I, *KEK Report 92-16*, (1992)
5. Murayama, H., Watanabe, I., Hagiwara, K., *KEK Report 91-11*, January 1992
6. Kawabata, S., *Compt. Phys. Commun.* **41** (1986)127