Study of Beamstrahlung in the Vertex Detector

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This study, based on fast simulation, was aimed at evaluating the effect of e^+e^- pair background from beamstrahlung on performance of Vertex Detector (VTX) for jet flavour tagging in the International Linear Collider (ILC). Five layer VTX geometry with varying radius of the first layer was tested. Also possibility of rejection of background hits in the VTX, based on hit cluster shape and direction was studied.

1 Simulation

The e^+e^- pair background from beamstrahlung was simulated with Guinea-Pig [2] for nominal accelerator parameters at 500 GeV with 14 mrad crossing angle. The ILC detector response was modelled with Simulation á Grande Vitesse 2.30 (SGV), a fast simulation program allowing simplified definition of the detector geometry. A long barrel VTX with 5 coaxial layers, each made of 50 μm thick silicon plates with track spatial resolution of 5 μm and layer radii listed in Table 1 was simulated.

A beryllium beampipe of 0.25 mm thickness and radius 1 mm smaller than the first layer of the VTX was assumed. Dedicated software was developed to track charged particles through the VTX, taking into account multiple scattering and energy loss. VTX was assumed to be read out 20 times per bunch train, implying that background hits accumulated over 131 bunch crossings and overlayed "physics" hits. Tracks were reconstructed using own software. Tracks detected in the central tracker were refitted with hits from the VTX (both physics and background hits), selected with the Kalman Filter. Jet flavour tagging was performed with ZVTOP [3].

Layer	Radius	# of ladders
1	8,10,12,15 mm	8
2	26 mm	22
3	37 mm	32
4	48 mm	40
5	60 mm	50

Table 1: VTX detector layer specifications.

2 Background hits rejection

Hit density in a given layer of the VTX depends on beam parameters and the radius of the layer. Example distributions for the first layer with different radii are shown on Figure 1.

A track going through a silicon pixel plate deposits charge in several pixels forming a cluster. The shape of a cluster depends on the direction of a track with respect to the detector plane. This direction is described by two angles, γ and ξ, as shown on Figure 2.

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Figure 5 shows that hits left by e^+e^- pair background have higher values of the ξ angle than hits left by physics tracks. Possibility of reconstructing the γ and ξ angles from the cluster shape would allow background rejection.

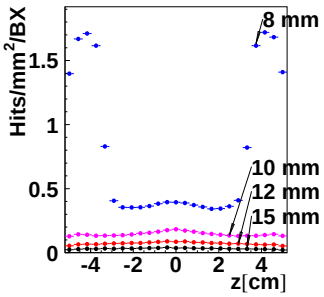

Figure 1: Hit density in the 1st layer

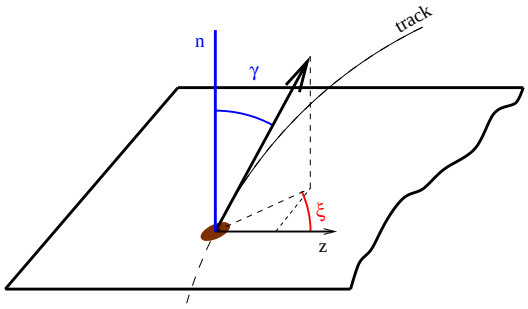

Figure 2: γ and ξ in local coordinate frame, z coincides with the global detector Z coordinate

3 Jet flavour tagging performance

Jet flavour tagging performance was tested with 45.6 GeV jets in presence of e^+e^- background. Scenarios with 131BX, 66BX and no background were studied. For each scenario efficiency of selection at fixed purity and purity of the sample at fixed efficiency were studied. Results for "b" and "c" jet selection are shown on Figures 3 and 4. In the presence of the background the optimal radius of the first layer is 12 mm.

References

[1] Slides:
`http://ilcagenda.linearcollider.org/contributionDisplay.py?contribId=296&sessionId=74&confId=1296`

[2] C.Rimbault, P.Bambade, K.Moenig, D.Schulte, Study of incoherent pair generation in Guinea-Pig, EUROTeV-Report-2005-016-1

[3] D. Jackson, ZvTop, NIM A388:247-253, 1997

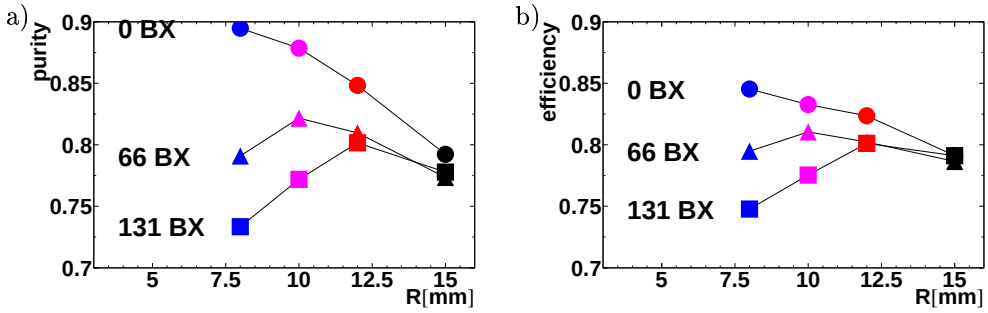

Figure 3: "b" jet selection a) purity at fixed efficiency of 0.8, b) efficiency at fixed purity of 0.8

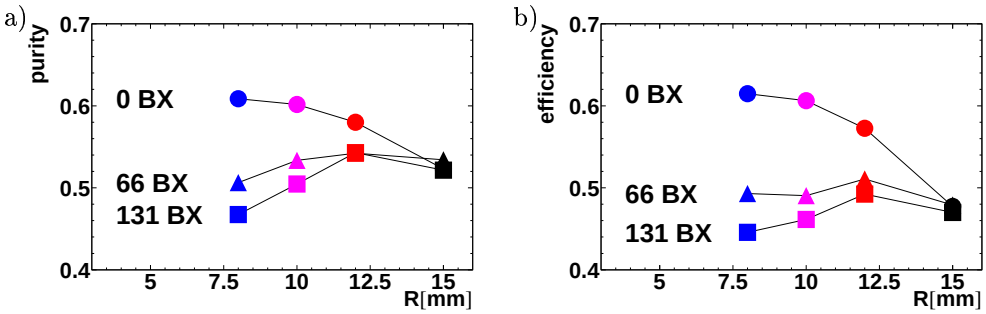

Figure 4: "c" jet selection a) purity at fixed efficiency of 0.6, b) efficiency at fixed purity of 0.6

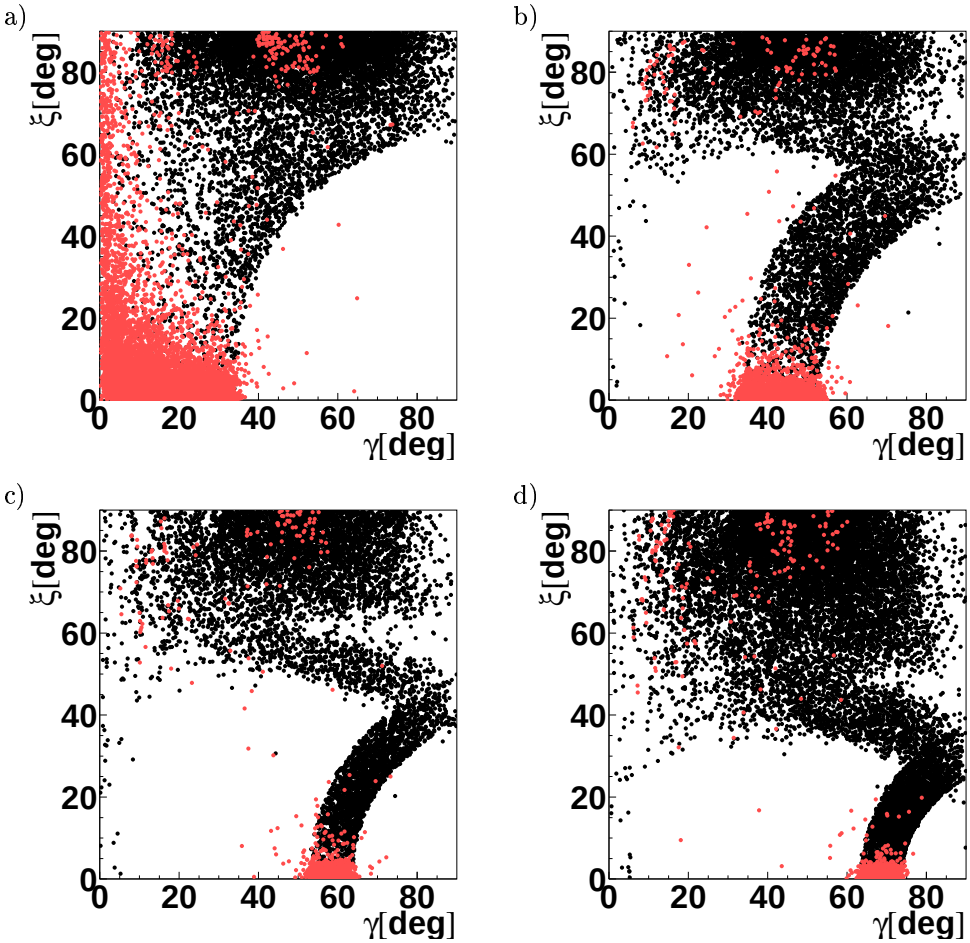

Figure 5: γ and ξ for signal (red/gray) and background (black) hits in the first layer at a) $|z| < 1$ cm, b) 1 cm $< |z| < 2$ cm, c) 2 cm $< |z| < 3$ cm, d) $|z| > 3$ cm (interaction point is at z = 0)