New JLC Mask System at B=3T

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Abstract. Beam background hits due to pair-background in JLC detector models with different magnetic field, mask design, and position of final quadrupole magnets have been estimated. Preliminary design of the beam dump line is described and the background generated by the lost beam in the dump line is also estimated.

INTRODUCTION

In linear collider (LC) experiments, several kinds of beam background are expected to hit the detector components. The background hit rate depends on the design of the detector, as well as the design of the accelerator. In JLC detector model [1] solenoid field of 2 T has been assumed. To reduce the number of hits in the vertex detector by low energy pair-background particles($e^{\pm}$), stronger magnetic field is preferable. In the JLC accelerator design [2], the final focus quadrupole magnets(QC1) are located 2 m away from the interaction point(l^{*}=2 m). Recently a new idea of final focus optics is proposed [3] which makes longer l^{*} of 4.3 m possible. With this optics, the backgroud particles (γ, $e^{\pm}$, neutron) due to backscattering from QC1 would be reduced. In this article, we present the results of simulation studies on the pair-background in several detector models which have different magnetic field, mask design, and l^{*}.

Another background source which might be serious for the detector is backscattering of neutrons produced by the disrupted beam lost in the dump line. A preliminary design of the dump line of the JLC with capability of beam energy measurement is presented here. Rough estimation of the neutron background from the dump line is also shown.

BACKGROUND IN DIFFERENT DETECTOR MODELS

Background hit rate has been studied for four detector models (table 1). Compared with the 2 T model [1,4], outer radius of the central drift chamber (CDC) and inner radius of the barrel calorimeter of the 3 T models are reduced in order to keep the minimum p_t of charged particles which reach the barrel calorimeter constant.

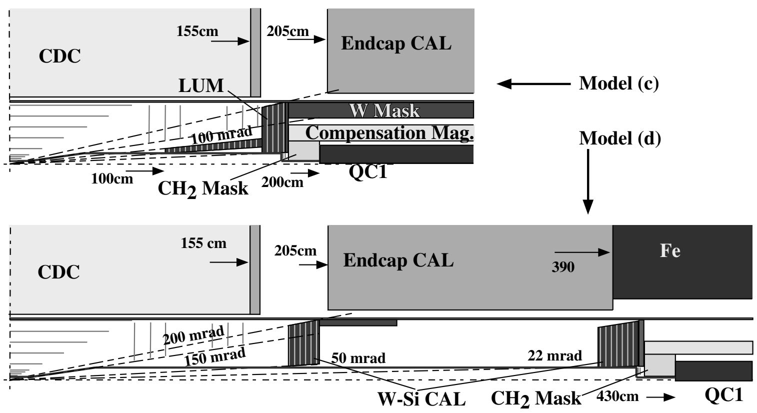

FIGURE 1. Schematic views of model c) and d) detectors.

The length in z direction of the CDC and the z position of the endcap calorimeter are also reduced in 3 T models. In models a) and b), large conical tungsten masks are placed to shield the backscatterd particles prodeced by the pair-background particles hitting the QC1. Smaller conical masks are used for the model c). Model d) is for the case of l^*=4.3 m. Two sets of forward calorimeters work as active masks in this model. Schematic views of model c) and d) are shown in fig. 1. The pair-background particles wewe generated using a program code CAIN [5] for the beam energy of 250 GeV and the luminosity of $0.88 \times 10^{34}/\mathrm{cm}^2\mathrm{s}$. These particles were put into a full detector simulation program JIM which is based on GEANT3. Magnetic fields of the QC1 and the compensation magnets were taken into account. The cut off energy was set to 10 keV for γ's and 1 keV for neutrons.

The result of the simulation is given in table 1. Background hit rate of CDC by neutrons in 2 T model is quite high because 10 cm thick tungsten mask is not enough to stop neutrons. In 3 T models, the CDC hit rate by neutrons is reduced because the neutron source (QC1) is surrounded by the endcap calorimeter which works as a neutron shield. With l^*=4.3 m optics, the background source is located farther from the detector components and the background hit rate of the detectors get still less. The simulation was also performed with another machine parameter set which gives about three times more luminosity ($2.61 \times 10^{34}/\mathrm{cm}^2\mathrm{s}$). This simulation gave about two times more background.

TABLE 1. Detector models and expected background hits per beam crossing: track density at the innermost layer (r=24 mm) of vertex detector(VTX), the number of hits in central tracker(CDC) by γ and neutron, and energy deposit in calorimeter(CAL).

	B(T)	l^*(m)	Mask	VTX(/cm^2)	CDC(γ)	CDC(n)	CAL(MeV)
Model a)	2	2	150 – 200 mrad	0.7	2	30	600
Model b)	3	2	150 – 200 mrad	0.4	1	2	900
Model c)	3	2	70 – 100 mrad	0.4	2	2	900
Model d)	3	4.3	–	0.4	1	0.1	30

BEAM DUMP LINE

Preliminary design of the dump line, beam line after the interaction point, was studied. SAD [6] was used for this design. In the beam line, energy distribution of the beam after the collision should be measured with resolution less than 0.1% for $\delta E/E > -1\%$ where $\delta E/E$ is the relative energy deviation from the nominal energy. On the other hand, beam loss in the line should be as little as possible to reduce background for the detector. In order to measure beam energy distribution, beam is focused again at the second focal point, FP2. And vertical bending is introduced to make vertical dispersion at FP2. The optics of the beam line is shown in fig. 2. Four quadrupole magnets, two sets of doublet, are used for re-focusing. Two vertical bending magnets are used for introducing dispersion. Magnetic fields of the two final quadrupole magnets of the opposite main (incoming) beam line were also considered. Transverse distribution of monochromatic beams at FP2 are shown in fig. 3. Each cluster of the distribution represents a distribution of electrons in a monochromatic beam of $-\delta E/E$=0, 0.2, 0.4, 0.6, 0.8 or 1.0%. Here, we assume the transverse beam parameters after collision as [7]: normalized emittance x/y=1600/20($\times 10^{-8}$ m), beta function x/y=4/0.15(mm). Energy distribution will be measured, for example, scanning a horizontal laser beam with small vertical size, detecting gamma rays produced by Compton scattering. And, roughly speaking, the resolution would be less than 0.1% for $\delta E/E > -1\%$.

To study beam loss, tracking was performed using SAD. 40000 macro particles were used in the tracking. The initial condition of the macro particles were calculated [7] using the computer code CAIN. Some simple aperture at each magnet was assumed and particles went out of it was assigned to be lost at the position. Fig. 4 shows the energy distribution of survived particles (solid) and that of lost particles (dashed). About 0.9% of the total particles (which had low energy) were lost. Fig. 5 shows the rate of neutron dose at the interaction point. We assumed that one neutron would be created per 10 GeV beam loss. The neutron dose was calculated considering the distance between the IP and the lost position assuming

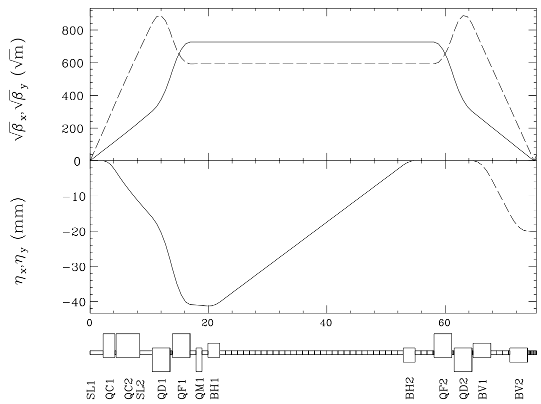

FIGURE 2. Optics of the beam extraction line.

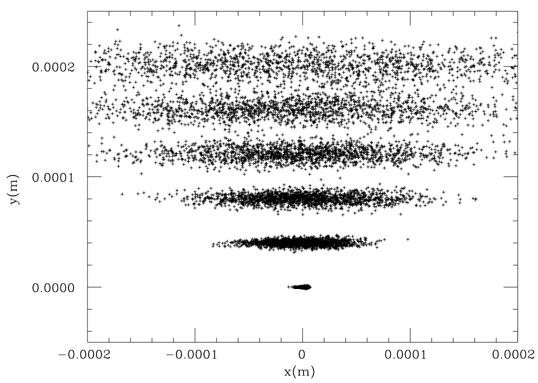

FIGURE 3. Transverse distribution of monochromatic beams at FP2.

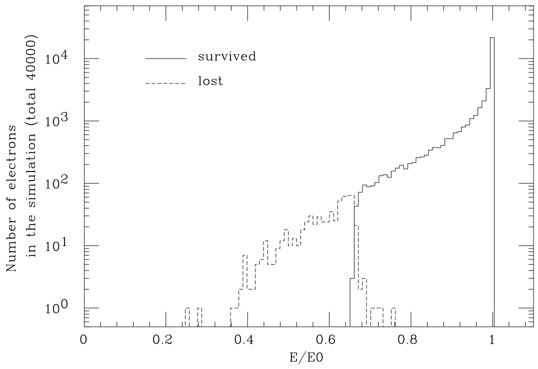

FIGURE 4. Energy distribution of survived particles (solid) and lost particles (dashed).

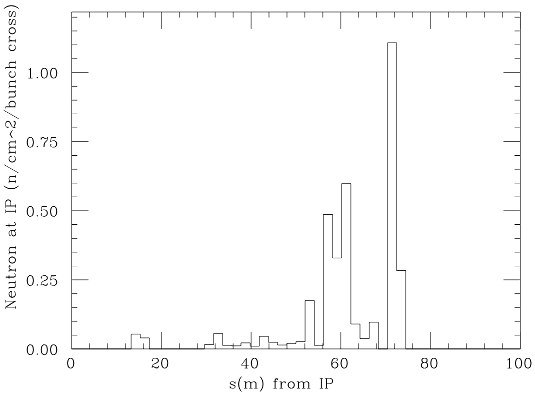

FIGURE 5. Rate of neutron dose at the interaction point (/cm^2/bunch crossing).

no shielding between them. In total, $4 \times 10^{11}/\mathrm{cm}^2$ neutron dose is expected in one year. This result may not be acceptable. But it should be noted that the self-shielding effect or additional shield is not included in this study. In addition, more realistic (and complicated) assumption of the aperture may reduce the beam loss. If we loosen the requirement for the resolution of the energy distribution measurement, the beam line optics may be modified to reduce the beam loss.

SUMMARY

We have studied beam background due to pair-background and demonstrated the advantage of 3 T detector model over 2 T model. The optics with l^* of 4.3 m is more advatageous in terms of beam background. A preliminary design of beam dump line and neutron background from the dumpline have been studied. The estimated neutron dose at the IP requires more sophisticated design or additional shielding.

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