VTX for GLD – B and Machine Parameter Dependence of $\mathrm{R_{VTX}}$

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GLD is one of three proposed detector concepts for ILC. Compared with other two detector models, GLD has weaker magnetic field of 3 T. Therefore, it might require larger inner radius of the vertex detector in order to avoid serious pair-background hits. We have estimated the minimum inner radius of the vertex detector R_{VTX} based on pair-background simulations for several machine parameters for different solenoid magnetic field of 3, 4, and 5 T. It was found that the B dependence of R_{VTX} is not so large compared with the machine-parameter dependence.

1. GLD DETECTOR CONCEPT AND THE VERTEX DETECTOR

GLD is a large detector model for ILC experiment based on a large gaseous tracker (see Figure 1). The large radius of the tracker (presumably TPC) gives excellent p_t resolution and particle ID capability by dE/dx measurement. The large radius of the calorimeter is preferable for good PFA performance. If the calorimeter has good timing resolution, particle ID is also possible using TOF. As the vertex detector for the ILC experiment, a lot of sensor technologies are proposed but none of them seems to be demonstrated to work satisfactorily at ILC. For the moment, we assume fine pixel option as the baseline design of GLD vertex detector just because it is unique (different configuration from standard pixel options which are assumed in other detector concepts, SiD and LDC). It does not mean that the standard pixel option is rejected for GLD, of course. A tentative baseline design is schematically shown in Figure 1.

Compared with other two detector concepts, GLD has relatively low magnetic field of 3 T (SiD and LDC have 5 T and 4 T, respectively). The impact of the magnetic field on the vertex detector design is the radius of the innermost layer. Higher magnetic field confines the pair-background in a smaller radius, and the beam pipe and the vertex detector can be put closer to the beam line. So the GLD vertex detector has to have slightly larger inner radius R_{VTX} to keep background hit density same as other detector concepts.

2. DETERMINATION OF $\mathrm{R_{VTX}}$

We have estimated the possible smallest radii of the beam pipe and the innermost layer of the vertex detector based on a simple model. The model we have used is shown in Figure 2. The radii were determined using following

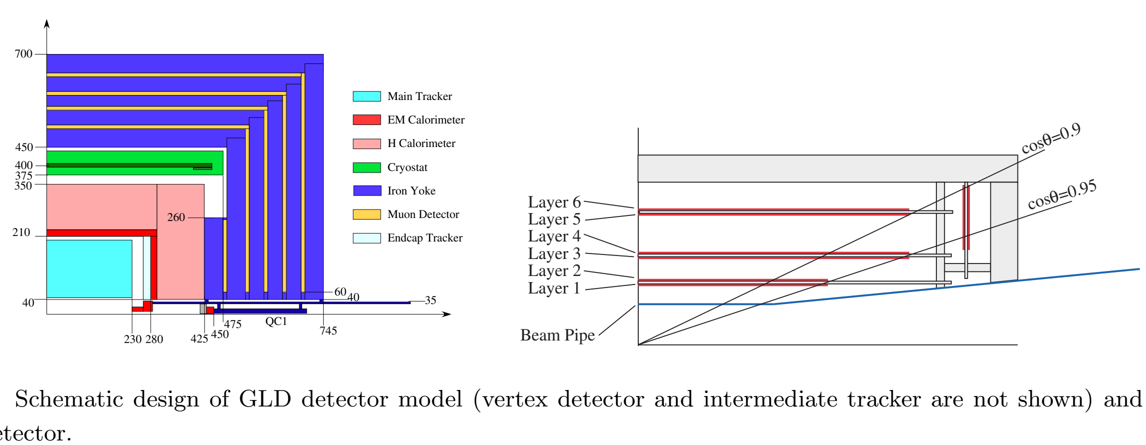

Figure 1: Schematic design of GLD detector model (vertex detector and intermediate tracker are not shown) and the GLD vertex detector.

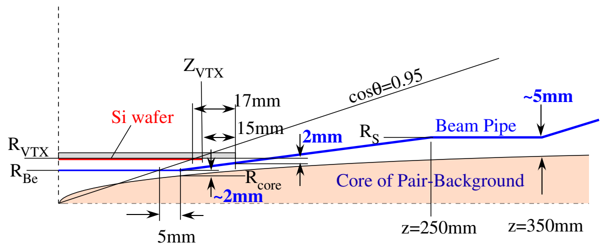

Figure 2: Model for estimation of radii of the beam pipe and innermost layer of the GLD vertex detector.

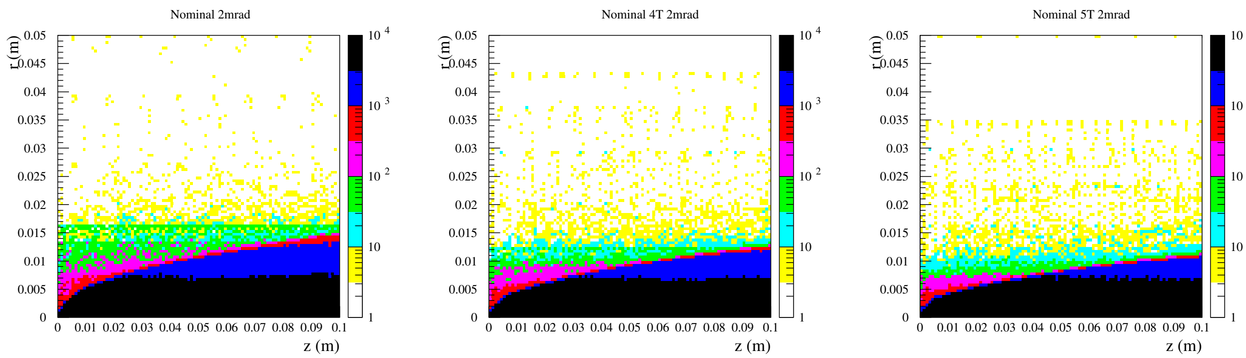

Figure 3: Pair-background track density (/cm^2/BX) with the nominal ILC machine parameter at 500 GeV and 2 mrad crossing angle in 3 T (left), 4 T (center), and 5 T (right) magnetic field.

design criteria:

- The dense core of the pair background should not hit the beam pipe. It should have $\sim$ 5 mm clearance at $z = 350$ mm and $\sim$ 2 mm clearance at the junction of the central beryllium part and the conical part.
- The silicon wafer is 2 mm longer than what is required to cover $|\cos\theta| < 0.95$.
- The ladder length is longer than the silicon wafer by 15 mm. The clearance between the ladder and the conical part of the beam pipe is 2 mm.

The simulation for pair background was done using CAIN for various ILC parameter sets. The track density of the pair background in z-r plane is shown in Figure 3 with the nominal ILC parameter set [1] and crossing angle of 2 mrad for 3, 4, and 5 T magnetic field. Figure 4 shows the track density distribution for high luminosity option of ILC parameters [1]. The distribution of the dense core of the pair-background tracks with the original high luminosity option is significantly broader than that with the nominal option. Recently, A. Seryi proposed new high-luminosity parameter sets [2]. These new high luminosity parameter sets give less and narrower pair background as can be seen from Figure 4. The beam-pipe parameters and R_{VTX} determined by the design criteria and the background simulation described above are summarized in Table I. We can see that R_{VTX} strongly depends on the machine parameter option.

3. SUMMARY

In order to see the impact of relatively weak magnetic field of GLD on the vertex detector design, the minimum radius of the vertex detector R_{VTX} has been estimated for several machine parameter sets and different magnetic

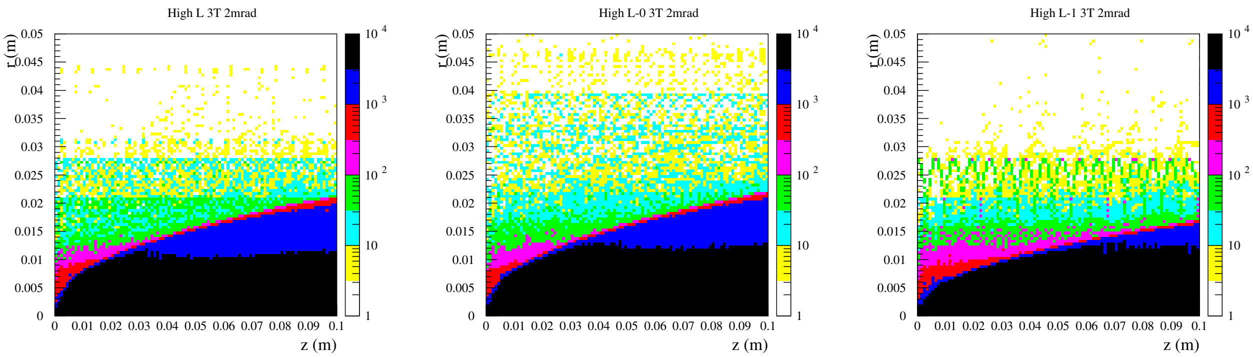

Figure 4: Pair-background track density (/cm^2/BX) with the high luminosity option of ILC machine parameter at 500 GeV (left), 1 TeV (center) [1], and the new high luminosity option at 1 TeV [2] (right). The crossing angle is 2 mrad and the magnetic field is 3 T for all three cases.

Table I: The beam-pipe parameters and R_{VTX} for several machine options and different magnetic field B based on a certain design criteria. High Lum-A1 and High Lum-A2 stand for the new high luminosity parameter sets proposed by A. Seryi. See Figure 2 for the definition of each parameter.

$\mathbf{E_{CM}}$	**Option**	**B (T)**	$\mathbf{R_{core}}$ **(mm)**	$\mathbf{R_{Be}}$ **(mm)**	$\mathbf{R_s}$ **(mm)**	$\mathbf{R_{VTX}}$ **(mm)**	$\mathbf{Z_{VTX}}$ **(mm)**
500 GeV	Nominal	3	10.5	12.5	30	16.6	52.4
		4	9	11	28	14.9	52.4
		5	7.5	9.5	25	13.2	42.0
	High Luminosity	3	16.5	18.5	42	24.1	75.4
		4	13.5	15.5	36	20.2	63.6
		5	12	14	33	18.4	57.6
1 TeV	Nominal	3	11	13	32	17.3	54.7
	High Luminosity	3	18.5	20.5	42	25.8	80.5
	High Lum-A1	3	13	15	34	19.4	61.1
	High Lum-A2	3	11.5	13.5	32	17.8	56.1

field strength B based on a certain design criteria and simulated pair-background tracks. We found R_{VTX} has weak B dependence ($\sim B^{-0.5}$ [3]) and strong dependence on machine parameter set. The high luminosity option requires larger R_{VTX} than the nominal option by 5 mm or more for all detector concepts. The new high luminosity options at 1 TeV proposed by A.Seryi are very attractive. His approach should also be applied to 500 GeV case. Disadvantage of the GLD vertex detector due to the low B field is not so serious, and it could be recovered by other features of GLD. For example, π/K separation by good dE/dx measurement with large TPC and good TOF measurement using scintillator-base calorimeter with long flight length will help quark flavor identification.

References

[1] T. Raubenheimer, "ILC Suggested Beam Parameter Range", accessible from http://www-project.slac.stanford.edu/ilc/acceldev/beamparameters.html

[2] A. Seryi, "Discussion of ILC high luminosity parameters", http://www-project.slac.stanford.edu/lc/bdir/Meetings/beamdelivery/2005-07-26/high_lumi_pars.ppt

[3] M. Battaglia, A. Andeazza, M. Caccia, and V. Telnov, HIP-1997-52-EXP (1997)