DØnote # 3363

Road Definition for Silicon Track Trigger

Ulrich Heintz
Fermi National Accelerator Laboratory, Batavia, IL

December 3, 1997

1 Introduction

The Silicon Trigger (STT) receives information from the Level 1 CFT trigger. This information is transmitted during the first 2.5 μs after a Level 1 accept, while the data from the silicon detector are digitized. The STT converts the CFT information into ranges of channel addresses in the silicon detector (roads). The roads encompass all silicon detector channels that can be hit by any possible track, consistent with the CFT information. After digitization is complete the silicon detector data are send to the data acquisition system and the STT. The STT clusters the hits and compares the cluster centroids to the roads. Cluster centroids that are inside a road are stacked into a FIFO for further processing.

This note addresses the following questions:

1. What information is required for a level 1 CFT track candidate to compute the roads in the silicon detector?

2. What size roads in the silicon detector are required to accept all hits from tracks up to a maximum impact parameter?

3. How big a section of the CFT can share tracks with one sector of the silicon detector?

4. Do we need to consider tracks that cross sectors in the silicon detector?

For this study, I have used a program written by Marvin Johnson[1] to compute the patterns of fibers hit in the CFT and extended it to compute the roads in the silicon detector. The program computes the patterns of fibers that tracks with $p_T > 1.5$ GeV can hit. The range of fibers in the outermost layer is restricted to fiber numbers 45–55. Tracks which hit a given outer fiber can hit one of 27 or 28 inner fibers.

[1] see DØ note 2615 for details.

2 Road Definition

The pattern of hit fibers in the CFT defines a family of tracks, which all go through the hit fibers. The envelope of all these tracks defines the road in the silicon detector, which corresponds to the pattern of CFT fibers. We begin with the assumption that the level 1 CFT trigger will transfer only the information about the inner- and outermost hit fibers. The pattern then consists only out of these two fibers. The tracks with the smallest and largest curvature define the envelope of all tracks, that pass through these two fibers, for radial positions smaller than that of the inner hit fiber. Figure 1 shows the road in the silicon detector spanned by two hit fibers in the CFT. The solid lines indicate road for tracks that pass through the origin. If we also want to accept all hits from tracks with non-zero impact parameters b the road widens as indicated by the dashed lines.

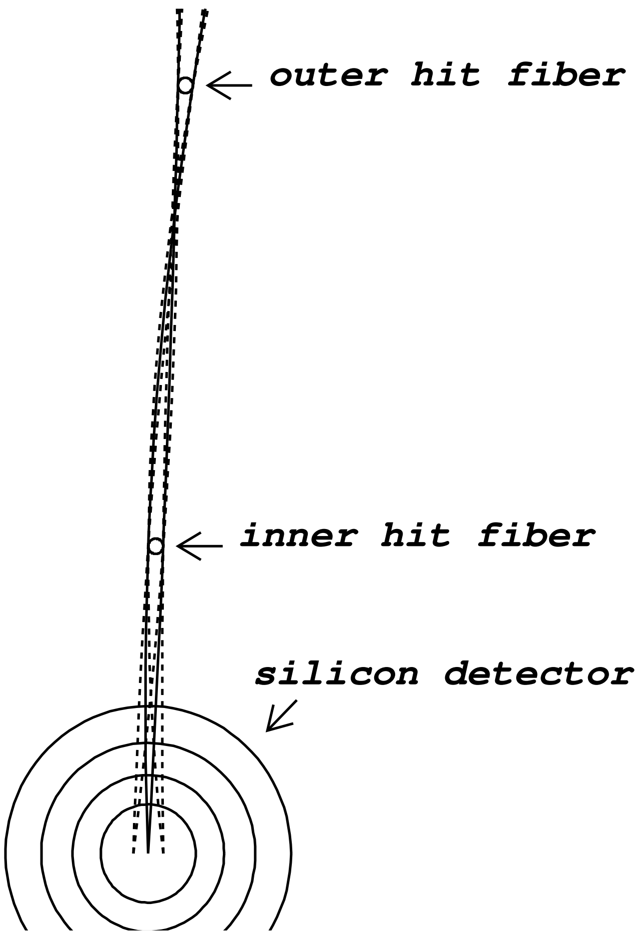

Figure 1: Road definition in the silicon detector.

Table 1: Road sizes in silicon detector.

layer	radius	road for $b=0$		road for $\|b\| < 1$ mm		road for $\|b\| < 2$ mm	
		mrad	mm	mrad	mm	mrad	mm
1a	2.72 cm	$\pm$ 4.2	$\pm$0.12	$\pm$34.3	$\pm$0.93	$\pm$64.4	$\pm$1.75
1b	3.65 cm	$\pm$ 4.1	$\pm$0.15	$\pm$24.8	$\pm$0.91	$\pm$45.7	$\pm$1.66
2a	4.55 cm	$\pm$ 4.0	$\pm$0.18	$\pm$19.4	$\pm$0.88	$\pm$34.8	$\pm$1.58
2b	5.55 cm	$\pm$ 3.9	$\pm$0.22	$\pm$15.4	$\pm$0.86	$\pm$27.0	$\pm$1.50
3a	6.77 cm	$\pm$ 3.8	$\pm$0.26	$\pm$12.1	$\pm$0.82	$\pm$20.6	$\pm$1.39
3b	7.58 cm	$\pm$ 3.7	$\pm$0.28	$\pm$10.5	$\pm$0.80	$\pm$17.5	$\pm$1.33
4a	9.10 cm	$\pm$ 3.6	$\pm$0.32	$\pm$ 8.4	$\pm$0.76	$\pm$13.2	$\pm$1.20
4b	10.05 cm	$\pm$ 3.4	$\pm$0.35	$\pm$ 7.3	$\pm$0.73	$\pm$11.2	$\pm$1.13

For simplicity, I approximate the silicon detector by eight concentric cylinders. Pairs of cylinders correspond to the layers of the silicon detector. The radius of each cylinder is equal to the mean radial position of the silicon strips. Table 1 lists the radii of the cylinders.

Each pair of inner and outer fibers define a road in the silicon detector. Figures 2 and 3 show plots of the azimuth of the road versus the index of the outer fiber for tracks with $p_T > 1.5$ GeV that go through the center of the detector. The 27 or 28 small vertical lines plotted for each outer fiber indicate the road defined by one pair of inner and outer fibers. The width of the road is the same for all pairs of fibers. All roads for one outer fiber cover $\pm 6°$ in azimuth for the innermost silicon detector layer (figure 3). This means a silicon strip may be in the road defined by patterns with an outer fiber that is separated from the silicon strip by up to 6° in azimuth. The road position is a strong function of the inner fiber index, but depends only weakly on the outer fiber index. This means that the outer fiber index could be given with a precision of less than one fiber without significant widening of the road. For a precision of two fibers the road would increase in width by about 12%, for a precision of four fibers by 25%.

3 Finite Impact Parameters

For tracks with finite impact parameters the roads defined by the pair of inner and outer fiber shift with respect to their location for zero impact parameter, as indicated by the dashed lines in figure 1. Figure 4 shows the width of the road in azimuth around the track, defined by the centers of the inner and outer fibers and the origin, versus radius. The black region is the road defined by tracks passing through the origin, the dark shaded region is the road defined by the envelope of all tracks with impact parameter $|b| < 1$ mm, and the light shaded region for $|b| < 2$ mm. Figure 5 shows the road widths in arclength. Table 1 lists the road widths at the radii of the silicon layers. In the table "a" and "b" refer to the two overlapping sublayers that make up one silicon layer.

4 Complete Patterns of Hit Fibers

If the complete pattern of eight fibers were available to determine the silicon roads, they could be computed with higher precision. Figure 6 shows the spectrum of road sizes for the individual patterns. The width of the roads defined by inner and outer fibers is 8.4 mrad. The distribution of road widths defined by eight fibers has a mean of 2 mrad with a long tail to high values.

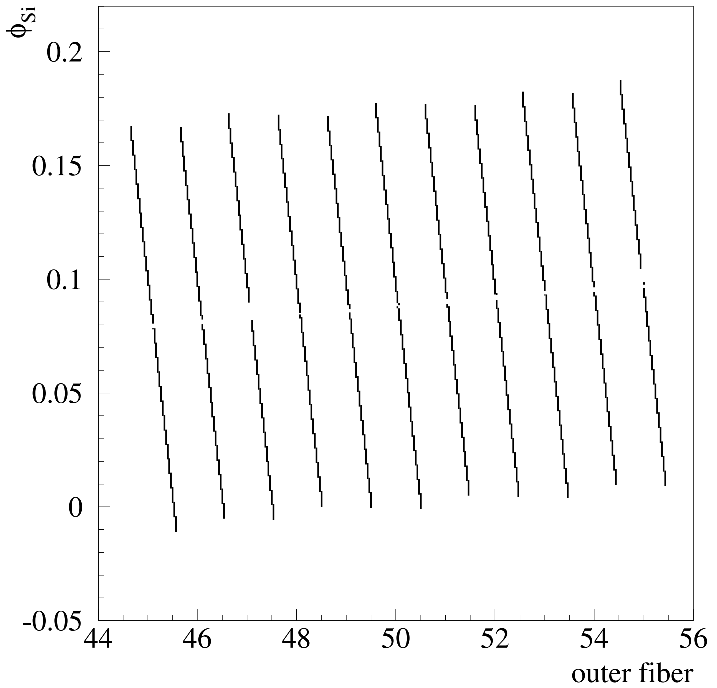

Figure 2: Width of silicon roads in outermost silicon layer.

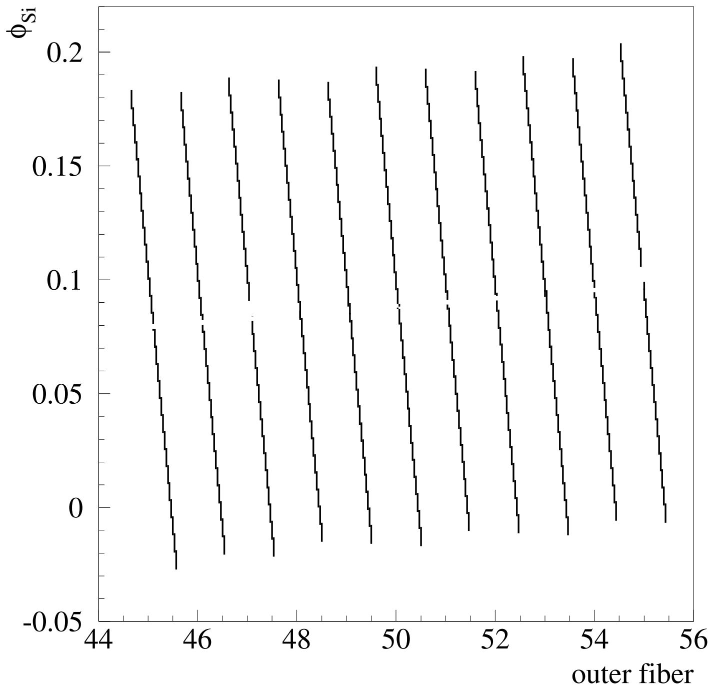

Figure 3: Width of silicon roads in innermost silicon layer.

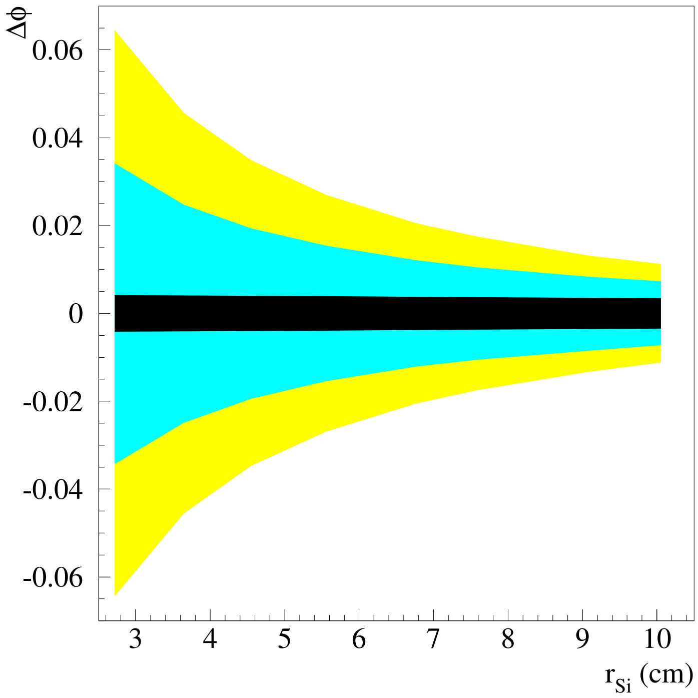

Figure 4: Width of silicon roads versus radius.

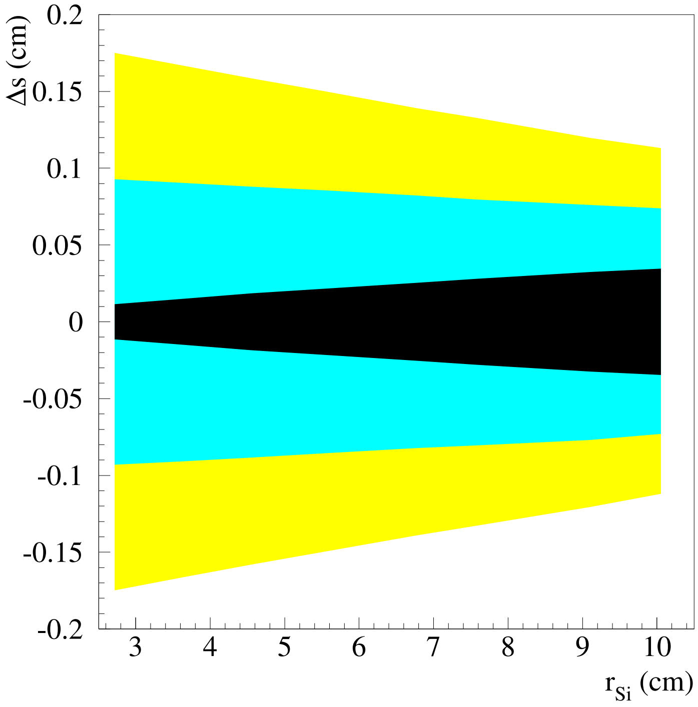

Figure 5: Width of silicon roads versus radius

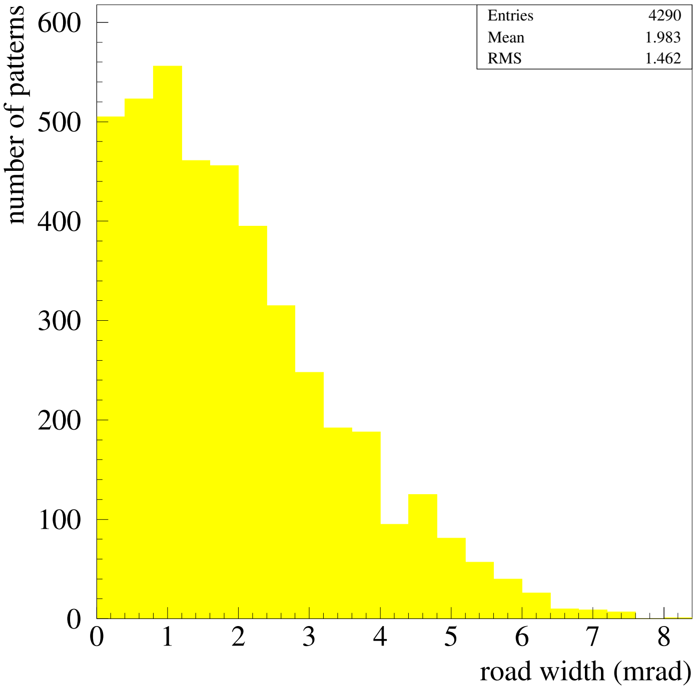

Figure 6: Width of silicon roads for eight-fiber hit patterns in innermost silicon layer.

5 Sector Boundaries in Silicon Detector

The design of the STT would be simplified by ignoring tracks that cross sector boundaries in the silicon detector. Figure 7 shows three 30° sectors in the silicon detector. The lines indicate the active areas of the ladders and the shaded regions the intervals in azimuth for which tracks with infinite momentum, coming from the origin, are contained in one 30° sector. There is only a tiny interval (1/4°), for which tracks hit two sectors. The acceptance loss from tracks that cross sectors depends in general on the p_T and the impact parameter b of the track. Figure 8 plots the acceptance loss versus curvature ($=1/p_T$) of the track for several impact parameter values. The plot of acceptance loss reflects the slight asymmetry of the detector between tracks with positive and negative curvatures and impact parameters. For $|p_T| > 1.5$ GeV the acceptance loss is never more than 1.2% for $b = 0$. For $b = 1$ mm it is on average 1.0% and for $b = 2$ mm it is 2.2%. This losss in acceptance is driven by the small overlap between the active regions of the ladders in layer 3. If tracks with hits in only the other three layers (1, 2, and 4) are accepted, the acceptance loss is zero.

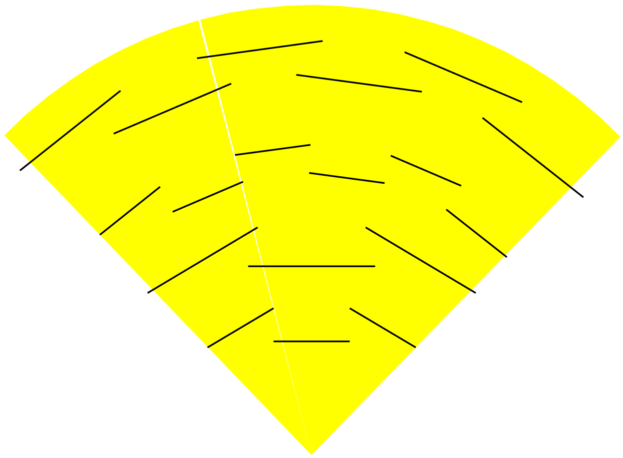

Figure 7: Three sectors in the silicon detector.

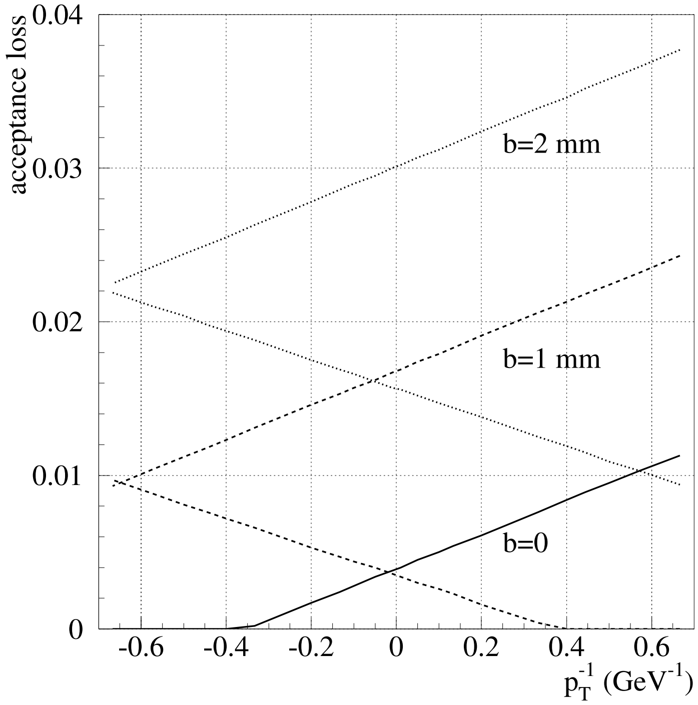

Figure 8: Acceptance loss vs curvature.

6 Conclusions

To return to the questions posed at the beginning:

1. The roads in the silicon detector can be computed as precisely as necessary if the inner and outer fibers hit by the track are specified. Better knowledge of the fiber hit pattern may reduce the road width by up to a factor four on average, but also requires roads of varying size. Ultimately, the width of the roads is dominated by the largest accepted impact parameter.

2. Table 1 lists the road sizes in the four layers of the silicon detector.

3. One silicon detector channel in the innermost layer can be hit by tracks that go through fibers in the outer CFT layer in a range of 12° in azimuth. If the track is allowed to have an impact parameter of 2 mm the range increases by another 7°. That means that a 15° sector in the silicon detector can share tracks with fibers in a range of 34° in azimuth or up to 9 CFT sectors. A 30° sector in the silicon detector can share tracks with fibers in a range of 49° in azimuth or up to 12 CFT sectors.

4. Tracks that cross sectors in the silicon detector can be ignored without significant loss in acceptance.