More Information on Tracks that Pass Through the STT Overlap Card

by

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Abstract

This note is intended to clarify several aspects of the STT Overlap Card, including, which tracks go to which card and how the tracks are distributed to the sextant cards.

Most of the information about the protocols for the transfer of data from the digital front ends to the STT is described in Manuel Martin's documentation [1]. This note is a supplement to that document, and covers two main topics. The first section covers which CFT sectors are sent to which collector and broadcaster boards before being sent to the STT. The second section describes which tracks the overlap cards sends to which sextant cards.

(With the passage of time the names of the STT collector and broadcaster boards has changed. Depending on the documentation the STT collector boards might be called Overlap, Overlay, STOV, or OLR boards. Likewise, the STT Broadcaster boards might be called Sextant, STSX, or SEXT boards. This document will attempt to stick to the terms Overlap and Sextant boards.)

1 Distribution of the Front End Sectors

The CFT is divided into 80 sectors and the SMT is divided into six sectors. Each sector can only be sent to either an overlap or a sextant board. The tracks in some of the CFT sectors will need to be sent to two different STT sectors, while the tracks in some CFT sectors need to go to only one STT sectors. The sectors that have tracks that need to be sent to two STT sectors are sent to the overlap cards and the other tracks are sent directly to the sextant cards.

In Manuel's documentation [1] he describes which CFT sectors are sent to which overlap and sextant boards. The problem is that at the time this documentation was written the divisions of the STT sectors was not decided. Manuel started the first STT sector at zero degrees, when it turns out that the first sector should start at -15 degrees. Following Manuel's method and taking into account the 15 degree offset, the sectors get remapped as shown in Table 1.

Overlap board	Sextant board	CFT Sectors	# Sectors	ϕ coverage	$\Delta\phi$ from sextant lower	upper
	0	$0-6$	7	$0.0-31.5$		
0		$7-12$	6	$31.5-58.5$	13.5	13.5
	1	$13-19$	7	$58.5-90.0$		
1		$20-25$	6	$90.0-117.0$	15.0	12.0
	2	$26-33$	8	$117.0-153.0$		
2		$34-39$	6	$153.0-180.0$	12.0	15.0
	3	$40-46$	7	$180.0-211.5$		
3		$47-52$	6	$211.5-238.5$	13.5	13.5
	4	$53-59$	7	$238.5-270.0$		
4		$60-65$	6	$270.0-297.0$	15.0	12.0
	5	$66-73$	8	$297.0-333.0$		
5		$73-79$	6	$333.0-360.0$	12.0	15.0

Table 1: Mapping of CFT sectors to overlap and sextant boards. Also shown are the number of CFT sectors and ϕ coverage of each board. The $\Delta\phi$ shows how far the region covered by the overlap board extends into the adjacent STT sector.

2 ϕ selection in the Overlap Board

The need for an overlap region is also described in Manuel's documentation [1]. In there Manuel calculated that the greatest displacement at the CFT H layer of a valid track that is completely contained in a STT sextant would be about 9.5 degrees beyond the edge of the sextant. Since Manuel did not take into account that the SMT detectors overlap and hence extend beyond their defined sextant boundry, the needed overlap will be investigated. In order to reduce the number of tracks that is sent to each sextant card, it has also been suggested that the tracks that that are to be sent to both cards be determined by their p_T bin and sign as opposed to just their sign. This will also be studied.

The maximum ϕ displacement of the track at the H layer of the CFT depends on many factors, including p_T of the track, impact parameter, where the particle passes through the silicon, and others. Figure 1 shows the track of a particle in the xy plane of the D0 detector. Since it is only the displacement that is of interest at the moment, the $x-$axis has been realigned to be on the same boundry as a sextant.

The position of the particle on the track shown in Figure 1 can be given in polar coordinates, (r, ϕ). The position of interest is that of the particle at the CFT H layer, (r_H, ϕ_H). The maximum displacement will depend on the position of the particle as it passes through the most exterior silicon detector, shown as (r_s, ϕ_s). The particle track is also constrained to

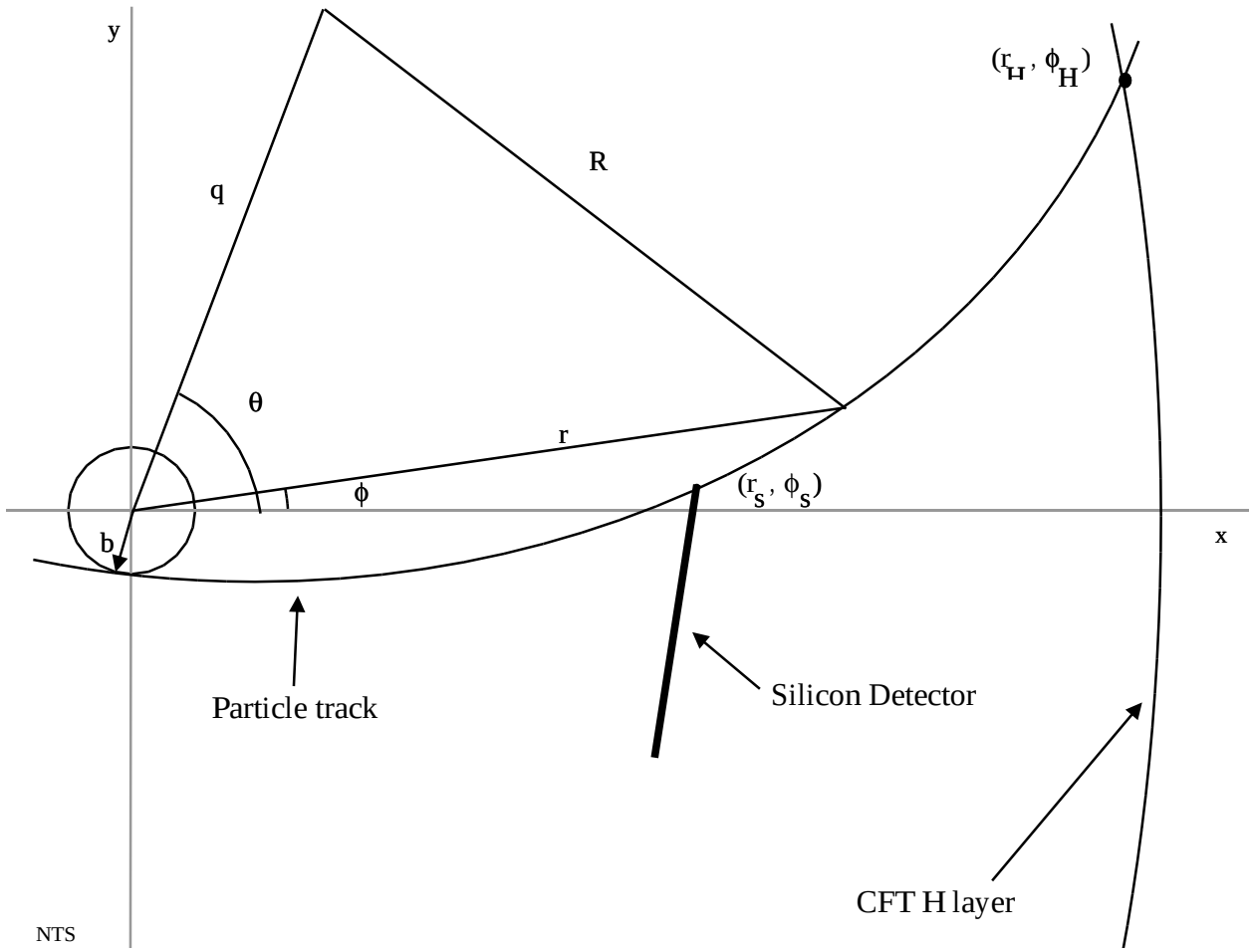

Figure 1: This figure shows a particle's track in the xy plane. See the description in the text for more information.

have a maximum impact parameter, b.

The track in the xy plane of a charged particle with transverse momentum, p_T, (in GeV/c) in a constant magnetic field, B, is given [2] to be a circle with a radius or curvature:

$$R = p_T/0.003B \tag{1}$$

where R is in centimeters and B is in Tesla. The center of the track's circle is defined to be (q, θ). This defines the triangle shown in Figure 1. From the law of cosines,

$$R^2 = q^2 + r^2 - 2qr\cos(\theta - \phi). \tag{2}$$

This leaves two unknowns, q and θ. Noting that the point at which the track is tangent to the impact parameter circle is 180 degrees from q gives, $q = R - b$. Plugging this equation and the point (r_s, ϕ_s) into Equation 2 and solving for θ gives:

$$\theta = \phi_s + \cos^{-1}[\frac{b^2 - 2Rb + r_s^2}{2(r-b)r_s}]. \tag{3}$$

Finally, if θ and q are plugged into Equation 2 and it is solved for ϕ gives:

$$\phi = \phi_s + \cos^{-1}[\frac{b^2 - 2Rb + r_s^2}{2(R-b)r_s}] - \cos^{-1}[\frac{b^2 - 2Rb + r^2}{2(R-b)r}]. \tag{4}$$

Now that ϕ is given as a function of r from Equation 4, all one needs to do is plug in the value of the radius of the CFT H layer, r_H to find ϕ at the CFT H layer, ϕ_H. However, the values of the variables: p_T, b, r_s, and ϕ_s, still need to be found to maximize ϕ_H. The values for p_T and b were found by putting Equation 4 into a program, and varying the values to see the trend. As expected, either decreasing p_T or increasing b causes ϕ to increase.

The variables r_s and ϕ_s could not be varied independently, as they depended on the position of the detector. There are also two valid detectors that the particle could pass through. Depending on z position and direction of curvature, the outer most silicon detector through which the particle could pass could be layer seven or layer eight. By running the simulator the various possible edges of the detectors were determined. These points were then run through a program to determine which would give the greatest ϕ. It turns out that layer seven had the greatest ϕ, not only due to a smaller r_s, but ϕ_s was also larger.

The final values that were used to give the largest ϕ, is shown in Table 2.

It has been suggested that to reduce the the number of tracks which are sent to the sextant cards, only those tracks whose ϕ is valid for the given p_T bin should be sent. The ϕ values for each p_T bin are given in Table 3. Since some error should probably be added, the ϕ values increased by 5% and 10% are also shown in the table.

Finally, Table 4 shows the sector and fiber cut-off for a given ptsign and ptbin for the +5% increase in ϕ.

variable	value
B	2.0 $Tesla$
p_T	1.5 Gev/c
b	0.2 cm
r_s	9.24023 cm
ϕ_s	2.4587 $degrees$
r_H	51.5189 cm

Table 2: The values used for maximum ϕ.

p_T	ϕ	+5%	+10%
1.5	8.34	8.75	9.17
3.0	5.90	6.20	6.49
5.0	4.93	5.18	5.42
10.0	4.20	4.41	4.62
2000.0	3.48		

Table 3: The maximum ϕ values for a given p_T.

References

[1] M. Martin, "The STT System [CFT information] communication protocals and data encoding," http://d0server1.fnal.gov/users/manuel/Protocols/final_STT.pdf.

[2] Groom *et al.*, "Review of particle physics," Eur. Phys. J. **C15**, 1 (2000).

Table 4: The maximum ϕ, sector and fiber values for each p_T bin on each overlap board for ptsign = 0.

ptsign = 0	ptbin											
overlap	0			1			2			3		
board	ϕ	sec	fib	ϕ	sec	fib	ϕ	sec	fib	ϕ	sec	fib
0	53.75	11	41	51.20	11	16	50.18	11	06	49.41	10	43
1	113.75	25	12	111.20	24	31	110.18	24	21	109.41	24	13
2	173.75	38	26	171.20	38	01	170.18	37	35	169.41	37	28
3	233.75	51	41	231.20	51	16	230.18	51	06	229.41	50	43
4	293.75	65	12	291.20	64	31	290.18	64	21	289.41	64	13
5	353.75	78	26	351.20	78	01	350.18	77	35	349.41	77	28
ptsign = 1	ptbin											
overlap	0			1			2			3		
board	ϕ	sec	fib	ϕ	sec	fib	ϕ	sec	fib	ϕ	sec	fib
0	36.25	08	02	38.80	08	27	39.2	08	37	40.59	09	00
1												
2												
3												
4												
5												