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SDC
SOLENOIDAL DETECTOR NOTES

STUDY OF LOSS DUE TO MISSED COVERAGE IN THE BARREL MUON DETECTOR

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Study of Loss due to Missed Coverage in the Barrel Muon Detector*

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Using the process $H^0 \rightarrow Z^0 Z^0 \rightarrow 2\mu^+ 2\mu^-$ we have studied the loss in detection efficiency due to cracks in the barrel muon octants. We have used two Pythia generated data samples, 5000 events each, and with a Higgs mass of 400 and 700 GeV respectively. The angular coverage in *phi* for each individual muon chamber was taken into account. To first order a track was considered lost in a crack if it missed any single muon chamber; a further investigation of exactly which chambers were missed was done afterwards. This study was performed within the SDC simulation program SDCSIM. In order to speed up the computations only the lead-scintillator calorimeter (AN) and the muon detector (MU) were made active in the simulation; in addition an 18 kG solenoidal magnetic field was used in the central tracking volume.

The type of chamber considered for each barrel muon module is described in the following table. The angular coverage of each octant in *phi* (provided by Colin H. Daly of the University of Washington) for each chamber is included; the chambers

Module	Chambers	ϕ Coverage	Octant 5
BW1	4 *theta*	$42°27'$	$36°13'$
	4 *phi*	$42°56'$	$36°52'$
BW2	4 *theta*	$43°16'$	$38°42'$
BW3	4 *theta*	$43°31'$	$39°41'$
	4 *phi*	$43°48'$	$40°13'$
	2 *stereo*	$43°38'$	$39°41'$

TABLE 1: *Angular coverage in ϕ of the barrel muons chambers.*

in the bottom octant (#5) have a slightly smaller coverage due to space allocated to the support structure.

The number of muons detected (accepted) in the barrel muon system for both a 400 GeV and a 700 GeV Higgs is given in table 2.

# Barrel	400 GeV	700 GeV
0	13.7 %	9.4 %
1	16.4	11.1
2	24.0	29.3
3	23.6	18.6
4	22.2	31.0

TABLE 2: *Muon acceptance in barrel muon system for a Higgs $\rightarrow 4\mu$ with a mass of 400 and 700 GeV.*

The number of muons that were lost in the cracks for each set of chambers is given in the following two tables for the 400 GeV Higgs and 700 GeV Higgs respectively. Overall 83.8 % (82.6 %) of the events from the 400 GeV (700 GeV) Higgs did not have any track missing; while 16.2 % (17.4 %) of the events had one or two missing muons. The number of events with three muons lost is negligibly small (5 events for the 400 GeV Higgs and just one event for the 700 GeV Higgs).

# Lost	All	BW1		BW2	BW3		
		theta	*phi*	*theta*	*theta*	*phi*	*stereo*
0	83.8 %	83.9	86.6	89.3	91.6	93.2	92.4
1	14.6	14.5	12.3	9.9	7.9	6.6	7.3
2	1.5	1.5	1.0	0.7	0.4	0.2	0.2

TABLE 3a: *Number of muons lost in the barrel cracks for a 400 GeV Higgs.*

In these two tables the individual fractions for each muon chamber overlap with one another. Notice that BW2 and BW3 provide a slightly better coverage

than BW1, this is consistent with the values listed in table 1. The breakdown of the numbers given in the second column (under "All") of tables 3a and 3b as a function of the number of muons detected in the barrel is shown in tables 4a and 4b.

# Lost	All	BW1		BW2	BW3		
		theta	*phi*	*theta*	*theta*	*phi*	*stereo*
0	82.6 %	82.7	86.1	89.1	91.6	93.1	92.4
1	16.3	16.2	13.1	10.4	8.0	6.7	7.3
2	1.1	1.1	0.8	0.5	0.3	0.2	0.3

TABLE 3b: *Number of muons lost in the barrel cracks for a 700 GeV Higgs.*

→ Detected ↓ Lost	1	2	3	4
0	767	1016	945	778
1	53	183	214	278
2		4	20	51
3				5

→ Detected ↓ Lost	1	2	3	4
0	510	1261	756	1120
1	46	196	169	391
2		8	6	39
3				1

TABLE 4: *Number of muons lost in cracks as a function of the number of muons detected in the barrel,* **a)** *for 400 GeV Higgs,* **b)** *for a 700 GeV Higgs.*

From these two tables we can deduce the fraction of events with at least one track missing as a function of the number of muons detected. This is shown in table 5. Thus for the case where all four muons are detected in the barrel about 30 % (28 %) of the events have at least one muon missing for a 400 GeV (700 GeV) Higgs.

# Barrel	400 GeV	700 GeV
1	6.5 %	8.3 %
2	15.5	13.9
3	19.8	18.8
4	29.7	27.7

TABLE 5: *Fraction of events with at least one track lost as a function of the number of muons detected.*

As mentioned above the meaning of "lost" refers to a track that missed any one muon chamber. Below we show in more detail where exactly the muon was lost.

Chambers missed	All		1 Lost		2 Lost	
	Trks	%	*Trks*	%	*Trks*	%
BW1 *theta*	160	17.9	130	17.8	28	18.6
BW1 *theta* + *phi*	152	17.0	125	17.1	24	16.0
BW1 *theta* + *phi* + BW2 *theta*	140	15.7	112	15.3	25	16.6
BW1 *theta* + *phi* + BW2 *theta* + BW3 *theta*	46	5.1	33	4.5	12	8.0
BW1 *theta* + *phi* + BW2 *theta* + BW3 *theta* + *stereo*	40	4.5	34	4.6	6	4.0
BW1 *theta* + *phi* + BW2 *theta* + BW3 *theta* + *phi* + *stereo*	341	38.2	282	38.7	54	36.0
SUM	879	98.4	716	98.2	149	99.3

TABLE 6a: *Number of muons lost in various (combinations of) muon chambers for a 400 GeV Higgs.*

For the 400 GeV Higgs, of the 893 tracks that were lost (from rows 3, 4, and 5 of table 4a) 341 tracks (38.2 %) missed all muon chambers, 312 tracks (34.9 %) were lost in all layers of BW1 (but produced hits in BW2 and BW3), 46 tracks (5.1 %) missed both BW1 and BW2, and 40 tracks (4.4 %) registered hits in the Phi layers of BW3 only. This is summarized in the following table where negligible fractions (< 1%) were omitted (this is reflected by the last row in the table which indicates the sum in each column). In addition, these numbers are given separately for the case where only one muon was missing and the case where two muons in the event were lost in the cracks.

Chambers missed	All		1 Lost		2 Lost	
	Trks	%	*Trks*	%	*Trks*	%
BW1 *theta*	184	20.2	161	20.0	22	21.1
BW1 *theta* + *phi*	164	18.0	148	18.4	16	15.4
BW1 *theta* + *phi* + BW2 *theta*	133	14.6	121	15.0	11	10.6
BW1 *theta* + *phi* + BW2 *theta* + BW3 *theta*	37	4.0	31	3.9	6	5.8
BW1 *theta* + *phi* + BW2 *theta* + BW3 *theta* + *stereo*	39	4.3	34	4.2	5	4.8
BW1 *theta* + *phi* + BW2 *theta* + BW3 *theta* + *phi* + *stereo*	343	37.6	299	37.2	43	41.3
SUM	899	98.7	794	98.7	103	99.0

TABLE 6b: *Number of muons lost in various (combinations of) muon chambers for a 700 GeV Higgs.*

In the case of the 700 GeV Higgs (table 6b), the fraction of tracks lost is similar to the 400 GeV case, except for the fraction of tracks missing BW1 which appears somewhat higher (38.2 % up from 34.9 %).

Note that within statistical fluctuations the losses in any chamber(s) are identical

whether one or two tracks were missing. If we consider the case mentioned above where 30 % of the 400 GeV Higgs events with all four muons detected in the barrel had at least one muon missing, we find from table 6a that only 38.2 % of those events had missed all muon chambers. In other words 11.3 % of the total number of events had at least one muon that did not register any hit in any muon chamber (for the 700 GeV case this number is 10.4 %). This reasoning can be applied to any other set of requirements needed to define a fully detected track in the muon system. A more meaningful interpretation of the losses can then be made of the figures presented in this analysis.

Octant	**BW1**		**BW2**	**BW3**		
	theta	*phi*	*theta*	*theta*	*phi*	*stereo*
# 5	44.7	42.6	47.1	46.2	47.8	46.3
Other	18.4	19.1	17.6	17.9	17.4	17.9

TABLE 7a: *Loss (fraction of tracks lost in %) in octant #5 compared to the average in the other seven octants. The fraction in any given octant is the sum of the relative losses in the two adjacent gaps to it. This table is for a 400 GeV Higgs.*

Octant	**BW1**		**BW2**	**BW3**		
	theta	*phi*	*theta*	*theta*	*phi*	*stereo*
# 5	42.0	43.2	43.5	44.6	46.6	44.6
Other	19.3	18.9	18.8	18.5	17.8	18.4

TABLE 7b: *Same as table 7a, for a 700 GeV Higgs.*

Finally we have made a comparison of the loss in octant #5 (which has a slightly reduced coverage) to the loss in the other seven octants. We find, as indicated by tables 7a and 7b, that the loss in the bottom octant of the detector is about two and a half times greater for all muon chambers. On average 20 to 25 % of the total loss is caused solely by the widening of the gaps around octant 5 to

accomodate the support frame.

In conclusion, we have performed a detailed study of the loss due to missed coverage in the barrel muon detector for a physics process involving exclusively muons in the final state. We have not made any a priori requirement as to which and how many chambers should be hit by a track in order to identify it as a muon. No information from a detector other than the muon system was used in this analysis. For the interesting case where all four muons from the Higgs are detected in the barrel, we estimate a loss of at least 10 %.