CLAS-NOTE 1999-03

Trigger Efficiency for Single Pion Photoproduction During the G1a Run

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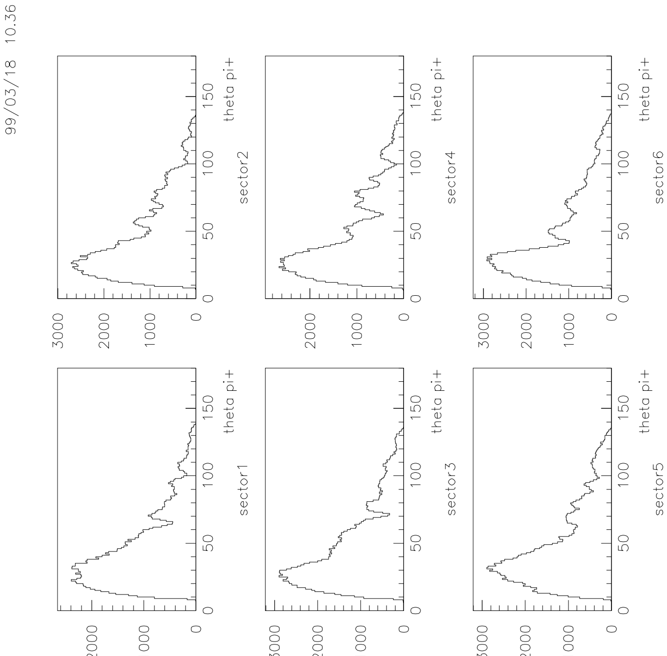
March 19, 1999

Abstract

We studied the trigger efficiency during G1a(May98) by looking at an exclusive $\gamma p \rightarrow \pi^+ n$ channel. The result shows that the trigger inefficiency was due to high TOF discrimination thresholds and missing signals in the TOF pretrigger board.

1 Introduction

The G1 trigger efficiency was uncovered by studying the $\gamma p \rightarrow \pi^+ n$ reaction. The π^+ was reconstructed using the tracking and identified using the time of flight. The neutron was identified by missing mass of the $\gamma p \rightarrow \pi^+ X$ reaction. By ploting the angular distribution of the π^+ in the lab system or ploting the TOF occupancies, the problem showed up as dip regions in those histograms, see Figure 1.



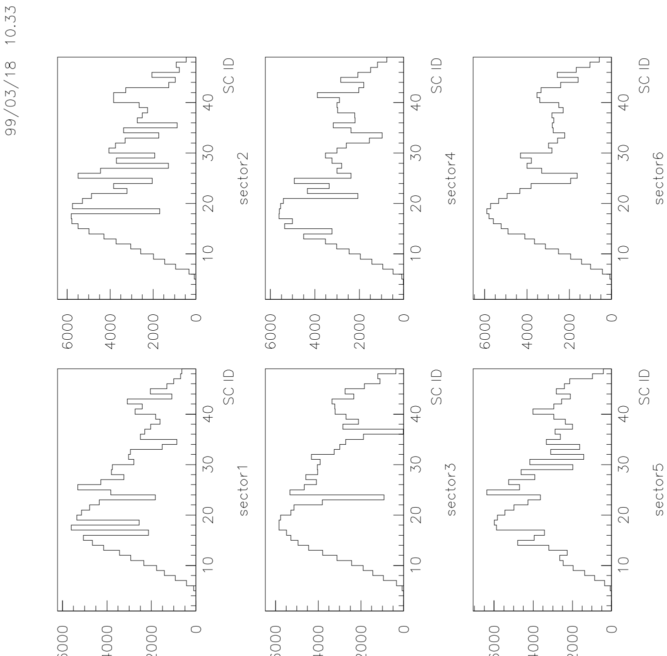


Figure 1: TOF occupancies and Angular distributions of the $\pi^+$from exclusive γp$\rightarrow$ π^+n in each sector

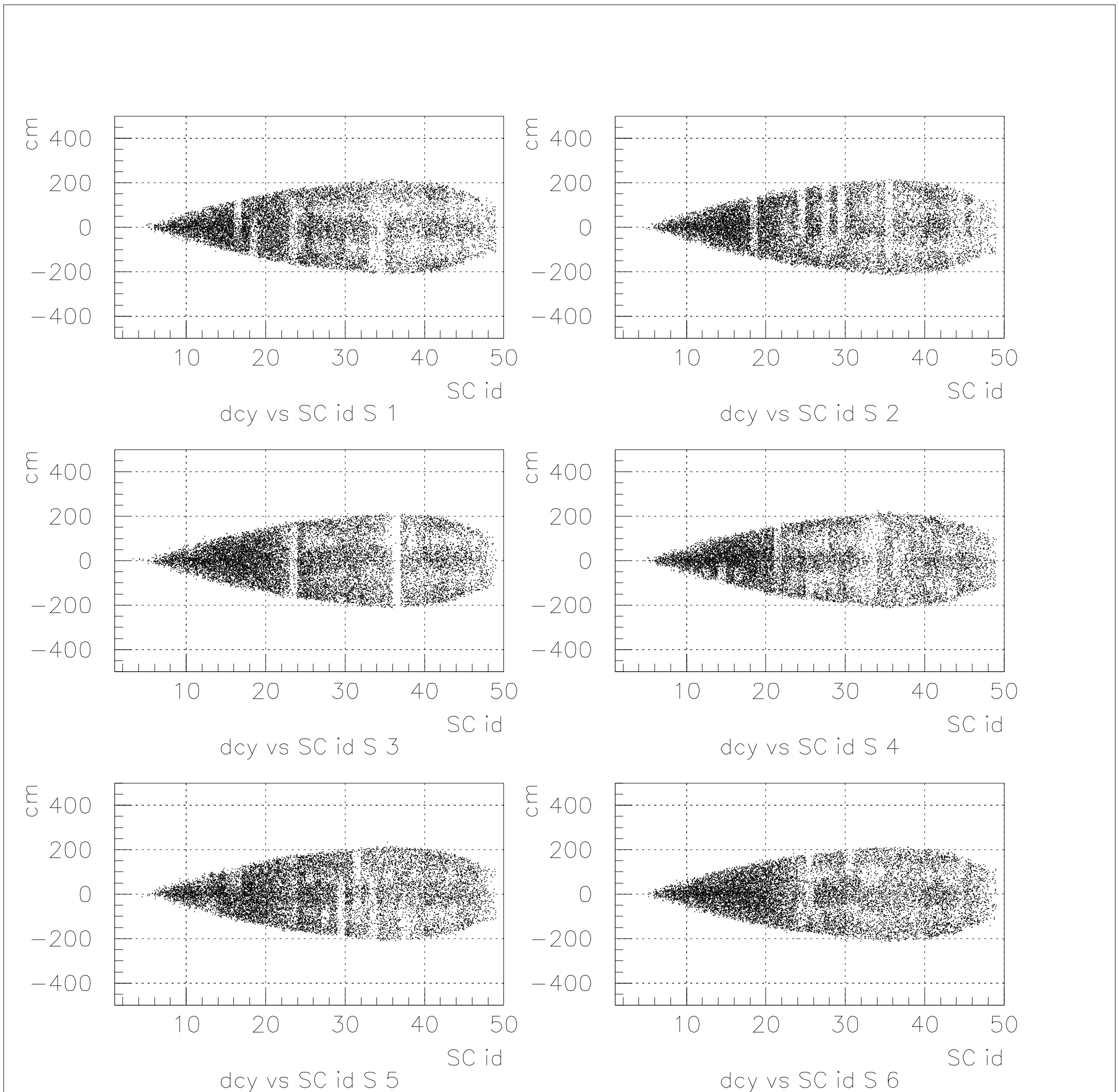


Figure 2: Hit positions along the scintillation counters of the π^+ from exclusive γp$\rightarrow$ π^+n in each sector.

One might suspect the dead regions in the drift chambers could cause those dips. A simulation test which included all the known dead wires in the drift chambers was studied but could not reproduce what we saw in the real data.

Figure 2 shows the hit positions along the scintillation counters of the π^+ from exclusive γp$\rightarrow$ π^+n in each sector. One can see that they are not evenly populated along the scintillator paddles. Some paddles are missing hits on one side or the other and there are depletion regions about L/4 and 3L/4 in every sector, where L is the length of a given scintillation counter.

2 Trigger Simulation

To understand the cause of these observations, we implemented a trigger simulation study to test our assumption that what we saw in the real data was caused by inefficient triggers. We postulated 2 hypotheses:

1. The depletion regions around L/4 and 3L/4 are caused by the TOF discrimination threshold are set too high.

2. The missing of the hits on one side or the other are caused by missing signals in the pretrigger board.

The G1 trigger is a coincidence between the tagger, the start counters and the time of flight system. We assume that the trigger logic of the tagger and the start counters worked as expected and the inefficiencies are caused by the time of flight trigger logic.

To simulate a pulse shape we used a typical TOF phototube pulse shape measured by a digital oscilloscope as a prototype as shown in Figure 3.

The energy loss in the scintillator was generated according to the Landau distribution and normalized to the measured minimum ionizing peak for each counter taken from SC_CALIBRATIONS.map file as for the real data. The hit position along a given scintillator was generated with a flat distribution and the pulse was attenuated using

$$P_L = Pe^{(\frac{L/2-x}{\lambda})}$$

$$P_R = Pe^{-(\frac{L/2-x}{\lambda})}$$

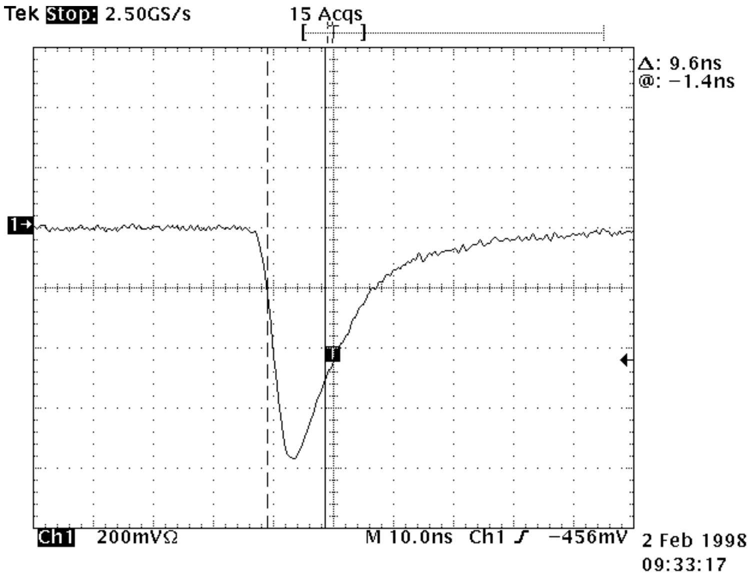


Figure 3: Pulse shape from TOF photomultiplier tube.

where P is the energy loss converted to ADC channels. P_L, P_R are the attenuated pulses seen by left PMT and right PMT, respectively. L is the length of the scintillator, λ is the attenuation length, and x is the random hit position along a given scintillator.

The resulting attenuated pulses from the left and right PMTs are summed together to simulate the function of the pretrigger board. If the amplitude of the summed pulse is above a given threshold then we have a successful trigger. Otherwise there is no trigger. In this simulation we ignored the timing response of the pretrigger board circuitry[1] but do not expect this to affect our general conclusions.

We studied 3 threshold settings(150 mV, 200 mV and 250 mV) and assigned the status words for each PMT as *nm*:

- n = 0, m = 0 $\Rightarrow$ signal to pretrigger board OK, ADC/TDC OK
- n = 0, m = 1 $\Rightarrow$ signal to pretrigger board OK but no readout ADC
- n = 0, m = 2 $\Rightarrow$ signal to pretrigger board OK but no readout TDC
- n = 0, m = 3 $\Rightarrow$ signal to pretrigger board OK but no readout ADC/TDC

- n = 1, m = 0 $\Rightarrow$ no signal to pretrigger board from Left PMT but ADC/TDC OK
- n = 2, m = 0 $\Rightarrow$ no signal to pretrigger board from Right PMT but ADC/TDC OK
- n $\neq$ 0, m $\neq$ 0 $\Rightarrow$ combination of above case

The status words used in this study are shown in Table 1. The first row of each sector represents the left PMT and second row the right PMT. The number in front of the parenthesis represents the TOF paddle ID(1-48) and the number inside parenthesis is the status word. All the other paddles which are not shown in this table have status words 0.

Sector	Status Words
1	18(10),33(10),34(10) 16(23)
2	- 18(20),24(20),27(20),29(20),35(20)
3	36(3) 16(3),18(2),36(3)
4	14(10),25(10) 21(22)
5	29(10),33(10),37(10) 15(20),16(23),31(20)
6	- 3(1),25(20),35(2)

Table 1: TOF status words used in this study.

3 Results and Discussion

The results of the summed pulse which indicated a successful or failure trigger are shown in Figure 4.

The red(dash) pulse is the attenuated pulse from left PMT and the blue(solid) pulse is the attenuated pulse from right PMT. The green(thick) is the sum of the left and the right pulses. The horizontal axis shows the relative time between the left and the right pulses. There are 4 cases: 2 contributed to successful trigger and 2 contributed to failure trigger.

- Top-Left: This plot shows the normal situation in which both the pulses from left and right PMTs contributed to the trigger. The summed pulse is above the threshold of 200 mV.
- Top-Right: In this case there is only one signal from the left PMT but it is high enough to reach the threshold. The success or failure of the trigger depends on the hit position along the scintillator. If it hits near the active PMT and deposits enough energy to reach the threshold limit then we have a successful trigger.
- Bottom-Left: In this case the readout TDC/ADC from both left and right PMT are OK but the signal to the pretrigger board of the right PMT is lost. Eventhough the signal from the right PMT is above the threshold, it does not take part in the pulse summation only the left one does. The summed pulse is exactly the same as the pulse from left PMT and never reach the threshold so the trigger fails.
- Bottom-Right: When the hit position is around L/4 or 3L/4, despite the readout TDC/ADC and signals to pretrigger board of the left and right PMTs are working properly, the failure of the trigger is because the threshold of 200 mV is too high. The scintillator light reaches the left and right PMTs are not in time so the summed pulse is below the threshold.

Figure 5, 6 and 7 show the results of this simulation with threshold 150 mV, 200 mV and 250 mV respectively. One starts to see the threshold problem in 200 mV case and more clearly for 250 mV. The lost signals in pretrigger board also show up as empty space on one side or the other.

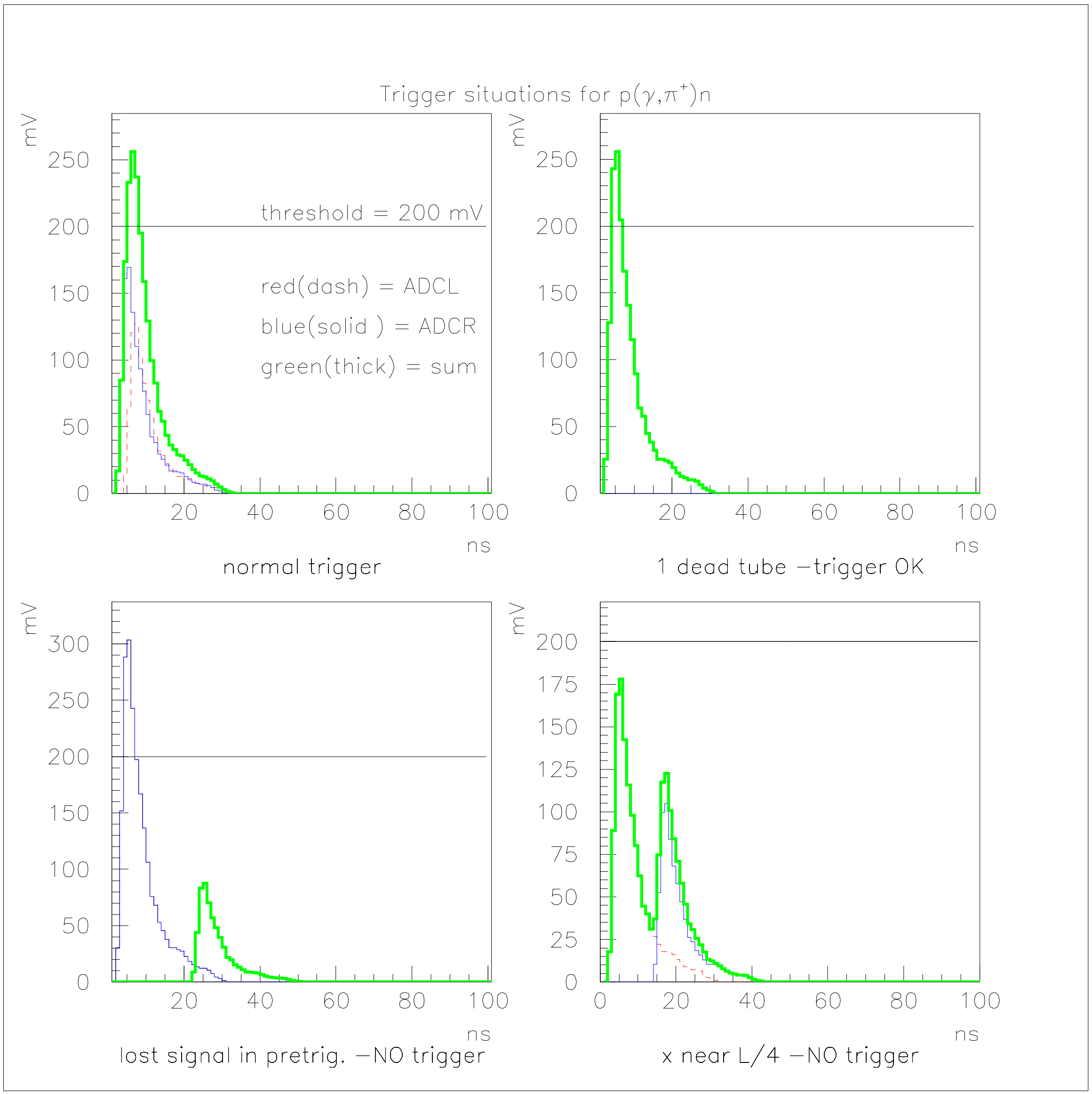


Figure 4: Simulated pulse output from the pretrigger board in various cases.

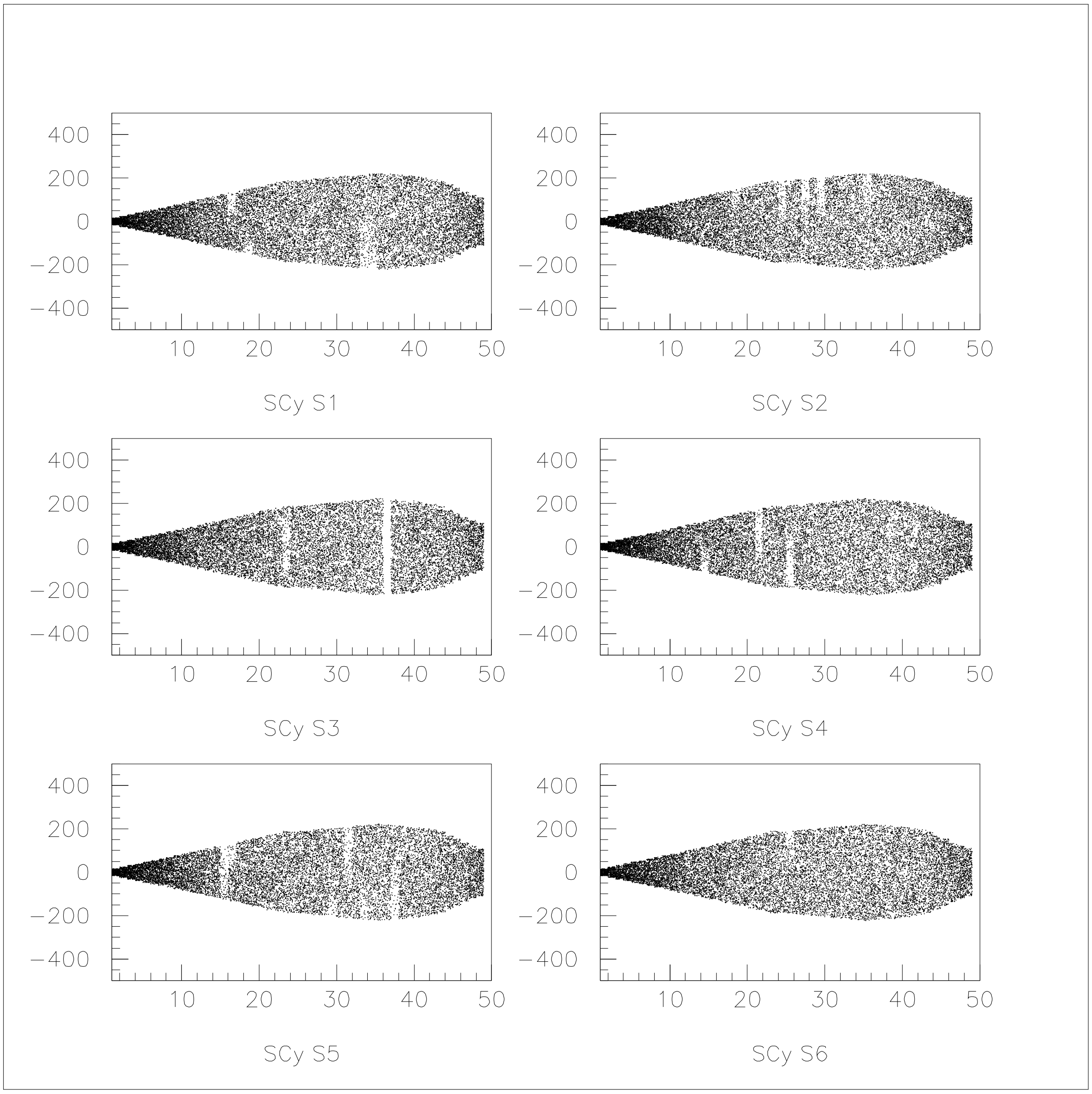


Figure 5: Trigger simulation result: Threshold = 150 mV.

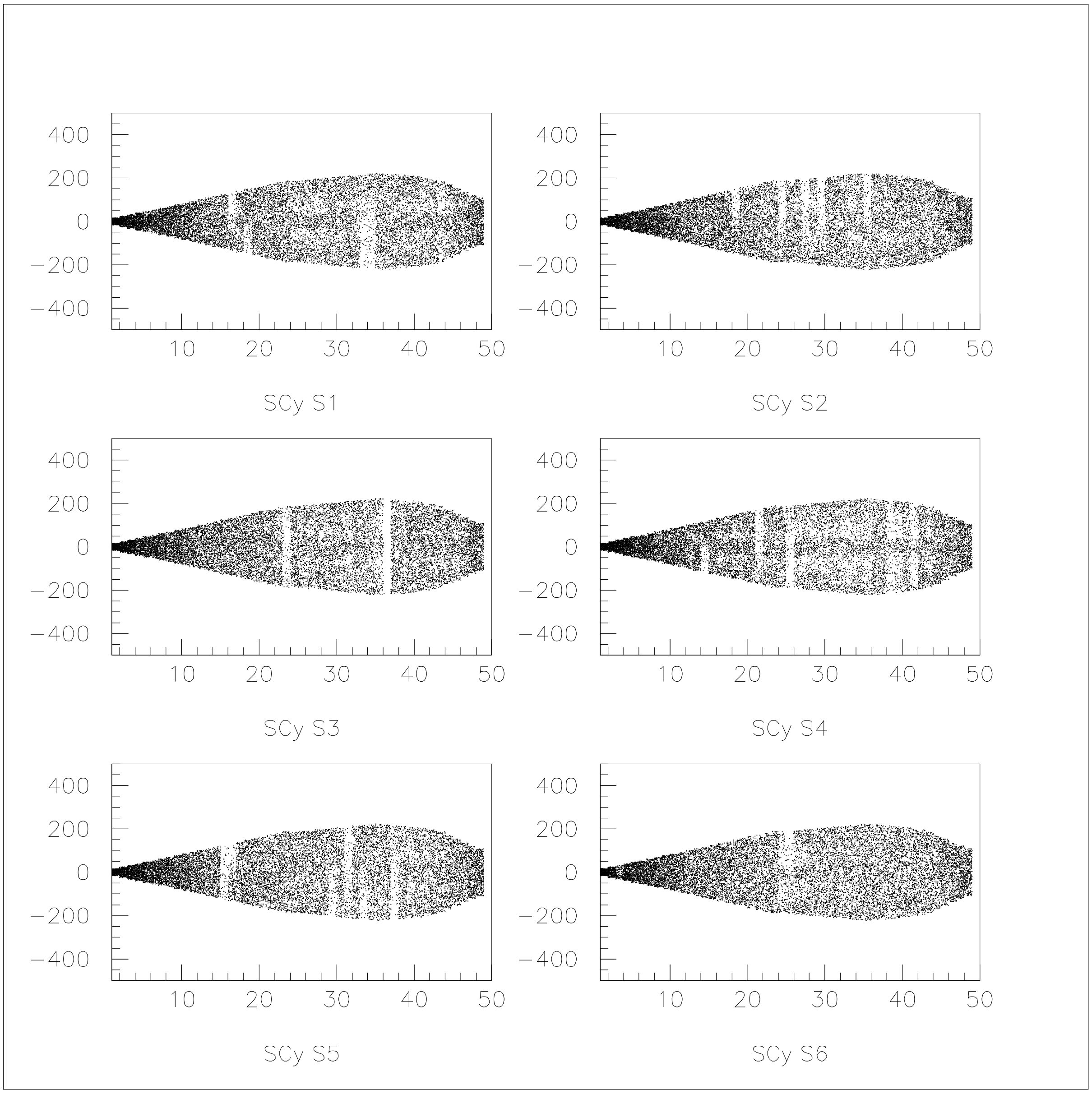


Figure 6: Trigger simulation result: Threshold = 200 mV.

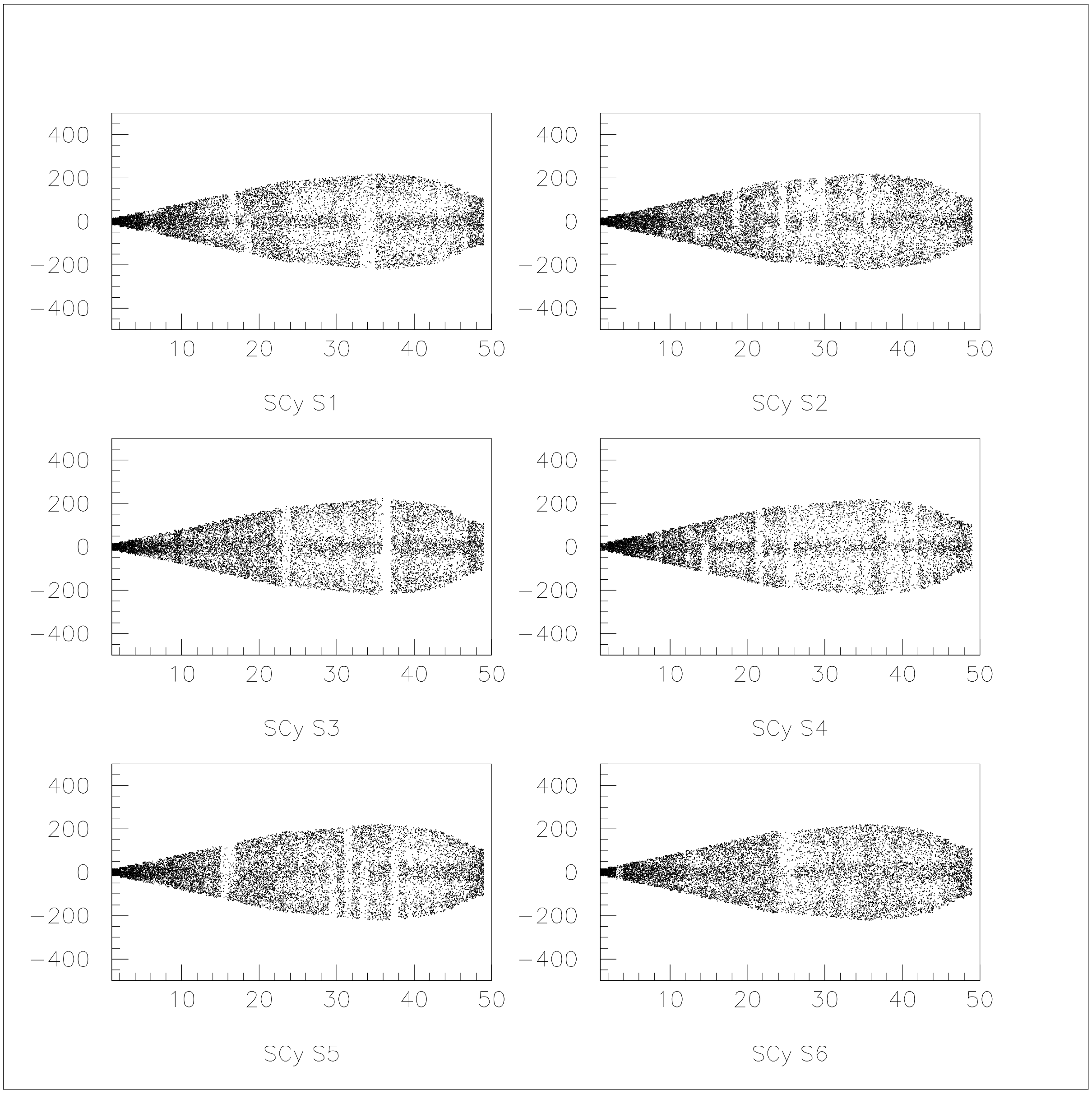


Figure 7: Trigger simulation result: Threshold = 250 mV.

Paddle ID	Threshold (mV)	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6
1	150	99	98	99	99	99	99
	200	99	98	99	83	99	99
	250	99	97	96	38	97	99
2	150	100	100	100	99	99	99
	200	100	100	100	99	98	99
	250	99	99	94	93	89	92
3	150	99	99	98	98	99	75
	200	99	99	98	98	98	33
	250	98	99	93	87	81	18
4	150	100	100	99	99	99	99
	200	99	97	97	98	97	97
	250	99	81	86	98	77	82
5	150	98	100	99	99	100	99
	200	82	100	92	99	99	99
	250	52	99	64	98	82	97
6	150	98	98	98	99	99	99
	200	81	96	90	98	90	99
	250	51	77	67	79	65	83
7	150	98	98	98	99	99	99
	200	98	97	97	99	95	96
	250	77	76	69	97	68	72
8	150	98	100	99	99	99	99
	200	98	100	84	78	98	95
	250	89	100	56	48	95	68
9	150	99	99	98	99	99	99
	200	99	90	97	98	98	98
	250	88	59	95	98	90	84
10	150	99	99	99	100	99	99
	200	98	99	93	99	99	98
	250	85	78	60	83	81	76

Paddle ID	Threshold (mV)	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6
11	150	99	99	100	99	98	99
	200	98	98	99	99	98	98
	250	97	96	86	97	96	77
12	150	99	98	99	99	99	98
	200	98	98	98	88	75	97
	250	77	95	79	55	74	76
13	150	99	98	99	99	98	99
	200	98	92	98	98	85	97
	250	53	56	80	88	76	80
14	150	99	99	99	97	99	98
	200	95	95	98	70	99	97
	250	67	70	71	60	94	84
15	150	99	99	99	98	98	100
	200	89	99	99	97	70	97
	250	61	92	89	88	59	73
16	150	63	99	99	98	98	98
	200	40	99	98	98	60	96
	250	31	92	89	80	40	70
17	150	98	98	99	98	99	98
	200	98	98	98	98	99	98
	250	54	93	94	80	98	92
18	150	81	77	99	99	98	99
	200	50	30	98	98	98	98
	250	45	20	80	80	93	89
19	150	99	99	98	99	99	99
	200	98	99	96	98	99	99
	250	85	99	80	80	97	99
20	150	99	98	98	99	99	99
	200	99	98	98	99	98	98
	250	84	97	94	90	96	88

Paddle ID	Threshold (mV)	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6
21	150	99	99	99	60	97	98
	200	98	99	99	40	97	98
	250	93	98	98	30	96	96
22	150	98	98	98	99	99	98
	200	98	81	88	94	97	98
	250	97	58	61	70	79	96
23	150	99	99	46	100	98	99
	200	50	98	19	90	98	99
	250	34	88	12	65	94	96
24	150	99	59	99	98	99	89
	200	77	38	96	95	98	44
	250	43	25	68	60	88	22
25	150	99	99	99	70	98	70
	200	86	95	83	50	83	40
	250	54	69	51	30	51	24
26	150	99	98	99	96	99	99
	200	80	88	82	69	98	76
	250	48	56	48	37	87	44
27	150	99	61	99	97	99	99
	200	78	30	90	72	90	82
	250	46	22	58	40	55	47
28	150	99	99	98	98	99	99
	200	86	79	86	70	97	91
	250	51	47	58	40	75	58
29	150	98	66	100	99	77	99
	200	91	44	95	83	53	98
	250	64	30	67	48	37	77
30	150	98	99	99	99	99	98
	200	77	95	98	77	98	86
	250	45	63	79	45	89	52

Paddle ID	Threshold (mV)	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6
31	150	98	99	97	98	70	99
	200	93	97	96	86	40	99
	250	68	75	70	54	30	98
32	150	99	99	99	97	97	98
	200	87	96	95	66	97	92
	250	57	67	70	35	84	62
33	150	68	98	99	96	81	98
	200	41	50	99	70	61	87
	250	19	39	79	39	40	50
34	150	63	99	99	97	98	99
	200	38	97	94	95	97	97
	250	21	80	67	85	81	72
35	150	99	68	97	97	98	100
	200	96	30	67	95	95	100
	250	74	20	35	85	67	98
36	150	100	99	0	99	99	99
	200	95	95	0	98	99	98
	250	66	71	0	90	89	87
37	150	98	98	100	99	98	99
	200	89	89	99	90	90	95
	250	61	59	81	62	80	71
38	150	99	100	99	98	99	98
	200	90	89	93	95	97	98
	250	59	57	67	60	74	76
39	150	98	99	99	98	98	99
	200	90	99	99	95	96	98
	250	61	88	88	60	75	85
40	150	99	97	100	98	98	99
	200	82	91	95	95	96	91
	250	50	64	65	64	75	64

Paddle ID	Threshold (mV)	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6
	150	99	99	99	98	99	99
41	200	80	95	95	95	95	92
	250	42	71	69	60	60	60
	150	98	98	99	99	99	99
42	200	93	97	94	93	94	96
	250	67	75	63	65	62	68
	150	95	99	98	98	99	99
43	200	52	80	85	70	95	94
	250	27	45	51	38	60	65
	150	98	98	98	98	99	99
44	200	80	91	93	97	96	85
	250	52	59	64	75	76	49
	150	99	98	98	98	99	99
45	200	91	89	73	87	96	97
	250	62	53	41	55	68	75
	150	98	98	98	99	99	98
46	200	78	74	87	90	97	92
	250	45	42	48	58	69	60
	150	100	99	99	99	99	99
47	200	99	96	98	98	98	99
	250	92	69	97	90	82	95
	150	99	100	100	98	100	99
48	200	98	98	91	93	100	99
	250	75	81	55	64	99	87

Table 2: π^+ trigger efficiencies for each scintillator paddles in 6 sectors.

Paddle ID	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6
1	99	99	99	83	99	99
2	100	100	100	99	98	99
3	99	99	99	98	96	33
4	99	97	99	98	97	97
5	80	100	90	99	99	99
6	83	97	92	96	92	99
7	98	97	97	99	95	96
8	98	100	89	83	99	95
9	99	94	97	98	98	98
10	98	98	94	100	98	98
11	99	99	98	99	98	98
12	97	98	98	90	99	97
13	87	89	98	98	97	86
14	95	93	95	70	99	97
15	88	99	98	98	98	97
16	33	99	98	98	80	96
17	85	98	98	98	99	98
18	50	30	98	98	98	98
19	97	99	97	98	99	99
20	98	98	98	99	98	98
21	98	99	99	40	97	98
22	98	81	91	94	97	98
23	94	98	16	97	98	99
24	87	40	98	96	98	35

Paddle ID	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6
25	92	98	95	40	95	35
26	91	95	95	85	98	90
27	93	27	98	87	96	94
28	90	91	96	87	97	96
29	97	50	98	90	46	98
30	90	98	99	94	98	95
31	98	98	98	89	40	99
32	90	99	98	88	97	98
33	50	50	99	84	54	96
34	28	99	98	99	97	99
35	98	30	87	99	98	100
36	98	97	0	98	99	98
37	97	98	98	98	90	98
38	98	98	99	98	99	98
39	96	100	99	98	91	98
40	96	97	99	90	98	98
41	92	98	98	98	91	98
42	97	98	98	97	98	99
43	77	96	97	91	97	98
44	93	98	97	98	99	94
45	95	96	88	95	99	97
46	94	95	96	97	98	98
47	99	98	99	99	99	99
48	99	99	97	98	100	99

Table 3: π^+ trigger efficiencies for each scintillator paddles $\pm$ 50 cm(or $\pm$ 5 degrees from midplane in 6 sectors. Threshold = 200 mV.

One can see from Figure 5, 6 and 7 and Table 2 that the efficiencies drop when the threshold is increased and the longer scintillator is affected more severely than the shorter one. The trigger efficiencies are approximately 100% around the midplane($\pm$ 5 degrees from midplane) as shown in Table 3.

4 Summary

This study shows that the trigger inefficiency during the G1 data taking period was caused by

1. The Time of Flight discrimination threshold was set too high(200 mV). We would recommend the threshold of 150 mV or lower for the future runs.

2. The missing signals either caused by bad cable connections to pretrigger board or malfunction of pretrigger board itself.

Although this trigger inefficiency affected more severely for the single charged particle in final state especially single π^+ production than the multiple charged particles, one should study this effect in the latter case as well.

5 Acknowledgement

We would like to thank Joe Manak and Simon Taylor for useful discussions and verifying our observation.

References

[1] Pretrigger circuit for Time-of-Flight counters, D. Jenkins *et al.*, CLAS Note 94-007.