Electronics Deadtime in Hall A

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This report describes measurements of the electronics deadtime during N-Δ experiment in the summer 2000 at JLab Hall A. We also discuss the improvements being made for future measurements and the applicability to earlier experiments.

A schematic of the electronics used to measure electronics deadtime is shown in fig 1. A pulser sent scintillator-type signals to a linear-or with the S1 paddle 1 and S2 paddle 1 in each arm. The rate of the pulser was $\approx$ 7 Hz. The pulser signal was also sent to a TDC channel in each arm so that the event was tagged as a pulser event. In addition the pulser was sent to a scaler. There is no direct measurement of the electronic deadtime (EDT). The EDT was determined by subtracting the global computer deadtime (CDT) from the combination of computer and electronic deadtime (ECDT). The ECDT was determined dividing the number of T5 pulser events in the datastream,N_{pul}, by the number of initial pulser events measured by the scaler, S_{pul}.

$$ECDT = 1 - \frac{N_{pul}}{S_{pul}}. \tag{1}$$

The CDT was determined by

$$CDT = 1 - \frac{\sum N_i}{\sum \frac{S_i'}{PS_i}}$$

$$S_1' = S_1 - \frac{S_5}{PS_5} \quad ; \quad S_3' = S_3 - \frac{S_5}{PS_5}$$

$$S_{2,4,5}' = S_{2,4,5} \quad ; \quad S_6' = S_6 - \frac{S_3}{PS_3}$$

where N_i is the number of events of type i in the data, and S_i is the scaler for each trigger and PS_i is the prescale factor. The deadtime was determined from data and scalers when the average current was above 5 μA for a scaler read. The scalers were read every 8 seconds. For runs less than 6 μA , the cut on the average current was 1 μA .

Table 1 lists the runs used in studying the deadtime. At four different kinematic settings of the experiment a current scan was done. For runs 3928-3934 the hadron arm was moved forward to increase the hadron rate and see the effects on the electronic deadtime. For runs 3928-29, the hadron spectrometer angle was 27° and, for runs 3930-34, the angle was 22°. The deadtimes are listed in Table 2. In Fig. 2 the deadtimes are plotted versus the sum of the hadron strobe and electron strobe rate. One strange effect is that for runs 3933 and 3934 when PS5 was set to 3 then EDT rose. These points are not plotted in Fig. 2. Another strange effect is that the CDT for low current runs is negative. To calculate the EDT, the CDT was set to zero for these runs.

In Fig. 3, the strobe rates in each arm are plotted versus the sum of the rates in each scintillator paddle (the logical "AND" of left with right sides) in both planes in an arm, and the data is listed in Table 3. The correlation for the electron arm is linear. The correlation for the hadron arm is fairly linearly though it is probably better fit by a quadratic. For earlier experiments which did not measure the strobe rate directly, the scintillator paddle rates must be used to compute the deadtime.

The expected deadtime is approximately 145 nsec per spectrometer and one has to add these to get the coincidence trigger deadtime. The percentage deadtime is then $\approx RT$ where R=rate and T= deadtime. A contribution of 45 nsec comes from the MLU according to the spec sheets. About 100 nsec comes from the strobe width, which may be reduced to 40 nsec in the future. The possiblity to replace the MLU's is also being considered. Actually, the strobe width contribution is more complicated; some early strobes can make good triggers with shifted timing and other early strobes can make the T2 and T4 triggers. A model for the trigger deadtime is being developed.

In the future we have the following aims: 1) To measure the deadtime accurately, 2) To reduce the deadtime by reducing strobe width and rate, and 3) To study how accurately the corrections can be applied to earlier experiments. This document will be updated as more information becomes available.

Before the next experiment due to run Oct 2000, we will implement one other paddle in the middle of the focal plane where the rates may be different. The EDT will be measured directly in scalers, separately in each spectrometer, although the more complicated method outlined in the text will still be available. The pulser will be triggered at a rate proportional to the beam current, and the pulser timing will move appropriately with hadron delay.

In the longer term, possibly by Thanksgiving, we want to completely instrument the focal plane, sending analog signals from a pulser to each PMT, triggering them in a sequence at a rate proportional to the beam current and typically 1 Hz per paddle (hence 6 Hz overall). A specification for this scheme is being written now, to be built by the JLab electronics group. The experience from these measurements should be applicable to previous experiments by parameterizing the deadtime correction in terms of the rates on the PMTs.

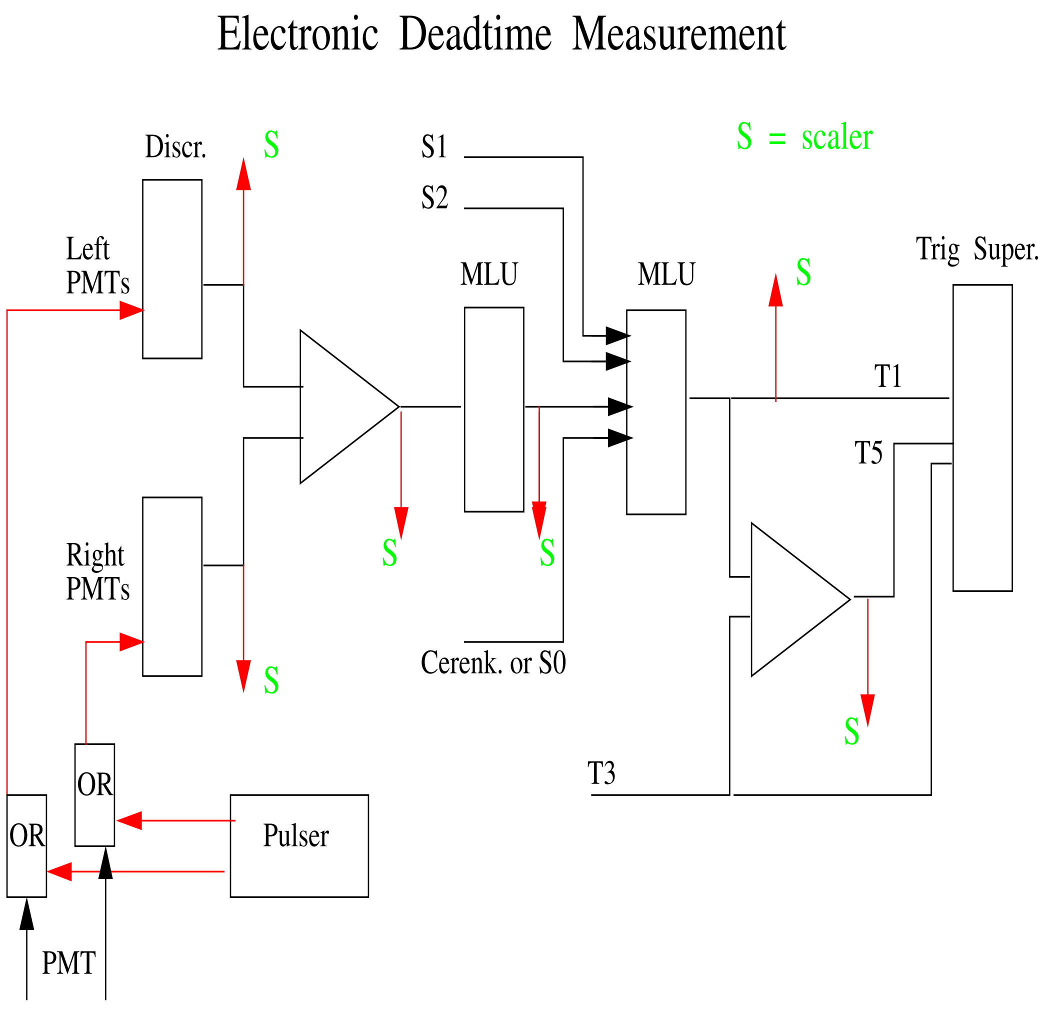


FIGURE 1. Schematic of system used to measure electronics deadtime during N-Δ experiment in summer 2000. The primary source of deadtime is at the leftmost MLU which is strobed by the PMT signals from the right sides of scintillator planes S1 and S2. The strobe rates often exceed the trigger rate, depending on the backgrounds, etc.

Run	θ_{cm}	Prescale	Current
3296	cosmic	1,1,1,100,1,65535	cosmic
3297	90	4500,400,9000,2500,1,14000	5.0
3298	90	4500,400,9000,2500,1,14000	9.8
3299	90	4500,400,9000,2500,1,14000	20.2
3300	90	4500,400,9000,2500,1,14000	39.0
3318	135	4000,50,80000,2800,1,15000	5.2
3319	135	4000,50,80000,2800,1,15000	10.1
3320	135	4000,50,80000,2800,1,15000	20.1
3321	135	4000,50,80000,2800,1,15000	37.5
3623	135	4407,297,13322,2718,1,21190	2.0
3763	155	5234,394,14661,2845,1,21040	4.8
3764	155	5234,394,14661,2845,1,21040	9.7
3765	155	5234,394,14661,2845,1,21040	19.6
3766	155	5234,394,14661,2845,1,21040	37.5
3767	155	5234,394,14661,2845,1,21040	39.5
3768	155	5234,394,14661,2845,1,21040	42.4
3928		7500,50,44000,5200,1,21040	40.96
3929		7500,50,44000,5200,1,21040	41.2
3930		7500,50,44000,5200,1,21040	41.2
3932		7500,50,44000,5200,1,21040	40.3
3933		7500,500,50000,6000,3,21040	40.6
3934		7500,500,50000,6000,3,21040	39.0
3951	180	6968,488,18592,3078,1,21040	29.3
3952	180	6968,488,18592,3078,1,21040	19.7
3953	180	6968,488,18592,3078,1,21040	10.3
3954	180	6968,488,18592,3078,1,21040	5.5

TABLE 1.

Run	H-Strobe	E-Strobe	ECDT	CDT	EDT
3296	1.7	1.7	0.68 ± 0.04	0.54	0.14 ± 0.04
3297	57	23	2.6 ± 0.2	-0.1	2.6 ± 0.2
3298	111	44	4.8 ± 0.2	0.6	4.2 ± 0.2
3299	177	71	10.6 ± 0.4	4.2	6.4 ± 0.4
3300	417	168	25.2 ± 0.6	17.0	8.2 ± 0.6
3318	66	19	2.7 ± 0.2	-0.2	2.7 ± 0.2
3319	127	36	4.7 ± 0.3	0.4	4.3 ± 0.3
3320	250	70	10.3 ± 0.4	3.2	7.1 ± 0.4
3321	452	129	27.4 ± 0.6	17.3	10.1 ± 0.6
3623	37	10.6	1.6 ± 0.2	-0.1	1.6 ± 0.2
3763	72	22	2.8 ± 0.1	-0.2	2.8 ± 0.1
3764	143	43	5.8 ± 0.2	0.7	4.1 ± 0.2
3765	287	85	13.1 ± 0.4	4.9	8.2 ± 0.4
3766	526	162	28.6 ± 1.5	18.1	9.5 ± 1.5
3767	548	169	31.0 ± 1.2	18.1	12.9 ± 1.2
3768	586	181	32.7 ± 0.7	21.5	11.2 ± 0.7
3928	820	176	46.2 ± 1.1	36.3	9.9 ± 1.1
3929	825	177	44.5 ± 1.1	33.8	10.7 ± 1.1
3930	1011	178	53.2 ± 1.3	41.7	11.5 ± 1.3
3932	987	172	50.0 ± 1.2	38.5	11.5 ± 1.2
3933	1000	175	20.1 ± 0.6	2.1	18.0 ± 0.6
3934	960	167	24.4 ± 0.8	2.2	22.2 ± 0.8
3951	265	125	15.7 ± 0.4	8.0	7.7 ± 0.4
3952	181	84	9.1 ± 0.3	3.6	5.5 ± 0.3
3953	95	44	4.3 ± 0.2	0.4	3.9 ± 0.2
3954	51	24	2.4 ± 0.1	-0.3	2.4 ± 0.1

TABLE 2.

Run	H-Strobe	E-Strobe	Sum Hadron scint	Sum Electron scint
3296	1.7	1.7	0.95	1.4
3297	57	23	72	32
3298	111	44	143	62
3299	223	89	289	123
3300	417	168	554	238
3318	65	19	81	26
3319	127	36	159	50
3320	250	70	315	99
3321	452	129	584	182
3623	37	10.6	45.5	14.0
3763	72	22	90	30.8
3764	144	43	180	60.7
3765	288	85	362	121
3766	526	162	687	230
3767	548	169	723	241
3768	586	181	775	258
3928	820	176	1125	249
3929	825	177	1132	249
3930	1011	178	1441	251
3932	987	172	1408	244
3933	1000	175	1421	248
3934	959	167	1364	236
3951	265	125	346	179
3952	181	84	234	120
3953	95	45	122	63.5
3954	51	24	65.5	34.5

TABLE 3.

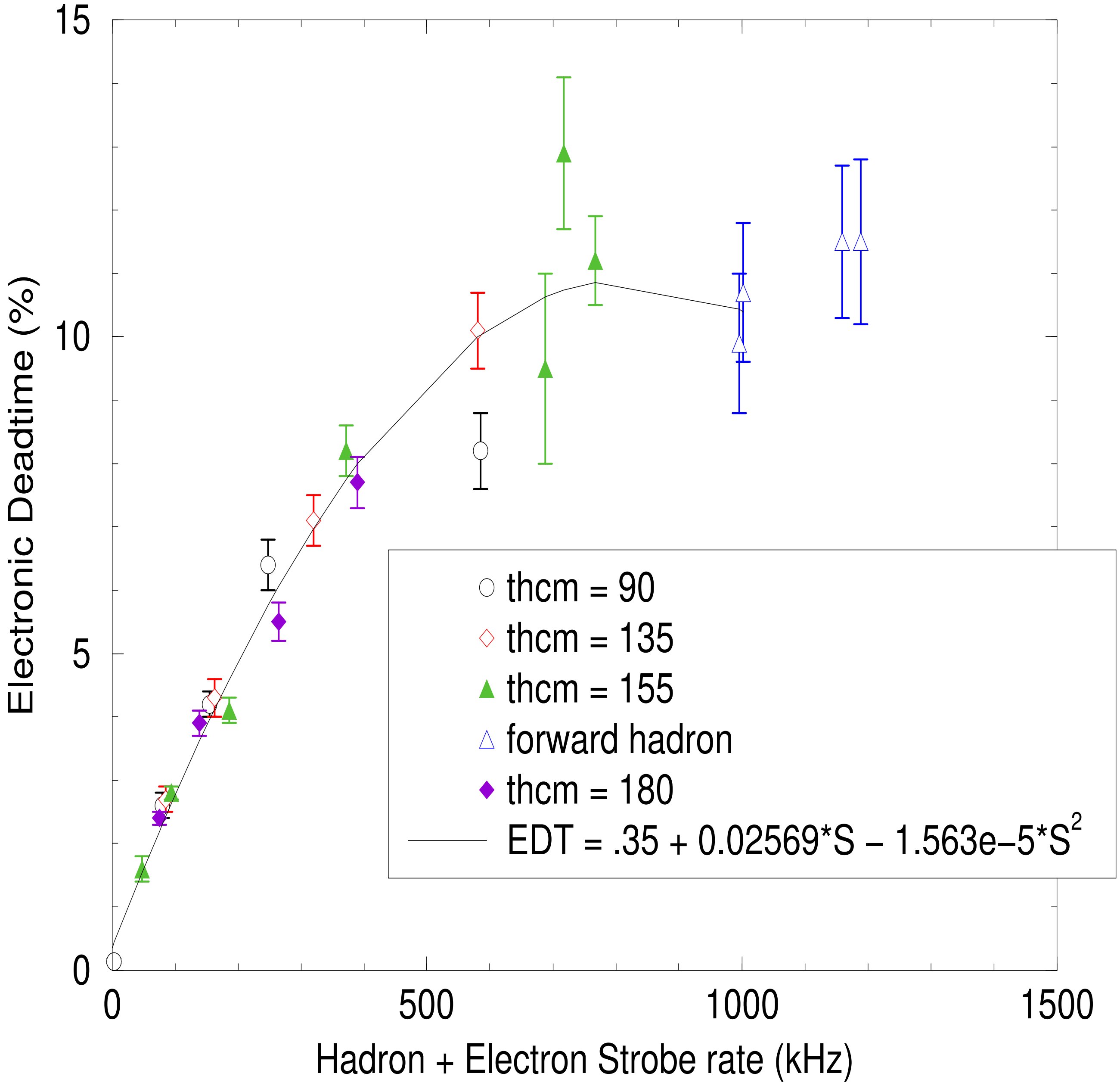
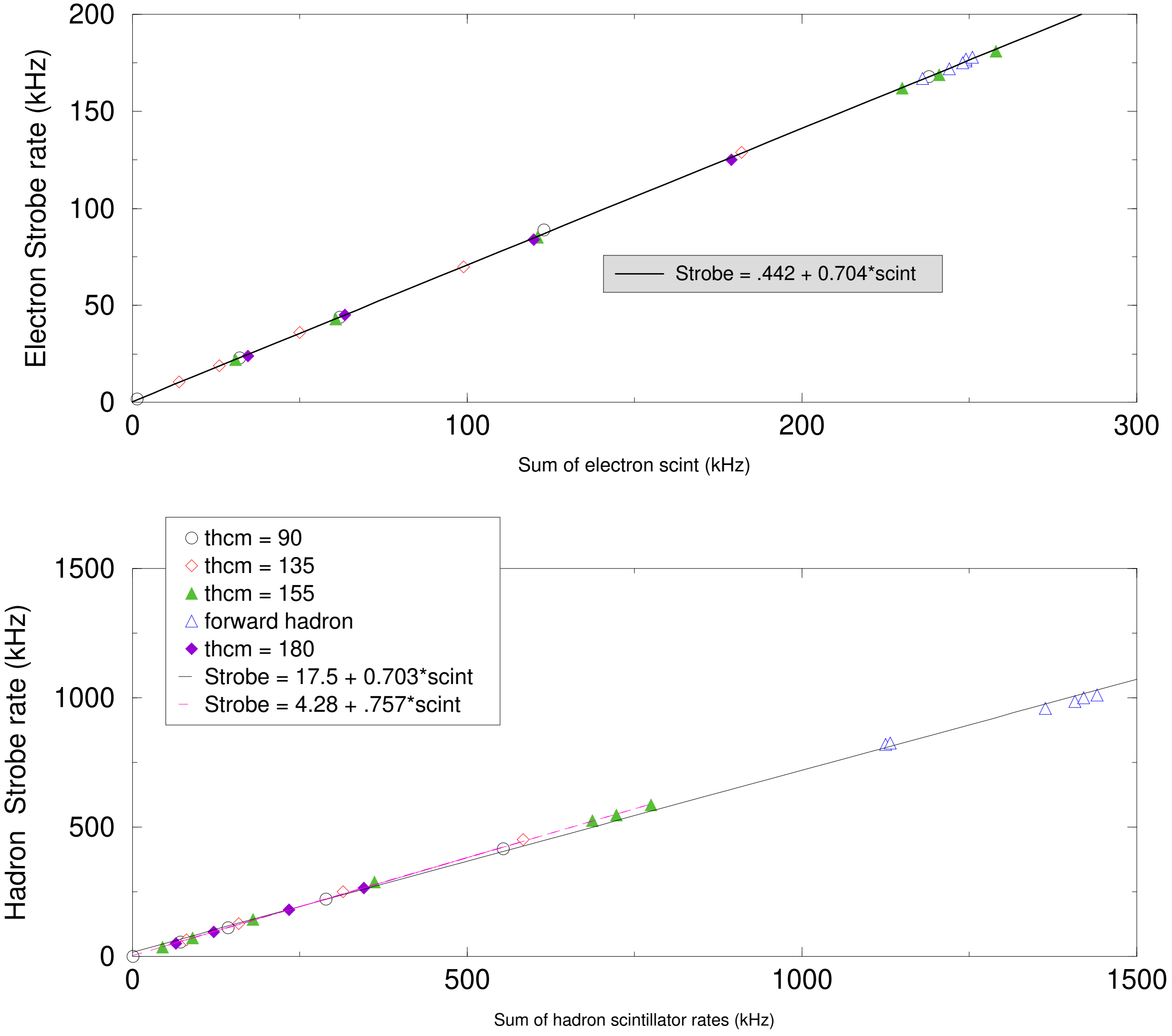


FIGURE 2. Electronics deadtime (%) versus the sum of strobe rates on E-arm and H-arm for coincidence triggers during N-Δ experiment

FIGURE 3.


Electron Strobe rate (kHz)
Sum of electron scint (kHz)
Strobe = .442 + 0.704*scint
Hadron Strobe rate (kHz)
Sum of hadron scintillator rates (kHz)
thcm = 90
thcm = 135
thcm = 155
forward hadron
thcm = 180
Strobe = 17.5 + 0.703*scint
Strobe = 4.28 + .757*scint