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SELECTION UNITS IN K-e SCATTERING EXPERIMENT AT 250 GeV

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ABSTRACT

The selection unit for fast analysis of primary drift-chamber information in Fermi National Accelerator Laboratory experiment E456 is described. The unit gives an "enable" signal for events when hits were registered in at least three of four drift-chamber planes in each of four groups before the hydrogen target and when there were no more than six hits in each four-plane group. The device is designed using exclusively Motorola 10 000 IC series.

Below we describe electronic selection units which were used in the K-e scattering experiment at 250 GeV at Fermilab for fast analysis of drift chamber[1,2,3] information. These selection units increased the spectrometer efficiency and made data more reliable.

In those experiments where it is important to measure the absolute cross section, special attention to coordinate detector efficiency and the reliability ot the information should be applied. Beside improvments of the detector itself, some selection criteria can be applied to information from the primary beam particle, increasing the efficiency and the reliability of further off-line reconstruction. Of course, it is necessary to be sure that the applied criteria are not correlated with the further fate of the incident particle.

In the kaon form factor experiment at 250 GeV, drift chambers[2] were used. The information from the drift chambers in the first block, i.e., before the hydrogen target, was analyzed at each passing of a beam particle. After maximal drift time (about 400 nsec) and some small time necessary for performing logic analysis (about 15 nsec), the selection unit gives a decision signal "yes" or "no" which is send to the coincidence with the signal from the rest of the beam monitor logic. A "yes" decision required signals from three of four drift planes in each of the four groups of chambers before the hydrogen target. This requirement guarantees 100% efficiency of primary track reconstruction. In addition to this, the "yes" signal was forbidden if in at least one of the four groups more than 6 wires were hit (number of working wires in each group equal to 10 -Fig.1). This requirement supressed possible cross-talk effects.

In the typical conditions of experiment, about 2% of the primary particles did not satisfy the above criteria. Selection units guarantee near 100% incident particle efficiency regardless any uncontrolled decreasing of the drift chambers efficiency.

Signals from the drift chambers[1,2,3] are processed by the amplifier-discriminators[4] located directly on the chambers; from there the signals are sent by high-frequency cables to LRS 620 discriminators (20 nsec pulse width) which send regenerated signals to the TDC's and to selection units. The selection units are designed entirely with Motorola 10 000 [5] series, and require that input NIM signals (Fig. 3) be translated to suitable ECL levels. Because of the range of drift time (0-400 nsec) in the chamber, signal coused by one particle may appear at different times and all information incoming from one event must be stored in the input latch register (MC10130). To exclude noise (Fig. 2) the input pulses are gated for 400 nsec. The latches operate as follows: the data inputs of the latches are held permanently at the "0" level, keepeng the register zeroed as long as the clock is low. When the device is strobed,"CLOCK" goes high, enabling the set latch inputs to which signal lines are connected (Fig.3). The "CLOCK" pulse is extended for 15 nsec over "STROBE-GATE" to assure that all d.c. processes are read completely. The trailing edge of the "CLOCK" pulse stores the decision state in the output latch, from which, after ECL-NIM translating, the result is fed to the "DECISION OUT". The decision remains stable until the next "STROBE-GATE" arrives. During the "CLOCK" activation decision status is unpredictable because of the non-synchronous nature of drift chambers signals, so decision gating is also provided.

As mentioned before, a physical event is considered correct from the cross-talk standpoint when it has no more than six hits and/or noise pulses yielded by one particle during one strobe time. The logical equation strictly describing such a case will be very complicated. It is much easier to treat the contents of input latches negatively, i.e., hits will correspond to negative values. The arguments to the processing electronics will be taken from the $\bar{Q}$ outputs of the input register (Fig.4). In this situation, one must find a logical equation which is satisfied by four or more "ones" in the input register.

The entire set of input arguments was divided for convenience into four subsets according to drift chamber planes. Symbols A,B,C,D indicate logical "and" for planes I,II,III,IV respectively which means 3,2,3,2 non-hits (see Table 1); letters a,b,c,d describe a logical "or", i.e., at least one non-hit in a given plane. The r and t become "true" when two of three non-hits (1.2 + 1.3 + 2.3) appear in the first or third plane. As shown in Table 1 all possible combonations of four non-hits could be minimized to nineteen items. Near the table conjunction describing in optimized form group of combinations are also presented. The found formula generates a "true" level not only in the case when four input arguments have a "1" value but even when more than four of ten arguments become positive. It is so because each combination with more than four non-hits is redundant to the described equation.

To satisfy drift chamber efficiency, i.e., presence of signal pulses in at least three of four planes, the following equation must be realized:

$$Q = a.b.c.d + \bar{a}.b.c.d + a.\bar{b}.c.d + a.b.\bar{c}.d + a.b.c.\bar{d}$$

which after optimization has a form:

$$Q = a.b(c + d) + c.d(a + b)$$

where a,b,c,d are logical or's of positive input register arguments.

This formula may be easily hard wired. Fig.4 shows the physical realization of the described selection logic. The entire logic is d.c. coupled throughout. For Integrated Circuits economy "wired-or" technique was extensively used. The asterisk at the logical unit outputs indicate the 510 ohm pull-down resistors.

The device was prepared in a single NIM module and contains logic for X and Y projections (20 channels). The positive decision is generated when decision coincidence of X and Y is achieved. Additionaly, for convenience, separate decisions for efficiency and cross-talk are available. One unit consumes about 40W from -6V power supply.

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Table 1.

PL.	I			II		III			IV		
CH.	1	2	3	4	5	6	7	8	9	10	
1	r (2)			B (2)		–			–		r.B
2	A (3)			b (1)		–			–		A.b
3	–			–		t (2)			D (2)		t.D
4	–			–		C (3)			d (1)		C.d
5	A (3)			–		(c + d) (1)					
6	r (2)			b (1)		(c + d) (1)					(A + r.b + a.B)(c + d)
7	a (1)			B (2)		(c + d) (1)					
8	(a + b) (1)					C (3)			–		
9	(a + b) (1)					t (2)			d (1)		(a + b)(C + t.d + c.D)
10	(a + b) (1)					c (1)			D (2)		
11	r (2)			–		t (2)			–		
12	r (2)			–		–			D (2)		(r + B)(t + D)
13	–			B (2)		t (2)			–		
14	–			B (2)		–			D (2)		
15	r (2)			–		c (1)			d (1)		(r + B)c.d
16	–			B (2)		c (1)			d (1)		
17	a (1)			b (1)		t (2)			–		a.b(t + D)
18	a (1)			b (1)		–			D (2)		
19	a (1)			b (1)		c (1)			d (1)		a.b.c.d

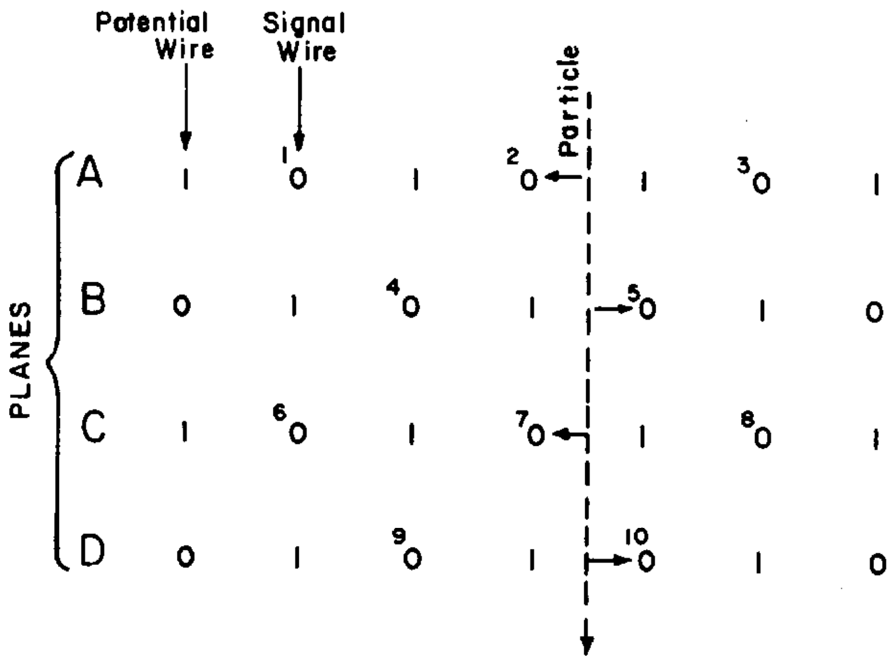

Fig. 1. Schematic wires allocation in one projection of the drift chamber.

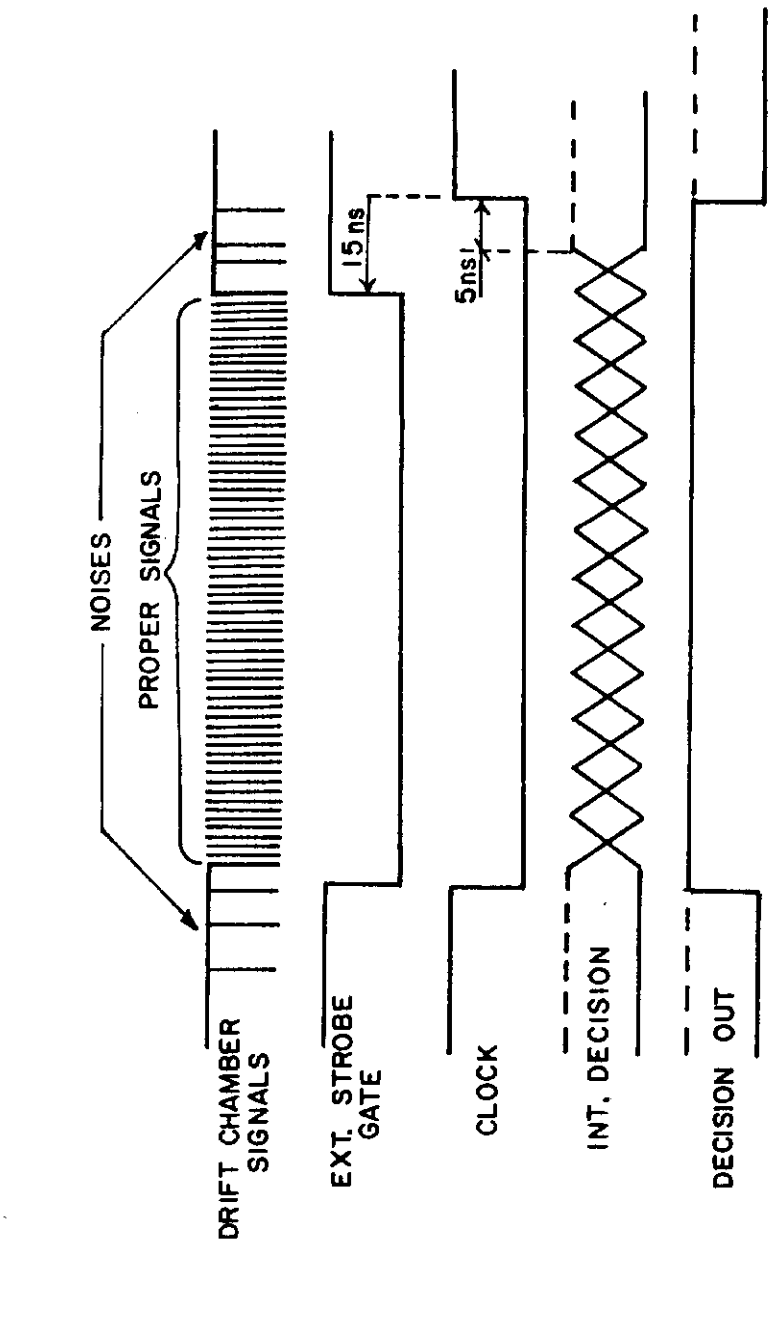

Fig. 2. Schematic diagram of the input and output section.

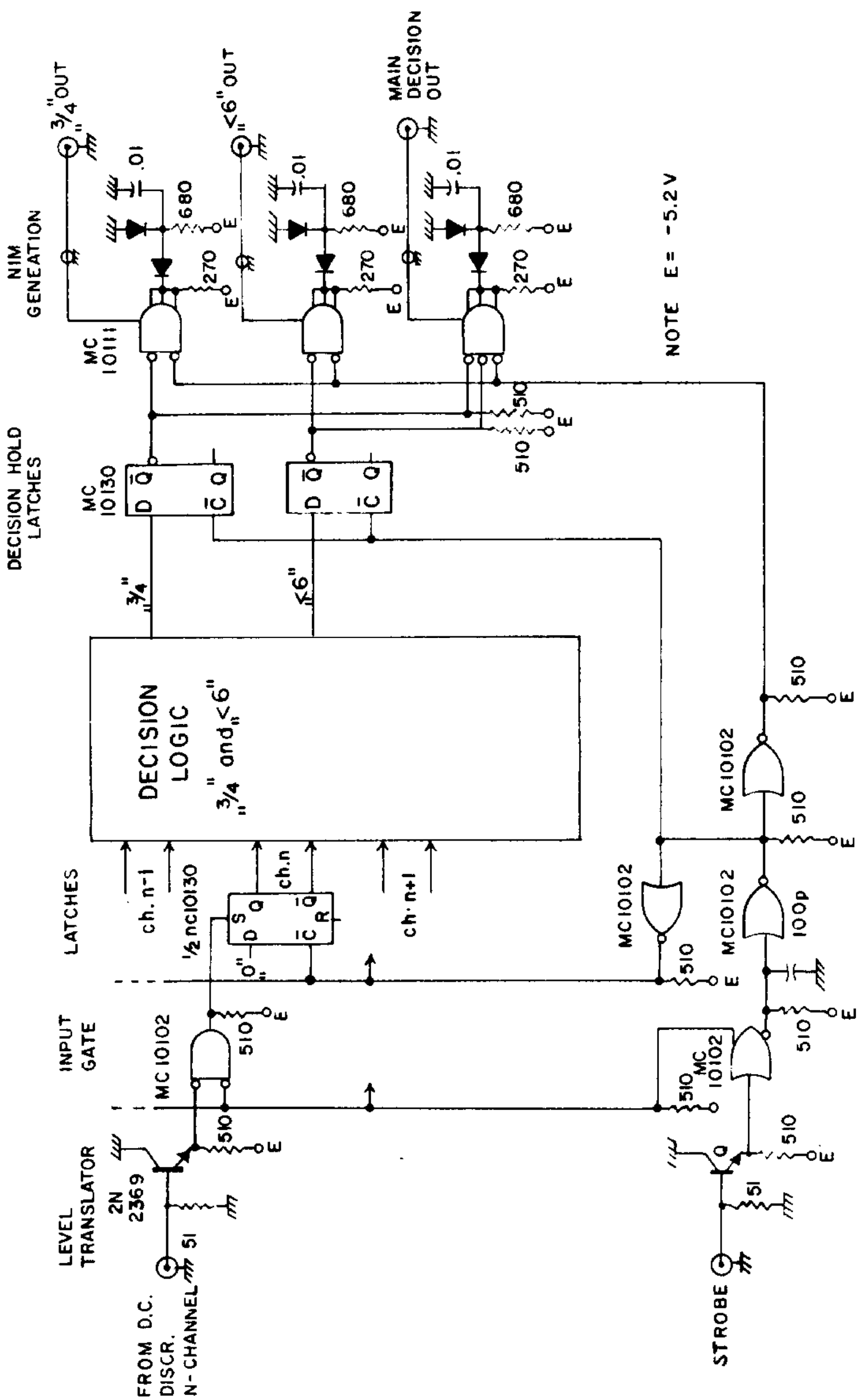

Fig. 3. Detailed logic diagram of the combinational selection part.

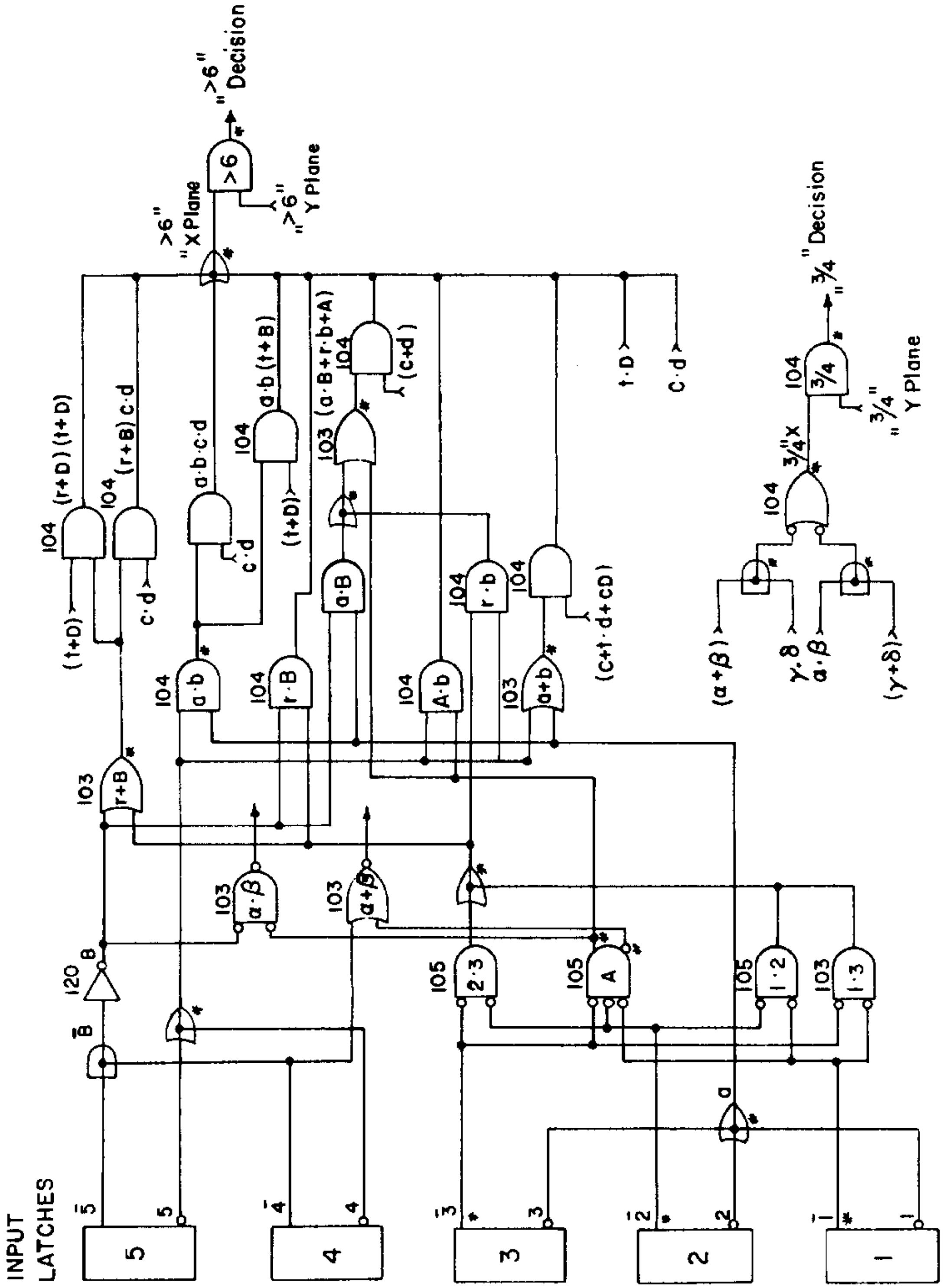

Fig. 4. The waveforms and timing of the device.