A CHARGED KAON TRIGGER USING THE M7

The E-400 Collaboration presented by Paul Lebrun
Fermi National Accelerator Laboratory*

Introduction

The goal of experiment E-400 is to accumulate a large sample of hadroproduced charmed events. Since the most likely decay of a charmed particle is via the emission of a kaon, a charged, high momentum kaon trigger has been designed using a previously build fast processor (the M7 computer)[1,2] for experiment E-401.[3] This report demonstrates the flexibility of such a processor.

The Experiment

The experiment is running in the neutral-wide band beam at Fermilab; the relevant parts of the spectrometer and the data acquisition system are shown in Fig. 1. The 10% interaction length target consist of Tungsten, Beryllium and active silicon and is followed by a vertex detector and a trigger counter. The first analysis magnet, characterized by a transverse momentum kick of 400 MeV/c, is followed by 3 multiwire proportional chambers and the first Cherenkov counter. The second analysis magnet (transverse momentum kick of 600 MeV/c) followed by 2 MWPC's gives us good momentum resolution for central, high momentum tracks. P3 has 2 mm wire spacing in all 3 views (x, non bend view, u and v, characterized by a stereoangle of 11 degrees). P4 has 3 mm wire spacing in the x view, 2 mm in the u and v view with the same stereoangle. The counters C1 and C2 have a pion threshold set at 5.4 GeV and 10.8 Gev, respectively. Each of those Cherenkov counters has 34 cells, the geometry for C1 and C2 is displayed in Fig. 2. On the downstream face of C2, a scintillation counter hodoscope (CH2) matching the C2 cell geometry is mounted, allowing Cherenkov related fast triggers.

A fast trigger is obtained by requiring a coincidence between the target counter and the trigger counter located downstream of P4. The second level trigger is obtained by requiring (i) a signal from the active target, (ii) the MWPC hit multiplicity average over P0, P1, and P2 being at least 4, average over P3 and P4, 2; (iii) the total energy deposit in the lead glass array and in the hadron calorimeter being greater then 100 GeV, allowing us to trigger on the high energy component of the neutron spectrum. This second level trigger achieves a factor of 4 in background rejection.

The M7 Trigger

The M7 is a small fast computer with an instruction set designed to match the on-line pattern recognition problem of a high-energy physics experiment. The processor is a five address, microprogrammed pipelined, ECL machine with simultaneous memory access to four operands which load two parallel multiplexers and an ALU.

A charged kaon with momentum between 20 and 40 GeV will produce light in C1 and not in C2 and hence will fire a fast electronic trigger consisting of CH2 C1 $\overline{C2}$. Unfortunately pions with momenta between 5.4 and 10.8 GeV will also fire this fast electronic trigger. In order to discriminate against these lower momentum tracks, the M7 processor provided a crude momentum measurement using hit information from chamber P3 and P4. Coarse hit information are defined as the "OR" signals from 8, 16, or 32 signal wires, depending on the location of the wires in the chamber; the central region being always the high density, fine grained region. This defines 32 active "bands" per plane. The M7 search for a triplet (x, u and v) in P4 aligned with an active Cherenkov cell, assumed the presumed track is issued from the target, and search for a corresponding hit in P3x (x refers to the non bend view). A triplet in P3 completes the candidate tracks, the track momentum can be measured by virtue of the different spectrometer momentum dispersions present at these two chambers. Because of the crudeness of this measurement, only a minimum momentum cut of 18 GeV is applied to discriminate against pions below the C2 threshold. Above 120 GeV, no momentum information is available.

The whole program was about 120 instructions long, the excecution time was typically 50 to 200 us, depending on the complexity of the event. Prior to data taking, the hardware has been checked on previously recorded data, by sending the pseudo hit information issued from the PDP 11/45 to the M7 interfaces through CAMAC. The M7 gives it's answer through the Transfer Memory modules (TM) to the 11/45, relevant tracks coordinates were compared, the set up was found to be better than 99% efficient. During normal data acquisition, the efficiency of the processor was constantly monitored by comparing TM data block with off-line FORTRAN emulators.

The M7 kaon trigger rejects 2/3 of the events satisfying the second level trigger while being 70% efficient at passing events with an analyzable kaon track identified by C1 and C2 in the extensive offline analysis. The 30% inefficiency is not due to hardware failure, but reflects problems inherent in the greatly simplified Cherenkov algorithm employed by the M7, such as sharing light of a given track amoung several Cherenkov cells or tracking confusion in high multiplicity events. Fig. 2 illustrates the algorithm by showing a typical event. Tracks locations are black dots, the circles represent the Cherenkov light ring, shaded bands are the active MWPC bands in P4 inducing the trigger. Finally, this trigger is fully programmable, allowing great flexibility. Triggering on proton versus antiproton, $K^{\pm}$, $K^{\pm}P$, or $K^{+}K^{-}$ is presently being considered.

References

*Operated by Universities Research Association Inc. under contract with the U.S. Department of Energy.

[1]The M7 - A Computer for On-line Track Finding, D. Harding et al., IEEE Trans. Nucl. Sci., Vol. NS-30, No. 5 (1983).

[2]The M7 - A High Speed Digital Processor for Second Level Trigger Selection, T. Droege et al., IEEE Trans. Nucl. Sci., Vol 25, No. 1, 698 (1978).

[3]Psi Photoproduction at at Mean Energy of 150 GeV, M. Binkley et al., Phys. Rev. Lett., 50, 302 (1983).

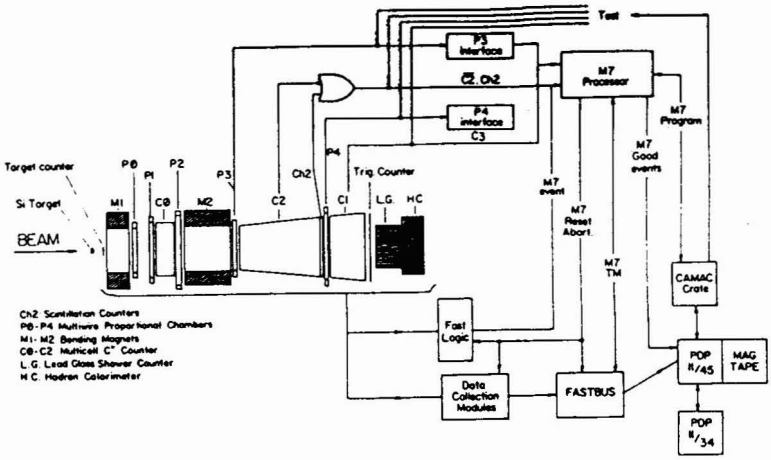

Fig. 1. The E-400 trigger elements and data acquisition.

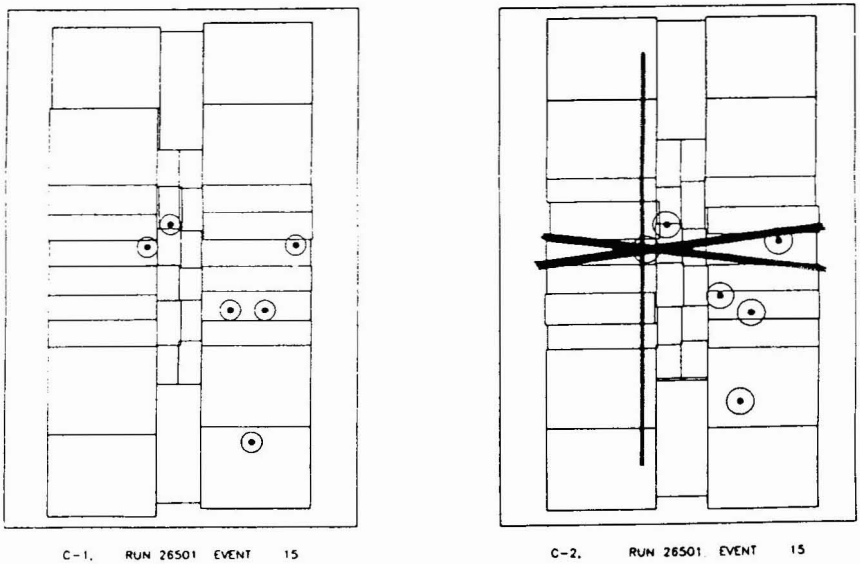

Fig. 2. Typical event display.

QUESTIONS AND ANSWERS

Q: 1) How many tapes do you write?

2) How do you analyze your tapes?

A. Brenner

A: 1) 1 tape/12 minutes.

2) Off line.

Q: You said you write one 6250 BPI tape per 12 minutes. How many tapes do you end up with after one "season" (i.e, year) of running?

M. Delfino

A: Approximately 1500 tapes.