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E781

The E781 Trigger and Data Acquisition System

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Abstract

The trigger and data acquisition system of Fermilab Experiment 781 (SELEX), a high statistics charm baryon experiment scheduled to run in the next Fermilab fixed target run in 1996, is briefly described. The first and second level hardware triggers are expected to reduce the trigger rate by at least a factor of 10 compared to the interaction rate. A third level software trigger searching for secondary vertices is expected to cut by another factor of 40.

1 Experiment Description

E781 [1] expects to collect several 10^5 reconstructed charm baryons. The experiment is described in more detail in [2]. Here we will only point out important parts used to trigger on charm particles.

Charm particles will be produced in a segmented target (4 % of an interaction length) by a 650 GeV, 2 MHz negative beam, mostly containing Σ^- and π^-. Twenty planes of 20 μm and 25 μm pitch silicon microstrip detectors immediately follow the target and are used to reconstruct tracks from the primary and secondary vertices with high precision. Three magnets surrounded by proportional wire and drift chambers are used to measure the momenta of charged particles. A TRD and a RICH are used for particle identification. The setup is completed by a three-stage electromagnetic leadglass calorimeter and a hadron calorimeter. The overall length of the experiment is about 50 meters. Scintillator hodoscopes are placed behind the second magnet to be used in the trigger.

2 Level One and Two Hardware Triggers

The first level trigger requires at least 3 positive particles in the hodoscopes behind the second magnet, which has an implicit momentum cut of $\approx$ 15 GeV/c. This, together with a signal from an interaction counter directly after the second microstrip plane and an (optional) beam particle tag obtained from the beam TRD, will form the first level trigger within $\leq$ 150 nsec after the interaction. We will use this signal to gate the front end electronics.

*for the E781 Collaboration

In the second level trigger we may use the hit correlation in the hodoscopes to select at least one positive track of $> 25\,\mathrm{GeV/c}$, but the second level is mostly needed for other physics triggers. After this signal we will start the front end readout, otherwise we will clear the front end electronics.

3 Trigger Rates and Readout Speed

We expect the hardware trigger (level one and two together) to reduce the interaction rate by at least a factor of ten. This was checked with data from E653 and with Monte Carlo. We expect a raw trigger rate of 10 KHz. With an online deadtime of $\leq 30\,\mu$sec and an event size of ≈ 5 KBytes we have to read out 35 MBytes/sec.

4 The Data Acquisition System

The data acquisition system was developed in close collaboration with other experiments and the FNAL OLS group as part of the Fermilab DART project [3]. The data will be collected in ten independent streams and stored in VME dual ported memories. We expect to collect 140,000 events with 700 MBytes of data over the twenty second spill. A schematic layout of the system is shown in figure 1.

During the whole 1 minute cycle time of the Tevatron we will transfer the data of two of the streams containing the silicon microstrip, the PWC, and the RICH data (about 25 % of the event size) via a fast VME to VME crate interconnect to an SGI Challenge L with twelve processors, with a total computing power of 1300 MIPs. The data will be distributed to twelve filter jobs using the DART Data Flow Manager (DFM) [4]. After a positive decision of the level three filter job the total event will be logged from the VME crate to 8 mm tape at a rate of about 300 KByte/sec.

5 The Level Three Software Filter

To select charm particles we make use of the long lifetime (several 100 femtoseconds) which produces typical laboratory flight paths of several millimeters. This secondary vertex can be separated from the primary vertex by a high-resolution vertex detector consisting of silicon microstrips. We will not reconstruct the full secondary vertex in the filter code. Instead we ask only that one of the tracks seen in the downstream spectrometer has a sizeable miss-distance (impact parameter) from the beam particle at the center of the thin (< 1.5 mm) production target.

First the tracks in the second spectrometer will be reconstructed, using only the information from the proportional wire chambers. The tracks will be extrapolated back to the silicon microstrip detector to select hits. The impact parameter of these tracks to the primary vertex reconstructed from the beam track is then calculated.

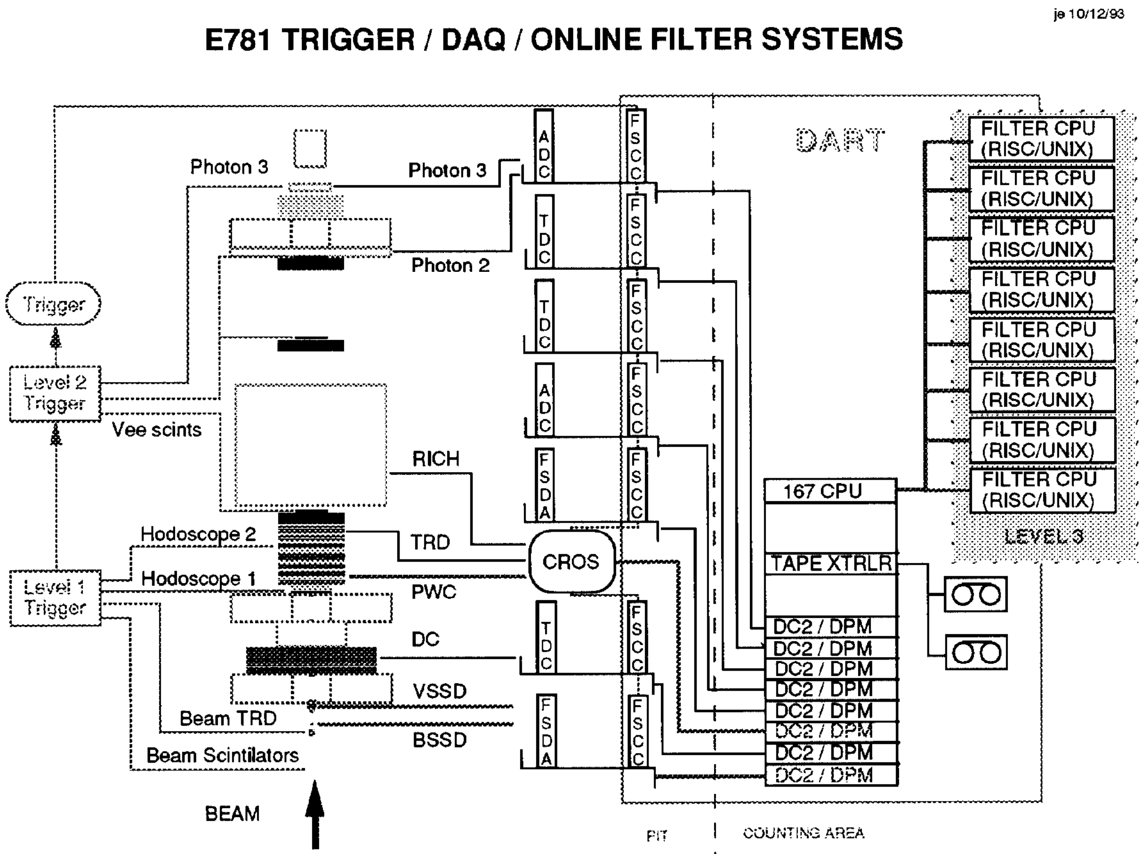

Figure 1: Schematic layout of the E781 data acquisition system

In Figure 2 we show the distribution of the maximum miss distance in each event for downstream 3-track events from the E781T data [5]. A cut at a miss distance of 30 μm gives a rejection factor of 10; extrapolating to the full E781 vertex detector, which will have 20 planes in 4 views instead of 8 planes in 2 views, we project gaining at least a factor of 2 in additional rejection.

With this algorithm we will select most of the charmed baryons with high efficiency. For states with extremely short lifetimes [6] we plan to use additional information from the RICH detector to select final states with a simultaneous K^- and proton, indicative of a Ξ_c^0 or Ω_c^0 decay, as well as to trigger on exotic strong-interaction states which have baryons in their decays.

To measure the speed of the algorithm, we used code developed for E781T and timed it on a SGI Challenge L. Currently, we need about 7 msec/event for the miss-distance algorithm, which will translate to about 1700 MIPs of computing power to process 140000 events/minute. However, we are confident that we can reduce the time by optimizing the code. We also also

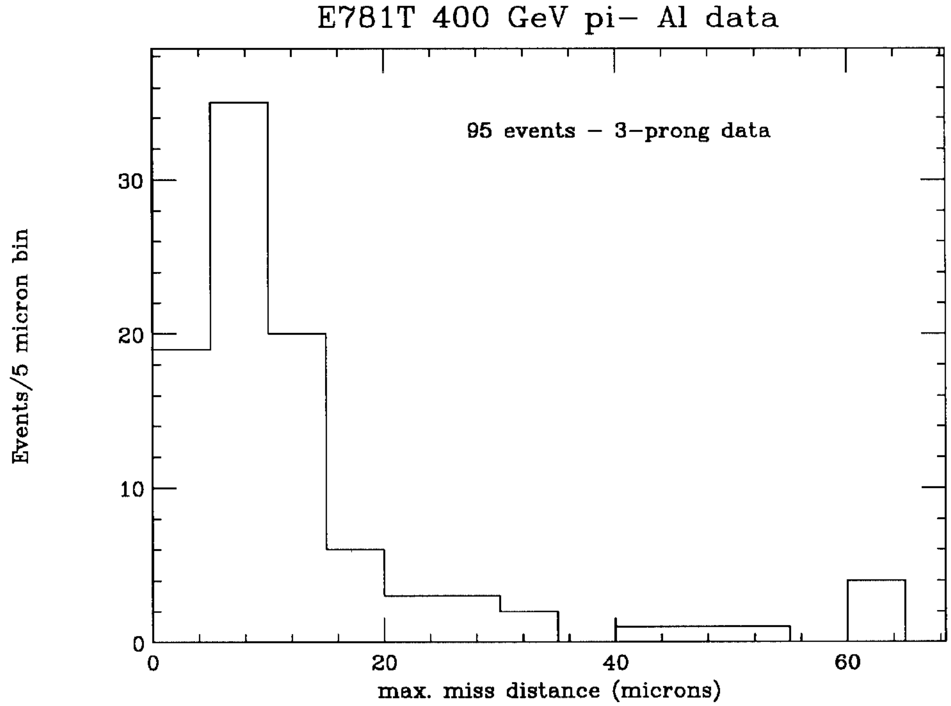

Figure 2: Maximum miss-distance for downstream 3-track events from E781T.

verified that the execution time was the same when running 10 processes on a ten–processor Challenge L. The RICH part will only add a few hundred μsec per event, since most of the information needed for the RICH algorithm, especially the track information from the second spectrometer, is already calculated for the miss distance algorithm.

References

[1] E781 Collaboration: Carnegie Mellon University, Fermilab, University of Iowa, University of Rochester, University of Washington, Petersburg Nuclear Physics Institute, ITEP (Moscow), IHEP (Protvino), Moscow State University, University of São Paulo, Centro Brasileiro de Pesquisas Fisicas, Universidade Federale de Paraiba, IHEP (Beijing), University of Bristol, Tel Aviv University, Max-Planck-Institut für Kernphysik (Heidelberg), Universidad Autonoma de San Luis Potosi.

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