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October 1985

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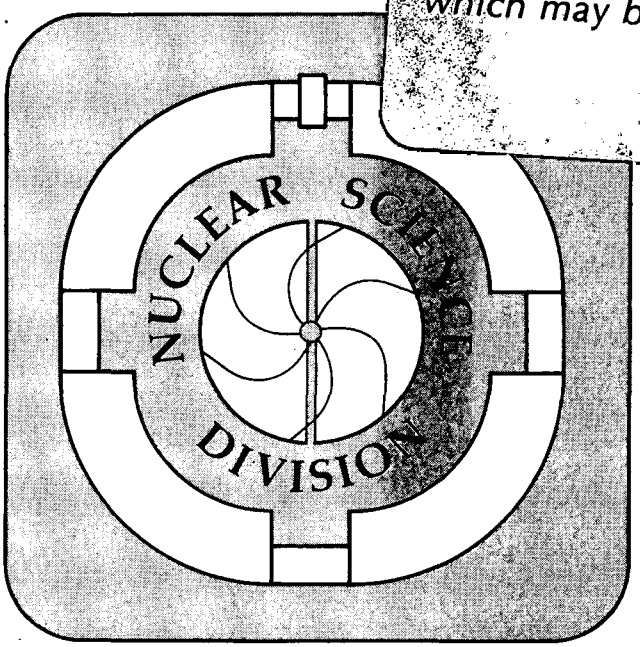

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Abstract

A data aquisition system using FASTBUS has been developed. FASTBUS TDC's are used to record hits from a drift chamber, while FASTBUS ADC's digitize the pulse heights from the chambers. FASTBUS data are transferred to CAMAC and then written to a VAX 11/750 using a MBD. The performance of this system is discussed.

Introduction

At the Lawrence Berkeley Laboratory, a new experiment,[1] which is called the Di-Lepton Spectrometer (DLS), is being constructed to measure the threshold dependence of electron-positron pairs. This experiment will use the facility called the Bevalac which can accelerate ions from protons to heavy ions. The DLS will measure pair production cross sections up to 4.9 GeV for proton beams and up to 2.1 GeV/N for various ions which range in mass up to calcium.

The low mass behavior of pair production has never had a satisfactory explanation. A previous experiment has already found excess single electron and positron production at 2.1 and 4.9 GeV.[2] However, there is no satisfactory explanation for this phenomenon. By measuring the threshold behavior of these pairs, we hope to find some clues to the process which causes their production.

The set-up follows the traditional design for pair experiments. Figure 1 shows the layout of the DLS. There are two identical arms; one of the arms is shown in detail. One set of drift chambers is situated before the bending magnet and another is located after the magnet. These sets are used to identify particles produced from the target and to momentum analyze their trajectory. There are two Cherenkov counters to determine whether a particle is an electron. Two sets of hodoscopes are included to help with the experimental trigger and also to aid the track reconstruction.

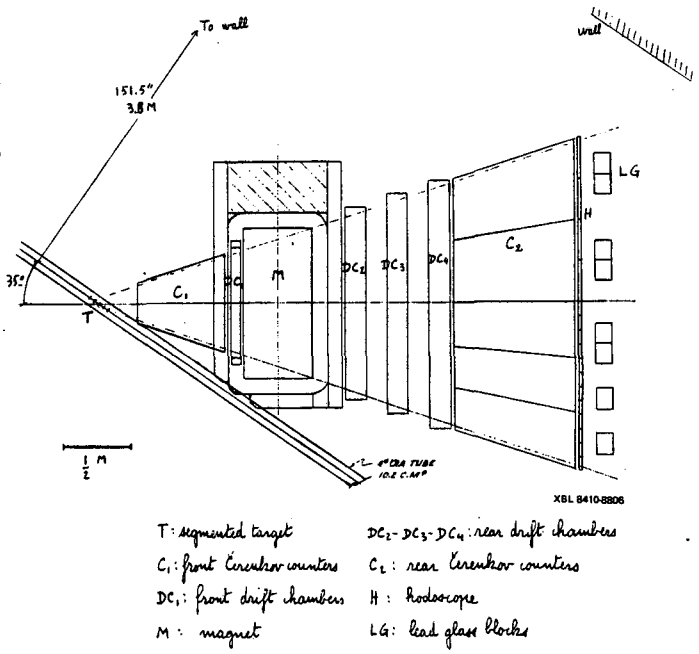

FIG. 1. Layout for the Di-Lepton Spectrometer. One arm is shown in detail. Drift chambers are labeled DC1-4, Cherenkov counters are C1-2, and hodoscope is H. The hodoscope after C1 is not shown.

The spectrometer has been designed to identify events with a multiplicity of five tracks in each arm. This requirement has influenced the segmentation of the Cherenkov and hodoscope counters. For this experiment, the trigger rate is estimated to be at several hertz and consequently, the data rate should be moderate.

Digital Electronics

In this experiment, it will be necessary to digitize the usual information and to store it on magnetic tape. Time to digital converters (TDC's) and analog to digital converters (ADC's) are used to measure respectively the time and amplitude information for the Cherenkov and the hodoscope counters. Drift chamber information is recorded with lower resolution TDC's.

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In order to modernize the electronics for accelerator experiments, a new standard, FASTBUS, has recently been developed.[3] Commercial modules are now available so that it is possible to use this new standard easily. Because of the cost, new features in these modules, and the high packing density, we have decided to use FASTBUS modules which are commercially available. All electronics in this experiment have been fabricated by commercial sources.

There are about 1600 wires and 200 phototubes that are read for each event. For this number of channels, one FASTBUS crate can easily handle all the ADC's and drift chamber TDC's. However, at this time there is no commercially available high precision FASTBUS TDC's for the time-of-flight hodoscopes, so it also necessary to have a number of crates of CAMAC instrumentation.

Figure 2 shows the block diagram for the data acquisition system. All FASTBUS data are collected in the FASTBUS crate by a LeCroy 1821 segment manager. The segment manager has been programmed to read all the drift chamber hits and ADC channels above pedestal. FASTBUS data are transferred to CAMAC through a LeCroy 2891 CAMAC interface. A MBD built by the BiRa Corporation is used to transfer both the CAMAC and FASTBUS data to a VAX 11/750.

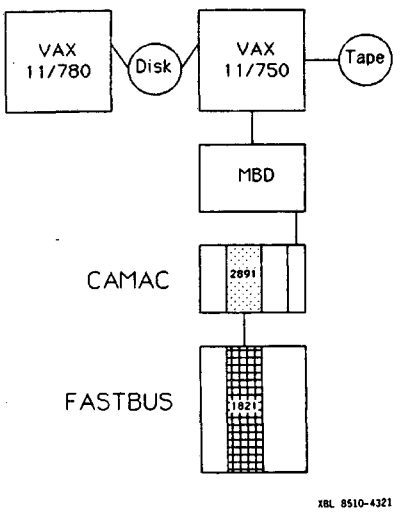

FIG. 2. Block layout of the data acquisition system.

We have selected the LeCroy 1879 TDC to digitize the time from the drift chambers. At its highest sensitivity of one nanosecond per channel and with its range of one microsecond, the TDC is well matched to the resolution and drift length for our chambers. Measurements of the resolution of the TDC's have shown an intrinsic resolution of 0.7 to 1.2 nanoseconds per channel. This value is sufficient to achieve the expected resolution of about 300 microns for the drift chambers.

To measure the pulse height of the Cherenkov and hodoscope counters, we have selected the LeCroy 1882 ADC FASTBUS system. These ADC's have sufficient resolution and linearity so that we can separate protons from minimum ionizing particles.

Online Software

In order to simplify the data acquisition software, we have tried to be compatible with existing VAX 11/750 data acquisition system developed by the GSI group resident at LBL.[4] In this experiment, as the total number of words read per event is estimated to be about 75 and the trigger rate is estimated to be close to several hertz, only moderate data transmission speed is needed. To eliminate the need for writing a software driver for the FASTBUS computer interface and to get rid of the need for modifying the existing data acquisition to merge the FASTBUS and CAMAC data streams, we decided to read the FASTBUS data through CAMAC.

The process of obtaining data and writing that information to magnetic tape requires programming three computers. The segment manager assembles the FASTBUS data. The MBD collects the CAMAC data and then sends it through the UNIBUS to the VAX 11/750. The VAX formats the data so that it can be written on magnetic tape and sends it to a disk file so that online analysis can be done on it. The disk file will be read both by the VAX 11/750 and another VAX 11/780 so that online data checking can be made.

The segment manager has been programmed using an micro-assembler to read out only those modules which have data in that event. First a broadcast is sent over the backplane to lock in all the ADC's. The channels are read and then piped to the 1821 memory. In this process, a pedestal subtraction is made. Only those modules which exceed a specified threshold are written to the memory. Next, using TPOLL logic, only those TDC's which contain hits are latched to the 1821. Data are read and then stored in the 1821 memory. A major advantage of the way that this code is written is that no change has to be made to either increase or decrease the number of TDC's or ADC's that are read each event.

After all data is transferred to the 1821, a Microprogrammed Branch Driver (MBD) transfers the data via CAMAC to the memory of a VAX 11/750. The coding of the MBD is very simple as it only takes about thirty 16 bit words to program the reading of the whole FASTBUS crate. It takes about 8 microseconds per FASTBUS 32-bit word to move the data to the VAX after the addresses have been digitized. While this time is slow compared to maximum speed of FASTBUS, it is fast enough compared to low trigger rate for this experiment. Using this system, we can collect about 100 events per second.

Auxiliary Software

In addition the code needed to readout the data, auxiliary code must be written to download information to the segment manager. As very fast data rates are not needed, the simplicity of FORTRAN coding has been used. Some of the subroutines have been modified from those developed at Fermilab.[5]

Programs have been developed to code and download the segment manager. In addition several programs have been developed to perform typical FASTBUS functions such as reading and writing to the modules. Several test programs have been written. These programs work sufficiently fast that it has not been necessary to use special coding in the MBD.

Performance

At present, the complete data acquisition system has been tested using a few counters and a prototype

drift chamber using cosmic rays. These tests have been made with almost a whole FASTBUS crate full of electronics -- 16 TDC's and 1 ADC. Over a period of three months we have had no failures with the FASTBUS system. This data acquisition system has worked so reliably that many members of our collaboration have used it without needing detailed knowledge of FASTBUS. Figure 3 shows a typical pulse height distribution for a scintillator counter from a FASTBUS ADC. That figure clearly shows the pedestal of the ADC and the signal from the light deposited in the scintillator. Similarly, Figure 4 shows the time spectrum for one wire from a cell in our drift chambers. At earliest time is the signals from hits close to the anode wire; at later time are the hits which occur farther away from the wire. The width of this spectrum is consistent with a drift region of 1 cm and a drift velocity of 50 microns per nanosecond.

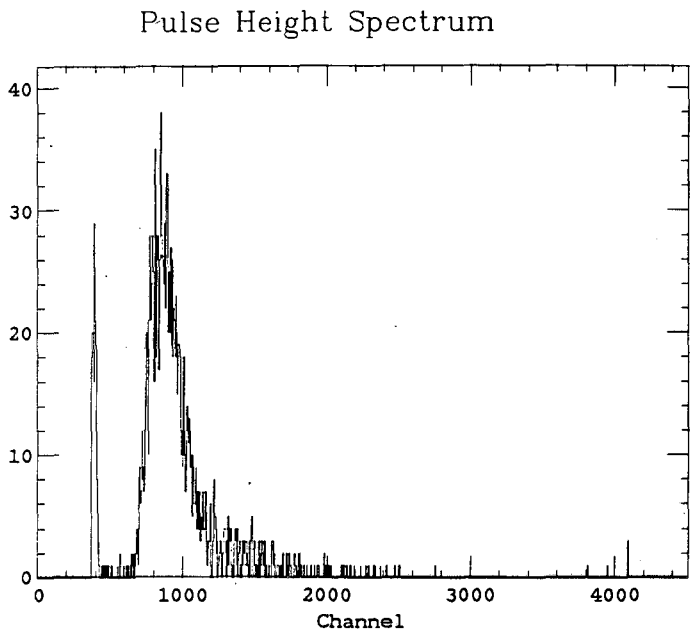

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FIG. 3. Pulse height spectrum for a scintillator. The data was taken with a LeCroy 1882 FASTBUS ADC.

Summary

A data acquisition has been developed for an experiment at the Bevalac. A significant fraction of the electronics reside in one FASTBUS crate. Tests have showed that the system is reliable and that it satisfactorily meets the requirements for recording data for the DLS experiment. Because of the lower cost, the flexibility of use, the new features in the electronics, the FASTBUS standard has provide significant advantages for the DLS experiment.

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We appreciate the advice that we received from the many people, from LBL and other institutions, with whom we discussed the implementation of this data acquisition system. We especially wish to acknowledge the help from B. Kolb of GSI, C. MacParland and M. Bronson of LBL, R. Poore of LANL, R. Pordes and T. Burnett of Fermilab, and L. Levitt of LeCroy. We wish to thank our project engineer R. Fulton and also T. Willbanks who did some of the tests.

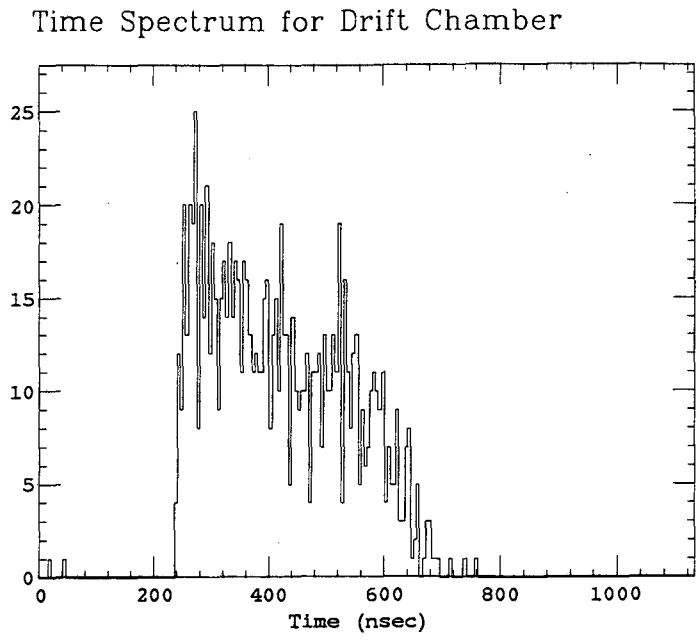

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FIG. 4. Histogram of the time for drift chamber hits for one wire. This data was taken using a LeCroy 1879 FASTBUS TDC.

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[2] J. B. Carroll et al., Bull. Am. Phy. Soc., Vol. 30, Sept. 1985, p. 1271.

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[4] B. Kolb, private communication.

[5] T. Burnett, private communication.

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