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G. A. Petitt, W. H. Nelson, Xiaochun He, and William Lee
Georgia State University

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1 Introduction

This is the final progress report for the experimental nuclear physics program at Georgia State University under the leadership of Gus Petitt. In June, 1996, Professor Petitt retired for health reasons and the DOE contract was extended for another year to enable the group to continue it's work.

This year has been a productive one. The group has been heavily involved in the E866 experiment at Fermilab where we have taken on the responsibility of developing a new level-3 trigger for the experiment. Bill Lee, the graduate student in our group expects to obtain his thesis data from the run extension currently in progress, which focuses on the A dependence of J/ψ 's and Υ 's from beryllium, tungsten, and iron targets.

In the past year and a half the GSU group has led the development of a new level-3 software trigger system for E866. Our work on this project is described in the following sections.

As the year has gone by, Professor He has essentially taken over leadership of the group, developing and coordinating E866 Level-3 project. He is also in the process of initiating an entirely new project working with the Nevis group on PHENIX. He will develop LVL2.5 trigger processing for the PHENIX APT's (Assembly and Trigger Processors). He will be submitting a new proposal to DOE to support this work.

2 Preliminary results of the E866 experiment

During the past year our group has devoted most of it's effort to participation in the E866 experiment at FNAL. We have been responsible for development of a level-3 or slow-trigger system which is described below. In addition, the members of our group have actively participated in the day-to-day operation of the experiment. During the past twelve months William Lee has spent an average of about 10 days each month at Fermilab; Xiaochun He has spent about a week per month there and

Gus Petitt a total of about two weeks. This time has been spent both in routine shift work on the experiment and in testing the level-3 trigger system. For example, in addition to writing a large portion of the level 3 trigger code, Bill Lee has also spent about 10 days per month at Fermilab assisting with the E866 experiment. While there, Bill has taken shifts running the experiment. He has also assisted in the repair of the data acquisition system, and other equipment as needed. Bill has run a large number of Monte Carlo programs, which has allowed him to calculate the expected yield for the various configurations of the spectrometer, as well as design the optimum trigger matrix for the fast trigger system. Bill has also assisted in the completion of the first pass analysis on the Fermilab farms.

Most of our time, however, has been spent in the lab at GSU working on development of the level-3 system which is described below.

The E866 experiment, designed to measure $\bar{u}_p/\bar{d}_p$, is being performed using the MEast spectrometer shown in Figure 1. This spectrometer detects particles through the use of its four tracking stations. A thick hadron absorbing wall located in the aperture of the SM12 analysing magnet is used for particle discrimination. The kinematics of the muon pairs are reconstructed from the trajectories of the surviving particles through the magnetic fields.

During the main data taking period, the MEast spectrometer was used to measure Drell-Yan yields from liquid H₂ and D₂ targets from which it is possible to extract $\bar{u}/\bar{d}$ with three different magnets settings: low, intermediate and high. The full data set for the run ending on March 24, 1997, contains over 3.5×10^5 Drell-Yan events, over 1×10^6 J/ψ events, and over 20,000 Υ events.

- Figure 2 shows the mass spectra of dimuons measured by E866.
- Figure 3 shows the ratio of $\sigma^{p\bar{d}}/2\sigma^{p\bar{p}}$, which is related to $\bar{u}/\bar{d}$, from the initial analysis of the high mass data set.

FNAL E866 (NUSEA)

Figure 1: The MEast Spectrometer

- Figure 4 shows the ratio of $\sigma^{pd}/2\sigma^{pp}$ as a function of $\sqrt{\tau}$, also from the initial analysis of the high mass data set.

The preliminary results from E866 (NUSEA) strongly confirm both the NMC evidence of $\bar{u}_p \neq \bar{d}_p$, as well as the NA51 result for $\bar{u}_p/\bar{d}_p$. Also, our data for $x > 0.2$ do not agree with the present CTEQ4M parameterization of the proton. These preliminary results have been presented by the E866 collaboration at several conferences and also at the DOE review at FNAL in April of 1997. In addition, an article for *Physical Review Letters* is in preparation.

The goal of E666 should be achieved after a full analysis of the data.

3 The E866 level-3 system

The E866 data acquisition (DAQ) system is a pipelined data driven system for maximizing system throughput. The E866 level-3 (also called a slow-trigger) is implemented as a data tagging and/or filtering process in the existing data pipeline. Fig-

Figure 2: E866 dimuon mass spectra

Figure 3: $\sigma^{pd}/2\sigma^{pp}$ vs. x_2 (high mass setting only)

Figure 4: $\sigma^{pd}/2\sigma^{pp}$ vs. x_2 (high mass setting only)

ure 5 shows the data pipeline of the E866 DAQ system with the level-3 processing inserted between the Packet Formatter and the Packet Distributor tasks.

Figure 5: The E866 DAQ data pipeline with level-3

The advantages of this architecture are the following: (1) it eases system integration, configuration and synchronization; (2) it provides scalability of the level-3 processing power. The “LVL3 Tagging Filtering” task in Figure 5 can be regarded as a one unit of a data processor farm which can be expanded if more processing power is needed.

Figure 6 shows the major hardware components of the E866 DAQ system. The only hardware required for the E866 level-3 processing is a single-width VME 6U board made by Image & Signal Processing, Inc.[5]. ISP calls this unit a “Blazer board”. As many as six Texas Instruments TMS320C40[4] digital signal processors (DSP) can be installed on a Blazer. We have three DSP’s currently installed on our Blazer. The software running on the VME host processor is VxWorks[6], a real-time operating system created by Wind River Systems, and for the DSP’s we use SPOX[7], a real-time OS for DSP’s by SPECTRON Microsystems, Inc. Each DSP on the Blazer can run independently with respect to the other DSP’s and can communicate with the

E866 Level-3 Processing Structure

Figure 7: The E866 level-3 architecture

The tasks inside the dashed box are the interfacing tasks running on the VME host processor to synchronize the level-3 processing on DSP's.

We have put together at GSU a development system for the level-3 trigger with the components shown in the block diagram in Fig. 8.

There are three distinct processor platforms, each with it's own distinct operating system, that we have had to deal with: the Sun workstation for code development, the VME host processor and the DSP's on a VME board (Blazer). In order to synchronize

Figure 8: Level-3 development system at GSU

the Level-3 processing tasks running on different DSP's with the VME host tasks, we have developed several sets of drivers for communications between tasks running on these processors. Over the past year, we have written over 35k lines of code for this project and tested it using this standalone test system.

With this system either the Silicon Graphics or Sun workstations can be used as the host system for loading and controlling the single board computer (SBC) and Blazer board in the VME crate. We have written all the code for the DSP's in ANSI-C using the Texas Instruments C-compiler and code development software package which runs only on the Sun workstation. The code is compiled on the Sun, then downloaded over the ethernet link to the VME host processor which, in turn, loads the executable files in the DSP memory.

As a result of Blazer hardware and SPOX software problems, this project has not yet been fully installed into the E866 main DAQ system for its major data taking period. The final integration is expected to be done before mid July 1997.

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