On the Commissioning of the 12 GeV HMS Drift Chambers, Electronics/Computer Dead Time Monitoring and Overview of the D(e,e'p)n Experimental Run Plan

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Abstract

Three separate topics, all of equal importance, are briefly discussed. The new (12 GeV Era) HMS Drift Chambers are ready to be put in the HMS detector stack, in place of the old HMS Chambers. Several efficcinecy tests were performed on one of the chambers during the second week of October 2017. The efficciecies were determined to be better than 99%. The second chamber has not been tested yet, but it is expected to behave the same since both chambers were tested under similar conditions in the past. Dead time studies are currently in progress to determine how many physics events (triggers) are actually lost due to computer and electronic deadtime inherent in our experimental equipment. There had been some technical issues found related to the computer livetime that are being addressed by the Jefferson Lab DAQ group. The experimental run plan of my thesis experiment, the electro-disintegration of Deuteron, is briefly discussed as the kinematics have slightly changed and new simulations had to be done.

I. INTRODUCTION

On March 7-10 of 2017, a 5 μA electron beam was delivered to a BeO and Carbon targets for the first time to experimental Hall C since the 12 GeV upgrade. The beam was delivered as part of the Key Performance Parameters (KPP) required by the Department of Energy (DOE) to demonstrate the operability of the High Momentum Spectrometer (HMS) and Super HMS (SHMS). Hall C was able to demonstrate KPP in four days of beam time before an important component of the accelerator was damaged which caused to accelerator to shut down for repair. The accelerator is expected to be operational starting December 4, 2017. As a result of this delay, the commissioning experiments that were scheduled to run on Fall 2017 have now shifted to Spring 2018. This time window has allowed the Hall C collaboration to work extensively in preparation for the commissioning of the spectrometers on December.

One of the projects I have been involved in is the ongoing work on testing and commissioning the 12 GeV HMS Drift Chambers. The chambers were constructed at Hampton University by Dr. Liguang Tang and his graduate students in 2016. They were made the same design as the SHMS chambers, but slightly different size. The chambers were transported to Jefferson Lab on November 2016, where they underwent extensive tests as part of conditioning the chambers to sustain High Voltages using a gas mixture[1] of 75:25 Argon/CO_2 by volume. The chambers were found to be operational below 1850 V which is below the expected value[2] of 1940 V. At high voltages above 1850 V, the chambers drew a significant amount of dark current which made the signals from the chamber noisy. It was determined that the most likely cause of the large currents drawn was the gas mixture[Ar/CO_2] being used, so the one of the chambers (HMS DC II) was transported to the experimental Hall C where a gas mixture of 50:50 Argon/Ethane by volume was used. A test stand for the chamber was set up in the HMS hut, where it has been tested and verified to be operational with the new gas mixture. The other chamber (HMS DC I) exhibited similar symptoms as the first with the addition that it had a few missing channels due to a bad connection between the sense wires and the discriminator cards. The second chamber is now ready to be transported to Hall C for further tests with the Argon/Ethane gas mixture before it can be put in the detector stack.

A second project I am currently involved in is the determination of electronic and computer dead times. In nuclear/particle physics experiments, the number of physics events (triggers) are counted via nuclear electronic modules. These triggers ultimately get processed by the DAQ before being written to tape. The deadtime refers to the time window in which the modules are unable to process triggers and physics events are lost. The electronic deadtime contribution comes from the electronic modules having a maximum rate capability. Typically, the electronic modules in Hall C can achieve rates from a few MHz to few hundred MHz. Once the modules reach their limit, a pileup of signals can occur which contributes to the total dead time. The computer deadtime contribution comes from finite processing time of the DAQ. These rates are typically on the order of a few kHz, therefore, the dominant contribution of total dead time comes from the DAQ, since it takes a few kHz of data before physics events are lost. These measurements are important for the determination of high precision cross section measurements in Hall C, since knowing how many events are actually lost can make a significant difference in the uncertainty of the cross section.

My thesis experiment, the *Electro-Disintegration of Deuteron at Very High Missing Momenta* is projected to run towards the end of February 2018, and will receive a total of six days of beam time. The experiment will be done at four

[1] This gas mixture is non-flammable and at lower cost compared to the gas mixture that the chambers run on during an experiment, which is why it is preferred during the testing phase of the detector.

[2] The HMS chambers are the same design as the SHMS chambers, which operate at $\sim$ 1940 V.

different spectrometer configurations. The kinematic setting have changed slightly from the original proposal, and will be briefly discussed in this paper.

II. 12 GeV HMS Drift Chambers

A. Design and Operation of the Chambers

The new HMS Drift Chambers were designed to be geometrically the same as the SHMS Drift Chambers. Each chamber consists of 6 wire planes and each wire plane is located between two cathode planes. The wire planes consist of alternating field and sense wires. The U, U', V and V' planes consist of 96 sense wires each and are oriented 60^o relative to the +x-coordinate. The X and X' planes consist of 102 sense wires and are oriented perpendicular to the x-axis (See Figures 1 and 2). The cathode planes and field

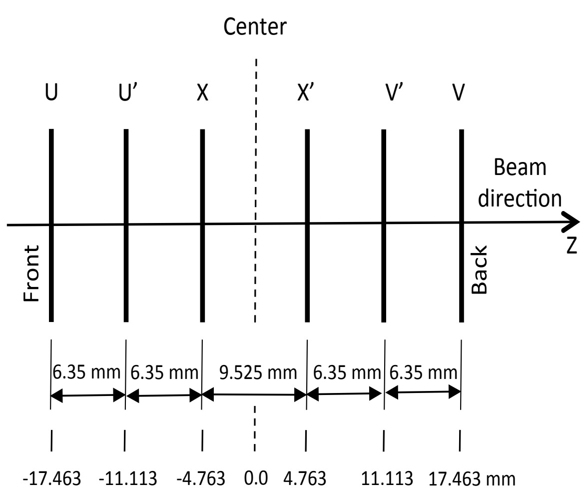

Fig. 1: HMS Drift Chamber 1 wire planes.

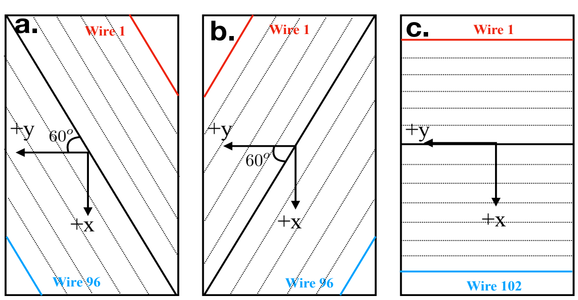

Fig. 2: HMS Drift Chamber wire orientation for planes a) U, U', b) V, V' and c) X, X' where the direction of the beam (+z) is into the plane of the paper.

wires are held at a negative high voltage and the sense wires are grounded which establihses a potential gradient causing an electric field between high voltage and grounded wires. Each chamber is filled with a gas mixture[3] of Argon with either CO_2 or Ethane. As the particles traverse the chamber, the free electrons from ionized Argon drift towards the sense wires producing a detectable signal which is read out via discriminator cards and into electronic modules.

[3]Argon is mixed with CO_2 or Ethane, where Argon is the ionizing agent the particles interact with, and Ethane/CO_2 are the quenching elements to control avalanche produced by secondary ionization

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$$\alpha + \beta = \chi \tag{1}$$

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TABLE I: An Example of a Table

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Three	Four

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Fig. 3: Inductance of oscillation winding on amorphous magnetic core versus DC bias magnetic field

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V. CONCLUSIONS

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APPENDIX

Appendixes should appear before the acknowledgment.

ACKNOWLEDGMENT

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References are important to the reader; therefore, each citation must be complete and correct. If at all possible, references should be commonly available publications.

References

[1] W. Leo, *Techniques for Nuclear and Particle Physics Experiments: A How-to-Approach*. New York: Springer-Verlag New York, LLC, 1987.