Status of the Control System for the CLAS Detector at Jefferson Lab

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Abstract

A control system for Hall B at the Thomas Jefferson National Accelerator Facility is being developed within the framework of the Experimental Physics and Industrial Control System (EPICS). The Hall B equipment currently under EPICS control includes numerous beam line devices, high voltage power supplies, detector gas systems, and safety systems. The status of the control system is described.

1 Introduction

The Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab provides a unique tool for basic research in nuclear physics. The central instrument of CEBAF is a superconducting electron accelerator with a maximum energy of 4-6 GeV, a 100% duty cycle, and a maximum current of 200 μA. These excellent beam characteristics allow for novel experiments that are being used to develop a quark-based fundamental understanding of nuclei.

The electron beam at CEBAF is used simultaneously for scattering experiments in three halls that contain complimentary experimental equipment. Hall B, shown in Figure 1, is devoted to experiments that require a large acceptance detector. The experimental equipment in Hall B can be divided into three main systems:

- The CEBAF Large Acceptance Spectrometer (CLAS).
- The photon tagging system.
- The target and beam line systems.

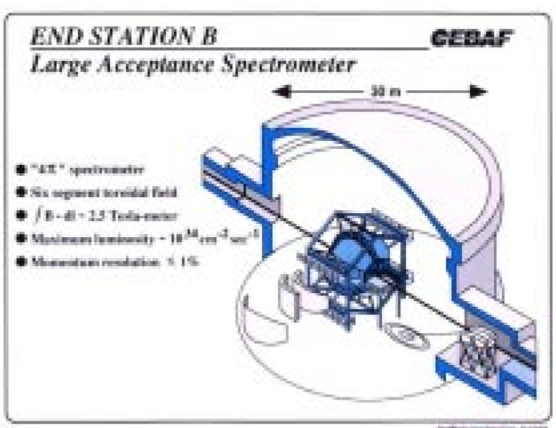

Figure 1: Hall B at Jefferson Lab.

The primary instrument in Hall B is the CLAS shown in Figure 2. This device is a toroidal multi-gap magnetic spectrometer and is described in detail in the Conceptual Design Report on CEBAF Basic Experimental Equipment [1]. The magnetic field is generated by six iron-free superconducting coils. The particle detection system consists of drift chambers to determine the trajectories of charged particles, Cerenkov detectors for the identification of electrons, scintillation counters for time-of-flight measurements, and electromagnetic calorimeters to identify electrons and to detect photons and neutrons. The six segments are instrumented individually to form six independent spectrometers. Commissioning of the CLAS was completed in the fall of 1997.

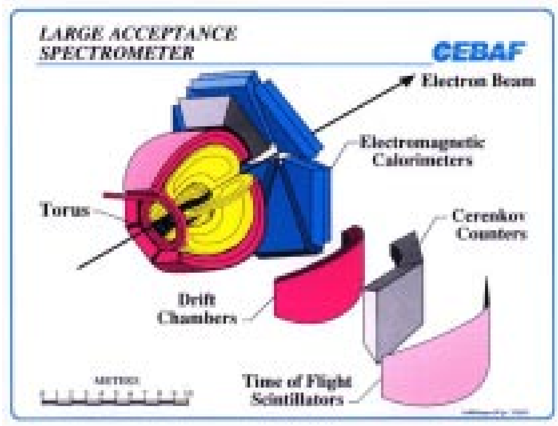

Figure 2: Exploded view of the CLAS.

The Hall B control system is being developed within the framework of EPICS [2] and is required to control and monitor the various systems in such a way as to allow:

- Safe operation of Hall B.
- Remote monitoring of signals.
- Remote control of system elements.
- Ease of use via graphical user interfaces (GUI).
- Detection of anomalous operational modes, alerting the users of such situations and, where possible, executing automatic procedures to ensure personnel and instrument protection.
- Archiving operational parameters for future restoration and analysis.
- Automation to handle the processing of very large numbers of signals.

The system currently uses four input/output controllers (IOC) to control numerous beam line devices, high voltage power supplies, detector gas systems, and safety systems. In this paper we describe the current status of the Hall B control system.

2 Beamline devices

Devices installed on the beam line are used to monitor and control the beam quality and to move targets in and out of the beam. The instruments currently under EPICS control include the target wheel, the harp, the photon collimator, the photon beam converter, and scalers.

The target wheel application uses an Oregon Microsystems (OMS) stepper motor to position solid targets in the beam at the center of the CLAS. The user selects one of twelve possible targets from a GUI that controls the motor.

The harp is positioned upstream of the photon tagger and is used to control the photon radiator and to perform beam scans. Real photon beams are created by putting a radiator in the electron beam. Four different targets can be selected from the GUI that controls the stepper motor. The device also has two wires mounted at 90^o to each other. To perform a beam scan, the two wires are swept through the beam while the counting rate in the beam line detectors is monitored with the scaler application. The counting rate as a function of the position of the wires is written to a disk file that is then processed by Perl scripts and Paw to produce beam profile plots. The result of a beam scan is shown in Figure 3.

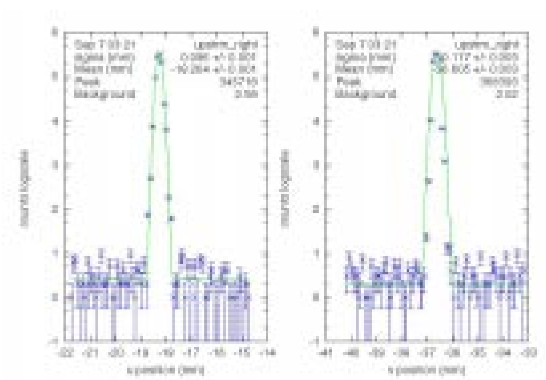

Figure 3: Beam profile plots.

The photon collimator application controls the position of two sets of collimators located downstream of the photon tagging system. These collimators are used to clean up the photon beam after it is generated by the radiator and tagged by the tagger. The collimators consist of bored nickel cylinders. The cylinders are positioned with high precision using an OMS stepper motor controlled by a GUI.

The scaler application uses 32 bit scalers to monitor the count rate in 11 detectors positioned around the beam line to measure the beam halo. The ouput of the scalers are displayed on a GUI. This application is used with the harp to perform beam scans.

The converter application uses an OMS stepper motor to move a metal plate into the photon beam downstream of the CLAS. Electron-positron pairs created by the incident photon beam on the plate are detected in coincidence to determine the intensity of the photon beam.

3 High voltage controls

The LeCroy 1450 Series High Voltage System is used to supply high voltage (HV) to all photomultiplier tubes in the CLAS detector. We are currently running fifteen 1458 HV mainframes, each containing up to sixteen 1461 HV modules. Each 1461 module has sixteen independent HV channels. Direct control of the mainframes is done by an EPICS IOC over an Arcnet local area network (LAN). We currently are running two such IOC/network combininations in the Hall.

The LeCroy system uses a call-and-response protocol where all transactions are initiated by the IOC. Because of the use of a LAN, transactions can take place between more than one mainframe at a time, improving system performance. The IOC software maintains a virtual image of the mainframes at a level below the EPICS database. The database only makes transactions with the virtual mainframes, and therefore the database sees a very fast response. The virtual mainframes then communicate with the low level device driver via a system of message pipes, on a time scale set by the real mainframes.

On the host side we have developed a Perl-based system to build databases from a flat ascii file. In addition we have developed a flexible program to build medm screens using a library of C callable routines which takes as input the same ascii file as that used by the database builder. The important features of this system are a configurable set of labels for channels in the resulting medm screens, guaranteed consistency between the EPICS database and their control screens, and the ability to create and modify control systems for various HV configurations very quickly.

4 Drift chamber gas system

Tracking of charged particles is accomplished with the CLAS using three regions of drift chambers that are located at different radial positions from the target. Achieving the design goals of better than 0.5% momentum measurement and angle resolutions of approximately 1 mrad requires placing constraints on the gas mixture within the chambers. These contraints require control and/or monitoring of the flow rates, mixtures, pressures, temperatures, and contaminant levels of the gas.

The quantities of interest are measured with sensors that are powered and monitored with three different hardware controllers that have local readout and programming capabilities. The flow controllers and transducers are operated with two MKS 647A mass flow controllers. Pressure sensors are controlled with three MKS 146B pressure gauge controllers. Panametrics instruments are used to monitor temperatures and the concentrations of oxygen, water, and carbon dioxide. All of these instruments have RS-232 interfaces for remote control and monitoring. Analog signals are also available for many of the parameters. The instruments have programmable alarms that produce signals that are used to bypass or shut down portions of the gas system. In the event of a failure due to any of a number of conditions, the chamber is bypassed automatically with electronically actuated valves immediately before and after the chambers. These safety features are hardwired and are not controlled by software. The computer control system is needed to monitor parameters and alert the operator of abnormal conditions so that they may be corrected to avoid hardware activated shut downs. The system is also needed for remote control of the hardware and archiving of parameters for analysis.

The analog signals from the gas system instrumentation are continuously monitored with XYCOM XVME-560 analog input cards. Many of these signals are configured for data logging and alarms.

Remote control of the hardware and verification of the analog readings are accomplished through the RS-232 interfaces. The RS-232 device support software has been written for all three types of hardware controllers. Standard EPICS analog output records and string input records are used to send commands to and receive data from the device support. The seven RS-232 instruments are interfaced through a Green Spring IP-octal 232 industry pack mounted on the Motorola MV 162 single board computer in the gas system IOC. More detail on the drift chamber gas system controls can be found in Ref. [3].

5 Safety

The CLAS spectrometer has a large number of cables and a large mass of exposed plastic scintillator. Because these materials are flammable, fire safety is a concern for the spectrometer. Among other safety systems, there is a multichannel Very Early Smoke Detection System (VESDA) which is a commercial high-sensitivity smoke detector with a distributed air sampling system. While this system is interfaced to the building fire alarm system in a conventional way, the analog outputs from it are monitored in EPICS using an XYCOM XVME-560 ADC. Each VESDA channel is monitored in the alarm handler, and the analog voltage signal is displayed in a prominent bar chart and strip chart format on a GUI. The use of this system allows significantly earlier warning of a developing problem than is provided by the building fire alarm system since the alarm handler thresholds can be set to a much lower value than those that activate the building fire alarm system.

Acknowledgements

This work is supported by the U. S. Department of Energy under Contract Nos. DE-AC0584ER40150 and DE-FG05-88ER40459, and by the University of Richmond.

References

[1] Conceptual Design Report, Basic Experimental Equipment, CEBAF Report, April,1990.

[2] The Experimental Physics and Industrial Control System (EPICS) is a set of software tools originally developed by Argonne National Laboratory and Los Alamos National Laboratory for the purpose of building distributed control systems. Information on EPICS can be found on the World Wide Web at http://www.aps.anl.gov/asd/controls.

[3] M. F. Vineyard, T. J. Carroll, and M. N. Lack, proceedings of ICALEPCS '95 The International Conference on Accelerator and Large Experimental Physics Control Systems, Oct. 29 - Nov. 3, 1995, Chicago, IL (FermiLab Report CONF-96/069).