Data Acquisition Systems

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Overview

The year 2006 has been a busy year for the DAQ group as new experiment setups have emerged and required attention (Titan, Pienu, T2K-TPC, T2K-FGD, Alpha, LiXe). In parallel, multiple smaller detector development DAQ test benches were necessary for R&D on those same larger experiments.

As the number of experiments increase, the need for greater computing power has in the last 2 years doubled the DAQ computer park with more than 60 computers dedicated to data acquisition. The management of such a park is not trivial; therefore effort has gone into restructuring the DAQ web site providing a more compact location for all DAQ-related information. This work has done in part by summer students and resulted in a successful web-site, including an inventory system accessible through *http://daq-plone.triumf.ca/*.

Software support has been addressed by providing new hardware device drivers within the standard DAQ package (MIDAS) and inviting Dr. Stefan Ritt from PSI to TRIUMF during the summer 2006, to focus on the multi-threading aspect of the slow control frontend, as well as multiple details such as 64 bit support, etc.

While software support is the main task of the DAQ group, the trend is moving towards a closer device programming scheme to provide better optimized capabilities and performances from the hardware. Physical devices such as Field Programmable Gate-Array (FPGA) or Application Specific Integrated Circuit (ASIC) are now common, and require special knowledge which we gained by collaboration with the electronic groups in developing specific TRIUMF hardware modules such as the VF48, VT48, VPC6, etc.

Data Acquisition Operations

Over the last 2 years, the DAQ group supervised two coop students i.e. Ms. Qing Gu, working on the migration of the DAQ web pages to the PLONE content management system, and on supporting the ISAC2 beam diagnostics DAQ system; and Mr. Simon Claret, developing a web-based inventory system for DAQ and LADD equipments. The main topics regarding software development have been MIDAS drivers for the CCUSB USB-CAMAC interface, support for the SY2527 High Voltage system, development of the ROODY online data display program, ROOT-based online and offline data analysis packages (currently being used by Dragon, ALPHA and PIENU), Linux devices drivers for PMC waveform digitizer (Titan), VME drivers for the SIS3820, VF48, VT48 and other modules, bug fixes and improvements to the MIDAS DAQ package.

The DAQ group maintains a large number of general computers and dedicated DAQ stations. During 2006, continuing maintenance of these machines saw phasing out of obsolete hardware, CPU and memory while providing disk upgrades to the DAQ stations. Standardization of operating systems to Scientific Linux 4 as well as improved monitoring of computer performance and health using ganglia and triumf_nodeinfo scripts. The group also contributes to general TRIUMF computing by providing expert knowledge. Konstantin Olchanski built and maintains the mirror.triumf.ca node used as the local source for nightly operating system updates, he's maintaining system update scripts and the site backup system using AMANDA. Further upgrades to increase the backup capacity in the upcoming year are planned.

DAQ systems

TWIST, Pienu and μSR have been the main experiments in the Meson Hall while in the ISAC-I, the HEBT beam line DAQ was upgraded with a new computer for running the E992 experiment in the Summer of 2006. The LTNO experimental station has been decommissioned as well as the DAQ system from which some hardware has been recycled for the upcoming Titan experiment. While some of the current experiments have been stable for several years, and require minimal attention from the DAQ group, more recent experiments such as Pienu, Liquid Xenon, μSR, TITAN have required extra effort from the DAQ group. Parallel to these setups, standalone DAQ for test bench of detectors (T2K, Tactic, HEBT, ...) have also required time for setup.

μSR, βNMR and βNQR at ISAC

The operating system of all 9 μSR DAQ machines were updated to SL4.3. Similar upgrades for βNMR and βNQR have been done.

"Dual channel" operation, where the beam is alternated between the BNMR and BNQR channels, has been used very successfully during the BNMR group's beam periods this year. This modification has been of great benefit, since while one channel is taking measurements after the beam is switched off, the other channel is using the beam to take data. Thus very little of the beam is wasted, and more experiments can be run during the beam period. Running as a "single channel" where only one of BNMR or BNQR is active is, of course, still an option. The modifications to the DAQ together with the hardware changes to the PPG and to the EPICS Helicity switch were designed to ensure that switching the DAQ between "dual channel" and "single channel" is as easy as possible for the users.

Data were also taken during the beam period using a new experimental mode, "LCR", a combination

of the existing "SLR" mode, and the "CAMP" scan mode, whereby a magnet (controlled by CAMP software) is scanned.

DRAGON

The Dragon group was assisted with testing of their latest VME ADCs and will move to a Linux/VMIC based VME system in a near future.

TWIST

More powerful host computers were installed in the TWIST DAQ setups and contributed to very smooth data taking in 2006. TWIST acquired some 22 TB of data mostly in the fall beam period.

Stability improvements have been made to the slow controls system, a software interlock was implemented between the gas system and the high voltage system, the local data acquisition network was upgraded to Gigabit Ethernet and the muon stopping position regulator was fine tuned.

TITAN

Initial work was started on the DAQ for Titan. The control of the operation sequence for the different measurement cycles for the MPET station will be managed by a VME sequencer board (PPG). The PPG (TRIUMF Pulse Programmer VME module incorporating a Pulseblaster) has been successfully used on BNMR/BNQR experiment; however for Titan the experimental parameters to program and control the PPG will be input using predefined blocks in the Midas ODB, rather than fixed templates as was used for BNMR/BNQR. Similar blocks will also be used to input the parameters for controlling the RF and programming the Arbitrary Waveform Generator (AWG). The main DAQ processor is a VME VMIC-7850 allowing for 3 PMC interface such as one Arbitrary Waveform Generator (AWG), one CANBus interface and possibly multiple RS232 interface. It was decided to use VME & CANBus to control dedicated experimental devices such as the High Voltage and Temperature. A Midas slow control driver has been written for that purpose using the TPMC810 PMC interface. Parallel to this option, EPICS will have initial control of those CANBus units until full understanding of the operation requirements with the complementary traps (EBIT) is available.

8Pi, Tigress

Gigabit network was constructed to link the ISAC-I counting room, 8pi area, HEBT area and Tigress lab in order to cope with the high data rate. 8Pi DAQ station has been upgraded with a new main computer, new VME CPU, and gigabit network link. For TIGRESS, a new DAQ system was built for running their first experiment in ISAC-I. While the 8Pi DAQ is in its stable phase, the Trigress DAQ is evolving as the hardware is brought into the experiment. Dedicated VXI (TIG10) and VME modules (TIGCOL) developed by Jean-Pierre Martin from U of Montreal have been implemented. The DAQ group has been involved in the overall data acquisition and more specifically into driver software development.

PIENU

The PIENU experiment was installed in M9A in the fall of 2006 and started using the former RMC counting room. A full VME DAQ system was deployed including a standard 6U VME crate containing CAEN ADCs and TDCs, TRIUMF VMEIO, VF48 plus a custom trigger module and a KEK Copper system, which is a modified 9U VME crate, containing two KEK 500 MHz digitizer modules with 4 channels each. The two crates were operated in parallel using hardware event number synchronization and a MIDAS software event builder. 1.5 TB of data were accumulated in less than two weeks. The main contributor to dead time was the VF48 used with minimal processing in the firmware. Several improvements to the VF48 firmware are underway to provide zero suppression, internal event buffering and faster readout throughput.

T2K

The T2K experiment is composed of different subdetectors for which TRIUMF is responsible i.e. the TPC (Time Projection Chamber) and the FGD (Fine Grained Detector). In the Detector Facility, parallel activities centered on both projects took place. For the T2K prototype TPC tests, ALICE TPC electronics were brought from CERN and a DAQ system has been developed and deployed at UVIC. Installation and final debugging required several trips by Konstantin Olchanski to UVic. This system is unique in using dual USB interfaces to acquire TPC data. The TPC gas system required another DAQ setup using the Canary Chamber for long term gas characteristics measurements. The FGD based on the SiPM photo-sensor has also a dedicated DAQ station for light yield and characterization of the SiPM in the detector facility as well as SiPM Photo-sensor performance monitored in the M11 area with beam particles.

In parallel, a portable scanning DAQ system and a permanent light yield measurement DAQ system were developed to process the 12,000 scintillator bars produced last fall. Both of these systems made use of a bar code scanner to record each bar serial number before taking measurements. The portable system consisted of a laptop, bar code scanner connected via USB, two calipers to measure the rectangular section of each bar and a camera to take pictures of the ends of the bars. The system operated under MIDAS software. Semi-

online analysis of the results allowed feedback to the operators when any deviation started to appear. The light yield measurement system consists of a Keithley Picoammeter to measure current from a photodiode, a set of motors to control the position of a source on a 4 x 2 meter XY table and a bar code scanner. This is used to measure light yield from scintillator bars with automated movement of a source along the length of the bar in a couple of minutes.

Liquid Xenon

In early 2006, the first run of the Liquid Xenon setup took place over a 3 month period. The overall data recorded during that period reached over 5 TB. The acquisition involved waveform digitizer at 1Gsps and 20Msps as well as multiple ADCs and TDCs modules. The online monitoring and analysis was based on the ROME framework analyzer and ROOT.

Alpha

Throughout 2005 and 2006, Konstantin Olchanski worked on the design and development of the MIDAS DAQ system for the ALPHA anti-hydrogen production and trapping experiment at CERN. In the summer of 2006, the DAQ system was installed at CERN and successfully used during the first data taking run of the experiment.

Other Development

Following the R&D for the Kopio experiment which was cancelled mid-august 2006, the development of the main acquisition boards such as the waveform digitizer and TDC has been repackaged to fit a standard VME board. While the VF48 (48 channels Waveform digitizer 20-65Msps) has been developed and manufactured by Dr. J.-P. Martin / U of Montreal in collaboration with TRIUMF, the VT48 (48 channels TDC deatimeless, 625ps) and VPC6 VME modules have been developed by Chris Ohlmann from the Micro Structure Lab. The VPC6 complements the VF48/VT48 as a generic Power & Control module for 6 possible frontend cards (pre-Amps). Currently available frontend cards are the 16 ch. cathode pre-amp based on the Buckeye and the 16 ch. anode pre-amp based on the ASD01. This VPC6 module contains a power distribution bus and 6 serial links for which a dedicated FPGA provides the VME interface for frontend configuration.

Other VME card such as the V1190 (CAEN 64ch TDC 200ps), V792/V785 (CAEN 32ch QDC/Peak Sensing), V1729 (4ch waveform digitizer 1,2Gsps) are now available for testing with the corresponding Midas drivers.

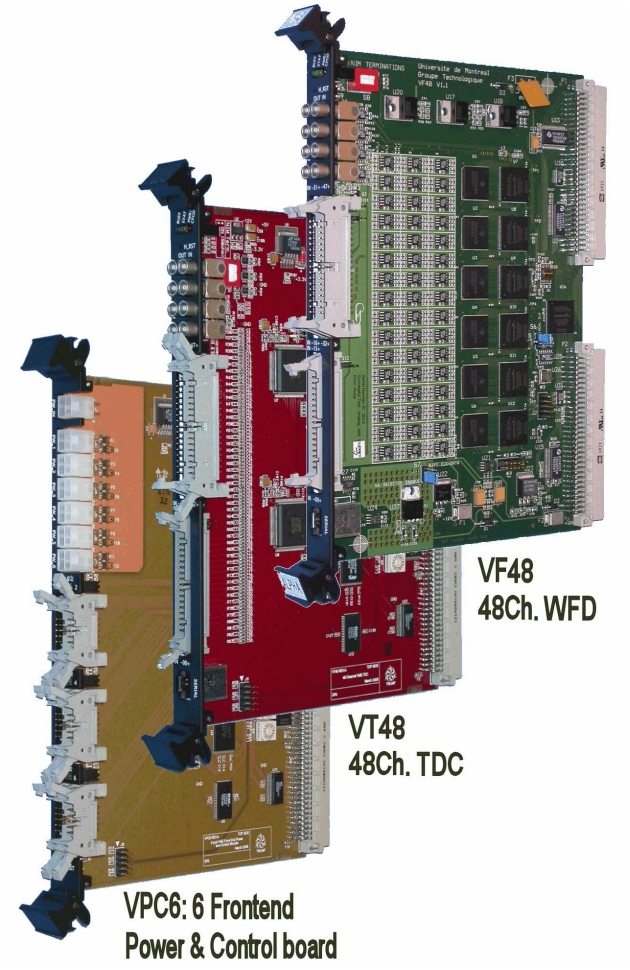

Fig. 1. VPC6, VT48, VF48 VME DAQ boards.