## Data Acquisition Systems

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### Overview

In 2004, the DAQ group continued to expand the number of DAQ systems around the site. Most of the new hardware deployed came from LADD (here I need some reference to the section on LADD in the annual report) purchases. It now stands at 35 PCs (Table 1), 10 VME PowerPCs 604 and 9 VME VMICs, all managed by members of the group. These machines provide also some offline analysis resources and disk storage. (*http://daq.triumf.ca/triumf_nodeinfo/*) Performance is monitored via Ganglia (*http://daq.triumf.ca/ganglia/*)

Development of an online analysis package based on ROOT (*http://root.cern.ch*) continued. The package is now called ROODY.

Table I. Computer systems managed by the DAQ group

| Name | Location | Type |
|---|---|---|
| daqlabpc | DAQ lab machine | PII/232 |
| dasdevpc | DAQ devel, web server | PIV/1700 |
| e614slow | TWIST Slow Control | 2xPIII/750 |
| epicsdragon | Dragon Epics Display | PII/300 |
| epicsm15 | M15 $\mu$SR Epics | PIII/871 |
| epicsm20 | M20 $\mu$SR Epics | PIII/400 |
| epicsm9b | M9B $\mu$SR Epics | PIII/550 |
| isdaq01 | ISAC-LE $\beta$NMR Trinat | 2xPIII/450 |
| isdaq02 | ISAC-LE, GP2, LTNO | Cel/795 |
| isdaq03 | ISAC-HE, Tuda | 2xPIII/550 |
| isdaq04 | ISAC-HE, Dragon | 2xAMD Ath/2000 |
| isdaq05 | ISAC-LE, Isac users | PIII/1000-256 |
| isdaq06 | ISAC-HE Isac users | PIII/1000 |
| isdaq08 | ISAC-LE, 8Π | 2xAMD Opt/2000 |
| ladd00 | LADD server | 2xAMD Opt/1800 |
| linm15 | M15 $\mu$SR users | AMD Ath/1500 |
| linm20 | M20 $\mu$SR users | AMD Ath/1500 |
| linm9b | M9B $\mu$SR users | AMD Ath/1500 |
| ltno01 | LTNO CR DAQ | 2xPIII/600 |
| midm15 | M15 $\mu$SR DAQ | 2xPIII/1000 |
| midm20 | M20 $\mu$SR DAQ | 2xPIII/1000 |
| midm9b | M9B $\mu$SR DAQ | 2xPIII/1000 |
| midmes01 | Detector Facility | PIII/500 |
| midmes03 | RMC DAQ | 2xPIII/550 |
| midmes04 | M11 DAQ | 2xPIII/750 |
| midmes05 | Detector Facility | Celeron/335 |
| midmes07 | Neutrino Devel DAQ | PII/400 |
| midtis01 | Trinat DAQ | 2xPIII/550 |
| midtis02 | Detector Facility | 2xPII/450 |
| midtis03 | LTNO platform DAQ | PII/350 |
| midtis04 | GP2 DAQ | 2xPIII/550 |
| midtis05 | 8Π cryo | PII/300 |
| midtis06 | Osaka DAQ | AMD Ath/2000 |
| midtis07 | Pol/CFBS SlowControl | Cel/375 |
| midtwist | Twist DAQ | 2xPIII/1000 |

### MIDAS and ROODY

The basic Midas Data Acquisition package is in a stable condition and it is used throughout TRIUMF. Although its operation is stable, constant efforts are dedicated to improve Midas in order to keep it up-to-date with current analysis package such as ROOT. This year this has been achieved with the help of Dr Stefan Ritt and Matthias Schneebeli from PSI who came to TRIUMF for a two weeks in September. The main improvements added are listed here. Midas Data logger can now produce ROOT files. Online DAQ access to external Database such as MySQL (equivalent to "runlog" option) has been added. The transition scheme has been modified allowing better control of the run transition sequences. The Event builder scheme has been improved for a simplified and more flexible handling of frontend equipments.

In parallel to these tasks, Matthias Schneebeli, the author of ROME, gave an introduction to this latest Root based stand-alone analyzer. ROME (*http://midas.psi.ch/rome*). is an OO generic analyzer framework builder, where the analysis definition is provided in XML format. The experiment specific class templates are then generated automatically, ready to receive the user code. ROME is fully Midas compatible for online and offline data retrieval, and contains an interface to a standard database.

The other main project of the DAQ group is the development of a Root based GUI for histogram display. This is a continuation of the MIROODAS project started in 2003. This application has been renamed to Roody (Root Display) to reflect the disconnect from Midas (*http://midas.triumf.ca/roody/html/*). While Roody can be used for online data display through the Midas analyzer, Midas is not a prerequisite for running Roody. Roody can also be coupled with the user specific ROME analyzer. Development and maintenance of Roody is managed mainly by Joe Chuma.

### DAQ systems

### $\beta$NMR and $\beta$NQR at ISAC

The operating system on all the DAQ machines for $\beta$NMR and $\mu$SR experiments, and the test systems (dasdevpc,daqlabpc) were updated to Linux Red Hat 9. The DAQ systems had to be upgraded to work correctly under the new OS .

The "Dual Channel Mode" was proposed by the $\beta$NMR group, where the beam will be alternated between the $\beta$NMR and $\beta$NQR beamlines. Required hardware modifications to the PPG boards for this mode were determined and made. The frontend code was modified to incorporate the "Dual Channel Mode", and to ensure that the "Single Channel Mode" works in a similar way to the old code. Work began on the "randomized frequency scan" and the requested change in helicity flipping for mode 1g.

Syd Kreitzman designed a new Pol Synth Module (PSM) which was built by the Electronics Group. With the help of Syd, a new mode called the "Quadrature Modulation Mode" was implemented to exploit this new module, and the PSM was thoroughly debugged for use in the $\beta$NQR experiment. The frequency scan code in the frontend was rearranged to incorporate the PSM code.

For POL, a new DAC scan was added to control the power supply for E920, replacing the old CAMP DAC scan. A readback of the DVM and Wavemeter were implemented. Support for a new experiment (of Phil Levy) to scan the NaCell was added, with a readback of the Faraday Cup. A jump in the scan values (i.e. a discontinuous scan) was implemented for POL, also an up/down scan and a variable offset for the NaCell readback.

During 2004, Dave Morris continued to offer some much appreciated support to the DAQ group, In particular, we used his expertise with GPIB drivers on Linux and his knowledge of Agilent DVM instruments to setup hardware and software slow control for a High Voltage unit. This HV provides retardation voltage for the Collinear Fast Beam Spectroscopy setup and was a crucial element in the DAQ system used by E920 last year.

**$\mu$SR systems**

With the help of Stefan Ritt, during his September visit, the annoying $\mu$SR "fragmented buffer problem" for large data buffers was finally solved.The lastest version of Midas (1.9.5) was installed on all $\mu$SR DAQ machines. The $\mu$SR DAQ systems seemed to be quite stable throughout 2004, with relatively small modifications required.

No progress was made to commission a MULTI type $\mu$SR system due to a lack of $\mu$SR software expert to write a suitable filter. In MULTI mode, the detector is segmented in 8 sections and the DAQ has to handle the equivalent of 8 parallel experiments.

**TWIST DAQ activities**

Ongoing modernization of the slow controls software was the main development activity on the TWIST DAQ in 2004. In particular, improvements to the M13 B1 and B2 dipole regulators were implemented. High precision measurements of muon polarization by the TWIST experiment require that the M13 beam line elements be controlled with precision and stability higher than that provided by standard TRIUMF magnet power supplies and power supply controls. We see 0.5-1 Gauss changes in the magnetic field of the B1 and B2 dipoles caused by day-and-night temperature variations. We also see long term drifts in B1 and B2, up to 1-2 Gauss over half a week. To improve the long term stability of B1 and B2, in 2002-2003, high precision "fine DACs" were added to the B1 and B2 magnet power supply controls and a closed-loop software regulation scheme was implemented. The MIDAS-based slow controls frontend reads the NMR probes installed inside the M13 B1 and B2 dipoles, filters the NMR readings, compares them with the "NMR setpoints" and minimizes the difference by adjusting the "fine DAC" controls via the M13 EPICS control system. Special care had to be taken to monitor and filter the NMR readings in order to avoid misregulation in the presence of spurious NMR readings caused by NMR signal degradation from radiation damage of the NMR probes. During the year 2003 running of TWIST, B1 and B2 were regulated with precision of 0.1 Gauss, compared to the precision of 1-2 Gauss without using the regulators. In early 2004 a hardware problem was identified and corrected in the implementation of the "fine DAC" controls, resulting in the improvement of controls precision from 0.03 Gauss/LSB to 0.003 Gauss/LSB. This resulted in an improvement of regulation precision from 0.1 Gauss during 2003 to 0.02 Gauss during the year 2004 running of TWIST. The achieved regulation precision is better than what is required for TWIST. Further precision improvements are limited by the very-short-term stability of the magnet power supplies and by the quality of NMR measurements. The regulator system is highly robust and reliable and is now routinely used by experiment operators with minimal training and minimal expert intervention.

Another important improvement was the development of a "muon stopping position regulator". The TWIST experiment stops the beam muons in a stopping target in the middle of the TWIST detector. To minimize the systematic errors in TWIST measurements, it is important to always stop the muons in the same place, to minimize any variation of the muon stopping position. The muon stopping position is controlled by adjusting the mixture of CO2 and He gases in the gas degrader volume in the muon path: because muon loses more energy in CO2, compared to He, increased CO2 contents makes the muons stop faster, moving their stopping position upstream. During offline analysis, the muon stopping position is measured using one of several methods. While analyzing the 2003 data, we observed a correlation between the atmospheric pressure and the muon stopping position: the CO2/He gas degrader is at atmospheric pressure and higher atmospheric pressure yields increased density of the CO2 gas, with a bigger muon stopping power, so the muons stop faster and the stopping position moves upstream. This effect was estimated to be big enough to affect the ultimate precision of the experiment and, based on our positive experience with the B1/B2 magnet regulators, we decided to implement a regulator for the muon stopping position. This task turned out to be harder than expected. There is no direct control over the CO2/He gas mixture: one controls only the gas flow rates into the degrader volume; gas mixture follows changes in flow rates, but the exact relation is unknown. There is no direct measurement of the muon stopping position: to obtain an adequate measurement, one has to analyze about 10-20 minutes worth of data, fill histograms and compute the average stopping position. Meanwhile, the atmospheric pressure changes and the stopping position moves. These difficulties with both controls and measurements reduce the reliability and robustness of normal proportional regulation schemes, like those used to control B1 and B2. Instead, a very simple relay regulator was used. If the muons stop too fast (too far upstream), the CO2 flow is reduced by 1%, otherwise, the CO2 flow is increased by 1%. The gas flows are adjusted each time a new measurement of the stopping position is available from the online data analysis (QOD), with at least 20 minutes between subsequent adjustments, to let the gas mixture to settle. The TWIST experiment are presently assessing the effectiveness of this regulation scheme. Preliminary results indicate improved stability compared to 2002 operation.

**Other experimental stations**

The Dragon system was upgraded from a standalone CAMAC system to a mixed VME/CAMAC system for additional functionality and speed increases.

The Canadian T2K Neutrino group which occupies the former Atlas clean room continued their program of detector development studies. One of the standard CAMAC DAQ test stations deployed last year was replaced by a VME LADD system where software drivers were developed for the new hardware as well as support for online analysis and ROODY.

Support for external MIDAS users is still ongoing. Pierre Amaudruz spent one week at Los Alamos as a consultant on MIDAS .