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TITLE: FRONTEND EVENT SELECTION WITH AN MBD USING Q

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FRONTEND EVENT SELECTION WITH AN MBD USING Q

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Summary

A problem common to many complex experiments in Nuclear Physics is the need to provide for event selection at a level beyond that readily available in a fast hardware trigger. This may be desirable as a means of reducing the amount of unwanted data going to tape, or be needed to reduce system deadtime, so as not to miss an infrequent good event. The latter criterion is particularly important at low duty factor accelerators such as LAMPF, where instantaneous trigger rates may be quite high.

The need for such an event selection mechanism has arisen in conjunction with the installation of a polarimeter in the focal plane of the High Resolution Spectrometer (HRS) at LAMPF. It has been met using a combination of buffered CAMAC electronics and an enhancement to the LAMPF standard Q data acquisition system.[1] The enhancement to Q allows the experimeter to specify at runtime, a set of simple tests to be performed on each event as it is processed by the MBD, and before it is passed to the PDP-11 for taping and further analysis.

The experimenter may specify constraints, either gates or anti-gates, on individual data words or on the sums and differences of any number of data words. In addition he may specify that one of every N events is to be passed along without testing, so that a random sample of all events may be examined. Events are flagged as to whether they are a "tested event" or a "one-of-N" event.

Introduction

As experiments in Medium Energy Physics have advanced in complexity there has been a growing need for an ability to provide more sophisticated event selection than is readily available in fast NIM electronics. This is of particular concern at low duty factor accelerators such as LAMPF where instantaneous trigger rates may be high enough to exceed the rate at which data may be transferred out of CAMAC, yet the rate of events of interest may be quite low.

Such a problem arose in conjunction with the installation of a polarimeter in the focal plane of the High Resolution Spectrometer (HRS) at LAMPF.[2] This polarimeter was designed to measure the spin of scattered protons by looking for asymmetries in their scattering in a Carbon analyzer situated behind the normal focal plane detector hardware. Even with the thick analyzers possible at medium energies, at most 10-15% of all protons incident on the carbon block undergo a useful nuclear scatter at an angle >3 deg. The problem was to record as many of the usefully scattered events as possible, while minimizing the amount of other data written to tape.

A number of possible solutions were considered. A hardwired logic box such as had previously been used on a polarimeter with multi-wire proportional chambers[3] was ruled out by the delay line readout system on our drift chambers. A combination of TAC's, summing amplifiers, single channel analyzers such as is used in the JANUS polarimeter at LAMPF[4] was rejected as too cumbersome and prone to misadjustment for a user facility such as HRS. In view of LAMPF's low duty factor (3-6%), it was concluded that the ideal solution would be to digitize as many events as possible during the time the beam was on and sort out the useful ones before taping during the time between beam spills.

Buffered Camac

In order to allow for the digitization of many events per beam burst it was necessary to overcome the slow readout of CAMAC (5.5 μsec/wd), since at this rate only 1 or 2 events of 60 words each could be digitized and read out per beam burst. This was accomplished by using a set of buffered CAMAC ADCs modified for us by LeCroy Research Systems to serve as Time to Digital Converters (TDCs). These TDCs have 9-bit resolution with a 32 word deep FIFO buffer on each of 12 channels. They have the additional advantage of having only a 10 usec effective conversion time, which implies that in theory, it is possible to take as many as 32 events during the normal 500 μs LAMPF beam spill. It is worth noting here that this implies an average data rate in excess of 200K words/sec, which exceeds the speed at which data may be written to tape by nearly a factor of 10. At this point some kind of event selection is needed to reduce the amount of unwanted data going to tape.

Testing in the MBD

The process of selecting out the 10% of all events suitable for taping could, in principle, be carried out either in the MBD or in the PDP-11. In practice however, event selection in the PDP-11 using Q under RSX-11D is impossible at high data rates. This is because all the event data must be moved at least twice and the data to be taped must be moved yet a third time as is shown in Fig. 1.

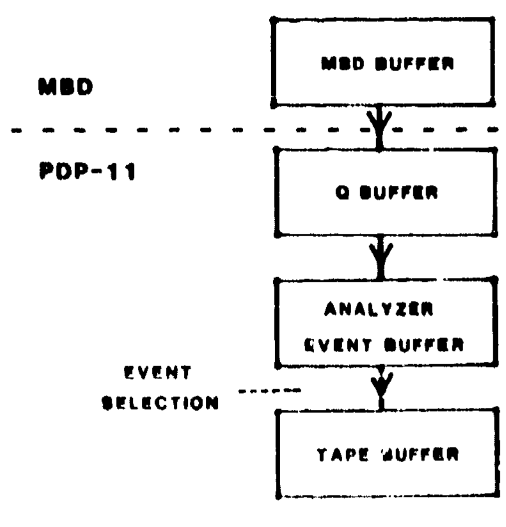

Fig. 1

This implies that the event selection must be done in the MBD. Unfortunately the MBD is poorly suited to much calculation since it lacks a convenient subroutine facility, any floating point capability or even an integer multiply instruction. Fortunately the QAL language provides the necessary hooks for the user to insert his own code for event testing.

Test Structure

In order to allow the user to have the greatest flexibility, the text system for the MBD was designed to allow complete specification of the tests to be performed at run time. A data file detailing the tests is created by the user and is encoded and transferred to the MBD by a control program, MTR(MBD Test Read). A corresponding program MTD (MBD Test Dump), retrieves the current test descriptors from the MBD, decodes them into the corresponding input format and lists them on the line printer.

The user may specify as many or as few tests on the data as desired within the constraint that all information describing the tests in the MBD not exceed 400 words. Each test has two required elements. The first consists of the keyword SUM followed by a list of the indices of the data words to be added. A negative index is taken to mean that the data word with a positive value of that index is to be subtracted from the current sum. If more values are to be summed than can conveniently be contained in a single line, this keyword may be repeated as many times as needed. The second required element contains a set of keywords giving a set of limits and specifying the action to be taken if the sum falls inside or outside those limits. The action keywords are of the form.

```
KEEP INSIDE  L1,L2
KEEP OUTSIDE  L1,L2
REJECT INSIDE  L1,L2
REJECT OUTSIDE  L1,L2
```

If the sum in question meets the conditions for a KEEP test, all further testing is stopped. The event is tagged as a "tested" event and MBD processing for that event is complete. If the sum does not meet the conditions for a KEEP test, the MBD goes on to perform the next specified test (if any). If there are no further tests to be performed, the event is tagged as a "tested" event and MBD processing for that event is complete.

If the sum in question meets the conditions for a REJECT test, all further testing is stopped and the internal MBD pointers are reset so that the data for this event will be overwritten. If the sum does not meet the conditions for a REJECT test, the MBD goes on to perform the next specified test. If there are no further tests to be performed, the event is tagged as a "tested" event and MBD processing for the event is complete. Note that this structure implies at least one REJECT test must be included if any events are ever to be rejected.

Two optional keywords are allowed. The first COUNT N, allows the user to specify that one of every N events is to be passed along to the PDP-11 without testing. A flag word indicating that this is a "one-of-N" event is inserted at the end of the data stream. This facility allows the user to have a tagged random sample of all events, or to conveniently disable MBD testing entirely by setting N equal to 1.

The second optional keyword must be used in conjunction with a SUM keyword, and is an attempt to allow for the lack of floating point capability in the MBD. It has the form;

```
OFFSET I1,NSHIFT,IOFF1,IOFF2 ...IOFFN
```

and results in the value in the data word whose index is I1 being taken and shifted NSHIFT bits to the right. The resulting shifted value is used to select one of N offsets IOFF1 ... IOFFN which is then added to the current sum. A given SUM may be modified by as many OFFSET keywords as desired within the total 400 word constraint. The OFFSET command is useful in accounting for such difficulties as various TDC channels having slightly different calibrations.

Performance

Timing measurements made on this system indicate that the overhead in the MBD for performing each test is ~20 usec for a single element SUM. Each additional data word summed adds another 5-6 μsec. Each OFFSET to the sum requires 15-20 μsec independent of the number of elements in the offset table. For the case of the Focal Plane Polarimeter, where it is desired to reject events for which all wire planes do not fire or for which the proton did not scatter at greater than 3 degrees, data can be processed at about 1000 events/sec with perhaps 200-300 of these being passed on to the PDP-11 for taping.

Once implemented, the MBD tests were found useful for a wide variety of experiments at HRS other than those involving the Focal Plane Polarimeter. It has served as a convenient mechanism for accepting only certain particle types via a test on pulse height versus time of flight. It has also been used extensively as a means for enhancing the statistics for scattering to weakly excited nuclear states by rejecting strongly populated low lying states. For these less complicated applications much higher data rates can be achieved, approaching the limit of ~3800/sec set by the depth of the FIFO buffer and the beam repetition rate.

Conclusions

We have demonstrated that the combination of fast CAMAC with internal FIFO buffers and a flexible event selection procedure in the front end processor (MBD), is capable of providing a simple and convenient way of improving data collection efficiency for infrequent events at low duty factor accelerators.

References

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