SLAC-PUB-6243
April 1993
(I)

PULSE TO PULSE MONITORING OF THE SLD DETECTOR[1]

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Abstract

The SLAC Linear Collider produces bunches of positrons and polarized electrons which collide at 120 hertz inside the SLD detector. A limited amount of information is collected for each pulse in the modules which do real-time data acquisition. Buffers of approximately ten seconds' worth of this monitor data are periodically delivered to a VAX. The generation and uses of the monitor data will be discussed.

I. Introduction

The SLD detector [1] was designed for use with the SLAC Linear Collider (SLC), a machine unusual for the discrete nature of its beams. SLC produces bunches of positrons and polarized electrons at 120 hertz which collide inside the detector. This low rate has its advantages; for example, there is time to make the trigger decision entirely in software. The additional flexibility has contributed significantly to the efficient use of the detector. However the assumption (warranted for storage ring machines) that conditions vary only slowly, that averaged quantities and sampled quantities are a faithful representation of these conditions, must be re-examined for the SLC. A particular SLC beam crossing may be quite unlike its neighbors. A small but carefully chosen set of information about each pulse has proven very useful for general trouble-shooting of SLC and SLD; we expect it to be equally useful off line in analyzing physics data.

A. SLD Detector and Data Acquisition

SLD consists of several nested subdetectors. Digitized data from the subdetectors appear at the front end of the data acquisition: a FASTBUS network. Within FASTBUS, trigger decisions are made and data volume reduced. Data flow from this network to a host VAX for display, analysis and logging to tape [2,3] (see Fig. 1).

B. FASTBUS

The FASTBUS system contains over one hundred intelligent slave modules of several types whose activities are coordinated by a small number of FASTBUS masters [4]. Of these subdetectors, the calorimeter, luminosity monitor and drift chamber provide information every pulse[2] which is used in making the trigger decision.

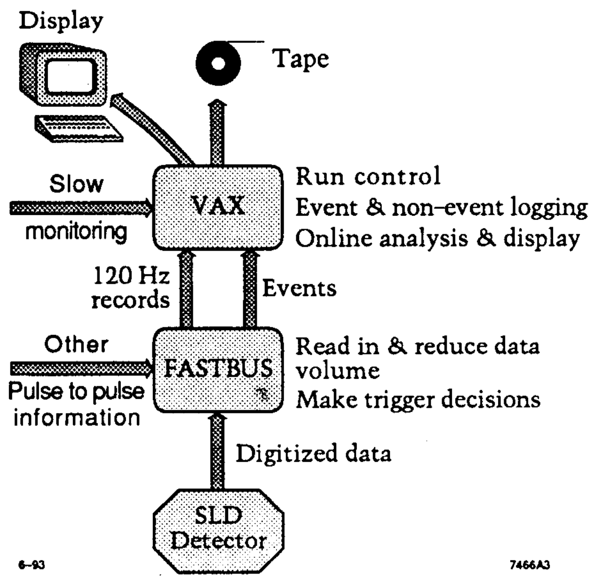

Figure 1. Data acquisition overview.

When an event is taken, some or all participating subdetectors, depending on the kind of trigger, are fully read out, a process which takes several beam crossings to complete. Meanwhile triggers which would read out an occupied subdetector are blocked. With current resources, it takes about 25 beam crossings to read out the full detector and process it in FASTBUS. The next stage (the VAX) cannot sustain even this rate.

II. Monitoring

Most beam crossings are not of immediate physics interest; it is the function of the trigger to select the most promising for read-out, based on the limited information which is available every beam crossing. However for monitoring

[1]Work supported by Department of Energy contract DE-AC03-76SF00515.

[2]For technical reasons, not quite every pulse in the case of the drift chamber

Presented at the 8th Real-Time Computer Applications in Nuclear, Particle and Plasma Physics (RT93), Vancouver, Canada, June 8-11, 1993

Table I

Item	Source
Polarization state	SLC injector
Beam state bits	SLC Control System
Beamstrahlung	SLC beamstrahlung monitor
Beam currents	SLC toroids
Luminosity	SLC radiative bhabha luminosity monitor
Beam polarization	Polarimeter
Beam energies	Energy spectrometer
Detector high voltage	Detector
Trigger information	Trigger control task

purposes all beam crossings are interesting. There are several kinds of monitoring one would like to do, particularly in the discrete environment of SLC/SLD:

- monitor the condition of the beams
- monitor the state of the detector hardware
- monitor the trigger

All of this information is helpful in optimizing the peformance of the accelerator and detector online; it also is important for some kinds of physics analysis. Traditionally, monitoring has been a not altogether benign parasite on event data. Statistics are accumulated from triggered events. In order to avoid some of the biases inherent in physics triggers, random triggers are also occasionally taken, but their rate cannot be too high or they will seriously affect the live time of the detector for physics.

The architecture of the SLD data acquisition in FASTBUS allows an alternate monitoring method: keep a small amount of data for each beam crossing, and occasionally send a buffer of such data (known as a monitor record) to the VAX for display, analysis and logging.

A. *Constraints*

To avoid impacting event flow, we insist that:

- individual monitor records be small enough and infrequent enough to make negligible demands on the data acquisition bandwidth.
- both record size and rate be nearly constant and unaffected by noisy beam conditions.

B. *Contents of a Monitor Record*

In the current implementation, records usually cover about 1200 beam crossings (10 seconds) and are emitted at approximately 10 second intervals. The records have three components:

- A static header
- One or more quasi-static records (QSRs)
- For each QSR, anywhere from 1 to 1200 beam pulse records immediately following the QSR. The total number of beam pulse records within a monitor record may not exceed 1200.

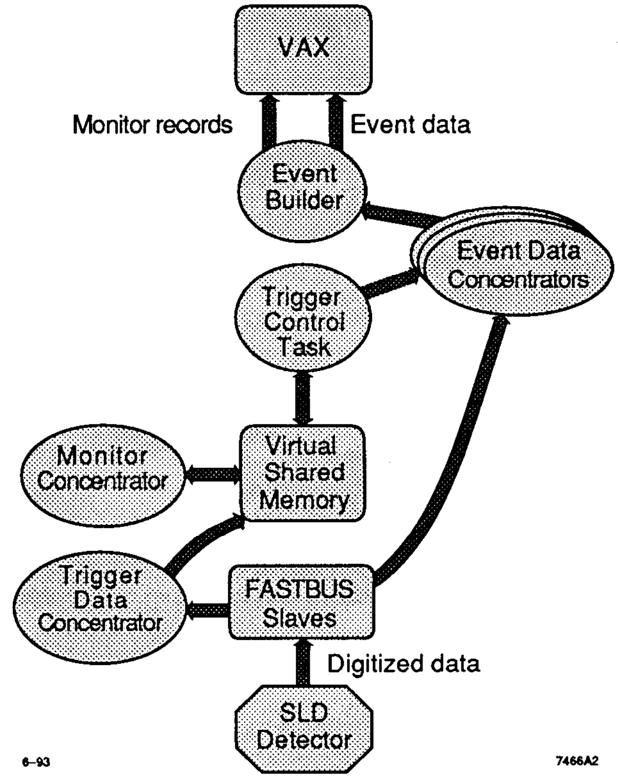

Figure 2. SLD data acquisition in FASTBUS.

The static header consists of information needed to interpret the remainder, such as thresholds, gain factors, etc. The information changes very rarely. In practice, it never changes during a physics run. It is included primarily as a convenience for offline users.

The QSR contains information which changes more frequently and applies to the immediately-following set of beam pulse records.

In the current implementation each beam pulse record is 20 bytes; this size could be increased somewhat with no noticeable degradation of data acquisition performance. The data come from a variety of sources (see Table 1).

C. *Implementation—FASTBUS*

The generation of monitor records with pulse-to-pulse information from a variety of sources was a relatively small perturbation of the pre-existing data acquisition because of the distributed architecture of that system. Tasks (concentration of data, packaging of data for delivery to the VAX, trigger decision, etc.) reside on several identical FASTBUS masters, distinguished only by their locations in the network. The masters may send messages to each other, but they are also linked by an implementation of virtual shared memory. Different kinds of 120 hertz data come from different masters, but are available to all, and in particular, to the master running the task which assembles the monitor records (see Fig. 2).

Enhancements were made to underlying software to support the generation of correctly tagged records and the flow

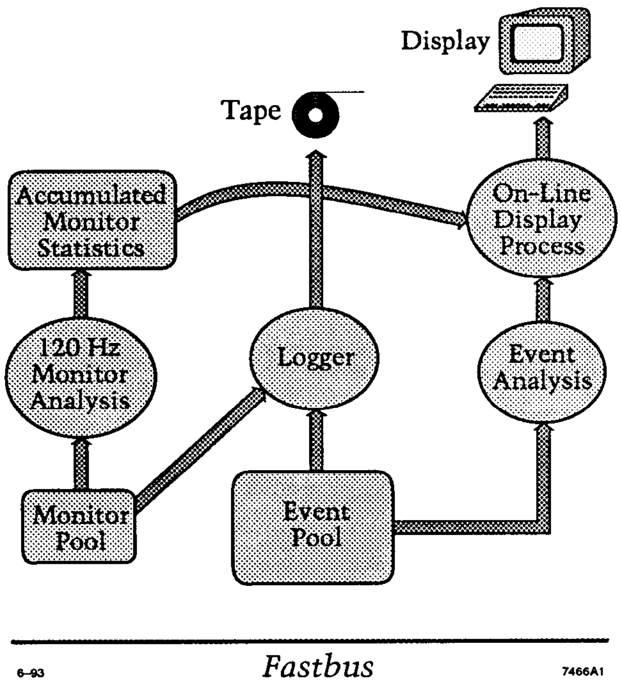

Figure 3. Data acquisition in the VAX.

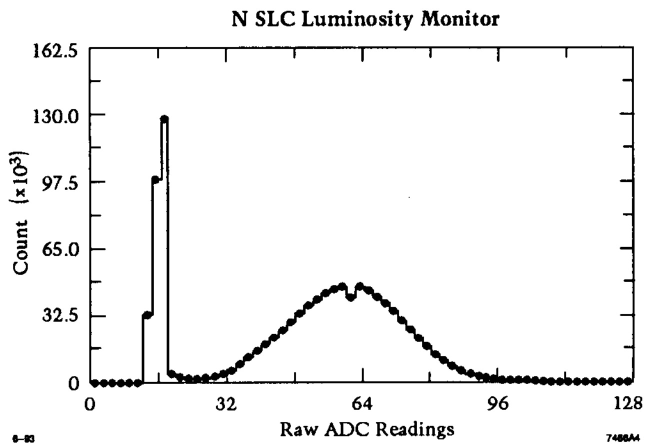

Figure 4. A typical display.

of the (unsolicited) 10-second buffers to the host VAX independent of activity on the event stream.

D. Implementation—VAX

Like event data, monitor records are written to a pool of shared memory on the VAX where multiple consumers may read them. One consumer is the tape logger. Another kind of consumer analyzes the monitor records online, producing histograms and other forms of accumulated statistics available to other processes for display or record-keeping (see Fig. 3). Currently, two such monitor processes are implemented: one general purpose, the other to look specifically at polarization information from the monitor records as well as from other sources.

III. Applications

Statistics derived from the 120 hertz records are kept online in a variety of forms. Accumulations over short time periods may be used to spot anomalous beam conditions or trigger behavior, useful for accelerator operators as well as experimentors. Accumulations over the course of a physics run (typically 3 or 4 hours during which the state of the detector is under tight control, and beam conditions do not vary wildly) give an overview of conditions during that run (see Fig. 4). Polarization information is monitored continuously to make sure SLC, SLD and the polarimeter agree on the sign of polarization (varied pseudo-randomly). Offline analysis of the data can aid in computing cross sections for physics events. As a post-mortem of accelerator and detector/trigger behavior, monitor data may suggest possible improvements.

IV. References

[1] M. Breidenbach, "Overview of the SLD" IEEE Trans. on Nucl. Sci. **NS-33**, No. 1, 46 (1986).

[2] D. J. Sherden, "The Data Acquisition System for SLD," SLAC-PUB-4297 (April 1987).

[3] J. Russell, "An Overview of the Data Acquisition System for SLD," presented at the Computing in High Energy Physics '92 Conference, Anncy, France, September 21–25, 1992.

[4] M. Huffer, "Software for the SLD FASTBUS Data Acquisition System," presented at the Computing in High Energy Physics '92 Conference, Anncy, France, September 21–25, 1992.