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A FAST SPARSE-DATA-SCAN SYSTEM

USING CAMAC COMPATIBLE ELEMENTS

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A FAST SPARSE-DATA-SCAN SYSTEM USING CAMAC COMPATIBLE ELEMENTS

Ludwig Pregernig and Michel Rabany^{*)}

Summary

Hodoscopes are used to measure the momentum of individual particles of the high intensity CERN SPS Muon-beam. They are read out through the fast Sparse-Data-Scan System described below which can be shared among several users.

1. Introduction

The secondary Muon-beam¹⁾ of the CERN-SPS (Super-Proton-Synchrotron) has been equipped with a spectrometer to provide a facility for momentum measurement of individual beam particles.

Due to the high fluxes, up to 10^9 particles per second, and the required accuracy of 1 % for the momentum measurement, four hodoscopes with 64 channels each are used to determine the particle coordinates at different locations.

Also, standard coincidence circuits with a time resolution of a few nanoseconds have therefore to be replaced or complemented by time-discrimination circuits with a resolution better than 100 ps to eliminate ambiguities in the reconstruction of particle trajectories.

Apart from the attention brought to the photomultiplier-electronics²⁾ much effort has been put into the design of the system to read out the spectrometer information with the following requirements in mind:

- i) any of the users of the beam-line should see the spectrometer as if it were his own (multiuser access),
- ii) complete particle data have to be sent to the user in a compact and intelligent form as quickly as possible after the user's request ($\ll 1$ ms) (data handling),
- iii) the system should largely be independent of the number of hodoscopes and channels per hodoscope (extensibility),
- iv) in case of trouble, on-line diagnostics should be possible in order to reduce repair time (availability).

Points i) and ii) are quite difficult to satisfy within CAMAC standard.

A compromise, differing as little as possible from CAMAC, has led to the Sparse-Data-Scan (SDS) System, which we are describing in this note.

2. System Description

2.1 General design criteria

Several users may share a common system as long as interference among the various users remains negligible.

If N is the access rate of each user, t the deadtime of the system and m the number of users, then the efficiency loss due to the sharing of the system is

$$N(m-1)t. \quad (1)$$

To obtain the required accuracy for the time discrimination (< 100 ps) we decided to use CAMAC Time-to-digital converters (TDC's), which are commercially available as

an improved version of an already existing model, offering a time resolution of 50 ps. This allows the use of a standard CAMAC crate with a standard power supply to accommodate the modules. Furthermore, acceptance tests and maintenance of the TDC's may be performed in any CAMAC set-up.

To make use of these advantages without encountering efficiency problems due to the excessive readout time through standard CAMAC, we were forced to the compromise of a fast SDS system, following our experience in a similar system built for multiwire proportional chambers³⁾.

In designing the system we had mainly to take into consideration:

- i) the structure of the sparse data,
- ii) how to extract them quickly.

2.2 Data structure

Compared to the digital readout of multiwire proportional chambers, where the number of a hit wire equals its address and already represents the information one is looking for, TDC-data are not self-addressed: the measured time interval has to be attached to the respective channel address.

2.3 Data extraction

With Schottky components instead of standard TTL ones in the CAMAC interface circuitry of the selected TDC-model⁴⁾, using a standard CAMAC-crate with a twisted-pairs dataway³⁾ and appropriate termination of the dataway lines in a dedicated crate controller, the duration of a read operation is reduced to 180 ns.

The selected Octal-TDC's will, after the end of the conversion, generate a LAM, if the addressed channel contains valid data. But, as the TDC's need 400 ns for LAM-determination when switching the readout from one subaddress to the next, the manufacturer suggested applying the following horizontal scanning scheme:

```
Set subaddress (starting with A(0))
Wait for LAM-determination (400 ns)
Read in sequence from N = 1 to N = 23 modules
    having generated a LAM request (180 ns/word).
```

2.4 Dataformat and datapacking

The requirement to stay within 16 bits per word and the horizontal scanning scheme led to the format illustrated in Fig. 2.

Bit 15 is used to distinguish between Marker and Datawords.

One datablock is packed with the first Markerword at the beginning followed by the Datawords at the indicated subaddress of the specified crate, or if none (no LAM at the indicated subaddress), by the next Markerword. The endmarker - the last word of the block - contains the total number of words transmitted.

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2.5 System configuration

As shown in Fig. 3, one controller "HOREC" (SC) has been provided to scan one "TDC-segment". Because of the data structure the different segments are vertically branched. This also offers the possibility to read out only part of the system.

"Monitor" and "Buffer-Memories" are the units necessary for the sharing of the SDS-system among several users.

To access the spectrometer data through the SDS-system the physicist sends a request to the "Monitor". This request, when it has been accepted, is used to start the TDC's and to trigger, after the conversion delay, the readout sequence. The data are transmitted via a parallel link into the "Buffer-Memory" assigned to the requesting user and "prewarned" by the "Monitor". This fast Buffer-Memory (1 k × 16 bits words) is normally located in the user's CAMAC crate where it can be read directly through a standard CAMAC controller.

3. Conclusions

Up to now three users are reading out through the described system four hodoscopes*) with 64 channels each with satisfactory performance.

A standard CAMAC system in block mode with Direct Memory Access could read out 4 × 64 channels in approximately 250 μs, but would still leave the problem of sorting valid data.

Working in interleave mode with interrupts the time to read the 20 valid datawords (5 hits per hodoscope) would still be of the order of 200 μs (10 μs per interrupt plus 4 dataway cycles of 3 μs each) but would solve the sorting problem.

Using the SDS system the readout time is reduced to about 13 μs.

4. Acknowledgements

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*) Four additional hodoscopes to be implemented by the end of this year.

FIG. 1 MUON-BEAM MOMENTUM SPECTROMETER

Each hodoscope plane is divided into 64 channels

Markerwords (Bit 15 = 1) : Bit 14: 1st word flag, on in 1st Markerword of block
 Bit 13: Last-word flag, on in last word of block, indicates that the Marker contains the Word-count

Datawords (Bit 15 = 0) : Option: 5 Bits for N

FIG. 2 FORMAT OF THE DATA

FIG. 3a LAYOUT OF THE HODOSCOPE READOUT INCLUDING SDS SYSTEM, MONITOR AND USER-BUFFERS