

## CONTROL MODULES FOR SCINTILLATION COUNTERS IN THE SPS EXPERIMENTAL AREAS

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### Abstract

The hardware used in the SPS Experimental Areas to control the beam instrumentation electronics and mechanics of the particle detectors is based on CAMAC and NIM modules. The maintenance of this hardware now presents very serious problems. The modules used to operate the Experimental Areas are numerous and older than 20 years so many of them cannot be repaired any more and CAMAC is no longer well supported by industry. The fast evolution of technology and a better understanding of the detectors allow a new equipment-oriented approach, which is more favourable for maintenance purposes and presents fewer data handling problems. VME and IP Modules were selected as standard components to implement the new electronics to control and read out the particle detectors. The first application implemented in this way concerns the instrumentation for the Scintillation Counters (formerly referred to as triggers). The fundamental options and the design features will be presented.

### 1 MOTIVATION AND HISTORY

Most of the detectors in the Experimental Areas of the SPS were implemented more than twenty years ago. At that time many detectors were at an experimental stage and the implementation of their control electronics and data acquisition were not yet in a final state. It was therefore convenient to have building blocks that made it easy to add new features whenever needed. The electronics were therefore implemented in a function-oriented way (see chapter 2), where many different systems, often located in different racks, constituted the building blocks of the detector control.

Our detectors are now well known and implemented in a well-defined manner. The advantage of the function-oriented approach has now vanished and has turned into a time consuming problem when it comes to maintenance and troubleshooting. For some detectors more than hundred cables are needed to interconnect their functional building blocks making fault finding very difficult.

Scintillation Counters are rather simple devices used to count the number of particles in a beam. They are made up of a scintillator that can be moved in or out of the beam and a photomultiplier to pick-up the scintillation light produced by each charged particle. When put in coincidence two Scintillation Counters are often used to

strobe a more complex detector (see Fig. 1). The old function-oriented approach presently implemented for the Scintillation Counters requires the interconnection of seventeen different electronic modules for their control and data acquisition (see chapter 2.1).

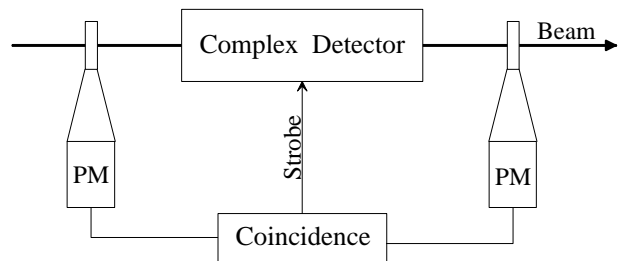


Figure 1: Scintillation Counters in coincidence.

## 2 FUNCTION ORIENTED APPROACH

### 2.1 Modules used for the old implementation

In the old function-oriented approach the different systems like Discriminators, Delays, DACs and ADCs have many channels connected to signals from many different types of equipment.

For the Scintillation Counter the electronic modules needed to implement the old function-oriented systems are listed below:

- Discriminator. 8 ch NIM module.
- Delay Driver. 64 ch CAMAC module.
- Quad Delay. 4 channel 19" chassis.
- Coincidence. 4 ch NIM module.
- Scaler. 6 ch CAMAC module.
- Programmable Fan Out. 16 ch Camac module.
- Led Driver. 16 ch NIM module.
- ADC. CAMAC module.
- Multiplexer Driver. 1024 ch CAMAC module.
- ADC multiplexer. 64 ch 19" chassis.
- Analogue MPX PP. 32 ch 19" chassis.
- DAC. 12 ch. CAMAC module.
- Output Register. 128 ch CAMAC module.
- Input Gate. 256 ch CAMAC module.
- Timing Repeater. 4 ch NIM module.
- Line Survey. 128 ch CAMAC module.
- I/O Motor Driver. Two ch NIM module.

## 2.2 Complex troubleshooting

These seventeen modules are located in different chassis and in different racks mixed with other types of equipment. In some cases the control electronics of a Scintillation Counter is located in one barrack whereas the data acquisition is located in another. This is what make troubleshooting extremely difficult and time consuming.

## 3 IP MODULES

### 3.1 Evolution of electronics

New electronic components now allow a designer to pack much more functionality in less space with increased reliability at reduced cost. This allows to move the function-oriented approach from the module level to the sub-module level.

### 3.2 From daughter boards to IP Modules

Many companies have developed electronic modules using daughter boards either to gain space for higher integration or in order to implement a standard functionality that can be re-used for another member of the same product family.

The trademark IndustryPacks, introduced as an open standard for daughter boards by GreenSpring Computers back in 1988, has now grown to a widely used industrial standard called IP Modules [1]. In the mid-nineties around 100 firms had adopted the standard and put IP Modules on their product program. Today you find a lot of standard functions implemented as general purpose IP Modules and some firms even offers custom design of daughter boards in this standard. In the case of a VME motherboard a maximum of four IP Modules can be added on (see Fig. 2).

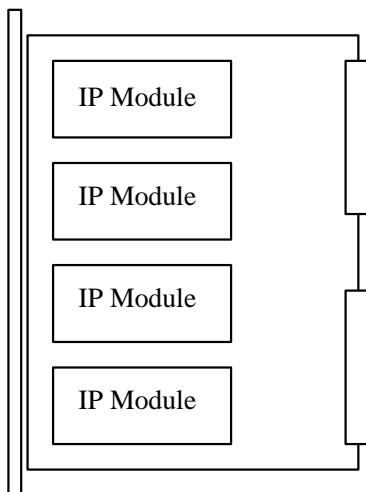


Figure 2: VME board with IP Modules.

## 4 EQUIPMENT ORIENTED APPROACH

### 4.1 Advantages

The aim of the new equipment-oriented approach is that one module only serves one equipment or at least one type of equipment. This approach has a number of advantages:

- Simplify the system structure.
- Decouple different types of equipment.
- Reduce the number of electronic modules.
- Suppress interconnecting cabling.
- Reduce the number of standards used.
- Regroup the electronics of equipment.
- Simplify the database and software.
- Increase reliability.

### 4.2 Module specifications

The main requirements for the new equipment-oriented module for the Scintillation Counters are:

- Dual equipment module to ease coincidence.
- High voltage control for the photomultipliers.
- Motor control of in/out movements.
- Signal discrimination and coincidence control.
- Count number of particles.
- Perform spill measurement (see chapter 5).

### 4.3 Collaboration with industry

As in most research laboratories the resources are getting rare so collaboration with industry is encouraged for new electronic developments. Standard industrial modules, modules designed from CERN specifications and a minimum of home design have therefore been key words for our new electronics.

For the update of the old function-oriented hardware of the Scintillation Counters the IP Modules represent an interesting choice. Other types of detectors based on photomultipliers will also be able to profit from these sub-modules to replace the functions originally implemented in NIM, CAMAC or 19 inch chassis. We have therefore tried to find partners in industry to produce IP Modules that fulfils most of the functionality needed for this family of detectors.

### 4.4 Implementation in VME

The new equipment-oriented module for the Scintillation Counters has been implemented as a VME board with three IP Modules:

- IP-A is a general-purpose input/output/counter module from Actis. This module features eight 12-bit DACs, eight 12-bit ADCs, three counters/timers and up to twenty digital inputs or outputs [2].

- IP-B is quad 100 MHz spill counter from Develco. It contains four individual counters plus a FIFO[3]. The contents of all four counters are transferred to the FIFO at the rate of the programmed sampling frequency from IP-A. The use of this new feature is described in chapter 5.
- IP-C is a dual discriminator and delay module developed at CERN. It features 100MHz signal processing of the photomultiplier signals and conditioning of the signals for the coincidence and the counters. The programmable delay and pulse width is implemented with an ASIC delay generator [4].

These three IP Modules fulfil most of the needs for the Scintillator control and data acquisition whereas the remaining equipment specific features are implemented on the motherboard. This is the case for the power stage for the motor control.

The interface from the VME-bus to the individual IP Modules is implemented in an Xilinx capable of controlling four IP Modules. In order to simplify the internal addressing, the functions implemented on the motherboard are controlled as a virtual IP-D module.

## 5 NEW FEATURES

The Scintillation Counters are used for the fixed target physics in the Experimental Areas of the SPS. Protons are extracted from the SPS accelerator towards a fixed target during a 2.4 seconds period referred to as the spill. From the Target Area the secondary beams are transported through long beam lines to the Experimental Areas. Each beam line is equipped with several Scintillation Counters in order to count the number of particles at different positions. As explained in chapter 1, they are also used to strobe more complex detectors.

As a new feature, it was requested that the Scintillation Counter Control Module could measure the stability of the beam extraction and the beam transport in order to know the intensity variation during the spill. This spill measurement has been implemented in the new module by storing away the counter content at regular intervals. By transferring the counter content to a FIFO every millisecond, useful information about the spill quality can be obtained. Fig.3 shows a spill measurement from a secondary beam line during the 2.4 second extraction

from the SPS towards the West Experimental Area. The first half of the spill shows normal stable beam intensity whereas the second half indicates a magnet problem in the beam transport.

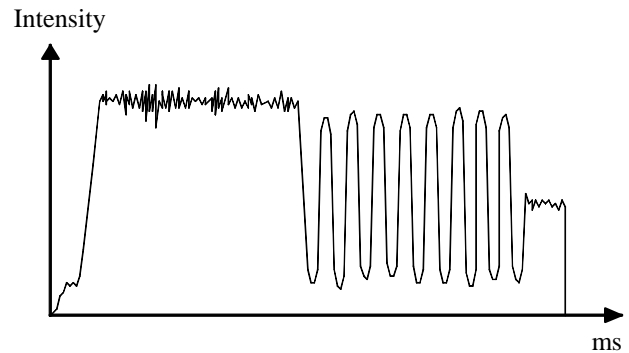


Figure 3: Spill measurement with a scintillation detector.

## 6 CONCLUSION

One single new control module for the Scintillation Counters replaces seventeen old CAMAC and NIM modules. The complex cabling between these old modules is suppressed and the new equipment-oriented design makes troubleshooting much easier and limits the number of industrial standards. Using the same standard IP Modules on other dedicated VME boards, several detectors will profit from the same upgrade in the future. The new equipment-oriented approach will increase the reliability of the electronics and make the overall maintenance load significantly smaller.

## REFERENCES

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