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JULIOS DETECTORS COMBINED TO A PC-BASED DATA ACQUISITION SYSTEM

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ABSTRACT

The linear JULIOS scintillation detector system, which is constructed for simultaneous position and time encoding of registered events, is extended and combined to a flexible and high capacity PC-based data acquisition system. A new timing interface module in the JULIOS electronics and a new memory module in the EISA-PC are based on user programmable logic cell arrays in the form of Xilinx XC4010 chips. The available address space can be flexibly allocated to a maximum of 12 bit position and 16 bit time channels. The standalone detector and data acquisition system is aimed at pulsed source instruments performing high resolution angle-dispersive time-of-flight experiments. Specific operational aspects of the system, which is installed at the redesigned ROTAX instrument at ISIS, are discussed.

1. Introduction

Linear and area solid state scintillations detectors are of special interest at pulsed spallation source instruments due to their comparatively wide spectral efficiency also at short wavelengths and due to their potential in high resolution time-of-flight applications. The physical characteristics and goodness of a pulsed white beam spallation source instrument is decisively determined by the potential of the detector system in collecting as many of the scattered neutrons as possible and in resolving the events sufficiently with respect to time-of-flight and scattering angle. For instance, angle-dispersive time-of-flight diffraction using pulsed white neutrons, is experienced as a highly efficient technology to exploit the thermal neutron spectrum and to gain simultaneous structural information in reciprocal space, which is obtained only in succession with monochromatic neutrons at steady state sources [1].

Keywords: linear detectors, TOF-diffraction, data acquisition, PC-system

A large neutron detector system performing high resolution time and position analysis, however, produces a huge amount of data to be stored in a huge memory during the measurement to be observed, handled and analysed possibly in the course of the experiment. For flexibility reasons and with respect to individual demands of data processing, we considered it desirable to have a standalone data acquisition system, which is permanently available and which operates independently from central data acquisition systems.

The combination of detector control and data acquisition into a standalone PC-based entity has been realized with the JULIOS scintillation detector system [2].

2. Linear JULIOS detectors

The linear JULIOS scintillation detectors are built in a modified Anger-technology using a 1 mm ^{6}Li-glass scintillator and a linear row of 24 photomultipliers (PM) for light spot position encoding [3]. Fast digital signal processing in a dedicated hardwired computer [4] results in a time resolution of subsequent events of better than 1 μs. Three types of linear JULIOS detectors are manufactured differing by spatial resolution and the dimensions of the effective detector windows; details are summarized in Table 1.

Table 1: Dimensions and physical properties of the linear JULIOS detectors: type H (high resolution), type S (standard) and type L (large window)

Type	JULIOS-H	JULIOS-S	JULIOS-L
Form	plane	plane	plane
Outer dimensions (mm)	320x390x115	900x450x125	1100x475x180
Sensitive window (mm)	200x20	680x25	940x75
Form of PM-photocathodes	rectangular	circular	rectangular
Size of PM-photocath. (mm)	6.8x24	28.6 Ø	40x80
Spatial resolution (mm)	1.2	2.3	3.3
Time resolution (s)	$< 10^{-6}$	$< 10^{-6}$	$< 10^{-6}$
Neutron efficiency, 1 Å (%)	65	65	65
Neutron efficiency, 2 Å (%)	85	85	85
Gamma sensitivity ($E_\gamma > 1$ MeV)	$< 10^{-4}$	$< 10^{-4}$	$< 10^{-4}$
Count rate capability (KHz)	100	100	100

The different JULIOS types are equipped with identical detector electronics made up of an analog and digital signal processing section, which is described in detail elsewhere, see e.g. [1]. Position computation is performed within 70 ns. The electronics provides for a 12 bit position resolution, at the most, exceeding the real linear physical resolution of the detectors by about one order of magnitude. The hardware of the JULIOS detectors and read out electronics comprising also modules for automatic gain stabilisation of the PMs and for correcting positional nonlinearities and inhomogenities of the scintillator material is shown in Fig. 1. The read out electronics is designed for on-line connection to a personal computer to control and process all detector activities and to store the data.

Alternatively to the PC data storage, the detector can be connected to an external timing and data acquisition system. For this purpose, the electronics interface provides a 12 bit position address with the necessary event flag to synchronize the detector events with an external timing reference.

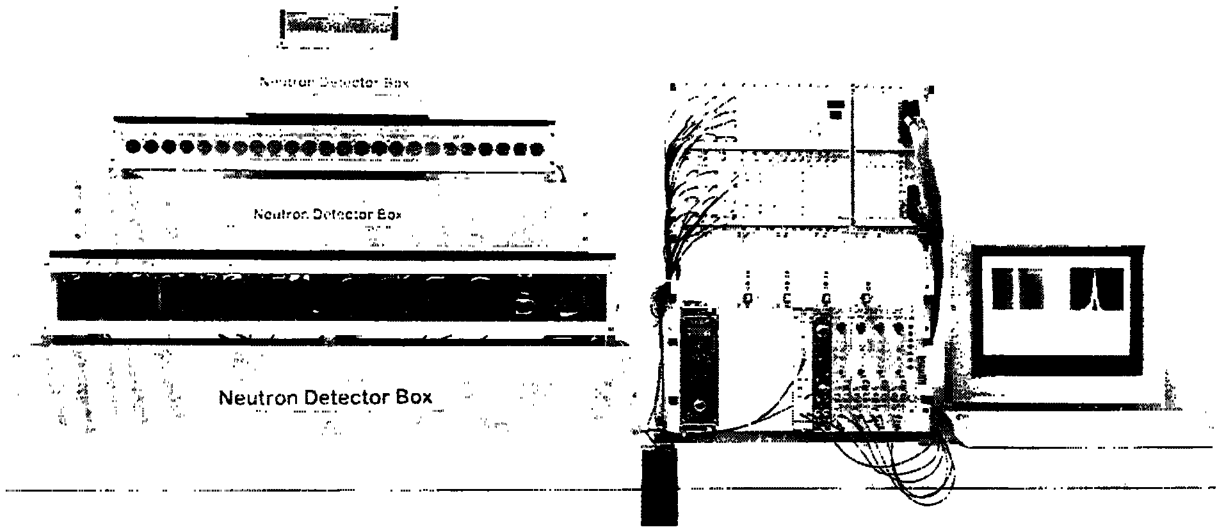

Fig. 1: Assembly of the JULIOS detector system: detector heads (on the left) 'type H' (top), 'type S' (middle), 'type L' (bottom); the units are taken out of the light-tight boxes (below in each case); associated detector electronics (on the right) connected to a PC

3. JULIOS timing interface

The interface module managing the signal transfer from the detector to the PC (Fig. 2) has been designed for high resolution time-of-flight applications. It is constructed as an integral part of the detector electronics which allows for setting a variable time window during which events are collected.

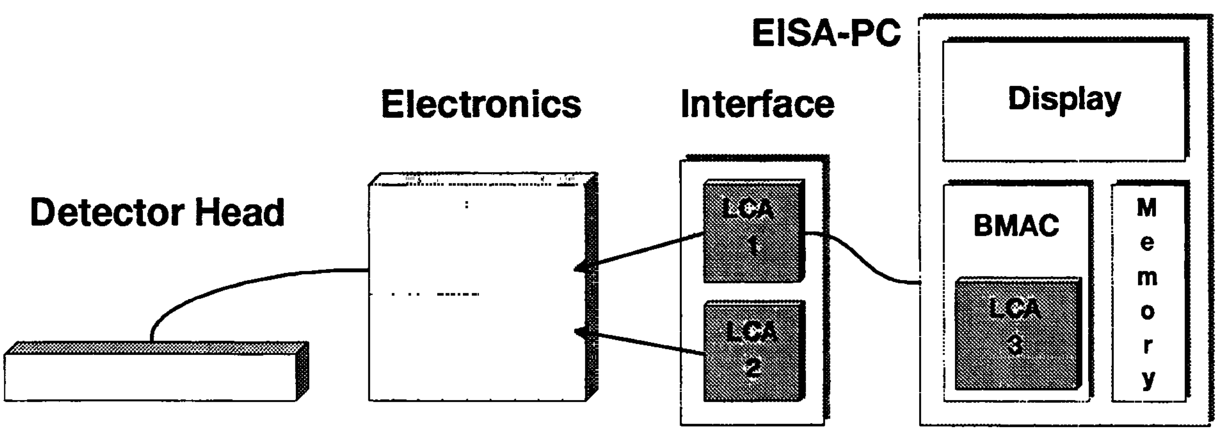

Fig. 2: Hardware structure of the JULIOS detector and data acquisition system (see text)

The core of the timing module are two user programmable logic cell arrays (LCA) in form of Xilinx XC4010 chips (see Fig. 2). The LCA-design offers high flexibility to realize variable configurations and several modes of operation. LCA-1 is used for initialization, configuration and control of the JULIOS detector; LCA-2 takes care of the actual timing functions. With respect to detector configuration and signal control, there are options to vary the number of position and time bits and to set levels of all signals separately according to actual experimental requirements. These timer options and specifications have been realized by registers containing:

1. the number of position bits to be included in the time/position address,
2. the polarities of the I/O-signals,
3. the time delay between the external reference (e.g. master pulse) and the active time window in μs,
4. the number of time slices within the time window,
5. the length of the individual time slices in μs.

The control of the JULIOS activities is performed by the PC through a dedicated I/O-card but is also possible by a RS232 serial interface, instead.

4. PC data acquisition

Position encoded and time stamped JULIOS events are transferred via a 28 bit connection to the PC with EISA-bus architecture. The data acquisition is realized by the so-called BMAC PC-module, which acts as Bus Master ADC Controller [5]. The BMAC module, again, is based on a LCA-array Xilinx-chip (see Fig. 2) allowing flexible and programmable configurations with respect to variable time-of-flight applications (compare [6]).

The data received by the BMAC-card serve as pointers to locations in a reserved memory area of the PC, the contents of which is to be incremented, much like a multi channel analyzer. This action takes about 480 ns per event and is about one order of magnitude faster than the preceding ADC-conversion of the events in the JULIOS electronics (compare Table 1).

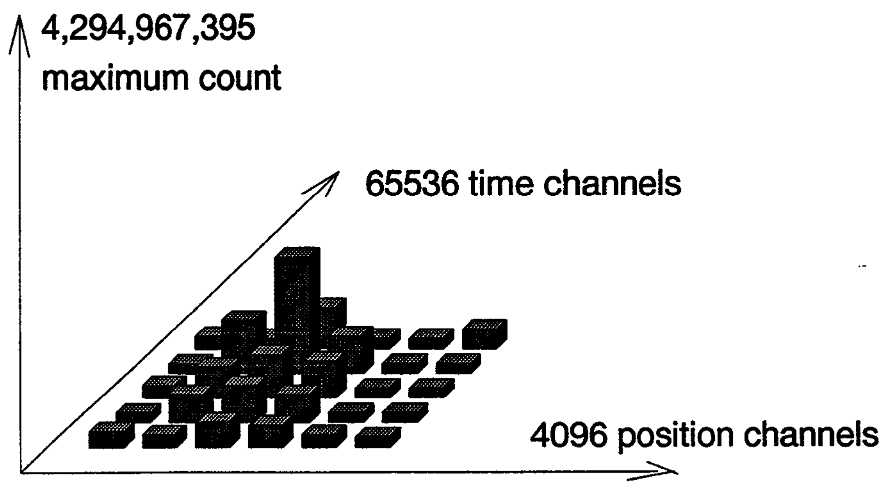

Fig. 3: Two-dimensional data array of the PC-memory for JULIOS time-of-flight data acquisition

For the total exploitation of the maximum position and time resolution, which can be provided by the detector electronics, an address space of 2^{28} locations of 4

Byte depth each would be required, which amounts to 1 GByte memory (Fig. 3). In practice, however, the address space can be reduced to about 2^{22} (= 4 M) taking into account the physical resolution of the detector. 16 MByte PC-memory are necessary to store double word data within the 4 M memory locations.

5. Software structure

The JULIOS detector and its PC-based processing electronics and data acquisition system is operated under the multitasking or quasimultitasking PC-shell of MS-WINDOWS (Fig. 4). Different functions can be performed simultaneously by opening several DOS-windows in the PC-shell. So it is possible to display spectra on-line on the PC-monitor and to evaluate them while collecting data.

The initialization of the detector is performed under DOS using the remote control program JULIOS-RM written in Turbo Pascal; specific parts like interrupt services are writen as assembler routines [7]. Different detector facilities and electronic configurations can be activated by special commands: e.g. performing PM calibration measurements, generation and loading of lookup-tables for fast position computation [4], control and stabilization of PM-gains [2], start and stop of the experimental data collection. The configuration of the BMAC-module, as well as the reservation of the PC-memory is performed under DOS.

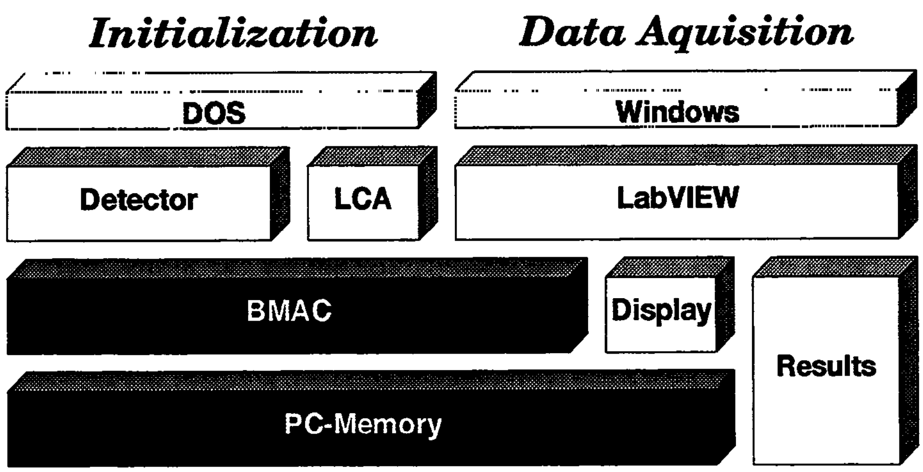

Fig. 4 Software structure of the combined JULIOS detector and data acquisition system

The data collected in the PC-memory are handled within another PC-window using the graphic facilities and service functions of the program package LabVIEW. Software has been developed, so far, to display the total data content of a 64 Mbyte memory on the PC-monitor. Special modes can be selected to display linear, two-dimensional or pseudo-three-dimensional spectra.

6. Discussion

The PC-based JULIOS detector and data acqusition system is in operation at the ROTAX-instrument at ISIS, which has been redesigned as angle-dispersive time-of-flight powder and texture diffractometer [8] The recent installation of the new JULIOS timing interface and the high capacity data acquisition system replaces the previous ISA-PC system limited by the 16 bit address space of the ISA-slots; this has been experienced to be insufficient [9]. Test measurements with the new system are in progress to establish the most favourable ratio of electronic position and time channels for the instrumental setup at ROTAX. This configuration has to guarantee, on the one hand, the best $\Delta d/d$-resolution of the instrument, but it should not lead, on the other hand, to an unreasonable waste of data and PC-memory. Probably, the balance will be obtained with 512 channels (9 bit) for position and 4096 channels (12 bit) for time, requiring a total of 8 Mbyte PC-memory. 9 bit position resolution is roughly equivalent to a data point density of $\Delta 2\Theta = 0.1°$. 12 bit time resolution, which is equivalent to a wavelength resolution of 10^{-3} Å corresponds to time-slices of 4 μs with respect to the ROTAX-specific time-window from 0.5 to 16.5 ms out of the 20 ms ISIS pulse.

The PC-based data acquisition system can be characterized by its capability of easy configurational changes, its flexibility with respect to different applications, and its independence from local mainframe installations. Independent of these technological aspects, the whole data acquisition system is rather inexpensive. It seemed natural to combine the JULIOS detector with such a PC-based system, as the whole detector system is PC-processed, anyway.

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