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A Time-Shared Computer Data Collection System at the Brookhaven Graphite Research Reactor*

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The increasing complexity of the data of nuclear physics has led to widespread interest in the possibility of utilizing a digital computer for on-line data collection. Through the combined efforts of the Instrumentation Division and the Neutron Physics group at Brookhaven such a system has been placed into operation. Several features of this system are believed to be unique and of interest to research groups centered about a major facility like a reactor or an accelerator.

The system provides for effectively simultaneous data collection for two physically unrelated neutron time-of-flight experiments at the Brookhaven Graphite reactor. For the fast neutron chopper the computer provides a 1024-channel time-of-flight analyzer for total or partial

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neutron cross section experiments, three auxiliary clocks, three total events scalers, and two monitor scalers. The 1024-channels can be split into halves to permit recording of data obtained in sample cycling operations. At the same time a 256-channel time analyzer, a clock, a total events and a monitor scaler are provided for slow neutron chopper experiments dealing largely with "cold" neutron scattering from solids, liquids, and gases. Completely independent operation of both experiments is always maintained.

A general-purpose, transistorized, digital computer[1] of a 2048 24 bit word memory is the heart of this system. The computer possesses a "priority interrupt" feature making it especially useful for time-shared operation. A signal on any one of 16 interrupt lines forces the computer to suspend its current operation and enter a special subroutine determined by the interrupt line which was signaled. Appropriate action is taken by the computer; e.g. incrementing a scaler, incrementing the contents of a time-of-flight channel, responding to a typewriter request, etc. The interrupt system is hierarchical in nature, each line being ordered as to time of execution. Thus simultaneous requests are processed in order according to their priority assignments. The computer also accepts 24 bit parallel input into its memory and is able to send out 24 bit parallel output information. Accordingly, binary encoded data may be

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1) The SDS-910, manufactured by Scientific Data Systems, Inc., Santa Monica, California.

easily transferred to and from the machine.

The data words are encoded by external circuitry using conventional modular logic cards.[2] Immediately following an interrupt request, an encoded time-of-flight address is presented to the input terminals of the computer, and it is subsequently accepted by the interrupt-initiated subroutine. The data-taking subroutine takes 96 microseconds for execution; however, a computer modification is available which will reduce this to 16 microseconds.

A block diagram of the entire system is presented in Fig. 1. To facilitate connection of external analog to digital converters a matrix type of connection board is employed.[3] The insertion of pins in this board assigns the significance of the bit patterns transferred between the computer and the external equipment, and also assigns the significance of the various interrupt lines. Figure 2 shows a photograph of the boards employed in the present system.

The program package placed in computer memory utilizes the computer typewriter keyboard for control of the data-taking operation. Sixteen 4-letter mnemonic codes are available to the user for starting and stopping runs, printing scaler readings, generating data tapes, and so on. For example, the code "FPUN" typed by the operator causes the following

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2) Computer Control Corporation, Framingham, Massachusetts, (S-Pac Series).

3) "Sealectoboard," manufactured by Sealectro Corporation, Mamaroneck, New York.

sequence of events:

1) Data taking with the fast chopper analyzer is terminated.

2) The computer types, with headings, the following:

   a) a master clock reading

   b) the accumulated live times for sample-in, sample-out, and background

   c) the total number of detected events for sample-in, sample-out, and background time periods

   d) beam monitor readings during sample-in and out times

   e) a calculation of the rotor speed in rpm

3) The computer generates a perforated tape containing the 1024-channel contents preceded by a readable array of holes denoting the absolute time as a tape identifier.

None of the above operation affects slow chopper data taking in any way except for a slight increase in deadtime (about 0.3%) during punchout. Similar commands exist for data typeouts, scaler and clock typeouts, data-taking terminations and initiations, etc. The time not occupied in input-output and data-taking is used in generating a display, which to the visual observer appears to be continuous. The display is maintained at all times with a switch controlling the choice of spectrum presented. The typed commands and corresponding responses from the computer constitute a permanent experimental log. Figure 3 shows a section of that log, illustrating several operations and formats.

The basic program package of dual analyzer simulation and typewriter control, output routines, binary-decimal conversion, etc. occupies approximately 700 words. With 1296 words of computer memory devoted to scalers and data channels, little room is available for on-line data processing programs in the remaining memory. Provision will be made for reading in special processing programs when desired from a spool of punched program tape. The time-shared data taking ability of the computer can be maintained during these operations, with only typewriter control to be given up. When normal operation is to be resumed after data processing is completed, the operator will be able to read back in the normal program system.

Memory expansion to 4096 words and the addition of a magnetic tape deck will greatly enhance the power of the present system. Ultimately, the computer will act as a multiparameter analyzer on both slow chopper and fast chopper experiments and will perform on-line data processing when required.

The versatility of the computer data taking system provides a built-in protection against obsolescence. In a sense the capabilities of these systems are limited only by the ingenuity of the programmer and user. We expect to see a rapid increase in the use of these systems in the near future and believe that the use of time-shared computers will become common practice among research teams using a large facility such as a nuclear reactor or an accelerator.

Figure Captions

Fig. 1: A block diagram of the time-shared data collection system.

Fig. 2: A photograph of the time-shared data collection system showing the "Sealectoboard" connection board for data transfer between the computer and peripheral equipment.

Fig. 3: A segment of the experimental log sheet automatically produced by the typewriter program package. Several of the mnemonic codes are shown. Also shown is the effect of typing an incorrect code which results in the typewriter producing the characters N G.

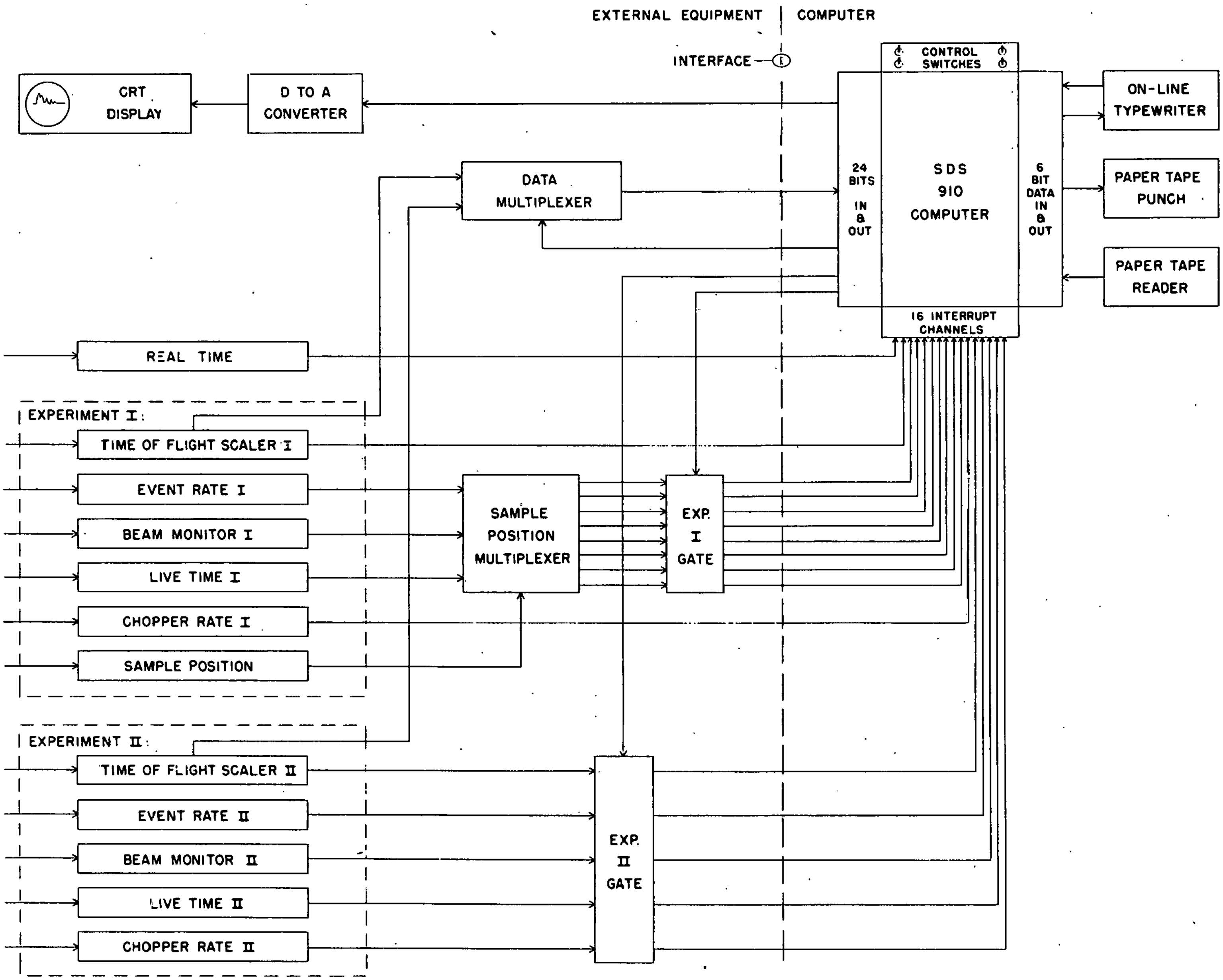
EXTERNAL EQUIPMENT
COMPUTER
INTERFACE
CONTROL SWITCHES
CRT DISPLAY
D TO A CONVERTER
ON-LINE TYPEWRITER
DATA MULTIPLEXER
24 BITS IN & OUT
SDS 910 COMPUTER
6 BIT DATA IN & OUT
PAPER TAPE PUNCH
PAPER TAPE READER
16 INTERRUPT CHANNELS
REAL TIME
EXPERIMENT I:
TIME OF FLIGHT SCALER I
EVENT RATE I
BEAM MONITOR I
LIVE TIME I
CHOPPER RATE I
SAMPLE POSITION
SAMPLE POSITION MULTIPLEXER
EXP. I GATE
EXPERIMENT II:
TIME OF FLIGHT SCALER II
EVENT RATE II
BEAM MONITOR II
LIVE TIME II
CHOPPER RATE II
EXP. II GATE

Fig. 1

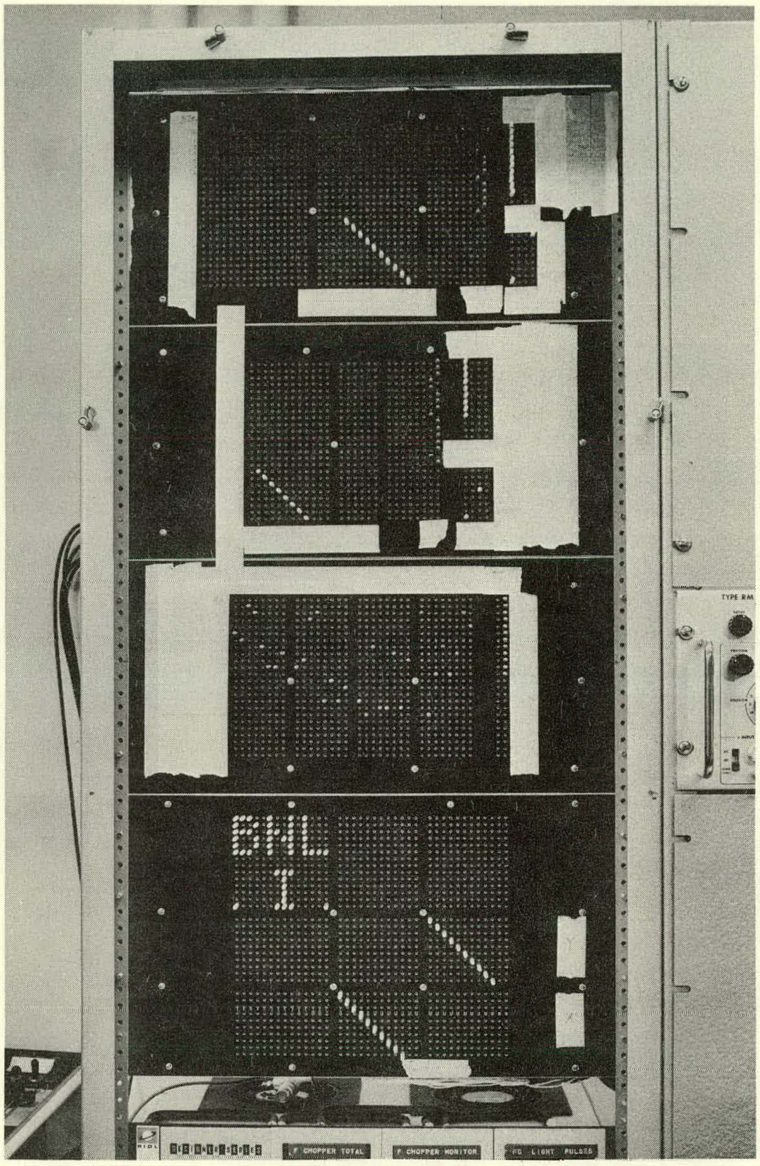
BNL
I
TYPE RM
F CHOPPER TOTAL
F CHOPPER MONITOR
FC LIGHT PULSES

Fig. 2

SONN ABS. TIME: Ø15Ø4

SLOW:	TIME	TOTALS	MONITOR	RPM
	ØØØØØ	ØØØØ3	ØØØØØ	Ø5781

FPUN ABS. TIME: Ø1511

FAST:	TIME	TOTALS	MONITOR	RPM
SAMPLE IN	Ø1139	ØØ387	Ø2757	Ø9566
NO SAMPLE	ØØØ37	ØØØØ3	ØØØ9Ø	
BACKGROUND	ØØØ37	ØØØØ5		

FOON N G

SCON ABS. TIME: Ø1542

SLOW:	TIME	TOTALS	MONITOR	RPM
	ØØØØØ	ØØØØ4	ØØØ42	Ø6875

FCLR ABS. TIME: Ø1661

FAST:	TIME	TOTALS	MONITOR	RPM
SAMPLE IN	Ø1139	ØØ387	Ø2757	Ø9595
NO SAMPLE	ØØØ37	ØØØØ3	ØØØ9Ø	
BACKGROUND	ØØØ37	ØØØØ5		

FONN ABS. TIME: Ø1694

FAST:	TIME	TOTALS	MONITOR	RPM
SAMPLE IN	ØØØØØ	ØØØØØ	ØØØØØ	ØØ176
NO SAMPLE	ØØØØØ	ØØØØØ	ØØØØØ	
BACKGROUND	ØØØØØ	ØØØØØ		

FCLR ABS. TIME: Ø1724

FAST:	TIME	TOTALS	MONITOR	RPM
SAMPLE IN	ØØØ26	ØØØØØ	ØØØ61	Ø9663
NO SAMPLE	ØØØØØ	ØØØØØ	ØØØØØ	
BACKGROUND	ØØØØØ	ØØØØØ		

FONN ABS. TIME: Ø1729 ← 1700 Sept 20 1963

FAST:	TIME	TOTALS	MONITOR	RPM
SAMPLE IN	ØØØØØ	ØØØØØ	ØØØØØ	ØØØ19

Fig. 3