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# Minicomputer On-line System for Measuring Projector of Bubble Chamber Film

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We have constructed the system to handle the measuring projector for bubble chamber films with aids by a minicomputer. This system has significantly reduced trivial errors of the measurements, and improved the quality of the data by means of man machine communication.

KEY WORDS Pattern recognition/ Bubble chamber film/ Minicomputer/

## I. INTRODUCTION

The bubble chamber experiment is the most important for high energy physics as well as the counter experiment. The bubble chamber is a receptacle which contains a liquid kept just below the boiling point by the external pressure. If charged particles traverse the liquid just after suddenly reducing the pressure, the liquid starts boiling to make bubbles along a trail of ions left by the charged particles. By taking a picture of the bubble chamber at that time, one can see the tracks of the charged particles as strings of tiny bubbles. If the particles interact with the nuclei of the liquid (usually liquid hydrogen), the interaction vertices are seen on the picture as well as the decaying vertices of neutral particles decaying into charged particles. Then, by measuring the coordinates of the bubble images on the films of stereo views (usually three views) one can reconstruct the directions and momenta of the emerging charged particles. In contrast with the counter experiment, the bubble chamber experiment has the excellent advantage that interaction vertices can be precisely reconstructed in space and the detection solid angle covers almost the whole range. Bubble chambers have been used for more than twenty years and important results were obtained by measuring a few hundreds of interactions. It became necessary, however, nowadays to measure much more events and perform elaborate calculations, so that the measuring and data taking procedures are needed to be made as simple as possible.

We have three scanning and measuring projectors, and the data were taken on the computer cards.[1] Check and correction of the data cards were done after the measuring procedure and cumbered us to make right book-keeping for the data. Then a lot of time consumption was caused by these check and correction procedures. So, we have attempted to reduce these processes by the aids of minicomputer control system.

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## II. GENERAL DESCRIPTION OF THE SYSTEM

As shown in Fig. 1, the system consists of a minicomputer (AICOM-C5), measuring machines (SMP) and the interfaces which were made by ourselves to send the data from SMP to the computer. This system has the following functions:

The computer receives the data from a SMP interface and checks the quality of the data with some given criteria, and then gives an operator its result by the warning lamp and buzzer. If the data are wrong, the operator corrects the data by sending an appropriate command to the computer. Then the good data are temporarily stored in the magnetic disk. The computer can also give some informations about the status of measurement on the character display, according to the request of an operator. The data accumulated in a day are transferred to a magnetic tape in the lump.

The data on a magnetic tape are used as the input data for spatial reconstruction that is done with a large computer.

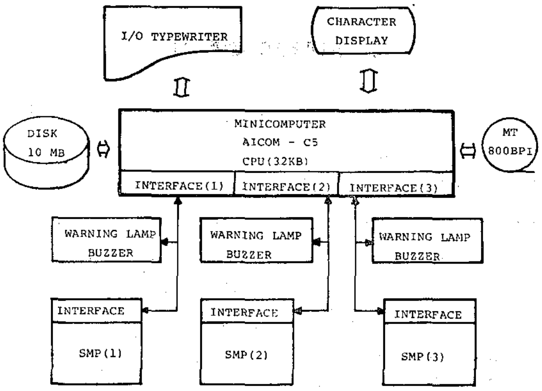


Fig. 1. Block diagram of the minicomputer on-line system.

## III. DATA TRANSFER

The data to be transferred from a SMP interface to the computer are classified as three blocks, which are COMMENT, MEASURE, and SPECIAL COMMENT. COMMENT contains machine and operator numbers, roll and frame numbers of film, identifications of event, tracks to be measured, and so on. MEASURE contains view number and x and y coordinates of measured point. SPECIAL COMMENT is used as a several kinds of request from an operator to the computer. These data are given with 14 (for MEASURE block) or 24 (for COMMENT and SPECIAL COMMENT blocks) units of 4 bits. The SMP interfaces are constructed to transfer successively the data in a unit of 4 bits by CLOCK signals which are sent from the computer.

Figure 2 shows the time sequence of signals for the data transfer. When a button switch (for COMMENT or MEASURE or SPECIAL COMMENT) is pushed, a START signal of about 1 msec wide is produced by a SCAN signal from the computer, and sets the data to be transferred in shift registers of the SMP interface. At the same time, this START signal is sent to the computer to return the BUSY signal to the SMP inter-

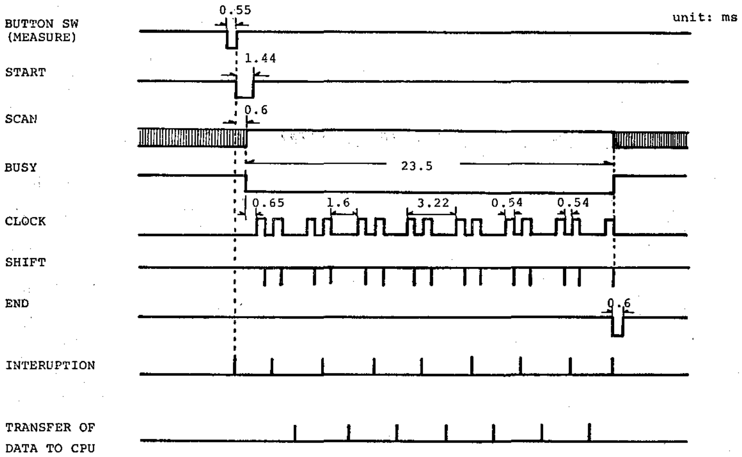


Fig. 2. Time sequence diagram of signals for data transfer from an SMP to the minicomputer.

face, according to the command of data processing program. In the time of BUSY, SCAN signals are inhibited, and the data are transferred to the computer from the shift registers in the unit of 4 bits per one CLOCK pulse, where the CLOCK signals are sent from the computer, till the number of a counter of CLOCK pulses coincides the suitable number (14 for MEASURE or 24 for COMMENT or SPECIAL COMMENT). In the computer, 2 units of 4 bits are stored in a buffer memory for a time, and then the data are transferred in the unit of 8 bits to CPU memory. After the data units were completely transferred, the SMP interface sends an END signal to the computer. Receiving the END signal, the computer starts sending the SCAN signals to the SMP interface by releasing the BUSY signal. Then the system becomes ready to do the next procedure.

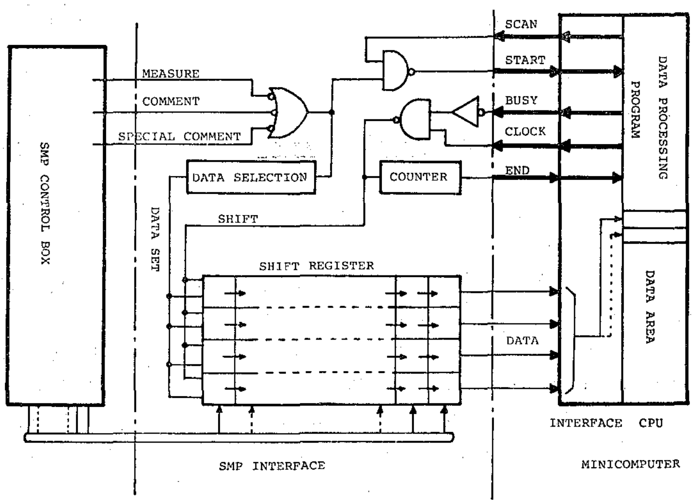


Fig. 3. Schematic diagram of the flow of control signals and data.

The data transferred in the CPU memory are processed according to the data processing program. Figure 3 shows the schematic diagram of the flow of control signal and data.

## IV. PROGRAM FOR THE DATA PROCESSING

As seen in Fig. 4 the program for data processing was constructed to have the following three functions.

1) Read the data sent from the SMP interface.

2) Check the data and send the signal to the operator to indicate with warning lamps and a buzzer whether the data are good or not. If good, transfer the data to the magnetic disk, and if wrong, send the request to the operator to correct the data.

3) Replace the wrong data in CPU by the good ones according to the request sent by the operator with SPECIAL COMMENT data.

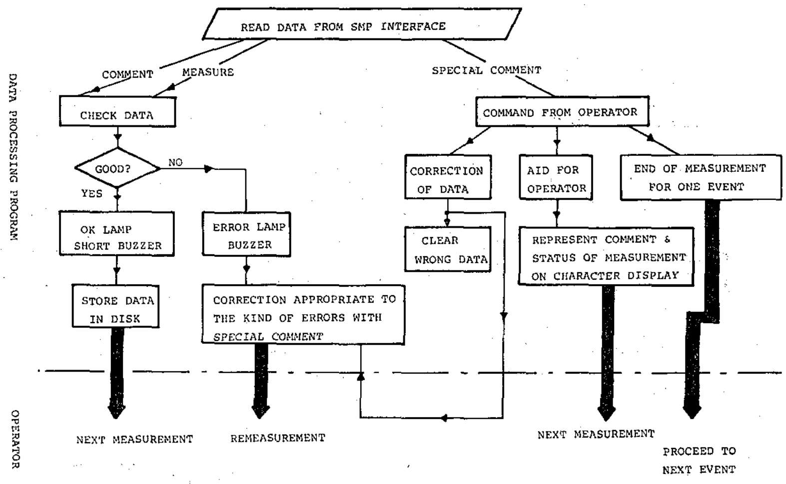


Fig. 4. Schematic diagram of the functions of data processing program.

## V. PERFORMANCES

We have examined the performances of this system comparing with the early data taking with the card-output system. The measurements were done for 70 mm films taken for 800 MeV/c antiprotons lead into the ANL 12 foot bubble chamber filled with the liquid hydrogen and neon mixture.

The number of measured points per track, the number of measured tracks and coordinates of measured points for fiducial marks and tracks are checked with the data processing program. For the track measurement, circle fitting is applied and the standard deviation is imposed to be within the criterion. If the data are wrong, the signals are sent with warning lamps and a buzzer to the operator to show what kind of errors occurred. Then the operator can command immediately the computer to correct the wrong data. So the operator became to be released from fatiguing and error-prone routine work. As a result, trivial errors in the measurements are much reduced and the quality of the data is considerably improved, so that the efficiency to pass the spatial reconstruction program became several times higher than that in the card-output system. For an example, fail of spatial reconstruction is less than one percent for this system, whereas for the card-output system the fail was about ten percents. This means that the remeasurement procedure can almost be omitted.

The average time necessary to measure one event is somewhat different between these two systems, *e.g.*, 21 minutes for the minicomputer on-line system and 19 minutes for the card-output system. But, taking accout of the extra tedious procedure for data card check in the card-output system, the considerable time saving was performed in this minicomputer on-line system.

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