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APPLICATION OF THE PDP-5 TO DATA HANDLING FOR MESON-PRODUCED X RAYS

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APPLICATION OF THE PDP-5 TO DATA HANDLING FOR MESON-PRODUCED X RAYS*

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Abstract

This paper describes a series of programs written to process, on a PDP-5 computer, data from an experiment measuring pi-meson-produced x-rays at the Lawrence Radiation Laboratory's 184-Inch Cyclotron. The programs display data from an A/D converter on an oscilloscope, record it on magnetic tape, and provide feedback to the gain and bias settings of the data amplifier for stabilization of the system transfer function. One program accepts 2048 incoming channels, the other accepts 4096. A third program permits analysis of data previously stored on tape, the area and centroid of a given peak being calculated using a light pen to set the peak boundaries and background line.

I. 2048 Channel Program

Memory Locations

Figure 1 shows the physical arrangement of the system. The 2048-channel program uses only half the full capacity of the Nuclear Data analogue-to-digital converter. Half of the 4096-word computer memory is reserved for the program, leaving the second half free to pulse-height sort the incoming data, each channel corresponding to one word. The maximum count of 4096 counts per channel available with the 12-bit word was found to provide adequate vertical resolution.

Oscilloscope Display

In operation, the fairly low count rate of 500 per second requires a time of at the least several minutes to produce a satisfactory spectrum. During the growth of the spectrum the horizontal scale and origin as well as the vertical scale may be varied, using commands inputted to the teletype. Eight horizontal scales and three vertical scales are provided so that the overall spectrum may first be viewed, then a particular peak selected for closer examination. The display continues while data is being stored. In order to minimize the deadtime between incoming data, the display is executed one point at a time. After each point, the program returns to check if a

new data word is ready to be processed; only if not does it return to display another point.

Tape Transfer

Once the spectrum growth has reached the size required for statistically accurate data, it may be transferred to magnetic tape, using a teletype option. Alternatively, the program may be asked to write out the memory on tape every time the highest peak grows off scale. An identification section is included in each data record placed on tape; this can also be altered using the teletype.

Stabilization

During data processing and display, the program is also stabilizing the transfer function of the system (see Fig. 2). This is accomplished by having in effect two separate input spectra. The first spectra consists of the actual meson-produced x rays that the experimenter wishes to measure; the second is produced by two radioactive sources. The peaks produced by the sources have an absolutely constant energy, and may thus be used as a reference. If an incoming datum is flagged by the scintillator circuitry associated with the sources (as opposed to a meson-produced x-ray), the program compares the data with a value previously inserted in the program by the operator. If the incoming

*This work was done under the auspices of the U. S. Atomic Energy Commission.

value is too high, the computer outputs a pulse to a 512-count scaler (see Fig. 3). The reading of this scaler is in turn transformed into an analogue signal which controls the gain (or bias) setting of the data amplifier. The calibration values of the peaks and window width (a range about each peak within which data must fall to be used for calibration) are typed in by the operator.

II. 4096-Channel Program

Storage

Since the memory of the PDP-5 cannot contain a separate word for each of 4096 incoming channels, the simple pulse-height sorting of the previous example cannot be used. Instead, incoming data is simply stored sequentially, one datum per word, in a 1536-word buffer. When full, this buffer is automatically dumped on tape.

The obvious disadvantage of this system is the much increased amount of tape necessary and the longer time to process it. The CDC-6600 is used to transform tape records of this type into ones similar to those obtained with the 2048-channel program above.

This disadvantage is partly compensated for by the fact that it is possible in effect to store two complete spectra at the same time; in this case the incoming spectrum composed of the stabilization peaks can be separated from the spectrum of the mesic-produced x rays. This is done by marking each datum from the stabilization spectrum with a preceding 7777. Thus, whenever the analysis program encounters a 7777 datum, it ignores it and assumes the following datum is part of the stabilization spectrum.

Oscilloscope Display

Another disadvantage is the impossibility of making an oscilloscope display out of the sequentially stored buffer. This problem was solved by using a separate 512-word buffer for the oscilloscope, and pulse-height sorting incoming data into it at the same time the data were being stored in the sequential buffer. This presented another difficulty, however, since 1-channel resolution of the spectrum on the oscilloscope was necessary, which was clearly impossible if the entire spectrum were viewed at once (since only 512 of the total 4096 channels would be displayed). Three separate storage modes for the oscilloscope memory were therefore used, the first stored every eighth channel and showed the entire spectrum, the second stored each channel, but only covered one-eighth of the

spectrum, while the third showed each channel of one sixty-fourth of the spectrum, or sixty-four channels total (see Fig. 4).

In operation, it is necessary therefore to erase the oscilloscope buffer when changing from one scale to another, and let the new picture "grow" again. The data rate was, however, sufficiently fast that this was not too inconvenient. The teletype could also be used to decrease the vertical scale by a factor of 2, so that during a long run the oscilloscope display would not grow off-scale.

Programming Comparisons

The penalty paid for having separate memories for the tape buffer and oscilloscope buffer is quite severe in terms of program space and complexity. Two routines are required for storage, clearing, updating, etc., where only one was required in the 2048-channel version. Many nonessential but convenient routines for which there was space in the 2048-channel program can not be accommodated in the 4096-channel program.

III. Analysis Program

Originally it was intended that the tapes generated would be analyzed on the CDC-6600. However, it was found that the PDP-5 itself, by permitting on-line examination of the spectra from the tapes, could give satisfactory results. Previously written tape records can be read into memory (in the 2048-channel format), and any part of the resulting spectrum examined in detail.

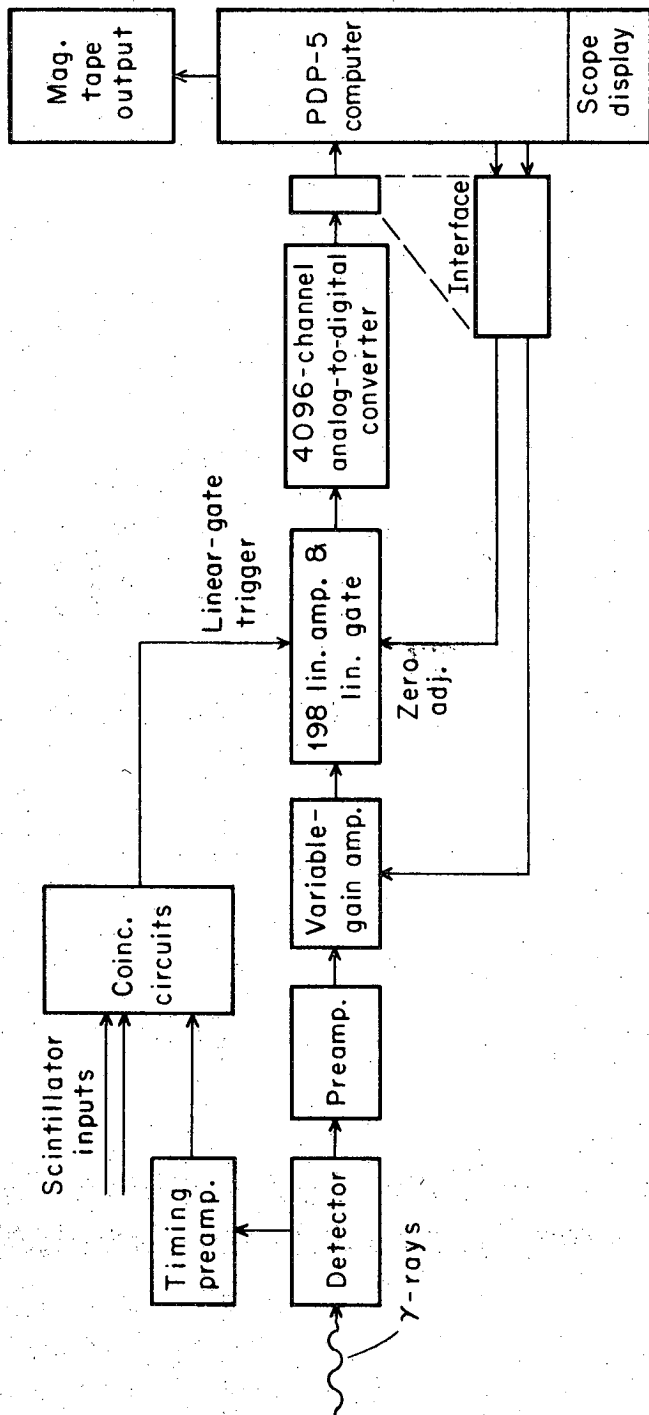
The centroid and area of specific spectrum peaks are the desired results, but the subtraction of a fuzzy background from the peak must be done before the calculations are made. To simplify the definition of the background, a light pen is used to draw in vertical lines bounding the peak, and a line connecting them for the background (see Fig. 5). Arithmetic routines then perform the area and centroid calculations, printing out results in decimal notation.

IV. Summary

The programs have provided a great measure of flexibility for the experiment and facilitated making the changes necessary to meet the experiment's evolving requirements. The use of the PDP-5 for 4096-channel analysis shows that it is not necessary (although certainly it is preferable) to be able to reserve one memory word for each incoming channel.

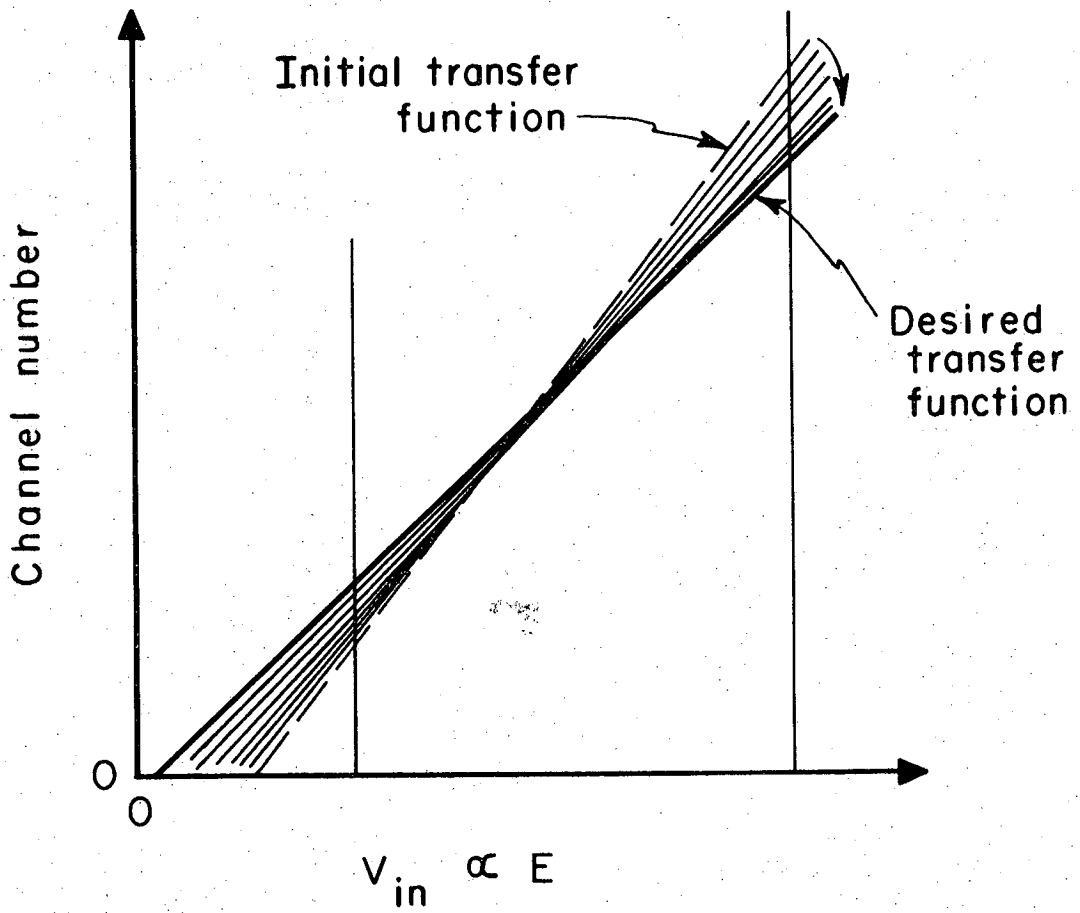
FIGURE LEGENDS

- Fig. 1. System block diagram.
- Fig. 2. Stabilization process.
- Fig. 3. Feedback block diagram.
- Fig. 4. Oscilloscope scales, 4096-channel program.
- Fig. 5. Oscilloscope display of spectrum peak. analysis program.



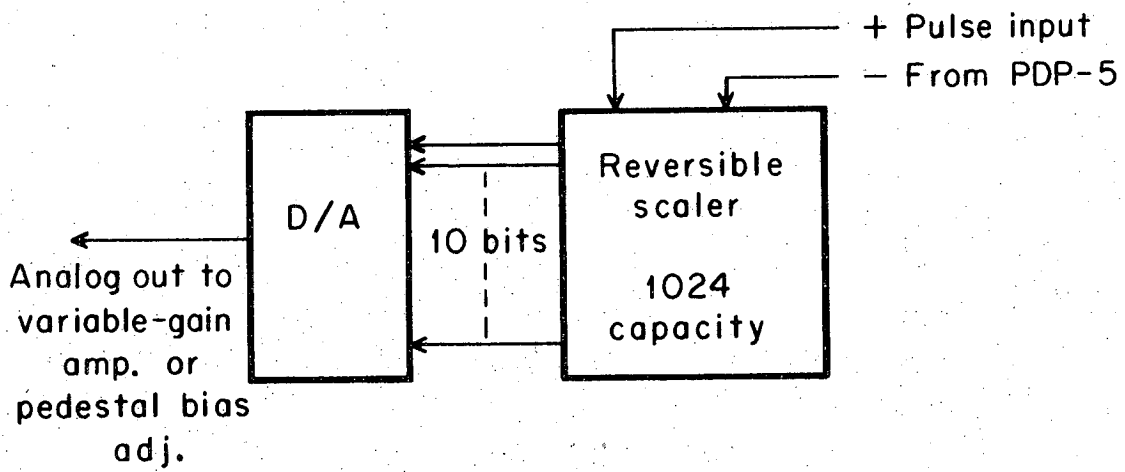
MUB-13721

Fig. 1



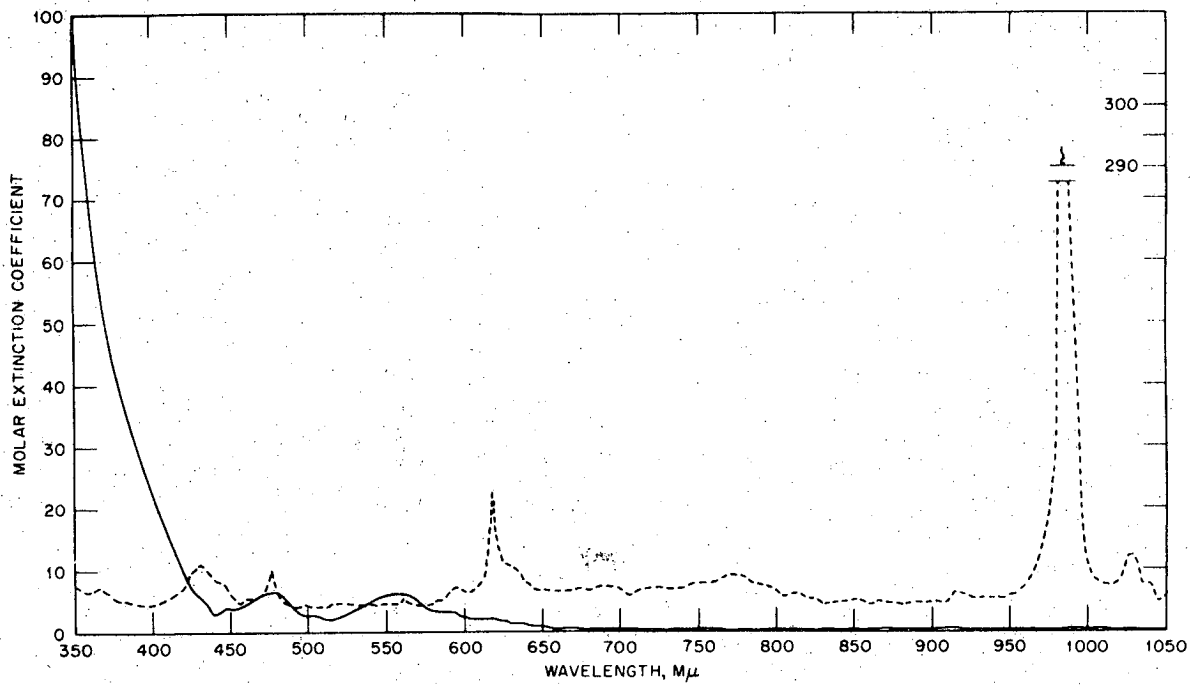
MUB-13722

Fig. 2



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Fig. 3



MU-10959

Fig. 4

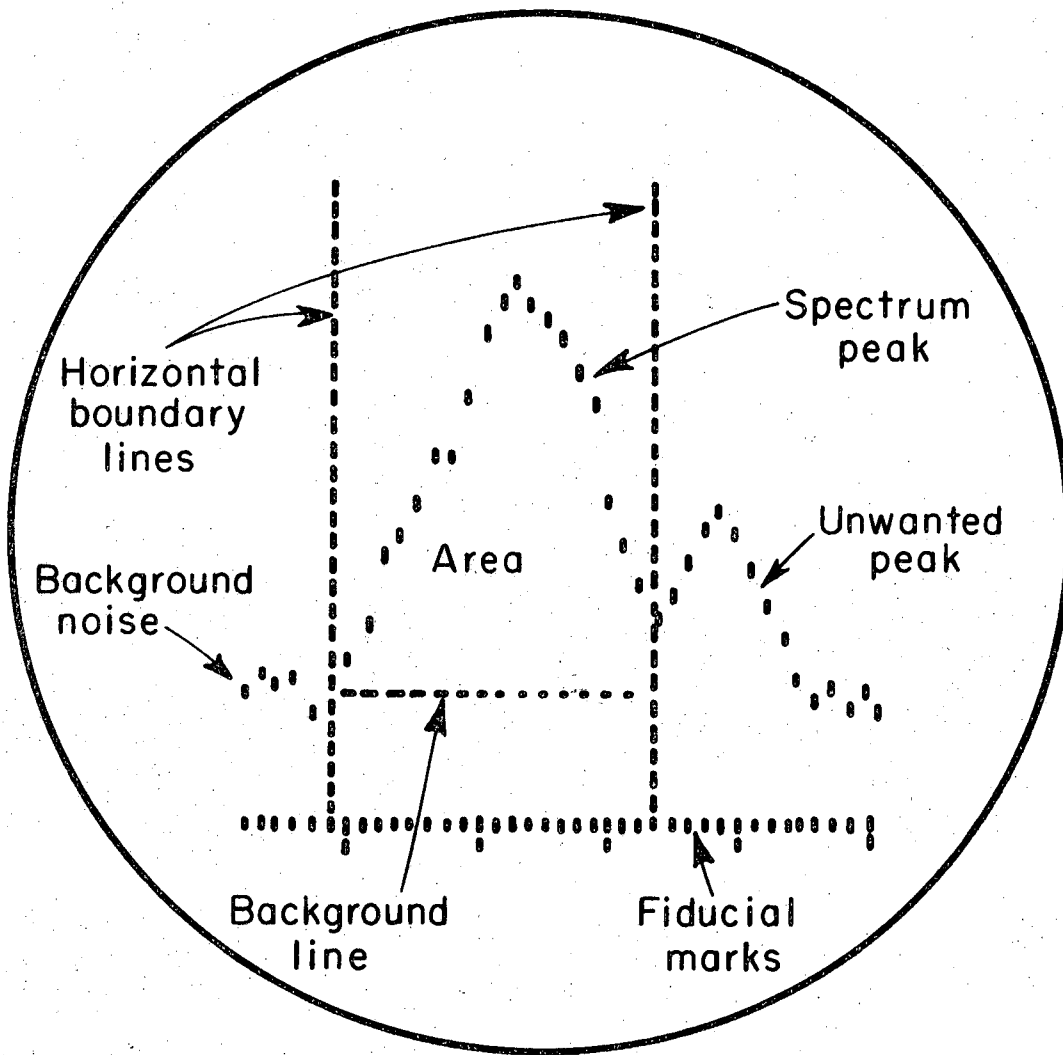


Fig. 5

MUB-13724

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