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A DATA ACQUISITION SYSTEM FOR ACCELERATOR MASS SPECTROMETRY

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ABSTRACT

A single and dual parameter data acquisition, ion beam measurements and control system for accelerator mass spectrometry is described. The system hardware has been constructed with the advantage of the lower cost and higher reliability. It is provided with varieties of functions such as selecting acquisition mode carrying out the multiple display, analyzing data and especially viewing isometric spectrum at different directions. It can also be used for ordinary nuclear spectrum system.

Key words: Accelerator mass spectrometry (AMS) Single and dual parameter data acquisition Nuclear spectrum Isometric display Data analysis

Ⅰ. INTRODUCTION

Accelerator mass spectrometry (AMS) is known to be ultrasensitive for measurement of the cosmogenic long-lived radionuclides. It has the advantage of high sensitivity (about 10^{-16}), less sample quantity (nearly undamaged analysis), and high efficiency. Since 1977 great progress with AMS technique has been made. Now a number of radioisotopes such as ^{14}C, ^{10}Be, ^{36}Cl, ^{26}Al, ^{129}I and ^{41}Ca, have been measured by AMS method. These isotopes as tracers or for dating purposes have been widely used in studies of geology, oceanography, hydrology, climatology and archaeology.

Supported by the National Natural Science Foundation of China, an EN tandem AMS facility is being set up at Peking University[1-3]. As a part of the project a data acquisition and control system based on an IBM PC/XT has been designed. It mainly consists of a single and dual parameter controller built in a NIM module and interfaces inserted in the slots of the computer for data acquisition and ion beam measurements. Its software functions and analytical programs are very powerful, not only for AMS, but also for conventional nuclear spectrum systems. The system can be well kept synchronoscopely with other parts of AMS and used flexibly as well as conveniently.

Ⅱ. SYSTEM CONSTRUCTION

In ordinary the AMS system is composed of a sputter ion source used for radioisotope sample measurements, a low energy injector, a tandem accelerator, a high energy analyzing system and a δ E– E counter telescope to which the single and dual parameter data acquisition system is responded. To determine isotopic ratios accurately, alternating injection of ^{12}C, ^{13}C and ^{14}C is used. The stable isotope currents are measured with an ion beam integrator at the low– end and image Faraday cups then read into the computer by the counting interface. The radioisotope and some interference enter the detector at the end of the beam line and go to the controller via the electronic system, then arrive at the computer from the interface. The layout of the hardware is shown in Fig.1. The timer is used for synchronizing operations of various parts of the AMS system.

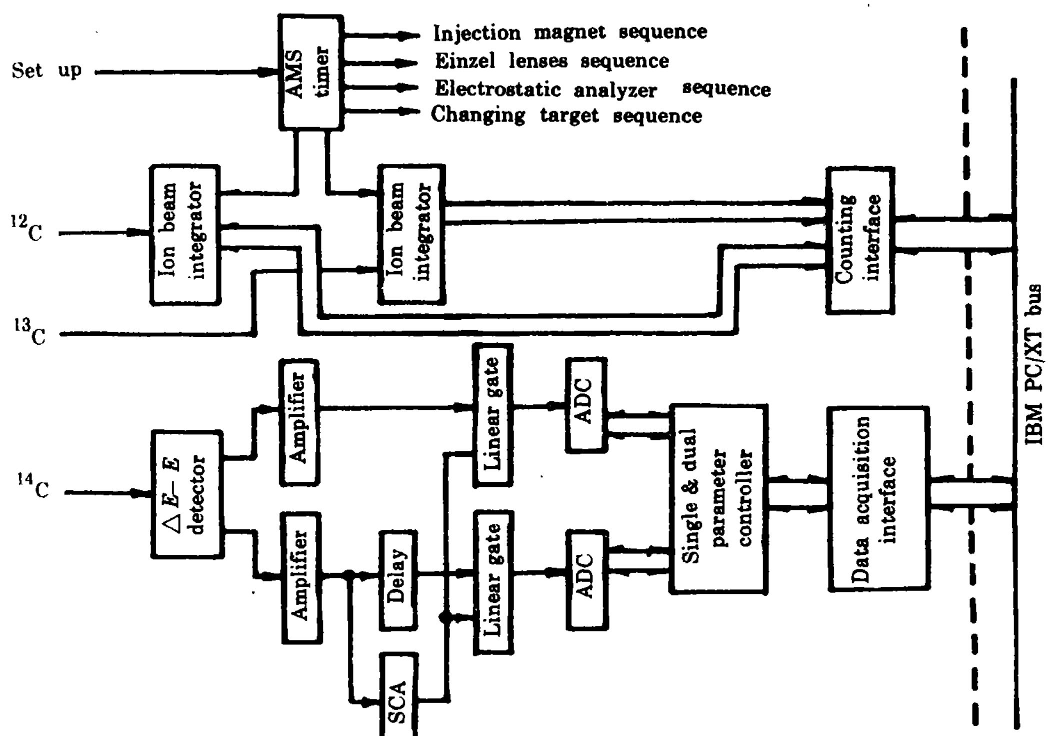

Fig.1 System hardware

The ion beam measurements and radioisotope data acquisition are grouped into cycles and sequences. One complete cycle consists of starting, waiting for steady current following a magnet change, maximizing the ion beam in the Faraday cup, probing ion beam measurements, reading the counting into the computer, acquiring data of ^{14}C for a fixed time, saving data on the disk, then changing the target and restarting another cycle. These sequences are produced by an AMS timer which is constructed with a TP801 single board microcomputer and some I/O circuits. It is necessary to spend some time in changing target. During this period we can make use of computer to analyze data and print consequences in a certain format. Under the control of the timer sequences, after the counting of ^{13}C has been finished and read into the computer, data of ^{14}C are immediately acquired on the interruption mode, at the same time the ion beam of ^{12}C is measured and counted. The spectrum of ^{14}C can be displayed with the single/dual parameter mode and multiple functions can be selected online. The logical circuits of the controller and data acquisition interface are shown in Fig.2.

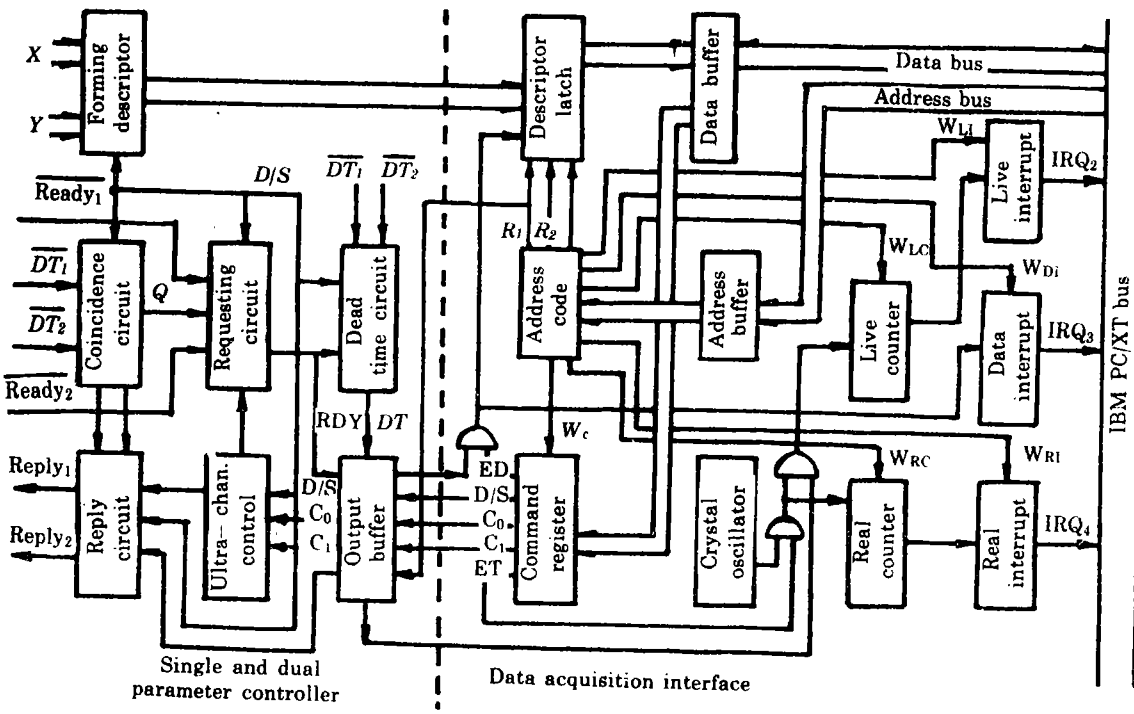

Fig.2

The code D/S determines the dual/single parameter acquisition mode and affects operations of various parts of the controller. In the case of dual, when the leading edges fo two ADC's dead time signals ($\overline{DT_1}$ and $\overline{DT_2}$) fall in the coincidental window, the output Q turns logical 1. As long as ultra– channel is not occurred, the ADC's memory requests $\overline{Ready_1}$ and $\overline{Ready_2}$ will construct final signal RDY which is sent to interface and formed an interruption request and the descriptors latch signal with the code ED being equal to 1. In the interrupt service routine the ADC's descriptors can be read up to three times. The first reading signal R_1 is considered to be a reply to ADC. At no coincidence, $Q=0$, RDY can't be produced, and coincidence circuit directly gives reply to corresponding ADC. The ultra– channel signal sends reply to ADC as well. To obtain the live time, total dead time $\overline{DT}$ is formed by adding ADC's dead time to acquiring time The codes C_0, C_1 determine acquisition scales (such as

512 * 256, 1024 * 256 in dual and 256, 512, 1024, 2048 etc. in single). Code ET is a time permission signal. At the single mode, coincidence circuit is not active, Q = 0, RDY is produced only by $ready_1$ and $reply_1$ to ADC_1. Other signal W_{LC}, W_{RC}; W_{LI}, W_{DI} and W_{RI} are produced by writting a certain port and used for clearing related signals. W_C is the writting command strobe.

The feature of the hardware as shown in Fig.2 is convenint, cheap, reliable and satisfacrtory for the middle counting rates.

Ⅲ. SOFTWARE SPECIFICATIONS

The 8086/8088 assembly language is used for data acquisition, ion beam measure– ments, system control and multiple function display. Some data analyses are carried out online with co– processor 8087 assembly language so that the running speed is very quick.

1. Single parameter mode

The Fig.3 shows the main control flowchart in the single mode. Each function is briefly written on the screen so that the user can see it clearly and operate conveniently.

The two removable cursors represented by LC and RC are used for setting multiple regions of interest (ROI), Indexing and deleting ROI, calculating peak parameters such as peak centroid, *FWHM*, gross and net areas and standard deviations, relative errors, calibrating energy and also for expanding and contracting display. The display channel interval can vary from 64 to 2048 (it can do more than that). In the horizontal two variables corresponding to pixel change and channel step are used for drawing various spectrum on the screen ranged in 512 points, and in the vertical a count between 0—65535 is presented with maximum 128 dots so that the spectra looks very realistic. When data acquisition is being carried out, the dots grow up gradually and are adjust on the vertical full scale (VFS) automatically or manually according to the linear or logarithmic operations.

The data acquisition can be asynchronous or synchronous with the operations of the AMS system, and it can run at multiple modes.

2. Dual parameter mode

In the dual parameter mode the two– dimension map and isometric display are available. Again the two cursors are used for setting rectangular ROI, expanding and contracting two– dimension display, finding the parameters of ROI. The map mode (contour mode) is suitable for online situation and it is seen to be four colour dots representing four kinds of counting. The display can be divided into 512* 256, 256* 128, 128* 64, 64* 32 with the scale values written on the axises ranged in 256* 128 points. These modes and VFS values can be changed dynamically by pressing

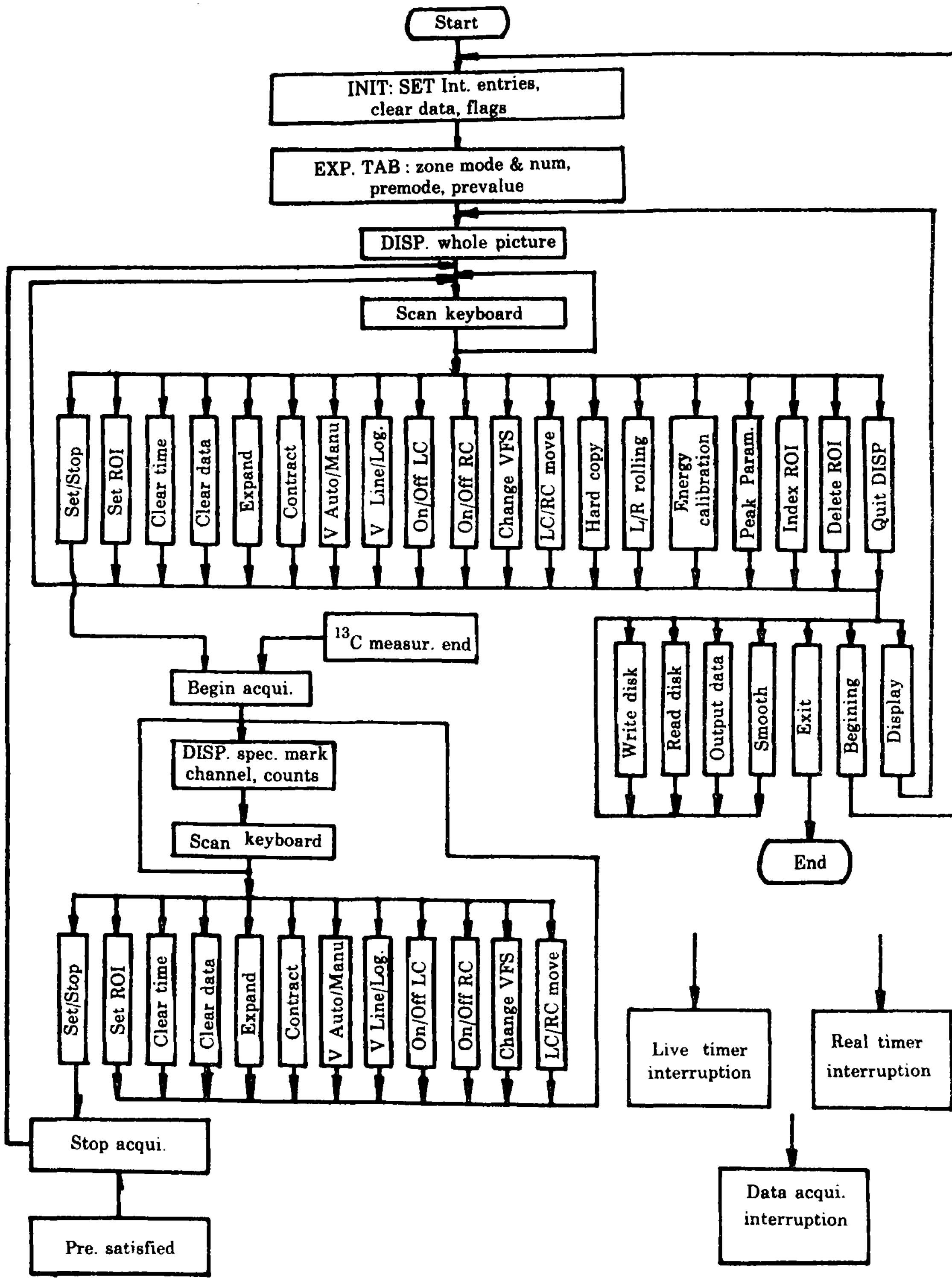

Fig. 3 Main control flowchart

Single parameter mode

certain function key.

The isometric display is sophisticated and it has the advantage of intense stereoscopic perception. The stereograph can be rotated quickly through four different directions at the interval of angle 90°. Under each situation the cross or longitudinal section can be plotted at the stereographical position of its own, and the data can be projected on the front and side of the cube respectively. Thus we can clearly see the single parametric spectrum and its change with another parameter. The projection drawing helps us to understand how the data are distributed in the certain orientation.

The expanding function makes a spectrum be viewed in detail. The display processes are very quick and refreshing time is very small because of the direct access to the graphic memory. The software also makes the measured spectrum $\delta E - E_r$ be converted quickly into $\delta E - E_t$ or vice– versa. Here E_r and E_t are refered to residual and total energy respectively in the detector.

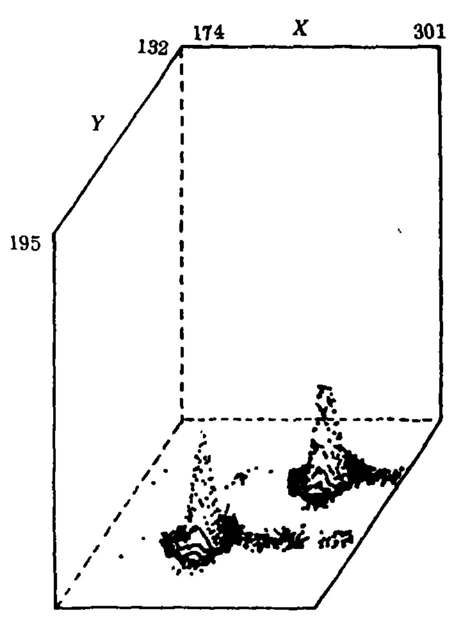

Fig. 4 Isometric display

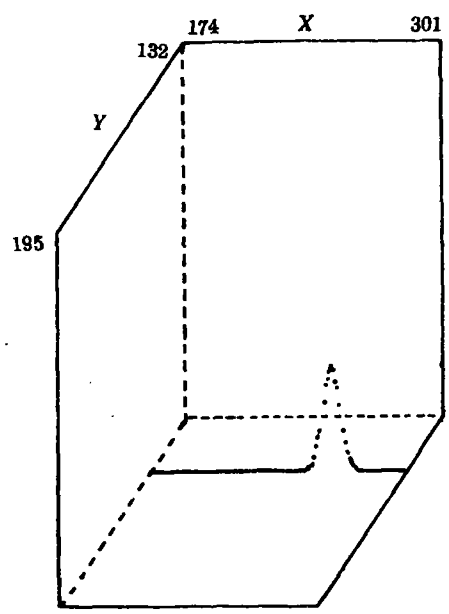

Fig.5 Cross section

F1 Quit F2 ROI(S/C) X: 198, 246 Y:157, 179 Sum = 139717 Max = 2313 x = 224 y = 172 F3 Xsec ty = 151 for Fig.5 F4 Ysec tx = F5 Expand 1:X 2:Y F6 Contract F7 Vinc VFS = 8192 F8 Vdec F9 LcMov Lc = 0 x = 225 y = 162 for Fig.4, 151 for Fig.5 F0 RcMoV Rc = 0 x = 246 y = 179 V: ChXYPosi W:ChYDirect X: Xcom Y:Ycom P: Pri.Screen

Fig.4 shows the stereoscopic spectrum produced by a simulated dual parameter generator[3]. On the picture, apart from the comments of the various functions the isometric display is marked by two parameters X, Y and its channel intervals. The two intervals can be changed independently. Fig. 5, 6, 7, 8 show the various pictures.

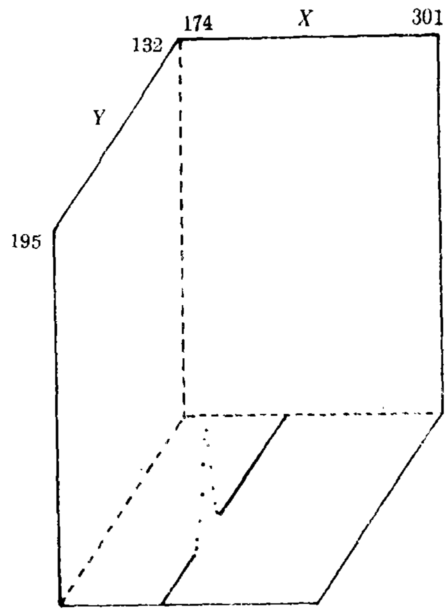

Fig.6 Longitudinal section

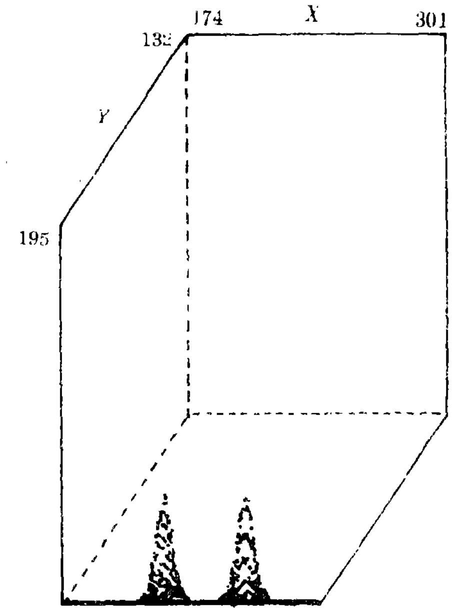

Fig.7 Projection drawing

F1 Quit F2 ROI(S/C) X: 198 246 Y:157, 179 Sum = 139717 Max = 2313 x = 224 y = 172 F3 Xsec ty = F4 Ysec tx = 225 F5 Expand 1:X 2:Y F6 Contract F7 Vinc VFC = 8192 F8 Vdec F9 LcMov Lc = 1 x = 225 for Fig.6, 205 for Fig.7 y = 183 for Fig.6, 145 for Fig.7 F0 RcMov Rc = 0 x = 246 for fig.6, 269 for Fig 7 y = 179 V: ChXYPosi W:ChYDirect X: Xcom Y:Ycom P: Pri Screen

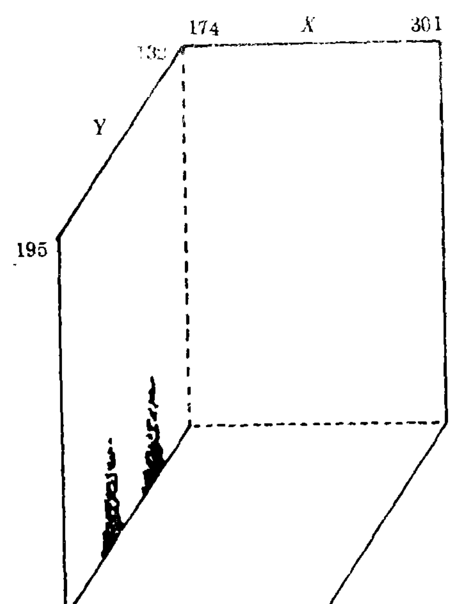

Fig.8 Projection drawing

F1 Quit F2 ROI(S/C) X: 198, 246 Y:157, 179 Sum = 139717 Max = 2313 x = 224 y = 172 F3 Xsec ty = F4 Ysec tx = F5 Expand 1:X 2:Y F6 Contract F7 Vinc VFS = 8192 F8 Vdec F9 LcMov Lc = 0 x = 205 y = 145 FORcMov Rc = 0 x = 269 y = 179 V: ChXYPosi W:ChYDirect X: Xcom Y:Ycom P: Pri.Screen

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