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NBN: A FAST, LOW COST, MINI DATA ACQUISITION SYSTEM FOR NUCLEAR PHYSICS

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Abstract

A multiparametric data acquisition system, based on VME system and Macintosh desktop computer, has been developed as an evolution towards smaller size (few tens of raw parameters) nuclear physics experiments of an acquisition system implemented for heavy ion induced nuclear reactions (few hundreds of parameters and high counting rates) using VME, CAMAC-FERA modules and middle size Work-Station (as Digital alpha station and/or HP WS).

The system acquires data from VME ADCs, processes and stores them on a SCSI storage media (EXABYTE or DLT unit).

The block diagram and the main features of the system and its friendly user interface will be described.

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1 - INTRODUCTION

NBN was developed to acquire data at NABONA (Napoli - Bochum - Nuclear Astrophysics) experiment at Tandem TTT3 of Dipartimento di Scienze Fisiche Università Federico II in Naples.

2 - SYSTEM FEATURES

The system, sketched in Fig.1, is composed of a data read-out, processing and storing unit and of a user interface unit.

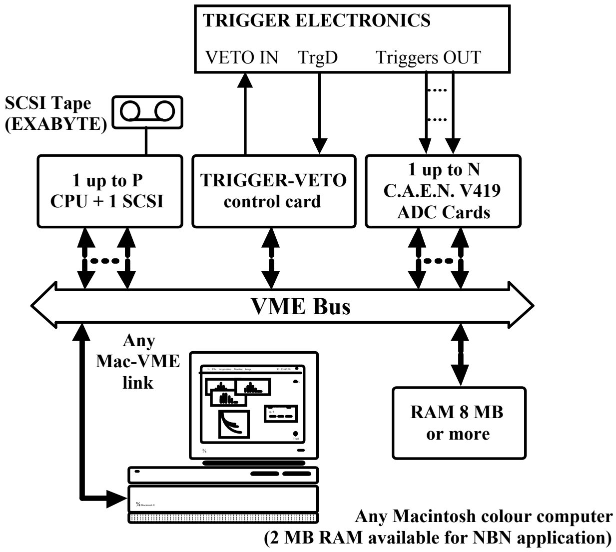


Fig. 1. NBN system schematic.

The data read-out unit consists in a VME system equipped with 1 or more 680X0 processor board, 8 MByte or more RAM memory card, 1 up to "N" C.A.E.N. V419 ADC cards (where N depends only on VME free slots available and on user's need), and a very simple, home-made, trigger-veto control card. Furthermore a SCSI interface is required to allow the data storing on a tape storage unit like EXABYTE. More than one process runs on VME CPU or CPUs. Each one takes care of one task, so there is a process for ADC read out, two different processes to build the 1D and 2D histograms, a different one to store data onto mass storage unit etc. The processes are organized into a chain. Each process works on its current buffer of data then it hands down these data to next process into chain and begins to work on new data. This organization makes the system "scalable", in other words it makes easy to configure systems with one or more than one CPUs and to insert a new process into the processes chain for a new different task.

The second unit is a Macintosh colour computer equipped with 2 MByte RAM available for the user interface NBN application and System 7.0 (or higher) Macintosh operating system version. As Macintosh-VME link it is possible to use an ETHERNET TCP/IP (socket based) link or any other hardware interface like Macintosh-GPIB-VME or like the Nubus MICRON-VME MacVEE by Bergoz. Presently our implementation uses, as Macintosh-VME link, the MICRON-MacVEE interface.

The user interface is represented by a single Macintosh application, that only requires 2 MByte of RAM, by means of which the user can control all operations of the system, can display and handle the histograms, can perform ADC setup, can define new histograms and so on. The main features of this user interface are the intuitive interaction user-system and the full trasparency of all low-level operations, like the setup of all system components. Furthermore, by means of activation/deactivation mechanisms of options (menu items, button, etc.), the interface is able to prevent the user from operate wrong actions and its fully hierarchical organization allows the user to start an acquisition run by means of only one mouse action since the system power on. The main key-word we followed when we was developing the NBN system was "DEFAULT" that means the user can use entirely the system without any training to do.

3 - TRIGGER ELECTRONICS SETUP.

The NBN uses the C.A.E.N. V419 4 channels peak sensing ADC VME cards. These ADC are equipped with an independent trigger line and RTP (Rise Time Protection) function for each ADC input but "BUSY" and trigger VETO functions are missing. So a simple "home-made" VME card (Fig.2) is used to provide for VETO to external electronics and to allow the read-out process to sense the trigger occurrence to perform the read-out and event building .

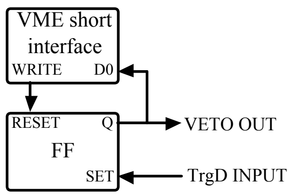


Fig.2 Trigger-VETO card.

In Fig.3a and 3b are sketched two typical trigger configurations.

In Fig.3a the external electronics provide for a “master” trigger. A trigger occurrence sets a bit into the Trigger-VETO card. This bit is routed to VETO OUT. The read-out process also checks this bit to start read-out cycle at trigger occurrence. After reading from all ADC the read-out process removes the VETO by writing into Trigger-VETO card register and the system is ready to acquire a new event.

Fig.3b represents a more complex case. The external electronics provide for individual triggers to each ADC card and/or to each ADC channel.

Since the Trigger-VETO card generates a VETO signal as soon as a trigger signal reaches the TrgD input an external delay is needed to allow to keep a time window for trigger acceptance before the VETO occurs. A timing diagram is reported in Fig.4.

The first leading edge of OR triggers opens the "Time Window" for acceptance of valid triggers. After a delay this OR signal reaches the TrgD input and VETO signal is generated to close the "Time Window".

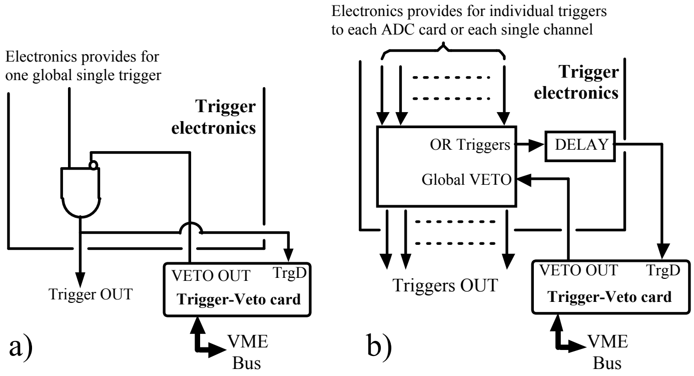
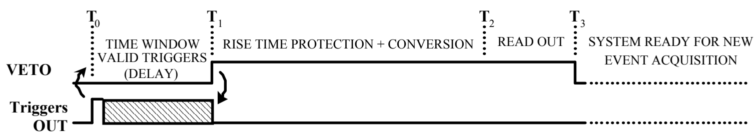


Fig. 3. Trigger electronics examples.

From the time T_1 instant the read-out process waits for RTP and conversion time, at T_2 it starts the read-out of all ADC into system then, at T_3, it removes VETO signal.



T0 : first trigger occorrence (first leading edge of OR Triggers)
T1 : after delay the first leading edge of OR Triggers reaches TrgD input
T1-T0 all triggers in this time interval are accepted, the width of this interval is setted by mens of a delay into external electronics
T2 : after RTP ADC internal GATE and completion of ADCs conversion, a CPU process starts read out from ADCs.
T3 : read out completion : the CPU process remove front end VETO by writing into Trigger-VETO card register.

Fig.4. Trigger, conversion and read-out cycle.

4 - THE ORGANIZATION OF THE DATA READ-OUT, PROCESSING AND STORING UNIT.

The VME system represents the data read-out, processing and main storing unit (it stores raw data, instead histograms are saved by NBN Macintosh application). The programs on VME CPUs run under OS9 operating system. Three main aspects are discussed into present paragraph : the system initialization, processes and buffers organization and Mac-VME communication.

4.1 The VME system initialization.

At system startup some tasks run to build a "System Info Table" and to allocate all the buffers that will be used by the system.

Only the System Info Table base address is fixed and known at beginning. All data and communication buffers are allocated by operating system as required by startup processes, and their address are written into System Info Table. Also, at startup, all ADC cards are searched, by means of "Bus Error" management, and related information are written in the same Table. This mechanism makes the whole system less hardware dependent, it allows hardware reconfiguration without any changes to the software. It also allows the system to perform the automatic default setup (ADC cards setup and on line analysis setup).

4.2 Processes and buffers organization.

By default six main processes (see Fig.5) run, on VME system, to perform respectively data read-out and event building, 1D histogram building, 2D histogram building, data compression (zero data suppression), tape storing and Macintosh-VME communication. All the processes except the last are organized into chain by means of related multi-event buffers. The size of each buffer depends only on RAM memory available into system.

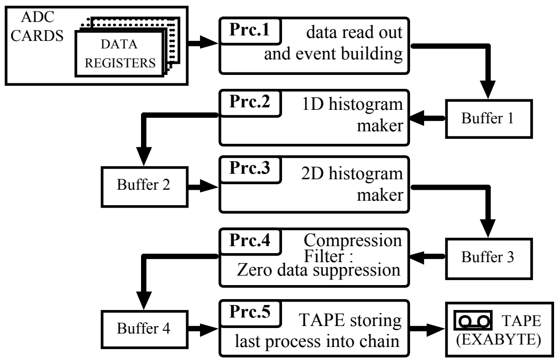


Fig.5 Processes and data buffers chain.

The first process, shown as "Prc.1" in Fig.5, waits for trigger by testing a register in the trigger-VETO card, at trigger occurrence it waits for RTP time (RTP defined by user or default value), it again waits for maximum ADC conversion time then it reads all ADC card, then it removes VETO, it builds the event by writing the data collected in the "buffer 1" and validates the event for the next process in the chain by writing an "event ready" code in the event semaphore. At this time an event read-out and building cycle is completed and the Prc.1 starts waiting for the next trigger occurrence. The simple event packing format is shown in Fig.6.

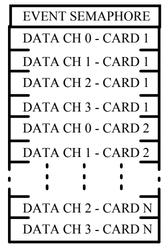


Fig. 6. Event format.

The second process in the chain, named "Prc.2" into Fig.5, continuously tests, at its current position into multievent buffer 1, the event semaphore waiting for a "block ready" code. At validation of Prc.1 the Prc.2 starts to read data from buffer 1, to build the related 1D histograms and to transfer data into buffer 2. At last it, like Prc.1, validates the event written into buffer 2 by writing the same "block ready" code into event semaphore position and releases the same event by writing a "block free" code at semaphore location into buffer 1. The other processes in the chain work in a similar way. This simple mechanism is shown in Fig.7.

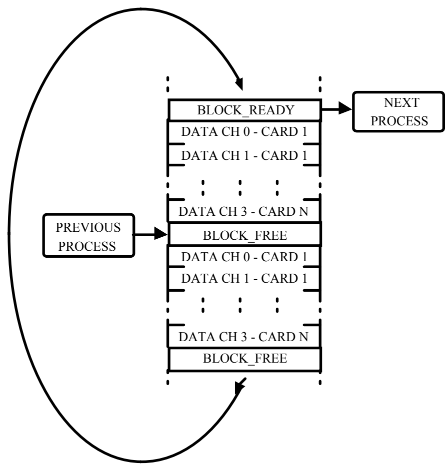


Fig. 7. Buffer management.

If there are in the system enough CPUs to allow each process to run on different CPU then the "pipelining" is effective: processes work in parallel to each other and while a process works on an event the following process in the chain works on an older event and so on. In this case the present buffer organization is fully exploited, since the CPUs we use are equipped with on board "dual port" RAM (see Fig.8). Each process works on a buffer allocated into the dual port RAM of the CPU on which it runs. Only data transfer needs VME access but semaphore tests and all data manipulation are performed inside CPU board reducing VME Bus traffic.

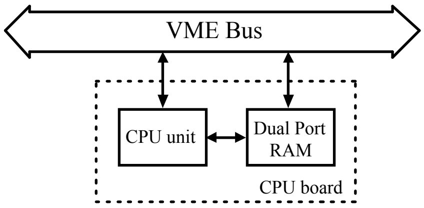


Fig. 8. CPU.

To improve the system performance the events are compressed before tape storing. The compression is ”zero data suppression" with event packing FERA like as shown in Fig.9.

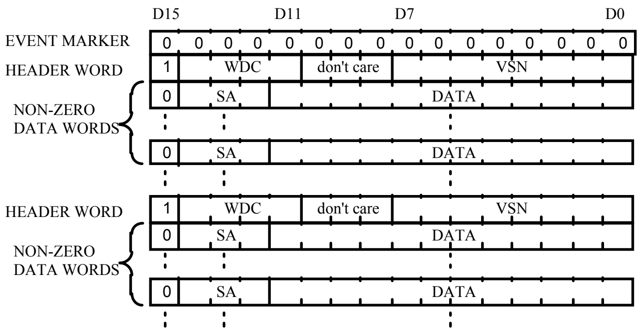


Fig. 9. Event compression "FERA like".

4.3 Mac-VME communication.

Macintosh - VME communication is performed by dedicated VME process so that it results easier to reconfigure the system.

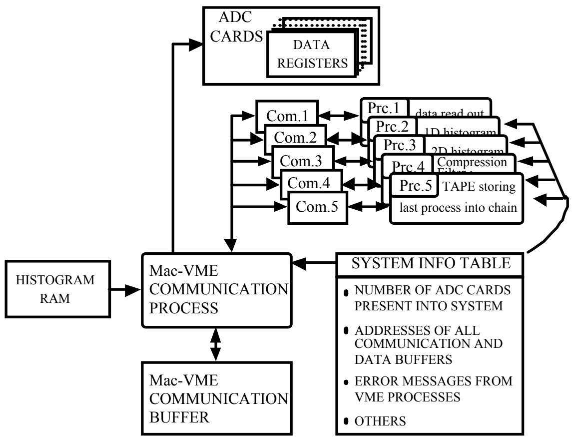


Fig.10. Macintosh-VME communication.

In Fig.10 it is sketched the organization of the communication. There the rectangles named "Com.1", "Com.2" etc. represent the communication buffers with respectively Prc.1, Prc.2 etc. The communication process performs all Mac-VME transaction as ADC setup, on-line analysis configuration and histograms reading.

5 - THE NBN MACINTOSH APPLICATION.

The program represents the user interface, fully Macintosh style, and it is organized in four menus.

Into each menu an ellipsis (...) following the text of a menu item indicates that selecting the item will bring up a dialog box that will allow to perform the action.

For example, in the menu “File” each menu item “Load setup ...”, “Save setup ...”, Load histogram ...” and “Save histogram ...” opens a window that allows the user to insert the file name for the corresponding action (load/save) on setup/histogram.

5.1 The Acquisition menu.

The Acquisition menu allows to access to three dialog boxes : the "Show Status" window and the "Control" and the "Tape" dialogs.

In the "Status" window (Fig.13) are reported informations about the acquisition status (“stopped” or “in progress”), the tape status (“enabled” or “disabled”), the events acquired in the last run, the average acquisition rate and number of run time errors.

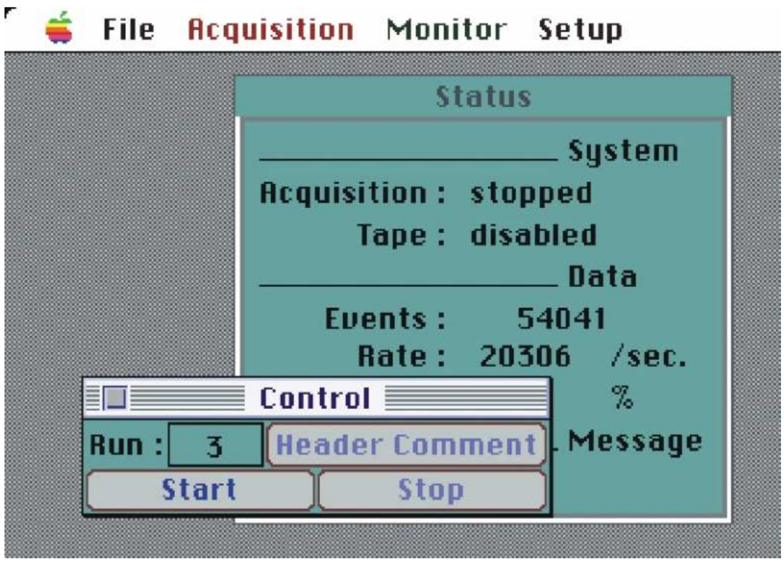


Fig. 11. The Status and the Control Dialog

With the “Control” dialog the user performs the operations of “start” and “stop” acquisition. If the tape device is ready the "Header Comment" control button opens an edit window by means of which it is possible to write a run comment on the tape. The "Header Comment" edit window is accessible through the "Tape" control panel too. By this panel it is possible to perform all ordinary operations on tape (i.e. rewind, skip and so on).

5.2 The Monitor menu.

Through the Monitor menu it is possible to access the tools for full management of on-line analysis performed by VME CPUs.

The two items "Get 1D histogram" and "Get 2D histogram" open the control panels to display the 1D and 2D histograms respectively.

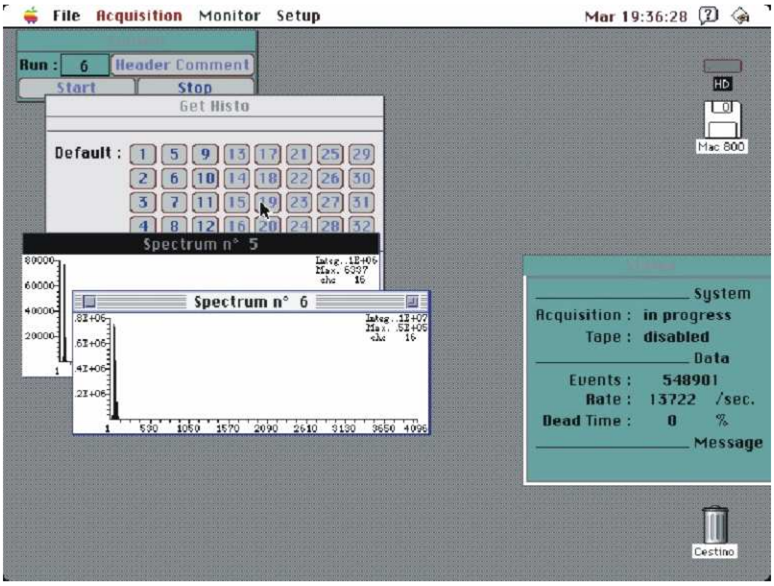


Fig 12. Get 1D Histogram Dialog

In the "Get Histogram" panel, shown in Fig.12, only 12 control button are active. This is the case in which, at startup, the system automatically found only 3, 4 input, ADC cards present into the VME crate. The action on a button opens the respective histogram as shown in the figure.

The action of the mouse pointer at right-bottom corner of a histogram window allows a resize of window without any restriction (Fig.13).

In order to handle the histograms it is necessary to open the "1D histogram handler", the fourth menu item into Monitor menu.

Fig. 13. Sizing the histograms windows

The handling is performed, in very easy and intuitive way, by means of mouse action into histograms windows and into “Histogram Handler” panel (Fig.14). If more than one histogram is present on desktop, to select the histogram to handle one has simply to click into the respective histogram window: the histogram handler automatically recognizes the desired histogram.

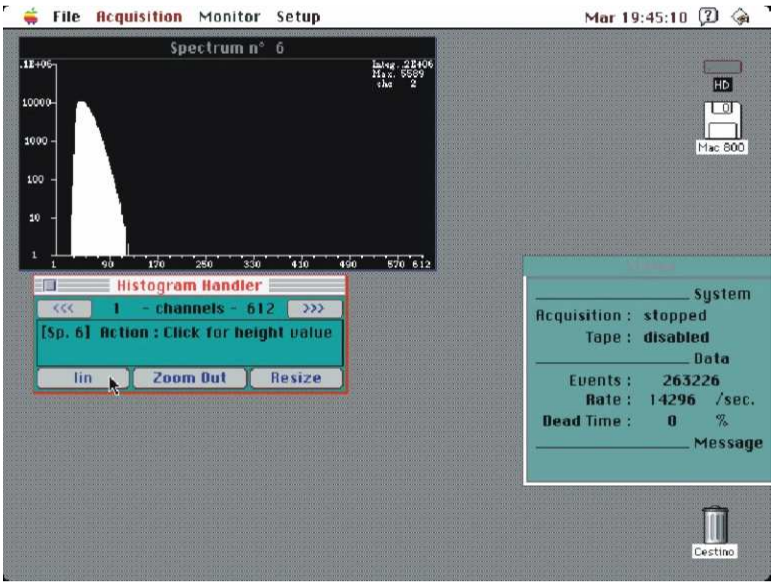


Fig 14. The Histogram Handler

In the same way, the “Get 2D Histogram” panel and the “2D Histogram Handler” allow to open and handle 2D histograms (Fig.15).

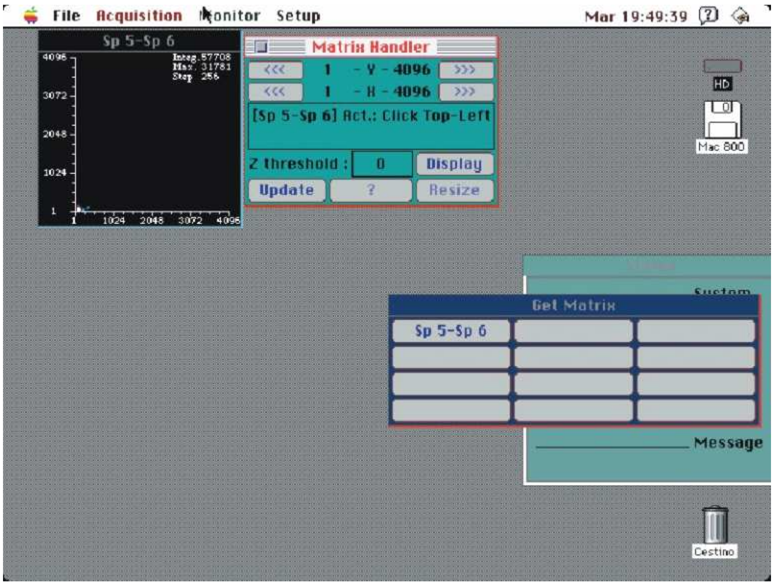


Fig. 15. The Get 2D dialog

At the startup the system automatically builds the default on-line analysis setup to send to VME CPUs. It defines the 1D histogram for every ADC input line present into the system. The system also builds the setup for one 2D histogram. By default this one is the 2D histogram of ADC input 1 and ADC input 2 (respectively as the X and Y component).

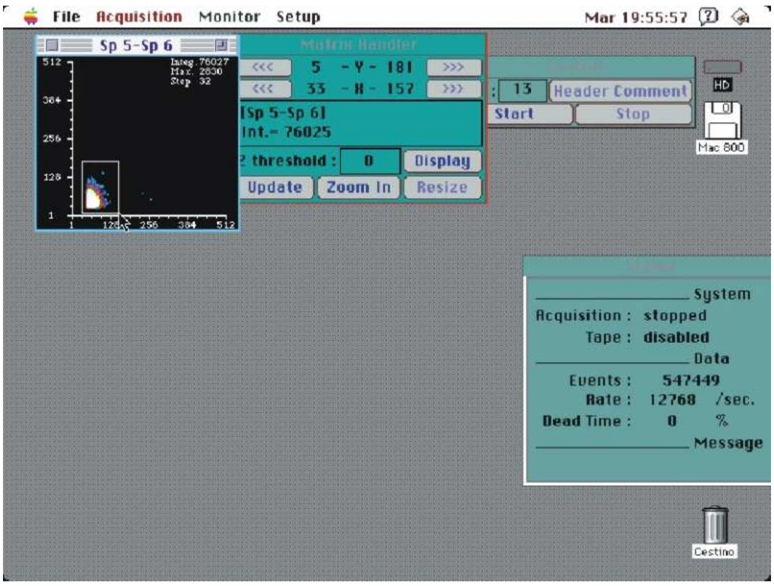


Fig. 16. Zooming a 2D histogram (before).

In Fig.16 it is shown the case in which the user is selecting a region (the “Zoom In” action becomes available and the integral on the counts into the selected region are shown) and, by clicking the mouse on “Zoom In” button, zooms the region (Fig.17).

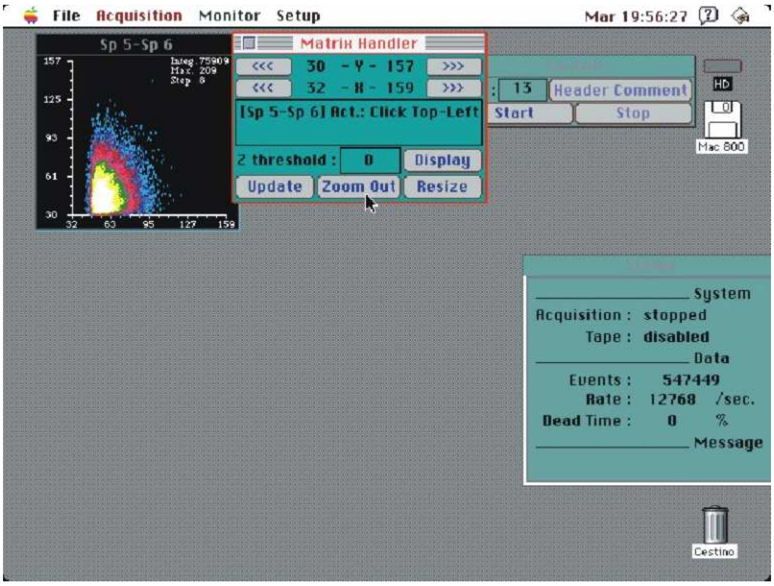


Fig. 17. Zooming 2D histogram (after).

All the histograms are built by VME on-line analysis CPUs into a VME memory card. When the Macintosh application opens a histogram or when the user acts on "Update" button into handler panels, the histogram content is loaded from the VME memory card. It is possible, by means of the "Auto update period" dialog box, to enable the application to perform by itself and periodically this update for all histograms opened.

5.3 The Setup menu.

Through the "Setup" menu it is possible to customize the setup of the system.

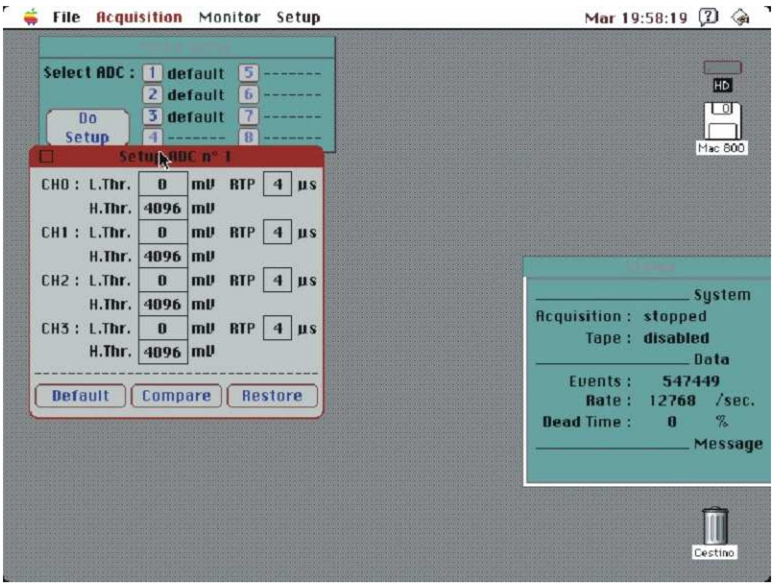


Fig. 18. The ADC Setup dialog.

The first menu item allows to open the panels to modify the setup of each ADC present into system (Fig.18). The second menu item of “Setup” menu opens a dialog by means of the user cans define new 2D histograms (Fig.19).

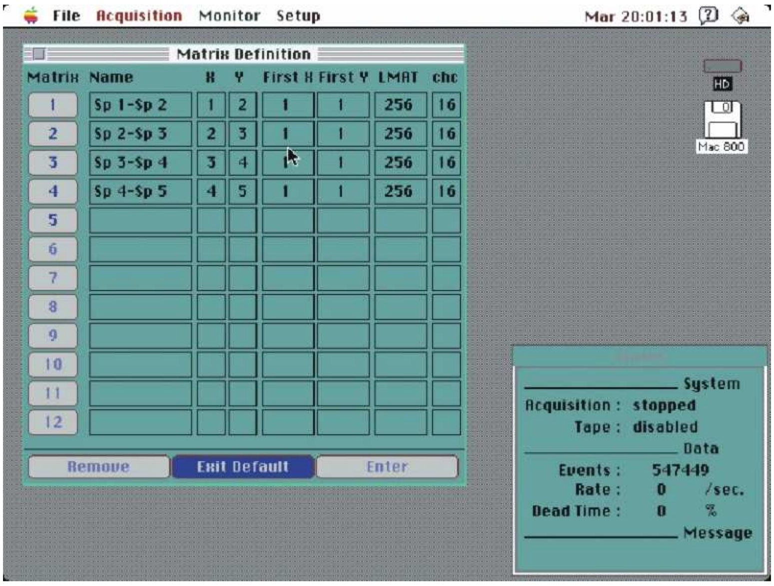


Fig.19. The 2D histograms definition dialog.

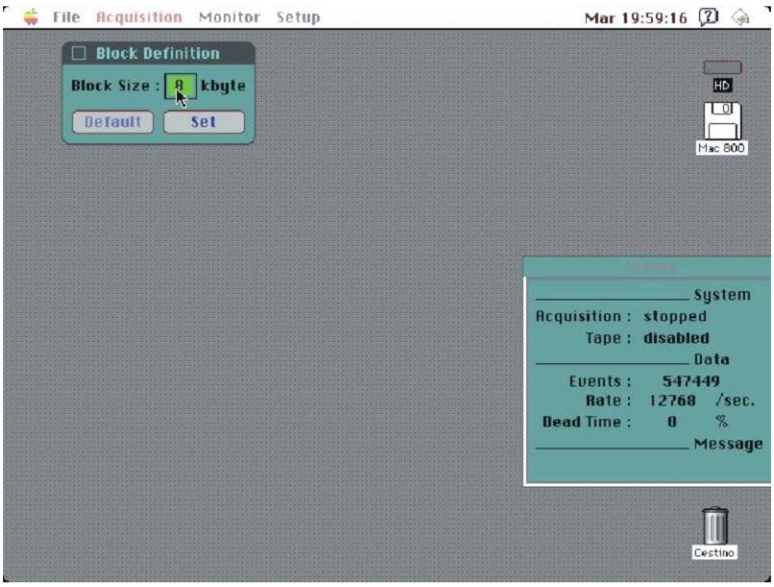


Fig. 20. The tape size block definition dialog.

The last menu item is to change the block lenght for tape storage (Fig.24).

CONCLUSIONS.

The NBN system is currently used at TTT3 Tandem laboratory of the Università degli Studi di Napoli Federico II for all the experiments requiring a multiparametric acquisition, like AMS (Accelerator Mass Spectrometry) and Nuclear Astrophysics experiment.