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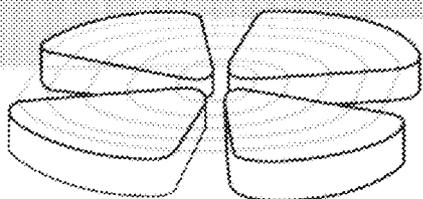
ACQUISITION & DISPLAY OF BEAM PROFILERS

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The ion beam adjustment requires the knowledge of its shape (its profile) that was provided until now by an analogic reading through Camac interfaces and displayed on oscilloscope screens in the main control room. For weak signals, very long integration time was necessary, and as only one plan was acquired at each top of clock, a gap in time happened when 8 profiles where displayed together.

No numerical values were available and therefore it could not be used by tuning programs for alignment or adaptation. The beam adjustment evolution on a profile could only be judged based on visual making, just as the comparison between two profiles. Moreover, the stocking of information was only made by manual photos.

A new electronic interface has been developed by the electronic group for the older multiwire profiles, while an other electronic equipment has been developed by the physics group for the gas profiles and the microchannel plates. The data from these interfaces are computed to get numerical values and profile shapes, then transmitted by the network to the main control room to be displayed (shapes & data) on every workstation, by different beam tuning programs.

1. CLIENT / SERVER PATTERN

1.1 New vme processors

The front end controllers corresponded before to a remote processor RTVAX 300, embedded in a Kinetics 3968 module, in a Camac crate connected to the network. Until now all the thirty front end controllers had the same functions, mainly driving different kinds of equipment such as motors, probes, power supplies... They are running under the VAXELN operating system, using Decnet as network protocol.

Now the new crates will be in VME standard, and some of them, such as the profile acquisition, will be dedicated to a special function.

To be able to use the same operating system and network protocol, before migrating to TCP/IP, we use AEON vme300 boards, also including a RTVAX processor.

1.2 Database

Although the management of the profiles is carried out in a much more specific way than with the other front end controllers, data totally follow the way already used in former drivers. These data, whatever their types, are integrated in the INGRES database from which, at boot time, they are extracted as files and loaded into the vme crate.

As this project is the first integration of VME in our control system, it has required the installation of the whole set of functionalities needed to manage the vme bus, added to the profiler acquisition program itself. Now these specific vme mechanisms are ready for the next installation to come (such as new power supplies and ion source devices required by the THI features).

1.3 Architecture

This project was easy to be integrated in the client-server architecture that had been defined from the beginning of the new control system. Indeed the control workstations are always clients of the camac crates in charge of reading or writing values in the equipments.

In this profile project, the acquisition and the management of numerical values are carried out by a VME crate used as a data server. This crate distributes the data through the network to every client program on a station in the control room or in the physics division. Therefore the same program can be used on different stations to get the profiles data, and several different programs (adaptation, alignment...) can ask simultaneously for different requests.

The network diagram is the following:
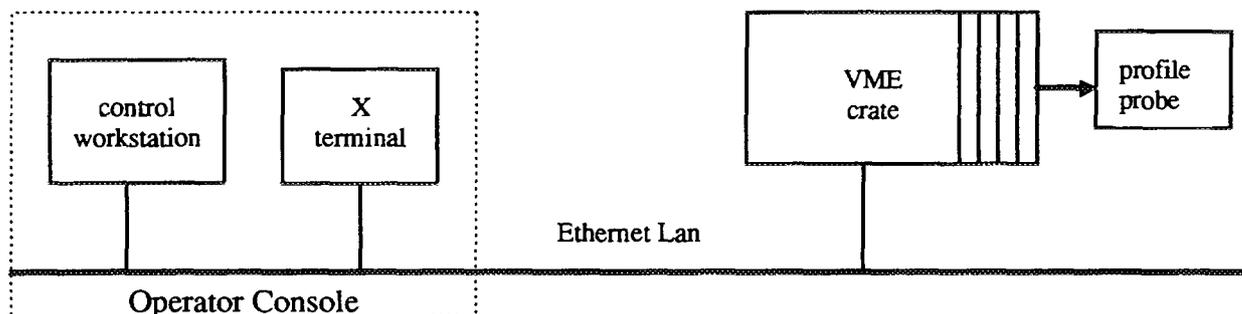
2. PROFILE PROBES

2.1 Multiwire profiles

They are constituted of a composed metallic grid with a plan of 47 horizontal wires and a plan of 47 vertical wires. The grid is located perpendicularly to the axis of the beam and each wire measures the intensity received on all its length. These profilers stop a part of the ion beam (5 to 10 %) and can't be used for high intensities.

2.2 Gas ionization profiles

They are constituted of a standard CHARPAK chamber filled with Ar-CO gas, with an horizontal and a vertical metallic grid inside with a gap of 1 mm between two wires. Each wire grid is situated between two electrodes. The beam ionizes the gas, so the positive particles are captured by the negative electrodes, and the electrons are collected by the wires. The ionization rate depends on the intensity of the beam and also on the high voltage applied to the polarization electrode (2500 V maximum).
These profilers are used with small beams intensities between 10^2 particles/s to 10^7 particles/s. They stop almost the whole ion beam and so they are moved in or out by pneumatic propellers.

2.3 Microchannel plate profiles

These detectors use the beam ionization of the residual gas, and particles are recovered on microchannel plates for electron amplification. The gap is 1mm, the high voltage (1500V maximum) and the integration time is adjustable. These profiles have a great dynamic going from 1nA to some μA and they don't stop the beam, but can easily be destroyed by too much high voltage on the microchannel plates.

2.4 Spiral scanner profiles

For medium energy beams, the multiwire or microchannel profiles cannot be used because of their fragility, neither can the gas ionization ones because the high voltage creates steering to the beam.
In cooperation with the Dubna Laboratory, new profilers are tested. They are composed of a helicoid shape wire set in a cylinder that is disposed to 45° as compared to the axis of the beam. While turning once, the wire will have covered the vertical axis and the horizontal axis, while intercepting the beam very little and without damage because of its size (1mm ∅) .

3. ELECTRONIC ACQUISITION

Three VME crates are dedicated to this acquisition that is seen as a lonely remote process. One is used for the accelerator profilers, an other is used for the experiment area beam lines profilers, and the last one is used for the special profilers (microchannel, gas ionization and spiral scanner).

3.1 VME Acquisition

The two crates used for multiwire profilers include a VME controller based on a processor RTVAX, memory interface board and acquisition boards.
Multiwire profilers are connected to the acquisition boards. Each board can manage 8 plans (4 profilers) and the crate contains 20 boards in order to access the 80 profilers of the transport beam lines. The conversion is made on 12 bits and then the acquisition is approximately carried out in 150 ms for 160 profilers plans, with an integration time ordered externally for all of them.
At each acquisition cycle, data are transferred in double access memory board, and an interruption is sent to signal that a new set of data is available for the processor.

2

3.2 Serial Acquisition

The VME crate used for the ionization gas and microchannel plate profiles contains the same vme controller and a board for serial bus access to the G64 crates involved in the acquisition.

Due to the two levels of computing, 200 ms are necessary to dispatch data up to the G64 crate, and again 200 ms to send them in the VME crate (speed 19200 bauds). As the serial JBUS line is a slave/master protocol, these times have to be multiplied by the number of profilers that are going to be read.

The four serial ports of the board are used in order to acquire several profiles at the same time.
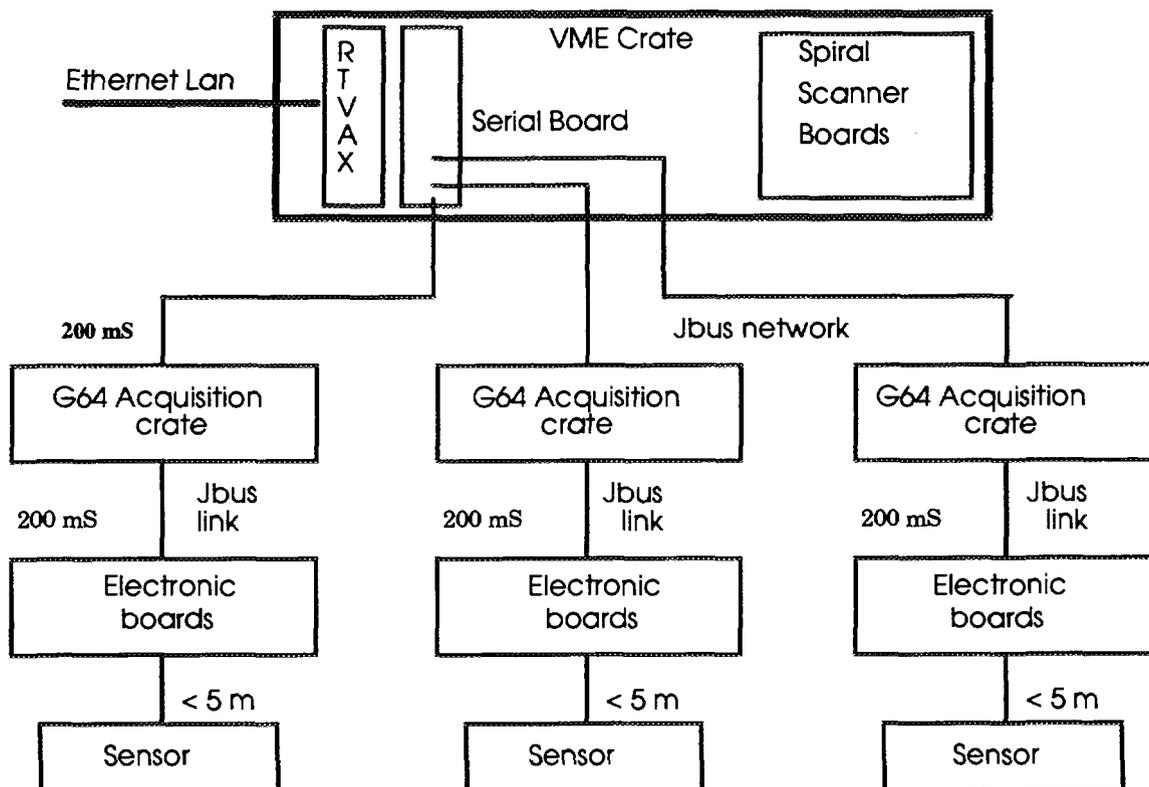
4. ACQUISITION SOFTWARE

4.1 Data Acquisition

In the control system, ADA was chosen as the common language, as well as for the workstation and the real-time crates, where the multitasking (e.g multithreading with C++) is commonly used.

The main package is built with two tasks, with also generic procedures and the starting entry for the other tasks. The first task is a loop for the acquisition of the 160 plans. The other task is the main part of the application. It reads in a mail-box, filled by the network, the names of the chosen profiles and returns values by sorting the profiles and calling adequate tasks for the different available functions.

For the ionization gas and microchannel plate profiles, a systematic reading of asked profiles is carried out by a polling program, used as a DATA COLLECTOR. When a workstation asks for a profile, the DATA COLLECTOR is scanned, so that data are immediately sent, but corresponding to a measure having taken place a little bit before. When it's a new profile which is not already in the data collector list, it is added to the list first.

A generic task was written to get or stock profile values, whatever their types. By instanciation, it becomes a task to read the multiwires and an other for the microchannel plates, using different drivers.

These tasks can be used for:

Refresh reading	a full polling cycle is made before sending
Immediate reading	reading in the data-collector
Offset reading	reading the offset value
Measure offset	a new measure of the offset average value

| Clear offset | set the offset to zero |
| First reading | new list of profiles to refresh |

4.2 Computing

Using data acquisition the ELN process undertakes some computations so as to provide numerical values to client programs on the workstations :
- gravity center.
- width at half height.
- width at the foot.
- surface

When a wire is broken, computations undertaken from measures on each wire are going to be wrong. Then it is useful to obtain a reconstituted profile by polishing the curve between the former wire and the following. This approximation will be signaled on the display, because it is necessary to be sure that the wire is really lacking and that it isn't a measure of weak value.

The electronic acquisition generates a background noise that is added to the measured signal. Therefore it is possible, when a profiler has been pulled out of the beam, to measure only the electronic noise. After, during usual measures, this offset that is stocked aside, is automatically subtracted to the values of the corresponding profile. The offset measure has to be a voluntary act (it is necessary as a preliminary to pull out the corresponding profile) because any change in the profile configuration can return offsets out of meaning. Therefore a special function exists to set the offset to zero.

4.3 Access Lists

So as to decrease the network traffic, all the means of access to the profiles crates have been made by list, to get data from several profiles at the same time.

In case of multiwire profiles, all of them are read at every acquisition cycle but only the ones asked are sent back to the client.

In case of gas or microchannel plate profiles, the only asked profiles are read by the data collector, in order to limit the JBUS line traffic.

The ADA/VMS package contains about twenty procedures that are used to read the data, clear the offset and command the integration time and the high voltage.

This package uses an other one that carries out network communication with all the different crates. If the list contains profiles dispatched on several crates, the package generates automatically a sub-list for each crate.

5. PROPELLER CONTROL

5.1 Commands

As most of the profilers stop the beam, they have to be pushed in the beam during the tuning, then pulled out after. That's why each profile is moved by a pneumatic propeller.

The control of the propellers is not carried out by the same VME crate but by other crates on the network. The display program on the stations can order them to push or pull the propellers.

Depending on the station on which this program runs, the available propeller list is different. Indeed it is not allowed to manipulate profiles that are in the beam lines from physics or experimental area workstations.

Therefore propellers have been listed by clusters and these ones are, or are not, displayed in the menus : injector 1 or 2, beam line 1, 2 or 3, exp. rooms. These menus are constituted from a database mainly used to define the different beam optics and beam paths, and depending on the workstation name.

Propellers are displayed in green if they are outside the beam, red if they are inside and yellow if their status is unknown.

It is possible to select only one propeller inside the list or a lot of them, by indicating the first and the last one, or the whole set of the list. After this selection, the menu allows to push the propeller in the beam or to pull it.

5.2 Protection

The profile shape display doesn't push automatically the propeller in the beam. The human operator must do it by himself, because it is quite difficult to know if the beam intensity won't be too high for the profile.

If it is too high, an electronic system (chopper) can cut part of the beam, but depending on the beam path and the beam parameters.

6. DISPLAY SOFTWARE

6.1 Multi-threading

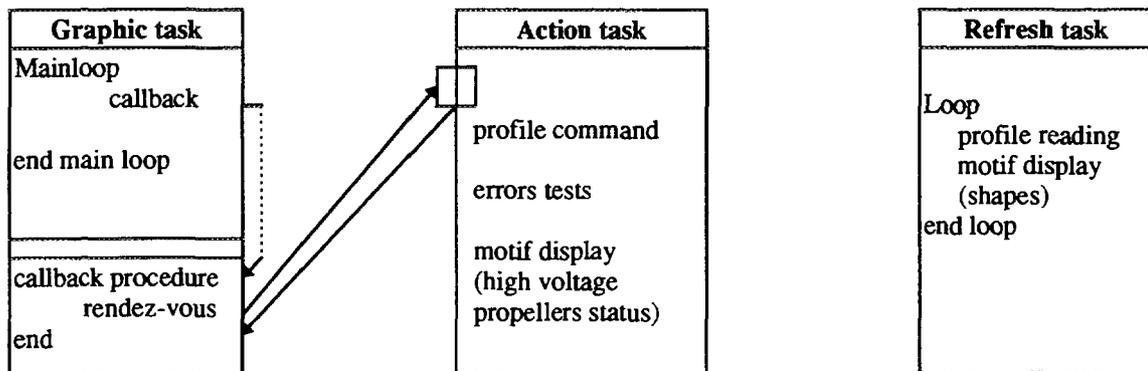As every ADA control program, this one is separated into three tasks :
- the graphic task is mainly composed of the motif main-loop, with an added delay for the other tasks to be able to run, and the motif callbacks (procedures activated by mouse clicks).
- the action task is activated by the command callbacks.
As the callbacks are run during the main loop, they cannot be used to control equipments and wait for replies, because the main loop would be in wait state and no operators clicks could be received. So the callbacks only give synchronization points called «rendezvous» to the action task that will be in charge of the equipment commands. After testing the possible errors, this task uses motif calls to display the data as numerical values.
- The refresh task is activated by only one callback
This task performs polling on the needed profiles and refreshes them on the screen, that can't neither be done in a callback.
When the first profile is chosen, the corresponding callback activates this task. After that, when a new profile is asked, the same callback adds its name to the polling list.

Graphic task	Action task	Refresh task

Mainloop
    callback
 	
end main loop
 	
callback procedure
    rendez-vous
end
	profile command
	
	errors tests
	
	motif display
	(high voltage
	propellers status)
		Loop
		    profile reading
		    motif display
		    (shapes)
		end loop

6.2 Menus

As the profilers are sometimes moved from one beam line to another, their names are not defined in the display program but in the database. The profilers are described in a tree-like structure, corresponding to the beam lines, read only at the start time of the display program.
The scrolled lists are built from these structures, in a recursive way, and when an operator wants to watch a new profile, there is no access to any disk but only in memory.
In these structures, other functions are also defined such as clustering together all the profilers used for a beam line adaptation and displaying them always in the same place.
Others specific profile characteristics are defined in the database, such as type of profile, distance between each wire, gap as compared to the axis of the beam ... .

6.3 Commands

6.3.1 Scale

In case of saturation, the graph becomes orange. The operator can modify the scale by clicking on the + and - push button on each profile. He can also use the automatic scale option, in the top menu bar to fit the profile to the maximum of the window.

6.3.2 Offset

It is necessary to be able to eliminate the background noise during measure. So, when there is no beam, the push button "offset measure" carries out a measure of noise. This measure will be subtracted from the real ones later, and the label "offset" is displayed under the shape, to mention it.
The button "clear offset" is useful when the beam intensity is very weak, not so different from the offset itself.

6.3.3 Integration time

For each profile, the current on each wire charges a capacitor, so the electronic is able to measure the voltage that will be displayed on the screens. If the current is too low, the voltage can be amplified by increasing the capacitor time charge, called the integration time.
For the multiwires profiler, the integration time is controlled by an external electronic system, but for the ionization gas and the microchannel plates, the integration time must be controlled separately for each profiler from the control room.

6.3.4 High voltage

For the gas ionization profiles, the amplification rate depends on the high voltage applied to the polarization electrode or between the microchannel plates. For these profiles, a push button in the shape display window opens a specific windows with two sliders dedicated to the high voltage and integration time control. This window is movable so as to see the result of the commands on the shape display.

6.4 Graphs & Widgets

The old oscilloscopes allowed us to see 8 profile plans, with 4 horizontal and 4 vertical.
The size of the workstation screen and its definition (1280x1024) is large enough to display 8 profiles, (e.g. 16 plans) and their associated commands in eight windows.
In each window, a push button can allocate the profile chosen by the menu. If two plans of a same profiler have been selected, then they will be displayed underneath in a same window.

A button allows to freeze in red the external shape of a profile, while its real time representation is still refreshed. The influence of an adjustment in comparison to a reference previously defined by the operator can be seen by this way.

Each profile window is divided into two parts
- A label for the profiler's name and buttons for the commands
- A graph for the profile'shape
The label and push buttons are standard MOTIF widgets but the graph is drawn with a commercial widget called XRT, from K.L group, also used in other GANIL beam tuning programs.

6.5 Numerical data

With two buttons, the graphic display can be replaced by an array of numerical values (HO for horizontal plan data and VE for vertical plan data) :
- gravity center
- integration time
- high voltage
- width at the foot
- width to mid-height
- surface

6.6 Archive storage

The numerical values and acquisition data can be saved in the database, in order to be able to restore them later during another beam tuning, for comparison by superposition with the measure in real time.
In addition to the profiler data, other relative data to the beam and the optic are automatically saved. In restitution, different sorting criterias can be used (notably the name, the date and the beam ident).

6.7 Printing

The print button in the main window opens a new menu to print either all the eight graphs of the screen, or only one profile (two plans) with its numerical data.
The print function of the XRT widget writes postscript format in a file with "print on close" attribute, to be directly sent to the printer at the end of this function.
For the profiles, the numerical values have to be written on the same page as the XRT graph.
A home-made postscript library has been developed to be called from the ADA programs and compatible with the XRT functions.
The initial procedure of this library tests a boolean notifying a completion of postscript by XRT and gets the name of the file created to transmit it later to XRT.
The text is written by the postscript routines and the file is closed without print (because of boolean). Then an XRT function opens the same file in append mode (and not in creation mode reserved when XRT is alone), writes in the file and closes it, sending it to the printer.
VMS logical names are used to dispatch the print on different printers, depending on the workstation submitting the job.

7. OTHER UTILIZATION

7.1 ECR source control

A specific program has been developed for the control of the ion sources. Beside the commands of all the source equipments, this program can display the shape of the profiler which is just at the source output.

The XRT widget is used exactly in the same way as in the common display program, so the operators can directly see the consequences of their actions on the ion source.

7.2 Adaptation

An optimization program wil be developed to tune the adaptation in the beam lines.
The operator will select the adaptation point among all those possible on the beam lines, then the 3 corresponding profiles will be displayed.
The program will control the quadrupoles magnets to have the right proportions between the three profiles.

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