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Automatic & Manual Requests of p-bar by the SPS. Description & First Appraisal.

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1)Introduction.

This note describes the piece of equipment which has been built & installed to make requests for p-bar from the CPS. The design follows the conclusions of a working party, consisting of members from the SPS & CPS divisions, which was set up to implement the proposals contained in the report SPS/AC/80-7. It is hoped that the installed system will enable the operations required for a p-bar request to develop & progress towards a standard operational procedure. To give maximum flexibility at this stage, both manual & automatic facilities for the request have been made available.

Two SPS machine development periods have been concerned with p-bar operation todate. The first occurred in July when the CPS/SPS organised the p-bar request using the intercom. In August, the second p-bar run took place & the request was made by the SPS using the new interface. Experience gained during this period will be discussed in terms of possible future developments.

2)The p-bar Request Panel.

The p-bar request panel has been mounted above the fixed target counterpart, at the top of the left-hand bay of the access console. FIG. 1 shows the layout of the front panel. It has been built as an independent module with a link from the fixed target panel containing, relevant information for p-bar requests & proton request information which is sent to the CPS. All information sent to the CPS concerning p-bar & proton requests now passes from the new panel, via a new multicore cable, through the CCR of the SPS, to building BIY opposite the PS Booster. From there, the CPS division transports the signals to their CCR. Operation of the fixed target panel is unchanged in that it completely controls the SPS proton request from the CPS.

The new panel contains status information in the form of lamps, red fault, green good; 3 request buttons for p-bar & a fast p-bar inhibit. At the right-hand side, a key is provided to select the mode of operation; manual red lamp, automatic green lamp. A strip lamp is situated below the 3 p-bar request buttons which indicates the time during which a manual p-bar request may be made.

3) CPS p-bar Operation.

The interface between the SPS & CPS machines, in terms of the modes of operation & the timing of requests, is made by the CPS PLS computer, 'program line sequencer'. This computer must be programmed according to the required usage of the CPS, i.e. AA, ISR, SPS, CPS, proton, p-bar etc. Information on the status of these machines enters the PLS computer as 'external conditions' (EC). These conditions are scanned once every linac pulse, & according to the programmed state of the PLS, decisions are made so as to optimise the use of the CPS. For example, if a request EC falls, it is possible for the PLS computer to give that particular CPS cycle to another user, called 'spare'. Apart from information arriving through the EC's of the PLS computer, it is possible for interrupts to be connected which have a much faster response time, of the order of 50 msec. Both types of inputs are used for the SPS/CPS p-bar dialogue.

The process of making a SPS p-bar request consists essentially of 2 stages. First it is necessary to inform the PLS computer of the mode of p-bar operation required i.e. number of pilot pulses, dense pulses etc. Transmission of this information will initially be made by telephone. A CPS operator will then give this information to the PLS computer. With the linking of the SPS & CPS computer networks, it is hoped to develop this stage to an automatic procedure. The second stage concerns the request itself. Once the PLS has been programmed for p-bar operation & the CPS & AA are ready, it is then possible for the SPS to make a p-bar request according to the program in the PLS computer. The timing of this request is determined by the CPS cycle & the scan time of the EC's of the PLS computer. Consider the case of 1 proton & 1 p-bar pulse, FIG. 2. The SPS cycle in this case is made up of 5 CPS cycles, each of duration 2.4 sec., giving a SPS cycle length of 12.0 sec. It should be noted that the PLS computer scan, Trace 2 FIG. 2, for a proton or p-bar pulse, takes place approximately 1 CPS cycle before the arrival time of that pulse in the SPS. This allows the PLS to reschedule the pulse if it finds that the SPS request has dropped. Bearing this in mind one can set the earliest & the duration of a p-bar request. This is shown in FIG 1 Trace 6 as being:

earliest - event 1, start of ramp + 1 CPS cycle
duration- up to event 1.

4) The p-bar Request Mechanism

In order to synchronise the request with the SPS cycle, 2 timing modules are used. These modules have been installed on the display computer & are situated in Rack 309 in the CCR. The first module, a TG2, provides a window in which the action of starting the request can be made. It is possible to program the module to start the window at a specified event plus a delay equal to the property delay 1. The width of the window is equal to the value of the property delay 2, which is set to the order of 2 sec. By using such a module it is possible to:

a) synchronise the start of the request with the SPS cycle.

b) arrange that the request always starts a set time before the arrival of the first p-bar pulse.

To achieve point b) it is necessary to know the arrival time of the first p-bar pulse. This is given in the Master File as variable IP(6). Since the minimum cycle length with p-bars is one with 1 proton & 1 p-bar pulse, as shown in FIG. 2, it can be seen that a maximum pre-warning of 3 CPS cycles can be given which satisfies the earliest request condition, Trace 6 FIG. 2. This can be achieved by setting the event property to event 1 & property delay 1 equal to:

IP(6)-3*L

where L=length of the CPS cycle.

Once the request line has been activated, it must stay in that state until all the relevant PLS scans for that SPS cycle have been made i.e. up to event 1. The length of the request is set by the second timing module, namely a TG1. This module provides a reset to the request line which can be set to occur at a specified event plus the value of property delay 1. According to the previous discussion on the earliest & the duration of the request, Traces 7 & 8 of FIG 1, show the window & the reset pulse generated by TG2 & TG1 respectively.

The logic behind the p-bar request panel, as shown in FIG. 3, is such that the request window, indicated by strip lamps below the request buttons, is only active if:

a) the timing module TG2 has been activated

b) all the states on the panel are 'green', i.e.:

SPS request -console + software
SPS ready -safty state
SPS RF ready
CPS ready for p-bar

The RF ready is a simple manual switch which is mounted on a panel in the Faraday cage. It allows the RF people to inhibit the p-bar injection for any reason. If all these conditions are satisfied, then a request can be made either manually or automatically, depending on the state of the switch on the right-hand side of the panel.

<u>For manual operation</u>, one of the 3 buttons can be pressed, they are:

a) pilot request

b) pilot & store

c) dense.

Each press of the button triggers a 1-shot such that the button is not held active by keeping it pressed. This means that to make a manual request, one must press the button during the time the request window lamp is illuminated. Although there is no difference between the requests, 'pilot' & 'pilot & store' for the CPS, these states obviously have a different meaning for the SPS & are therefore defined as different states. On demanding a 'pilot & store', this request must be followed by a command to place the MPS into store mode. This action must be executed at the appropriate time, & would normally be done from a console.

<u>In automatic mode</u>, the request panel expects a command, via a CAMAC module, from the ALARM computer. This enables such a command to be incorporated into a console program. Such a program can be triggered from the TREE: TRUNK, FOREST, DIALOGUE: PILOT, PILOT & STORE, DENSE. This program will develop with time & experience, but essentially will do the following:

a)make certain checks on critical machine parameters
b)synchronise itself with the request window
c)make the request
d)monitor critical machine parameters
e)place the MPS & other machine components into store mode.

Whether the request is made manually or automatically, a request 'latch' is set which is finally pulled down by the reset pulse. The request command & request latch can be seen as Traces 9 & 10, FIG 1. During the time the request latch is active, an audible sound is generated, both in the MCR & the Faraday cage, to indicate the imminent arrival of the p-bar.

If, after the p-bar request has been made, the SPS develops a fault which renders it incapable of using the p-bar pulses, a fast inhibit has been provided which does 2 things:

a)it resets the request latch, which enters the PLS computer as an external condition & therefore curtails further p-bar requests in that SPS cycle.
b)it enters the PLS computer as an external interrupt which will be treated within 50 msec. & will stop the AA p-bar extraction of the current p-bar cycle.

This inhibit line can be activated from either the 'p-bar request panel' via the large red inhibit button, the RF switch, from the 4 console inhibit switches, or the standard software switch. It should be noted that the red inhibit button & the RF switch only acts on the p-bar request, whereas the console & software switches act on the proton injection as well as the p-bar request.

5)<u>Changing The Mode of The SPS To p-bar Operation.</u>

The mode of the SPS is defined by the Master File according to the arrays BEAMST-beam status, & MACHST-machine status. Values of MACHST define the highest possible state that the machine can attain for the current run, & therefore remain fairly constant during that run. In contrast, BEAMST defines the real state of the machine & therefore varies during a run according to the particular state of the machine at any one time. Using this information, paticularly that contained in BEAMST, it is possible to determine when the machine is being set up to receive p-bar pulses. It is during this time that the request window & reset pulse need to be active. This activation is done automatically in the ALARM computer by the system surveillance program.

This program runs every half minute in the ALARM computer, & amongst other things, checks if the beam status has changed. If it finds that the state has changed from a non p-bar state to one of p-bar injection, then it enables the 2 timing modules in the display computer such that the request window & request reset are generated each SPS cycle. When the beam state changes to one of no p-bar injection, then the program disables the 2 timing modules.

6) Experience Gained During The MD of August.

The MD, August 17-21, saw the second run of the SPS using p-bars. Preparation had been made to use the SPS p-bar request equipment. Both the manual & automatic request mechanisms were available, with the automatic request arranged to purely make the request with no other action being made by the console program. It was left to the discretion of the MD crew to choose the method of request. Since it was necessary to use a console to place the SPS into store mode, it was decided to use the automatic request mechanism from a console. When all three machines were ready, AA, CPS & SPS the first automatic SPS request for p-bars was made. The request was completely successful with p-bars being seen in the SPS ring. After the third automatic request, it was decided to extend the request program to include the program which:

a) placed the MPS into store mode at the appropriate time
b) updated the BEAMST function in the network.

This sequence worked perfectly for the fourth & subsequent p-bar pulses. During the thirteen or so p-bar pulses, various observations were made concerning the conditions for the request, the problem of informing personnel when the request had been accepted & the result of the request in terms of the quality of the proton & p-bar pulses. These will know be discussed in more detail.

For each of the p-bar injections, it was noted that the last condition to become ready was the CPS p-bar line. This is perhaps not surprising since it was the CPS which made the request to the AA to place the p-bar pilot onto the extraction orbit. Having done this, the CPS enabled their CPS p-bar ready line. It was also observed that as soon as the p-bar had been injected into the SPS, the CPS p-bar ready line dropped to a disabled state, which also disabled the generation of the p-bar request window. The fact that it was this line which controlled the request window & not the p-bar inject bit in BEAMST did not limit the request mechanism at all. From the SPS point of view, the request window will continue to be enabled according to the p-bar inject bit of BEAMST. This bit is set when the ZS polarity is changed & is reset when the SPS is placed into store mode. It should be noted that in due course, it will be the SPS who will finally give the request for the AA to place the requested p-bar pulse onto the extraction orbit. This will enable the SPS to establish a more controlled 'count down' to p-bar injection.

The design of the automatic request was made such that one could in practice make the request at any time, leaving it to the computer to decide if all conditions were good, & when in the cycle to actually make the request. It turned out that, initially the person making the request announced the fact at the time he pressed the button on the console, suggesting that p-bars would arrive on the next cycle. This turned out to be misleading for several reasons. Due to the tense situation, either he found himself on the wrong page of the tree, or he failed to press the button, or he pressed the button too late for the next cycle. Eventually it was realised that when the request was finally accepted by the computer, the audible warning was triggered, commencing 3 CPS cycles before the arrival time of the p-bar, this being a much more reliable indication of the arrival of the p-bars. Acceptance of this strategy will become more important as the request program develops to include more checks. It has been suggested that at the time the request is accepted, Page 1 should be completely rewritten with a message to the effect:

"p-bar injection imminent"

Observation of the machine state, just prior to the p-bar injection proved rather interesting. It was evident that analogue metering devices of the proton bunches often showed very clearly that these bunches were not optimised, & in these cases, a cancellation of the current p-bar request cycle would have been preferred. Although the fast inhibit was designed specifically for this application, it was not used during this MD. However, consideration should be given to analysing the state of the proton injection with a view to inhibiting the p-bar injection if necessary. Initially this can be done manually using the fast inhibit buttons & switches, but a more direct approach using detectors , the computers & the SOFTWARE switch, should be developed to minimise the possibility of having to store badly injected proton pulses.

The MD showed that automatic requests made from the SPS for p-bar pulses was possible, & eased the burden of the personnel in the control room. Even during the MD it was possible to upgrade the request program in a way which reduced the risk of losing the p-bars. There is no doubt that the automatic request can be developed in a way which will reduce the risk of either losing the p-bars altogether or accepting them under adverse conditions.

7) Acknowledgements.

J. Viatour designed, built & installed the interface panel; L. DeJonge modified & installed a CAMAC button module to read all the states of the panel & G. Daems & P. Heymans were the link men with the CPS.

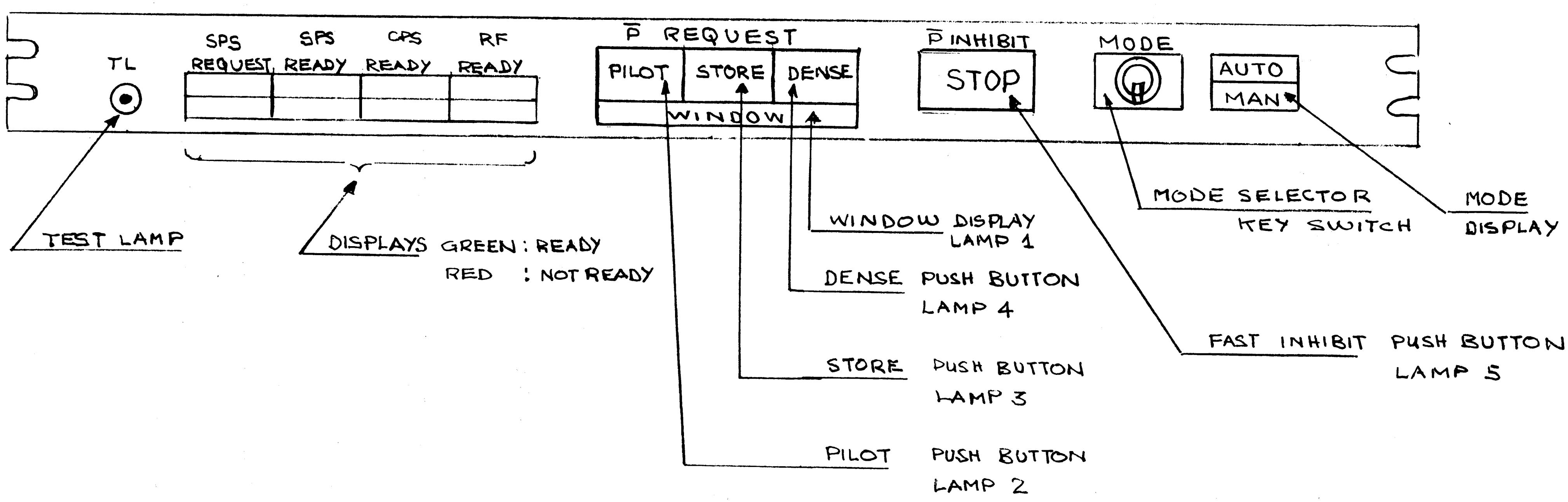


FIG. 1

CERN SPS-AES PERSONNEL PROTECTION	
CPS ENABLE SWITCH	21.09.81
FRONT PANEL LAYOUT	C. JACOT

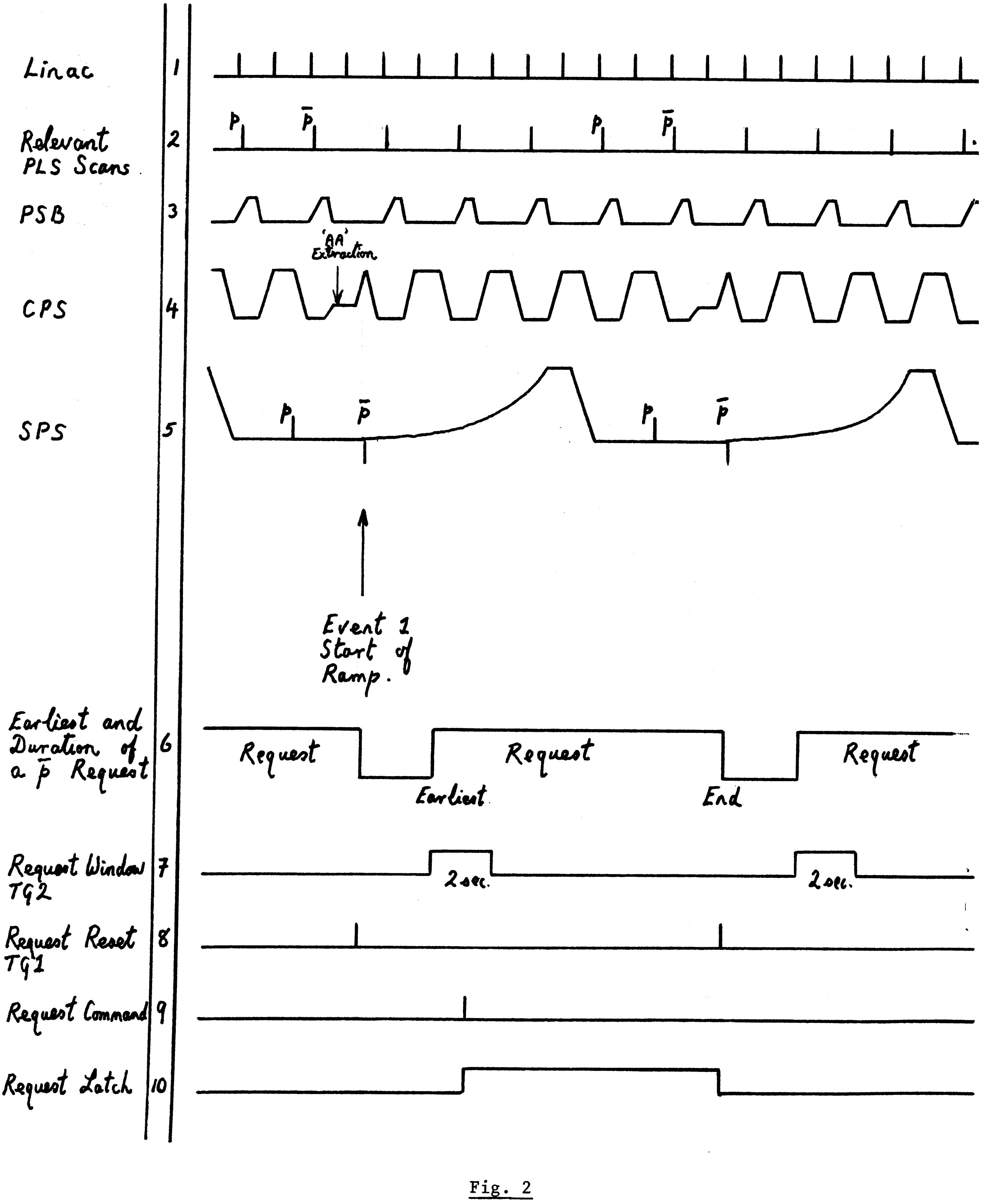
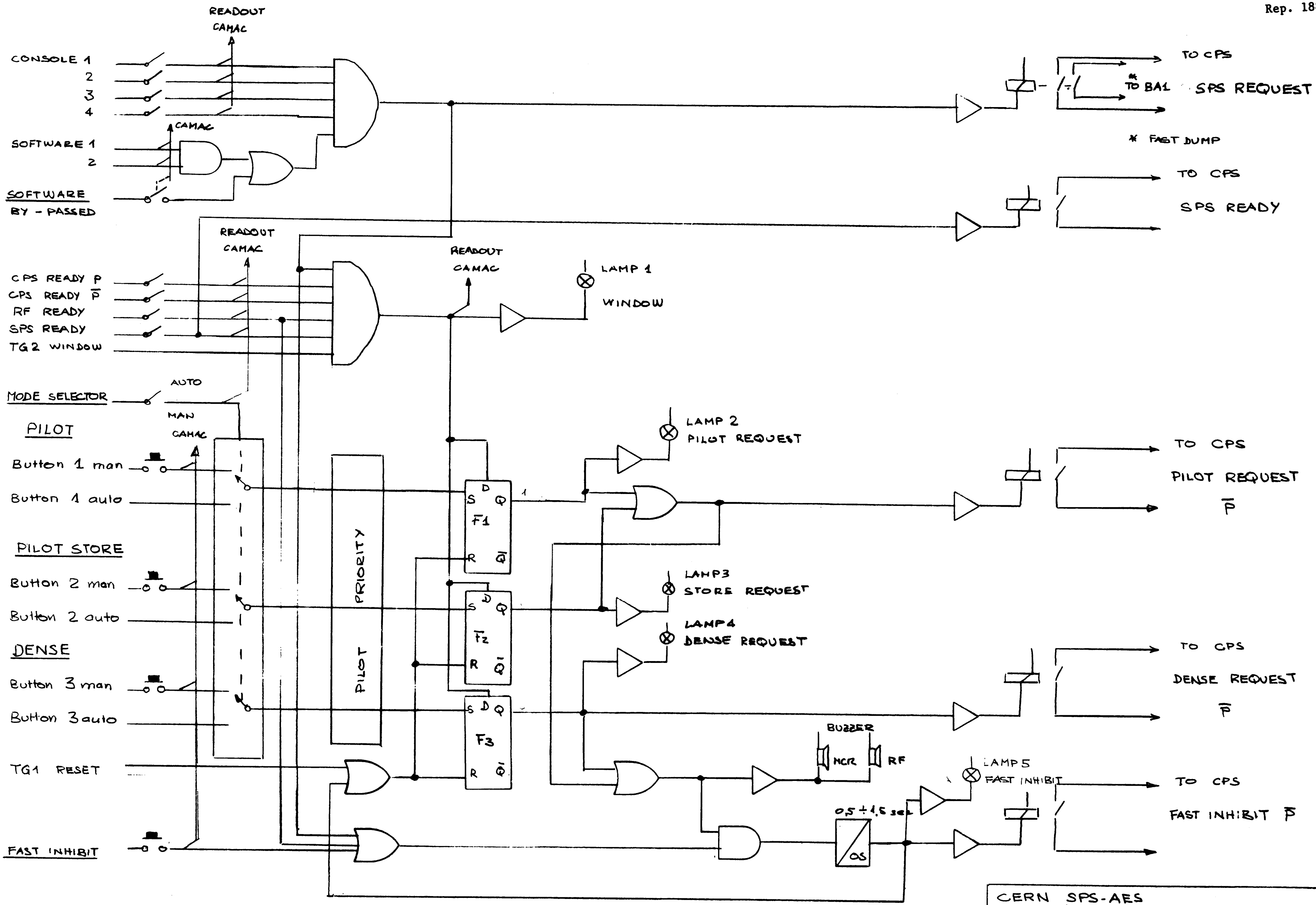

Linac
1
Relevant PLS Scans
2
p
p̄
PSB
3
'AA' Extraction
CPS
4
SPS
5
p
p̄
Event 1 Start of Ramp.
Earliest and Duration of a p̄ Request
6
Request
Earliest
Request
End
Request
Request Window TG2
7
2 sec.
2 sec.
Request Reset TG1
8
Request Command
9
Request Latch
10

Fig. 2



CERN SPS-AES
PERSONNEL PROTECTION SYSTEM

CPS ENABLE SWITCH

Mod 22.09.81
C. JACOT

FIG. 3