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REPLACEMENT OF THE ISIS CONTROL SYSTEM

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Abstract

In operation since 1985, ISIS is the world's most powerful pulsed spallation neutron source. The decision has been taken to replace the existing ISIS control system, which has been in use for over ten years. The problems of such a project, given the legacy of processor specific hardware and software are discussed, along with the problems associated with incorporating existing interface hardware into any new system. Present progress using commercial workstation based control software is presented with, an assessment of the benefits and pitfalls of such an approach.

I. INTRODUCTION

ISIS is based on an 800MeV proton synchrotron, running at 50Hz, providing an average beam current of 120μA onto a Uranium target. The injector, synchrotron, extracted proton beam line and target station have been under control of the present system both during commissioning (1980-85) and operation. Work is in progress to attain the design current of 200μA within two years.

The control system (old CERN-SPS pattern), is based on 5 GEC computers, assembly language Data Modules, a general purpose multiplex system for equipment interfacing (MPX) , CAMAC based operator interfaces (see Fig. 1) and an interpretive control language. There are approximately 15000 lines of data module source code. The equipment interface consists of 700 modules in 70 crates. There are several hundred control programs in use.

The present control computers are very modest in power and are very limited in storage capacity. The operating system allows us to control hardware from a number of concurrent interpreter processes on each processor. High priority processes communicating with hardware completely lock out all others. Communication with other systems is non-existent, peripherals such as floppy disks are obsolete and unsupported, backups require shutting down the control system and maintenance is expensive (24hr cover is essential). The various branches of the interface hardware are tied explicitly to particular processors– reconfiguring after a processor failure is impossible– a serious disk drive fault can, and has, shut down the accelerator for a few hours. An average ISIS experiment lasts two days, within which several data taking runs, all of which are essential, must be performed. These sorts of breakdowns, although infrequent, are highly undesirable.

The new system is required to take over all the current functions of the existing control (at least as well) and have the capability for much increased data storage, greater reliability, easy reconfiguration and extension and almost transparent communications with other computer systems.

The available effort is about 25% of that when the original system was created, when both decreases in staff and the load of supporting the existing system are taken into account.

II. PROJECT PLAN

The system currently being developed is based on the Vista Controls[1] software suite, and the Hytec Electronics[2] Ethernet CAMAC Crate Controller (ECC). The new software provides a fully distributed database driven control system with a graphical interface over a number of DECnet nodes (currently VMS only although work is in hand on a POSIX-compliant version). Each control or monitoring object is referred to as a *channel* and, by using the *channel name*, control screens can be generated with an interactive draw package. Our current development system is based on two DEC VAXstation 3100 colour workstations and two DEC VT1300 X-terminals, although it is not clear that the choice of processors is optimal. Figure 2 shows a general arrangement of the proposed new system, based on Ethernet (an alternative transmission medium would be FDDI).

The use of channel names, database and handlers (equipment routines) maps very well on to our existing system based on Data Modules. The graphical interface provided with the new software should enable the functions of 75% of the control software to be replaced without recourse to writing code.

The system-wide nature of the databases and the networked nature of the CAMAC driver crates makes access to all equipment possible from any processor– something which was not previously possible.

Terminals with any level of access to the control system can easily be added anywhere on site (if desirable!). A con-

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trol system for a new beam line can be provided by buying a workstation, another CAMAC controller and local interfacing hardware. The incorporation of this into the existing system is automatic (subject to the licensing agreement and an upper limit on the number of databases).

The current operator interfaces (touch sensitive screens , tracker balls, colour displays, knobs etc.) which are all obsolete or nearly so, will be replaced by high quality mouse/tracker ball and keyboard driven workstation type displays.

No new system will look or behave as the old one did. Users are familiar with the old system and will be reluctant to change. Any shortcomings in the new system will be picked on and amplified, shortcomings in the old system having been assimilated years ago. Use of the new system from a user-written program is more complex and less flexible– we are currently developing a simple interface to improve this..

There are three major parts to the management of change:

1. Transport of existing software.

2. Connecting to the new control system.

3. Training users

Most of #1 can be done off-line, that is to say without interfering with the operation of the accelerator, and this is currently in progress.

#2 is straightforward because all equipment below the dotted line on figure 2 is to remain the same. The CAMAC crates which drive our MPX branches merely have to have their crate controllers removed and replaced with the ECC controller modules. Changing the existing main control desk is highly problematic. Workstations will have to be installed side by side with the old control system on the first live runs, so that the old system can be reverted to if necessary. It must be stressed that ISIS runs as if it were a commercial enterprise, and our "customers" will not allow scheduled run time to be removed or interfered with for development purposes.

Training of staff, given our limited resources, is difficult. The operation of ISIS, although still to be further developed, could be said to be stable, so a straightforward functional replacement would be an acceptable first stage.

There is a long shutdown period of 3 months every year when it is expected that changes will take place.

The original time scale was for a two year project, culminating in a long shutdown. This is not feasible given the current manpower levels, so April 1993 is now the target date for a live run of the new system..

III. Progress

Three databases have been written, those for the injector magnets, the injector timing system and the injector general purpose status modules– a total of 1200 channels so far. Handlers for the programmable timing modules, the most complicated of our magnet power supplies, and the status reading hardware have been written. We are preparing a specification for extra functions to be added to the Ethernet CAMAC crate controller, to reduce the overheads on equipment access. Control screens for the timer modules and magnet power supplies have been prepared and a suite of hardware test programs written for test access of interface modules via the ECC controller (external to the database).

Fig. 3 shows a workstation in use in the new control system. The menu windows running around the bottom right hand corner are replacements for our existing touch screens, where further menus and/or control screens are called up. The main part of the display is occupied by a control screen for the quadrupoles in the Low Energy Drift Space of the ISIS LINAC, showing control sliders and a monitoring strip chart. Fig 4 shows the operation of the control screen for the ISIS LINAC programmable timing system. No high level programming was required to generate these windows.

A significant amount of time has been spent deciding how to modify the standard usage of the Vista software to suit our needs and in moving to new versions. Now this has been done, production of software should speed up.

The choice of processor platforms on which to mount the system is not obvious. It is driven by the need to maximise perceived response time. We are not sure at this stage whether workstations are more or less appropriate than a powerful multi-user VAX running several X-terminals. Increases in workstation power may overtake this problem.

There is a lack of flexibility in hardware calls routed through the database, stemming from the inability to parameterize calls. One might wish to be able to retrieve the value of a single status bit from a 16-bit status port. In the present system, this is done by specifying the module, port and bit number– a 0 or 1 is returned. In the new system, to be able to randomly access any single bit in this manner would require database channels for every single bit, which would be very wasteful. We have opted to assign an integer channel to each 16-bit port, individual bit channels being set up on demand. On the other hand, this rigidness leads to a strong "typing" of database channels, minimising errors.

Complex control screens may be devised without any programming effort, however the hierarchical control over which screens may be displayed at any one time seems lack-

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ing to us and we are devising our own software to handle this.

Quick turn round support is available from the vendors by e-mail, phone or Fax.

On any physical Ethernet segment up to 256 CAMAC crates (each driving up to three MPX branches with up to 16 MPX crates per branch) can be simultaneously available from any processor with the ability to restrict access to individual modules to particular processors if required. The ECC modules have been reliable in operation with excellent support from the manufacturers.

The major difficulty with the ECC controller is an overhead (on single operations) of 10mS per transfer. The 10mS is a fixed feature of the VAX-Ethernet configuration and is not affected by transfer size. In a data acquisition environment the problem starts to disappear as the blocks of data transferred get larger. For a control system such as ours, where accesses to the hardware are much more random and multi-sourced, this is a large problem for which there is no clear solution as yet. The advantages of the ECC solution are the total flexibility and the overcoming of many of the limitations of CAMAC (to the extent of giving it a new lease of life).

IV. CONCLUSIONS

The choice of commercially available software must be correct for those establishments where lack of effort and staff turnover are problems. Good local support and constant updating of the product are also essential, as is the ability to feed requirements into the supplier's development plan. Even so the effort involved in changing to a new system is always under-estimated, both by the customer and by the supplier.

No commercial product will allow the easy assimilation of an existing control system. Whatever practises and methods prevail in an operating machine are the "right" ones by virtue of the fact that they are in use and familiar to those who use them. Any new system must be modified to fit what exists– not the best way to proceed. It is also clear that the only timing information of any interest to the user are the times taken to (1) present the control window required on the screen and (2) to operate a piece of hardware and see the effect on the screen, what happens underneath being irrelevant.

We are happy that the new control system will meet all our expectations with regard to extensibility, reconfiguration and communication and will perform as well as or better than the existing system. It seems to be an unwritten law of control systems that, as the power of the processors increases, the complexity of the software rises until the perceived response time drops to the minimum acceptable. We would hope that the extra complexity in the new system will be achieved without a drop in perceived response time.

The suitability of Ethernet (or any general purpose network system) as the main i/o channel is unclear. On the one hand emerging computer systems are frequently only supplied with an Ethernet port and moving away from this becomes expensive. It is truly distributed and configuring the system and expanding it become trivial. On the other hand, the generality of the system means that it is slow. It is clearly unsuitable for a fast data acquisition system but may be well suited to a supervisory control system such as ours. It allows the integration of PC's, CAMAC, VME, STEbus, and other systems in a controlled manner. Together with distributed software such as that described, it provides a system which is easily reconfigurable should a processor fail. In the ECC CAMAC controller itself there is also a large amount of untapped power although an easier way of accessing this would be an advantage.

REFERENCES AND ACKNOWLEDGEMENTS

1. Vista Controls Inc.
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(These companies are reciprocal agents)

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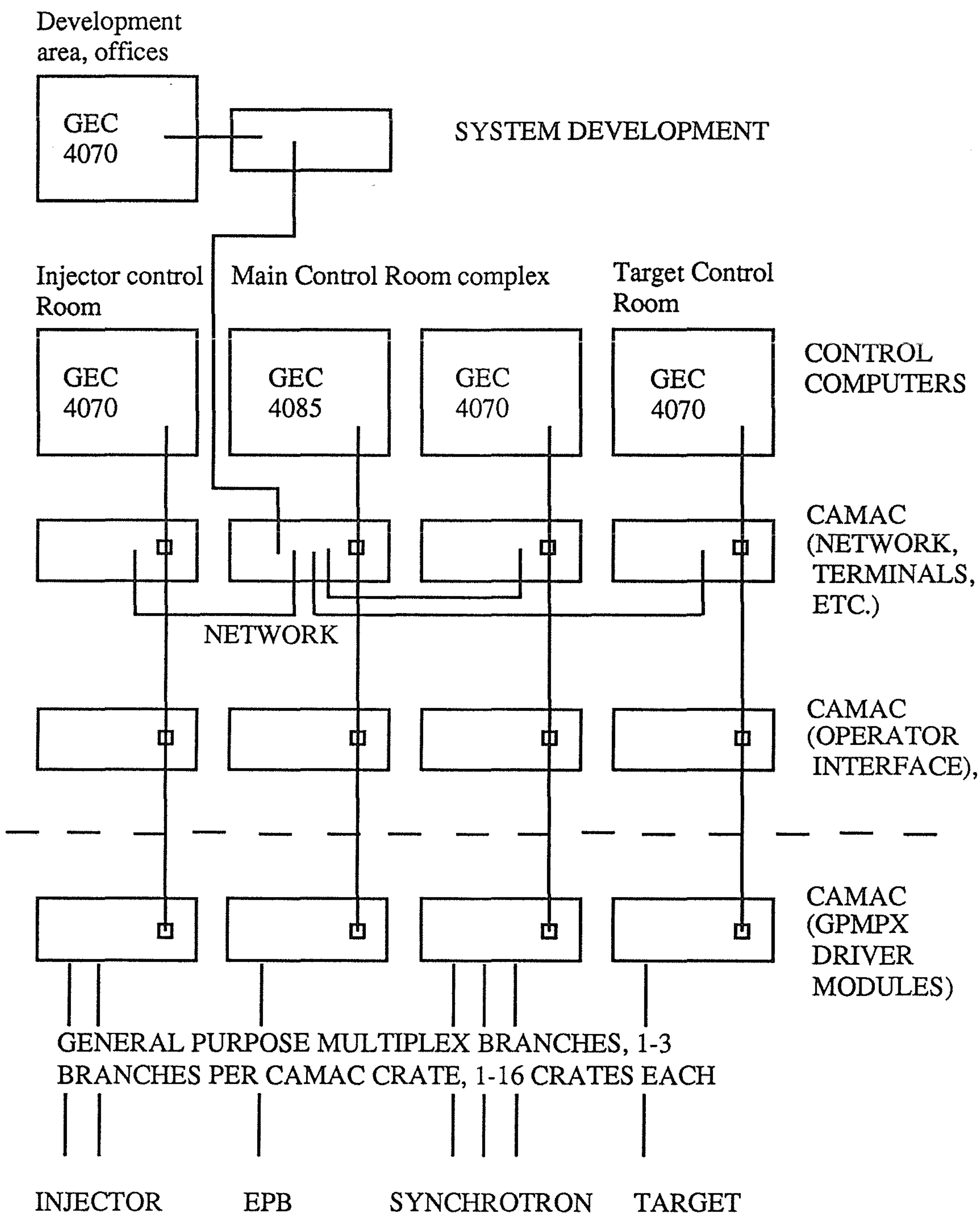

FIGURE 1. General arrangement of present system

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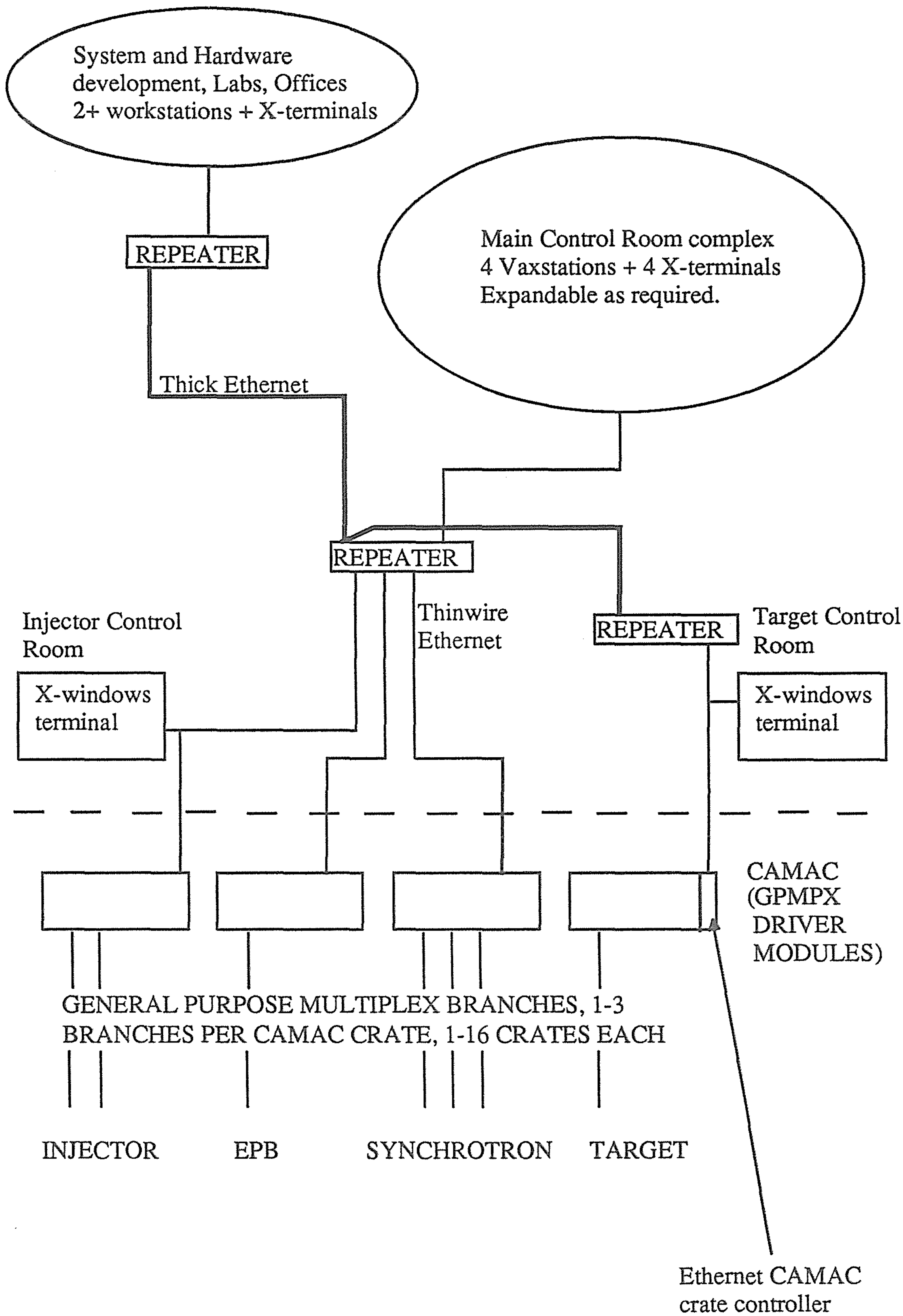

FIGURE 2. General arrangement of proposed system

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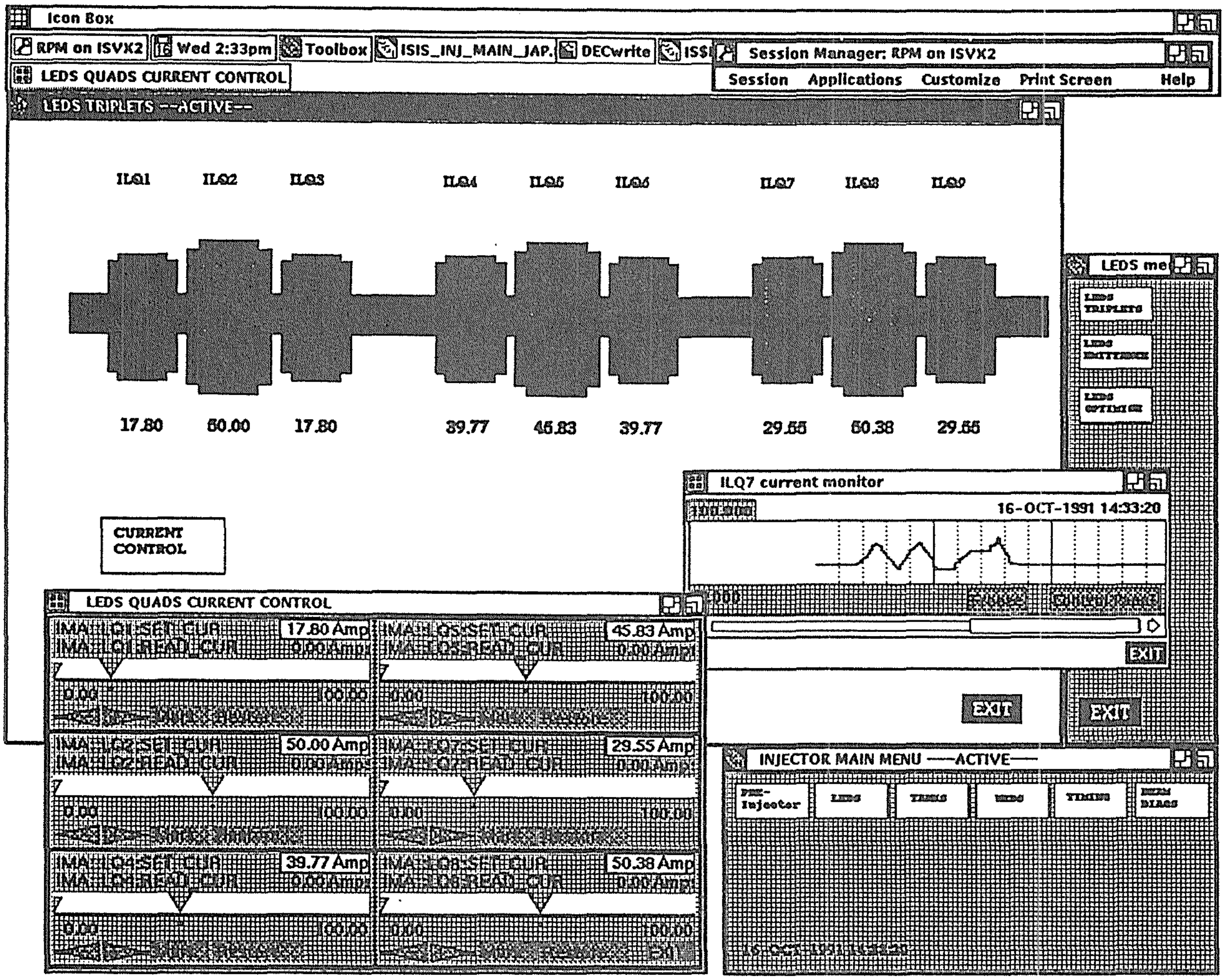

Figure 3: Example control screen– ISIS LINAC Low Energy Drift Space triplets.

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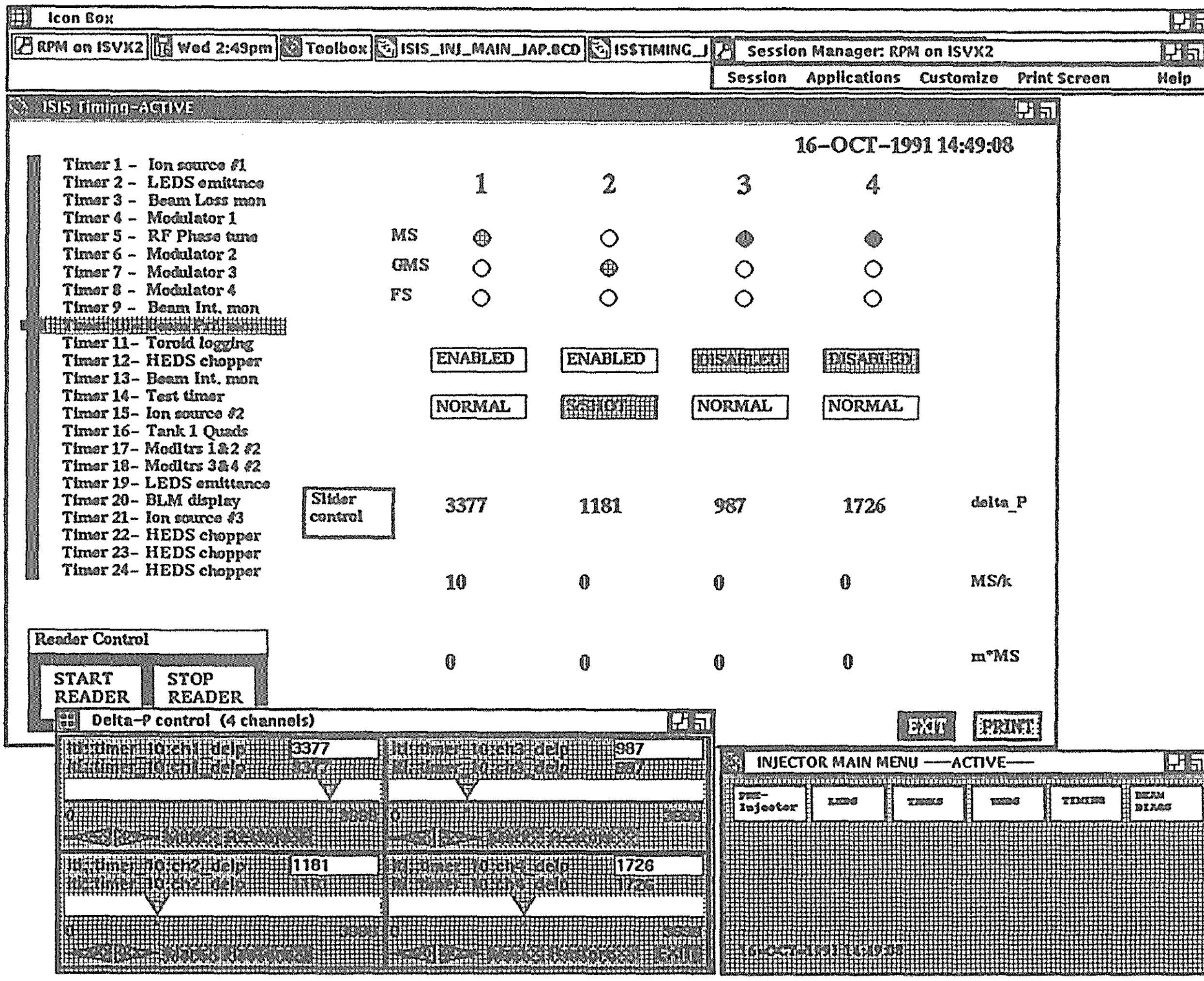

Figure 4: Example control screen– ISIS LINAC timers.