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PS/CO/WP 83-33
PS/LPI/Note 83-2
21.3.1983

LIL INTERFACE LAYOUT

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1. INTRODUCTION

In December 1982 the original proposal of LAL to deliver the LIL process "sous-ensembles", each equipped with one readily programmed local processor, had to be abandoned in favour of a more conventional approach, also based on serial CAMAC interfacing and on the PS software structures. This decision had to be taken when it became clear that the foreseeable staffing level of the two PS groups involved (CO and LPI) will be inadequate for supporting substantial quantities of hardware and software deviating from PS conventions and standards.

The present note gives the broad lines of the LIL controls layout, which should provide the framework in which the next phase - the detailed module choice and specific electronics definition - should be taking place.

Using the principles developed in this note, another one on the EPA interface layout is to follow.

2. CONSIDERATIONS ON GROUPINGS

Arriving at a choice of CAMAC and CAMAC related interface modules is fairly straightforward when using the PS module spectrum and typical combinations of these for e.g. power supplies, vacuum, beam instrumentation, etc., as described in the Interface Handbook. The result is for a good part dictated by the list of controls parameters and by the operational and engineering controls requirements. Obviously, the latter must have been defined in some detail beforehand.

There is more margin for controversy when considering which modules should be grouped together, e.g. in one and the same CAMAC crate. Amongst the grouping criteria, one could mention two extremes, which have in the past and also in the LAL-CERN meeting of Decmber 1982, led to some discussions. They are: (i) system oriented and (ii) function orientend controls grouping.

A system oriented controls approach tends to group controls so as to favour process equipment groupings ("systems") forming some sort of organic entity, relevant to, say, operation, engineering, etc.. Typically, a "system" has more internal transactions than external ones. A system thus defined tends to have the need for a combination of controls functions of different kinds: e.g. in accelerators, for power supplies, vacuum, timing, etc. Control and acquisition of all devices making up a system can be locally concentrated by a multiplexer, thus yielding savings in cable cost for connecting that system up to the central controls. If there is some means of local interaction or even a local processor, then there may result a stand-alone capability which can be helpful for certain engineering and commissioning operations and/or - more rarely - for beam operation.

The function oriented approach tends to group controls of the same or of similar kind. The advantages claimed are conceptual simplicity and (related) ease of checkout and maintenance of the controls side. The maintenance aspect is emphasized by the tendency to have specialized teams responsible for servicing the different functions such as vacuum, timing, etc. The cable lengths for the function oriented approach tend to be longer than for the system oriented one, since the systems to which the functions connect are usually spread in space. It is thus clear that for the large machines such as the SPS a function oriented approach is unthinkable due to prohibitive cable costs. In LIL/EPA, however, a function oriented approach would be feasible from the cable point of view.

In SPS and LEP Main Ring, the distances involved force yet another grouping, the geographical one: all control and acquisition in a particular area are concentrated (and pre-processed) there, independent of organic relationships. In numerous cases, the actual organic relationship is spread over several concentrators/processors so that integration into "systems" can only be higher up, e.g. at SPS by the software in the console computers. This example underlines that controls integration is a key aspect in the grouping argument.

In the present PSB and PS controls the integration is done in the ND-10 process minicomputers since at the CAMAC level the Auxiliary Crate Controller (ACC) executes only simple slave tasks (there are some exceptions). Grouping at the CAMAC level is therefore no major issue. Controls in PSB and PS are then mainly function oriented for simplicity. The situation becomes different when powerful local processors, so-called Super ACCs or SACCs, become available in the CAMAC crates. These yield the possibility for meaningful controls integration (hence stand-alone capacity) at the CAMAC level, in so far the "system" in question can be interfaced in one CAMAC crate. By far the dominant constraint in integration at the CAMAC level is the memory capacity of the SACC as related to the software tasks and structures (Ref. 1). This must be explained.

In a function oriented SACC there is one kind or at most a few kinds of programs, since the crate contains, for example, only timing modules. The logical operations for control and acquisition are the same and only the data table differs, say from one timing channel to another. This works for limited memory capacity requirements, conceptual simplicity and limited protection requirements.

Not so in a system oriented SACC. Its CAMAC crate will typically contain one or a few of a number of different types of modules. The SACC will therefore have to allow cohabitation of a number of different kinds of programs, one or more for each kind of CAMAC module, even if there is only one single piece of that kind. The data tables of each program will be more modest, since numbers of each type of module tend to be smaller. However, since the number of CAMAC modules (whatever type) per crate is similar in the average (say 15 slots or so), the volume of data tables tends in the average to be comparable for systems and functions oriented SACCs. There remains then a significantly greater volume of programs for the systems oriented approach and this may meet memory capacity problems in the PS applications software philosophy. To understand this we have to open a parenthesis on the latter.

In some industrial equipment an astounding number of functions is programmed into one processor of modest memory capacity. In the PS context the memory requirements are a multiple. Why ?

This difference is a direct consequence of the dominant requirement of high flexibility in accelerator control. In most industrial software the number of options is frozen and software is not evolving. Programming is therefore ad hoc, can be monolithic and the result is compact. This is adequate and - if not altered - even economic if produced in large series of identical units. In contrast, software in accelerators is constantly growing and being modified and hardware is frequently being reconfigured. In order to cope with this constant change, yet avoiding chaos, a substantial investment in software modularisation and protection mechanisms must be made and a substantial software overhead must be accepted as a conconmitant. Although it would be physically possible to do ad hoc programming in accelerators (thus strongly reducing memory requirements), this would be intolerable in exploitation: modifications and extensions will often imply complete rewriting and reliability would be disastrous at our rates of evolution.

It is then unavoidable that, when we want to decentralize software into the Super ACCs, we must provide substantial memory capacity and that the systems oriented approach requires yet substantially more memory than the function oriented one. It is thus probably not by chance that a recent Japanese controls layout (Ref. 2) with its (on paper) appealing geographical symmetry, is using minicomputers (hence mass storage disks !) where we discuss SACCs (~ 5% of the price of a mini !).

The preceeding arguments show the origin of our reticence towards lighthearted discussion of the advantages of systems orientation since there is a very substantial bill, hardware wise and sofware wise. The real needs should be identified and the price tag should be as clear as possible at this stage.

3. ON GROUPINGS FOR LIL

Let us consider the "sous-ensembles" listed in the scenarios by P. Brunet (Ref. 3). These are probably the broad classes which have some obvious identity for the electron Linac user. They are:

- modulators + klystrons
- gun Linac V
- gun Linac W
- focussing and steering
- RF distribution and phasing
- vacuum
- beam instrumentation
- timing
- beam transport
- power and fluid distribution
- radiation security

These groupings are not homogeneous in their nature. Some constitute "systems", in the sense of what was explained in section 2. Amongst these could be modulators/klystrons and the guns, which have some spatial (geographic) identity. Others, like focusing guidance, phasing, vacuum, beam transport, radiation security and, to some extent, timing and beam instrumentation are spatially distributed but do have some organic coherence. Finally, power and fluid distribution are spatially distributed and seem to have no cohesion other than category. There is also some orthogonality in that the controls of timings and vacuum sectors could be distributed over other groupings they serve, such as modulators/klystrons and guns, if such a distribution were appropriate. So does power and fluid distribution. Other categories like focusing and steering make little sense being distributed over other groupings.

What then are the criteria for grouping ? In Section 2 it has been explained that software economy, memory space economy and CAMAC material economy point a priori towards functional grouping. These factors by far outweigh the additional cable cost for small machines like LIL/EPA. Only where compelling arguments (operational and/or engineering) for systems orientation can be fielded, should one go to systems oriented grouping, yet absolutely minimizing the diversity of software required in each CAMAC crte.

Let us look at Brunet's "sous-ensembles" one by one.

Modulators/klystrons

For beam operation they are all used together except klystron 2 (only for e^+). Since the controls can be made identical they could be grouped and then probably fit into one CAMAC crate.

For engineering operations, however, a meaningful stand-alone capability (each of these groups separately), would be convenient as well as access to controls from next to each cage in the klystron gallery. The engineering operations, namely thyratron tuning, klystron tuning and outgassing of RF wave-guides and accelerating sections, would be favoured if also the controls for the RF distribution and LIPS are included. Some vacuum thresholds must be interlocked with the modulator/klystron group and some vacuum measurements and status should be visible near the relevant cages.

Electron guns V and W

Since their controls can be made identical, these could logically be grouped. For beam operation there seems to be no objection and stand-alone capability for engineering activities, such as cathode formation, is possible separately for each gun. The W injection line and converter could also be grouped here. Organically, the latter does not belong anywhere in particular.

Focusing and steering

Except possibly for the pulsed high field solenoid at the converter, these functions seem to be super-imposed on the whole Linac and seem not to be favoured by grouping with other equipment. Engineering tests are favoured by grouping in a separate group, hence functional grouping. Sine the beam transport has similar morphology, it could be included. All this is probably not exceeding the capacity of one crate.

RF distribution and phasing

Although related by their relevance to RF, they have no coherence neither for beam operation nor for engineering activities. As stated under the relevant heading, there is for engineering activities a good case to group the controls of RF distribution with its modulator/klystron. The phasing, i.e. the fine adjustment of the beam and RF phase lock to the phase of the reference wave guide, has only operational relevance as a whole and also for engineering activities, these are favoured by functional grouping. The Booster modulator/klystron could be grouped here (if it is not functionally grouped with all the other ones). It leaves the same stand-alone capability as the others, since the phasing is irrelevant for the engineering operations. The acquisitions from the reference wave-guide thus also belong here.

Vacuum

Since there are isolating valves between RF sections belongs to different klystrons (for the very engineering activities mentioned), one could think of controlling the vacuum equipment relevant to certain klystrons together with the latter. The benefits if any are minor, however, while the whole vacuum exploitation is favoured by a functional grouping and there is the memory capacity problem speaking against system grouping. Functional grouping of vacuum still allows manipulation per sector even during service to other sectors. Vacuum information can be distributed to certain points by video.

Beam instrumentation

Beam measurements seem only to have relevance for LIL as a whole or at worst for the V Linac and the W Linac separately. Software and engineering arguments favour functional grouping. There are four kinds of measurements: (i) intensity, (ii) position, (iii) SEM grid (profile, energy dispersion) and (iv) slow scanning (micro-bunch and wire). The quantity corresponds to two CAMAC crates, so SEM grids could be grouped with intensity for normalisation.

Timing

Some arguments may be made for distributing preset delays over the groupings such as modulators/klystrons and beam instrumentation. On the other hand, there is the software argument and the engineering activity which speak for grouping preset delays together functionally. Engineering activities on modulators/klystron groups need the pulse train (at least simulated) anyway, so if that part is working, the functionally grouped presets delays will also. Besides, timing is not changed for the modulators/klystron engineering activities in question. Most beam instrumentation timing pulses serve to open and close gates before and after bunch passage. They are uncritical and, once correctly adjusted, do not change. In case of time slicing inside the bunch (Ref. 4), some fine delays can be grouped in the beam instrumentation crate, since this timing variation is part of the measurement.

Beam transport

See focusing and steering.

Power and fluid distribution

Acquisition of status and possible control (electrovalves) seem only to make sense in combination with the other relevant groupings. There is no case for a separate power and fluid distribution grouping.

Radiation security, etc.

This will be incorporated in the general personnel access control system of the PS and operated from the PS Security console. This is a completely separate hardwired system. So there is no relation with the controls as such. There may, however, be a case for a CAMAC crate for collecting sundry status not related to one of the groupings, e.g. for alalrms, etc. This could be added if and when the need really arises, and will thus be ignored here.

4. PROPOSED LAYOUT

The grouping of the sub-systems over the various CAMAC crates should be seen in the context of the layout of the whole PS controls system. In an earlier text (Ref. 5), arguments have been advanced to make the LIL and EPA controls a natural extension of the existing PS controls system.

PS/LPI controls hardware layout

In a simplified form this is given in Fig. 1. On the right hand side is the existing PS controls system. A central message handling computer (MHC) connects all minicomputers by a store-and-forward package switching protocol. On the upper side are the console computers, each driving one main operator console in the Main Control Room (MCR). The consoles are general purpose, i.e. they are all identical in hardware and software and each of them can access all processes in the same way. This means that when the console capacity must be increased, like when this becomes necessary by addition of substantial new processes to be operated concurrently, one can simply connect new consoles with their computers to the MHC and load them with the same software. In principle all minicomputers are in the Main Nord Room (MNR), which yields advantages by way of a patch-panel backup scheme, for servicing and for conditioned environment. The connection between console and its computer does not allow distances of more than 20 to 50 m. The console(s) required locally in the Local Console Room (LCR) of LIL and EPA must therefore have their computers nearby. The message transfer system allows to place these computers at considerable distance from the MCR, i.e. next to the LCR and LIL in the local Electronics Room (LER) in building EB1.

On the lower side are the process computers, each communicating with one process through a CAMAC interface. The process computers are connected to the so-called mother crate via the parallel Branch Highway. The serial driver in the mother crate drives the CAMAC serial highway to CAMAC crates in the equipment clustering points of the process. Like for the consoles, further process computers can be connected to the MHC in a straightforward manner. One new minicomputer each, for LIL and EPA, will be used. The serial highway permits keeping these two new computers in the MNR. Again, the serial CAMAC highway runs along the clustering points of process equipment which will here be (i) the klystron gallery, (ii) the Local Electronics Room next to the Local Console Room, (iii) the power supply building EB3 and (iv) building EB2. One or more loops may be used on each minicomputer.

In particular in the commissioning phase and later for engineering operations during shutdowns, an important issue is a certain stand-alone capability of the systems connected to certain CAMAC crates and, obviously related, also the issue of local computer access. The stand-alone capability should be given for almost every CAMAC crate of LIL and EPA by a so-called Super ACC (SACC), a Motorola 68000 microcomputer with a substantial memory capacity, which can access all equipment interface in that CAMAC crate. Local computer access is available at three levels of which two are depicted in Fig.1. First, a local CRT terminal with printer and a double floppy disk drive, called Trottinette, may be plugged into the SACC. Second, a CRT terminal with printer may be plugged into an outlet of the 20 mA current loops, connected to the LIL or EPA process computer and running along the CAMAC clustering points. This terminal can access all CAMAC crates on the minicomputer in question. The local access issue is more explicitly explained in Rf. 5.

Proposed groupings

The grouping of subsystems in CAMAC crates for LIL is given in Fig. 2. Most arguments for this grouping have already been made in Sec. 3, when discussing the "sous-ensembles" of Brunet. The result is about 14 crates for LIL. Crates 1 through 7 are more or less systems oriented, crates 9, 10, 11 and 14 are function oriented, crates 8, 12 and 13 are more or less mixed.

Some remarks are in place.

This grouping leaves some margin for changes, if this proves to be the appropriate thing during the detailed layout of each subsystem. In particular boundary cases may only be decided at that time. An example of a boundary case is the phase jump of the phase lock when going from e^+ to e^-. It could be grouped with the reference line and phasing in crate 8, but functionally it is close to the use of electron gun V or W and the converter in crate 1. There are obviously more cases of this sort. They will only gradually become clearer through the year 1983, as the process subsystems of LIL become ore fully defined.

There is obviously a connection with EPA. A salient point is the timing. It is almost exclusively derived from the EPA radiofrequency and controls also the inflection and ejection towards PS. There will thus probably be a common pulse conditiong unit (Timing Clock Generator) for both LIL and EPA, which will also receive the PLS telegram. The principles of this conditioning have been stated in Ref. 7 and will be somewhat elaborated and discussed in hardware terms in a forthcoming note. Another boundary case may be given by some beam instrumentation. As for power supplies, it seems reasonable to count the inflection and matching as the first elements to be grouped with EPA, after the beam transport which may be grouped with LIL.

Like elsewhere, it is aimed to have crates only 60 to 70% full so as to leave some margin for modest additions and change.

Geographical layout

The geographical layout has already partly been discussed under the heading PS/LPI Controls Hardware Layout, but it is more explicitly given in Fig. 3. New minicomputers and their mother crates will be located in the Main Nord Room (MNR), which will for that purpose be extended towards the west. An exception is made for the local console computers with will be located in the Local Electronics Room (LER), next to the Local Console Room (LCR). CAMAC crates 1 through 8, as well as 12 and 13 will be in the klystron gallery. Crates 9, 10 and 11 will be in the LER. Crate 14 will be with the power supplies electronics in building EB3.

5. NEXT STEPS

Further progress on the detailed definition of the hardware layout can now only be made in tripartite collaboration between LAL and the LPI and CO groups of CERN/PS. This will follow at the pace in which the subsystems of the LIL process become more fully defined. The first exercise should concern the modulator/klystron groups, since the manufacturing specifications must now be written and these involve detailed wiring diagrammes for the specific controls electronics. A more precise frame for these groups has been given in Ref. 5. Since the RF distribution of each modulator/klystron group is interfaced in the same CAMAC crate, this distribution must soon be fully defined as to its controls acquisitions. The electron guns may be the next in sequence. In parallel, the timing problems will be further elaborated inside CERN.

6. REFERENCES

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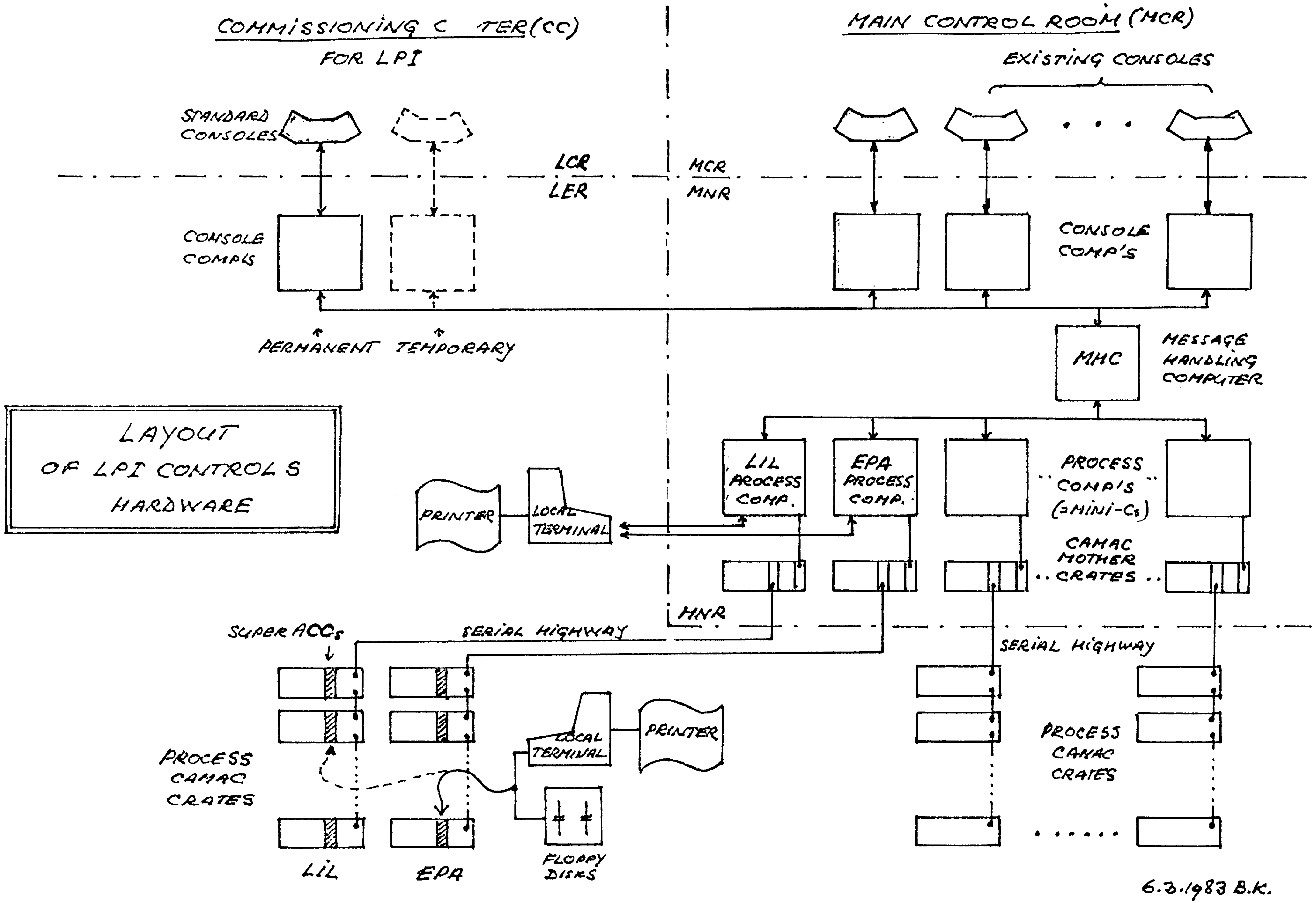

Fig. 1. PS/LPI CONTROLS HARDWARE LAYOUT

Fig. 2

PROPOSED GROUPINGS OF LIL SUBSYSTEMS IN CAMAC CRATES

1
Electron gun V
Electron gun W
Converter

2
klystron 1
Modulator
Waveguides
Bunchers

3
klystron 2
Modulator
Waveguides, LIPS
Acc. sections

4
klystron 3
Modulator
Waveguide
Acc. sections

5
. . . . 4
. . . .
. . . . , LIPS
. . . .

6
. . . . 5
. . . .
. . . . , LIPS
. . . .

7
. . . . 6
. . . .
. . . .
. . . .

8
Booster klystron
Modulator
Reference line + phasings

9
TIMING :
–
– Delays

10
TIMING :
– More delays ?

11
VACUUM

12
BEAM INSTRUMENT'N

13
BEAM INSTRUMENT'N

14.
FOCUSING
STEERING
BEAM TRANSPORT

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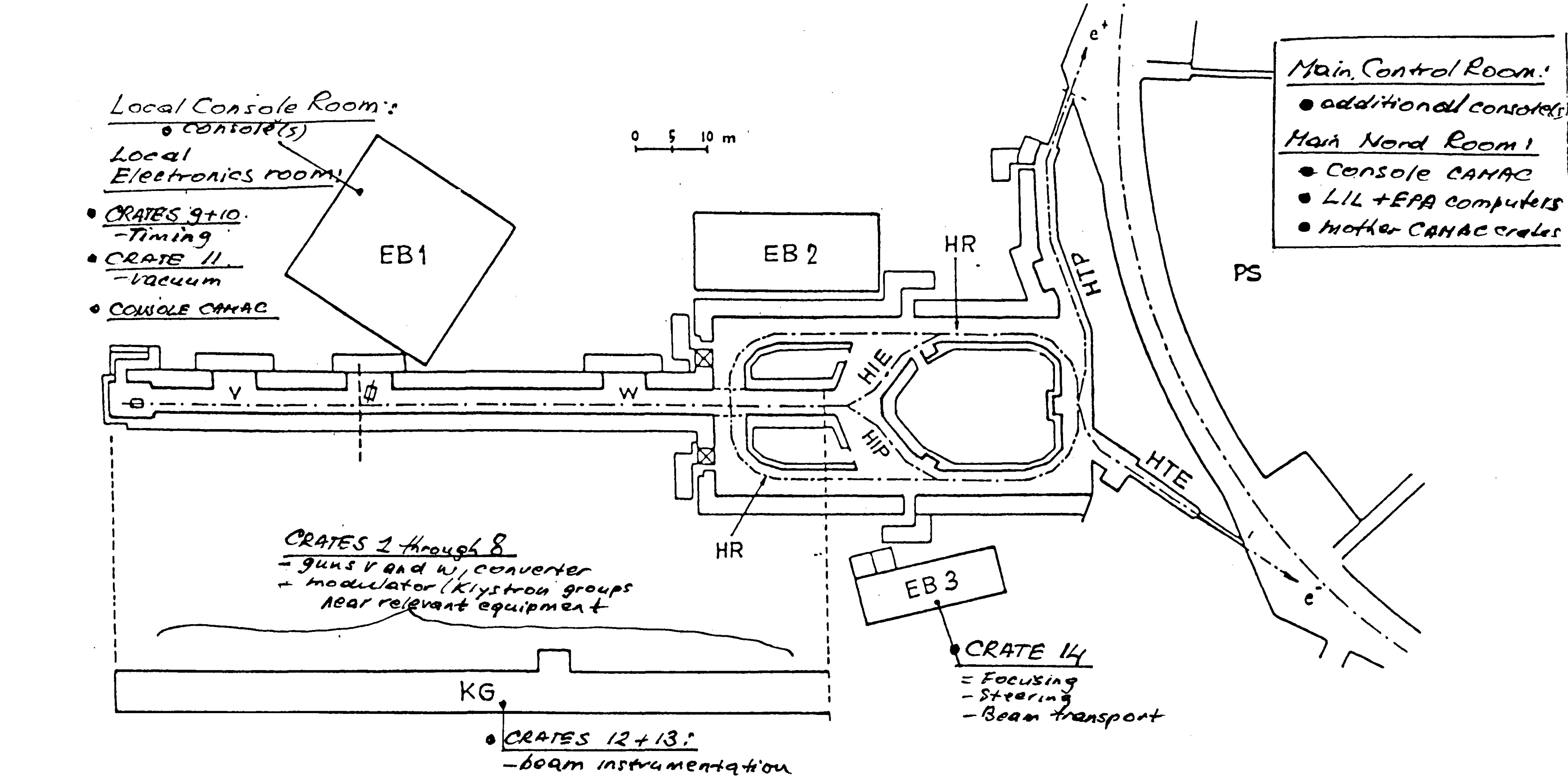

LEGEND

V, W	LIL, DIVIDED INTO 2 ZONES
KG	KLYSTRON GALLERY
HR	EPA RING
HIE	e^- INJECTION LINE LIL/EPA
HIP	e^+ INJECTION LINE LIL/EPA
HTE	e^- TRANSFER LINE EPA/PS
HTP	e^+ TRANSFER LINE EPA/PS
EB1	EQUIPMENT BUILDINGS NO. 1 (BLDG. 179)
EB2	EQUIPMENT BUILDINGS NO. 2 (BLDG. 2002)
EB3	EQUIPMENT BUILDINGS NO. 3 (BLDG. 278)

GEOGRAPHICAL LAYOUT
OF LIL CONTROLS HARDWARE

Fig. 3

CERN | L I L | 7 P E | 0 0 0 0 | 8 0 0 0 | + | A |

10.12.82. 4.2.82. A: Brought up-to-date
14.3.82 B.K.