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ACCELERATOR CONTROLS AT DESY

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Summary

Six $e^+ e^-$ accelerators are working at DESY. All of them are operated from one central control room via the new common control system. The report describes some design aspects, system structure, first experience, and the control room.

Introduction

Particle accelerators may vary in type, size, and complexity, but their control task assignments have many things in common. In spite of these similarities different control system philosophies have evolved at different accelerator sites, and the main area of difference is system structure. Modularity, flexibility, maintainability, cost effectiveness, and system overhead are only some of the consequences of the system structure.

One of the designing factors in structure decisions has been the historical development of the specific laboratory. Since its foundation in 1958 a number of different accelerators had come into operation. The layout is shown in Fig. 1.

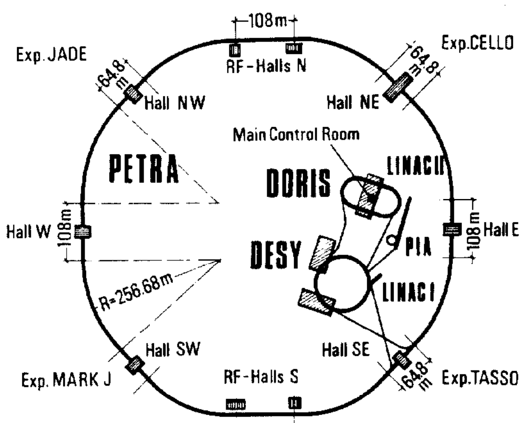

Fig. 1: The layout of the accelerators

- 1963 the first linear accelerator prod. 40 MeV e^-
- 1964 the synchrotron DESY acceler. the first beam
- 1970 the 400 MeV LINAC-II produces e^- and e^+
- 1974 the double ring DORIS has colliding beams
- 1978 PETRA the large e^+e^- single ring in operation
- 1979 the positron accumulator PIA is commissioned
- 1982 the new single ring DORIS-II is completed.

Each of these machines started operation with controls, according to the state of the art at that time, and each (except DORIS-II) had its own control room. With PETRA[1], a new generation of controls had to be built in-house. The system is marked by the following attributes:
a computer based system, with parallel and serial data ways, multi-user operating system, use of high level language and interactive man-machine communication.

While PETRA controls were improved continuously, the existing machines were equipped or rebuilt according to the PETRA[2] control standard.

- 1979 PIA started with a copy of PETRA beam instrumentation and controls
- 1980 a major part of LINAC-II and beamlines became accessible on the new control system.
- 1981 LINAC-I, the synchrotron DESY, and the rest of the beamlines were incorporated.
- 1982 DORIS-II started operating very successfully with the new beam instrumentation and new controls.

This relatively fast extension of the PETRA control system into the other accelerators was made possible by three main reasons:
- the major part of the control system was built in-house. This provides all individualls with a high degree of experience, which in turn allows quick action at low overhead
- the uniformity of machine instrumentation, process equipment, control devices, and software at different machines allows improvements in one accelerator to be quickly incorporated into the others
- the modularity and redundancy of the control system permit its extension without the need for extra shut down periods.

Control System Structure

System modularity was the main design criterion in deciding upon the system structure.

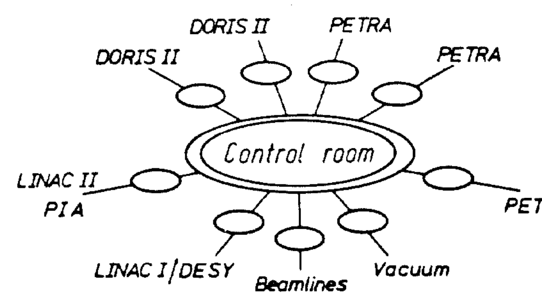

Fig. 2: The control system structure

Currently the whole accelerator complex is divided into nine task. See Fig. 2. Each task is connected to the control room via one control setup (the bubbles in Fig. 2) consisting of the following building blocks:

- "mini" type process computer (NORD 10 or NORD 100) with 256 KB main storage, running under multi-user operating system
- DISK storage (10 MByte)
- alphanumeric video terminals
- a SErial Data ACquisition System SEDAC[3] connecting the computer to the process, (several lines)
- a PArallel Data ACquisition System PADAC[4] which, handles the consol devices such as tracker ball, TV-displays, RGB-displays including fullgraphic and semigraphic buffers, cursors etc.

Each of these control setups together with its process and console equipment will be termed a CONTROL CELL. Each control cell is independent and can be operated without connection to its neighbour cells. Cell-to-cell communication is effected by shared memory at the control room site (see Fig. 2). It should be noted that the need for these communications is strictly limited. Only a few words of memory have been implemented to keep the control cells independent

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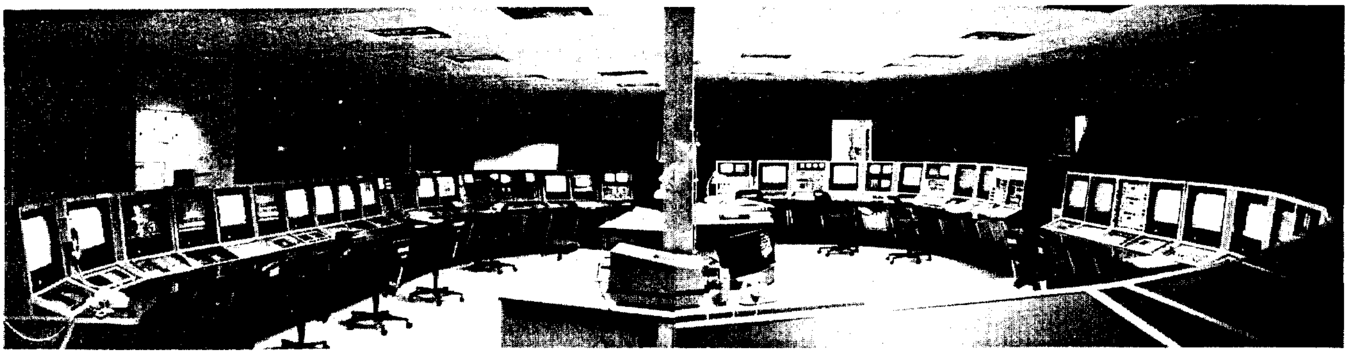

Fig. 3: The common control room of all accelerators at the DESY site

of each other as far as possible. This minimal cell-cell communication has been the main criterion in defining cell boundaries.

Other criteria for control cell size are, of course, even and homogeneous load distribution of the complete process between all cells.

Load adjustment or system expansion by adding a cell can be implemented easily because of hardware and software modularity at all levels.

The resulting process divisions shows Fig. 2. The control cell "vacuum" handles vacuum equipment and pressure in several accelerators while the remaining control task of a machine such as PETRA is split between three cells.

Economic reasons provided three variants for change-over of existing accelerator controls to the new standard.

- The old beam instrumentation, process equipment, and interface is completely replaced by a copy of an existing control system standard.
- beam instrumentation is kept while the process equipment is modified to enable its control with existing or modified interfaces of the new type.
- instrumentation and process equipment is kept. A new interface modul has been developed, the control system is expanded by one new standard.

Currently about 4000 process elements, for example magnet power supplies, cavities, RF-transmitters, vacuum pumps, or monitor electronics, are handled by the new control system.

The experience with the control system structure can be summarized as follows:

- task oriented process division, stand alone capability of the control cells, and uniformity of these cells in hardware and basic software have been successful
- all improvements (mainly in the software) have been immediately available at all accelerators without significant extra work.

The control room

The central control room is the heart and show piece of every control system. See. Fig. 3.

This room has to fulfill a variety of requirements. It has to be furnished in a functional and task specific way, keeping in mind asthetic and ergonomic considerations. Two operating situations show the spectrum of the requirements.

Situation A: The storage rings PETRA and DORIS are running for high energy physics. Luminosity is produced in six interaction regions (4 in PETRA, 2 in DORIS-II) and registered by the control system. Fig. 4 depict the e^+ e^- currents of both accelerators.

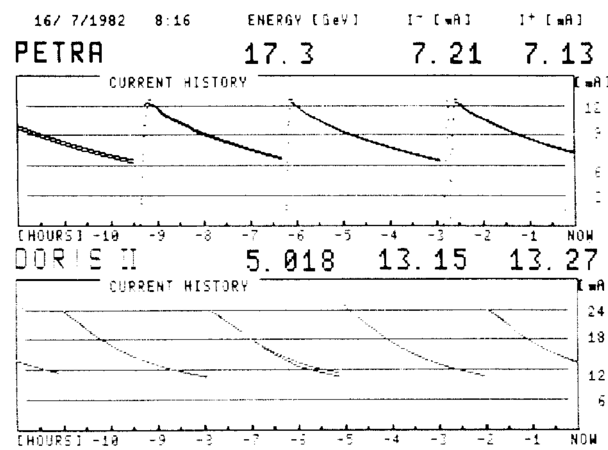

Fig. 4: The e^+ e^- current over the previous 12 hours

The injection accelerators and beam lines are switched on only during the filling periods of the storage rings and returned to the "power save state" in between.

The integrated luminosity per day versus a run period is a down time indicator of the whole process.

For example: Fig. 5 shows the mean luminosity registered at PETRA over a consecutive run period of continuous 24 hour service during the summer vacations. The control room was occupied by three or four operators.

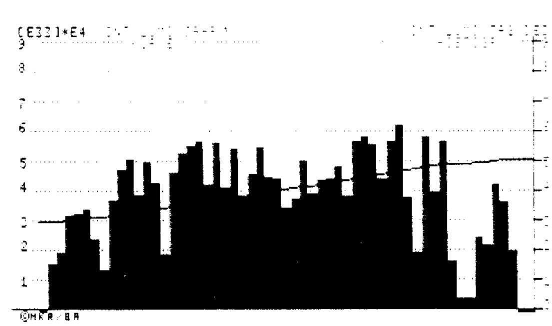

Fig. 5: The PETRA luminosity profile
100 nb-1 per div. and day vs. eight weeks

Most of the necessary procedures are running under automatic control. The programs at the involved process tasks and accelerators are synchronized by cell-to-cell communications.

Situation B

During development periods, machine studies or shut down activities control system service are required by the different accelerators and control cells in parallel. At that time the individual multi-user demands are nearly independent.

For economic reasons the major part of the process equipment remains exclusive accessible by the control system tools. Besides the action from the control room, access is also possible via the SEDAC system with alphanumeric terminals on the site.

During rush hour periods more than a dozen experts are working at the consoles together with a number of colleagues.

The control system has to cope with the interactive procedures without noticeable interference and in a fast response time.

Currently the control room is equiped with eleven independent work stations. Fig. 6 shows one of these.

Each station consist of standard man-machine tools such as: keyboard, two tracker balls, program echo screen, alarm-screen, and two 19" RGB-screens, besides station specific equipment.

Operation of the whole control room is possible without programming skills. The programs necessary for service, machine studies, and production were written by software experts. They are executable by selection from suggestive menus.

Four classes of programs are standarized:

- alarm programs are running in the background under automatic control.
- service programs provide equipment oriented dialog for all details of the specific unit, including recommendations for exchange procedures.
- accelerator operation programs provide process oriented information, the operator is guided by dialogues.
- permanent display programs continuously generate histograms and trend displays, which are distributed throughout the control room as TV pictures. The operator receives continuous information on major process states. Correlations which cannot be foreseen and therefore cannot be programmed can be visualized.

These trend displays are important in several ways:
- the operator can check the status of certain process areas at stand by just turning his head
- time relationship becomes transparent by looking at their histories (strip chart recorder feature).

Meaningful displays and quick updating of information provides the user with a feeling of awareness and thus of satisfaction with the system. If the operator can furthermore base his own decisions on this information, the control system has fullfilled its purpose.

To sum up accelerator controls at DESY:

It has been shown that the task of controls for accelerators of different types and sizes are very similar.

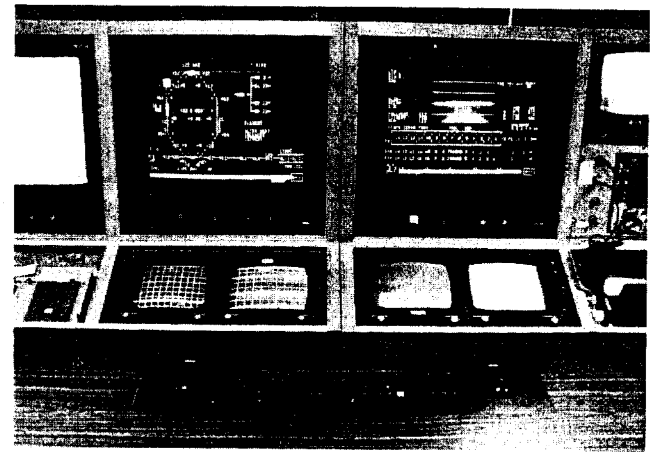

Fig. 6: One of the console working stations

This, of course, requires the view of the control problem as a whole, consisting of beam instrumentation, process equipment, control system, and making adaptions where this can be done with minimum effort.

The uniform controls of the whole accelerator complex and the realized common control room for all machines has been rather advantageous for set up, operation and improvements.

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