ISBN: 978-3-95450-254-7 ISSN: 2226-0358 doi:10.18429/JACoW-ICALEPCS1991-S04SRS03

STATUS OF THE CONTROL AND BEAM DIAGNOSTIC SYSTEMS OF THE CRYRING PROJECT

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Abstract—CRYRING is a facility for research in atomic, molecular and nuclear physics. It uses a cryogenic electron beam ion source, CRYSIS, together with an RFQ linear accelerator as injector into a synchrotron/storage ring for very highly charged, heavy ions. The first circulating beam was achieved in december 1990. The status of the systems for control and beam diagnostics are described.

INTRODUCTION

The CRYRING project [1] is centered around a synchrotron/storage ring of maximum rigidity 1.44 Tm, corresponding to an energy of 24 MeV per nucleon at a charge-to-mass ratio $q/A = 0.5$. It is mainly intended for highly charged, heavy ions produced by an electron-beam ion source (CRYSIS).

Light atomic or molecular ions can also be injected from a small plasmatron source (MINIS). Ions from the ion sources are accelerated electrostatically to 10 keV per nucleon and transported to a radiofrequency-quadrupole linear accelerator (RFQ) which brings them to 300 keV per nucleon. The ions are inflected electrostatically into the ring where they are accelerated using a driven drift tube. The stored ions will be cooled by an electron cooler. Fig. 1 shows a layout of the CRYRING facility.

The control system is based upon the LEAR (Low Energy Antiproton Ring) control system at CERN [2]. The principles of the system, the main part of the software and some parts of the actual hardware implementation are copied from the LEAR system. A substantial amount of development work has nevertheless been put into the CRYRING control system in order to adapt it to our operational needs which are partly different from the ones at LEAR.

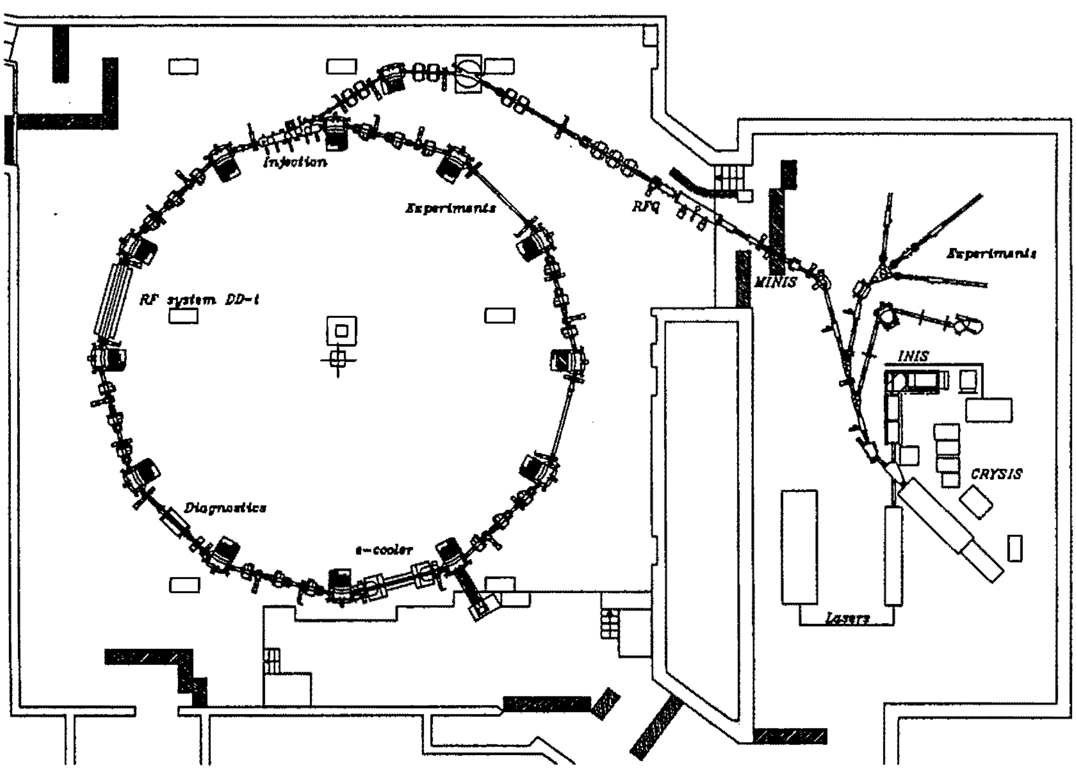

Fig 1 CRYRING layout.

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CRYRING is equipped with different diagnostic elements to measure the low energy ion beam profile and current in the injection lines, to monitor the beam properties in the ring and to control the frequency of the accelerator structure keeping the beam centered in the beam tube.

THE CONTROL SYSTEM

The control system is based upon the LEAR control system at CERN. The architecture of the system, as well as the main part of the software and some parts of the actual hardware implementation are copied from the LEAR system. The development work in the CRYRING system has mainly been done in two areas. One is the low-level interfacing to our accelerator equipment using microprocessor systems with software written to allow local control for test purposes and thus make trouble-shooting easier. The second is the adaption of the software in the main computer to the actual hardware and to our operational needs which partly differ from the ones at LEAR. The system controls the whole CRYRING complex, that is the ion sources, the beamlines and the ring. The electron cooler, which will be installed this winter, will also be controlled by the same system. The general structure of the control system is shown in fig. 2.

Structure of the system

The main components of the systems are:

- The main computer, a PDP-11/73, with terminals and two operators consoles.
- A serial CAMAC loop for distribution of data and timing.
- A large number of G-64 microprocessor systems for interfacing to the machine equipment.

A piece of accelerator equipment connected to the system is called a parameter. Analog control signal output to parameters from interfaces in G-64 systems can be of two different types: static, controlled directly by the main computer, or ramped, controlled via programmable function generators in the G-64 systems. These function generators, called GFDs [3], have the shape of the function down-loaded from the main computer via the CAMAC serial loop. They can then be started, stopped, held and released synchronously with each other by pulses from the timing system. The timing system [4] consists of one master and a number of decoder modules, all sitting in CAMAC, interconnected with a timing distribution cable.

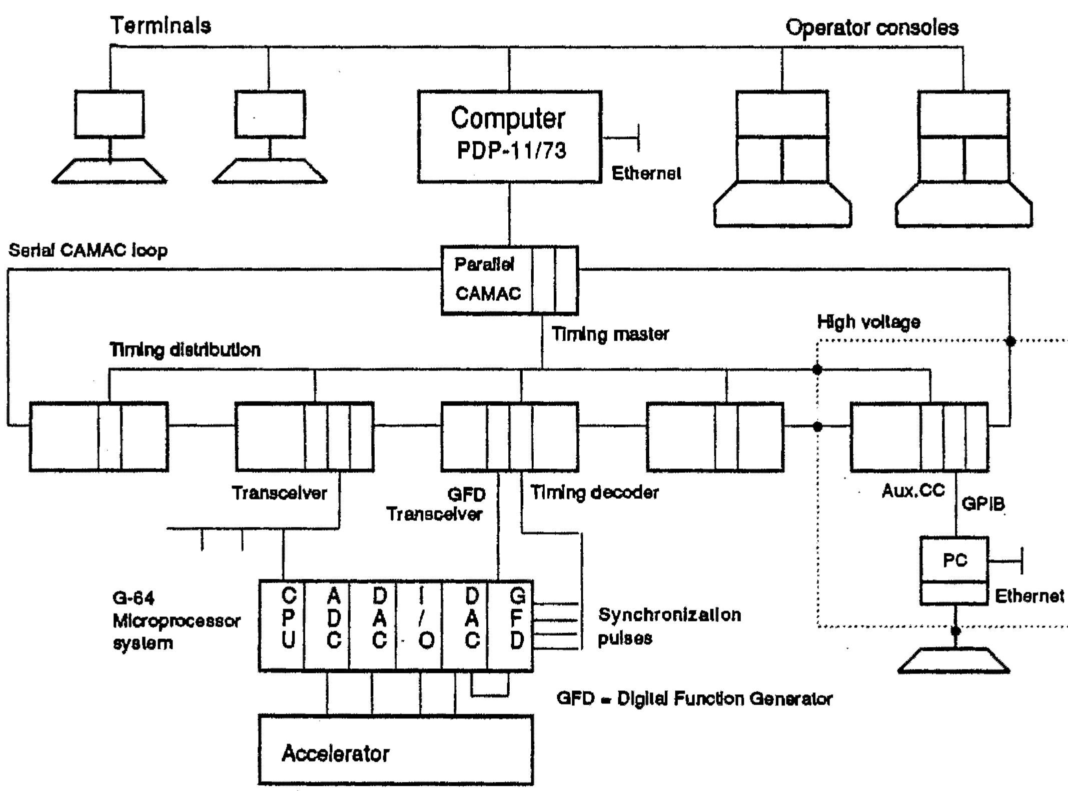

Fig 2 The control system.

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The master and decoders are programmed via CAMAC by the computer to execute a predifined set of timing events, a machine cycle. Starting, stopping and repeating the machine cycle is done by external pulse inputs. This means that once the GFDs and the timing system have been loaded the cycling of the ramped parameters is done without need for intervention by the main computer.

The control of the CRYSIS ion source demands special flexibility and quick responses, as well as a more developed local control. These needs have been met by adding a PC that has access to the necessary hardware via an auxiliary crate controller in one of the CAMAC crates. This has requred an optical link between this PC itself and its keyboard, because the PC as well as the mentioned CAMAC crate is put on a 50 kV platform.

Status, November 1991:

The control system

- has been running since the first parts of the accelerator system were taken into operation in 1987.
- presently controls around 160 static and 20 ramped parameters. New parameters are successively added.
- allows control from both control room and equipment areas.

The G-64 systems

- control from 1 to 16 parameters each.
- have hardware and software tailored for their actual applications.
- can be equipped with terminals and run in local mode, thus making it easier to trace faults in accelerator hardware and in main computer software.

Development:

Some upgrades are being considered to improve performance and user interface. These developments are parts of today's control system at LEAR and would be logical updates to the CRYRING system:

- More computing power can be added by network linking to VAX computers at the institute.
- Workstations and PCs are considered as complement to the operators consoles. Operation with graphic presentation, also from equipment rooms and experimental areas, is desired.

DIAGNOSTICS

The beam intercepting devices in the transfer lines are Faraday cups for intensity measurements and strip detectors for beam profile and emittance measurements. Also, chromium doped Al_2O_3 plates viewed through TV-ca/-me/-ras are used here.

The control system moves these devices into/out of the beam, switches TV-cameras to different monitors and the read-out of the beam current to selected instruments.

The signals from strip detectors (each detector consists of 16 horizontal and 16 vertical strips) are amplified, multiplexed and sent to ADC's in a VME computer system placed in the control room, fig. 3.

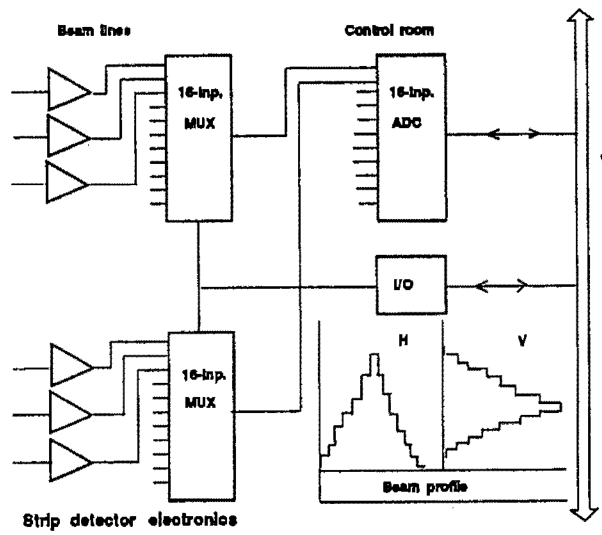

Fig 3 Strip detectors.

In the ring non-destructive measurements are performed using 9 horizontal and 9 vertical electrostatic pick-ups, a beam current transformer and a Schottky noise detector.

The signals from the pick-ups, fig. 4, can be processed by a fast peak-detection system [5] or by using synchronous rectifiers for low-bandwidth measurements. An even faster peak-detection system is now being installed on one pick-up, to allow for measurement over 128 consecutive turns, to study transient behavior of the beam [6].

A high resolution (300 nA) current transformer from Ber/-goz, for measuring the absolute value of the current of the unbunched beam, was installed. So far there has been problems with the signal-to-noise ratio where the noise has been observed to come mainly from the ring magnets . Work is going on to solve this problem. The electronics of the Schottky detector is shown in fig. 5.

3rd Int. Conf. Accel. Large Exp. Phys. Control Syst. ICALEPCS1991, Tsukuba, Japan JACoW Publishing
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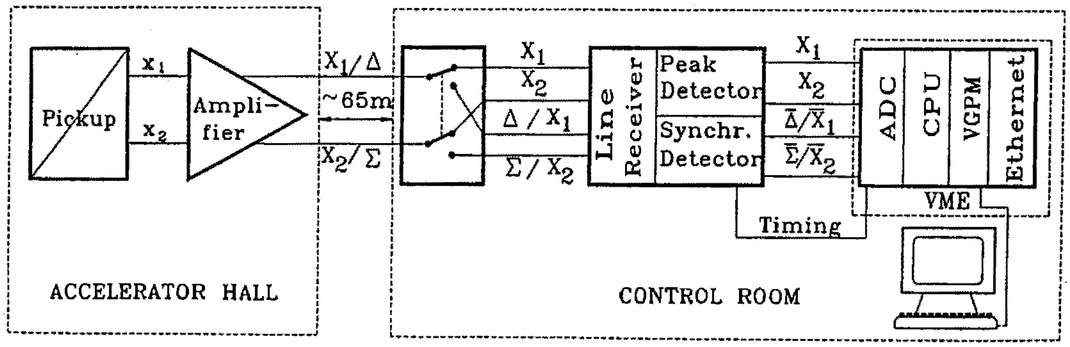

Fig 4 Pick-up detection system.

The input signals are amplified by high bandwidth (.01-50 MHz) amplifiers and the difference and sum signals are created in a passive circuit consisting of three power splitters. Frequency analysis of these signals can yield the q-value of betatron oscillations and the momentum spread of the beam, as indicated in the figure.

The same result, but much faster, can be obtained by processing the signals in a DSP consisting of a flash-ADC and a FFT processor. It is considered to include this type of module in the VME system. The VME computer is equipped with a GPIB controller which allows control and read-out of auxiliary instruments.

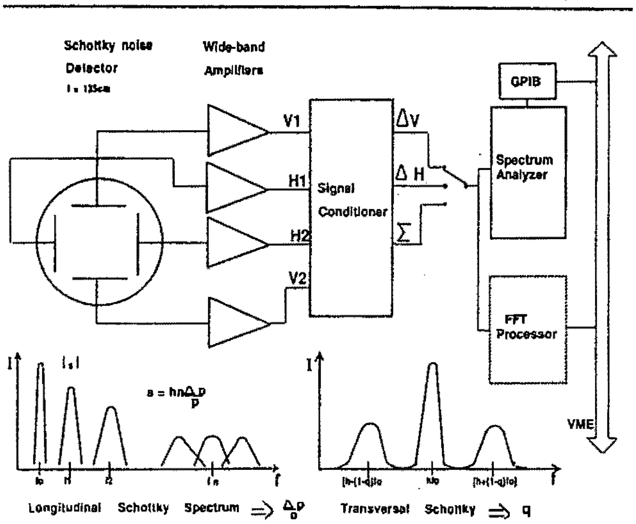

Fig 5 Schottky detector.

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