KURCHATOV SYNCHROTRON RADIATION SOURCE: GENERAL - PURPOSE TV SYSTEM FOR BEAM MONITORING AND INSPECTION OF ACCELERATOR - EQUIPMENT ROOMS

L.I. Ioudin, V.V. Martynenko, and V.A. Rezvov
KSRS, Kurchatov Institute RRC, pl. Kurchatova 1,
Moscow, 123182 Russia; e-mail: ioudin@ksrs.msk.su

ABSTRACT

Project of a general-purpose TV system for the Kurchatov Synchrotron Radiation Source (KSRS) is reported. The TV system is intended for beam monitoring in 17 beamlines of both the small and large storage rings. In addition, it will ensure a prompt inspection of all work-rooms. The cross-section of every beam will be accurately mapped with the aid of four probes per beamline. Two of them will be ionization beam-section image detector (BSID); the remaining two will be beam-interceptive phosphor-coated probes. The design of a BSID pilot sample is described. The computer-processed image of the beam cross-section and its numerical parameters will be displayed on the monitor screen. The use of commutators, quadrators, and TV movement detectors will substantially reduce the routine of inspecting work-rooms.

1. INTRODUCTION

Now the adjustment of the Kurchatov Synchrotron Radiation Source (KSRS) facility [1] at the Kurchatov Institute RRC is near to completion (Fig.1). At present, the S1 ring is operating steadily at its rated electron energy of 450 MeV and a current of 100 mA. The electron energy in the S2 storage ring has achieved its rated value of 2.5 GeV. The next stage of the facility finalization will involve SR beamline implementation. Up to date, three VUV beamlines, supported by the S1 ring, are already operational. We also plan to have 14 x-ray beamlines.

The aim of the considered project is to create a prompt data system. The system should be based on state-of-the-art experimental techniques. It must provide a multichannel and multiparameter monitoring of all our SR beamlines. The visual-light diagnostics already available at KSRS will be adequately included in the future beam-monitoring service. The SR will be monitored at two levels, namely a qualitative (in-line visualisation)and a quantitative (computer processed measurement results) ones. We plan to use phosphor probes as beam-intercepting detectors. The non-destructive beam cross-section probes will be of the BSID type. The ionization beam-section image detector was tested on the different charged particle beams [2,3] and recently the first experiments of SR parameters registration was provided on the DCI [3].

The second aim of the project is to implement efficient means of inspecting all the KSRS work-rooms in order to enhance the general, fire, and radiation safety.

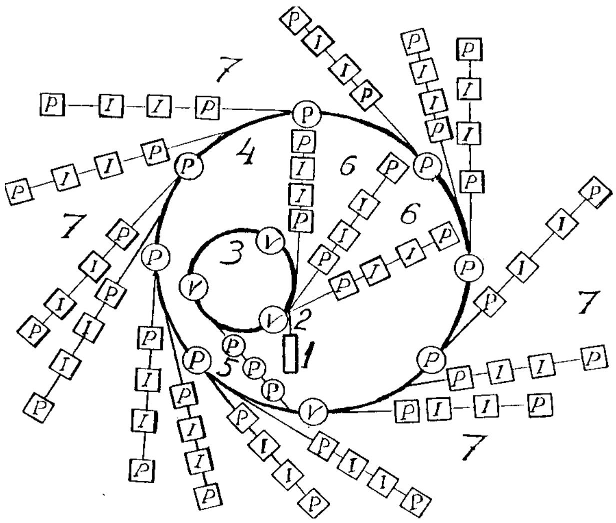

Fig. 1. KSRS facility layout and probe accommodation:
1- electron linac; 2- electron transfer line ETL1; 3- booster storage ring S1; 4- large electron storage ring S2; 5- electron transfer line ETL2; 6- VUV-beamlines; 7-X-ray beamlines; I- imaging ionization probe; P- phosphor probe; V- visual-light TV pickup camera. Circles and square boxes represent operational and planned probes, respectively.

2. TV MONITORING OF BEAM GEOMETRY AND INTENSITY IN STORAGE RING, BEAMLINES AND ETL2 LINE

The KSRS facility has several distinct operating regimes: S1 ring adjustment; current accumulation in S1 ring and electron energy rise; current storage in S1 ring for experiments with VUV radiation; use of the S1 ring as a booster during the electron injection to the S2 ring; parasitic use of VUV beams for experiments during S2 ring adjustment; extraction and use of x-ray radiation from the S2 ring.

In the S1 ring adjustment regime one needs to observe simultaneously the beam patterns picked up by three visual-sensitive TV cameras. Therefore the TV

cameras of the phosphor-coated probes, accommodated on the ETL2 electron transfer line and on the S2 ring, operate in the single-frame mode. The TV image processed in the interface
is saved only upon the arrival of an external trigger signal.

The system of visual beam monitoring is so composed that the data, concerning all the operating modes of the S1 ring and VUV beamlines, are concentrated on a single monitor screen with the aid of a quadrator. Intermittently, this monitor shows in turn the TV images from the three phosphor probes of the ETL2 line as well as some TV pictures provided by a visual-light pickup TV camera of the S2 ring. The diagram in Fig.2 illustrates the structure of the visualised diagnostics comprising the S1 ring, one VUV beamline, and the ETL2 line (the latter serves for electron injection from S1 to the S2 storage rings). There are also two additional VUV beamlines, but in Fig. 2 their circuits are omitted. This diagram is simple enough and we will not comment it. The operator can select some of those video signals and send them at will to various destinations. The electronics let the phosphor and ionization imaging probes operate intermittently (in turn). The entire video information is being transmitted to the user's monitor and computer through commutators AC8-AC10.

The diagnostic service, consisting of 14 x-ray beamlines, is divided into four identical branches. Each branch supports four identical diagnostic channels. Fig. 3 presents the scheme of the first of these branches (this branch includes the diagnostics of the S2 storage ring). The AC1 commutator connects in turn the S2 phosphor probes P1-P7 to the monitor and computer. After the completion of beam guidance around the S2 ring, the monitor unremittingly displays the image transmitted by visual-light camera V belonging to this ring. The AC2-AC5 and AC6-AC8 commutators make it possible to observe signals from any probe of the four x-ray beamlines. The AC9 commutator is capable to send any beam image to a computer. It should be outlined that one monitor must not display more than three images provided by probes belonging to the investigated beamline.

Commutators AC10-AC13 enable the user to check the image supplied by any probe (belonging to the user's beamline) on his personal terminal. For this purpose he should use his monitor and computer. For beamline diagnostics, there will be 4 monitors and 4 quadrators in the control room, together with the necessary switches, switch drivers, and also many computers. The beam visualisation program will require from 58 to 60 pickup TV cameras.

We hope that in the future the phosphor and ionization imaging probes would share common boxes accommodated in the beamlines. Such a coexistence could reduce the number of TV cameras by a half.

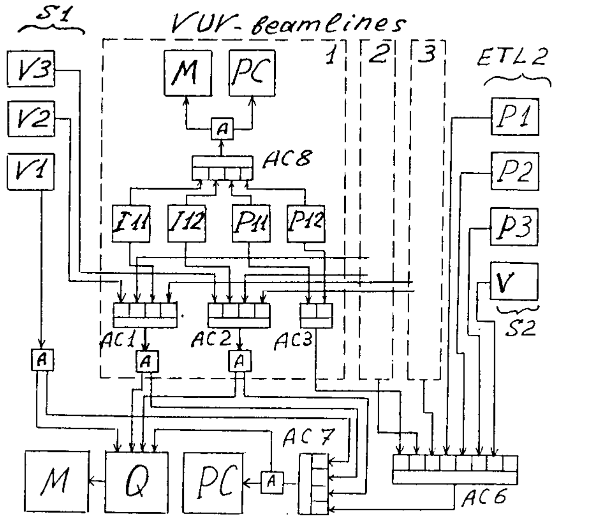

Fig. 2. Beam diagnostics in booster S1, VUV beamlines, and ETL2 line: V1-V3 visual-light TV cameras of the S1 booster; A- matching amplifiers; I11, I12- imaging ionization detectors of the first VUV beamline; P11, P12-phosphor probes of the same beamline; M- television monitor; PCpersonal computer; Q- quadrator; AC1-AC3, AC6-AC8 analogue commutators; P1-P3 phosphor probes of the ETL2 line; V visual-light TV pickup camera on the S2 ring.

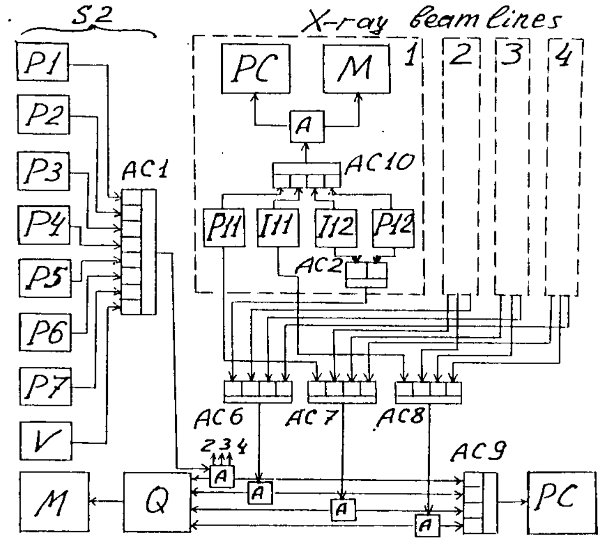

Fig. 3. Block diagram of a beam-diagnostics branch (S2 storage ring and four x-ray beamlines):P1-P7 Phosphor probes of the S2 ring; V visual-light TV pickup camera of the S2 ring; P11, P12 phosphor probes of an x-ray beamline; I11, I12 imaging ionization detectors of the same beamline; AC-analogue commutator; A- matching amplifier; M-monitor; Q- quadrator; PC personal computer.

3. VISUAL SURVEY OF WORK - ROOMS

We plan to ensure a quick TV survey of the accelerator premises and the majority of work-rooms accommodating high-power equipment. The total number of TV cameras needed for the in-line inspection of all the premises is estimated to be 60. The system is divided in four identical branches. A branch supports 16 survey TV cameras. Each branch is divided in four identical channels (Fig.4). It comprises four TV cameras, several analogue commutators, movement detectors, quadrators, and a display monitor (the control circuits are omitted). The 2-position analogue commutators AC1 and AC2 ensure the selection of the operating mode of TV cameras : cycling commutation or address operation mode. The mode selection is up to the operator. The commutators are actuated manually or by a computer.

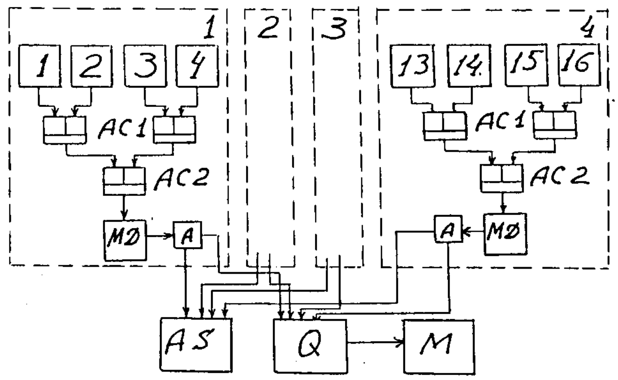

Fig. 4. Block diagram of a branch of TV room-survey system (16 channels): 1-16 visual-light survey TV cameras; AC1, AC2- analogue commutators; A- matching amplifier; AS- alarm signal switch; Q-quadrator; M- monitor.

An observer is known to need from 4 to 10 s to recognise a TV picture-depending on its complexity level [4]. Therefore, the comprehension time in the case of overall inspection of pictures appearing at the screens of four closely arranged monitors may be estimated as 15-30 s. Hence, the general survey of our premises can require a 2-5 min repetition rate.

The quick TV survey of premises is very valuable in some situations. For example, it is important before switching-on separate units or the accelerator-storage ring facility as a whole. During the facility normal operation, the operator may practically ignore the survey monitors until an emergency alarm signal. In fact, the occurrence of any change in the frame picture, sent by any survey TV camera, actuates a motion detector (MD). There is an MD ahead of the input of every quadrator (Q). The MD will send an alarm signal which arrives to the emergency multi-input commutator (EC), connected in parallel with the quadrator. The EC fixes the address of the suspicious-image TV camera.

Of course the operator is able to select any of the TV cameras (in the address regime), send its TV picture to a corresponding monitor and zoom the TV picture up to the full-screen size. If the light in the inspected premises is turned off, the survey TV cameras would detect a fire burning in our premises.

4. CONCLUSION

The presented scheme of beam monitoring is fulfilled in accordance with the algorithm of the accelerator-storage ring facility operation. The set of diagnostics and the technique of experimental data presentation ensure a descriptive visual mapping of the investigated beam properties: the real cross-section, its size, position, and qualitative relations. For each stage of accelerator operation we have specified an adequate system of beam mapping.

The number of data-presenting TV monitors was minimised. A single monitor displays all the visualised data concerning the behaviour of the S1 booster ring in any operation mode. There are also four monitors yielding all the information about the behaviour of one of the S2 large storage ring beams and also of any x-ray beamline. The TV images can be archived and qualitatively assessed at any stage of work. Various TV devices (including four monitors) will survey the KSRS work premises all the time. This will practically liberate the operator from routine procedures of room inspection.

5. REFERENCES

1. A. Artemiev, N. Dudina, V. Moryakov, Nucl. Instr. and Meth. A 359(1995)29-33

2. Mikhailov V.C., Ioudin L.I., Leonov V.V., at al. Proc. 4th. Europ. Part, Accelerator, London, 1994, vol. 1, pp. 1743-1745.

3. Mikhailov V.C., Lightenshtein V.H., Rezvov at al. “The development of the ionisation detectors for measuring the main parameters of the accelerated ionising beams”. In press.

4. Dzhakoniya V.E., Gogol A.A., Erganzhiev,N.A., et al. Televidenie (Television), Moscow: Radiosvyaz', 1986.