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RADIATION MONITORING SYSTEM OF HLSII *

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Abstract

Monitoring of ionizing radiation of synchrotron radiation facility is very important for the safety of staff and users of the light source. Radiation monitoring system of HLSII has been built and the whole system consists of local radiation monitoring spots and central control system, and a web-based monitoring dynamic release system. The local radiation monitoring spot consists of a high air pressure ionization type gamma detector and a BF_3 counting tube neutron detector, and the radiation data are calculated by microcontroller locally and acquired by the data server for further processing. The dynamic release system is integrated with EPICS interface and radiation safety interlock system. Other accelerator systems could obtain radiation data from the server and the interlock system is triggered by the radiation data to shut down the machine in case the radiation exceeds the safety threshold.

INTRODUCTION

The ionizing radiation of a synchrotron radiation facility is a non-stationary and strong instantaneous radiation field, mixed with bremsstrahlung by electrons and derived neutron radiation, and it must be under monitoring for safety consideration for the users and the public [1-4]. HLSII consists of a Linac, a transport line and a storage ring. The energy of Linac increases from 200 MeV to 800 MeV due to the upgrade of HLS by 2014, and operation mode of electron beam pulse changes from 1us to 1ns(repetition of beam remains 1Hz). The Linac is in the underground tunnel and there is no ionizing radiation influence monitored on the ground. The storage ring of HLSII is 800 MeV energy with 66.13 m circumference, and injects 3 times a day now for decay mode. The radiation shield of storage ring is made up of 5 cm thick lead bricks, steel sheds and concrete wall surrounding the vacuum chamber of the storage ring. The injection and operation of storage ring will cause the ionizing radiation, which mainly consists of gamma and neutron radiation for wide energy spectrum. The real-time monitoring of the radiation field can not only protect personnel safety, but also grasp the comprehensive information of the radiation field. The top-off upgrade will be finished by 2018, and the radiation monitoring system, radiation shield and interlock system need to be upgraded. The whole monitoring system and its commissioning results will be presented in this article.

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SYSTEM ARCHITECTURE

The Architecture of radiation monitoring system of HLSII is shown as Fig. 1. The whole system consists of 2 environmental radiation monitoring spots and 19 regional radiation monitoring spots. Environmental spots are outside the accelerator for environmental monitoring, and regional spots monitor the radiation dose data for the staff and users of the lab.

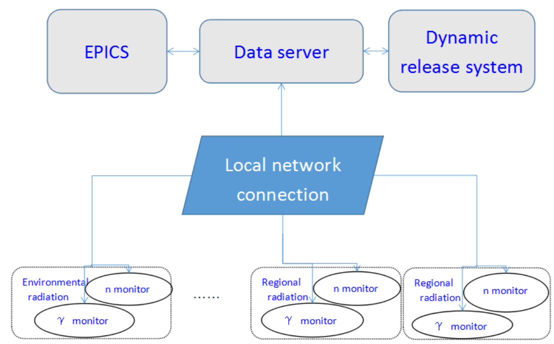

Figure 1: Architecture of radiation monitoring system of HLSII.

The radiation data are acquired, processed and stored locally at every monitoring spot, and they are sent to the data server via local network. The data server has epics interface connected to other system of accelerator and the server also implements a web-based dynamic release system for the users and the public.

Radiation Monitoring Spots and Distribution

The radiation monitoring spot is shown as Fig. 2. Every monitoring spot consists of one gamma detector and one neutron detector.

Figure 2: #16 radiation monitoring spot.

The gamma detector is a high air pressure ionization type detector. The ionization chamber is a spherical type chamber with 180 mm diameter and 2 mm thickness, within 3 litres volume 25 atm pressure argon is stored. The operating voltage of the chamber is in the range -600 ~ -1200 V, and the plateau area is -400~-1000 V, with 1.13 pA/uGy.h^{-1} sensitivity, and the energy response of the detector is in the range 50 keV~3 MeV. The neutron

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detector consists of a BF_3 counting tube, a polythene moderator and electronic circuits. The BF_3 tube is 146mm long with 25.4 mm diameter, and the operating voltage is about 1850 V, with more than 200 V flat length and less than 3%/100V plateau slope. The energy response of neutron detector is in the range 0.025 eV~17 MeV with sensitivity about 0.2 cps/(uSv/h).

The output current of the gamma ionization chamber is converted to pulse signal by electronic circuit, and the frequency of pulse is in direct ration to output current of the chamber [5]. The output of neutron detector is amplified by trans-impedance operational amplifier, and then distinguished by comparator to get rid of the pulse signal due to gamma. Both the pulse signals of gamma detector and neutron detector are counted and calculated locally for monitoring and also acquired by the data server for further application.

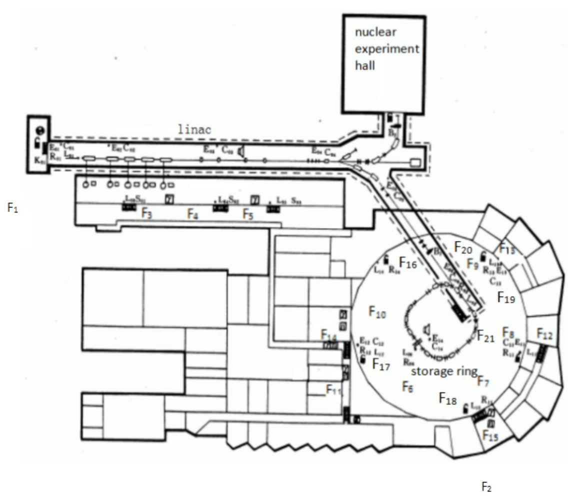

Figure 3: Distribution of monitoring spots of HLSII.

The distribution of monitoring spots of HLSII is shown as Fig. 3. There is two spots of environmental radiation monitoring areas: F1 is on the south-west side of the Linac, and F2 is on the south side of the storage ring, over against the injection point. Regional radiation monitoring spots consists of 8 workplace spots and 11 storage ring hall spots. Workplace spots: F3, F4, F5, F11, F12, F13, F14, F15. F3, F4 and F5 are on the inner wall of the klystron corridor, consisting of only one gamma detector. Because the radiation in this area is mainly caused by the X ray produced by the klystron during operation and no staff is allowed enter this area during klystron operation, the radiation level is relatively low. The radiation monitoring points of F11, F12, F13, F14 and F15 are located surround the storage ring, outside the storage ring hall, where the staff often work and stay for a long time. The other 11 regional radiation monitoring spots are located in the storage ring hall, to monitor the injection and operation status of radiation.

Upgrade for Top-off

The storage ring injects 3 times a day now for decay mode, and people need to leave the storage ring hall during injection. The upgrade for top-off will be finished by 2018, by then people could stay in the storage ring hall during injection and operation. For top-off operation, storage ring injects every several minutes, and more monitoring spots are needed. F16, F17, F18, F19, F20, F21 are new monitoring spots added for top-off operation as Fig. 3. Also more shield are equipped around the injection point and beamlines. The interlock system is upgraded for top-off operation as follow:

1. The upper layer software and computer storage system are upgraded to enhance safety security system by sharing data.
2. Different threshold of alarm for several areas are set, and the interlock system could be triggered when the radiation reach the threshold. The accelerator will be shut down by the interlock system.
3. The logic of access controller of storage ring hall is changed not to relate with injection.
4. The threshold of injection efficiency is set with interlock system. When injection efficiency is lower than the threshold, the injection stops.

Dynamic Release System

A web-based dynamic release system for a real-time and remote multipoint radiation monitoring of HLSII is developed [6]. Data acquisition and storage section are implemented by using LabVIEW, and the system is integrated into EPICS database with the interface designed by CA Lab. Java combining with Java Server Page(JSP) technique is adopted to complete the design and implementation of the data query system based on Browser / Server. Real time monitoring and historical data query can be more efficient and convenient for administrators and users.

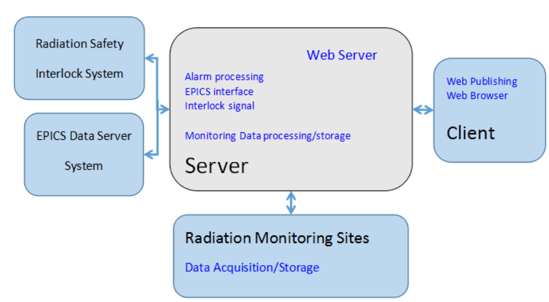

Figure 4: Structure of dynamic release system.

The structure of dynamic release system is shown as Fig. 4. The radiation dose data are collected and stored in monitoring spots, and transferred to the host computer by intranet for real time display, and then stored in the server. The server has alarm function when the radiation data exceeds threshold to trigger the radiation interlock system. The EPICS communication interface is integrated in the server for sharing and collecting data with other

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accelerator systems. The server is mainly composed of a Web server software (Tomcat) and a data server, which is responsible for data storing and monitoring and also responds to requests from the clients. The browser oriented user client can access Web server directly through the browser. When the user sends a HTTP request to the server side, Tomcat calls its JSP application to complete the request-response, and returns the visual results to the user browser end.

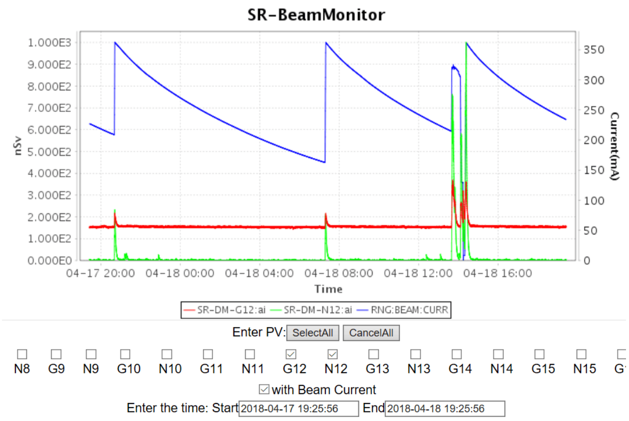

Figure 5: #12 monitoring spots radiation data and its corresponding operation condition.

The #12 monitoring spots radiation data and its corresponding operation condition could be obtained by the browser via the dynamic release system, as shown in Fig. 5.

Further Plan

The gamma and neutron detectors are needed to be upgraded to improve accuracy and responding speed of the detectors, and EPICS will be integrated inside for direct communication, get rid of current intranet for data acquisition. The test for upgrade of radiation monitoring system for top-off operation will be done by 2018 and results will be reported by then.

SUMMARY

A radiation monitoring system has been developed in HLSII, and is working properly. Optimization of the whole system for top-off operation is made: more monitoring spots and more radiation shield of accelerator are added to the system to enhance the radiation information gathering and also for the protection of people and machine. The interlock system is also upgraded for top-off operation. The gamma and neutron detectors needs to be upgraded to improve accuracy and EPICS will be integrated inside for direct access by the control system of accelerator.

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