A PROTOTYPE BLM SYSTEM FOR NSRL BEAM TRANSPORTATION LINE

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Abstract:

A new beam loss monitor system has been built for NSRL beam transportation line. This system can diagnose the beam position and direction in the strong radiation field, whose duty cycle is nearly 10^{-7}, around the transportation line. This article introduces the design of this system.

Keyword:

BLM, transportation line, Ionization chamber, I-F converter

1: INTRODUCTION

Hefei Light Source (HLS) is a second-generation dedicated light source at NSRL (National Synchrotron Radiation Laboratory), composed of a 200Mev linac injector, an 88-meters transportation line and an 800Mev storage ring. Figure 1 is the sketch map of NSRL.

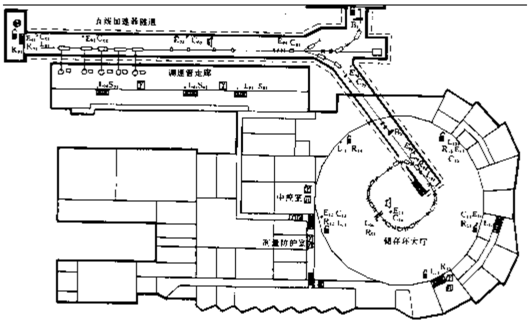

Figure1: sketch map of NSRL

A BLM system for the NSRL storage ring has been running over three years, which has provided some significant results to help to tune the machine parameters. The detail of the beam in the storage ring is under care now, thus we would need a beam diagnostic and monitoring tool for the linac injector and storage ring.

A prototype BLM system for the NSRL beam transportation line has been successfully tested. It is greatly different from the BLM system for the storage ring.

BLM system for storage ring uses two pin-diode detectors installed on both inside and outside of the vacuum chamber to detect the charged particles produced when the beam hits the vacuum chamber wall. But it can’t work for the transportation line because of the strong-pulsed radiation field around the line. The linac injector of NSRL produces 100 pulses (the pulse width is 1μs) every two seconds, only one pulse goes through the transportation line. The duty cycle of the radiation field is around 5×10^{-7}, the pin-diode detector can give out only one count during this short period.

The prototype system uses ion chambers detectors instead to diagnose the beam position and direction in the transportation line.

2: ION CHAMBER

Ion chamber is a common and reliable technique used in various detectors, we do not build the ion chamber ourselves but select a type from the many commercial products, which is originally designed for the Tsinghua Tongfang container inspection system.

The chamber is as small as 10*10*470mm, a shorter type is available, that makes it possible to be installed along the linac injector and transportation line. The chamber is filled with mixed gas of argon and xenon at 25 barometric pressures, and has a high sensitivity. The high voltage fed to the chamber can be adjusted from –400V to –1000V. A picture of the chamber is shown in Figure 2.

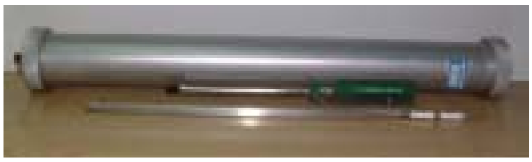

Figure 2: a picture of the Ion chamber

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3: DETECTOR

To measure the weak current from ion chamber, a high-sensitive I-F converter is used as the amplifier, which can measure the low level current in the scope of 10^{-12}A, reach a dynamic arrange up to 5 decades and an sensitivity as high as one pulse per pCoulomb. The output pulse number is proportional to the dose rate of the beam loss radiation field.

The chamber is fixed on the Printed Circuit Board containing this I-F converter circuit, and the I-F converter circuit can integrate the current from the chamber immediately. The circuit provides a shaped pulse signal.

The printed circuit board containing the ion chamber is fixed on a duralumin plate-cover, all the electronic signals of the circuit are connected to a lemo connector which is fixed on the plate-cover too. The whole module is then inserted into a duralumin cylinder. The cylinder and the plate-cover can be screwed together. The high voltage is provided from a connector fixed on the other plate-cover screwed at the other side of the cylinder. The cylinder with two plate-cover screwed is airproof to moisture and can shield Electro Magnetic Radiation, which may greatly influence the I-F converter circuit.

4: DATA ACQUISITION SYSTEM

The DAQ system is composed of tens of front-end nodes and a console.

Each front node contains four detectors (the screwed cylinder with ion chamber and circuit inside). These detectors are installed at the top, the bottom, the left and the right of the vacuum chamber of the transportation line. The node is in charge of providing high voltage and power to the detectors and collecting the pulse queues from the detectors. A 32bits micro-controller 68332 from Motorola is used in the node to collect the pulse queue, store the count number, do some simple calculations, show the count information on local LCD, and communicate with the console. It also provides a RS232 port that can connect to a terminal, which is useful for debugging and updating. Figure 3 shows a node connected with 4 detectors.

Figure 3 One node with 4 detectors

The nodes are installed along the 88-meter transportation line. The average pulse rate of different nodes shows the position of the beam, and the difference among the 4 ion chambers shows the direction of the beam.

All the nodes are connected via a CAN bus, and a Personal Computer with a CAN adapter card is also connected into this bus to serve as the console. The console requests all the nodes for the count numbers and illustrates them in diagrams or curves. The console analyzes the data to show the whole orbit of beam in the transport line and finds the position where the beam loss exceeds a pre-defined level.

If desired the BLM information can be sent to the control room through the Ethernet link of the console. These results are very useful to help operators to adjust the machine parameters.

5: TESTING RESULTS

After installation, we have done many tests. Since the whole HLS is under update and doesn't work stably, the test is not continuous and systematic.

After power on, the I-F converter circuit needs a long time to integrate to its base line voltage, after that the node can collect pulse counts from detectors. Figure 4 shows a count record.

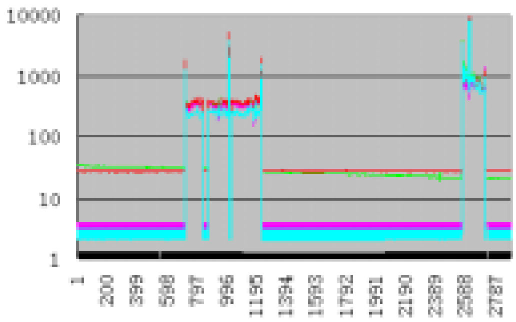

figure 4 : a count record curve

The four detectors act in the same way. There are four different counting levels exist from the record according to the different operation of the linac injector and transportation line as described in table 1.

Table 1: Count level to machine operation

Level	Operation	Count Level (every 20s)
1	Linac injector stopped	< 30
2	Linac injector operates normally, Transportation line closed	300~500
3	Linac injector and Transportation line operates normally	700~900
4	Flag inserts into the transportation line	16000~20000

The influence from the running of linac injector can be seen from level 2. During this time, no pulse passes through the transportation line. All the counts are resulted from the linac injector. These counts are not expected for they can't show any beam information of the transportation line. We will take some actions to reduce this influence.

From the count level 3, we can know that the influence from the 99 pulses hitting on the beam dump at the end of linac injector and the influence from the only pulse passes through the transportation line are nearly at the same level. So it is very important to reduce the influence from linac injector.

When a flag is inserted into the transportation line, the beam pulse is absolutely scattered and the count level 4 reflects this clearly.

To test the direction diagnose function of this system, we have adjusted the transportation line's driving coils to change the beam's direction. The record result is shown in figure 5.

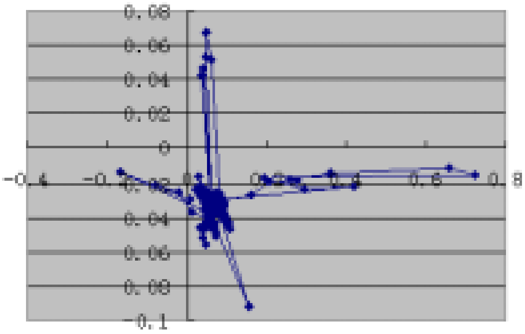

figure 5 a record curve to beam direction change

Each point in the curve is calculated as below to show the relative position of the beam pulse in the vacuum chamber:

$$X=(X_A-X_B)/(X_A+X_B);$$

$$Y=(Y_A-Y_B)/(Y_A+Y_B);$$

Where X_A and X_B are the counts from the detectors installed at the left and right of the transportation line, and the Y_A, Y_B are from the top and bottom ones. The twist of the beam orbit is clearly shown in this figure.

6: CONCLUSIONS

This beam loss monitor system for linac injector and transportation line is proved to be a useful diagnosing tool for machine study and operation. After several months' running, some new ideas to improve this system have been proposed, which will be done in the following months.

7: REFERENCES

[1] Li Yuxiong, Cui Yonggang, "The beam loss monitoring system for HLS storage ring ", NIM, 2001.

[2] K. Wittenburg, "Beam Loss Detection", DIPAC'93, Montreus,May,1993,CERN SL/93-95 (BI),p.11