DESIGN STATUS OF BEPCII-LINAC BEAM MONITOR SYSTEM

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Abstract

BEPC Linac beam monitor system, which includes 4 categories of 73 monitors, such as wall current monitor fluorescent screen monitor, beam loss monitor, and beam analyzing station, was most necessary for only the initial stage of the machine commissioning and operation. These beam monitoring systems have been put into operation since the year of 1987. Because all of beam monitoring systems in BEPC linac have no computer interfaces for the measurement control and the data acquisition. So it is very inconvenient in the BEPC normal operation. This paper will describe the present status of the beam monitoring system of the BEPC linac and its upgrade status for the BEPCII.

INTRODUCTION

The Beijing Electron-Positron Collider (BEPC), which has been put into operation since 1989, consists of a 200-meter linac injector, a 120-meter beam transport line and a 240 -meter storage ring. The collider can provide beams for the high-energy physics experiment as well as for the synchrotron radiation research in parasitic and dedicated modes. Usually, electrons and positrons are injected into the storage ring at the energy of 1.3 GeV, and are then accelerated to 1.55 GeV for the collision or to 2.2 GeV for the synchrotron radiation research. In order to increase the luminosity, it is proposed that BEPC will be upgraded to BEPCII, a double ring collider.

Since there has no any BPMs and beam emittance measurement devices in BEPC linac, it is very hard to know and to control the beam quality, as well as high beam transmission. Matching between linac and transport line became a problem for BEPC normal operation. Because the injection efficiency into the storage ring is critically dependent on the linac beam emittance, current, stable energy and orbit. So the main upgrade tasks for the BEPCII linac beam monitoring system are: BPM, BCT, Emittance and energy spread measurement. In this paper, we will briefly describe the present status of the BEPC linac beam monitoring system, and then give an introduction to the design status of BEPCII linac beam monitor system.

BEPC LINAC BEAM MONITOR SYSTEM

BEPC linac beam monitor system includes 4 categories of 73 monitors, such as wall current monitor, fluorescent screen monitor, beam loss monitor and beam analyzing station. The beam diagnostic devices for BEPC linac are listed in Table 1.

Table 1: Monitor Types of the BEPC Linac

Monitor type	Qt.
Fluorescent Screen	8
Wall Current Monitor	22
Energy Analytical Station	3
Beam Loss Monitor	40

As you can see from Table 1, there are only a few kinds of beam instrumentation systems in the BEPC linac.

Fluorescent Screens

A total of 8 fluorescent screen monitors were installed along the BEPC linac. The screen inserted into the beam line by an air cylinder. A TV camera picks up the signal and feeds the signal to linac control room. The screen size is 50 mm x 50 mm (Model AF995R). They played an important role during the early period of the machine commissioning.

Wall Current Monitor

There are 22 wall current monitors along the linac. 12 fast pulse monitors are used for the ns beam bunch. The sensitivity of the WCMs can be expected to reach 3 mV/mA. It is high frequency response can be reached up to 1.5 GHz. An amplifier with 1 GHz band-width is used for measuring the positron beam. High frequency coaxial switches are used to select the monitors. Usually, operators of the linac can only observe the waveform using an oscilloscope, and calculate the beam current value by a calibration data table.

Energy Analytical Station

There have three beam analyzing stations, each consists of a bending magnet (AM), a wall current monitor, a fluorescent screen monitor and a dump. AM1 is located at the pre-injector exit. AM2 is after the solenoid of the positron source. AM3 is at the end of linac. These energy analyzing station are used to monitor beam energy and to measure the beam energy spread.

Beam Loss Monitors (BLM)

There are 40 BLM with ionization chamber (AIC) structure along the two side of the linac vacuum pipe. The BLM consists of an 8-meter long special coaxial cable. An oscilloscope and electronics located in the control room. The electronics include integrators, variable gain amplifiers, multiplexers and a high voltage power supply.

DESIGN STATUS OF THE BEPCII-LINAC BEAM MONITORING SYSTEM

Because the injection efficiency into the storage ring is critically dependent on the linac beam emittance, current, stable energy and orbit. So the main upgrade tasks for BEPCII injector beam instrumentation system are BPM, BCT, emittance and energy spread measurement. So following the linac upgrade, we will upgrade not only all the existing beam instrumentation systems, but also develop a set of beam position monitor (BPM) system as well. In order to meet the requirements of the BEPCII linac upgrade, a set of distributed control system will also be built, and the beam instrumentation system should be merged into the new control system for the data acquisition and data processing. These systems are described as below in detail.

Beam Position Monitor

The main focusing system of BEPCII linac consists of 15 sets of quadruple triplets. We are going to install a strip line BPM in each quadruple triplet, and install x and y correctors right up stream as shown in this Fig.1. In that case, we can not only measure beam positions along the linac, but also realize “one by one” orbit correction. To satisfy the requirement of linac beam orbit correction, 19 BPMs are required. Among the 19 BPMs, 15 BPMs will be installed at each quadruple triplets, two BPMs (BPM_{01}, BPM_{02}) will be installed at the section of gun exit to preinjector, one BPM is located at the section of A0 exit to AM1. One BPM is located at the linac end. Because the installation of BPM_{01} and BPM_{02} is limitated by the narrow lognitudinal space, so the BPM_{01} and BPM_{02} will adopt button type. Other BPMs will adopt stripline type. In the summer shut down of 2002, we installed one BPM prototype at the gap of sixth triplet magnet. Before the installation of the BPM prototype into the linac tunnel, test-bench calibration to the prototype BPM was carried out in the laboratory with a movable wire in order to find out the offset value and BPM sensitivity. We determined the center of the prototype by measuring the wire resistance, and then moved the wire step-by-step over the desired area from the center of BPM assembly. We adopted several data acquisition tools to calibrate this prototype such as oscilloscope, network analyzer, and Bergoz BPM electronics. We used a 500MHz RF signal, which is generated by the HP 4400B and was amplified to boost the signal and delivered to the movable wire. We had a coarse calibration and a fine calibration. The measurement range for each calibration is ±5mm with 1mm step, and ±2mm with 0.05mm, respectively. The measurement is completely automatic. Once the calibration data are obtained, the curve fitting in MATLAB was used to extract polynomial coefficients by the least square root method. The mapping results of the sensitivity of BPM in the x and y directions are 8.603mm and 8.638mm, respectively.

Regarding the signal processing electronics, we will adopt the LR-BPM signal processing electronics of the Bergoz Company to perform the pulse beam measurement. We did some experiments by using the prototype BPM to test the adjusting capability of the corrector. The experiment results shown that the adjusting capability of the corrector is about 1mm/A in both the vertical and horizontal direction. This is enough for us.

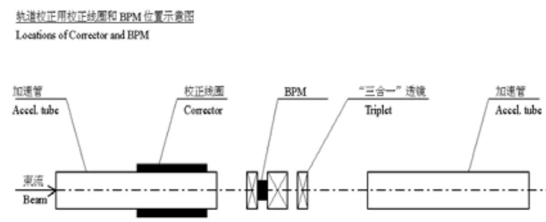

Figure 1: BPM and corrector locations.

Bunch Current Monitor

We will still use the wall current monitors as the detectors of bunch current monitor. However, the signal processing and data acquisition will be upgraded. In our design, we will use model SR255 gated integrator to measure the ns beam current. The SR255 fast sampler module is a gated integrator with four discrete user-selected gate widths from 100 ps to 1 ns. All of the necessary electronics are built into this high speed module including an A/D, D/A and a correction circuit to eliminate the inherent non linearities in the sampling bridge. The SR255 is perfect for fast pulsed experiments.

Emittance and spread Measurement

We mainly use the fluorescent screen monitoring system to measure the beam transverse emittance by means of varying the strength of the quadrupole magnet. In the summer shut down of 2001, we installed two sets of beam emittance measurement devices at both pre-injector exit and linac end. Twiss parameters are derived from beam size measurements by MATLAB, while varying the strengths of the upstream quadrupole magnets. The test results (shown in table 2) were good enough for the electron beam, comparing with theoretical predictions. But we can not measure the positron emittance properly, due to the positron beam is very weak for about 3pC per bunch.

For energy spread measurement, there are three beam-analyzing stations in BEPCII linac. We will still use the fluorescent screen monitoring system to measure the beam energy spread.

Table 2: The results of Emittance measurement

Time	Location	ε_x (mm mrad)	ε_y (mm mrad)
22/10/2001	preinjector exit	3.8455	5.6235
23/10/2001	preinjector exit	3.3560	5.4544
23/10/2001	Linac end	0.2854	0.5728
23/10/2001	Linac end	0.2871	0.5798

Epics environment set up

In order to develop the IOC quickly and conveniently, we specially built up a set of small IOC development platform in our laboratory. It uses an industry PC running Linux operating system to serve as a small EPICS development platform. The IOC is a power PC 750 serial microprocessor MVME5100 running VxWorks real-time operating system. With this development platform, we successfully developed an IOC for the online testing BPM prototype, and did some experiments with beam to verify the BPM prototype performance and IOC status. Fig.2 is the experiment results.

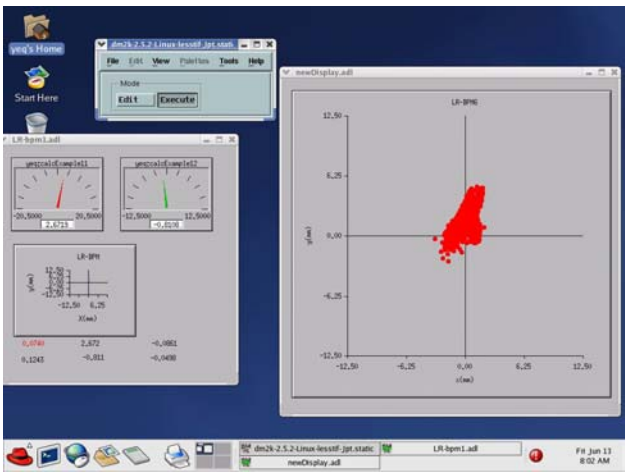

Figure 2: Online test results of the BPM prototype.

The DAQ System

As mentioned above, in order to satisfy the requirements of the BEPCII linac upgrade, a set of distributed control system will be built, and the beam instrumentation system should be merged into the new control system for the data acquisition and data processing. The control system of BEPCII will be constructed under the EPICS environment. The operating system will run in the VME computer is VxWorks. Fig.3 shows the data acquisition structure of the linac beam instrumentation system. There are 5 measurement stations, which will be located along the linac gallery. The beam signals from the detectors are fed to a VME crate by through a set of low loss RF coaxial cables, and then the signals are digitized. The measured data will be stored into the real time database. The data transmission between the local stations and the central control room will be performed through Ethernet.

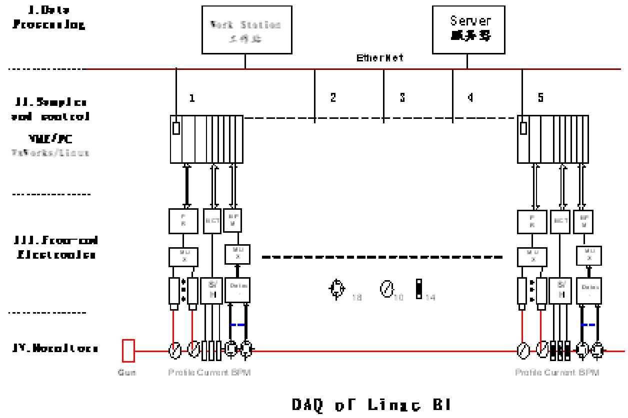

Figure 3: The DAQ structure of linac BI system.

SUMMARY

The upgrade works of the beam instrumentation system for the BEPCII linac is in progress smoothly. But some issues need to be considered. One issue is about EMC. In order to improve the measurement accuracy, we must pay attention to the issue of electromagnetic interfering, especially in the linac gallery. There are many high powers, RF equipments. Another issue is regarding the hard radiation. At some locations, hard radiation damaged the CCD camera and BNC receptacles of the wall current monitors according to the experience of the BEPC operation. We are now trying to shield the camera from a hard radiation by using more heavy material.

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