THE BEAM LOSS MONITORING SYSTEM FOR HLS STORAGE RING

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Abstract

A beam loss monitoring system has been established at HLS. This paper gives its principle and scientific grounds. Study on the ring's TBA structure and utilization of Monte-Carlo calculation to the shower electrons is important in its design. The system composition and performance are also introduced. The detector BLMs, data acquisition devices and host PC are linked via CAN bus. This system is helpful to analyze beam loss distribution and regulate the machine operation parameters.

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HLS(Hefei Light Source) is a second-generation dedicated light source at NSRL (National Synchrotron Radiation Laboratory), composed of a 200MeV linac injector, an 800 MeV storage ring, several photon beam lines and experimental stations. Fig 1 is a sketch map of HLS. The electron storage ring possesses of four long straight sections and twelve dipoles with 30^0 bend angle each. Recently, we designed a beam loss monitoring system by radiation measurement along the ring.

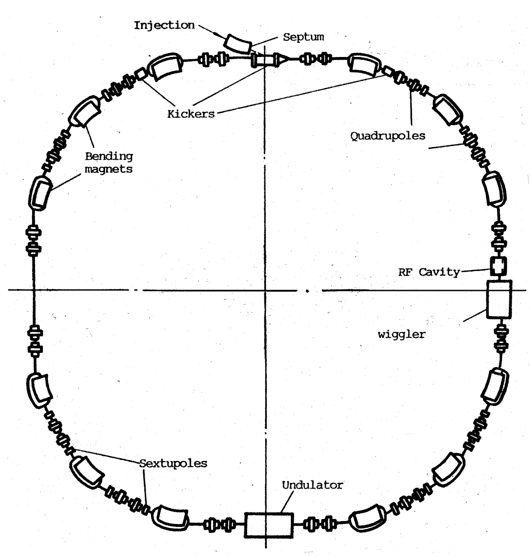


Fig 1

1.Principle and scientific grounds:

The beam lifetime is closely related to beam loss, described roughly as below:

$$\frac{1}{\tau} = \frac{1}{\tau_T} + \frac{1}{\tau_q} + \frac{1}{\tau_v}$$

τ - beam lifetime τ_T-Touchek lifetime

τ_q-quantum lifetime τ_v-vacuum lifetime

Here τ_q can usually be omitted since it is much longer than τ_T and τ_v when the machine operates well. The collision among inner-bunch electrons is an elastic one and may bring about large momentum deviations and hence electron loss, that determines Touchek life τ_T. This kind of loss always involves a pair of electrons, for which the chances to hit inner or outer wall of the vacuum chamber are equal. The electron colliding with residual gas may lose energy, and then hit the inward wall of the chamber during or after passing dipoles, if the energy loss exceeds a certain amount. Fig 2 shows the paths of electrons with energy loss through a TBA cell at HLS, assuming that the incidence point is the entrance of the 1st dipole. The shower caused by electrons hitting the chamber wall is mainly in a narrow area near the orbit plane. For knowing the distribution, we tracked shower electrons with energies down to 1.5 MeV outside of the chamber wall with EGS4 code. The result of 10000 events by Monte-Carlo calculation is shown in Fig 3, where Gamma has not been tracked, because the detector's response to Gamma is about three magnitudes lower than that to electrons and can be omitted. The shower electron distribution towards the chamber cross section is calculated too. Its flux density in every direction is nearly even, except the one along the 0^0 direction, which is about three magnitudes higher.

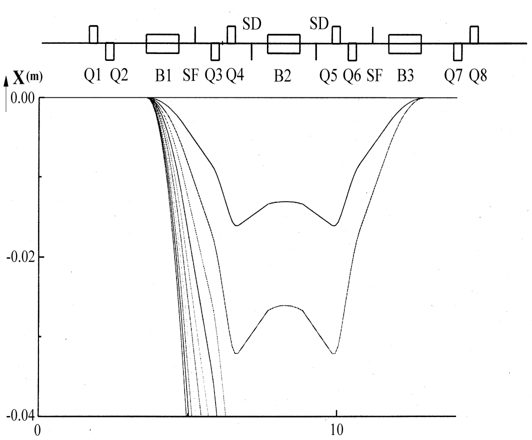


Fig 2

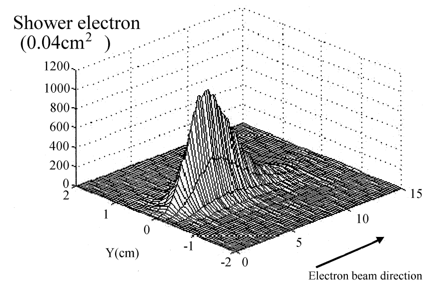


Fig 3

2.Detectors and their installation positions

BLM-XS detectors, originally developed by DESY[1] and manufactured by Bergoz Instrumentation, are applied to the HLS beam loss monitoring system. It is suitable to use in a mixed radiation field, featuring its strong resolving power to the high-energy stray electrons, small size and light weight. Their radiation resistant property is also satisfactory. According to the calculation mentioned previously and the space available, the installation positions of the detectors can be decided. Since the shower electrons distribute in a narrow range and the effective area of the detector is only $7mm^2$, the vertical position must be strictly on the central plane when they are fixed on the ring chamber.

3.Data acquisition and control

The beam loss system is a typical distributed data acquisition system. Fig 4 is its structure sketch map.

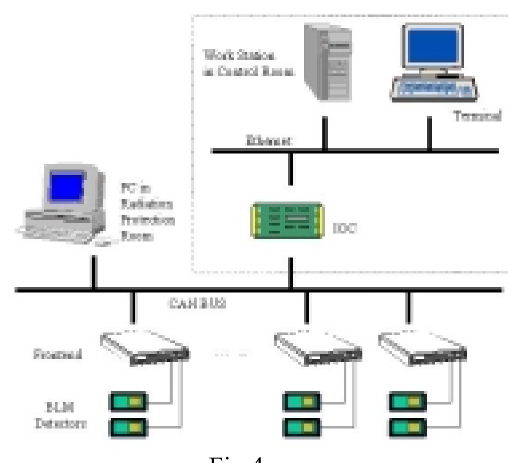
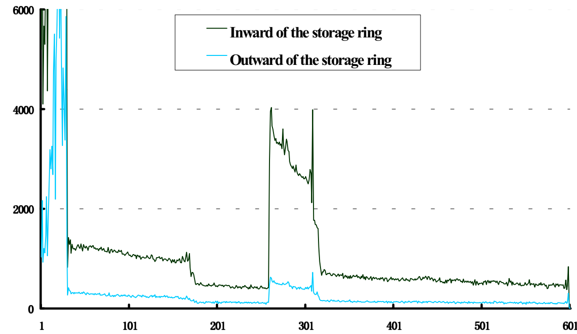


Fig 4

The most important information is those that come from the measure points downstream of every dipole and one long straight sections. So twenty-six detectors and thirteen data acquisition devices (as the front-ends) are used at the measure points selected. The detectors are stuck to the vacuum chamber in pairs, on the opposite positions of the chamber wall outer surface at the beam orbit plane separately. The data acquisition device composes of an MCU as the main controller and a high-speed counter designed with CPLD. Each one controls two detectors. The pulse signals from detectors are received and stored by it first, and then transmitted to the host PC via CAN bus. Besides controlling all the acquisition devices, the PC is also in charge of data processing and store, diagram display and printing, etc. CAN bus is propitious to such a system for the acquisition device quantity can be easily changed. Obviously, the sensitivity of this system is high enough to reflect different machine operation conditions.

The application runs in the Windows environment. The counter rate of every detector can be shown on the CRT in histogram. Needless to say, a big orbit distortion will cause counter rates going up at a few positions and beam lifetime going down due to shortened τ_q. We are interested in the counter rate sum of the detectors fixed outward of the ring (the two on long straight sections not included). It reflects the beam elastic collision loss. The sum of the ones from the detectors fixed inward of the ring is also important. And the difference between the two sums may reflect the instantaneous mean vacuum pressure of the whole ring. In a test of a BLM module, we found the inward rate is about three times higher than the outward rate when the vacuum is good, and the difference goes over ten times under poor vacuum. A big difference between a pair of detectors is a symptom that local vacuum somewhere upstream is bad. Therefore any vacuum leakage can be immediately revealed. For this purpose, the sums and the difference are listed on the CRT. Also the counter rate of every detector versus time can be shown in curves, and the interested region can be looked into with more detail. Fig.5 is a count-time curve from the result we got when storage ring was running and Fig 6 is an example of the display frame.

Fig 5



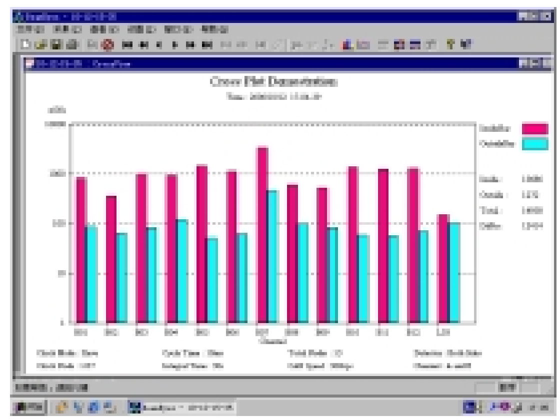


Fig 6

The beam loss monitoring system, as one part of HLS upgrading project, has been completed. But the whole project is still under construction. A serious of experiments will be done after HLS operation is restored. We are sure that this system is helpful to analyze beam loss distribution and regulate the machine operation parameters.

References: [1] W.Bialowons, F.Ridoutt, K.Wittenburg, Electron Beam Loss Monitors for HERA, Beam Loss Monitor User's Manual