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Improvements of the HERA Electron Beam Loss Monitor System

by

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Abstract

The Pin Diode Beam Loss Monitors at the HERA Electron ring (BLMe) have a high intrinsic suppression of synchrotron radiation background (Ref. 1). But even so, the rate of Synchrotron Radiation background (SR) has been too high to identify local beam losses which may be responsible for the lifetime reductions at 27 GeV/c. In the following we describe the changes which were done to improve the background to signal ratio of the BLMe system.

I. Introduction

The Pin Diode Beam Loss Monitors were originally designed to prevent the superconducting magnets of the HERA proton ring from beam loss induced quenches (Ref. 2). The coincidence readout of the two PIN Diode detectors of the BLM and the counting technique are responsible for the high suppression of background from the synchrotron radiation relative to the signal from showers of high energy particles. A similar BLM System was installed in 1993 at the HERA electron ring to observe the local losses during the unexpected lifetime reductions. This system was very helpful to study the behavior and to determine the main source of the lifetime reduction (Ref. 3). After the integrated ion getter pumps were replaced with Non-Evaporative-Getter (NEG) pumps, the lifetime reductions have become less significant but are still present at a beam energy of 27.6 GeV.

The use of the BLMe system for a localization of the losses is limited by the high quantity of SR at this high beam energy. The huge amount of SR photons at the BLM location (on the inside of the beam pipe) is responsible for a high probability of conversion of two photons at the same time (within about 30 ns) in the two diodes. This kind of background cannot be distinguished from electromagnetic showers from real beam losses. Unfortunately, the count rate of showers was about one order of magnitude smaller than the background rate. Therefore an improvement of the signal to background ratio was very important to improve the detection of beam losses at high electron beam energies.

II. Hardware improvements

Two effects contribute to the background rate:

a) A high energy Photo- or Compton- electron produced by a SR photon conversion in the first diode can reach the other diode and creates a coincident signal in the two diodes.

b) The high photon rate of the SR gives a high probability for the coincident conversion of two photons in the two diodes.

a) Photo- or Compton- electrons:

One can find in Ref. 3 a detailed description how a copper inlay between the two diodes reduces the probability of background counts due to Photo- or Compton- electrons.

Fig. 1 shows the main result of Ref. 3, namely that one can expect a background reduction due to a copper inlay by about a factor 5 at high photon fluxes as in HERAe. Note that this factor increases with the decrease of the photon flux at the monitor! The efficiency of the BLM to beam losses is not changed by this inlay.

b) High photon rate

A reduction of the high photon flux helps in 2 ways: First the probability for a coincident conversion of two photons is reduced and secondly the background rate of

Photo- or Compton electrons is also reduced. A reduction can be achieved by additional lead shielding.

Experiments

Our first try was to add lead around the BLM, but not at the side facing the beam pipe. In this case, there was no observable reduction in the background rate. This indicates, that the main part of the synchrotron radiation hitting the BLMs comes from the inner beam pipe (see Fig. 2). Therefore, an additional[1] layer of lead between the pipe and the BLM can be expected to reduce the background. Unfortunately, the signal from showers will also be reduced because some of the charged particles created in the shower will stop in the additional lead layer. Nevertheless, one can gain in the signal to background ratio because the lead absorbs the low energy SR-photons more efficiently than the high energy shower particles. Therefore, we installed at some monitors a layer of 12 [illegible] additional lead and the copper layer between the two diodes. Fig. 3 shows the comparison between four different BLMs with and without these changes. The monitors were at equivalent locations in the north and in the south of HERAe. The changes reduce the background rate by a factor 200.

Two local bumps were driven with maxima close to the BLMs to study the response of the BLMs to showers; one in the north (BLM NR357; modified) and an equivalent bump in the south (SR357; unchanged). The lifetime of the beam and the local count rate of the BLMs were observed at different amplitudes of each bump. Note that the beam optic of HERAe at the two locations is the same. Fig. 4 shows the results of this experiment. The count rate of the modified BLM were reduced by about a factor of 10 in respect to the unchanged one. Therefore the signal to background ratio has been improved by about a factor 20 due to the modifications of the BLM.

These studies were done at a beam energy of 12 GeV, in order to keep the background level as low as possible. However, the result is valid for all energies, because the parameters of the shower particles reaching the BLMs depend only a little on the beam energy.

III. Conclusions

In order to improve the signal to background ratio of the HERAe BLMs, the following two steps where performed: 1) Installing a thin copper layer between the two PIN – Photodiodes of the BLM to suppress coincidences coming from Compton- or Photo-electrons which make a signal in both diodes, and 2) adding a 12 mm lead layer between the beam pipe and the BLM.

These steps led to an improvement of the signal to background ratio by about a factor 20. Unfortunately, there was no time to study other combinations of lead shields, but the achieved improvement is sufficient to study the lifetime problem of HERAe in more detail.

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[1] A 5 mm lead shield already exist.

IV. Acknowledgements

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Figures

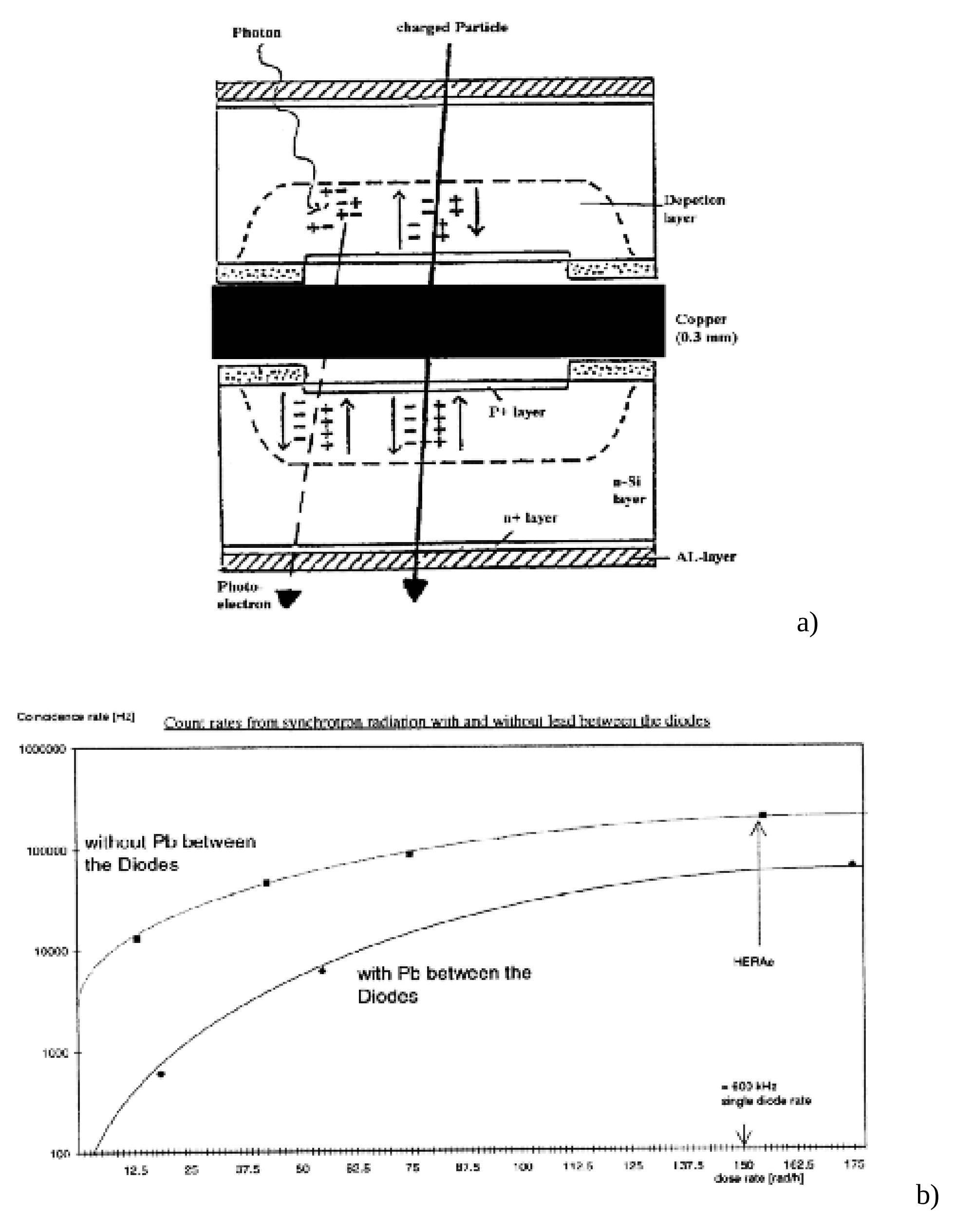


Fig. 1 (from Ref. 3): a) The copper inlay and b) the reduction of the background rates (actually it was measured with a lead inlay, but copper has the same effect!)

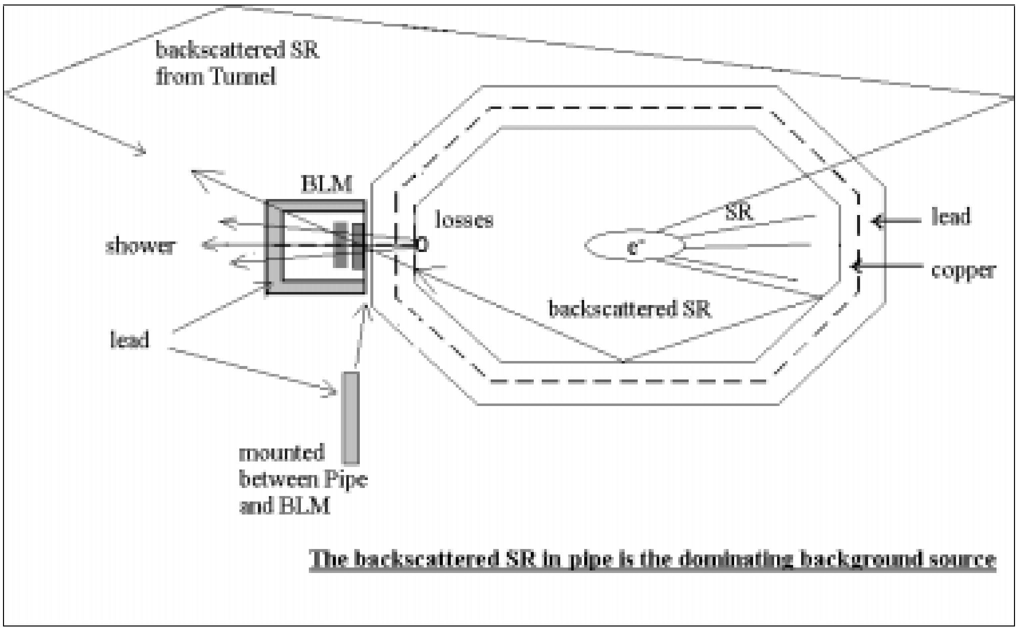
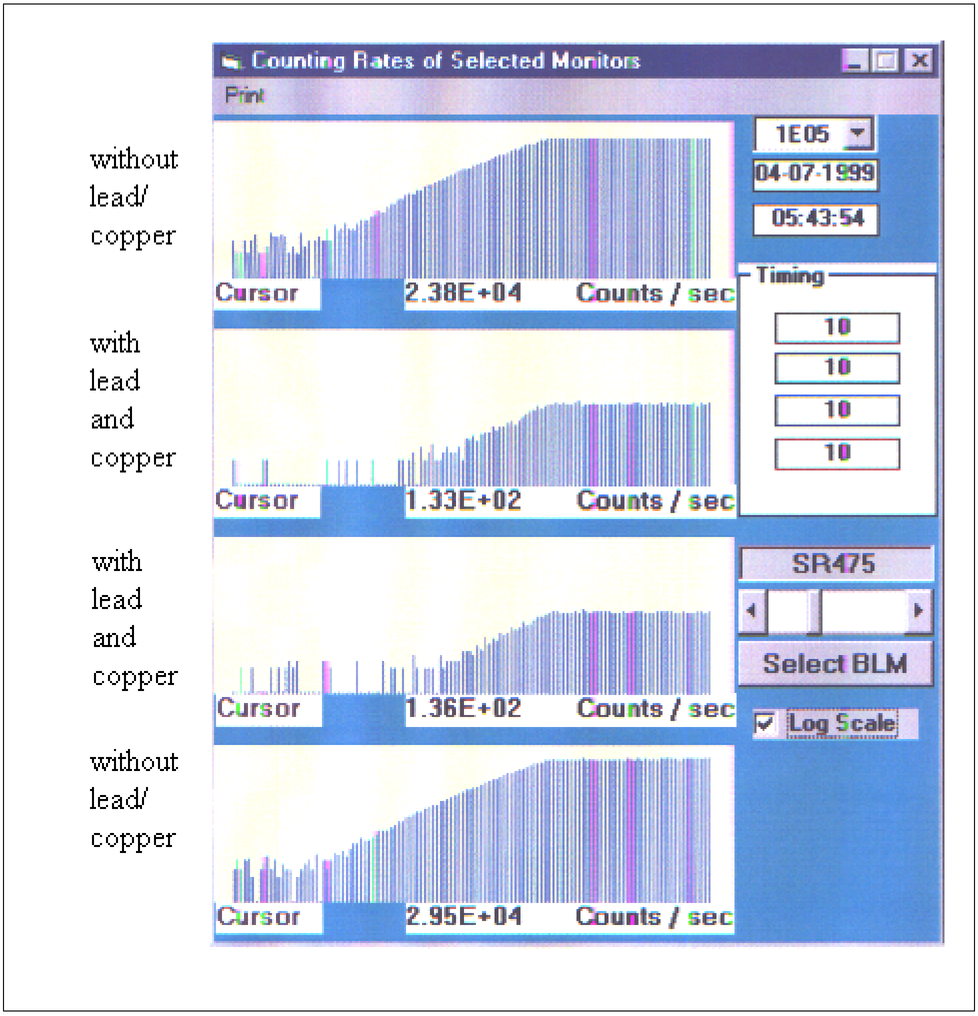


Fig. 2: The directions of synchrotron radiation and losses



1E05

04-07-1999

05:43:54

Cursor 2.38E+04 Counts / sec

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Cursor 2.95E+04 Counts / sec

Timing: 10, 10, 10, 10

SR475

Fig. 3: Four different BLMs during ramping of HERAe. The upper and lower one are unchanged BLMs while the two in the center are equipped with a copper layer between the diodes as well as an additional lead layer between the BLMs and the beam pipe. The numbers below each picture is the count rate at maximum. The scale is logarithmic.

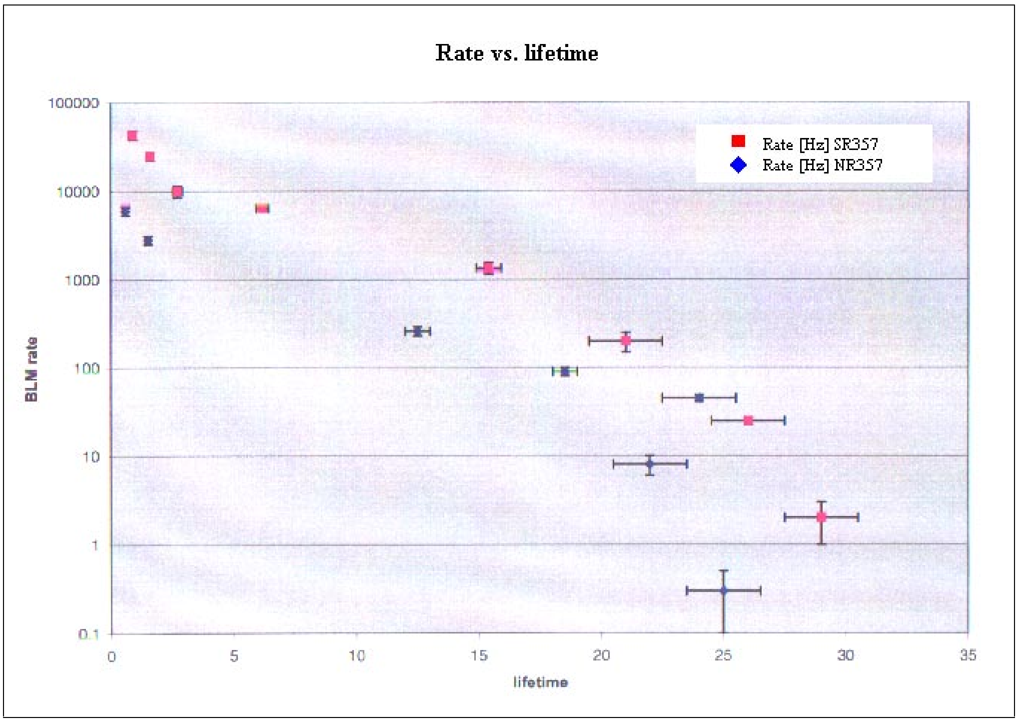

Fig. 4: BLM count rates versus lifetime of the HERAe beam. The lifetime of the HERAe beam was adjusted by the amplitude of a local bump in the north or south region around the adjacent BLM, respectively.