INFLUENCE OF VARIOUS INTEGRATED ION GETTER PUMPS ON ELECTRON LIFETIME

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Abstract

The spontaneous reduction of the lifetime in electron storage rings is a well known problem and may be severe for B-Factories. Experience with the HERA electron ring indicates that the lifetime is affected by the distributed sputter-ion pumps. In order to investigate the role of such pumps different types have been installed in PETRA dipoles. Their effect on the lifetime of both electrons and positrons was studied by provoking lifetime disruptions by increasing the pumping voltage. These disruptions were then investigated using loss monitors which detect the lost electrons and a lead glass shower counter to detect bremsstrahlung coming from the interaction of electrons or positrons with a target in the machine. The results show that conventional dipole pumps with grounded cathodes and positive charged anodes cause both spontaneous and provoked lifetime reductions. On the contrary inverted sputter-ion pumps with grounded anodes and negatively charged cathodes do not show such dramatic effects. Shielding the direct path between the dipole pump and the beam by installing a metallic screen between the anode and pumping holes does not suppress significantly the breakdown of the beam lifetime.

1 INTRODUCTION

The accelerator complex HERA has been built to study the collisions of protons with either electrons or positrons [1].

Already in 1992 an unexpected problem with the electron lifetime has been observed[2]. Electron runs suffer from sudden lifetime reductions if the current and the energy exceed certain threshold values. The lifetime does not recover even if the current drops below the threshold current. This problem leads to a reduction of the integrated luminosity. Also the background rate at the experiments is higher so that data taking is more difficult then in case of positrons. These negative effects have never been observed during positron operation.

There are strong hints that the lifetime problem is correlated with the status of the distributed sputter-ion pumps but the role of the pumps is not yet clear. To study the influence of the pumps various modified sputter-ion pumps have been installed in PETRA. The impact of these pumps on the lifetime of both positrons and electrons has been studied.

2 DESCRIPTION OF THE PUMPS

We concentrated our study on distributed sputter-ion pumps integrated in the vacuum chamber of the dipole magnets. Fig. 1 shows the standard dipole chamber in PETRA. Over the length of the bending magnet the wall between the pumping channel and the beam volume is perforated.

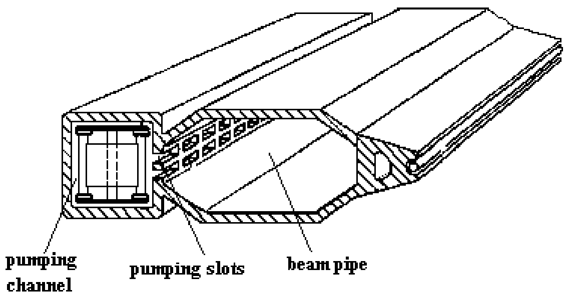


Fig. 1: A sketch of the dipole vacuum chamber in PETRA [3]

Fig. 2a shows the standard distributed sputter-ion **PETRA pump**. The cathode is made from titanium metal sheets. The anode which is housed between the cathode plates consists of stainless steel cells. The electrical potential of the anode is +5 kV whereas the cathode as well as the whole surface of the pumping channel is grounded.

In Fig. 2b is shown the standard **HERA pump** which is smaller than the PETRA pump. The main difference in comparison to the PETRA pump is the construction of the anode which consists of three perforated stainless steel plates. That means that the field configuration is almost identical to the PETRA pump but the sides of the anode of the HERA pump are open.

In order to check whether this difference in construction is responsible for the lifetime problem in HERA. A modified pump has been constructed in which the direct path from the anode to the vacuum chamber is blocked by a metallic screen. This so-called **screened pump** can be seen fig. 2c.

It was also conjectured that sparking in pumps is a main ingredient of the process leading to lifetime disruptions. In order to examine the effect of sparking a pump has been constructed in which the anode is replaced by a square metal tube so that the electric field in the pumping area is similar to that in a normal pump but the pumping process (Penning discharge) does not take place. A sketch of this so-called **dummy pump** is shown in fig. 2d.

A HERA pump was modified by isolating the cathode so that the electrical potential of the cathode could be set to -5kV and the anode could be grounded. In comparison to the normal pump the electric potential has been „inverted“ so that this pump is called **inverted pump**.

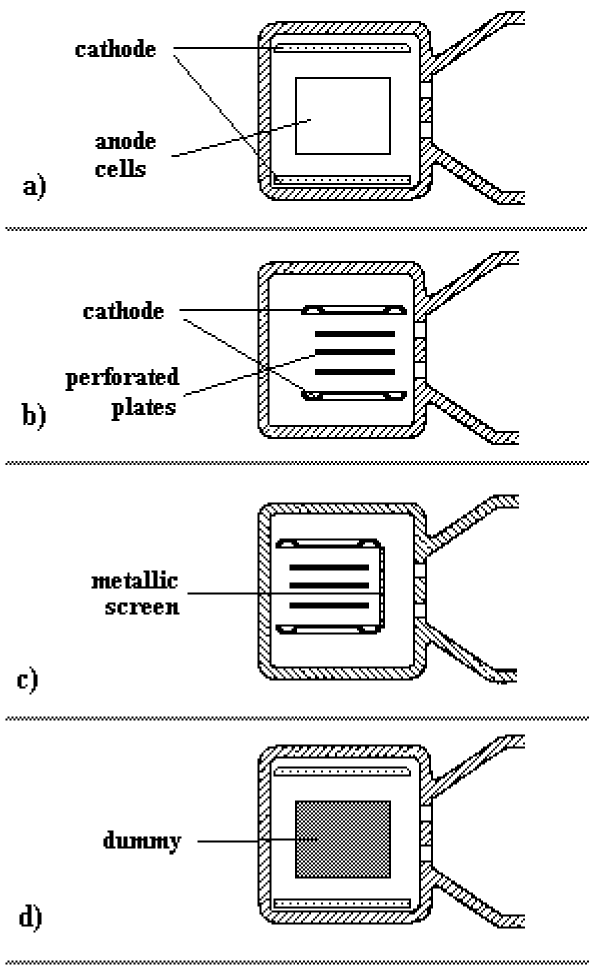


Fig. 2: Sketches of the various pumps
a) PETRA pump b) HERA pump c) screen pump
d) dummy pump

3 EXPERIMENTAL PROCEDURE

The influence on the lifetime of these pumps is measured by Pin diode loss monitors [4] which detect lost electrons. These monitors have been installed in the neighbourhood of the pumps.

In addition a lead glass counter was installed at the end of a photon beam line. With this monitor it is possible to observe bremsstrahlung produced in the region of one test pump. The synchrotron light background produced in the dipole could be easily suppressed because the energy of the bremsstrahlungs photons is much higher than that of synchrotron light. Since the time resolution of this monitor is 10 micro seconds (the revolution time is 7.6 microseconds) it was possible to study effects which occur at the beginning of lifetime disruptions.

Spontaneous lifetime disruptions occur infrequently therefore for the pump studies a method was needed to provoke such events. It was found that by setting the pumping voltage to 9 kV instead of the normal 5 kV and switching these pumps on and off disruption could be induced. Coincidence of an increase in beam loss monitor rate with the switching of a pump was taken as a proof that this specific pump caused the lifetime disruption.

The experiments were usually done at 12 GeV with some performed at 7 GeV. The initial currents were typically around 40 mA (10^12 particles) stored in 42 bunches.

4 RESULTS

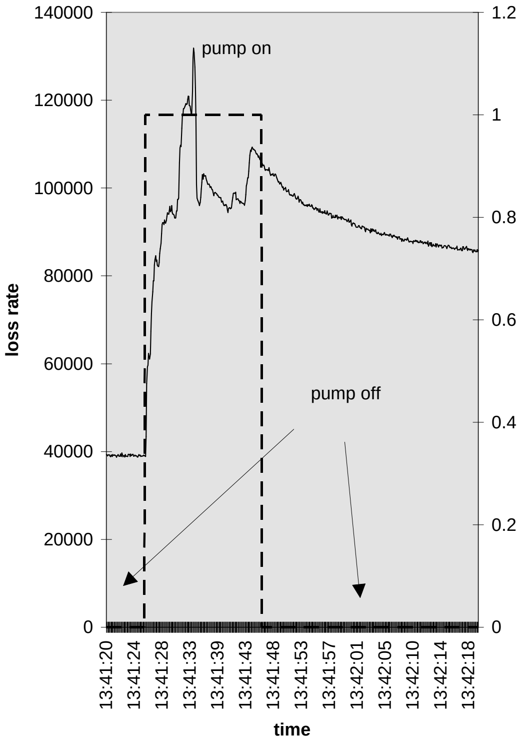
In contrast to positrons electron runs were effected by spontaneous lifetime reductions. In addition spikes could be observed on the beam loss monitors whereas in case of positron runs the loss rates were always smooth. It was nearly impossible to provoke lifetime disruptions at 7 GeV.

Both spontaneous and provoked lifetime disruptions could be removed by exciting the beam horizontally with one of the injection kickers. Kicks were applied for a few seconds every 160 millisecond with a resulting amplitude of about 20 mm.

The target that causes the lifetime reduction appears to be formed over an extended period of time an example of which is shown in fig.3. This result was confirmed by measurements with the lead glass counter. The removal of the target with the injection kicker also occurred sometimes in steps. Observation with both the loss monitors and the lead glass counter showed that parts of the target were carried around the ring. Especially the signature of the lifetime reduction measured with the lead glass counter convinced us that the provoked lifetime disruptions are very similar to the spontaneous ones because the look very similar to data taken in HERA[5].

In order to check whether the strength of the discharge in the pump has any influence on lifetime reductions gas was deliberately let in the HERA pump. Although a local deterioration of the vacuum and an increase of the pumping current occurred no irreversible lifetime reduction was observed.

In 80 % of the attempts to provoke a lifetime reduction with the **PETRA pump** we could observe a deterioration of the lifetime. Typically the lifetime drops from 8 hours to 1 or 2 hours. In case of the **HERA pump** in 90 % of the provocations we achieved a worsening of the lifetime from about 8 hours to 1 to 2 hours.



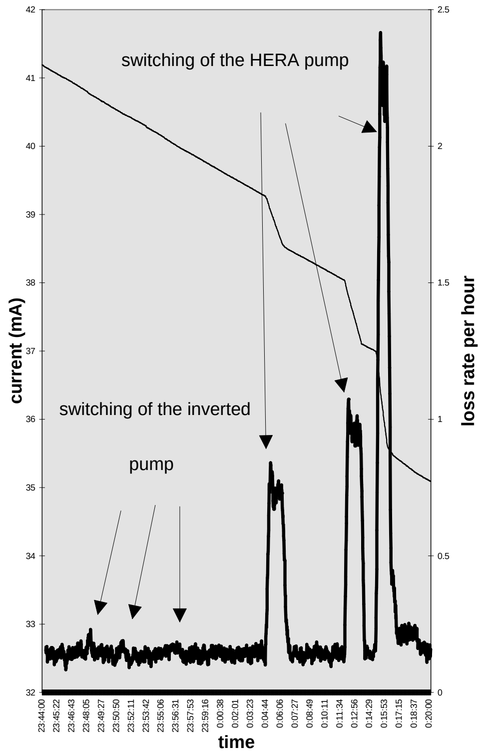


Fig. 3: Loss rates before and after switching a pump

Fig. 4: Comparison of the effect of the inverted pump and the HERA pump

The screen in front of the anode plates of the **screen pump** did not prevent lifetime reductions. This pump was almost as bad as the HERA pump since in 70 % of the attempts we observed a worsening of the lifetime which was as strong as in case of the HERA pump.

It was not possible to provoke lifetime breakdowns with the **dummy pump** although arcing took place. Therefore the pumping process is an important ingredient of the lifetime problem.

At the end of the run last year the **inverted pump** was tested. At the beginning of the tests lifetime reductions were observed but this may have been caused by the initially bad vacuum and by arcing between the cathode and the surface of the pumping channel. After conditioning of the pump at 11 kV the pump only caused minor problems when the pump was switched off. Fig.4 shows a comparison of the inverted pump with the HERA pump. Since only very few experiments could be done a final conclusion about the inverted pump can not be given now. The pump of the dipole that can be observed with the lead glass counter has been replaced by an inverted pump. We hope that tests in '96 will clarify whether this type of pump does not lead to lifetime deterioration.

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