TRANSVERSE FEEDBACK SYSTEM FOR THE COOLER SYNCHROTRON COSY-JÜLICH – FIRST RESULTS

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Abstract

The intensity of an electron cooled beam at COSY is limited by transverse instabilities. The major losses are due to the vertical coherent beam oscillations. To damp these instabilities a transverse feedback system is under construction. First results with a simple feedback are presented. Due to operation of the system the intensity and lifetime of an electron cooled proton beam at injection energy could be significantly increased. Measurements in frequency and time domains illustrate the performance of the system.

INTRODUCTION

The cooler synchrotron COSY delivers unpolarized and polarized protons and deuterons in the momentum range 300 MeV/c up to 3.65 GeV/c. Electron cooling at injection level and stochastic cooling covering the range from 1.5 GeV/c up to maximum momentum are available to prepare high precision beams for internal as well as for external experiments in hadron physics. Electron cooled beam at injection energy can become unstable [1,2]. Major current losses result from the vertical coherent oscillations of the dense electron cooled beam. One of possible cures of this problem is an active feedback system which damps the instabilities [3].

DOES COSY NEED A FEEDBACK SYSTEM

Let us look at the behaviour of an electron cooled intense proton beam at injection energy. To do this standard diagnostic equipment such as beam current transformer (BCT) and beam position monitor (BPM) have been used. BPM difference (Δ) signals in time and frequency domains have been simultaneously analysed.

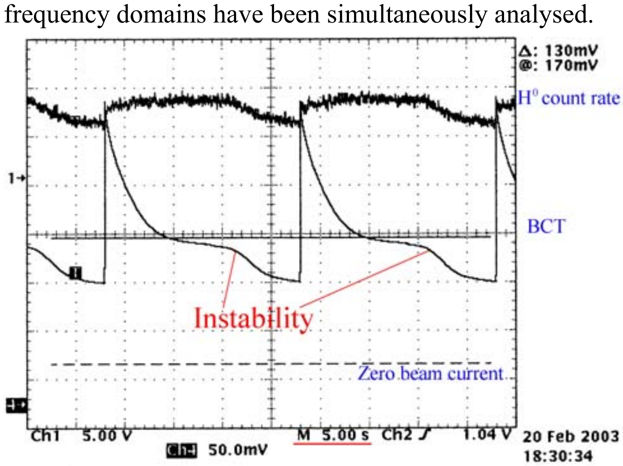

Figure 1: BCT (100 mV are equal to 1 mA beam current) and H^0 count rate signals.

On Fig. 1 the beam losses due to the instability are shown. The proton beam was cooled by 170 mA electron current. Vertical and horizontal BPM difference signals together with BCT signal are demonstrated on Fig. 2. Since the vertical aperture of the vacuum chamber in the arcs is more then two times smaller then the horizontal one

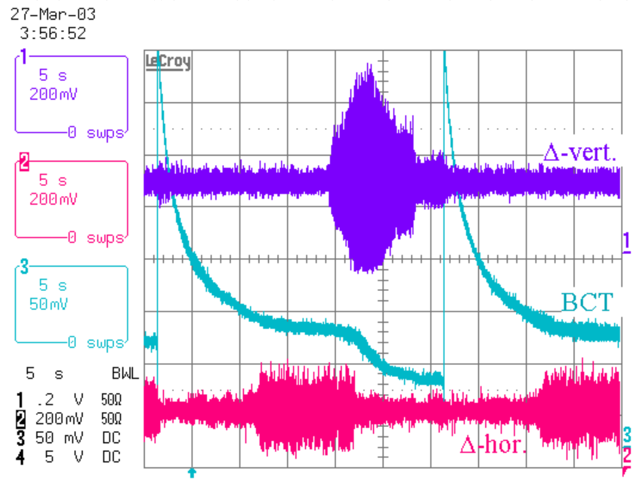

Figure 2: Vertical/horizontal BPM Δ-signals and BCT.

the beam oscillations in vertical plane are more dangerous and result in significant losses (see Fig. 2). Due to these reasons there is a necessity of the vertical damping.

SIMPLE FEEDBACK SYSTEM

The goal is to damp coherent vertical oscillations of the coasting proton beam at injection energy [4]. If the cavity gap is properly short-circuited the frequency spectrum of the vertical Δ-signal contains only vertical betatron sidebands (see Fig. 3).

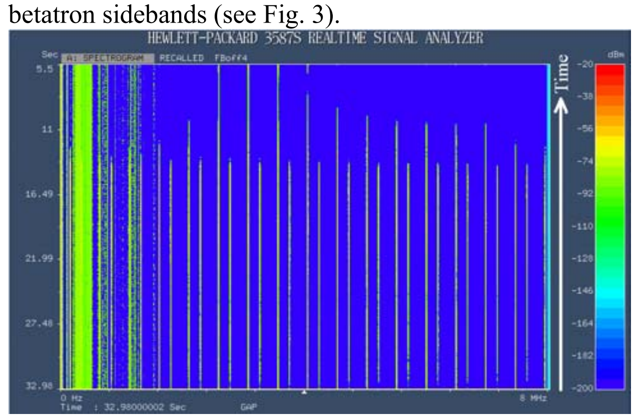

Figure 3: Frequency spectrum of the vertical Δ-signal.

In such a case the feedback system consists of a pick-up with a hybrid, preamplifier, delay, 180°-splitter, power amplifier and a kicker. No additional signal processing is necessary.

Hardware

One of the beam position monitors (electrostatic, diagonally cut) with high impedance preamplifiers and analog electronics with 70 MHz bandwidth was used to measure the beam position deviation (see Fig. 2) [5]. This signal was delayed by means of a very well shielded coaxial cable and fed into a 180° splitter. Two power amplifiers drive the stripline kicker wired in differential mode. Each of the downstream ports of the kicker was terminated with 50 Ω. The betatron phase advance from the pick-up to the kicker by typical tunes was about 97°.

RESULTS AND SYSTEM PERFORMANCE

Through the operation of the feedback system major beam losses could be prevented (see Fig. 4).

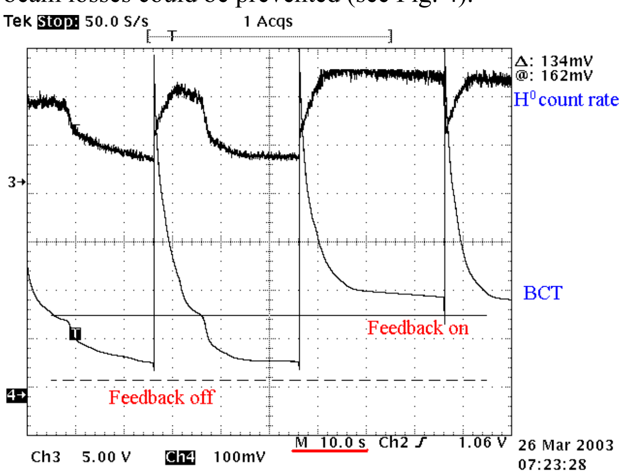

Figure 4: BCT and H^0 count rate signals with feedback on and off.

Measurements in time and frequency domains show that the coherent beam oscillations are effectively damped. Even in presence of external interference up to 1.5 MHz no beam disturbing could be detected (see Fig. 3,5).

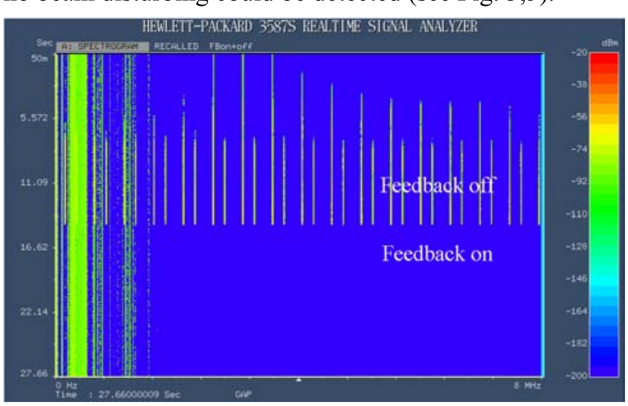

Figure 5: Frequency spectrum of the vertical Δ-signal with feedback on and off.

One of the interesting applications of the system is stacking of proton and deuteron beams. Stacking of electron cooled proton beam during several minutes has been observed. About 160 injections were stacked and accelerated (see Fig. 6). This improvement is especially important for internal experiments which run with polarized protons and long cycle times. In this case stacking of many injections would not change the machine duty cycle significantly but the luminosity would be remarkably increased [6].

OUTLOOK

The next step in the development of the feedback system will be the improvement of signal to noise ratio. We expect this will bring more stacked beam intensity and quality. It is also planed to extend the system in horizontal plane. It seems to be necessary because the amplitude of horizontal oscillations has become bigger due to the intensity increase.

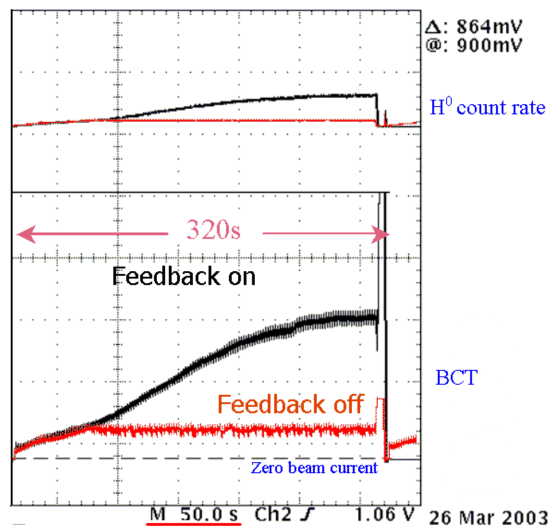

Figure 6: Staking process with feedback on and off.

However some additional signal processing such as beam offset suppressing (BOS) and filtering will become necessary [7]. The first prototype of the BOS circuit will be tested during next weeks.

ACKNOWLEDGEMENTS

The authors are very grateful to H.J. Stein, D. Prasuhn and COSY team for useful discussions and support.

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