Application of Fast Pockels Cells to Beam Diagnostics on the SPring-8 Storage Ring

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In the SPring-8 storage ring, the minimum spacing between bunches is 2.0 ns, which is a period of the accelerating RF field. From the point of the beam diagnostics view, it is meaningful to select a bunch in a consecutive bunch train and to measure its parameters turn by turn. For instance, continuous measurements of the transverse beam size of a certain bunch after injection will give the information about shrinking of the beam emittance. Synchrotron radiation emitted by electrons is a useful tool for non-destructive beam diagnostics. We propose an application of a fast Pockels cell as an optical shutter which selects a light pulse from an electron bunch.

A Pockels cell makes use of the linear electrooptical effect of birefringent crystals, known as Pockels effect [1]. Figure 1 shows a schematic of a shutter system with a Pockels cell and two polarizers. Let us consider the case that linearly polarized light enters the cell. When no voltage is applied to the cell, the direction of polarization of the light is unchanged and the light can not pass through the second polarizer. When a certain voltage is applied, the direction of polarization of the light is rotated by 90 degrees and the light can pass through the second polarizer. The cell and the polarizers work as an optical shutter. A shutter system with the rise time of less than 1 ns can be constructed with a commercially available Pockels cell and a high voltage pulser.

A useful application of Pockels cells other than bunch by bunch beam observations is the single-bunch impurity measurement. In the SPring-8 storage ring, some time resolved experiments demand single-bunch impurity smaller than 10^{-6}. A photon counting method is usually used for impurity measurement [2]. In the method, the efficiency of photon detection is reduced to the level of one photon detection per revolution, and the number of photons, which is proportional to the number of electrons within a bunch, is counted. By the difference of the detected timing of a photon, we can distinguish the bunch which emitted the photon. In case of the impurity of 10^{-7}, it takes more than one thousand seconds for the ordinary measurement to detect ten photons from an undesired bunch accompanying the main bunch.

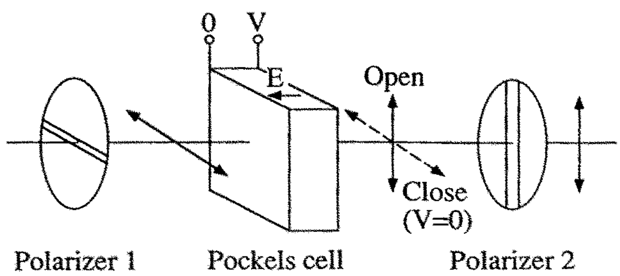

Fig. 1. The optical shuttering by using a Pockels cell.

In order to shorten the measuring time, we can use a Pockels cell with the shuttering repetition rate of frep and the extinction ratio of δ (Fig. 2). Assuming that photon flux from the main bunch is sufficient, and that the transmission of the cell is unity, we can raise the detection efficiency of photons from the undesired bunch by a factor of δ , and decrease the measuring time by a factor of δ -frep/frev. The measuring time is shortened to be a few seconds with the shutter system having 10 kHz repetition rate and 10^4 extinction ratio.

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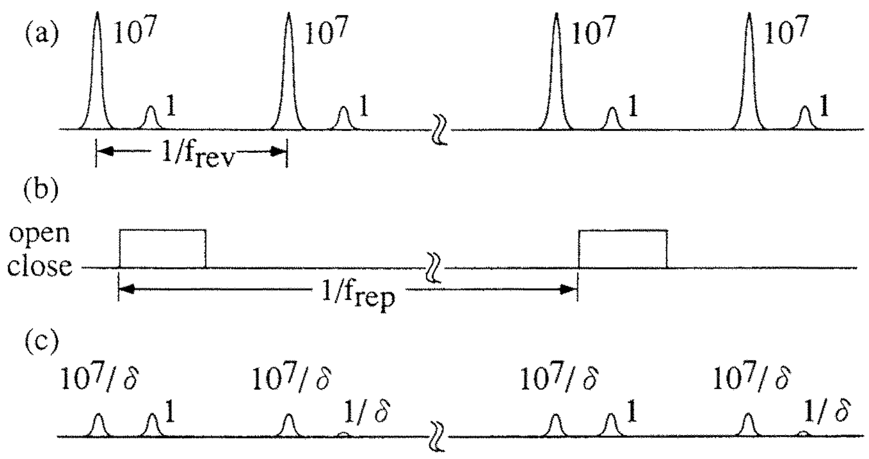

Fig. 2. Single-bunch impurity measurement with a Pockels cell shutter. (a) Incident light pulses to the shutter repeated with the revolution frequency frev. (b). The Pockels cell shutter operated with a frequency of frep. (c) Output light pulses from the shutter.

References

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