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FAST BEAMPROFILE MEASUREMENT

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Summary

The paper deals with a set-up utilizing synchrotron light which allows a fast measurement of beam width and beam height. The most important component of this device is a combination of an image-converter tube with an electron multiplying dynode system. The scan velocity is between .1 and .3 mm/µs and could be made even faster. This makes possible the measurements of acceptance, beam emittance, dynamical change of beam position and change of transverse beam dimensions during an accelarating cycle in an electron synchrotron. The device has also been used to measure fast cross section changes in the PETRA storage ring.

Introduction

Measuring beam profiles utilizing synchrotron radiation means generally scanning the image of the beam cross section. These scanning devices often consist of rotating mirrors or slits with all the disadvantages of mechanical systems. The use of rotation slits involves errors because of a change of the scanning direction and due to the rather low scanning speed. An electronic scan would offer advantages like fast and variable scan rates and avoid mechanical problems.

Such a device, as it is used in the DESY-synchrotron, will be described here[1)].

Description of apparatus

The main component of the beam scanner is a so called image-dissector. This tube is a combination of an image converter and a photomultiplier, both separated by a small aperture.

An optical system forms the image of the beam cross section on the photocathode of the image converter. All electrons emitted from each point of this cathode are accelerated and focused on the plane of the dissecting aperture. The resulting electron image is then electronically deflected across the aperture, which is followed by the electron multiplier (Fig. 1).

The features of this device are: Fast response (no storage), wide dynamic range, high resolution and variable scan.

In DESY two different modes of operation are possible. To get many profile-scans during one accelerating cycle, the "multiple scan mode" will be used. The deflecting field is generated by a sawtooth generator with a constant frequency of about 3.6 kHz and variable amplitude. The real scan time is 200 µs and the fly-back time is 15 µs. By varying the amplitude the scan velocity will be changed and with that the resolution of the read out. The scan sweeps only in one

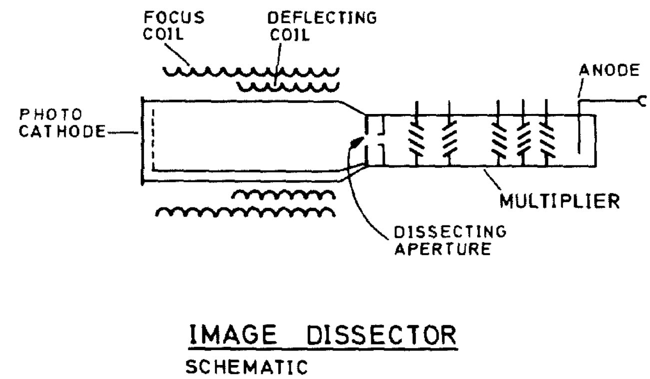

Fig. 1: Schematic drawing of the "Image Dissector"

plane which can be adjusted with a DC-bias on the perpendicular deflecting coil. All deflecting coils have the same electrical parameters, so one can switch from one direction to the other. This operation mode results in a relief like display on a large screen scope with about 40 lines within 10 ms between injection and maximum energy. It gives a quantitative impression of damping and antidamping effects, instabilities and dynamic changes of beam position during acceleration (Fig. 2).

Fig. 2: Relief like display of the beam profile with increasing energy from top to bottom

To get qualitative numbers of beam width and height a "single scan mode" will be used to facilitate the read out. The sweep will be done only once within the accelerating cycle with a repetition rate of 50 Hz. The energy at which the measurement will be done is determined by an energy-synchronized trigger pulse. The full width half maximum will be measured electronically and displayed digitally. Also an analog value can be displayed on a x-y plotter

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or on a storage scope. The x-deflection will be derived from the magnetic field of the synchrotron magnets.

This mode can also be used for measurements in a storage ring. For that purpose the 50 Hz-trigger pulse has to be replaced by pulses, deduced from the revolution frequency in the storage ring. The minimum space must not be smaller than the period of the sawtooth-frequency. With this arrangement beam blow up effects were measured in the PETRA storage ring[2].

The resolution of this system depends on the size of the dissecting aperture and on the magnification of the optical system. In our case we achieved a resolution of 0.2 mm. The dark current in an image dissector is commonly negligible. The disturbing effect is shot noise with a noise current proportional to the square root of the total current. The quantum efficiency is about 22 % at 4200 Å, the dynamic range 40 dB.

The linearity is 1.5 % in both directions and the uniformity is ± 10 % over 1.4 inch diameter circle, which is nearly the sensitive cathode area.

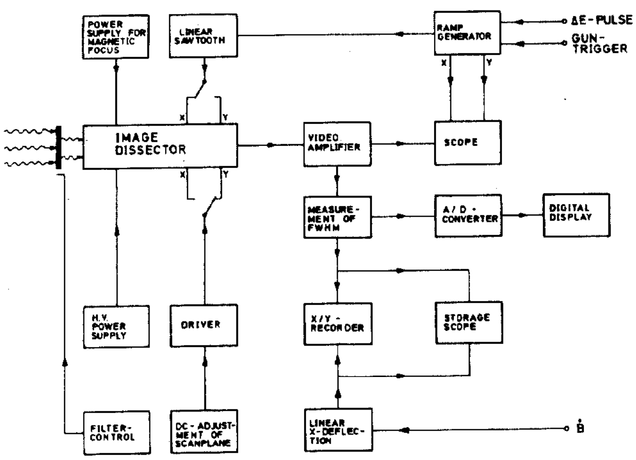

Fig. 3: Block diagram of the beam profile measurement apparatus

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