SHEET ELECTRON BEAM TOMOGRAPHY

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Abstract

An electron beam probe has been successfully used for determination of accelerated particle density distributions. However, the apparatus used for this diagnostic had a large size and complex design which limit the broad use of this diagnostic for tomography of accelerated bunches. We propose a new approach to electron beam tomography: we will generate a pulsed sheet of electrons. As the ion beam bunches pass through the sheet, they cause distortions in the distribution of sheet electrons arriving at luminescent screen with CCD device on the other side of the beam that are interpreted to give a continuous measurement of the beam profile. The apparatus to generate the sheet beam is a strip cathode, which, compared to the scanning electron beam probe, is smaller, has simpler design and less expensive manufacturing, has better magnetic shielding, has higher sensitivity, higher resolution, has better accuracy of measurement and better time resolution. With this device it is possible to develop almost ideal tomography diagnostics of bunches in linear accelerators and in circular accelerators and storage rings.

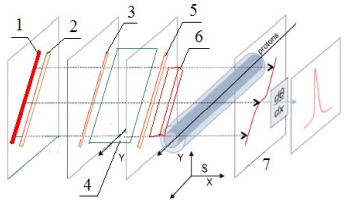

Fig. 1. Sheet Electron Probe Beam profile monitor with a strip cathode

ADVANCED SHEET ELECTRON PROBE BEAM PROFILE MONITOR

The advanced sheet electron probe beam profile monitor (SEPBPM) with the strip cathode is proposed as shown in Fig. 1. For the slice (6) of sheet electron probe formation is used the strip cathode (1) with extractor (2). The sheet electron probe is formed by collimator with two slits (3) and (5). The short slid of sheet electron probe (6) is formed by deflection of sheet electron probe through slit (5) by a pulsed voltage on deflecting plates (4).

Electrons of electron probe slid after deflection by electric field of proton bunch is visualized on the luminescent screen (7) and fixed by fast CCD camera for further processing by corresponding software discussed above.

This version of the SEPBPM is smaller, easy for fabrication, operation and magnetic shielding. Several similar systems can be integrated for production of the tomographic 3-D image of proton bunches. The proposed tomographic system is more compact, easier to operate and less expensive than residual gas ionization profile monitor (IPM) discussed above.

A simplified diagram of SEPBPM is shown in Fig. 1.
1-high voltage pulser; 2-high voltage insulator of electron gun; 3-sheet slice of electron probe; 4-MCP; 5-luminescent screen; 6-sheet electron source; 7-proton/ion bunch; 8-CCD camera.

A slice of the sheet electron beam (3) is formed by the sheet electron source (6) and crosses the bunch (7). Sheet electrons are deflected by electric and magnetic fields of the bunch (7). This deflection is sensed by the position of the electron images on the luminescent screen (5) and recorded by the CCD camera (8). Electron multiplication with a microchannel plate (MCP) (4) can be used for synchronization and for brightness amplification. A pulsed high voltage (~50 kV) power supply (1) is used for electron beam acceleration (extraction). Electron source with cathode (1) is supported by high voltage insulator (2).

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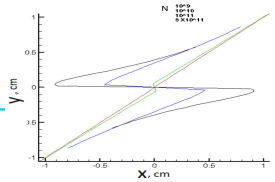

Fig. 4. Simulations of deformation sheet electron probe beam by proton bunch.

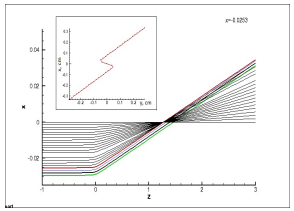

Fig. 5. Trajectories of deflection shit electron probe beam by proton bunch.

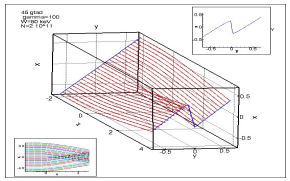

Fig. 6. Simulation of sheet electron beam trajectories deflected by proton bunch.

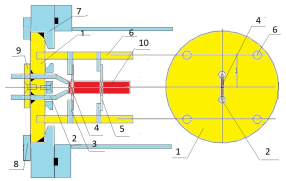

Fig. 7. Design of Electron Gun for production of Sheet Electron Probe Beam

SIMULATION PROBE BEAM DEFLECTION BY PROTON BUNCH

A computer program for simulation probe beam deflection by proton bunch has been developed.
Examples of simulations are presented in Fig. 4, 5. In Fig. 4 is shown a simulations of deformation sheet electron probe beam with energy 30 keV by proton bunch with γ=10 and different proton numbers.

In Fig. 5 is shown a trajectories of deflection sheet electron probe beam of 30 keV by proton bunch with γ=10 and number of proton N=2 10^{11}. A proton trajectories crossing the proton bunch is focused in one point. Proton density in bunch is described by formula
$\rho(x, y, z) = eN (\exp -x^2/a^2 - y^2/b^2 - z^2/c^2) / 84abc(\pi)^{3/2}$
where a=0.02 cm, b=6 cm, c=0,001 cm. A screen for sheet electron beam visualization is located in distance h=4 cm from centre of bunch.
Electrons passing proton bunch outside is deflected divergent. In Fig. 6 shows the simulation of sheet electron beam trajectories deflected by proton bunch.

Fig. 7. Design of electron gun for production of Sheet electron Probe Beam.
1-ceramic disc, 2-current leads, 3- extractor electrode, 4- IrCe emitter of electron , 5-accelerating electrode, 6-ceramic support roads, 7-flange, 8-compression flange, 9-compression ceramic, 10-sheet electron Probe Beam.