METHOD OF BUNCH PHASE DISTRIBUTION MEASUREMENT BASED ON A M∅LLER SCATTERING

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Abstract

Design of a bunch phase distribution monitor with resolution in fs-time range operating on the principle of rf-sweeping of secondary electrons produced in a result of a M⌀ller scattering in a wire target is considered. To minimize chromatic aberration the scattered electrons are separated in narrow energy band in kV-range by spectrometer installed after the monitor rf-deflector so that the planes of the electron analysis in rf-phase and energy one are orthogonal to each other. Apparatus function of the monitor primary converter in a form of a time - energy distribution of the electrons passing through the hole of collimator installed in front of the rf-deflector is defined with a Monte Carlo calculation on a scheme of individual collisions.

Introduction

Method for bunch phase distribution measurement based on rf-sweeping of secondary electrons produced in a result of M⌀ller scattering was proposed by one of the authors of the paper 25 years ago [1]. Option of this method was defined by fundamental properties of chosen physical process allowing to fulfilled the measurements with resolution in fs-time range. During these years the author has carried out researches for creation the monitor realizing this method which, to some extent, had been restricted by possibilities of computers and the level of development of physical models for transport calculation of electrons in keV-energy range those time. In connection with interest to this measurements, increased extremely at present, in the paper this monitor is described. New precise calculations of electron transport in a carbon target for real geometry of the monitor have been accomplished, and some results are presented here below.

Bunch phase distribution monitor

The monitor is schematically shown in Fig.1. Delta-electrons produced in a result of a primary beam (1) interaction with carbon fibre (2) of 8 μm diameter are selected at scattering angle of 90° in a view of a narrow beam by means of a collimator (with hole of 1 mm diameter) installed in front of rf-resonator (3) on a distance 5 mm from the target (2). The phase distribution of selected delta-electrons is coherently transformed into transverse one through rf-modulation in the rf-deflector (3). The rf-deflector is a resonator of a slit-hole type the cross section of which is shown in Fig.1,a where the length from point A to B along the resonator surface is a quarter of wave length. Resonance frequency does not depend on h-distance, and the last is determined by the electron transit phase. To minimize chromatic aberration the delta-electrons are also separated in narrow energy band by spectrometer (5) installed so that the planes of the electron analysis in rf-phase and energy are orthogonal to each other. Radius of main electron trajectory in the spectrometer is 100 mm. The target (2) together with the rf-deflector (3) is moved in the beam (1) for a time of measurements.

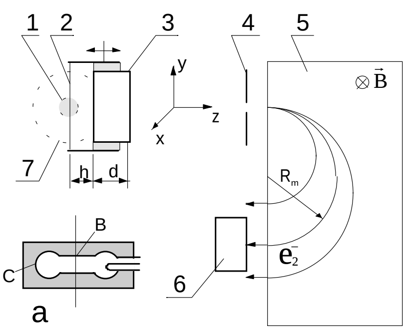

Fig.1. Scheme of bunch phase distribution monitor.

Monitors are similar to the above mentioned one, but operating on the low energy secondary electrons, have been successfully realized already. As to this monitor there are two main questions which have to be solved, namely: temporal apparatus function of the primary converter of the monitor and its efficiency.

Time distribution of the delta - electrons escaping from carbon wire

Apparatus function of the primary converter is determined as a flight time of electrons from the start plane which is perpendicular to the primary beam axis and tangent the target to the finish one being perpendicular to the delta-electron beam axis and tangent the target too, i.e. the time involves the flight time of both beams. The function was calculated with Monte Carlo simulation using some results from [2,3]. The apparatus function in a view of the time distribution of the delta-electrons with energies of 10 and 50 keV within +_50 eV and at the condition of their passing through the collimator hole are shown in Fig.2.

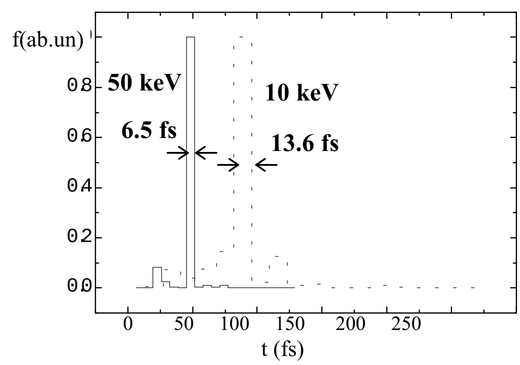

Fig.2. Time distribution of the delta - electrons with energy of 10 and 50keV scattered by the 10 MeV electrons in the carbon fibre of 8 μm diameter.

FWHM of these distribution for the electrons with energies of 50 keV and 10 keV are 6.5 fs and 13.6 fs, respectively. It should be noted that these results have been determined for the beam radius of 1 mm, uniform beam current distribution and at installation of the target in the beam current maximum. The electron energy of the primary beam is 10 MeV.

Probability of escaping of the delta-electron captured by the collimator hole per an electron of the primary beam have been determined at the same conditions as for the time dispersion calculations. For the delta-electron energies equaled to 1, 3, 10 and 50 keV the probabilities are $1.2\cdot10^{-7}$, $5.2\cdot10^{-8}$, $2.2\cdot10^{-8}$ and $4.5\cdot10^{-9}$, respectively. Hence, having an electron beam with 10 13 or more population for a time of measurements one can measure the bunch phase distribution with the above mentioned resolution (Fig.2).

Acknowledgments

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References

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