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Electron beam line design of A4 Compton backscattering polarimeter

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Abstract. The new beam line has been built to measure the polarization of the electron. The transverse position and emittance of the MAMI beam are determined from measurements of the beam size on three wire scanners. The position measurement has been done and the emittance measurement is still progressing.

PACS. 29.27.Eg Beam handling; beam transport – 29.27.Fh Beam characteristics

1 Introduction

The A4 collaboration measures the parity-violating asymmetry for elastic electron scattering off an unpolarized proton. To extract the physics asymmetry, it will be crucial to determine the polarization of the electron beam to high accuracy. For this reason, Compton polarimeter has been installed. The one of advantages of Compton polarimeter is that it is not a destructive method. That means the continuous on-line monitoring of the electron polarization would be possible with the same electron beam conditions.

2 Beam conditions in the chicane

A beam line, which is called a *chicane*, was designed to measure the polarization of the electron. The chicane has the same four dipole magnets, which separate the scattered photons from the electrons, and contributes to the dispersion functions due to the magnets. The dispersion must be eliminated to preserve the same beam properties by introducing two quadrupoles. TRANSPORT [1], which uses a matrix formalism to design a beam transport system, was used to design the chicane. The chicane has been built and is fully operational.

The motion of particles beam can be represented by the ellipse (e.g., Twiss) parameters, β, α, and γ. For transport lines, there is no periodic boundary condition about the parameters, which depend on the initial beam profiles. However, although the chicane is the transport line, two requirements must be fulfilled to achieve the good luminosity and to keep the same beam properties at the beginning and at the end of the chicane; the first one is that the electron beam has a waist at the middle of the chicane($\alpha_w = 0$ and $\beta_w = 1/\gamma_w$) and the second one is the Twiss parameters are the same at the beginning and end of the chicane($\beta_f = \beta_i$, $\alpha_f = \alpha_i$, and $\gamma_f = \gamma_i$). Moreover, it is necessary for the good luminosity to determine the Rayleigh length of the electron beam. The Rayleigh length can be determined by using the equation $x = \sqrt{\epsilon(\beta - 2\alpha s + \gamma s^2)}$, where ϵ stands for the emittance, s denotes the location of the beam, and x is the beam size at s. The design value of the Rayleigh length is 9.617 meter.

[a] comprises part of PhD thesis

3 Position and emittance measurement

To make the scattering between the electron and the photon possible, it might be necessary to determine a transverse position of both of the beams. Moreover, to get the actual values of the Twiss parameters and the emittance of the electron beam [2], it would be needed to measure the size of the beam. The achievement of the two purposes will be done by three wire scanners that are the most commonly tool used to diagnose a beam profile in the middle of the chicane. However, the wire scanner, which A4 uses, is not the common type but the four-bar linkage type. The equation of motion of the wire scanner is therefore needed. The analysis of the wire scanner and the beam position measurement were done.

The horizontal and vertical emittance of the MAMI electron beam are $\epsilon_h = 7.760\pi \times 10^{-3}$mm · mrad and $\epsilon_v = 1.017\pi \times 10^{-3}$mm · mrad. The actual values of Twiss parameters and the emittance can be deduced from the measured electron beam profiles. It is a challenge to make them coincide with their design values.

References

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