The Compton Polarimeter at ELSA

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ABSTRACT

Since 1995 a Compton polarimeter for the stretcherring ELSA of Bonn University is under construction. From numerical simulations an analyzing power of about 70 microns shift of the center of the distribution of the backscattered photons is expected. A computer controlled feedback system enhances the long term beam pointing stability of the laser beam significantly. Using a silicon microstrip detector, we expect to reach measuring times of about two minutes for a circulating current of 100 mA and a polarization error of 5%.

1. Introduction

At the ELSA stretcherring, a fast polarimeter to measure the transverse polarization of the stored electron beam with an energy of 1.2 to 3 GeV is built up. The measurement is based on the Compton backscattering of a circular polarized cw laser beam from the circulating electrons. The spin dependend scattering amplitude gives a vertical up-down asymmetry in the distribution of the backscattered photons, which is recorded by a position sensitive detector. In the following, we will report on the results of numerical simulations of the polarimeter, the computer controlled laser beamline and the detector system.

2. Numerical Simulations

Numerical simulations were performed in order to study the energy dependend analyzing power of the polarimeter. The simulations are based on a 5-dim. integration

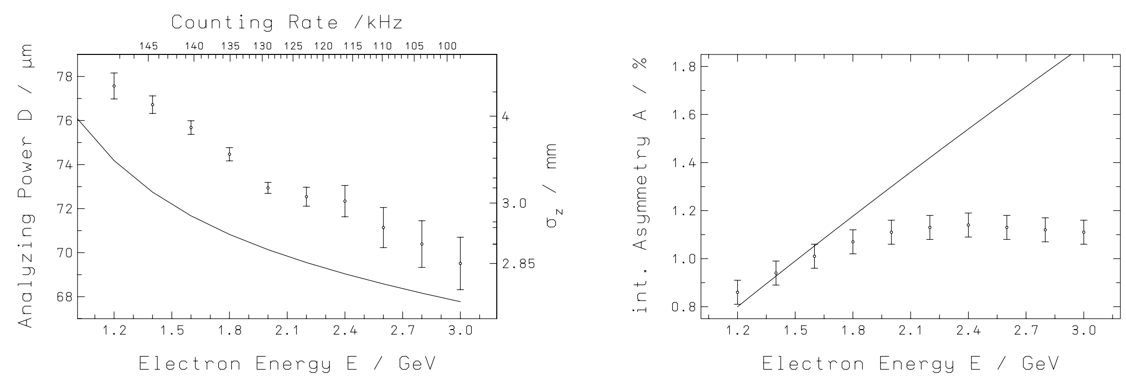

Figure 1: Analyzing power D and A versus electron energy E (see text). In addition, the total counting rate and the width of the distribution of the backscattered photons are shown in the left hand panel.

over the phase-space of the stored electrons and incoming photons. Two kinds of simulations were made: one for ideal point-like electron and photon beams indicated by the solid lines in figure 1, and one for realistic beams represented by the datapoints in figure 1. The errorbars indicate an estimate of the uncertainties of the simulations. The right hand panel of figure 1 shows the shift of the center (CM) of the distribution of the Compton backscattered photons in case of switching from right hand circular polarized laser light to left hand polarization. The left hand panel of figure 1 shows the analyzing power in case of determing the integral asymmetry $A = (A_+ - A_-)/(A_+ + A_-)$ where A_+ is the number of photons detected above and A_- is the number of photons detected below the accelerator plane. In case of measuring integral asymmetries a significant loss of analyzing power is observed at energies above 2 GeV which is attributed to the growing emittance ϵ of the electron beam ($\epsilon \propto E^2$).

3. The Laser Optics

As a light source for the compton polarimeter a commercially available Argon-Ion–Laser is used which delivers a cw beam with 12 Watt at 514 nm. The laser beam is circularly polarized by means of a Pockels cell. The laser, the Pockels cell and a beam expanding telescope are located in a laser laboratory 40 meters apart from the interaction point (IP) in ELSA. The beam is guided to the IP by several dielectric mirrors in an evacuated beam transport line. A final telescope focuses the laser beam to a diameter of two milimeters at the IP. The polarization of the laser beam is monitored after the interaction.

Variations of the laser beam position at the IP may result in additional errors in the electron polarization measurement. To eliminate these errors we built a computer controlled feedback system stabilizing the beam position on each mirror. The dielectric mirrors in the transport line are adjustable by piezo actuators with a tilt range of 4 mrad and a resonance frequency of 300 Hz. The beam position is measured by four-element photo diodes detecting the small fraction of laser light that is transmitted through each mirror. As a result of the feedback any long term drift of the laser beam is eliminated and position oscillations with a frequency up to 10 Hz are reduced, giving a position stability of the beam on each mirror of better than $100 \mu m$.

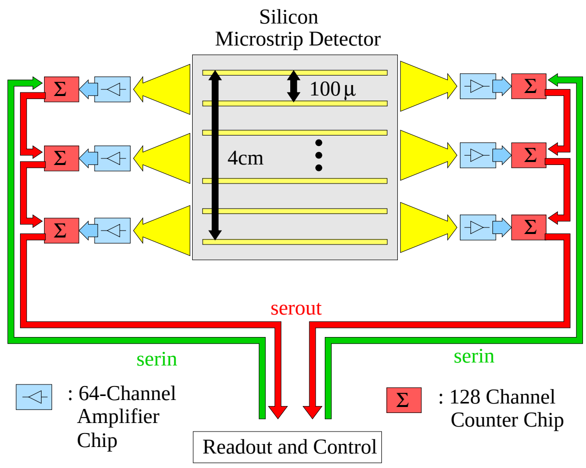

Figure 2: The Silicon Strip Detector and its Readout Units.

4. The Detector

The detector is based on a silicon microstrip detector with an active area of $4x4cm^2$. It consists of 400 strips at a pitch of $100 \mu m$. The position resolution of this detector should be sufficient to determine the CM of the

scattered photons with an error less than 1 micron. The Compton backscattered photons are converted into charged particles by means of a tungsten plate placed in front of the detector. Simulations performed with the EGS4 software package show that the conversion is most efficient (about 50 %) with a converter thickness of 1 radiation length while the broadening of the distribution is less than 1 mm. The readout of the strip detector is performed by six 64-channel amplifier chips and six recently designed 128-channel counter chips. The amplifier chip (analog front-end IC AFEIC) was developed for the ATLAS Semiconductor Tracker (SCT) and consists of a charge sensitive amplifier, a shaper and a discriminator for every channel. It has a double pulse resolution of 128 ns, which is sufficient compared with a maximal rate of incoming photons of 10^5 Hz, and gives a current signal of about $35\mu A$.
To count the number of hits for each strip of the detector seperately we use a counter chip with 128 channels. Each channel consists of a 15 bit linear feedback shift register to count up to 32767 events with a maximum clocking frequency of 50 MHz. The 128 registers in one chip as well as several counter chips can be daisy chained for serial readout of the detector. The counter chip is gateable to allow energy selective counting of particles in combination with an energy resolving detector.

5. Expected Performance

Figure 3 shows the expected performance of the polarimeter in case of 100 mA Stored current in ELSA. The measuring time scales linear with reciprocal current. Systematic errors which may arise from an energy dependent efficiency of detetector had not been taken into acount.

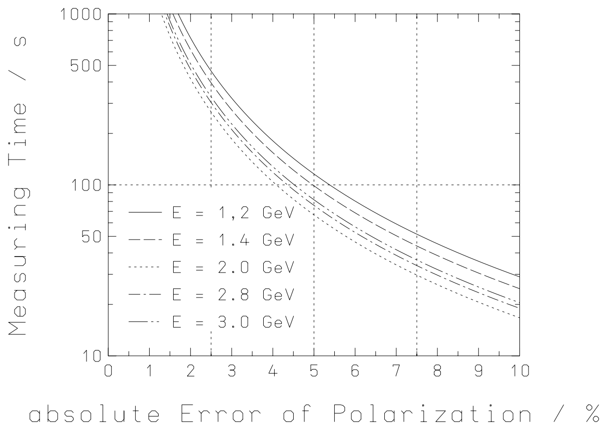

Figure 3: The.

[1] R. Windmolders, 11th International Symposium on High Energy Spin Physics, Bloomington in 1994, ISBN 1-56396-374-4, AIP Conference Proceedings **343** (1995) 719.