A Compton Polarimeter for a parity violation experiment at the Jefferson Laboratory's End Station A

T. Pussieux for the Compton Polarimeter Collaboration
CEA Saclay, DSM/DAPNIA/SPhN,
91191 Gif sur Yvette Cedex, France
E-mail: pussieux@cea.fr
Web pages: http://www.jlab.org/compton

We present the state of the art of the Compton Polarimeter for End Station A at Jefferson Laboratory

1 Introduction

The measurement of the electron beam polarization is the main contribution to the systematic error of the parity violation experiment performed by the HAPPEX[a] collaboration at the Jefferson Laboratory (JLab, Virginia, USA). Both Mott and Møller polarimetry techniques have been used for the first sample of the data taking in 1998. The Møller polarimeter will be suitable only at low current (typically 10 μA) and the Mott polarimeter is located at the injector[b]. In addition, both techniques are destructive for the beam properties so that the beam polarization measurement cannot be performed simultaneously with the parity violation experiment. A Compton polarimeter will give a non destructive measurement for higher current beam up to 100 μA at Jefferson Lab.

2 Compton polarimetry

The electron beam polarization P_e is extracted from the measured asymmetry $A_{exp} = \frac{n^+ - n^-}{n^+ + n^-} = P_e P_\gamma A_l$ in elastic scattering of circularly polarized light off the electron beam (n_+ and n_- are the numbers of Compton events for the two helicity states of the electrons). The polarization of the light P_γ will be measured and the asymmetry A_l on the Compton cross section is calculated via QED.

To increase the analysis power, as the longitudinal asymmetry A_l is negative at low energy and positive for high energy, A_{exp} will be measured as a function of the backscattered photon energy. The Compton polarimeter[1] therefore consists of three parts. A circularly polarized photon source with a

[a] See Etienne Burtin's contribution in these proceedings
[b] See Scott Price's contribution in these proceedings

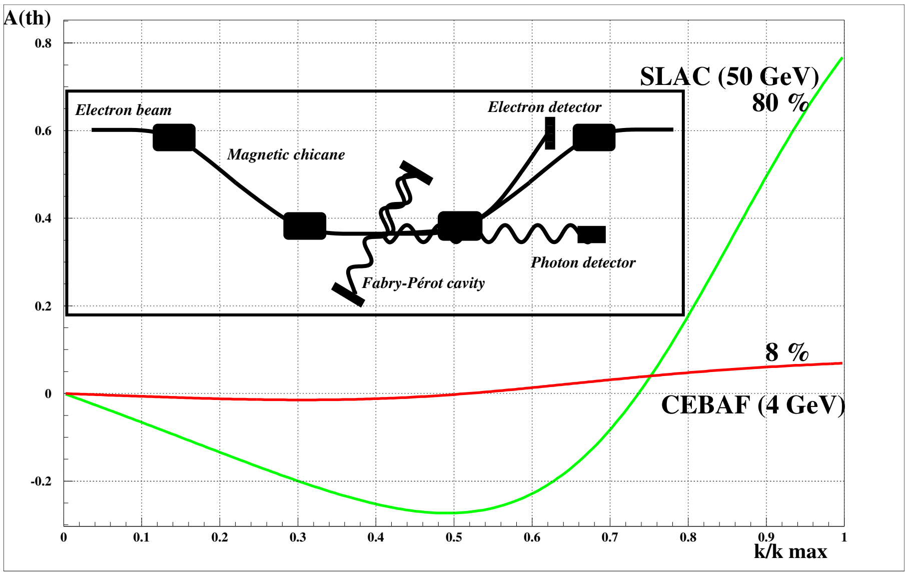

Figure 1: The theoretical cross sections asymmetry at SLAC and CEBAF energies and the sketch of the Compton Polarimeter at Jefferson Lab

photometric setup, a magnetic chicane to extract the scattered photons from the beam line while preserving the electron beam properties (see figure 1). To increase the luminosity at the Compton interaction point (CIP), an optical cavity will amplify a low power laser.

3 The Fabry-Prot Cavity

The Fabry-Pérot cavity[2] is $L = 0.85$ m long and made of two identical concave mirrors of high reflectivity (finesse of 24000), with a radius of curvature of 0.5 m and a diameter of 10 mm. This cavity is fed by a laser beam (1064 nm Nd:YAG 300 mW) correctly matched with the cavity geometry. The regenerative feedback effect allows to get a high power inside the cavity (gain of 3000, intra-cavity power of 900 W) locked during more than 60 hours.
The size (σ) of the gaussian beam is about 120μm at the centre of the cavity. A Pockels cell allows to get a measured circularly left and right polarization of the photon beam around 98 % at the CIP. With such a cavity, we should be able to measure the electron beam polarization within an half-hour at 1 % statistical error. This cavity will be installed at Jefferson Lab in January 1999.

4 The "Mini-Compton" at Jefferson Laboratory in 1998

The "Mini-Compton" at Jefferson Lab consists of the magnetic chicane (4 magnets 1T-1m) under a good vacuum (10^{-9} mbar), the photon detector[3] (a 5X5 matrix of $PbWO_4$ crystals) and the optical setup (with a Nd:YAG laser (1064 nm, 700 mW) without the cavity and Pockels cell replaced by a $\lambda/4$ plate). At the CIP, we measured a power of 500 mW, a photon polarization of $\pm 94\%$ and a waist of $300\mu m$. At $4\,GeV$ and $100\,\mu$A, we expected a photon signal around 100 Hz with a Compton edge at 250 MeV. The sources of background are the synchrotron due to the chicane and the electron bremsstrahlung in the vacuum around CIP. The total expected rates are around 80 Hz[1] . In march 1998, the magnetic chicane has been commissioned at two different energies (1.6 and 4 GeV) with pulsed beam and CW beam up to 100 μA. In addition, vertical and horizontal excursions of the electron beam inside the chicane have been performed to show that the beam properties on the Hall A target (30 m downstream) remain unchanged. The abnormally elevated counting rates around 30 kHz have been measured continuously in the photon detector. Several background studies have been performed. These unexpected rates could be explained by a Hall A beam halo (2 pA at 1 cm of the 100 μA). To reduce it, injector and machine engineers of the Jefferson Laboratory are working on the bunch length compression and the reduction of the beam energy dispersion.

5 Conclusions

The installation and exploitation of the Mini-Compton are successful. The measurement of the electron beam polarization at 1 % statistical error within half an hour should be feasible with the Fabry-Prot cavity in 1999. We would like to thank all Jefferson Laboratory's staff members working on this project for their efficient work and support.

References

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3. M. Baylac *et al*, *Mesure du temps de decroissance et de la photoluminescence des cristaux de $PbWO_4$ (english version)*, Internal Report DAPNIA-SPhN-97-47 (1997).