Internal Report
DESY M-80/11
August 1980

FIRST RESULTS FROM THE PETRA-POLARIMETER

H.D. Bremer, H.C. Dehne, H.C. Lewin, H. Mais, R. Neumann,
R. Rossmanith, R. Schmidt

FIRST RESULTS FROM THE PETRA-POLARIMETER

H.D. Bremer, H.C. Dehne, H.C. Lewin, H. Mais, R. Neumann, R. Rossmanith and R. Schmidt

Deutsches Elektronen-Synchrotron DESY, Hamburg, W.Germany

ABSTRACT

Electron beam polarization was measured in the storage ring PETRA. Laser photons are Compton-scattered by the electron beam. If the beam is transversely polarized vertical asymmetries in the backscattered photons are seen. In addition depolarization with a time dependent horizontal magnetic field has been demonstrated.

The beams in electron-positron storage rings get vertically polarized by the synchrotron radiation[1)], but various depolarization mechanisms can have an adverse effect on polarization.

With the PETRA polarimeter it is possible for the first time to compare depolarizing theories and experiments in a storage ring the size of PETRA (beam energies between 5 and 19 GeV, circumference 2.3 km). The results of polarization measurements in other storage rings are summarized e.g. in[2)]. The PETRA polarimeter is described more detailed in [3)]. The basic idea is the following: circularly polarized photons are directed against the electron beam. In the case of vertical electron beam polarization a different number of photons is scattered into the upper and the lower half plane. By detecting the difference in the number of photons between the two half planes, the degree of the polarization of the electron beam can be determined.

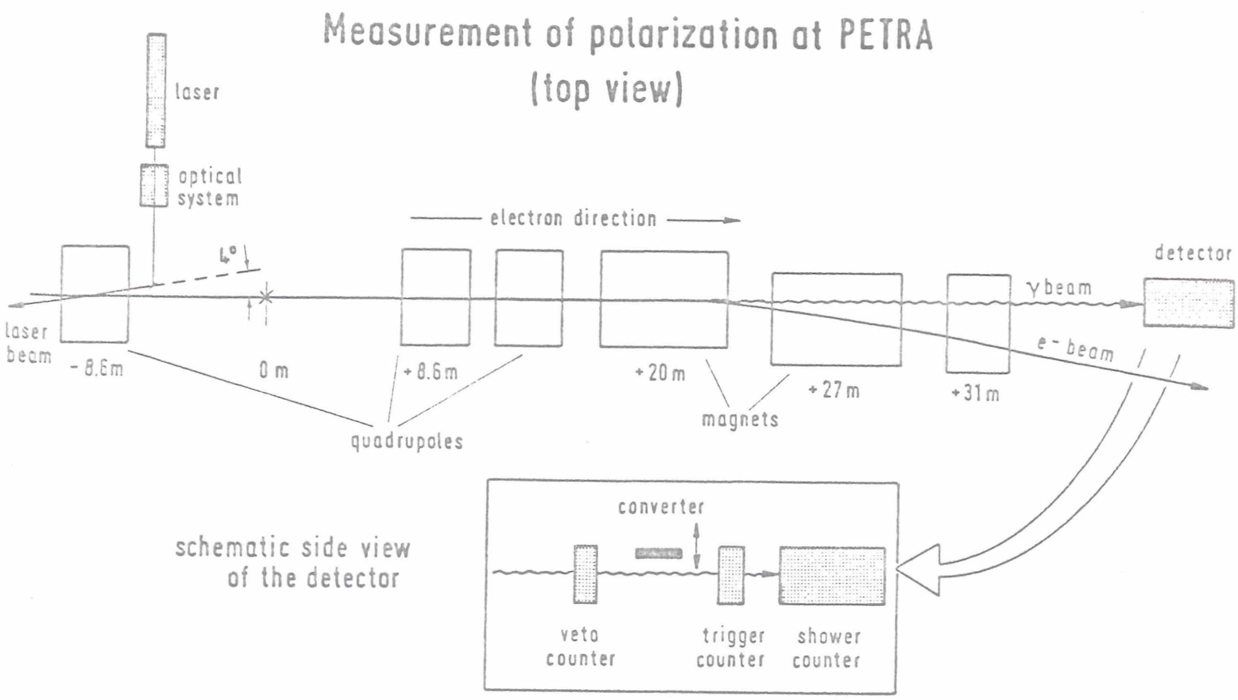
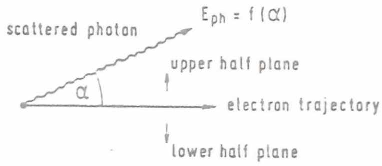


Fig. 1: The polarimeter and the detector assembly

Fig. 1 shows the principal arrangement of the polarimeter: The Ar^+-laser emits a green light pulse when an electron bunch approaches the quadrupole. The vertically polarized laser pulse is converted by a Pockels crystal into circularly polarized light and meets the electron bunch in the vacuum chamber via two mirrors. The helicity of the photon beam depends on the sign of the high voltage applied on the Pockels crystal and can simply be altered by changing the high voltage polarity. Some of the laser photons are converted by the electron beam into high energy photons. The high energy photons travel with the electron beam up to the first weakly excited bending magnet, are separated from the electron beam in this bending magnet, leave the vacuum chamber in the following bending magnet and enter the detection system 45 m from the point where they are generated.

The detection system consists of a combination of counters. Since vertical asymmetries in the counting rates are to be detected the heart of the detector is a vertically movable converter between an assembly of counters. The veto counters suppress the charged particles generated outside the detector and the trigger counters trigger the electronics when a photon in the converter plate (a tungsten plate with a height of 1 mm) is converted. A shower counter at the end of the detector measures the energy of the photon.

Fig. 2a shows the measured spectrum of the backscattered photons. Each energy corresponds to a certain scattering angle α. Photons being scattered under a scattering angle α have the less energy the larger the angle α is.



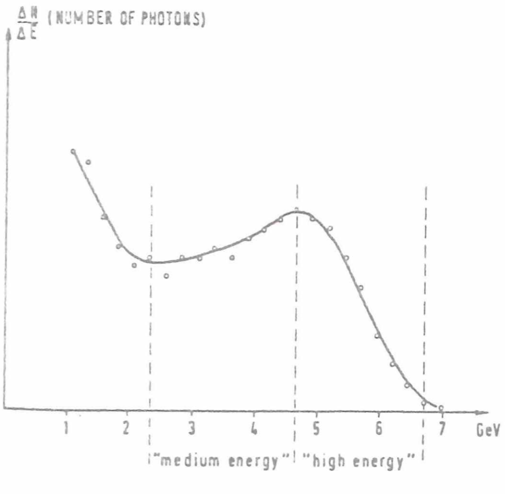


Fig. 2a: Energy spectrum of the scattered photons

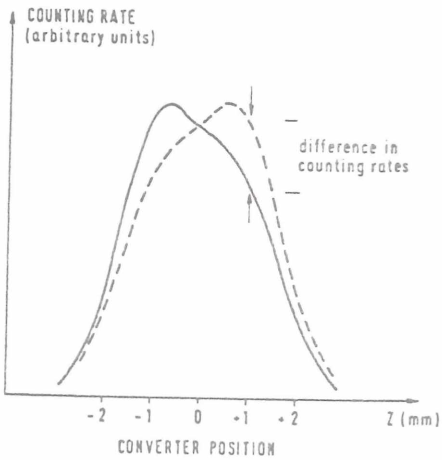


Fig. 2b: Vertical profile of medium energy photons scattered by a polarized electron beam. The two curves relate to different helicities of the laser photons.

In the spectrum two different energy regions are marked. In the one region the photons with the highest possible energy are included (in the following called high energy photons) and in the second region the photons emitted under the angle $\alpha = {}^{1}/\gamma$ (in the following called medium energy photons).

The polarization of the electron beam is measured by using a circularly polarized photon beam. The calculated vertical beam profile for complete electron beam polarization and right and lefthanded circularly polarized light is shown in Fig. 2b. From this figure it is evident that the polarization measurements can be carried out in two different ways:

a) half of the profile is shadowed off by an absorber and the difference in the counting rates between left and righthanded photons is measured
b) the difference in the counting rates between left and righthanded photons is measured as a function of the converter position.

It is evident that for precise measurements method b) is the more accurate, but method a) can be used for faster measurements.

Fig. 3 shows tests for beam polarization at two different energies. The calculated difference in the counting rate for complete polarization is compared with the measured asymmetries. At 15.2 GeV the electron beam is polarized up to about 40 % (±10 %) and at 15.3 GeV the polarization of the electron beam is either very small or non-existent. At 15.3 GeV the beam polarization is destroyed by the depolarizing resonance: $\gamma \cdot (g-2)/2 = 58-Q_z$.
Both curves are measured under the following conditions:

a) The beam energies were 15.2 resp. 15.3 GeV
b) The vertical beta in the interaction region was 140 cm
c) The machine was only filled with electrons
d) The feedback-system was out of operation
e) The solenoids of the experiments were switched off

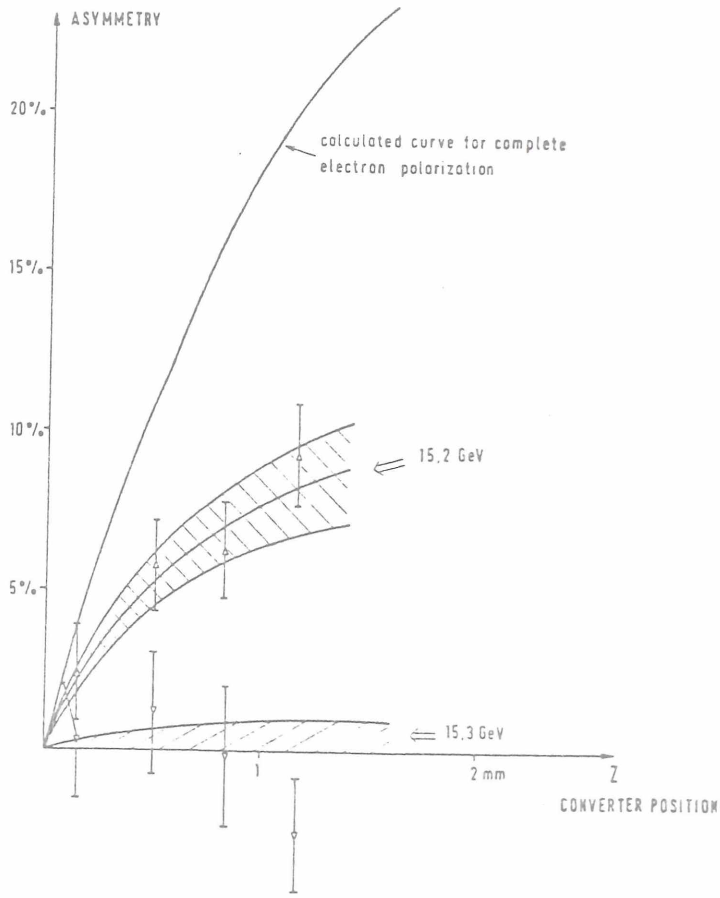


Fig. 3: Difference in counting rates between right and lefthanded circularly polarized light (asymmetry) as a function of the position of the converter. The solid line shows the expected difference for complete beam polarization.

This measurement was repeated about four and eight weeks later and similar results were obtained. In addition measurements with luminosity optics (vertical beta 20 cm) were carried out with and without beam-beam interaction. With the polarimeter in these optics up to now no beam polarization was detected[4] but one of the PETRA experiments reported beam polarization at an energy where no polarimeter measurements were done[5]. One of the future aims will be to measure polarization using these optics.

In order to destroy the beam polarization without changing the energy a fast depolarizing device was installed. The basic idea is as follows: polarization can be destroyed by horizontal magnetic fields with the frequency f_{pert}

$$\left(\left(\frac{g-2}{2}\right)\cdot\gamma - m\right)\cdot f_o = f_{pert}$$

f_o ... revolution frequency of the beam
m ... integer part of $\frac{g-2}{2}\cdot\gamma$

A sweep generator was connected to the vertical PETRA feedback system. The central frequency was tuned to the value for f_{pert} calculated from the usual energy indicator of PETRA. The results with a sweep of 20 kHz are shown in Fig. 4.

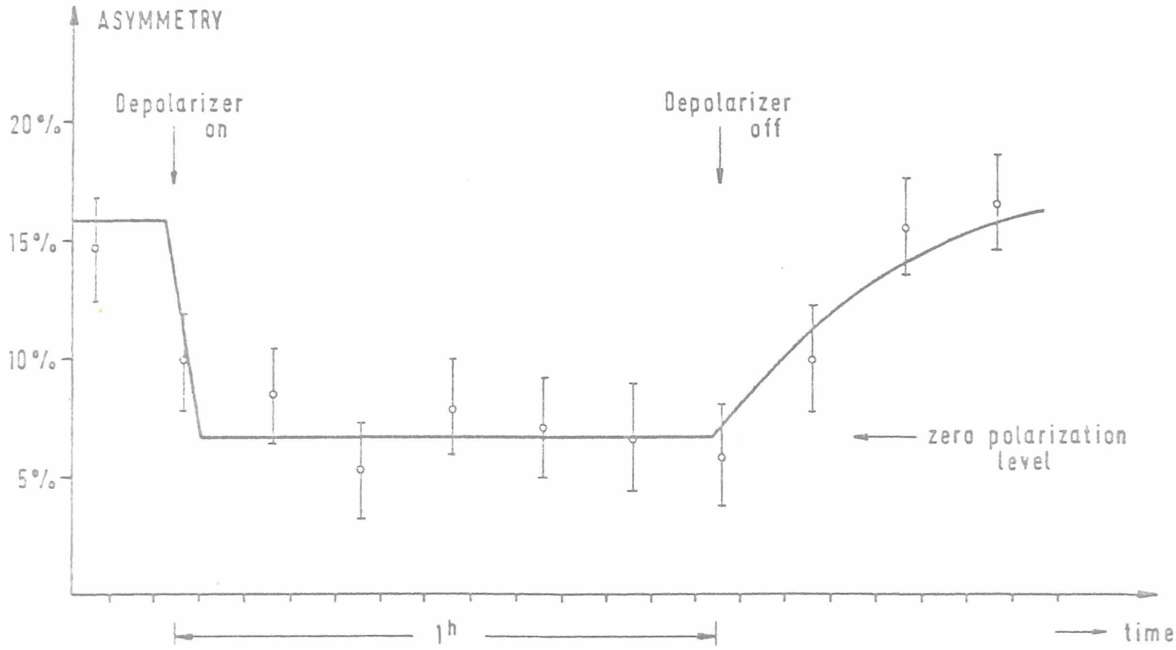


Fig. 4: The beam is depolarized by a fast depolarizing device (beam energy 15.2 GeV). After switching off this device the polarization builds up again. The measurements were done by method a): the residual linear polarization of the laser beam causes a residual asymmetry value even when the beam is completely depolarized.

The polarized beam becomes depolarized within a relatively short time after the depolarizer was switched on and remains depolarized. The residual asymmetry in the case of complete depolarization is due to the linear polarization component of the laser. After the depolarizer has been switched off the polarization builds up again. With this method a calibration of the beam energy is possible similar to the energy calibration done with longitudinal RF-fields at VEPP-2M[6]. An exact measurement of the absolute energy will be one of the aims of future investigations.

SUMMARY

With the PETRA polarimeter electron beam polarization was detected. Up to now the polarization was only detected under certain machine conditions, e.g. without beam-beam interaction. The aim of the future measuring program will be to find out which parameters are decisive for the polarisation.

***

REFERENCES

1) V.N. Baier
XLVI Corso Internationale di Fisica "Enrico Fermi", 1969, Academic Press, New York 1971

2) R.F. Schwitters
Conference Proc. AIP No. 51
High Energy Physics with Polarized Beams and Targets, p. 91

3) Rüdiger Schmidt
Aufbau und Test des Polarisationsmonitors an PETRA,
DESY M 80-4

4) D. Degèle et al.
Results on Machine Physics Studies on PETRA in 1979,
DESY 80/10

5) S. Orito, JADE-Collaboration
Int. Symposium on Electron and Photon Interactions at High Energies,
1979 FNAL, Batavia, Ill., Editors T.B.W. Kirk, H.D.I. Abarbanel, p. 52

6) S.I. Serednyakov et al. Sov. Phys. IETP, 44 (1976), 1063