CERN LIBRARIES, GENEVA

CM-P00061035

TRANSVERSE POLARIZATION IN LEP

J.-P. Koutchouk

Abstract

A significant asymmetry of the Compton back-scattered photons was observed when illuminating the LEP beam with circularly polarized laser shots. The corresponding polarization level is estimated to be about 9%. The asymmetry could be modified by exciting a spin resonance. This experiment was made at dedicated energy and machine optics. The consistency of the measurement with the prediction of the polarization is satisfactory.

*Paper presented at the Workshop on
"Siberian Snakes and Polarization in Circular Machine"
Bonn, Germany, 6-8 September 1990*

Geneva, Switzerland

December 1990

TRANSVERSE POLARIZATION IN LEP

J.P. Koutchouk
CERN, CH-1211 Geneva 23

ABSTRACT

A significant asymmetry of the Compton back-scattered photons was observed when illuminating the LEP beam with circularly polarized laser shots. The corresponding polarization level is estimated to be about 9 %. The asymmetry could be modified by exciting a spin resonance. This experiment was made at dedicated energy and machine optics. The consistency of the measurement with the prediction of the polarization is satisfactory.

1 INTRODUCTION

The programme of transverse and longitudinal polarization in LEP is now in an active phase. The two aims are: 1/ Energy calibration at the Z^0 energy to an accuracy better than the presently achieved 12 MeV per beam [1], 2/ Physics with longitudinally polarized beam at the Z^0 peak, for an accurate check of the Standard Model [2]. The LEP polarization project is described in detail in [3]. It incorporates strongly asymmetrical wigglers which reduce the polarization rise-time from 300 to 36 minutes, a Compton polarimeter [4] and a Richter-Schwytter spin rotator [3].

2 EXPECTED POLARIZATION LEVEL

As discussed in [3], the depolarization in LEP is significantly enhanced compared to SPEAR and PETRA, due to the higher energy and to the higher-order spin resonances driven by the large beam energy spread. An estimate of the tolerances on the alignment and the field imperfections allowed the computation of the disturbed optics and asymptotic polarization level. Even with the enhanced beam energy spread due to the wigglers, a detectable polarization level should be observed.

In practice, however, the optics imperfections have been measured to be larger than expected and the predicted polarization much lower:

Optics parameters	$\langle x \rangle$ mm at $\bar{\beta}$	$\langle y \rangle$ mm at $\bar{\beta}$	$\langle D_y \rangle$ m at $\bar{\beta}$	ϵ_y/ϵ_x %	P_∞ (calculated in linear approx) %
Expected	0.75	0.75	6	≤ 1	20 to 40
Measured	1.40	1.00	17 to 21	5 to 10	5

Simulation of the spherical spin motion showed that, for low polarization levels, the higher-order spin resonances further decrease P_∞ by a factor of 2. Therefore no measurable polarization can develop on the standard LEP optics (figure 1).

Figure 3: Expected polarization on the improved polarization optics

$\nu = 105$ (zero polarization) and $\nu = 105.6$ were explored.

3.1 BETATRON TUNES

The working point should be as close as possible to the integer to leave a maximum resonance-free area around the half-integer spin tune. There is a more specific requirement to lower Q_x so as to avoid the horizontal betatron spin resonance excited by the parasitic skew gradient in the vacuum chamber.

Starting from the tunes initially used for physics ($Q_x = 71.38$, $Q_y = 77.28$), a new working point meeting the polarization and beam life and size criteria was found at $Q_x = .12$, $Q_y = .20$. In spite of the closeness of strong synchro-betatron resonances, the beam was very stable and the emittance ratio lower.

3.2 CLOSED ORBIT AND DISPERSION

During normal operation, the residual vertical closed orbit is corrected down to about 1 mm rms. The vertical dispersion measured is then 17 to 21 cm rms and the emittance ratio estimated to be some 5 %.

The depolarization goes with D_y^2 and higher powers. The gain to be expected from lowering the vertical dispersion is large, once the betatron tunes have been lowered. To achieve it, the closed orbit correction procedure was pushed to yield 0.5 mm rms residuals for the last polarization runs. To obtain these results, it is necessary to eliminate the 'faulty' PU's. Visual inspection, distribution cuts and harmonic analysis were used. Not more than 15 % of the PU's were eliminated. The MICADO algorithm was used with a large number of orbit correctors. Harmonic analysis of the residuals showed that 0.5 mm rms was not the ultimate. More refined tools will need to be prepared to go beyond.

Following orbit correction, the vertical dispersion was measured to be only $< D_y > = 11$ cm. This fortunate result is beyond the prevision and will require further analysis. The emittance ratio decreased to less than 2 %. Altogether the optics improvements are calculated to allow the polarization to build up to around 20 % at the chosen spin tune of 105.5 (figure 3). The higher-order spin resonances should reduce this value by up to a factor of 2.

ferent manipulations took place: natural rise after depolarization, depolarization by the excitation of the spin resonance 106 by means of vertical orbit bumps, depolarization by bumps simulating the solenoids. In all cases, the evolution of the polarization is governed by:

$$P(t) = P_{\infty} + (P_{init} - P_{\infty})e^{-(1/\tau_p + 1/\tau_d)t}$$

where P_{init} is the initial polarization level. P_{∞} is provided by the polarimeter. The rise time may either be calculated from P_{∞} or from the known excitation of the spin resonance. The results are presented in a table:

Period	P_{∞} %	τ_{calc} minutes	τ_{fit} minutes	Comment
1	9	29		asymptotic polarization
2		24	18	excitation of $\nu=106 \times 1$
3		1	8	excitation of $\nu=106 \times 5$
4	9	29	47	natural rise
5	2.1	9	7	solenoids
6	9	29		asymptotic level
7	2.1	9	6	solenoids
8	9	29		asymptotic level
9	1	3.3	7	excitation of $\nu=106 \times 2.5$
10	9	29	44	natural rise

5 CONCLUSION AND FUTURE PLANS

The measured asymmetry of the back-scattered photons is consistent with a polarization signal. This first measurement is important as there has been much debate as to whether polarization could ever be observed at LEP. The ability to polarize the LEP beam even at this low level relied on the predictivity of the theory of the polarization which led us to change the LEP optics accordingly. It is satisfactory and very promising that the experiment confirmed the predictions. Next year's programme will focus on the LEP energy calibration and the improvement of the polarization level.

References

- [1] A. Hofmann *et al.*, 2nd European Particle Acc. Conf., Nice 1990.
- [2] 'Polarization at LEP', CERN 88-06, 1988.
- [3] A. Blondel *et al.*, 8th Int. Symp. on H.-E. Spin Physics, Minneapolis 1988 and this conference.
- [4] M. Placidi *et al.*, this conference.
- [5] J. Billan *et al.*, 2nd EPAC, Nice 1990.
- [6] J.P. Koutchouk, 8th Int. Symp. on H.-E. Spin Physics, Minneapolis 1988.