LEP PERFORMANCE AND PLANS FOR THE FUTURE

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Abstract

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LEP PERFORMANCE AND PLANS FOR THE FUTURE

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1. Introduction

This year, LEP has been operated since April. The LEP performance achieved since then is discussed in Chapter 2. Plans for the development of LEP in the future and their present state of preparation are discussed in Chapter 3. Earlier performance reviews were published in\textsuperscript{1,2} and the references quoted there. A Workshop on LEP Performance was held at Chamonix, France, in January 1991.\textsuperscript{3}

![Graph](image1.png)

**Figure 1:** Integrated luminosity [1/\(\text{pb}\)] vs. Fill number from 17 April to 21 July 91

![Diagram](image2.png)

**Figure 2:** Positron orbit in full pretzel scheme

P1, P2, P3, P4, P5, P6, P7, P8

Full pretzel scheme (1992 MD and physics?)

60° lattice
2. Current Performance

2.1. Achievements

Fig. 1 shows the integrated luminosity from 17 April to 21 July 1991. The figure reached so far, 7.5 pb\(^{-1}\), shows an improvement compared to the integrated luminosity in 1990 which was 12 pb\(^{-1}\). The best week had an integrated luminosity of 1.4 pb\(^{-1}\); during a good fill, the experiments collect about 6000 Z\(^0\)'s each. The improvement in luminosity is believed to be due to a change of the integral parts of the tunes from \((Q_x, Q_y) = (71, 77)\) to \((70, 76)\), found by beam-beam simulations. The vertical tune \(Q_y\) close to a multiple of four made LEP much more sensitive to various errors.

2.2. Comparison with Design Aims

A comparison between the design\(^4,5\) and actual values of various times is shown in Tab. 1 which covers 78 fills between 17 April and 21 July 1991 or 97 calendar days. During this period, LEP was filled on 49 days, i.e. on about half the available days. A typical LEP cycle consists of (i) injection at 20 GeV, (ii) ramping the energy to about 46 GeV, (iii) decreasing the amplitude functions \(\beta\) at the experimental interaction points from the injection to the operating value (in the design, this was assumed to happen during the ramp), (iv) the coast with the beams in collision at the even pits, and (v) a gap which was intended for cycling the magnets. The best achieved times are not too far from the design values. However, the mean and rms values, in particular for the gap, are much longer than expected. The mean gap is longer than the mean coast.

<table>
<thead>
<tr>
<th></th>
<th>Inj</th>
<th>Rmp</th>
<th>Squz</th>
<th>Coast</th>
<th>Gap</th>
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<td>0:06</td>
<td>0:02</td>
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<th>(\tau)</th>
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<td>10.9</td>
<td>3.67</td>
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Table 1: Statistics on LEP injection, ramp, squeeze, coast and gap times [h:m]  
Table 2: Luminosity \(L[\mu b^{-1}s^{-1}]\), beam current \(I[\text{mA}]\) and lifetime \(\tau[h:\text{m}]\)

A comparison of the design and actual values of initial and average luminosity, initial current in both beams, and beam lifetime is shown in Tab. 2 for the same period as in Tab. 1. The best initial luminosity \(\bar{L}\) is within 85% of the design value, the best average luminosity \(\bar{L}\) is even a little higher than the design value, but their mean and rms values remain below 50% of the design values. The total beam current reaches at best about 60% of the design value, indicating that there is at least one reason for a current limitation in LEP which for the time being is not fully understood. The beam lifetime is much better than assumed in the design. This can be partly explained by
the smaller losses due to beam-beam bremsstrahlung. The longer beam lifetime made possible longer coast than foreseen in the design.

Both tables indicate that there is nothing fundamentally wrong with LEP. However, the large spread between good and bad fills implies that much remains to be done in order to improve the availability, reliability and reproducibility.

3. Plans for the Future and State of Preparation

3.1. Luminosity Increase

A long-term luminosity increase with up to 36 bunches in each beam has been studied.\(^6\) Meanwhile, a “Crash Pretzel Programme” will be completed in early 1992.\(^3\) Electrostatic separators with horizontal fields, recuperated from the SppS collider and installed around all even LEP pits, cause horizontal orbit distortions of opposite sign for e\(^-\) and e\(^+\) in all arcs, avoiding beam-beam collisions there, as shown schematically in Fig. 2. Doubling the number of bunches is possible without substantial upgrading of machine components and relatively minor changes to the experiments. Experiments with combinations of electrostatic and magnetically simulated pretzel orbits were very satisfactory. The sparking rate of the separators is \(\sim\)oo high. With half the separators installed, it will be possible to collide trains of three bunches this year for machine development. After the completion of the LEP energy upgrade, the number of bunches in each beam will be increased by a factor up to 9 at the Z\(^0\) energy, and by a factor 2 – 3 above the W threshold, increasing the luminosity by similar factors.

3.2. Energy Upgrade

<table>
<thead>
<tr>
<th>Year</th>
<th>No.s.c. cav.</th>
<th>(E_{\text{max}}) GeV</th>
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<tr>
<td>1991</td>
<td>12</td>
<td>59</td>
</tr>
<tr>
<td>1992</td>
<td>32</td>
<td>65</td>
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<td>77</td>
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<td>192</td>
<td>87</td>
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Table 3: Energy Upgrade Schedule

The LEP Energy Upgrade Project will raise the LEP beam energy beyond the W pair production threshold. The installation schedule for the superconducting (s.c.) RF cavities is shown in Tab. 3. The maximum beam energies assume that both Cu and s.c. RF systems are used, and that the average voltage gradient in the s.c. system is 5 MV/m.

The 12 installed cavities have already delivered about 75% of the design gradient. Orders are placed for 20 cavities of solid Nb and 160 Nb-sputtered Cu cavities. All the remaining RF equipment, i.e. 1.3 MW klystrons, circulators, waveguides, electronics, etc. is defined, and mostly ordered.

The civil engineering work for excavating new klystron galleries near Pit 8 and Pit 4 is expected to be completed by early 1992 and early 1993, respectively. Orders have been placed for four 12–18 kW refrigerators and other components of the cryogenic
system. The upgrading of the cooling, ventilation and electric power systems is under way. Tests have started on a LEP configuration with 90° phase advance in the arc cells instead of the 60° in the present LEP configuration. The design of new straight sections near all eight pits has been completed. They are needed because the present ones cannot be used beyond 65 GeV, and will be installed early in 1993.

The physics aim of the LEP energy upgrade is the production of 8000 W pairs. At 90 GeV, where the W pair production cross section is 16 pb, this requires an integrated luminosity of 500 pb⁻¹. Assuming that LEP is in coast during 10000 hours during two years, this implies a mean luminosity of 14 μb⁻¹s⁻¹.

3.3. Polarization

Last year’s observation of transverse polarization⁷ was repeated. The aim of the polarization MD this year is the calibration of the LEP energy by measuring the fractional part of the spin tune and an increase of the degree of polarization from the 10% presently observed. Extra polarization wiggler magnets which reduce the polarization time from 310 min to 36 min have been installed.

For precise tests of the Standard Model the LEP physics community has asked for longitudinally polarized beams at the LEP experiments. Spin rotators of the Richter-Schwitters design rotate the spin by an asymmetric system of vertical bends. The contribution of the spin rotators to depolarizing resonances has been shown to be much smaller than that of the errors in LEP without spin rotators.

A demonstration spin rotator might be installed in an odd interaction point in 1993. If the results are encouraging, a longitudinal spin physics programme might be launched for installation after 1997, and take about a year of precision measurements at the Z⁰ peak.

4. Concluding Remarks

The LEP performance is within better than a factor of two of the design values. A current limitation will hopefully be understood in the future. The availability, reliability and reproducibility need to be improved. The luminosity increase, the energy upgrade and the longitudinal polarization programme will provide an attractive physics programme up to the end of the 1990’s.

References