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Preliminary evaluation of the LEP centre-of-mass energy for data taken in May and June 1999

The LEP Energy Working Group [1]

Abstract

A preliminary analysis has been performed of the centre-of-mass energy for the first two months of the 1999 LEP run, and an error of 50 MeV assigned to the beam energy. An improved precision is expected when a revised analysis is performed at the end of the run.

1 Introduction

During the first two months of 1999 operation LEP delivered $\sim 27\,\mathrm{pb}^{-1}$ and $\sim 24\,\mathrm{pb}^{-1}$ at nominal centre-of-mass energies ($\mathrm{E_{cm}}$) of 191.6 GeV and 195.6 GeV respectively. The last fill considered in this preliminary analysis is 5831 (30/6/99). The high energy operation was preceeded by a run at Z^0 energies of $2.5\,\mathrm{pb}^{-1}$ for detector alignment.

Two successful experiments have so far been performed to measure the beam energy ($\mathrm{E_b}$) with resonant depolarisation. Fill 5670 (7/6/99) was depolarised at energies of 41.2 and 44.7 GeV. Fill 5799 (25/6/99) was depolarised at energies of 41.2, 44.7 and 50.0 GeV. These were made with the dedicated '60/60' polarisation optics.

Finally, five flux loop cycles have been recorded. These are designated by the number of the adjacent fill: 5441 (27/4/99), 5612 (26/5/99), 5639 (31/5/99), 5671 (8/6/99) and 5676 (9/6/99).

A preliminary determination of the centre-of-mass energies during physics operation has been performed, following the magnetic extrapolation procedure of earlier years [1, 2]. The scale of the dipole field energy has been set by calibrating NMR probes against the points measured by resonant depolarisation, and this calibration has been applied at high energy. The validity of the magnetic extrapolation has been checked by cross-calibrating the NMR probes against the flux loop cycles. Corrections are applied to account for quadrupole effects, any change of the dipole field during the fill, and the RF system, in order to arrive at $\mathrm{E_{cm}}$ for each interaction point. These are propagated to the experiments in a time-stamped file.

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2 Centre-of-mass energy determination

Following the procedure of earlier years, a two parameter fit was performed between the readings of the 16 NMR probes [2] and the depolarisation measurements. In the first calibration many of the probes were suffering from radiation damage and only locked intermittently. For this reason 11 probes were replaced before the second calibration. A difference of 5 MeV in E_b at high energy was observed when switching between the coefficients of the combined fit and coefficients from a similar fit to the 1998 depolarisation data. The predicted dipole energy at start of fill from the NMR calibration is shown in figure 1, against day of fill for the three energy regimes.

Corrections were applied to E_b of the same nature as discussed in [1, 2]. The most significant of these accounted for changes in the RF frequency, which gave a mean shift of −215 MeV in E_b for the high energy running. In calculating E_{cm}, interaction point specific corrections were applied to model the effect of the RF system. These ranged on average between ∼ 5 MeV and ∼ 15 MeV per experiment.

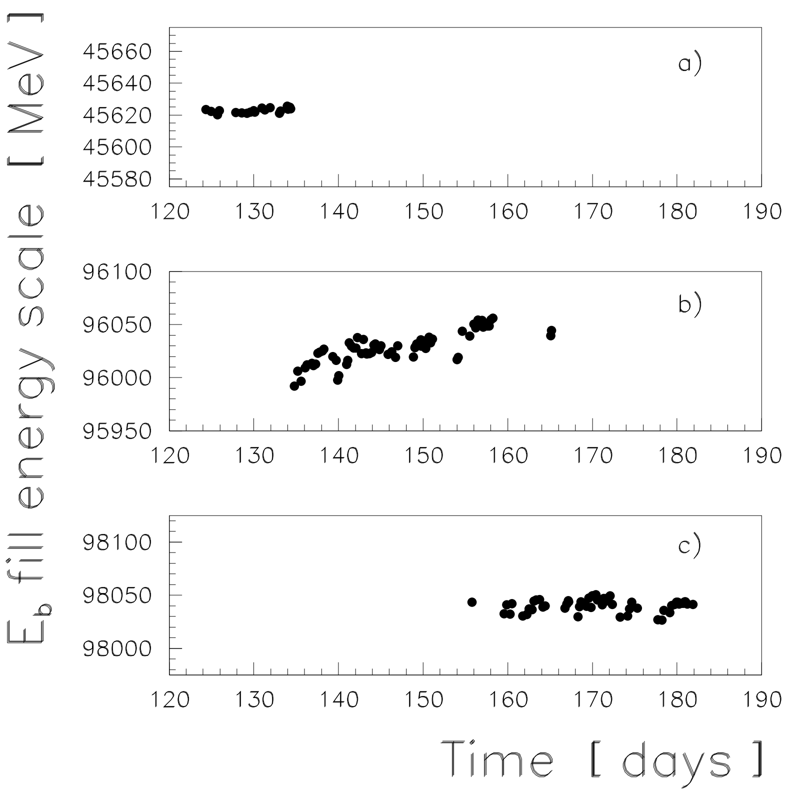

Figure 1: 1999 Dipole energy at start of fill shown against day into year, for Z^0 running (a), 191.6 GeV running (b) and 195.6 GeV running (c).

[2]Note that two additional probes are present this year, in octant 1. These have not yet been included in the analysis.

3 Analysis of the flux loop experiments

To check the linearity of the magnetic extrapolation, the NMR probes were also fitted against the flux loop readings, with individual fits made for each cycle. The fits were performed for fields equivalent to 40 – 60 GeV and the NMR prediction compared with the flux loop measurement at fields equivalent to physics energies (here E_{cm} = 192 GeV). This residual, averaged over all available NMRs and expressed as an energy, is shown in figure 2 for each cycle. As in previous years, there is some variation in residual between cycles. There is no evidence of any non-linearity larger than 10–20 MeV. It should be noted, however, that due to ageing and radiation damage, the 1999 cycles sample only 6 of the 8 octants of the ring.

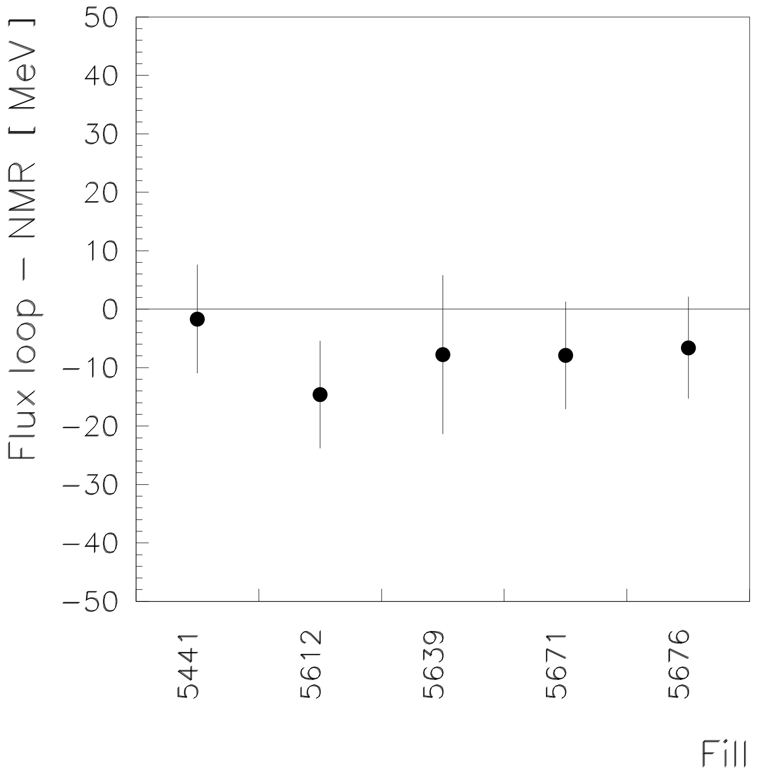

Figure 2: Residuals at 192 GeV from NMR fits to 1999 flux loop cycles. These are the means of the individual residuals for each available NMR, with error bars showing the statistical scatter on these means.

4 Preliminary error assignment and future prospects

An uncertainty of 50 MeV on E_b has been assigned to the preliminary analysis of the 1999 energies. The self-consistency of the depolarisation data, and the linearity check performed with the flux loop cycles suggests that any error on the magnetic extrapolation lies well within this bound. From the experience of earlier years it is believed that the errors associated with the other components of the analysis are significantly smaller. However, until further checks have been performed and until more depolarisation and flux loop measurements are available, a conservative uncertainty will be assumed.

A revised analysis will be performed at the end of the run. In addition to improved confidence in the magnetic extrapolation through established methods and new data, it is hoped to be able to benefit from the first operation of the LEP spectrometer.

References

[1] LEP Energy Working Group, "Evaluation of the LEP centre-of-mass energy above the W-pair production threshold", CERN-EP/98-191, CERN-SL/98-073, December 1998, submitted to Eur. Phys. J. C.

[2] "Evaluation of the LEP centre-of-mass energy for data taken in 1998", LEP Energy Working Group, 99/01, 17 March 1999.