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Error on the LEP Beam Energy for 1996

The LEP Energy Working Group

This document summarises briefly the errors on the LEP beam energy assigned for the 1996 running. The analysis will be documented soon in LEP Energy Working Group Internal Note 97-01, "LEP Energy Calibration in 1996". The numbers are not expected to change, but should be quoted as preliminary until this internal note is available.

The analysis has followed the scheme adopted for 1995 (LEP Energy Working Group Note 96-05) with the following modifications:

- No resonant depolarisation measurement is possible at physics energy. The energy scale is derived from polarisation measurements at 45 and 50 GeV, using the 16 NMR probes in the tunnel and the flux loop measurements to extrapolate to physics energy, assuming a linear behaviour. This gives rise to the "Extrapolation" error.

- The initial energy for each fill was fixed using the NMR probe readings at start of fill. The normalisation of the NMR's was fixed from the available resonant depolarisation measurements at lower energy. Errors such as "fill to fill scatter" assigned in the Z line shape analysis are therefore replaced by an error due to the new normalisation scheme.

- Modelling the energy rise during a fill due to temperature and train effects is made simpler by the availability of 16 NMR probes in the LEP tunnel. The rise per fill is taken directly from the average measured behaviour of the NMR's, without needing a model of temperature and train effects in order to infer the behaviour of the whole ring from just two NMR's. This removes uncertainties such as those due to the different temperature coefficients of the two NMR's and the LEP ring as a whole. The typical rise per fill is 5 MeV in E_{beam}.

The estimated systematic errors are listed in Table 1.

The influence of polarisation systematics, the e^+e^- energy difference, horizontal orbit correctors, the tide model and opposite sign vertical dispersion are negligible, each contributing ≤ 1 MeV.

The fill normalisation error is larger for the 161 GeV period. This is because several of the NMR probes were unreliable during this time, and in particular were not working for the one successful polarisation measurement at the end of the 161 GeV running period. Repair work on these probes between the two running periods means that the normalisation is not necessarily the same for the 161 and 172 GeV running for some of the octants. There is therefore an increased uncertainty on the normalisation of some octants for the earlier period. For both periods, the central value is taken from the normalisation averaging over available probes and over the whole year.

$\sigma(E_{beam})$ [MeV] at	80.5 GeV	86 GeV
Energy Scale Errors:		
Polarisation systematic	1	1
e^+e^- energy difference	1	1
Fill-by-fill normalisation	10	5
Extrapolation	24	29
Orbit correctors	1	1
Variation within a fill:		
Tide model	1	1
NMR/temperature model	2	2
IP specific:		
Dispersion	1	1
RF	5	5
Total	27	30

Table 1: The errors on the beam energy in MeV.

The extrapolation error estimates from NMR and flux loop are typically 10 to 12 MeV. However these rely heavily on a single fill (3719) in which resonant depolarisation measurements were made at two different energies in the same fill. With only two different polarised energies, it is also difficult to constrain the linearity of the extrapolation. This is partly tested by NMR/flux-loop comparisons. Possible additional effects not included in this comparison come from magnet fringe fields and the short, stronger dipoles in the injection region. Using the flux loop absolute energy scale would give a deviation of about 20 MeV compared to the energy derived from a linear extrapolation of the polarisation points. In view of all these considerations we conservatively assign an extrapolation error as indicated in the table. The error is proportional to the difference between the physics energy and 50 GeV, and is fully correlated between the two energies.

The error from the rise in a fill is estimated by trying several prescriptions for implementing the NMR data.

The RF model uncertainty reflects the present knowledge of the RF unit alignment and the uncertainty in the operating phase of each unit.

We expect to be able to reduce the dominant error from extrapolation in 1997 with the help of more resonant depolarisation measurements at more energies.