Minutes of the 113th Energy Calibration Meeting held on 06 December 1996

1 Flux Loop Precision

Knud Henrichsen reviewed the history of measurements of the LEP dipoles before installation and in the tunnel with the flux loop. The dominant aging effects are from the shrinkage of the concrete and the subsequent compression of the steel. This lead to the "cracking" treatment, in which the magnet cap was forced open and closed by 3mm to release the stress. All the magnets were measured relative to the steel only reference magnet (i.e. to be compared with the field display or flip coil value). The effective surface of the flux loops was measured for each dipole allowing a two standard deviation precision of better than 5×10^{-4} on the integrated B field around the ring. Flux loop measurements in the tunnel year by year show a steep decrease (aging) in 1989-1990, and a slight increase over the last four years. Octant 3 also shows a lower than average measured field, due to its unusual humidity.

The method being used by Joerg Wenninger to calibrate the flux loop w.r.t. polarisation measurements takes out the uncertainty on the relative aging of concrete tunnel dipoles and the reference magnet, and also reduces the uncertainty from the remnant field.

The field plates next to the NMR's mean that they measure a slightly different excitation curve to the average, giving the 1.8% difference in slope pointed out in the previous meeting.

The estimated extrapolation error from the flux loop is 12 MeV, with final values awaiting NMR rise data for the polarisation fill.

2 Extrapolation error estimated from NMR's

Mike Koratzinos showed his estimate of the extrapolation error from the NMR's using fill 3719. This is based on the scatter of the NMR measured energy differences between different depolarisation calibrations. There were 5 calibrations at 44 GeV, 3 at 50 GeV with 5% polarisation and 3 at 50 GeV 5 hours later with 12% polarisation. These are referred to as calibrations 1 to 9 in Mike's presentation. The rms scatter of 8 NMR's (one per octant) for the energy difference between each of these calibrations was shown, and for the energy difference between the average of the 44 GeV and average of the 50 GeV points. This last gives a difference of 0.7 MeV, and an rms scatter of 5 MeV, leading to an estimate of the "non-linearity" on the 44 to 50 GeV difference of 0.7 ± 1.9 MeV. This then gives an error on the extrapolation to 80 GeV of about 12 MeV.

3 Summary of energy error estimates at high energy

Pippa Wells showed a summary of the current status of error estimates for the 1996 data. These are listed in the table with the values updated according to the discussion in the meeting. The error table follows the list of uncertainties for the 93–95 analyses. Any

	$\sigma(E_{beam})$ [MeV]
Energy Scale Errors:	
Polarisation systematic	1
e+e− difference	1
Fill-to-fill scatter	10
Extrapolation	24
Correctors	1
Variation within a fill:	
Tide model	1
NMR/temperature model	6
IP specific:	
Dispersion	1
RF	5
Total	27

small effects are rounded up to 1 MeV, just to keep track of them. The fill-to-fill scatter is taken from the r.m.s. model to EOF polarisation scatter on the Z, scaled up for the higher energy (i.e. assuming a fractional effect).

The extrapolation error estimates from NMR and flux loop are both about 12 MeV. However, these rely on a single polarisation fill with just two polarisation energies. Next year we would like to have about half a dozen fills with at least two energies to judge the scatter of the extrapolation, and some fills with more than two energies (and a better lever arm) to judge the linearity of the extrapolation. We increase the error to 24 MeV to reflect our current lack of tests of the stability of the extrapolation. Other possible effects come from the fringe fields (2 MeV) and the short, stronger dipoles in the injection region (2% of the total Bdl). The error from the rise in a fill and the NMR48 model for the 1995 analysis totals 1.5 MeV. This could be scaled up to 3 MeV to take into account the larger error, but is more reasonably scaled up to 6 MeV to take into account that the total rise observed in 1996 is a factor of 4 larger than in 1995. The modelling is however expected to be more reliable in 1996 because there are many more NMR's with which to sample the behaviour, and there is no need to apportion the rise to trains or temperature. The RF model uncertainty is from Mike Hildreth and reflects the present knowledge of the RF phases of each unit.

An attempt to provide the central values of the 1996 energies will be made by Guy Wilkinson next week. This will automatically give a more thorough review of the data quality. The other polarised fills may be used to check that the fill-to-fill scatter error is still reasonable.

4 Review of long term polarisation experiments in 1992–1994

Angelika Drees presented a summary of fills with many polarisation points in 1992 to 1994. These will be needed to constrain the final temperature/train model error for 1993 in particular. The fills in 1992 are the 2 adjacent fills forming the tide experiment. There are 5 fills with more than 4 hours between polarisation points from 1993, and 1 fill from 1994. The plots shown for each fill include the tide correction. Curves show the effect of a "classical" temperature correction with several coefficients. For the 1992 fills, there is a scatter of about 1MeV in the NMR measurements. This is improved by the introduction of field plates in later years. Two of the 1993 fills were used to fit the temperature coefficient (and therefore show good agreement with the temperature corrected curve!). The 1994 fill was for measuring the e+e– energy difference. Only half of a jump in the reference NMR was seen by the beam. This is now understood as being the difference between an NMR inside and outside the beampipe (shielding effect). Attempting to fit a rise per hour for all fills as a function of the time before the first measurement, no trend is observed.

5 Sensitivity of 93–95 analysis to temperature coefficients

Pete Renton showed the effects of varying temperature coefficients CT and CTmax in a relatively large range, both for the ring and for the NMR48 combination. The whole model fitting procedure is repeated for each choice of coefficients. First the ring coefficients are varied from the nominal values, then the NMR48 coefficients. For 1993 and 1995, the maximum shift seen is 2.4 MeV (except for the peak energy, where a maximum shift of 3.2 MeV is seen). The shifts are not always the same for peak–2 and peak+2. Typical shifts are less than or up to 1 MeV.

6 Temperature coefficients from 1996 data

Pete also showed an updated table of the latest estimates of temperature coefficients from 161 and 172 GeV data. Since the temperature always rises in these data, the effective coefficient is CTmax–CTclassical. An attempt to fit the coefficients in adjacent dipoles or adjacent octants assuming a common TGV rise term has also been made.

7 LEP temperature experiment

Enrico Bravin showed a further analysis of the temperature test of 26 November. The NMR readings are corrected for train current, and are then compared to the predictions of the ISR temperature model. There is a bump in the plots which is dominated by the water temperature change (i.e. the gradient term becomes important for a short time). Plots of T, Tmax, Tmin and Twater were also shown.

8 Train current amplitude variation in ISR

Enrico also showed a series of tests with different current amplitude. Each pair of plots shows the raw NMR data and the fully corrected NMR data. The relative amplitudes are +1, −1, −2, +2 and +4. The −2 experiments in particular suffered from activity at a nearby test magnet in the ISR tunnel. (It is possible to deduce the working hours of the team working there, including lunch breaks...) The temperature was constant during these tests. The same current recording combined with an increasing temperature gave rise to more NMR jumps (see previous meetings, with the full Bmax/temperature model).

9 Proposals for future study

The question of whether the current amplitude measured in LEP is the same for 1995 and 1996 was raised.

It was also proposed that the ISR test magnet team and the "dipole model" fitters should have an additional dedicated meeting to decide how to converge on a complete analysis of the 93–95 data. For example, it may be necessary to deduce the Bmax(t) for NMR48 from the fast sampling which is still stored. This would then allow a fit to the 1995 data of a combined TGV/temperature model. This could then be tested against the BOF/EOF polarisation calibrations. A 1993 model using a "typical current spike" model from 1995 data folded with the different temperature profile of 1993 could then be made.

10 k modulation

Bernd Dehning informed us that the polarisaion group are studying the gains that could be made from a better alignment of pick ups to allow deterministic harmonic spin matching for polarisation. This will be discussed at the 1997 Chamonix workshop. The extra cables installed could also be used for LHC, where this will be essential, which might help find a source of funding.

11 Next Meeting

The next meeting will be at 14:00 on Friday 13 December in the pavillon. This will be the last meeting of 1996.

Pippa Wells, 9 December 1996.