Minutes of the 144th Energy Calibration Meeting held on 21 November 1997

1 Status of the 1993–1995 Paper

Tiziano Camporesi sent the message that the final draft of the paper is nearly ready. Those present were in favour of arranging a time to meet to discuss the comments that have been received and to go through the final version.

2 Energy shifts between optics

Joerg Wenninger has been checking the energy difference expected between the 90/60 and 60/60 optics. The effect from quads and sextupoles for a well corrected orbit is negligible. The QF-QD compensation loop is NOT used, so there is a correction $E(90/60) - E(60/60) = -1.4 \pm 0.4$ MeV at peak-2. This scales with energy. The horizontal corrector settings used were rather different for 90/60 and 60/60. Comparing the two models for the dipole contribution gives $E(90/60) - E(60/60) = -4.6 \pm 0.5$ MeV at peak-2, again scaling with energy. An additional contribution from the change of orbit through the quads would also be expected but has not been calculated so far ($\mathcal{O}$ MeV). The net effect is therefore roughly $E(90/60) - E(60/60) = -6 \pm 1$ MeV compared to the measured difference of about -4 MeV. The difference should scale with energy, since the dominant contributions scale with energy.

3 Field profile of the ISR test dipole

Enrico Bravin showed a plot from an old test bench measurement. The magnetic field in the LEP dipole in the ISR test set up is measured at 2000A and 4000A excitation current. If the field for 2000A is scaled by a factor to be exactly the same as the field for 4000A at one point, then in other regions of the magnet the fields are different by up to the equivalent of 50 MeV. This is because the magnets are made with a selection of iron plates such that the average field is correct, but the field is not necessarily uniform along the magnet.

4 NMR flux-loop Comparisons

Joerg Wenning pointed out that the residuals shown for the NMR flux-loop plots are with respect to a fitted line. The local slope in the residual plots are therefore not necessarily correlated with the slopes in the Epol-NMR plots. Joerg and Guy Wilkinson will try to make a more complete comparison of NMR-FL-pol behaviour in the next two weeks.

Joerg went on to show some flux loop data. There were a total of 8 FL-NMR cross calibrations during the year. Three have all NMR's working. The very last ones have fewer NMR's working, but include extra points between 60 and 80 GeV.

For the calibrations with all NMR's working, the scatter of the slopes is below 10^{-4}. Averaging over the NMRs the residuals w.r.t. to the average fitted slope (average over the three calibrations) are less than 10 MeV equivalent. For individual NMR's there can be larger residuals, but the behaviour is well reproduced from calibration to calibration. For those probes which are working, the points between 60 and 80 GeV show no surprises, lying smoothly between the surrounding points.

5 Dispersion measurements and vernier scans

Joerg finally showed the results of the dispersion measurements from fills 4360 and 4370. A hardware problem resulted in no measurements for IP4. The data quality is good, and the results are reproducible. However, the measurements are not in good agreement with the MAD prediction.

```
         MAD with radiation        Measurement
IP2          0.68                   1.3 +- 0.2    \ two fills
                                    1.5 +- 0.2    /
IP6          0.73                   1.2 +- 0.2
IP8         -0.66                  -0.5 +- 0.2
```

Small differences of up to 0.15mm at each IP could be explained by the separator configuration, but there is no explanation of the large discrepency. However, the resulting systematic uncertainty should still be small.

A constraint from the vertical beam size and energy spread would be $\Delta D_y^* \approx$ 4mm.

There were 442 good quality beam-beam deflection scans out of a total of 509 scans, shared reasonably equally around the IPs. Large changes came from the correction of the vertical difference orbits, changes of β_H^* (eg. fills with 91.0 GeV did not have the extra horizontal squeeze from 2.0 to 1.5 m), change of optics and MD fills.

6 Update on Epol NMR comparisons

Guy Wilkinson has updated his analysis to include the last polarisation fill 4372 with RDP at 41GeV and peak-2, at which points 6 and 12 NMR probes respectively were working.

Following the previous work, the probes are normalised at peak-2. At 41 GeV there is an energy difference of Epol–ENMR$=-1.6 \pm 2.0$ MeV, consistent with previous calibrations For those probes that are working, the behaviour is also consistent with previous fills. The new point has been added to existing plots.

Comparing the normalisations at peak-2 for all fills, using fill 4372 arbitrarily to fix the scale, there is an offset of 4.1 MeV between 90/60 and 60/60. The rms of the 60/60 fills is 1.2 MeV (5 fills) and of the 90/60 fills is 0.4 MeV (2 fills). The effect of horizontal orbit corrections has not yet been included.

7 Discussion

The tentative timescale for analysis of the 1997 data is to have central values available to the experiments by the end of February, with errors shortly afterwards, in time for the Spring conferences.

The most crucial ingredient is the NMR-fluxloop-polarisation comparison, which must be used to estimate the "non-linearity" contribution, and to assess if a correction to the "NMR" central value of the extrapolation is needed.

A constraint on the correction due to opposite sign vertical dispersion and the updated RF model should be possible on this time scale.

It is also important to control the behaviour of the bending field outside the flux loop. These effects were not considered in any detail for the 1996 analysis. The following is taken from the minutes of the meeting of 5 September 1997:

"The flux loop samples more than 98% of the bending field of the normal dipoles. These dipoles make up 98.4% of the total bending field, with 1.4% from the injection dipoles and 0.2% from the 10% dipoles at the end of the straight sections. In other words, the flux loop samples directly 96.4% of the bending field. The remainder must therefore be controlled to the 1% level to achieve overall 10^{-4}."

At present these fields can only be controlled from old measurements. For example, the fringe field effect is included in the "effective length" of the flux loop. Up to date measurement to check that aging has not changed the behaviour are desirable.

We then discussed hardware requests for the shutdown. So far the list is:

- Refurbish NMR's in the tunnel
- Bring the test magnet in the ISR tunnel back on line to make some tests of NMR-flux loop comparisons, field variations along the length and maybe measure fringe fields.
- Find out the cost of equipping extra magnets with NMR's. However, the group does not think there is a strong case for equipping more normal dipoles.
- Equip two injection dipoles with NMR's. (This would allow a direct control of 1.4% of the bending field as yet unmeasured.)
- Extra flux-loops or flip coils to check the fringe fields between normal dipoles.
- Polarisation MD in 1998 should be emphasised in the early part of the running while the NMR's are in good condition. We might plan a program of NMR resuscitation during the tehcnical stop at the beginning of October.

8 Next Meeting

The next meeting will be at 14:00 in the Pavillon on Friday 5 December.

Pippa Wells, 24 November 1997