LEP Energy Working Group Memo 02/01
November 2002

Preparation of the final LEP2 energy files and arising numbers of interest

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Abstract

This memo briefly summarises to the LEP ECAL group the situation regarding the final energy files. Additional information is given on the values of luminosity weighted corrections in the model, throughout the LEP2 running, and on the stability of the NMR calibration year to year.

1 Preparation of final energy files

The preliminary energy files for 1996, 1997, 1998 and 1999 have been replaced by 'final' files. These files are final in all respects apart from a possible offset to the absolute energy scale, to correct for any bias in the NMR model at high energy. This issue is being studied at present, using the results of the flux loop, the Q_s calibration and the spectrometer as input. This offset will be communicated to the experiments in early Spring 2003, and may vary from energy point to energy point, but will otherwise be time independent.

In updating the energy files all inputs were carefully checked. The main changes with respect to the preliminary files are as follows:

- Bugs were corrected (eg. incorrectly typed values of the momentum compaction factor.)
- The model was made uniform throughout the datasets, and components added to the calculation of the early energies which were not initially present (eg. horizontal correctors, QFQD etc).
- Some of the input data were upgraded to the 'state of the art' (eg. Jorg's central frequency files).
- A 2 parameter fit was implemented in the calibration of the 1996 data.

The variation in mean energy between these files and the preliminary files differs year to year. It is always well within the preliminary error estimation.

Note no update has been made to the 2000 file. Here the preliminary file can be considered 'final', modulo any offset.

2 Luminosity weighted model components

The NMR energy model has an initial energy scale, determined from the NMRs, on top of which are applied corrections from a variety of well known sources. The luminosity weighted values of these model components have been calculated (using the DELPHI luminosity profile) and these are shown in table 1 for each energy point. Presumably this table will be a useful input in assigning the model errors.

Some comments:

- The dipole rise differs significantly year to year. This is both because of length of fills, and because in not all years was bending modulation deployed. But this point needs to be followed up...
- At first it may be surprising that the tide correction, though small, is always positive and 1-2 MeV. That is because there is always a non-zero tide definition at Geneva latitudes.
- That the 'xarc' correction is similar year to year is a consequence of the characteristic seasonal time dependence in the ground deformation around CERN.

Year	'96		'97	'98	'99				'00	
E_{cm} [GeV]	161	172	183	189	192	196	200	202	205	207
Dipole rise	3.6	7.0	1.7	0.8	0.7	-0.1	-0.7	-0.7	1.5	2.2
Tide	1.1	0.8	1.2	1.7	1.9	2.2	1.4	1.8	2.0	1.8
fRFc ('xarc')	-13.8	-14.2	-20.2	-27.5	1.2	-27.8	-40.0	-24.4	-32.3	-40.2
f_{RF}	0.0	-3.0	-152.4	-187.0	-222.2	-229.7	-194.9	-129.8	-85.9	-29.6
Hcor (BFS)	-2.8	-3.0	-5.6	-7.8	-1.1	-1.6	-0.4	1.1	357.6	430.0
QFQD	-2.6	-2.4	-2.8	-1.3	-1.3	-1.4	-1.4	-1.4	-1.4	-1.4
RF point 2	9.9	9.7	4.1	3.0	4.4	4.1	4.0	4.0	1.7	1.5
RF point 4	-2.8	-2.9	-5.4	-4.6	-6.3	-7.0	-6.9	-6.5	-5.5	-4.9
RF point 6	10.3	9.9	2.8	-1.3	-2.9	-2.6	-2.7	-2.2	-0.3	0.0
RF point 8	-4.7	-4.2	-6.6	-5.2	-8.6	-8.0	-7.5	-7.0	-5.7	-4.9

Table 1: The luminosity weighted corrections to E_b in MeV from each component in the energy model, at each nominal energy point. (The two energy points in 2000, designated '205' and '207', refer to data with E_{cm} between 202.5 and 205.5 GeV, and above 205.5 GeV respectively.)

- As expected, 'f_{RF}', the energy variation coming from an offset in the RF frequency is a *big* correction! This is implemented from a time-stamped file of frequency trims. To check for gross errors, mean energies have also been calculated for most energy points using the regularly logged values in the database. Compatible results were found within 1–2 MeV. The value of the correction depends on the momentum compaction factor. This is probably known to 1% – this is an error we should account for which has been ignored in the past.

- The 'Hcor' correction in 2000 is of course superseeded by the energy boost from the BFS. This was checked carefully at the time of the 2000 energy file production, but has not been looked at since. One of the outstanding tasks in completing our paper is to assign a reliable error to this term.

3 Year to year stability

It is important to assess how stable the NMR model is year to year. This is because ideally we would wish to apply the results from the flux loop, Q_s and spectrometer measurements, made in specific years, to the full data set.

The stability of the model can be quantified in various ways. Most familiarly the 'banana' plot shows very good reproducibility between the model and the RDP measurements, as seen using all 1997-2000 data in figure 1.

A second figure of merit which can be studied is the difference between an individual NMRs estimate of E_b at high energy, and the mean over all NMRs. This is shown in figure 2 separately for 1997-2000 and 1996. Table 2 quantifies this behaviour, giving the RMS spread in each year, and the RMS spread of the *difference* in residuals between each

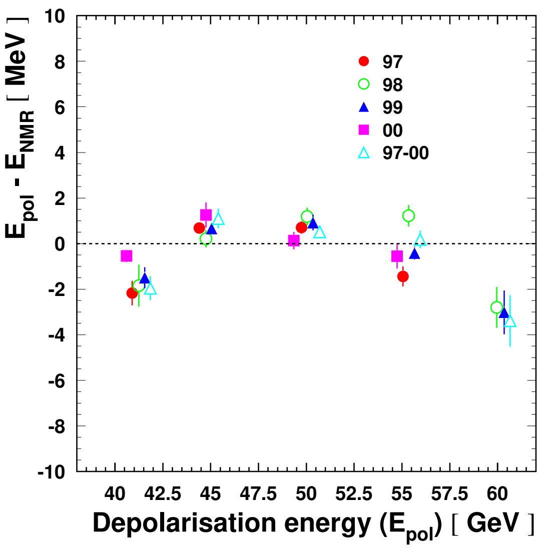


Figure 1: Residuals of model to resonant depolarisation for data in 1997-2000. Each point is the mean over the available measurements at that energy, with the error bar the statistical uncertainty on this mean.

	'96	'97	'98	'99	'00	'97-'00
RMS	46.3	46.2	33.3	45.2	49.8	42.5
RMS (year minus '97-'00)	53.4	10.6	11.3	6.6	14.9	/

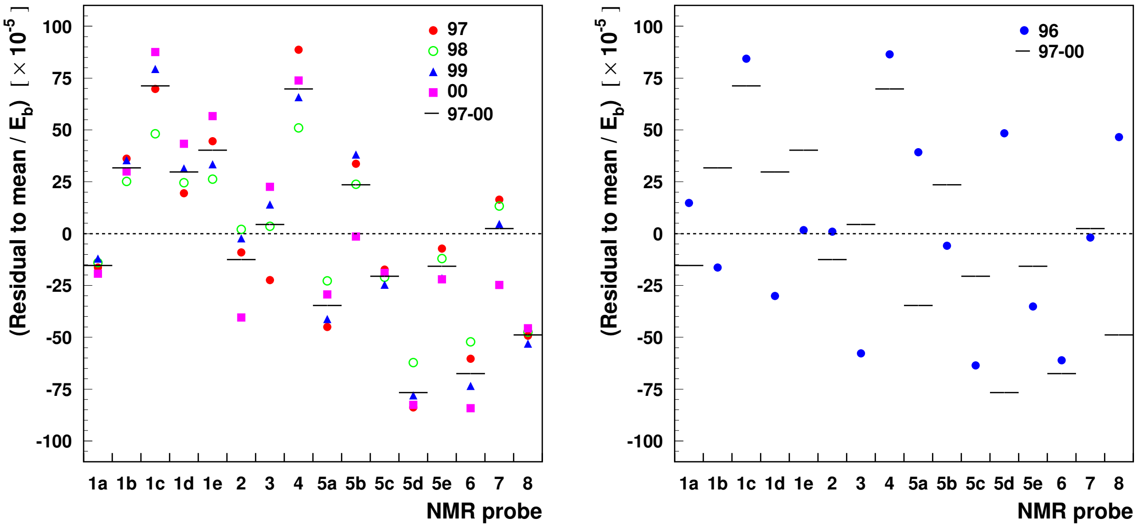
Table 2: Year-to-year RMS scatter of the distribution of each NMR's estimate of E_b, expressed relative to E_b in that year $\times 10^{-5}$. Also shown is the scatter of distribution when the mean '97-'00 value has been subtracted.

year and the average of 1997-2000. These results suggest that throughout 1997-2000 the pattern of residuals is fairly similar, although differences do exist. The implication is that the central value of the model should be robust year to year. Comparison with 1996 shows much greater variations however.

The most direct way to check the stability of the model, however, is to determine the shifts in mean E_b which occur when the calibration coefficients are swapped between years. This is shown in table 3 for all possible combinations. It can be seen that the model is extremely stable in 1997-2000, with variations of no more than 4 MeV observed. The 1997-2000 model, however, appears to be wholly inappropriate for 1996.

The explanation for the difference in stability between 1996 and 1997-2000 lies in the fact that from 1997 onwards, precision mounts were used for each NMR, and great attention played to reposition the probes exactly each year. This was not the case in 1996.

In conclusion, the NMR model seems to be exceptionally stable for the years 1997-2000, and any test of the model made in one year can be applied to another year with confidence. (Perhaps table 3 can be used to assign a appropriate small uncertainty to this assumption?) The situation in 1996 is not so straightforward, although all the flux



(a) (b)

Figure 2: Relative residuals of each NMR estimate of E_b at high energy to the mean E_b averaged over all NMRs. Plot (a) shows the residuals for 1997-2000. Plot (b) shows the residuals in 1996, and the mean residuals for 1997-2000.

	Dataset				
Fit	'96	'97	'98	'99	'00
'96	0	32.0	34.7	36.9	39.0
'97	-27.5	0	4.1	1.5	0.9
'98	-29.1	-3.6	0	-2.5	-0.3
'99	-27.5	-1.8	1.9	0	2.1
'00	-28.9	-3.6	-0.1	-1.7	0
'97-'00	-27.7	-2.0	1.8	-0.6	1.8

Table 3: Shift in mean E_b (MeV) observed at high energy when the data are reprocessed with NMR calibration coefficients determined in a *different* year.

loop/Q_s/spectrometer tests of 1997-2000 presumably tell us *something* about the 1996 data set. All this is to be discussed.