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Presentation of LEP Electroweak Heavy Flavour Results for Summer 1994 Conferences

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Abstract

In this document we make some specific suggestions for the presentation of electroweak heavy flavour results so that the task of making LEP averages is more straight forward. These suggestions include a format for presenting systematic errors and specific values and ranges for some of the more influential input parameters.

The suggestions in this document apply to results for conferences in the Summer of 1994.

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1 Introduction

In this note we describe a format for presenting heavy flavour electroweak results. We hope that the LEP experiments will be able to translate their existing and new results into this format as the first step in making LEP averages for the Summer conferences. We also discuss the procedure for making average numbers, and the schedule leading up to the Glasgow conference.

2 Identification of published results which have been superseded

Several published results are superseded by later analyses including a larger data sample. This should be made explicit by the experiments.

Certain early results (eg. based on 1989 data only) should in any case be excluded from the LEP average. These results have an extremely small weight in the final average values. The treatment of systemtatic errors tends to be much less sophisticated in these early analyses. Although this was adequate at the time of publication for the individual measurement with a large statistical error, it leads to problems when trying to assess the correlations with recent, much more precise measurements.

Each LEP experiment should specify which of their results are superseded or obsolete.

3 Presentation of the results of each analysis

3.1 General strategy

- Provide the explicit dependence on other electroweak quantities
- Provide the statistical and systematic covariance matrices among quantities measured in the same analysis.
- Provide a full breakdown of the systematic errors on the final quantities **including all their signs**. This information should be sufficient to reconstruct the covariance matrix, and is needed to calculate the off diagonal parts of the full LEP covariance matrix.
- Asymmetry measurements should be quoted together with the corresponding average centre-of-mass energy and details of any corrections (QCD, QED...) which have been applied. On-peak asymmetry measurements will subsequently be corrected to a centre-of-mass energy of 91.26 GeV to be combined. However, the preference is for the experiments to provide "raw" values with no corrections applied.
- Where possible the results should follow the suggestions in [1].

To this end, the experiments are **requested to provide supplementary tables for each result**, including existing publications or notes, giving extra details (eg. signs of errors) which were not initially quoted. The central values and systematic errors should be adjusted to reflect the agreed common values and ranges for the parameters listed in table 1.

3.2 Template table including default values and ranges

Suggestions were given in a previous note [1] for certain input parameters and models. For consistency one has to try to correct the individual experiment numbers to the same set of input parameters, for example the same semileptonic decay models, and the same range for evaluating the systematic uncertainty. If the experiments can translate each of their results to have the errors split up into the same categories, and corrected to the same central values, the task of averaging becomes much less ambiguous. The element of guess work needed to work out the off diagonal elements of the correlation matrices is much reduced.

The proposed set of systematic errors for making heavy flavour LEP averages for the summer 1994 conferences are given in table 1. A flat file version of this table will be available on the LEP Electroweak working group disk on CERNVM (PUBWS 261).

Error Source	Proposed Range	Uncertainty
Internal experimental effects	...	...
$\langle x_E(\mathrm{b})\rangle$	Fitted or 0.70 ± 0.02	
$\langle x_E(\mathrm{c})\rangle$	Fitted or 0.51 ± 0.02	
Choice of b fragmentation function	See note 1	
Choice of c fragmentation function	See note 1	
$\mathrm{Br}(\mathrm{b} \to \ell)$	Fitted or $(10.5 \pm 0.5 \pm 0.6(\mathrm{model}))\%$	
$\mathrm{Br}(\mathrm{b} \to \mathrm{c} \to \ell^+)$	Fitted or $(7.9 \pm 1.2 \pm 1.1(\mathrm{model}))\%$	
$\mathrm{Br}(\mathrm{b} \to \bar{\mathrm{c}} \to \ell^-)$	$(1.3 \pm 0.5)\%$	
$\mathrm{Br}(\mathrm{b} \to \tau \to \ell)$	$(0.7 \pm 0.2)\%$	
$\mathrm{Br}(\mathrm{b} \to \mathrm{J}/\psi \to \ell^+\ell^-)$	$(0.07 \pm 0.02)\%$	
$\mathrm{Br}(\mathrm{c} \to \ell)$	$(9.8 \pm 0.5)\%$	
$\mathrm{Br}(\mathrm{c} \to \mathrm{D}^* \to \mathrm{D}^0\pi \to \mathrm{K}\pi\pi)$	$(0.71 \pm 0.05)\%$	
Semilept. model $\mathrm{b} \to \ell$ [1]	ACCMM $\left(^{+\mathrm{ISGW}}_{-\mathrm{ISGW**}}\right)$	
Semilept. model $\mathrm{c} \to \ell$ [1]	ACCMM1 $\left(^{+\mathrm{ACCMM2}}_{-\mathrm{ACCMM3}}\right)$	
$\mathrm{b} \to \mathrm{D}$ model. [1]	Peterson $\epsilon = 0.42 \pm 0.07$	
D^0 fraction in $\mathrm{c\bar{c}}$ events	0.557 ± 0.053	
D^+ fraction in $\mathrm{c\bar{c}}$ events	0.248 ± 0.037	
$(\mathrm{D}^0 + \mathrm{D}^+)$ fraction in $\mathrm{c\bar{c}}$ events	0.80 ± 0.07	
$\mathrm{D_s}$ fraction in $\mathrm{c\bar{c}}$ events	0.12 ± 0.05	
Λ_c fraction in $\mathrm{c\bar{c}}$ events	See note 2	
D^0 lifetime	0.420 ± 0.008 ps	
D^+ lifetime	1.066 ± 0.023 ps	
$\mathrm{D_s}$ lifetime	$0.450^{+0.030}_{-0.026}$ ps	
Λ_c lifetime	$0.191^{+0.015}_{-0.012}$ ps	
B decay multiplicity	5.5 ± 0.5	
D decay multiplicity	2.39 ± 0.14	
$\mathrm{g} \to \mathrm{b\bar{b}}$ per multihadron [2]	$(0.18 \pm 0.09)\%$	
$\mathrm{g} \to \mathrm{c\bar{c}}$ per multihadron [2]	$(1.3 \pm 0.7)\%$	
Rate of long-lived light hadrons	Tuned JETSET$\pm$10% (See note 3)	
Light quark fragmentation	See note 4	

Table 1: Template table of systematic errors. (Quantities that are fitted do not also give rise to a systematic error in the same analysis.)

Note 0 Each source of error is quoted as $x \pm y$. Please quote the resulting error as positive if the measured quantity increases when $x \to x + y$.

Note 1 The choice of fragmentation functions is rather arbitrary so far. Those considered include:

$$\text{Peterson: [4]} \qquad f(z) \propto [z(1 - \frac{1}{z} - \frac{\epsilon_Q}{(1-z)})^2]^{-1}$$

$$\text{Collins \& Spiller: [5]} \qquad f(z) \propto \frac{[\frac{(1-z)}{z} + \frac{(2-z)}{(1-z)}\epsilon_Q](1+z^2)}{(1 - \frac{1}{z} - \frac{\epsilon_Q}{(1-z)})^2}$$

$$\text{Lund symmetric: [6]} \qquad f(z) \propto z^{-1}(1-z)^a \exp(-bm_T^2/z)$$

$$\text{Kartvelishvili: [7]} \qquad f(z) \propto z^{\alpha_q}(1-z)$$

Note 2 The proposed variations of charm hadron fractions is based on [1]:

$$\begin{aligned}
f(\mathrm{D^0}) &= 0.557 \pm 0.053 \text{ keeping } \mathrm{D^+} \text{ fixed (i.e. excess} \to \mathrm{D_s} + \Lambda_c) \\
f(\mathrm{D^+}) &= 0.248 \pm 0.037 \text{ keeping } \mathrm{D^0} \text{ fixed (i.e. excess} \to \mathrm{D_s} + \Lambda_c) \\
f(\mathrm{D^0} + \mathrm{D^+}) &= 0.80 \pm 0.07 \text{ (i.e. excess} \to \mathrm{D_s} + \Lambda_c) \\
f(\mathrm{D_s}) &= 0.12 \pm 0.05 \text{ (i.e. excess} \to \Lambda_c)
\end{aligned}$$

Note 3 "Tuned JETSET" refers to the versions of JETSET used by the LEP experiments tuned to their data. The resulting rate of long-lived hadrons should be quoted to allow comparison.

Note 4 A detailed common scheme for varying light quark Monte Carlo parameters has not yet been established.

4 Presentation of experiment averages

The information provided for each analysis should be sufficient for a reviewer to make per-experiment and overall-LEP averages. However, it is more time efficient and more reliable for each experiment to provide their average results for the standard set of parameters. Since results using the same method, such as double-lifetime-tag $\Gamma_{b\bar{b}}/\Gamma_{had}$ measurements, have many errors in common then it is desirable for each experiment to provide the two sets of averages, from the many parameter lepton fits and the from other methods, to be used in forming the LEP averages.

4.1 Parameter set to be used for Summer 1994 conferences

The working group has agreed that it will consider the parameter set used for the Winter 1994 conferences:

- $R_b = \Gamma_{b\bar{b}}/\Gamma_{had}$
- $R_c = \Gamma_{c\bar{c}}/\Gamma_{had}$
- $Br(b \to \ell)$

- $\mathrm{Br}(\mathrm{b} \rightarrow \mathrm{c} \rightarrow \ell)$
- $\overline{\chi}$
- $A_{\mathrm{FB}}^{\mathrm{b\overline{b}}}$
- $A_{\mathrm{FB}}^{\mathrm{c\overline{c}}}$

5 Calculation of LEP averages

5.1 The averaging procedure

We have agreed that more cross checks, eg. making averages for $\Gamma_{\mathrm{b\overline{b}}}/\Gamma_{\mathrm{had}}$ alone, will be made within the working group.

For convenience, a program can be used to read the tables of systematic errors, construct the overall LEP covariance matrix and then minimise the $\chi^2 = \Delta^T Cov^{-1} \Delta$ to find the final LEP average parameters. This code will read the full error breakdown from each experiment, and so it can be used to check the consistency of the covariance matrices of the individual experiments.

Sijbrand de Jong has a set of programs he used for the Winter '94 conferences. These need some repackaging so that they can be used more widely (i.e. by people who don't have an Apollo on their desk!). Sijband's routines have the advantage that they read a table of systematic errors in TEX format, which saves alot of retyping and editing when it comes to writing up the results.

5.2 Timetable

- By end of May – finalise and distribute this note
- During June – make the programs for the averaging procedure more widely available. Try to put existing measurements into this framework.
- During June – experiments also have to work on new analyses!
- 1st July – target date for making all new analyses available
- First week of July – incorporate new analyses into the by now debugged and understood framework.
- Second week of July – heavy flavour averages available for incorporation into LEP++ electroweak fits for Glasgow
- 18th July – Dorothee Schaile leaves for Glasgow and results are cast in concrete for her electroweak review.

5.3 Some additional technical details

QCD correction to asymmetry: Checks are in progress of the modelling of analytic first order QCD calculations by JETSET. These will be discussed during July. The calculation is described in [3].

Modelling of gluon splitting to heavy flavours: The gluon splitting in JETSET is considered reliable to the level of 50%, following the discovery of a bug in Ariadne which explains the larger discrepancy which used to exist. JETSET and HERWIG agree well with analytic calculations [2].

References

[1] *A Consistent Treatment of Systematic Errors for LEP Electroweak Heavy Flavour Analyses*, LEP Electroweak Working Group, LEPHF/94-01, ALEPH Note 94-30, DELPHI 94-23 Phys 357, L3 Note 1577, OPAL Technical Note TN213.

[2] *Heavy Quark Pair Multiplicity in* e^+e^- *Events*, M.H.Seymour, LU TP 94-7, May 1994.

[3] *A note on QCD corrections to* $A_{FB}^{b\bar{b}}$ *using thrust to determine the b-quark direction*, B. Lampe, MPI-Ph/93-74.

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