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DELPHI Results on Electroweak Physics with Quarks contributed to the Glasgow conference

Preliminary

DELPHI Collaboration

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Abstract

Using the high statistics LEP runs in 1991, 1992 and partially 1993, DELPHI has updated the measurements on the width of the Z decaying into b quarks $\Gamma_{b\bar{b}}/\Gamma_{had}$ and the forward backward asymmetries for b and c quarks. For the first time a measurement of the forward backward asymmetry of s quarks is presented.

1 Introduction

In this note electroweak results from measurements of hadronic final states as contributed by DELPHI to the Glasgow conference are summarized. The details of the analyses are given elsewhere. In all cases the analyses have used the recommendations of the LEP electroweak working group (LEPHF) [1] as far as possible. However sometimes the analyses have been already too advanced at the time [1] appeared. As far as possible these numbers have been changed a posteriori to meet the recommendations. In these cases the numbers are given here after the change.

2 Global lepton fit

A global fit to single and double lepton spectra has been performed using data from 1991 and 1992. Details of the analysis can be found in [2]. The final result obtained is:

$$\begin{aligned}
R_b &= 0.2145 \pm 0.0089(stat) \pm 0.0063(exp) \pm 0.0023(model) \\
BR(b \to l) &= (11.41 \pm 0.45(stat) \pm 0.50(exp) \pm 0.33(model))\% \\
BR(b \to c \to l) &= (7.26 \pm 0.49(stat) \pm 0.94(exp) \pm 0.55(model))\% \\
R_c &= 0.1623 \pm 0.0085(stat) \pm 0.0168(exp) \pm 0.0124(model) \\
< x_E > &= 0.702 \pm 0.004(stat) \pm 0.002(exp) \pm 0.011(model)
\end{aligned}$$

3 $\frac{\Gamma_{b\bar{b}}}{\Gamma_{had}}$

Three different analyses using lifetime tagging techniques have been presented. In [3] two analyses using 1991 data are presented. The first uses a tagging variable derived from impact parameters. $\Gamma_{b\bar{b}}/\Gamma_{had}$ is calculated from single and double hemisphere tagging rates where the background is taken from Monte Carlo. The second analysis uses a multivariate tagging using lifetime and event shapes variables. $\Gamma_{b\bar{b}}/\Gamma_{had}$ is derived in an as far as possible Monte Carlo independent way. Both analyses have been updated using 1992 data [4, 5]. The results combined for 91/92 analyses are:

$$R_b = 0.2217 \pm 0.0022(stat) \pm 0.0032(syst) \pm 0.0018(\Gamma_{c\bar{c}})$$

for the first analysis and

$$R_b = 0.2196 \pm 0.0044(stat) \pm 0.0029(syst) \pm 0.0005(\Gamma_{c\bar{c}})$$

for the second one.

The third analysis, using only 1992 data, measures the efficiency of the lifetime tag using a high transverse momentum lepton sample [2]. The result is:

$$R_b = 0.2208 \pm 0.0042(stat.) \pm 0.0033(syst.) \pm 0.0012(\Gamma_{c\bar{c}}).$$

These analyses have been combined taking into account common systematic errors and statistical correlations. The combined result is:

$$R_b = 0.2214 \pm 0.0020(stat) \pm 0.0028(syst) \pm 0.0015(\Gamma_{c\bar{c}}).$$

The breakdown of the error is given in table 1.

Error Source	Range	Uncertainty
Internal experimental effects:		
Hemisphere correlations		± 0.0012
Resolution function		± 0.0015
other items		± 0.0006
$\langle x_E(c) \rangle$	0.51 ± 0.02	∓ 0.0004
$\mathrm{Br}(c \to \ell)$	$(9.8 \pm 0.5)\%$	± 0.0003
Semilept. model $b \to \ell$ [1]	ACCMM $(^{+\mathrm{ISGW}}_{-\mathrm{ISGW}**})$	± 0.0003
Semilept. model $c \to \ell$ [1]	ACCMM1 $(^{+\mathrm{ACCMM2}}_{-\mathrm{ACCMM3}})$	∓ 0.0002
D^0 fraction in $c\bar{c}$ events	0.557 ± 0.053	∓ 0.0001
D^+ fraction in $c\bar{c}$ events	0.248 ± 0.037	∓ 0.0011
$(D^0 + D^+)$ fraction in $c\bar{c}$ events	0.80 ± 0.07	∓ 0.0007
D_s fraction in $c\bar{c}$ events	0.15 ± 0.03	∓ 0.0005
D^0 lifetime	0.420 ± 0.008 ps	∓ 0.0002
D^+ lifetime	1.066 ± 0.023 ps	∓ 0.0003
D_s lifetime	$0.450^{+0.030}_{-0.026}$ ps	∓ 0.0002
Λ_c lifetime	$0.191^{+0.015}_{-0.012}$ ps	0
D decay multiplicity	2.53 ± 0.06	∓ 0.0005
$BR(D \to K^0 X)$	0.46 ± 0.06	± 0.0007
g $\to b\bar{b}$ per multihadron	$(0.18 \pm 0.09)\%$	∓ 0.0002
g $\to c\bar{c}$ per multihadron	$(1.3 \pm 0.7)\%$	∓ 0.0001
Rate of long-lived light hadrons	Tuned JETSET$\pm$10%	∓ 0.0007

Table 1: Summary of systematic errors on R_b obtained from the combination of the three analyses. Detailed explanations how the different error sources are obtained can be found in [1].

4 $\frac{\Gamma_{c\bar{c}}}{\Gamma_{had}}$

A measurement of $\frac{\Gamma_{c\bar{c}}}{\Gamma_{had}}$ has been presented comparing the $D^{\pm}, D^0$ yields from $c\bar{c}$ events in the continuum below the Υ_{4S} with those at LEP [6]. This measurement uses the data taken in 1991 and 1992. The final result is

$$\frac{\Gamma_{c\bar{c}}}{\Gamma_{had}} = 0.209 \pm 0.019\ (stat) \pm 0.013\ (sys.DELPHI) \pm 0.022\ (sys.\Upsilon_{4S}).$$

5 Forward backward asymmetries for b and c quarks

Two papers are presented using 1991 and 1992 data [7, 8]. The first contains a measurement of the b and c asymmetry using inclusive leptons and a measurement of the b asymmetry with lifetime tag and a jet charge measurement. The lepton measurement of $A_{FB}^{b\bar{b}}$ has been updated using events containing inclusive muons measured in 1993 [9]. Using the LEPHF recommendations and the mixing parameter measured by DELPHI, $\chi = 0.121 \pm 0.016 \pm 0.004$, the lepton measurement gives

- for $\sqrt{s} = 89.433 GeV$

$$A_{FB}^{b\bar{b}} = 0.0629 \pm 0.0383(stat) \pm 0.0023(syst) \pm 0.0028(mix)$$

- for $\sqrt{s} = 91.255 GeV$

$$A_{FB}^{b\bar{b}} = 0.1065 \pm 0.0110(stat) \pm 0.0043(syst) \pm 0.0046(mix)$$

- for $\sqrt{s} = 93.017 GeV$

$$A_{FB}^{b\bar{b}} = 0.1489 \pm 0.0356(stat) \pm 0.0061(syst) \pm 0.0065(mix)$$

- for $\sqrt{s} = 91.269 GeV$

$$A_{FB}^{c\bar{c}} = 0.0802 \pm 0.0225(stat) \pm 0.0161(syst).$$

A full breakdown of the systematic errors is give in table 2.

The jet charge measurement yields:

$$A_{FB}^{b\bar{b}} = 0.115 \pm 0.017(stat) \pm 0.010(syst) \pm 0.003(mix).$$

The second paper contains a measurement of the c (and b) asymmetry using D^*-mesons. The result is

$$A_{FB}^{c\bar{c}} = 0.081 \pm 0.029(stat) \pm 0.012(syst)$$

$$A_{FB}^{b\bar{b}} = 0.046 \pm 0.059(stat) \pm 0.026(syst).$$

The mean centre of mass energy for the D^* analysis is 91.27 GeV, for the jet charge 91.28 GeV.

Averaging the DELPHI measurements on the peak yields ($\sqrt{s} = 91.26 GeV$)

$$\begin{aligned} A_{FB}^{b\bar{b}} &= 0.1066 \pm 0.0105 \\ A_{FB}^{c\bar{c}} &= 0.075 \pm 0.018. \end{aligned}$$

Changed parameters	Central value	Variations applied	$\Delta A_{FB}^{b\bar{b}}$ Peak-2	$\Delta A_{FB}^{b\bar{b}}$ Peak	$\Delta A_{FB}^{b\bar{b}}$ Peak+2	$\Delta A_{FB}^{c\bar{c}}$ Peak
b decay model	$ACCMM$	$\pm IGSW^{**}$	$\pm$ 0.0015	$\pm$ 0.0004	$\pm$ 0.0015	$\mp$ 0.0060
c decay model	$m_s = 1MeV$	$m_s =^{1}_{153} MeV$	$\pm$ 0.0004	$\pm$ 0.0018	$\pm$ 0.0022	$\mp$ 0.0013
	$p_f = 467MeV$	$p_f =^{353}_{467} MeV$				
$Br(b \to l)$	0.11	$\pm$ 0.0034	$\mp$ 0.0003	$\mp$ 0.0012	$\mp$ 0.0010	$\pm$ 0.0015
$Br(b \to c \to l)$	0.079	$\pm$ 0.005	$\pm$ 0.0001	$\pm$ 0.0003	$\pm$ 0.0003	$\mp$ 0.0025
$Br(b \to \bar{c} \to l)$	0.013	$\pm$ 0.005	$\pm$ 0.0001	$\pm$ 0.0007	$\pm$ 0.0017	$\pm$ 0.0038
$Br(c \to l)$	0.098	$\pm$ 0.005	$\pm$ 0.0003	$\pm$ 0.0004	$\pm$ 0.0007	$\mp$ 0.0037
$\Gamma_{b\bar{b}}/\Gamma_{had}$	0.217	$\pm$ 0.003	$\mp$ 0.0001	$\mp$ 0.0004	$\mp$ 0.0004	$\pm$ 0.0004
$\Gamma_{c\bar{c}}/\Gamma_{had}$	0.171	$\pm$ 0.014	$\pm$ 0.0001	$\pm$ 0.0009	$\mp$ 0.0008	$\mp$ 0.0053
ϵ_b	0.005	$\pm$ 0.0006	$\mp$ 0.0002	$\pm$ 0.0001	$\pm$ 0.0001	$\pm$ 0.0005
ϵ_c	0.064	$\pm$ 0.015	$\pm$ 0.0001	$\mp$ 0.0011	$\mp$ 0.0014	$\mp$ 0.0001
background and		$\pm$ 15 %				
efficiency for Muons		$\mp$ 3 %	$\pm$ 0.0013	$\pm$ 0.0021	$\pm$ 0.0040	$\pm$ 0.0051
background and		$\pm$ 20 %	0	$\pm$ 0.0014	0	$\pm$ 0.0025
efficiency for electrons		$\mp$ 3 %				
background asymmetry		$\pm$ 50 %	$\mp$ 0.0001	$\mp$ 0.0010	$\pm$ 0.0001	$\pm$ 0.0102
p_t and thrust reconstruction			$\pm$ 0.0006	$\pm$ 0.0013	$\pm$ 0.0020	$\pm$ 0.0009
Sample binning,fit method			$\pm$ 0.0006	$\pm$ 0.0013	$\pm$ 0.0020	$\pm$ 0.0045
total			0.0023	0.0043	0.0061	0.0161

Table 2: Different contributions to the systematic error in the χ^2 fit of the lepton sample. The estimated correlation between the systematics of the b and the c asymmetries is -0.04.

6 Strange Quark Asymmetry

For the first time a measurement of the strange quark asymmetry is presented [10]. Three methods are presented using fast $K^{\pm}$, fast Λ's and neutral hadronic showers in combination with a jet charge technique. The results are

$$\begin{aligned} A^s_{FB}(K^{\pm}) &= 0.129 \pm 0.032(stat) \pm 0.018(syst) \\ A^s_{FB}(\Lambda^0) &= 0.130 \pm 0.050(stat) \pm 0.061(syst) \\ A^{s,d}_{FB}(K^0_L, n) &= 0.111 \pm 0.031(stat)^{+0.070}_{-0.056}(syst). \end{aligned}$$

Averaging the first two numbers a final s quark asymmetry of

$$A^s_{FB} = 0.129 \pm 0.027(stat) \pm 0.018(syst)$$

is obtained.

7 Conclusions

DELPHI has presented 9 papers to the Glasgow conference measuring electroweak quantities from hadronic final states. The final results are:
From the global lepton fit:

$$\begin{aligned} R_b &= 0.2145 \pm 0.0089(stat) \pm 0.0063(exp) \pm 0.0023(model) \\ BR(b \to l) &= (11.41 \pm 0.45(stat) \pm 0.50(exp) \pm 0.33(model))\% \\ BR(b \to c \to l) &= (7.26 \pm 0.49(stat) \pm 0.94(exp) \pm 0.55(model))\% \\ R_c &= 0.1623 \pm 0.0085(stat) \pm 0.0168(exp) \pm 0.0124(model) \\ < x_E > &= 0.702 \pm 0.004(stat) \pm 0.002(exp) \pm 0.011(model) \end{aligned}$$

and from the other measurements:

$$\begin{aligned} R_b &= 0.2214 \pm 0.0020(stat) \pm 0.0028(syst) \pm 0.0015(\Gamma_{c\bar{c}}) \\ R_c &= 0.209 \pm 0.019\ (stat) \pm 0.013\ (sys.DELPHI) \pm 0.022\ (sys.\Upsilon_{4S}) \\ A^{b\bar{b}}_{FB} &= 0.0629 \pm 0.0385 \quad (\sqrt{s} = 89.433GeV) \\ A^{b\bar{b}}_{FB} &= 0.1066 \pm 0.0105 \quad (\sqrt{s} = 91.26GeV) \\ A^{b\bar{b}}_{FB} &= 0.1489 \pm 0.0367 \quad (\sqrt{s} = 93.017GeV) \\ A^{c\bar{c}}_{FB} &= 0.075 \pm 0.018 \quad (\sqrt{s} = 91.26GeV) \\ A^{s\bar{s}}_{FB} &= 0.129 \pm 0.027(stat) \pm 0.018(syst)\ (\sqrt{s} = 91.28GeV). \end{aligned}$$

References

[1] The LEP Electroweak Working Group, ALEPH Note 94-90, DELPHI 94-23/add , L3 Note 1613, OPAL Technical Note TN237 , 10 June 1994

[2] DELPHI collaboration, Measurement of $\frac{\Gamma_{b\bar{b}}}{\Gamma_{had}}$ using micro-vertex and lepton tags, DELPHI 94-91 PHYS 408

[3] DELPHI collaboration, Measurement of the $\Gamma_{b\bar{b}}/\Gamma_{had}$ Branching Ratio of the Z by Double Hemisphere Tagging, DELPHI 94-61 PHYS 382

[4] DELPHI collaboration, New Measurement of $\Gamma_{b\bar{b}}$ /Γ_{had} with Lifetime Tag Technique, DELPHI 94-90 PHYS 407

[5] DELPHI collaboration,New Measurement of the $\Gamma_{b\bar{b}}/\Gamma_{had}$ Branching Ratio of the Z with Minimal Model Dependence, DELPHI 94-93 PHYS 410

[6] DELPHI collaboration, Study of D, D*, and D** Production in Z^0 Hadronic Decays, DELPHI 94-103 PHYS 420

[7] DELPHI collaboration, Measurement of the Forward-Backward Asymmetry of $e^+e^- \rightarrow Z \rightarrow b\overline{b}$ using prompt leptons and lifetime tag, DELPHI 94-62 PHYS 383

[8] DELPHI collaboration,Measurement of the Forward Backward Asymmetry of charm and bottom Quarks at the Z Pole using $D^{*\pm}$ Mesons, DELPHI 94-95 PHYS 412

[9] DELPHI collaboration, Measurement of the Forward-Backward Asymmetry of $e^+e^- \rightarrow Z \rightarrow b\overline{b}$ using prompt leptons, DELPHI 94-107 PHYS 424

[10] DELPHI collaboration, First Measurement of the Strange Quark Asymmetry at the Z^0 Pole, DELPHI 94-96 PHYS 413