B PHYSICS AT LEP

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Abstract

The main new results in B physics for this conference are in the field of B hadrons lifetimes and oscillations. The individual B hadron lifetimes are now measured with a precision of about 5 %. The B_d^0 oscillation frequency is know with a 4 % accuracy. The B_s^0 oscillation frequency is still unmeasured and the 95 % CL limit is now $\Delta m_s > 6.6\ ps^{-1}$. In addition, new results competitive with the CLEO results have been obtained for charmless hadronic B decays and are presented. The Λ_b mass is extracted from the reconstruction of exclusive decay modes : $M_{\Lambda_b} = 5646 \pm 14$ MeV/c^2.

1 Introduction

B physics at LEP is a broad subject, therefore I had to select some particular topics I will therefore present some new results about charmless B decays, Λ_b mass measurement, B hadron lifetimes as well as B^0_d and B^0_s oscillations. All the data accumulated between 1990 and 1995 by the four LEP collaborations is now available for B physics : about three million of hadronic Z decays per experiment.

2 Charmless B decays

The first observation for charmless B decays has been reported in 1993 by the CLEO experiment [1]. These decays are due to V_{bu} transitions or penguins diagrams. Using nearly their full statistics, ALEPH [2] and DELPHI [3] have measured the branching ratio of B hadrons decaying into hadronic charmless final state.

The main features of the analysis consist in selecting two energetic charged tracks displaced from the primary vertex. These two tracks are combined to form the B vertex. The resulting B should have a momentum greater than 20 to 30 GeV/c and its decay vertex should be well separated from the primary vertex. Using all the data accumulated between 1991 and 1995 the ALEPH analysis selects 4 events with an invariant mass greater than 5 GeV/c^2 for an expected background of about 0.05 event. This leads to a branching ratio of $\mathrm{BR}(b \rightarrow h^+h^-) = (2 \pm 1)\ 10^{-5}$. DELPHI has analysed the data registered from 1991 to 1994 and has found 5 events compatible with a B hadron mass for an expected background of 0.15 ± 0.05 event allowing to extract $\mathrm{BR}(B^0_d \rightarrow \pi\pi, K\pi) = (2.8^{+1.5}_{-1.0}\pm0.2)\ 10^{-5}$. Taking into account their mass measurement, dE/dx and RICH information, they conclude that the contributions of the V_{bu} and of the penguin diagrams are roughly equal.

3 Λ_b mass and exclusive branching ratio measurements

The Λ_b is reconstructed using the following decay modes : $\Lambda_b \rightarrow \Lambda_c\pi$, $\Lambda_b \rightarrow \Lambda_c a_1$ and $a_1 \rightarrow \pi\pi\pi$. The Λ_c itself is reconstructed using the decay modes $pK\pi$, pK^0_s or $\Lambda\pi\pi\pi$. The decay mode $\Lambda_b \rightarrow J/\psi\Lambda$ is also searched for, as it has a very low background level, and would allow a precise mass reconstruction. The various results are summarised in Table 1. Using the two decay modes involving a Λ_c, DELPHI has measured : $M_{\Lambda_b} = 5668 \pm 16 \pm 8$MeV/$c^2$ [4]. However the average decay time of these events is low (.22 ps) which happens with a 2.5 % probability for signal events. The ALEPH experiment using the 4 events recorded in the channel $\Lambda_b \rightarrow \Lambda_c\pi$ has measured $M_{\Lambda_b} = 5614 \pm 21 \pm 4$ MeV/c^2 [5]. These two measurements can be averaged : $M_{\Lambda_b} = 5646 \pm 14$ MeV/c^2 [1].

	$\Lambda_b \rightarrow \Lambda_c\pi$	$\Lambda_b \rightarrow \Lambda_c a_1$	$(b \rightarrow \Lambda_b)(\Lambda_b \rightarrow J/\psi\Lambda)$
ALEPH (91-95)	4 events	–	–
DELPHI (91-94)	3 events	1 event	$< 7\ 10^{-4}$
OPAL (90-93)	$< 2\ 10^{-3}$	–	$< 3.4\ 10^{-4}$

Table 1: Summary of the various results obtained by the LEP collaborations for exclusive Λ_b reconstruction. For the decay modes where a number of events is reported, a mass measurement has been performed. All the upper limits for the branching ratios are given at 90 % CL.

[1]The CDF collaboration has measured $M_{\Lambda_b} = 5623 \pm 5 \pm 4$ MeV/c^2 using the decay mode $\Lambda_b \rightarrow J/\psi\Lambda$ [6]

4 B hadrons lifetimes

The spectator model which predicts equal lifetimes for all B hadrons has been shown to be incorrect in the charm sector. Using the OPE formalism, the corrections to the spectator model for B hadrons are expected to be small : of the order of $1/M_b^2$ [7]. Explicitly it is expected that $\tau(B^+)/\tau(B_d^0) \sim 1. + .05 \times f_B^2/(200\ \mathrm{MeV})^2$, $\tau(B_s^0) \sim \tau(B_d^0)$ and $\tau(\Lambda_b)/\tau(B_d^0) \sim .9$. It has been recently pointed out [8] that the situation may be not so clear. This theoretical activity clearly indicates that high precision measurements are welcome.

In most of the analyses, the lifetime measurement is performed using the decay time of the B hadron which is computed using the decay length of the B and its momentum. The decay length is reconstructed in two steps. The charm vertex is found and the tracks attached to this vertex are used to inferred the charm track which is vertexed with the lepton or the hadron produced by the W. Depending on the analysis, the B momentum is estimated from the simulation or is measured using the energy information of the event.

4.1 B^- and B_d^0 lifetimes

The high number of analyses developed to measure $\tau(B_d^0)$ and $\tau(B^+)$ can be divided into 3 types : $B \rightarrow D^{(*)}\ell\nu X$, $B \rightarrow D^{(*)}h$ and fully reconstructed B. The results [9] [10] [11] are summarised in Figure 1 . A new analysis has been presented to this conference by the DELPHI collaboration citebdelphi for the B_d^0 lifetime measurement. The B_d^0 is reconstructed in the $B_d^0 \rightarrow D^{*-}\ell^+\nu X$ channel, with $D^{*-} \rightarrow D^0\pi^-_{soft}$. Due to the small mass difference between the D^* and the D^0, the soft pion has a quite low momentum and is the only explicitly identified particle (with the lepton). This technique yields a large sample of events with a reasonable background level allowing an accurate measurement of the lifetime (Figure 1). Furthermore, the systematic error being dominated by statistical uncertainties, improvements could be foreseen if the other experiments apply the same method. Averaging all the results following the LEP procedure [12] leads to $\tau(B_d^0) = 1.53 \pm 0.04$ ps and $\tau(B^+) = 1.63 \pm 0.06$ ps. The average for the ratio of these two lifetimes is 1.08 ± 0.05.

4.2 B_s^0 lifetime

The measurement of the B_s^0 lifetime is performed using two main decay modes: $B_s^0 \rightarrow D_s^-\ell^+\nu X$ and $B_s^0 \rightarrow D_s^{(*)}h$. In order to increase as much as possible the number of events, the D_s^- can be reconstructed in up to seven modes $\phi\pi^-$, $K^{*0}K^-$, $K_s^0K^-$, $\phi\pi^+\pi^-\pi^-$, $K^{*0}K^{*-}$, $\phi e^-\nu$ and $\phi\mu^-\nu$. The most recent results from ALEPH [13], DELPHI [14] and OPAL [15] are summarised in Figure 2. Averaging all the results leads to a 6 % precision measurement : $\tau(B_s^0) = 1.60 \pm 0.10$ ps.

4.3 Λ_b lifetime

The analysis for the Λ_b lifetime is performed using the clean but statistically limited channel $\Lambda_b \rightarrow \Lambda_c^+\ell^-\nu X$ or the more inclusive channel $\Lambda_b \rightarrow \Lambda\ell^-\nu X$ for which additional contributions from other b-baryons are also present. All the results from ALEPH [16], DELPHI [17] and OPAL [18] are schematically shown in Figure 3. The combined value for the Λ_b lifetime is $\tau(\Lambda_b) = 1.21 \pm 0.06$ ps which is a 5 % precision measurement.

4.4 Ξ_b lifetime

The strange b baryon Ξ_b is expected to be produced at LEP in b quark hadronization. Its decay, via weak interaction, gives rise to a Ξ_c and a lepton. The experimental signature for this observation is the same sign correlation of a Ξ and a lepton, the Ξ being reconstructed in the decay mode $\Lambda\pi$. The product of branching ratio $(b - \Xi_b)(\Xi_b \rightarrow \Xi^{\pm}\ell^{\pm}\nu X)$ and the Ξ_b lifetime have been measured by ALEPH [19] and DELPHI [20]. The results are summarised in Table 2. The average for the lifetime $\tau(\Xi_b) = 1.39 \pm 0.35$ ps is statistically limited but nevertheless in good agreement with the Λ_b baryon lifetime.

	$(b \rightarrow \Xi_b)(\Xi_b \rightarrow \Xi^{\pm}\ell^{\pm}\nu X)$	$\tau(\Xi_b)$
ALEPH (91-95)	$(5.1 \pm 1.1 \pm 0.6)\ 10^{-4}$	$1.35^{+.37}_{-.28} \pm .17$ ps
DELPHI (91-93)	$(6.6 \pm 1.7 \pm 1.0)\ 10^{-4}$	$1.5^{+.7}_{-.4} \pm .3$ ps

Table 2: Summary of the results obtained by ALEPH and DELPHI for the Ξ_b production rate and lifetime. The DELPHI result for the production rate has been obtained using data from 1991 to 1994 contrary to the lifetime.

4.5 Lifetime results summary

All the individual B hadrons lifetimes are measured with a precision of the order of 5 to 6 % (except the Ξ_b lifetime : $\sim 25\%$). The vast majority of these measurements is dominated by statistical uncertainties but future improvements should now come from new ideas more than from additional millions of Z. Nevertheless precise comparisons with the theoretical predictions for the ratios of individual lifetimes can be performed (Table 3). There is a general agreement between data and theory, the difference for the ratio $\tau(\Lambda_b)/\tau(B^0_d)$ being presently of the order of 2 standard deviations.

	LEP measurements	Predictions [7]
$\tau(B^+)/\tau(B^0_d)$	1.08 ± 0.05	$\sim 1. + .05 \times f_B^2/(200\ \text{MeV})^2$
$\tau(B^0_s)/\tau(B^0_d)$	1.04 ± 0.06	$\sim 1.$
$\tau(\Lambda_b)/\tau(B^0_d)$	0.79 ± 0.05	$\sim .9$

Table 3: Comparison of the results obtained by the LEP collaborations for the ratio of individual B hadron lifetimes with the theoretical predictions.

5 $B^0\bar{B}^0$ oscillations

5.1 $B^0\bar{B}^0$ formalism within the Standard Model

The observed B^0_d and $\bar{B}^0_d$ states are linear combinations of the two mass eigenstates. The same holds for B^0_s and $\bar{B}^0_s$ mesons. For an initially pure B^0 state, the probability density of observing the decay of a $\bar{B}^0$ (B^0) at time t is

$$\mathcal{P}_{m(u)} = \frac{1}{\tau}\, e^{-t/\tau}\, \frac{1 - (+)\cos(\Delta m t)}{2},$$

the m (u) index standing for "mixed" ("unmixed"); τ is the neutral B meson lifetime, t is the proper time and Δm is the mass difference of the two mass eigenstates. These expressions are obtained assuming equal lifetimes for the two states and neglecting CP violation. Within the Standard Model, the mass differences for the $B^0_s\bar{B}^0_s$ and the $B^0_d\bar{B}^0_d$ systems occur due to the presence of box diagrams for which top quark exchange dominates. The mass differences depend on the Cabibbo–Kobayashi–Maskawa (CKM) matrix elements, on the top quark mass and on QCD correction factors, both perturbative and non–perturbative. These QCD factors are not precisely computed but their ratios for the B_d^0 and B_s^0 have less uncertainty allowing the ratio $\Delta m_s/\Delta m_d$ and the CKM matrix elements to be linked with higher accuracy;

$$\frac{\Delta m_s}{\Delta m_d} = \frac{m_{B_s^0}}{m_{B_d^0}} \left| \frac{V_{ts}}{V_{td}} \right|^2 \xi^2 \frac{\hat{\eta}_s}{\hat{\eta}_d}. \tag{1}$$

The $\hat{\eta}_s$ and $\hat{\eta}_d$ correction factors for the B_s^0 and the B_d^0 are identical [22]. The ratio of the hadronic matrix elements for the B_d^0 and the B_s^0 is estimated to be $\xi = 1.16 \pm 0.10$ [23]. Therefore, measurements of Δm_s and Δm_d will constrain the ratio of the CKM matrix elements V_{ts} and V_{td}.

5.2 $B^0\bar{B}^0$ analyses overview

In order to measure the $B^0\bar{B}^0$ oscillation frequency several informations are needed : the decay time of the B meson, its decay state (B^0 or $\bar{B}^0$) and its production state. In most of the analyses the decay time is measured in a way similar to the lifetime analyses. The proper time resolution σ_t depends on the proper time itself: $\sigma_t^2 = \left(\frac{m\sigma_L}{p}\right)^2 + t^2\left(\frac{\sigma_p}{p}\right)^2$ where σ_p is the uncertainty on the B momentum and σ_L is the uncertainty on the reconstructed decay length. Therefore, for large decay time, the boost resolution dominates the proper time resolution. As a consequence for analyses aiming at measuring fast oscillations, not only the decay length measurement is important but also the precision with which the B meson momentum is reconstructed. The final state tagging is performed using the charge of the particle which signs the presence of the B^0 (*eg.* the charge of a high p_T lepton). The initial state tagging is slightly more delicate. Several methods have been developed : the majority uses the fact that $Z \rightarrow b\bar{b}$ and identify the charge of the b quark in the hemisphere opposite to the B meson. Other approaches consist in measuring the b charge in the B hemisphere at the production time using jet charge information and taking advantage of the fragmentation tracks. The dilution of the frequency measurement is proportional to $(1-2\eta)^2$ where the mistag fraction η is $\frac{N_{\text{Wrong tag evts}}}{N_{\text{tag evts}}}$. The wrongly tagged events are due to detector effects and physics processes (selection of cascade lepton from $b \rightarrow c \rightarrow \ell$ instead of direct leptons from b, or mixing in the B opposite hemisphere). The effects of both time reconstruction and mistagging are sketched in Figure 4 for a slow ($\Delta m = .46$ ps^{-1}) and for a fast ($\Delta m = 12$ ps^{-1}) oscillation frequency.

5.3 Time integrated measurements

Integrating over time, the probability that an oscillation occurs gives $\chi = \frac{x^2}{2(x^2+1)}$ where $x = \Delta m\tau$. This expression for χ being non linear it appears clearly that time dependent analyses are mandatory to resolve high oscillations frequencies. At LEP, using high p_T leptons, a weighted average of χ_s and χ_d is measured : $\bar{\chi} = f_s\chi_s + f_d\chi_d$ where f_d and f_s are the probabilities that a b quark produces a B_d^0 or a B_s^0 . This f_s parameter is important for analyses relying, for example, on inclusive high p_T lepton samples. Using [21] $\chi_s = 1/2$, $f_u + f_d + f_s + f_{baryons} = 1$ and $f_d = f_u$ as well as the measurements of $f_{baryons} = (12.8 \pm 3.9)\%$,$\bar{\chi} = .115 \pm .006$ and $\chi_d = .170 \pm .011$, one deduces $f_s = (9.9 \pm 1.9)\%$. An analysis based on the branching ratio measurement of $f_s BR(b \rightarrow B_s^0) BR(B_s^0 \rightarrow D_s^- \ell^+ \nu X)$ leads to $f_s = (11.0 \pm 2.8)\%$ [13]. These two values can be combined to give $f_s = (10.2 \pm 1.6)\%$[21] .

5.4 $B_d^0\bar{B}_d^0$ oscillations

The analyses can be divided into three main types : dileptons, lepton–jet charge and $D^*(\ell)$–jet charge. The first two ones consist in selecting events with high p_T lepton (typically more than 1 GeV/c).

These leptons are used to reconstruct the B vertex, to measure its decay time and to tag the B_d^0 decay state. The B initial state is either tagged by an opposite hemisphere high p_T lepton or by the jet charge. The jet charge can be calculated in the hemisphere opposite to the B or in the B hemisphere. In some of these analyses the two jet charges are combined linearly to take advantage of the $Z \rightarrow b\bar{b}$ decay. Due to the B semileptonic branching ratio the efficiency of the initial state tagging with high p_T lepton is at maximum of the order of 20 % whereas for jet charge tagging it can reach 100 % as the jet charge can be computed for each event. The mistag fraction is of the order of 20 % for dileptons analyses and of 30 to 35 % for lepton–jet charges analyses. These two inclusive samples contain not only B_d^0 but all species of B hadrons and are also used for Δm_s analyses (see next section). Their exact content in B_d^0 depends on f_d and is of the order of 40 %.

The third type of analysis is a more exclusive one ; the B_d^0 is reconstructed using $B_d^0 \rightarrow D^{*-}X'$ or $B_d^0 \rightarrow D^{*-}\ell^+\nu$, $D^{*-} \rightarrow D^0\pi^-_{soft}$ and the D^0 itself using $K\pi$, $K3\pi$ or $K\pi\pi^0$ (as for the B_d^0 lifetime measurements). The charge of the D^{*-} tags the B_d^0 final state whereas the B_d^0 initial state is usually tagged by jet charge techniques in order to keep a reasonably high number of signal events. For most of the analyses the decay length resolution is of 200 to 300 μm and the boost resolution of 10 to 15 %.

The results from ALEPH [24], DELPHI [25], L3 [26] and OPAL [27] are summarised in Figure 5. The L3 results are new and make first use of their silicon vertex detector which has been installed in 1993. An illustration of the fraction of mixed events (which should behave as $1 - cos\Delta mt$ in absence of background and with perfect detector resolution) is given in Figure 6 for the DELPHI analysis using ℓ to select B_d^0 events and jet charge to tag the initial state.

5.5 $B_s^0\bar{B}_s^0$ oscillations

Historically the first $B_s^0\bar{B}_s^0$ oscillations analyses have been performed using inclusive samples : dileptons or lepton–jet charge as for the Δm_d measurements. These methods have the advantage of large events samples (typically 40,000 to 60,000 events) but only about 10 % of these events are B_s^0 and the results depend on f_s which is not precisely known. Later on, other analyses have been developed in an orthogonal direction : they make use of a small sample of events but highly enriched in B_s^0 meson (about 65 %, due to a more exclusive final state) with a more precise time reconstruction.

No measurement of Δm_s has been obtained so far and only lower 95% CL limit have been set. The results of ALEPH [28], DELPHI [29] and OPAL [30] are shown in Figure 7. ALEPH presents here a new analysis using $D_s^-\ell^+$ combinations and a global tagging technique which obtains competitive results with only 300 events : $\Delta m_s > 6.6$ ps^{-1} at 95 % CL. The DELPHI results have been combined leading to the global preliminary 95 % CL limit of 4.6 ps^{-1}. This is also the case for the OPAL analyses for which the combined limit is also $\Delta m_s > 4.6$ ps^{-1} at 95 % CL. An example of the likelihood curve and of the 95 % CL limit setting is shown in Figure 8.

5.6 Implications on the Standard Model

Using Eq. 1, $M_{B_s^0} = 5370 \pm 2$ MeV/c^2, $M_{B_d^0} = 5279.9 \pm 1.6$ MeV/c^2, $\Delta m_d = .464 \pm .018$ ps^{-1}, as no combination can be simply performed. the highest Δm_s lower limit $\Delta m_s > 6.6$ ps^{-1} at 95 % CL and performing finally an *ad-hoc* fluctuation of -1σ on all measured values one obtains :

$$\left|\frac{V_{ts}}{V_{td}}\right| > 2.9 \text{ at } 95\%\text{CL}$$

This result is just at the border of the Standard Model allowed range and thus clearly indicates that all these results should be combined in order to be constraining.

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References

[1] M. Battle *et al.* CLEO Coll., Phys. Rev. Lett. **71**, (1993) 3992.
D. M. Asner *et al.* CLEO Coll., CLNS-95-1338.

[2] ALEPH Coll., "Observation of Charmless Hadronic Beauty Decays", draft in preparation, to be submitted to Phys. Lett. B, ALEPH Internal Note 96-049.

[3] DELPHI Coll., "Study of rare b decays with the DELPHI detector at LEP", DELPHI Draft0133, submitted to Z. Phys. C.

[4] DELPHI Coll., "Search for exclusive decays of the Λ_b baryon and measurement of its mass", CERN PPE/96-16, submitted to Phys. Lett. B

[5] ALEPH Coll., "Measurement of the Mass of the Λ_b Baryon", CERN PPE/96-28, submitted to Phys. Lett. B.

[6] CDF Coll., Internal Note, "Evidence for $\Lambda_b \rightarrow J/\psi\Lambda$", http://www-cdf.fnal.gov/physics/new/bottom/cdf3352/cdf3352.html

[7] I. Bigi *et al.* , "Non leptonic decays of beauty hadrons – from phenomenology to theory ", CERN-TH 7132/94, to appear in the second edition of " B Decays", S. Stone (Ed.), World Scientific.

[8] M. Neubert *et al.* , "Spectator Effects in Inclusive Decays of Beauty Hadrons", CERN-TH/96-16, submitted to Nuclear Physics B.
G. Altarelli *et al.* , "Failure of local duality in inclusive non-leptonic heavy flavour decays", CERN-TH/96-77.

[9] ALEPH Coll., "Improved Measurement of the B^0_d and B^- lifetimes ", CERN PPE/96-14, submitted to Z. Phys. C.

[10] DELPHI Coll., "A Measurement of B^+ and B^0 Lifetimes using $\overline{D}\ell^+$ events", CERN PPE/95-60, submitted to Z. Phys. C.
DELPHI Coll., " Lifetimes of Charged and Neutral B Hadrons Using Event Topology ", CERN PPE/95-59, submitted to Z. Phys. C.
DELPHI Coll., "Accurate measurement of the B^0_d lifetime", DELPHI Internal Note.

[11] R. Akers *et al.* , OPAL Collaboration, Z. Phys. **C67** (1995) 273.

[12] L. Di Ciaccio *et al.* ,"Averaging Lifetimes for B Hadron Species at LEP", ALEPH Internal Note 94-199 .

[13] D. Buskulic *et al.*, ALEPH Coll., Phys. Lett. **B361** (1995) 221. D. Buskulic *et al.*, ALEPH Coll., Z. Phys. **C69** (1996) 365.

[14] DELPHI Coll., "Mean lifetime of the B^0_s meson", CERN PPE/96-32, submitted to Z. Phys. C.

[15] R. Akers *et al.*, OPAL Coll., Phys. Lett. **B350** (1995) 273.

[16] ALEPH Coll., " Update Measurement of the b Baryon Lifetime", Contribution to the International Europhysics Conference on High Energy Physics, Brussels, Belgium, 27 July - 2 August, 1995, Ref. EPS-0169

[17] DELPHI Coll., "Determination of the average lifetime of b-baryons ", CERN PPE/96--21, submitted to Z. Phys. **C**.

[18] R. Akers *et al.*, OPAL Coll., Phys. Lett. **B353** (1995) 402. R. Akers *et al.*, OPAL Coll., Z. Phys. **C69** (1996) 195.

[19] ALEPH Coll., " Evidence for strange b baryon production in Z decays",Contribution to the International Europhysics Conference on High Energy Physics, Brussels, Belgium, 27 July - 2 August, 1995, Ref. EPS-0406

'ALEPH Coll., " Strange b baryon production and lifetime in Z decays ", draft in preparation, to be submitted to Phys. Lett. **B**.

[20] P. Abreu *et al.*, DELPHI Coll., Z. Phys. **C68** (1995) 541.

DELPHI Coll., "Beauty–baryons production properties and lifetimes", Contribution to the International Europhysics Conference on High Energy Physics, Brussels, Belgium, 27 July - 2 August, 1995, Ref. EPS-0564

[21] O. Schneider, "$B_s^0\bar{B}_s^0$ Mixing", to be published in the proceedings of the International Europhysics Conference on High Energy Physics, Brussels, Belgium, 1995.

[22] A.J. Buras, M. Jamin and P.H. Weisz, Nucl. Phys. **B347** (1990) 491.

[23] A. Ali and D. London, Z. Phys. **C65** (1995) 431.

[24] ALEPH Coll., " Improved measurement of the $B_d^0\bar{B}_d^0$ oscillation frequency", Aleph Internal Note 96–024 and ref. therein.

[25] DELPHI Coll., " Measurement of $B_d^0\bar{B}_d^0$ oscillations", Delphi Internal Note and ref. therein.

[26] L3 Coll., " Measurement of the B_d^0 meson frequency using dilepton events", L3 Internal Note 1913.

[27] OPAL Coll., "Update of the measurement of the B_d^0 oscillation frequency using a jet charge technique",Opal Internal Note, Contribution to the International Europhysics Conference on High Energy Physics, Brussels, Belgium, 27 July - 2 August, 1995,

OPAL Coll., "A measurement of the B_d^0 oscillation frequency using leptons and $D^{*\pm}$ mesons", Opal Internal Note 207.

OPAL Coll., "A study of B meson oscillations using dilepton events", CERN PPE/95–12, submitted to Z. Phys. **C**.

OPAL Coll., "A study of B meson oscillations using inclusive lepton events" Opal Internal Note 196, contribution to the Lepton-Photon Symposium, Beijing, 10-15 August 1995.

[28] ALEPH Coll., "Measurement of the $B_d^0\bar{B}_d^0$ oscillation frequency", submitted to the International Europhysics Conference on High Energy Physics, Brussels, Belgium, 1995, ref. EPS-0409.

D. Buskulic *et al.*, ALEPH Coll., Phys. Lett. **B356** (1995) 409.

ALEPH Coll., "Time dependent B_s^0 mixing from lepton-kaon correlations", submitted to the International Europhysics Conference on High Energy Physics, Brussels, Belgium, 1995, ref. EPS-0410.

D. Buskulic *et al.*, ALEPH Coll., CERN PPE/96-30, to be published in Phys. Lett. **B**

[29] DELPHI Coll., "Search for $B_s^0\bar{B}_s^0$ oscillations", DELPHI Internal Note and ref. therein.

[30] OPAL Coll., "OPAL combined study of B_s^0 oscillations", OPAL Internal Note 210 and ref. therein.

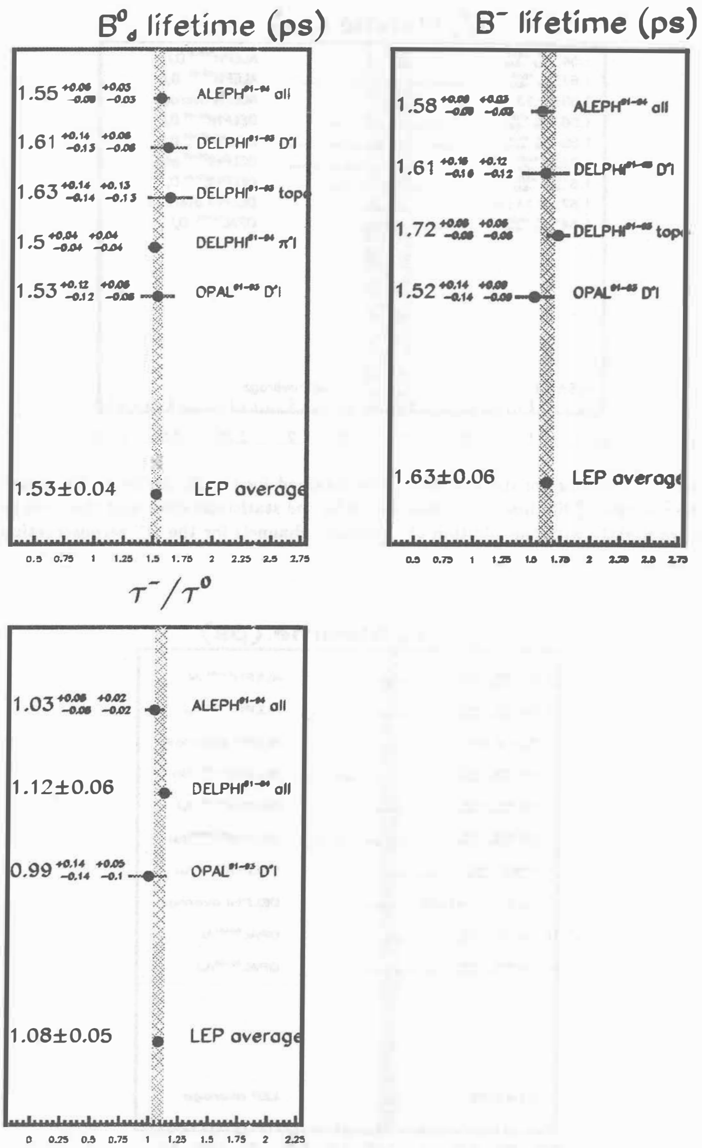

Figure 1: Summary of all the measurements for the B^- and B_d^0 lifetimes. The ratio of the two lifetimes is also given.

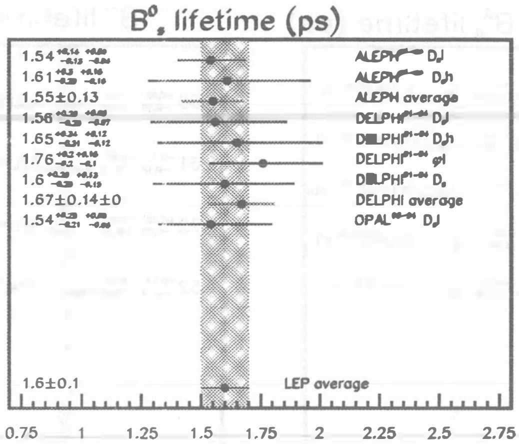

Figure 2: Summary of the various values obtained for the B^0_s lifetime. The uncertainty on the average B^0_s lifetime is still dominated by the statistical error and thus will possibly improve slightly with the addition of additional channels for the D^-_s reconstruction.

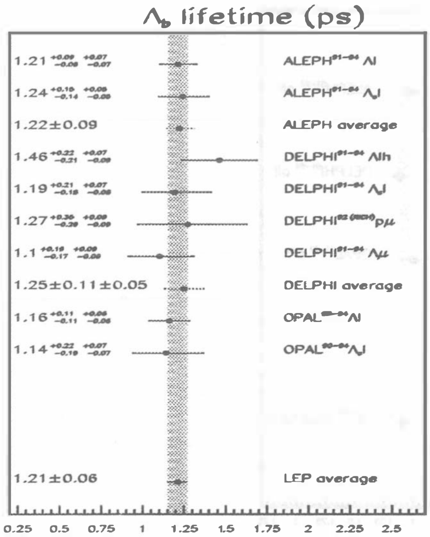

Figure 3: Summary of the different measurements of the Λ_b lifetime.

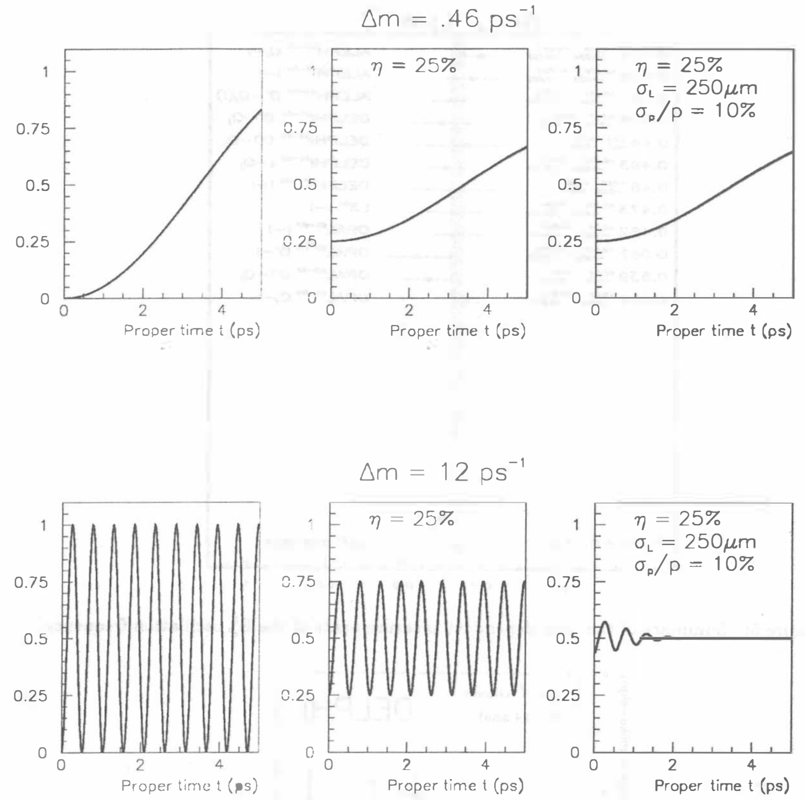

Figure 4: Sketch of the effects of the time resolution and of the mistagging. Going from left to right, the cumulative effects of the mistagging (η is the fraction of wrong tags) and of the proper time resolution on the fraction of mixed events are displayed. In absence of mistagging and with perfect time reconstruction the fraction of mixed events behaves as $1/2 \times (1 - \cos \Delta m t)$

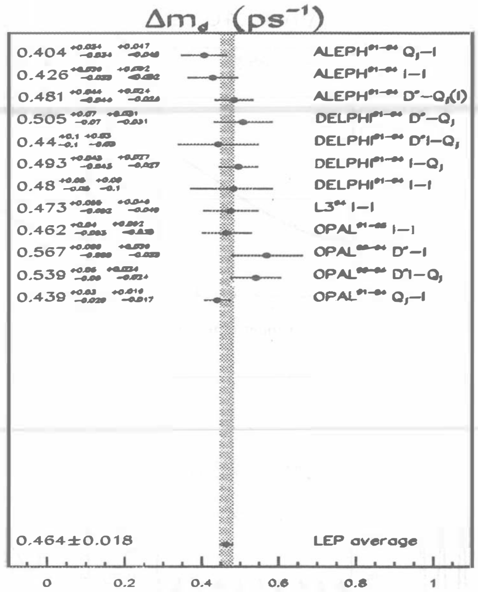

Figure 5: Summary of the time dependent measurements of the B_d^0 oscillation frequency.

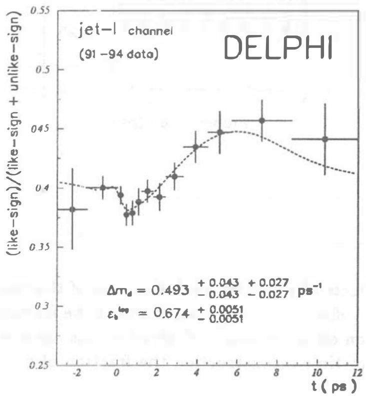

Figure 6: An example for the fraction of mixed events taken from the DELPHI analysis using jet charge ℓ correlations. Due to the slow frequency the oscillation in the case of the B_d^0 is visible by eye on the plot.

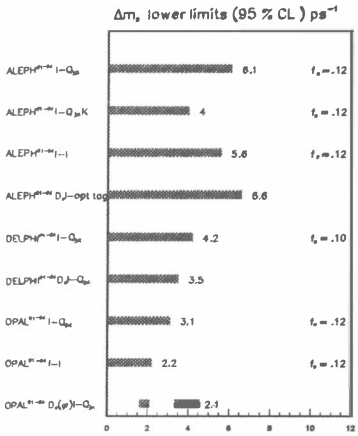

Figure 7: Summary of the 95 % CL limits on the B_s^0 oscillation frequency. The grey regions indicate the Δm_s domains excluded at 95 % CL.

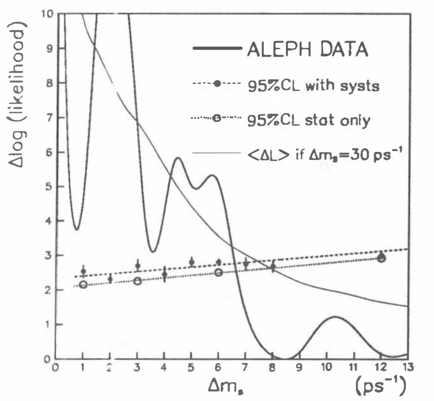

Figure 8: Example of the likelihood behaviour with Δm_s obtained by the ALEPH collaboration using $D_s^- \ell^+$ correlations for the data (solid curve), the 95% CL curve obtained from the fast Monte Carlo with (dashed) and without (dotted) the inclusion of systematic uncertainties. The thin solid curve shows the average behaviour of the likelihood if the true value of Δm_s is 30 ps^{-1}.