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M. Bonesini:

B_s^0 PRODUCTION AND DECAY AT LEP AND CDF

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Abstract

Recent LEP and CDF data on B_s^0 production and decay are described. The world average for m_{B_s} is (5368.1 ± 3.8) MeV/c^2, to be compared with theoretical predictions in the range $5345 - 5388$ MeV/c^2. The B_s^0 production rate is $f(b \to B_s^0) = (12.2 \pm 3.0)\%$, in agreement with expectations. The world average for the B_s^0 lifetime is (1.56 ± 0.14) ps, giving $\tau(B_d^0)/\tau(B_s^0) = (1.04 \pm 0.11)$ to be compared with a theoretical expectation of (1.00 ± 0.01).

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[*] Based on a review talk given at ICHEP 94, Glasgow

1. Introduction

While at b-factories, at the $\Upsilon(4S)$ threshold, only B_d^0 and $B^{\pm}$ mesons can be produced, about 12% of the b hadrons produced at LEP are B_s^0 mesons, carrying both beauty and strangeness ($B_s^0 = (\bar{b}s)$ †).

1.1. Early indirect evidence for B_s^0 production

The existence of the B_s^0 meson was indicated by the comparison of the rates of same sign dileptons at the $\Upsilon(4S)$ and at high energy colliders and from data at the $\Upsilon(5S)$ obtained from CUSB at CESR.

The production of same sign dileptons was larger at e^+e^- and $p\bar{p}$ colliders than at the $\Upsilon(4S)$ threshold [1] and this could be explained by the production, at a rate of around 12%, of strange B_s^0 mesons, which undergo complete mixing.

Moreover the CUSB collaboration [2], using a bismuth germanate (BGO) electromagnetic calorimeter inserted in the CUSB-I NaI-Pb-glass array, has studied the inclusive photon spectrum from 2.9×10^4 $\Upsilon(5S)$ decays. A broad structure around 50 MeV was clearly seen, in particular for electron-tagged events. This confirmed the association of these photons with B mesons, undergoing a semileptonic decay. The channels $B\overline{B^*} + B^*\overline{B}$, $B^*\overline{B^*}$, $B_s\overline{B_s^*} + B_s^*\overline{B_s}$ and $B_s^*\overline{B_s^*}$ could contribute to the observed photon signal, via $B_{d,s}^* \rightarrow B_{d,s}\gamma$. Two solutions were found for $\Delta(M) = M(B_s) - M(B_d)$ and the fraction $f = N(B_s)/N(B)$ of strange to nonstrange B's produced at the $\Upsilon(5S)$:

$$\Delta(M) = 82.5 \pm 2.5 \ MeV/c^2 \quad f = 0.36 \pm 0.12$$

$$\Delta(M) = 121 \pm 9 \ MeV/c^2 \quad f = 0.24 = \pm 0.12$$

giving $M(B_s) - M(B_d)$ between 80 and 130 MeV/c² and the fraction of strange B mesons, at the $\Upsilon(5S)$, to be between 12% and 48%, at the 1σ extremes.

1.2. Evidence for B_s^0 production at LEP

Preliminary evidence for B_s^0 production was obtained at LEP from the partial reconstruction of its semileptonic decays via a study of opposite sign $D_s^{\pm}l^{\mp}$ combinations in the same hemisphere [3]. The relevant diagram is shown in fig. 1. Although the B_s^0 meson is not fully reconstructed, requiring a lepton transverse momentum $p_T^l \geq 1.2$ GeV/c the backgrounds are suppressed at a level lower than 10%. Background processes are due to semileptonic B decay ($\overline{B} \rightarrow (D_s^+K^-)l^-\overline{\nu}_l$ via an intermediate D^{**}) or B decay into two charmed mesons ($\overline{B} \rightarrow D_s^-D^+$)). Looking at $D_s^{\pm}l^{\mp}$ events DELPHI had
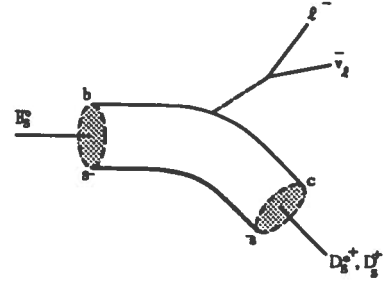

Figure 1. B_s^0 signal process giving $D_s^{\pm}l^{\mp}$ events

the first evidence at LEP, soon confirmed by ALEPH and OPAL, of B_s^0 production. Using two different decay modes ($D_s^+ \rightarrow \phi\pi^+$, $\phi \rightarrow K^+K^-$ and $D_s^+ \rightarrow \overline{K}^{*0}K^+, \overline{K}^{0*} \rightarrow K^-\pi^+$) the signal found by DELPHI is shown in fig. 2, for $p_T^l \geq 1.2$ GeV/c. In addition
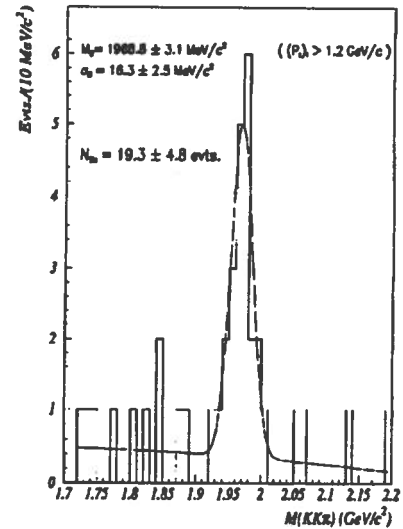

Figure 2. DELPHI: $KK\pi$ mass distribution for D_s candidates accompanied by a lepton of opposite sign in the same hemisphere

to the first evidence of B_s^0 production at LEP, (D_s-l) correlations have been used to study B_s^0 lifetimes and production rates.

To increase statistics, samples with smaller purity in B_s^0 (inclusive D_s events and ($\phi - l$) events) have also been used. Since the presence of a D_s meson indicates an enriched B_s^0 sample, the first consist of events containing a D_s meson decaying to $\phi\pi$ or $K^{*0}K^-$.

Inclusive D_s meson production has been studied by DELPHI [4] and OPAL Collaborations to measure B_s^0 production and lifetime. Subtracting the D_s events

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† In all this paper the symbol for a particle is taken to include the corresponding antiparticle, unless explicitly stated otherwise

due to the fragmentation of primary c quarks and from B^+, B^0 decays, the excess can be attributed to $B_s^0 \to D_s^- X$ decays.

The second sample contains events with a high p_T lepton accompanied by a ϕ meson in the same jet. The idea of using $\phi - l$ correlations, pioneered by DELPHI [4], is based on the fact that D_s meson production in a B_s^0 meson decay is an order of magnitude larger than in non-strange B decays and that ϕ are preferentially produced in D_s (than in D^0 or D^+) decays. Asking $p_T^l \geq 1$ GeV/c, a rather pure sample of $B_s^0 \to \phi l X$ events can be isolated. Direct evidence for B_s^0 production and a precise measurement of its mass have been obtained later, both at LEP and Tevatron, from fully reconstructed charged mode decays [5].

1.3. Exclusive B_s^0 reconstruction

The B_s^0 decay modes, useful for exclusive reconstruction, include

(1) $B_s^0 \to J/\psi(\psi')\phi$

(2) $B_s^0 \to D_s^{*-}(D_s^-)\pi^+(a_1^+; \rho^+)$

(3) $B_s^0 \to K^- \overline{D^0}\pi^+(a_1^+; \rho^+)$

where the J/ψ or ψ' are tagged via leptonic decay modes and the "D's" through decays with an intermediate ϕ, K or K*.

The main experimental problem is the search for a few B_s^0 candidates, distributed over many different decay modes, in the presence of potentially high sources of background. Backgrounds are due to track combinatorics (*combinatorial*, negligible in channels with a ϕ due to its narrowness), or π/K misidentification (*reflections*). For example, $\overline{B_d^0} \to D^+\pi^-$ could fake a $\overline{B_s^0} \to D_s^+\pi^-$, when the π^+ from D^+ decay is misinterpreted as a kaon. The reflection background (from B_d^0 or Λ_b) is broad (~ 50 MeV/c^2 for B_d^0 and ~ 150 MeV/c^2 for Λ_b) and peaks around 5.36-5.40 GeV/c^2.

All LEP experiments have searched for B_s^0 fully reconstructed states in the channels (1) to (3), while CDF has searched B_s^0 candidates only in channel (1). The experimental requirements, mainly due to the need to have a tight control over backgrounds, are:

- a good tracking resolution ($\delta p/p \sim 0.001 \times p$), to have precise mass reconstruction
- good vertex reconstruction capabilities, to exploit the multivertex topologies of the B_s^0 decay chains
- good particle identification capabilities (PID), to discriminate efficiently between energetic π and K.

On the top of this there is obviously the requirement to choose physical channels with less background (e.g. involving a ϕ), when possible.

2. The B_s^0 mass determination

2.1. The LEP experiments

All LEP experiments, measuring the B_s^0 mass, fulfill the previous requirements, in particular on particle identification through the energy loss of charged particles (dE/dx) and in DELPHI also using the Barrel Rich [6]. As an example in OPAL the PID is obtained through the measurement of dE/dx in the jet chamber (159 samplings) with a π/K separation at 2σ's for $2 \leq p \leq 16$ GeV/c , see fig. 3. In DELPHI the PID
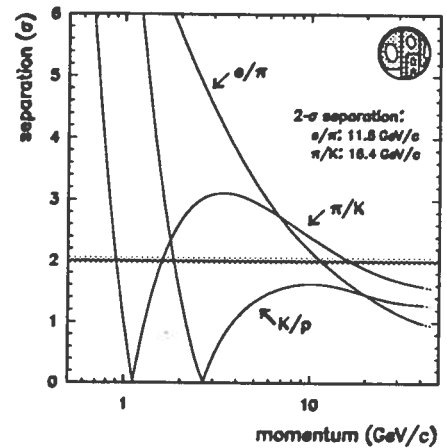

Figure 3. π/K separation, from dE/dx for OPAL

is obtained from the measurement of dE/dx in the TPC (192 samplings) with a π/K separation at 1.5 σ's for $4 \leq p \leq 25$ GeV/c (average rejection factor 5) and from the Barrel Rich (average rejection factor 12-15).

OPAL and ALEPH have analysed samples from the 90+91+92 data taking (about 1.2×10^6 hadronic Z), while DELPHI has analyzed the 92 data sample only (about 0.8×10^6 hadronic Z).

2.1.1. OPAL
searched for B_s^0 candidates in the channels: (1) $D_s^-(\to \phi\pi^-; \to K^{*0}K^-)\pi^+$ and (2) $J/\psi\phi$. The mass plot for the exclusively reconstructed B_s^0 candidates is shown in fig. 5. Six candidates were found in the mass window 5.1-5.5 GeV/c^2 in channel (1), giving a mass of 5370 ± 40 MeV/c^2. From the single candidate in the channel (2): one unambiguos $J/\psi \to e^+e^-$ candidate (found in the 1990-1991 data sample and shown in fig. 4), the B_s^0 mass was determined as $m_{B_s} = 5359 \pm 19 \pm 7$ MeV/c^2. The probability that this event comes from a B_d^0 reflection ($B_d^0 \to J/\psi K^+\pi^-$, where a π is misidentified as a K) is negligible. Systematic errors take into account track parameters and their covariance after kinematic refit (19 MeV), mass scale errors (5 MeV) and additional systematics on momentum measurement (4 MeV).
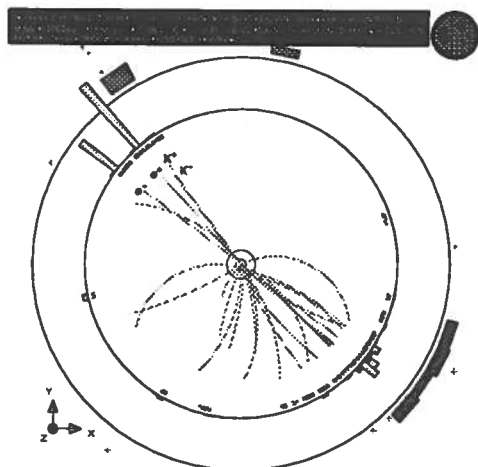
Figure 4. OPAL: Display of the $B_s^0 \to J/\psi(\to e^+e^-)\phi$ candidate in the transverse plane.
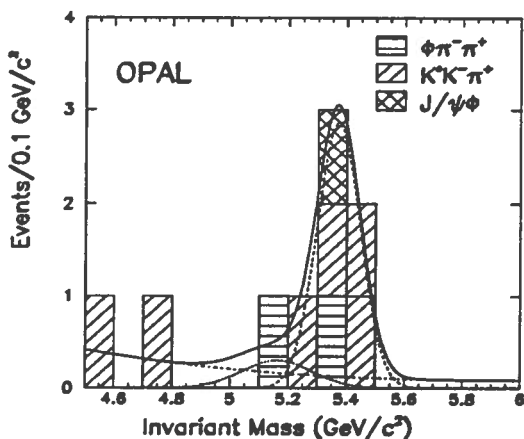

Fig. 5

Figure 5. B_s^0 invariant mass distribution in OPAL. The fit includes Gaussian terms for the different sources of B_s^0 signal and a parametrization of the combinatorial background.

2.1.2. ALEPH searched for B_s^0 candidates in the channels: (1) $D_s^- n\pi$, (2) $J/\psi(\psi')\phi$ and (3) $K^-\overline{D^0}\pi^+$. The analysis is characterized by very good resolution in the mass constrained fit (about 8.5 MeV for the $B_s \to \psi'\phi$ decay) and about nine candidates were reconstructed in the mass window 5.3-5.42 GeV/^{2}. The B_s mass is measured using only two unambiguos candidates: (a) one $B_s^0 \to \psi'\phi$ and (b) one $B_s^0 \to D_s^+(\to \phi\pi^+)\pi^-$, giving a weighted average $m_{B_s} = 5368.6 \pm 5.6\pm1.5$ MeV/c^2. The main sources of systematic errors

are the mass scale (1.1 MeV) and the alignment of the tracking system (0.9 MeV). Fig. 7 shows a fisheye $r - \phi$ view of the $B_s^0 \to \psi'\phi$ candidate, which due to its very small error dominates the LEP average. For this event the expected combinatorial background is less than 0.006 equivalent events at 95% CL and the expected backgrounds from B_d^0 or Λ_b decays are less than 0.0003 or 0.00008 equivalent events. As expected for a process of hadronization of a b quark into a $\overline{B}_s^0$ meson, the most energetic particle in the same hemisphere is a kaon. A K_s^0 with measured mass of 0.486 $\pm$ 0.008 GeV/c^2, momentum of 1.63 GeV/c and decay length of 7.39$\pm$0.48 cm was found.
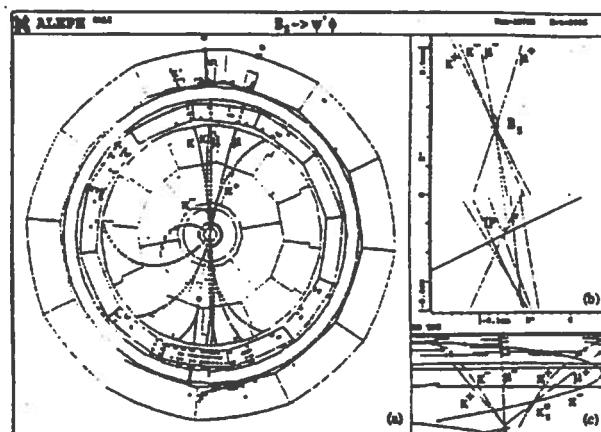

Figure 6. ALEPH: a fisheye $r - \phi$ view of the $B_s \to \psi'\phi$ event

2.1.3. DELPHI searched for B_s^0 candidates in final states formed by two kaons and either two or four lighter particles. The charged K identification performed by the combined use of the RICH and the dE/dx measurements allowed a clean reconstruction of B_s^0 states. The DELPHI analysis provided three B_s^0 candidates: one $D_s^-(\to \phi\pi^-)a_1$, one $D_s^-(\to \phi\pi^-)\pi^+$ and one $J/\psi\phi$, whose main characteristics are shown in table 1. To

mode	B_s^0 mass (MeV/c^2)	Reflected mass (MeV/c^2)	Energy (GeV)	Decay (mm)
$D_s(\phi\pi)\pi$	5325 $\pm$ 32	5200	27.1	2.3
$D_s(\phi\pi)a_1$	5345 $\pm$ 32	5130	26.7	1.4
$J\psi\phi$	5389 $\pm$ 16	5275	36.9	1.6

Table 1. DELPHI: B_s^0 fully reconstructed candidates

take properly into account the sources of biases due to reflections (0.20 equivalent events), the combinatorial background (0.30 equivalent events) and the $D_s^* \to D_s\gamma$ decay, where the photon is not detected, a global

likelihood fit was performed. The resulting likelihood distribution is shown in fig. 7 also, as a function of the B_s^0 mass. The fit result $m_{B_s} = (5374 \pm 16)$ MeV/c^2 takes into account statistical errors and the previous systematics. An additional systematic coming from the absolute mass scale calibration is estimated around 2 MeV.
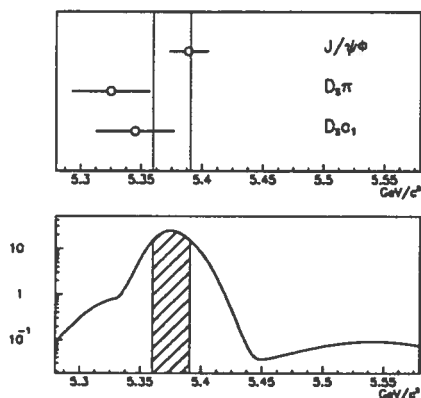
meson	Number	B mass (MeV/c^2)	Width (MeV/c^2)	Background (per 5 MeV/c^2)
B^+	140 ± 15	5279.6 ± 1.7	15.2 ± 1.8	3.2 ± 0.3
B^0	57 ± 10	5279.9 ± 2.5	13.6 ± 2.2	1.7 ± 0.2
B_s^0	33 ± 7	5367.7 ± 2.4	10.5 ± 1.9	1.1 ± 0.1

Table 2. CDF results on B meson reconstruction for the 1992-1993 data sample

Figure 7. DELPHI: (a) The three B_s^0 candidate masses and errors; (b) the global likelihood distribution obtained from the fit with the resulting B_s^0 mass and the 68% confidence interval.

2.2. The search at Tevatron: CDF

In the 1988-89 Tevatron run, CDF showed the capability to trigger and reconstruct $B \to J/\psi(\to \mu^+\mu^-)X$ decays in $p\bar{p}$ collisions at $\sqrt{s} = 1.8$ TeV. The further addition of a Silicon Vertex Detector (SVX) and the increase in dimuon acceptance has given to CDF the possibility to make high-statistics B physics studies, such as mass or lifetimes measurements. B_s^0 candidates are searched for in the channel $J/\psi(\to \mu^+\mu^-)\phi$, where having no PID each track is considered as a π or as a kaon if $p_T \geq 2$ GeV/c. ϕ candidates are formed from pairs of tracks assigned to kaon mass, with combined mass consistent with the nominal ϕ mass value. The invariant mass of the four-track system is calculated subject to the constraint that they originate from a common decay vertex and the total momentum points back to the beam position. In addition the condition $p_T(B) \geq 6$ GeV/c and a positive flight are required. Preliminary results on the reconstruction of B^+, B_d^0 and B_s^0 mesons are shown in table 2. In the full 1992-1993 data sample (run 1A: 19.3 pb^{-1}) 33 ± 7 B_s^0 candidates were reconstructed. From a binned likelihood fit to the mass spectra a preliminary mass value of $5367.7 \pm 2.4 \pm 4.8$ MeV/c^2 was obtained. The mass plot is shown in fig. 8.

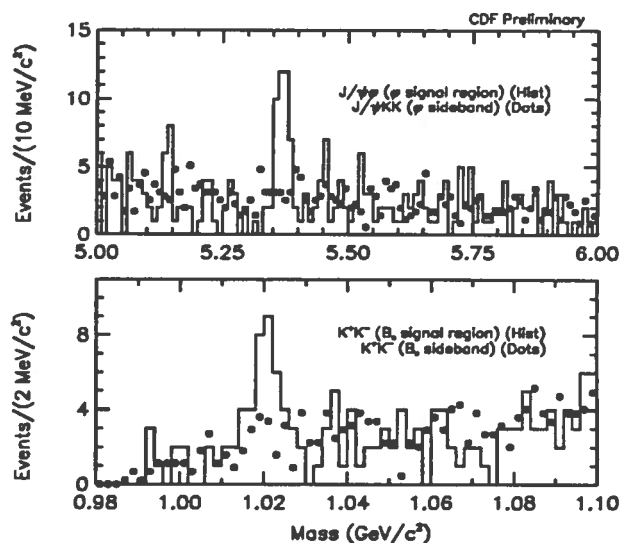Systematic errors include the p_T scale (1.1 MeV),

Figure 8. CDF: (a) $J/\psi\phi$ invariant mass plot ; (b) ϕ signal.

uncertainties in tracking errors (1.0 MeV), stability of selection criteria (2.8 MeV), fitting procedure (1.2 MeV) and variation in the reconstructed J/ψ mass (3.2 MeV).

2.3. World average for the B_s^0 mass value

The data on B_s^0 mass reconstruction, coming from LEP exclusive fully reconstructed events and from the CDF fit to the $(J/\psi)\phi$ mass plot, are shown in figure 9. The world average for the B_s^0 mass is : 5368.1 ± 3.8 MeV/c^2, being dominated by the CDF measurement and the LEP $\psi'\phi$ ALEPH candidate. This must be compared with theoretical predictions in the range 5345-5388 MeV/c^2 [7]. From the effective theory for heavy quarks (HQET) a prediction of 5379 MeV/c^2 was given in [10], using the experimental values for M_B, M_{B^*}, M_D, M_{D^*}, M_{D_S}, $M_{D_S^*}$. So the measurement of B_s mass, together with those of Λ_b, Ξ_b, B_s^* and Σ_b masses, can provide an important test of the theory and of the correctness of the basic assumptions of hadron dynamics.

M(B$_s$)

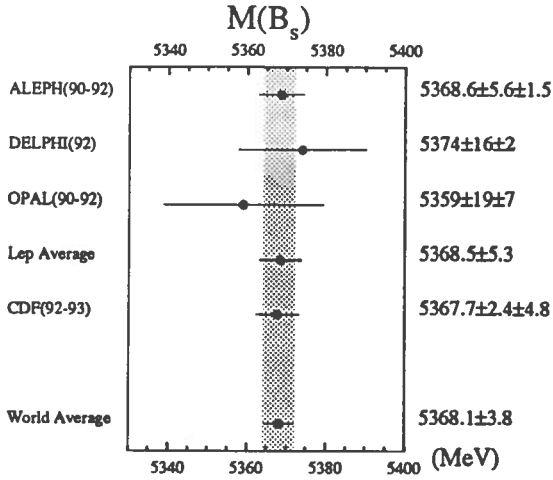|		
ALEPH(90-92)		5368.6±5.6±1.5
DELPHI(92)		5374±16±2
OPAL(90-92)		5359±19±7
Lep Average		5368.5±5.3
CDF(92-93)		5367.7±2.4±4.8
World Average		5368.1±3.8

(MeV)

Figure 9. Summary of B_s^0 mass measurement from LEP and CDF, with averages computed assuming no correlation between experiments

3. B_s^0 production rates and decays

Theoretical predictions for exclusive two-body decays of B_s^0 to final states containing only stable charged particles (e.g. $B_s^0 \to D_s^- \pi^+$, ...) sum up to about 10^{-3} [9]. B_s^0 decay rates have been mainly studied at LEP. The seen fully reconstructed B_s^0 decay modes are:

- $D_s X$
- $D_s^- \pi^+$
- $J/\psi(1S)\phi$
- $\psi(2S)\phi$

The statistics in all channels is very poor, going from the single $\psi(2S)\phi$ candidate seen by ALEPH, to the around thirty $J/\psi\phi$ candidates seen by CDF+OPAL+DELPHI. Some results, coming from the $B_s^0 \to D_s^- l^+ \nu X$ semileptonic decay, on production branching fractions are quoted in table 3.

Experiment	Data	Branching ratio
ALEPH	90-91	$(5.6 \pm 1.5 \pm 0.9) \times 10^{-4}$
DELPHI	90-91	$(5.4 \pm 2.4 \pm 0.9) \times 10^{-4}$
OPAL	90-91	$(3.9 \pm 1.1 \pm 0.8) \times 10^{-4}$
LEP AVERAGE		$(4.7 \pm 1.0) \times 10^{-4}$

Table 3. $f(b \to B_s^0) \times Br(B_s^0 \to D_s^- l^+ \nu X) \times Br(D_s^- \to \phi\pi^-)$

From these, the B_s^0 meson production rate ($f_s \equiv f(b \to B_s^0)$) can be evaluated. Using $Br(D_s^- \to \phi\pi) = (3.5 \pm 0.4)\%$ and assuming $Br(B_s^0 \to D_s^- l^+ \nu X) = 11\%$ [8], one obtains $(12.2 \pm 2.6 \pm 1.4)\%$, where the second error is given by the poor knowledge of the $D_s \to \phi\pi$ branching ratio. This result must be compared with an expected rate of about 12% [11]. f_s can be derived also

from the measurement of the average mixing parameter $\overline{\chi} = f_s \cdot \chi_s + f_d \cdot \chi_d$ at LEP and the measurement of χ_d from the $\Upsilon(4S)$, assuming $\chi_s \simeq 0.5$ as predicted from the Standard Model and a b-baryon fraction of 0.10 ± 0.04. This gives $f_s = 0.10 \pm 0.03$.

4. The B_s^0 Lifetime

In the spectator model picture [12], the b quark decay is treated by analogy with the μ decay and for all the B hadrons the lifetime is the same as the free b quark, since light quarks play only a passive role in the decay mechanism. However, as seen in the charm sector, non-spectator effects such as annihilation diagrams, exchange diagrams or interference diagrams cause the lifetime of the various hadrons to be different. Theoretical expectations in the framework of HQET give (to a few percent accuracy) for the b sector $\tau_{B_d^0}/\tau_{B_s^0} = 1 \pm .01$ and a definite hierarchy of lifetimes $(\tau(B^+)/\tau(B^0) = 1.05, \tau(\Lambda_b^0)/\tau(B^0) \simeq 0.9)$[13].

For neutral B-mesons, this simple picture is complicated by the effects due to particle-antiparticle mixing, which appear as a lifetime difference between the mass eigenstates. The effect can be relevant for the B_s^0 states and could be seen as a lifetime difference in B_s^0 decays to a CP-eigenstate, such as $J/\psi\phi$, respect to semileptonic decays [13]

A compilation of individual b-hadron lifetimes is shown in figure 10 [14], [17].
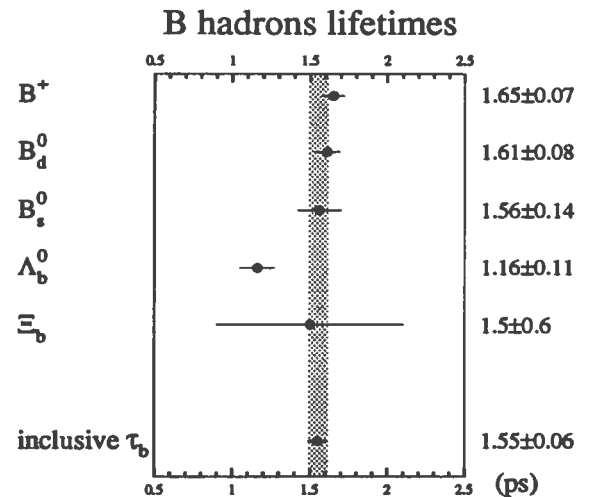
B hadrons lifetimes

B^+	1.65±0.07
B_d^0	1.61±0.08
B_s^0	1.56±0.14
Λ_b^0	1.16±0.11
Ξ_b	1.5±0.6
inclusive τ_b	1.55±0.06

(ps)

Figure 10. Summary of experimental measurements for b-hadrons lifetimes

In the B_s^0 lifetime determination, the B_s^0 is either partially or fully reconstructed. In the various methods

proposed, the purity (defined as the ratio of B_s^0 over all the B mesons contained in the sample) goes from $55\% - 70\%$ ($D_s X, D_s h$ tag) to $\sim 90\%$ ($(D_s - l)$ correlation tag).

The LEP collaborations (DELPHI, ALEPH, OPAL) have recently reported results from the 91+92+93 data sample (about 1.8×10^6 hadronic Z) and CDF from the 92-93 Tevatron collider run. ALEPH, DELPHI, OPAL [15] and CDF [16] use $(D_s - l)$ correlations (see figure 1) to tag samples of B_s mesons to measure its lifetime, through the semileptonic decay chains:

$$B_s \to D_s^-(\to K^{*0}(\to K^+\pi^-)K^-)l^+\nu X$$

$$B_s \to D_s^-(\to \phi\pi^-)l^+\nu X$$

After having reconstructed a D_s meson, an association with a "right sign" lepton (e.g. $D_s^+l^-$ or $D_s^-l^+$) is looked for. Simple kinematic cuts, such as a minimum p_T on the associated lepton, are used to reduce backgrounds, due to $B_{u,d} \to D_s^+\overline{D}(\to l\nu X)X$ and $B_{u,d} \to D_s^-Kl^+\nu X$. The proper-time of B_s^0 (OPAL, ALEPH and CDF) $\tau = t_B$ or the sum of the proper times of B_s and D_s (DELPHI) $\tau = t_B+t_D$ is determined as : $\tau = \frac{L}{\gamma\beta c} = L \times \frac{M(B_s)}{p(B_s)}$, using an estimate of the boost β and measuring the decay length L of B_s or $B_s + D_s$. A maximum likelihood method is then used to fit the proper-time distribution, taking into account signal and background components. The likelihood function L is defined as :

$$L = \alpha \times P(t) + (1 - \alpha) \times P_{comb}(t)$$

where α is the relative proportion of signal and background, as determined from the $D_s \to KK\pi$ invariant mass plot and $P(t)$, $P_{comb}(t)$ are the normalized proper-time probability distributions for signal and background. For DELPHI, where a signal of 37 ± 8 events was observed, the proper-time distribution is shown in figure 11. The dominant systematic errors are connected with the estimation of background levels, boost estimate and fit procedure. This measure is still dominated by statistical errors. The results of the B_s^0 lifetime measurement with the $(D_s - l)$ correlation method are shown in figure 12. Similar methods to measure B_s^0 lifetime are based on D_s−hadron correlations (ALEPH) and $D_s - X$ events (DELPHI). In the first method a $D_s^\pm$ is reconstructed in the K^*K or $\phi\pi$ mode and an opposite sign hadron $h^\mp$ of high momentum is looked for. In the second method the inclusive channel $D_s \to \phi\pi$ is searched for. Both methods have larger systematics ($\sim 15\%$), due mainly to uncertainty on the background composition and boost estimates, compared to those based on the $(D_s - l)$ correlations ($\sim 5\%$) and comparable statistical errors.

CDF uses also fully reconstructed $B_s \to J/\psi(\to \mu^+\mu^-)\phi(\to K^+K^-)$ events [16] to determine the B_s
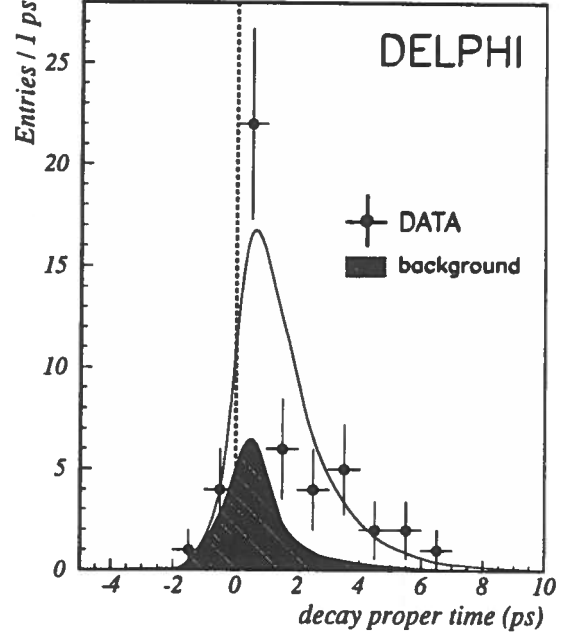

Figure 11. The proper-time distribution for D_s mesons: opposite sign ($D_s^\pm l^\mp$) events shown as points with error bars and background events (obtained from $D_s^\pm l^\pm$ combinations), shown as shaded area. The solid line shows the likelihood fit result
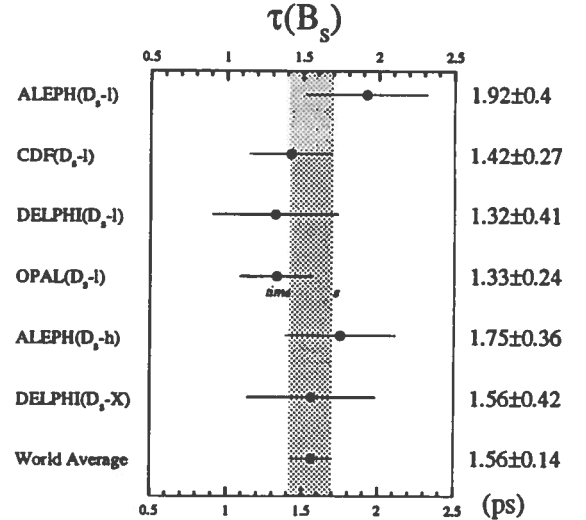

Figure 12. Summary of the most recent B_s^0 lifetime measurements from LEP and CDF

lifetime as : $\tau_{B_s} = 1.74^{+0.90}_{-0.60} \pm 0.07$ ps. The four candidate tracks (μ^+, μ^-, K^+, K^-) are constrained to a common vertex and the fit probability is required to be greater than 2%. Additional requirements, to select good tracks in the microvertex detector (SVX), give a

sample of 11 events with an expected signal of 9.5 ± 3.1.

The most recent data on B_s^0 lifetime, coming from LEP and CDF, are shown in figure 12, giving a world average of: 1.56 ± 0.14 ps, still dominated by statistical errors. From the world average of B_d^0 lifetimes (1.614 ± 0.078) ps [17], we have : $\tau(B_d^0)/\tau(B_s^0) = (1.04 \pm 0.11)$, to be compared to a theoretical expectation of (1.00 ± 0.01).

The future precision of the lifetime ratios for b-hadron species will be at the level of 5% at best, with the expected data sample from CDF and LEP experiments by the end of 95. Clearly, to have stringent tests of the theory (at the 1% level) it will be necessary to wait for the next generation of colliders. Meanwhile, evidence of the anticipated lifetime hierarchy in the b sector is emerging (see figure 10). From present data the probability that all lifetimes of weakly decaying b-hadrons are the same is less than 1%.

5. Conclusions

The world average for m_{B_s} is (5368.1 ± 3.8) MeV/c^2, to be compared with theoretical predictions in the range $5345 - 5388$ MeV/c^2. The good precision of the experimental value is a challenge to theoretical predictions. Clearly more unambiguos candidates of the type $\psi\phi$, $\psi'\phi$ at LEP are needed to reduce the errors. Some decay channels of B_s^0 have been seen, mainly at LEP. The accuracy on the B_s^0 meson production rate $(f_s = 12.2 \pm 3.0\%)$ is still limited.

The world average for the B_s^0 lifetime is (1.56 ± 0.14) ps, giving $\tau(B_d^0)/\tau(B_s^0) = (1.04 \pm 0.11)$ to be compared with a theoretical expectation of (1.00 ± 0.01). This measurement is still dominated by statistical errors and although it agrees with theory, it is not precise enough to test it.

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