Parallel Session 17

Heavy Quarks (b and c Quarks)

Organiser

D. MacFarlane *(MCGUI)*

Recent Charm Results from ARGUS

Steven Ball
MPI fur Kernphysik, Heidelberg, Germany
representing the ARGUS Collaboration

Abstract

Results on charmed hadrons from data taken with the ARGUS detector at the e⁺e" storage ring DORIS II are presented. The most accurate measurement of decay *D+ -> f]'ir⁺* **to this date has served to clarify a confusing experimental situation and provide important information on** D_s **decays. We find the ratio of BR(I>+ -> T/TT⁺) relative to** *BR(D+* **to be 2.5 ± 0.5 ± 0.3. We have also observed the semileptonic decays D+ -** *$t+v* **and D+** *K*°e+v.* **We find BR(D+ -+ 0e+i/)/BR(Z>+ -»** *<jn+)* **= 0.57 ± 0.15 ± 0.15 and BR(P+ -** *K*°e+v)/BR(D+ ~>* **- 0.55 ± 0.08 ± 0.10. These measurements of similar semileptonic decays leads to an estimate of the absolute branching ratio BR(D+ -> <£7r⁺) = (2.5 ± 1.0)%. The polarization assymetry in the decay À+ -> À7T⁺" has been measured with an indication for parity violation. We find C*A = -1.0 ± 0.4. Decays and masses of the charmed-strange** E_c **baryons have been measured. Included is the first observation of the decay E° -> H~7r⁺7r"⁺'7r".**

1 Introduction

The study of charmed particles has been found to be favorable in the environment of e⁺e~ annL ilation in the center-of-mass energy region of the T resonances, *<Js* « lOGeV. Since this energy is far above the threshold for cc production, a wide spectrum of charmed hadrons is produced with a hard fragmentation distribution. Soft combinatorial background can therefore be avoided. However, since the cross section falls rapidly throughout the region below the *Z°* resonance as *a* ~ 1/s, the Ï region is also not too unfavorably far above the cc threshold. There are approximately 500,000 cc events in the ARGUS data sample of 455p6⁻¹. The ARGUS detector and its particle identification capabilities are described in detail elsewhere [1]. We present results on the decays *Dj* -> *T)'TT+* \ *D+* -> <£e⁺**i/,** and *D⁺* -> iT°e+**i/,** the polarization assymetry in the decay A+ —• A7T+, and decays and masses of the charm-strange E_c baryons.

2 $D_s^+ \to \eta'\pi^+$

Since the decays of charmed mesons are expected to be mostly **2**-body hadronic decays, and since there is now very little data on D_s decays, the decay *D+* —> *TJT* is of interest in helping to fill in the large gap of missing D_s decays. Theoretical expectations for the ratio of BR(D+ -> iyV⁺) to BR(£+ -> *<j)T)* lie between **0.5** and **2 [2].** The experimental situation has also been very unclear due to conflicting measurements, the MARK II and NA14' collaborations having quoted very large values for this ratio, 4.8 ±2.1 [3] and 5.0 ± 1.8 ± 1.2 [4] respectively, whereas the MARK III and E691 collaborations have quoted very stringent upper limits, < 1.9 [5] and < 1.7 [6] respectively at the 90% confidence level.

ARGUS has analysed the decay *Dj* -» 7/V⁺ with two independent decay channels of the 77', namely

$$D_s^+ \to \eta'\pi^+ \qquad\qquad D_s^+ \to \eta'\pi^+$$
$$\hookrightarrow \rho^0\gamma \qquad\qquad \hookrightarrow \eta\pi^+\pi^-$$
$$\hookrightarrow \pi^+\pi^- \qquad\qquad \hookrightarrow \gamma\gamma$$

In both analyses of the *Dj* -> *TJ'TT^* decay we require x_p = ***p/pmax*** > 0.6. Figure 1 shows the resulting mass distribution of *rj'ir** combinations for the ?/' -» ***p*** ° ^ decay channel. A fit with a smooth polynomial for the background and a gaussian with a width of 18 MeV fixed from Monte Carlo for the signal, yields a signal of 164 ± 34 events at a mass of 1969 ± 5 MeV. An identical analysis of the 77' sidebands yields no evidence for a signal. A similar analysis with the decay channel *TJ'* -» Tj7r⁺7r~ yields a signal of 51 ± 17 events.

Since the production rate of D_s mesons is not known due to the uncertainty in the scale of absolute D_s branching ratios, we obtain only the ratio of BR(D+ -> T/7r+) relative to BR(£+ -> **<£TT+)**². The values for the independent methods are 3.2 ±0.7 ±0.5

[1] **References in this paper to a specific charged state are to be interpreted as implying the charge conjugate state also.**

[2] **We have used the previous ARGUS measurement of the decay £>+ —•** *<f>Tt⁺* **from reference [7].**

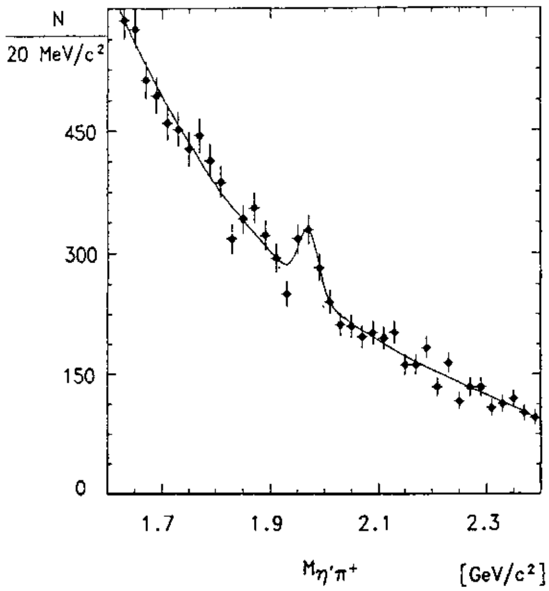

Figure 1: Mass spectrum of 7/ 7r· where rj -> p°y

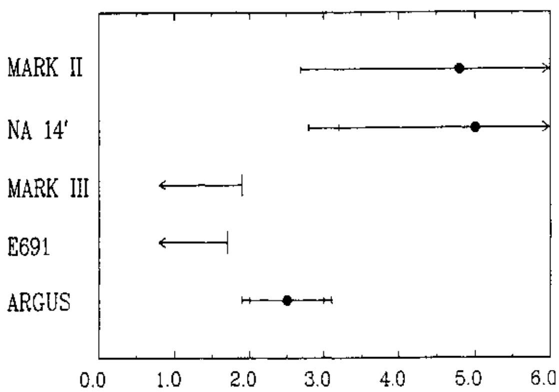

Figure 2: $\mathrm{BR}(D_s^+ \to \eta'\pi^+)/\mathrm{BR}(D_s^+ \to \phi\pi^+)$ results

and 1.9±0.7±0.3. These are consistent and thus can be averaged to obtain the result

$$\frac{BR(D_s^+ \to \eta'\pi^+)}{BR(D_s^+ \to \phi\pi^+)} = 2.5 \pm 0.5 \pm 0.3$$

where the first error is statistical and the second systematic. For comparison with the other measurements and limits, the values are shown in Figure 2, where given systematic errors are added in quadrature with the statistical errors. The ARGUS result is the most accurate measurement and lies between the other measurements, serving to clarify the experimental confusion. This value is on the high side of the range of theoretical expectations. The **large value** indicates that a large fraction of D_s decays may indeed be accounted for by 2-body decays. However, measurements of more D„ decays and a precise determination of the absolute branching ratio scale are needed.

3 $D_s^+ \to \phi e^+\nu$ and $D^+ \to \bar{K}^{*0}e^+\nu$

The semileptonic decays of charmed mesons are expected to be more favorably described by a simple spectator model than the hadronic decays due to the reduction of strong interaction effects. One can use this advantage to arrive at a determination of the absolute branching ratio scale of D_s decays through the similarity of semileptonic D and D_s decays and the reasonably well known scale of the D decays. We present results on the decays *Df* —> *<j>e'v* and

Efficient electron identification with very low fake rates (~ 0.6% [1]) is possible with the ARGUS detector for momenta above 400 MeV. The low momentum cutoff reduces model dependence in the acceptance in extrapolating for the entire spectrum. Two general cuts are made to reduce background sources. Since most of the ARGUS data is taken on the *T(4S)* resonance and since the undetected neutrino does not allow complete kinematic reconstruction of the decay, we make a topological cut to suppress T(45) contributions, namely $H_2 > 0.35$ where H_2 is the second Fox-Wolfram moment. This removes (93 ± 3)% of T(4£) events. We also require the vector meson and the electron to be in the same hemisphere, utilizing the hard charm spectrum which yields small opening angles between decay products.

From the analysis of -» 0e'i/, Figure 3 shows the mass distribution of *K'K~* pairs from events with identified electrons. The fit to the clear *<j>* signal is not sensitive to the treatment of the background

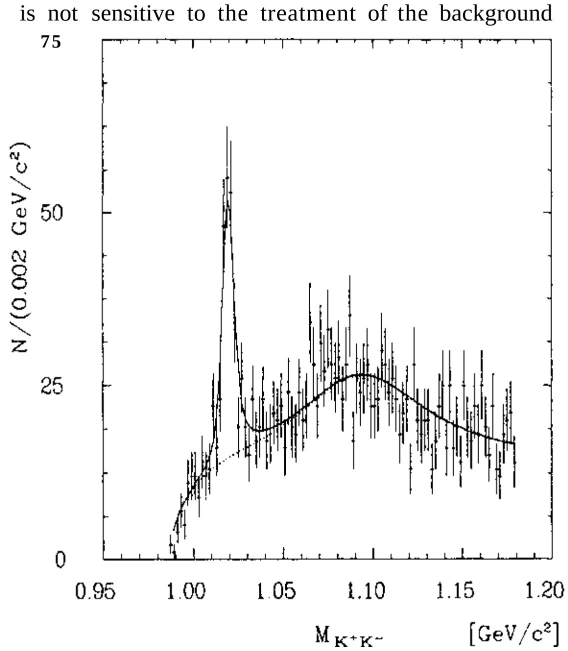

Figure 3: Mass spectrum of *K'K* combinations for events with an identified electron

Combination	ϕe^+	$\bar{K}^{*0}e^+$ right sign	$\bar{K}^{*0}e^-$ wrong sign
Fitted events	200 ± 21	1441 ± 97	573 ± 80
Backgrounds:			
1. Faked e^+	45 ± 9	256 ± 51	259 ± 52
2. Fragment.	35 ± 11	185 ± 46	260 ± 65
3. $\Upsilon(4S)$	16 ± 7	120 ± 52	67 ± 29
Signal events	104 ± 26	880 ± 129	-13 ± 119

Table 1: Signals of Semileptonic Charm Decays

which includes a reflection from the decay $D^+ \to K^{*0}e^+\nu$. We obtain 200 ± 21 events. The background sources include faked electrons, events with a ϕ originating from the fragmentation process rather than the charm decay, and residual $\Upsilon(4S)$ background. Table 1 lists the contributions from the various backgrounds. After subtracting the background sources, we are left with 104 ± 26 events which we attribute to the decay $D_s^+ \to \phi e^+\nu$. We arrive at the result[2]

$$\frac{BR(D_s^+ \to \phi e^+\nu)}{BR(D_s^+ \to \phi\pi^+)} = 0.57 \pm 0.15 \pm 0.15$$

The analysis of the decay $D^+ \to K^{*0}e^+\nu$ provides a good cross-check on the previous analysis. For this analysis we define right and wrong sign combinations as $K^{*0}e^+$ and $K^{*0}e^-$ pairs respectively. We then use the wrong sign combinations as a check on the background subtraction procedure. We find in the right sign combinations a signal of 1441 ± 97 events and in the wrong sign combinations 573 ± 80 events. The background sources, similar to those in the previous analysis (Table 1), account for 586 ± 88 of the wrong sign combinations, in good agreement with the observed signal. There remain 880 ± 129 events in the right sign combinations after subraction of backgrounds which we attribute to the decay $D^+ \to K^{*0}e^+\nu$. We find[3]

$$\frac{BR(D^+ \to \bar{K}^{*0}e^+\nu)}{BR(D^+ \to K^-\pi^+\pi^+)} = 0.55 \pm 0.08 \pm 0.10$$

in agreement with the E691 measurement of $0.49 \pm 0.04 \pm 0.05$ [9]. Using the branching ratio $BR(D^+ \to K^-\pi^+\pi^+) = (7.7 \pm 1.0)\%$ from reference [10], we find from the average of the ARGUS and E691 results: $BR(D^+ \to K^{*0}e^+\nu) = (3.9 \pm 0.4 \pm 0.5)\%$, where the first error is the statistical and systematic errors added in quadrature and the second error is due to the uncertainty in the absolute branching ratio of $D^+ \to K^-\pi^+\pi^+$.

[3] **We have used the previous ARGUS measurement of the decay $D^+ \to K^-\pi^+\pi^+$ from reference [8].**

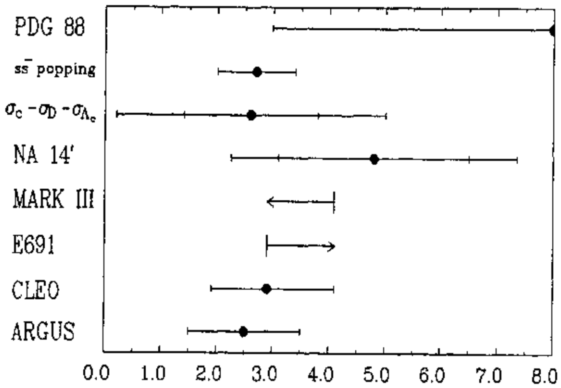

Figure 4: Estimates of $BR(D_s^+ \to \phi\pi^+)$ (%)

From this branching ratio one can derive an estimate of $BR(D_s^+ \to \phi e^+\nu)$. We use the WBS model prediction $\Gamma(D_s^+ \to \phi e^+\nu) = 0.83 * \Gamma(D^+ \to \bar{K}^{*0}e^+\nu)$ [11] and the D^+ and D_s lifetimes [10] to arrive at the estimate $BR(D_s^+ \to \phi e^+\nu) = (1.4 \pm 0.3)\%$. From this and our measurment of $BR(D_s^+ \to \phi e^+\nu)/BR(D_s^+ \to \phi\pi^+)$ we obtain $BR(D_s^+ \to \phi\pi^+) = (2.5 \pm 1.0)\%$. For comparison with other estimates of this absolute branching ratio from references [10,12] the results are shown in Figure 4. The lower 3 values are from similar analyses of $D_s^+ \to \phi e^+\nu$, whereas the upper values have been derived from completely independent methods, which have different systematic uncertainties, all in remarkably good agreement. The improvement of the recent estimates over the Particle Data Group 1988 value is substantial.

4 Parity Violation in $\Lambda_c^+ \to \Lambda\pi^+$

The weak decay $\Lambda_c^+ \to \Lambda\pi^+$ lends itself to an unambiguous test of parity violation, observed through a Λ polarization assymetry. In the decay chain

$$\Lambda_c^+ \to \Lambda\pi^+ \quad \Lambda \to p\pi^-$$

we define θ as the angle between the Λ_c and the proton in the rest frame of the decay Λ. This angle enters the decay rate $W(\theta)$ as $W(\theta) \sim 1 + \alpha_{\Lambda_c}\alpha_{\Lambda}\cos\theta$. The value of α_{Λ} is well known, $\alpha_{\Lambda} = 0.642 \pm 0.013$ [10]. From fits to the $\Lambda_c^+ \to \Lambda\pi^+$ signal in bins of $\cos\theta$ we obtain

$$\alpha_{\Lambda_c} = -1.0 \pm 0.4.$$

This value corresponds to a maximum possible polarization assymetry, thus providing an indication for parity violation in the decay $\Lambda_c^+ \to \Lambda\pi^+$. Also of interest is the branching ratio. We find $BR(\Lambda_c^+ \to \Lambda\pi^+)/BR(\Lambda_c^+ \to pK^-\pi^+) = 0.18 \pm 0.03 \pm 0.04$.

5 Charm-Strange S$_c$ Baryons

We have observed the production of charm-strange E$_c$ baryons through the decays E° ~> S~7r', $E°_c$ S~7r'7T'7r~, and S+ -> E~7r'7r', where E~ -> Â7r~. The decay E£ -> E~7r'7r'7r~ represents a new observation. Figure 5 shows the mass distribution for E~7r'7r'7r" candidates, where we have required x_p = *p/Pmax* > 0.5. The fit yields 36 ± 9 events at a mass of 2471 ± 3 MeV. We have measured the production rates times branching ratios where an extrapolation to lower x_p values is made by fitting the x_p distribution with a Peterson fragmentation function. We obtain e = 0.24 ± 0.08. The results for the production rates times branching ratios and masses are listed in Table 2. The mass difference Af(E+) - *M(Z°c)* = (-7 ± 4 ± 2)MeV is in good agreement with the CLEO (-5±4±1)MeV [13] and ACCMOR (-6.8±3.3±0.5)MeV [14] results.

Decay Mode	$\sigma * BR$ (pb)	Mass (MeV)
$\Xi_c^0 \to \Xi^-\pi^+$	$0.77 \pm 0.24 \pm 0.16$	$2476 \pm 6 \pm 3$
$\hookrightarrow \Xi^-\pi^+\pi^+\pi^-$	$2.55 \pm 0.64 \pm 0.39$	$2471 \pm 3 \pm 2$
$\Xi_c^+ \to \Xi^-\pi^+\pi^+$	$1.50 \pm 0.39 \pm 0.23$	$2465 \pm 4 \pm 2$
$M_{\Xi_c^+} - M_{\Xi_c^0}$		$-7 \pm 4 \pm 2$

Table 2: Results for Ξ_c baryons

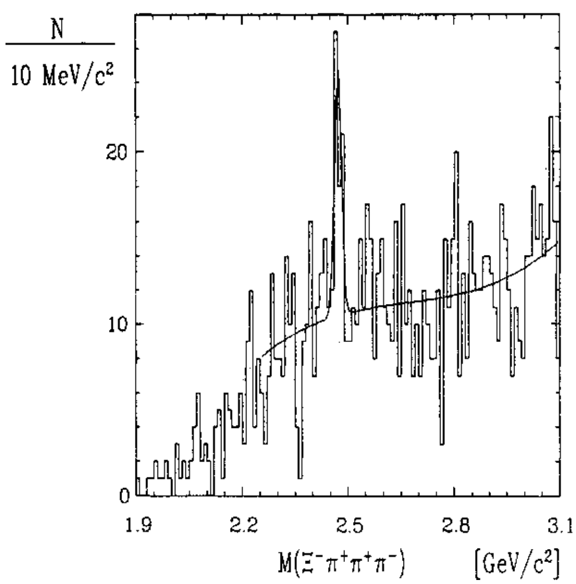

Figure 5: Mass distribution of E ir'ir'ir candidates

6 Summary

In summary, we have measured the charm decays D+ -+ **I/TT'**, *Dt -> <t*e+v,* and -» *K'TT^.* We find the ratios BR(D+ -> 77'7r')/BR(D+ -> 0**TT')** = 2.5 ± 0.5 ± 0.3, *BR(D+ -* <j>e'v)/BR{D+ -** ^**TT') =** 0.57±0.15±0.15 and BR(D' *K*°e'v)/BR(D' ->* ,ftT-7r'7r') = 0.55 ± 0.08 ± 0.10. The similarities of the semileptonic decays leads to an estimate of the absolute branching ratio *BR(Dj* -> <^7r') = (2.5 ± 1.0)%. In addition we have measured the polarization assymetry in the decay —> *kn*+ and find from the result *a*\$_c$ = —1.0 ± 0.4 an indication for parity violation. Finally, we have measured the decays and masses of the charmed-strange S$_c$ baryons, including the first observation of the decay E° E"7r'7r'7r~,

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RECENT CLEO RESULTS ON CHARM PHYSICS

E. I. SHIBATA (CLEO Collaboration)
Department of Physics, Purdue University
West Lafayette, IN 47907, U. S. A.

ABSTRACT

A summary of recent charm physics results from CLEO 1.5 is presented. Branching fractions for *D*° decays to *K+K~, K°K°*, **TT+TT", TTV**, and some other modes involving a *w*° or an r? are given. Using the observation of *Df* -+ *<j>l+v,* the absolute branching fraction for *Df* -> *<j>n+* has been derived. A$_c$ results include branching fractions into *pK~x*$^+$, *pK°*, *pR*^{0}*^^*, A?r+, and *Air*$^+$*it~w+*$_f$ and the A$_c$ decay asymmetry parameter.

Introduction

The charm physics results reported in this paper are from **e**$^+$**e~"** annihilation data collected by the CLEO 1.5 detector[1] at the Cornell Electron Storage Ring (CESR) in Ithaca, New York. The data set corresponds to integrated luminosities of 101 pb"^{1} below the T(4S) and 212 pb~^{1} at the T(4S) taken in 1987 and 116 pb~* taken at the T(5S) in early 1988. About - 1,100,000 hadronic events from the continuum are contained in this data set. Throughout this paper charge conjugate states are implied.

D° decays

While many of the theoretical calculations for rates of two-body, non-leptonic decays of the *D*° are in agreement with experimental measurements, D° -+ *KK* and *D*° -* *ww* present problems. The current world average[3] for the ratio of branching fractions *B{D*° -> *K+K~)/B(D*° -> *+*-) is 3,9 ± 1.2. This is not easily reconciled with theoretical expectations[3] which range from 1 to 1.4. In lowest order the process D° -> *K°K°* proceeds through two VP-exchange diagrams whose sum cancels in the limit of exact *SU(Z)* flavor symmetry, so *B(D*° -> *K°K°)* is predicted to be small[4] (~ 10"^{4} or less) in a simple quark picture.

Using **J9*$^+$ -* D^{0}TT+** events, selected by requiring |AAf - 145.45 MeV/c^2| < 2.4 MeV/c^2, where AM = M(D*+) - *M(D°)* and *x(D*+)* = *p/pmax* > 0.5, the *K+K~* and ?r$^+$jr~ invariant mass distributions shown in Figs. 1(a) and 1(b) were obtained. The peaks centered at an invariant mass of 1.865 GeV/c^2 are from *D*° -> JfT+iT (249±21 events) and *D*° **-+ TT+T**T (110±15 events), respectively. The other structures are due to reflections from the copious *D*° *K^w*$^+$ and *D*° ->

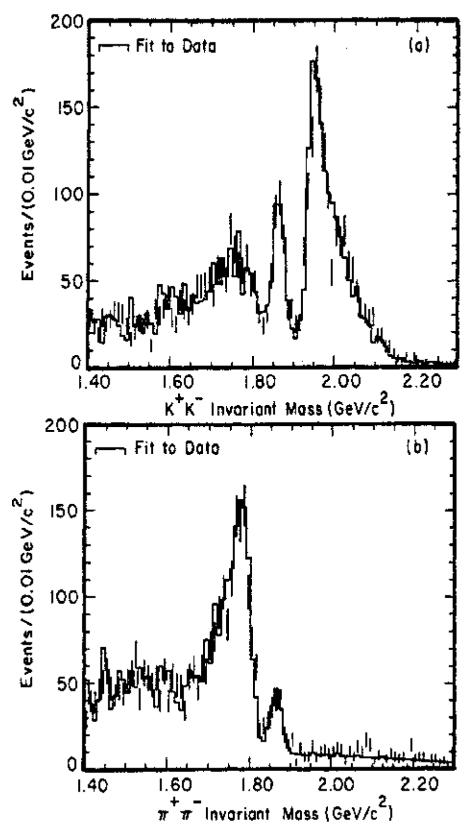

Fig. 1. Invariant mass distributions for (a) *K+K~* and (b) *r$^+$?r. The fit to the data is by the sum of a Monte Carlo simulated background from D° decays, a polynomial background, and a Gaussian signal.

K p' decay modes. Normalizing to the decay channel D° -> K~TÇ+ and correcting for efficiencies, we find B{D° -4 K+K~) = (0.49 ± 0.04 ± 0.03±0.06)% and B{D° -> Tr+Tr") = (0.21±0.03± 0.02 ± 0.03)%, where the third error is due to the uncertainty in B(D° -> K~7r') = (4.2 ± 0.6)%. Thus, the ratio of branching fractions B(D° -+ K+K-)/B{D° -> tt+tT) is 2.35 ± 0.37 ± 0.28, lower than the current world average but higher than theoretical expectations.

D° -> K®K® candidates were selected from D*+ -> D°7T events by requiring that |AM - 145.45 MeV/c²| < 1.2 MeV/c², M{w'it~) to be within 12.5 MeV/c² of M{K°s) and x{D*+) > 0.5. We observe 5 events with masses consistent with D° decay. From Monte Carlo simulations the background is estimated to be 0.3 events. In order to reduce the systematic error in the determination of the D° -> K°sKJ branching fraction, we normalized to the decay channel D° K%n'ir~. Using the branching ratio[5] D° -> K°w^n' = (6.4 ± 1.1)%, we find B{D° K°K°) = (0.13^5 7 ± 0.02)%, where the systematic error is dominated by the uncertainty in J5(jD° -> This result is consistent with Pham's calculation[4] based on non-perturbative hadronic final state interactions, in which he obtained B(D° ~> K°K°) « \B{D° -> K+K-) « 0.25%. Here we have used our value for B(D° -» K'K") given above.

D° decays involving a **tt°** *or an n*

Branching fractions for D° decays involving a 7T° or an 77 are summarized in the Table 1 below. Also shown are theoretical predictions by Bauer, Steck, and Wirbel[6] (BSW) and Blok and Shifman[7] (BS). Our measurements are in good agreement with the BSW predictions, but are somewhat higher than the BS predictions.

Table 1. *D°* branching fractions for decays involving a *é* or an *rj.*

Mode	CLEO	BSW	BS
$K^-\pi^+\pi^0$	$11.5 \pm 0.6 \pm 2.1$		
$\bar{K}^0\pi^0$	$2.3 \pm 0.4 \pm 0.5$	2.5	1.5
$K^-\pi^+\pi^-\pi^+\pi^0$	$5.0 \pm 0.7^{+1.3}_{-1.0}$		
$\bar{K}^0\omega$	$3.4 \pm 0.9 \pm 1.0$	2.7	1.5
$\bar{K}^{*0}\eta$	$2.3^{+0.7}_{-1.1}$	2.5	0.3
$\pi^0\pi^0$	< 0.46 (90% C.L.)		

Df -+ and Df -+ <t>w'.

Through the observation of Df -> ft+v, we have made a determination of the absolute branching fraction for Dj -* 07r'.[8] It is found that the cuts p($+) > 2 GeV/c and p[<f>) > 1 GeV/c isolate D+ -» <j>l'v events. After lepton fake and BE background subtractions there are 37.4 ± 9.0 and 17.0 ± 6.4 events. There are 400 ± 27 D+ -> 07r' events. Averaging the and <f>e'v data samples and correcting for efficiencies, we find

B{Df - <t>l'v)/B{D+ -+ <t>ir') = 0.49±010l°;}°.

The value for the i ? ' -> <j>l+v branching fraction is derived from the following relation:

B[Dt -> V+y) = " £ f ° = W - 4*+")*D.
= (0.80 ± 0.08) • B{D+ -> K*°l+v) • TsJTD+
The factor 0.8 is the average of two predictions,[9] and the error reflects a large range of possible differences in form factor. The measured branching fraction[10] for B{D+ -> K*°l+v) is (4.5 ± 0.7 ± 0.5)% and the ratio of Ds and D' lifetimes is 0.42 ± 0.03. The resulting estimate for B(Df -> <f>l+v) is (1.50 ± 0.31)%. Thus, B{D+ -> ^r+) = (3.1±0.61q'6±0.6)%, where the first error is statistical, the second is systematic, and the third is also systematic and arises from the uncertainty on the predicted value of B(Df -» <f>l+v). This value for B(D+ -> <^7r') can be compared with the Mark III upper limit[11] of 4.1% and the E691 lower limit[12] of 3.4%

Ac branching fractions and decay asymmetry

Ac branching fractions

Absolute branching fractions for several Ac decay modes are shown in Table 2 along with the values given by the Particle Data Group[2] (PDG). The CLEO numbers are based on B(Kc -+ pK~n') = (4.3 ± 1.4)%, which is a weighted average[13] of CLEO and ARGUS estimates.

Table 2. Ac branching fractions.

Decay mode	CLEO	PDG
$pK^-\pi^+$	4.3 ± 1.4	2.8 ± 0.8
$p\bar{K}^0$	2.1 ± 0.7	1.6 ± 0.6
$p\bar{K}^0\pi^-\pi^+$	1.8 ± 0.8	8.1 ± 3.5
$\Lambda\pi^+$	0.7 ± 0.3	seen
$\Lambda\pi^+\pi^-\pi^+$	2.8 ± 1.0	1.9 ± 0.7

A_c decay asymmetry parameter and A_c polarization

Violation of parity conservation in the weak decays of charmed baryons is expected. The decay A+ -> A7r+ is analogous to the decay A *px~,* for which the parity-violating asymmetry decay parameter has been measured[2] to be «**A** = 0.642 ± 0.013. The form of the angular distribution of the proton in the decay A+ -> *An+*, where A *pw~,* is given by *dN/dcos 61* = |(1 + **CKAO^COSÔI**), where *6%* is the angle between the A direction in the A_c rest frame and the decay proton's line of flight in the A rest frame. The fit to the CLEO data is shown in Fig. 2 and gives *a^c* = -1.O1^**Q**, constraining **OA**c to physical values, indicating that parity conservation is violated in the weak decay A+ —• A7r+ as is expected.

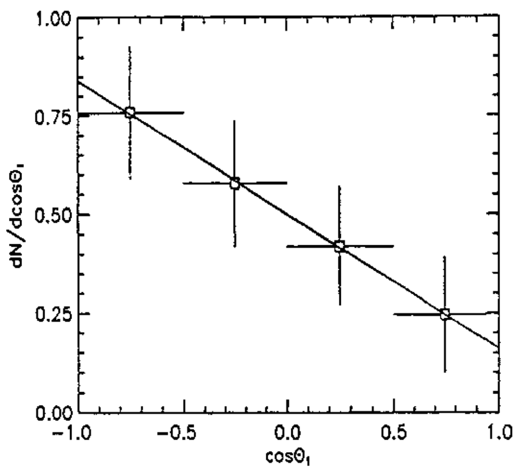

Fig. 2. Angular distribution of the decay proton in the A rest frame. The slope of the distribution is *^a^a^*. The fit line has a slope of -0.34 ± 0.14.

Parity conservation in electromagnetic annihilation requires A_c polarization, if it exists, to be normal to the production plane. In addition, the polarization must be the same for particle and antiparticle states since *C* is a conserved quantum number for A_c production. We define the normal to the production plane as n = *p^c* x e+, the cross product of the A_c momentum vector and the direction of the positron beam. In the A+ rest frame the angular distribution of the A relative to n has the form *dN/dcos 62* = |(1 + **POJA**c cos **#2),** where *P* is the polarization and *62* is the angle between n and the A direction in the A_c rest frame. Since *a^c* = -a^c, subtracting the *lc* distribution from the A_c distribution yields *dN/d cos $2* = **+PaA**c cos **02**- The fit to this distribution, shown in Fig. 3, gives *P* = -0.2 ± 0.2, assuming that a**A**n = -1.0. Thus, we see no evidence for the production of polarized A_c.

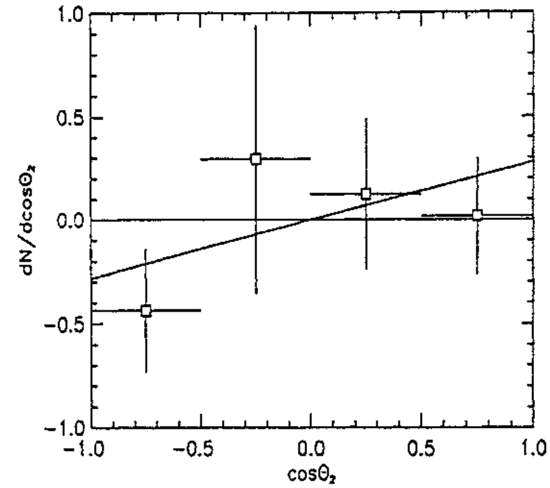

Fig. 3. The angular distribution of the À relative to n. The slope of the distribution is +Pe*A$_c$. The fit line has a slope of+0.24 ±0.24.

Acknowledgements

The author wishes to thank his CLEO collaborators for their many contributions and helpful suggestions and the CESR staff for their efforts. This work was supported in part by the U. S. Department of Energy under contract DE-AC02-76ER01428.

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Q. A. N. Kamalff/niv. *Alberta)* : I am a little surprised that you said that the theoretical expectation for the ratio *B(D°* *K+K-)/B(D°* **-* TT+TT'**) is 1 to 1.4. In fact, it is easy to get a value of 2, and if one is prepared to play with QCD coefficients *a* and *ai* of Bauer, Stech and Wirbel, one can get up to 3 for this ratio, putting in final state interactions.

A. E. Shibata: That is good news. It shows that final state interactions are important.

SEARCH FOR DOUBLY CABIBBO-SUPPRESSED JD+ DECAYS*

RAFE H. SCHINDLER
The Stanford Linear Accelerator Center
Stanford University, Stanford, CA 94309 USA
REPRESENTING
THE MARKIII COLLABORATION

ABSTRACT

Preliminary results of a search for the doubly Cabibbo-suppressed D' decays *D+* -> and *K+TT°,* in the MarkIII detector at SPEAR are presented. Theoretical arguments suggest that these decays may be enhanced relative to Cabibbo-allowed D' decays. Use of hadronically tagged *D* + *D* ~ events produced in the decay of the ^(3770), reduce backgrounds significantly, allowing the isolation of three candidate events in the if'7r+7r~ final state and a limit on the relative decay rate of the ijf'7r° channel.

INTRODUCTION

Double Cabibbo-suppressed decays (DCSD) of the D° and *D'* present a rich test of our understanding of weak hadronic decays![1] The rate for DCSD relative to Cabibbo-allowed decays (CAD) goes naively like ~ tan'0. For Z)° decay, a mild deviation from this estimate is expected within the factorization hypothesis, arising from SU(3) and SU(6) breaking, and from form-factors.[2] Evidence for 3 D°i)° events at the 0(3770), was previously reported[3] when 0.4 ±0.2 background events were expected. For small values of the mixing parameter *(rj)* < 4 **X** 10~³), the events can be interpreted as evidence for DCSD with I ***PK-M*** |²> 1.9 at 90% C.L.

Unlike the Z)°, the D' DCSD are expected in many cases to have large enhancements over CAD resulting from the lack of interference amongst their amplitudes. Interference is believed responsible for **r(£+)** < *T(D°).* Equivalent^, the possibility of both 1=1/2 and 1=3/2 final states in *D*+ DCSD would lead to an enhanced width. Estimates using factorization but not considering final state interactions (FSI)[2] for four candidate DCSD are :

$$|\bar{\rho}_{K^+\pi^0}|^2 = \frac{\Gamma(D^+ \to K^+\pi^0)}{\Gamma(D^+ \to \bar{K}^0\pi^+)} \cdot \frac{1}{\tan^4\theta_c} \approx 3$$

$$|\bar{\rho}_{K^{*}\pi^+}|^2 = \frac{\Gamma(D^+ \to K^{*0}\pi^+)}{\Gamma(D^+ \to \bar{K}^{*0}\pi^+)} \cdot \frac{1}{\tan^4\theta_c} \approx 5 - 11$$

$$|\bar{\rho}_{K^{*+}\pi^0}|^2 = \frac{\Gamma(D^+ \to K^{*+}\pi^0)}{\Gamma(D^+ \to \bar{K}^{*0}\pi^+)} \cdot \frac{1}{\tan^4\theta_c} \approx 12 - 25$$

$$|\bar{\rho}_{K^+\rho^0}|^2 = \frac{\Gamma(D^+ \to K^+\rho^0)}{\Gamma(D^+ \to \bar{K}^0\rho^+)} \cdot \frac{1}{\tan^4\theta_c} \approx 0.4$$

No prediction for non-resonant Z)' —> *K* ' *K* 7r' exists. A search for all except the *K*7R°* final state is reported here.

THE ^'7r~7R' FINAL STATE

In the analysis, a sample of 2538 hadronic *tags* is selected. Events are required to contain three additional charged tracks satisfying total charge zero. The recoiling charged tracks are loosely assigned particle-ID by time-of-flight (TOF) and dE/dX. Combinations opposite a tag and consistent with a *K'TR^7:'* assignment are plotted in invariant versus beam constrained (BC) mass. The invariant mass is sensitive to particle miss-ID, reflecting ±120 MeV for a single 7r **F±** *K* interchange. Double miss-ID however, reflects back to the same invariant mass. The BC-mass follows the candidate's momentum, which is monochromatic for pair-produced and remains unchanged by particle miss-ID. Figure 1(a) shows the data. The signal region is defined by ~ 2.5a vertical and horizontal bands (1.862-1.876 and 1.819-1.919 GeV/c², respectively). There are 19 events in the signal region, as well as higher and lower mass reflections of Cabibbo-suppressed decays with single miss-ID. Two background events from A'jA'±,

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with 7r'7r~ pairs having the mass are rejected. The 17 remaining events are reduced to six, (Figure 1(b)) by tightening particle-ID requirements. This reduces the single miss-ID reflections, and eliminates most double miss-ID in the signal region. Residual background comes from **D + i r** and **JD°D**°, where the tag has a **JRT§**, and particle interchange *across* the event has occurred. In those events, easily swapped **7r**'s determine the charge and hence the charm. An example is jf°**7r**'7r~ *vs* if'7r~7r'7r~ identified as 7?°7r'**7r**~7r~ *vs* if'7T~7r'. By testing all such combinations, these events are entirely eliminated. Fake events also occur from lost x° accompanied by single **7T** *K* miss-ID. Vetoing events with extra photons eliminates this background.

Figure 1(c) shows five surviving events, three belonging to the signal region. Residual background from double miss-ID is estimated to be 0.8 ±0.3 ±0.3 events. The detection efficiency for *KKK* final states is ~ 0.35. Using the number of tags, the detection efficiency and the CAD branching ratios, 0.2-0.5 ^*p*° and 0.1 *K*°TT*' events are expected under the factorization hypothesis, while instead, two events consistent with if*/?°, and one event consistent with *K*°n*' are observed.

Non-resonant decays cannot be distinguished from resonant ones. If | *p* |^2= 1 for non-resonant decays, 0.2 events would be detected. After background subtraction a value | *PX*™ |^2~ 11 is extracted, assuming all events are non-resonant.

THE #+7T' FINAL STATE

For this analysis the tag sample is reduced to 2255 by removing those tags containing a **7r°.** This improves the missing energy resolution subsequently used in the analysis. To improve efficiency, **7r°** reconstruction is explicitly avoided. The search proceeds by identifying tags with one and only one correct-charge track (assigned the kaon mass) in the recoil, and > one photon within | cos *9* |> 0.84 of the *PMISS* (7T°) direction. Figure 2(a) shows the data plotted in the variable *U* = *Z{P$_E$VENT - PTAGY • {PK)V* A real *K+ir*® signal will be 97% contained for 1.8 < *U* < 1.92 (GeV/c^2)^2. Thirty candidate signal events are observed. The backgrounds from **D** ' -» 7r+7r° and *K*°*K*+ where either **TT+** ^ *K*' or I?° -> *(K*°$_s$ -* 7r°7r°) or -> ifj, are shifted to higher and lower U values, and rejected.

The principle CAD background D' -* **J?°7r**' manifests itself by **TT**' *K*+ and *K*° —• 7r°7r° or *Ki,* where the 7r°s are asymmetric, or the *Ki* interacts faking a photon. Misidentified peak at the same U value where a Iif'7r° signal would peak. A *K*w*° signal has at least one photon of energy >0.4 GeV/c^2 within a tighter cone | cos£ |> 0.98 around the expected 7r° direction There are no additional photons of energy > 0.3 GeV/c^2 outside the cone. Figure 2(b) results from these energy and veto cuts. Five events remain. The sum of photon directions *fâconePy)* within the initial cone, relative to *PMISS* is peaked sharply for the signal, but has a large dispersion when originating from *K* interactions or multi-7r°'s from *Kg* -+ x°**7r°.** Figure 2(c) shows the result after a tight direction cut; one signal event and one event on the cut boundary remains, with an expectation of 2.8 events from Monte Carlo. Requiring positive kaon-ID eliminates four events including the one signal candidate (Figure 2(d)). Less than 0.2 background events in the signal region, less than one *K*°*K*' event below and less than 0.5 **7r**'7r° events above the signal region are expected. A visual scan of these remaining events confirms their origin.

Taking the factorization estimate, the detection efficiency of 0.37 and the *BV(K°K')* one predicts that 0.2 events would be seen. No events are observed (with an expected background <0.2), leading to a preliminary limit of | **^+TT°** |^2< 30 at 90% CL.

CONCLUSIONS

In a preliminary analysis of D' DCSD, three events are observed in the *K^TT^TT"* final state, with 0.8 ± 0.3 ± 0.3 expected background events. The excess events are consistent with a value of | *p* |^2> 1, divided between the different final states, as anticipated for D' DCSD and similar to that observed for the *D*° DCSD. No events are seen for *D*+ -> JCM and a weak limit on | *p* |^2 is derived, consistent with factorization. FSI have not been considered in the predictions, and may play an important role in the presence of potentially large channels like lf'**7r°.**

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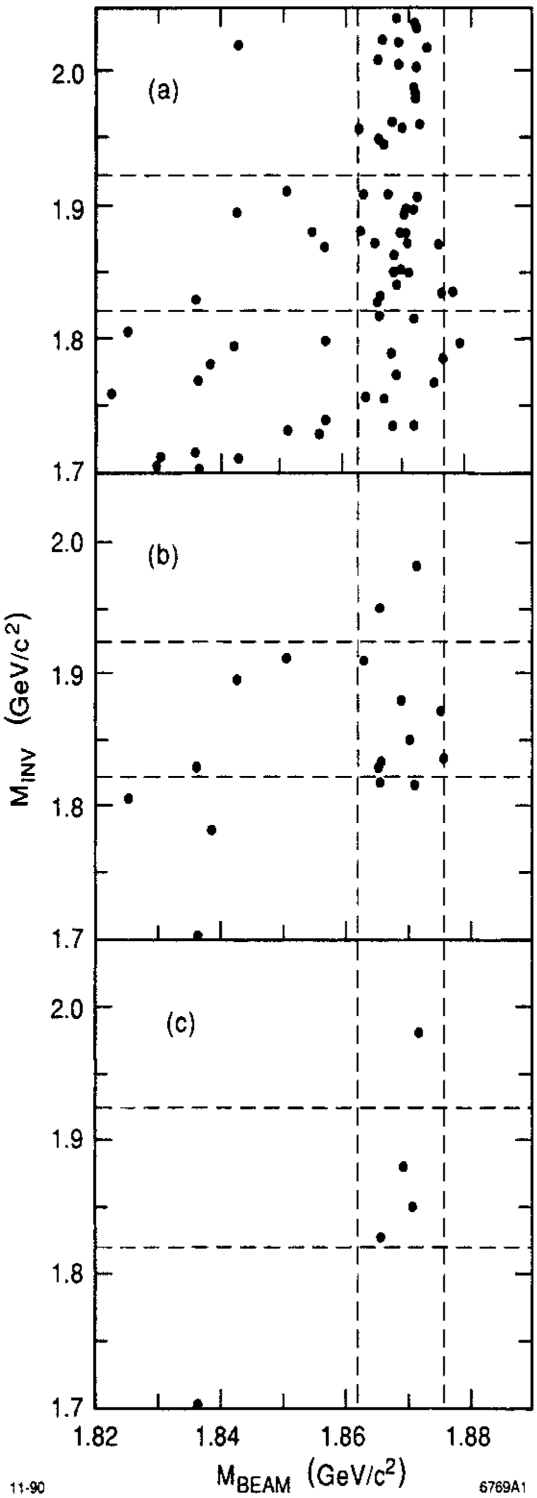
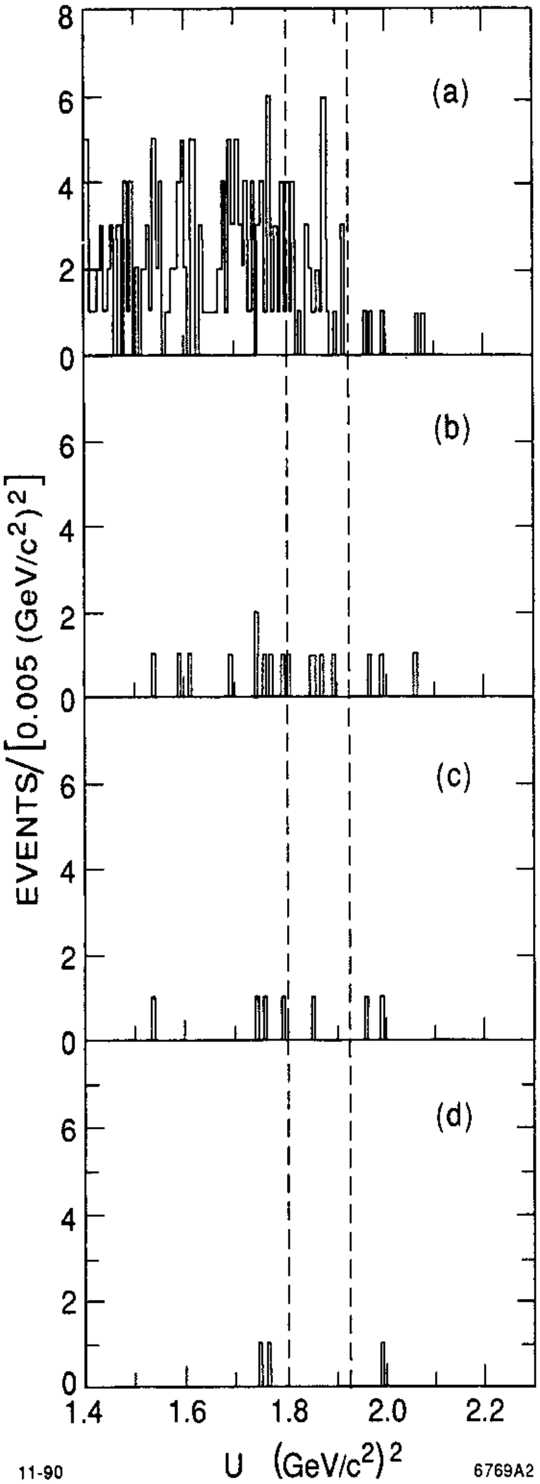


1) (a)Invariant vs. beam constrained mass, loose cuts. Dashed lines indicate the signal region. (b)After *mti-K°* and tighter particle-ID cuts. (c)After final cuts to reduce *D*ˆ*D*~ and *D°D°* feedown.



2) (a) U for events before cuts, (b) U after photon energy and veto cuts, (c) U after photon direction cuts, (d) **U** after demanding K identification.

A Measurement of the Z° —> bb Partial Decay Width

The **L3** Collaboration

Vincenzo Innocente
INFN, Sezione di Napoli, Napoli, Italy
and

CERN, Geneva, Switzerland

ABSTRACT

We have measured the partial decay width of the Z° into bb using hadronic events containing muons. We have also determined the fragmentation function of the b quark at *yfs* « 91 GeV. From a fit to the muon p and pi spectra, we determine $f_b b$ = 367±39 MeV and (x_E) = Q.66±0.02.

Introduction

Measurements of decays of the Z° Boson into bb pairs may be used to precisely determine the weak neutral couplings of heavy quarks, and to test the universality of the quark couplings. In the Standard Model [1] the partial width of Z° ~> qq depends on the weak isospin of the quark: the partial width is expected to be larger for down-type quarks than for up-type quarks. Precise determinations of the partial decay width for Z° —» bb ($\mathbf{r}_b$fc) and of the forward-backward asymmetry (Abb) w ^ " " * S " statistics at LEP may therefore be used to perform stringent tests of the Standard Model and to accurately measure $\sin^2 0w$ [2].

Our measurements are based on a study of inclusive muons in the reaction: e^+e^- —> /i -f hadrons. The data sample corresponds to 2.9 $p6^{-1}$ collected during a scan of the Z° resonance using the L3 detector at LEP. The center-of-mass energies are distributed over the range 88.2 < < 94.2 GeV. The clean identification and measurement of muons in the L3 detector allows us to select inclusive muons events from the reaction e^+e^- —> bb, where the muon has a large transverse momentum with respect to the nearest jet, with little background from c'c or light qq production.

The **L3** Detector

The L3 detector covers 99% of 4?r. The detector consists of a central tracking chamber, a high resolution electromagnetic calorimeter composed of BGO crystals, a ring of scintillation counters, a uranium and brass hadron calorimeter with proportional wire chamber readout, and an accurate muon chamber system. These detectors are installed in a 12 m diameter magnet which provides a uniform field of 0.5 T along the beam direction.

The fine segmentation of the BGO detector and the hadron calorimeter allow us to measure the direction of jets with an angular resolution of 2.5°, and to measure the total energy of hadronic events from Z° decay with a resolution of 10.2%. The muon detector consists of 3 layers of precise drift chambers, which measure a muon's trajectory 56 times in the bending plane, and 8 times in the non-bending direction.

Figure 1 displays a reconstructed Z° -> ^-fhadrons event observed in the L3 detector (cut perpendicular to the e^+e^- beam line). Shown are the charged tracks measured in the vertex chamber, the energy deposited in the electromagnetic calorimeter and in the hadron detector and a muon measured in the muon chambers.

For the present analysis, we use the data collected in the following ranges of polar angles:

- for the central chamber, 41° < *9* < 139°,
- for the electromagnetic calorimeter, 42.4° < *9* < 137.6°.
- for the hadron calorimeter, 5° < *9* < 175°,
- for the muon chambers, 35.8° < *9* < 144.2°.

A detailed description of each detector subsystem, and its performance, is given in Reference [3].

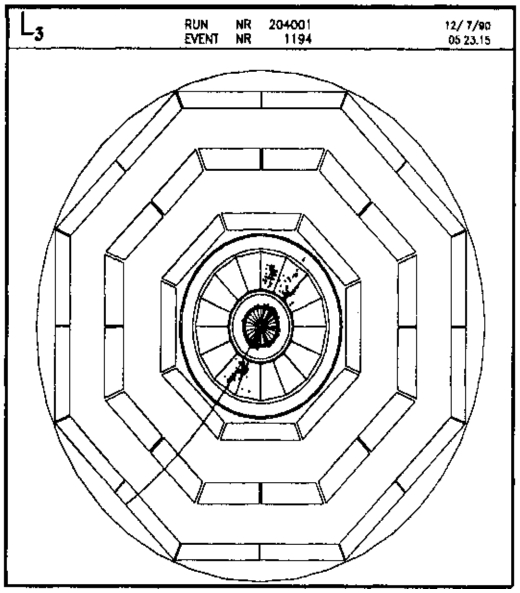


Figure 1: ***An inclusive \i event observed in the L3 detector.***

Selection of 66 Events

Events of the type Z° —> bb are identified by the observation of a hadronic event containing a ***fi*** coming from the semileptonic decay of the b or b quark. These inclusive muon events are triggered by several independent triggers. The primary trigger requires a total energy of 15 GeV in the BGO and hadron calorimeters. A second trigger requires one of sixteen barrel scintillation counters in coincidence with a track in the muon chambers. These triggers, combined with an independent charged track trigger and a barrel scintillation counter trigger, give a trigger efficiency greater than 99.9% for hadronic events containing one or more muons.

In this analysis we first select hadronic events using the following criteria:

(1) E_{cal} > 38 GeV,

(2) Longitudinal Energy Imbalance: **jj^** < 0.4,

(3) Transverse Energy Imbalance: **-jr'**- < 0.5,

where E_{ca}i is the total energy observed in the calorimeters, and E_v**is** is the sum of the calorimetric energy and the energy of the muon as measured in the muon chambers.

The number of jets is found using a two-step algorithm which groups the energy deposited in the BGO crystals and in the hadron calorimeter towers into clusters, before collecting the clusters into jets [4]. We require that there be at least one jet which has more than 10 GeV in the calorimeters.

The clustering algorithm normally reconstructs one cluster in the BGO for each electron or photon shower, and a few clusters for r's. 'We reject r^+r~ events by requiring a minimum of 10 clusters in the BGO, each with energy greater than 100 MeV.

A total of 65379 hadronic events were collected during the scan of the Z° until August 1990.

Muons are identified and measured in the muon chamber system. We require that a muon track consists of track segments in two of three layers of muon chambers, and that the muon track points to the interaction region. We make the additional requirement that the transverse distance of closest approach of the muon track is less than 3cr from the vertex, and that the longitudinal distance of closest approach is less than **4<7.** The effects of multiple scattering of the muon in the calorimeters are included in the errors. In order to be used in this analysis, the momentum of the muon must be larger than 4 GeV.

A total of 3198 inclusive muon events have been selected.

To determine the acceptance for inclusive muon events, we use the Lund parton shower program [5] with **ALL** = 290 MeV and string fragmentation. For b and c quarks we use the Peterson fragmentation function [6]. For b quarks, the fragmentation function is adjusted to match our inclusive muon data (see discussion in the following section). The generated events are passed through the L3 detector simulation [7], which includes the effects of energy loss, multiple scattering, interactions and decays in the detector materials and beam pipe. We use the average of the semileptonic branching ratios measured by previous experiments at high energies (PEP and PETRA) [8]: Br(6 -> ^ + X) = (11.8 ± 1.1)% and Br(c **-+ *p + X)*** = (8.0 ± 1.0)%. We determine that the efficiency for observing a prompt b -* *FI* decay is 39.4%.

Figure 2 shows the momentum spectrum for inclusive muons passing the selection cuts given above. Figure 3 shows the measured transverse momentum, pj_, of each muon with respect to the nearest jet. In defining the axis of the nearest jet, the measured energy of the muon is first excluded from the jet. If there is no jet with an energy greater than 6 GeV remaining in the same hemisphere as the muon, then p± is calculated relative to the thrust axis of the event. As can be seen from the Monte Carlo distributions also shown in these figures, the fraction of prompt b —• \i events increases at higher p and p±.

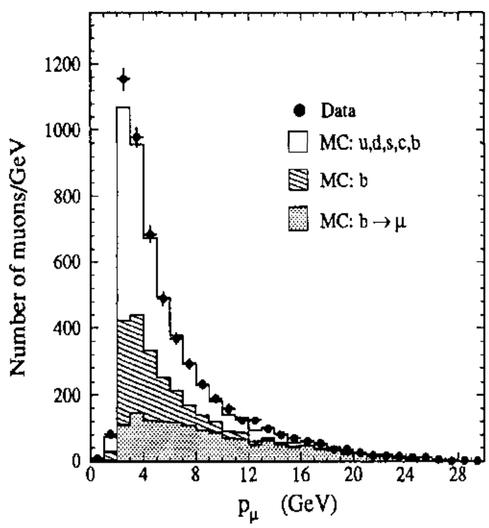


Figure 2: *The measured muon momentum distribution for inclusive muon events compared to the Monte Carlo simulation. No p± cut has been applied. The contributions of the various processes are indicated.*

Table 1 shows the results of Monte Carlo studies giving the fraction of each source of muons and background for data samples with no cut on p± and also with a cut at 1.5 GeV.

Determination of and e_b

In order to measure accurately, it is necessary to study the fragmentation functions for b and c quarks, since the momentum distribution of the muons observed in the final state is directly related to the B-hadron spectrum prior to decay. We therefore determined T$_b$£ in a fit to the data which allowed both the fragmentation function for B-hadrons and T_h^ to vary. We characterized the fragmentation of b quarks in terms of the scaled energy x_E = ^ a n, using the functional form

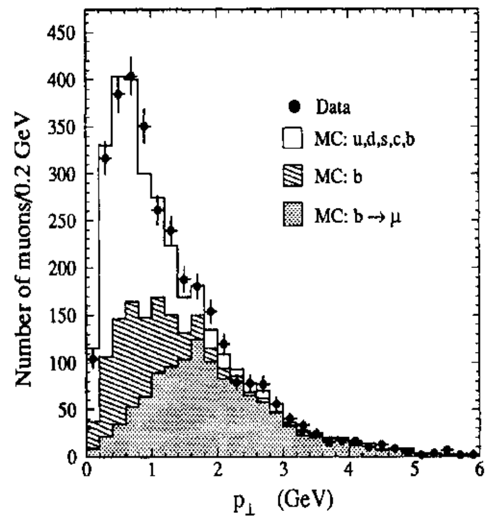


Figure 3: *The measured distributions of the transverse momentum p± of the muon with respect to the nearest jet. A cut ofpn>4 GeV* lias *been applied. The contributions of the various processes are indicated. The* data at large *pi* are *dominated by b -+ fi decays.*

given by Peterson *et al.* [6]

$$f(x_E) \propto x_E^{-1}\left[1 - x_E^{-1} - \frac{\epsilon_b}{1 - x_E}\right]^{-2}$$

which depends on a single fragmentation parameter e_b. The commonly used [9] fractional "energy" of the primordial heavy hadron, z_{rec} = ^J^ff^i as reconstructed from the Monte Carlo four-vectors, is not meaningful in parton shower models. Because of the radiation of energetic gluons and the subsequent recombination of part of those gluons

Table 1: *Monte Carlo estimâtes of the fractions of each type of muon in the* data *sa,mple.*

Source	$p_\mu > 4$ GeV	
	$p_\perp > 0$	$p_\perp > 1.5$
$b \to \mu$	38.1%	77.9%
$b \to c \to \mu$	12.0%	4.7%
$b \to \tau \to \mu$	2.1%	1.5%
$b \to \bar{c} \to \mu$	1.9%	0.6%
$c \to \mu$	17.5%	4.7%
background	28.4%	10.6%

into the B-hadrons, values of z_{rec} greater than unity are often observed in the JETSET model at Z° energies. The variable x_E = ^{2} ^{E} ^ M bas been chosen because it can be directly measured, and because its definition is independent of fragmentation models. As a result of our fragmentation study (see below) we found that Γ_{bb} is relatively insensitive to the choice of the b quark fragmentation function.

We performed an unbinned maximum likelihood fit to the two-dimensional p_M vs. pi distribution using all inclusive muons with 4 GeV < p_M < **30** GeV and no pi cut. The p_M vs. pi distribution is sensitive to both Γ_{bb} and to e_b.

The distribution in p_M vs. pi was simulated using JETSET **7.2** and various fragmentation functions. Distributions for different fragmentation parameters were obtained in the fit by re weighting the Monte Carlo events as a function of x_E, assuming the Peterson functional form. The Monte Carlo predictions were normalized to the same total number of hadronic events as the data.

The direct results of the fit are: F_{bb} = **367** ± **12** MeV and e_b = **0.065 îjgg.** This value of e_b corresponds to (x_E) = **0.66** ± **0.01.** The fragmentation function which we determined can be reproduced with reasonable accuracy using JETSET **7.2** at = M_z with A_{LL} = **290** MeV, with the input parameter for $e^{\wedge and}$ set to **0.015.** To check the result of the fit we perform various tests changing the contribution from the lighter quarks (udsc) and the amount of background from punch through. The fit has been also repeated by leaving the charm fragmentation, T_c**c** and the semileptonic branching ratio Br(c —> p) free. From the results of these tests, we estimate a relative systematic error of **±5%** in Γ_{bb} and **±3%** in (x_E). The uncertainty in the B semi-muonic branching ratio leads to an additional systematic uncertainty of **33** MeV in T_{bt}. The final results from the fit are:

Γ_{bB} = **367** ± **12**(ata*) ± **18**(sys) ± **33**(6^**0** MeV
and
(x_E) = **0.66 ±0.01 ±0.02,**

where the first error is statistical, and the second is systematic. Our measurement agrees with the expected partial width in the Standard Model, Γ_{b6} = **378** MeV (for M_z = **91.164** GeV, A_s = **0.115,** M_{top} = **130** GeV, and M_{Higgs} - **100** GeV **[10]).** We can also express our result in terms of the ratio of bb events to all hadronic events. Our measurements yield:

$$\frac{\Gamma_{b\bar{b}}}{\Gamma_{hadrons}} = \mathbf{0.210} \pm 0M2\{stat + sys) \pm 0.014(6.r.).$$

Our measured value of this ratio agrees with the Standard Model expectation $\Gamma_{bb}/\Gamma_{hadrons}$ **= 0.217.**

Alternatively, we can assume the value of T_{bb} = **378 ± 6** MeV predicted by the Standard Model, and convert our result into a measurement of the branching ratio of B-hadrons into muons:

$$Br(B \to FI) = \mathbf{11.6\% \pm 0.4\% \pm 0.4\%},$$

where the first error is statistical, and the second is systematic, which includes the uncertainty on the prediction from the Standard Model.

As an additional check of the validity of the description of the b-quark fragmentation by the Peterson function, we performed a parameterization-free fit to the data. In this fit the fragmentation function is represented by its value in six x_E bins. These six parameters are allowed to vary freely with the constraint that their sum should be one. In this case we find (x_E) = **0.67** ± **0.02,** in agreement with the previous fit. Figure **4** shows the result of such a parameterization-free fit compared with the fit to the Peterson function and with the result from The JADE experiment **[8].** The good agreement between the data points and the Peterson function confirms the validity of such a parameterization of the fragmentation as a function of x_E, even in the presence of large scaling violations due to the radiation of hard and soft gluons. The effect of such "parton showering" is evidentiated by the difference between the x_E spectrum at PETRA and LEP, the latter being softer than the one at lower energy.

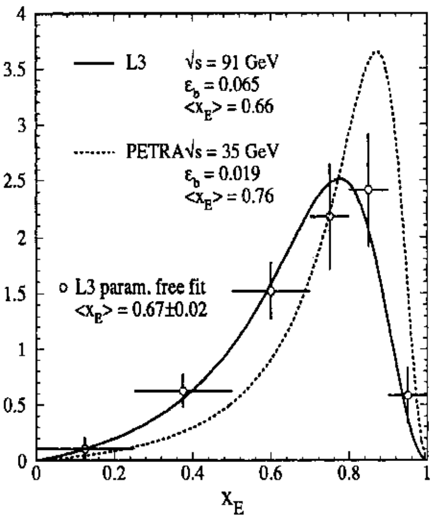


Figure 4: *b quark* **fragmentation** *function.* **Data** *points are the result of the parameterization-free fit to the L3 inclusive muon data described in the text. The full line curve is the Peterson function fit to our data. For comparison the result from* **a Petra experiment** *[8] is also shown.*

Conclusions

From a sample of 3198 inclusive muon events out of 65379 Z° hadronic decays, we have measured the partial decay width of Z° into bb

$$\Gamma_{b\bar{b}} = 367 \pm 12 \pm 18 \pm 33 \text{ MeV}$$

and the average energy fraction carried by the B-hadron in the b-quark jet fragmentation at *y/s «* 91 GeV

$$\langle x_E \rangle \equiv \frac{2\langle E_B \rangle}{\sqrt{s}} = 0.66 \pm 0.01 \pm 0.02.$$

Assuming $\Gamma_{b\bar{b}}$ = 378 ± 6 MeV, as expected by the Standard Model, this result corresponds to a measurement of the branching ratio of the B-hadrons into muons:

Br(B ->/i) = 11.6% ± 0.4% ± 0.4%,

in good agreement with previous measurements performed at PEP and PETRA.

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DELPHI-Results on the Z^0 Partial Widths into Heavy Quark Pairs

The DELPHI Collaboration

Presented by W. Adam
Institut für Ilochenergiephysik d. OAW, Nikolsdorferg. 18, Vienna, Austria

ABSTRACT

Measurements of **the partial widths of the $Z°$ into c and b quark pairs have been performed using data from** scans **around the $Z°$ peak.** The **results,** r£ = **(282 ± 103) *MeV* and = (367 ± 76) *MeV'*, are in agreement** with the predictions of the Standard Model.

Detector and Event Sample

DELPHI is a general-purpose detector covering a large fraction of the full solid angle with tracking and calorimetry [1]. The components relevant for this analysis are the tracking detectors in the barrel region: The *Inner Detector* and the *Outer Detector* are drift chambers measuring *R§* at radii of 12 *cm* - 28 cm and 198 cm-206 cm respectively. The *TPC* provides up to 16 space points/track at radii of about 35 cm - 110 cm.

The analysis is based on data collected during scans around the **Z°** peak from September 1989 to May 1990. Only information from the reconstruction of charged particles was used. To ensure the quality of the reconstruction of charged tracks cuts were defined by

- a minimum angle w.r.t, the beam axis
- a minimum momentum
- a. minimum length inside the *TPC*
- a maximum distance to the nominal interaction point both || and *1* to the beam axis

The Decay in c Quark Pairs

The analysis is based on the excess of *low--*p_t tracks in *cc* events compared to other hadronic channels [2]. The c *(c)* quark fragments with high probability into D*⁺ *{D*~*)*, which in turn decays with a branching ratio of about 50% into *D°w*⁺ **(/}°7T)** [3, 4]. As a consequence of the low Q-value of this decay the transverse momentum of the w.r.t. the D** is limited to about 40 *MeV/c,* Since the observed quantity is the transverse momentum w.r.t. the jet axis the distribution is smeared due to the error in the determination of this axis and to its difference compared to the *D**^-direction. Fig. 1 shows the enhancement of the ^-distribution in the low p_t region for *cc* events compared to a mixture of *uû, dd, ss* and *bb* events.

Event Selection

Hadronic events were selected requiring at least 5 charged particles and a lower limit for the invariant mass of all charged tracks of 12 GeV/c^2. The resulting sample consists of 36900 events.

For the clusterization into jets the standard LUCLUS algorithm was used [5]. In order to enhance the low p_t signal from **A^'S** the jet axis was defined as the thrust axis calculated with momentum squared weight.

The requirements for **TT***-candidates were

- *Lb GeV/c* < *p* < 2.5 *GeV*
- closest approach to the nominal interaction point in the transverse projection < *2 cm*

The corresponding jet had to have

- at least 3 charged particles, one of them with a higher momentum than the **TT***-candidate
- a polar angle with |cos6j$_{et}$| < 0.8
- a total energy of charged particles in the jet > 90% of the energy of all charged particles in the same hemisphere (as defined by the sphericity axis)

The selection described above was also applied to a sample of 34500 *qq* events, generated with the JETSET 6.3 Parton Shower Monte Carlo [5] and including the full detector simulation.

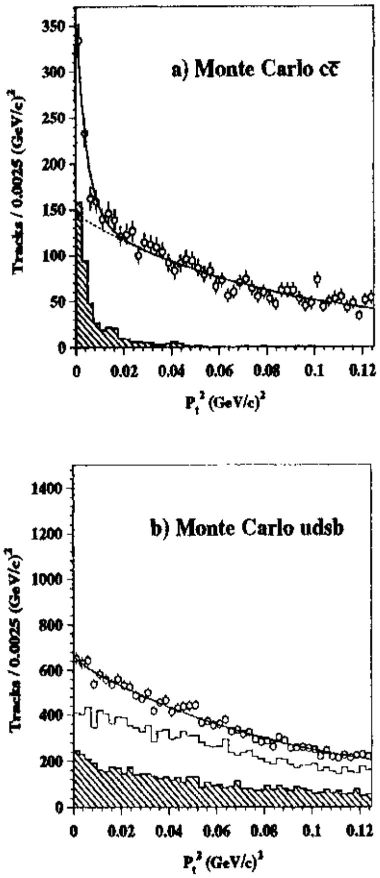

Figure 1: **Monte Carlo distributions of *p]* (fitted using function *S* -f *B\)*, originating from a) ce events, the dashed line is the extrapolation of Z?i, the hatched area is the signal from x's in the *D**-decay considered; b) 66 (hatched histogram), tm,drf,$s (hollow histogram) and the sum (circles)**

Analysis and Results

The calculation of the relative branching fraction was done in 3 steps:

- parametrization of the signal using Monte Carlo
- fit of signal and background to the p\-distribution of the data sample, keeping the signal shape fixed and estimating the background parameters and the normalization factors
- correction for inefficiencies

The signal was parametrized according to

$$S(p_t^2) \sim 1/A^2\, e^{-p_t^2/A^2}$$

For the background two different parametrizations were used:

$$B_1(p_t^2) \sim \alpha_1 + \beta_1\, e^{-p_t^2/\gamma_1}$$
$$B_2(p_t^2) \sim \frac{\alpha_1}{1 + \beta_2\, {p_t}^2 + \gamma_2\, {p_t}^4}$$

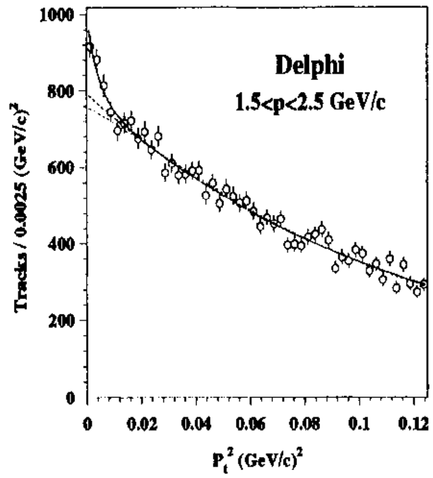

Figure 2: **Distribution ofpf for 36900 hadronic events. The solid line corresponds to a fit using *S* + the dashed and dashed-dotted lines to the extrapolations of *B* resp. B_2-**

In order to check systematic effects the distributions from real data and Monte Carlo events were fitted using both background parametrizafcions. The results are summarized in Table 1 and shown in Figure 2.

An alternative way to determine the fraction of low-pt fl-*'s is to use the high p_t region to fit the background parameters and to obtain the size of the signal by subtracting the extrapolation to low p_t from the observed distribution. The resulting signal is consistent with that quoted in Table 1.

The relative branching fraction

$$R_{c\bar{c}} := \frac{\sigma(Z^0 \to c\bar{c})}{\sigma(Z^0 \to hadrons)} \tag{3}$$

can be expressed as

$$R_{c\bar{c}} = \frac{N_S/\epsilon_S}{\epsilon_{c\bar{c}}} \times \frac{\epsilon_h}{N_h} \tag{4}$$

where the index *h* denotes the number and efficiency for hadronic events, *cc* the efficiency for cc events and *S* the size and efficiency for the reconstruction of the signal. For the selection criteria used €*h* and e_cc are practically equal *(ch/cc* — 1-000 ± 0.005 from Monte Carlo), whereas 65 can be expressed as a. product of

- the probability to produce n^'s via the selected channel: based on results at lower ***fs** [3, 6] Pi = 0.31 ± 0.05,
- the probability for such a 7r to be reconstructed and to pass the cuts: from Monte Carlo P_2 = 0.27 ± 0.02,

Table 1: **Fit results for signal size and slope using Monte Carlo and real data**

Function	$c \to D^{*+} \to D^0\pi^+$ and c.c.	$c\bar{c}$ only	no $c\bar{c}$	Real Data
	Monte Carlo			
S	$N = 366 \pm 22$ $A = 65 \pm 3\ MeV/c$	—	—	—
$S + B_1$	—	$N = 392 \pm 38$	$N = 28 \pm 60$	$N = 279 \pm 56$
$S + B_2$	—	$N = 360 \pm 45$	$N = 12 \pm 64$	$N = 354 \pm 63$

- and the part of these 7r's contained in the fitted signal: from Monte Carlo $P_3 = 0.78 \pm 0.05$.

This results in a branching fraction of

$$R_{c\bar{c}} = 0.162 \pm 0.030\ (stat) \pm 0.050\ (syst) \quad (5)$$

Using the measurement of the hadronic width of the $Z°$ [7] this corresponds to

$$T_cc = 282 \pm 53\ (stat) \pm 88\ (syst)\ MeV \quad (6)$$

The Decay in b Quark Pairs

The 66-channel can be characterized by its special event shape distribution caused by the high mass of the decaying particle [8]. This can be quantified by the boosted sphericity product $S_1 \times 5_2$, a variable already used by other experiments to obtain enriched samples of hadrons containing b quarks [9], Since this quantity involves the product of the sphericities of both jets it is sensitive to events with heavy particles in both hemispheres and the transformation to the approximate rest frame of such particles enhances this effect.

Event Selection

Hadronic events were selected requiring

- t £ $E > 3$ GeV" for each of the hemispheres defined by the polar angle
- X) $E > 15\ GeV$ for the sum of both hemispheres
- at least 5 particles with $p > 0.2\ GeV/c$
- $40° < Q_{SPHER} < 140°$

where the sums extend over all charged tracks. Out of these only 2-jet events according to the JADE minimum rescaled invariant mass algorithm[1] were retained [10]. The resulting data sample consists of 17747 events.

[1] **using $y_{cut} = 0.08$**

Analysis and Results

Using the JETSET 6.3 Parton Shower Monte Carlo [5] with symmetric fragmentation functions « 20000 $Z°$ decays into u,d,s,c and b quark pairs were generated and processed by the detector simulation. This is known to reproduce the distribution of various topological variables of the hadronic data sample well [12].

The optimum sensitivity on the contents of 66-events was found using /? = 0.96 in the calculation of the boosted sphericity product (Fig. 3). The appropriately normalized Si x S_2-distributions for 66 and non-66 events in the range $0.1 < SIXS_2 < 0.5$ were then fitted to the observed one (Fig. 4) by a single parameter least squares fit, resulting in a relative branching fraction

$$D_{ob} := \frac{a(Z° \quad 66)}{(T(Z° \to hadrons)} = 0.209 \pm 0.030\ (stat) \quad (7)$$

The model dependent systematic error was estimated using two other Monte Carlo samples:

- JETSET 7.2 parton shower with Peterson fragmentation functions, the fragmentation parameters for c and b quarks $e_c = 0.024$ *loml* and $€_b = 0.006$ ±SSo3 [11] were allowed to vary within *la*-intervals
- JETSET 7.2 matrix element retuned with Peterson fragmentation functions using the parameters of Ref. [12]

An additional contribution to the systematic error originates from the uncertainty on the determination of the $Z° \to cc$ branching fraction. Finally one obtains

$$Rg = 0.209 \text{ db } 0.030\ (stat) \pm 0.031\ (syst) \quad (8)$$

With the measurement of the hadronic width of the $Z°$ [13] this corresponds to

$$\mathbf{r}, F = 367 \pm 76 MeF \quad (9)$$

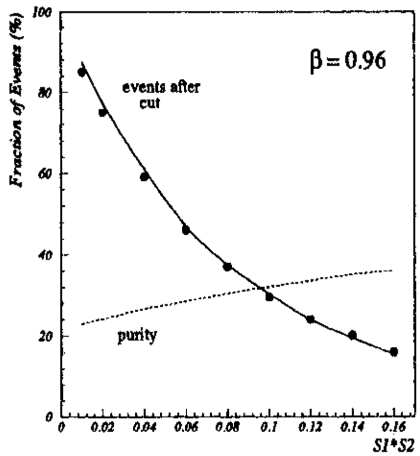

Figure 3: **Fraction of events passing a $S\backslash \times 52$ cut for data (full circles) and Monte Carlo (solid line) and the optimized parameter /3 for the Lorentz transformation. The dashed line shows the 6 purity of the sample.**

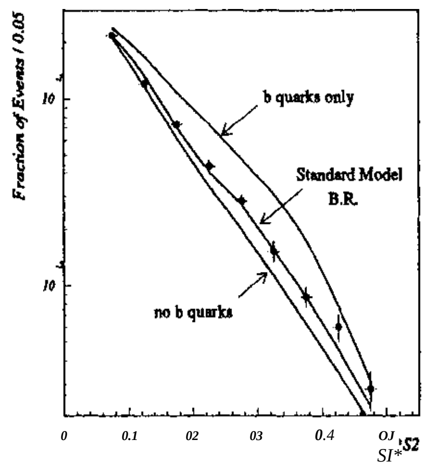

Figure 4: **Differential $S\backslash$ X 52 distribution for data (full circles) and simulation with a fraction of 66 events of 0%, 21.7% (Standard Model) and 100%.**

Conclusions

Inclusive analyses of the branching fractions of the $Z°$ into c and b quark pairs relative to the total hadronic cross section have been performed using data from the first two data taking periods at the LEP collider. The results,

$$R_{c\bar{c}} = 0.162 \pm 0.030\ (riot) \pm 0.050\ \{syst)\ \text{and} \quad (10)$$
$$R_{b}\hat{\imath} = 0.209 \pm 0.030\ (stai) \pm 0.031\ (syst),$$

show agreement both with the expectations of the Standard Model and with other recent measurements [11, 14].

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DISCUSSION

Q. **A. Roussarie** *(Saciay):* You are fitting an exponential for the signal. The D* signal has in fact tails because part of the time the *D** axis is wrongly determined (neutrals, hadrons from fragmentation). Do you take that into account?

A. **W. Adam** : Yes it enters through a correction to the rate.

MEASUREMENT OF THE Z° COUPLINGS TO QUARKS WITH THE OPAL DETECTOR AT LEP

A. JAWAHERY

Department of Physics, University of Maryland,
College Park, MD 20742, U.S.A.

Representing The OPAL Collaboration

Abstract

Based on an analysis of inclusive muons in hadronic decays of Z° detected with the OPAL detector at LEP, we present a measurement of the partial width and forward-backward asymmetry for the process Z° -+ 65. We also report on a measurement of the partial widths for Z° $q_u q_u$ and $Z^\circ \rightarrow q_d q_d$, where q_u and q_d stand for u-like and d-like quarks respectively, infered from the measured rate for final state photon radiations in hadronic Z° decays.

1 Introduction

The recent data, from LEP and SLC have provided precision measurements of the Z° total width as well as the partial widths into lepton pairs and into hadrons. With these results the number of neutrino generations and the Z° coupling to leptons have been determined[l]. Determination of the Z° coupling to quarks provide additional test of the predictions of the standard model and an independent measurement of $\sin^2 0_w$. In particular a precision determination of the partial width for $Z^\circ \longrightarrow bb$ has been proposed as an important test of the radiative corrections in the electroweak model[2]. In this article, I will report on a measurement of the partial width and the forward-backward asymmetry for the process $Z^\circ \longrightarrow bb$. The measurement is based on an analysis of inclusive muons in data recorded with the OPAL detector at LEP. We have also obtained a measurmeut of the Z° partial widths into u-like and into d-like quarks from a measurement of the rate for final state photon radiation in the reaction $Z^\circ \longrightarrow qq$. The data used in this analysis corresponds to 72,000 hadronic events at and around the Z° peak collected with the OPAL detector at LEP.

2 The OPAL detector

The OPAL detector has been described in detail in our recent publications[4].

Briefly, the main components are a central tracking system which consist of a jet chamber, a vertex detector, and a z-chamber positioned inside a solenoidal coil, surrounded by a time-of-flight counter array, a lead glass electromagnetic calorimeter and presampler, return yoke of the magnet instrumented with 9 layers of streamer tubes, forming the hadron calorimeter (HCAL), and the outer muon chambers. The outer muon chambers together with the hadron calorimeter form the muon identification system.

3 Event Selection and Identification of Inclusive Muons

The selection criteria for hadronic events is described in our recent publications[5]. Here we also impose several conditions on the quality and the number of charged tracks in the events, to suppress various background contributions.

Inclusive muons are identified by associating central detector tracks to track segments in the muon subdetectors. Track segments are straight lines reconstructed independently in each subdetector, from strip clusters in the HCAL layers, two dimensional hits in the muon barrel drift chambers and in the muon endcap streamer tubes. For this analysis we also require that tracks be in the angular range $|\cos Q| < 0.9$.

The overall efficiency for the muon selection criteria is estimated from muon pair events, with corrections applied to account for the effect of the presence of nearby hadronic activity in the multihadronic events. The overall efficiency is found to be 81.0 ± 2.5%. Hadronic contamination in the muon candidates is determined by using Monte Carlo simulated multihadronic events in the OPAL detector. We find an overall fake rate of 1.3% per track for muon candidates of momentum $p > 3.0$. The reliability of the Monte Carlo predictions for the background rate is checked by measuring the muon fake probability for pions selected using kinematically identified K_9 ~> *w^w~* decays. We find a fake rate per pion of 0.9 ± 0.15% in data as compared with 0.85 ±0.1% for Monte Carlo simulated events. We assign a systematic uncertainty of 25% to the Monte Carlo predictions of the background rate.

4 The Partial Width *T{Z° -* bb)*

Inclusive muons in hadronic decays of *Z*° originate from several sources as described in the following, (a) Semileptonic decays of b- hadrons where, *Z*° —• 66, 6 ~> (b) the cascade process where *Z*° —*y* 66, followed by the decay chain, 6 -> *c* —> (c) semileptonic decays of charmed hadrons where *Z*° —> cc, c —> and (d) hadronic fake contamination which includes muons from decays of light hadrons. Muons from b quark decays are distinguished by their characteristic distributions in momentum and transverse momentum, pr, relative to the direction of the parent hadron. The hard fragmentation of the b quark and its large mass gives rise to hard distributions in momentum and transverse momentum for muons. Monte Carlo simulations show that the charm and the cascade decays yield considerably softer distributions in both variables.

We identify 7029 events containing a muon candidate track. In each event charged tracks are grouped into jets using the JADE jet finding algorithm^]. The thrust axis of the jet containing the muon candidate track is used as an estimate of the direction of the parent hadron. The transverse momentum, pr, of the muon candidate is then calculated with respect to this axis. In order to insure that events are well contained we require *\cos0*$_{ja}$** < 0.8.

The distribution in *p?* for muon candidates with momenta greater than 4.5 GeV/c is shown in Fig. la. This momentum cut was determined from Monte Carlo studies to suppress the contributions of the charm and cascade reactions. Fig. lb shows the momentum distribution of the muon candidates. Overplotted in Figs, la and lb are the Monte Carlo predicted distributions for the inclusive muons assuming standard model values for the partial widths for *Z*° -> 66 and *Z*° ~^ *cc*. The LUND shower Monte Carlo JETSET7.2 **[7]** with the Peterson parametrization for the fragmentation function was used for the simulation of heavy quark events.

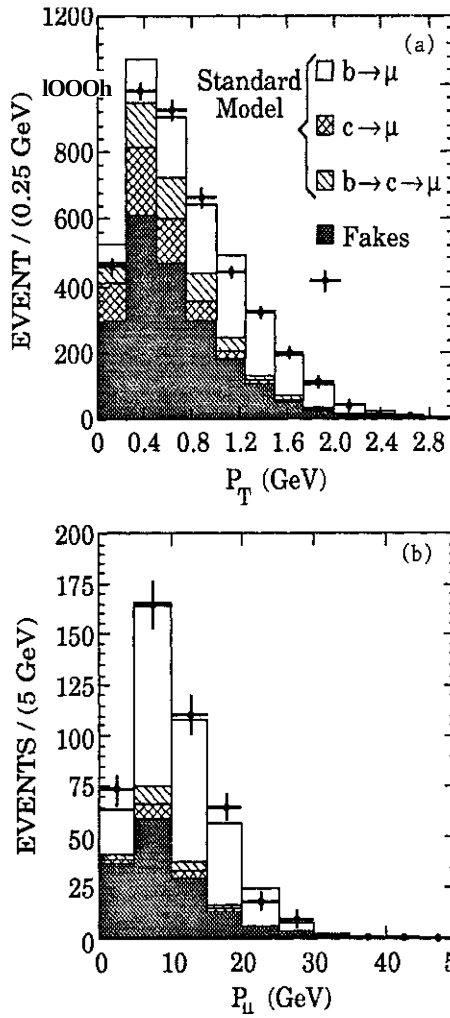

Fig. 1: (a) ***PT*** distribution of muon candidates with $p > 4.5$ GeV/c, (b) Momentum distribution of muon candidates with $pr > 1.5$ GeV/c.

In order to determine the number of muons from b decays we make use of the high ***PT*** region, ***PT*** > 1.0 GeV/c where the contributions from the charm and cascade reactions are further suppressed. The fraction of the b quark events is determinée! using,

$$_T z \quad W \quad \wedge o)_{x \; i \; ? \; x \; (1 + / \hat{u} cc / 6r)}$$

where Fjf is the total $Z°$ hadronic width; iV(/i), AT*, and i\T^afce are the observed number of muons, the predicted number of muons from charm decays and the number of hadronic fakes, respectively. *N(Z°)* is the total number of *Z°* events, and ***i*l*** accounts for the muon identification efficiecny, event selection and kinematic acceptances, The last term in the denominator accounts for the contribution of the cascade component, where = *B(b -> c -> fi)/B(b -* ft)* and f_{acc} is the ratio of the kinematic acceptances for muons from direct b quark decays and cascades. We use /&r = 1.05 as reported in reference [8] and and f_{acc} = 0.106 estimated from Monte Carlo studies. The charm contribution is estimated by using the prediction of the standard model for *T(Z° -+* cc)/Ff=0.17 [2] and < *B(c -» fi)* >= 0.10, obtained from an average of the PEP/PETRA measurements.

A free parameter of the Monte Carlo predictions is the fragmentation parameter e&. By comparing the measured mean momentum of the muon candidates with ***PT*** > 1.5 GeV/c with that predicted by the Monte Carlo simulations we determine $< X_B >= 2 < p_B > /s$ = 0.70 ±0.025, where ***PB*** is the mean momentum of the B hadron. This corresponds to = 0.0038ÎS5ot

We find, **(r**(Z° ~> 66)/Tf)xB(6 -> **,i)** = 0.0206i 0.0008 ± 0.0025. The errors are statistical and systematic, respectively. The systematic error accounts for the effect of the uncerainties in the normalization of hadronic contamination, the predictions of the cascade and the charm components and the fragmentation parameters. The hadronic fake uncertainty is by far the largest contributor to the systematic error. Varying the charm and cascade components by 50% results in less than 3% change in the result.

In order to extract the value of the hadronic branching ratio *B{Z°* 66) - *T{Z°* -> **66)/rf** from the above measurement we need to know the average semileptonic branching ratio < *B(b —> fx* >. The current measurements are from the experiments at the **T**(45) and from the PEP and PETRA experiments at center of mass energies around 30 GeV. At LEP energies the composition of b-hadrom may be different from those at LEP energies. This combined with a possible difference in the lifetime of the various b-hadron species could result in a different value for the average semileptonic branching ratio. However, in the absence of a direct measurement at LEP and in order to compare our results with the standard model, we use the measurement at the **T(45)** of *B(B -> pX)* = 10.2 ± 0.2 ± 0.7 [8]. This gives, *B{Z°* -> 66) = 0.204 ± 0.008 ± 0.025, consistent with the standard model prediction of *B{Z°* -> 66) = 0.217. Using the measured hadronic width *T%* = 1778 ± 26[1], we find r(Z°->&&) = 363 ±47MeV.

5 The Forward Backward Asymme-

The angular distribution of the reaction e^+e^-~ -* *Z°* —» 66 is described by

$$da/d\{cos9\} \propto (1 + cos^2 9 + \{8/Z\}A(^B cos9) \quad (1)$$

where *9* is the angle between the outgoing b quark and the incoming electron beam, and $A\%^B$ gives the the forward-backward asymmetry of the reaction.

Since $A(^B$ is dependent on the center of mass energy, we restrict this analysis to the sample collected at the *Z°* peak, corresponding to **50,000** events. The off peak data is statistically too small to yield a meaningful measurement at this point. In this analysis, we use the thrust axis of the event for estimating the angle *9.* The flavor of the b quark is tagged using the sign of the electric charge of the muon candidate, *Q^.* In Fig. **2** is shown the distribution in *-Q^cos9* for the muon candidates in the kinematic region *p* > **4.5** GeV/c and p_T > **1.0** GeV/c, after subtraction of the background effects and correction for the *cos9* dependence of the identification efficiency. Fitting this distribution to the equation **(1)** and correcting for the angular acceptance of the analysis (|eos0| < **0.8),** gives **i4£^B(0) = 0.02 ±0.08.**

In order to compare with the standard model predictions, the observed forward-backward *A(^B(0)* must be corrected for the effect of, *B°B°* mixing. Mixing, where *B°* -> *B°* ~~> has the effect of reducing the true asymmetry by a factor of (l-**2x),** where % is the average mixing rate defined as, % = *(B-**4B-*** i$^+$)/((B -> *B* -> + - > *B* - > *I')).* The mixing for the mesons have been measured by the CLEO and ARGUS collaborations to be ***X*** **= 0.17 ± 0.05[9].** At LEP energies however, the effective mixing rate is an average of mixing in the *Bd* and B_s meson. Given the large mixing in the *Bj* system, the mixing in the B_s mesons is expected to be maximal. By assuming a production ratio of 35%i?$_d$, 35%5$_u$, 15%5$_s$ and 15%J?$_{baryon}$, we expect the average mixing rate for the b-hadrons to be X = 0.130. This gives $A\{^B$ = 0.027 ± 0.11, consistent with the standard model prediction at the $Z°$ peak of 0.10.

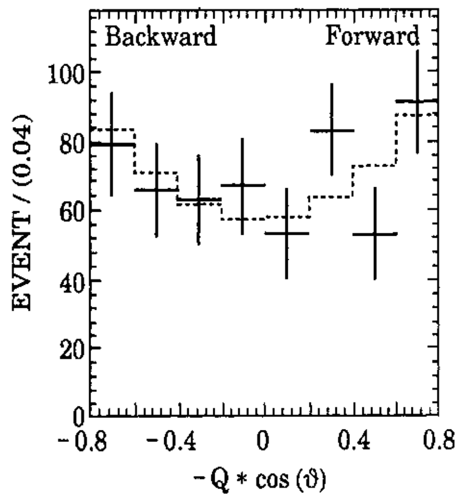

Fig. 2: The distribution in *-Q^cosê* of the muon candidates after background subtraction.

6 Final State Photon Radiation

By using the measured total hadronic width (F^) and a measurement of the rate for final state photon radiations in hadronic $Z°$ decays, we have determined the partial widths for $Z°$ decays into u-like and into d-like quarks[10]. In this analysis we make use of the fact that *T(Z° -> qq)* oc *(a^2_q* + V g) , where as the rate for final state photon radiation in the reaction $Z°$ —• *qq{^)* is proportional to *{Qq)^2{a* + vj), where Q_q is the electric charge of the quark. Assuming the same electroweak couplings *(a$_v$ v$_q$)*, for all u-like(2/3 charged) quarks and for all d-like (1/3 charged) quarks, the above argument yields the following two equations,

r (Z ° ^ ^ $_7$) o c 3 (l / 3) ^{2} Q + 2(2/3)^{2}c$_n$,

and

Y(Z° —» hadron) oc 3**q** + 2c$_u$

where c_d = *a* + *v* and c_u = $a^2_u + v^2_u$.

Final state radiation events are identified by selecting events containing an isolated, energetic photon in the detector. The photon candidate is required to have an energy of at least 10 GeV, to have a transverse momentum P^, calculated with respect to the event thrust axis, of greater than 5 GeV, and be isolated from any charged track and electromagnetic cluster within a cone of half angle 20 degrees. Cuts are also applied on the transverse profile of the photon candidates to reduce backgrounds from neutral hadrons and 7r°'s.

In 50,000 hadronic decays used in this analysis, we find a total of 78.0 candidate high energy, isolated photon events. The main background components are from fragmentation debris and initial state radiation. Using Monte Carlo studies we estimate a contribution of 8.0 ± 5.0 events from the fragmentation background and 5.1±1.4from initial state radiation. The remaining 61.9 ± 10.2 events are consistent with the predictions for the yield of final state photon radiation of 61 ± 2.6 events.

Using the measured yield for photons and *Th$_e$d* = 1778 ± 26 MeV[l], we find F(Z° -> *uxt)* = 330 ± 99 MeV, and *T{Z°   dd)* = 369 ± 67 MeV. The latter is consistent with our direct measurement of the rate for *Z°* —* 66.

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Q. F. Couchot*(LALf Orsay):* What is the size of systematica on the potential width measurements to like and unlike quarks using *qqf* final states?

A. N. Jawahery: Presently, the errors are dominated by statistics. The systematics come mainly from the background modélisation (photons arising from hadronic fragmentation).

Coupling of the Z to *bb* and *cc* and *B-B* Mixing

Robert P. Johnson
Department of Physics, University of Wisconsin
Madison, Wisconsin 53706 U.S.A.

Abstract

Using the **ALBPH** detector at **LEP**, we have obtained from measurements of prompt leptons in *Z* decays results on the rates of **66** and *cc* production, *B-B* mixing, and forward-backward charge asymmetry in *Z* **-» 66.** We find Br**(6** e). *T^/T*$_M$ = **0.0224 ± 0.0016 ± 0.0010,** and Br(c -» e) • *T*$_c$*/T*$_{hBd}$ = **0.0133 ± 0.0040**îgggff. The mixing result is expressed as a probability **x»** averaged over all **6** hadrons produced at **LlP,** for a **6** hadron observed to decay to have originated as a **6** hadron, giving *%* **= 0.129** îo**.*044**- The forward-backward asymmetry in **66** production is measured to be *A^*$_B$ **= 0.181 ± 0.073 ± 0.059,** after correcting for mixing according to our measured value of **x«**

Introduction

The large number of *Z* bosons produced at **LEP** in the clean environment of e$^+$e" collisions provides the first opportunity to study in detail the decays of the *Z* to **6** quarks and also provides a rich source of *b* hadrons that is complimentary to the T(45) decays extensively studied at **CESR** and **DORIS.** The analyses presented here employ the excellent electron and muon identification capabilities of the **ALEPH** detector to tag heavy hadrons by their semileptonic decays. Decays of *c* hadrons are distinguished from those of *b* hadrons by the relatively large transverse momentum, *p*±$_J$ with respect to the jet direction of the leptons from *b* decay. The production rates of leptons from both c and *b* hadrons are measured by fitting the observed lepton spectrum in the *p-p*± plane. This provides essential input for all of the further analyses and also allows one, by using values of other experiments for the semileptonic branching ratios of c and *b* hadrons, to verify the predictions of the Standard Model for the branching ratios of *Z* —• *cc* and *Z* -+ *bb.*

The level of mixing of **6**-hadrons is sensitive to some of the remaining unknown parameters of the Standard Model, such as the mass of the top quark and elements of the Cabibbo-Kobayashi-Maskawa (CKM) matrix involving the coupling of the top quark [1]. *B4* mixing has been measured at the X(45) [3] and found to be large, leading to expectations that *B*$_s$ mixing is close to maximal. The large amount of data expected from **LEP** in the next few years promises to provide a clear measurement of *B*$_s$ mixing. Here we present preliminary results on *b* mixing, from roughly half of the present **ALEPH** data sample, obtained from an observation of an excess in the number of like-sign lepton pairs in events with two high-pi leptons.

The forward-backward charge asymmetry in *Z* *bb* promises eventually, with the full statistics from **LEP,** to give a measurement of *sin*^{2} *9w* which is competitive with other methods, thus providing an important test of the Standard Model. Here we present a preliminary analysis of *A$*$_{B}$ from roughly half of the present **ALEPH** data sample, in which the charges of electrons and muons from semileptonic decays are used to distinguish between the *b* quark and the anti-i quark.

Apparatus

The **ALEPH** detector has been described in detail elsewhere [4]. Here only a brief mention is made of those components used in this analysis. The inner drift chamber (ITC) and the time projection chamber (TPC) are used for charge particle tracking within the range |cos *0* < 0.95, where *6* is the polar angle. With the 1.5 Tesla axial magnetic field, they measure momentum with a resolution, measured from dimuon events, of *8p/p*^{2} = 0.0008 (GeV)$^{-1}$. The TPC also provides up to 330 measurements of the specific ionization *(dE/dx)* of each charged track, giving a resolution, measured in in hadronic events, of 5.0% for 330 ionization samples. The electromagnetic calorimeter (ECAL), which surrounds the TPC but is inside the coil of the superconducting solenoid, is used, along with the TPC, to identify electrons. It covers the angular region |cos0| < **0.98** and is finely segmented into projective towers, each subtending an angle of **1°** by **1°** and read out in **3** samples in depth. Muons are identified by the hadron calorimeter (HCAL), composed of the iron of the magnet return yoke interleaved with **23** layers of streamer tubes, and the muon chambers, an additional **2** layers of streamer tubes surrounding the calorimeter.

Event Selection and Lepton Identification

Hadronic events are selected by requiring at least five charged tracks measured in the TPC which originate from near the interaction point, with a total of at least **20%** of the c.m.s. energy **[5].** This gives a sample of about **23,000** events from the **1989** data set and about **57,000** from the first half of the **1990** data set. Jets are found using the scaled-invariant-mass clustering algorithm **[6]** with charged tracks only. Only events with at least two jets are accepted. The *p±* of a lepton is then determined by subtracting the lepton's momentum vector from that of the jet and calculating the momentum of the lepton transverse to the resulting axis.

The identification of leptons with the **ALEPH** detector has been discussed in detail elsewhere **[7].** In cases where high background rejection is important, such as fitting the lepton spectrum at low pi, all electron candidates are required to have at least **80** isolated TPC wire hits for *dE/dx.* Requiring both the *dE/dx* and the calorimeter energy deposit to be consistent with an electron then results in a hadron rejection ranging from **4 • 10~^{4}** at p = **2.5** GeV to **2 • 10"^{3}** at p = **15** GeV. In the analyses of asymmetry and mixing, where only high pi leptons are considered, the *dE/dx* is used only as a veto, with no requirement on the number of wire hits, giving an efficiency of **(80 ±2)%** and a hadron rejection, in case only ECAL information is available, of **6 • 10~^{3}.** For the **1989** data the muon identification is restricted to the barrel region of the HCAL, while for the later data the HCAL endcaps and the muon chambers are included. The muon chambers are treated as an additional layer to the HCAL, with the advantage of giving a **3**-D point for each muon, rather than a **2**-D point as given by each layer of the HCAL. The muon identification efficiency is typically **(83 ± 3)%** with a hadron rejection of **1.1 • 10*^{2}.**

The *cc* and 66 Fractions

The rates of cc and **66** production in hadronic events have not yet been measured from the full data sample, but results have been published in Ref. **7** for the **1989** data sample. Since the background rejection is much better for electrons than for muons, only electrons were included in a **4**-parameter fit to the p-pi spectrum for p > **2** GeV and pi > **0.** The *cc* and **66** fractions and the average *XE* = **^hadron/^bcam** for c and **6** hadrons were allowed to vary freely. The muon data were fit only in the region p > **3** GeV and pi > **2** GeV. The results are

Br**(6**-> e) • **r**$_{bg}$**/r**$_{had}$ = **0.0224 ± 0.0016 ± 0.0010**

Br(c^e)**.'r**$_{cc}$**Vr**$_{httd}$ = **0.0133 ± 0.00401°$_0$S**

(4) = 0.67ÎSS **(1)**

= **o**.52îS**:S.**

At the time of this conference, the analyses of **6** mixing and **66** asymmetry have been completed for a data sample almost four times larger than that used to obtain the results of Eqn. **1.** Preliminary fits of these data for pi > **2** GeV give a **66** fraction which is consistent with that given in Eqn. **1.**

B-B Mixing

B-B mixing has been studied by looking for an excess of like-sign dileptons in *Z* —• hadrons, as has been done at several lower-energy experiments **[2,3]** in order to measure the probability % that a **6** hadron which is observed to decay originated as **6** hadron. There are several backgrounds to the signal. *Z* —> cc contributes to the opposite-sign sample, while cascade decays, **6 —*** *c* —• *I,* contribute to the like-sign sample even if **x = 0.** In addition, fake leptons contribute to both the like and unlike-sign samples (from the data one finds that in the cases where a true lepton is paired with a fake, **55%** of the time they are of opposite sign).

To reduce significantly the background, we require that both lepton candidates have $p > 5$ GeV and $p_\pm > 1$ GeV. We then find a total of 202 lepton pairs, of which 67 are of like sign and 135 of opposite sign. From the fit of the p~p± spectrum of single leptons, along with Monte Carlo simulation, one can predict for each p-pi bin the relative probabilities of the signal and backgrounds. For the p, pi cuts mentioned above, we expect 187 ± 14 lepton pairs and predict that 66% are from events with two 6 -» I decays, 15% are from events with one 6 —• I and one 6 —> c —* t, 2% are from Z —> cc, and 16% are from fake or non-prompt leptons. If there were no mixing, then we would expect 42 like-sign pairs in the sample of 202 pairs observed. Thus a positive signal for mixing is seen, giving the preliminary result

v - n 100+0045 +0.016
A — V*'^-0.039 -0.020 > (2)

where the systematic error is dominated by uncertainty in the fraction of cascade decays but also includes significant contributions from uncertainty in the background levels and the 6 and c fragmentation.

The 6-hadron sample at LEP is a mixture of B<j, B_u, and B_s mesons plus some b baryons. Only the BD and the B_9 can mix, so the observed x must be a linear combination of contributions from the two neutral mesons:

X = XSFS + XDFD . (3)

If one assumes (from the **JETSET**-6.3 model [8]) that F_D = 0.375 and /, = 0.150, then the measurement x of Eqn. 2 combined with an average of the XD results from experiments at the T(45) [3], XI = 0.17 ± 0.04, gives $_x$. = 0.43î^. This is consistent with theoretical expectations that $\%_s$ is close to the upper limit of 0.5 [1], but the statistical error is still too large to rule out zero B_A mixing.

Forward-Backward Asymmetry

The asymmetry measurement has been restricted to the 55,000 hadronic events taken at the peak of the Z resonance. Only those leptons with $p >$ 3 GeV and $p_\pm >$ 2 GeV are considered, giving a sample in which 67% are from primary b decay. For each lepton, a value of cos 6_a is calculated from the polar angle of the event thrust axis times the sign of the lepton charge. The distribution of cos 6_a is fit to the form

f(e$_a$) oc (1 + cos^{2}0$_a$) + f^^b_B^{s}cos0$_a$ **(4)**

to extract the observed asymmetry A^fi = 0.069 ± 0.027. In Fig. 1 is shown the measured angular distribution with the fit to Eqn. **4** overplotted.

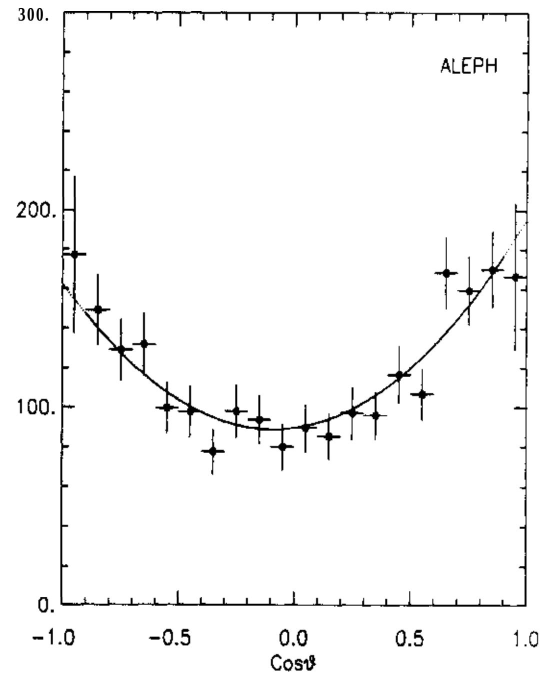

Figure 1: The distribution of the polar angle of the event thrust axis, signed by the charge of high-pi lepton. Overplotted is a fit to the function of Eqn. **4.**

The true 66 asymmetry is diluted by the background of non-prompt leptons, for which the data show no evidence of any asymmetry, the cc background, which gives an apparent asymmetry of the opposite sign from that of 66, the cascade decays 6 —> c t, which also give an effect of the opposite sign, and by B-B mixing, which reduces the observed asymmetry by a factor of (1 - 2%). To account for the cc contribution, we assume that the cc and 66 asymmetries are related by Ap_B = 0.73 • Ap_B, which follows from calculations of **i4p$_B$,** including radiative corrections, in the Standard Model at the Z pole, using the program **EXPOSTAR** [9]. After correcting for all of these effects, using our measured value of %, we find the preliminary result

4_B = 0.181 ±0.073 ±0.059, **(5)**

where the systematic error is due to uncertainties in the relative fractions of the cascade decays, leptons from primary c, and background leptons, uncertainties in c and 6 fragmentation, and the error on **x.**

Conclusions

For hadronic decays of the Z, we have measured, using inclusive lepton production, the 66 and *cc* fractions times semileptonic branching ratios, obtaining the values given in Eqn. 1. Averaging over previous measurements of the *b* and c semileptonic branching ratios (see Ref. 7 for a complete list of references used in the average), we assume Br(6 -> e) = 0.102±0.010andBr(c -* e) = 0.090± 0.013 to arrive at heavy-flavor fractions of r_{65}/r_{h}**ad** = 0.220 ± 0.029 and $r_{c?}/r_{had}$ = 0.148 ± 0.062. These compare well with the Standard-Model predictions of 0.217 and 0.171, respectively (assuming m_{top} = 150 GeV). We also have measured the forward-backward charge asymmetry in *Z* -> 66 to be Ap_{B} = 0.181 ± 0.094 (preliminary), which translates into an effective weak mixing angle of $\sin^2 d*_{w}$ = 0.218 ± 0.017. From events with pairs of leptons, we observe a signal for *B-B* mixing which is 3 standard deviations above zero and obtain a result for the average mixing probability of 6 hadrons from the *Z* of % = 0.129 j^JS (preliminary). This result is consistent with the Standard-Model expectations of maximal B_s mixing but does not rule out zero B_a mixing. In the near future, as more data from **LEP** become available, these results on asymmetry and mixing will be refined, resulting in much smaller statistical errors. The systematic errors also will decrease substantially, from use of more powerful jet définitions to obtain a more pure 6 sample, and from a better understanding of the background fractions and c and 6 fragmentation from the data themselves.

The results presented here are some of the fruits of a cooperative effort of about 360 physicists from 30 institutions, forming the **ALEPH** collaboration. We wish to express our appreciation to the technical staffs of **CERN** and the outside institutions for their support in constructing **ALEPH** and to the **LEP** division for the construction and operation of the accelerator.

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SELECTED CLEO RESULTS ON b-QUARK PHYSICS AT T(4S)

RONALD A. POLING
University of Minnesota
Minneapolis, Minnesota 55455 USA
and
AHREN J. SADOFF
Ithaca College
Ithaca, New York 14850 USA

ABSTRACT

We present new results on b-quark physics from studies of T(4S) decays with the CLEO detector. New B -meson exclusive decay modes are reported, as are updated charged and neutral B-meson masses. Studies of exclusive and inclusive semileptonic decays have yielded a new determination of \V^\ and other results. An improved measurement of the B-meson semileptonic branching fraction of approximately 10% is significantly below theoretical expectations. We review CLEO's evidence for non-BB decays of T(4S), and present a 95% confidence level upper limit on the overall fraction of such decays of 17%. Finally, we consider the implications of non-BB processes for the recent measurements of charmless semileptonic b decays.

The original CLEO detector continues to provide valuable insight into b-quark physics more than two years after it acquired its last event. In the first part of this report we describe several new results on exclusive and inclusive hadronic and semileptonic B-meson decays. The second part presents a review of the present understanding of non-BB decays of T(4S). A new limit on the rate for non-BB processes, based on the comparison of single-lepton and dilepton production in T(4S) decays, is presented. We also consider the implications of non-BB processes for last year's observation of charmless semileptonic decays of B mesons. The data sample for the results reported here is from CESR's very successful 1987 T(4S) run. During this run CLEO accumulated 212 *pb""* of e⁺e~ annihilation data at the peak of the resonance, and 101 *pb"* of continuum data at an energy 60 *MeV* below the resonance.

NEW DEVELOPMENTS IN B-MESON DECAYS

The roster of fully reconstructed B-meson decay modes grows steadily. CLEO has recently observed the decays B° -» D*+ aj", B° -> D+x+7r~"?r"~, and B~ —• D°7r+7r""7r"~. The masses of exclusive B and B~ candidates are shown in Fig. 1. Table 1 summarizes the exclusive branching fractions measured by CLEO, and for comparison, similar results from a previous CLEO analysis[2] and from Argus![3] We find the masses of the B mesons to be 5278.0 ± 0.4 ± 2.0 *MeV,* and 5278.3 ± 0.4 ± 2.0 *MeV,* for the neutral and charged mesons, respectively. The difference of the masses, -0.4 ± 0.6 ± 0.5, is consistent with zero, and suggests equal proportions of charged and neutral B mesons in T(4S) decays.

There are also newly reconstructed semileptonic decays in CLEO data!*[1] CLEO last year applied a technique first used by Argus, to study the decay B° -4D*+£~F, using the D*+£ missing mass spectrum![5] This year we have applied this approach to *D°l* and D+l combinations. Backgrounds are more severe, and we demand pD+>1.5 *GeV/c* to

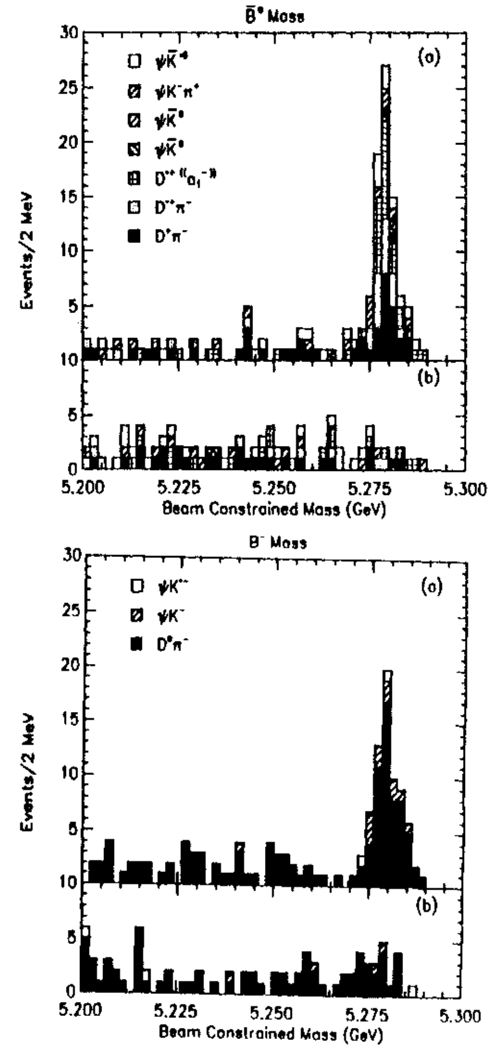

Fig. 1 Mass distributions for B° and B candidate (a) and sideband background (b) samples.

control combinatorics. The missing mass squared distributions are shown in Fig. 2. By fitting these with a Gaussian signal and the expected shape for background processes, we find exclusive semileptonic branching fractions (assuming 50% charged, 50% neutral B-meson production at T(4S)) of

Br(B~ -+D°/-F)=(1.6±0.6±0.3)%,

Br(B° ->D+/-F)=(1.8±0.6±0.3)%,

Br(B" -»D*°*-F)=(4.1±0.8±0.9)%, and

Br(B° -»D*+rF)=(4.6±0.5±0.7)%.

We infer from these that the vector to pseudoscalar

Mode	CLEO 1987	CLEO 1985	ARGUS
$B^- \to D^0\pi^-$	$0.50 \pm 0.07 \pm 0.09$	$0.54 \pm 0.17 \pm 0.11$	$0.20 \pm 0.08 \pm 0.06$
$B^- \to D^{*0}\pi^-$	$0.72 \pm 0.18 \pm 0.25$		$0.40 \pm 0.14 \pm 0.12$
$B^- \to D^{*+}\pi^-\pi^-$	< 0.4	$0.23 \pm 0.15 \pm 0.07$	$0.26 \pm 0.14 \pm 0.07$
$B^- \to \psi K^-$	$0.08 \pm 0.02 \pm 0.02$	$0.10 \pm 0.07 \pm 0.2$	$0.07 \pm 0.03 \pm 0.01$
$B^- \to \psi K^{*-}$	$0.13 \pm 0.09 \pm 0.03$		$0.16 \pm 0.11 \pm 0.03$
$B^- \to \psi K^-\pi^+\pi^-$	$0.12 \pm 0.06 \pm 0.03$		< 0.16
$B^- \to \psi' K^-$	< 0.05		$0.18 \pm 0.08 \pm 0.04$
$B^- \to \psi' K^{*-}$	< 0.35		< 0.49
$B^- \to D^0 D_s^-$	$1.8 \pm 0.6 \pm 0.8$		
$\bar{B}^0 \to D^+\pi^-$	$0.26 \pm 0.06 \pm 0.05$	$0.51 \pm 0.27 \pm 0.14$	$0.48 \pm 0.11 \pm 0.11$
$\bar{B}^0 \to D^{*+}\pi^-$	$0.40 \pm 0.09 \pm 0.09$	$0.27 \pm 0.13 \pm 0.08$	$0.28 \pm 0.09 \pm 0.06$
$\bar{B}^0 \to D^{*+}\rho^-$	$1.9 \pm 0.9 \pm 1.3$		$0.7 \pm 0.3 \pm 0.3$
$\bar{B}^0 \to D^{*+} a_1^-$	$2.6 \pm 0.5 \pm 0.6$		
$\bar{B}^0 \to D^0\rho^0$	< 0.1		
$\bar{B}^0 \to \psi \bar{K}^0$	$0.06 \pm 0.03 \pm 0.02$		$0.08 \pm 0.06 \pm 0.02$
$\bar{B}^0 \to \psi \bar{K}^{*0}$	$0.11 \pm 0.05 \pm 0.03$	$0.35 \pm 0.16 \pm 0.03$	$0.11 \pm 0.05 \pm 0.02$
$\bar{B}^0 \to \psi K^-\pi^+$	$0.10 \pm 0.04 \pm 0.03$		< 0.10
$\bar{B}^0 \to \psi' \bar{K}^0$	< 0.15		< 0.28
$\bar{B}^0 \to \psi' \bar{K}^{*0}$	$0.14 \pm 0.08 \pm 0.04$		< 0.23
$\bar{B}^0 \to D^+ D_s^-$	$0.75 \pm 0.21 \pm 0.32$		
$\bar{B}^0 \to D^{*+} D_s^-$	$1.5 \pm 0.9 \pm 0.7$		

Table 1 B-meson exclusive branching fractions (%).

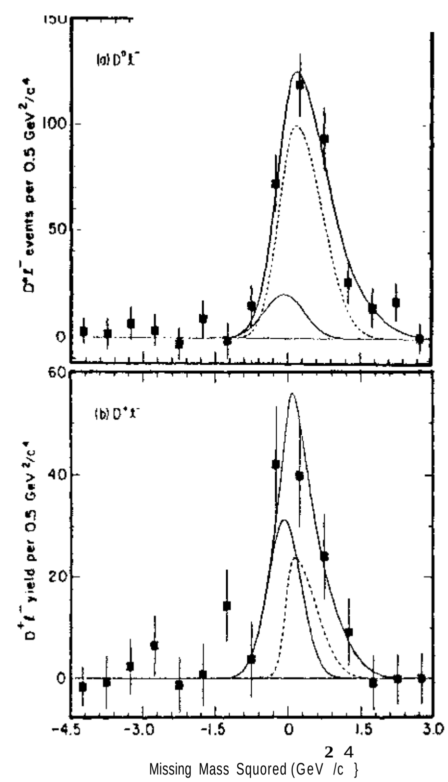

Fig. 2 MM² distributions with functions for B decay into *Di~U* (solid), *WtV* (dash), and D***"ï (dot), and for B decaying to D/D*, B to £~ (dot-dash).

ratio in B-meson decays is

r$_s$z**(D*)/r**$_s$x**(D)** = 2.6Îj;**J ÎJJ**

The ratio of the charged and neutral B-meson lifetimes can be extracted from the ratio of the charged and neutral B-meson branching fractions to *J)LU* and *V*TV:*

t(**B**-)/t(**B**°) = 0.89±0.19±0.13,

again under the assumption of equal numbers of charged and neutral B's at T(4S). It is also possible to extract from these branching fractions a value for *\V$_c$i* which is independent of the previous determination from the average semileptonic branching fraction. For two theoretical models of B-meson semileptonic decay, we find

\V$_{cb}$ = 0.037±0.005 (ISGW model),[16] and

= 0.043±0.005 (WSB model)![7]

We have also updated our measurement of the B-meson semileptonic decay momentum spectrum (electrons are shown in Fig. 3)[8] The overall fit of this spectrum to two theoretical predictions of the spectral shapes for *B-* DV* and *B* -> c -> *sip* yields the following branching fractions:

B(B -4 *XTV)* **= (10.5±0.3±0.4)%** (Altarelli**)f**'

B(B - 4 l l F) = (10.1±0.3±0.4)% (ISGW).

This result remains considerably below the 12% to 13% range expected from theoretical considerations. There is good agreement between this result and that reported by Argus P[01] This discrepancy, as well as the evidence for charmless semileptonic B-meson decays in the high-momentum details of this spectrum, are discussed in the next section.

NON-BB DECAYS of T**(4S)**

The observed decay of T(4S) to $ mesons which are too energetic to be produced in B-meson decayestablishes that T(4S) decays to BB less than 100% of the time. The CLEO signal is shown in Fig. 4. The number of ^'s with momenta above 2

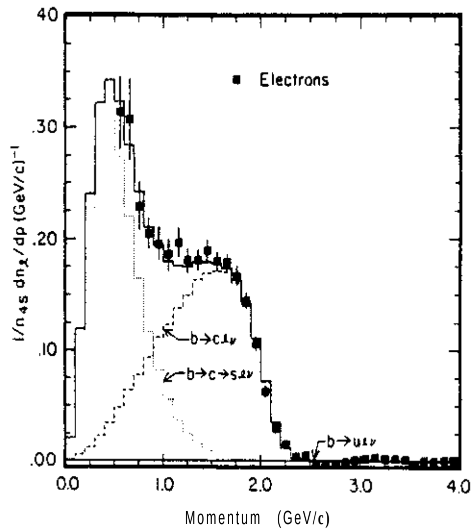

Fig. 3 CLEO electron spectrum from Ï(4S).

GeV/c (the kinematic limit for *B* -> is *l^t\%* leading to a branching fraction for these decays of (0.22±0.06±0.04)% There is no evidence of $ production in the continuum, with a 2.8% probability that the observed signal could result from a fluctuation upward of the measured continuum background level When T(5S) data is included in this determination, and the kinematic limit is raised to account for the higher center-of-mass energy, it is found that the probability of a continuum fluctuation producing the observed signal is 1.4%. Confirmation of the CLEO result has been reported by Argus J[10]î

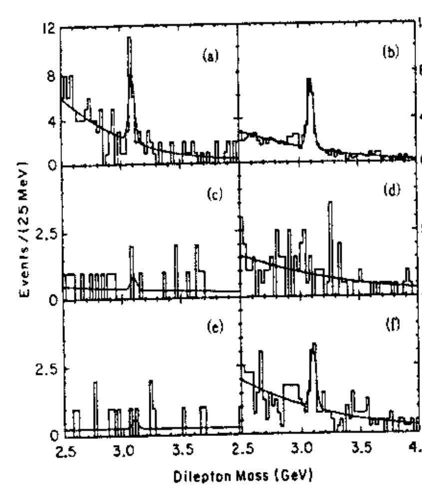

Fig. 4 Dilepton mass for ***ij)*** momenta above and below the maximum for B-» </>7r, for T(4S) (a and b), continuum (c and d) and T(5S) (e and f) data.

This is a very intriguing result on several levels. It indicates a large total rate for non-BB decays and/or a surprisingly high branching ratio for the decay of the non-BB final state to That T(4S) might decay to final states other than BB is not a complete surprise. A precedent exists in <^ decays, and suspicions that such behavior might be important for ?/>(3770) and T(4S) have been voiced![121131] The task of constructing an explanation for this phenomenon is complicated by the lack of evidence for non-BB decays other than the high-momentum t/>'s. In order to set a reliable overall bound on the total rate for non-BB decays, we have followed an approach we pursued several years ago/[13]! based on the comparison of the single-lepton and dilepton yields in T(4S) decays.

If all leptons in T(4S) decay are from BB , then the single-lepton and dilepton yields are given by

$$i\wedge = 2b_B€_B \ (W)iV_4\mathbf{S}, \text{and}$$

$$\% = b|£|(l-/)iV4S,$$

where *h%* (b|) is the mean (mean squared) semileptonic branching fraction for B's at X(4S), en is the lepton detection efficiency, *N±$* is the number of T(4S) decays, and / is the fraction of T(4S) decays to non-BB final states. Our experimental measurements of JV/, *Nu* [a]nd iVis determine the quantity

which is related to the non-BB fraction / by

$$/ = 1 - [b| /(b_B)^2$$

Since b| $/(be)^2$ must be greater than or equal to 1, an upper limit $a_u\backslash$ gives an upper limit on /,

$$/ < 1 - l/a_{ul}.$$

This analysis must be corrected to account for lepton production in non-BB decays.

We have searched the CLEO 1987 T(4S) data set for leptons and dileptons, using the same procedures of our search for charmless semileptonic B decays![14] Observed leptons were excluded whenever they formed a pair with any other track with effective mass within 60 *MeV* of the nominal *ij)* mass. A small additional correction (determined by Monte Carlo) was included to account for leptons from ^ which leaked through this veto. Electron-positron pairs with mass less than 50 *MeV* were discarded as likely photon conversions. The Off-4S data were used to measure continuum lepton and dilepton production, and our fits of the T(4S) electron spectra were used to estimate the contribution of leptons from the decay chain B -» D —• *L* Misidentification makes a small contribution to the lepton (3%) and dilepton (10%) totals. A correction based on T(1S) data was applied. We find *Nt* = 23134 ± 276, and N_a = 579 ± 43, in a full sample of JV_{4S} = 237000 ± 3000 of T(4S), leading to

$$a = 1.026 \pm 0.080.$$

This is consistent the previous résulta of 1.02 ± 0.10, or *a* < 1.175 at 95% confidence level. The corresponding 95% confidence level upper limit on the non-BB fraction / is 0.150, assuming no lepton production from the non-BB decays.

Although non-BB decays of T(4S) are seen only in the *tj)* channel, DD production is also likely. This could have significant impact on studies of semileptonic B decay at T(4S), including the signal for 6 -> *u* in leptons above the *b* -» c kinematic limit,![14]! and the non-BB limit above.

New attempts to explain the mechanism for *if)* production in non-BB[u] make predictions about the nature of the final states, but there is no detailed understanding yet. Therefore we attempted an exhaustive examination of possible mechanisms for lepton production in non-BB decays. Among electromagnetic processes, *i/)* is vetoed, as are electrons from 7T° photon conversions. Others (/)°'s, <^'s, u?'s) have very small branching ratios. and 71-* decays are calculated as fakes, also small. Only weak decays of charm are potentially a significant source of lepton production.

For a model of non-BB decays to account for lepton production near the *b* —> *c* endpoint, it must agree with the yield above the *b* -* *u* endpoint, and with the number of high momentum tracks. We used our numbers of charged tracks between 2.47 and 3.0 *GeV/c* (36 ± 448, < 90 at 95% confidence), and of leptons between 2.6 and 3.0 GeV/c (-1 ± 34, < 65 at 95% confidence), to set limits on the contribution of non-BB decays to the lepton signals in which we are interested. It is notable that high-momentum charged tracks give a stronger constraint on non-BB than the lepton yield above the B endpoint.

Our models are of three types. The first comprises decays T(4S)-> cc, where the fragmentation was varied over a broad range. The second consists of decays T(4S)-> DDX, X masss from 0.8 to 5.0 *GeV/c*^{2}, and X decays to from 2 to 18 7r's by N-body phase space. Our third set of models has X(4S)-» DDXY, where X and Y were **7r,** *p* , ai or *p'*. A total of 61 cases were considered.

If non-BB decays produce leptons, the value of *a* is affected through both *NI* and JV#. For each model we determined a corrected value for *a*. The deterioration of our non-BB limit is small For all models but two the 95% confidence level limit remained at 15% or increased to 16%. For the others, T(4S) -+ DD X, X -* (9 or 13) tt, the limit was 17%. Based on the breadth of models considered, we feel comfortable in concluding that the 95% confidence level upper limit on non-BB decays is 17%.

Our approach can also be applied to the measurement of lepton production near and above the *b* —» *c* endpoint, the basis for observations of nonzero *b* ~> *u* . CLEO observed 76±18 leptons in the momentum interval 2.4 - *2SGeV/c*. The crucial question is how many of these could be from non-BB decays. Most of our models do not have significant lepton production in this range. The worst was T(4S)-»DDX followed by X-* 13 Even for this case, however, no more than 14% (95% confidence) of our *b* —• *u* signal can be attributed to non-BB decays. This is a very conservative limit, since it corresponds to the case where all of the non-BB decays come in our worst channel.

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ARGUS Results on *B* Decays via *b* -» *C* Transitions

Henning Schroder
DESY, Hamburg, Germany

ABSTRACT

Using the ARGUS detector at the e⁺e~ storage ring DORIS II at DESY new results on beauty physics have been obtained. About 280 *B* mesons have been reconstructed in 26 hadronic decay modes. The masses and lifetimes of charged and neutral *B* mesons are the same within the errors. Fast J/^ mesons (1.4< *pj^* < 2.0 GeV/c) in *B* decays have helicity 0. An indication of non-jBB decays of the T(45) into J/t/> mesons is shown.

1 Introduction

More than 200 000 T(45) decays have been collected by the ARGUS experiment at the e⁺e~ storage ring DORIS II at DESY. A total of *J Ldt* = *2Z7pb~ʲ* was accumulated at the T(45) resonance and / *Ldt* = 98p6⁻¹ in the e⁺e~ continuum at energies about 100 MeV below the T(45) mass. These data form the basis of the following analysis.

2 Reconstruction of *B* Mesons

Hadronic decays of *B* mesons are not easy to reconstruct since high multiplicity decays dominate the decay rate. These suffer from low acceptances and high backgrounds, especially if they contain **7r°** mesons. With the ARGUS experiment acceptable signals have so far been obtained in 12 *B°* and 14 j**B**⁻ decay modes (see tables 1 and 2 and figures 1 and 2) [1]. The total of 280 *B* mesons reconstructed in hadronic decays represents a fraction of less than 0.1% of the number of *B* mesons produced.

B decay	branching ratio
$B^- \to D^0\pi^-$	$(0.20 \pm 0.08 \pm 0.06)\%$
$B^- \to D^0\rho^-$	$(1.3 \pm 0.4 \pm 0.4)\%$
$B^- \to D^{*0}\pi^-$	$(0.40 \pm 0.14 \pm 0.12)\%$
$B^- \to D^{*0}\rho^-$	$(1.0 \pm 0.6 \pm 0.4)\%$
$B^- \to D^{*+}\pi^-\pi^-$	$(0.26 \pm 0.14 \pm 0.07)\%$
$B^- \to D^{*+}\pi^-\pi^-\pi^0$	$(1.8 \pm 0.7 \pm 0.5)\%$
$B^- \to D^{*+}\pi^-\pi^-\pi^-\pi^+$	$< 1.0\%$ at 90% C.L.
$B^- \to J/\psi K^-$	$(0.07 \pm 0.03 \pm 0.01)\%$
$B^- \to \psi' K^-$	$(0.18 \pm 0.08 \pm 0.04)\%$
$B^- \to J/\psi K^{*-}$	$(0.16 \pm 0.11 \pm 0.03)\%$
$B^- \to \psi' K^{*-}$	$< 0.49\%$ at 90% C.L.
$B^- \to J/\psi K^-\pi^+\pi^-$	$< 0.16\%$ at 90% C.L.
$B^- \to \psi' K^-\pi^+\pi^-$	$(0.19 \pm 0.11 \pm 0.04)\%$

Table 1: B^- decay modes

B decay	branching ratio
$\overline{B}^0 \to D^+\pi^-$	$(0.48 \pm 0.11 \pm 0.11)\%$
$\overline{B}^0 \to D^+\rho^-$	$(0.9 \pm 0.5 \pm 0.3)\%$
$\overline{B}^0 \to D^{*+}\pi^-$	$(0.28 \pm 0.09 \pm 0.06)\%$
$\overline{B}^0 \to D^{*+}\pi^-\pi^0$	$(1.8 \pm 0.4 \pm 0.5)\%$
$\overline{B}^0 \to D^{*+}\pi^-\pi^-\pi^+$	$(1.2 \pm 0.3 \pm 0.4)\%$
$\overline{B}^0 \to D^{*+}\pi^-\pi^-\pi^+\pi^0$	$(4.1 \pm 1.5 \pm 1.6)\%$
$\overline{B}^0 \to J/\psi K^0_S$	$(0.04 \pm 0.03 \pm 0.01)\%$
$\overline{B}^0 \to \psi' K^0_S$	$< 0.14\%$ at 90% C.L.
$\overline{B}^0 \to J/\psi K^{*0}$	$(0.11 \pm 0.05 \pm 0.02)\%$
$\overline{B}^0 \to \psi' K^{*0}$	$< 0.23\%$ at 90% C.L.
$\overline{B}^0 \to \psi' K^-\pi^+$	$< 0.10\%$ at 90% C.L.

Table 2: B decay modes

The rates for two body decays can be compared to theoretical predictions for weak decays of heavy quarks, e.g. the model of Bauer-Stech-Wirbel [2], In this model the two-body decays are described by two amplitudes only, which are characterized by the parameters *ai* and a 2 . The analysis of the measured branching fractions yields *d* = 1.03 ±0.09 and *a₂* = -0.20 ± 0.03 [1], in excellent agreement with the predicted values of *a* = 1.1 and *ai* = -0.24 [2].

Preliminary results have been obtained for the decays *B* —» *D^D[*^* (Figure 2) where a signal of 24.7 ± 5.3 reconstructed *B* mesons is observed on a very low background.

The determination of the masses of the *B* mesons is of particular interest since the relative production rates /⁺ and /° of pairs of charged or neutral *B* mesons in X(45) decays depend on them. For the mass determination, only those decay channels are used where the background is low (Figure 1). The masses of the *B* mesons are determined from an energy constrained fit which uses the fact that the energy of a *B* meson lias to coincide with the beam energy. This fit gives the following masses

m$_B$**O** = **(5279.6 ± 0.7 ± 2.0)** MeV/c^2

m$_B$- - **(5280.5 ± 1.0 ± 2.0)** MeV/c^2

The mass difference of the neutral and charged B meson is compatible with zero:

m$_B$**O** - m$_B$- = **(-0.9 ± 1.2** m **0.5)** MeV/c^2.

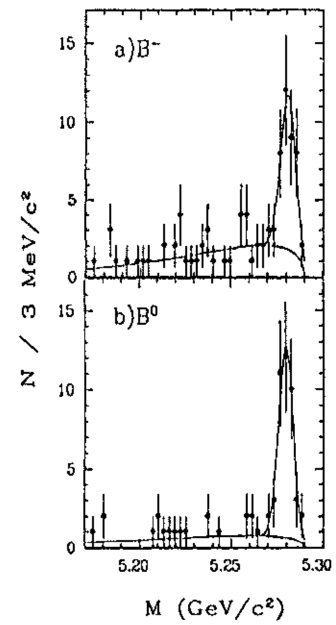

Figure 1: Mass distribution for B candidates in clean two-body channels:
(a) B~ candidates from the channels: B" -> D°7r~, D*V, **D**^iT, *2ji* (K",K-) and **^K"**
(b) **B** candidates from the channels: B° —> D'7r~, D*'**7R**-,andJ/^ **(K°,K*°)**

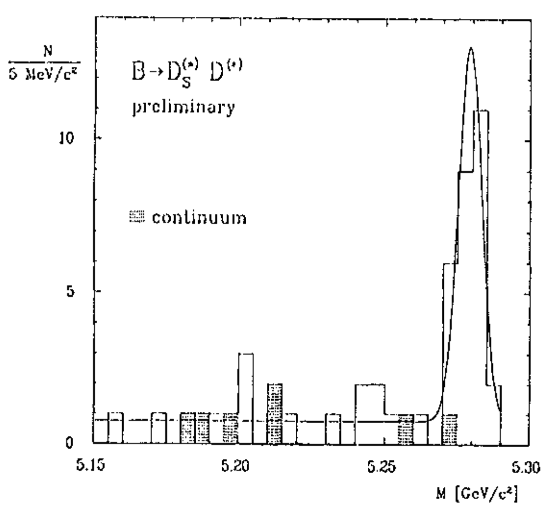

Figure 2* Mass distribution for B candidates in the decays *B -> DD,(D = D°,D+,D*+,D$_s$ = D~$_s$,D*~).*

3 Semileptonic *B* Decays and Measurement of T5./r^O

The inclusive lepton spectra taken at the T(45) are dominated by *b* —> cô/ transitions in the lepton momentum range between 1.4 and 2.3 GeV/c and by continuum contributions above *p(* = 2.3 GeV/c (Figure 3) [3]. The branching ratio for *B* £A' is measured to be

BR(B -> **^A***) - (10.3 ± 0.7 ± 0.2)%

using the model of Altarelli et al. [4]. This number is too small to be understood in a straightforward way in the spectator model where branching ratios of (12 - 15)% are predicted.

Using the observed branching ratio together with the 6 quark lifetime [5] one obtains for the Kobayashi-Maskawa matrix element

V$_{cb}$**I** = 0.046 ±0.005.

Similar values are obtained from studies of the decays B° -> *D*+tv* [6] [7] and B° -> *D+tv* [8].

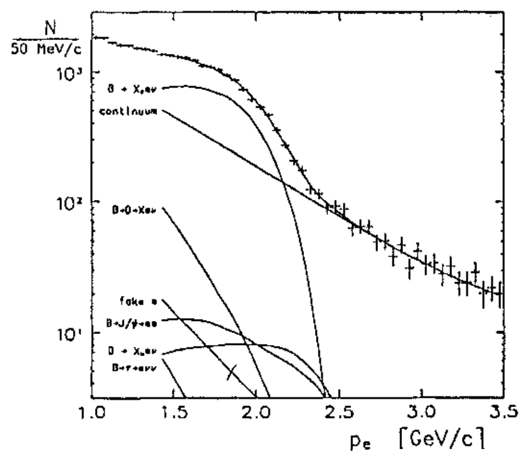

Figure 3: ARGUS inclusive electron spectrum from direct T(45) decays

The lifetime ratio t#+ / **RGO** is given by

BR(B' -> tx) / *BR(B°->lx)*

assuming equal semileptonic decay rates for charged and neutral *B* mesons. The above ratio can be approximated by

*BR(B+-+tx)^* / *BR(B° -» tx)* ~ *BR(B+-*D*°£V,DHP)* / *BR(B° -> D*+t-v,D+£u)*

The equality of the above relation would imply that in semileptonic decays of charged *B* mesons we observe only $D°$ mesons, whereas for neutral B mesons we observe mainly D^* mesons, plus those D° mesons originating from the well measured decay $B°$ -> $D*+tv,D*^+$ [6,7]. The lifetime ratio is then given by

$$tJ5+ \quad \_ \quad \frac{N'(D°t) - N'(D*+t,D*^+ \quad J°7T^-)}{A''(Z>+0 + JV'(JD*+f-,£>-+ \quad i?°7r+)}$$

for a production rate $/^+//°$ = 1. **A'''** are the acceptance and efficiency corrected numbers of events containing each *Dl* combination. The above formula is only slightly altered by considering the possible decay *B* —» *D**t+v*, which can contribute only for a small fraction of semileptonic *B* decays. This effect can be taken into account [9].

Using these measurements one obtains, after correcting for branching ratios and acceptances,

$$\frac{—}{Tpo} = 1.00 \pm 0.23 \pm 0.14.$$

The lifetime ratio can also be inferred by comparing single lepton rates *(Ni)* with dilepton rates $\{N_{ll}\}$ in T(45) decays:

$$a \quad \frac{/M*ff/)^+ + /M*fli)^+}{(f«.(BR°_{sl}) + f+.(BR+)y}$$

$$BB \quad {}_{N\ I}$$

where $BR°_{sl}$ = $BR\{B°$ -> $Ix)$ and **BJKj** - £iî(B$^+$ -» &c). With JV_z = 19394 and JV^ = 645 a value a = 0.96 ± 0.07 is obtained which implies : 0.66 < = ^ < 1.5 [10], Combining both measurements on the lifetime ratio ARGUS obtains finally:

$$— = \mathbf{i.oo}\wedge l$$

which is consistent with the expectations of the spectator model.

The measurement of a, which has to be a > 1 if all T(45) mesons decay into *BB* pairs, can be used to get an upper limit on non-B5 decays of the T(4S) :

$$fl\#(T(4S) -H\ BB) < 14\%\ (90\%CI).$$

4 Polarization of *J/xj;* Mesons in *B* -> *J/xfcX* Decays

J / V ' mesons from *B* decays can be in a helicity À = 0 or ±1 state which leads to the angular distributions:

$$\frac{—}{dil}\ \text{a}\ 1 + \cos^2 0\ \text{for A - ±1}$$

$$\text{oc}\ \sin^2 6\ \text{for A - 0}$$

where *9* is the decay angle of the lepton from the J/V> decay in the cm-system of the J/î/> meson with respect to the direction of the *J/ift* meson in the *B* meson cm-system.

For fast *J/rj)* mesons (1.4< p_3 ^ < 2.0 GeV/c) produced in T(45) decays the angular distribution exhibits a $\sin^2 9$ distribution (Figure 4). A fit to the measured angular distribution : ^ oc 1 -f *f3* • $\cos^2 9$ yields /? = -1.17 ± 0.17. This implies that *J/i>* mesons from *B* —> *Jjij)K** which are in the above momentum range, have predominantly helicity 0. This fact can be used for the measurement of CP-violation in *B* decays [111.

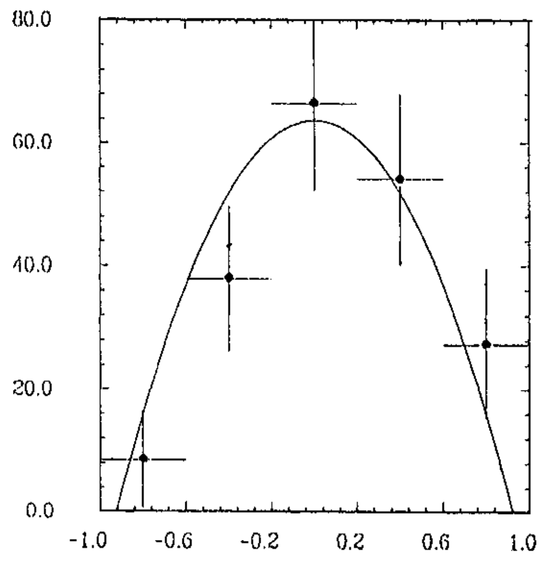

Figure 4: Decay angular distribution of leptons from fast *J/tf)* mesons (1.4< *pjj$* < 2.0 GeV/c) produced in T(4S) decays.

5 Search for non-JSi? decays of T(45)

Evidence of non-SB decays of the T(45) meson was obtained by ARGUS through the observation of fast J/V' mesons (2.0< *pj/^* GeV/c) produced in direct T(45) decays. The invariant c e~ and mass spectrum for *C £~* momenta above the kinematic limit for *B* meson decays (*pa* > 2 GeV/c) (Figure 5a) exhibits a peak at the J/^ mass for data taken at the X(4S) resonance The peak sits on a large and steeply falling background. Nevertheless, the shape of the background is reasonably well known because the major part of it arises from uncorrected semileptonic decays of both *B* mesons. This can be demonstrated either by a Monte Carlo or by studing the *e+fi~* mass spectrum. A fit with a background shape fixed using the e/x™ spectrum gives 27 ± 7 events in the *J/if)* peak, whereas a fit with a free smooth background leads to a similar result of 22 ± 7 events.

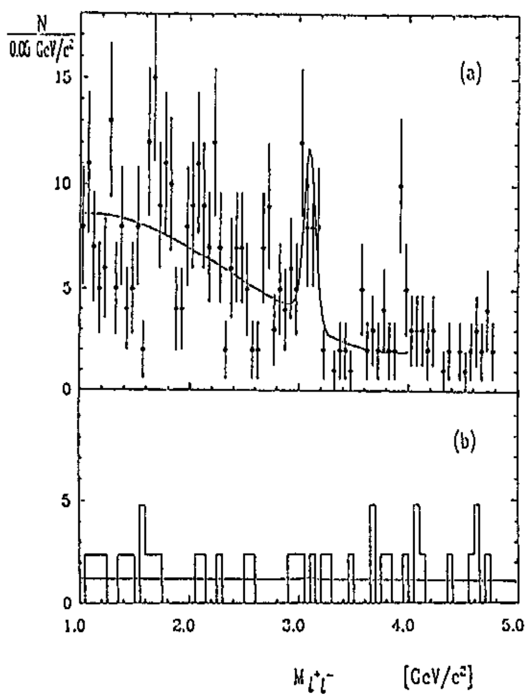

Figure 5: Mass(f^"") for *T+L~* combinations with momenta above 2.0 GeV/c in (a) T(45) data and (b) continuum data (scaled).

Since there is no sign of J/V> production in the continuum (Figure 5b) this indicates direct *J/if)* production in T(45) decays with an unexpectedly large branching ratio of Biî(T(4S) -» J/y>X, pj/^ > 2 GeV/c) = (0.22 ±0.06)%, where only statistical errors are shown. However, the probability that the peak in fig.5a is due to J/V» production in the continuum is not negligible, namely about 1%.

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DISCUSSION

Q. C. Buchanan *(UCLA):* Estin Eichten at FNAL and Nina Byers at UCLA have calculated on the *B+B~* vs *B°B* production rates using the 74, wave function, the coulomb attraction for the *B B~*, and the *B* vs *B°* mass difference. They find the *B+B~* rate exceeds the *B°B°* by ~0 to 30%, depending sensitively on the mass difference since the *Y±* is so close to the threshold. This, of course, affects the lifetime ratio and mixing measurements. The question: Which did you say was heavier?

A. H. Schroeder: The charged *B* is slightly heavier, but with a large error bar.

MEASUREMENT OF THE LIFETIME OF BOTTOM HADRONS

Rainer Geiges
Institute for High Energy Physics Heidelberg University
Fed. Rep. of Germany

Abstract

The average lifetime of bottom hadrons from $Z°$ decays was measured with the Aleph detector at the new LEP storage ring. The lifetime was determined by measuring the impact parameter distribution of leptons produced in bottom decays. The result of the analysis is r_B = (1.28 ± 0.08 ± 0.12) x10~^{12} sec.

The measurement of the bottom hadron lifetime is an important factor in the determination of the matrix elements and of the Kobayashi - Maskawa mixing matrix. It is therefore of great interest to determine this number as precisely as possible. Current measurements of the B-lifetime still suffer from large experimental errors (> 10%) [1,2,3]. In the decay of $Z°$ particles B - B hadrons are produced with a branching fraction of about 15%. These B's can be efficiently tagged by searching for high (p,pr) leptons originating from the semileptonic decays of these hadrons. Therefore the data collected by the ALEPH detector [5] at the LEP storage ring at CERN offer a sample of events well suited to measuring the B - lifetime. The analysis presented in this article is based on total sample of 120000 $Z°$ decays recorded in the running periods from October 1989 to June 1990.

The average lifetime of the B - hadrons is determined from the projected signed impact parameter distribution of leptons produced in the decays of the hadrons [4], The impact parameter S is defined as the distance of closest approach between the lepton trajectory , projected in the plane perpendicular to the beams, and the production vertex of the hadrons. The impact parameter is signed positive if the intersection of the lepton trajectory with the trajectory of the parent hadron Mes in the direction of flight of the hadron as seen from the production point. It is signed negative otherwise.

Since the production point is difficult to determine on an event by event basis it is estimated by the centroid of the beamspot averaged over a fill. By plotting the distance of closest approach to the origin as a function of the azimuthal angle of a track, for all tracks in a fill we are able to determine the position of the beam centroid with an accuracy of *(The* ~ 30/an.

The direction of flight of the B - hadron is estimated by the axis of the jet to which the decay lepton is associated. The jets are formed with the scaled invariant mass clustering algorithm using all charged tracks in the event with a momentum > 0.2GeF and setting y_{cut} = 0.02.

Candidates for semileptonic B - decays are selected from the hadronic events by the following selection criteria. All candidates are required to have a total charged energy of > 0.2£$_{cm}$ and > 5 good charged tracks, where a good track is considered to have > 5 coordinates in the Time Projection Chamber (TPC) and a polar angle in the range of I cos ^| < 0,95, The distance of the trajectory to the beam spot must be $\backslash d_0\backslash$ < *2cm* in the $r<f>$ plane perpendicular to the beams and the distance along the beam must be $|z_0|$ < 10cm. These cuts select hadronic decays from the $Z°$ with an efficiency of 97.5 ± 0.6%. The background from T^+T'' and e$^+$e~ •f hadrons events is < 0.3% with this selection.

The methods for muon and electron identification are described in detail in [6]. The main features of the methods will be described briefly in the following paragraphs.

Candidates of muon tracks are identified by the penetration of the track in the hadronic calorimeter. The calorimeter consists of 23 layers of 5cm thick iron slabs interspaced with streamer tubes. A muon candidate is required to have >10 planes hit, > 5 planes hit out of the last 10 and >1 out of the last

3 planes. The efficiency of the muon identification is 83 ± 3%. The background in the muon sample due to dacays in flight, hadron punch-trough and sail-trough is in the order of a few percent.

The electrons are identified by using the information on the energy - momentum balance of their shower in the electromagnetic calorimeter, the longitudinal and transverse profile of the shower and the dE/dx measurement of the track in the TPC. The efficiency of the electron identification is 70 ±3%. The background from 7 conversions and it^0 ~* $7e^+e^-$ is reduced to 3 - 10%, depending on the momentum range, by a pair finding algorithm and a cut on *do*. The hadron missidentification background amounts to 0.05 - 0.3% as measured from the data.

From this sample of events with lepton candidates an enriched subsample of bottom decay candidates is selected by cutting on the lepton momentum p and the momentum component *pr* transverse to the jet containing the lepton. The signed impact parameter distribution obtained from these leptons with $p > hGeV$ and $px > 2GeV$ is shown in figure 1. The distribution shows a clear skew to positive values with $< 8 >$= 140/um. To extract the average lifetime of the B - hadrons contained in the event sample a fit with a maximum likelihood technique is used.

The events contain lepton candidates from five possible sources: direct b - hadron decays (B); B - hadron cascade decays (BC); direct c - hadron decays (C); misidentification background from hadrons which are identified as leptons (MIS); decay background, these are real leptons coming from decays in flight or from 7 - conversions (DEC). The contribution to the measured impact parameter distribution from an event i can be described by the following fitting function:

K

The function = *{B,BC,C...}* determines for each lepton the probability to be from source *K* as a function of (p,pr)« The probability density function P_K determines for each lepton source the probability of having a measured impact parameter *8*.

The values of f_K are obtained from the analysis of the semileptonic branching fractions of the decays *Z°* *bb* [6] The functions P_K are obtained from data and Monte Carlo calculations. For the misidentification background the impact parameter distribution for tracks that satisfy all selection cuts except the lepton identification is obtained from data. This distribution is then weighted by the fraction of misidentified hadrons *{MIS* and parametrized using

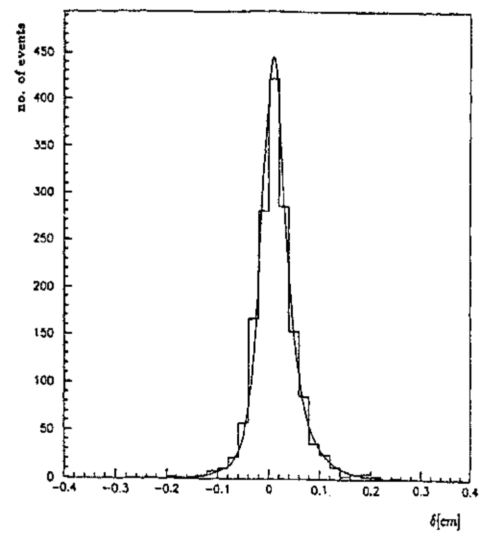

Figure 1: Impact parameter distribution for lepton candidate tracks with momentum $p > 2GeV$. The solid line shows the result of the fit.

gaussian and exponential functions. Monte Carlo studies of the decay background showed that one can use the *PMIS* distribution broadened by a factor 2 to describe the contribution from this lepton source. The impact parameter distribution for the direct lepton sources are obtained in a two-step process. Monte Carlo techniques are used to generate semileptonic decays of the three different types (B, BC, C) without taking resolution effects into account. The resulting distribution is parameterized with exponential functions which scale with the quantity $y = 8/cr$. The lifetime of the charm quark was fixed to be r_c = (0.68 ± Q.10)ps, so the lifefime of the bottom quarks remains the only free parameter in the fit. In the second step the true impact parameter distributions from the Monte Carlo are convoluted with the experimental resolution function. This resolution function is obtained from data by selecting tracks with a *p?* vector pointing out of the ↯ plane. Any nonzero impact parameter of these tracks must be due to resolution effects.

The result of the fit for leptons with a $p > 5GeV$ and $pT > 2GeV$ is shown as solid line in figure 1, the lifetime derived is T_B = (1.28 ± 0.08)10""12sec. Several checks on the consistency of the analysis have been made. The lifetime was evaluted for electrons and muons seperately, the lifetime obtained from positive and negative tracks was compared and also the results from the 89 and 90 data were conpared to each other. All values of the lifetime are consistent within the experimental error. A careful evaluation of the systematic errors was done. Uncertainties in the lepton source fractions f_{κ} the resolution function, the lepton bremsstrahlung, the charm lifetime and the fragmentation effects amount to a 10% systematic error in the measured B - lifetime.

To conclude, we have measured the average lifetime of B - hadrons produced in the decay of ***Z°*** particles and foundry = (1.28±0.08±0.12)10^{-12}sec. This result is still preliminary, there are further studies in progress to reduce the systematic error and to make full use of the data sample available from the 1990 run period. Nevertheless our measurement of ***TB*** has already a greater precision than previous measurements [1,2,3].

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RESULTS ON B-PHYSICS FROM UA1

JORMA TUOMMEMI

Department of High Energy Physics, University of Helsinki
Helsinki, Finland

and

UA1 Collaboration, CERN
Geneva, Switzerland

ABSTRACT

New results on B-physics from the UA1 experiment at the CERN proton -antiproton collider are reported. They are based on the data collected in 1988-89, corresponding to a total of 4.7 pfcr' integrated luminosity. The B°B° mixing parameter X has been measured to be 0.144±0.037. Upper limits for the branching ratios of the rare decays B -» u+u", B-» u+u"X, and Bd u+u" K*° have been determined. Some results on the search for the exclusive decay channels B~>Jyy+K*° and B->JA|/-Hj> are presented.

INTRODUCTION

The cross section for the reaction

$$pp \rightarrow bbX \qquad (1)$$

is of the order of 10 \ib at Vs=630 GeV as measured by the UA1 experiment [1], UA1 can detect the production of b-quarks through their decay into muons with its large acceptance muon detector [1], capable of recording muons up to pseudorapidity T)=2. The momenta of the muons are measured through bending in the magnetic field, the momentum resolution being

$$dp/p = 0.01p[GeV/c] \qquad (2)$$

The cross section for reaction (1) with at least one of the b-quarks having transverse momentum larger than 6 GeV/c and pseudorapidity smaller than 1.5 was measured to 4.8 ± 1.7 mb [2]. This corresponds to 2.5x10⁷ events in the data collected by UA1 during the runs in 1988-89. Hence appreciable samples of b-events could be obtained even with detection efficiencies less than 10%.

The data have been used to determine the B°-B° mixing parameter % and upper limits for the branching ratios of rare decays of B°'s into muons. In addition, some results have been obtained for the exclusive decays of B°'s into JA|/ and K*° or <}>.

B° - B^ MIXING

B°-B° mixing was discovered by UA1 in 1985 [3] through the excess of like sign dimuon events over the expected number of like sign events from B°B° production with a second generation charm decaying into a muon. The excess was interpreted as B°B°-events where one of the B's "mixes". The amount of mixing was estimated using the different shapes of the pt distributions of the muons from the primary B-decays and the secondary charm decays, respectively.

From this analysis %= 0.16 ± 0.06 [3] was obtained, where % is the fraction of events with a B° decaying into a wrong sign (negatively charged) lepton. The statistical and systematic errors contribute roughly equally to the total error.

In the analysis of the 1988-89 data a different, more sensitive method was used to separate the contributions of different processes to the dimuon events. Namely, the transverse momentum relative the b-jet axis, p_t^{rel}, was calculated for each muon. The distributions of p_t^{rel} again have different shapes for the different processes contributing to dimuon events. With this method some statistics is lost because p_t^{rel} cannot be defined for all events.

The value %= 0.144 ± 0.037 was obtained from the analysis. Since a large part of the measurement error still comes from statistics, we combine here the value

from the 1985 analysis with the new result. This gives X= 0.15 ±0.03.

In order to determine the mixing parameter % separately for B°_d and B°_s the probabilities *U* and f_s are needed that the beauty quark hadronizes into a B°d and a B°_s meson, respectively. By assuming f_s=0.18 and f_d=0.36 [3] we get the result shown in Fig. 1.

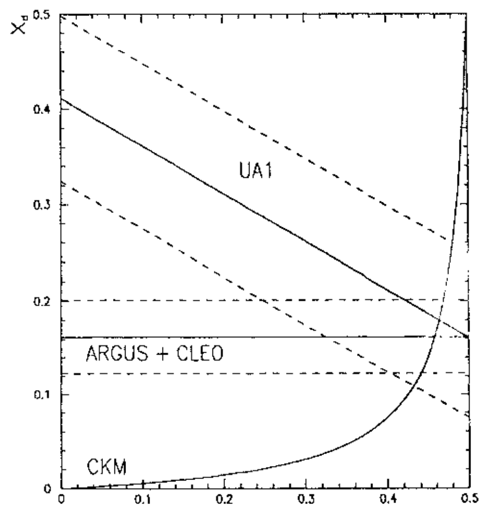

Fig. 1. Plot of Xs vs.xd from UA1 (1985 and 1988-89 measurements combined). The combined value of xd f*°" CLEO and ARGUS as well as the region allowed by the present constraints from the CKM matrix are also shown.

Combining the UA1 measurement with the measurement of *u* fr<>" ARGUS and CLEO a 90% CL lower limit Xs= 0.12 is obtained. By combining this with the CKS matrix constraint the limit becomes much higher.

SEARCH FOR RARE B-DECAYS

In the Standard model the decays

B-*|i+|T (3)

B -» Jl+Ji-X, (4)

are forbidden at the tree diagram level as flavour changing neutral current processes. They are possible through higher order mechanisms described by "penquin" and box diagrams.

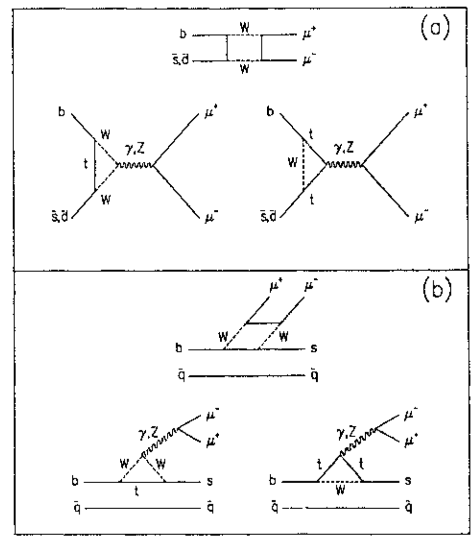

Fig. 2a. The diagrams contributing to the decay B -> u+u" (a) and to the decay B -» u+u"X, (b).

The branching ratios predicted by the minimal standard model are 10^{-9} for reaction (3) and 10"^{5} for reaction (4).

The best experimental upper limits for the branching ratios so far are from CLEO and ARGUS, $5x10^{-5}$ for reaction (3) and 2.4x10-**3** for reaction (4) [4].

B-mesons can decay into a muon pair also through the channels

B->JA|f + X (5)

B~> y' + X (5')

The branching ratio for decay channel (5) is three orders of magnitude larger than for the non-resonance decays. The amplitudes of channels (5)-(5') and of channels (3) and (4) can interfere, leading to structures in the dimuon mass distribution near the J/y and masses [5].

The data sample used to look for decays (3)-(4) was chosen from the data collected with the dimuon trigger. Combining the 1985 and 1988-89 runs gives a total of 5.3 pb^{-1} integrated luminosity.

To reduce the fake muon background the transverse momenta of the muon candidates were required to be larger than 3 GeV/c. In order to obtain a uniform efficiency and maximum sensitivity for channels (3) and (4) the transverse momentum of the dimuon system was required to be larger than 7 GeV/c. This selection leads to 331 events, for which the dimuon mass distribution is shown in Fig. 3.

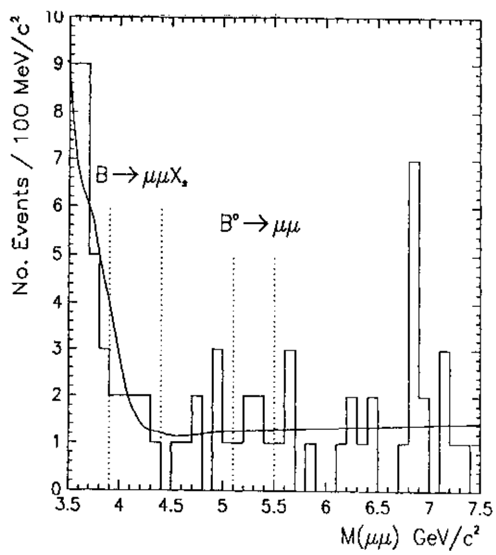

Fig. 3 Mass distribution of the U-+U- system.

This mass distribution was parametrized with a function linear in plus two gaussians for J/y and y, respectively, also shown in the Fig 3.

In order to search for decay (3) we looked for enhancements in the dimuon mass around the mass of the Bdor the B_s meson (we use m(Bd) =5.28 GeV/c^2 and assume $m(B_s)$= 5.38 GeV/c^2). The mass interval between 5.1 and 5.5 GeV/c^2 was chosen corresponding to the estimated mass resolution in this mass region. No signal is seen in that region in Fig.2. There are 6 events in this mass bin while the fit to the dimuon mass distribution gives a background estimate of 5±1 events. The acceptance for the production of a B-meson and its decay into channels (3)-(5) was estimated with ISAJET and a full detector simulation Monte Carlo program. For channel (3) the acceptance 4% was obtained. With these numbers the upper limit $8x10^6$ is obtained for the branching ratio at 90% CL. Note that the limit applies for $B°_s$ and $B°_d$ together.

When searching for process (4) we wanted to avoid the interference effects with channel (5) and therefore limited our search to the mass region 3.9 GeV/c^2 < < 4.4 GeV/c^2 above the y ' resonance. No excess of events is seen in this case either. There are 9 events in the chosen mass bin to be compared to an estimated background of 8.7±1.7 events. The acceptance is 1.110.5%. This gave an upper limit for the branching ratio of $5.0x10^5$ at 90% CL, which is three orders of magnitude more stringent than the result from CLEO. Here again the branching ratio is for an unseparated mixture of Bd, B* and $B°_s$.

We also looked for the exclusive decay process

$$B_d -> \wedge - K*° \qquad (6)$$

Here the mass window was kept the same as above but the dimuon transverse momentum cut was relaxed to 4 GeV/c^2 because of the additional constraints on the K*. In order to pick up the K*° decays we selected the events with at least two tracks in the central detector having p_t > 100 MeV/c within a cone AR<1 around the dimuon system. For further enhancement of the K* signal the p_t of the Ktc system was required to be more than 2 GeV/c and the momentum of the kaon more than half of the momentum of the pion. We looked for the signal of channel (6) within ±40MeV/c^2 of the K* mass (896 MeV/c^2) and within ±0.2 GeV/c^2 of the B_d mass. Two events were observed. The background was estimated to be 2.8±0.7 events and the acceptance 2.3%. This gave an upper limit 1.1x1O"5 for the branching ratio at 90% CL.

Since the amplitude of channel (4) involves the mass of the top quark the upper limit for the branching ratio of of this channel can be used to set a limit for the mass of the top. This limit is independent of any earlier measured limits. Using the calculation of ref. [6] we obtained m_{top} < 440 GeV/c^2 at 90% CL.

DECAY CHANNELS B-»J/y + K*°/ф

We have also searched for the exclusive decay channels

B->J/f + K*° (7)

B->J/y + ф (8)

To do this we first selected a sample of the inclusive decays

B->J/y + K*°+X (9)

by requiring the same cuts as for reaction (6). The Krc invariant mass for the selected events is shown in Fig. 4

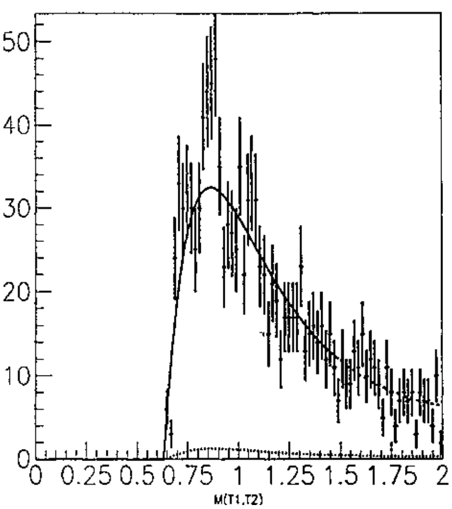

Fig. 4 Mass distribution of two oppositely charged tracks fulfilling the selection described in the text

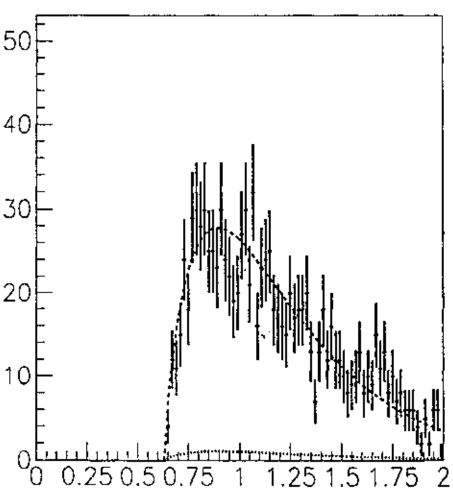

Fig. 5. Mass distribution of two same sign charged tracks fulfilling the selection described in the text

The background curve is determined by Monte Carlo simulation and agrees well with the mass distribution of two same sign charged tracks fulfilling the above cuts, shown in Fig. 5.

The K* signal is visible in Fig. 4. We next looked at the JA^Ktc mass. In Fig. 6. we plot the mass difference m(J/fKïï)-m(J/v|T).

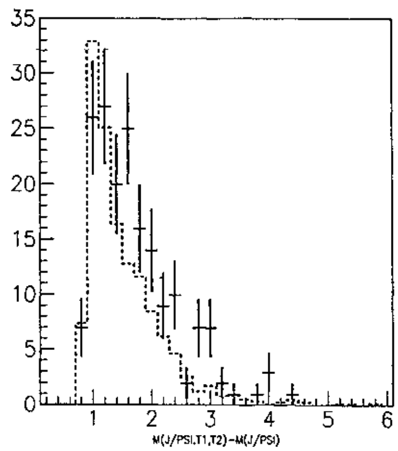

Fig.6. Distribution of the mass difference m(JA|(K7i)-m(J/y).

No peak is observed at the place of the K*, around 2.18 GeV/c^2. On the other hand, from the Monte Carlo calculation we expect 4 ± 3 events from decay channel (6) (the branching ratio B_d-> J/\|H-K*° = 0.11 ±0.05 ± 0.03 % from CLEO was used), which is consistent with the number of events in the K* region in Fig. 6.

To search for the ф signal we looked for charged kaon tracks within the cone AR<1. around the b-jet axis. The expected number of events for channel (7), using the theoretical prediction 0.5% for the branching ratio and a Monte Carlo estimate for the acceptance, is *6*5.* This is consistent with one event found in the relevant mass bin.

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DISCUSSION

Q. **H. Newman** *(Caltech):* In searching for rare *B* decays involving inclusive pairs, do you see off-shell photons from final state radiation from the quarks? Is the background from these /x"*>~ pairs understood?

A. **J. Tuominiemi** : Yes, we have studied the low mass spectrum exclusively and it is well understood. We have published results on it earlier.