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

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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~'* 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.

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

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

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

$$m_{B}O = (5279.6 \pm 0.7 \pm 2.0) \text{ MeV/c}^2$$

$$m_{B}- - (5280.5 \pm 1.0 \pm 2.0) \text{ MeV/c}^2$$

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

$$m_{B}O - m_{B}- = (-0.9 \pm 1.2 \text{ m } 0.5) \text{ MeV/c}^2.$$

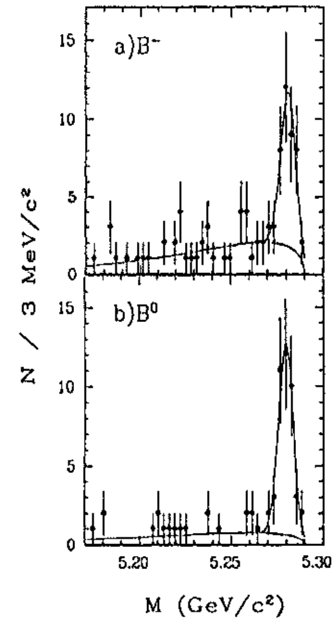

Figure 1: Mass distribution for B candidates in clean two-body channels:
(a) B~ candidates from the channels: B" -> D°7r~, D*V, D^iT, 2ji (K",K-) and ^K"
(b) B candidates from the channels: B° —> D'7r~, D*'7R-,andJ/^ (K°,K*°)

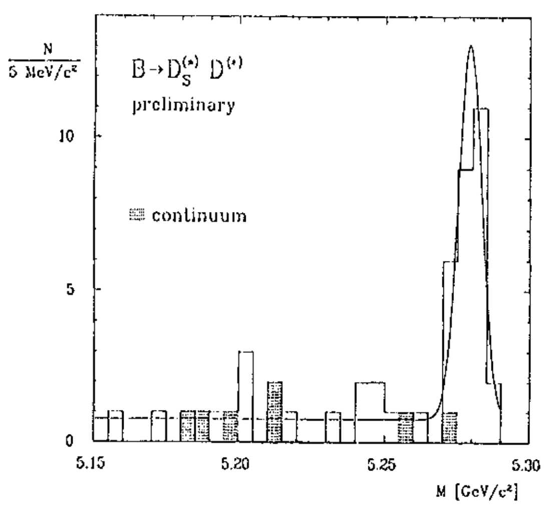

Figure 2* Mass distribution for B candidates in the decays B -> $DD,(D = D°,D+,D*+,D_{s} = D\sim_{s},D*\sim)$.

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

$$BR(B \;\text{->}\; \wedge A^*) - (10.3 \pm 0.7 \pm 0.2)\%$$

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

$$\backslash V_{cb} I = 0.046 \pm 0.005.$$

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

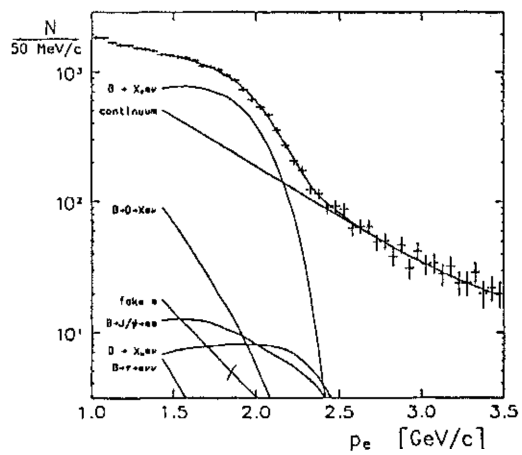

Figure 3: ARGUS inclusive electron spectrum from direct T(45) decays

The lifetime ratio t#+ / RGO is given by

$$T**^{LR!!} = \frac{BR(B' \;\text{->}\; tx)}{BR(B° \text{->} lx)}$$

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

$$\frac{BR(B+\text{-}+tx)\wedge}{BR(B° \;\text{-»}\; tx)} \sim \frac{BR(B+\text{-}*D*°£V,DHP)}{BR(B° \;\text{->}\; D*+t\text{-}v,D+£u)}$$

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 $B^\circ \to D^{*+}tv,D^{*+}$ [6,7]. The lifetime ratio is then given by

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

for a production rate $/^{+}//^{\circ} = 1$. $A^{n''}$ 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 $B \to D^{**}t+v$, 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,

$$\frac{}{T p o} = 1.00 \pm 0.23 \pm 0.14.$$

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

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

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

where BR°_{a} = *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:

$$— \quad = \quad \mathbf{i.oo}^{\wedge} l$$

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:

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

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

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.

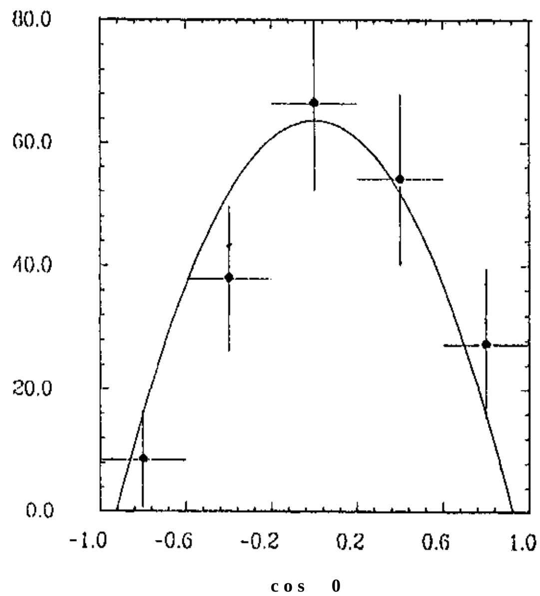

Figure 4: Decay angular distribution of leptons from fast *J/tf)* mesons (1.4< ***pjj$*** < 2.0 GeV/c) produced in T(4S) decays.

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.

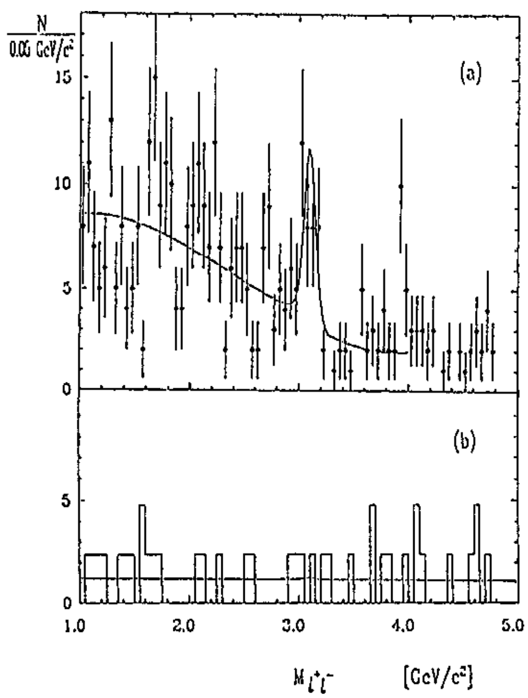

Figure 5: Mass(f^"") for *T+L~* combinations with momenta above 2.0 GeV/c in (a) T(45) data and (b) continuum data (scaled).

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%.

References

[1] H.Albrecht et al (ARGUS collaboration), DESY preprint DESY 90-046, May 1990

[2] M.Bauer et al, Z.Phys. C34 (1987) 103

[3] H.Albrecht et al (ARGUS collaboration), DESY preprint DESY 90-088, July 1990

[4] G.Altarelli et al Nucl.Phys. B208 (1982) 365

[5] Particle Data Group, Phys.Lett. 204B (1988) 1

[6] H.Albrecht et al (ARGUS collaboration), Phys.Lett. 197B 452 (1987)

[7] H.Albrecht et al (ARGUS collaboration), Phys.Lett. 219B 121 (1989)

[8] H.Albrecht et al (ARGUS collaboration), Phys.Lett. 229B 175 (1989)

[9] H.Albrecht et al (ARGUS collaboration), Phys.Lett. 232B 554 (1989)

[10] H.Albrecht et al (ARGUS collaboration), Contributed paper to this conference.

[11] B.Kayser, Talk at this conference.

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.