# OBSERVATION OF CHARMLESS B MESON DECAYS

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Using the ARGUS detector at the $e^+e^-$ storage ring DORIS II, we have observed charmless decays of B mesons into the final states $p\bar{p}\pi^\pm$ and $p\bar{p}\pi^+\pi^-$. The significance of the signal corresponds to more than five standard deviations. The branching ratios are $(5.2 \pm 1.4 \pm 1.9) \times 10^{-4}$ for the three-body and $(6.0 \pm 2.0 \pm 2.2) \times 10^{-4}$ for the four-body final state. These decays cannot proceed via the dominant b→c transitions, and we show that they are not the result of penguin-type processes. Thus, the observed decays must represent b→u quark transitions. Consequently, the Kobayashi–Maskawa matrix element $V_{ub}$ is non-zero.

We report the first observation of charmless B meson decays. This measurement is based on the analysis of a sample of B mesons produced in $\Upsilon(4S)$ decays using the ARGUS detector at the $e^+e^-$ storage ring DORIS II at DESY.

The aim of this study is to establish the existence of weak b→u transitions. The frequency of these transitions is described by the Kobayashi–Maskawa matrix element $V_{ub}$ [1], one of the basic parameters of the standard model. Previously, only exclusive decays caused by b→c transitions have been observed [2–4]. Upper limits for the ratio $\Gamma(b\to u)/\Gamma(b\to c)$ have been obtained from the analysis of inclusive lepton spectra in semileptonic decays of B mesons [5], from the study of the reaction $B\to\rho\ell\bar{\nu}$ [6], and from investigating charmless hadronic B meson decays, heretofore mainly into multipion final states [4]. A common feature of all these analyses is the strong model dependence of the upper limits derived for the Kobayashi–Maskawa matrix element $V_{ub}$. However, the observation of a charmless B meson decay does provide evidence for a finite b→u coupling.

Charmless B meson decays have been studied in final states containing baryons. This is motivated by the fact that if more of the available phase space is absorbed as mass, larger branching ratios for low multiplicity channels could result. Following this line of thought, the following decay channels [#1] have been investigated:

$$B^+\to p\bar{p}\pi^+, \quad B^0\to p\bar{p}\pi^+\pi^- .$$

The available data sample consists of B mesons produced in 96 000 $\Upsilon(4S)$ decays, corresponding to an integrated luminosity of 103 $pb^{-1}$. For continuum studies, a sample of 49 $pb^{-1}$ is used, obtained at centre-of-mass energies below the $\Upsilon(4S)$.

A description of the ARGUS detector and its trigger can be found in ref. [7]. Particle identification is made on the basis of specific ionization in the drift chamber and of time-of-flight measurements; the likelihood ratio [8] for the p ($\pi$) hypothesis has to be larger than 0.01 in order to accept a particle as p ($\pi$). The probability for the sum of all $\chi^2$ contributions from particle identification of the $p\bar{p}$ system is required to exceed 2%.

We require the B candidates to have $|E(B) - E(\text{beam})| < 2\sigma_E$, where $E(B)$ is the measured energy and $\sigma_E$ the corresponding error, exploiting the fact that B mesons produced at the $\Upsilon(4S)$ must have the beam energy. Typically, $\sigma_E$ is 40 MeV and candidates with an error greater than $\sigma_E > 60$ MeV are rejected. For the accepted candidates, an energy constraint fit is performed. Thereby, we effectively measure the mass difference between $M(B)$ and a fixed value for $M(\Upsilon(4S))/2$; $M(\Upsilon(4S))$ is set to 10 580 MeV/$c^2$ [4]. The mass resolution obtained by this fit depends on the ARGUS momentum resolution, on the DORIS beam energy spread, and on the $\Upsilon(4S)$ width and is estimated to be 4 MeV/$c^2$.

Background from continuum events is reduced by three topological cuts. First, we calculate two thrust axes for each event: one axis for the particle contributing to the reconstructed B candidate and the other formed by the remaining charged and neutral particles. For $B\bar{B}$ events, there is no correlation between

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[#1] References to a specific particle state should be interpreted as implying the charge-conjugate state also.

the two directions, as the B mesons are produced almost at rest and decay isotropically. In continuum events, the thrust axes for the putative B candidate and for the rest of the event are both correlated to the true event jet axis and hence to each other. Therefore, we require $|\cos\delta_{\text{thrust}}| \leqslant 0.8$ where $\delta_{\text{thrust}}$ is the angle between the two thrust axes.

Second, the multiplicity of charged particles in the remainder of the event, excluding the particles contributing to the B candidate, is required to be larger than three. This cut exploits the fact that the multiplicity in $\Upsilon(4S)$ decays is larger than in the continuum. In addition, it is a precondition for the implementation of the third cut: the Fox–Wolfram moment $H_2$ [9] of the remaining charged and neutral particles in the event has to be less than 0.3, thereby selecting spherical events.

Candidates which pass these cuts and have an invariant mass in the B mass region show a prominent peak at 180° in the distribution of the opening angle between proton and antiproton $\delta_{\mathrm{p\bar{p}}}$ (fig. 1a). This behaviour is readily understood if two-body final states, consisting of protons and low mass baryonic resonances, dominate. As an example, the $\delta_{\mathrm{p\bar{p}}}$ distribution for Monte Carlo generated $\mathrm{B}\to\bar{\mathrm{p}}\Delta$, $\Delta\to\mathrm{p}\pi$ decays shown in fig. 1b exhibits the same back-to-back peaking as the B candidates. In contrast, the $\delta_{\mathrm{p\bar{p}}}$ distribution for candidates below the B mass region in $\Upsilon(4S)$ sample (fig. 1d), as well as for continuum data (fig. 1c), shows a significantly less pronounced peaking at 180°. Exploiting this difference, we require $\cos\delta_{\mathrm{p\bar{p}}} \leqslant -0.98$. This cut clearly favours low pπ invariant masses.

After applying these cuts, in the mass range be-

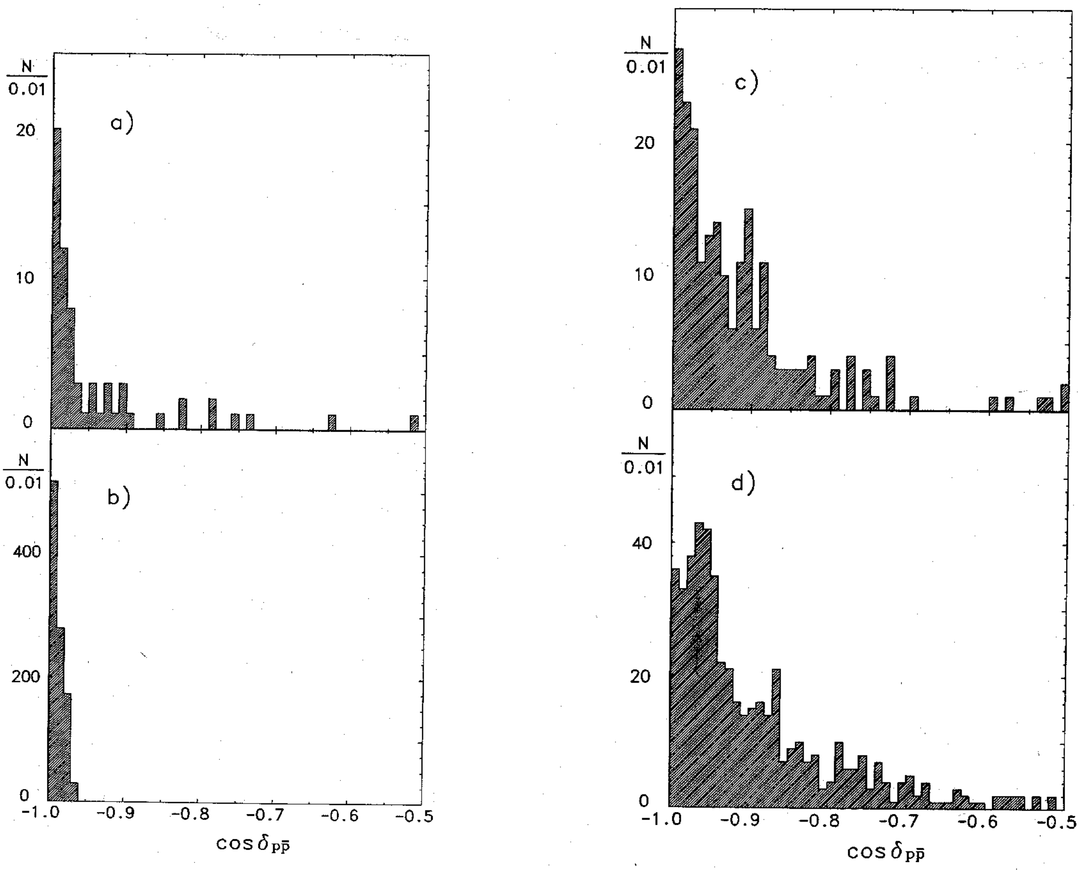

Fig. 1. Opening angle distribution $\cos\delta_{\mathrm{p\bar{p}}}$ for (a) $\Upsilon(4S)$ data; $5.272 \leqslant M_{\mathrm{p\bar{p}}\pi^+(\pi^-)} \leqslant 5.285$ GeV/$c^2$. (b) Monte Carlo events $\mathrm{B}\to\Delta\bar{\mathrm{p}}$. (c) Continuum data; $5.100 \leqslant M_{\mathrm{p\bar{p}}\pi^+(\pi^-)} \leqslant 5.290$ GeV/$c^2$. (d) $\Upsilon(4S)$ data; $5.100 \leqslant M_{\mathrm{p\bar{p}}\pi^+(\pi^-)} \leqslant 5.260$ GeV/$c^2$.

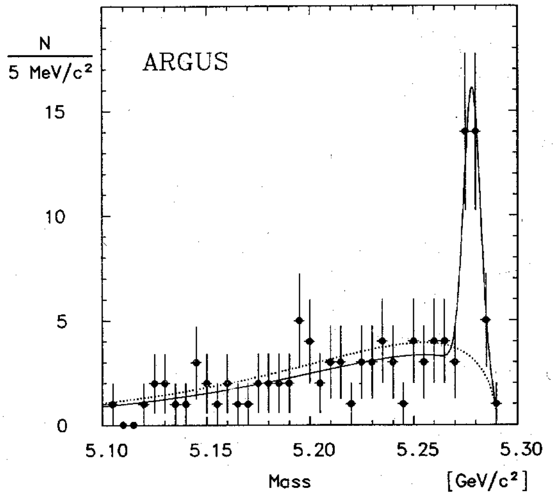

Fig. 2. Mass distribution of B meson candidates in both channels for ϒ(4S) data (points with error bars) with the fit described in the text (full line). The dotted line corresponds to the fit to continuum data, normalized as described in the text.

tween 5.1 GeV/$c^2$ and the kinematic limit at 5.29 GeV/$c^2$, 18% of the events contain more than one B candidate in one of the decay channels and 7% contain candidates in both channels. Only one candidate per channel is accepted. This is achieved by choosing the candidate with the smallest $\chi^2$ from the beam energy constraint fit.

The resulting mass spectrum for the ϒ(4S) data (fig. 2) shows a pronounced peak in the B mass region. The shape of the background is described by the form

$$\frac{N}{\mathrm{d}M} \sim M\sqrt{1-M^2/E_{\mathrm{beam}}^2}\,\exp[\alpha(1-M^2/E_{\mathrm{beam}}^2)]\,.$$

The first factor is derived by assuming that the background is uniformly distributed in phase space while the exponential factor describes empirically the decrease of background towards lower masses using a free parameter $\alpha$. Since the level of background is small, the results are not sensitive to the chosen form.

From a fit with a gaussian above this background we find a signal at a mass of $(5278.3\pm1.1\pm3.0)$ MeV/$c^2$ with a width, consistent with expectation, of $\sigma_{\mathrm{M}}=(4.2\pm1.0)$ MeV/$c^2$. In a ±1.5 sigma region around the B mass, we observe in total 34 events. Only $9\pm4$ of these events can be attributed to the background where the error includes a systematic contribution from the uncertainty of the background shape. The probability that the observed excess of events is a statistical fluctuation of the background corresponds to more than five standard deviations.

The sample can be divided into neutral and charged B mesons (fig. 3). The masses obtained by separate fits to these distributions are given in table 1. They

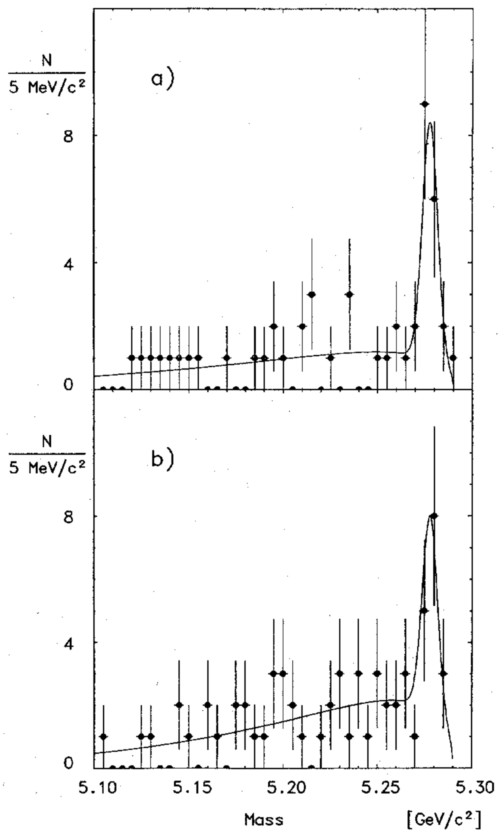

Fig. 3. Mass distribution of B meson candidates in the decay channels (a) $\mathrm{B}^+\to\mathrm{p}\bar{\mathrm{p}}\pi^+$, (b) $\mathrm{B}^0\to\mathrm{p}\bar{\mathrm{p}}\pi^+\pi^-$.

Table 1
Comparison of fitted mass values for $\mathrm{B}^0$ and $\mathrm{B}^+$ in MeV/$c^2$. The $\mathrm{D}^{*+}+n\pi$ mass values are from ref. [2], readjusted to $M(\Upsilon(4\mathrm{S}))=10580$ MeV/$c^2$.

| Mass | $\mathrm{p}\bar{\mathrm{p}}\pi^+(\pi^-)$ | $\mathrm{D}^{*+}+n\pi$ |
|---|---|---|
| $M(\mathrm{B}^0)$ | $5278.8\pm1.7\pm3.0$ | $5279.7\pm1.0\pm3.0$ |
| $M(\mathrm{B}^+)$ | $5277.8\pm1.2\pm3.0$ | $5277.3\pm1.3\pm3.0$ |
| $M(\mathrm{B}^0)-M(\mathrm{B}^+)$ | $1.0\pm2.1\pm1.0$ | $2.4\pm1.6\pm1.0$ |

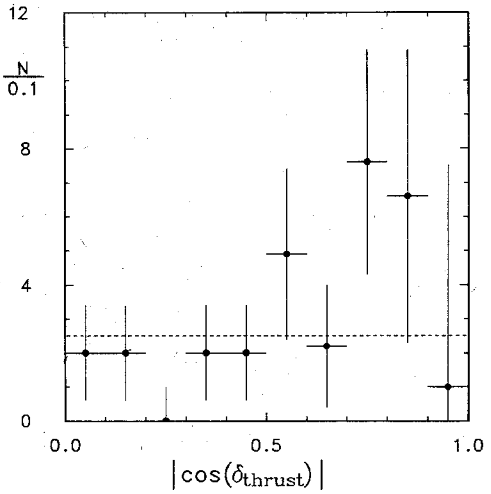

Fig. 4. Thrust axes angle distribution $|\cos\delta_{\mathrm{thrust}}|$, obtained by separate fits to mass distribution in each $|\cos\delta_{\mathrm{thrust}}|$ bin. The dashed line corresponds to the observed signal.

agree nicely with previous measurements in the decay channels $B \to D^{*+} n\pi$, $n = 1,2,3$ [2]. In order to determine branching ratios, we assume that 55% of $\Upsilon(4S)$ mesons decay into $B^+B^-$ pairs and 45% into pairs of neutral B mesons. A Monte Carlo simulation is used to calculate the geometrical acceptance. Since the $|\cos\delta_{\mathrm{thrust}}|$ distribution is expected to be flat, the acceptance for the cut on the thrust axes angle is taken to be 0.8. Fitting the invariant mass distribution in separate bins, the angular distribution shown in fig. 4 has been determined for our data. Within the errors, the data is consistent with being flat. The acceptance of the cut on the opening angle between proton and antiproton is evaluated by fitting the observed signal without this requirement. The losses due to the other cuts are determined by the same method, taking into account possible correlations between the different requirements. By this means we find

$$\mathrm{Br}(B^+ \to p\bar{p}\pi^+) = (5.2 \pm 1.4 \pm 1.9) \times 10^{-4},$$

$$\mathrm{Br}(B^0 \to p\bar{p}\pi^+\pi^-) = (6.0 \pm 2.0 \pm 2.2) \times 10^{-4},$$

where the first is the statistical and the second the systematic error, including a contribution introduced by our assumed background function.

A comparison of these values with upper limits for branching ratios of the decay channels $B^0 \to p\bar{p}$ and $B^+ \to p\bar{p}\pi^+\pi^+\pi^-$ in our data is given in table 2. The analysis of the two-prong and five-prong channels is identical to the analysis described above, except that the cut on the angle between p and $\bar{p}$ is not applied.

Table 2
Branching ratios for the decay channels $B \to p\bar{p} + n\pi$ and $B \to p\bar{\Lambda} + n\pi$.

| | |
|---|---|
| $\mathrm{Br}(B^0 \to p\bar{p})$ | $< 1.3 \times 10^{-4}$ (90% CL) |
| $\mathrm{Br}(B^+ \to p\bar{p}\pi^+)$ | $(5.2 \pm 1.4 \pm 1.9) \times 10^{-4}$ |
| $\mathrm{Br}(B^0 \to p\bar{p}\pi^+\pi^-)$ | $(6.0 \pm 2.0 \pm 2.2) \times 10^{-4}$ |
| $\mathrm{Br}(B^+ \to p\bar{p}\pi^+\pi^+\pi^-)$ | $< 4.7 \times 10^{-4}$ (90% CL) |
| $\mathrm{Br}(B^+ \to p\bar{\Lambda})$ | $< 8.5 \times 10^{-5}$ (90% CL) |
| $\mathrm{Br}(B^0 \to p\bar{\Lambda}\pi^-)$ | $< 2.0 \times 10^{-4}$ (90% CL) |
| $\mathrm{Br}(B^+ \to p\bar{\Lambda}\pi^+\pi^-)$ | $< 1.8 \times 10^{-4}$ (90% CL) |

In general, background arises from resonant $e^+e^- \to \Upsilon(4S)$ events and from continuum $e^+e^- \to q\bar{q}$ events. The continuum mass distribution (fig. 5a) does not show any excess of events at the B mass. Thus, the observed signal originates from $\Upsilon(4S)$ decays and cannot be faked by any background from continuum events. Outside the B mass region, continuum and $\Upsilon(4S)$ data agree in magnitude within one standard deviation. This is shown in fig. 2 where the continuum data are normalized according to the ratio of luminosities taken on and off the $\Upsilon(4S)$ resonance. Thus, the background in the $\Upsilon(4S)$ sample can be explained as originating mainly from nonresonant $e^+e^- \to q\bar{q}$ events, and, at least outside the enhancement at the B mass, the contribution from $e^+e^- \to \Upsilon(4S)$ resonance decays must be small.

The only remaining background sources which could conceivably produce a peak are reflections from other B meson decay channels. Reflections may occur if particles are used with a wrong mass hypothesis (particle misidentification) or if particles are added to or removed from the true final state (adding or losing particles).

Particle misidentification alone cannot explain any kind of reflection in this analysis. The pions in the investigated final states have momenta below 800 MeV/$c$ and are, in general, unambiguously identified. Most of the protons have momenta above 1.5 GeV/$c$ where particle identification allows at best for a 1.5 standard deviation K–p or π–p separation on a single track basis. However, an additional check was made on the validity of the proton identification in our sample of events. For this purpose, we compared

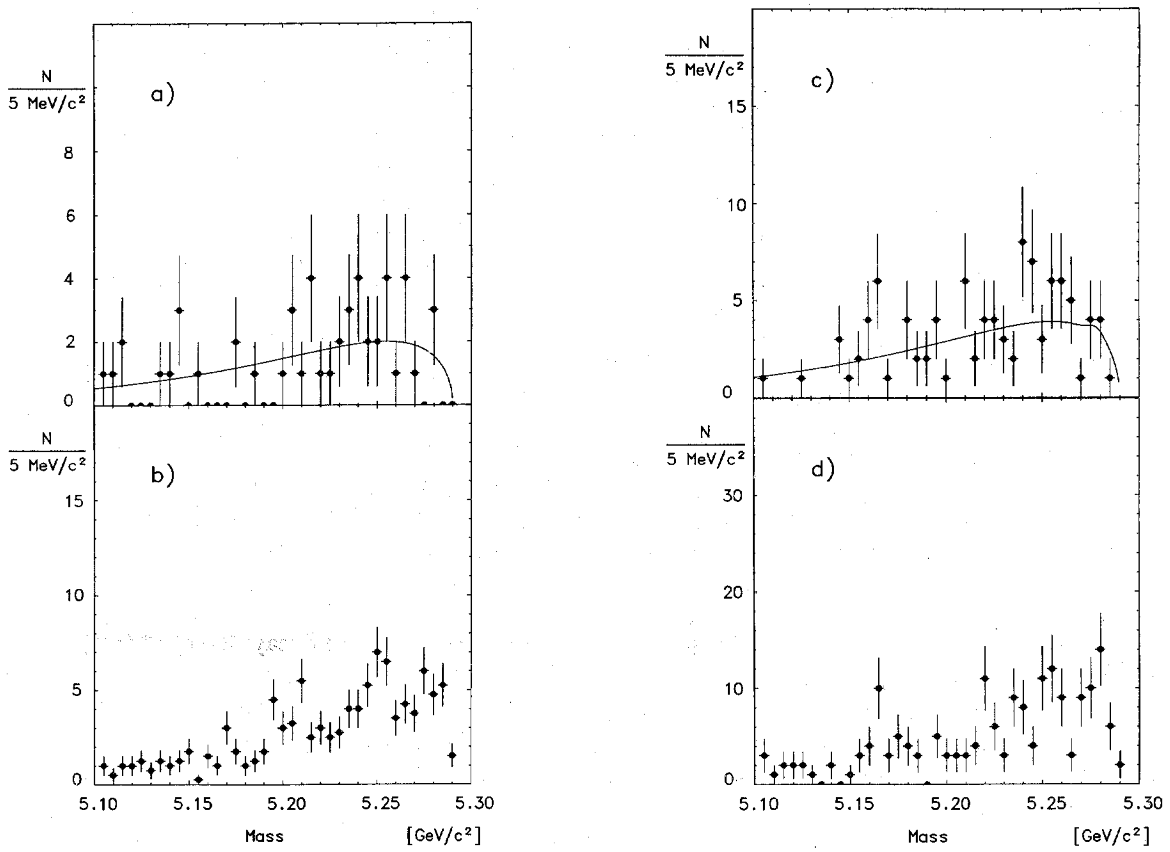

Fig. 5. Mass distribution of $p\bar{p}\pi(\pi)$ combinations for (a) continuum data, (b) wrong energy candidates. The differences between the true B meson energy and the chosen energies are ±300 MeV and ±500 MeV. The mass scale is shifted accordingly. (c) Forbidden combinations ($pp\pi^-$ and $pp\pi^-\pi^-$). (d) Monte Carlo generated events with $b\to c$ transitions only. The number of Monte Carlo events corresponds to 11 times the number of measured $\Upsilon(4S)$ events.

the properties of the proton and antiproton candidates with the properties of a sample of uniquely identified protons and antiprotons of similar momenta, produced from $\Lambda$ and $\bar{\Lambda}$ decays, respectively. For the shower counters, comparisons were made of both the energy deposited and the lateral shape of the showers. Further studies were made, for the two samples, of the measured specific ionization in the drift chamber and of data from the time of flight counters. The response of the protons and antiprotons in the B candidates was in all cases found to be in excellent agreement with the observed behaviour of the $\Lambda$- and $\bar{\Lambda}$-tagged samples, respectively.

One component of the correlated background can be eliminated from the start by recognizing that the mass difference between protons and kaons (pions) is large enough to kinematically separate related final states where kaons (pions) are misidentified as protons. Combinations with a wrong mass assignment do not pass the energy cut, provided everything else is interpreted correctly. Similarly, adding or losing a single particle is excluded as a source of reflections as long as only one of these misinterpretations takes place. Again, these combinations are rejected by the energy cut.

As a consequence, only those reflections need to be considered which have two or more simultaneous mistakes (particle misidentification and adding or losing particles) affecting the energy balance in different directions and fulfilling the energy constraint, thereby producing a peak at the expected mass with the expected narrow width.

An estimate of these background contributions can be obtained by intentionally using wrong B meson energies and, correspondingly, wrong B meson masses in the analysis. The mass distribution obtained by this procedure does not show any peak at the assumed B mass (fig. 5b). This method overestimates the background because reflections show up more easily at wrong energies: particle misidentification alone or adding or losing a particle alone may fulfil the energy constraint, in contrast to reflections at the correct energy.

Background from B meson decays into charmed final states is estimated by the following method: a search for decays of the particles $D^{\pm}$, $D^0$, $D_s^{\pm}$, and $\Lambda_c$ has been performed by analysing invariant mass distributions of all meaningful particle combinations. These combinations are obtained by assigning all allowed mass hypotheses to all particles in the observed final states. Searches were made for both Cabibbo-allowed and suppressed charmed particle decays, and for the decays of $\Lambda$ or $K_s^0$ with undetected decay vertices. In total, only one candidate is consistent with originating from charmed particle decays. As it appears in the Cabibbo-suppressed decay mode $\Lambda_c \to p\pi^+\pi^-$, it can be readily interpreted as an accidental combination.

Most reflections are expected to be visible in combinations, such as $pp\pi^-$, which are forbidden by baryon number conservation. These should occur at a rate comparable with, if not larger than, that for the allowed channels. However, no enhancement is observed in the B mass region for forbidden combinations in the $\Upsilon(4S)$ data sample (fig. 5c).

Finally, the same analysis repeated for $2.1 \times 10^6$ Monte Carlo B decays, generated via $b \to c$ transitions alone, does not show an enhancement at the B mass in the charmless final states (fig. 5d). Normalized to the data, this contribution corresponds to at most one entry per bin. The Monte Carlo generator has been carefully adjusted to reproduce all known inclusive and exclusive branching ratios of B meson decays. There are some special charm decay channels which can occasionally produce a narrow reflection in the B-mass region. However, the contribution of all such channels is much too small to fake the observed signal. In summary, there is no indication for any background source which could be responsible for a peak at the B mass, in particular for a peak with the observed narrow width.

It is conceivable that the observed decay channels $B^+ \to p\bar{p}\pi^+$ and $B^0 \to p\bar{p}\pi^+\pi^-$ are due to penguin-type loop diagrams [10]. Contributions of such diagrams are expected to be small. Moreover, the observed decays should be suppressed relative to channels containing strangeness in the final state by a factor $|V_{ts}/V_{td}|^2$. Therefore, we investigate analogous decay modes with a strange baryon in the final state. Using the same requirements as described above, except the cut in the angle between the baryons, we find no signal in the decay channels $B^0 \to p\bar{\Lambda}\pi^-$ and $B^+ \to p\bar{\Lambda}\pi^+\pi^-$ (table 2) which leads to an upper limit

$$\frac{\mathrm{Br}(B \to p\bar{\Lambda}\pi^-(\pi^+))}{\mathrm{Br}(B \to p\bar{p}\pi^-(\pi^+))} \leqslant 0.4 \quad (90\%\ \mathrm{CL})\ .$$

Corresponding channels with a $\Sigma^0$ instead of a $\Lambda$ are experimentally not accessible. Any reasonable assumption about the relative $\Lambda/\Sigma^0$ rate, however, leads to the conclusion that loop diagram contributions are at least one order of magnitude too small to account for the signal in the decays $B \to p\bar{p}\pi^+(\pi^-)$.

Therefore, we find that the only viable interpretation of our observation is to attribute these decays to $b \to u$ transitions. Estimates of the inclusive baryon rate in B decays have been made [11] but these are not sufficient to allow for a quantitative statement about the strength of the $b \to u$ coupling. However, we can conclude these charmless decay modes represent the first evidence that the Kobayashi–Maskawa matrix $V_{ub}$ is non-zero. This, in itself, is a significant discovery, with wide implications for the standard model explanation of *CP* violation.

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## References

[1] M. Kobayashi and T. Maskawa, Prog. Theor. Phys. 49 (1973) 652.
[2] ARGUS Collab., H. Albrecht et al., Phys. Lett. B 185 (1987) 218.

[3] CLEO Collab., M.S. Alam et al., Phys. Rev. D 34 (1986) 3279;
ARGUS Collab., H. Albrecht et al., Phys. Lett. B 197 (1987) 452; B 199 (1987) 451.
[4] CLEO Collab., C. Bebek et al., Phys. Rev. D 36 (1987) 1289.
[5] CUSB Collab., C. Klopfenstein et al., Phys. Lett. B 130 (1983) 444;
CLEO Collab., A. Chen et al., Phys. Rev. Lett. 52 (1984) 1084;
CUSB Collab., G. Levman et al., Phys. Lett. B 141 (1984) 271;
CLEO Collab., S. Behrends et al., Phys. Rev. Lett. 59 (1987) 407;
CRYSTAL BALL Collab., K. Wachs, DESY preprint DESY 87-084 (1987);
ARGUS Collab., K.R. Schubert, Proc. XXIIIrd Intern. Conf. on High energy physics (Berkeley, CA, 1987).
[6] CLEO Collab., A. Bean et al., Contributed paper 1987 Intern. Symp. on Lepton and photon interactions (DESY, Hamburg, 1987);
ARGUS Collab., H. Schröder, 23rd Rencontre de Moriond (Les Arcs, 1988).
[7] ARGUS Collab. H. Albrecht et al., Phys. Lett. B 134 (1984) 137.
[8] ARGUS Collab., H. Albrecht et al., Phys. Lett. B 150 (1985) 235.
[9] G.C. Fox and S. Wolfram, Phys. Lett. B 82 (1979) 134.
[10] L.L. Chau and H.Y. Cheng, Phys. Rev. Lett. 53 (1984) 1037;
M.B. Gavela et al., Phys. Lett. B 154 (1985) 425; Phys. Lett. B 165 (1986) 429;
P.J. O'Donnell, Phys. Lett. B 175 (1986) 369;
N.G. Deshpande, Proc. UCLA Workshop on SSC physics (1986);
L.Lukaszuk et al., Phys. Lett. B 202 (1988) 388.
[11] I.I. Bigi, Phys. Lett. B 106 (1981) 510;
B. Stech, Phys. Rev. D 36 (1987) 975;
M. Gronau and J.L. Rosner, University of Chicago preprint EFI 87-55 (1987);
N.G. Deshpande, J. Trampetic and A. Soni, University of Oregon preprint OITS 370 (1987);
M.A. Shifman, Proc. 1987 Intern. Symp. on Lepton and photon interactions (DESY, Hamburg, 1987) p. 289;
S. Barshay, E. Eich and L. Sehgal, Phys. Lett. B 202 (1988) 402;
J.G. Körner, University of Mainz preprint MZ-TH/88-01 (1988).