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Determination of $BR(c \to l)$ at LEP

Preliminary

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Abstract

The $c \to l$ semi-leptonic branching fraction was measured using a double tag method based on the detection of exclusively reconstructed D mesons accompanied by a lepton in the opposite hemisphere.

From the analysis of ~3.0 Million Z^0 events collected in 1991-94 runs, (5369 ± 182) $D^{*\pm}$ or D^0 decays with high charm purity were selected. From a sample of (411 ± 26) identified leptons opposite to the reconstructed D mesons, the charm semi-leptonic branching ratio was measured to be :

$$BR(c \to l) = (9.7 \pm 0.8(stat) \pm 0.4(syst)) \cdot 10^{-2}$$

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1 Introduction

The charm semi-leptonic branching fraction is measured with a rather large error in low energy experiments [1]. Its uncertainty is an important source of systematic error for the R_b measurement using b semi-leptonic decays [2] and for the study of B^0 oscillation based on the lepton-jet charge correlation [3].

In this paper, a method based on the tagging of charm production in Z^0 hadronic decays by an energetic fully reconstructed D^* or D^0 meson is presented. The charm semi-leptonic decay is detected by the presence of an identified muon or electron in the opposite hemisphere.

Section 2 gives a short description of the DELPHI detector and its features relevant to the present analysis, and briefly describes the selection of Z^0 hadronic decays. The reconstruction of exclusive $D^{*+} \to D^0\pi^+$ and $D^0 \to K^-\pi^+$ [1] decays is reported in Section 3, while Section 4 deals with the determination of the $c \to l$ semileptonic branching fraction.

2 The DELPHI detector and hadronic selection

The DELPHI detector has been described in detail elsewhere [4, 5]. Both charged particle tracking through the uniform axial field, and kaon and lepton identification are important in this analysis. The detector elements used for tracking are the Vertex Detector (VD), the Inner Detector (ID), the Time Projection Chamber (TPC), the Outer Detector (OD) and the Forward Chambers in the endcap regions. The other important detectors are the Ring Imaging Cherenkov detector (RICH) for hadron identification, the barrel electromagnetic calorimeter (HPC) and the muon chambers for lepton identification. The ionization loss measurements in the TPC are also used for particle identification.

The VD, consisting of 3 cylindrical layers of silicon detectors (radii 6, 8 and 11 cm), provides up to 3 hits per track (or more in small overlapping regions) in the polar angle range $43^o < \theta < 137^o$. The intrinsic resolution of the VD points is $\pm 8\mu$m, measured in the plane transverse to the beam direction ($r\phi$ plane). The precision on the impact parameter with respect to the primary vertex of a track having hits associated in the VD is $\pm 26\mu$m, measured in dimuon Z^0 events.

Charged particle tracks were reconstructed with 95% efficiency and with a momentum resolution $\sigma_p/p < 2.0 \times 10^{-3} p$ (GeV/c). The primary vertex of the e^+e^- interaction was reconstructed on an event-by-event basis using a beam spot constraint. The position of the primary vertex could be determined in this way to a precision of about $40\mu m$ (slightly dependent on the flavour of the primary quark-antiquark pair) in the plane transverse to the beam direction. In this plane secondary vertices from beauty and charm decays were reconstructed with a precision of $\pm 300\mu$m along the flight direction of the decaying particles.

Hadron identification relied on the specific ionization measurement, dE/dx, performed by the TPC and by the RICH detector. The dE/dx measurement had a precision of $\pm 7\%$ in the momentum range $4 < p < 25$ GeV/c. The RICH detector consisted of a liquid radiator which provided $p/K/\pi$ separation in the intermediate momentum region 2.5–8

[1] charged conjugate states are always implied throughout this paper

GeV/c, and a gas radiator which worked in veto mode for proton rejection in the region 8–16 GeV/c and separated protons from kaons for momenta less than 30 GeV/c.

The barrel electromagnetic calorimeter (HPC), covered the polar angle region $46^\circ < \theta < 134^\circ$, and detected electrons with an energy precision $\sigma_E/E \simeq 0.25/\sqrt{E}(GeV)$. Two planes of muon chambers covered the polar angle region $20^\circ < \theta < 160^\circ$, except for two regions of $\pm 3^\circ$ around $\theta = 42^\circ$ and $\theta = 138^\circ$. The first layer was inside the return yoke of the magnet, after 90 cm of iron, while the second was mounted outside the yoke, behind a further 20 cm of iron.

Hadronic events from Z^0 decays were selected by requiring a charged multiplicity greater than 4 and a total reconstructed energy greater than 0.12 $\sqrt{s}$; charged particles were required to have a momentum greater than 0.4 GeV/c and polar angle between 20^o and 160^o. The overall trigger and selection efficiency was 0.95 ± 0.01 [5].

3 Exclusive D^* and D^0 selection

Charged D^* mesons were reconstructed through their $D^{*+} \to D^0\pi^+$ decay with the D^0 meson fully reconstructed in the channels $D^0 \to K^-\pi^+, K^-\pi^+\pi^+\pi^-$ or partially reconstructed using the decay channels $D^0 \to K^-l^+\nu X$ and $D^0 \to K^-\pi^+X$. The D^0 decay products had to fit a secondary vertex; its decay length projected onto the plane transverse to the beam direction was required to be greater than the error on the vertex position. The D^0 flight direction had to be compatible within 5^0 with the direction of the reconstructed D^0 momentum. In all the considered D^0 decay channels except the $D^0 \to K^-\pi^+$ one, the χ^2 probability of the vertex fit was required to be larger than 0.001.

To reduce the combinatorial background and to enrich the D^* signal sample of mesons coming from the c-quark fragmentation, $D^{*+} \to D^0\pi^+$ candidates with and pion momentum greater than 1 GeV/c and $X_E = E(D^*)/E_{beam} > 0.30$ (0.20 for the $K\pi$ channel) were selected. The momentum of all the D^0 decay products was greater than 1 GeV/c. The pion tracks from D^0 candidates were required to be incompatible with the kaon hypothesis according to the RICH identification [5]. In addition, the charged kaon candidate had the lowest energy loss in the TPC among all the charged particle tracks of the secondary vertex or had to be identified as kaon by the RICH.

The invariant mass of the charged particle system was required to be in the range reported in Table 1. The distributions of the mass difference $\Delta M = M(D^0\pi^+) - M(D^0)$ for the selected candidates in the four D^0 decay modes considered are shown in Figs.1a-d respectively. The background-subtracted distribution of the energy (normalized to the beam energy) of D^* candidates with ΔM within the ranges reported in Table 1 (referred as 'ΔM signal range' in the following) is shown in Fig.1e and compared with the simulation prediction for D^* produced in $Z \to q\bar{q}$ hadronic channels ($q = c, b$). In the simulation, the value $r = R_b \cdot P(b \to D^*)/R_c \cdot P(c \to D^*) = 1.23$ was assumed for the D^* meson production in Z^0 hadronic decays.

The simulation predicts a non-negligible contribution of D^* coming from $b\bar{b}$ events in the selected sample. In order to reduce this contribution, an anti-b tag selection was applied, based on the event probability P_{btag} defined by the b-tagging algorithm used in the R_b measurement [6]. The distribution of this probability for the events with a reconstructed D^* candidates with ΔM in the signal range is shown in Fig.2 for the 1994 data sample. A final sample of events enriched in D^* mesons originating from

Table 1: Number of D^* decays in the selected samples and corresponding fractions f_c of the D^* signal coming from $c\bar{c}$ events predicted by the simulation.

D^0 channel	D^0 Mass range	ΔM range	Nr.of signal events	f_c
$D^0 \to K\pi$	1.80-1.92	0.143-0.148	1689 ± 110	0.78 ± 0.02
$D^0 \to K\pi(\pi^0)$	1.40-1.70	0.140-0.160	1549 ± 106	0.85 ± 0.02
$D^0 \to Kl\nu X$	1.30-1.70	0.140-0.170	858 ± 33	0.86 ± 0.02
$D^0 \to K3\pi$	1.83-1.90	0.143-0.148	609 ± 84	0.80 ± 0.02
All channels			4705 ± 177	0.817 ± 0.015

c-quark fragmentation was selected imposing the cut $P_{btag} > 0.001$. The resulting ΔM distributions are shown in Figs.3a-d and the background subtracted energy distribution of D^* candidates is shown in Fig.3e.

The ΔM distributions were fitted by a signal function superimposed to a background function with threshold behaviour : $f_{backg} = A \cdot (\Delta M - m_\pi)^\alpha$. The signal function was the sum of 2 gaussians with central values equal to 145 MeV/c^2 and widths σ_1, σ_2 left as free parameters in the fit. The results of the 6 parameters ($A, \alpha, \sigma_1, \sigma_2$ and the signal yields associated to the 2 gaussian curves) are shown by the continous lines in Fig.4. The fitted number of D^* decays in each channel is reported in Table 1.

The total number of reconstructed D^* was $N_{D^*} = 4705 \pm 177$. The fractions f_c of D^* signal expected to come from $c\bar{c}$ events were computed from the equation : $f_c = 1/(1 + r \cdot r_\epsilon)$, where $r_\epsilon = \epsilon_b/\epsilon_c$(=0.19, averaged on all the considered channels) is the simulation prediction for the ratio between the overall reconstruction and selection efficiencies for D^* from b and c decays. The error on the fractions f_c includes the statistical error of the simulation sample and the systematic error originating from the uncertainties on the charm and beauty relative productions and decay properties. In the f_c computation, the prediction of the simulation for this quantity was corrected using the experimental value $r = R_b \cdot P(b \to D^*)/R_c \cdot P(c \to D^*) = 1.225 \pm 0.09$ [7].

An independent selection of the $D^0 \to K\pi$ channel was used, based on a tighter identification of the decay D^0 products : the kaon candidate track was identified as kaon according to the tight RICH selection defined in [5] or a 'standard' kaon identification in the RICH and an energy loss measurement in the TPC at least 0.5 standard deviations lower than the expected value for the pion hypothesis; the pion track candidate had not to be identified as kaon or proton by the RICH and had an energy loss in the TPC, if measured, compatible with the pion hypothesis within 2.3 standard deviations. The resulting $M(K\pi)$ invariant mass spectrum for candidates not coming from D^* decays, after the anti-btag selection and the cut $X_E > 0.20$, is shown in Fig.5. A fit to the distribution with a Gaussian superimposed to a sum of two exponential functions parametrizing the background gives a D^0 yield :

$$N_{D^0} = 664 \pm 42$$

where the statistical error takes into account the background subtraction; the purity in $c\bar{c}$ events was $f_c = 0.80 \pm 0.03$. In the f_c computation, the prediction of the simulation for this quantity was corrected using the experimental value :

Table 2: Electron and muon efficiencies for the 1993 and 1994 data. The error takes into account both the indetermination of ϵ^0 from the data (see text) and the amount of simulated events used to compute the additional correction from simulation.

	1993 data	1994 data
$\epsilon_e\%$	47.9 ± 1.3	48.3 ± 1.2
$\epsilon_\mu\%$	65.7 ± 1.2	63.8 ± 1.6

$r = R_b \cdot P(b \to D^0)/R_c \cdot P(c \to D^0) = \frac{R_b}{R_c} \cdot (1.07 \pm 0.15 \pm 0.08) = 1.38 \pm 0.21$ [8].

The D^0 candidates had to be in the $M(K\pi)$ invariant mass region shown by the arrows in Fig.5. The total amount of D mesons after the cuts was:

$$N_{D^0+D^*} = 5369 \pm 182$$

out of which a fraction $f_c = 0.817 \pm 0.04(stat) \pm 0.014(syst)$ was estimated by the simulation to be produced in $c\bar{c}$ events.

4 Measurement of $BR(c \to l)$

4.1 Lepton selection

Semileptonic decays of charm quark were selected by looking for electrons and muons with momenta $p > 3\ GeV/c$ in the hemisphere opposite to the reconstructed D mesons.

Lepton identification is described in [5, 11]. The electron identification efficiency inside the angular acceptance of the barrel electromagnetic calorimeter (HPC) was measured on the data and found to be $\epsilon_e^0 = (61.7 \pm 1.0)\%$ and $\epsilon_e^0 = (60.3 \pm 1.2)\%$ respectively for 1993 and 1994 data, with a hadron misidentification probability of $(0.37 \pm 0.03)\%$. The muon identification efficiency inside the angular acceptance of the muon chambers was $\epsilon_\mu^0 = (82.3 \pm 0.7)\%$ and $\epsilon_\mu^0 = (82.1 \pm 0.8)\%$ for the same periods, with a hadron misidentification probability of $(0.8 \pm 0.1)\%$.

These efficiencies had to be corrected for the events with a reconstructed D^* having an electron (muon) from a semileptonic c-decay in the opposite side outside the fiducial volume of the HPC (muon chambers). The correction factors, computed from the simulation, were $\epsilon_e^{MC} = (80.2 \pm 1.6)\%, \epsilon_\mu^{MC} = (77.7 \pm 1.3)\%$. Table 2 shows the resulting lepton efficiencies for 1993 and 1994 data.

Only the leptons with opposite charge with respect to the slow pion in the D^* sample or with the same charge as the kaon in the D^0 sample were selected, in order to tag the semileptonic decay of the c quark in the hemisphere opposite to the reconstructed D meson decay and to reduce the contamination due to the decays of b quarks. In the following, they will be referred as 'leptons with right charge correlation'. No requirement was imposed on the transverse momentum of the lepton, p_T, w.r.t. its jet axis.

4.2 Determination of $BR(c \to l)$

To determine the number of lepton candidates opposite to genuine D mesons, the number N_{backg}^{lep} of leptons associated to background D meson candidates must be subtracted to the total number of leptons accompanying reconstructed D^* or D^0 in the signal regions defined above (see Table 1 for D^* and Fig.5 for D^0). The number N^{lep}_{backg} was computed by the number of identified leptons accompanying D meson candidates in the side bands of the mass distributions, scaled by the proper normalization factor determined from the fits to the mass distribution described in Sect.3. The effect of kinematic reflections from true $D^0/\bar{D}^0$ decays with the wrong $M(K\pi)$ assignement was studied on the simulation and found negligible. The background subtracted p and p_T distributions of the selected lepton candidates are shown in Fig.6 for real (dots) and simulated data (histograms). The hatched histograms show the simulation prediction for lepton candidates accompanying a genuine D^* produced in $b\bar{b}$ events.

After the background subtraction, the number of lepton candidates in the hemisphere opposite to genuine D mesons and with the right charge correlation was:

$$N^e(p > 3\ GeV/c) = 186 \pm 18$$
$$N^\mu(p > 3\ GeV/c) = 225 \pm 19$$

For each of the two flavours, the total amount of lepton candidates is the sum of different contributions:

$$(3) \qquad N^{lep} = N_c^{true} h_c^{true} + N_c^{fake} h_c^{fake} + N_b^{true} h_b^{true} + N_b^{fake} h_b^{fake}$$

where $N^{true}_{c,b}$ are the numbers of true leptons coming from the semileptonic decays of c, b quarks and $N^{fake}_{c,b}$ result from the sum of genuine leptons from the decay of light particles with misidentified hadrons in $c\bar{c}$ and $b\bar{b}$ events respectively. The factors $h_c^{true,fake}$ and $h_b^{true,fake}$ in the previous formula are small corrections predicted by the simulation to take into account the fact that, due to hard gluon radiation, the two heavy partons could hadronize in the same hemisphere. The fractions of $c\bar{c}$ and $b\bar{b}$ events in which the lepton and the D meson are produced in opposite hemispheres are $h_c^{true} = 0.984 \pm 0.001$, $h_c^{fake} = 0.993 \pm 0.001$, $h_b^{true} = 0.984 \pm 0.001$, $h_b^{fake} = 0.989 \pm 0.002$ according to the simulation.

In the above formula, the number of true leptons coming from b decays with the right charge correlation with the slow pion (kaon) from the $D^*(D^0)$ decays can be computed by the equation:

$$(4)\ N_b^{true} = \epsilon^{lep} N_D^b [\chi^D_{eff}(BR_{b\to l}F_{b\to l} + BR_{b\to\bar{c}\to l}F_{b\to\bar{c}\to l} + BR_{b\to\tau\to l}F_{b\to\tau\to l}) + (1-\chi^D_{eff})BR_{b\to c\to l}F_{b\to c\to l})]$$

where N_D^b is the number of D mesons in the selected sample originating from b-quark predicted by the simulation, ϵ^{lep} is the lepton efficiency, and χ^D_{eff} is the effective mixing parameter $\chi^D_{eff} = \chi_D(1-\chi) + \chi(1-\chi_D)$.

In the last formula, $\chi = f_d\chi_d + f_s\chi_s = 0.133 \pm 0.011$ [9] and $\chi_D = (1 - f_D^+)\chi_d$, where $\chi_d = 0.168 \pm 0.019$ is the world averaged value for the B_d^0 mixing parameter [9] and $f^+_{D^*} = 0.16$, $f^+_{D^0} = 0.69$ are the assumed branching fractions for the decays $B^+ \to D^{*+}X$ and $B^+ \to D^0 X$, based on the measurement of the D production in semileptonic charged B meson decays [10].

$F_{b\to x}$ are the fractions of leptons with momentum greater than 3 GeV/c for the different semileptonic decays with branching fractions $BR_{b\to x}$. To determine these kinematic

Table 3: Branching fractions used in eq.(4) for the semileptonic decays of b quark and lepton kinematic acceptances for the cut $p_l > 3\ GeV/c$ predicted by the simulation. The first error is the statistical one, the second is due to the semileptonic modelling and the third to the uncertainty on X_E.

Decay	BR	$F(p > 3\ GeV/c)$
$b \to l$	0.1120 ± 0.0040	$0.763 \pm 0.002 \pm 0.007 \pm 0.002$
$b \to c \to l$	0.0820 ± 0.0120	$0.427 \pm 0.002 \pm 0.005 \pm 0.005$
$b \to \tau \to l$	0.0045 ± 0.0007	$0.562 \pm 0.010 \pm 0.004 \pm 0.006$
$b \to \bar{c} \to l$	0.0130 ± 0.0050	$0.434 \pm 0.007 \pm 0.005 \pm 0.008$
$c \to l$	$-$	$0.588 \pm 0.004 \pm 0.009 \pm 0.002$

Table 4: Fractions of true leptons fitted on data in inclusive identified lepton sample and computed for the lepton sample with a D meson in the opposite hemisphere.

	Electrons	Muons
$P_c^{incl}\%$	66.1 ± 1.5	73.1 ± 1.9
$P_b^{incl}\%$	80.4 ± 0.9	84.0 ± 1.1
$P_c^D(\%)$	80.8 ± 1.1	84.5 ± 1.3
$P_b^D(\%)$	75.7 ± 1.5	80.2 ± 1.6

acceptances, the simulated leptons were weighted to reproduce the data according to the results reported by the Electro Weak Working Group [12]. To describe the b semileptonic decays, the $ACCM$ model was assumed and the systematic error on $F_{b\to x}$ was given comparing the result with the predictions of the $IGSW$ and $IGSW^{**}$ models. For the c semileptonic decay the $ACCM$ model was used and the systematics were estimated comparing the results obtained with different choices for m_s and the Fermi momentum P_F. The simulated leptons were weighted in terms of z_{fragm} to reproduce the average ratio between the heavy mesons energy and the energy of the beam measured for $c\bar{c}$ and $b\bar{b}$ events: $X_{E,c} = 0.484 \pm 0.008$, $X_{E,b} = 0.702 \pm 0.008$. The b semileptonic branching fractions, fixed to the $EWWG$ values, are reported in Tab. 3 together with the kinematic acceptances for the different semileptonic decays of the b and the c quarks.

Equation (3) can be written as:

$$(5) \qquad N^{lep} = N_c^{true}[h_c^{true} + \frac{1-P_c^D}{P_c^D} h_c^{fake}] + N_b^{true}[h_b^{true} + \frac{1-P_b^D}{P_b^D} h_b^{fake}]$$

where $P_{c,b}^D = \frac{N_{c,b}^{true}}{N_{c,b}^{true}+N_{c,b}^{fake}}$ are the fractions of the true leptons in the D mesons subsample coming from $c\bar{c}$ ($b\bar{b}$) events. These fractions were computed using the fractions of true leptons in $c\bar{c}$ and $b\bar{b}$ events, $P_{c,b}^{incl}$ respectively, determined on the data from the fit to the inclusive (p, p_T) spectra of identified leptons [2] reported in Table 4.

For the D subsample produced in $c\bar{c}$ events, P_c^D can be expressed as :

$$P_c^D = \frac{P_c^{incl}}{P_c^{incl}+B_c(1-P_c^{incl})}$$

Table 5: Results on $BR(c \to l)$ ($\cdot 10^2$) for the different samples with the statistical error.

	D^*	D^0	$D^* + D^0$
$BR(c \to e)(\%)$	10.0 ± 1.3	8.2 ± 3.5	9.8 ± 1.2
$BR(c \to \mu)(\%)$	9.2 ± 1.1	12.3 ± 3.5	9.6 ± 1.0
$BR(c \to l)(\%)$	9.5 ± 0.8	10.2 ± 2.5	9.7 ± 0.8

where B_c is the fraction of fake leptons with the right charge correlation with the slow pion (kaon): $B_c = 0.500 \pm .016$ (μ sample) and $B_c = 0.464 \pm .012$ (e sample) according to the simulation.

For the D subsample produced in $b\bar{b}$ events, the situation is complicated by the presence of the effective mixing which destroys the charge correlation between the lepton and the slow pion(kaon), thus:

$$P_b^D = \frac{P_b^{incl}}{P_b^{incl} + B_b(1+R)(1-P_b^{incl})}$$

where R is the ratio between the numbers of the true leptons from b decays with the wrong and right charge correlation respectively. The latter is N_{true}^b given by eq.(4); the former is obtained by eq.(4) by exchanging χ_{eff}^D and $(1 - \chi_{eff}^D)$ in the formula. From this computation one obtains $R = 1.63 \pm 0.14$. Finally, the simulation prediction for the fraction B_b, defined in the same way as B_c, was $B_b = 0.494 \pm .015$ (μ sample) and $B_b = 0.503 \pm .013$ (e sample).

The resulting values for $P_{c,b}^D$ are reported in Table 4. The error on these fractions is due to the statistics of real and simulated data used in the fit to the lepton spectra, the uncertainty on the fitted parameters, the lepton identification efficiencies and the hadron misidentification probability.

The number of leptons coming from charm decays, obtained from equation (5) were:

$$N_c^{e,true} = 124 \pm 14(stat) \pm 5(syst)$$
$$N_c^{\mu,true} = 158 \pm 16(stat) \pm 6(syst)$$

The branching fraction $BR(c \to l)$ was obtained from the relation:

$$N_c^{true} = \epsilon^{lep} f_c N_{D^*+D^0} F_{c\to l} BR(c \to l)$$

where $F_{c\to l}$ is the last entry in Table 3. The results on $BR(c \to l)$ for the $D^* - lepton$ and the $D^0 - lepton$ analysis are reported in Table 5 for electrons and muons separately. The quoted errors are statistical only. The table shows also the average results.

The result obtained combining the D^* and D^0 samples and averaging the two lepton flavours was:

$$BR(c \to l) = (9.7 \pm 0.8(stat) \pm 0.4(syst)) \cdot 10^{-2}$$

The different contributions to the systematic error are listed in Table 6. The error due to the lepton purity quoted in the table takes into account the effect of the number of events used in the fit, the indetermination on the fitted parameters, the hadron misidentification probability together with the uncertainties on R and $B_{c,b}$. The errors due to the lepton efficiency, hadron misidentification and $B_{c,b}$ were considered as uncorrelated in the average of the results for electrons and muons.

Table 6: Contributions to the systematic error in the computation of $BR(c \to l)$.

Error Source	Variation	Syst.error
$\chi_{eff}(D^*)$	0.24 ± 0.04	∓ 0.0004
$\chi_{eff}(D^0)$	0.17 ± 0.02	∓ 0.0002
$r = R_b \cdot P(b \to D^*)/R_c \cdot P(c \to D^*)$	1.225 ± 0.094	± 0.0001
$r = R_b \cdot P(b \to D^0)/R_c \cdot P(c \to D^0)$	1.38 ± 0.21	± 0.0001
f_c	0.817 ± 0.015	∓ 0.0010
Lepton purity	see text	± 0.0013
ϵ^{lep}	"	∓ 0.0022
$BR_{b \to l}$	0.1120 ± 0.0040	∓ 0.0003
$BR_{b \to c \to l}$	0.0820 ± 0.0120	∓ 0.0014
$BR_{b \to \tau \to l}$	0.0045 ± 0.0007	∓ 0.0001
$BR_{b \to \bar{c} \to l}$	0.0130 ± 0.0050	∓ 0.0001
Kinematic acceptances:		
a) Simulation statistics	see Table 3	∓ 0.0007
b) Decay models	"	± 0.0016
c) Fragmentation	"	∓ 0.0004
Total	–	± 0.0036

5 Conclusions

Using a double tag method based on the detection of a lepton opposite to fully reconstructed D^* and D^0 mesons, the charm semileptonic branching fraction was measured from a sample of $Z \to c\bar{c}$ decays selected with high purity at LEP. The following result was found :

$$BR(c \to l) = (9.7 \pm 0.8(stat) \pm 0.4(syst)) \cdot 10^{-2}$$

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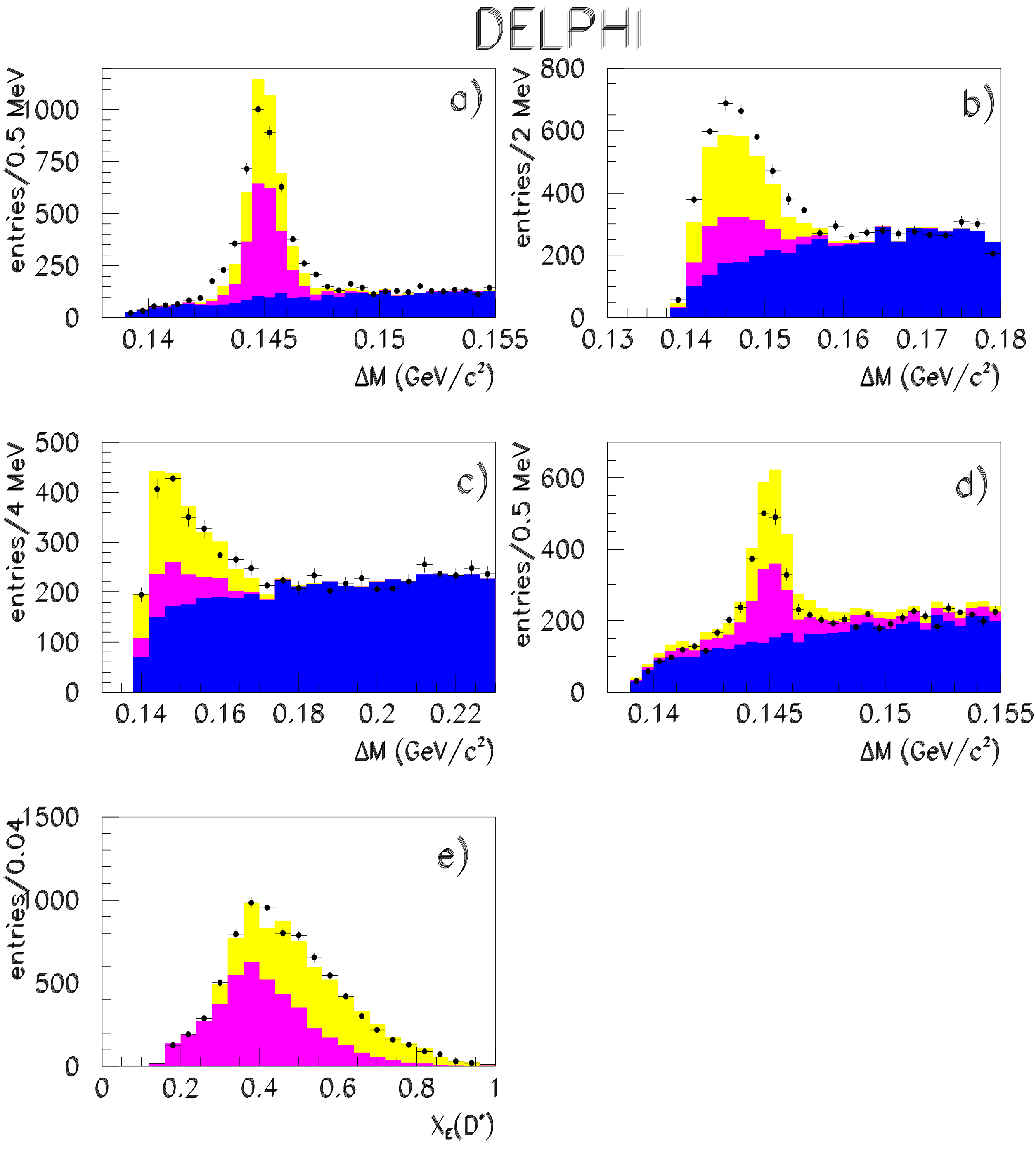

Figure 1: a-d) $\Delta M = M(D^0\pi) - M(D^0)$ mass difference distribution for the D^* candidate decays in the four D^0 channels considered. $D^0\pi^+$ combinations in the data are shown by dots; the light-shaded (dark-shaded) histograms show the simulation prediction for the contributions from $c \to D^*$ ($b \to D^*$); the black histograms show the combinatorial background; e) normalized energy distribution of the background-subtracted D^* signal for $D^* \to D^0\pi$ candidate decays.

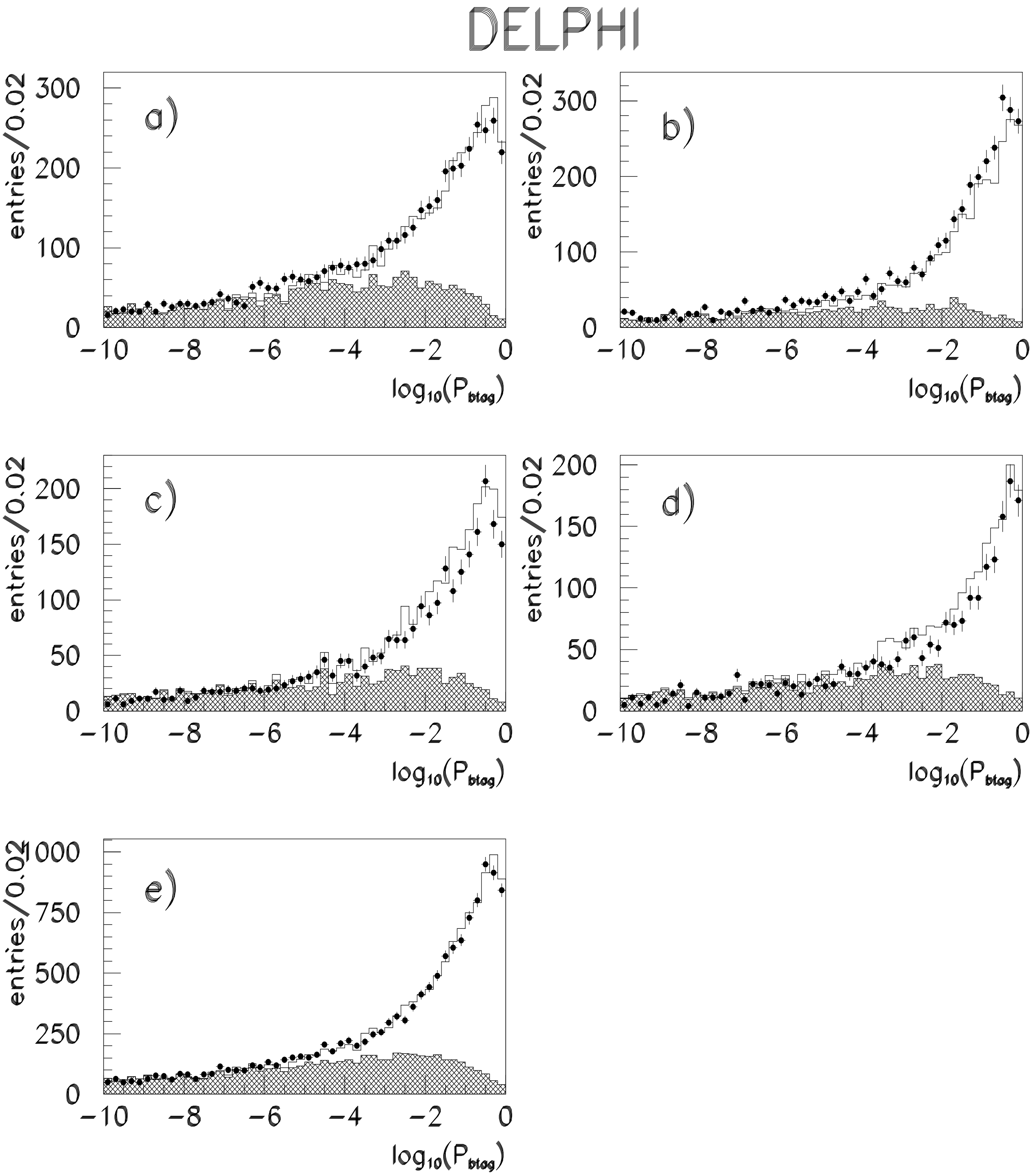

Figure 2: b-tagging event probability distribution for events with a reconstructed D^* candidate in the ΔM signal range, reported in Table 1, in the 1994 real data samples (full dots): a-d) the four individual channels considered in the analysis; e) all channels. The histogram is the simulation prediction; the hatched areas show the contribution from $b\bar{b}$ events.

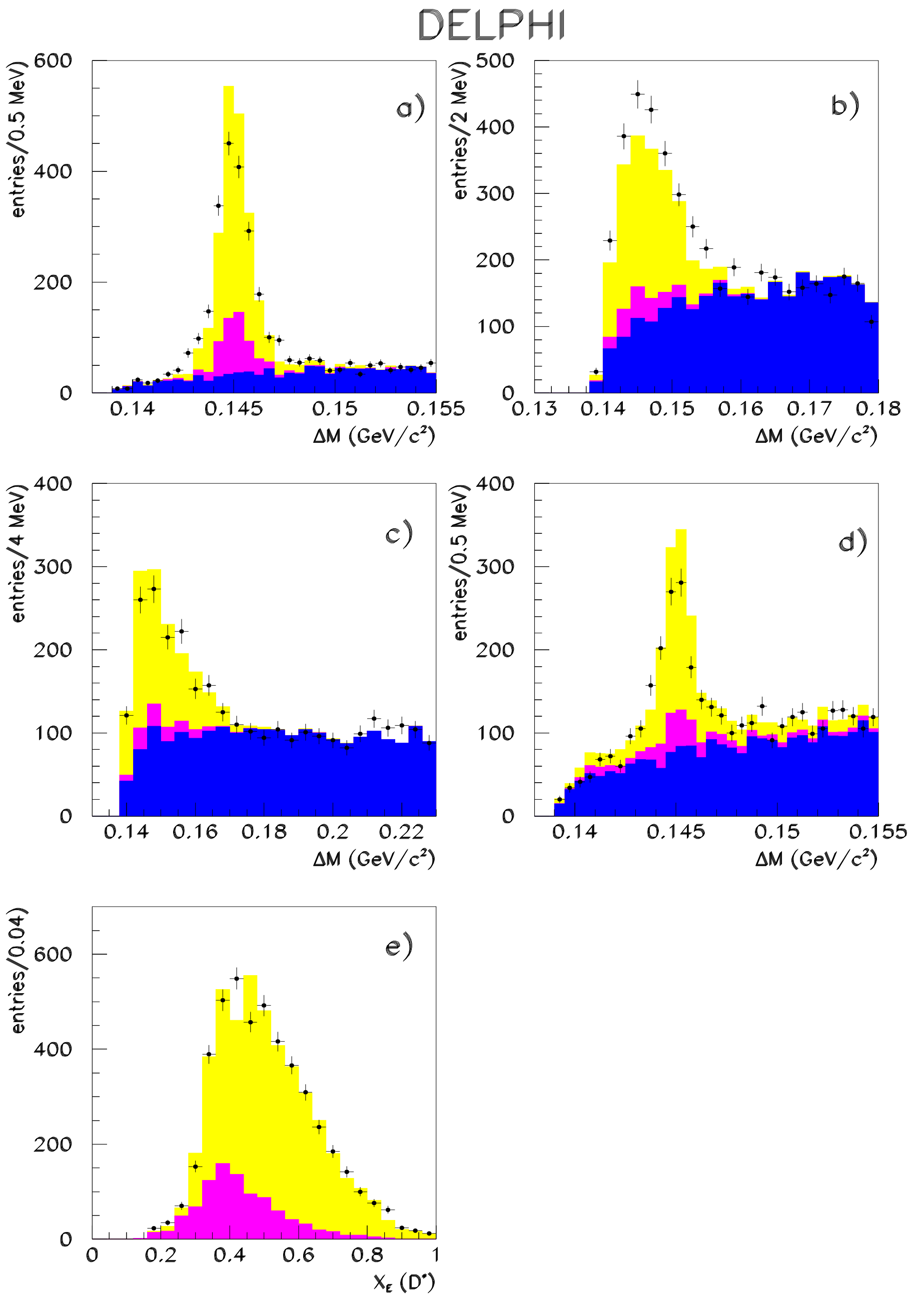

Figure 3: a-d) $\Delta M = M(D^0\pi) - M(D^0)$ mass difference distribution for D^* candidate decays after the anti-b tag selection. The meaning of the colors and symbols is as in Fig.1; e) normalized energy distribution of the background-subtracted D^* signal for $D^* \to D^0\pi$ candidate decays.

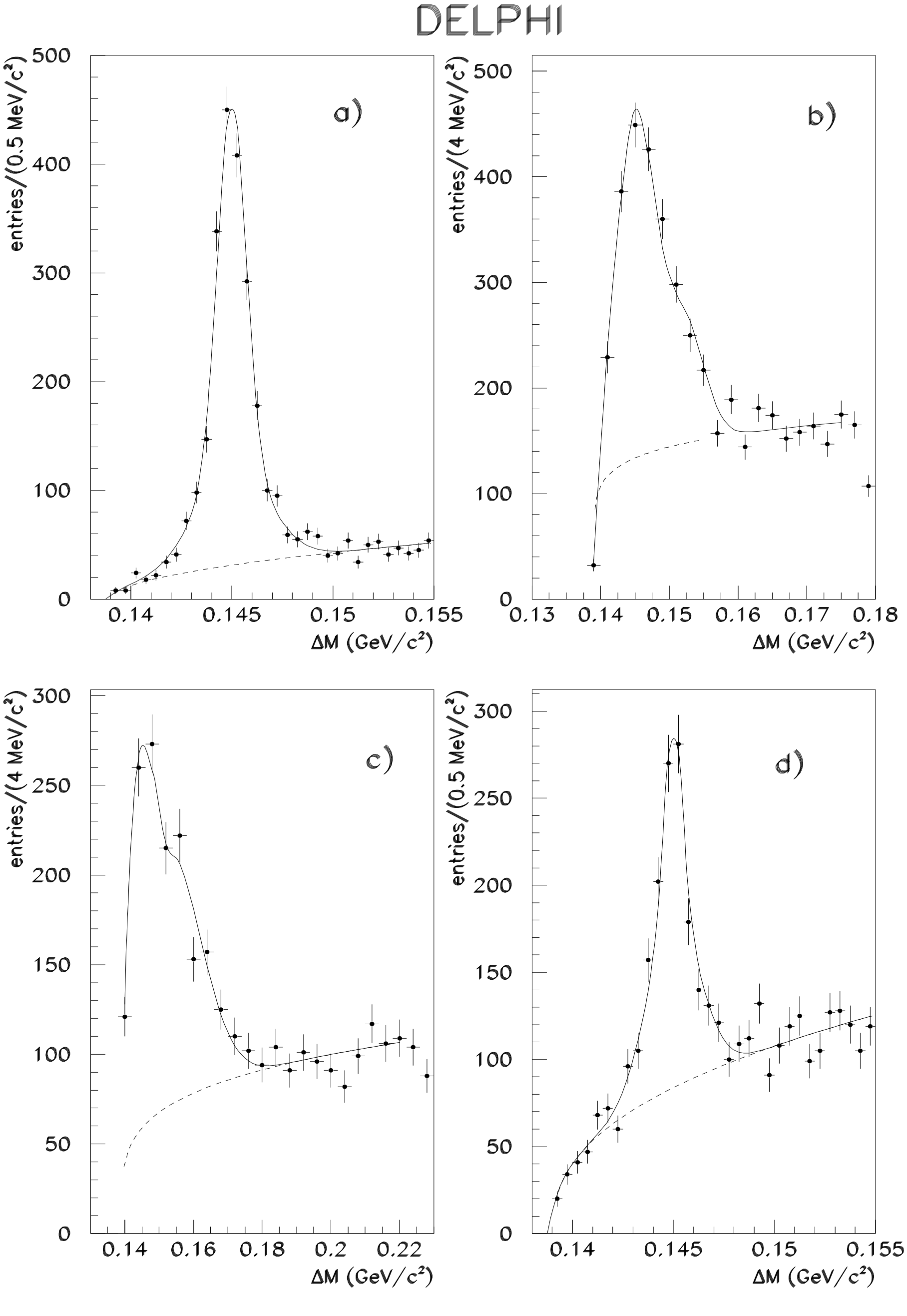

Figure 4: a-d) Results of the fit described in the text (continous line) to ΔM distributions in the data. The dashed line is the fitted background distribution.

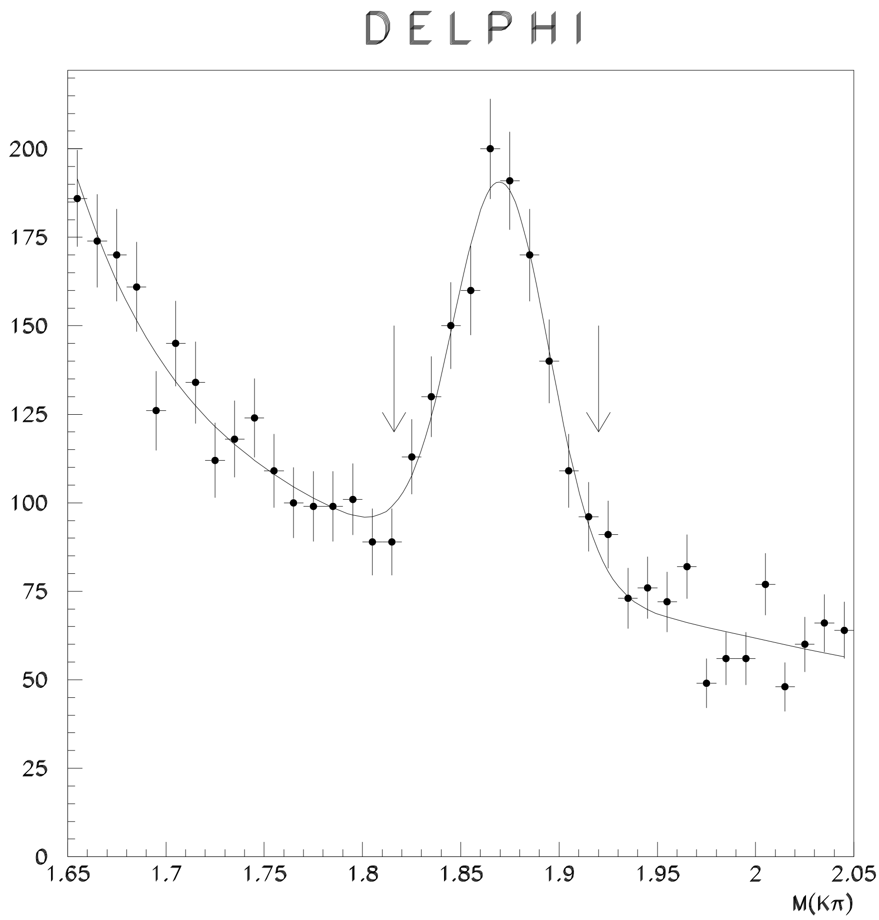

Figure 5: $M(K\pi)$ invariant mass spectrum for D^0 candidate decays selected with a tight particle identification of the D^0 decay products (see text); D^0 from D^* decays are excluded from this plot.

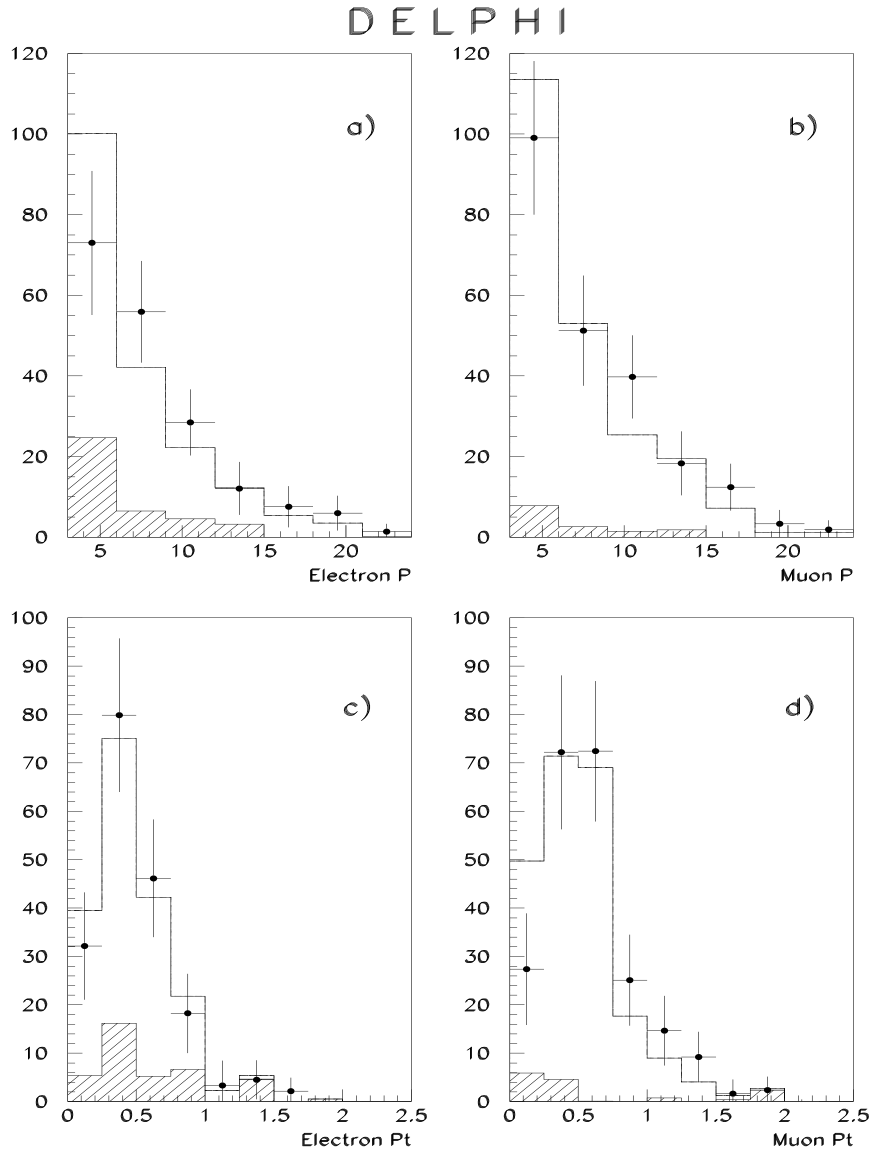

Figure 6: a,b) momentum distribution of muons and electron candidates with $p > 3GeV/c$ opposite to reconstructed D mesons; c,d) transverse momentum distribution for muons and electrons candidates. Dots and histograms show real and simulated data respectively. The hatched histograms show the simulation distributions for lepton candidates in $b\bar{b}$ events.