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Analysis of the Cabbibo Suppressed decay $D^+ \to \rho^0 \mu^+ \nu$ from FOCUS

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Using data collected by FOCUS, we present a preliminary measurement for the vector meson semileptonic branching ratio $\frac{\Gamma(D^+\to\rho^0\mu^+\nu)}{\Gamma(D^+\to\overline{K}^{*0}\mu^+\nu)}$. Using a sample of 397 ± 42 and $11,811 \pm 151$ $D^+ \to \rho^0\mu^+\nu$ and $D^+ \to \overline{K}^{*0}\mu^+\nu$ events, respectively, we find $\frac{\Gamma(D^+\to\rho^0\mu^+\nu)}{\Gamma(D^+\to\overline{K}^{*0}\mu^+\nu)} = 0.0381 \pm 0.0041 \pm 0.0052$

Keywords: Charm; Semileptonic

1. Introduction

Semileptonic decays provide an ideal environment for the study of the hadronic current since the leptonic and hadronic currents can be factorized. In particular, Heavy Quark Symmetry relates the form factors of the decay $c \to dW^+$ to those of the decay $b \to u$. Precise determination of these form factors can lead to a more accurate model-independent determination of $|V_{ub}|$. Previous measurements of $\frac{\Gamma(D^+\to\rho^0\mu^+\nu)}{\Gamma(D^+\to\overline{K}^{*0}\mu^+\nu)}$ have suffered from lack of statistics[6,7], while theoretical predictions[9,10,11] differ by at least 2σ from the PDG[4] average. In this paper, we present a preliminary measurement of this branching ratio based on almost 400 $D^+ \to \rho^0\mu^+\nu$ events.

2. Event Selection

The data for this analysis were collected by FOCUS, a fixed target photoproduction experiment that ran during the 1996–97 fixed target run at Fermilab. The FOCUS spectrometer is a two magnet spectrometer with excellent vertex resolution and particle identification. It was designed to measure the interactions of high energy photons with a segmented BeO target. A detailed description of the spectrometer can be found elsewhere.[1,3,2]

The semileptonic decay modes $D^+ \to \rho^0\mu^+\nu$ and $D^+ \to \overline{K}^{*0}\mu^+\nu$ are reconstructed by requiring two oppositely charged hadrons and a muon to form a vertex 2σ outside of the target material. To reduce systematic effects due to our cut selection, both signals have the same cuts except for the hadron identification cuts. To reduce backgrounds associated with non-charm decays, we impose a cut in $L/\sigma_L > 20$, where L/σ_L is the ratio of the length

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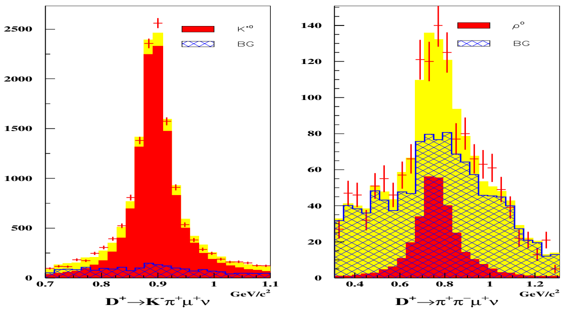

Fig. 1. Fits to the invariant mass distributions for $D^+ \to \overline{K}^{*0}\mu^+\nu$ (left) and $D^+ \to \rho^0\mu^+\nu$ (right). In both cases the fitted histogram is superimposed on the data (error bars). The dark solid histogram represents the signal, while the hatched histogram represents the background. In the $D^+ \to \rho^0\mu^+\nu$ case, the background is dominated by combinatoric background.

(L) between the primary vertex and the secondary vertex with respect to the uncertainty in L (σ_L). The secondary vertex must be a good vertex $(CL > 1\%)$ with no other tracks associated with it. The primary vertex is found after excluding the secondary tracks from the search and looking for the vertex $(CL > 1\%$) with the highest multiplicity.

Only muons from the Inner Muon system with confidence level greater than 1% and momentum greater than 10 GeV/c are used in this analysis. The momentum of the muon track, when measured in the two magnets, must be consistent to reduce in-flight pion decays. The two pions from ρ^0 have different Čerenkov requirements. This is done to reduce contamination from $D^+ \to \overline{K}^{*0}\mu^+\nu$ where the kaon with opposite charge to the muon is misidentified as a pion. This opposite charge pion is required to have a Čerenkov light pattern more consistent with that of a pion than that of a kaon by three units of likelihood, while for the same charge pion, the pion hypothesis must be favored over the kaon hypothesis by one unit of likelihood.

Contamination from the decay chain $D^{*0} \to D^0\pi^+, D^0 \to \pi^-\mu^+\nu$, where the soft pion from the primary vertex is erroneously assigned to the secondary, is removed by requiring a minimaum invariant mass difference: $M(\pi^+\pi^-\mu^+) - M(\pi^-\mu^+) > 0.20$. In order to allow for the missing neutrino while suppressing backgrounds from decays with extra particles, we restrict the visible invariant mass to lie in the range $1.2 \leq M(\pi^+\pi^-\mu^+) \leq 1.8$.

3. Fitting Technique and Results

The yields for our signal and normalization modes are obtained by fitting the invariant mass distribution with a binned maximum log likelihood fit with shapes determined by our Monte Carlo simulation. The $D^+ \to \rho^0\mu^+\nu$ fit histogram is composed of the signal, backgrounds from charm semileptonic decays with at least two charged pions in the final state and contaminations from K/π misid, μ-misid and combinatoric background. The semileptonic backgrounds are constrained using the PDG[4] values for their corresponding

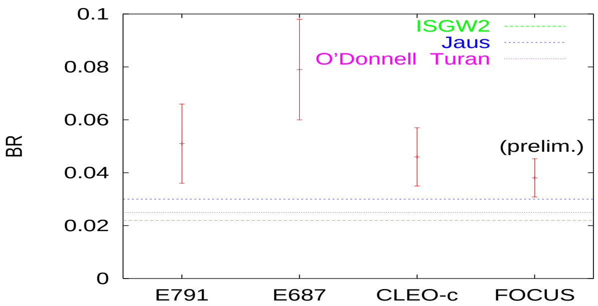

Fig. 2. FOCUS $\frac{\Gamma(D^+\to\rho^0\mu^+\nu)}{\Gamma(D^+\to\overline{K}^{*0}\mu^+\nu)}$ preliminary result compared to previous experimental results and theoretical predictions. The CLEO-c result is related to ours via isospin.

branching ratios. The $D^+ \to \overline{K}^{*0}\mu^+\nu$ fit histogram is composed of signal and combinatoric background.

We find a total of 397 ± 42 and $11,811 \pm 151$ $D^+ \to \rho^0\mu^+\nu$ and $D^+ \to \overline{K}^{*0}\mu^+\nu$ events, respectively. Different cut selections and fit variations are performed in order to assess the systematic uncertainty in our measurement. We have investigated 192 different cut selections, changing the branching ratios that constrain the semileptonic contributions by $\pm 1\sigma$, changing the binning scheme and allowing parameters that are fixed in the fit to float freely. The r.m.s. of these variations were added in quadrature and are reported as our systematic error.

Using the above yields and correcting for the detection efficiency, we report a preliminary measurement $\frac{\Gamma(D^+\to\rho^0\mu^+\nu)}{\Gamma(D^+\to\overline{K}^{*0}\mu^+\nu)} = 0.0381 \pm 0.0041(\mathrm{stat.}) \pm 0.0052(\mathrm{syst.})$. This preliminary result includes a correction due to the S-wave interference present in the $D^+ \to K^-\pi^+\mu^+\nu$ reported by FOCUS.[5]

A comparison between our result, previous experimental results and theoretical predictions is presented in Fig. 2. The CLEO-c preliminary result is based on a data sample of $60\mathrm{pb}^{-1}$ looking at the mode $D^0 \to \rho^-\mu^+\nu$.[8] To this date, the FOCUS preliminary result is the most precise measurement of this branching ratio.

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