Hot Results from CLEO-c

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I briefly review some of the latest results obtained using the CLEO-c detector.

I. INTRODUCTION

The CLEO detector has been taking data at the Cornell Electron Storage Ring since 1980. Its latest (and last) configuration is CLEO-c, which is optimized for running in the charm threshold region. The main differences between it and the CLEO III configuration, is the replacement of the silicon vertex detector with a lightweight inner drift chamber. The magnetic field is now 1T. These two changes both help with the measurement of low momentum tracks.

The main datasets taken by CLEO-c are a) around 54 pb^{-1} taken at the $\psi(2S)$ resonance (corresponding to around 27,000,000 $\psi(2S)$ decays), b) a large block of running at the $\psi(3770)$, of which 281 pb^{-1} is processed, more is already taken, and the target is $670pb^{-1}$, c) running at just above 4170 MeV, which is just above the $D_s D_s^*$, of which most analyses use $\approx$ 195 pb^{-1}, some use $\approx$ 300 pb^{-1}, and more data will be taken (with a target of $720pb^{-1}$), and d) an energy scan in the region 3970-4260 MeV. Note, that there is no longer any running planned at the J/ψ energy, although some J/ψ studies can be made using the $\psi(2S)$ decays. The data-taking program will end in Spring 2008.

II. D^0 AND D^+ HADRONIC BRANCHING FRACTIONS

There have been many measurements of the D hadronic branching fractions, but to there is no environment can compete with an e^+e^- collider running at the $\psi(3770)$ energy. CLEO has published these fractions using 56 pb^{-1} of data [1]; here I show preliminary results using 281 pb^{-1} of data. This second analysis has been presented in detail elsewhere [2]. We already have doubled this dataset, but that new data has not yet been analyzed, and yet more is on the way.

The basic technique depends on the fact that if there is one D meson in the event, there must be one $\bar{D}$ meson, and nothing else. By first cutting on $\Delta(E) = E_{D-TAG} - E_{BEAM}$, we can plot $M_{BC} = \sqrt{E_{BEAM}^2 - p_{D-TAG}^2}$ and the signals are spectacularly clean. We then calculate the ratio of doubly-tagged events (those where both the D and $\bar{D}$ were constructed), to singly-tagged events (those where only one of the two is reconstructed), we can extract the absolute branching fractions for 3 D^+ decays and 6 D^0 decays.

The results of this analysis are shown in Table I. Further comparisons with the rest of the world data are shown elsewhere [2]. Note that these results will supercede those of the previous analysis.

TABLE I: D Hadronic Branching Fractions

Particle	Decay	Branching Fraction (%)
D^0	$K^-\pi^+$	$3.88 \pm 0.04 \pm 0.09$
D^0	$K^-\pi^+\pi^0$	$14.6 \pm 0.1 \pm 0.4$
D^0	$K^-\pi^+\pi^-\pi^+$	$8.3 \pm 0.1 \pm 0.3$
D^+	$K^-\pi^+\pi^+$	$9.2 \pm 0.1 \pm 0.3$
D^+	$K^-\pi^+\pi^+\pi^0$	$6.0 \pm 0.1 \pm 0.2$
D^+	$K_s^0\pi^+$	$1.55 \pm 0.02 \pm 0.05$
D^+	$K_s^0\pi^+\pi^0$	$7.2 \pm 0.1 \pm 0.3$
D^+	$K_s^0\pi^+\pi^-\pi^+$	$3.13 \pm 0.05 \pm 0.14$
D^+	$K^-K^+\pi^-$	$0.93 \pm 0.02 \pm 0.03$

I would just like to mention that CLEO-c has also recently made the most precise measurement of the D^0 mass [3]. This was made using the decay mode $D^0 \rightarrow K_s^0\phi$. The result is $M(D^0) = 1864.847 \pm 0.150 \pm 0.095$ MeV. The result is particularly important because it leads to the conclusion that the binding energy of the X(3872) when interpreted as a $D\bar{D}$ molecule is 0.6 ± 0.6 MeV.

III. D_s BRANCHING FRACTIONS

It is fitting that CLEO is still interested in the D_s, as it was responsible for the discovery of the particle in 1984 [4]. That, and many other measurements in this sector, were performed using e^+e^- collision energies in the Υ region. Now, we have the chance to work at a little above D_s threshold. First, a scan was taken in the energy range 3.97-4.26 GeV. It was found that the optimal place to operate is 4.17 GeV, and so 314 pb^{-1} of data has been taken there. At each energy of the scan, the cross section for D_sD_s, $D_s^*D_s$, and $D_s^*D_s^*$ was calculated along with the cross section of $D\bar{D}$. These cross-sections are interesting in themselves, and details can be seen elsewhere [5].

At the energy of 4.17 GeV, the majority of the D_s mesons are produced via $D_sD_s^*$. This produces a complication not present in the non-strange case, as there is a low-energy photon in the event as well as the two mesons we are interested in. However, there is good

kinematic separation between the modes. This analysis (based on 195 pb^{-1} of data), is presented in more detail elsewhere [6]. Here I just present the D_s absolute branching fractions in Table II.

TABLE II: D_s Hadronic Branching Fractions

Particle	Decay	Branching Fraction (%)
D_s^+	$K_s^0 K^+$	$1.50 \pm 0.09 \pm 0.05$
D_s^+	$K^- K^+ \pi^+$	$5.57 \pm 0.30 \pm 0.19$
D_s^+	$K^- K^+ \pi^+ \pi^0$	$5.62 \pm 0.33 \pm 0.51$
D_s^+	$\pi^- \pi^+ \pi^+$	$1.12 \pm 0.08 \pm 0.05$
D_s^+	$\pi^+ \eta$	$1.47 \pm 0.12 \pm 0.14$
D_s+	$\pi^+ \eta'$	$4.02 \pm 0.27 \pm 0.30$

Note that we do not include the traditional normalizing mode for D_s decays, namely $\phi\pi^+$. This is because there is a non-trivial background to the $\phi \to K^+ K^-$ signal, and different experiments have chosen different ϕ mass cuts, leading to different amounts of this background being included. The complicated substructure of this decay mode make it a candidate for an amplitude analysis rather than using it as a normalizing mode.

IV. DECAY MODES OF D_s INTO TWO PSEUDO-SCALARS

The analysis technique here is straightforward as we look for single D_s decays in the 4170 MeV data (note that in this *preliminary* analysis, $\approx 300 pb^{-1}$ are used). We search for four Cabibbo suppressed modes ($\pi^0 K^+, K^+\eta, K^+\eta'$), one decay that is expected to be forbidden ($\pi^+\pi^0$), and compare these with three Caibibbo-allowed decays measured in the same dataset ($\pi^+\eta$, $\pi^+\eta'$, and K^+K^0). The *preliminary* results for the branching ratios, seen in public for the first time are:

$(D_s \to K^+\eta)/(D_s \to \pi^+\eta) = 0.080 \pm 0.015$
$(D_s \to K^+\eta')/(D_s \to \pi^+\eta') = 0.039 \pm 0.013$
$(D_s \to K^0\pi^+)/(D_s \to K^+K^0) = 0.083 \pm 0.009$
$(D_s \to K^+\pi^0)/(D_s \to K^+K^0) = 0.042 \pm 0.012$
$(D_s \to \pi^+\pi^0)/(D_s \to K^+K^0) < 0.04$

These results are *preliminary* statistics dominated, and more statistics will be available.

V. CHARMED MESON DECAY CONSTANTS

Measurement of the decay constants f_{D^+} and f_{D_s} are of great interest, but are very difficult experimen-

tally because they require investigation of modes with neutrinos in their final state. CLEO-c has published analyses of $D^+ \to \mu^+\nu$ and $D^+ \to e^+\nu$ [7], and also $D^+ \to \tau^+\nu$ [8], each with the $281pb^{-1}$ dataset. The analysis of $D_s^+ \to \mu^+\nu$ and $D_s^+ \to \tau^+\nu, \tau \to \pi^+\nu$ has now been sent for publication using $314pb^{-1}$ [9], and details can be found there. The second D_s analysis, using the decays of the τ into electrons, is complementary to the first and largely independent of it. The value for f_D is found to be $(223 \pm 17 \pm 3)$ MeV, the combined value for f_{D_s} is $(273 \pm 10 \pm 5)$ MeV, and the ratio, $(f_{D_s}/f_D) = 1.22 \pm 0.09 \pm 0.03$ (these results are all preliminary). This ratio is very consistent with most models, including recent lattice QCD models.

VI. $\psi(2S)$ DATA

There are already some results shown using $\psi(2S)$ data, demonstrating its use as a factory for χ_c production. We now have an order of magnitude more data taken. This will enable us to study the decays of all three χ_c states, the η_c and the h_c in unprecedented detail. It is also possible to do some detailed analysis of J/ψ decays found from the di-pion decays of the $\psi(2S)$. Just one example of χ_c physics is the decays into $KK\pi\pi$, which can be seen in six different charge combinations, each with good signal to noise ratios. It will take a lot of work to understand the rich resonant substructure of these decay modes. These are just a few of the 50 or so χ_c decay modes that we can measure, and we are limited only by the manpower to do the necessary analyses.

VII. CONCLUSIONS

I have presented a series of results, most preliminary and some final, from the data taken by the CLEO-c detector configuration. With much more data becoming available, please expect many more results in the next months and years.

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[4] A. Chen *et al.* PRL 51:634 (1984).

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