FIRST RESULTS OF E835 2000 DATA RUN

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During 2000, E835 has been taking data which include scans of the triplet P states of charmonium, χ_{c2}, χ_{c1} and χ_{c0}. Preliminary analyses of the reactions $\bar{p}p \rightarrow \chi_{c2}, \chi_{c1}, \chi_{c0} \rightarrow \gamma J/\psi \rightarrow \gamma(e^+e^-)$ have been performed. The preliminary results for mass, Γ and $\Gamma_{\bar{p}p}/\Gamma$ for χ_{c2}, χ_{c1} and χ_{c0} are presented and compared with previous measurements done by E760 in 1990 and E835 in 1997.

1 Introduction

Fermilab experiment E835 has taken data in 2000 continuing the study of charmonium produced in antiproton-proton annihilations. As in the earlier Fermilab charmonium experiments, E760 (1990-1991) and E835 (1996-1997), precision spectroscopic measurements have been made using the stochastically cooled circulating antiproton beam ($\Delta p/p \approx 10^{-4}$) intersecting a molecular hydrogen gas jet target for luminosities of 1-4 $\times 10^{-31}$ cm^{-2} s^{-1}. The E760/E835 method of stepping the beam energy through a resonance and using the detector to identify electromagnetic decays of the charmonium states allows us to effectively map out the excitation curve (the convolution of the beam energy distribution and the Breit-Wigner resonance).

The electromagnetic decays are used to identify charmonium candidate events in the presence of the large hadronic background ($\approx$ 60 mb). One of the best signatures is when there is a transition from a charmonium resonance to J/ψ, which in turn decays to e^+e^-. The e^+e^- kinematics from a J/ψ decay are easy to trigger upon and can be quickly analyzed. We report preliminary results of the triplet P states through the study of the reactions

$$\bar{p}p \rightarrow \chi_{c2}, \chi_{c1}, \chi_{c0} \rightarrow \gamma J/\psi \rightarrow \gamma(e^+e^-), \quad (1)$$

where the resonances have been scanned separately.

2 Detector

The E835 detector[1] is non-magnetic and has large acceptance, covering the complete azimuth (ϕ) and polar angles (θ) from 3° to 70°. The cylindrical central part of the detector consists of three scintillator hodoscopes (ϕ segmented into 8, 24 and 32 elements), two 2-layer sets of straw tubes (ϕ measurement), two 2-layer scintillating fiber detectors (θ measurement), a 16-cell threshold Čerenkov counter and a 1280 lead-glass array (20θ by 64ϕ) forming the central electromagnetic calorimeter (CCAL). In the forward direction there are an 8 element scintillator hodoscope and a planar electromagnetic calorimeter (FCAL) consisting of 144 lead-glass counters. The luminosity is measured by detecting recoil protons from the jet target which have been elastically scattered by the antiproton beam at 86.5° to the beam direction.

3 Event Selection

We require that the final state e^+e^- of reactions 1 to be within the electron/pion discriminating Čherenkov counter: $15° < \theta < 65°$. In the trigger, a *candidate track* is defined by coincidence between the azimuthally corresponding elements of two of the central hodoscopes and a cell of the Čherenkov. In addition, summed CCAL counters signals are formed and sums above θ-dependent

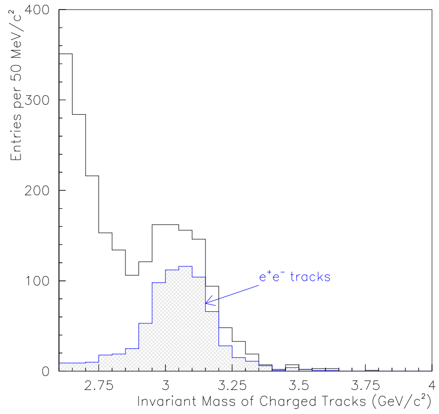

Figure 1. Invariant mass for all pairs of charged tracks (open) and identified e^+e^- tracks (shaded). Data are from the χ_{c1} scan.

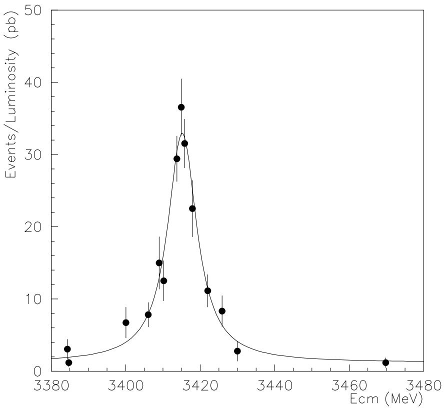

Figure 2. Candidate events per pb^{-1} for the χ_{c0} scan.

thresholds are defined as *energetic particles*. The overall trigger for reactions 1 requires that there are at least two candidate tracks and, independently, at least two well separated energetic particles; the latter effectively requires an invariant mass greater than 1.8 GeV/c^2 in the CCAL.

The first step of the analysis is to associate each candidate track with an energetic particle in the CCAL; the open histogram in Figure 1 shows the invariant mass of pairs of associated charged tracks. For each associated charged track, further cuts on the pulse heights from each scintillator counter and Čherenkov cell are performed to remove charged hadrons and photon conversion pairs. In addition, the characteristics of the CCAL signals (shape analysis) are used to ensure that only one electromagnetic shower contributed to each energy deposit. The invariant masses of events with two associated tracks that satisfy these criteria are shown as the shaded plot in Figure 1.

A third, single electromagnetic shower energy deposit, in either the CCAL or FCAL, is assigned to be the the transition photon of reactions 1. A $5C$ kinematical fit is performed to select the final candidate events.

4 Preliminary Results

The number of candidate events per pb^{-1} at the peaks of the resonances ranges from 35 to 600 while the background is ≈ 2 events per pb^{-1}. In Figure 2, the χ_{c0} scan data and excitation curve are shown. The overall acceptance-efficiency is estimated to be 0.3. The data are then fit to excitation curves, Breit-Wigner resonances convoluted with the beam energy distributions, and a flat background.

The preliminary results for the mass, Γ and $\Gamma_{\bar{p}p}/\Gamma$ for the charmonium triplet P states are given in Table 1; all errors are statistical. The previous results of E760[2] and E835[3] are included for comparisons. In addition, the integrated luminosities used for performing each scan are given.

5 Discussion

All of the preliminary results are in agreement with the previous measurements. The χ_{c2} and χ_{c1} scans are statistically the same as the previous measurements and possibly later in the running in 2000 further scan statistics may be collected. The increased amount of integrated luminosity expended to the χ_{c0}

Table 1. Comparison of preliminary results with previous E760 and E835 results.

	Experiment	$\int L\ dt$ (pb^{-1})	Mass (MeV/c^2)	Γ (MeV)	$\Gamma_{\bar{p}p}/\Gamma$ (10^{-4})
χ_{c2}	E835(2000 prelim.)	1.115	3555.9 $\pm$ 0.1	2.3 $\pm$ 0.2	0.89 $\pm$ 0.08
	E760(1990)	1.160	3556.15 $\pm$ 0.07	1.98 $\pm$ 0.17	1.00 $\pm$ 0.08
χ_{c1}	E835(2000 prelim.)	1.330	3510.64 $\pm$ 0.03	0.94 $\pm$ 0.08	0.87 $\pm$ 0.08
	E760(1990)	1.030	3510.53 $\pm$ 0.04	0.88 $\pm$ 0.11	0.86 $\pm$ 0.10
χ_{c0}	E835(2000 prelim.)	29.289	3415.2 $\pm$ 0.4	9.4 $\pm$ 1.1	5.5 $\pm$ 0.4
	E835(1997)	3.522	3417.4 $\pm$ 1.9	16.6 $\pm$ 5.2	4.8 $\pm$ 0.9

scan has decreased the statistical errors significantly.

In 1997, the χ_{c0} resonance was near an unstable operating beam energy of the Accumulator. For the current data taking, the Accumulator lattice has been changed such that the unstable operation point has been moved away from the χ_{c0}.

The $\Gamma_{\bar{p}p}/\Gamma$ for χ_{c2} and χ_{c1} are nearly the same and it is surprising that the same quantity for χ_{c0} is larger. All E760/E835 measurements for the $\chi_c \to \bar{p}p$ branching fractions are dependent upon the accepted values for the branching fractions[4] $\chi_c \to \gamma J/\psi$. These branching fractions for χ_{c2} and χ_{c1} are known to better than 8% while the χ_{c0} radiative transition is known to 27%. It should be noted that the BES collaboration[5] has reported the χ_{c0} branching fraction to $\bar{p}p$ to be larger than the χ_{c2} and χ_{c1}. However, BES measurements for all of the triplet P state branching fractions to $\bar{p}p$ are smaller by nearly a factor of two than the E760 and E835 measurements.

E835 will be analyzing other final states from the decays of the triplet P states. In addition, E835 has taken, and will be taking, data at the ψ' and the h_c (singlet P wave state of charmonium, ^{1}P$_1$).

Acknowledgments

I would like to thank my colleagues from Fermilab, INFN & University of Ferrara, INFN & University of Genova, University of California at Irvine, University of Minnesota, Northwestern University and INFN & University of Torino for their collaborative effort in the experiment's preparation, data taking, analyses and help in preparing this talk and paper. We would like to thank the support staffs of the participating institutions and in particular to the effort of the operation of the Accumulator by the Fermilab Antiproton Source Department and the Beams Division. This work is supported by the U. S. Department of Energy and the Italian Istituto Nazionale di Fisica Nucleare.

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