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Charm and Bottom Production in FNAL Fixed Target Experiments

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CHARM AND BOTTOM PRODUCTION IN FNAL FIXED TARGET EXPERIMENTS

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Abstract

In this talk we will review current results concerning bottom and charm physics from Fermilab Fixed Target experiments E672/E706, E769, E771, E781 (SELEX), E789, E791, E831 (FOCUS). Both production and decay physics wil be reviewed. Results from Charmonium production will be presented in another talk[1)] at this conference.

1 Introduction

We report here about recent results from Fermilab Fixed Target experiment, which are either just published or will be published very soon. There are too many new results to be presented in this talk, so the author selected the most interesting ones.

Experiments E672/E706, E687, E769, E771, E789, and E791 took data in the last fixed target run in 1990 and 1991. New results on total bottom production cross section, exclusive D, D^*, D_s, and Λ_c cross section, and on production (particle–antiparticle) asymmetries are available. New limits on D^0 $\overline{D^0}$ mixing and flavour changing neutral current decays of $D^0 \to \mu^+\mu^-$ and $D^+ \to X\mu^+\mu^-$ were recently published.

At the end we will present the current status of SELEX and FOCUS, which are taking data since July 1996.

2 Bottom Production

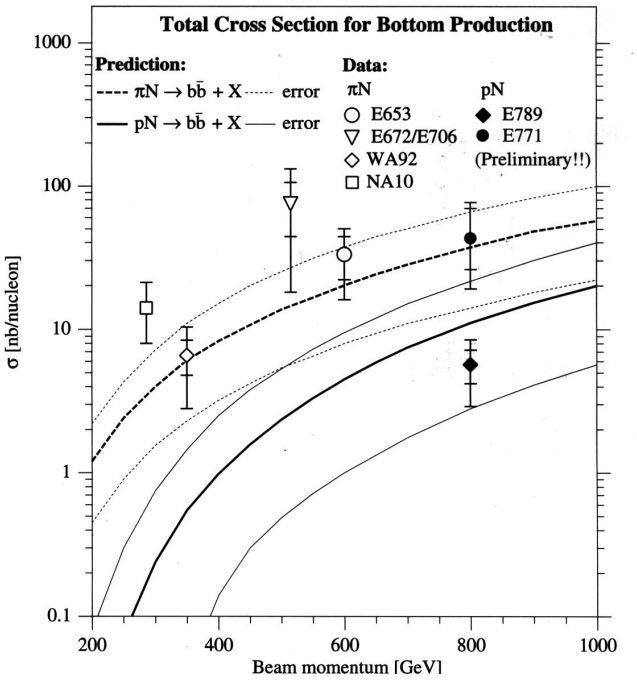

Figure 1: Cross Section for b Production[4,5].

A summary of all measurement to date are presented in figure 1. Experiment E762/E706, which used an 515 GeV π^- beam published[2] a total cross section of $(75 \pm 31 \pm 26)$ nb/nucleon, based on a sample of 8 ± 2.3 events. Experiment E789, based on a sample of 19 ± 5 events, reports[3] a total cross section for an 800 GeV proton beam $(5.7 \pm 1.5 \pm 1.3)$ nb/nucleon, whereas experiment E771, also using an 800 GeV proton beam reports as a preliminary results[4] a cross section for $\sigma(pN \to b\bar{b} + X)$ of $(42 \pm 22 \pm 7)$ nb/nucleon. with a sample of 6 ± 2.45 events. Due to the large errors the two 800 GeV proton measurements differ only by $1.5\,\sigma$.

3 Charm Production

3.1 Cross Sections

Experiment E769, which used $\pi^\pm$, $K^\pm$, p as beam particles with a momentum of 250 GeV/c published a measurement of the forward cross sections[6] for the production of D^+, D^0, D_s, D^{*+}, and Λ_c of all beam particles. This is the first systematic measurement for different beams and different particles by the same experiment. The same collaboration measured also the differential cross section for all D mesons ($D^\pm$, D^0, D_s) as a function of x_F and p_T[7]. The results are shown the figure 2.

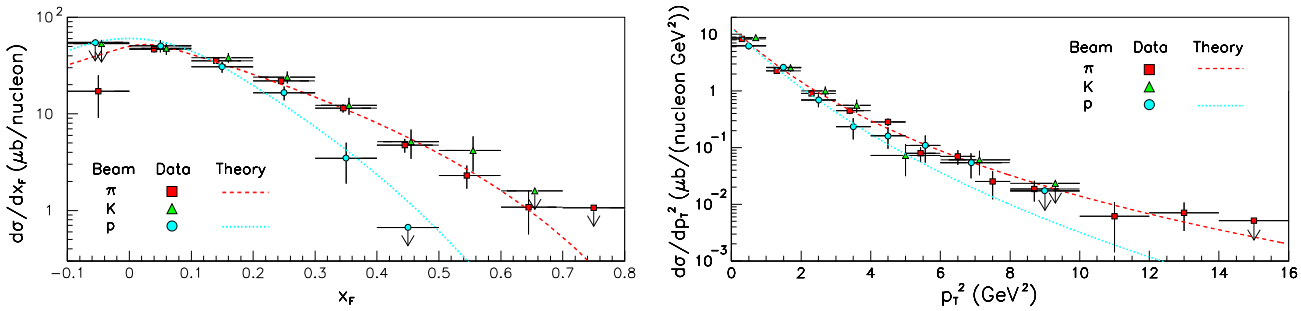

Figure 2: Differential cross section for total D meson production (from[7])

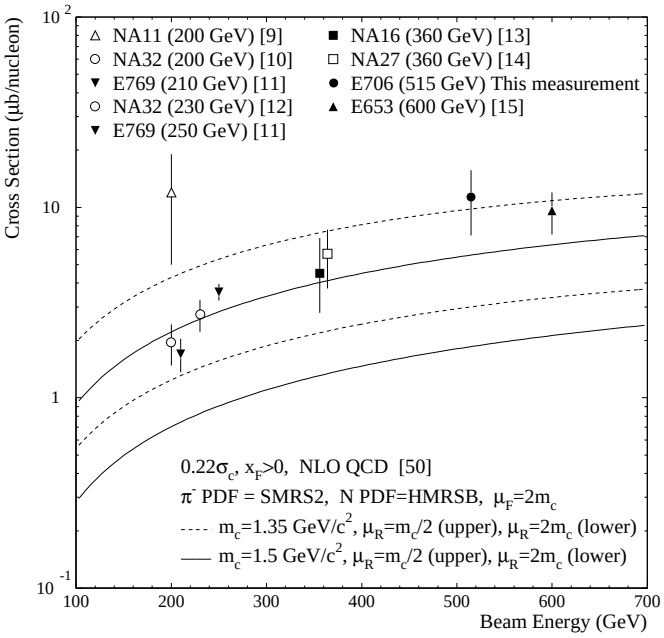

Figure 3: Integrated cross section for inclusive $D^{\pm}$ production for $x_F > 0$. For more details see[8]

Experiment E706 measured recently[8] the total $D^{\pm}$ cross section with a 515 GeV/c π^- beam to $(16.6 \pm 4.5 \pm 4.8)\,\mu$b/nucleon. In fig. 3 the results is plotted together with results from other experiments, including the previously mentioned result from E769. The results seems to prefer a low charm quark mass.

3.2 Particle–Antiparticle Production Asymmetries

After observing an asymmetry in the production of D^+ and D^- with a 500 GeV π^- beam[9], experiment E791 has now some results about the D_s as well[10]. In fig. 4 the asymmetry is plotted as a function of x_F and p_t^2, together with their results for the D^+. Only a small asymmetry is observed.

In the previously mentioned paper by E769[6] some particle–antiparticle productions are mentioned as well.

All results seem to be compatible with a leading particle effect, but models still fail to describe the differential behaviour versus x_f and p_t in detail correctly.

3.3 Other Charm Physics Results

Two more papers of E791 should be mentioned: the first about the production and mass splitting of the Σ_c^0 and the Σ_c^{++}[11]. This is the best measurent for the mass difference between Λ_c and $\Sigma_c^{0,++}$; and the second about the first observation of $D - \pi$ production correlations[12].

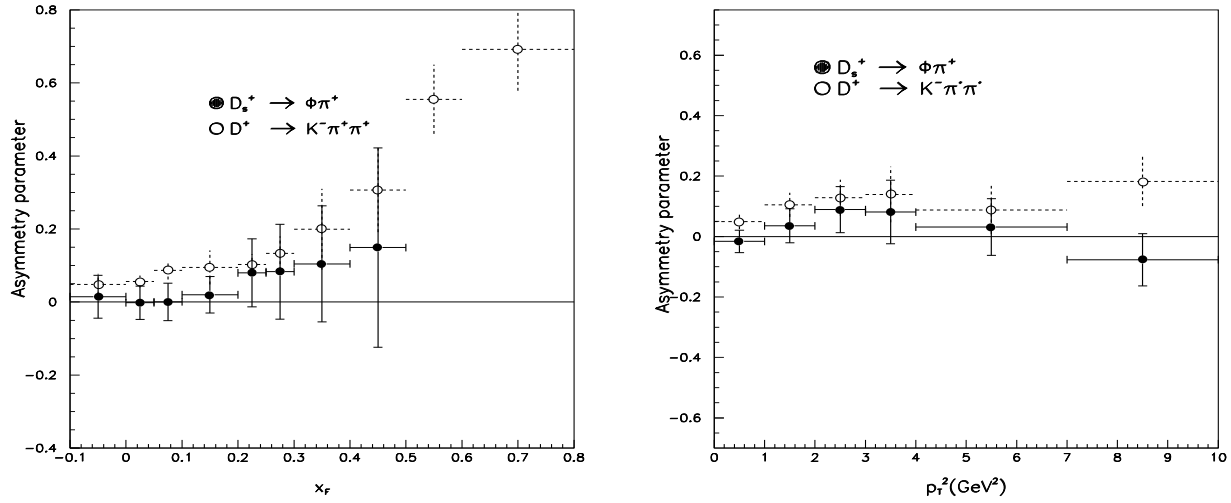

Figure 4: Production asymmetry for D_s and D^+ versus x_F and p_t^2 (from[10]).

4 Charm Decays

4.1 Flavour Changing Neutral Current

These decays have in the standard model very small branching ratios, in the helicity suppressed two body decay in the order of 10^{-19}, for the 3-body decay around 10^{-10}, but some extensions of the standard model predict higher branchings. Experiment E791 published[13] upper limits; $B(D^+ \to \pi^+\mu^+\mu^-) < 1.8 \times 10^{-5}$ and $B(D^+ \to \pi^+e^+e^-) < 6.6 \times 10^{-5}$, both at a 90 % confidence level.

E771 found[14] an upper limit for $B(D^0 \to \mu^+\mu^-) < 4.2 \times 10^{-6}$; this experiment is working on $D^\pm \to X\mu^+\mu^-$ and hopes to reach a limit of a few $\times 10^{-5}$

4.2 $D^0 - \overline{D^0}$ mixing

Experiment E791 submitted two papers, one searching for mixing with the D^0 decaying into hadronic final states[15] the second in semileptinc decays[16]; hadronic final states can also be reached via doubly–Cabibbo supressed diagrams, so that only the semileptinc results can be interpreted without further assumptions; the final results gives $\Gamma(D^0 \to \overline{D^0} \to K^+l^-\bar{\nu}_l)/\Gamma(D^0 \to K^+l^-\bar{\nu}_l) < 0.50\%$ at a 90 % confidence level.

5 Status of Running Experiments

In the current fixed target run, which started in July 1996 and will last until September 1997, two experiments which are studying charm physics are running at this moment.

5.1 FOCUS – E831

FOCUS is using a photon beam (maximum energy 300 GeV, average 190 GeV). The experiment is a follow-up of E687, which published more than 30 papers[17] in the last 5 years. FOCUS is

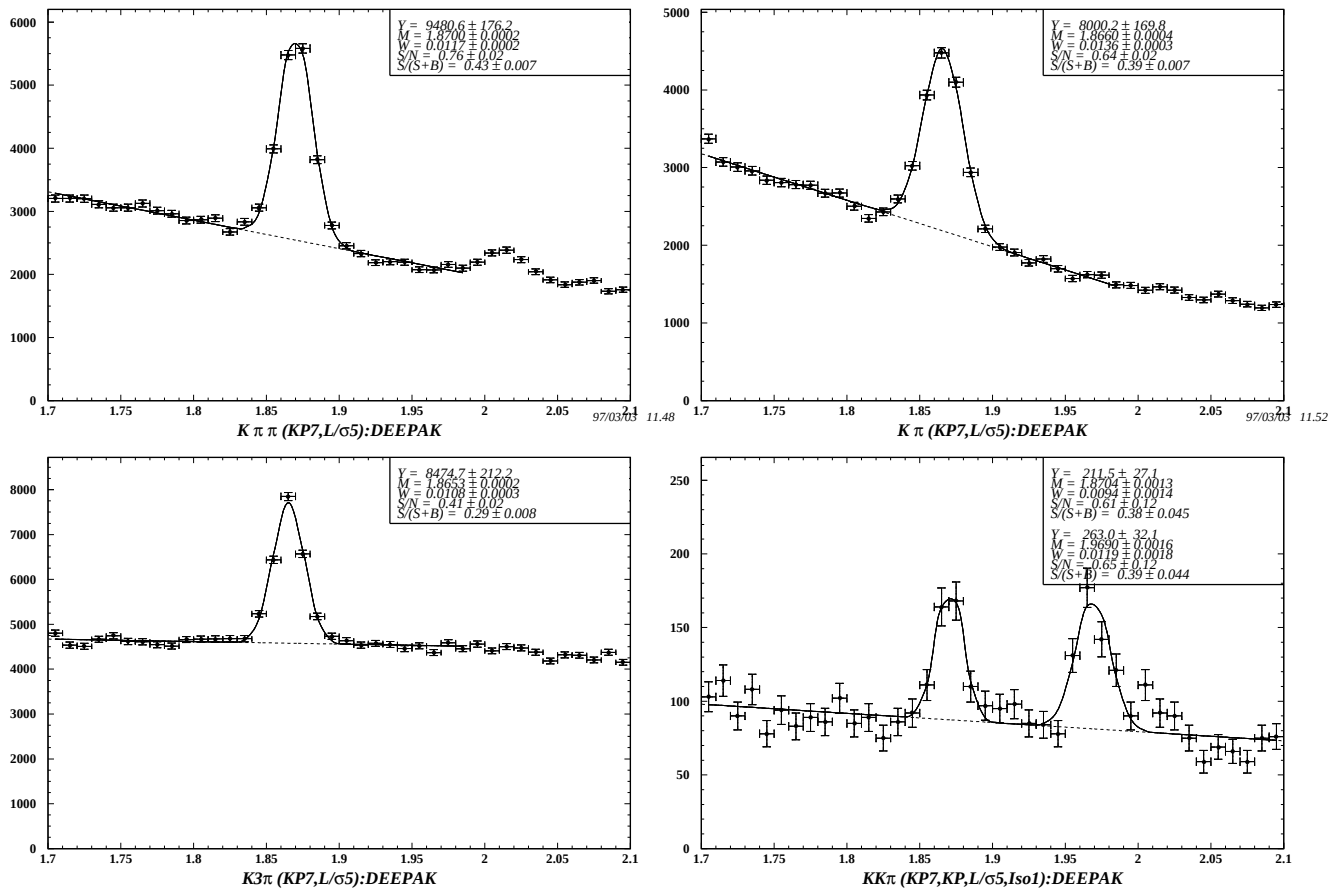

Figure 5: Preliminary mass peaks from FOCUS[18]. 288 Million raw events where analysed to obtain these plots; a cut of $L/\sigma > 5$ was applied.

running at an increased beam intensity and with an improved detector. Some first mass peaks from this experiment are shown in fig. 5. Up to date the experiment wrote about 3.3×10^9 events to tape and is on track to reach their goal of 10 times the statistics taken by E687 by the end of this running period, as demonstrated in fig. 6.

5.2 SELEX – E781

SELEX uses a 600 GeV Σ^- and π^- beam. It is a new experiment with new detector. It uses an online software filtering on secondary vertices. At the current moment, all detectors and the filter software is commisioned and serious datataking started. First results for reconstructed $D^0 \to K^-\pi^+$ and $\Lambda_c^+ \to pK^-\pi^+$ are presented in fig. 7.

This experiment is well on track to collect the most significant charmed baryon sample.

6 Acknowledgement

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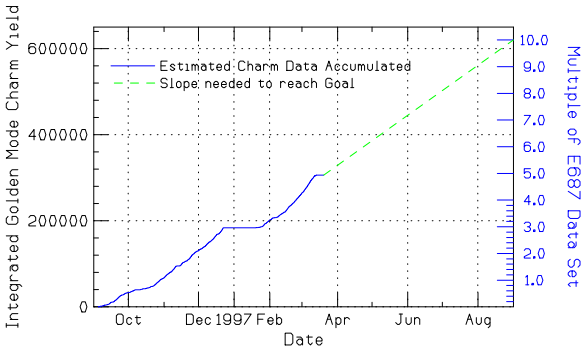

Figure 6: Projected number of reconstructed golden mode D decays for a particular L/σ cut by FOCUS[18]. The goal is to reach 10 times the size of the E687 data set.

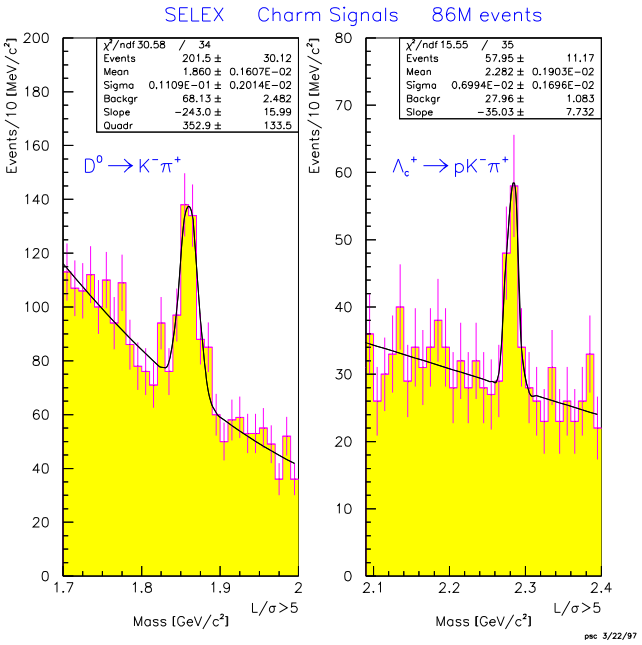

Figure 7: First reconstructed charm particles from SELEX. 86 Million events (after software filtering) where analysed to produce these plots. Only part of the geometrical acceptance was used.

7 References

1. K. Gollwitzer, these proceedings
2. R. Jesik et al. (E672/E706), Phys. Rev. Lett. **74,** 495 (1995).
3. D.M. Jansen et al. (E789), Phys. Rev. Lett. **74,** 3118 (1995).
4. T. Murphy, L. Spiegel, (E771), private communication.
5. QCD Predict.: P. Nason, S. Dawson, R.K. Ellis, Nucl. Phys. B**303,** 607 (1988), B**327,** 49 (1989), and B**335,** 260 (1990)
6. G.A. Alves et al. (E769), Phys. Rev. Lett. **77,** 2388 (1996).
7. G.A. Alves et al. (E769), Phys. Rev. Lett. **77,** 2392 (1996).
8. L. Apanasevich et al. (E706), FERMILAB–PUB–97/030–E, submitted to Phys. Rev. D.
9. E.M. Aitala et al. (E791), Phys. Lett. B **371,** 157 (1996).
10. E.M. Aitala et al. (E791), FERMILAB-Pub–97/105–E, submitted to Phys. Lett. B.
11. E.M. Aitala et al. (E791), Phys. Lett. B **379,** 292 (1996).
12. E.M. Aitala et al. (E791), FERMILAB-Pub–96/206–E, accepted by Phys. Lett. B.
13. E.M. Aitala et al. (E791), Phys. Rev. Lett. **76,** 364 (1996).
14. T. Alexopoulus et al. (E771), Phys. Rev. Lett. **77,** 2380 (1996).
15. E.M. Aitala et al. (E791), FERMILAB–Pub–96/214–E, submitted to Phys. Rev. D.
16. E.M. Aitala et al. (E791), Phys. Rev. Lett. **77,** 2384 (1996).
17. For a list of E687 publications, see *http://www.hep.uiuc.edu/e687/*
18. H. Cheung, J. Cummelat, (FOCUS), private communication.