Physics from HERA-B

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Data taking 2002/03

Data taking


~ 35 % running time delivered
of which ~ 70 % used for data taking

~ 150 \cdot 10^6 dilepton triggered events

~ 210 \cdot 10^6 minimum bias events

achieved $J/\psi$ rates: 1200 – 1400 $J/\psi$ per hour

30 - 40 $J/\psi$ per hour (2000)
J/ψ - Statistics

**J/ψ? e⁺e⁻: 40 % of statistics**

- \( N(J/ψ) \): 52.8 k
- \( M(J/ψ) \): 3.125 GeV
- \( σ(J/ψ) \): 63 MeV

No Bremsstrahlung requirement

**J/ψ? μ⁺μ⁻: full statistics**

- \( N(J/ψ) \): 166 k
- \( M(J/ψ) \): 3.095 GeV
- \( σ(J/ψ) \): 45 MeV

\( N(ψ(2s)) \): 2.7 k
\( M(ψ(2s)) \): 3.672 GeV
\( σ(ψ(2s)) \): 53 MeV

\( μ⁺μ⁻ \) invariant mass [GeV/c²]

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Analysis in Progress

- **Improve pN? bbX cross section measurement**
  - higher statistics in inclusive analysis: b? J/? X (J/? ? ee/µµ)
  - Understand double semileptonic b decays: b? µµX

- **Atomic number dependence of charmonium production in pN**
  - extend existing Fermilab measurements of J/? , ? to negative x_F
  - measurement of atomic number dependence of ?

- **Minimum Bias physics**
  - Open charm production
  - Strangeness production in nuclear matter
  - ? polarization

- **Measurement of pA? ? cross section (ee/µµ)**
- **Upper limit on Br(D0? µ+µ−)**
- **Direct photons**
- …
**bb Cross Section Measurement**

Inclusive reaction

\[ pA \rightarrow bbX, \]

with \( bb \rightarrow J/\psi X \rightarrow (e^+ e^- / \mu^+ \mu^-) X \)

Select \( b \rightarrow J/\psi X \) via detached \( J/\psi \) vertices

Normalization to prompt \( J/\psi \)

\[ \tau(pA \rightarrow J/\psi X) \]

Minimize systematic errors
Detached $J/\psi$ Analysis

$J/\psi? \, e^+e^-$
(40 % of statistics)

$\Delta z/\sigma_z > 10$
impact par. cut

No bremsstrahlung
requirement

$\# \ J/\psi = 40 \pm 12$

$J/\psi? \, \mu^+\mu^-$
(60 % of statistics)

$\Delta z < -0.5 \text{ cm}$

$\Delta z > 0.5 \text{ cm}$

Impact par. cut

$\# \ J/\psi = 40 \pm 11$

2000:
$\eta_B > 8.6, 3.9, 3.2$

$\Delta z < -0.5 \text{ cm}$
No upstream $J/\psi$

$\Delta z > 0.5 \text{ cm}$

Entries: 740
$X^2/\text{ndf}$: 22.73/26
$N(J/\psi)$: 40.35 ± 11.22
$M(J/\psi)$: 3.087 ± 0.022
$\sigma(J/\psi)$: 0.0696 ± 0.0154

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Charmonium Production

Typical parametrisation of $pA$ cross section
if $a = 1$ for all $x_F, p_T$  $\rightarrow$  no nuclear effects

Measure for $J/\psi$ and $\Upsilon_c$ nuclear dependence vs. $x_F, p_T$

Using Carbon & Tungsten
2-wire sample

Input to test
different models

$c$ production characteristics, nuclear dependence nearly unexplored

$S_{pA} = S_{pN} \cdot A^a$
Charmonium Production

\[ \beta^{J/\zeta} > \frac{1}{\ln(A_w / A_C)} \ln \frac{N_{W}^{J/\zeta} - \phi_{C}^{J/\zeta} - L_C}{N_{C}^{J/\zeta} - \phi_{W}^{J/\zeta} - L_W} \]

\( x_F \) distribution

No corrections applied!

- \( x_F \) range: \([-0.35, 0.15]\)

- Statistical error estimation for 2-wire sample (only \( \mu \)-channel)

- \( e \)-channel increases statistics up to factor 2 (depending on particle ID cuts)

Muon channel full statistics

\( n \) distribution

\( n \) range: \([-1, 0.15]\)
Charmonium Production : $\chi_c$

Fraction of $J/\psi$ produced via $\chi_c$

\[
R_{\delta c} > \sum \tau(\delta_{ci}) Br(\delta_{ci} \downarrow J/\zeta \eta) \frac{\tau(J/\zeta)}{\tau(J/\zeta)_{tot}}
\]

Measurement 2000 based on $380 \pm 74 \chi_c$

$R_{\chi_c} = 0.32 \pm 0.06_{\text{stat}} \pm 0.04_{\text{sys}}$

First measurement of $\chi_c$ suppression in nuclear matter possible!

$N(\chi_c) = 6806 \pm 1058$

$M(\chi_c) = 0.437 \pm 0.004$ GeV

$\sigma(\chi_c) = 0.044 \pm 0.008$ GeV

Only $\mu$-channel

Preliminary
Measurement of the $\Upsilon$ production cross section is feasible may help to distinguish between Fermilab measurements
Minimum Bias Data sample

Open charm signals

\[ N(D^0) = 162 \pm 27 \]
\[ M(D^0) = 1.865 \text{ GeV} \]
\[ \sigma(D^0) = 30 \pm 5 \text{ MeV} \]

85% of statistics

\[ N(D^+) = 82 \pm 12 \]
\[ M(D^+) = 1.868 \text{ GeV} \]
\[ \sigma(D^+) = 26 \pm 4 \text{ MeV} \]

85% of statistics

\(~210 \cdot 10^6\) events recorded on Carbon, Tungsten and Titanium wire

\[ K^0_s, 2.8 \text{ M} \]
\[ M^0, 620 \text{ k} \]
\[ \bar{M}^0, 310 \text{ k} \]
\[ \Psi, 10 \text{ k} \]
\[ \Psi^*, 6.2 \text{ k} \]
\[ \Psi^0(1530), 1.5 \text{ k} \]
\[ \Xi^-, 500 \]
\[ \Xi^+, 460 \]
\[ K^{*0} + \bar{K}^{*0}, 1.1 \text{ M} \]
\[ \Gamma, 63 \text{ k} \]

85% of statistics

~factor 300 to 2000 statistics

Measurements of differential cross sections, atomic number dependence

Measurement of ratio \((D^+/D^0)\)
Summary

• HERA-B detector & trigger in good shape
  - 1200-1400 $J/\psi$ per hour, 70% of available beam time used
  - ~300,000 triggered $J/\psi$ ($e^+e^-/\mu^+\mu^-$)
  - ~210·10$^6$ Minimum bias events

• Analysis of 2002/03 data in progress
  - Quality of recorded data looks good, first preliminary results promising

Expect preliminary results for summer conferences.