

Measurement of J/ψ and $\psi(2S)$ production in $p + p$ and $p + d$ interactions at 120 GeV[†]

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We report the $p + p$ and $p + d$ differential cross sections measured in the SeaQuest experiment for J/ψ and $\psi(2S)$ production at 120 GeV beam energy covering the forward x -Feynman (x_F) range of $0.5 < x_F < 0.9$. We had measured the cross-section ratio for the Drell-Yan process in $p + p$ and $p + d$ ($\sigma^{pd}/2\sigma^{pp}$), to reveal the flavor asymmetry between the \bar{u} and \bar{d} quark distributions in the proton ($\bar{d}(x)/\bar{u}(x)$).¹⁻³⁾ A simultaneous measurement of the charmonium productions together with the Drell-Yan process provides complementary information on the partonic structures of the nucleon. In particular, the cross section for charmonium production is expected to be sensitive to the distributions of gluons as well as antiquarks.

The SeaQuest spectrometer was designed for detecting high-mass dimuon pairs from the Drell-Yan process and charmonium decays.⁴⁾ The SeaQuest data were recorded in 2014–2017 and separately analyzed as two datasets based on spectrometer conditions. Details of the data analysis procedure can be found in Refs. 1) and 2). Figure 1 shows the dimuon mass spectrum for $p + d$ data collected in the second dataset. The yields of J/ψ and $\psi(2S)$ were extracted with the component fit drawn in the figure. For experimental acceptance and efficiency, they were then corrected based on a simulation to derive the cross sections.

The x_F dependence of the J/ψ and $\psi(2S)$ production cross sections in $p + p$ and $p + d$ collisions is shown in Fig. 2. The measured cross sections are in good agreement with theoretical calculations based on the non-relativistic QCD (NRQCD).⁵⁾ The ratio of $\sigma_{\psi(2S)}$ to $\sigma_{J/\psi}$ increases as x_F increases in both $p + p$ and $p + d$, indicating that the $q\bar{q}$ annihilation process has larger contributions in the $\psi(2S)$ production than in the J/ψ production.

In conclusion, we observed that the charmonium cross sections at the forward x_F region are well described with the NRQCD calculation and have larger contributions from the $q\bar{q}$ annihilation process, particularly in case of $\sigma_{\psi(2S)}$. The cross sections are thus sensitive to the \bar{d}/\bar{u} flavor asymmetry of the proton sea, analogous to the Drell-Yan process. It would be interesting to include the $\sigma_{pd}/2\sigma_{pp}$ J/ψ data in a future

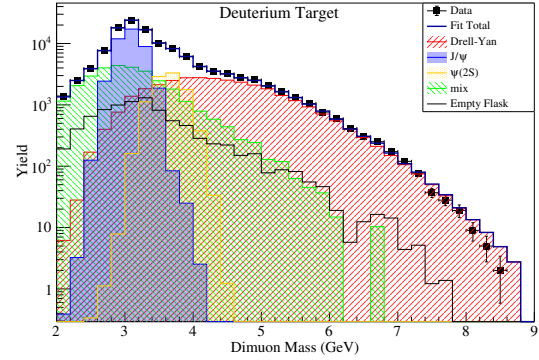


Fig. 1. Dimuon mass distribution for events collected on a liquid deuterium target for the second data set. The data points (solid squares) are compared with a fit (solid blue line) consisting of various components.

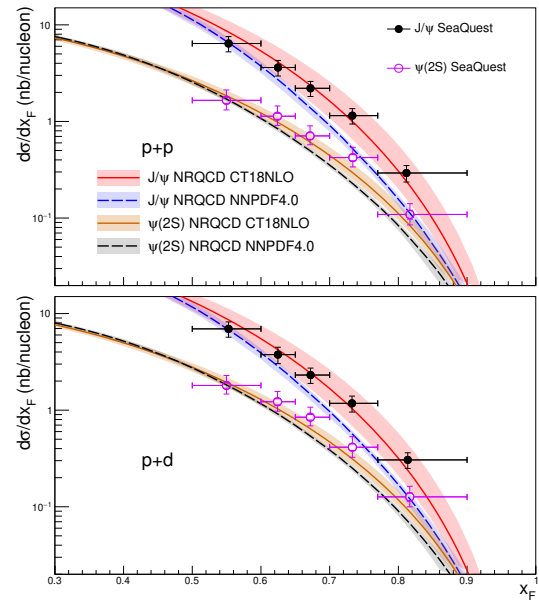


Fig. 2. Differential cross section per nucleon $d\sigma/dx_F$ for J/ψ and $\psi(2S)$ production in $p + p$ and $p + d$ interactions at 120 GeV, integrated over p_T . The error bars represent the total uncertainties. The curves correspond to NRQCD calculation.⁵⁾

extraction of the \bar{d}/\bar{u} asymmetry of the proton.

References

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[†] Condensed from the article in Phys. Lett. B **858**, 139032 (2024)

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