PRECISION MEASUREMENTS OF DIMUONS FROM p+p, p+d, and p+A COLLISIONS AT 800 GeV/c

FNAL-E866/NuSea Collaboration
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The E866 experiment at Fermilab, also called "NuSea," measured muon pair production from 800-GeV Tevatron proton beams incident on targets of liquid hydrogen and liquid deuterium, as well as solid Be and W; it follows FNAL experiments E772 and E789 with upgraded apparatus. The primary goal of the experiment was to make a precision measurement of the production ratio $\sigma(p+d \rightarrow \mu^+\mu^-)/2\sigma(p+p \rightarrow \mu^+\mu^-)$ which is directly related to the light flavor asymmetry $\bar{u}(x) - \bar{d}(x)$ in the nucleon sea where x is Bjorken x (hence "NuSea"), as described in the Gottfried Sum Rule (GSR). The experiment's large acceptance, high beam rate capability, and general control of systematic errors allowed the $\bar{u}(x) - \bar{d}(x)$ measurement to be made at a much higher accuracy, and at much finer resolution in x, than in any previous experiment. Additionally, E866 dimuon measurements allow the investigation of many other topics, including: J/ψ and $\psi\prime$, Υ and Υ(2S) production, particularly their nuclear dependence; J/ψ angular distributions and thus polarization; and backward x_F and very forward x_F production of J/ψ's and Drell-Yan pairs.

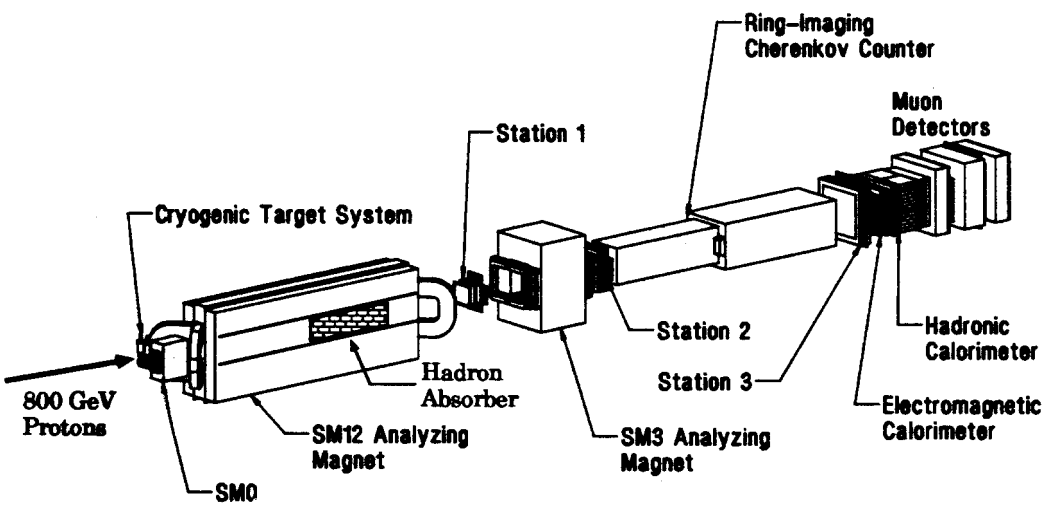

Figure 1: The E866 apparatus, in the Meson East hall at Fermilab. Principal components are the cryogenic target, the analyzing magnets, the three tracking stations, and the muon absorber/identifier stack.

The E866 apparatus is shown in Fig. 1: the Tevatron proton beam impinges on the target and continues into a beam dump; the long spectrometer magnet bends high-mass

opposite sign dimuons around the beam dump and into the analyzing magnet with its tracking system, followed by the absorber/muon identifier stack. The HER Group participated in upgrades to the spectrometer and general commissioning and operation of it, as well as in the design and programming of a high-level trigger system.

A sample dimuon invariant mass spectrum from the data is shown in Fig. 2. Sufficient resolution to distinguish the J/ψ from the $\psi\prime$ and the Υ from the Υ(2S) is apparent, as are the excellent statistics available for measurement of Drell-Yan continuum pairs (the $\bar{u}(x) - \bar{d}(x)$ derivation involves only these continuum pairs). The result of the E866 light flavor asymmetry measurement is shown in Fig. 3 in the form of the ratio $\bar{d}(x)/\bar{u}(x)$ versus x. In the simple GSR case this ratio would be 1 at all x. The NA51 point represents the best pre-existing measurement at a single value of x, which showed a clear violation of the GSR. The E866 results now reveal an interesting structure which had not been anticipated in previous parton-distribution-function calculations.

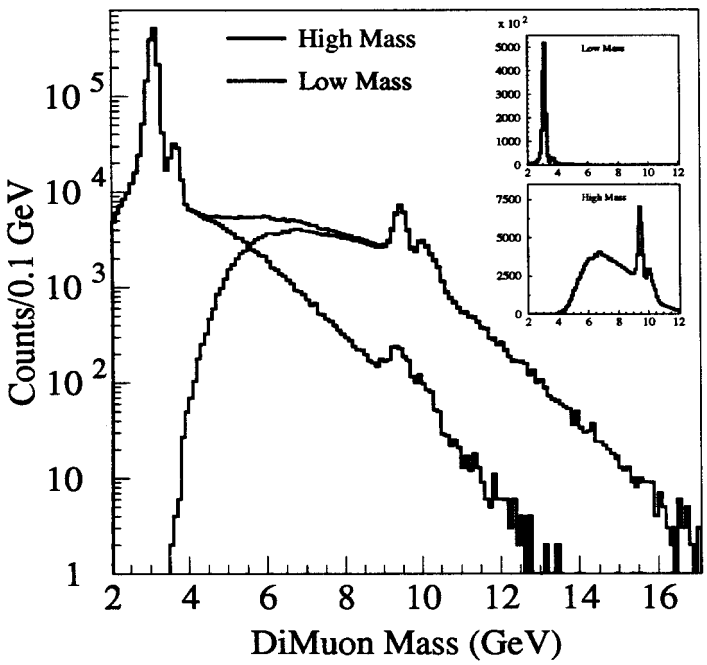

Figure 2: Dimuon pair invariant mass spectrum produced by 800 GeV/c protons on the hydrogen target. Two different spectrometer settings are shown; in combination they cover the J/ψ and Υ mass ranges, as well as the intermediate continuum, with excellent statistics.

The E866 collaboration has published the basic result for the light flavor asymmetry of the nucleon sea, and an “interpretations” paper exploring the possible origins of the effect (see bibliography). A popular article describing this measurement has appeared recently in *Science* magazine (Jan. 1999, vol. 283, p. 472). A number of other publications on vari-

ous topics are expected in the near future. The HER Group is particularly interested in results on the nuclear dependence of heavy vector meson and high-mass Drell-Yan production, since these will form part of the basic understanding required to interpret the same measurements in the RHIC environment (see page on the PHENIX experiment).

$$800 \text{ GeV } p + p \text{ and } p + d \rightarrow \mu^+ \mu^- X$$

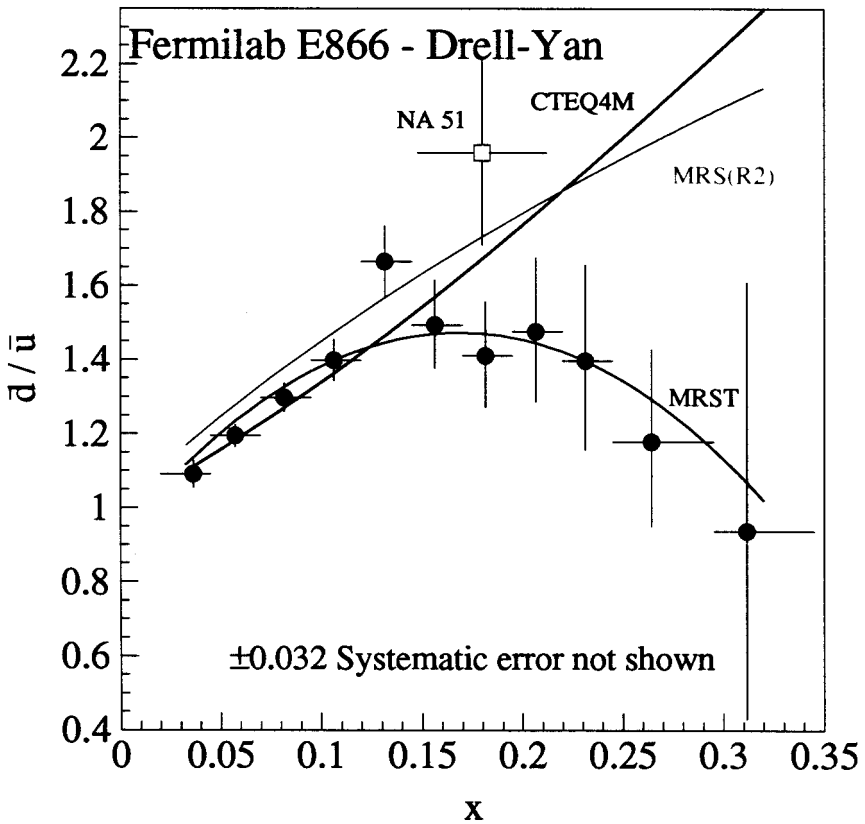

Figure 3: Basic E866 result (solid circles) for the light flavor asymmetry $\bar{d}(x)/\bar{u}(x)$. The open square is the best pre-existing measurement at a single value of x. The curves are predictions from various structure function sets.