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Study of the Isospin Symmetry Breaking in the Light Quark Sea of the Nucleon from the Drell-Yan Process
NA51 Collaboration

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Abstract

The ratio of cross-sections for muon pair production through the Drell-Yan process in p-p and p-d reactions has been measured at y ≈ 0, with 450 GeV/c incident protons. The asymmetry $A_{DY} = \frac{\sigma^{pp}-\sigma^{pn}}{\sigma^{pp}+\sigma^{pn}}$ amounts to $-0.09 \pm 0.02 \pm 0.025$. The ratio $\frac{\bar{u}}{\bar{d}}$ of the nucleon sea structure functions derived from this measurement amounts to $0.51 \pm 0.04 \pm 0.05$ at x = 0.18 and suggests that isospin symmetry is broken in the light quark sea of the nucleon.

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1 Introduction

Deep inelastic muon scattering measurements done by the New Muon Collaboration [1, 2] suggest that SU(2) isospin symmetry could be broken in the quark sea of the nucleon [3, 4]. An alternative explanation would require to modify the small x behaviour of the parton distributions [5]. Both interpretations are able to reproduce the NMC experimental observation which, apparently, leads to the violation of the Gottfried sum rule [1, 2].

As noticed by Ellis and Stirling [6], an elegant way to discriminate between these two interpretations is to use the Drell-Yan process and compare dilepton production by protons on hydrogen and deuterium targets.

Our measurement of the ratio of the two cross-sections suggests isospin symmetry breaking in the light quark sea of the proton.

2 Parton distributions from deep inelastic scattering

The NMC Collaboration has measured deep inelastic muon scattering (DIS) on hydrogen and deuterium targets at 90 and 280 GeV/c. They derive the integral [2]

$$S_G(0.004-0.8)=\int_{0.004}^{0.8}(F_2^p-F_2^n)dx/x \tag{1}$$

and find

$$S_G(0.004-0.8)=0.221\ \pm\ 0.008\ (stat) \tag{2}$$

at $Q^2=4$ GeV^2.

Assuming a smooth extrapolation of F_2^n/F_2^p from x = 0.8 to 1 and a Regge behaviour in the extrapolation to x = 0, they obtain

$$S_G(0.-1.)\ =\ 0.235\ \pm\ 0.026 \tag{3}$$

On the other hand, the Gottfried sum rule can be written as

$$\begin{aligned} S_G &= \frac{1}{3}\int_0^1[u_V(x)-d_V(x)]\,dx \\ &+ \frac{2}{3}\int_0^1[\bar{u}(x)-\bar{d}(x)]\,dx \end{aligned} \tag{4}$$

where u_V (d_V) and $\bar{u}$ ($\bar{d}$) are the valence and sea distributions of the u (d) quark in the proton. In the parton model, the integration of the first term gives 1/3 and the second term vanishes when $\bar{u}(x)=\bar{d}(x)$ is assumed. The discrepancy between the experimental result (3) and 1/3 suggests that either SU(2) isospin symmetry is violated in the light quark sea of the proton [3, 4, 6] or the onset of Regge behaviour of the quarks is postponed to much lower x values than currently used [5]. In the first hypothesis, the Gottfried sum rule gives a value lower than 1/3; the second hypothesis leads to a non-negligible contribution of the valence term for x between 0 and 0.004 so that the extrapolation of the measured value $S_G(0.004\text{-}0.8)$ to $S_G(0.\text{-}1.)$ reaches 1/3. It should be noticed that isospin symmetry breaking could, in principle, originate from two different scenarios or from a combination of both. The first one results from flavour assymetry in the proton, namely $\bar{u}(x) \neq \bar{d}(x)$. The second one assumes symmetry breaking between the proton and the neutron, namely $\bar{u}_p(x) \neq \bar{d}_n(x)$. In this paper, as generally admitted, we will consider that isospin symmetry between the proton and the neutron is preserved.

In table 1 are listed five sets of parton distributions which have been considered in order to explain these experimental observations and will be used to compare the results of theoretical calculations with our measurement.

3 Parton distributions from the Drell-Yan process

It has been shown by Ellis and Stirling [6] that the Drell-Yan process in proton-nucleon collisions, $p\mathcal{N} \rightarrow \ell^+\ell^- + X$, can provide excellent discrimination between isospin symmetric and non-symmetric sea parton distributions. We consider the p-n cross-section asymmetry defined as

$$A_{DY} = \frac{\sigma^{pp} - \sigma^{pn}}{\sigma^{pp} + \sigma^{pn}} \tag{5}$$

where σ^{pp} and σ^{pn} are the cross-sections for dileptons produced in p-p and p-n collisions. In the Drell-Yan model, the differential cross-sections and the asymmetry can be written in terms of valence and sea quark structure functions.

For the sake of simplicity, let us write the proton-nucleon cross-section for dileptons produced at a given mass M and at fixed c.m.s. rapidity y = 0

$$\sigma^{p\mathcal{N}} = \frac{d^2\sigma(p\,\mathcal{N} \rightarrow \ell^+\ell^- X)}{d\sqrt{\tau}dy}\,|_{y=0} \tag{6}$$

where $\sqrt{\tau} = M \;/\; \sqrt{s}$, $\sqrt{s}$ being the energy of the collision in the c.m.s.. At y = 0, the fractional momenta x_1 and x_2 of the interacting hadrons carried by the projectile and target quarks are both equal to x, with $x = \sqrt{\tau}$. Neglecting the sea-sea contributions to the cross-sections, we get

$$\sigma^{pp} = \frac{8\pi\alpha^2}{9\sqrt{\tau}}\,(\frac{8}{9}u_V(x)\bar{u}(x) + \frac{2}{9}d_V(x)\bar{d}(x)) \tag{7}$$

$$\sigma^{pn} = \frac{8\pi\alpha^2}{9\sqrt{\tau}}\,\frac{5}{9}(u_V(x)\bar{d}(x) + d_V(x)\bar{u}(x)) \tag{8}$$

and the asymmetry becomes

$$A_{DY} = \frac{(4u_V - d_V)(\bar{u} - \bar{d}) + (u_V - d_V)(4\bar{u} - \bar{d})}{(4u_V + d_V)(\bar{u} + \bar{d}) + (u_V + d_V)(4\bar{u} + \bar{d})} \tag{9}$$

With these simplifying assumptions, A_{DY} depends only on the up quark to down quark ratios for the valence and sea parton distributions, $\lambda_V(x) = u_V(x)/d_V(x)$ and $\lambda_s(x) = \bar{u}(x)/\bar{d}(x)$, and becomes

$$A_{DY} = \frac{(4\lambda_V - 1)(\lambda_s - 1) + (\lambda_V - 1)(4\lambda_s - 1)}{(4\lambda_V + 1)(\lambda_s + 1) + (\lambda_V + 1)(4\lambda_s + 1)} \tag{10}$$

In the x range of our experiment, typical values for λ_V are slightly higher than 2 for any currently considered set of parton distributions. Sea isospin symmetry means $\lambda_s = 1$ and, for $\lambda_V = 2$, leads to $A_{DY} = 0.09$. On the other hand, an asymmetric sea with $\lambda_s = 0.72$ is required to obtain $A_{DY} = 0$.

Experimentally, the asymmetry A_{DY} can be measured from the ratio of Drell-Yan cross-sections for proton-proton and proton-deuteron reactions. It can be written as follows

$$A_{DY} = 2\,\frac{\sigma^{pp}}{\sigma^{pd}} - 1 \qquad (11)$$

if one assumes that $\sigma^{pd} = \sigma^{pp} + \sigma^{pn}$, i.e. that shadowing is negligible, which is the case for the x-range of the experiment described hereafter [10].

4 The NA51 experiment

The NA51 experiment has been specifically designed to study the problem discussed in the previous sections. Compared to previous experimental searches [11], it is a devoted experiment which has the required sensitivity to discriminate between the predictions of currently used parton distributions. It uses a 450 GeV/c primary proton beam ($\sqrt{s} = 29$ GeV) from the CERN-SPS at an average intensity of 10^9 protons per second. Muon pairs are detected with the NA10 spectrometer [12], especially designed for high intensity incident beams. Its main characteristics are a 4.8 m long hadron absorber, a toroidal air-core magnet ($\int B.d\ell \approx 2.1\ T.m$ at a radius of 75 cm), a double set of 4 multiwire chambers, located upstream and downstream from the magnet, and 4 scintillator hodoscopes, adapted to the hexagonal symmetry of the magnet, which define the trigger.

Mass resolution is 180 MeV/c^2 (r.m.s.) for the ψ'. We limit the accepted rapidity range to [-0.5, 0.6], where the differential acceptance is higher than 1 %. The integrated acceptance over this rapidity range and for M $\geq$ 4.3 GeV/c^2 is (7.89$\pm$0.02) % for the H_2 target and (7.96$\pm$0.02) % for the D_2 target, the difference arising from the shapes for $d\sigma/dy$ in the accepted rapidity range.

The target system consists of three identical vessels, respectively empty (10^{-2} torr) and filled with liquid hydrogen and deuterium. Each target is 120 cm long and 3 cm in diameter which, given the beam spot size and divergence, ensures 100 % targetting efficiency. In addition to the target contents, the beam intercepts the vessel windows made of a total of 30 μm of stainless steel and 76 μm of aluminium. The characteristics of the target materials are summarized in table 2. The uncertainty on the densities leads to an absolute systematic error on the asymmetry of about 0.01. The targets are mounted on a remote-controlled table which allows to change periodically (every run) the target exposed to the beam. Runs with empty target are used to subtract dimuons produced in the windows of the vessel. The z-resolution (along the beam line) is given by

$$\sigma_z = \frac{85\ cm}{M_{\mu\mu}\ (GeV/c^2)} \qquad (12)$$

and is good enough to reject events produced by collisions of the beam in the plug of the absorber, located 160 cm downstream from the center of the target.

A precise measurement of the ratio σ^{pp}/σ^{pd} requires an accurate knowledge of the relative incident flux of the three target exposures. For this purpose, three independent multifoil ionization chambers filled with argon are used along the beam. Their linearity was checked at low intensity with scintillating counters, then monitored at high intensity by means of three scintillator telescopes pointing at 90^0 to the target.

5 Analysis

Reconstructed dimuons with mass higher than 1.5 GeV/c^2 were selected in order to estimate correctly the continuum below the J/ψ and the ψ' resonances (see table 3). The asymmetry measurement is performed for muon pairs with mass higher than 4.3 GeV/c^2 , 3.4 standard deviations away from the ψ' mass, which ensures the sample to be purely produced by the Drell-Yan process.

Set of parton distributions	*Usual Regge behaviour*	*Symmetric sea*	*Gottfried integral*	*Ref.*
$MRS\ S'_0$	*no*	*yes*	0.33	[7]
$MRS\ D'_0$	*no*	*no*	0.26	[7]
$MRS\ D'_-$	*yes*	*no*	0.24	[7]
$GRVHO$	*no*	*yes*	0.33	[8]
$CTEQ\ 2M$	*no*	*no*	0.24	[9]

Table 1: Characteristics of the studied sets of parton distributions.

	λ_I g/cm^2	ρ g/cm^3	L cm	$\rho\ L_{eff}$ g/cm^2
H_2	50.8	0.0708 ± 0.0003	120.0	7.82 ± 0.04
D_2	54.7	0.162 ± 0.001	120.0	16.36 ± 0.09
Al	106.4	2.70	0.0076	0.02
Fe	131.9	7.87	0.0030	0.02

Table 2: Characteristics of the various materials intercepting the beam line in the target assembly. $L_{eff} = \lambda_I\,(1 - \exp(-L/\lambda_I))$ is the effective length of each target.

	Total	*H2*	*D2*	*empty*
Total nb of evts	$2.3\ 10^7$	$1.0\ 10^7$	$1.3\ 10^7$	$7\ 10^5$
Selected runs	360	122	132	106
$M > 1.5$	$2.9\ 10^6$	1173130	1722152	8936
$2.7 < M < 3.5$		434623	450878	2637
$M > 4.3$		2763	3007	16

Table 3: NA51 data, showing the number of selected runs and selected events with dimuon mass higher than 1.5, between 2.7 and 3.5 and higher than 4.3 GeV/c^2 .

Special attention was devoted to the reconstruction efficiency, which is a function of the chamber efficiency and of the event multiplicity. Simulated J/ψ events, for which chamber inefficiency was taken into account, were merged with high multiplicity experimental events. This study led to a severe check of the reconstruction procedure. The resulting absolute systematic error on the asymmetry could thus be estimated to 0.02.

The main source of background in the dimuon sample is due to pion and kaon decays. The $\mu^+\mu^-$ background is estimated from the $\mu^+\mu^+$ and the $\mu^-\mu^-$ data and subtracted from the opposite sign dimuon spectra according to the procedure described in ref. [13]. The background and the signal mass spectra are displayed on figure 1. The background to signal ratio is less than 1% in the J/ψ mass region and even lower for higher masses. The number of J/ψ and ψ' events is obtained by a fit of the signal mass spectrum. The result of the fit is also shown on figure 1.

The production of high mass dimuons from secondary interactions in the target was studied by simulation programs and found to be very small with respect to primary interactions (of the order of 10^{-3}). This leads to a negligible contribution to the systematic error on the asymmetry.

The absolute number of incoming protons is not needed for the asymmetry calculation and is only known with an accuracy of about 10 %. The ratio of incoming protons on the hydrogen and deuterium targets, accurately deduced from the ionization chambers measurements, induces a systematic error of 0.005 on the asymmetry.

6 Results

The experimental asymmetry is expressed by the equation (11), where σ^{pp} and σ^{pd} are now defined as

$$\begin{aligned} \sigma^{pp} &= \int_{-.5}^{.6}\int_{4.3}^{8.5} \frac{d^2\sigma(pp \to \mu^+\mu^- X)}{dM\,dy} dM\,dy \\ \sigma^{pd} &= \int_{-.5}^{.6}\int_{4.3}^{8.5} \frac{d^2\sigma(pd \to \mu^+\mu^- X)}{dM\,dy} dM\,dy \end{aligned} \tag{13}$$

The data lead to

$$A_{DY} = -0.09 \pm 0.02\,(stat) \pm 0.025\,(syst) \tag{14}$$

The corresponding value for the J/ψ asymmetry A_ψ is

$$A_\psi = -0.03 \pm 0.002\,(stat) \pm 0.025\,(syst) \tag{15}$$

Table 4 presents the Drell-Yan and J/ψ asymmetries in the mass and rapidity range of the experimental result, computed for the different sets of parton distributions previously mentioned and obtained from PDFLIB [14]. As already noticed, isospin symmetric sea parton distributions lead to large positive values of A_{DY}, higher than 0.08, whereas much lower values are obtained using isospin symmetry violating sea parton distributions. The experimental result on A_{DY} is 4 standard deviations away from the values obtained with an isospin symmetric sea.

The calculation of A_ψ is more difficult because a model is needed to describe the J/ψ production. It has been assumed here that the J/ψ is produced either by gluon-gluon fusion (about 80 % of the process) or by quark-antiquark annihilation (20 %) and is not subsequently reabsorbed inside the nucleus, i.e. $\sigma^{pd} = \sigma^{pp} + \sigma^{pn}$. Whatever the production model, A_ψ is expected to be zero if the sea is isospin symmetric. It becomes negative if the quark-antiquark annihilation process is involved and $\bar{u}$ is smaller than $\bar{d}$. Our measurement of A_ψ is consistent with these two assumptions.

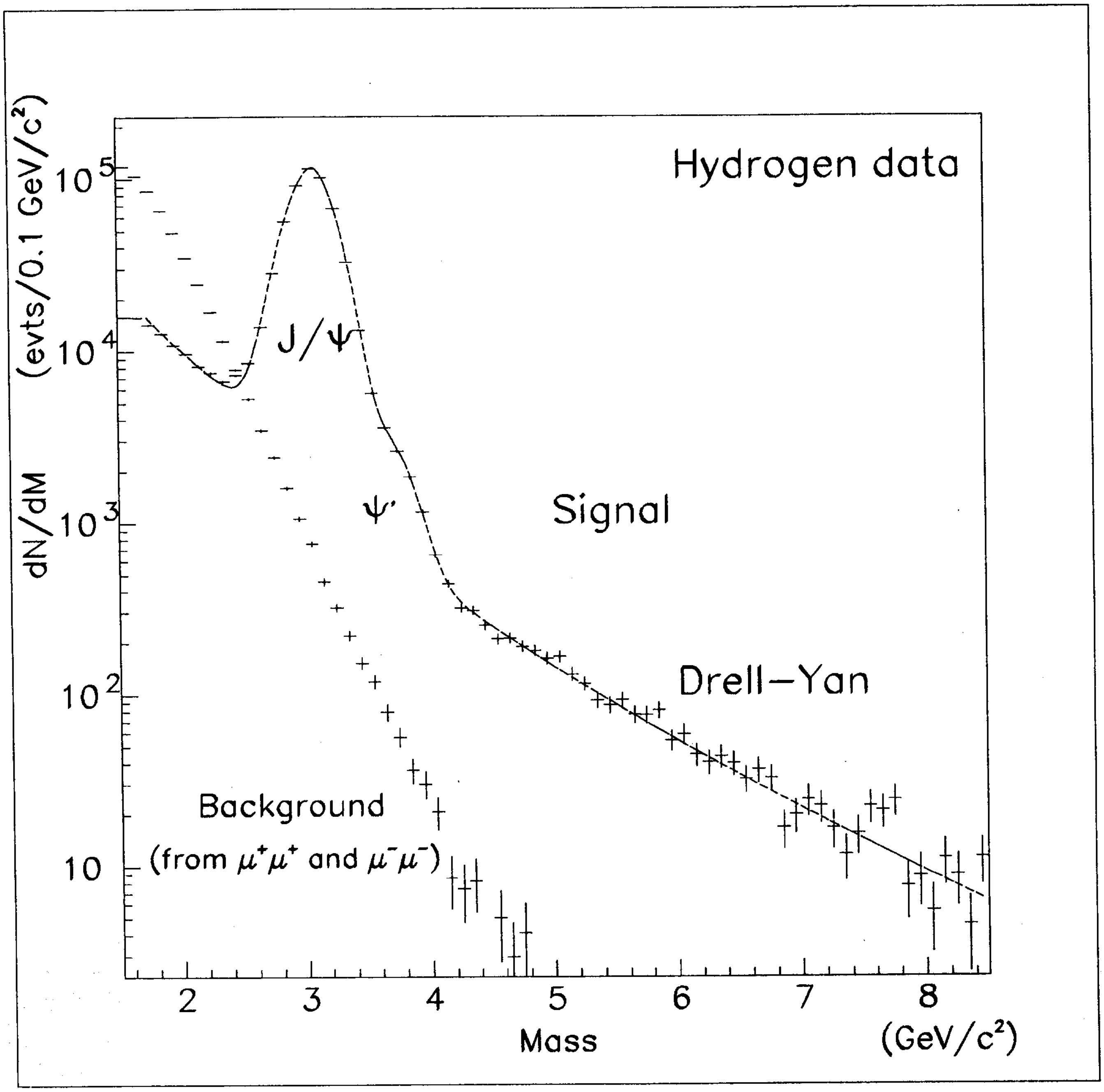

Figure 1: Mass spectra of background and signal for p-p events.

For the Drell-Yan process, our result can be expressed in terms of the previously defined quantity $\lambda_s(x) = \bar{u}(x)/\bar{d}(x)$. Rewriting equation (10) as

$$\lambda_s = \frac{-(2+5\lambda_V)A_{DY} \ + \ (2-5\lambda_V)}{(5+8\lambda_V)A_{DY} \ + \ (5-8\lambda_V)} \tag{16}$$

one can see that, for y = 0 and as far as the sea-sea terms of the cross-sections are negligible, the value of λ_s, at a given x, depends only on $\lambda_V(x)$ and $A_{DY}(x)$. From the experimental point of view, its derivation has to take into account the facts that A_{DY} is measured in a finite range of mass and rapidity and that the sea-sea contribution cannot be completely neglected. Both x_1 and x_2 lie within the range [0.08-0.53]. However, due to a narrow rapidity acceptance centered at y = 0 and a steeply decreasing mass spectrum, a good approximation is to apply relation (16) at y = 0 and at the mean x-value $< M > /\sqrt{s} \ = \ 0.18$. The correction for the sea-sea terms and the estimate of the systematic error induced by our approximation can be obtained from the computations of A_{DY} for different sets of structure functions. The results of these calculations are presented in table 5, where we quote successively the values of λ_V and λ_s at x = 0.18 as given by PDFLIB, then the computed asymmetry at y = 0, $\sqrt{\tau} \ = \ 0.18$ without (column a) and with (column b) the contribution of the sea-sea terms. We observe that introducing the sea-sea terms tends to decrease the absolute value of A_{DY}. In column c, the asymmetry is computed in the whole experimental (M, y) range. The agreement between columns b and c confirms that the x = 0.18 approximation is valid. The final check is to compute, in the last column of table 5, the values of λ_s from equation (16) with an averaged $\lambda_V \ = \ 2.2$ and A_{DY} taken from column c, corrected for the average contribution of sea-sea terms and x-domain approximation, i.e.

$$|A_{DY}^{corr}| \ = \ |A_{DY}^{column\ c}| \ + \ 0.012 \tag{17}$$

A good consistency between input and recomputed values of λ_s is obtained. We estimate that the overall systematic error on λ_s due to this procedure is 0.03.

We now apply the same procedure to the measured A_{DY} in order to get the experimental value of λ_s. Values of λ_V are taken within the range [2.00, 2.70] and induce an additional systematic uncertainty of 0.01 on λ_s. We add quadratically these systematic errors to the one induced by the measurement of A_{DY}, so that our measured value of λ_s at x = 0.18 is

$$\lambda_s \ = \ 0.51 \ \pm \ 0.04\,(stat) \ \pm \ 0.05\,(syst) \tag{18}$$

This result suggests that isospin symmetry is violated in the light quark sea of the nucleon.

7 Conclusion

The ratio of cross-sections for Drell-Yan muon pair production in p-p and p-d reactions has been measured at y ≈ 0 and leads to

$$\frac{\sigma^{pp} - \sigma^{pn}}{\sigma^{pp} + \sigma^{pn}} \ = \ -0.09 \ \pm \ 0.02\,(stat) \ \pm \ 0.025\,(syst)$$

The ratio $\lambda_s \ = \ \frac{\bar{u}}{\bar{d}}$ of the light quark sea parton distributions in the nucleon deduced from this measurement is

$$\lambda_s \ = \ 0.51 \ \pm \ 0.04\,(stat) \ \pm \ 0.05\,(syst)$$

at $\sqrt{\tau} = 0.18$.

This result is a clear indication of isospin symmetry violation in the light quark sea of the nucleon.

Parton distributions	A_{DY}	A_{ψ}
$MRS\ S'_0$	0.085	0.000
$MRS\ D'_0$	0.049	−0.007
$MRS\ D'_-$	0.019	−0.010
$GRVHO$	0.087	0.000
$CTEQ\ 2M$	−0.119	−0.020

Table 4: Results of theoretical asymmetry calculations for Drell-Yan dimuons (mass > 4.3 GeV/c^2) and J/ψ s, for several sets of parton distributions.

Parton distributions	λ_V (0.18)	λ_s (0.18)	A_{DY} (a)	A_{DY} (b)	A_{DY} (c)	λ_s
$MRS\ S'_0$	2.13	1.00	0.098	0.086	0.085	1.00
$MRS\ D'_0$	2.19	0.88	0.064	0.052	0.049	0.90
$MRS\ D'_-$	2.28	0.78	0.029	0.019	0.019	0.78
$GRV\ HO$	2.13	1.00	0.098	0.088	0.087	1.00
$CTEQ\ 2M$	2.73	0.46	−0.143	−0.139	−0.119	0.47

Table 5: Sea-sea contribution and corrections induced by the experimental method for different parton distributions (see text for details).

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References

[1] P. Amaudruz et al., Phys. Rev. Lett. 66 (1991) 2712.

[2] A. Brüll, talk delivered at the International Workshop on Deep Inelastic Scattering, Eilat (ISRAEL), Feb. 1993;
M. Arneodo et al., CERN-PPE 93-117 (1993).

[3] G. Preparata, P.G. Ratcliffe and J. Soffer, Phys. Rev. Lett. 66 (1991) 687.

[4] Bo-Qiang Ma, Phys. Lett. B 274 (1991) 111.

[5] A.D. Martin, R.G. Roberts and W.J. Stirling, Rutherford Appleton Laboratory preprint RAL-90-068 (1990).

[6] S.D. Ellis and W.J. Stirling, Phys. Lett. B 256 (1991) 258.

[7] A.D. Martin, W.J. Stirling and R.G. Roberts, Phys. Lett. B 306 (1993) 145.

[8] M. Glück, E. Reya and A. Vogt, Zeit. Phys. C 53 (1992) 127;
M. Glück, E. Reya and A. Vogt, Phys. Lett. B 306 (1993) 391.

[9] J. Botts et al, Phys. Lett. B304, (1993) 159.

[10] V. Barone et al., Zeit. Phys. C 58 (1993) 541;
P. Castorina, A. Donnachie and P. Hariman, preprint M/C-TH 93/04.

[11] A.S. Ito et al, Phys. Rev. D 23, 3 (1981) 604;
P.L. McGaughey et al, Phys. Rev. Lett. 69, (1992) 1726.

[12] NA10 Collaboration, N.I.M. 223 (1984) 26;
NA38 Collaboration, Phys. Lett. B 220 (1989) 471.

[13] NA38 Collaboration, Zeit. Phys. C 38 (1988) 117.

[14] H. Plothow-Besch, Proc. of the 3rd Workshop on Detector and Event Simulation in High Energy Physics, Amsterdam, 1991.