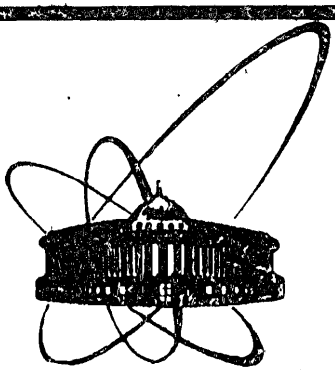

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NEW RESULTS ON NUCLEAR EFFECTS IN DEEP INELASTIC MUON SCATTERING ON DEUTERIUM AND IRON TARGETS

BCDMS Collaboration

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Several muon and electron scattering experiments at CERN and SLAC have investigated the effect that a nucleon embedded in a nucleus has a quark structure different from that of a free nucleon. In deep inelastic scattering, this "EMC effect" is studied by comparing the nucleon structure function $F_2^A(x)$ measured on a heavy target of mass A to the deuterium structure function $F_2^{D2}(x)$, where x is the Bjorken scaling variable. While all experiments agree on the pattern of the nuclear effect in the valence quark region $x > 0.3$, namely a softening of the structure function when measured on a heavy target, the experimental situation in the low x region is controversial. The EMC in their original measurement [1] observed the ratio $F_2^{Fe}(x)/F_2^{D2}(x)$ to increase lineary towards small x. On the contrary, the SLAC E139 experiment[2] which studied the effect for a variety of nuclei found no significant effect in the region of small $x < 0.3$, independent of the target mass. An earlier SLAC experiment[3] at small four-momentum transfers $Q^2 \approx 1$ GeV^2 had observed an enhancement around $x \simeq 0.15$ and a turnover at very small $x \simeq 0.05$.

In a previous paper [4] we have presented data on the structure function ratios $F_2^A(x)/F_2^{D2}(x)$ for nitrogen (A = 14) and iron (A = 56). The N_2 data covered the range $0.08 \leq x \leq 0.70$ and exhibited no significant enhancement at small x in agreement with the SLAC E139 data. The Fe data extended over the range $0.20 \leq x \leq 0.70$ only and allowed no conclusion on the behaviour of the effect at low x. Here, we report on preliminary data from a complementary experiment with deuterium and iron targets which was specifically designed to study the ratio $F_2^{Fe}(x)/F_2^{D2}(x)$ in this kinematic domain with good statistical and systematic accuracy.

The experiment was performed at the CERN SPS muon beam with a high luminosity spectrometer which is described in detail elsewhere[5].

A schematic view of the experimental set-up is shown in Fig.1.

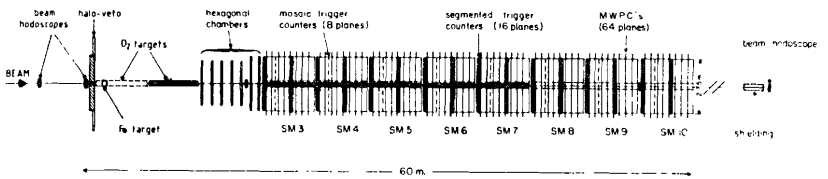

Fig.1. Schematic view of the apparatus.

The apparatus consists of a 40 m long magnetized iron toroid which is subdivided into 8 modules and instrumented with scintillation trigger counters and multiwire proportional chambers. The central bores of the first six modules contain target vessels ("internal" targets) filled with liquid deuterium. Two external targets in front of the magnet, followed by a set of MWPC with three-coordinate read-out, extend the acceptance of the spectrometer to small angles, i.e. to smaller Q^2 and x than are accessible with the internal targets. For a part of the data-taking, the first of the external targets was replaced by a 45 cm long iron target. The data were recorded with a beam of 200 GeV positive muons and average intensity of $2 \cdot 10^7 \mu$/sec. The total beam flux was $17.1 \cdot 10^{11}$ for the "all D_2" and $6.0 \cdot 10^{11}$ for the "Fe/D_2" target configurations. The D_2 targets were filled during the first half of the iron data taking only. The deuterium data taken simultaneously with the iron data are not included in the present analysis.

The extraction of structure functions from the experimental data is very similar to the one described in refs./4,6/. Due to the vertex resolution of the spectrometer, the iron sample is contaminated by events from the neighbouring D_2 target. This background was determined both by a Monte Carlo study of the vertex resolution and by a direct comparison of the iron samples taken with and without D_2

in the second target. With both methods we find a contamination of 1.3% for which the data are corrected. A background from target wall interactions which amounts to 0.7% for the external and 2.5% for the internal targets is subtracted from the D_2 data. The experimental distributions are converted to deep inelastic cross sections, correcting for acceptance and resolution of the spectrometer by a detailed Monte Carlo simulation of the experiment. To evaluate the structure functions $F_2(x, Q^2)$ we assume a constant value $R = \sigma_L/\sigma_T = 0$. Although this approximation is inadequate in the region of small x, it does not affect the F_2 ratio. The deuterium structure function is computed separately for events from internal and external targets for which the acceptance of the spectrometer is very different. In the kinematical region of overlap, the structure functions are in agreement within statistical errors and we combine them for the subsequent analysis. The iron data are corrected for the non-isoscalarity of ^{56}Fe assuming a neutron/proton structure function ratio $F_2^n/F_2^p = 1 - 0.75 \cdot x$. No corrections are applied for the Fermi motion of nucleons inside the nucleus. The results presented here are based on $2.3 \cdot 10^5$ reconstructed events originating from the Fe and $3.8 \cdot 10^5$ events from the D_2 targets.

The sources of systematic errors in the F_2 ratio are largely the same as in our earlier experiment/4/. They are mainly due to the resolution of the spectrometer, small uncertainties on energy loss and multiple scattering in the different target materials, hadronic shower feed-through, and the reproducibility of the spectrometer magnetic field settings. An additional uncertainty not present in our previous data arises from the fact that the spectrometer acceptance for events from the external targets decreases along the beam direction and is therefore different for the two target materials. Errors on the acceptance correction due to this effect were calculated by varying slightly the vertex resolution in the Monte Carlo simulation of the

experiment. As before, we estimate the uncertainty on the relative luminosity calibration of the Fe and D_2 data to 1.5%.

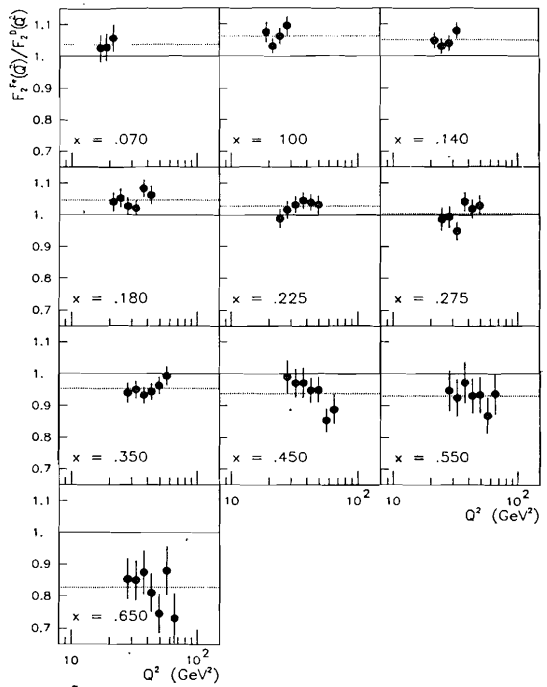

Fig.2. The structure function ratio $F_2^{Fe}/F_2^{D_2}$ in bins of x and Q^2. Only statistical errors are shown. The dotted lines indicate the average over the respective x bin.

The $F_2^{Fe}/F_2^{D_2}$ ratio is shown as a function of x and Q^2 in Fig.2 and exhibits no significant Q^2 dependence. The data are therefore averaged over Q^2 and are shown as a function of x and compared to our previously published data[4] in Fig.3. We observe good agreement between our two measurements in the kinematical region of overlap and combine the two data sets for a comparison to other experiments which is shown in Fig.4. The comparison to the EMC data[1] shows good agreement for $x > 0.15$, apart from a 3% shift in the relative normalization. For $x < 0.15$, the two measurements are marginally compatible within the quoted systematic errors. The agreement with the SLAC E139 data[2] is excellent for $x > 0.25$ but rather poor at small x. In this region, we observe however a very good agreement

with the earlier SLAC experiment on a copper target[3] at small $Q^2 \approx 1$ GeV^2.

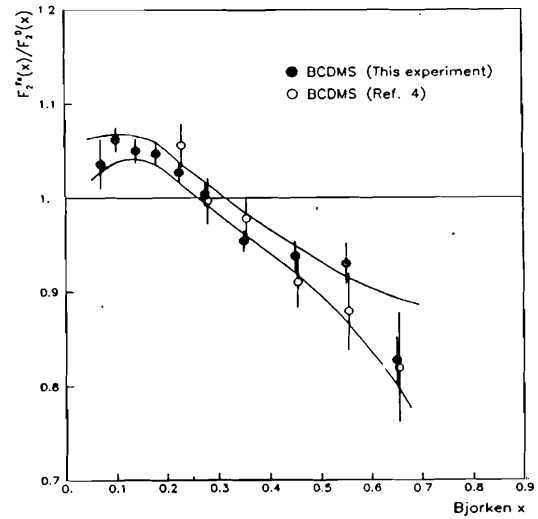

Fig.3. The structure function ratio $F_2^{Fe}(x)/F_2^{D_2}(x)$ measured in this and in a previous[4] experiment. The solid lines indicate an estimate of the point-to-point systematic errors of the present experiment. In addition, there is a 1.5% uncertainty on the relative normalization of Fe and D_2 data.

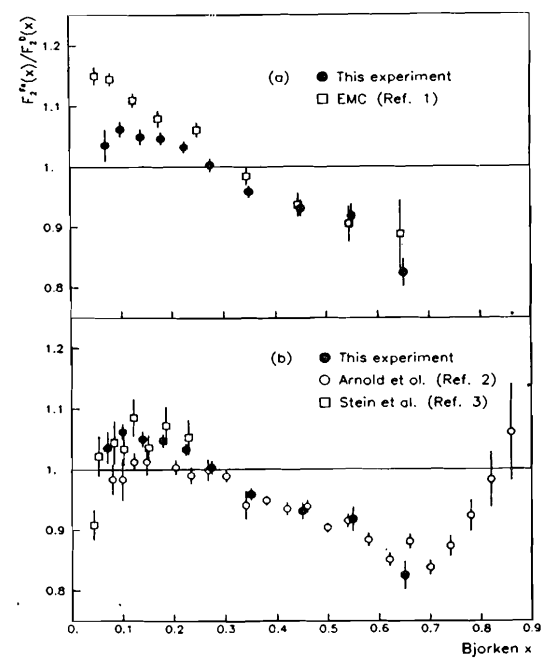

Fig.4. The structure function ratio $F_2^{Fe}(x)/F_2^{D_2}(x)$ from this and from our previous measurement[4] combined, compared to earlier muon (a) and electron (b) scattering experiments. The data from ref.[3] were taken with a copper target. Only statistical errors are shown.

In summary, we have complemented our earlier measurement of the structure function ratio $F_2^{Fe}(x, Q^2)/F_2^{D2}(x, Q^2)$ by new data covering the region of small $x(0.06 \leq x \leq 0.20)$ and improving the statistical accuracy at large $x > 0.20$. No Q^2 dependence of the nuclear effect is observed over the kinematic range of the experiment. In the region of large $x > 0.2$, we find good agreement with all earlier charged lepton experiments[1,2,4]. For low $x < 0.2$, we observe only a small but significant enhancement of the structure function ratio of approximately 5%.

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Бенвенути А.С. и др.
E1-86-591

Новые результаты по ядерным эффектам в глубоконеупругом рассеянии мюонов на мишенях из дейтерия и железа

Приводятся новые результаты измерения отклонений структурных функций $F_2(x,Q^2)$ в эксперименте по глубоконеупругому рассеянию мюонов на дейтериевой и железной мишенях при больших значениях Q^2. Отношение $F_2^{Fe}(x)/F_2^{D_2}(x)$ измерено в кинематической области $0,06 \leq x \leq 0,70$, $14\ ГэВ^2 \leq Q^2 \leq 70\ ГэВ^2$. Полученные результаты хорошо согласуются с прежними измерениями в области значений $x > 0,3$. В области значений ниже $x = 0,20$ измеренное отношение структурных функций выше единицы примерно на 5%.

Препринт Объединенного института ядерных исследований. Дубна 1986

Benvenuti A.C., et al.
E1-86-591

New Results on Nuclear Effects in Deep Inelastic Muon Scattering on Deuterium and Iron Target

We present new results on the ratio of structure functions $F_2(x, Q^2)$ measured in deep inelastic muon scattering on deuterium and iron targets at large Q^2. The ratio $F_2^{Fe}(x)/F_2^{D_2}(x)$ is measured in the kinematic range $0.06 \leq x \leq 0.70$, $14\ GeV^2 \leq Q^2 \leq 70\ GeV^2$ and is in good agreement with earlier measurements in the region of large $x > 0.3$. Below $x = 0.20$, the structure function ratio exhibits an enhancement of $\approx 5\%$.

Preprint of the Joint Institute for Nuclear Research. Dubna 1986