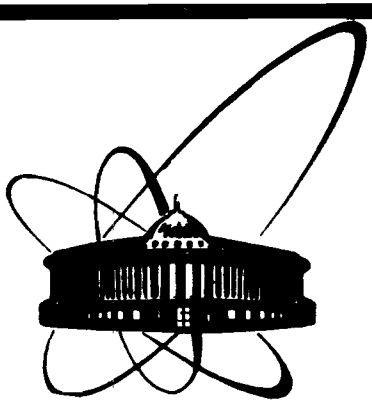

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NUCLEAR EFFECTS IN DEEP INELASTIC MUON SCATTERING ON DEUTERIUM AND IRON TARGETS

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 distribution 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 nucleus 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 linearly towards small x. On the contrary, the SLAC E139 experiment[/2/] which measured cross section ratios σ^A/σ^D for a variety of nuclei found no significant effect in the region of $x < 0.3$, independent of the target mass. An earlier SLAC experiment[/3/] at small four-momentum transfers $Q^2 \simeq 1$ 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) measured at a beam energy of 280 GeV. 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. In this letter, we report on a new experiment with deuterium and iron targets which was specially 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. 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 readout, 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 of $2 \cdot 10^7/\mu$sec average intensity. The total beam flux was $17.2 \cdot 10^{11}\,\mu$ for the "all D_2" target arrangement and $6.0 \cdot 10^{11}\,\mu$ with the iron target installed.

Due to the vertex resolution of the spectrometer, the deuterium data are strongly contaminated by iron events when both target materials are exposed to the beam simultaneously. The deuterium events from this period of data taking are therefore not included in the present analysis. For the second half of the iron data taking the deuterium targets were emptied. The inverse contamination of the iron data by events from the neighbouring D_2 target is much smaller due to the strongly different target densities. This background was determi-

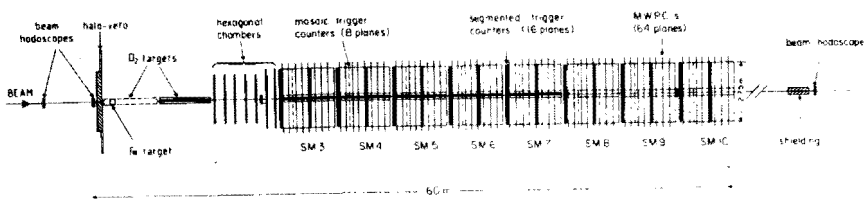

Fig.1. Schematic view of the apparatus.

ned 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 structure functions are obtained from the experimental data in a way which is very similar to the one described in ref.[4]. The experimental distributions are converted to 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 is an approximation in the region of small x, it does not affect the F_2 ratio provided that R is independent of atomic mass. The deuterium structure function is computed separately for events from internal and external targets for which the acceptance of the spectrometer is different. In the kinematical region of overlap, the structure functions are in agreement within statistical errors and were combined 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 $4.1 \cdot 10^5$ reconstructed events originating from the deuterium and $2.8 \cdot 10^5$ events from the iron 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 the energy loss in the different target materials, hadronic shower punch-through into the proportional chambers, and the reproducibility of the spectrometer magnetic field settings. The uncertainty from the spectrometer resolution is larger than our previous data because the acceptance of the apparatus 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 the vertex resolution in the Monte-Carlo simulation of the experiment. The uncertainty on the relative luminosity calibration of the Fe and D_2 data is estimated to be 1.5%.

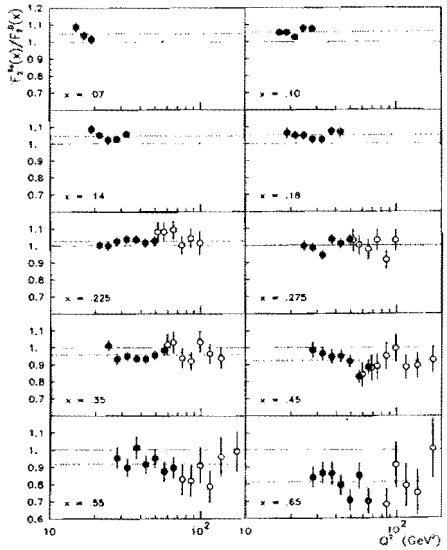

Fig.2. The structure function ratio F_2^{Fe}/F_2^{D2} in bins of x and Q^2 from this experiment at 200 GeV beam energy (closed points) and from an earlier experiment at 280 GeV[4] (open points). Only statistical errors are shown. The dotted lines indicate the average over the respective x bin.

The F_2^{Fe}/F_2^{D2} ratio is shown as a function of x and Q^2 in Fig.2 and does not exhibit a significant Q^2 dependence. It is therefore averaged over Q^2 and is shown as a function of x in Fig.3 together with our previously published data[4]. Good agreement is observed between the two measurements and the structure function ratio $F_2^{Fe}(x)/F_2^{D2}(x)$ from the combined data sets is given in the Table.

The results from this and from other charged lepton experiments are shown in Fig.4. The comparison to the EMC iron 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. Preliminary data

from the EMC collaboration on a copper target show a less pronounced effect at small x in good agreement with our result[6]. 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.

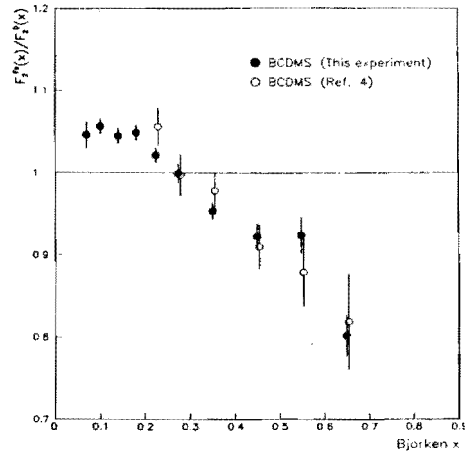

Fig.3. The structure function ratio $F_2^{Fe}(x)/F_2^{D2}(x)$ measured in this and in a previous[4] experiment. Only statistical errors are shown.

Table. Results for $R(x) = F_2^{Fe}(x)/F_2^{D2}(x)$ from this experiment and ref.[4] combined

x	Q^2 range (GeV^2)	R(x)	statist. error	syst. error
0.07	14 - 20	1.048	0.016	0.016
0.10	16 - 30	1.057	0.009	0.012
0.14	18 - 35	1.046	0.009	0.011
0.18	18 - 46	1.050	0.009	0.009
0.225	20 - 106	1.027	0.009	0.010
0.275	23 - 106	1.000	0.011	0.010
0.35	23 - 150	0.959	0.009	0.011
0.45	26 - 200	0.923	0.013	0.015
0.55	26 - 200	0.917	0.019	0.021
0.65	26 - 200	0.813	0.023	0.030

The systematic errors do not include the 1.5% uncertainty on the relative normalization of Fe and D_2 data.

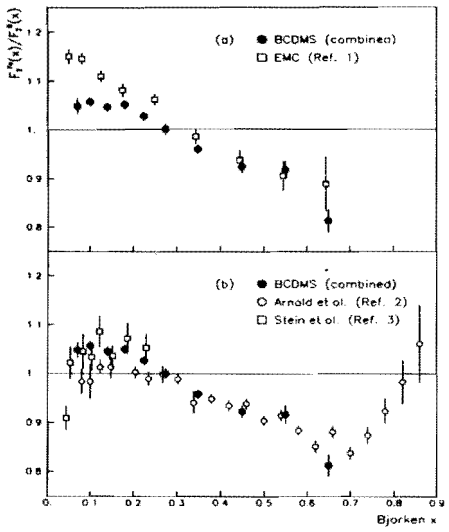

Fig.4. The structure function ratio $F_2^{Fe}(x)/F_2^{D2}(x)$ from this and from a previous measurement[4] combined, compared to other muon (a) and electron (b) scattering experiments. The data from ref.[3] were taken with a copper target. Only statistical errors are shown.

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 larger x. No Q^2 dependence of the nuclear effect is observed over the kinematic range of the experiment. In the region of $x > 0.25$, we find good agreement with all other charged lepton experiments[1,2,4,6]. For $x < 0.25$, we observe an enhancement of the structure function ratio of 4.5% ± 0.5% (stat.) ± 2.0% (syst.) where the systematic error includes the uncertainty on the relative normalization of iron and deuterium data.

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Бенвенути А.С. и др.
E1-87-99

Ядерные эффекты в глубоконеупругом рассеянии мюонов на мишенях из дейтерия и железа

Представляются новые результаты, полученные при изучении ядерных эффектов в глубоконеупругом рассеянии мюонов на мишенях из дейтерия и железа при больших Q^2. Измеренное в кинематической области $0,06 \leq x \leq 0,70$; $14\ ГэВ^2 \leq Q^2 \leq 70\ ГэВ^2$ отношение $F_2^{Fe}(x)/F_2^{D2}(x)$ при значениях $x > 0,25$ находится в хорошем согласии с более ранними измерениями. При малых x величина отношения структурных функций превышает 1 на ≈ 5%.

Препринт Объединенного института ядерных исследований. Дубна 1987

Benvenuti A.C. et al.
E1-87-99

Nuclear Effects in Deep Inelastic Muon Scattering on Deuterium and Iron Targets

New results are presented on nuclear effects in deep inelastic muon scattering on deuterium and iron targets at large Q^2. The ratio $F_2^{Fe}(x)/F_2^{D2}(x)$ measured in the kinematic range $0.06 \leq x \leq 0.70$, $14\ GeV^2 \leq Q^2 \leq 70\ GeV^2$ is in good agreement with earlier measurements in the region of $x > 0.25$. At lower x, the structure function ratio exhibits an enhancement of ≈ 5%.

Preprint of the Joint Institute for Nuclear Research. Dubna 1987