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E 133 Addendum

Addendum to E-133: Measurement of the e-D Inclusive Cross Section at Large Q^2 near x=1

Experimenters: R.Arnold, B.Chertok, B.Mecking, S.Rock, I.Schmidt, Z.Szalata, R.York and R.Zdarko

Spokesmen: S.Rock and Z.Szalata

Abstract

We request 9 days of high rate running at the end of experiment E-133 in order to measure the inclusive reaction $e + D \rightarrow e' + X$ at a momentum transfer, $Q^2 = 8\ GeV^2$ in the region $0.75 < x_D < 1$.

Introduction

Since the measurements by the present group of the deuteron reactions, $e + D \rightarrow e' + D'$ (1) and $e + D \rightarrow e' + X$ (2) have appeared, there have been a number of theoretical ideas and models advanced in order to explain the new data on the elastic and inelastic deuteron structure functions. The elastic cross section falls rapidly out to the limit-measurement at $Q^2=6\ GeV^2$, and the inelastic cross section in the vicinity of $x_D=(Q^2/2M_D\nu)=1$ or $x_p=2$ appear to approach a universal curve when combined with the data from deep inelastic scattering. This latter observation is displayed in Fig.1[(2)]; note that the measurements of νW_{2D} extends the structure function by a factor of 10^5. Schütz et al.[(2)] gave an empirical fit to the data as $(\omega'-\frac{1}{2})^6$ for the scaling region, $0.7 < \omega' < 1.1$ where $\omega' = \omega_p' = 1 + W^2/Q^2$.

Theoretical Background

The theoretical analyses have been along several paths in order to describe both the elastic and inelastic measurements as $x \rightarrow 1$.

1. The Dimensional Scaling Quark Model has been refined by including binding effects, and a parton model analysis used to derive the inclusive-exclusive connection.[(3)]

2. A Relativistic Impulse Approximation(RIA) calculation using quark counting rules has been developed which includes diagrams with scaling, non-scaling and resonance contributions.[(4)]

3. A RIA calculation has been carried out using the Gribov approach to space-time diagrams together with non-relativistic deuteron wave functions.[(5)]

4. Explicit 6 quark calculations of the deuteron and final N-N wave functions together with dimensional counting have been used to fit elastic and threshold inelastic structure functions.[6]

5. An empirical fit to the elastic form factor data used together with the elastic-inelastic connection, gave a consistent fit to the inelastic data.[7]

It is notable that many of the above calculations appear to agree with the measurements out to $Q^2=6$ GeV^2, but they seem to rapidly diverge beyond that boundary. Secondly the measurements seem to support the exclusive-inclusive connection so that the parton-model result,

$$\frac{d^2\sigma}{dQ^2 dW^2} = \frac{d\sigma_{el}}{dQ^2} \cdot \rho(W^2) \qquad (1)$$

or Bloom-Gilman duality,

$$\nu W_2 = (M_R^2 - M_D^2 + Q^2)\, G^2(Q^2)\, \delta(W^2 - M_R^2) \qquad (2)$$

describe the results as is Fig.2 [2]. That is for $M_R^2 = M_D^2$,

then, $\nu W_2 \simeq Q^2 F_D^2 \rho(W^2)$.

Thus a measurement of the inclusive cross section, $e + D \rightarrow e' + X$ at larger Q^2 would determine the elastic deuteron form factor via Eqs. 1 and 2 as in Fig. 2.

<u>Proposed Measurement</u>

We propose to measure e-D inelastic scattering at $Q^2 = 8$ GeV^2 in the region $0.75 < x_D < 1$, that is near the exclusive limit, to extend the data from $Q^2=6$ GeV^2. This would be done at the conclusion of E-133 with the same experimental setup and following beam parameters: $E_o = 21$ GeV, $\theta_e = 8^o$ and full beam intensity for approximately 6 Coulombs(8 days). This would be a factor of three improvement in sensitivity over our measurement of the same reaction in E-101 [1,2] at $Q^2 = 6$GeV^2.

The down time after E-133 would be minimal with only the 20 GeV spectrometer to be moved from 10^o to 8^o; this would not require a resurvey of that instrument. The background is estimated to be small from our previous measurements. The target background cell for E-133 has windows which are the equivalent radiator of the 30 cm.-long deuterium target(.04 r.l.). One additional day at full beam would be required to measure backgrounds from this empty cell.

Table: Estimated Event Sample

E_f(GeV)	x_D	ref.2	ref.3	ref.7
18.86	1	0	0	0
18.67	0.91	2	1	3
18.49	0.83	17	5	38
18.30	0.77	67	12	200

Notes: the parameters are: $Q^2=8$ GeV^2, $\theta_e = 8.15^o$, $E_o=21$ GeV, $n_o=6$ Coul.

The prediction of ref.4 have the same shape as ref.3 but are a factor of 2 to 3 smaller.

The approximate form given in ref.5; $\nu W_2 = 0.1(\omega'-\frac{1}{2})^{5.7}$ gives results larger than in ref.7 above but it seems to be a poor characterization of their exact result.(5)

It is clear from the Table of events that the proposed measurement can distinguish from among the theoretical predictions, phenomenological and empirical predictions.

From the viewpoint of placing bounds on the elastic form factor by this inclusive measurement at $Q^2=8$ GeV^2, the uncertainity in the result from Eqs. 1 or 2 depends on the event statistics versus x_D and the uncertainity in the function $\rho(W^2)$ from Fig.2. A determination of the elastic deuteron structure function to within a factor of 2 appears reasonable within this context.

References

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Inelastic Deuteron Structure Function

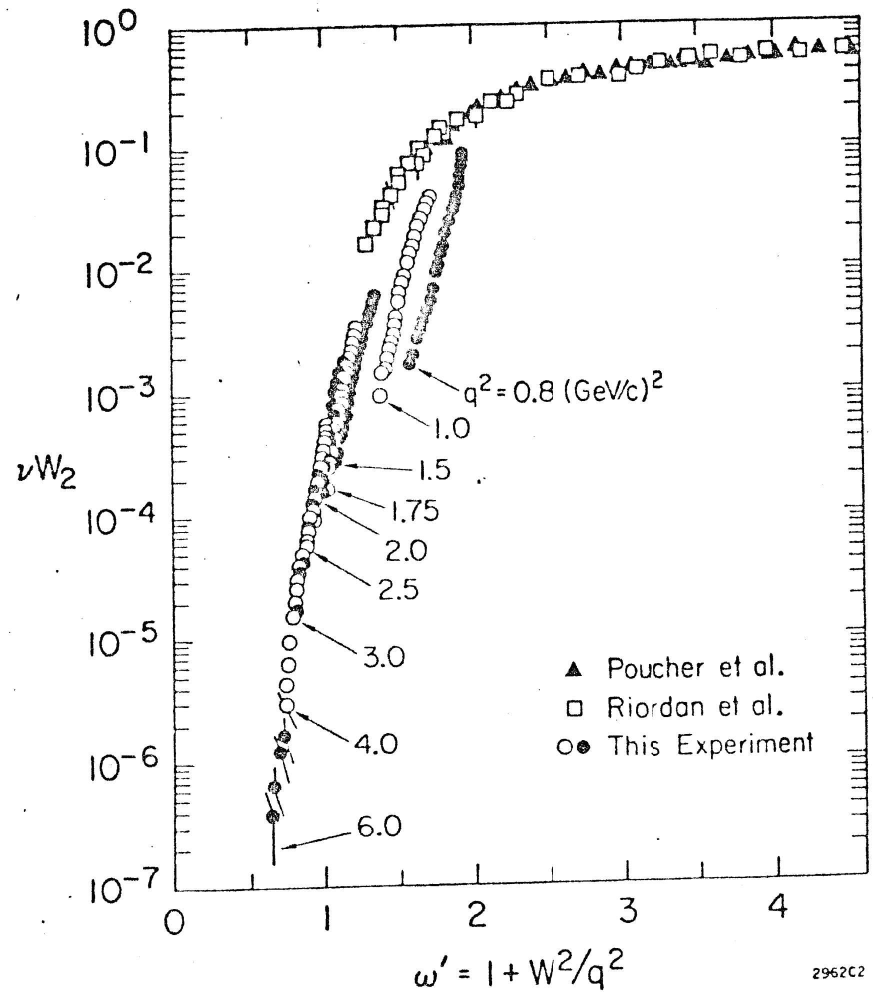

Fig. 1

from ref. 2

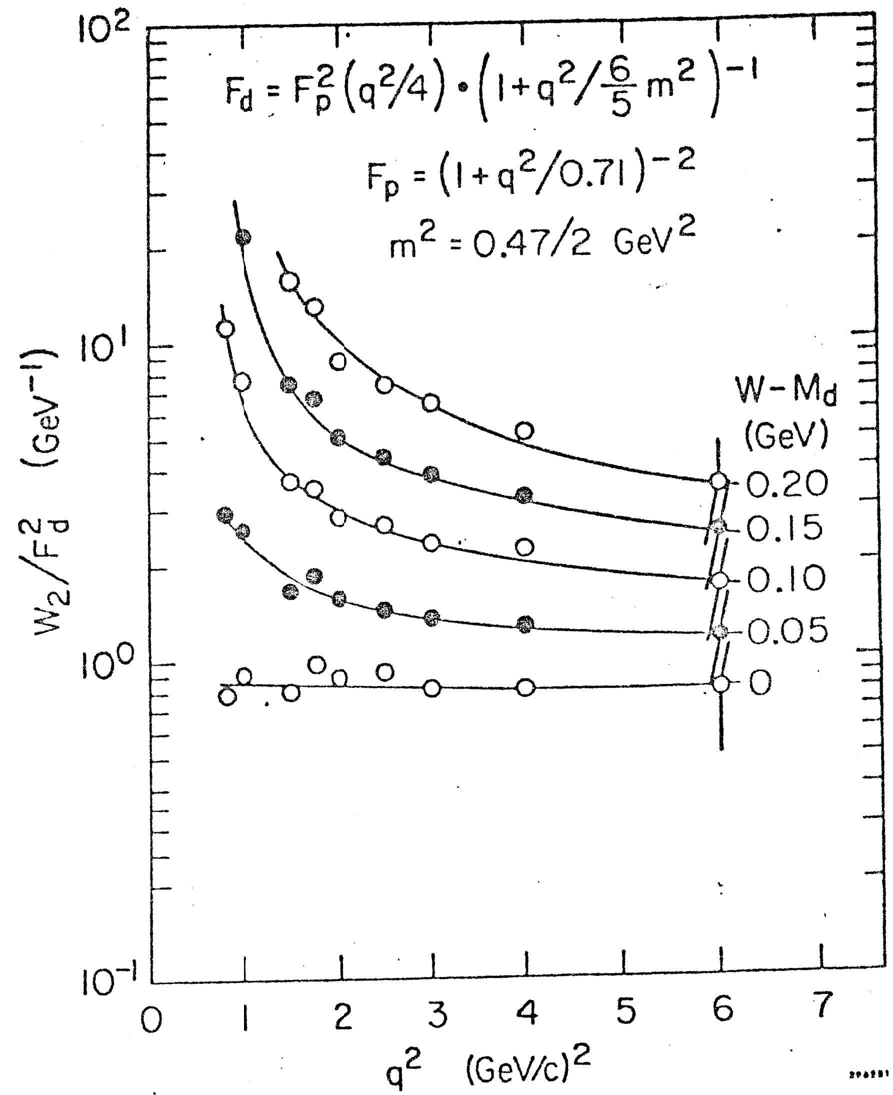

Fig. 2