Inclusive Measurements at $x > 1$ with High Energy Beams

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Abstract

Inclusive electron scattering measured in the kinematic range of Bjorken $x > 1$ and high momentum transfers can provide important information on reaction mechanisms through the study of scaling violations, and can provide insight on the transition from deep inelastic scattering from quarks to quasielastic scattering from nucleons. Some preliminary results from Jefferson Lab Experiment E89-008 will be presented as well as the increased kinematic range expected for the approved E89-008 Extension with a 6 GeV beam. The increased scope for physics studies with a 12 GeV beam and improved Hall C instrumentation are then discussed.

The response of the nucleus in the range of Bjorken $x > 1$ is expected to be composed of both deep-inelastic scattering (DIS) from quarks in the nucleus and quasi-elastic (QE) scattering from the bound nucleons. In both cases it is the non-zero momentum of the bound nucleons that permits scattering into a kinematic region that is forbidden for the free nucleon. Scattering from quarks is expected to exhibit scaling in the x variable, while scattering from the nucleons exhibits y scaling. A possible connection [1] between the two has been suggested when the nuclear structure functions are analyzed in terms of the Nachtmann scaling variable, ξ. Exploring this transition from y scaling to x scaling requires measurements at the highest possible Q^2. Preliminary data [2] for the structure function $\nu W_2/A$ vs x from Jefferson Lab E89-008, which used a 4 GeV CEBAF beam, is shown in Figure 1. No scaling is observed for $x > 1$.

In the impulse approximation (IA) the strength at large momentum transfer Q^2 and small energy transfer

ν originates from nucleons that have large momenta k before the scattering. Study of the inclusive response at low ν thus allows the study of properties of the nuclear spectral function $S(k, E)$ at large k. More data in the region of large Q^2 and moderate x would allow study of these high momentum wave function components.

Both the study of the transition fron QE to DIS scattering and the study of the high momentum components of the wave function would benefit from data in unexplored kinematic regions. A plot of the kinematic coverage in x versus Q^2 that is possible at Jefferson Lab is shown in Figure 2. The lower curve represents the kinematics of data possible with a 4 GeV CEBAF beam, then 6 GeV, 8 GeV, 10 GeV, and 12 GeV incident beam energies are shown in the higher curves. Several assumptions were made in calculating rates and range. A 6% radiation length Fe target with 80 μA of current was assumed, and a cap of 12 hours of runtime per x bin was used to give a maximum 25% error per bin. The maximum momentum is assumed to be the present limit of the Hall C HMS spectrometer which is 7.2 (GeV/c). The limiting factor that determines the left edge of this kinematic range is the large background rates at backward angles. The limiting factor on the right side is the spectrometer momentum, which limits the x range for data as Q^2 increases.

While the cross section is dropping rapidly at these kinematics, clearly a new region of data at large Q^2 and moderate x is possible even with the existing Hall C equipment and higher beam energies. An experiment [3] to measure inclusive cross sections at $x > 1$ with a 6 GeV CEBAF beam has been approved, Jefferson Lab E89-008 Extension. An increase in available beam energy from 6 GeV to 12 GeV would almost double the Q^2 range for scaling data (see Figure 3). This would greatly enhance the ability to examine scaling violations for x, y, and ξ scaling, and also allow study of the Q^2 dependence of the ratios of nuclear targets to deuterium cross sections. If a modest ($\approx$ 10%) increase in spectrometer momentum could be achieved, then the x range would be increased sufficiently to make a study of the nuclear effects very interesting. If a significant increase in spectrometer momentum were possible, such as with the Super HMS being discussed at this Workshop, then the combination of large Q^2 range and moderately high x range would make possible studies of the high momentum components of the wave function, short range correlations, and nuclear ratios to deuterium at large x.

In summary, a rich program of physics using studies of scaling violations with inclusive scattering from electrons at $x > 1$ is possible with a high energy CEBAF beam. If a modest, or large, increase in spectrometer momentum were also achieved, then the increased x range expands the physics interest to include studies of the high momentum components of the wave function and the ratios of nuclear to deuterium cross sections over the full range of the deuteron spectral function (up to $x \approx 2$).

[1] B. W. Filippone *et al.*, Phys. Rev. **C45**, 1582 (1992).

[2] J. Arrington, Ph.D. Thesis, Caltech (1998), unpublished.

[3] A. Lung, D. Day, and B. Filippone, CEBAF Approved Experiment E89-008 Extension, 1995.

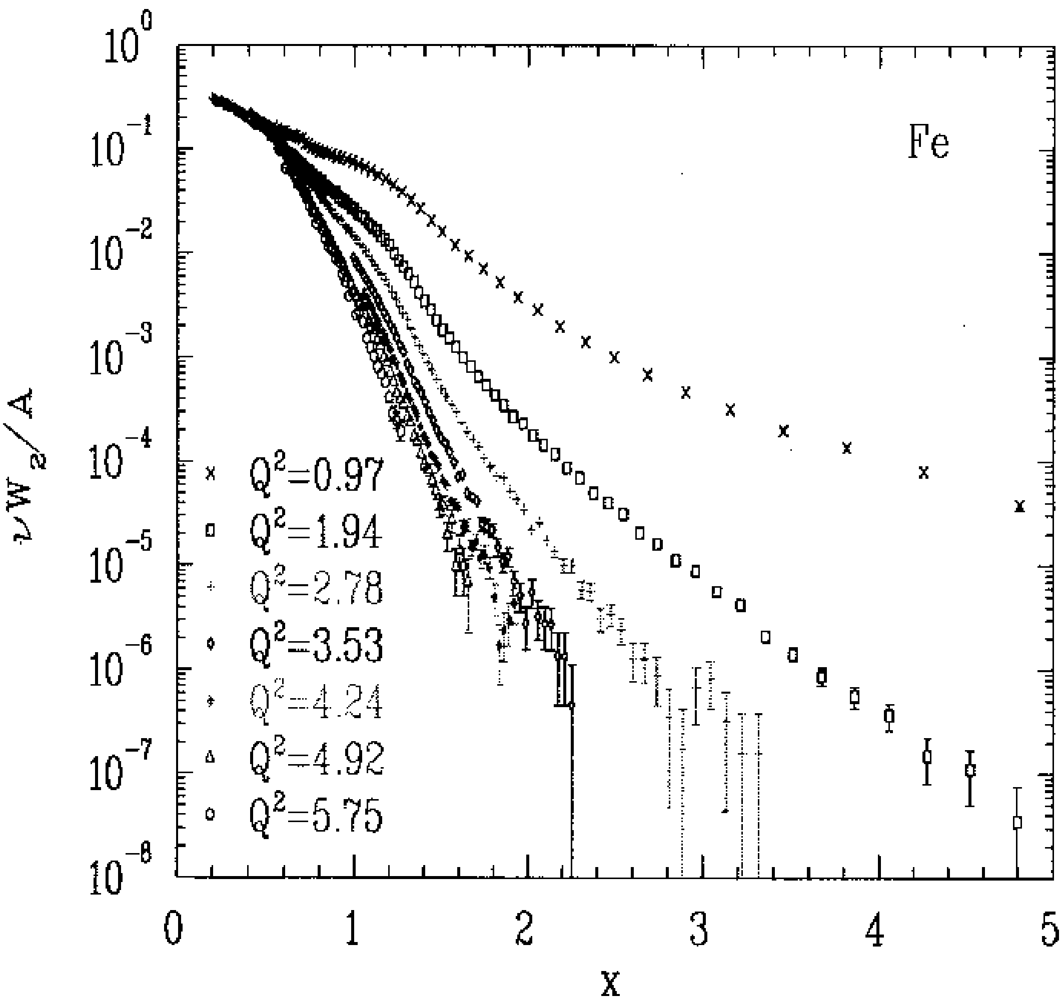

FIG. 1. Preliminary $\nu W_2/A$ vs x data for Experiment E89-008.

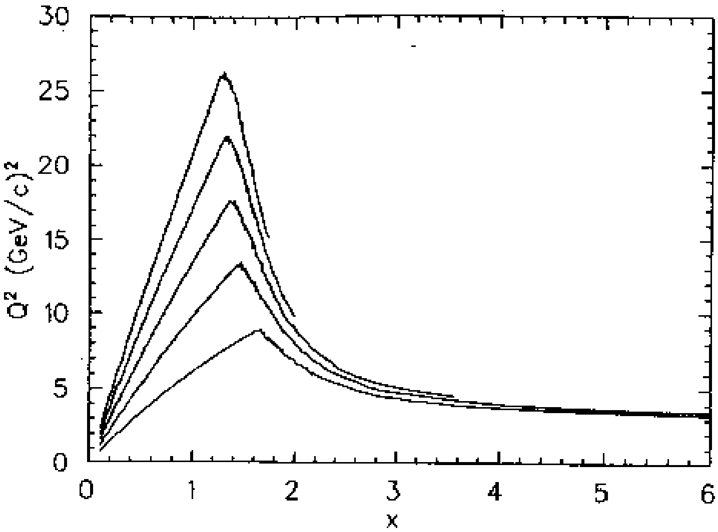

FIG. 2. Kinematic coverage x vs Q^2 for inclusive scattering from nuclear targets. Lower curve is with a 4 GeV CEBAF beam and in increasing order 6, 8, 10, and 12 GeV beam energies.

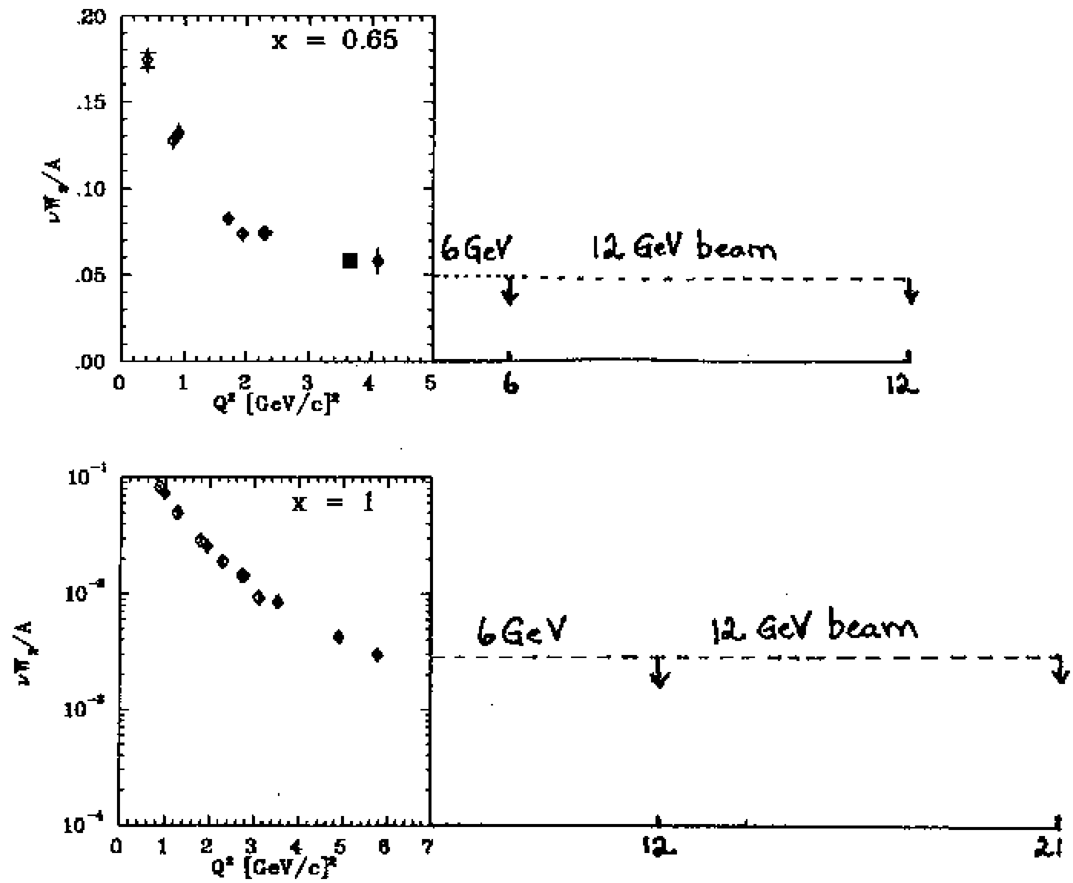

FIG. 3. Preliminary $\nu W_2/A$ vs Q^2 data for Experiment E89-008 for two bins in x. Open diamonds are SLAC NE3 data [1]. The extended Q^2 range possible with a 6 GeV and a 12 GeV CEBAF beam are indicated.