Precise Measurement of EMC Effect in Few Body Nuclei And at Large X

Jlab expt E03-103; Spokespersons: John Arrington and Dave Gaskell

For the E03-103 collaboration

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Outline

• Motivation and existing data
• Jlab experiment E03-103
• Analysis status
• Preliminary results
Measurements of $F_{2A}/F_{2D}$ have demonstrated modifications of quark distributions in nuclei.

Magnitude depends on $A$ but shape more or less same.

Several models, but valid only in certain kinematical regions.
Introduction

EMC effect

- Extensive measurements on heavy targets (SLAC, NMC, BCDMS ...)
- But poor precision at large \( x \)
- Limited world data for light nuclei

E03-103 main goals

First measurement of EMC effect on \(^3\text{He}\) for \( x > 0.4 \)

Precision data at large \( x \) for heavy nuclei
Introduction

Ratios can be parameterized as log(A) or linear density dependence.

$^{4}\text{He}/\text{D}$ is more sensitive, but uncertainty is large for existing data and consistent with both parameterizations.

Addition of $^{3}\text{He}$ data will help to determine if EMC effect depends on nucleon number (A) or average nuclear density ($\rho$).
Ran summer and fall of 2004 in HALL C of JLAB with 5.77 GeV.

Cryo targets

\[ \text{H, } ^2\text{H, } ^3\text{He, } ^4\text{He} \]

Solid targets

\[ \text{^9Be, } ^{12}\text{C, } ^{27}\text{Al, } ^{63}\text{Cu, } ^{197}\text{Au} \]

Additional data at 5 GeV on carbon and deuterium to investigate \( Q^2 \) dependence in the EMC ratios.
Elastic yield: SIMC analysis

Representative detector distributions

Cross checking the elastic yields with Hall C Monte Carlo

Yield Ratios
Analysis
Model iteration

Same cross section model for radiative corrections, bin centering and Coulomb corrections $2 < Q^2 < 10 \text{ GeV}^2$

For all $X$

**LD2 model** $\rightarrow$ E. Christy $F_{2p}$ fit + P. Bosted $F_{2n}$ fit (free n) + smearing (QE parameters from XEM data)

See N. Fomin's Talk

**Nuclear model**

\[ \text{sig\_born\_total} = \text{sig\_born\_inel} + \text{sig\_born\_qe} \]

$X < 0.8 \rightarrow F_{2D} \times \text{emc\_fit}$

$X > 0.9 \rightarrow \text{smearing}$

\[(\text{QE parameters from xem data})\]

$0.8 > X > 0.9 \rightarrow X \text{ weighted average}$
Analysis

Radiative corrections

Negligible nuclear elastic contribution, so we ignore it.
(P. Bosted Code)
Model iteration

Subset of XEM data: data to model ratio

LD2 total

He4 total

C total

Cu total
Corrections to data
Isoscalar corrections

$F_{2n}/F_{2p}$ correction large for $^3$He and heavy nuclei @ large $X$.

(at large $X$, size of the correction $\sim 15\%$)

SLAC parametrization: $1 - 0.8x$

NMC: $F_{2n} = F_{2D} - F_{2p}$

CTEQ fit: global fit @ $10 \text{GeV}^2$

SLAC fit is used for this analysis
Corrections to data
Coulomb corrections

Incoming and scattered electron kinematics are shifted and a correction factor is determined using the born model to account for the coulomb distortion effects.

\[
\text{correction factor} = \frac{\sigma_{\text{Born}}}{(F^2 \cdot \sigma_{\text{BornShifted}})}
\]

F is the focusing factor which accounts for the focusing of incoming electron wave in the nuclear center.

Corrections to data
Charge symmetric background

For heavy nuclei and at low $X$
Signal~ background

$e^+$ and $e^-$ data acquisition on HMS
Preliminary results

Scaling of $F_2$

\[ \xi \] is the Nachtmann variable and at large $Q^2$, \[ \xi \sim x \]

In nuclei, extended scaling in resonance region due to increased Fermi smearing
Preliminary results

$Q^2$ dependence in the emc ratios

At $X=0.7$, $Q^2:4-6\text{ GeV}^2$

XEM error bars are only statistical
Preliminary results
EMC ratios in $\xi$

E139 DIS region
E89008 Resonance region

Preliminary results indicate no significant $A$ dependence for the cross over at large $\xi$

XEM error bars are only statistical
Preliminary results

EMC ratios for $^4$He and C

$^4$He and C: Isoscalar nuclei
Small Coulomb distortions

No significant difference in size and shape of the effect

XEM error bars are only statistical
Preliminary results

$^3\text{He}$ EMC ratios: without isoscalar correction

Result very sensitive to isoscalar corrections

XEM error bars are only statistical
HERMES normalization 0.9%
XEM normalization 1.9%
(large temperature and pressure derivatives)
Preliminary results

$^3$He EMC ratios: with isoscalar correction

Result very sensitive to isoscalar corrections
HERMES used NMC fit
XEM: SLAC fit (1-0.8x)

XEM error bars are only statistical
HERMES normalization 0.9%
XEM normalization 1.9%
(large temperature and pressure derivatives)
Summary

- Study of the EMC effect in light nuclei will help us to distinguish between models and impose new constraints.

- E03-103 data in resonance region allows to study the large x behavior of EMC ratios. Need to look into detailed scaling studies.

- Precise measurement of $Q^2$ dependence of $F_2$ and EMC ratios.

- Systematic uncertainties and model dependency of radiative corrections and isoscalar corrections are still under investigation.
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