Investigation of the EMC effect with kinematic variables and a Monte Carlo simulation

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MARATHON Collaboration
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Motivation

- **MARATHON**
- Group of experiments in Jefferson Lab, Hall A beginning in Spring of 2017
  - Focus on $A=3$ nuclei
  - $^3$He and Tritium($^3$H)
  - Mirror Nuclei
  - EMC
    - Isospin Dependence
EMC effect

- European Muon Collaboration
- EMC effect (.3 - .7 $X_B$)

Aubert et al. 1983

Seeley et al. 2009

Carbon data
Investigation

Phenomenological investigation of the effect of target momentum on the EMC effect:

- Develop a Simulation
- Systematic and Monte Carlo
- Model Independent

- Scatter off a moving proton
- Change the initial conditions
- Change the initial direction of the proton
- Change the scattered angle of the electron

- Complete a set of Lorentz Transformation to allow for a systematic scattering process
Transformation

1. **Initial vectors**
   - Rotate & Boost into rest frame

2. **Boosted vectors**
   - Rotate & prepare for scattering

3. **Boosted and Rotated**
   - Rotate & Boost into lab frame

4. **After Scattering**
   - Rotate & Boost into lab frame

5. **Boosted back**
   - Rotate & calculate Final variables

6. **Final vectors**
   - Rotate & calculate Final variables
Elastic scattering Results

- Effect of giving the proton an initial momentum?
- $P_i = 0 \text{ GeV/c}$
Elastic scattering Results

- Effect of giving the proton an initial momentum?

- $P_i = 0.25 \text{ GeV/c}$
  - Fermi Level
  - $X_B$ 0.7 and 1.3
Elastic scattering Results

- Effect of giving the proton an initial momentum?
  - $P_i = 0.5 \text{ GeV/c}$
- Anti-Collider
- Collider
Apply a Momentum distribution to our target proton

- Model the distributions after av18 results
- Base distribution
  - Modeled from $^2\text{H}$
- High momentum tails have the same functional form.
- Scale the high momentum tail of the sequential distributions

PHYSICAL REVIEW C 87, 034603 (2013)
M. Alvioli, C. Ciofi degli Atti, and et al.
Apply a Momentum distribution to our target proton

Momentum distributions

P(K), Probability of receiving k.

High Momentum Tail

Scale up

Normalize

--- $^2\text{H}$
Inelastic scattering Results

Counts in bins of Xb.

Ratio of the scaled by 2 run and the base run
Inelastic scattering Results

Counts in bins of $X_b$.

Ratio of the scaled by 4 run and the base run.
Inelastic scattering Results

Counts in bins of Xb.

Scaled by 8
Base Run

Ratio of the scaled by 8 run and the base run

*8/Base

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Conclusion and Future work

- Counts in $X_B$ - Significant changes in counts at different levels of momentum.
- Momentum greater than 250 MeV/c plays an important role in the EMC effect.
- Ratio of counts in $X_B$ show downward trend similar to the EMC effect

Future work:
- Weight results with cross section data
- Scientifically advance the systematic scattering method
- Include more rigorous Monte Carlo techniques
Thank you!

• Special Thanks
  – Doug Higinbotham
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  – Tritium Group at JLab
  – University of Tennessee
Back Up Slides

Transformation

- Electron scattering off a moving proton.

- Incident proton has some angle lambda in the lab frame with the electron beam axis.

- In order to simplify the scattering, three transformations are made: rotation, Lorentz boost, and another rotation.
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- Electron scattering off a moving proton.

- Incident proton has some angle lambda in the lab frame with the electron beam axis.

- In order to simplify the scattering, three transformations are made: rotation, Lorentz boost, and another rotation by delta.
Transformation

- After a simple elastic scattering calculation, three more transformation are used to get the correct lab frame kinematics
  - Rotation by delta
  - Lorentz boost
  - Rotation by lambda
Transformation

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  - Lorentz boost
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  - **Lorentz boost**
  - Rotation by lambda
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  - **Rotation by lambda**