C. CIOFI degli ATTI

TAGGING the EMC EFFECT and HADRONIZATION MECHANISMS by SEMI-INCLUSIVE DIS with DETECTION of SLOW RECOILING NUCLEI

International Workshop
"In-Medium Effects in Hadronic and Partonic Systems"
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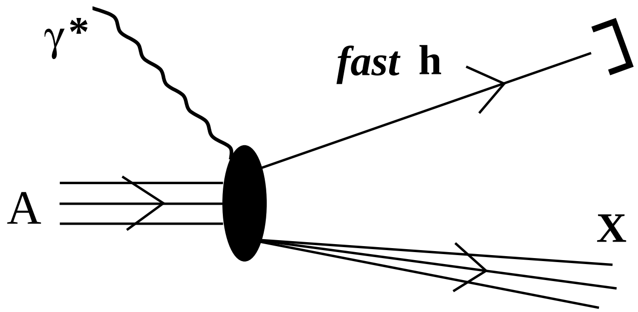
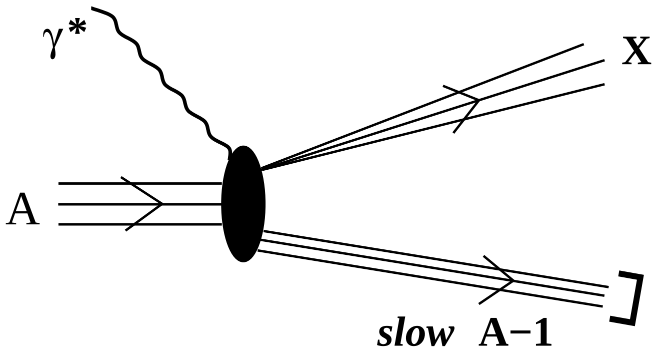
PHYSICS DEPARTMENT

ABSTRACT

In spite of many experimental and theoretical efforts, the origin of the nuclear EMC effect appearing in INCLUSIVE Deep Inelastic Scattering (IDIS) of leptons off nuclei, has not yet been fully clarified, and the problem as to whether and to what extent the quark distributions of nucleons undergo deformations due to the nuclear medium remains open. At the same time, various aspects of in-medium hadronization, necessitate further investigation. It will be shown that in SEMI-INCLUSIVE DIS (SIDIS) of electrons off a complex nucleus A, the detection, in coincidence with the scattered electron, of a nucleus $(A-1)$ in the ground state, may provide new information on: $i)$ the medium induced modifications of the nucleon structure function and the origin of the EMC effect, and $ii)$ the mechanism of quark hadronization in the nuclear medium.

"CLASSICAL" and "NEW" SIDIS





In the "classical" SIDIS (left) off nuclei $A(e,e'h)X$ (HERA, Jlab) a high energy ("fast") hadron arising from quark hadronization ("current fragmentation ") is detected

The new SIDIS processes (right) $A(e,e'(A-1))X$: e' and $(A-1)$ are detected The process is assumed to occur via the so called "spectator mechanism" $(A = 2\ F\&S)$

Eur. Phys. J. A 5, 191–207 (1999)

THE EUROPEAN PHYSICAL JOURNAL A

Semi-inclusive deep inelastic lepton scattering off complex nuclei

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Abstract. It is shown that in semi-inclusive deep inelastic scattering (DIS) of electrons off complex nuclei, the detection, in coincidence with the scattered electron, of a nucleus $(A-1)$ in the ground state, as well

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THE EUROPEAN PHYSICAL JOURNAL A

Final-state interaction in semi-inclusive DIS off nuclei

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Letter of Intent
to the
Jefferson Laboratory Program Advisory Committee

Measurement of Complete Final States in Deep Inelastic Scattering from Light Nuclei to Study the EMC Effect

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December 14, 2009

Nuclear Exclusive and Semi-inclusive Physics with a New CLAS12 Low Energy Recoil Detector

JLab Letter of Intent to PAC35 — *14 December 2009*

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Semi-inclusive Deep Inelastic Scattering from Light Nuclei by Tagging Low Momentum Spectators

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(Dated: November 24, 2010)

TWO EXPECTED ADVANTAGES

- By detecting $(A-1)$ in different energy states, DIS on nucleons bound with different energies could be investigated..

- The new SIDIS process can provide further insight into the space-time development of hadronization. The classical DIS provides relevant information on hadronization, but in a complicated way, since cascading inside the nuclear medium essentially modifies the observables. Measuring the recoil nucleus one get rid of cascading and the survival probability of the recoil nucleus should be sensitive to the multiparticle components of the jet .

OUTLINE

1. The cross sections of the SIDIS processes $A(e, e'(A-1))X$.
2. The debris-nucleon effective cross section and Final State Interaction (FSI).
3. Plane Wave Impulse Approximation vs. FSI.
4. Tagging the spectator mechanism and the EMC effects.
5. Tagging the hadronization mechanisms.
6. Check of the FSI model:comparison with experimental data on the process $^2H(e, e'p)X$.
7. Experimental perspectives.
8. Conclusions.

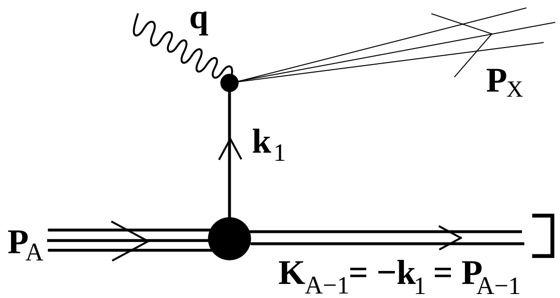
Thanks to:

Leonid Kaptari, Boris Kopeliovich, Chiara Benedetta Mezzetti, Hiko Morita, Veronica Palli

1. THE CROSS SECTIONS of the PROCESS $A(e, e'(A-1))X$ WITHIN the SPECTATOR MECHANISM

(CdA, Scopetta, Kaptari, Eur. Phys.J. A5 (1999) 191 (CKS).)

1.2.1 A(e,e'(A-1))X - PWIA



$$\left(\frac{d\sigma^A}{dx_{Bj}dQ^2d\boldsymbol{P}_{A-1}}\right)^{PWIA} = K(x_{Bj}, y, Q^2) z_1^{(A)} F_2^{N/A}(x^A, k_1^2)\, n_0^A(|\boldsymbol{P}_{A-1}|),$$

$$y = \frac{\nu}{E_e}\ , \quad z_1^{(A)} = \frac{k_1 \cdot q}{m_N \nu}\ , \quad x_{Bj} = \frac{Q^2}{2m_N\nu}\ , \quad x^A = \frac{x_{Bj}}{z_1^{(A)}}$$

$F_2^{N/A}(x^A, k_1^2)$ - off-shell (via x^A and k_1^2) DIS structure function of bound nucleons

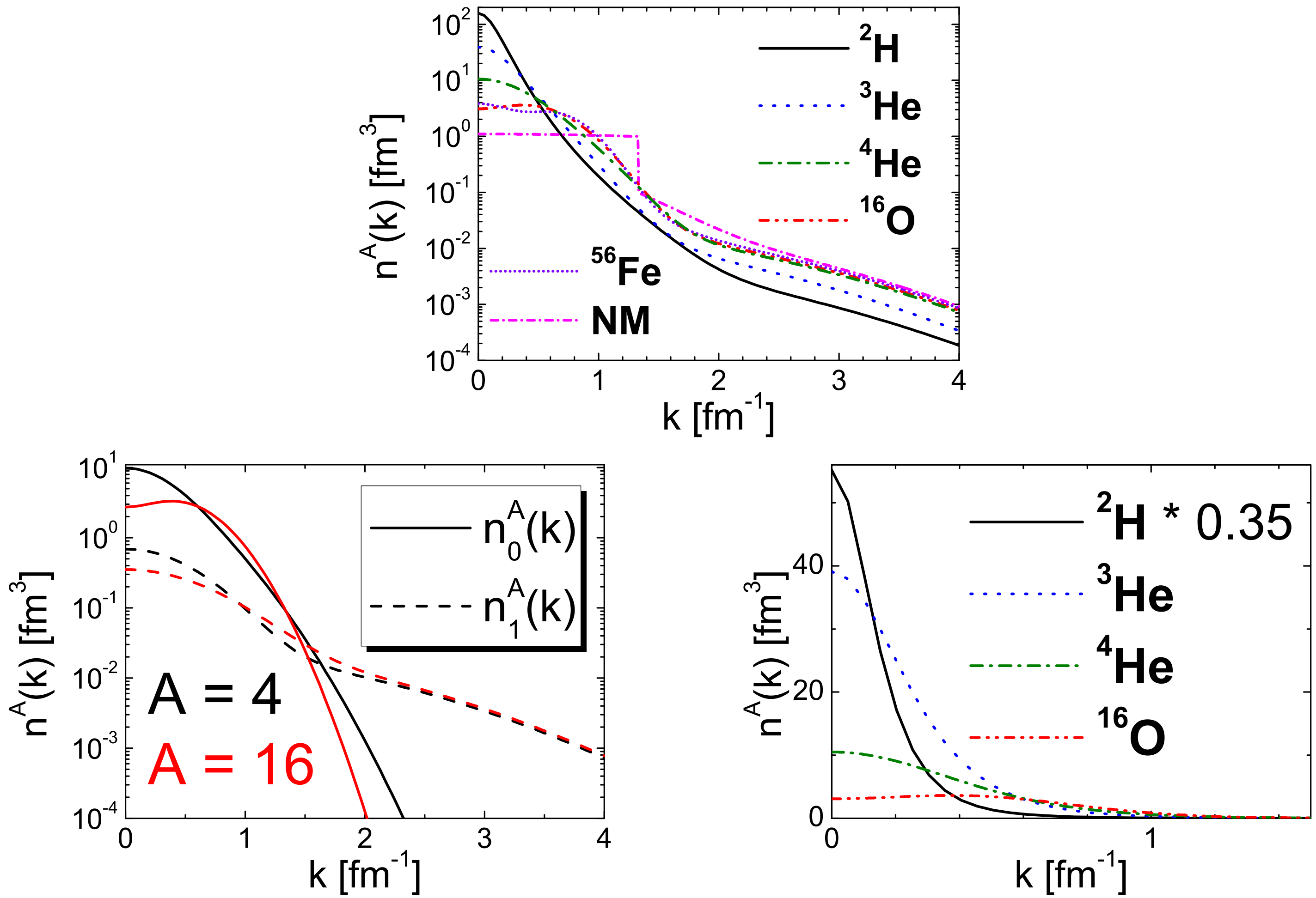
$$n_0^A(|\mathbf{P}_{A-1}|) \propto \left| \int d\mathbf{r} \exp(-i\mathbf{P}_{A-1}\mathbf{r}) \langle \Psi^0_{A-1}(\mathbf{r}_2 \dots \mathbf{r}_A) | \Psi^0_A(\mathbf{r}, \mathbf{r}_2 \dots \mathbf{r}_A) \rangle \right|^2$$

Ground-state momentum distributions ($\Psi^0_A \rightarrow \Psi^0_{A-1}$)

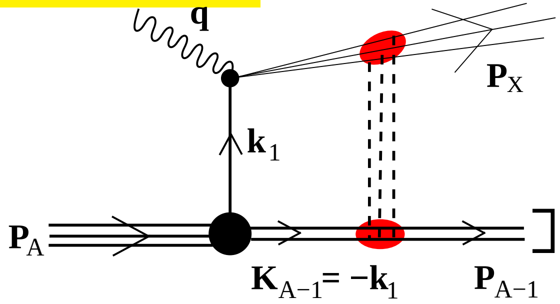
??Main features of the X-section??

1.2.2 ABOUT the NUCLEON MOMENTUM DISTRIBUTIONS

$$n^A(k) = \int e^{-i\mathbf{k}\cdot(\mathbf{r}_1-\mathbf{r}_1')}\rho(\mathbf{r}_1,\mathbf{r}_1')d^3\,r_1 d^3\,r_1' = \sum_{f=0}^{\infty}\left|\int e^{-i\mathbf{k}\cdot\mathbf{r}_1}\,d^3r_1 \int \Psi_{A-1}^{f\,*}(\tau)\Psi_A^0(\mathbf{r}_1,\tau)d\tau\right|^2$$



1.2.3 FINAL STATE INTERACTION



$$\left(\frac{d\sigma^A}{dx_{Bj}dQ^2 d\boldsymbol{P}_{A-1}}\right)^{FSI} = K^N(x_{Bj}, y, Q^2) z_1^{(A)} F_2^{N/A}(x^A, k_1^2)\, n_0^{A,FSI}(\boldsymbol{P}_{A-1}),$$

$n_0^{A,FSI}(\boldsymbol{P}_{A-1})$ - The angular dependent distorted momentum distribution of the bound nucleon.

$$n_0^{A,FSI}(\mathbf{P}_{A-1}) \propto \left| \int d\mathbf{r} \exp(-i\mathbf{P}_{A-1}\mathbf{r}) \langle \Psi_{A-1}(\mathbf{r}_2 \ldots \mathbf{r}_A) \prod_{i=2}^{A} S_{FSI}^{XN}(\mathbf{r} - \mathbf{r}_i, \mathbf{q}) | \Psi_A(\mathbf{r}, \mathbf{r}_2 \ldots \mathbf{r}_A) \rangle \right|^2$$

S_{FSI}^{XN}- The debris-nucleon eikonal scattering amplitude

$$S_{FSI}^{XN}(\mathbf{r}_{1i}, \mathbf{q}) = 1 - \theta(z_{i1})\, \Gamma^{XN}(\mathbf{b}_{1,i}, z_{1,i}) \qquad \Gamma^{XN}(\mathbf{b}_{1i}, z_{1i}) = \frac{(1 - i\,\alpha)\ \sigma_{eff}(z, x_{Bj}, Q^2)}{2\,\pi\, B} \exp\left[-\frac{\mathbf{b}_{1i}^2}{2\,B}\right]$$

!!!Direct access to $F_2^{N/A}$ and to the debris-Nucleon (XN) interaction i.e on hadronization via the effects generateted by $\sigma_{eff}(z, x_{Bj}, Q^2) \equiv \sigma_{eff}$!!!

The FSI in the SIDIS process $A(e, e'(A-1))X$ is the reinteraction of the hadronizing quark and diquark X(the debris) with the nucleons of the spectator nucleus $(A-1)$. According to CdA, Kopeliovich, Eur. Phys.J. A17 (2003) 133) such a FSI can be described by the increasing with time (or with distance from the $\gamma^* - q$ interaction point) of mesons created by the color string breaking and by gluon bremsstrahlung. It has the form.

$$\sigma_{eff}^{XN}(z, x_{Bj}, Q^2) = \sigma_{tot}^{NN} + \sigma_{tot}^{\pi N}\left[n_M(z) + n_G(z, x_{Bj}, Q^2) \right] \equiv \sigma_{eff}(z)$$

where $n_M(z)$ and $n_G(z, x_{Bj}, Q^2)$ are the time-dependent multiplicities of mesons due to the string breaking and gluon radiation, respectively.

2. THE DEBRIS-NUCLEON CROSS SECTION

(CdA, B. Z. KOPELIOVICH, Eur. Phys.J. A5 (1999) 191)

The TIME-DEPENDENT Debris-Nucleon CROSS SECTION

Obtained from the hadronization model by :

B. Kopeliovich, J. Nemchik, E. Predazzi, A. Hayashigaki, Nucl.Phys. A740(2004)212

The hadronization model:

the formation of the final hadrons occurs during and after the propagation of the created nucleon debris through the nucleus, with a sequence of soft and hard production processes.

soft production $\rightarrow Q < \lambda = 0.65\ GeV$ npQCD, string model
hard production $\rightarrow Q > \lambda = 0.65\ GeV$ pQCD, gluon radiation model .

String decay:

- probability $W(t)$ for a string to create no quark pairs since its origin;
- time dependent length of the string $L(t)$, with $L_{max} = \frac{m_{qq}}{\kappa}$ with m_{qq}-mass of the "diquark" and $\kappa \simeq 1\,GeV\,fm^{-1}$ - the string tension;
- first breaking of the string (**S**) (within $\Delta t \simeq 1\,fm$) into a shorter string and a baryon (B);
- the creation of mesons (M) occurs as follows

$$\mathbf{S} \Rightarrow \mathrm{B} + \mathbf{S} \Rightarrow \mathrm{B} + \mathbf{S} + \mathrm{M} \Rightarrow \mathrm{B} + \mathbf{S} + \mathbf{2}\,\mathrm{M} + \ldots$$

The mean multiplicity of Mesons due to string decay:

$$\mathbf{n_M(t)} = \ln(\mathbf{1} + \mathbf{t}/\boldsymbol{\Delta}\mathbf{t})/\ln\mathbf{2}$$

Gluon radiation mechanism

- mean number of radiated gluons

$$n_G(t) = \int_{\lambda^2}^{Q^2} dk_T^2 \int_{k_T/E_q}^{1} d\alpha \, \frac{dn_G}{dk_T^2\, d\alpha} \Theta(t - t_c) \ ,$$

with

$$\frac{dn_G}{d\alpha\, dk_T^2} = \frac{4\alpha_s(k_T^2)}{3\,\pi} \frac{1}{\alpha\, k_T^2} \qquad t_c = \frac{2\, E_q\, \alpha\, (1-\alpha)}{k_T^2}$$

- Time dependence of the gluon radiation controlled by the parameter $\mathbf{t_0 = (m_N\, x_{Bj})^{-1} = 0.2\, fm/x_{Bj}}$

- Integration yields

- $t < t_0$

$$n_G(t) = \frac{16}{27}\left\{\ln\left(\frac{Q}{\lambda}\right) + \ln\left(\frac{t\,\Lambda_{QCD}}{2}\right)\,\ln\left[\frac{\ln(Q/\Lambda_{QCD})}{\ln(\lambda/\Lambda_{QCD}}\right]\right\}$$

- $t > t_0$

$$n_G(t) = \frac{16}{27}\left\{\ln\left(\frac{Q}{\lambda}\frac{t_0}{t}\right) + \ln\left(\frac{t\,\Lambda_{QCD}}{2}\right)\,\ln\left[\frac{\ln(Q/\Lambda_{QCD}\sqrt{t_0/t})}{\ln(\lambda/\Lambda_{QCD})}\right]\right.$$
$$\left. + \ln\left(\frac{Q^2\,t_0}{2\,\Lambda_{QCD}}\right)\,\ln\left[\frac{\ln(Q/\Lambda_{QCD})}{\ln(Q/\Lambda_{QCD}\,\sqrt{t_0/t})}\right]\right\}$$

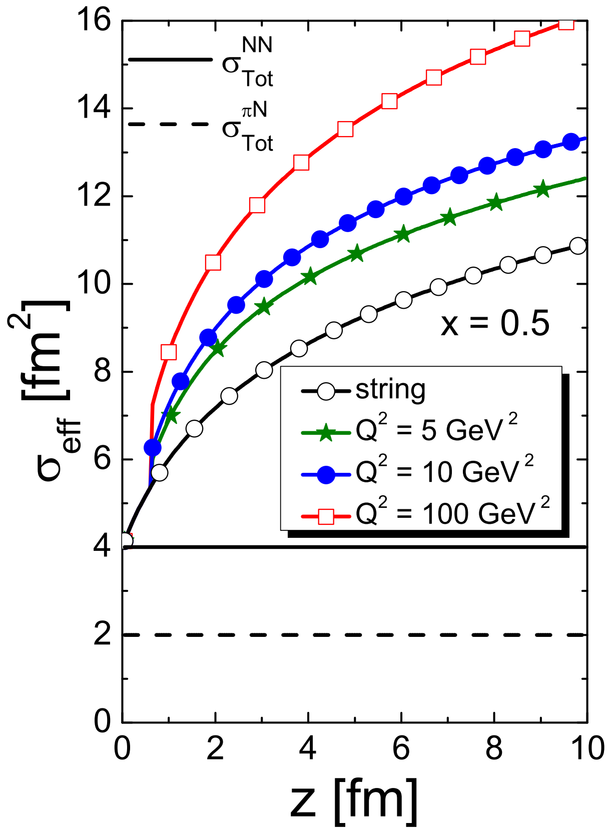
- **saturation at** $t > t_0\,Q^2/\lambda^2$.

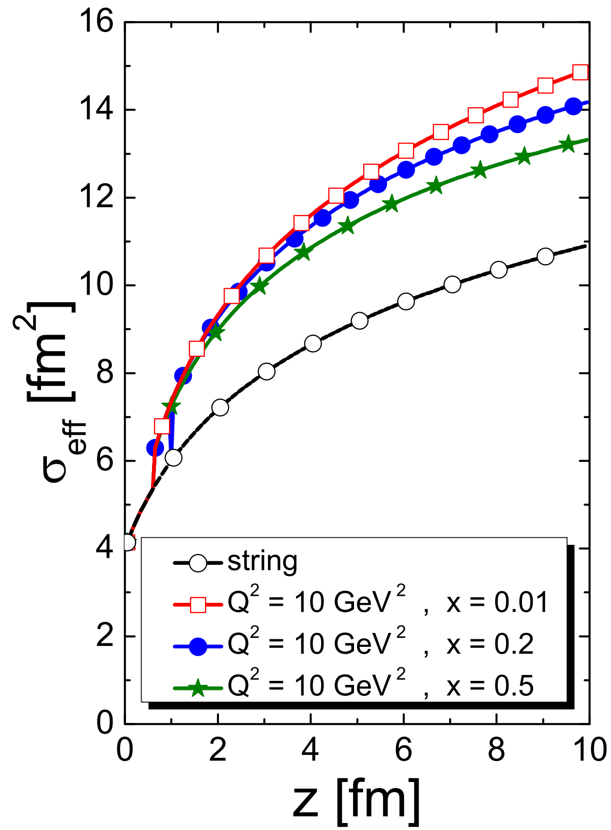
BASIC ASSUMPTIONS

- Mesons from string breaking are pions
- Each radiated gluon is replaced by a colorless $q\bar{q}$ dipole which is assumed is treated as a meson

The debris-nucleon effective cross section

$$\sigma_{eff}(z, x_{Bj}, Q^2,) \equiv \sigma_{eff}(z) = \sigma_{tot}^{NN} + \sigma_{tot}^{\pi N}\left[n_M(z) + n_G(z)\right]$$





Large Q^2 dependence

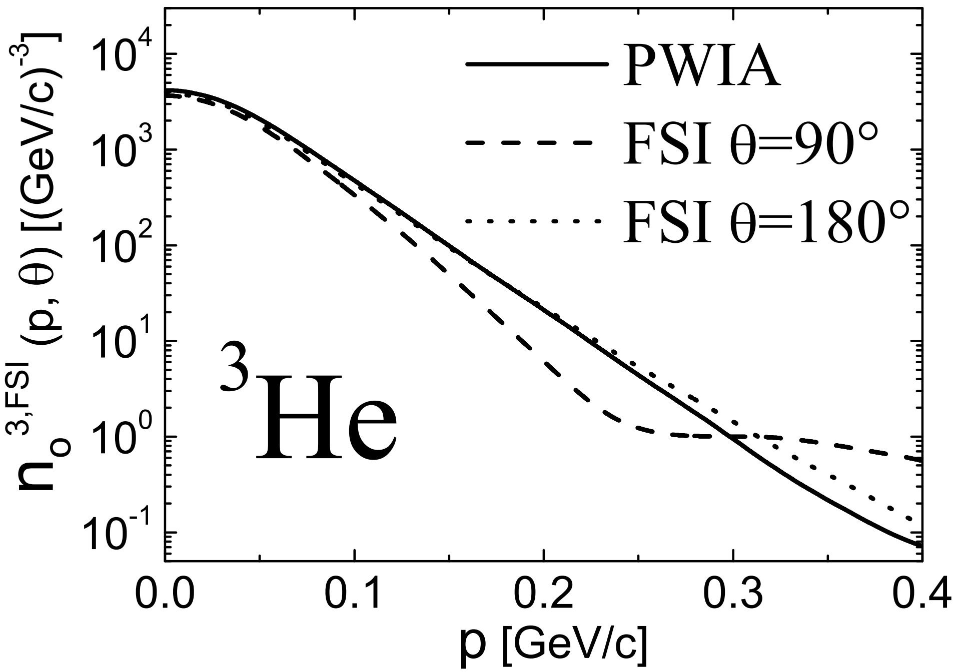
Small x_{Bj} dependence

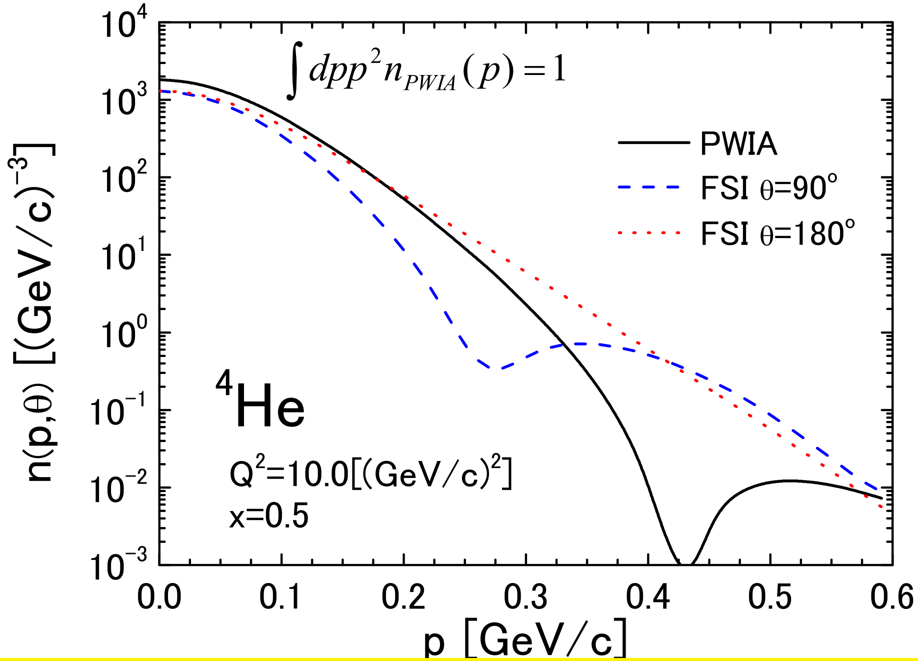
3. PLANE WAVE IMPULSE APPROXIMATION vs. FINAL STATE INTERACTION

(Calculations performed with status of art nuclear wave functions: Faddeev or variational calculations with Argonne V18 interaction)

The processes $^3He(e,e'D)X$ and $^4He(e,e'^3He)X$

(CDA, Kaptari, C. B. Mezzetti, H. Morita, Phys. Rev., in press .)





- low momentum and $\theta = 180^0$: FSI small → check the spectator mechanism and the EMC effect.
- "high" momenta and $\theta = 90^0$: Dominance of FSI → check FSI and hadronization

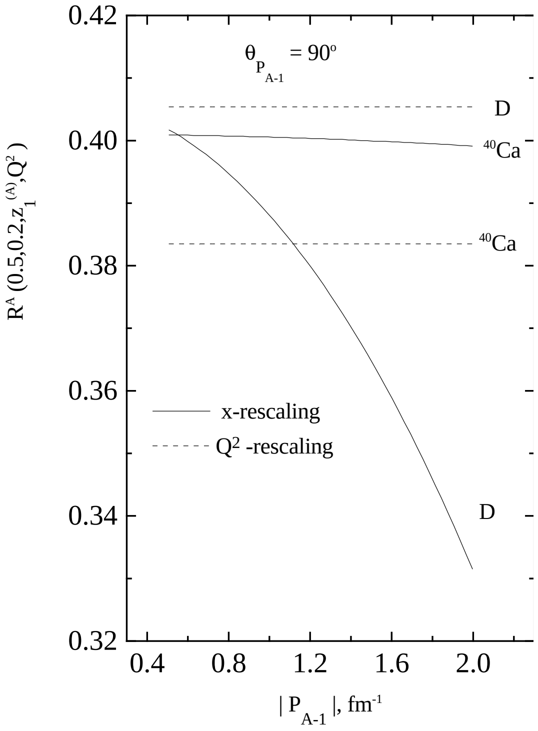
4. TAGGING the SPECTATOR MECHANISM and the EMC EFFECT by the NEW SIDIS PROCESS

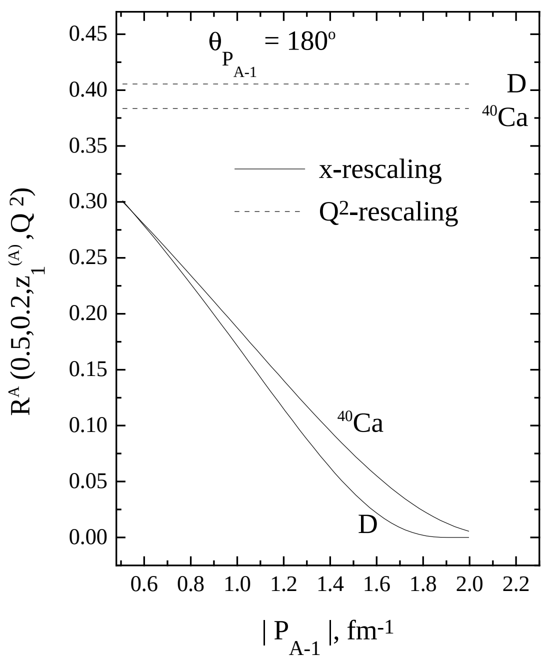
4.1 The in-medium structure function $F_2^{N/A}(x^A, k_1^2)$

$$\sigma_1^A(x_{Bj}, Q^2, \boldsymbol{P}_{A-1}) \equiv d\sigma^A/dx_{Bj}dQ^2d\boldsymbol{P}_{A-1}$$

Measure $\sigma_1^A(x_{Bj}, Q^2, \boldsymbol{P}_{A-1})$ on nucleus A at two different values of x_{Bj}

$$R^A(x_{Bj}, x'_{Bj}, \boldsymbol{P}_{A-1}, Q^2) = \frac{\sigma_1^A(x_{Bj}, Q^2, \boldsymbol{P}_{A-1})}{\sigma_1^A(x'_{Bj}, Q^2, \boldsymbol{P}_{A-1})} = \frac{x'_{Bj}}{x_{Bj}} \frac{F_2^{N/A}(x^A, k_1^2)}{F_2^{N/A}((x^A)', k_1^2)}$$





Two different $F_2^{N/A}(x^A, Q^2)$:

x-rescaling (off-shell nucleon):

$x^A = \frac{x_{Bj}}{z_1^A}$

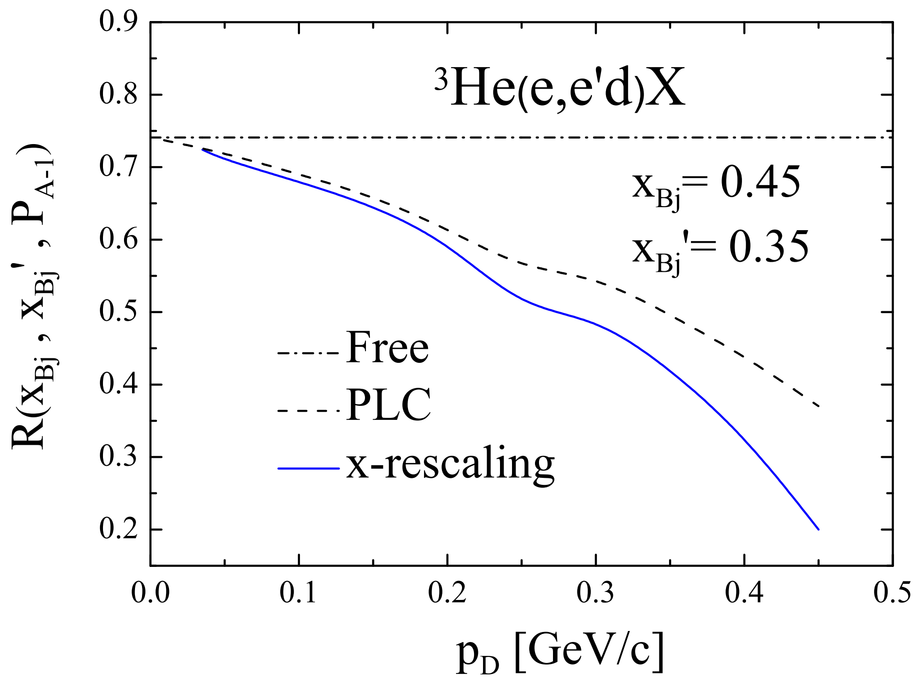
$z_1^A = [p_0 - p_3]/m_N \simeq$

$1 - \frac{E_{min}}{m_N} - \frac{\mathbf{P}_{A-1}^2}{2m_N^2(A-1)} + \frac{|\mathbf{P}_{A-1}|}{m_N} cos\theta_{\widehat{\mathbf{P}_{A-1}\mathbf{q}}}$

Q^2-rescaling (on shell nucleon):

$x_A = x_{Bj} \qquad Q^2 = Q^2\xi_A(Q^2)$

Calculation with three different structure functions of the proton



- **Free**: $F_2^{N/A}\left(x^A\right) = F_2^{N/A}\left(x_{Bj}\right)$

- **Off-shell(x-rescaling)**: $F_2^{N/A}\left(x^A\right) = F_2^{N/A}\left(\frac{x_{Bj}}{z_1^A}\right)$

  $z_1^A = [p_0^{off} - \mathbf{p}_3]/m_N$
  $p_0^{off} = M_A - \sqrt{(M_{A-1}^*)^2 + \mathbf{p}^2}$

- **Reduction of point-like configurations (PLC)**:

  $F_2^{N/A}\left(x_{Bj}^{(A)}\right) = F_2^{N/A}\left(x_{Bj}/z_1\right) \cdot \delta_A(x_{Bj}, V(\mathbf{p}, E))$
  $z_1^N = [p_0^{on} - \mathbf{p}_3]/m_N,\ p_0^{on} = \sqrt{(m_N)^2 + (\mathbf{p}_D)^2}$

  $V(\mathbf{p}, E))$= **nucleon virtuality**=

  $= \left(M_A - \sqrt{(M_{A-1}^*)^2 + P_{A-1}^2)}\right)^2 - P_{A-1}^2 - m_N^2$

  .

  CdA, Frankfurt, Kaptari, Strikman, Phys. Rev.C 76, 055206 (2007)

4.2 The local EMC effect

PHYSICAL REVIEW C VOLUME 41, NUMBER 4 APRI

Dependence of the European Muon Collaboration effect on nuclear structure

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(Received 4 December 1989)

We investigate a dependence of the "old" European Muon Collaboration (EMC) effect on nuclear structure, namely the dependence on the location of the struck quark within a nucleus ("local" EMC effect). The EMC effect is examined by the rescaling model and also by the nuclear binding model. We find that they give similar results in the sense that scattering from a central or deeply bound constituent gives a larger EMC effect than scattering from a surface or weakly bound constituent. If accurate experimental data become available, these interesting effects could be investigated in detail.

Nuclear Physics A532 (1991) 235c–240c
North-Holland, Amsterdam

NUCLEAR PHYSICS A

ON THE INTERPRETATION OF SEMI-INCLUSIVE NEUTRINO NUCLEUS SCATTERING

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ABSTRACT. The effects of nucleon-nucleon correlations as a possible mechanism to explain recent experimental results on semi-inclusive deep inelastic scattering of neutrinos off nuclei are investigated. Events with slowly moving nucleons (dark tracks) produced in the primary neutrino-nucleus interaction are associated to the recoiling nucleon of a correlated pair, whereas events without dark tracks are ascribed to configurations in which the final nuclear system recoils coherently. The direct production of slow protons by diquark fragmentation, as a further source of dark tracks, is also analyzed.

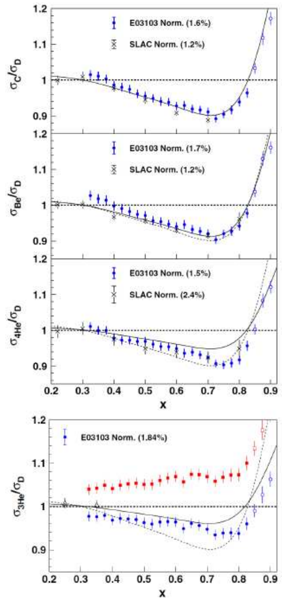
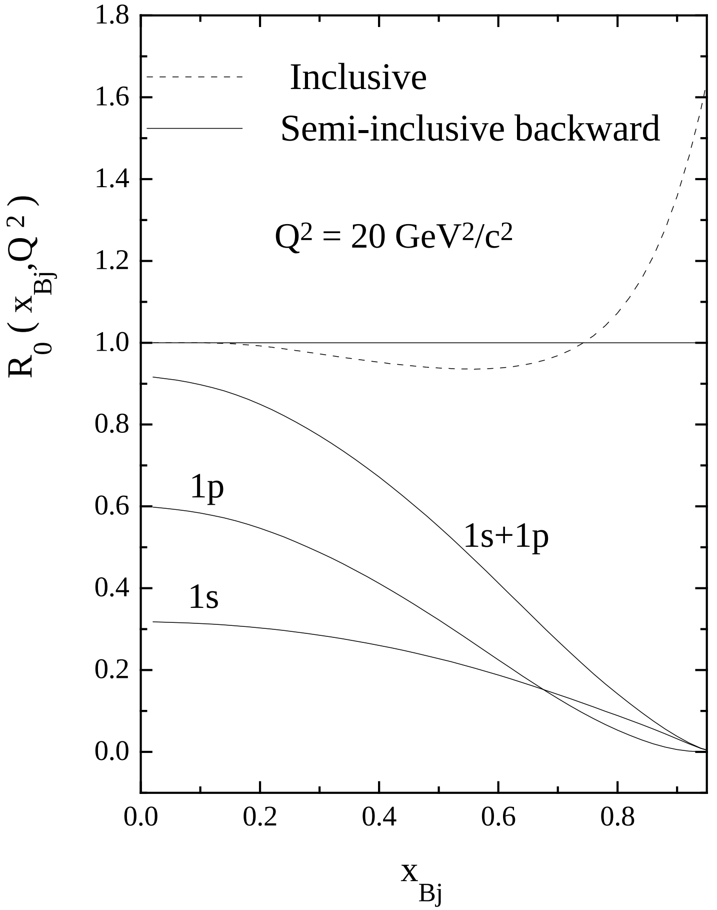


FIG. 1. EMC ratio for ^{12}C, ^{9}Be and ^{4}He compared to SLAC [2]. The solid curve is the A-dependent fit to the SLAC data, while the dashed curve is the fit to ^{12}C. For the ^{3}He ratio, the upper squares are the raw $^{3}He/^{2}H$ ratios, while the bottom circles show the isoscalar EMC ratio. The triangles are the HERMES results [13] which use a different isoscalar correction. The solid (dashed) curves are the SLAC A-dependent fits to carbon and ^{3}He [12].

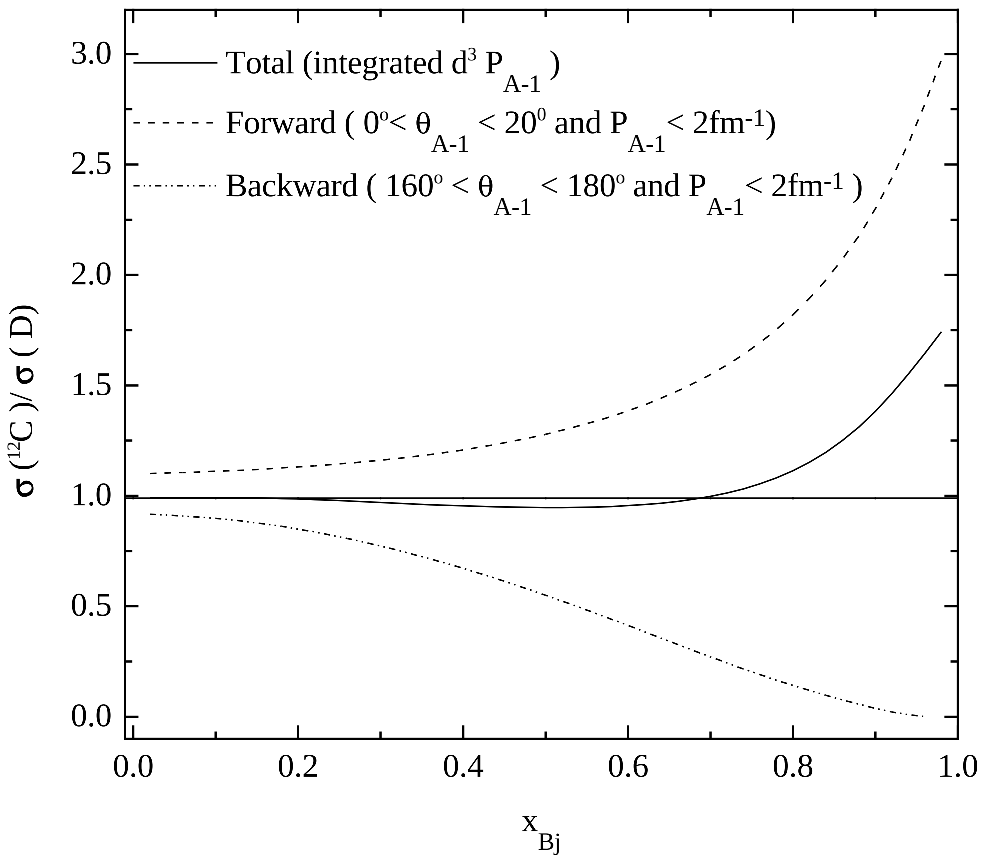
Recent data on EMC show that the A-dependence of the effect disagrees with the one predicted by SLAC data, indicating some local origin of the effect, which could be explained by a nucleon virtuality dependence of the structure function. Few percent effects. How can we investigate these effects by SIDIS ? By detecting $(A-1)$ in different energy states

$$R_0(x_{Bj},Q^2) = \frac{\int_a^b \sigma^A(x_{Bj},Q^2,\boldsymbol{P}_{A-1})d\,\boldsymbol{P}_{A-1}}{\int_a^b \sigma^D(x_{Bj},Q^2,\boldsymbol{P}_{A-1})d\,\boldsymbol{P}_{A-1}}; \qquad 160^o < \theta < 180^o; \quad \boldsymbol{P}_{A-1} < 0.4\ GeV/c$$



The backward semi-inclusive local EMC effect on ^{12}C due to the shell model nucleons with $\epsilon_{1s} = 36\,MeV$ and $\epsilon_{1p} = 16\,MeV$. The dashed curve represents the corresponding inclusive EMC ratio.

CdA, Kaptari, Scopetta,
Eur. Phys. J. A5 (1999) 191



The seminclusive local EMC ratio $\sigma(^{12}C)/\sigma(D) \equiv R_o(x_{Bj}, Q^2)$, corresponding to nuclei emitted backward and forward, in the kinematical ranges shown in the Figure. The full curve is the usual inclusive EMC ratio.

CdA, Kaptari, Scopetta, Eur. Phys. J. A5 (1999) 191

5. TAGGING HADRONIZATION BY THE NEW SIDIS PROCESS

Measure $\sigma_1^A(x_{Bj}, Q^2, \boldsymbol{P}_{A-1})$ on nuclei A and A' at the same x_{Bj}

$$R(x_{Bj}, Q^2, \boldsymbol{P}_{A-1}, A, A') = \frac{\sigma_1^A(x_{Bj},Q^2,\boldsymbol{P}_{A-1})}{\sigma_1^{A'}(x_{Bj},Q^2,\boldsymbol{P}_{A-1})} \equiv R(|\boldsymbol{P}_{A-1}|, \theta_{\widehat{\mathbf{P}_{A-1}\mathbf{q}}} \equiv \theta)$$

$$R(|\boldsymbol{P}_{A-1}|, \theta = 180^0) \simeq \frac{n_0^A(|\boldsymbol{P}_{A-1}|)}{n_0^{A'}(|\boldsymbol{P}_{A-1}|)}$$

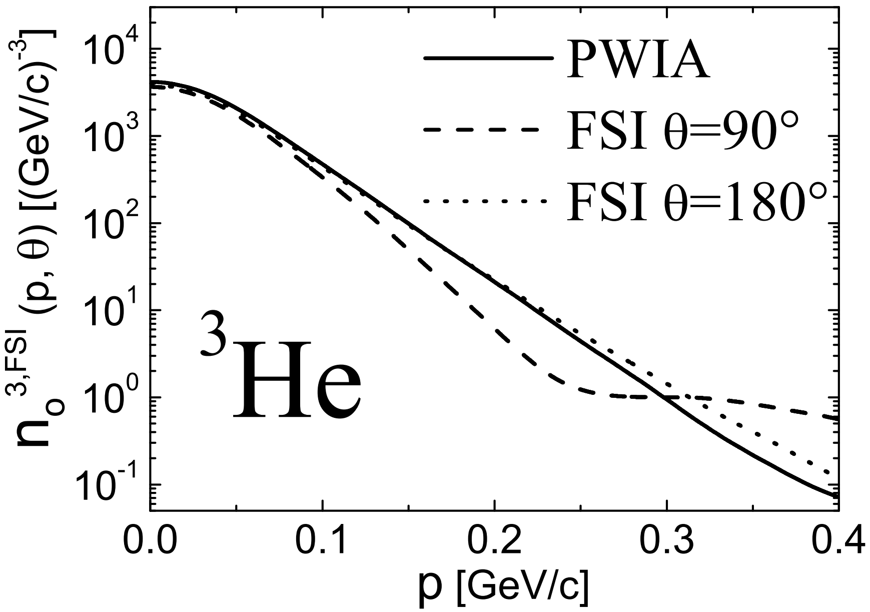
Check of the spectator mechanism

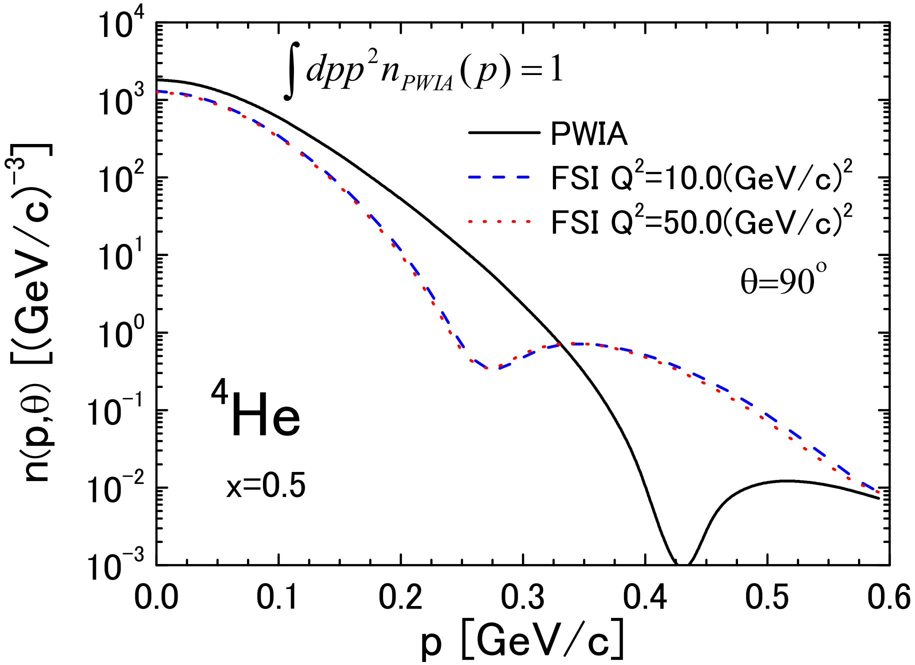
$$R(|\boldsymbol{P}_{A-1}|, \theta = 90^0) \simeq \frac{n_0^{FSI,A}(|\boldsymbol{P}_{A-1}|,\theta=90^0)}{n_0^{FSI,A'}(|\boldsymbol{P}_{A-1}|,\theta=90^0)}$$

Check of the FSI (i.e. the effective debris-nucleon cross section i.e. the hadronization mechanism).

The processes $^3He(e, e'D)X$ and $^4He(e, e'^3He)X$

(CDA, Kaptari, Phys. Rev, in press .)





- FSI will affect the survival probability (SP) of $(A - 1)$ depending on the hadronization mechanism.

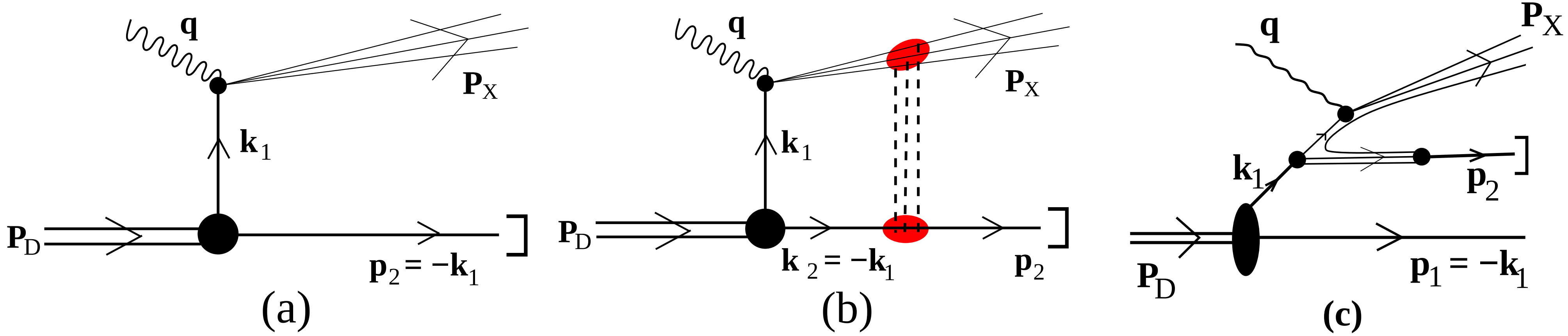
$$\mathrm{SP(A{=}4)} = 0.4 \quad \mathrm{(0.8\ in\ QE\ SCATTERING)}$$

- Q^2-dependence small (gluon radiation).

6. CHECK of the FSI MODEL: COMPARISON WITH EXPERIMENTAL DATA on $^2H(e, e'p)X$ PROCESS (JLAB "DEEPS")

6.1 The PROCESS $^2H(e,e'p)X$

If only a nucleon is detected it can originate from different processes



- (a) Spectator mechanism within the PWIA.
- (b) Various FSI contributions.
- (c) Proton production by target fragmentation.

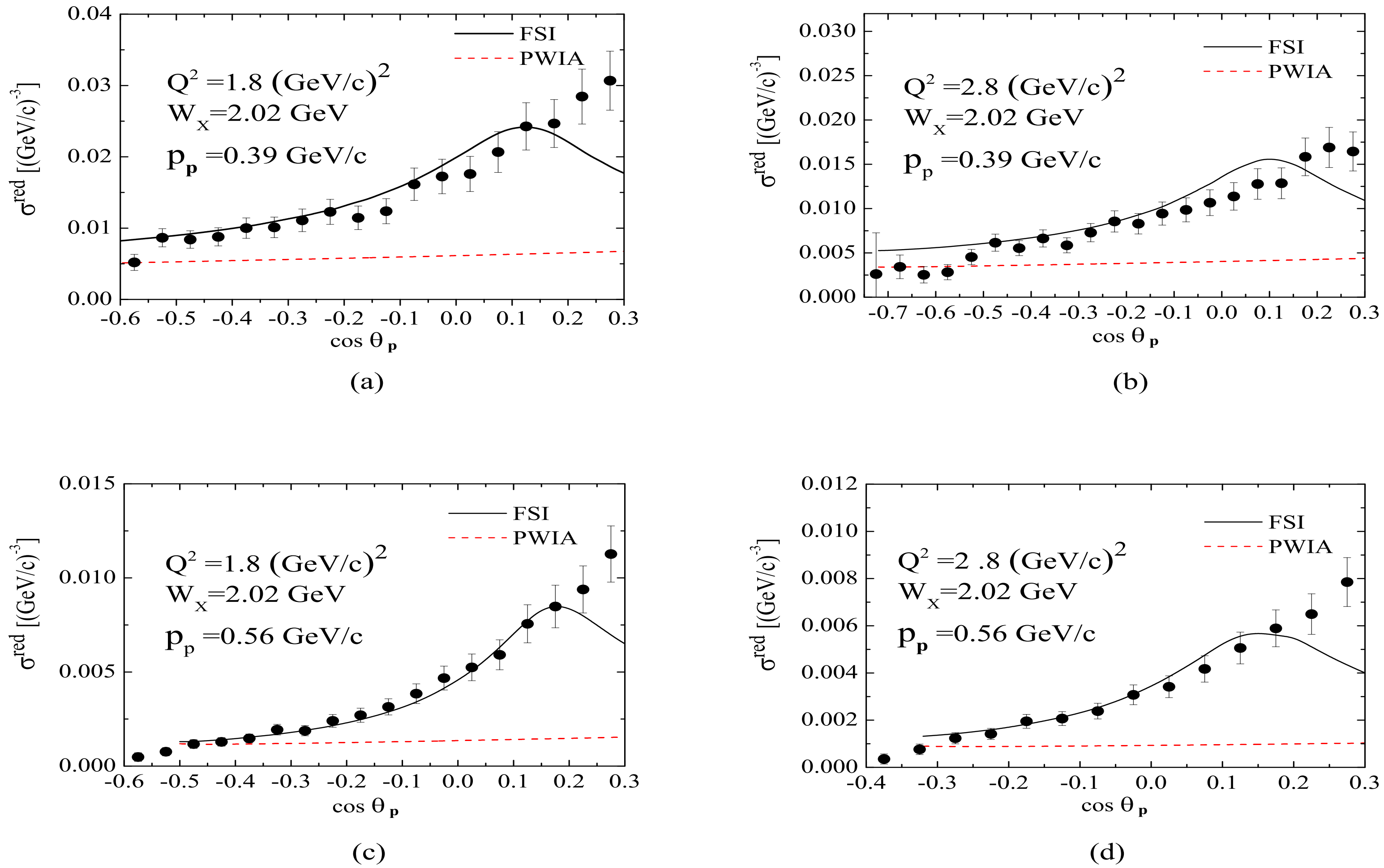
6.2 Comparison betwen theory and experiment

The experimental reduced cross section Jlab "DEEPS" Kuhn et al Phys. Rev. C80 (2009) 054610 and Private communications

$$RedX = \frac{d\sigma^{exp}}{K(x_{Bj}, y, Q^2)}$$

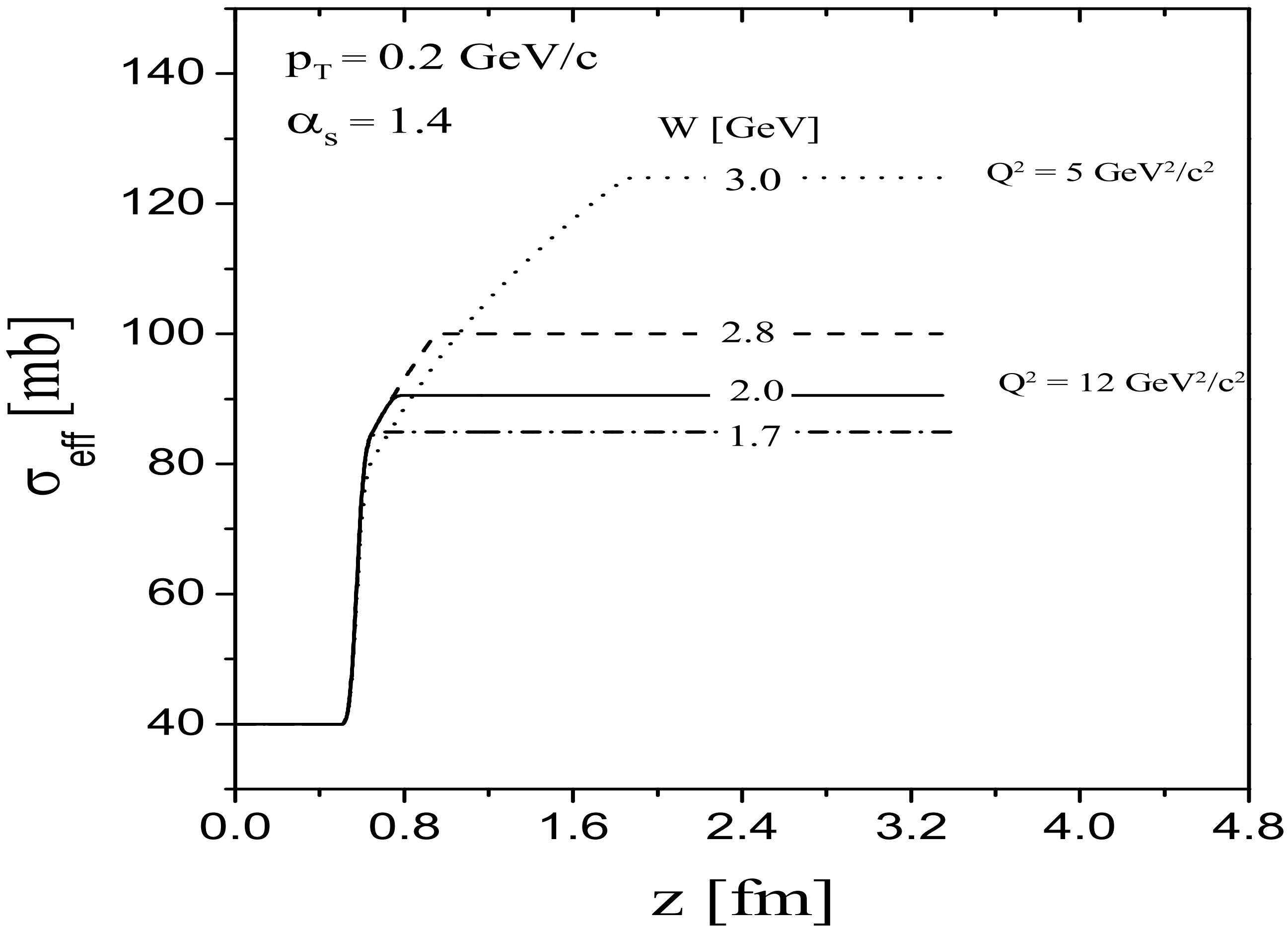
$$1.2 < Q^2 < 5\,GeV^2 \qquad 1.1 < W_X < 2.7\,GeV$$
$$0.28 < |\mathbf{p}_p| < 0.7\,GeV \qquad -0.8 < \cos\theta_p < 0.7$$

compared with parameter-free theoretical calculations (CDA, Kaptari, Phys. Rev., in press.)

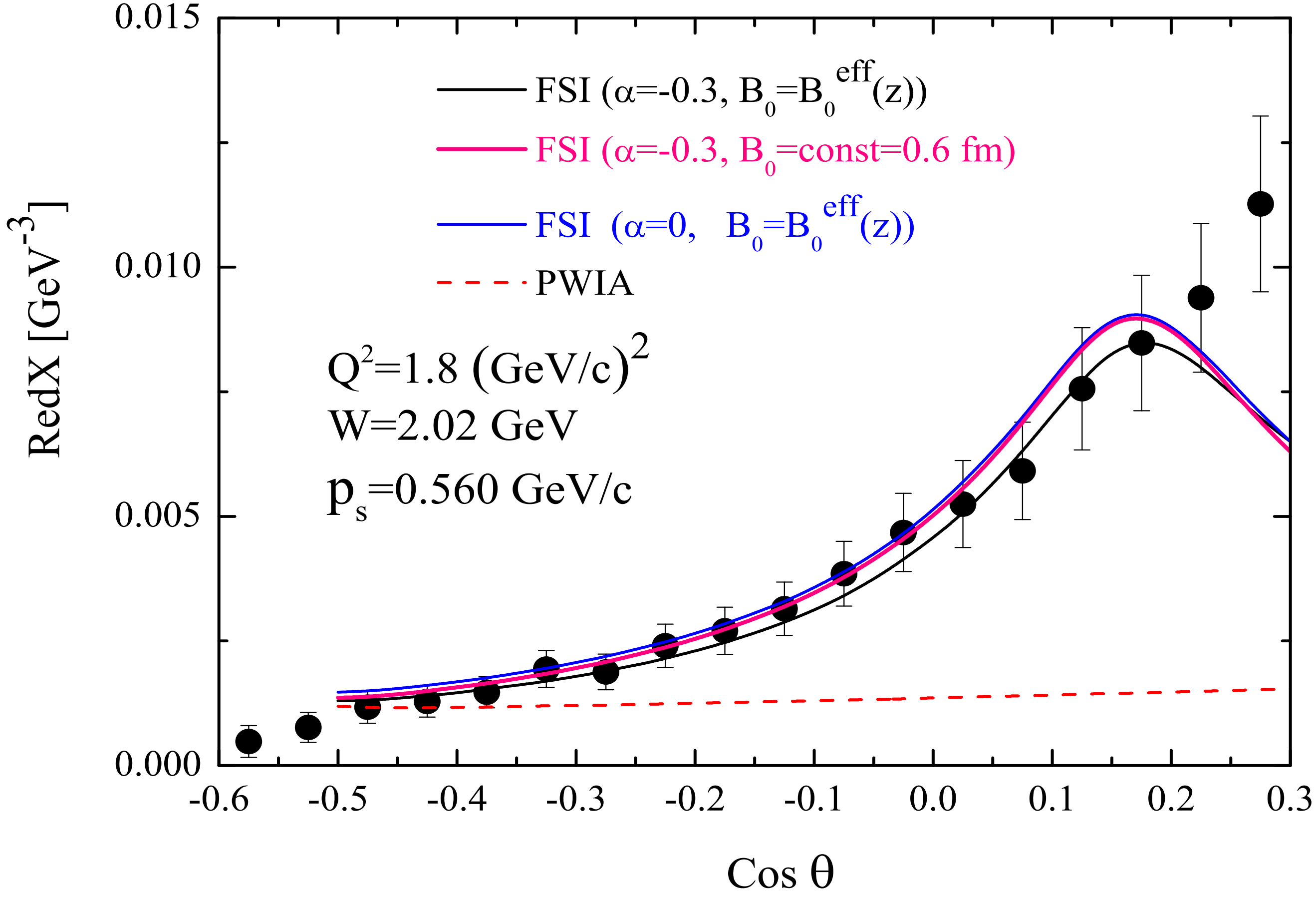


FSI
PWIA
Q² =1.8 (GeV/c)²
W_X=2.02 GeV
p_p =0.39 GeV/c
σ^red [(GeV/c)^-3]
cos θ_p
(a)
Q² =2.8 (GeV/c)²
W_X=2.02 GeV
p_p =0.39 GeV/c
(b)
Q² =1.8 (GeV/c)²
W_X=2.02 GeV
p_p =0.56 GeV/c
(c)
Q² =2 .8 (GeV/c)²
W_X=2.02 GeV
p_p =0.56 GeV/c
(d)

"DEEPS" KINEMATICS and $\sigma_{eff}(z)$



"B and α DEPENDENCES in DEEPS"



6.3 Proton production by target fragmentation

The cross section

$$\frac{d^4\sigma_{tf}}{dx\, dQ^2\, d\boldsymbol{p}_2/E_2} = K(x,y,Q^2) H_2^A\left(x, z_2, \mathbf{p}_{2\perp}^2\right)$$

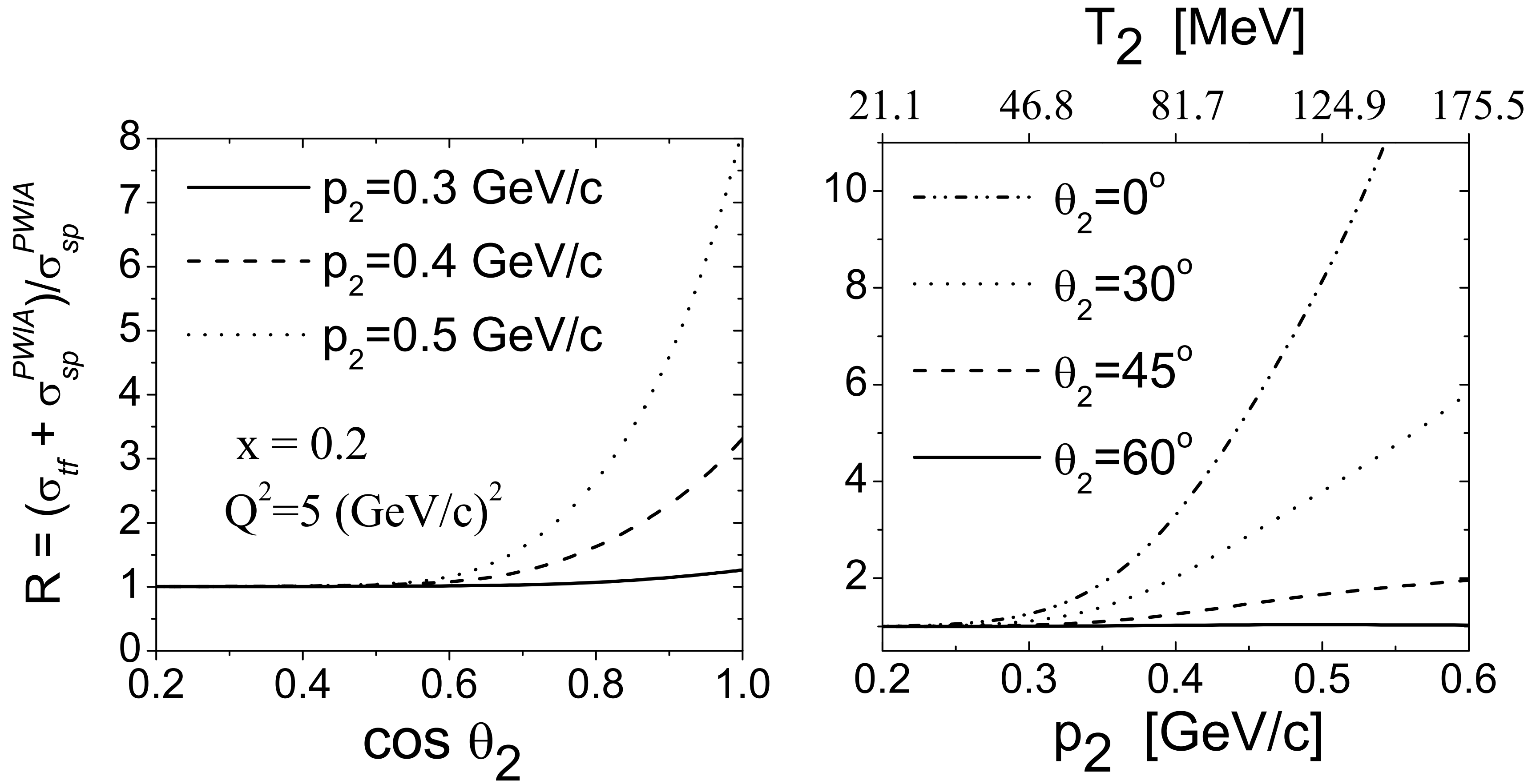
Here H_2^A is the convolution of the nucleon target fragmentation function with the nuclear spectral function of nucleon "1", $P_{N_1}(|\boldsymbol{k}_1|, E)$,

$$H_2^A\left(x, z_2, \mathbf{p}_{2\perp}^2\right) = \int dz_1\, f_{N_1}(z_1)\, H_2^{N_1\to N_2}\left(\frac{x}{z_1}, \frac{z_2}{z_1 - x}, \mathbf{p}_{2\perp}^2\right),$$

where $f_{N_1}(z_1)$ is the light cone momentum distribution of the nucleon given by

$$f_{N_1}(z_1) = \int d\mathbf{k}_1\, dE\, P_{N_1}(|\mathbf{k}_1|, E)\, z_1\, \delta\left(z_1 - \frac{k_1 \cdot q}{m_N\, \nu}\right)$$

and $H_2^{N_1\to N_2}$ is the target fragmentation function of the struck nucleon N_1 producing the detected nucleon N_2.



Proton production by target fragmentation in $D(e, e'p)X$.

The quantity $R_{tf} = (d\sigma_{tf} + d\sigma_{sm}^{PWIA})/d\sigma_{sm}^{PWIA}$ ***vs.*** $\cos\theta_2$ and $|\boldsymbol{p}_2| \equiv p_2$

(Palli, CdA, Kaptari, Mezzetti, Alvioli, Phys. Rev.C80 (2009) 054610)

!!!Protons are produced in a very narrow forward cone !!!

7. EXPERIMENTAL PERSPECTIVES

Nuclear Exclusive and Semi-inclusive Physics with a New CLAS12 Low Energy Recoil Detector

JLab Letter of Intent to PAC35 — *14 December 2009*

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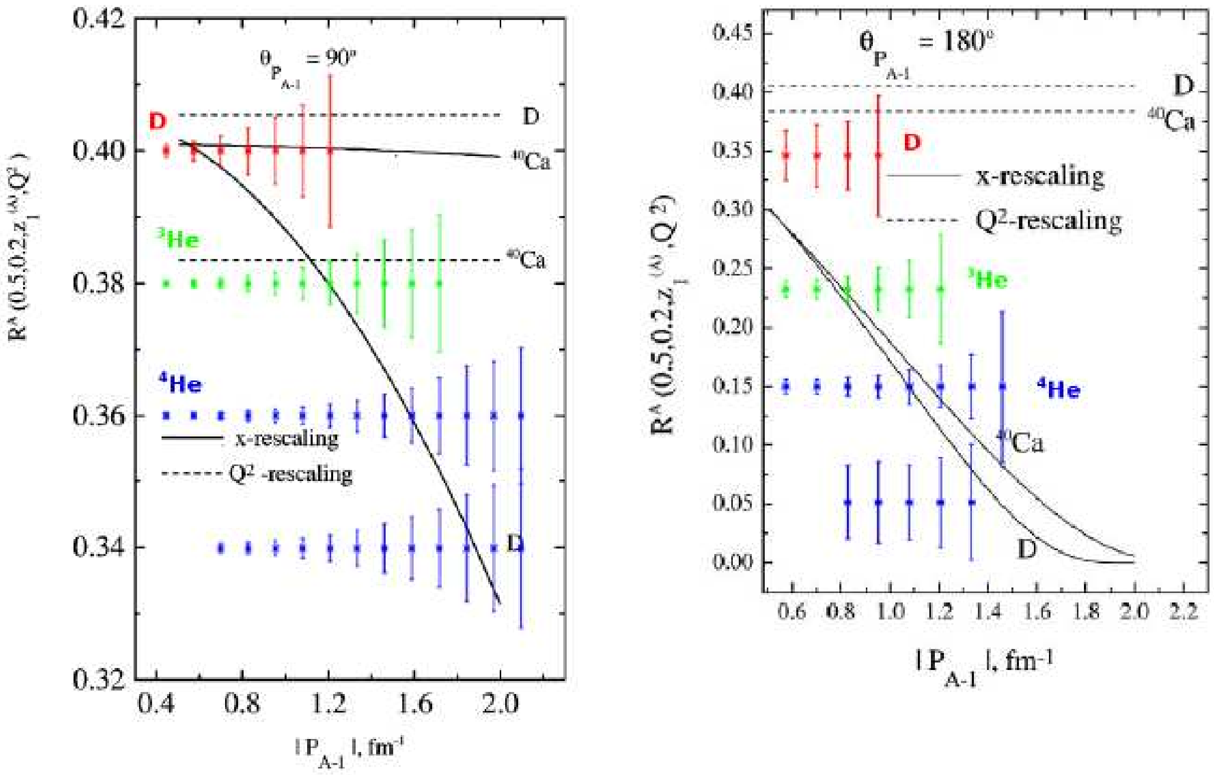

FIG. 16. This figure is similar to figure 5 with projections for A = 2,3 and 4 (for ^{4}He the two series of points corresponf to tagged ^{3}H and ^{3}He)

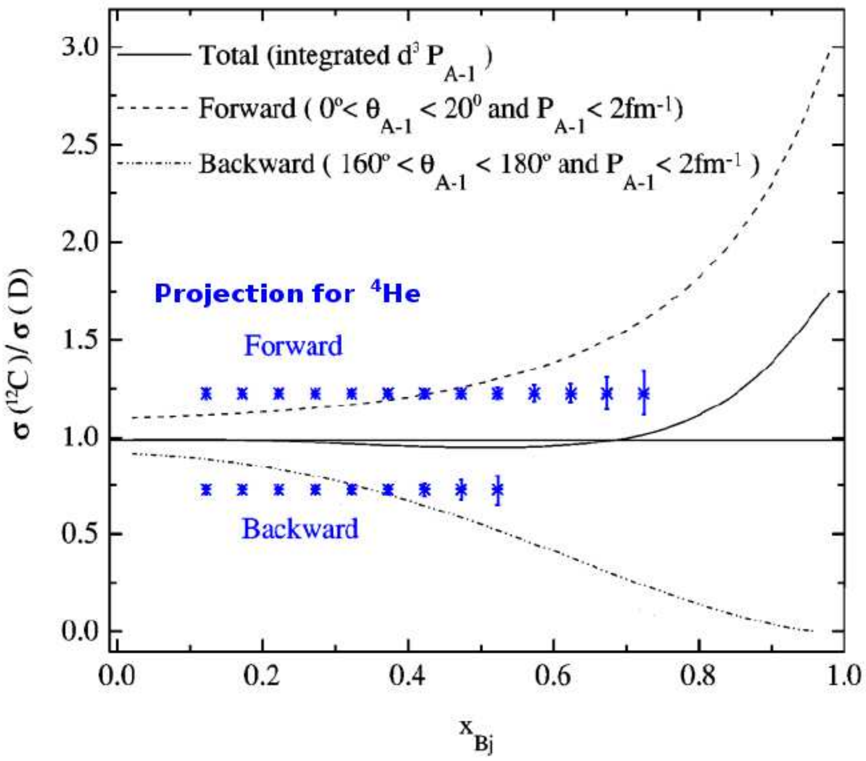

FIG. 17. This figure is similar to figure 6 with projections for ^{4}He

.....we propose the SIDIS measurement on various light nuclei (D, ^3He and ^4He) by tagging the backward recoiling spectator..we will be able to cover a large range in x_{Bj}... the measured semi-inclusive EMC ratio is expected to provide new insight into the origin of the EMC effect...

CONCLUSIONS

- In SIDIS with detection of slow recoiling nuclei, a large variety of kinematical conditions can be chosen, which would allow a detailed investigation of: i) medium effects on the nucleon structure function, ii) the origin of the EMC effect, iii)the space-time evolution of hadronization.

- The 11 GeV beam at Jlab, CLAS12, BONUS detector and the newly proposed recoil detectors, are natural candidates to start an experimental program in this new and interesting field of modern nuclear physics.

- Theoretical calculation within other approaches for the FSI in the new SIDIS process are welcome (transport theory?).

* *

* *

THANK YOU ULRICH FOR WHAT YOU HAVE GIVEN TO THE NUCLEAR PHYSICS COMMUNITY AND FOR WHAT YOU WILL GIVE IN THE FUTURE

(If I may suggest, amongst your various choices, choose "BOTH")

ALL THE BEST, TAKE CARE AND....DON'T STOP SKYING!

SEE YOU IN TRENTO !

* *

* *