PARTON PROPAGATION AND FINAL STATE INTERACTION IN DIS OFF NUCLEI

C. Ciofi degli Atti

ECT*, OCTOBER 2005

Università degli Studi di Perugia

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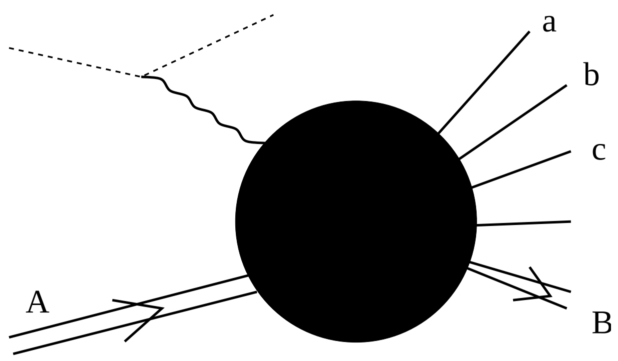
1. INTRODUCTION

The process



Some definitions

A(e,e')X-inclusive A(e,e'h)X-semi-inclusive A(e,e'h)B-exclusive

Aim

Opening the black spot by detecting various particles in the final state so as to learn about the partonic structure of the hadronic matter and the propagation of partons in the matter.

2. PROPAGATION OF HADRONS IN THE MEDIUM: THE THEORETICAL FRAMEWORK

The medium:

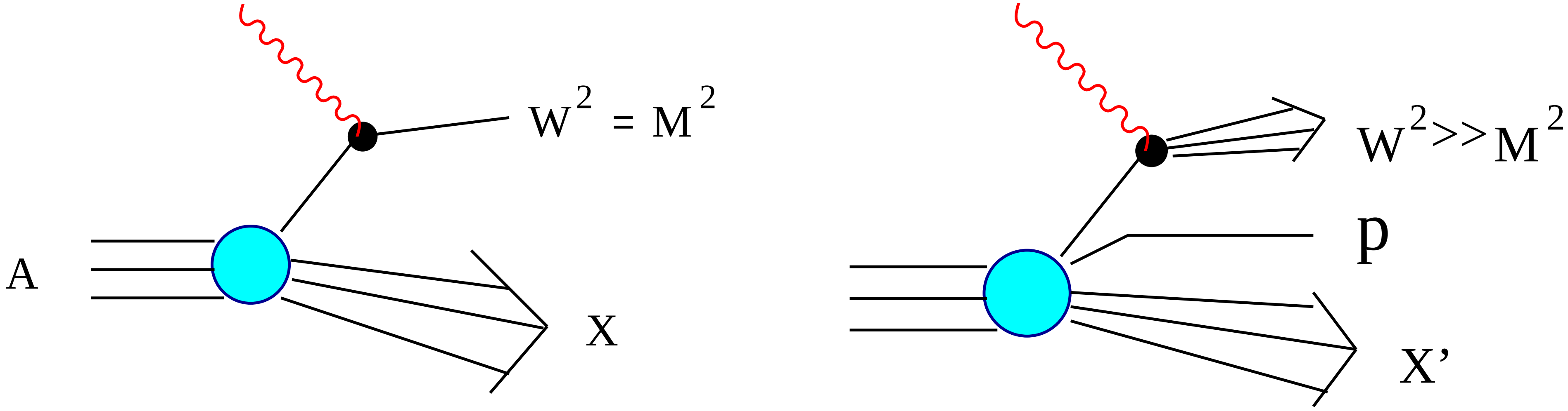
a) Initial state: any realistic nuclear wave function for the target nucleus.

b) Final state: difficult problem

Let us start with the simplest assumption:

the Plane Wave Impulse Approximation (PWIA)
i.e. let us suppose that $\gamma*$ interacts with a parton which leaves the nucleus without re-interaction (no FSI) and consider the process $A(e, e'N)X$

We have, e.g., the following processes :

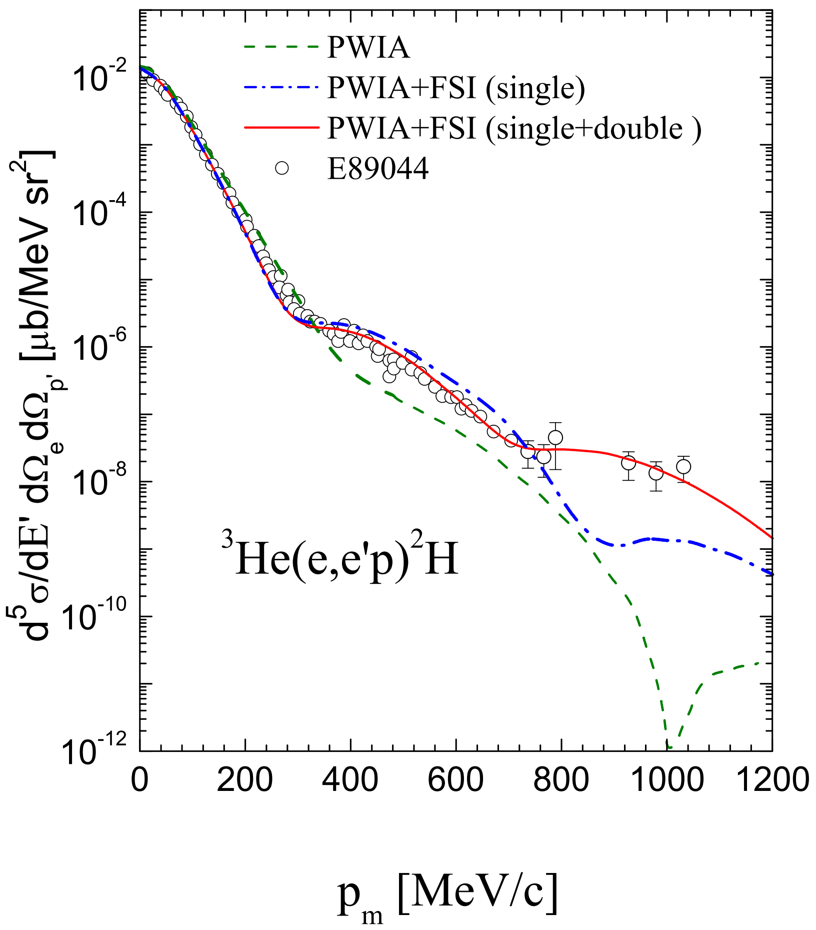


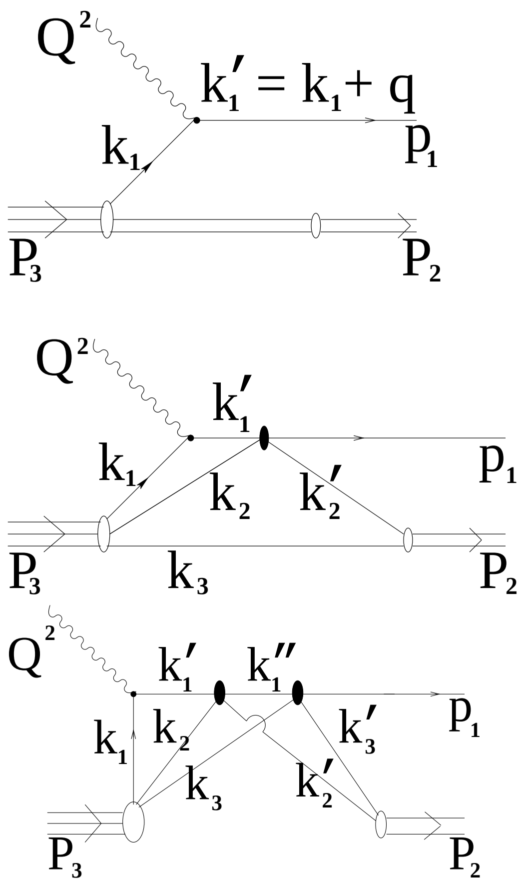
The left one (Quasi elastic scattering on a bound nucleon) might provide information on $G^N(Q^2)$ of a nucleon in the medium (upper vertex), provided we know its Spectral Function $P(p,E)$ (lower vertex). The right one (DIS on a nucleon of a correlated pair)might provide information on the PDF $F^{N/A}(x,Q^2)$ and FF $D^{h/A}(z,Q^2)$ of a nucleon in the medium (upper vertex) provided we know the two-nucleon Spectral Function $P(p_1,p_2,E)$ (lower vertex).

We do need information on the nucleon structure functions in the medium. Most of the information comes from inclusive scattering (e.g. EMC). Semi-inclusive and exclusive processes might provide more reliable information. One-body, two-body,etc ground state Spectral Functions are well known from many-body physics. The real problem is the treatment of the final state, i.e. the treatment of the re-interaction of the particles produced in the final state.

At sufficiently high energies the eikonal-Glauber approximation appears to be the right approach. Let us demonstrate it by an example in the quasi-elastic kinematics.

$^3He(e,e'p)^2H$ at $Q^2 \simeq 1.55\ (GeV/c)^2,\ \ x = 1$

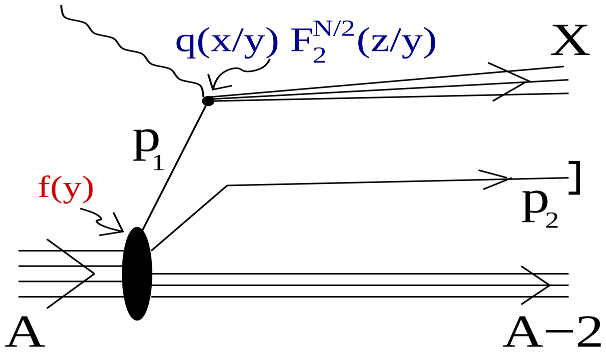


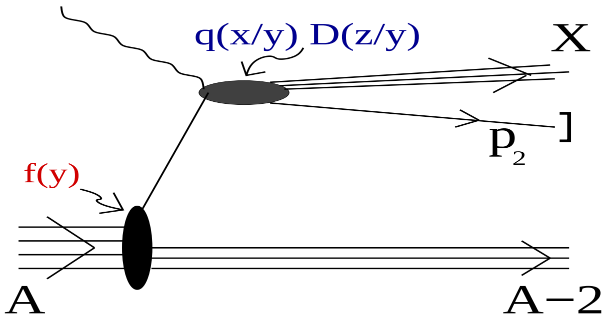


Theory: C.d.A., L. P. Kaptari, Phys. Rev. Lett., **95** *(2005)052502*

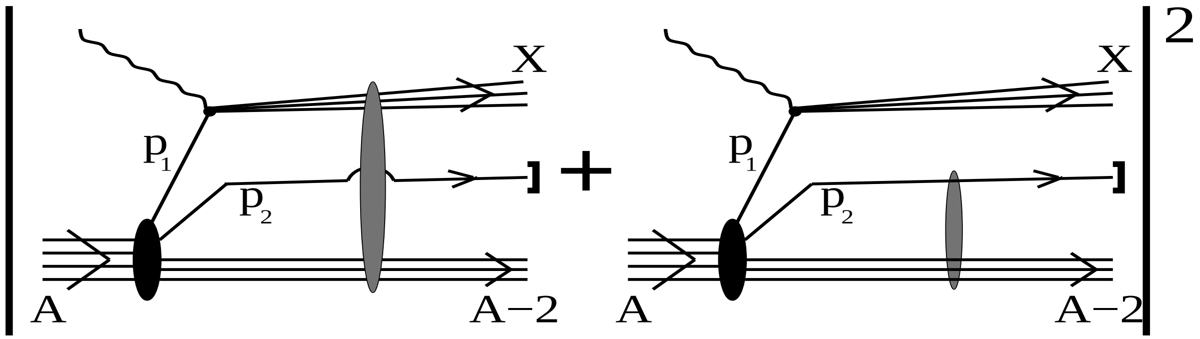
Experiment: M. M. Rvachev et al., Phys. Rev. Lett. **94***(2005)192302*

Deep Inelastic Scattering





The PDF and FF in the medium could be investigated by tagging. Many calculations but what about the FSI?



What is the interaction of the nucleon debris with the medium?

We need a model for hadronization.

Nuclear targets serve as a natural and unique analyzer of the space-time development of strong interactions at high energies:

$$Hadron\ Formation\ Length\ \simeq\ order\ of\ fermis \Rightarrow\ Nuclear\ Target$$

The cross section of the final state interaction (FSI) increases and the nucleus may act as a filter of hadronization mechanisms.

The most investigated process: attenuation of leading hadrons created in Semi-Inclusive DIS(SIDIS) off Nuclei (HERMES at HERA)

$$R = \frac{d^2\sigma^A/dzdx}{d\sigma^N/dzd\nu}\,\frac{\sigma^{N,incl}}{\sigma^{A,incl}} \qquad d^2\sigma^A/dzdx = \frac{\sum_f\ e_f^2\ q_f(x,Q^2)\ D_f(z,Q^2)}{\sum_f\ e_f^2\ q_f(x,Q^2)}$$

MODELS of HADRON FORMATION MECHANISMS

Gluon Radiation Mechanism

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

Induced Energy Loss

Wang, Phys. Rev. Lett,89(02)162301

Nuclear Absorption

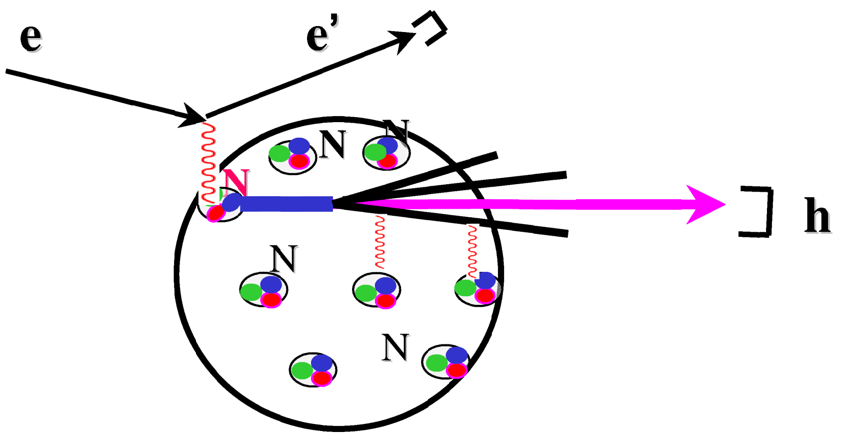
Falter, Mosel et al, Nucl-th/0303011

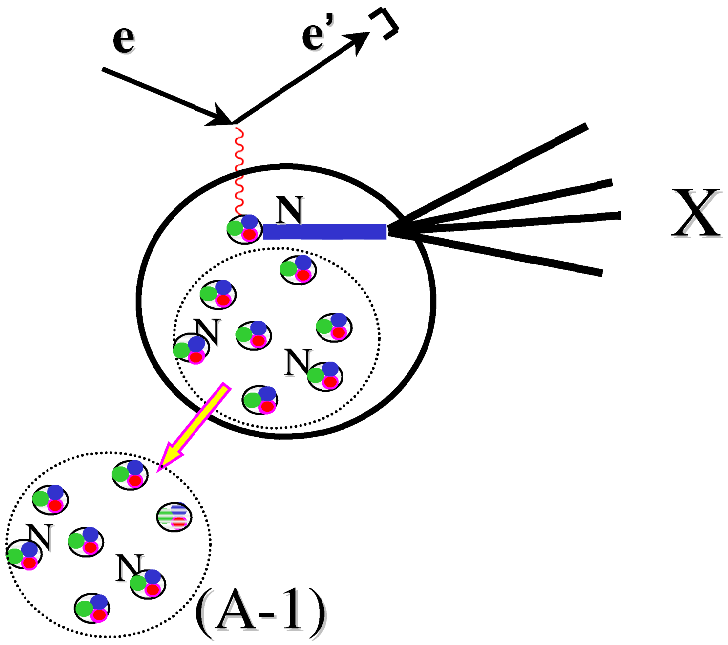
Rescaling of fragmentation functions

Accardi, Muccifora, Pirner, Nucl. Phys.A720(03)131

Various approaches based upon different physical ideas explain the experimental data . Apparently not yet conclusive answer to the basic question concerning the origin of hadron attenuation.

Aim of our work: approach the problem in a complementary way. Unlike the rare process of leading hadron production (left) we will analyze possible processes which depend upon the bulk of the final state interaction(e.g. right).



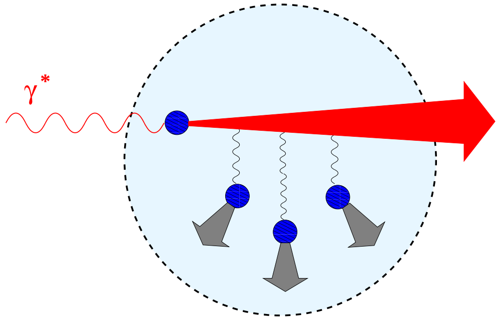


3. DIS: a model for hadronization and final state interaction .

We considered:

- **Grey Tracks (GT) production in SIDIS.**

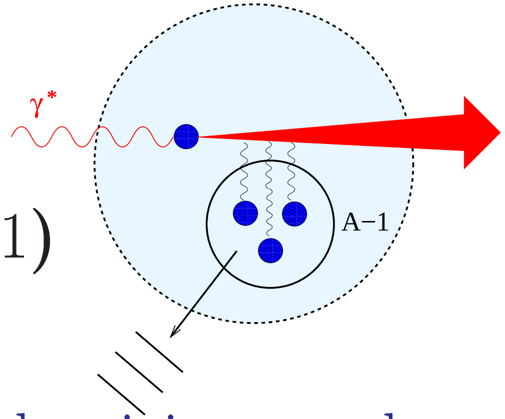
  GT-recoiling protons created in the inelastic collisions of the hadronizing quark with the spectator nucleons.



- **Semi- Exclusive DIS (SEDIS) processes** $A(e, e'B)X$ **.**

  B- **detected recoiling heavy fragment (e.g** $A - 1$)

  X- **unobserved jets from hadronization;**



Both processes depend upon the bulk of the FSI of the hadronizing quark with the nuclear medium. The theoretical treatment of both processes within a Glauber-like treatment of FSI requires an **effective time-dependent nucleon debris-nucleon cross section**

The EFFECTIVE Debris-Nucleon CROSS SECTION (CdA, B. Kopeliovich, EPJA, A17(2003)133)

The hadronization model:

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

the formation of the final hadrons occurs during and after the propagation of th e 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

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

The mean multiplicity of Mesons:

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

Gluon radiation mechanism

- coherence time

$$t_c = \frac{2\,E_q\,\alpha\,(1-\alpha)}{k_T^2}\ ,$$

time which elapses from the creation of the leading quark and the emission of the gluon which lost coherence with the color field of the quark. α, $k_T = |\mathbf{k}_T|$, and E_q are the fraction of the quark light-cone momentum carried by the radiated quantum, its transverse momentum, and the quark energy, respectively.

- 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

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

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

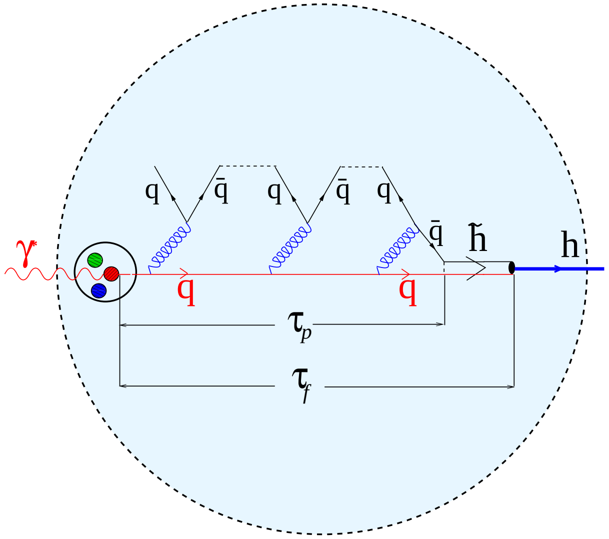
$$\mathbf{t < t_0} \quad \mathbf{n_G(t)} = \frac{16}{27}\left\{\ln\left(\frac{Q}{\lambda}\right) + \ln\left(\frac{t\,\Lambda_{QCD}}{2}\right)\ \ln\left[\frac{\ln(Q/\Lambda_{QCD})}{\ln(\lambda/\Lambda_{QCD}}\right]\right\}$$

levels off at

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

and saturates at $t > t_0\, Q^2/\lambda^2 = 2\nu/\lambda^2$.

- transverse size of the decaying pre-hadrons from the string $\simeq$ hadronic transverse size; the same cross section;
- $\bar{q}q$ colorless dipoles treated as mesons (M).



Attenuation of the leading hadron(*formed at* τ_f) $\Longrightarrow$absorption of the pre-hadron $\tilde{h}$ (the small $\bar{q}q$ configuration, *formed at* τ_p) produced in the color neutralization of the radiating quark created in the hard $\gamma*$-nucleon interaction.

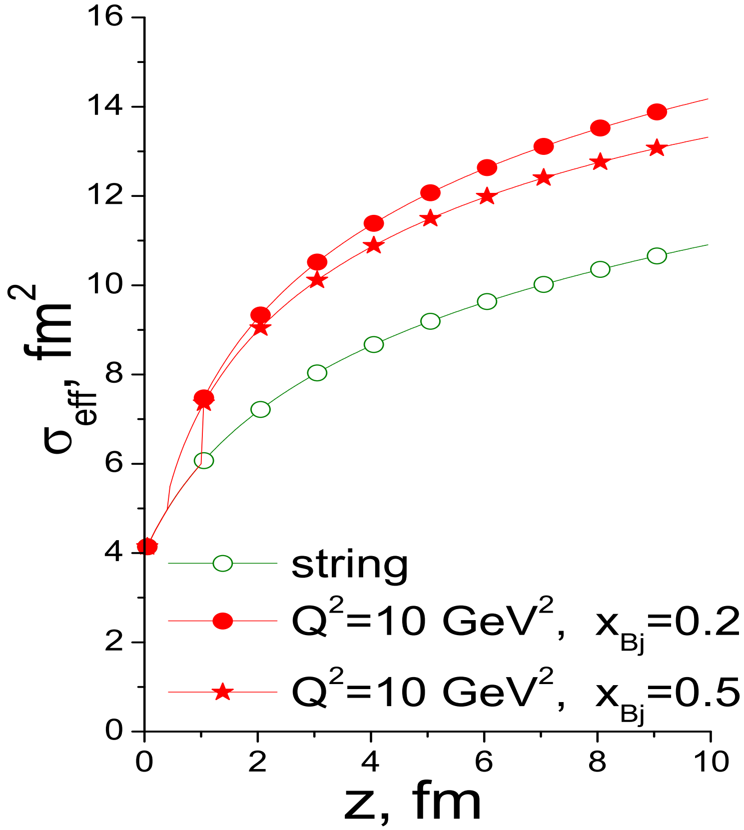
The multiplicity of the produced pre-hadrons (colorless dipoles)

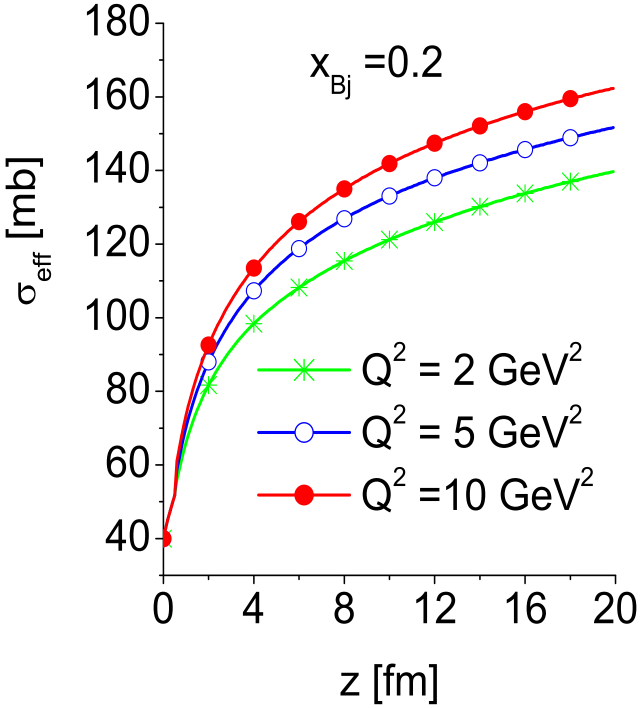
$$\langle\, \mathbf{n_h(t)} \,\rangle = \mathbf{n_M(t)} + \mathbf{n_G(t)}$$

The debris-nucleon cross section

$$\sigma_{\mathbf{eff}}(\mathbf{t}) = \sigma_{\mathbf{tot}}^{\mathbf{NN}} + \sigma_{\mathbf{tot}}^{\mathbf{MN}}[\mathbf{n_M(t)} + \mathbf{n_G(t)}]$$

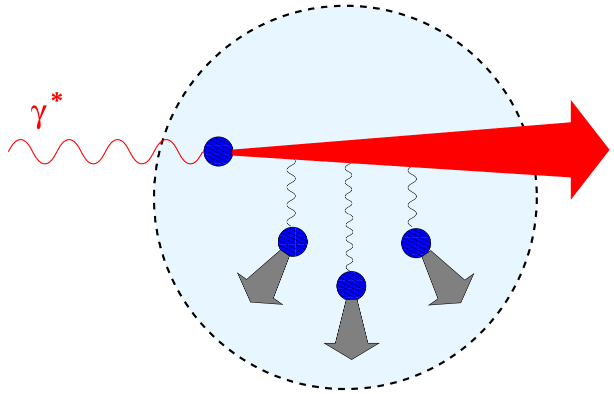
The debris-nucleon effective cross section





- Steep rise with time (distance).
- Q^2 and x_Bj dependence due to gluon radiation mechanism.

4. HADRONIZATION AND GREY TRACKS PRODUCTION



- Dominant channels of DIS $\Longrightarrow$ the recoiling nucleus B breaks apart to fragments whose distribution in Q^2 and could shed light on the time evolution of the jet in the nuclear medium.
- The whole jet inelastically interacts with spectators nucleons, which recoil and form Grey Tracks (GT). GT production covers the main bulk of inelastic events, and its Q^2 dependence is a very sensitive tool to discriminate between different models of hadronization.

A recent calculation of GT production

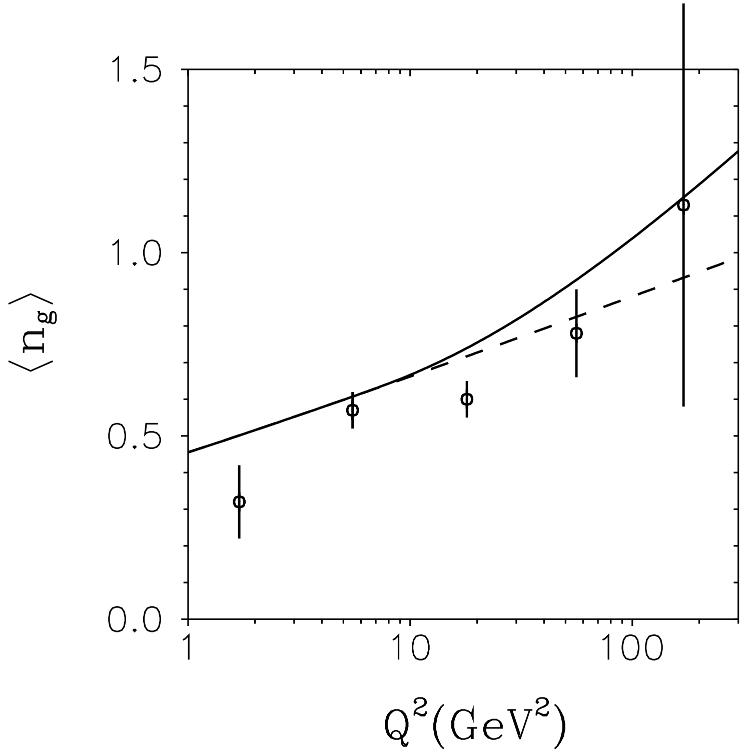
(**CdA, Kopeliovich,** Phys. Lett. **B606**(2005)281)

- **The Model**: DIS on a bound nucleon at coordinate $(\vec{b}, z)$. The hadronizing quark (The debris) propagates through the nucleus interacting with spectator nucleons via $\sigma_{eff}(z - z')$. The mean number of collisions , (plus the recoiling nucleon formed in the hard $\gamma * -N$ act) is

$$\langle \nu_c \rangle = \int d^2b \int_{-\infty}^{\infty} dz\, \rho_A(\vec{b}, z) \int_{z}^{\infty} dz'\, \rho_A(\vec{b}, z')\, \sigma_{eff}(z - z') + 1 \; .$$

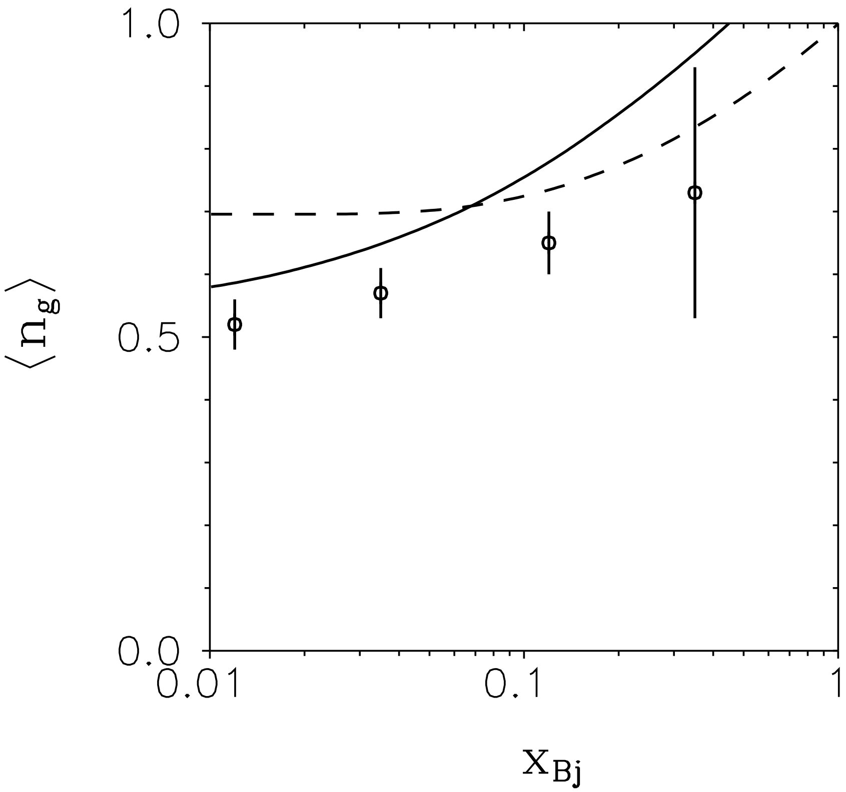
- **Experiment:** Fermilab E665($\mu - Xe$ and $\mu - D$ processes at 490 GeV beam energy; GT- protons with momentum $200 - 600$ MeV/c).
- **Empirical relation**: between the mean number of collisions , $\langle \nu_c \rangle$, and the mean number of GT $< n_g >$

$$< n_g >= \frac{\langle \nu_c \rangle - (2.08 \pm 0.13)}{(3.72 \pm 0.14)}$$



The mean number of grey tracks $\langle n_g \rangle$ produced in the μXe SIDIS *vs* Q^2 in the non-shadowing region with fixed $x_{Bj} = 0.07$ (dashed). The solid curve includes the $Q^2 - x_{Bj}$ correlation.

The Debris-Nucleon cross section,with no readjustment of the parameterscorrectly predicts the Q^2 dependence, thanks to the Q^2 and x_{Bj}- dependent gluon radiation mechanism



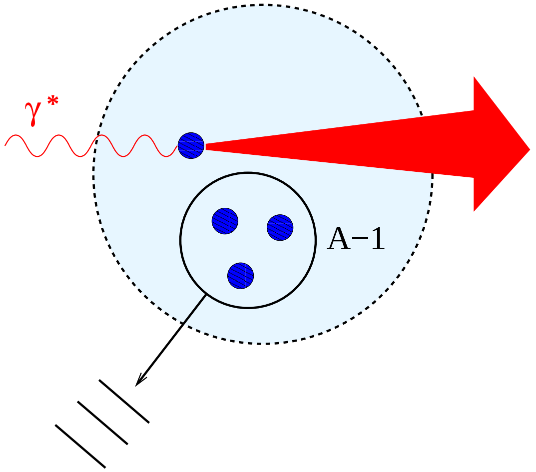
The mean number of grey tracks $\langle n_g \rangle$ produced in the μXe SIDIS *vs* x_{Bj}. The dashed curve shows the results corresponding to a fixed value of $Q^2 = 14.3\ GeV^2$, whereas the solid curve includes the $Q^2 - x_{Bj}$ correlation .

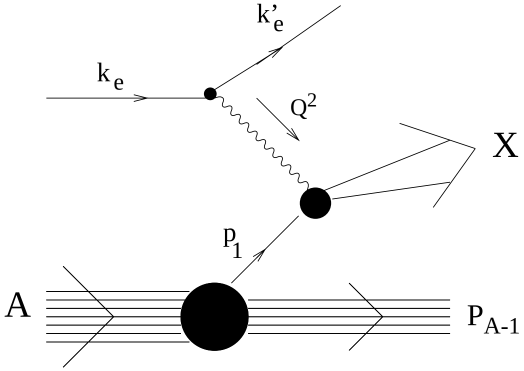
Comments:

- the Debris-Nucleon cross section, **with no readjustment of the parameters**, successfully passed the Grey Tracks test;
- The amount of grey tracks doubles within the range of Q^2 covered by the kinematics of the E665 experiment; the Debris-Nucleon cross section, **correctly predicts such a trend thanks to the Q^2-dependent gluon radiation mechanism**;
- the results of calculations may be subject to further corrections (resonance decays: formation time of hadronic wave function is much shorter than the resonance life time and is rather short for pre-hadrons produced within the nucleus. Color transparency is disregarded for the same reason);
- we assumed that the value of Bjorken scaling variable x_{Bj} is sufficiently large to neglect the sea, and this is the reason why we compared our results with the E665 data at large values of x_{Bj}.

5. THE SEMI-INCLUSIVE $A(e, e'B)X$ PROCESS

PWIA : **The debris propagates through the nucleus freely**





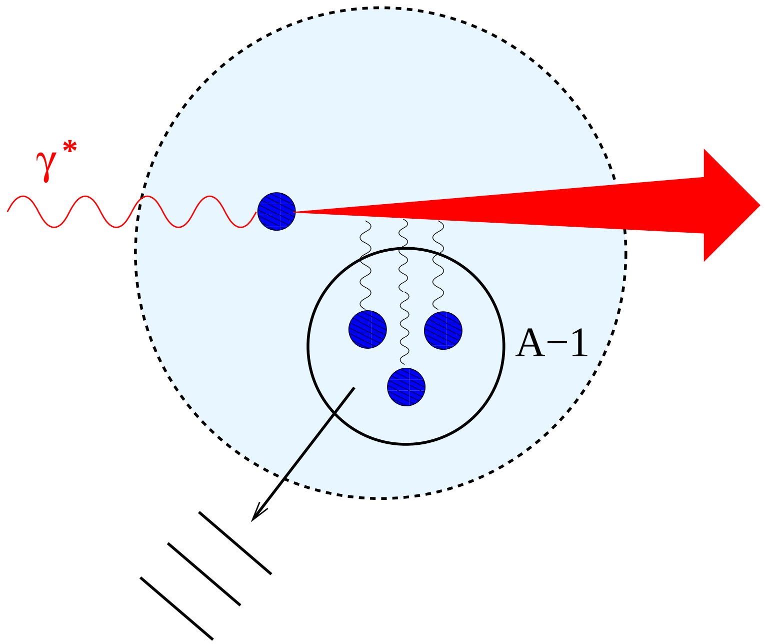
a)

$$\frac{d\sigma^A}{dx\,dQ^2\,d\vec{P}_{A-1}} \propto F_2^{N/A}(x_A, Q^2, p_1^2)\, N_A(|\vec{p}_1|) \qquad \vec{p_1} \equiv -\vec{P}_{A-1}$$

$F_2^{N/A}(x_A, Q^2, p_1^2)$ **Bound Nucleon Structure Function**

$N_A(|\vec{p}_1|)$ **Nucleon Momentum Distribution**

FSI: the debris multiple scatters in the medium



- The hadronizing quark interacts with the spectator nucleons via $\sigma_{eff}(t)$
- The **survival probability** of (A-1) is reduced depending on the features of $\sigma_{eff}(t)$.

CdA, Kopeliovich, EPJA17(2003)133

$N_A(|\vec{P}_1|) \Longrightarrow$ *Distorted* **(D) Momentum Distributions** $N_A^D(\vec{P}_{A-1})$

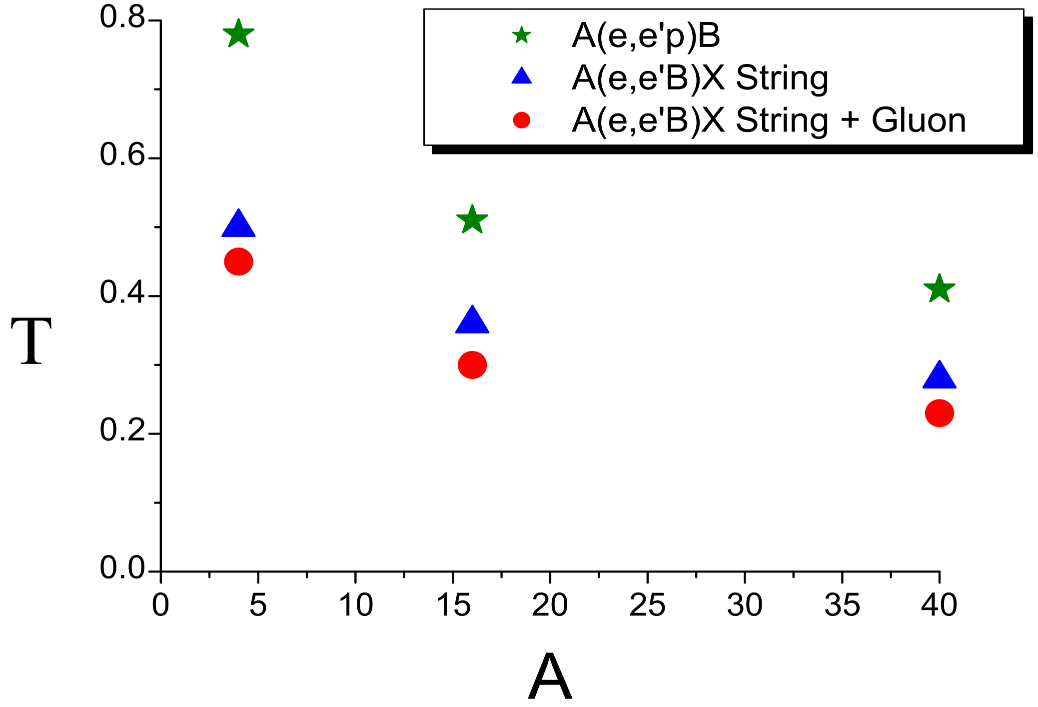
Glauber time-independent profile $\Longrightarrow$ time-dependent profile function

$$\Gamma^{NN}(\mathbf{b}_1 - \mathbf{b}_i) \Longrightarrow \Gamma^{N^*N}(\mathbf{b_1 - b_i, z_i - z_1})$$

$$\mathbf{N_A^D(P_{A-1}) = \left| \int\limits_{z}^{\infty} e^{iP_{A-1}\cdot r} \phi(b,z) e^{-\frac{1}{2}S(b,z)} \right|^2}$$

$$\mathbf{S(\vec{b},z) = \int\limits_{z}^{\infty} dz' \,\rho_A(\vec{b},z')\, \sigma_{eff}(z'-z)} \qquad (1)$$

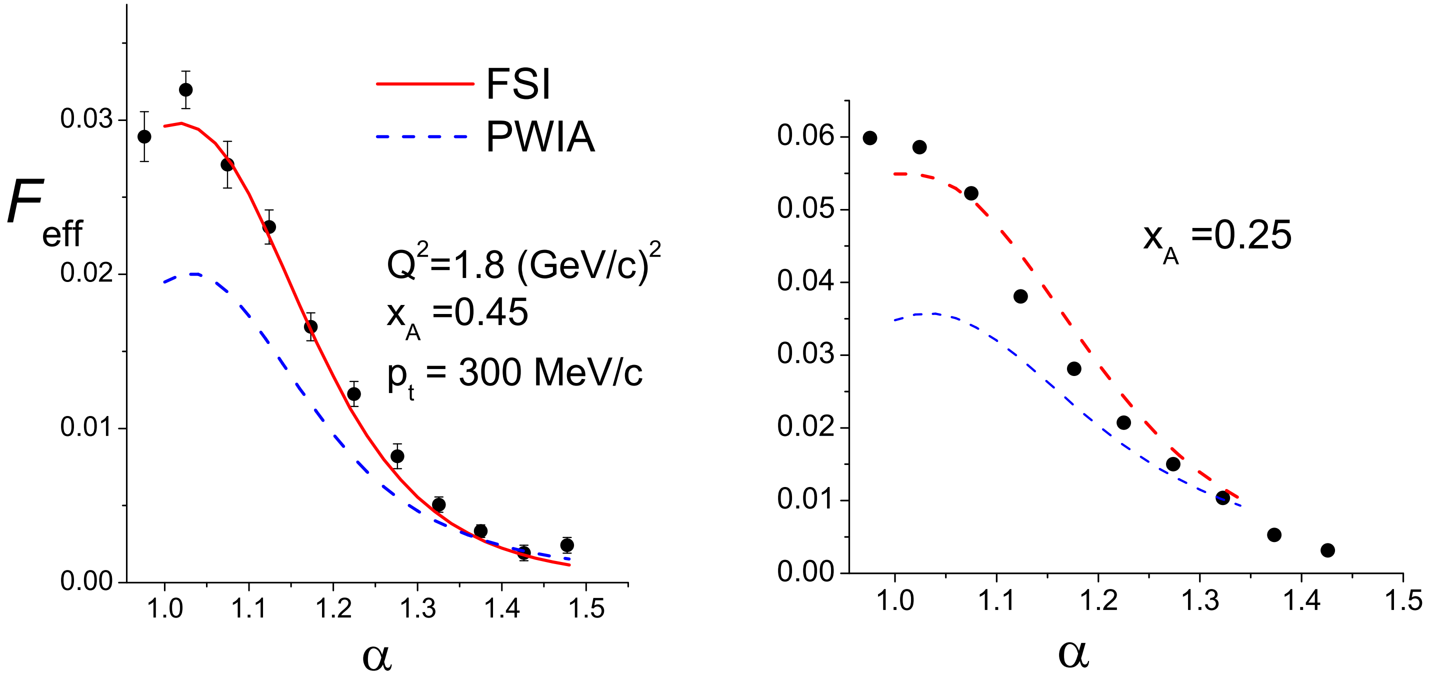
Survival probability of A-1



$$T = \int_{-\infty}^{\infty} dz\, \rho(\vec{b}, z) \exp\left[- S(\vec{b}, z)\right] \qquad S(\vec{b}, z) = \int_{z}^{\infty} dz'\, \rho_A(\vec{b}, z')\, \sigma_{eff}(z' - z)$$

(After CdA, Kopeliovich, EPJA17(2002)133)

$^2H(e,e'p)X$ theory *vs.* experiment



$$F_{eff} \equiv N_A^D(\alpha, \mathbf{p}_T) F_2^{(N/A)}\left(\frac{x_{Bj}}{2-\alpha}, Q^2\right) \qquad \alpha = \frac{E - p_\parallel}{m_N}$$

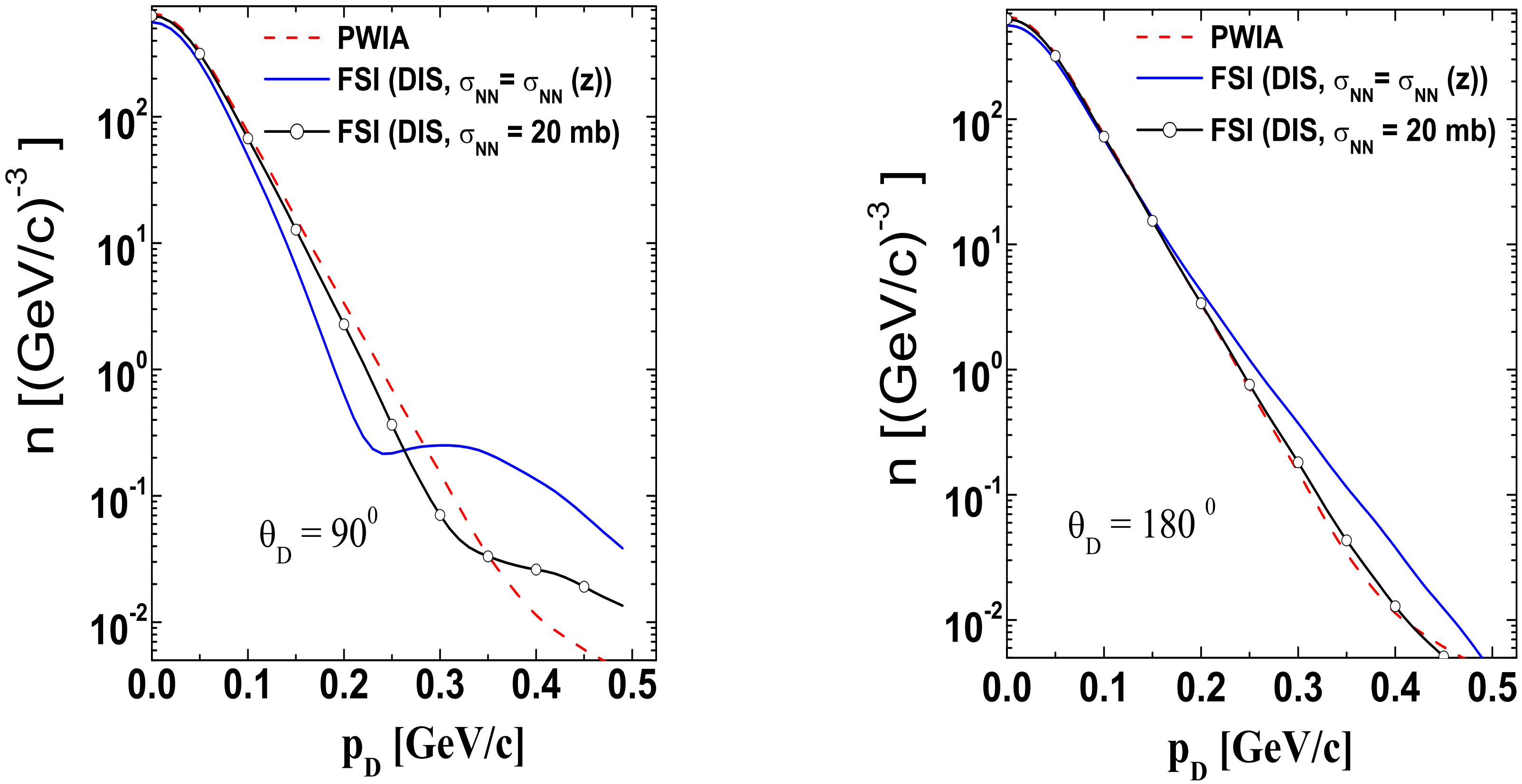
Experiment(PRELIMINARY):

Jlab 94-102 S. E. Kuhn, K. A. Griffioen , co-spokespersons,

Inelastic electron scattering off a **moving nucleon** *in deuterium*

Theory : CdA, Kaptari, to appear

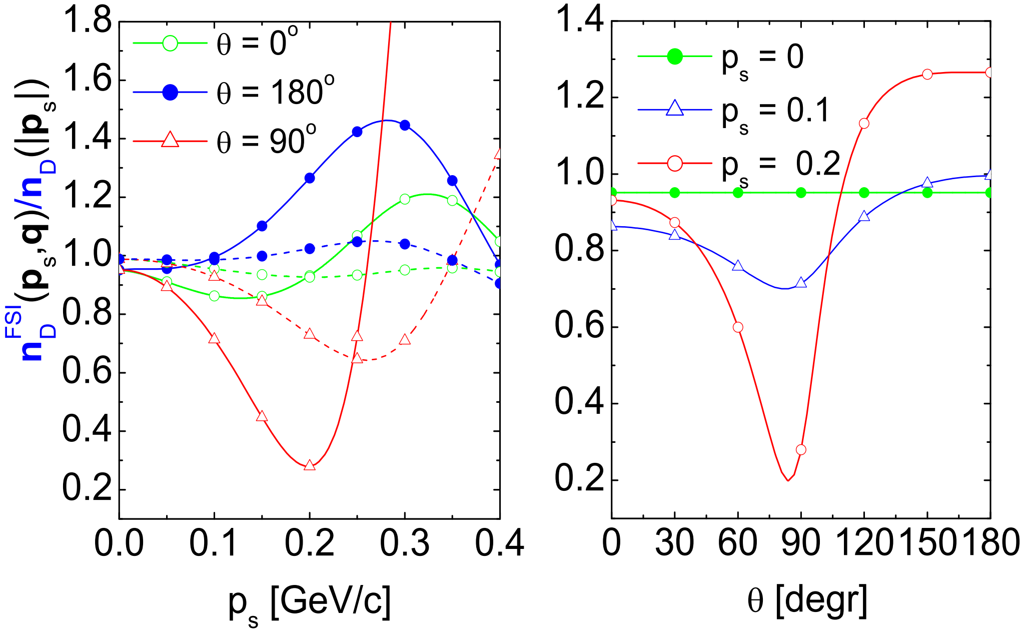
$\boxed{^3He(e,e'D)X}$



$$\theta_D = \widehat{\mathbf{q}\mathbf{p}}_D$$

(After CdA, Kaptari unpublished)

$^2H(e, e'p)X$

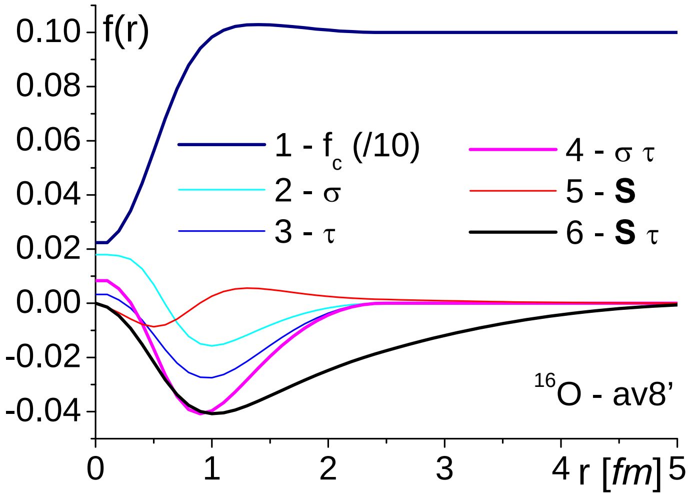


The SIDIS ratio n_D^{FSI}/n_D with n_D^{FSI}, calculated *vs.* the momentum $p_s \equiv |\mathbf{p}_s|$ of the spectator nucleon emitted at different angles θ_s. The full lines correspond to the Q^2- and z-dependent debris-nucleon effective cross section σ_{eff}, whereas the dashed lines correspond to a constant cross section $\sigma_{eff} = 20\,mb$. $Q^2 = 5\ (GeV/c)^2$, $x = 0.2$.

6 The nuclear wave function and high energy scattering

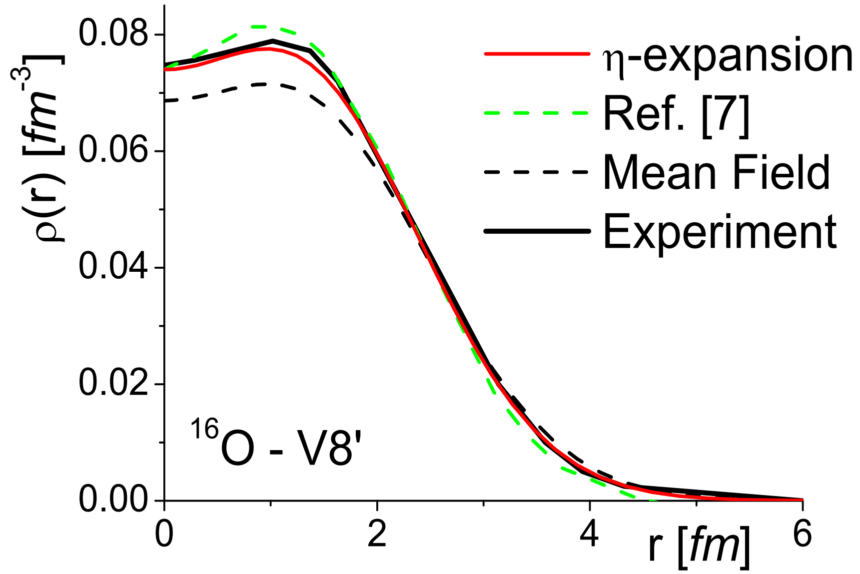
	$< V_c >$	$< V_\sigma >$	$< V_\tau >$	$< V_{\sigma\tau} >$	$< V_S >$	$< V_{S\tau} >$	$< \mathbf{V} >$	$< \mathbf{T} >$	$\mathbf{E}$	$\mathbf{E/A}$
$\eta - exp$	0.19	-35.88	-9.47	-171.32	-0.003	-172.89	-389.40	323.50	-65.90	-4.12
FHNC	0.694	-40.13	-10.61	-180.00	-0.07	-160.32	-390.30	325.18	-65.12	-4.07

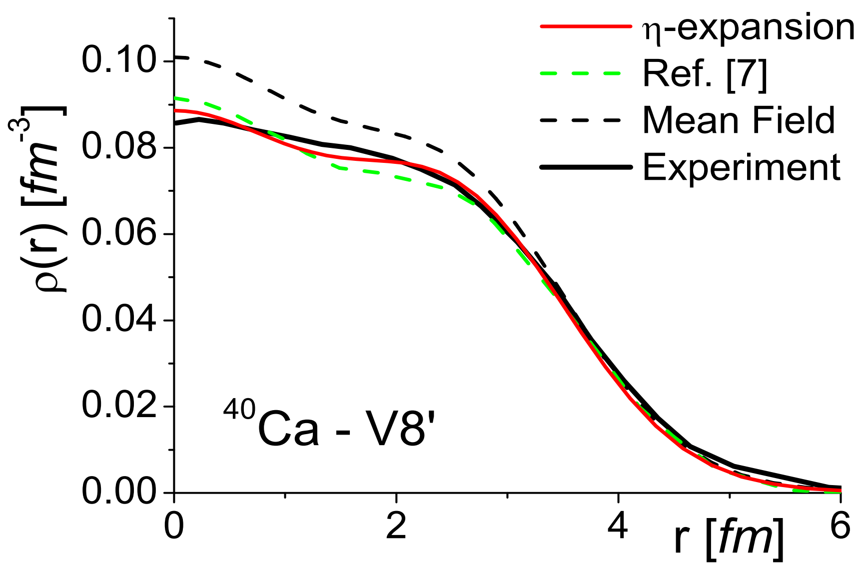
(All quantities in MeV)



A. Fabrocini, G. Co' ***Phys. Rev.*** **C61 (2000) 044302**

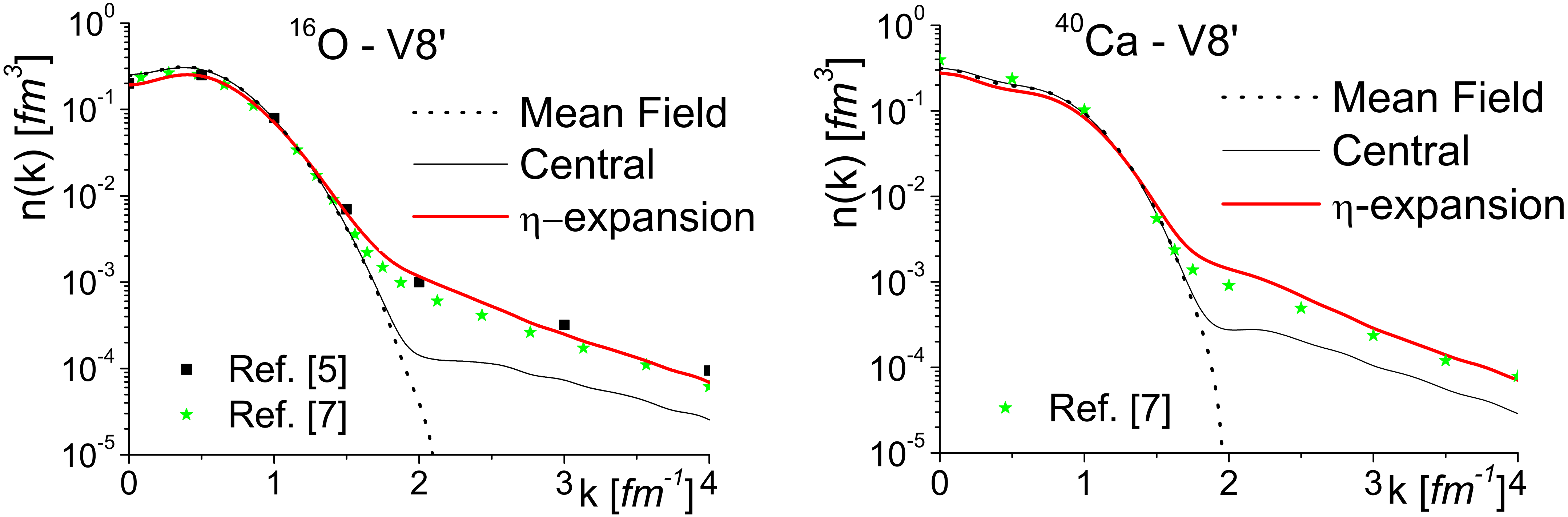
The charge density





[7] *FHNC*: ***Fabrocini, de Saavedra, Co'***
***Phys. Rev.* C61, (2000) 044302**
η − exp.: ***M.Alvioli, C.d.A., H.Morita; Phys. Rev.* C *in press***

The momentum distributions



[5]VMC: ***Pieper, Wiringa, Pandharipande, Phys. Rev. C46, (1992) 1741***

[7]*FHNC*: ***Fabrocini, de Saavedra, Co', Phys. Rev. C61, (2000) 044302***

η − exp.: ***M.Alvioli, C.d.A., H.Morita; Phys. Rev. C in press***

6.1 *Applications: Example 1*: the distorted momentum distributions

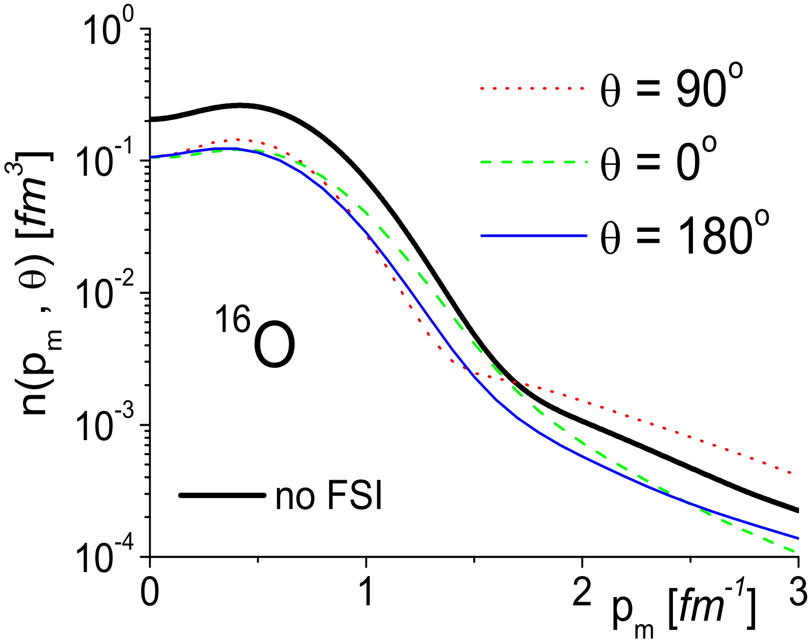
Definition of *distorted momentum distribution* **:**

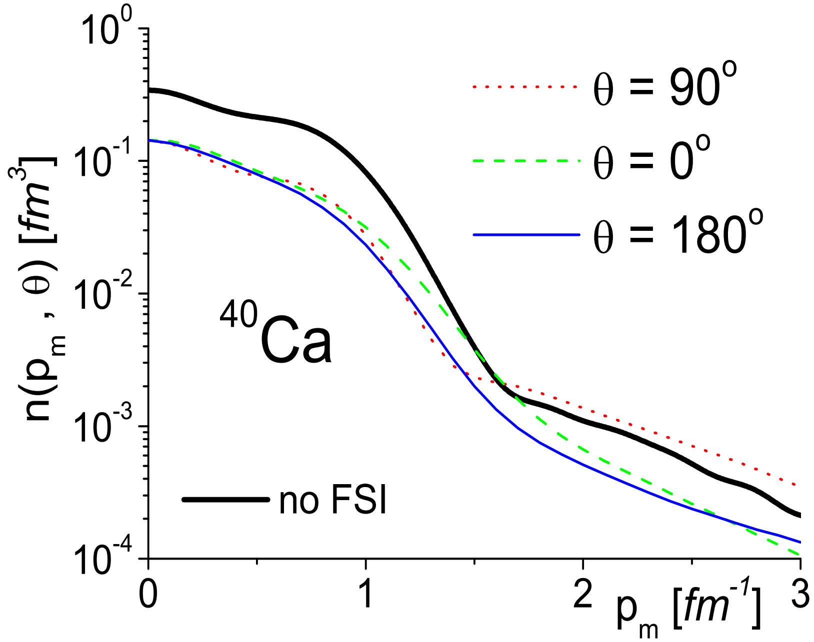
$$n_A^D(\boldsymbol{p}_m) = \frac{1}{(2\pi)^3} \int d\boldsymbol{r}_1 d\boldsymbol{r}'_1 \, e^{i\,\boldsymbol{p}_m\cdot(\boldsymbol{r}_1-\boldsymbol{r}'_1)} \, \rho_D(\boldsymbol{r},\boldsymbol{r}')$$

$$\rho_D(\boldsymbol{r},\boldsymbol{r}') = \frac{\langle\Psi_o|\, \hat{S}_G^\dagger \;\; \hat{\rho}^{(1)}(\boldsymbol{r},\boldsymbol{r}') \;\; \hat{S}_G \,|\Psi_o\rangle}{\langle\Psi_o|\, \hat{S}_G^\dagger \, \hat{S}_G \,|\Psi_o\rangle}$$

$$\Psi_o = \left[\sum_n f^{(n)}(r_{ij})\,\hat{\mathcal{O}}_{ij}^{(n)}\right] \phi_o$$

Cluster expansion of $\rho_D(\boldsymbol{r},\boldsymbol{r}')$ at 1st order in $\eta_{ij} \equiv 1 - f^*_{ij} f_{ij}$ including rescattering to all orders(CdA, D. Treleani, Phys. Rev. C60(1999)024602; M.Alvioli, C.d.A., H.Morita, *Phys. Rev. C, in press*)





$$|\boldsymbol{p}_m| = |\boldsymbol{q} - \boldsymbol{p}'| \qquad \cos\theta = \frac{\boldsymbol{p}'\,\boldsymbol{q}}{|\boldsymbol{p}'|\,|\boldsymbol{q}|}$$

$$n_A(\boldsymbol{p}_m) \equiv n_A(p_m, \theta)$$

Applications. Example 2: the total *neutron – Nucleus* cross section at high energies

$$\boxed{\sigma_{tot} = \frac{4\pi}{k} Im\left[F_{00}(0)\right] \qquad F_{00}(\boldsymbol{q}) = \frac{ik}{2\pi}\int d^2 b_n e^{i\mathbf{q}\cdot\mathbf{b_n}}\left[1 - \mathrm{e}^{\mathbf{i}\,\chi_{\mathbf{opt}}(\mathbf{b_n})}\right]}$$

$$\mathrm{e}^{\mathbf{i}\,\chi_{\mathbf{opt}}(\boldsymbol{b}_{\mathbf{n}})} = \int \prod_{j=1}^{A}\left[1 - \Gamma(\boldsymbol{b}_n - \boldsymbol{s}_j)\right] |\Psi_0(\boldsymbol{r}_1, ..., \boldsymbol{r}_A)|^2 \delta\left(\frac{1}{A}\Sigma\mathbf{r}_j\right) \prod_{j=1}^{A} d\boldsymbol{r}_j. \qquad (2)$$

The exact expansion of $|\Psi|^2$ (Foldy & Walecka):

$$|\Psi(\boldsymbol{r}_1, ..., \boldsymbol{r}_A)|^2 = \prod_{j=1}^{A} \rho(\boldsymbol{r}_j) + \sum_{i<j=1}^{A} \boldsymbol{\Delta}(\boldsymbol{r}_{\mathbf{i}}, \boldsymbol{r}_{\mathbf{j}}) \prod_{k\neq(il)}^{A} \rho(\boldsymbol{r}_k) + ... \qquad (3)$$

where the *two-body contraction* Δ is

$$\boldsymbol{\Delta}(\boldsymbol{r}_{\mathbf{1}}, \boldsymbol{r}_{\mathbf{2}}) = \left[\rho^{(2)}(\boldsymbol{r}_1, \boldsymbol{r}_2) - \rho^{(1)}(\boldsymbol{r}_1)\,\rho^{(1)}(\boldsymbol{r}_2)\right]$$

and the various density matrices are

$$\rho(\boldsymbol{r}_j) \equiv \rho^{(1)}(\boldsymbol{r}_j) = \int |\Psi(\boldsymbol{r}_1, ..., \boldsymbol{r}_A)|^2 \, d\boldsymbol{r}_2 ....d\boldsymbol{r}_A \tag{4}$$

$$\rho^{(2)}(\boldsymbol{r}_1, \boldsymbol{r}_2) = \int |\Psi(\boldsymbol{r}_1, ..., \boldsymbol{r}_A)|^2 \, d\boldsymbol{r}_3 ....d\boldsymbol{r}_A \tag{5}$$

and so on. The one- body and two-body density matrices have been calculated by the cluster expansion, the two-body contraction has been obtained and the optical phase shifts becomes

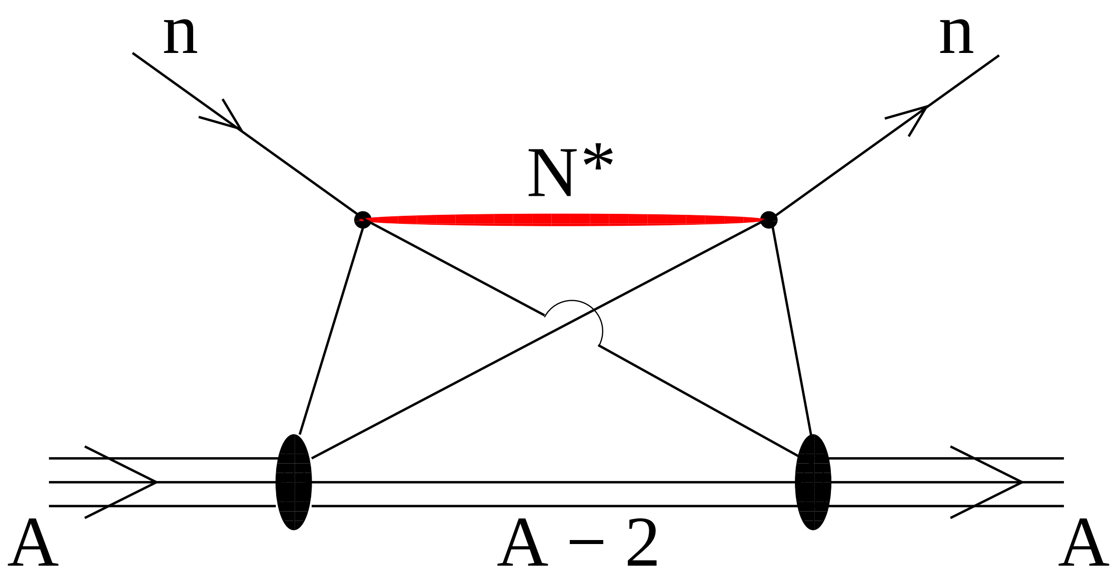
$$\mathrm{e}^{\mathrm{i}\,\chi_{\mathrm{opt}}(\boldsymbol{b}_{\mathrm{n}})} \simeq$$
$$exp\left[- A \int d\boldsymbol{r}_1\, \rho(\boldsymbol{r}_1)\, \Gamma(\boldsymbol{b}_n - \boldsymbol{s}_1) + A^2 \frac{\int d\boldsymbol{r}_1 d\boldsymbol{r}_2\, \boldsymbol{\Delta}(\boldsymbol{r}_1, \boldsymbol{r}_2)\, \Gamma(\boldsymbol{b}_n - \boldsymbol{s}_1)\, \Gamma(\boldsymbol{b}_n - \boldsymbol{s}_2)}{1 - \int d\boldsymbol{r}_1\, \rho(\boldsymbol{r}_1)\, \Gamma(\boldsymbol{b}_n - \boldsymbol{s}_1)}\right]$$

The effects of correlations on the total cross section can therefore be realistically evaluated.

Inelastic shadowing

(Diffractive excitation of the projectile)

V. N. Gribov, Sov. JETP 29(1969)483;
V. A. Karmanov, L. A. Kondratyuk, Sov. JETP Lett. 18(1973)451;
B. K. Jennings, G. A. Miller, Phys. Rev. C49 (1999)2637

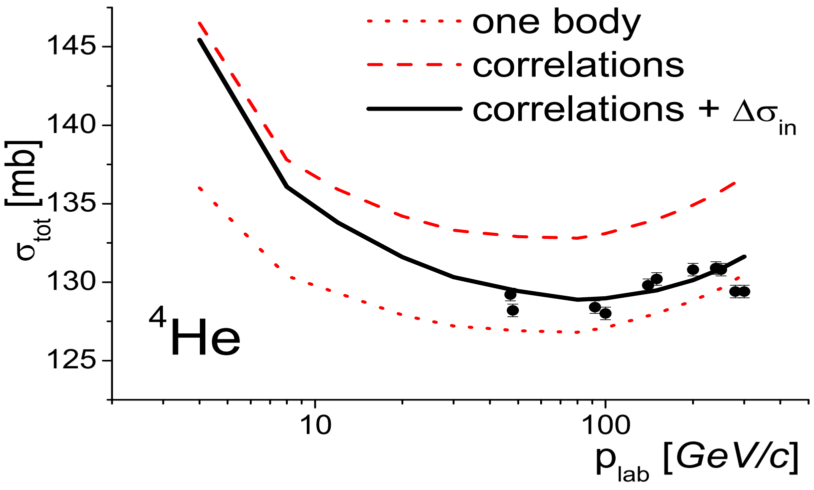


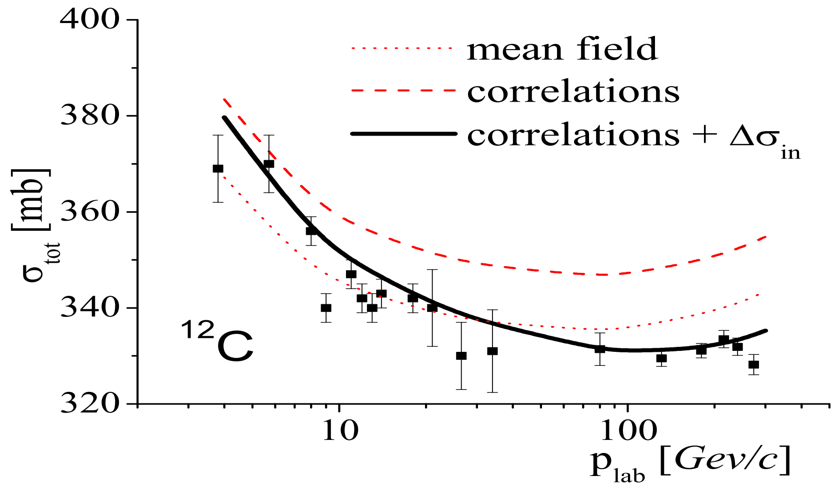
$$\sigma_{tot} = \frac{4\pi}{k} Im\,[F_{00}(0)] + \Delta\sigma_{in}$$

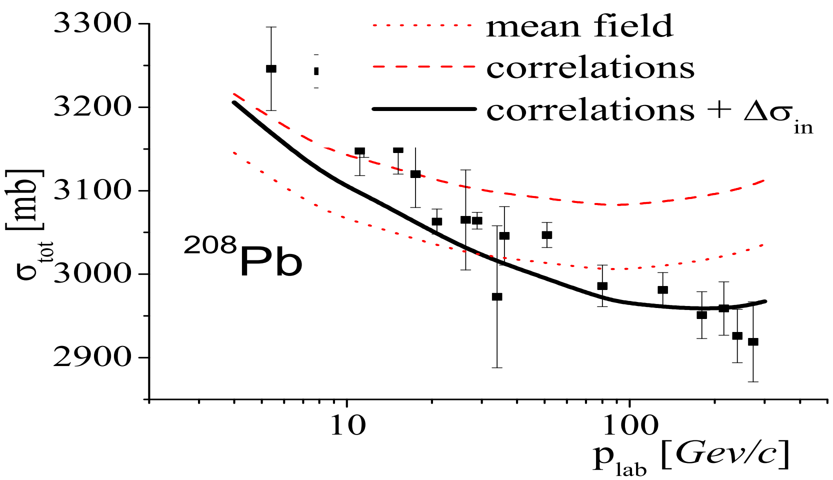
RESULTS

Isabella Marchino, Diploma Thesis (2004)

M. Alvioli, C.d.A, I. Marchino, H. Morita, to appear

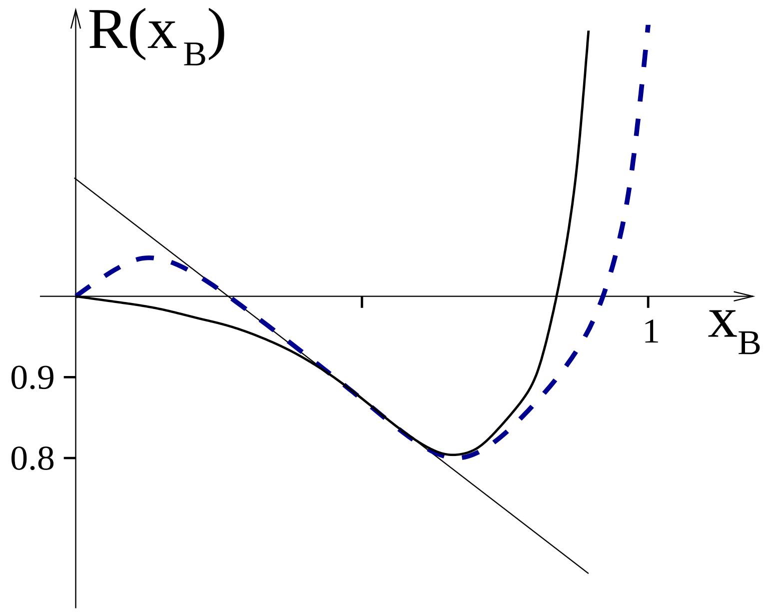






No adjustable parameters

Applications. Example 3: the PDF in the medium



Inclusive Deep Inelastic- EMC

Q^2 rescaling

Fermi motion and binding

5. CONCLUSIONS

- a time-dependent debris-nucleon cross section has been obtained; it incorporates both non perturbative (string) and Q^2-dependent perturbative (gluon radiation) effects; it accounts for the bulk of the FSI interaction of the debris created by the hard interaction of a bound nucleon with $\gamma*$;
- the (parameter-free) calculation of the Q^2 and x_{Bj} dependence of the average number of the Grey Tracks produced in Deep Inelastic $\mu - Xe$ scattering exhibits a very satisfactory agreement with the experimental data, thanks to the gluon radiation mechanism for hadron production;
- the preliminary calculation of the Semi Exclusive DIS off the deuteron seems to exhibits good agreement with preliminary data from Jlab; the agreement is a qualitative one (no detector acceptance, etc), but a systematic investigation of the x_{Bj}

and Q^2 dependence of SIDIS would shed further light on the hadronization mechanisms and bound structure functions.

- **The role of the nuclear wave function in some high energy scattering processes has been carefully analyzed. The role might e large and should be further investigatd**