Color Transparency from Generalized Parton Distributions

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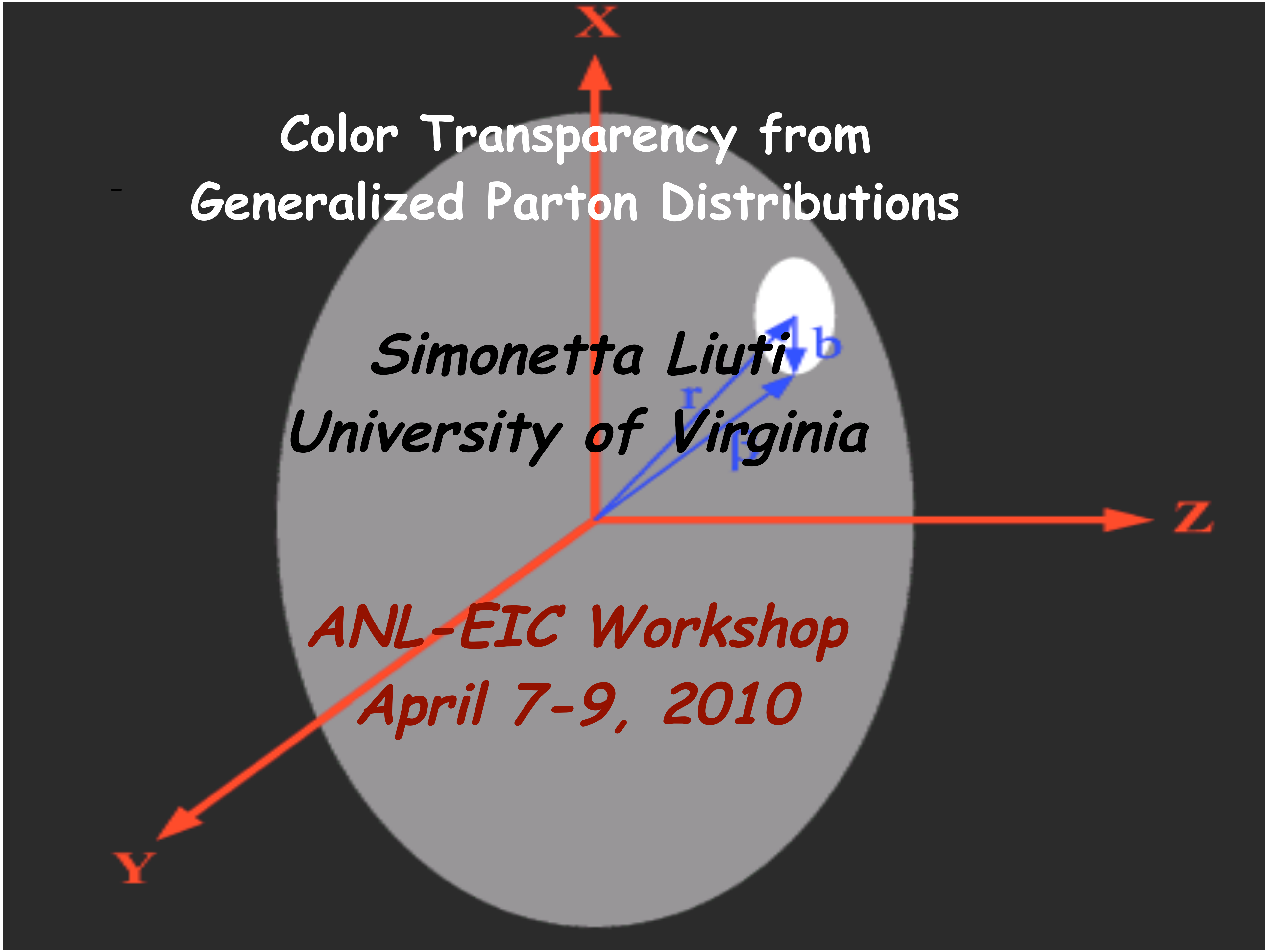
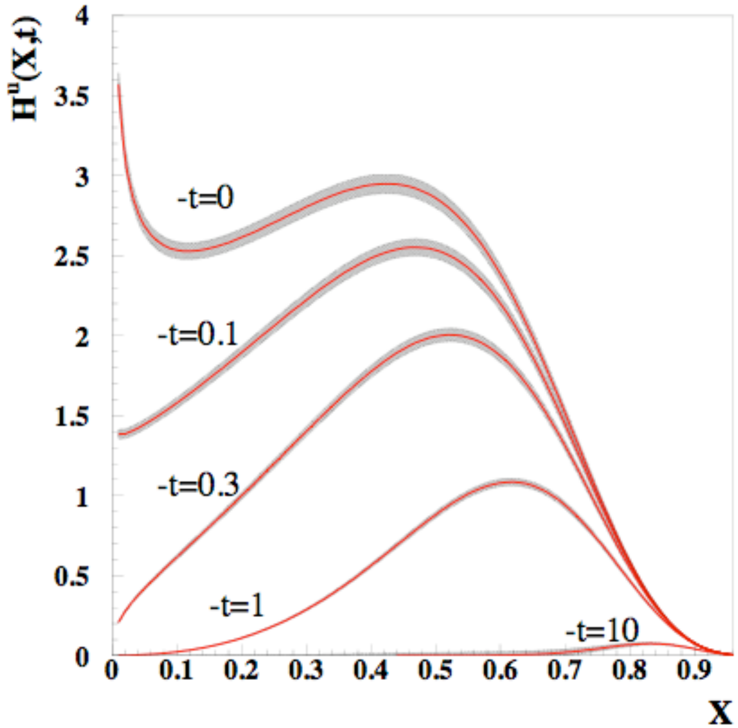


First of all: the purpose of this talk is to facilitate discussions (I am presenting a far from complete picture).

Two papers, so far, directly on the subject:
Burkardt and Miller, Phys.Rev.D74:034015,2006
Liuti and Taneja, Phys.Rev.D70:074019,2004

To start talking, I will use a model and/or parametrization of GPDs that is consistent with available data on both inclusive and exclusive scattering



" reggeized diquark model",
Ahmad, Honkanen, S.L., Taneja
Phys.Rev.D75:094003,2007
Eur.Phys.J.C63:407-421,2009

$H_q(X, \zeta\ t) = R(X, \zeta\ t)\ G(X, \zeta\ t)$

"Regge" Quark-Diquark

AHLT Parameterization

ζ=0

v1

$$H^I(X,t) = G_{M_X^I}^{\lambda^I}(X,t)\, X^{-\alpha^I - \beta_1^I (1-X)^{p_1^I} t}$$

$$E^I(X,t) = \kappa\, G_{M_X^I}^{\lambda^I}(X,t)\, X^{-\alpha^I - \beta_2^I (1-X)^{p_2^I} t}$$

7 + 1 (Q_o) parameters

v2

$$H^{II}(X,t) = G_{M_X^{II}}^{\lambda^{II}}(X,t)\, X^{-\alpha^{II} - \beta_1^{II} (1-X)^{p_1^{II}} t}$$

$$E^{II}(X,t) = G_{\widetilde{M}_X^{II}}^{\widetilde{\lambda}^{II}}(X,t)\, X^{-\widetilde{\alpha}^{II} - \beta_2^{II} (1-X)^{p_2^{II}} t}$$

10 + 1 (Q_o) parameters

$\Rightarrow$ **use v1 for DGLAP region (X > ζ)**

$\zeta \neq 0$

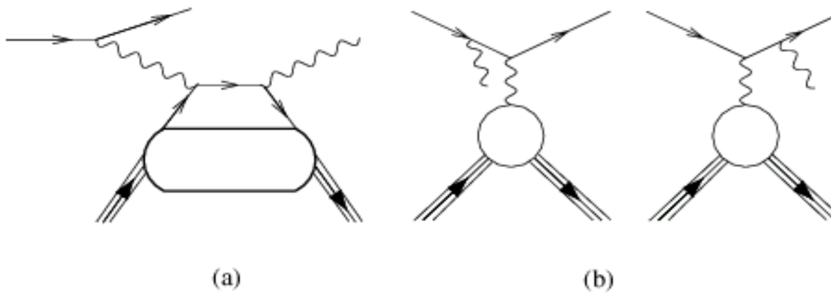
$$H^I(X,\zeta,t) = G_{M_X^I}^{\lambda^I}(X,\zeta,t)\, R_1^I(X,\zeta,t)$$

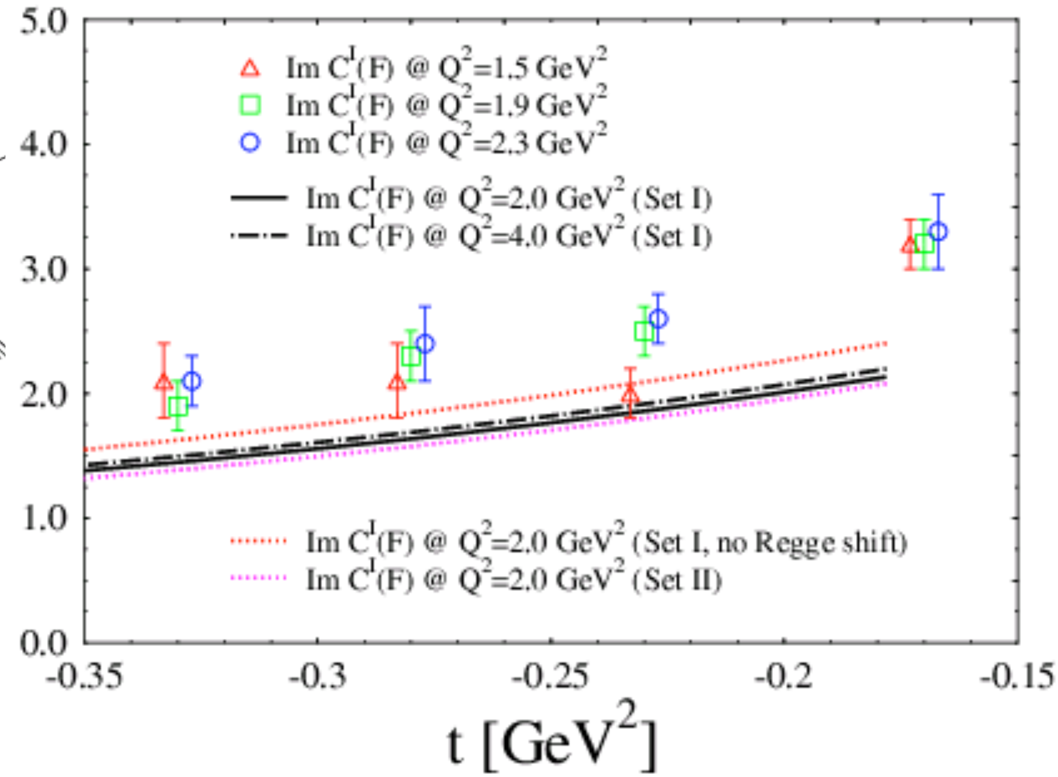
$$E^I(X,\zeta,t) = \kappa\, G_{M_X^I}^{\lambda^I}(X,\zeta,t)\, R_2^I(X,\zeta,t)$$

More details in AHLT, PRD 2007

Comparison with Jlab Hall A data (proton)

Munoz Camacho et al. (2006)





- Observable given by Interference Term between DVCS (a) and BH(b):

$$d\sigma^{\rightarrow} - d\sigma^{\leftarrow} \propto \sin\phi \left[F_1(\Delta^2)\mathcal{H} + \frac{x}{2-x}(F_1+F_2)\widetilde{\mathcal{H}} + \frac{\Delta^2}{M^2}F_2(\Delta^2)\mathcal{E}\right]$$

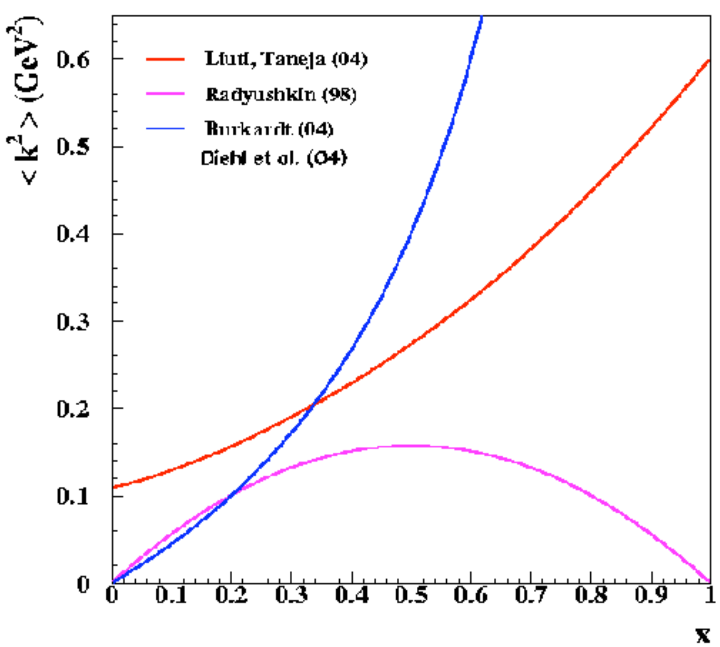
$$\mathcal{H} = \sum_q e_q^2 \left(H(\xi,\xi,\Delta^2) - H(-\xi,\xi,\Delta^2)\right)$$

Note!!

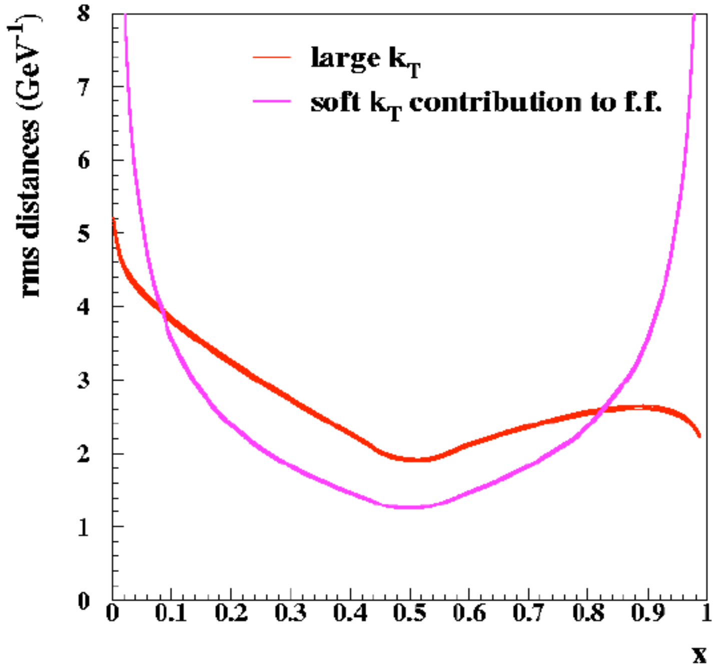
Im *H* from asymmetry

Re *H* from x-section

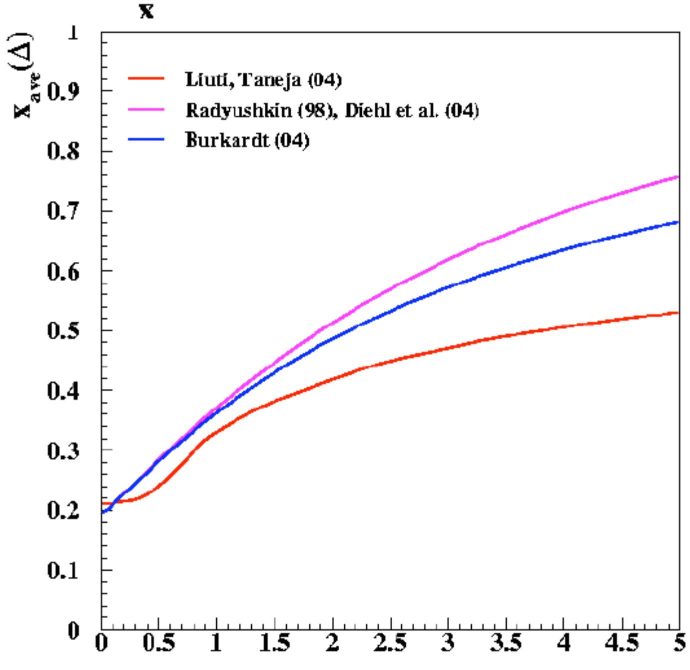
$\langle k_T^2 \rangle$ vs. x



$\langle r^2 \rangle = \langle b^2 \rangle / (1-x)$ vs. x *(M. Burkardt)*



$\langle x \rangle$ vs. Δ



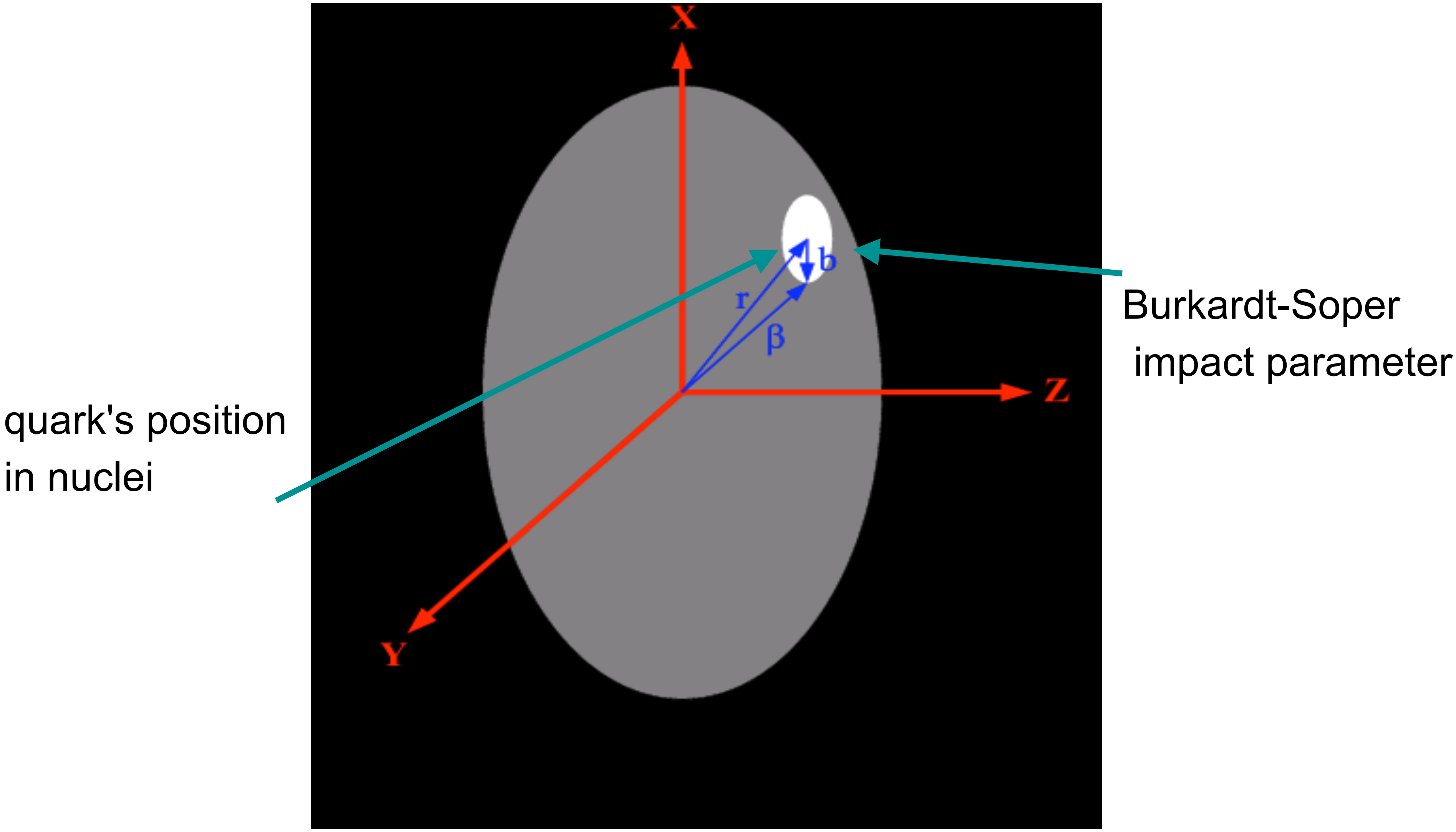
Color Transparency

Onset of Color Transparency requires that:

1) Interaction of the hadron in the nuclear medium is reduced due to decreased gluon radiation from a small size color dipole
2) Small size configuration, which evolves with time into larger configurations remains sufficiently small during the time it crosses the nucleus.

However… many corrections are possible (see M.Strikman's talk), in particular ISI… the in medium form factor is different from the on-shell one

Spatial structure of quarks and gluons in nuclei



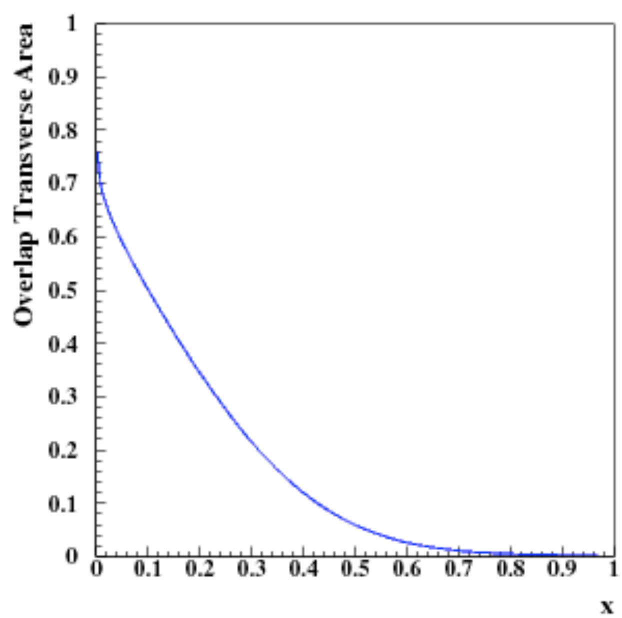
Transverse "Area Overlap" for a hard nuclear process

$$\langle b_A^2(X)\rangle = \frac{1}{q_A(X)}\left[\int_X^A dY\langle b_N^2(X/Y)\rangle q_N(X/Y) f_A(Y) + \int_X^A dY\langle \beta^2(Y)\rangle q_N(X/Y) f_A(Y)\right].$$

$$A_{op} = \frac{\langle b_N^2(X)\rangle}{\langle b_A^2(X)\rangle} = \frac{1}{1+\frac{\langle \beta^2(X)\rangle}{\langle b_N^2(X)\rangle}}$$

Overlap volume previously calculated with "semi-empirical" models!

Transverse "Area Overlap"



Nuclear Exclusive: Form Factor in Nuclei

S.L., hep-ph/0601125

$$\boxed{F_A(t) = \int_0^A dx H_A(x,t)}$$

$$F_A^{LC}(t) = F_A^{point}(t) F_N(t)$$

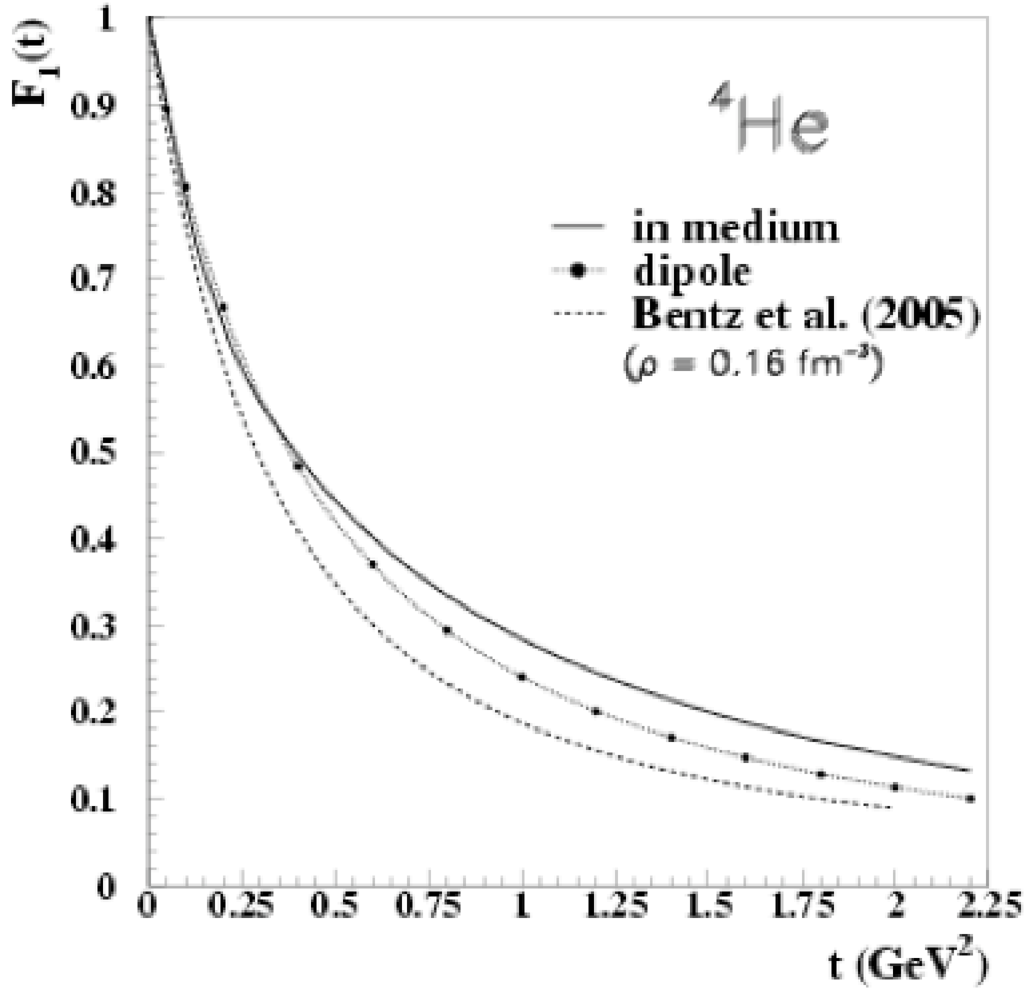
$$F_A(t) = \int_X^A dY \int dP^2 \rho_A(Y,t;P^2) H_N\left(\frac{X}{Y}, t; P^2\right)$$

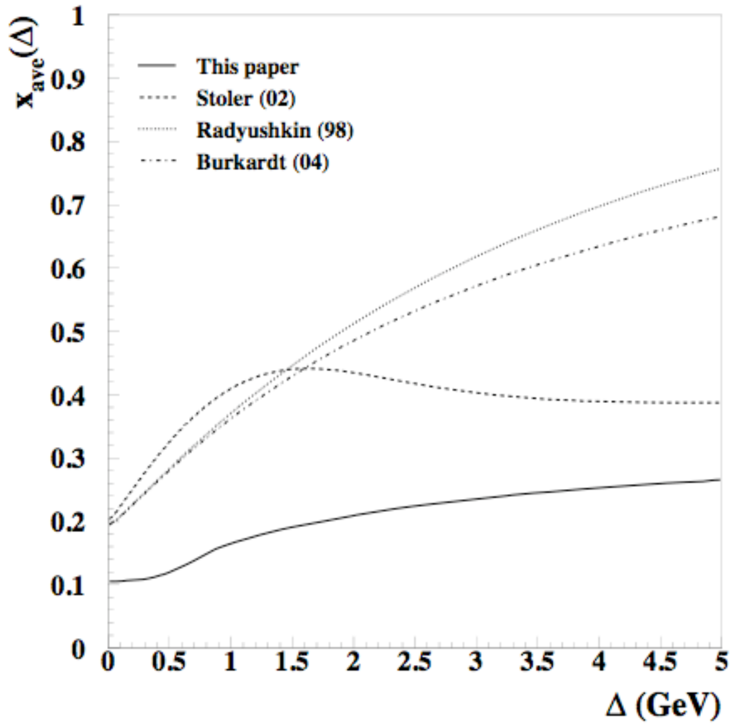
$$\boxed{\hat{F}_1^N(t) = \left[\frac{F^A(t)}{F_{LC}^A(t)}\right] F_1^N(t)}$$

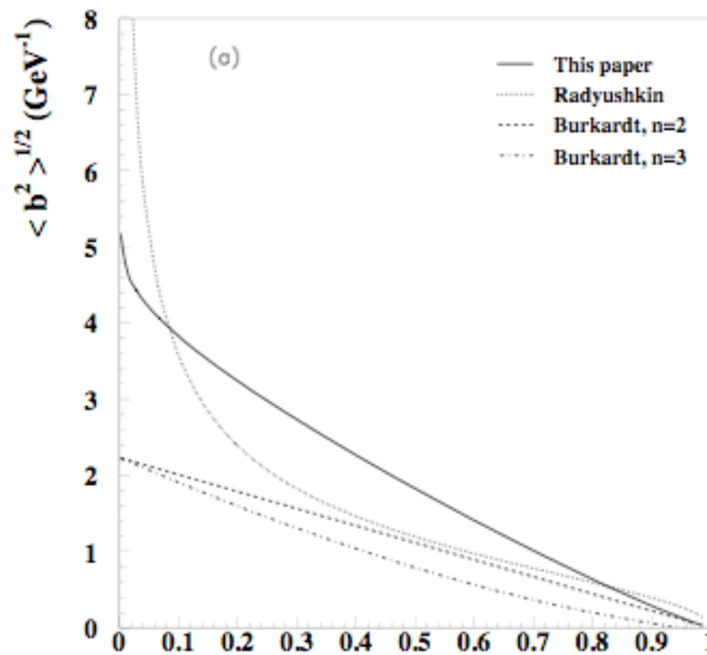
↑ **Medium Modified Form Factor** ↑

Form Factor in Nuclei

S.L., hep-ph/0601125





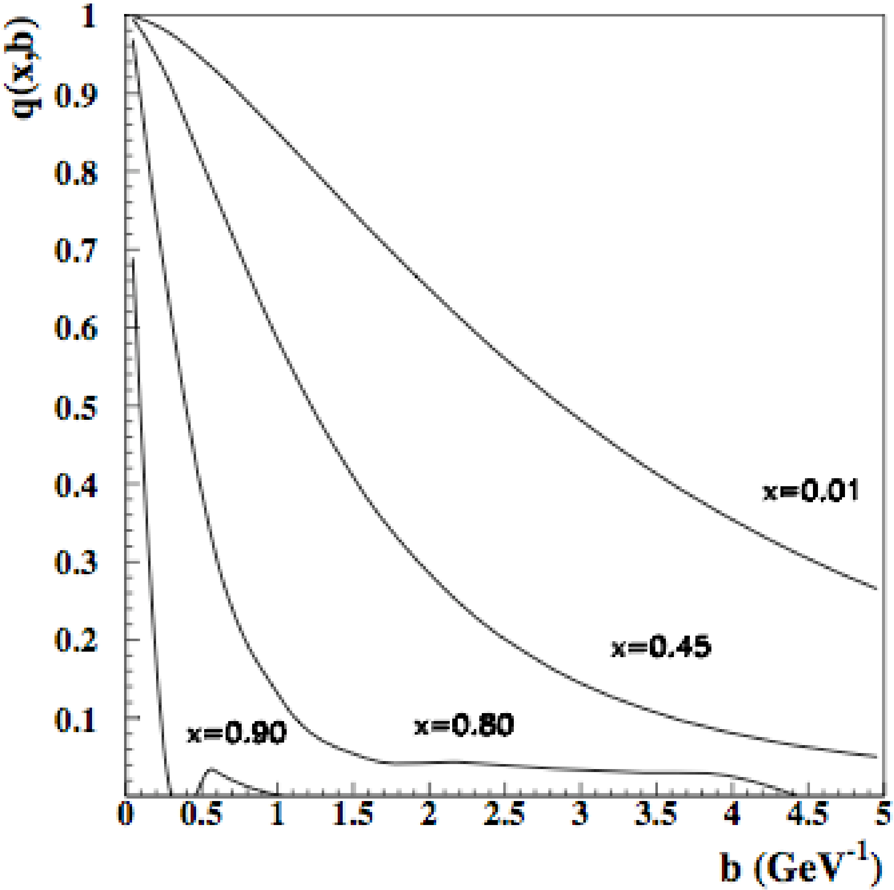


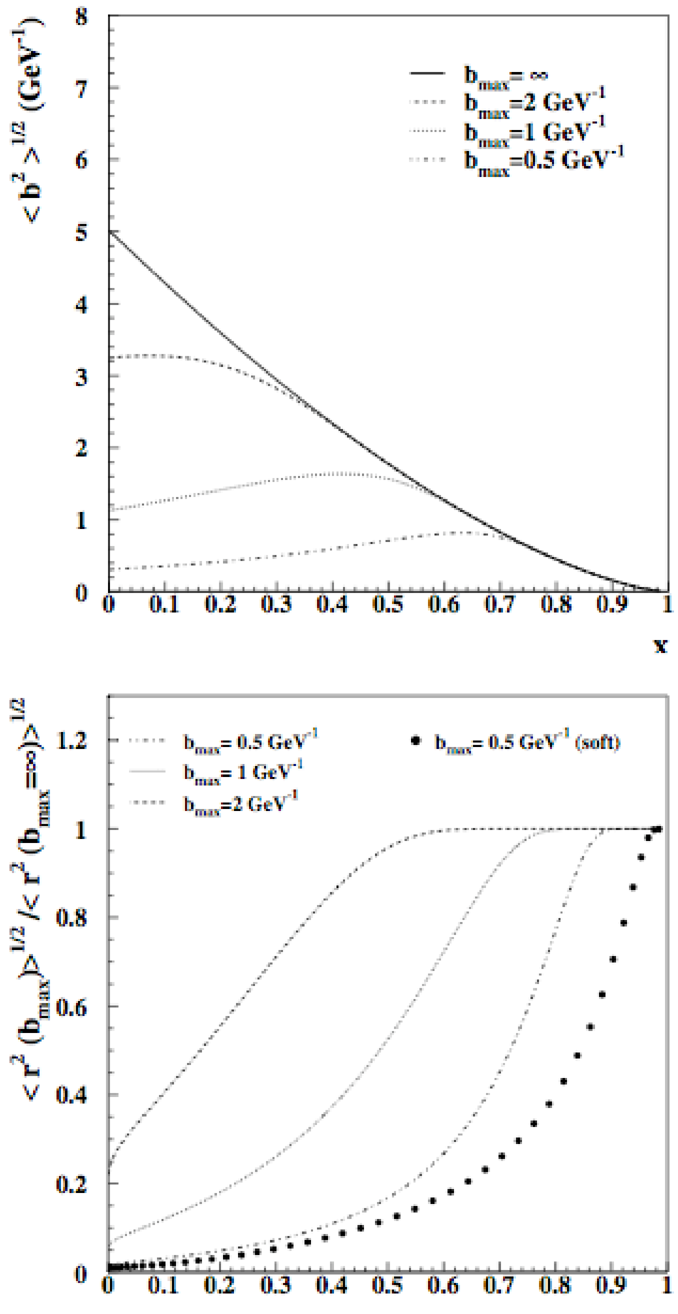
$$x_{ave}(\Delta) = \frac{\int H(x,\Delta)xdx}{\int H(x,\Delta)dx}$$

$$\langle b^2 \rangle = \frac{\int q(x,b)b^2 d^2 b}{\int q(x,b)d^2 b}$$

Average x grows with Δ

Average transverse distance decreases with x


q(x,b)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
b (GeV^-1)
x=0.01
x=0.45
x=0.80
x=0.90



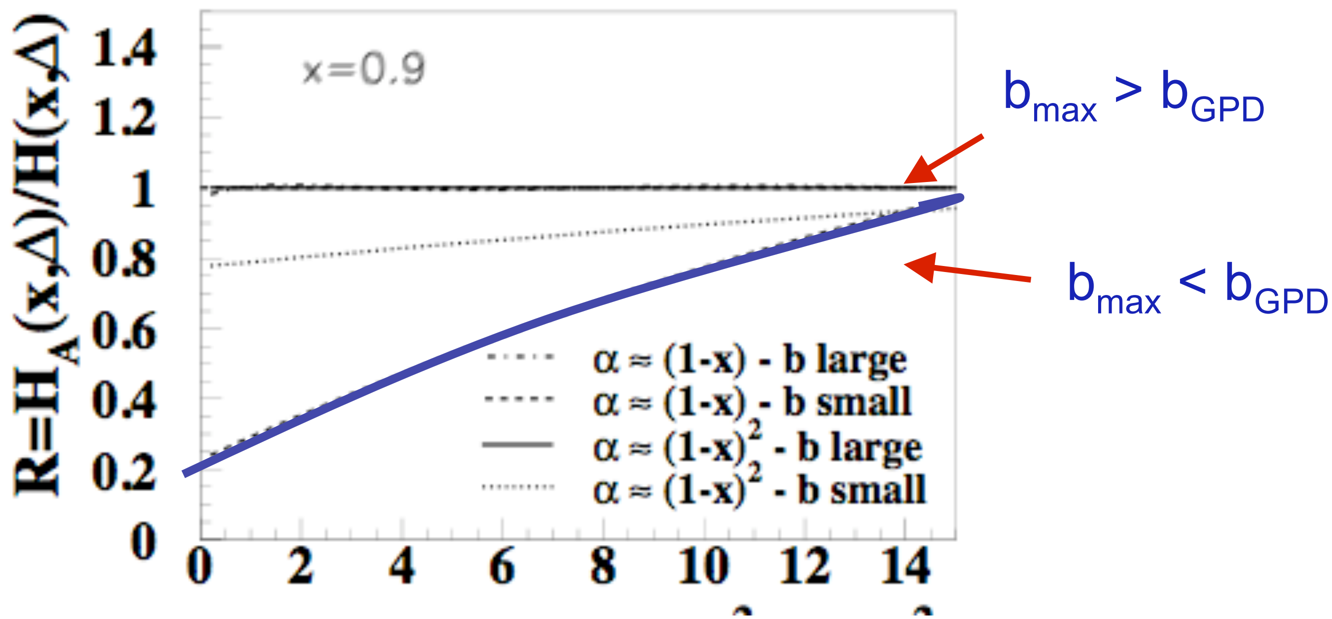
$<b^2>^{1/2}$ (GeV^{-1})
$b_{max}=\infty$
b_{max}=2 GeV^{-1}
b_{max}=1 GeV^{-1}
b_{max}=0.5 GeV^{-1}
x
$<r^2(b_{max})>^{1/2}/<r^2(b_{max}=\infty)>^{1/2}$
b_{max}= 0.5 GeV^{-1}
b_{max}= 1 GeV^{-1}
b_{max}=2 GeV^{-1}
b_{max}= 0.5 GeV^{-1} (soft)

"If configurations with small radii exist, they can be isolated by performing CT and/or nuclear filtering experiments"

Define filter as
$$\Pi(b) = \begin{cases} 1 & b < b_{max}(A) \\ 0 & b \geq b_{max}(A) \end{cases}$$

This affects the GPD as
$$H_A(x,Q^2) = \int_0^{b_{max}(A)} db\, b\, q(x,b) J_0(b\Delta),$$

Transparency ratio
$$T_A(Q^2) = \frac{\left[\int_0^1 dx H_A(x,\Delta)\right]^2}{\left[\int_0^1 dx H(x,\Delta)\right]^2},$$



$$q(x,b) = A(x)\exp\left[-\alpha(x)\, b\right]$$

$\alpha(x) \approx (1-x)$ soft k_T, large nucleon size

$\alpha(x) \approx (1-x)^2$ hard k_T, small nucleon size

$$\boxed{R = 1 - \exp(-\alpha b_{\max})[\alpha b_{\max} J_0(\Delta b_{\max}) + \cos(\Delta b_{\max})].}$$

This procedure, systematically applied to a sufficiently large body of data including both existing and planned measurements [6,13,14,43], gives a much more direct test of the transverse sizes involved. Once this basic information is known from measurements—and not inferred from theoretical scenarios—one would be able to introduce more sophisticated modeling of, e.g., rescattering

Unrelated…

New! Test OAM SR in Spin 1 system: Deuteron

(S. Taneja, K. Kathuria, S.L.)

$$\boxed{J_q = \frac{1}{2}\int dX\, X\, H_2^q(X,0,0) \equiv \frac{1}{2} G_{5,2}(0)}$$

$$\int_{-1}^{1} dx\, H_i(x,\xi,t) = G_i(t) \qquad (i = 1,2,3).$$

Cano and Pire PRL78 (2001)

(Near) Future working plan for EIC

-- Need to study more systematically interdependence of k_T, b, x

-- Very much need a systematic study of what ranges of observables, x_{Bj}, t, Q^2, are needed to extract "b" dependence at both proton and nuclear level

-- b_{max} can already be extracted from existing body of data