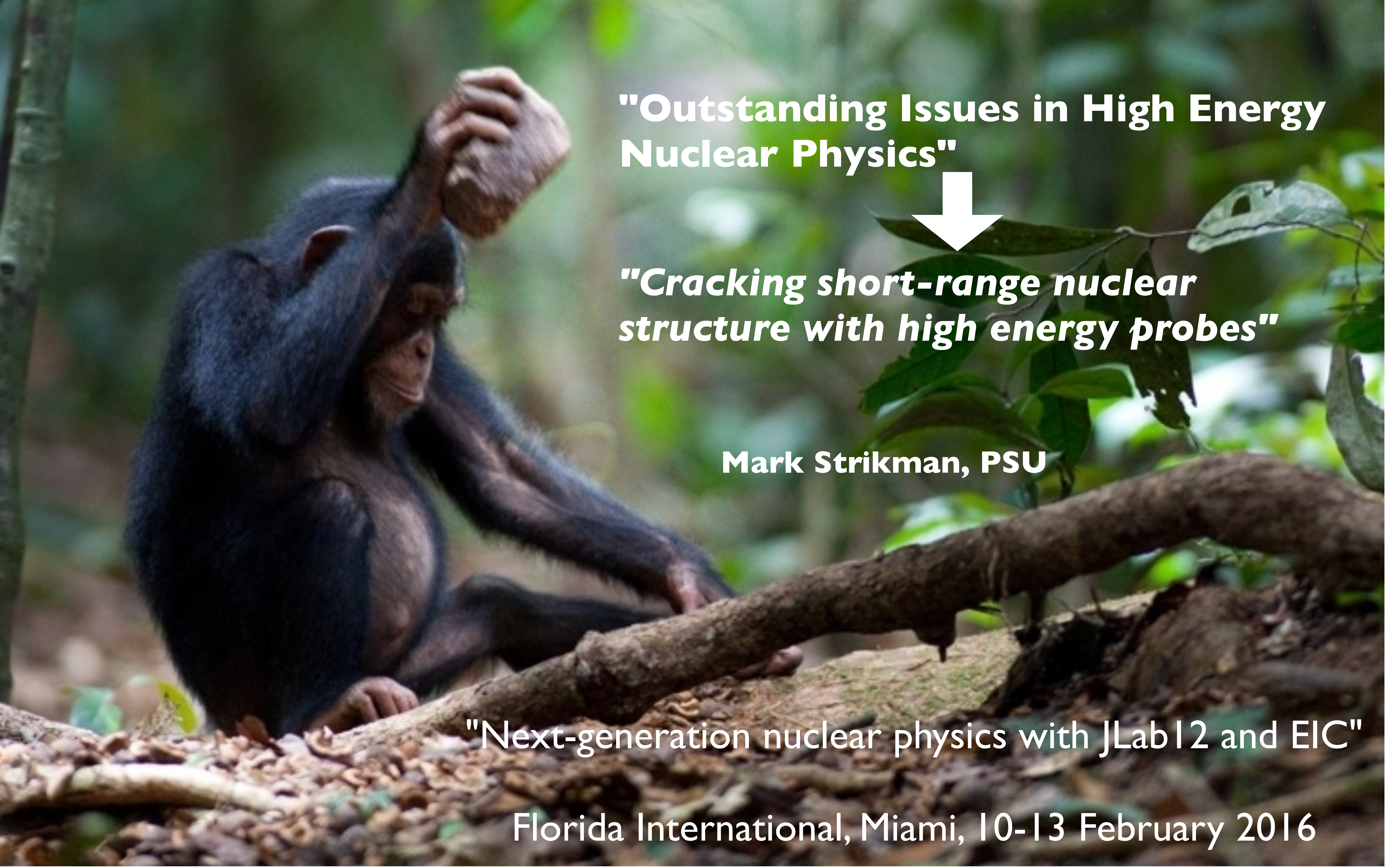

"Outstanding Issues in High Energy Nuclear Physics"
"Cracking short-range nuclear structure with high energy probes"
Mark Strikman, PSU
"Next-generation nuclear physics with JLab12 and EIC"
Florida International, Miami, 10-13 February 2016

Main topics to be discussed

Open questions of microscopic nuclear structure

Four resolution scales in resolving structure of nuclei

Why high energies are necessary to probe short-range structure of nuclei

Δ-isobars, 3N in nuclei - towards direct observations;
2N - directions for detailed studies

EMC effect: unambiguous evidence of non-nucleonic degrees of freedom in A; constrains on the mechanism, message from LHC pA collisions

Strategies for further studies: Jlab, muon beams, EIC...

Experience of quantum field theory - interactions at different resolutions (momentum transfer) resolve different degrees of freedom - renormalization,.... No simple relation between relevant degrees of freedom at different scales.

➟ Complexity of the problem

Four energy momentum transfer scales in structure (interactions with) nuclei with different role of low momentum nucleons ($k < k_F$ -naive estimate of the highest momenta in nuclei for non-interacting gas) *and high momentum nucleons due to local NN interactions (slow decrease with k distribution).*

Precision determination of the nuclear structure at different resolution scales requires understanding of the fine details of the interaction dynamics.

Examples: *At what Q squeezing sets in for the nucleon form factors ?*

Final state interactions in eA scattering: formation time, etc

① Nuclear observables at low energy scale: treat nucleus as a Landau-Migdal Fermi liquid with nucleons as quasiparticles (close connection to mean field approaches) - should work for processes with energy transfer $\lesssim E_F$ and momentum transfer $q \lesssim k_F$. Nucleon effective masses ~0.7 m_N, effective interactions - SRC are hidden in effective parameters. Similar logic in the chiral perturbation theory / effective field theory approaches - very careful treatment at large distances ~ $1/m_\pi$, exponential cutoff of high momentum tail of the NN potential

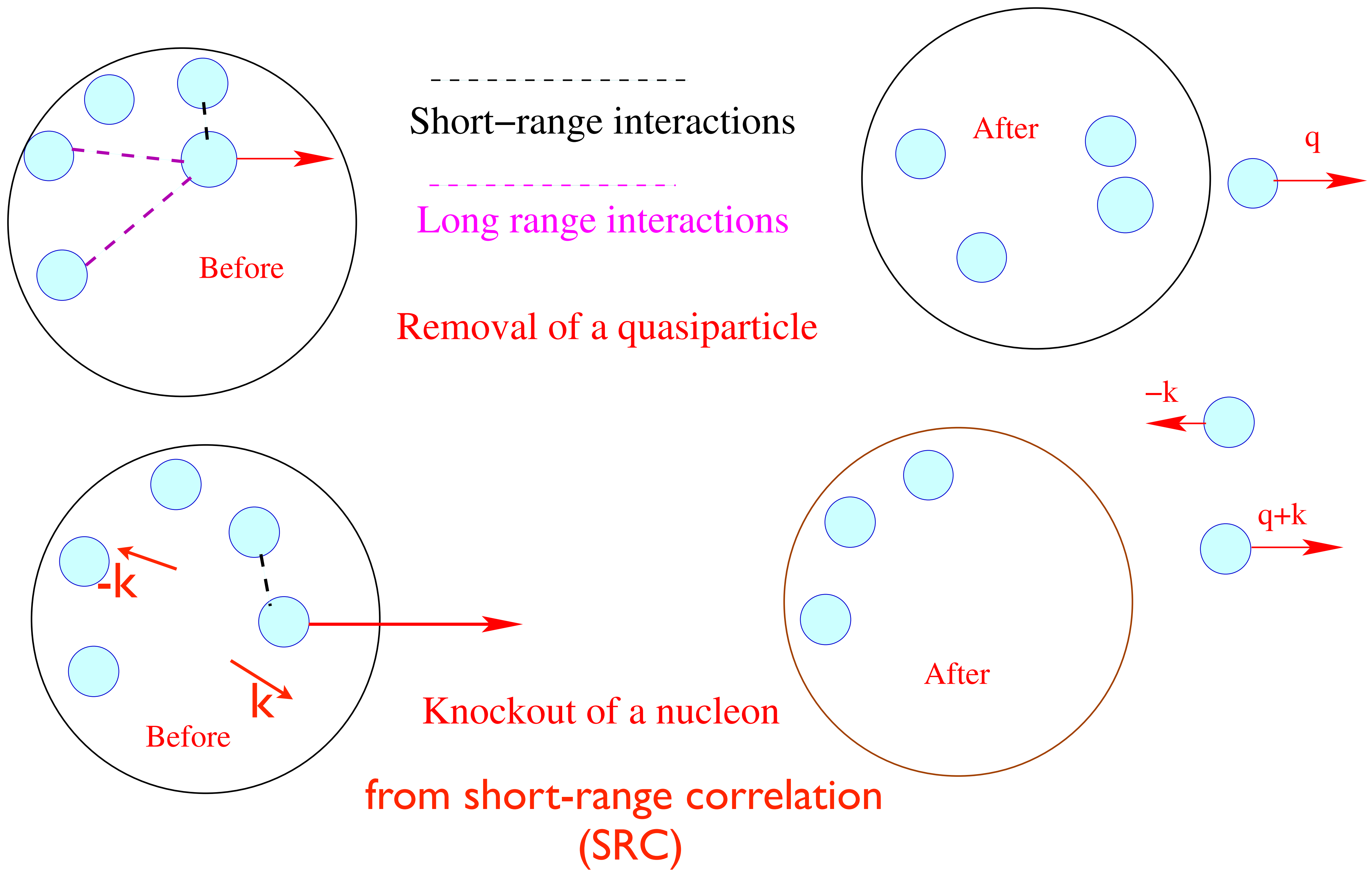
② Nuclear observables at intermediate energy scale: energy transfer < 1 GeV and momentum transfer q < 1 GeV. Transition from quasiparticles to bare nucleons - very difficult region - observation of the momentum dependence of quenching (suppression) factor Q for A(e,e'p) (Lapikas, MS, LF, Van Steenhoven, Zhalov 2000)

③ Hard nuclear reactions I: energy transfer > 1 GeV and momentum transfer q > 1 GeV. Resolve SRCs = direct observation of SRCs but not sensitive to quark-gluon structure of the bound states

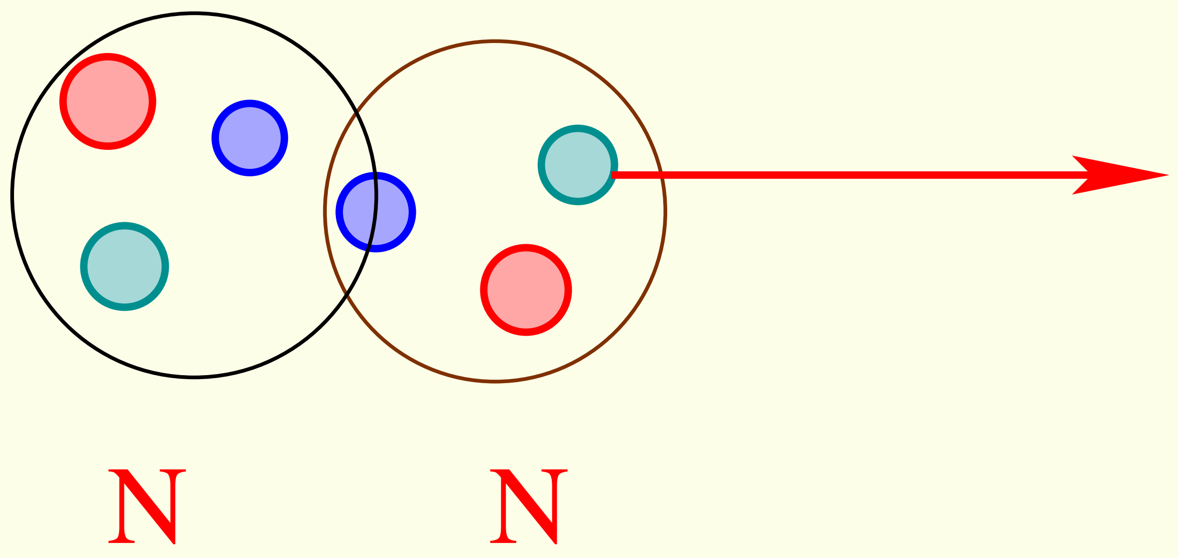
④ Hard nuclear reactions II: energy transfer ≫ 1 GeV and momentum transfer q ≫ 1 GeV. May involve nucleons in special (for example small size configurations). Allow to resolve quark-gluon structure of SRC: difference between bound and free nucleon wave function, exotic configurations

Low Q^2 scale

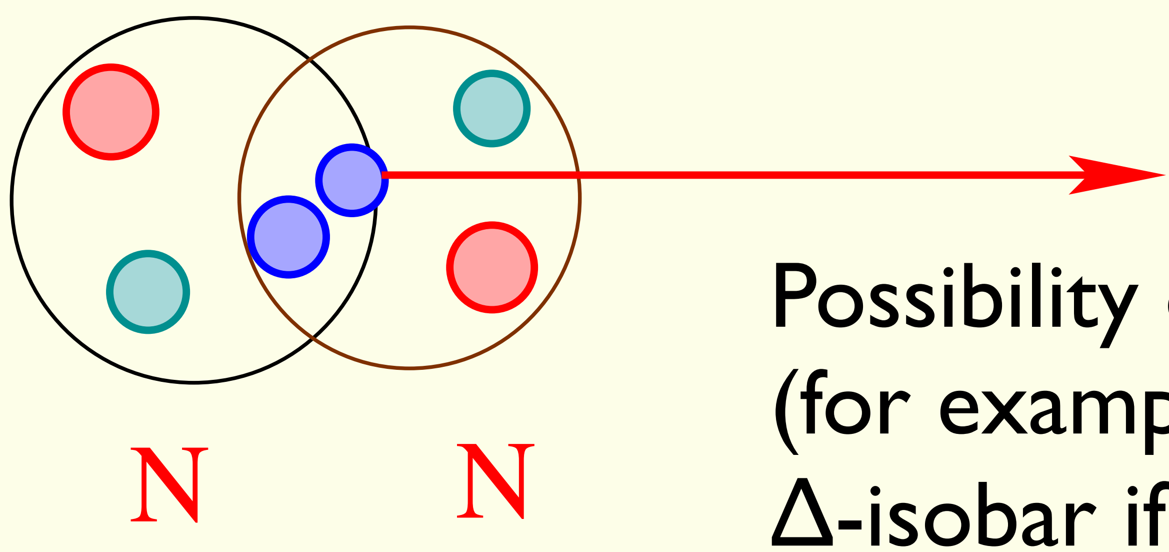
High Q^2 scale I



High Q^2 scale II Quark removal in the DIS kinematics



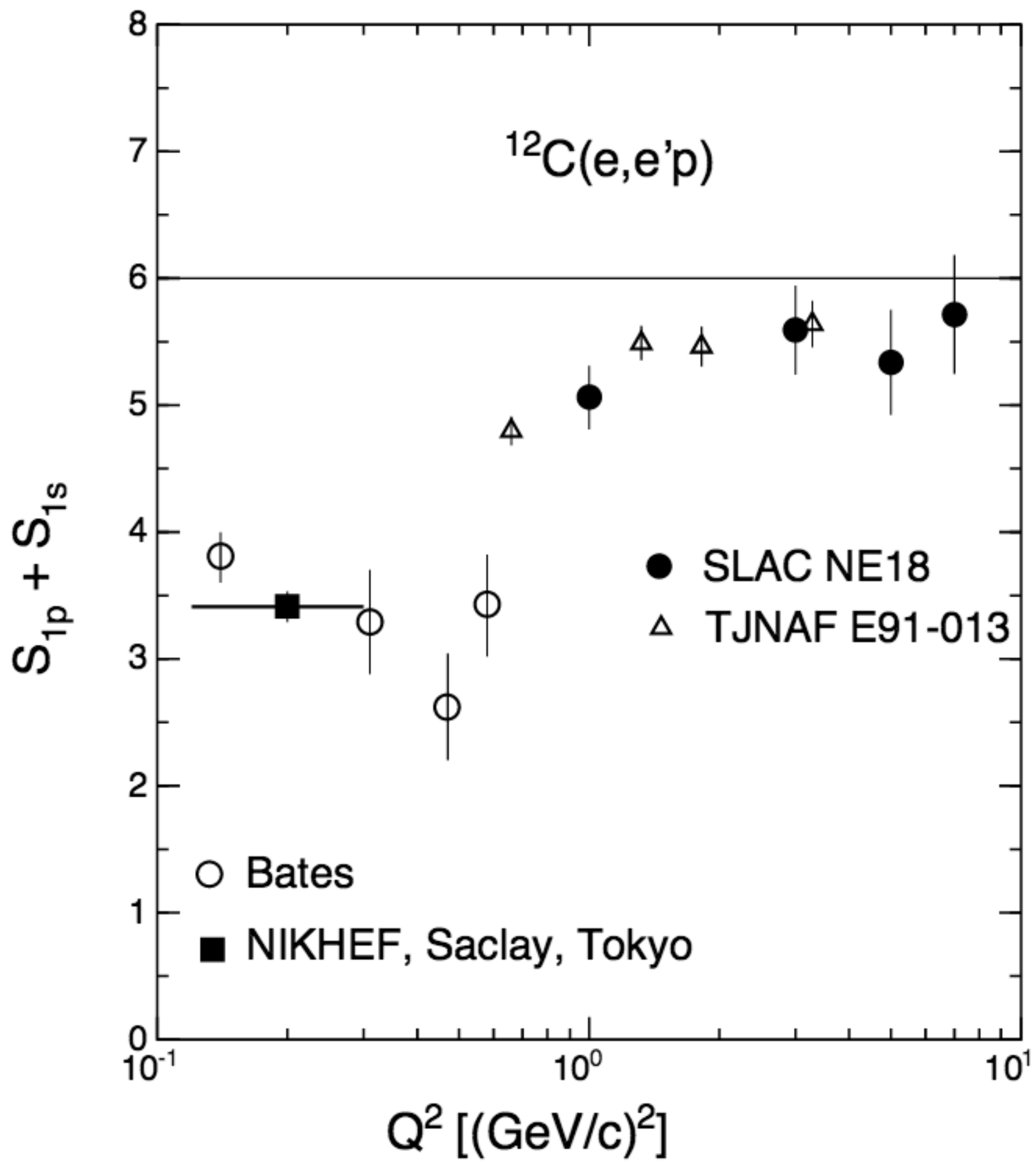
Removal of a quark of a nucleon



Removal of interchanged quark

Possibility of decay of the residual system with production of slow (for example backward in the nucleus rest frame) baryons like N*, Δ-isobar if color is not localized in one nucleon.

New effects if one would remove a valence gluon (EIC) ?



Q^2 dependence of the spectroscopic factor

Lapikas, van der Steenhoven, Frankfurt, MS Zhalov, Phys.Rev. C, 2000

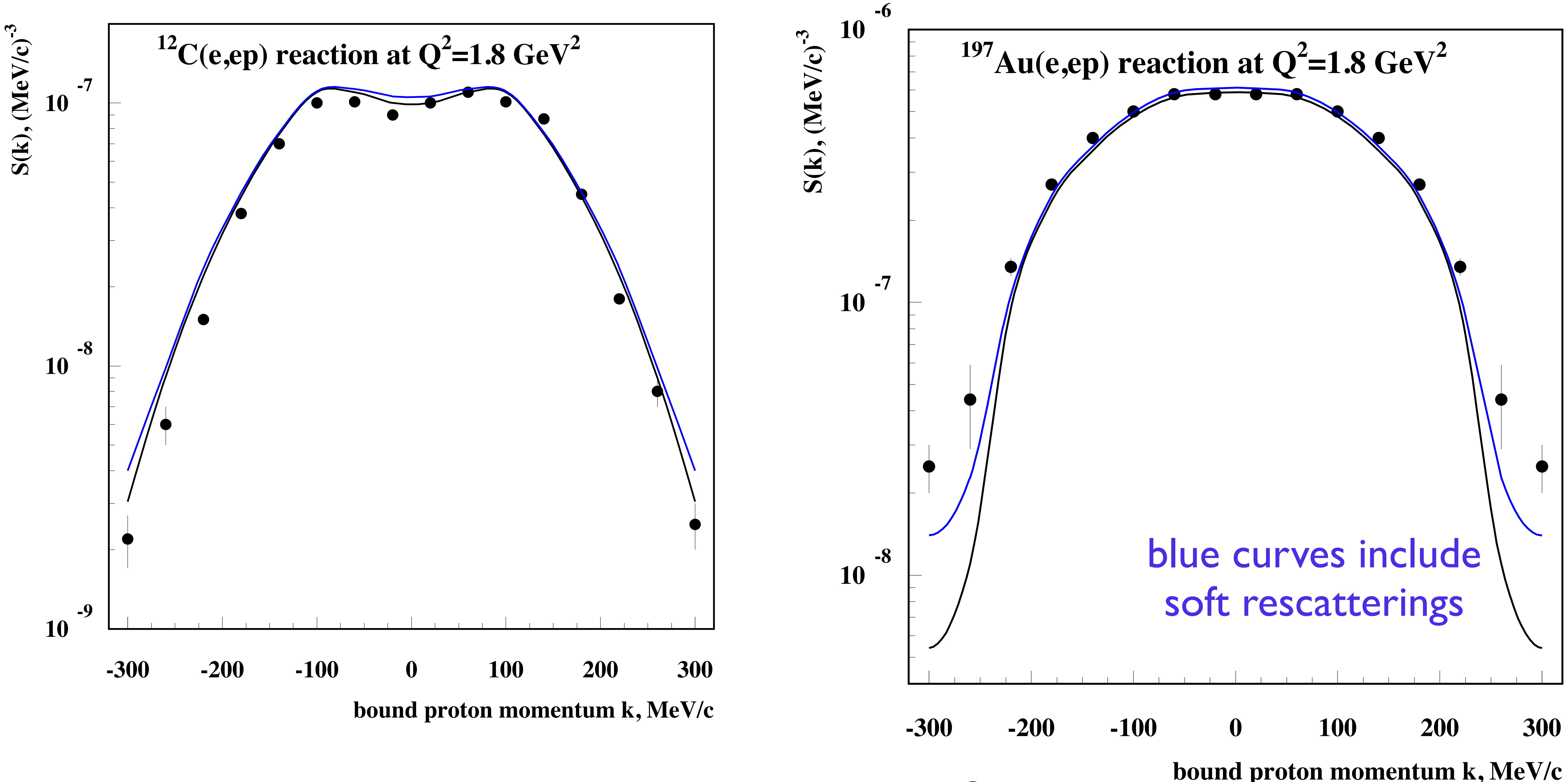
Rather rapid transition from regime of interaction with quasiparticles to regime of interaction with nucleons $Q^2_{transition} \approx 0.8$ GeV^2

Still need to study transition in a single experiment.

Jlab data (E94-139) agree well with

Glauber model calculation with with Hartree-Fock-Skyrme:spectral function

(Frankfurt, Strikman Zhalov,Phys.Lett. B503 (2001) 73-80)

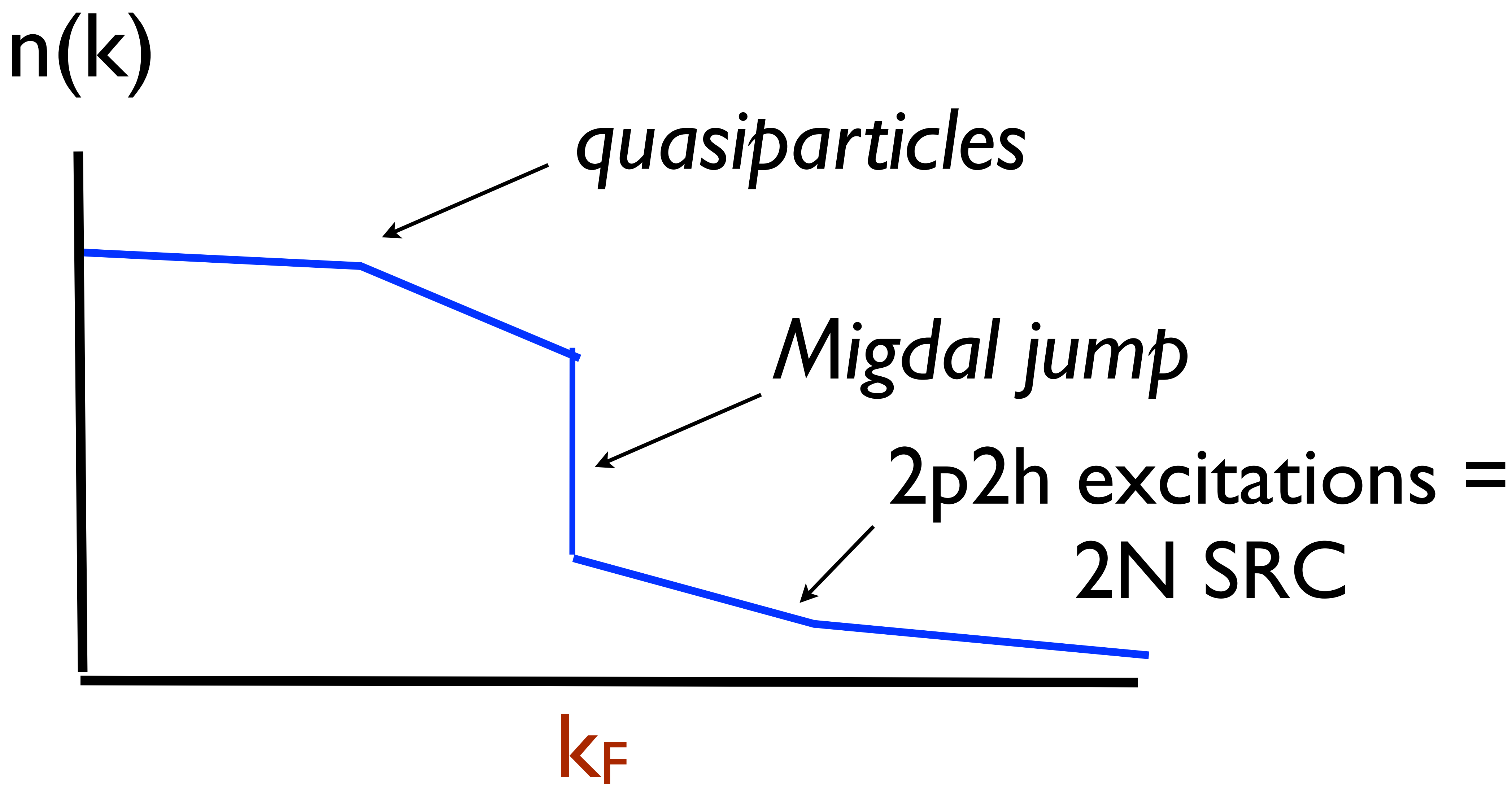


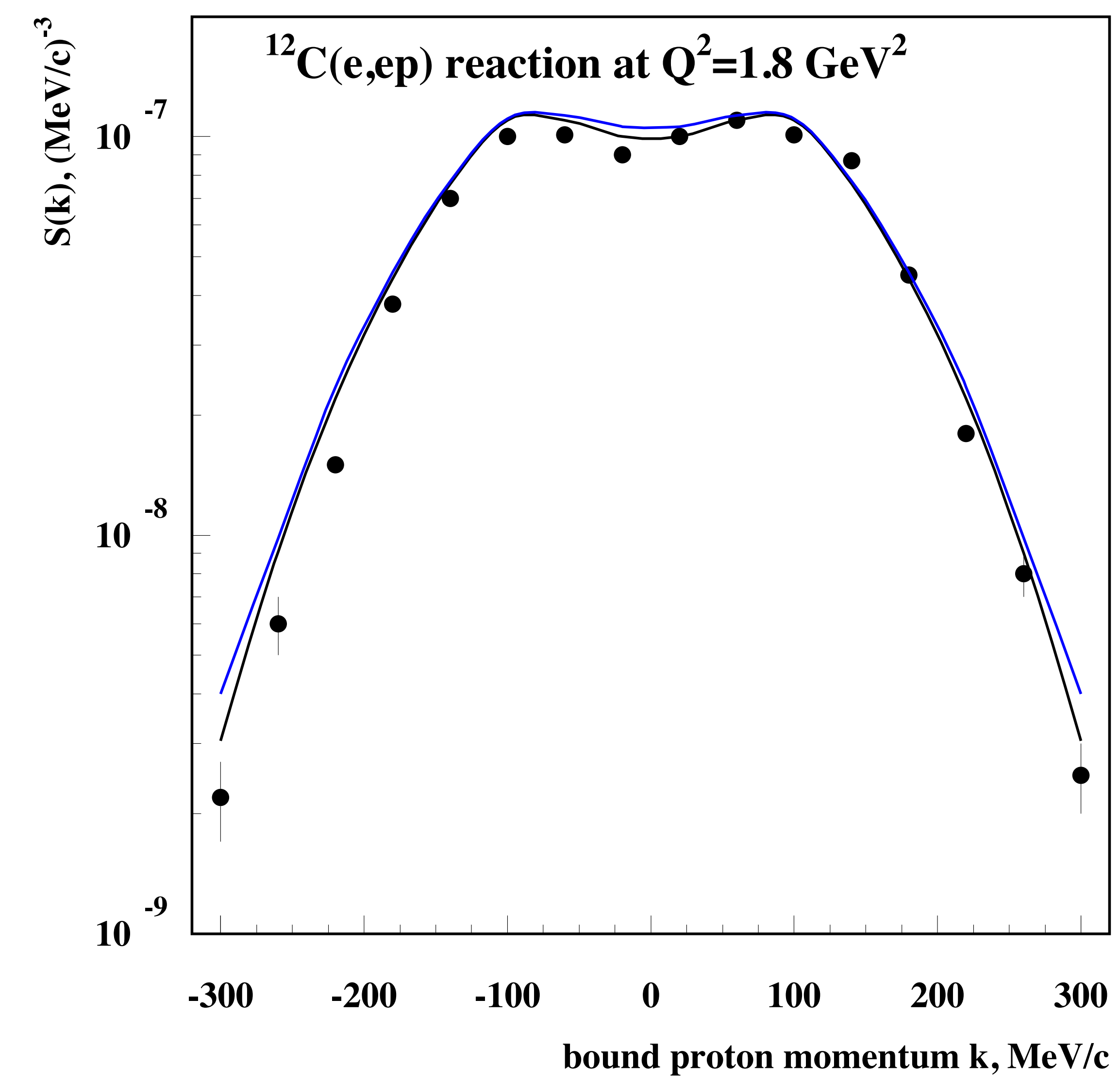
No evidence of suppression at large Q^2 : Quenching factor > 0.9

Q^2 dependence of bound nucleon form factor as for free nucleon

Warning: G_M gives dominant contribution. Necessary to test kinematics sensitive to G_E

Outstanding questions: Fermi step / Migdal jump & transition from mean field to short-range correlations (SRC)



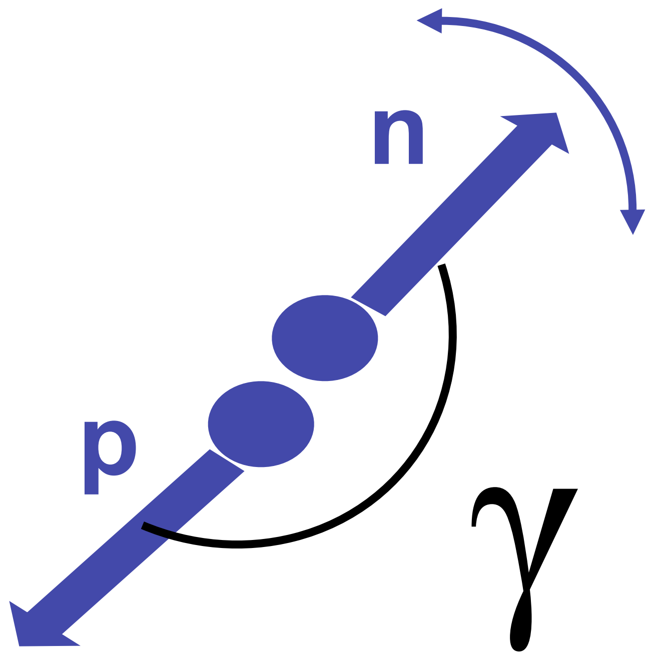


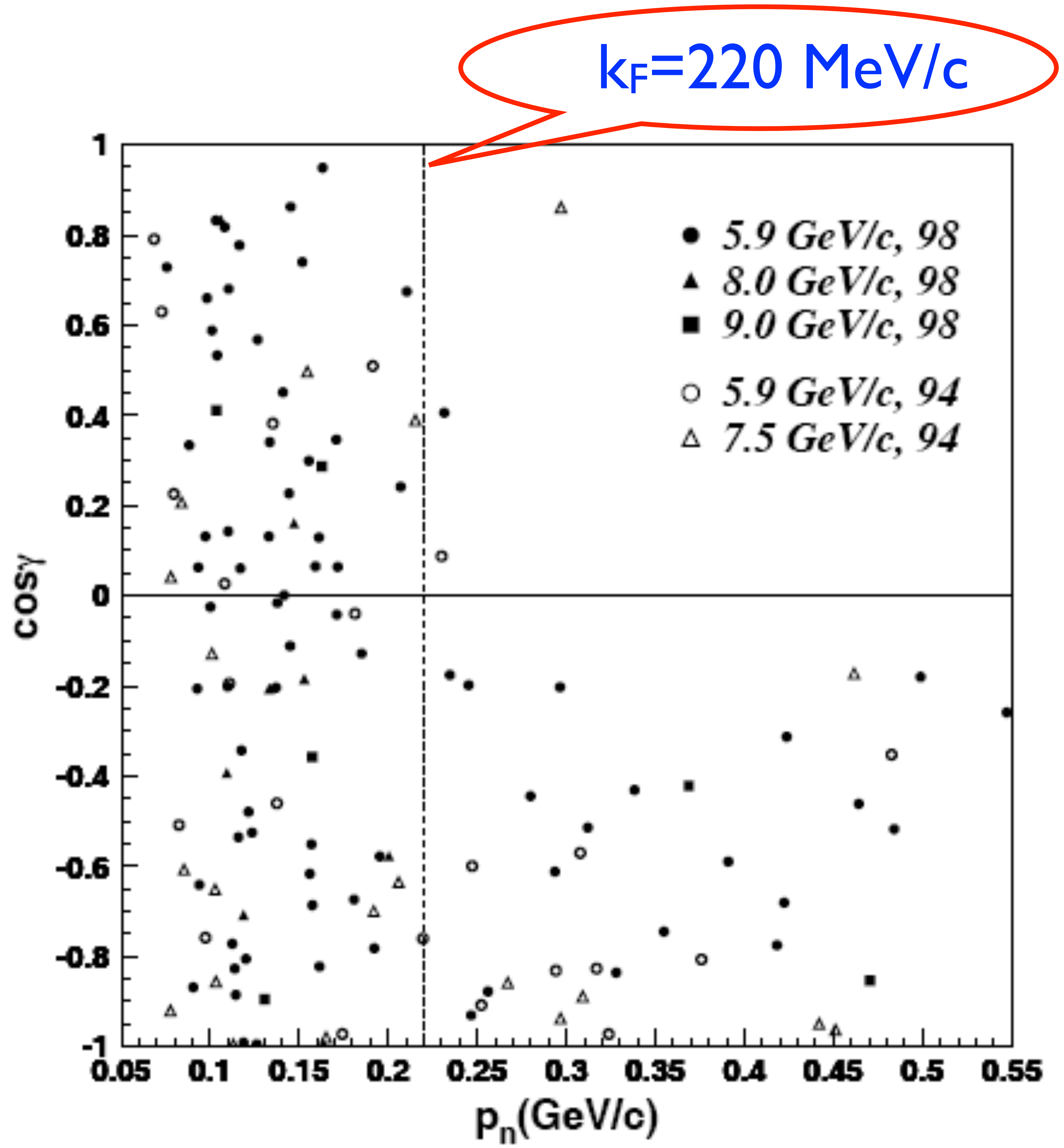
E94-139 seems to indicate a strong washout of the jump

- *Is it possible to observe directly jump? Smearing of the jump at Q^2 resolving nucleons. Effect of nucleon absorption in (e,e'p). Smaller effective $\rho_A(r)$*

- *At what $k > k_F$ 2N SRC dominate?* *Evidence from (p,ppn): starting at $k \sim k_F$ (Eli's talk). The same pattern for (e,e'pn)?*

effective $<\rho_A(r)>_{e,e'pn} > <\rho_A(r)>_{p,ppn}$





BNL Carbon data of 94-98. The correlation between p_n and its direction γ relative to p_i. The momenta on the labels are the beam momenta. The dotted vertical line corresponds to k_F=220 MeV/c.

SRC appear to dominate at momenta k> 250 MeV/c - very close to k_F. *A bit of surprise* - we expected dominance for k> 300 - 350 MeV/c. Naive inspection of the realistic model predictions for $n_A(k)$ clearly shows dominance only for k > 350 MeV/c. Important to check a.s.p.

2N Short-range correlations (SRC) - outstanding questions - hadronic scale resolution

Current situation:

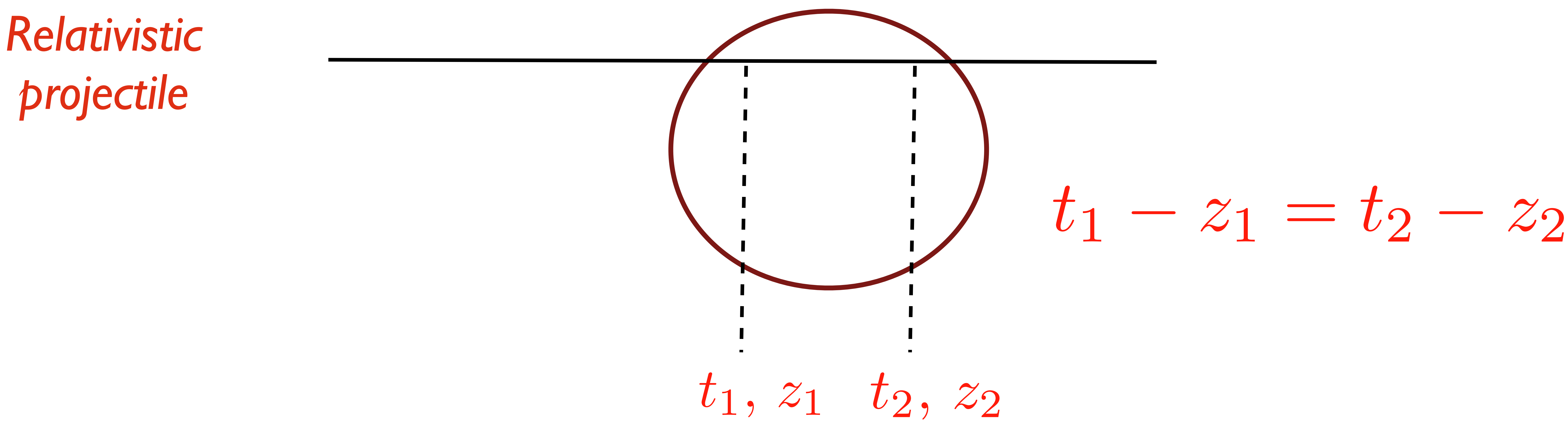
(e,e') 2>x>1.4 -scaling of the rations at LC fractions corresponding to nucleon momenta k ≥ 300 MeV/c. Measures relative strength and universality of 2N SRCs

(p,2pn), (e,e'pn(pp)) the process is expressed through the nuclear decay function
So far the model 2N SRC pair moving in mean field works.

Outstanding issues:

- (e,e') - absolute cross sections, role of f.s.i. (predominantly in 2N SRC)
- (p,2pn), e,e'pn(pp) - need differential studies, accuracy of the model, are absolute cross sections consistent?
- Do we understand sufficiently well D(e,e'pn) in the probed Q^2 range, intermediate state Δ-isobars ? (Boeglin talk)

High energy processes develops along the light cone.

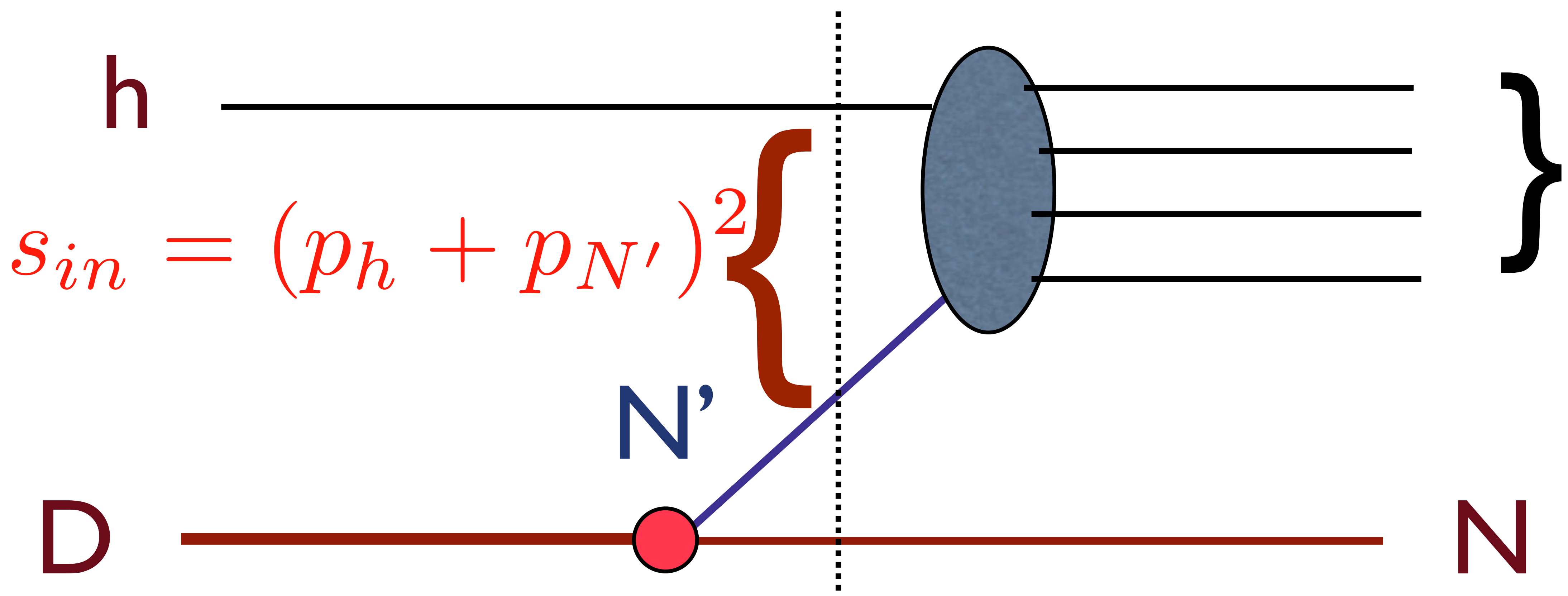


Similar to the perturbative QCD the amplitudes of the processes are expressed through the wave functions on the light cone. *Note: in general no benefit for using LC for low energy processes.*

Noncovariant and covariant approaches

LC quantization is uniquely selected in high energy processes if one tries to express cross section through elementary amplitudes near energy shell.

Consider the break up of the deuteron in the impulse approximation: h+D→X+N, for $E_h \to \infty$



$$\Delta \equiv (s_{in} - s_f) \to M^2_{NN} - M^2_D$$

where M^2_{NN} is invariant mass squared of the two nucleon system

is finite at high energies. hN' amplitude depends on Δ

In covariant (Feynman diagram) approach elementary cross section

depends on virtuality of N' $\propto \Delta$

Dependence of the hard amplitude on the off-shellness /virtuality

- Off-shell effects are proportional to virtuality for small virtualities

- Dependence on virtualities is weakest if the probe interacts with nucleon in average configuration. For small size configurations drop with off shellness is large.

Will elaborate when discussing EMC effect

No evidence for color transparencies in processes where momentum transfer (Q^2) to the nucleon is $\leq$ 4 GeV^2. (e.m. form factor, large angle scattering). Hence a large range where we can expect factorization :

σ = "Spectral function" x "elementary on shell cross section"

In quantum mechanical treatment amplitude is far off energy shell ($\propto$ s) - wrong diagrams

In both relativistic approaches -- virtual nucleon and non covariant LC-- the first step is matching NR and relativistic descriptions of the wave function, and next modeling elementary amplitude

The best way to look for the difference between LC and NR/Virtual nucleon seems to be scattering off the polarized deuteron. Off-shell effects mostly cancel in the ratio.

$$\frac{\mathrm{d}\sigma(\mathrm{e}+\mathrm{D}_\Omega \to \mathrm{e}+\mathrm{N}+\mathrm{X})}{(\mathrm{d}\alpha/\alpha)\ \mathrm{d}^2 p_\mathrm{t}} \Bigg/ \frac{\mathrm{d}\sigma(\mathrm{e}+\mathrm{D} \to \mathrm{e}+\mathrm{N}+\mathrm{X})}{(\mathrm{d}\alpha/\alpha)\ \mathrm{d}^2 p_\mathrm{t}}$$

$$= 1 + \left(\frac{3k_i k_j}{k^2}\ \Omega_{ij} - 1\right) \frac{\frac{1}{2}w^2(k) + \sqrt{2}u(k)w(k)}{u^2(k)+w^2(k)} \equiv P(\Omega, k)$$

Ω is the spin density matrix of the deuteron, $\mathrm{Sp}\Omega = 1$

Consider

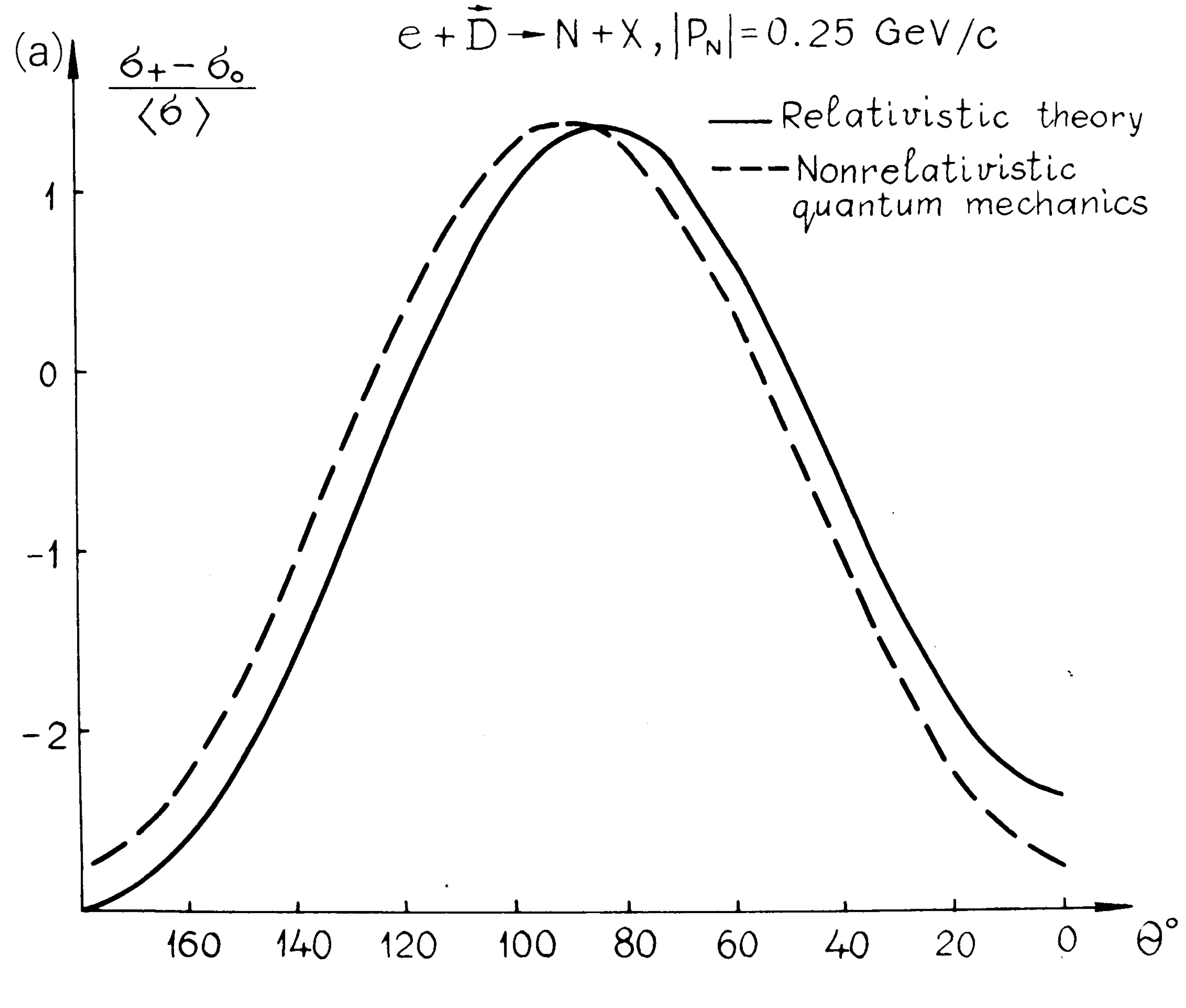
$$R = T_{20} = \left[\frac{1}{2}(\sigma_+ - \sigma_-) - \sigma_0\right] \Big/ \langle\sigma\rangle$$

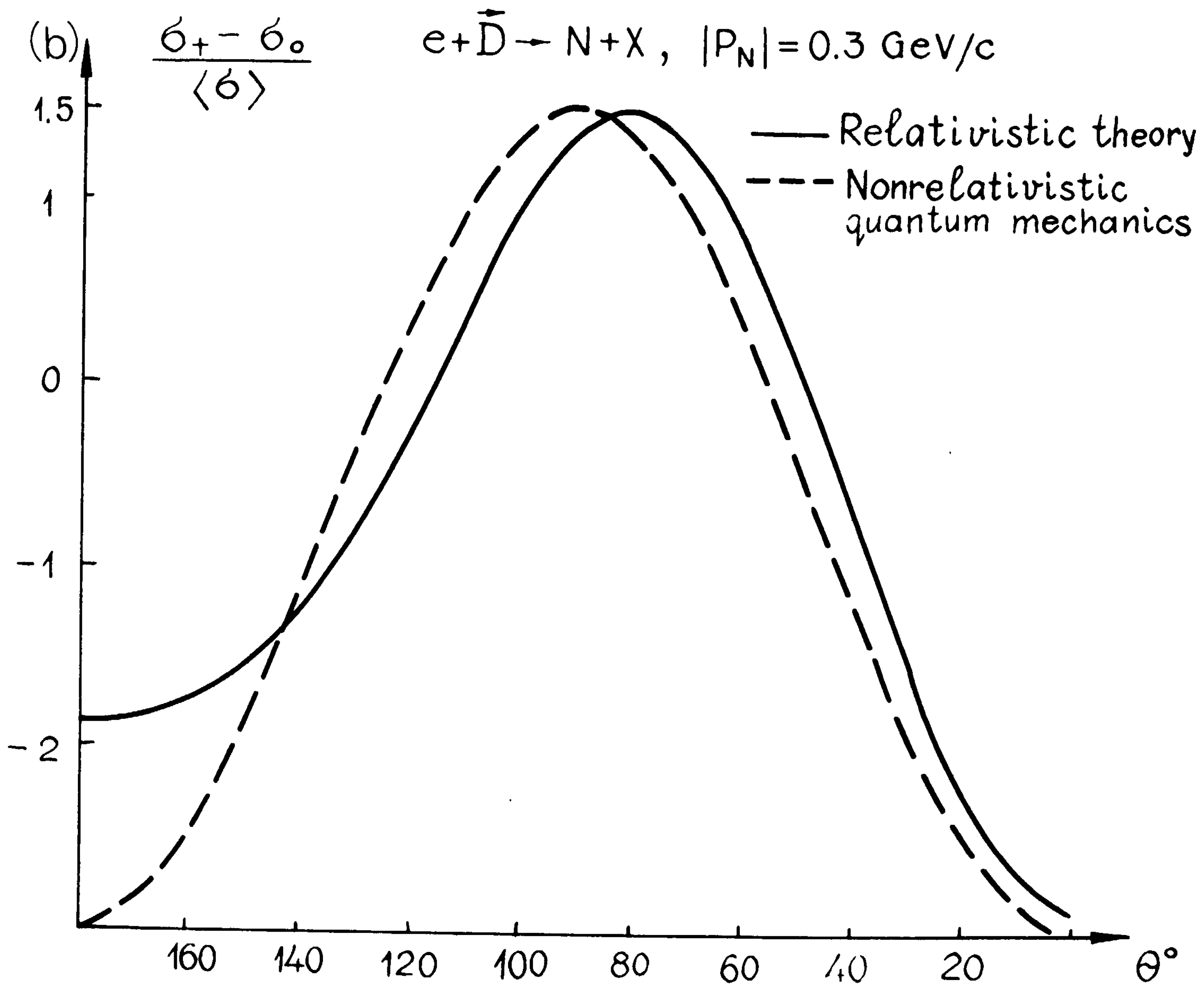
$$R(p_\mathrm{s}) = \frac{3(k_\mathrm{t}^2/2 - k_z^2)}{k^2}\ \frac{u(k)w(k)\sqrt{2} + \frac{1}{2}w^2(k)}{u^2(k)+w^2(k)}$$

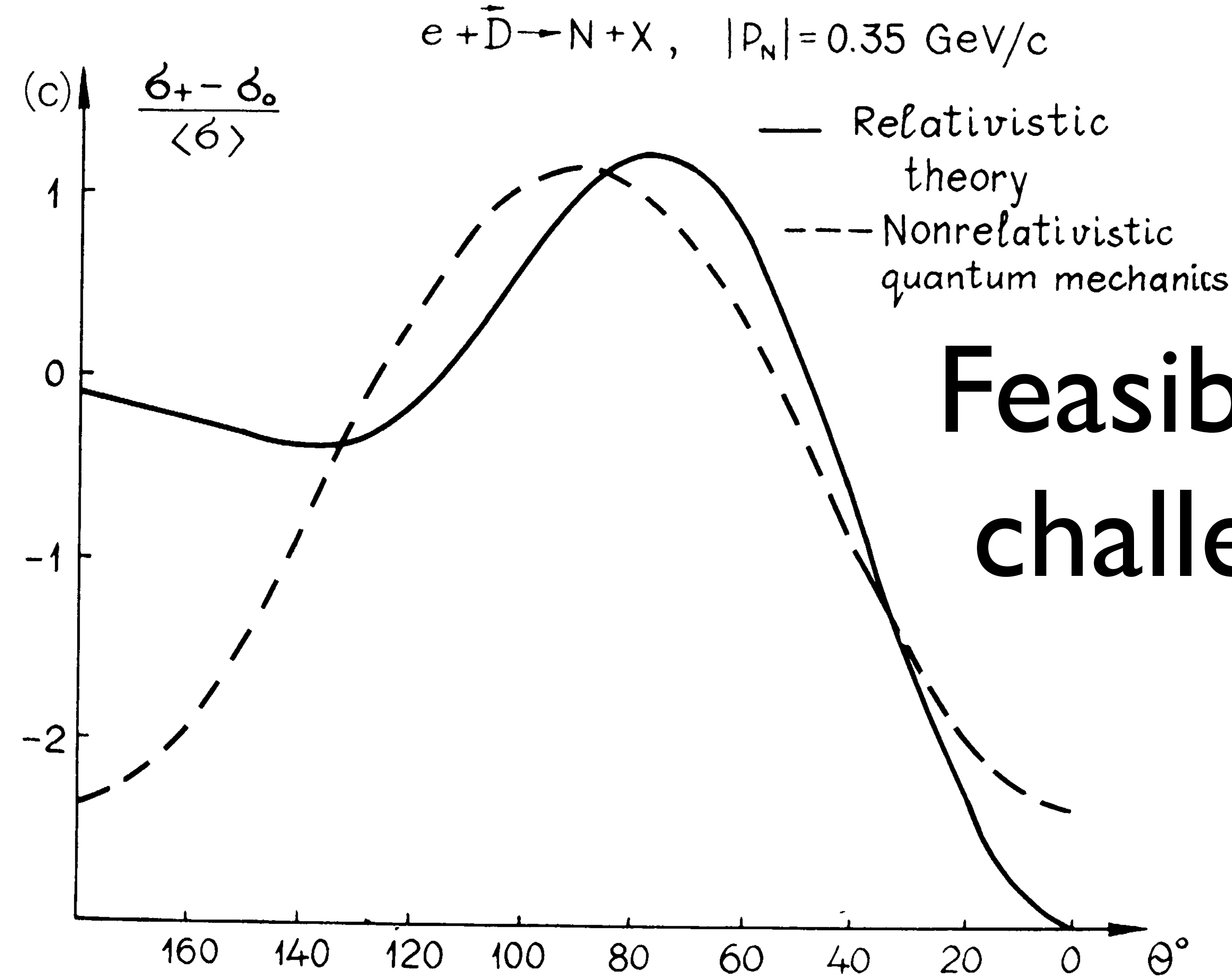
nonlinear relation between k and p_s

$$R^{\mathrm{nonrel}}(p_\mathrm{s}) = \frac{3(p_\mathrm{t}^2/2 - p_z^2)}{p^2}\ \frac{u(p)w(p)\sqrt{2} + \frac{1}{2}w^2(p)}{u^2(p)+w^2(p)}$$

trivial angular dependence for fixed p_s







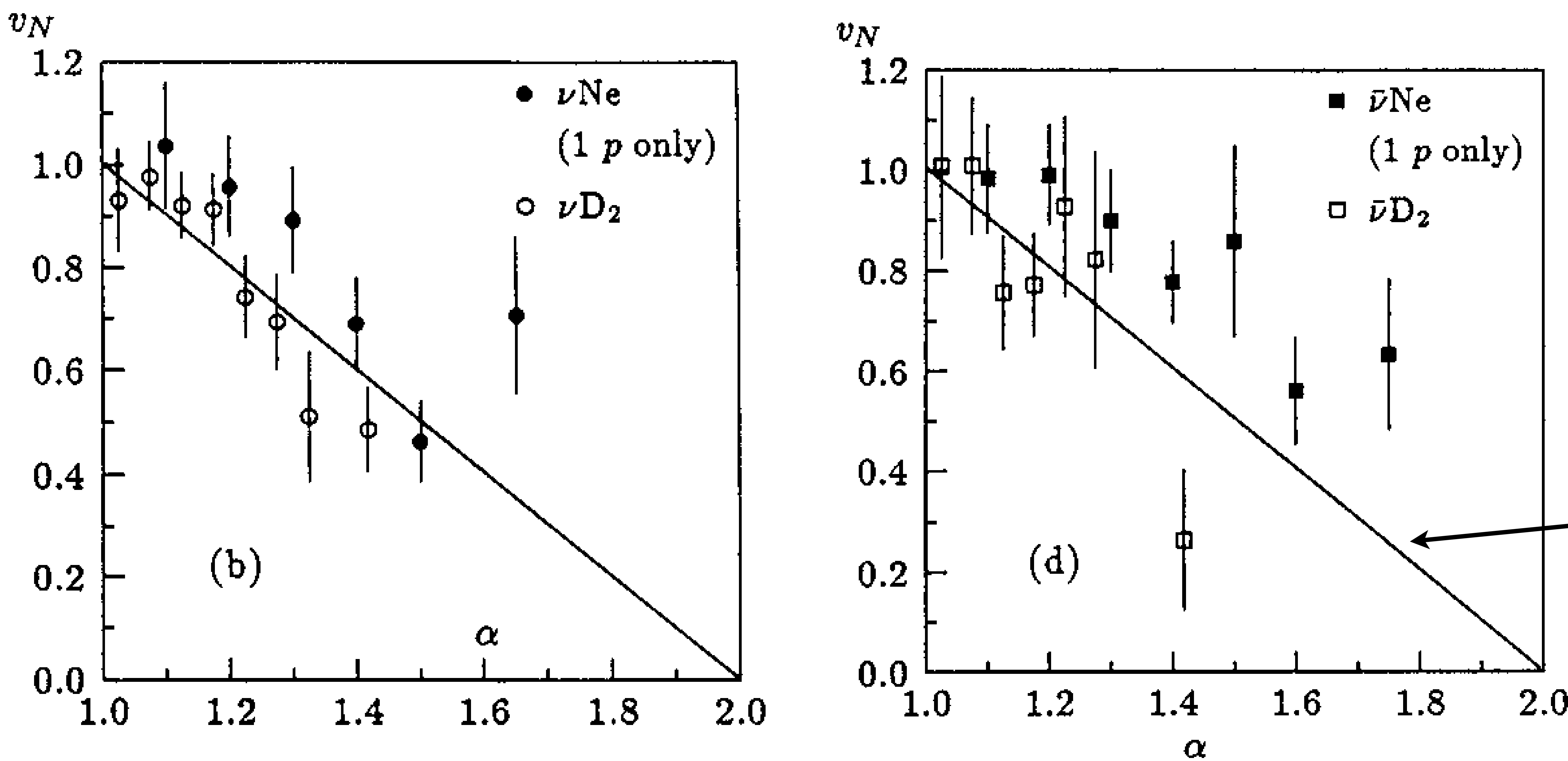
Feasible at EIC;
challenging at Jlab (spin observables)

To use semiinclusive processes like

$$l(e,\nu,\bar{\nu}) + A \to l' + \text{backward nucleon} + X$$

- one needs to understand f.s.i.. Example: BEBC $\nu, \bar{\nu} +$ Ne data 1989

$v_N(\alpha) = \langle xy(\alpha)\rangle / \langle xy\rangle$ sample without 2p backward



α - light cone fraction carried by backward proton

$v_N(\alpha) = 2 - \alpha$

2N SRC prediction

Future studies - use the lightest nuclei; explore f.s.i. in interaction with the 2N SRC

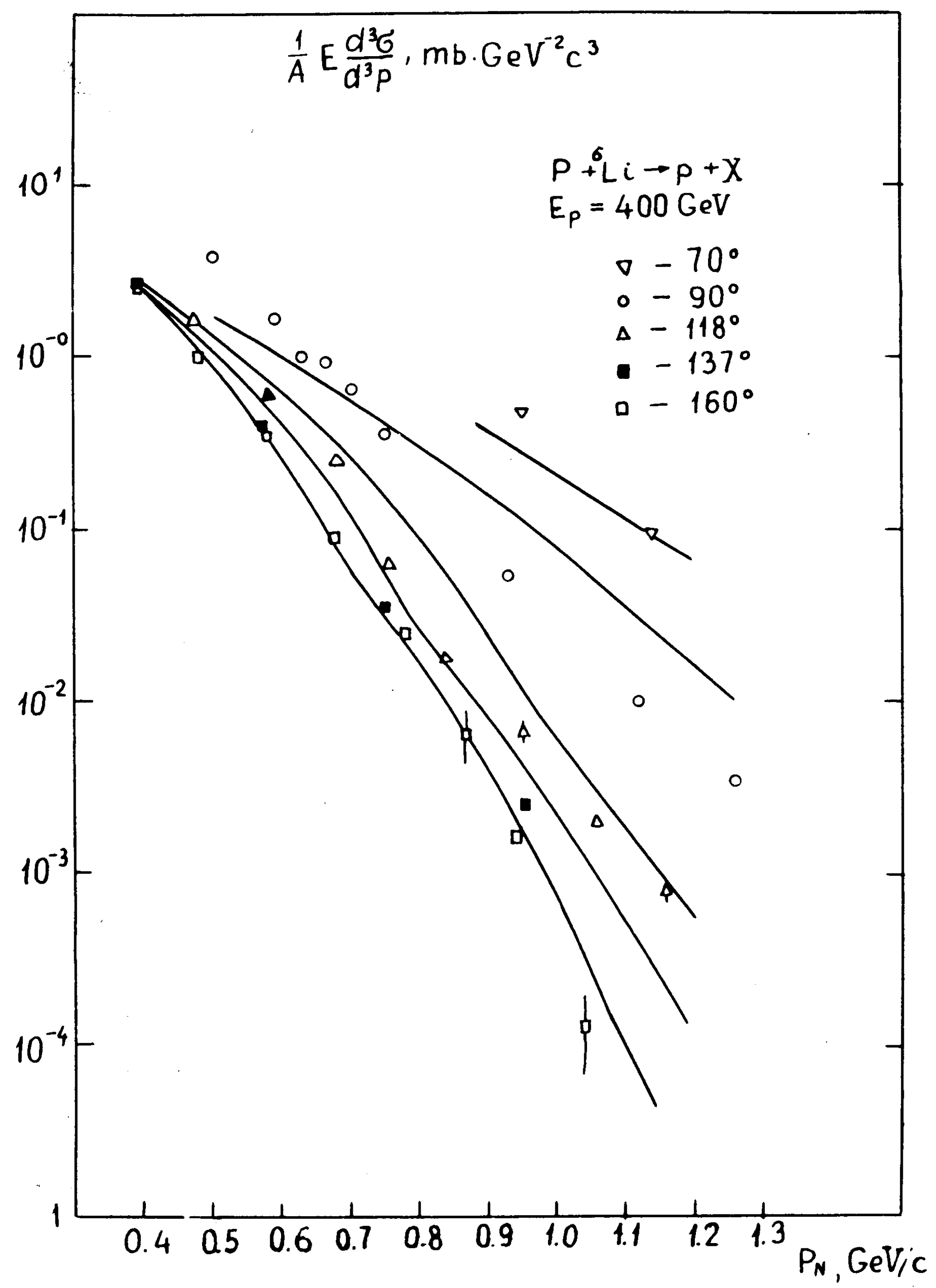
Large momentum transfer hadronic scale: outstanding questions - discovery potential

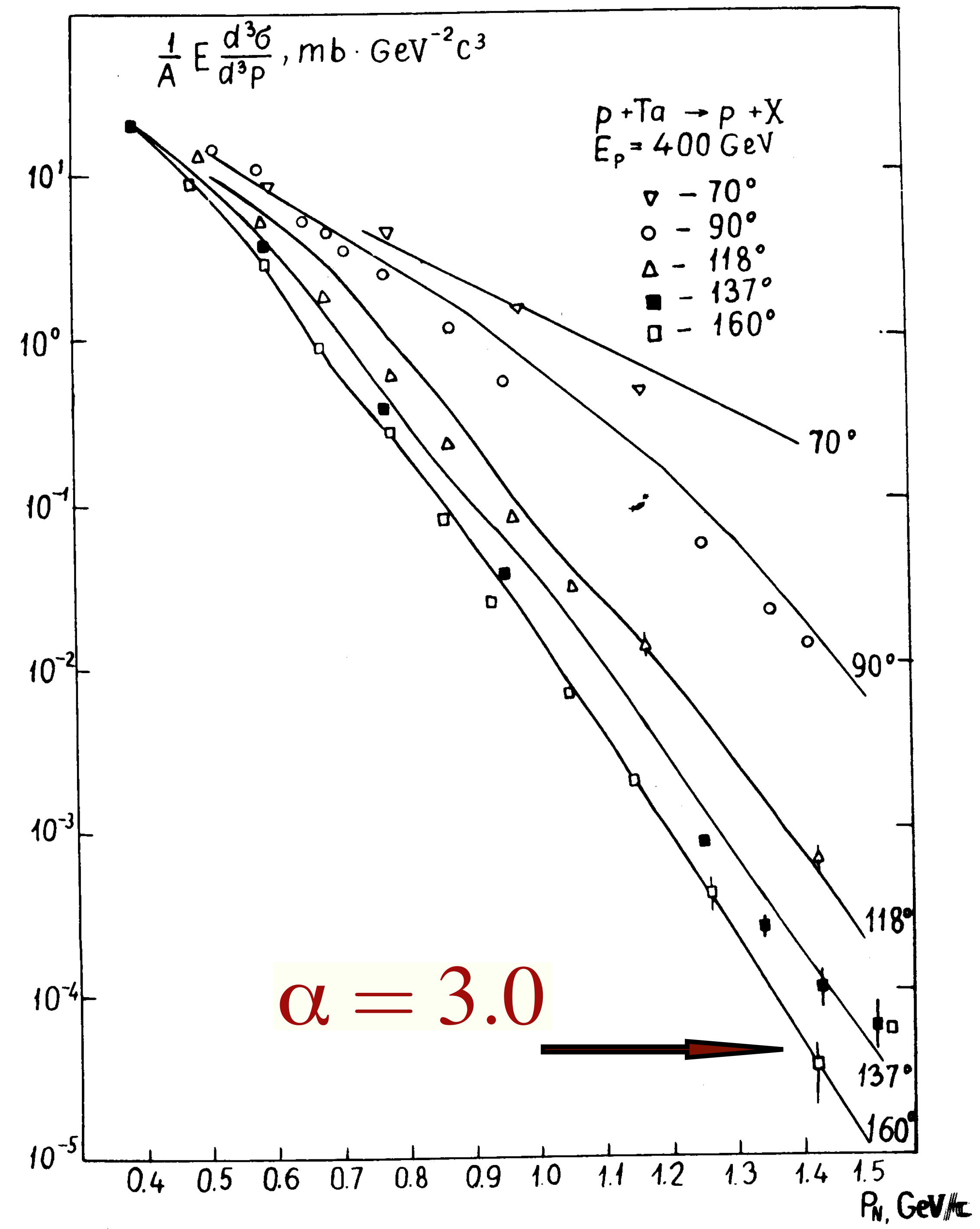
Direct observation and theoretical studies of 3N,... SRC.

Direct observation of non-nucleonic hadronic components in nuclei -- Δ- isobars

N> 2 SRCs

Evidence from fast backward nucleon production:
(π,γ,p) +A→ "backward proton" +X

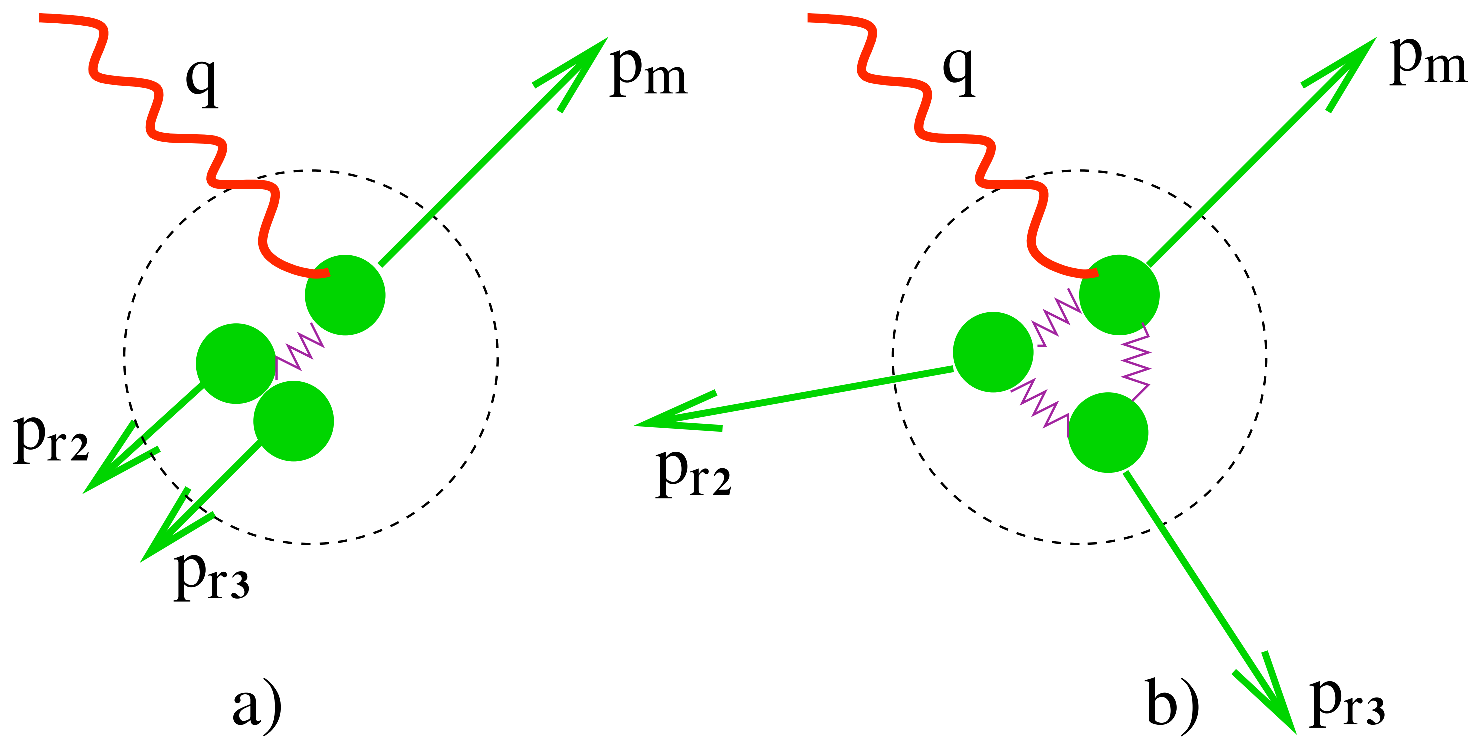




Comparison of the few nucleon correlation model with the 400 GeV data on the fast backward nucleon production.

To reach α=3 one needs scattering off at least 4N SRC

- **3N Correlations**



Sargsian et al

-Type 3N-I correlations: $E_m^{(2N-I)} \approx |\epsilon_A|$

-Type 3N-II correlations: $E_m^{(3N-II)} = 2\sqrt{m^2 + p_m^2} - 2m - T_{A-1}$

Expectations:

P(ppn) ~P(pnn) >> P(ppp)

P(3N)/ P(2N) ~ 0.1 - 0.2 for A~40 & ~ 1 for neutron stars

Observation of 3N in (e,e') $x > 2,\ Q^2 \geq 3 \div 4\mathrm{GeV}^2$ Day's talk

eA →e + 2 backward protons + 1 forward nucleon + (A-3)* Cohen's talk

Open questions: NR vs LC wf , spectral functions, decay functions. 3N forces,...

Non-nucleonic degrees of freedom:

A hidden parameter (FS 75-81) : in NN interactions: direct pion production is suppressed for a wide range of energies due to chiral properties of the NN interactions:

⇒ Main inelasticity for NN scattering for $T_p \leq 1$ GeV is single Δ-isobar

in the deuteron channel only 2 Δ's allowed

Correspondence argument: wave function - continuum ⇒ Small parameter for inelastic effects

in the deuteron/nucleus WF, while relativistic effects are already significant since $p_N/m_N \leq 1$

Data: No enhancement of antiquarks in nuclei ⇒ weak

modification of the pion field

Δ-isobars are natural candidate for the most important nonnucl. degrees of freedom

Large energy denominator for NN →NΔ transition

➡ Δ's **predominantly in SRCs**

➡ Δ's **much more important in I=1 (pp,nn) SRCs**

➡ Δ's **much broader distribution in momenta (α,k_t)**

➡ ***Worth looking for Δ's in the forbidden kinematics***

Expectations during EMC effect rush

TABLE II. Pion excess and Δ fraction in nuclear matter (NM) and nuclei.

	$\langle \delta n^{\pi} \rangle / A$	$\langle n^{\Delta} \rangle / A$
NM, $k_F = 0.93$	0.08	0.03
NM, $k_F = 1.13$	0.12	0.04
NM, $k_F = 1.33$	0.18	0.06
^{2}H	0.024	0.005
^{3}He	0.05	0.02
^{4}He	0.09	0.04
^{27}Al	0.11	0.04
^{56}Fe	0.12	0.04
^{208}Pb	0.14	0.05

Friman, Pandharipande, WIringa 1983

ruled out by Drell - Yan data

1% to satisfy Bjorken sum rule, Guzey et al

$$\frac{P(\Delta)}{P_{SRC}(N)} \sim \frac{0.04}{0.2} \sim 0.2$$

Too much ?

Evidence for Δ's in nuclei

- Δ 's in 3He on 1% level from Bjorken sum rule for A=3 - Guzey &F&S 96
- Indications from DESY AGRUS data (1990) on electron - air scattering at E_e=5 GeV (Degtyarenko et al).

Measured Δ^{++}/p, Δ^0/p for the same light cone fraction α.

$$\frac{\sigma(e+A\to\Delta^0+X)}{\sigma(e+A\to\Delta^{++}+X)}=0.93\pm0.2\pm0.3$$

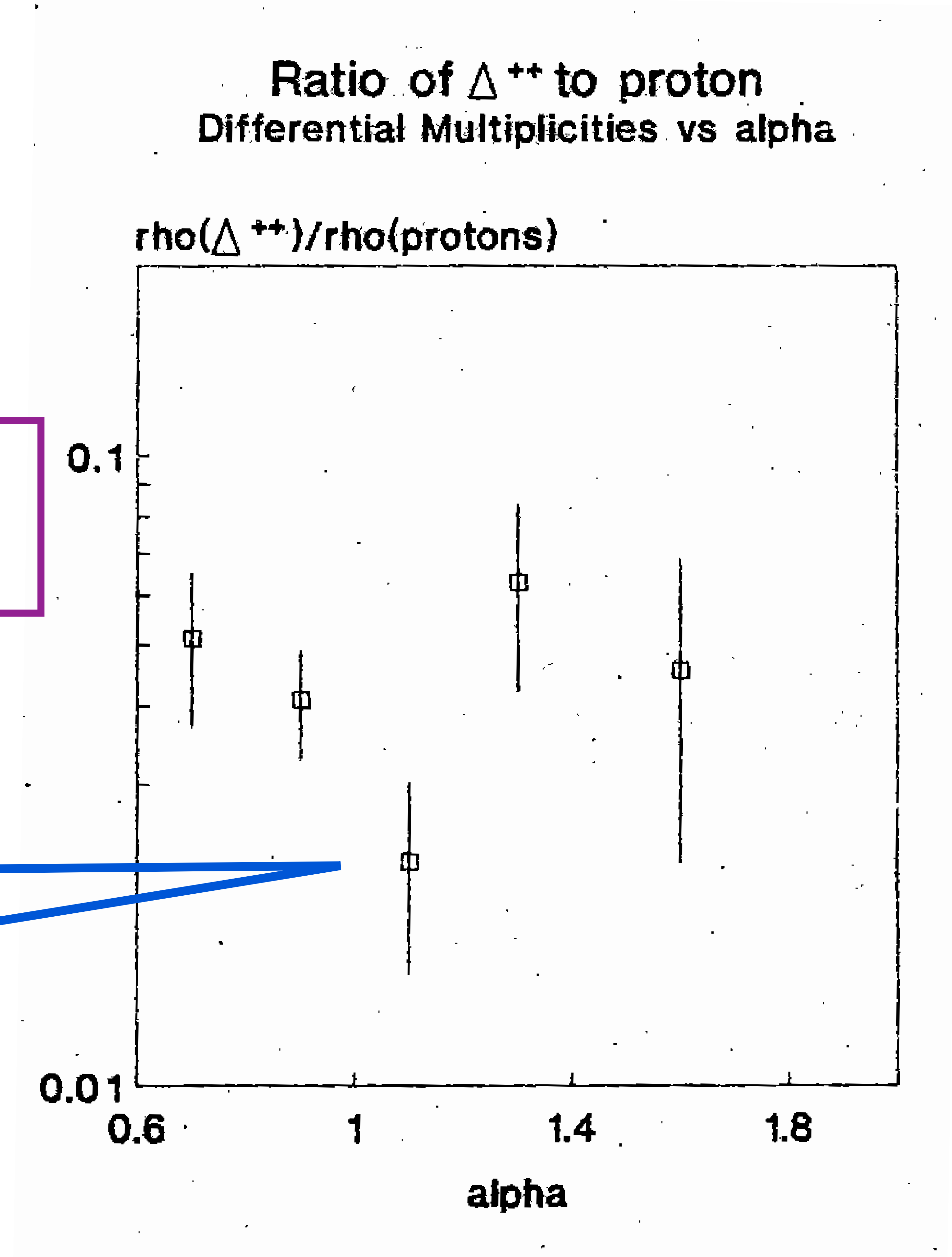
expect R=1 for isosinglet nucleus

$$\frac{\sigma(e+A\to\Delta^{++}+X)}{\sigma(e+A\to p+X)}=(4.5\pm0.6\pm1.5)\cdot10^{-2}$$

$$\Downarrow$$

$$\frac{P(\Delta)}{P_{SRC}(N)}\sim\ 0.1$$

suppression at α~1



New data are necessary: many options in Jlab kinematics ? New Jlab experiments ?

Perfect kinematics for EIC in particular $\vec{e}+\vec{D}\to e+\Delta^{++}+X(or\ forward\,\pi^{\pm})$

Promising channels for searching/discovering baryonic nonnucleonic degrees of freedom in nuclei

(a) Knockout of Δ^{++} isobar in

$$e + {}^2H \rightarrow e + \ forward\ \Delta^{++} + \ slow\ \Delta^-$$
$$e + {}^3He \rightarrow e + \ forward\ \Delta^{++} + \ slow\ nn$$

Sufficiently large Q are necessary to suppress two step processes where Δ^{++} isobar is produced via charge exchange

(b) $$e + {}^2H({}^3He) \rightarrow e + backward\,\Delta + X$$

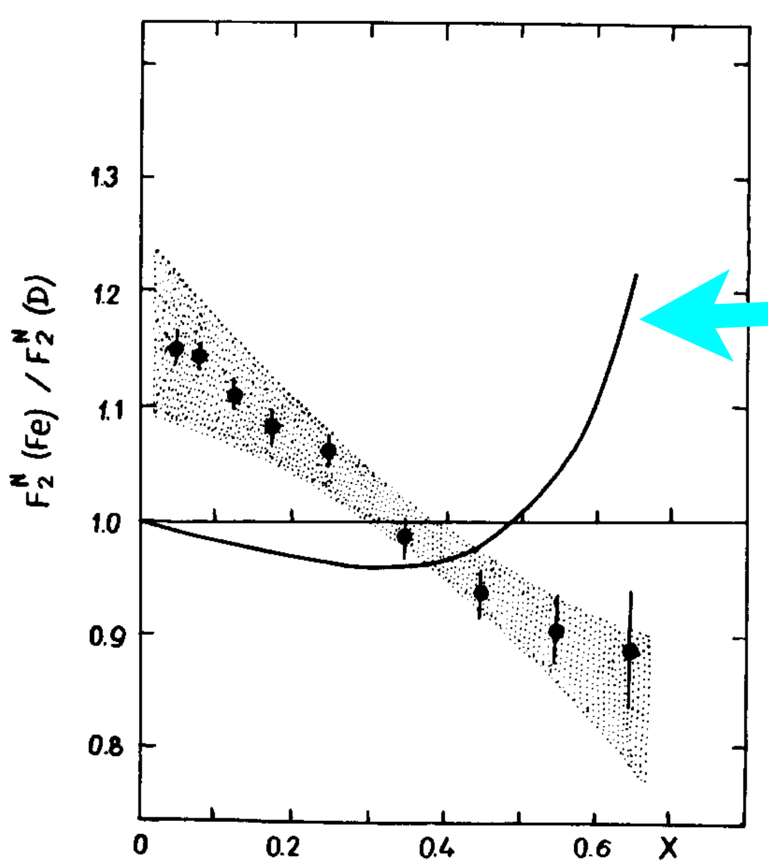
forward (along nuclear beam) at EIC

The highest resolution possible for probing the distribution of constituents in hadrons is deep inelastic scattering (DIS) (and other hard inclusive processes)

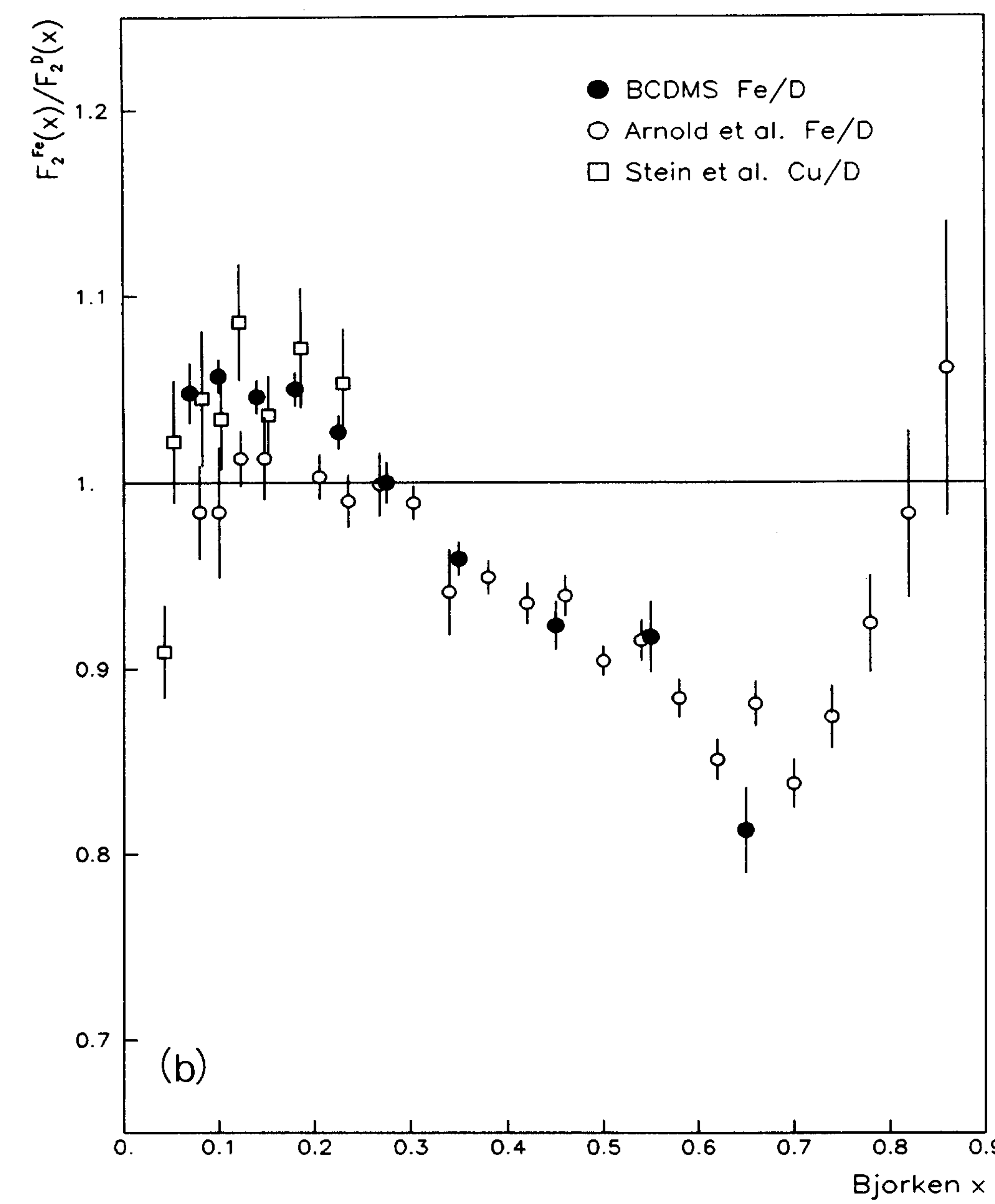
Reference point: nucleus is a collection of quasifree nucleons.

A hard probe incoherently interacts with individual nucleons

EMC ratio $R_A(x,Q^2) \equiv \dfrac{\sigma_A(x,Q^2)}{Z\sigma_p(x,Q^2) + N\sigma_n(x,Q^2)} = 1$



Theoretical expectation under assumption that nucleus consists only of nucleons FS 81



One should not be surprised by presence of the effect but by its smallness for x<0.35 where bulk of quarks are since distances between nucleons are comparable to the radii of nucleons.

Large effects for atoms in this limit.

Can account of Fermi motion describe the EMC effect?

YES

If one violates baryon charge conservation or momentum conservation or both

Many nucleon approximation:

$$\int \rho_A^N(\alpha, p_t)\frac{d\alpha}{\alpha}d^2p_t = A$$ baryon charge sum rule

$$\frac{1}{A}\int \alpha\rho_A^N(\alpha, p_t)\frac{d\alpha}{\alpha}d^2p_t = 1 - \lambda_A$$

λ_A: fraction of nucleus momentum NOT carried by nucleons

=0 in many nucl. approx.

Generic models of the EMC effect (no qualitatively new models in 30 years)

- Pionic model: extra pions - $\lambda_\pi \sim 4\%$ -actually for fitting Jlab and SLAC data ~ 6%

$R_A(x,Q^2) = 1 - \frac{\lambda_A n x}{1-x}$ + enhancement from scattering off pion field with $\alpha_\pi \sim 0.15$

- 6 quark configurations in nuclei with $P_{6q} \sim$ 20-30%

- *Nucleon swelling - radius of the nucleus is 20--15% larger in nuclei. Color is significantly delocalized in nuclei*

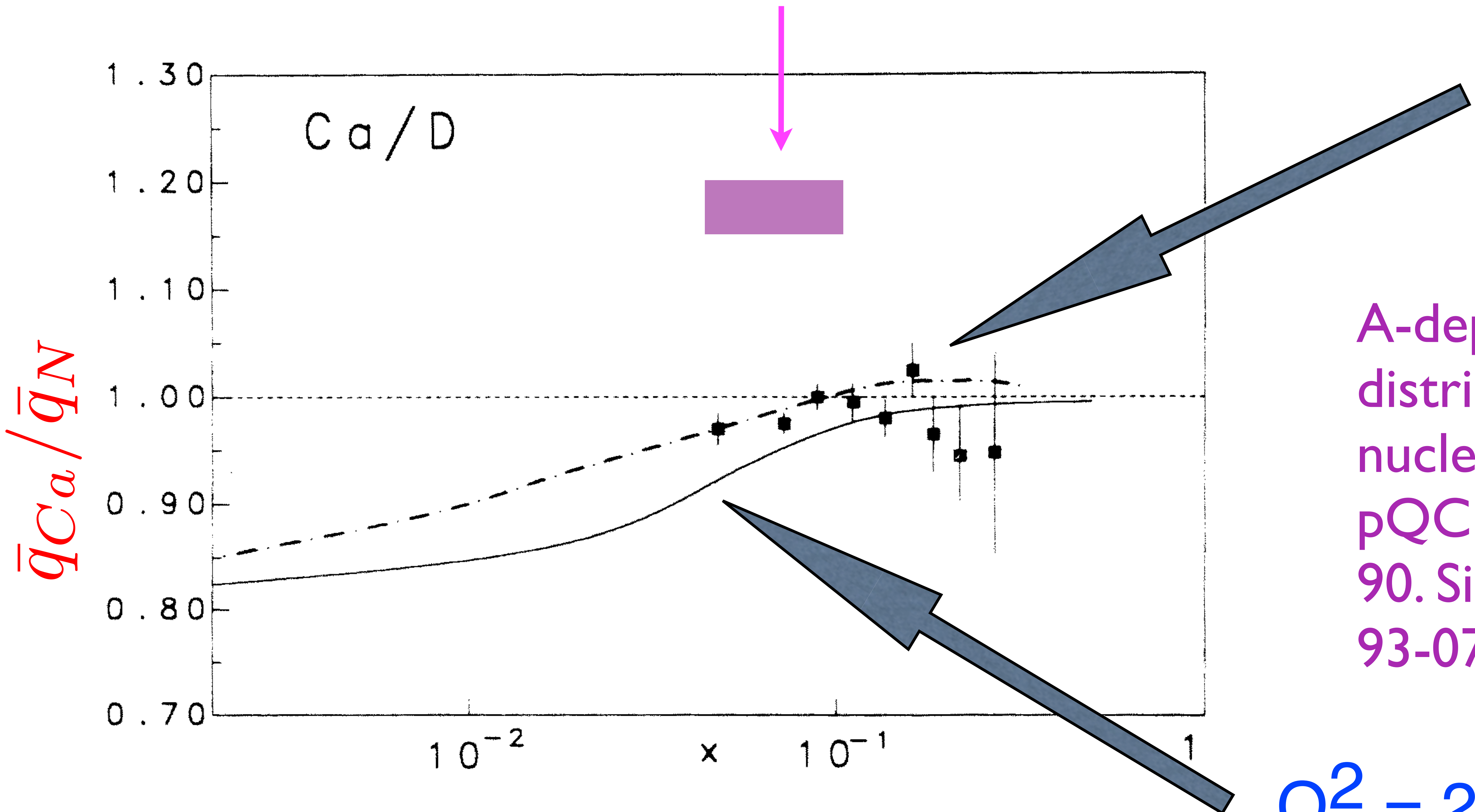
  Larger size →fewer fast quarks - possible mechanism: gluon radiation starting at lower Q^2 $(1/A)F_{2A}(x,Q^2) = F_{2D}(x, Q^2\xi_A(Q^2))/2$

- Mini delocalization (color screening model) - small swelling - enhancement of deformation at large x due to suppression of small size configurations in bound nucleons + valence quark antishadowing with effect roughly $\propto k_{nucl}^2$

Drell-Yan experiments: $\bar{q}_{Ca}/\bar{q}_N \approx 0.97$
1989

vs Prediction $\bar{q}_{Ca}(x)/\bar{q}_N = 1.1 \div 1.2_{|\, x=0.05 \div 0.1}$

meson model expectation
$\bar{q}_{Ca}(x)/\bar{q}_N = 1.1 \div 1.2_{|\, x=0.05 \div 0.1}$



A-dependence of antiquark distribution, data are from FNAL nuclear Drell-Yan experiment, curves - pQCD analysis of Frankfurt, Liuti, MS 90. Similar conclusions by Eskola et al 93-07 data analyses

✳ *Combined analysis of (e,e') and knockout data*

Structure of 2N correlations - probability ~ 20% for A>12

→ dominant but not the only term in kinetic energy

90% pn + 10% pp < 10% exotics ⇒ probability of exotics < 2%

✳ Analysis of (e,e') SLAC data at x=1 -- tests Q^2 dependence of the nucleon form factor for nucleon momenta k_N < 150 MeV/c and Q^2 > 1 GeV^2 :

☛ $$r_N^{bound}/r_N^{free} < 1.036$$

Similar conclusions from combined analysis of (e,e'p) and (e,e') JLab data

Analysis of elastic pA scattering $|r_{\rm N}^{\rm bound}/r_{\rm N}^{\rm free} - 1| \lesssim 0.04$

Problem for the nucleon swelling models of the EMC effect which 20% swelling

Very few models of the EMC effect survive when constraints due to the observations of the SRC are included as well as lack of enhancement of antiquarks and Q^2 dependence of the quasielastic (e,e') at x=1

- essentially one scenario survives - strong deformation of rare configurations in bound nucleons increasing with nucleon momentum and with most of the effect due to the SRCs .

Dynamical model - color screening model of the EMC effect (FS 83-85)

Combination of two ideas:

(a) Nucleon in a quark-gluon configurations of a size << average size (PLC) should interact weaker than in average configuration. Already application of the variational principle indicates that probability of such configurations in bound nucleons is suppressed.

(b) Quarks in nucleon with $x>0.5$ --0.6 belong to small size configurations with strongly suppressed pion field.

prediction for pA with trigger - confirmed by pA run (discuss in a couple of slides)

ening model modification of average properties is < 2- 3 %.

Introducing in the wave function of the nucleus explicit dependence of the internal variables

$$\left[-\frac{1}{2m_{\rm N}}\sum_j \nabla_i^2 + {\sum_{i,j}}' V(R_{ij}, y_i, y_j) + \sum_i H_0(y_i)\right]\psi(y_i, R_{ij}) = E\psi(y_i, R_{ij}).$$

$$U(R_{ij}) = \sum_{y_i, y_j, \tilde{y}_i, \tilde{y}_j} \langle \varphi_{\rm N}(y_i)\varphi_{\rm N}(y_j)|V(R_{ij}, y_i, y_j, \tilde{y}_i, \tilde{y}_j)|\varphi_{\rm N}(\tilde{y}_i)\varphi_{\rm N}(\tilde{y}_j)\rangle,$$

NR potential

In the first order perturbation theory for V << U using closure we find

$$\delta = \left|\frac{\psi_0 + \delta\psi_0}{\psi_0}\right|^2 \simeq 1 + 2{\sum_j}' U(R_{ij})/\Delta E_A.$$

$$\Delta E_A = m_{N^*} - m_N$$

For average configurations in nucleon (V ≝ U) no deformations

➠ modification of average properties of bound nucleons is < 2- 3 %

Momentum space $\delta_D(\mathbf{p}) = \left(1 + \frac{2\frac{\mathbf{p}^2}{2m} + \epsilon_D}{\Delta E_D}\right)^{-2}$

$$\delta(p, E_{exc}) = \left(1 - \frac{p_{int}^2 - m^2}{2\Delta E}\right)^{-2}$$

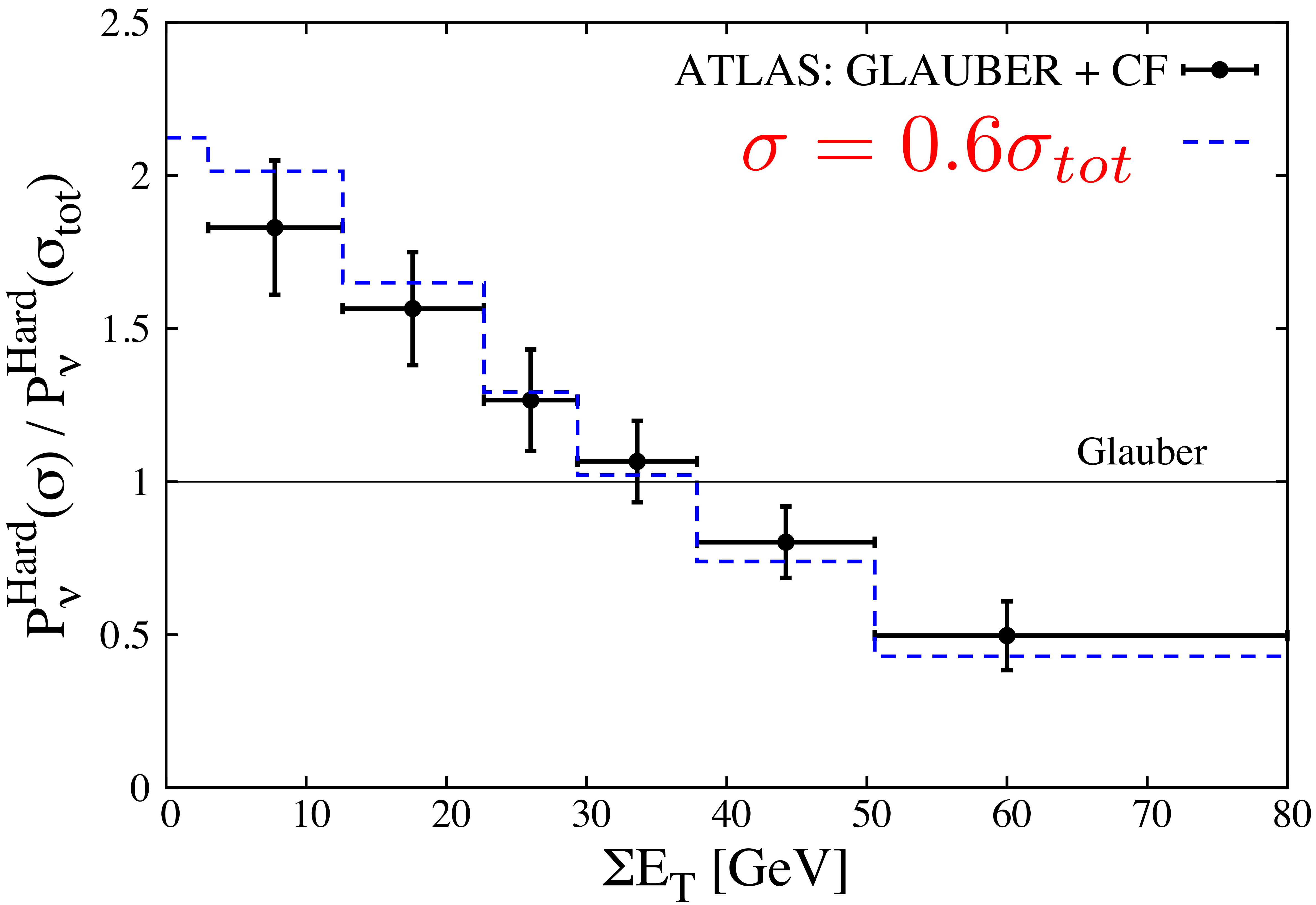
general case

effect ∝ virtuality

Critical test we suggested in 1983:

Hadron production in pA scattering with trigger on large x hard process. If large x corresponds to small sizes in proton, number wounded nucleonsat large x would be smaller and hadron production should be suppressed. In other words - trigger for large activity - suppression of events with large x.

ATLAS and CMS reported the effect of such kind. Our analysis (M.Alvioli, B.Cole. LF, . D.Perepelitsa, MS) suggests that for x~ 0.6 the transverse size of probed configurations is a factor of ~2 smaller than average.



Relative probability of hard processes corresponding to a small σ selection as a function of ΣE_T .ATLAS data are for x = 0.6

Dependence of suppression we find for small virtualities: $1-c(p^2_{int}-m^2)$

seems to be very general for the modification of the nucleon properties. Indeed, consider analytic continuation of the scattering amplitude to $p^2_{int}-m^2=0$. In this point modification should vanish. Our quantum mechanical treatment of 85 automatically took this into account.

Our dynamical model for dependence of bound nucleon pdf on virtuality - explains why effect is large for large x and practically absent for x~ 0.2 (average configurations V(conf) ~ <V>)

This generalization of initial formula allows a more accurate study of the A-dependence of the EMC effect.

Simple parametrization of suppression: no suppression $x \leq 0.45$, by factor $\delta_A(k)$ for $x \geq 0.65$, and linear interpolation in between

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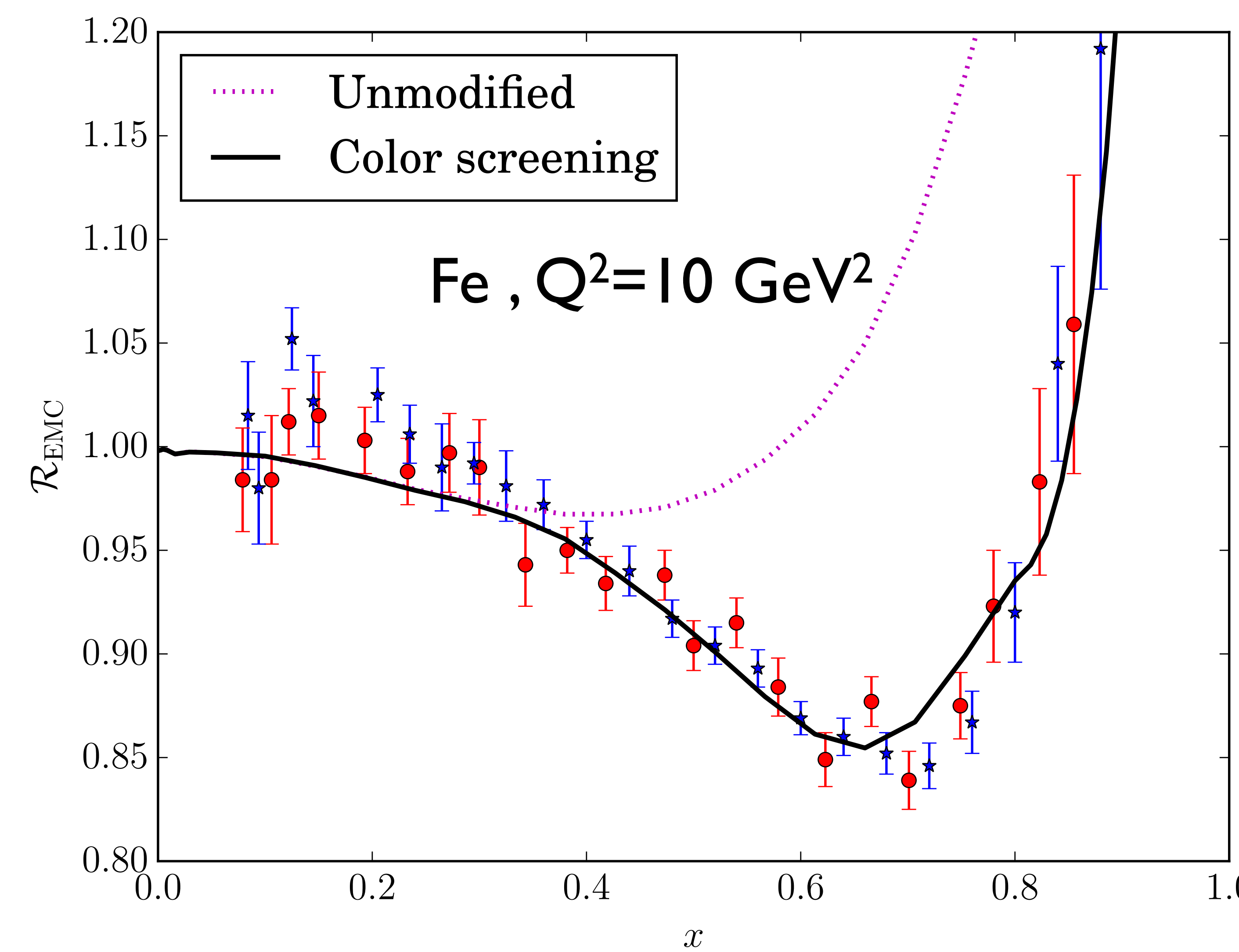
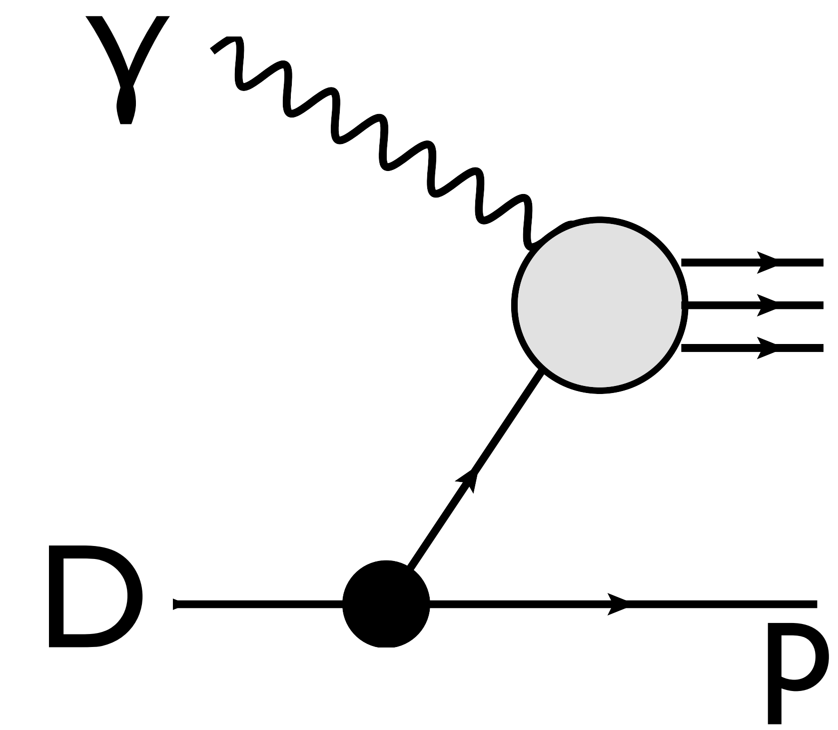


Freese, Sargsian, MS 14

“Gold plated test” (FS85) (Silver?)

Tagging of proton and neutron in e+D→e+ backward N +X (lab frame). Collider kinematics -- nucleons with $p_N > p_D/2$ - C.Weiss talk



interesting to measure tagged structure functions where modification is expected to increase quadratically with tagged nucleon momentum. It is applicable for searches of the form factor modification in (e,e’N). If an effect is observed at say100 MeV/c - go to 200 MeV/c and see whether the effect would increase by a factor of ~3-4.

$$1 - F_{2N}^{bound}(x/\alpha, Q^2)/F_{2N}(x/\alpha, Q^2) = f(x/\alpha, Q^2)(m^2 - p_{int}^2)$$

Here α is the light cone fraction of interacting nucleon

$$\alpha_{spect} = (2 - \alpha) = (E_N - p_{3N})/(m_D/2)$$

A>2 -- two step contribution, motion of the pair. mask effect.
In neutrino scattering BEBC tried to remove two step processes to see better 2N SRC “Doppler” shift

Experimental challenges

- Jlab Q range - separate LT and HT (50 :50) contribution to the EMC effect

Measurements at LHC in dijet production in pA feasible: Freese, Sargsian, MS 14

COMPASS DIS --- improve old DIS data which have errors ~50% for x=0.6

- *Superfast (x> 1) quarks* Jlab: Study of Q^2 dependence, trying to reach LT regime for x~ 1 at Q^2 ~ 15 GeV^2

$$F_{2A}(x=1)/F_{2D}(x=1) > a_2(A)$$

x~1 LHC dijet production in pPb feasible: Freese, Sargsian, MS 14

- EIC --- x~0.1: u-, d- quarks, gluons

Interesting possibility - EMC effect maybe missing some significant deformations which average out when integrated over the angles

A priori the deformation of a bound nucleon can also depend on the angle φ between the momentum of the struck nucleon and the reaction axis as

$$d\sigma/d\Omega/ < d\sigma/d\Omega >= 1 + c(p,q).$$

Here $<\sigma>$ is cross section averaged over φ and $d\Omega$ is the phase volume and the factor c characterizes non-spherical deformation.

Such non-spherical polarization is well known in atomic physics *(discussion with H.Bethe)*. Contrary to QED detailed calculations of this effect are not possible in QCD. However, a qualitatively similar deformation of the bound nucleons should arise in QCD. One may expect that the deformation of bound nucleon should be maximal in the direction of radius vector between two nucleons of SRC.

Next ten years

Discovery of non-nucleonic degrees of freedom in nuclei: Δ's , tagged structure function (testing origin of the EMC effect); observation of superfast quarks

Direct observation of the 3N correlations

High statistic studies of 2N correlations: determining at what momenta SRC set in, node in pp SRC, S/D wave separation in deuteron, deviations from universality of SRC

Factorization of SRC dominated cross sections at large Q^2(t) - Jlab vs hadronic probes

Theory: FSI effects, calculation of the decay function, solving LC many body equations,...