ACCURACY OF eA MEASUREMENTS AT eRHIC

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SYNOPSIS

① STUDY OF INCLUSIVE MEASUREMENTS

$$eA \rightarrow e' X$$

— TRIGGERED BY e' OR EJECTED QUARK

② COMPUTE COUNT RATES USING ONE PHOTON EXCHANGE APPROXIMATION:-

$$\frac{d^2\sigma}{dx\, dQ^2} = \frac{4\pi\alpha^2}{x Q^4}\left[1 - y + \frac{y^2}{2(1+R)}\right] F_2(x, Q^2)$$

$$F_2 = \sum e_i^2 x\, q_i(x, Q^2)$$

$q_i(x, Q^2)$ & $R(x, Q^2)$ COMPUTED FROM MRSA.

③ COMPUTE STATISTICAL ACCURACIES

— SYSTEMATIC ERRORS NEED TO BE ADDRESSED.

④ CONCENTRATE ON SHADOWING MEASUREMENTS

$$R_{NUC} = \frac{F_2^A}{F_2^D} \approx \frac{\text{COUNT RATE FROM } A}{\text{" " " } D} \quad [R?]$$

WHY SHADOWING?

MODELS

SCHILDNECHT
SHAW
BRODSKY, HOYER
MELNITCHOUK & THOMAS
PILLER, RATZKA
WEISE

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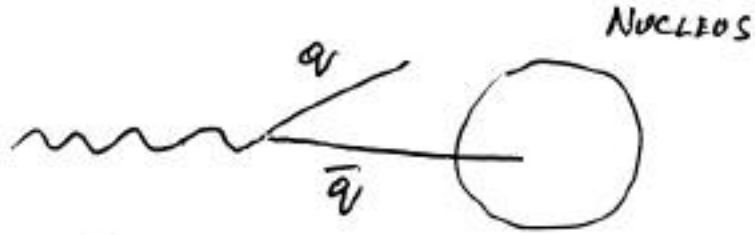
- LAB FRAME ARGUMENT.

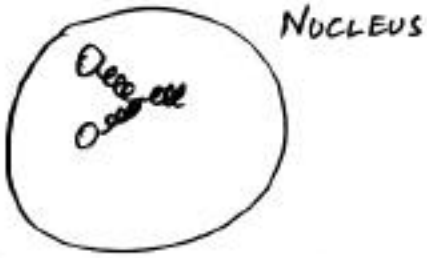


DOUBLE SCATTER AMPLITUDE INTERFERES DESTRUCTIVELY WITH SINGLE SCATTER SINCE AMPLITUDES ARE IMAGINARY.

$$\therefore \quad \sigma_{\gamma A} < A\,\sigma_{\gamma N}$$

- LIGHT CONE ARGUMENT

NICHOLAEV, ZAKHAROV
MUELLER, QIU.



- DENSE SOFT PARTONS FROM ONE NUCLEON FUSE TO DEPLETE PARTONS AT VERY LOW x. ($x \lesssim .01$)

- LEADS TO ACCRETION OF MOMENTUM AT HIGHER x ($\sim .05$) i.e. ANTISHADOWING

CAN SHADOWING LIMIT GROWTH OF $F_2 \to Q^2$ AT SMALL x? (3)

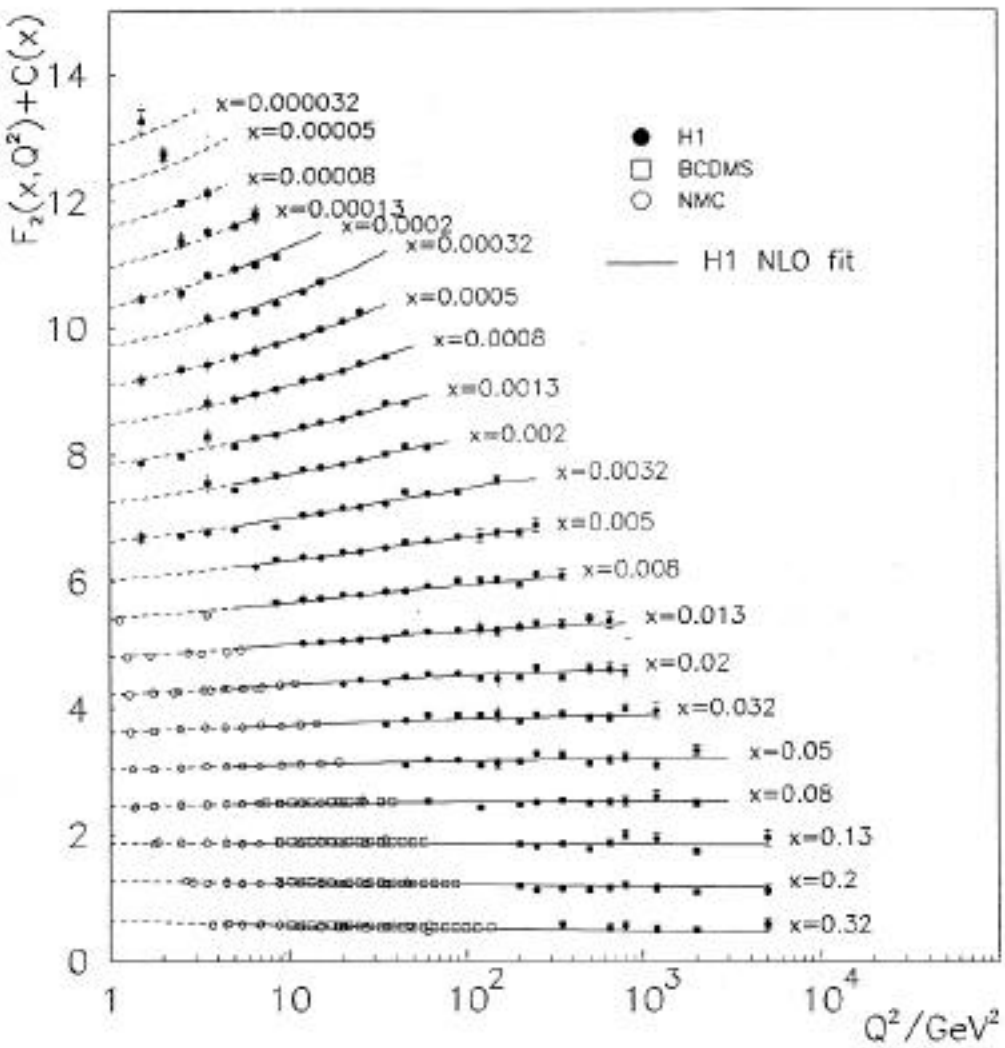


Figure 11: $F_2(x,Q^2)$ measured by H1 together with BCDMS [41] and NMC [40] fixed target results. The full line corresponds to the NLO QCD fit, see sect.7.4, which includes the data for $Q^2 \geq 5$ GeV^2. The extension of the curves below 5 GeV^2 represents only the backward evolution of the fit. The F_2 values are plotted in a linear scale adding a constant $c(x) = 0.6(i-0.4)$ where i is the x bin number starting at $i=1$ from $x = 0.32$. The inner error bar is the statistical error, the outer corresponds to the full error resulting from adding the statistical and systematic error in quadrature. Some H1 data points at lower Q^2 where shifted to nearby x values for graphical representation of the data.

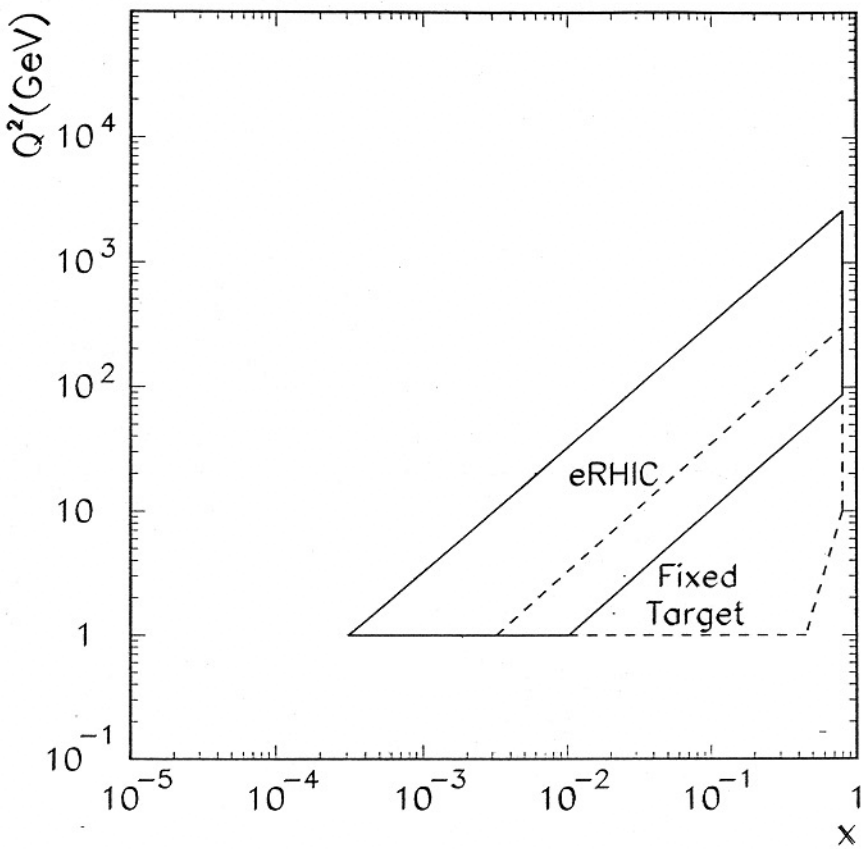


Fig 1a Kinematic ranges of the existing fixed target data compared to the projected measurements at RHIC.

$$Q^2 = s\,x\,y \qquad (.03 < y < 0.9)$$

$$y = 1 - \frac{E'(1-\cos\theta)}{2E} \approx \frac{E-E'}{E}$$

CUTS

$E' > 2$ GeV, $\theta_e > 3^\circ$ OR $E_q > 5$ GeV, $\theta_q > 10^\circ$

$Q^2 > 1$ GeV^2

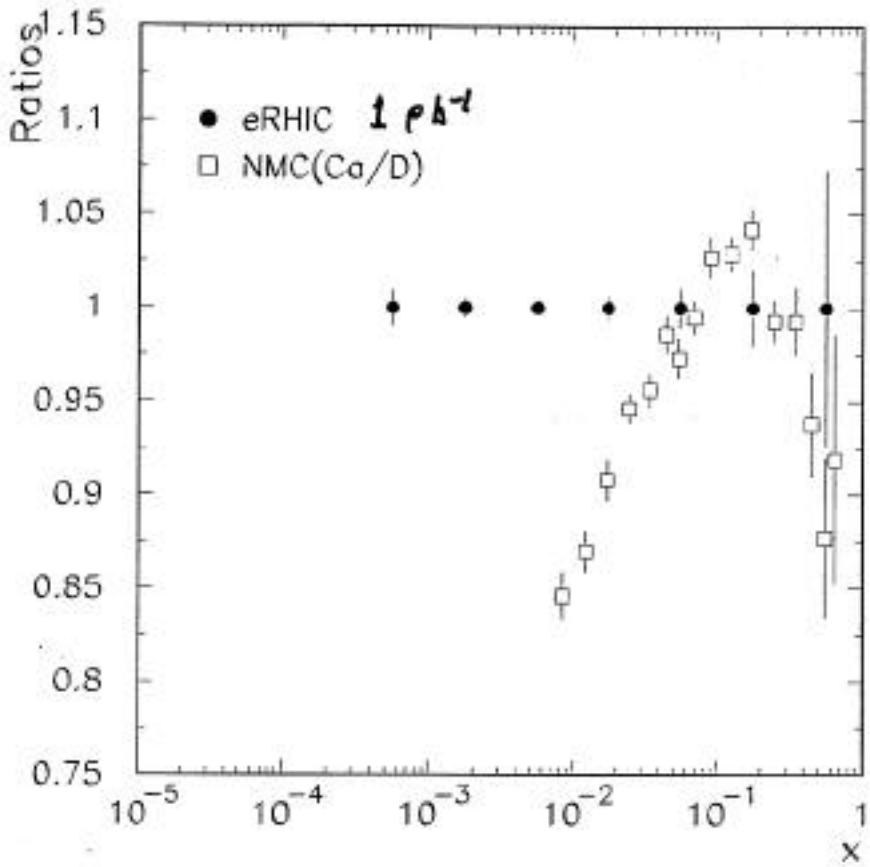


Figure 2a. The estimated accuracy per pb^{-1} luminosity of the ratios R_{nuc} at RHIC compared with the NMC measurements for Ca/D with $Q^2 > 1$ GeV^2.

INTEGRATED LUMI PER YEAR ($\sim 10^7$ secs)

$$= \underset{\text{sec/yr}}{10^7} \times \underset{\text{pb}^{-1}\text{s}^{-1}}{2 \times 10^{30}} \times \underset{\text{Gold}}{197} \times \text{fraction live}$$

$$= 4000 \text{ pb}^{-1}/\text{year} \times \text{fraction live}.$$

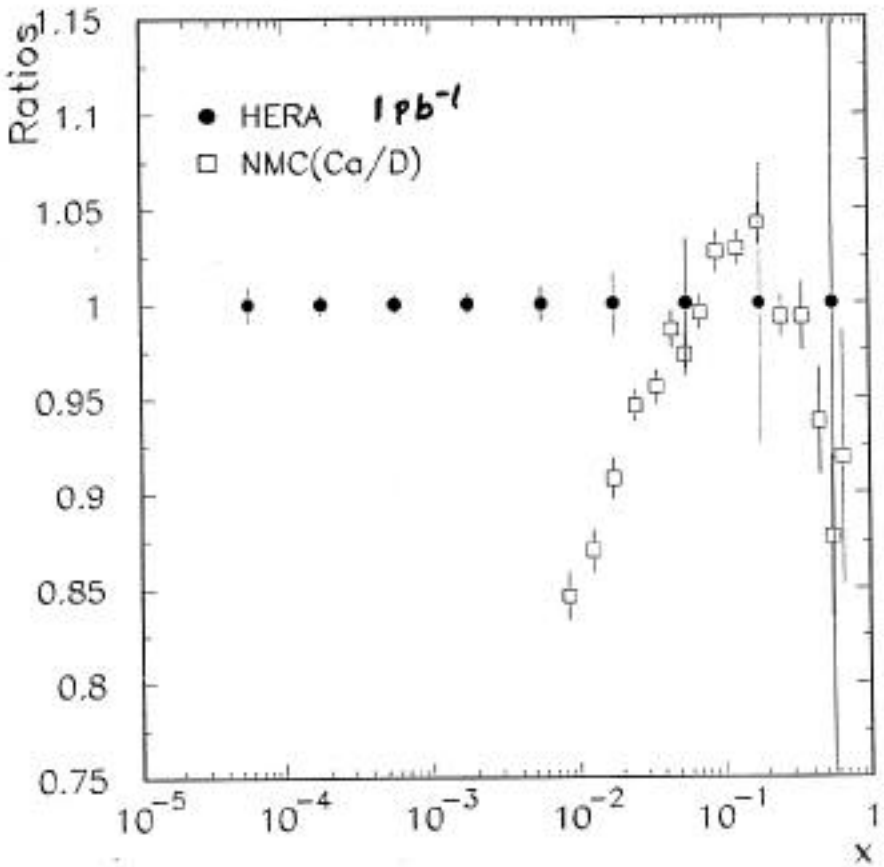


Figure 2b The estimated accuracy of the ratios R_{esc} per pb^{-1} luminosity at HERA compared with the NMC measurements for Ca/D with $Q^2 > 1$ GeV^2.

SAME CALCULATION FOR HERA PROTONS (NOW)

INTEGRATED LUMI = 10^7 s/yr × 10^{31} pb^{-1}s^{-1} × fraction LIVE.

= 100 pb^{-1} yr^{-1} × fraction live

(X ~5, UPGRADE)

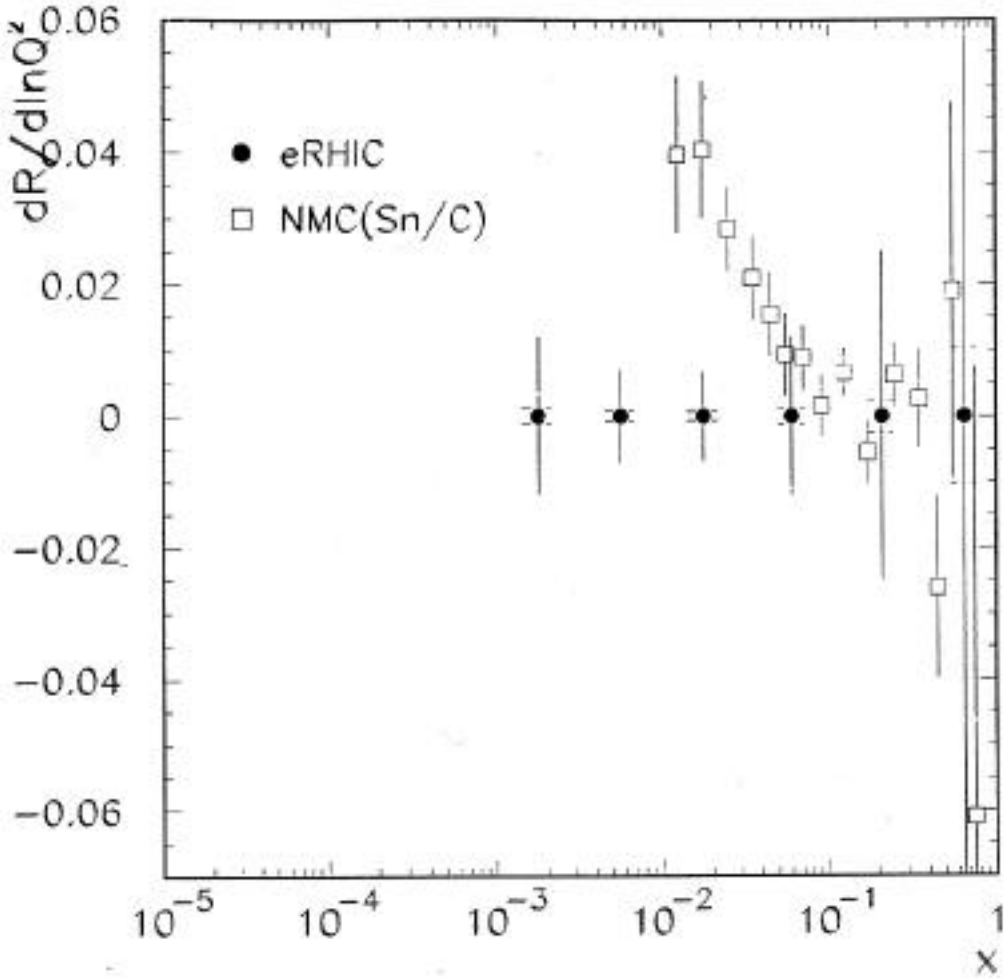


Figure 3a. The slopes $\frac{dR}{d\ln Q^2}$ as function of x showing the NMC data [1] (open squares) and the statistical accuracy of an experiment with 1 pb^{-1} per nucleon per target at eRHIC. The inner error bars show the accuracy for an experimental luminosity of 100 pb^{-1} (ie roughly a 5 day run at eRHIC). The NMC systematic errors which are about the same size as the statistical errors are not included.

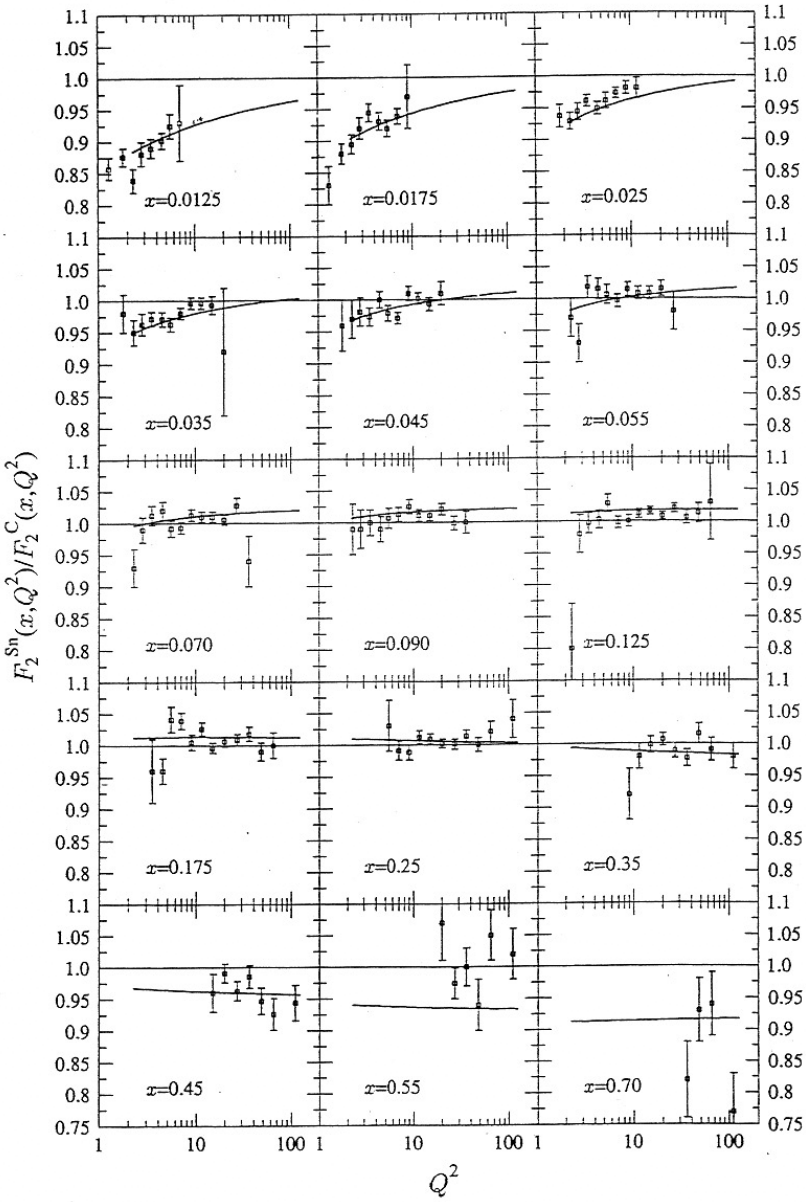


Fig. 10. The calculated scale evolution of $F_2^{\mathrm{Sn}}(x,Q^2)/F_2^{\mathrm{C}}(x,Q^2)$ compared with the NMC data [3] at different fixed values of x. The data are plotted with statistical errors only.

the data. The changes in the sign of $\partial(F_2^{\mathrm{Sn}}/F_2^{\mathrm{C}})/\partial Q^2$ do not seem to be in contradiction with the data, either. It is also interesting to notice [illegible]

$$\int_{x_1}^{x_2} \left[\frac{F_2^A}{F_2^D} - 1 \right] F_2^D \, dx$$

(× CORRS ~1)

= CHANGE IN FRACTION OF MOMENTUM OF NUCLEON CARRIED BY QUARKS.

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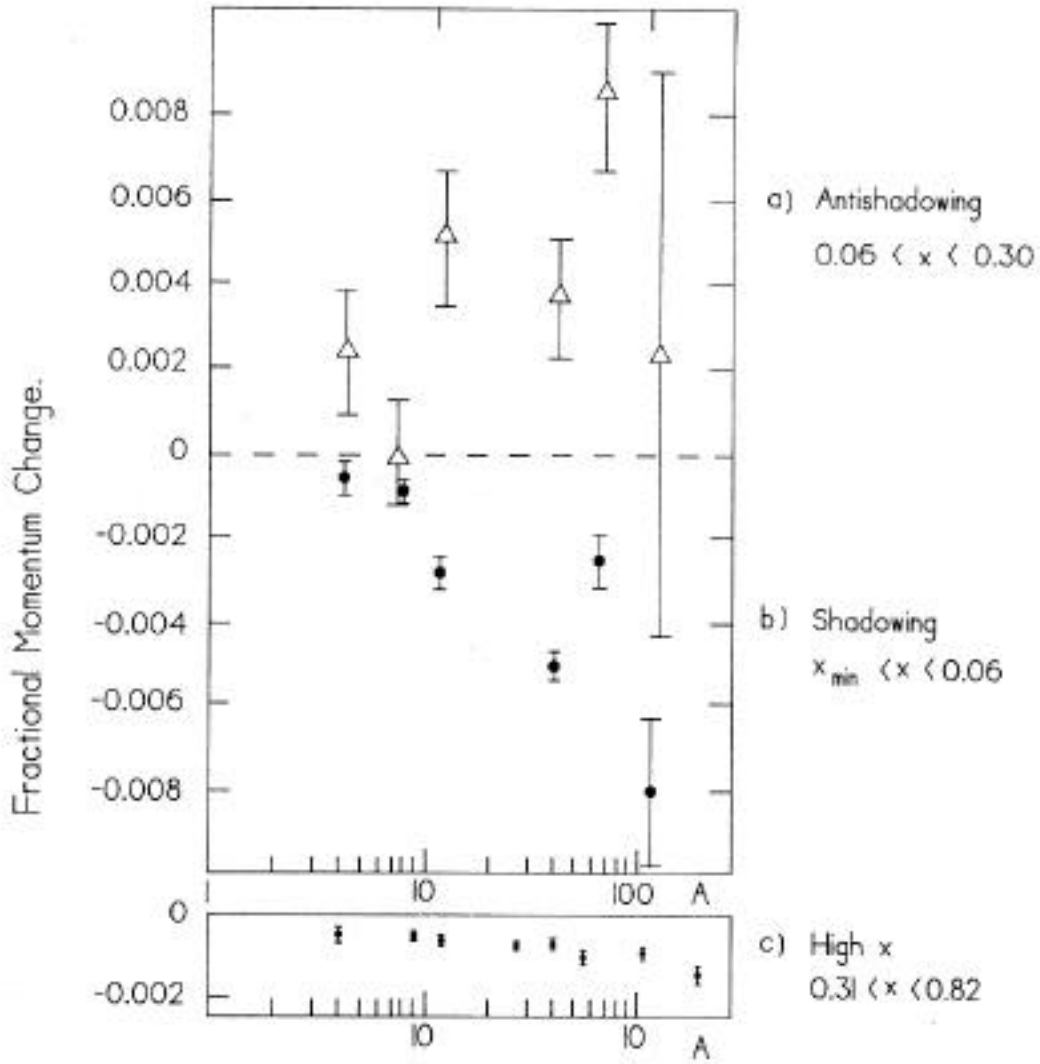

Fig. 8

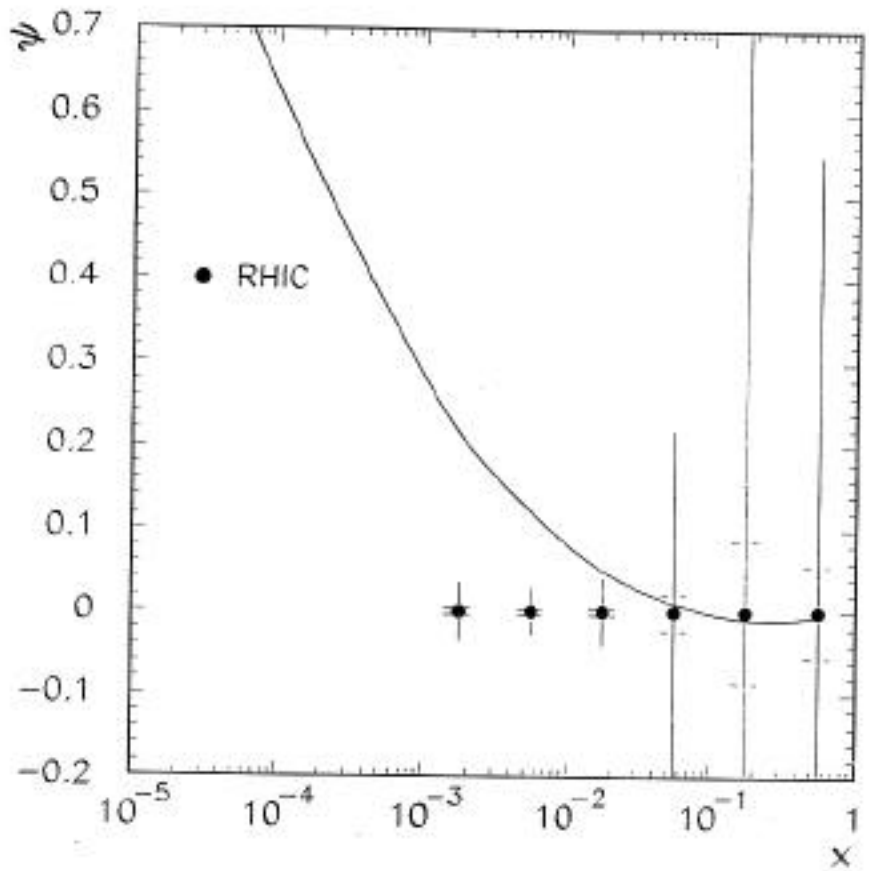

Figure 4a. The slopes ψ (see text) as a function of x showing the statistical accuracy of an experiment with 1 pb^{-1} per nucleon per target at RHIC. The smooth curve shows $dF_2^p/d\ln Q^2$ expected from QCD and calculated from the MRSA parton distribution functions. The inner error bars show the accuracy for an experimental luminosity of 100 pb^{-1} (ie roughly a 5 day run at eRHIC).

$$\psi = \frac{\frac{dF_2^A}{d\ln Q^2} - \frac{dF_2^D}{d\ln Q^2}}{\frac{dF_2^p}{d\ln Q^2}} \approx \frac{\Delta G}{G}$$

EXPERIMENTAL CONSIDERATIONS

- LOW ELECTRON ENERGY – 10 GeV
  - NEED TO DETECT & IDENTIFY SCATTERED ELECTRONS DOWN TO $E' \sim 2\text{-}3$ GeV.
- e A RHIC IS A HIGH LUMINOSITY MACHINE
  - NEED SELECTIVE TRIGGERS TO AVOID DEAD TIME PROBLEMS.
- NEED LOW A AND HIGH A NUCLEI AS WELL AS DEUTERONS
  - CAN A AND D BE STORED SIMULTANEOUSLY TO MINIMIZE SYSTEMATIC ERRORS
- NEED HERMETIC DETECTOR FOR EVENT RECONSTRUCTION
  - PROBABLY DIFFERENT FROM EXISTING RHIC DETECTORS.

CONCLUSIONS

- VERY HIGH STATISTICAL PRECISION IS POSSIBLE AT THE HIGH LUMINOSITY e RHIC
- SYSTEMATIC ERRORS NEED TO BE CONTROLLED.