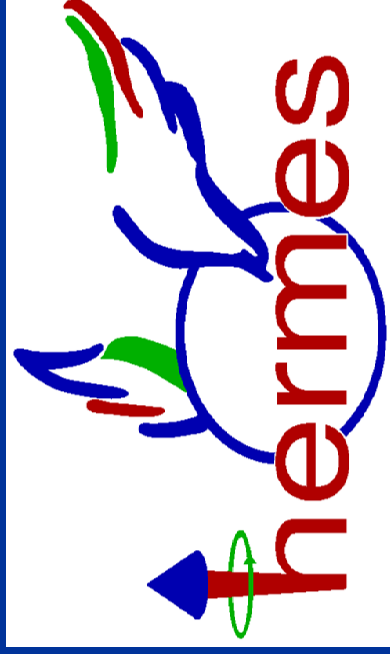


# Recent Results from



M.Amarian

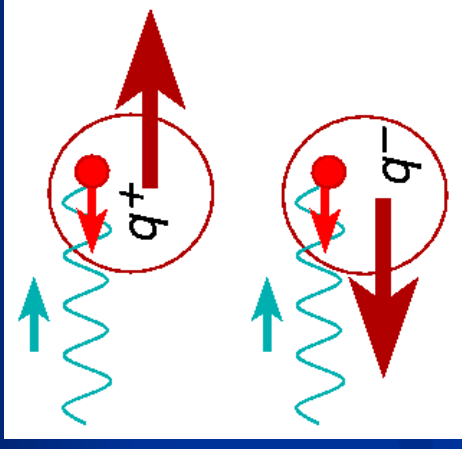
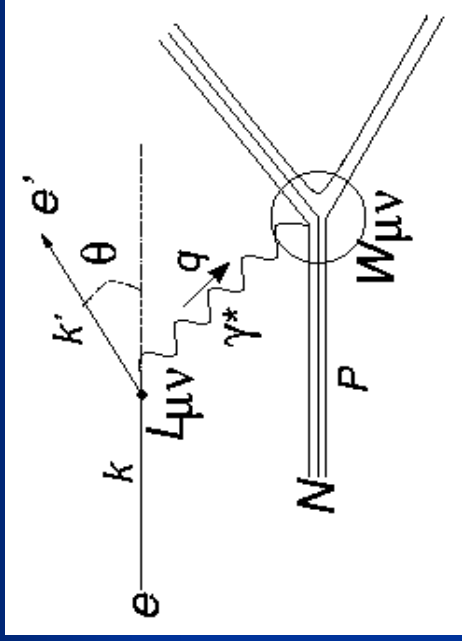
DESY-Zeuthen

(on behalf of Collaboration)

# OUTLINE

- NLO QCD Fit to the  $g_1(x, Q^2)$  World Data
- Hadron attenuation in nuclei
- Electroproduction of  $f^0(980)$
- Measurement of *Transversity*
- Future prospects
- Summary

# Unpolarized and Polarized DIS



■ In DIS we measure  $F_1$

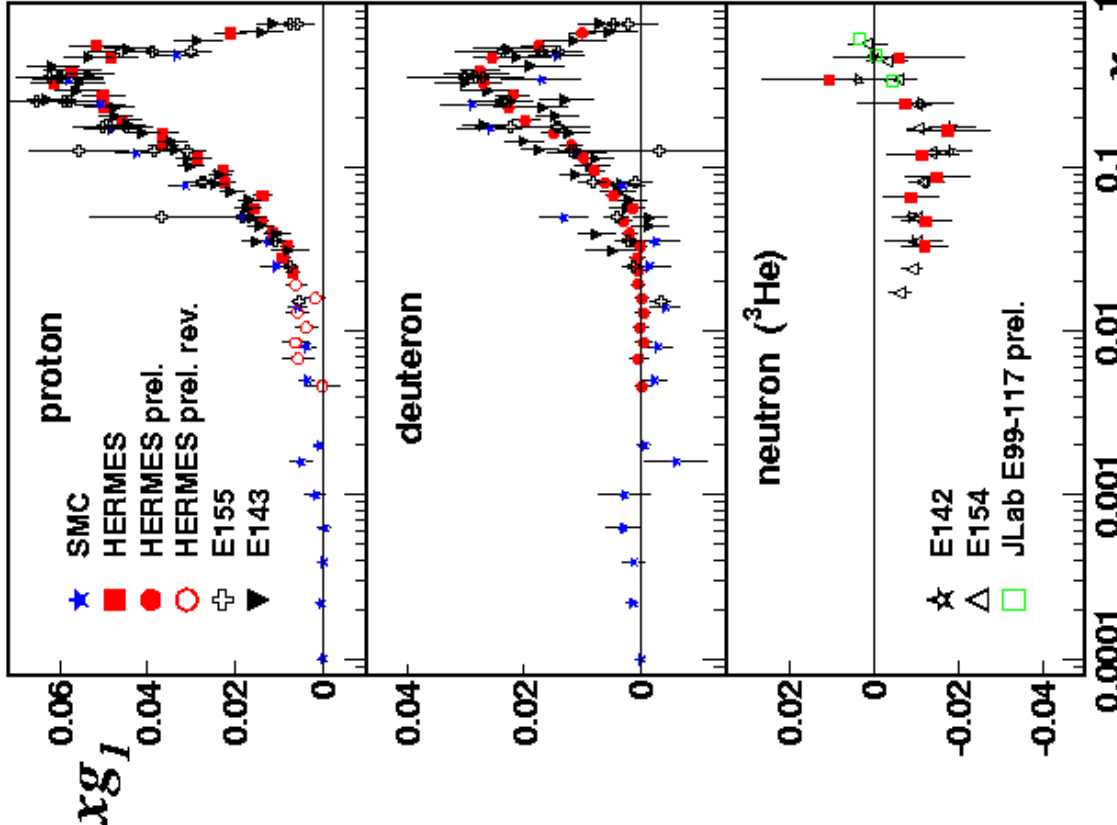
$$F_1(x) > \frac{1}{2} \sum_f e_f^2 [q_f(x), q_f(x)]$$

■ In polarized case  $g_1$

$$g_1(x) > \frac{1}{2} \sum_f e_f^2 [q_f(x) \cdot q_f(x)]$$

# World Data on $g_1$

HERMES contributes to  
the world data on  $g_1$   
especially providing most  
precise data on deuteron

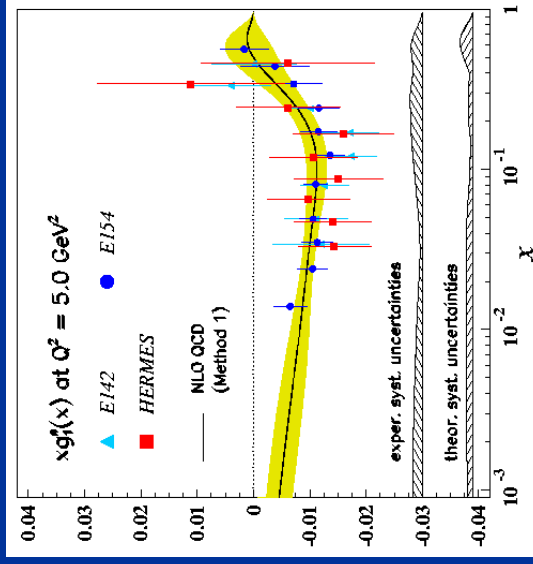
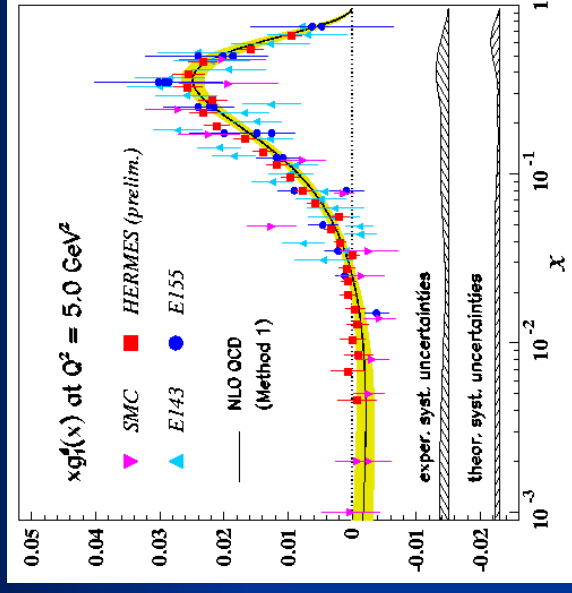
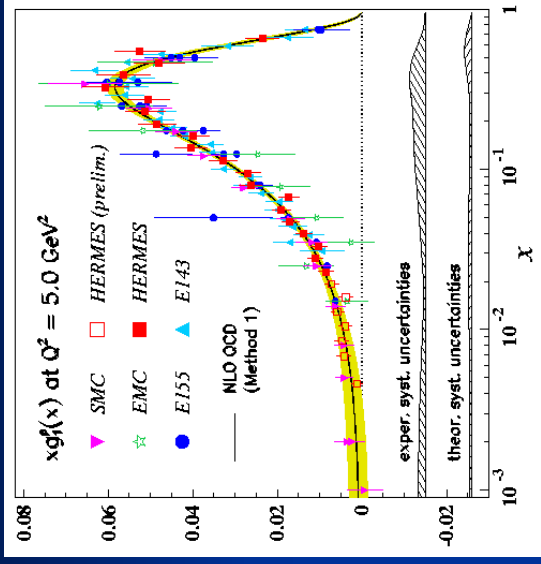


$$x \Delta q_i(x, Q_0^2) = \eta_i A_i x^{\alpha_i} (1-x)^{\beta_i} (1 + \gamma_i x + \rho_i x^{\frac{1}{2}})$$

Method 1	Method 2
$\overline{MS}$	$\overline{MS}$
Mellin Transform	Finite differences
$\Delta u_v, \Delta d_v, \Delta \bar{q}_s, \Delta G$	$\Delta q_{NS}^p, \Delta q_{NS}^n, \Delta \Sigma, \Delta G$
symmetric sea: $\Delta \bar{q}_s = \Delta \bar{u}_s = \Delta \bar{d}_s = \Delta s = \Delta \bar{s}$	no assumption (in the fit)
$\eta_{u_v}, \eta_{d_v}$ fixed by $F, D$	$\eta_{q_p}^{NS}, \eta_{q_n}^{NS}$ fixed by $F, D$
$\gamma_{u_v}, \gamma_{d_v} \neq 0$ fixed	$\gamma_{q_p}^{NS} = \gamma_{q_n}^{NS} \neq 0$ fixed
$a_G = a_{sea} + 1$	$\left\{ \begin{array}{l} \text{no such} \\ \text{relations} \end{array} \right.$
$\left. \begin{array}{l} \frac{b_{\bar{q}_s}}{b_G} \Big _{pol} = \frac{b_{\bar{q}_s}}{b_G} \Big _{unpol} \\ b_{\bar{q}_s} = 8.08, b_G = 5.61 \end{array} \right\}^*$	
$\gamma_{\bar{q}_s} = 0, \gamma_G = 0$	$b_G = 5.61$
$\rho = 0$ for all densities	$\gamma_\Sigma \neq 0$ fixed, $\gamma_G = 0$
$\rightarrow 7$ fit parameters	$\rho = 0$ for all densities $\rightarrow 7$ fit parameters
$\Lambda_{QCD}^{(4)} = 291 \pm 30 \text{ MeV}$	$\alpha_s(M_Z^2) = 0.117 \pm 0.002$
$Q_0^2 = 4 \text{ GeV}^2$	$Q_0^2 = 4 \text{ GeV}^2$
data: $Q^2 > 1 \text{ GeV}^2$	data: $Q^2 > 1 \text{ GeV}^2$

\* lead to sensitivity for  $\Lambda_{\bar{s}}$  and  $\Lambda_{\bar{c}}$

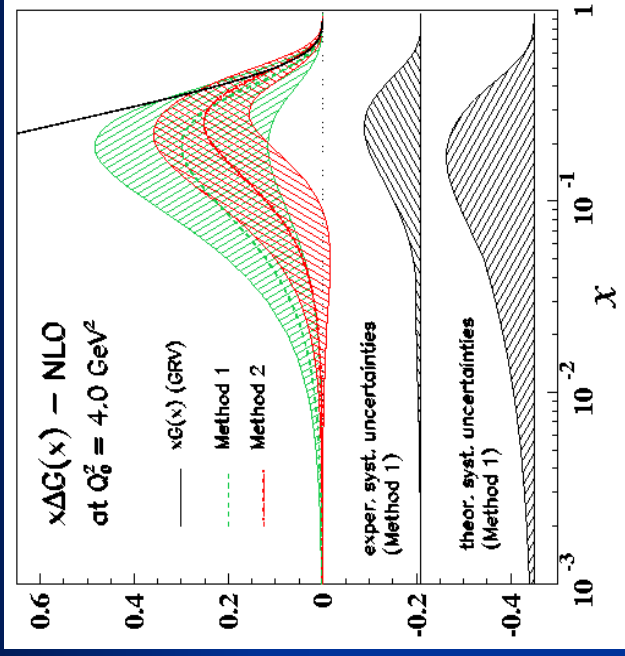
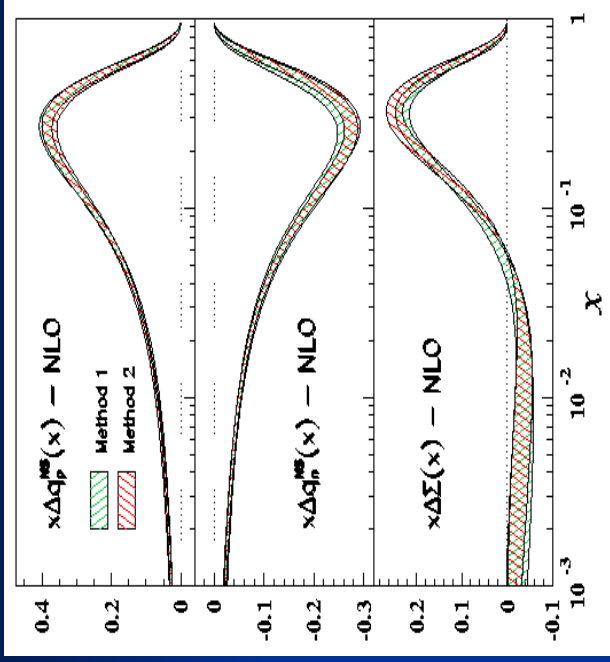
# World Data on $g_1(x, Q^2)$ with NLO Fit



- For the first time with high precision HERMES data on Deuteron with full error propagation

$$\delta^2 / df > 0.9$$

# Final Results of QCD Fit



$$ET > (Eu, E\bar{u}), (Ed, E\bar{d}), (Es, E\bar{s})$$

$$Eq_n^{NS} > \frac{1}{2}(2(Ed, E\bar{d}), (Eu, E\bar{u}), (Es, E\bar{s}))$$

$$Eq_p^{NS} > \frac{1}{2}(2(Eu, E\bar{u}), (Ed, E\bar{d}), (Es, E\bar{s}))$$

# Hadron Attenuation in Nuclei

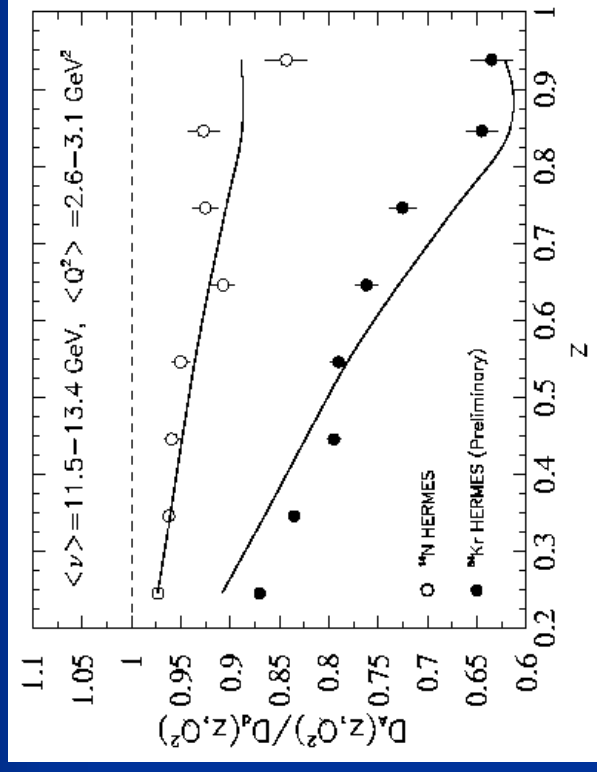
■ The main physics question here is : how does fragmentation change in nuclear medium?

■ Study multiplicity ratio Nucleus/Deuterium

■ From preliminary **HERMES** Data on N and Kr targets  **$dE/dx = 0.5 \text{ GeV}/fm$**

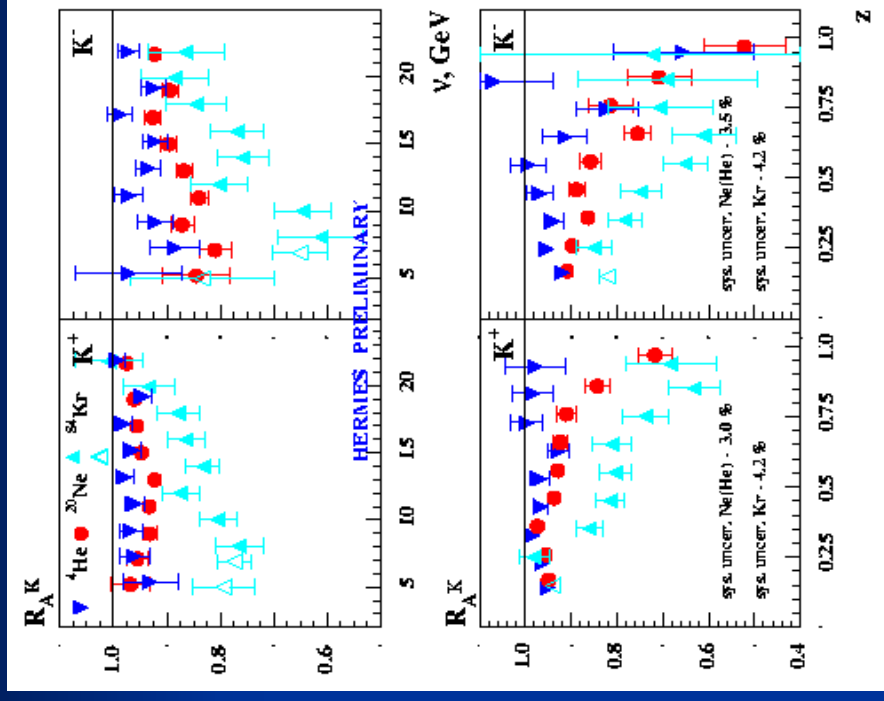
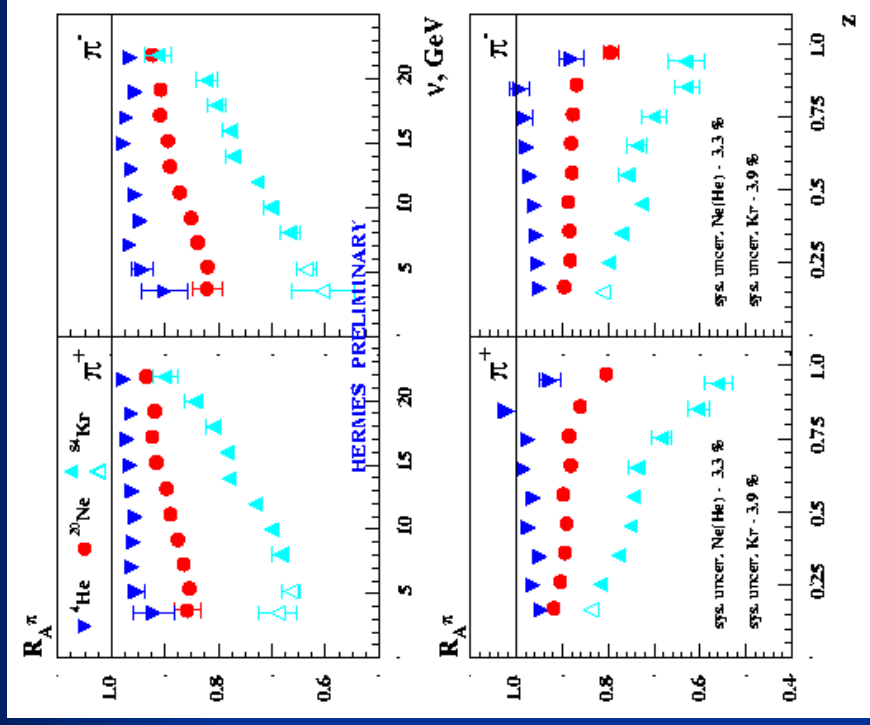
■ From **RHIC** Au+Au  **$dE/dx=7.3 \text{ GeV}/fm$**

■ Is Gluon density in hot matter order of magnitude higher? (E.Wang and X.-N.Wang hep-ph/0202105)



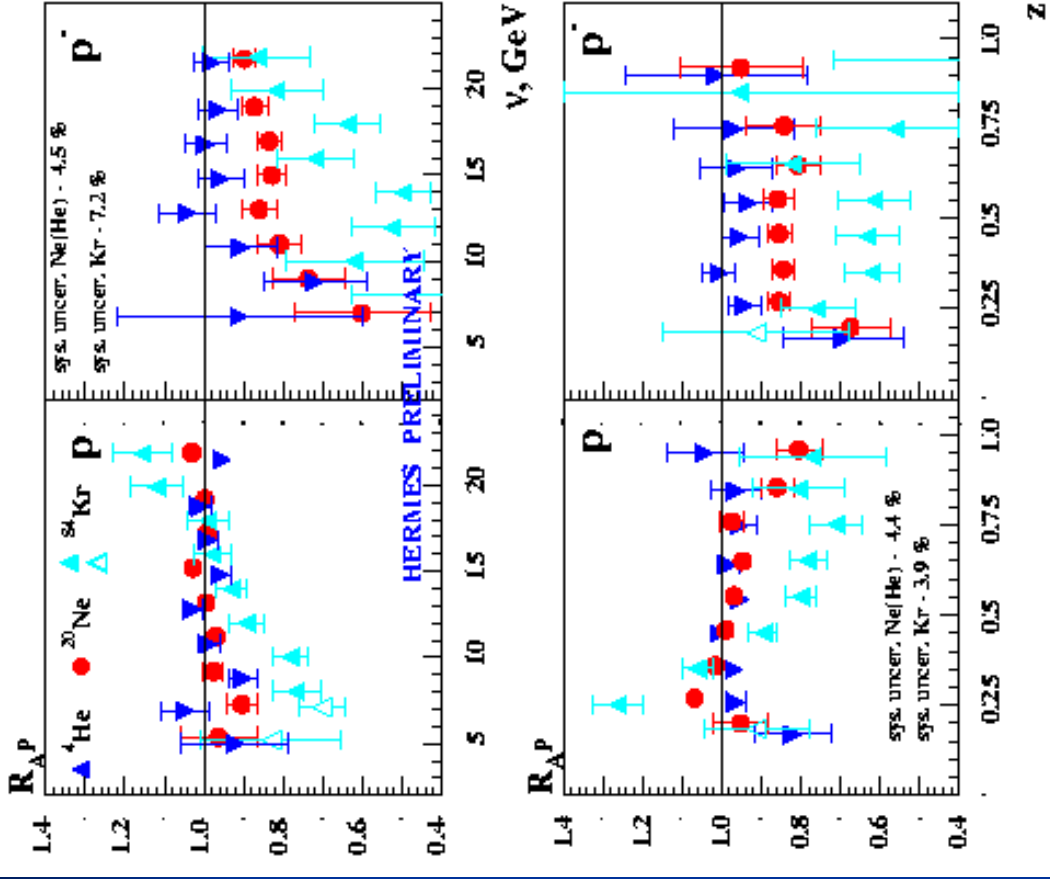


# Meson attenuation in nuclei



■ High statistics data for He, Ne and Kr targets

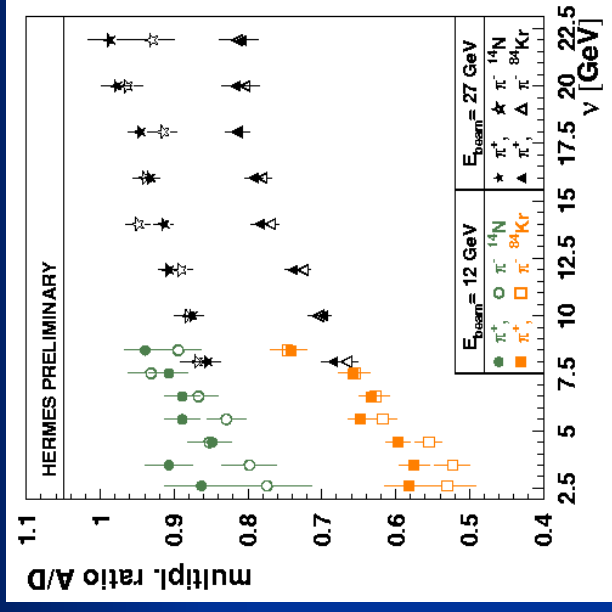
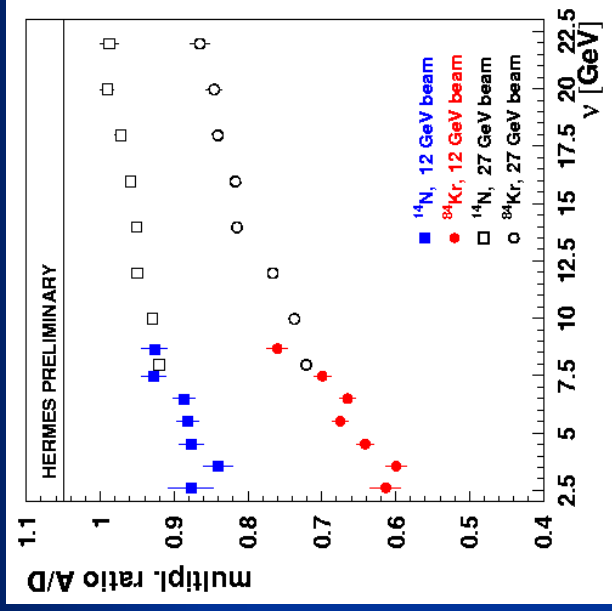
# Baryon attenuation in nuclei



□ Protons are attenuated  
less than anti-protons

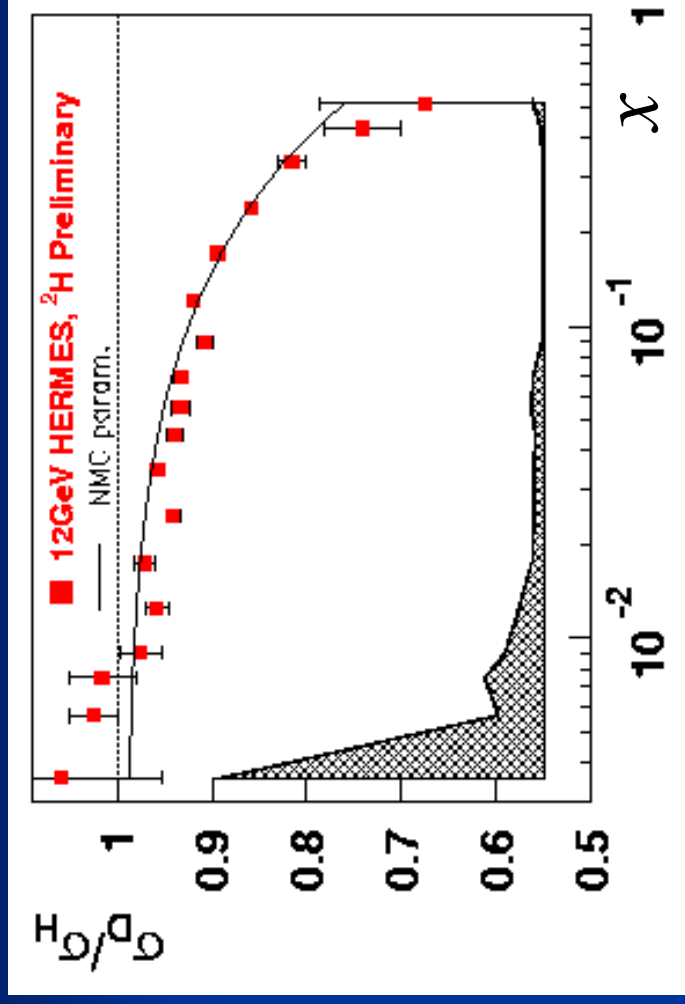
□ z-distributions are  
flatter than for mesons

# First Results from 12 GeV Positron Beam of HERA



- Only few days of 12 GeV running
- Significantly extended kinematical range for multiplicity ratio A/D

# Inclusive Cross Section Ratio at 12 GeV



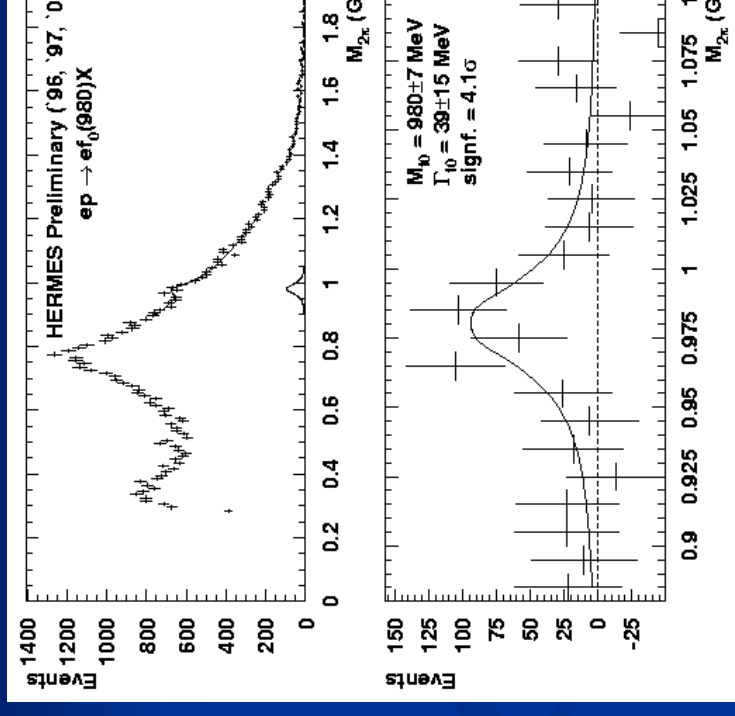
- *e, e' cross section ratio agrees with NMC parametrization for the ratio D/H at much higher Q<sup>2</sup>*

# Electroproduction of $f^0(980)$

- Why  $f^0(980)$  is so interesting?
- Having mass on the order of  $\eta'$  it has one order of magnitude smaller **radiative width**
- Being close to two Kaons mass it was proposed to be **kaon molecule**
- It also was suggested to be **4-quark state**
- being  $0^{++}$  state it has quantum numbers of QCD vacuum, thus considered as an **“eye-witness of confinement”** and much more ...

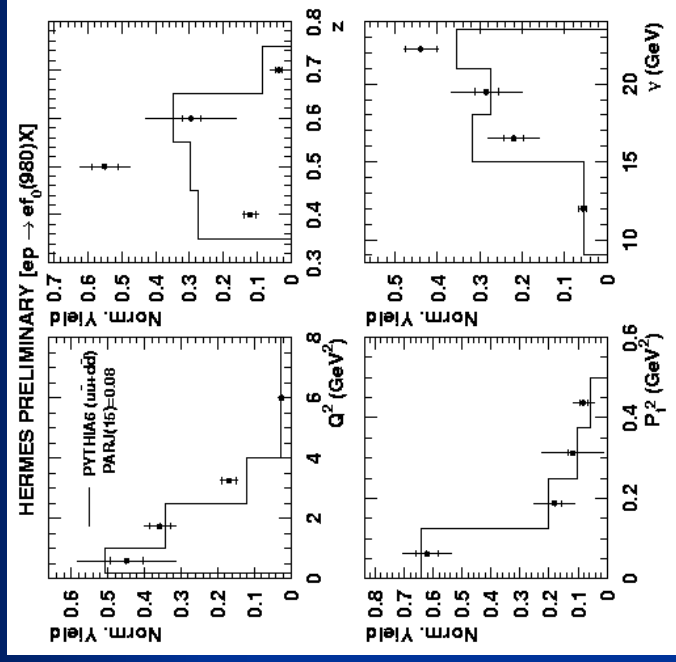
# Mass peak of $f_0(980)$

- Mass:  $M_{f_0} > 980$  MeV
- Width:  $H(f_0 \rightarrow \theta^+ \theta^-) > 39$  MeV
- Significance = 4.1 $\sigma$

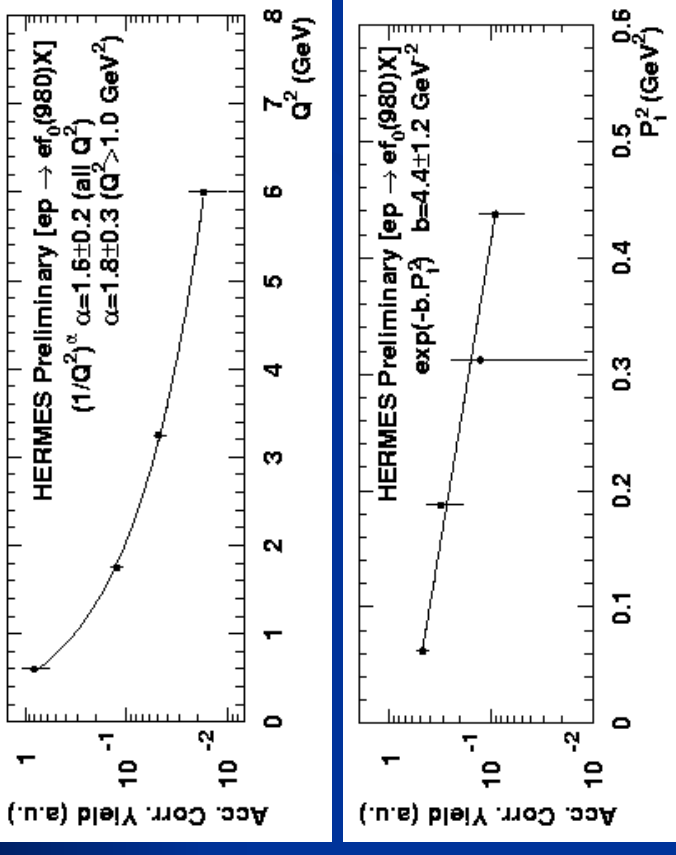


# Kinematical Distributions of $f_0(980)$

*In HERMES*



*In 4θ*



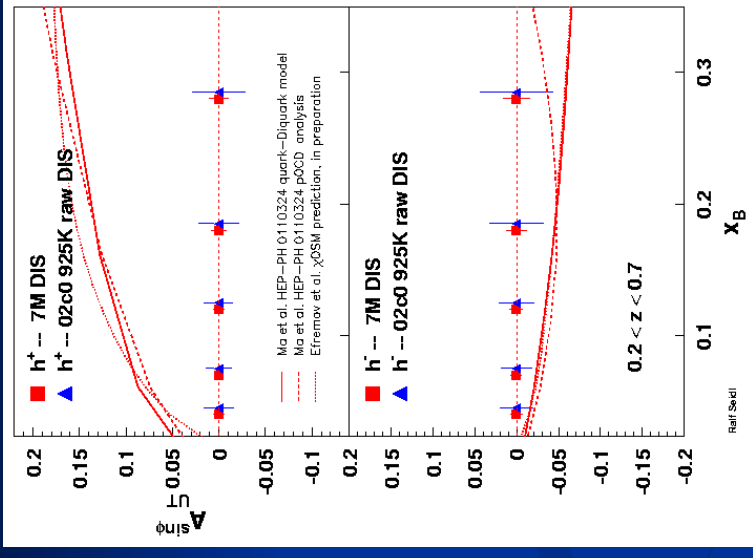
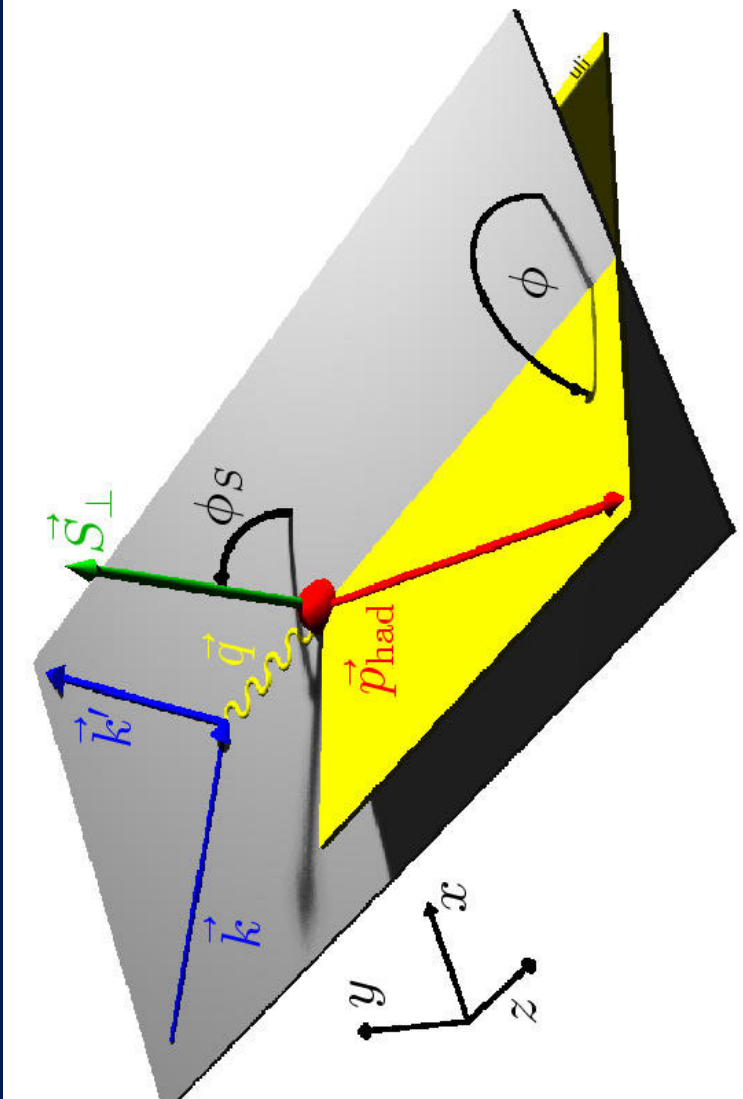
- For  $(1/Q^2)^\alpha$   $\alpha = 1.8 \pm 0.3$  similar to other mesons
- $P_t^2$  slope  $b = 4.4 \pm 1.2$  GeV<sup>2</sup> consistent with NOMAD  $(5.3 \pm 0.3)$
- Data from different nuclei and decay to  $\pi^0\pi^0$  is under study

# Transversity

- In DIS at twist-2 level there are three independent correlation functions:
  - $\overline{Z} | \eta^\nu | Z$  ? related to **vector charge** and structure function  $F_1$  accessible in unpolarized measurement
  - $\overline{Z} | \eta^\nu \eta_5 | Z$  ? related to **axial-vector** charge and structure function  $g_1$  accessible with longitudinally polarized beam and target
  - $\overline{Z} | \tau^{\nu\sigma} | Z$  ? related to **tensor charge** and structure function  $h_1$  accessible with transversely polarized target
- ❖  $F_1$  and  $g_1$  conserve chirality, while  $h_1$  violates it
- ❖ The latter, also called **transversity** structure function, can be extracted from semi-inclusive meson production



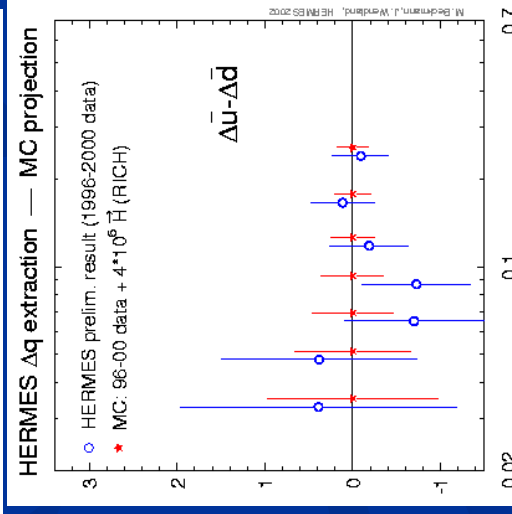
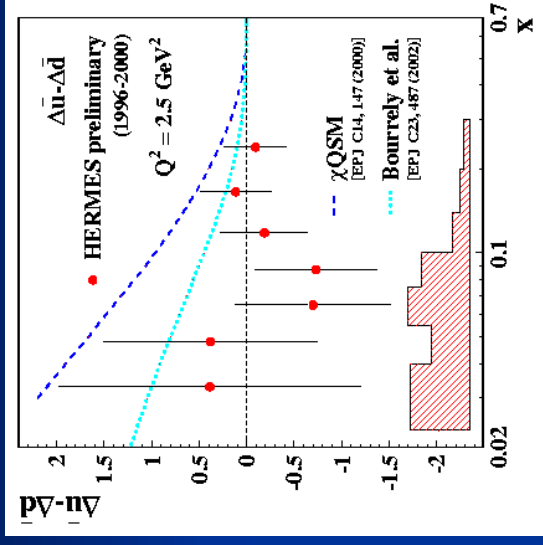
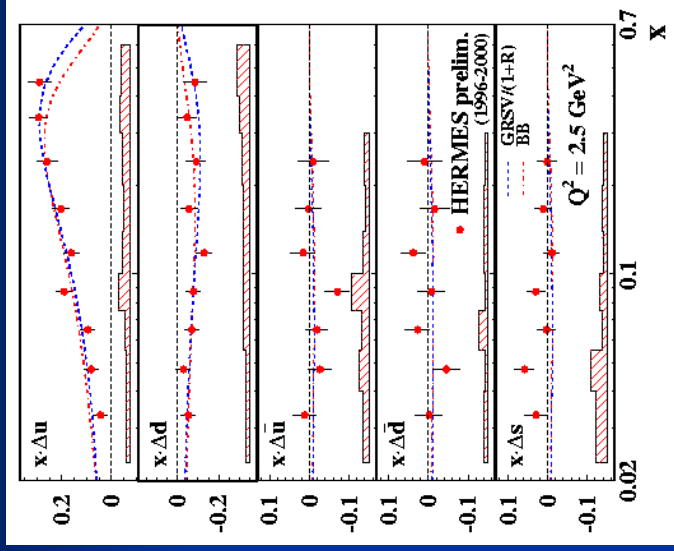
# Measurement of Transversity



$$A_{UT} \sim h_1(x)H_1(z)\sin(\Phi+\Phi_s)$$

$H_1(z)$  is Collins fragmentation function

# Future prospects



- Strange see *is not negative* ?
- Difference of up-down antiquarks : *crucial test* of  $SU(3)_f$  symmetry

# Summary

- HERMES collected high quality polarized and unpolarized data from HERA Run-1
- Analysis of this data brings more and more results on very different topics
- We have also collected data from HERA Run-2 and results are expected soon
- There is a rich physics potential that will materialize with few more years of running