Hadronization via Attenuation in e+A Collisions

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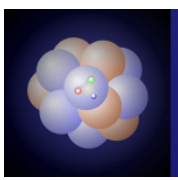
- Motivation
- Model
  - Pythia, GiBUU, prehadronic FSI
- Results
  - EMC&Hermes, JLAB@12, JLAB@5
- Problems



Institut für Theoretische Physik

JUSTUS-LIEBIG-UNIVERSITÄT GIESSEN

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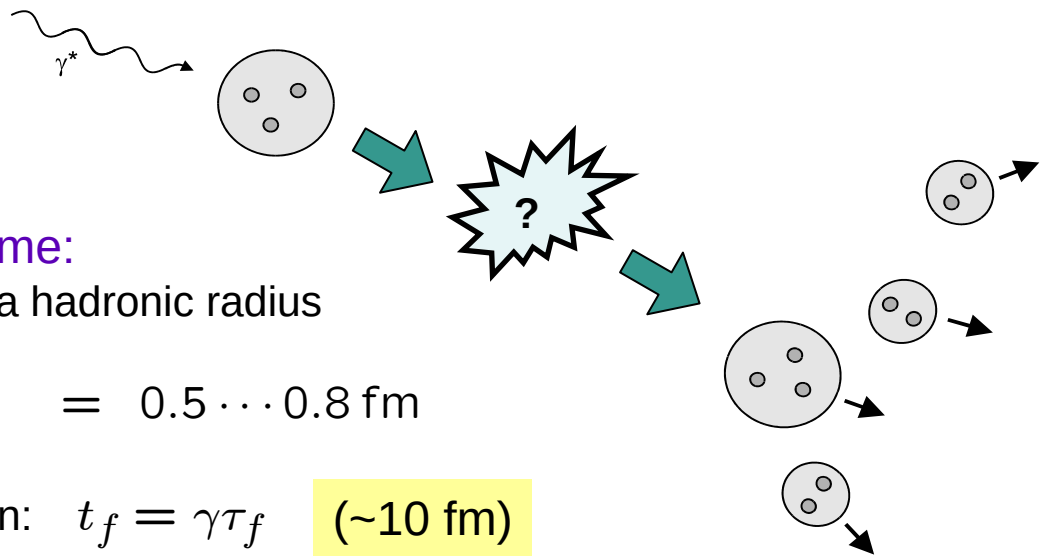
Milos, 10-15.9.2007

Motivation

- elementary reactions (*eN*, γN) on nucleon:



formation time:
estimation via hadronic radius

$$\tau_f \geq \frac{r_h}{c} = 0.5 \cdots 0.8 \text{ fm}$$

time dilatation: $t_f = \gamma \tau_f$ (~10 fm)

reaction products hadronize long before they reach the detector

- nuclear reactions (*eA*, γA @ GeV energies) :

interactions with nuclear medium during t_f

→ space-time picture of hadronization

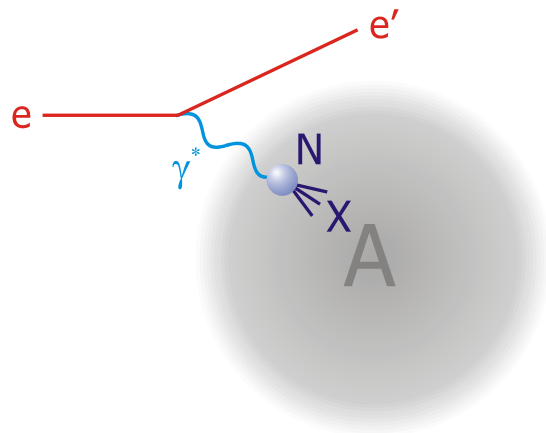
$$\sigma^* / \sigma_H \sim t^{0,\,1,\,2,\cdots}$$

Model

- $\gamma^*N \rightarrow X$ using PYTHIA

  additional:

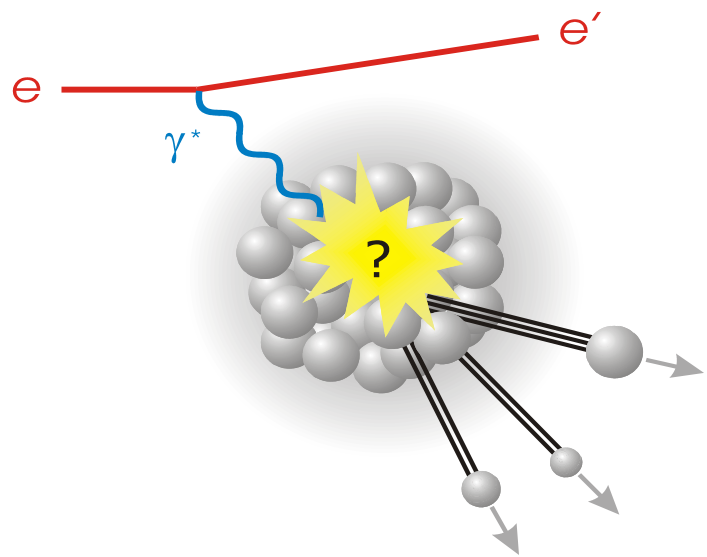
  - binding energies
  - Fermi motion
  - Pauli blocking
  - coherence length effects



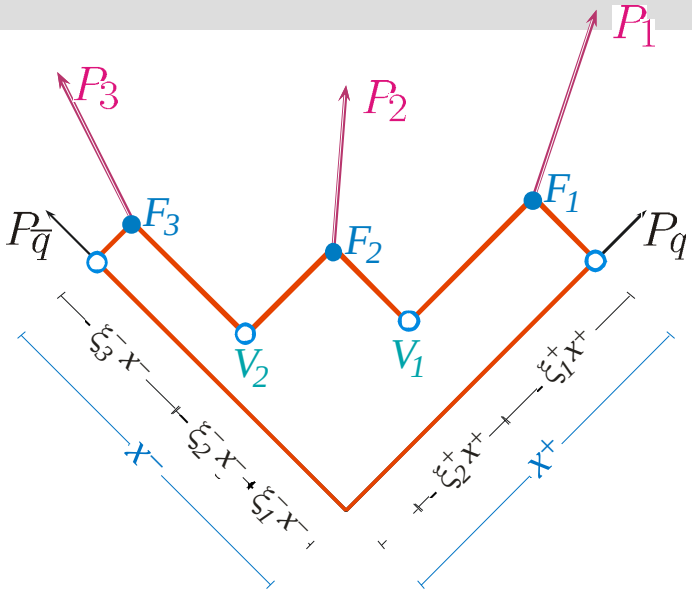
- propagation of final state X within GiBUU transport model

  - elastic/inelastic scatterings (coupled channels)

  - experimental acceptance



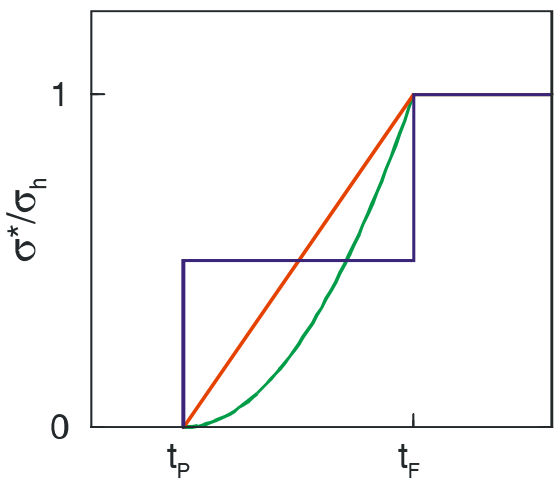
Model: Hadronization in String Model (Pythia/Jetset)

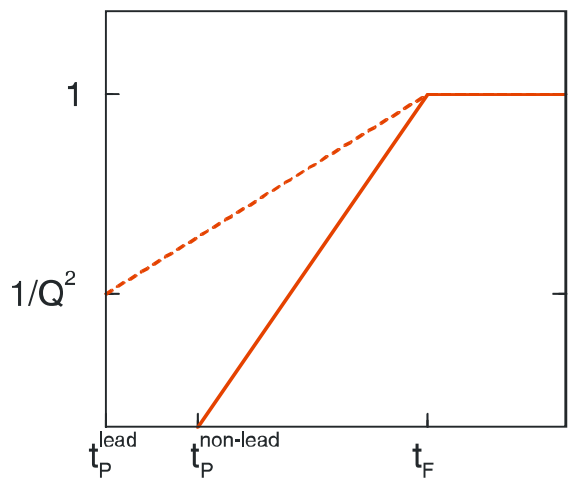


- 3 times/points per particle:
  - „Production 1“ String-Break
  - „Production 2“ String-Break
  - „Formation“ Line Meeting
- leading vs. non-leading

CT

- XS evolution scenarios:





Observables, Experiments

- multiplicity ratio

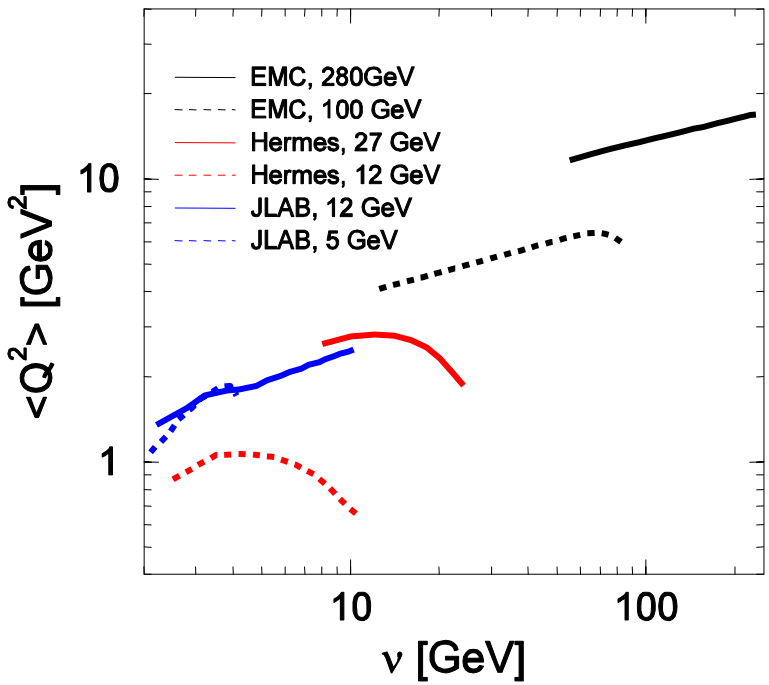
$$R_M^h(z_h,\ldots) = \frac{\left(\frac{N_h(z_h,\ldots)}{N_e(\ldots)}\right)_A}{\left(\frac{N_h(z_h,\ldots)}{N_e(\ldots)}\right)_D}$$

- hadronic: $z_h = \frac{E_h}{\nu}$, $p_\perp$, $\ldots$
- photonic: ν, Q^2, W, x_B, $\ldots$

- Experiments

	E_{lepton} =
EMC	100…280 GeV
Hermes	27 GeV
Hermes	12 GeV
CLAS	12 GeV
CLAS	5 GeV

…multiple combinations of targets



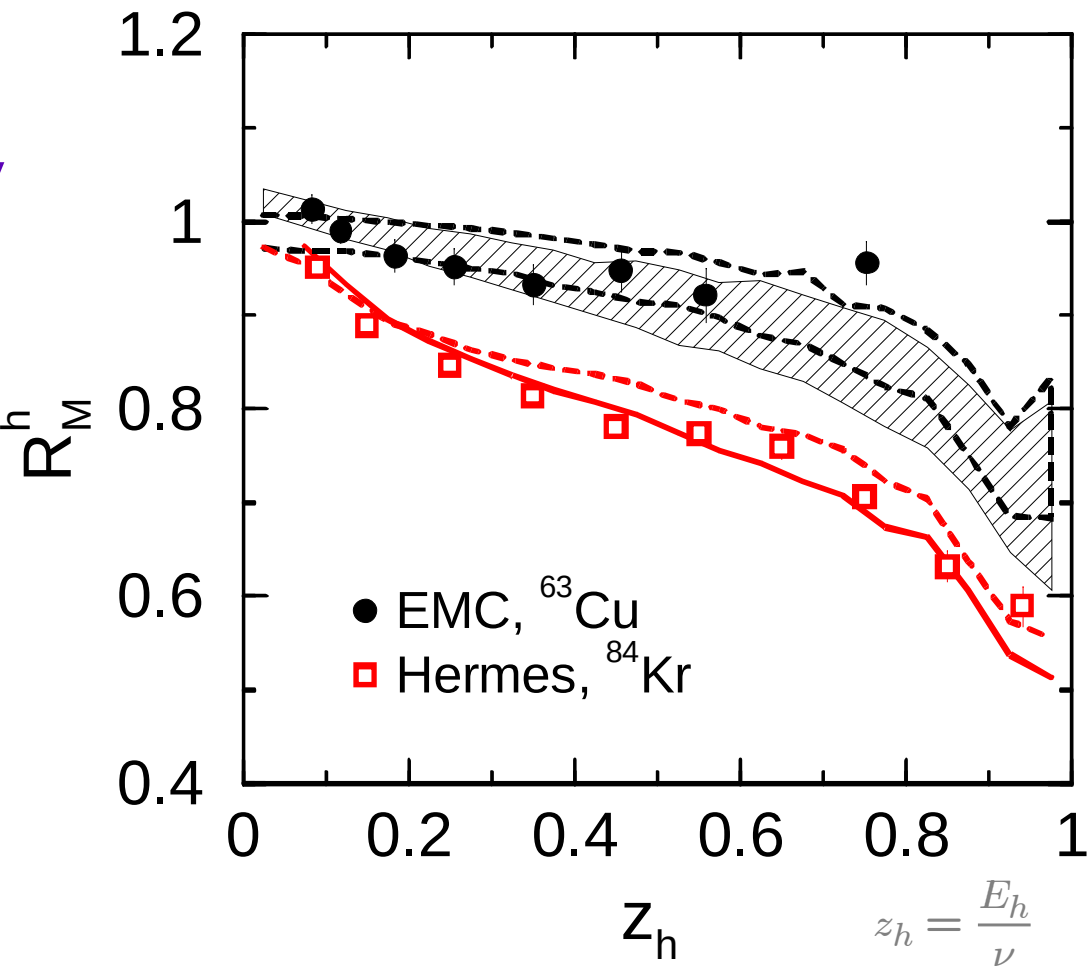
Results: EMC & Hermes

$$\frac{\sigma^*}{\sigma_h} = \frac{r_{\text{lead}}}{Q^2} + \left(1 - \frac{r_{\text{lead}}}{Q^2}\right)\left(\frac{t - t_{P_1}}{t_F - t_{P_1}}\right)$$

EMC@100...280 GeV
and
Hermes@27 GeV
described
simultanously

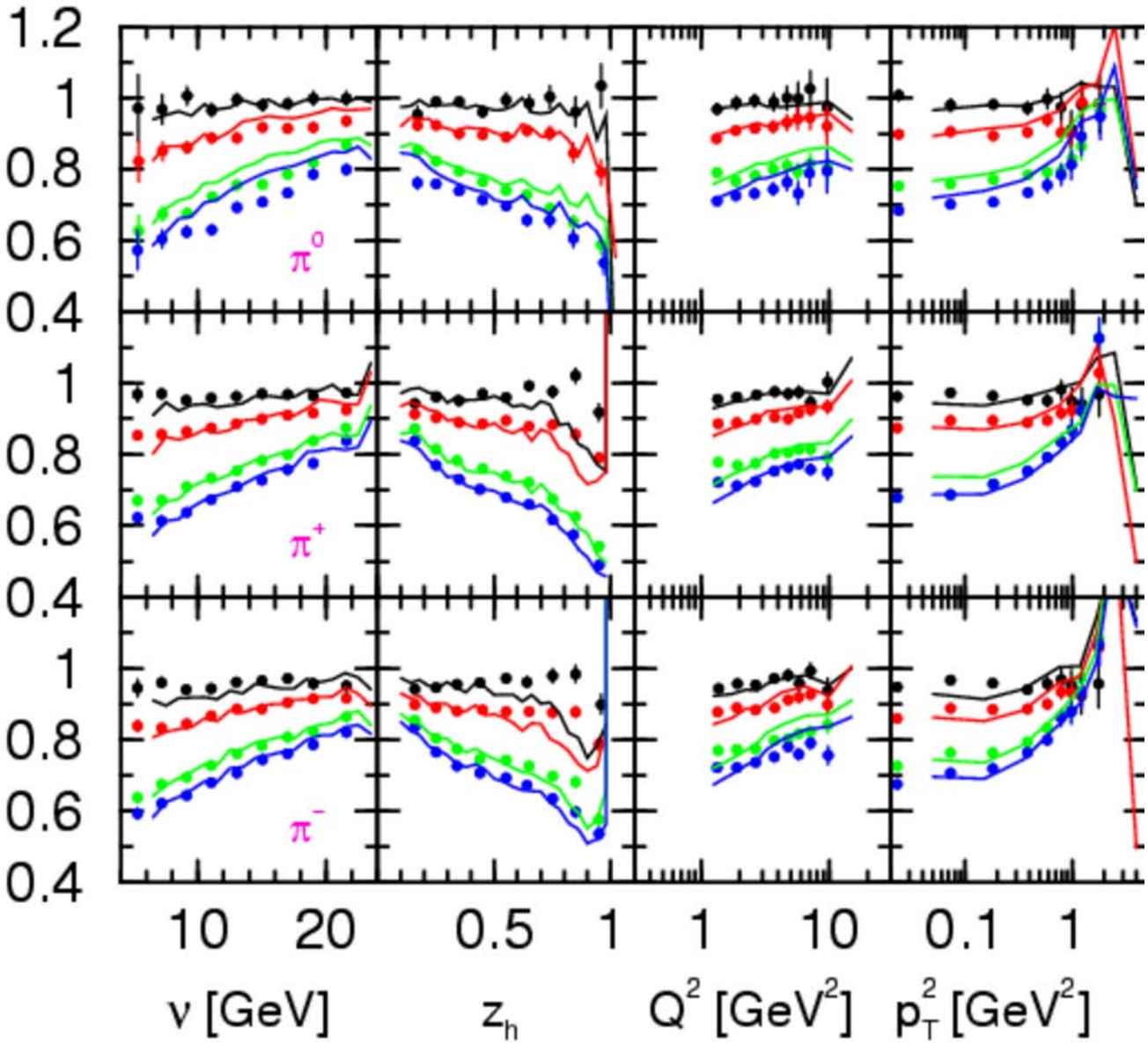
!

Color transparency?
…small effect!



$$z_h = \frac{E_h}{\nu}$$

Hermes@27: A.Airapetian et al., arXiv:0704.3270v1



Pions

$^{2}d_{1}$

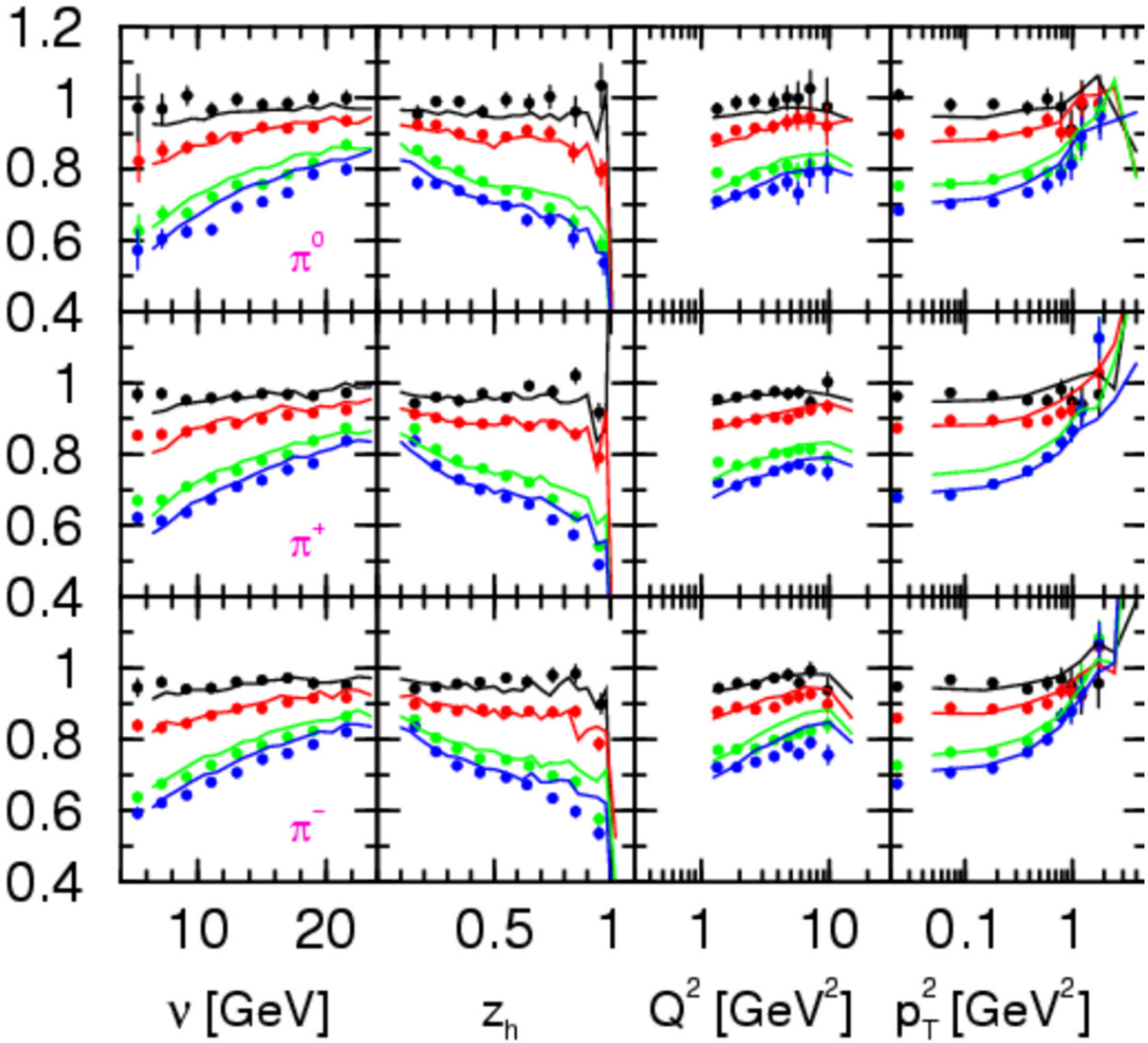
$^{4}He_{2}$

$^{20}Ne_{10}$

$^{84}Kr_{36}$

$^{131}Xe_{54}$

Hermes@27: A.Airapetian et al., arXiv:0704.3270v1



Pions

$^{2}d_{1}$

$^{4}He_{2}$

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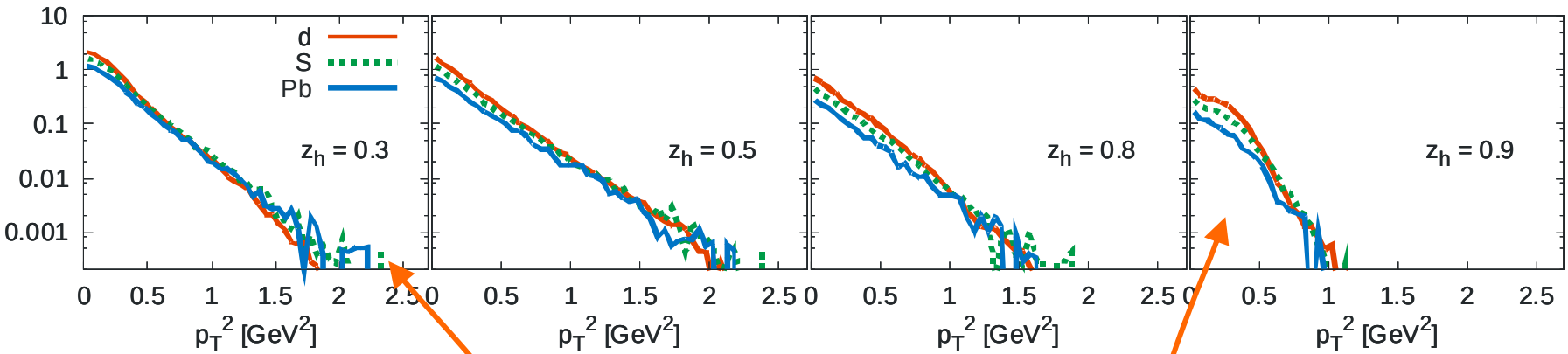
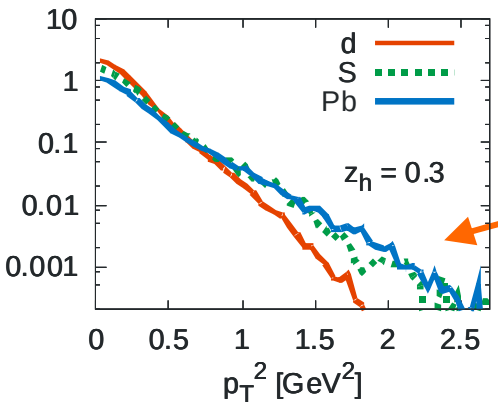
$^{131}Xe_{54}$

- no diffractive

JLAB@12GeV

$$\frac{d\sigma}{dp_\perp} \Longleftrightarrow \begin{cases} R_M(p_\perp, \dots) \\ \Delta p_\perp^2 = \langle p_\perp^2 \rangle_A - \langle p_\perp^2 \rangle_d \end{cases}$$





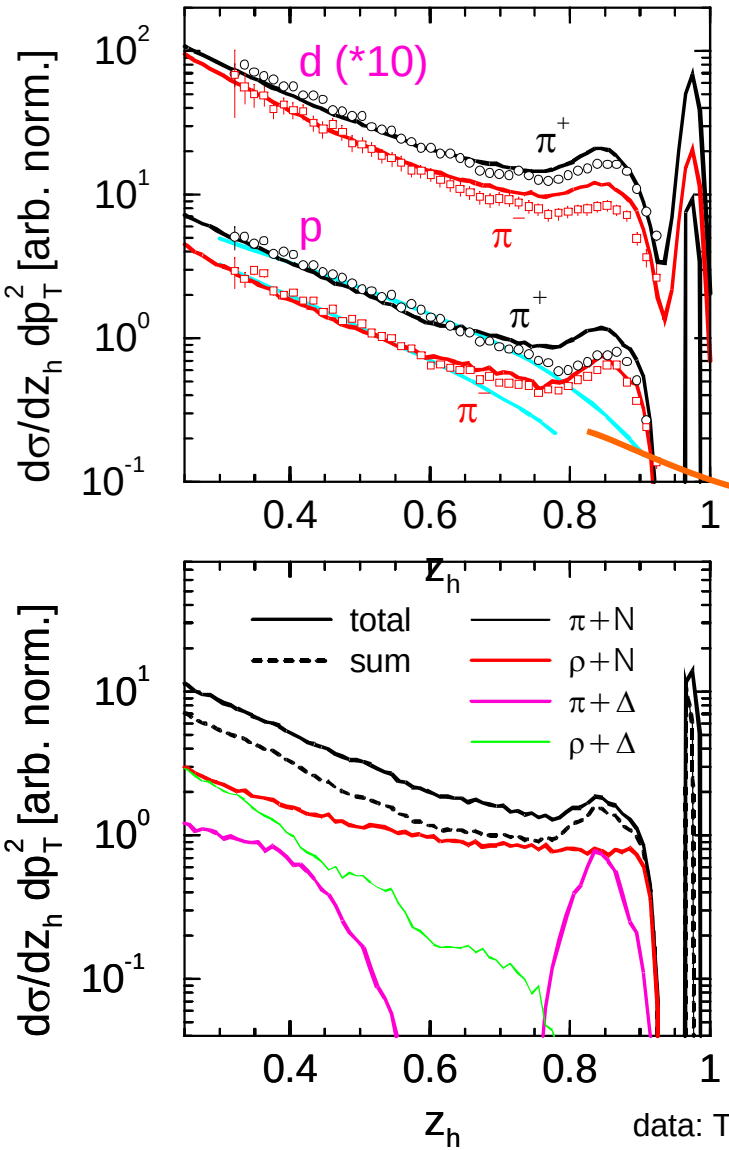
model uncertainty in angular distribution

$$\rho + N \to \pi + X$$

kinematical constraints

JLAB@5GeV

- E00-108: „Duality“



$$\frac{dN}{dz_h} \sim \sum_q e_q^2 \underbrace{q(x,Q^2)}_{\text{CTEQ5}} \underbrace{D_{q\to\pi}(z_h,Q^2)}_{\text{BKK}}$$

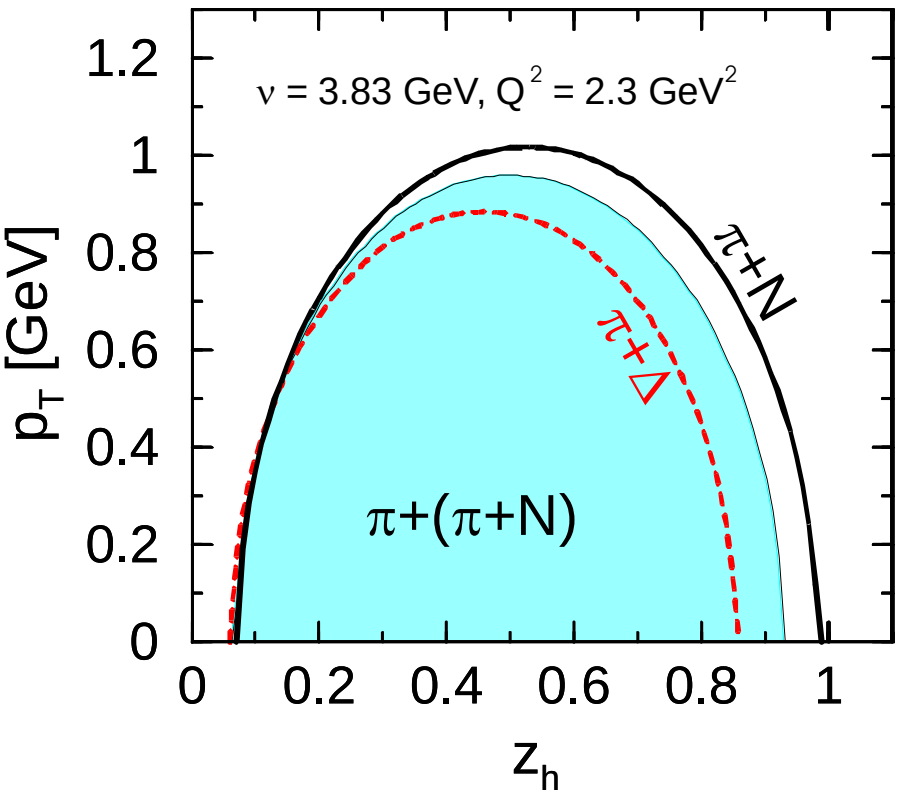
$$x = \frac{Q^2}{2m\nu} = \text{fix}$$

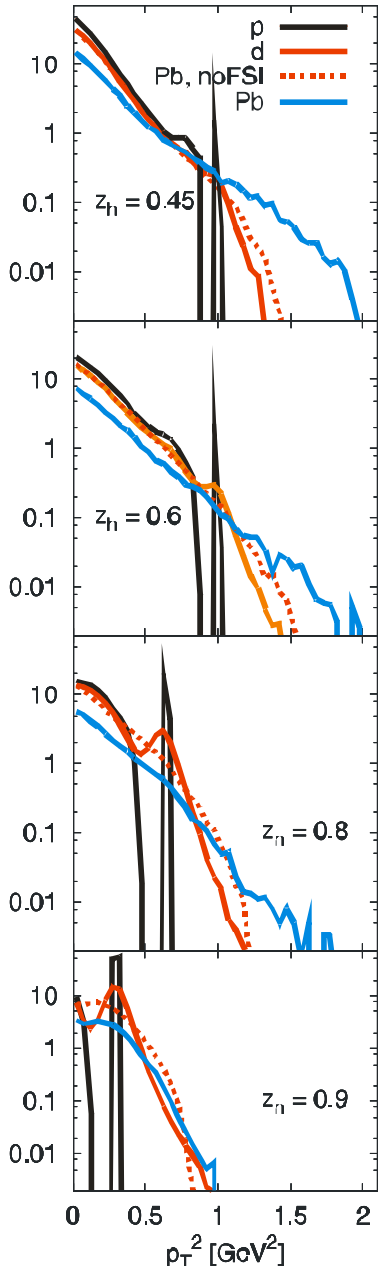
$$z_h = \frac{E_h}{\nu}$$

data: T.Navasardyan et al., PRL 98(2007), 022001

JLAB@5GeV

- kinematical constraints





- Fermi motion !!!!!

Summary

- model for γ and *e* induced reactions at GeV energies
  - combines:
    - QM coherence in entrance channel
    - coupled channel transport description of FSI
    - 4D production/formation points per every particle
  - GiBUU is multi purpose transport code
  - can describe:
    - coherence length effects in exclusive ρ^0 production
    - hadron attenuation
    - …*much more*…

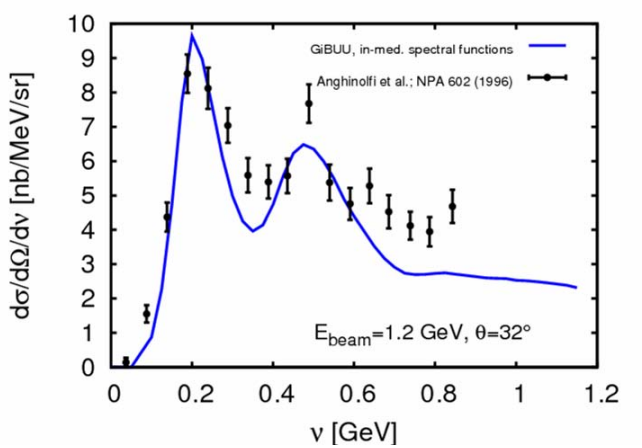
  } **EMC** **HERMES** JLAB

- pre-hadronic cross section increases linear in time
- tiny hints towards color transparency

Summary II: Future

- unique model for hadron production off nuclei between nucleon resonance region **and** DIS region

- match PYTHIA and low energy model



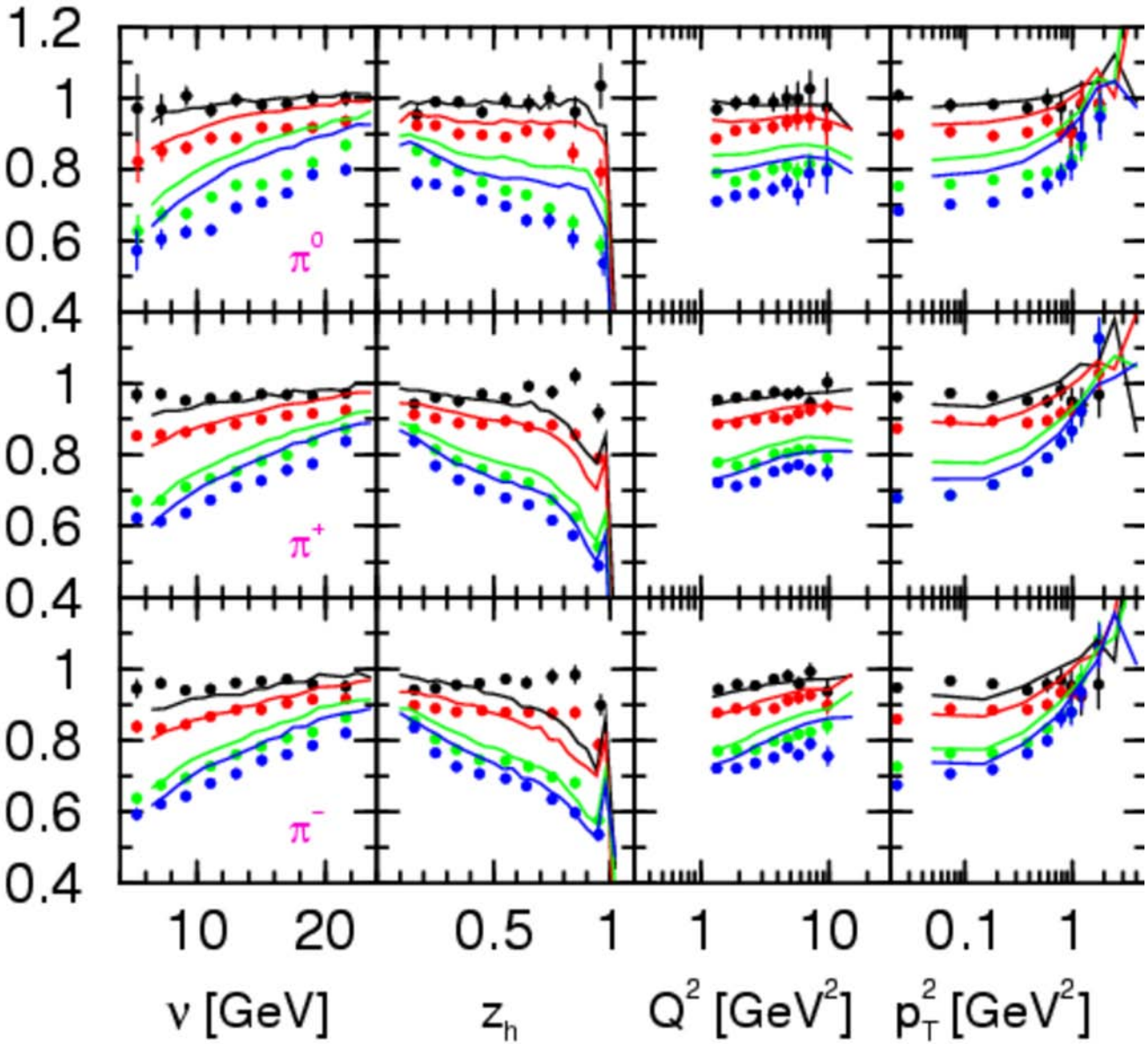
O.Buss et al., nucl-th/0703060

- duality at low energies (prehadronic vs. hadronic)

- CT at low energies

Backup slides

Hermes@27: recent paper, no Q^2 pedestal



Pions

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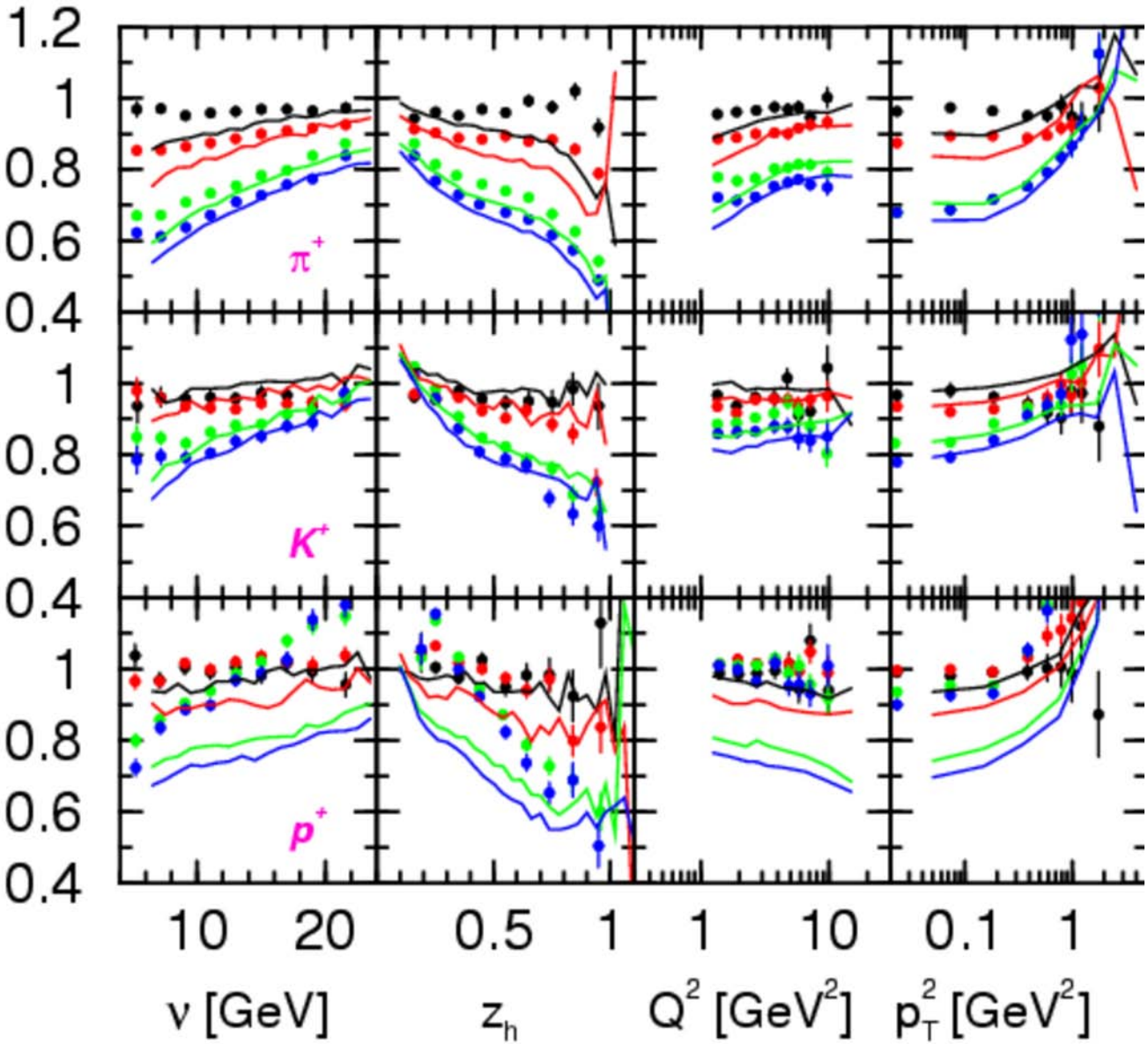
Hermes@27: recent paper



charge: +

$^{2}d_{1}$

$^{4}He_{2}$

$^{20}Ne_{10}$

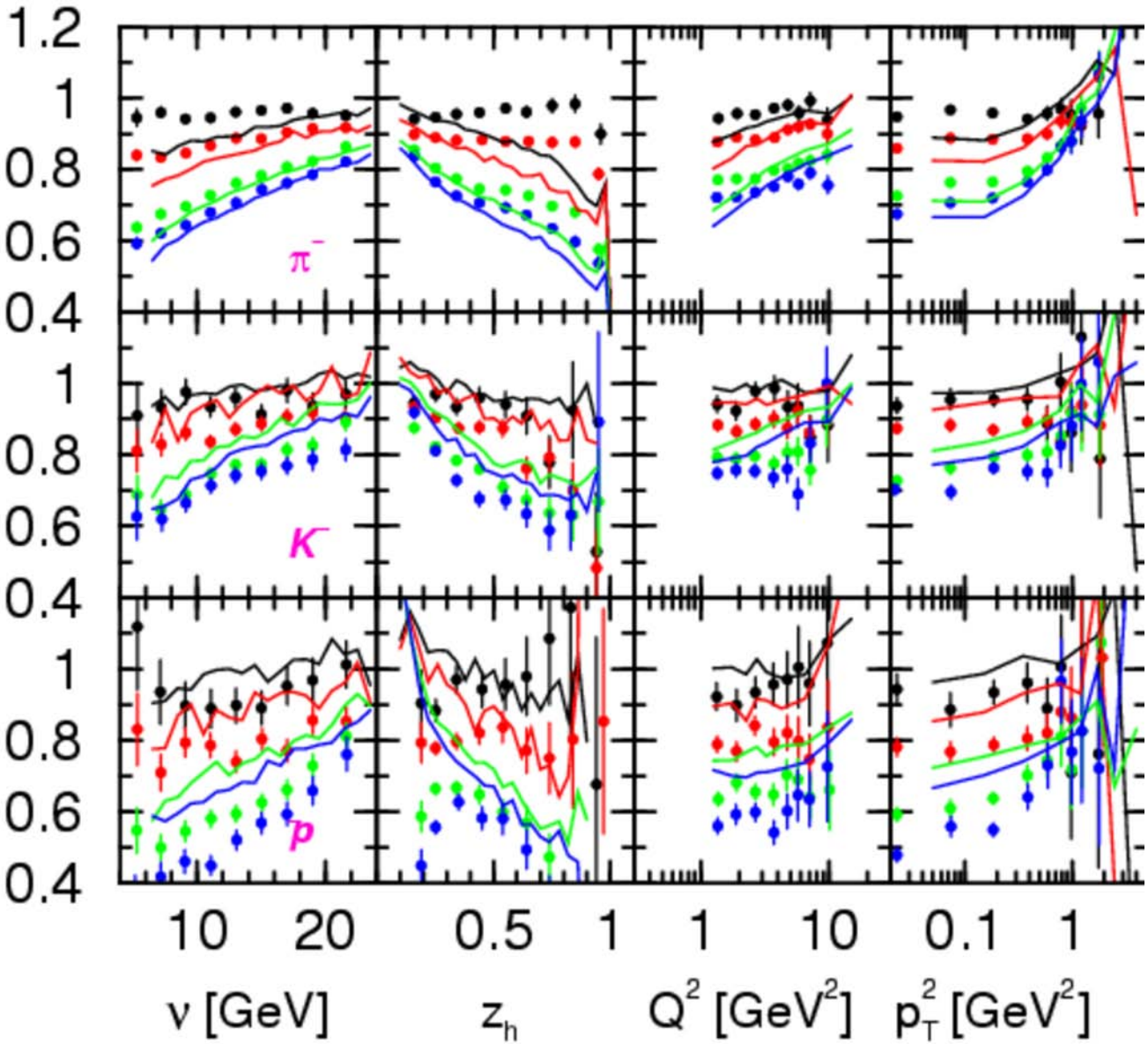
$^{84}Kr_{36}$

$^{131}Xe_{54}$

Protons:

„known to be bad“

Hermes@27: recent paper



charge: -

$^{2}d_{1}$

$^{4}He_{2}$

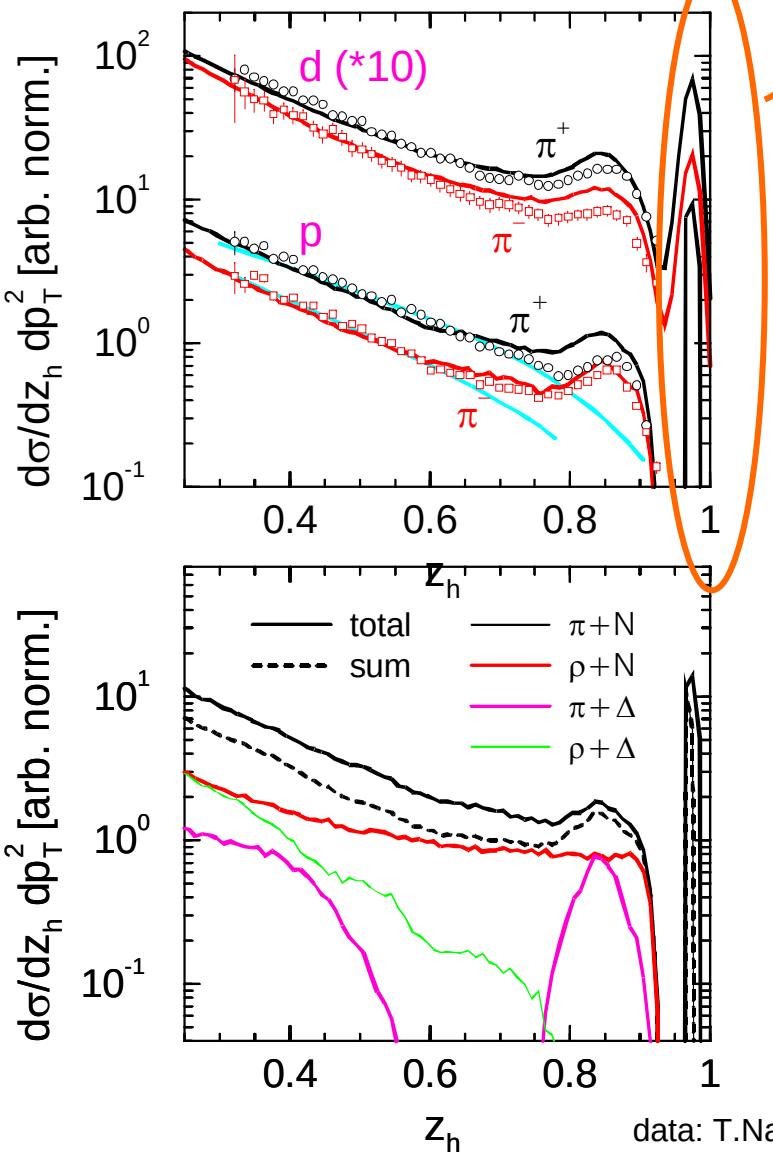
$^{20}Ne_{10}$

$^{84}Kr_{36}$

$^{131}Xe_{54}$

JLAB@5GeV

- E00-108: „Duality“
- E00-107: „CT“



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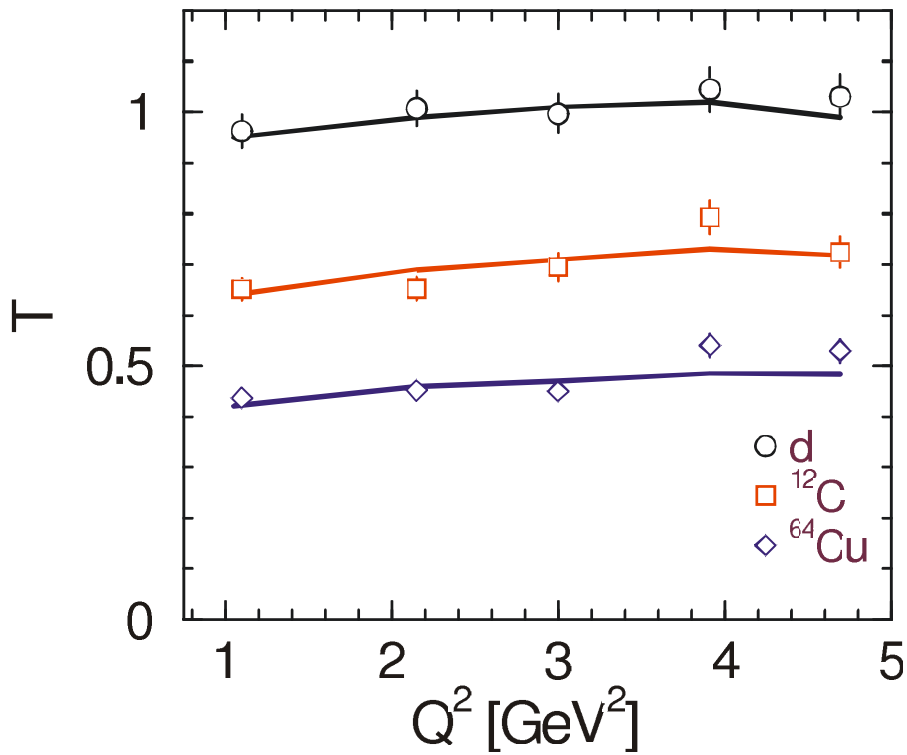

data: B.Clasie, PhD thesis, MIT, 2006