Hadronization in eA collisions

K. Gallmeister for the GiBUU group
Goethe-Universität, Frankfurt

Motivation, Variables

Hermes & EMC comparison

Conclusions:

- leading hadrons!
- cross section evolves linear with time

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

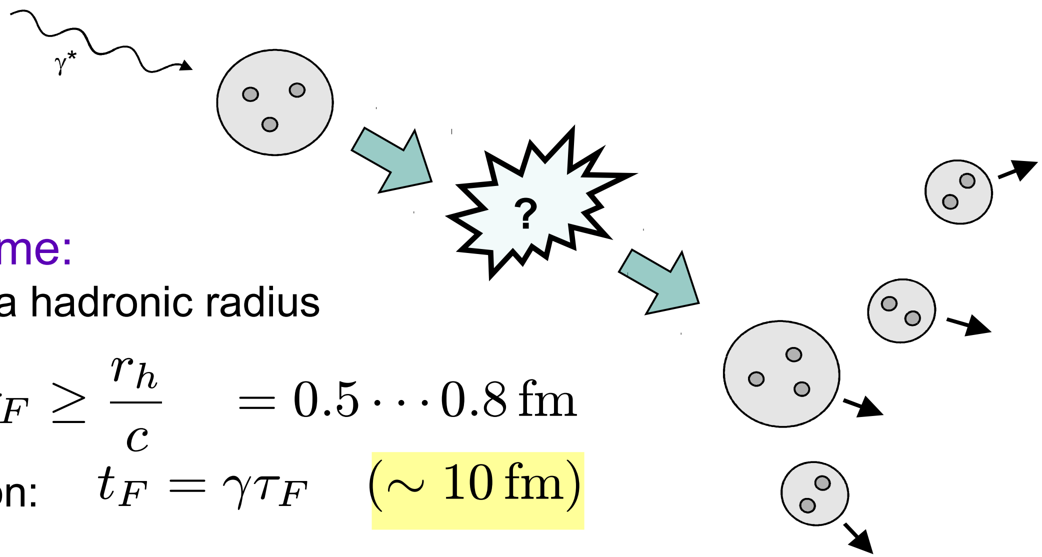
Bundesministerium für Bildung und Forschung

NuSTEC Workshop S&DIS

Gran Sasso Science Institute, L'Aquila, Italy, 11-13 Oct 2018

Motivation

- elementary reactions (*eN*, γ*N*) on nucleon:



formation time:
estimation via hadronic radius

$$\tau_F \geq \frac{r_h}{c} \qquad = 0.5 \cdots 0.8\,\mathrm{fm}$$

time dilatation: $t_F = \gamma \tau_F \quad (\sim 10\,\mathrm{fm})$

reaction products hadronize long before they reach the detector

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

interactions with nuclear medium during formation

→ space-time picture of hadronization

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

Observables, Experiments

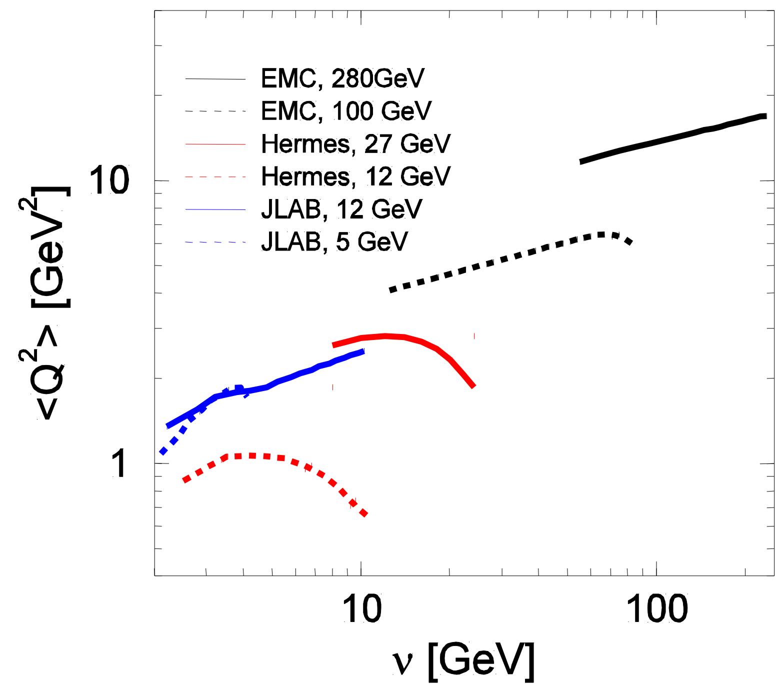
- $$R^h(z_h,\dots) = \frac{\left.\frac{N_h(z_h,\dots)}{N_e(\dots)}\right|_A}{\left.\frac{N_h(z_h,\dots)}{N_e(\dots)}\right|_D}$$
- $$\Delta p_T^2 = \langle p_T^2\rangle_A - \langle p_T^2\rangle_D$$

- hadronic: $z_h = \frac{E_h}{\nu}\ , \quad p_T\ , \cdots$
- photonic: $\nu\ , \ Q^2\ , \ W\ , \ x_{\rm B}\ , \dots$

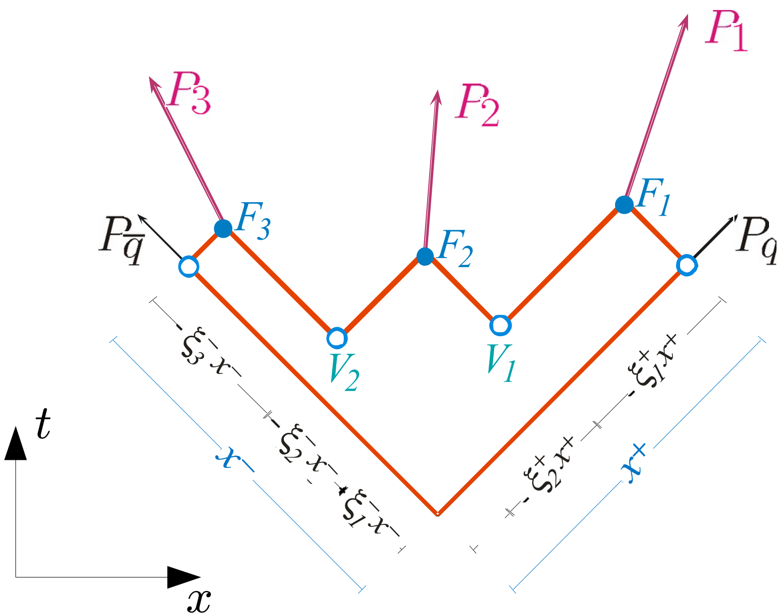
- Experiments

	E_{lepton} =
EMC	**100…280 GeV**
Hermes	**27 GeV**
	12 GeV
CLAS	12 GeV (upgrade)
	5 GeV
EIC	e.g. 3+30 GeV

…multiple combinations of targets



Model: Hadronization in String Model (PYTHIA/JETSET)

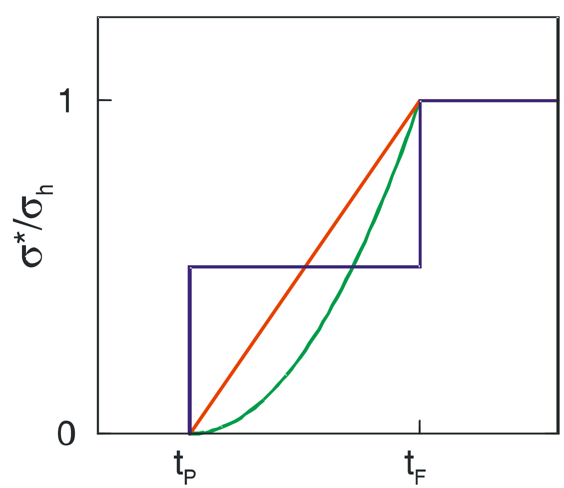


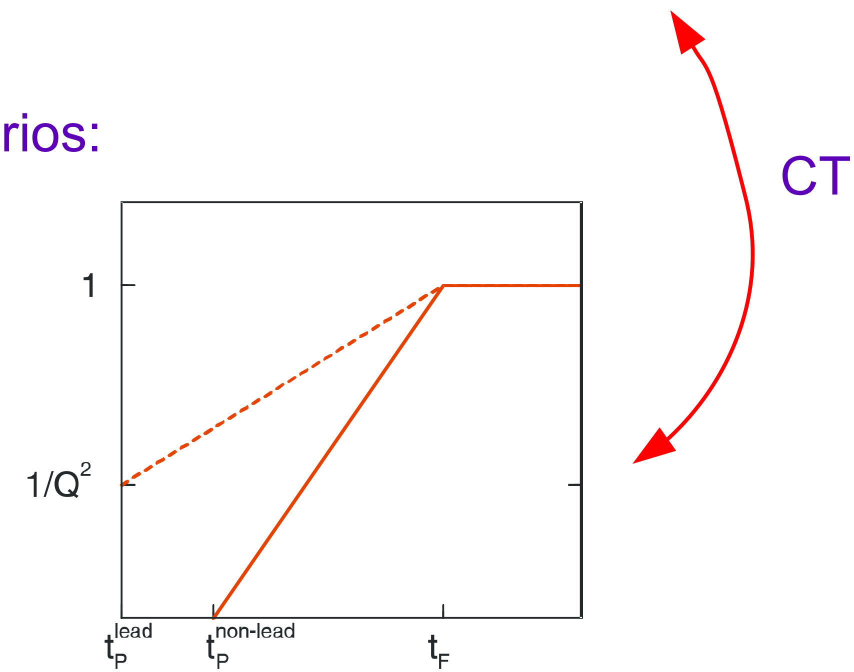
- **3 times/points per particle:**
  - „Production 1“ — *String-Breaking*
  - „Production 2“ — *String-Breaking*
  - „Formation“ — *Line-Meeting*

- **Leading vs. Non-leading**

  Connection to interaction vertex

- **Cross section evolution scenarios:**





Results: EMC & Hermes

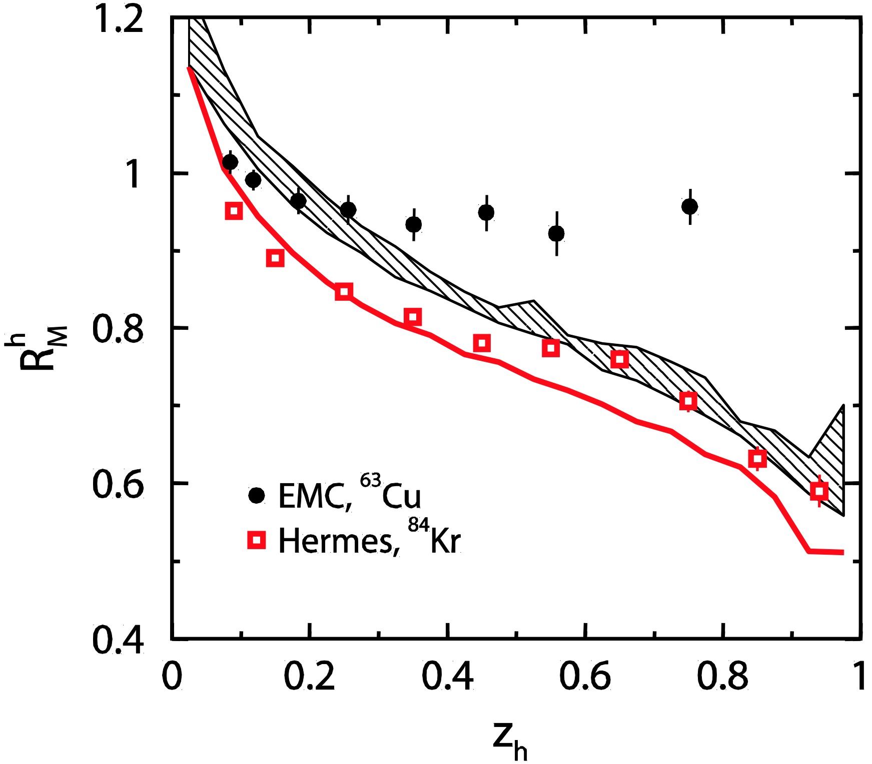
- constant cross section

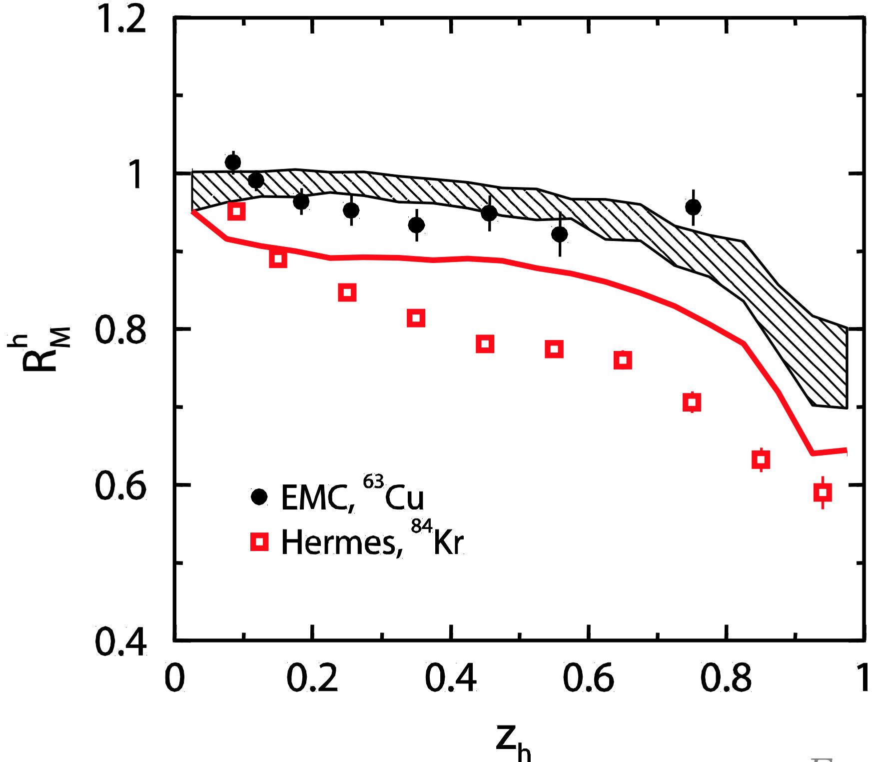
$$t = t_{\rm P} \cdots t_{\rm F}:$$

$$\sigma^* = 0.5\,\sigma_H$$

- quadratic increase

$$\sigma^* = \left(\frac{t - t_{\rm P}}{t_{\rm F} - t_{\rm P}}\right)^2 \sigma_H$$





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

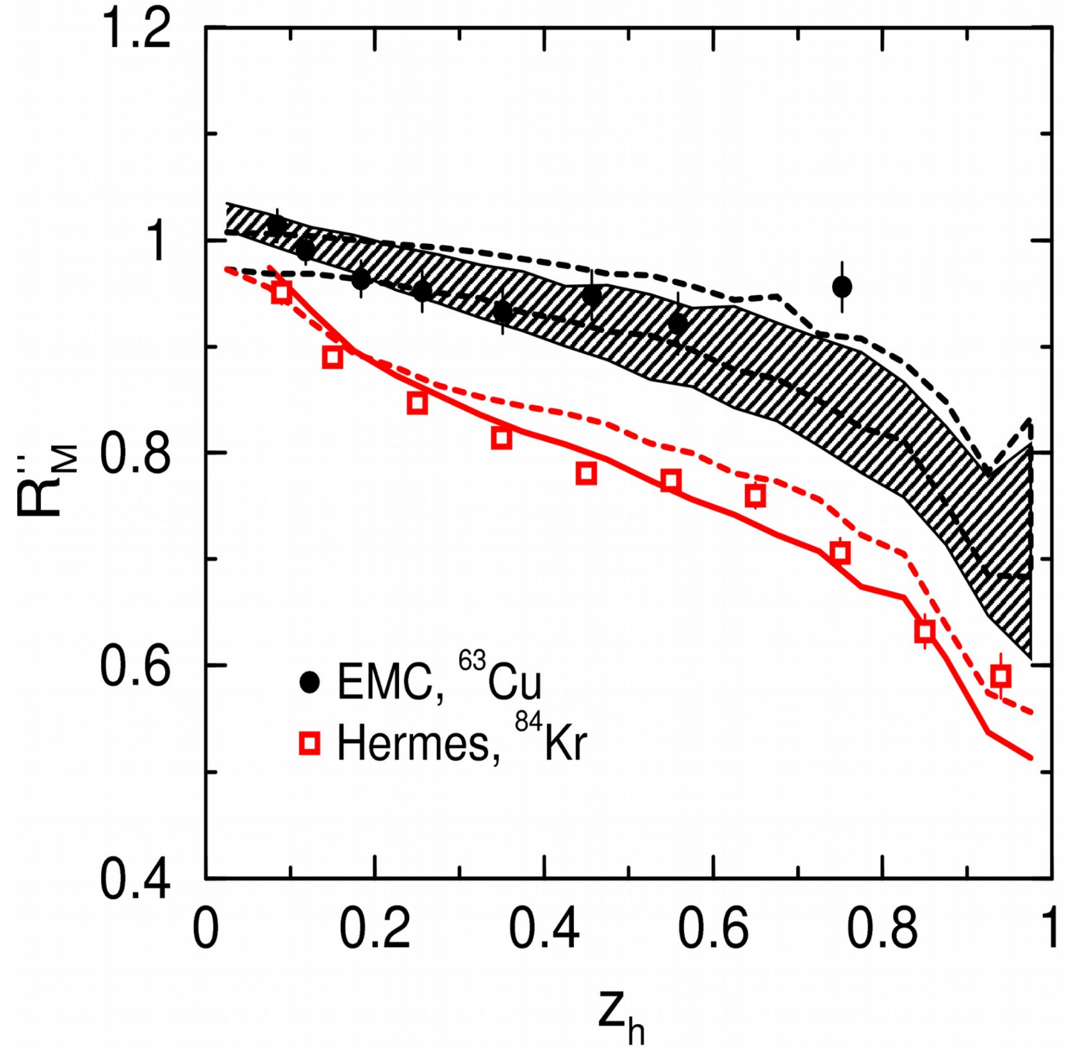
Results: EMC & Hermes

$$\frac{\sigma^*}{\sigma_H} = \frac{r_{\rm lead}}{Q^2} + \left(1 - \frac{r_{\rm lead}}{Q^2}\right)\left(\frac{t - t_{\rm P}}{t_{\rm F} - t_{\rm P}}\right)$$

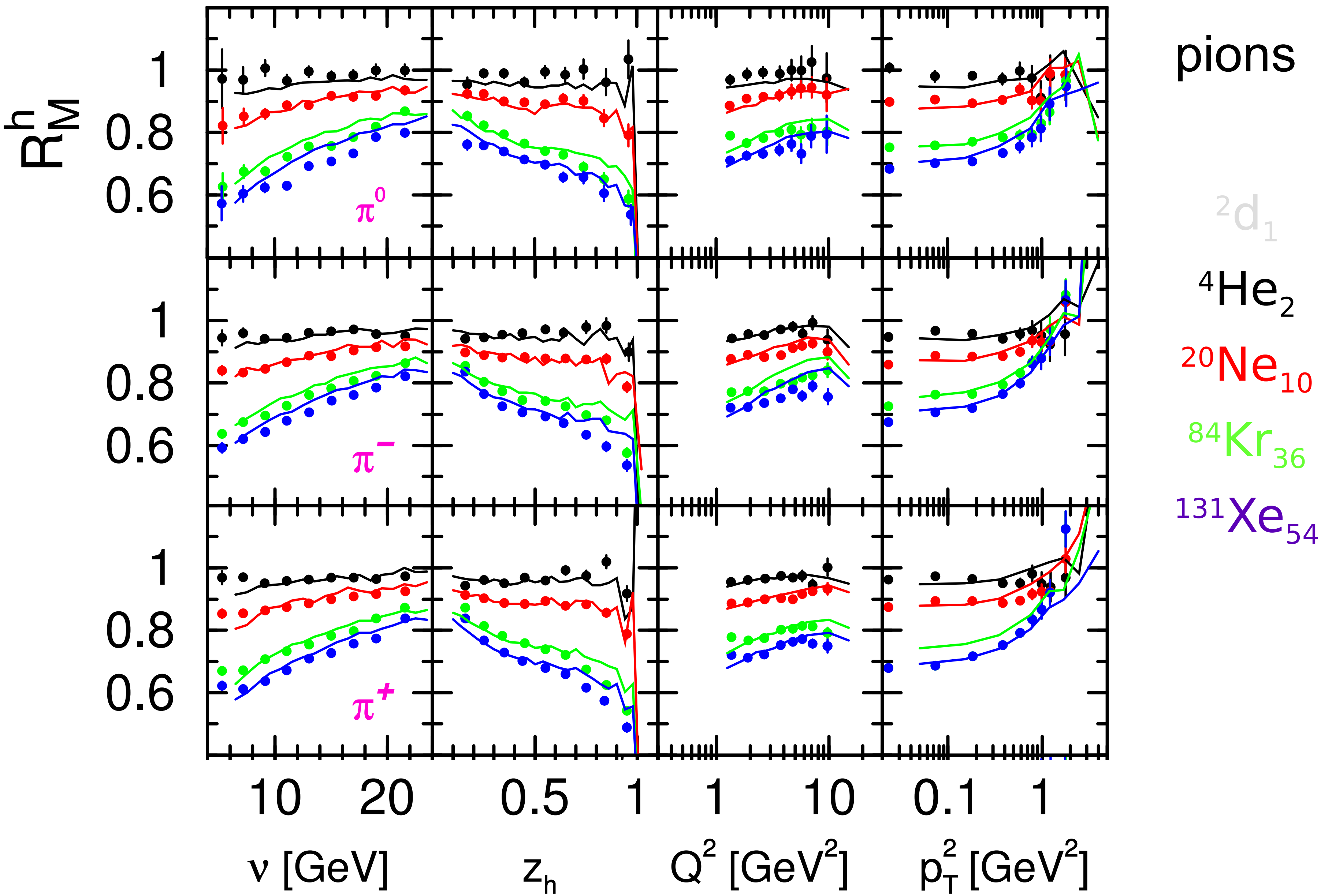
!

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

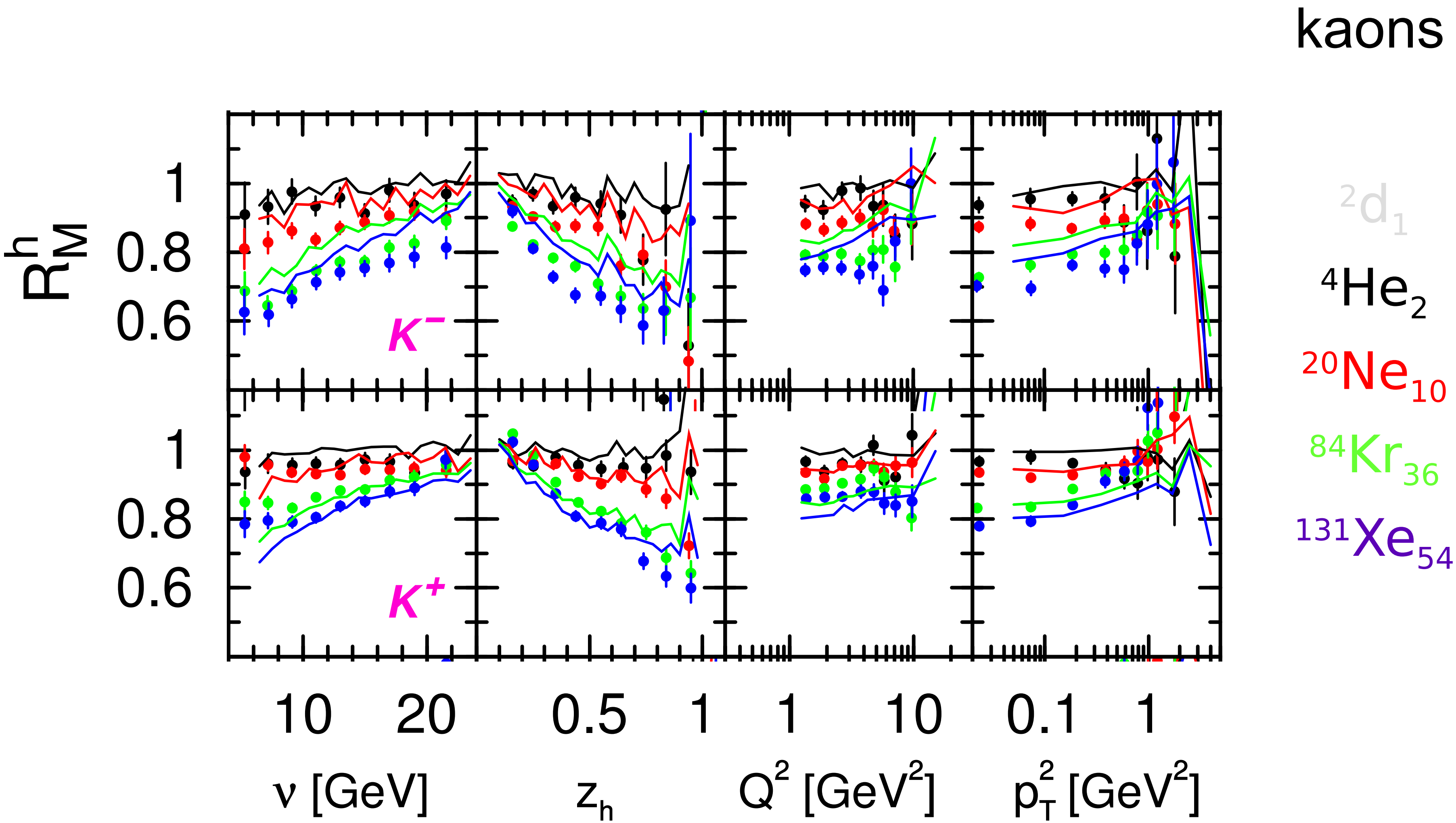
1/Q2 pedestal value?
…small effect!



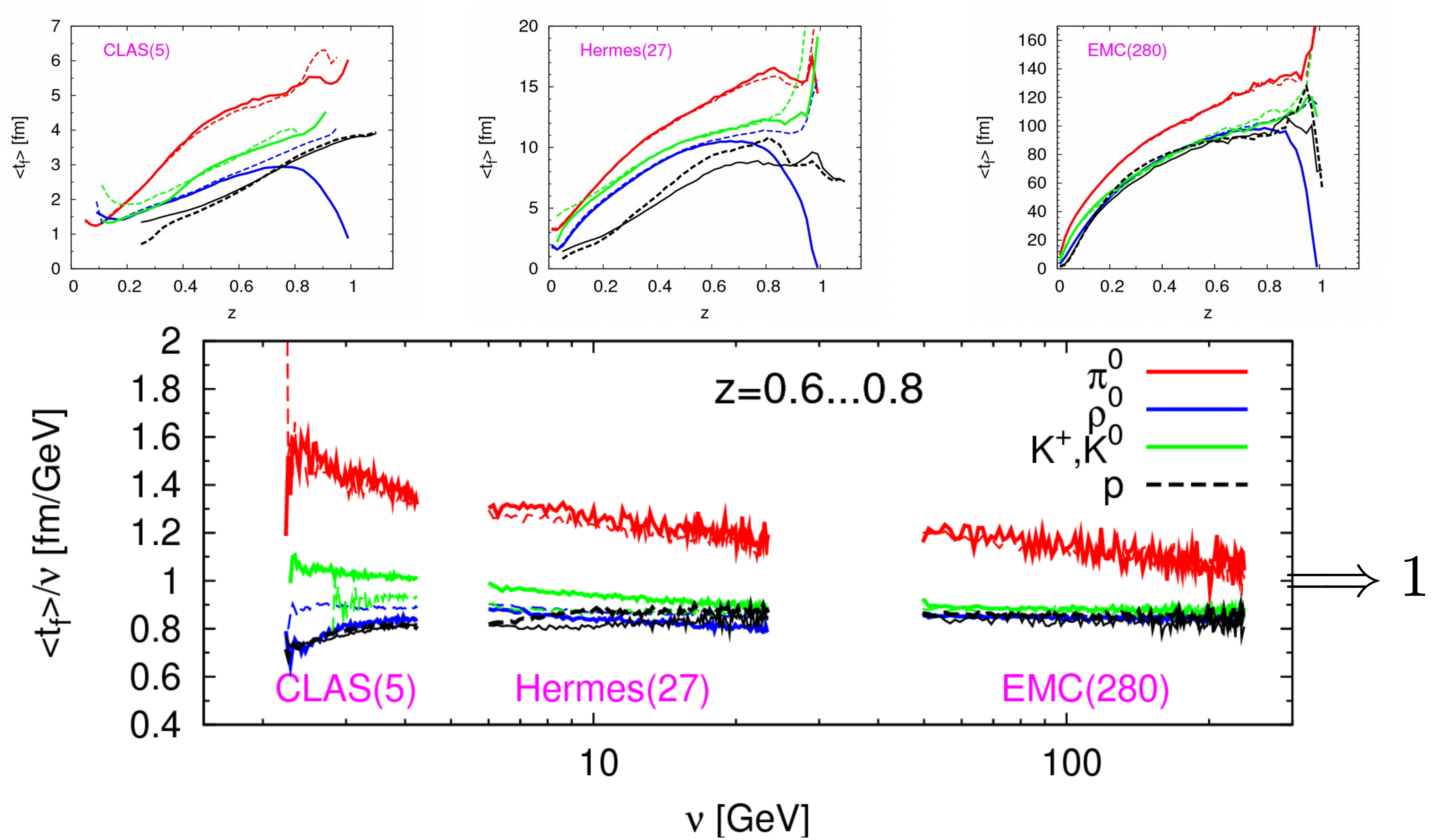
Hermes@27: A.Airapetian et al., NPB780(2007)1



Hermes@27: A.Airapetian et al., NPB780(2007)1



Times

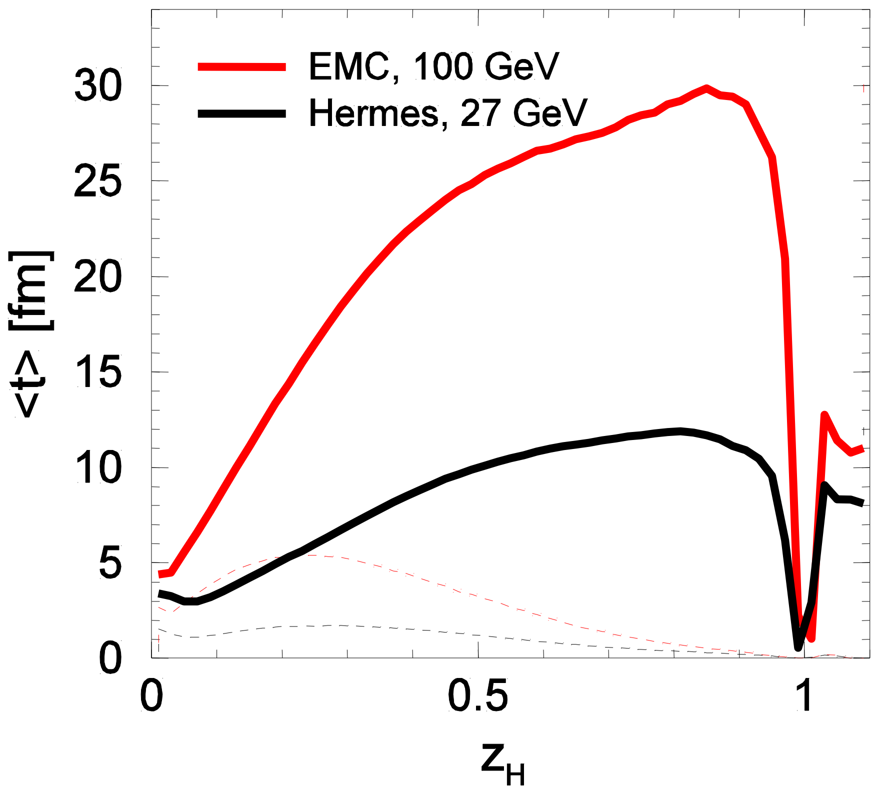


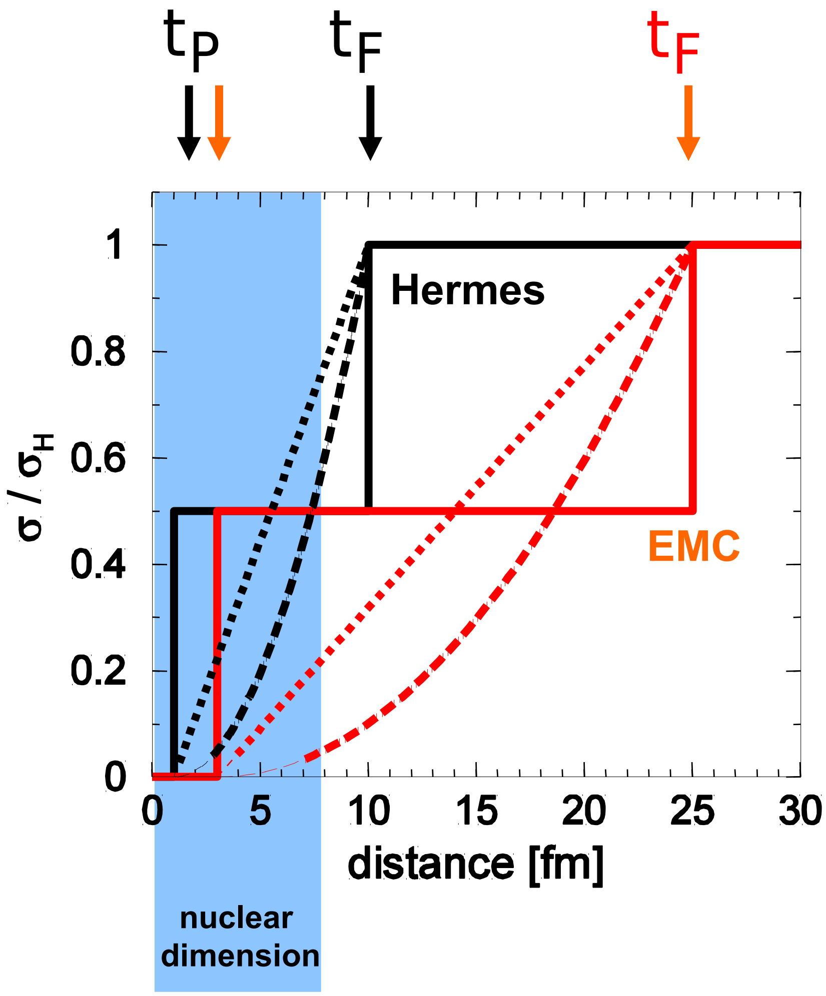
$$t_F = \gamma \tau_F = \frac{E_h}{m_h} \tau_F$$

$$\frac{t_F}{\nu} \sim \frac{t_F}{E_h} \sim 1$$

$$\tau_F \sim m_h$$

Times





here: averaged times

in code: individual times

Conclusions

- GiBUU (as all other transport models):
  - leading vs. non-leading hadrons
- e+A:
  - Hermes & EMC: great combination of energies
  - interaction increases linear
  - not conclusive about CT effects
  - relevant for CLAS and EIC

K. Gallmeister, U. Mosel,
``Time Dependent Hadronization via HERMES and EMC Data Consistency,''
Nucl. Phys. A **801**(2008), 68

K. Gallmeister, T. Falter,
``Space-time picture of fragmentation in PYTHIA/JETSET for HERMES and RHIC,''
Phys. Lett. B **630** (2005), 40