

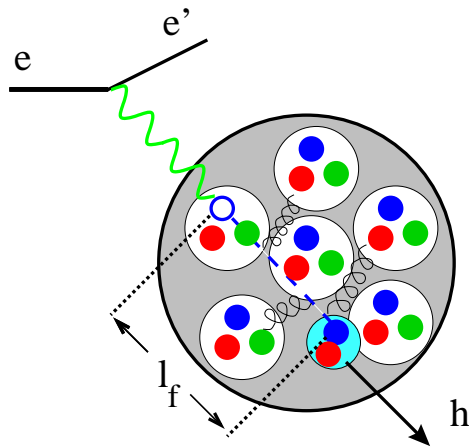
Attenuation of hadrons in nuclei

Paul Bastiaan van der Nat (NIKHEF)

On behalf of the HERMES collaboration

Layout:

- Introduction
- NEW Results:
 - more targets (^4He , ^{14}N , ^{20}Ne , ^{84}Kr)
 - various hadrons (π^+ , π^- , K^+ , K^- , p , $\bar{\text{p}}$)
 - different beam energies (27/12 GeV)
- Comparison with models
- A dependence
- Conclusions



Nuclear Attenuation

reduction of multiplicity of the fast forward hadrons due to:

- gluon radiation
- parton rescattering
- hadron absorption

$$R_M(z, \nu) = \frac{\left[\frac{1}{N_e} \frac{d^2 N_h}{dz d\nu} \right]_A}{\left[\frac{1}{N_e} \frac{d^2 N_h}{dz d\nu} \right]_D}$$

Formation time:

$$\tau_f = \frac{l_f}{c}$$

$$\frac{1}{N_e} \frac{d^2 N_h(x, z)}{dx dz} = \frac{\sum_i e_i^2 q_i(x) D_i^h(z)}{\sum_i e_i^2 q_i(x)}$$

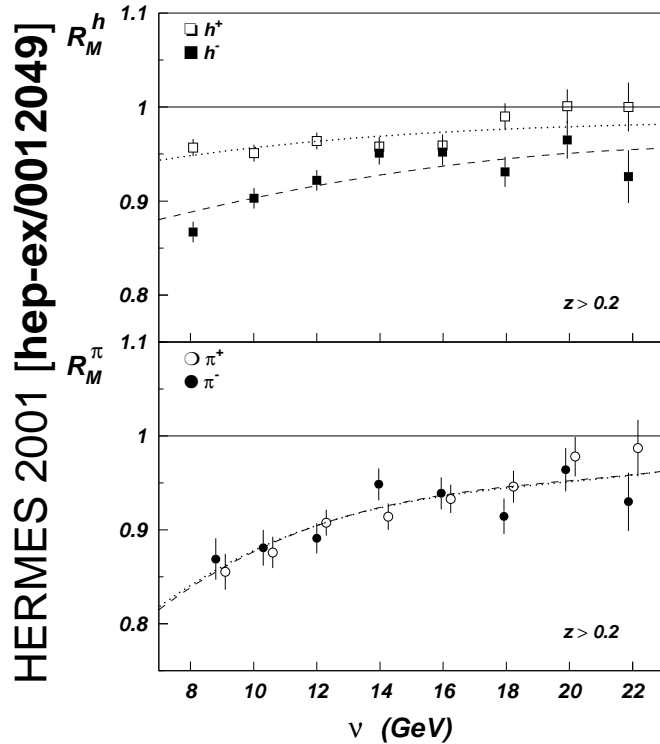
DF FF

Why study hadronization?

- Check QCD prediction of parton energy loss in nuclei

$$\Delta E \propto r_A^2 \implies (1 - R_M) \propto A^{2/3}$$

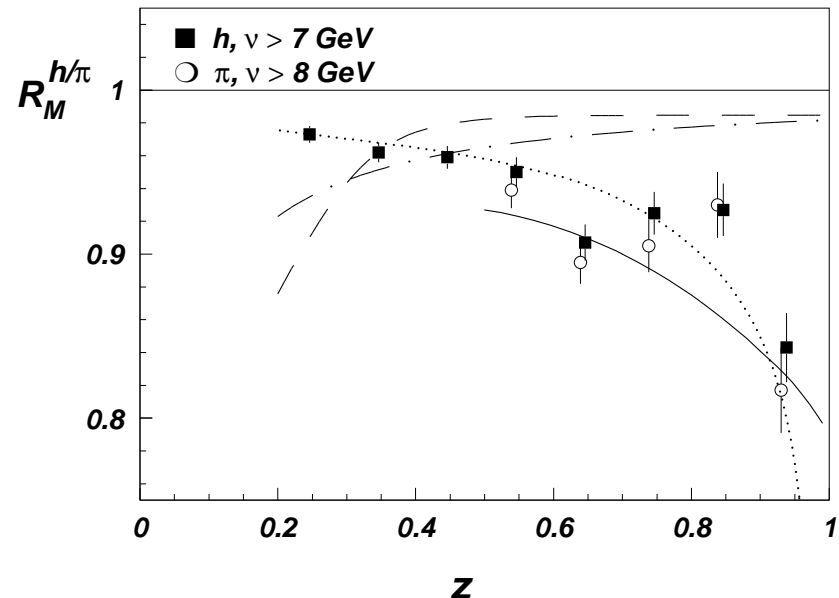
- τ_f for different hadron types
- Link to heavy-ion physics: parton energy loss related to gluon density of quark-gluon plasma.

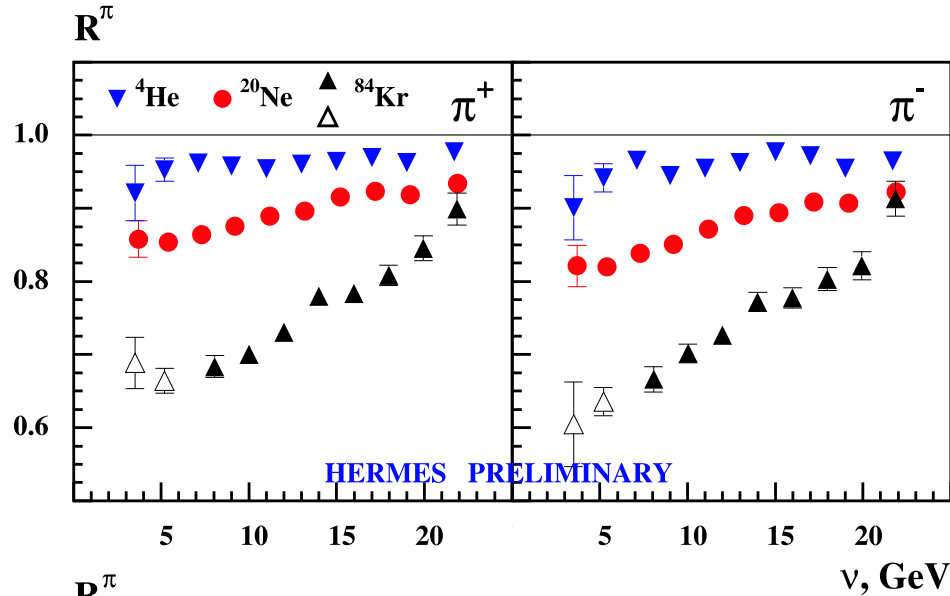


- decrease of attenuation versus ν
 - no charge dependence for pions
 - charge dependence hadrons:
- $$(1 - R_M^p) < (1 - R_M^\pi) \Rightarrow \tau_f^p > \tau_f^\pi$$
- suppression of high-z hadrons

Possible interpretation suppression at high z:

- high z: quarks emit few gluons
- small formation time
- long time for hadron-nucleus interaction

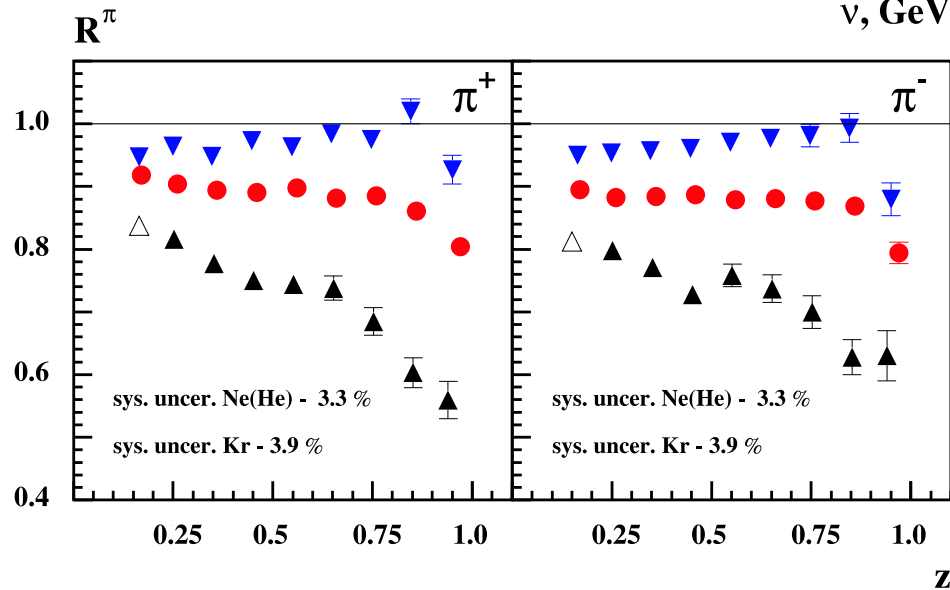


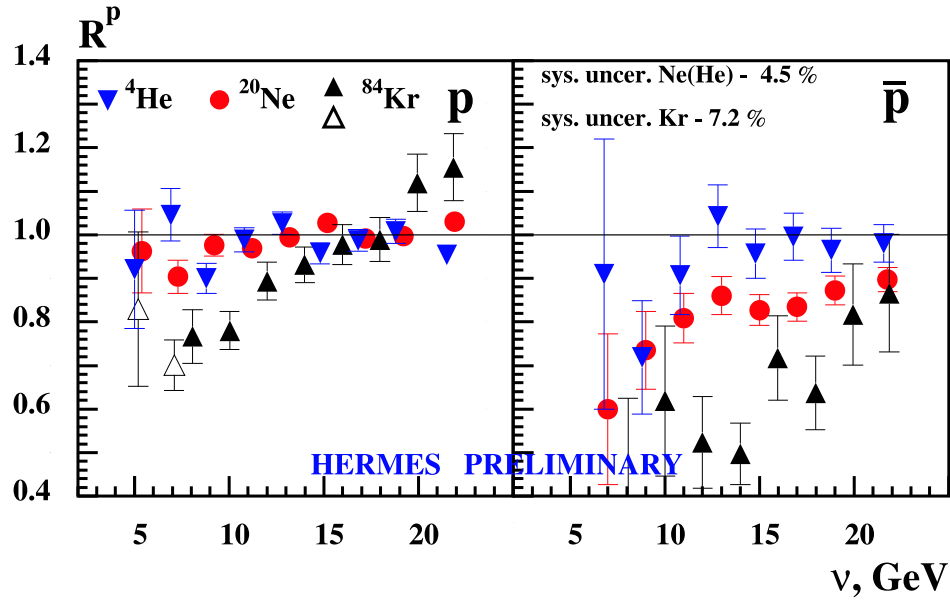


- Strong A dependence

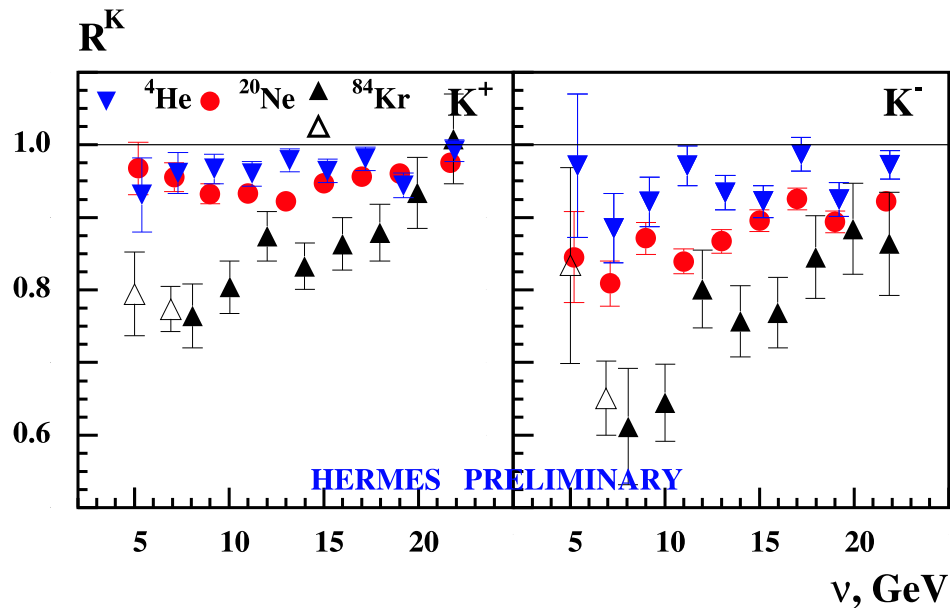
$$R_M^{\pi^+}(\nu, z) = R_M^{\pi^-}(\nu, z)$$

- confirmed by new targets

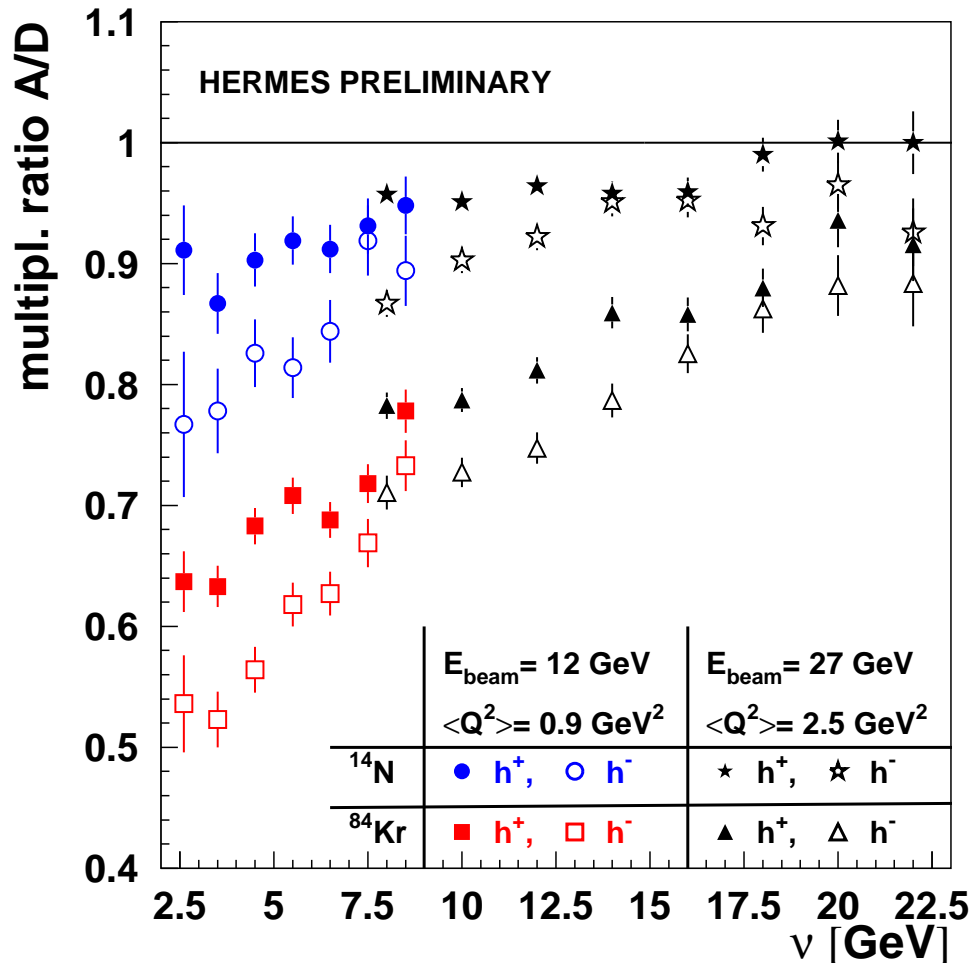




$$R_M^p > R_M^{\bar{p}}, \quad R_M^{K^+} > R_M^{K^-}$$



New data extends existing data to lower ν : Large Attenuation!



qualitative behavior of
27 GeV data confirmed

I fragmentation function modification:

$$D_f^{h|A}(z, Q^2) = D_f^h(z, Q^2) + \Delta D_f^h(z, Q^2)$$

pQCD based model, with:

- multiple scattering
- induced gluon radiation

Wang et al. [PRL **89**(2002) 162301]

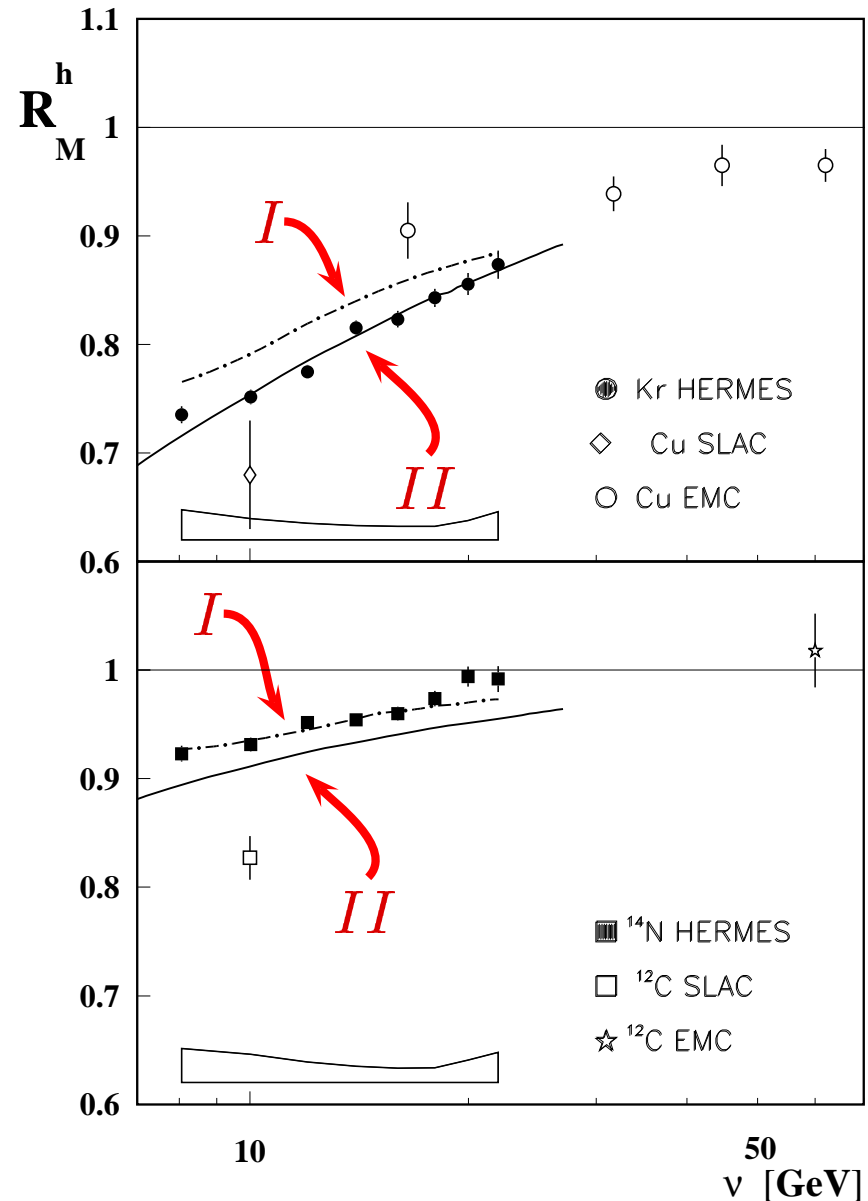
II Rescaling model:

$$q_f^A(x, Q^2) = q_f(x, \xi_A(Q)Q^2)$$

$$D_f^{h|A}(z, Q^2) = D_f^h(z, \xi_A(Q)Q^2)$$

comb. with (pre-)hadron absorption

A. Accardi et al. (2003)[nucl-th/0211011]



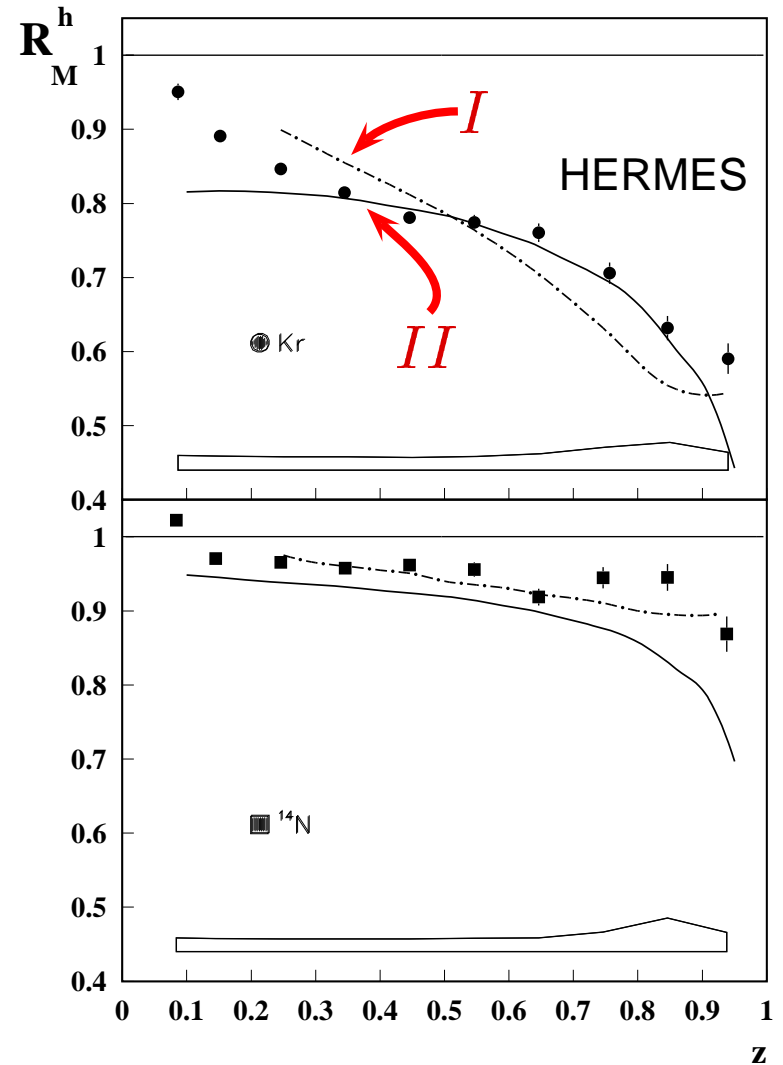
- models reproduce qualitative behavior of $R_M(\nu, z)$
- both models tune 1 parameter to the data

Important difference models:

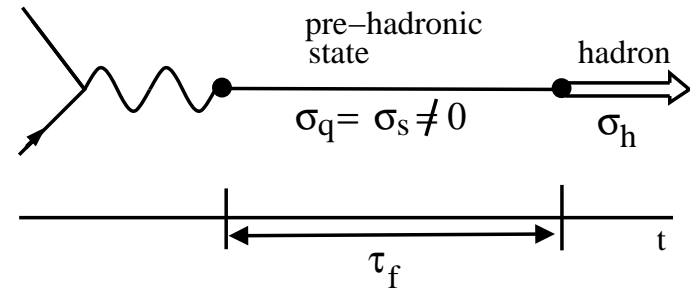
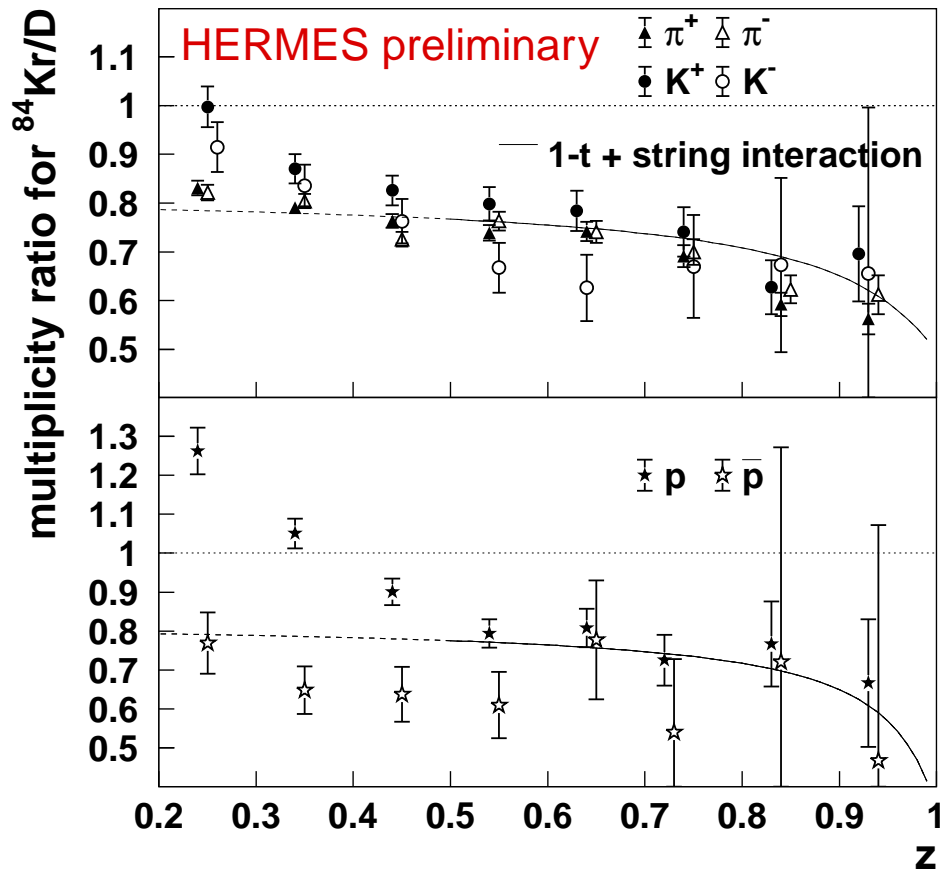
I FF. modification $\implies \alpha = 2/3$

II rescaling model:
nucl. absorption part $\implies \alpha = 1/3$

using $1 - R_M \propto A^\alpha$



Fits to HERMES data, by E. Garutti et al, PhD Thesis UvA - 2003, to be published



using

$$\tau_f = \frac{\nu}{k}(1 - z)$$

Fit results:

	^{84}Kr (mesons)	^{14}N (pions)
σ_s [mb]	4.2 ± 0.7	2.7 ± 0.6
k [GeV c fm $^{-1}$]	0.28 ± 0.06	0.12 ± 0.04

- fit results target dependent
- ⇒ nuclear abs. models don't reproduce A dependence

A dependence provides a way to distinguish between models:

- nuclear absorption models $\implies \alpha = 1/3$
- pQCD based models $\implies \alpha = 2/3$
(Wang et al.)

Extracted A dependence using:

$$1 - R_M \propto A^\alpha$$

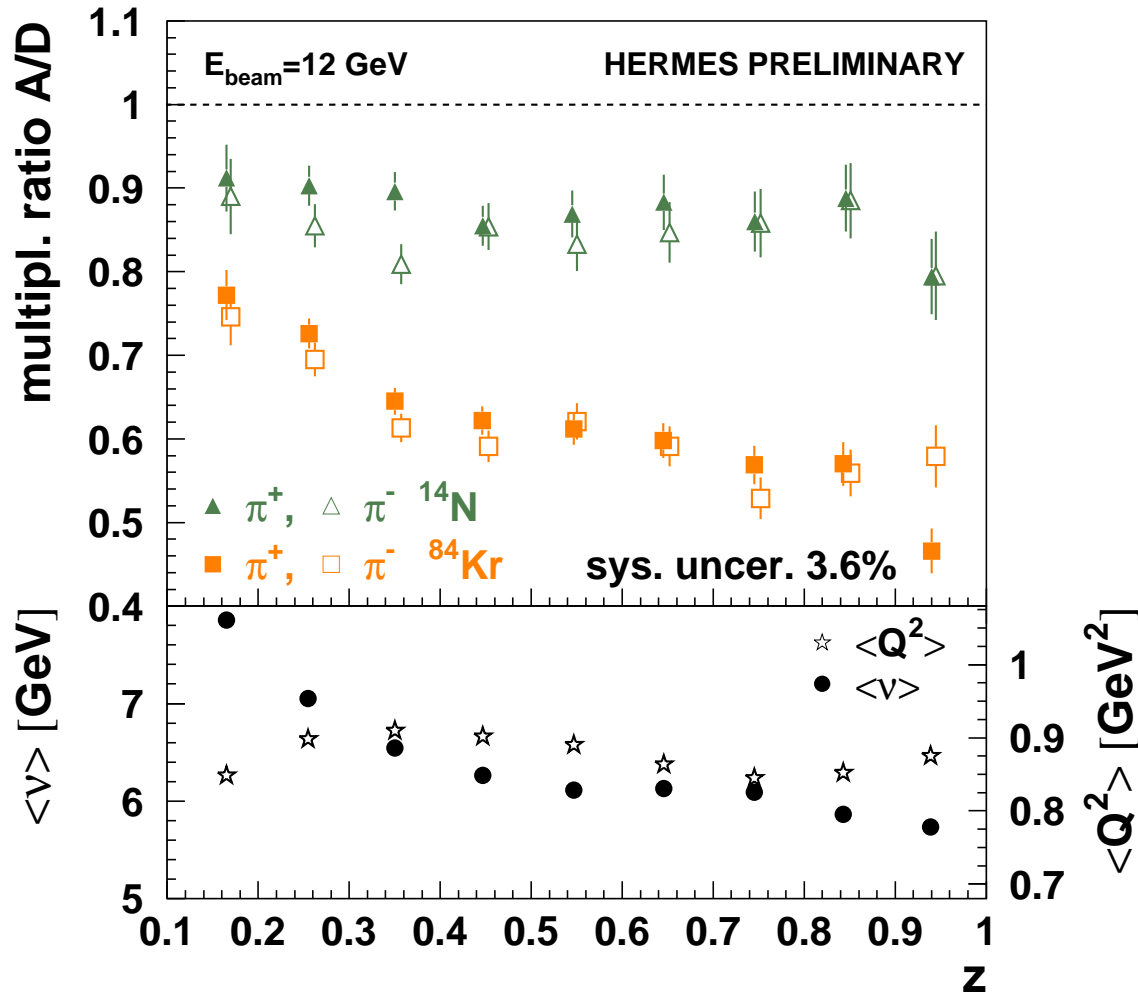
Combining ^{14}N and ^{84}Kr :

$$\alpha = \ln \left(\frac{1 - R_M^{\text{N}}}{1 - R_M^{\text{Kr}}} \right) / \ln \left(\frac{14}{84} \right)$$

\implies data indicate $\alpha \simeq 2/3$, but further study is needed
using all targets

Conclusions:

- Strong A dependence of $R_M(\nu, z)$
- New targets confirm behavior of R_M vs. ν and z
- No charge dependence of attenuation for pions
- $R_M^{K^+}(\nu, z) > R_M^{K^-}(\nu, z)$ and $R_M^p(\nu, z) > R_M^{\bar{p}}(\nu, z)$
- 12 GeV beam energy extends existing data to low ν
- first prelim. study of A dependence of data indicate $\alpha \simeq 2/3$



Large increase of attenuation vs. z

