

Medium-modified fragmentation functions



Rodolfo Sassot
Universidad de Buenos Aires

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in collaboration with M. Stratmann and P. Zurita

DIS2009, Madrid, April 2009

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1. significant progress in the pQCD description of hadroproduction

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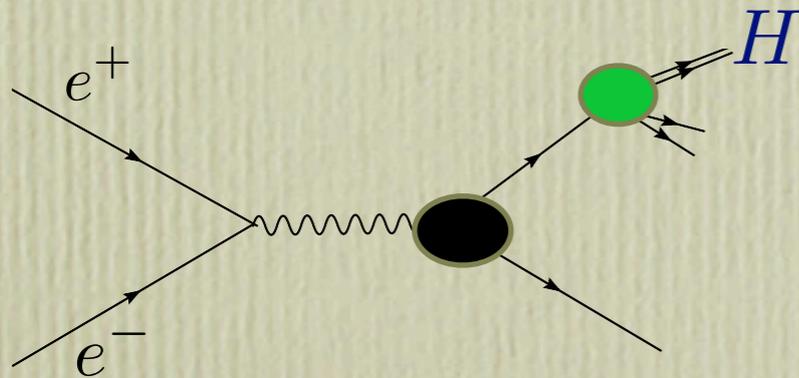
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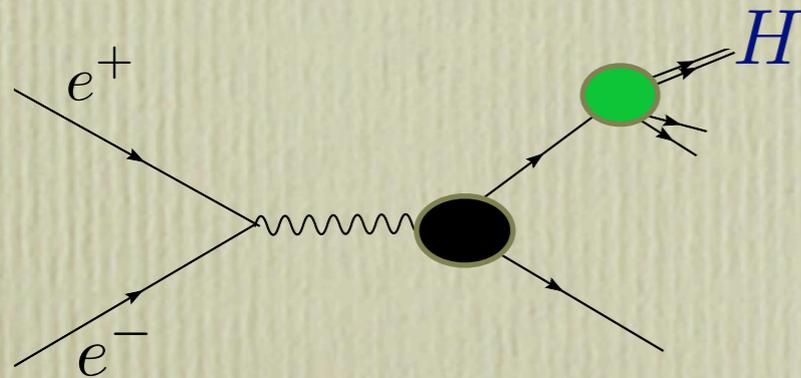
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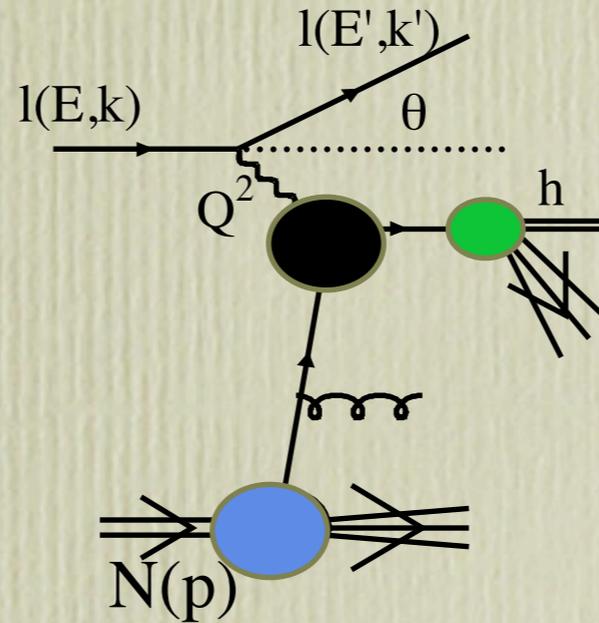
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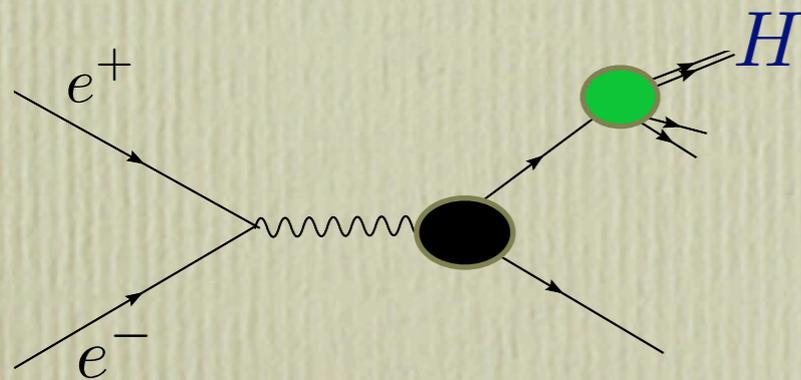
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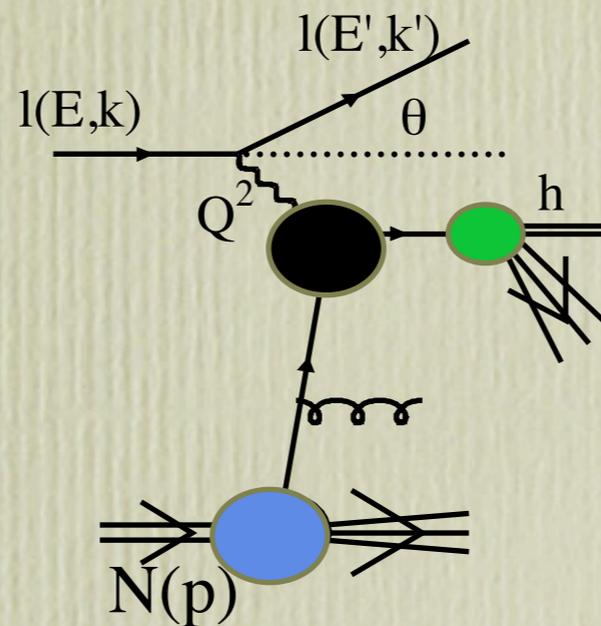
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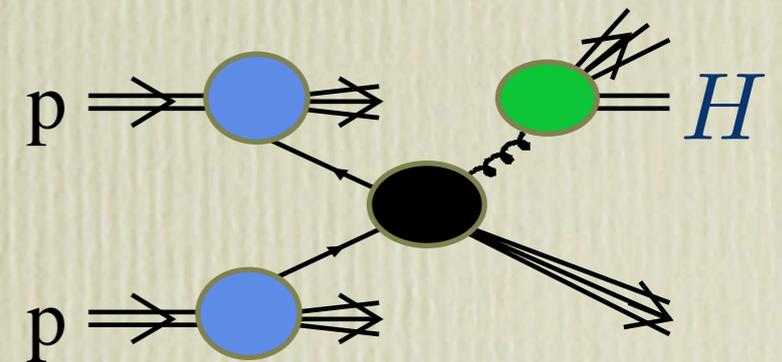
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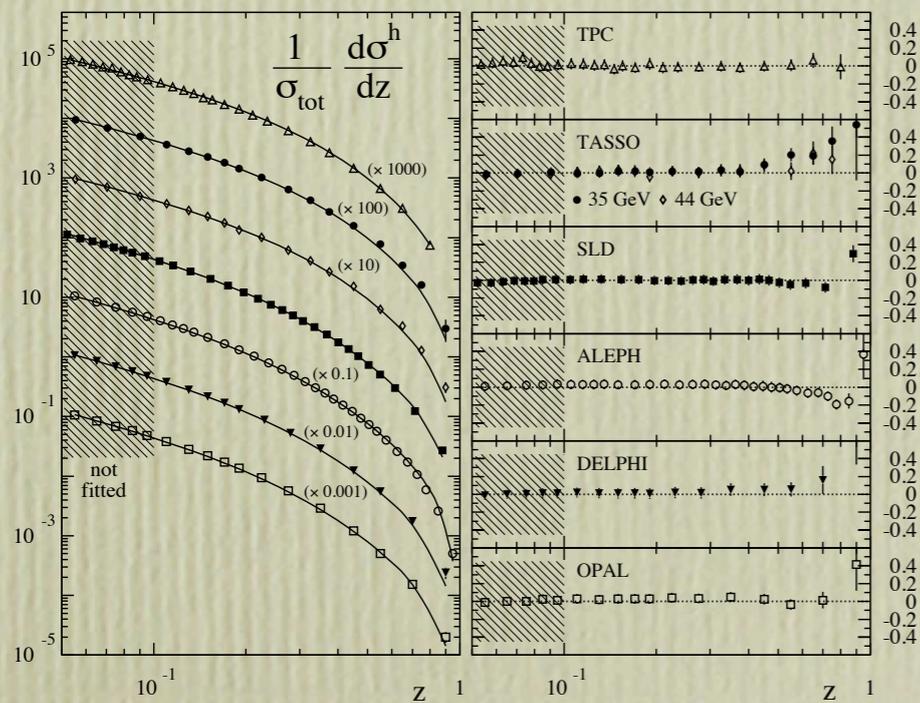
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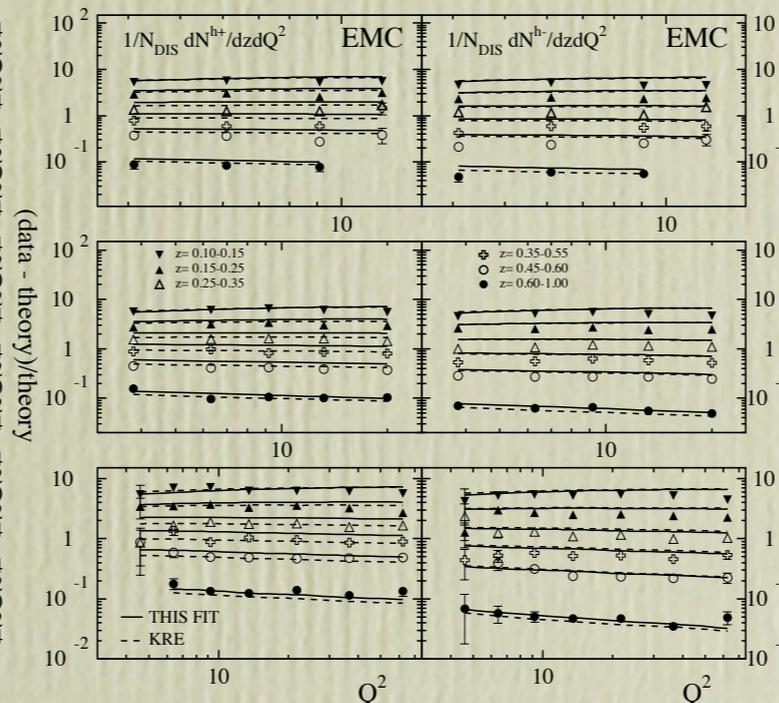
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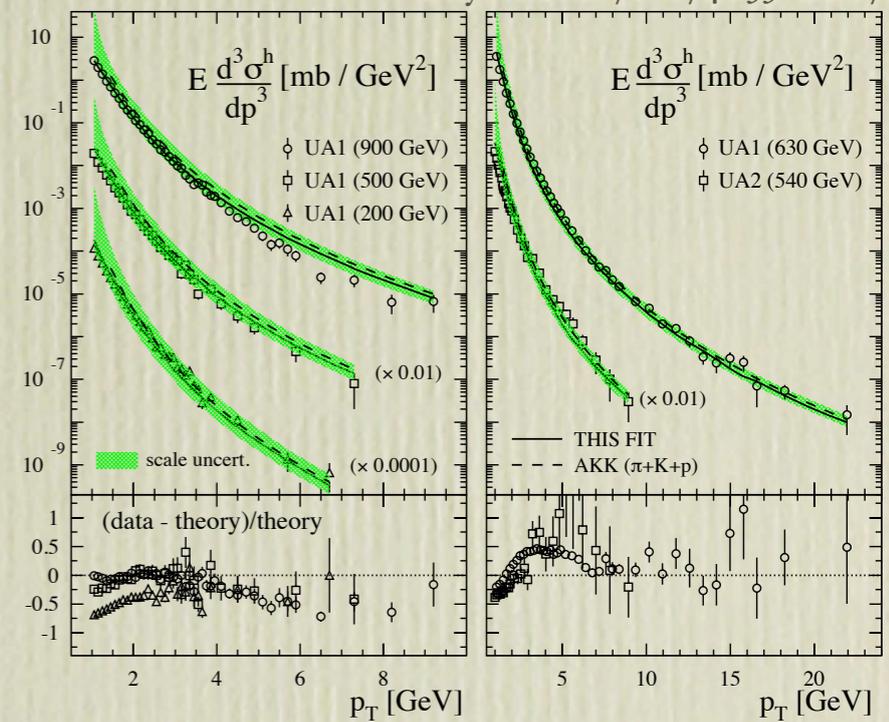


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D. de Florian, R.S, M. Stratmann Phys.Rev.D75 114010 (2007)
Phys.Rev.D76 074033 (2007)



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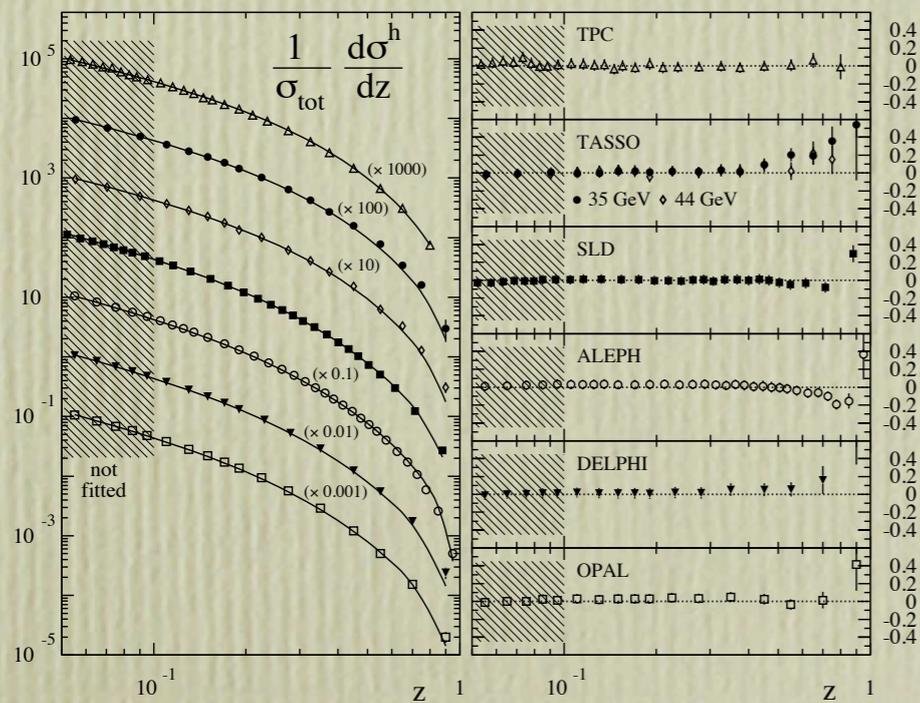
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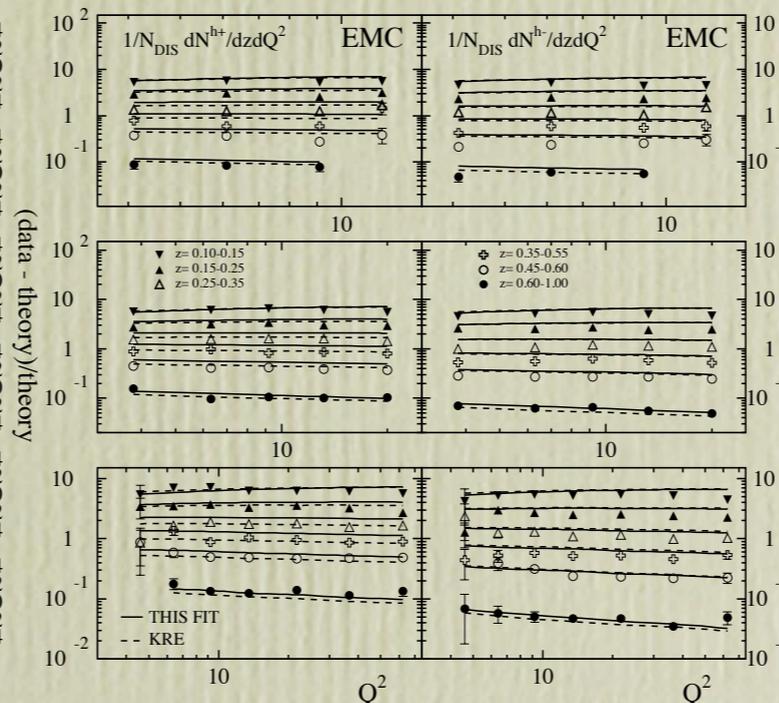
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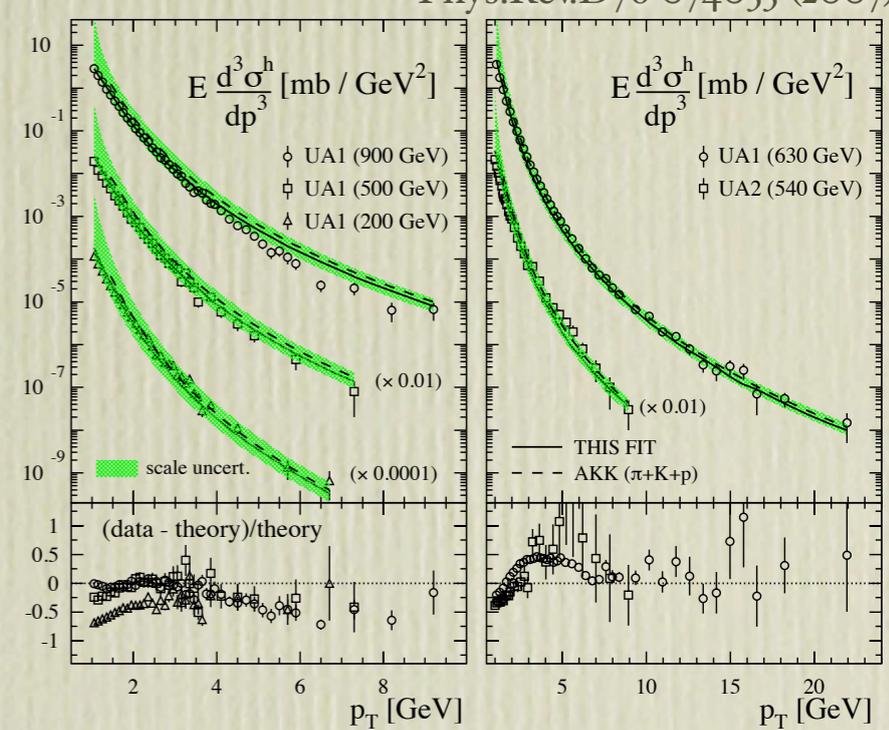
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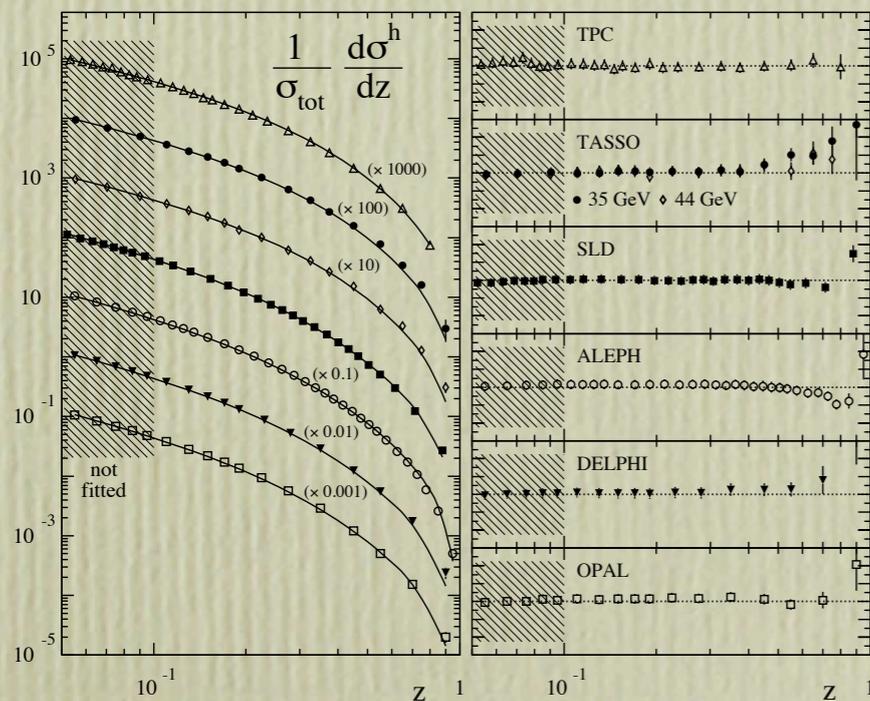
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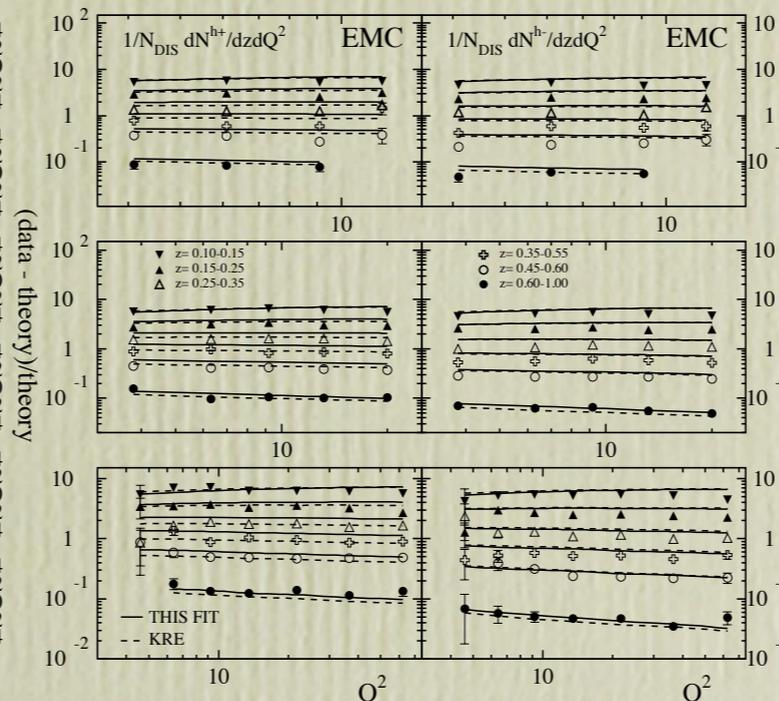
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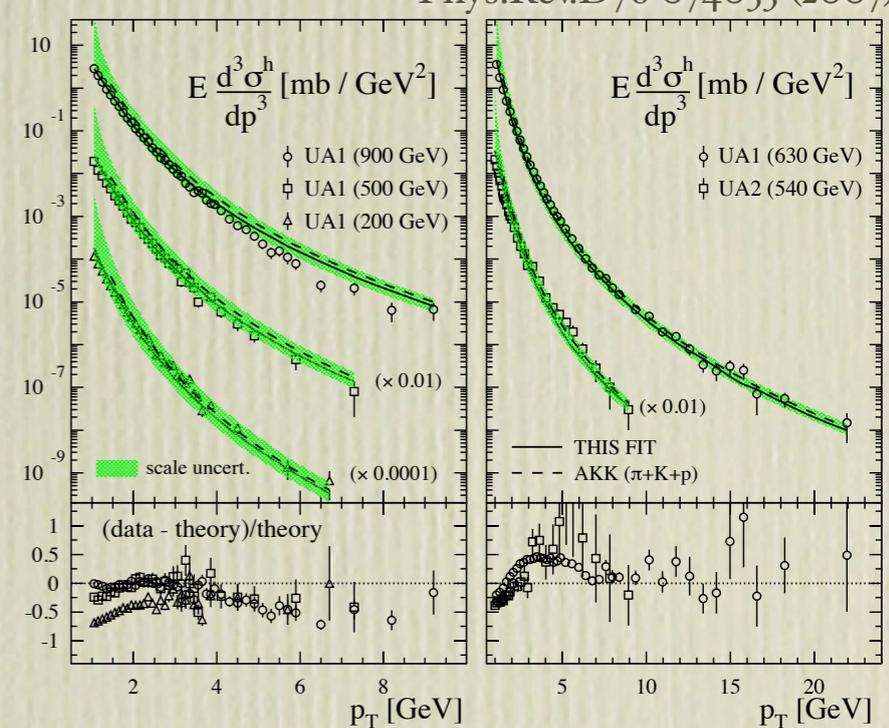
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but not the whole picture ...

Motivation II:

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HERMES SIDIS off nuclei: d, He, Ne, Kr and Xe

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interaction of the seed parton (energy loss)

modified FFs through evolution equations

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see reviews F. Arleo arXiv:0810.1193, 2008

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➡ reproduce the main features of the data
(in spite of very different approaches and ingredients!)

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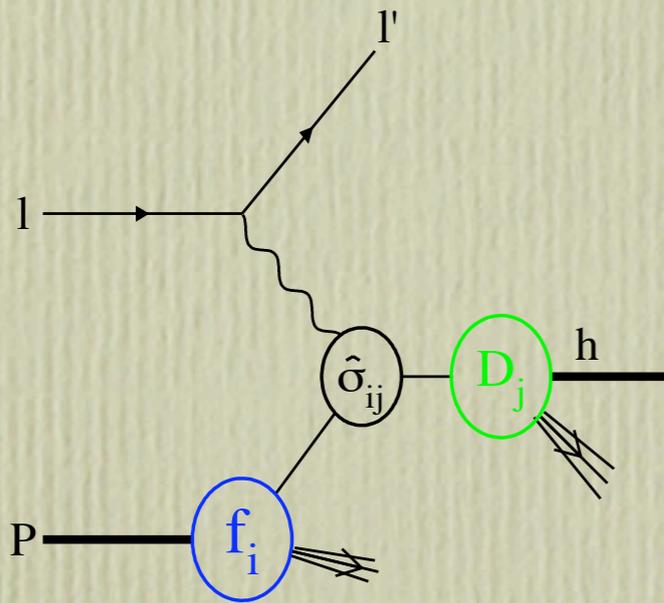
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$$D_{i/p}^h(z, Q^2)$$

vacuum/nucleon

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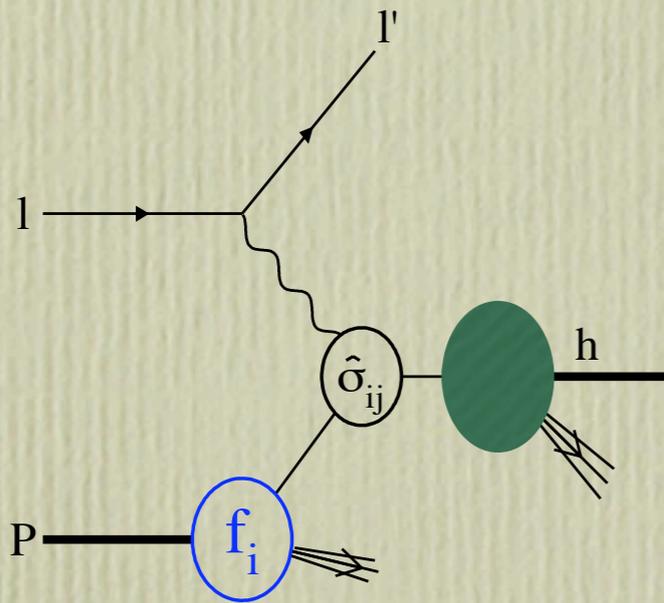
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vacuum/nucleon nuclei

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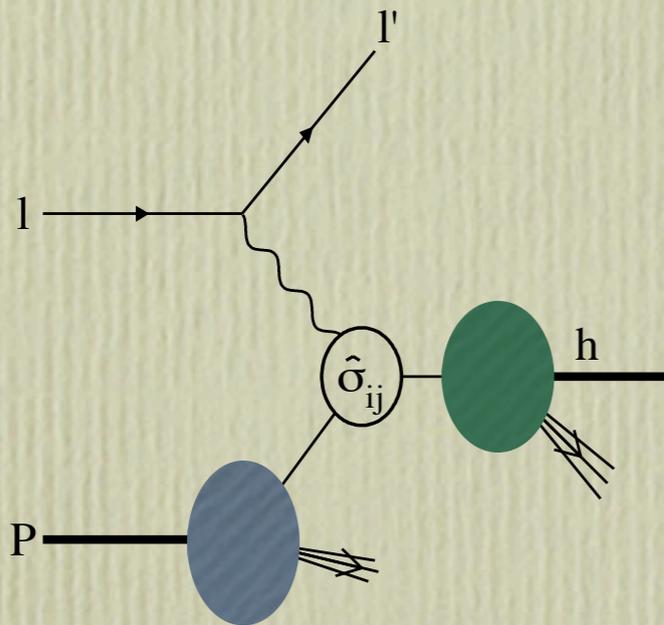
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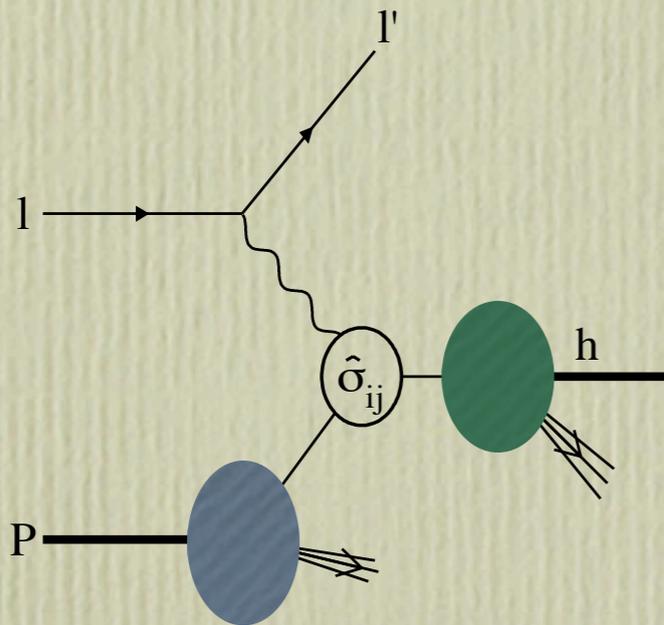
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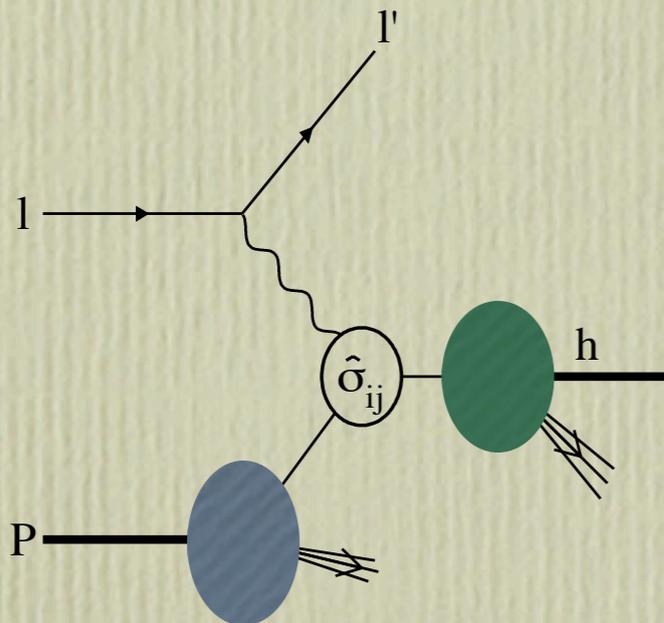
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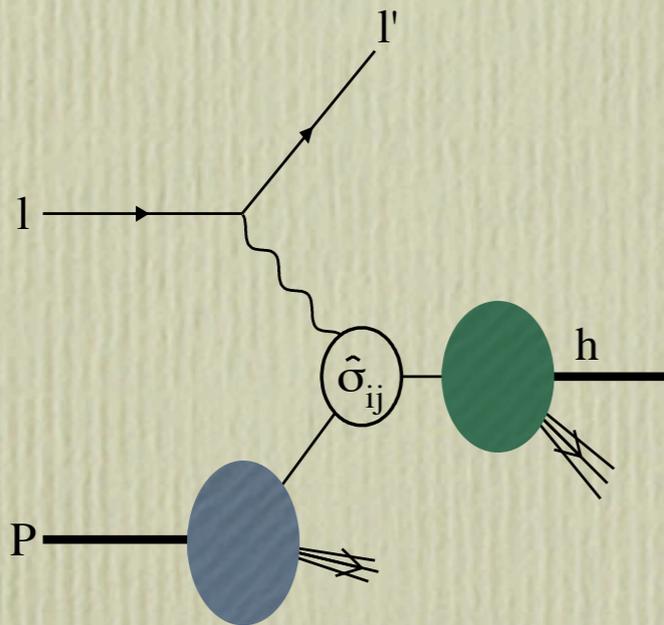
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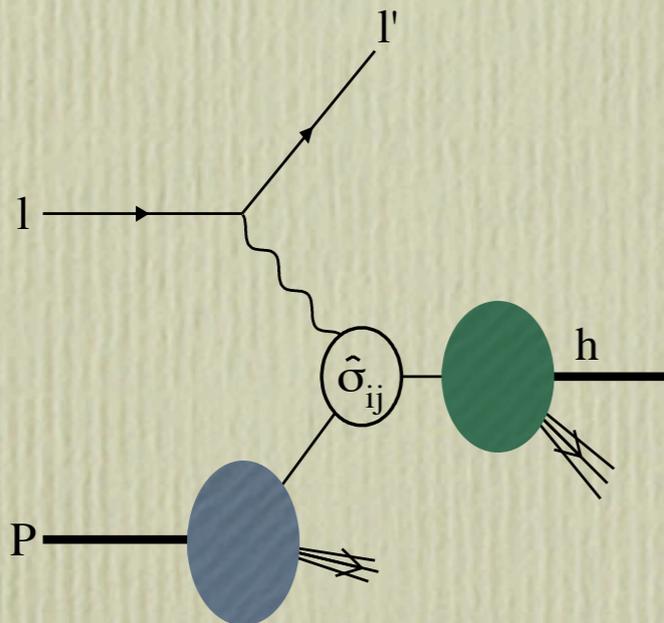
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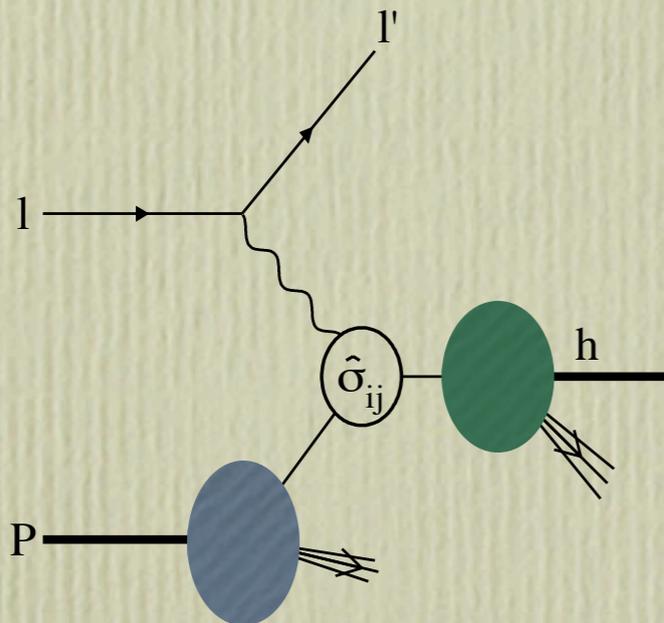
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why standard evolution equations?

standard evolution works fine for nPDFs
first step, let's check it

Convolution approach:

$$D_{i/A}^h(z, Q_0^2) = \int_z^1 dy W_i(y, A, Q_0^2) D_i^h\left(\frac{z}{y}, Q_0^2\right)$$

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re-scalings/shifts
modifies FFs
natural language NLO

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$$W_i(y, A, Q_0^2) = \delta(1 - y)$$

no effects

$$W_i(y, A, Q_0^2) = \delta(1 - \epsilon - y)$$

z-shift \sim energy loss

$$W_i(y, A, Q_0^2) = n_i y^{\alpha_i} (1 - y)^{\beta_i}$$

enhancement/suppression, re-shape

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weighting coefficients $\epsilon_i, n_i, \alpha_i, \beta_i$ with a smooth A dependence

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A simple example:

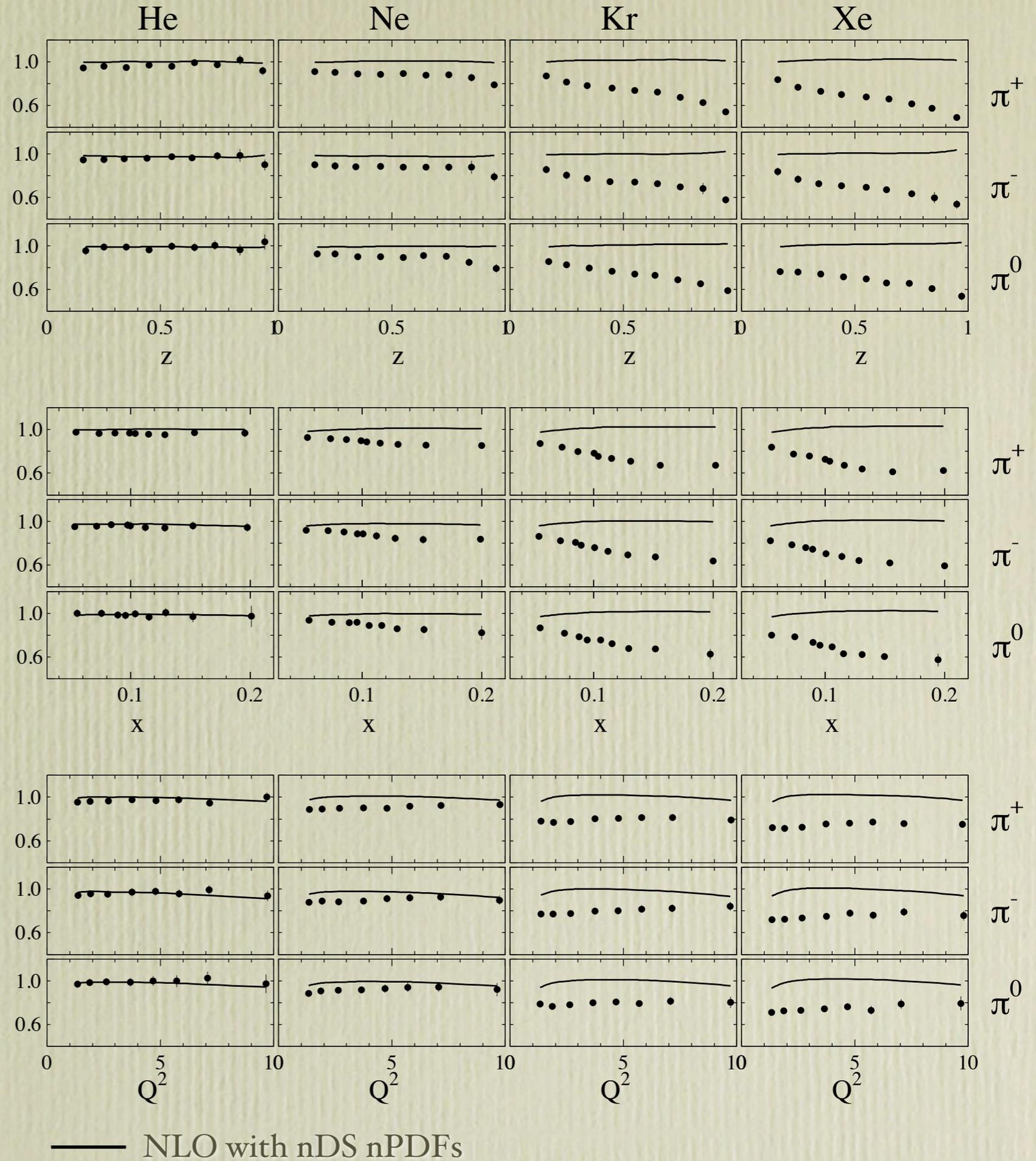
$$W(y, A, Q_0^2) = n_1 \delta(1 - \epsilon_1 - y) + n_2 \delta(1 - \epsilon_2 - y)$$

HERMES rates

$$R(z, Q^2, \nu) = \frac{\left(\frac{N^{sidis}}{N^{inc}}\right)_A}{\left(\frac{N^{sidis}}{N^{inc}}\right)_D}$$

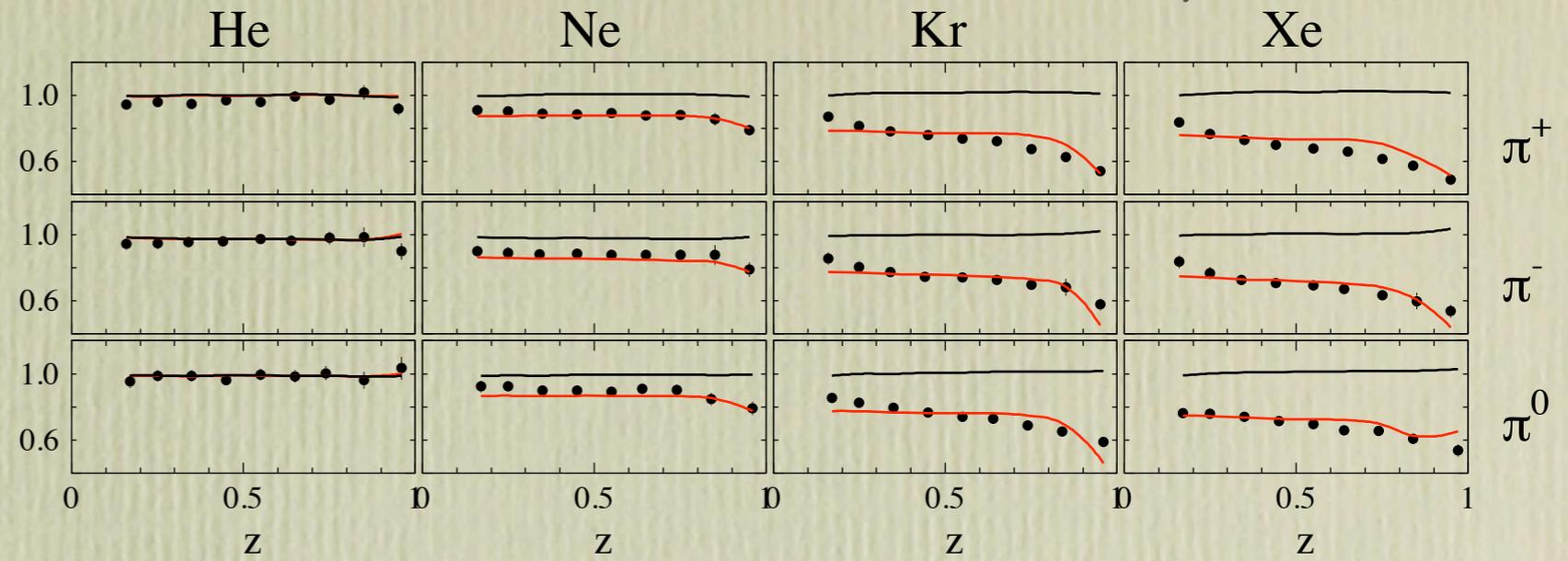
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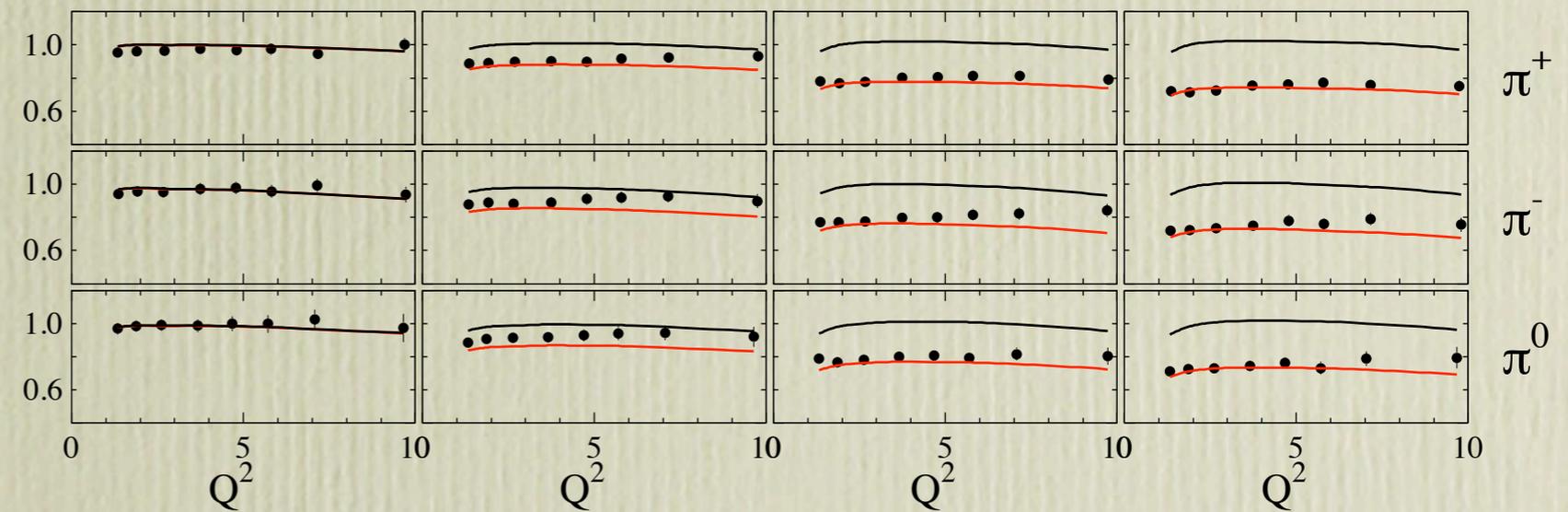
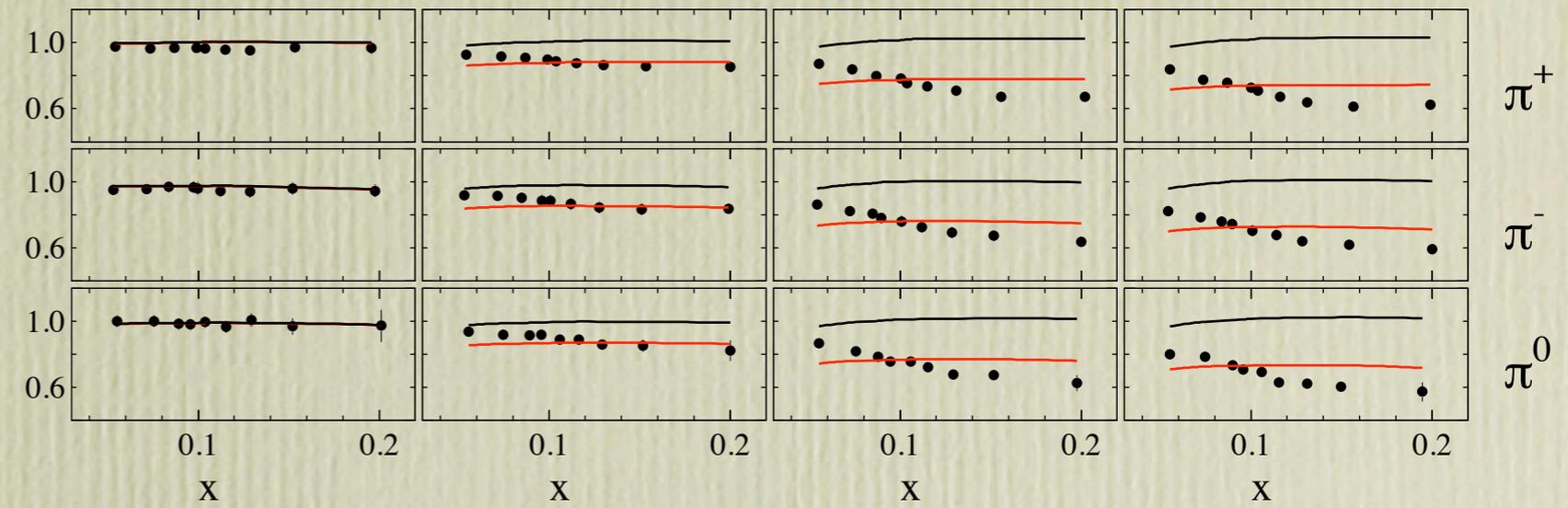


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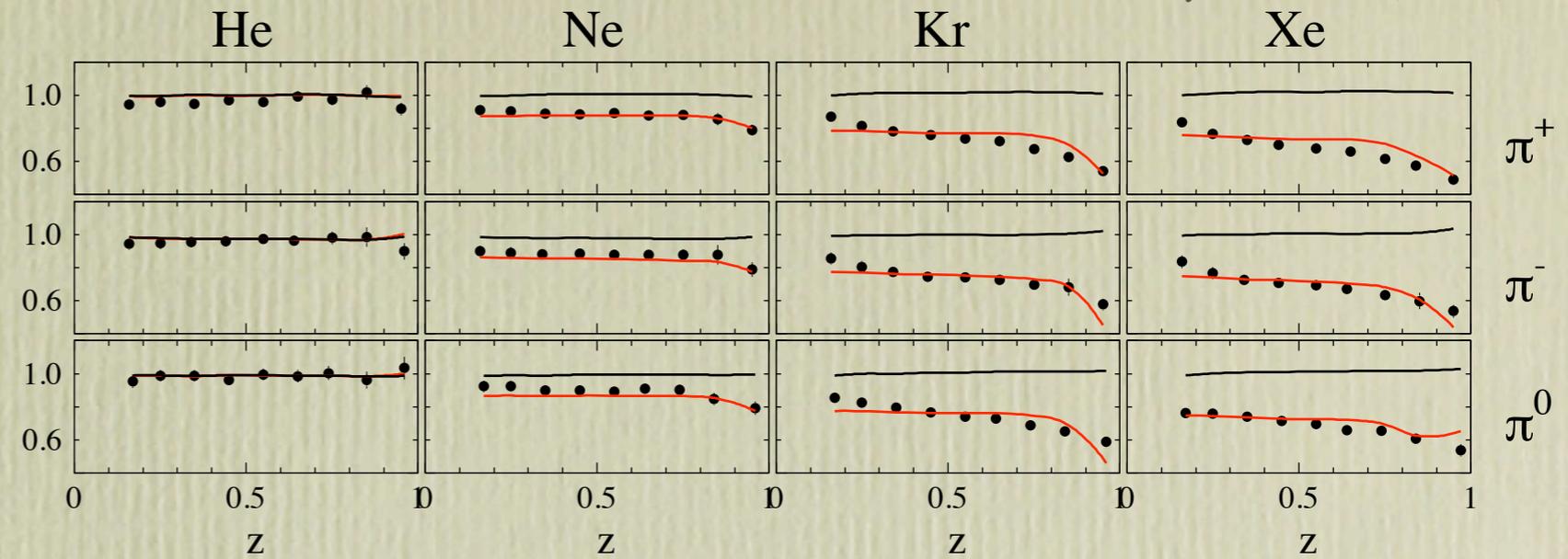


— NLO with nDS nPDFs

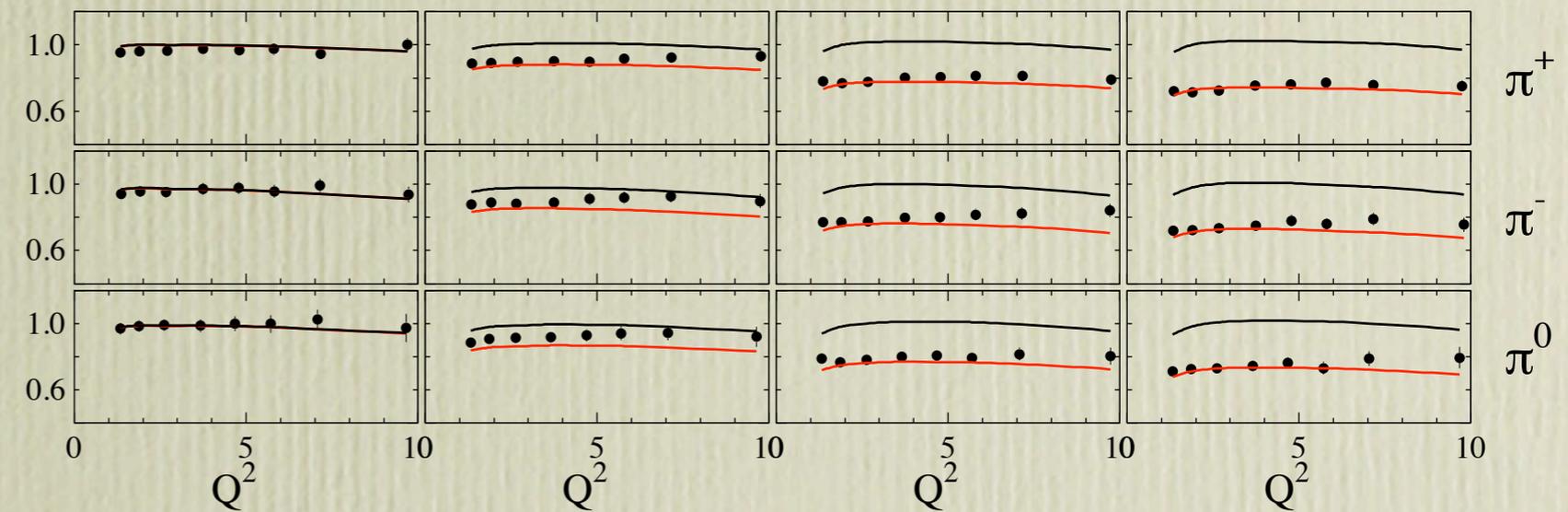
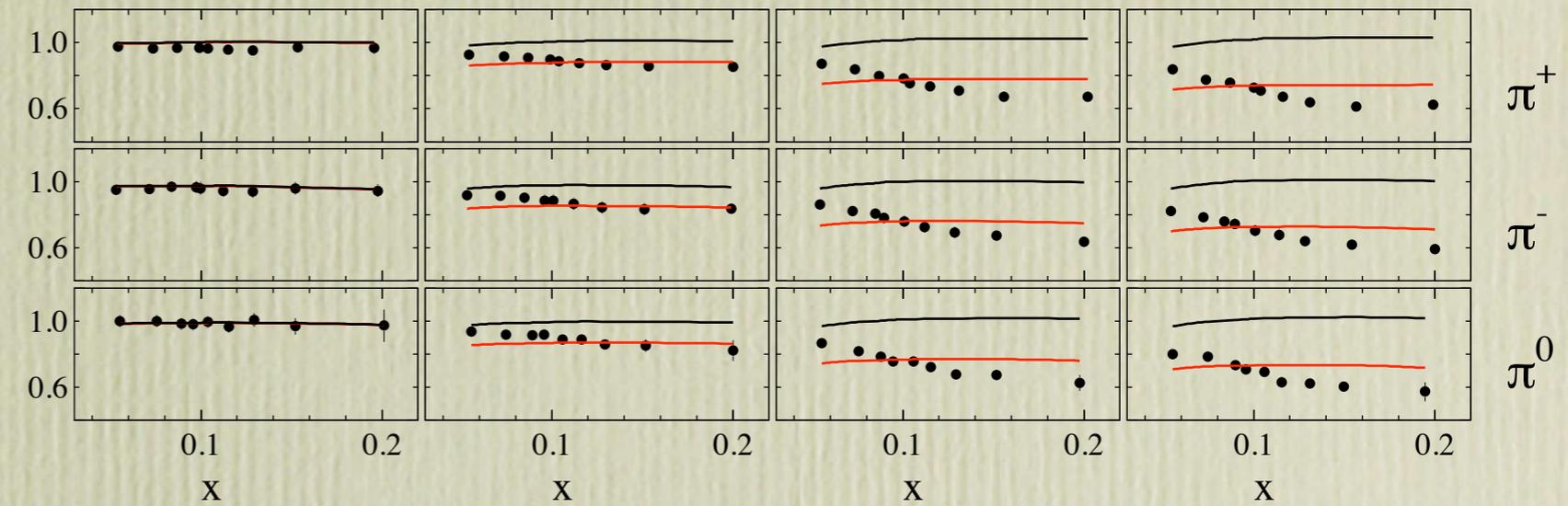
— idem + nFFs

HERMES rates

$$R(z, Q^2, \nu) = \frac{\left(\frac{N^{sidis}}{N^{inc}}\right)_A}{\left(\frac{N^{sidis}}{N^{inc}}\right)_D}$$



$$W(y, A, Q_0^2) = n_1 \delta(1 - \epsilon_1 - y) + n_2 \delta(1 - \epsilon_2 - y)$$



— NLO with nDS nPDFs

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A	n_1	ϵ_1	n_2	ϵ_2
He	0.694	-0.006	0.304	0.011
Ne	0.611	-0.007	0.267	0.027
Kr	0.545	-0.008	0.238	0.078
Xe	0.526	-0.009	0.229	0.111
Au	0.509	-0.009	0.222	0.154

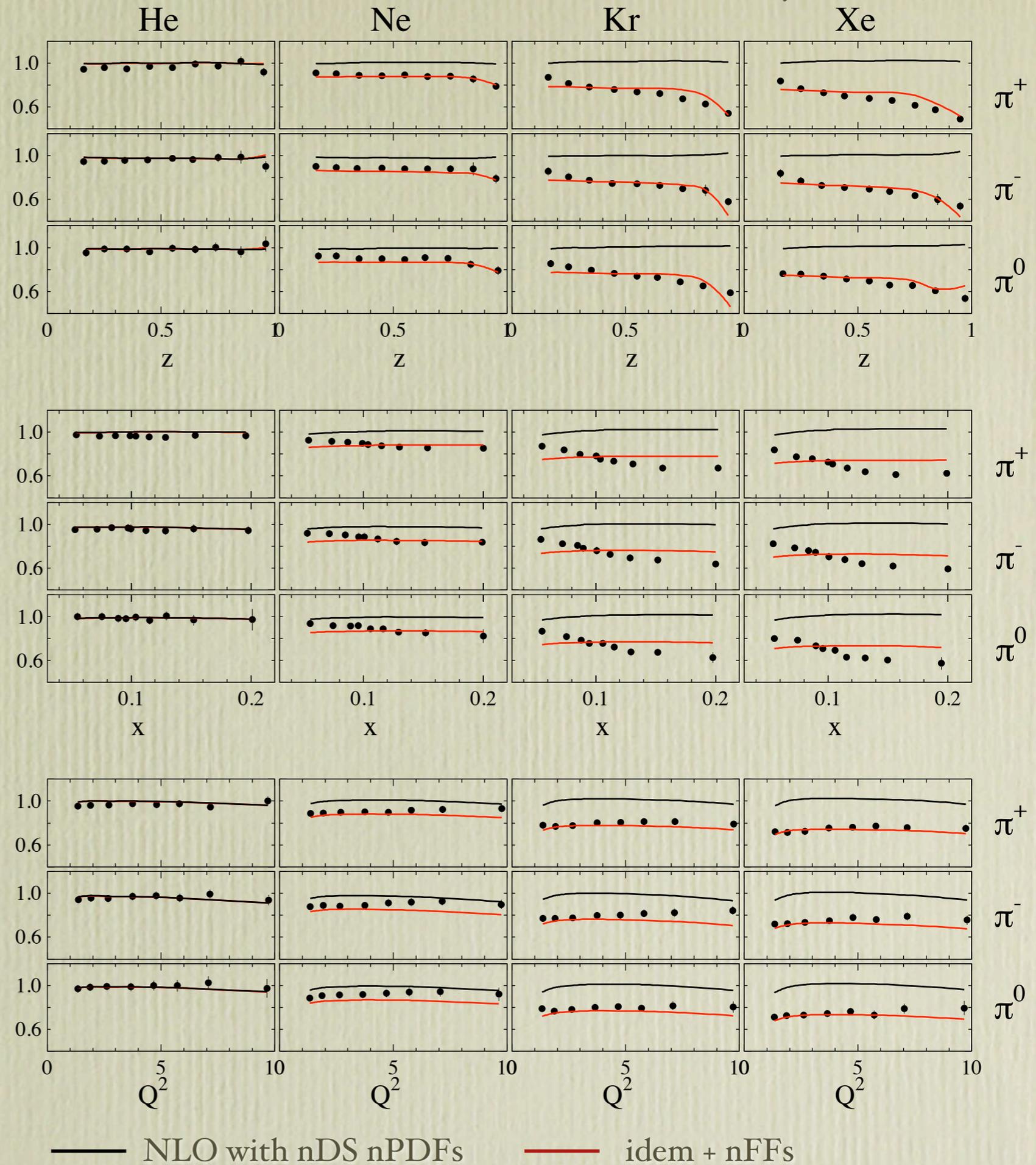
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\sim vacuum FF



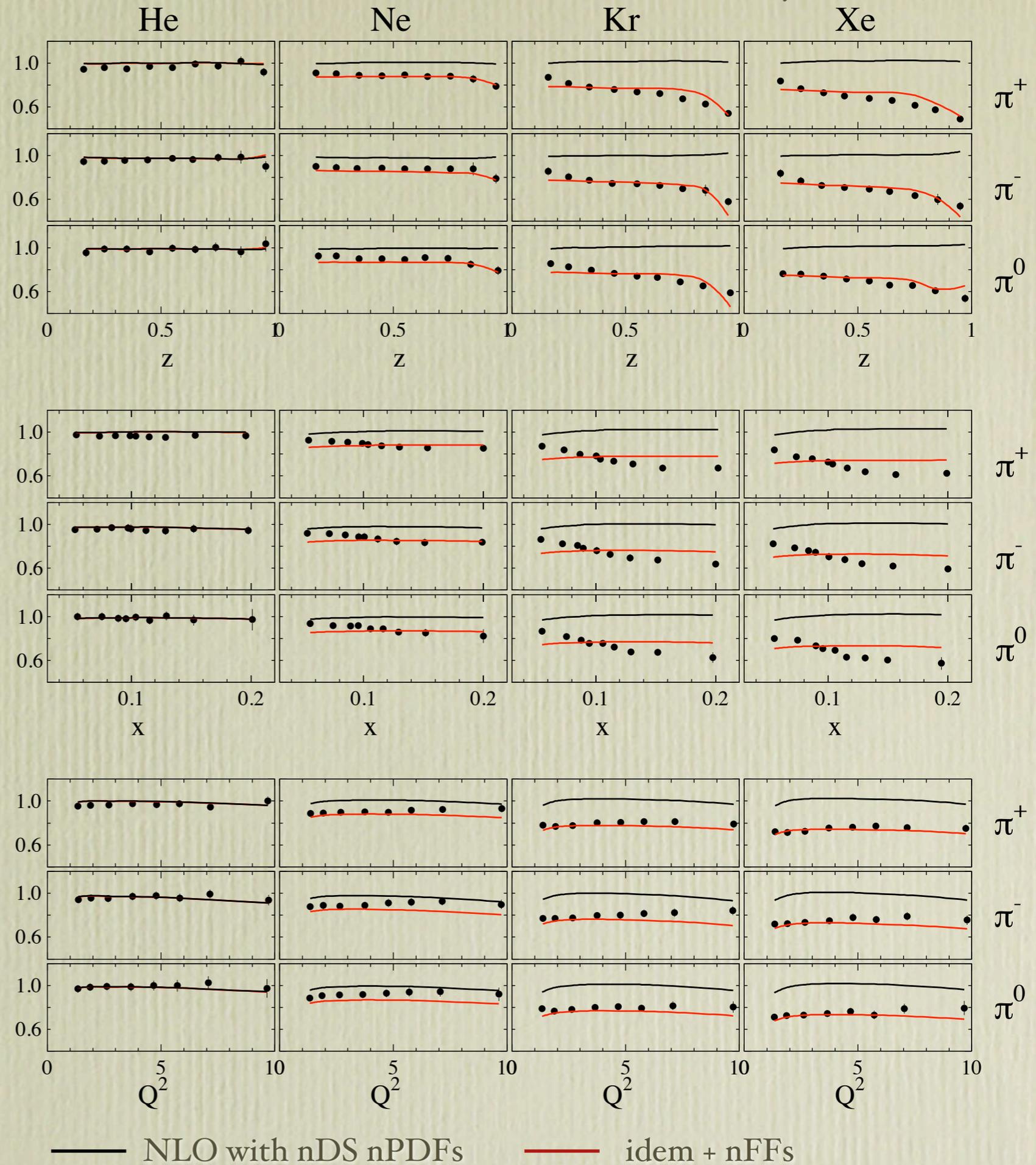
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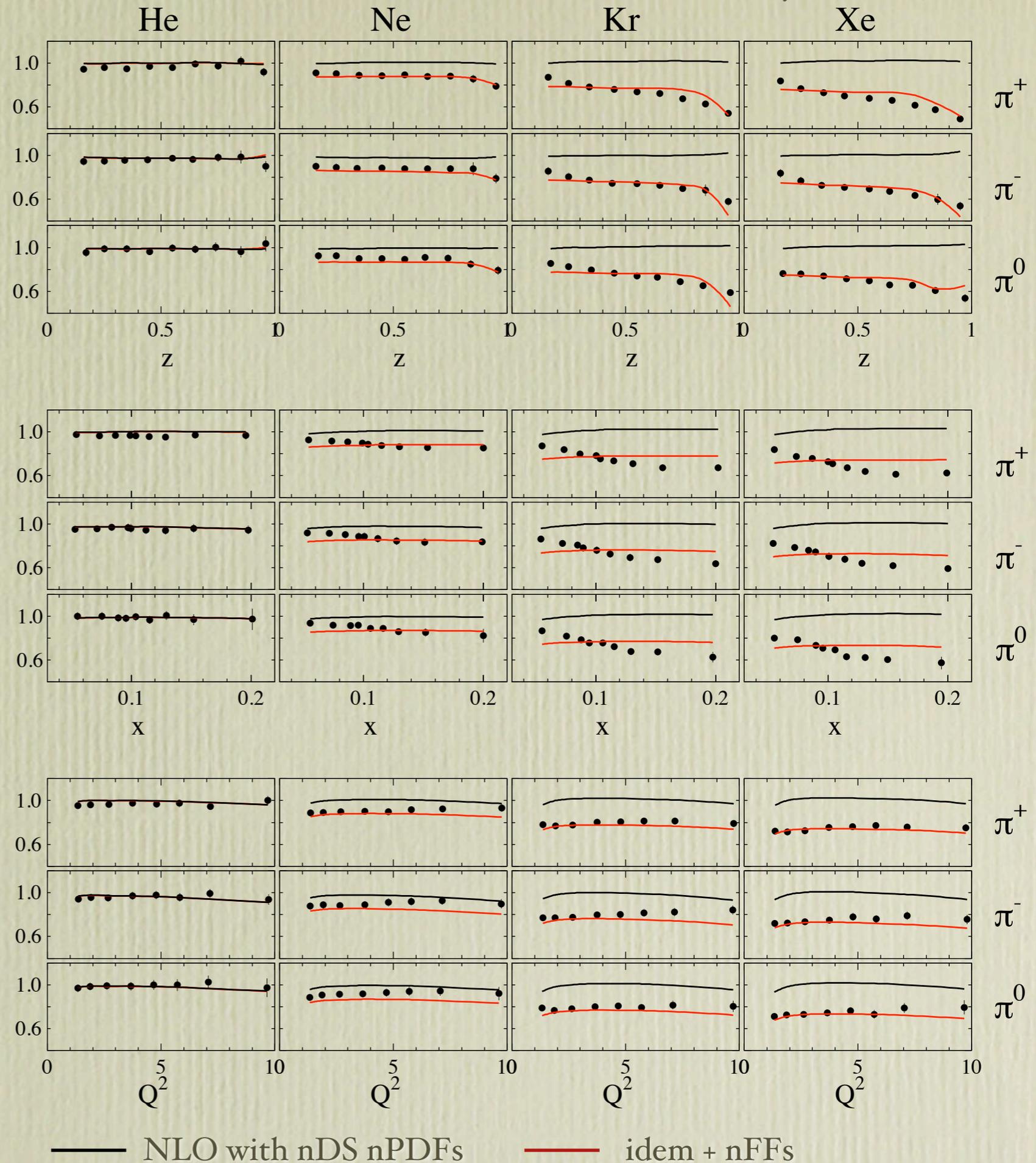
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\sim vacuum FF energy loss

$$n_i = \lambda^{n_i} + \gamma^{n_i} A^{\delta^{n_i}}$$

\sim 10 parameters



Refined parameterization:

$$W_q(y, A, Q_0^2) = n_q \delta(1 - \epsilon_q - y) + n'_q y^{\alpha_q} (1 - y)^{\beta_q}$$

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needs to be constrained by dAu collision data

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$$\begin{aligned} \lambda^n &\sim 1 \\ \lambda^{n'} &\sim 0 \end{aligned} \quad \text{effects vanish as } A \longrightarrow 1$$

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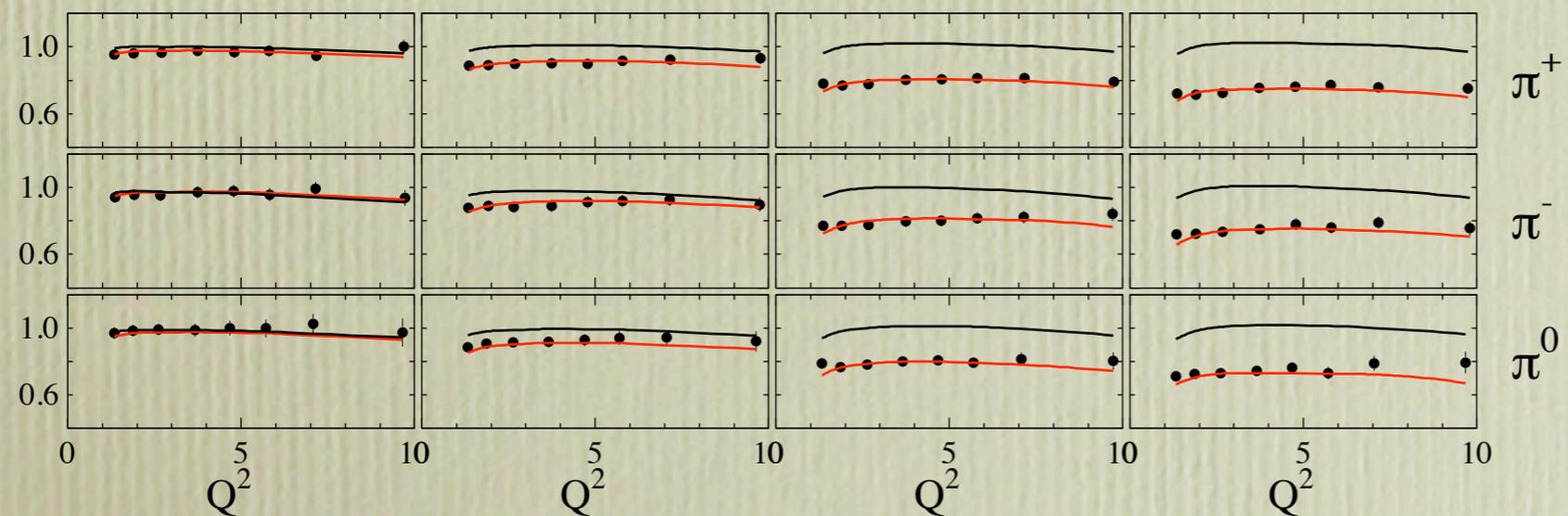
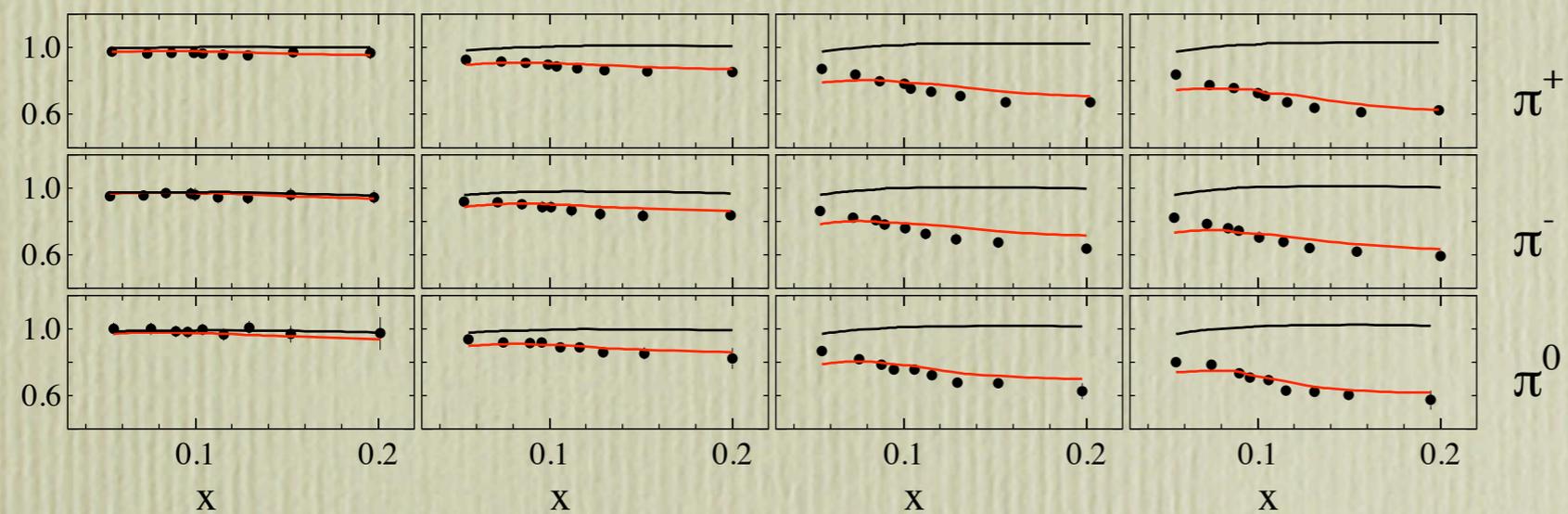
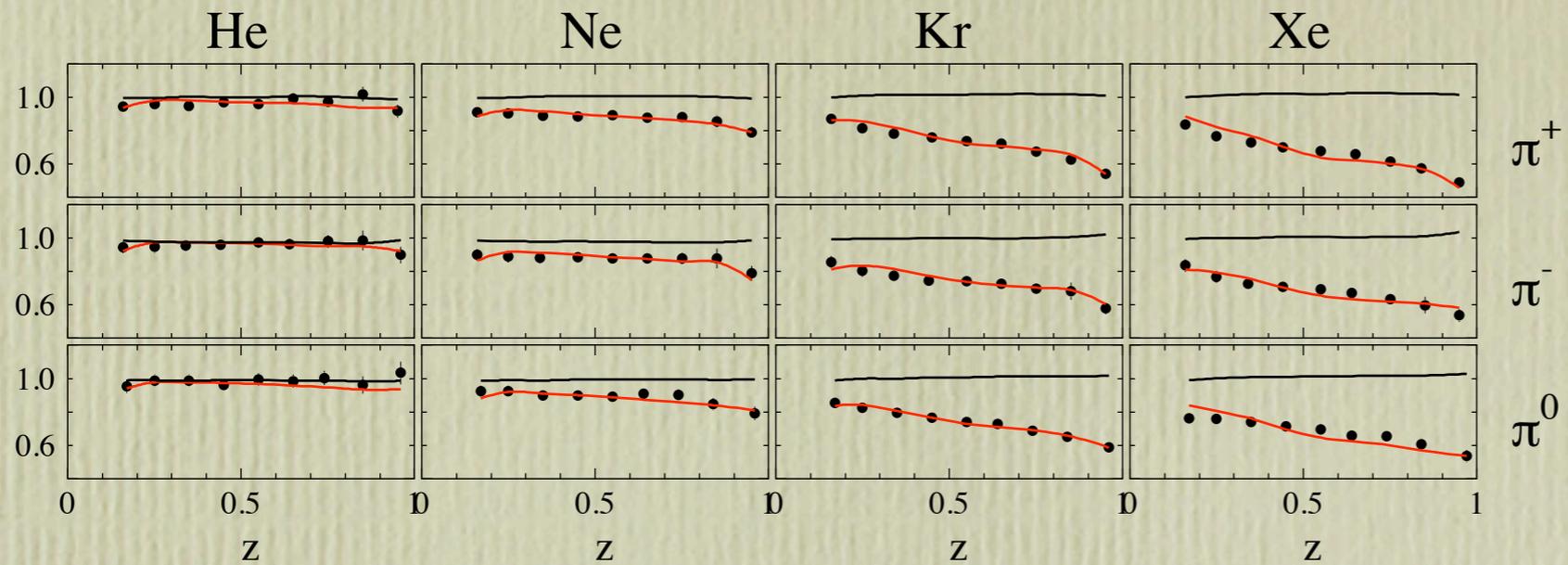
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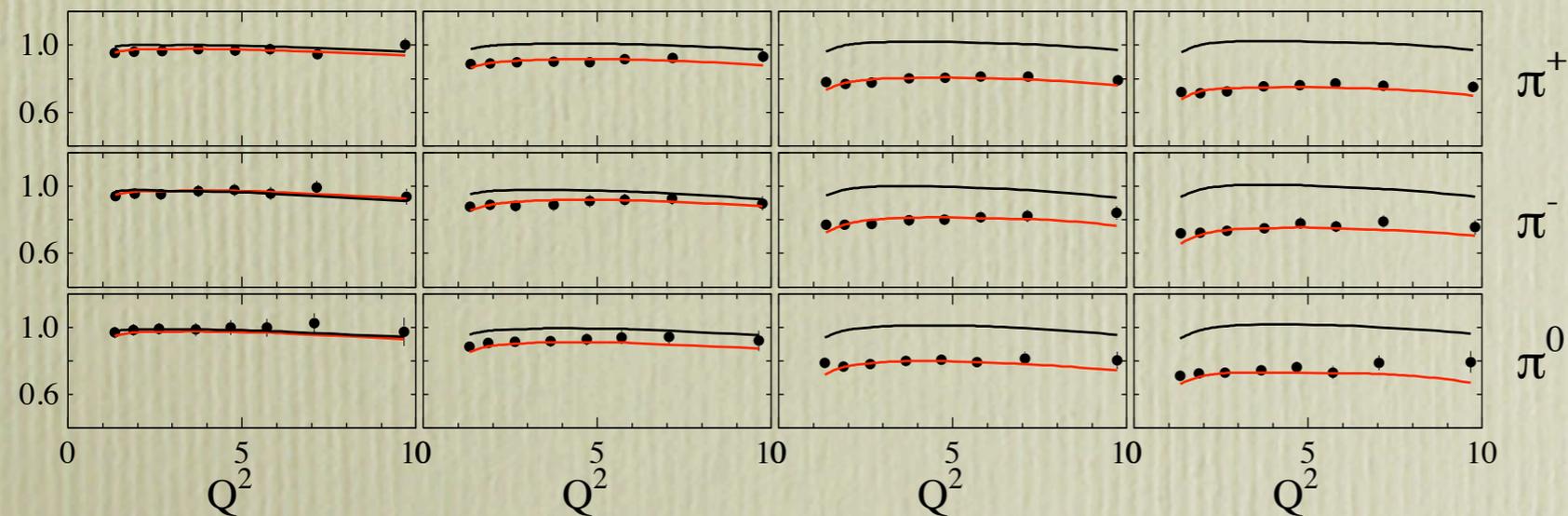
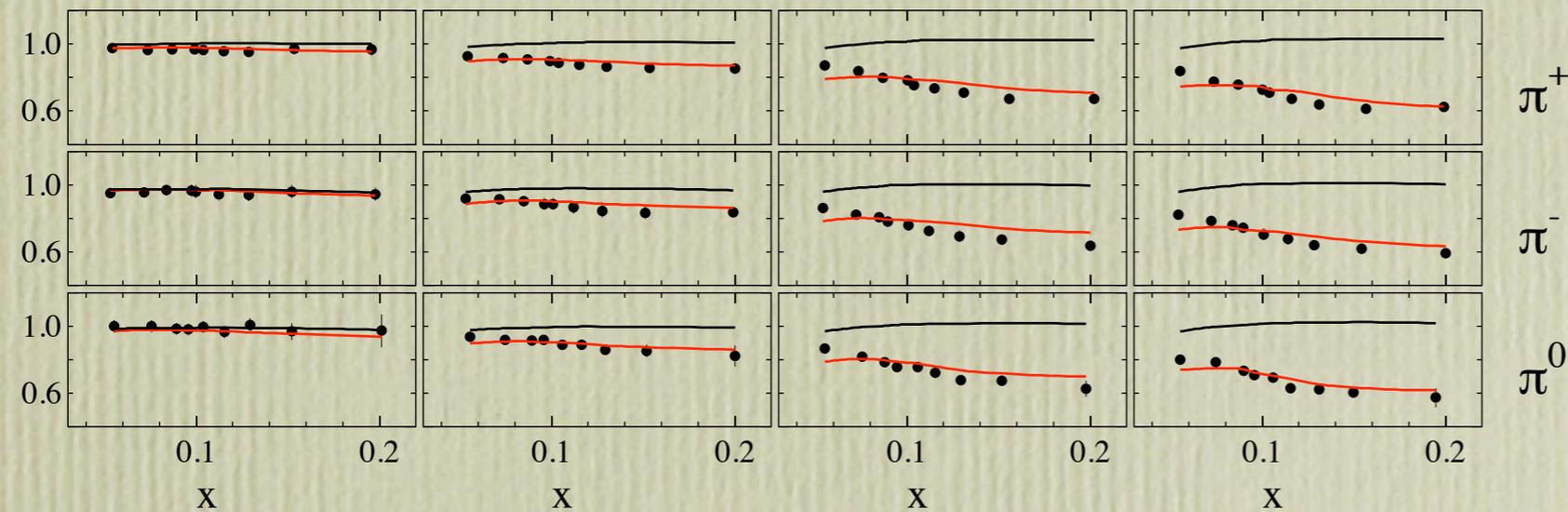
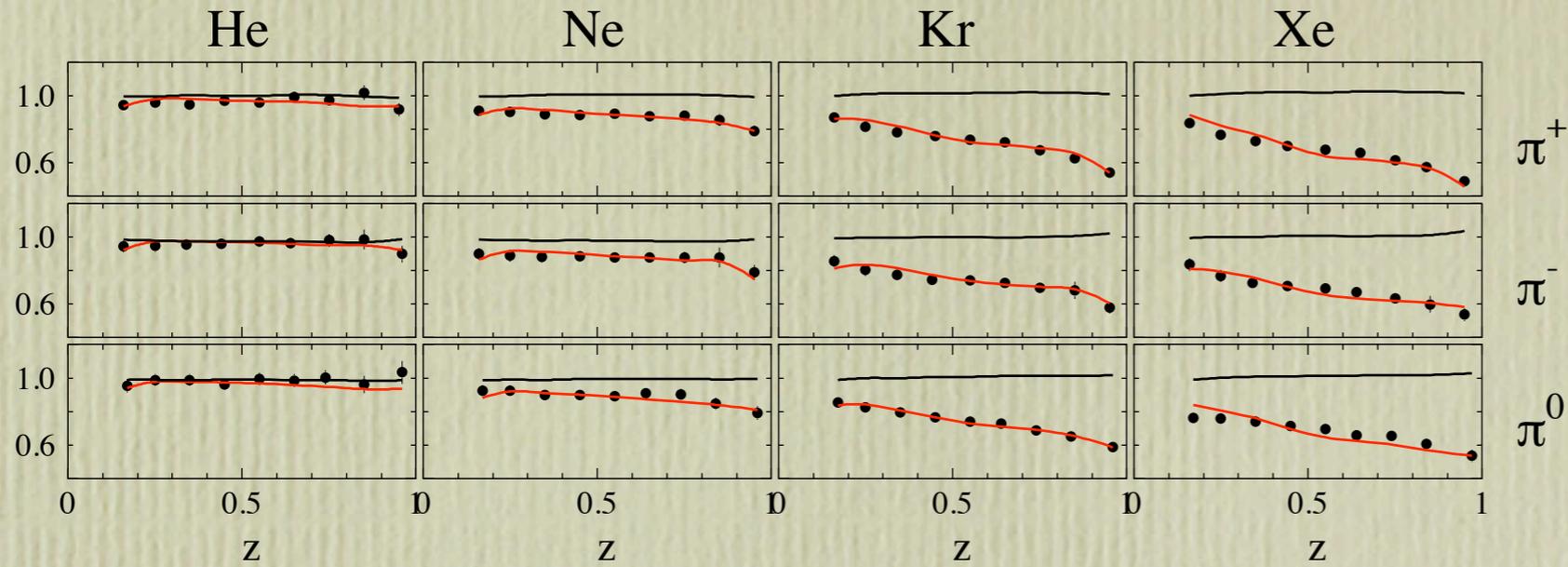
effects vanish as $A \rightarrow 1$

~ 17 parameters

most (but not all!) δ^n can be approximated as $\delta^n = 1$



— NLO with nDS nPDFs — idem + nFFs



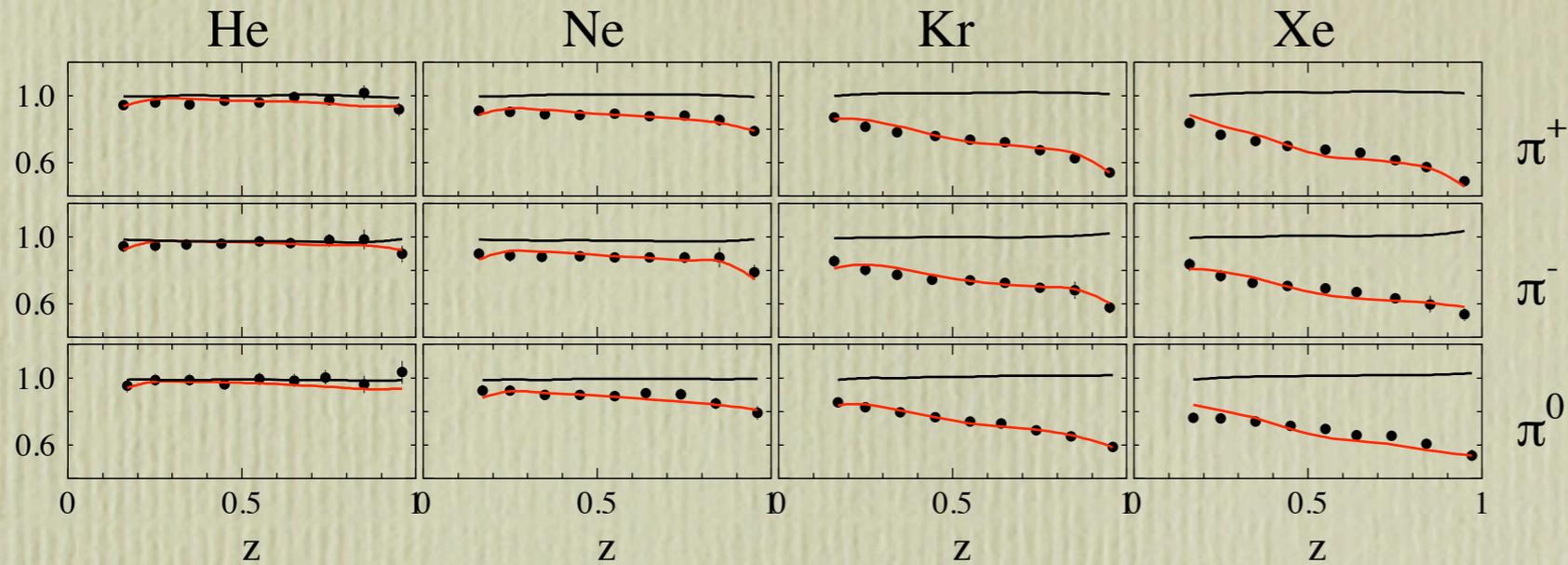
— NLO with nDS nPDFs — idem + nFFs

$\chi^2 = 350.45$

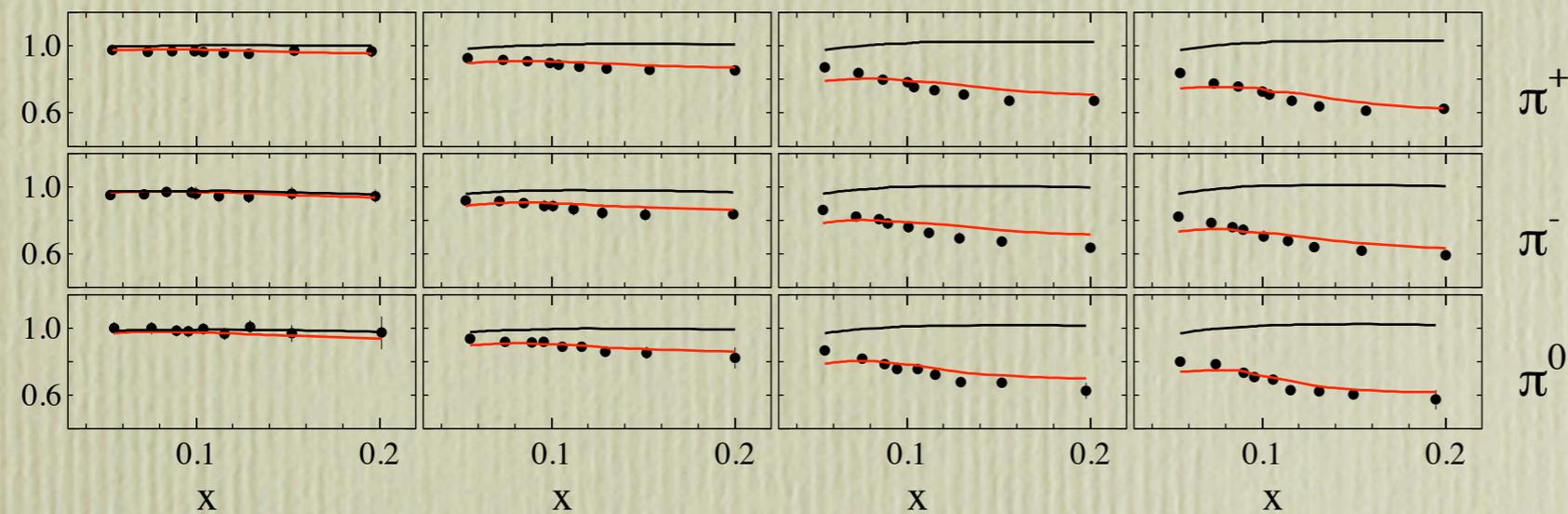
368 data points

17 parameters

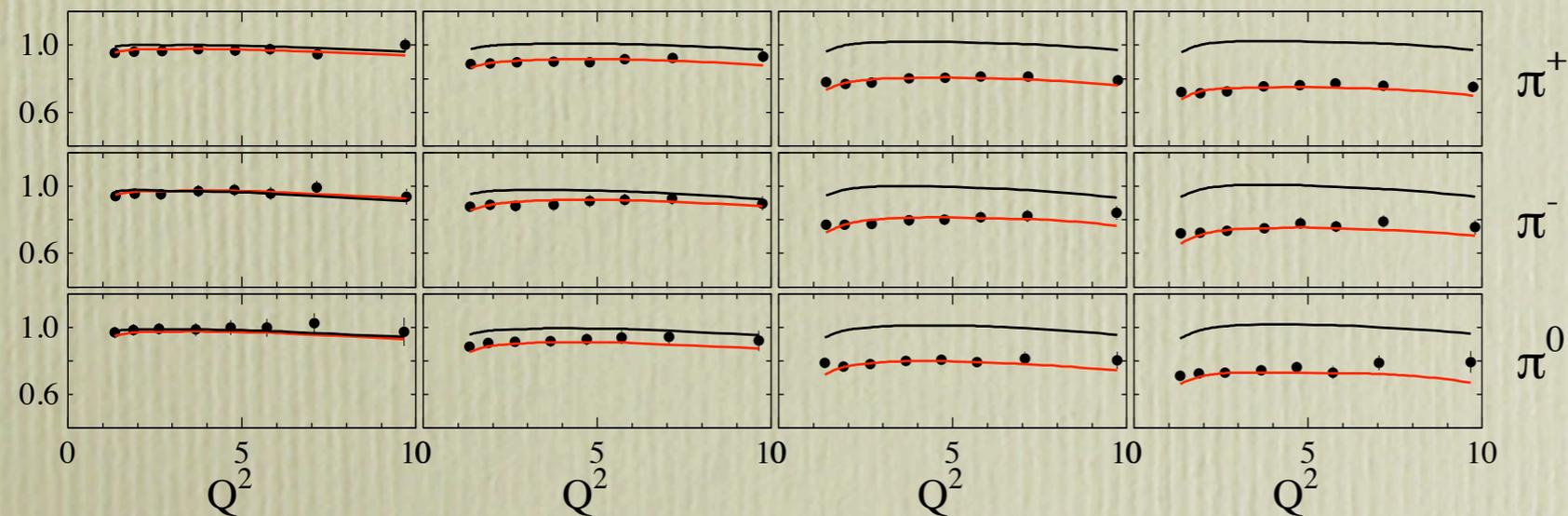
$\chi^2/d.o.f = 0.997$



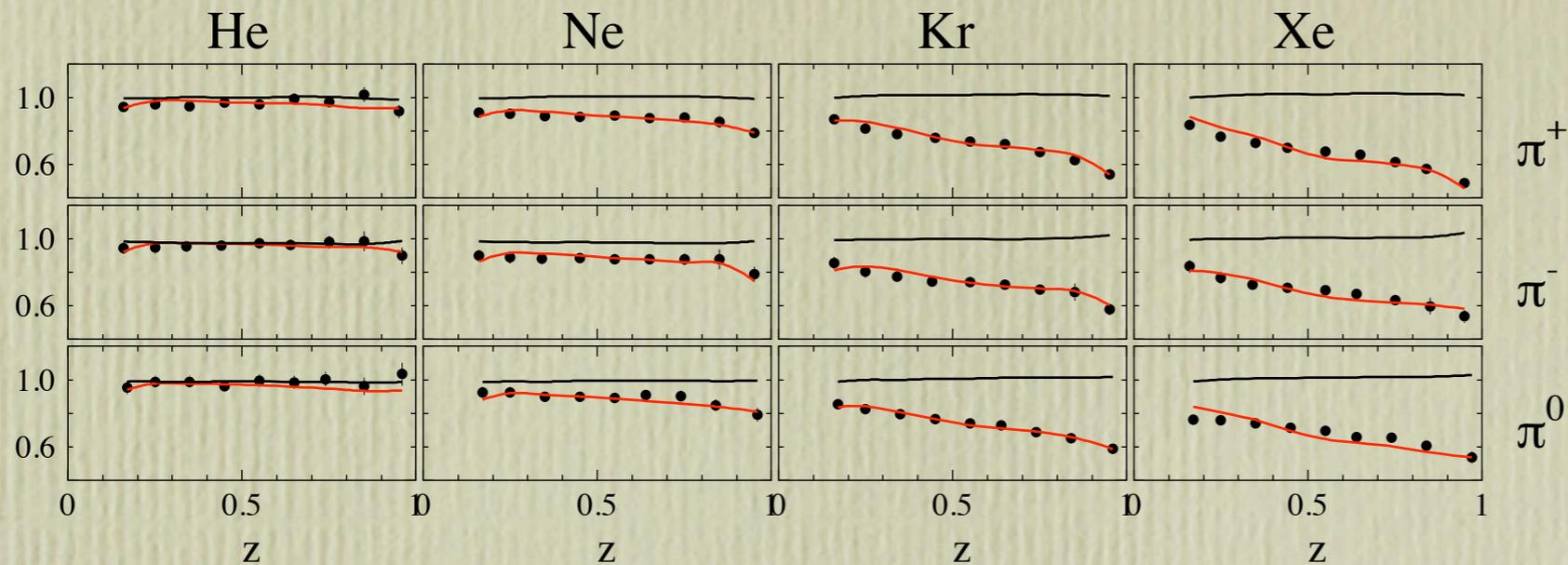
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x (or v)-dependence reproduced



— NLO with nDS nPDFs — idem + nFFs

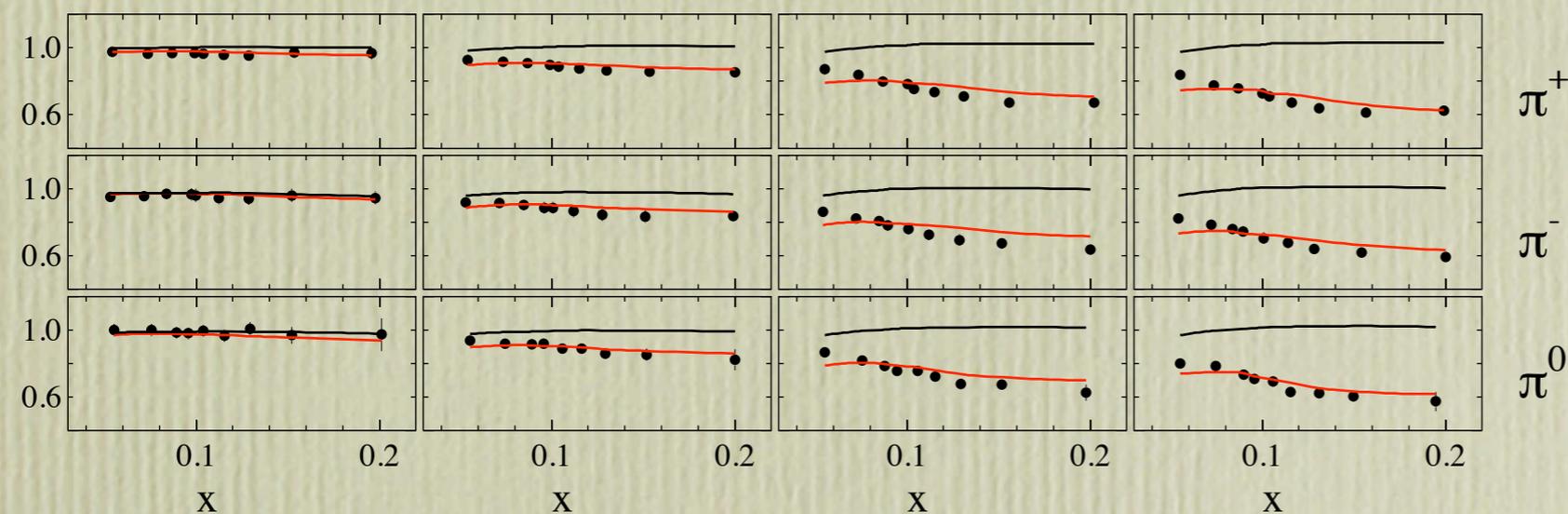


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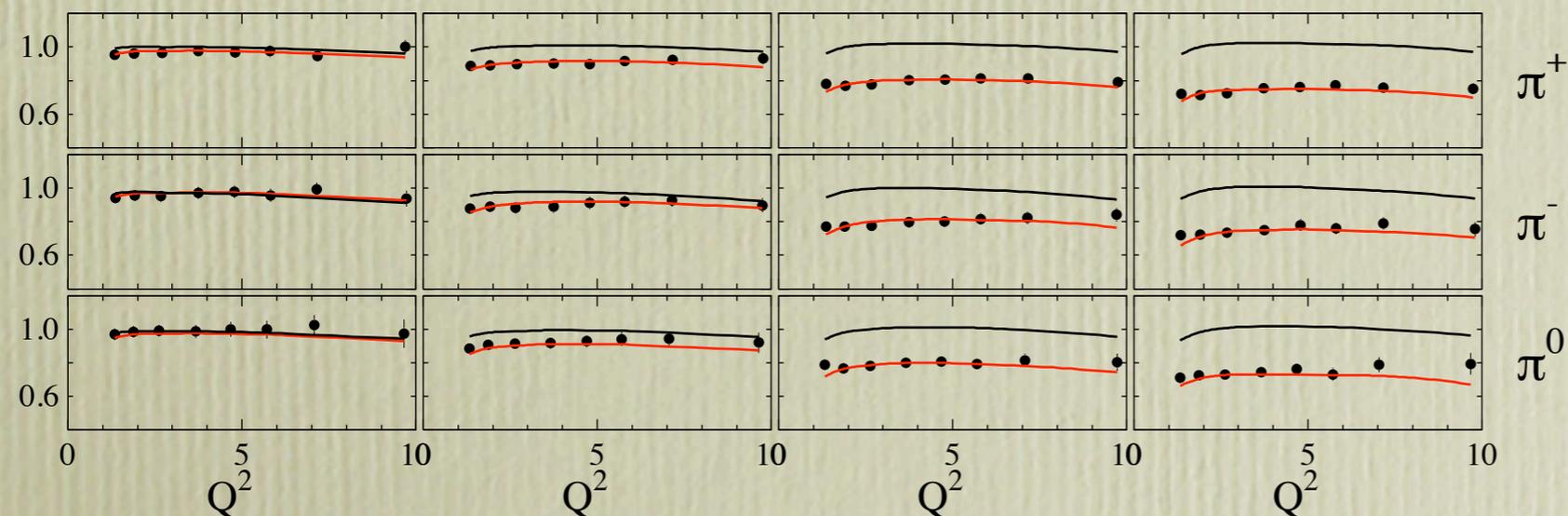
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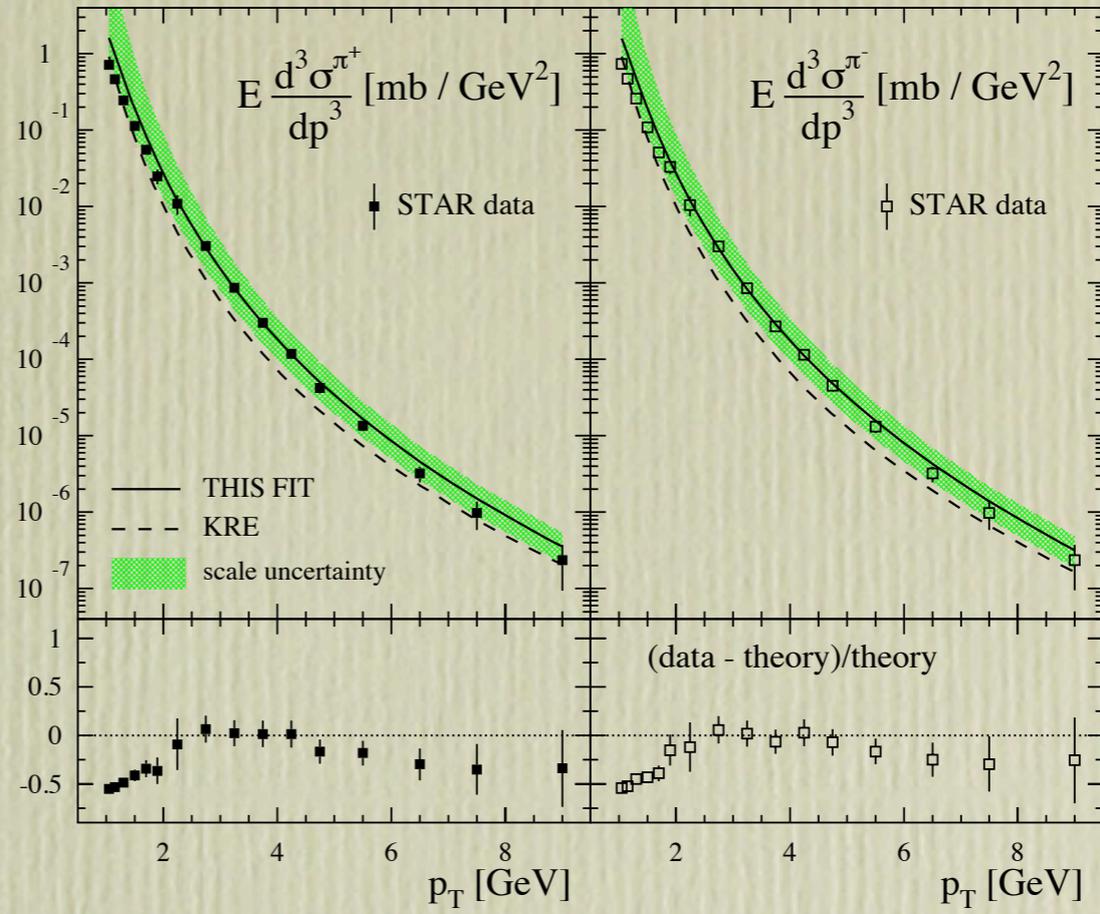
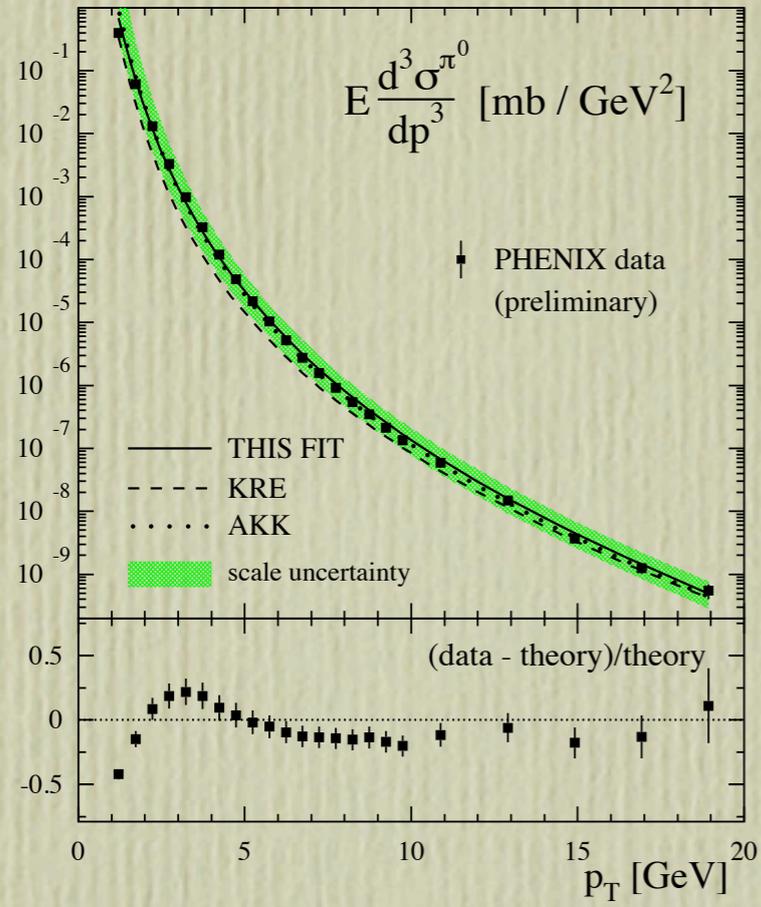
x (or v)-dependence reproduced



no conflict with standard evolution?

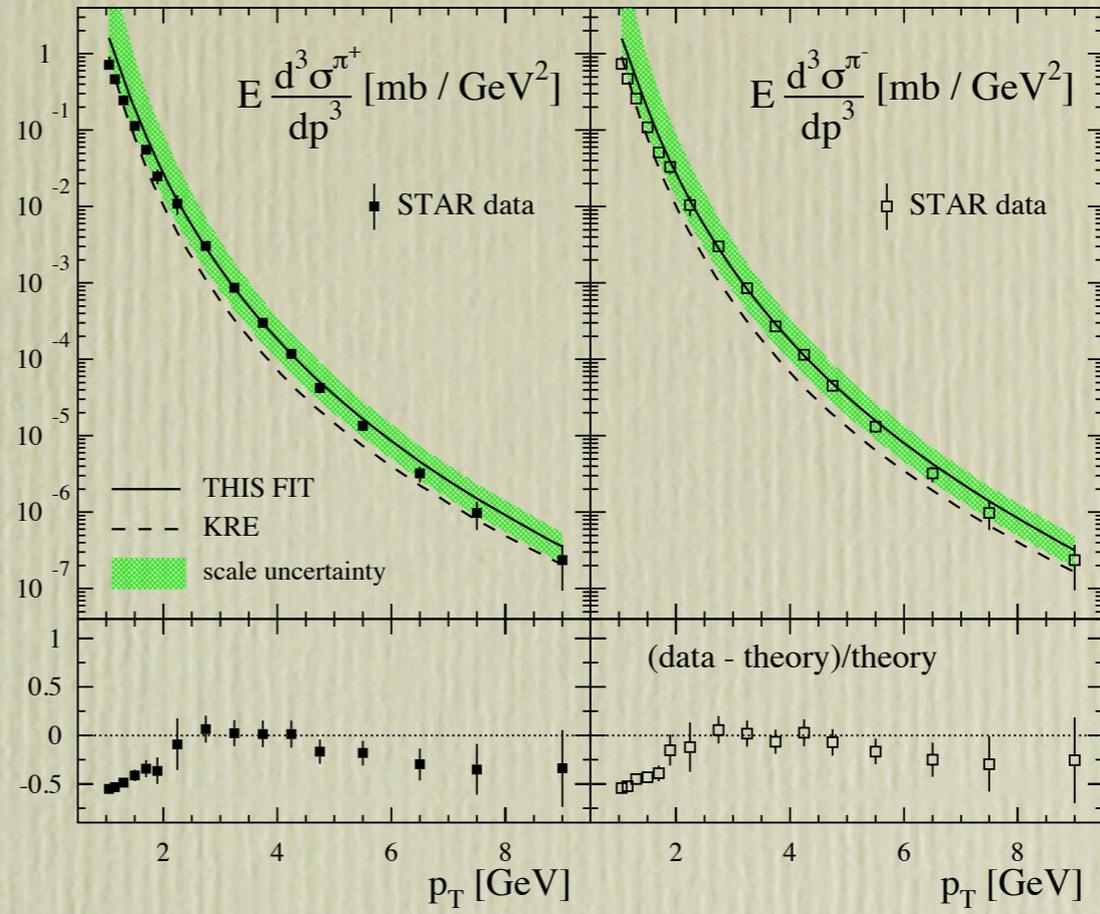
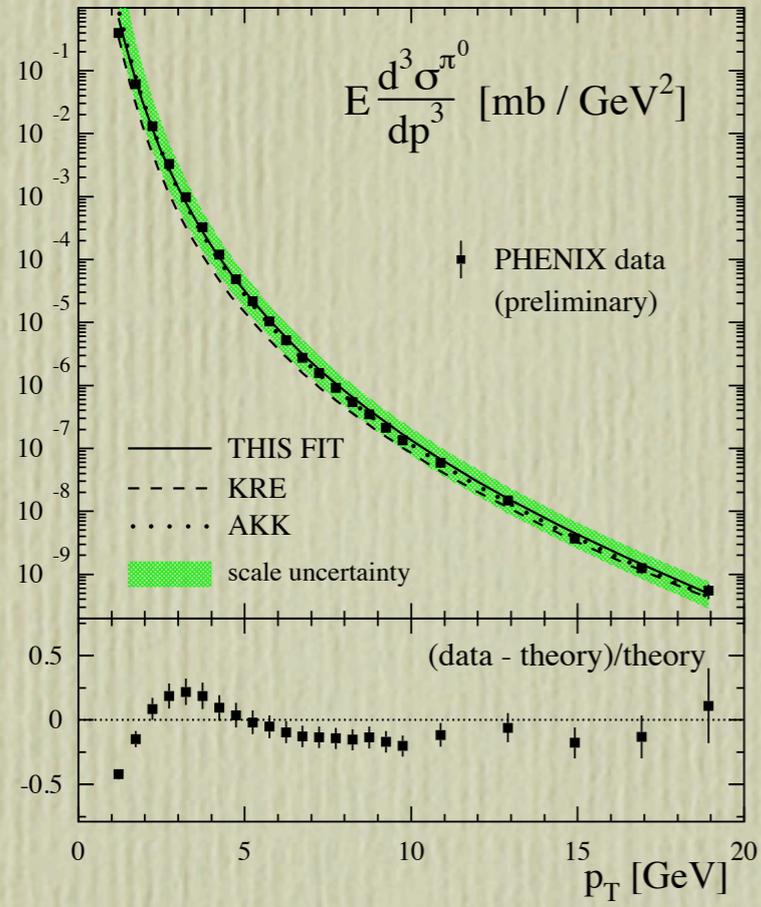
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pp



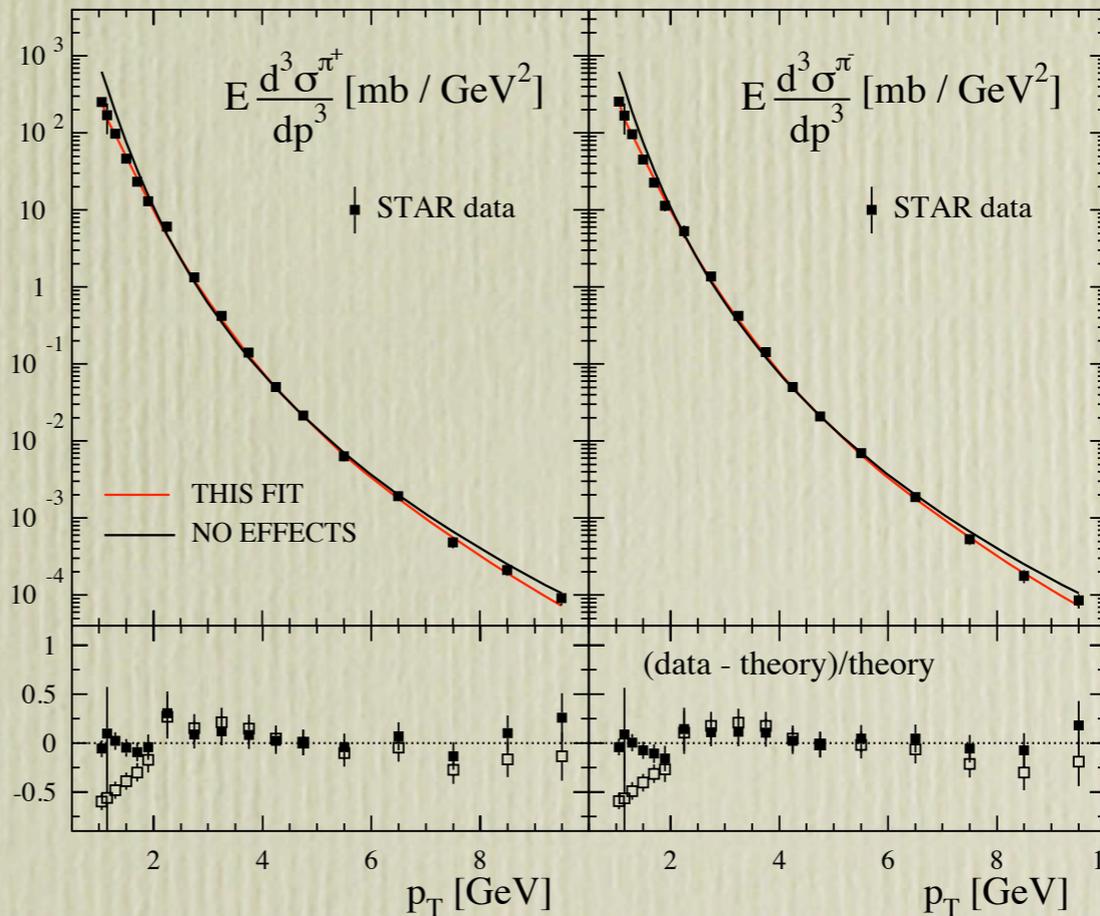
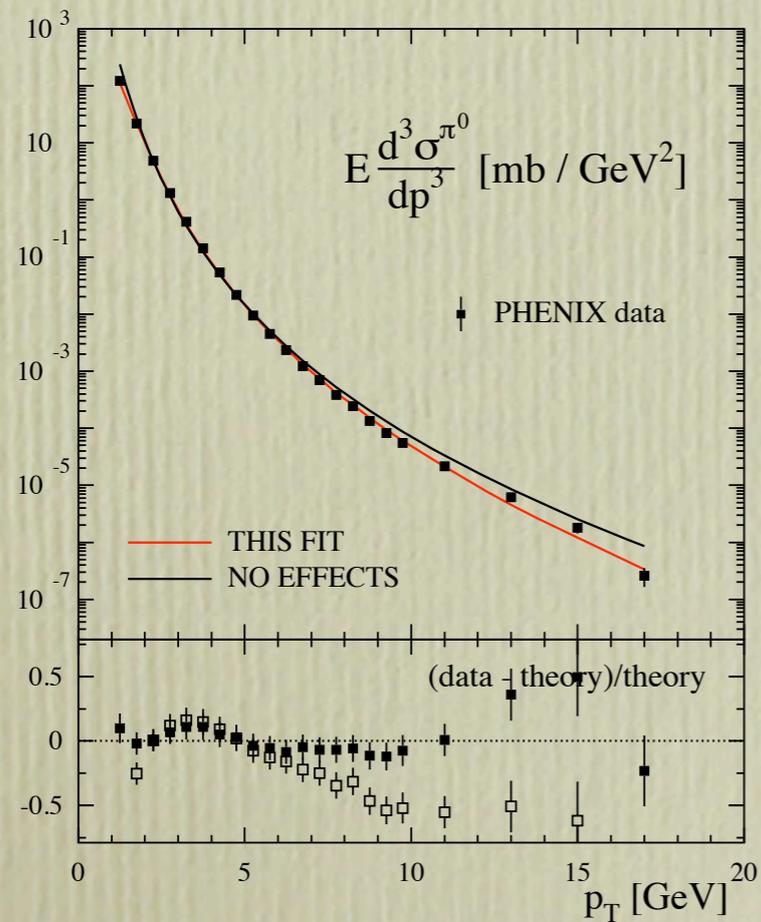
DSS FFs D. de Florian, R.S, M. Stratmann Phys.Rev.D75 114010 (2007)
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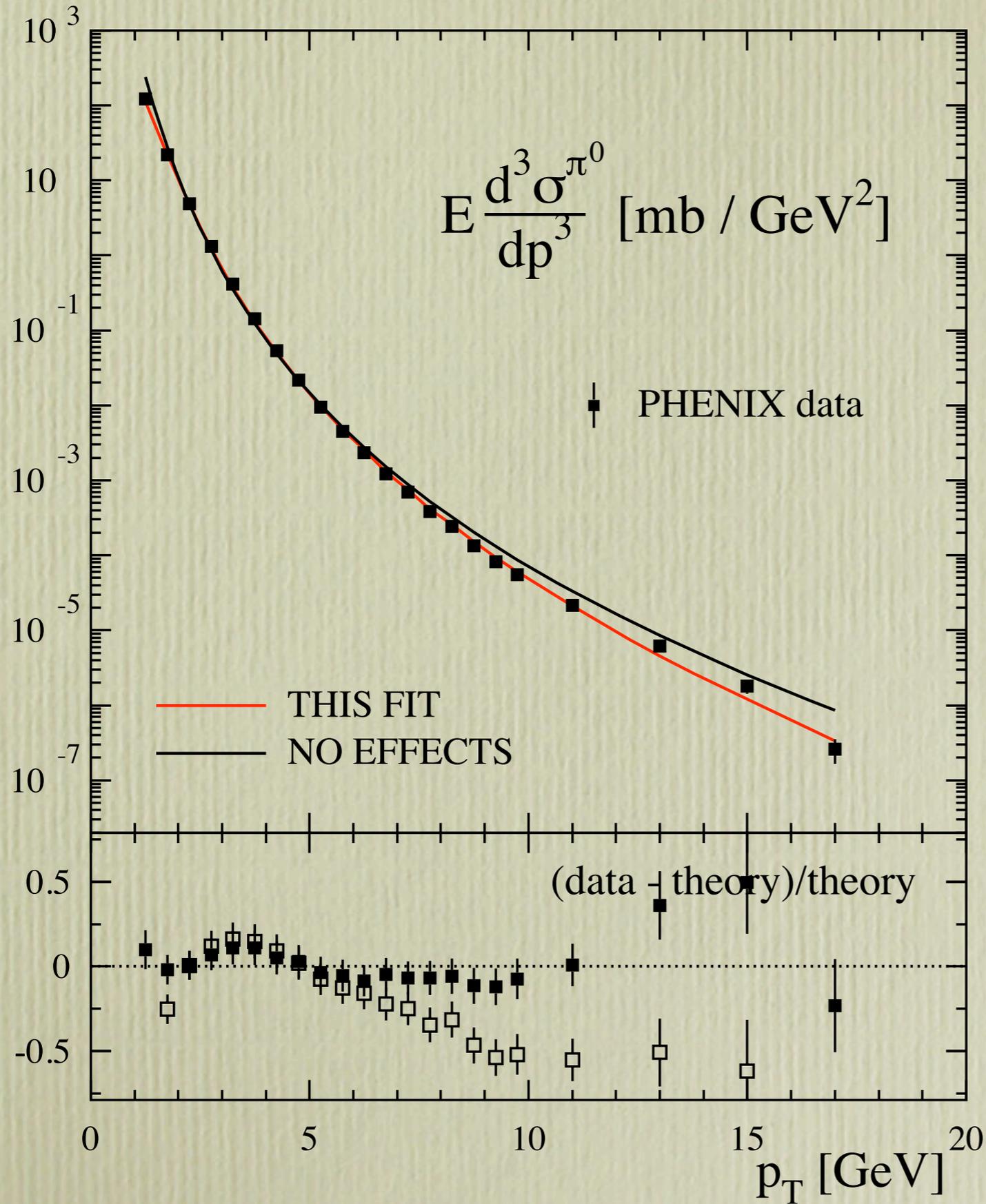
pp



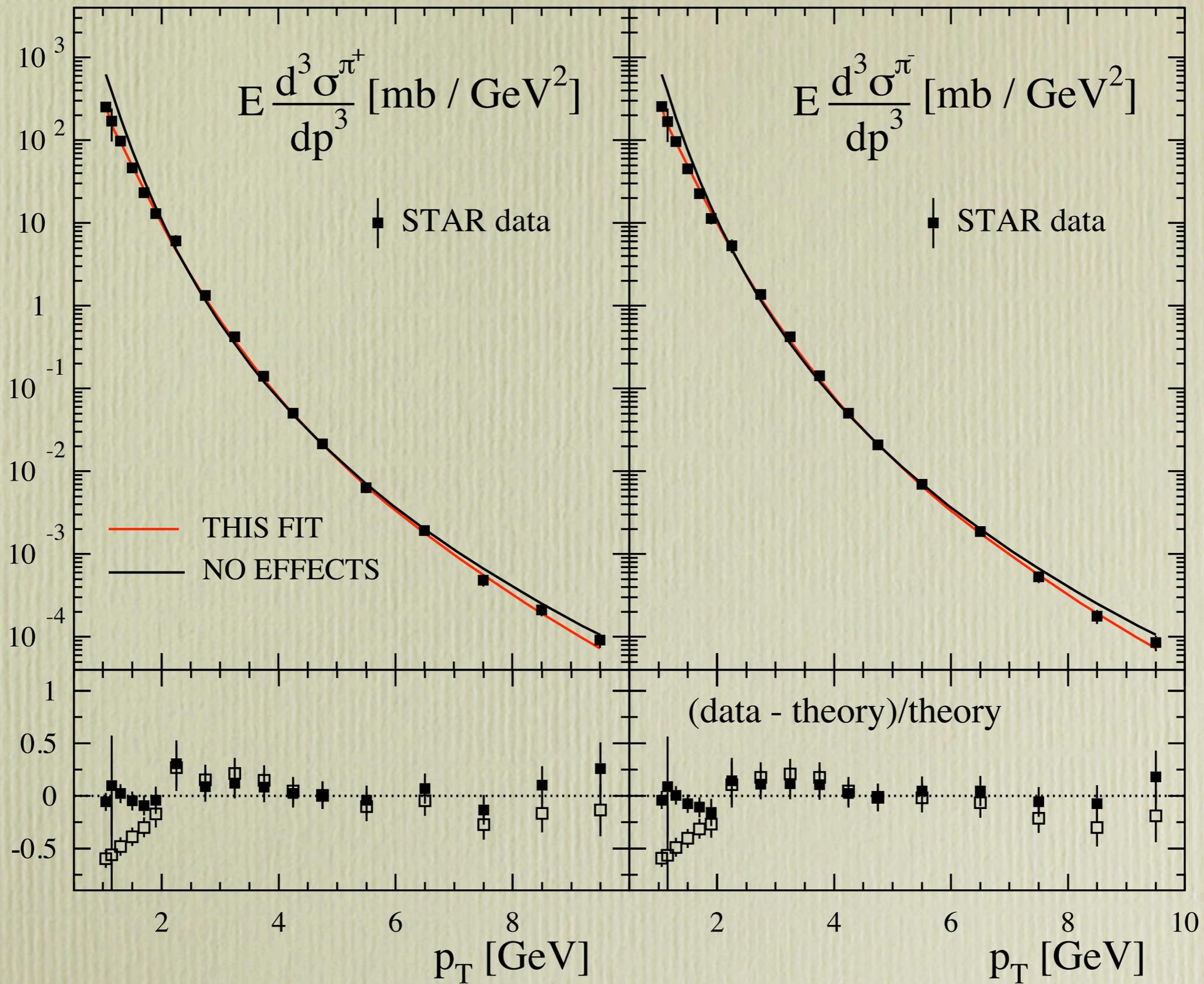
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dAu





$$\chi_{FIT}^2 = 16.49 \quad (273.30)$$



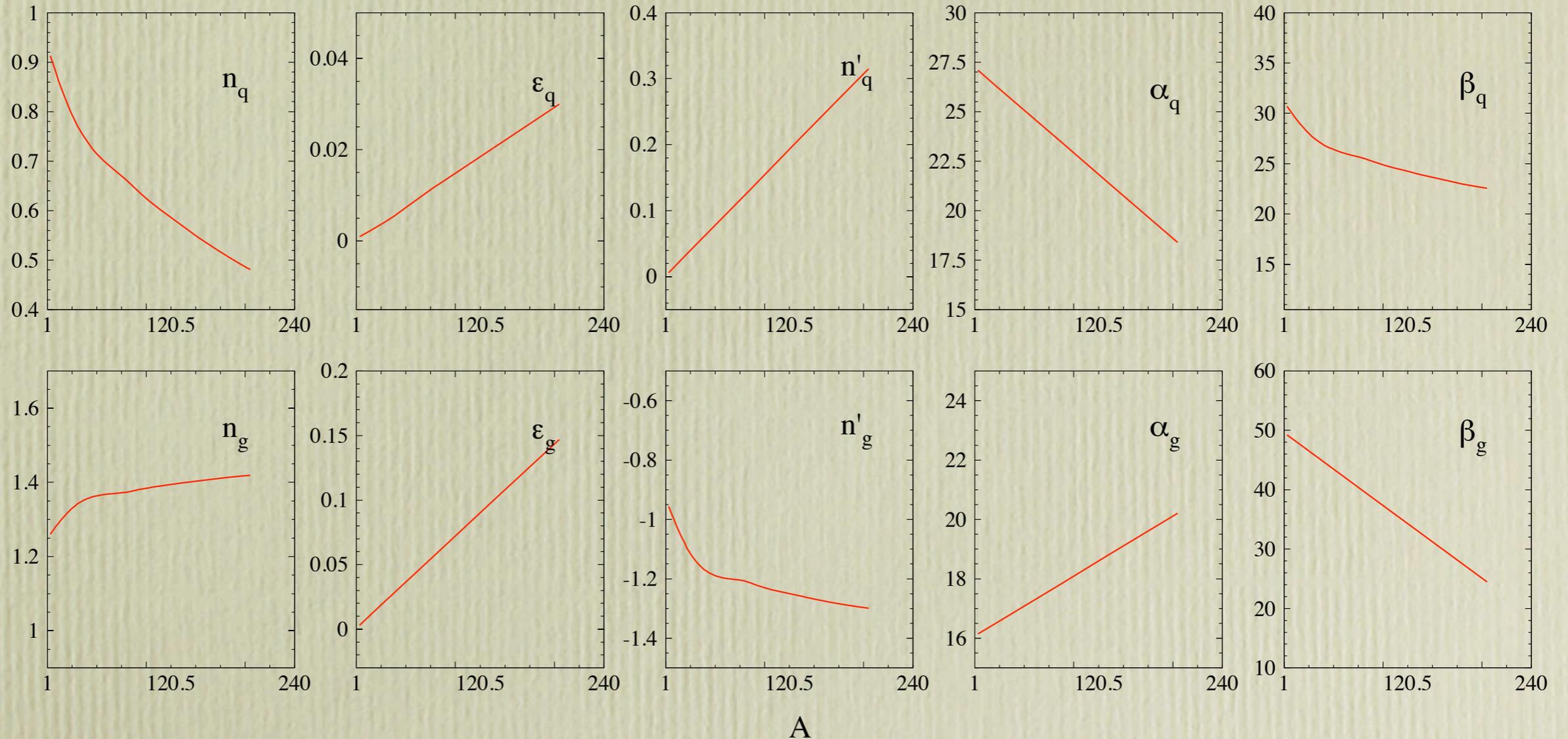
$$\chi_{FIT}^2 = 8.27 \quad (677.22)$$

$$\chi_{FIT}^2 = 7.07 \quad (485.97)$$

A-dependence

$$W_q(y, A, Q_0^2) = n_q \delta(1 - \epsilon_q - y) + n'_q y^{\alpha_q} (1 - y)^{\beta_q}$$

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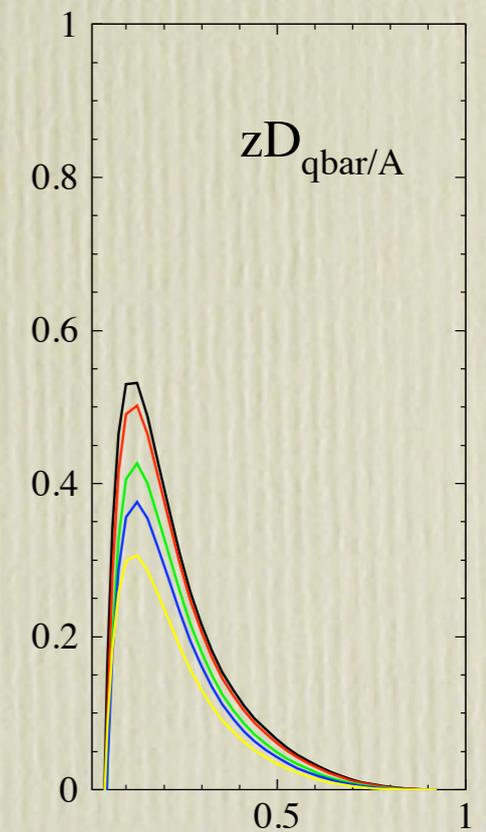
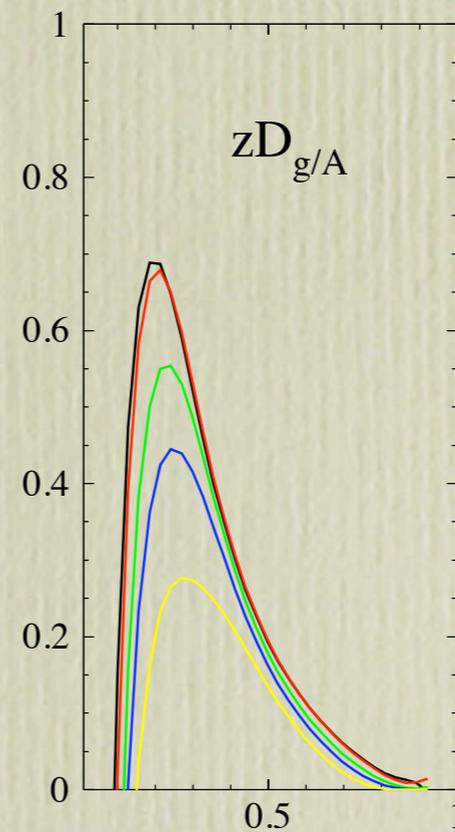
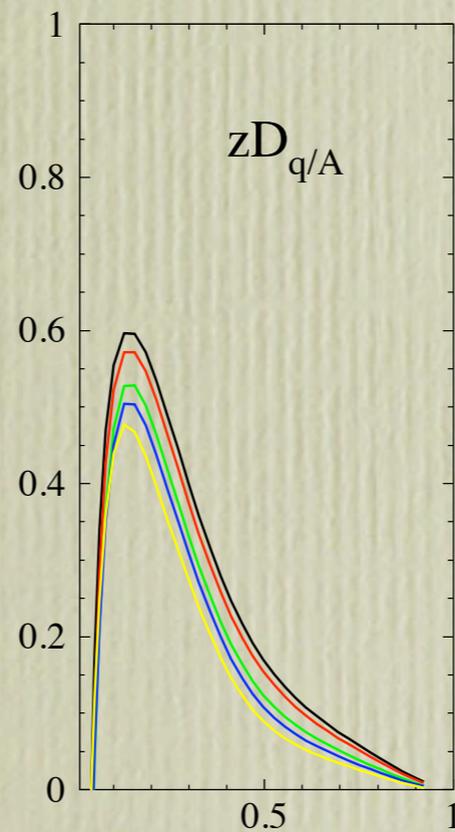
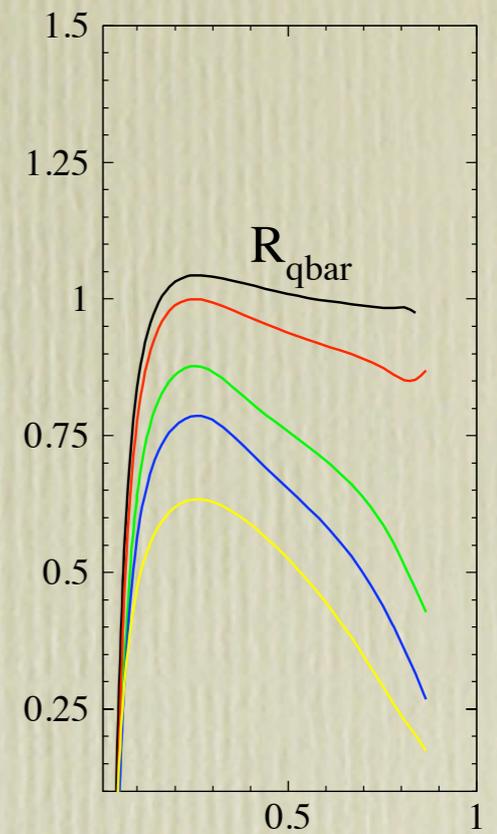
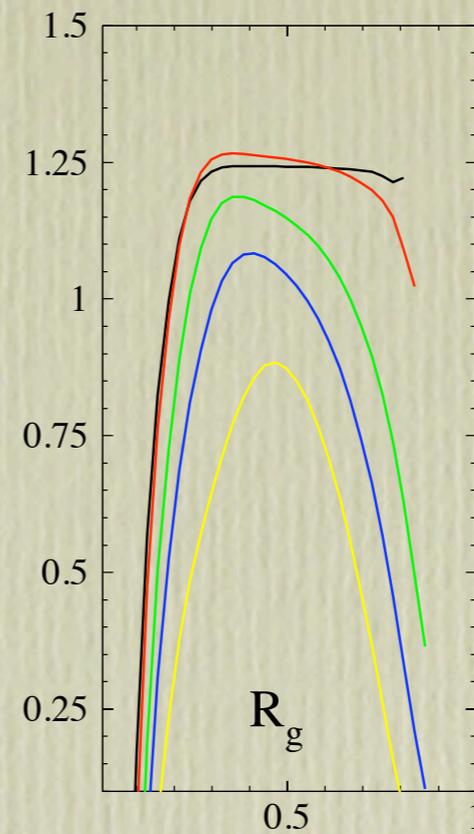
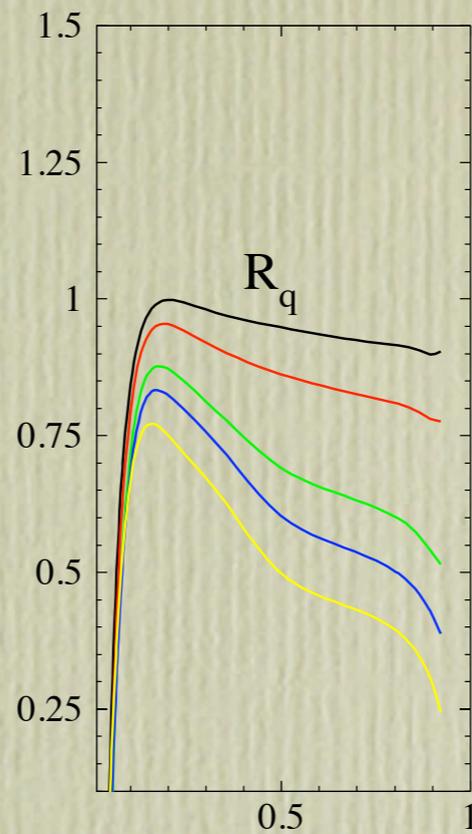
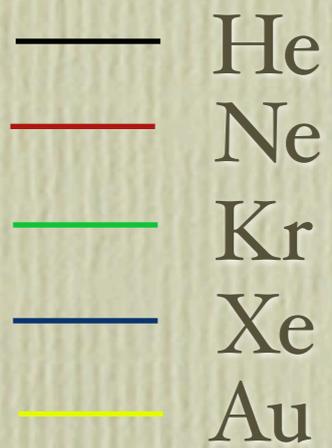


A	n_q	ϵ_q	n'_q	α_q	β_q	n_g	ϵ_g	n'_g	α_g	β_g
He	0.913	0.001	0.006	27.095	30.711	1.260	0.003	-0.956	16.142	49.243
Ne	0.818	0.003	0.032	26.374	28.534	1.317	0.015	-1.085	16.480	47.190
Kr	0.649	0.013	0.134	23.490	25.317	1.377	0.063	-1.215	17.830	38.979
Ze	0.570	0.020	0.210	21.372	23.967	1.398	0.098	-1.258	18.822	32.949
Au	0.481	0.030	0.315	18.398	22.538	1.419	0.147	-1.299	20.214	24.481

z -dependence

$$R_q = \frac{D_{q/A}(z, Q^2)}{D_{q/p}(z, Q^2)}$$

$$Q^2 = 10 \text{ GeV}^2$$



does it work for p/\bar{p} or for kaons?

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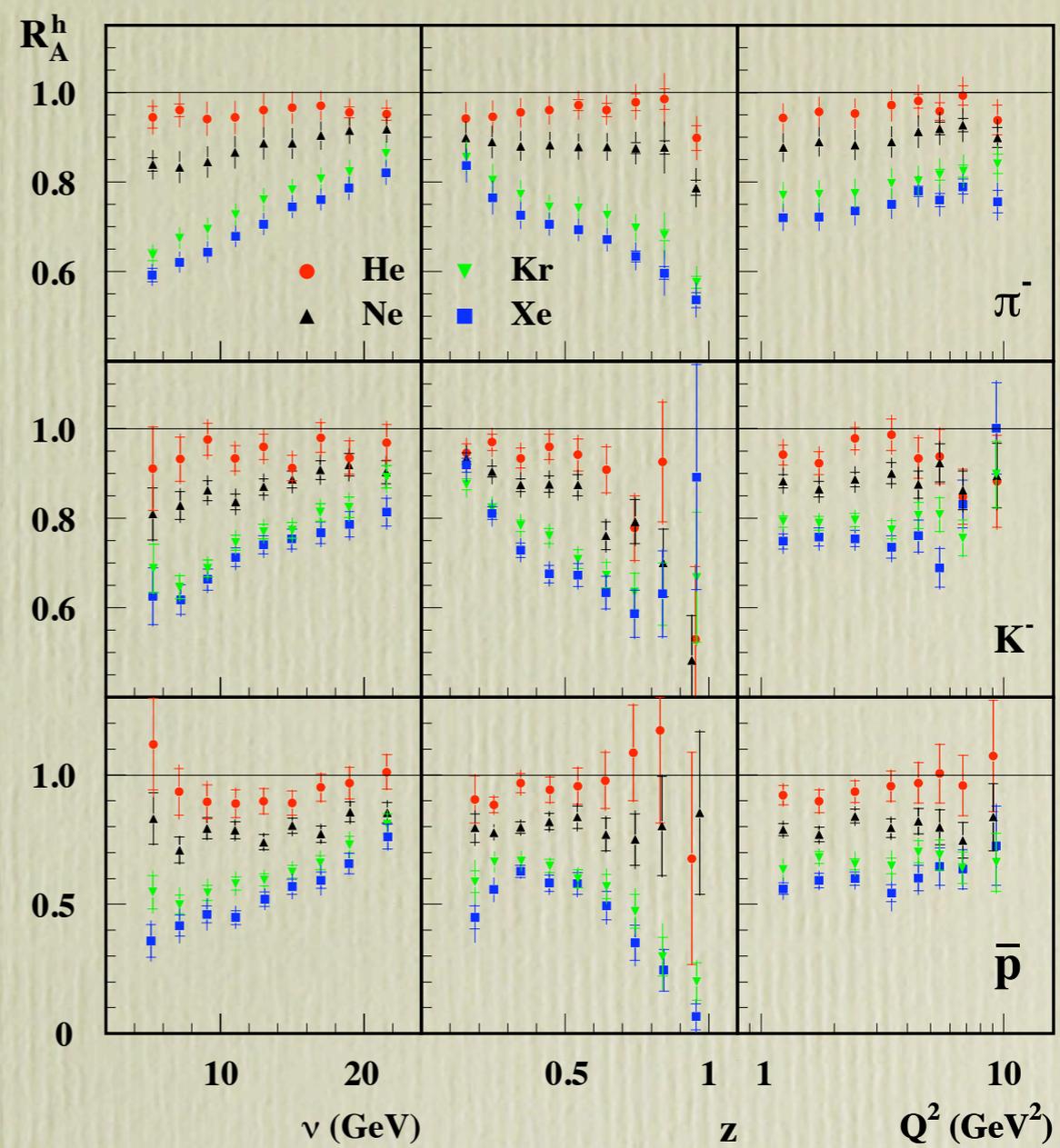
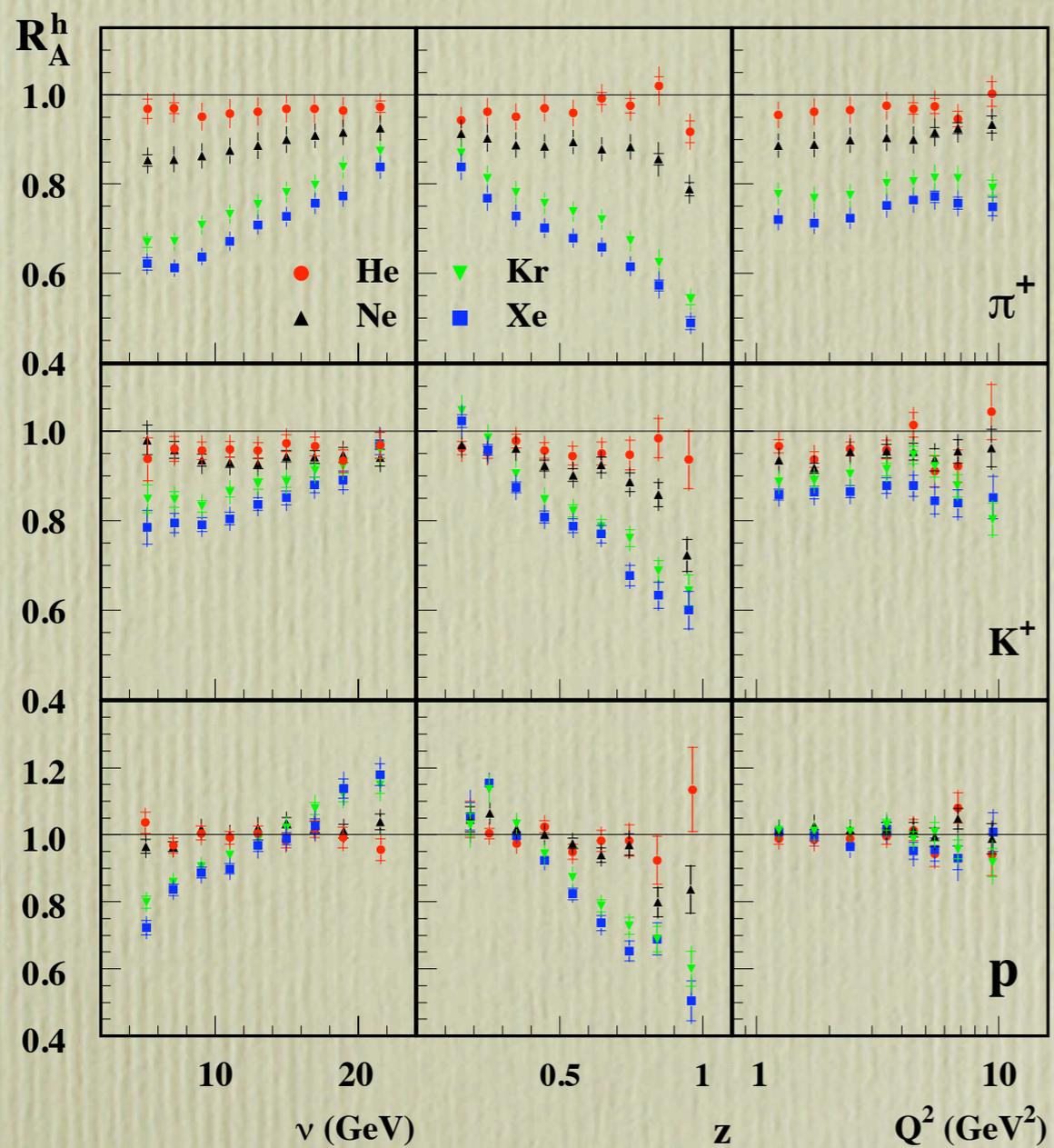
yes, but...

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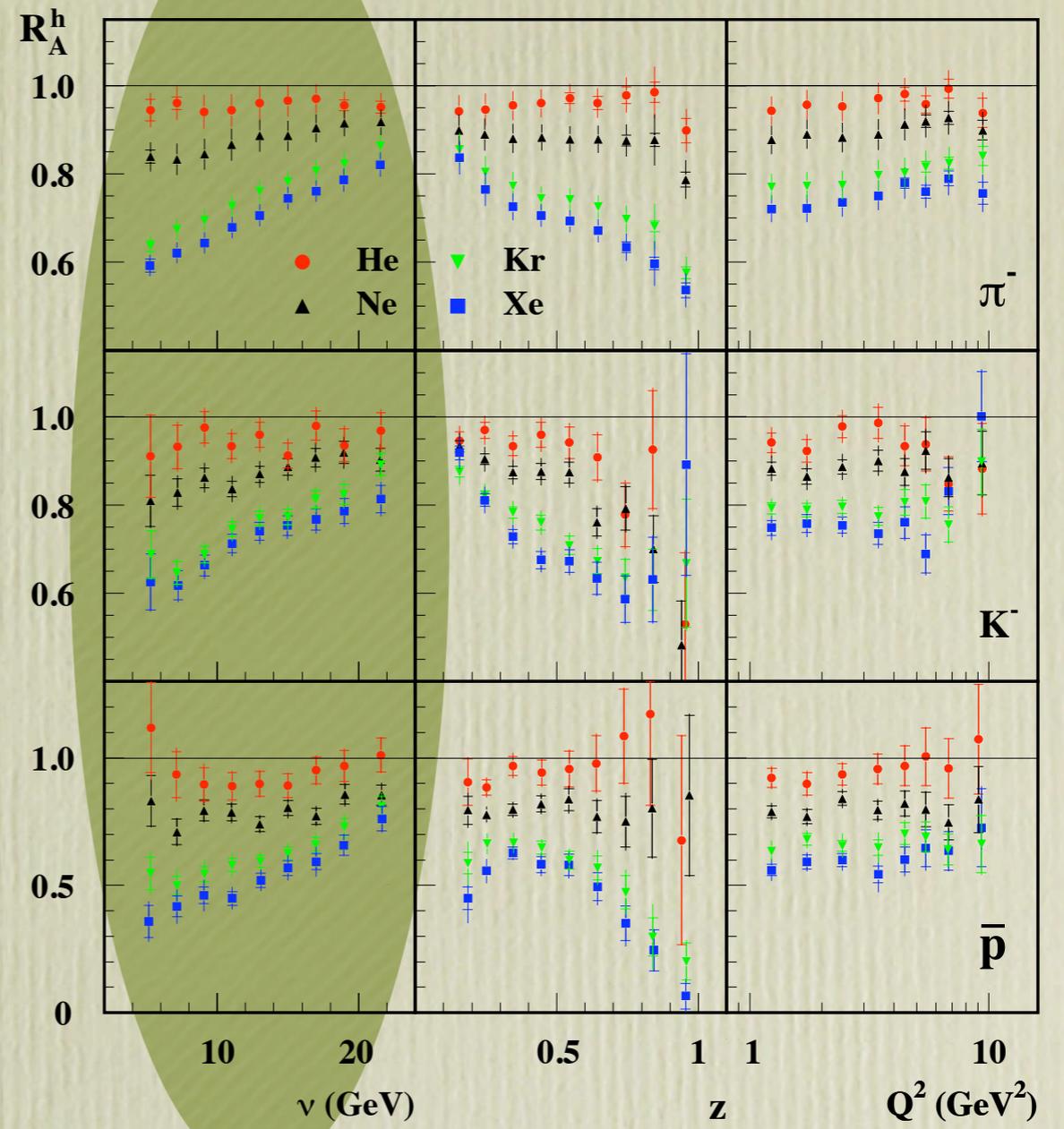
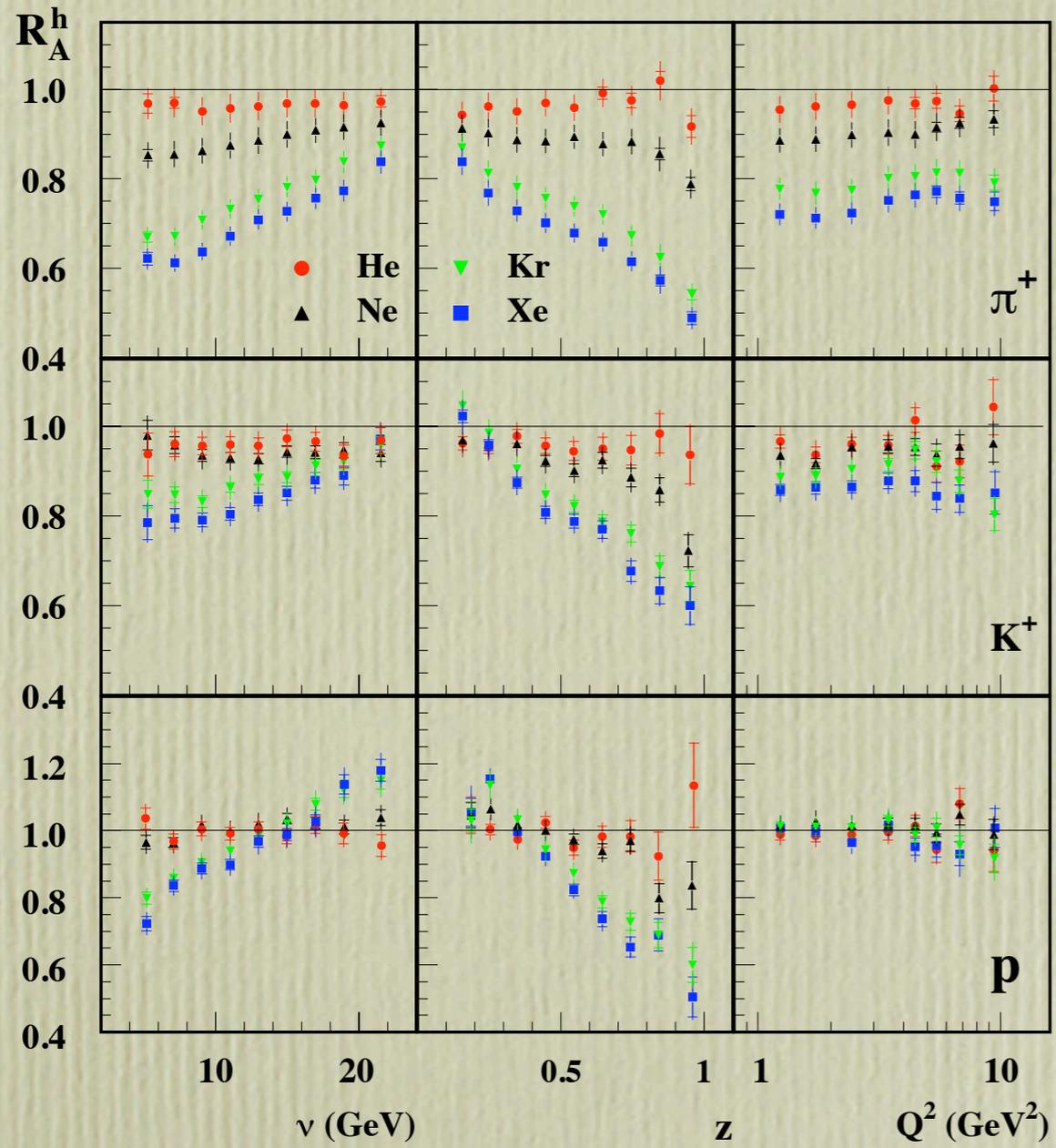
p/\bar{p}

different behavior p/\bar{p}

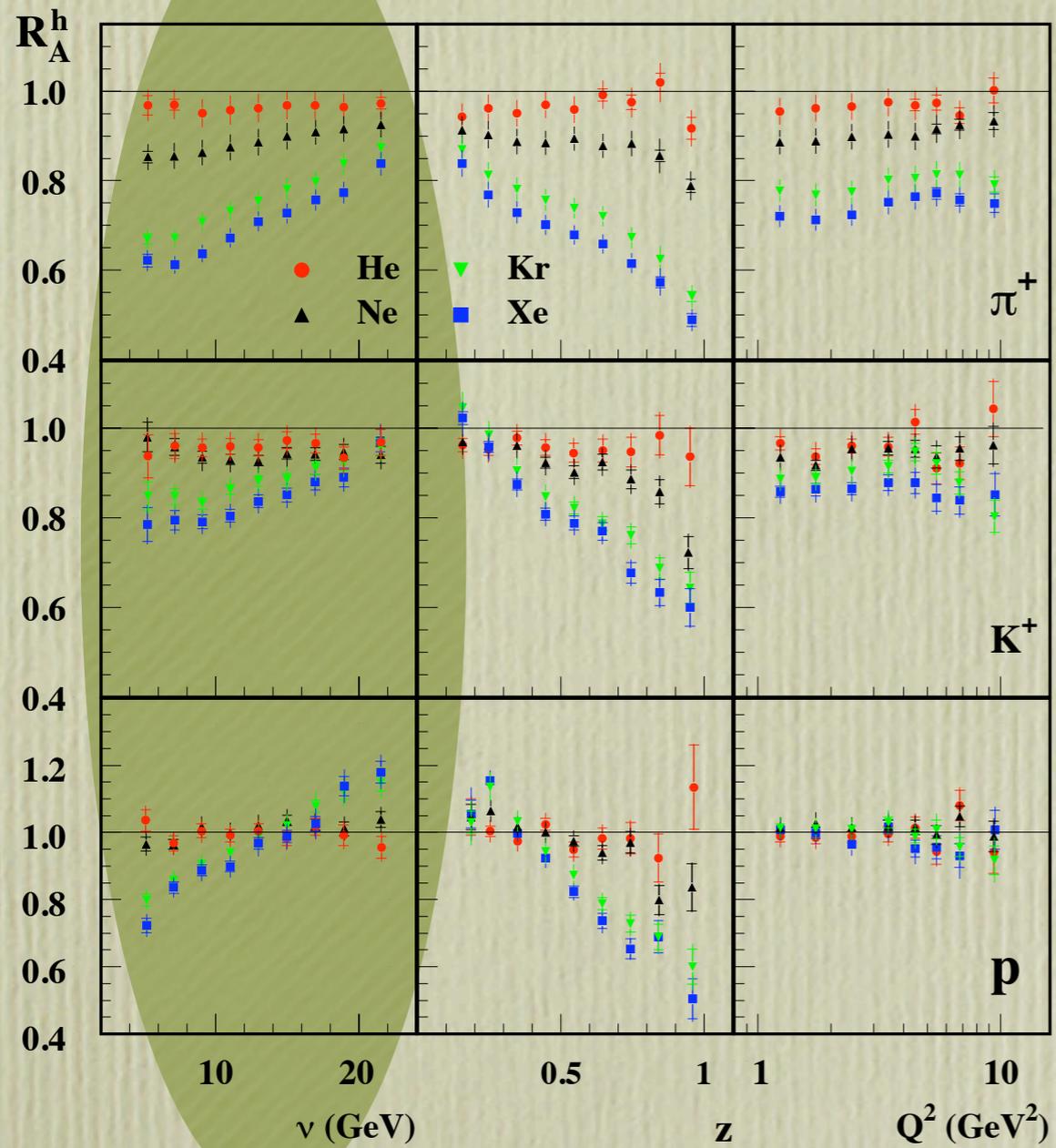


\bar{p} π^- K^-

Hermes Collab. Nucl.Phys.B780:1-27,2007.

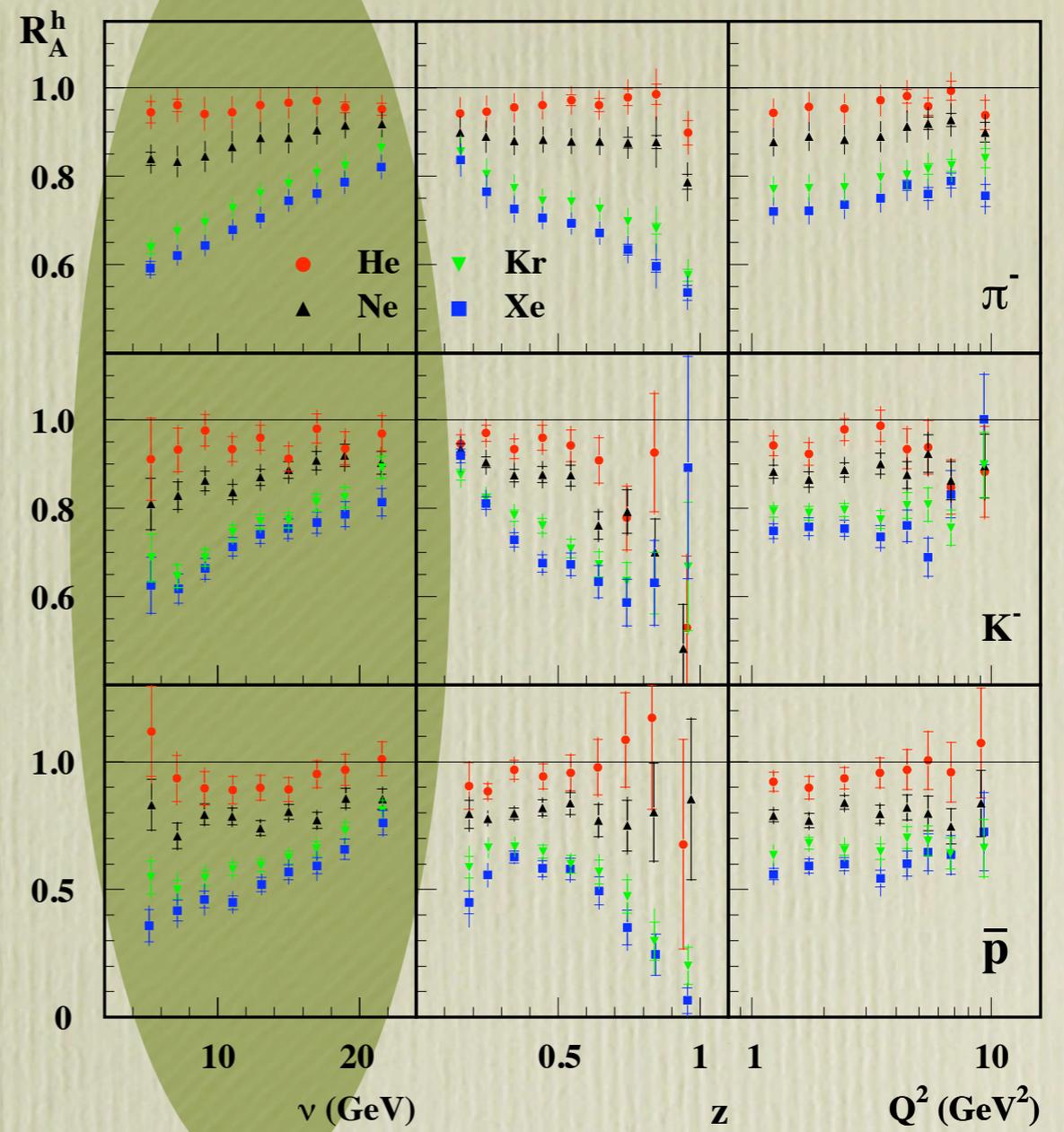


p π^+ K^+



\bar{p} π^- K^-

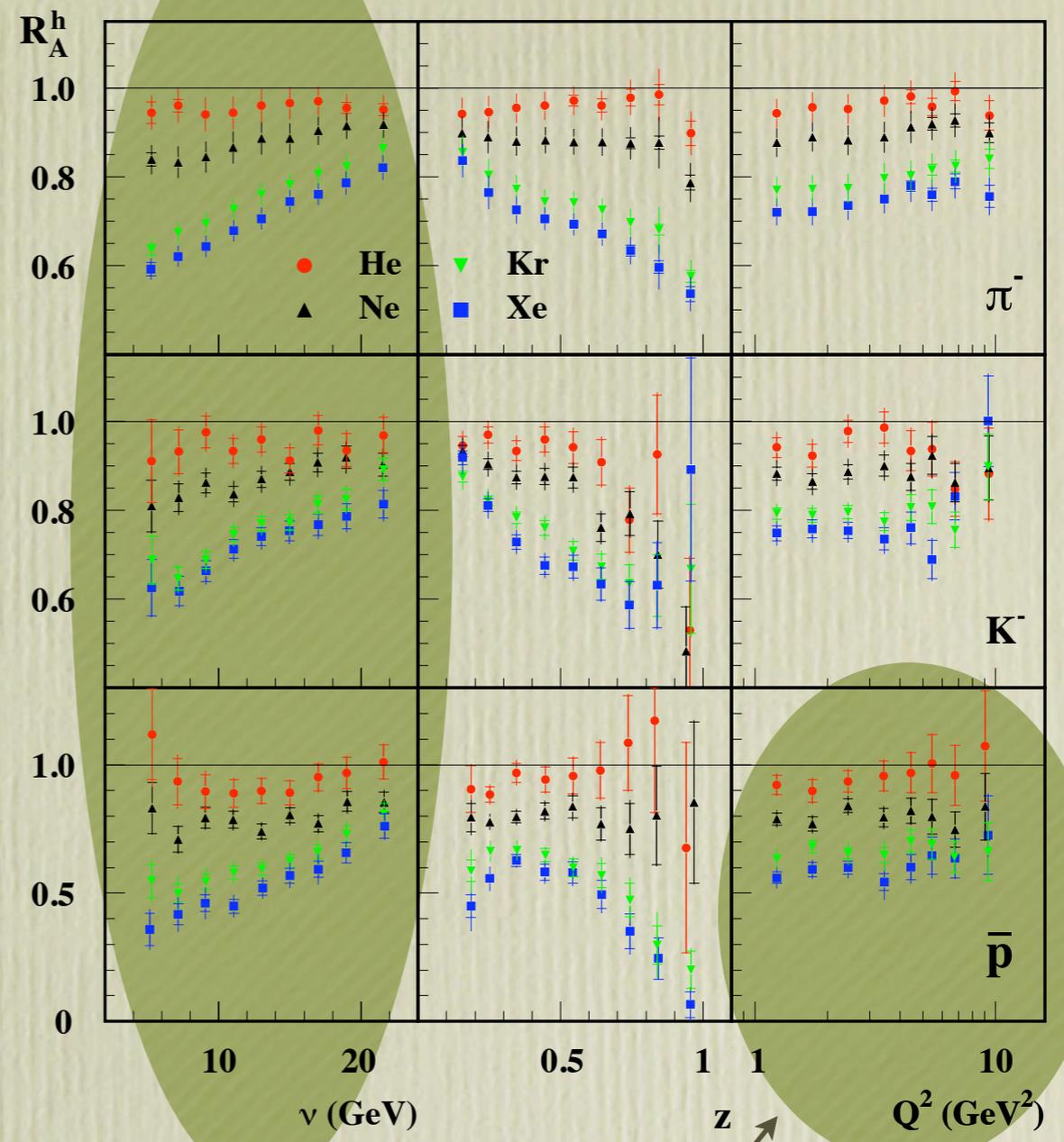
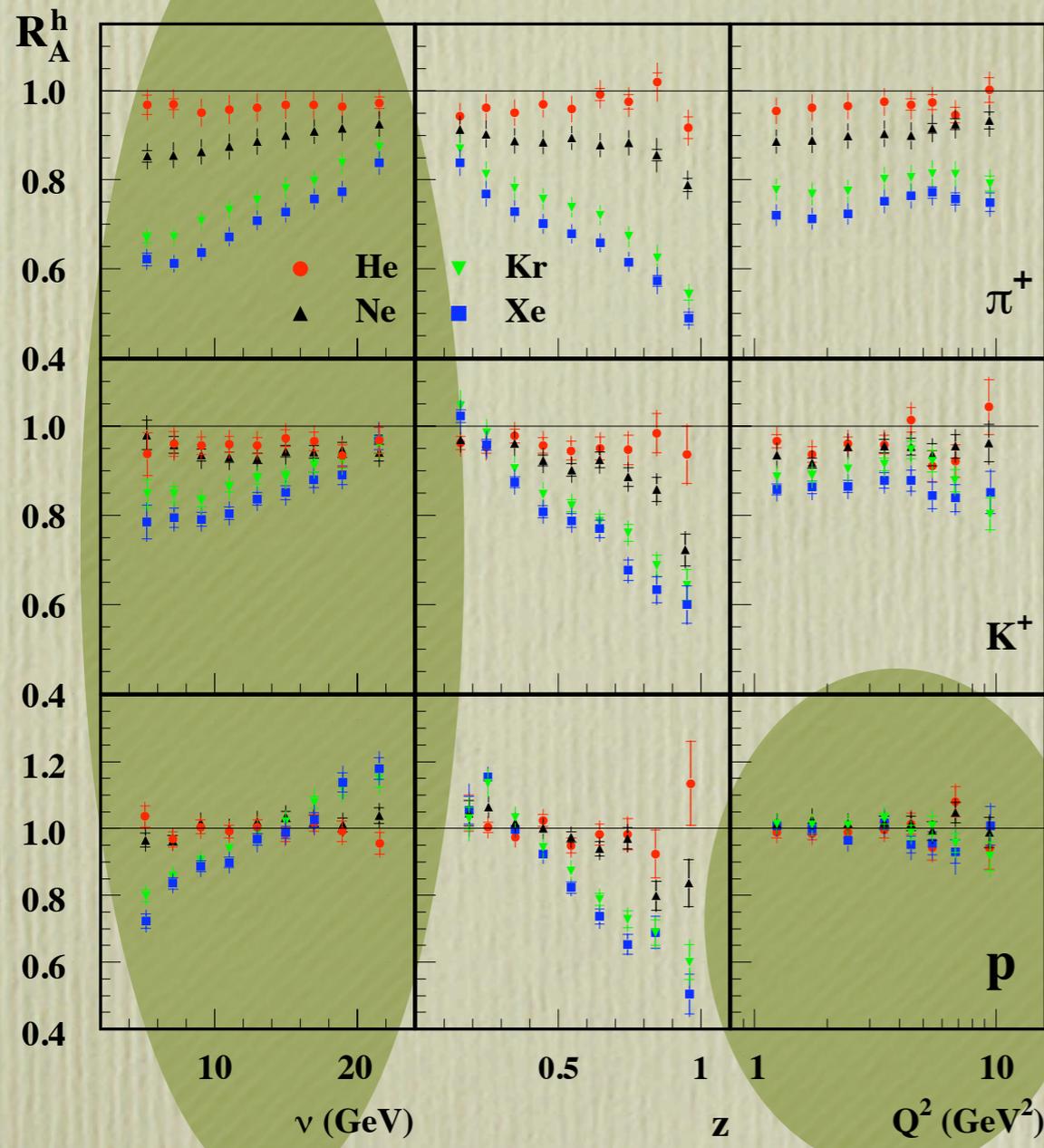
Hermes Collab. Nucl.Phys.B780:1-27,2007.



p π^+ K^+

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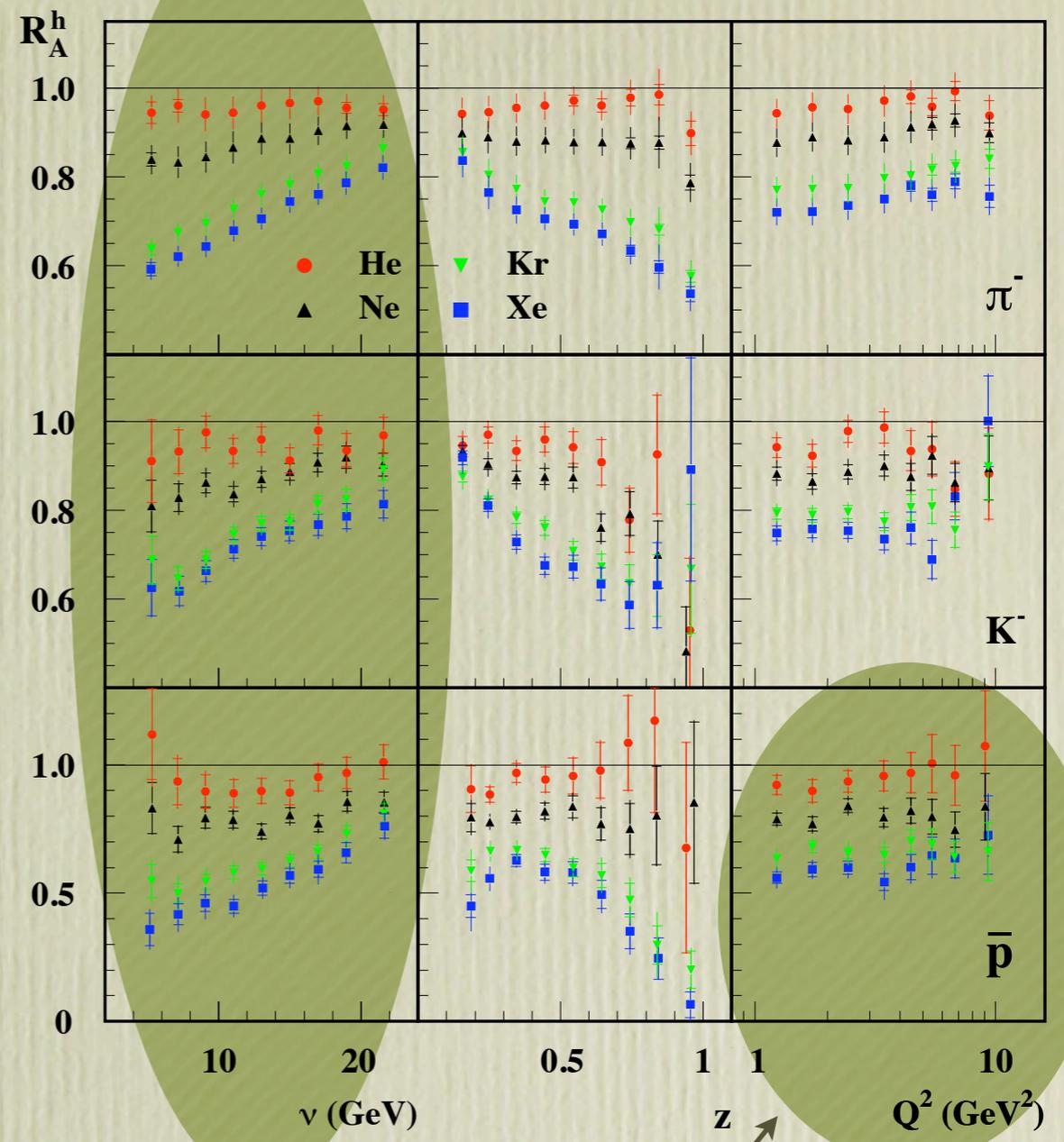
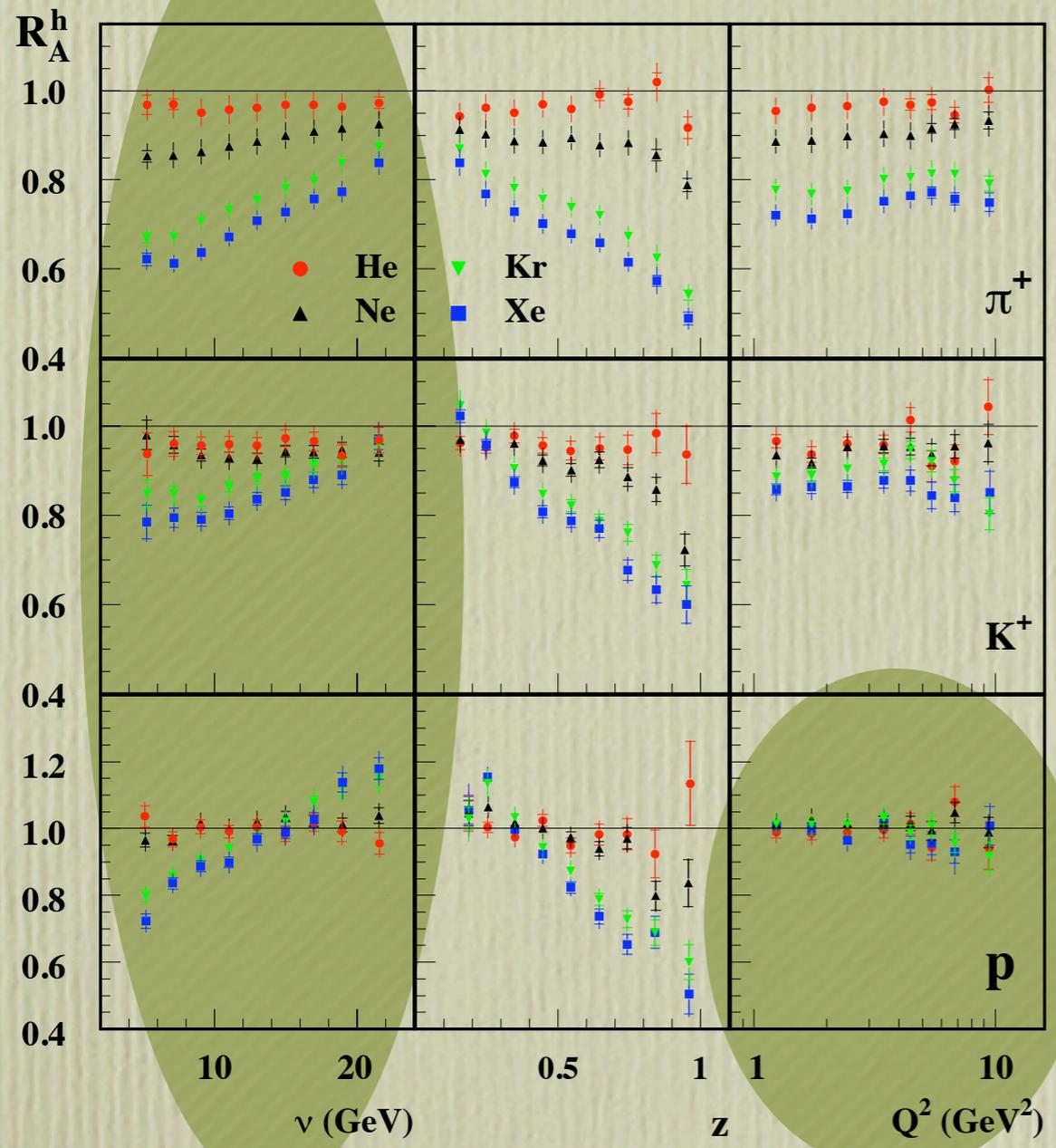


different
 A -dependence

$p \quad \pi^+ \quad K^+$

$\bar{p} \quad \pi^- \quad K^-$

Hermes Collab. Nucl.Phys.B780:1-27,2007.



$W_q^{p/\bar{p}}, W_{\bar{q}}^{p/\bar{p}}, W_g^{p/\bar{p}} \rightarrow \chi^2/d.o.f. \sim 1.5$

different A-dependence

does it work for p/\bar{p} or for kaons?

yes, but...

p/\bar{p}

different behavior p/\bar{p}

larger uncertainties in vacuum FFs

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kaons

larger uncertainties in FFs
only preliminary dAu data

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data reproduced in a **factorizable** scheme with **effective nFF**

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z, Q^2 and ν -dependence of data

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sensitivity to quark/antiquark fragmentation?

iGracias!

Backups