EMC effect and jet energy loss in dAu collisions at RHIC

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Outline

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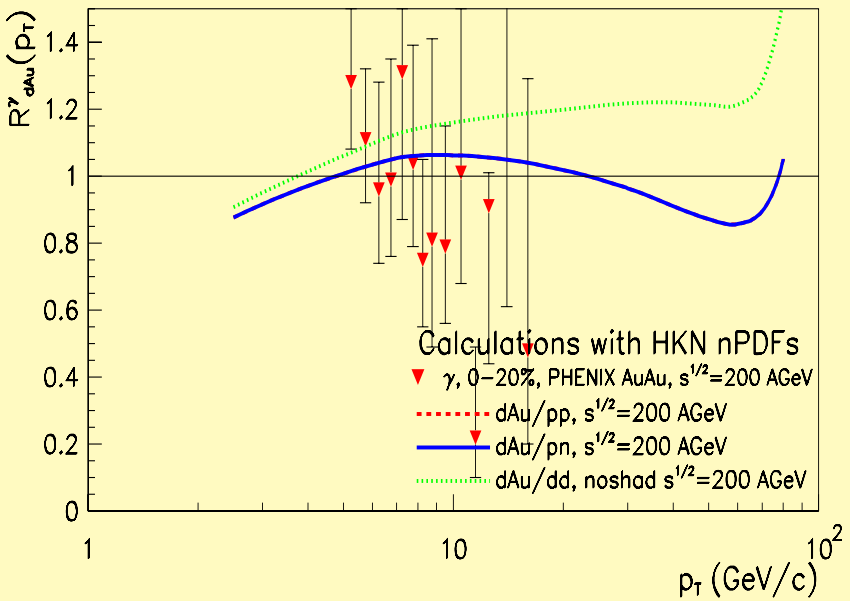
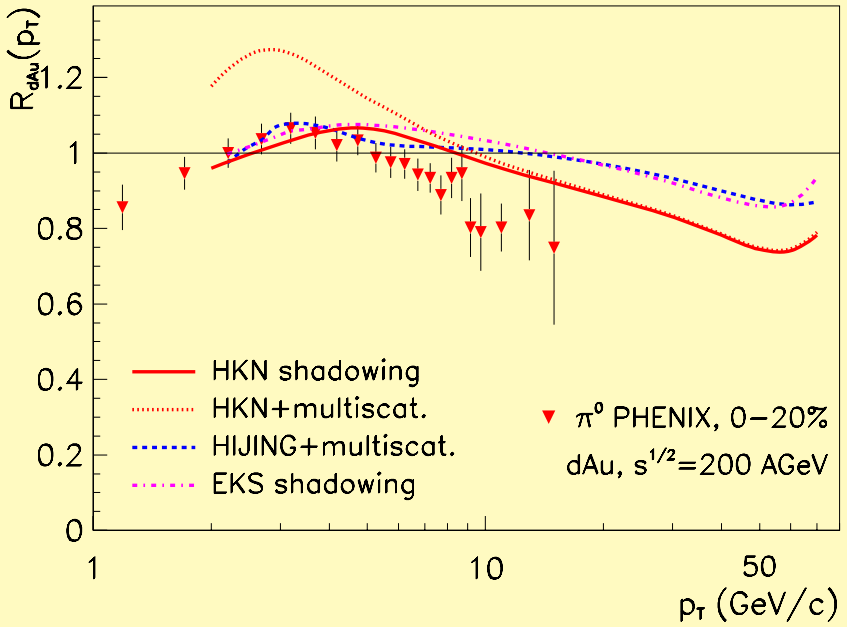
γ and π^0 production at high p_T dAu

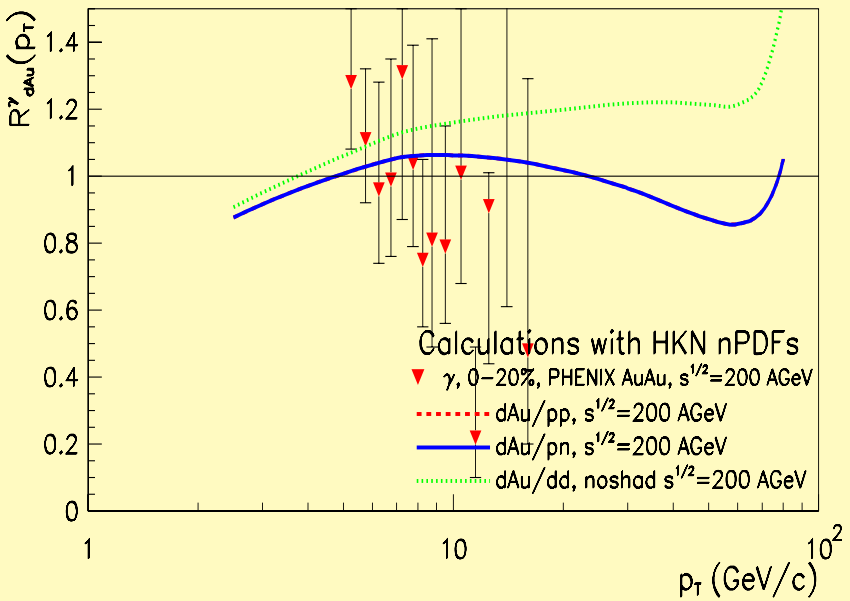


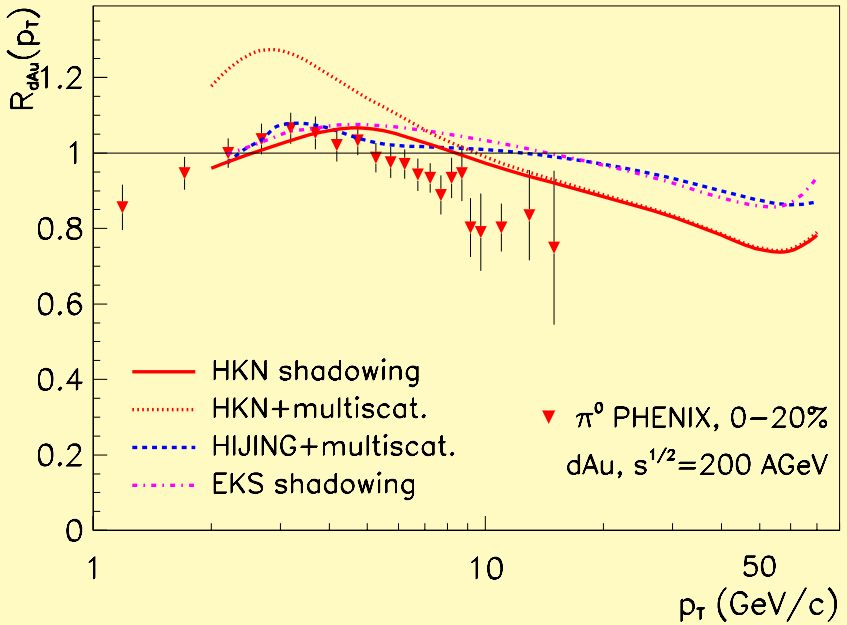


Observation

π^0, γ production in dAu are suppressed at RHIC high p_T.
What is the reason for it?
Does it survive at LHC?

γ and π^0 production at high p_T dAu





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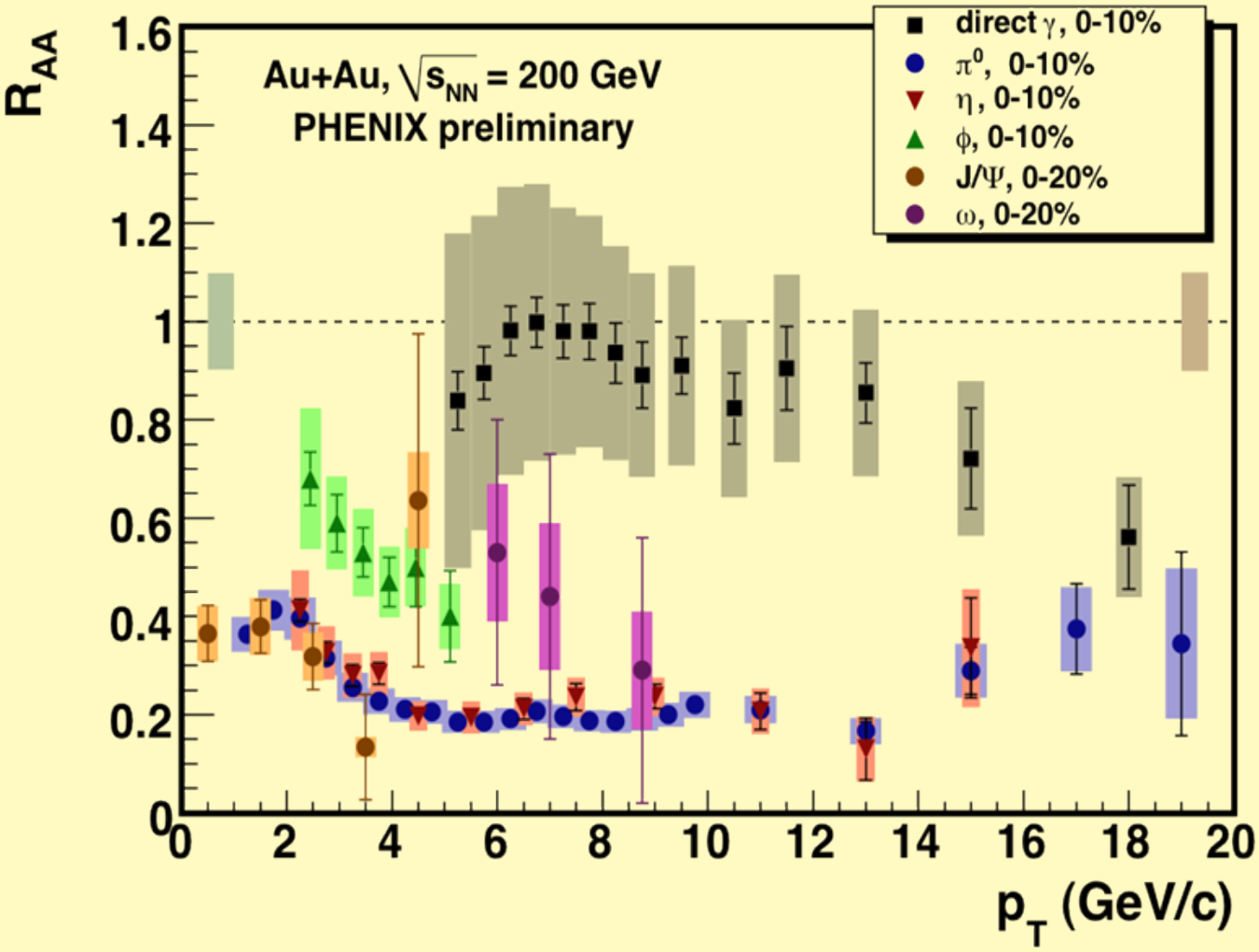
γ production at high p_T AuAu



Suppression appears even in AuAu γ production (no jet quenching ...)

PRL 94, 232301 (2005) + Run 4 (QM06)

Outline

Factorization

$$E_\pi \frac{\mathrm{d}\sigma_\pi^{dAu}}{\mathrm{d}^3 p_\pi} = f_{a/d}(x_a, Q^2; \mathbf{k}_{Ta}) \otimes f_{b/Au}(x_b, Q^2; \mathbf{k}_{Tb}) \otimes \frac{\mathrm{d}\sigma^{ab\to cd}}{\mathrm{d}\hat{t}} \otimes \frac{D_{\pi/c}(z_c, \hat{Q}^2)}{\pi z_c^2}$$

Notation

$f_{a/A}(x_a, Q^2; \mathbf{k}_{Ta})$ Particle Distribution Function

$D_{\pi/c}(z_c, \hat{Q}^2)$ Fragmentation Function

Calculation: integradients

Components

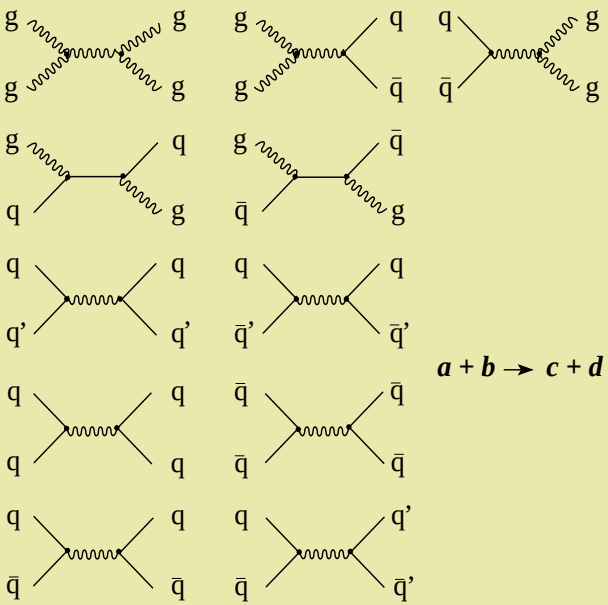
$f_{a/A}(x_a, Q^2; \mathbf{k}_{Ta})$ Evolution is governed by AP equations (in Q), the shape at given Q is determined from experiment.

$D_{\pi/c}(z_c, \hat{Q}^2)$ Determined from experiment

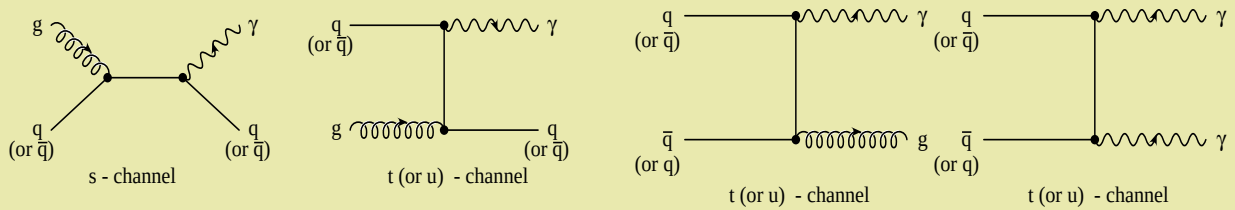
$\frac{d\sigma^{ab\to cd}}{d\hat{t}}$ pQCD cross section (quarks, gluons): fully controlled by theory.

Calculation: cross section

Partonic channels for π^0

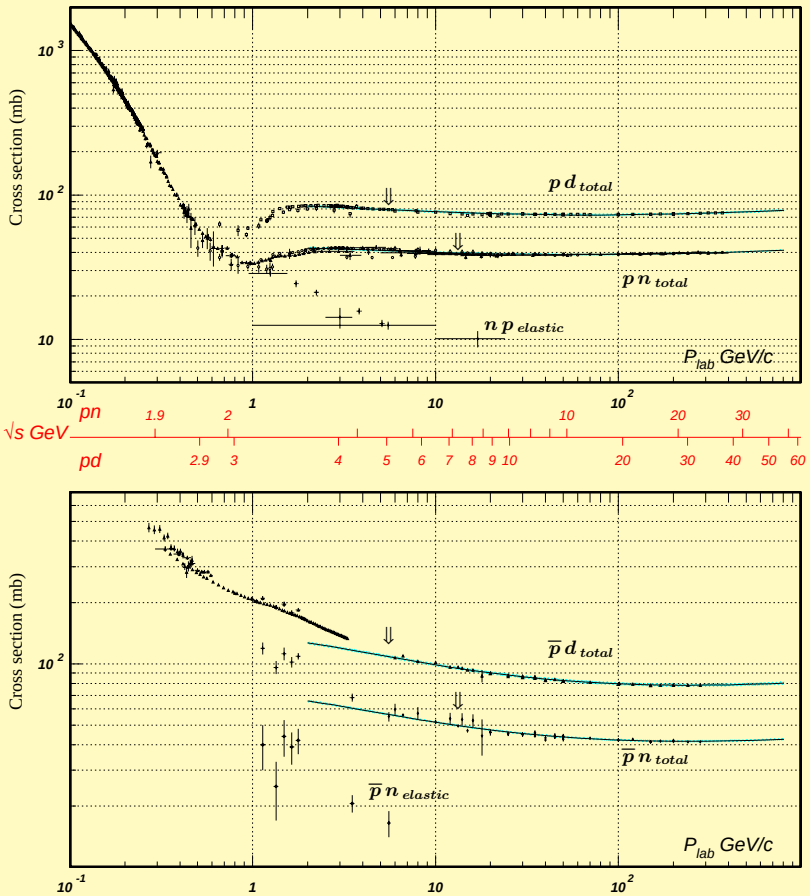


Partonic channels for γ



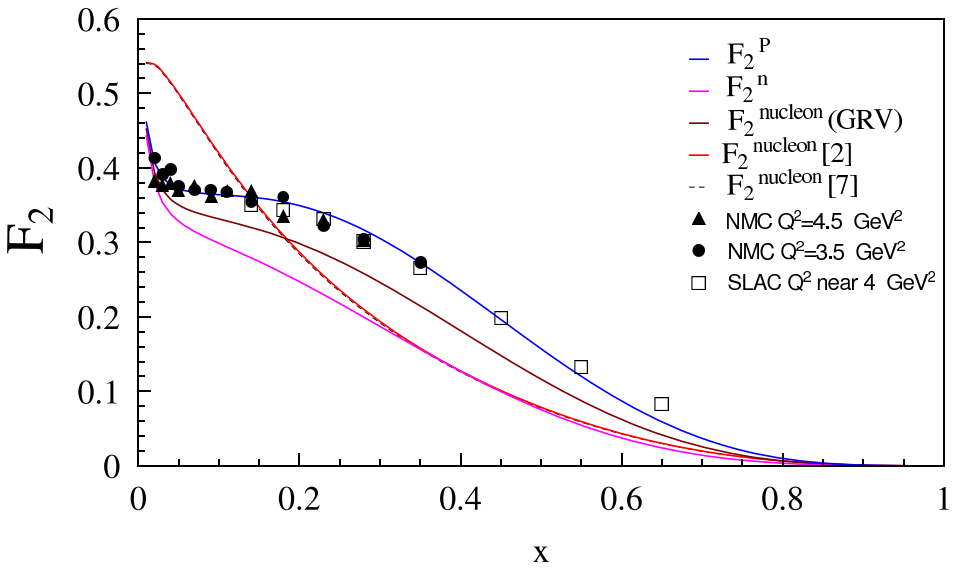
Outline

Isospin effect: cross section



- There is a difference in *pp* and *nn* cross sections ($\sqrt{s}$ dependent) reduces R_{dAu}.
- However, the effect is small, less, than the measured suppression (furthermore, there is no data for this region available) .

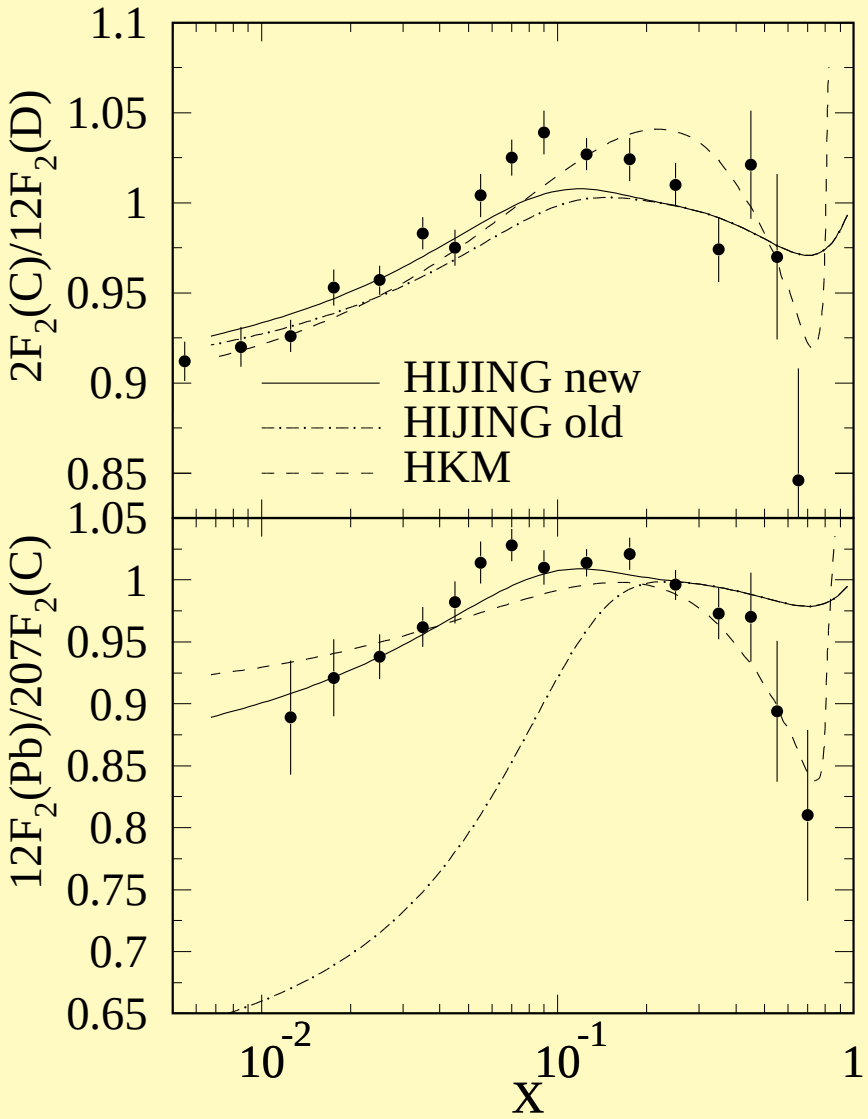
Isospin effect: PDF



- PDF satisfies $f_{u(d)/p}(x, Q^2) = f_{d(u)/n}(x, Q^2)$
- Heavy quark distributions are the same
- For symmetric projectile (like d) no effect is expected for π^0 and γ!

F. Zolfagharpour: arXiv:0802.1623v1

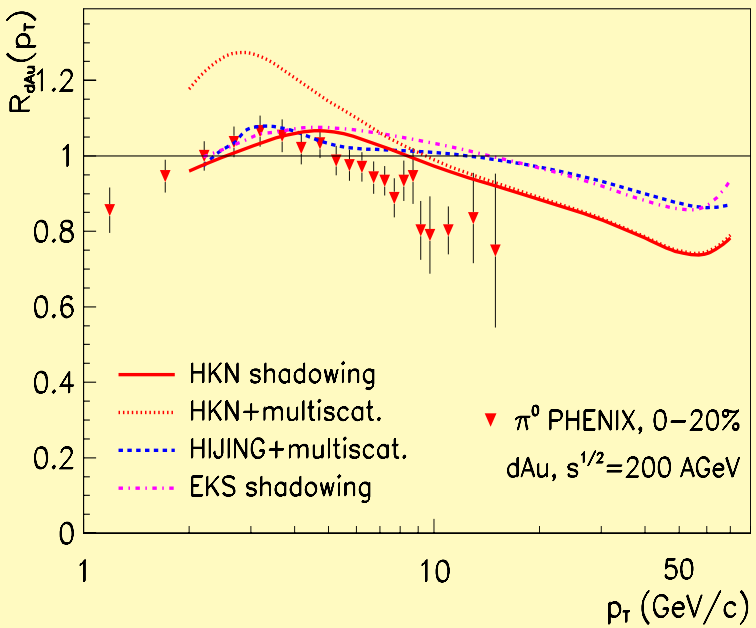
Nuclear Shadowing



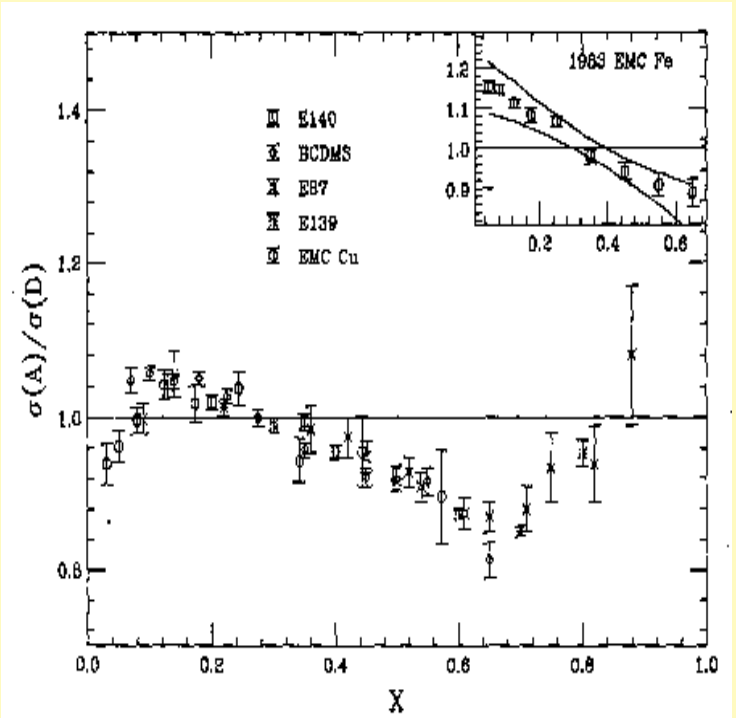
- Partons from proton/neutron inside a nucleus behaves differently compared to the free ones!
- The modification is independent on reaction, energy (not the scales: x and Q^2).
- Measured only for some nuclei :-(

Oops

$R^{\pi^0}_{dAu}$



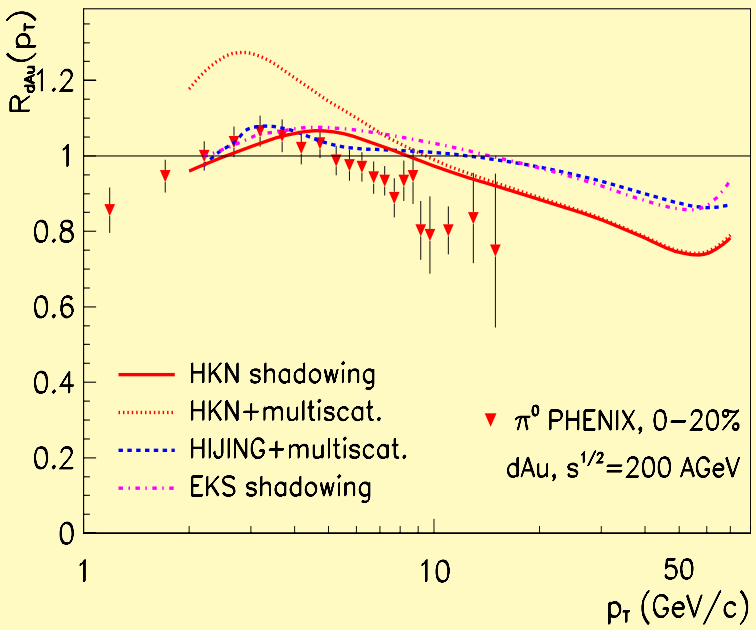
Nuclear modification

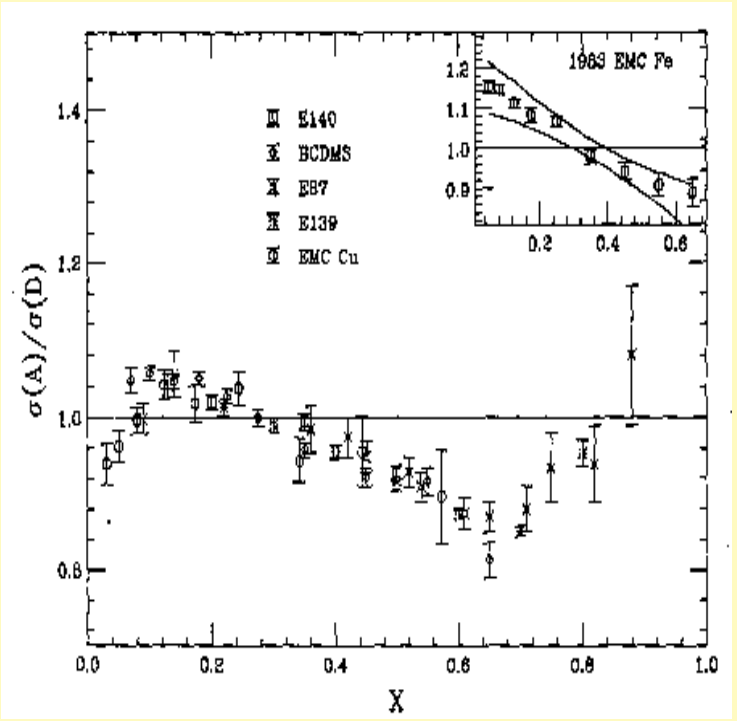


Nice, or are we still missing something?

- Factorization
- Final state interaction

Oops





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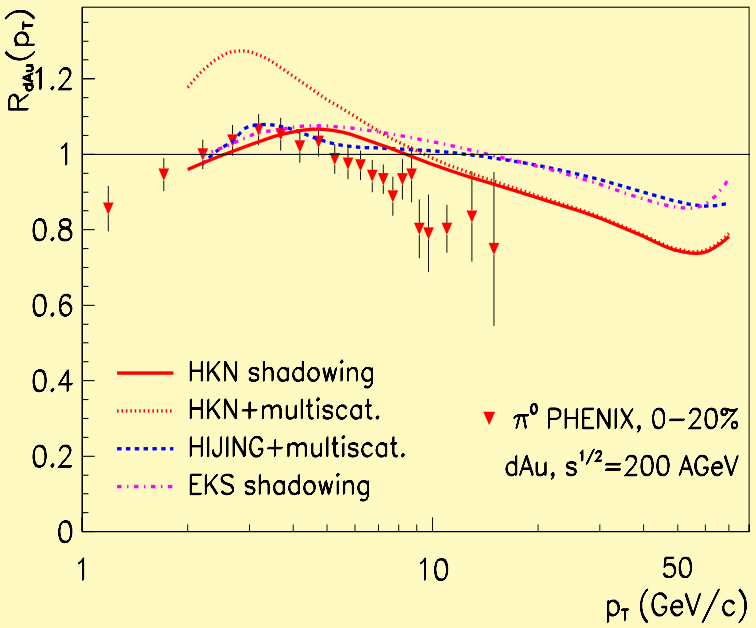
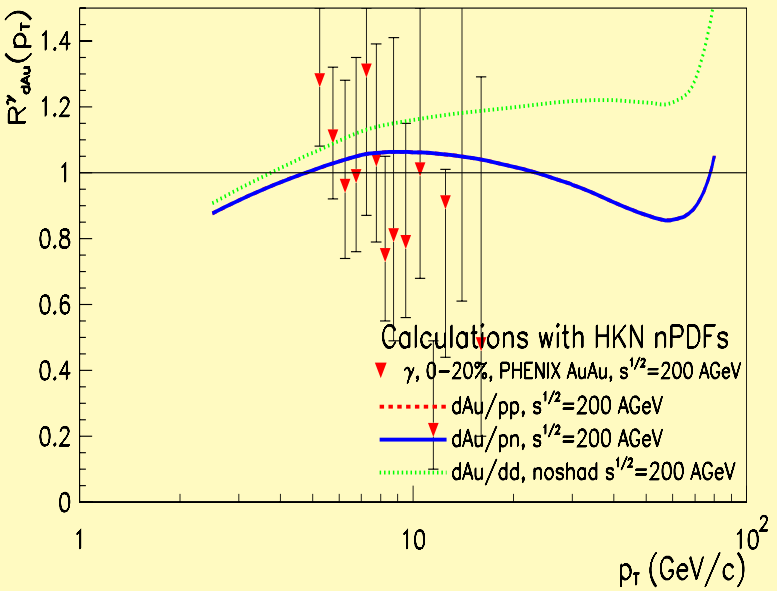
Fotons

π^0



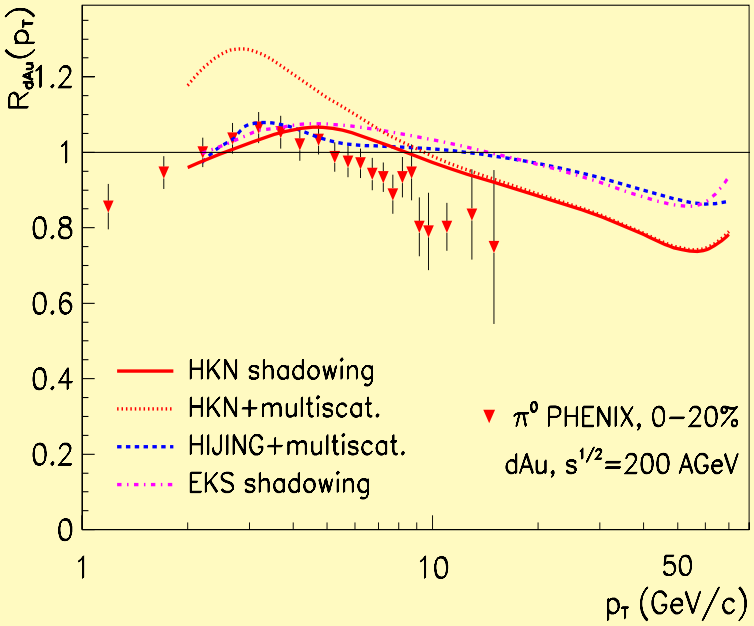
γ

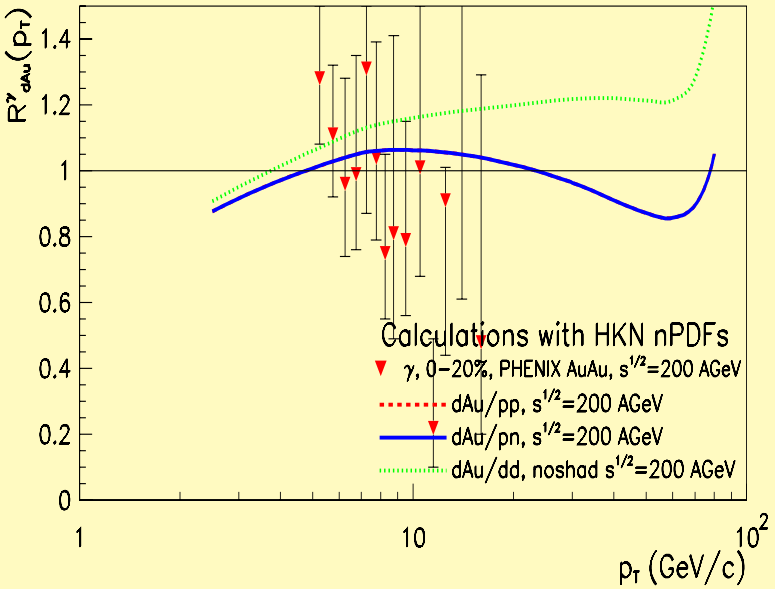


Differences

- γ has less data
- and larger experimental errors
- and the "interesting" region starts at higher p_T.

Fotons





Differences

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Parameterization

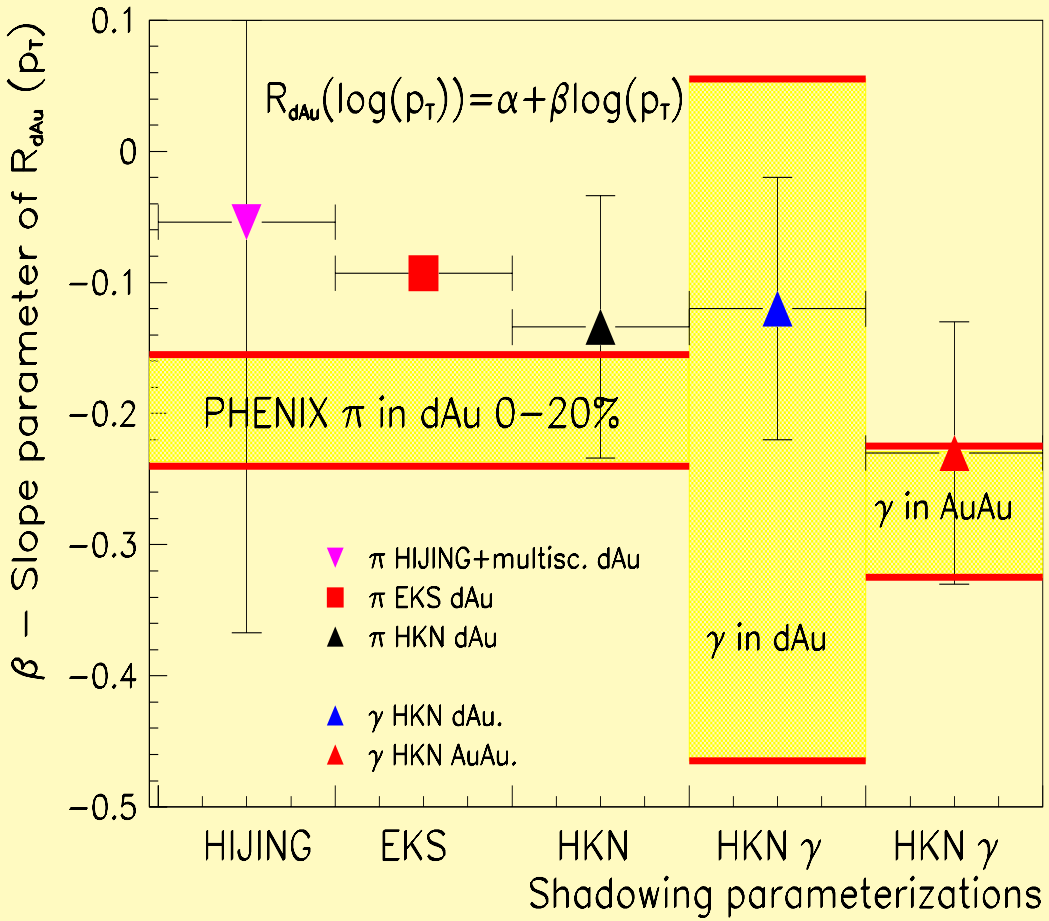
PDF with nuclear modification

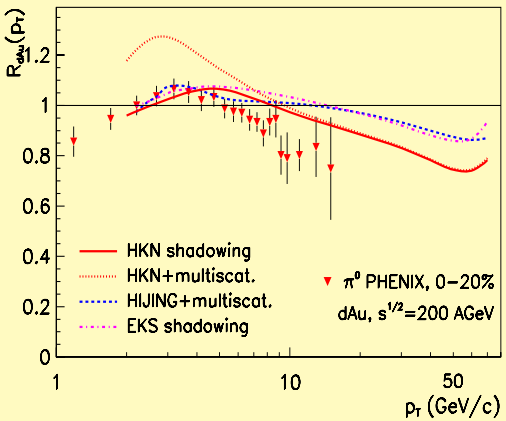
- mixes isospin
- modifies the ”free” PDF

$$f_{a/A}\left(x,Q^2\right) = S_{a/A}(x,b)\left[\frac{Z}{A}f_{a/p}\left(x,Q^2\right) + \left(1-\frac{Z}{A}\right)f_{a/n}\left(x,Q^2\right)\right]$$

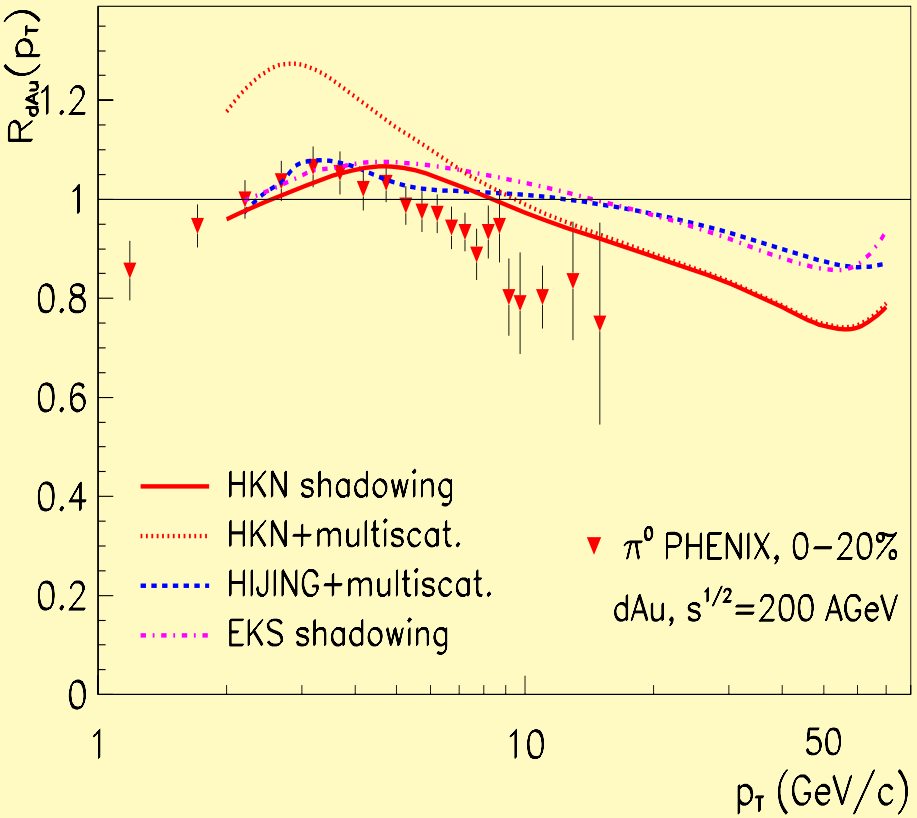
$S_{a/A}(x,b)$ is determined from experiments (HIJING, EKS). There are trickier parameterizations as well, e.g. HKN (systematic errors!).

p_T slope


$R_{dAu}(\log(p_T))=\alpha+\beta\log(p_T)$
PHENIX π in dAu 0−20%
γ in dAu
γ in AuAu
π HIJING+multisc. dAu
π EKS dAu
π HKN dAu
γ HKN dAu.
γ HKN AuAu.
β − Slope parameter of R_{dAu} (p_T)
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.5
HIJING
EKS
HKN
HKN γ
HKN γ
Shadowing parameterizations

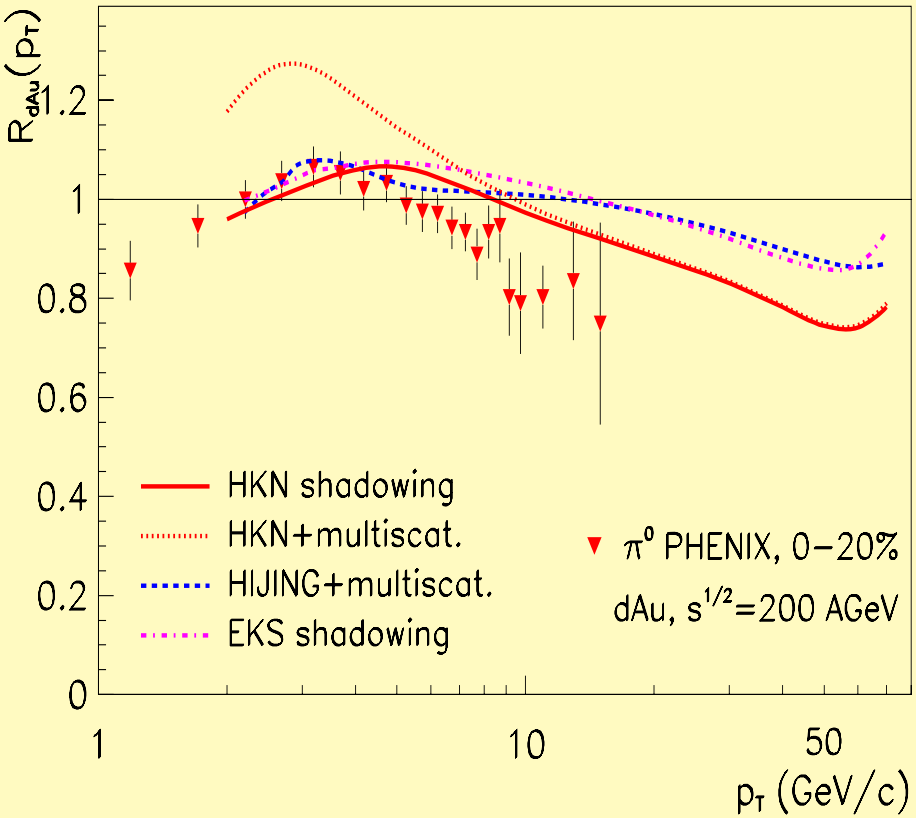

$R_{dAu}(p_T)$
1.2
1
0.8
0.6
0.4
0.2
0
1
10
50
p_T (GeV/c)
HKN shadowing
HKN+multiscat.
HIJING+multiscat.
EKS shadowing
π⁰ PHENIX, 0−20%
dAu, $s^{1/2}$=200 AGeV

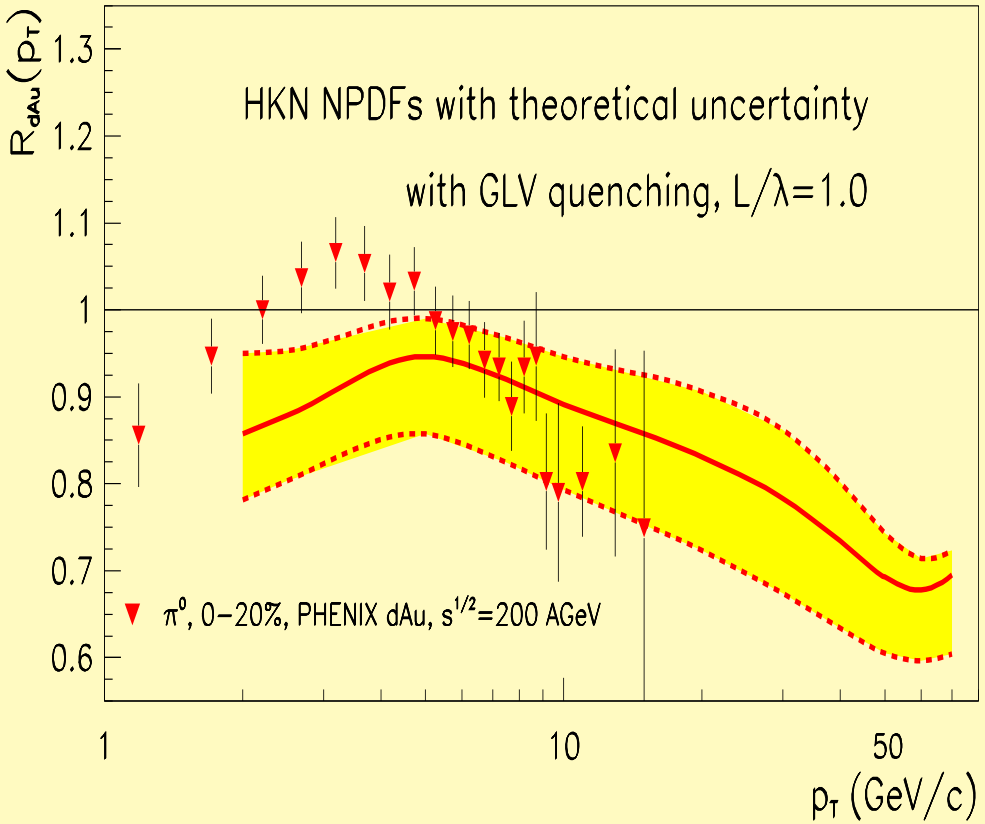
GLV jet quenching



There is some room for futher suppression coming from e.g. jet quenching.

GLV jet quenching

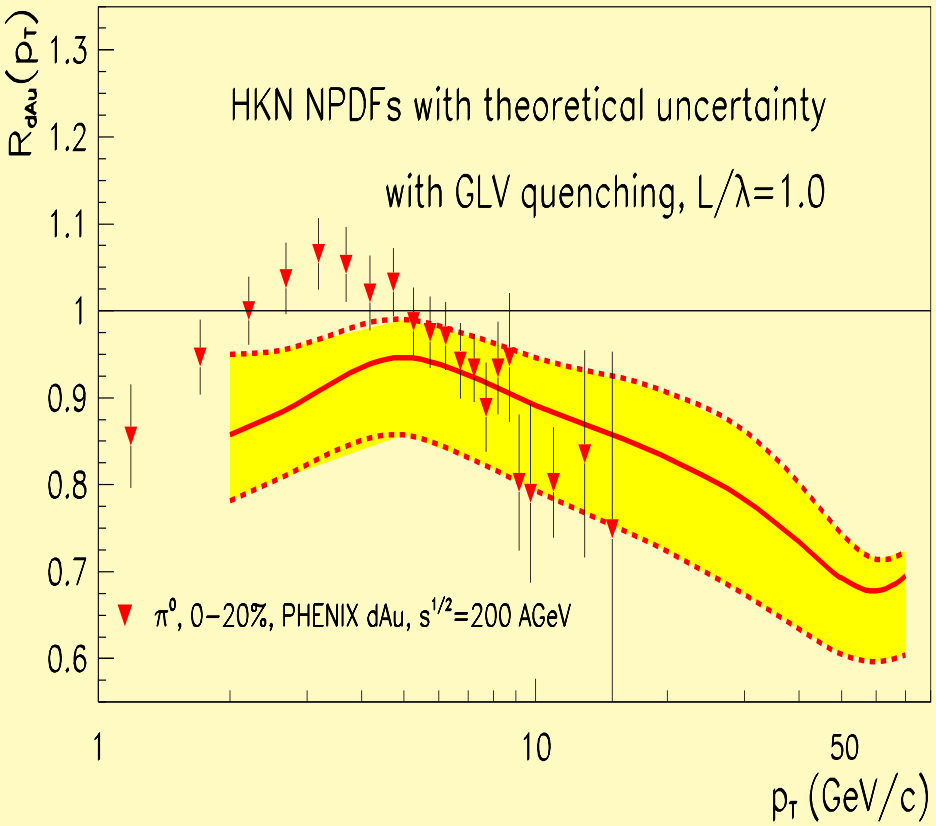




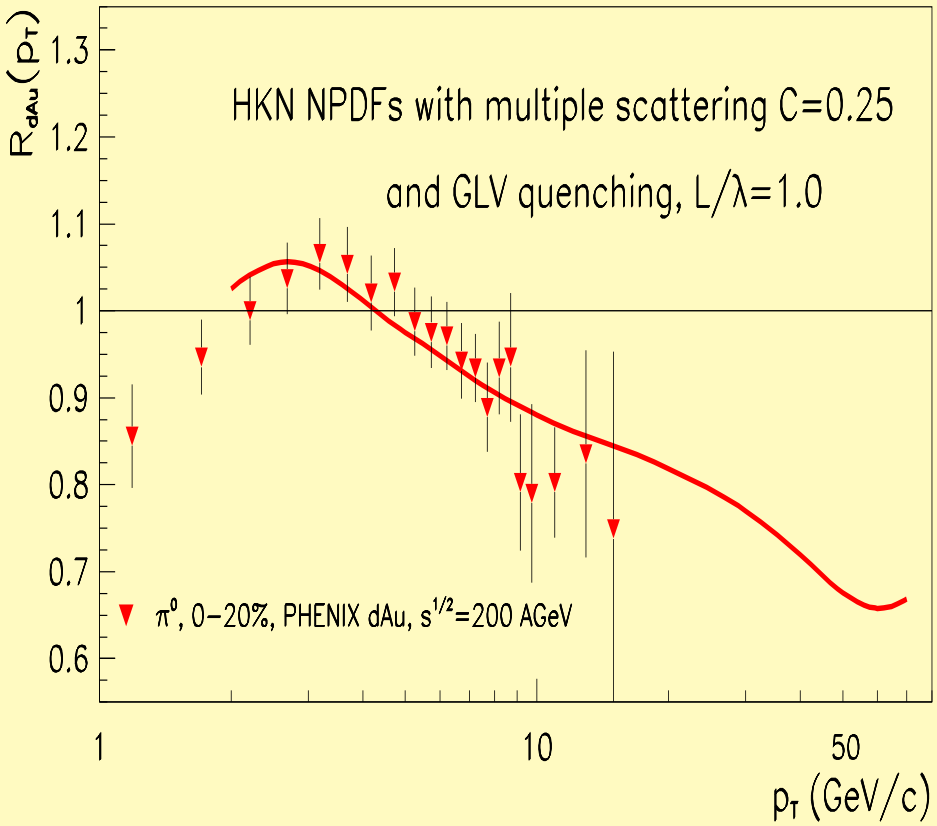
There is some room for futher suppression coming from e.g. jet quenching.

HKN with "cold" quenching and no extra multiscattering effect.

GLV jet quenching with HKN analysis



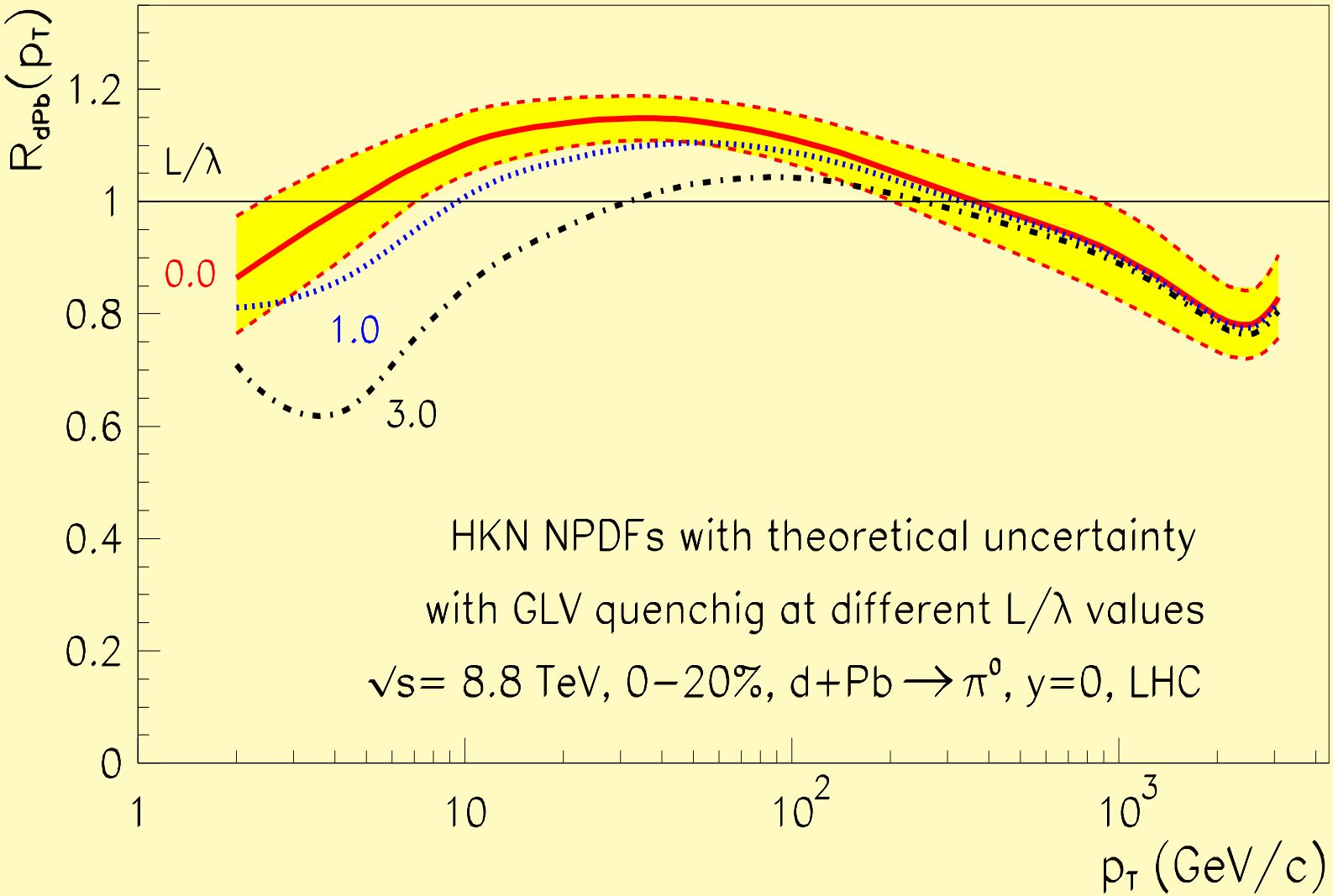
HKN without multiscattering.



HKN with multiscattering.

Outline

LHC


$R_{dPb}(p_T)$
1.2
1
0.8
0.6
0.4
0.2
0
L/λ
0.0
1.0
3.0
HKN NPDFs with theoretical uncertainty
with GLV quenchig at different L/λ values
√s= 8.8 TeV, 0−20%, d+Pb → π⁰, y=0, LHC
1
10
10^2
10^3
p_T (GeV/c)

Outline

Summary

- Suppression of π^0 and γ in d+Au collisions at RHIC is consistent with the EMC effect.
- There is some room for jet quenching in dAu@RHIC, however not too much.
- HKN is doing better as PDF, however still suffers problems.
- At LHC further parts of nuclear modification may reveal (from $p_T \approx 8$ GeV – see P. Lévai's talk): antishadowing, shadowing.