Nuclear PDFs

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3rd CERN-ECFA-NuPECC Workshop on the LHeC

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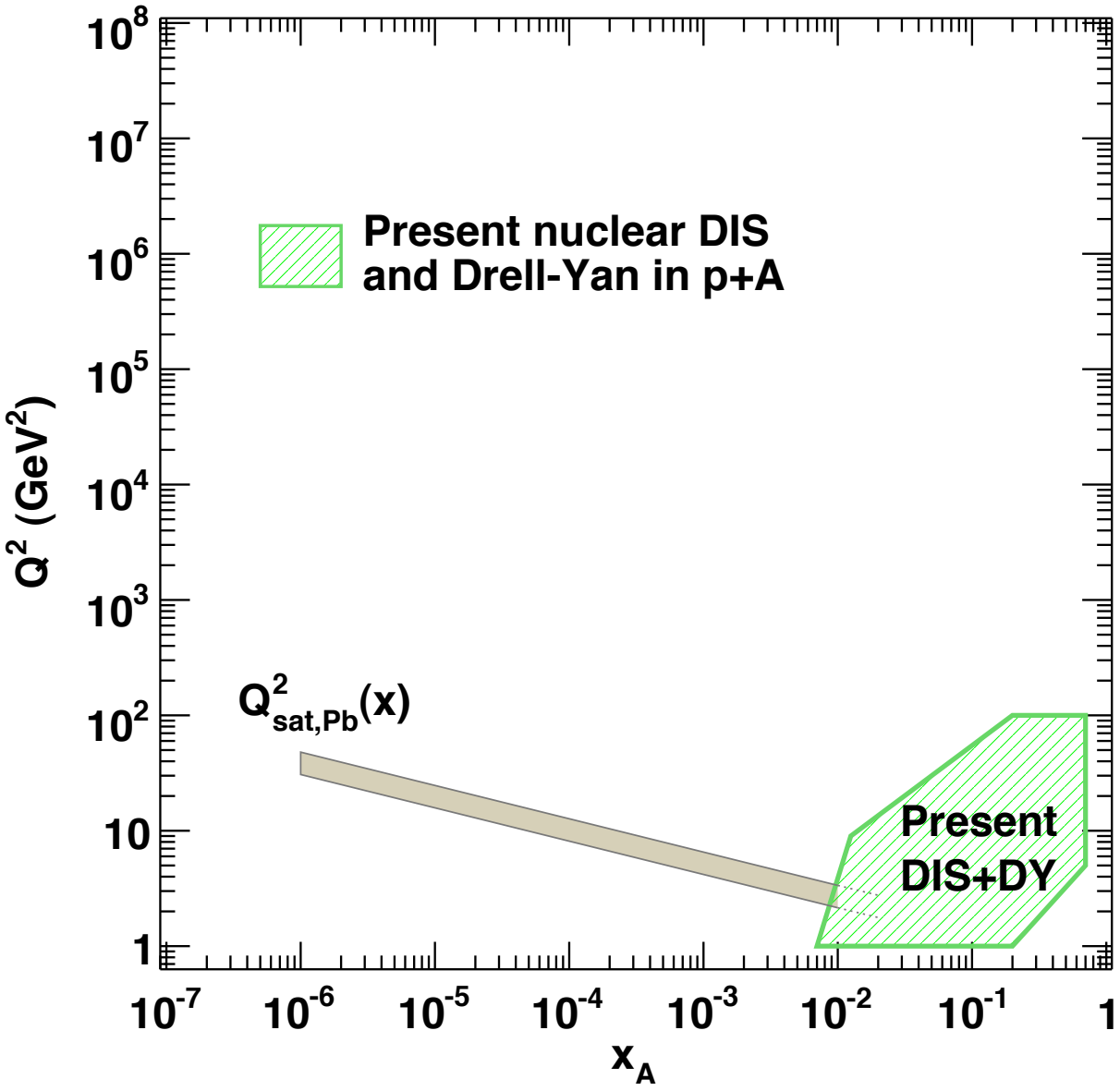
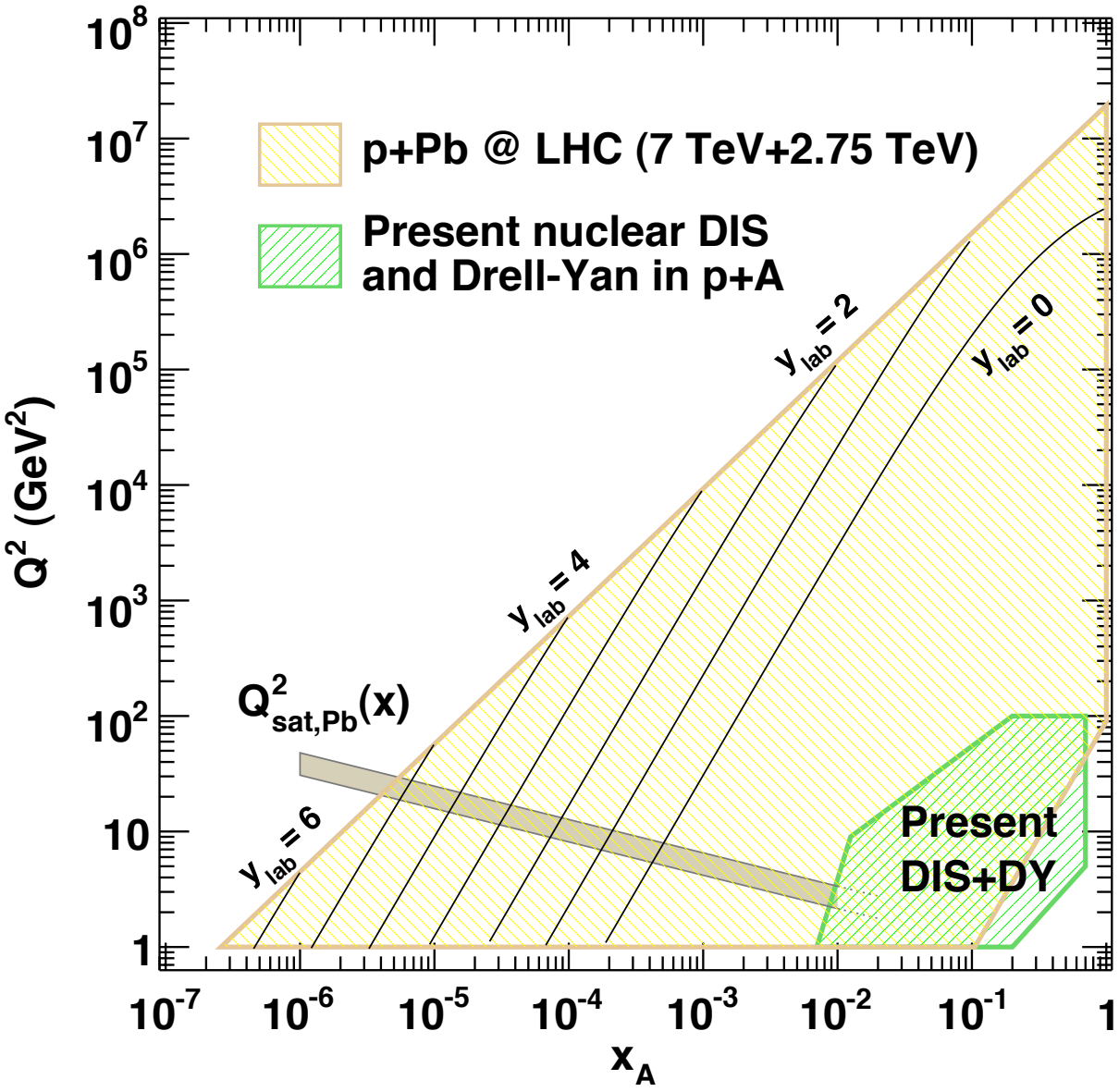
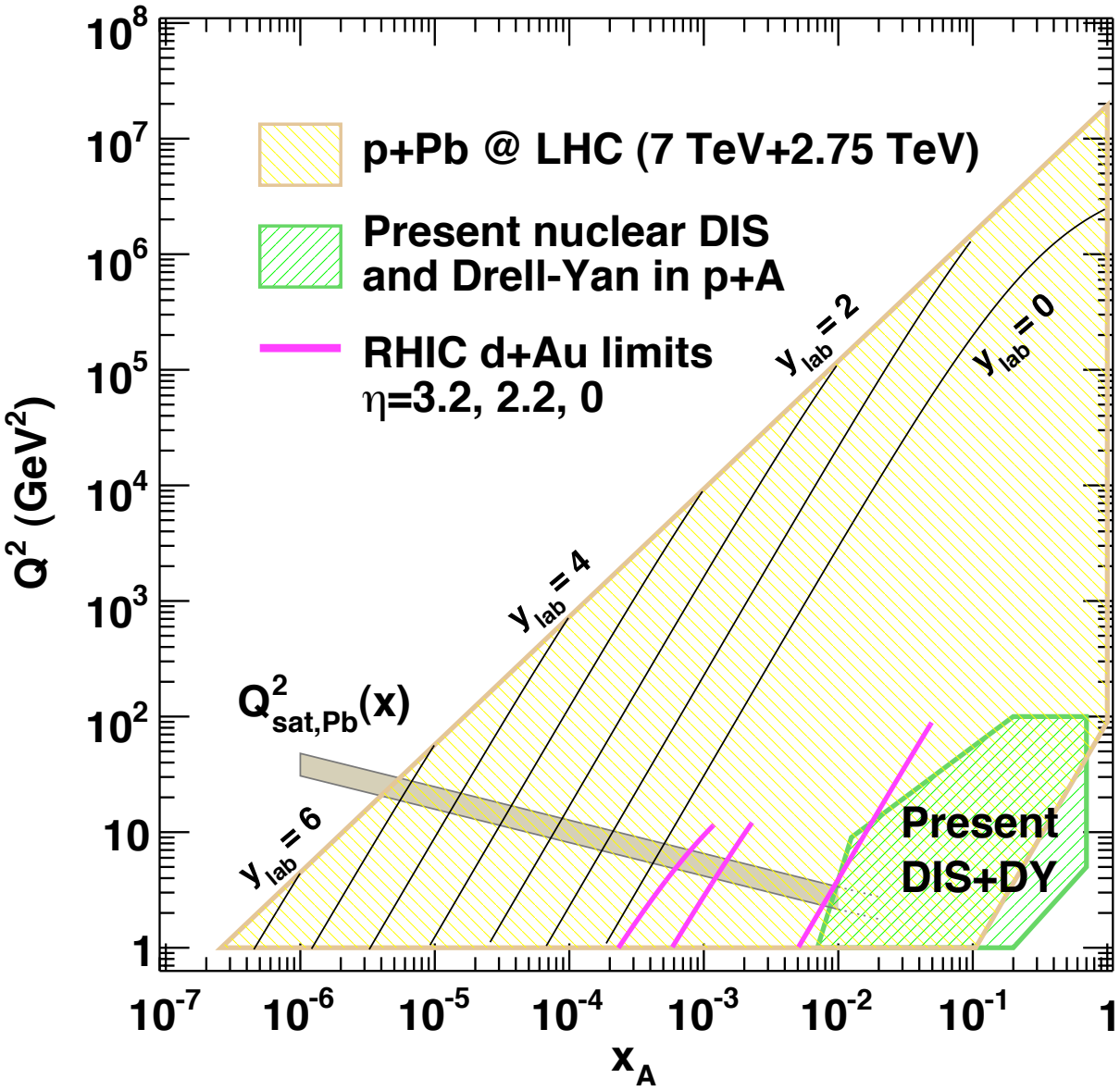
Kinematical reach in nuclear collisions



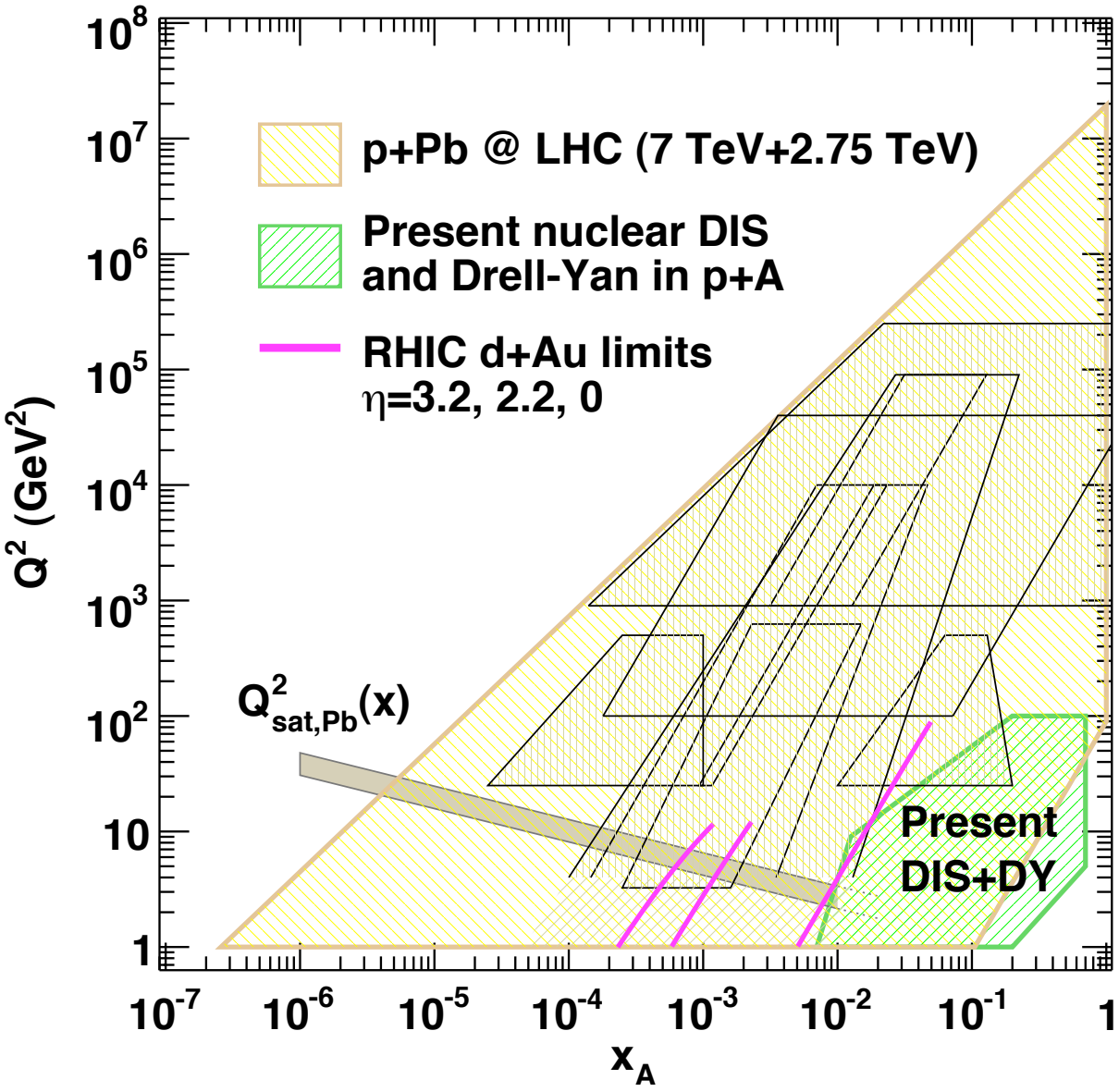
Kinematical reach in nuclear collisions



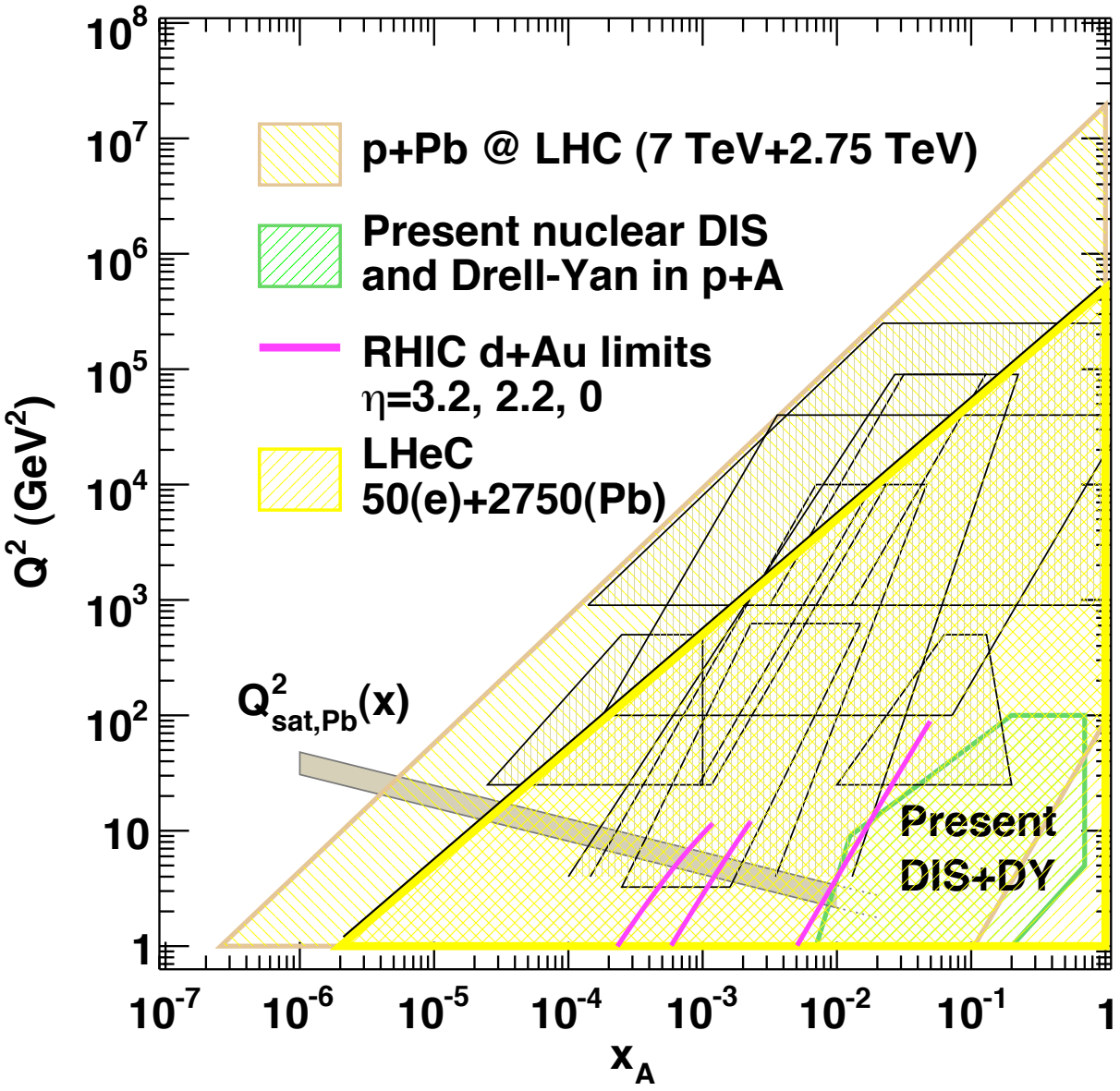
Kinematical reach in nuclear collisions



Kinematical reach in nuclear collisions



Kinematical reach in nuclear collisions



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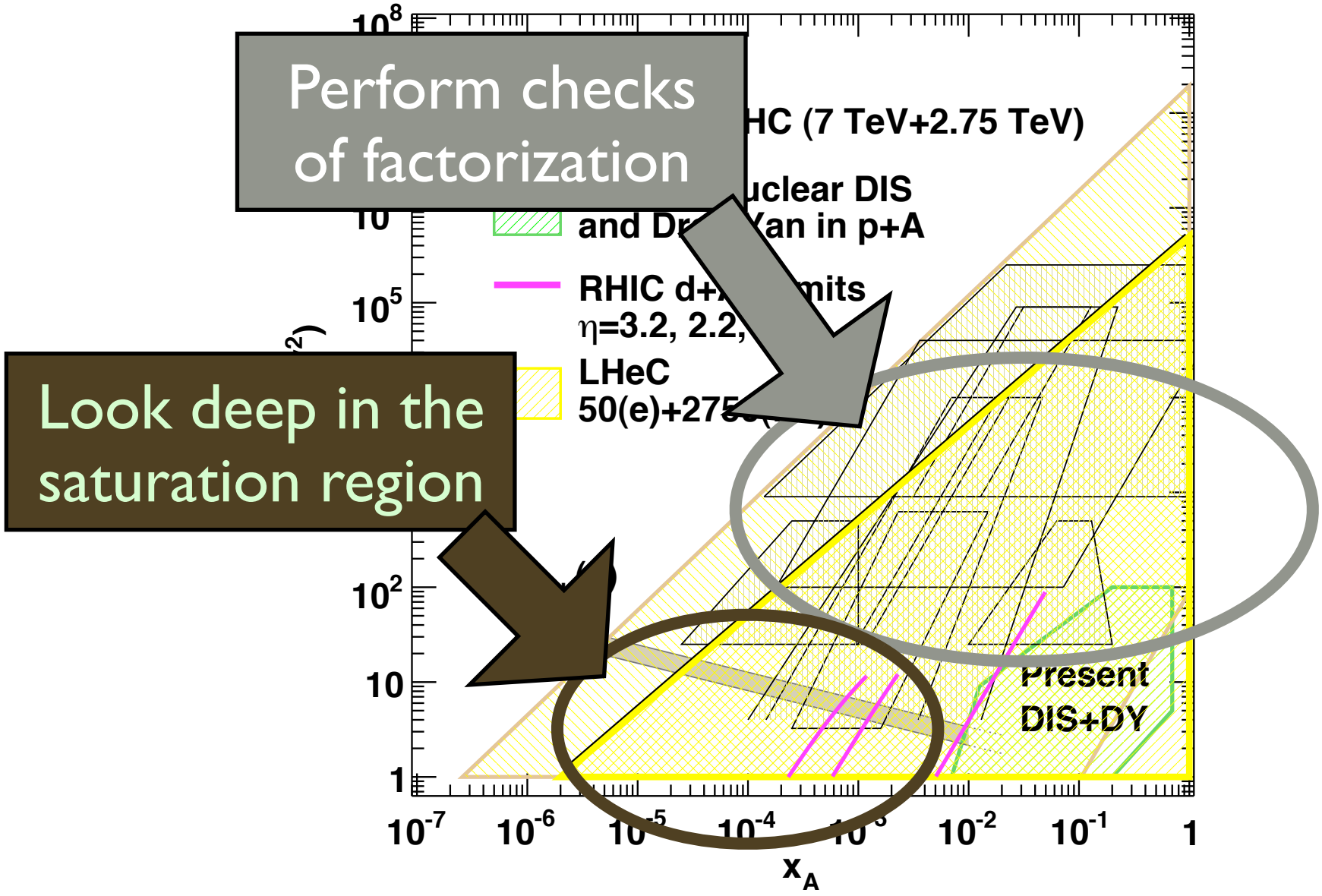


The strategy of nPDF fits

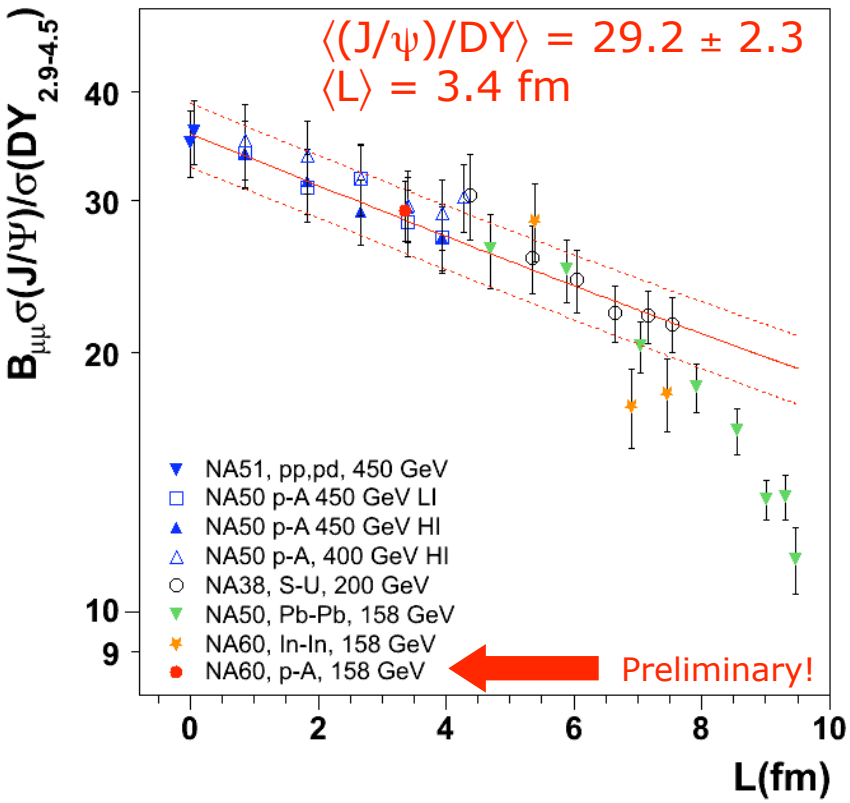
- Use a global fit analysis similar to the free proton case
- The main limitation is the amount of data
  - Order 1000 data with order 10 different nuclei
  - Not possible to do a fit for a single nuclei
- A-dependence need to be parametrized

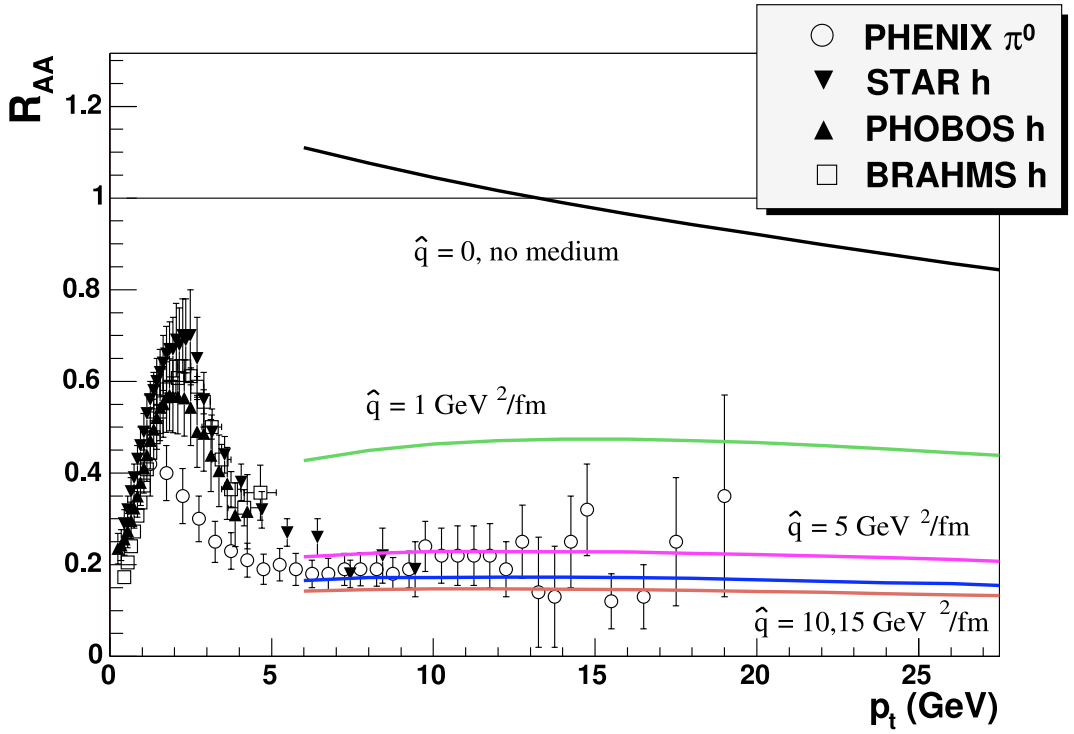
- As a result: parametrize ratios and not actual distributions
  - Take a known set of proton PDFs as reference

$$R_i^A(x,Q^2) = \frac{f_i^A(x,Q^2)}{f_i^p(x,Q^2)}$$

Background subtraction in nuclear collisions

- What is the cold nuclear matter background? in particular PDFs
  - Essential for a correct characterization of the medium properties





- Examples: J/Psi or high-pT particle suppression observed in AA
  - Proposed as signals of the produced hot medium

nPDFs: global analyses. Status

- Main goals
  - Check the factorization of nPDFs for hard processes
  - Fix the benchmark for HI hot matter or saturation

EKS98 [Eskola, Kolhinen, Salgado 1998]

nDS [de Florian, Sassot, 2003]

HKM, HKN [Hirai, Kumano, Miyama, Nagai, 2001; 2004; 2007]

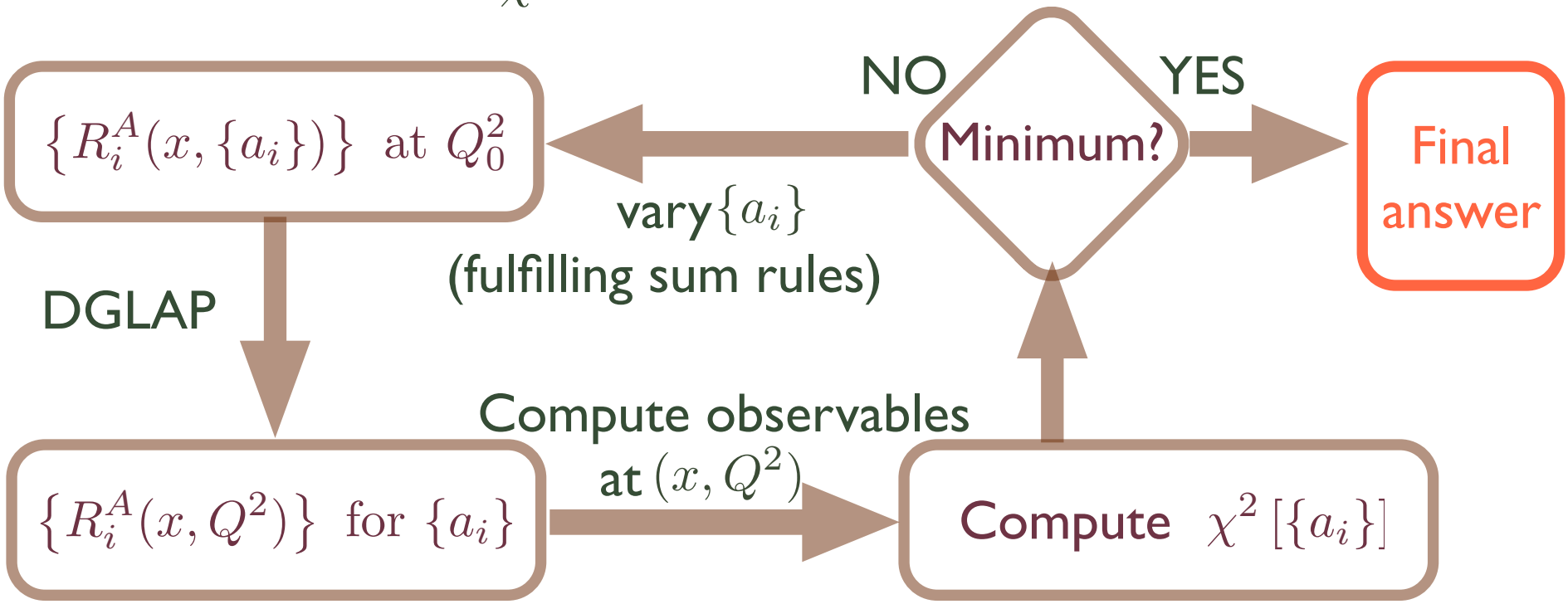
EKPS [Eskola, Kolhinen, Paukkunen, Salgado, 2007]

EPS08 [Eskola, Paukkunen, Salgado, 2008]

EPS09 [Eskola, Paukkunen, Salgado, 2009]

How?: follow free proton approach

- Cross sections computed in collinear factorization
- Define $$R_i^A(x,Q^2) = \frac{f_i^A(x,Q^2)}{f_i^p(x,Q^2)}$$
- Using a known set for free protons (CTEQ, MRST....)
- and DGLAP evolution of the nuclear and free proton PDFs
- Find the minimum of χ^2



Data sets

DIS: (484 points)
SLAC-E-139
NMC 95, 95re, 96 + EMC
- leave E665 out

DY in p+A (92 points)
E772 & E866

RHIC inclusive dAu (51 points)
PHENIX/STAR: midrapidity
BRAHMS: forward
Include only $p_T > 2\,\mathrm{GeV}$

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NMC 95	DIS	Li(6)/D	15	30.7	1	[27]
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FNAL-E772	DY	C/D	9	8.9	10	[29]
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NMC 96, Q^2 dep. $x \leq 0.025$	DIS	Sn/C	24	9.4	10	[32]
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Sea quarks

Gluons

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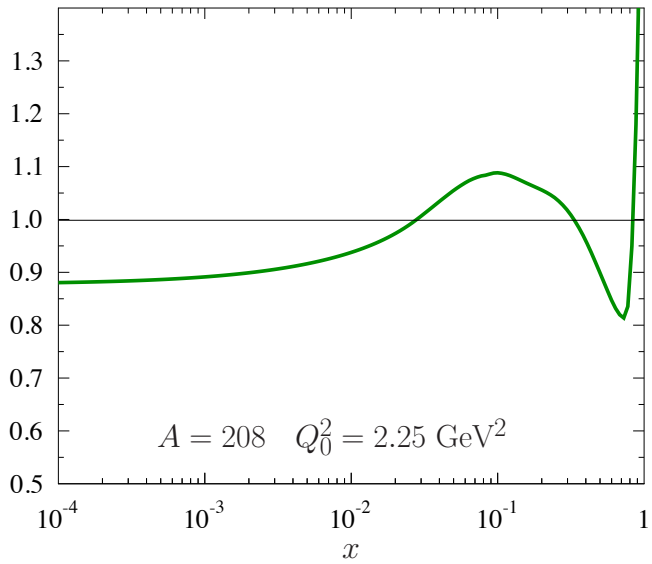
Sea quarks

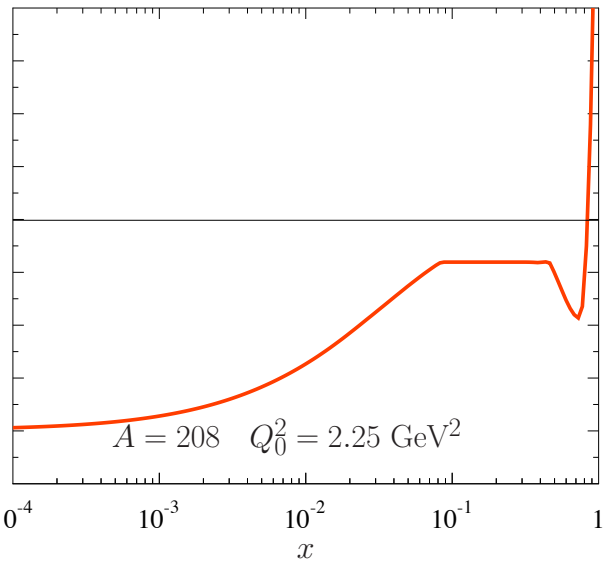
Gluons

Approximate ranges and constrains in EPS09

Valence



Sea quarks



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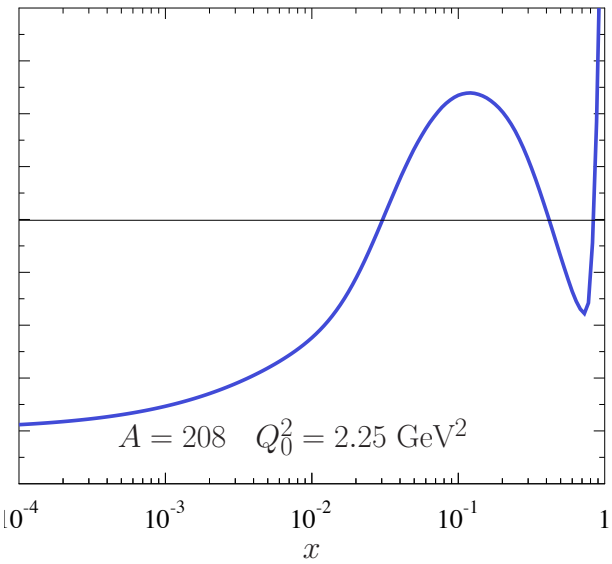

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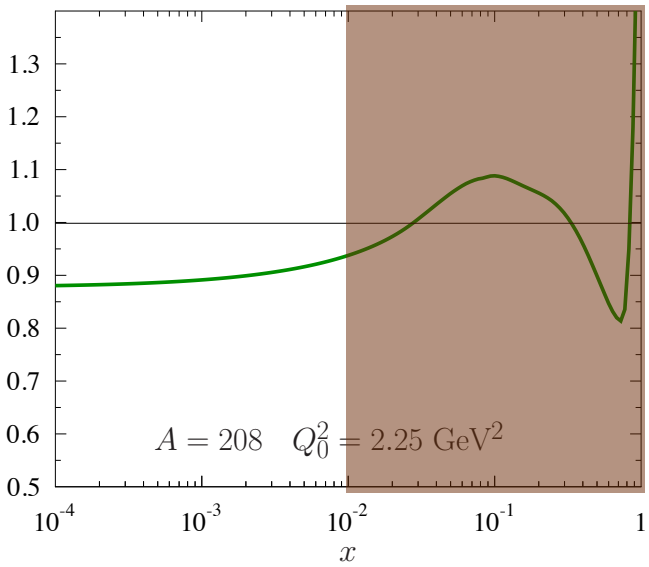

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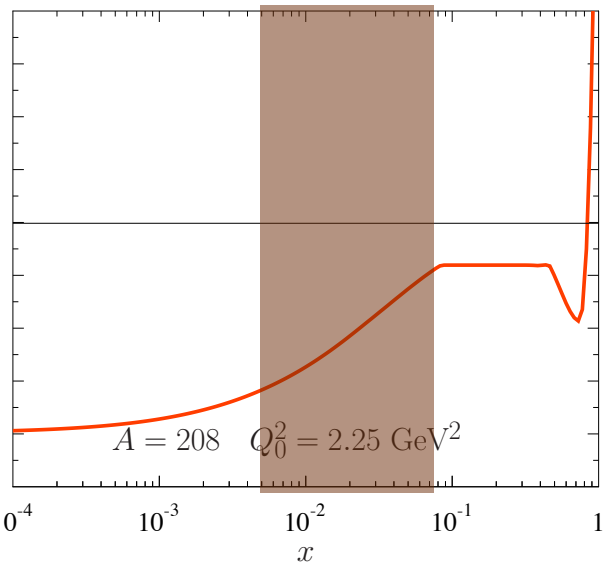

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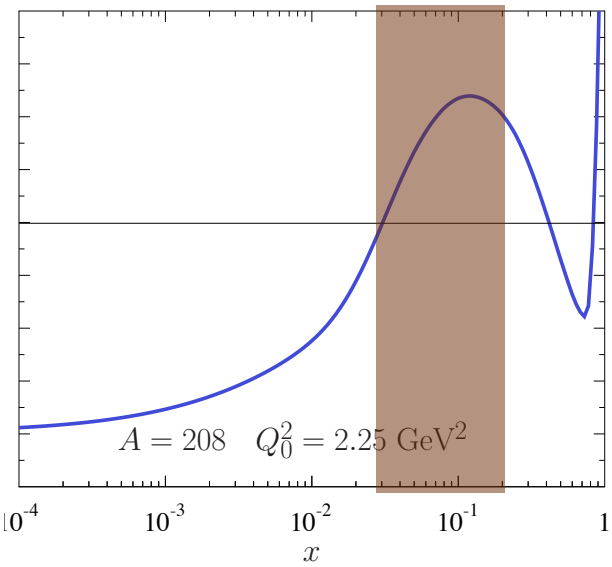

Constrained by DIS

Approximate ranges and constrains in EPS09

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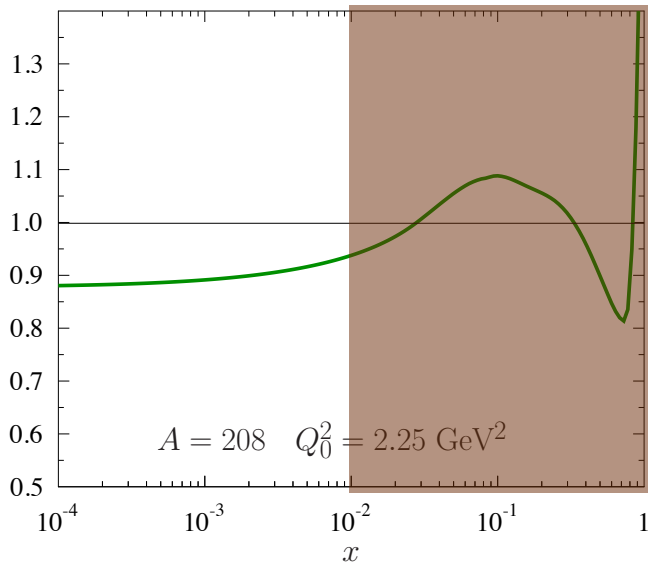

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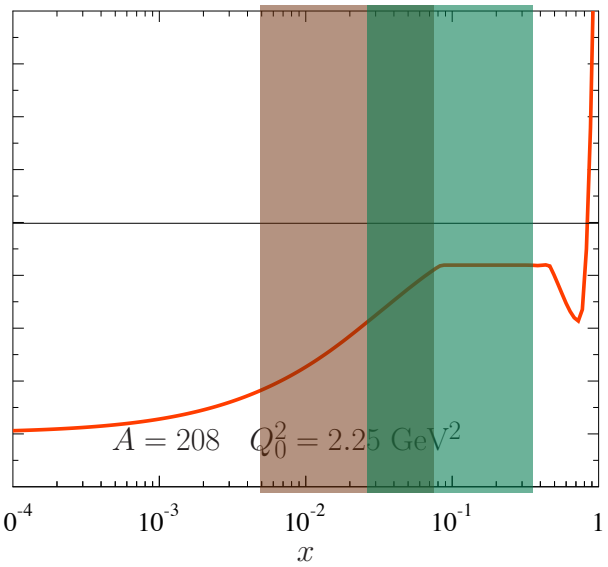

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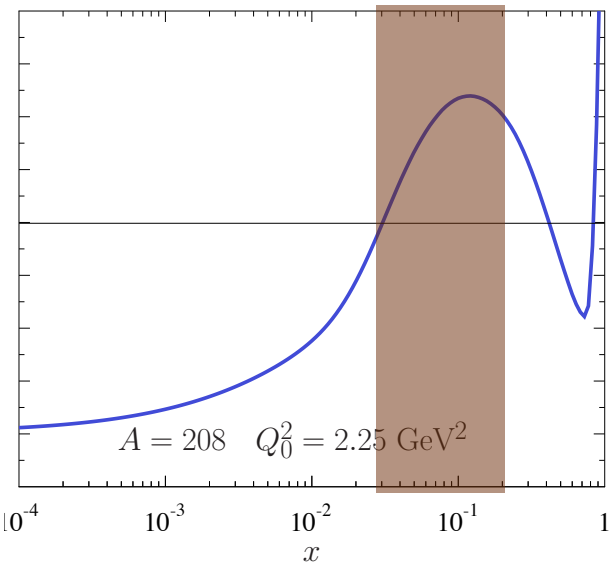

Constrained by DIS

Constrained by DY

Approximate ranges and constrains in EPS09

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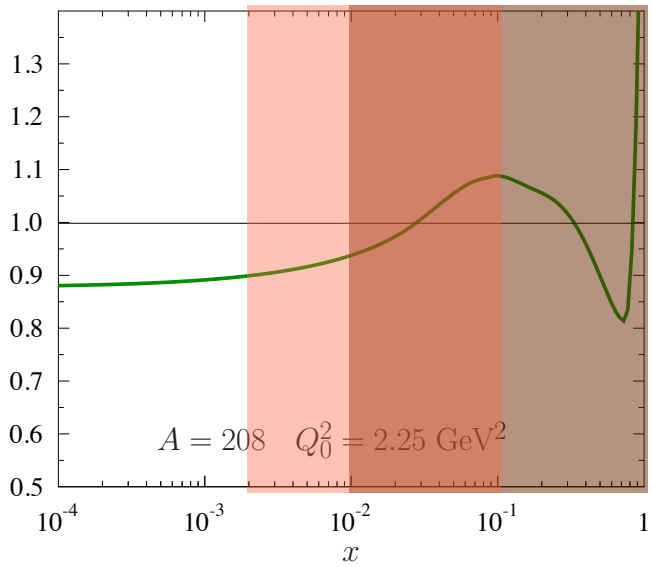

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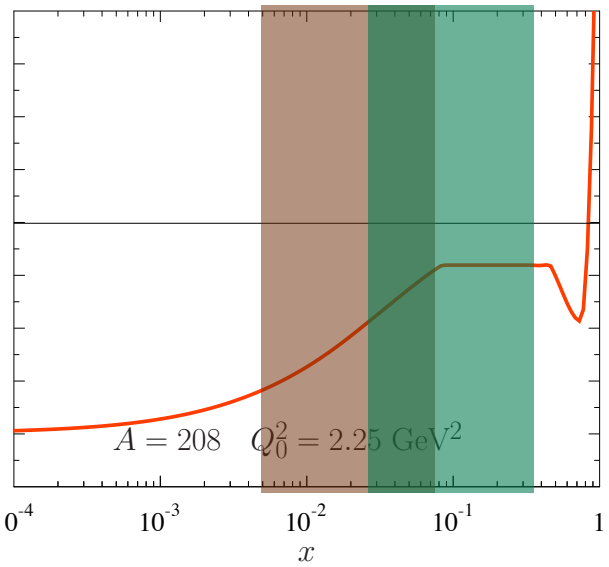

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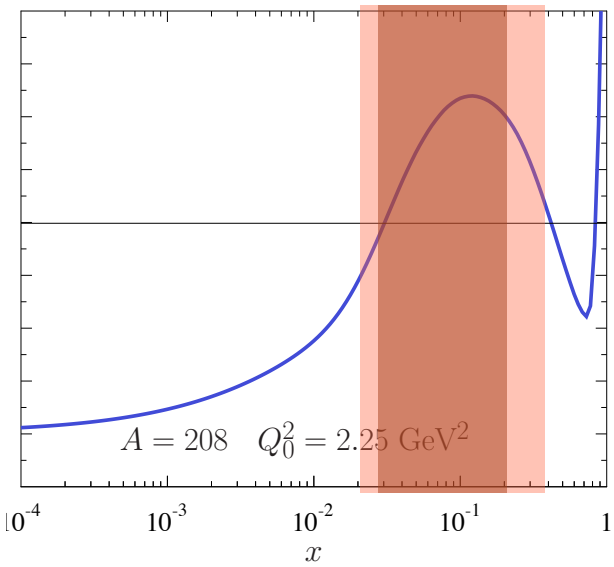

Constrained by DIS

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Sum rules and dAu@RHIC

Approximate ranges and constrains in EPS09

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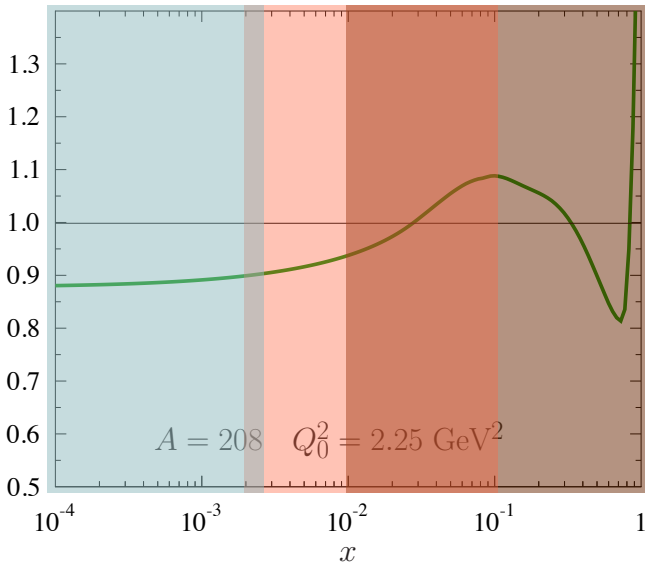

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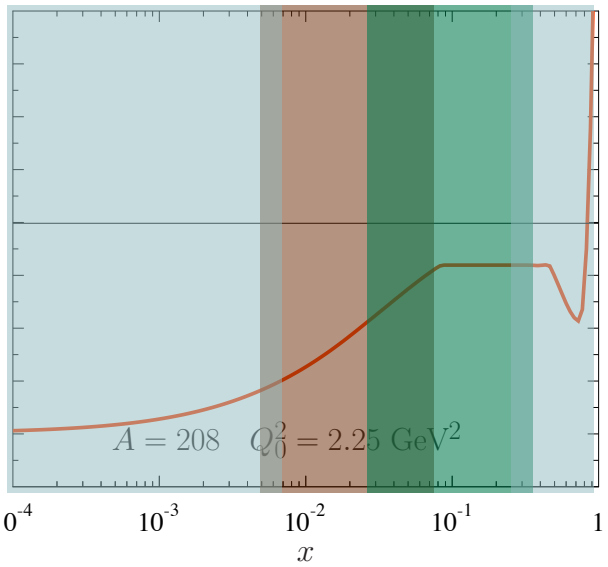

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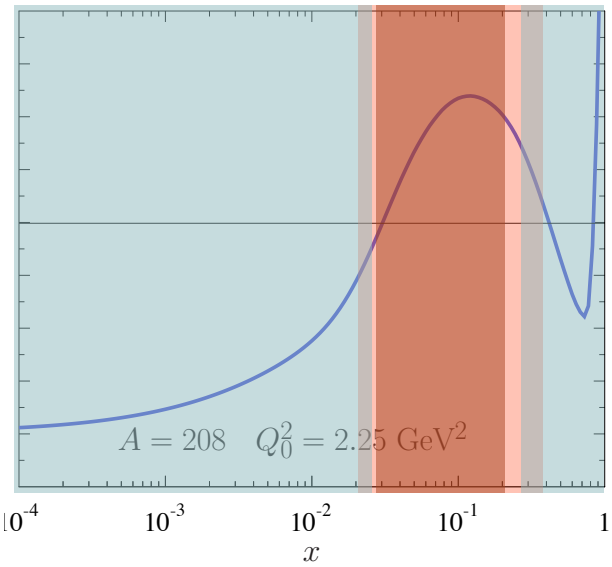

Constrained by DIS

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Sum rules and dAu@RHIC

Unconstrained

Approximate ranges and constrains in EPS09

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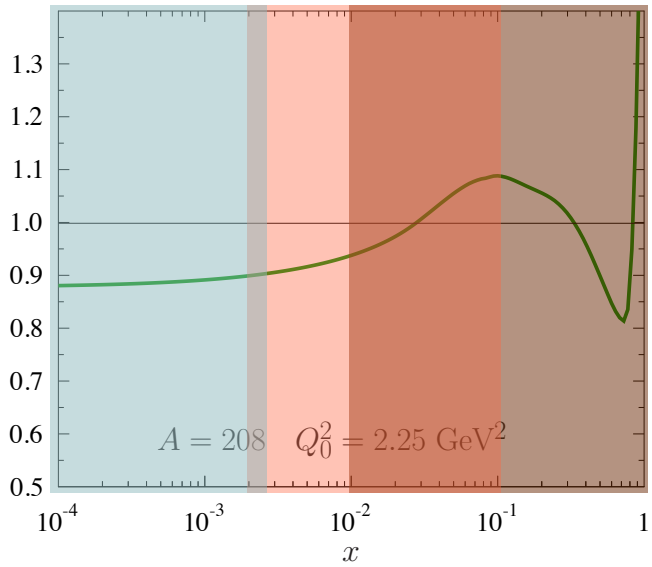

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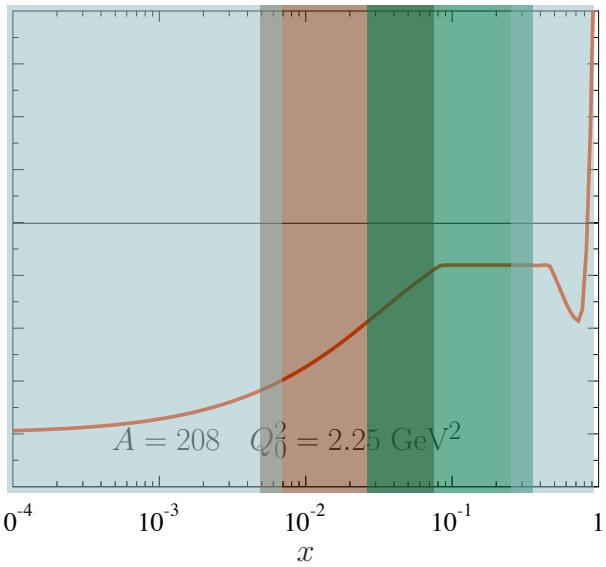

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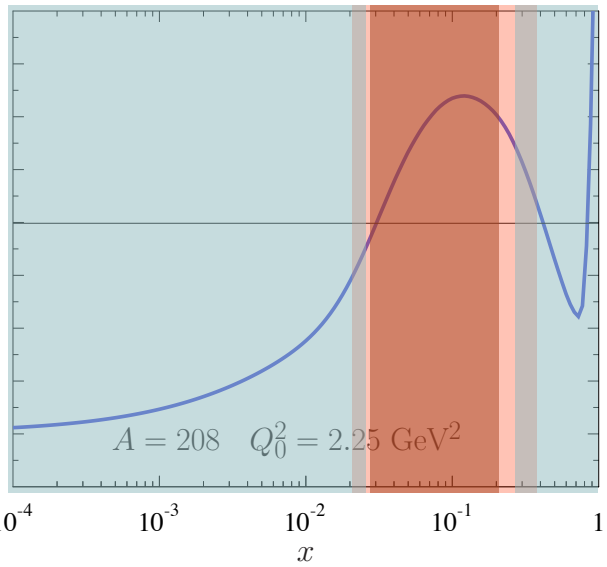

Constrained by DIS

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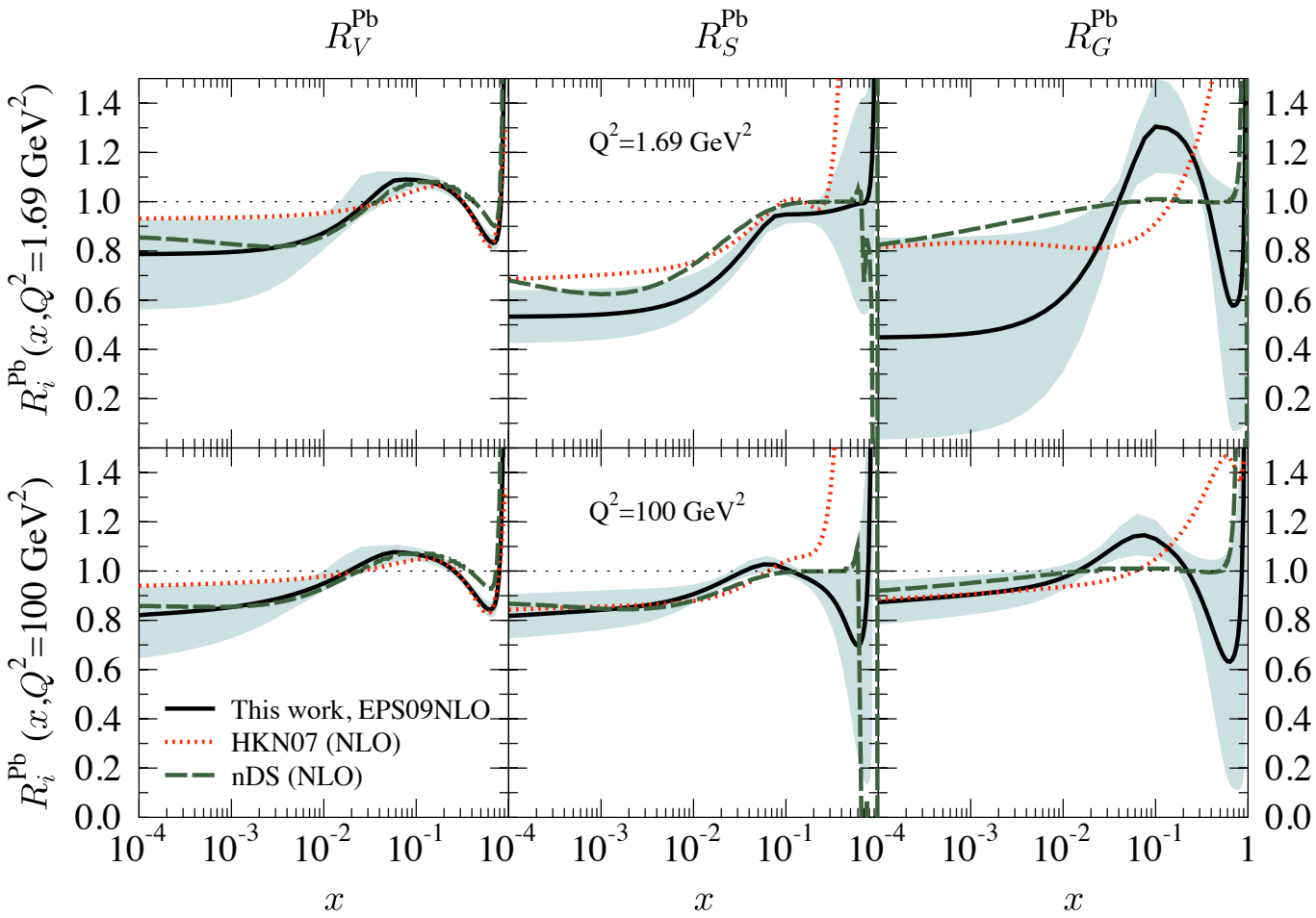
Sum rules and dAu@RHIC

Unconstrained

[these ranges are very approximative... but valid in general for other analyses]

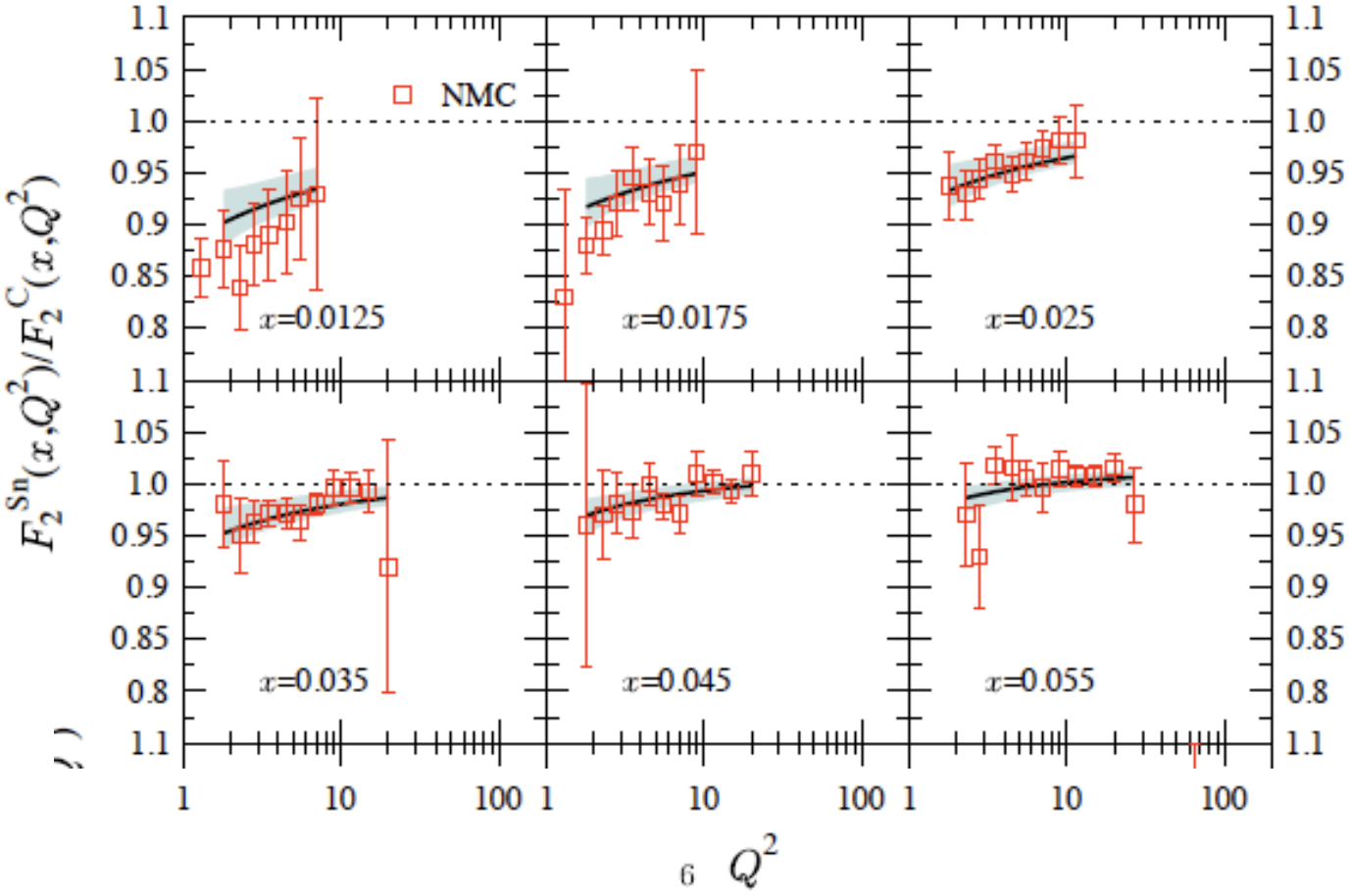
Results of the fits: EPS09

⇒ Initial conditions and error analysis compared with other NLO sets



[Eskola, Paukkunen, Salgado 2009]

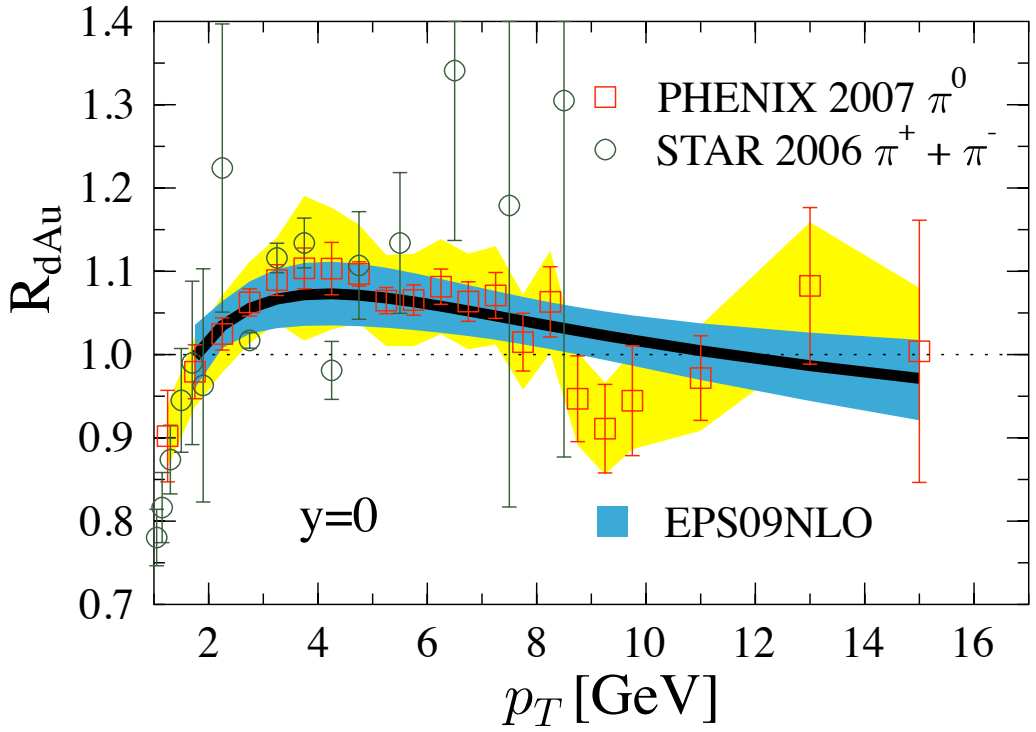
Comparison with data DIS



⇒ This set of data provides independent constrains for the gluons

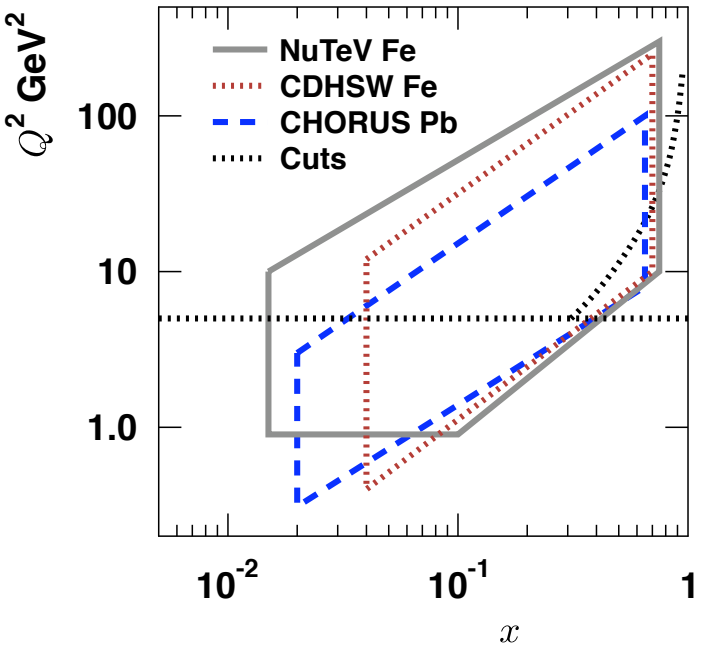
Central rapidity RHIC - EPS09

$$R_{\rm dAu} = \frac{dN^{\rm dAu}/dydp_T}{N_{\rm coll} dN^{\rm pp}/dydp_T}$$

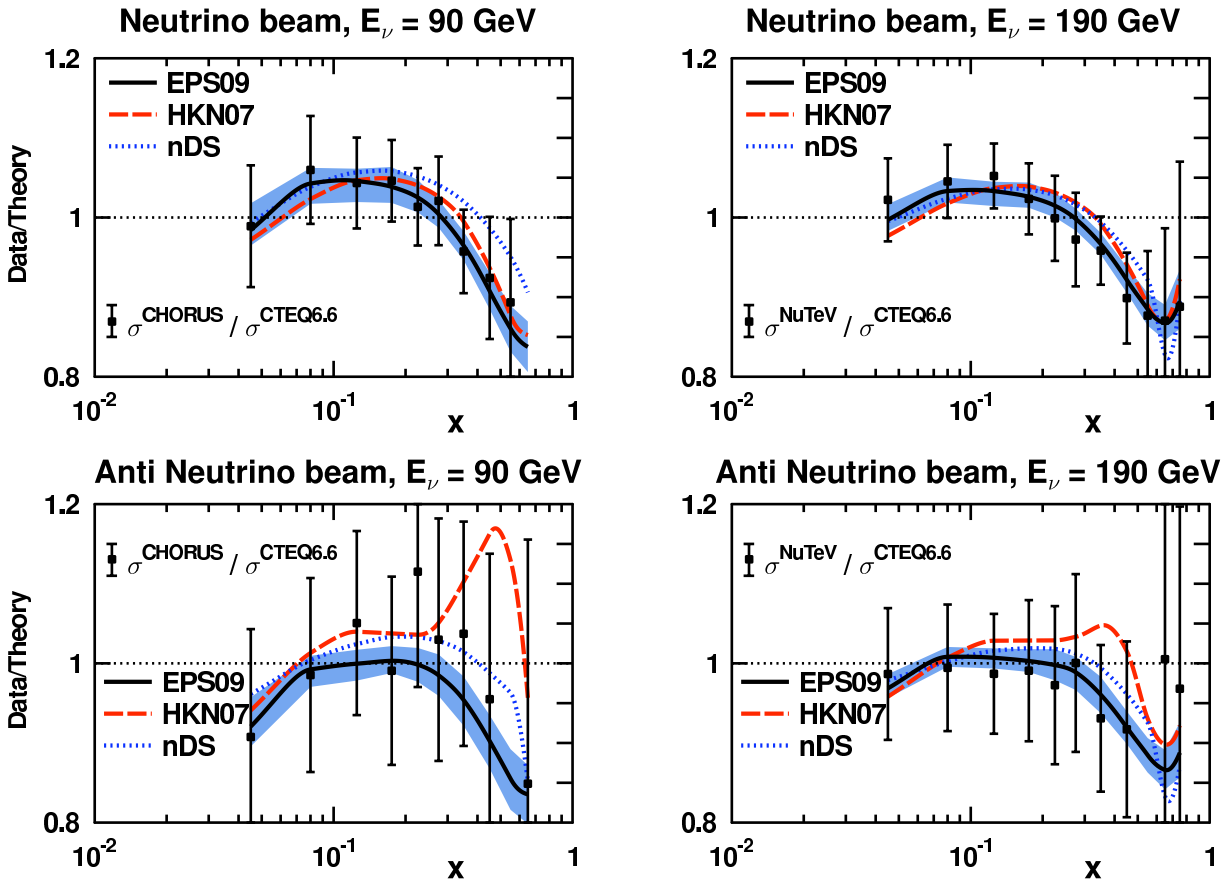


⇒ Direct constrains for gluons at moderate-large-x

Additional checks of factorization: neutrino DIS



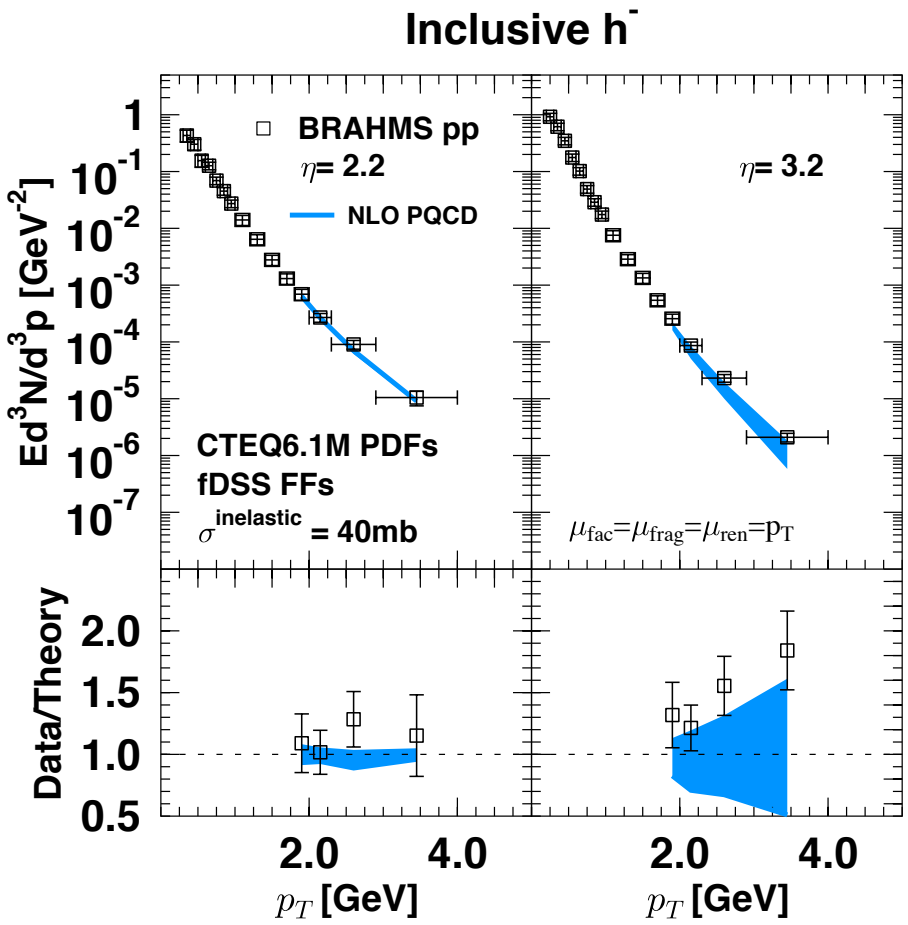
NuTeV: 2618 data
CDHSW: 1533 data
CHORUS: 1214 data

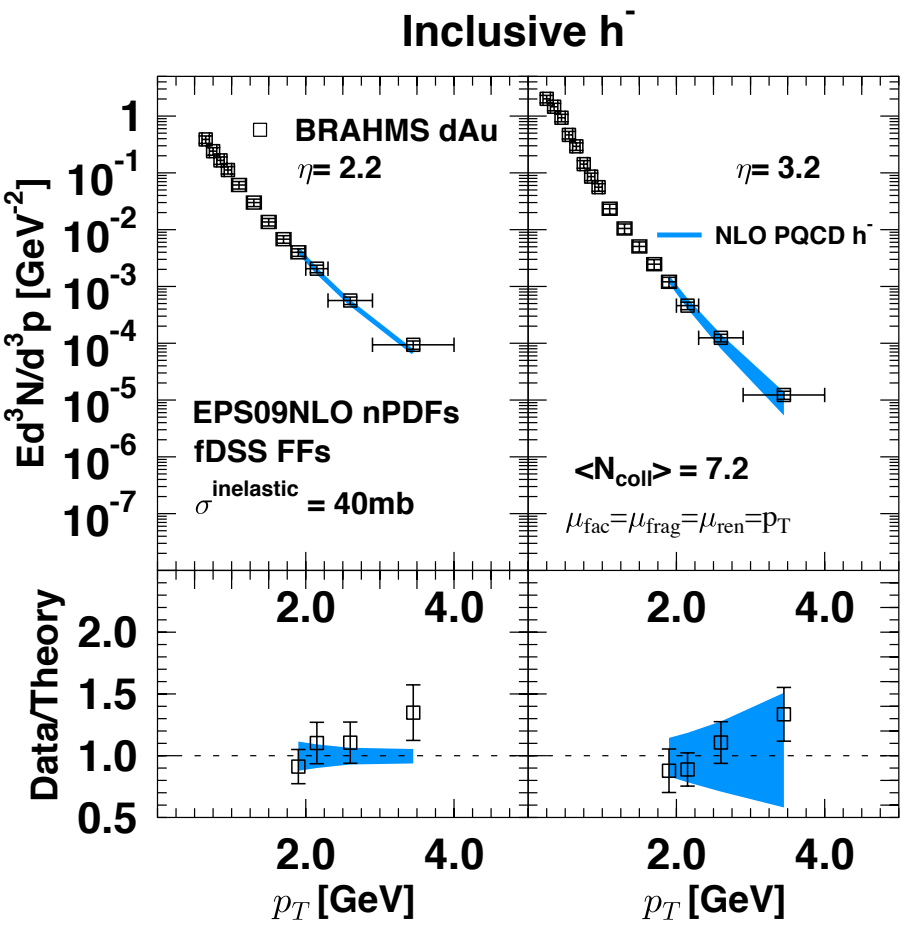


[Paukkunen, Salgado, 2010]

⇒ Non-trivial check: couplings are different in neutrino and charged-lepton DIS (neutrino data not yet included in the fit)

Forward rapidities: Brahms data





- Good description except for pp @ y=3.2
- Main problem not in nuclear but in pp collisions

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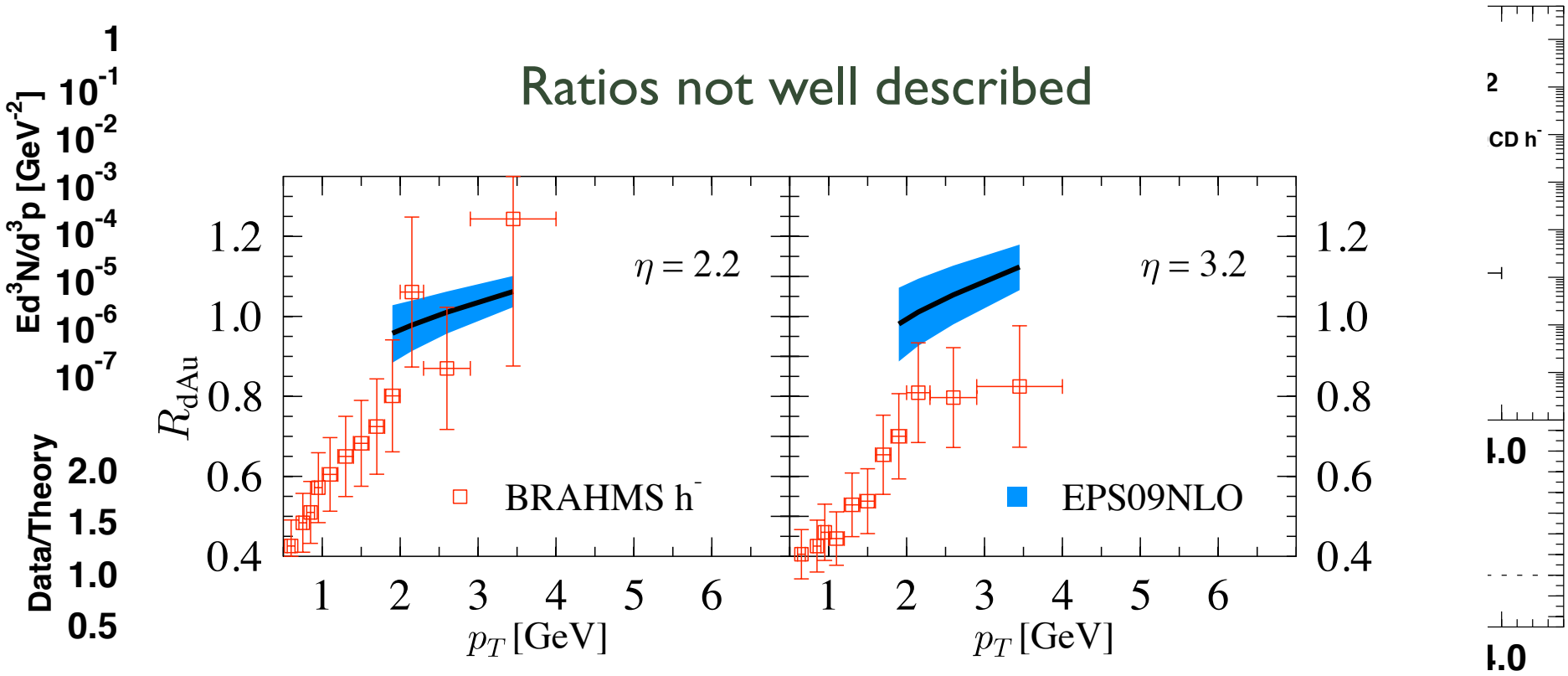

- Good description except for pp @ y=3.2
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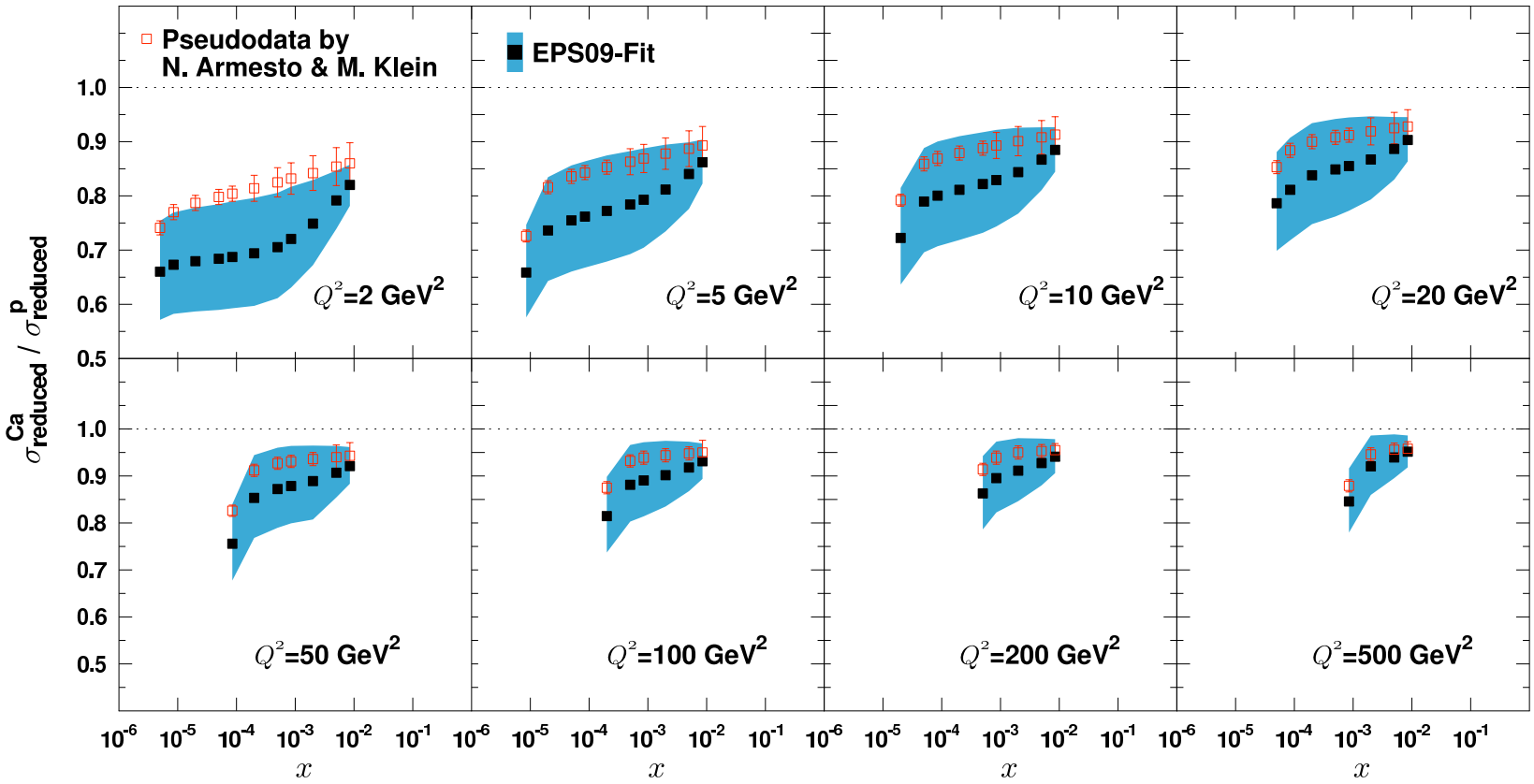
Including the LHeC

LHeC pseudodata

⇒ Ratios of reduced cross sections w/ statistical & systematic errors for 50(e)+7000(p)/3500(Ca)/2750(Pb)



⇒ Curves are the original EPS09

[Pseudodata generated used a simple model from N.Armesto, EPJC26 (2002) 35]

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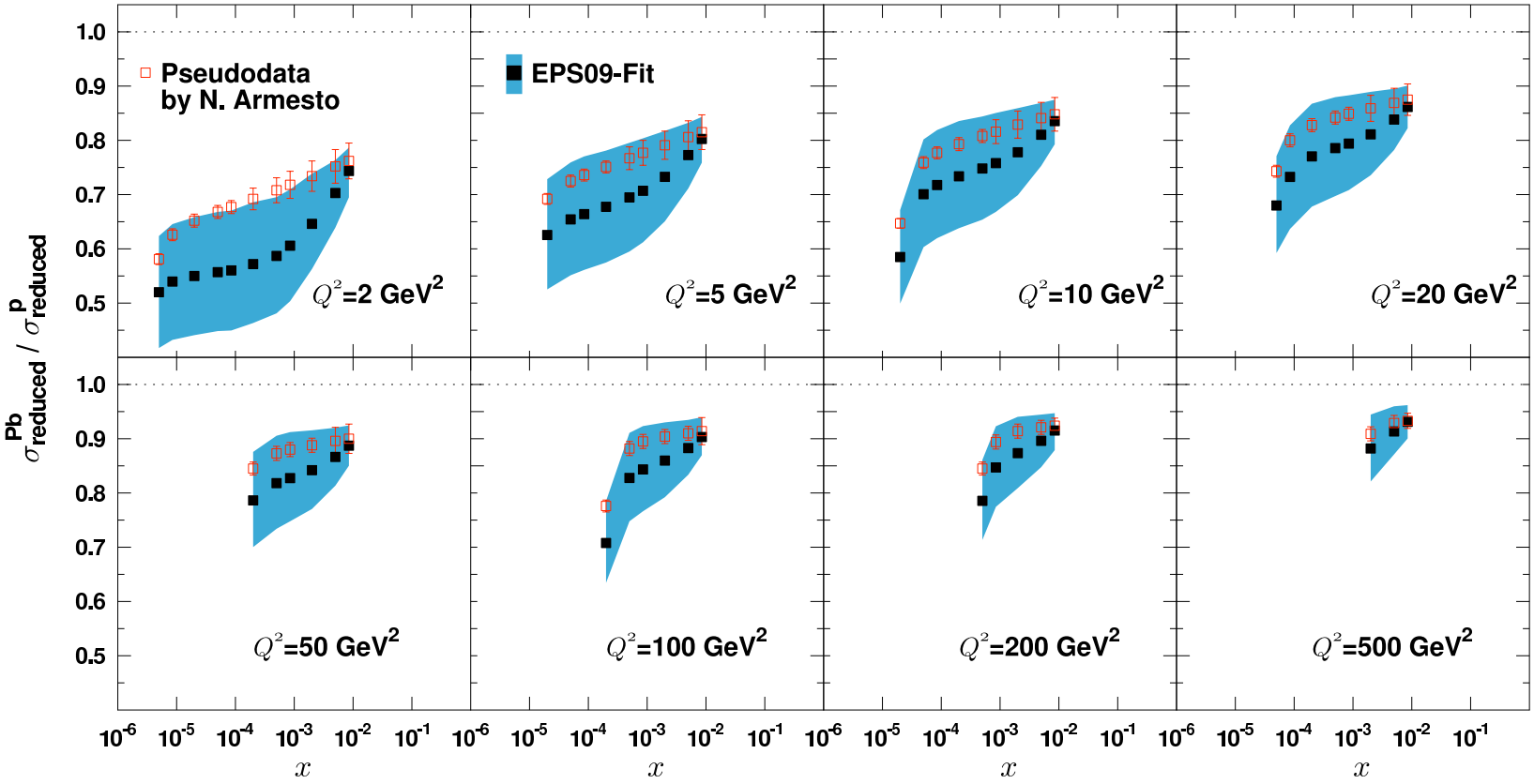

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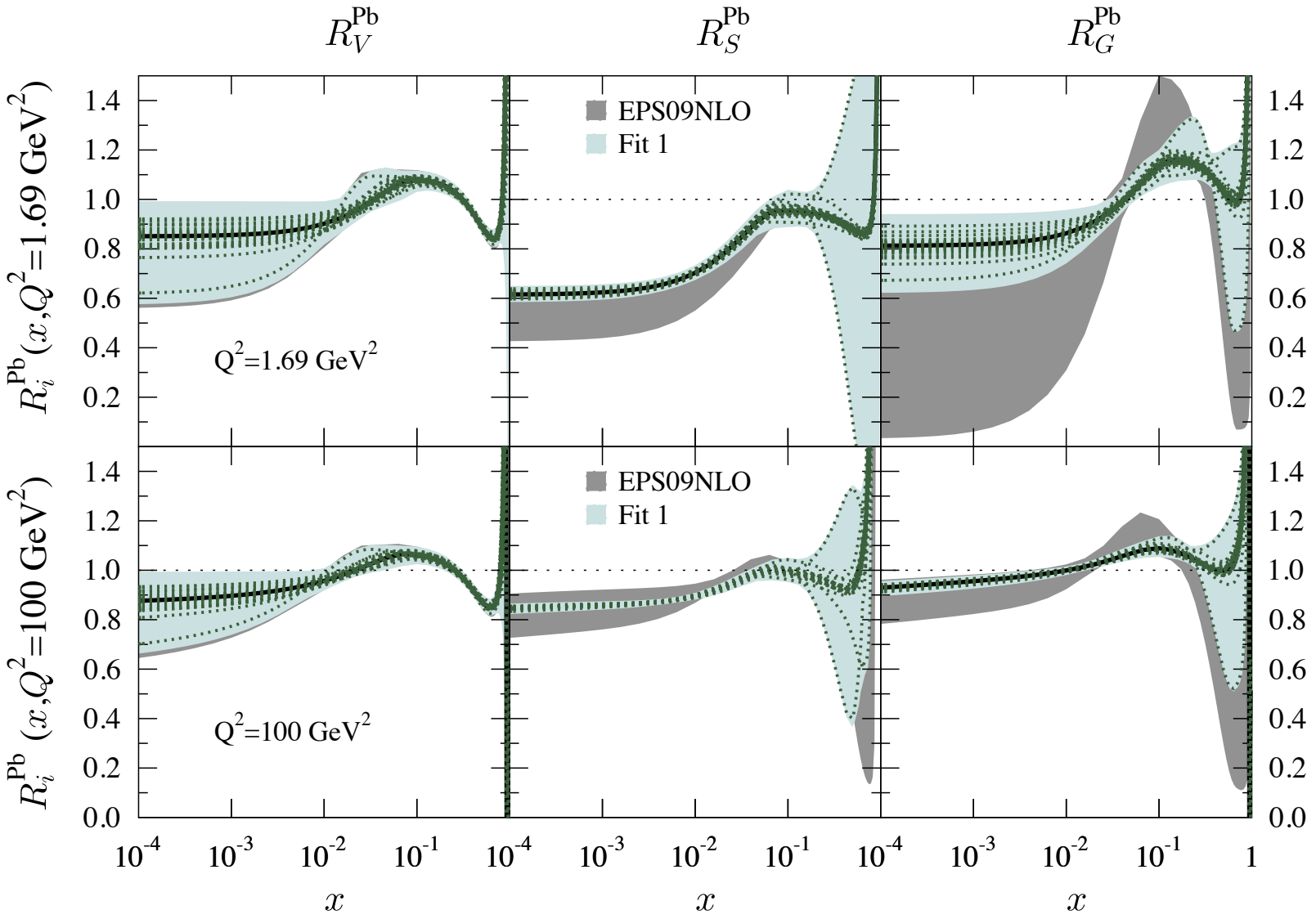
Fit after including the LHeC pseudodata



⇒ Clear improvement, especially at small-x and for gluons - Fit 1

Results of the fit with LHeC pseudodata

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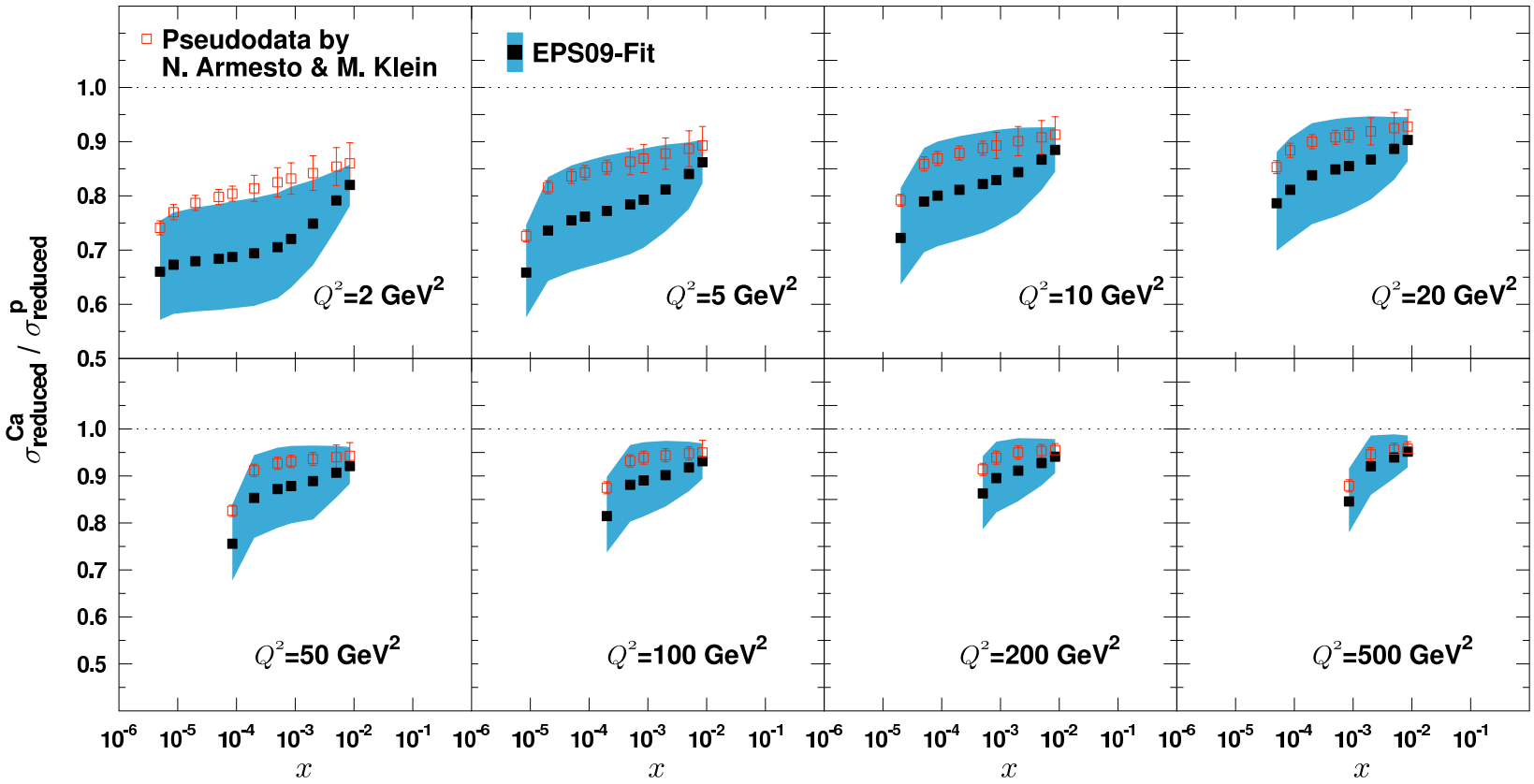

⇒ Pseudodata fitted within the EPS09 framework

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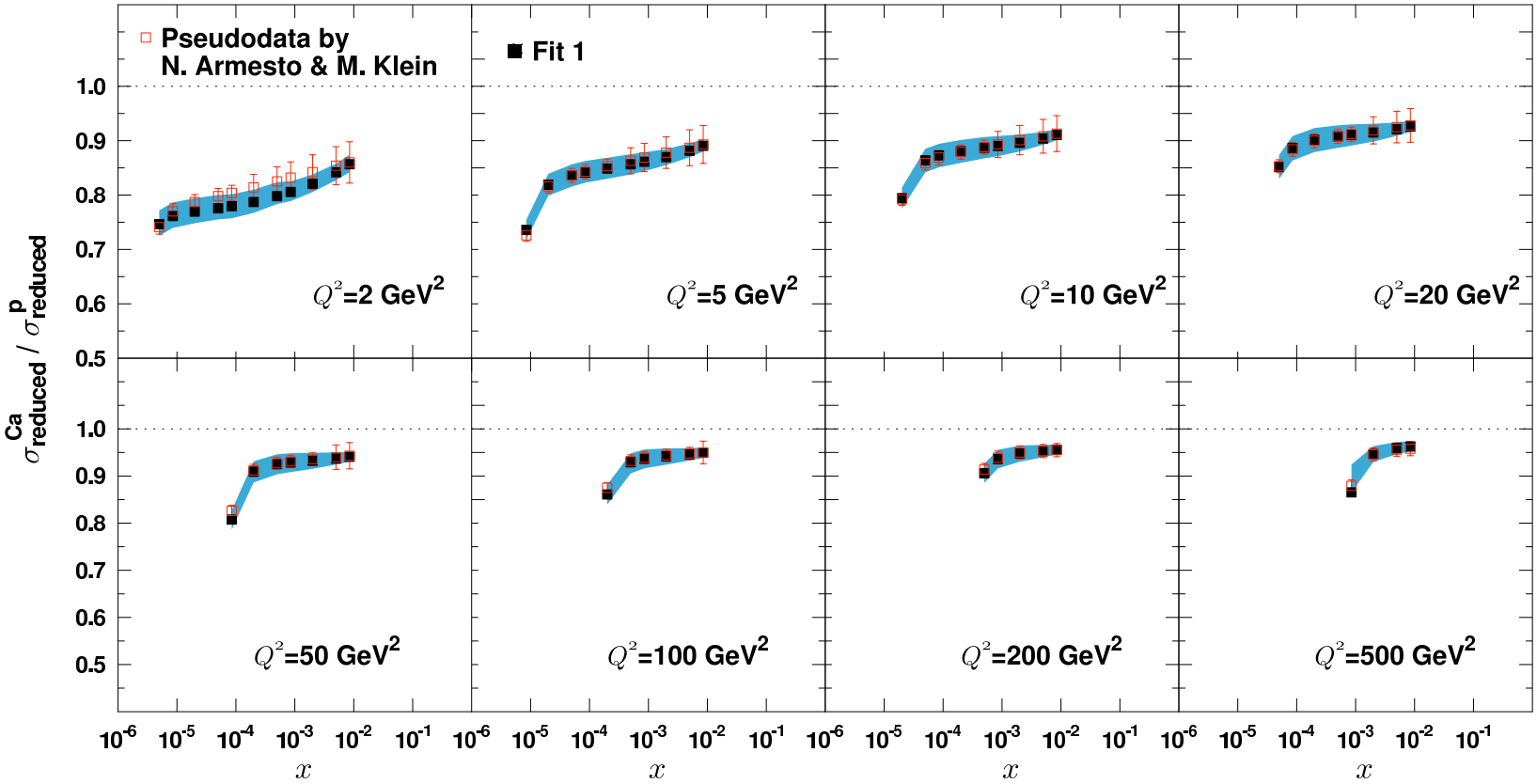

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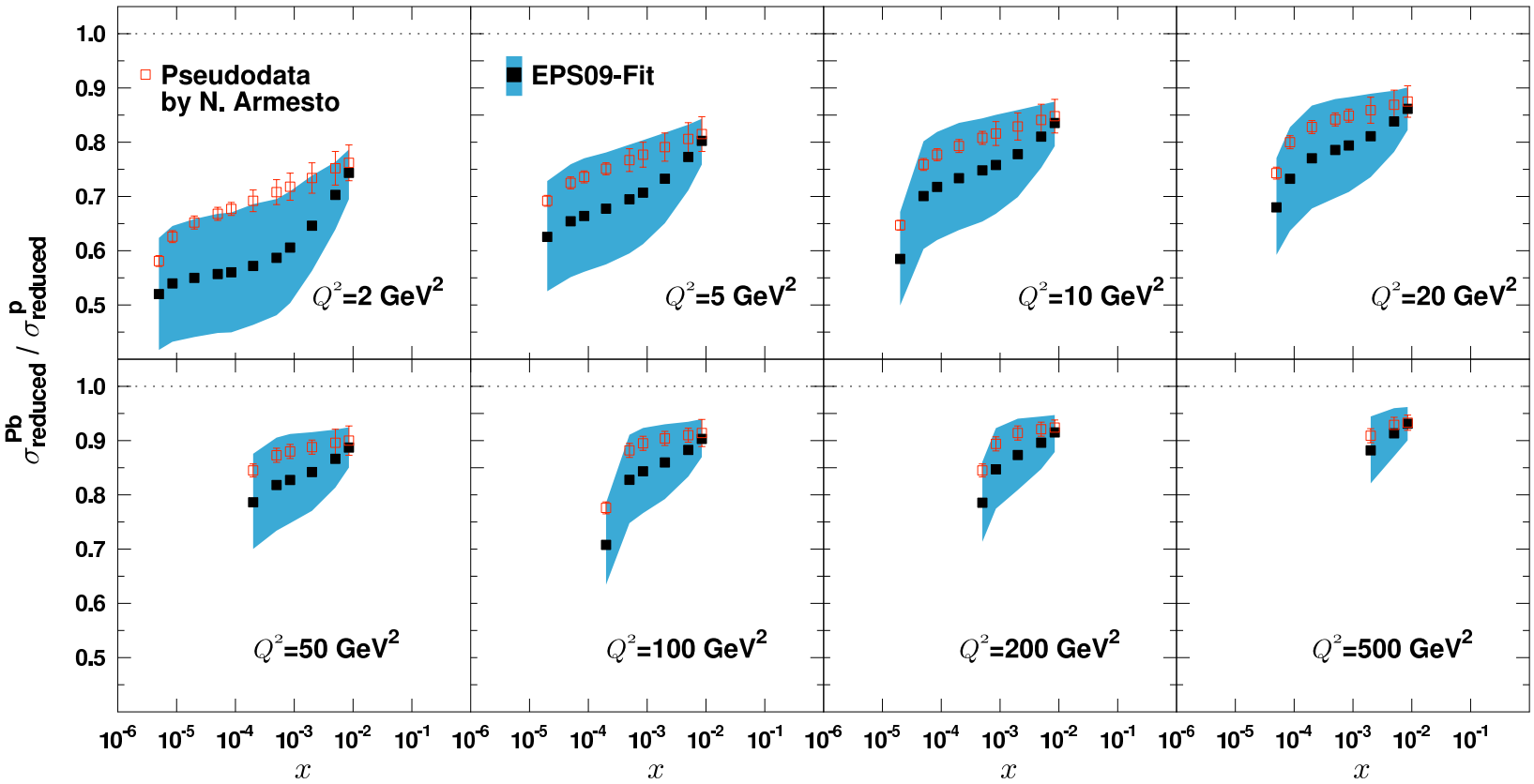

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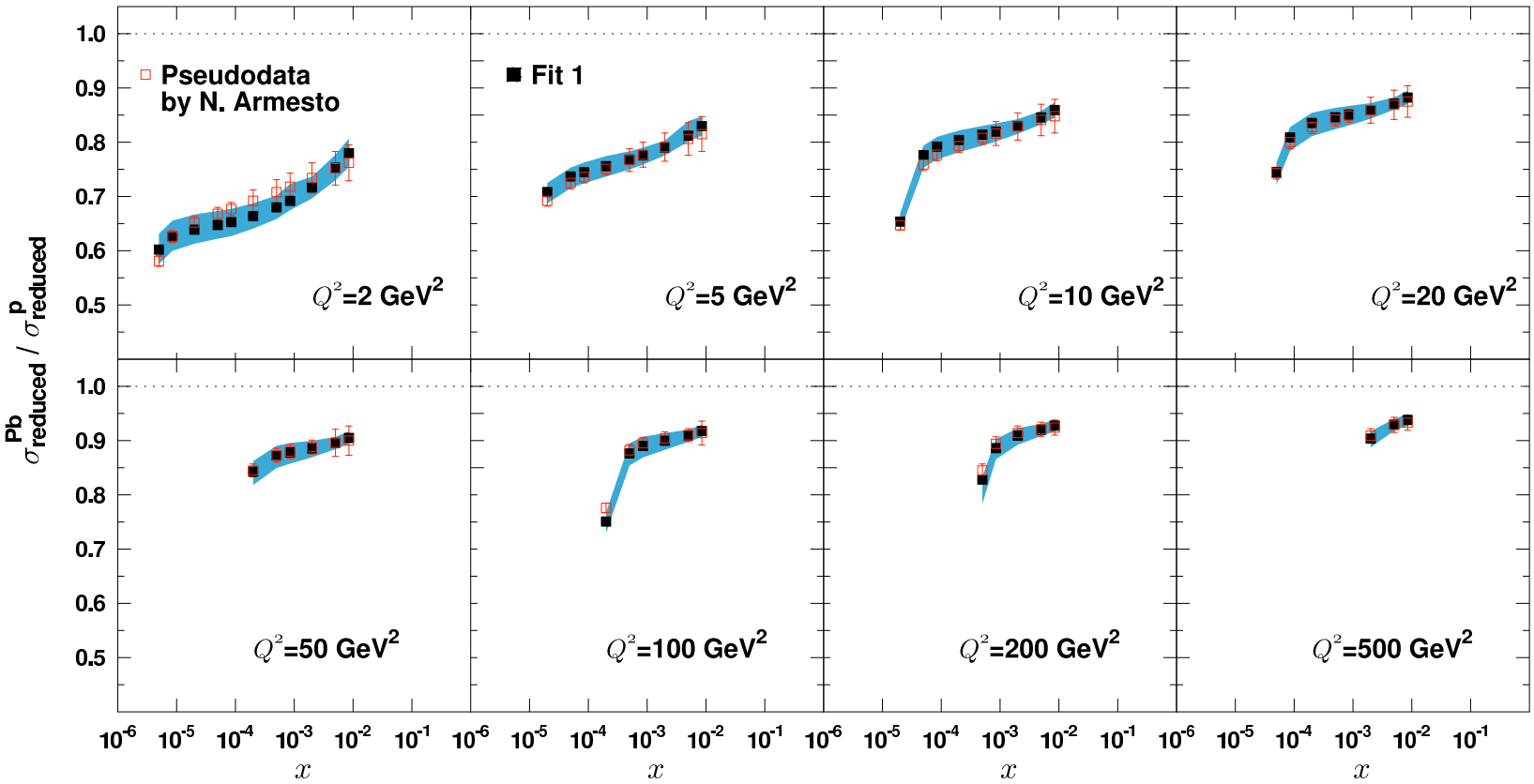

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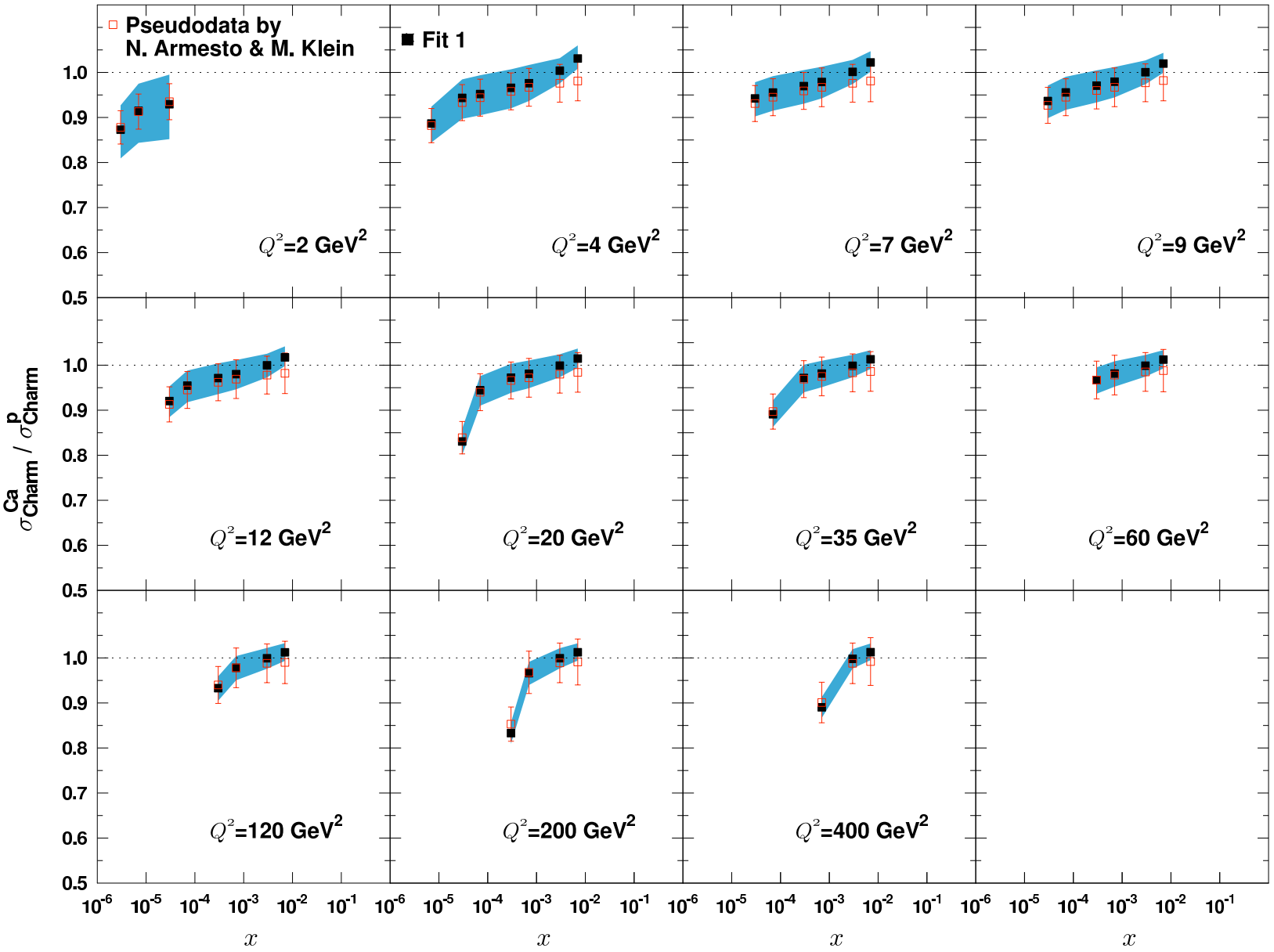
Pseudodata for charm and bottom



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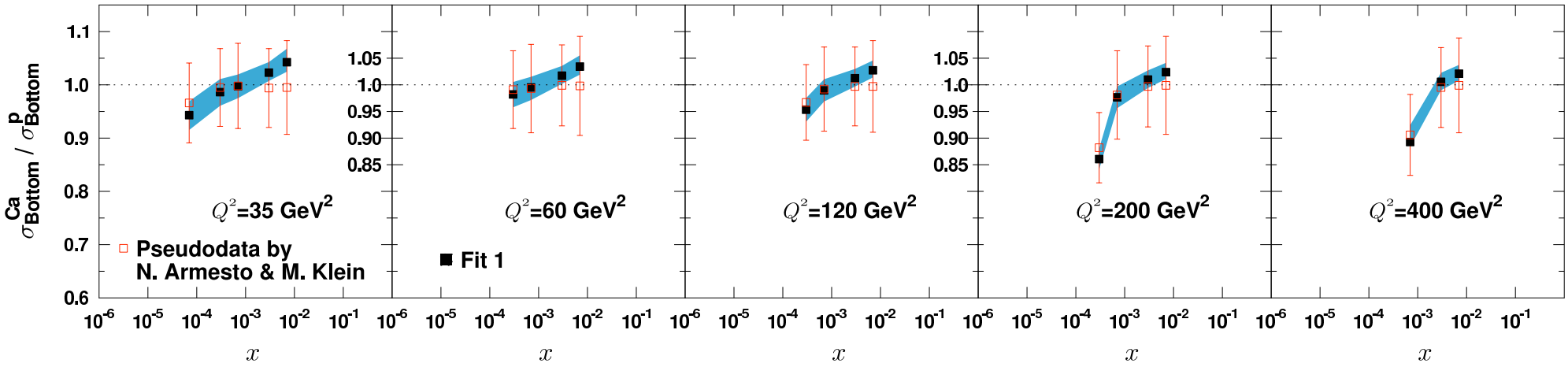
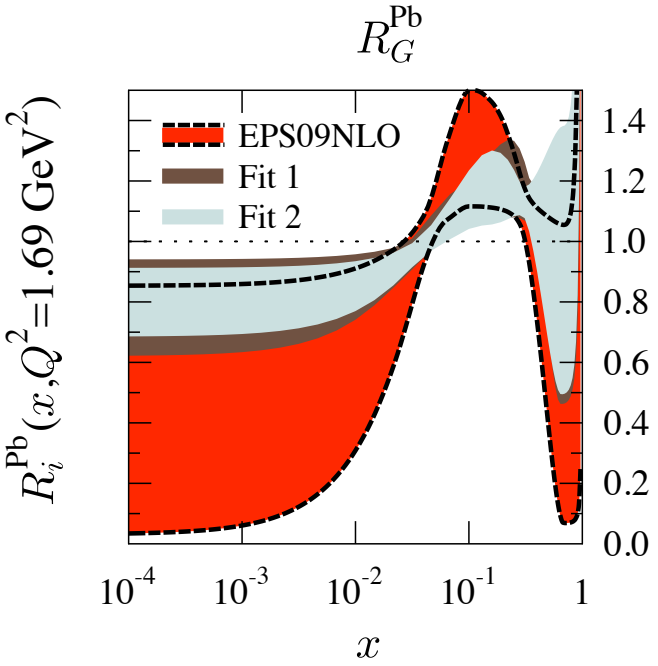
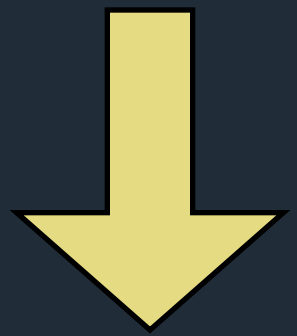


- Flavour decomposition
- Provides further constrains for gluons
- Not very large improvement (for this particular model)



Summary nPDFs

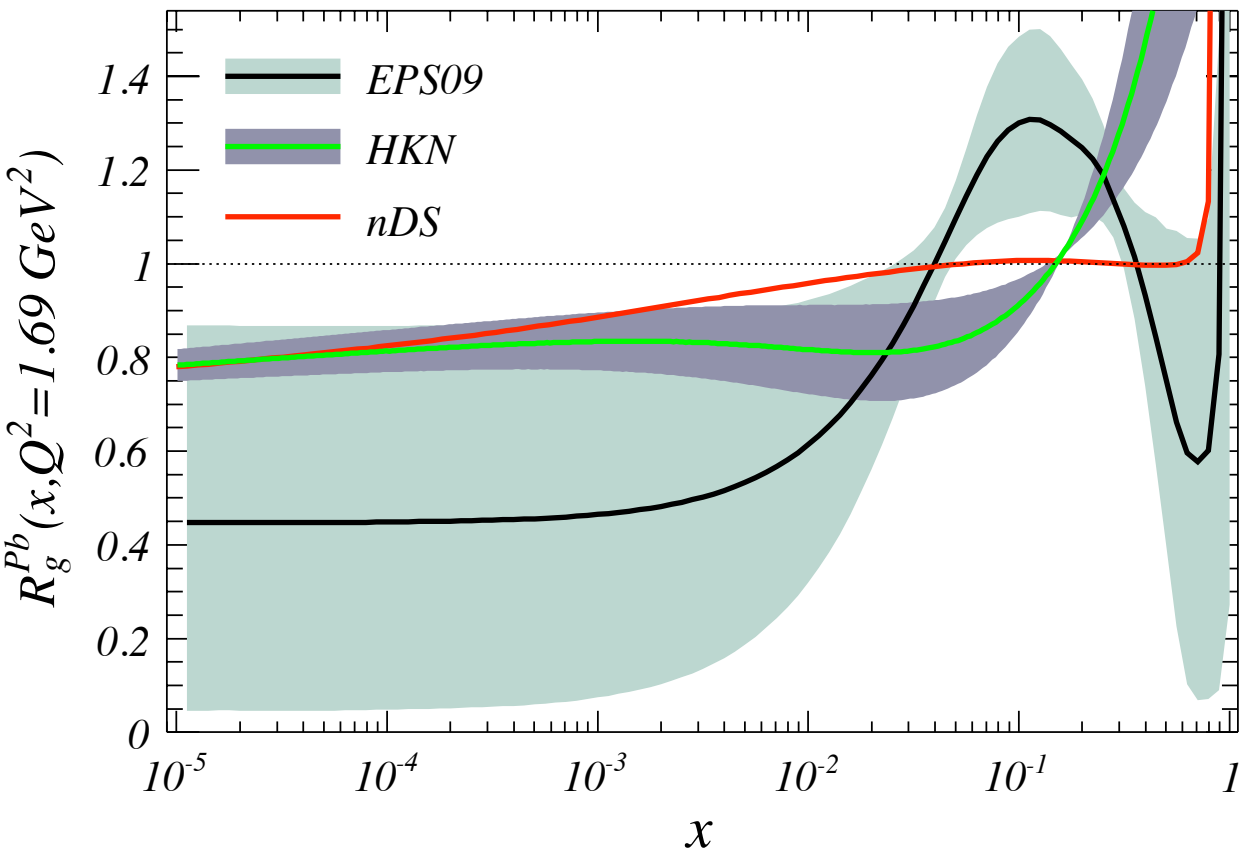
- *Huge uncertainties at small-x, specially for gluons*
- *Factorization checked in a number of observables*



Huge improvements at the LHeC

Title

Uncertainties in nuclear PDFs



Latest NLO sets of nuclear PDFs

nDS [de Florian, Sassot, 2003]

HKN [Hirai, Kumano, Nagai, 2007]

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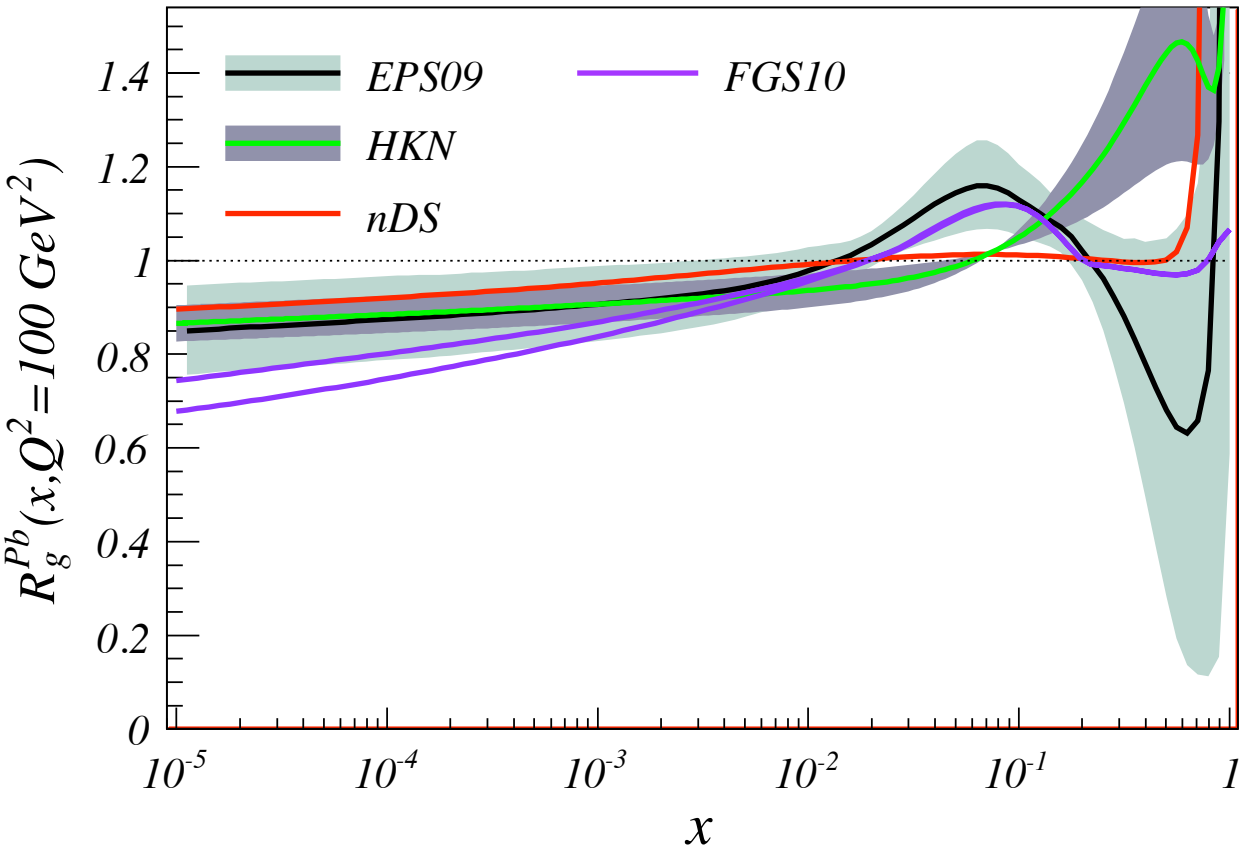

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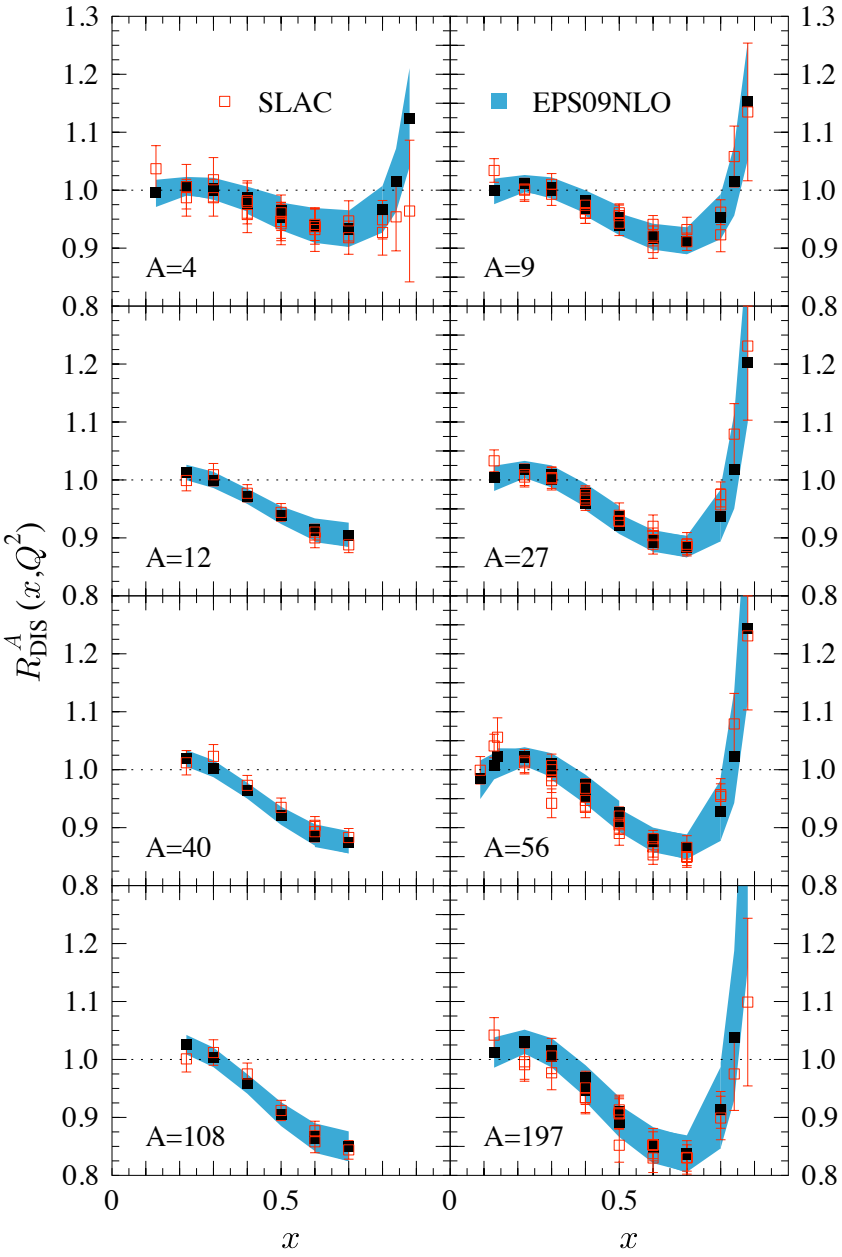
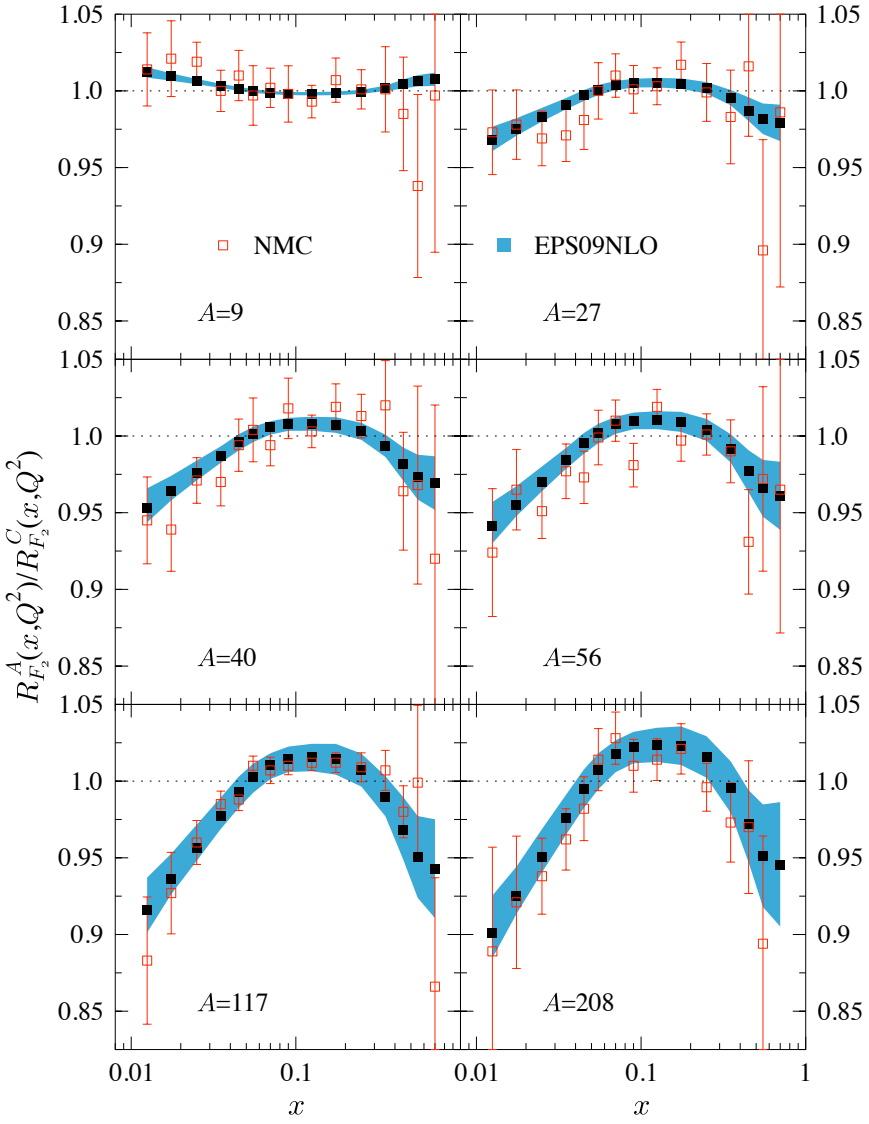
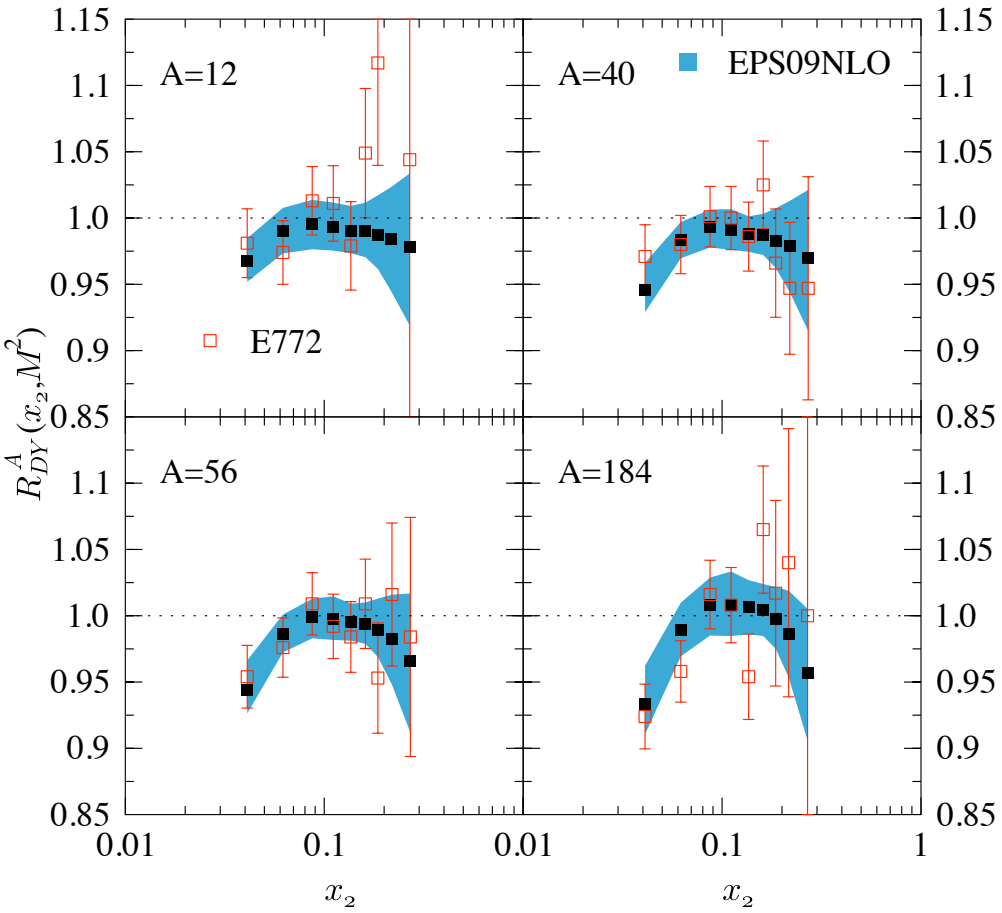
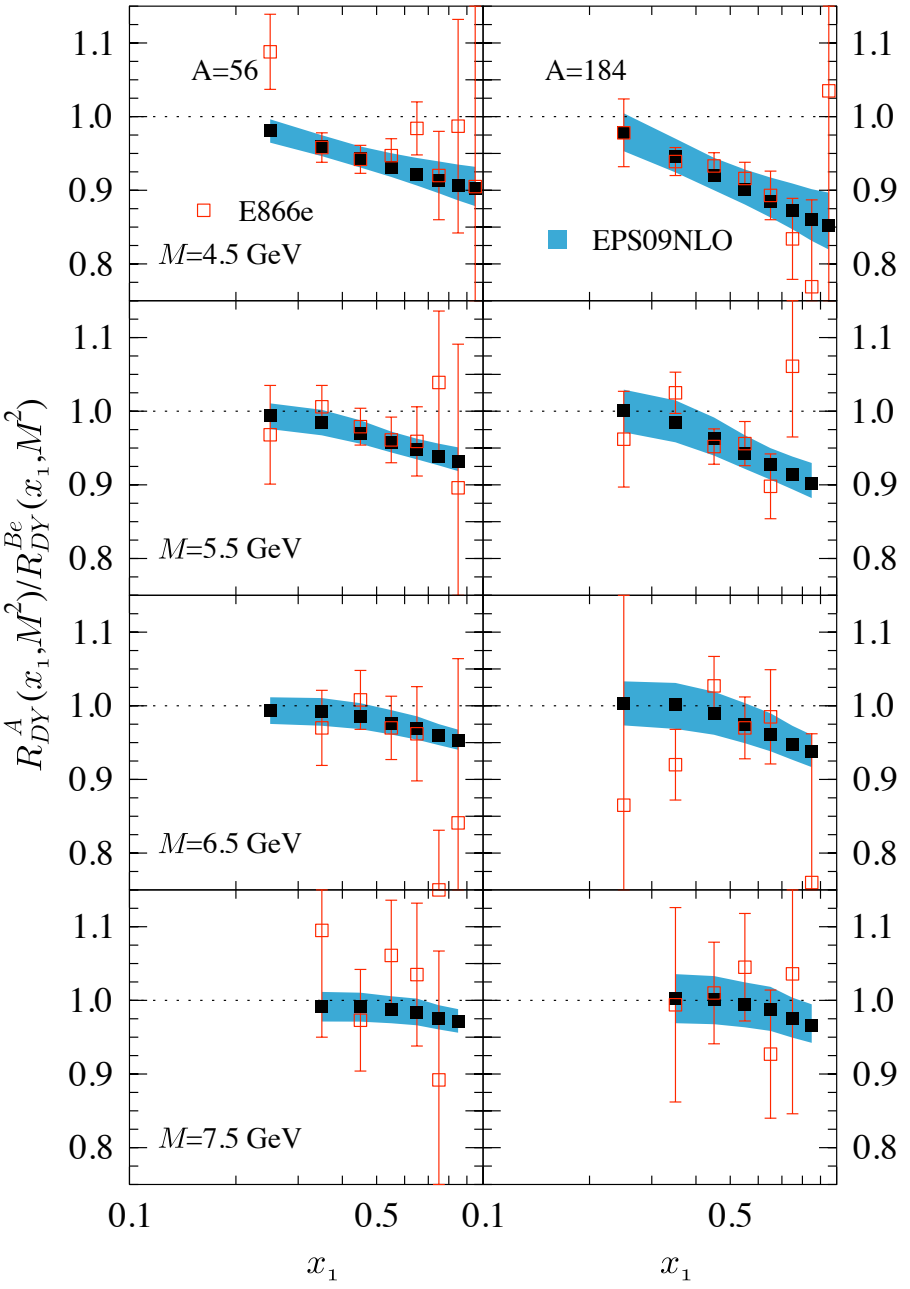
Description of the data: DIS





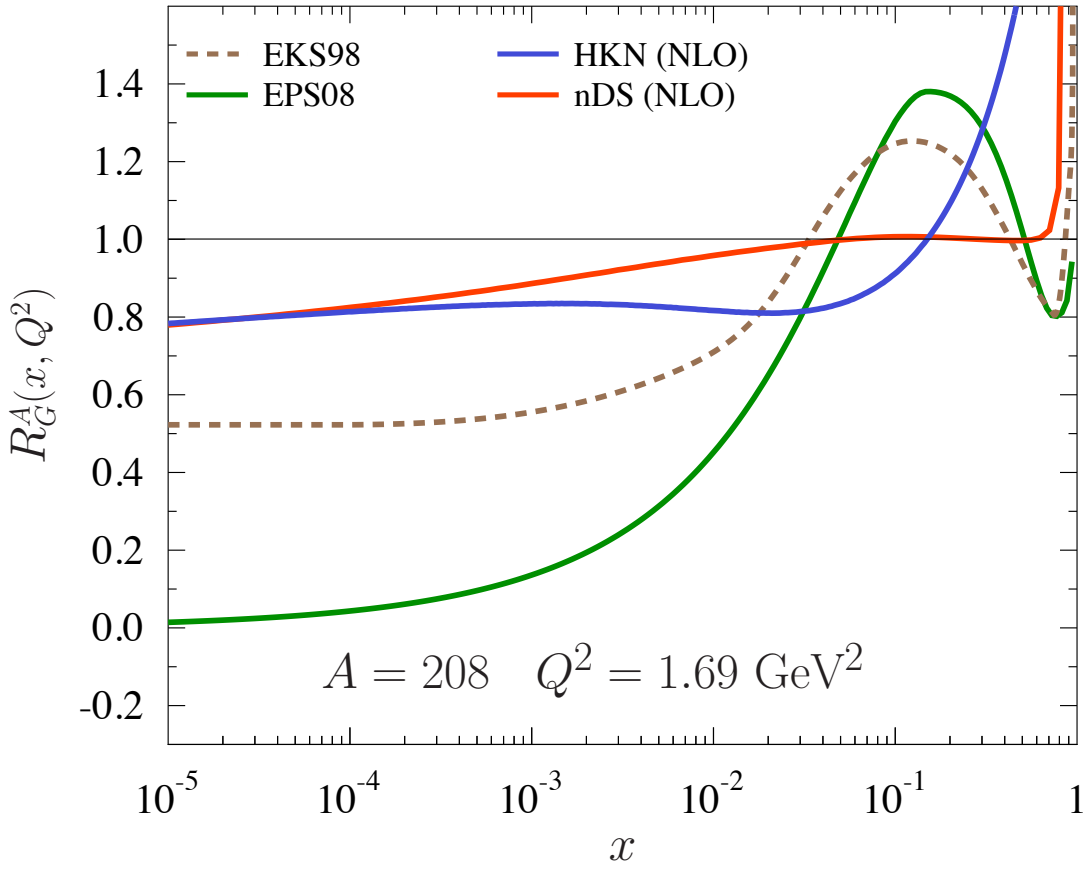
Description of the data: DY





DGLAP evolution of the ratios

Ratios for gluons and Pb nuclei



⇒ The DGLAP evolution removes the nuclear effects very efficiently

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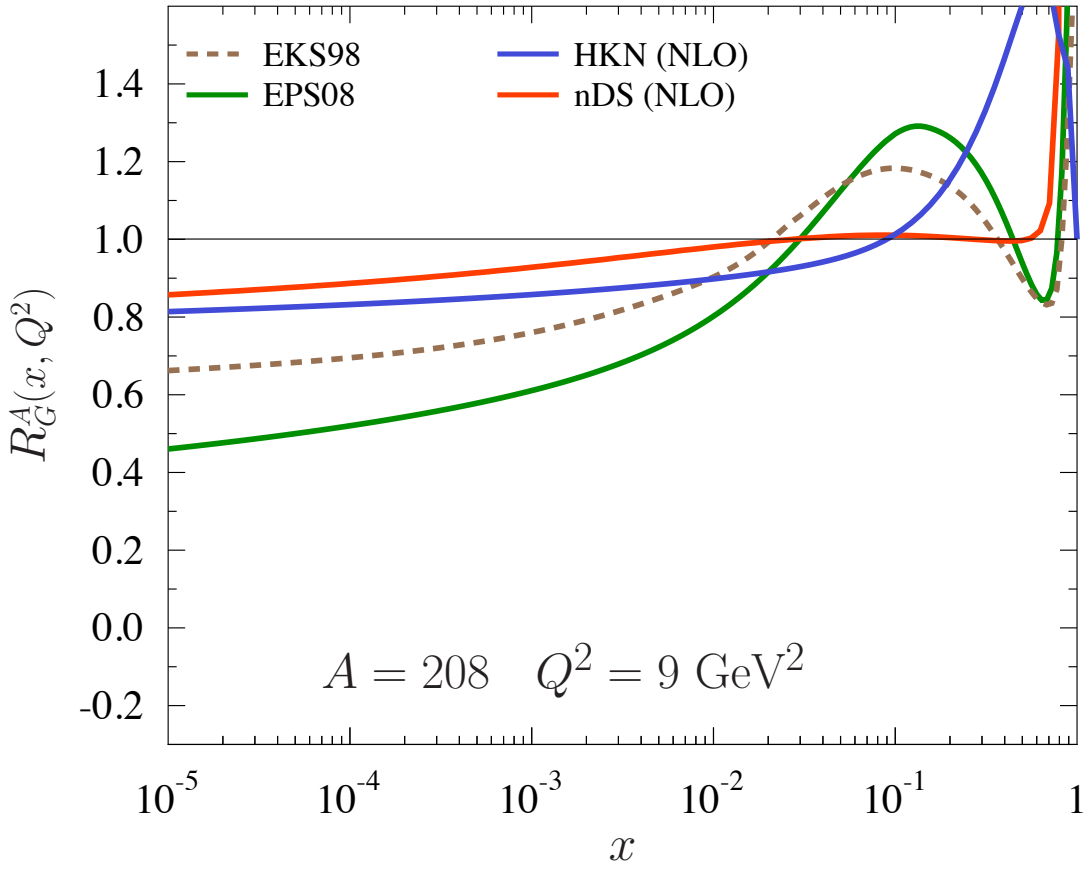

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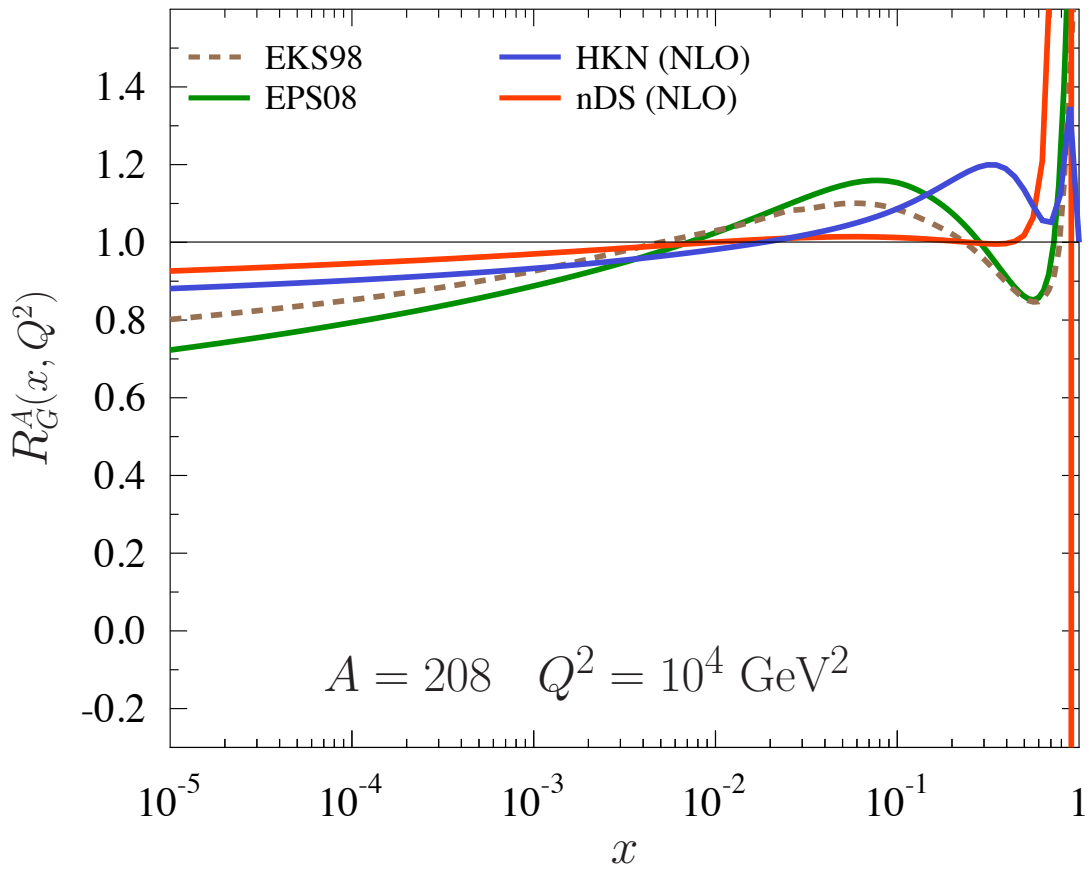

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