

# EPS09s and EKS98s: Impact parameter dependent nPDF sets

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# Nuclear Parton Distribution Functions (nPDFs)

## Collinear Factorization:

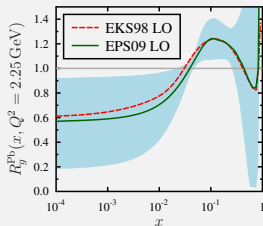
$$dN^{AB \rightarrow k+X}(\mathbf{b}) = T_{AB}(\mathbf{b}) \sum_{i,j,X'} f_i^A(x, Q^2) \otimes f_j^B(x, Q^2) \otimes d\hat{\sigma}^{ij \rightarrow k+X'}$$

## Nuclear Modification of the PDFs

- Bound nucleon PDFs  $\neq$  free proton PDFs

$$f_i^A(x, Q^2) = R_i^A(x, Q^2) \cdot f_i^N(x, Q^2)$$

- $R_i^A(x, Q^2)$  determined via global analyses
  - EKS98 (LO DGLAP evolution)
  - EPS09 (LO and NLO + error sets)



- So far, no spatial dependence in the globally fitted nPDFs!
- ⇒ Centrality dependence of the cross sections?

# Framework

## Nuclear modifications with spatial dependence

- We replace

$$R_i^A(x, Q^2) \rightarrow r_i^A(x, Q^2, \mathbf{s}),$$

where  $\mathbf{s}$  = the transverse position of the nucleon

- Definition

$$R_i^A(x, Q^2) \equiv \frac{1}{A} \int d^2\mathbf{s} T_A(\mathbf{s}) r_i^A(x, Q^2, \mathbf{s}),$$

where  $R_i^A(x, Q^2)$  is taken from EKS98 or EPS09 global fits

- Assumption:** spatial dependence related to  $T_A(\mathbf{s})$  as follows:

$$r_i^A(x, Q^2, \mathbf{s}) = 1 + \sum_{j=1}^n c_j^i(x, Q^2) [T_A(\mathbf{s})]^j$$

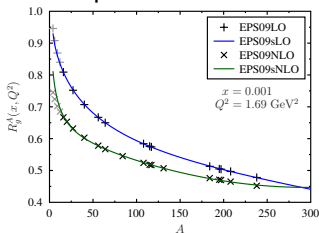
- Important:** No  $A$ -dependence in the fit parameters  $c_j(x, Q^2)$

# Fitting Procedure

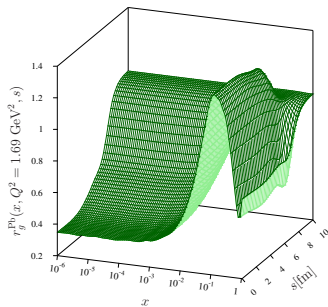
Parameters  $c_j(x, Q^2)$  obtained by minimizing the  $\chi^2$

$$\chi_i^2(x, Q^2) = \sum_A \left[ \frac{R_i^A(x, Q^2) - \frac{1}{A} \int d^2\mathbf{s} T_A(\mathbf{s}) r_i^A(x, Q^2, \mathbf{s})}{W_i^A(x, Q^2)} \right]^2$$

- $A$ -dependence of  $R_i^A(x, Q^2)$  well reproduced with  $n = 4$ :



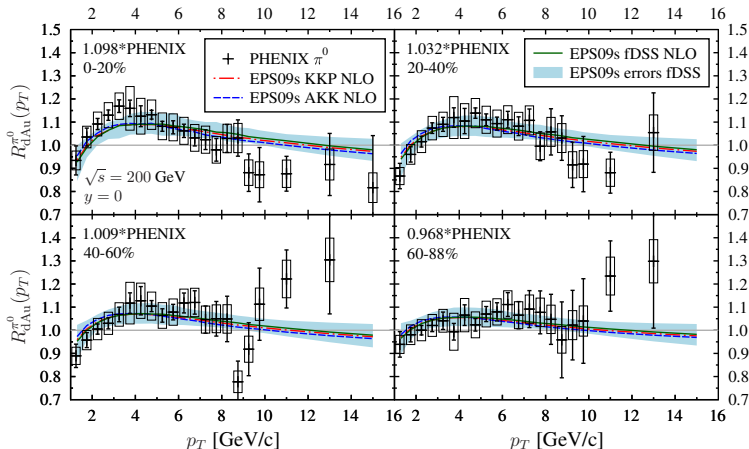
- Fitting is done also for the EPS09 error sets (LO&NLO)



**Outcome:** Spatially dependent nPDF sets **EPS09s** and **EKS98s**

# d+Au collisions at RHIC (run 3)

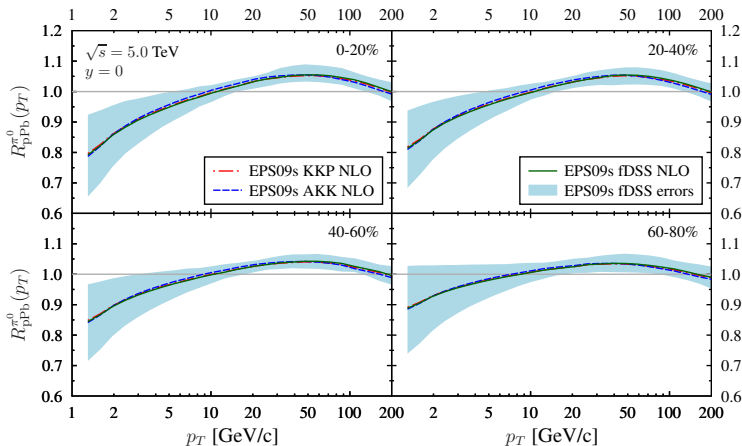
$R_{dAu}$  for  $\pi^0$  production at  $y = 0$  in different centrality classes in NLO (calculated with INCNLO) (PHENIX:  $|\eta| < 0.35$ )



- Within uncertainties, good agreement with the data

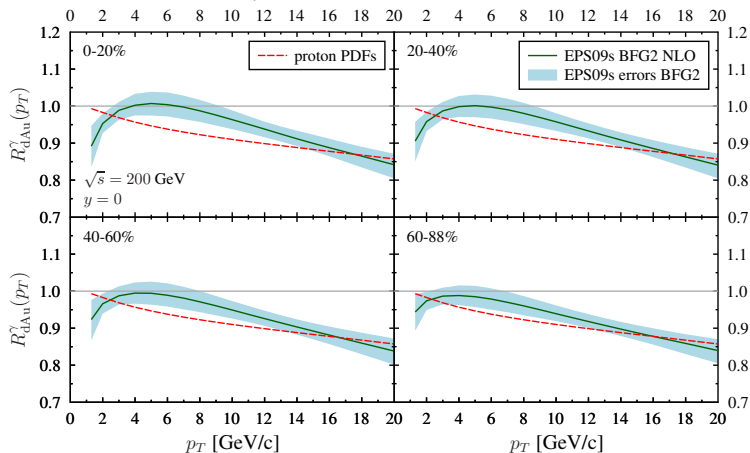
# p+Pb collisions at LHC

$R_{pPb}$  for  $\pi^0$  production at  $y = 0$  in different centrality classes in NLO (calculated with INCNLO)



# Inclusive Photons in d+Au

$R_{dAu}$  for inclusive (direct+fragmentation) photon production at  $y = 0$  in different centrality classes in NLO (preliminary results, calculated with INCNLO)



# Summary

## We have

- Determined new spatially dependent nPDF sets **EPS09s** and **EKS98s** based on
  - $A$ -dependence of the globally fitted nPDFs (EPS09 and EKS98)
  - Power series ansatz in  $T_A(s)$
- Published these at our web page:  
<https://www.jyu.fi/fysiikka/en/research/highenergy/urhic/nPDFs>
- Calculated  $R_{dAu}$  for neutral pion and inclusive photon production at RHIC and  $R_{pPb}$  for neutral pion production at LHC in different centrality classes