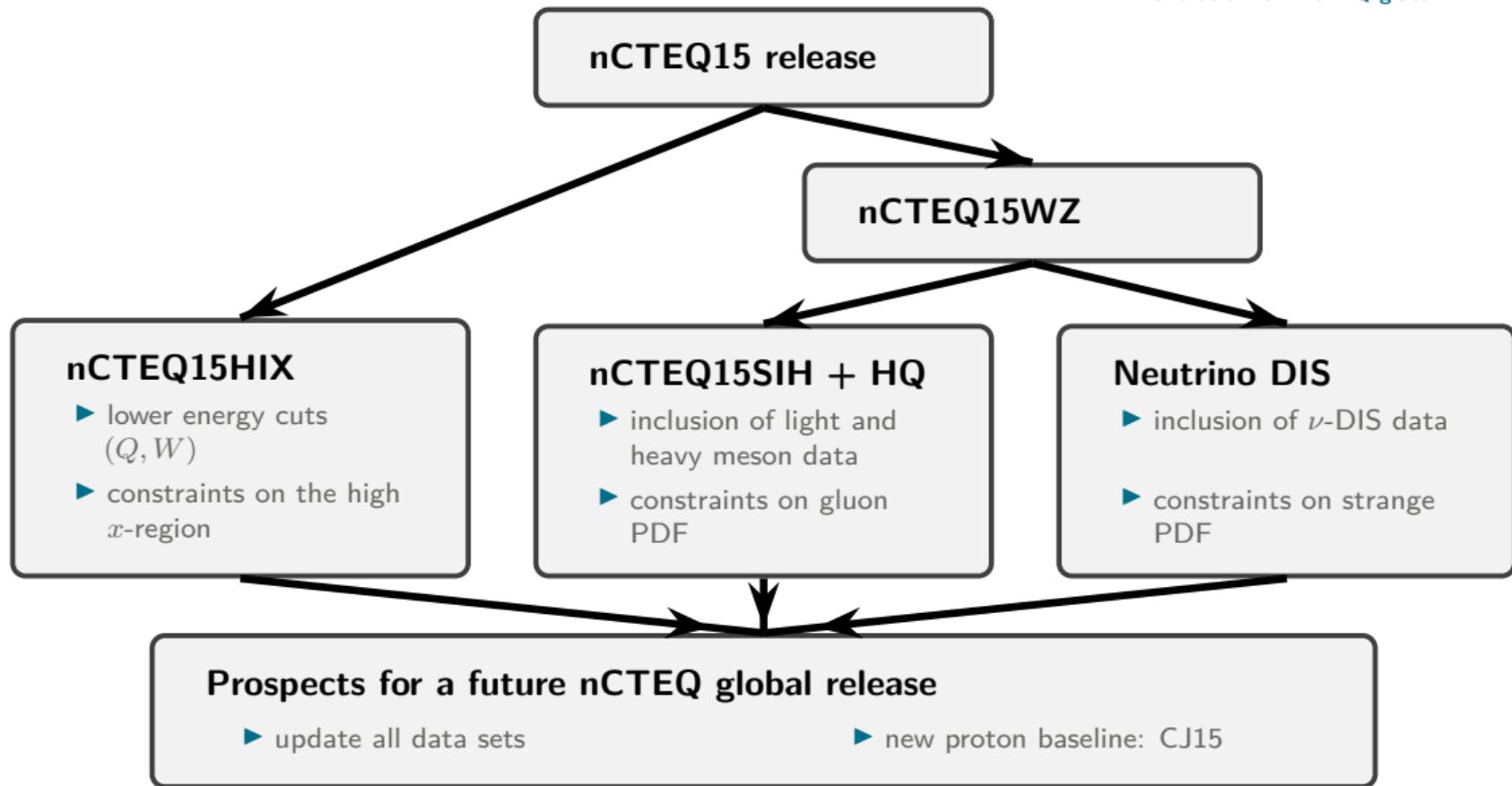


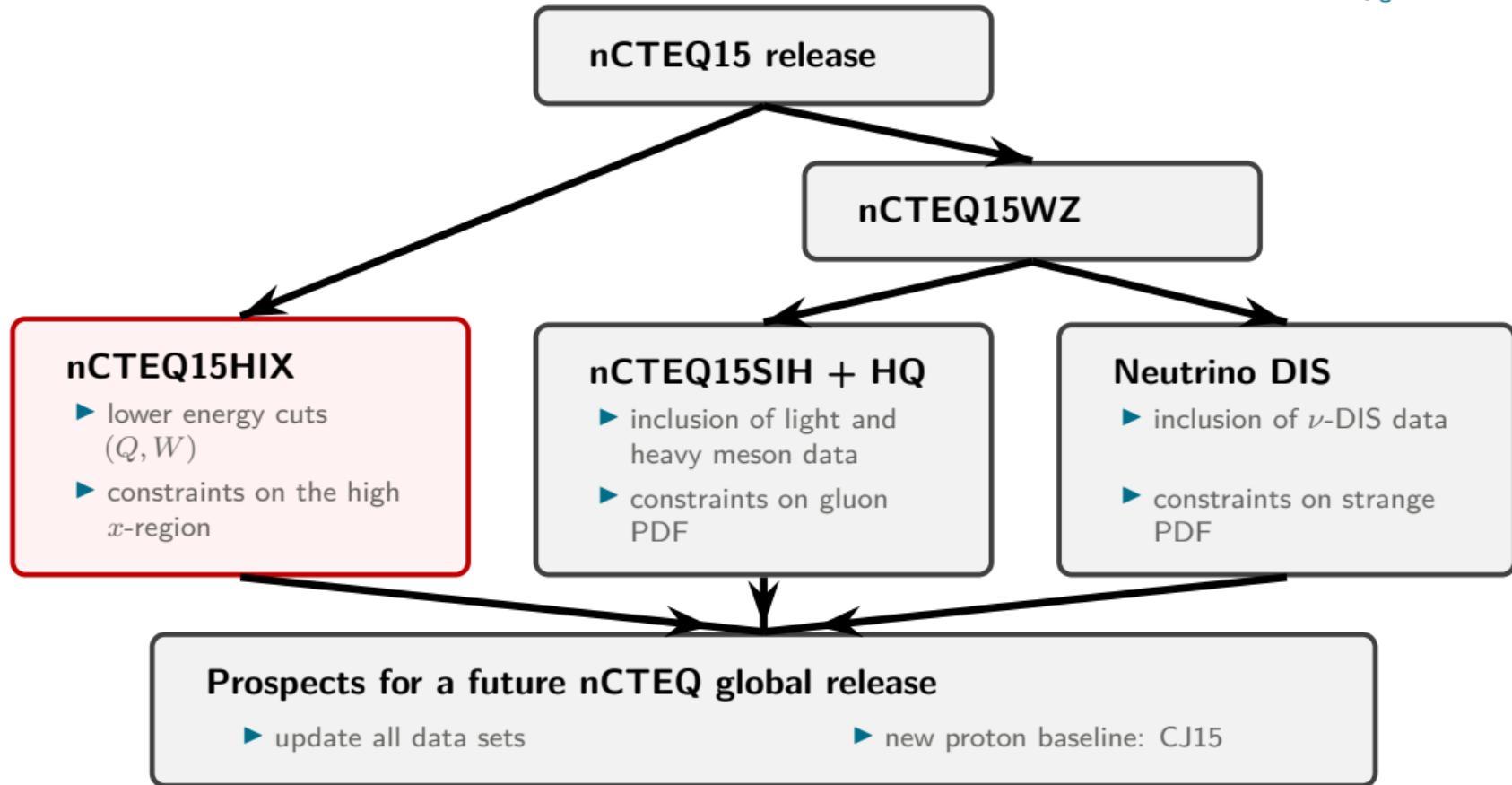
# Towards a New nCTEQ global nPDF Release

DIS 2023 – Michigan State University

Peter Risse (risse.p@uni-muenster.de)







# Motivation – Lowering the data cuts

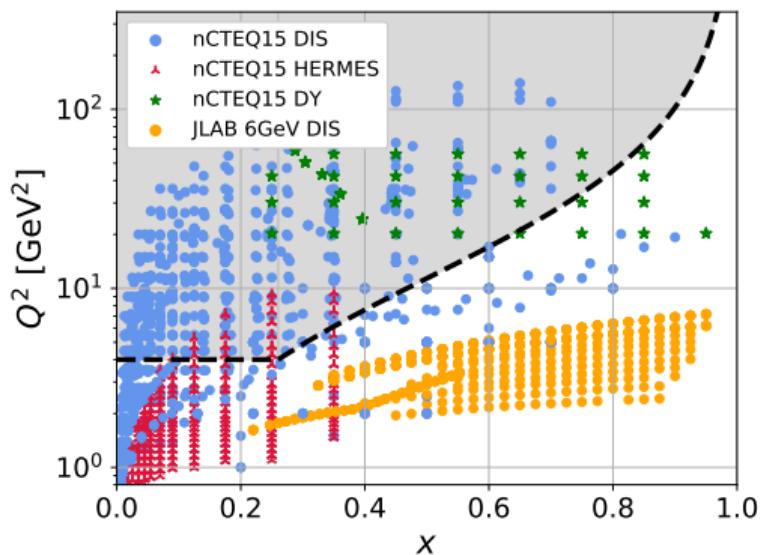
Segarra *et al*, arXiv:2012.11566

Why are we interested in lowering the data cuts?

**OLD:  $Q = 2 \text{ GeV}$  and  $W = 3.5 \text{ GeV}$**

- ▶ data points: 708

- ▶ a lot of data points are excluded i.e.
  - ▶ data from JLab
  - ▶ most data from HERMES



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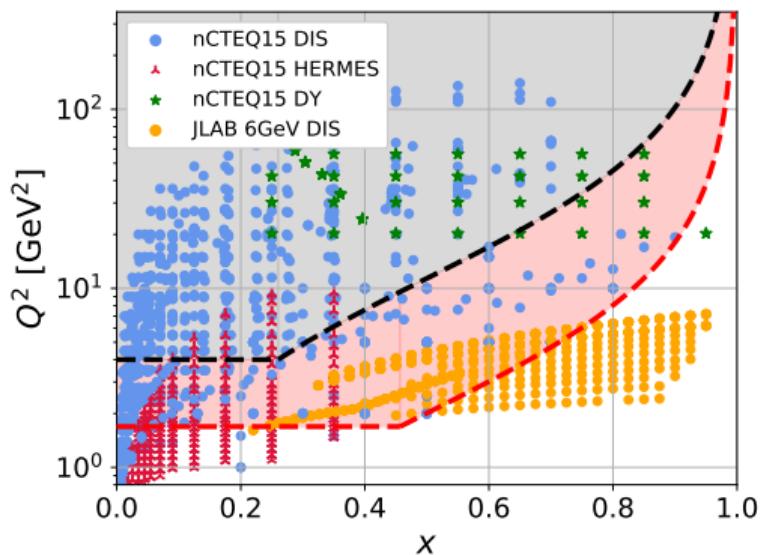
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**NEW:  $Q = 1.3 \text{ GeV}$  and  $W = 1.7 \text{ GeV}$**

- ▶ data points: 1564

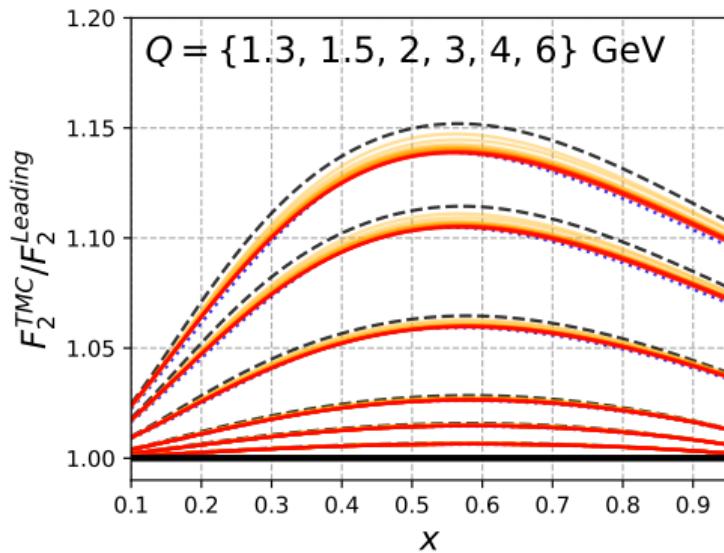


# Effects at lower energy

Ruiz *et al*, arXiv:2301.07715

## 1. Target mass corrections

- ▶ need to be investigated for nuclear DIS  
Schienbein (WG1: Mar 28 10:00AM)



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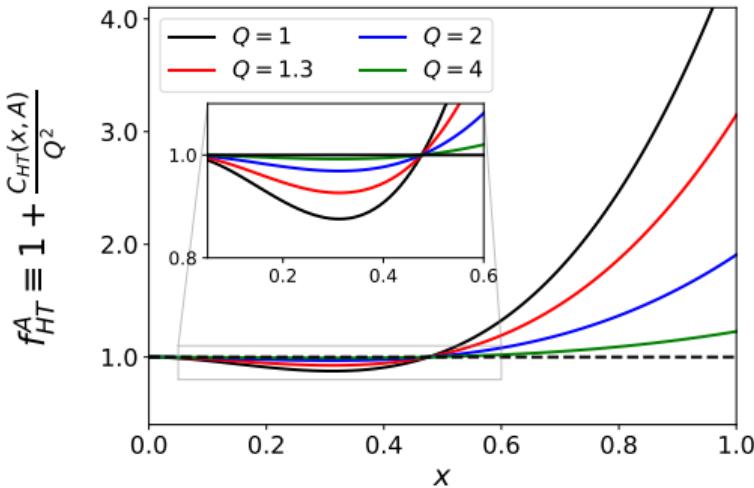
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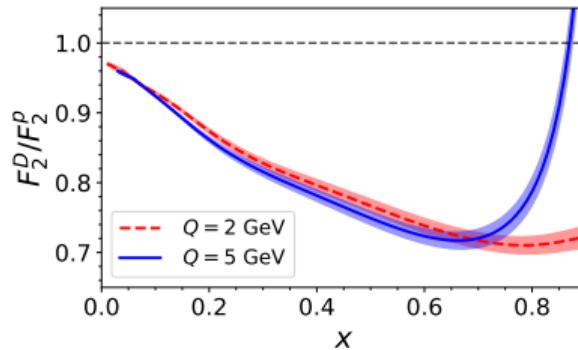


CJ15 analysis: Accardi *et al.*, arXiv:1602.03154

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3. Special treatment of Deuterium
  - ▶ Deuterium is the lightest bound nucleus
  - ▶ differs from heavier target considerably
  - ▶ corrections have been extracted in the CJ15 analysis

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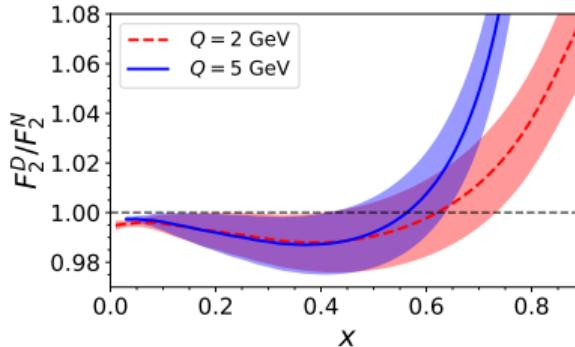
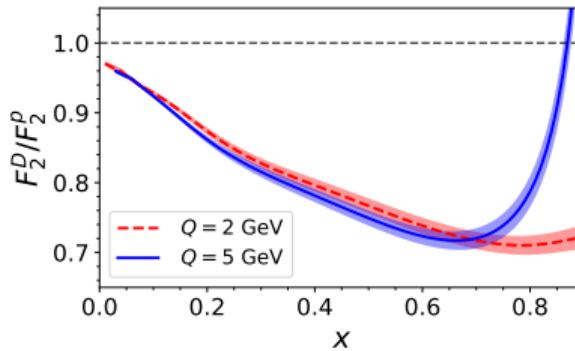
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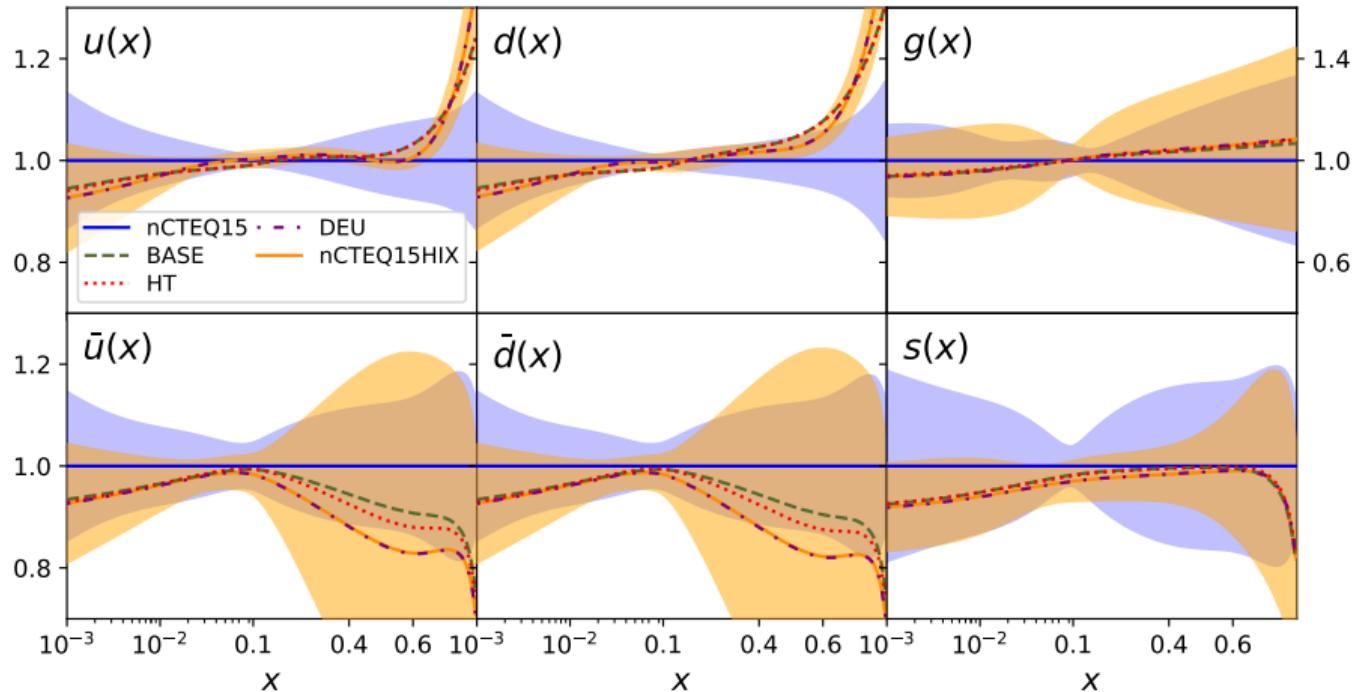
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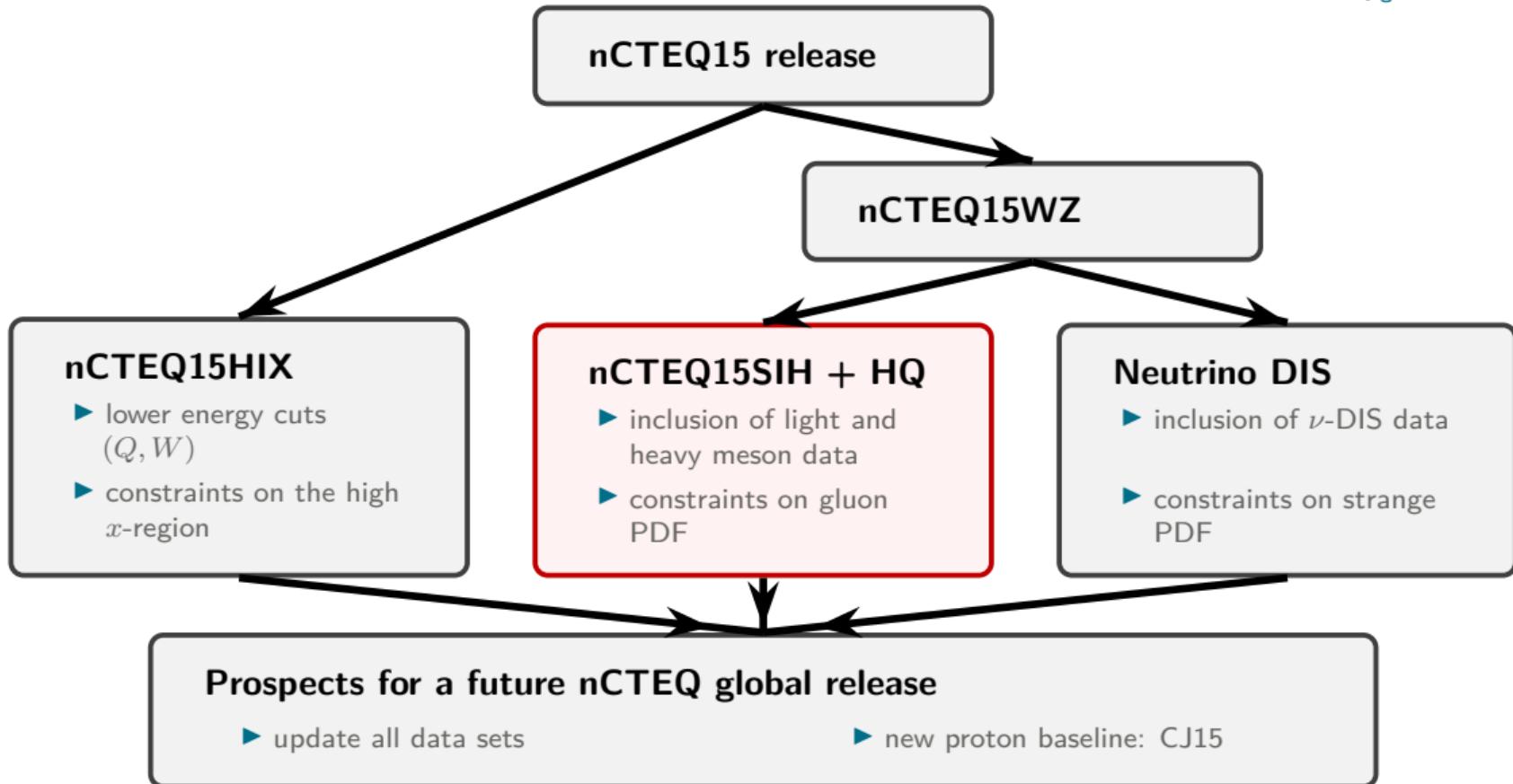
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# nCTEQ15HIX result

Segarra *et al*, arXiv:2012.11566Iron PDF Ratios to nCTEQ15 ( $Q = 2$  GeV)



# Motivation – Light meson production

Duwentäster *et al.*, arXiv:2105.09873

Why are we interested in Single Inclusive Hadron production (SIH) data?

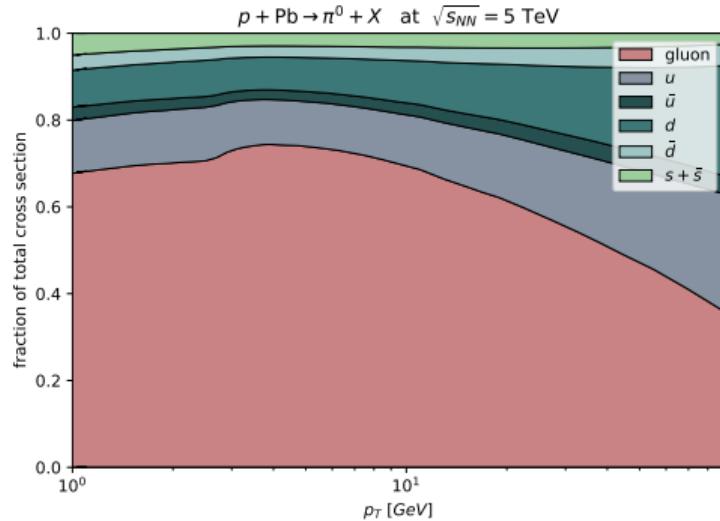
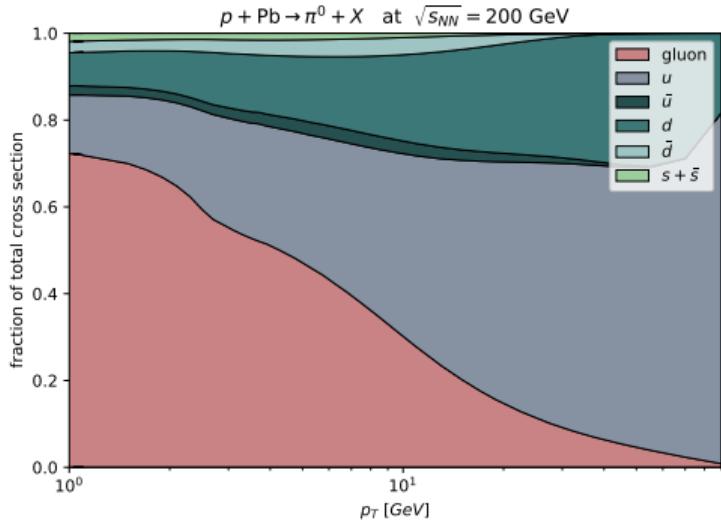
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- ▶ sensitivity to nuclear gluon PDF → **dominates cross section** at high  $\sqrt{s}$  (or low  $p_T$ )

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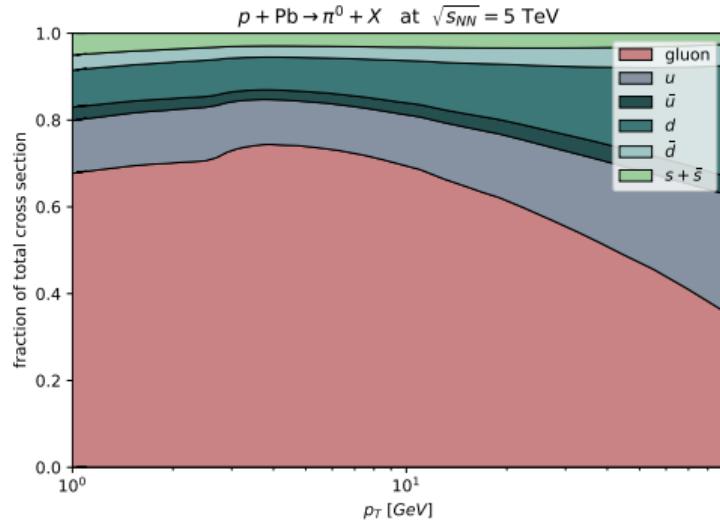
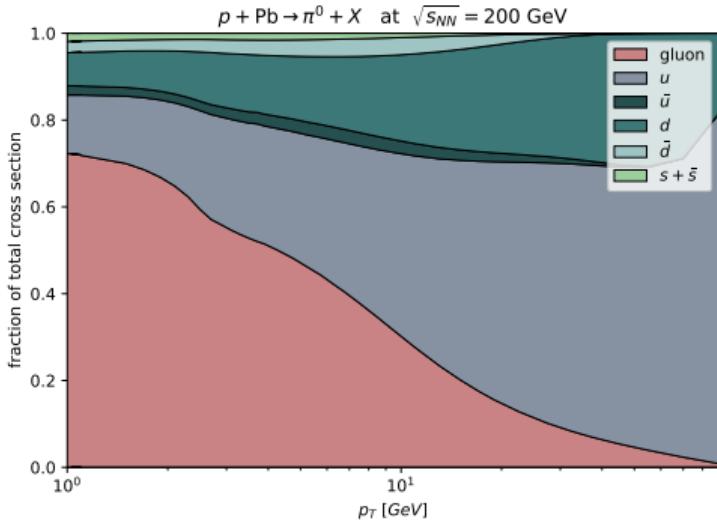


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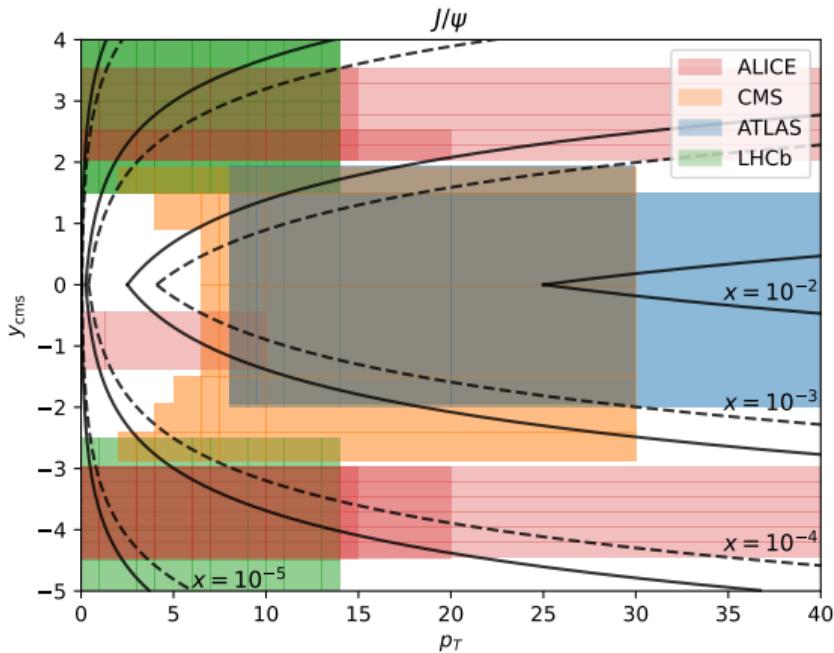
**Challenges?** Fragmentation Function dependence and most precise data at low  $p_T$  (non-perturbative!)

# Motivation – Heavy meson production

Duwentäster *et al*, arXiv:2204.09982

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- ▶ large available data sets from multiple LHC experiments
- ▶ sensitivity to gluon pdf down to **very low**  $x \approx 10^{-5}$  values



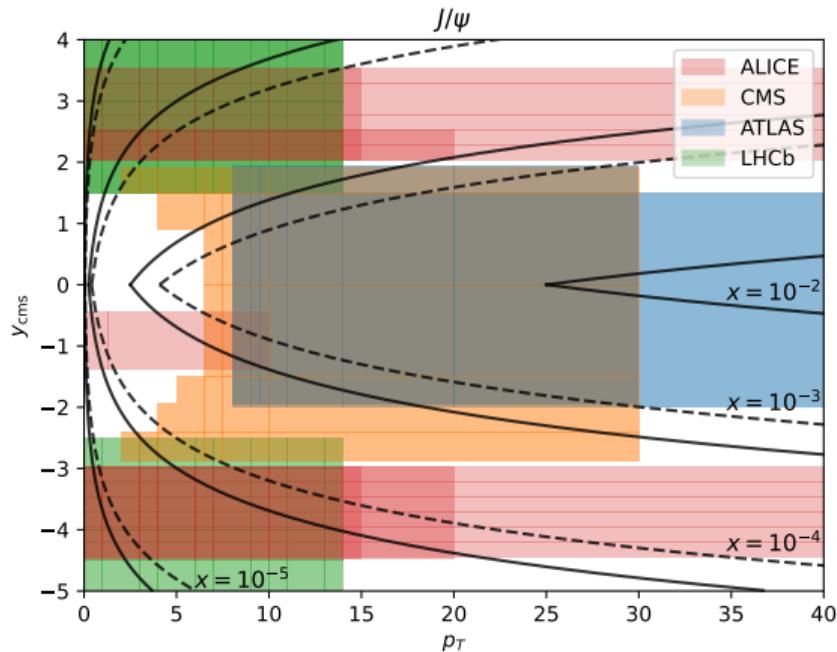
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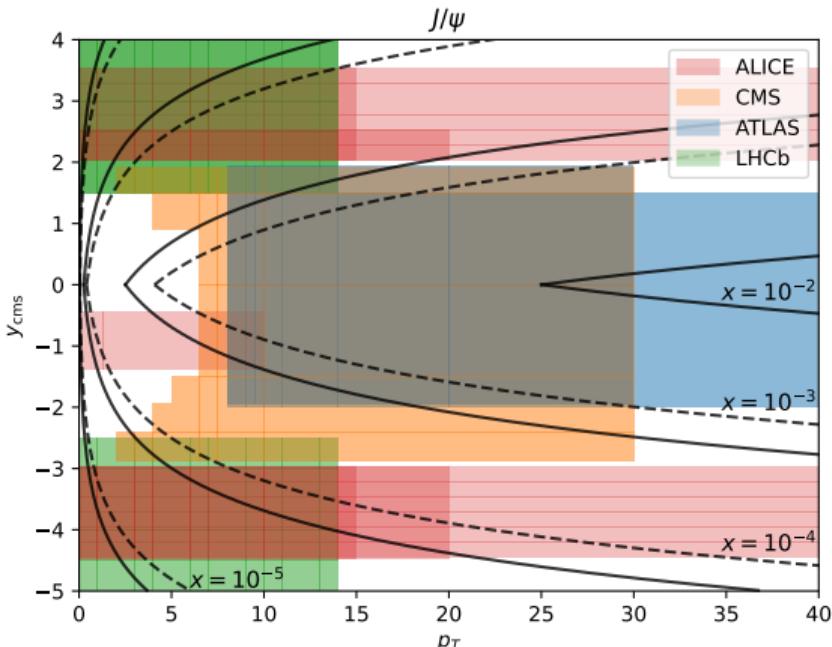
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Kusina *et al.*, PRL 121 (2018) 052004; PRD 104 (2021) 014010

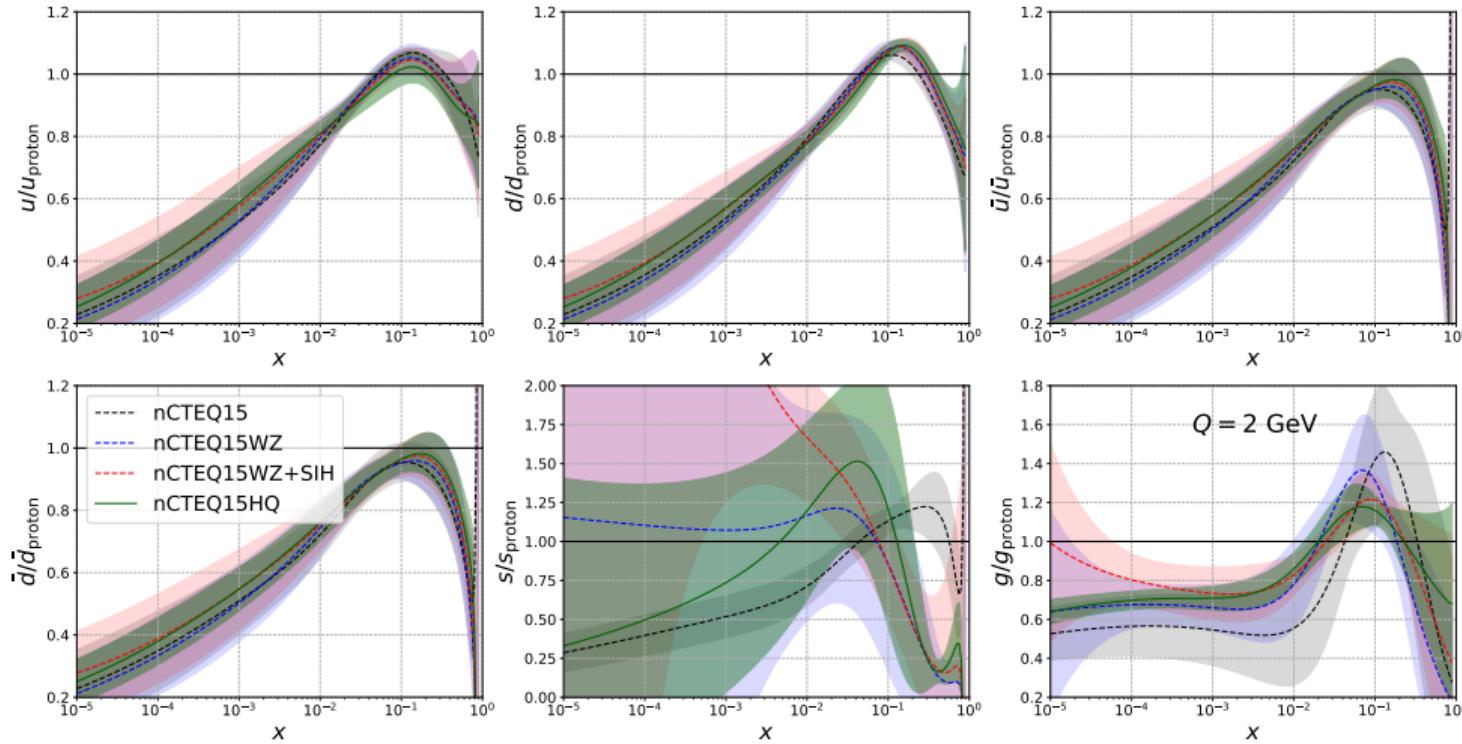
- ▶ pQCD theory prediction too slow for fitting
  - ▶ only available for prompt production
  - ▶ needs gridding

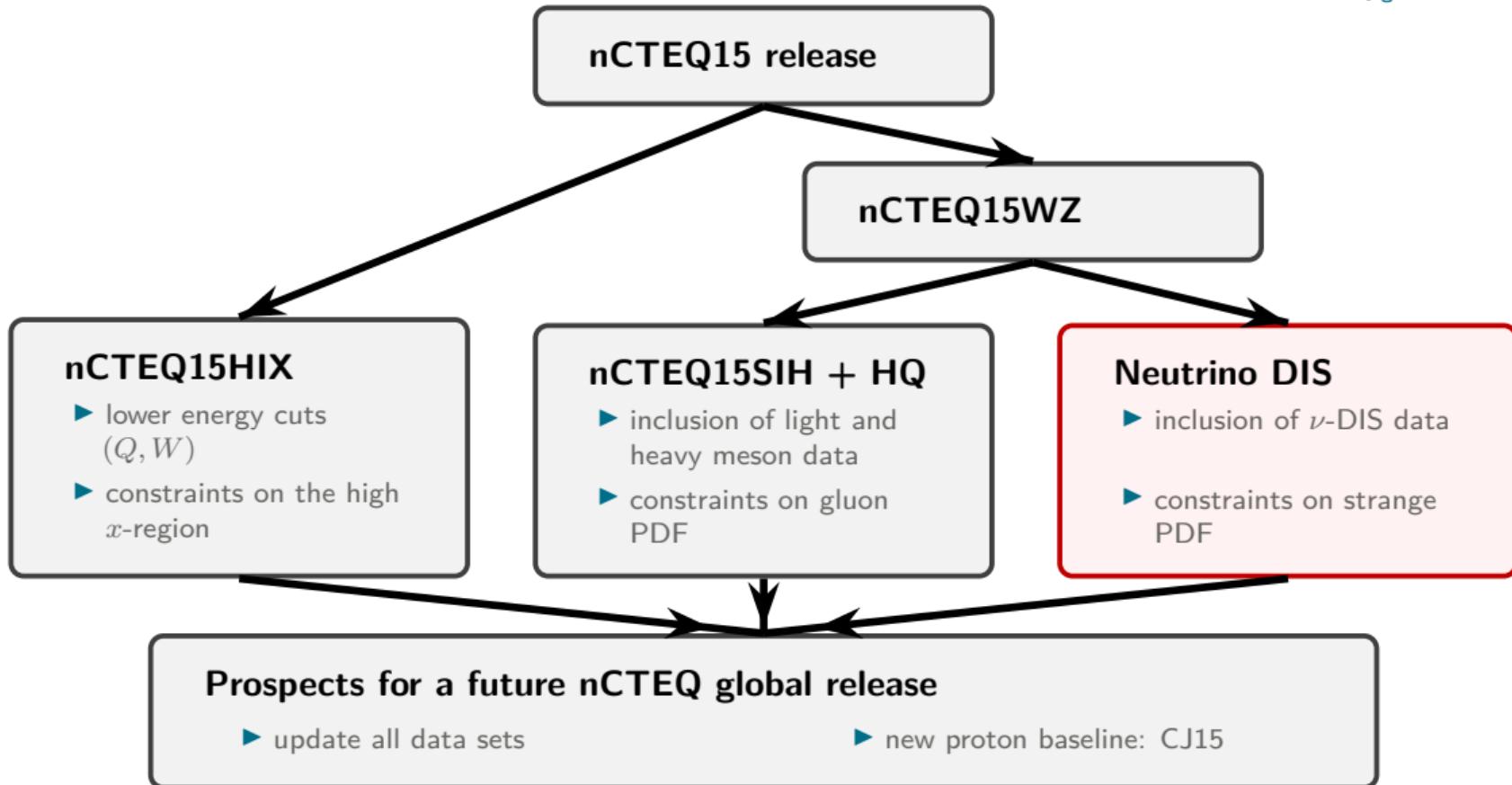


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# nCTEQHQ Fit – Bound Lead ratio to Proton

Duwentäster *et al*, arXiv:2204.09982





# Neutrino DIS – Motivation

Why are we interested in  $\nu$ -DIS data?

- ▶ want to **reduce the uncertainties on the strange PDF**
- ▶ improved separation between up and down
- ▶ large amount of data points

Muzakka *et al.*, arXiv:2204.13157

Neutrino Data used in this analysis:

Data set	Nucleus	#pts	Corr.sys.
CDHSW $\nu$	Fe	465	No
CDHSW $\bar{\nu}$		464	
CCFR $\nu$	Fe	1109	No
CCFR $\bar{\nu}$		1098	
NuTeV $\nu$	Fe	1170	Yes
NuTeV $\bar{\nu}$		966	
Chorus $\nu$	Pb	412	Yes
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Challenges?

- ▶ **tension**
  - ▶ within individual  $\nu$ -DIS data sets
  - ▶ also with **base data** sets
- ▶ extensive compatibility study
  - ▶ remove **data with  $x < 0.1$**
  - ▶ or use only **Chorus and dimuon data**

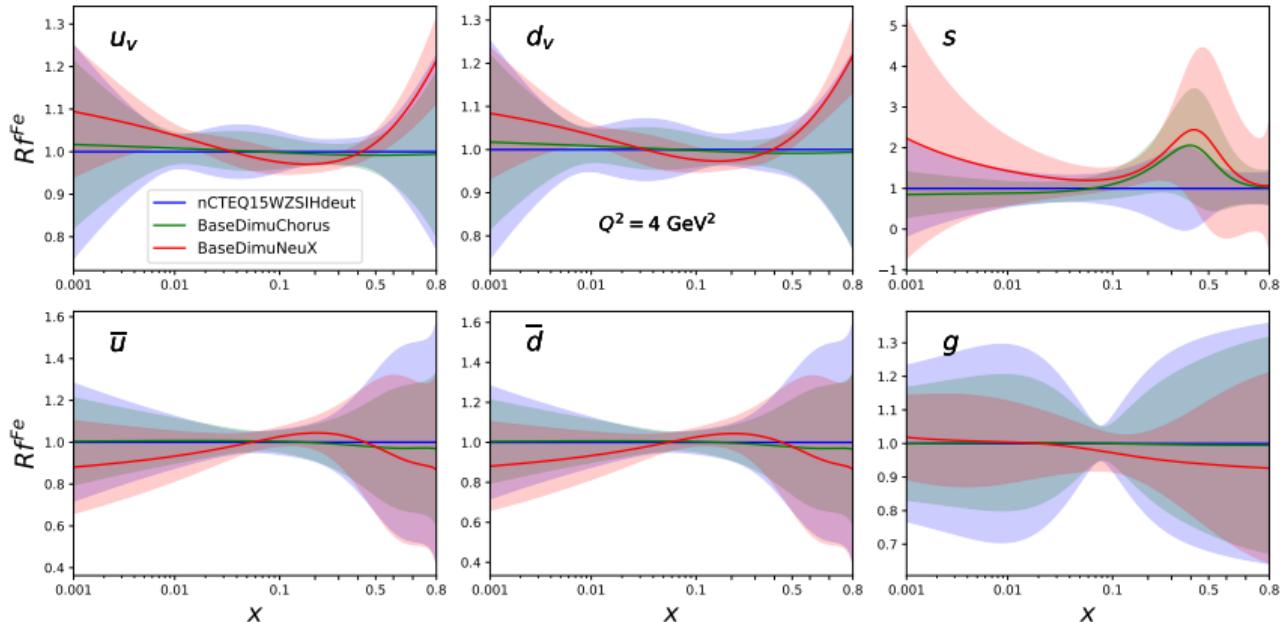
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# Neutrino DIS – Compatible Fits

Muzakka *et al.*, arXiv:2204.13157



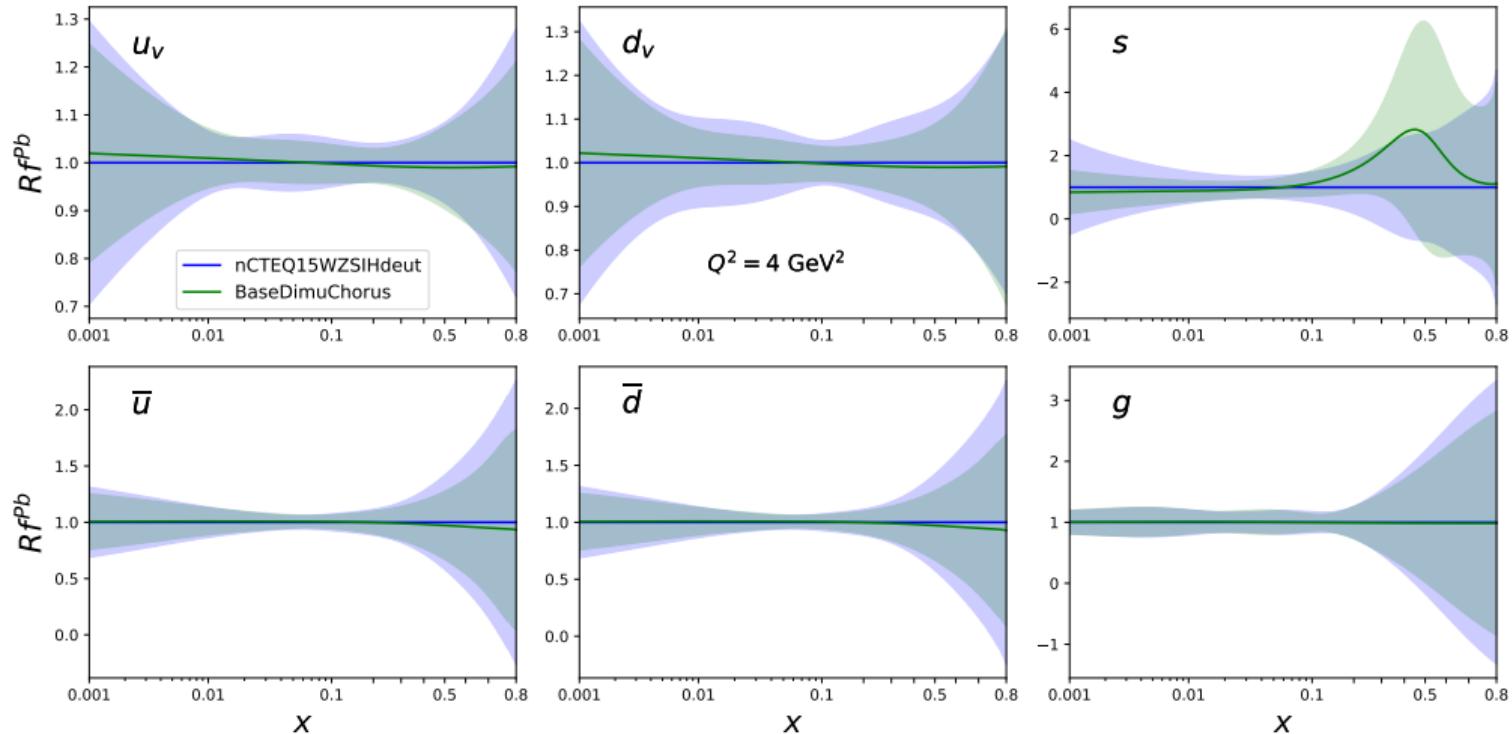
**nCTEQ15WZSIHdeut**  
 $l^\pm \text{DIS+DY+SIH+WZ}$   
(940 pts)  
⇒ **Base fit**

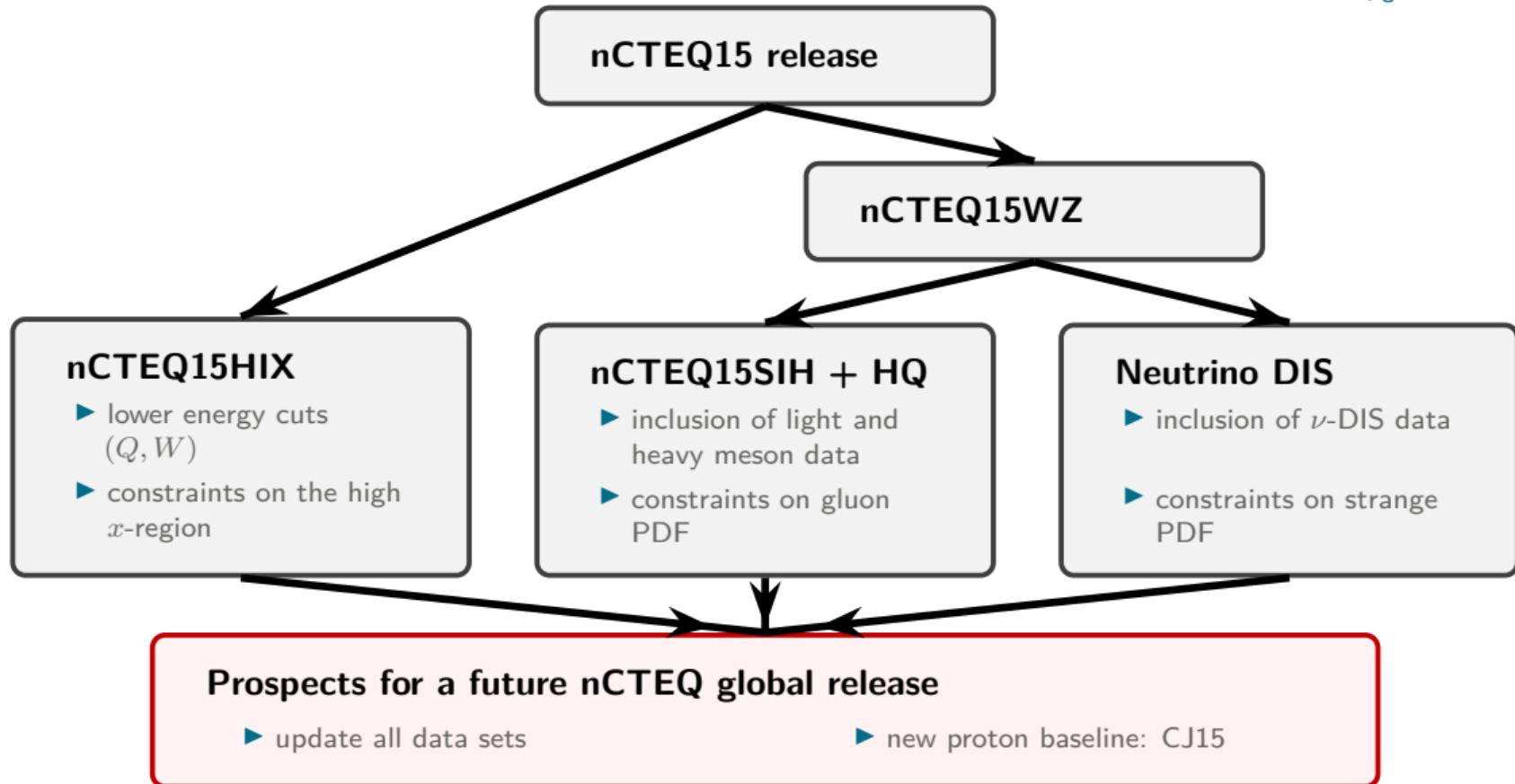
**BaseDimuChorus**  
Base + Dimuon + Chorus  
(1914 pts)

**BaseDimuNeuX**  
Base + all  $\nu$ -DIS  
 $x \leq 0.1$  removed  
(5584 pts)

# Neutrino DIS – Ratio vs BaseFit

Muzakka *et al.*, arXiv:2204.13157





# Towards a new nCTEQ global nPDF analysis

## Combine nCTEQ15HIX, nCTEQ15SIH+HQ and nCTEQ15- $\nu$ -DIS

- ▶ match cuts
- ▶ match open parameters
- ▶ control increased amount of data
- ▶ increase fitting performance

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## Set proton baseline similarly to CJ15

Accardi *et al.*, arXiv:1602.03154

$$x f_i(x, Q_0^2) = c_0 x^{c_1} (1-x)^{c_2} \left( 1 + c_3 \sqrt{x} + c_4 x + c_5 \sqrt{x}^3 \right) \quad i = u_v, d_v, g, \bar{u} + \bar{d}$$
$$\bar{d}/\bar{u}(x, Q_0) = a_0 x^{c_1} (1-x)^{c_2} + 1 + c_3 x (1-x)^{c_4}$$

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## Update the data sets

- ▶ new  $W/Z$  data from pPB collisions at the LHC
- ▶ new SIH data from RHIC & LHC

# Further investigations

## New observables

- ▶ direct Photon measurements from LHC
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## Parametrization updates

- ▶ change nuclear  $A$ -dependence

**OLD:**  $c_k \rightarrow c_k(A) \equiv p_k + a_k (1 - A^{-b_k})$

$$\Downarrow \qquad \Downarrow$$

**NEW:**  $c_k \rightarrow c_k(A) \equiv p_k + a_k \ln(A) + \underbrace{b_k \ln^2(A)}_{??}$

