



Measurements of electroweak boson production in p-Pb and Pb-Pb collisions at $\sqrt{s_{NN}}$ 5.02 TeV with ALICE

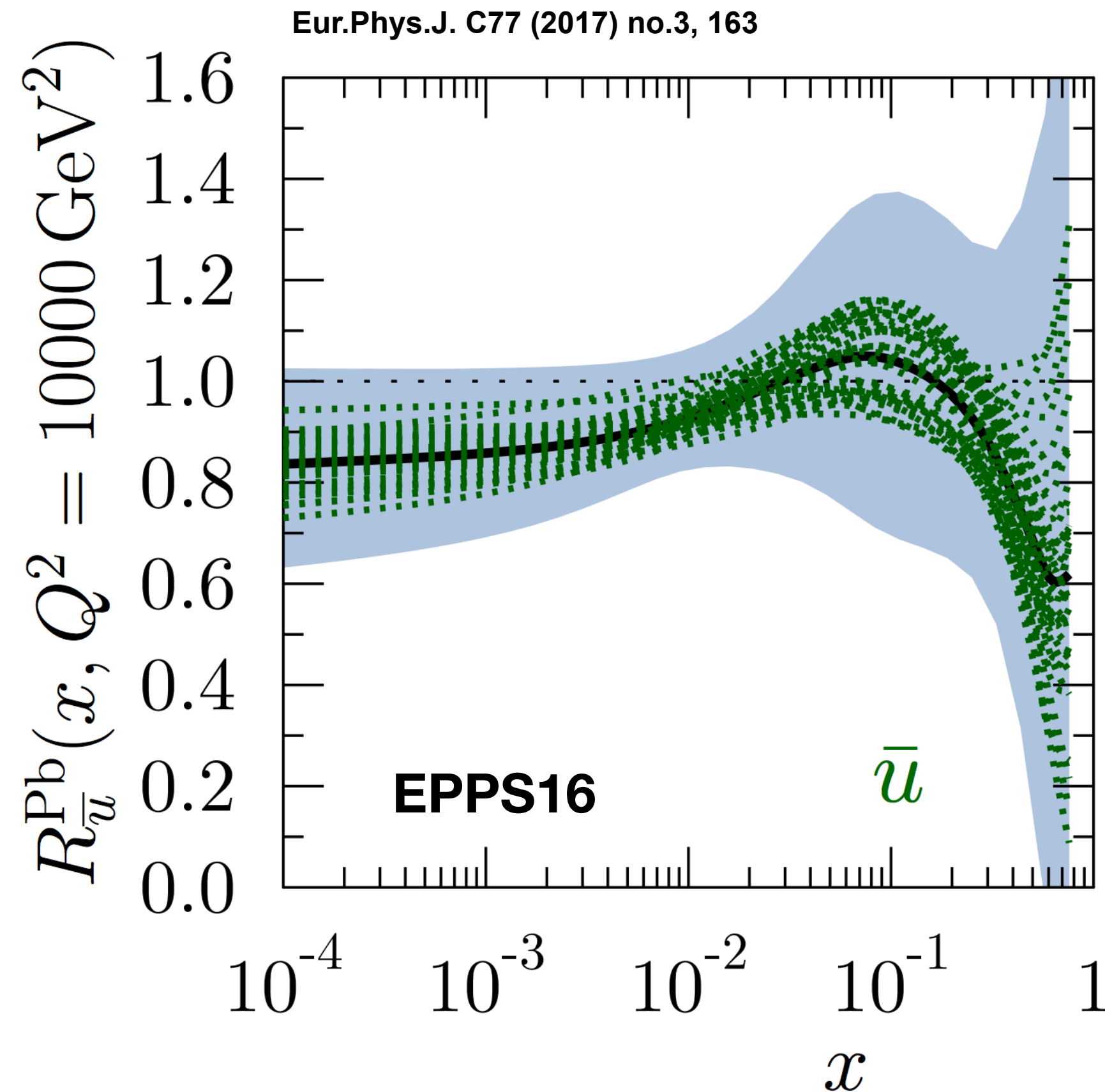


Mohamad Tarhini
For the ALICE collaboration

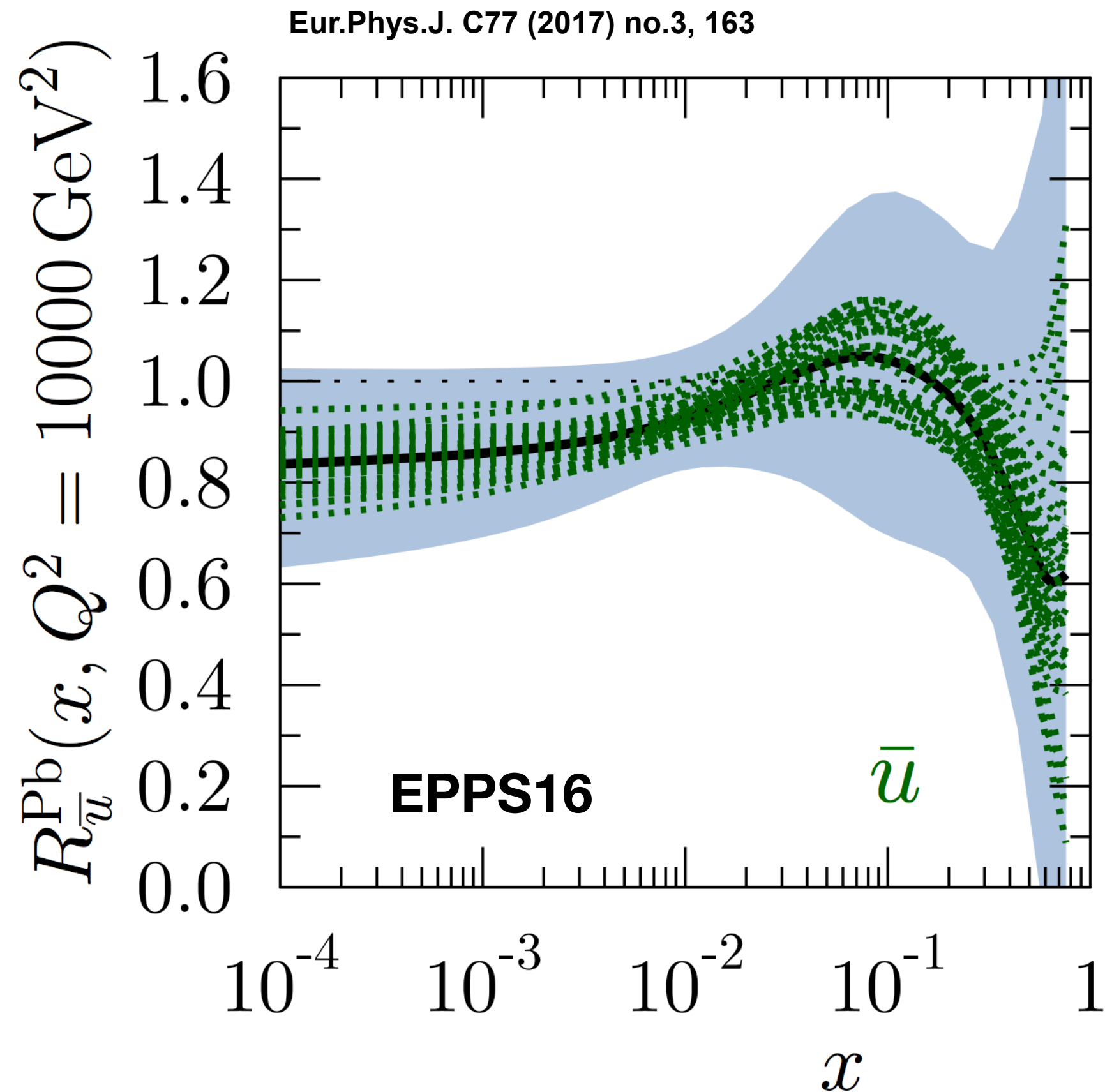


- Heavy-ion collisions represent a unique experimental tool to create and study the quark-gluon plasma (QGP)
- Non-QGP effects exist for some observables

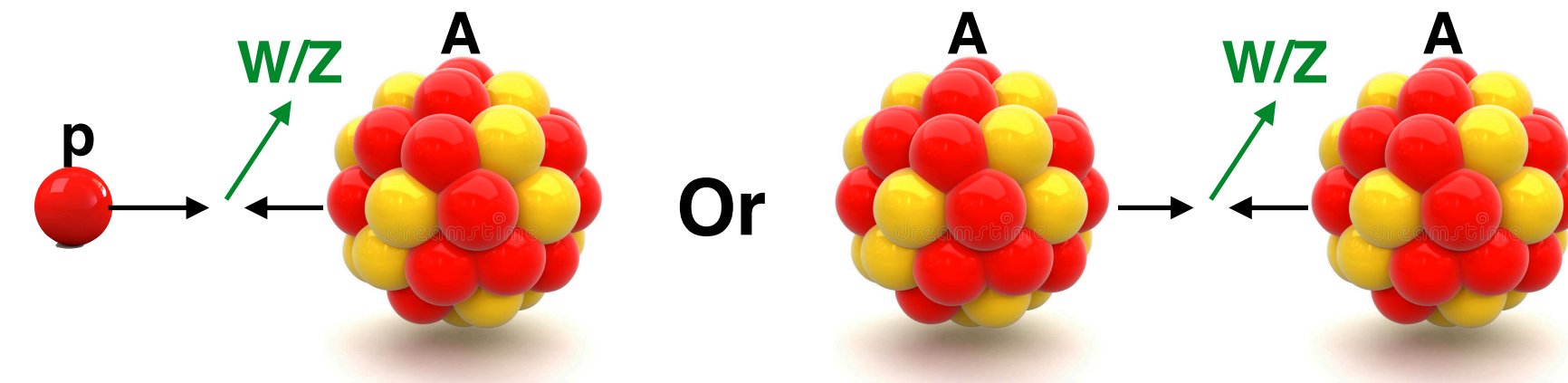
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 - e.g: in nuclei, parton distribution functions (PDFs) are modified (**nPDFs**)
 - Lack of experimental datasets to constrain nPDFs → **large uncertainties**



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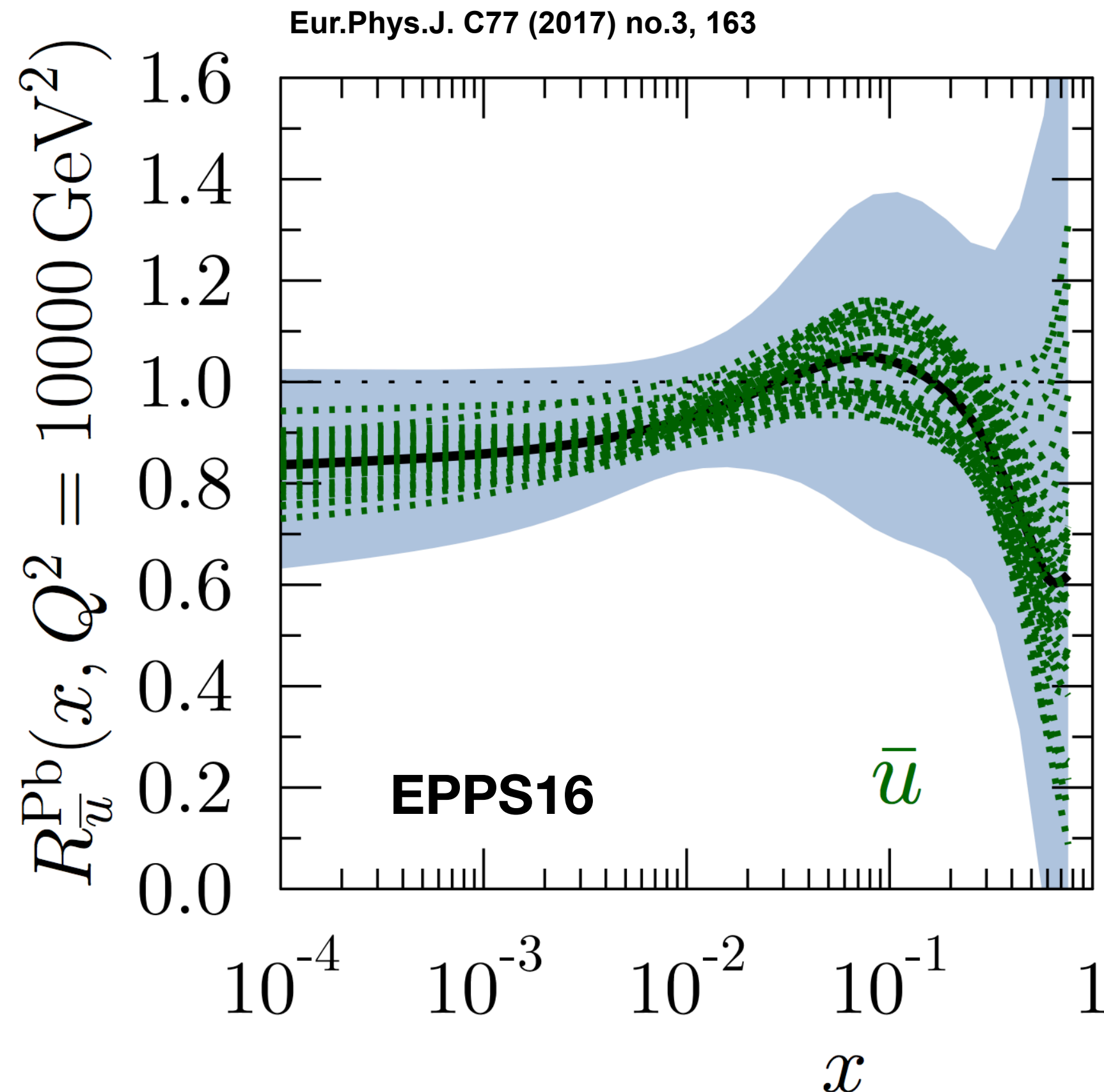


- **W/Z** boson production in heavy-ion collisions:

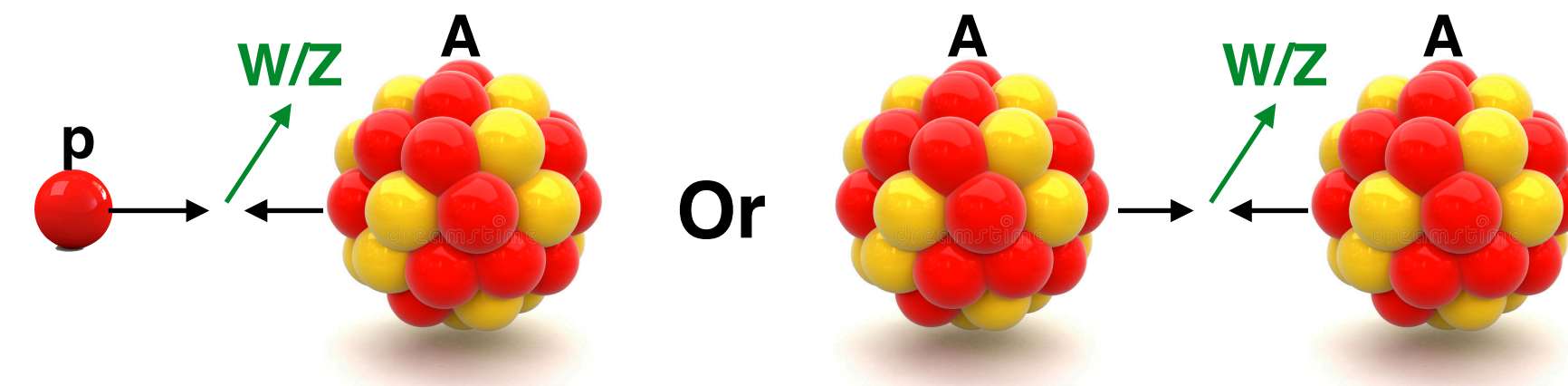


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- The PDF modification is the major Cold Nuclear Matter (CNM) effect

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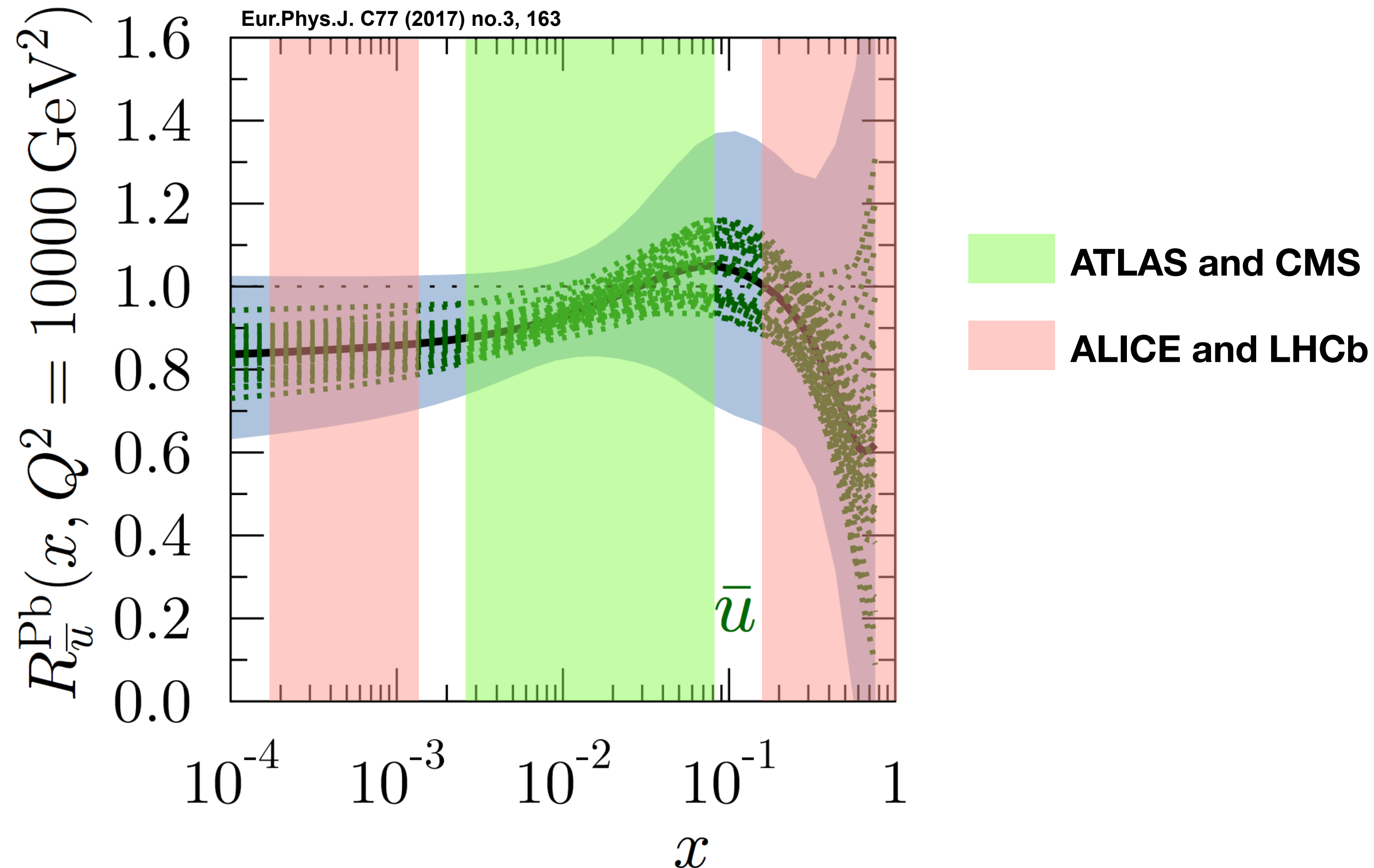
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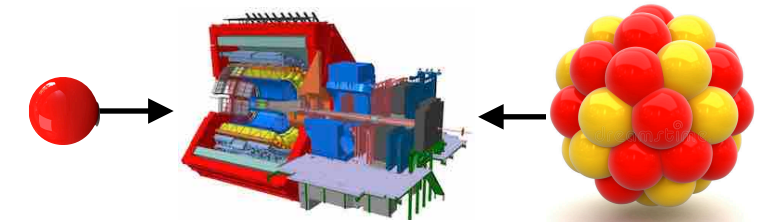
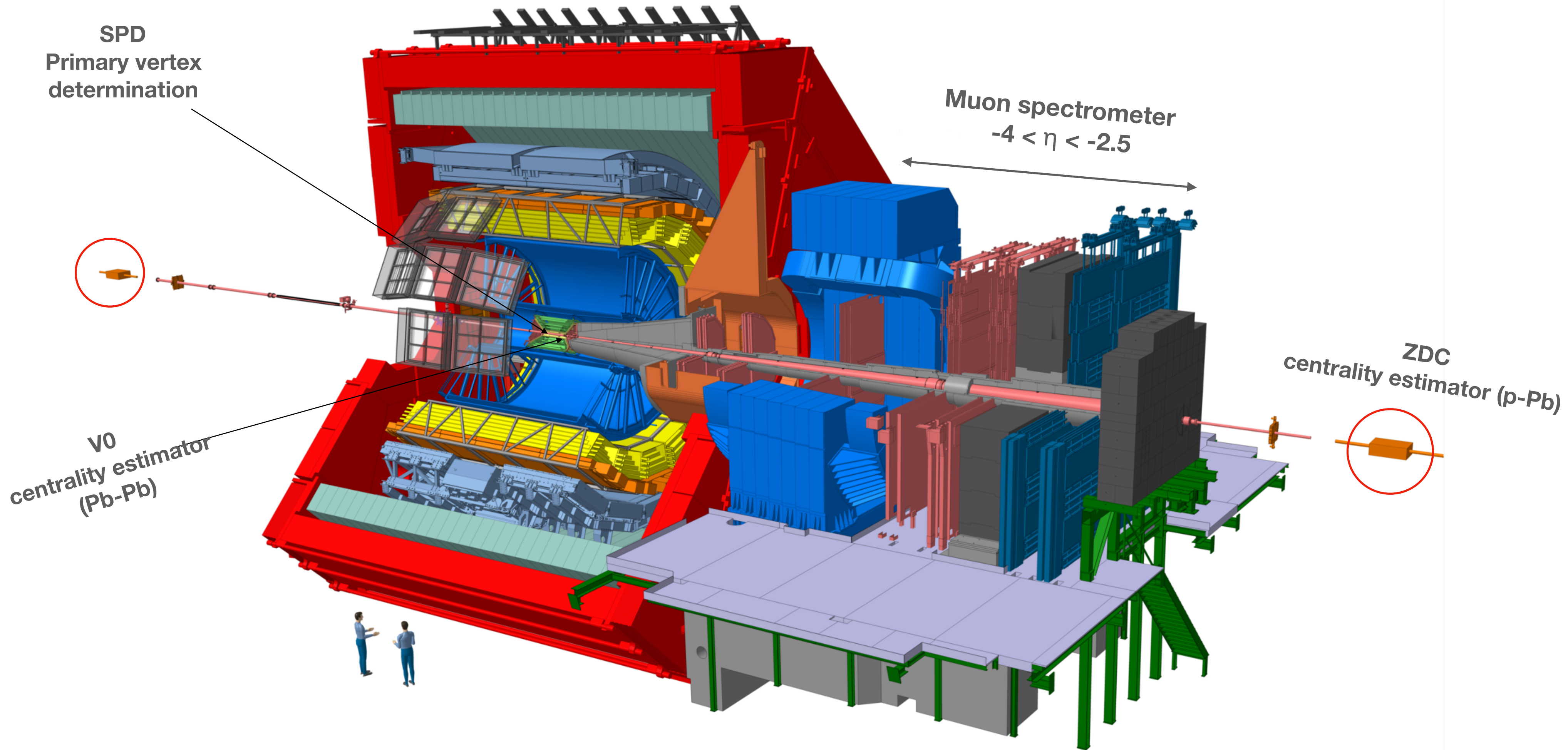
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➔ **W/Z** bosons measurement in heavy-ion collisions can constrain nPDFs at large Q^2

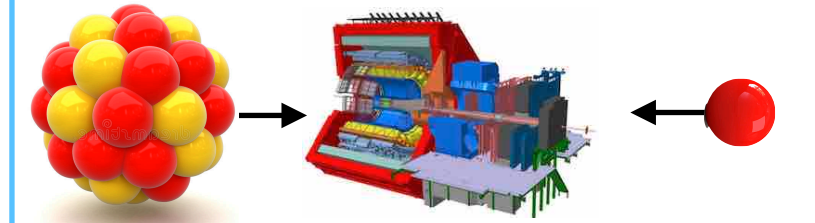
- The LHC experiments are complementary in the phase-space coverage



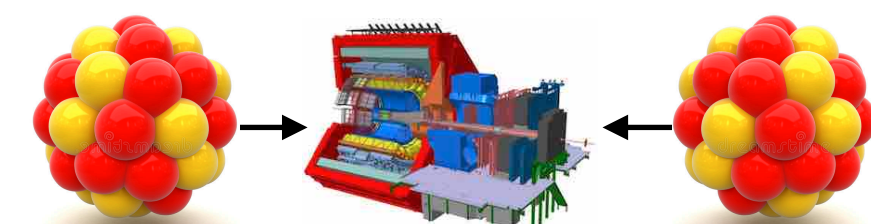
- ALICE can (in p-Pb and Pb-Pb collisions) access the large- x region where nPDFs are least constrained



p-Pb at $\sqrt{s_{NN}} = 5.02$ TeV
(p-going)
 $2.03 < y_{cms} < 3.53$
 $L_{int} \sim 5.1 \text{ nb}^{-1}$



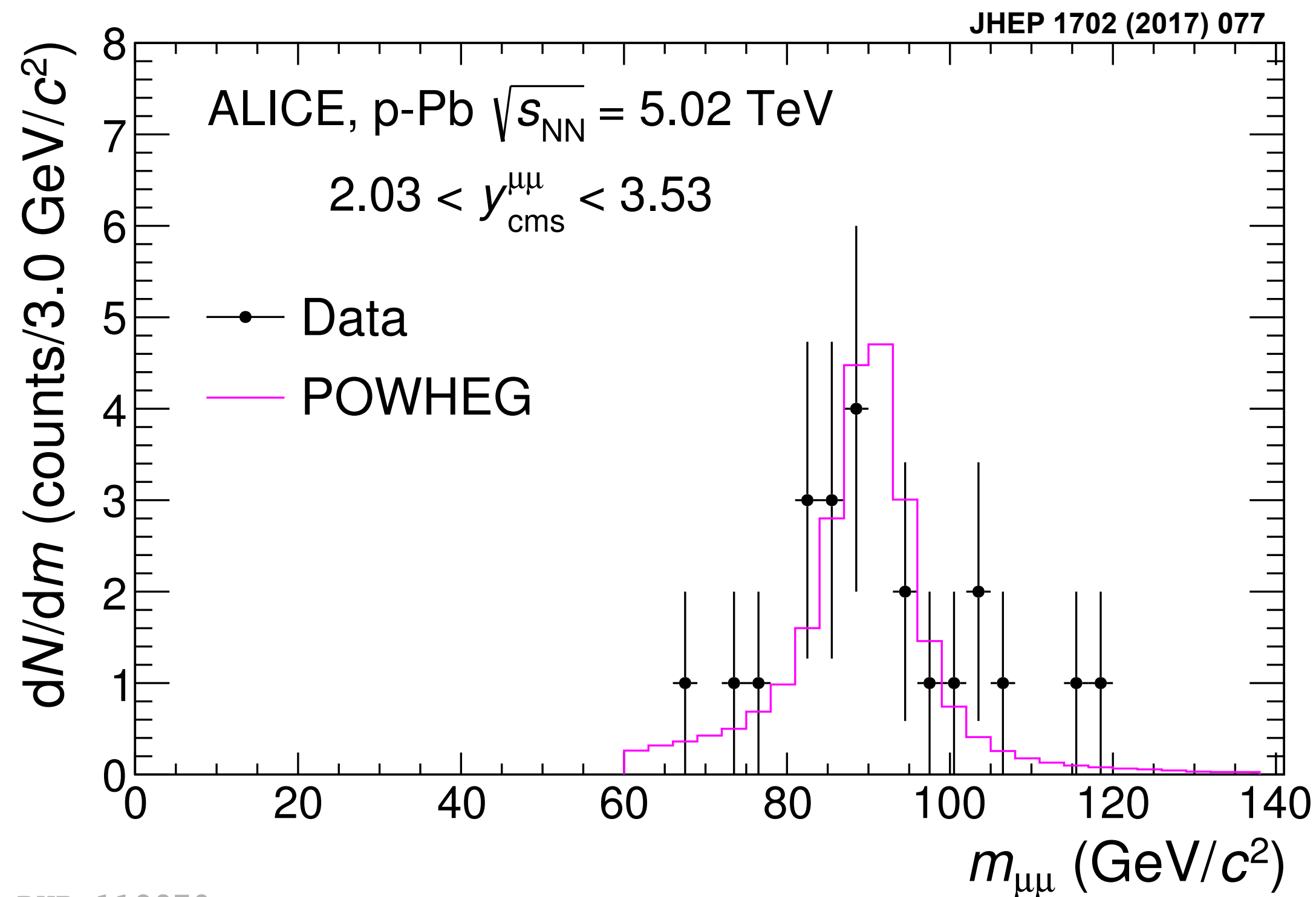
p-Pb at $\sqrt{s_{NN}} = 5.02$ TeV
(Pb-going)
 $-4.46 < y_{cms} < -2.96$
 $L_{int} \sim 5.8 \text{ nb}^{-1}$



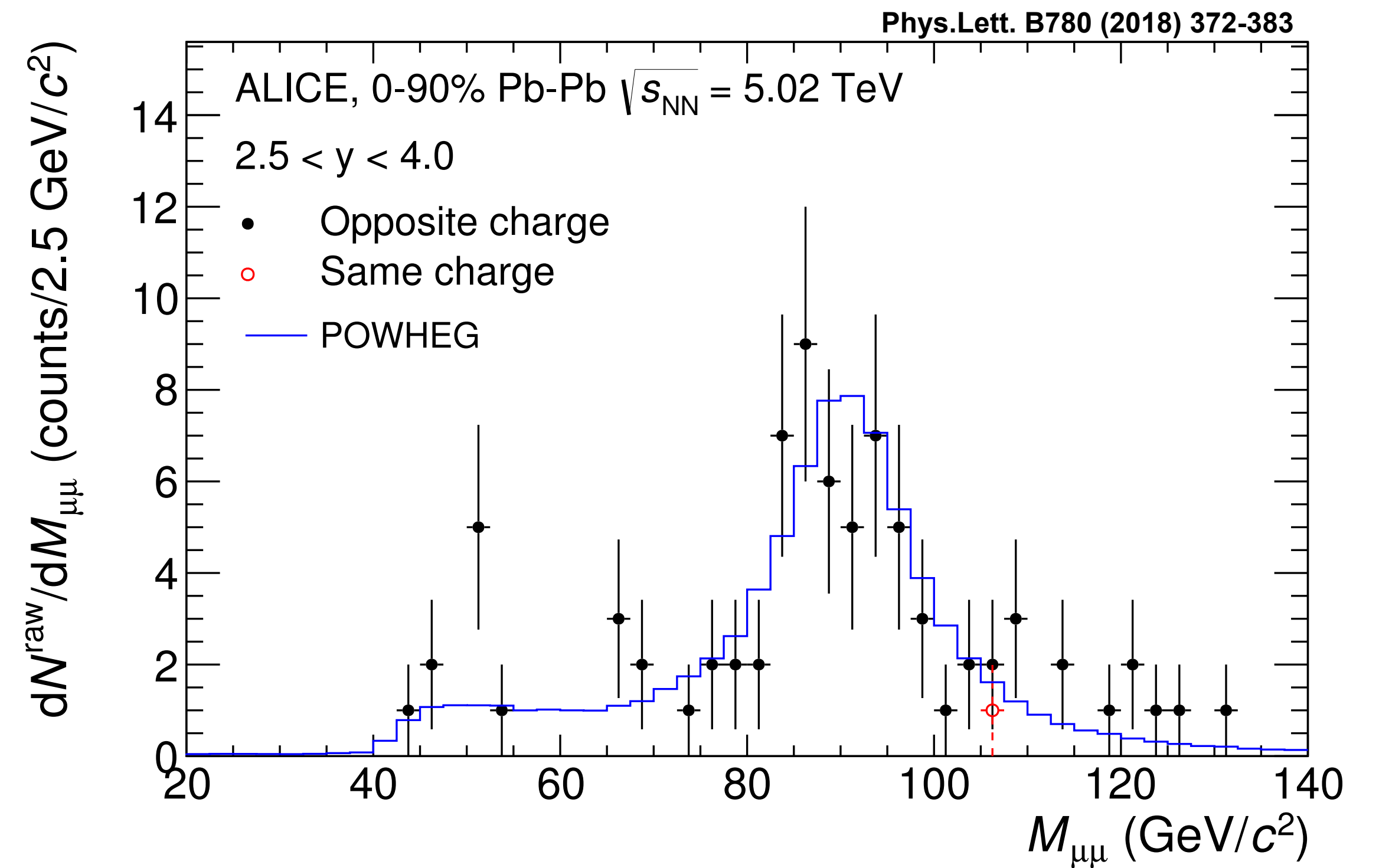
Pb-Pb at $\sqrt{s_{NN}} = 5.02$ TeV
 $2.5 < y < 4$
 $L_{int} \sim 225 \mu\text{b}^{-1}$

Signal extraction

- The Z-boson signal is extracted by counting $\mu^+\mu^-$ candidates with $60 < M_{\mu\mu} < 120 \text{ GeV}/c^2$, and $p_T > 20 \text{ GeV}/c$ for each muon
- Contribution from other physics background sources ($b\bar{b}$, $c\bar{c}$, $t\bar{t}$, $Z \rightarrow \tau\tau \rightarrow \mu\mu$) estimated w.r.t $[Z \rightarrow \mu\mu]$ using PYTHIA and POWHEG simulations ($< 1\%$)



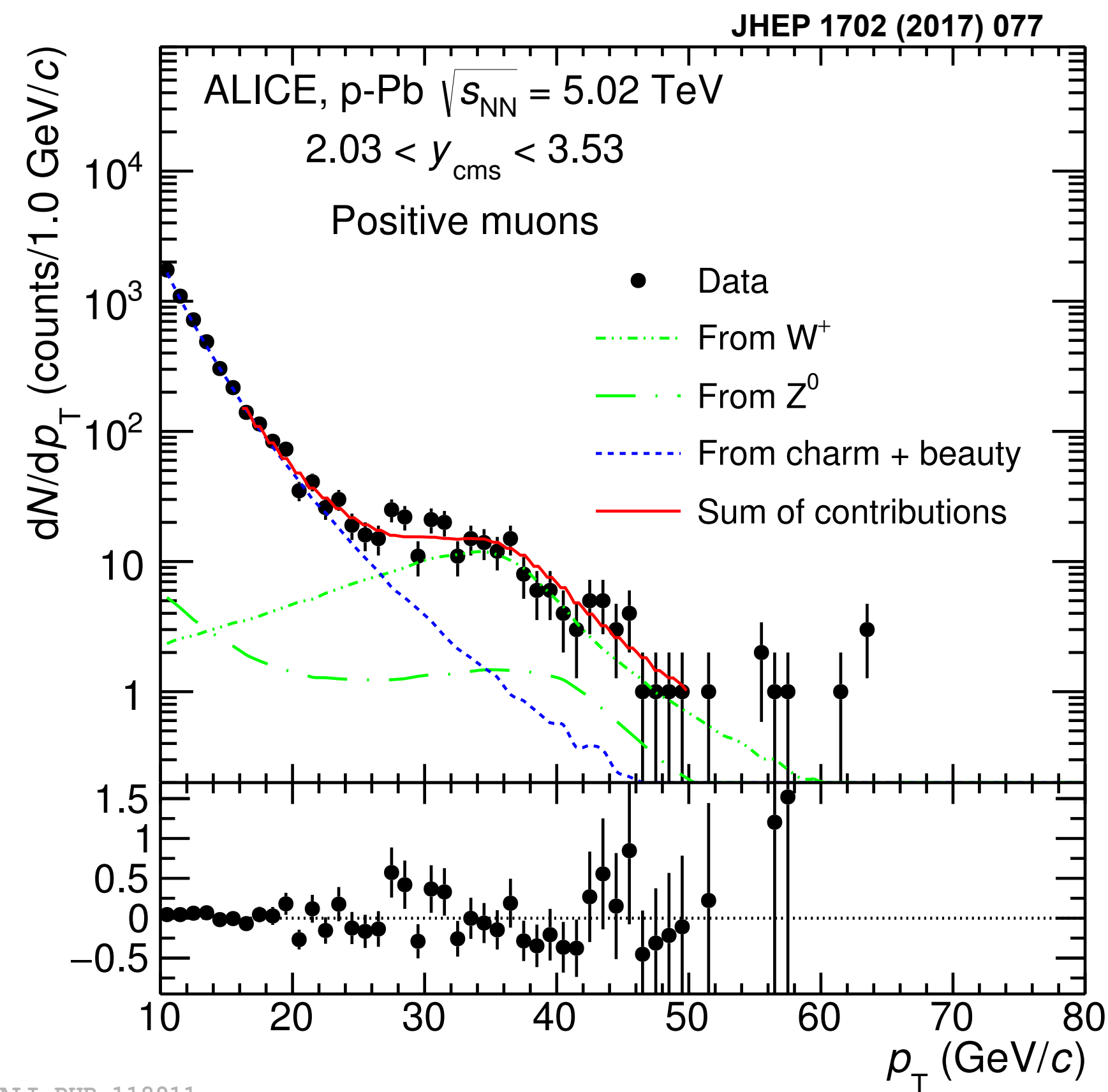
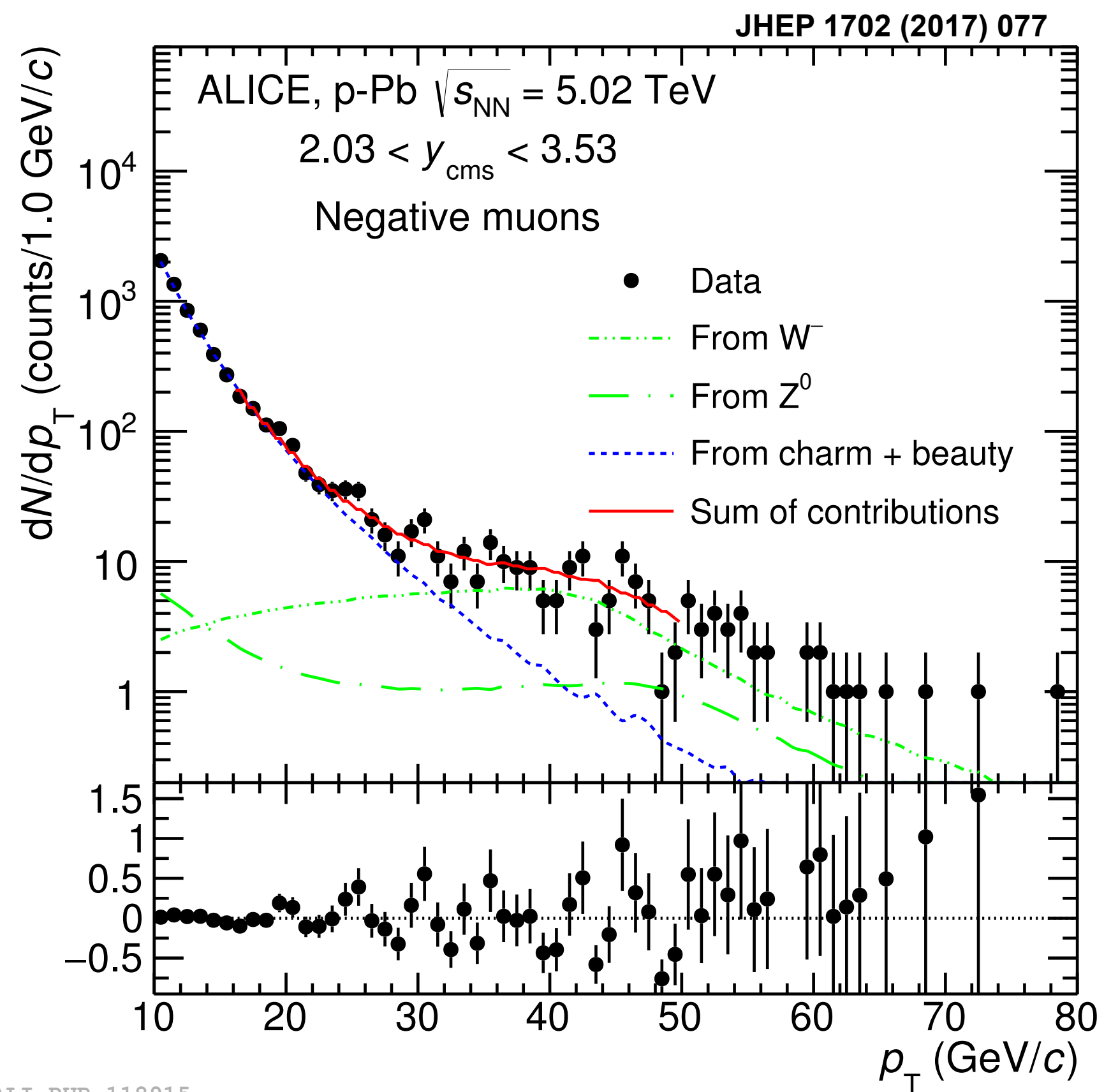
ALI-PUB-118970



ALI-PUB-146511

- Combinatorial background accounted for by looking at the same-charge dimuon distribution
- The raw yield is corrected by the detector acceptance-times-efficiency obtained via MC simulations

- The signal is extracted using a MC template fit of the single muon distribution ($p_T > 10$ GeV/c)
- Taking into account contributions of muons from heavy-flavour and Drell-Yan decays

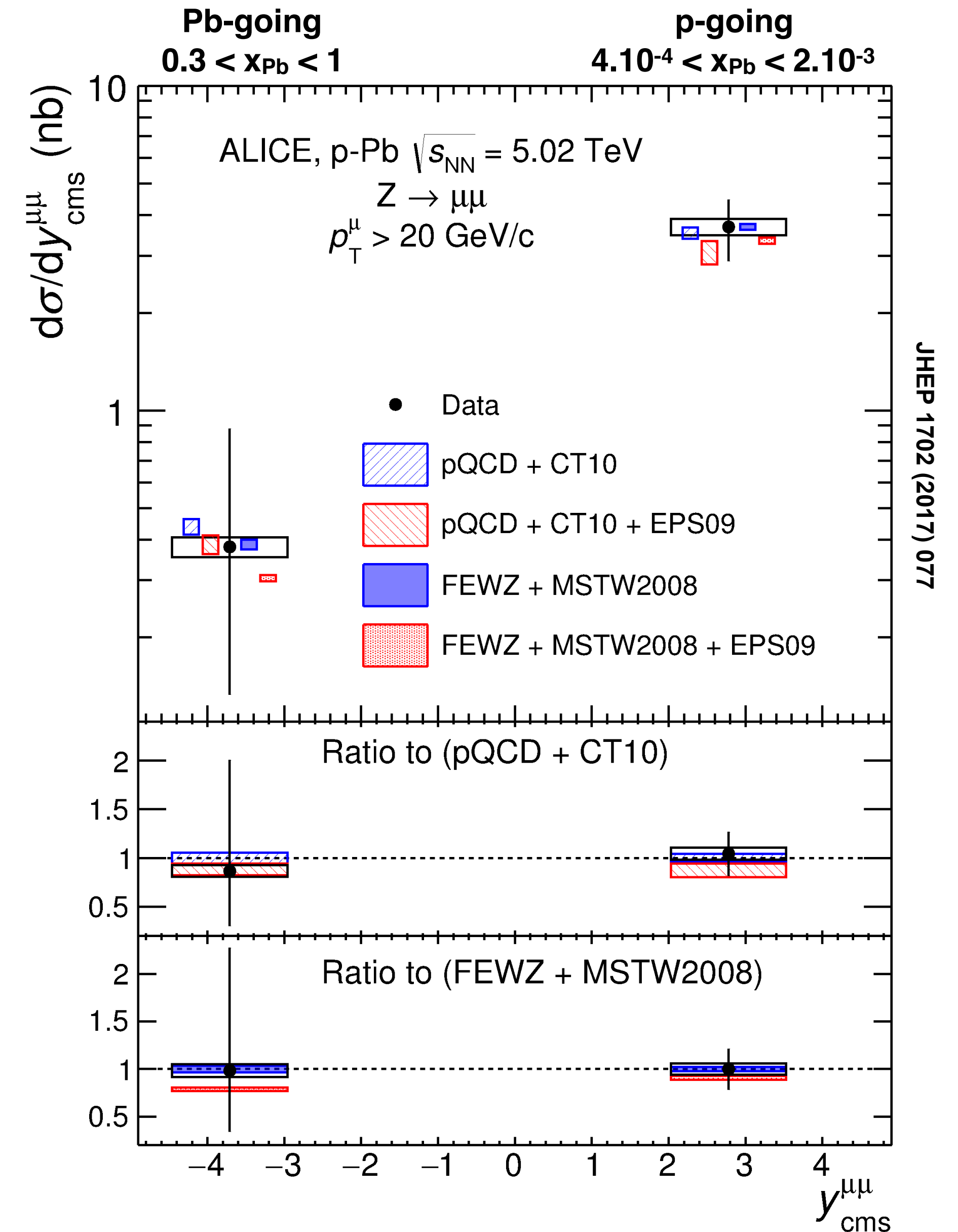


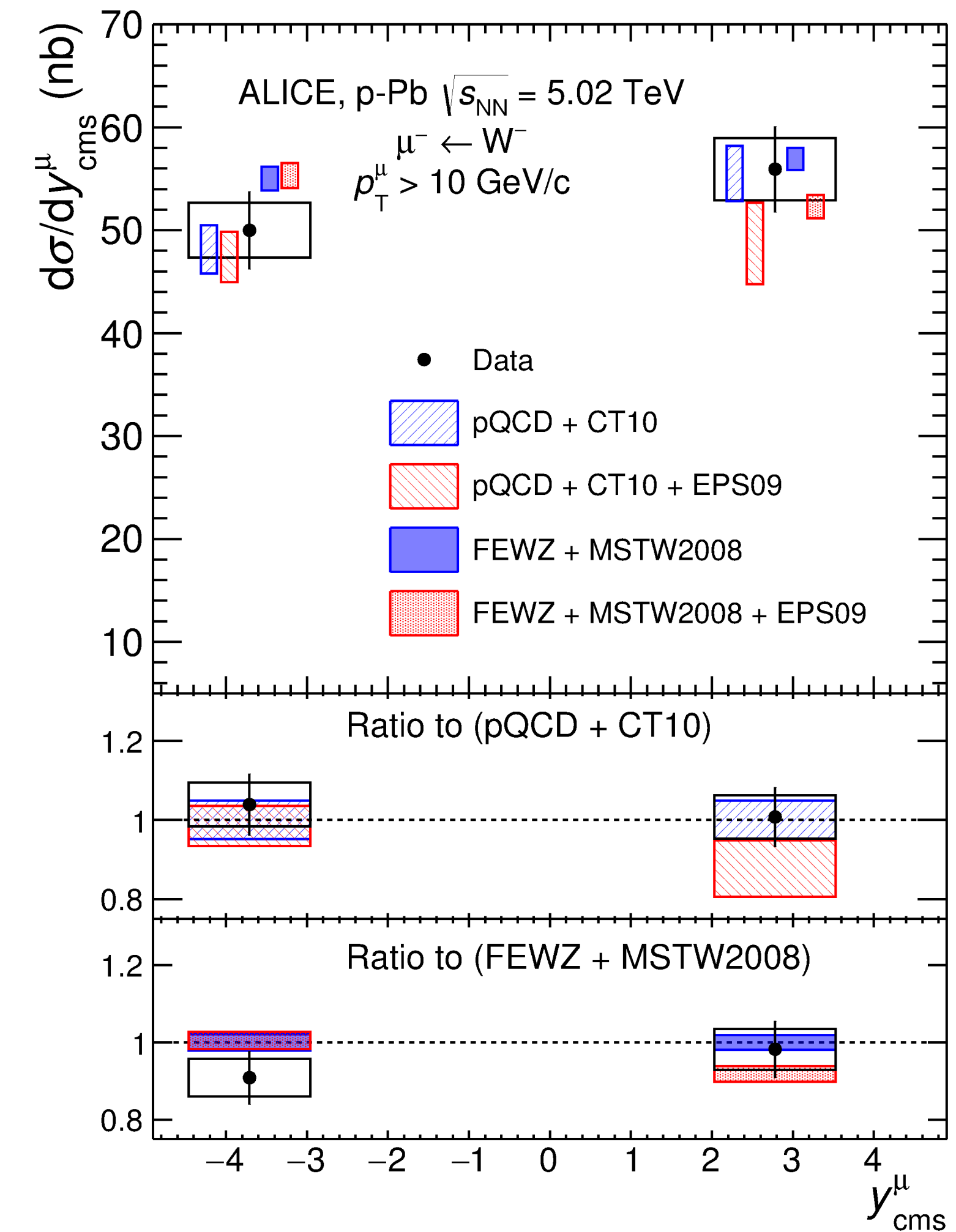
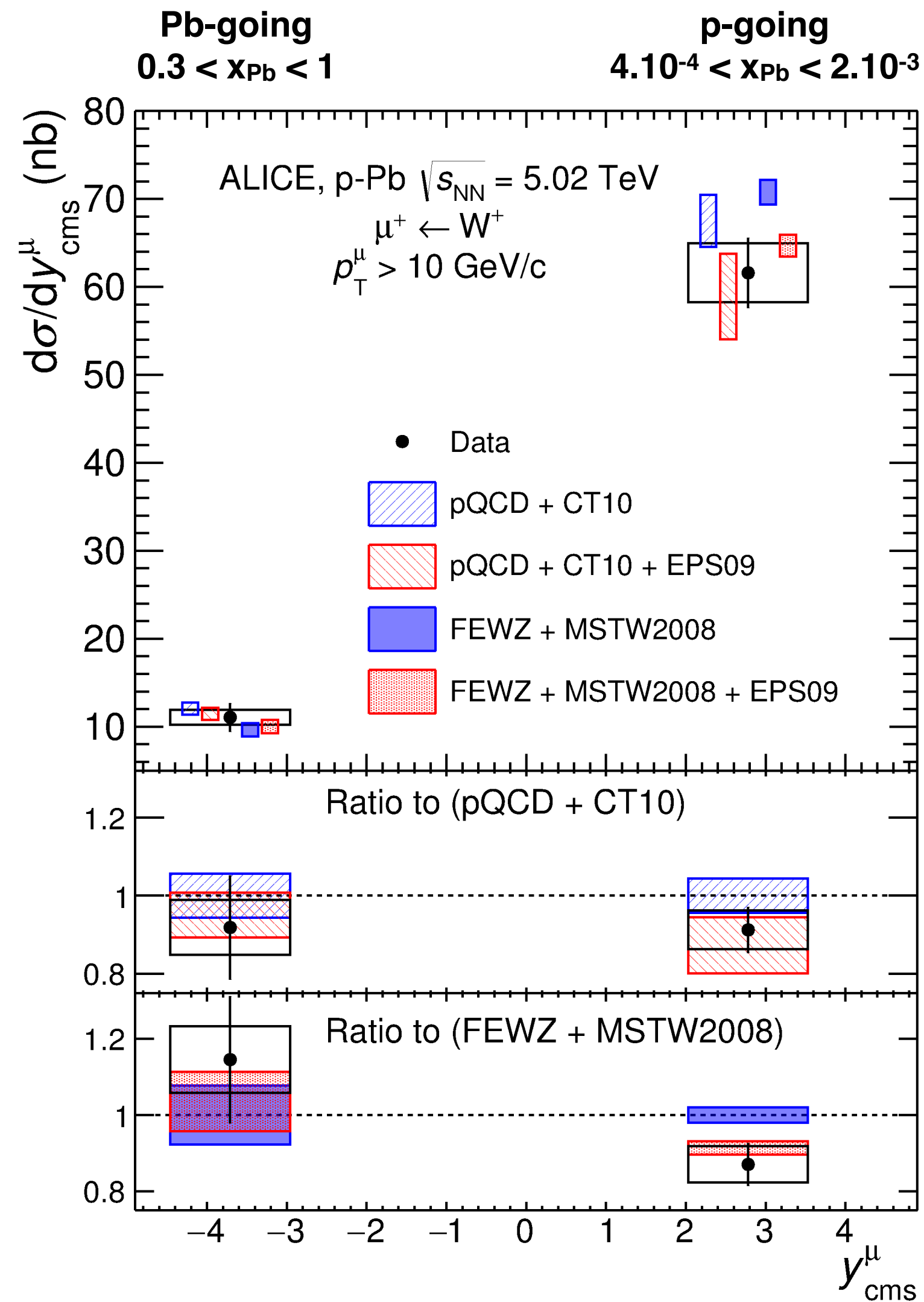
- The raw yield is corrected by the acceptance-times-efficiency of the detector

Results: p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

(JHEP 1702 (2017) 077)

- **First Z-boson measurement in ALICE**
 - Cross section compared to:
 - pQCD calculations (NLO) [using CT10 NLO]
 - FEWZ calculations (NNLO) [using MSTW2008NNLO]
 - Results in agreement with calculations **with** and **without** including nPDFs (EPS09)
- The measurement is compatible with the different calculations. More precision is needed to constrain nPDFs





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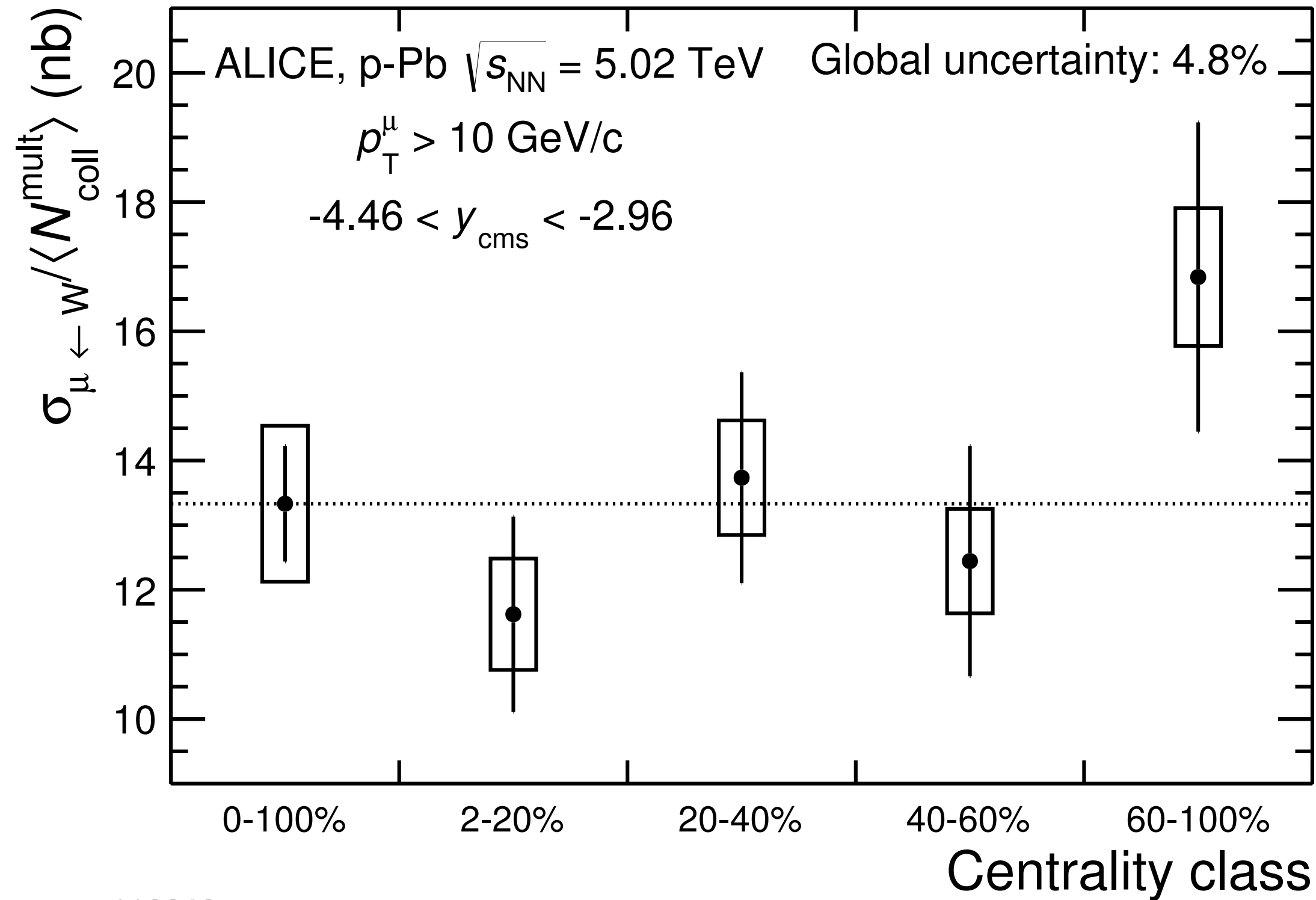
- Calculations **with** and **without** nPDF can reproduce the results
- As for the Z-boson results, more precision is needed to constrain nPDFs



W-boson production in p-Pb collisions as a function of centrality

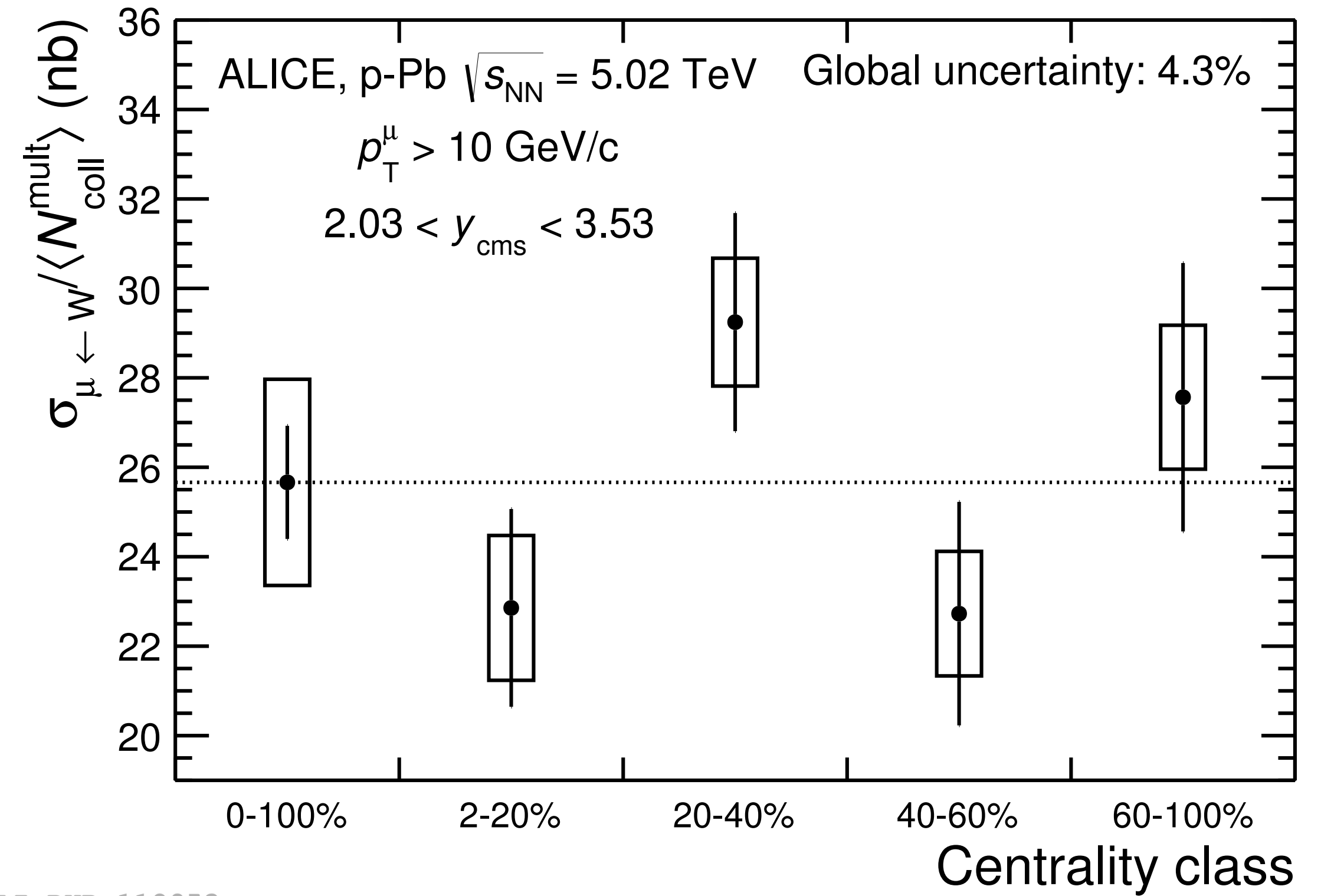
- For the centrality dependence, the contributions from W^+ and W^- are added

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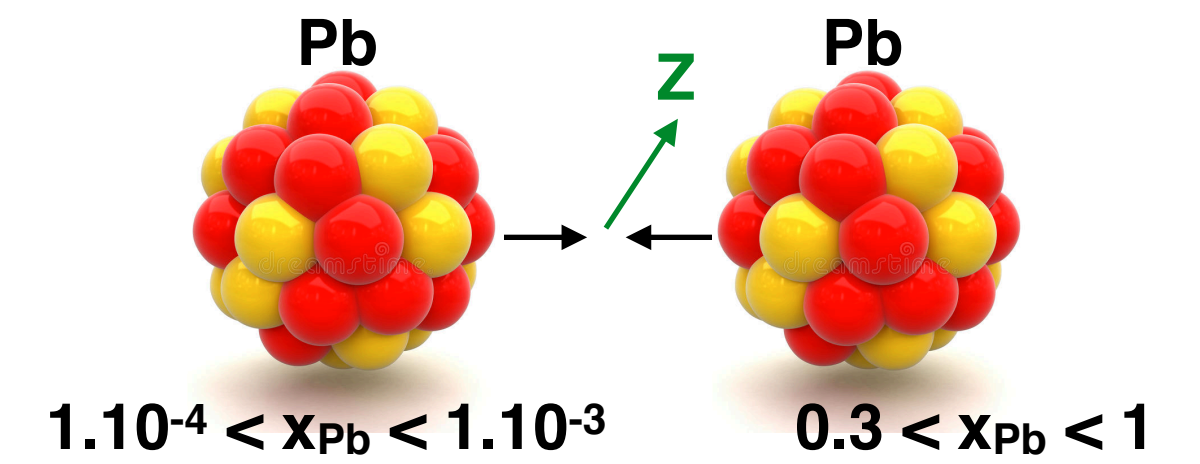
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- Within uncertainties, no centrality dependence of W-boson production

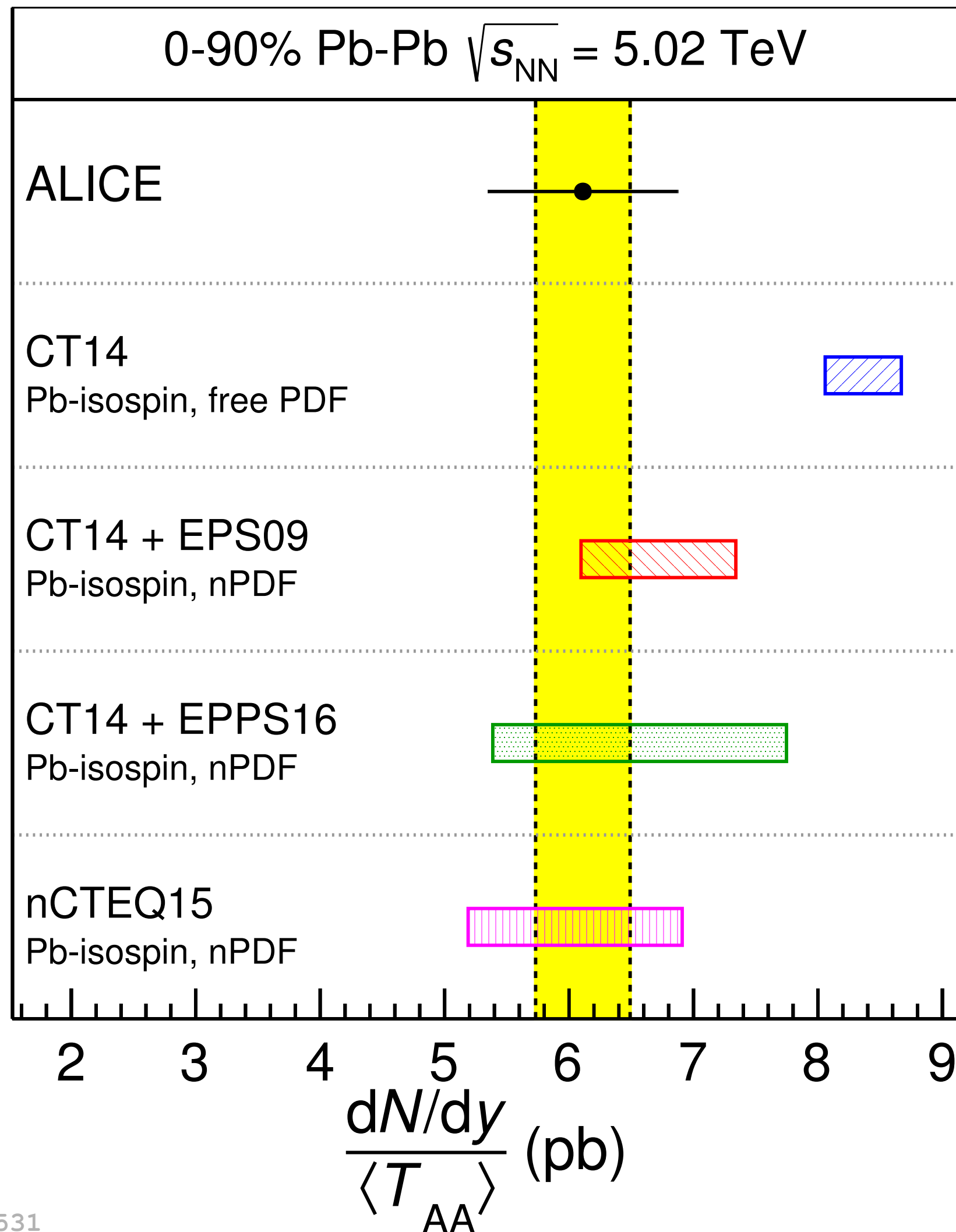
Results: Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

(Phys. Lett. B780 (2018) 372-383)

- Larger data sample than in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV



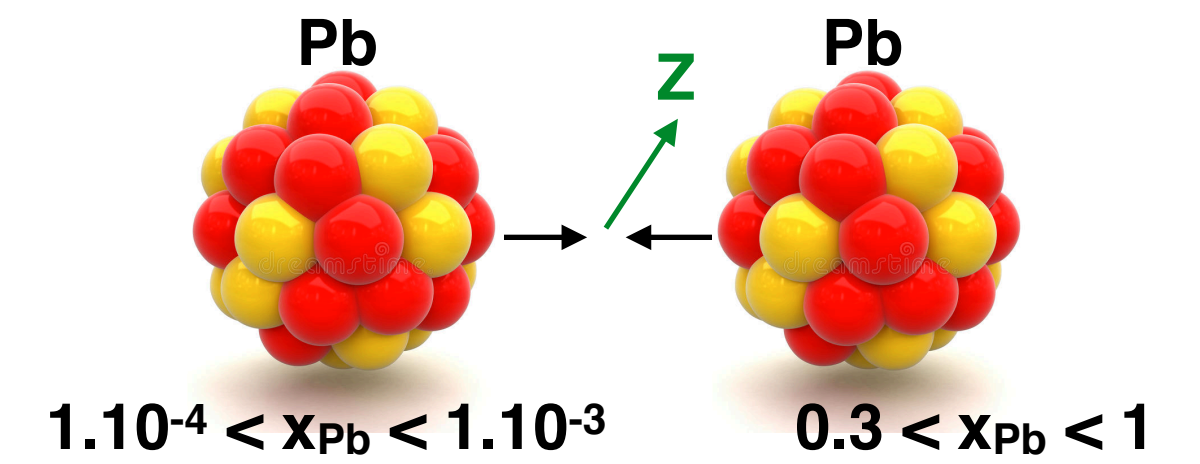
Phys.Lett. B780 (2018) 372-383



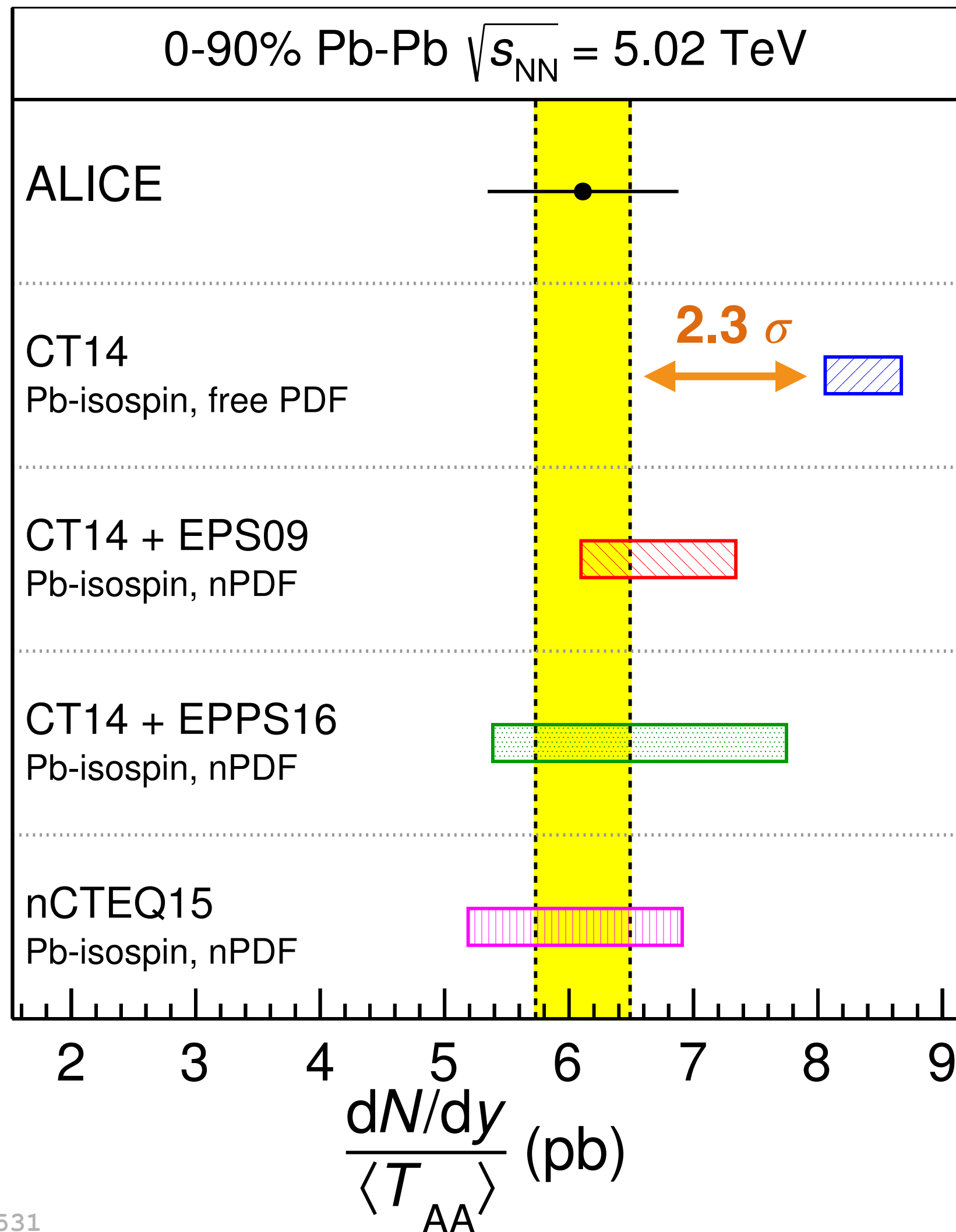

 Systematic uncertainty

- Within uncertainties, the result is in agreement with the calculation using three different nPDFs

- Larger data sample than in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

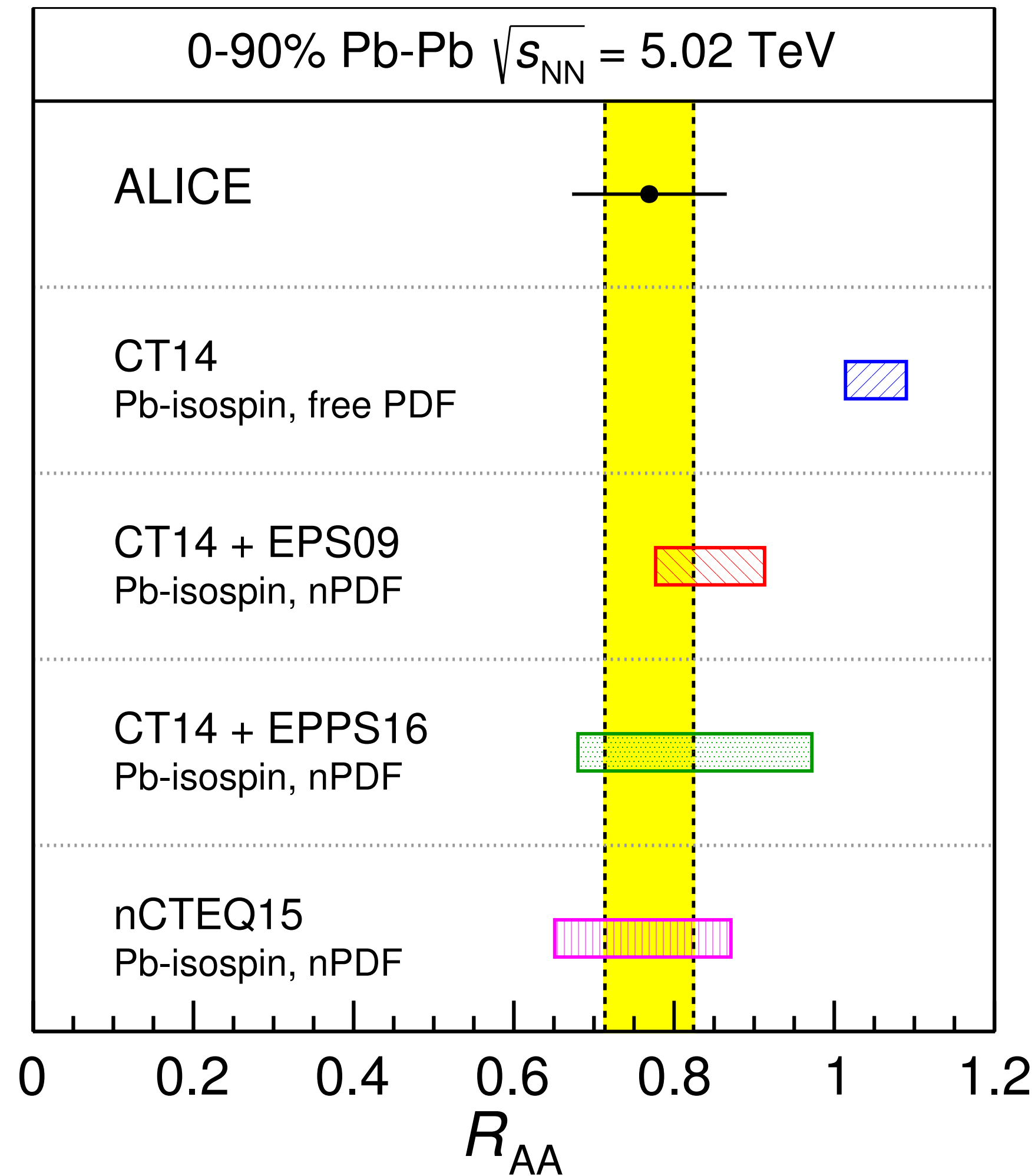
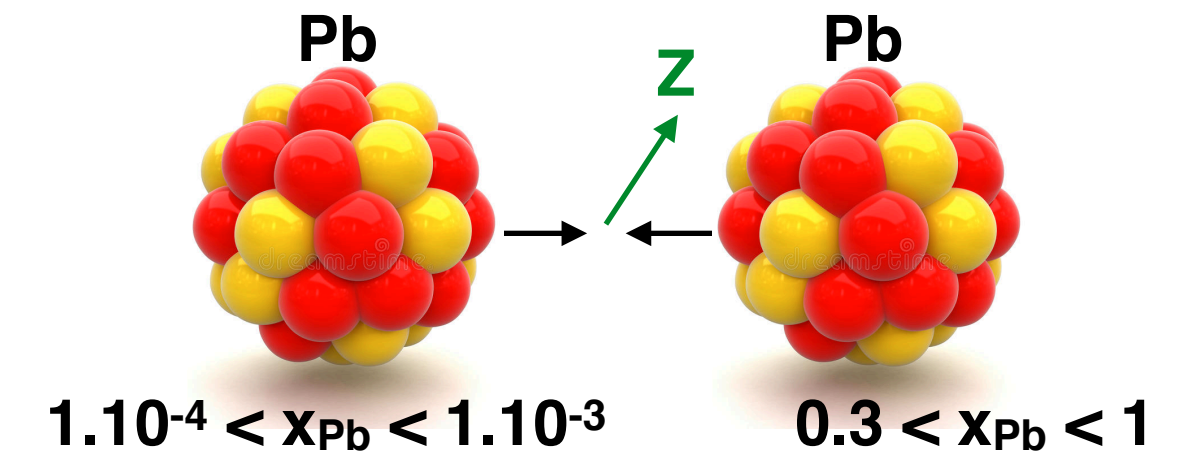


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 Systematic uncertainty

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- 2.3 σ separation between the results and the calculations without including nPDF

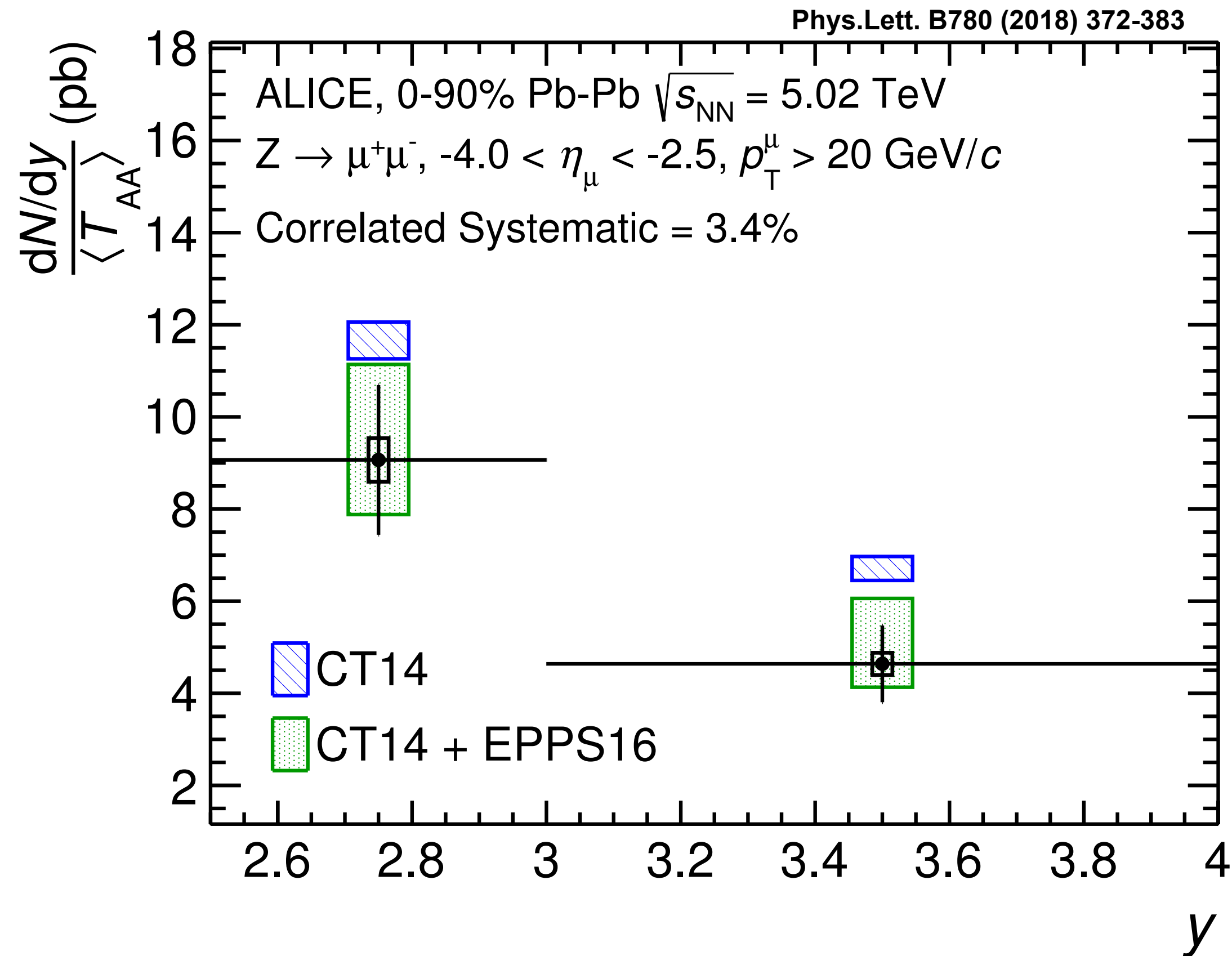
- Larger data sample than in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV



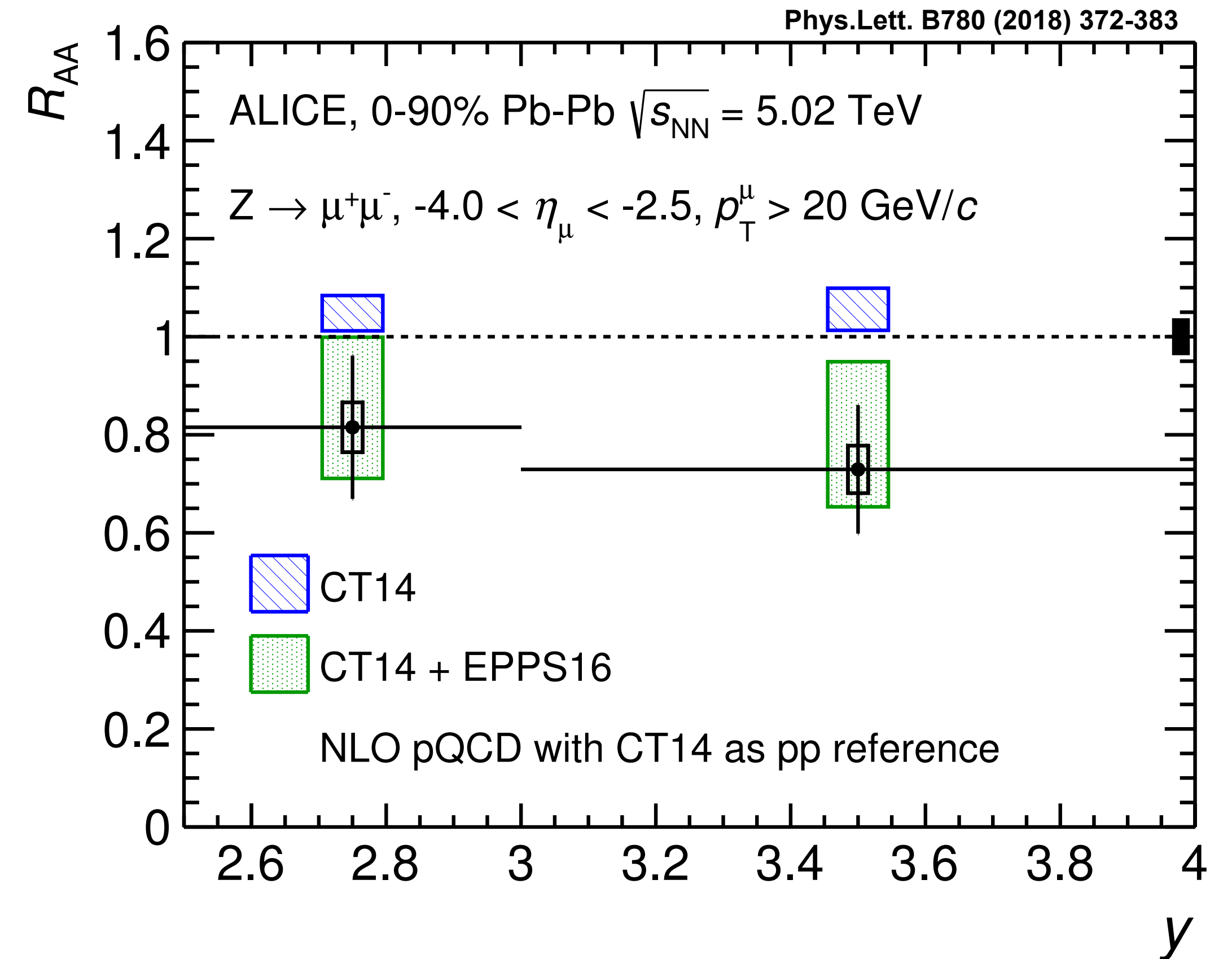
 Systematic uncertainty

- Within uncertainties, the result is in agreement with the calculation using three different nPDFs
- 2.3σ separation between the results and the calculations without including nPDF
- The R_{AA} is evaluated, dividing the normalised yield by CT14 pp cross section ($\sigma_{pp} = 11.92 \pm 0.43$ pb)

- The PDFs modification depends on the rapidity



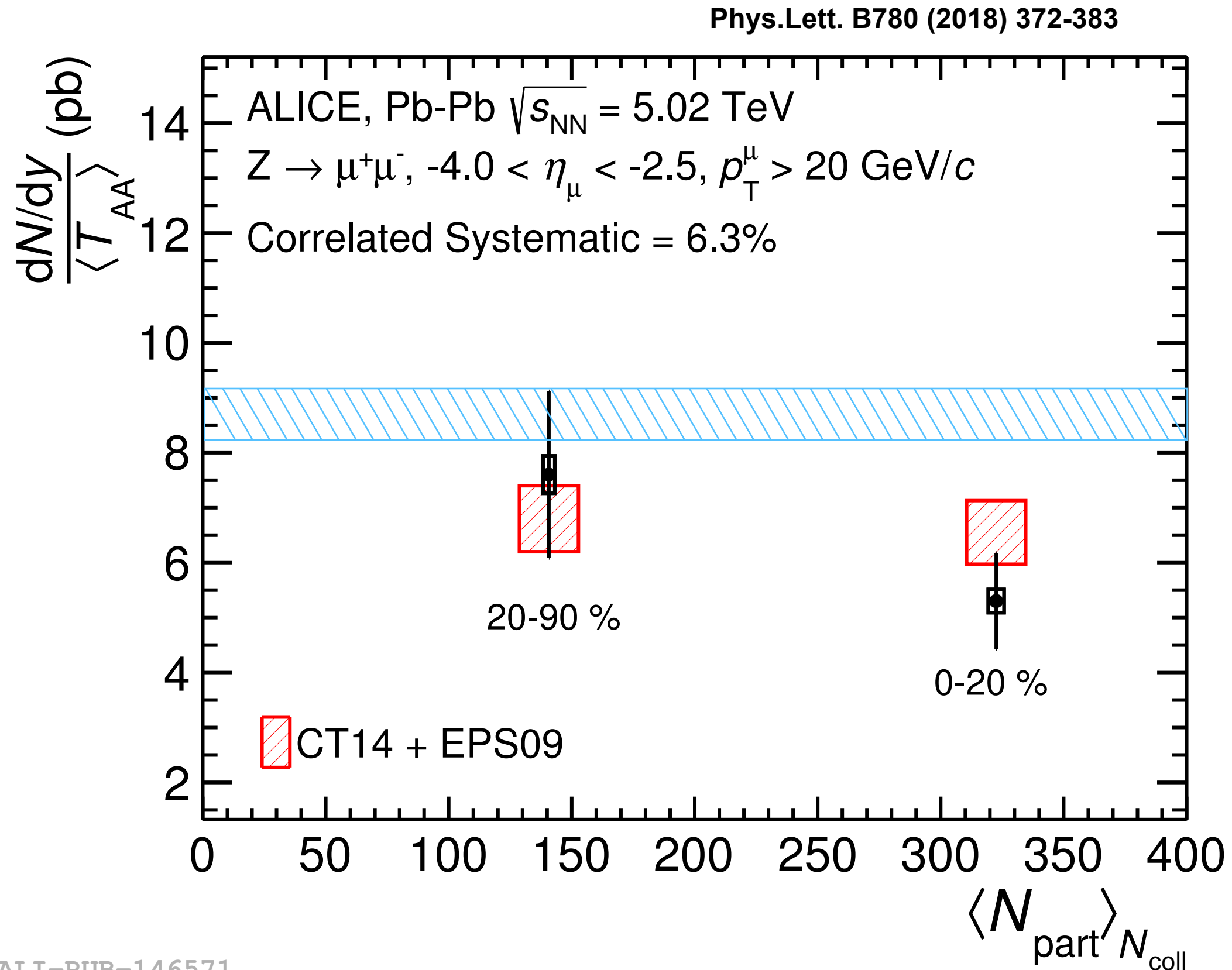
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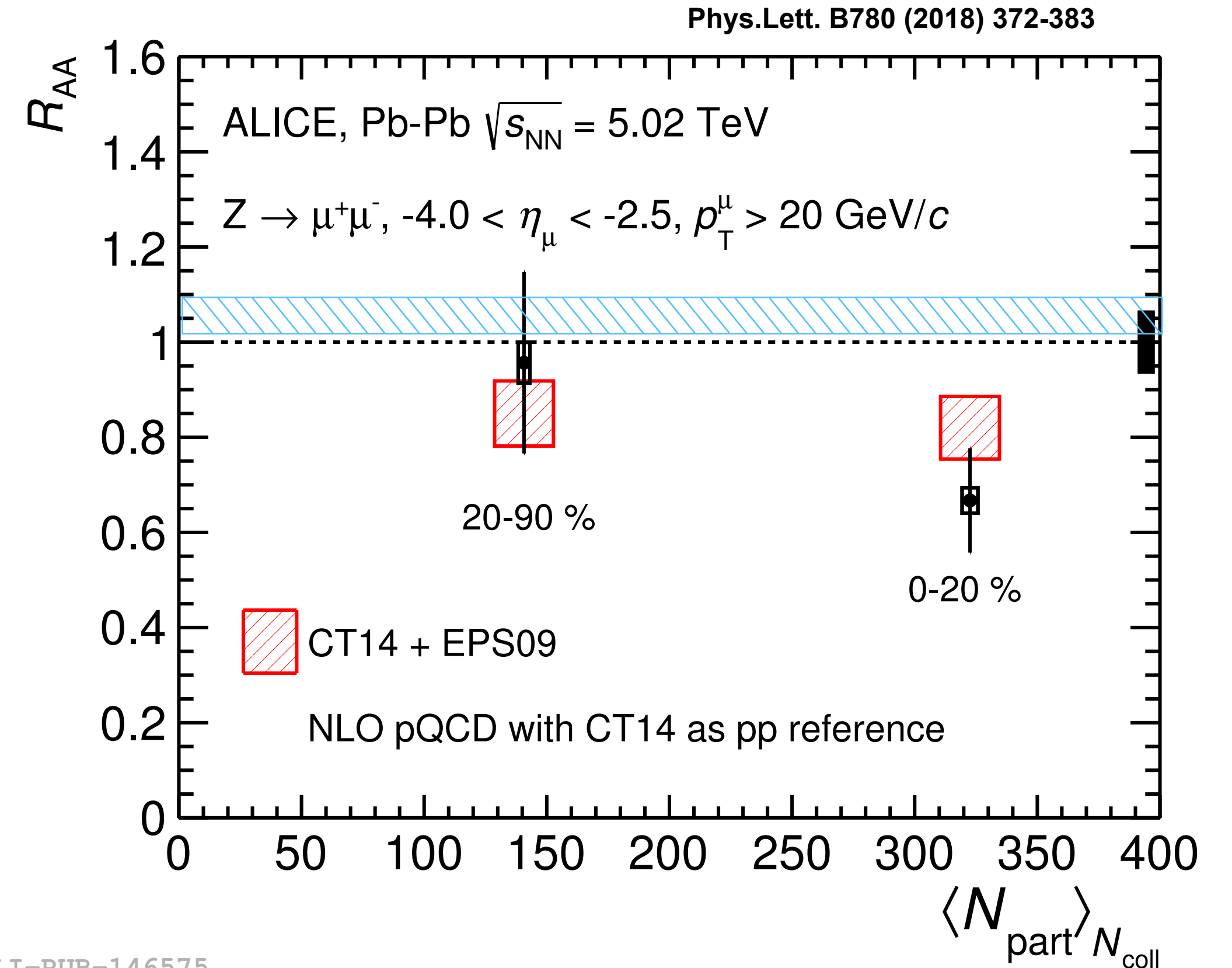
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- The results are in a better agreement with the calculation that includes PDFs modification

- The nPDF is expected to slightly depend on the centrality



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- Free PDFs prediction** overestimates the measurement by $\sim 3 \sigma$ for 0-20% centrality
- The results are in agreement within uncertainties with calculations based on EPS09

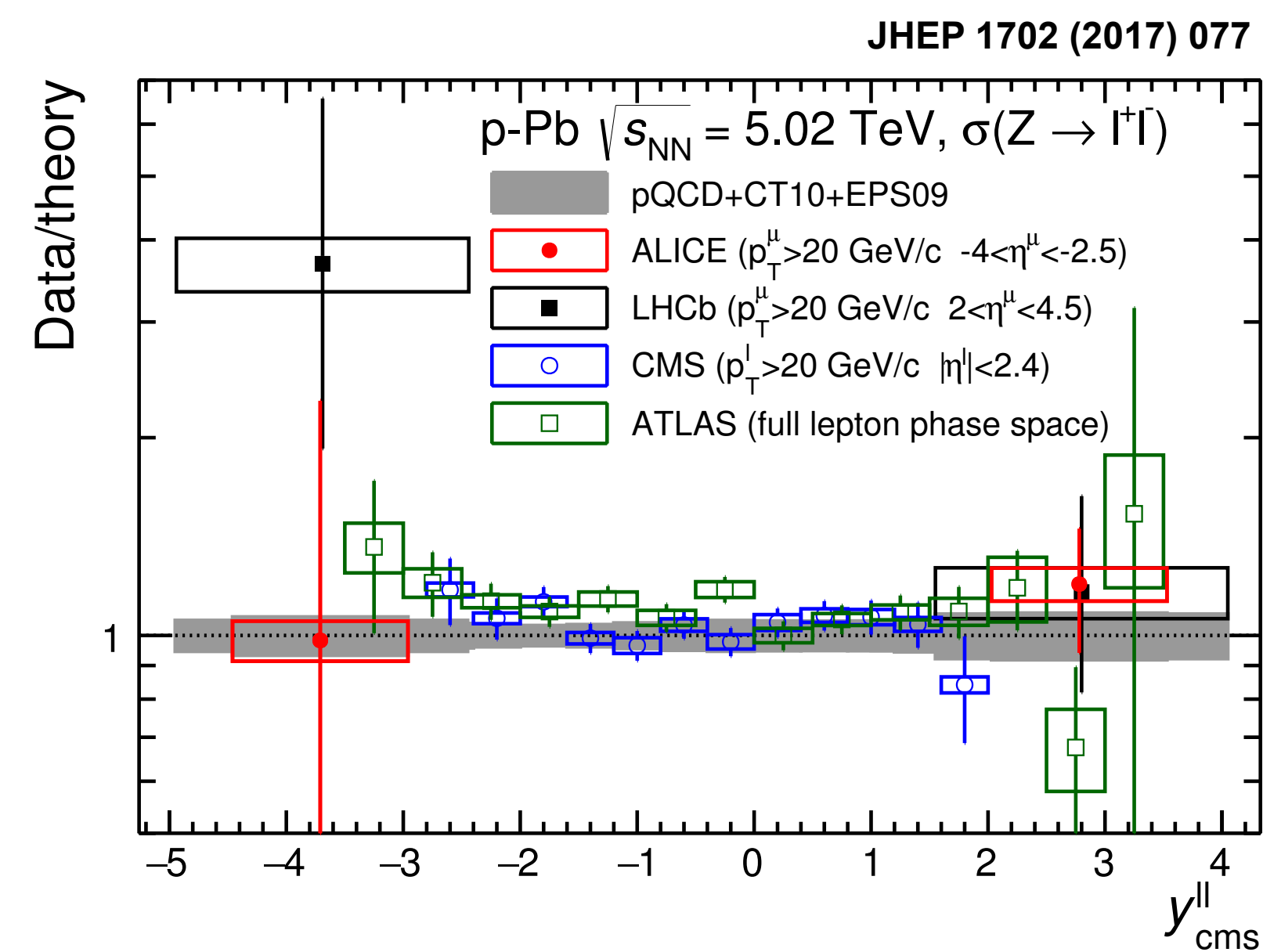
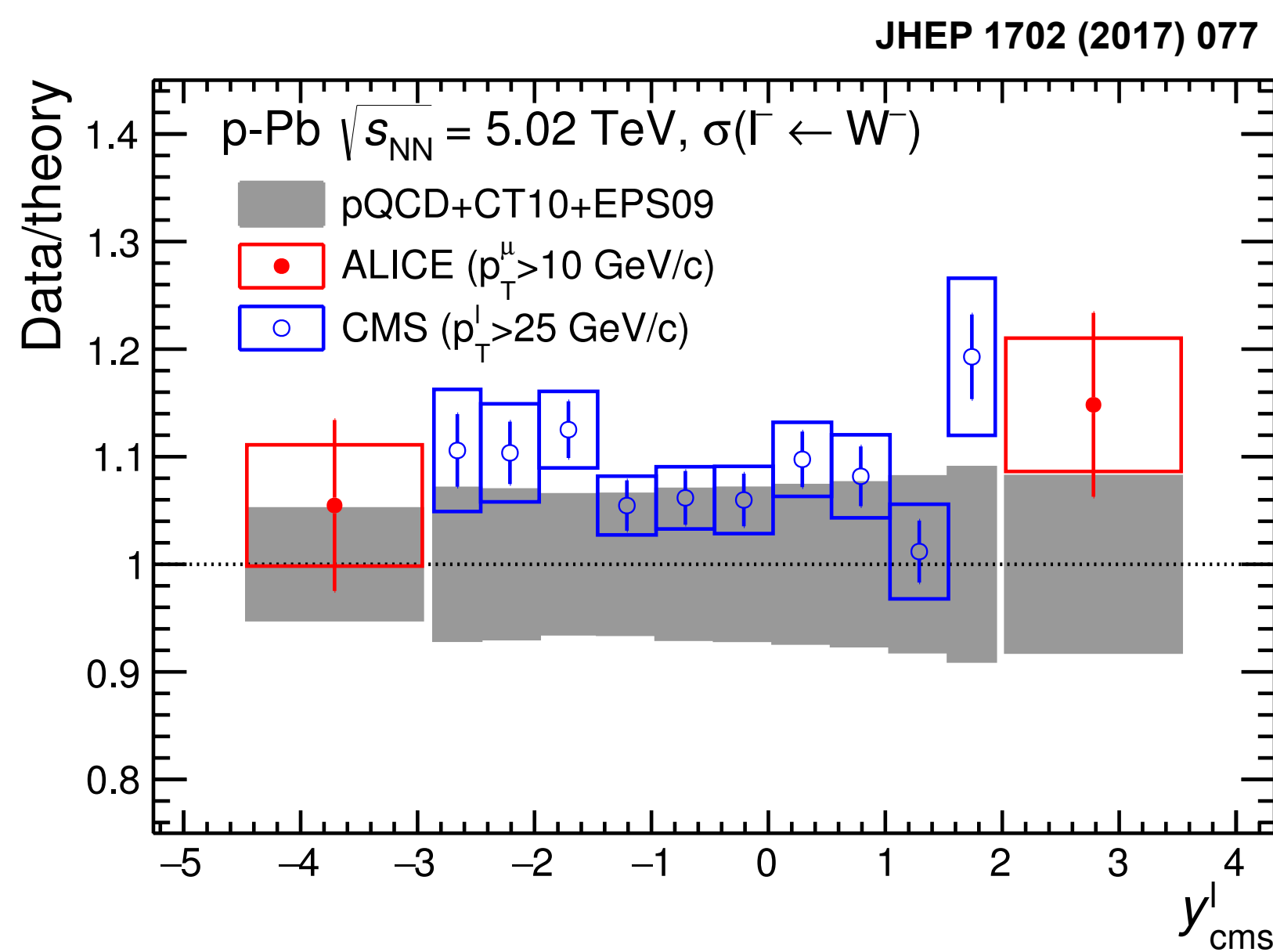
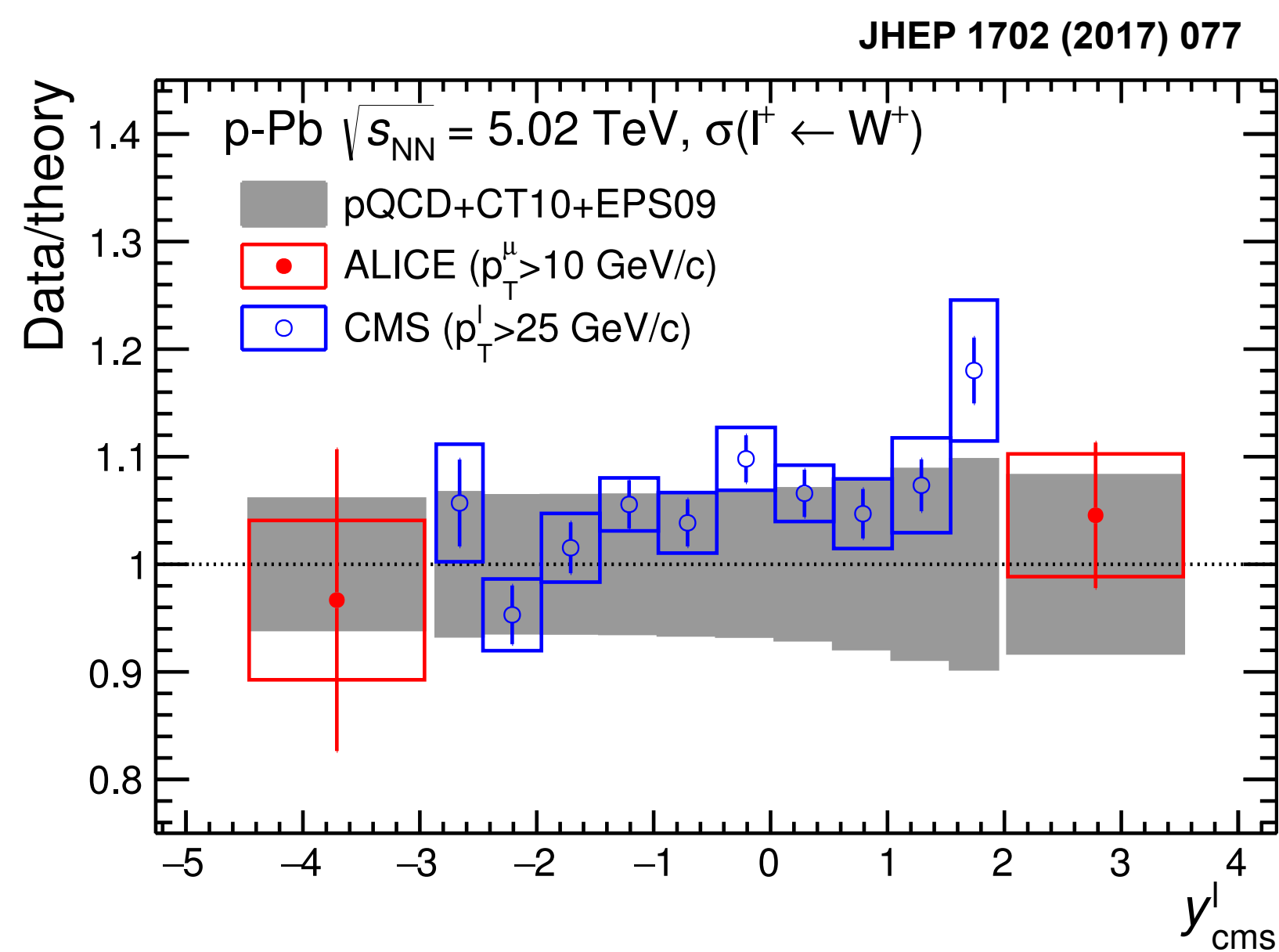
- **W/Z-boson production in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV**
 - Results can be described by theoretical calculations within uncertainties
 - More precision is needed to conclude on the nPDFs
 - Analysis of the $\sqrt{s_{NN}} = 8.16$ TeV data sample is ongoing: 4 (12) x more statistics expected in the p-going (Pb-going) direction
- **Z-boson production in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV**
 - Calculations with free PDFs overestimate the measurement by 2.3σ (3σ for the 20% most central collisions)
 - Larger Pb-Pb data sample is expected later in 2018
- **Analysis is ongoing to measure the W-boson production in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV**
- **Results can be included in nPDF global fits**

Extra slides

W/Z-boson production in p-Pb collisions

comparison to other LHC results

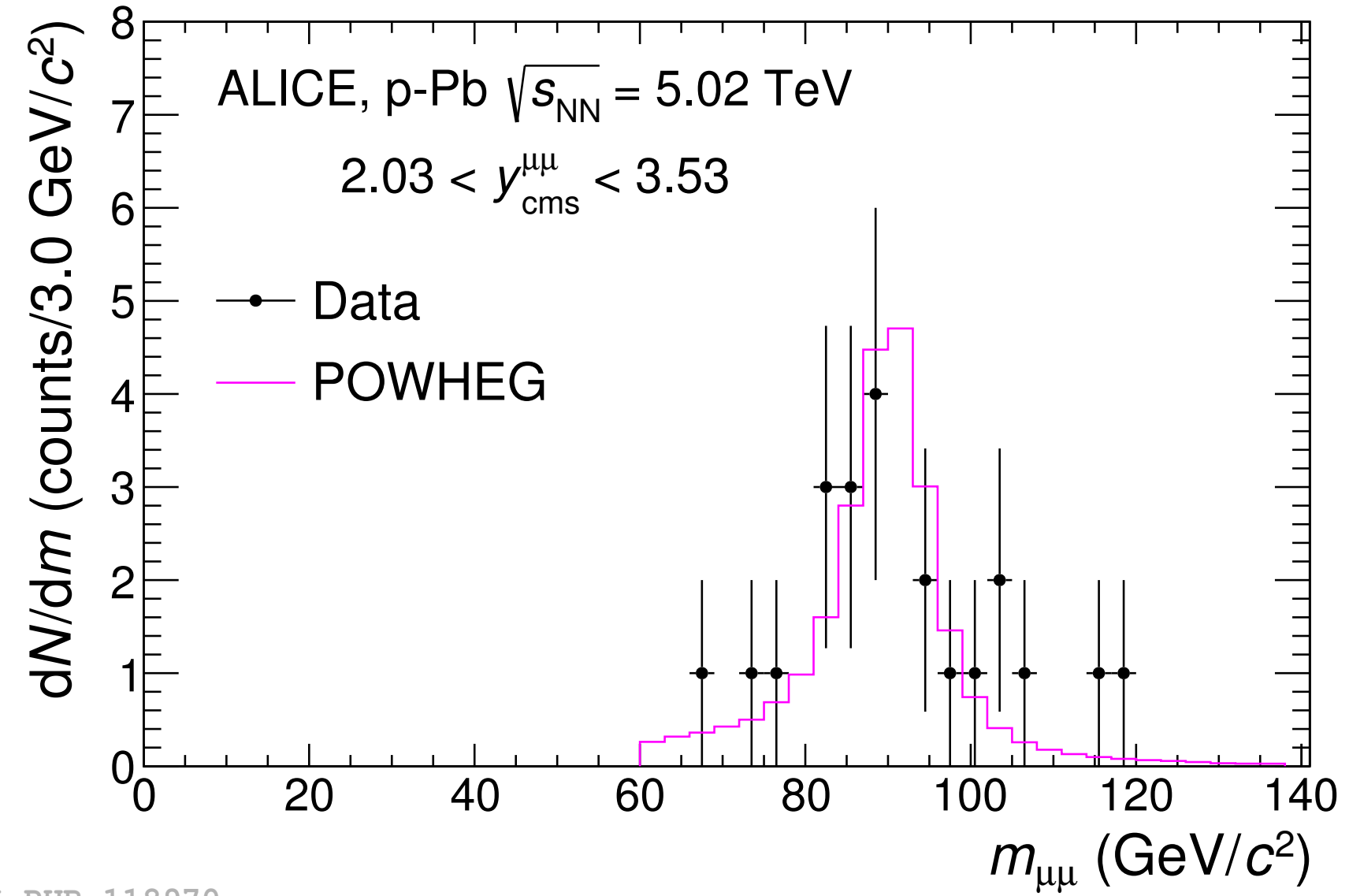
- Results not directly comparable (different kinematic cuts) → compare the ratio data over the corresponding pQCD predictions



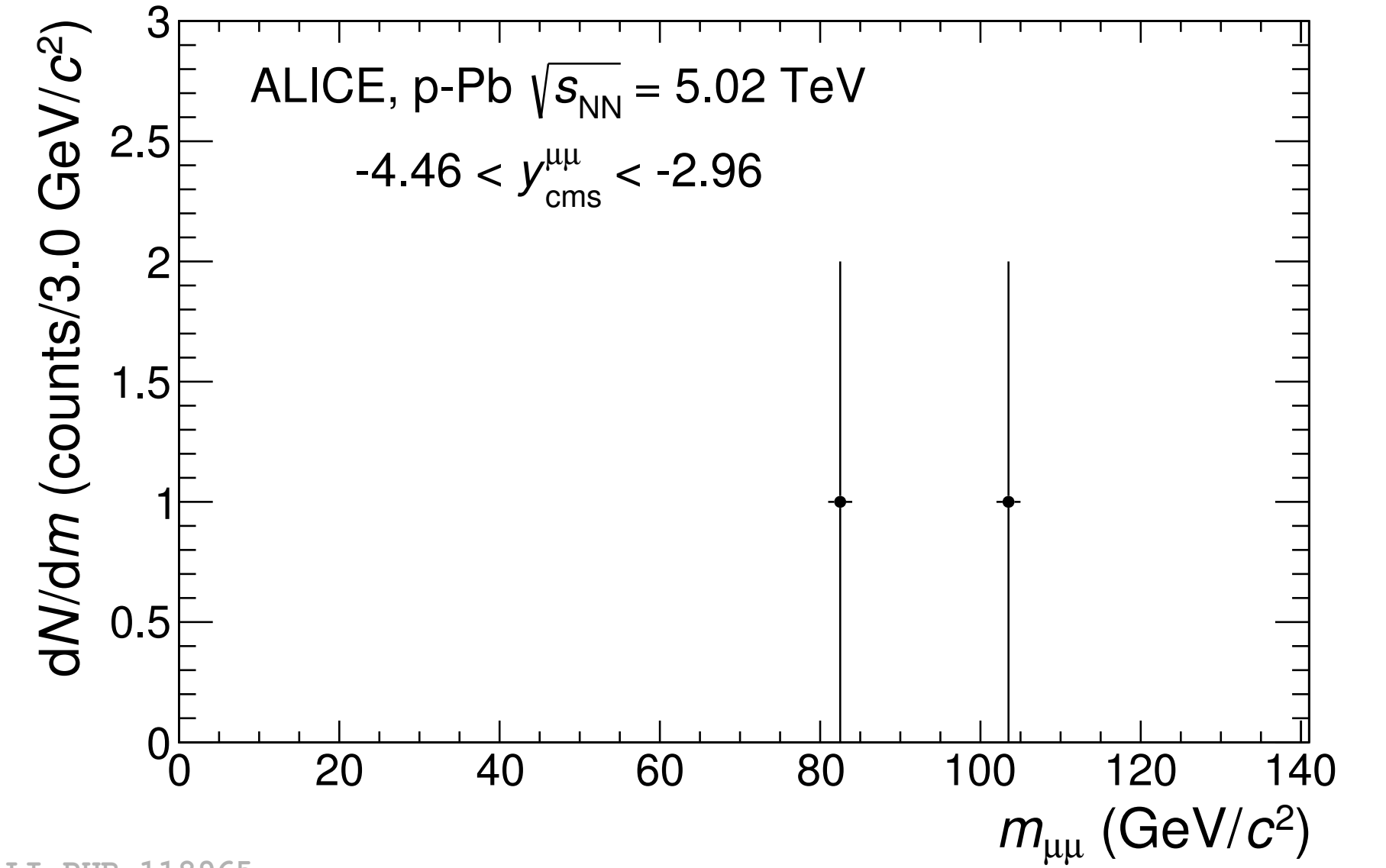
- Calculations including EPS09 PDFs modification can describe data within uncertainties over the full rapidity interval

Dimuon invariant mass distributions

p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV

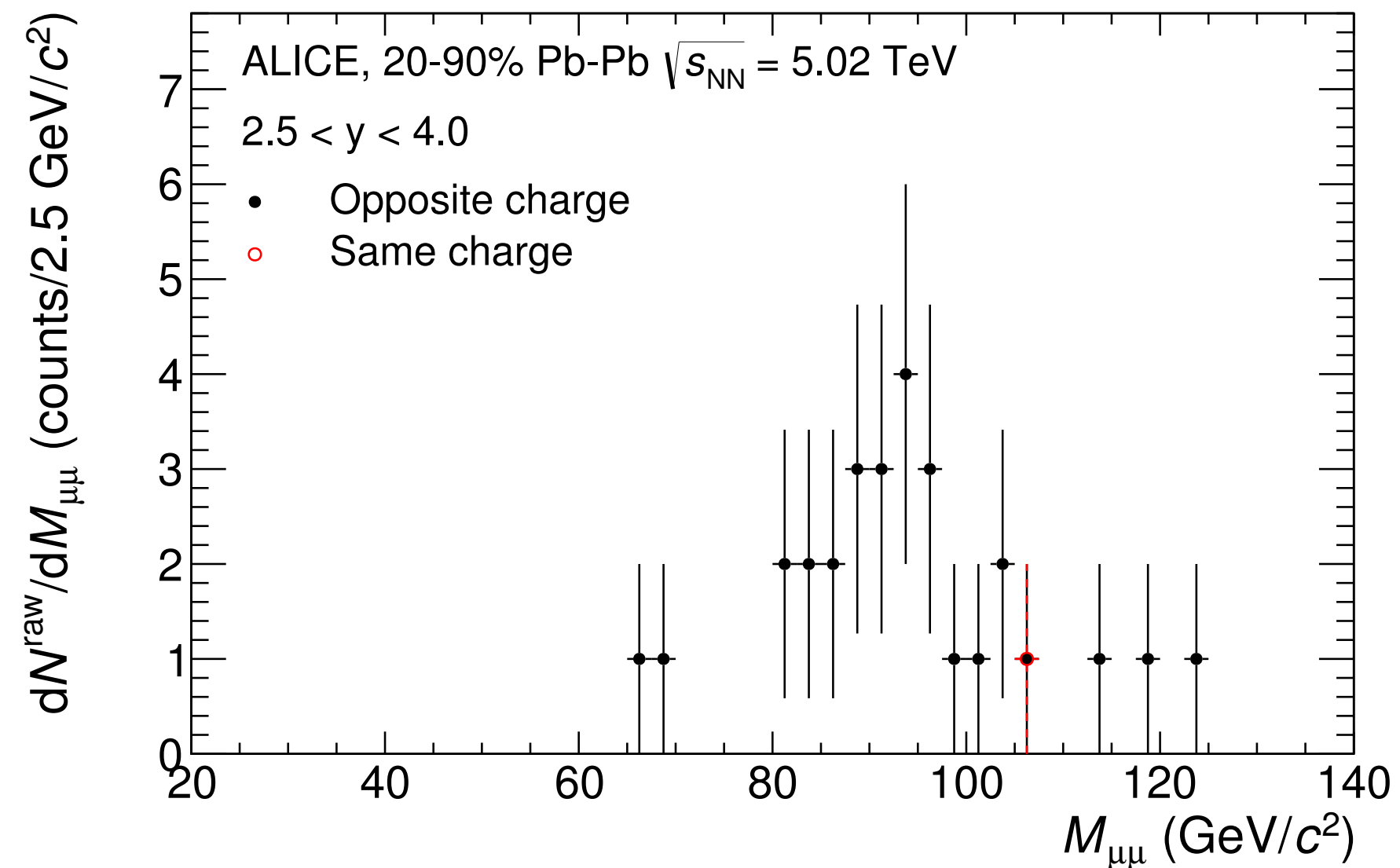


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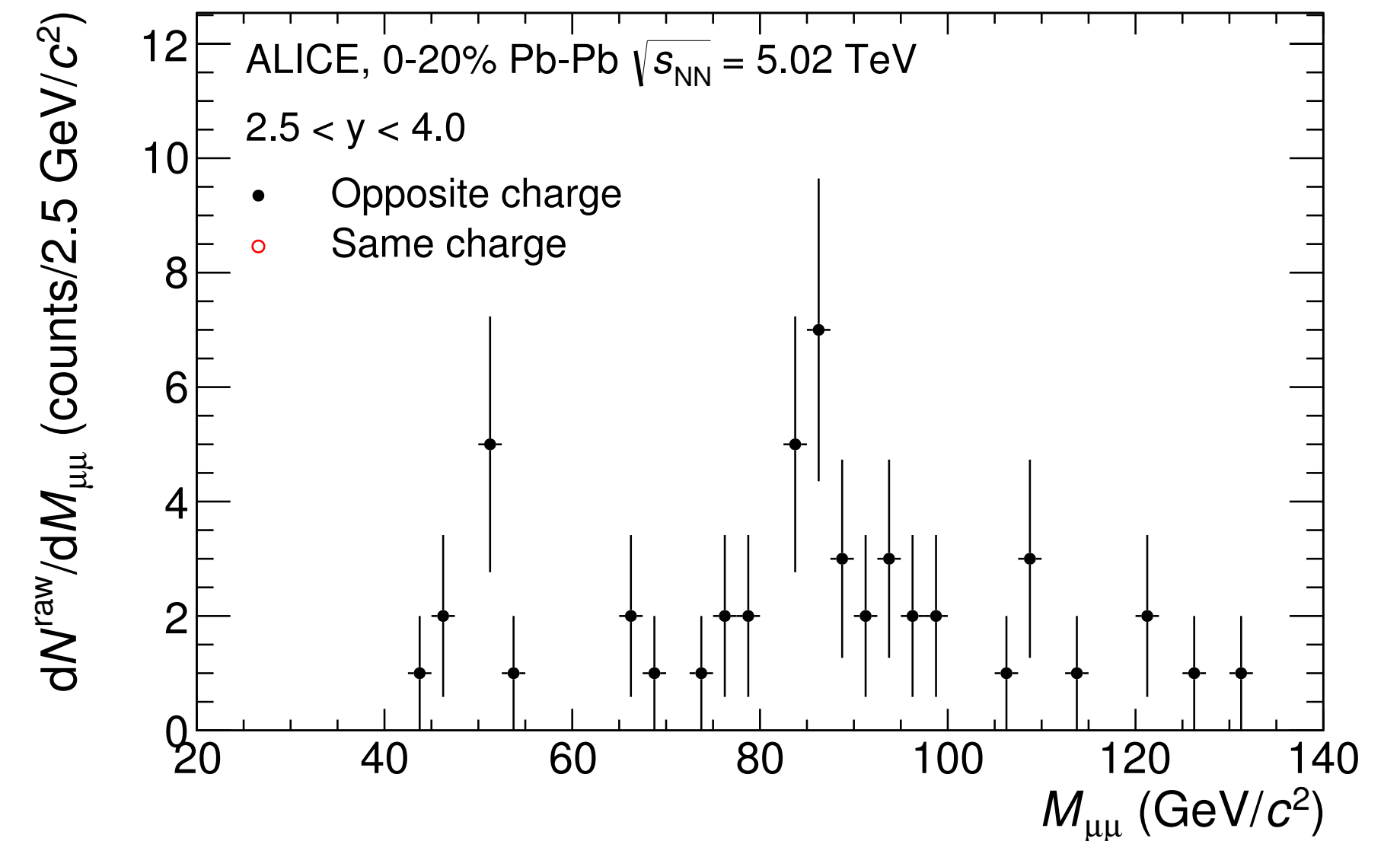


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Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV



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ALI-PUB-146523

nPDF sets

nPDF set	EPPS16	EPS09	DSSZ12	nCTEQ15
Order	NLO	NLO	NLO	NLO
Flavour separation	Full	none	none	partial
Baseline PDFs	CT14	CTEQ6	MSTW2008	
# Free parameters	20	15	25	17
# data points	1811	929	1579	708
	Included experimental data			
Neutral current DIS				
DY lepton in pA				
RHIC pions in d-Au				
neutrino nucleus DIS				
LHC p-Pb jets				
LHC p-Pb W,Z				