

Measurement of electroweak-boson production in p-Pb and Pb-Pb collisions at the LHC with ALICE

Nicolò Valle University and INFN, Pavia, Italy

for the ALICE Collaboration



Electroweak Bosons in Heavy-Ion Collisions

Produced in the hard processes at the initial stages of the collisions

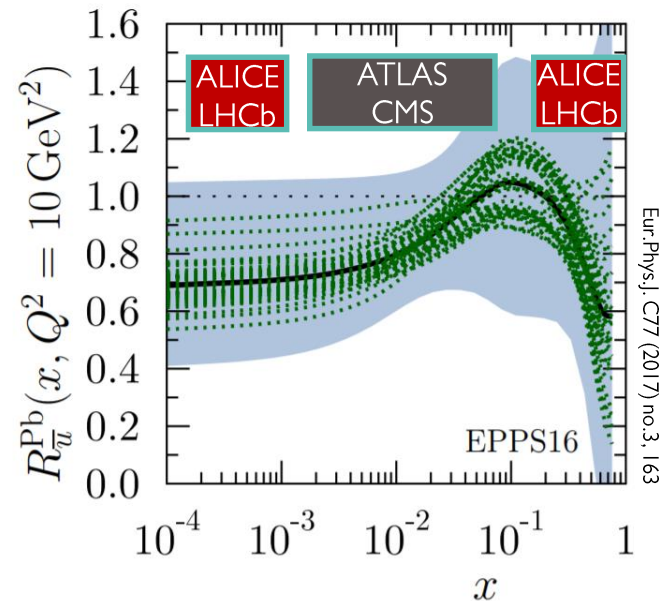
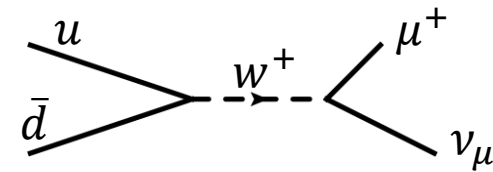
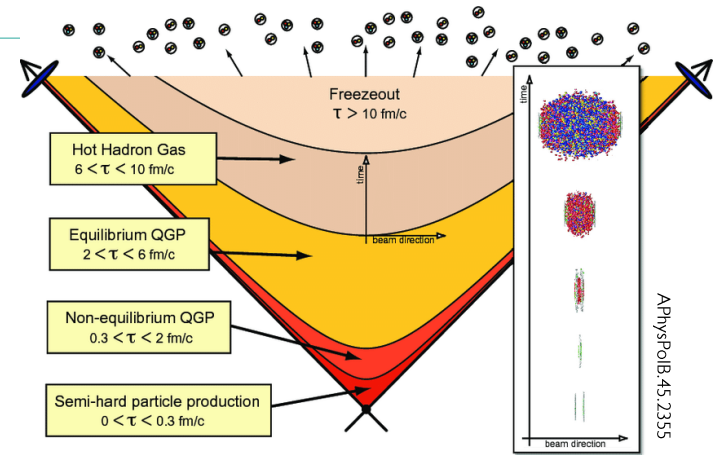
Insensitive to the presence of the strongly-interacting medium

A good way to access Parton Distribution Functions (in the proton) and their nuclear modification (nPDFs, in nuclei)

Flavour-dependent modifications of quark densities in nuclei accessible by studying W^+ / W^- asymmetry

Such initial stage effects can be studied in pA collisions

Reference for hot-matter effects on other probes



Z and W bosons with the ALICE Detector

Looking for muons from

$$Z \rightarrow \mu^+ \mu^- \quad W^\pm \rightarrow \mu^\pm \nu_\mu$$

Muon spectrometer coverage:

$$-4 < \eta < -2.5$$

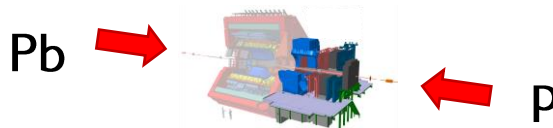
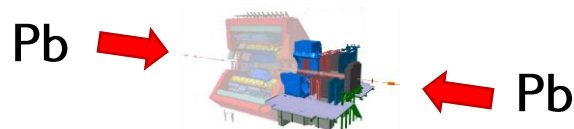
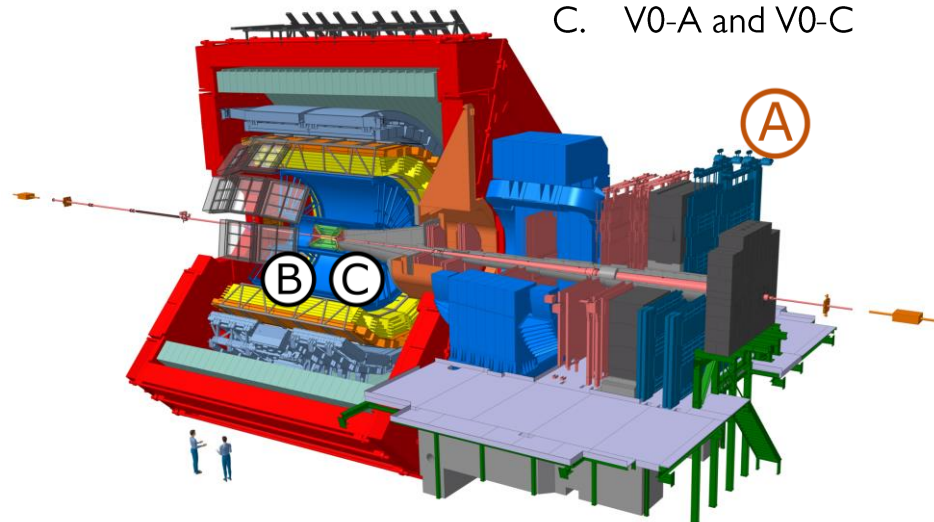
Pb-p and p-Pb asymmetry \rightarrow access to different rapidity and Bjorken- x ranges:

Pb-Pb: $2.5 < y_{\text{cms}} < 4$

“p-going”: $2.03 < y_{\text{cms}} < 3.53$

“Pb-going”: $-4.46 < y_{\text{cms}} < -2.96$

- A. Muon Spectrometer
- B. Silicon Pixel Detector
- C. V0-A and V0-C



Z and W bosons with the ALICE Detector

Looking for muons from

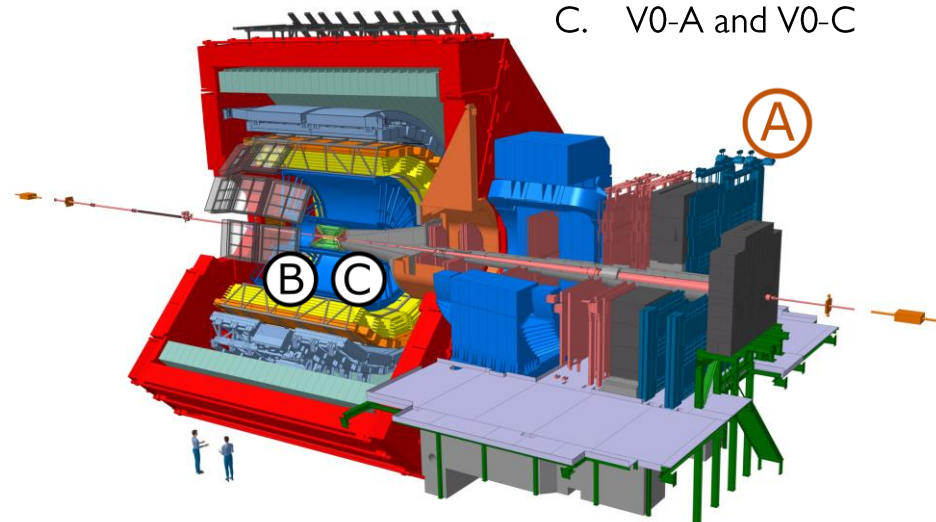
$$Z \rightarrow \mu^+ \mu^- \quad W^\pm \rightarrow \mu^\pm \nu_\mu$$

Muon spectrometer coverage:

$$-4 < \eta < -2.5$$

Pb-p and p-Pb asymmetry \rightarrow access to different rapidity and Bjorken- x ranges:

- A. Muon Spectrometer
- B. Silicon Pixel Detector
- C. V0-A and V0-C



collision system	$\sqrt{s_{NN}}$	L_{int}	collected in	presented here	
Pb-Pb	5.02 TeV	$\sim 225 \mu b^{-1}$	2015	Z boson	[1]
p-Pb Pb-p	5.02 TeV	$5.03 \pm 0.18 nb^{-1}$ $5.81 \pm 0.20 nb^{-1}$	2013	Z, W bosons	[2]
p-Pb Pb-p	8.16 TeV	$8.47 \pm 0.18 nb^{-1}$ $12.75 \pm 0.25 nb^{-1}$	2016	Z boson	New

[1] Phys. Lett. B780 (2018) 372-383

[2] JHEP 1702 (2017) 077

Z-boson Signal Extraction

Opposite-sign muon pairs reconstructed in the spectrometer

Only high- p_T muons are used

$$p_{T,\mu} > 20 \text{ GeV}/c$$

Signal extraction by counting candidates in

$$60 < m_{\mu\mu} < 120 \text{ GeV}/c^2$$

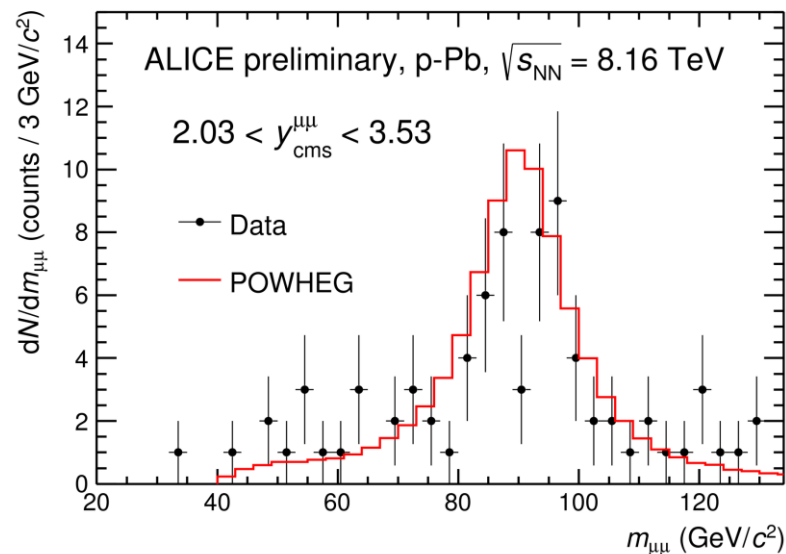
Residual background from

$$Z/\gamma^* \rightarrow \tau\tau \rightarrow \mu\mu \quad t\bar{t} \rightarrow \mu\mu$$

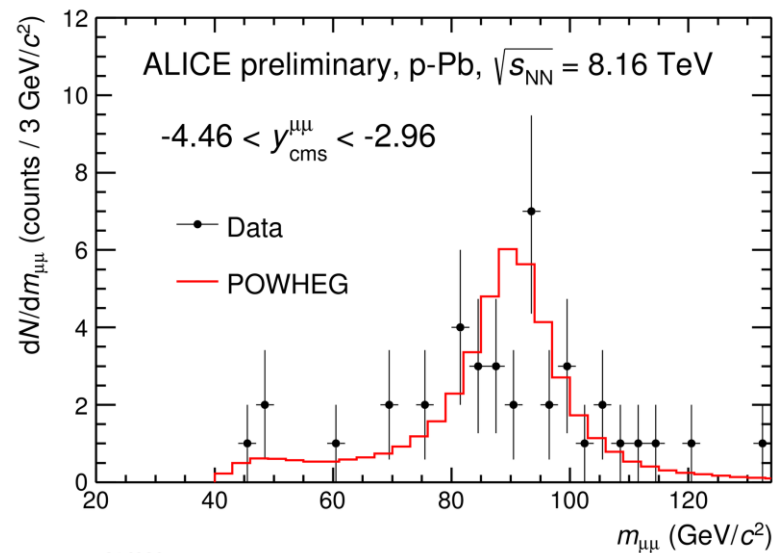
→ ~1% of the yield (POWHEG and PYTHIA)

Combinatorial background → small

Acceptance and efficiency are estimated with POWHEG simulations (embedding for centrality dependence)



ALI-PREL-316224



ALI-PREL-316228

W-boson Signal Extraction

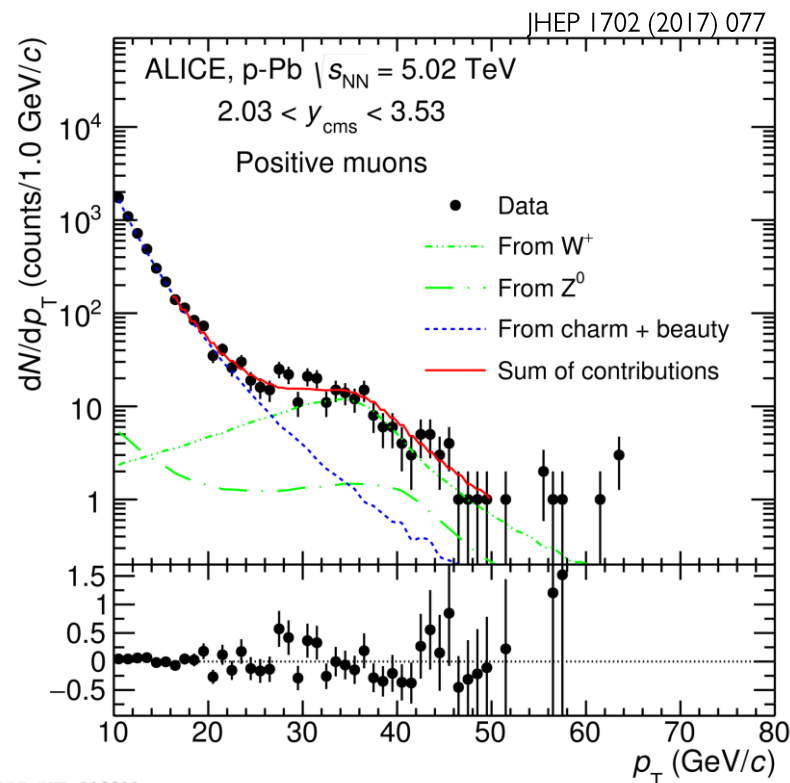
Monte-Carlo template fit of the p_T distribution of single muons

High p_T :

- Heavy-flavoured hadrons (FONLL pQCD calculations [1])
 - Z-bosons and Drell-Yan
 - ✓ Semi-leptonic decays of W
- (POWHEG)

Isospin effects taken into account by simulating pp, pn, np, nn separately

Acceptance and efficiency are estimated with POWHEG simulations



[1] JHEP 1210 (2012) 137

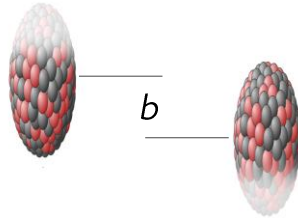
Results



Z-boson in Pb-Pb collisions, $\sqrt{s_{NN}} = 5.02$ TeV

Phys. Lett. B780 (2018) 372-383

$$R_{AA} = \frac{dN/dy}{\langle T_{AA} \rangle \sigma_{pp}}$$

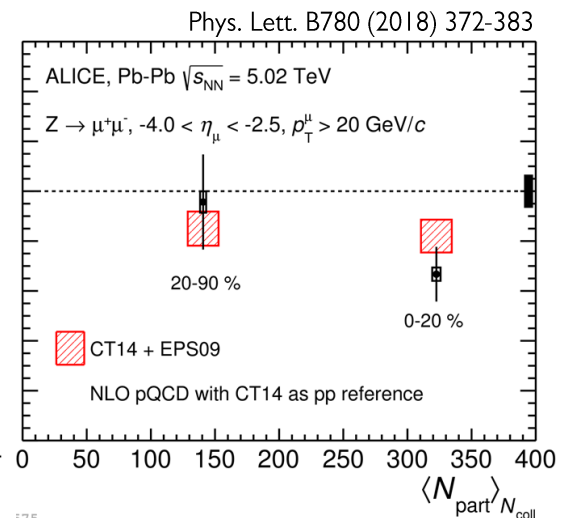
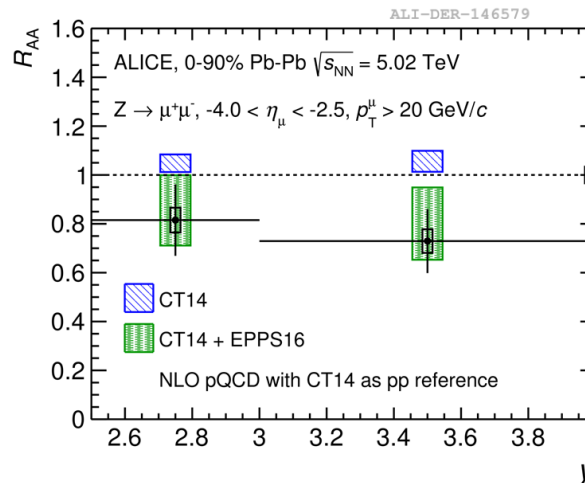
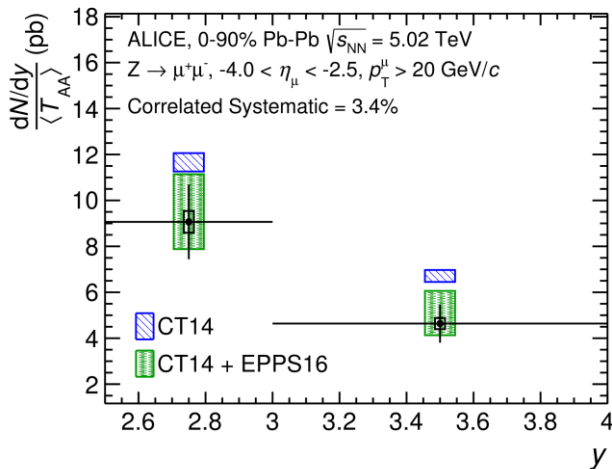
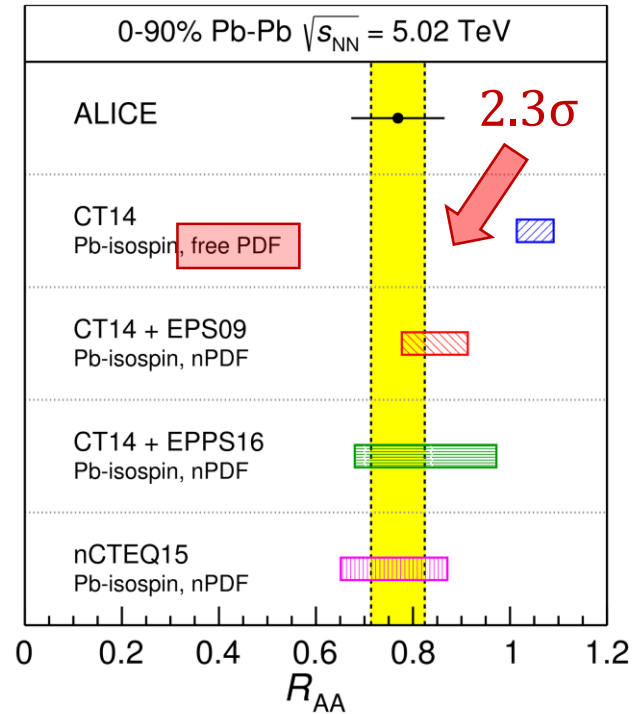


Nuclear overlap function T_{AA} by Glauber model

CT14 calculations^[1] are used for σ_{pp}

Yield and R_{AA} measured as a function of rapidity and centrality

Comparison with different theoretical calculations at NLO, with free PDFs and nPDFs [1-4]



[1] Phys.Rev. D93 (2016) no.3, 033006

[2] JHEP 0904 (2009) 065

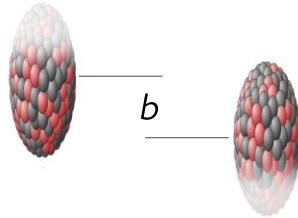
[3] Eur.Phys.J. C77 (2017) no.3, 163

[4] Eur.Phys.J. C77 (2017) no.7, 488

Z-boson in Pb-Pb collisions, $\sqrt{s_{NN}} = 5.02$ TeV

Phys. Lett. B780 (2018) 372-383

$$R_{AA} = \frac{dN/dy}{\langle T_{AA} \rangle \sigma_{pp}}$$



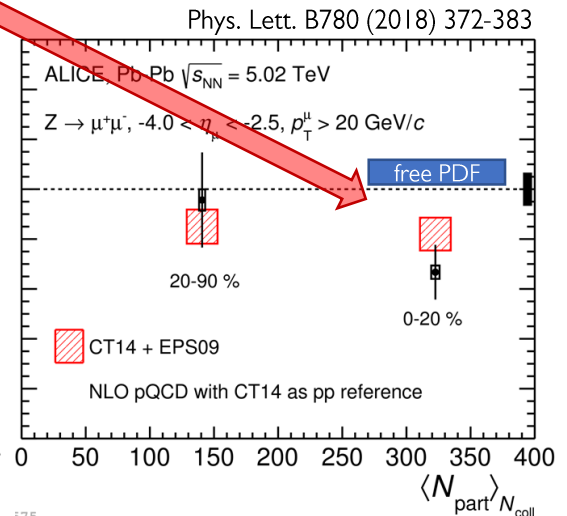
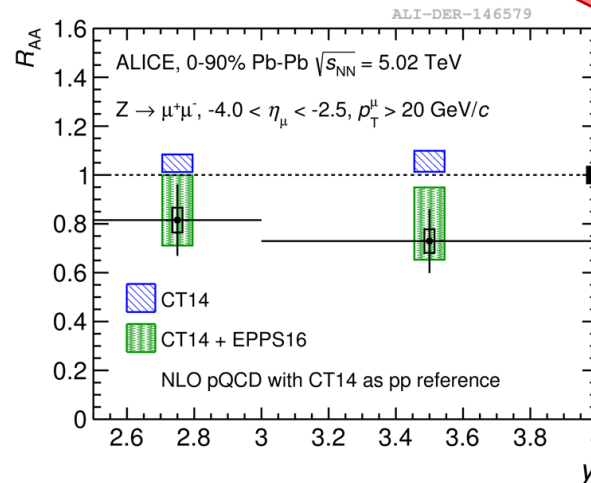
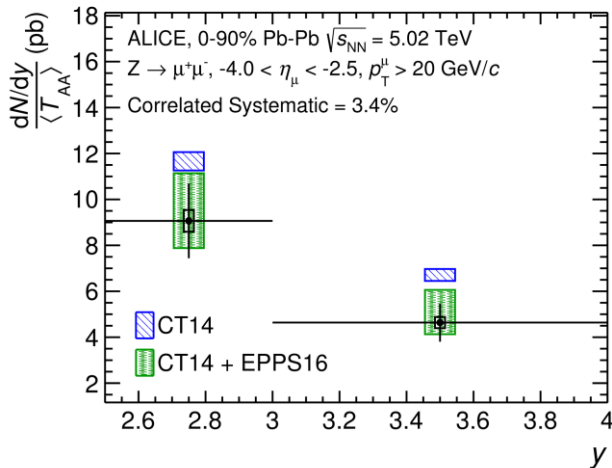
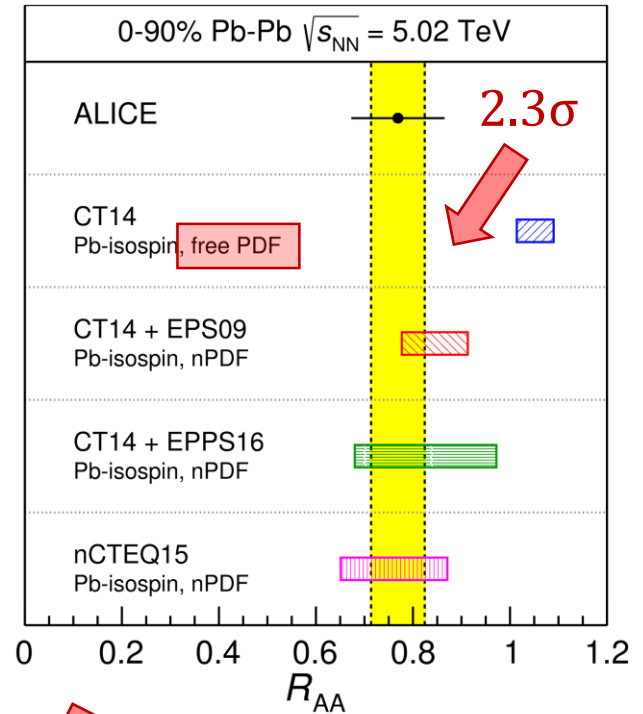
Nuclear overlap function T_{AA} by Glauber model

CT14 calculations^[1] are used for σ_{pp}

Yield and R_{AA} measured as a function of rapidity and centrality

Comparison with different theoretical calculations at NLO, with free PDFs and nPDFs [1-4]

Free PDFs calculations deviate from experiment, up to 3σ



[1] Phys.Rev. D93 (2016) no.3, 033006

[2] JHEP 0904 (2009) 065

[3] Eur.Phys.J. C77 (2017) no.3, 163

[4] Eur.Phys.J. C77 (2017) no.7, 488

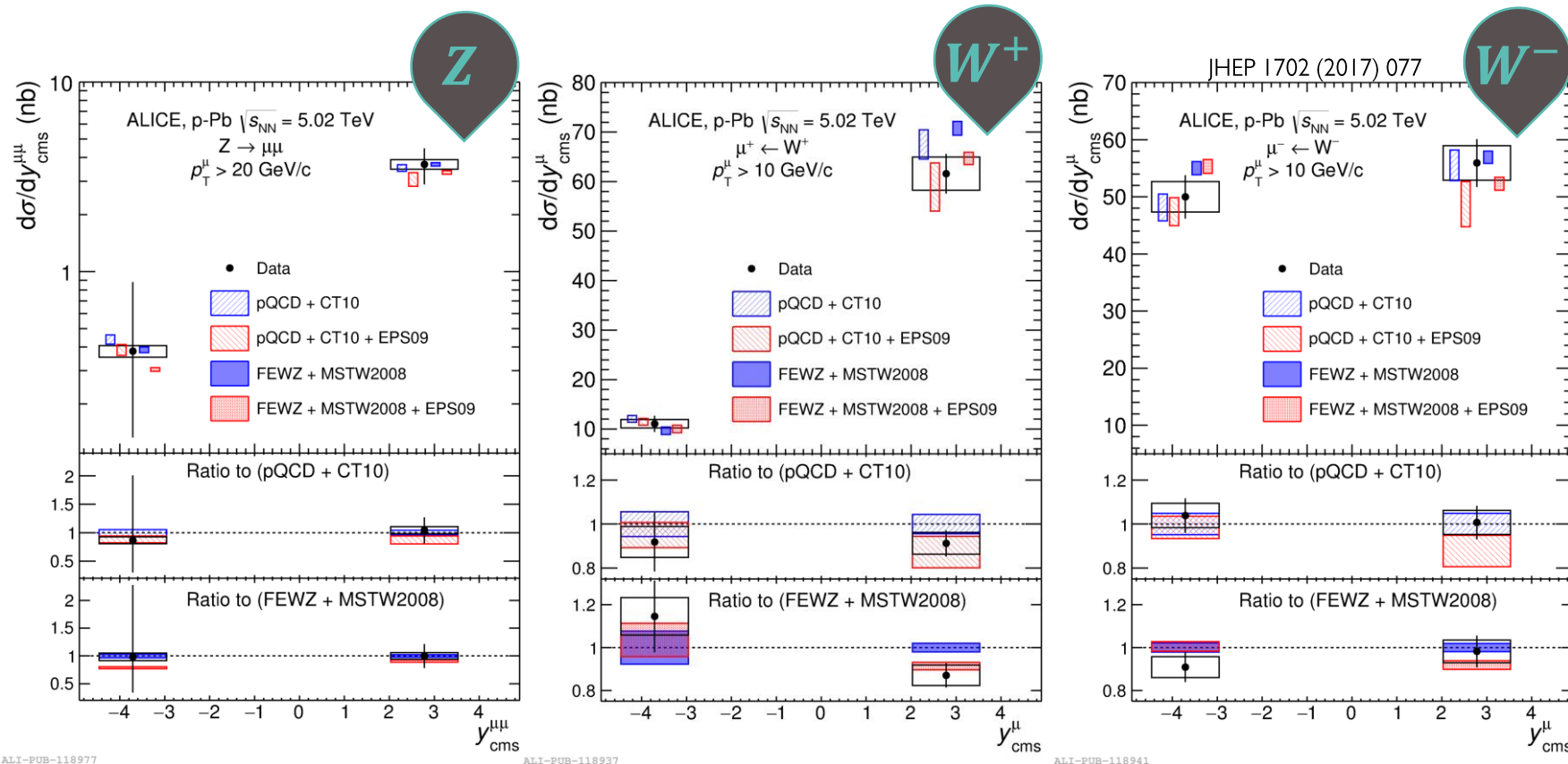
W and Z bosons in p-Pb collisions, $\sqrt{s_{NN}} = 5.02$ TeV

JHEP 1702 (2017) 077

Results compared with NLO (based on CT10 PDFs^[1]) and NNLO (with FEWZ, based on MSTW2008 PDFs^[2-3]) predictions

EPS09 nPDF^[4] for the nuclear modification

Here the precision of the data does not allow to draw conclusions on PDF modifications



ALI-PUB-118977

ALI-PUB-118937

ALI-PUB-118941

[1] Phys.Rev. D82 (2010) 074024

[2] Comput.Phys.Commun. 182 (2011) 2388-2403

[3] Eur.Phys.J. C63 (2009) 189-285

[4] JHEP 0904 (2009) 065

W and Z bosons in p-Pb collisions, $\sqrt{s_{NN}} = 5.02$ TeV

JHEP 1702 (2017) 077

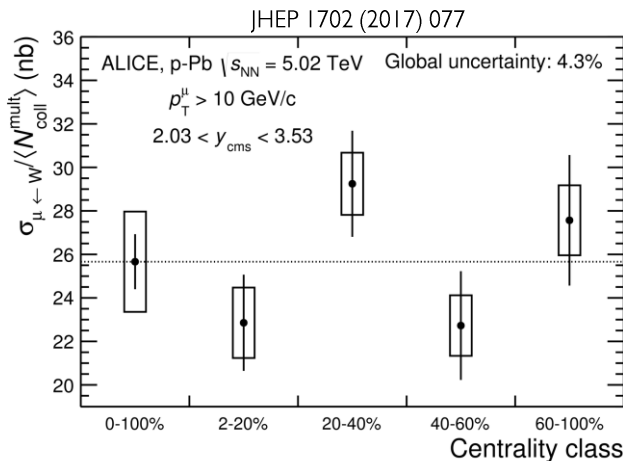
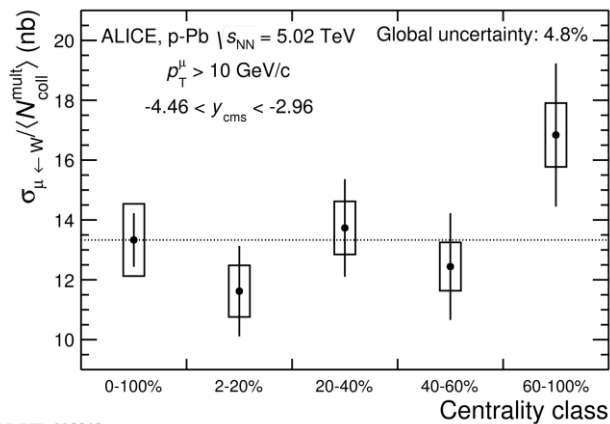
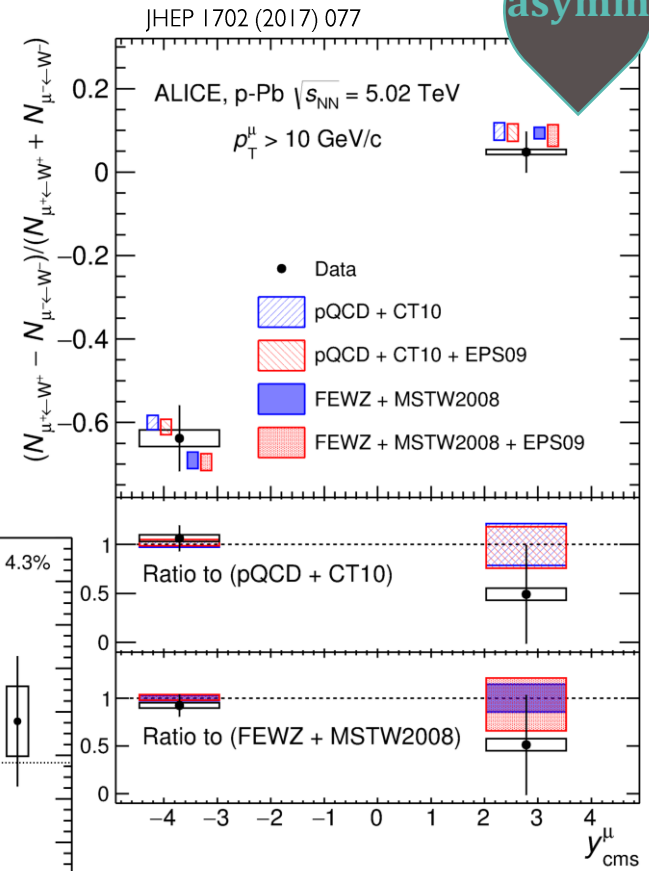
Results compared with NLO (based on CT10 PDFs^[1]) and NNLO (with FEWZ, based on MSTW2008 PDFs^[2-3]) predictions

EPS09 nPDF^[4] for the nuclear modification

Here the precision of the data does not allow to draw conclusions on PDF modifications

Uncertainties reduced when measuring W^+ / W^- asymmetry

Within the uncertainties the production cross-section scales with the number of binary collisions



[1] Phys.Rev. D82 (2010) 074024 [2] Comput.Phys.Commun. 182 (2011) 2388-2403 [3] Eur.Phys.J. C63 (2009) 189-285 [4] JHEP 0904 (2009) 065

Z-boson in p-Pb collisions, $\sqrt{s_{NN}} = 8.16$ TeV



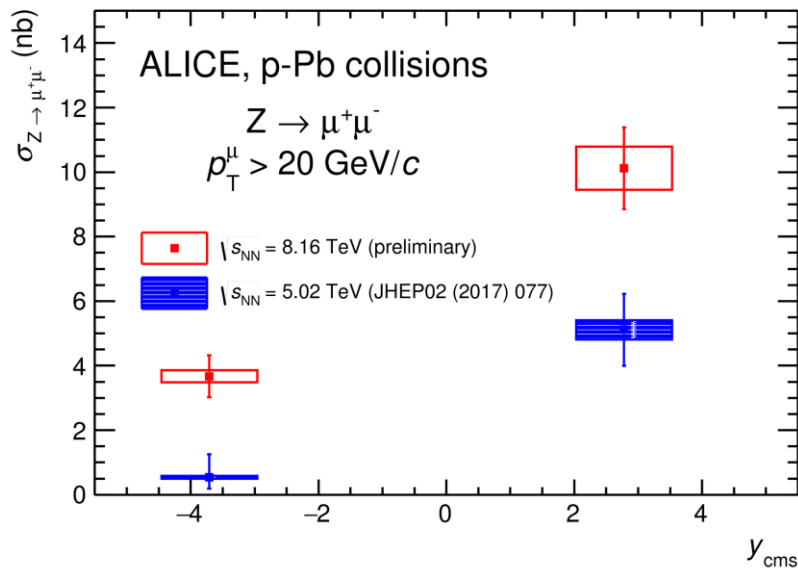
First measurement of Z in p-Pb collisions at 8.16 TeV

Increased luminosity (almost 2 times greater) with respect to p-Pb at 5.02 TeV

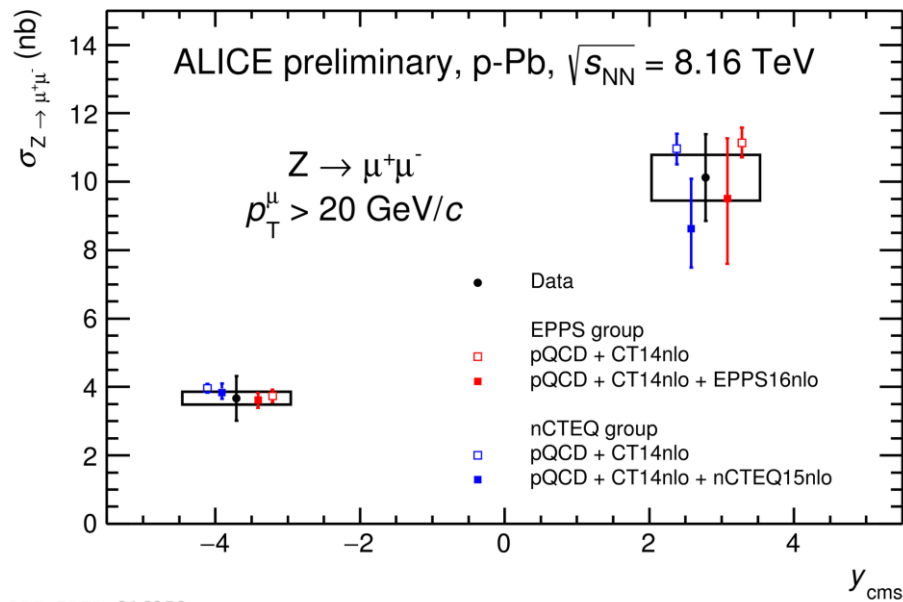
Cross section measured at forward and backward rapidity

Comparison with different theoretical calculations at NLO, with free PDFs (CT14^[1]) and nPDFs (from EPPS and nCTEQ groups^[2-3])

With this precision (on both experimental data and models) no firm conclusions on PDF modifications



ALI-PREL-316244



ALI-PREL-316252

Summary

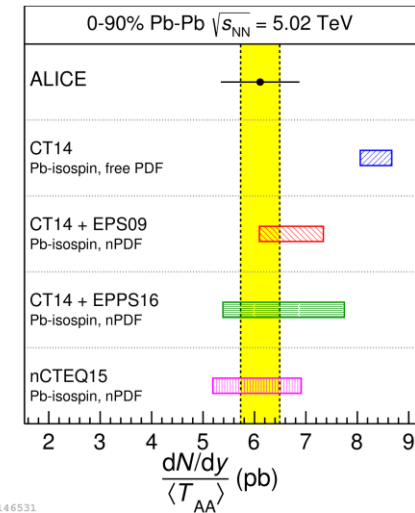
The measurements at large rapidities provide data in a kinematic region where the nPDFs are less constrained

The results from Pb-Pb data are better described by calculations including nuclear modification of PDFs

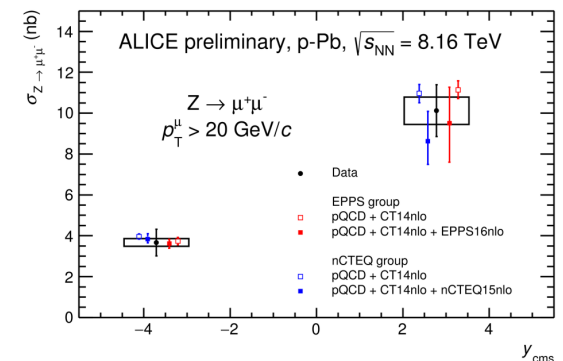
p-Pb results are still statistically limited but these new measurements can be included in nPDFs global fits



Analyses ongoing on Z and W bosons production in Pb-Pb at 5.02 TeV, and on W-boson production at 8.16 TeV



ALI-PUB-146531



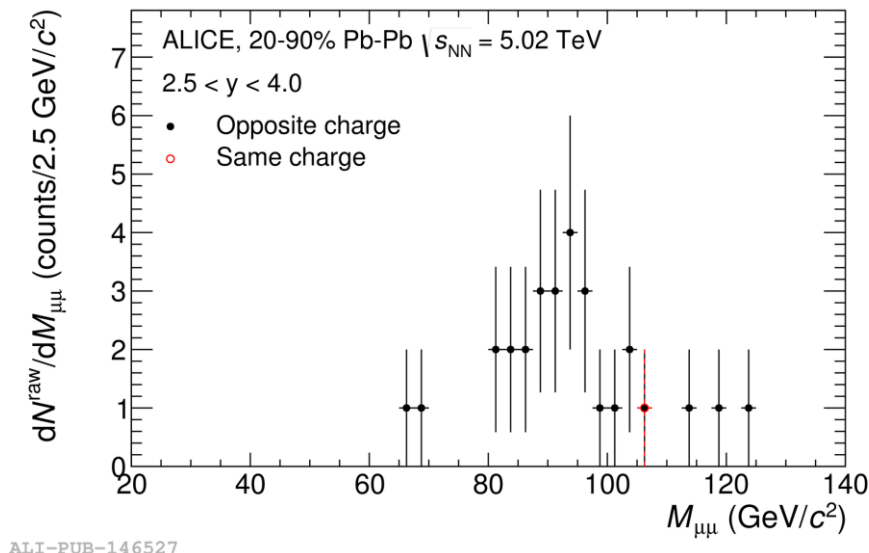
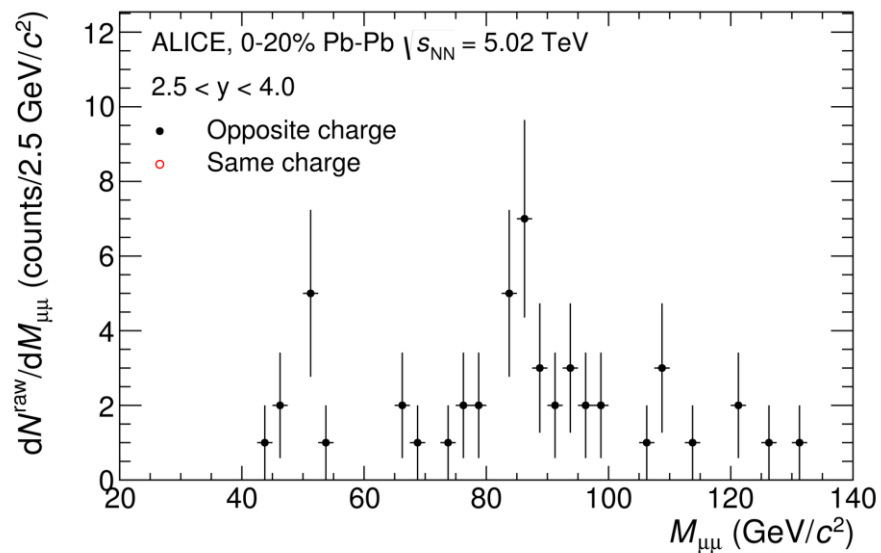
ALI-PREL-316252



Extra Images



Z signal extraction - centrality



ALI-PUB-146523

ALI-PUB-146527



Comparison with other experiments

