Z production in pPb collisions at LHCb

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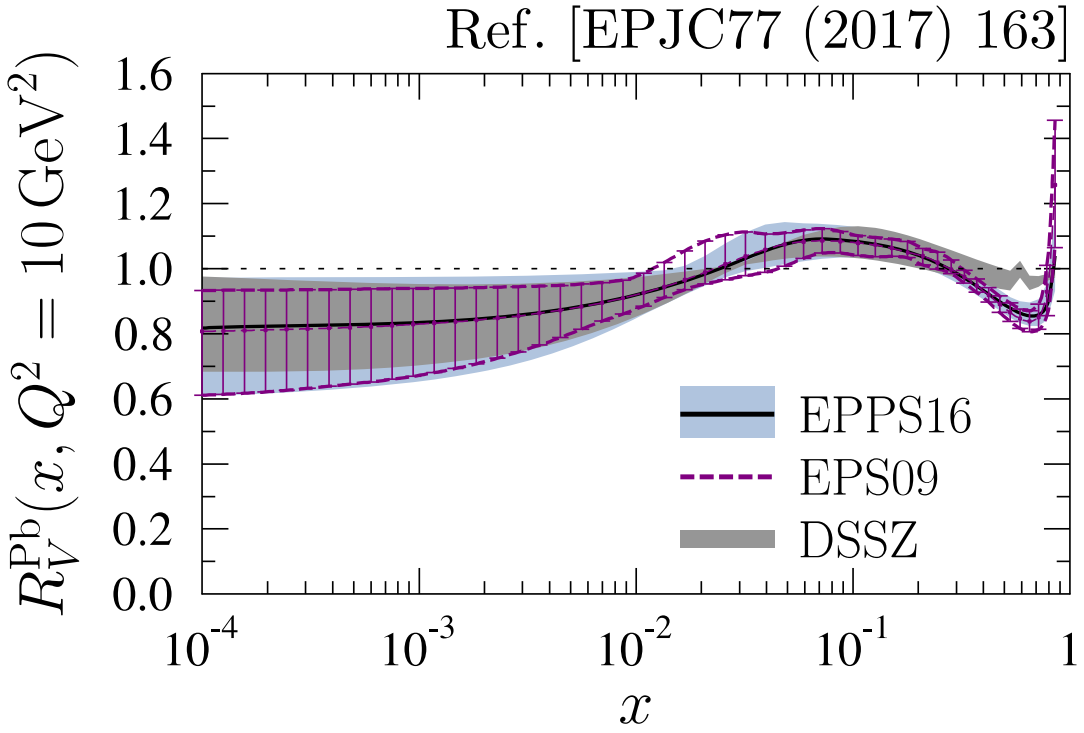
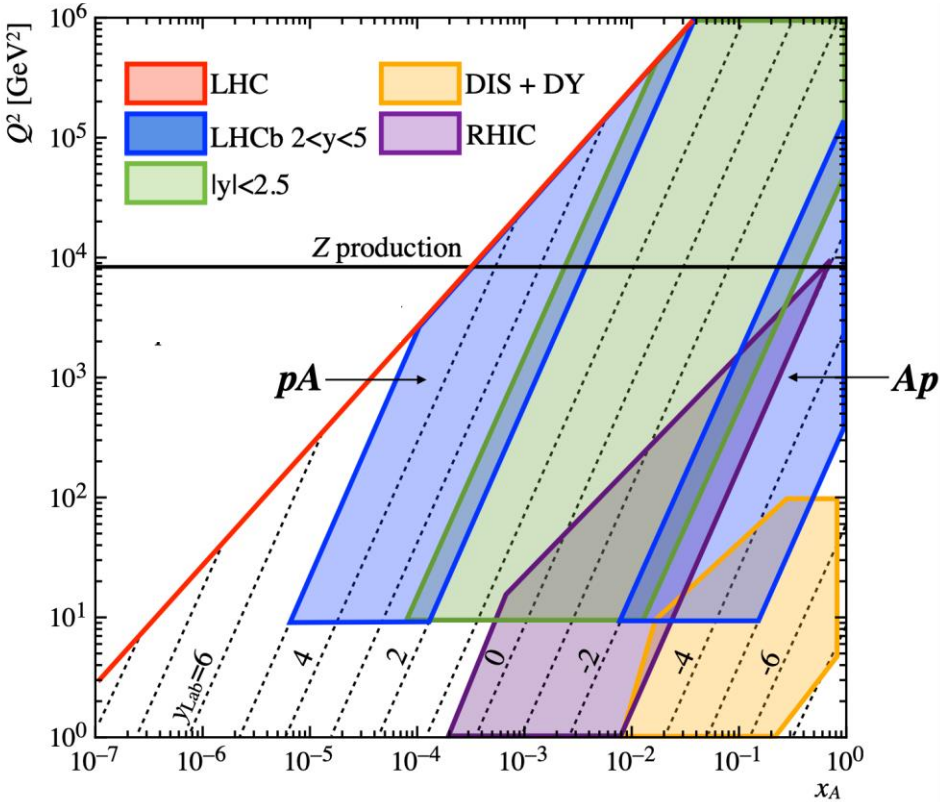
on behalf of the LHCb collaboration

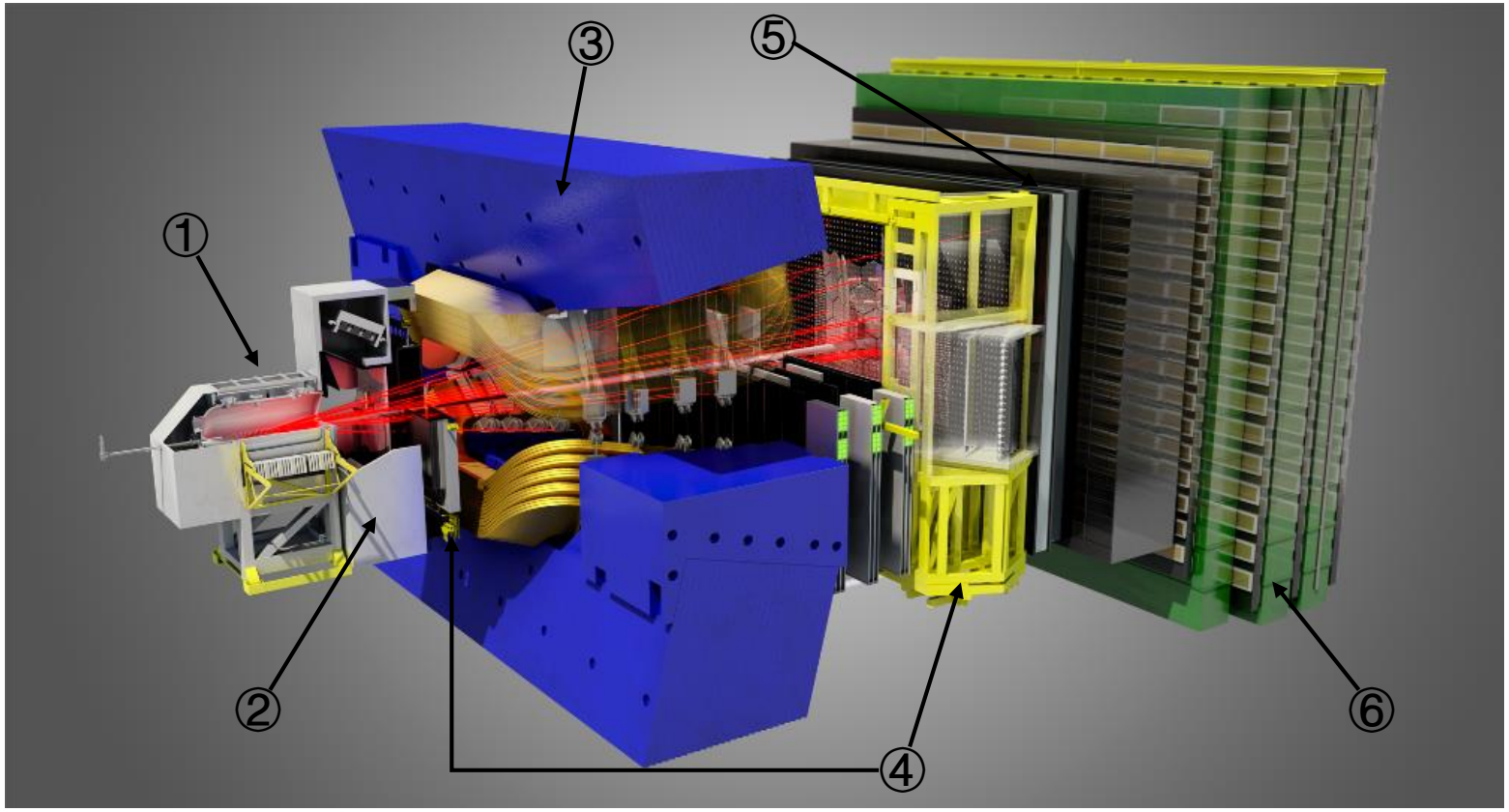
Physics motivation





Electroweak bosons are unmodified by the hot and dense medium created in nucleus–nucleus collisions, Their leptonic decays pass through the medium without being affected by the strong interaction.
Therefore, electroweak boson productions well "conserved" the initial conditions of the collisions, can be used to probe (cold) nuclear effects and constraint nPDFs for Bjorken-x from 10^{-4} to 1 at $Q^2 \sim 10^4$ GeV^2

LHCb Detector



LHCb is the only detector fully instrumented in forward region.

Kinematic coverage:

$2 < \eta < 5$

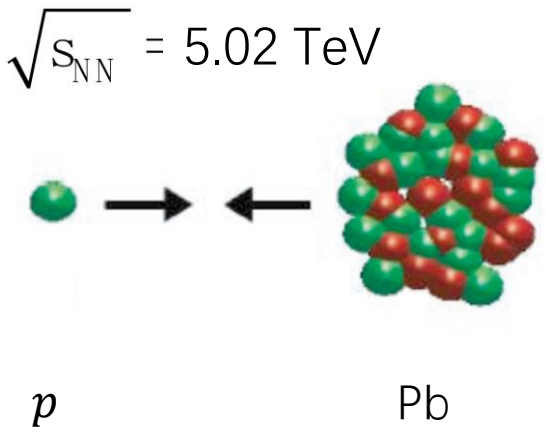
A high precision device, down to very low-p_T, excellent particle ID, precision vertex reconstruction and tracking.

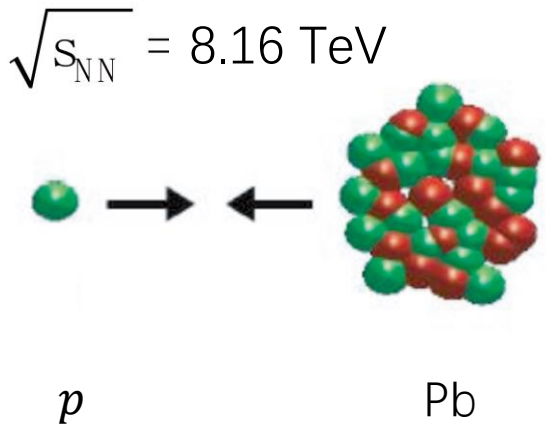
① Vertex Detector : reconstruct vertices
② Dipole Magnet : bending power: 4 Tm
③ RICH Detector : K/Π/p separation
④ Tracking System: momentum resolution
⑤ Calorimeters : energy measurement
⑥ Muon System : muon identification

Data samples

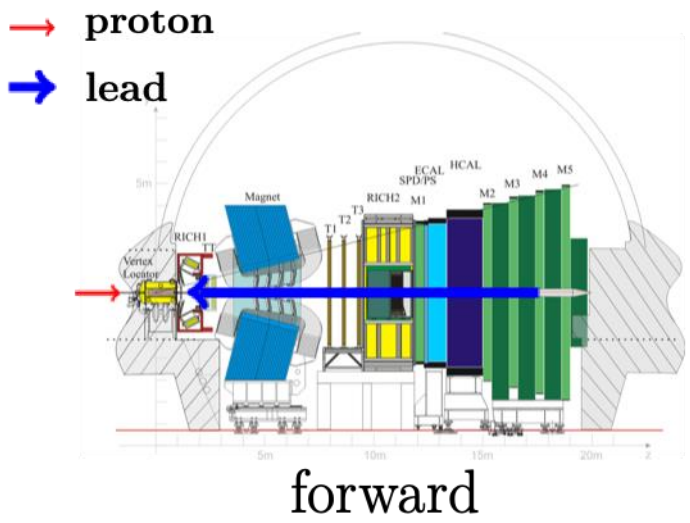
$\sqrt{S_{NN}}$	2013 (5.02 TeV)		2016 (8.16 TeV)	
$\mathcal{L}$	pPb	Pbp	pPb	Pbp
	1.1 nb^{-1}	0.5 nb^{-1}	13.6 nb^{-1}	20.8 nb^{-1}

Collider Mode:

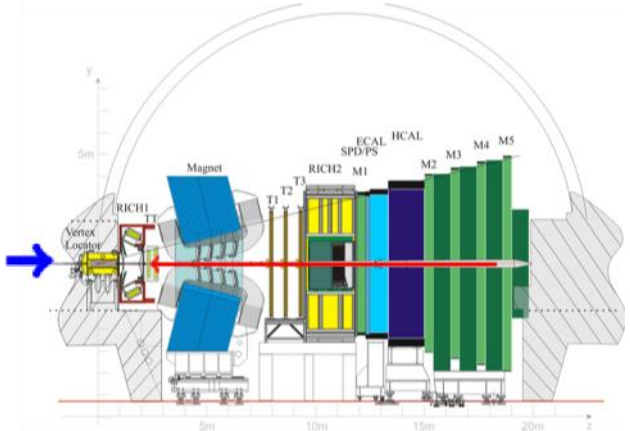




Setups for proton-ion collisions



forward



backward

Forward production:

Center of mass rapidity coverage: $1.5<y^{*}<4.0$

Backward production:

Center of mass rapidity coverage: $-5.0<y^{*}<-2.5$

Rapidity coverage in center of mass frame considers a rapidity shift of about 0.47 with respect to the lab frame coverage $2.0<y<4.5$.

Common range for the measurements: $2.5<|y^{*}|<4.0$

Analysis Strategy

$$\sigma_{Z\to\mu^+\mu^-,p\mathrm{Pb},\mathrm{Pb}p} = \frac{N_{\mathrm{cand}} \times \rho}{\mathcal{L} \times \epsilon}$$

where

- N_{cand} is the number of observed candidates after selection,
- ρ is the purity (the fraction of actual signal events),
- $\mathcal{L}$ is the integrated luminosity,
- ϵ is the total efficiency.

Z production in pPb collisions at 5 TeV

Integrated luminosity:

forward ($1.099 \pm 0.021\ \mathrm{nb}^{-1}$) / backward($0.521 \pm 0.011\ \mathrm{nb}^{-1}$)

Yields:

backward (4 events) / forward (11 events)

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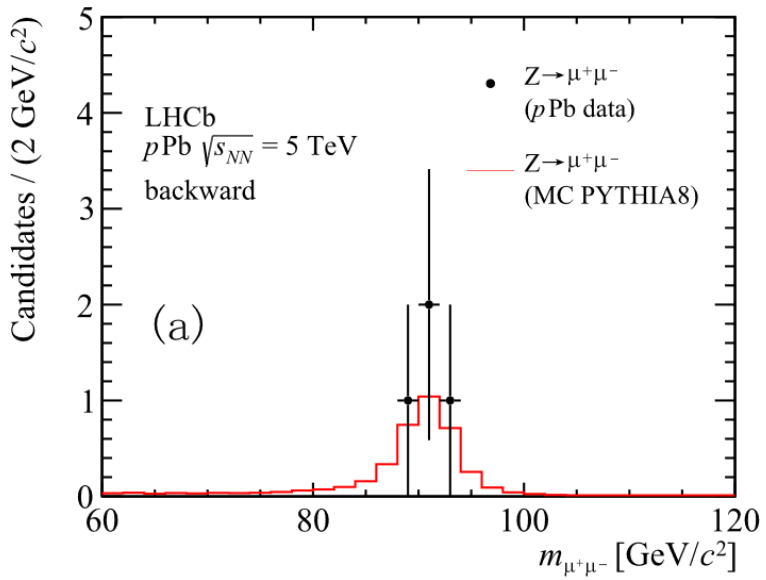

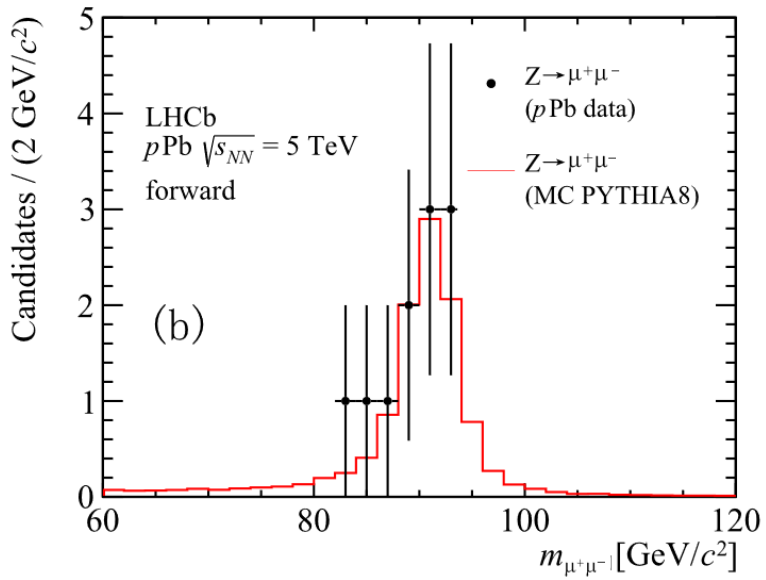

Z production in pPb collisions at 5 TeV

Cross-section in acceptance:

$60 < m_{\mu^+\mu^-} < 120$ GeV

$p_T(\mu^\pm) > 20$ GeV

$2.0 < \eta(\mu^\pm) < 4.5$

Results:

$\sigma_{Z\to\mu^+\mu^-}(\text{fwd}) = 13.5^{+5.4}_{-4.0}(\text{stat.}) \pm 1.2(\text{syst.})$ nb

$\sigma_{Z\to\mu^+\mu^-}(\text{bwd}) = 10.7^{+8.4}_{-5.1}(\text{stat.}) \pm 1.0(\text{syst.})$ nb

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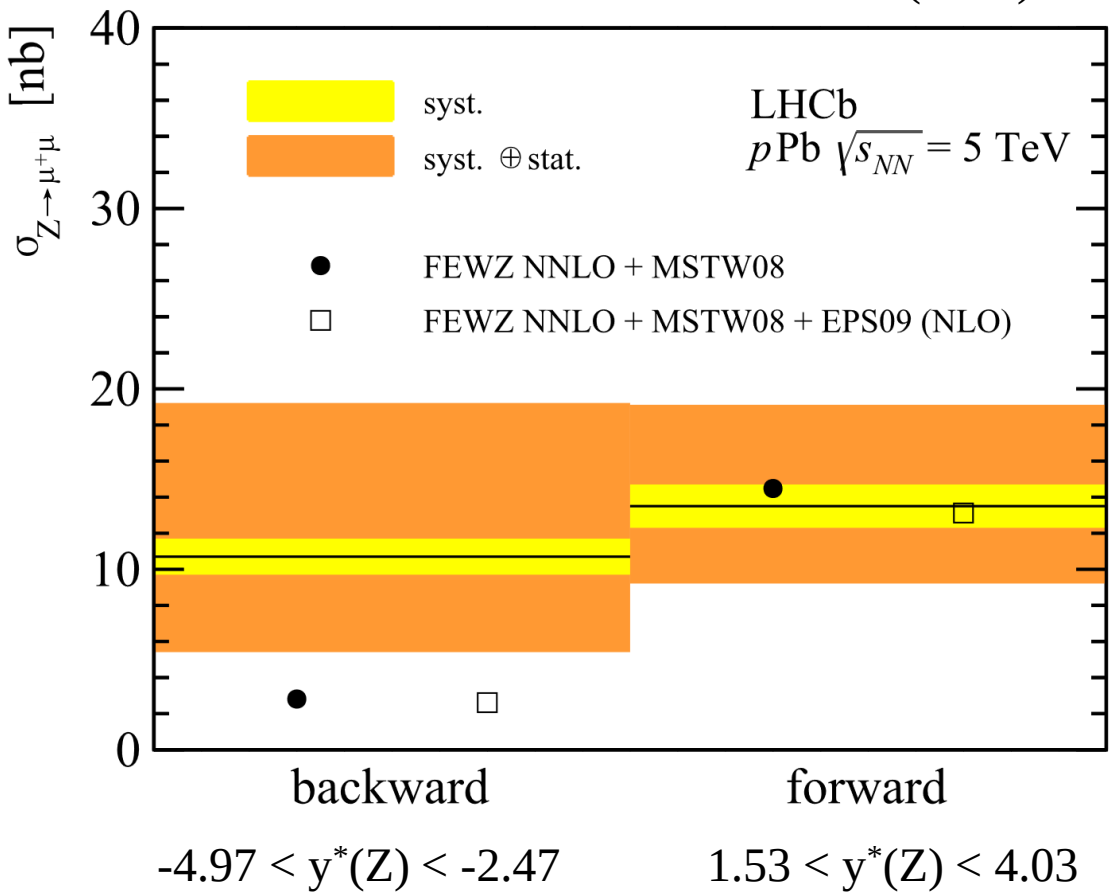
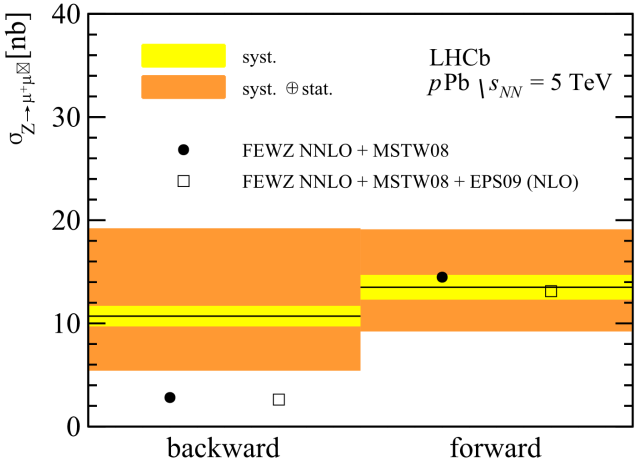


Compare with other experiments

LHCb



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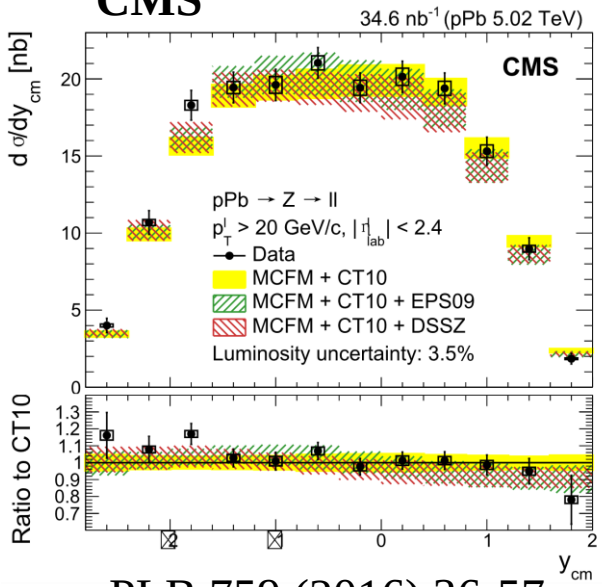
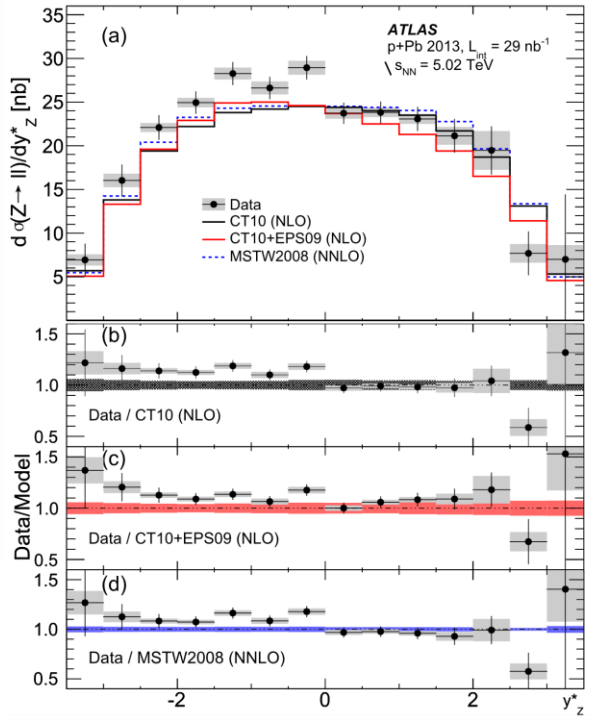
CMS



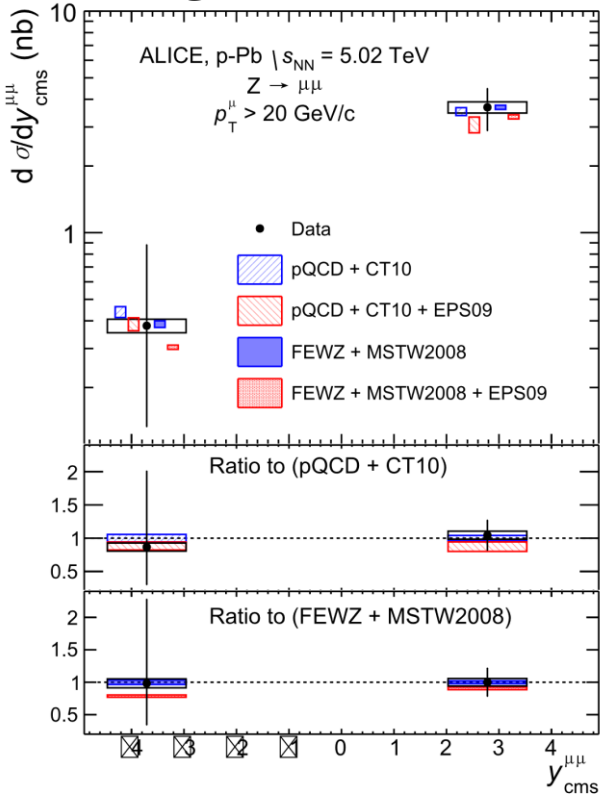
PLB 759 (2016) 36-57

ATLAS



PRC 92, 044915 (2015)

ALICE



JHEP 02 (2017) 077

Forward:

All show good agreement

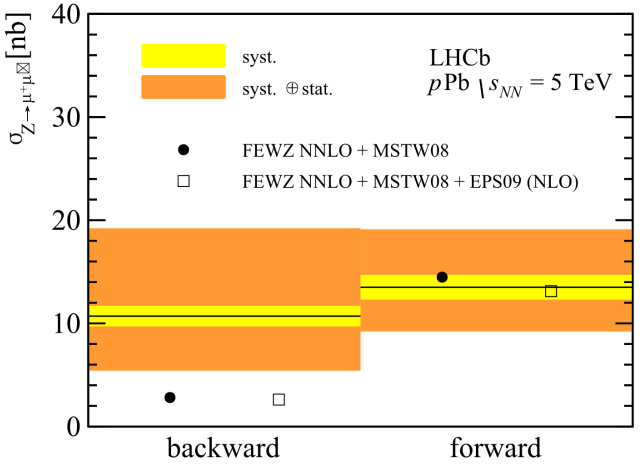
Backward:

LHCb, CMS and ATLAS: theory prediction below data measurement

ALICE: theory prediction good agreement with data measurement, but data error bar is huge.

Compare with other experiments

LHCb



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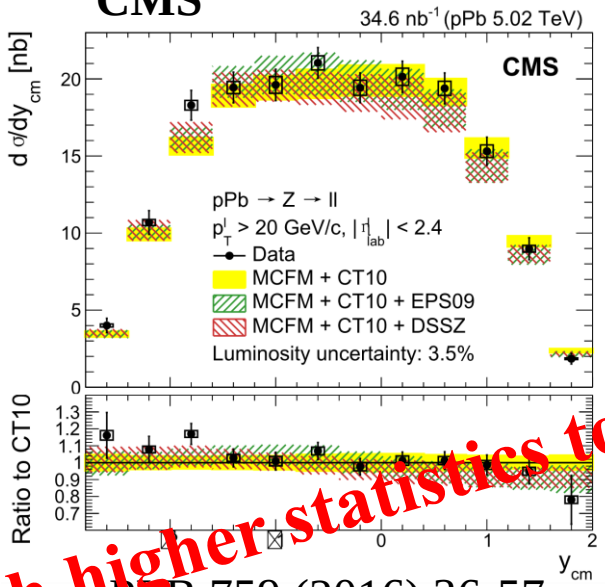
CMS



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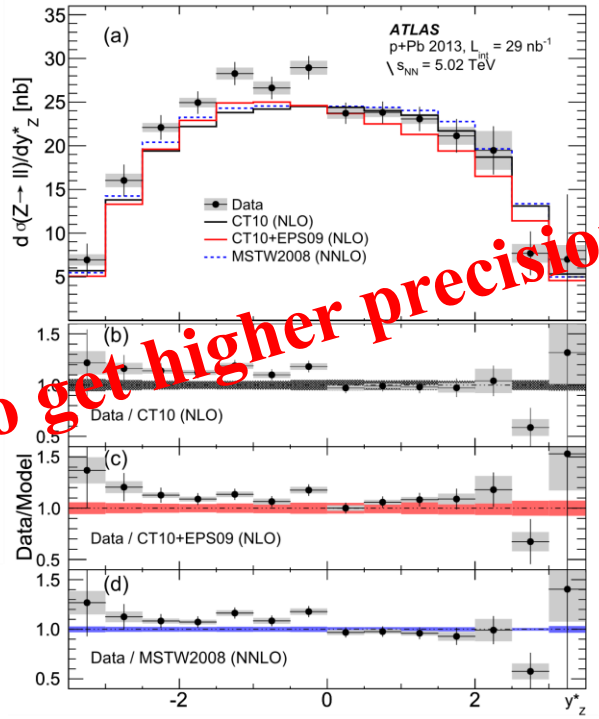

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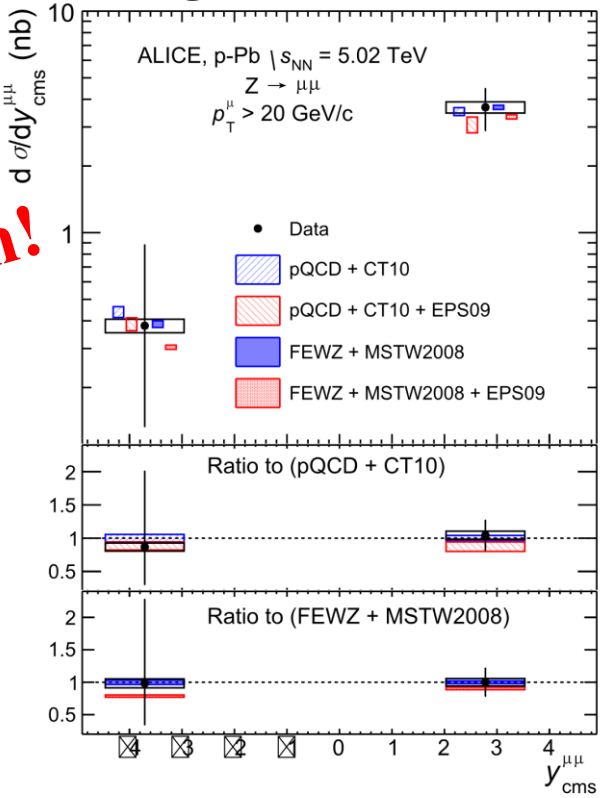

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Need much higher statistics to get higher precision!

Forward:

all show good agreement

Backward:

LHCb, CMS and ATLAS: theory prediction below data measurement

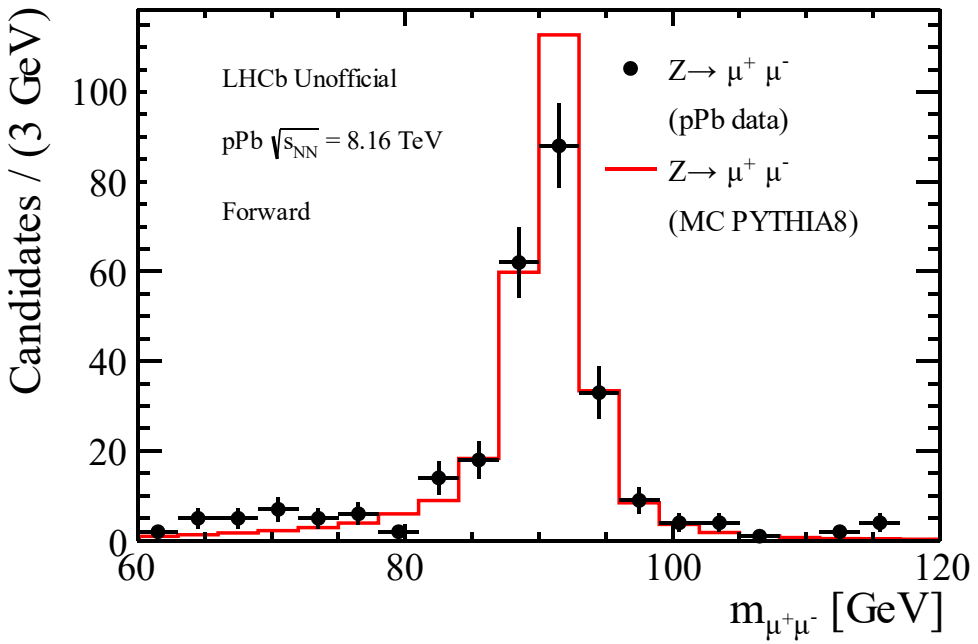
ALICE: theory prediction good agreement with data measurement, but data error bar is huge.

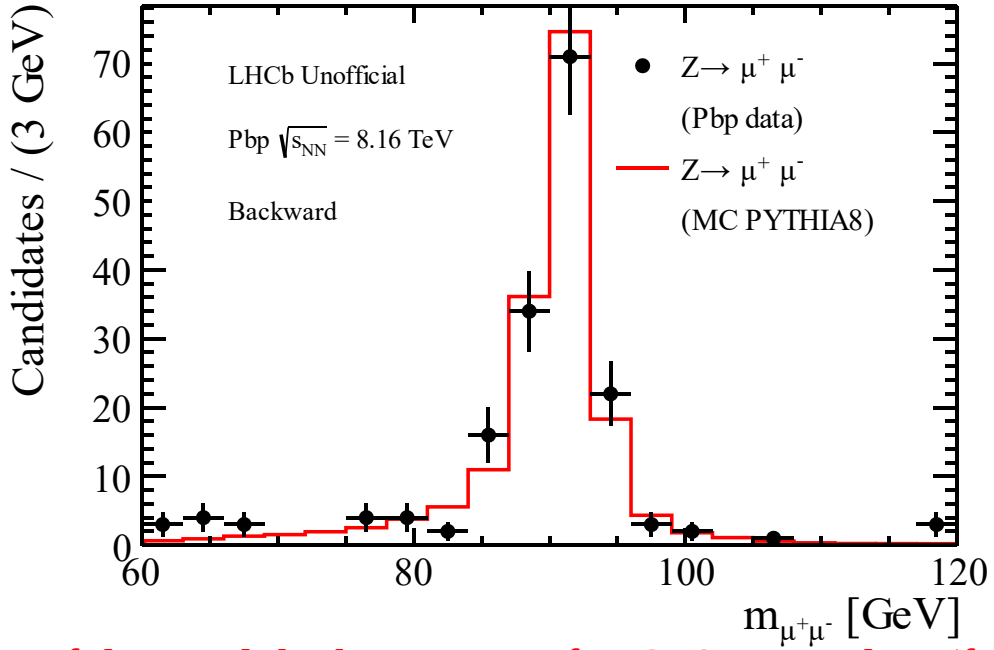
Z production in pPb collisions at 8 TeV

Z production in pPb collisions at 8TeV (expected to be ready for QM 2019)

Integrated luminosity:

forward ($12.18 \pm 0.32\ \mathrm{nb}^{-1}$) / backward($18.58 \pm 0.46\ \mathrm{nb}^{-1}$)





Data points are generated randomly according to the number of data and the histogram of MC. Asimov data (fake data) is shown here.

Z production in pPb collisions at 8 TeV

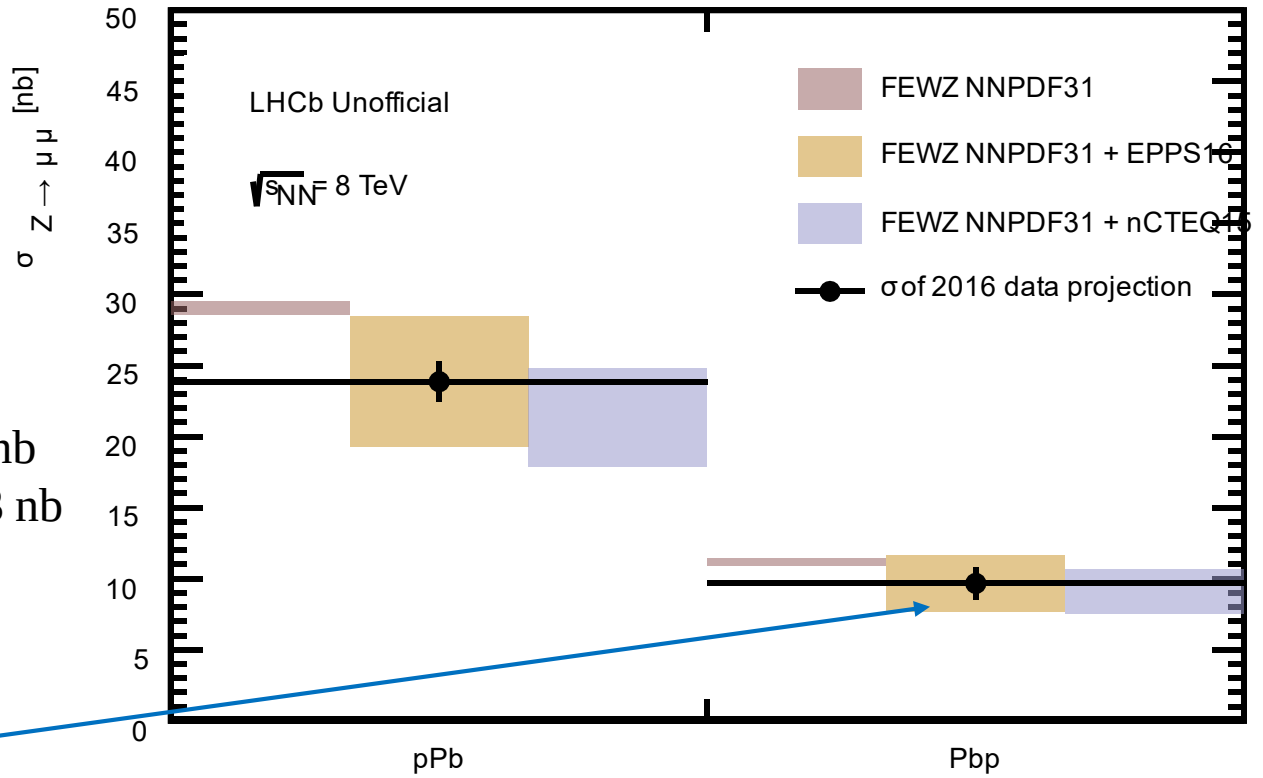
Projection based on 2013 5 TeV results

Central values:

FEWZ NNPDF31 + EPPS16

Projected uncertainties:

Forward : 4.7/sqrt(12.18/1.099)=1.41 nb
Backward: 6.75/sqrt(18.58/0.521)=1.13 nb



With the 2016 8 TeV dataset higher precision, it would be interesting to see if measured value is still higher than the theory prediction!

Conclusion

- LHCb provides a unique opportunity to probe the cold nuclear matter effects using Z boson production
- pPb: Z boson production at 5 TeV is published
- pPb: Z boson production at 8 TeV is expected to be public for QM 2019.

Back Up