Z-boson production in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV with the ALICE muon spectrometer

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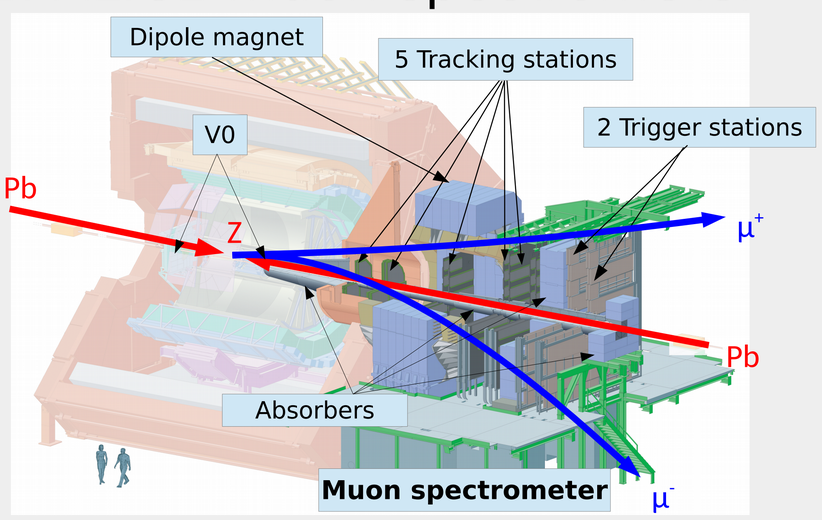
1. Physics motivation

The vector bosons W and Z are excellent probes of the initial state in heavy-ion physics; due to their large masses, their production cross section can be precisely calculated with **perturbative quantum chromodynamics (pQCD)** up to **next-to-next-to-leading order (NNLO)** [1]. Their production occurs through Drell-Yan like processes of quark-antiquark annihilation [2]. For the computation, **parton distribution functions (PDFs)** are used. It has been demonstrated that the PDFs of nuclei are not simply the weighted sum of the proton and neutron PDFs that form it. In order to properly compute the W and Z cross sections, **nuclear modifications of the PDFs (nPDFs)** are needed [3]. Due to lack of data, uncertainties on the nPDFs are large. Measurements of electroweak bosons in heavy-ion collisions can help to **constrain the nPDFs**, which will allow for **more accurate predictions of other cross sections**.

2. ALICE muon spectrometer



Absorber system: Stop π, K and low momentum μ
Dipole magnet: Integrated field strength of 3 Tm
Muon tracking chambers: Reconstruct charged particle tracks
Muon trigger chambers: Trigger decision for muon events and muon identification
V0: Trigger for minimum bias (MB) events, reject beam-gas events, determine event centrality

3. Analysis procedure

Data selection

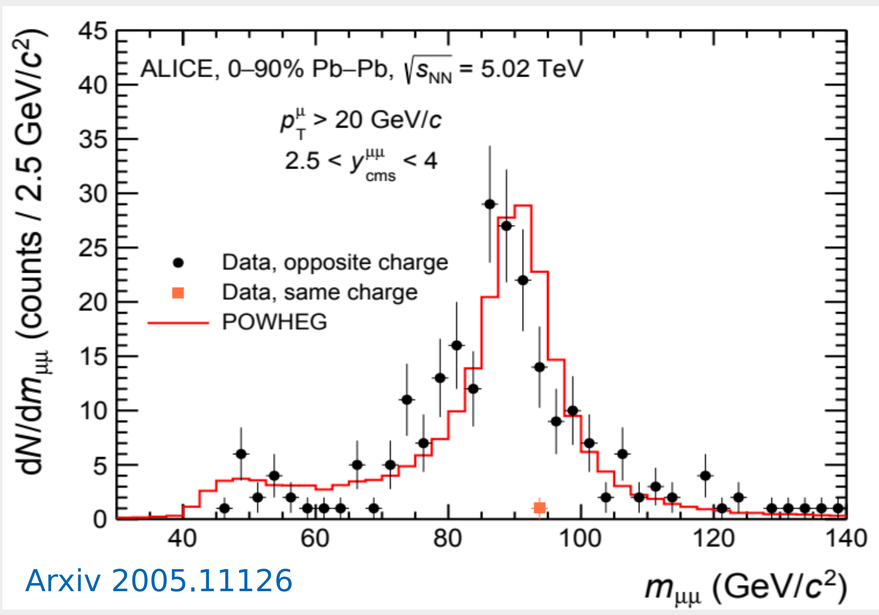
Data taken from Pb-Pb collisions in 2015 and 2018 at $\sqrt{s_{NN}}$ = 5.02 TeV.
Event selection: opposite-charge dimuon trigger, 0-90% centrality class
Track selection: $-4 < \eta < -2.5$, $2^o < \theta_{abs} < 10^o$, matching trigger-tracker tracks, $p_T > 20$ GeV/c
Dimuon selection: $2.5 < y < 4$, two muons of opposite charge

Signal extraction

- Pair all opposite-sign muons
- Compute invariant mass spectrum
- Mass cut $60 < m_{\mu\mu} < 120$ GeV/c^2

Details

- Background subtraction: like-sign pairs
- Correct for reconstruction and selection efficiency of detector
- Convert number of dimuon-triggered events to number of minimum bias events



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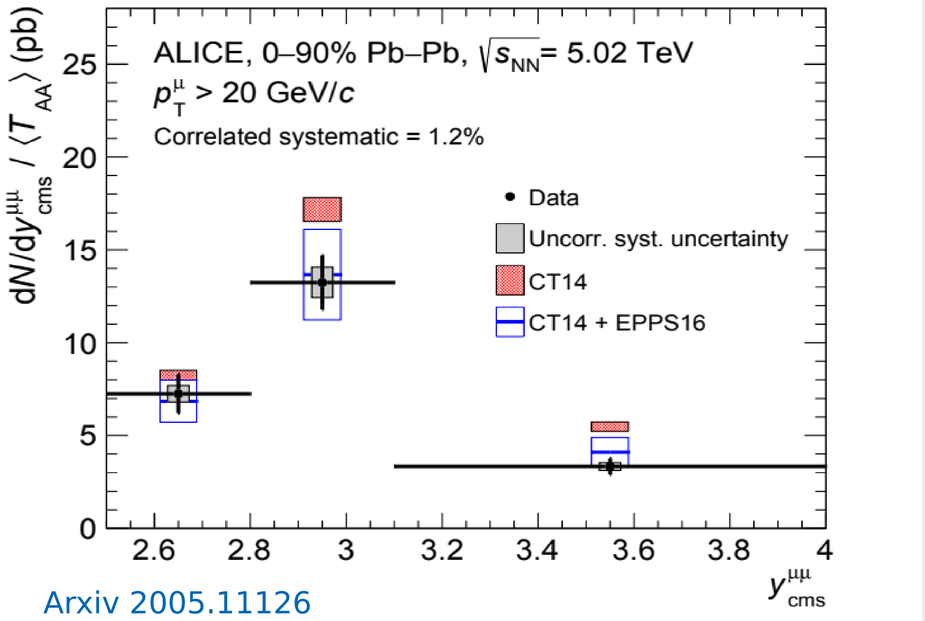
4. Results

Normalized invariant yield

$$\mathrm{d}N/\mathrm{d}y = \frac{N_Z}{\langle T_{AA}\rangle \times N_{MB} \times \Delta y \times A\epsilon}$$

N_Z number of candidates, $\langle T_{AA}\rangle$ average nuclear-overlap function
N_{MB} number of MB events, $A\varepsilon$ acceptance x efficiency



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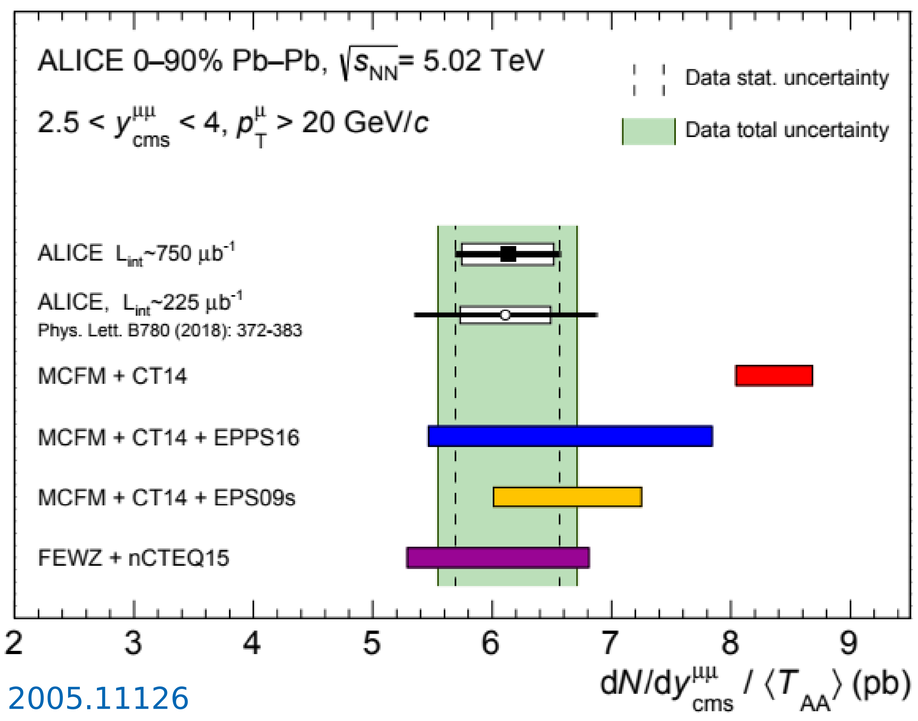
The discrepancy between data and free PDFs grows with increasing rapidity. The data is better described by the model that includes nuclear modifications. The differential measurements can help to constrain nPDFs.



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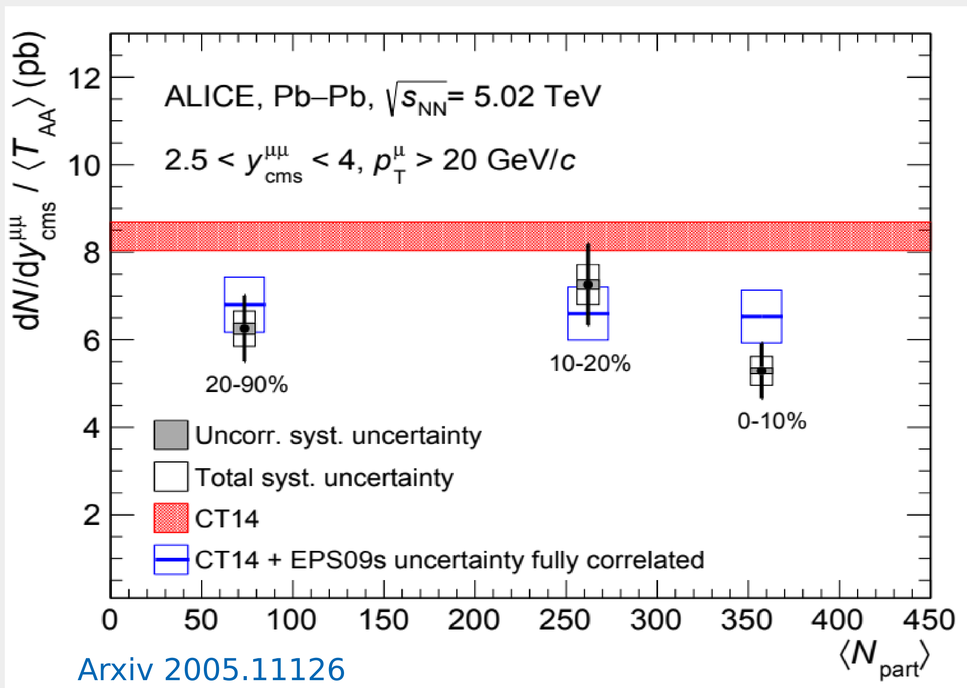
A **3.4σ deviation** is seen **between the data and 'free' PDF** (no nuclear modifications). In order to properly describe the cross section, nuclear modifications [4-7] are needed.



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Free PDFs tend to overestimate the data, especially in central collisions

5. Summary

- The production of Z bosons in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV has been presented.
- The results are compared with theoretical predictions, both with and without nuclear modifications.
  - In the integrated yield, a 3.4σ deviation is seen between the data and free PDF model
  - The models that include nuclear modifications agree with the data
- The differential yields, both versus centrality and rapidity will help constrain nPDFs.

6. References
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