J/ψ Suppression and Z Boson Production Measurements in $\sqrt{s_{NN}} = 2.76$ TeV Pb-Pb Collisions at the ATLAS Detector at LHC

Why Study J/ψ in Heavy Ions Collisions?
- Suppression of J/ψ yield is expected in highly central events in Hi collisions
- The suppression is of interest because:
  - gives experimental sensitivity to medium temperature
  - could be due to quark gluon plasma production
- A suppression was already observed in past experiments:
  - NA50 at CERN SPS in Pb-Pb collisions at $\sqrt{s_{NN}} = 17.3$ GeV
  - PHENIX at RHIC in Au-Au collisions at $\sqrt{s_{NN}} = 200$ GeV
- The study of J/ψ yield at the Large Hadron Collider (LHC)?
  - suppression mechanisms not fully understood, new effects might be there
  - proposal of J/ψ enhancement at high energies from charm quark recombination
  - at the LHC the first Z measurement in Pb-Pb is possible
  - Z measurement is interesting as no suppression is expected in this case

Goal of this Analysis

$$R_c = \frac{N_{corr}^{10-40}(J/\psi \rightarrow \mu^+\mu^-)}{N_{corr}^{40-80}(J/\psi \rightarrow \mu^+\mu^-)} \cdot R_{coll}$$

- $R_c$ is the ratio defined as the J/ψ yield in centrality bin $c$ divided by its yield in the most peripheral bin
- $c$ subscript indicates that the given quantity is related to the $c$-th centrality bin
- $N_{corr}$ is the measured efficiency of the J/ψ in the centrality bin, and $w_i$ is the centrality bin width
- $R_{coll}$ is the normalized mean number of binary collisions
- Normalization on the most peripheral bin simplifies the measurement → only centrality-dependent effects should be considered in the efficiency computation and in the systematics assessment

Heavy Ions Collisions aren’t Point-Like: $R_{coll}$ Definition

- In each ion-ion collision we have $N_{coll}$ binary collisions between nucleons
- Hence any yield measurement must be normalized to $N_{coll}$
- $N_{coll}$ is estimated using Glauher Monte Carlo simulation
- $N_{coll}$ depends on the Impact Parameter (IP) between the two ions

How do we Measure the IP in Real Life? centrality bins definition

- We can use the observation that the event track multiplicity increases as the IP decreases
- Using the transverse energy deposited in the forward calorimeters (3.2 < |η| < 4.9) we define centrality, where:
  - central event → big IP
  - peripheral event → small IP
- We only use peripheral events up to 80% to reduce systematic on $R_{coll}$

Efficiency Extraction and Monte Carlo Reliability

- We need to assess muon reconstruction efficiency dependence on centrality
- Not enough statistics for data-driven method
- Using Monte Carlo (MC) sample with Pythia p-p J/ψ candidates overlaid to Hijing simulated heavy ions events
- MC has been validated comparing tracks properties with data → very good agreement
- Small centrality dependence found: efficiency drop of ~3% for most central events w.r.t most peripheral ones

First Observation of J/ψ Yield Suppression at LHC

- 613 candidates selected
- Two alternative methods used
- Sideband subtraction method:
  - assuming linear background
  - signal region: $m_{\gamma\gamma} \in [2.95, 3.25]$ GeV
- sidebands: $m_{\gamma\gamma} \in [2.4, 2.8] \cup [3.4, 3.6]$ GeV
- Unbinned maximum likelihood invariant mass fit with per-candidate uncertainty

First Observation of Z Boson in Pb-Pb Collisions

- 38 Z boson candidates found
- Left plot: Z Invariant mass peak in data (black points) compared to what expected in Monte Carlo simulation (grey histogram)
- Right plot: normalized Z yield ratio, black bars for statistical uncertainty, grey bands for systematic and statistical uncertainties summed in quadrature
- Systematics conservatively the same as for J/ψ measurement
- No trend observed: not enough statistics but still useful check

Bibliography

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