

Recent heavy ion results from CMS

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The conditions in collisions of ultra-relativistic nuclei correspond to a very early time of the universe. At CERN's Large Hadron Collider (LHC), studies of the properties of the produced hot and dense strongly-interacting matter are carried out by all four big experiments. In this talk, we will give an overview of recent exciting heavy-ion results from the Compact Muon Solenoid experiment. We will cover different areas of interest, such as, heavy-flavour probes on Quark Gluon Plasma (QGP), initial states, and bulk QGP physics.

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1. Introduction

One of the major challenges of heavy-ion physics is to understand the properties of the hot and dense medium, known as Quark Gluon Plasma (QGP), produced in ultra-relativistic nucleus-nucleus collisions [1]. Various probes, such as heavy-flavour hadrons and electroweak bosons, are used to understand more about the properties of heavy-ion collisions such as the initial state geometry, including the spatial distribution of nucleons and their fluctuations. In addition, other observables are used to study the QGP medium effects, such as particle correlation, jet-quenching, flow etc. [2]. This note presents the overview of various recent interesting and exciting heavy-ion results from the CMS experiment [3].

2. Initial state interaction

In this section, we will discuss the T_{AA} -normalized yields of Z bosons calculated as a function of centrality in lead-lead (PbPb) collisions. We will also discuss the Δv_2 from prompt D^0 and \bar{D}^0 . Finally, we will cover some exciting results in multiplicity dependence of dimuon acoplanarity and mean mass.

The Z boson azimuthal anisotropy (v_2) as a function of centrality is shown in Fig 1. The Z boson v_2

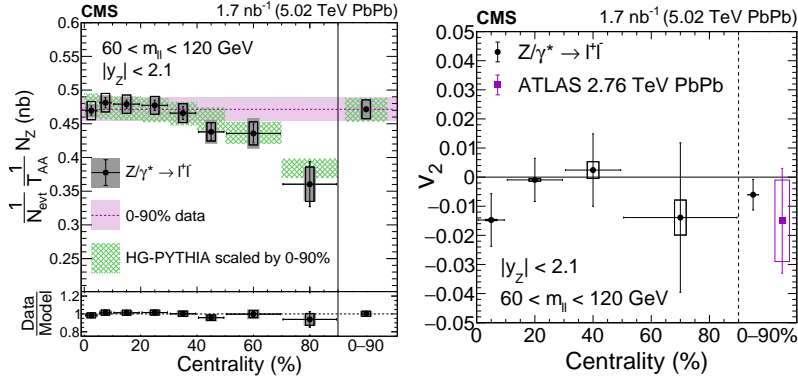


Figure 1: Left side figure shows the T_{AA} -normalized yields of Z bosons as a function of centrality [4]. The value of the 0%–90% data point and the scaled HG-PYTHIA model are shown for comparison, with the width of the bands representing the contribution from the total 0%–90% data point uncertainty. The right side figure shows the elliptic azimuthal anisotropy of Z boson in PbPb collision as a function of centrality [4].

measurement is compatible with zero within the statistical uncertainties [4] and significantly more precise than the previous ATLAS measurement [5]. It confirms that, since the Z boson is produced and decay very early in the collision and their leptonic daughters carry no color charge, it is largely unaffected by the final state effects such as hydro-dynamic flow and energy loss of the medium.

The T_{AA} scaling can describe the measurements for central events (less than 40%) as well as for the inclusive centrality (0%–90%). However, a deviation is observed towards the peripheral collisions, indicating the presence of initial-state geometry and centrality calibration potential bias. Initial-state geometry effects can arise because bound nucleons have a spatial distribution that can shift the average nucleon-nucleon impact parameter away from that of proton-proton (pp) collisions [6].

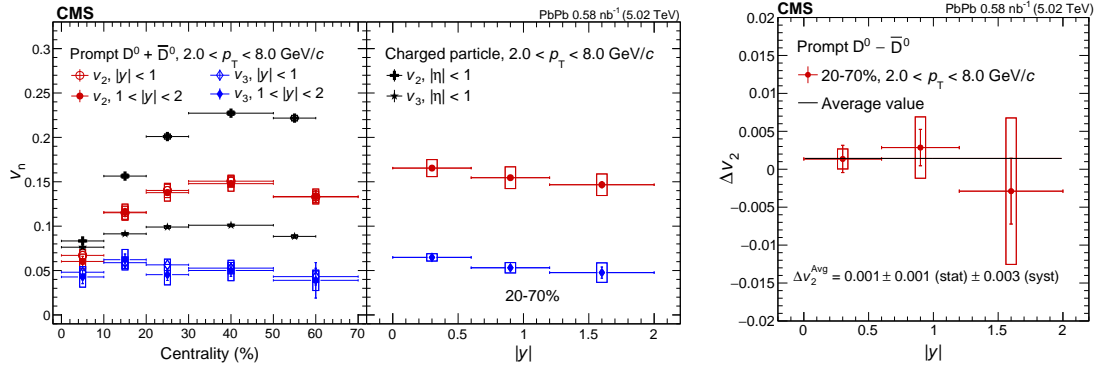


Figure 2: Left side figure shows the azimuthal anisotropies as a function of centrality and rapidity. Right side figure shows Δv_2 of prompt $D^0 - \bar{D}^0$ [7].

The azimuthal anisotropies of prompt $D^0 + \bar{D}^0$ in centrality and rapidity have been measured. Both in forward and mid-rapidity, the v_2 results show a clear increase in the value from central to mid-central region and declining towards peripheral collisions [7]. The right side plot of Fig 2. shows the rapidity average of Δv_2 in centrality 20%–70%. For all rapidity bins, the values of Δv_2 is compatible with zero within the uncertainties. The average value in $|y| < 2$ is $\Delta v_2 = 0.001 \pm 0.001$ (stat) ± 0.003 (syst) [8].

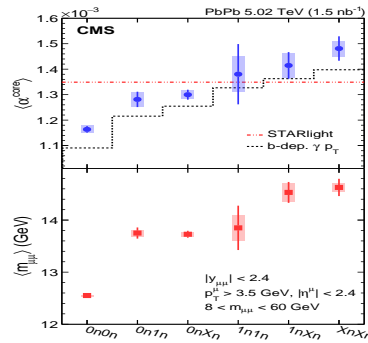


Figure 3: The above figure shows the neutron multiplicity dependence of the mean mass (bottom) and the core component of the average acoplanarity (top) of dimuons. [9]

A strong neutron multiplicity dependence of the core component of the average dimuon acoplanarity $\langle \alpha_{core} \rangle$ is measured [9]. Since the core part is formed from the leading order interaction, which is directly related to the photon p_T , the measurements show that the initial photon p_T increases with the decrease of impact parameter. STARLIGHT MC [10] does not have this increasing trend but the CMS results are qualitatively described by the leading order QED model [11] calculation, which incorporates the impact parameter dependence of photon p_T . Our data results are five times higher than the model because of the absence of higher-order corrections for the soft photon radiation from the produced muon [12]. Also, the dimuon mean mass increases with increasing multiplicity since it is directly related to the initial photon energy. This also provides the information

for the initial photon energy which is increasing with decreasing impact parameter [9].

3. QGP medium effect

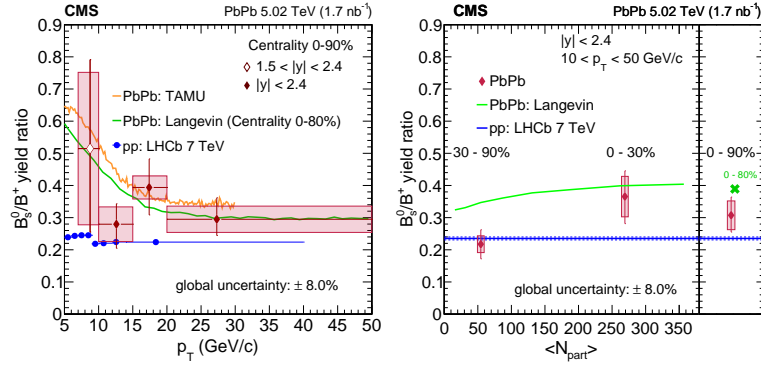


Figure 4: The ratio of B_s^0 and B^+ meson production yields, as a function of p_T (left) and collision centrality (right) [13].

The ratio of B_s^0 and B^+ meson production has been studied for $|y| < 2.4$, $1.5 < y < 2.4$ and $p_T < 50$ GeV/c [13]. These results are compatible with the previously reported results by CMS [14] and based on a three-fold larger PbPb data sample. The ratio of production yields of the two mesons in PbPb collisions is determined and it is found to be statistically compatible with the corresponding ratio in pp results [15].

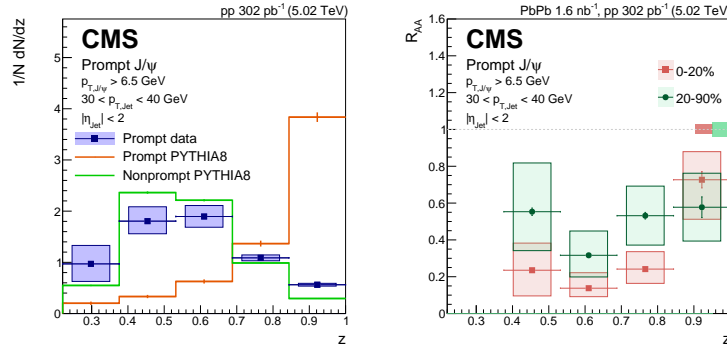


Figure 5: The prompt J/Ψ normalized z distribution in pp collisions compared to PYTHIA8 calculations (left) [16] and nuclear modification factor R_{AA} as a function of z for two centrality ranges of PbPb collisions (right) [16].

Measurements of the prompt J/Ψ normalized z (the ratio of the J/Ψ p_T to the p_T of the jet into which it is clustered) distribution in pp data have been performed, as shown in Fig 5. Its shape is compared to PYTHIA 8 calculations for prompt and non-prompt J/Ψ . The z distribution in data is described by PYTHIA 8 for non prompt J/Ψ , which contains a larger jet-like component from fragmentation, as well as other products of the b-hadron decay. In the case of prompt J/Ψ , the

data show a relatively large degree of surrounding jet activity, indicative of J/Ψ production inside of parton showers. The value of R_{AA} is estimated in two different centrality intervals 0%–20% and 20%–90%. A large degree of suppression is observed for the more central collisions, which is expected because of the jet-medium interactions in QGP [16].

4. Conclusion

In this presentation we have discussed results from the initial and final state effects. Z-boson v_2 is compatible with zero within the statistical uncertainties while the yield spectra deviates from T_{AA} -scaling towards peripheral collisions, hinting the presence of initial-state geometry and centrality calibration potential bias. The average D^0 meson Δv_2 is measured and found to be $0.001 \pm 0.001(\text{stat}) \pm 0.003(\text{syst})$. This indicates there is no evidence that charm hadron collective flow is affected by strong Coulomb field generated in heavy-ion collisions. The dimuon mean mass and $\langle\alpha_{core}\rangle$ increases with the increase of neutron multiplicity. The J/Ψ mesons formed within a jet are found to be more suppressed in central collisions than peripheral collisions. The ratio of production yields of the B_s^0 and B^+ meson in PbPb collisions is determined and it is found to be statistically compatible with the corresponding ratio in pp results.

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