PROCEEDINGS OF SCIENCE

Measurements of strange and non strange beauty production in PbPb collisions at 5.02 TeV with the CMS detector

Hao Qiu on behalf of the CMS Collaboration*
Purdue University
E-mail: hqiu0114@gmail.com

Production yields of strange and non strange beauty particles are measured by the CMS collaboration in proton-proton and PbPb collisions at 5.02 TeV. Consistent suppression of B^+, nonprompt J/ψ (coming from decays of b hadrons) and nonprompt D^0 is observed in PbPb collisions compared to proton-proton collisions. Beauty particles seem to be less suppressed than charm and light flavor particles at transverse momentum around 10 GeV/c, which is in line with expectation from mass ordering of parton energy loss. We also report the first measurement of B_s^0 yield in heavy ion collisions. There is an indication of less suppression of B_s^0 comparing to B^+, which is consistent with the strangeness enhancement in quark-gluon plasma and the recombination production mechanism of B_s^0.

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*Speaker.

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1. Production of Non Strange Beauty Particles

A quark-gluon plasma (QGP) phase, consisting of deconfined quarks and gluons, is created in the extremely high temperatures and/or densities in heavy ion collisions by experiments at the RHIC and the LHC. Heavy quarks (charm and beauty) are valuable probes for studying the properties of QGP. They are mostly produced in primary hard QCD scatterings at an early stage of the collision, and lose energy via radiative and collisional interactions with the medium constituents. Parton energy loss can be studied using the nuclear modification factor (R_{AA}), defined as the ratio of the particle yield in nucleus-nucleus (AA) to that in proton-proton (pp) collisions, normalized by the number of binary nucleon-nucleon collisions (N_{coll}). Precise measurements of R_{AA} for particles containing light, charm, and beauty quarks can provide both important tests of QCD at extreme densities and temperatures, and constraints on theoretical models describing the system evolution in heavy ion collisions. In this section we present the R_{AA} of nonprompt J/ψ, nonprompt D^0 and fully reconstructed B^+ mesons measured at $\sqrt{s_{NN}} = 5.02TeV$ by the CMS collaboration [1].

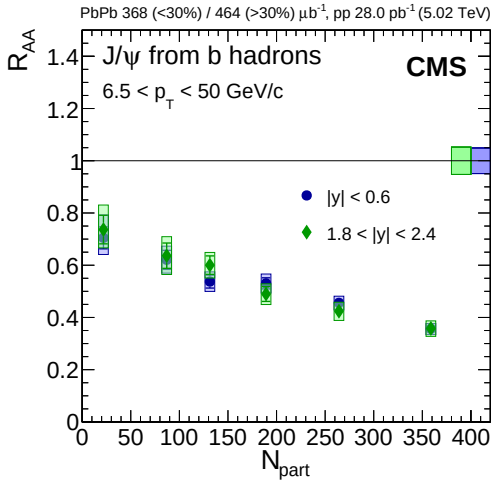

Figure 1: Nuclear modification factor R_{AA} of J/ψ mesons from b hadrons as a function of N_{part} at mid- and forward rapidity [2].

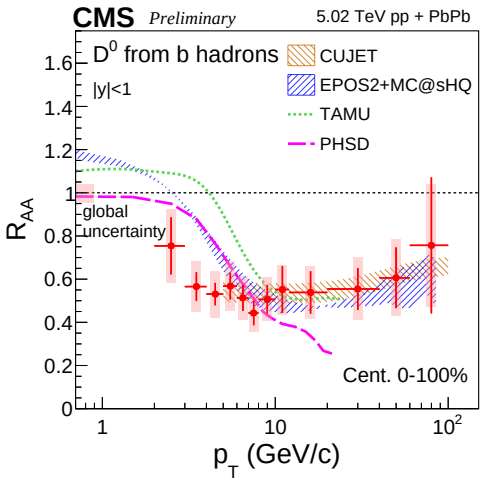

Figure 2: Nuclear modification factor R_{AA} of D^0 mesons from b hadrons vs p_T compared to theoretical predictions [3, and references therein].

Figure 1 shows R_{AA} of J/ψ mesons from b hadrons (nonprompt J/ψ) as a function of number of participating nucleons N_{part} [2]. The bars (boxes) represent statistical (systematic) point-by-point uncertainties. The boxes plotted at $R_{AA} = 1$ indicate the size of the global relative uncertainties. This protocol is followed all through this proceedings report. A strong suppression of nonprompt J/ψ is observed. And the suppression is stronger in more central events (higher N_{part}) relative to more peripheral events (lower N_{part}).

Figure 2 shows R_{AA} of D^0 mesons from b hadrons as a function of transverse momentum p_T, comparing with theoretical predictions [3, and references therein]. D^0 from b hadrons is suppressed in the measured p_T range of 2-100 GeV/c. The suppression is consistent with several models at high p_T. However, a hint of stronger suppression than all available models at low p_T is observed.

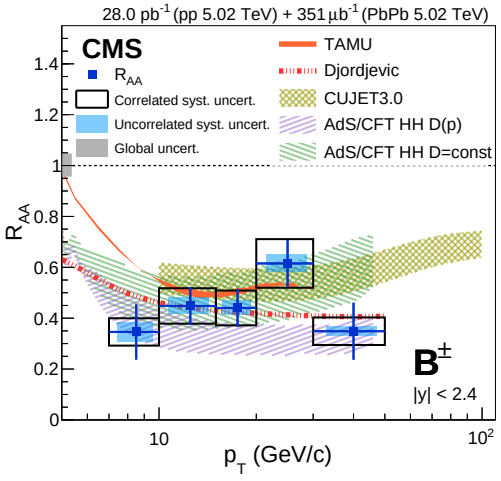

Figure 3: The p_T dependent nuclear modification factor R_{AA} of B^+, compared to various theoretical predictions [4, and references therein].

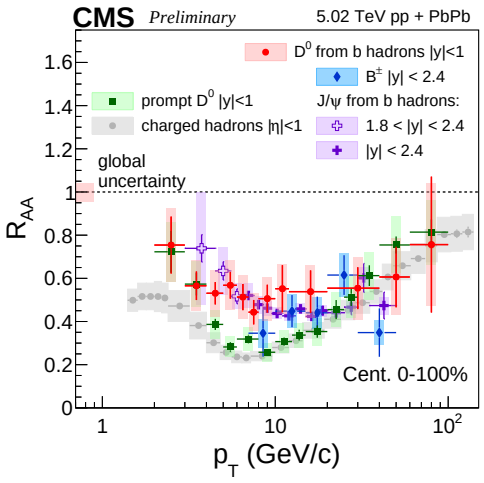

Figure 4: Comparison of the p_T dependent R_{AA} for J/ψ from b hadrons, D^0 from b hadrons, fully reconstructed B^+ mesons, prompt D^0 and charged hadrons [2, 3, 4, and references therein].

Figure 3 shows the p_T dependent R_{AA} of fully reconstructed B^+ mesons [4, and references therein]. A strong suppression of B^+ production in PbPb collisions is observed. The result is compatible with theory predictions within uncertainty.

In Fig. 4, R_{AA} for J/ψ from b hadrons, D^0 from b hadrons and fully reconstructed B^+ mesons are compared to prompt D^0 and charged hadrons [2, 3, 4, and references therein]. The R_{AA} for J/ψ from b hadrons, D^0 from b hadrons and fully reconstructed B^+ mesons are consistent within uncertainty. At p_T around 10 GeV/c, J/ψ from b hadrons and D^0 from b hadrons are less suppressed than prompt D^0 and charged hadrons. This is in line with expectation from the mass ordering of parton energy loss, although a direct comparison requires a full modeling of the quark initial spectrum and hadronization, as well as of the decay kinematics.

2. Production of Strange Beauty Particle B_s^0

It is proposed that an enhancement of strangeness in a thermally and chemically equilibrated state is expected if the critical temperature is above the strange quark mass. In the presence of a medium with increased strangeness content, the relative yield of B_s^0 mesons with respect to non-strange beauty mesons at low-intermediate p_T can be enhanced in AA collisions compared to pp interactions, if recombination is a relevant mechanism of beauty hadronization in the QGP.

In this section we report the first B_s^0 production yield measurement in heavy ion collisions, conducted by CMS at $\sqrt{s_{NN}} = 5.02TeV$. Figure 5 shows nuclear modification factor of B_s^0 mesons, compared to B^+ mesons [5]. The B_s^0 R_{AA} is consistent with unity. There is an indication of less suppression of B_s^0 comparing to B^+, which is consistent with strangeness enhancement in the QGP and the recombination production mechanism of B_s^0. This indication is more clearly presented by the R_{AA} ratio between B_s^0 and B^+ in Fig. 6.

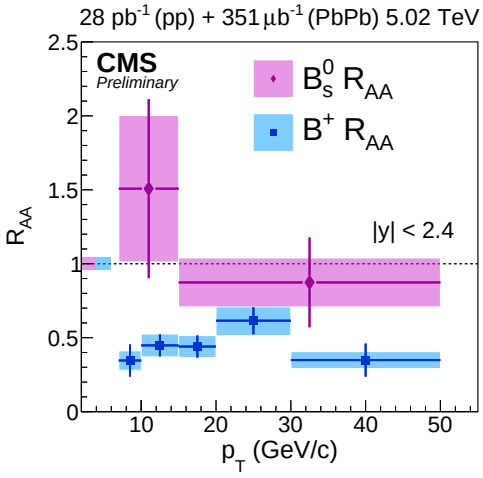

Figure 5: p_T dependent nuclear modification factor R_{AA} of B_s^0.

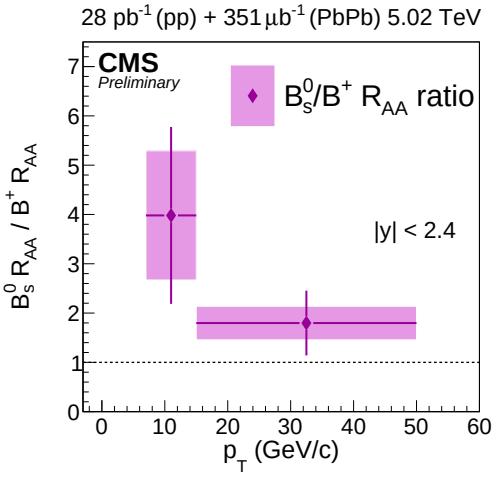

Figure 6: p_T dependent nuclear modification factor R_{AA} ratio between B_s^0 and B^+.

3. Summary

In summary, production yields of strange and non strange beauty particles are measured by the CMS collaboration in proton-proton and PbPb collisions at 5.02 TeV. Consistent suppression of B^+, nonprompt J/ψ and nonprompt D^0 is observed in PbPb collisions compared to proton-proton collisions. Beauty particles seem to be less suppressed than charm and light flavor particles at transverse momentum around 10 GeV/c, which is in line with expectation from mass ordering of parton energy loss. We also report the first measurement of B_s^0 yield in heavy ion collisions. There is an indication of less suppression of B_s^0 comparing to B^+, which is consistent with the strangeness enhancement in quark-gluon plasma and the recombination production mechanism of B_s^0.

References

[1] CMS collaboration, S. Chatrchyan et al., *The CMS Experiment at the CERN LHC*, *JINST* **3** (2008) S08004.

[2] CMS collaboration, A. M. Sirunyan et al., *Measurement of prompt and nonprompt charmonium suppression in PbPb collisions at 5.02 TeV*, *Eur. Phys. J.* **C78** (2018) 509 [1712.08959].

[3] CMS collaboration, *Studies of beauty suppression via measurements of nonprompt D^0 mesons in PbPb collisions at $\sqrt{s_{NN}}$=5.02 TeV*, CMS Physics Analysis Summary CMS-PAS-HIN-16-016, 2018.

[4] CMS collaboration, A. M. Sirunyan et al., *Measurement of the $B^{\pm}$ Meson Nuclear Modification Factor in Pb-Pb Collisions at $\sqrt{s_{NN}} = 5.02$TeV*, *Phys. Rev. Lett.* **119** (2017) 152301 [1705.04727].

[5] CMS collaboration, *Measurement of the B_s^0 meson nuclear modification factor in PbPb collisions at $\sqrt{s_{NN}} = 5.02$ TeV*, CMS Physics Analysis Summary CMS-PAS-HIN-17-008, 2018.