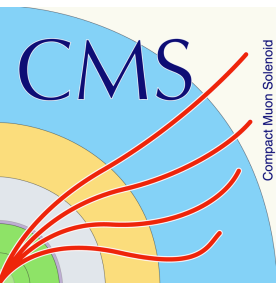


Measurements of strange and non strange beauty production in PbPb collisions at 5.02 TeV with the CMS detector

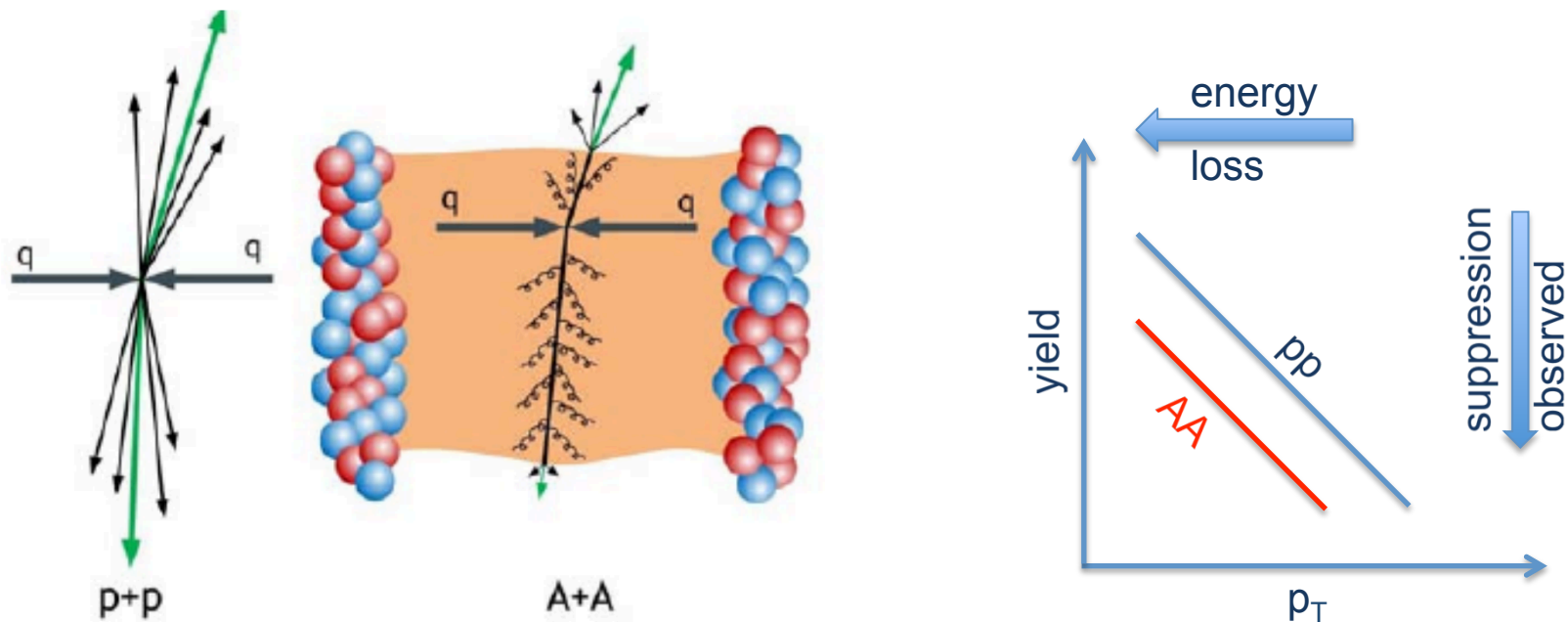
Hao Qiu

for the CMS Collaboration

Purdue University



Probe QGP with parton energy loss

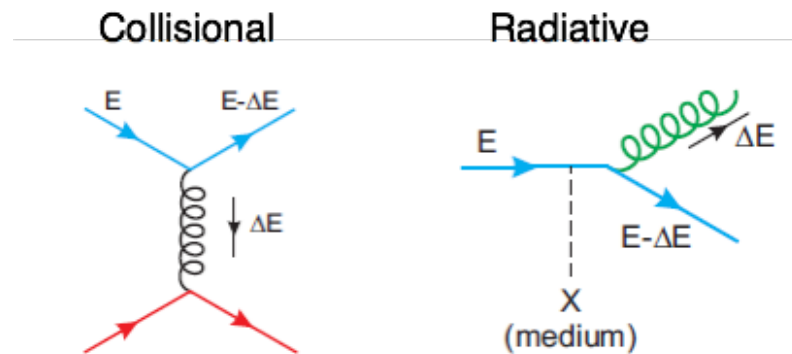


- Quark-gluon plasma (QGP) is created in heavy ion collisions.
- High energy partons lose energy by interacting with the QGP medium.
- Particle p_T spectra will be modified.
- A measure to quantify this: nuclear modification factor

$$R_{AA} = \frac{1}{T_{AA}} \frac{dN_{PbPb}}{dp_T} \bigg/ \frac{d\sigma_{pp}}{dp_T}$$

Heavy quark energy loss

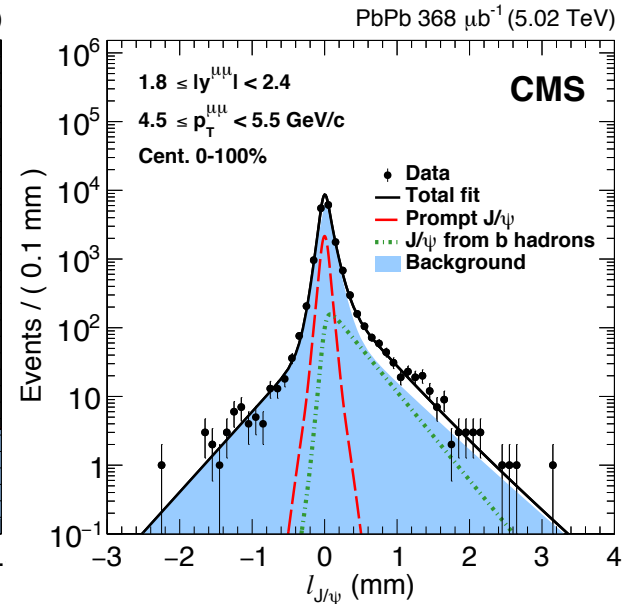
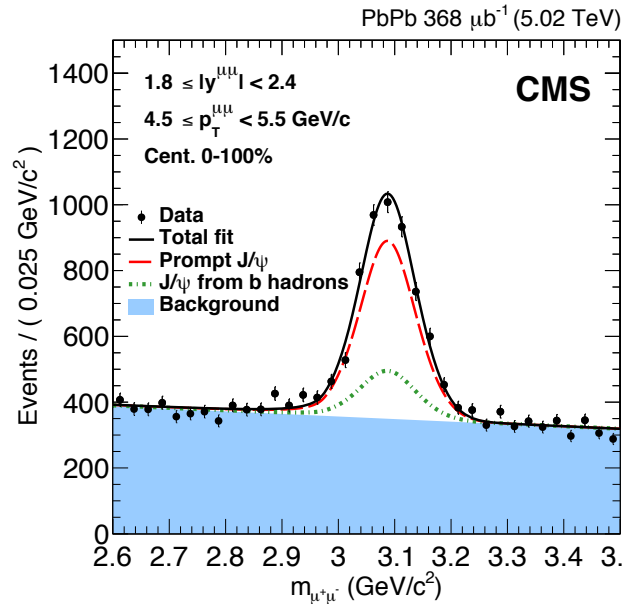
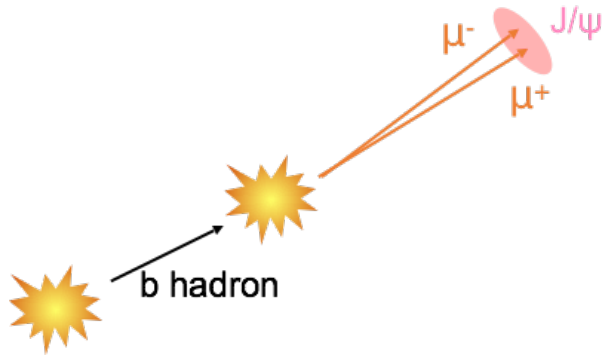
- Heavy \rightarrow negligible thermal production, predominantly produced in the early hard scatterings
 \rightarrow carry information of QGP evolution history
- 2 types of medium induced energy loss (Eloss):



- “Dead cone effect” [1]: gluon radiation is suppressed at angles $<$ quark mass/energy
 - Eloss in light quarks $>$ Eloss in heavy quarks: parton mass dependence of Eloss
 - Suppression of gluon radiation at low p_T
- The first part of this talk will focus on studying the energy loss of b quark via B^\pm , $B \rightarrow J/\psi$, and $B \rightarrow D^0$

[1] Y.L. Dokshitzer, D. E. Kharzeev, Phys. Lett. B 519 (2001) 199.

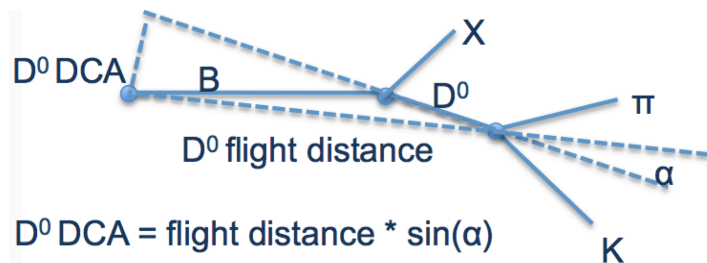
J/ψ reconstruction and prompt / nonprompt separation



Eur. Phys. J. C 78 (2018) 509

- Muon pair fit to a common vertex \rightarrow J/ψ candidates
- 2D fit on invariant mass and decay length spectra, to separate signal / background, and prompt / nonprompt J/ψ

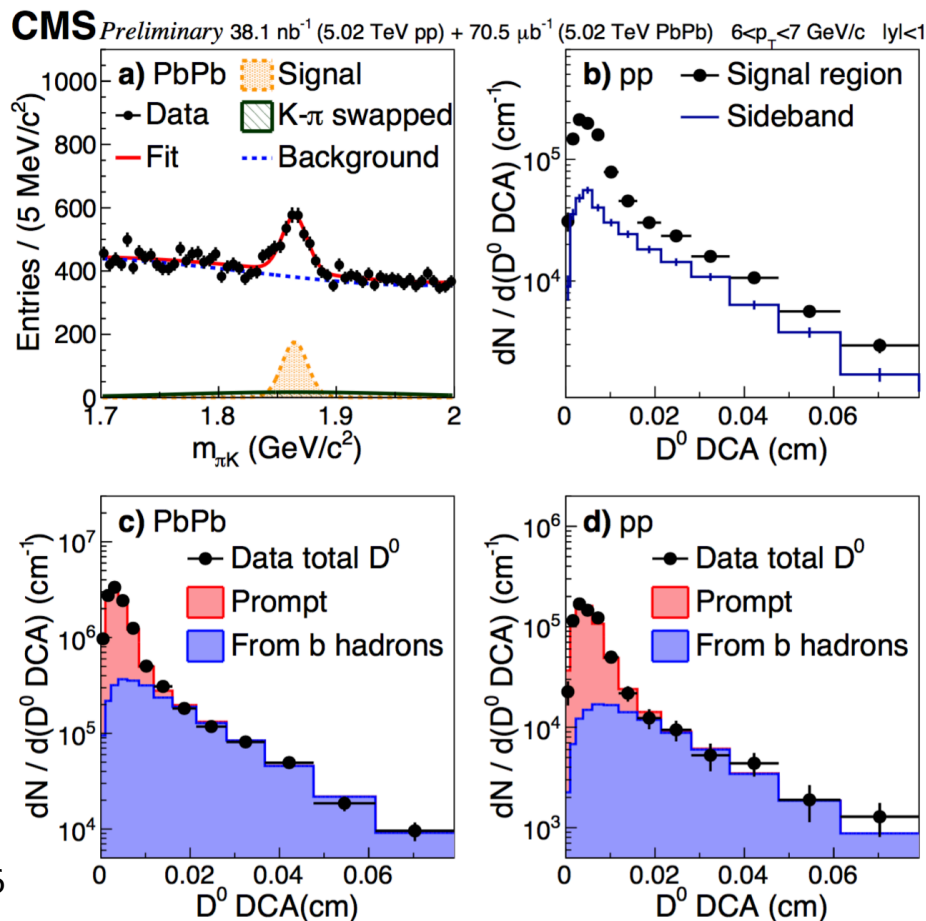
D⁰ reconstruction and prompt / nonprompt separation



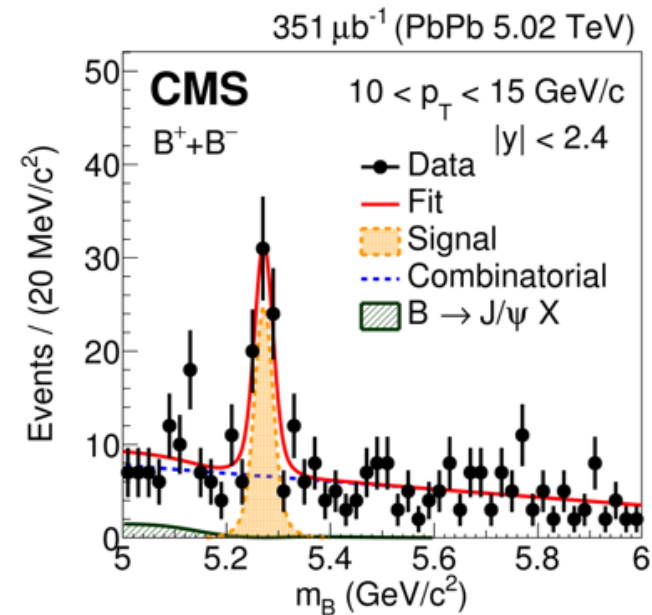
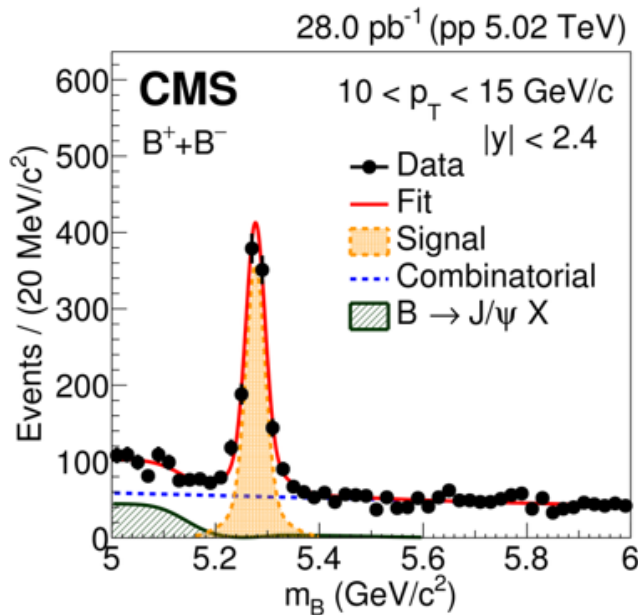
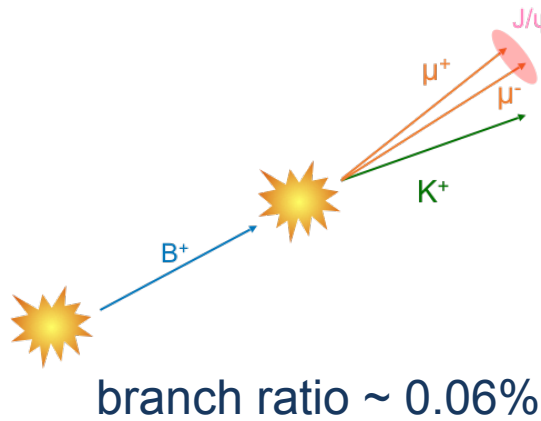
- cuts optimized for best nonprompt D⁰ significance:
 - flight distance significance
 - daughter track DCA significance
 - decay vertex fitting probability

CMS-PAS-HIN-16-016

- D⁰ signal extraction within a DCA bin with invariant mass fit or side band subtraction
- 2 component fit with MC DCA templates, to get prompt and nonprompt D⁰ yields



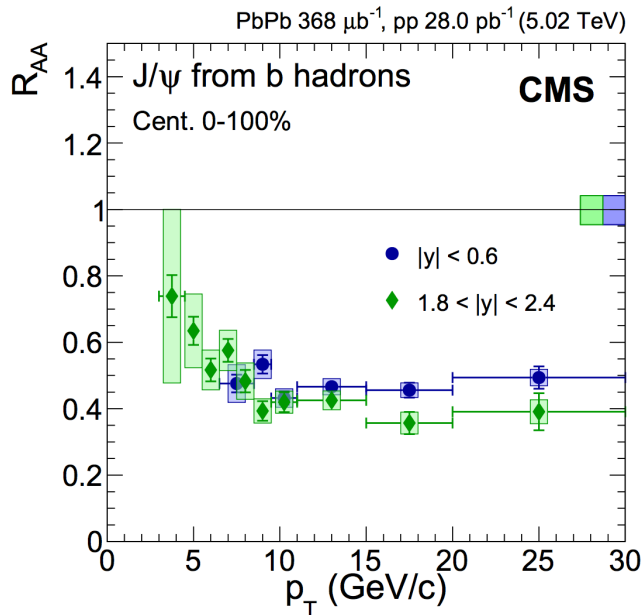
B^\pm reconstruction and signal



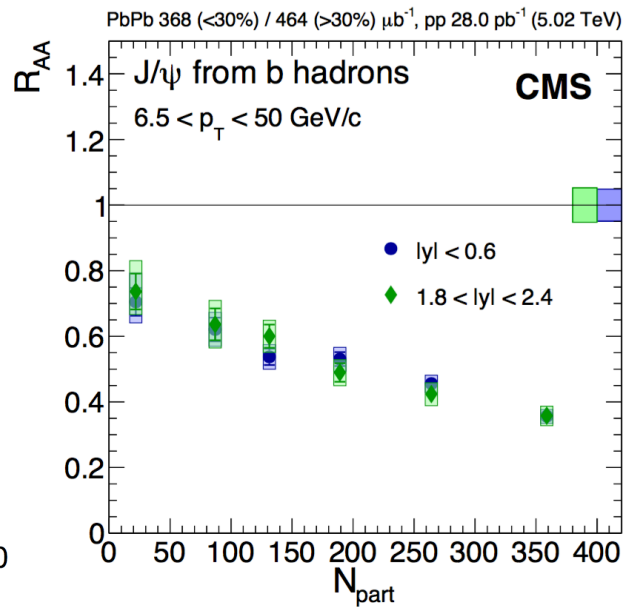
Phys. Rev. Lett. 119, 152301

- Identified muon pair (J/ψ mass cut) + track (assuming Kaon mass)
- TMVA cut optimization with Boosted Decision Tree (BDT):
 - Track kinematics (p_T , rapidity...)
 - Decay vertex fitting probability
 - Opening angle
 - Decay length

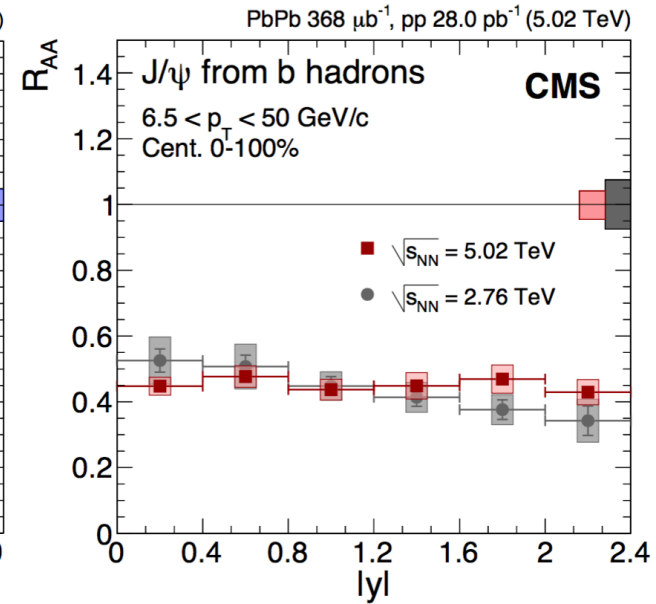
R_{AA} of J/ψ from b hadrons



- strong suppression of J/ψ from b hadrons
- begin to show less suppression at low p_T



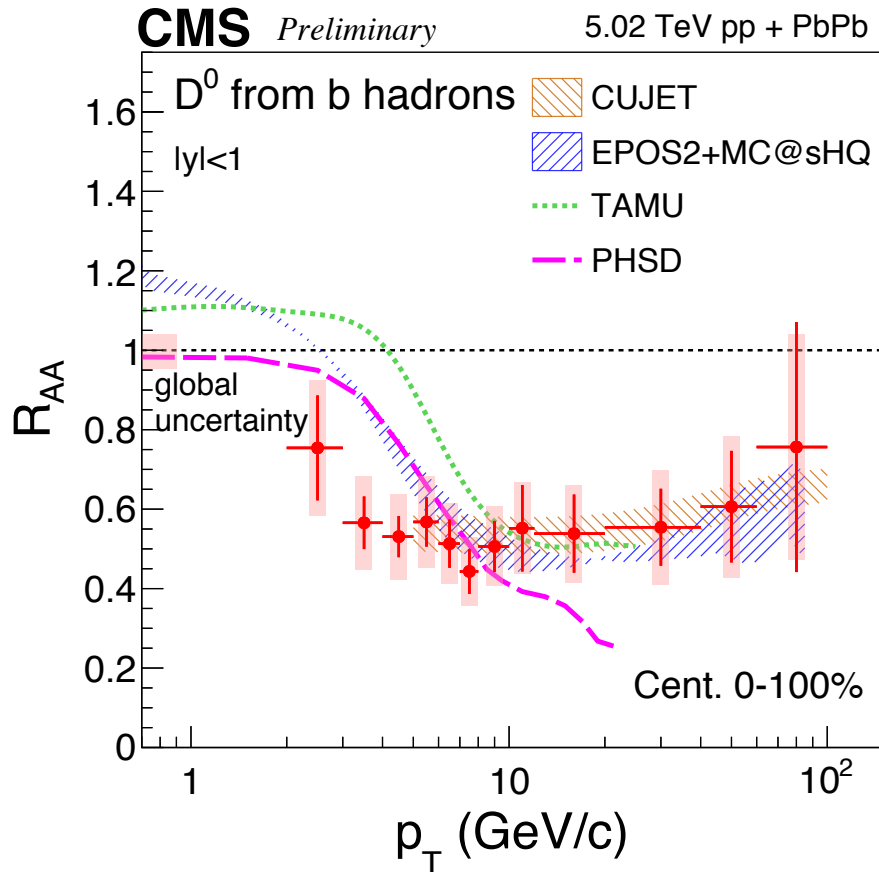
- stronger suppression in more central events



- mild indication of rapidity dependence 2.76 TeV
- no y -dependence at 5 TeV
- compatible between 2.76 and 5.02 TeV

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R_{AA} of D^0 from b hadrons

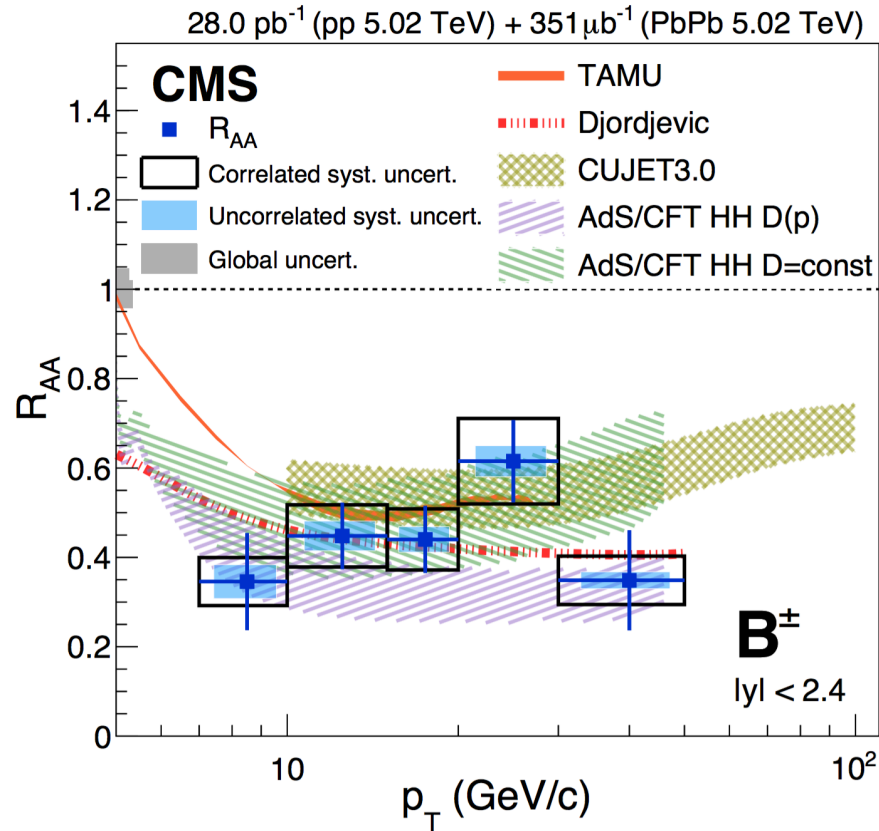


CMS-PAS-HIN-16-016

CUJET: X. Jiechen et al., JHEP 2 (2016) 169
EPOS2+MC@sHQ: P. B. Gossiaux et al, Nucl. Phys., A931 (2014) 581
TAMU: M. He et al., Phys. Lett. B 735 (2014) 445
PHSD: T. Song et al., Phys. Rev. C 92 (2015)

- suppression in most of the measured p_T range of 2-100 GeV/c
- consistent with several models at high p_T
- hint of stronger suppression than all available models at low p_T

$B^\pm R_{AA}$

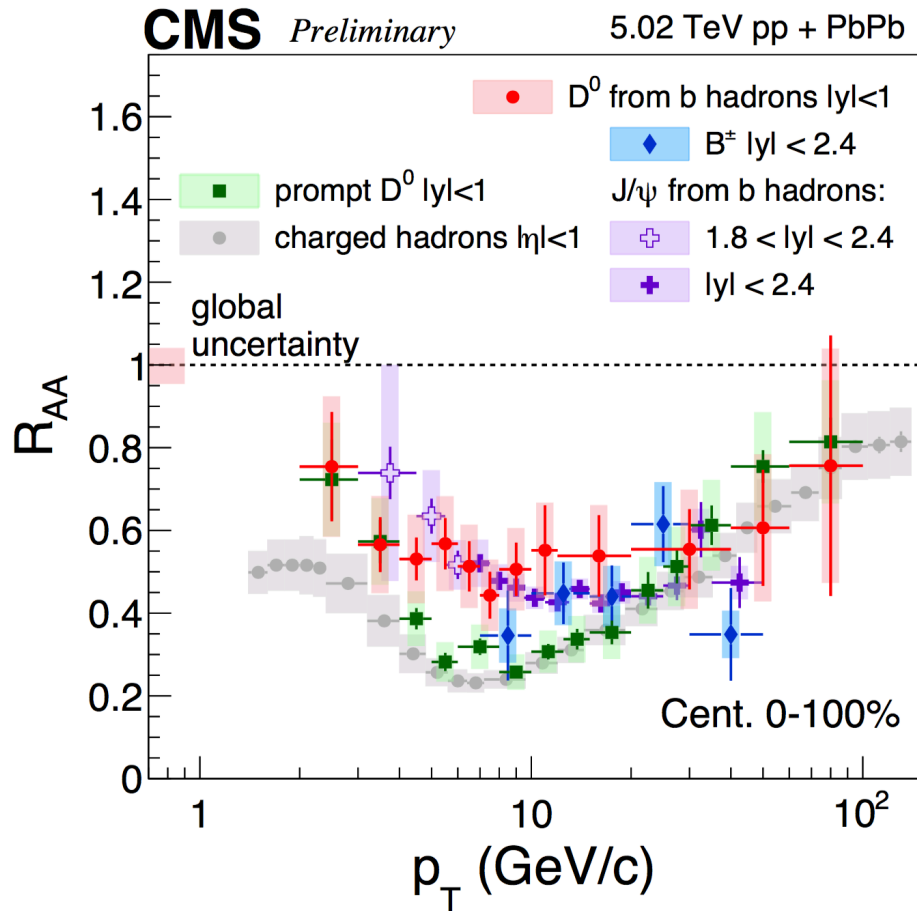


Phys. Rev. Lett. 119, 152301

TAMU: M. He et al., Physics Letters B 735 (2014) 445
 Djordjevic: M. Djordjevic, Phys. Rev. C 94 (Oct, 2016) 044908
 CUJET: X. Jiechen et al., JHEP 2 (2016) 169
 AdS/CFT HH D(p): W. A. Horowitz, Phys. Rev. D 91 (2015) 085019
 AdS/CFT HH D=const: P. B. Gossiaux et al, Nucl. Phys., A931 (2014) 581

- suppression of B^\pm
- Compatible with theory prediction within uncertainty for p_T 10-50 GeV/c

Beauty suppression with all channels

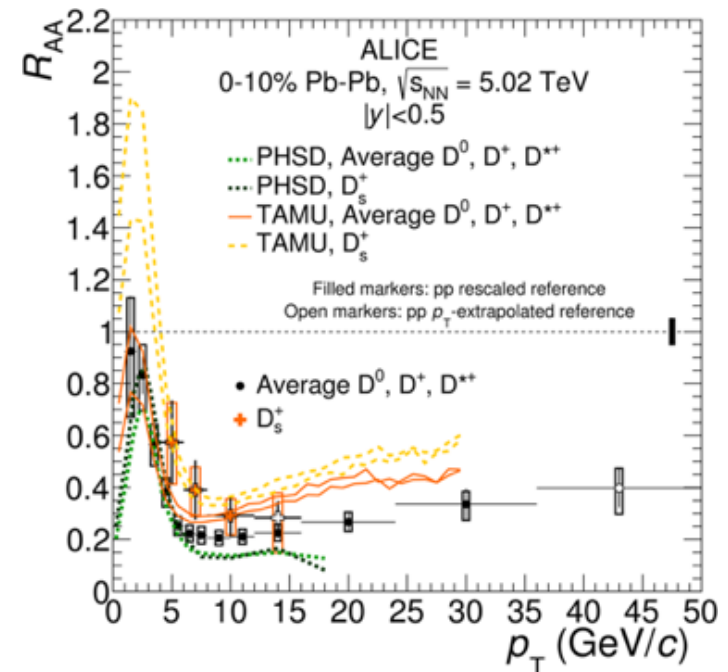
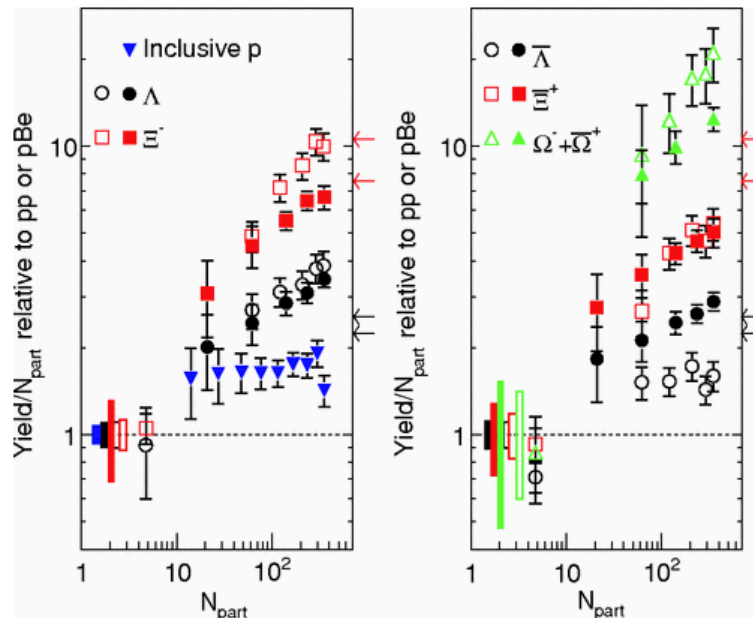


prompt D^0 : Phys. Lett. B 782 (2018) 474
 $B \rightarrow J/\psi$: Eur. Phys. J. C 78 (2018) 509
 $B \rightarrow D^0$: CMS-PAS-HIN-16-016
 B^\pm : Phys. Rev. Lett. 119, 152301

- $B \rightarrow J/\psi$, $B \rightarrow D^0$, B meson R_{AA} consistent within uncertainty
- $B \rightarrow J/\psi$ and $B \rightarrow D^0$ less suppressed than D^0 and charged hadrons for $p_T \sim 10$ GeV/c
 - consistent with expectation from the mass ordering of parton energy loss, although decay kinematics should be considered

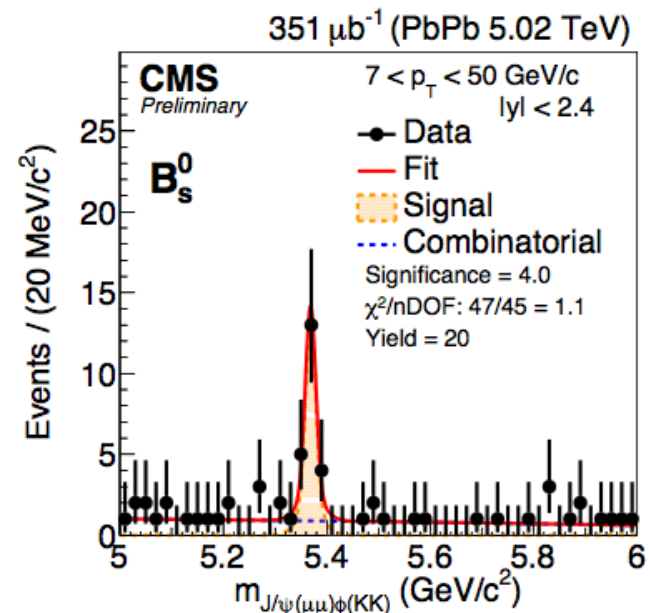
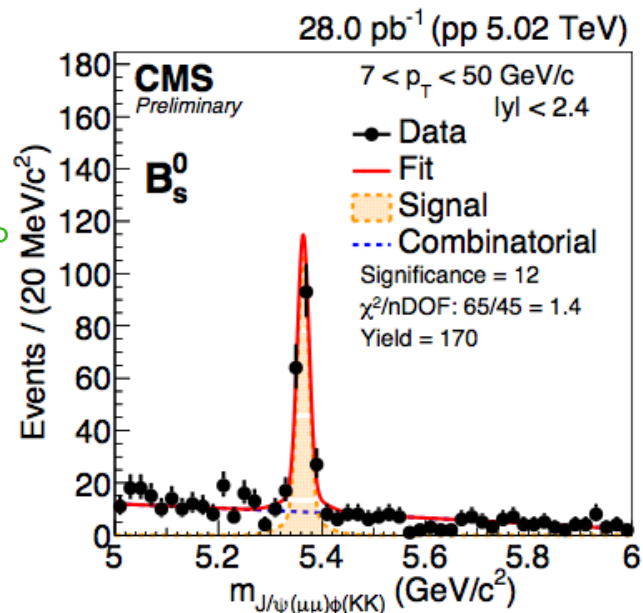
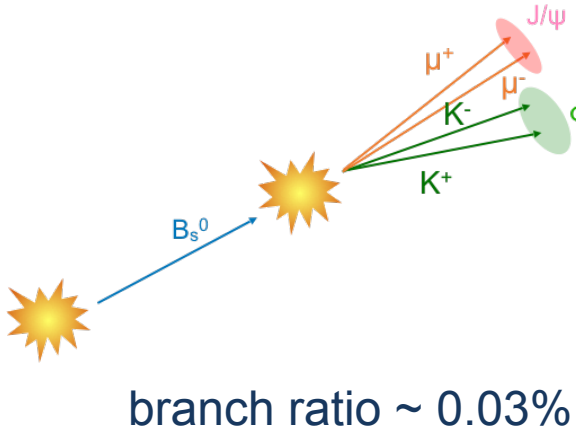
Strangeness enhancement & recombination mechanism

- An enhancement of strangeness in the QGP state comparing to hadron gas is proposed [1]
- Verified by RHIC in strange baryon production measurements [2]
- It's also suggested that heavy quarks could hadronize via a recombination with other quarks in the medium, in addition to fragmentation.
- ALICE: indication of $R_{AA}(D_s) > R_{AA}(D)$ [3]
- How about beauty and strangeness? $\rightarrow B_s^0$



- [1] J. Rafelski et. al, Phys. Rev. Lett. 48, 1066
 [2] STAR Collaboration, Phys. Rev. C 77, 044908
 [3] ALICE Collaboration, arXiv:1804.09083

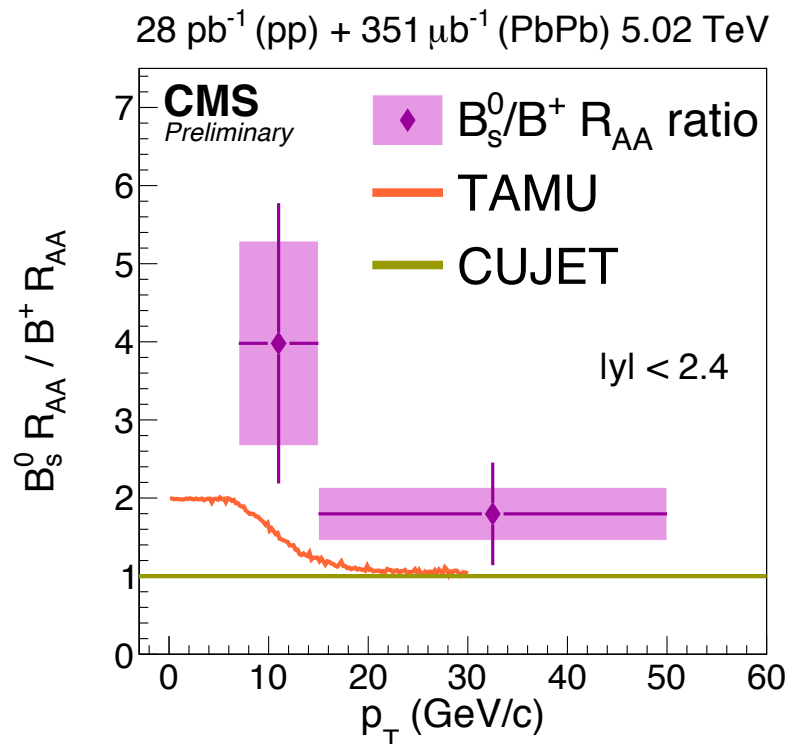
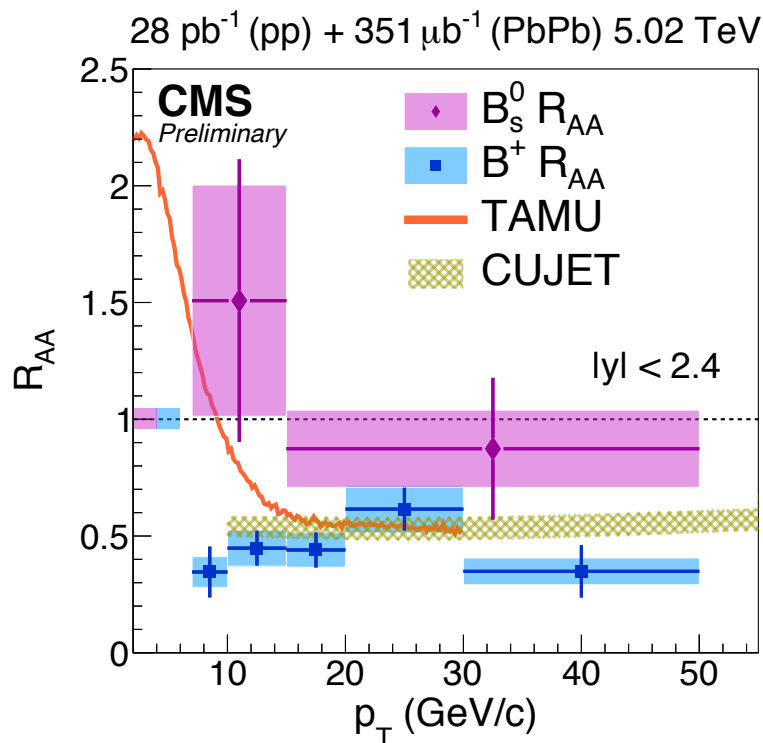
B_s^0 reconstruction and signal



CMS-PAS-HIN-17-008

- Identified muon pair (J/ψ mass cut) + track pair (ϕ mass cut)
- TMVA cut optimization with Boosted Decision Tree (BDT):
 - Track kinematics (p_T, rapidity...)
 - Decay vertex fitting probability
 - Opening angle
 - Decay length
- First B_s^0 signal in heavy ion collisions

B_s^0 results



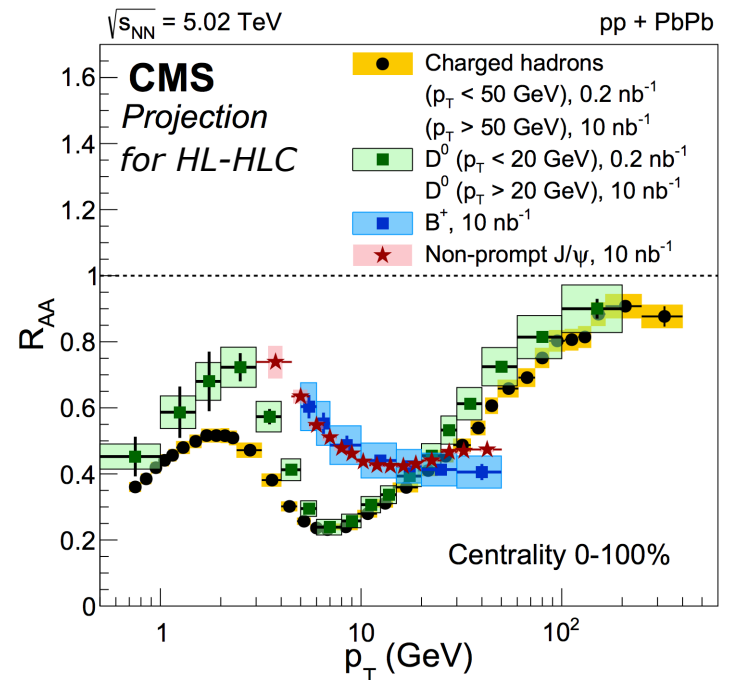
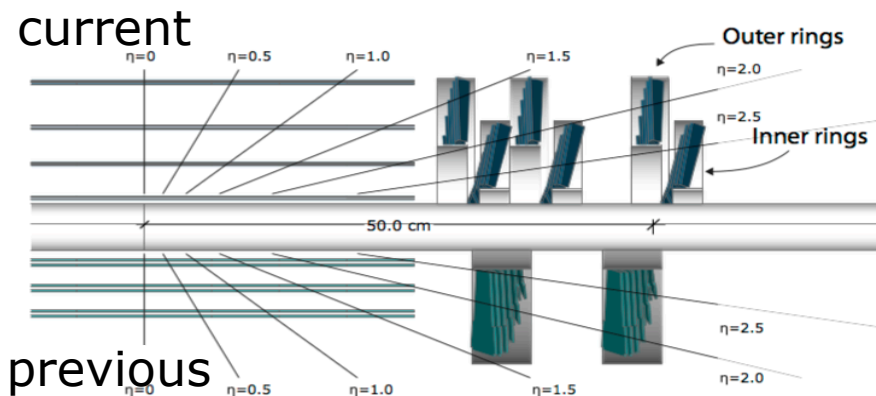
CMS-PAS-HIN-17-008

TAMU: M. He et al., Phys. Lett. B 735 (2014) 445
 CUJET: X. Jiechen et al., JHEP 2 (2016) 169

- First time probing strangeness enhancement & recombination mechanism with beauty
- $B_s^0 R_{AA}$ consistent with 1.
- Indication of less suppression of B_s^0 comparing to B^+
 - consistent with strangeness enhancement and recombination mechanism

Summary and outlook

- Consistent suppression for B^+ , non-prompt J/ψ , and non-prompt D
- Beauty seems to be less suppressed than charm and light flavor at ~ 10 GeV
 - consistent with expectation from mass ordering of parton energy loss
- First B_s measurement in heavy ion collisions
- Indication of less suppression of B_s^0 comparing to B^+
 - consistent with strangeness enhancement & recombination mechanism
- More precise measurements in the future
 - 3x statistics with year 2018 data
 - pixel detector upgrade



Thank you

