Studies of beauty suppression via nonprompt D^0 mesons in PbPb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV

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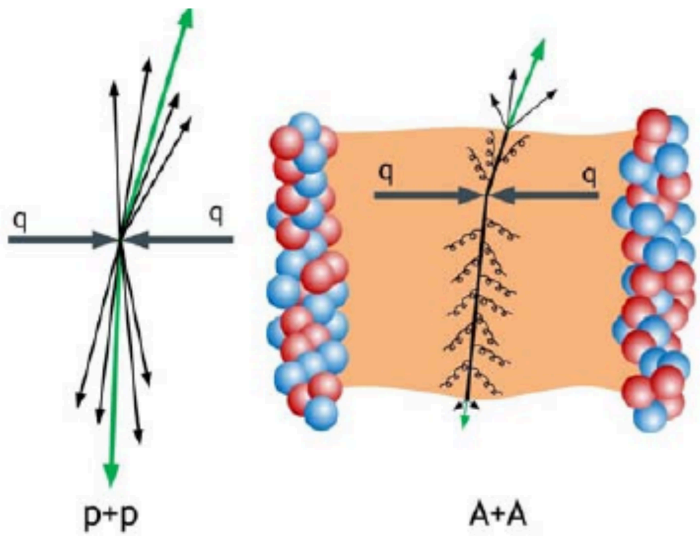
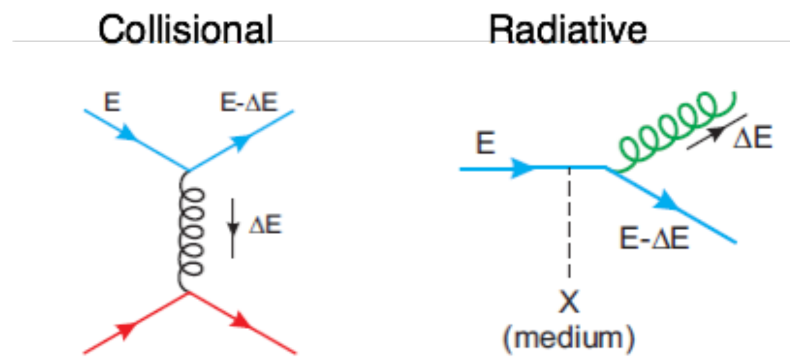
Hard Probes 2018

Probing QGP with heavy quark energy loss

- Quark-gluon plasma (QGP) is created in heavy ion collisions.
- Heavy ⇨ predominantly produced in the early hard scatterings ⇨ carry information about QGP evolution history



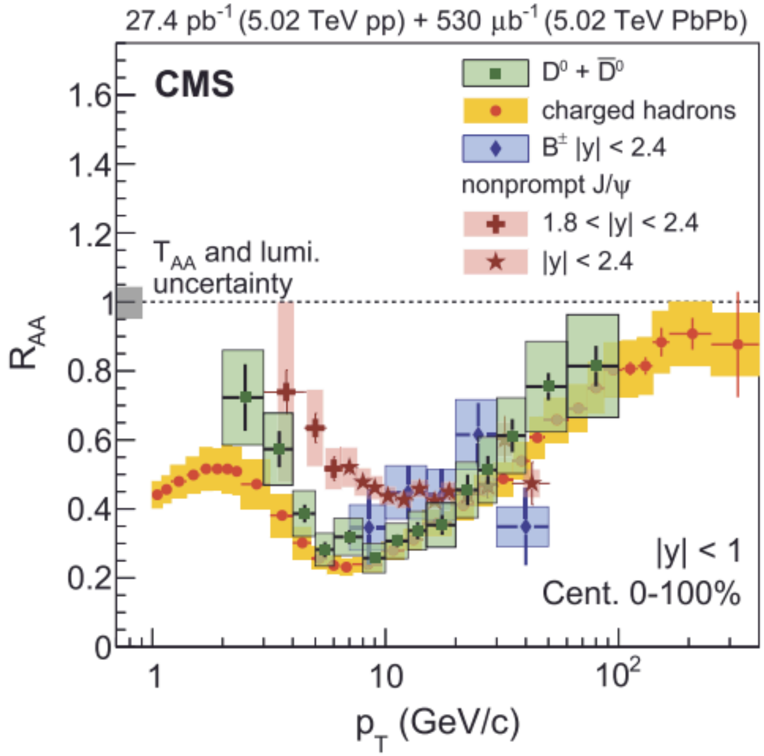


dominant at low p_T dominant at high p_T

- Heavy quarks can lose energy in QGP medium by collisional and radiative interatctions
- Particle p_T spectra will be modified, quantified with nuclear modification factor:

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

Probing QGP with heavy quark energy loss



PLB 782 (2018) 474

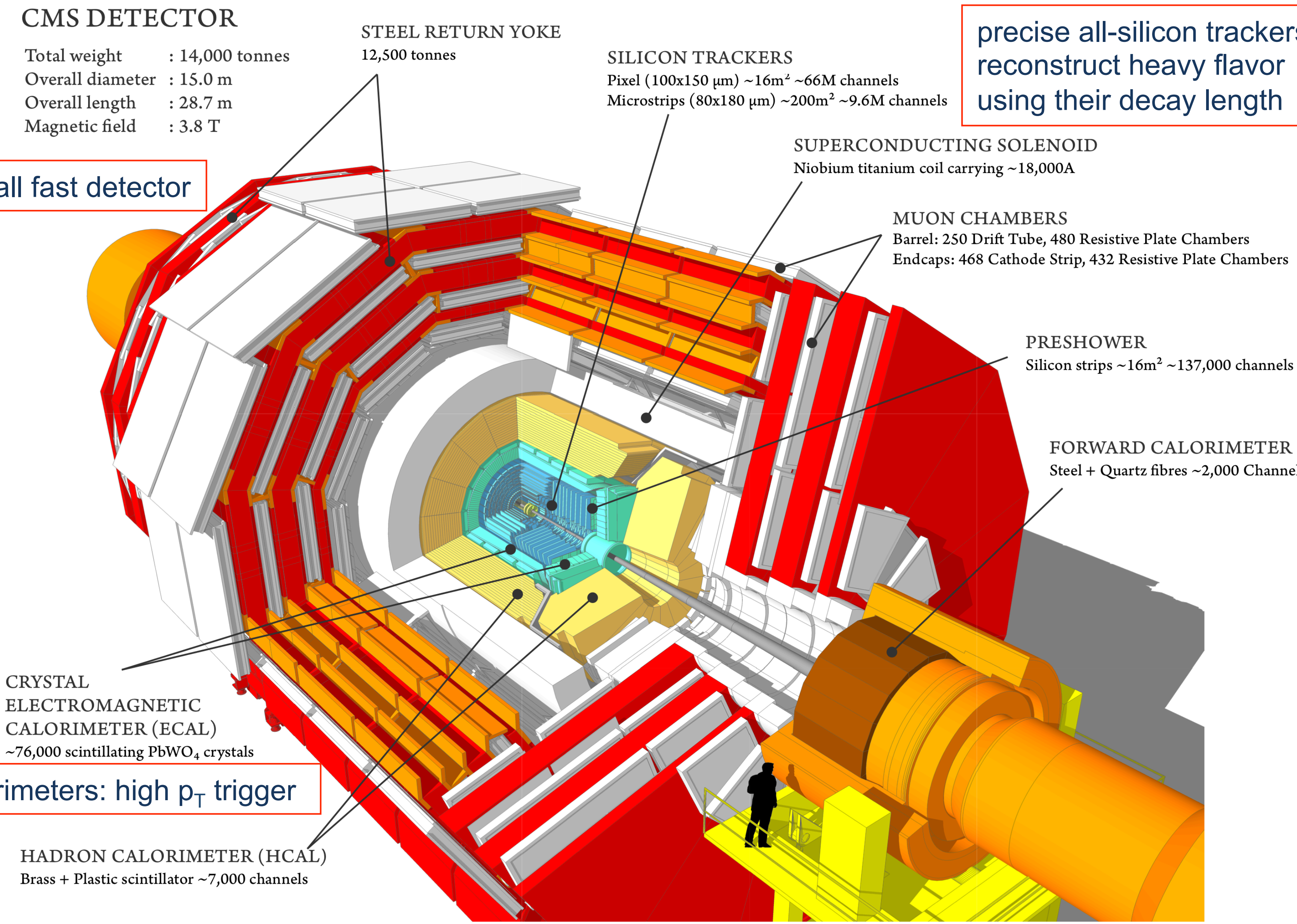
B➔J/ψ: EPJC 78 (2018) 509
B±: PRL 119 (2017) 152301
charged hadrons: JHEP 04 (2017) 039

- Mass and p_T dependence of heavy quark R_{AA} are observed
- This talk: studying the energy loss of b quark via B➔D^0
  - larger decay BR than B➔J/ψ & fully reconstructed $B^{+/-}$ ➔ larger B sample
  - larger p_T coverage ➔ discriminate radiative vs. collisional parton energy loss

CMS detector

precise all-silicon trackers: reconstruct heavy flavor using their decay length

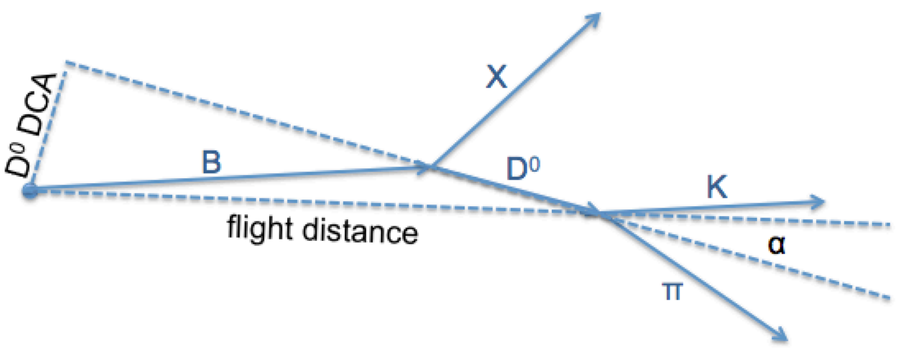
all fast detector



calorimeters: high p_T trigger

Data sets and analysis channel

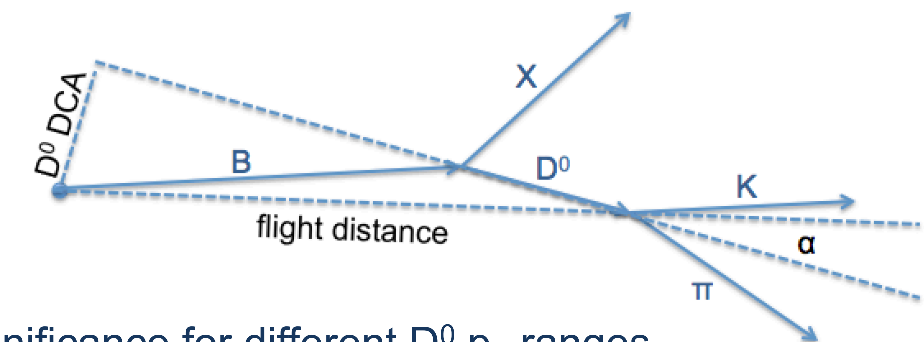
- 2015 pp @ 5.02 TeV
  - minimum-bias (MB) events: 2.67 B collisions
  - high p_T D^0 triggers: 27.4 pb-1
- 2015 PbPb @ 5.02 TeV
  - MB events: 294 M
  - high p_T D^0 triggers: 530 μb-1



- $D^0 \rightarrow K^- \pi^+$
  - BR = (3.88±0.05)%
  - $c\tau(D^0)$ = 122.9 μm
- $B \rightarrow D^0$ and prompt D^0 separation
  - $B \rightarrow D^0$: non-zero Distance of Closest Approach (DCA) due to B decay
  - Prompt D^0: DCA only from track and vertex resolution

D^0 reconstruction

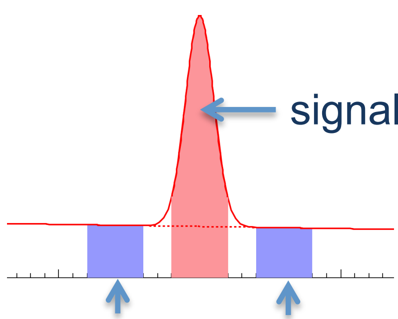
- $D^0 \rightarrow K^- \pi^+$ each track pair reconstructed twice assuming Kπ and πK
- Daughter track selection
  - $|\eta| < 1.5$
  - $p_T > 1$ GeV/c (minimum-bias), $p_T > 2$ GeV/c (pp D^0 triggered), $p_T > 8.5$ GeV/c (PbPb D^0 triggered)



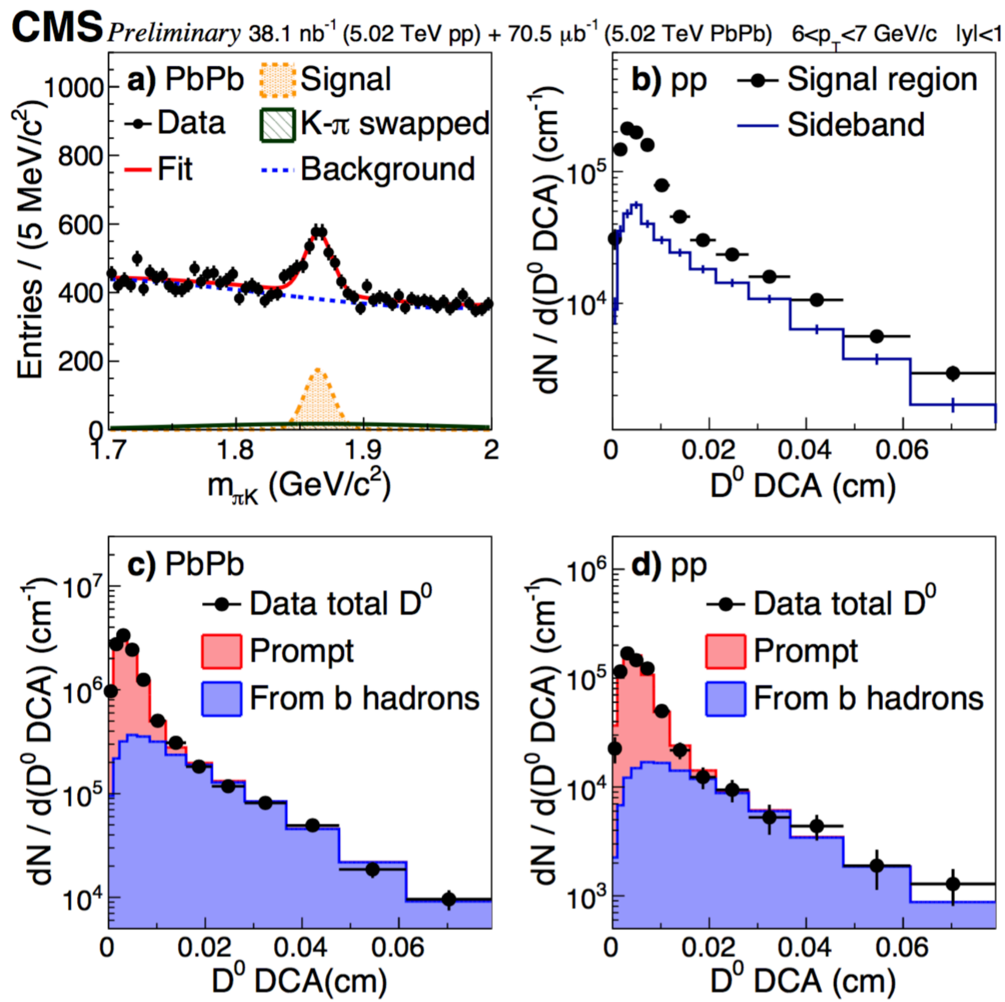
- Geometry cuts, optimized for $B \rightarrow D^0$ significance for different D^0 p_T ranges
  - minimum probability that the two tracks comes from a common decay vertex
  - minimum flight distance / σ(flight distance)
  - minimum daughter track DCA / σ(daughter track DCA)

D^0 signal extraction and prompt / nonprompt separation

- D^0 signal extraction within a DCA bin
  - invariant mass fit: PbPb low p_T (larger background)
  - side bands subtraction: pp and PbPb high p_T (low background)



- 2-component fit with MC DCA templates, to get prompt and nonprompt D^0 yields



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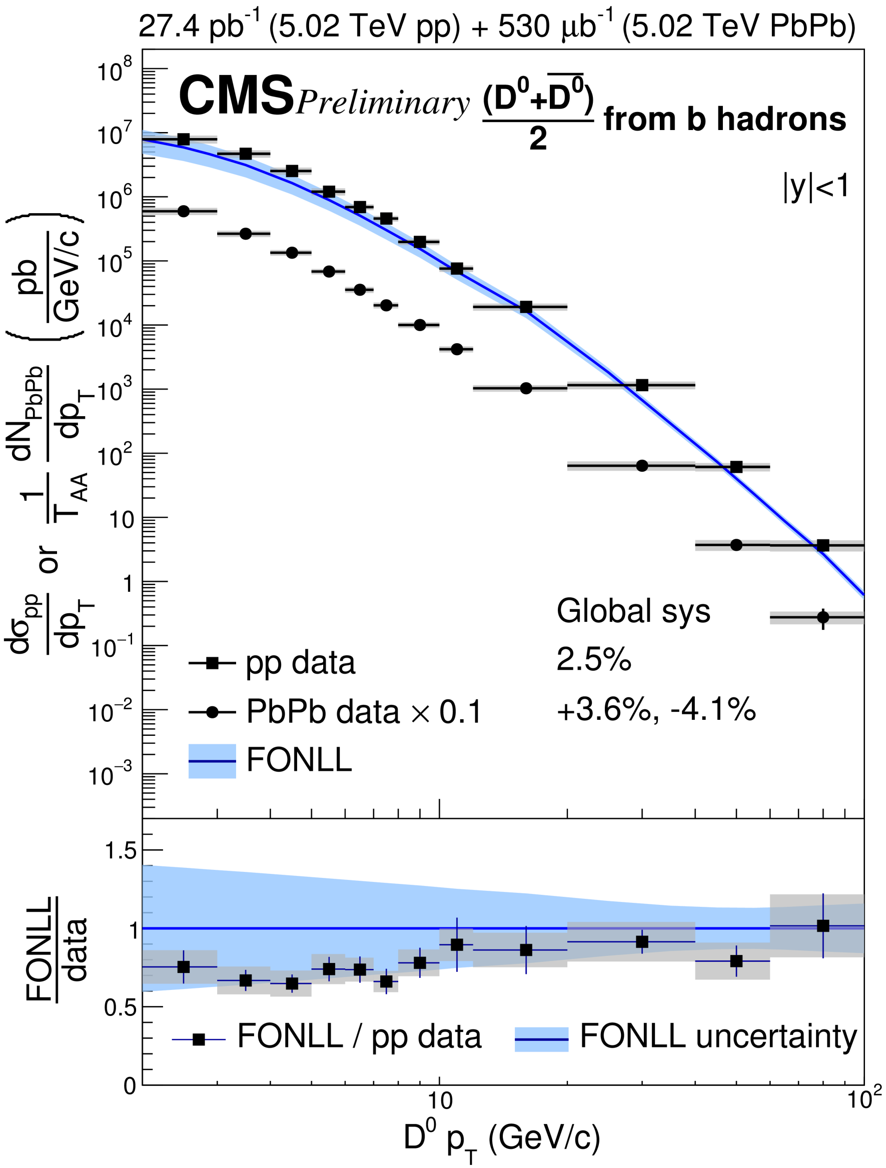
p_T spectra



$$\left.\frac{d\sigma_{pp}^{B\to D^0}}{dp_T}\right|_{|y|<1} = \frac{1}{2\mathcal{L}\Delta p_T\mathcal{B}} \left.\frac{N_{pp}^{B\to D^0+\overline{D}^0}}{\alpha\epsilon}\right|_{|y|<1}$$

$$\frac{1}{T_{AA}}\left.\frac{dN_{PbPb}^{B\to D^0}}{dp_T}\right|_{|y|<1} = \frac{1}{T_{AA}}\frac{1}{2N_{events}\Delta p_T\mathcal{B}} \left.\frac{N_{PbPb}^{B\to D^0+\overline{D}^0}}{\alpha\epsilon}\right|_{|y|<1}$$

- close to the upper bound of the FONLL calculation in pp

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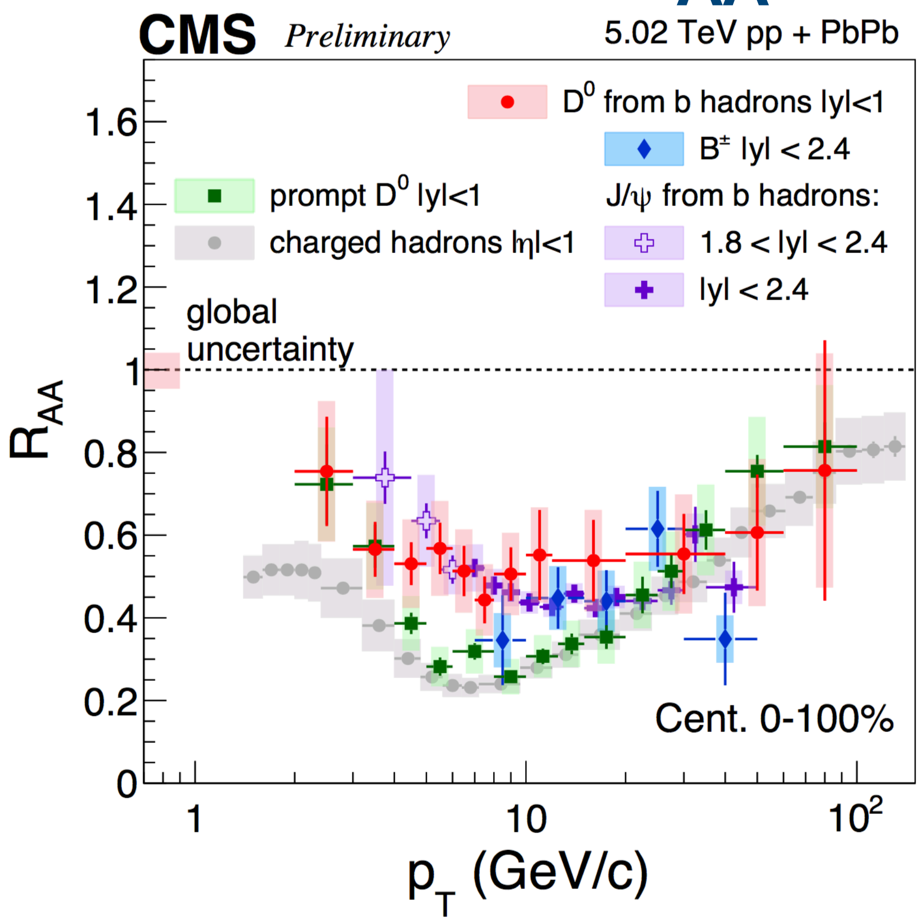
R_{AA}



$$R_{AA} = \frac{1}{T_{AA}} \frac{dN^{B\to D^0}_{PbPb}}{dp_T} \Big/ \frac{d\sigma^{B\to D^0}_{pp}}{dp_T}$$

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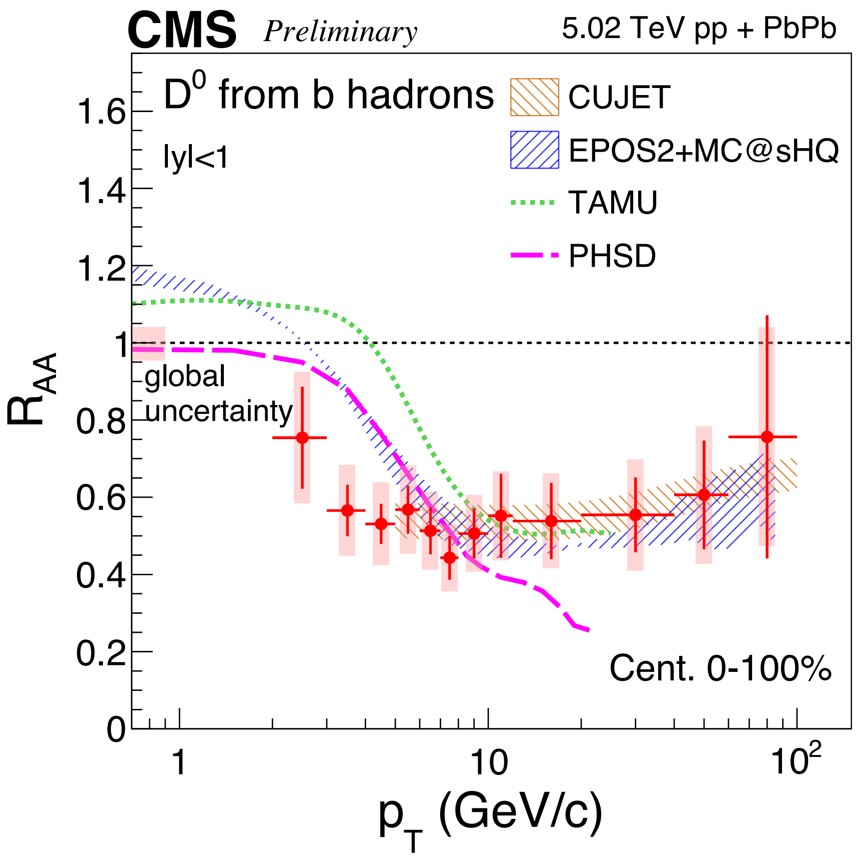
- R_{AA}(B➔D0) ≈ R_{AA}(B➔ J/ψ) ≈ R_{AA}(B meson)
- R_{AA}(B➔ J/ψ), R_{AA}(B➔D0) > R_{AA}(D0), R_{AA}(charged hadrons), for p_T ~ 10 GeV/c
    - quark mass ordering
    - decay kinematics should be considered: e.g. ancestor B p_T ≠ daughter D0 or J/ψ p_T

R_{AA}



CUJET3, EPOS2+MC@sHQ: perturbative QCD-based models that includes both collisional and radiative energy loss.
Xu, Liao, Gyulassy JHEP 1602 (2016) 169
Gossiaux et al., NPA 931 (2014) 581

TAMU: non-perturbative transport model with thermodynamic T-matrix approach.
He, Fries, Rapp, PLB 735 (2014) 445

PHSD: microscopic off-shell transport model based on a Boltzmann approach that includes collisional energy loss only.
Song et al., PRC 92 (2015) 014910

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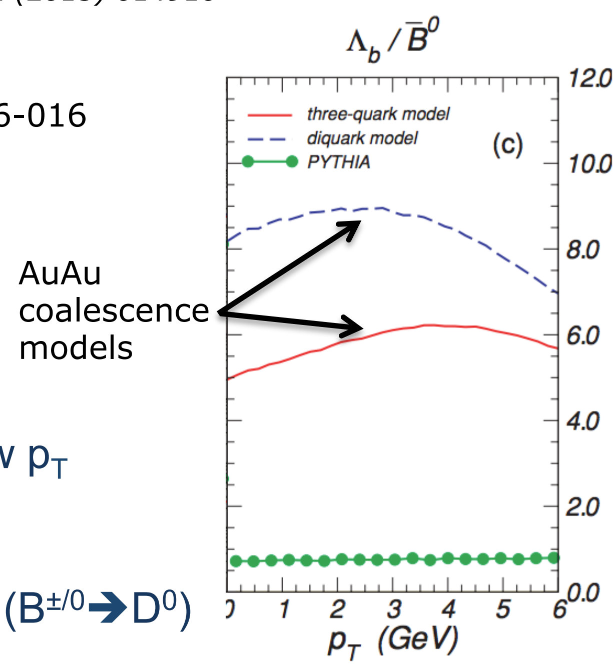
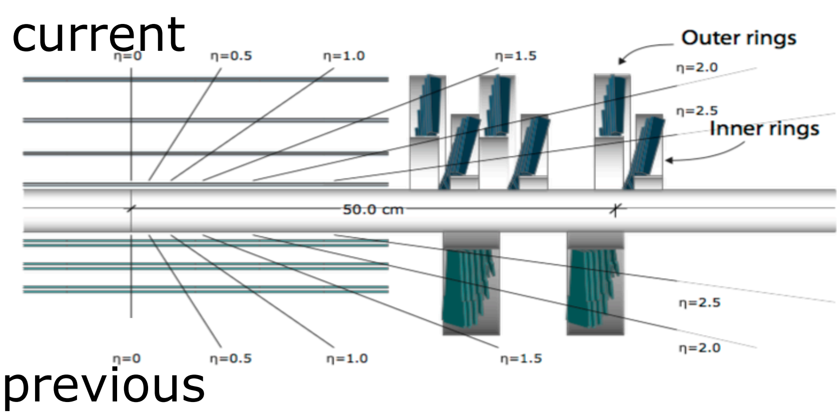


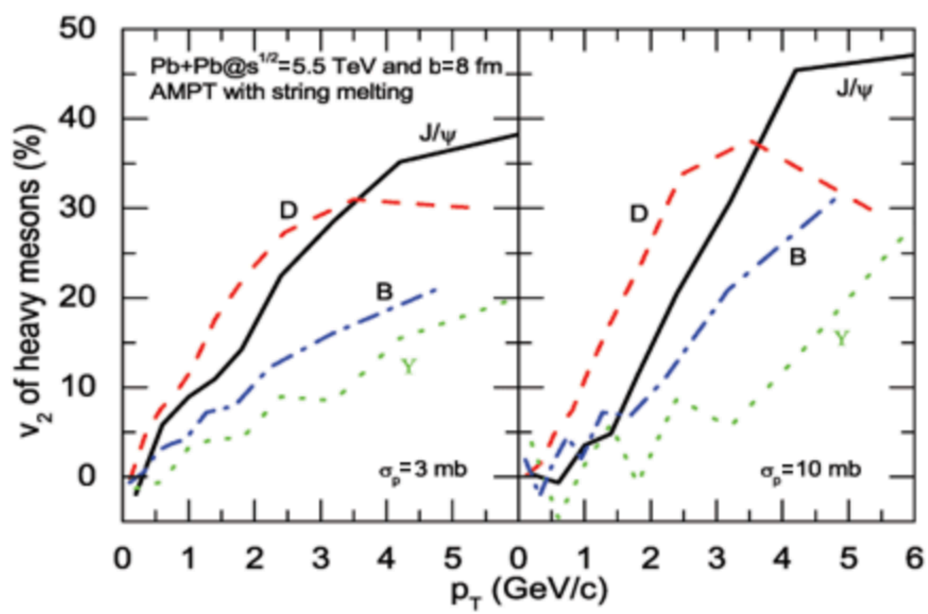
Oh et al., Phys. Rev. C 79 (2009) 044905

- consistent with several models at high p_T
- hint of stronger suppression than all available models at low p_T
  - stronger b quark energy loss?
  - baryon enhancement? BR (b baryon→D^0) << BR ($B^{\pm/0}$→D^0)

Outlook

- More precise and differential measurements in the future
  - 20x MB data statistics in year 2018
  - pixel detector upgrade: 3 ➔ 4 layers
  - B➔D^0 v_2 error projection: ~3% for best p_T bins

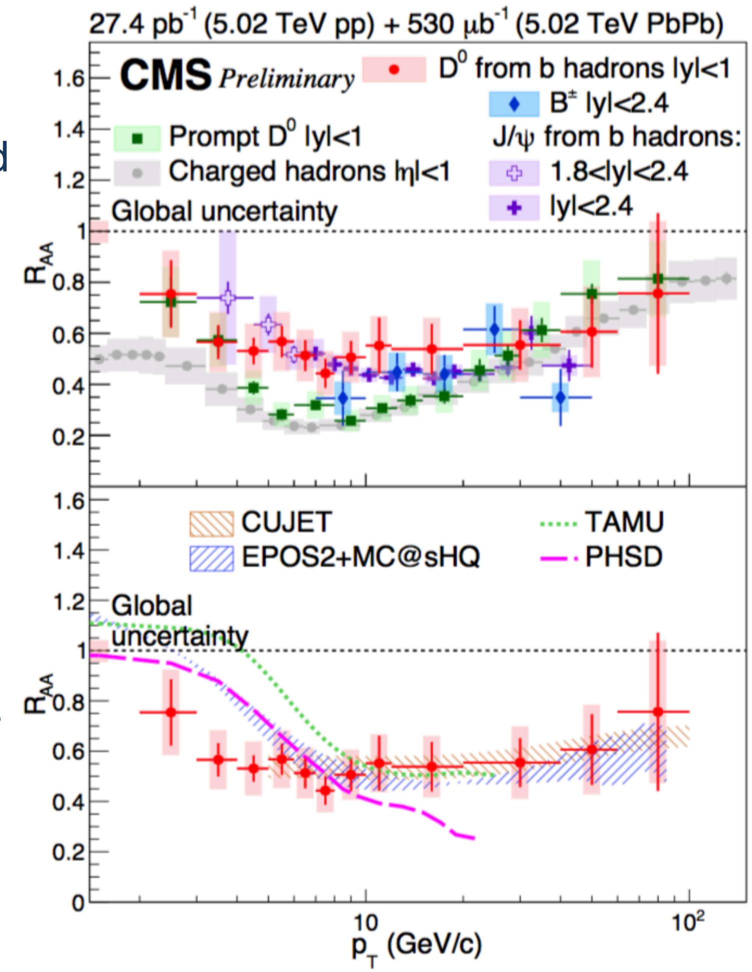




Che Ming Ko et al. Braz. J. Phys. vol.37 no.3a 2007

Summary

- R_{AA}(B➔D^0) ≈ R_{AA} (B➔ J/ψ) ≈ R_{AA}(B meson)
- Beauty seems to be less suppressed than charm and light flavor at ~ 10 GeV.
    - quark mass ordering



- B➔D^0 R_{AA} result is consistent with models at high p_T.
- Hint of stronger suppression than models at low p_T

Thank you

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