Measurement of the B^+ differential cross section as a function of transverse momentum and multiplicity in pPb collisions at 8.16 TeV

Reunión Anual de la División de Partículas y Campos 2024
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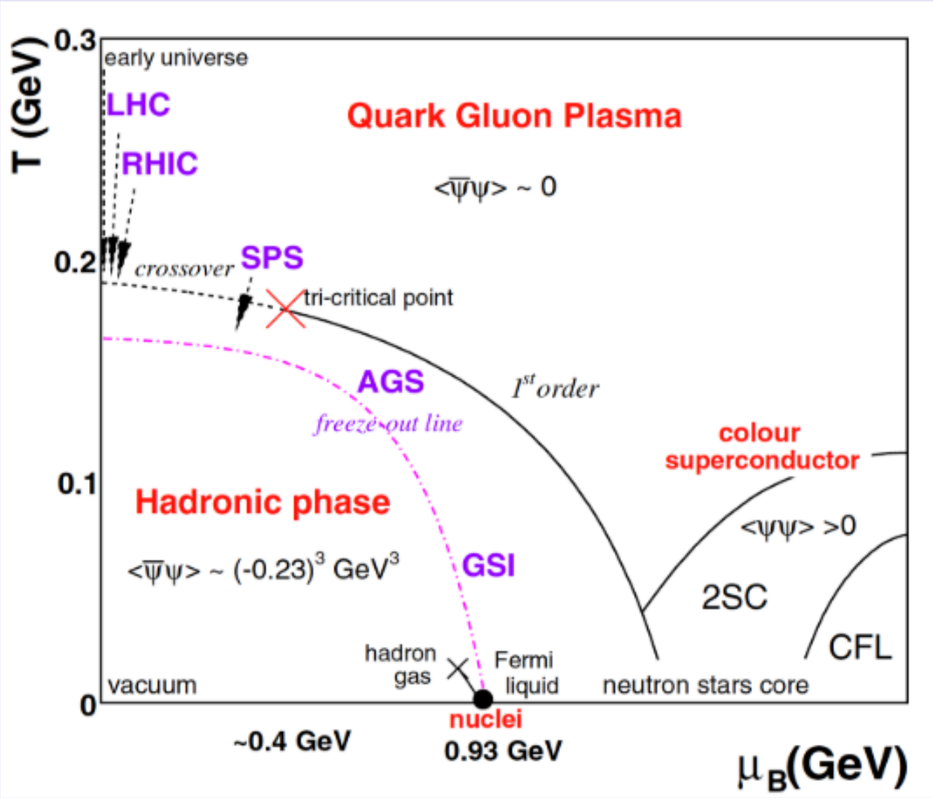
Motivation and previous results: Some insights in b-mesons nuclear modification factor and multiplicity studies.



The schematic phase diagram of QCD in terms of T, showing the QGP state. [1]

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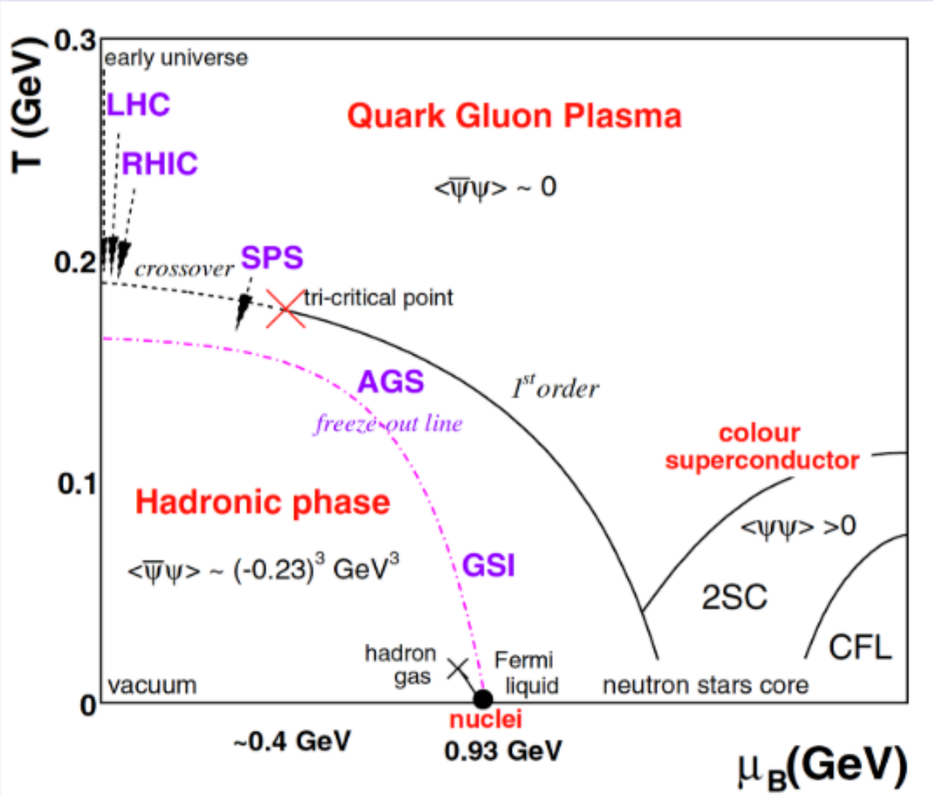

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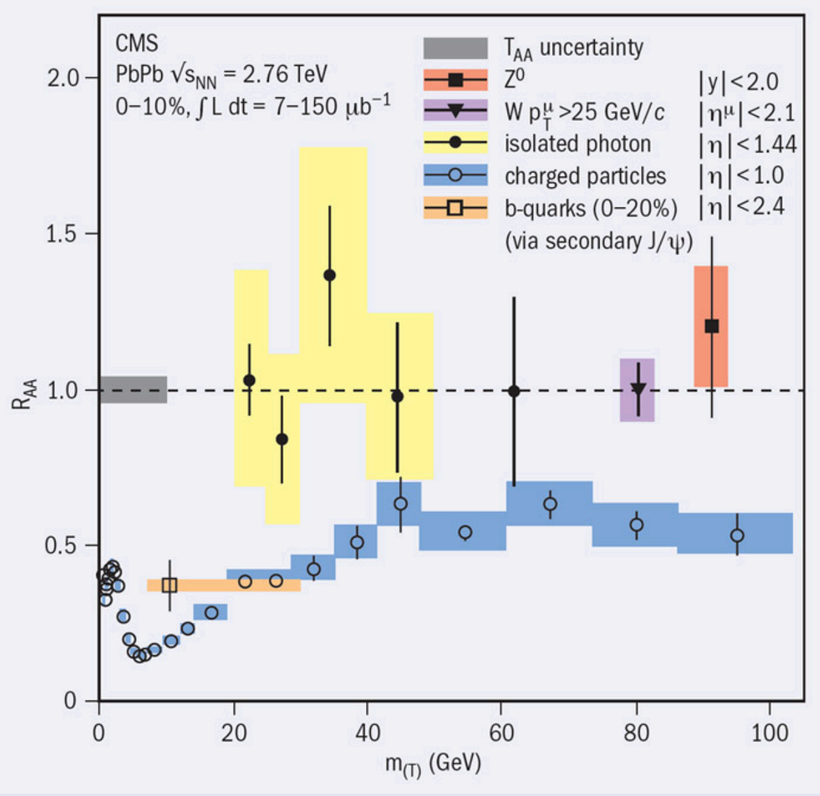
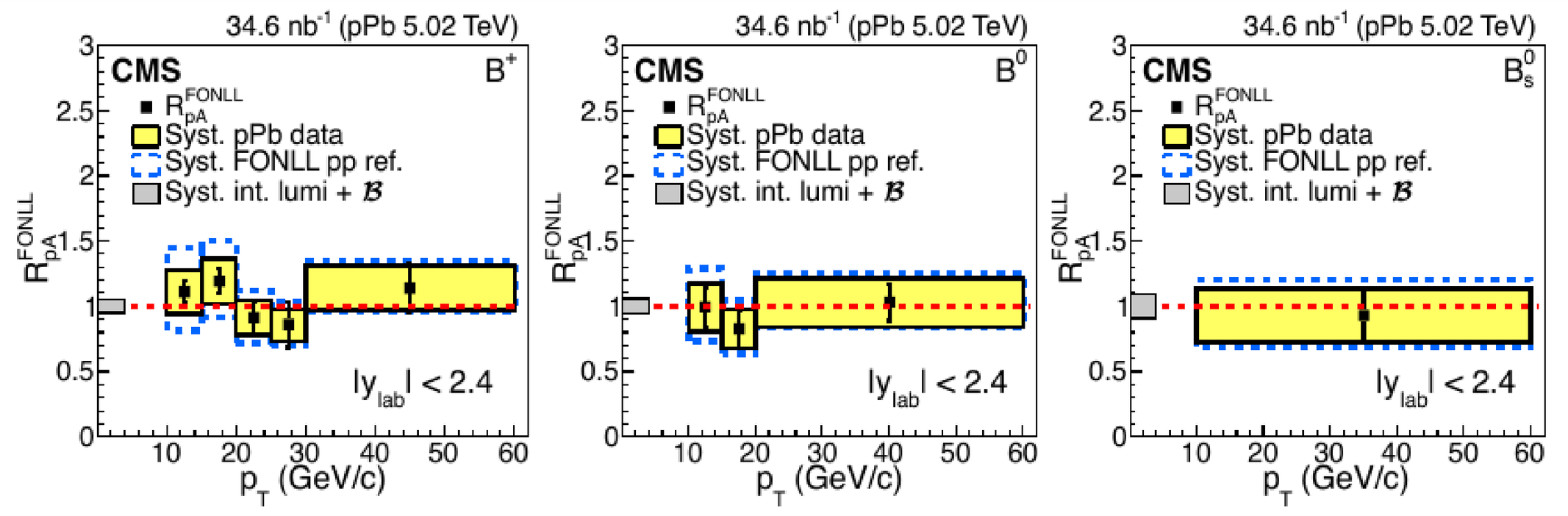


The nuclear modification factor is a quantity that measures the production suppression due to in-medium collective effects. [2]

Study of B meson production in pPb collisions at 5.02 TeV using exclusive hadronic decays

[3] CMS HIN-14-004
Phys. Rev. Lett. 116 (2016) 032301



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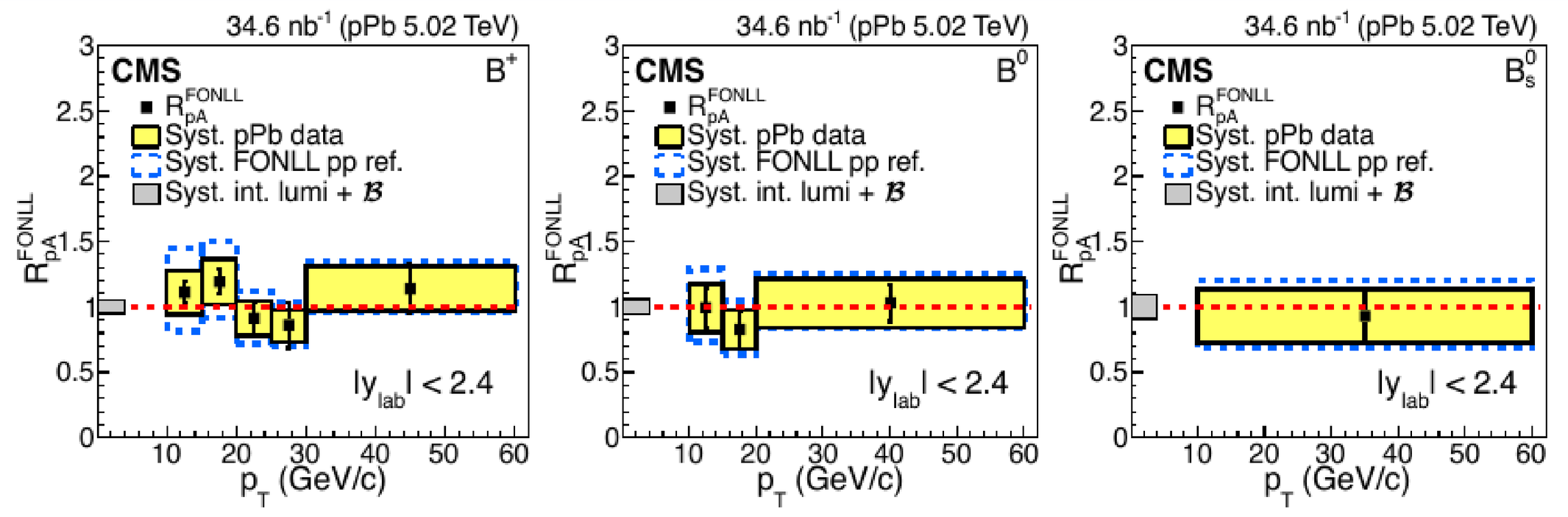
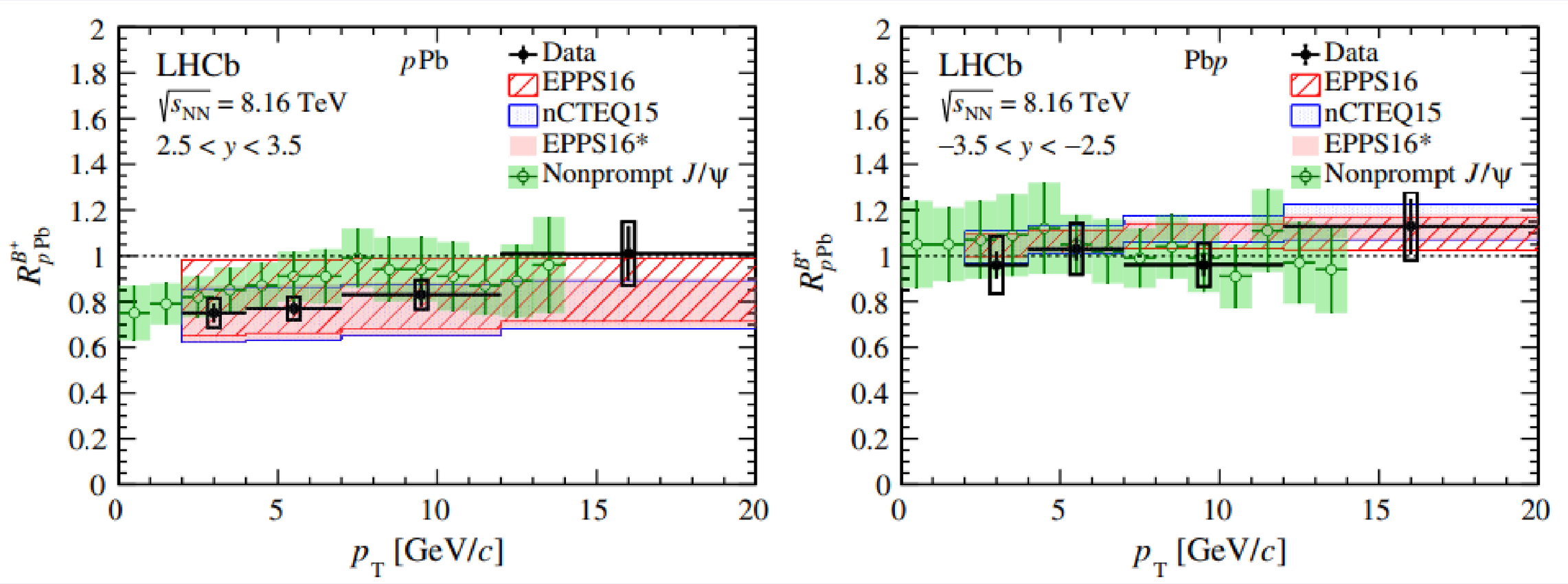


- The nuclear modification factors of the three B mesons do not show evidence for modification of pPb data compared to the FONLL reference
- These results provide a baseline for the study of in-medium b quark energy loss in PbPb collisions.

Nuclear modification factor in pPb collisions for B+ mesons as function of y and as a function of pT

[4] LHCb Collaboration
Phys. Rev. D 99, (2019) 052011



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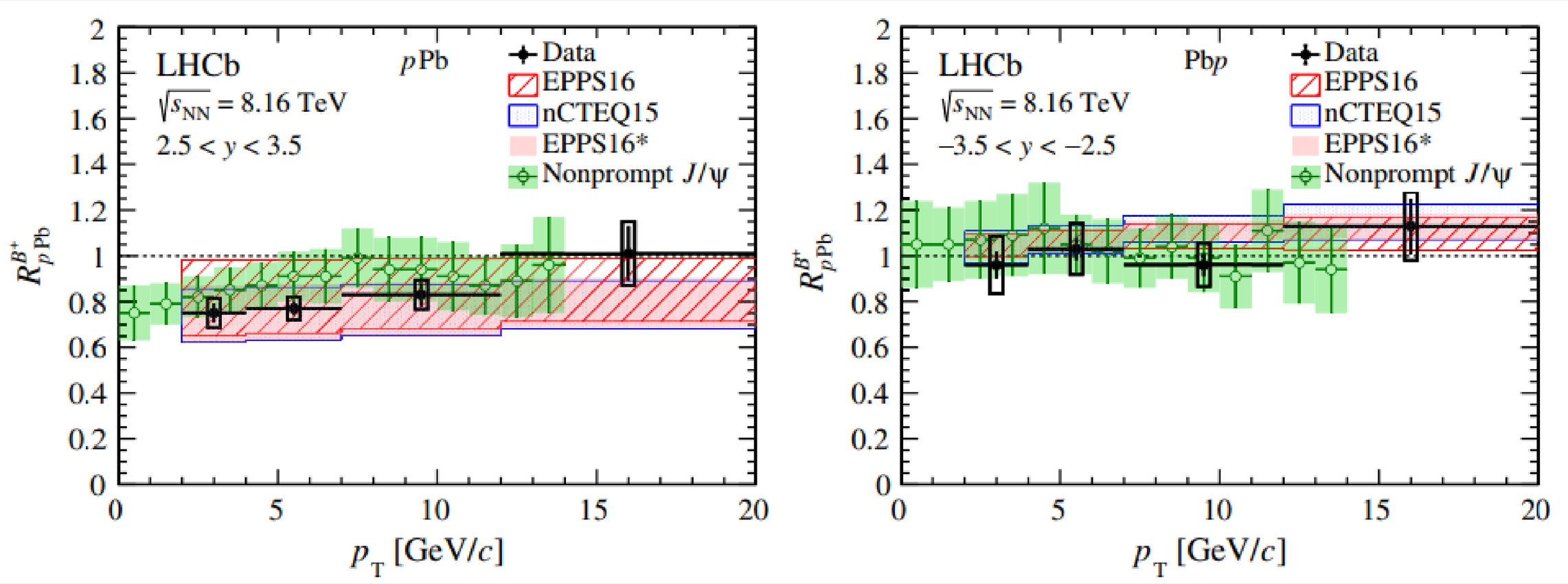
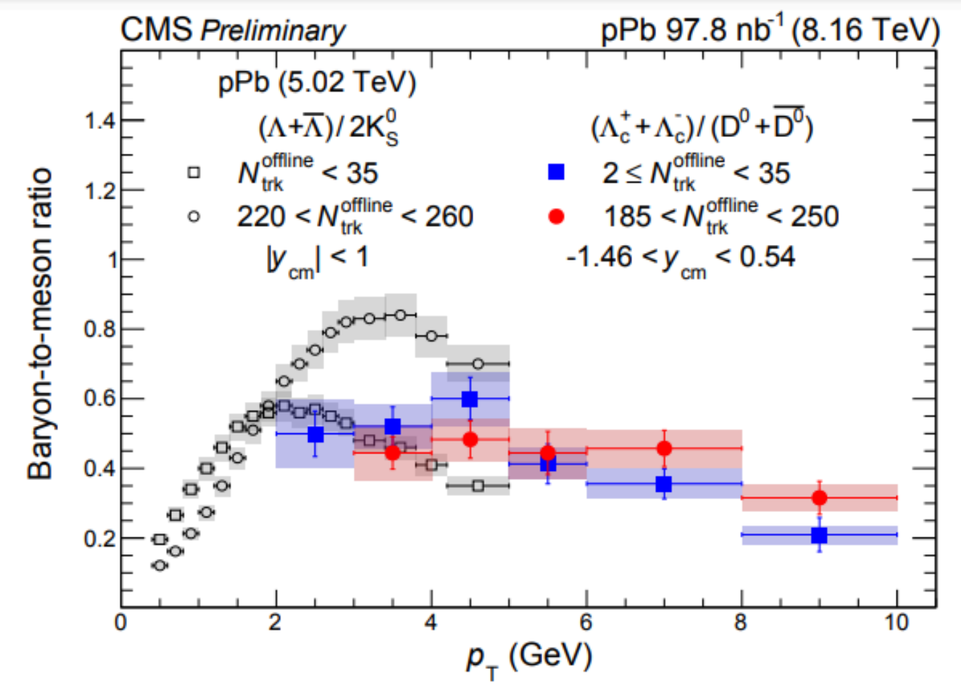
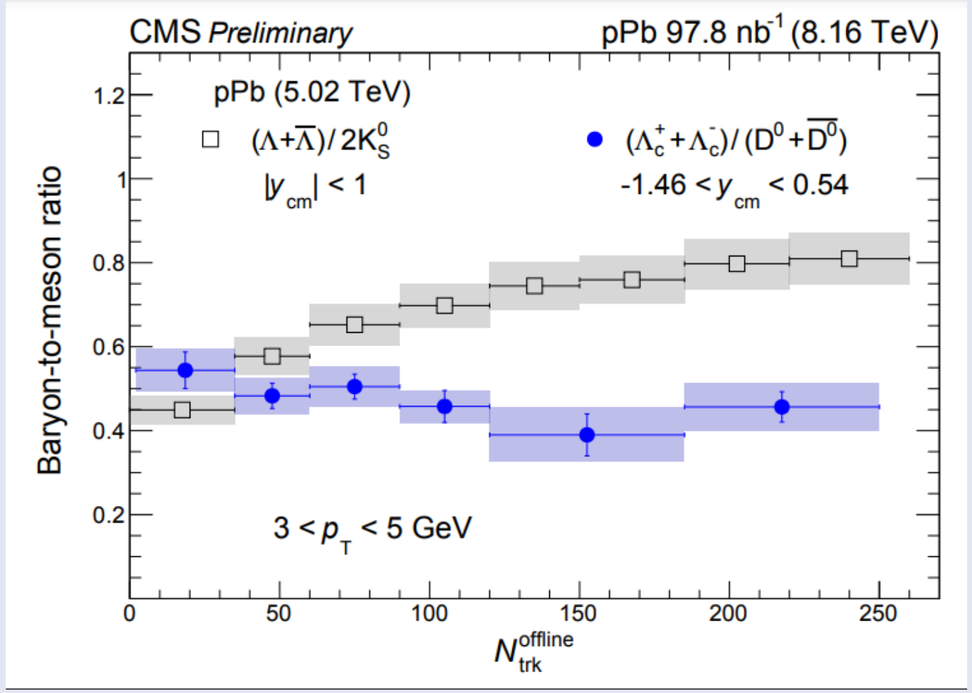


- Forward-to-backward nuclear modification factors indicate a significant nuclear suppression at positive rapidity.

Multiplicity dependence of charm baryon and meson production in pPb collisions at 8.16 TeV

[5] CMS-PAS-HIN-21-016





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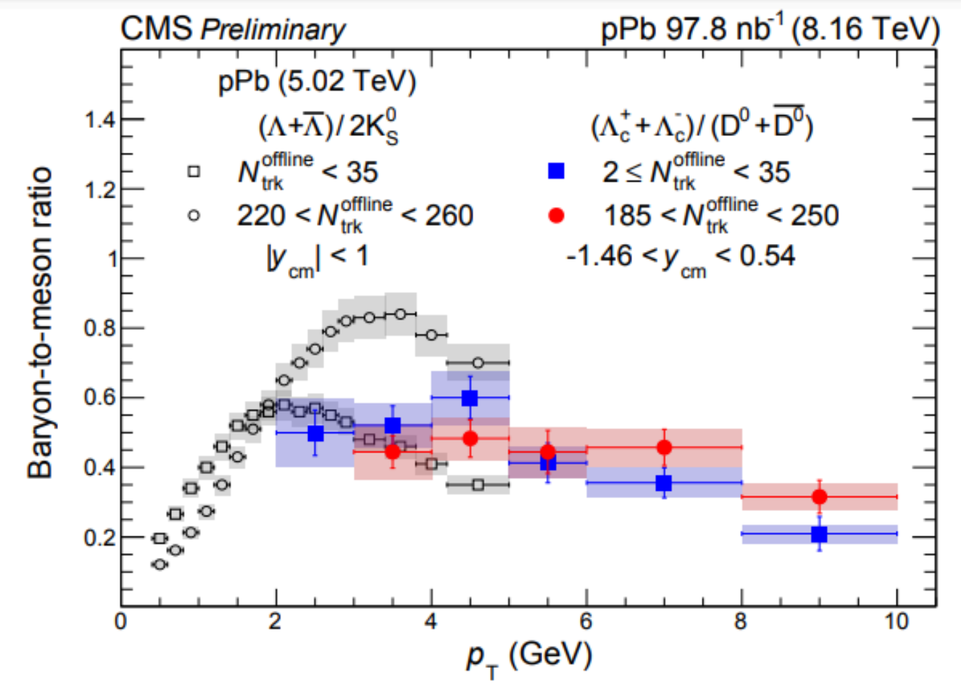

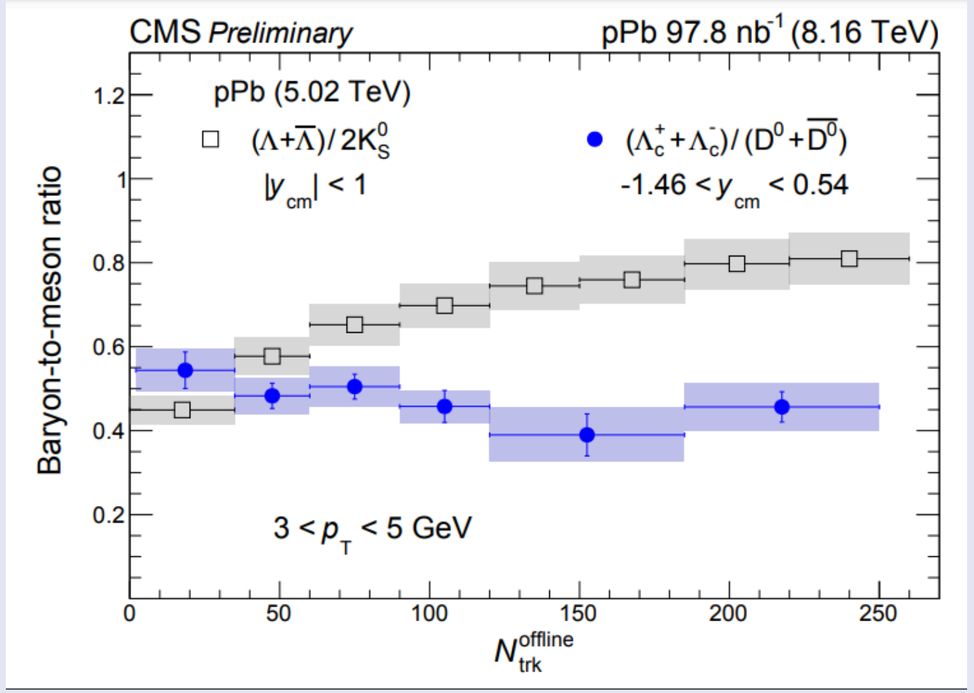

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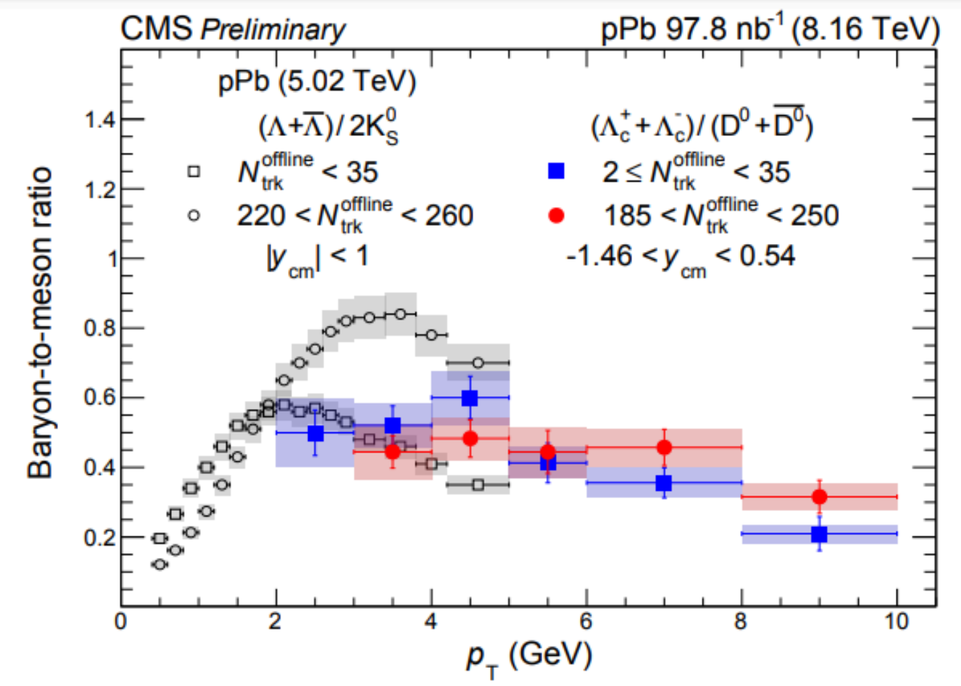

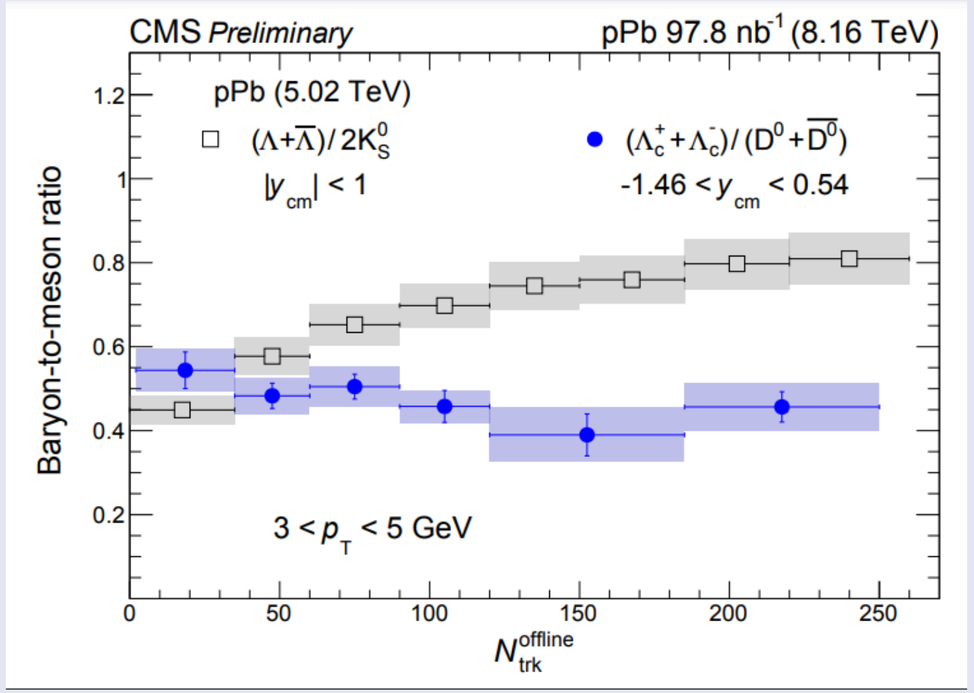

- Evidence of charm hadronization mechanism possibly in presence of a dense medium produced in high-multiplicity pPb collisions.
- Reported results may indicate different event multiplicity evolution of hadronization mechanism for charm quarks than light flavor strange quarks

[6] CMS-PAS-HIN-22-001

Measurement of the B^+ differential cross section as a function of transverse momentum and multiplicity in pPb collisions at 8.16 TeV

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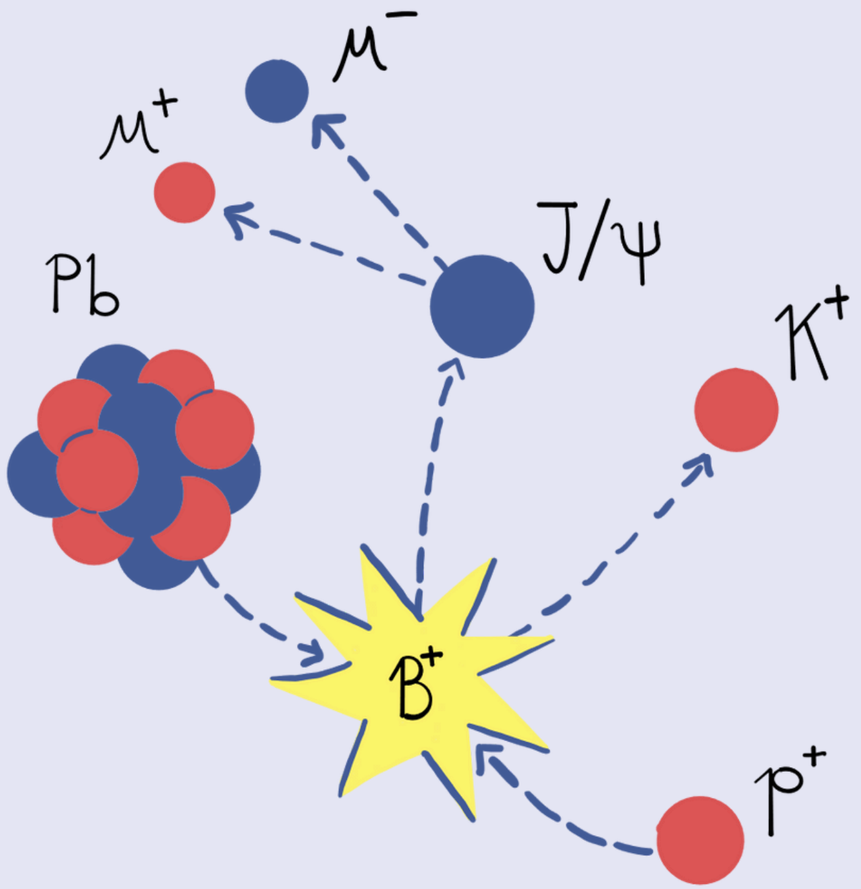

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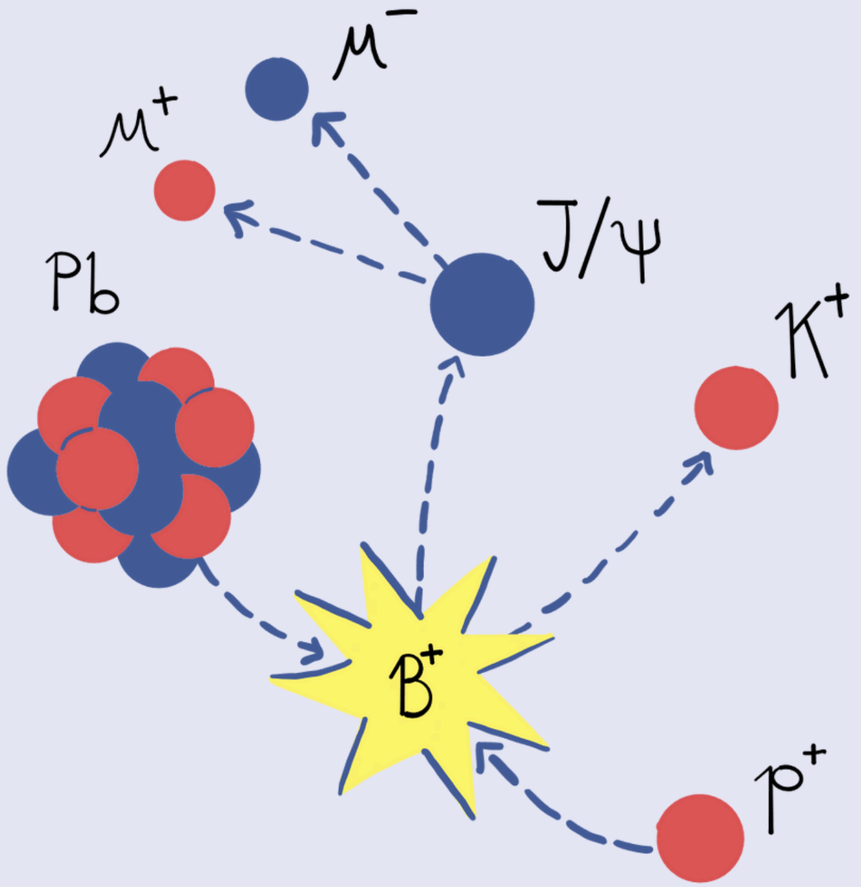
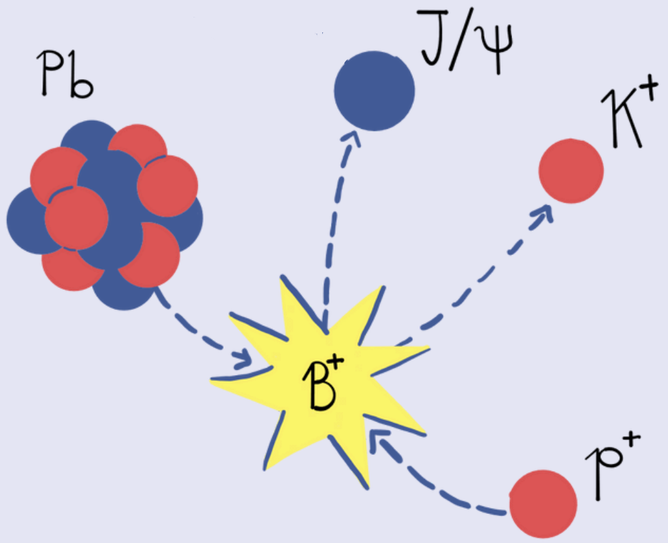


Recent observations of QGP-like phenomena in small collision systems, such as pp and pPb collisions, challenge our understanding of high-energy heavy ion physics.

Data sets and selection details

CMS-PAS-HIN-22-001

$$B^+ \rightarrow J/\psi\, K^+$$



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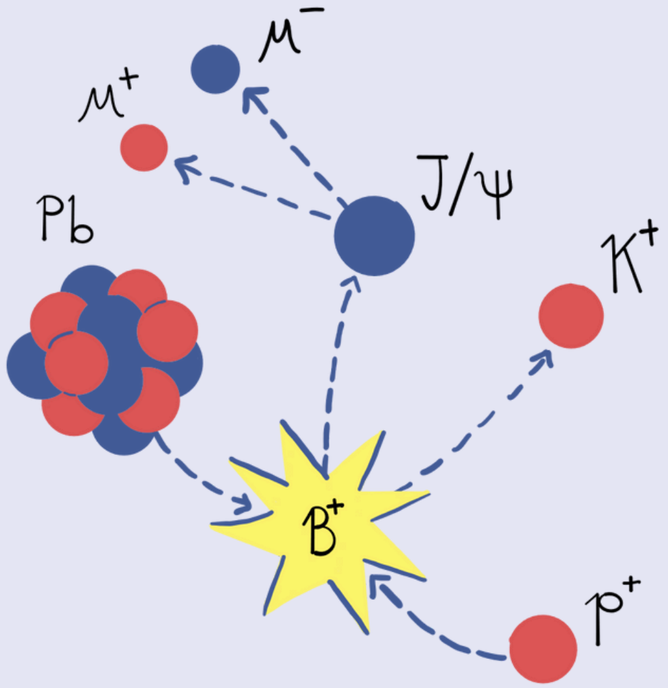

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J/ψ selection details:

- Prob(vtx) > 0.01 (1%)
- 2.9 < Mass(J/ψ) < 3.3 GeV
- pT(μ) > 2.0 GeV, |η(μ)| < 2.4
- Soft Muon ID

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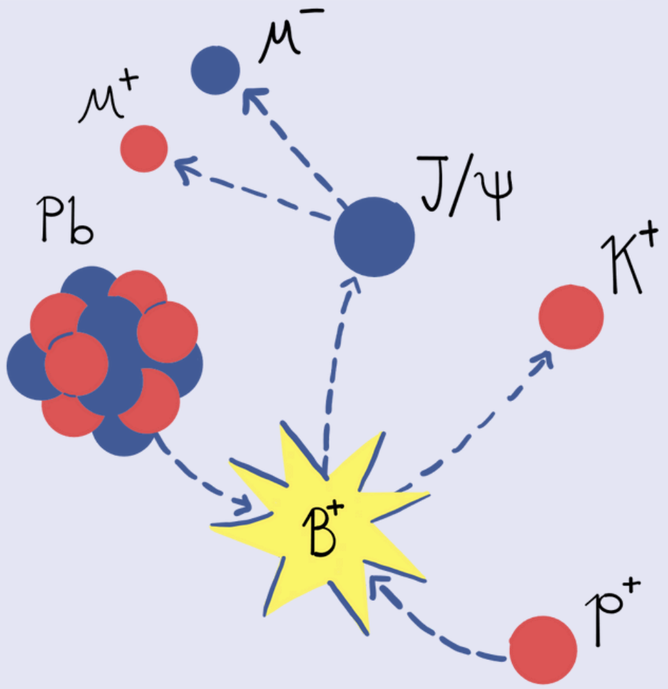

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Datasets

- /PADoubleMuon/PARun2016A-PromptReco-v1/AOD
- /PADoubleMuon/PARun2016B-PromptReco-v1/AOD
- /PADoubleMuon/PARun2016C-PromptReco-v1/AOD
- /PADoubleMuon/PARun2016D-PromptReco-v1/AOD

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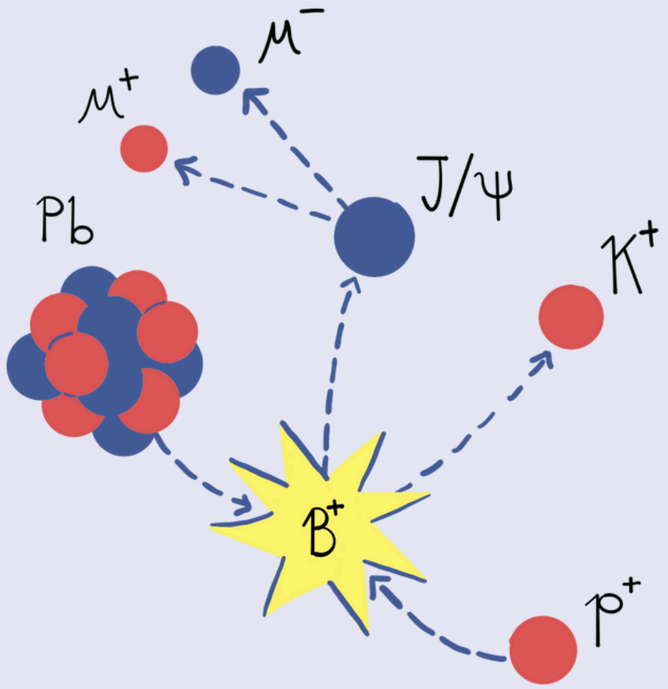

Dimuon trigger

CMS-PAS-HIN-22-001

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year	part of the run	L_{int} (nb^{-1})
2016	for pPb	62.65
2016	for Pbp	111.92
	Total luminosity	174.57

Charged-particle multiplicity

CMS-PAS-HIN-22-001

- Number of charged particles produced in a collision.

Multiplicity class	Fraction (%)	$\langle N_{\mathrm{trk}} \rangle$	$\langle N_{\mathrm{trk}}^{\mathrm{corrected}} \rangle$
$2 \leq N_{\mathrm{trk}} < 250$	100.0	88	102 ± 2
$2 \leq N_{\mathrm{trk}} < 60$	27.5	42	49 ± 1
$60 \leq N_{\mathrm{trk}} < 85$	24.1	72	84 ± 2
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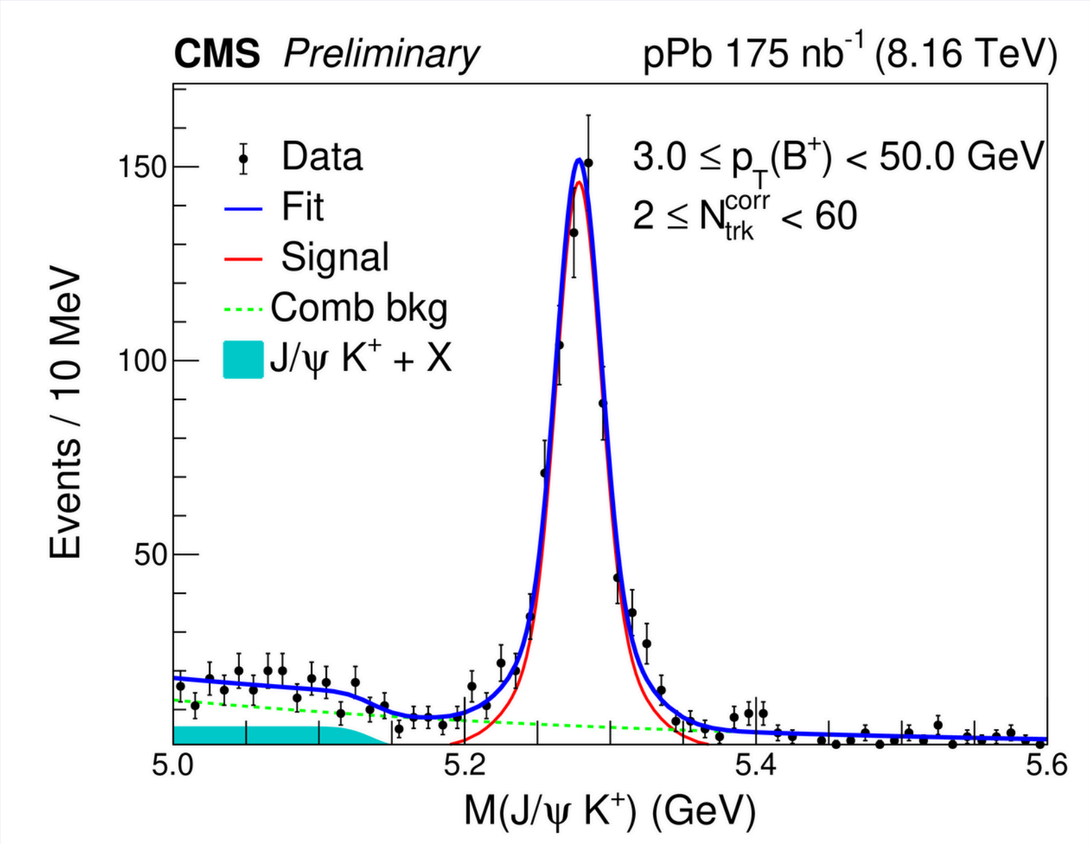
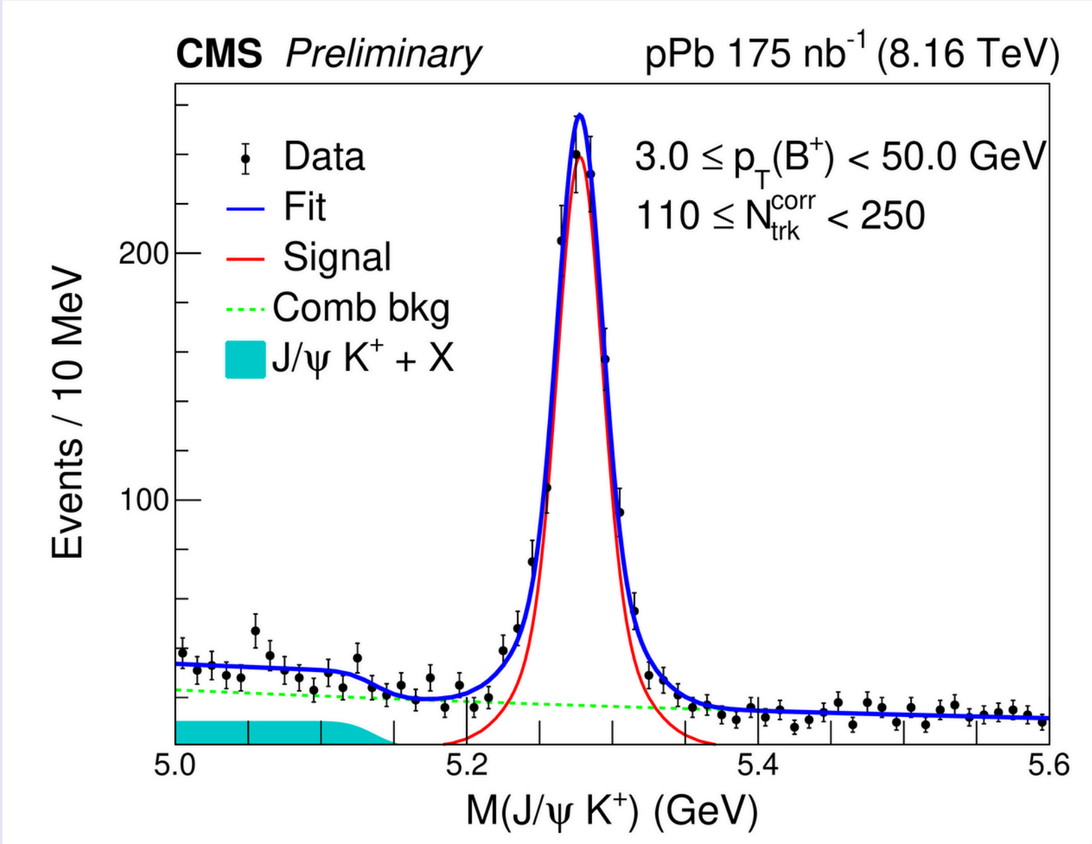
First B+ meson studies at different charged particle multiplicities in pPb collisions.

Invariant mass distribution

CMS-PAS-HIN-22-001





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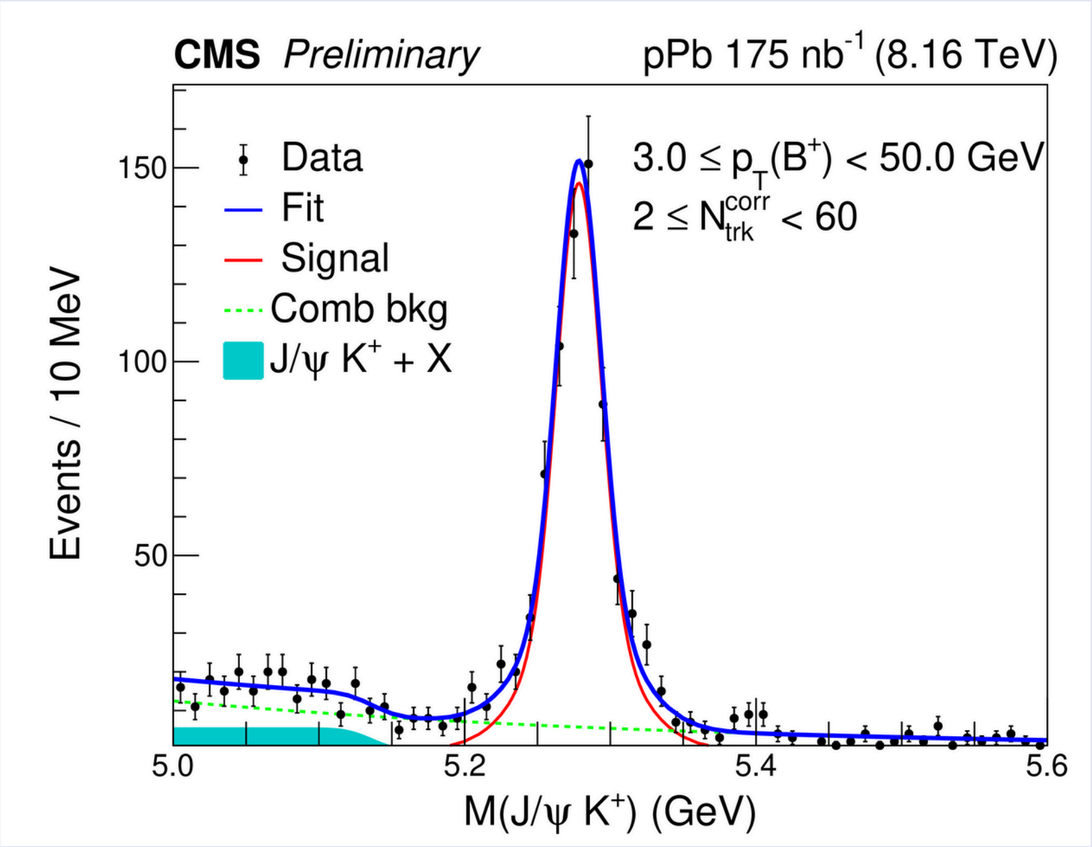

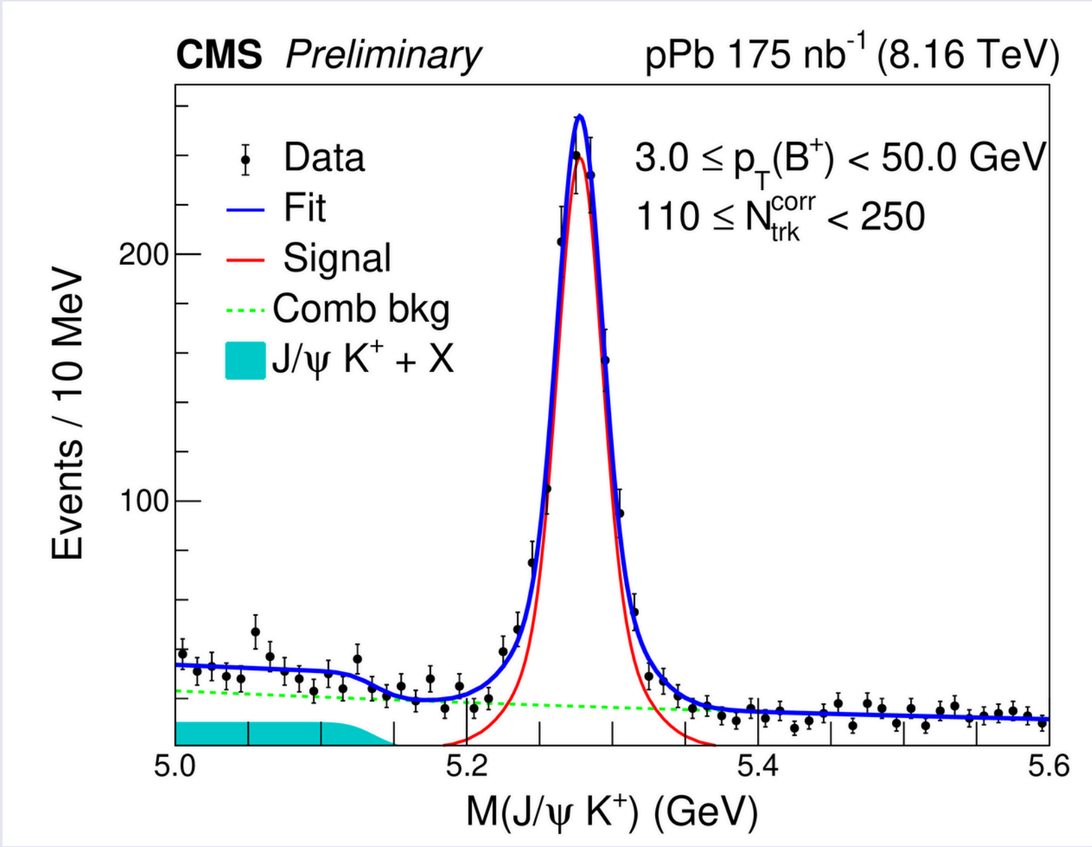

- B+ yields are obtained by unbinned maximum likelihood.
- Signal modeled by: double-gaussian; backgroud by: error function and exponential.
- Results are obtained for 6 pT bins and 4 multiplicity classes.

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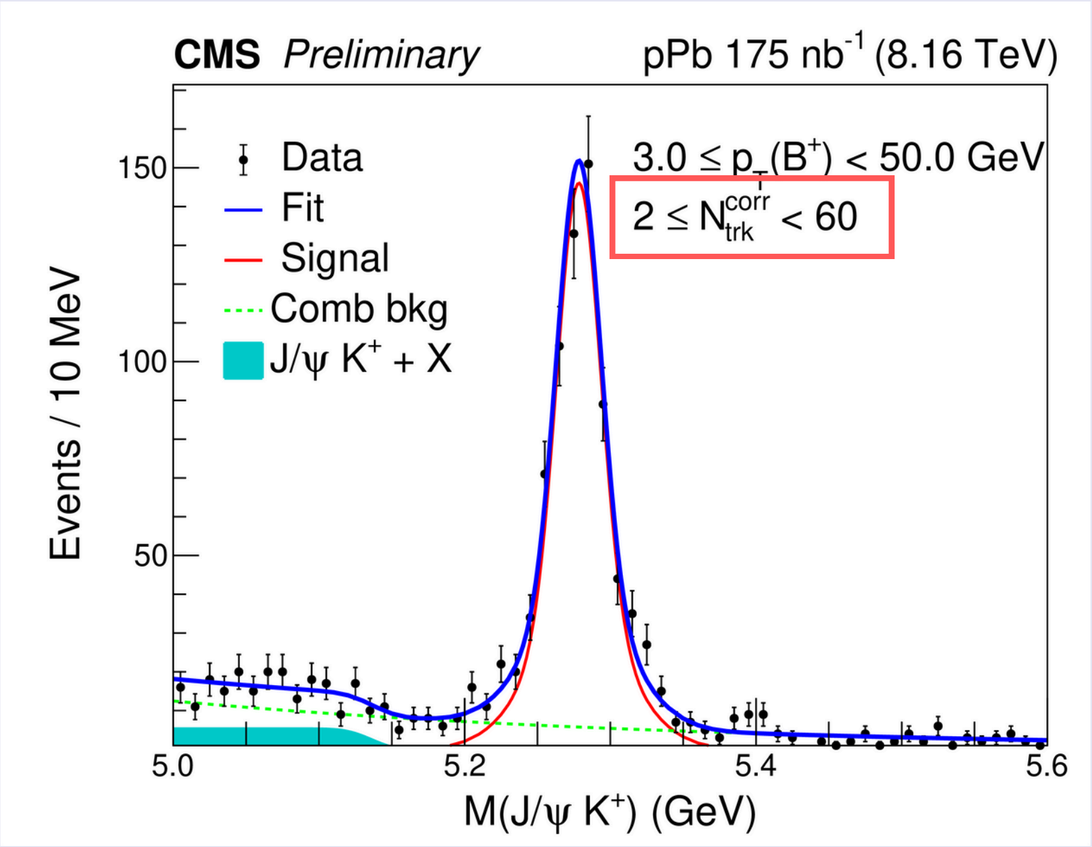

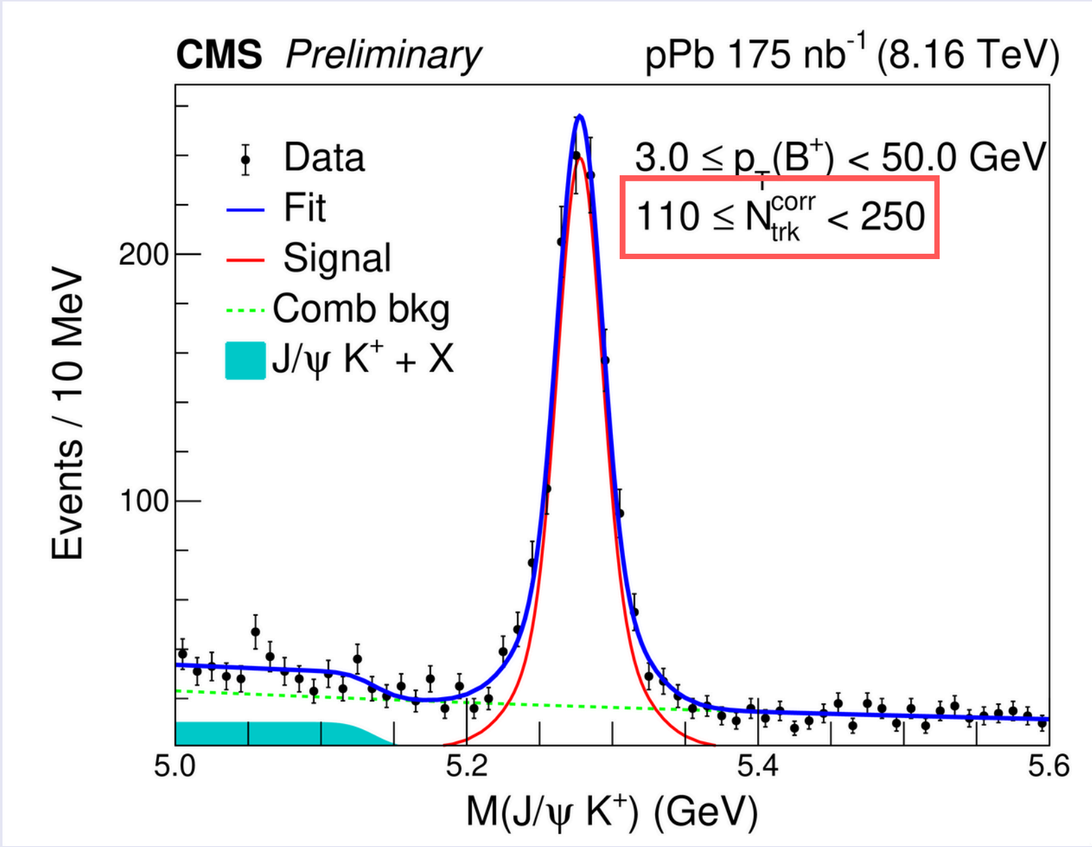

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Monte Carlo and Efficiency

Monte Carlo

- MC samples with PYTHIA, EVTGEN, PHOTOS, EPOS and GEANT 4.
- Correction with tag and probe scale factors derived from efficiency ratio between the data and the MC in J/ψ analysis for each muon (RECO).
- Slightly discrepancies between data and MC in kinematic distributions. Corrected with reweighting (RECO).

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Total Efficiency

$$\epsilon = A \times \epsilon_R$$

Acceptance A

Number of events passing the so called pre-filtercuts is divided by the number of events generated.

Reconstruction Efficiency ϵ_R

Number of reconstructed events after the full selection divided with respect to the number of generated b decays.

Differential cross section

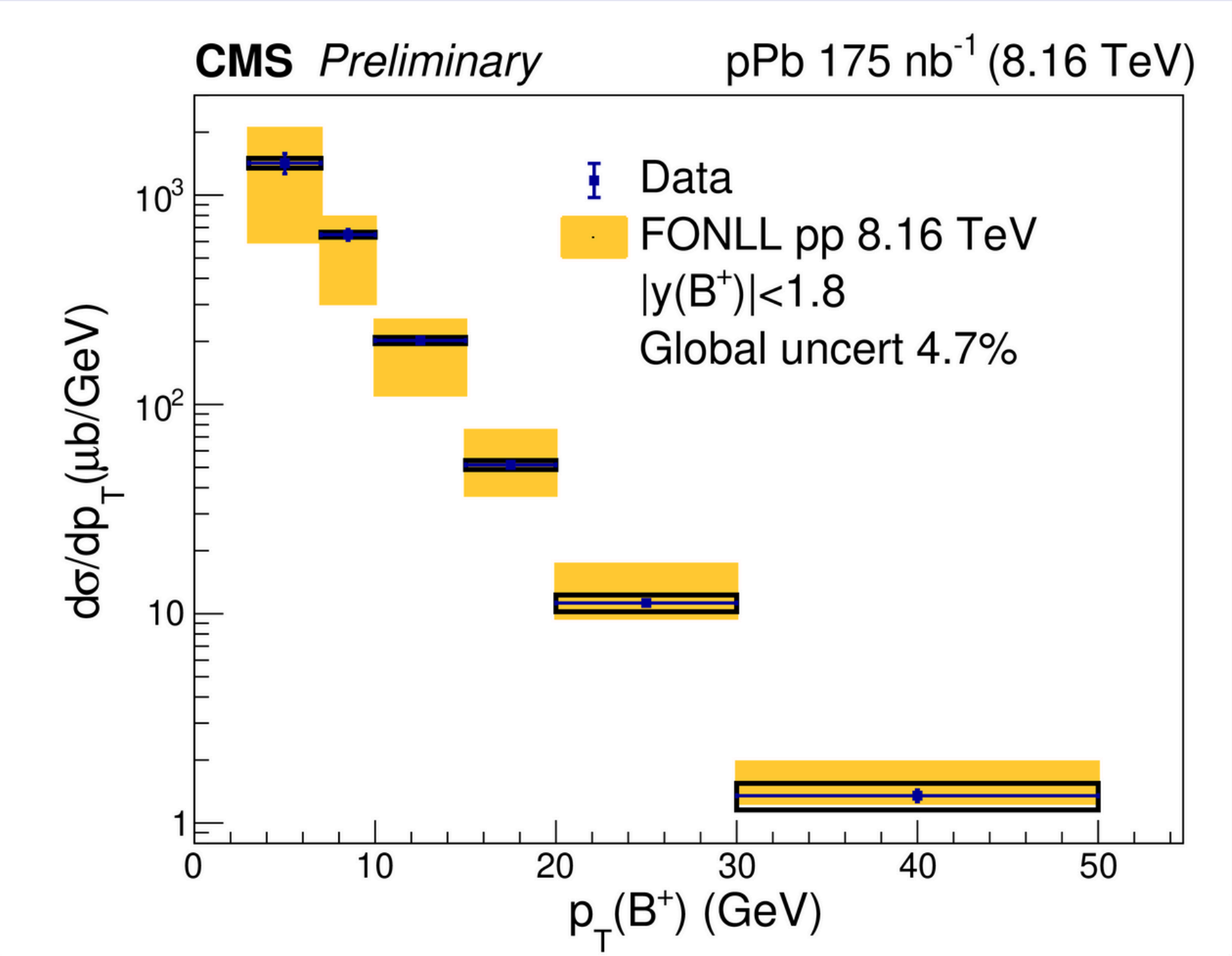
CMS-PAS-HIN-22-001

$$\frac{\mathrm{d}\sigma}{\mathrm{d}p_{\mathrm{T}}} = \frac{1}{2}\frac{1}{\Delta p_{\mathrm{T}}}\frac{N(p_{\mathrm{T}})}{\epsilon\,\mathcal{B}\mathcal{L}}$$

- $N(p_{\mathrm{T}})$ is the measured yield.
- $\mathcal{B}$ product world-average branching fractions.
- ϵ is the total efficiency.
- $\mathcal{L}$ is the integrated luminosity.

Differential cross section

CMS-PAS-HIN-22-001



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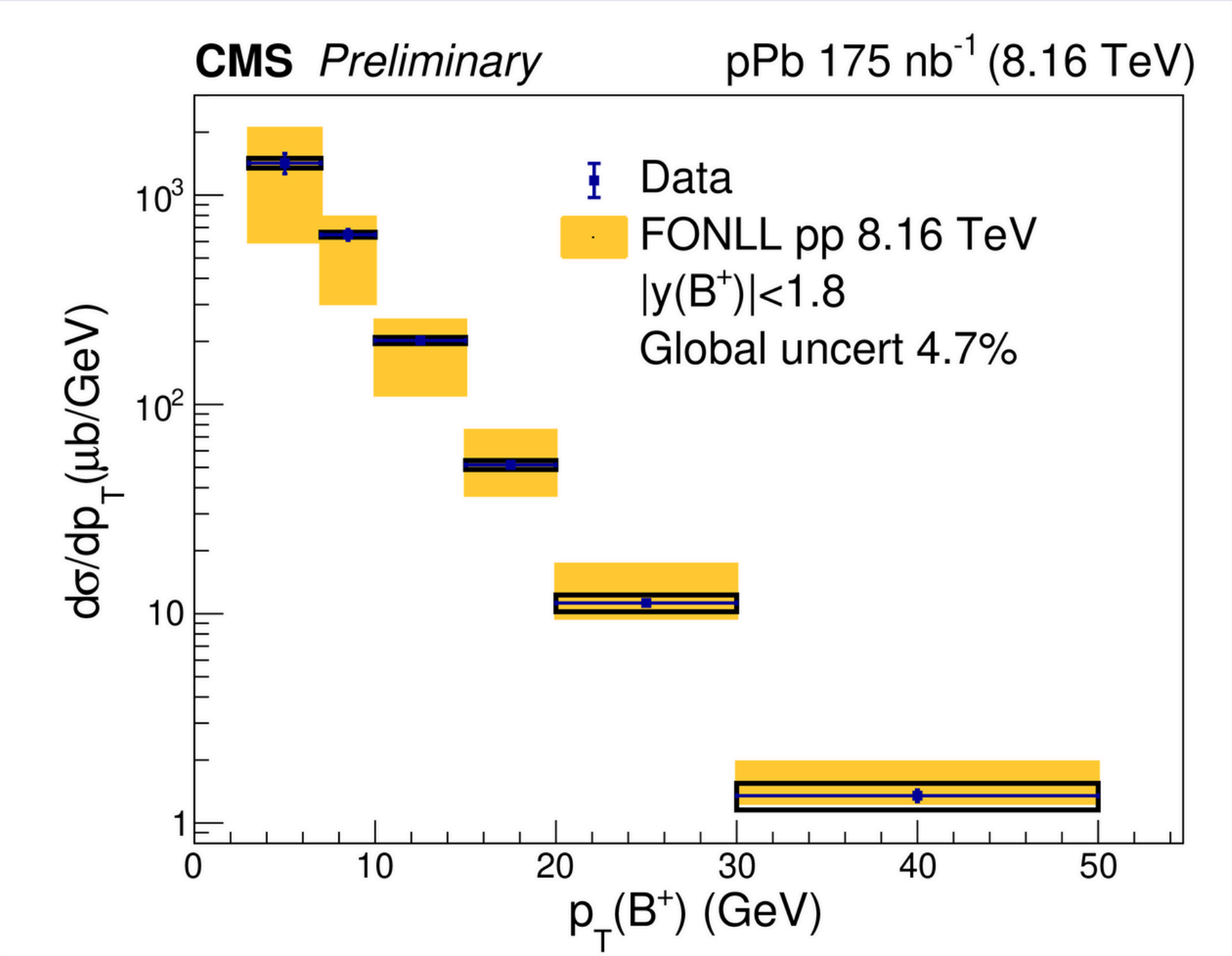

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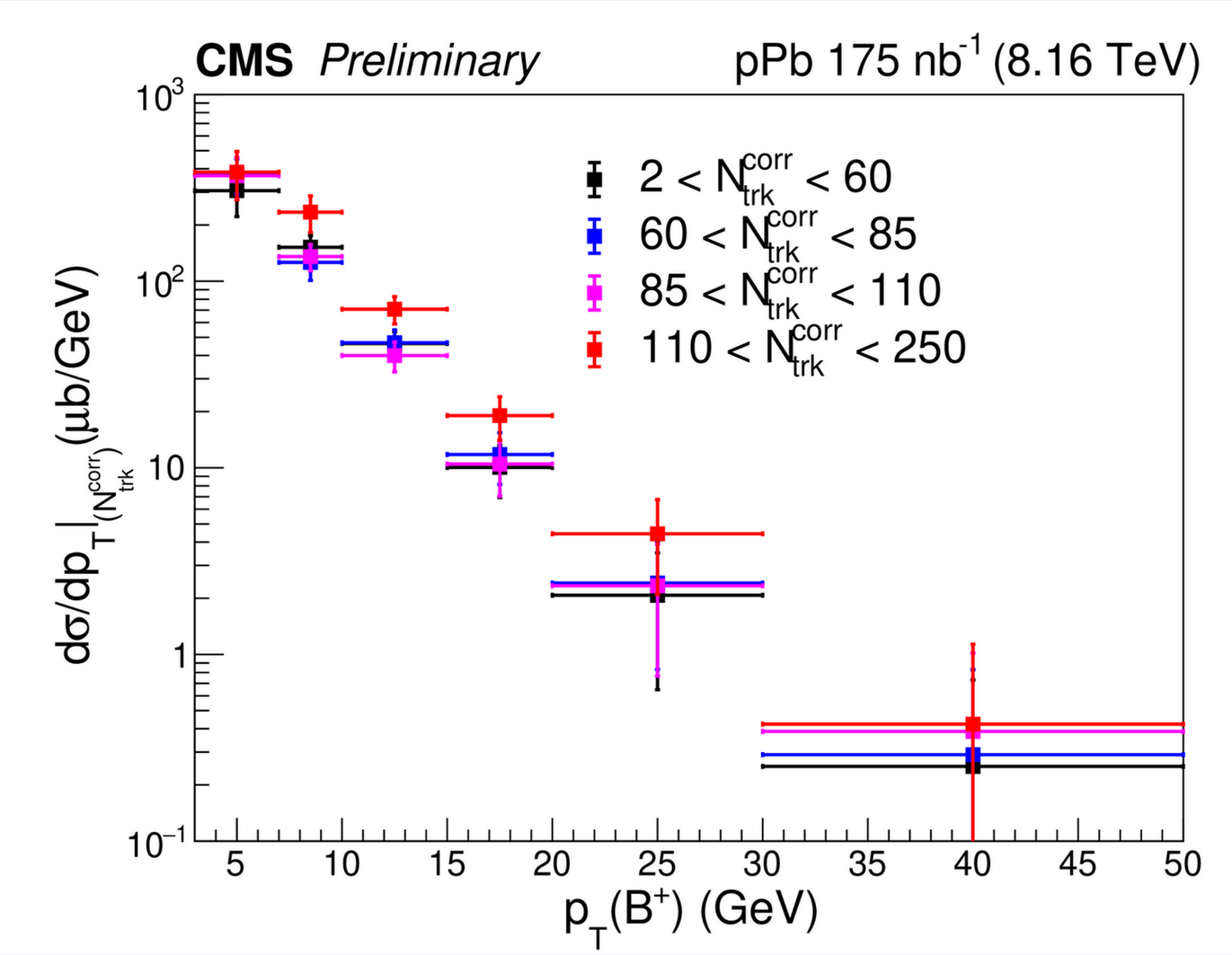
The theoretical predictions of FONLL are in good agreement with the measurements

B+ cross section in multiplicity clases

CMS-PAS-HIN-22-001



- Cross section vs. multiplicity.
- Total uncertainties are shown.

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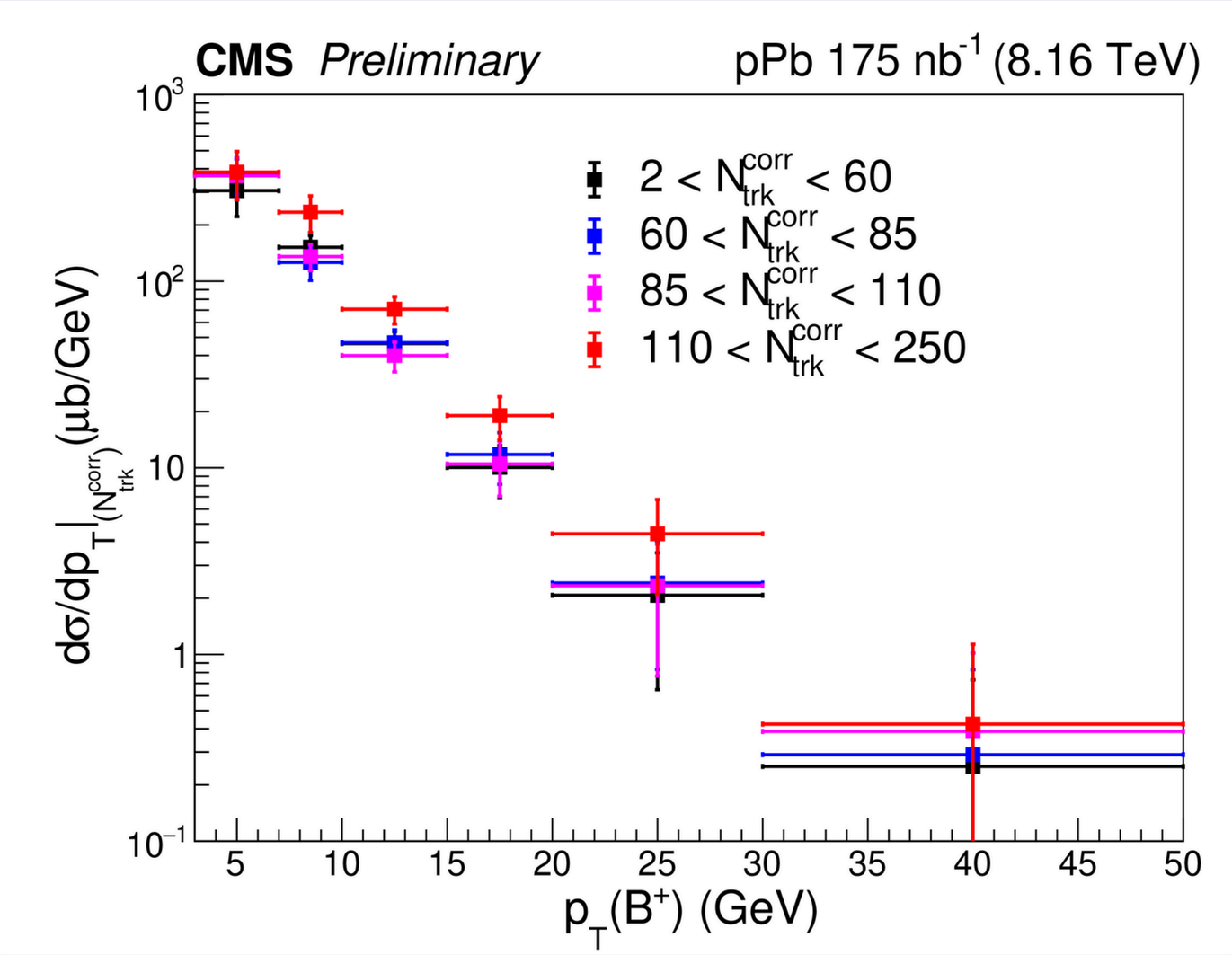

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For the first time in pPb collisions.

Conclusions and next steps

CMS-PAS-HIN-22-001

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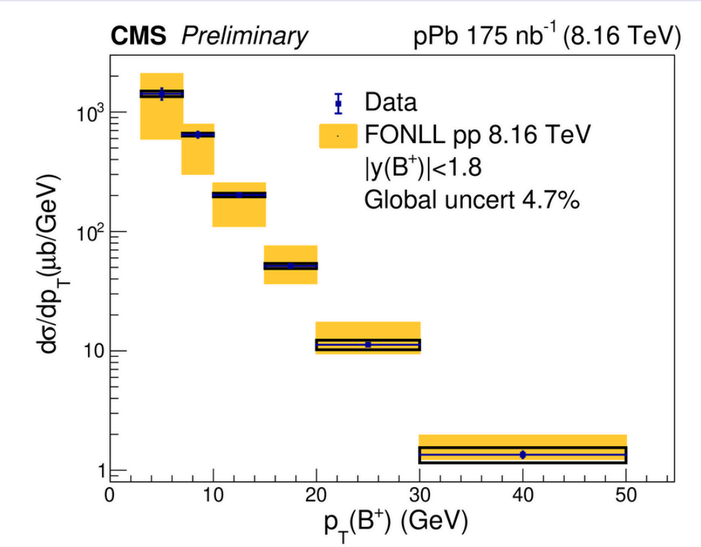
Conclusions

- B+ differential cross section measurement is in good agreement with the theoretical predictions.

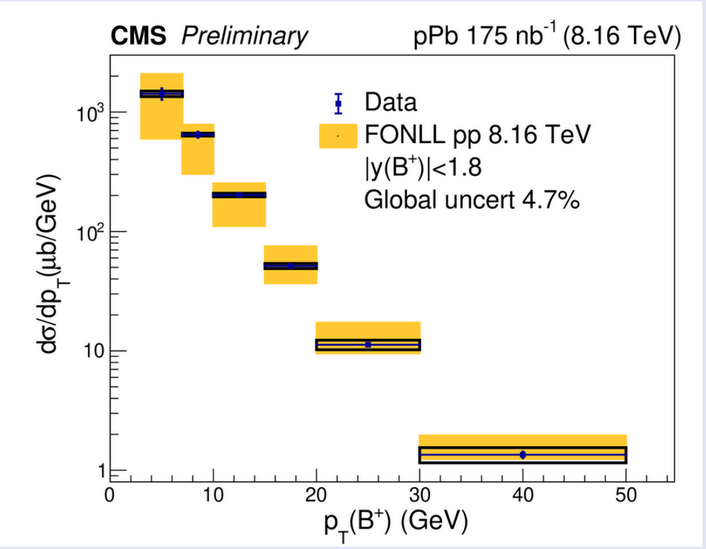


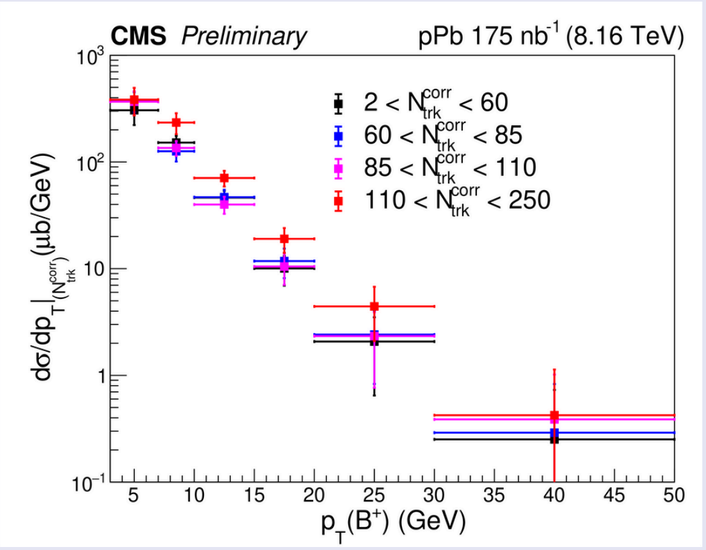
Conclusions and next steps

CMS-PAS-HIN-22-001

Conclusions

- B+ differential cross section measurement is in good agreement with the theoretical predictions.
- First measurement of B+ differential cross section in multiplicity classes in pPb collisions.





Conclusions and next steps

CMS-PAS-HIN-22-001

Conclusions

- B+ differential cross section measurement is in good agreement with the theoretical predictions.
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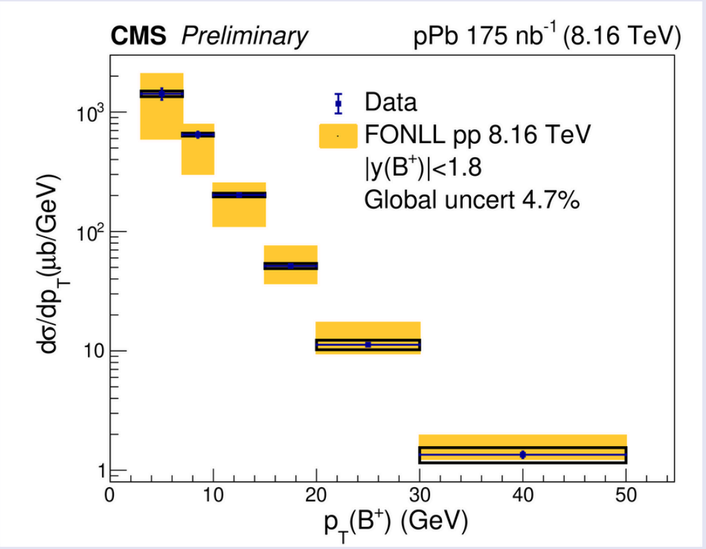
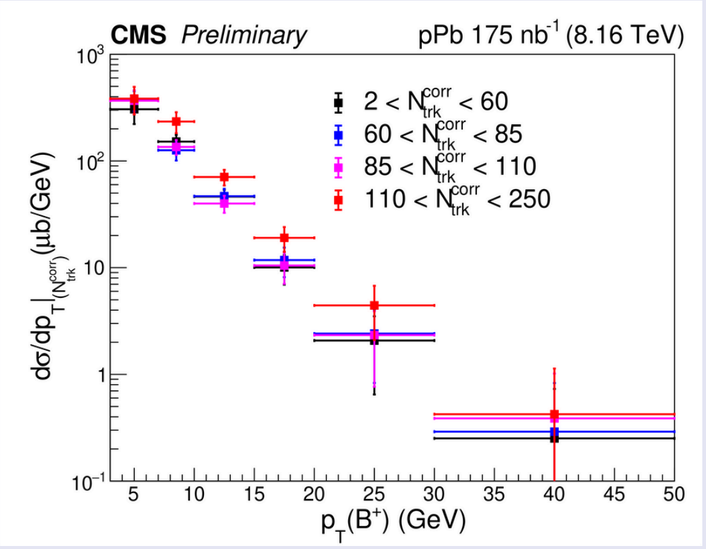
Next steps

- Studying the suppression via the ratios of Nuclear Modification Factors and multiplicity dependence.





Conclusions and next steps

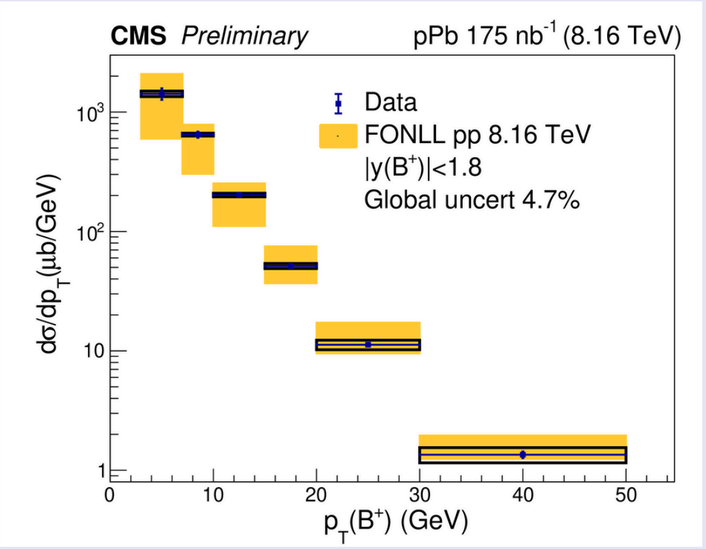
CMS-PAS-HIN-22-001

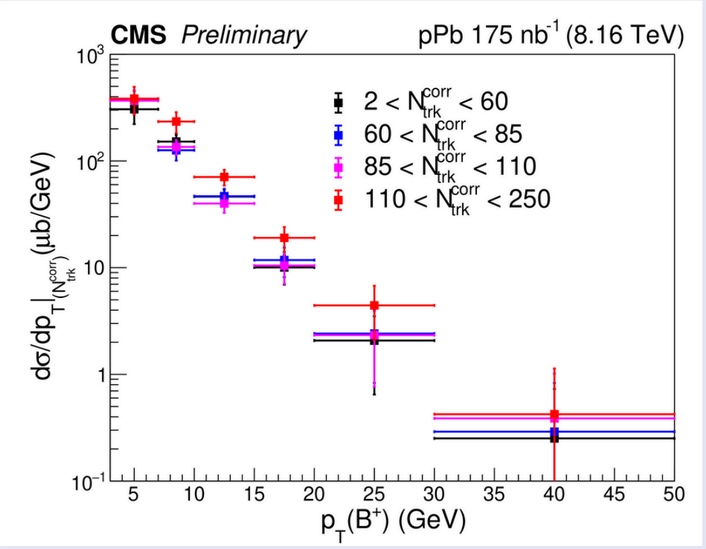
Conclusions

- B+ differential cross section measurement is in good agreement with the theoretical predictions.
- First measurement of B+ differential cross section in multiplicity classes in pPb collisions.

Next steps

- Studying the suppression via the ratios of Nuclear Modification Factors and multiplicity dependence.
- Publishing the article in next weeks with these results: **We are in the Final Reading!**





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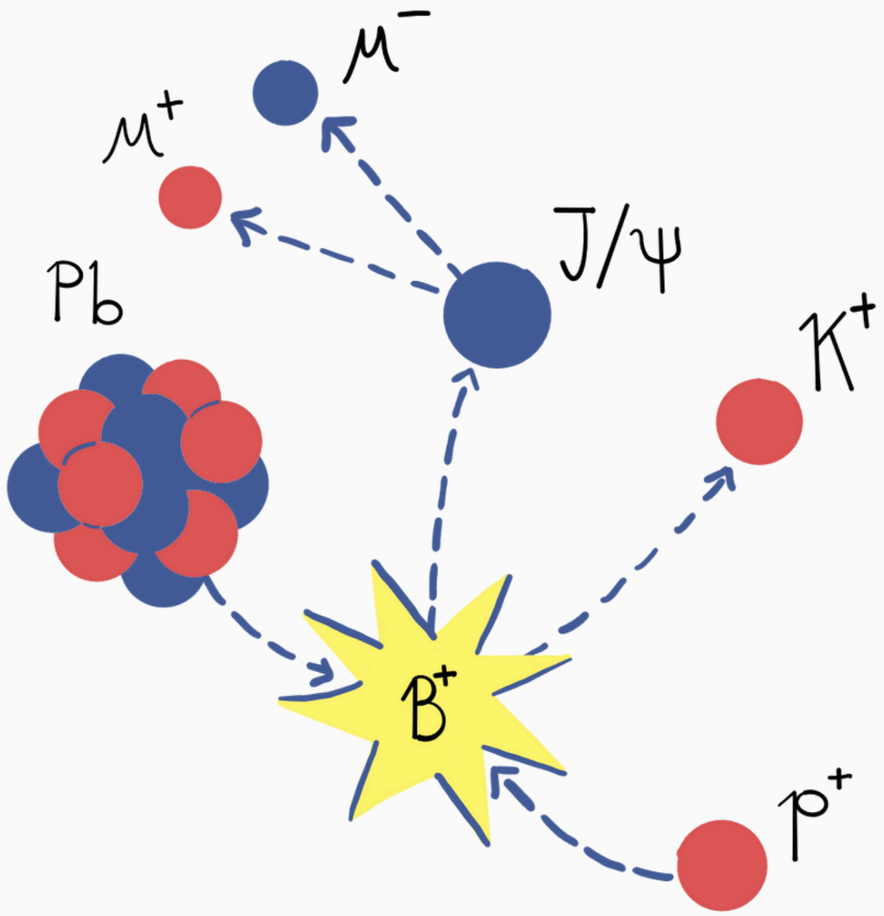

Thanks for listening!

Back-up

Summary table of differential cross sections of B+ in pPb

pt (GeV)	$\mathrm{d}\sigma/\mathrm{d}p_{\mathrm{T}}$ $(\mu b\ GeV^{-1})$	stat. error $(\mu b\ GeV^{-1})$	sys. error $(\mu b\ GeV^{-1})$
3 – 7	1422.79	157.19	75.82
7 – 10	647.10	38.61	17.67
10 – 15	202.10	7.24	7.04
15 – 20	51.41	2.02	2.54
20 – 30	11.25	0.47	1.03
30 – 50	1.35	0.09	0.20