



Data-driven measurements of the total beauty production in pp, p–Pb, Pb–Pb collisions at the LHC

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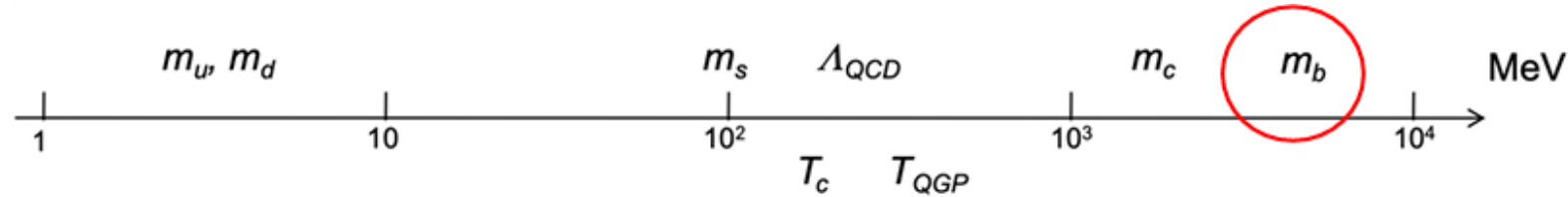
2026年7月16日 广州

Outline

- Introduction and motivation
- The Bayesian unfolding method
- Results and discussions
- Summary

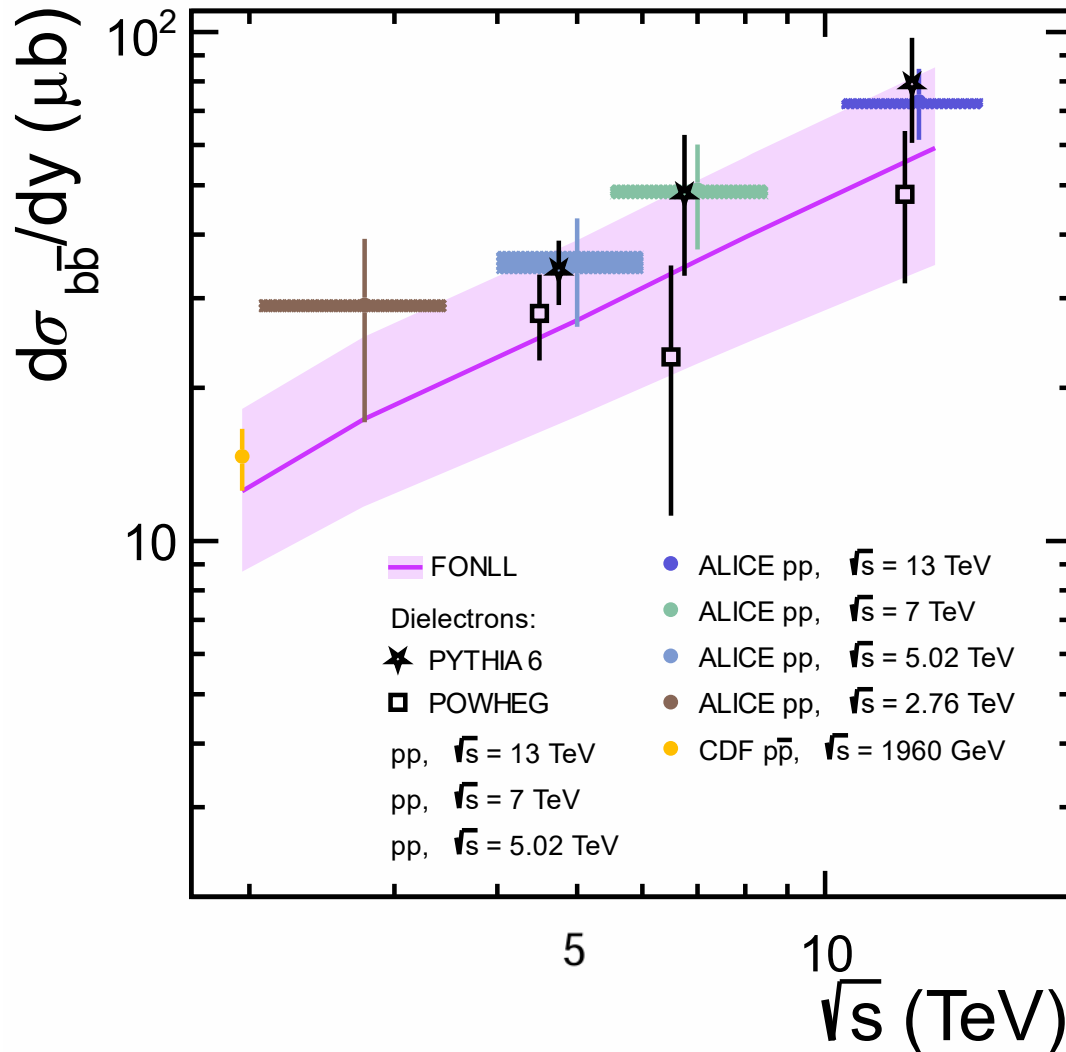
Introduction and motivation

- Heavy quark mass $\gg \Lambda_{\text{QCD}} \gg$ light quark mass



- Heavy quarks are predominantly produced via initial hard scatterings, their production cross section can be evaluated by pQCD in pp collisions.
- Heavy quarks experience the full evolution of the system. Their production cross section in pp collisions can provide a reference for studying the nuclear medium effects and the properties of the QGP in heavy-ion collisions. In p-Pb and Pb-Pb collisions, heavy quarks serve as excellent probes to study cold nuclear matter effects and hot nuclear matter effects respectively.

Introduction and motivation

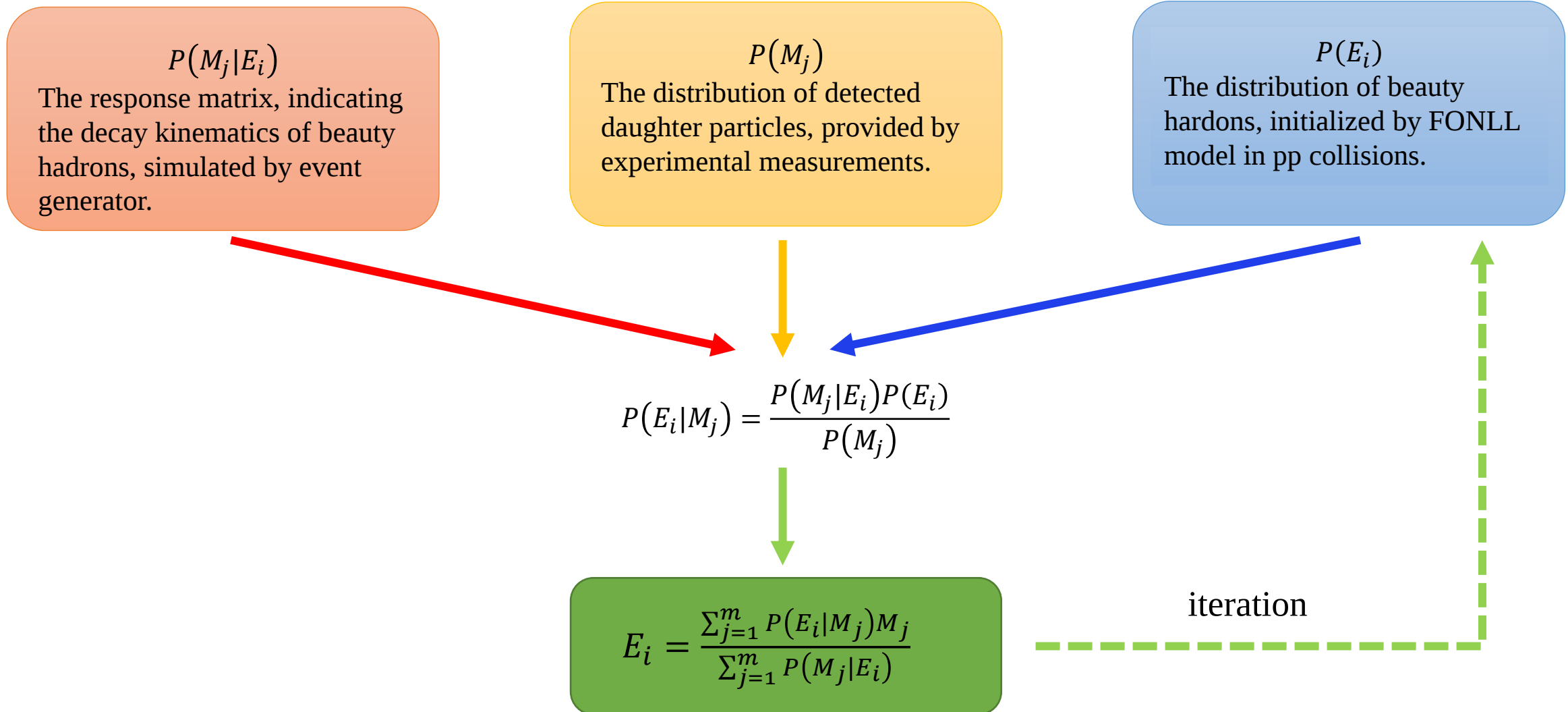


- Both experiments and models are with large uncertainties.
- The small decay branching ratio and production cross section make it difficult to measure $b\bar{b}$ cross section.
- The Bayesian unfolding approach can be used for recovering the full beauty information based on the measured non-prompt D^0 and J/ψ .

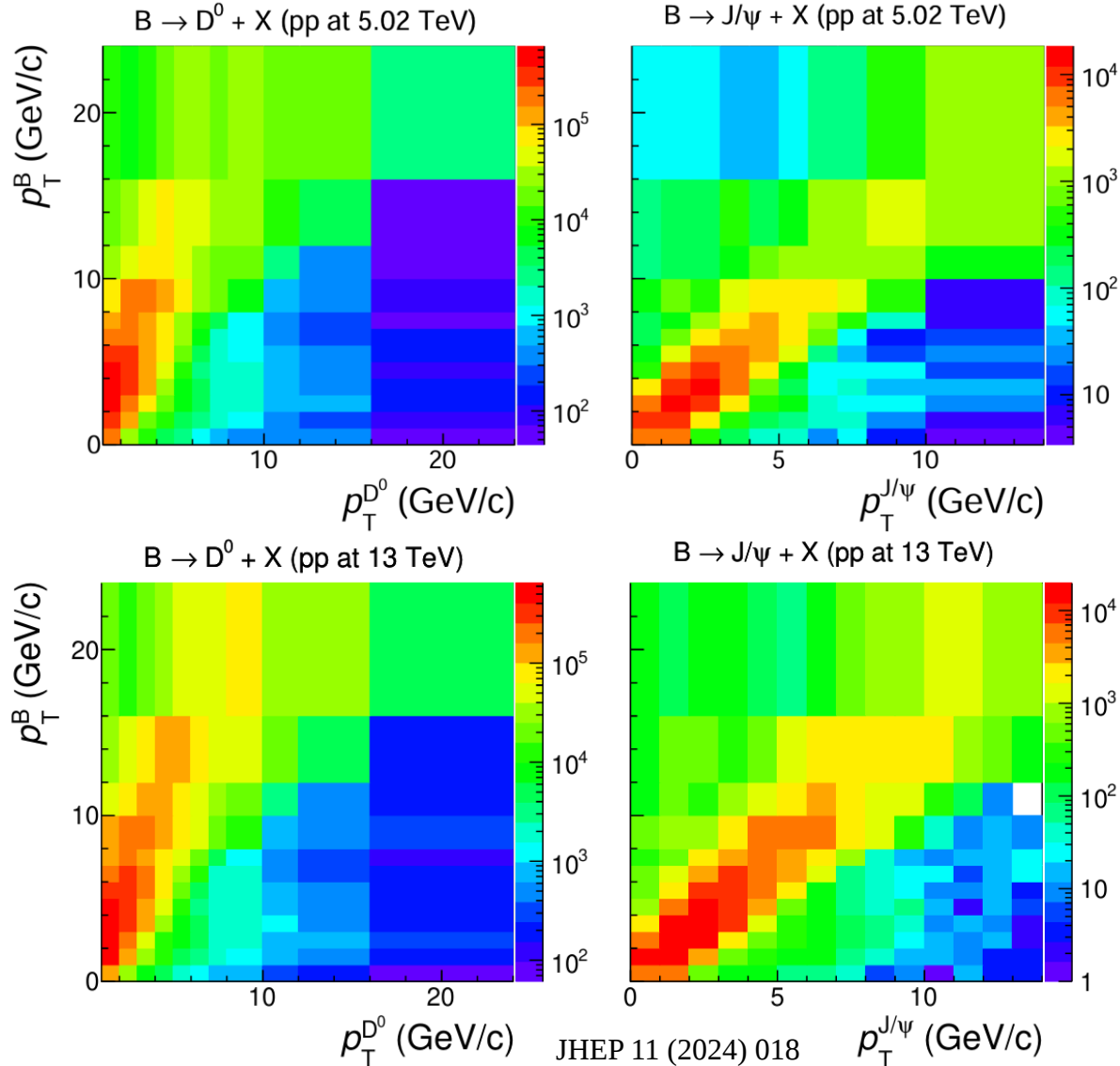
JHEP 05 (2021) 220
 JHEP 03 (2022) 190
 PRC 102 (2020) 005204
 JHEP 09 (2007) 126

PLB 721 (2013) 13-23
 PLB 738 (2014) 97-108
 PRD 71 (2005) 032001

The Bayesian unfolding method



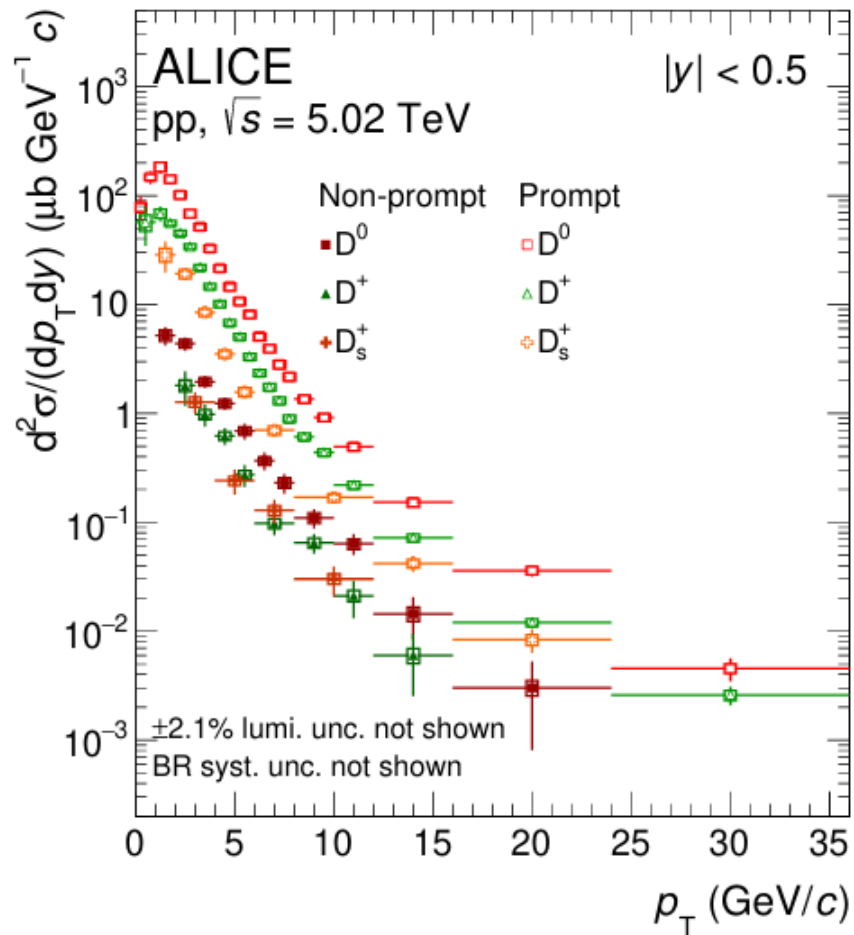
Illustrators of response matrices



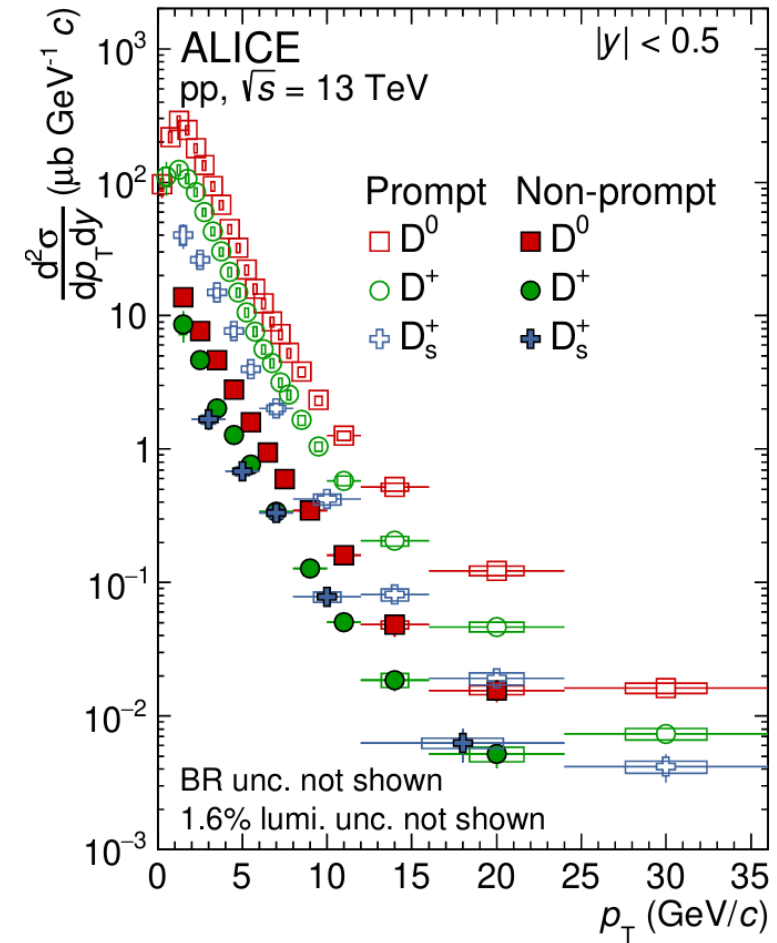
- Event generator: PYTHIA 8.3 (generate beauty hadrons) + EvtGen (simulate the decay of beauty hadrons)
- Illustrators of the beauty hadrons as a function of the non-prompt D^0 (left) and J/ψ (right) in pp collisions at $\sqrt{s} = 5.02$ TeV and 13 TeV.

Input distributions of daughter particles

➤ Mid-rapidity non-prompt D^0 from ALICE



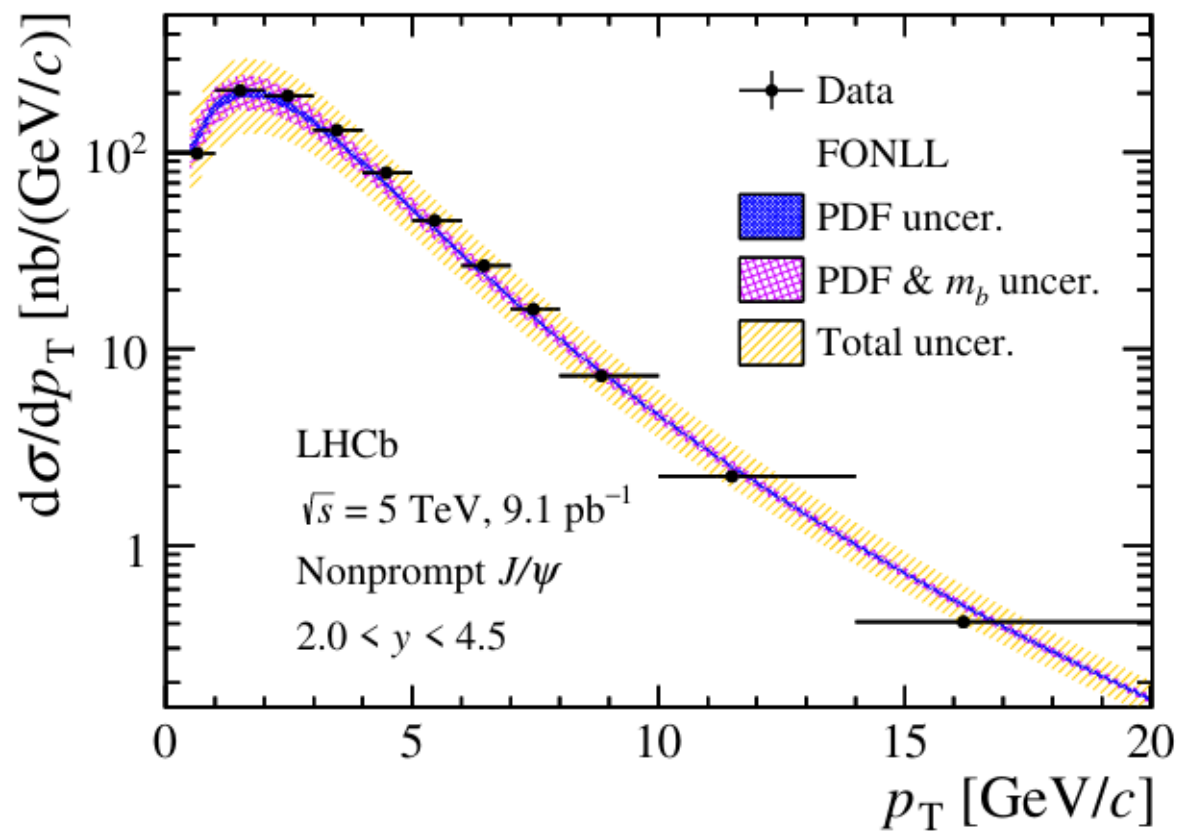
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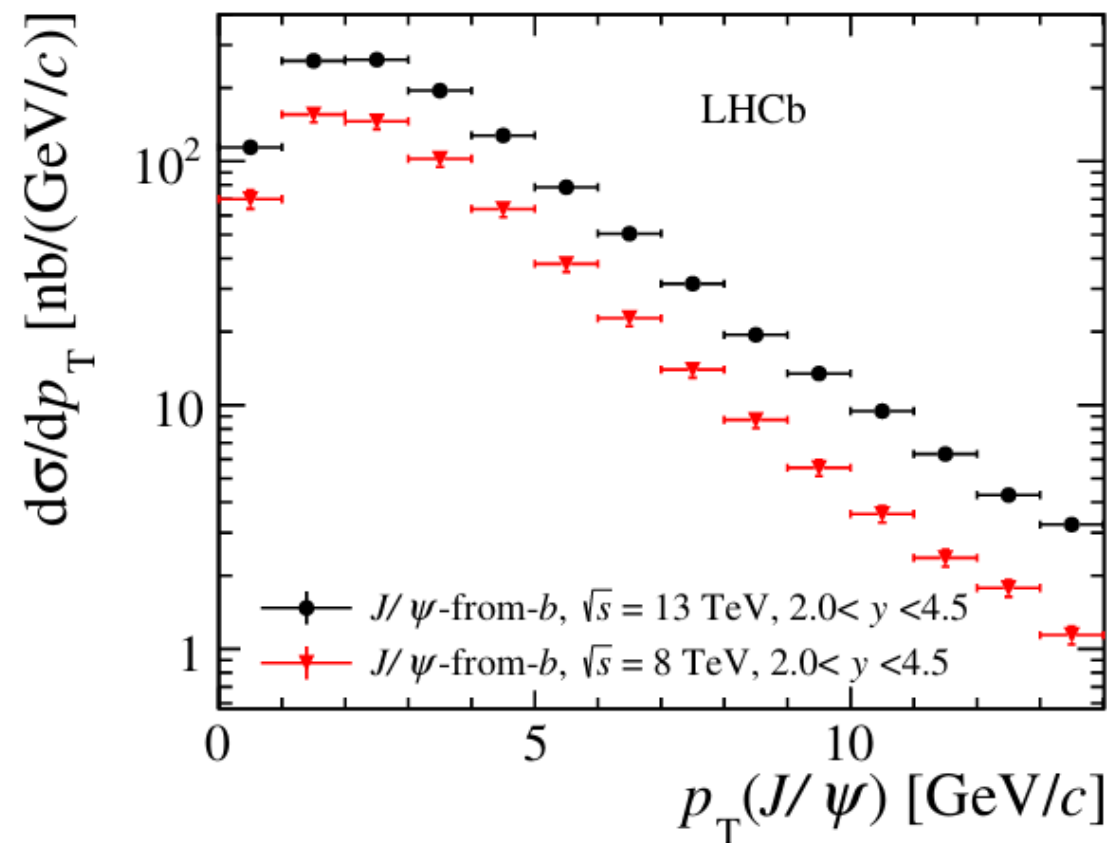
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Input distributions of daughter particles

➤ Forward non-prompt J/ψ from LHCb

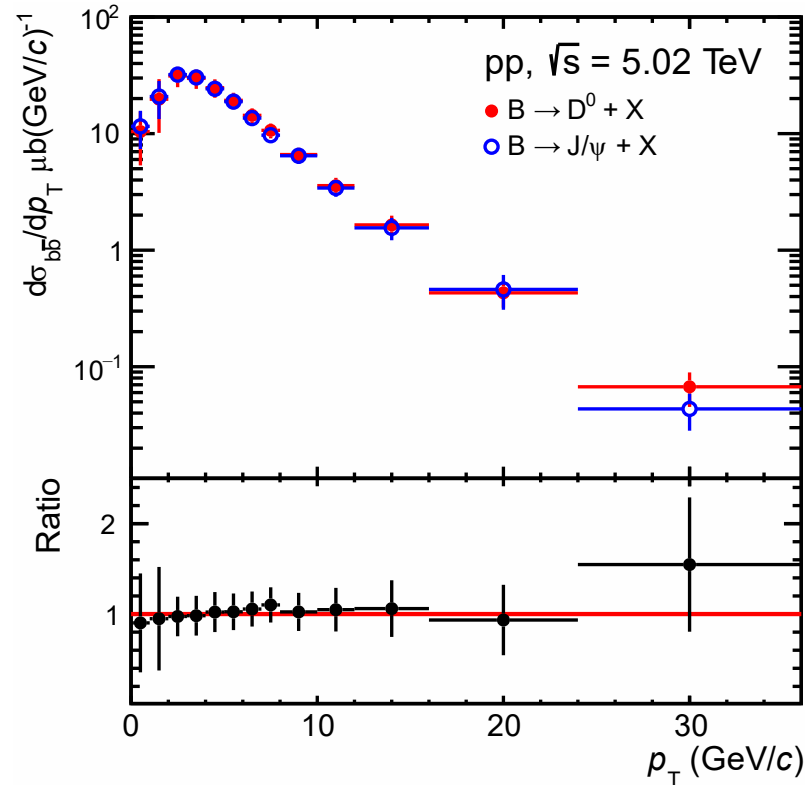


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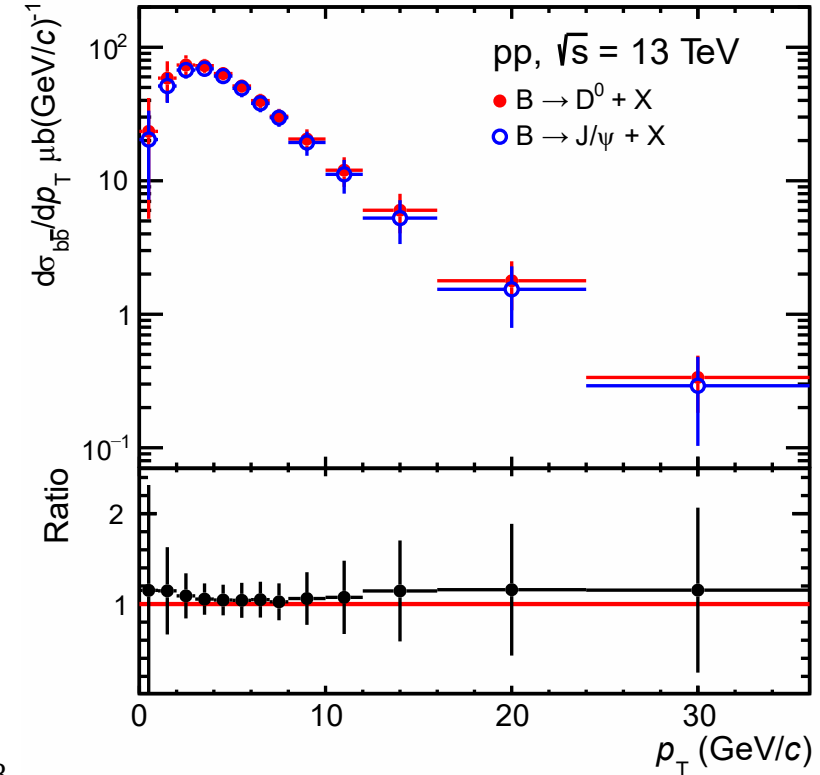


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$b\bar{b}$ production cross section in pp collisions

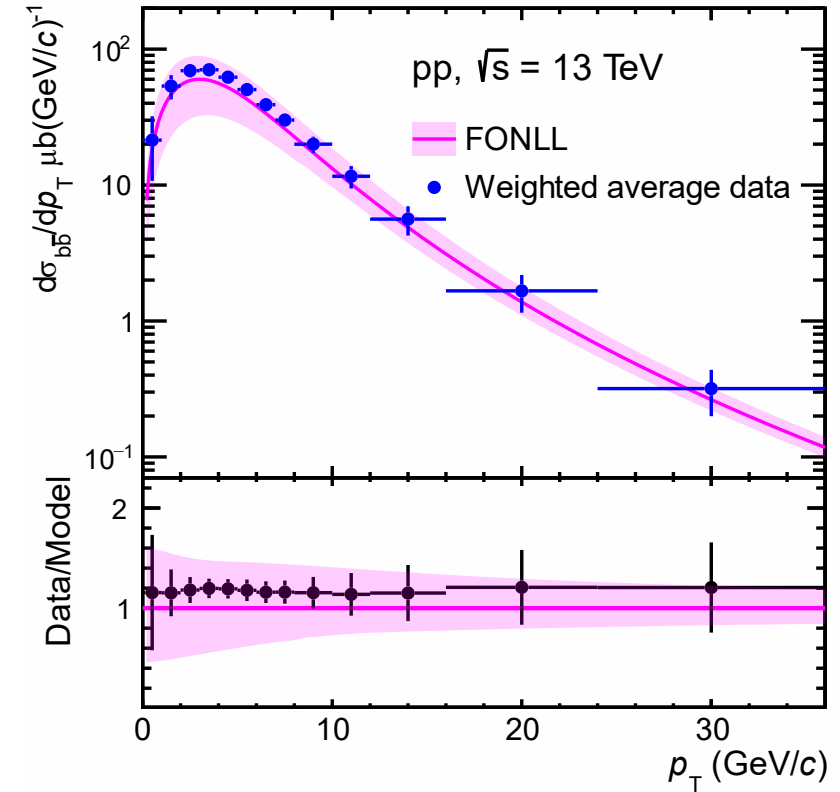
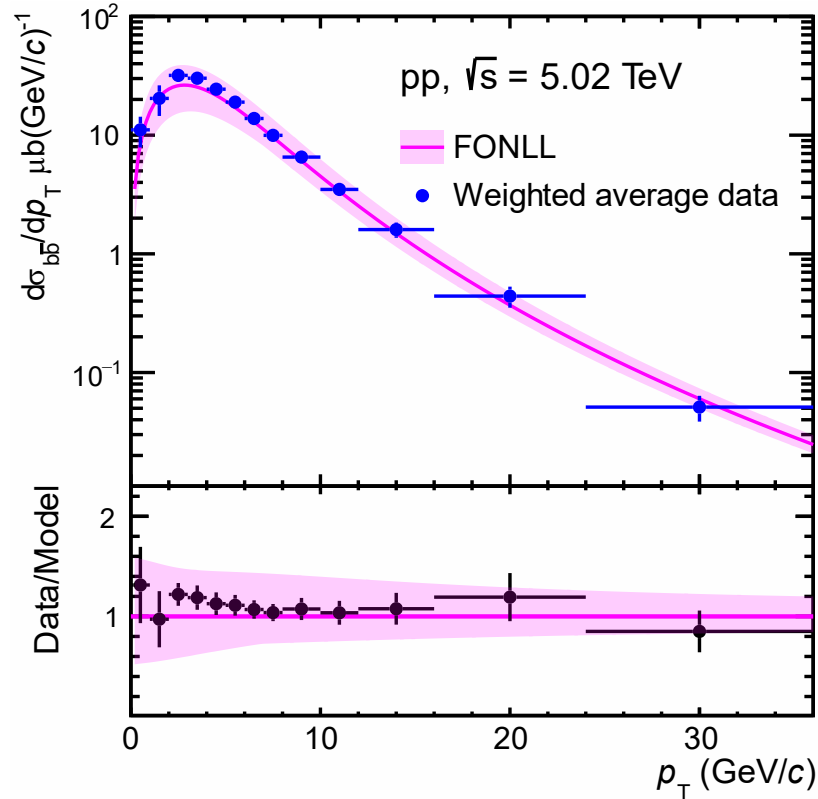


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- The unfolded open beauty production cross section as a function of p_T in pp collisions at $\sqrt{s} = 5.02$ TeV (left) and 13 TeV (right).
- The results derived from ALICE non-prompt D^0 and LHCb non-prompt J/ψ decay channel are perfectly consistent within their uncertainties, although they are from very different measured rapidity coverage and decay kinematics.

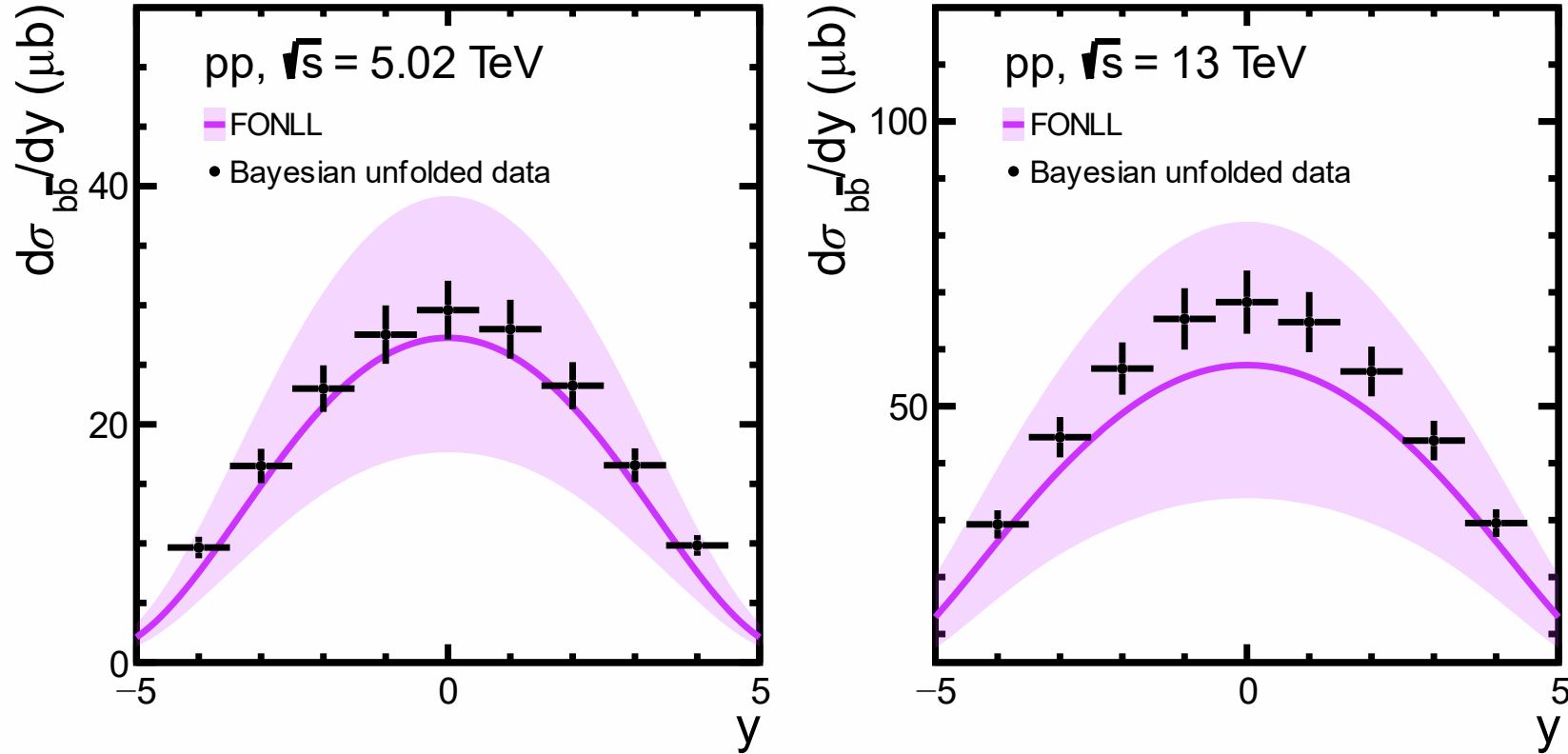
Weight-averaged $b\bar{b}$ production cross section in pp collisions



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- Weight-averaged open beauty production cross section from the individual non-prompt measurements can be described by the FONLL calculations at 5.02 TeV (left) and 13 TeV (right).
- The inversed quadratic of the uncertainties are used as the weight factor in the averaged value evaluation.

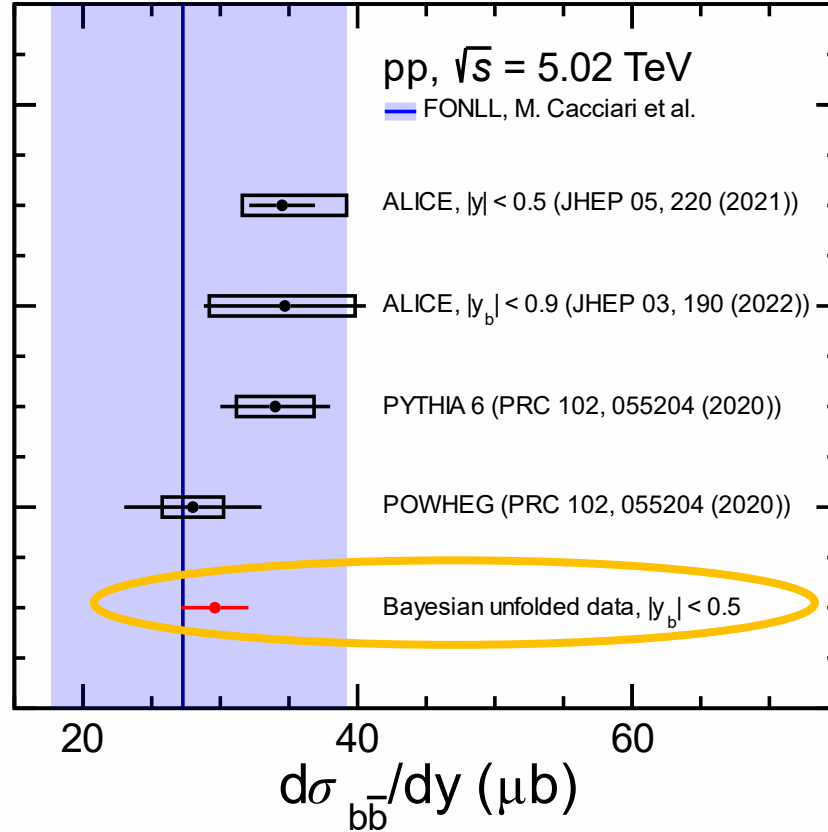
$b\bar{b}$ production cross section vs. rapidity in pp collisions



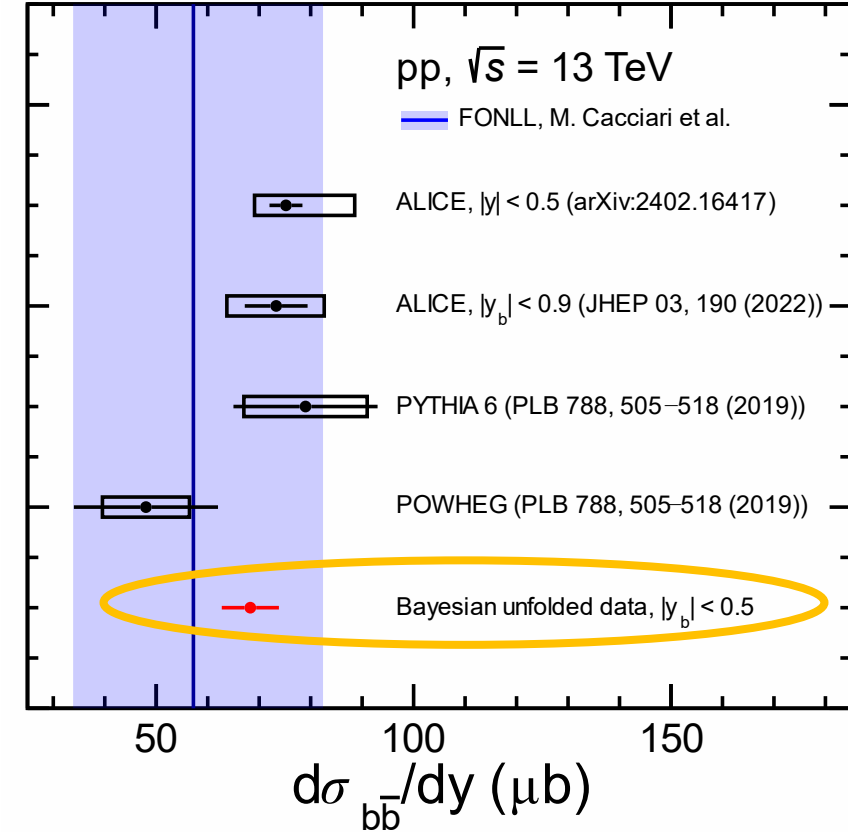
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- Measurements of p_T -integrated $b\bar{b}$ production cross section at large rapidity for the first time.
- The p_T -integrated $b\bar{b}$ production cross section as a function of the rapidity in pp collision at $\sqrt{s} = 5.02 \text{ TeV}$ (left) and 13 TeV (right) , consistent with FONLL model in wide rapidity range.

Total $b\bar{b}$ production cross section in pp collisions

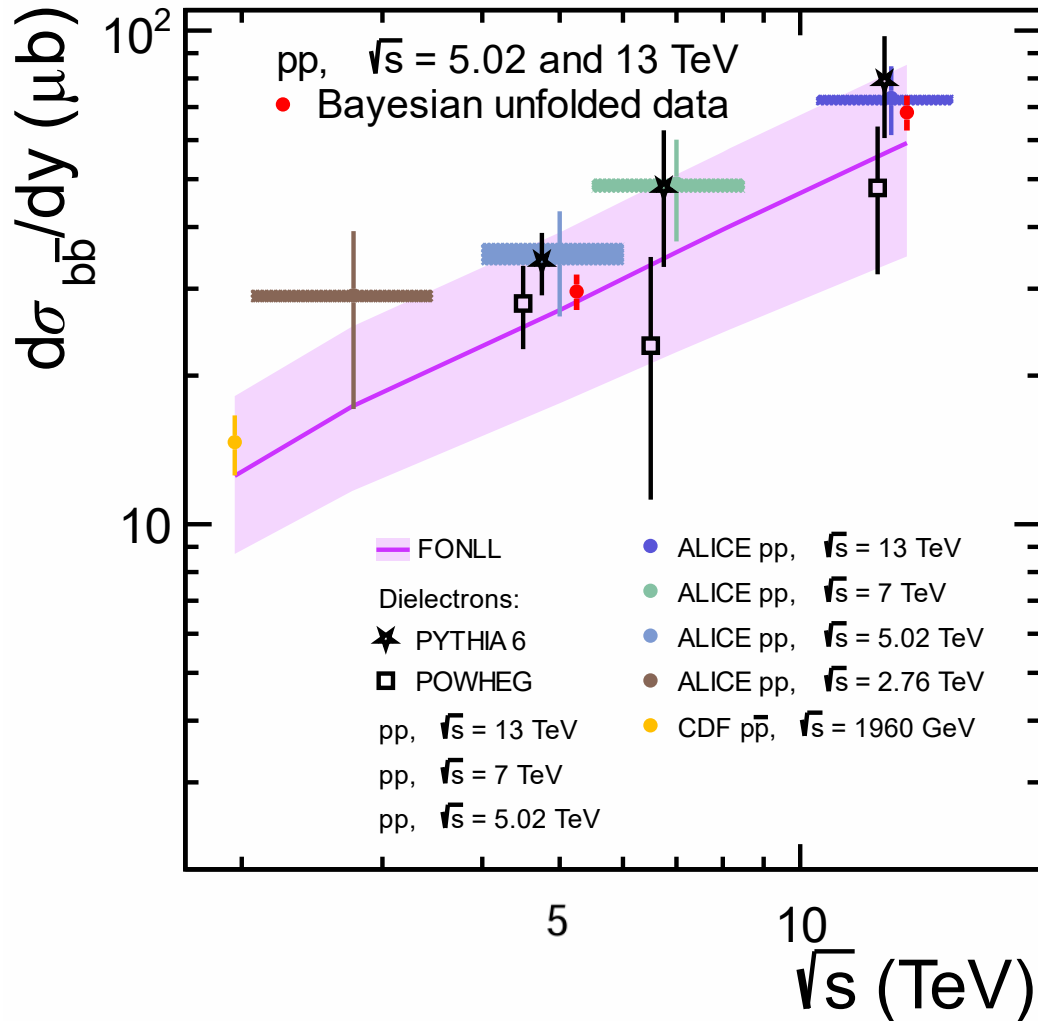


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- Total $b\bar{b}$ production cross section at mid-rapidity consistent with ALICE measurements and PYTHIA or POWHEG simulations.

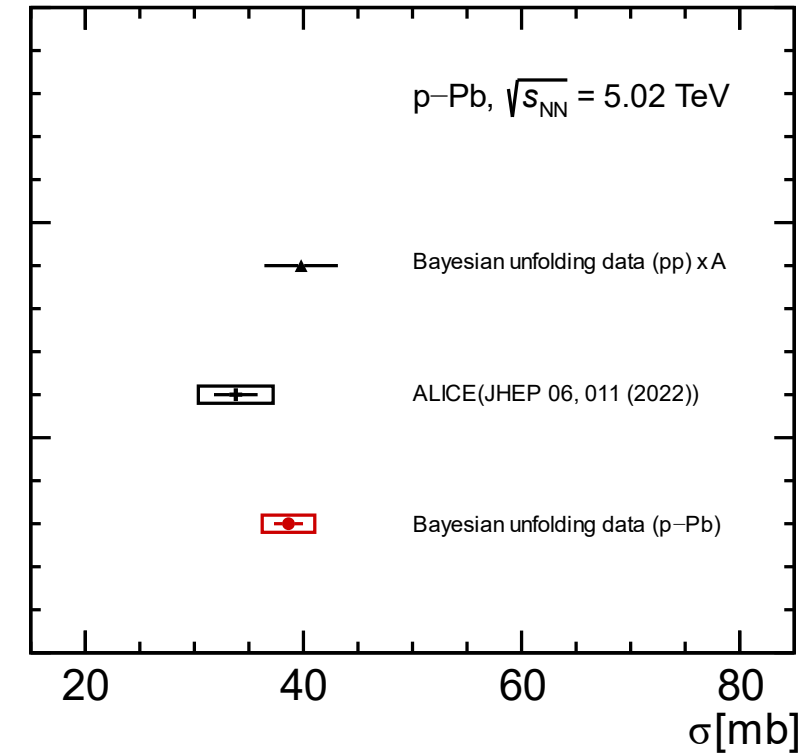
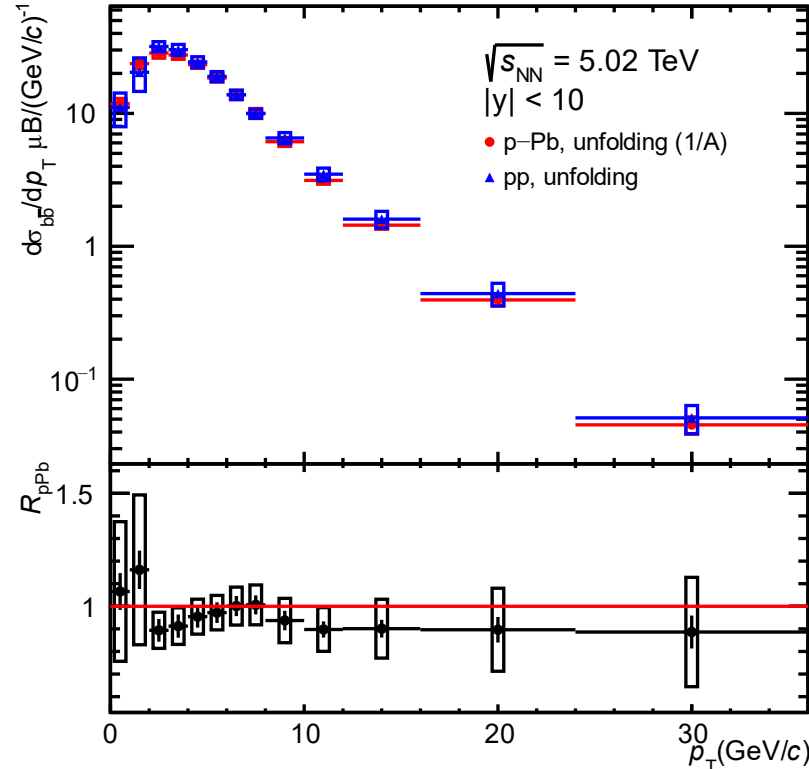
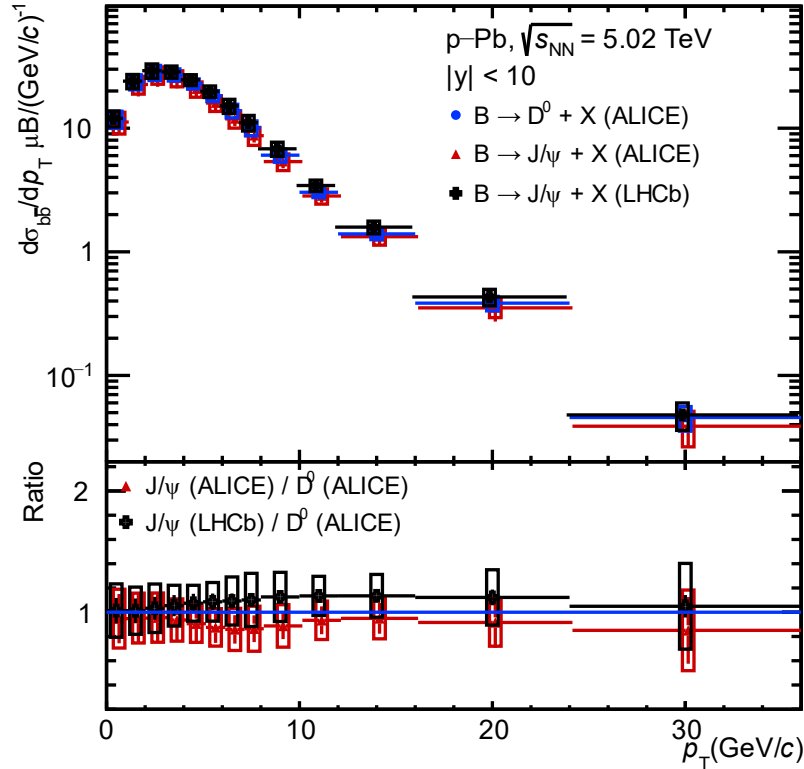
Total $b\bar{b}$ production cross sections vs. beam energy in pp collisions



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- Total $b\bar{b}$ production cross section at $\sqrt{s} = 5.02$ TeV and 13 TeV are obtained and shown as a function of center of mass energy.
- The precision of new results significantly improve compared to the previous published results from the individual measurements, providing constraints to theoretical calculations.

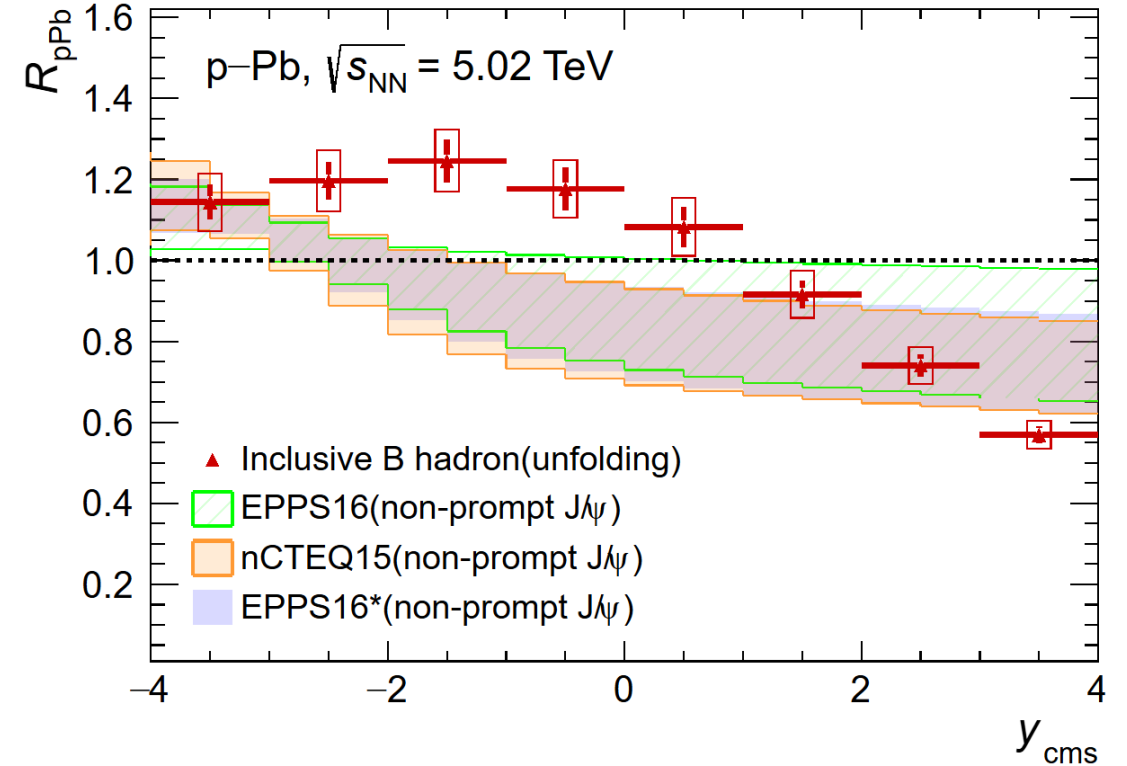
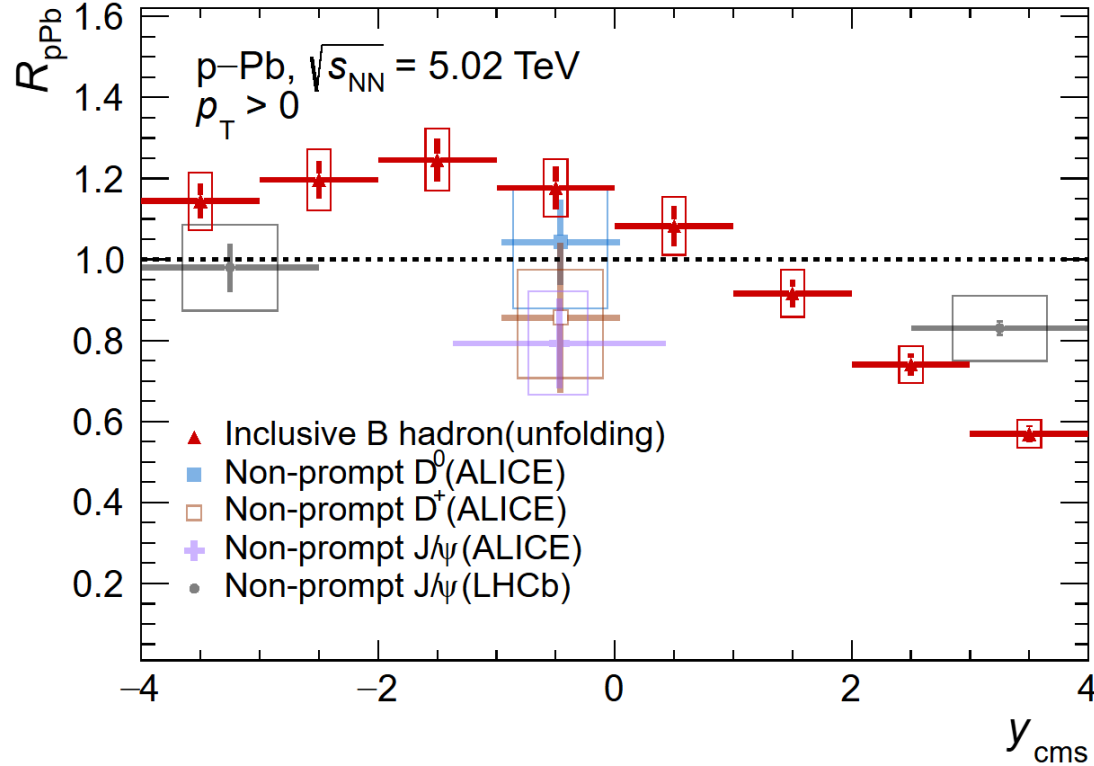
$b\bar{b}$ production cross sections in p-Pb collisions



- The results derived from non-prompt D^0 and non-prompt J/ψ are consistent within uncertainties.
- The R_{pA} in p-Pb collisions is approximate to 1, indicating little QGP generation in p-Pb collisions.
- Total $b\bar{b}$ production cross section in p-Pb collisions shows consistence with the experiment measurement.

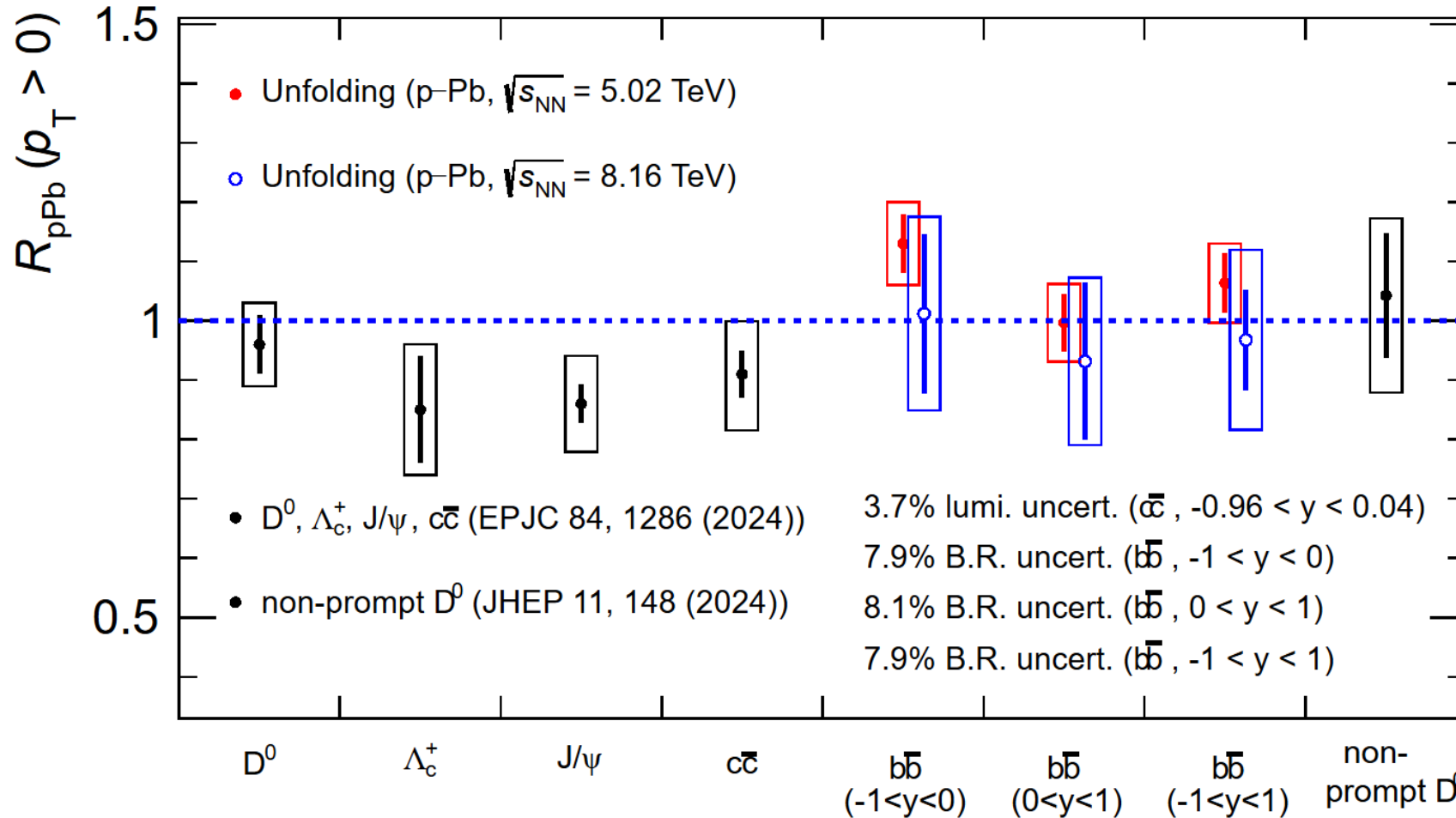
Paper draft under preparation

R_{pA} vs. rapidity in p-Pb collisions



- The R_{pA} is first extracted in large rapidity intervals, compared with R_{pA} of non-prompt D^0 , D^+ , J/ψ and model calculations. Suppression in the forward rapidity and enhancement in the backward rapidity are observed.

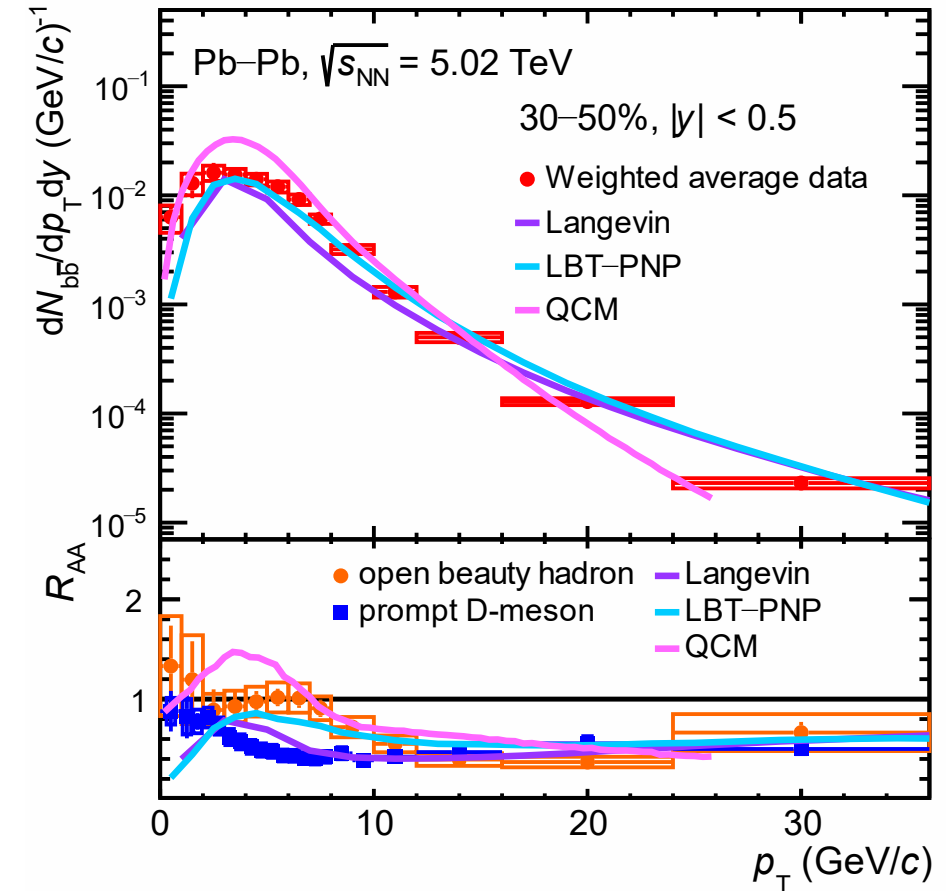
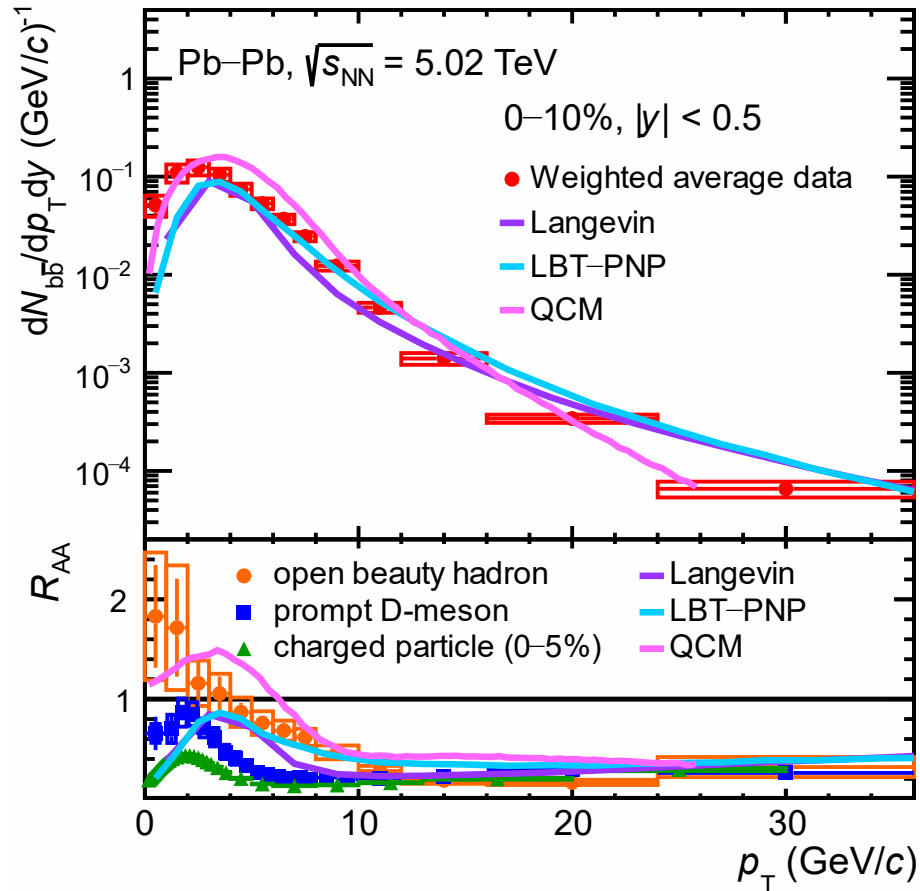
R_{pA} in p-Pb collisions



➤ The comparison of the r_{pA} of open beauty hadron and open charm hadron. Hint of different production mechanism of beauty quark and charm quark.

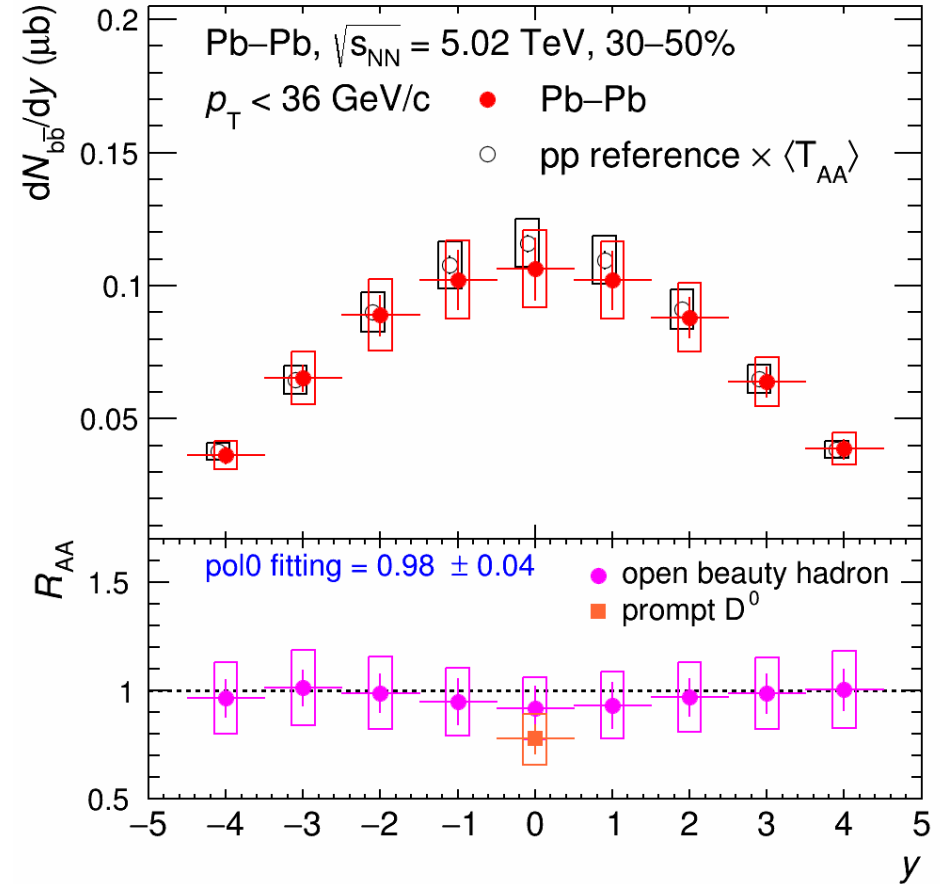
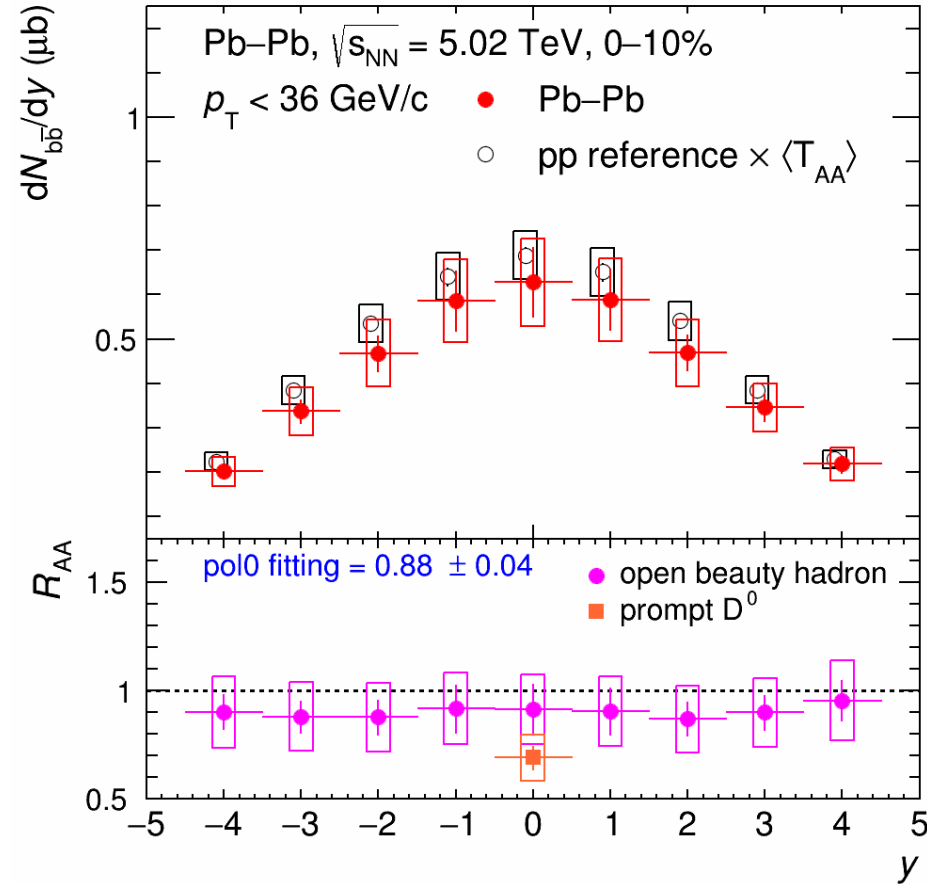
Paper draft under preparation

Weight-averaged $b\bar{b}$ production cross sections in Pb–Pb collisions



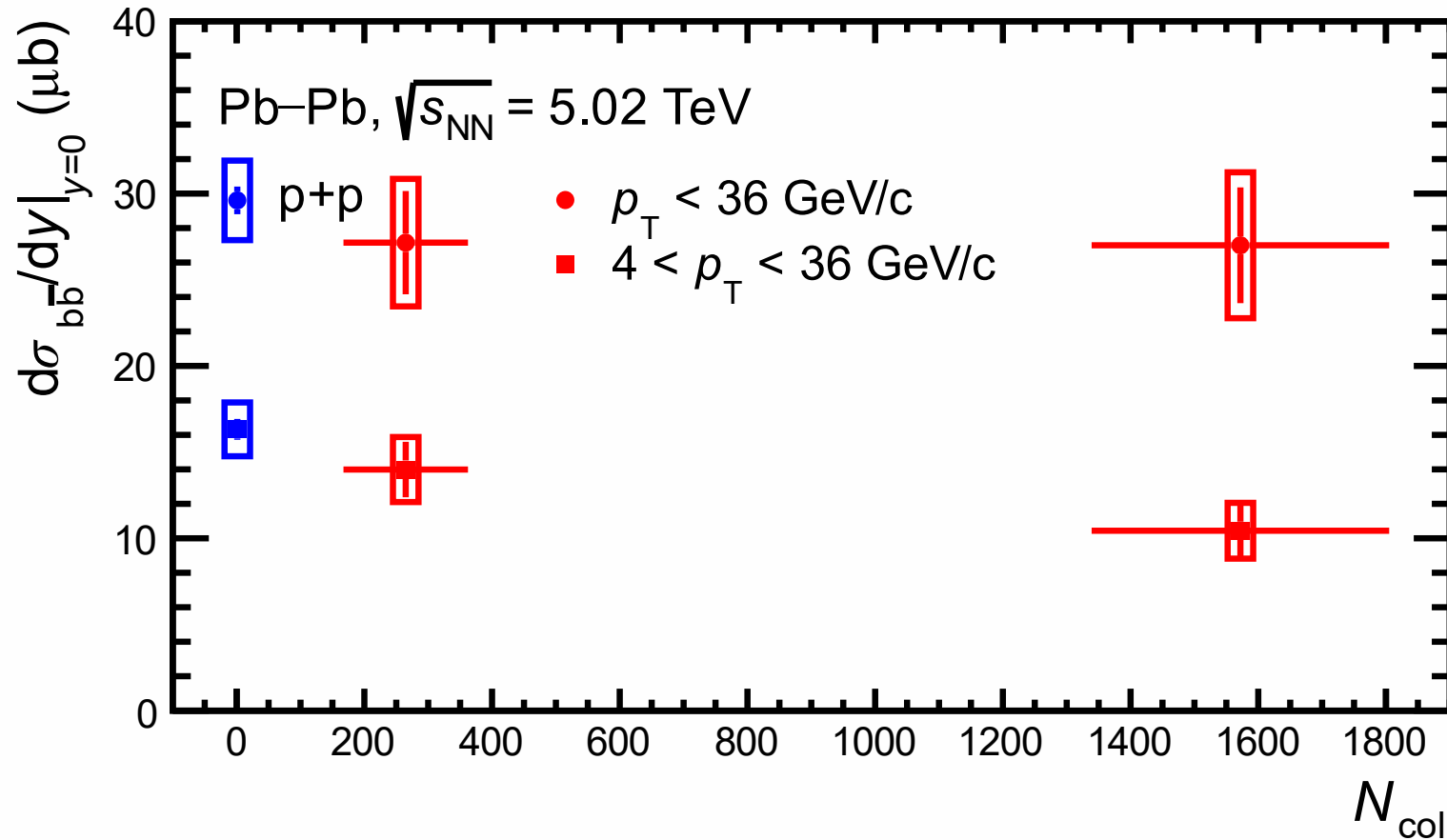
- The Bayesian unfolded results are compared with model calculations and other particles. The results show strong suppression at high p_T , however consist with or higher than 1 at low p_T .

$b\bar{b}$ production cross sections vs. rapidity in Pb–Pb collisions



- The R_{AA} of open beauty hadron is larger systematically than that of prompt D^0 in the full rapidity range, which can be explained by the mass dependent energy loss effect in hot nuclear matter.

Total $b\bar{b}$ production cross sections and mean p_T in Pb–Pb collisions



- Total $b\bar{b}$ production cross sections in pp and Pb–Pb collisions at mid-rapidity are consistent with N_{coll} scaling.
- Decreasing trend of total $b\bar{b}$ production cross sections at mid-rapidity in the high p_T region.

Summary

- The data-driven Bayesian unfolded open beauty production cross sections from non-prompt D^0 and non-prompt J/ψ are found fully compatible within uncertainties.
- The weight-averaged results in pp collisions are consistent with FONLL model and worldwide measurements within uncertainties, significantly improving the uncertainties compared to the worldwide results.
- Open beauty production cross sections in full rapidity in p–Pb collisions are obtained. R_{pPb} shows different trend in the forward and backward rapidity.
- Beauty quark conservation and mass dependent energy loss effect are observed in Pb–Pb collisions.

Thanks