Measurement of prompt and non-prompt J/ψ production at mid-rapidity in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV with ALICE
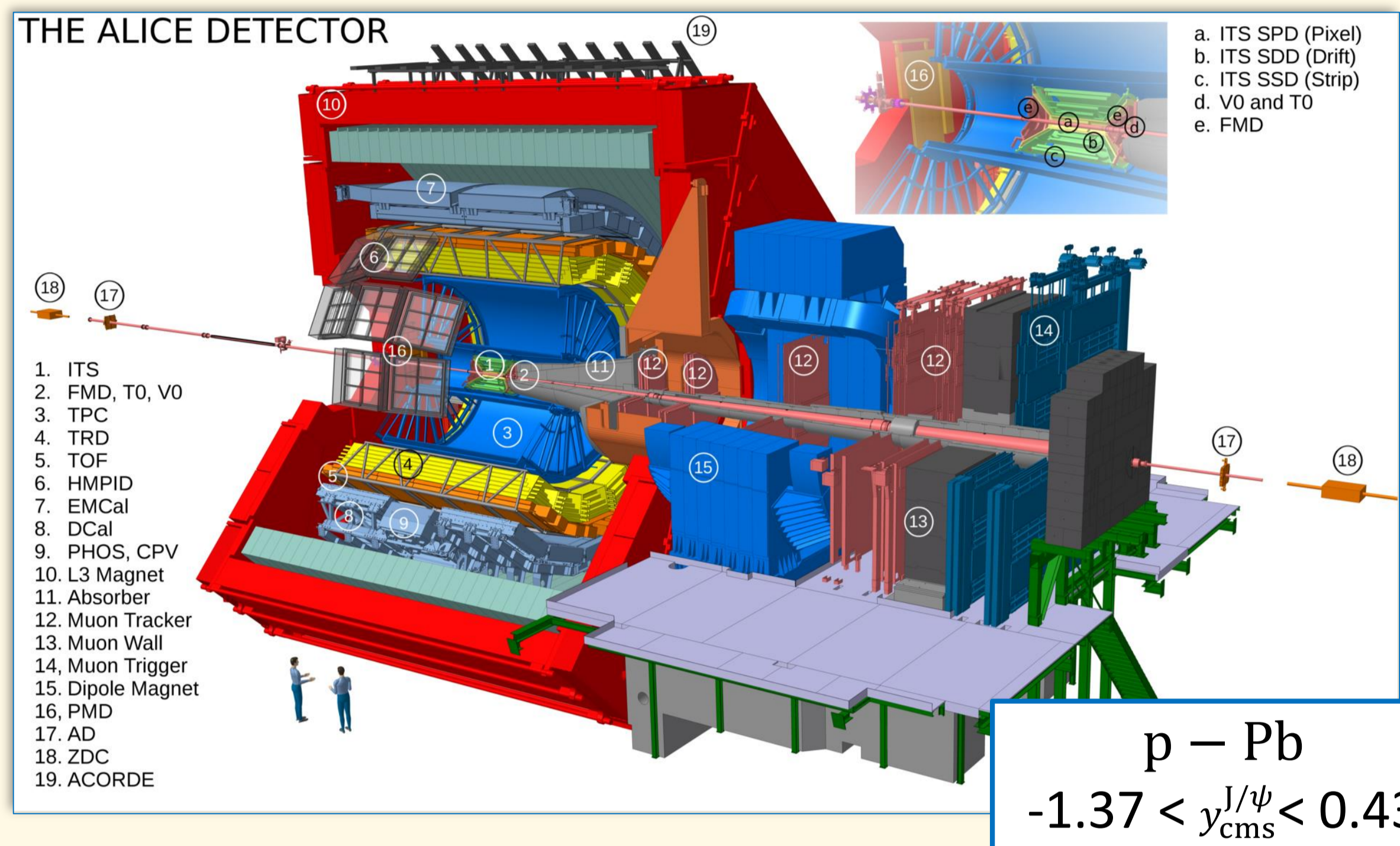
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J/ψ mesons have long been proposed as ideal probes capable of providing evidences of the formation of **Quark–Gluon Plasma (QGP)** in ultra-relativistic heavy-ion collisions. Various **Cold Nuclear Matter (CNM)** effects, such as nuclear shadowing or partonic energy loss, are however expected to affect J/ψ production in addition to the modifications due to the presence of the QGP, and the study of p–Pb collisions represents a crucial tool to assess the influence of CNM on J/ψ production. Besides prompt J/ψ produced at the interaction vertex, a significant component of the inclusive J/ψ yield at the LHC consists of non-prompt J/ψ produced after the weak decay of beauty-flavoured hadrons. The separation of such component provides a measurement of the inclusive b-quark production, and its study in p-Pb systems allows the evaluation of CNM effects on beauty production.

J/ψ IDENTIFICATION AT MID RAPIDITY WITH ALICE

THE ALICE DETECTOR

a. ITS SPD (Pixel)
b. ITS SDD (Drift)
c. ITS SSD (Strip)
d. V0 and T0
e. FMD

1. ITS
2. FMD, T0, V0
3. TPC
4. TRD
5. TOF
6. HMPID
7. EMCal
8. DCal
9. PHOS, CPV
10. L3 Magnet
11. Absorber
12. Muon Tracker
13. Muon Wall
14. Muon Trigger
15. Dipole Magnet
16. PMD
17. AD
18. ZDC
19. ACORDE

p − Pb
$-1.37 < y_{cms}^{J/\psi} < 0.43$

The ALICE experiment at the LHC is capable of efficiently reconstructing J/ψ at mid rapidity through their di-electronic decay channel: $J/\psi \rightarrow e^+ e^-$.

The low-momentum electron identification capabilities and the unique acceptance of ALICE central barrel allow reconstruction of inclusive J/ψ down to zero p_T, as well as the separation of non-prompt J/ψ down to $p_T \sim 1$ GeV/c, in a complementary transverse momentum region with respect to other LHC experiments.

DETECTORS USED

ITS (Inner Tracking System):
made up of 6 cylindrical layers of silicon detectors providing excellent spatial resolution and allowing **secondary vertex determination**.
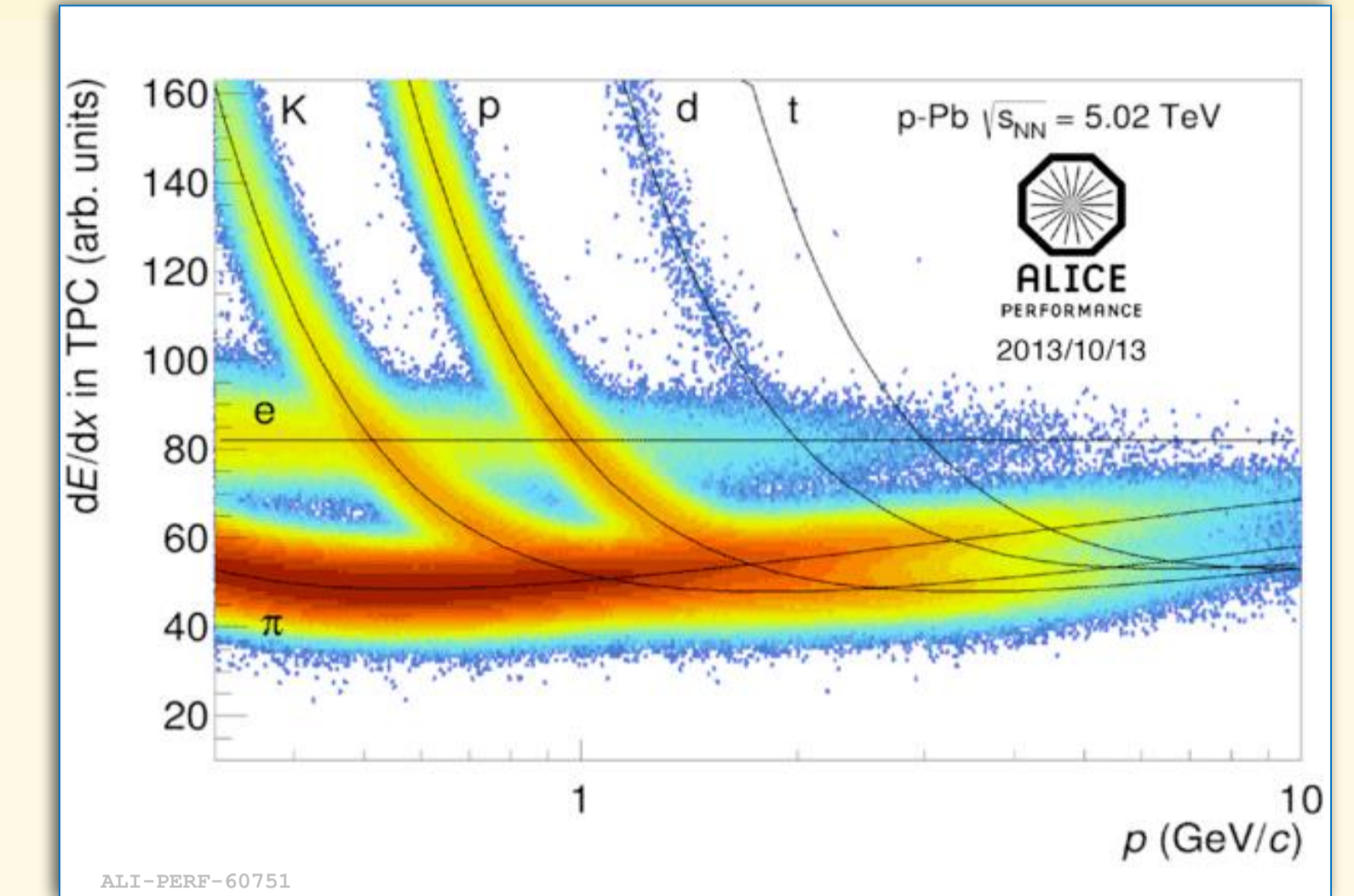
TPC (*Time Projection Chamber*):
main central barrel detector dedicated to tracking and allowing **electron identification** through specific energy loss (dE/dx) measurement.

NON-PROMPT J/ψ FRACTION MEASUREMENT

The measurement of the fraction of non-prompt J/ψ in ALICE relies on the statistical discrimination of J/ψ mesons produced far from the primary collision vertex by means of the **pseudo-proper decay length (x)** variable.

$$x = \frac{\vec{L}\cdot\vec{p}_T}{p_T}\cdot\frac{c\cdot m_{J/\psi}}{p_T}$$

An un-binned likelihood fit to the two-dimensional distribution of invariant mass $m_{e^+e^-}$ and x of the di-electron pairs is performed after modelling, for both the prompt and non-prompt component, the $m_{e^+e^-}$ and x distributions of both signal and background di-electron pairs.

From the analysis of LHC Run 1 data (2009-2013), ALICE produced measurements of prompt and non-prompt J/ψ production in pp collisions at $\sqrt{s}$ = 7 TeV [1], Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV [2], and p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV [3].

The analysis on p-Pb data was performed on a sample of about 10^8 MB events, in three transverse momentum intervals, down to p_T as low as 1.3 GeV/c.
Figures on the left show the projections of the maximized likelihood functions over the the $m_{e^+e^-}$ and x distributions of the selected di-electron pairs. The non-prompt J/ψ fractions f_B, resulting from the fits, are reported in the right figure, in comparison to similar measurements [3].
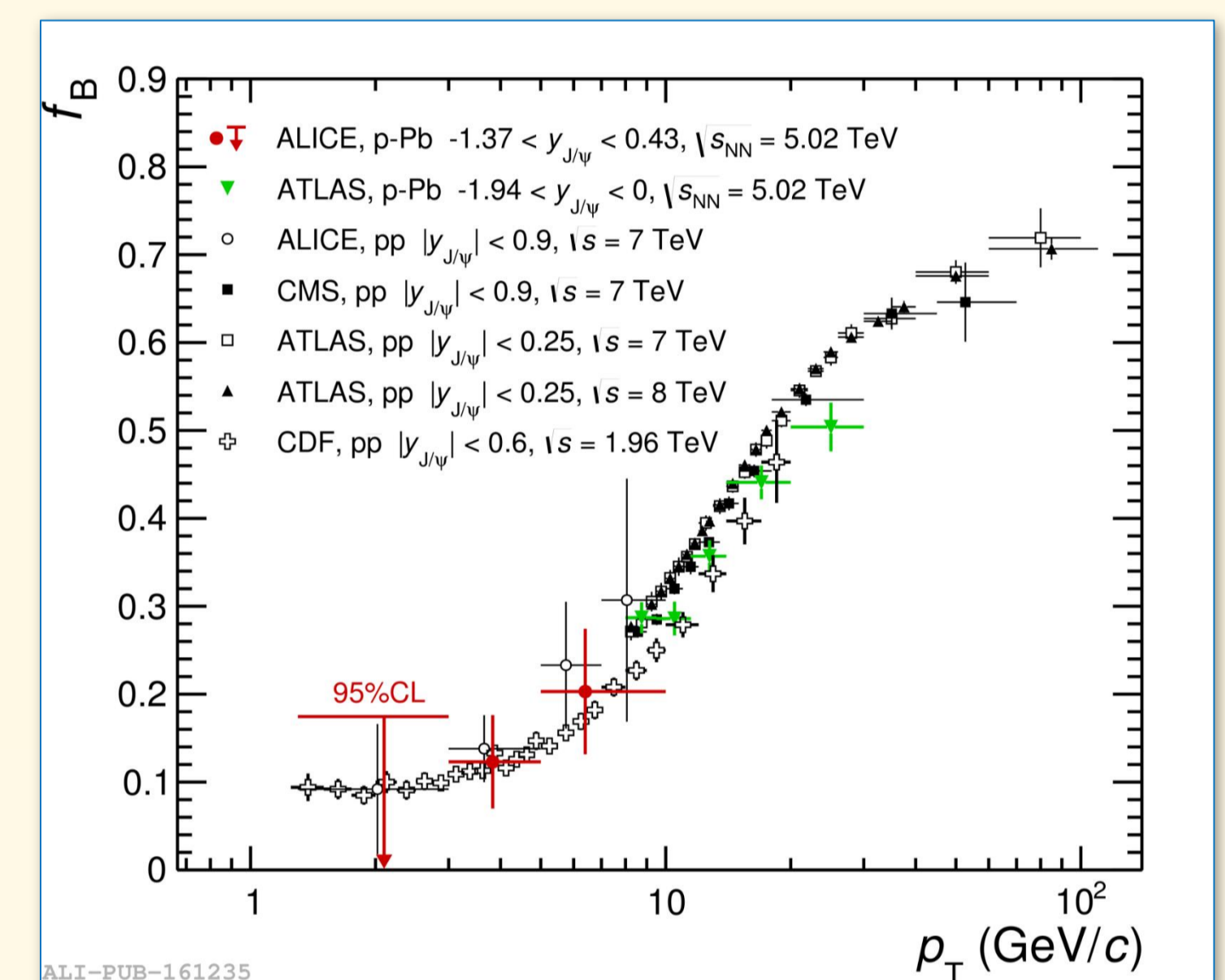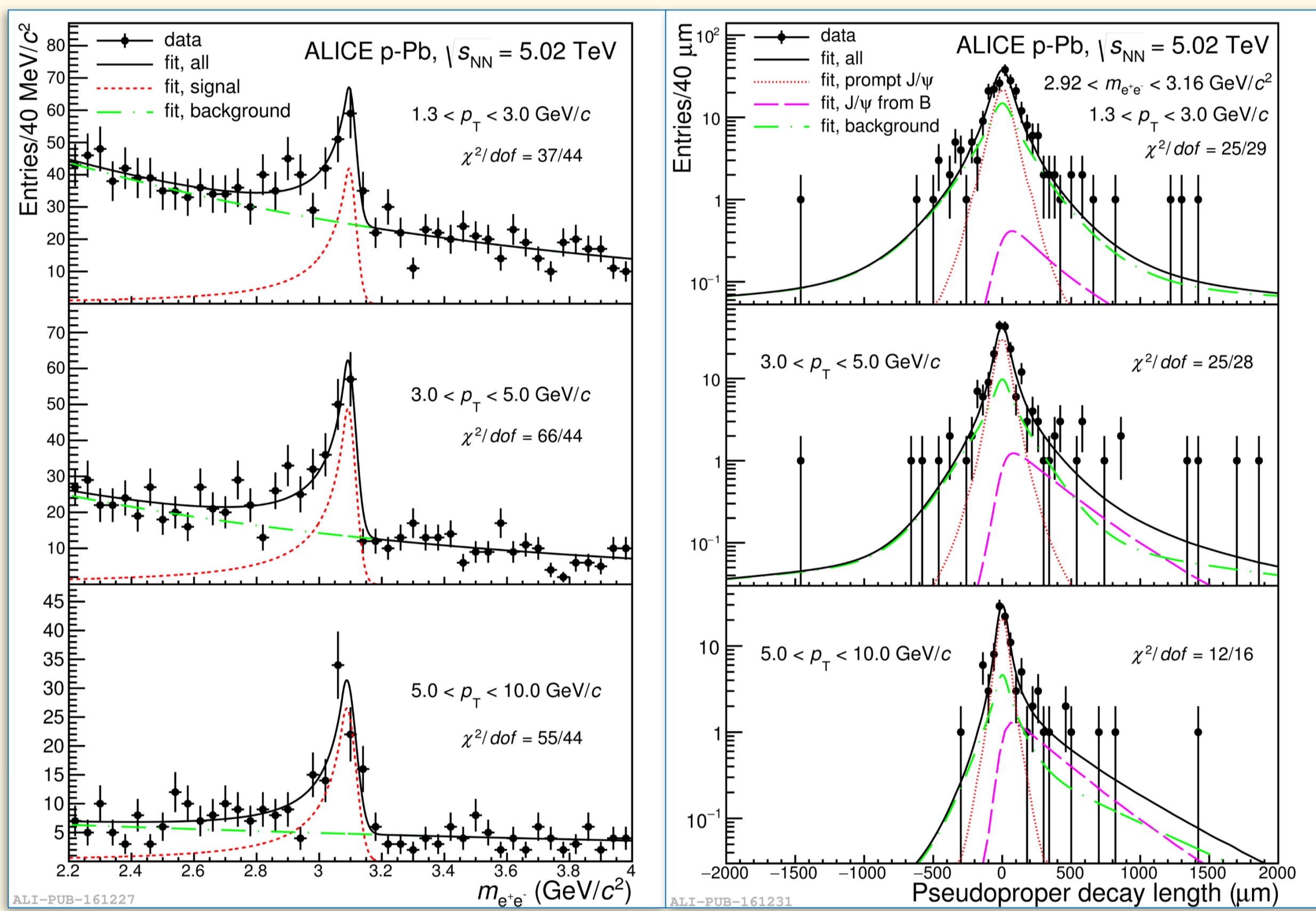
NUCLEAR MATTER EFFECTS

Modifications affecting J/ψ production due to the presence of the nuclear medium have been evaluated by means of the **nuclear modification factor R_{pPb}**:

$$R_{pPb}(y, p_T) = \frac{d^2\sigma_{pPb}/dyd p_T}{A_{Pb}\cdot d^2\sigma_{pPb}/dyd p_T}$$
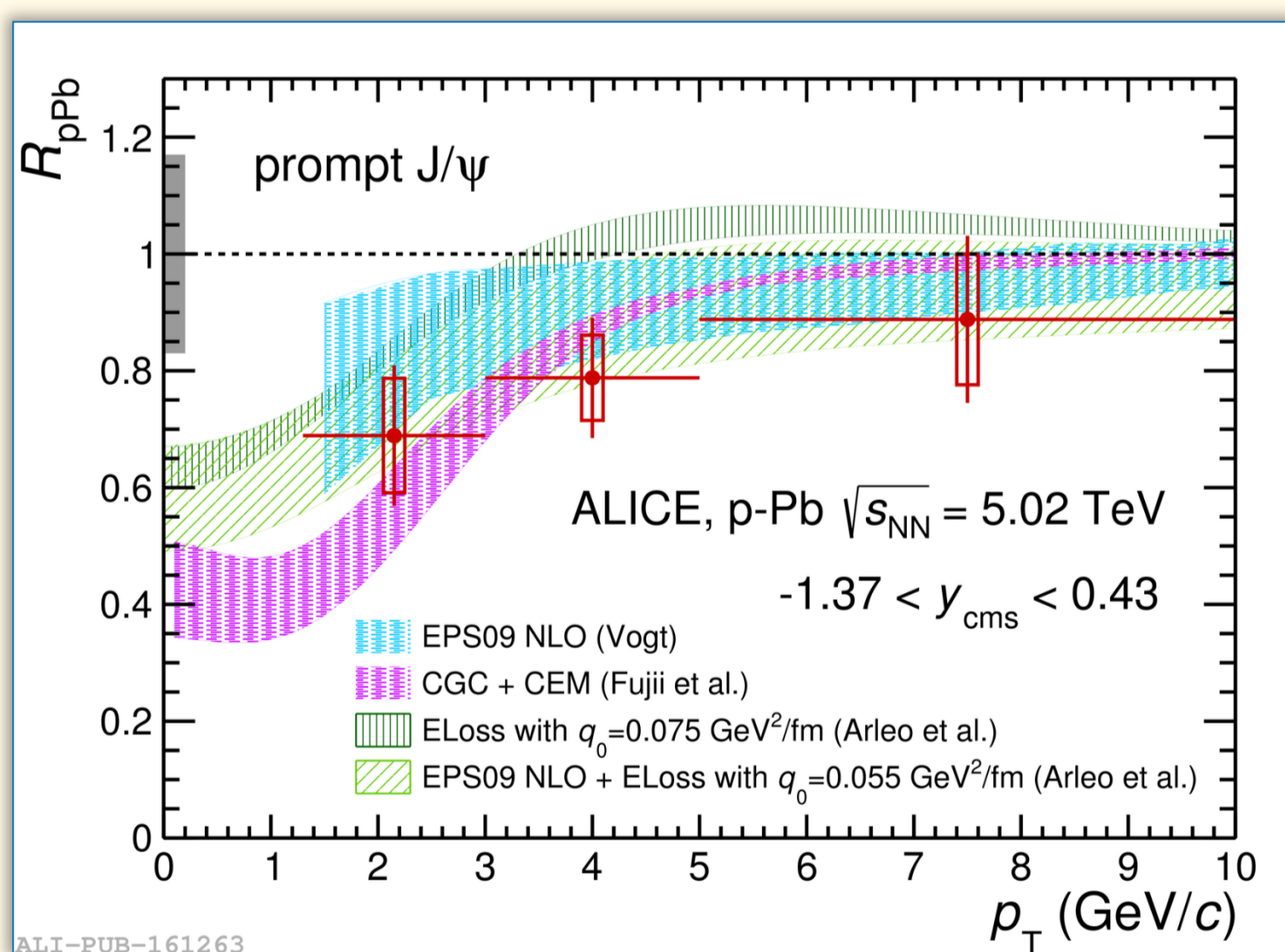
By combining the measurements of f_B in p-Pb collisions with the R_{pPb} of inclusive J/ψ measured from the same data sample [4] and with the interpolated value of f_B in pp collisions at $\sqrt{s}$ = 5.02 TeV, the nuclear modification factor for prompt and non-prompt J/ψ mesons at mid-rapidity was determined, either p_T-integrated or as a function of transverse momentum.

The figures on the left show the R_{pPb} of prompt (top) and non-prompt J/ψ (bottom) in three transverse momentum intervals, in comparison to theoretical calculations implementing different CNM effects, as well as to CMS measurements for non-prompt J/ψ.

Results suggest that the reduced production observed at mid-rapidity for both prompt and non-prompt J/ψ with respect to expectations from scaled pp collisions is a low-p_T effect. The suppression is compatible with theoretical predictions employing CNM effects, although within rather large uncertainties.
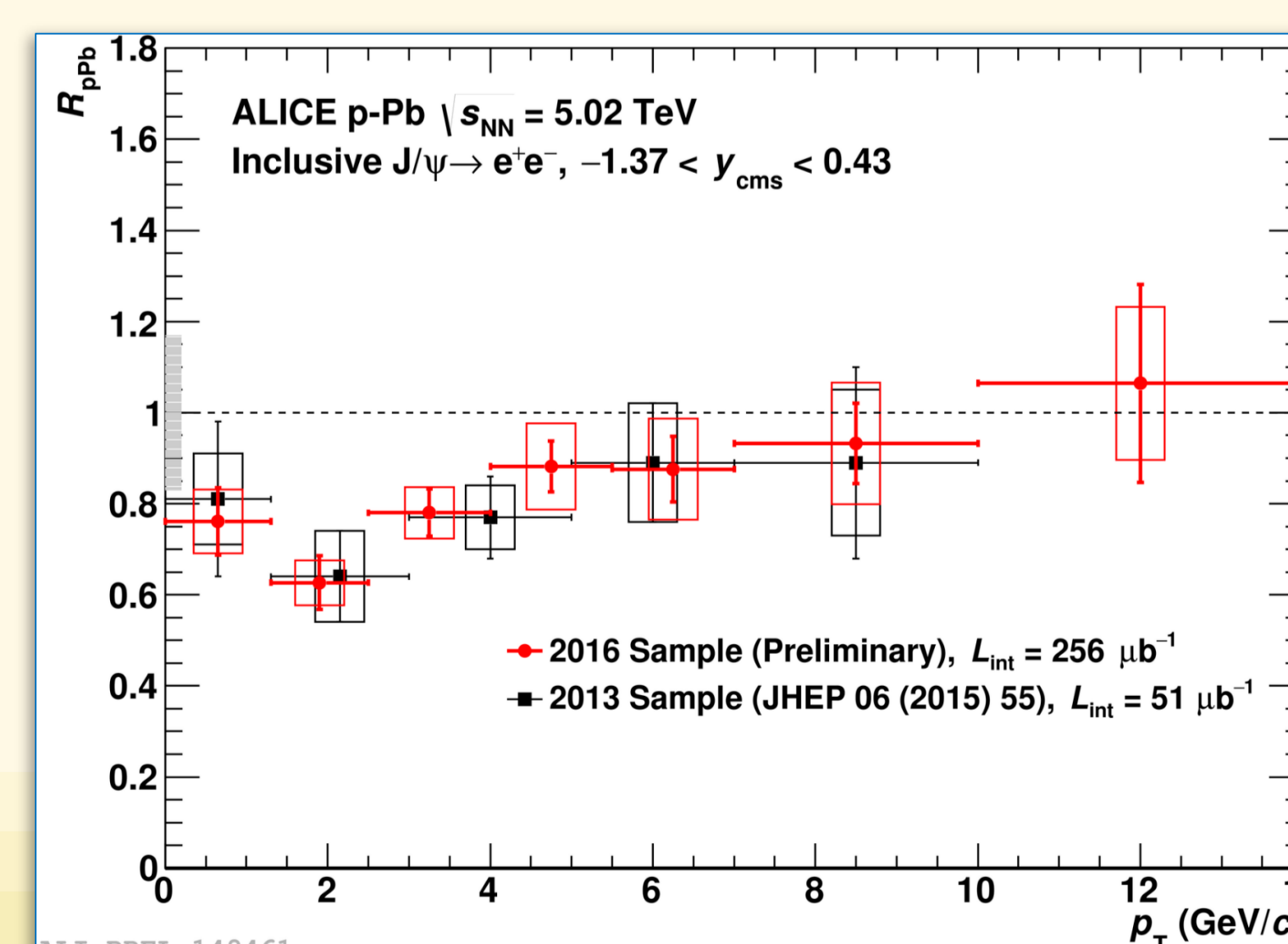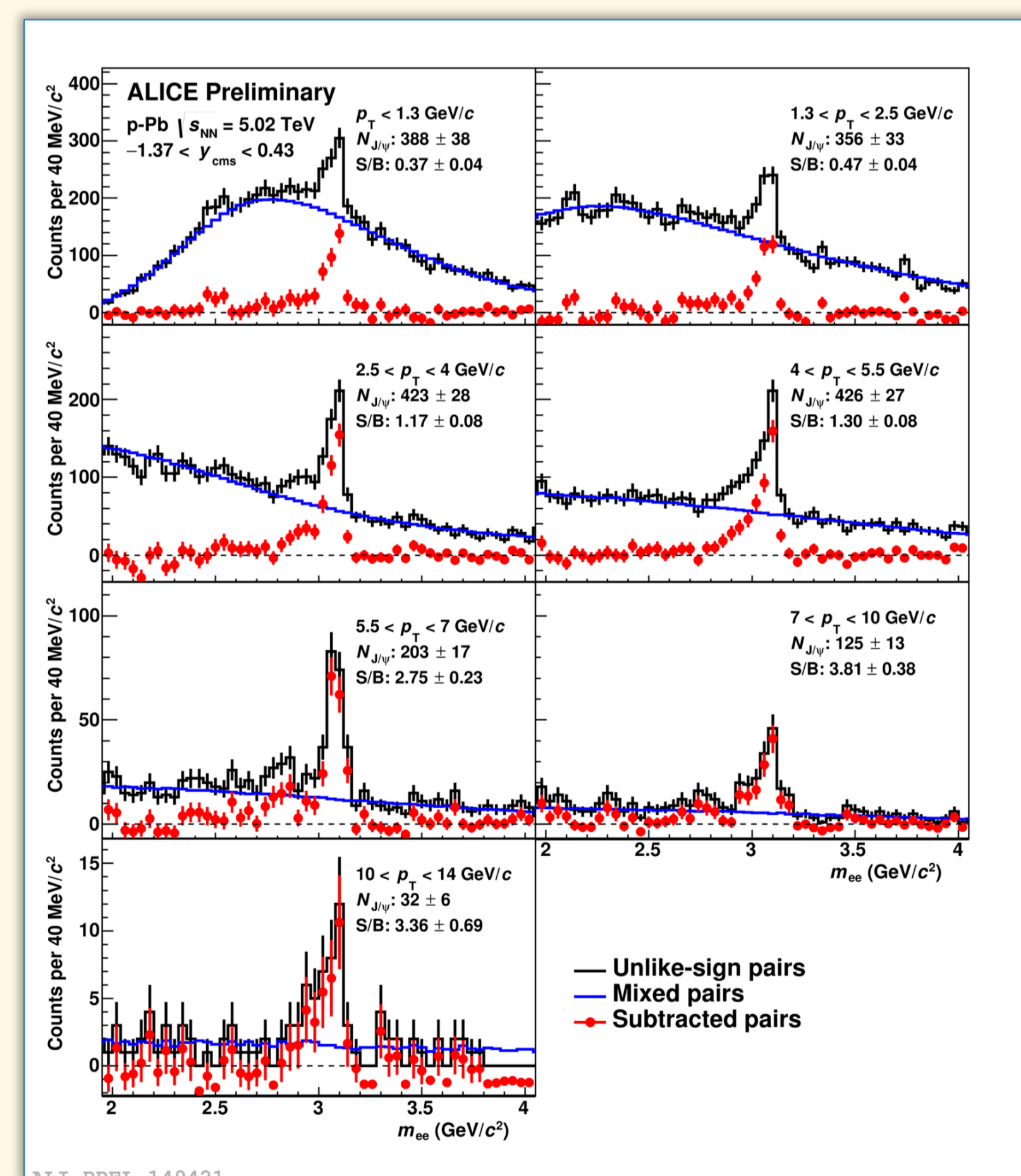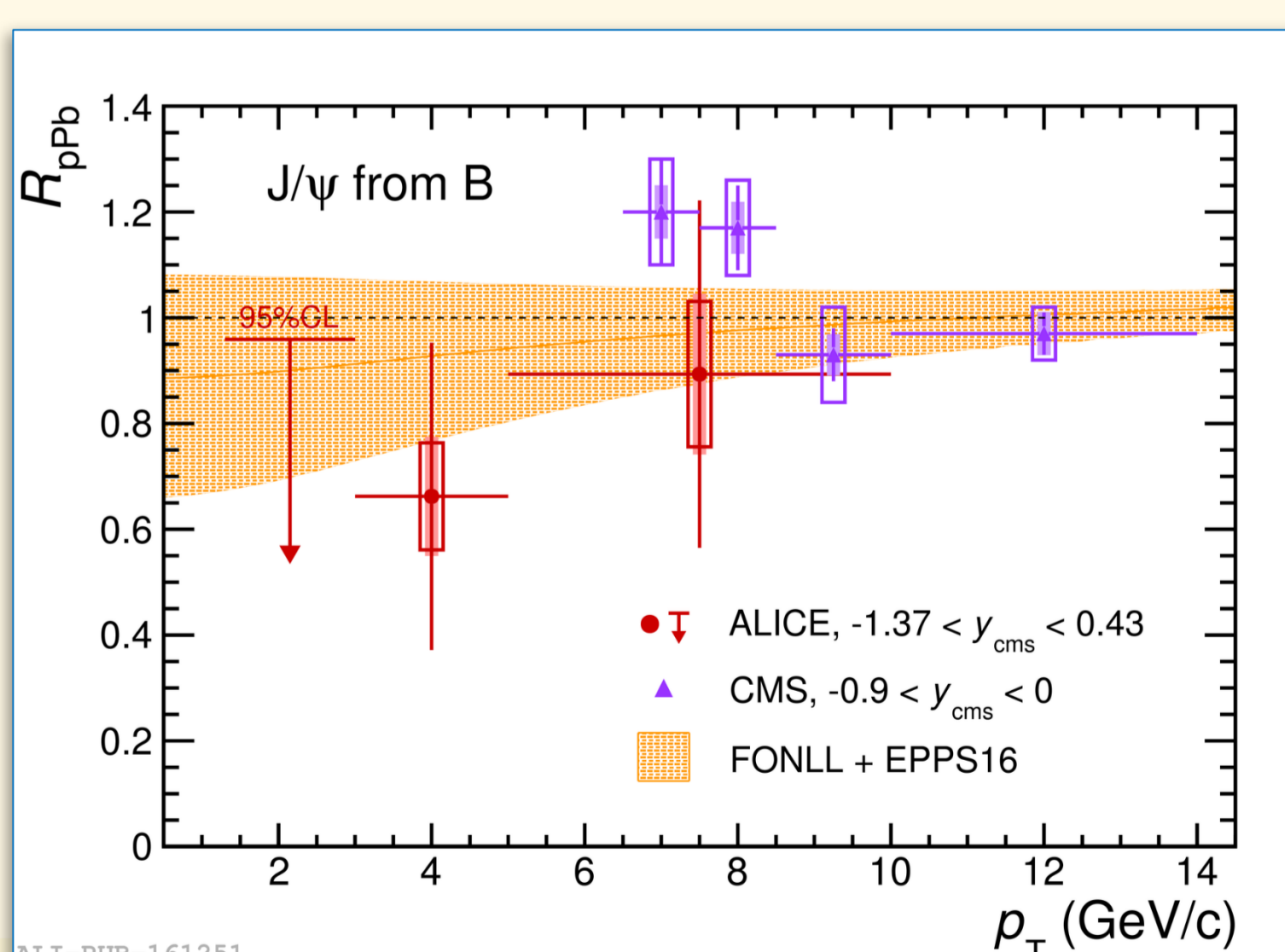
STATUS OF RUN 2 ANALYSES

New data of p-Pb collisions has been collected during LHC Run 2 data taking campaign (2015-2018), granting a significant increase in luminosity for J/ψ analyses at mid-rapidity with respect to Run 1 data.

The new analyses for the measurement of the inclusive J/ψ production in p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV, as well as for the determination of the prompt and non-prompt J/ψ components, are on-going.

A significant reduction of uncertainties, as well as a higher p_T reach and a more differential p_T binning, have been achieved with respect to Run 1 results.

Figures on the left show preliminary results for the raw inclusive J/ψ yield (top), extracted as a function of transverse momentum, and for the inclusive J/ψ nuclear modification factor (bottom), in comparison to Run 1 measurements.

REFERENCES

[1] Abelev B., *et al.* (ALICE Coll.), JHEP 1211 (2012) 065
[2] Adam J., *et al.* (ALICE Coll.), JHEP 1507 (2015) 051
[3] Acharya S., et al. (ALICE Coll.), EPJC 78 (2018) 466
[4] Adam J., et al. (ALICE Coll.), JHEP 1506 (2015) 055