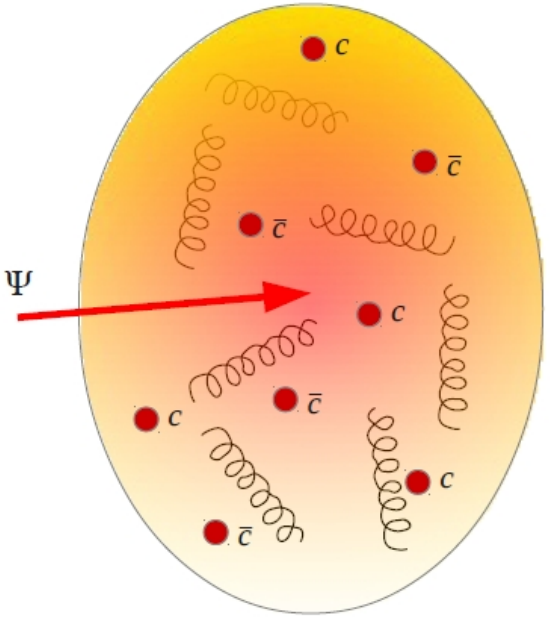
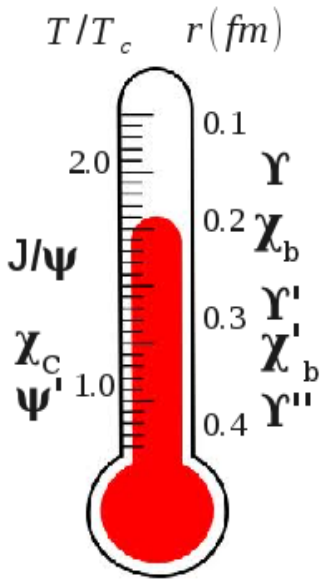
J/ψ production at mid-rapidity in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV

Ionut-Cristian Arsene
for the ALICE Collaboration

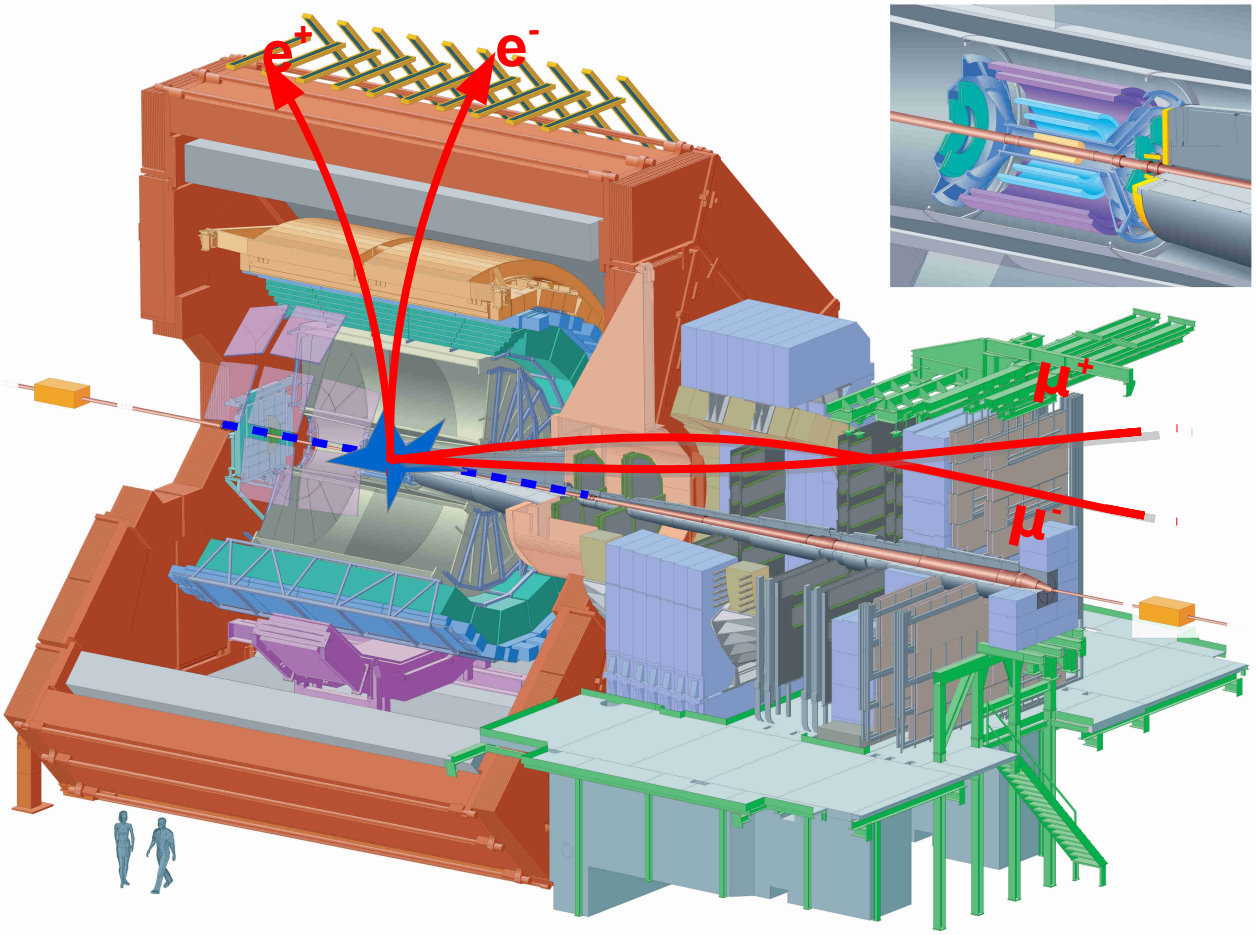
Quarkonia in a hot and dense nuclear medium

- Sensitive to properties of the hot and dense nuclear matter and a probe for a deconfined phase (quark-gluon plasma)
  - T.Matsui and H.Satz, Phys.Lett.B 178 (1986) 416
- Test for deconfinement and hadronization of charm quarks at the phase boundary
  - P.Braun-Munzinger, J.Stachel, Phys.Lett.B490 (2000) 196
  - A.Andronic et al., Nucl.Phys.A789 (2007) 334-356
- Quarkonium states survival may depend on the medium temperature
  - A.Mocsy, P.Petreczky, Phys.Rev.Lett. 99 (2007) 211602





J/ψ measurements in ALICE



- J/ψ→e^+e^- ($|y| < 0.9$)
  - Tracking and particle identification detectors in the central barrel
- J/ψ→$\mu^+\mu^-$ ($2.5<y<4$)
  - Tracking and trigger chambers behind thick hadron absorbers in the forward muon arm.

R.Arnaldi, Tuesday 1D

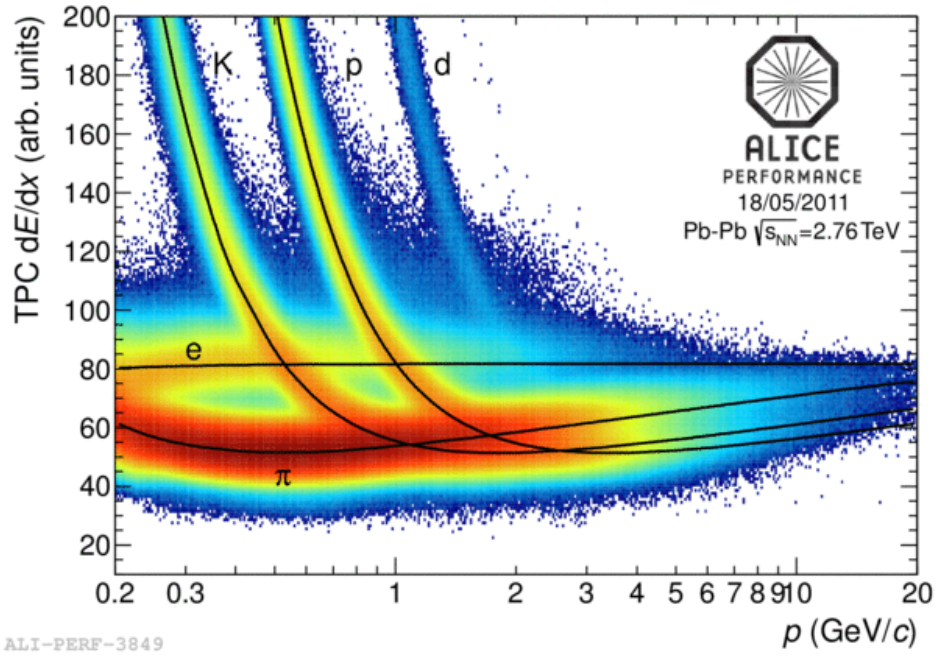
H.Yang, Friday 7A

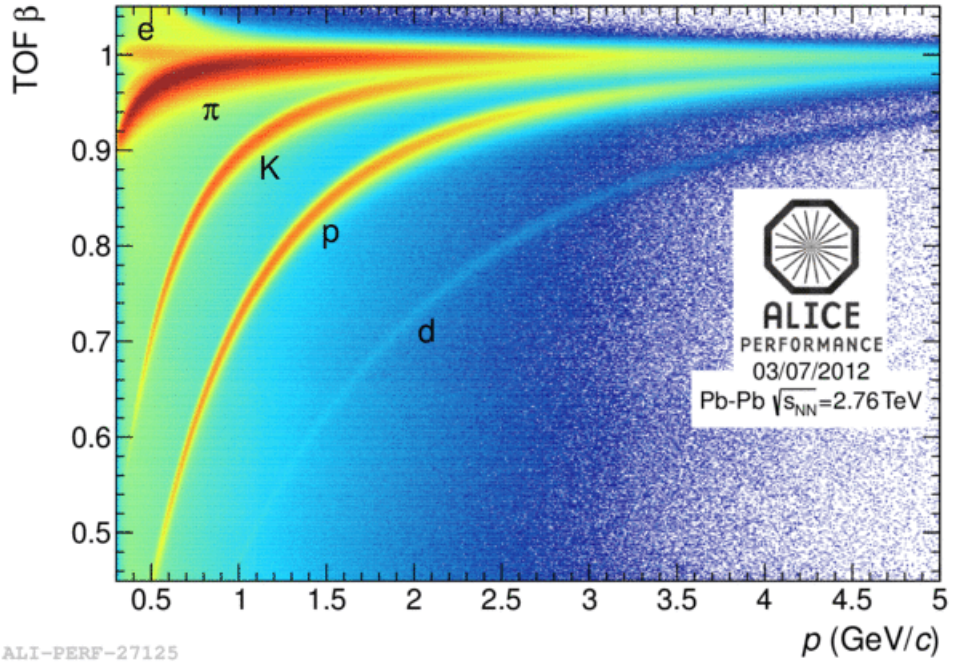
- In both rapidity regions, the J/ψ acceptance goes to zero p_T

Data at mid-rapidity:

- Pb-Pb at $\sqrt{s_{NN}}$=2.76 TeV
  - Centrality 0-10% 11.6 x 10^6 events
  - Centrality 10-40% 12.3 x 10^6 events
  - Centrality 40-80% 6.4 x 10^6 events
- pp at $\sqrt{s}$=2.76 TeV
  - Minimum bias: 1.1 nb^{-1}

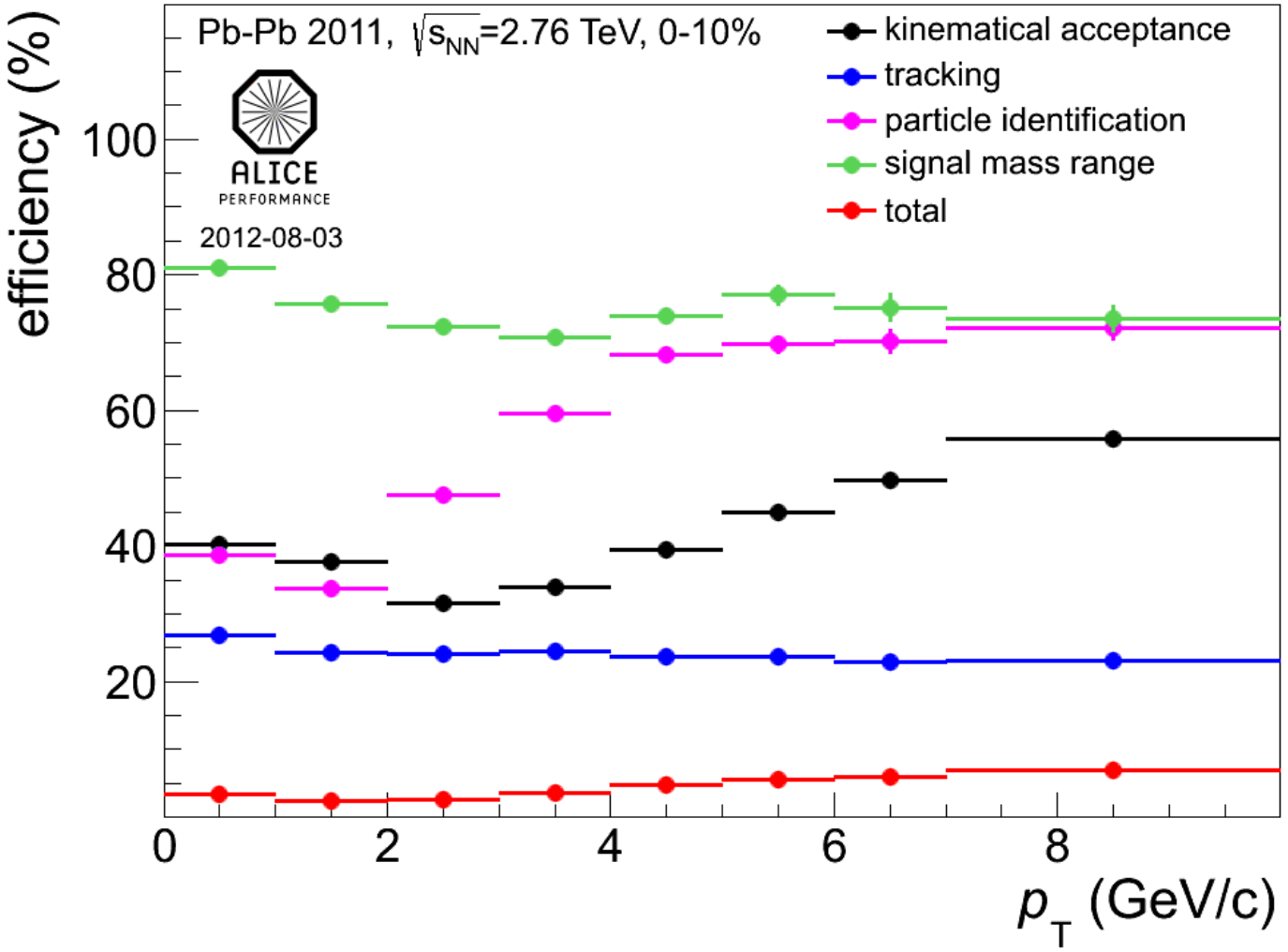
J/ψ→e$^+$e$^-$ reconstruction





- Kinematics
  - $|\eta|<0.9$, $p_T>0.85$ GeV/c
- Tracking
  - Primary track requirements using ITS and TPC
- Particle identification
  - TPC+TOF
- Conversion electrons rejection
  - ITS cluster requirements on electron candidates
  - Removal of tracks from reconstructed γ-conversion V_0 's

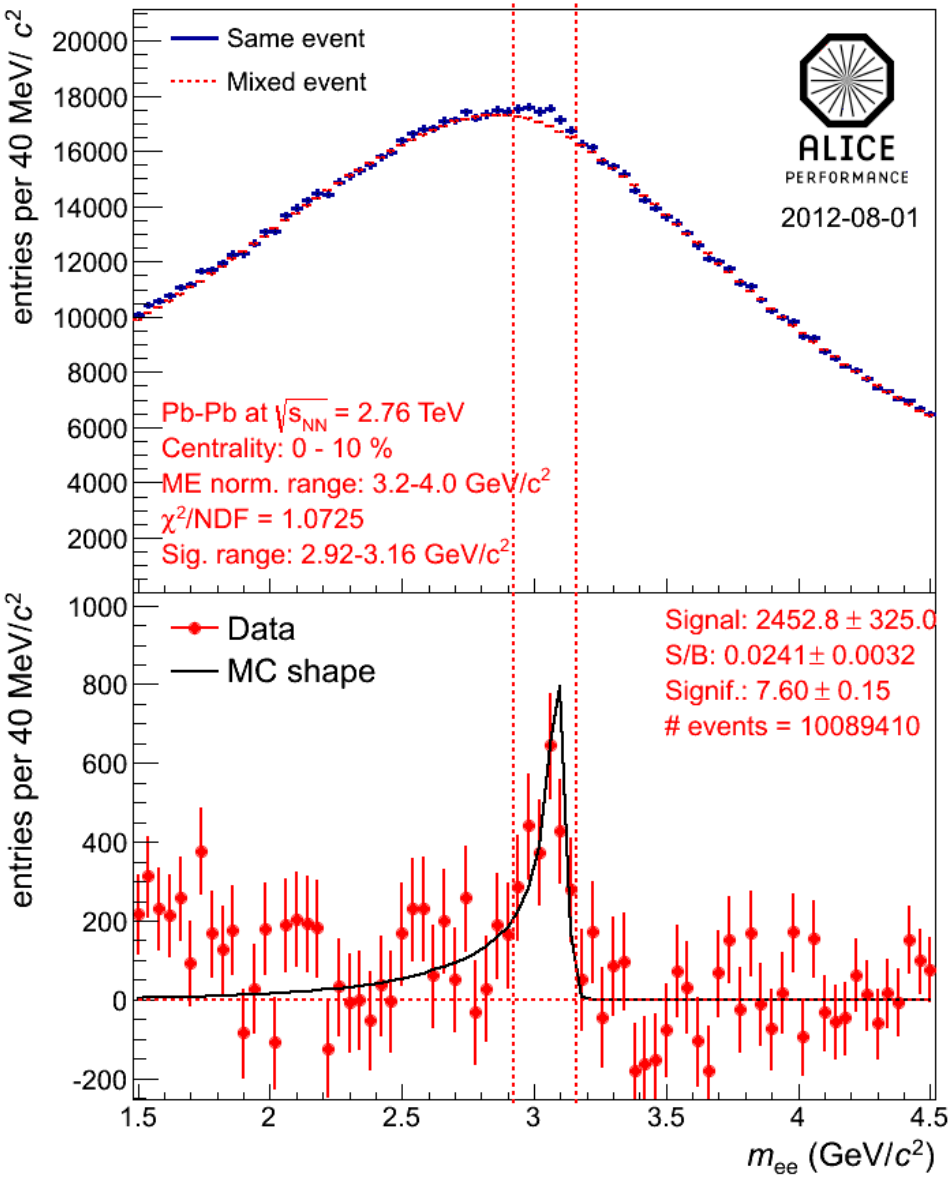
J/ψ reconstruction efficiency



- Efficiencies calculated using MC Pb-Pb events enriched with J/ψ particles.
- The generated particles are transported through the ALICE setup simulated in GEANT 3.21.

Signal extraction (centrality 0-10%)

- J/ψ yield obtained by subtracting the mixed event background from the opposite sign dielectron invariant mass spectrum
- Mixed event background is normalized to the same event distribution in the mass region 3.2-4.0 GeV/c^2
- Good matching between the data and the Monte-Carlo signal shape is obtained.
- The MC signal shape includes the bremsstrahlung of the electrons in the detector material and the radiative decay channel $e^+e^-\gamma$ (internal bremsstrahlung)



Signal extraction (centrality 10-40%)

- J/ψ yield obtained by subtracting the mixed event background from the opposite sign dielectron invariant mass spectrum
- Mixed event background is normalized to the same event distribution in the mass region 3.2-4.0 GeV/c^2
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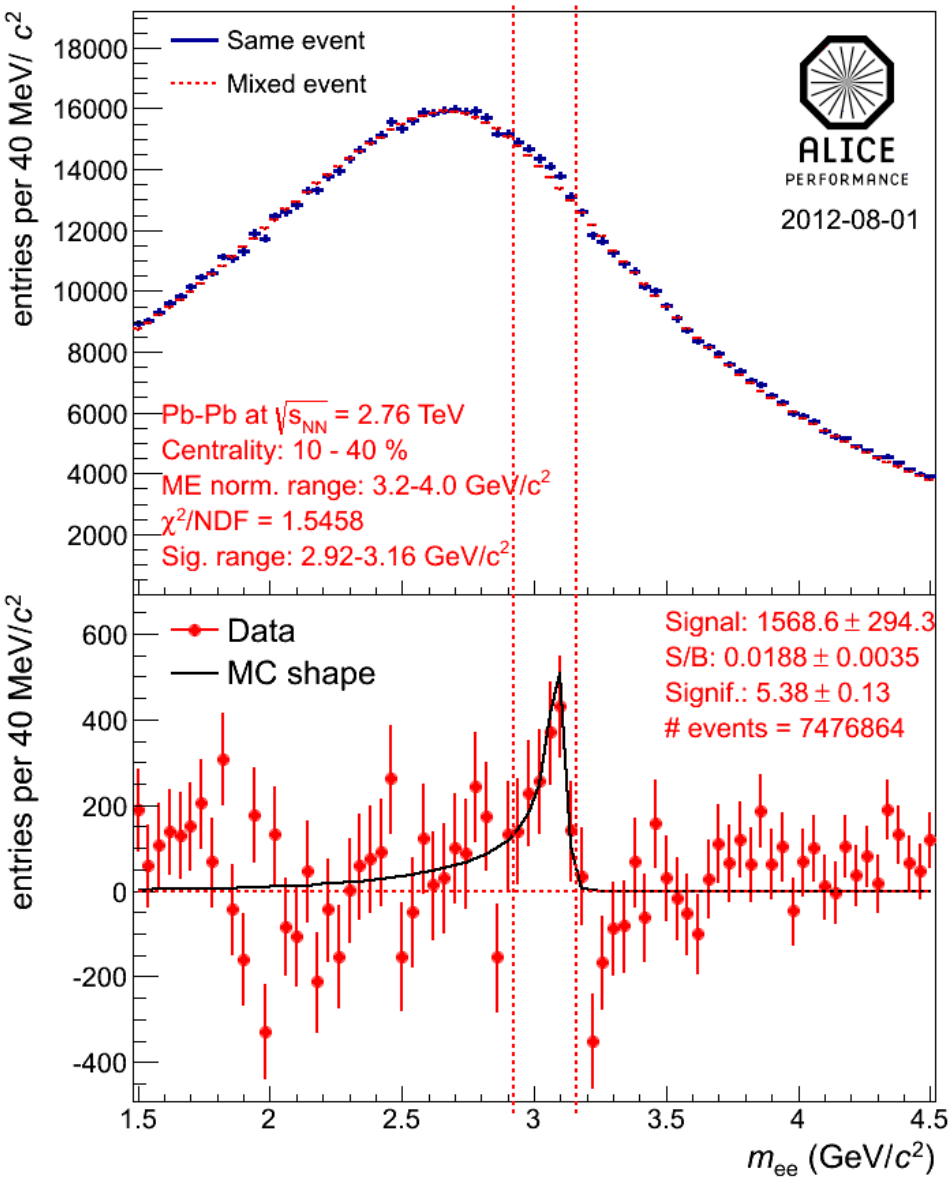

Signal extraction (centrality 40-80%)

- J/ψ yield obtained by subtracting the mixed event background from the opposite sign dielectron invariant mass spectrum
- Mixed event background is normalized to the same event distribution in the mass region 3.2-4.0 GeV/c^2
- Good matching between the data and the Monte-Carlo signal shape is obtained.
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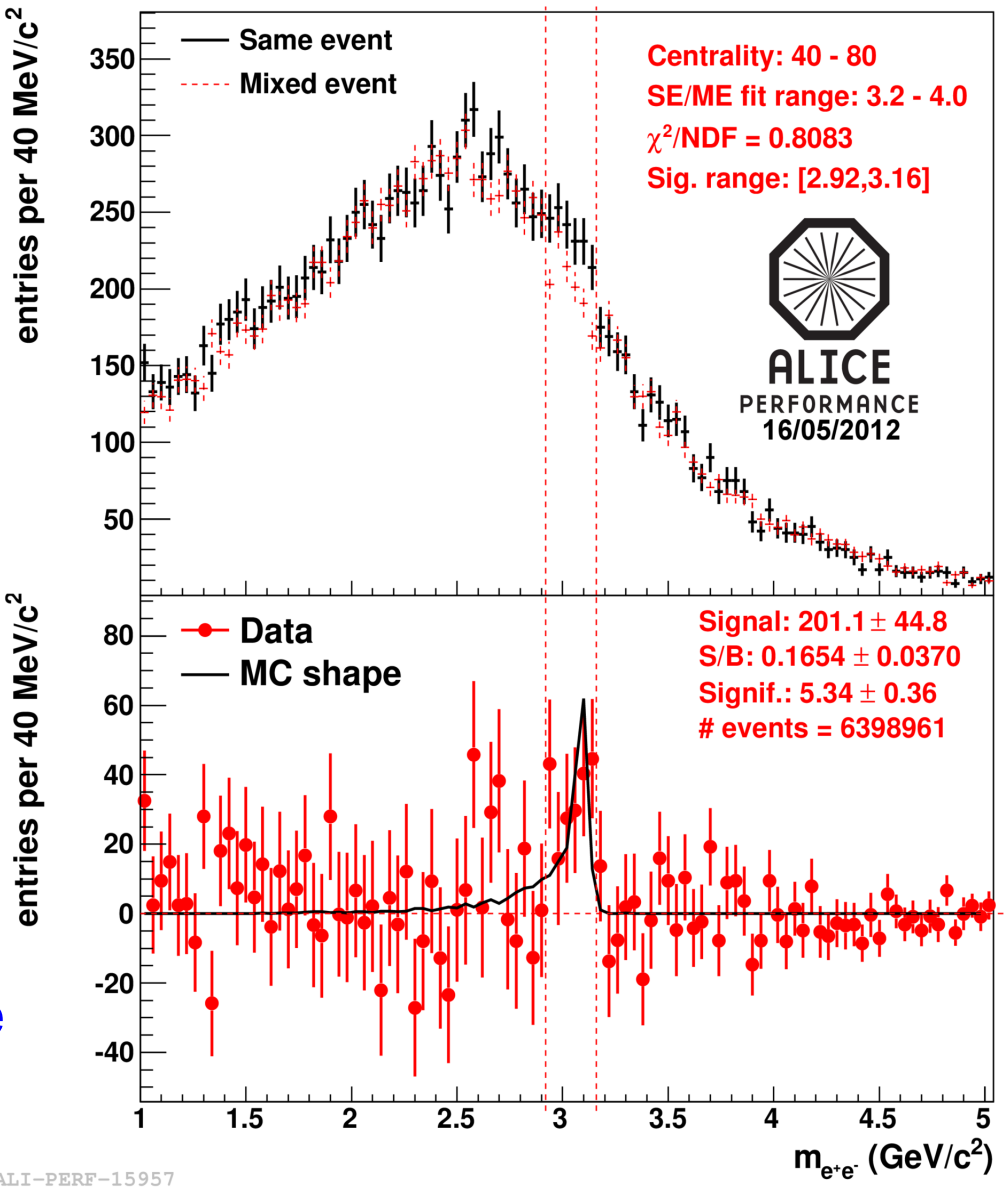
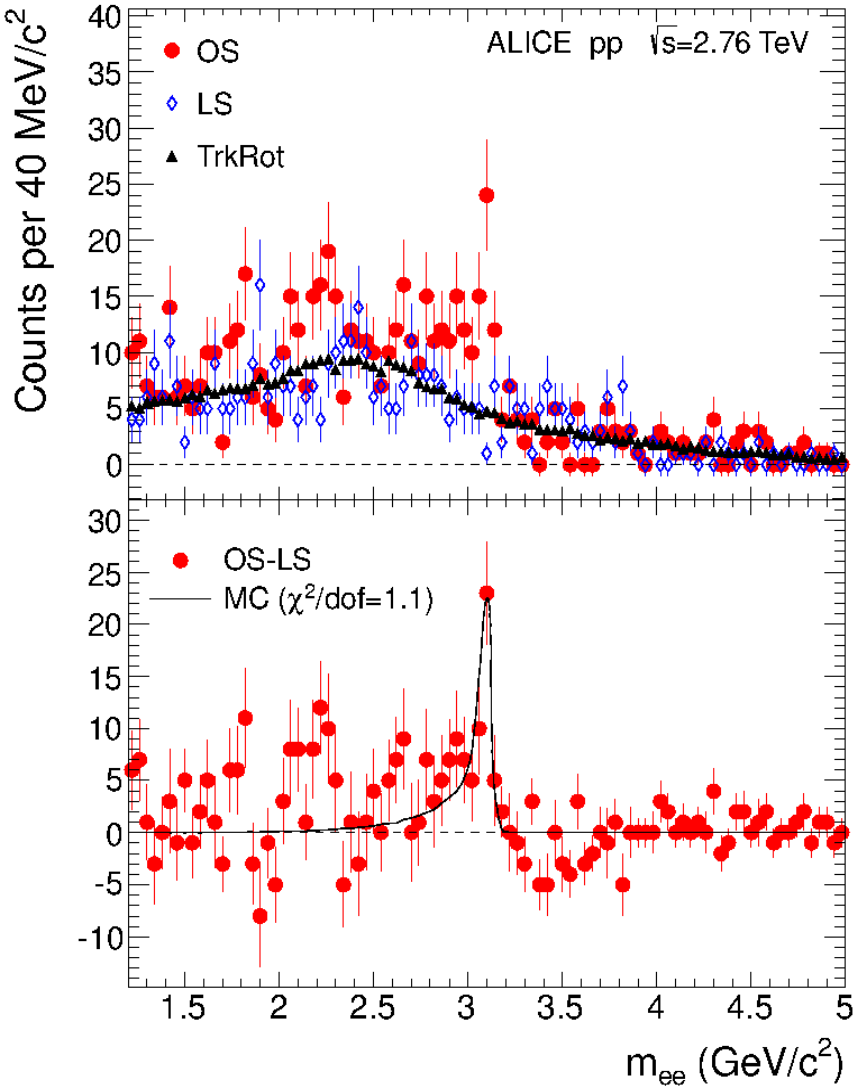
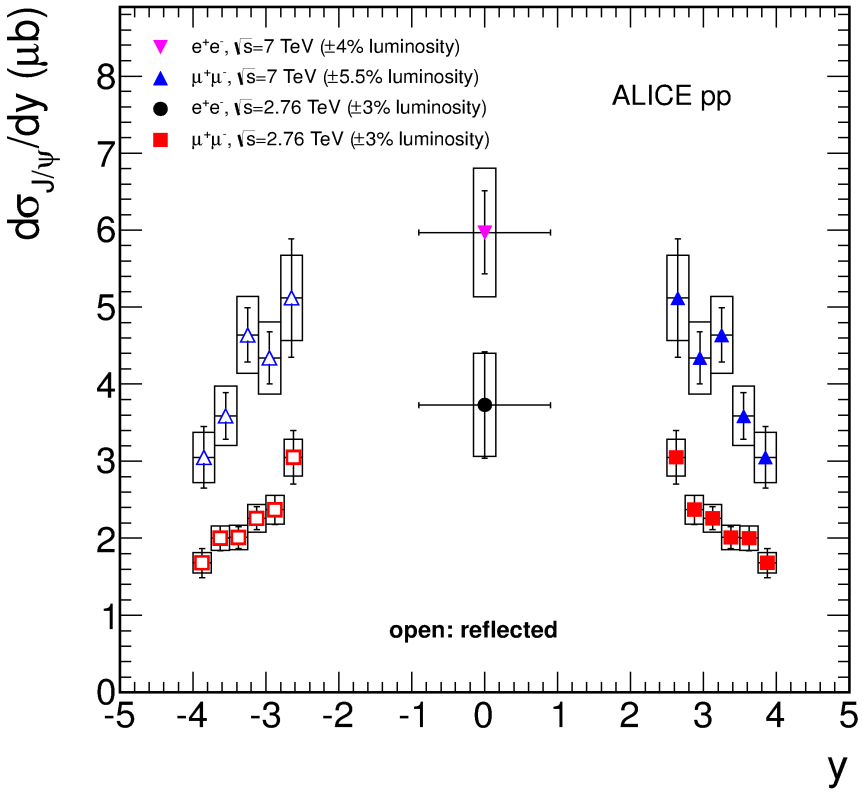


The pp reference

ALICE Collaboration, arXiv:1203.3641

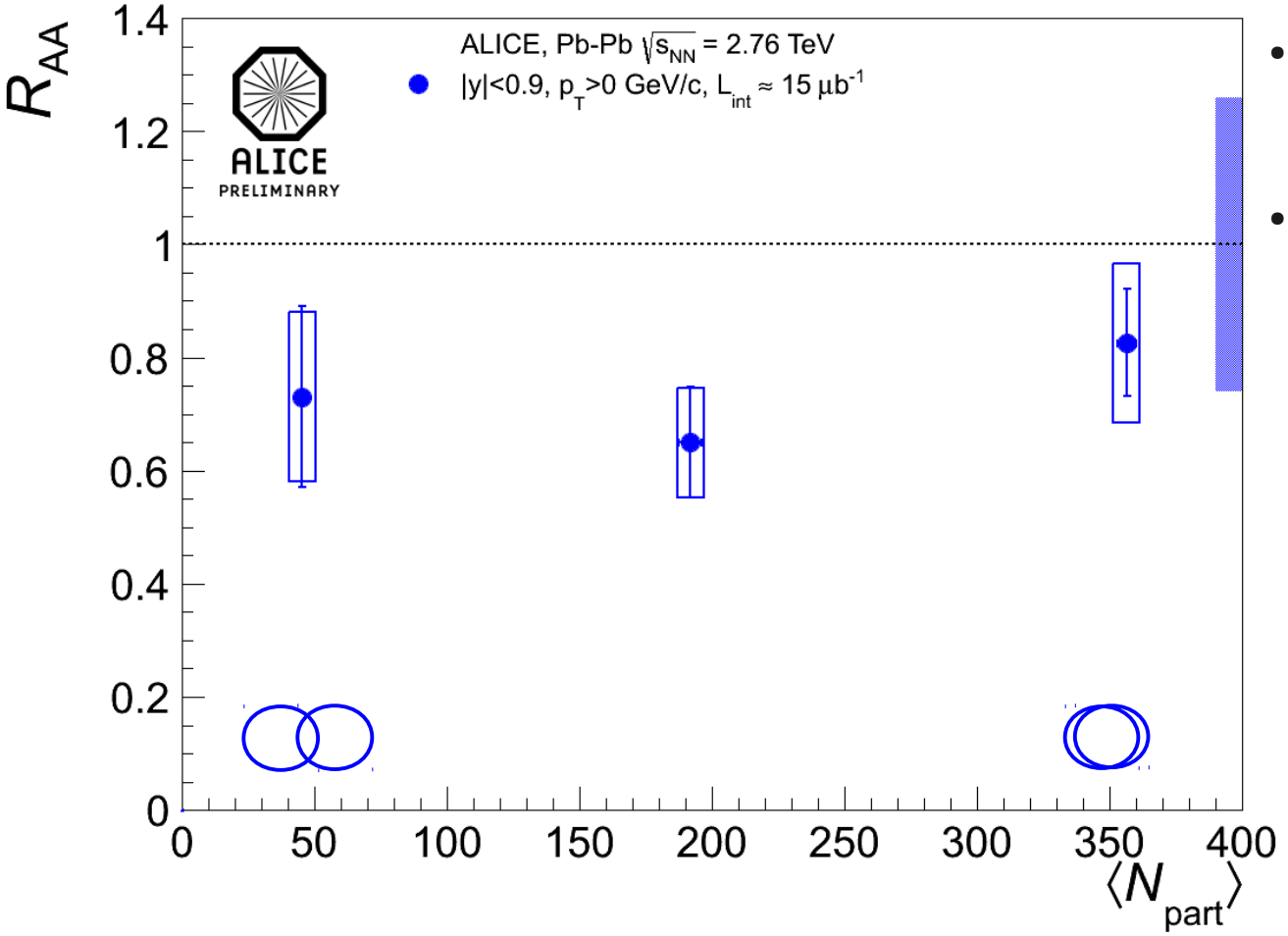




- ALICE measured the J/ψ cross-section in pp at 2.76 TeV
- Combined statistical and systematic error: 26%

$$\sigma_{J/\psi}(|y|<0.9) = 6.71 \pm 1.24\,(stat.) \pm 1.22\,(syst.)\,\mu b$$

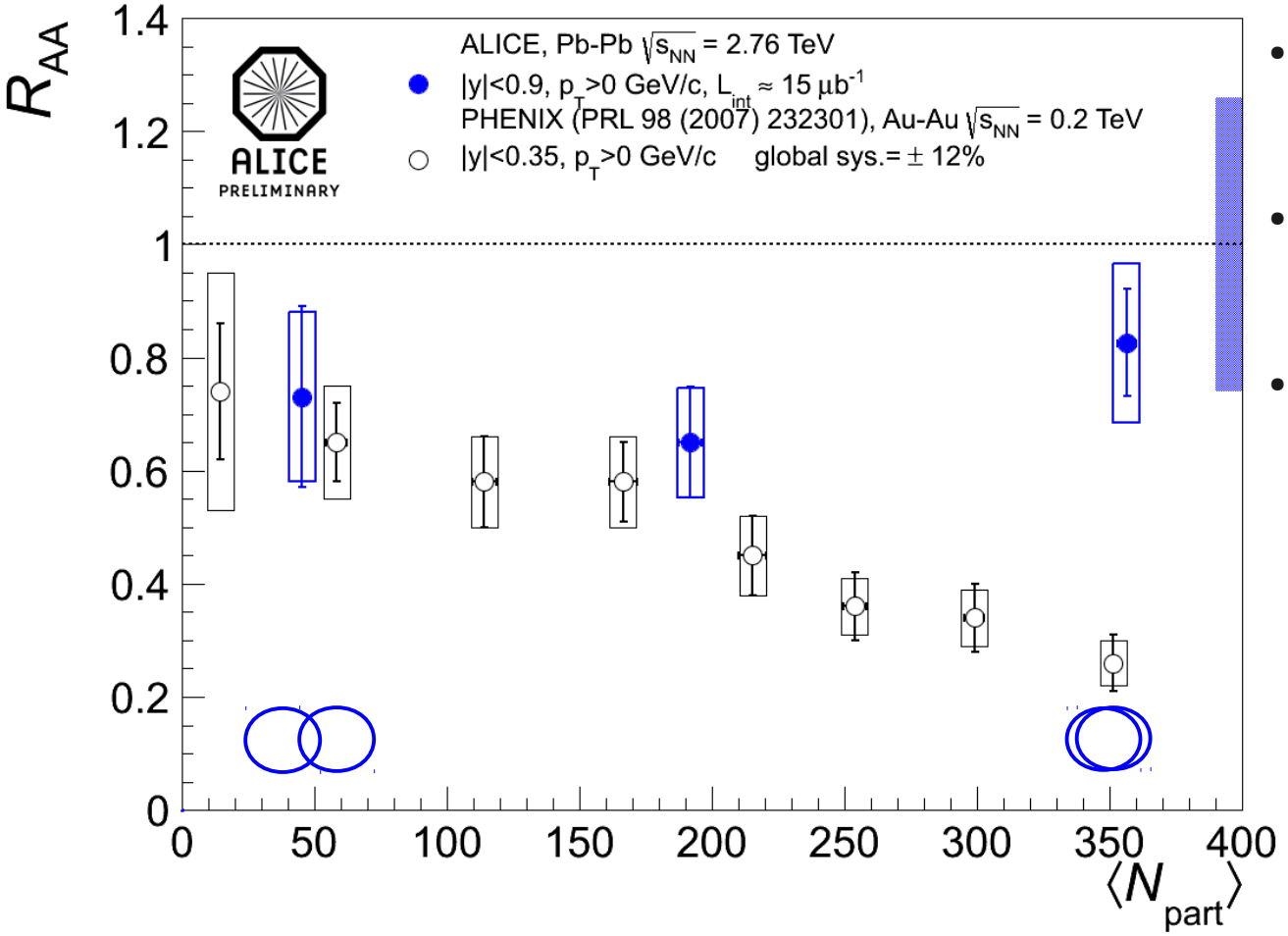
Inclusive J/ψ R_{AA} vs. centrality



$$R_{AA} = \frac{N_{J/\psi}}{N_{ev} \times eff. \times B.R.} \frac{1}{\langle T_{AA} \rangle \times \sigma^{pp}_{J/\psi}}$$

- Inclusive J/ψ R_{AA} in the 0-10% centrality bin is 0.83 ± 0.09 (stat.) ± 0.26 (syst.)
- No significant centrality dependence within the error bars

Inclusive J/ψ R_{AA} vs. centrality (comparison to PHENIX)



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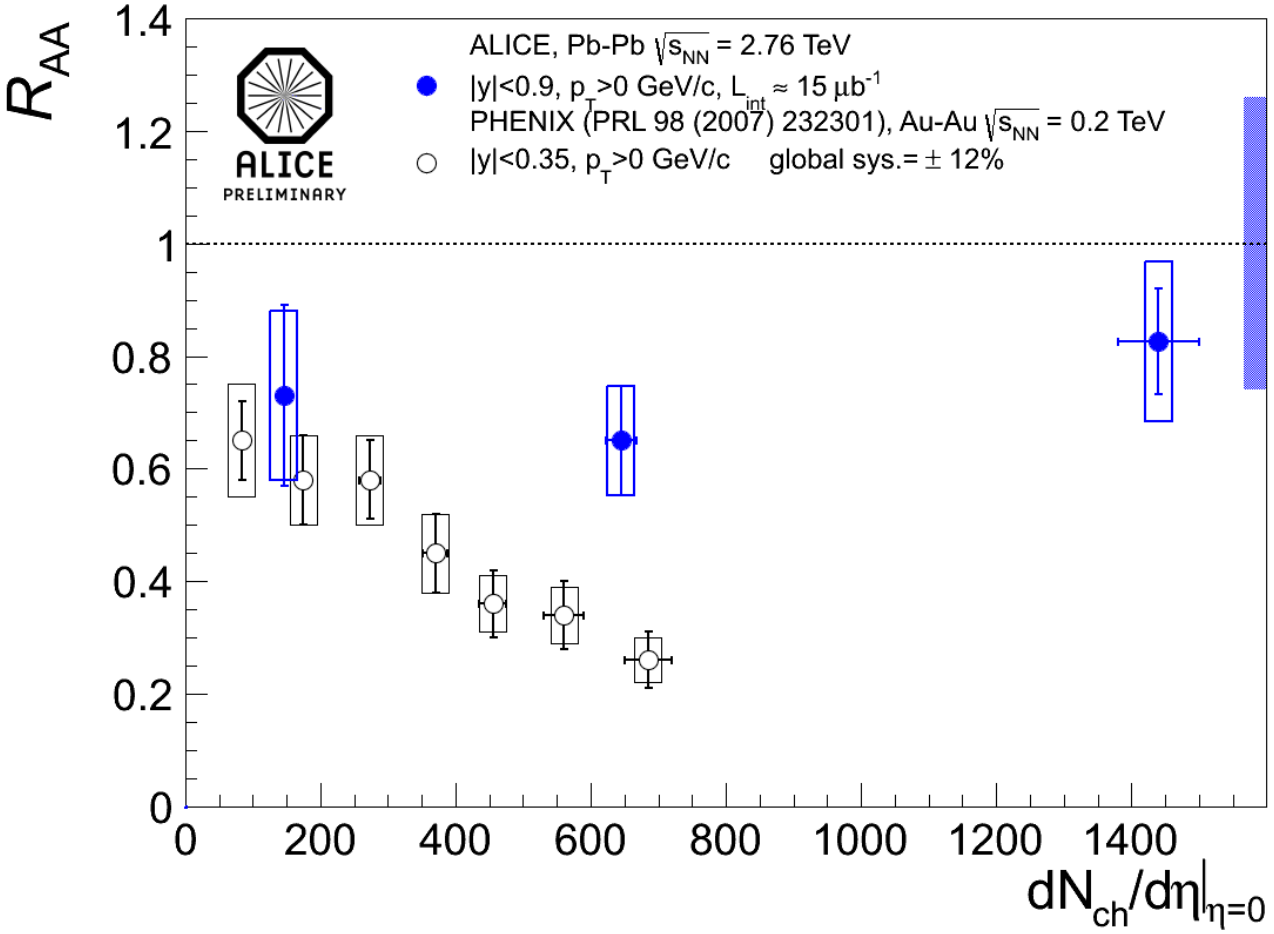
- R_{AA} in central collisions is higher by a factor ~3 compared to the PHENIX results

Inclusive J/ψ R_{AA} vs. particle density (comparison to PHENIX)



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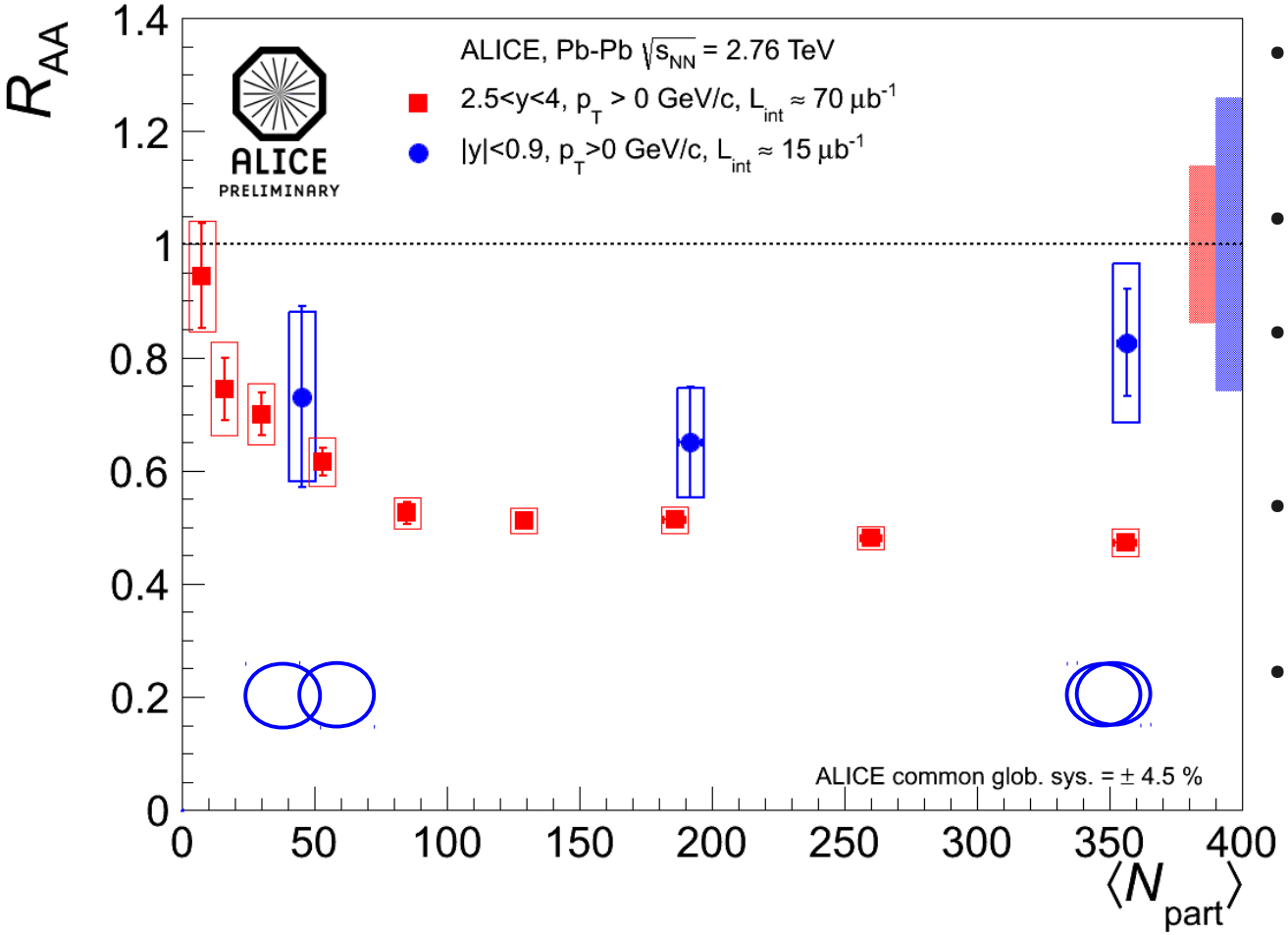
- J/ψ R_{AA} at the same charged particle density grows with energy

Inclusive J/ψ R_{AA} vs. centrality (mid- vs forward-rapidity)



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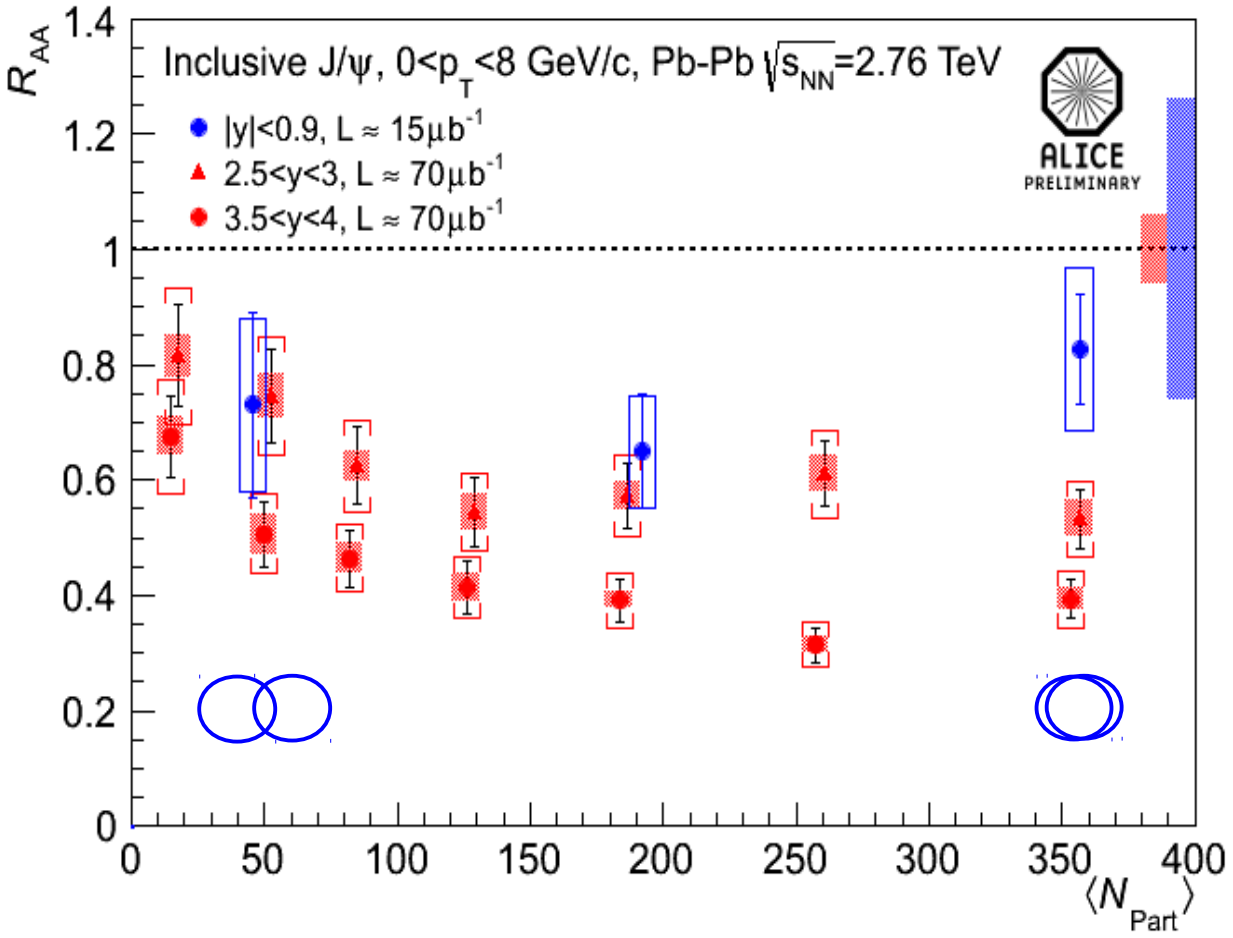
- Hint of a smaller suppression at mid- than at forward-rapidity in central collisions

Inclusive J/ψ R_{AA} vs. centrality (mid- vs forward-rapidity)



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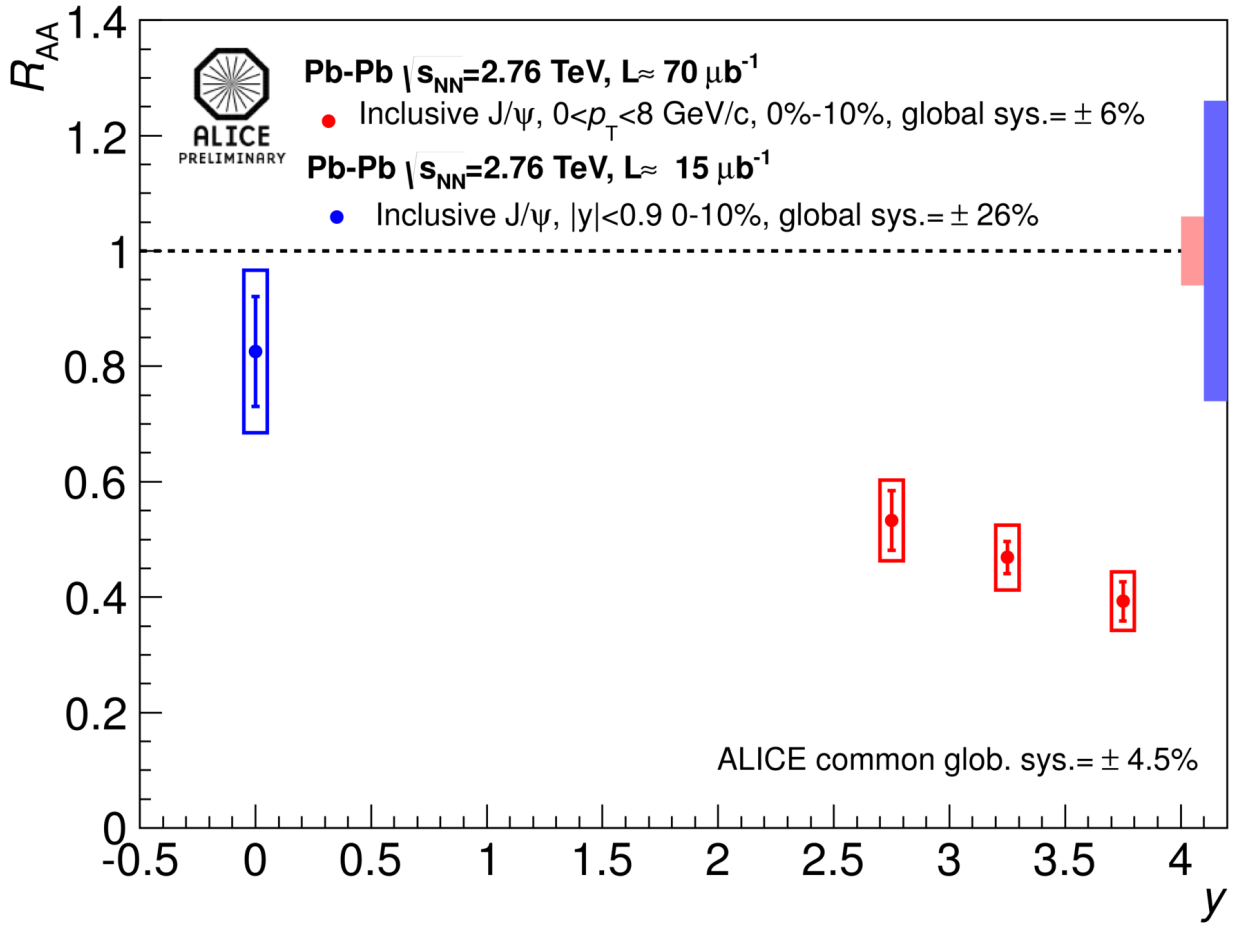
Inclusive J/ψ R_{AA} vs. rapidity



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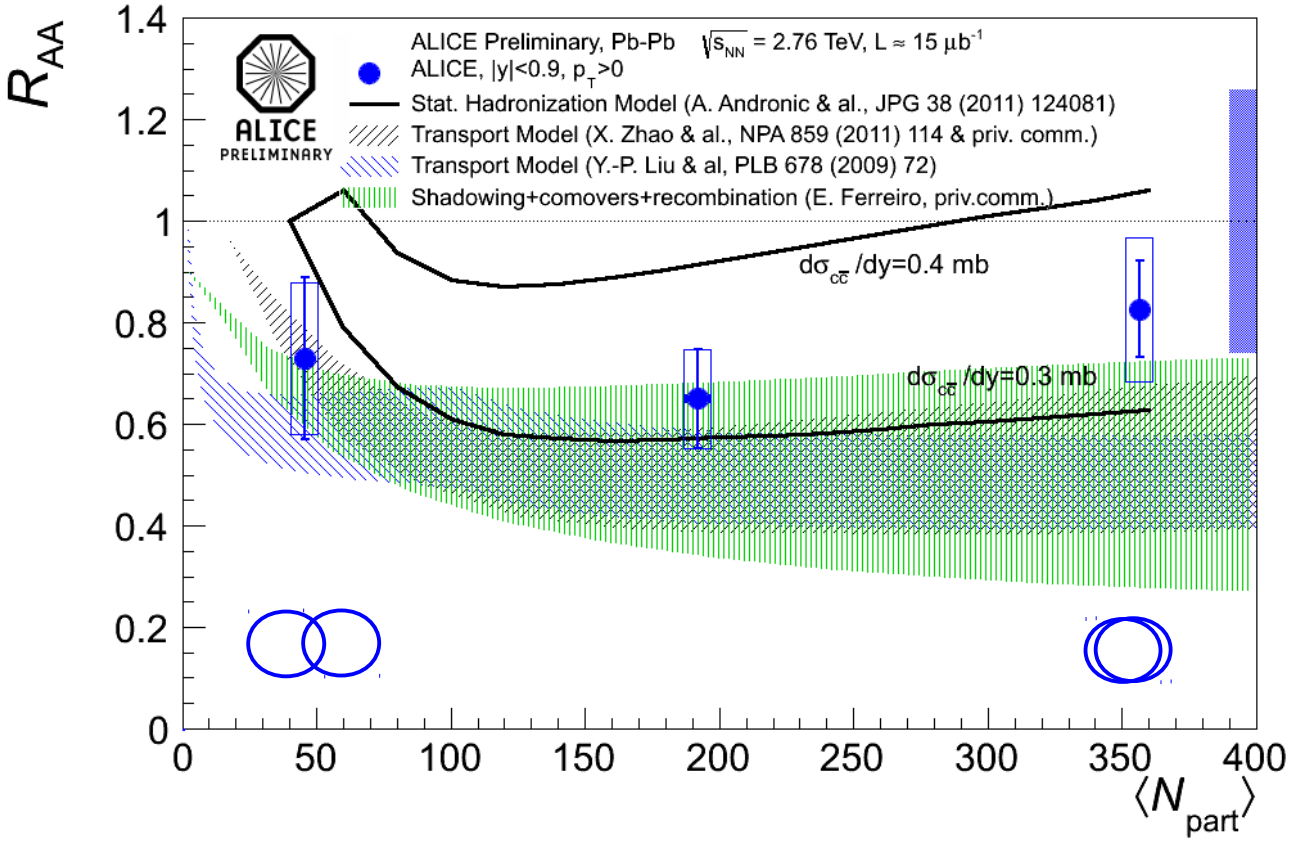
Inclusive J/ψ R_{AA} vs. centrality (models)



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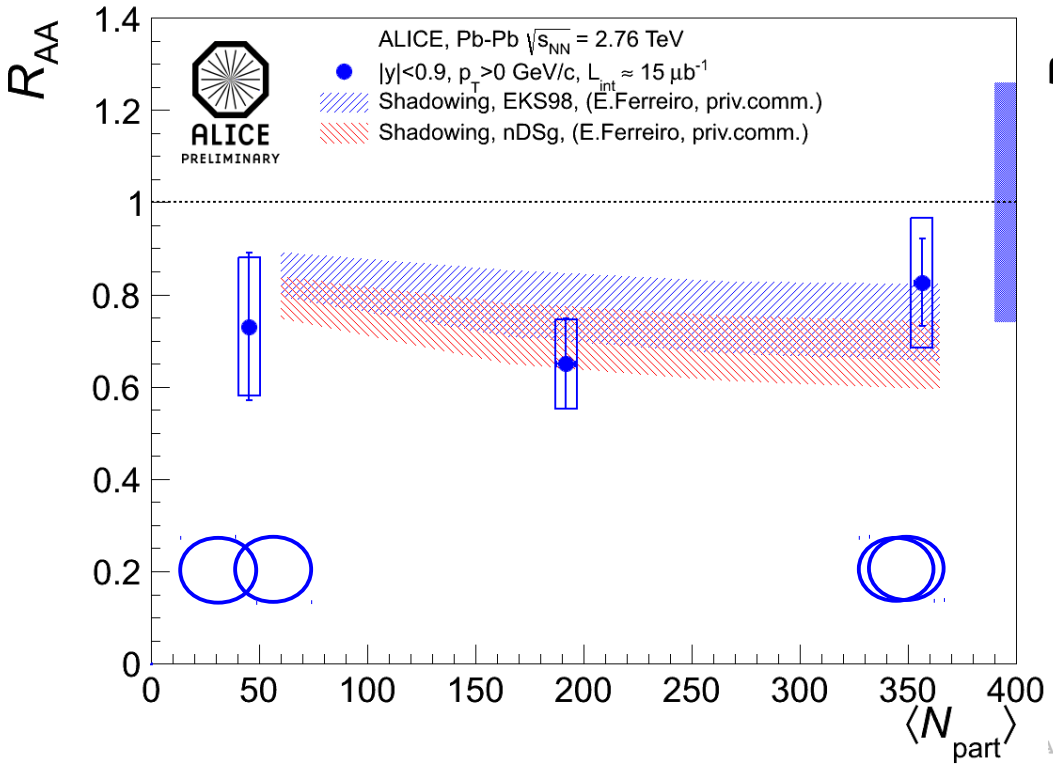
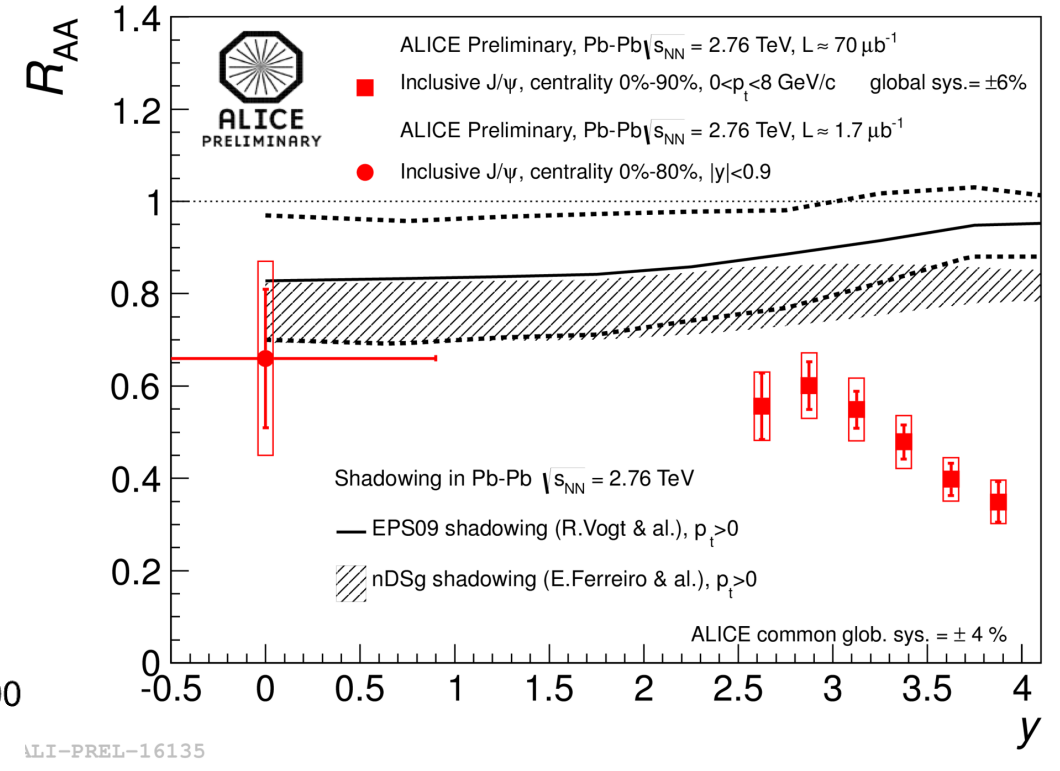
- J/ψ R_{AA} at the same charged particle density grows with energy
- Hint of a smaller suppression at mid- than at forward-rapidity in central collisions

- Models which consider the (re)combination of charm pairs at chemical freeze-out or during QGP lifetime are close to the data.
- Total cc-bar cross-section measurements necessary to constrain models

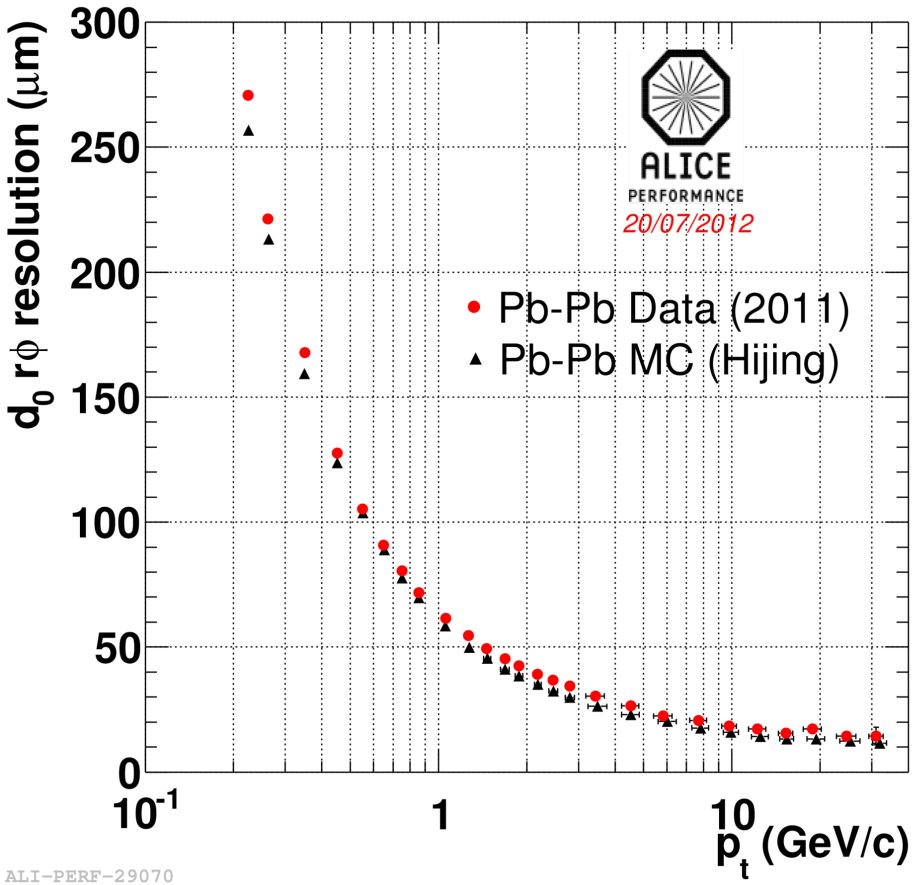
Inclusive J/ψ R_{AA} (shadowing corrections)



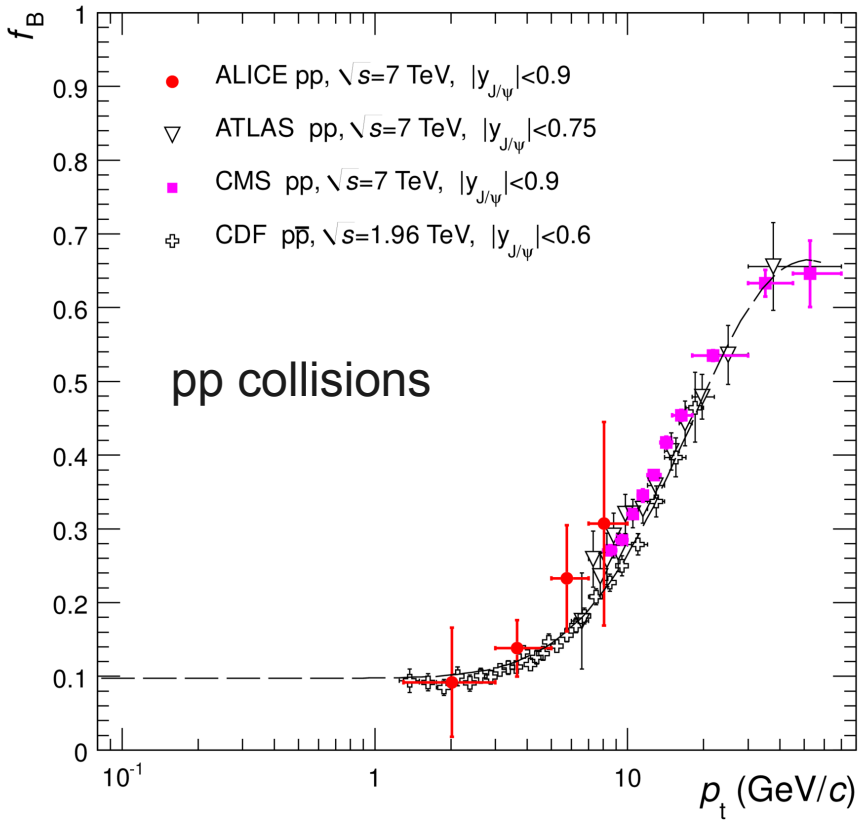


- J/ψ at mid-rapidity even less suppressed when considering current theoretical shadowing calculations.
- Cold nuclear matter effects will be investigated in the p-Pb run in 2013

Outlook: Prompt vs. non-prompt J/ψ suppression



ALICE Collaboration, arXiv:1205.5880



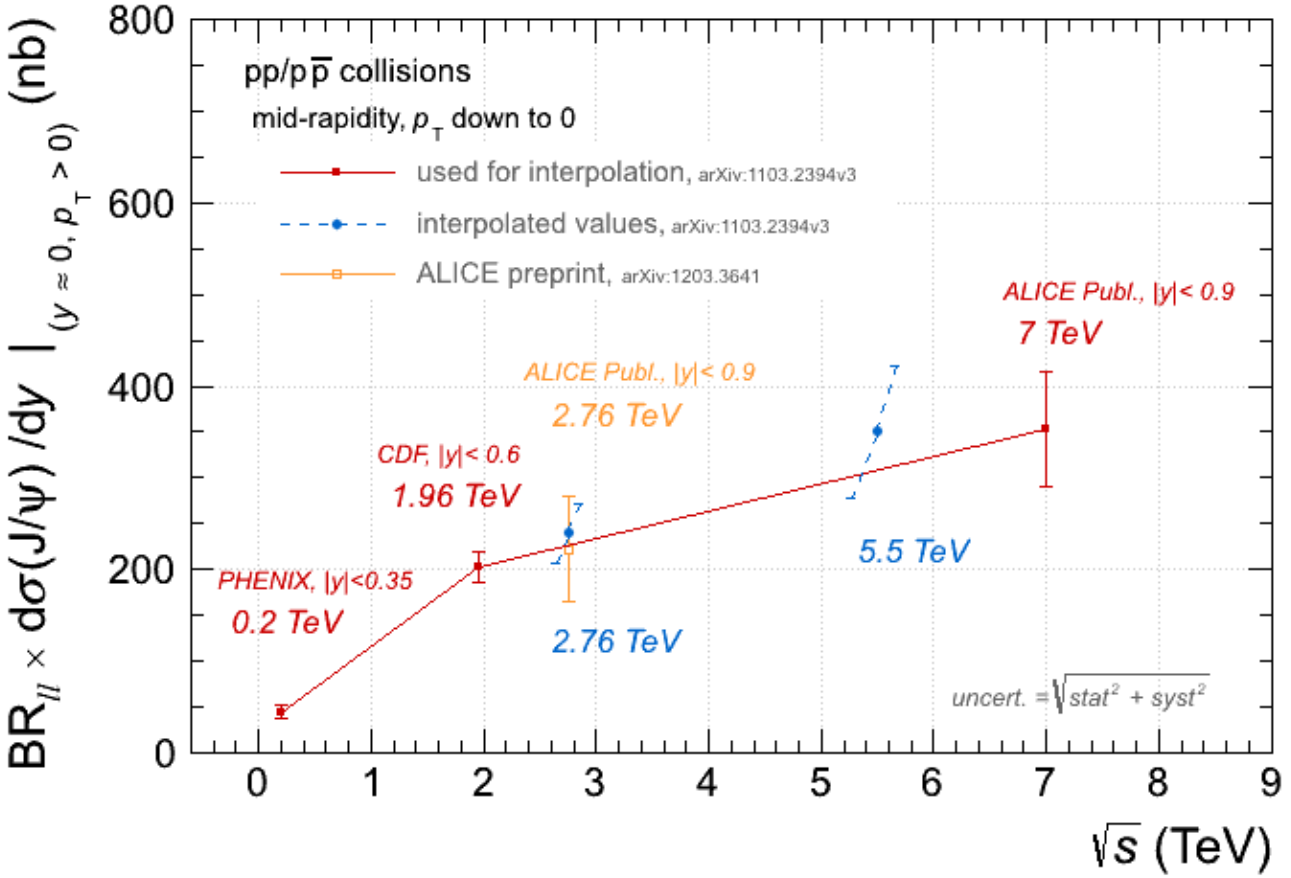
- The spatial resolution for tracks with p_T>1 GeV/c is better than 50 μm
  - Non-prompt J/ψ fraction from beauty decays can be extracted at mid-rapidity
  - Analysis already performed for pp collisions
- The R_{AA} for beauty hadrons can be obtained via the secondary vertex analysis
- No significant impact on the prompt J/ψ R_{AA}

Summary

- The nuclear modification factor for the inclusive J/ψ production has been measured in Pb-Pb collisions at mid-rapidity
  - R_{AA} at mid-rapidity in the most central collisions is higher than the PHENIX results at the top RHIC energy by approximately a factor 3.
  - R_{AA} decreases by a factor 2 from mid-rapidity to y~4
  - Calculations from models which include the mechanism of (re)combination during transport or at freeze-out are consistent with the data.
- Within uncertainties, the measured R_{AA} at central rapidity is consistent with no suppression relative to nuclear shadowing.
- Shadowing effects will be measured in the p-Pb run in 2013

Backup slides

pp reference for R_{AA} : interpolation



- Interpolation of $d\sigma/dy$ in pp collisions at $\sqrt{s}$ = 2.76 TeV at $y \approx 0$ using:
  - **PHENIX** data at $\sqrt{s}$ = 0.2 TeV
  - **CDF** data at $\sqrt{s}$ = 1.96 TeV
  - **ALICE** data at $\sqrt{s}$ = 7 TeV
- 3 interpolation strategies :
  - *ad hoc* functional form
  - FONLL based approach
  - LO CEM based approach

  → See arXiv:1103.2394v3

- Overall uncertainty of interpolated value approximately **2 times lower** than for the measured one