Inclusive J/ψ production at mid-rapidity in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV with ALICE

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ALICE

HGS-HIRe for FAIR
Helmholtz Graduate School for Hadron and Ion Research

UNIVERSITÄT
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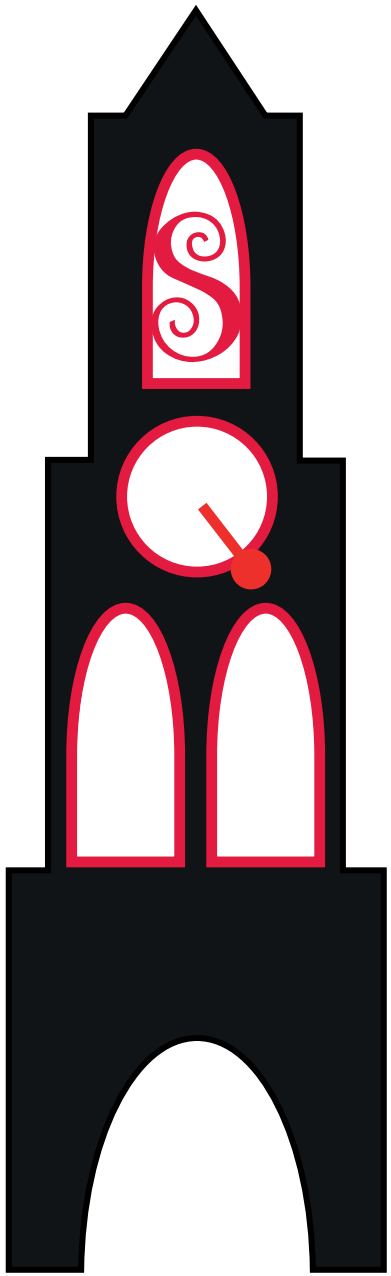
Outline

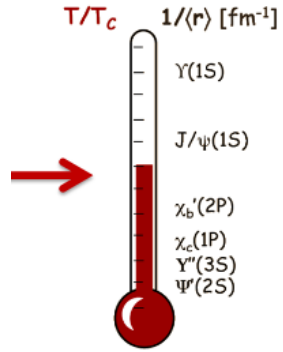
Utrecht 2017



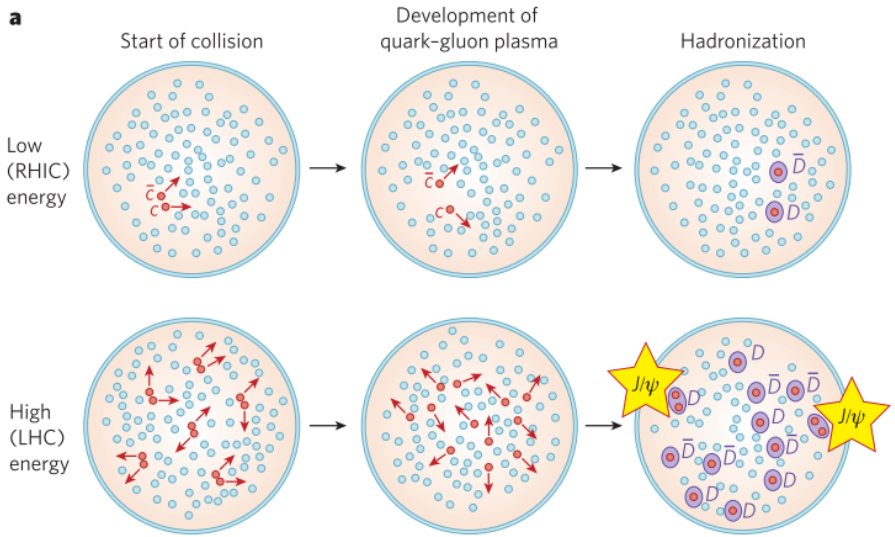
- **Introduction**
- **Results**
  - **Centrality and rapidity dependence**
  - **NEW: Transverse momentum dependence**
  - **Low p_T excess**
- **Summary and outlook**

Introduction

- J/ψ suppression via color screening initially suggested as sign of deconfinement (Matsui and Satz 1986)



- At LHC energies production of J/ψ at late stages from (re)combination of deconfined quarks is discussed:
  - Production at the phase boundary from fully thermalized charm
    (Stachel, Braun-Munzinger, 2000)
    $\rightarrow$ **Statistical hadronization model**
  - Production and destruction during lifetime of deconfined phase
    (Thews, Schroedter, Rafelski, 2001)
    $\rightarrow$ **Transport models**

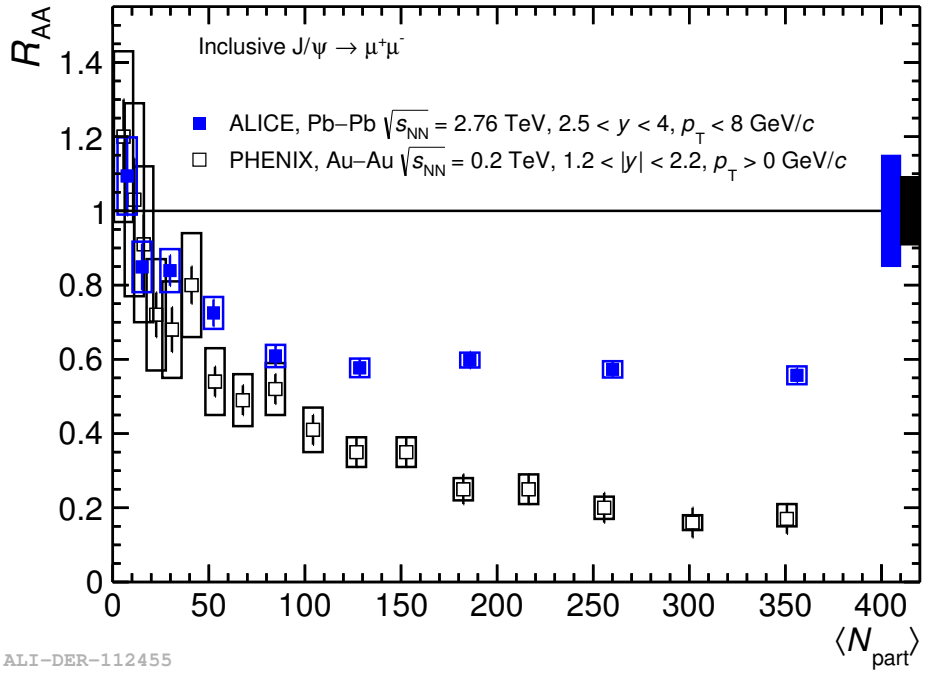


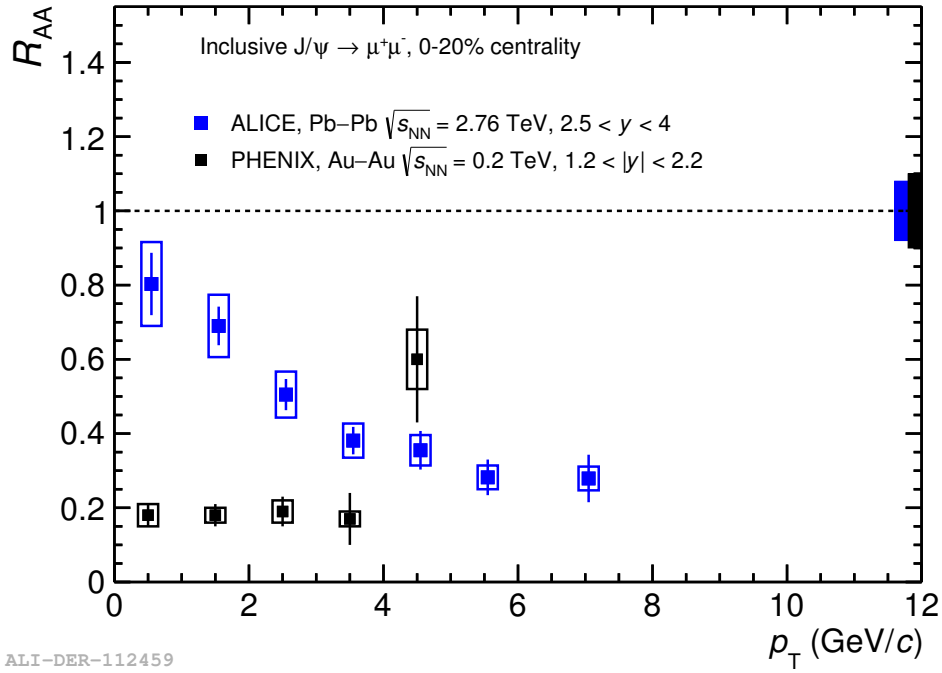
P. Braun-Munzinger, J. Stachel, Nature 448 (2007) 302

- J/ψ production in Pb-Pb is sensitive to deconfinement and thermalization of charm

Reminder: Lower energies ($\sqrt{s_{\mathrm{NN}}}$ = 0.2 TeV, 2.76 TeV)

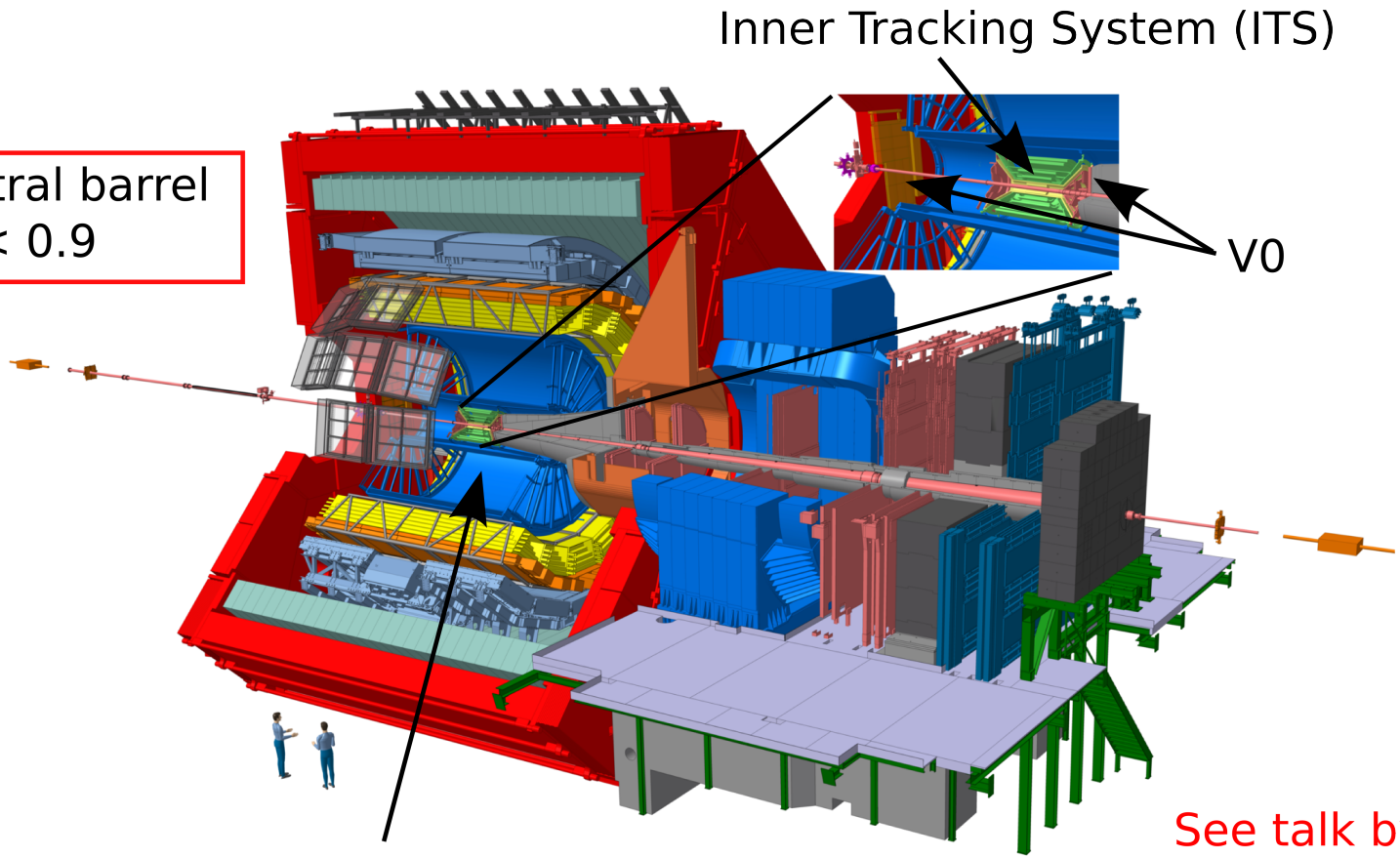
- Comparison of ALICE and PHENIX forward measurements:





- At LHC a significantly higher R_{AA} was observed at high centrality and low transverse momentum
- Was interpreted as a sign of J/ψ production by (re)combination
- How does it look at even higher collision energy?

The ALICE detector



See talk by A. Francisco (Parallel Heavy flavour 3)

- Reconstruction of $J/\psi \rightarrow e^+e^-$ (central barrel) and $J/\psi \rightarrow \mu^+\mu^-$ (muon spectrometer)
- Charmonium reconstruction down to $p_T = 0$

Electron selection

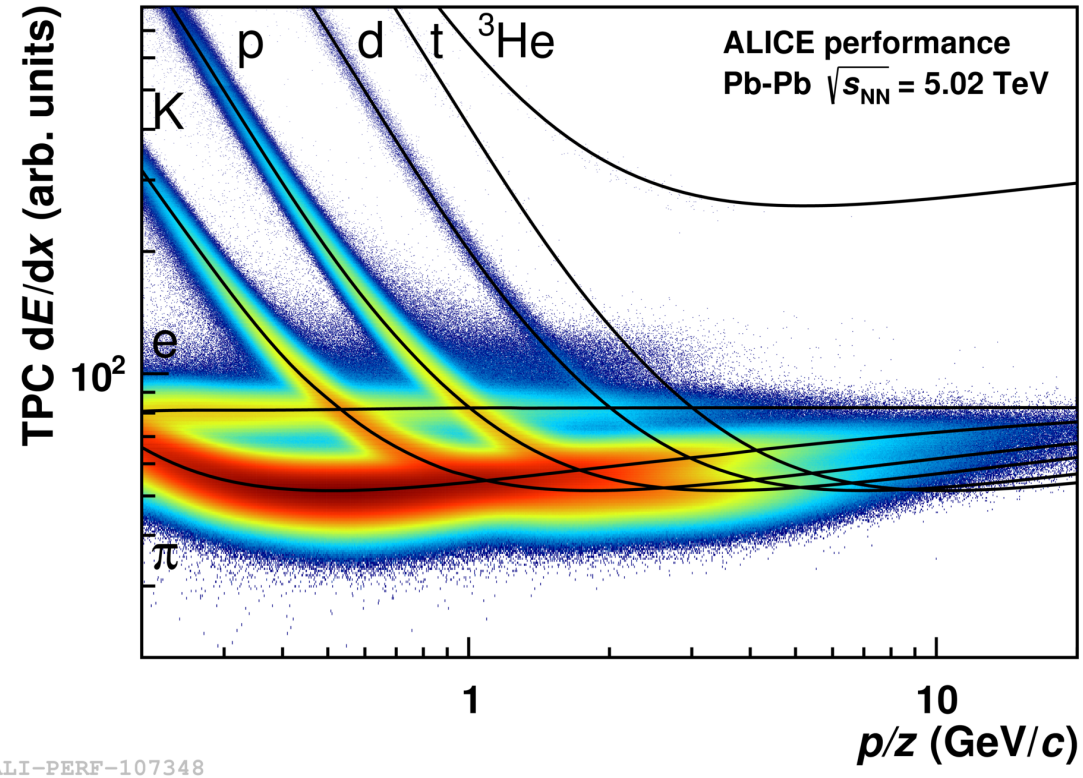
Kinematic cuts:
$p_{\mathrm{T}} > 1.0$ GeV/c
$|\eta| < 0.9$

PID cuts:
TPC dE/dx consistent with electron expectation

Tracking cuts:
Primary track selection

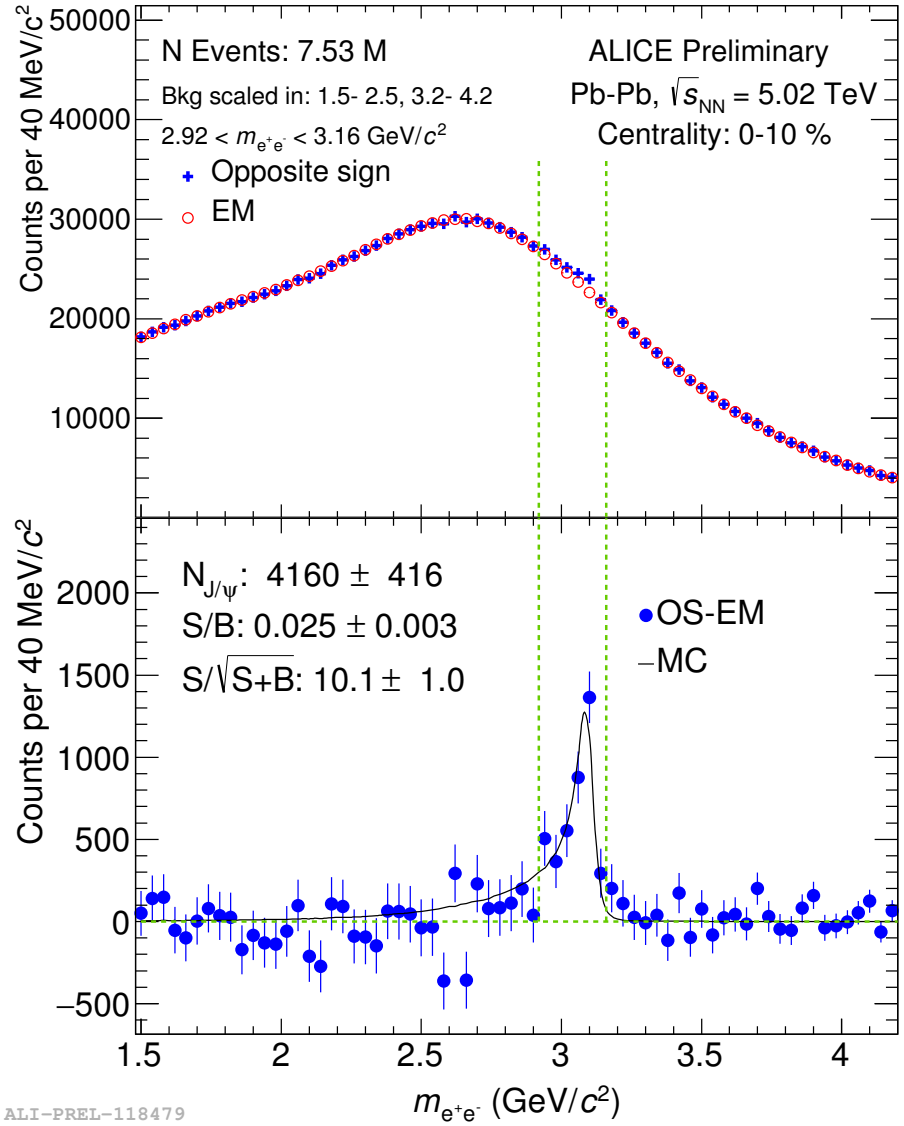
Conversion rejection:
Rejection of electrons from photon conversions

- Single track properties
- Invariant mass of pair

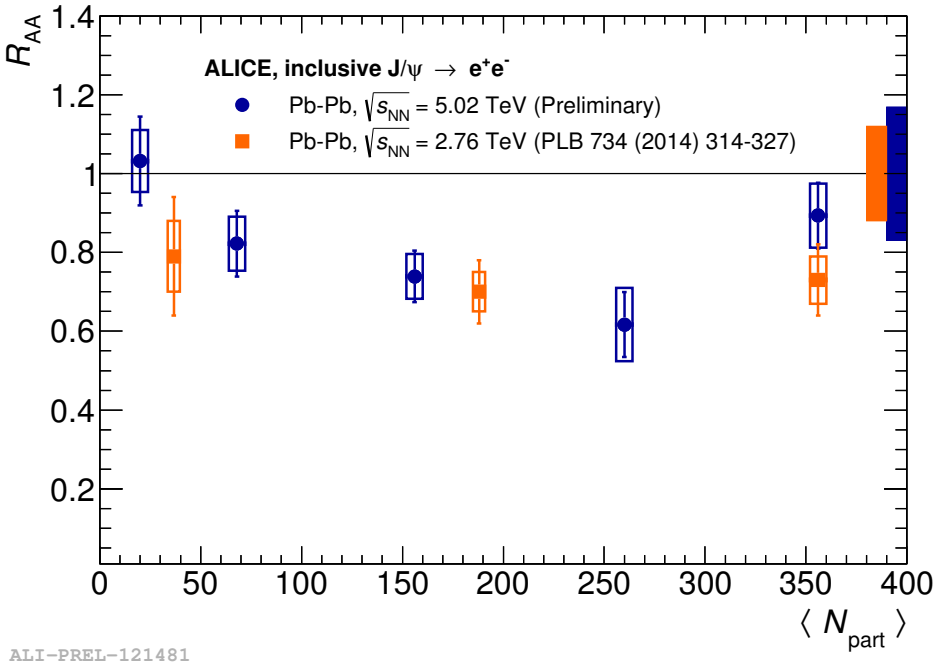


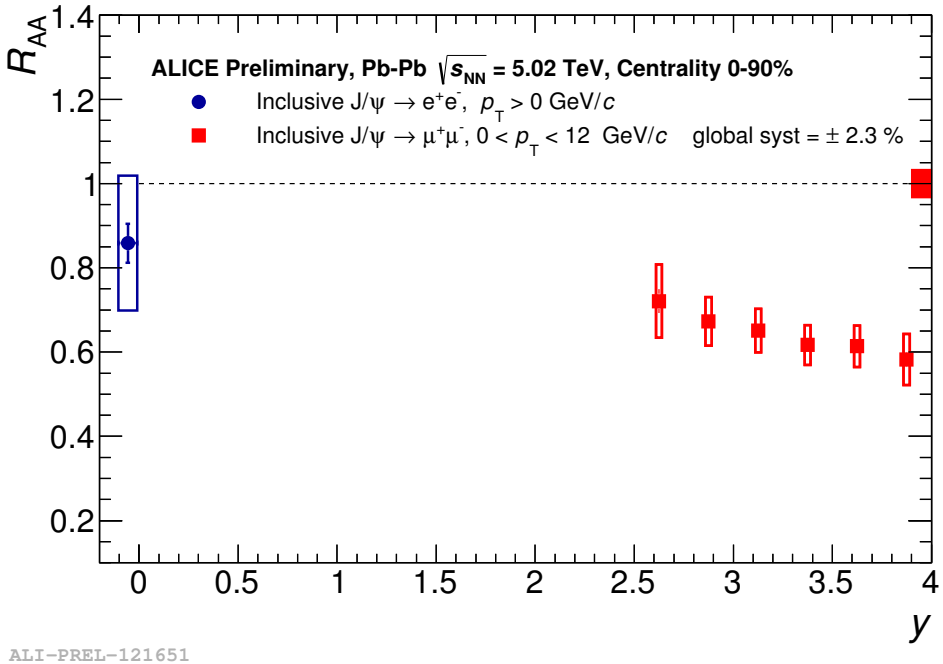
Signal extraction

- Mixed event background is normalized to the same event distribution in the mass range outside the signal region
- Raw J/ψ yield obtained by bin counting in the signal window (after background subtraction)
- Good description of peak shape by Monte Carlo template



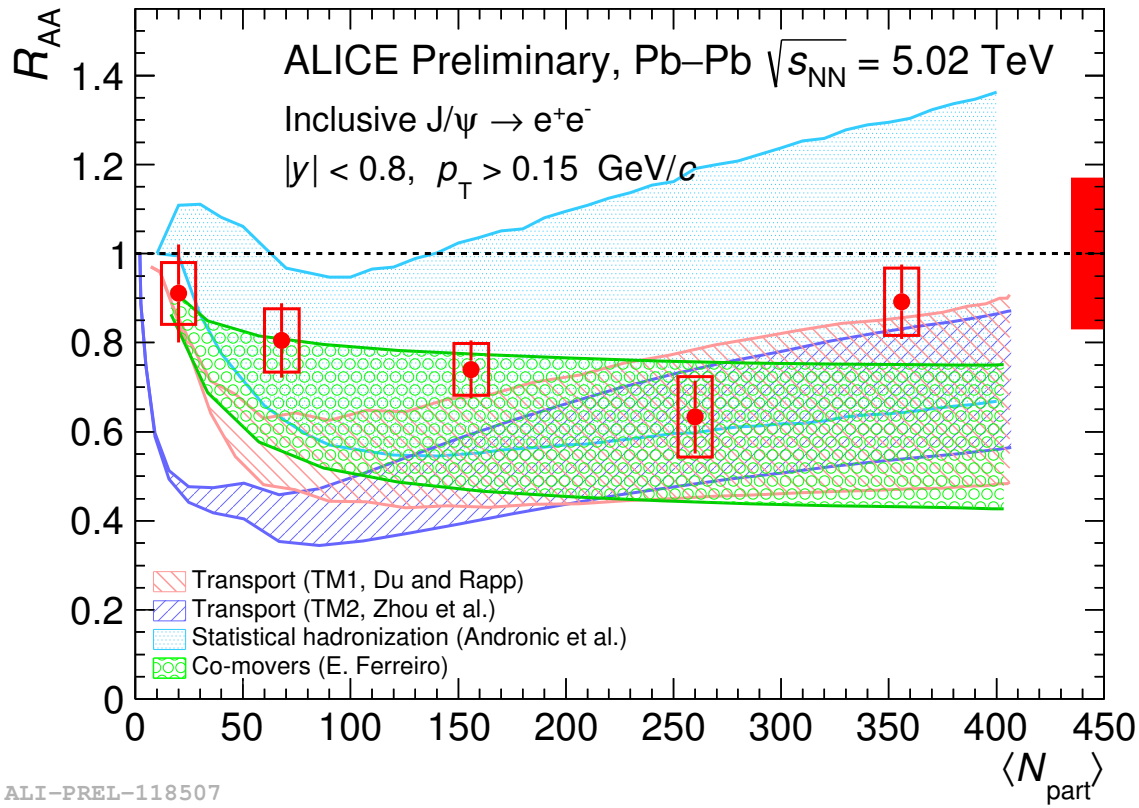
Centrality and rapidity dependence ($\sqrt{s_{NN}} = 5.02$ TeV)





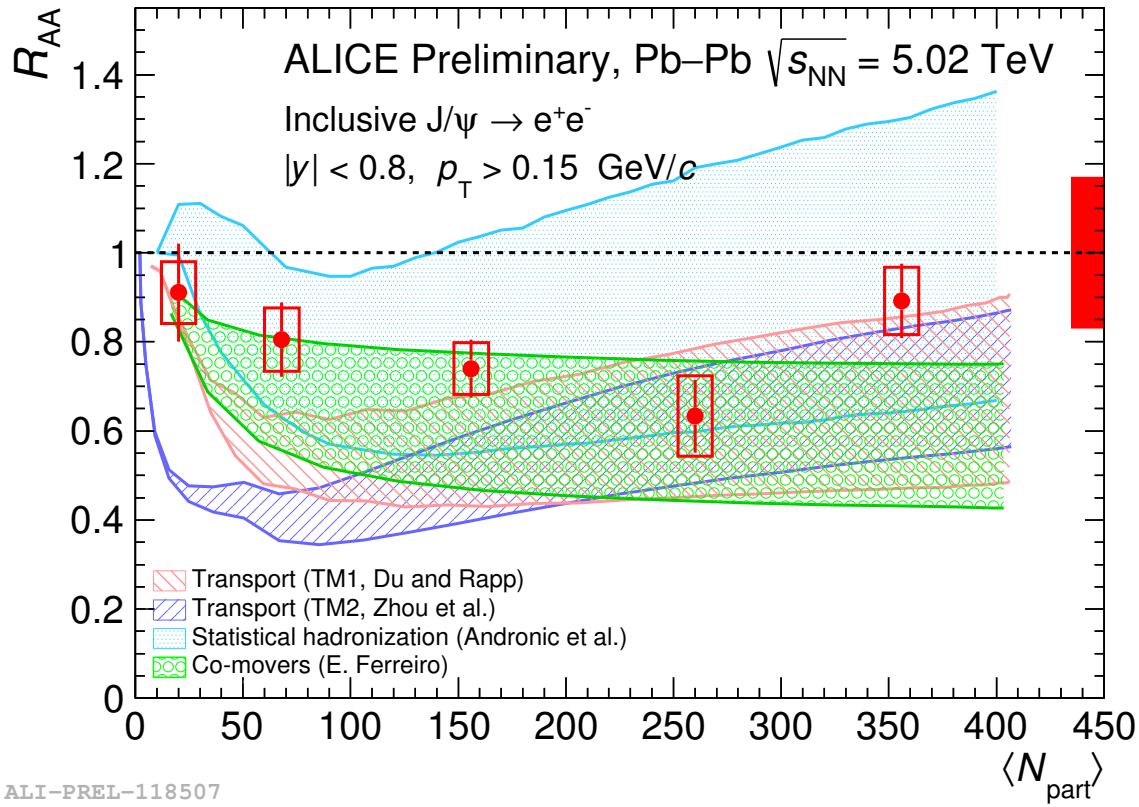
- pp reference cross-section is taken from an interpolation of measurements at $\sqrt{s} = 0.2$ (PHENIX), 1.96 (CDF), 2.76 (ALICE) and 7 TeV (ALICE)
- Hint of increase in most central collisions compared to lower collision energy (consistent with fluctuation)
- The data show a trend of enhanced J/ψ production towards mid-rapidity (expected by (re)combination models)

Centrality dependence: Model comparisons



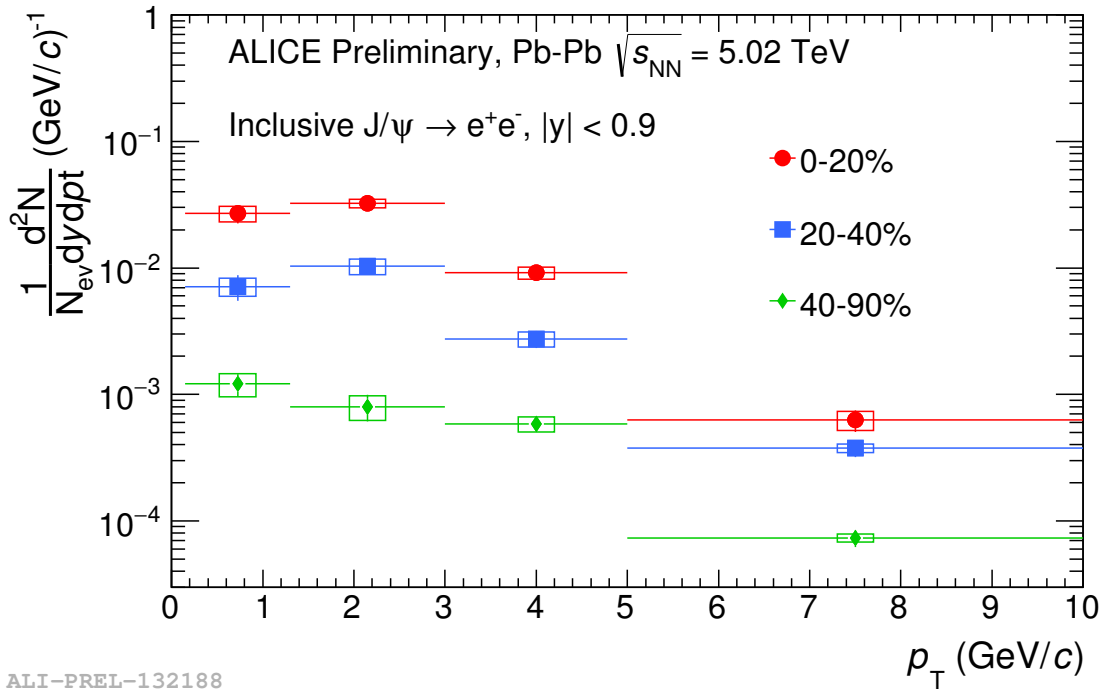
- **Transport models:** Part of J/ψ from direct hard production, part dynamically generated in QGP, part at hadronization (Nucl. Phys. A859 (2011), 114; Phys. Rev. C89 (2014) 054911)
- **Statistical hadronization model:** Assumes complete thermalization of charm, J/ψ are produced by recombination at the freeze-out stage (Nucl. Phys. A904-905 (2013) 535c)
- **Comover model:** Effective description of J/ψ destruction and (re)combination without assuming thermal equilibrium (Phys. Lett. B. 731 (2014), 57)

Centrality dependence: Model comparisons



- A strong (re)combination component is required to describe the data
- Models use different charm cross-sections
- Models are consistent with the data within their large uncertainties
- Theory uncertainties are dominated by $c\bar{c}$ cross-section and shadowing

NEW: Results for transverse momentum dependence!

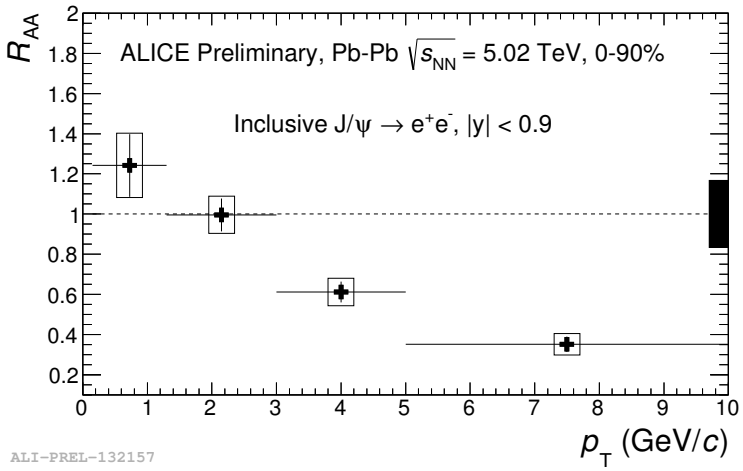


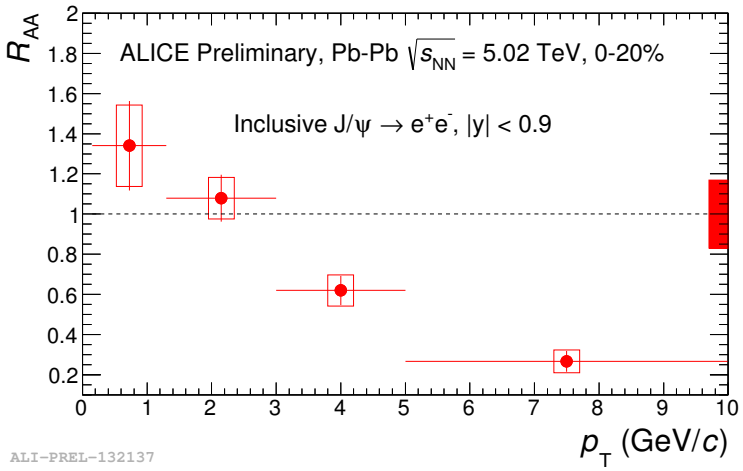
- J/ψ spectra obtained in 3 centrality intervals
- Photoproduction component ($p_T < 150$ MeV/c) is excluded

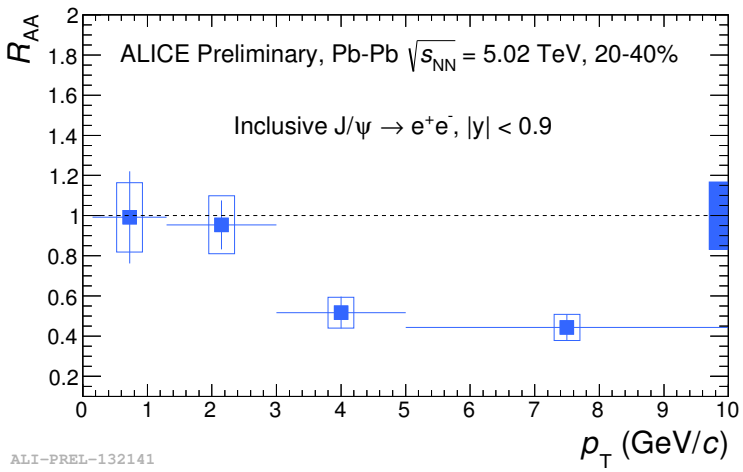
NEW

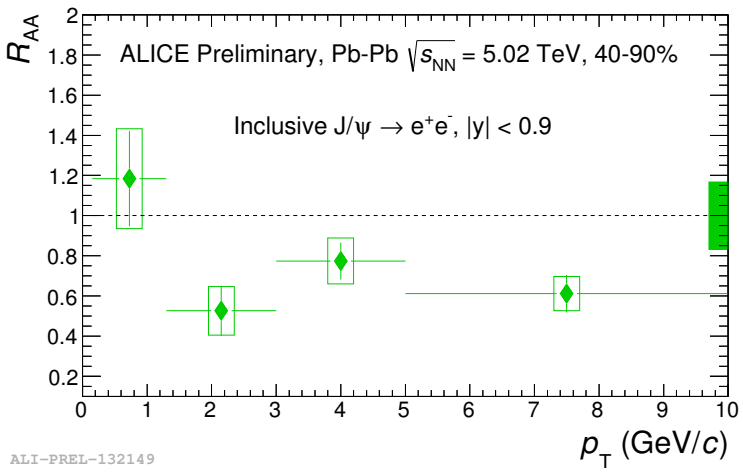
Transverse momentum dependence

NEW



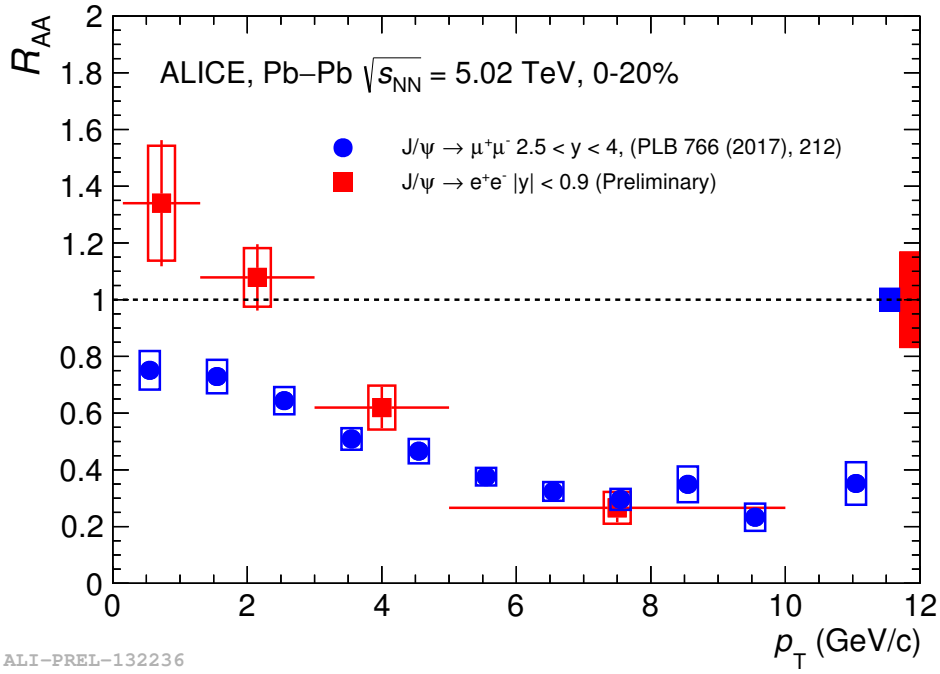


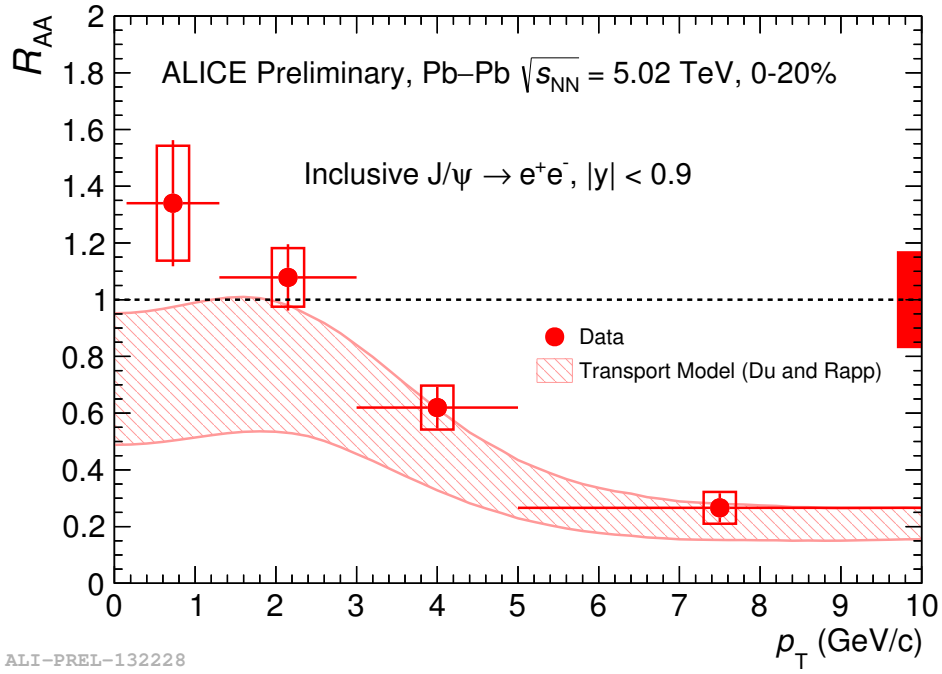




- Increase at low p_T points towards recombination
- Suppression at high p_T stronger in more central collisions

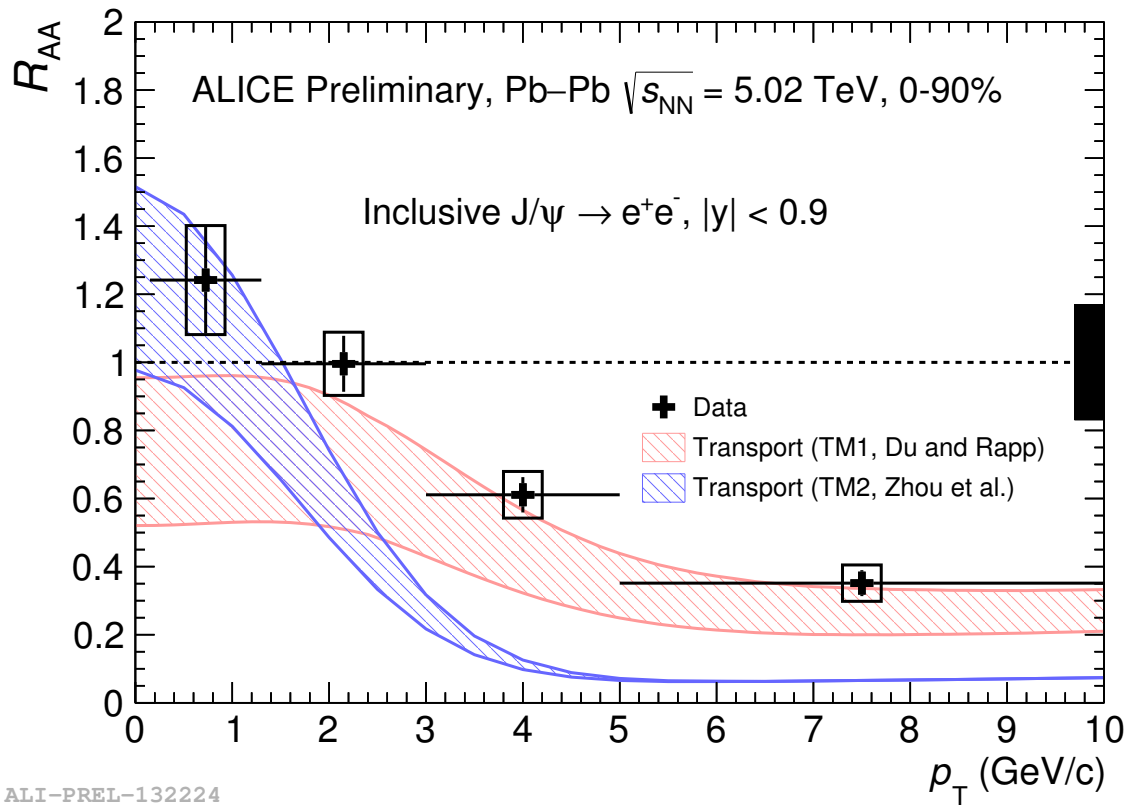
NEW Transverse momentum dependence: 0-20% centrality NEW





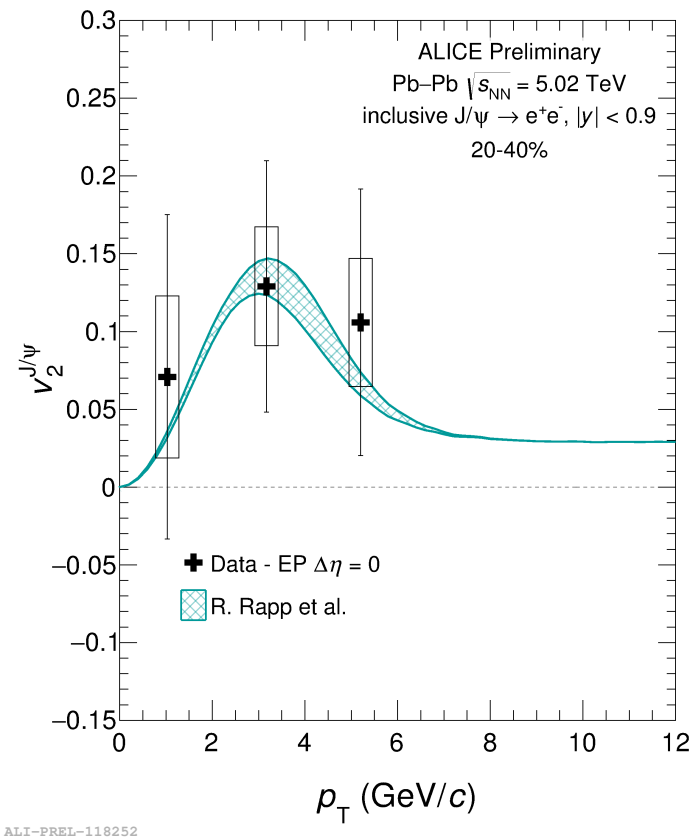
- Increase at low p_T compared to forward measurement ($R_{AA} \geq 1$!)
- Transport Model by Du and Rapp can describe the data within the uncertainties

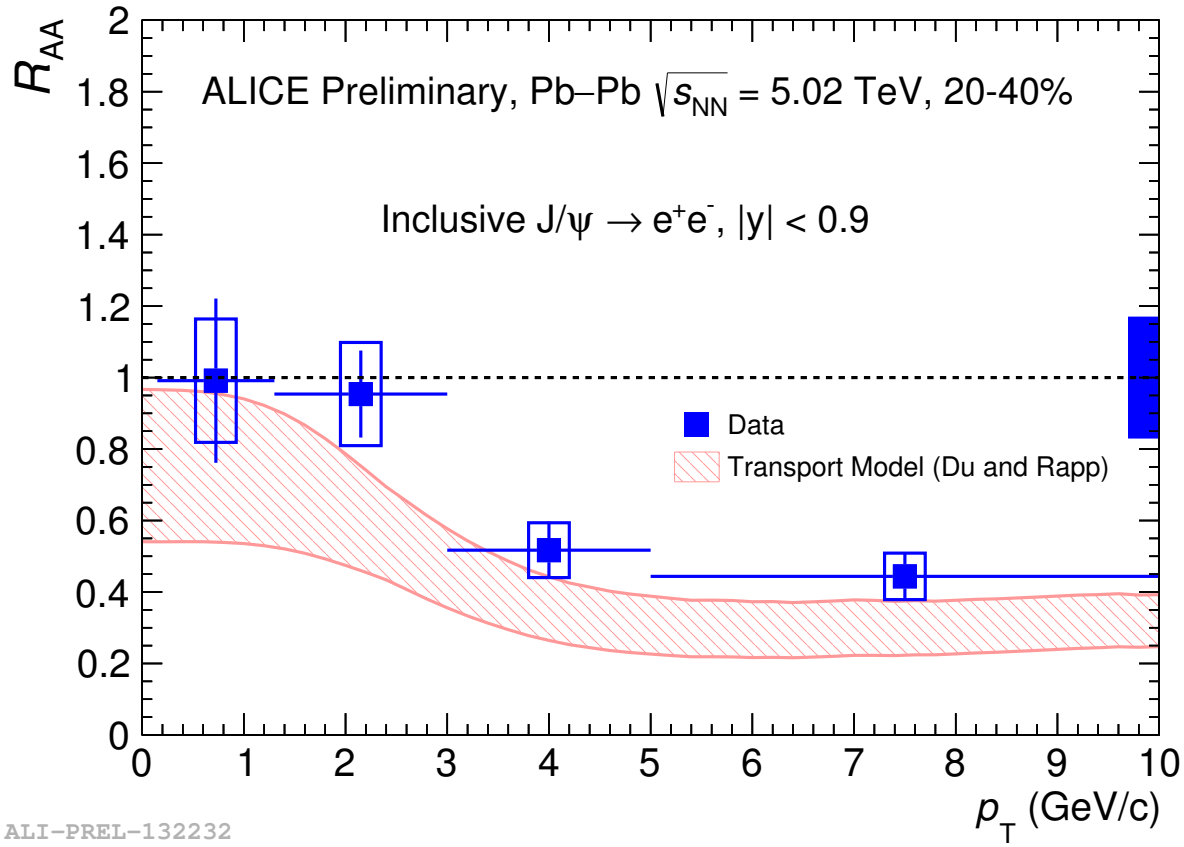
NEW Transverse momentum dependence: 0-90% centrality NEW



- Transport Model by Du and Rapp can describe the data within the uncertainties
- Transport Model by Zhou et al. significantly undershoots the data at high p_T

NEW Transverse momentum dependence: 20-40% centrality NEW

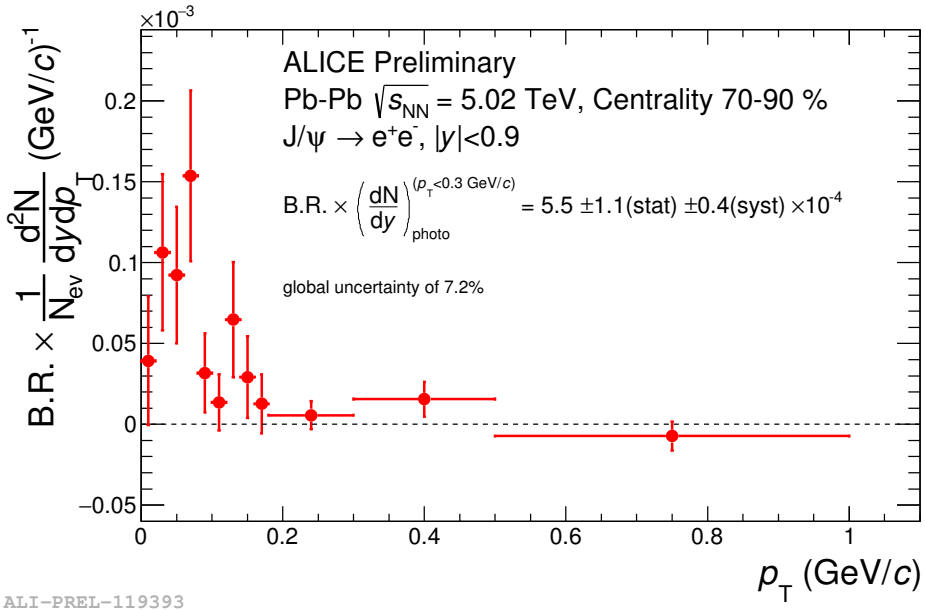


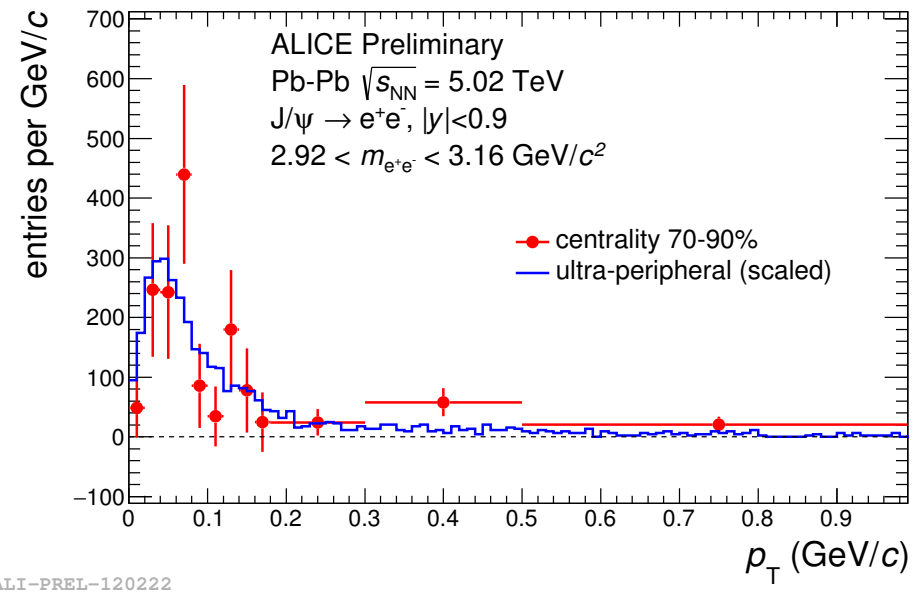


- Hint of non-zero elliptic flow of J/ψ indicates charm flow and supports (re)generation picture
- Both R_{AA} and v_2 are described by transport model by R. Rapp et al.

Low p_{T} J/ψ excess

- Observation of yield excess at very low transverse momentum in peripheral collisions:





- p_{T} distribution matches expectation from coherent photoproduction of J/ψ measured in **ultra-peripheral** collisions

Summary and Outlook

Summary

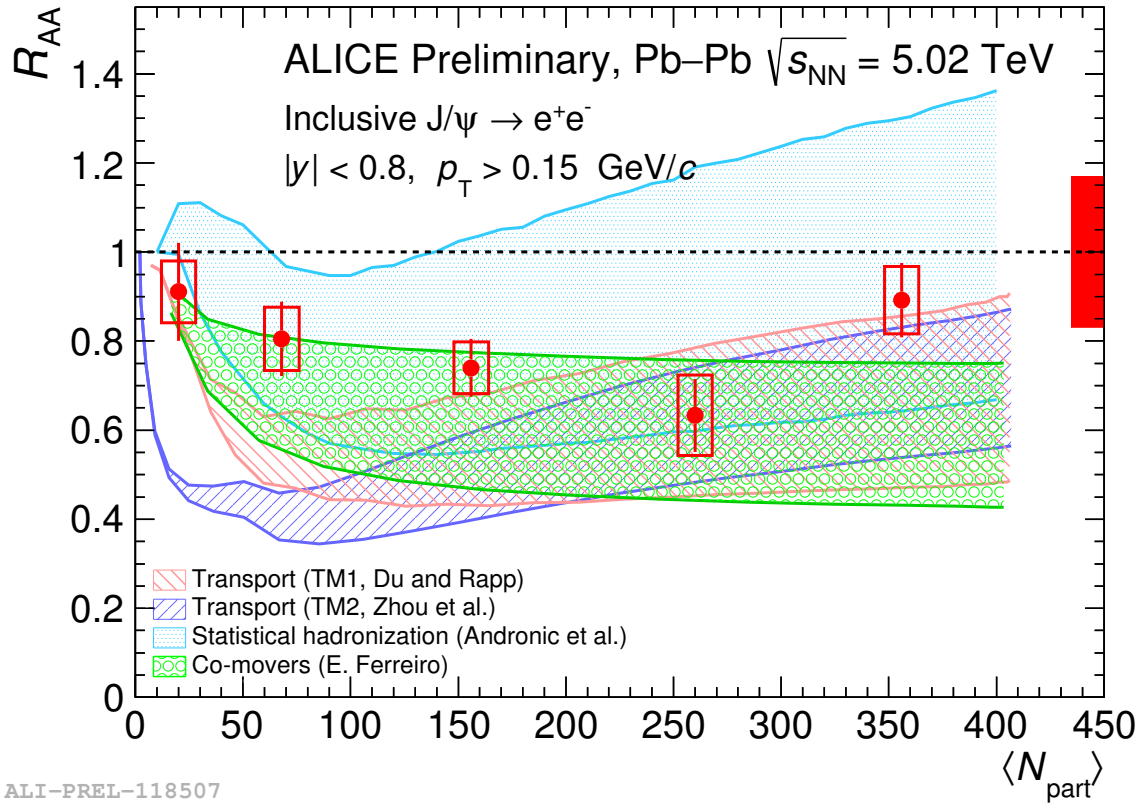
- We presented the measurement of the inclusive J/ψ R_{AA} as function of centrality, rapidity and transverse momentum
- Observation of an increase in R_{AA} at low p_{T} compared measurements at forward rapidity and at 2.76 TeV
- Inclusion of strong (re)combination component is required for models to describe the data

Outlook

- High statistics Pb-Pb run in the end of 2018
  $\rightarrow$ further reduction of statistical uncertainties
- Theory uncertainties need to be reduced to distinguish between models
  $\rightarrow$ measurement of charm cross-section in Pb-Pb in LHC Run3
- First measurement of J/ψ yield excess at very low p_{T} at mid-rapidity
  $\rightarrow$ new results soon to come

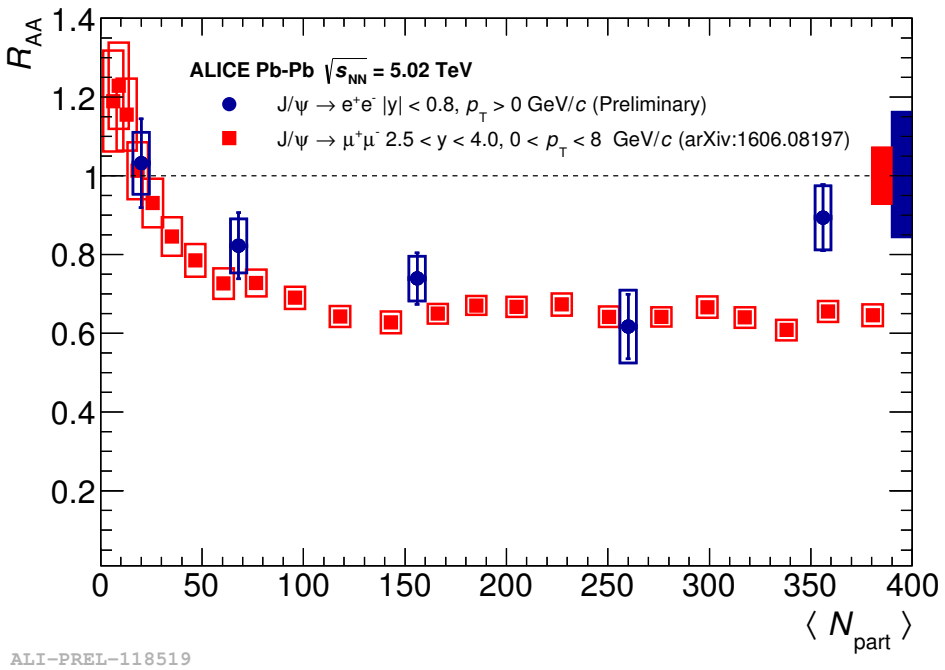
Backup

Model parameters



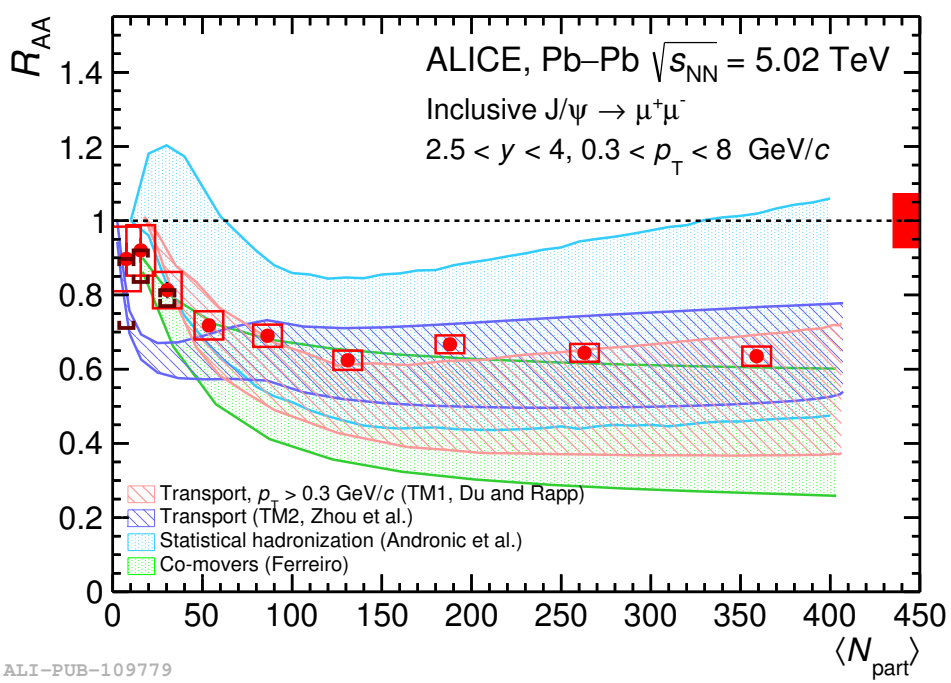
Model	$d\sigma_{c\bar{c}}/dy$ (mb)	Shadowing
TM1 (Du and Rapp)	0.72 ± 0.13	EPS09 NLO
TM2 (Zhou et al.)	0.86 ± 0.085	EPS09 NLO
SHM	0.560 ± 0.106	EPS09 NLO
Comovers	0.555 ± 0.105	Glauber-Gribov theory

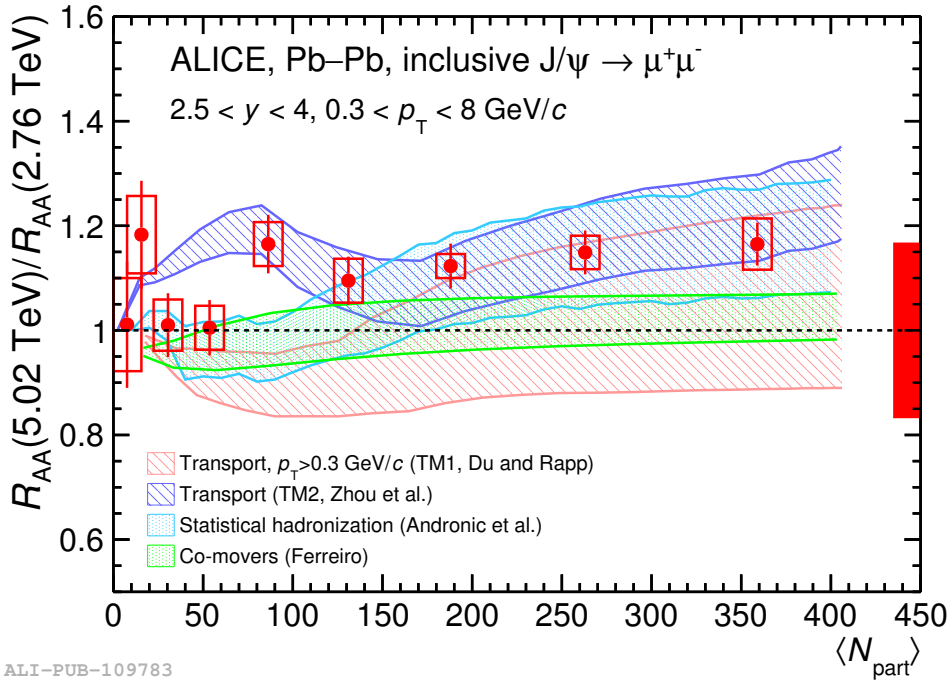
Centrality dependence compared to forward measurement



- Hint of increase with respect to forward measurement

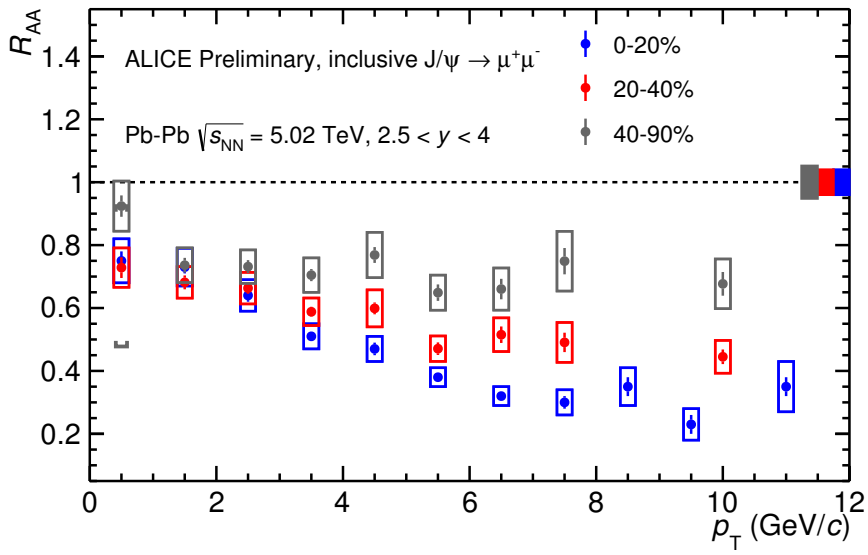
Forward results compared to model predictions





- Models can describe the data within their uncertainties
- Hint of increase with respect to measurement at lower energy

Transverse momentum dependence at forward rapidity in centrality bins



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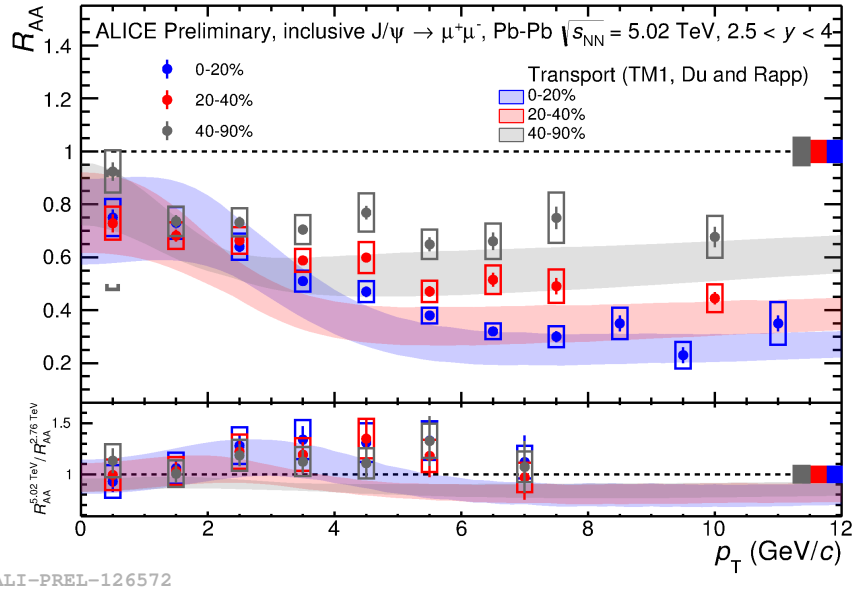

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- Higher supression observed in more central collisions at high p_T

Low p_T J/ψ excess

- In LHC Run1: First observation of yield excess of J/ψ in peripheral collisions measured at forward rapidity