INCLUSIVE J/ψ PRODUCTION IN pp, p-Pb AND Pb-Pb COLLISIONS AT FORWARD RAPIDITY WITH ALICE AT THE LHC

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for the ALICE collaboration

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OUTLINE

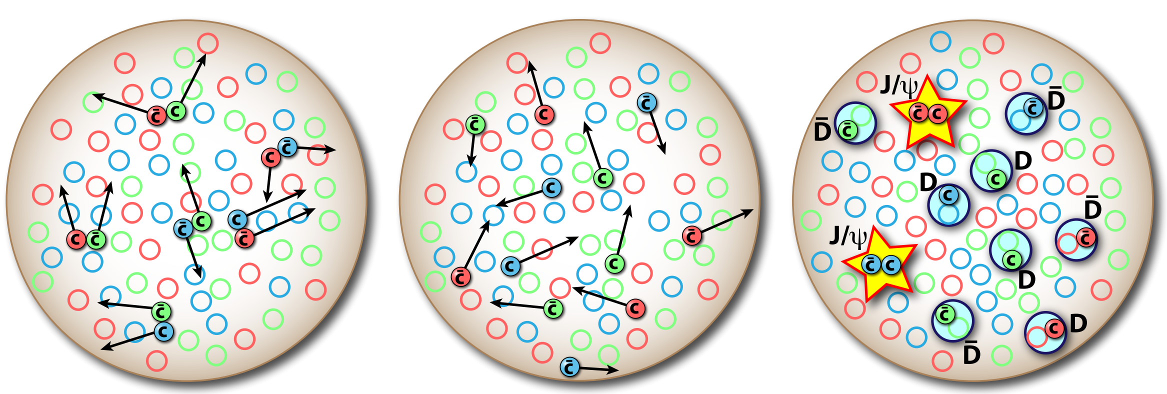
- Motivation
- Analysis
- Results
  - pp cross section
  - Nuclear modification factor in Pb-Pb
  - J/ψ elliptic flow in Pb-Pb
  - Nuclear modification factor in p-Pb
  - Cold nuclear matter effects in Pb-Pb
- Conclusions

MOTIVATION

Quark gluon plasma: Deconfined state of strongly interacting matter

In Pb-Pb collisions the conditions for QGP formation can be reached

- J/ψ suppression proposed as a signature of QGP formation
  - Melting due to Debye color-screening in the medium. [1]
- Temperature dependent sequential suppression of the quarkonium states [2]
- Cold nuclear matter effects play a role on J/ψ production
- Possible (re)combination of (un)correlated $c\bar{c}$ pairs could play a major role at LHC energies [3] [4] :
  - **Statistical Hadronization models [5]:** Deconfinement and thermalization of the bulk of the $c\bar{c}$ pairs. Statistical hadronization of charm quarks at the phase boundary responsible of charmonium production.
  - **Transport models [6]:** Dynamical competition between suppression in the QGP and regeneration mechanism.



[1] Phys.Lett. B 178(4), 416-422 (1986)
[2] Z. Phys. C51, 209 (1991)
[3] e.g. Phys.Lett. B 490, 196–202 (2000)
[4] e.g. Phys.Rev. C 63, 054905 (2001)
[5] e.g. JPG 38 (2011) 124081
[6] e.g. Phys.Lett. B 678 (2009) 72

MOTIVATION

Why study p-Pb collisions?

- Understand cold nuclear matter effects
- Necessary to disentangle hot (QGP related) and cold nuclear matter effects in Pb-Pb collisions

[1] e.g. Phys. Rev. C 88(2013) 047901
[2] e.g. arXiv:1205.1554 (2012)
[3] e.g. Phys. Rev. Lett. 109(2012)122301
[4] e.g. Nucl. Phys. A700(2002)539

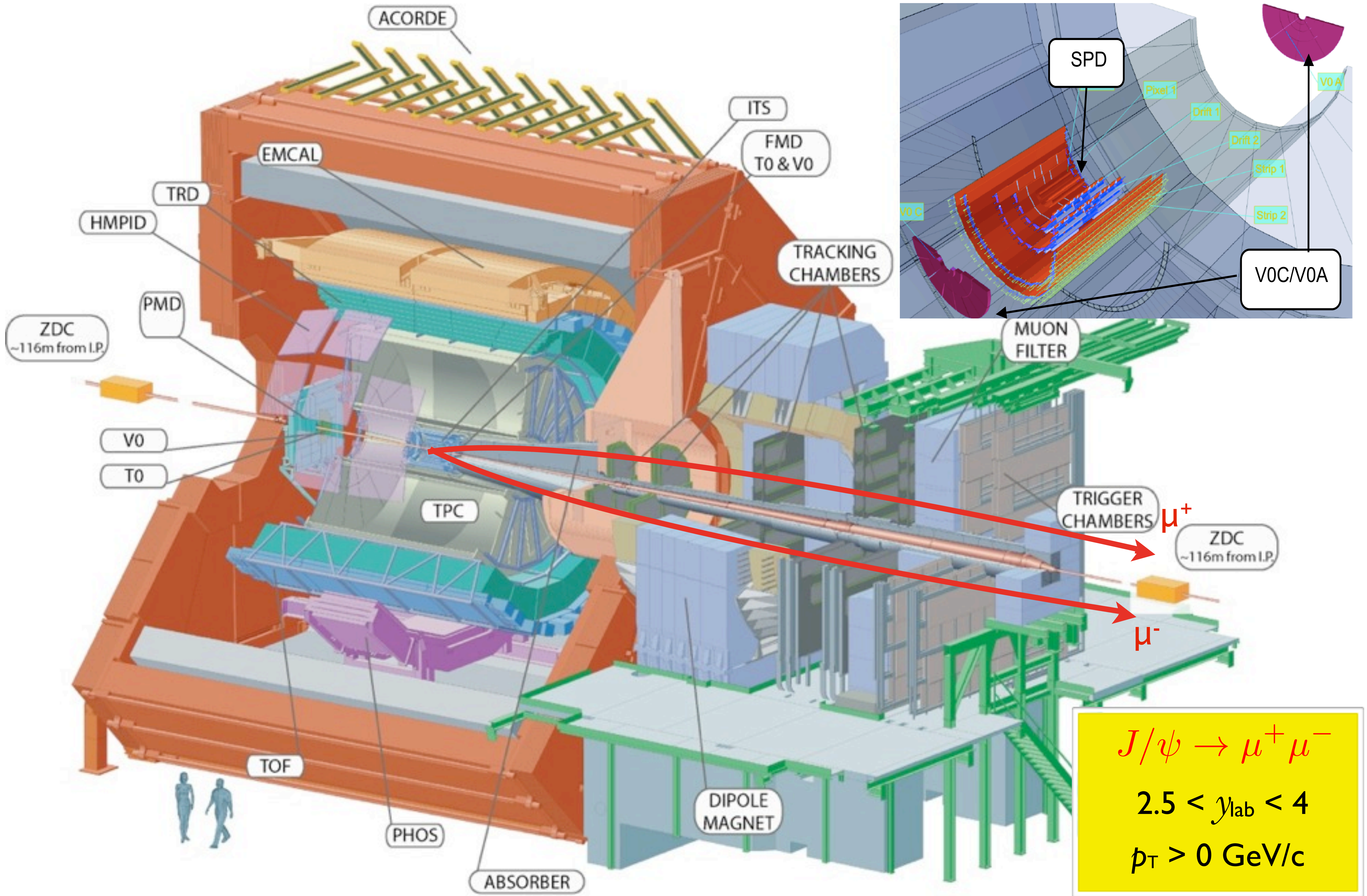
Cold nuclear matter effects:

- Initial state effects: **Gluon shadowing** [1] (or **saturation** [2])
  - Shadowing: gluon pdf in a nucleus $\neq$ in a nucleon (saturation: when energy is high enough, gluons start to recombine)

    Expected to be significant at LHC energies, depending on the kinematic domain
- **Coherent energy loss** [3]
  - The medium-induced gluon radiation modifies the initial-state gluon kinematics and affects the final-state $c\bar{c}$ pair
- Final state effects: **Nuclear absorption** [4]
  - Destruction of pre-resonant or final state J/ψ by collisions with nucleons

    Should be negligible at the LHC since crossing-times are smaller than quarkonium formation times.

THE ALICE DETECTOR



$J/\psi \to \mu^+\mu^-$

$2.5 < y_{lab} < 4$

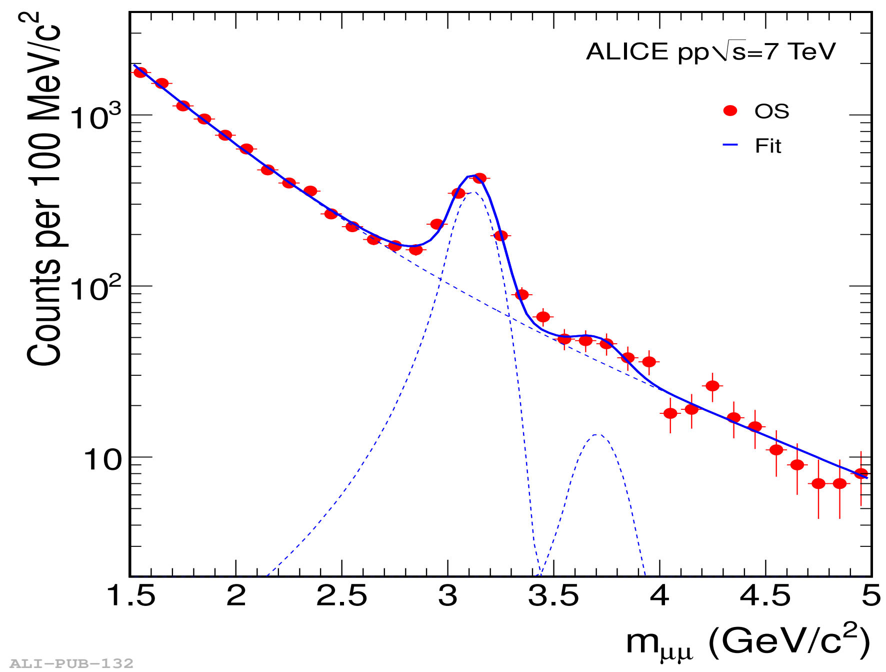
$p_T > 0$ GeV/c

DATA SELECTION

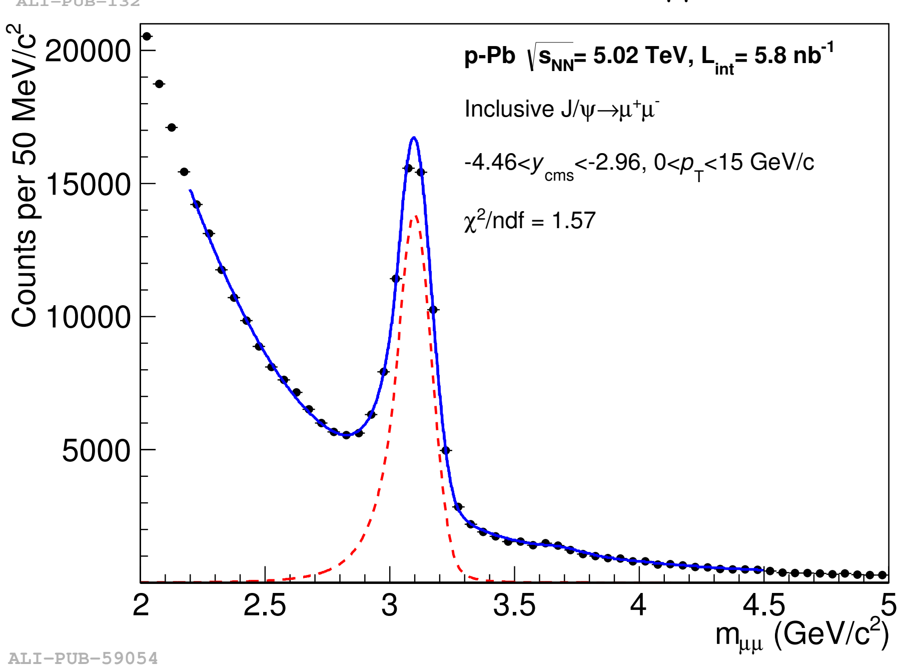
- **Event selection**
  - Minimum Bias (MB) trigger in pp : Signal in one of the two VZERO ($2.8 < \eta^{lab} < 5.1$ and $-3.7 < \eta^{lab} < -1.7$) or in the SPD.
  - MB trigger in Pb-Pb and p-Pb : Coincidence of the two VZERO detectors.
  - Rejection of beam-gas and electromagnetic interactions.
  - SPD used for vertex determination.
  - VZERO used for centrality determination in Pb-Pb and VZERO+ZDC in p-Pb.
- **Dimuon trigger**
  - MB & two opposite sign muon tracks in the trigger chambers
- **Dimuon analysis cuts**
  - Muon trigger matching
  - $-4 < \eta_{\mu}^{lab} < -2.5$
  - 17.6 cm < R_{abs} < 89.5 cm (R_{abs} is the track radial position at the end of the absorber)
  - $2.5 < y_{\mu\mu}^{lab} < 4$

SIGNAL EXTRACTION

pp and p-Pb

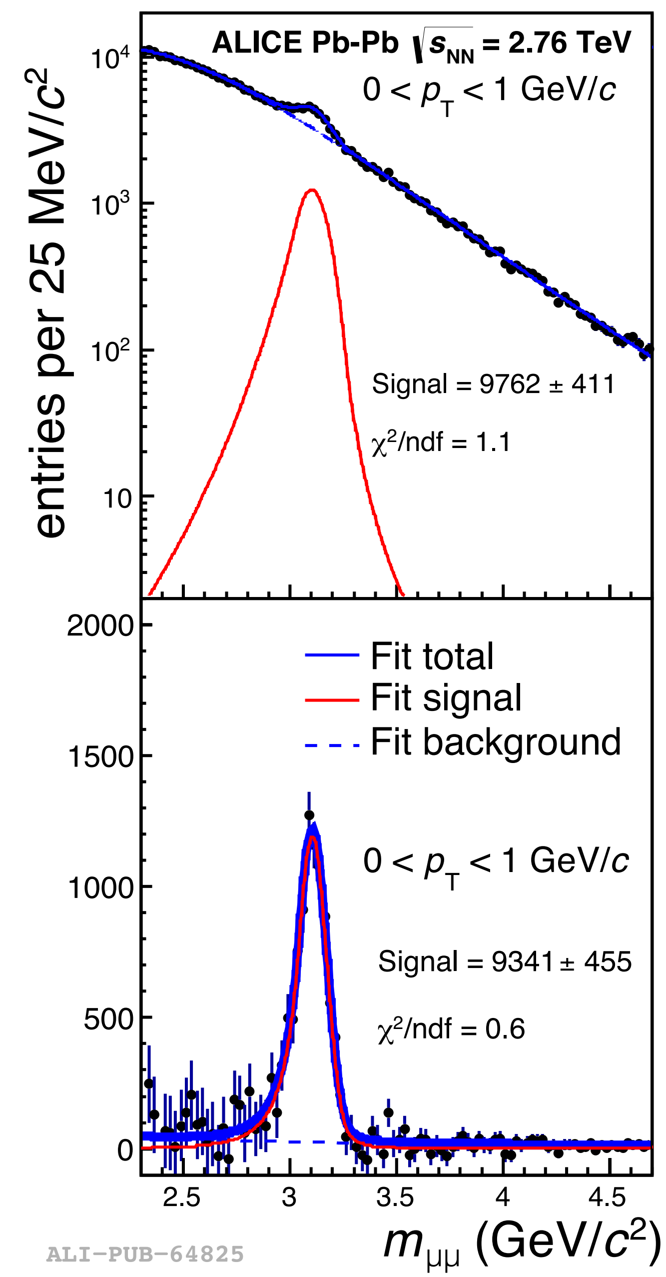


Phys.Lett. B704 (2011) 442-455



JHEP 02 (2014) 073

Pb-Pb



Phys.Lett. B734 (2014) 314-327

- **Background:** Sum of two exponentials (pp) or variable-width Gaussian or polynomial x exponential parametrization (p-Pb).
- **Resonance:** Crystal Ball or pseudo-gaussian function (only for p-Pb) with tails parameters tuned on MC.

- **Background:** variable-width Gaussian parametrization (top) or mixed event technique for subtraction (bottom).
- **Resonance:** Crystal Ball function.

pp CROSS SECTION

- pp measurements are crucial for a deeper understanding of the physics involving hadroproduction processes
- They provide also the reference for the measurement of nuclear effects in particle production in Pb-Pb and p-Pb

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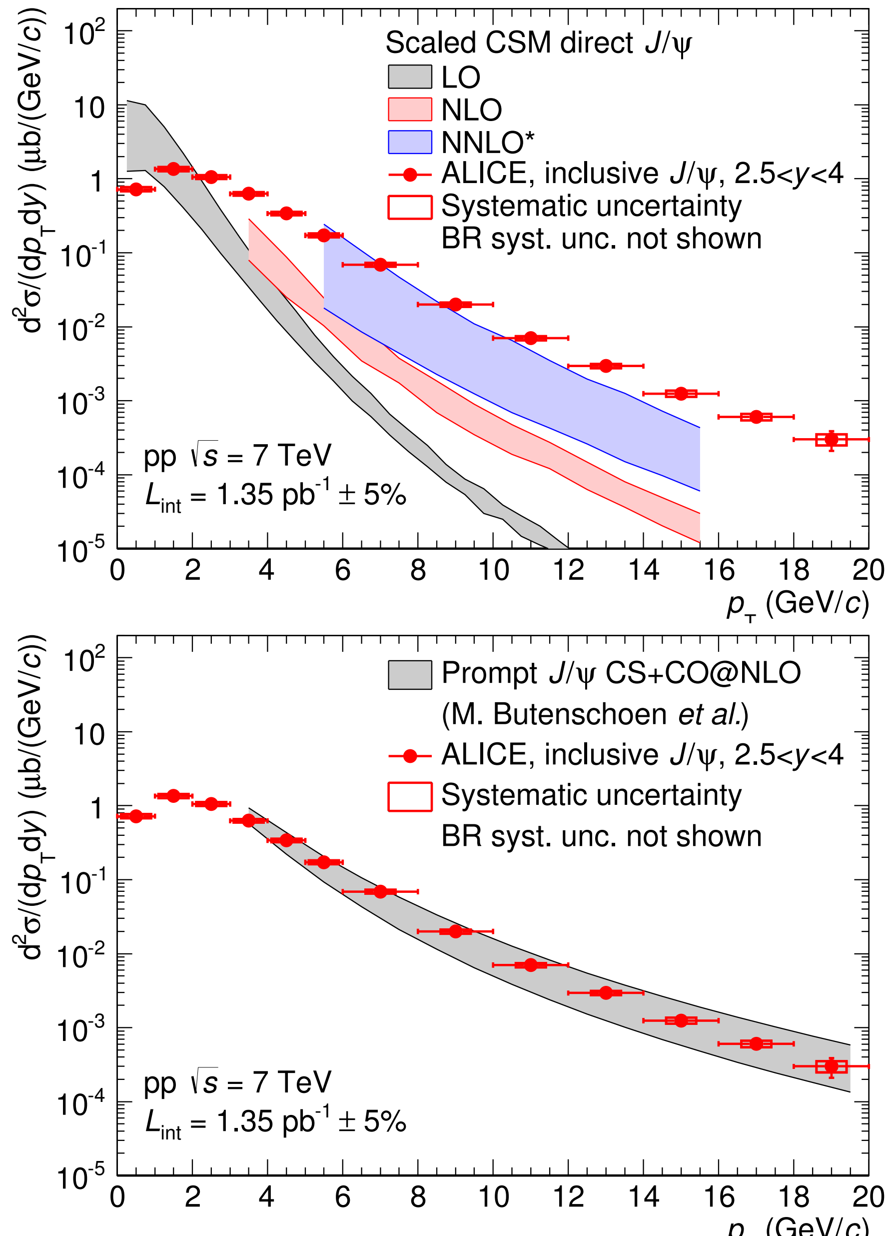
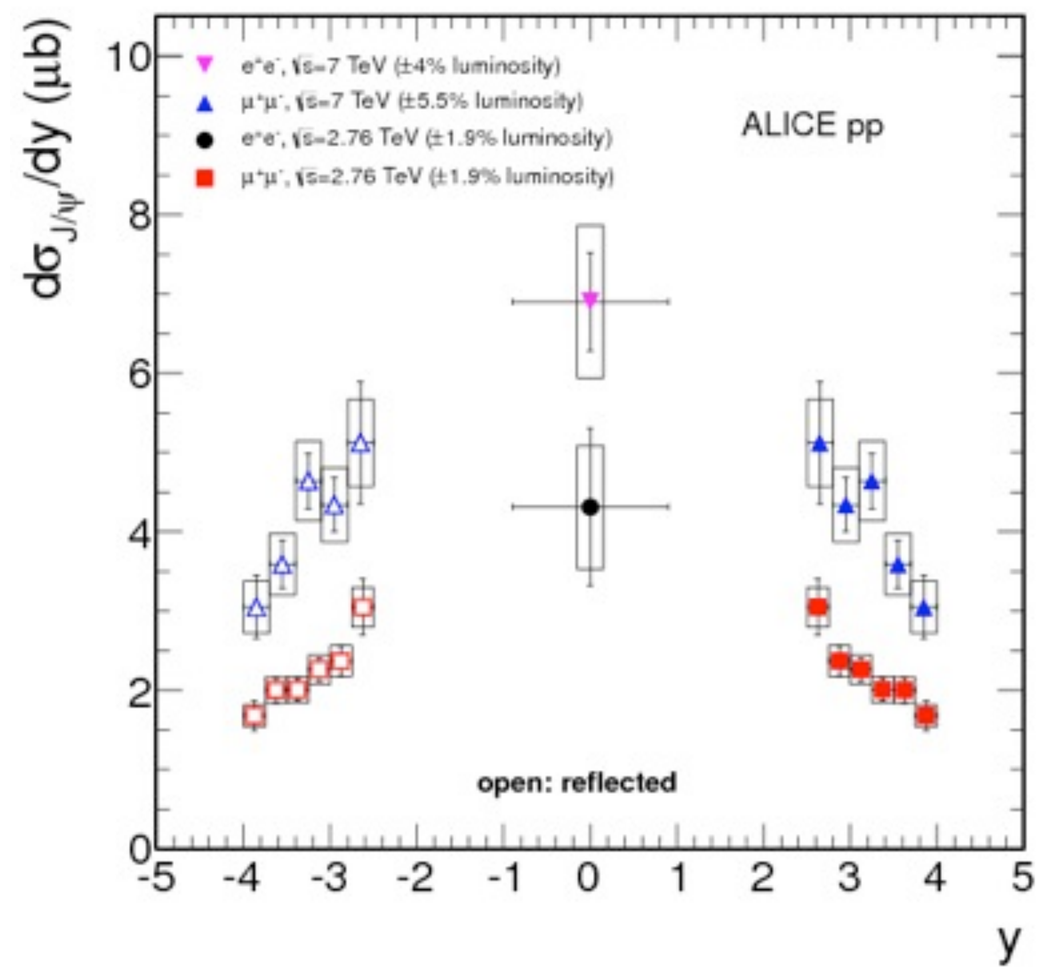


Eur.Phys.J. C74 (2014) 2974



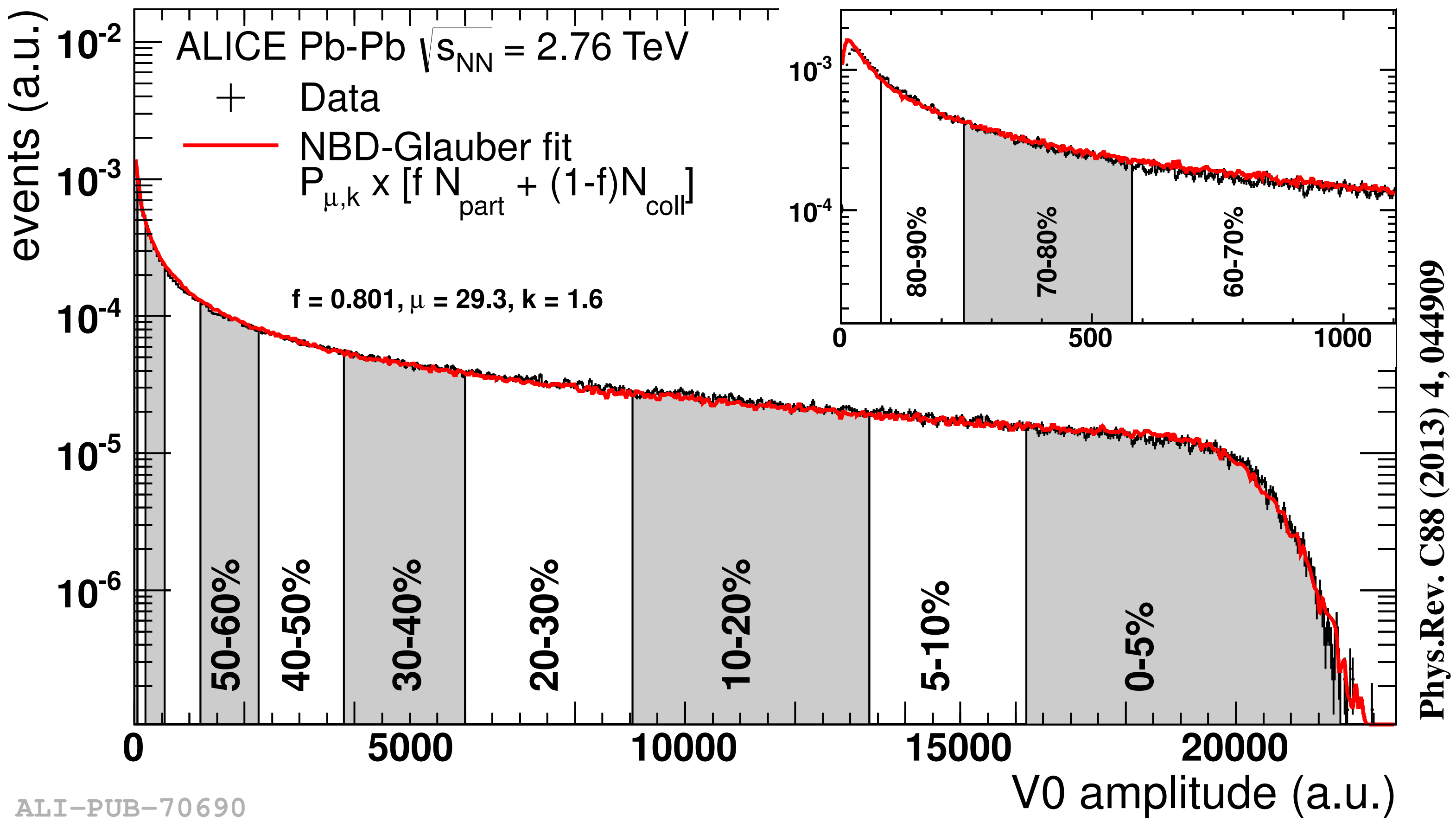
Phys.Lett. B718 (2012) 295-306

- CSM (only color-singlet (CS) quark pairs considered) at LO underestimate the data for p_T > 2 GeV/c, the addition of NLO and some NNLO terms improves the agreement at high p_T
- NRQCD calculations with CS and CO terms describe the p_T dependence of data

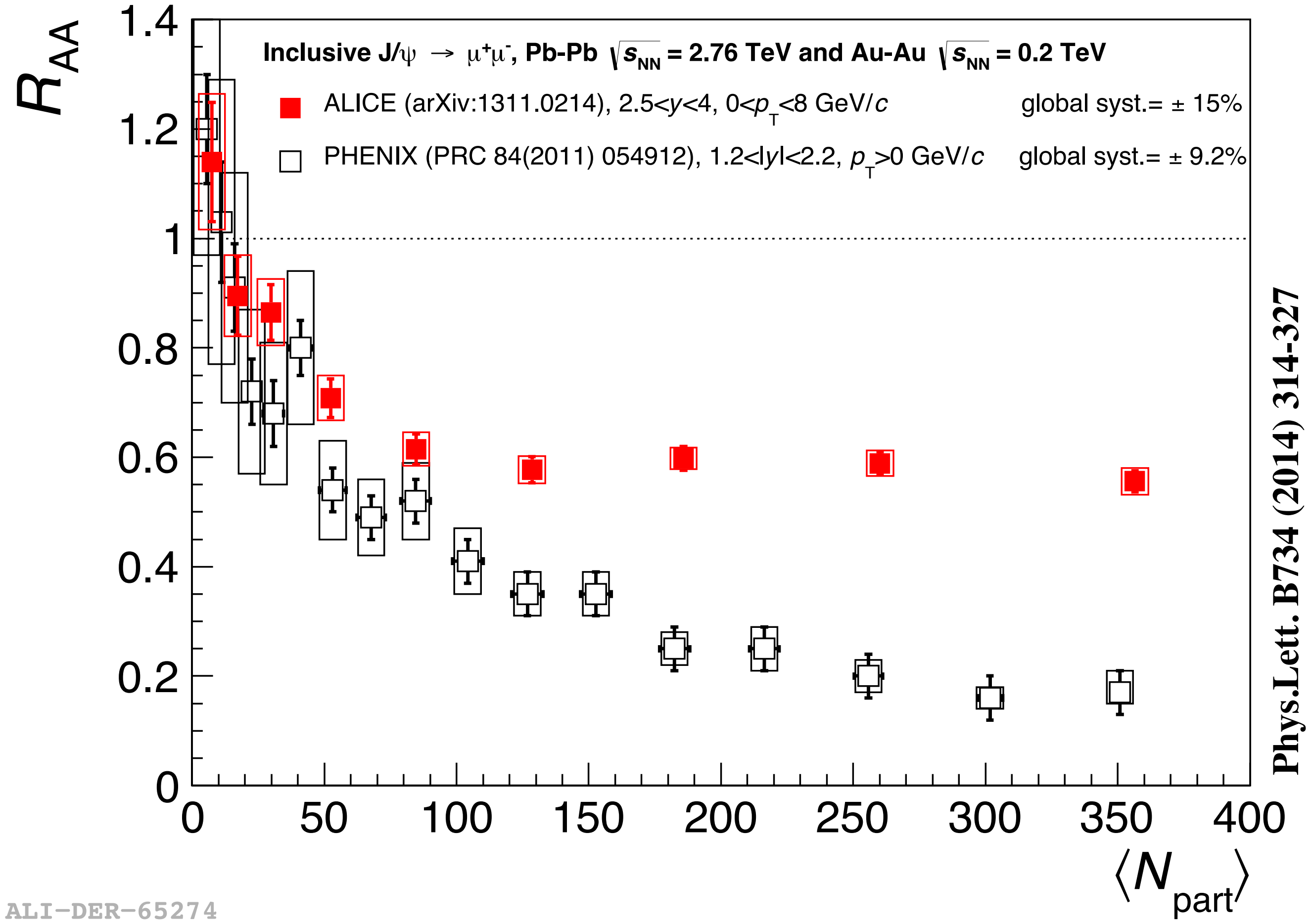
R_{PbPb} MEASUREMENT

$$R_{PbPb}^{J/\psi} = \frac{Y_{PbPb}^{J/\psi}}{< T_{PbPb} > \sigma_{pp}^{J/\psi}}$$

- **pp reference cross-section**: pp at 2.76 TeV cross sections measurements.
- **Nuclear thickness function**: From a Glauber model fit to the VZERO amplitude distributions in centrality classes.



R_{PbPb} VS CENTRALITY



- Significantly less suppression than at lower energy at RHIC
- No strong centrality dependence for $N_{part} > 70$

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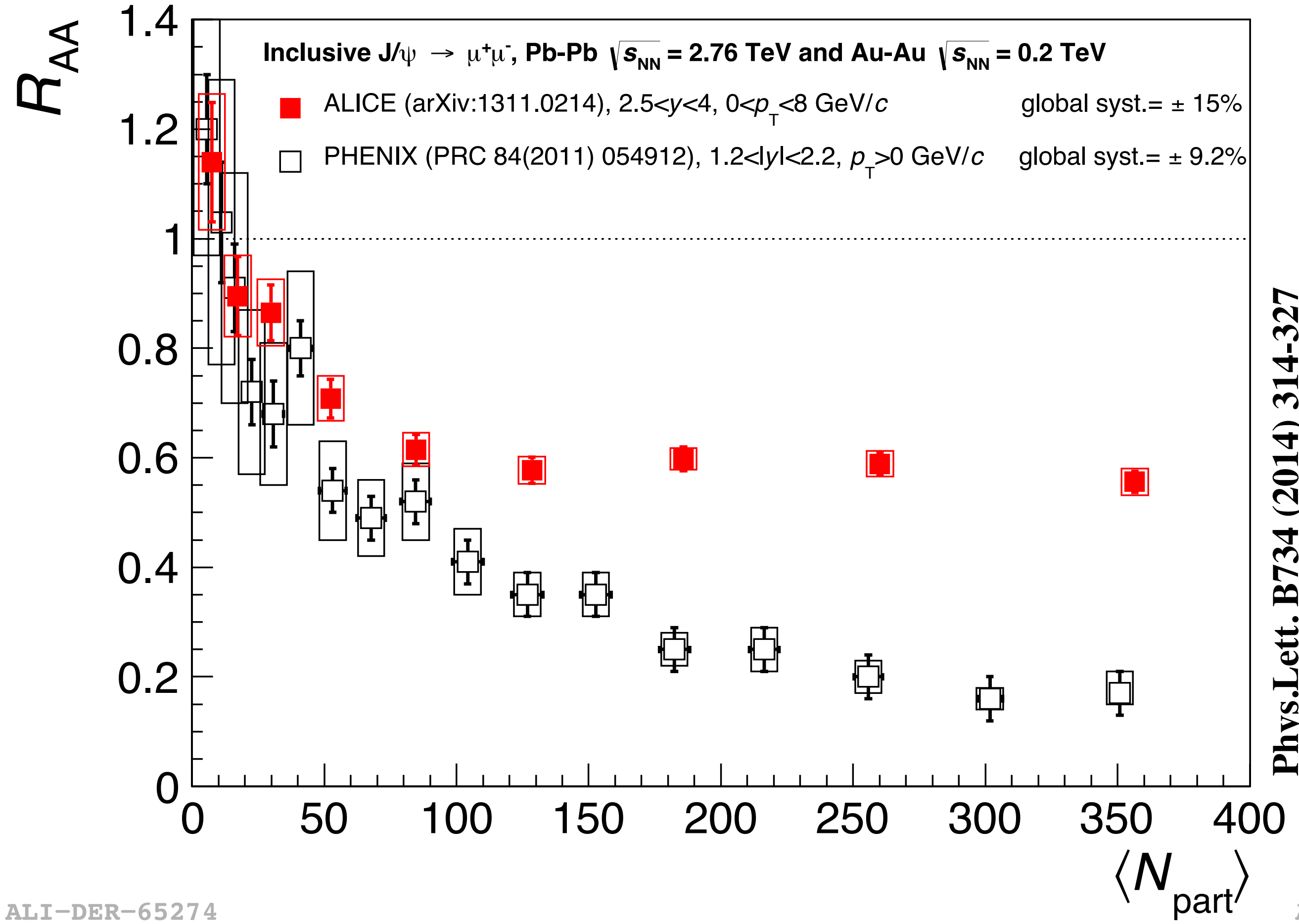
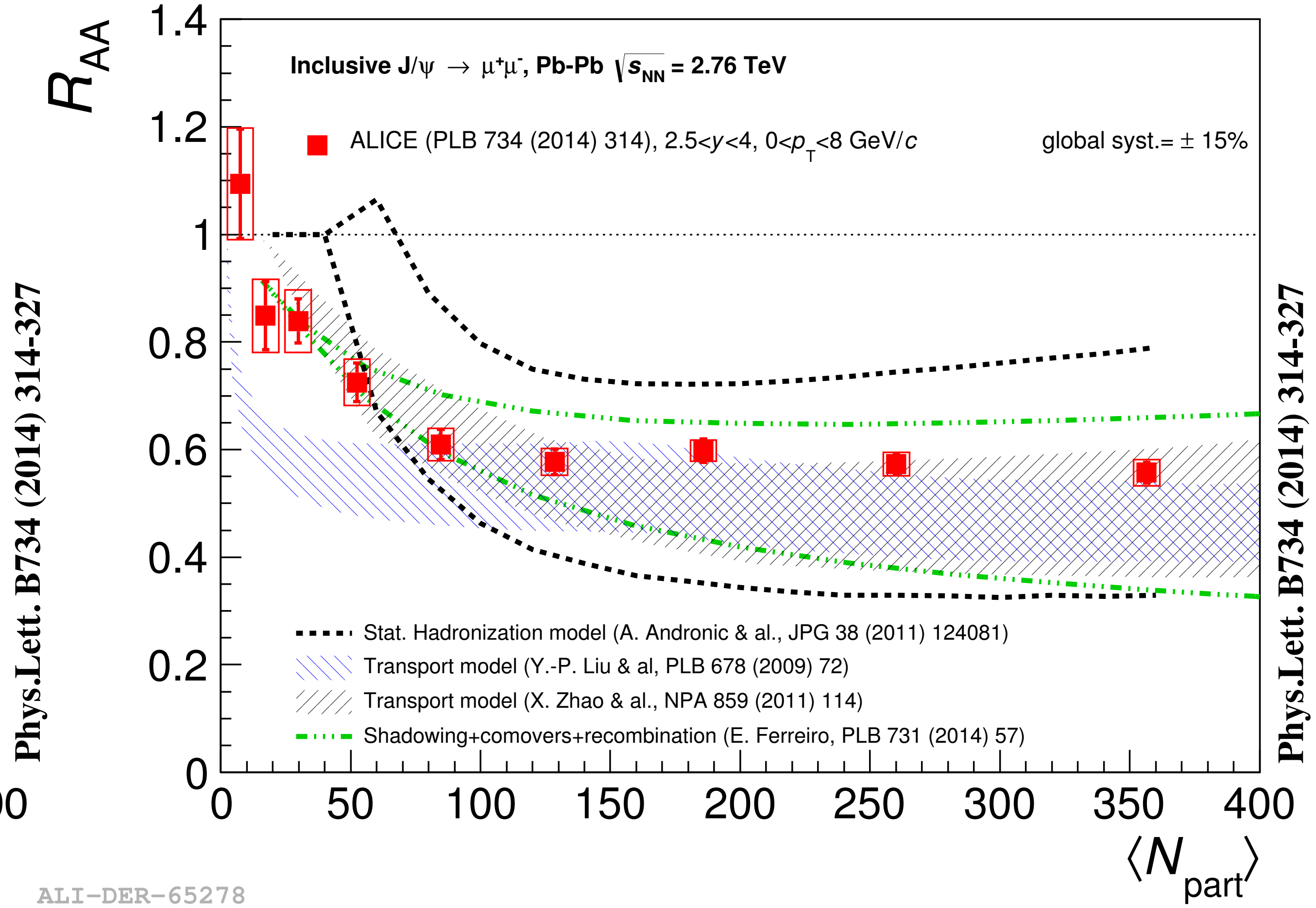
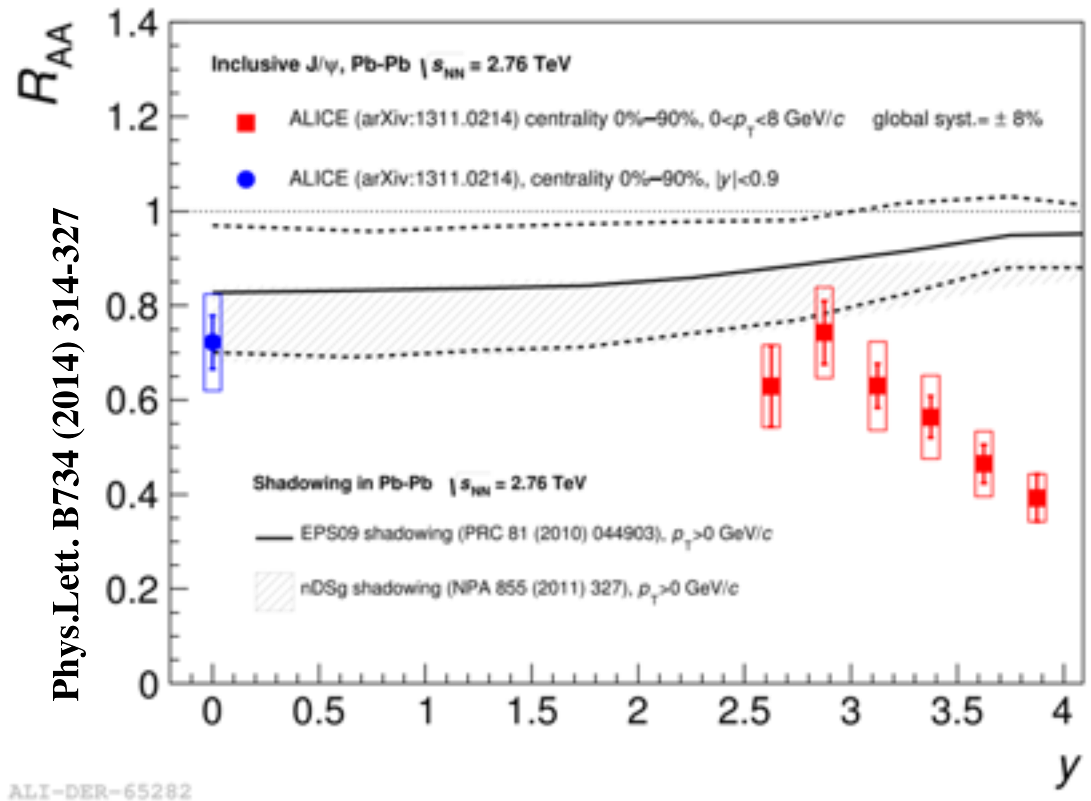




- Significantly less suppression than at lower energy at RHIC
- No strong centrality dependence for N_{part} > 70
- Statistical hadronization and transport models describe the data ((re)combination)
- Shadowing+comovers+recombination model also describes data
- Need a precise measurement of $\sigma_{c\bar{c}}$ and shadowing amount to sharpen the conclusions

R_{PbPb} VS RAPIDITY AND p_T



- More suppression at forward rapidity
- Shadowing calculations cannot describe

the y-dependence in the large rapidity domain measured by ALICE

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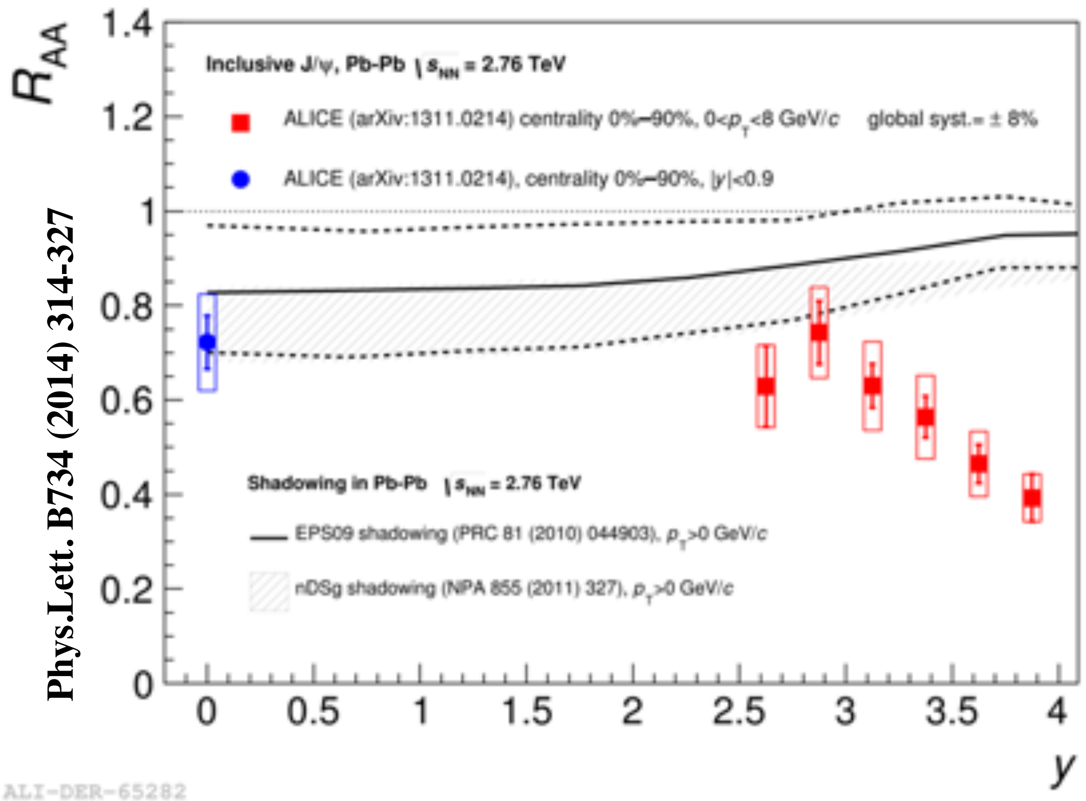

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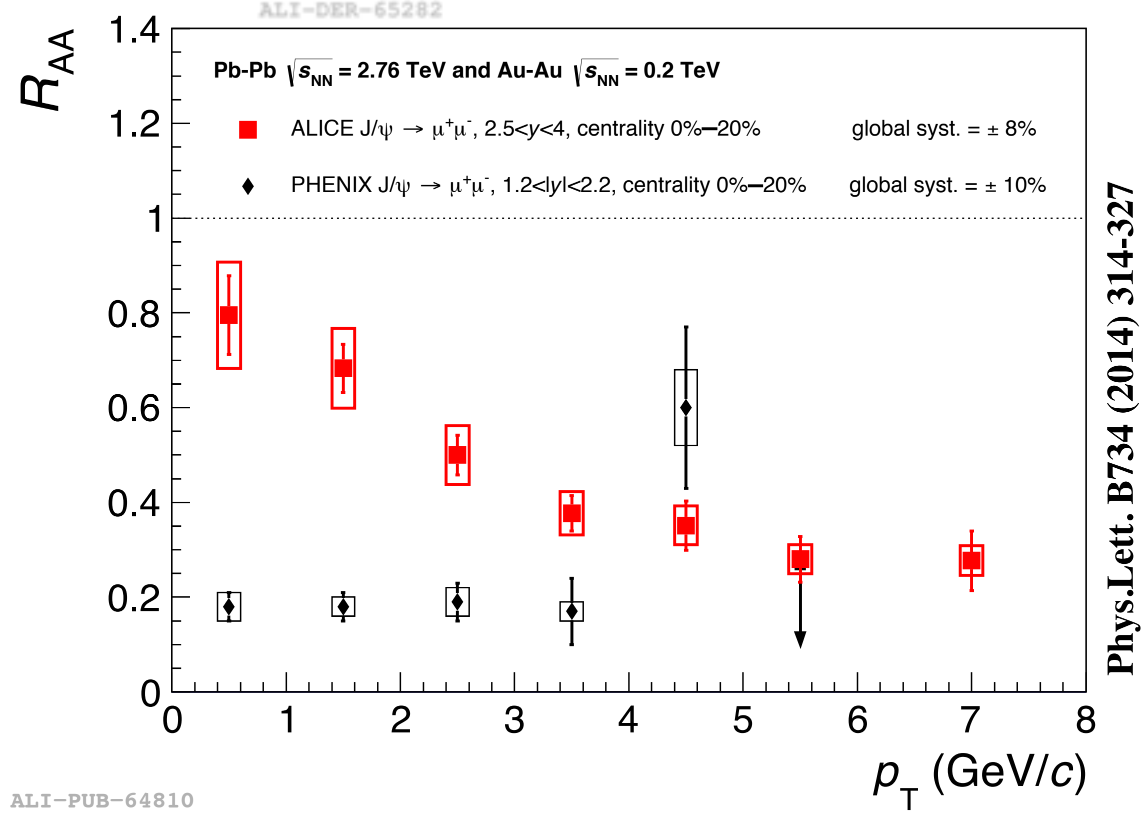

- Less suppression at low p_T than at lower energies

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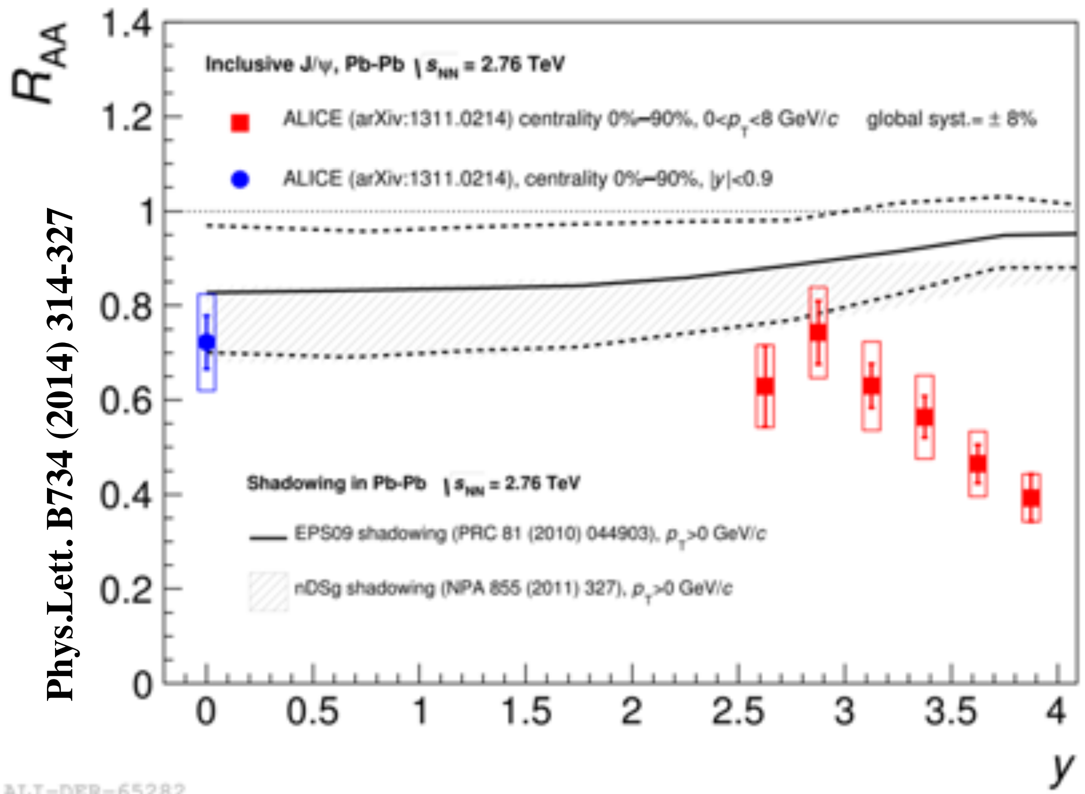

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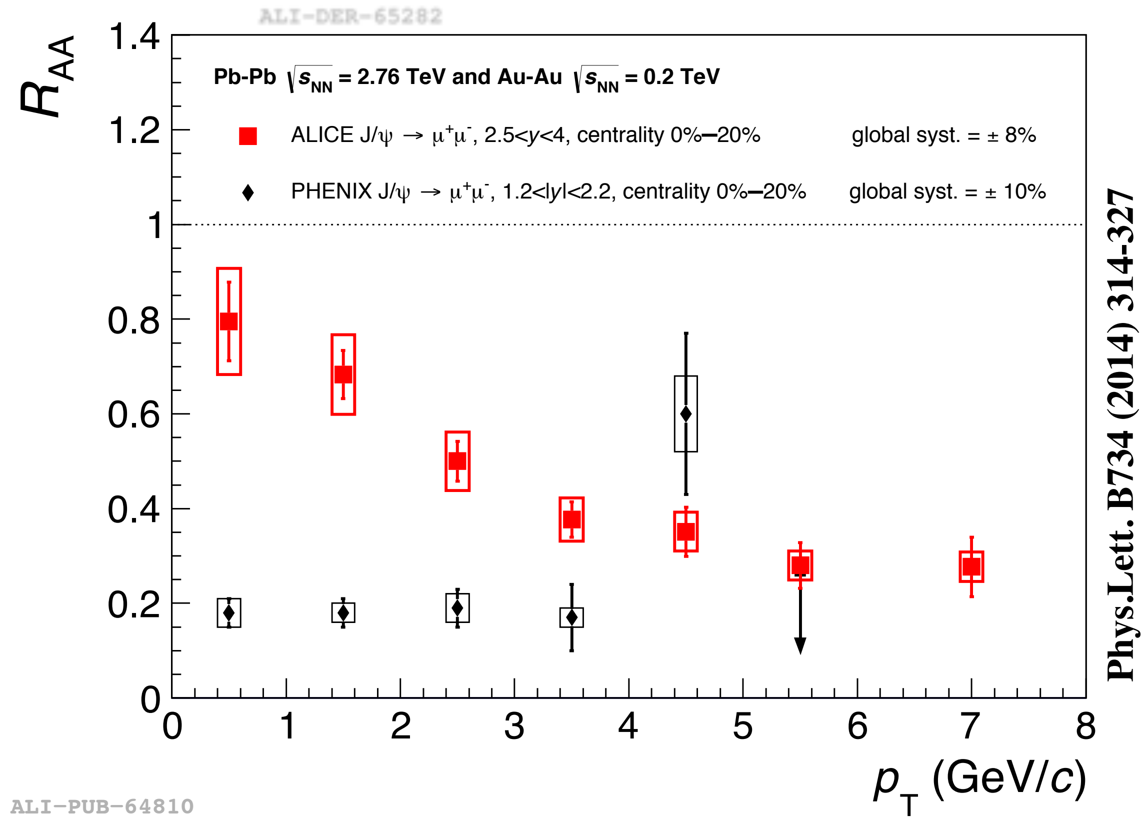
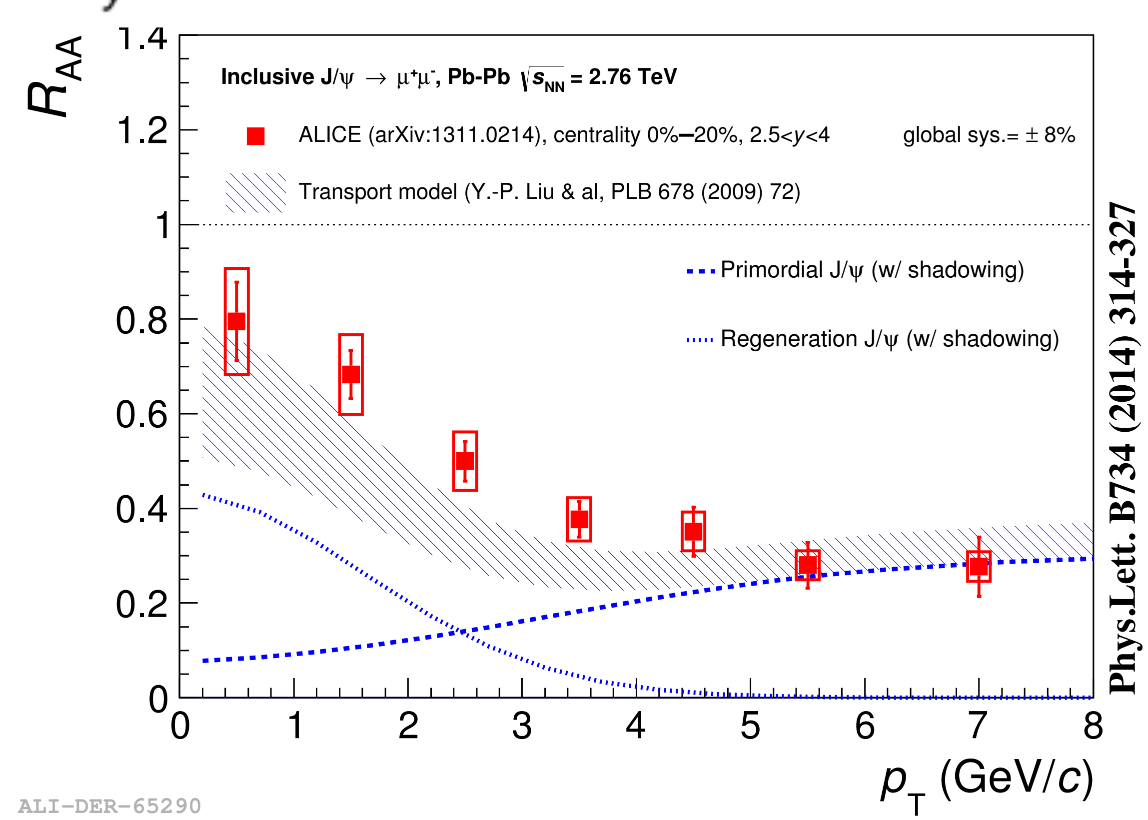
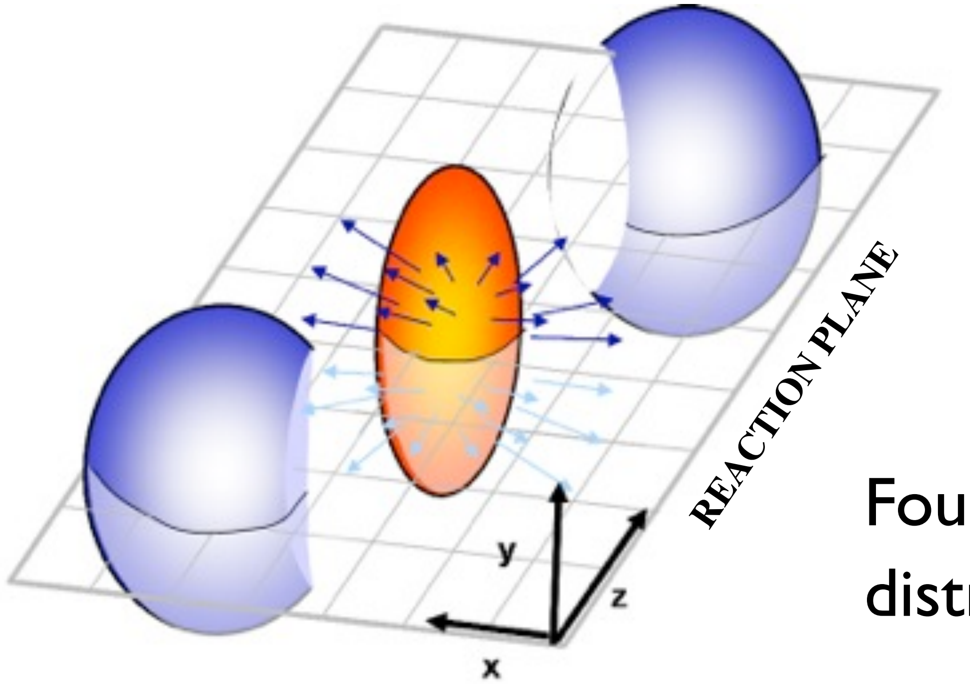




- Less suppression at low p_T than at lower energies
- Transport model describes the data. Recombination contribution important al low p_T

J/ψ ELLIPTIC FLOW vs p_T



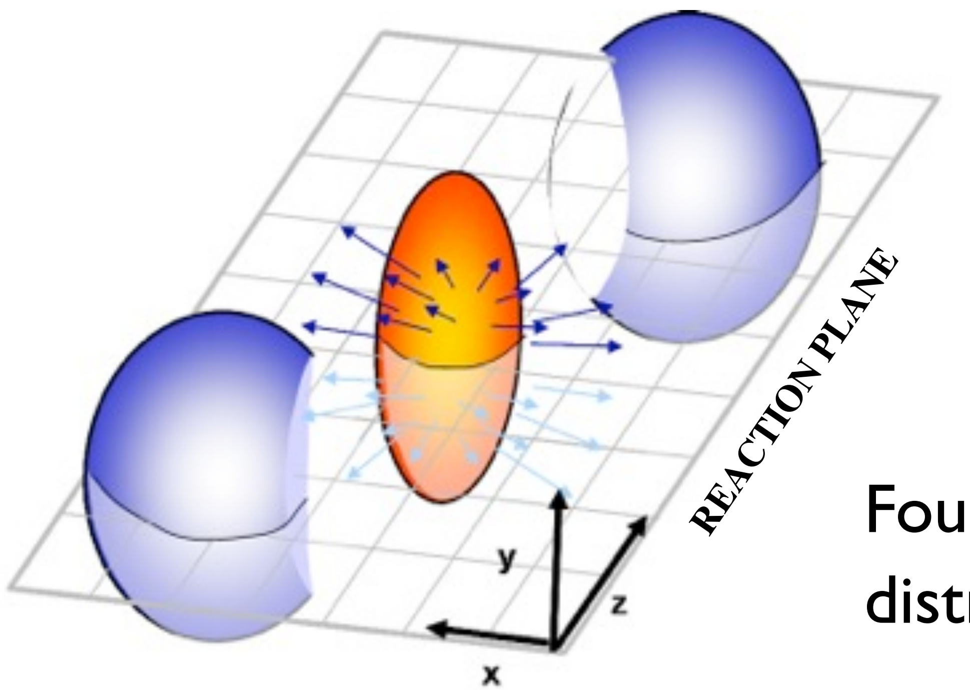
In AA non-central collisions the initial matter distributions are anisotropic

↓

Anisotropic momentum distribution

Fourier expansion of the final state particle azimuthal distribution ⟶ Second harmonic v_2 is called **elliptic flow**

J/ψ ELLIPTIC FLOW vs p_T



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Anisotropic momentum distribution

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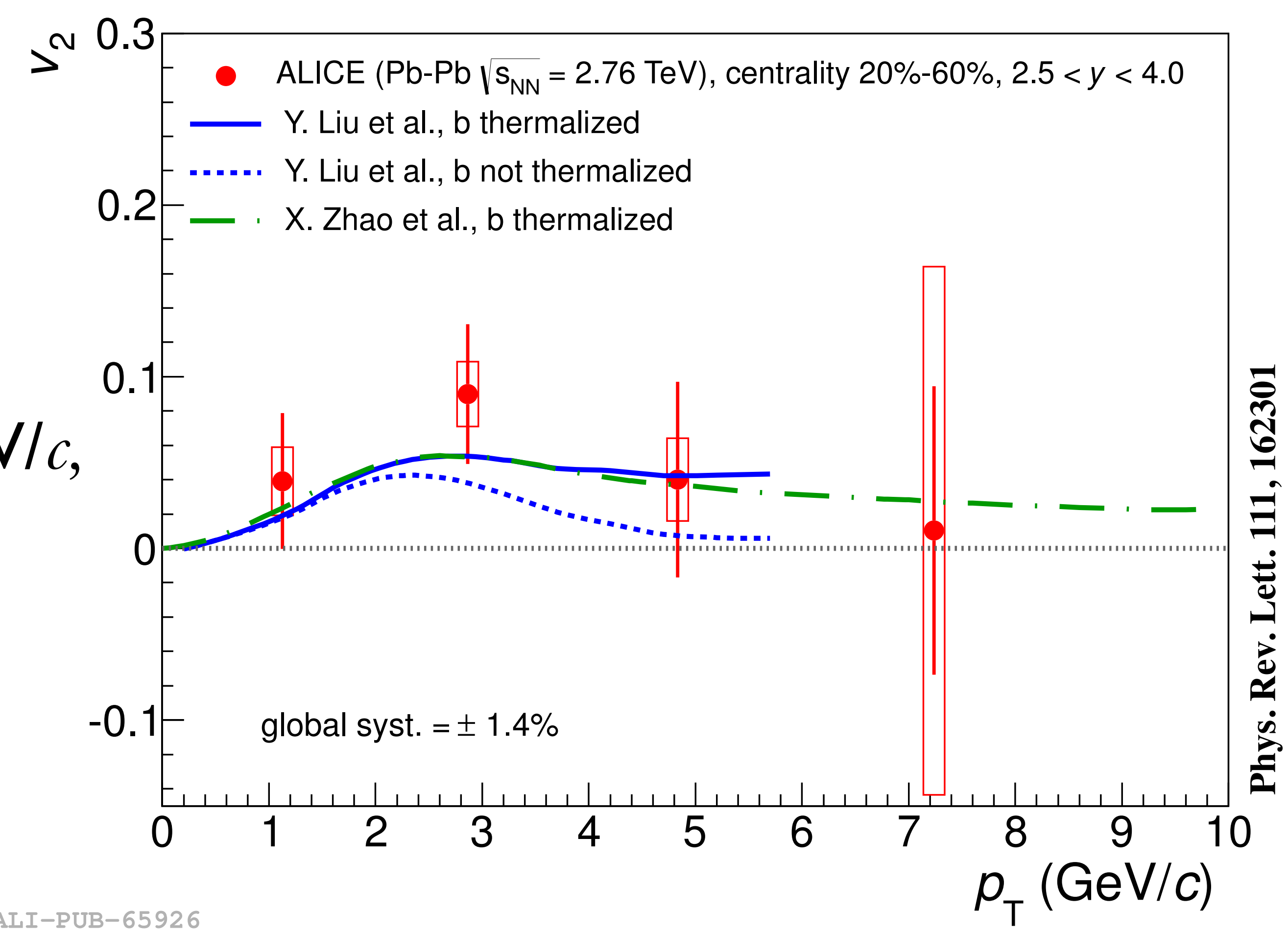
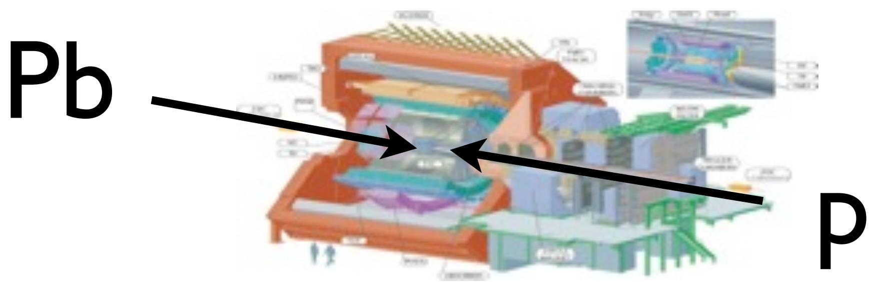
LHCb : J/ψ from B mesons in pp@2.76TeV ~7%

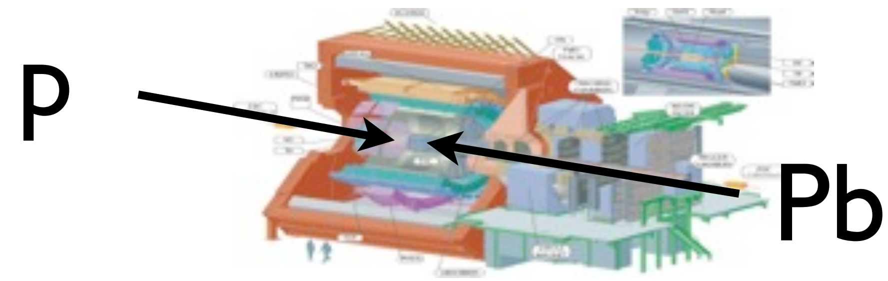


- 2σ significance of nonzero v_2 in $2 < p_T < 4$ GeV/c, not observed at RHIC
- Transport models assuming thermalization of c quarks qualitatively describes the data
- Another hint of recombination at low p_T

R_{pPb} MEASUREMENT



$-4.46 < y_{cms} < -2.96$



$2.03 < y_{cms} < 3.53$

$$R_{pPb}^{J/\psi} = \frac{Y_{pPb}^{J/\psi}}{< T_{pPb} > \sigma_{pp}^{J/\psi}}$$

- Computed in the **full acceptance windows ($2.03 < y_{cms} < 3.53$ and $-4.46 < y_{cms} < -2.96$)**

- **Nuclear thickness function**

  $<T_{pPb}> = 0.0983 \pm 0.0034$ mb^{-1}

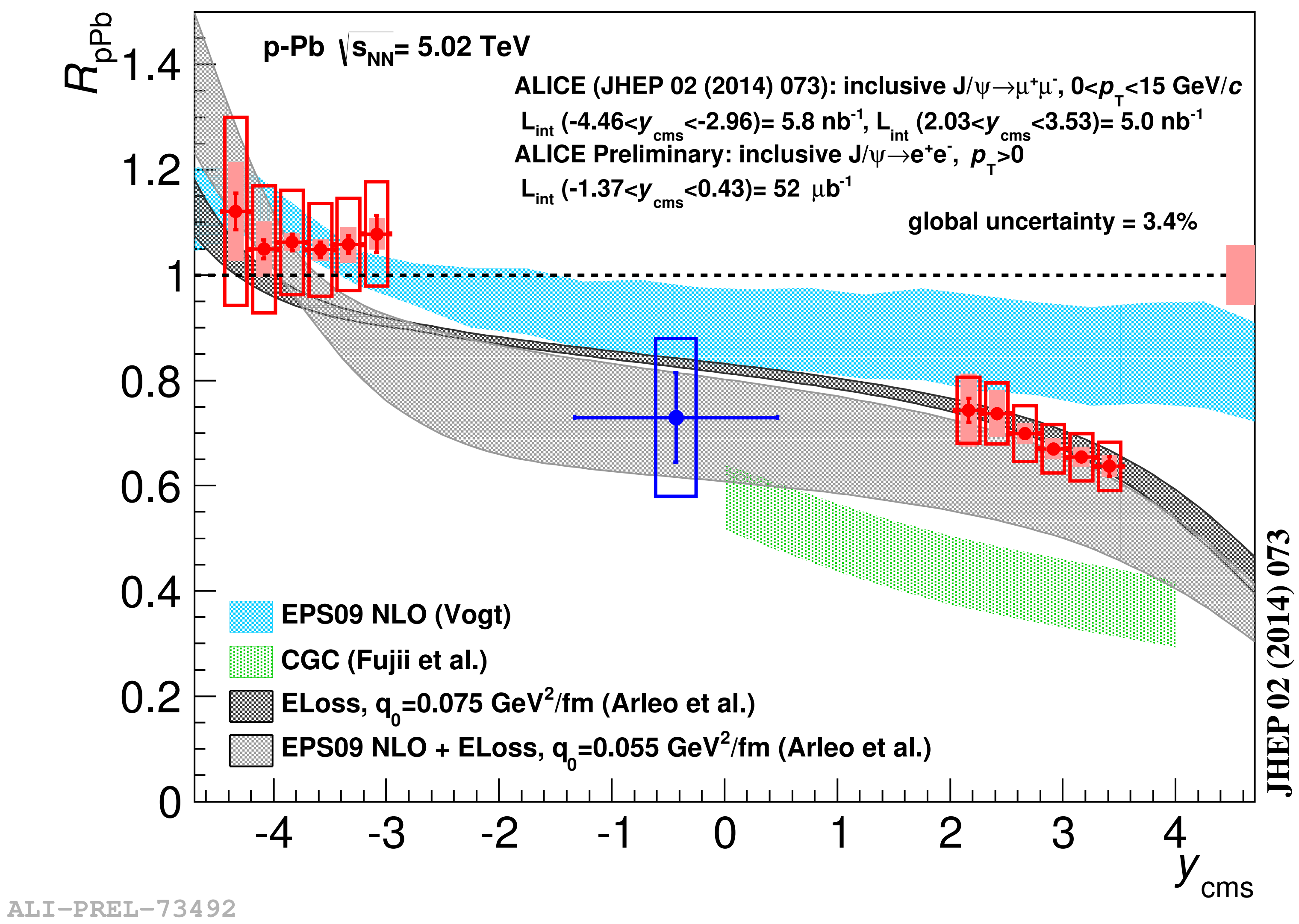
- **pp reference cross-section**: no measurement at required energy (5.02 TeV), need to interpolate. Two step procedure [1] :

  1) $\sqrt{s}$ interpolation: performed bin-per-bin in rapidity (or p_T) using available ALICE pp results at 2.76 and 7 TeV

  2) Further rapidity extrapolation: due to rapidity shift, p-Pb y_{cms}-range lies slightly outside the pp y_{cms}-range

[1] ALICE-PUBLIC-2013-002

R_{pPb} vs RAPIDITY

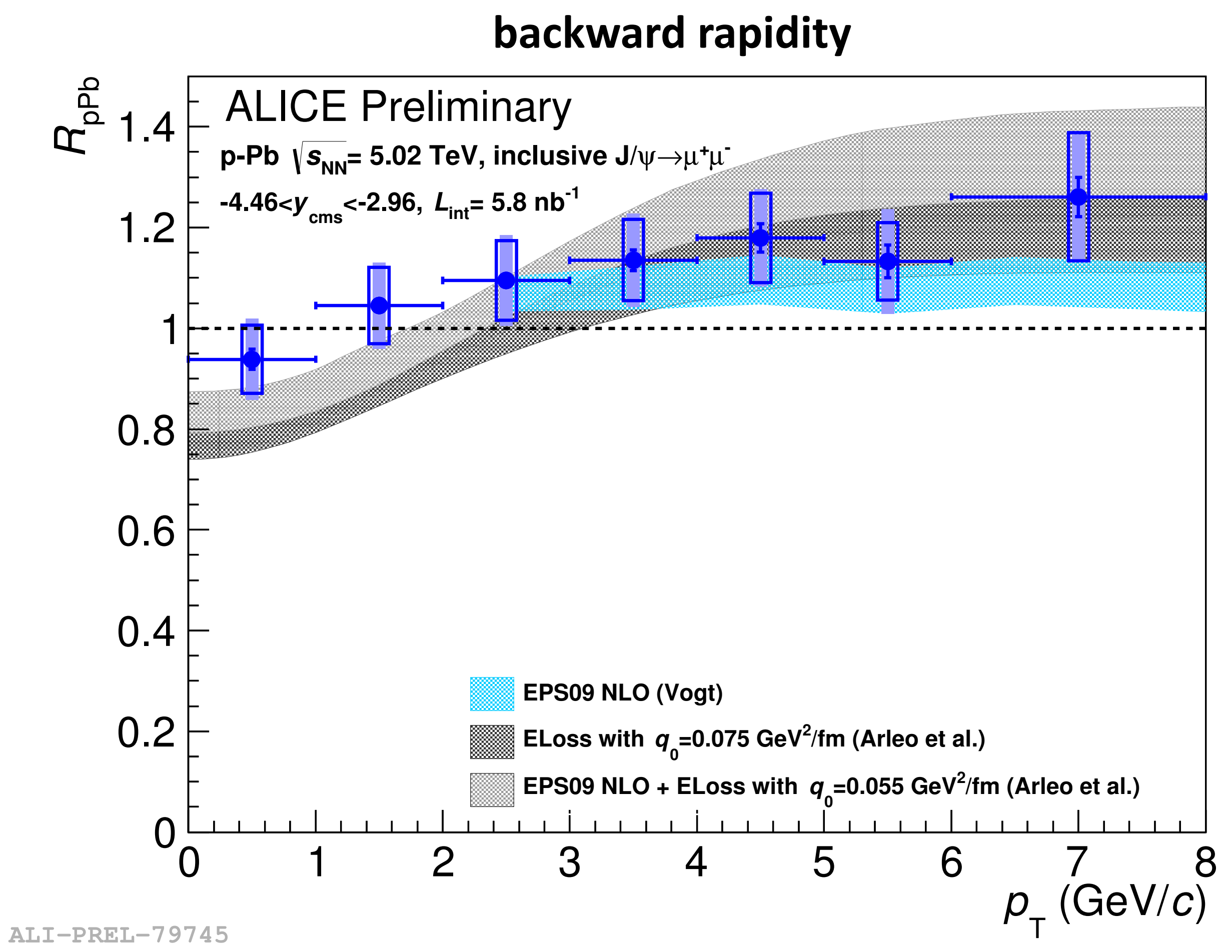


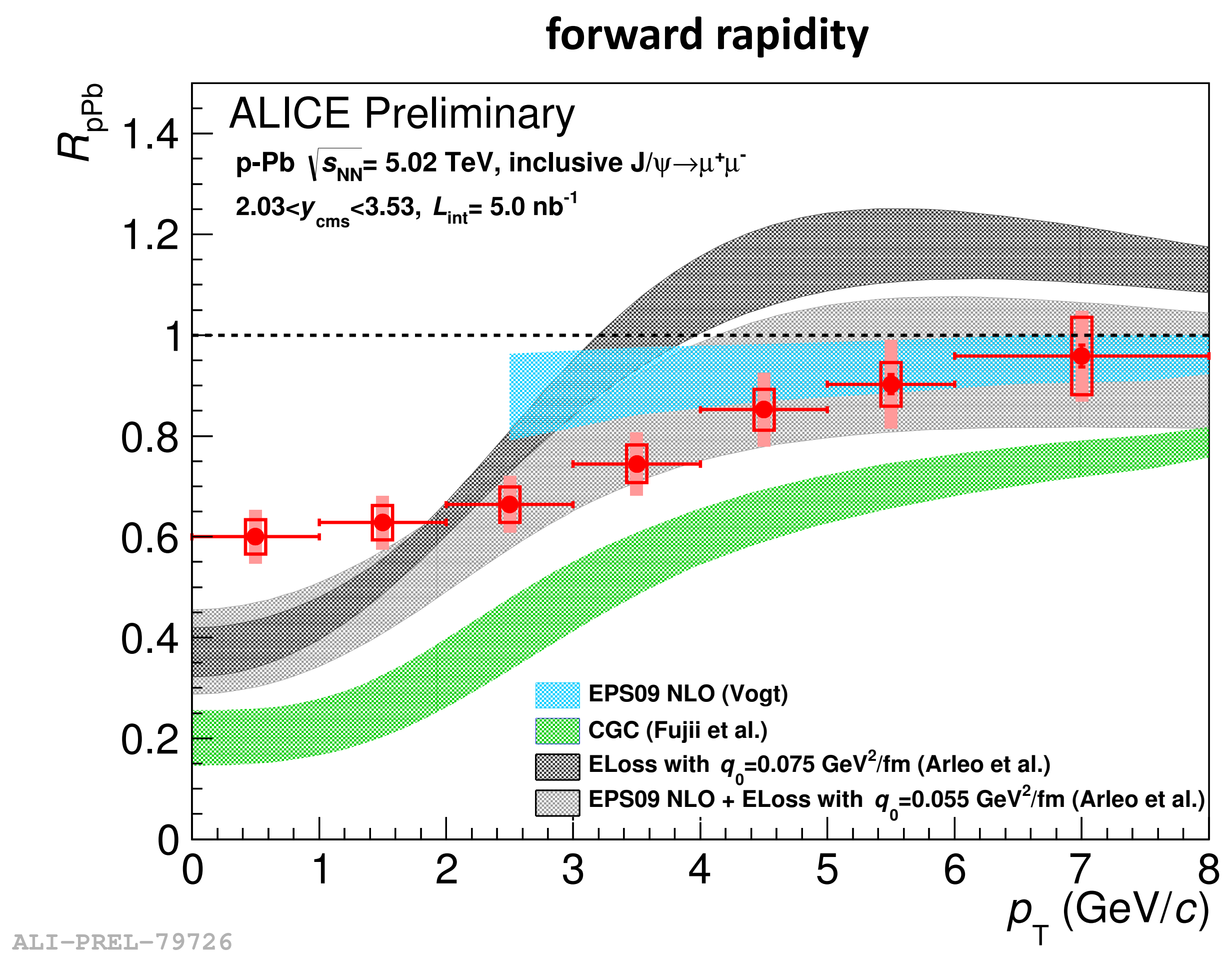
Systematic uncertainties:
- Colored boxes : uncorrelated
- Shaded areas : partially correlated
- Box around unity : fully correlated

- Strong suppression at mid and forward rapidity
- No suppression at backward rapidity

- Shadowing model describes trend of data but underestimates suppression at forward rapidity
- Data are consistent with energy loss models including shadowing or not
- Color Glass Condensate (CGC) inspired model underestimates the data at forward rapidity

R_{pPb} vs p_T



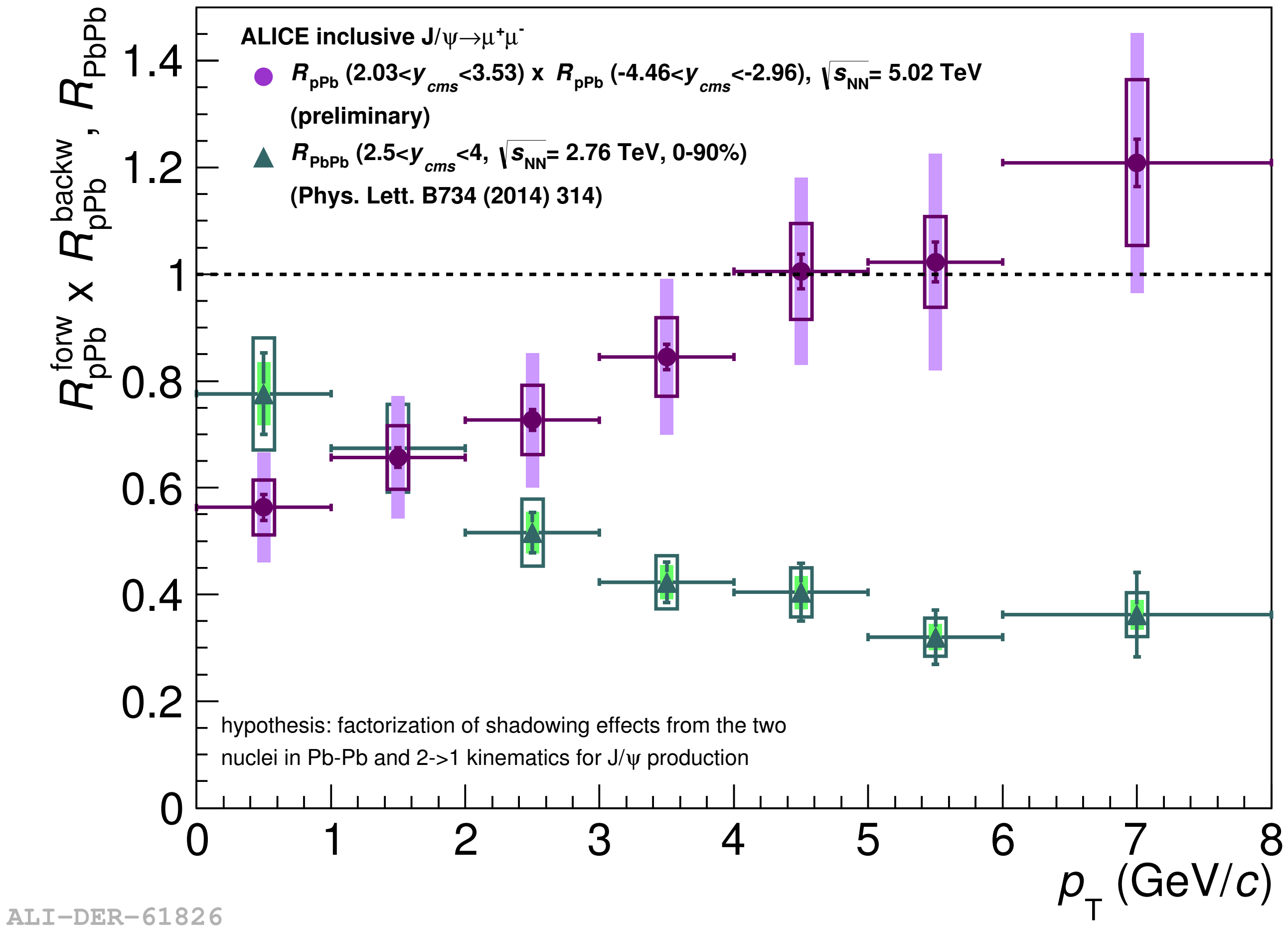


- Small p_T dependence, compatible with unity
- Increases with p_T, compatible with unity for $p_T \gtrsim 5$ GeV/c

- Shadowing only model (calculation for $p_T > 2.5$ GeV/c) describes trend of data but underestimates suppression at forward rapidity and 2.5 GeV/c < p_T < 3 GeV/c
- Coherent energy loss with shadowing describes data at high p_T but overestimates suppression at forward rapidity and low p_T
- CGC overestimates suppression at forward rapidity

COLD NUCLEAR MATTER EFFECTS IN Pb-Pb

Assumptions:
- Production mechanism: $g + g \rightarrow J/\psi$
- CNM effects factorize in p-nucleus and are dominated by shadowing



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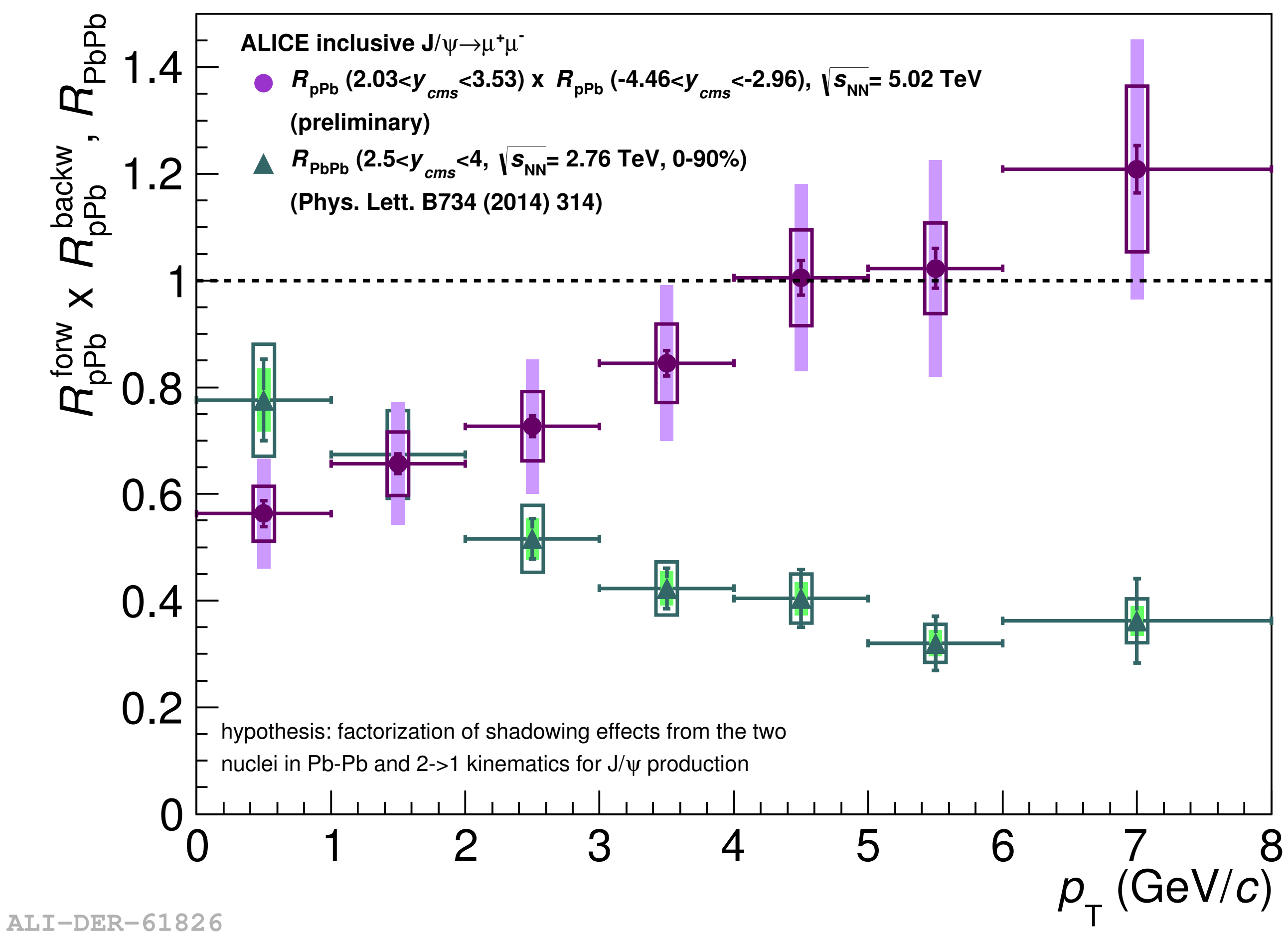
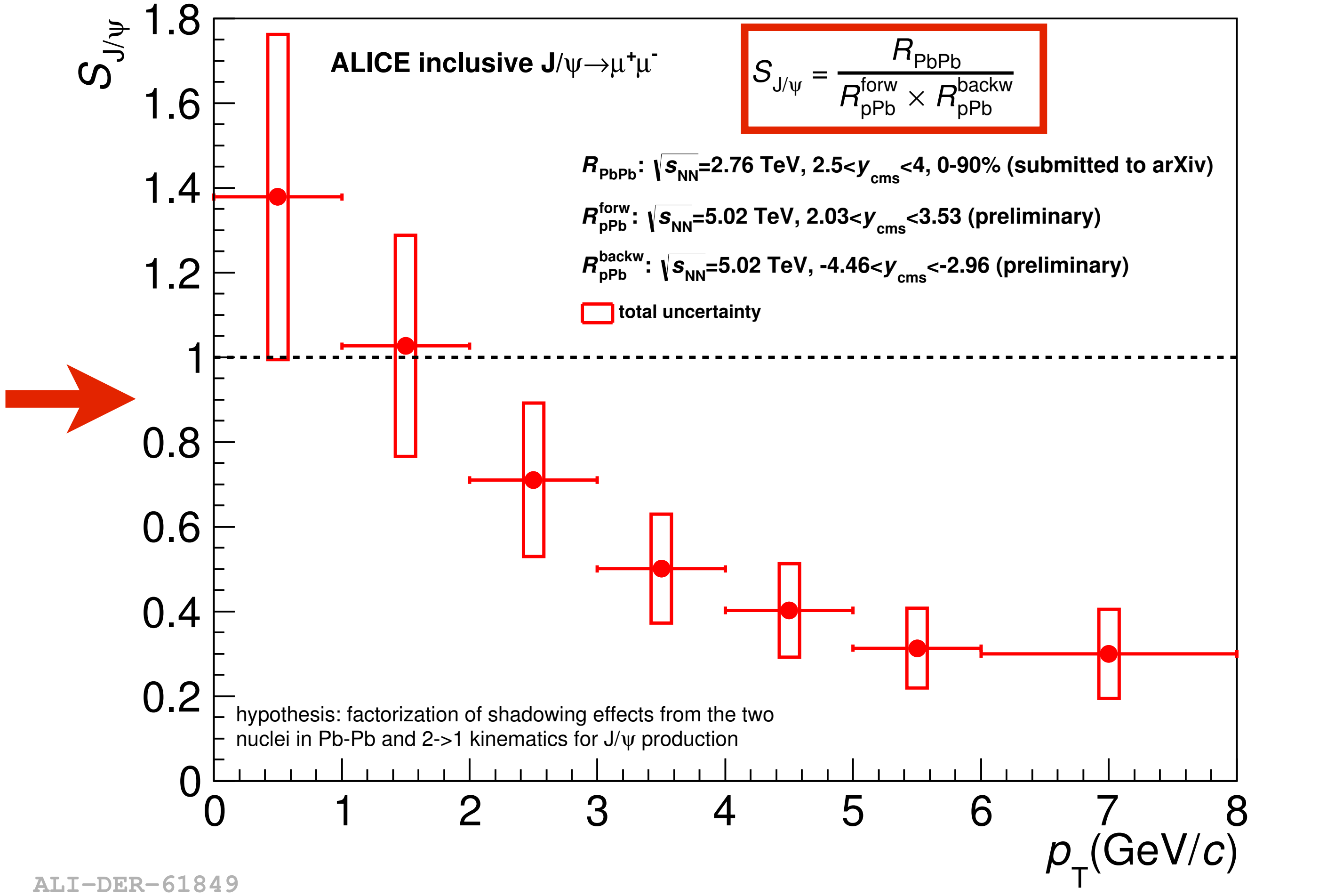




- Increase of $S_{J/\psi}$ at low p_T (observation that favors (re)combination scenario in Pb-Pb)
- Strong suppression at high p_T due to the hot medium

CONCLUSIONS

Results from ALICE measurement of J/ψ production in pp, p-Pb and Pb-Pb collisions at forward rapidity shows:

- R_{PbPb} vs centrality show less suppression at LHC energies than at lower energies which suggests a (re)combination component of the J/ψ production. Models with a full or partial J/ψ production from charm quarks in the QGP phase describe the data.

- R_{PbPb} vs p_{T} shows less suppression at low p_{T} than at lower energies. Transport models reproduce data, suggesting an important contribution of recombination at low p_{T}.

- Non negligible J/ψ v_2 at intermediate p_{T} in Pb-Pb. Hint for the recombination mechanism.

- R_{pPb} shows a significant suppression at forward rapidity but no suppression at backward rapidity. Fair agreement with shadowing and coherent energy loss models.

- R_{pPb} vs p_{T} shows suppression at forward rapidity for low p_{T}. Good agreement with available models, except at forward rapidity and low p_{T}.

- Simple extrapolation of CNM effects from p-Pb to Pb-Pb collisions shows a strong suppression at large p_{T} and gives further hints of (re)combination at low p_{T}.

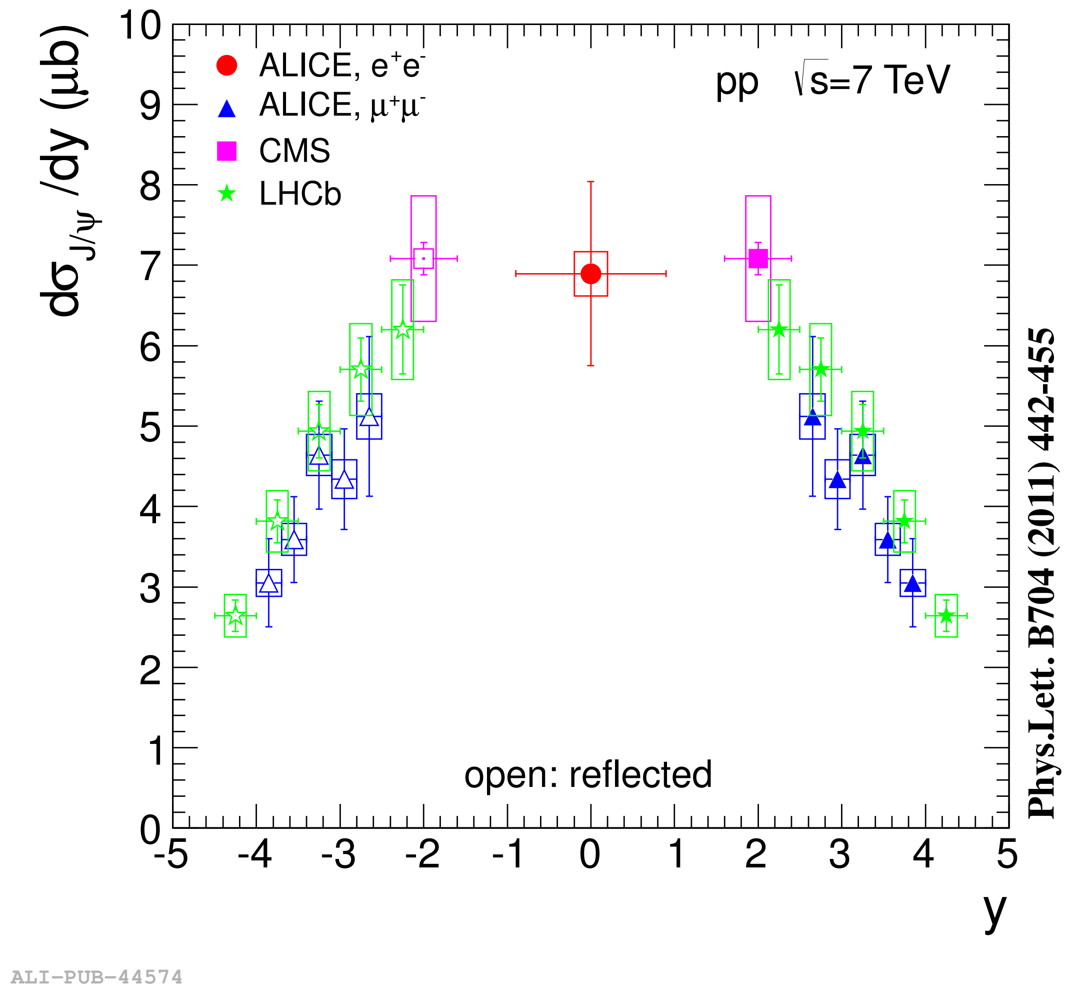
THANK YOU FOR YOUR ATTENTION

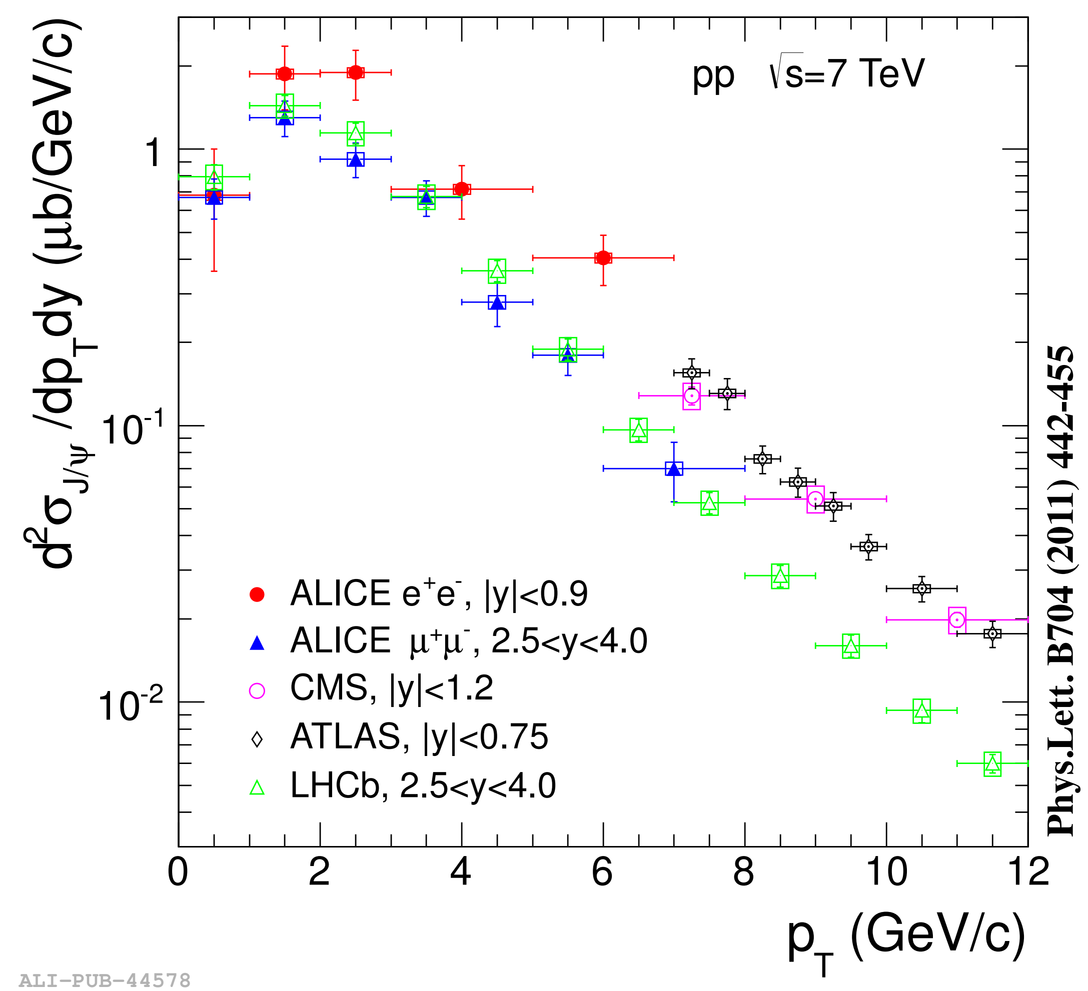
BACKUP

pp CROSS SECTION

$$\frac{d^2\sigma}{dydp_T} = \frac{Y_{J/\psi\rightarrow\mu^+\mu^-(e^+e^-)}(\Delta p_T, \Delta y)}{BR(J/\psi \rightarrow \mu^+\mu^-(e^+e^-)) \times \Delta p_T \times \Delta y} \times \sigma_{MB}$$

$$Y_{J/\psi\rightarrow\mu^+\mu^-(e^+e^-)}(\Delta p_T, \Delta y) = \frac{N_{J/\psi\rightarrow\mu^+\mu^-(e^+e^-)}(\Delta p_T, \Delta y)}{N_{MB} \times A\epsilon}$$

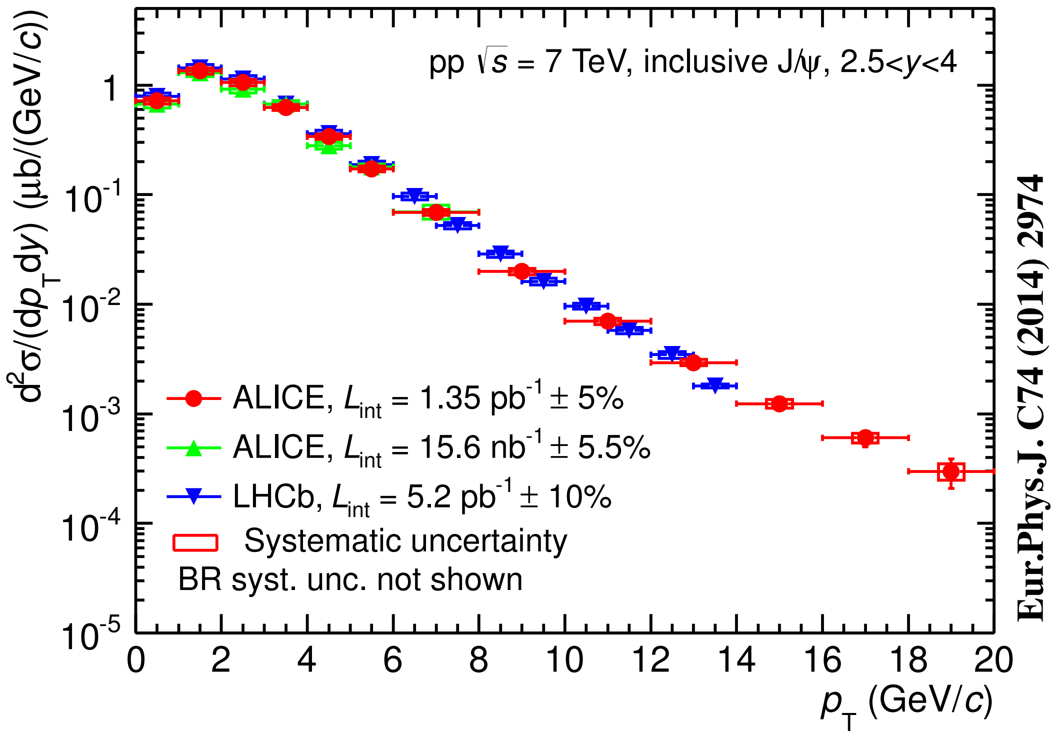


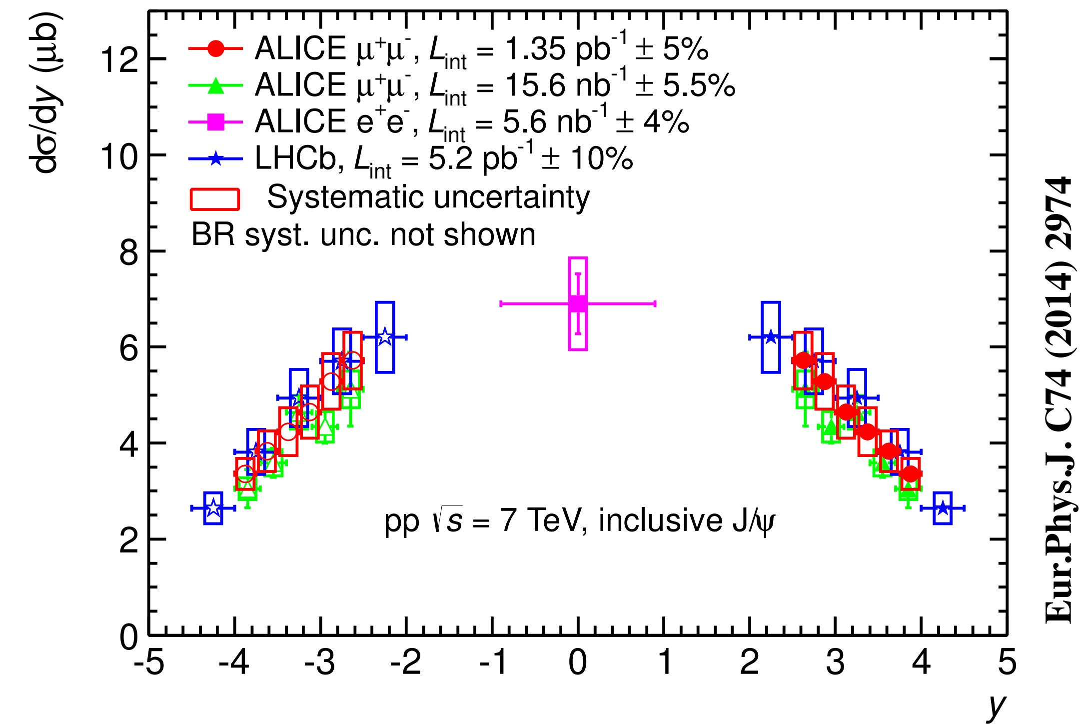


- Good agreement between results.

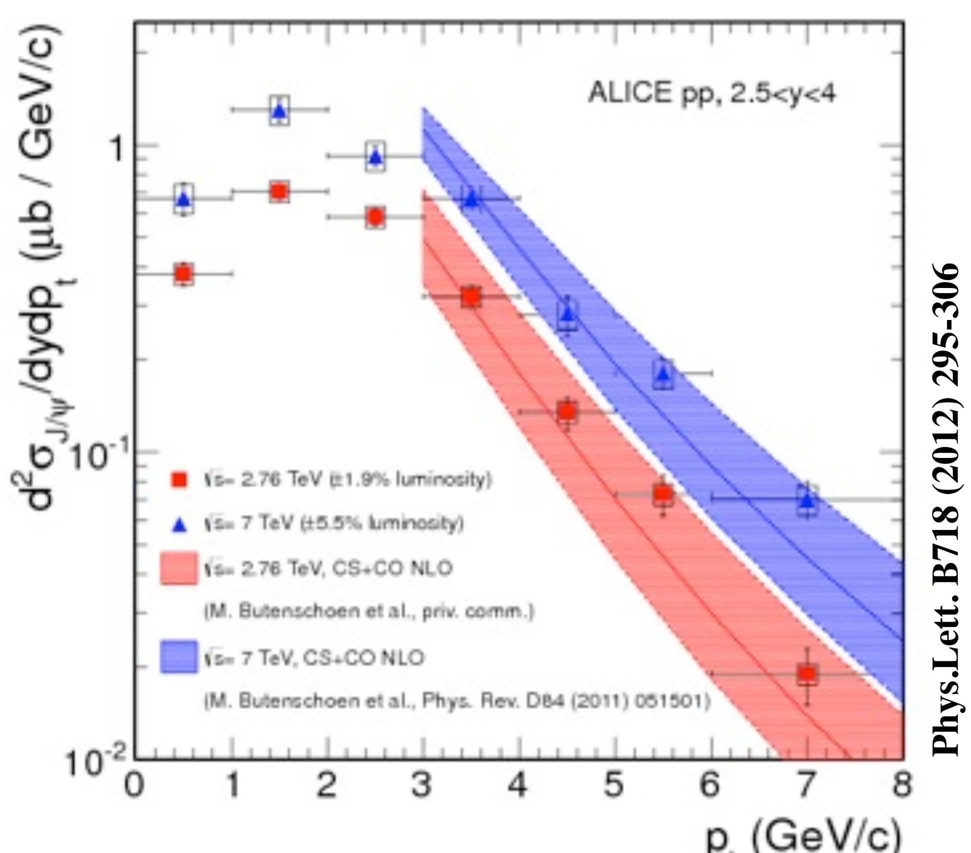
- Good agreement between results at forward rapidity.
- Complementary measures at mid-rapidity.

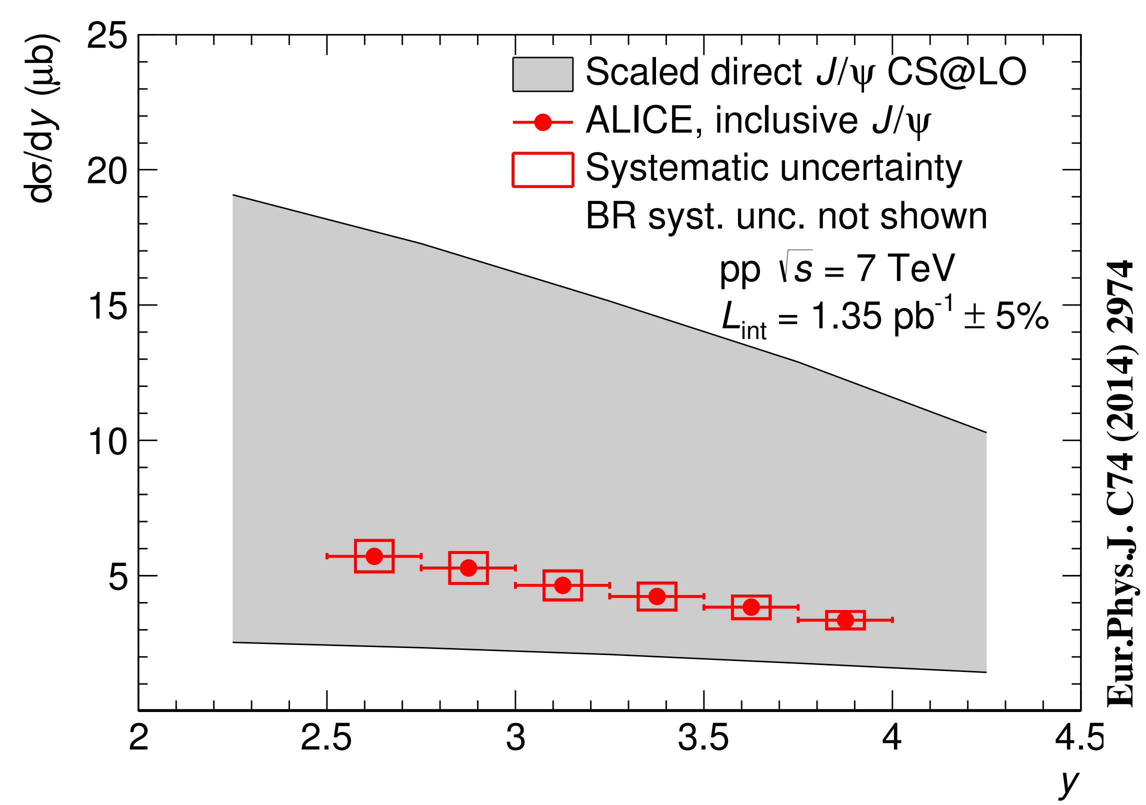
pp CROSS SECTION





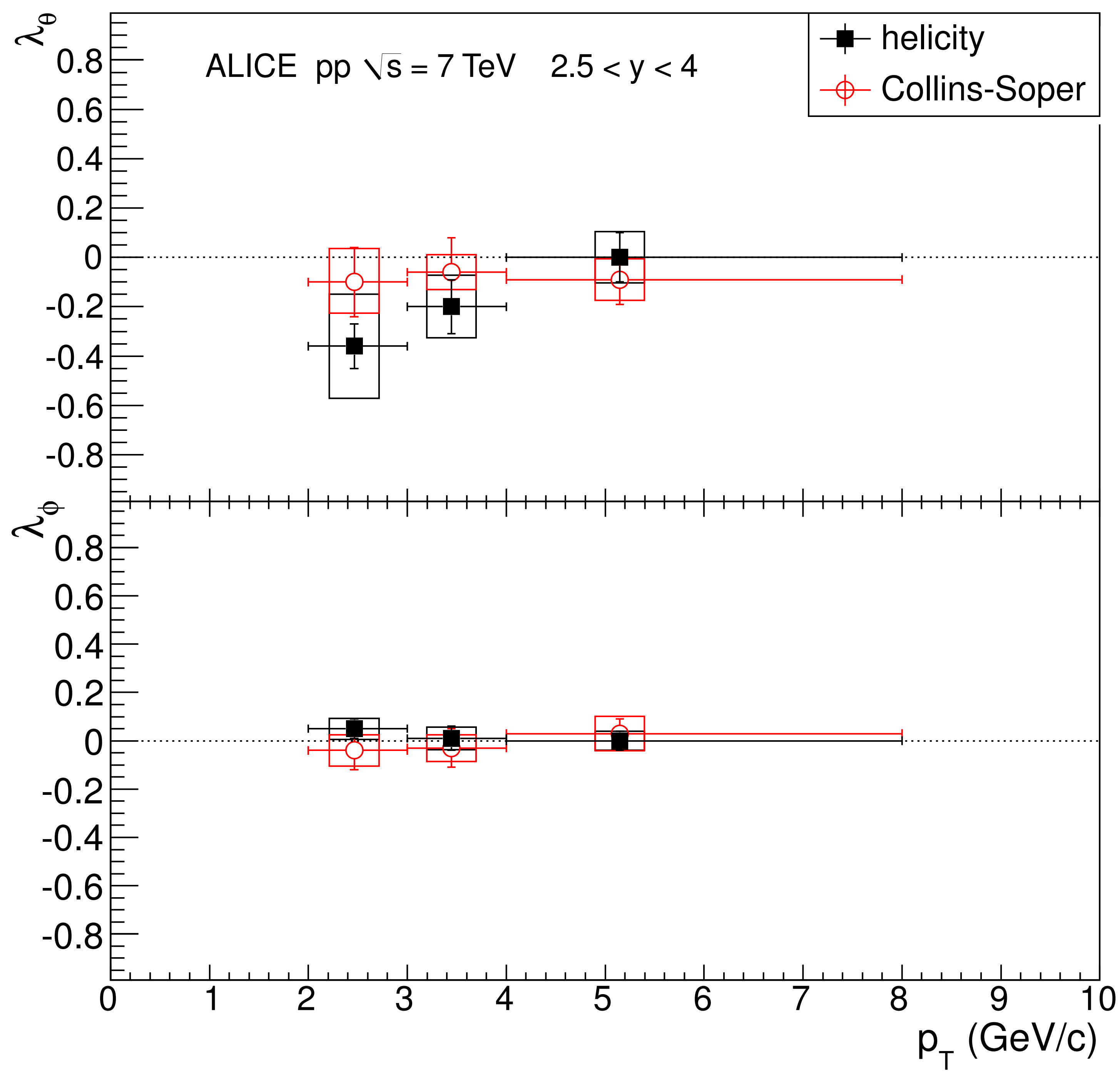
• Good agreement with other experiments





• NRQCD calculations with CS and CO terms describe the p_T dependence of data

J/ψ POLARIZATION IN pp

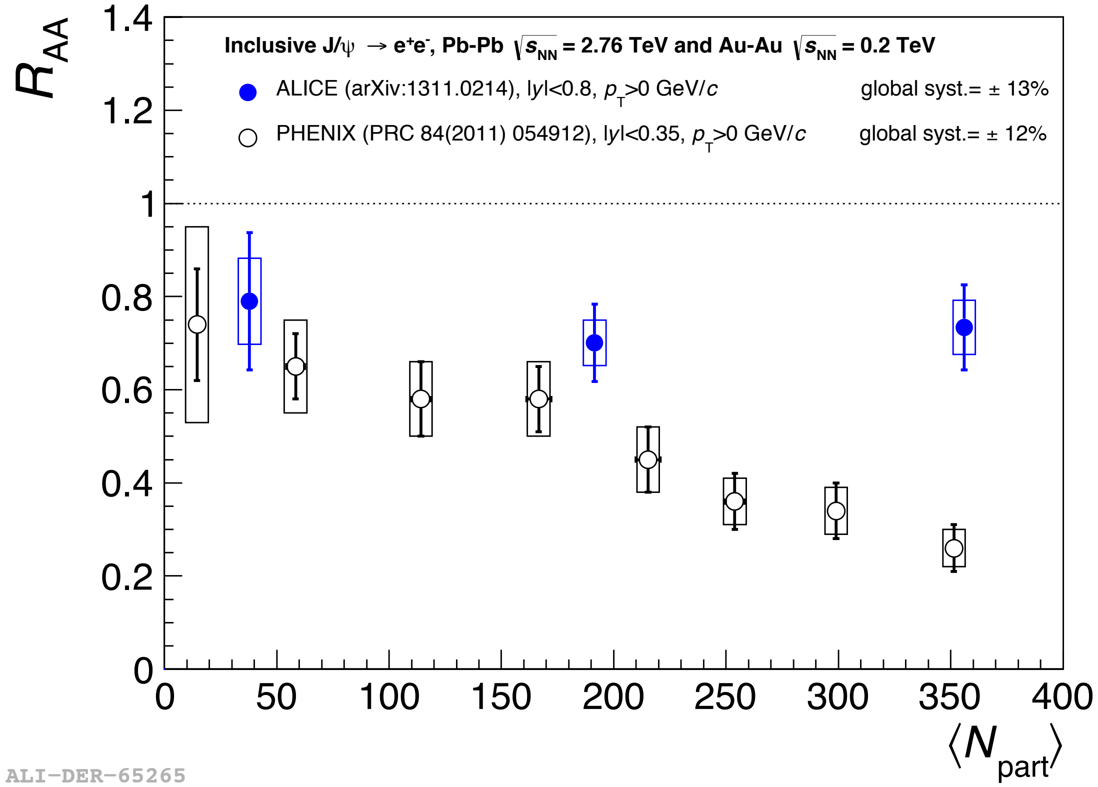


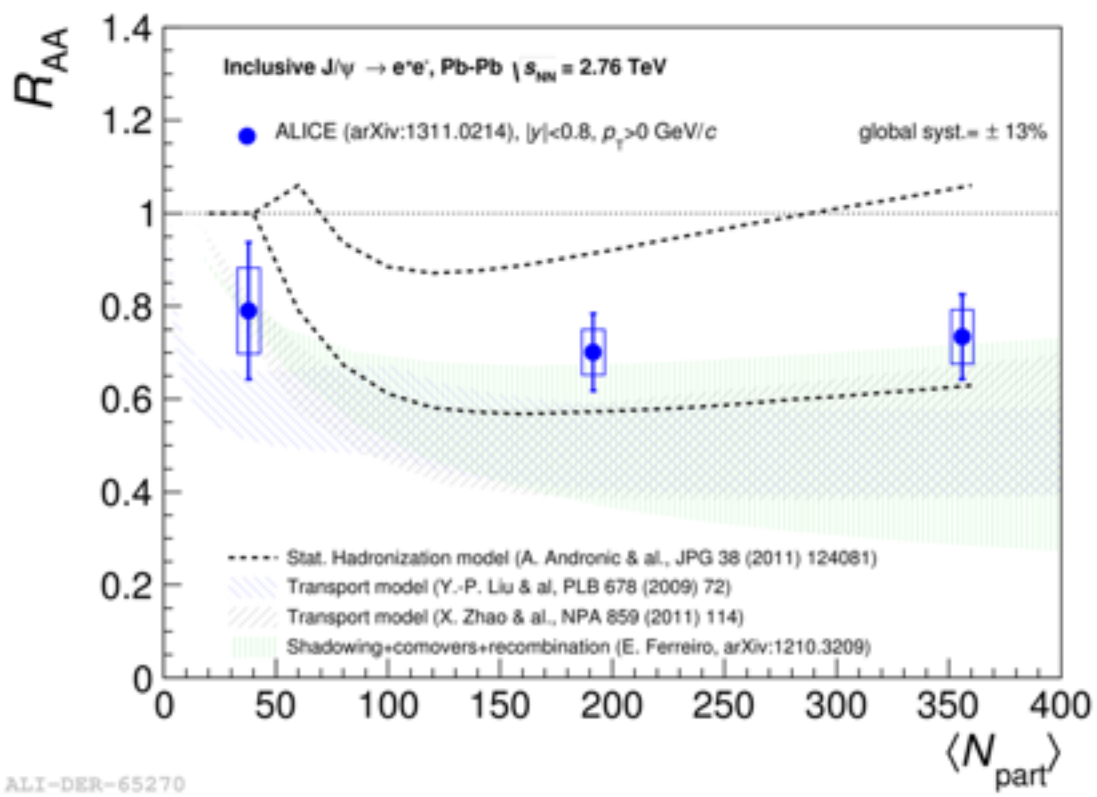
ALI-PUB-12784

- Polarization parameters consistent with zero in both reference frames
- NRQCD calculations predict a large longitudinal and transverse polarization in contrast with the data

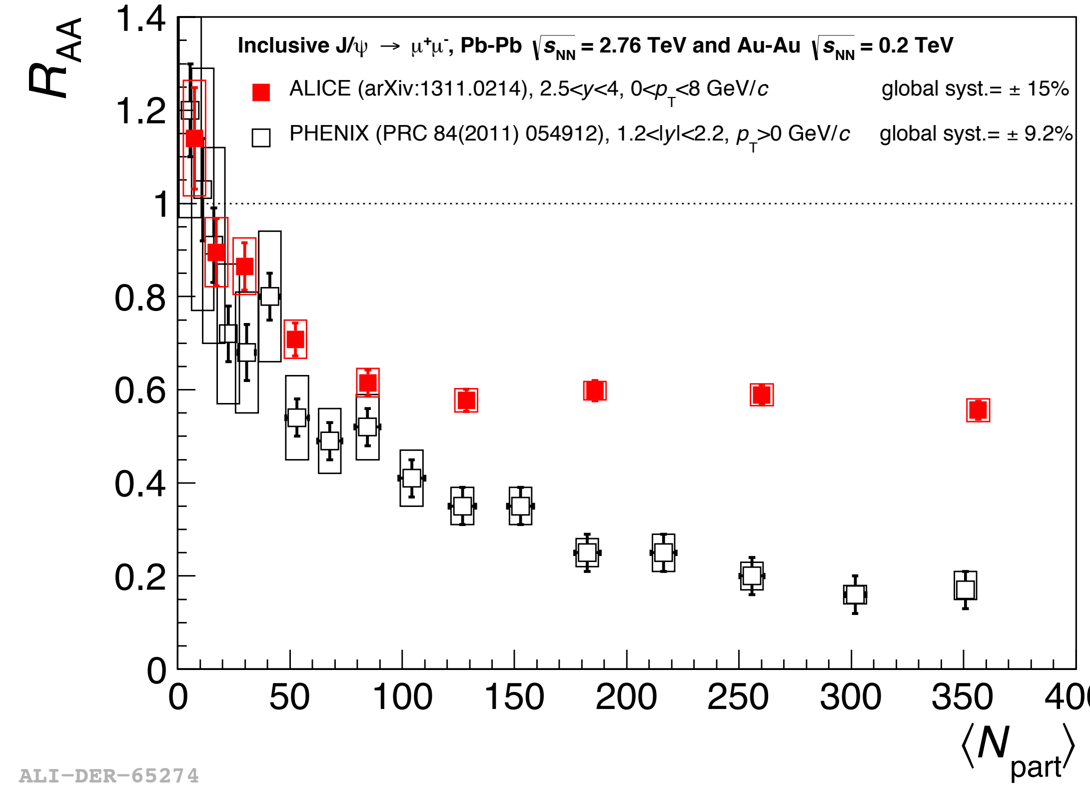
R_{PbPb} VS *CENTRALITY*

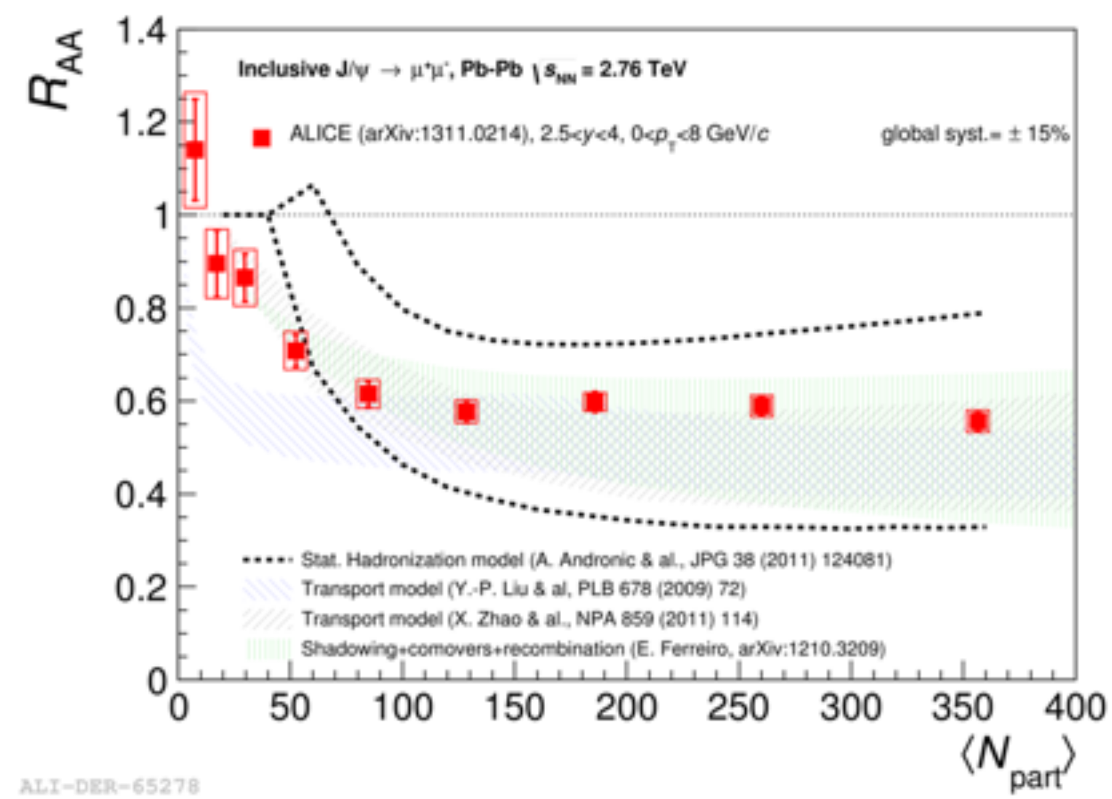
mid-rapidity |y|<0.8





forward rapidity 2.5<y<4

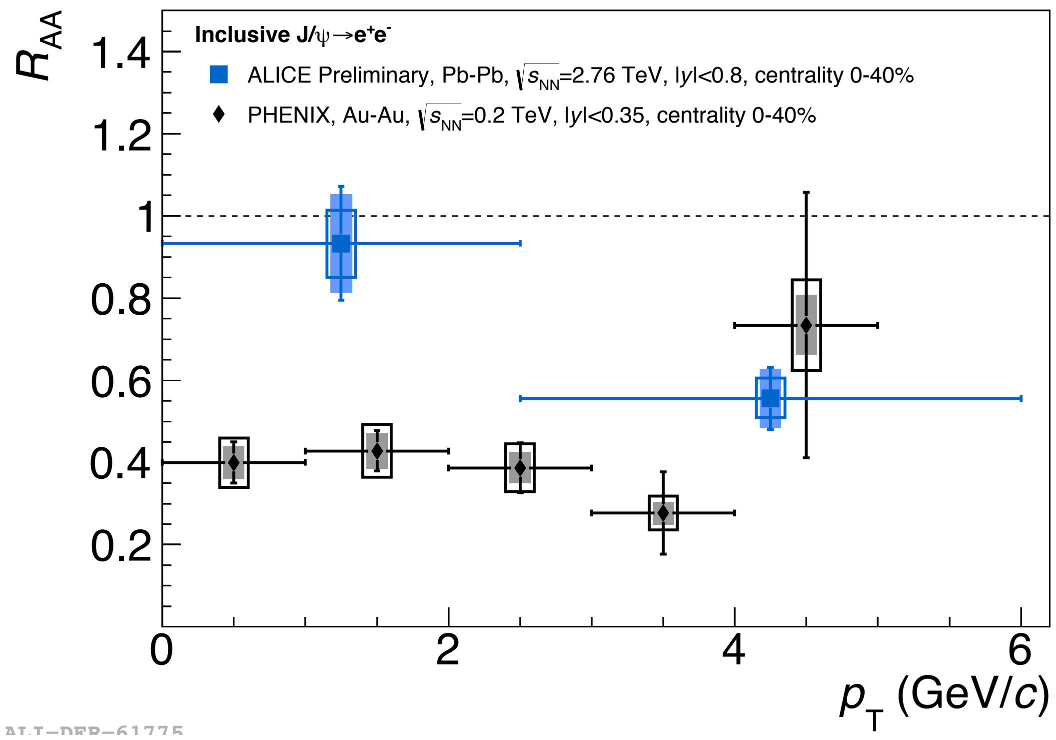




- Similar conclusions at mid and forward rapidity

R_{PbPb} vs p_T

mid-rapidity |y|<0.8



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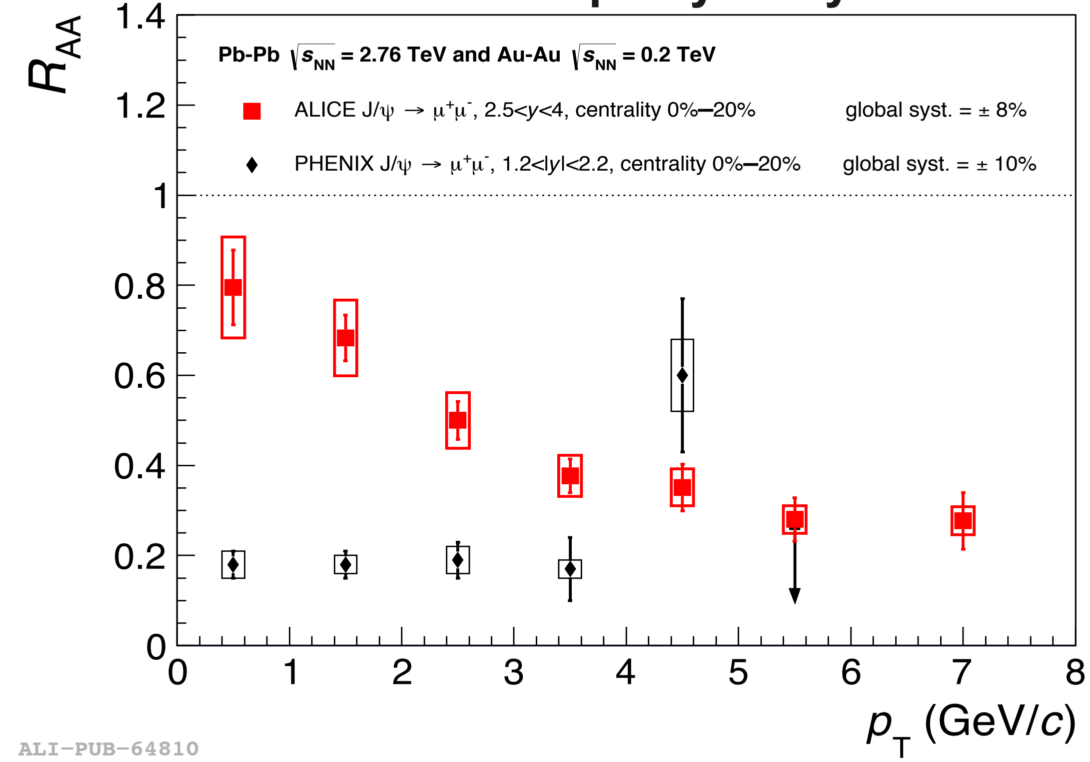
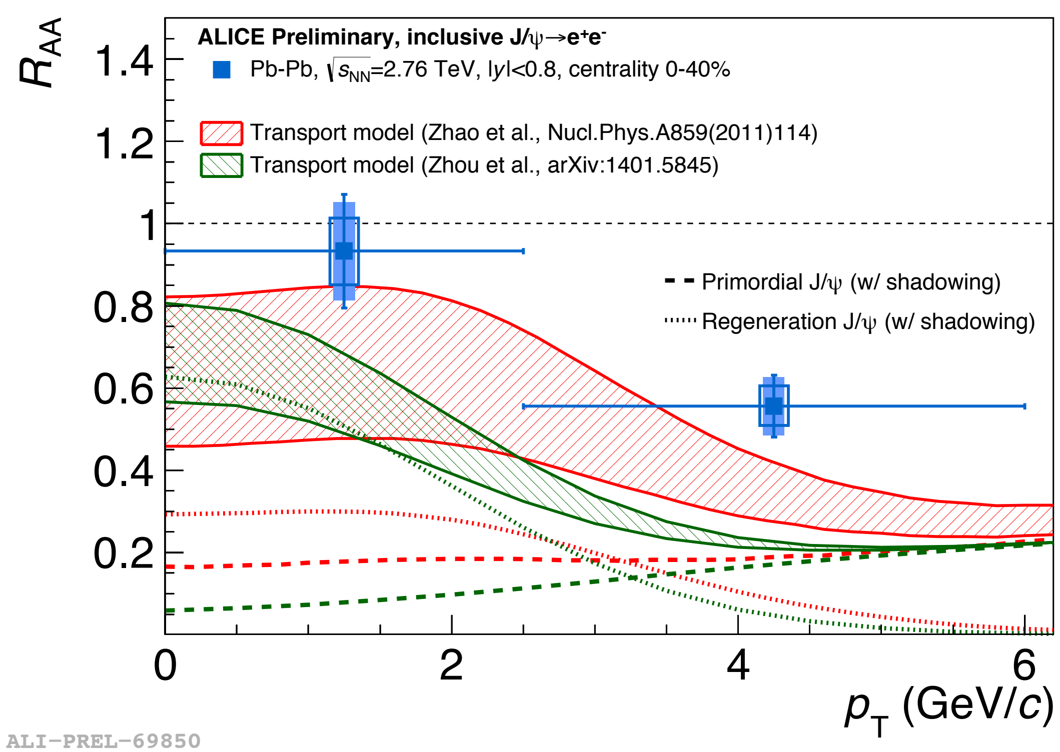
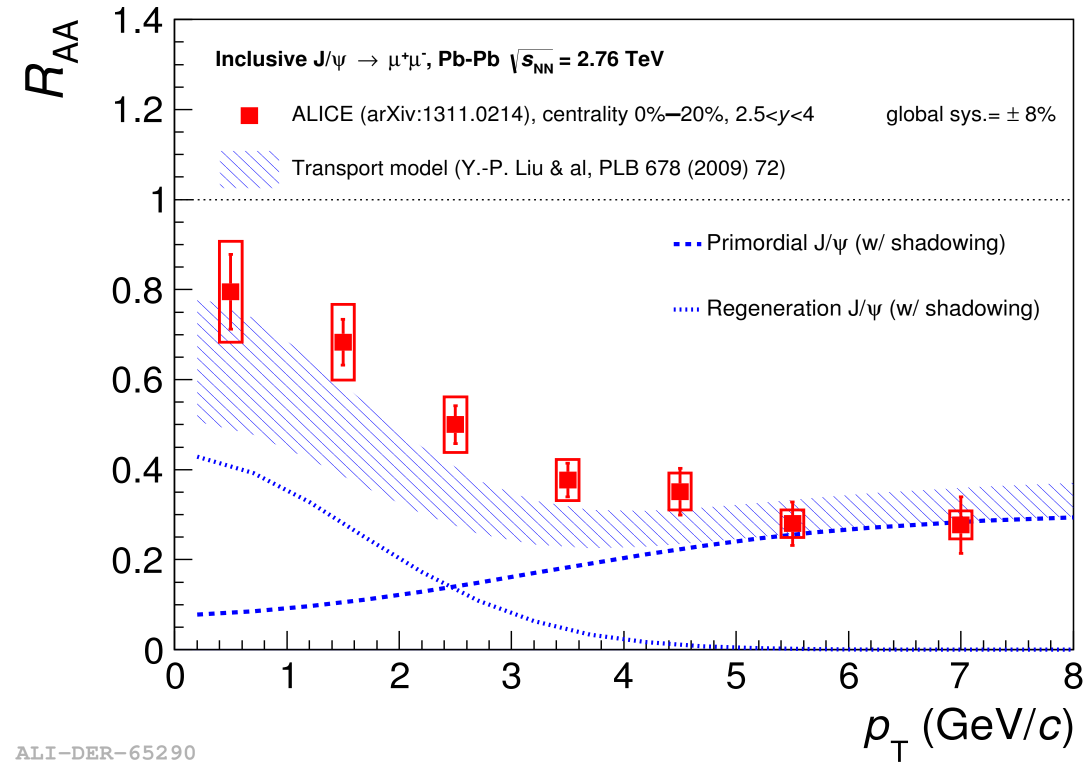






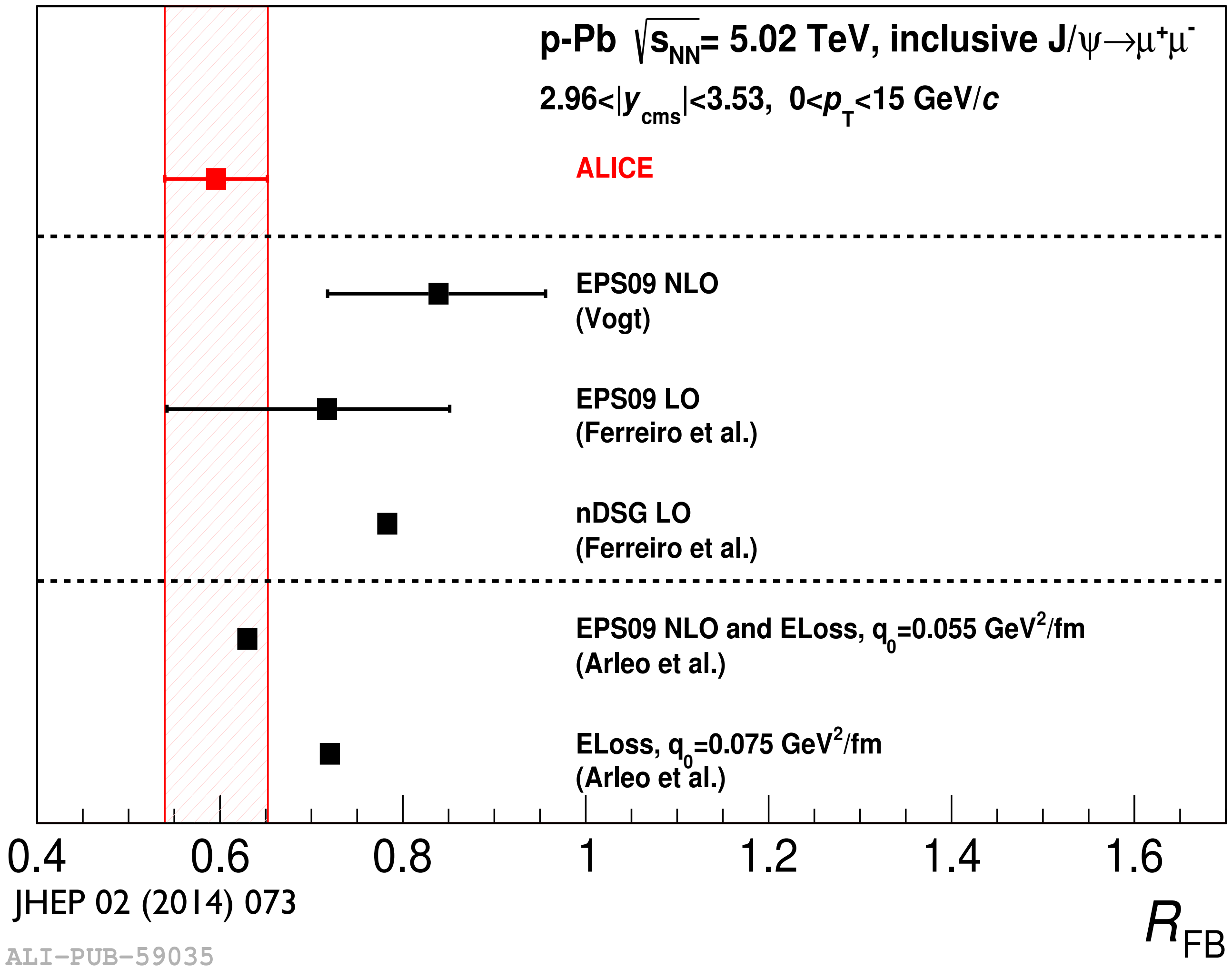
- Less suppression at low p_T than at lower energies
- Transport model describes the data. Recombination contribution important al low p_T

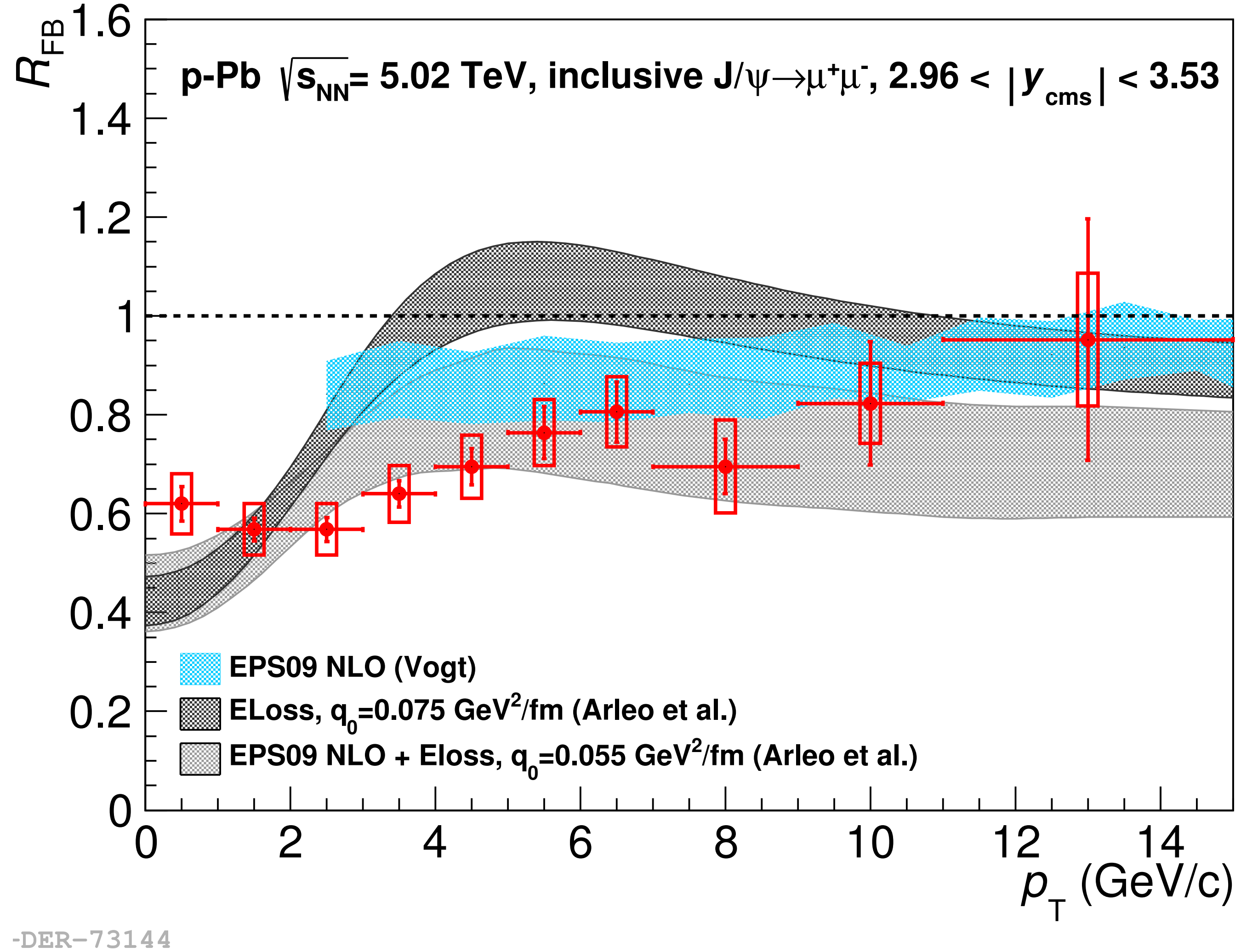
INTEGRATED AND p_T DIFFERENTIAL R_{FB}

$$R_{FB}^{J/\psi} = \frac{Y^{Forward}_{J/\psi\to\mu^+\mu^-}}{Y^{Backward}_{J/\psi\to\mu^+\mu^-}}$$

Independent of nuclear thickness (T_{pPb}) and pp cross section

Computed in the y_{cms} **range common to p-Pb and Pb-p** **(2.96 < |y_{cms}| < 3.53)**





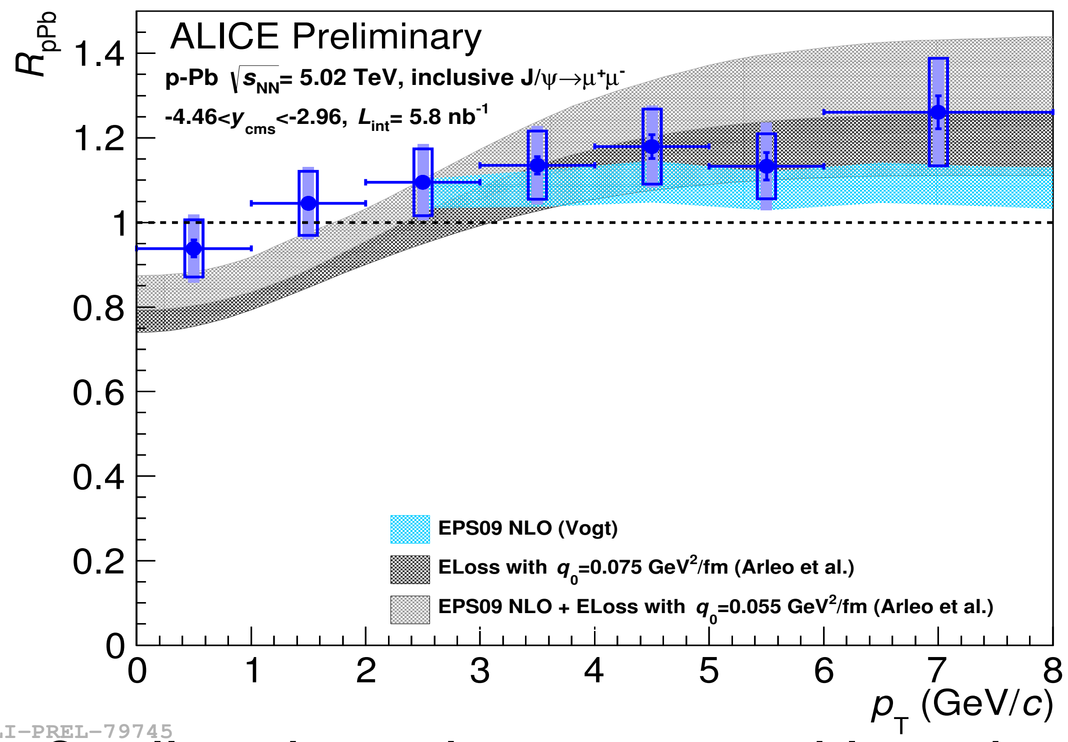
- Pure shadowing slightly overestimates data
- Shadowing with energy loss in good agreement with data

- Dependence with p_T is observed
- The suppression is stronger at low p_T

- Data are consistent with shadowing + energy loss models

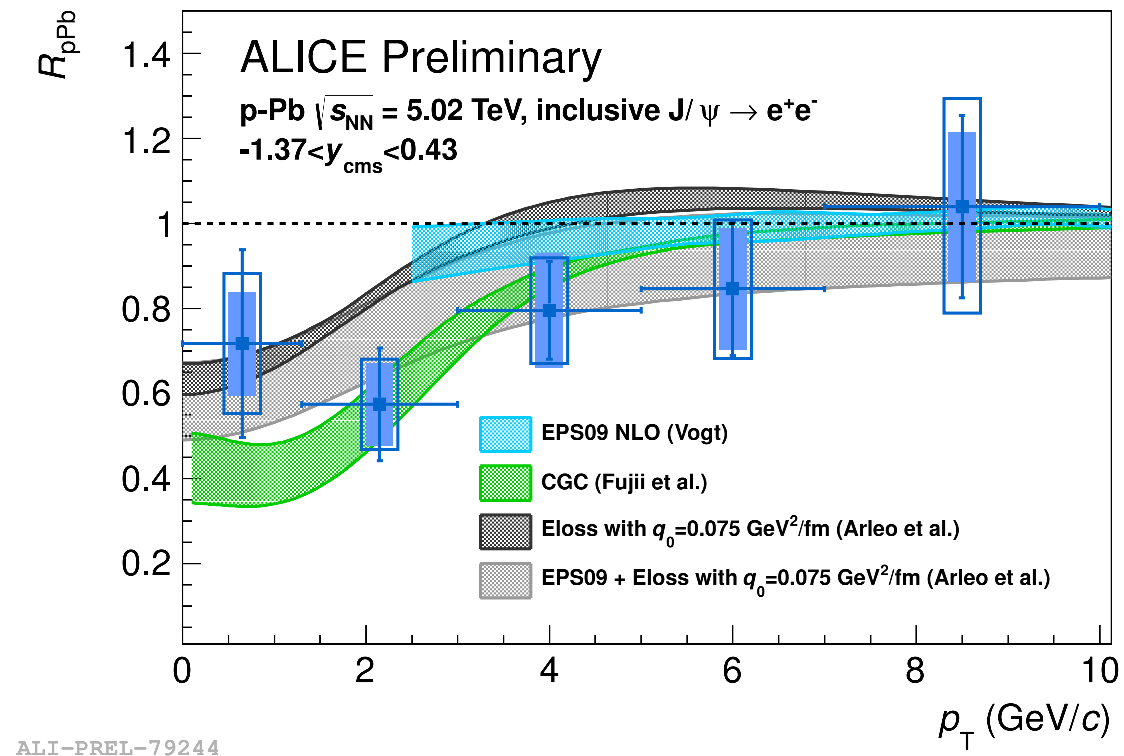
$\mathcal{R}_{\mathrm{pPb}}$ vs p_{T}

backward rapidity



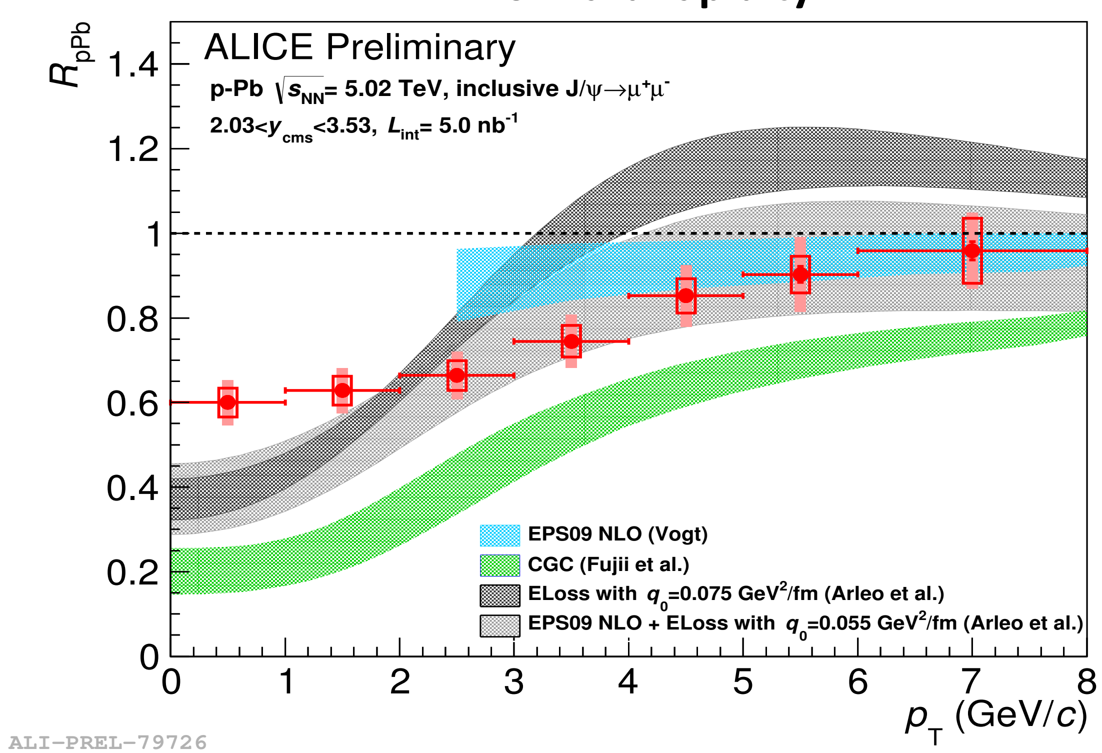
- Small p_{T} dependence, compatible with unity

midrapidity



- Small p_{T} dependence, compatible with unity for $p_{\mathrm{T}} \gtrsim 3$ GeV/c

forward rapidity



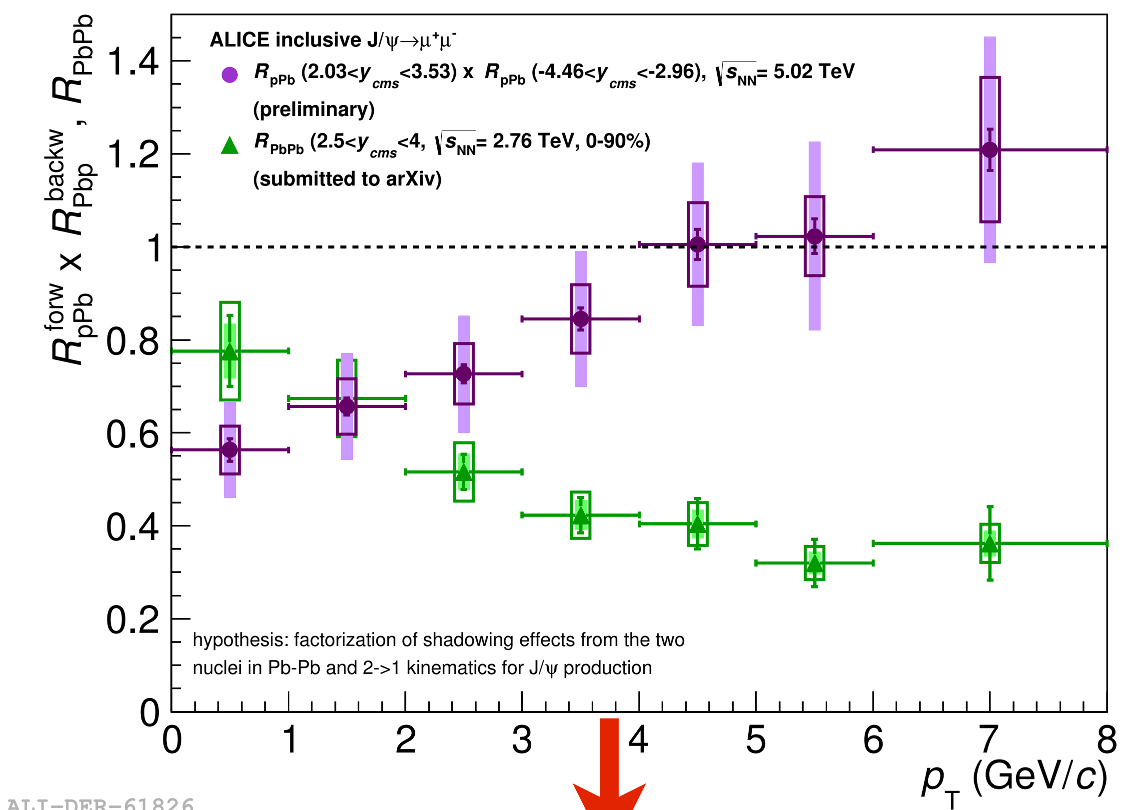
- Increases with p_{T}, compatible with unity for $p_{\mathrm{T}} \gtrsim 5$ GeV/c

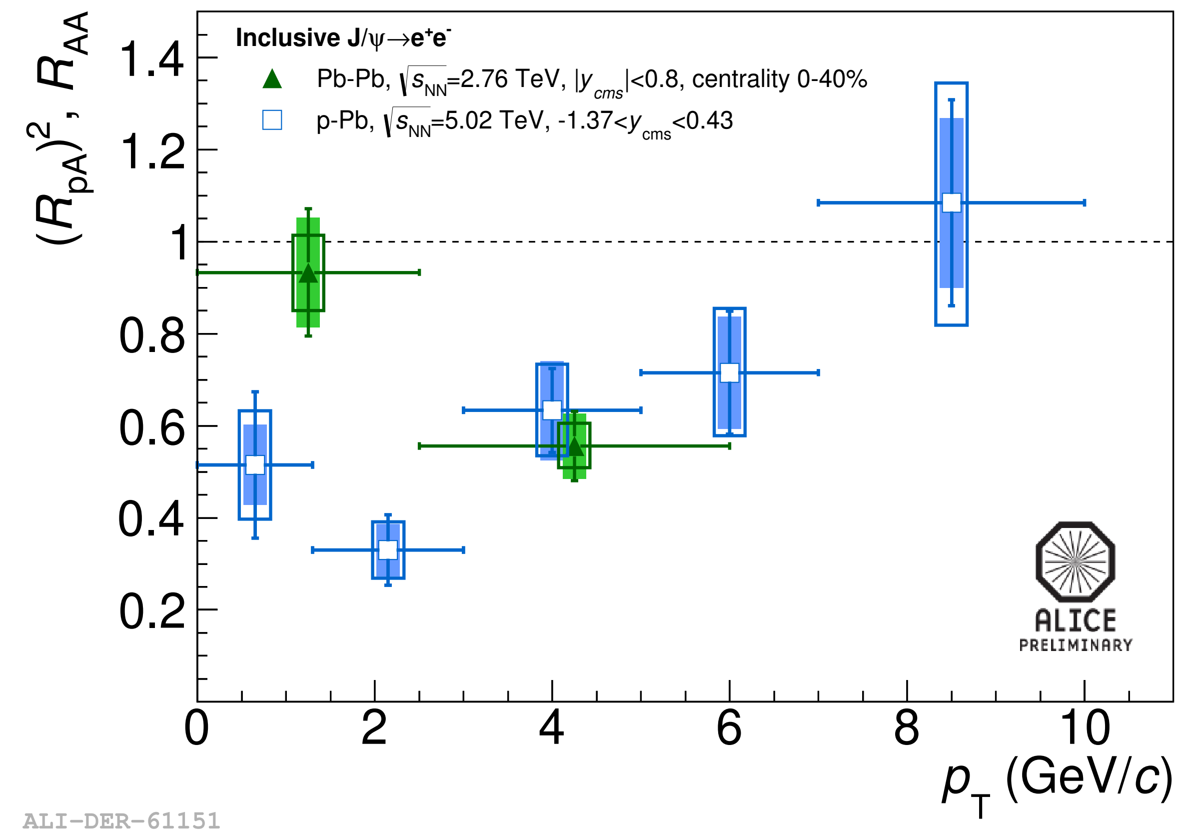
- Data are consistent with shadowing only model (calculation for $p_{\mathrm{T}} > 2.5$ GeV/c)
- Coherent energy loss overestimates suppression at forward rapidity and low p_{T}
- CGC overestimates suppression at forward rapidity

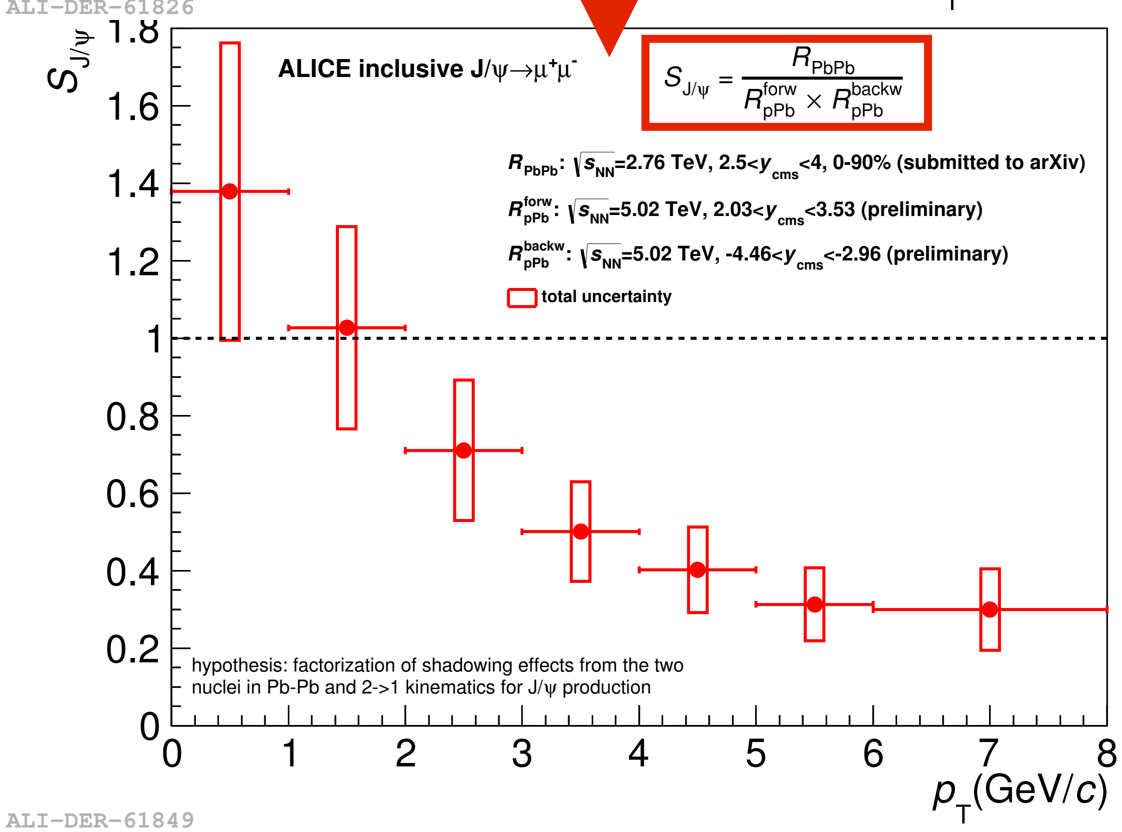
COLD NUCLEAR MATTER EFFECTS IN Pb-Pb

Assumptions:

- Production mechanism: $g + g \rightarrow J/\psi$
- CNM effects factorize in p-nucleus and are dominated by shadowing





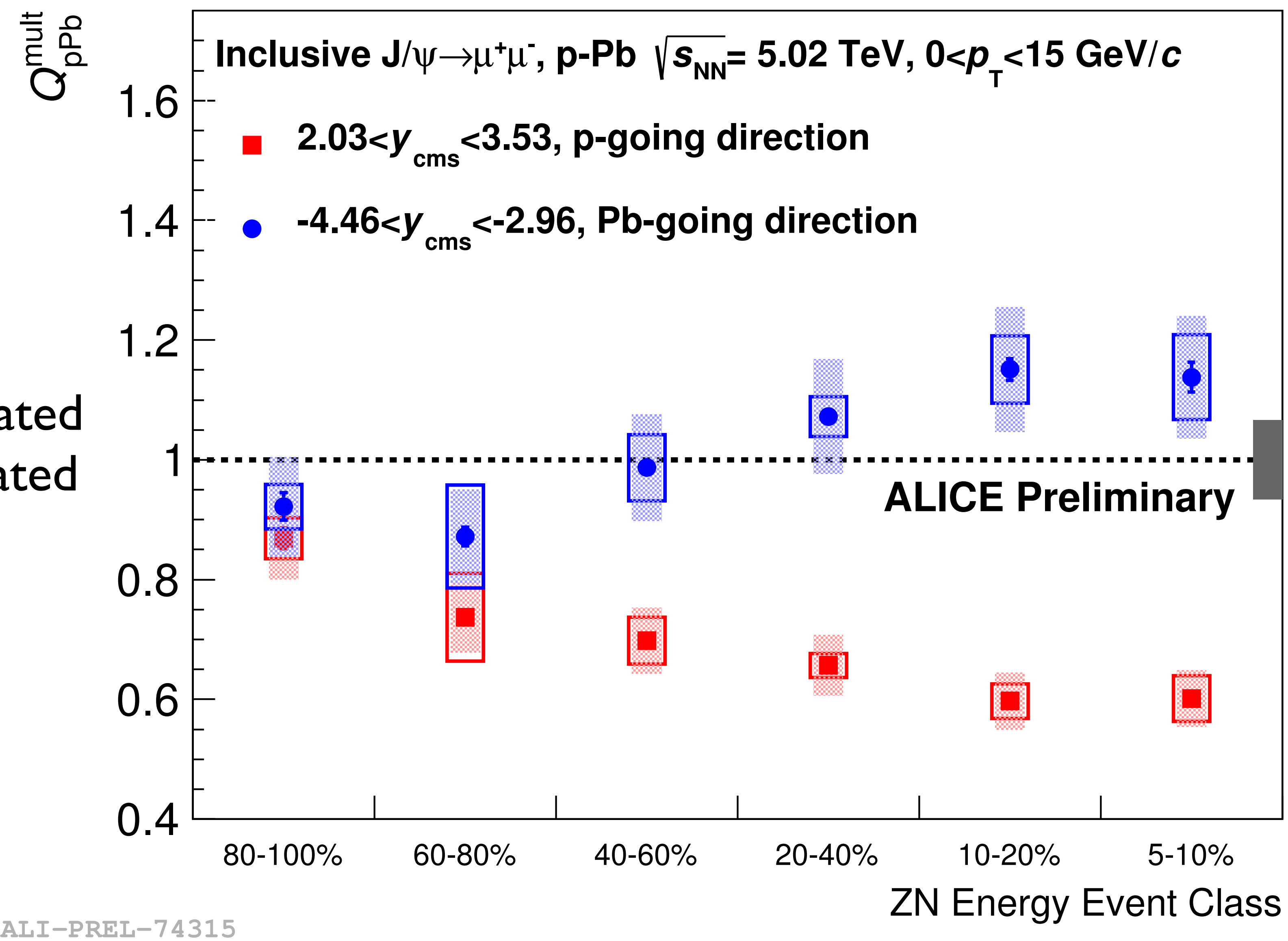


- Increase of $S_{J/\psi}$ at low p_T (observation that favors recombination scenario in Pb-Pb)
- Strong suppression at high p_T

p_T-INTEGRATED Q_{pPb} VS EVENT ACTIVITY

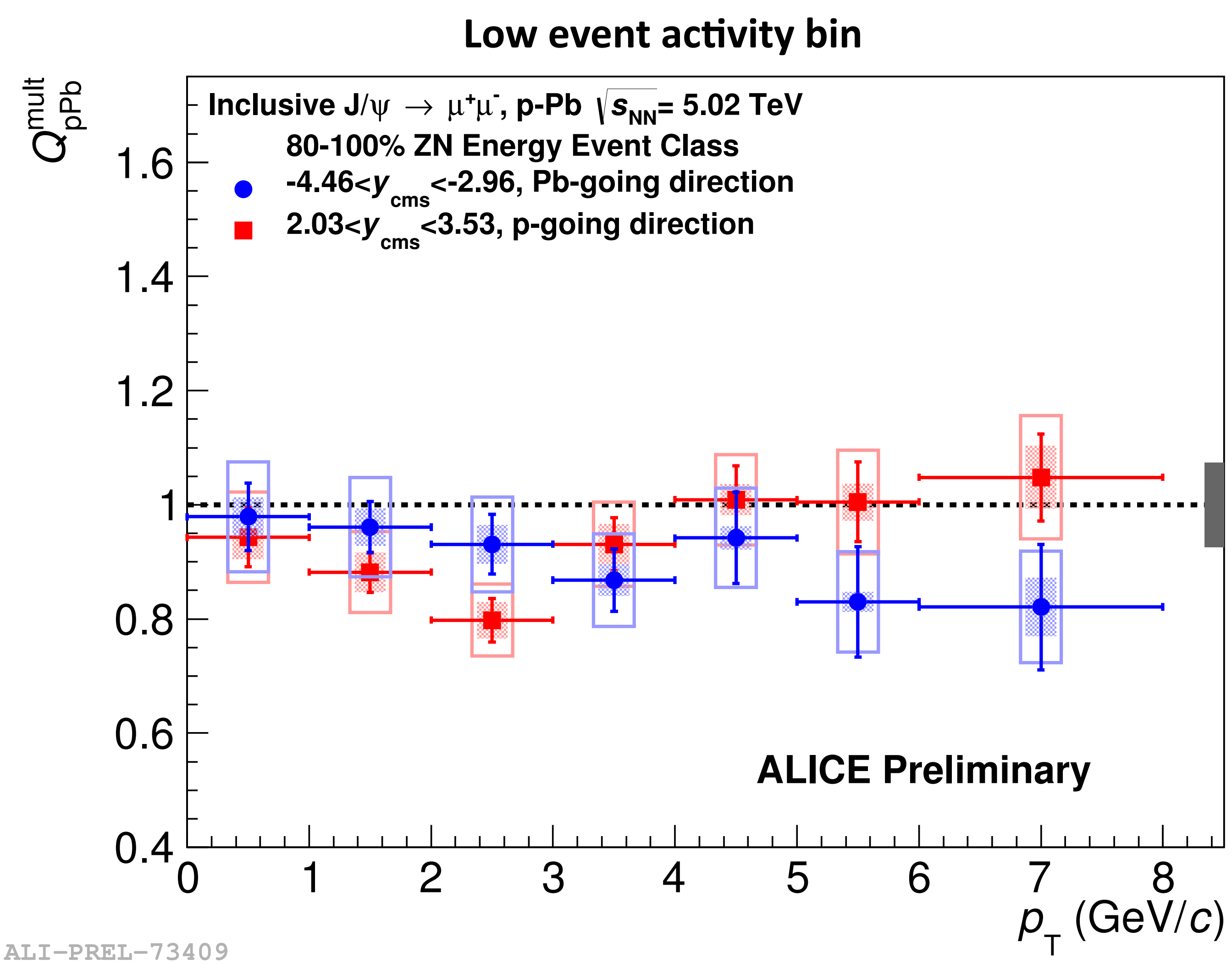
Q_{pPb} has the same definition of R_{pPb}. A different notation is used due to potential biases in the event activity estimator (ZN energy) not related to nuclear effects

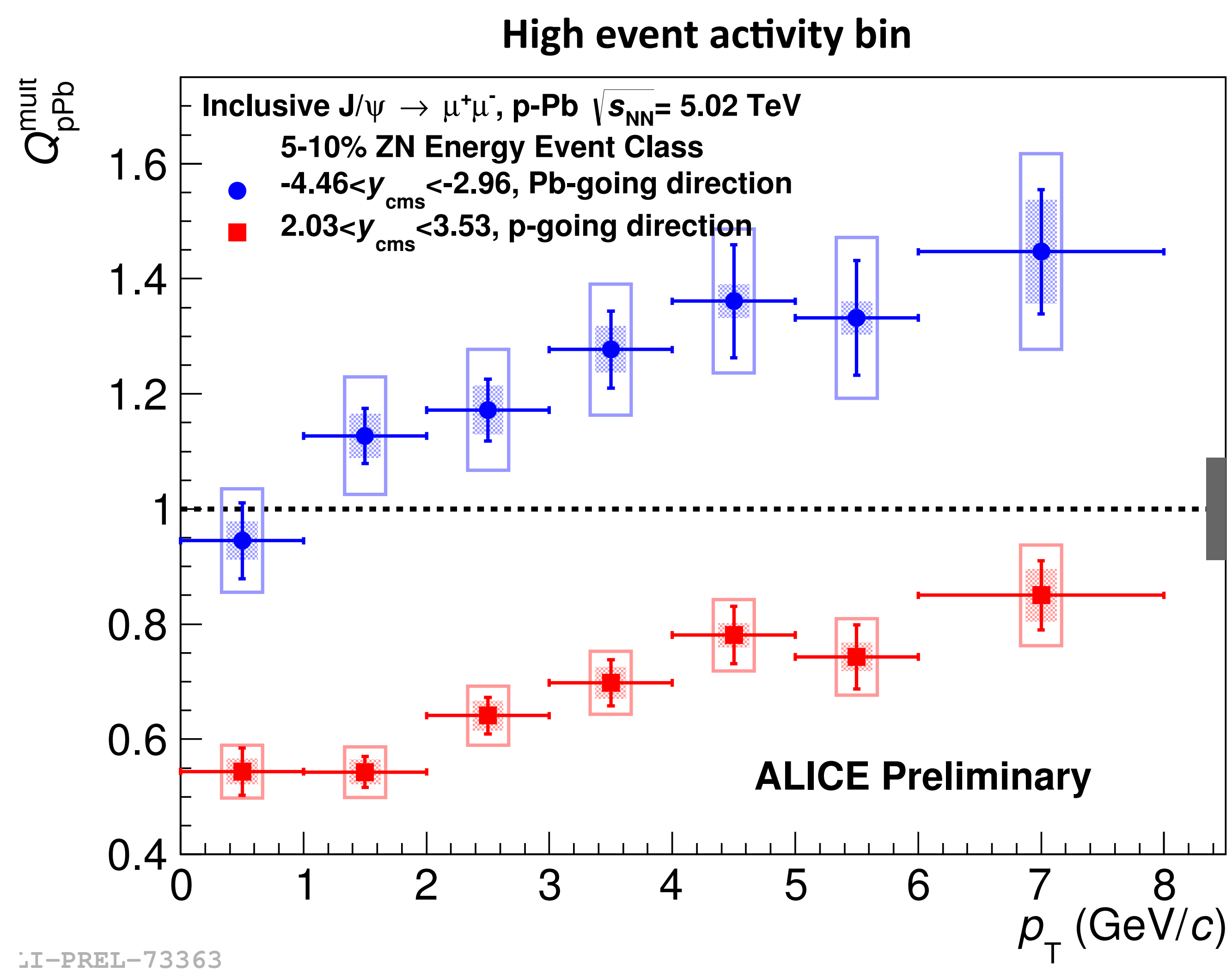
Systematic uncertainties:
- Colored boxes : uncorrelated
- Shaded areas : partially correlated
- Box around unity : fully correlated



- Decrease of Q_{pPb} from low to high event activity at forward rapidity is observed
- Q_{pPb} is consistent with unity at backward rapidity

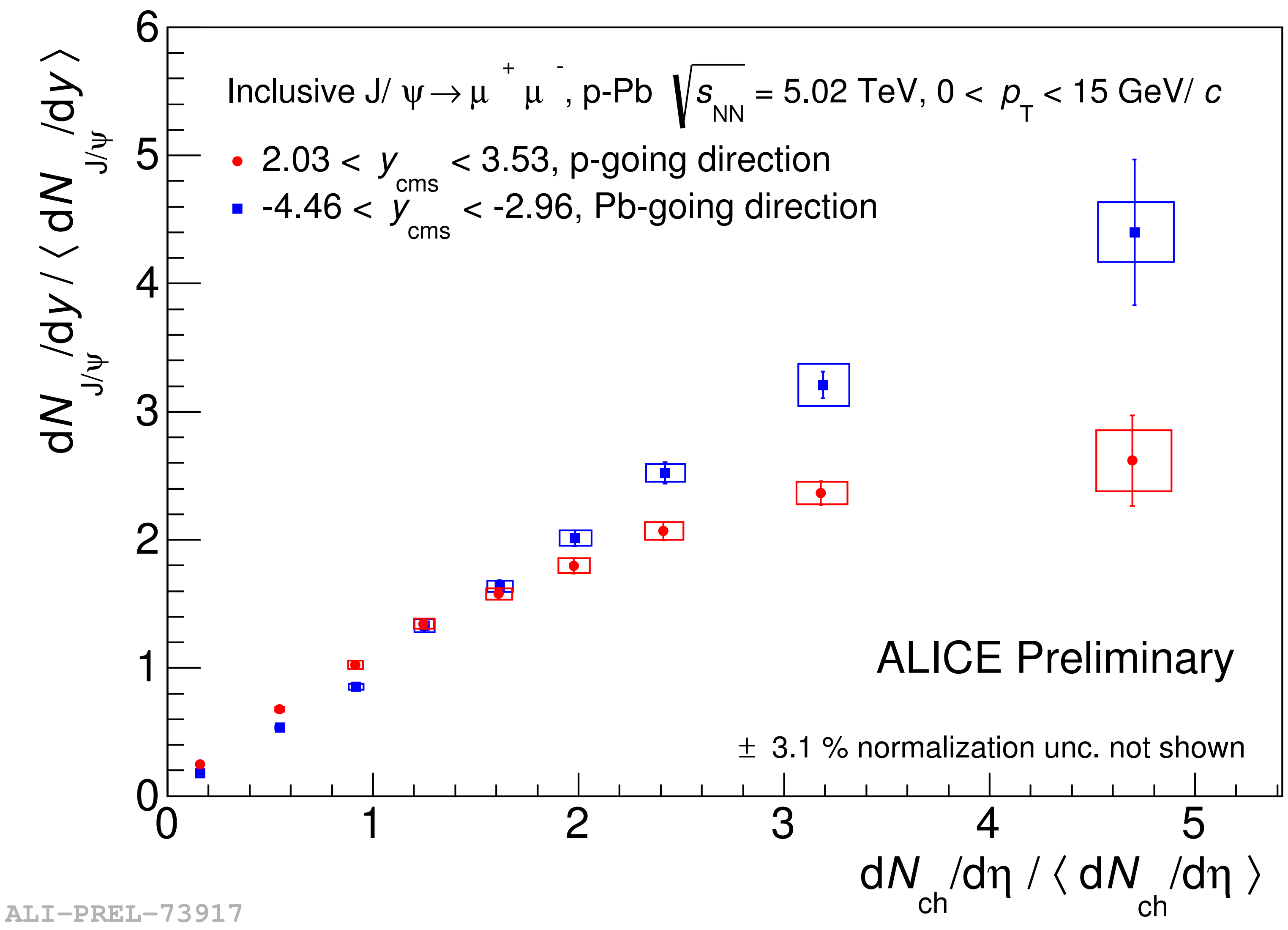
Q_{pPb} vs p_T : EVENT ACTIVITY DEPENDENCE





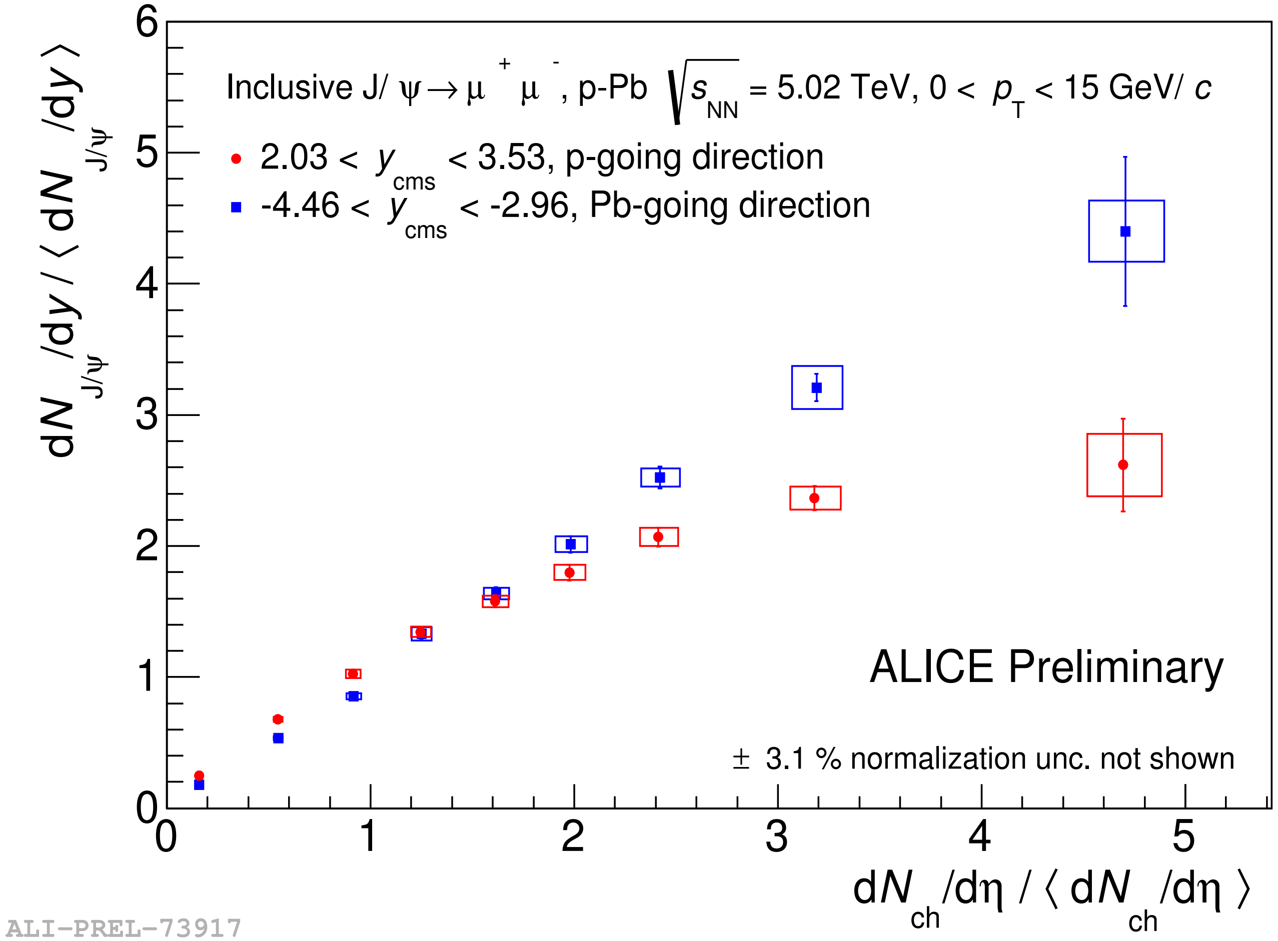
- **Increase** of Q_{pPb} for increasing event activity at **backward** rapidity. A clear p_T dependence is also observed at high event activity, with a stronger enhancement at high p_T
- **Decrease** of Q_{pPb} for increasing event activity at **forward** rapidity. A clear p_T dependence is also observed at high event activity, with a stronger suppression at low p_T
- For increasing event activity the difference between forward and backward rapidity results becomes much stronger

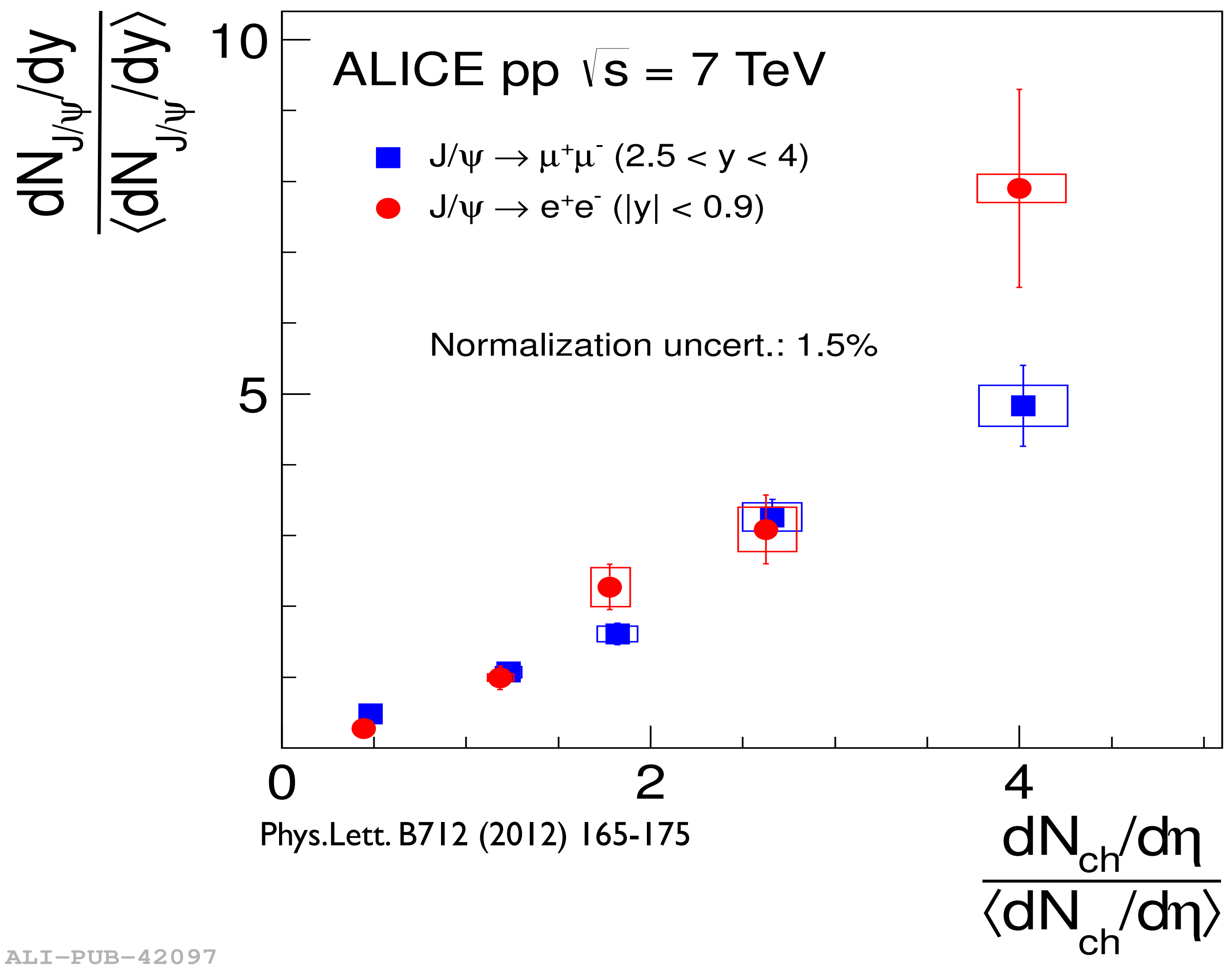
RELATIVE YIELD vs MID-y RELATIVE MULTIPLICITY



- **Strong increase** of relative J/ψ yields at forward and backward rapidity with relative multiplicity

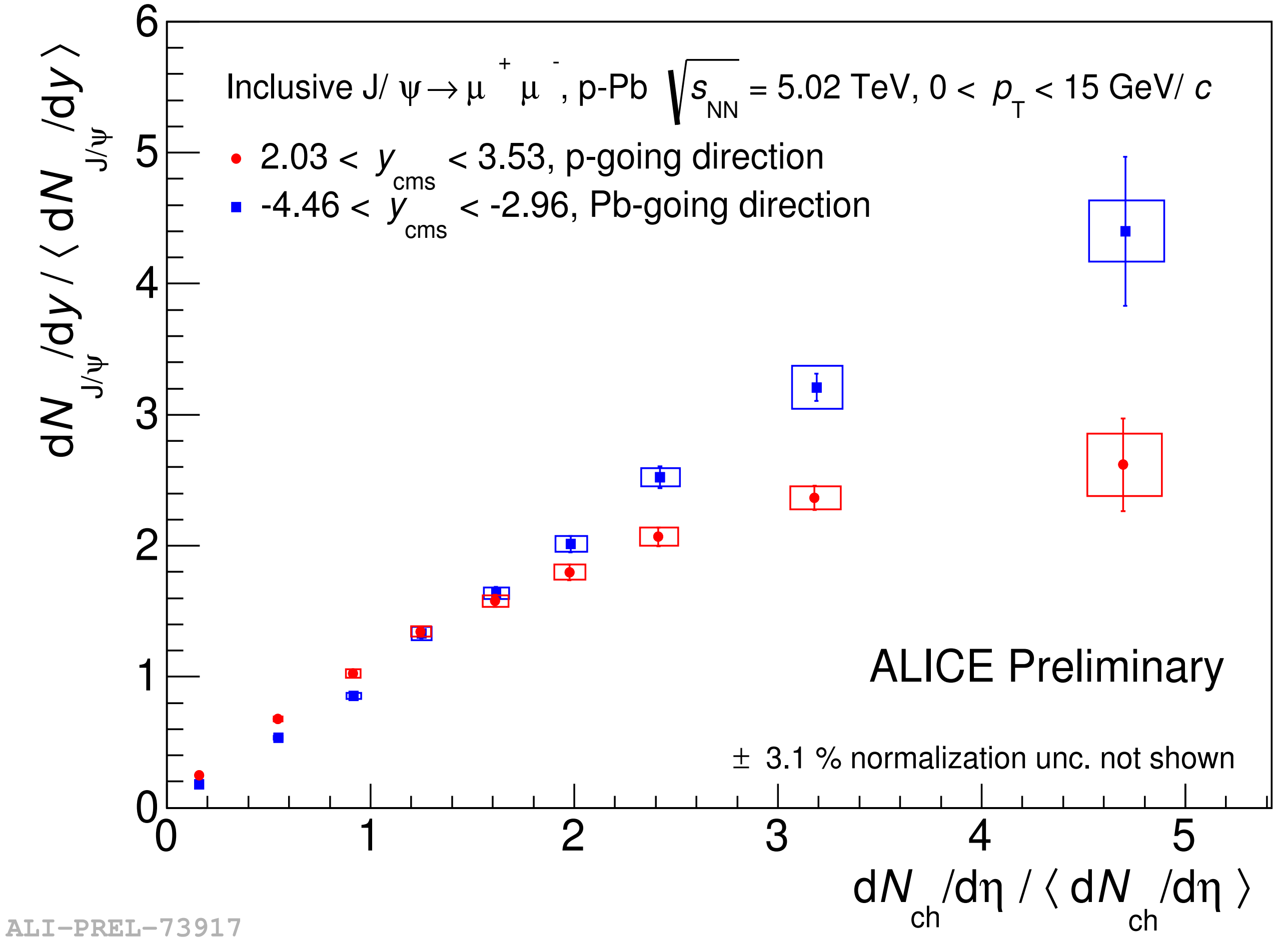
RELATIVE YIELD vs MID-y RELATIVE MULTIPLICITY

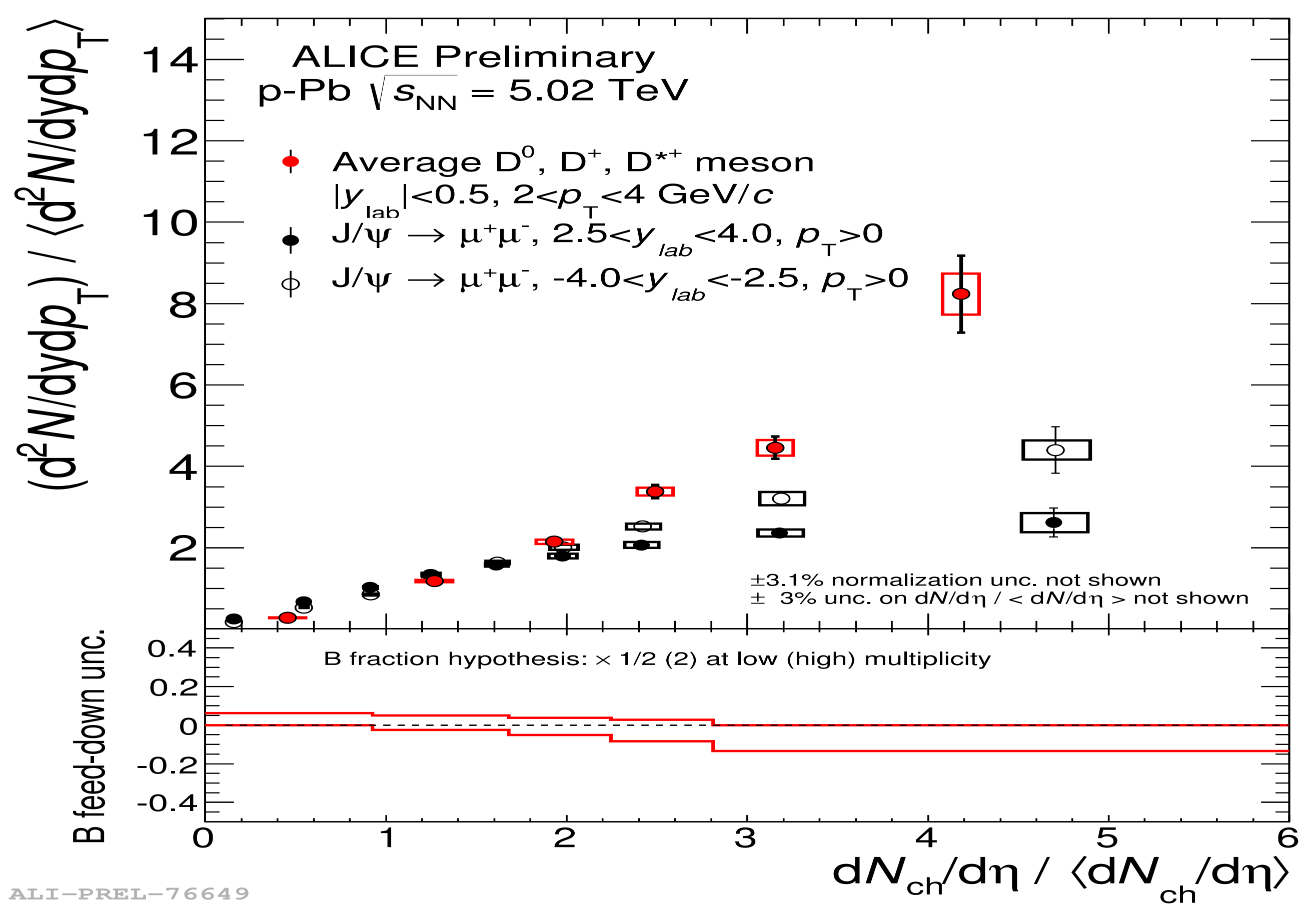




- **Strong increase** of relative J/ψ yields at forward and backward rapidity with relative multiplicity
- At backward rapidity similar behavior as found in pp collisions, deviation at forward rapidity

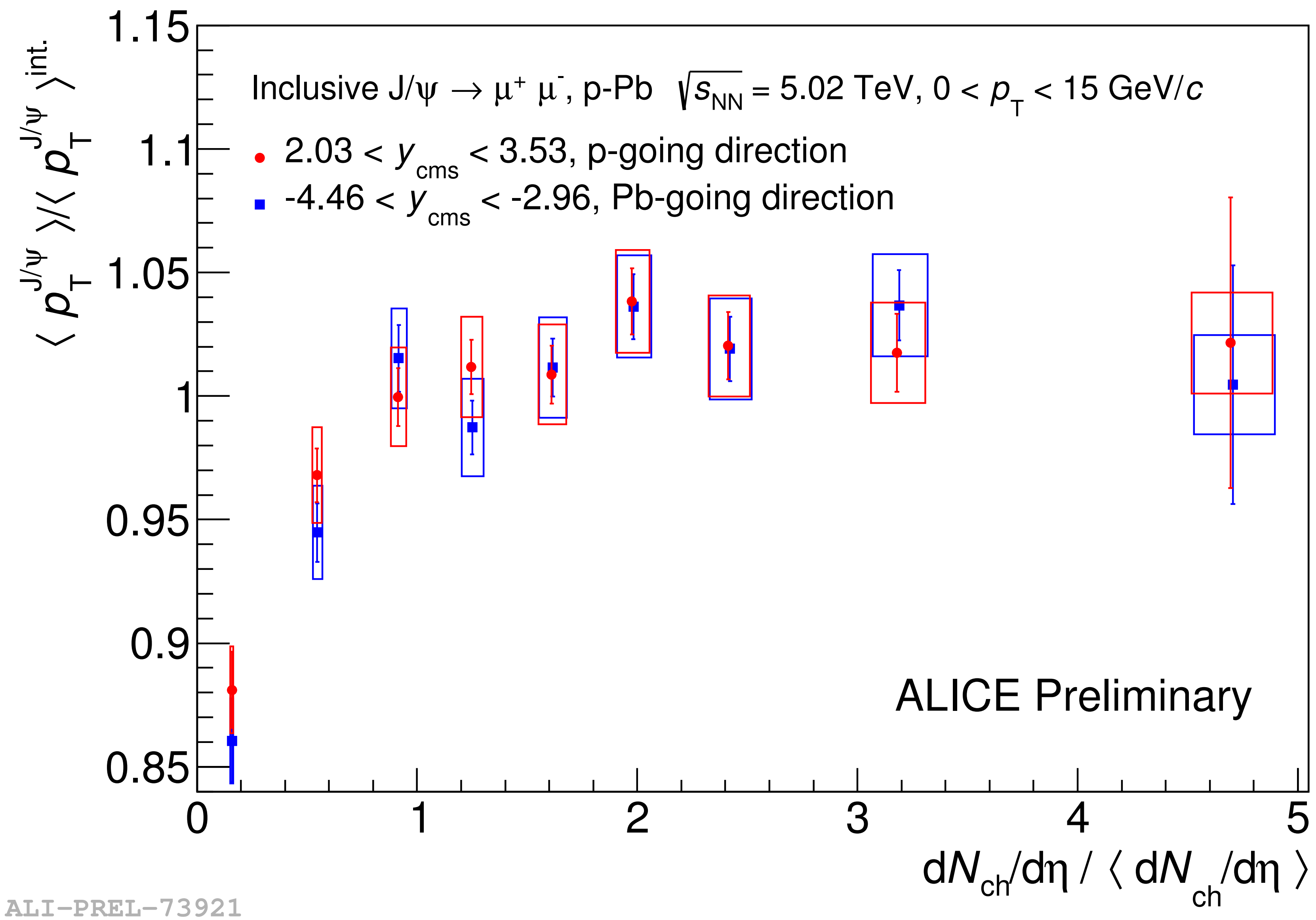
RELATIVE YIELD vs MID-y RELATIVE MULTIPLICITY





- **Strong increase** of relative J/ψ yields at forward and backward rapidity with relative multiplicity
- At backward rapidity similar behavior as found in pp collisions, deviation at forward rapidity
- D meson relative yield at central rapidity shows also a **strong increase**

$<p_T>$ vs MID-y RELATIVE MULTIPLICITY

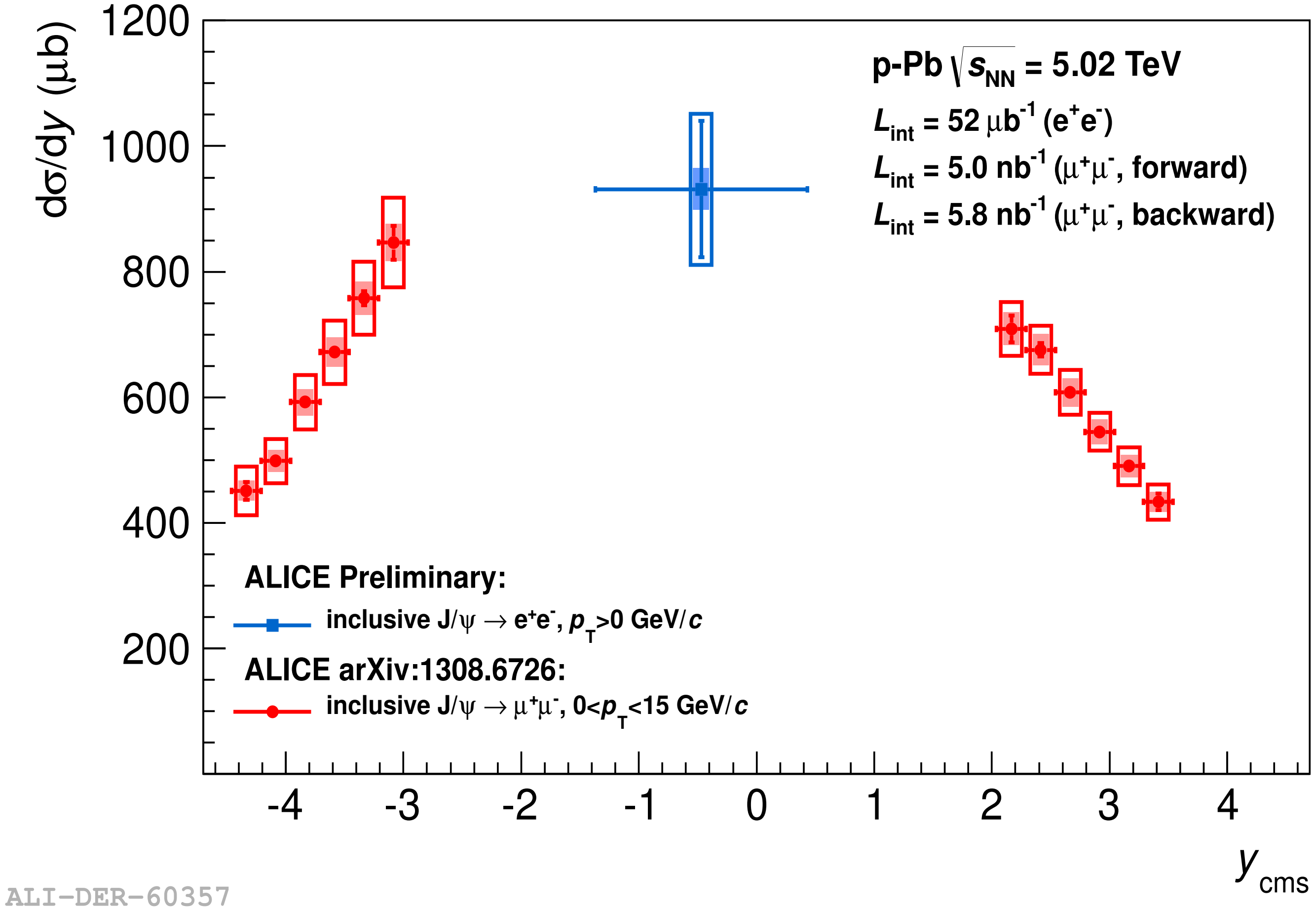


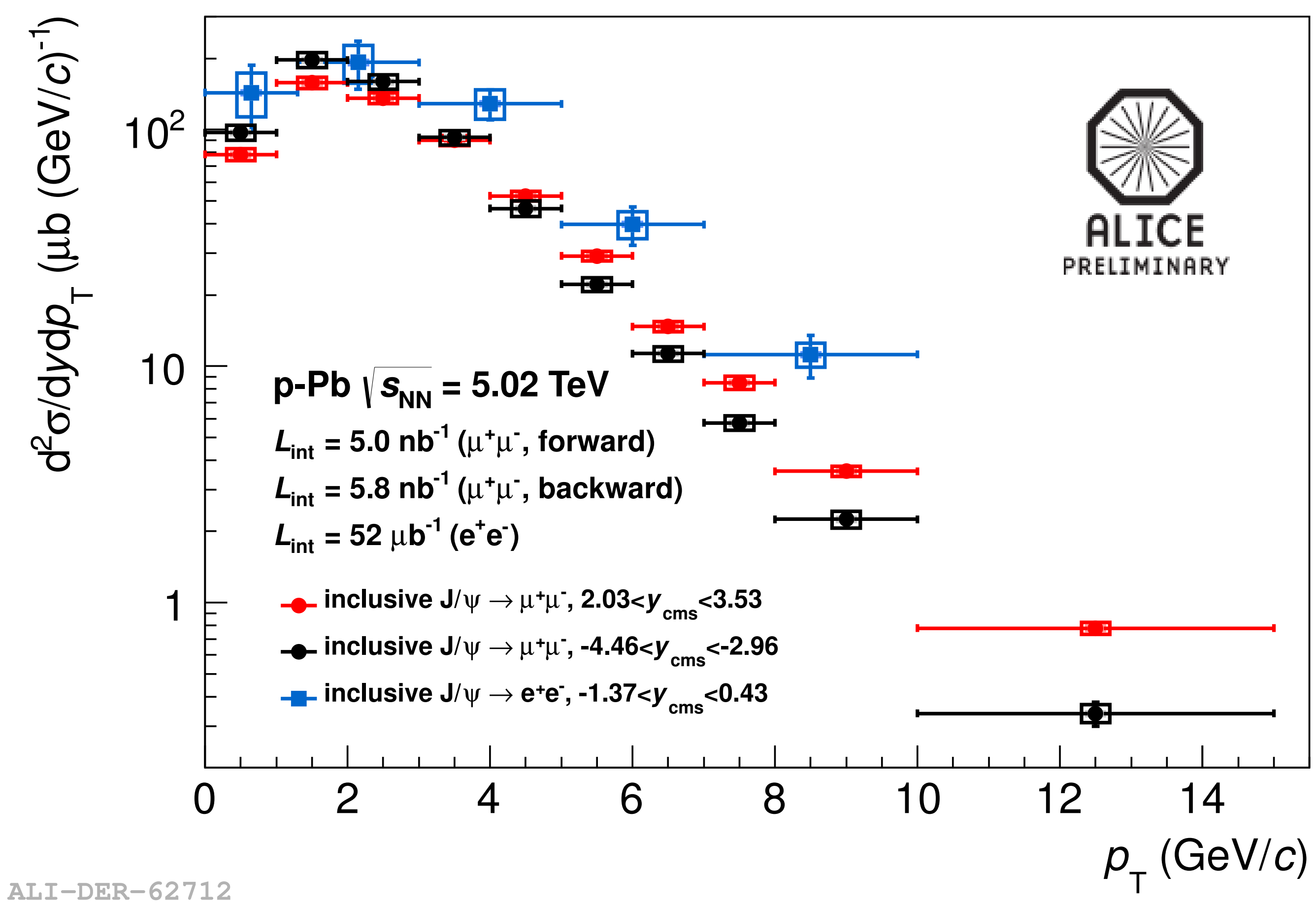
- The relative J/ψ $<p_T>$ increases with the mid-rapidity relative event multiplicity and then saturates beyond $dN_{ch}/d\eta/<dN_{ch}/d\eta>$ ~1.5
- The same behavior is observed for forward and backward rapidity J/ψ

p-Pb DIFFERENTIAL CROSS

$$\frac{d^2\sigma}{dydp_T} = \frac{Y_{J/\psi\to\mu^+\mu^-(e^+e^-)}(\Delta p_T,\Delta y)}{BR(J/\psi\to\mu^+\mu^-(e^+e^-))\times\Delta p_T\times\Delta y}\times\sigma_{MB}$$

$$Y_{J/\psi\to\mu^+\mu^-(e^+e^-)}(\Delta p_T,\Delta y) = \frac{N_{J/\psi\to\mu^+\mu^-(e^+e^-)}(\Delta p_T,\Delta y)}{N_{MB}\times A\epsilon}$$



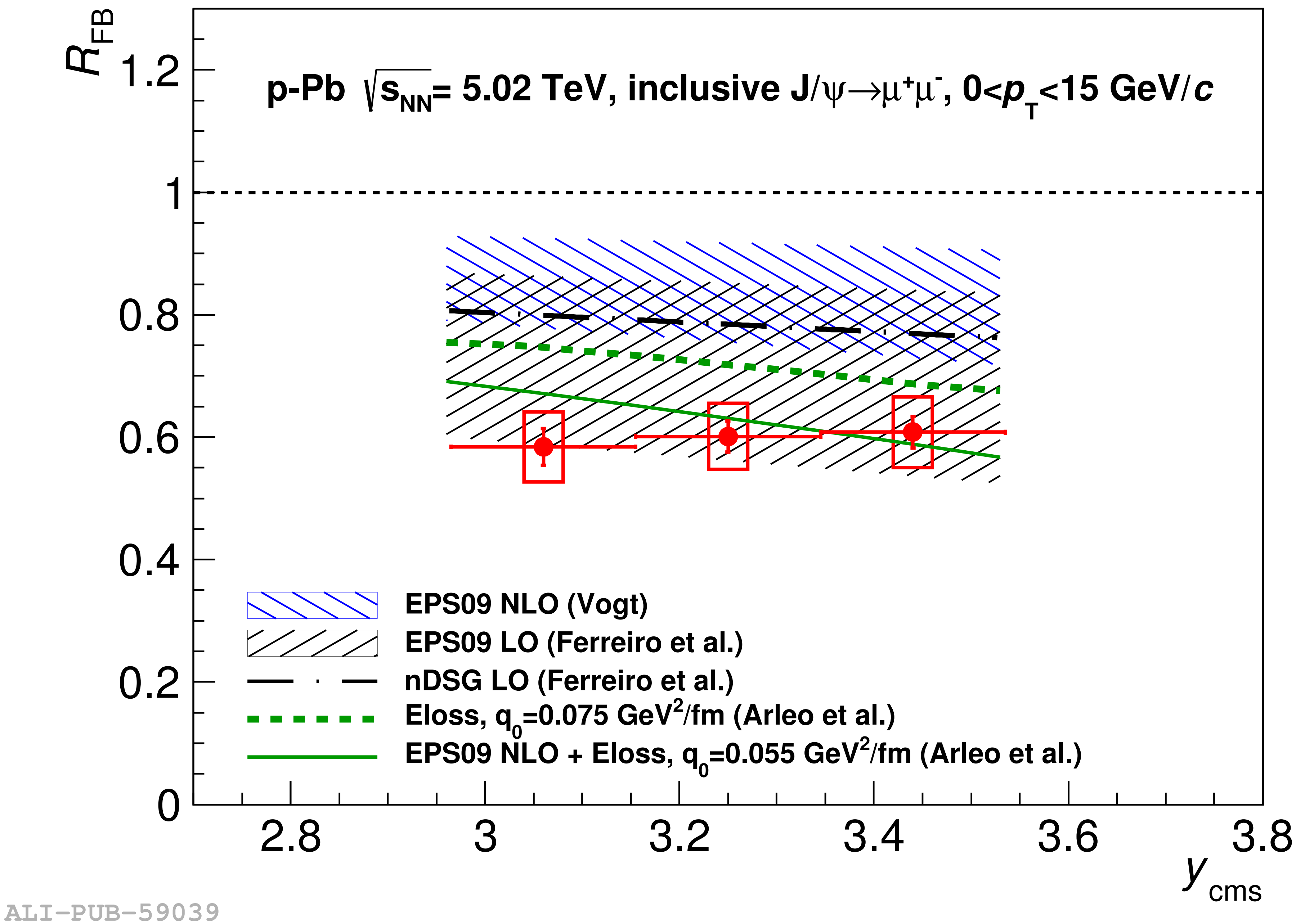


Cross-sections are higher in the backward rapidity region than in the forward region

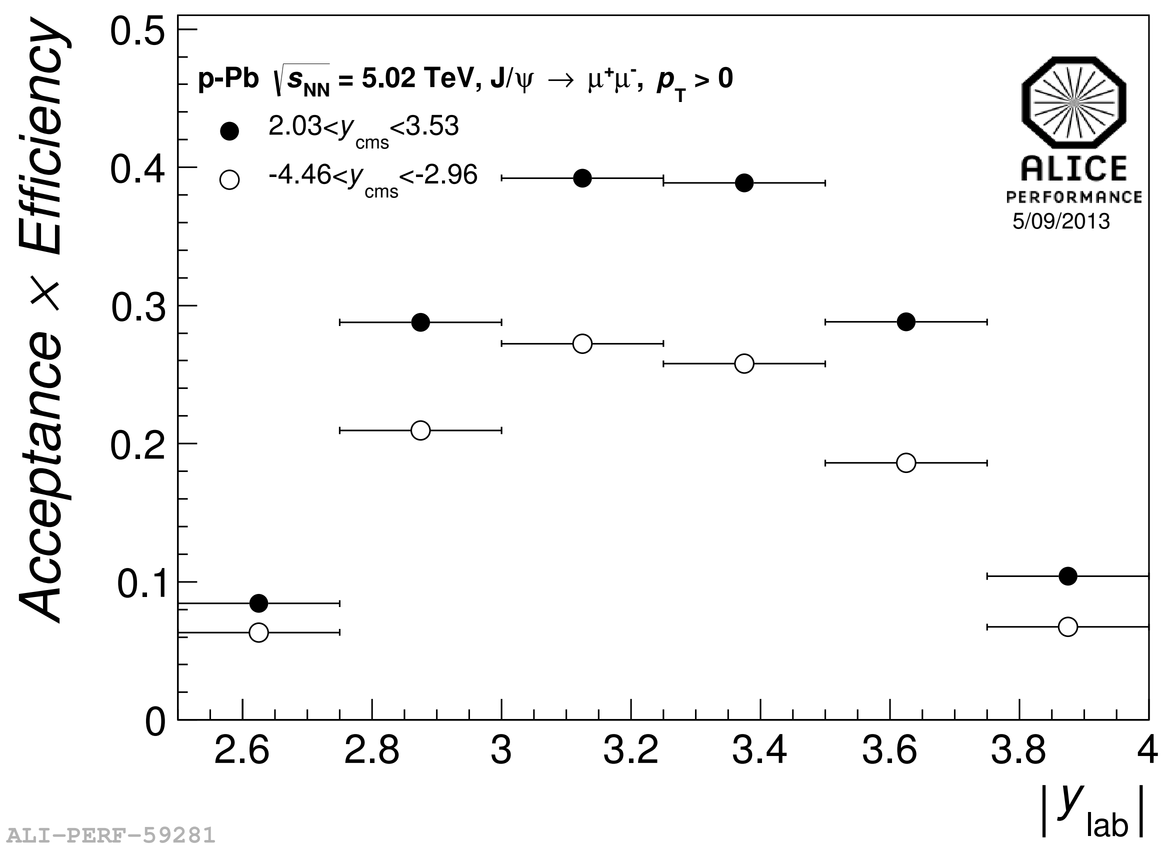
$\langle p_T\rangle_{0<pt<15} = 2.77 \pm 0.01^{stat.} \pm 0.02^{syst.}$ GeV/c

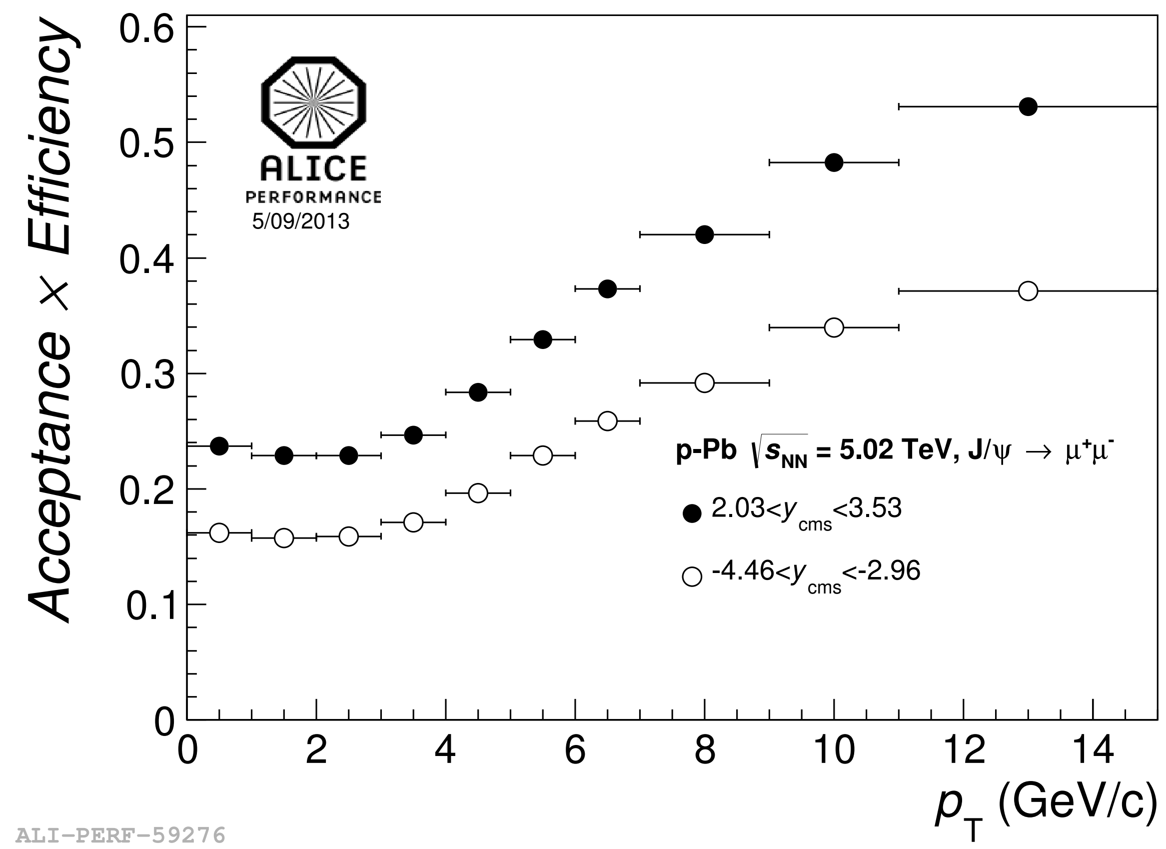
$\langle p_T\rangle_{0<pt<15} = 2.47 \pm 0.01^{stat.} \pm 0.02^{syst.}$ GeV/c

R_{FB} vs RAPIDITY



ACCEPTANCE × EFFICIENCY





R_{pPb} UNCERTAINTIES: MIDRAPIDITY

Systematic uncertainties

	p_T-integrated	p_T-differential
S. Extraction & PID uncorr. between p_T bins	11.1 %	10 - 20 %
Tracking efficiency uncorr. between p_T bins	6 %	6 %
MC kinematics	3 %	negligible
$\langle T_{pPb} \rangle$ fully corr. wrt. forward and backward results	3.4 %	-
σ_{pPb}^{MB} corr between p_T bins and wrt forward result	-	3.4 %
$\sigma_{pp}^{J/\psi}$ 16.6% corr. between p_T bins	16.6 %	17 - 27 %

UNCERTAINTIES: FORWARD/BACKWARD RAPIDITY

Systematic uncertainties (not exhaustive, just indicative)

	p-going direction	Pb-going direction
Tracking Efficiency	4 %	6 %
Trigger Efficiency	2.8 % (2-3.6%****)	3.2 % (2-3.6%***)
Signal extraction	1.3 % (1 - 4 %)	1.2 % (1.2 - 6.7 %)
MC input	1.5 % (0.1 - 3 %)	1.5 % (0.1 - 4.2 %)
Matching efficiency	1 %	1 %
F	1 %	1 %
$\sigma_{pp}^{J/\psi}$ **	4.3 % (3.1 - 6.0 %)	4.6 % (1.5 - 13.4 %)
$\langle T_{pPb} \rangle$ ***	(1.5-9.5 %)	(1.5-9.5 %)
σ_{pPb}^{MB} *	3.2 %	3 %
$\sigma_{pp}^{J/\psi}$ **	3.7 % (2.7 - 9.2 %)	3.1 % (1.2 - 8.3 %)
Pile-up***	2 %	2 %
B.R	1 %	
$\langle T_{pPb} \rangle$ **	3.6 %	
$\sigma_{pp}^{J/\psi}$ **	5.5 %	

Uncorrelated (in p_T/y and betw. systems)
Partially correlated (c. in p_T/y, uc. betw. systems)
Correlated (fully correlated)

Note: The sharing of the uncertainties may change slightly in event activity bins depending on the quantities plotted.

* for $\sigma_{pPb}^{J/\psi}$ only

() min-max values in p_T, y or ZN-bins

** for R_{pPb} and Q_{pPb} only

*** for Q_{pPb} and $\sigma_{pPb}^{J/\psi}$ in ev. act bins only

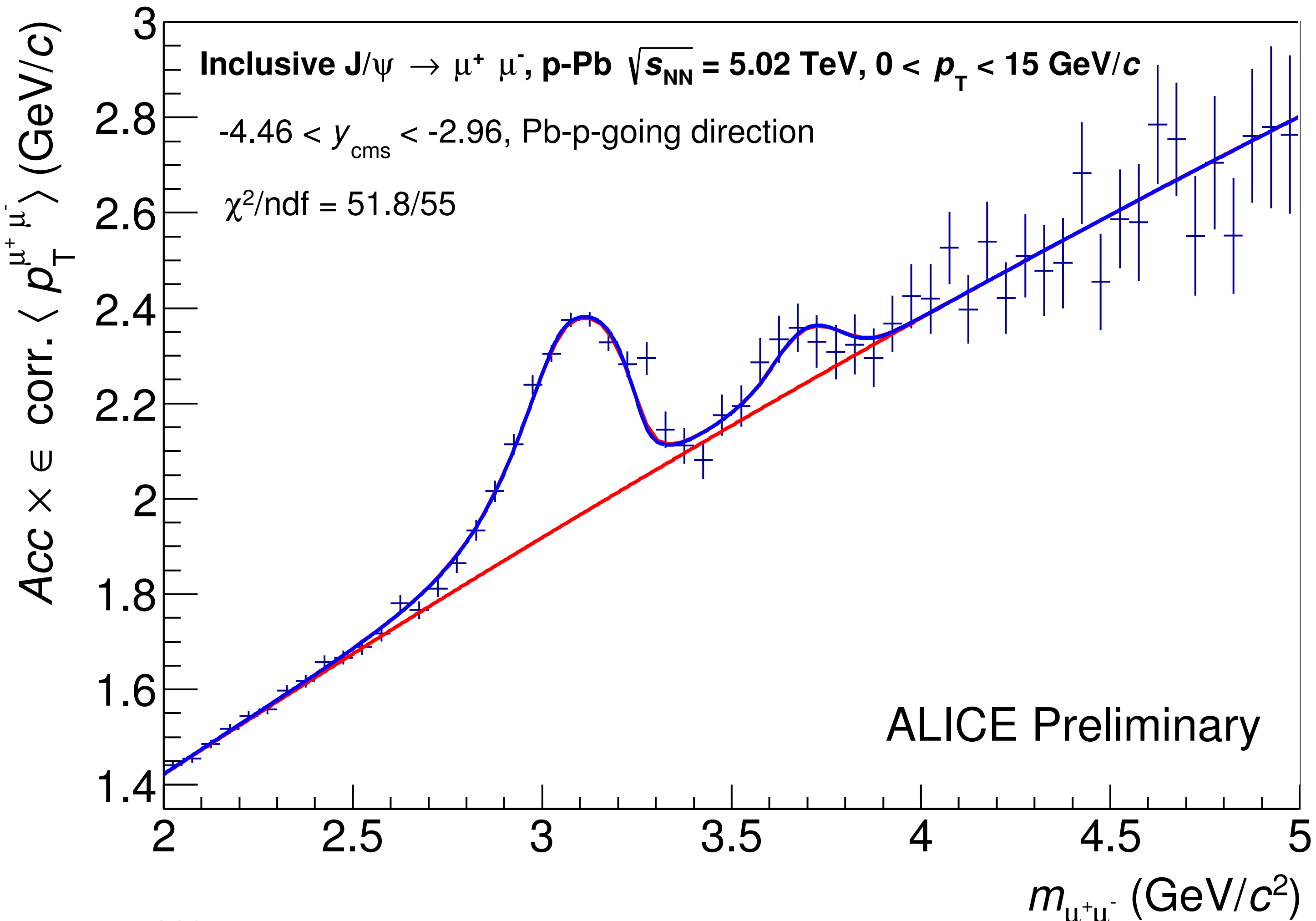
**** for p_T bins only

RELATIVE YIELD AND $<p_T>$ vs MID-y RELATIVE MULTIPLICITY ANALYSIS STRATEGY

J/ψ signal extraction and $<p_T>$ extraction from J/ψ $Acc \times \varepsilon\,(p_T, y)$ corrected spectra in multiplicity bins

Yield extraction procedure similar to previous analysis, for $<p_T>$ a different method used:

$$< p_T >^{\mu^+\mu^-}(M_{\mu^+\mu^-}) = \alpha^{J/\psi}(M_{\mu^+\mu^-})\times < p_T >^{J/\psi} + \alpha^{\psi\prime}(M_{\mu^+\mu^-})\times < p_T >^{\psi\prime} + (1 - \alpha^{J/\psi}(M_{\mu^+\mu^-}) - \alpha^{\psi\prime}(M_{\mu^+\mu^-}))\times < p_T >^{bkg}$$



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Based on Signal-Background ratio:

$$\alpha(M_{\mu^+\mu^-}) = \frac{S(M_{\mu^+\mu^-})}{S(M_{\mu^+\mu^-}) + B(M_{\mu^+\mu^-})}$$

$$< p_T >^{J/\psi} \rightarrow constant$$

$$< p_T >^{\psi\prime} \rightarrow constant$$

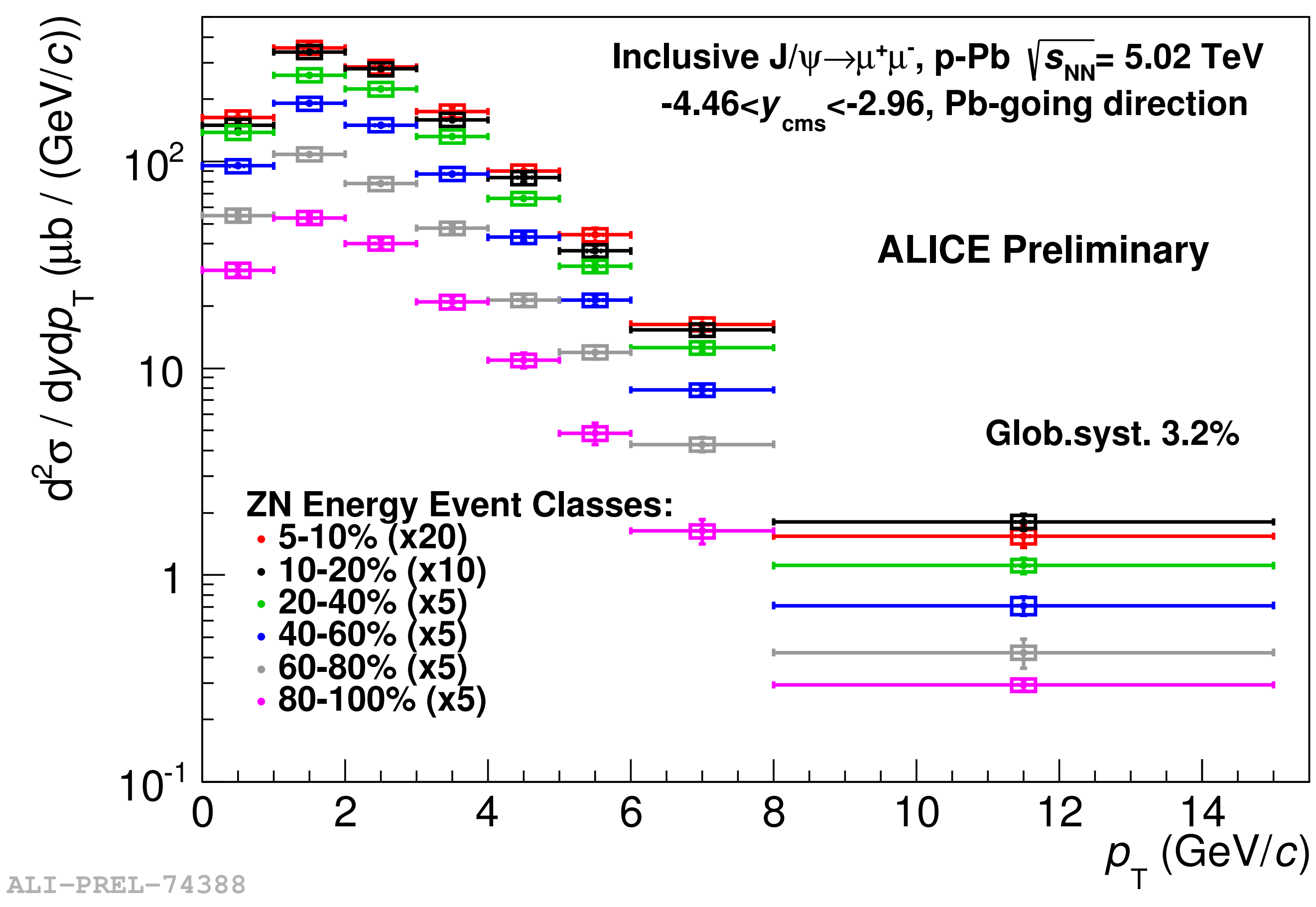
$$< p_T >^{bkg} = pol2$$

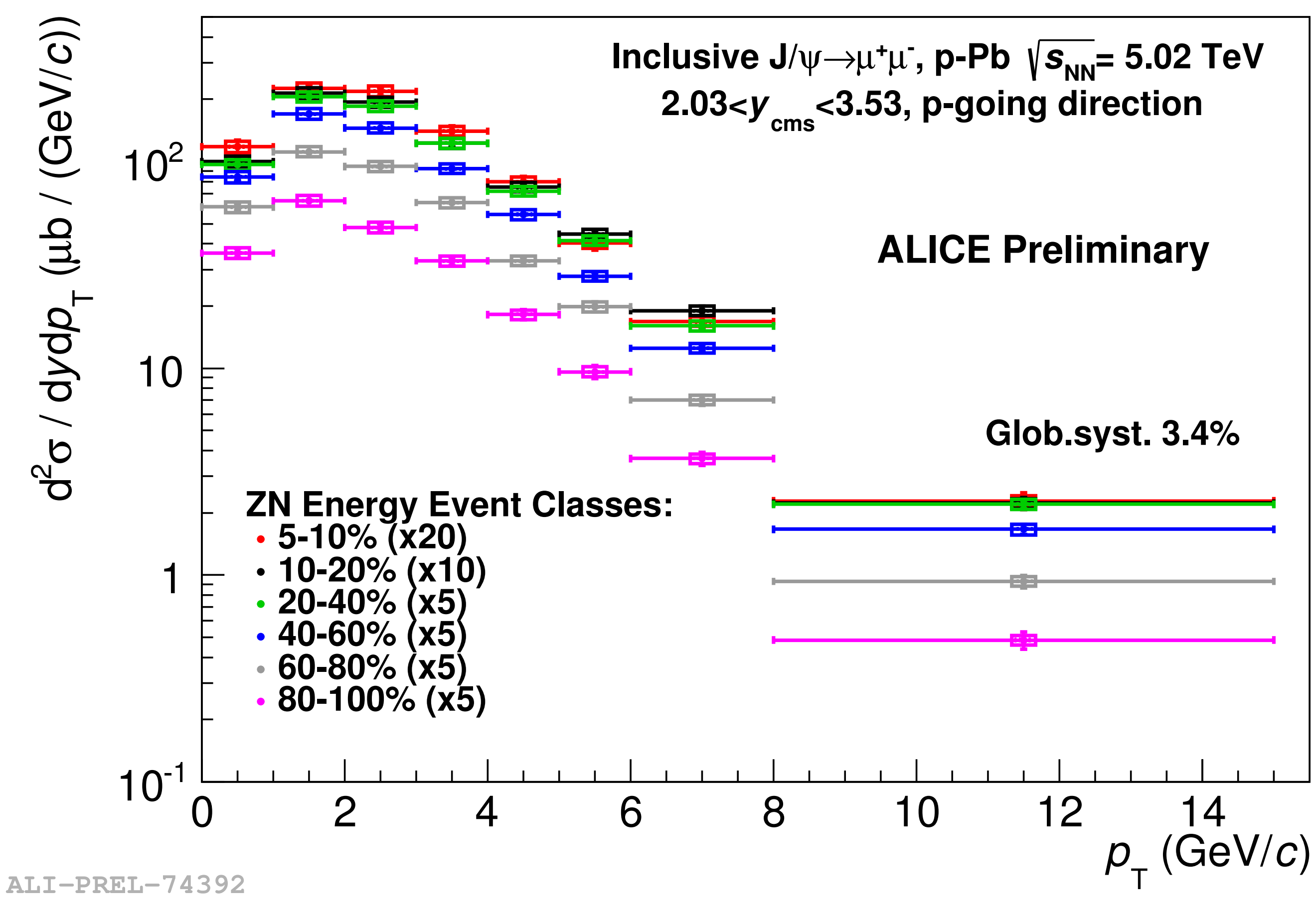
RELATIVE YIELD AND <p_T> vs MID-y RELATIVE MULTIPLICITY UNCERTAINTIES

Only uncorrelated systematic uncertainties remains at first order in relative quantities

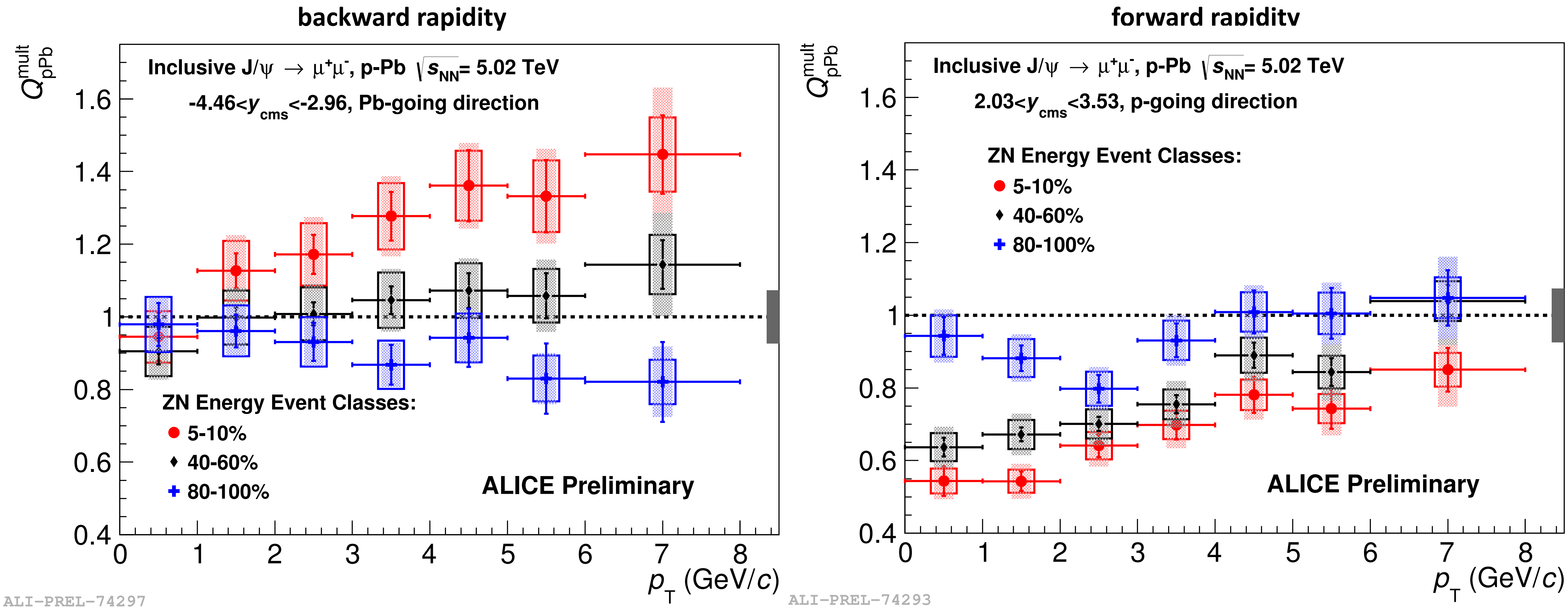
	Forward-y	Backward-y
Extraction method $N_{J/\psi}^{bin}$	1.5-7 %	1.5-7 %
S. Extraction $N_{J/\psi}^{bin}/N_{J/\psi}$	1.5-3.3 %	1.5-4.6 %
$\langle p_T \rangle$ MC input	2 %	2 %
Extraction $\langle p_T \rangle / \langle p_T \rangle^{int.}$	0.1-0.4 %	0.1-1.2 %
F	1-7 %	1-4%
$\langle dN_{ch}/d\eta \rangle$	3.9%	3.9%
Pile up	1-4%	1-2%

p_T-DIFFERENTIAL CROSS SECTION EVENT ACTIVITY DEPENDENCE IN p-Pb



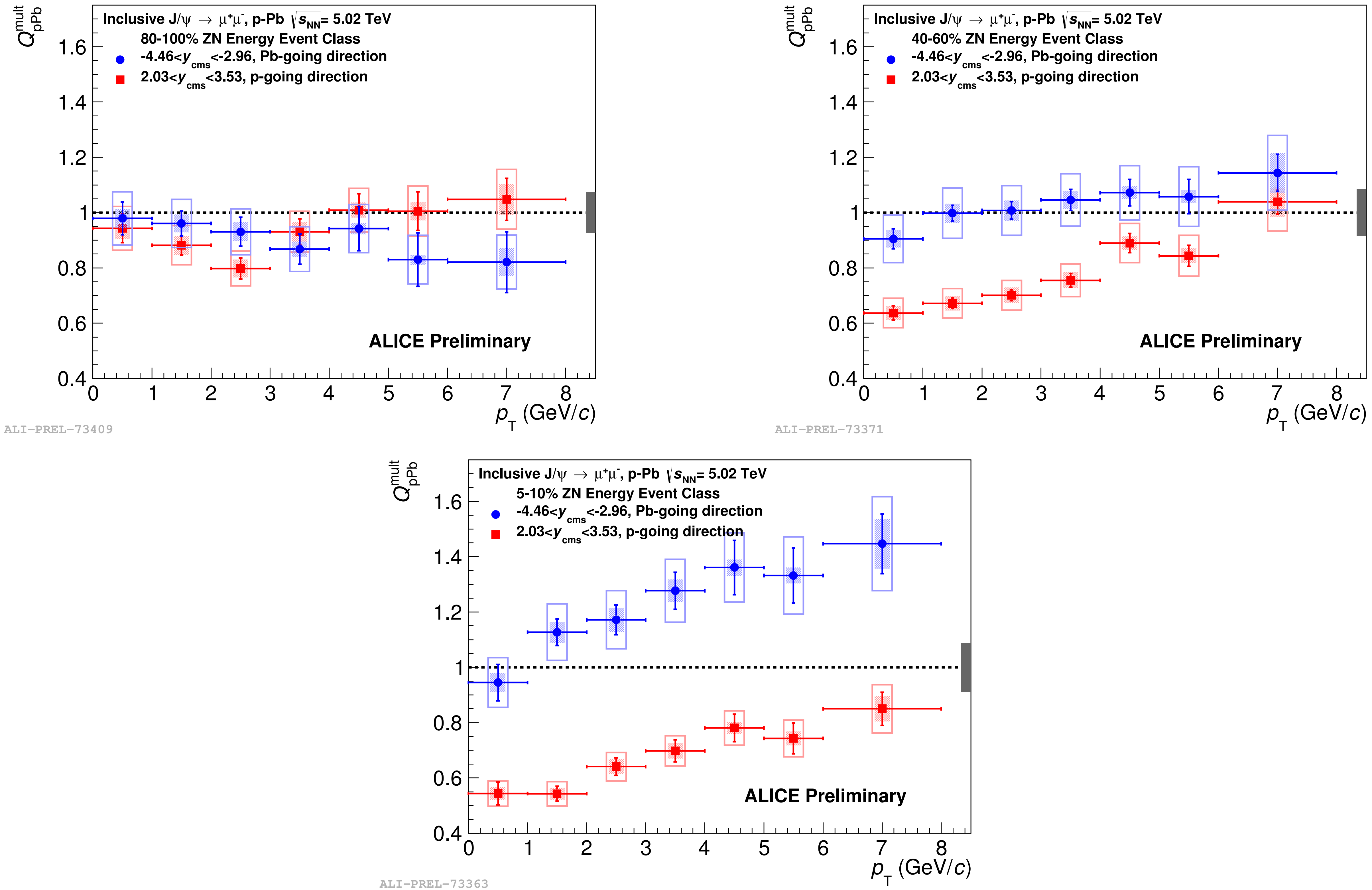


Q_{pPb} vs p_T : EVENT ACTIVITY DEPENDENCE



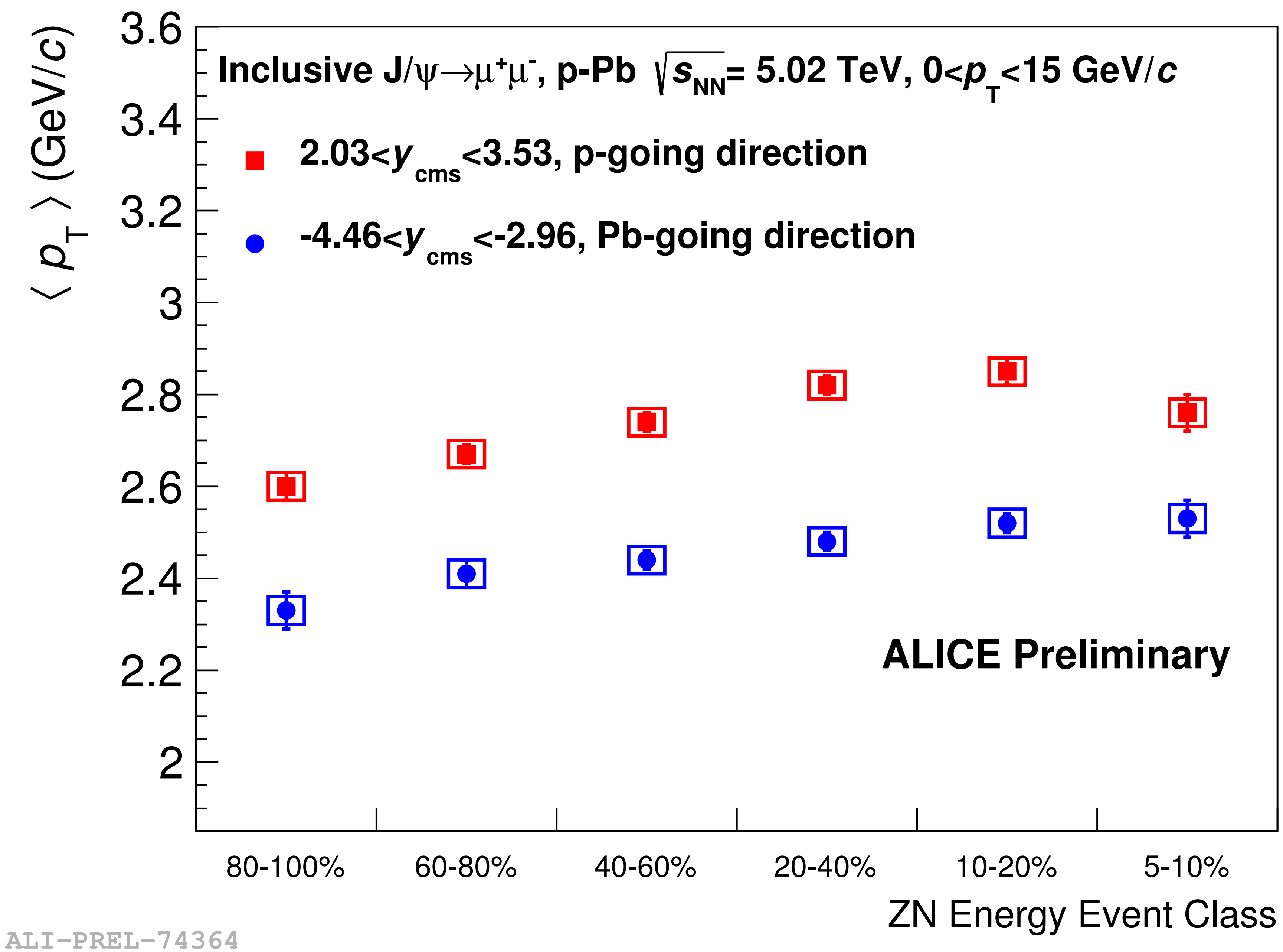
- **Increase** of Q_{pPb} for increasing event activity at **backward** rapidity. A p_T dependence is also observed, showing a stronger enhancement at high p_T
- **Decrease** of Q_{pPb} for increasing event activity at **forward** rapidity. A p_T dependence is also observed, showing stronger suppression at low p_T

Q_{pPb} vs p_T : EVENT ACTIVITY DEPENDENCE



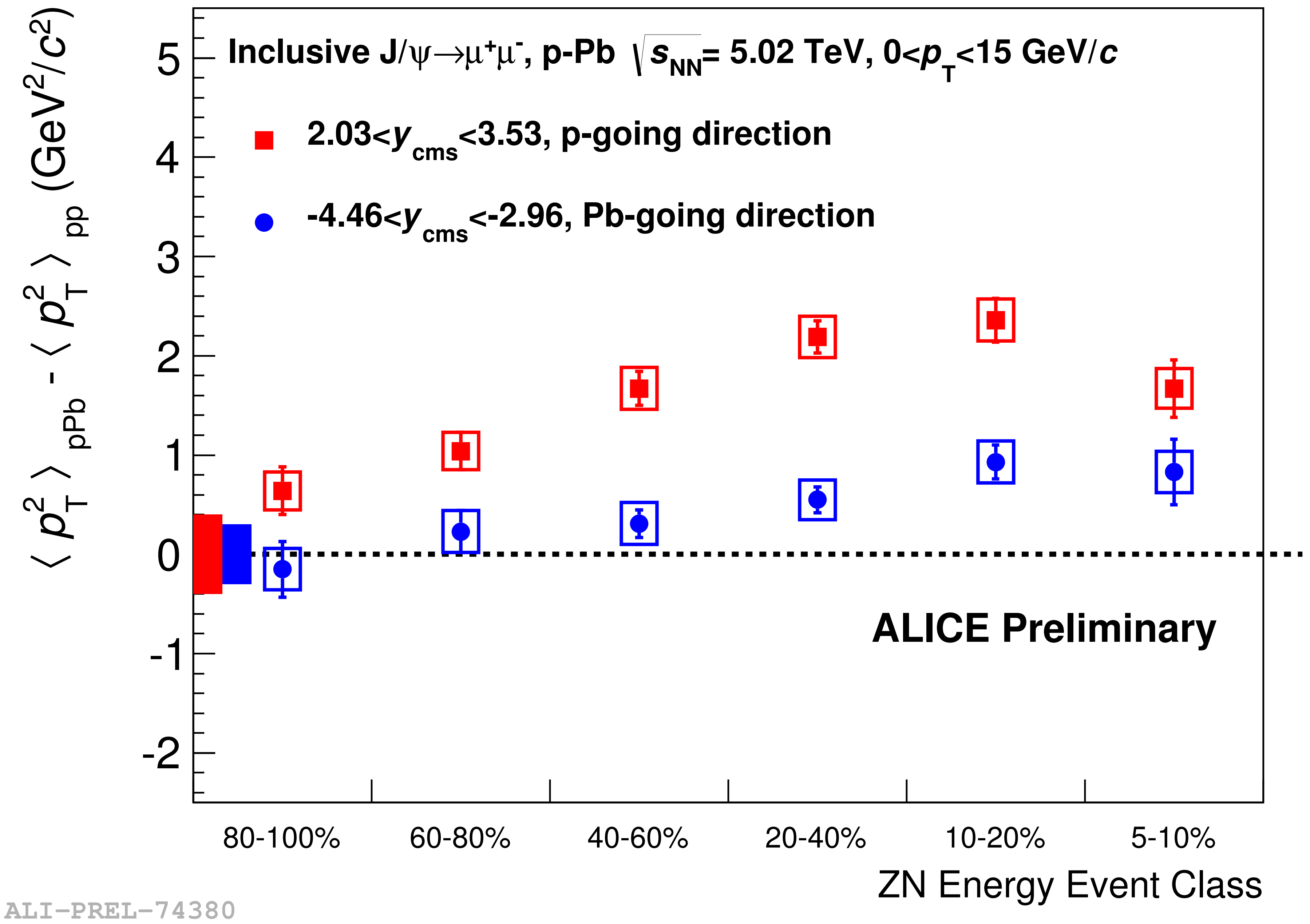
- For increasing event activity the difference between forward and backward rapidity results becomes much stronger

<p_T> vs EVENT ACTIVITY



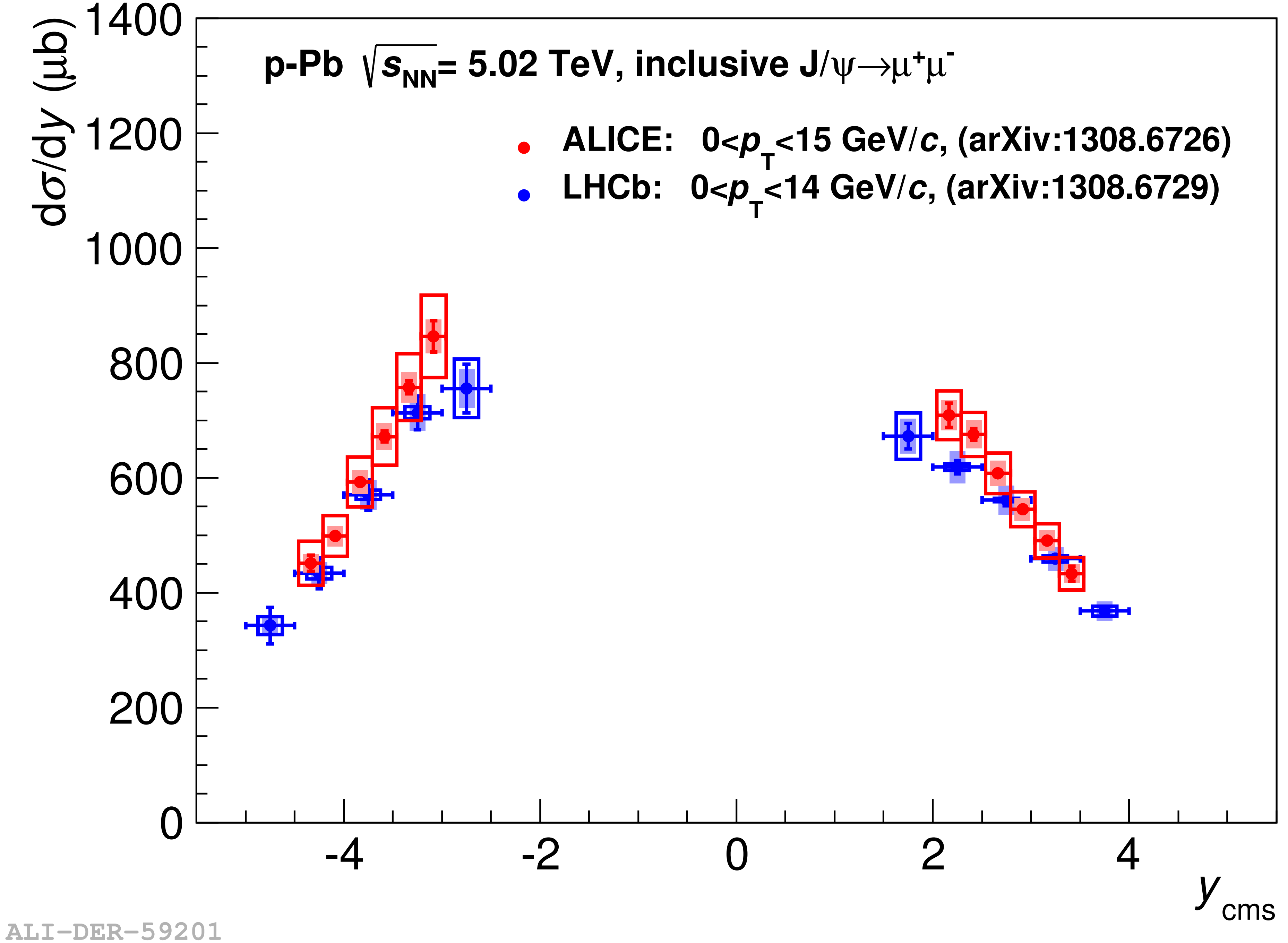
- <p_T> shows an increase with the event activity at forward and backward rapidity
- <p_T> is systematically higher at forward than at backward rapidity

$\langle p_T \rangle$ BROADENING vs EVENT ACTIVITY



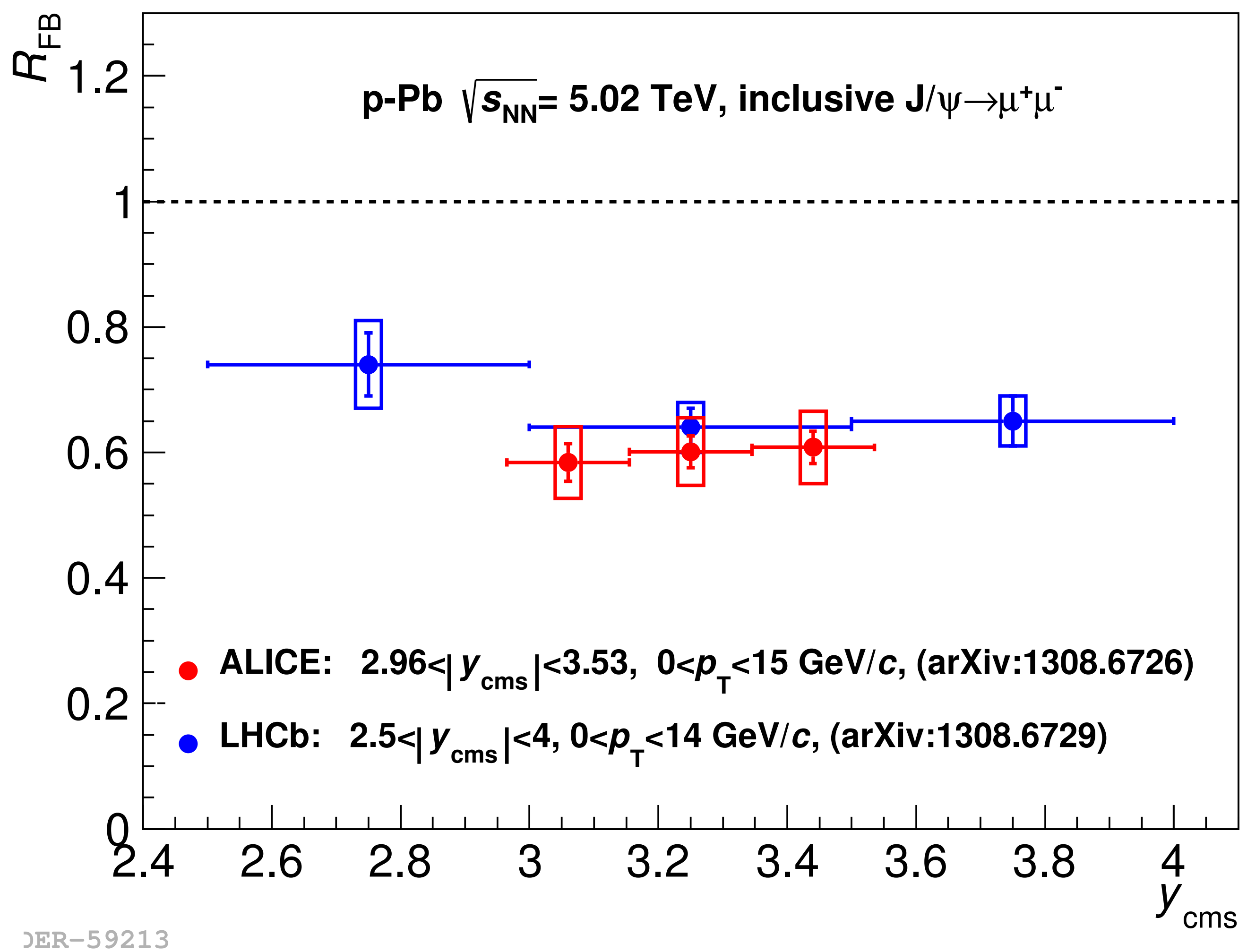
- $\Delta\langle p_T^2\rangle^{J/\psi}$ compatible with pp value for the lowest energy event class
- $\Delta\langle p_T^2\rangle^{J/\psi}$ increases with energy event class
- $\Delta\langle p_T^2\rangle^{J/\psi}$ values systematically higher at forward than at backward rapidity

p-Pb ALICE AND LHCb COMPARISON

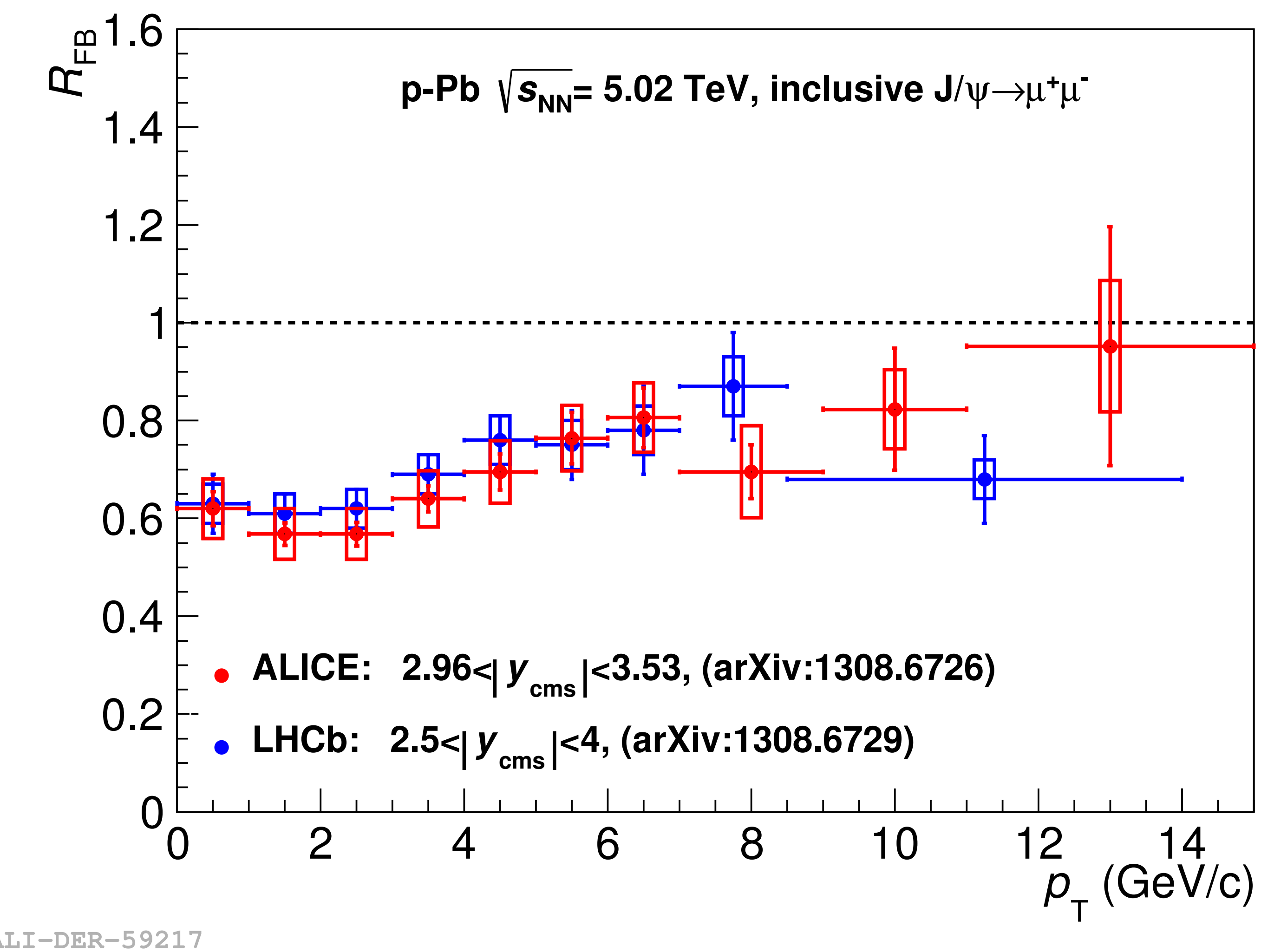


- Results in good agreement within uncertainties

p-Pb ALICE AND LHCb COMPARISON



- Results in good agreement within uncertainties



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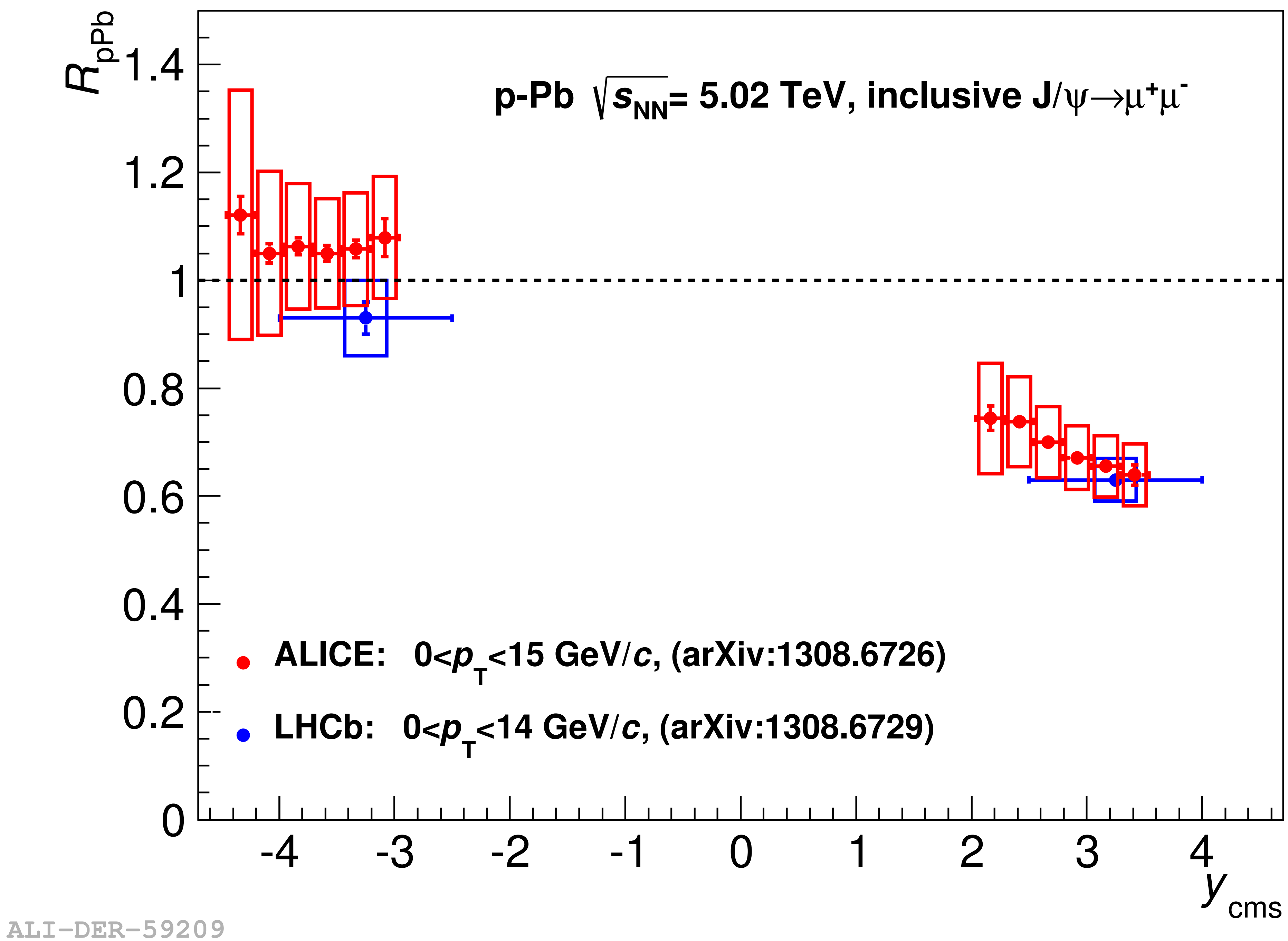
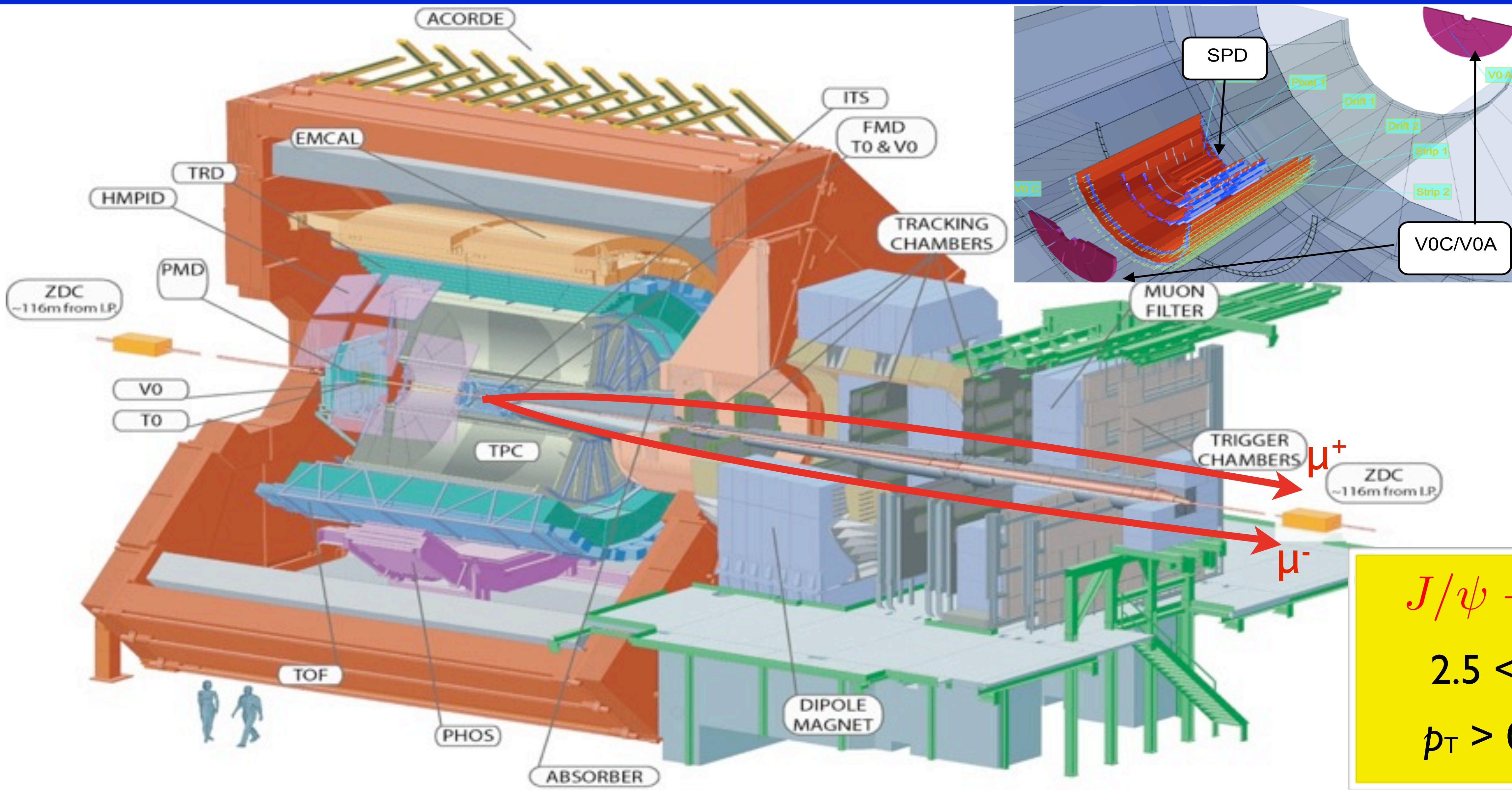
p-Pb ALICE AND LHCb COMPARISON



- Results in good agreement within uncertainties

THE ALICE DETECTOR

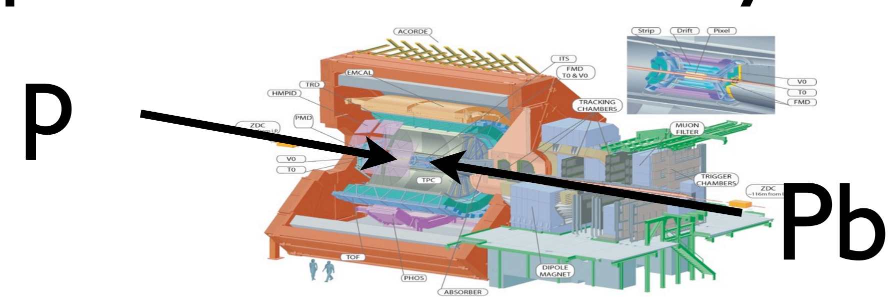


$J/\psi \to \mu^+\mu^-$

$2.5 < y_{lab} < 4$

$p_T > 0$ GeV/c

In p-Pb, LHC beam asymmetry → $|\Delta y|_{cms} = 0.5Log(Z_{Pb}A_p/Z_pA_{Pb}) = 0.465$

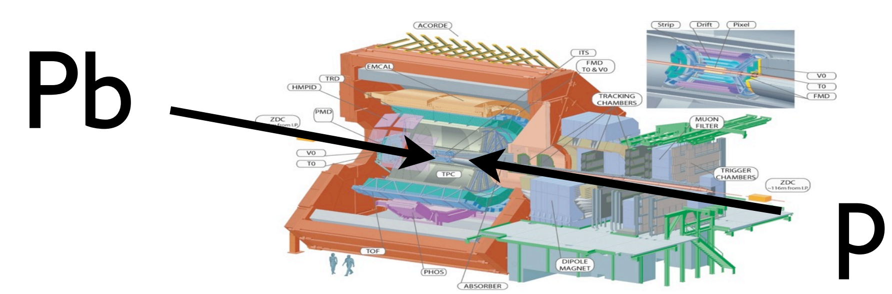


$2.03 < y_{cms} < 3.53$

$1.8 \cdot 10^{-5} < x_{Bjorken} < 8.1 \cdot 10^{-5}$

Common range:

$2.96 < |y_{cms}| < 3.53$



$-4.46 < y_{cms} < -2.96$

$1.2 \cdot 10^{-2} < x_{Bjorken} < 5.3 \cdot 10^{-2}$

R_{PbPb} MEASUREMENT

$$R^{J/\psi}_{PbPb} = \frac{Y^{J/\psi}_{PbPb}}{< T_{PbPb} > \sigma^{J/\psi}_{pp}}$$

- **pp reference cross-section**: pp at 2.76 TeV cross sections measurements.
- **Nuclear thickness function**: From a Glauber model fit to the VZERO amplitude distributions in centrality classes.

Centrality	$<N_{part}>$	$<T_{PbPb}>$ (mb^{-1})
0%-10%	356.0 ± 3.6	23.44 ± 0.76
10%-20%	260.1 ± 3.8	14.39 ± 0.45
20%-30%	185.8 ± 3.3	8.70 ± 0.27
30%-40%	128.5 ± 2.9	5.00 ± 0.18
40%-50%	84.7 ± 2.4	2.68 ± 0.12
50%-60%	52.4 ± 1.6	1.317 ± 0.071
60%-70%	29.77 ± 0.98	0.591 ± 0.036
70%-80%	15.27 ± 0.55	0.243 ± 0.016
80%-90%	7.49 ± 0.22	0.0983 ± 0.0076
0%-90%	124.4 ± 2.2	6.27 ± 0.21