J/ψ Production in Pb-Pb Collisions at $\sqrt{s_{NN}}$ = 2.76 TeV

Julian Book
for the ALICE Collaboration

Motivation: J/ψ in Heavy-Ion Collisions

Quark-Gluon Plasma (QGP): Deconfined state of strongly interacting matter

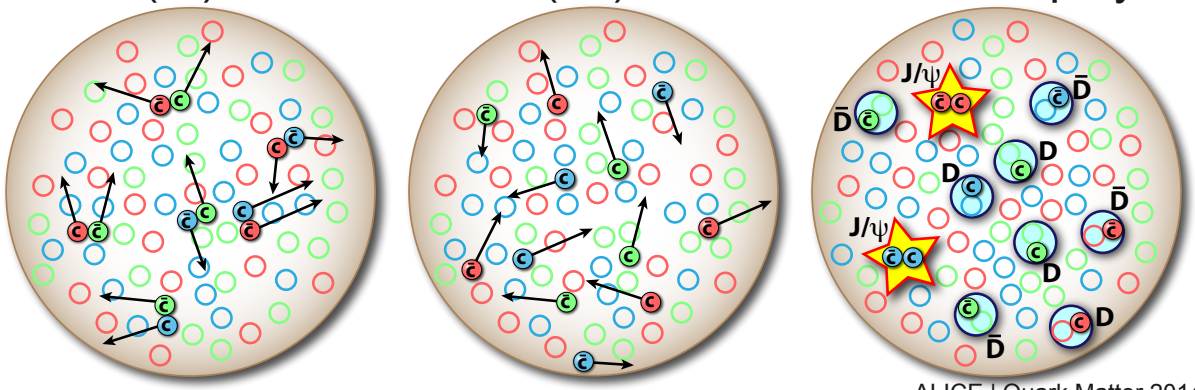
- J/ψ suppression proposed as a signature [T.Matsui, H.Satz, Phys.Lett. B178(4), 416-422 (1986)]

  ⇒ Melting due to Debye-like color screening ↓

- Temperature dependent sequential suppression of states ↓ [F.Karsch, H.Satz, Z.Phys. C51, 209 (1991)]

- Cold Nuclear Matter effects (Nuclear absorption ↓, Shadowing ↓)

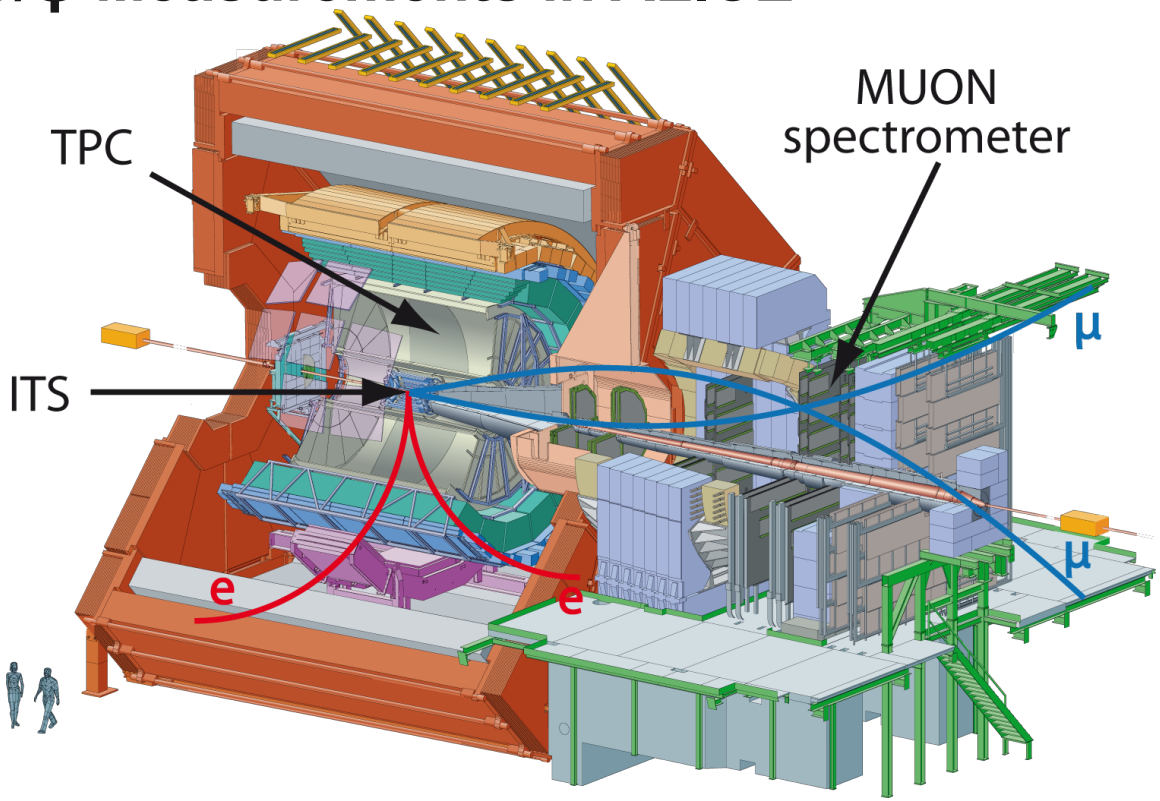
- Possible (re)combination of (un)correlated $c\bar{c}$ could play a major role at LHC ↑



[P.Braun-Munzinger, J.Stachel, Phys.Lett. B490, 196–202 (2000)]

[R.L.Thews, M.Schroedter, J.Rafelski, Phys.Rev. C63, 054905 (2001)]

Inclusive J/ψ Measurements in ALICE



J/ψ → e^+e^- in |y|<0.9
Tracking and particle identification with ITS + TPC in the Central Barrel

J/ψ → $\mu^+\mu^-$ in 2.5<y<4
Tracking and trigger chambers behind hadron absorber in the Muon spectrometer

J/ψ acceptance down to $p_T = 0$

J/ψ Reconstruction in Pb-Pb Collisions

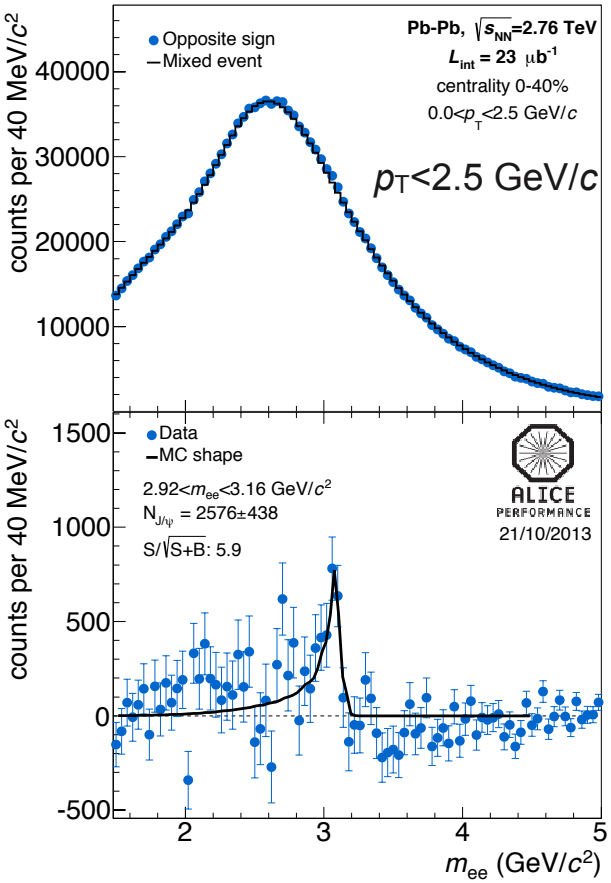
Invariant mass spectrum for all e^+e^- or $\mu^+\mu^-$ pair combinations

Mixed event and fitting technique for background estimation

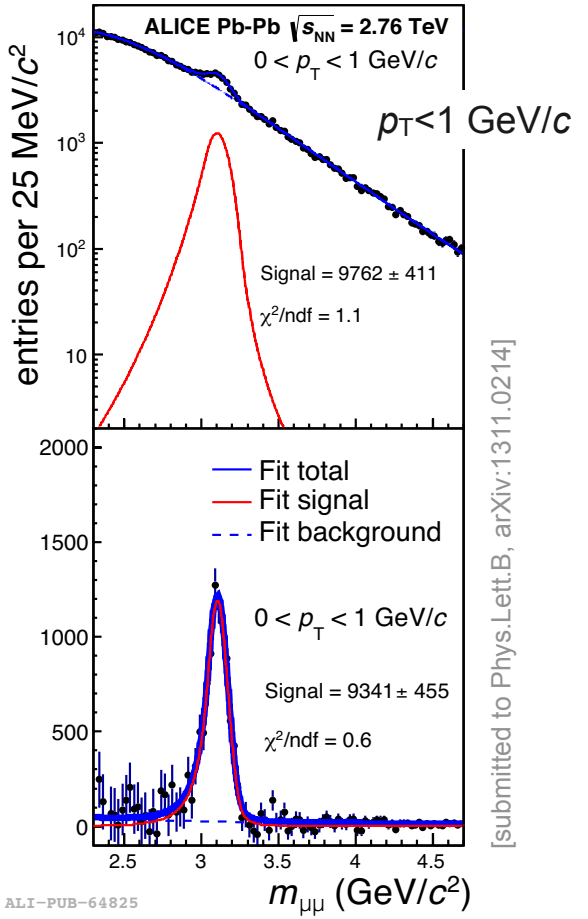
Signal description by MC (|y|<0.8) or extended Crystal Ball (2.5<y<4)

Signal extraction in **rapidity, p_T and centrality**

mid-rapidity |y|<0.8



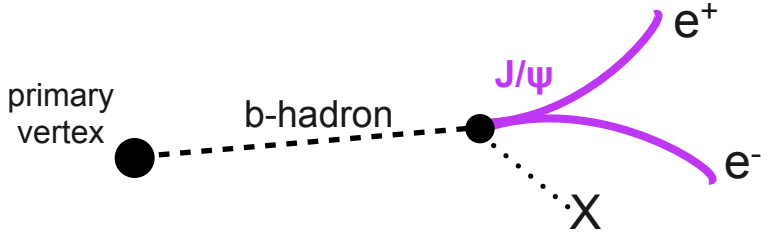
forward rapidity 2.5<y<4

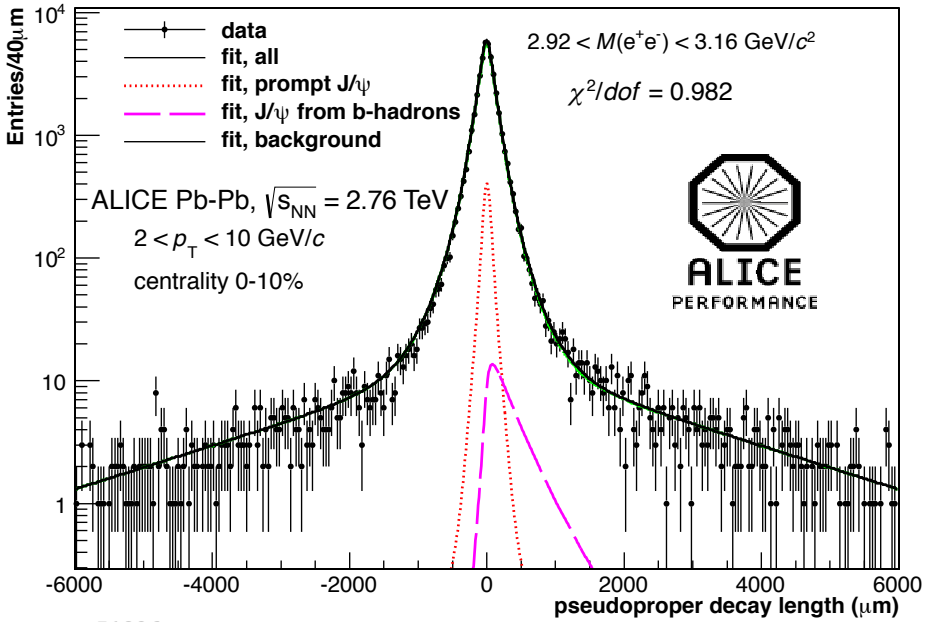


[submitted to Phys.Lett.B, arXiv:1311.0214]

Prompt and Non-Prompt J/ψ Separation

via secondary vertex identification exploiting the ITS capabilities





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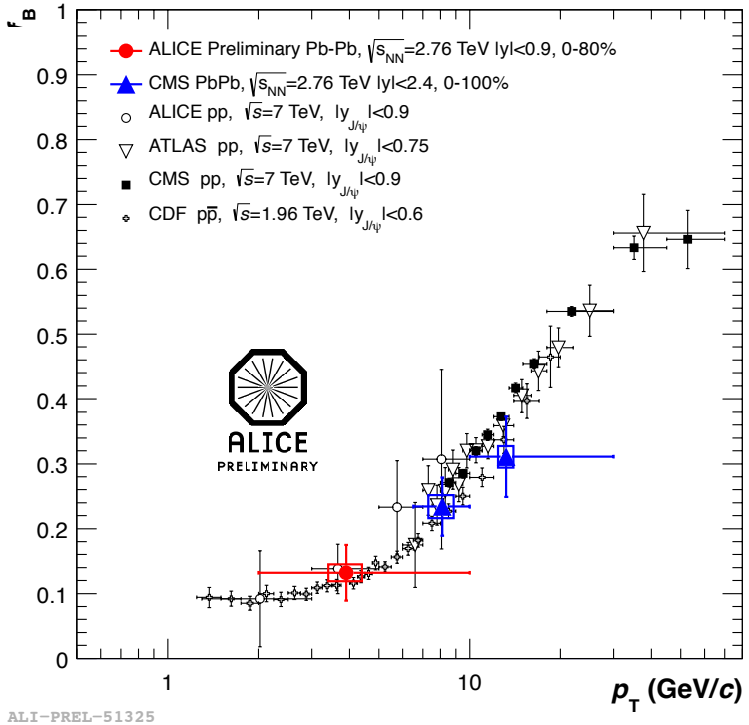

ALI-PREL-51325

fraction of b-hadron decays obtained down to $p_{T,J/\psi}$ = 2 GeV/c

Nuclear Modification Factor R_{AA}

$$R_{AA} = \frac{dN/dy}{\langle T_{AA} \rangle \times d\sigma^{pp}_{J/\psi}/dy}$$

- Differential in p_T, rapidity and centrality
- Nuclear Overlap $\langle T_{AA} \rangle$ from Glauber simulation

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pp Reference

- mid-rapidity: Interpolation of measured inclusive J/ψ cross sections

[PHENIX, Phys.Rev. D85, 092004 (2012),
CDF, Phys.Rev. D71, 032001 (2005),
ALICE, Phys.Lett. B718, 295 & 692 (2012)]

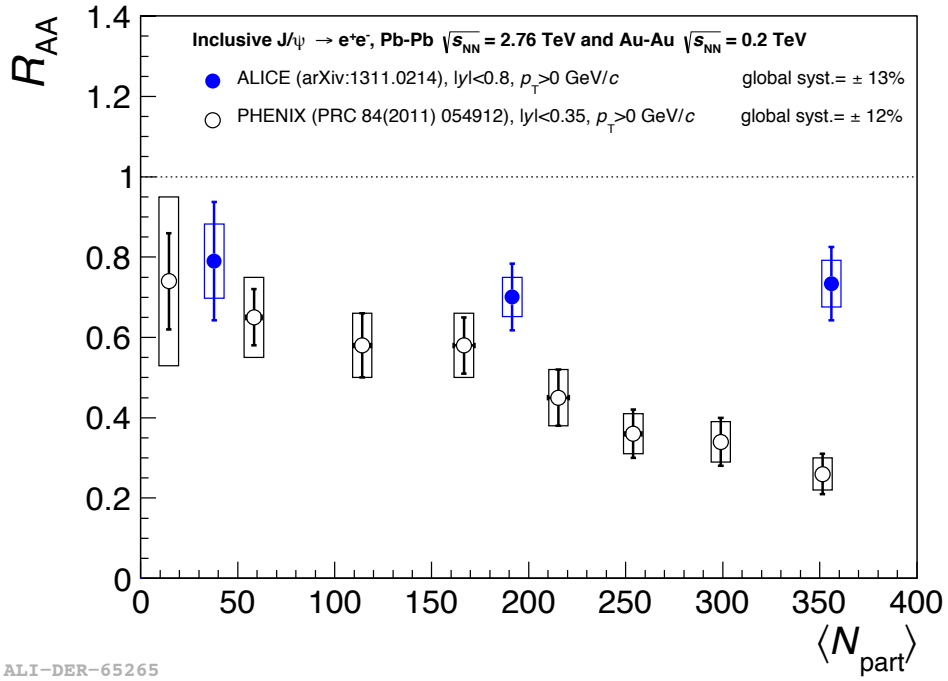
- forward rapidity: ALICE measurement of J/ψ cross sections

[ALICE, Phys.Lett. B718, 295 (2012)]

Inclusive J/ψ R_{AA} versus Event Centrality

Comparison to results by PHENIX ($\sqrt{s_{NN}}$ = 0.2 TeV)

mid-rapidity |y|<0.8



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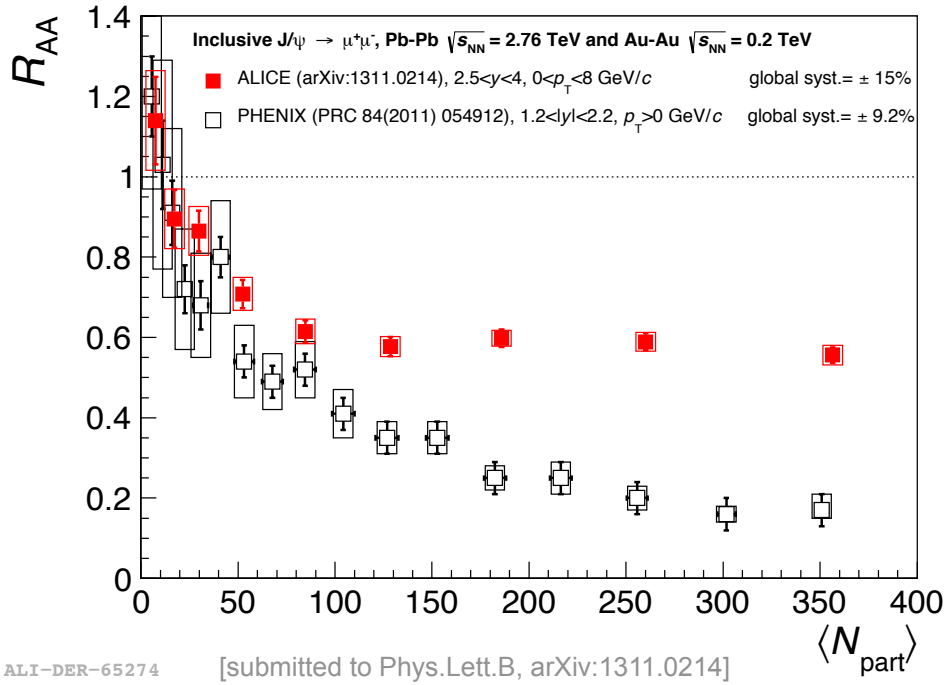
forward rapidity 2.5<y<4



ALI-DER-65274 [submitted to Phys.Lett.B, arXiv:1311.0214]

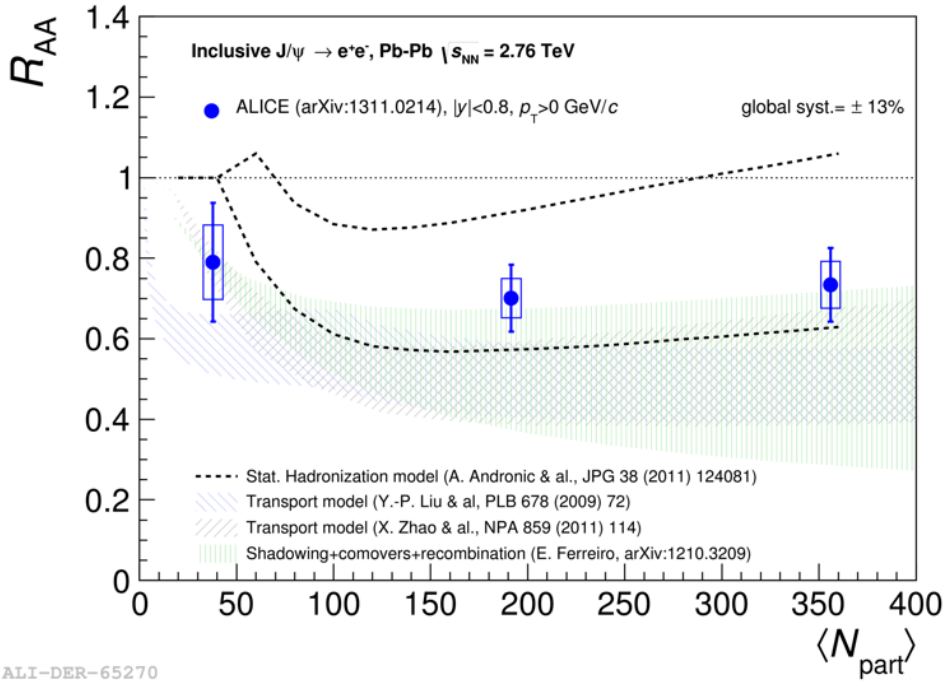
No strong centrality dependence (for N_{part} > 70)

Significantly different than at lower collision energy

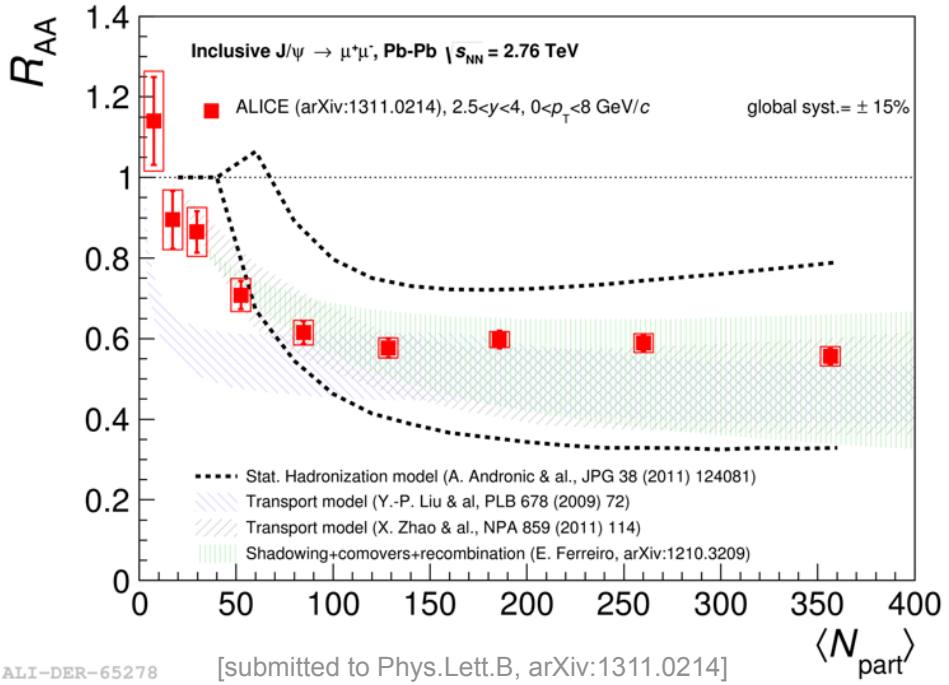
Inclusive J/ψ R_{AA} versus Event Centrality

Comparison to theory calculations

mid-rapidity |y|<0.8



forward rapidity 2.5<y<4



[submitted to Phys.Lett.B, arXiv:1311.0214]

Statistical hadronization and transport models with
recombination component can describe the trend in data

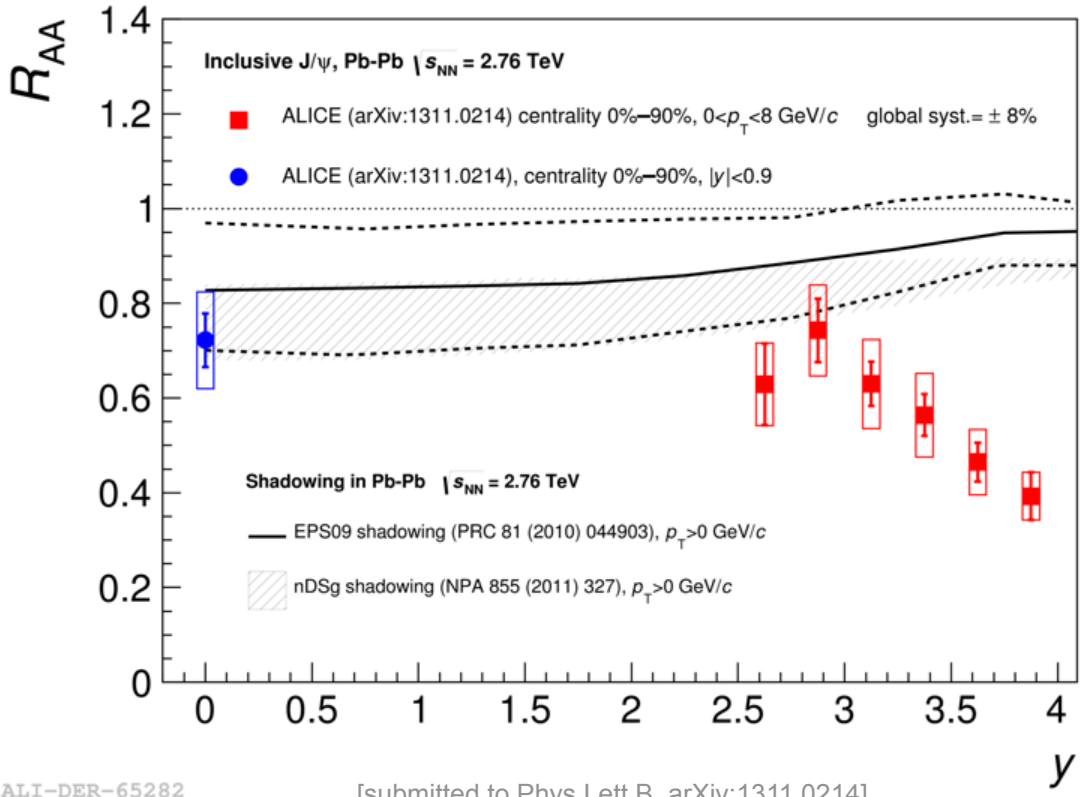
Inclusive J/ψ R_{AA} versus Rapidity

Results integrated over p_T and centrality

Up to 40% more suppression at forward rapidity

Shadowing calculations consistent with R_{AA} only within |y|<3

Charm density increases towards mid-rapidity



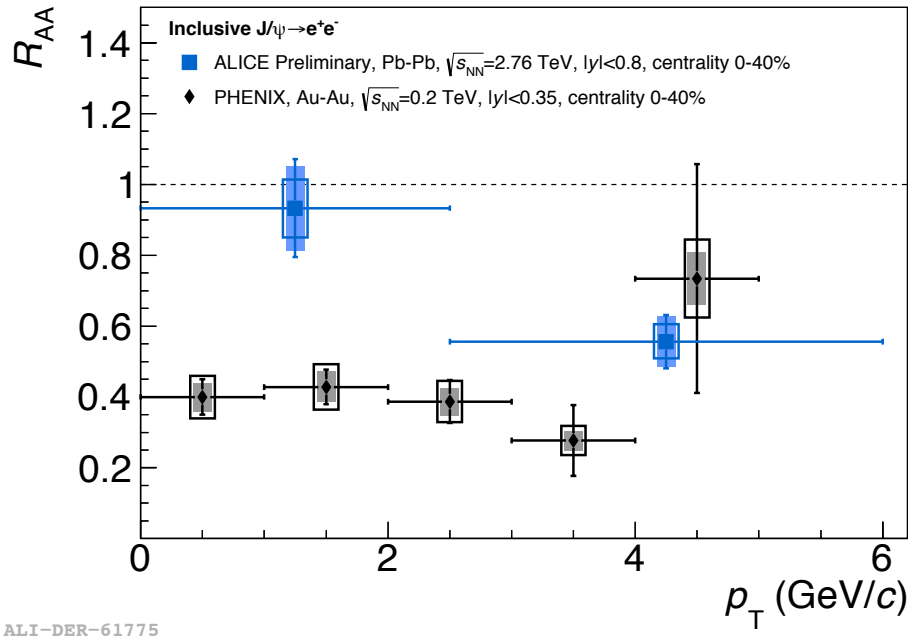
ALI-DER-65282

[submitted to Phys.Lett.B, arXiv:1311.0214]

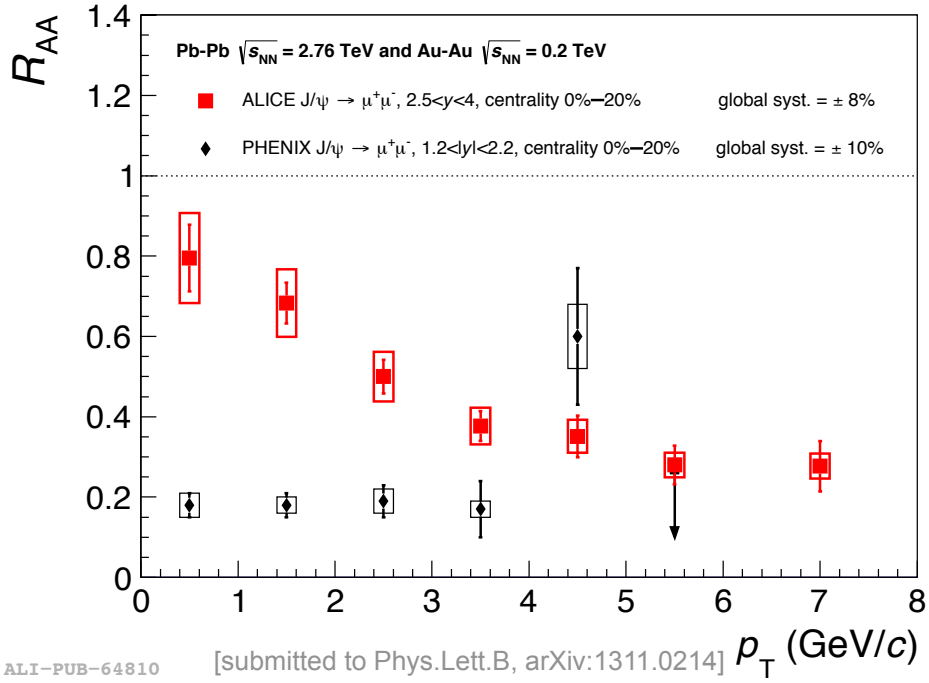
Inclusive J/ψ R_{AA} versus Transverse Momentum

Comparison to results by PHENIX ($\sqrt{s_{NN}}$ = 0.2 TeV)

mid-rapidity



forward rapidity



[submitted to Phys.Lett.B, arXiv:1311.0214]

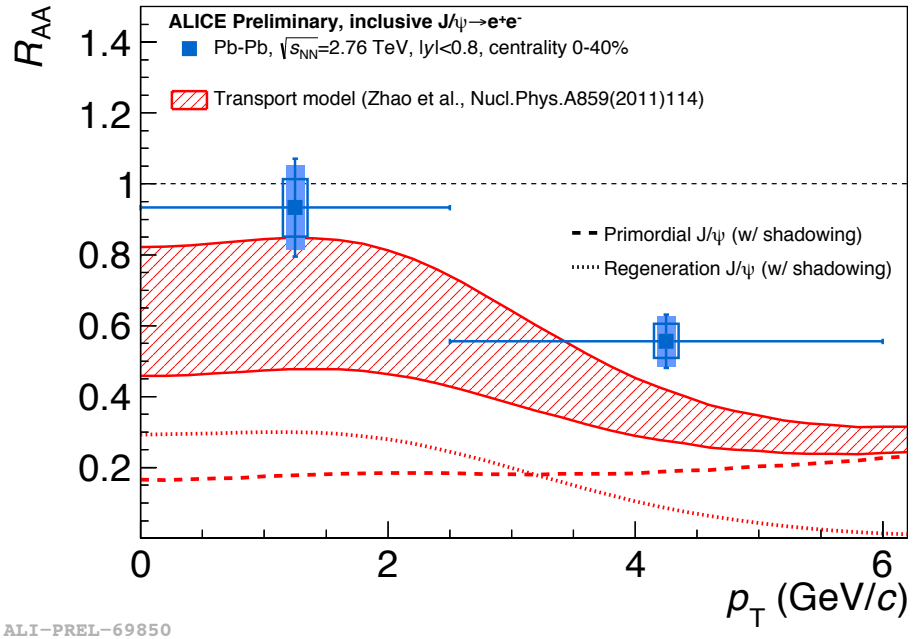
Similar p_T dependence in both rapidity ranges

Less suppression at low p_T compared to RHIC

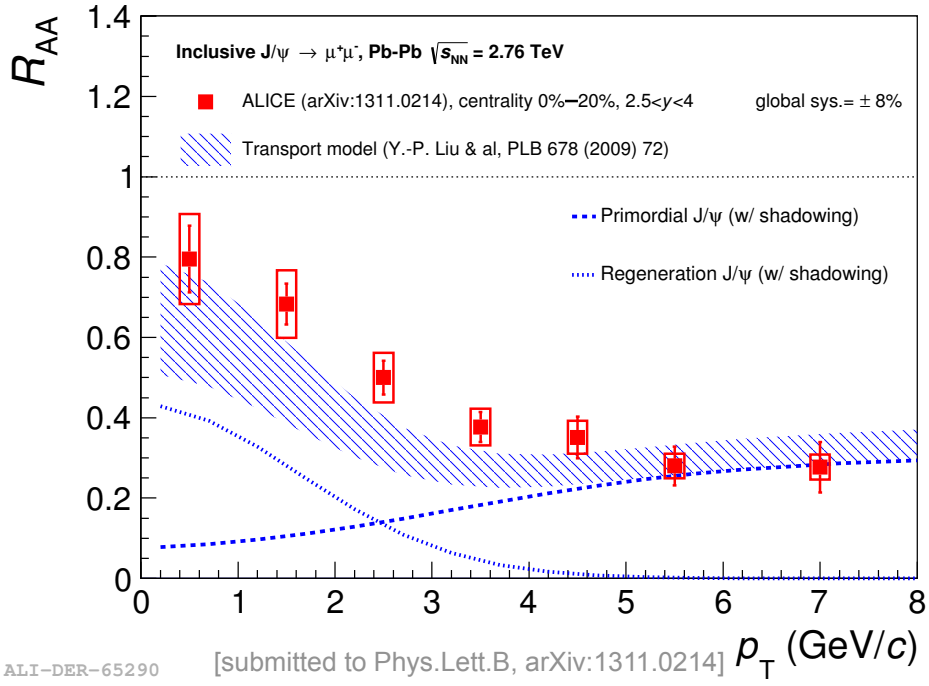
Inclusive J/ψ R_{AA} versus Transverse Momentum

Comparison to theory calculations

mid-rapidity |y|<0.8



forward rapidity 2.5<y<4



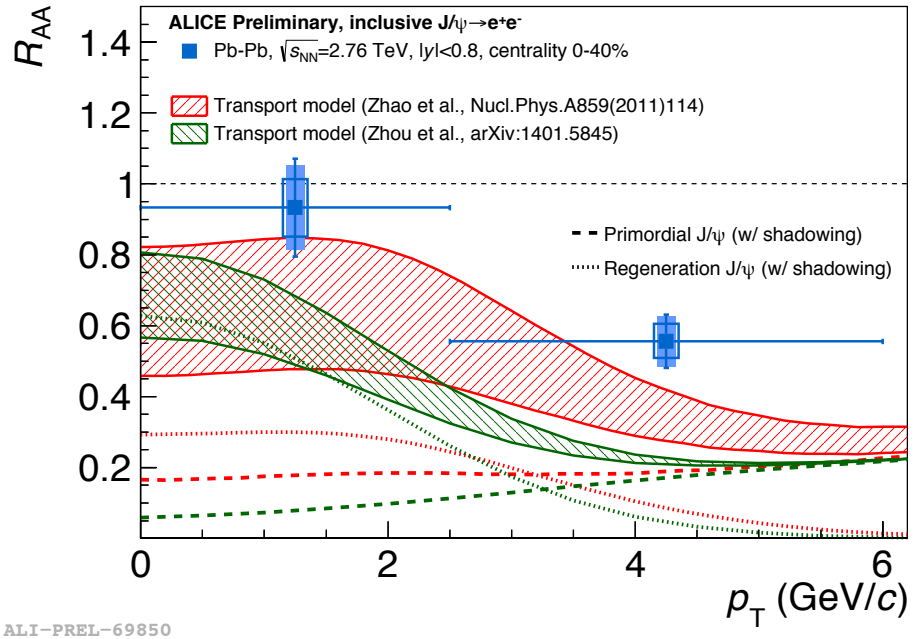
Transport models with suppression and regeneration components

Recombination contribution important at low p_T

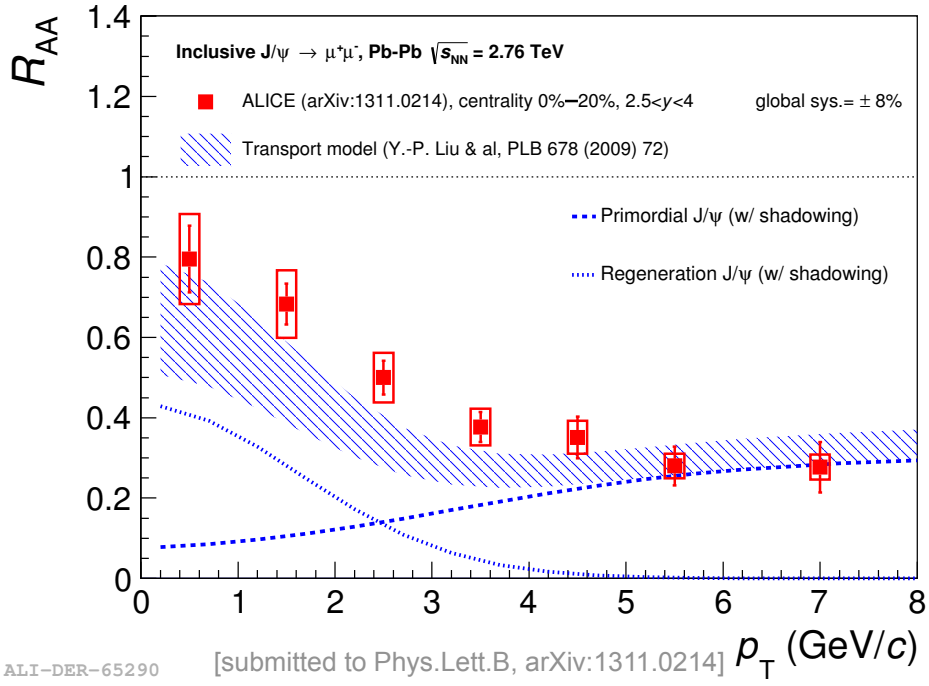
Inclusive J/ψ R_{AA} versus Transverse Momentum

Comparison to theory calculations

mid-rapidity |y|<0.8



forward rapidity 2.5<y<4



[submitted to Phys.Lett.B, arXiv:1311.0214]

Transport models with suppression and regeneration components

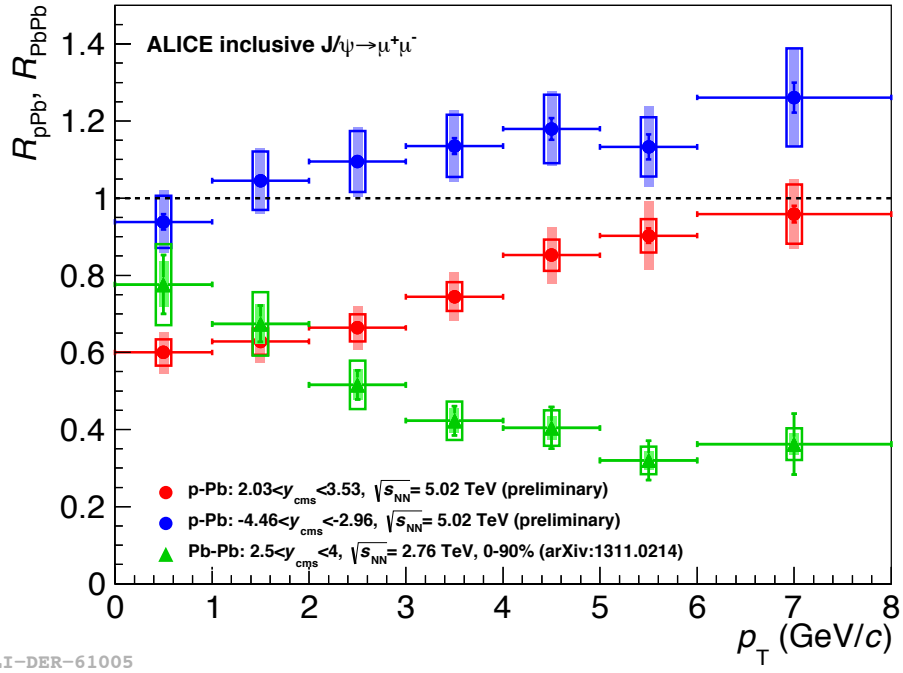
Recombination contribution important at low p_T

Comparison to Cold Nuclear Matter Effects

Hypothesis: J/ψ production mechanism dominated by 2→1 kinematics and shadowing as main CNM effect

Similar gluon-x in Pb for p-Pb at $\sqrt{s_{NN}}$=5.02 TeV and Pb-Pb at $\sqrt{s_{NN}}$=2.76 TeV

forward rapidity



see pPb talk by J.Martin after lunch

Strong suppression at high p_T

Hint for enhancement at low p_T relative to combined pPb

Comparison to Cold Nuclear Matter Effects

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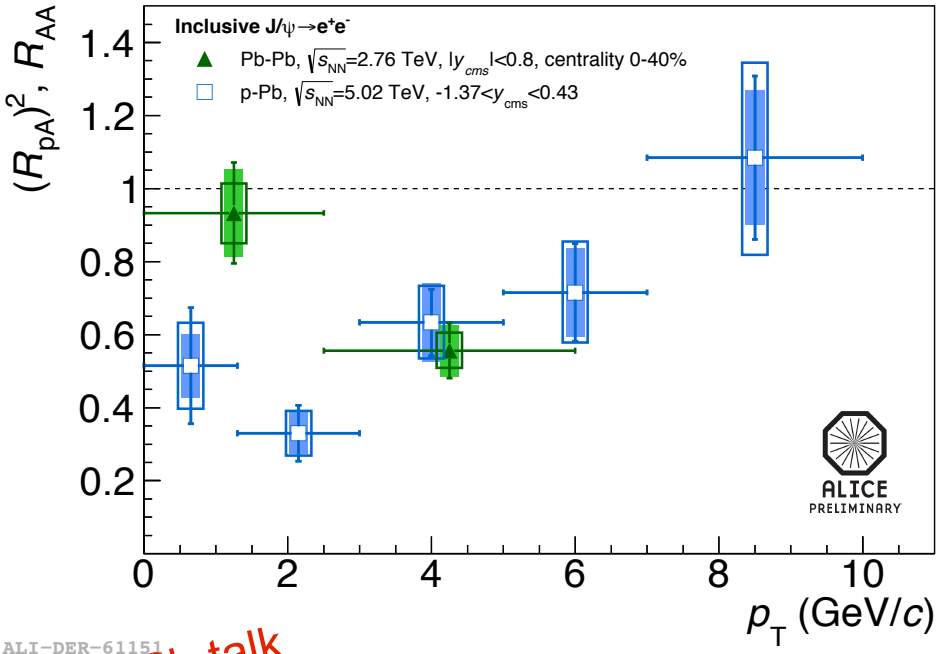
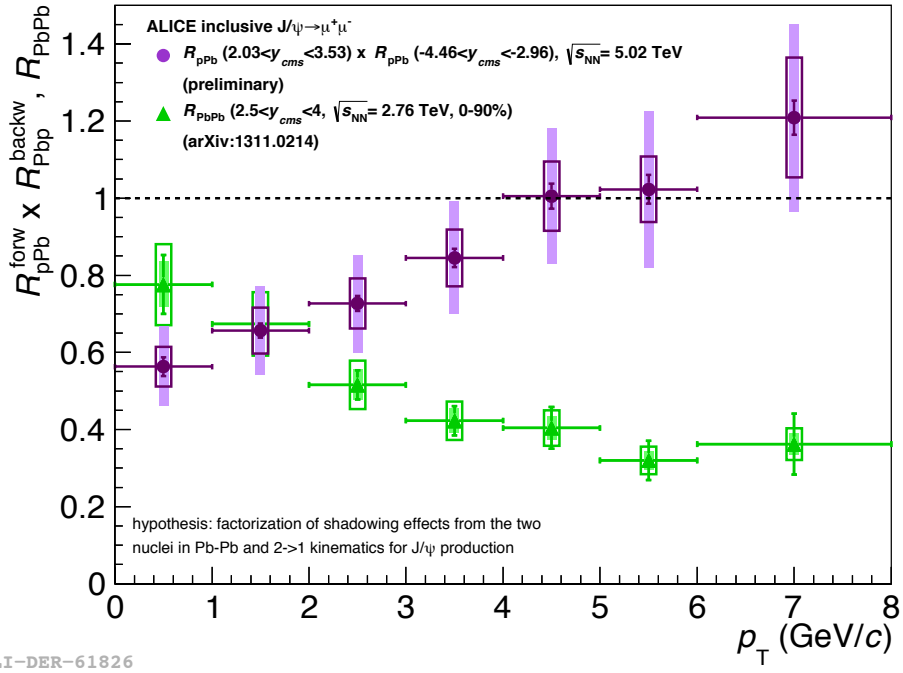
Similar gluon-x in Pb for p-Pb at $\sqrt{s_{NN}}$=5.02 TeV and Pb-Pb at $\sqrt{s_{NN}}$=2.76 TeV

mid-rapidity



ALI-DER-61151

forward rapidity



ALI-DER-61826

see pPb talk by J.Martin after lunch

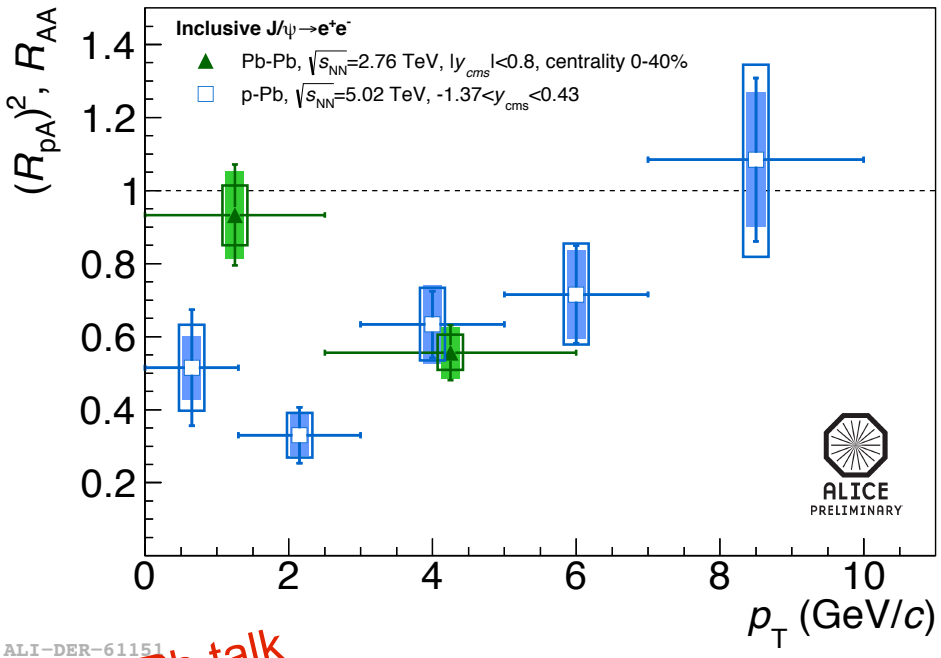
Strong suppression at high p_T

Hint for enhancement at low p_T relative to combined pPb

Comparison to Cold Nuclear Matter Effects

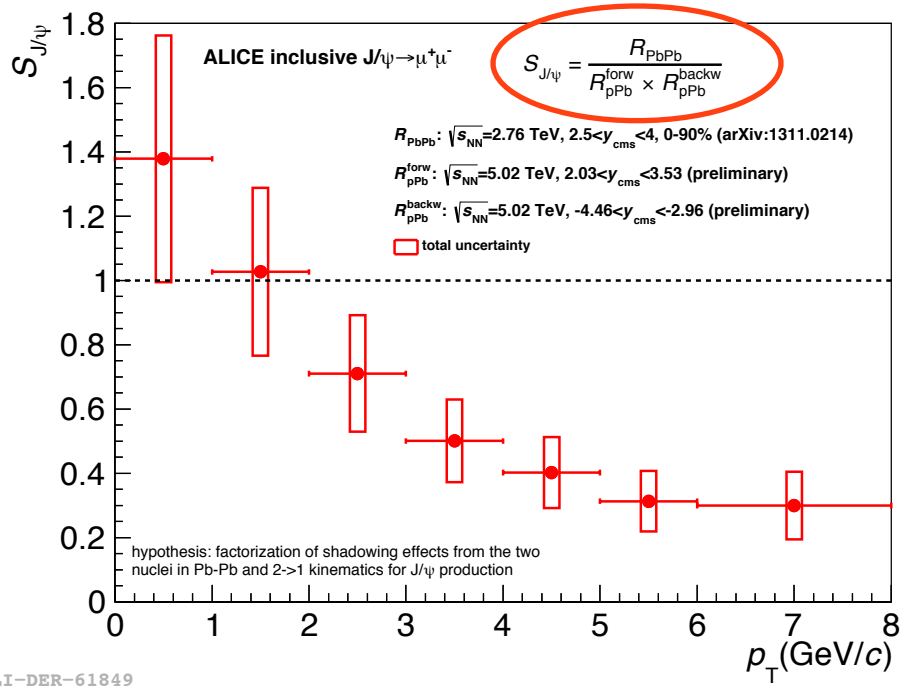
Hypothesis: J/ψ production mechanism dominated by 2→1 kinematics and shadowing as main CNM effect
Similar gluon-x in Pb for p-Pb at $\sqrt{s_{NN}}$=5.02 TeV and Pb-Pb at $\sqrt{s_{NN}}$=2.76 TeV

mid-rapidity



ALI-DER-61151

forward rapidity



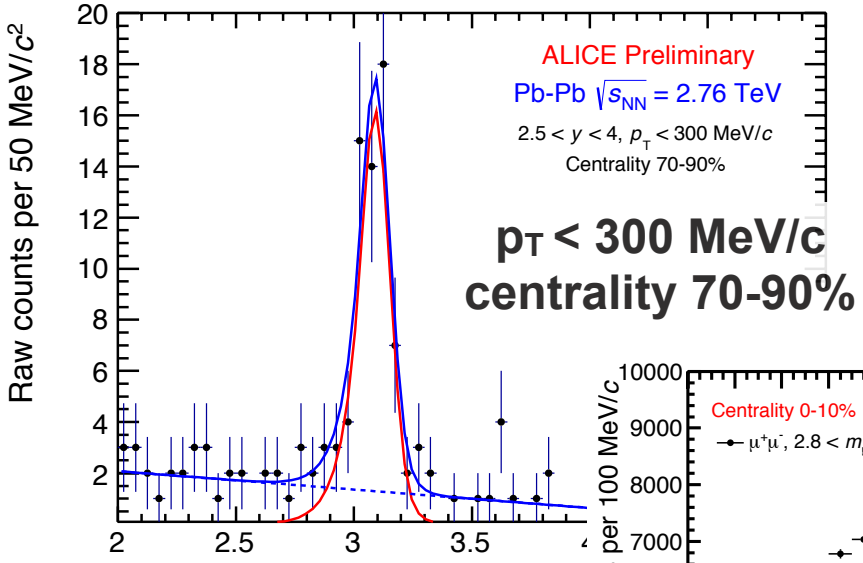
ALI-DER-61849

see pPb talk by J.Martin after lunch

Strong suppression at high p_T
Hint for enhancement at low p_T relative to combined pPb

Inclusive J/ψ → μ⁺μ⁻ Production at very low p_T

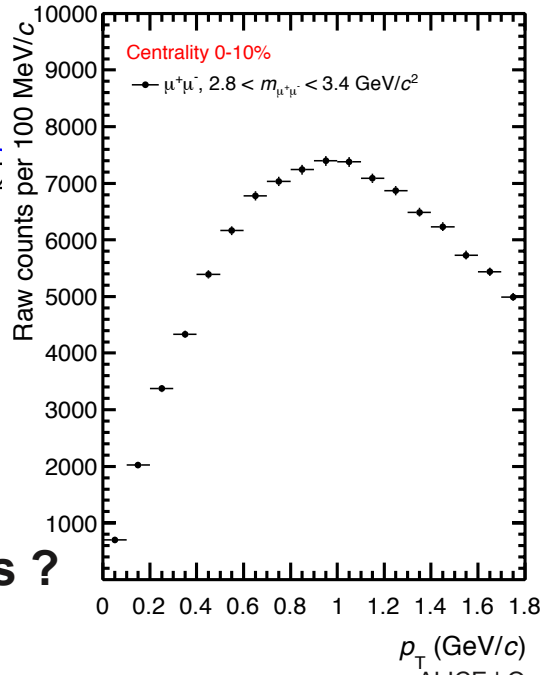
Signal extraction with the Muon spectrometer at forward rapidity

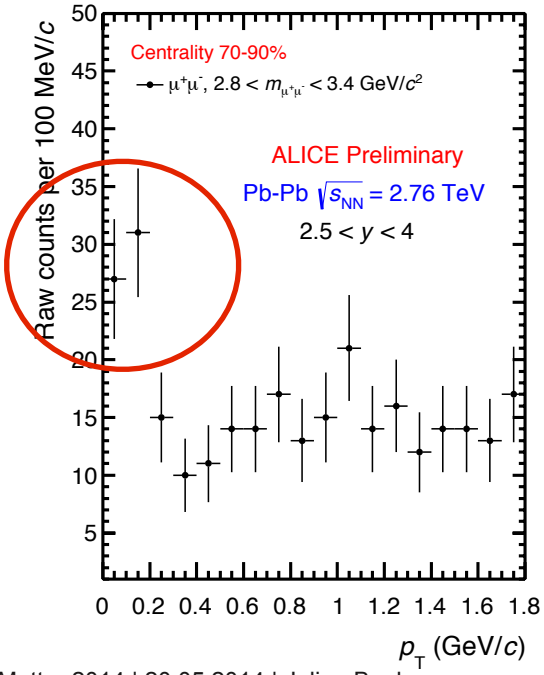


p_T < 300 MeV/c
centrality 70-90%

ALI-PREL-69080

see poster F-32 by L.Massacrier this afternoon



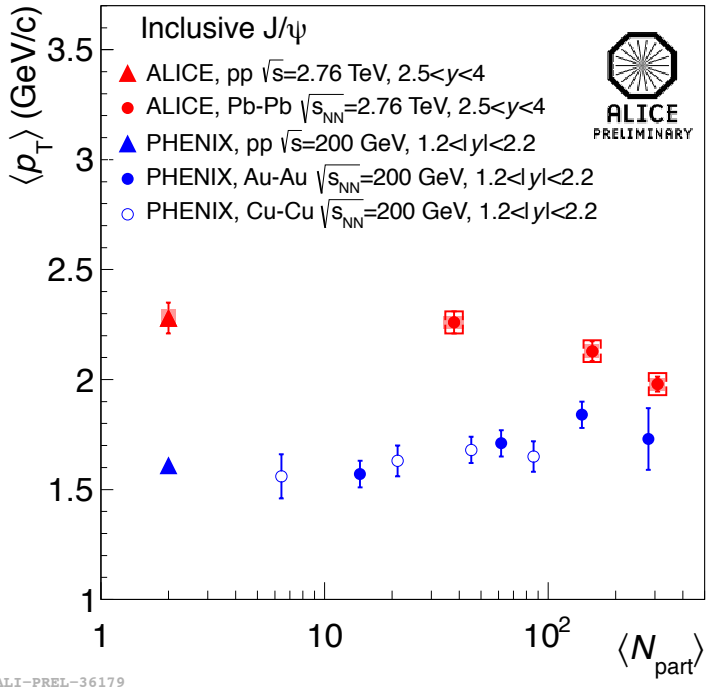


Intriguing excess of low-p_T J/ψ for peripheral events

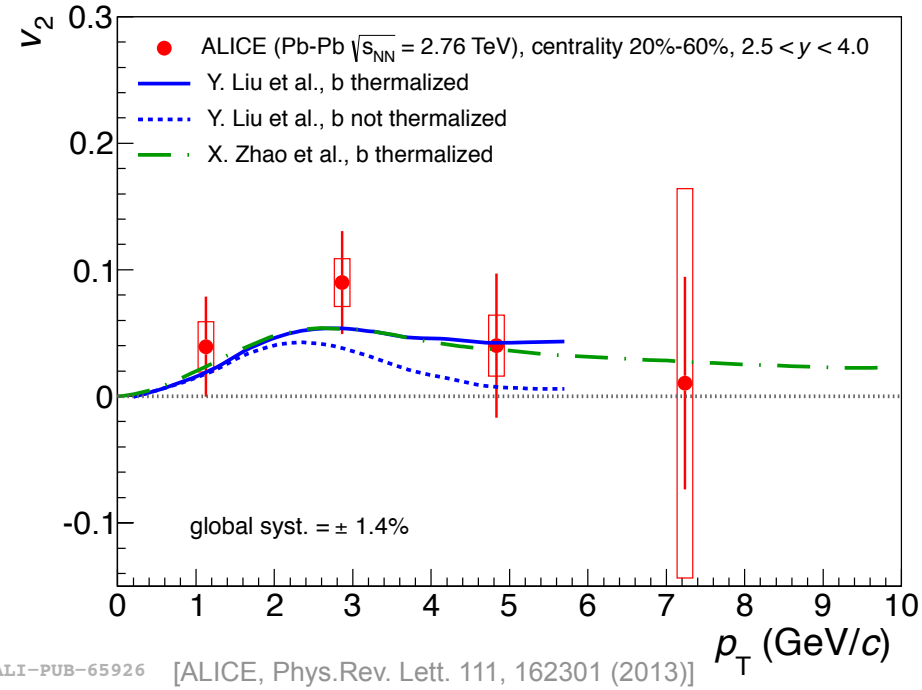
Hint of e.m. production process ?

ALI-PREL-69095

<p_T> and Elliptic Flow v_2



2σ Significance in 2<p_T<6 GeV/c



[ALICE, Phys.Rev. Lett. 111, 162301 (2013)]

In-medium J/ψ <p_T> lower than in pp collisions

Not observed at lower collision energy

Non-zero J/ψ v_2 observed at intermediate p_T

Well described by models including recombination

Conclusion

J/ψ Production in Pb-Pb Collisions at $\sqrt{s_{NN}}$ = 2.76 TeV

- No significant centrality dependence (for $N_{part} > 70$)
- Less suppression at low p_T
- Hint for enhancement at low p_T with respect to a simple extrapolation of CNM effect estimated from p-Pb results
- Lower $\langle p_T \rangle$ in Pb-Pb collisions compared to pp
- Non-zero elliptic flow at intermediate p_T

Results significantly different to lower collision energy results

→ Clear Indication for (re)combination contribution at LHC