Quarkonium measurements in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV with the ALICE Muon Spectrometer

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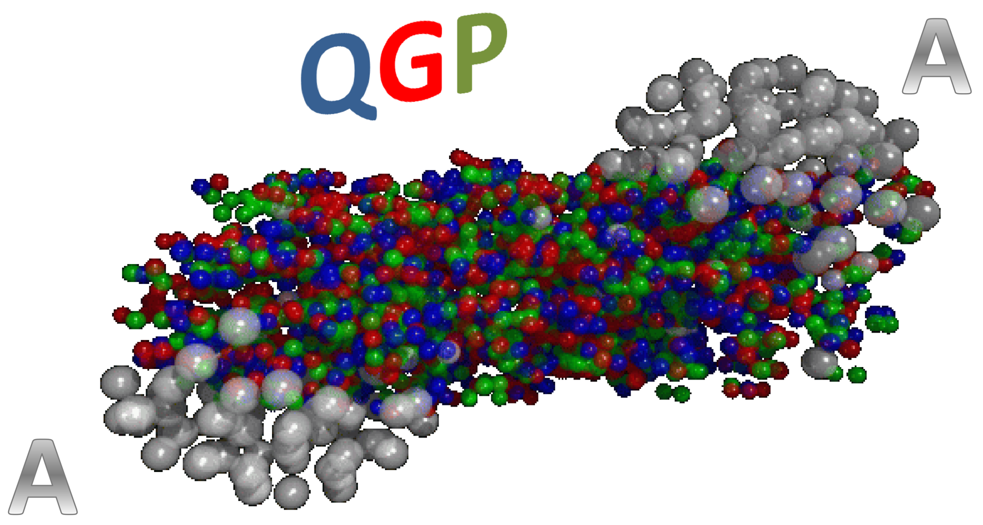
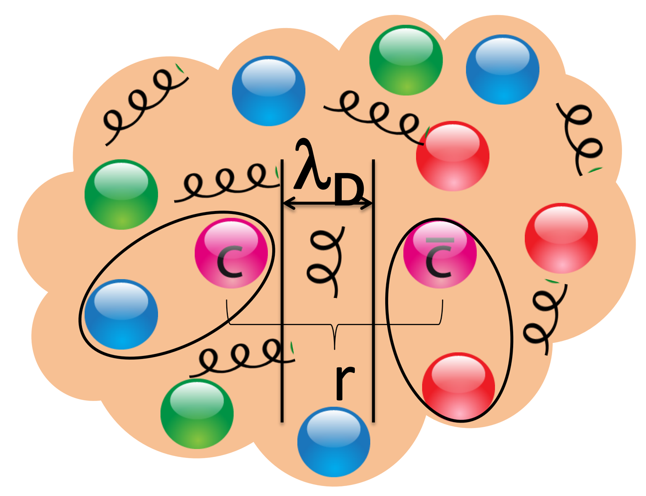
Physics motivations





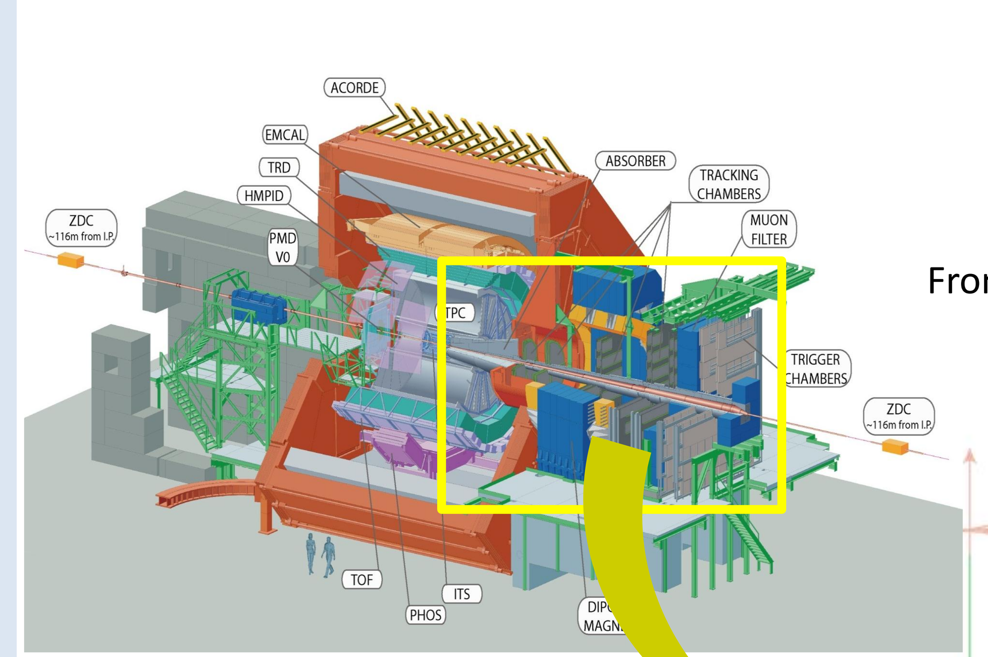
Relativistic heavy-ion collisions at the LHC ➔ high energy densities.

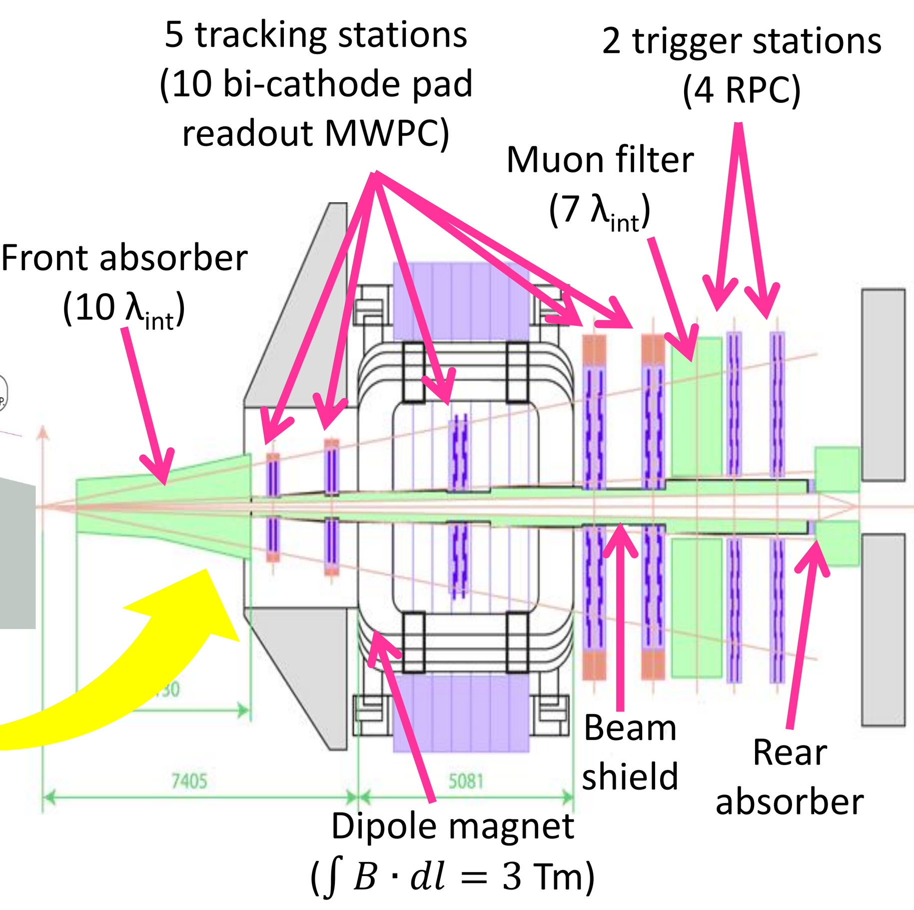
Quark Gluon Plasma (QGP): deconfined state of quarks and gluons.

Quarkonium as a probe of deconfinement [1,2]:

- ✓ Created in the early stages of the collisions.
- ✓ Suppressed by Debye screening.
- ✓ Different radii & binding energies in the quarkonium family ➔ sequential suppression.

ALICE and the Muon Spectrometer





ALICE is the heavy-ion dedicated experiment at the LHC [3].

The Muon Spectrometer performs inclusive J/ψ measurements at forward rapidity ($2.5 < \eta < 4$) and down to p_T = 0 GeV/c.

Analysis

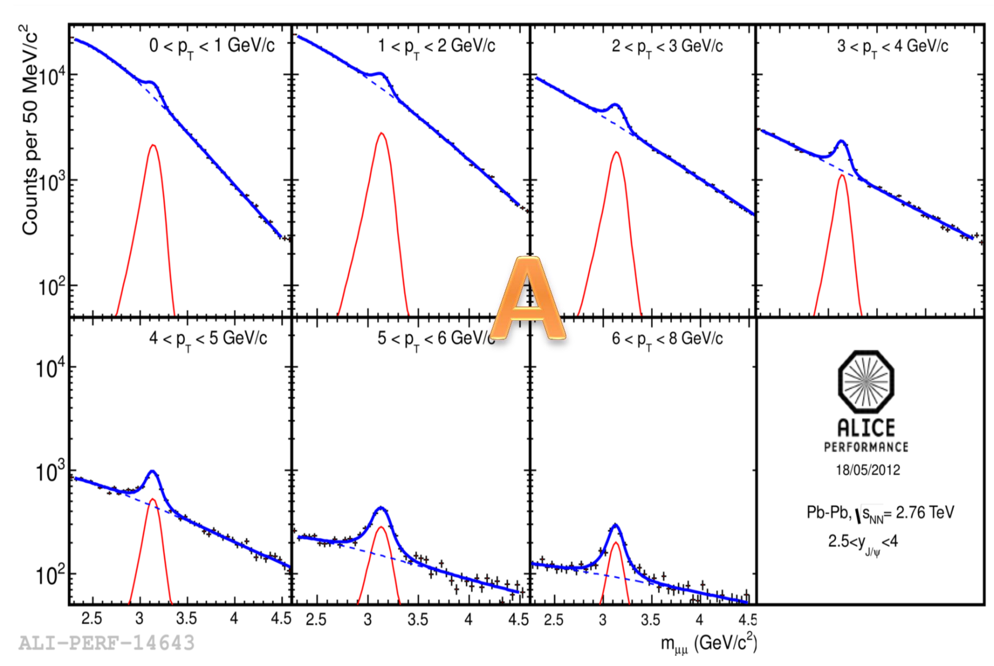
The J/ψ → μμ studies shown here make use of the 2011 Pb-Pb collisions. A dedicated trigger based on the coincidence of a minimum bias (MB) condition with the detection of two opposite sign tracks in the trigger chambers (dimuon trigger) was required. A total of 17.5 million events are used for this analysis, corresponding to an integrated luminosity of 69.5 μb^{-1}.

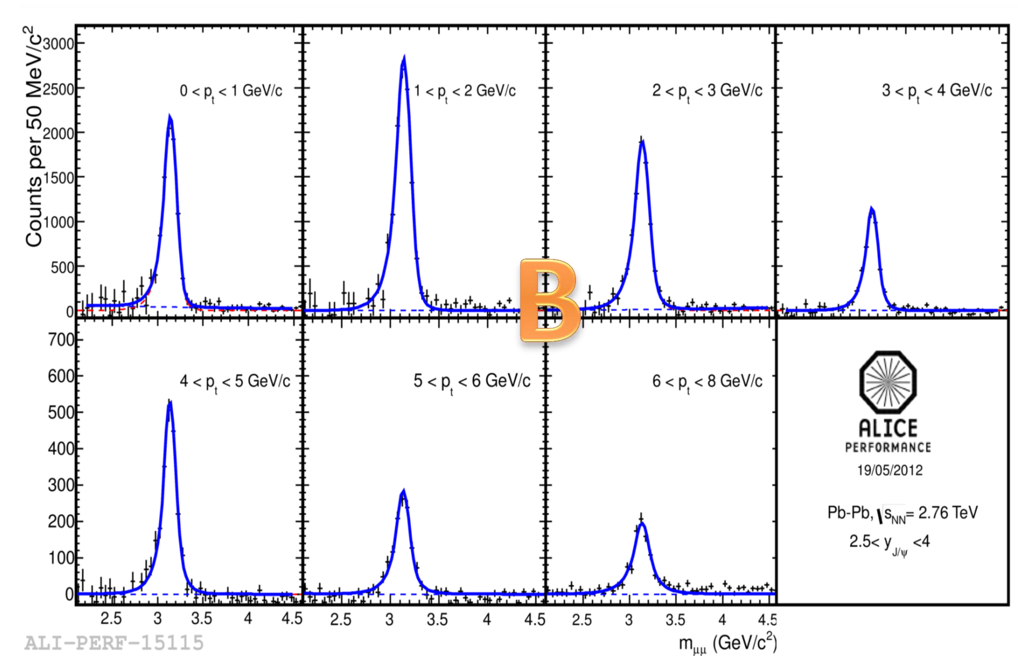
The invariant yield is computed as

$$Y_{J/\psi} = \frac{N_{J/\psi}}{BR_{J/\psi\rightarrow\mu\mu} \times N_{events} \times A \times \varepsilon}$$

$N_{J/\psi}$: extracted by fitting

A. The unlike-sign invariant dimuon mass spectrum.
B. The signal after subtracting the background using the event mixing technique.





N_{events}: number of MB events. Computed via a normalization factor (F_{Norm}) that gives the probability of having a dimuon trigger when the MB condition is verified.

$A \times \varepsilon$: obtained with the embedding technique, this is, MC J/ψ injected into the raw data of real events. Embedding allows to account for the centrality dependence of the reconstruction efficiency [4].

Systematic uncertainties

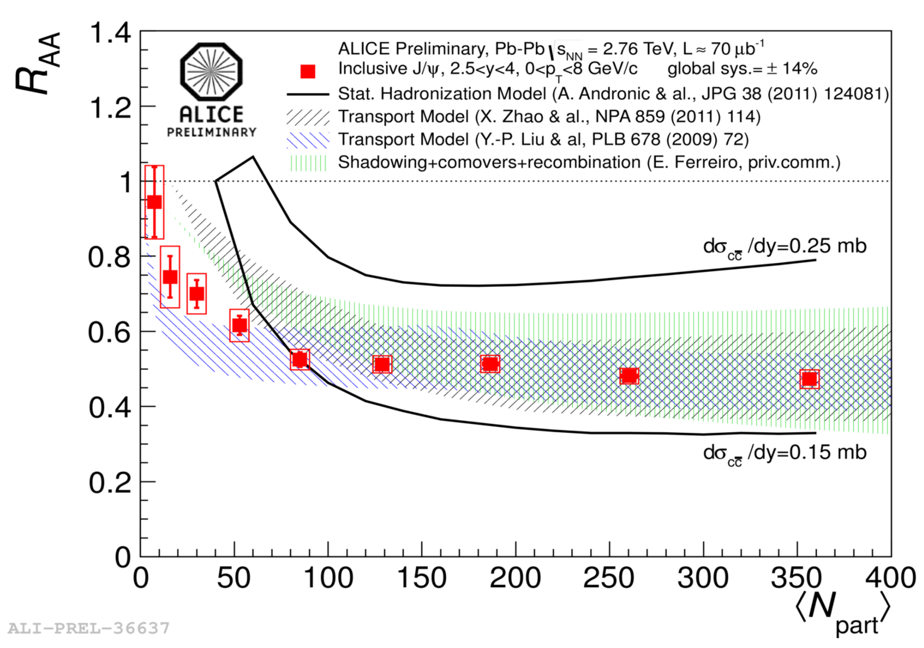
	Centrality		p_T / y	
	Value	Type	Value	Type
Signal extraction	1-3 %	II	3-6 %	II
MC Input	5 %	I	5 %	II
Tracking	6 %	I	6 %	I
Trigger	6.4 %	I	6.4 %	I
Matching	2 %	I	2 %	II
T_{AA}	4-8 %	II	4 %	I
σ^{pp}	9 %	I	6/8 %	I and II
F_{Norm}	2 %	I	2 %	I

Type I (II) correlated (uncorrelated).

Results

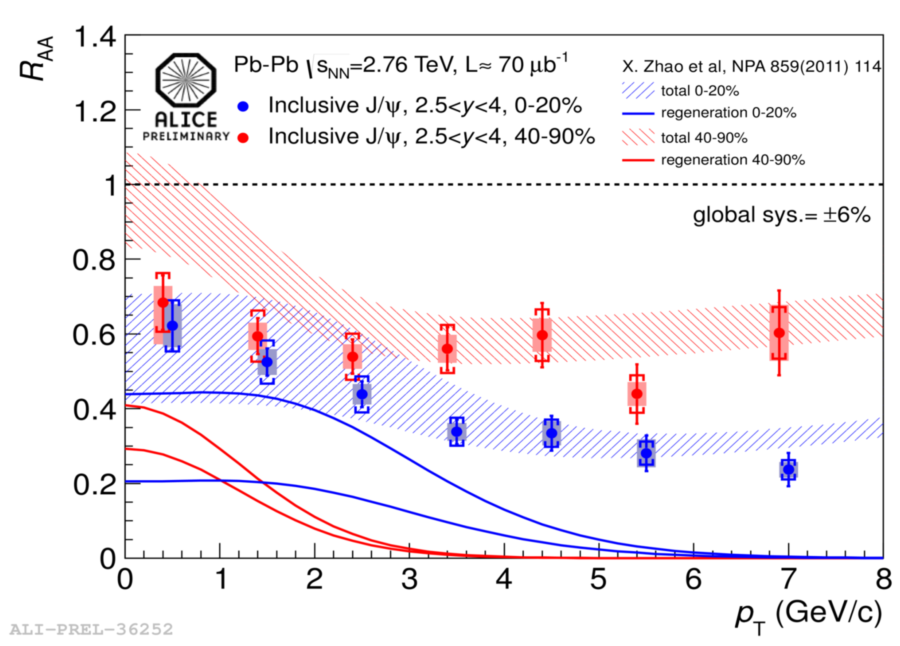
The Nuclear Modification Factor (R_{AA}) is computed dividing the invariant yield in Pb-Pb by the J/ψ pp cross-section at 2.76 TeV [5] scaled by the Nuclear Overlap Function ($\langle T_{AA}\rangle$)

$$R_{AA} = \frac{Y^{Pb-Pb}_{J/\psi}}{\langle T_{AA}\rangle \times \sigma^{pp}_{J/\psi}}$$



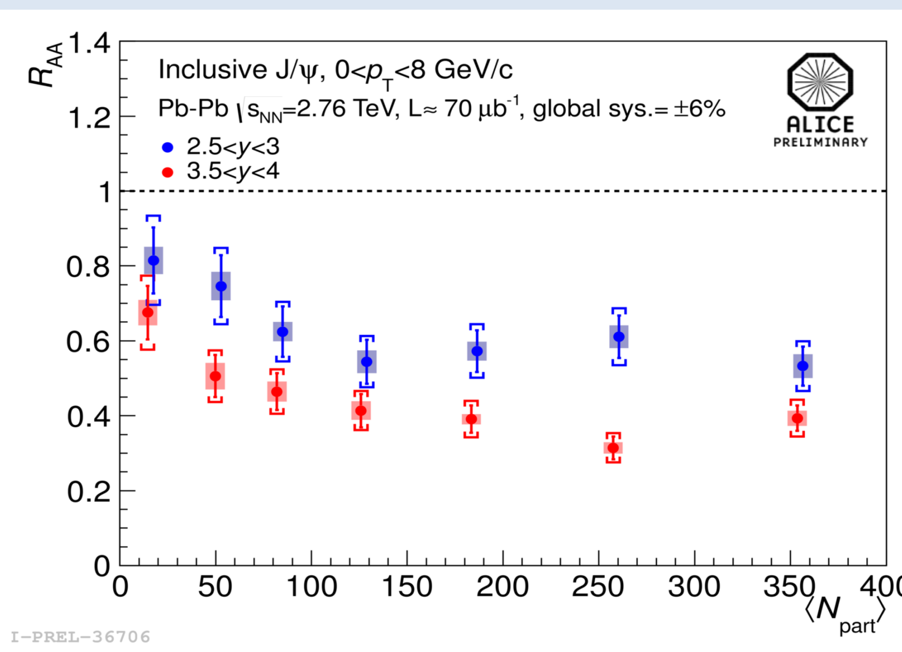
p_T-and y-integrated R_{AA} vs N_{part} (centrality):

- ✓ Same behavior as 2010 results [6].
- ✓ Flat centrality dependece for N_{part} > 100.
- ✓ $R_{AA}^{ALICE} \sim 3 \times R_{AA}^{PHENIX}$ for N_{part} > 200 [7].



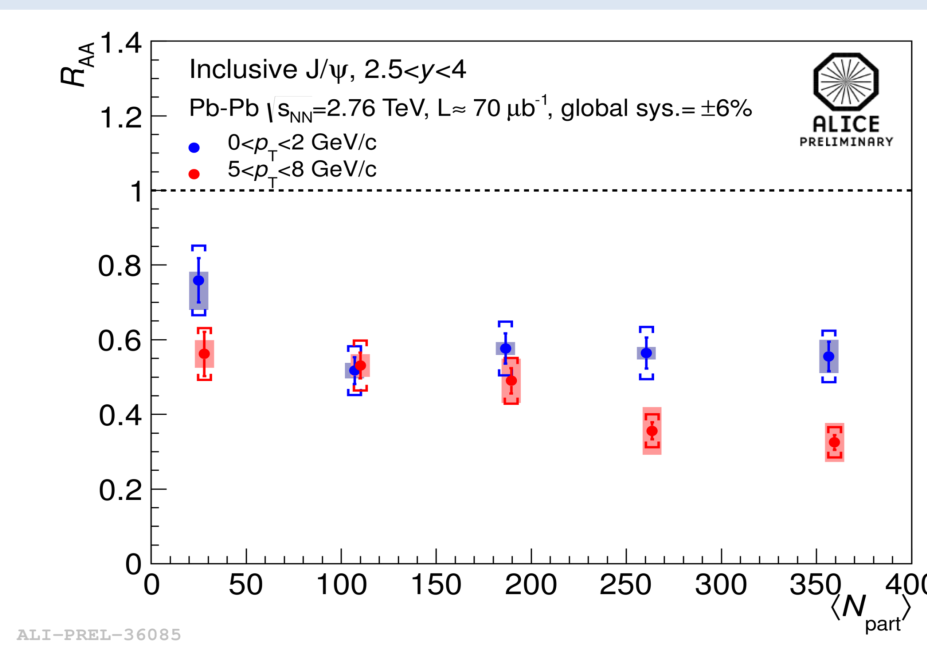
R_{AA} vs p_T in centrality bins:

- ✓ Less suppression in the most peripheral bin.
- ✓ Transport Model ➔ recombination at work in the low-p_T regime and dominant contribution for central collisions.



R_{AA} vs centrality in rapidity bins:

- ✓ Stronger suppression in the most forward region.
- ✓ Same centrality behavior, no strong dependence for N_{part} > 100.



R_{AA} vs centrality for two p_T bins:

- ✓ Larger suppression for high-p_T J/ψ in the most central collisions.
- ✓ Centrality independent (dependent) for low-p_T (high-p_T) J/ψ and N_{part} > 100.

Theoretical predictions:

- Stat. Hadronisation Model: all initial J/ψ suppressed in QGP ➔ J/ψ produced via recombination.
- Transport Models: initial J/ψ partially suppressed in QGP ✚ J/ψ produced via recombination.
- Green band: no initial J/ψ suppressed in QGP **but** J/ψ interaction with comovers ✚ J/ψ produced via recombination.

Need to measure Cold Nuclear Matter effects in pPb collisions.

Conclusions

ALICE has studied the inclusive J/ψ R_{AA} as a function of centrality, p_T and y in Pb-Pb collisions at 2.76 TeV down to zero p_T.

R_{AA} vs N_{part} shows a flat centrality dependence for the most central collisions, a striking difference relative to RHIC energies. In particular, $R_{AA}^{ALICE} \sim 3 \times R_{AA}^{PHENIX}$ for N_{part} > 200.

Stronger suppression at the most forward region and for high- p_T J/ψ.

Comparison to theoretical models points to (re)generation.

References

[1] *Matsui & Satz, PLB 178 (1986) 416.*
[2] *Digal et al.*, PRD 64 (2001) 0940150.
[3] *Aamodt et al., JINST 3 (2008) S08002.*
[4] *Aamodt et al.*, PRL. 106 (2011) 032301.
[5] *Abelev et al.*, PLB 718 (2012) 295.
[6] *Abelev et al.*, PRL 109 (2012) 072301.
[7] *Adare et al.*, PRC 84 (2011) 054912.