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Nuclear modification of J/ψ production in Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV

Jens Wiechula
for the ALICE Collaboration

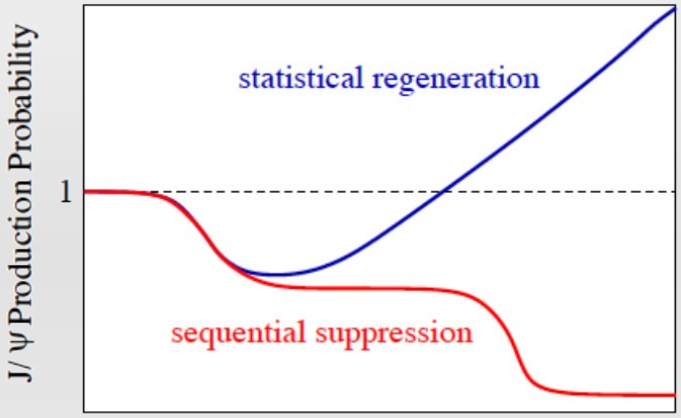
Outline

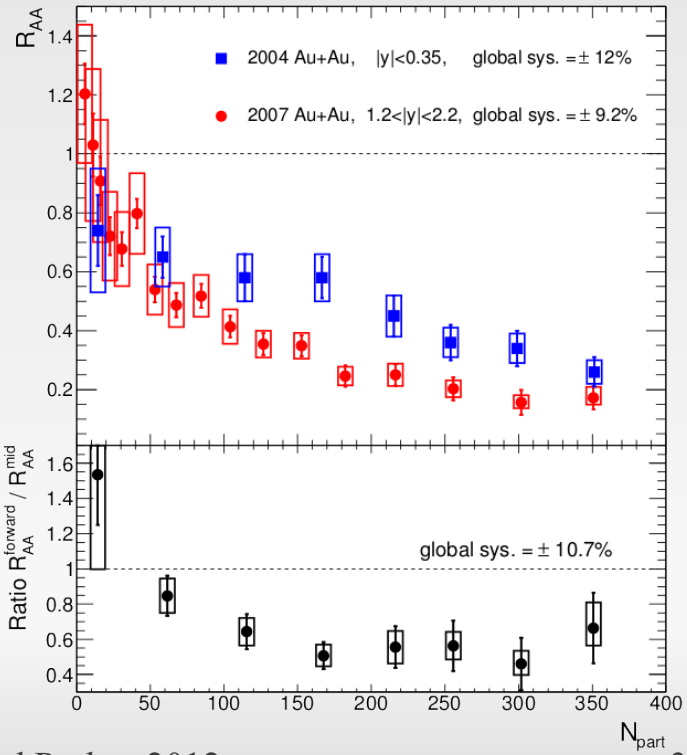
- Motivation
- J/ψ measurement in ALICE
- J/ψ analysis in Pb-Pb collisions
- R_{AA} preliminary results
- Comparison with other experiments
- Comparison with models
- Conclusions

Motivation

- Interesting interplay between expected sequential suppression
  (T. Matsui and H. Satz, Phys. Lett. B 178, 416 (1986))
  and statistical (re)generation
  (e.g. Andronic *et al.* Phys. Lett. B652 (2007) 659)
  of J/ψ production at LHC energies

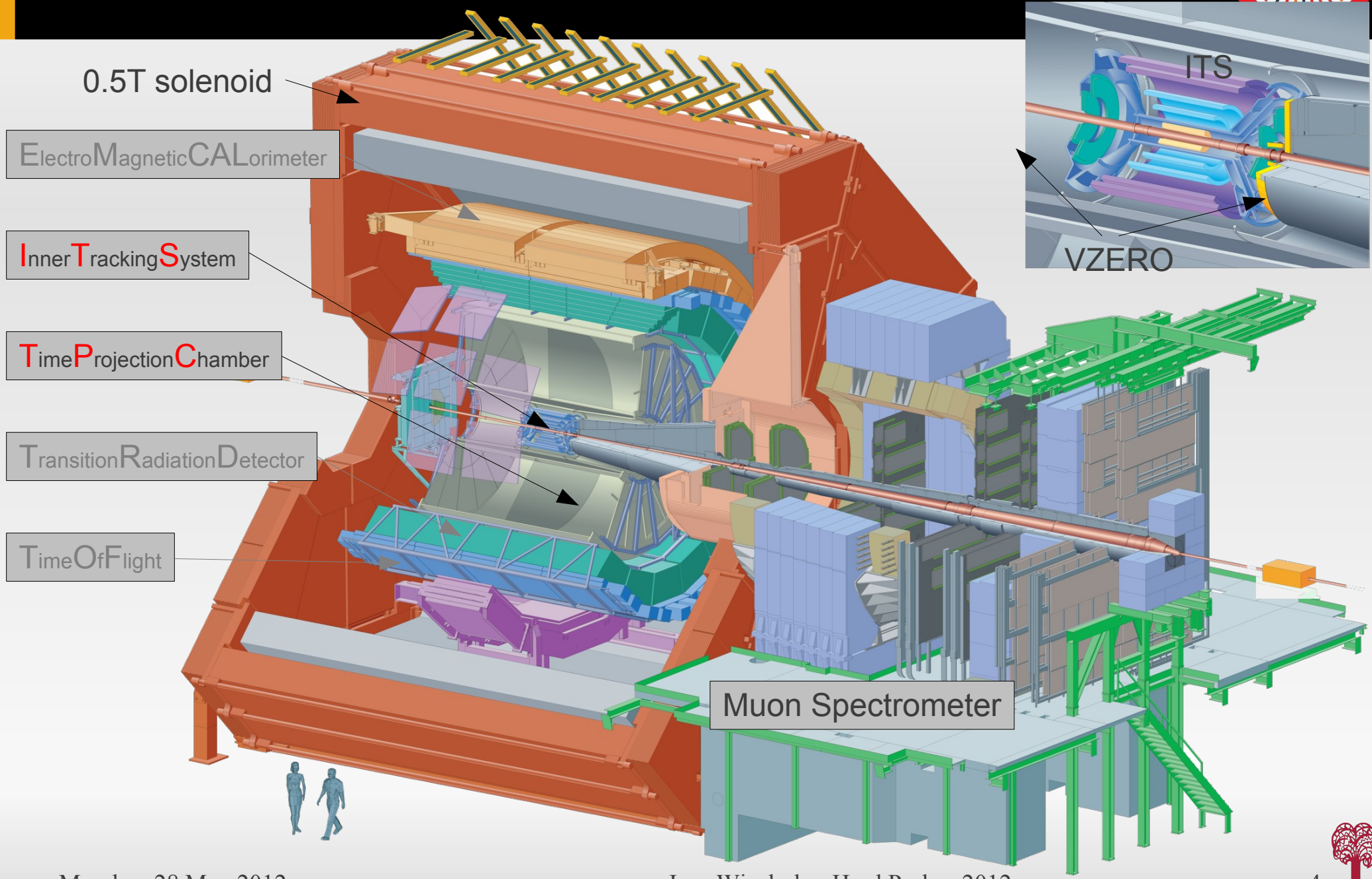
- Higher J/ψ suppression at forward than mid rapidity measured at RHIC energies
  - Rapidity dependence important to determine the total cross section (down to p_t=0) at LHC energy





arXiv:1103.6269v1 [nucl-ex] (PHENIX)

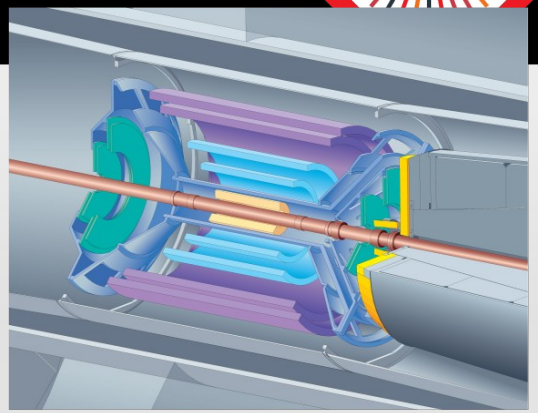
The ALICE detector



J/ψ measurement in ALICE

di-electron channel

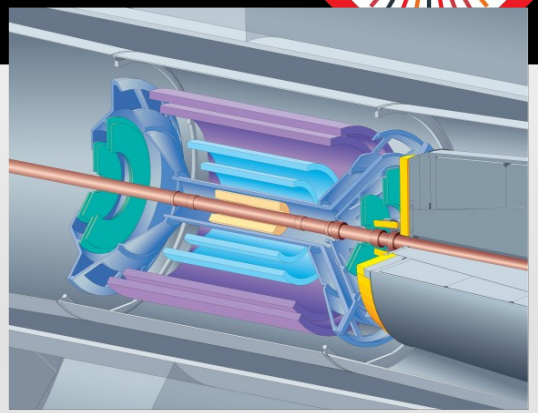
Acceptance:
$0 < \varphi < 2\pi$
$|\eta^e| < 0.9$
$p_t > 0$



J/ψ measurement in ALICE

di-muon channel

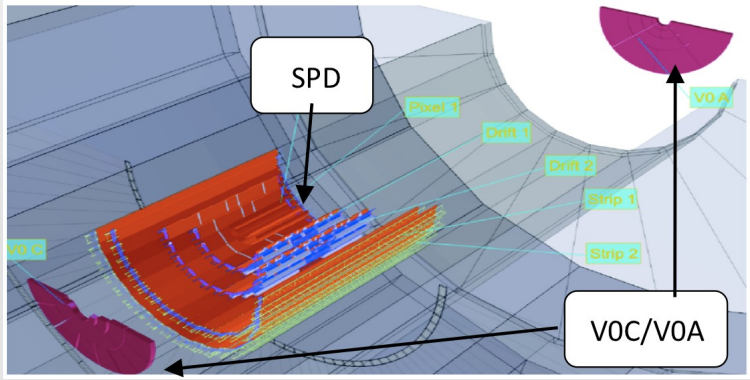
Acceptance:
$0 < \varphi < 2\pi$
$2.5 < \eta^{\mu} < 4$
$p_t > 0$

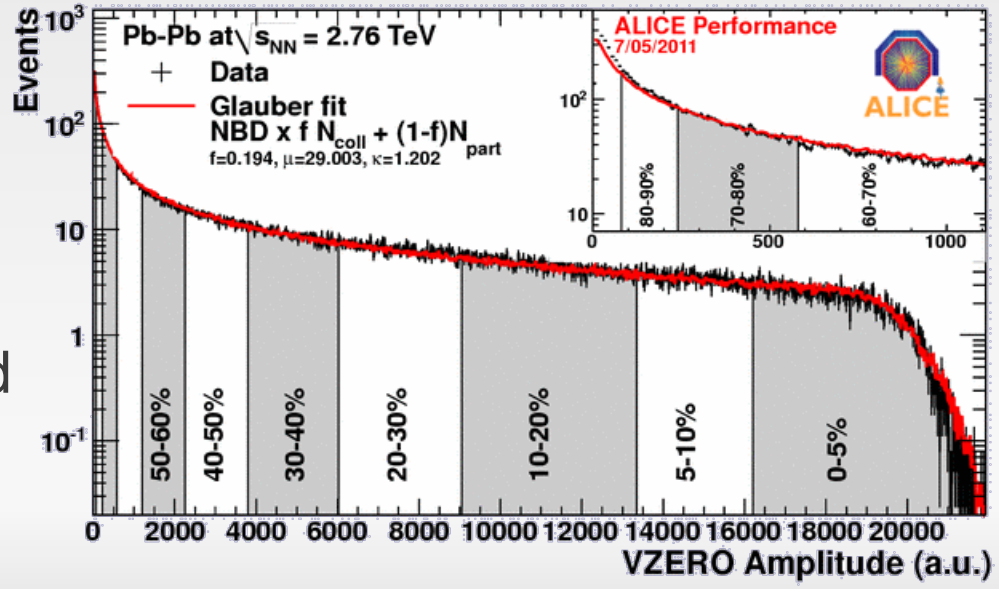


Analysis

Event statistics and centrality

- Di-electron channel
  - Minimum bias trigger (12.8M events)
  - 2010 data set (L_{int}=1.7μb^{-1})
- Di-muon channel
  - di-muon trigger (17.7M events)
  - 2011 data set (L_{int}=70μb^{-1})
- Centrality selection
  - Based on VZERO amplitude
  - Fitted with distribution obtained by a geometrical Glauber MC

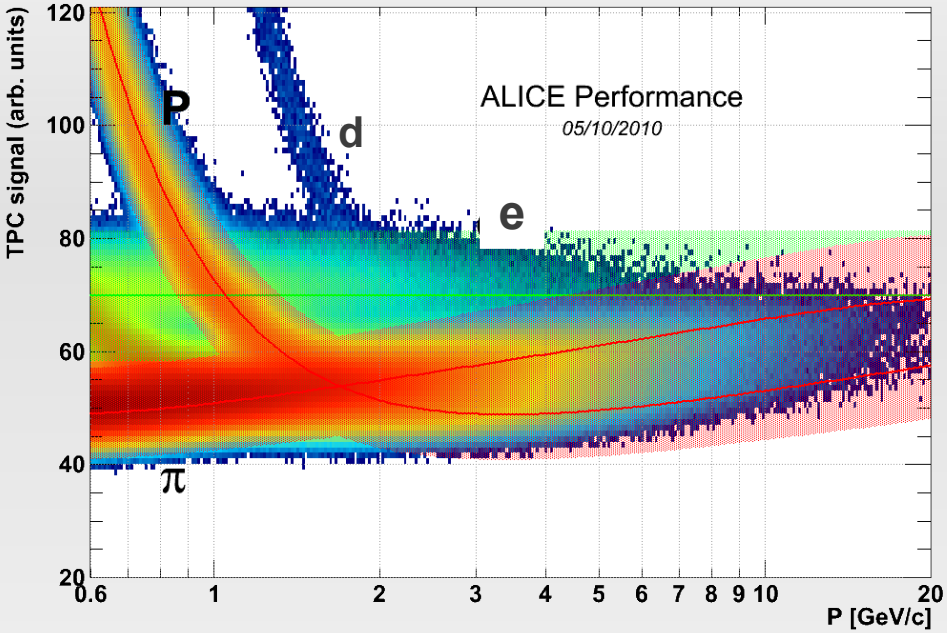


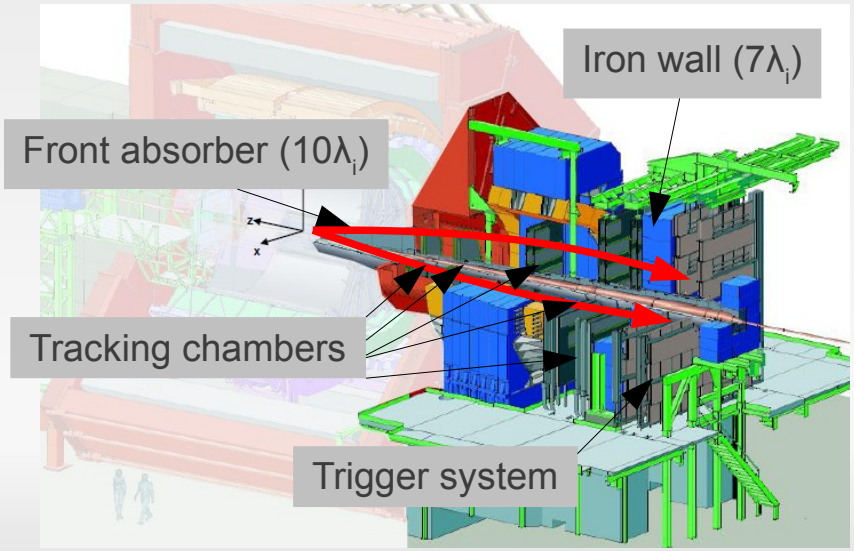


ALI-PERF-400

Analysis

Track and Pair selection

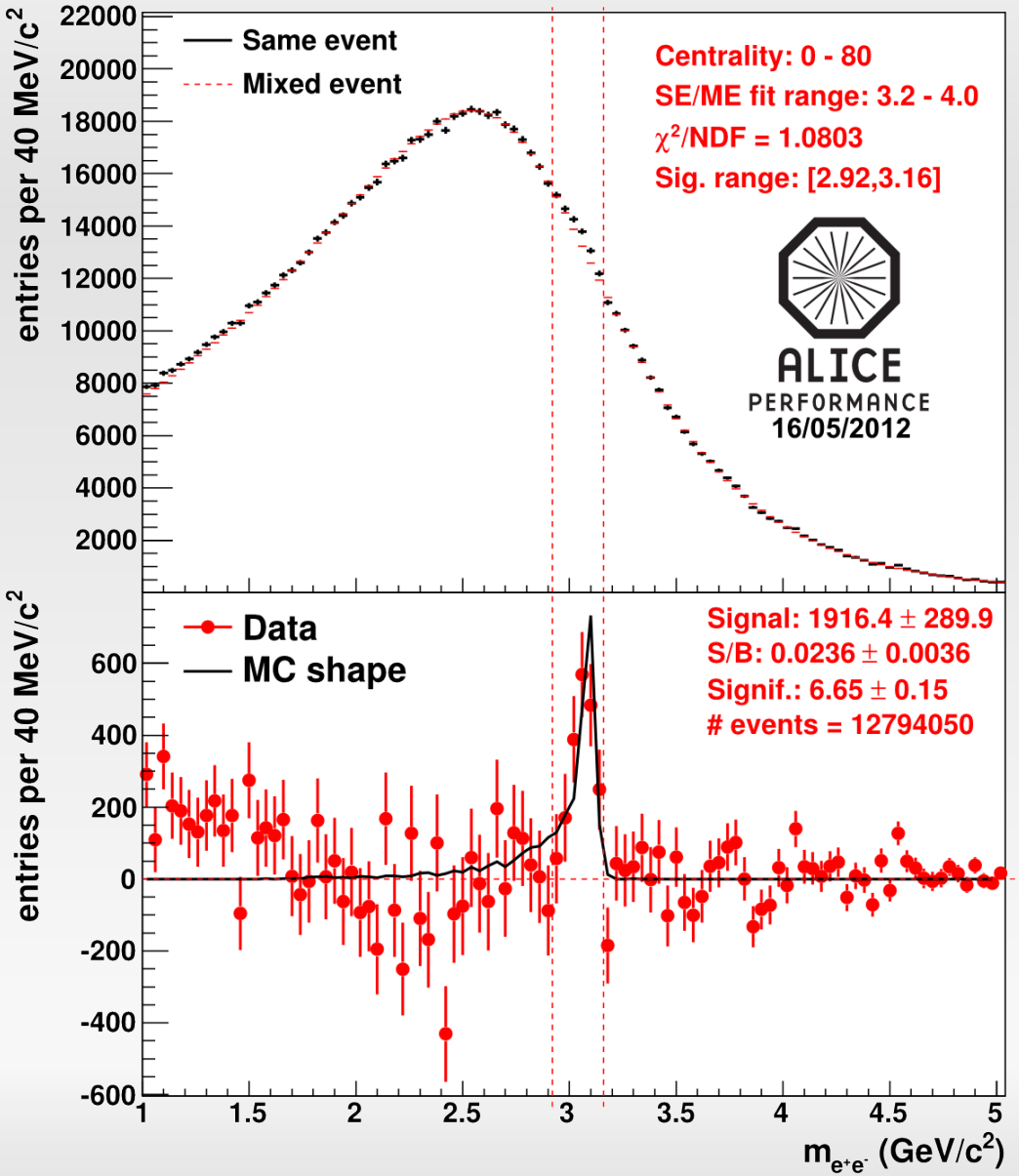




- Di-electron channel
  - Particle Identification via d*E*/d*x* using TPC only ($|n\sigma_e|<3$, $|n\sigma_{p,\pi}|>3.5$)
  - $|y^{J/\psi}| < 0.9$
- Di-muon channel
  - Hadrons stopped by front absorber and iron wall of the trigger
  - Muon candidates are required to have hits in the muon trigger chambers
  - $2.5 < y^{J/\psi} < 4$

Analysis

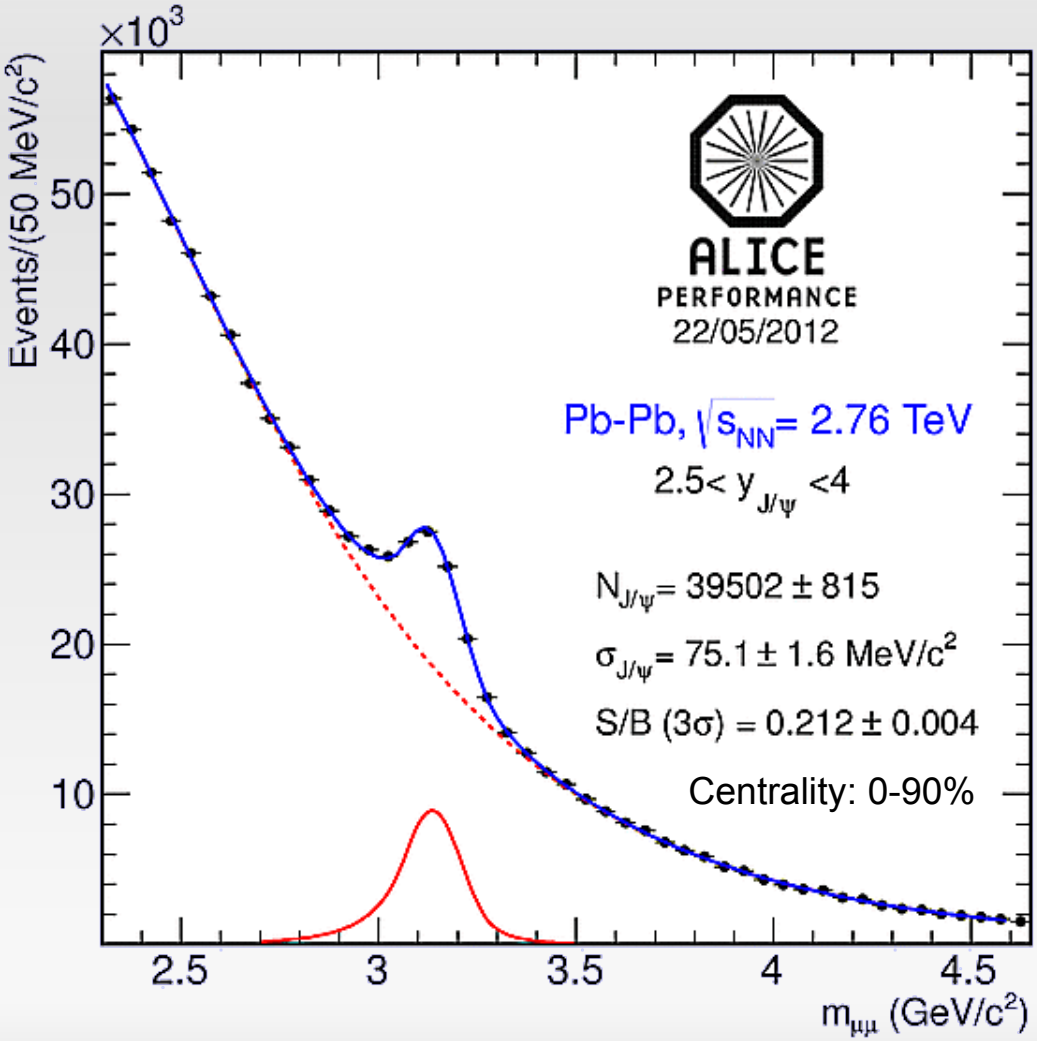
Signal extraction in the di-electron channel



- Background
  - Described using event mixing (ME)
  - Scaled to same-event spectrum in 3.2 < M < 4.0 GeV/c^2
- Signal extraction
  - Subtract ME background
  - Signal integration within 2.92 < M < 3.16 GeV/c^2
  - About 2000 J/ψ in analysed data sample

Analysis

Signal extraction in the di-muon channel

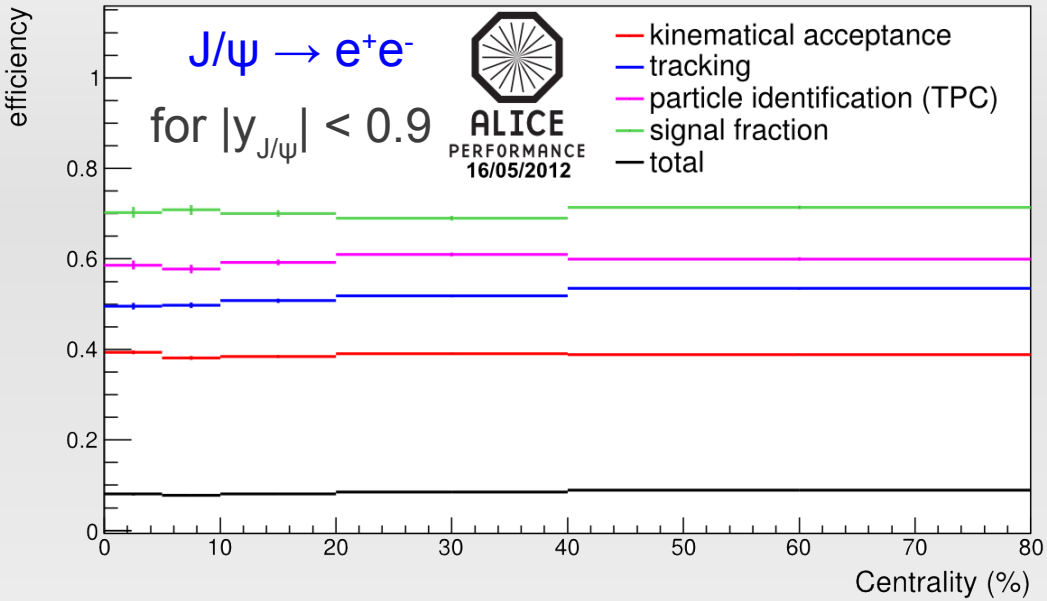


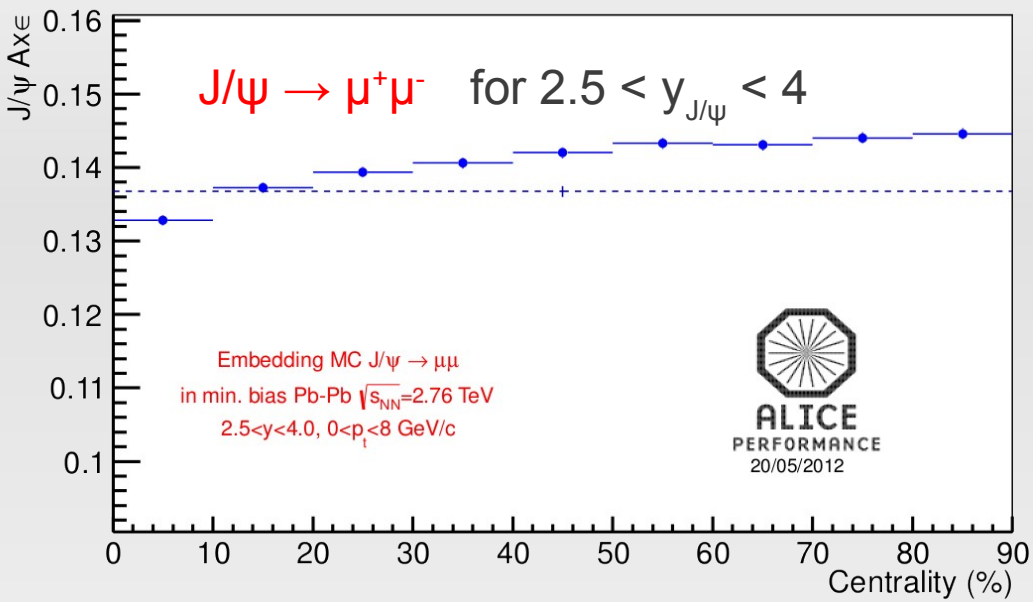
ALI-PERF-15494

- Background
  - Several methods used (variable width gaussian, sum of two exponentials, event mixing)
- Signal extraction
  - Shape described by an extended Crystal Ball function (allows for non-gaussian tail on the r.h.s. of the peak)
  - Combined fit with background shape
  - About 40k J/ψ in analysed data sample

Analysis

Efficiencies





- For di-electron eff. Hijing enriched with J/ψ
- For di-muon channel real Pb-Pb events enriched with MC J/ψ (embedding)
- Only weak dependence on centrality
- Realistic J/ψ parametrizations
  - for p_t and y based on interpolated data from RHIC to LHC energies (F.Bossu *et al.*, arXiv:1103.2394 [nucl-ex])
  - Shadowing from EKS98 calculations (K.J.Eskola *et al.*, Eur. Phys. J. C9, 61 (1999))
  - Polarisation assumed to be 0 (measured in pp: PRL 108, 082001 (2012))

Nuclear modification factor

Normalisation

- Corrected yield in each centrality bin *i*

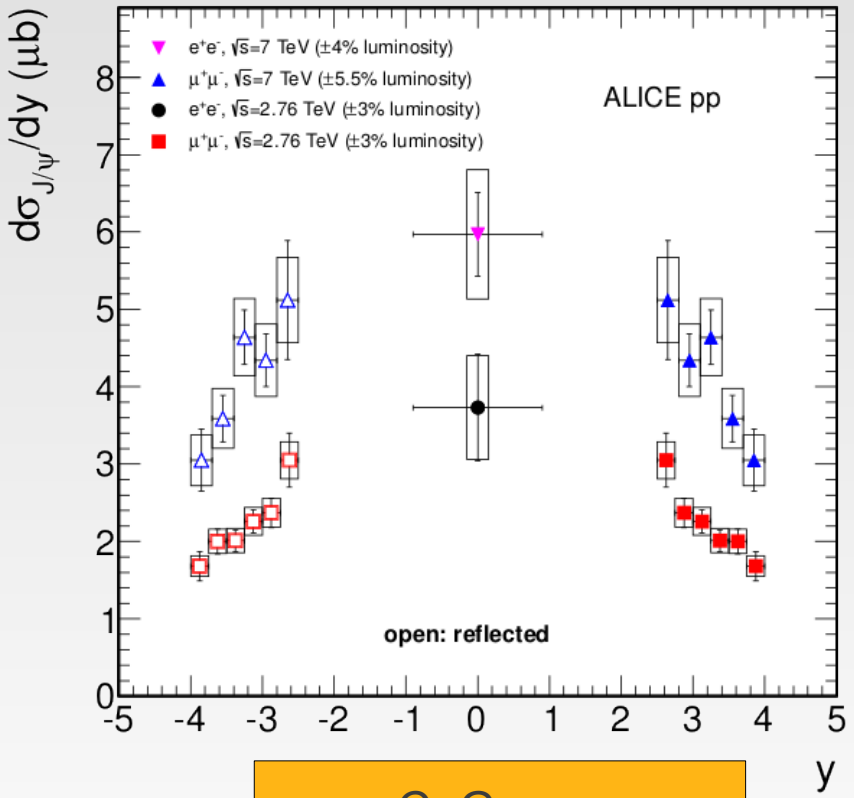
$$Y_{J/\psi}^{PbPb,i} = \frac{N_{J/\psi}^{PbPb,i}}{BR \times A\epsilon^{i} \times N_{MB}^{events,i}}$$

- Normalised to measured pp cross-section at same $\sqrt{s_{NN}}$, scaled by T_{AA} (Glauber MC)

$$R_{AA}^{i} = \frac{Y_{J/\psi}^{PbPb,i}}{T_{AA}^{i} \times \sigma_{J/\psi}^{pp}}$$

pp measurement from ALICE data

arXiv:1203.3641v1 [hep-ex]



C. Geuna
(IIIa - Tue 14:35 - T3)

Nuclear modification factor

Systematic uncertainties in the di-electron channel

Source	Centrality		
	0-10%	**10-40%**	**40-80%**
Signal extraction	29%	18%	18%
T_{AA}	4.3%	4.2%	6%
Matching data - MC	< 10%		
J/ψ p_t distribution in MC	~2%		
Total	**30%**	**20%**	**20%**

- Dominated by signal extraction
  - Description of background shape (ME)
  - Small signal / background ratio
- Correlated contribution:
  - pp reference: 26%

Nuclear modification factor

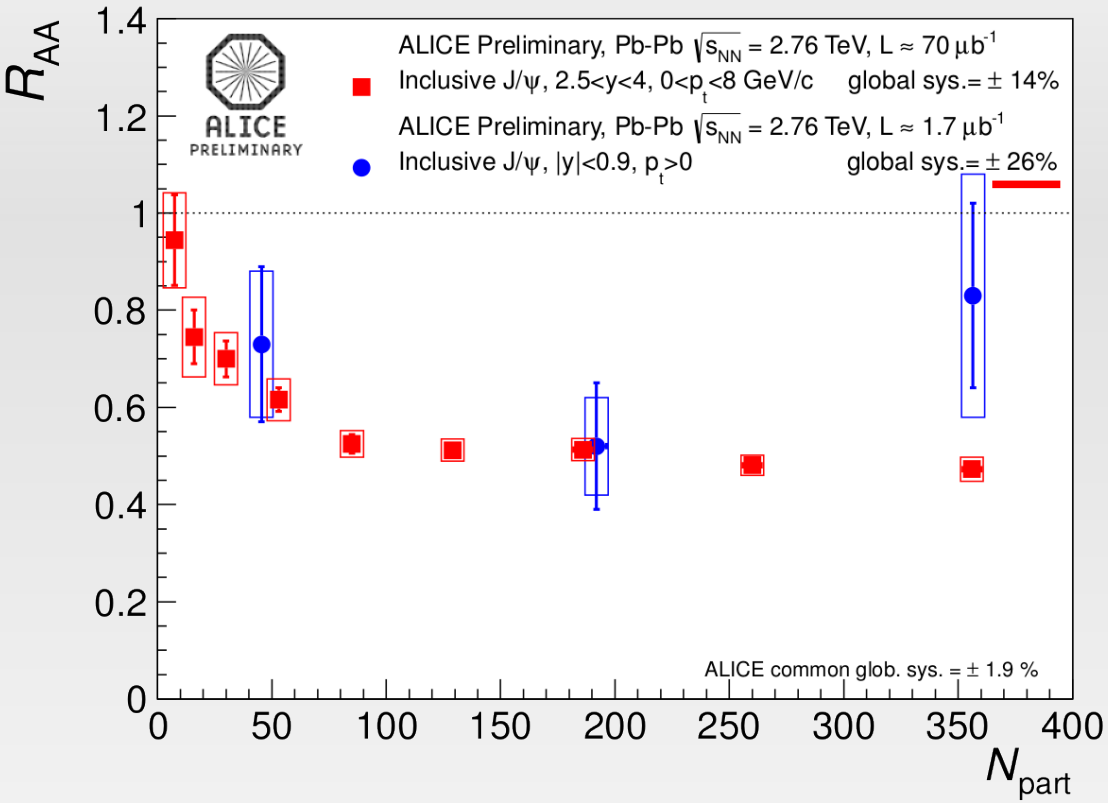
Systematic uncertainties in the di-muon channel

Source (uncorrelated)	Centrality (% most central)								
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90
Signal extraction	2.3%	1.2%	1.2%	1.1%	0.9%	0.9%	1.5%	1.9%	2.4%
T_{AA}	4.3%	4.2%	4.2%	4.4%	5.2%	6.8%	7.6%	10.8%	10.1%
Trigger (uncorr.)	2.0%	1.5%	1.0%	0.5%	-				
Tracking (uncorr.)	1.0%	0.5%	-						
Total	**5.3**	**4.4**	**4.5**	**4.5**	**5.1**	**7.0**	**7.7**	**11.0**	**10.4**

- Uncorrelated systematic uncertainty dominated by T_{AA}
- Correlated contributions:
  - PbPb: 6.4% trigger eff., 6% tracking eff., 5% MC J/ψ distr., 2% matching eff., 2% trigger normalisation
  - pp reference: 8.2%
  - Total: 14%

Nuclear modification factor

Preliminary R_{AA} vs. Npart

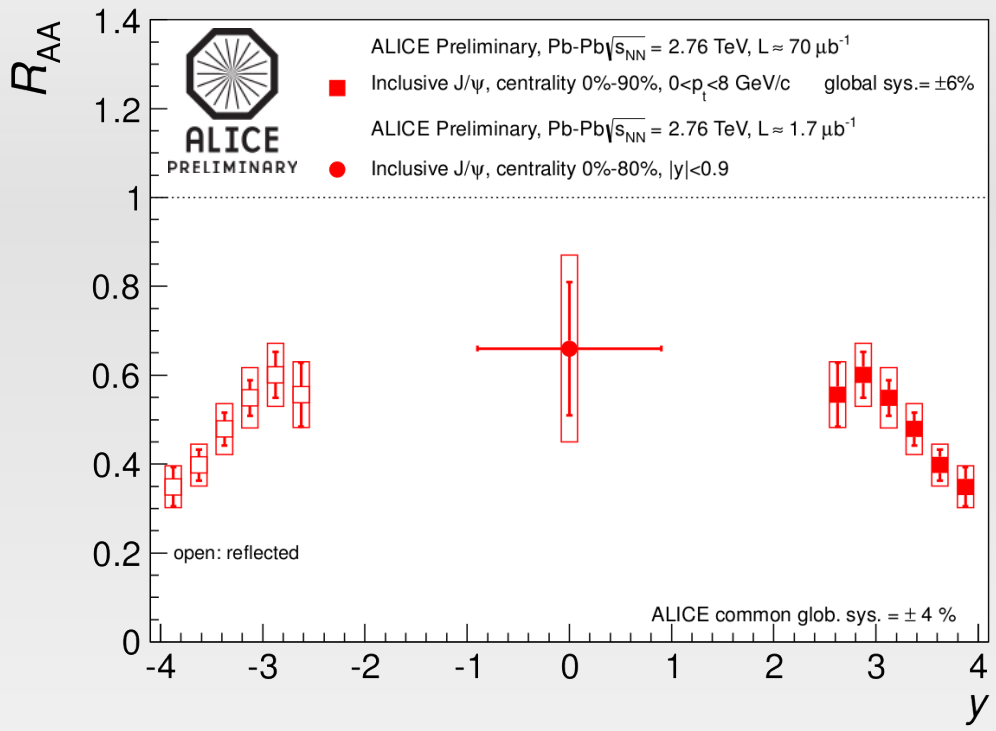


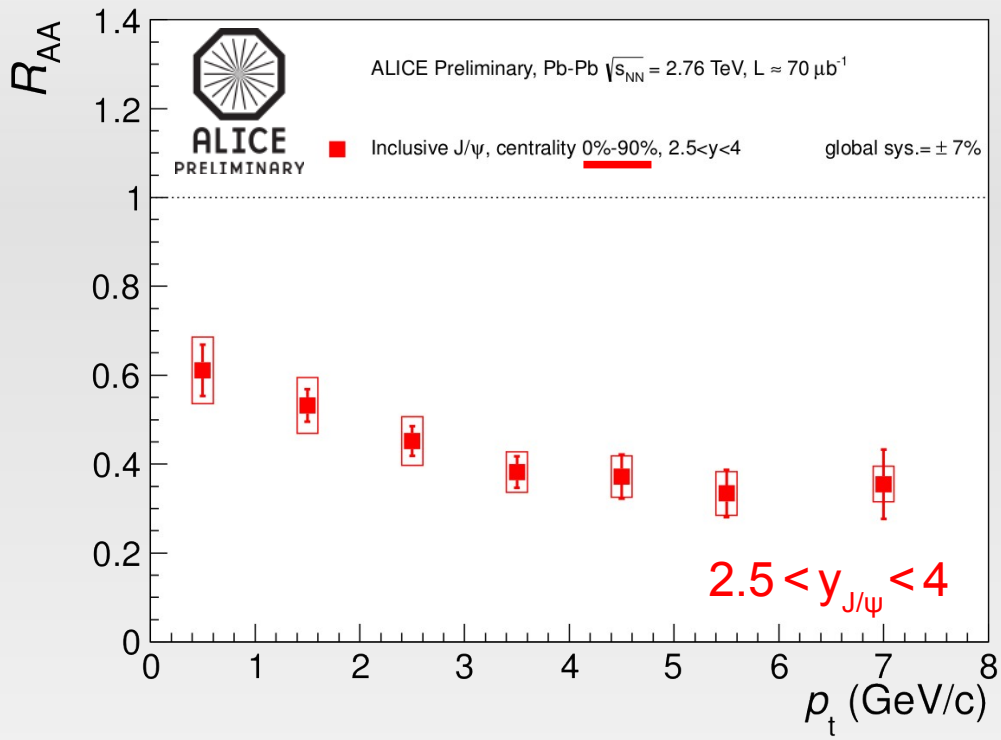
- Large global uncertainty at mid rapidity due to pp reference
- Factor 20 in L_{int} for results at forward rapidity compared to previously published results (arXiv:1202.1383v1 [hep-ex])

- Error bars: statistical uncertainty in Pb-Pb
- Boxes: uncorrelated systematic uncertainty in Pb-Pb
- Global systematic: correlated uncertainty in Pb-Pb and uncertainties in pp added in quadrature
- ALICE common global syst.: luminosity uncertainty in pp @ 2.76 TeV

Nuclear modification factor

Preliminary R_{AA} vs. rapidity and p_t

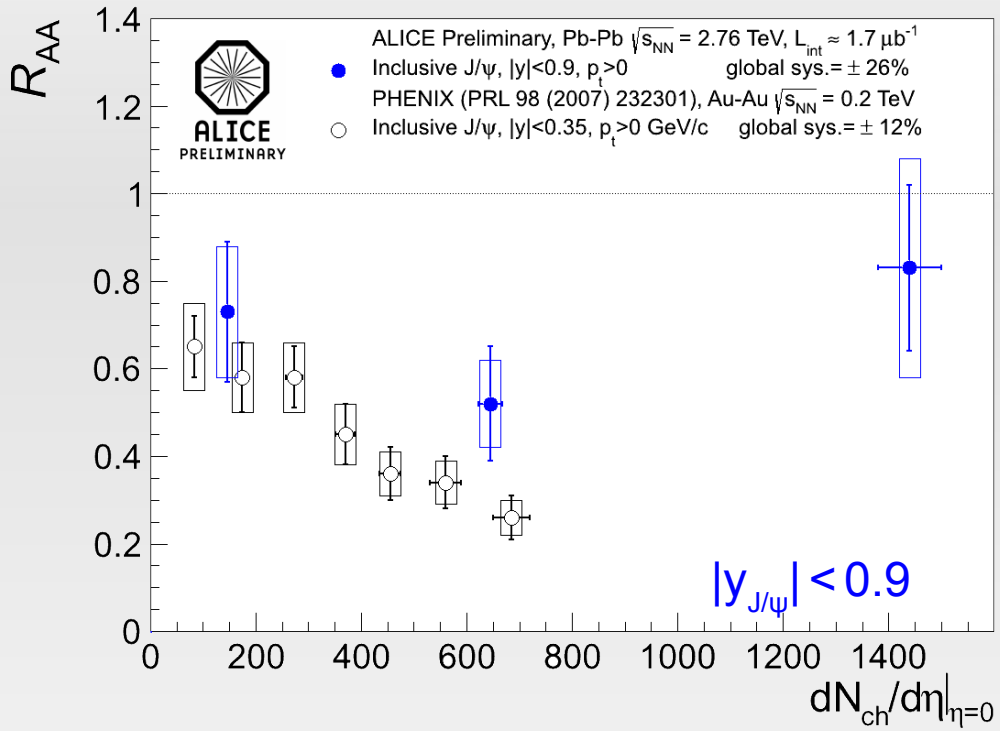


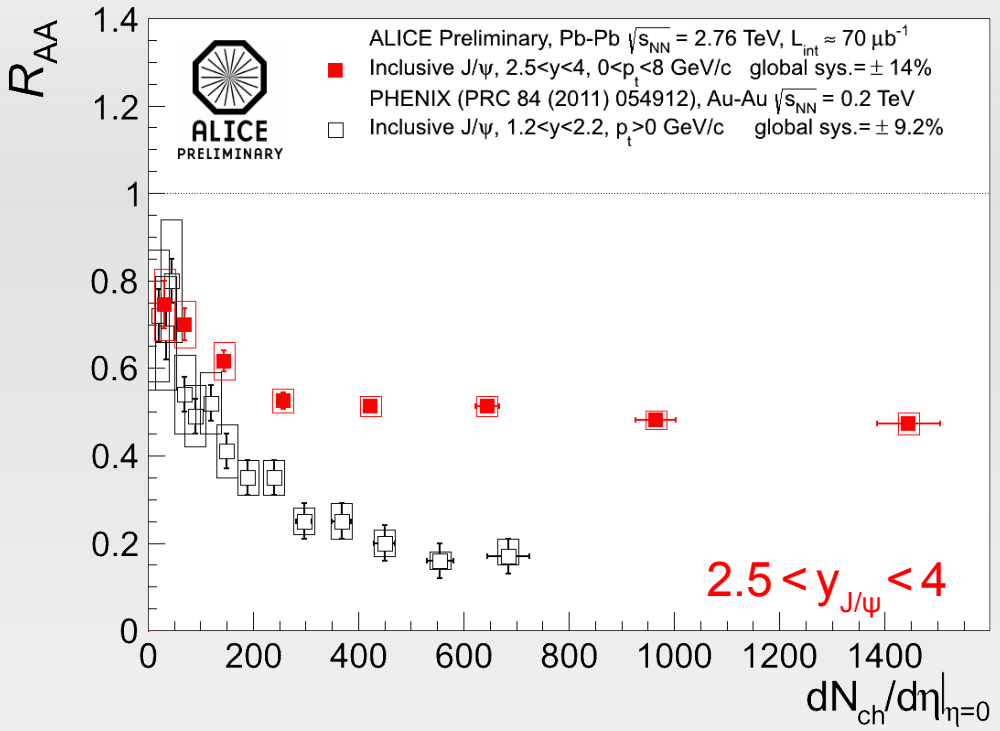


- R_{AA} decreases with y
- R_{AA} increases for low p_t (forward rapidity)

Nuclear modification factor

Comparison to PHENIX

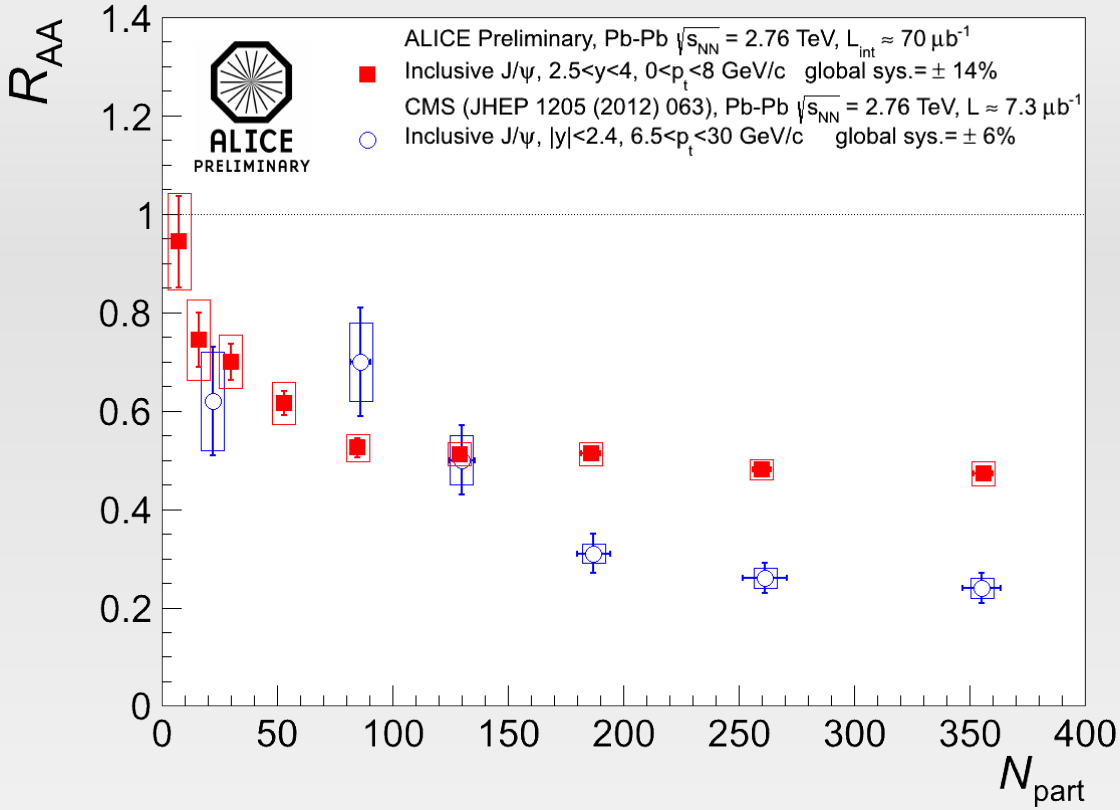




- Larger R_{AA} at LHC energies than at RHIC
- Seen both at mid and forward rapidity

Nuclear modification factor

Comparison to CMS

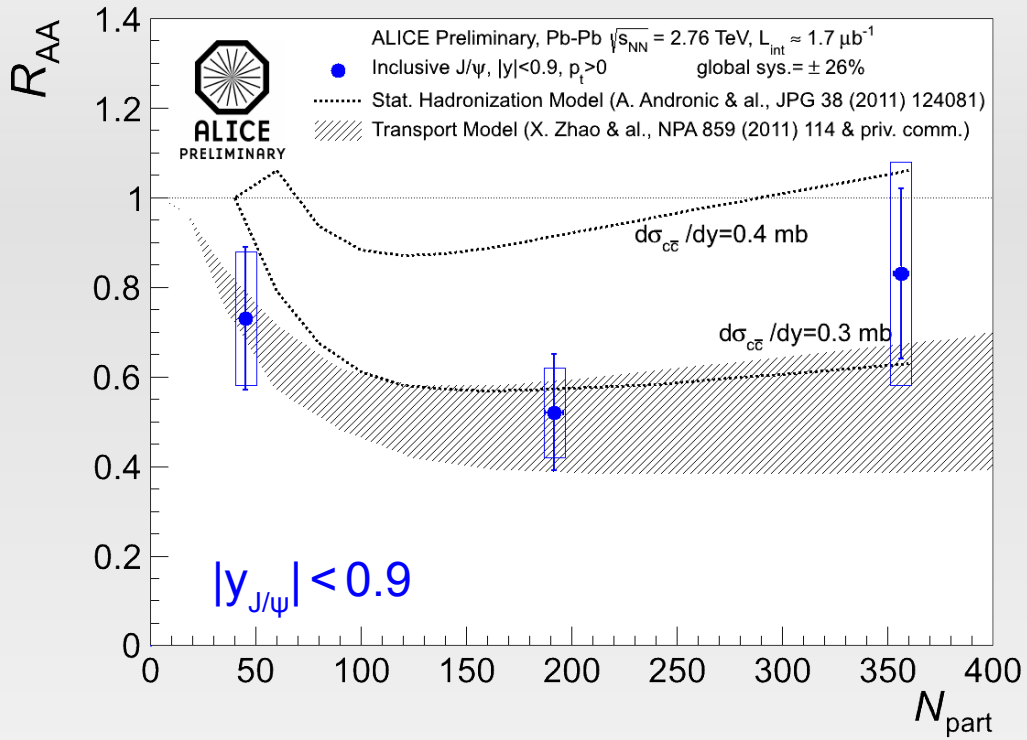


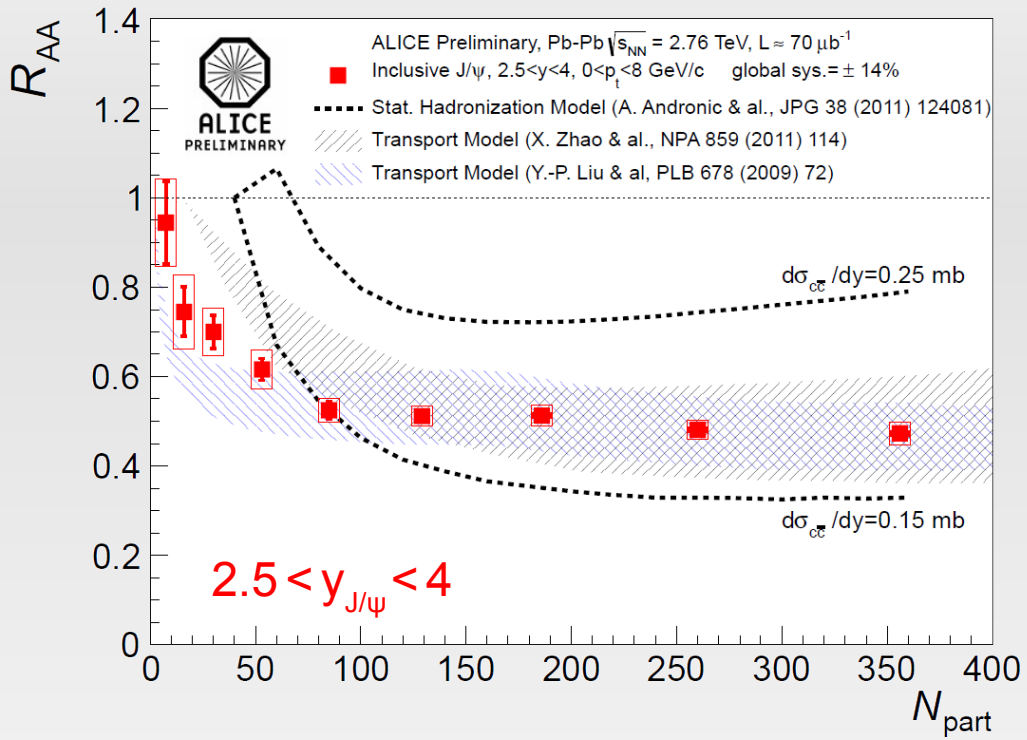
C. Suire
(Plenary 3B - Wed 11:00)

- ALICE results for low p_t J/ψ ($0 < p_t < 8$ GeV/c)
- CMS results for high p_t J/ψ ($6.5 < p_t < 30$ GeV/c)
- Comparison shows smaller R_{AA} for high pt J/ψ at more central collisions

Nuclear modification factor

Comparison to different models





- Comparison with models that take into account statistical (re)generation
- Statistical Hadronisation and Transport models agree with measurements within uncertainties for N_{part}>50

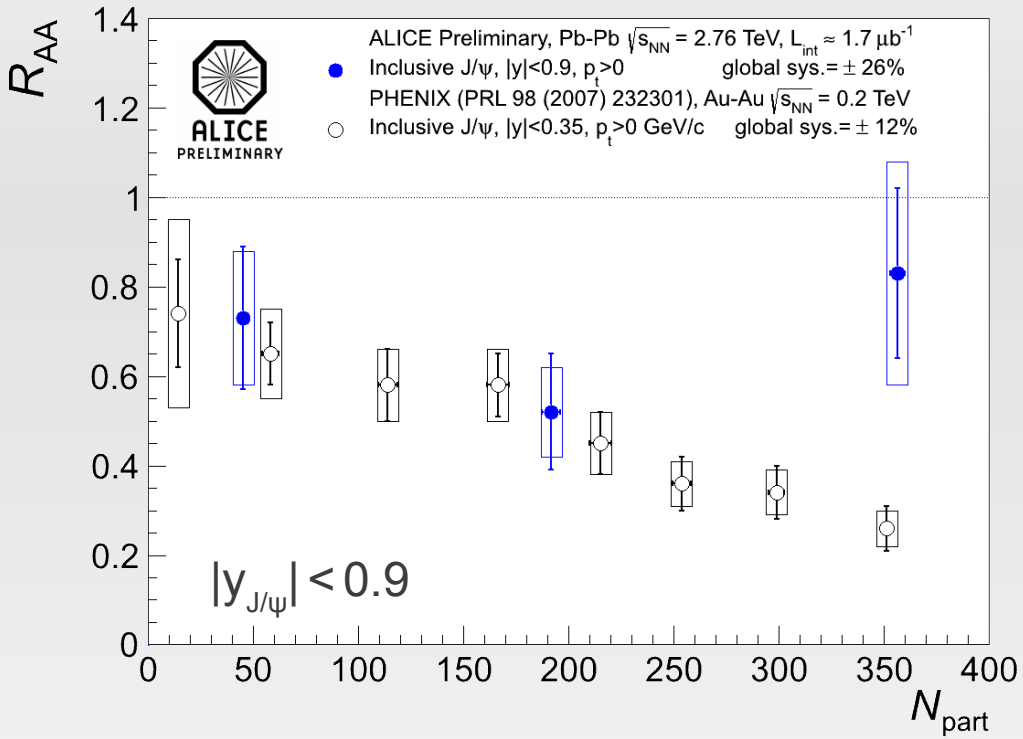
Summary

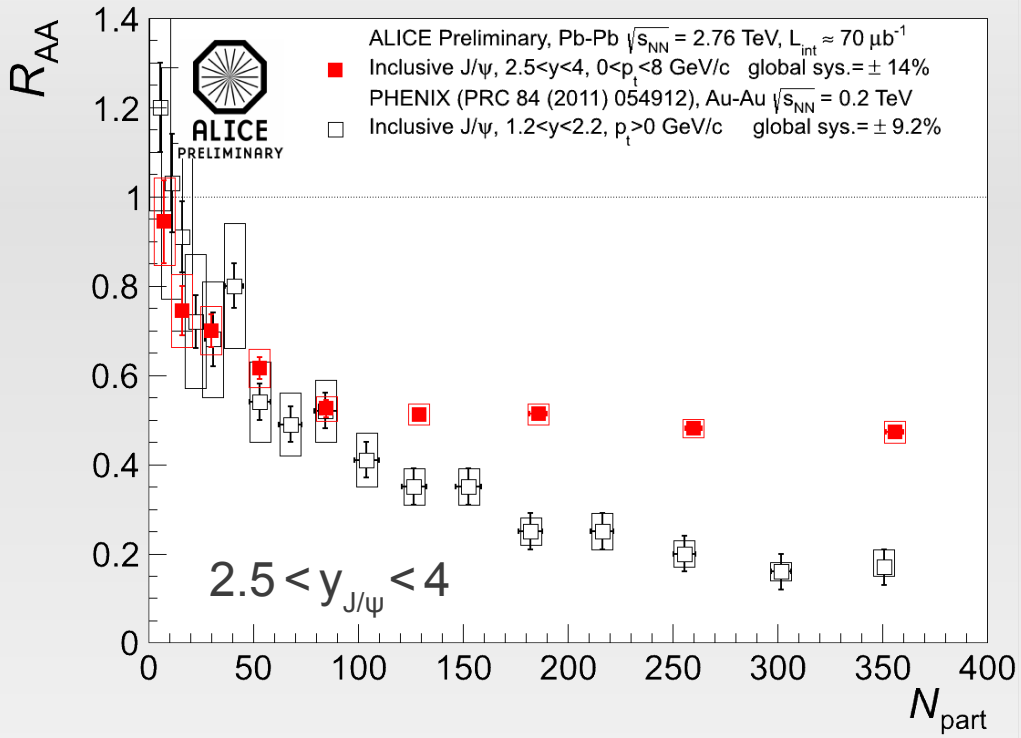
- Inclusive J/ψ R_{AA} in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV
- Measurements at central (|y|<0.9) and forward rapidity (2.5<y<4), both down to p_t=0
- R_{AA} decreases with y
- Higher R_{AA} at small p_t
- Less suppression at LHC than RHIC
- Statistical Hadronisation and Transport models agree with measurements for N_{part}>50
- Shadowing at LHC: will be addressed by results from p-Pb run end 2012

Backup

Nuclear modification factor

Comparison to PHENIX





- Less suppression at LHC energies than at RHIC
- Seen both at mid and forward rapidity

Nuclear modification factor

Comparison to PHENIX and CMS (p_t dependence)