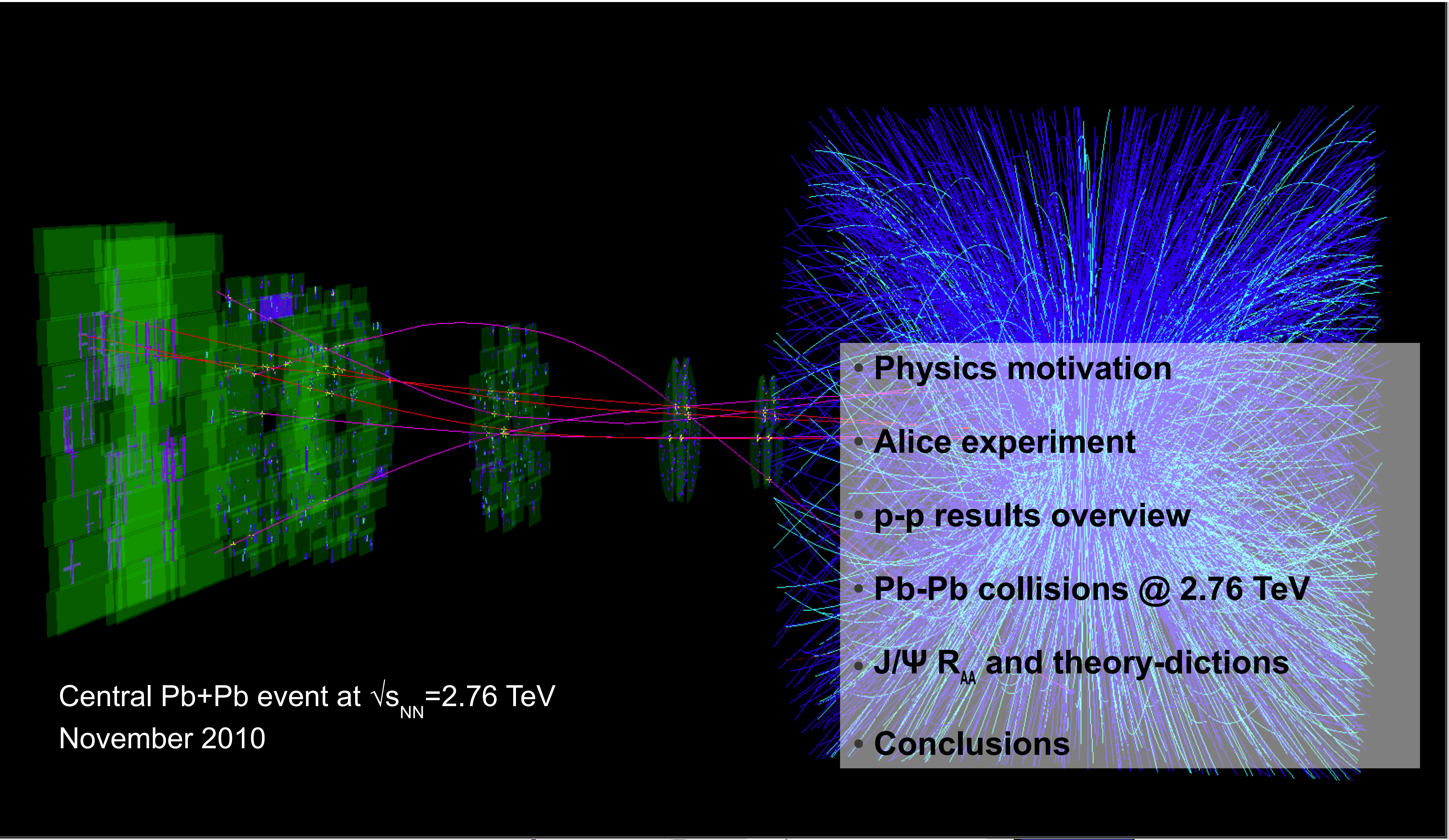
Quarkonia in ALICE



Central Pb+Pb event at $\sqrt{s_{NN}}$=2.76 TeV
November 2010

- **Physics motivation**
- **Alice experiment**
- **p-p results overview**
- **Pb-Pb collisions @ 2.76 TeV**
- **J/Ψ R_{AA} and theory-dictions**
- **Conclusions**

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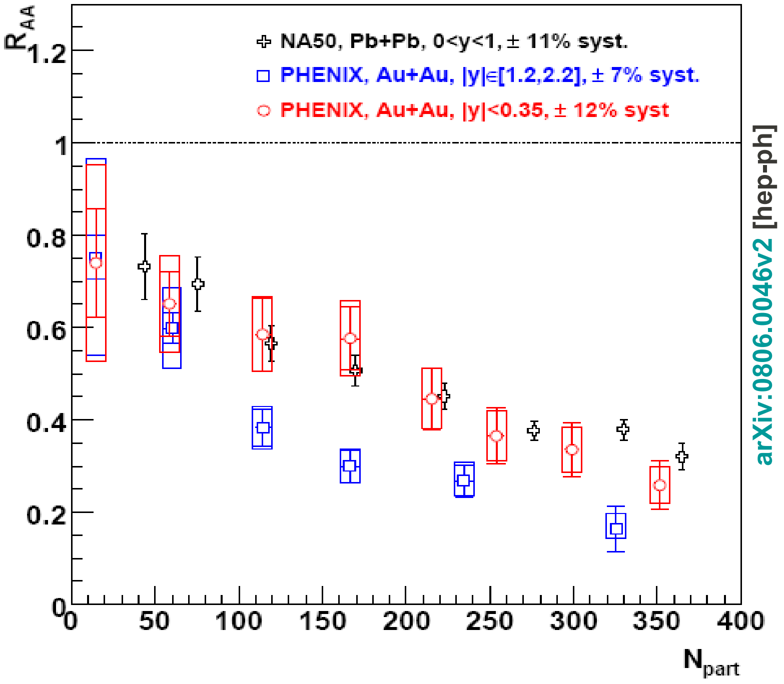
Quarkonia : the J/Ψ case

The long standing unambiguous signature of deconfined quark matter has somehow become ambiguous:

    suppression pattern “anomalously”

    comparable at SPS and RHIC.



Rapidity dependence

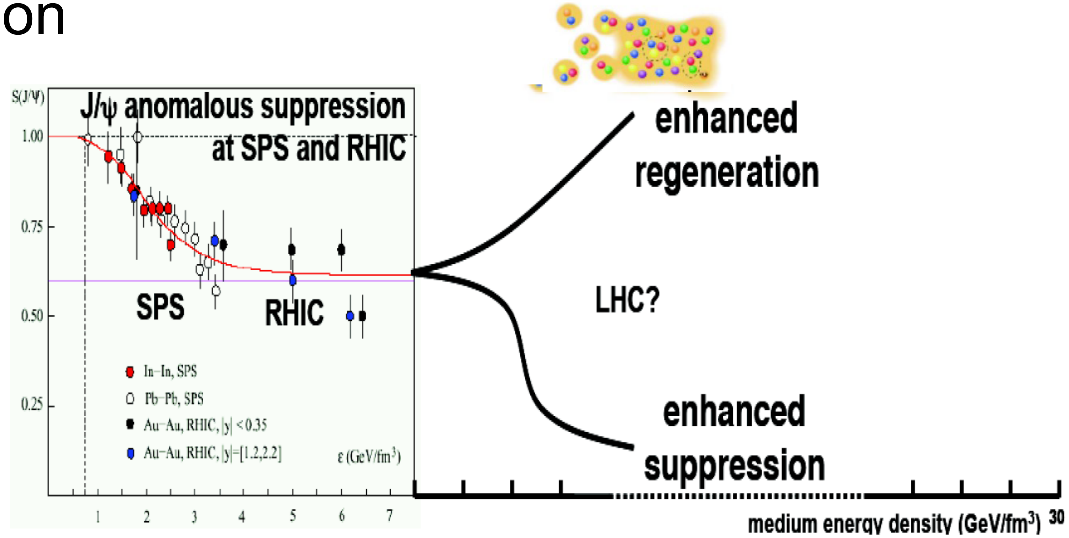
Different CNM effects

Sequential melting: ψ’, χ_C only

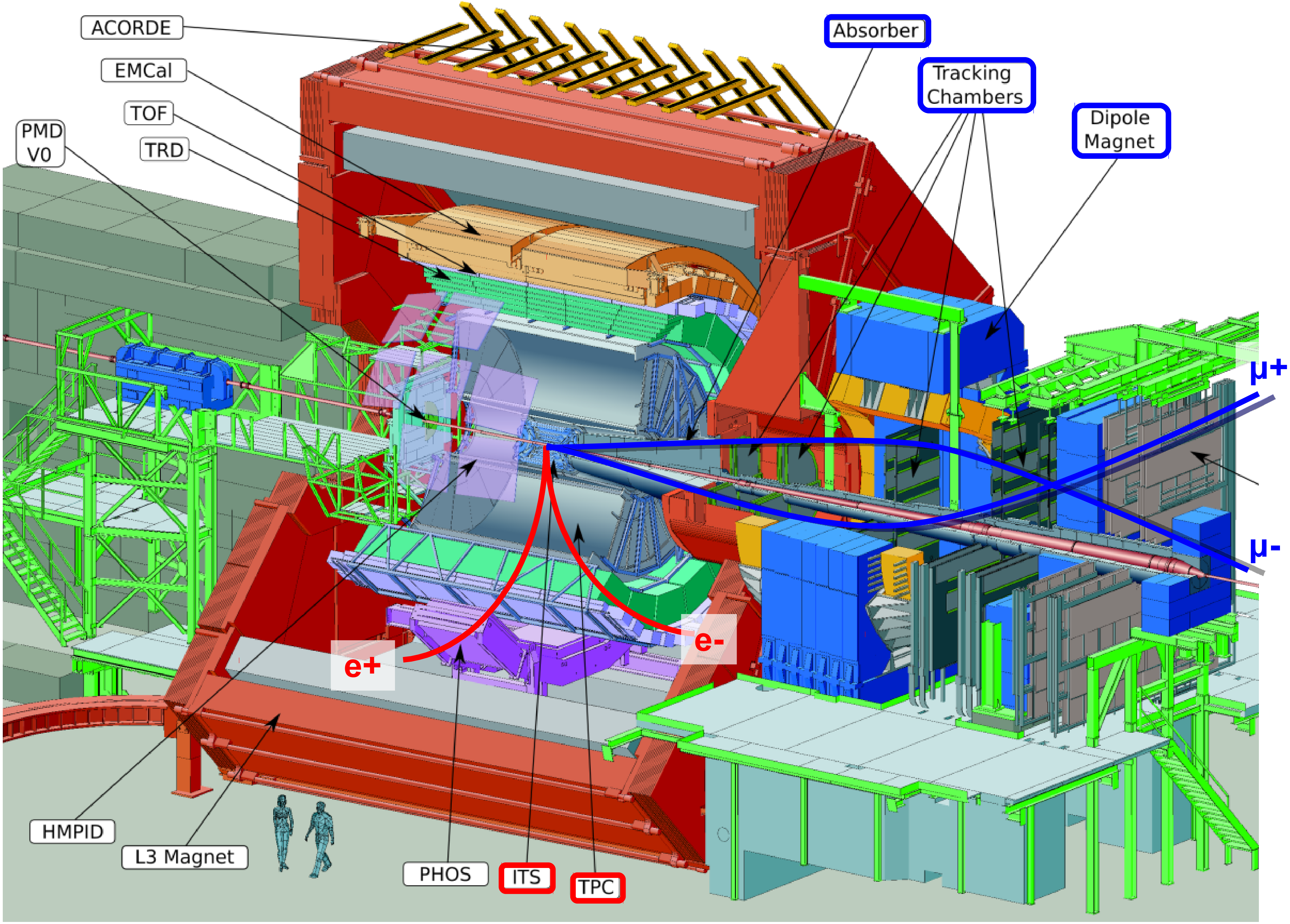
Statistical hadronization and regeneration

large charm production in Pb+Pb collisions

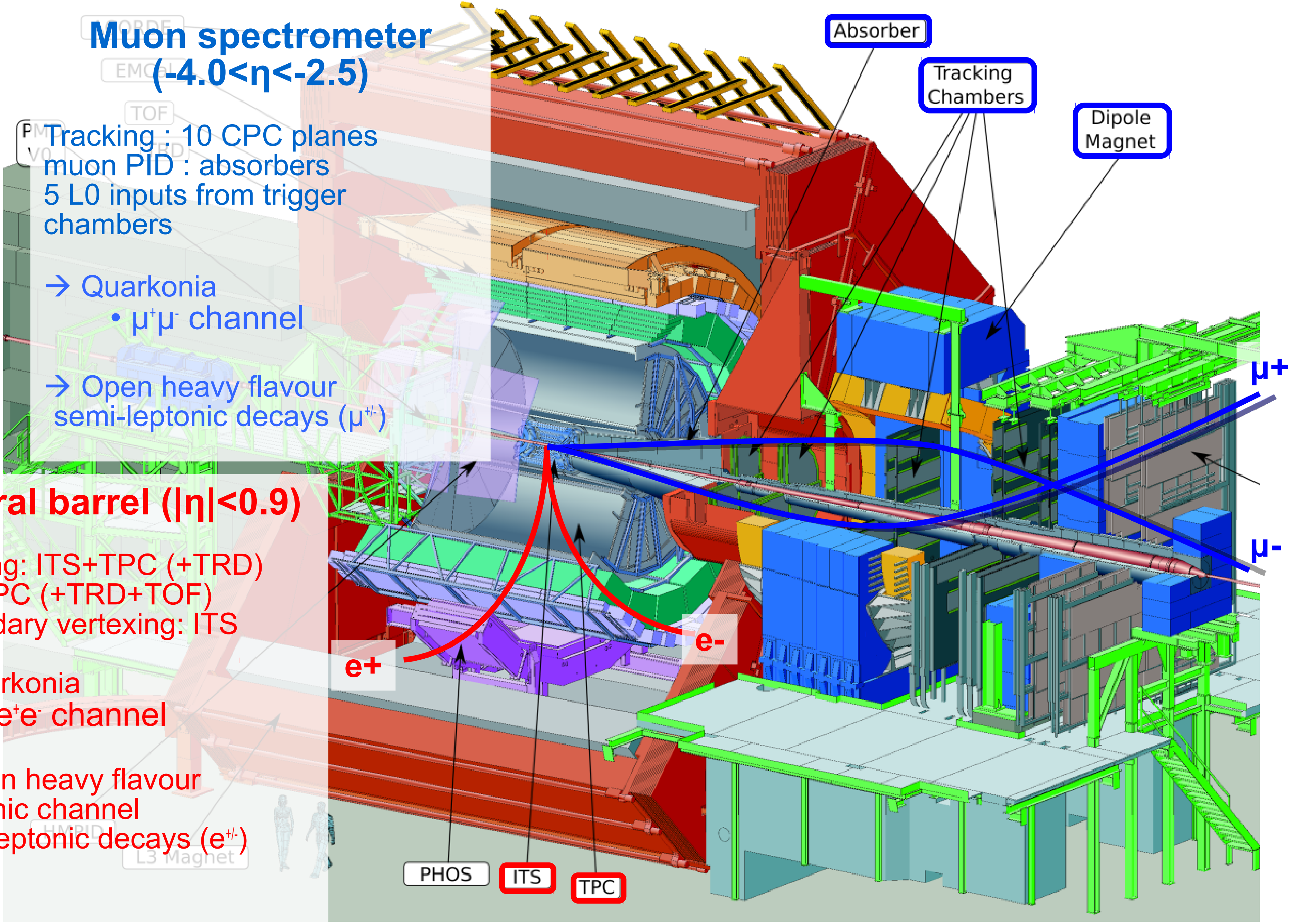
	SPS	RHIC	LHC-2010
Charm	0.2	10	56
beauty		0.05	2



The ALICE detector



The ALICE detector



Muon spectrometer ($-4.0<\eta<-2.5$)

Tracking : 10 CPC planes
muon PID : absorbers
5 L0 inputs from trigger chambers

→ Quarkonia
  - $\mu^+\mu^-$ channel

→ Open heavy flavour semi-leptonic decays ($\mu^{+/-}$)

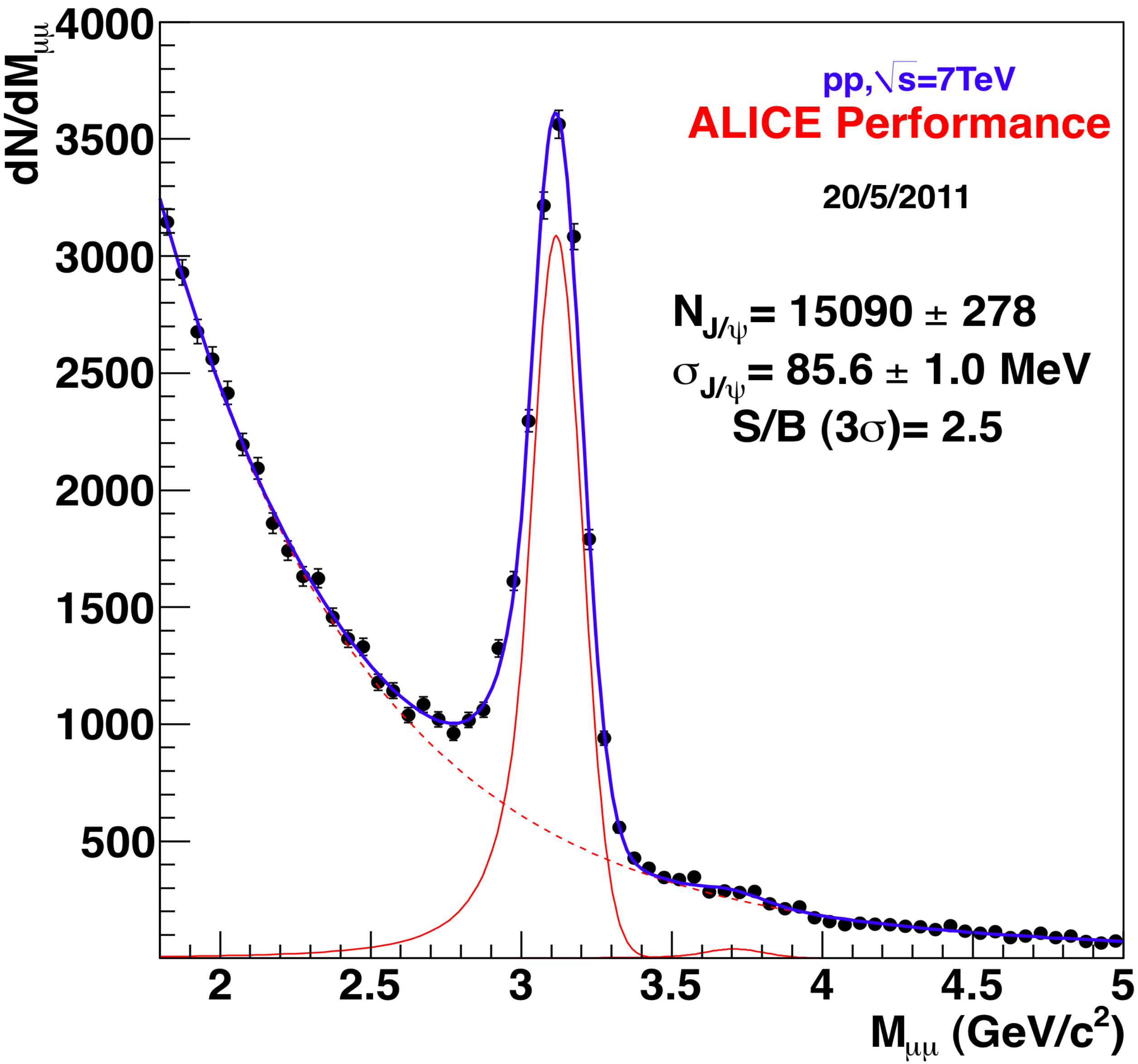
Central barrel ($|\eta|<0.9$)

Tracking: ITS+TPC (+TRD)
PID: TPC (+TRD+TOF)
Secondary vertexing: ITS

→ Quarkonia
  - e^+e^- channel

→ Open heavy flavour hadronic channel semi-leptonic decays ($e^{+/-}$)

J/Ψ in ALICE : p-p collisions



In p-p collisions, ALICE has measured charmonia

→ at $\sqrt{s_{NN}}$ = 2.76 and 7 TeV

→ in $\mu^+\mu^-$, e^+e^- chanels

→ at y [-4;-2.5] and [-0.9;0.9]

→ **down to p_T = 0**

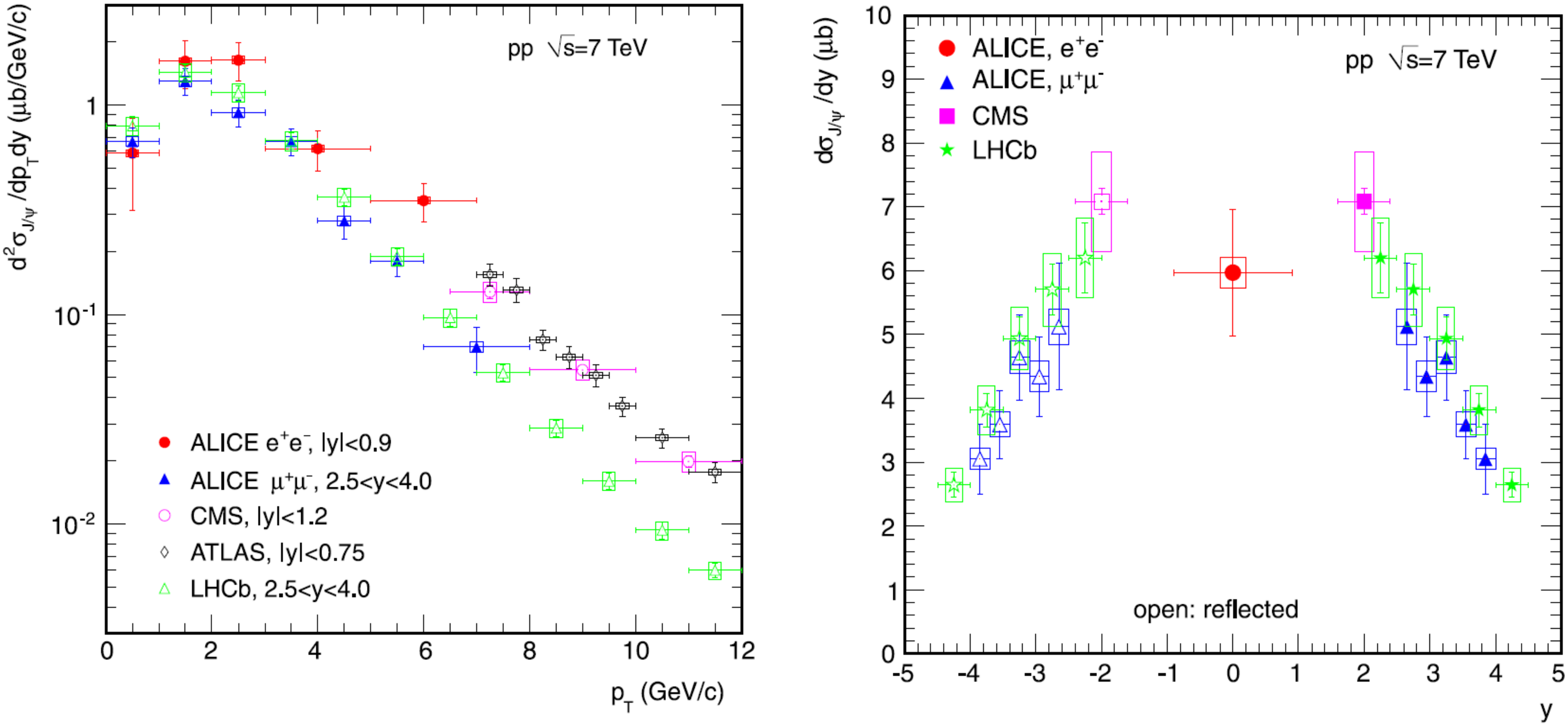
→ differentially in p_T, y

→ as a function of $dN_{ch}/d\eta$

→ preliminary results on polarization

J/Ψs at LHC : p-p collisions

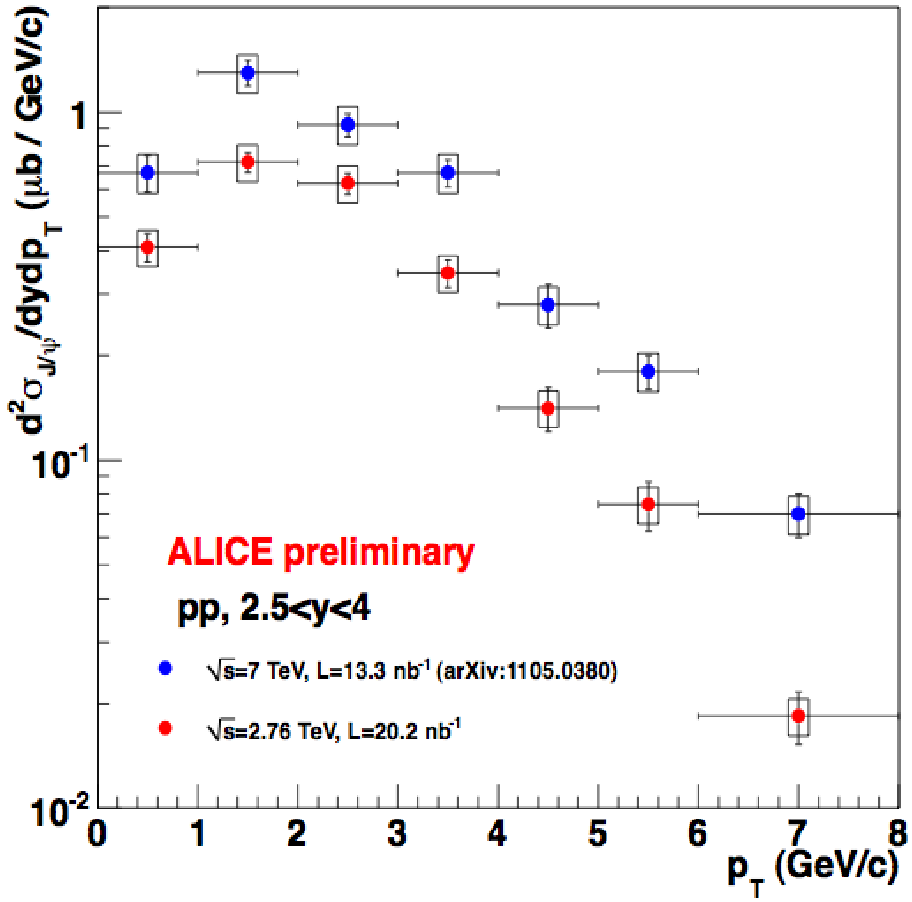
Rapidity and transverse momentum dependence of inclusive J/ψ production in pp collisions at $\sqrt{s_{NN}} = 7$ TeV
Physics Letters B 704 (2011), pp. 442-455.

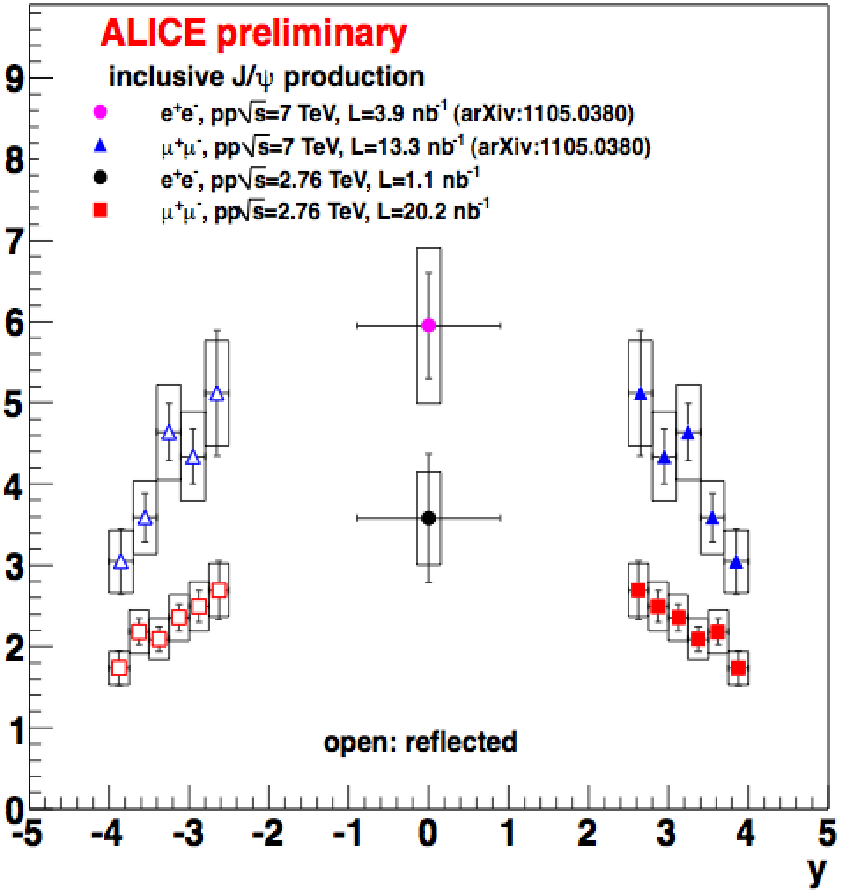


Bars = statistical and systematic errors, excluding luminosity and polarisation
Box = systematic uncertainties on luminosity
Good agreement between ALICE and LHCb for 2.5 < y < 4
ALICE is unique in its broad rapidity coverage from $p_T = 0$

J/Ψs in ALICE : p-p collisions @ $\sqrt{s_{NN}}$ = 2.76 TeV

`Measurement of J/Psi production in pp collisions sqrt(s)=2.76 and 7 TeV with ALICE, arXiv:1107.0137, (2011).`





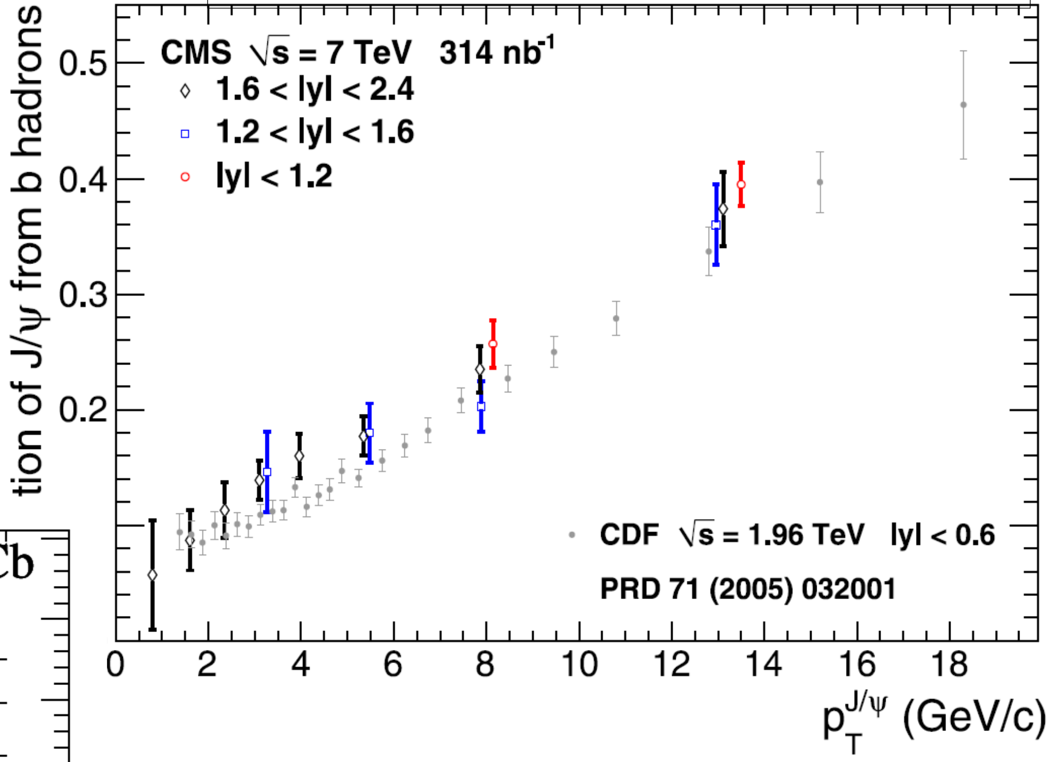
Reference measurement at 2.76 TeV: **Crucial to compute the R_{AA}**

non-prompts J/Ψs at LHC : p-p collisions

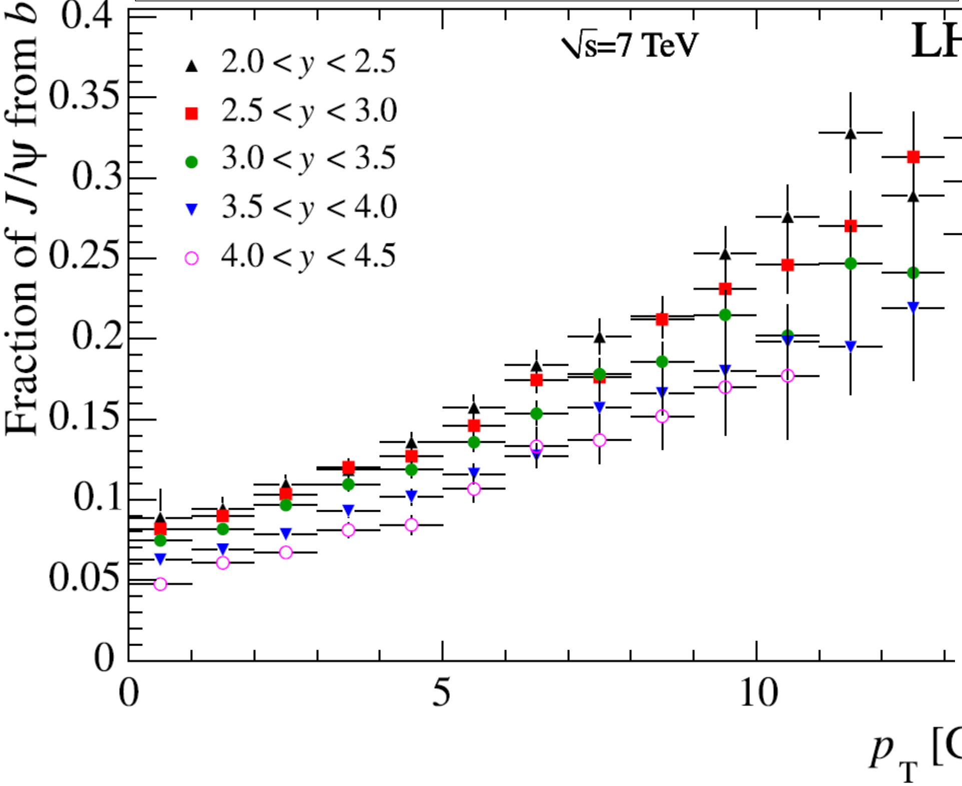
LHC experiments have excellent measurement capabilities

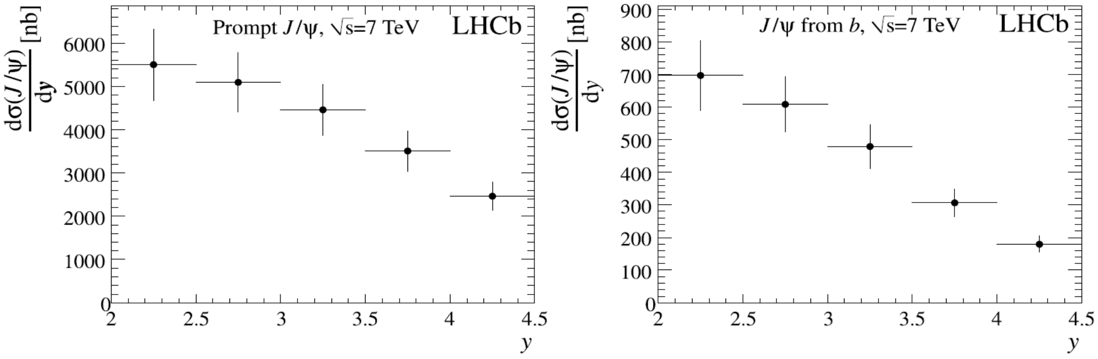
In p-p, LHCb is overlapping ALICE acceptance both in p_T (down to 0) and y. At y=0, CMS covers the $p_T > 3$ GeV/c region.

Eur. Phys. J. C (2011) 71: 1575 CMS collaboration



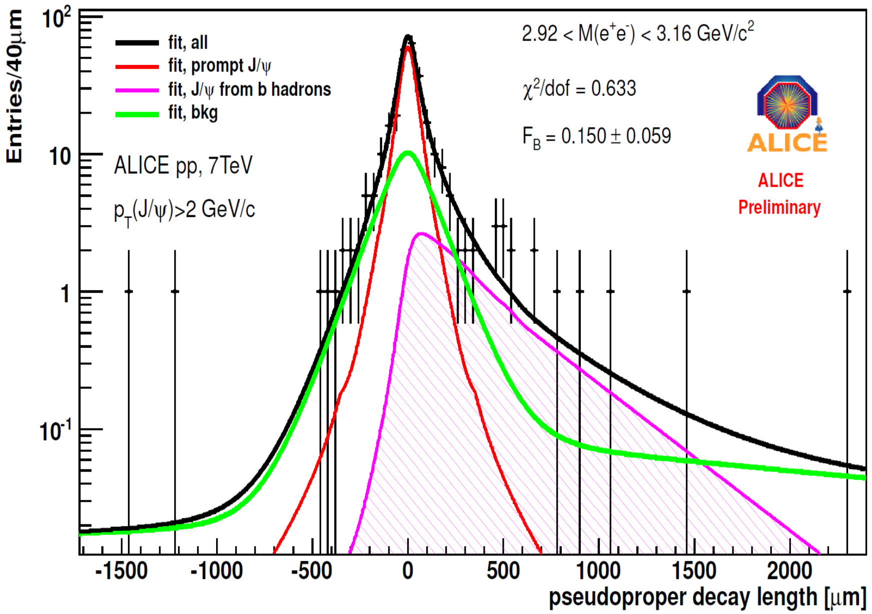
Eur. Phys. J. C71 (2011) 1645 LHCB collaboration

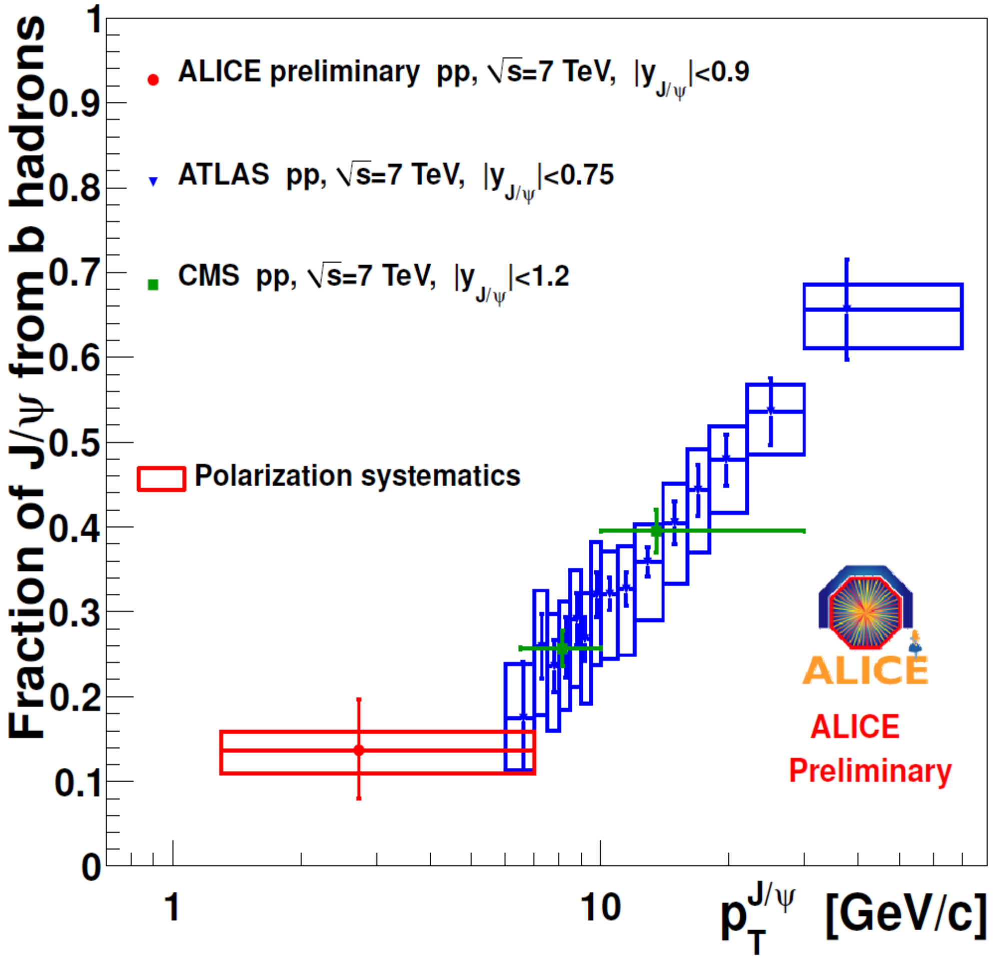




non-prompts J/Ψs in ALICE : p-p collisions

Impact parameter resolution: $\sigma_{r\varphi}$ < 75 μm for p_T>1 GeV/c, at mid-rapidity
→ Contributions from B decays estimated from the pseudo-proper decay length



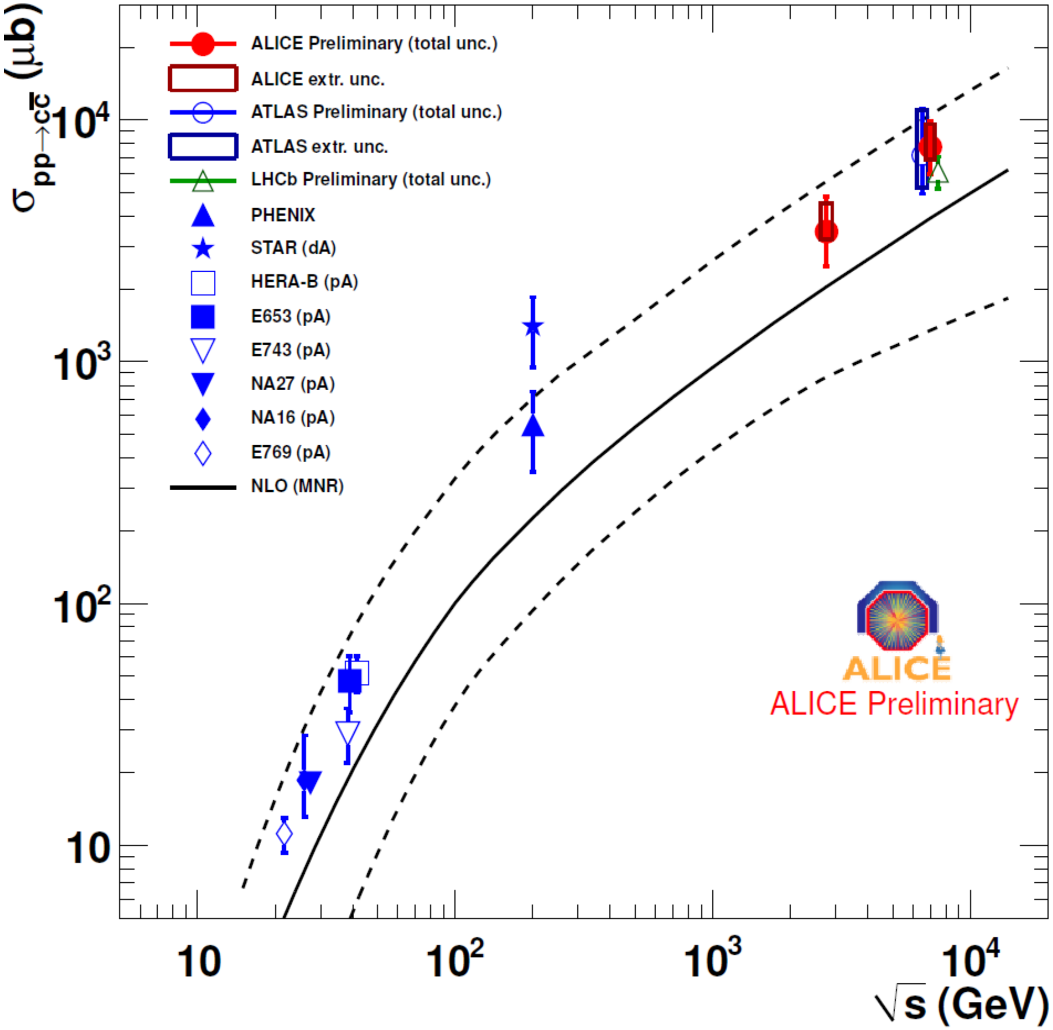


J/ψ from B decays at mid rapidity and low p_T: unique at LHC!

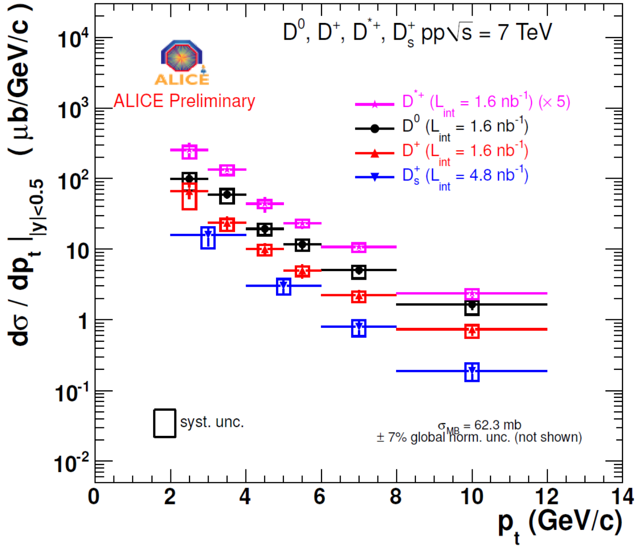
σJ/ψ (prompt, |y|<0.9, p_T>2GeV/c) = 3.2 ± 0.38 (stat) ± 0.43 (syst) + 0.82 - 0.58 (pol) ± 4% (lum) μb

→ improvements to come: higher stat. and dedicated trigger.

Charm at LHC : p-p collisions



In Alice, extrapolation from the D mesons cross section



- **Extrapolation down to p_T=0 and full rapidity using FONLL**
- **Good agreement with ATLAS and LHCb measurements**
- **Measurements show a consistent behavior vs MNR (NLO) with √s**

σ(ALICE, 2.76TeV) = 3.45 ± 0.41(stat.) +0.72, -0.84 (syst.) ±0.17(lum.) +1.09, -0.24(extr.) mb

σ(ALICE, 7TeV) = 7.73 ± 0.54 (stat.) +0.74, -1.38 (syst.) ±0.43 (lum.) +1.90, -0.87(extr.) mb

σ(ATLAS, 7TeV) = 7.13 ± 0.28 (stat.) +0.90, -0.66 (syst.) ±0.78(lum.) +3.82, -1.90(extr.) mb

σ(LHCb, 7TeV) = 6.10 ± 0.93 (total) mb

J/Ψ analysis in Pb-Pb

- Event selection
  - MB trigger = signal in

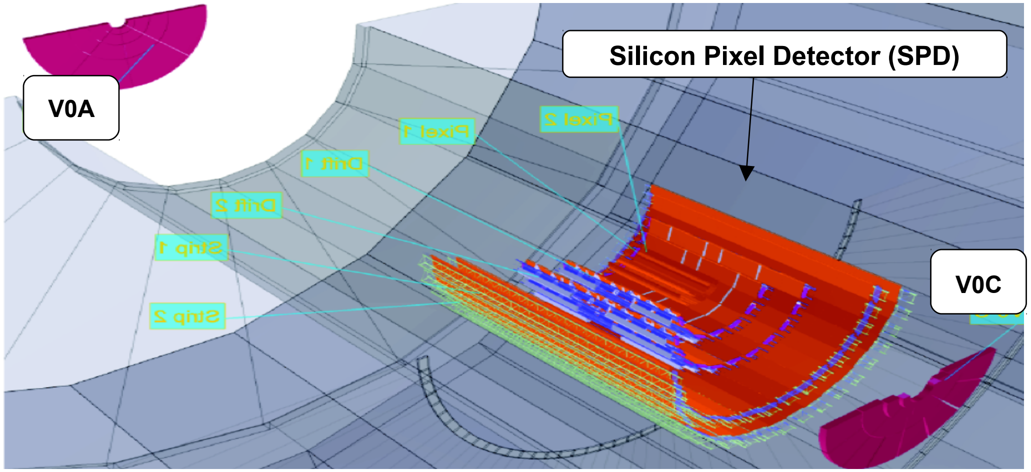
    i) V0A ($2.8 < \eta < 5.1$)

    AND

    ii) V0C ($-3.7 < \eta < -1.7$)

    AND

    iii) SPD ($|\eta| < 2.$)



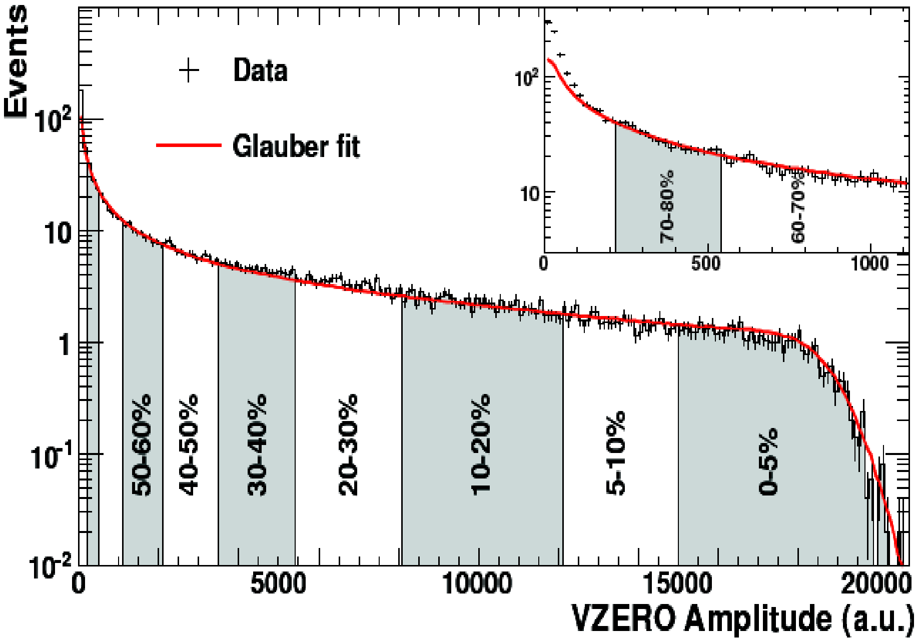
- Centrality from V0 amplitude fit and Glauber
  - Centrality bins:
  - [0, 10],[10, 20],[20-40],[40-80]% at forward rapidity
  - [0-40] and [40-80]% at mid-rapidity

+ negligible contamination of EM background for centrality > 80% (+ ZDC rejection)

+ rejection of beam-gas via V0 timing cuts

→ $\mathcal{L} = 2.7\ \mu b^{-1}$

[ALICE Collaboration] PRL106 (2011) 032301

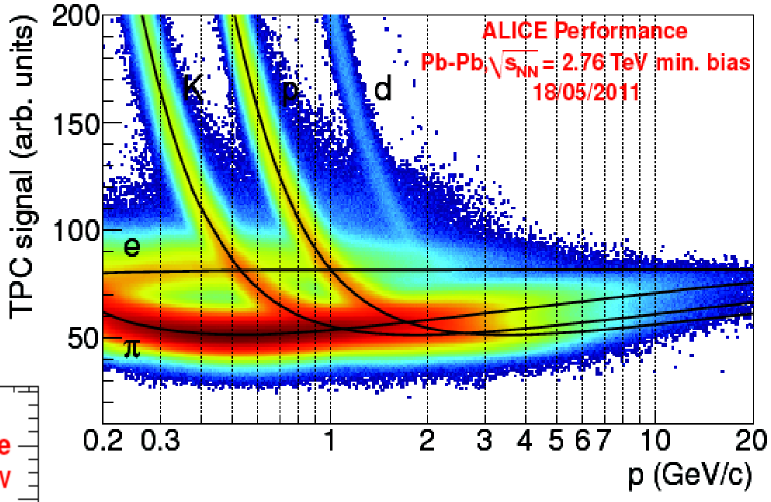


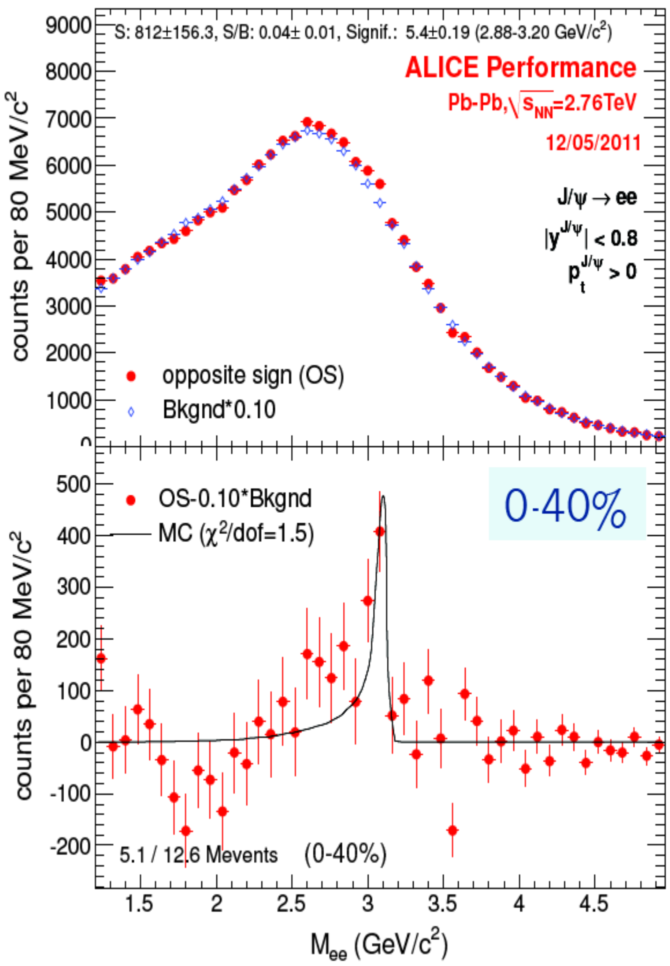
J/Ψ yields at mid-rapidity (e^+e^- channel)

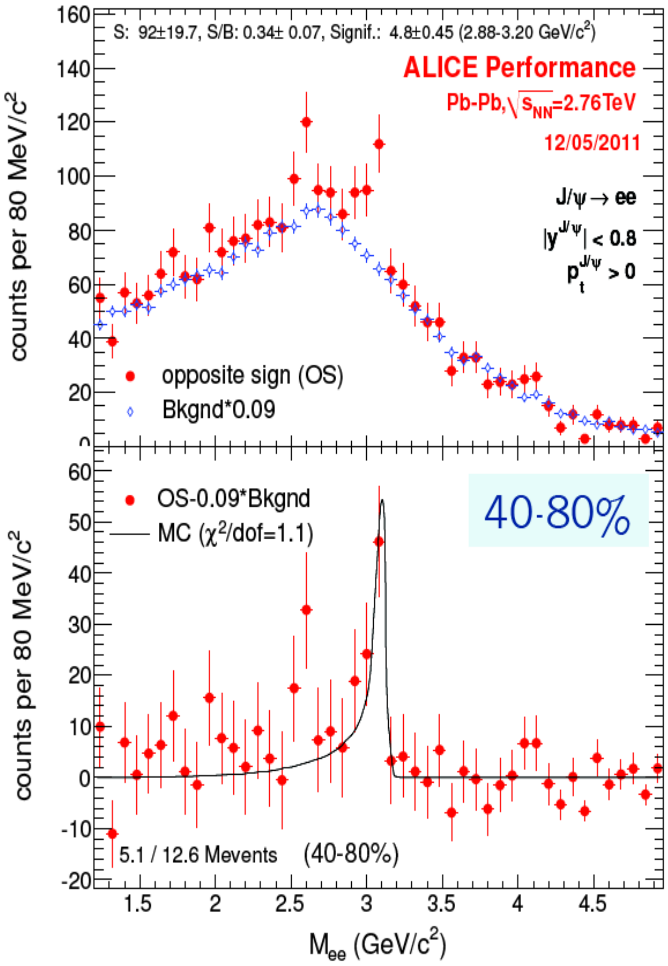
- J/ψ candidates selection
  - Mid-rapidity : unlike-sign dielectrons within $|y_{e+e-}| < 0.8$

    → Select electrons using TPC only PID within $|\eta^e|<0.8$

    (next : use TOF and TRD)







Very challenging analysis but despite a low S/B the J/Ψ signal is clearly visible.

→ will be improve with the addition of TOF and TRD in the PID.

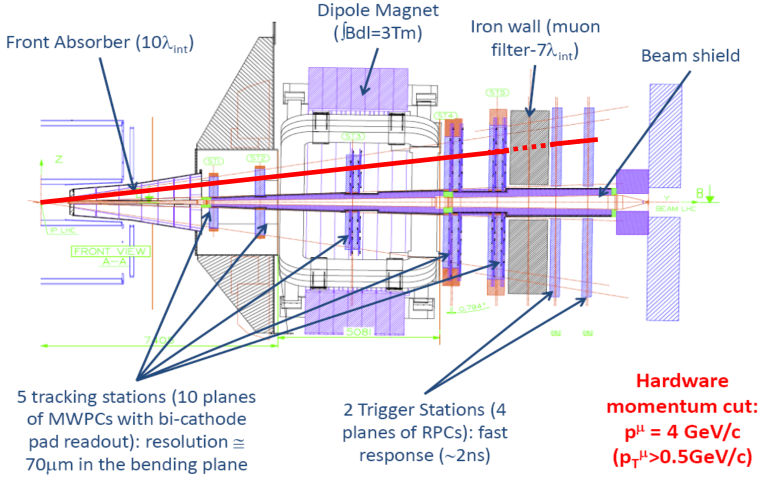
J/Ψ yields at forward rapidity (μ+μ− channel)

- J/ψ candidates selection
  - Forward rapidity : unlike-sign muon pairs with 2.5<y<4

    [→ R_{ABS} cut]

    → track-trigger matching within 4<|η^{μ}|<2.5

    → p_T > 0 GeV/c



Front Absorber ($10\lambda_{int}$)

Dipole Magnet ($\int Bdl$=3Tm)

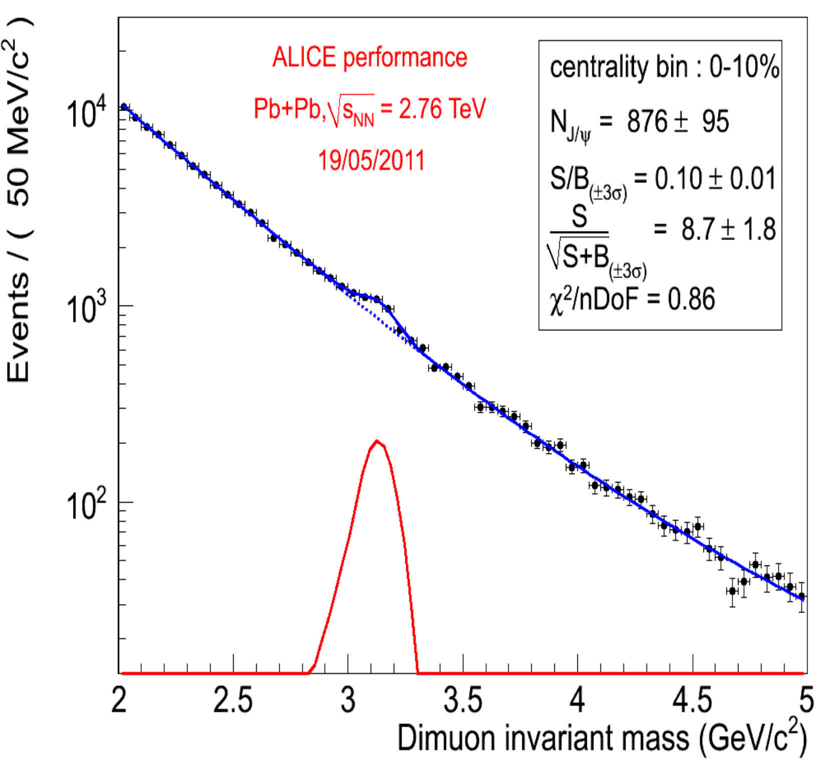
Iron wall (muon filter-$7\lambda_{int}$)

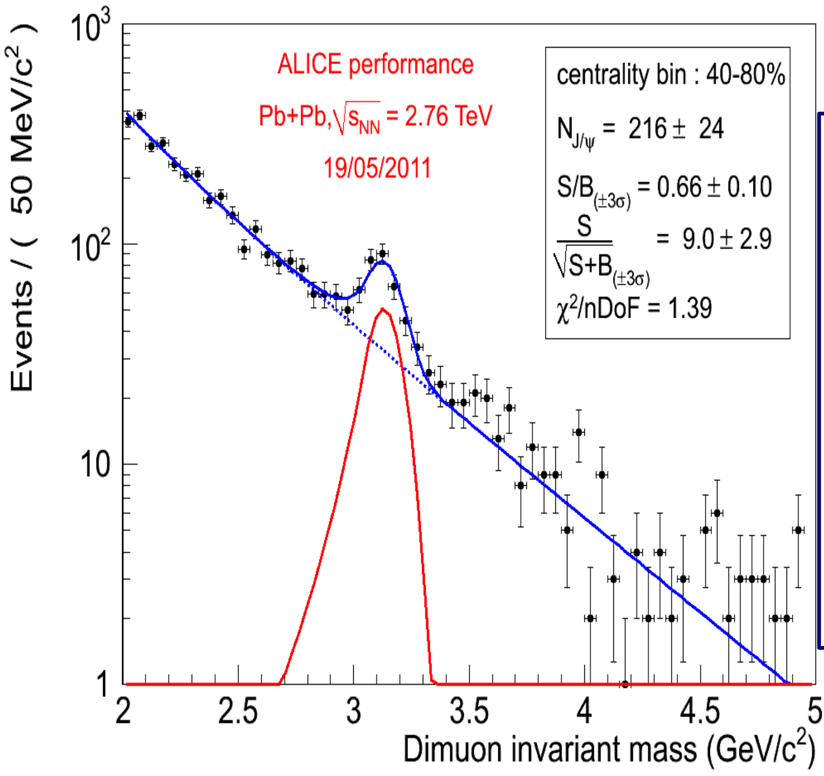
Beam shield

5 tracking stations (10 planes of MWPCs with bi-cathode pad readout): resolution ≅ 70μm in the bending plane

2 Trigger Stations (4 planes of RPCs): fast response (~2ns)

Hardware momentum cut: p^{μ} = 4 GeV/c (p_T^{μ}>0.5GeV/c)

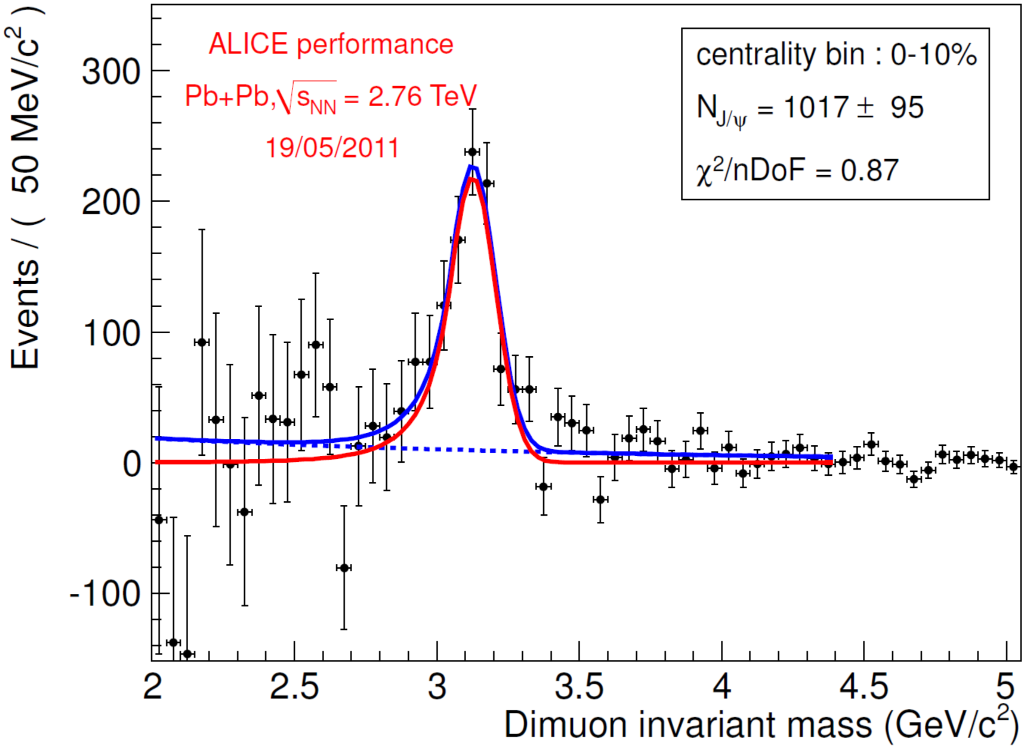


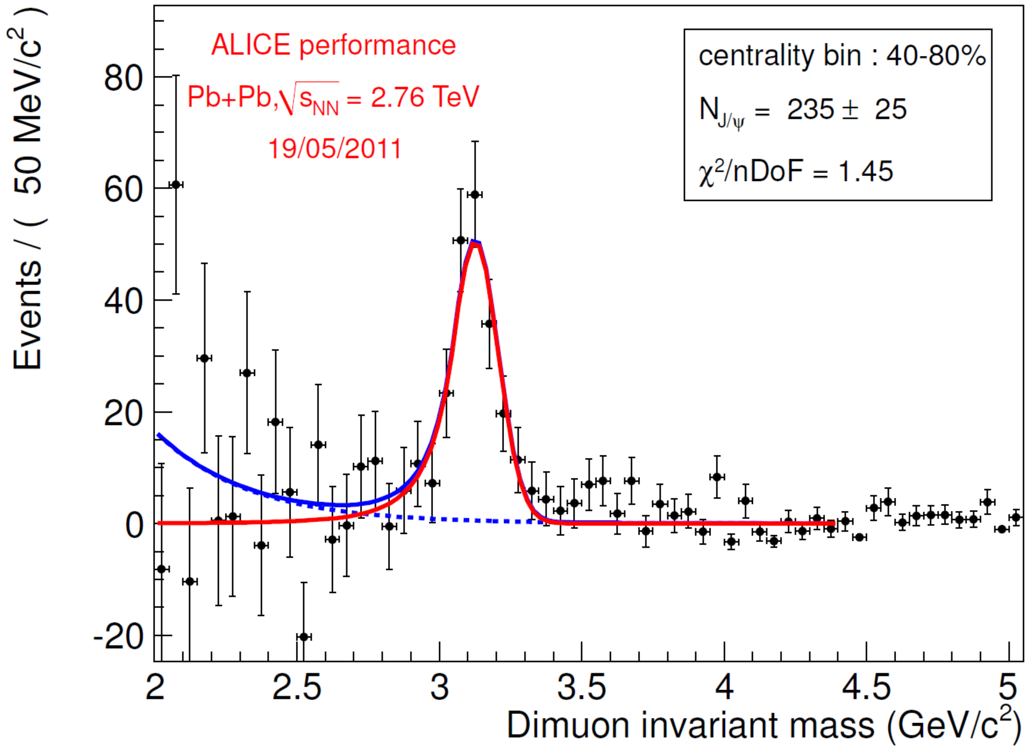


Fit the invariant mass of opposite sign dimuons within range [2;5] GeV/c^2 with a Crystal Ball function as signal and two exponential functions as background

J/Ψ yields at forward rapidity (μ+μ− channel)

- Subtract the background using event mixing technique:
  - Mixed pair invariant mas distribution normalized to data in the range [1.5,2.5] GeV/c^2
- Fit the background subtracted mass distribution in the range [2,4.5] GeV/c^2
  - Residual background: exponential or straight line
  - Signal: various CB shape used in the first method





→ Results obtained with different techniques combined to extract <NJ/ψ> and systematics

Nuclear Modification Factor R_{AA}

- In a given centrality bin :

$$Y_{J/\psi} = \frac{N^{J/\psi}}{B.R.\times AccEff\times N_{evt}}$$

$$R_{AA} = \frac{Y_{J/\psi}}{<T_{AA}>\times\sigma^{p+p}_{J/\psi}(inclusive)}$$

$$R_{CP} = \frac{Y_{J/\psi}\times<T^{40-80\%}_{AA}>}{<T_{AA}>\times Y^{40-80\%}_{J/\psi}}$$

$Y_{J/\psi}$ is the corrected yield in centrality bin i

T_{AA} is the nuclear thickness $<N_{COLL}>/\sigma_{pp}$
R_{AA} = 1 no effects,
$R_{AA}<1$ suppression,
$R_{AA}>1$ enhancement.

R_{CP} is also used. Many systematics cancel and pp reference not needed.
→ but peripheral bin is not completely equivalent to pp

R_{CP} at LHC

R_{CP} at LHC, independent of the p-p reference. One assumes here that 40-80% centrality bin is equal to binary collision scaled p-p reference...

→ ALICE, $2.5<y<4.0$

$p_T \geq 0$ GeV/c

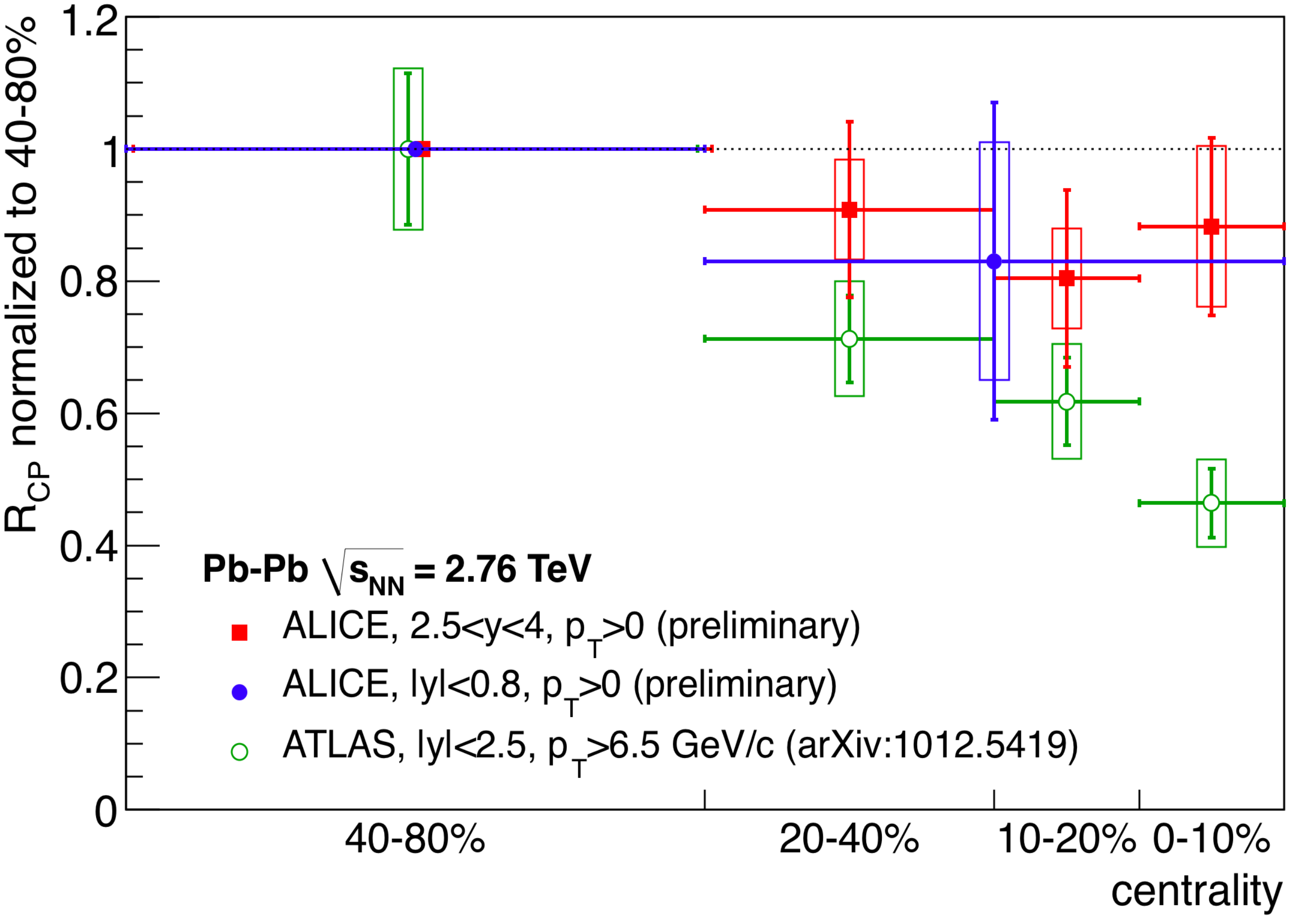
→ ALICE, $|y|<0.8$

$p_T \geq 0$ GeV/c

→ ATLAS, $|y|<2.4$

80% J/ψ with $p_T \geq 6.5$ GeV/c;

Error in 40-80% centrality bin not propagated.



Same collision energy but VERY different phase space

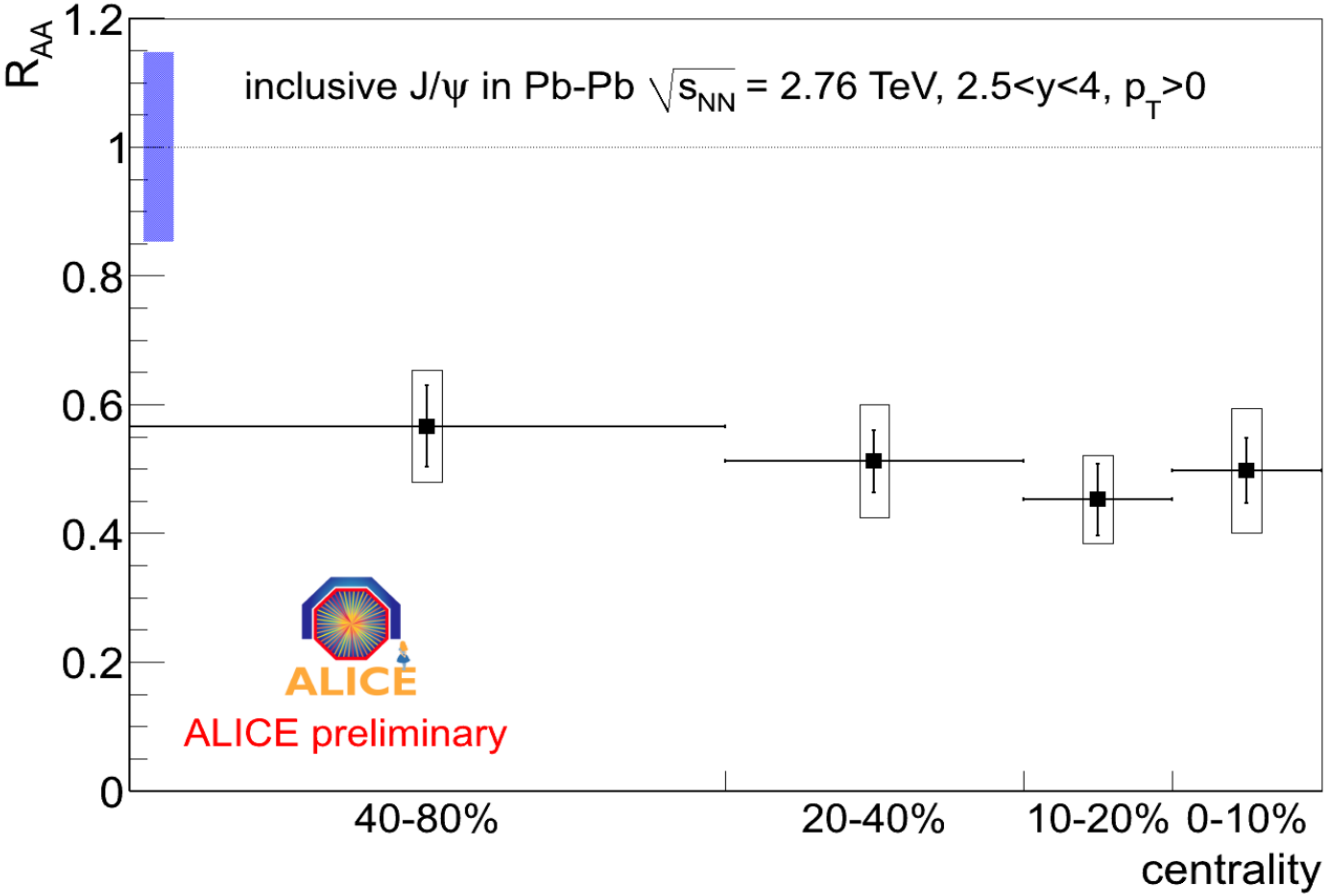
→ J/ψ from beauty contamination is large at high p_T

→ Less suppression at low p_T

→ Challenging measurement at y=0 and $p_T \geq 0$ GeV/c

→ better to work with R_{AA}

R_{AA} in Pb-Pb collisions



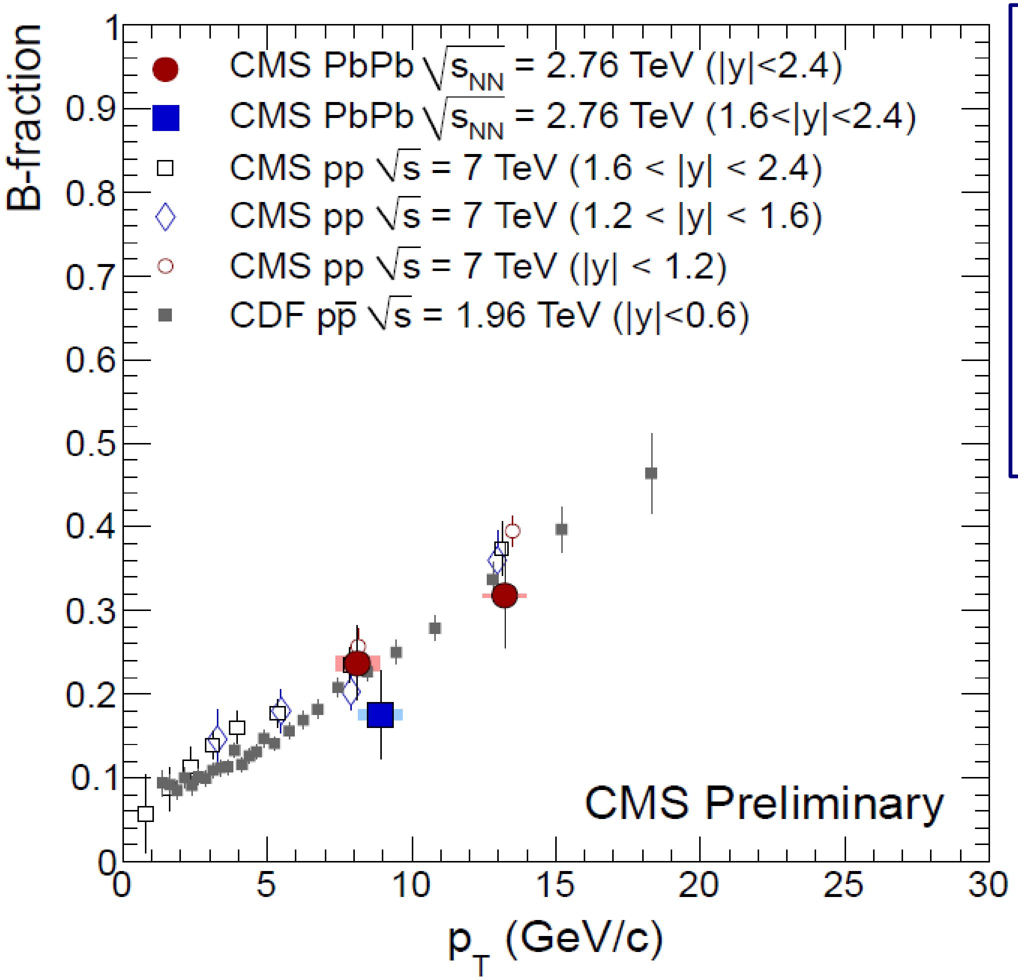
Bars: statistical uncertainty

Open box: centrality dependent sys. uncertainty

Blue box: common sys. uncertainty

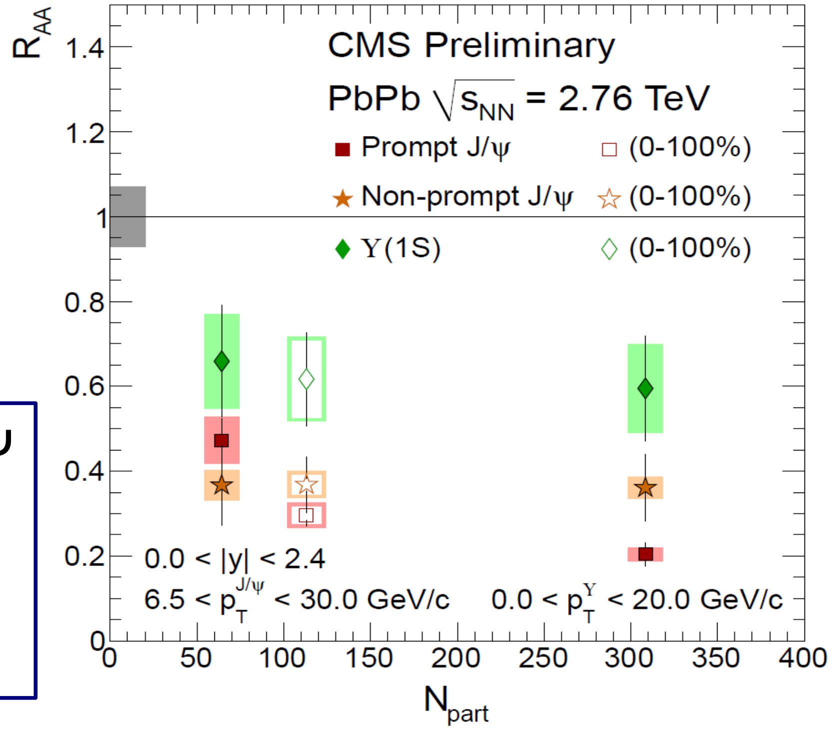
Inclusive J/ψ $R_{AA}^{0\text{-}80\%}$ = 0.49 ± 0.03 (stat.) ± 0.11 (sys.)
Prompt J/ψ $R_{AA}^{0\text{-}80\%}$ is about 11% smaller due to beauty contribution
(assuming no beauty shadowing nor quenching).

R_{AA} in Pb-Pb collisions : non-prompt J/Ψ

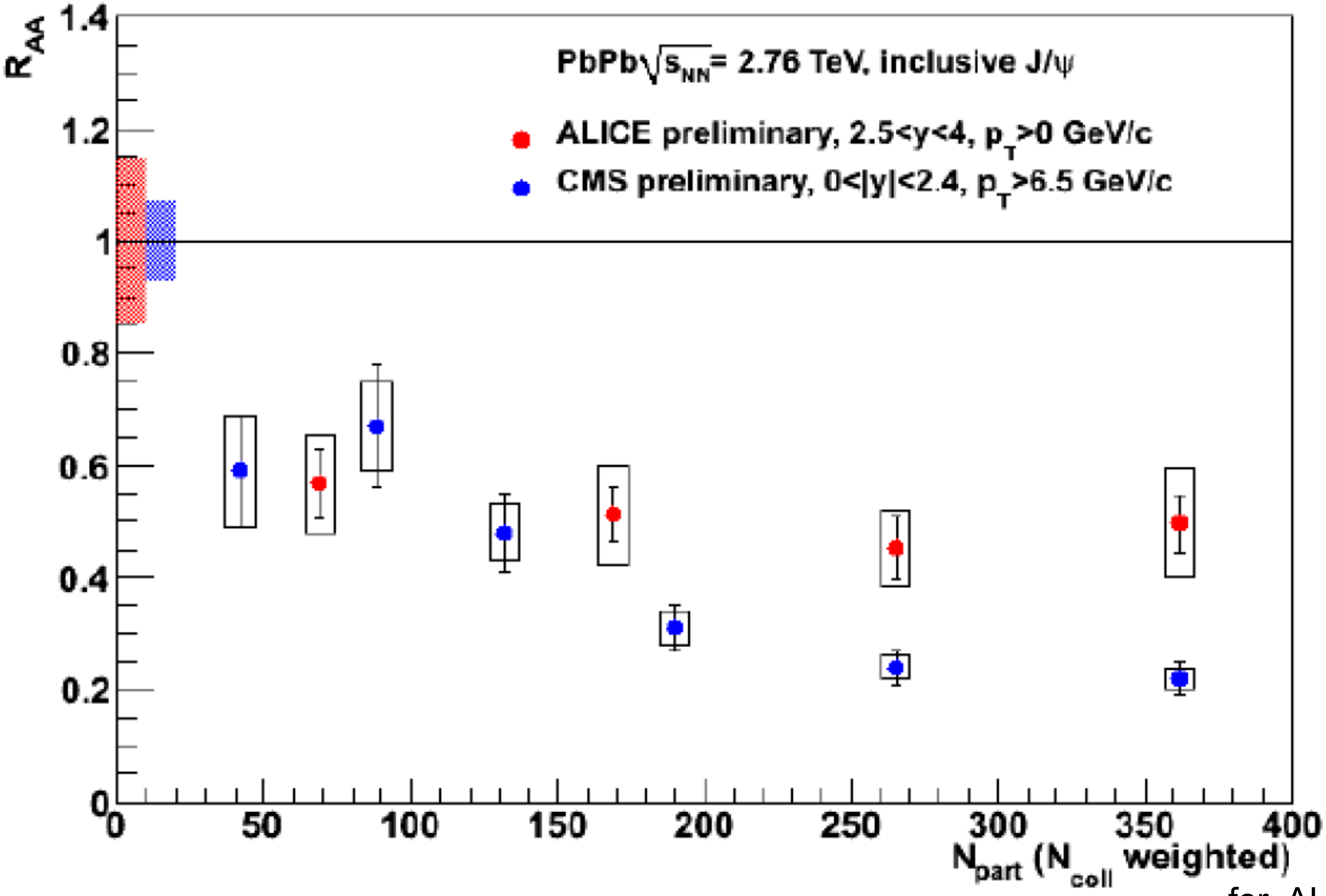


1) within uncertainties J/ψ from B in Pb-Pb do not exhibit any deviation from J/ψ from B in p+p.
2) energy dependence seems quite small
→ We have estimated the non-prompt J/ψ from LHCb p+p 7 TeV to be 11%

CMS has measured a low R_{AA} for non-prompts J/Ψ in |y| < 2.4 but at high p_T (>6.5 GeV/c).
→ one can not extrapolate to low p_T...



R_{AA} in Pb-Pb collisions, ALICE and CMS



for ALICE only

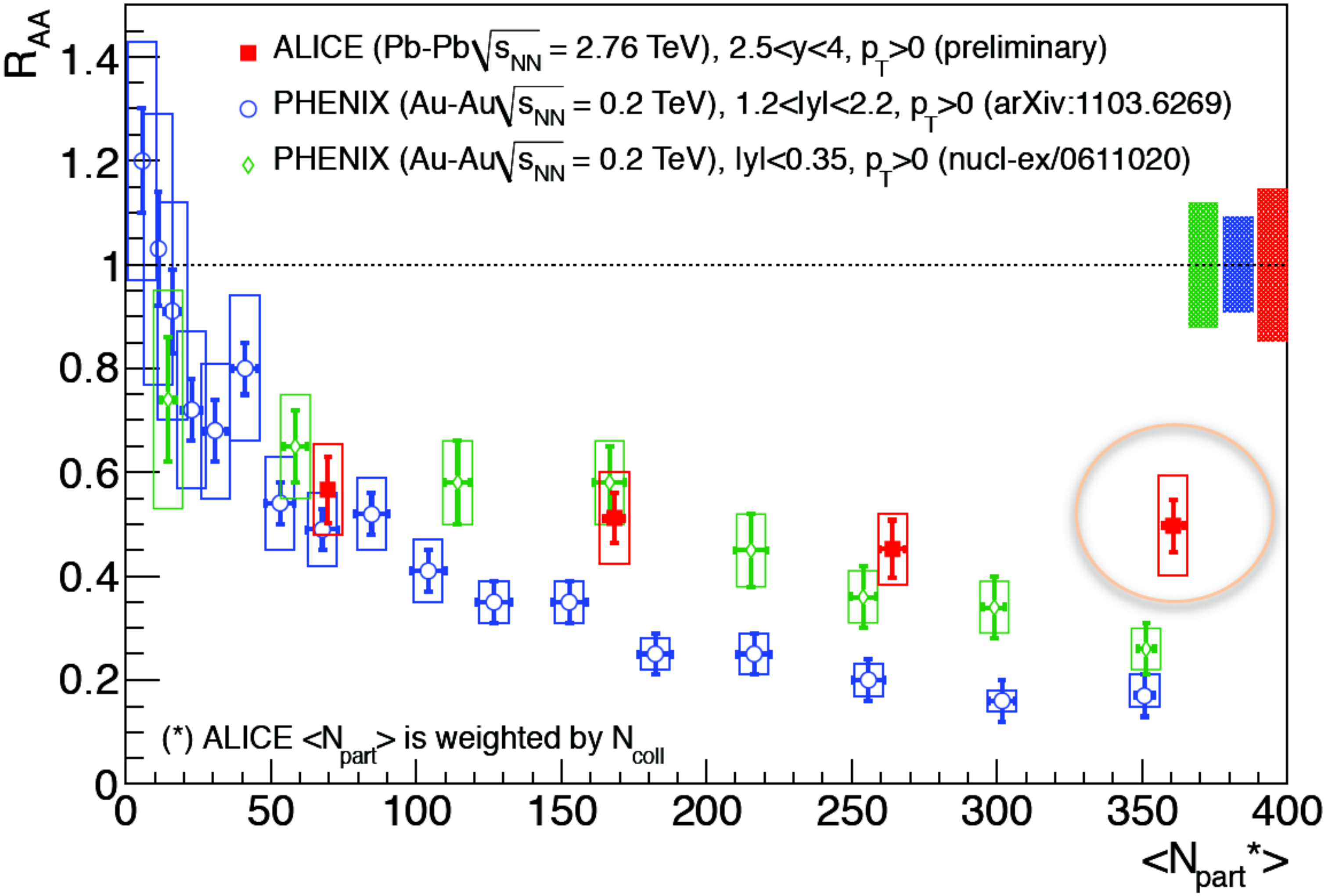
Bars: statistical uncertainty

Open box: centrality dependent sys. uncertainty

Blue box: common sys. uncertainty

ALICE observes less J/Ψ suppression in most central collisions than CMS
→ but p_T (y) ranges are separated : no overlap at all !

R_{AA} in Pb-Pb collisions, ALICE and PHENIX



Bars: statistical uncertainty

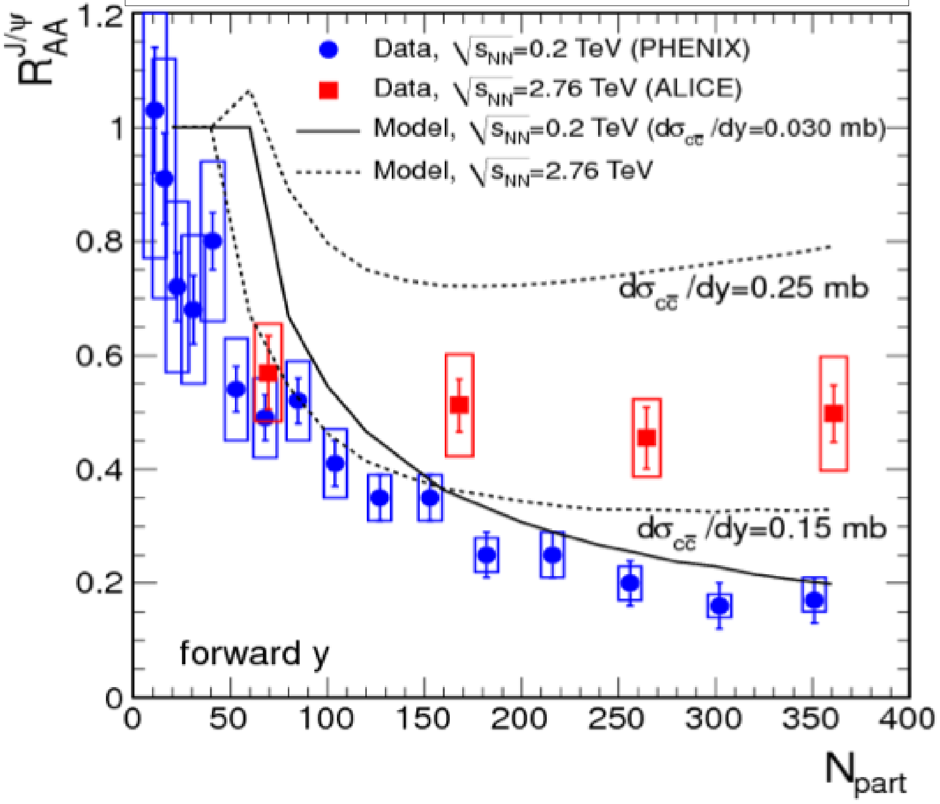
Open box: centrality dependent sys. uncertainty

Blue box: common sys. uncertainty

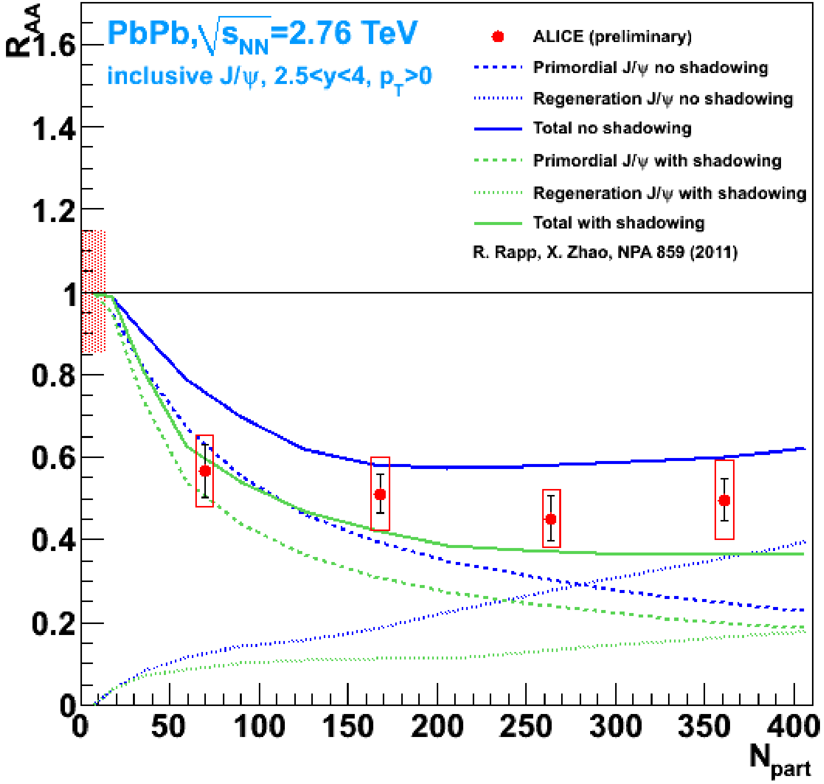
Inclusive J/ψ $R_{AA}^{0\text{-}80\%}$ = 0.49 ± 0.03 (stat.) ± 0.11 (sys.)
ALICE observes less J/Ψ suppression in most central collisions than PHENIX and centrality dependence seems flatter.
(but higher rapidity and factor 10 in $\sqrt{s_{NN}} \rightarrow$ different CNM)

Models at LHC

P. Braun-Münzinger & J. Stachel, PLB490 (2000) 196
A. Andronic @ QM2011, A. Andronic et al., PLB571 (2003) 36



X. Zhao, R. Rapp, NPA859 (2011) 114-125
R. Rapp, private communication

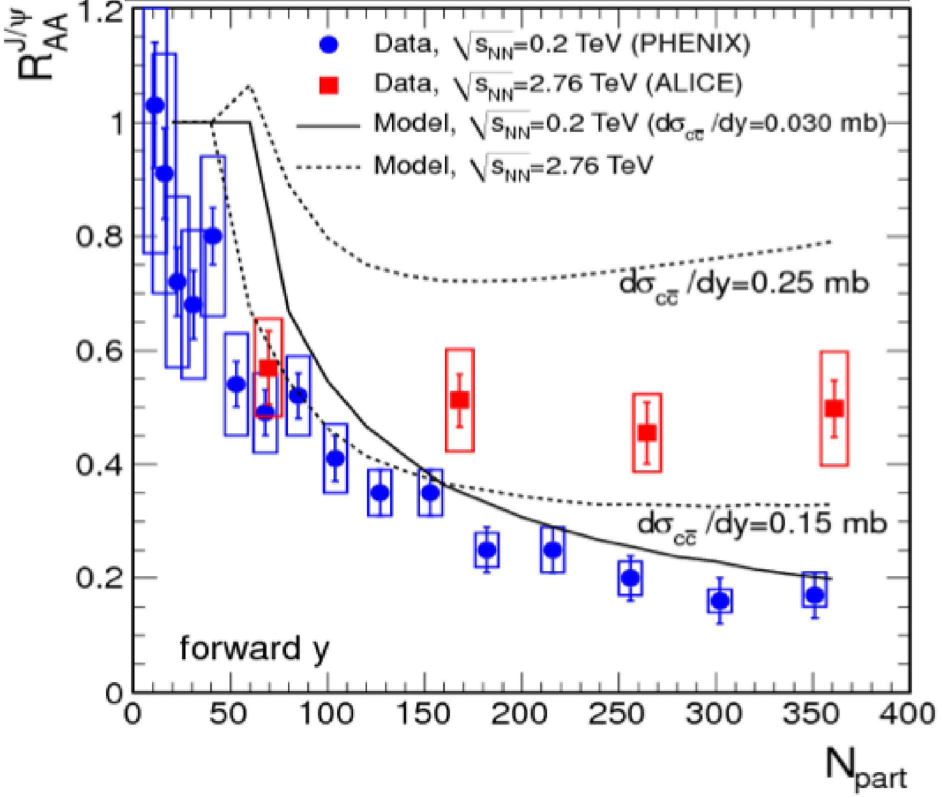


Statistical hadronization:
→ Screening by QGP of **all** direct J/ψ's
→ CNM (shadowing) on open charm
→ Charmonium production at phase boundary by statistical combination of uncorrelated charm quarks

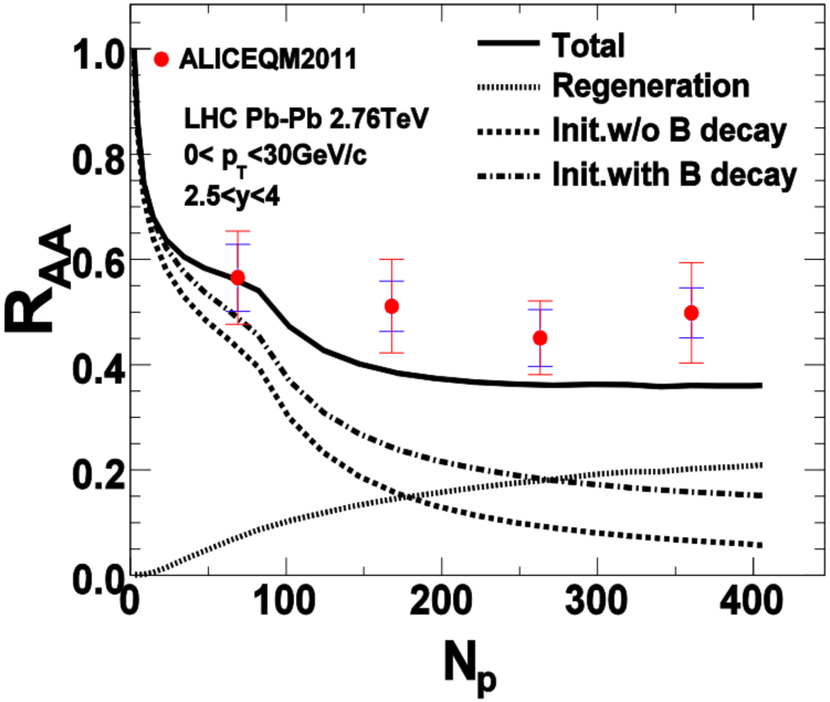
J/Ψ transport
→ Shadowing effect
→ prompt J/ψ dissociation in QGP
→ J/ψ regeneration by charm quark pair recombination
→ Feed-down contributions from B

Models

P. Braun-Münzinger & J. Stachel, PLB490 (2000) 196
A. Andronic @ QM2011, A. Andronic et al., PLB571 (2003) 36



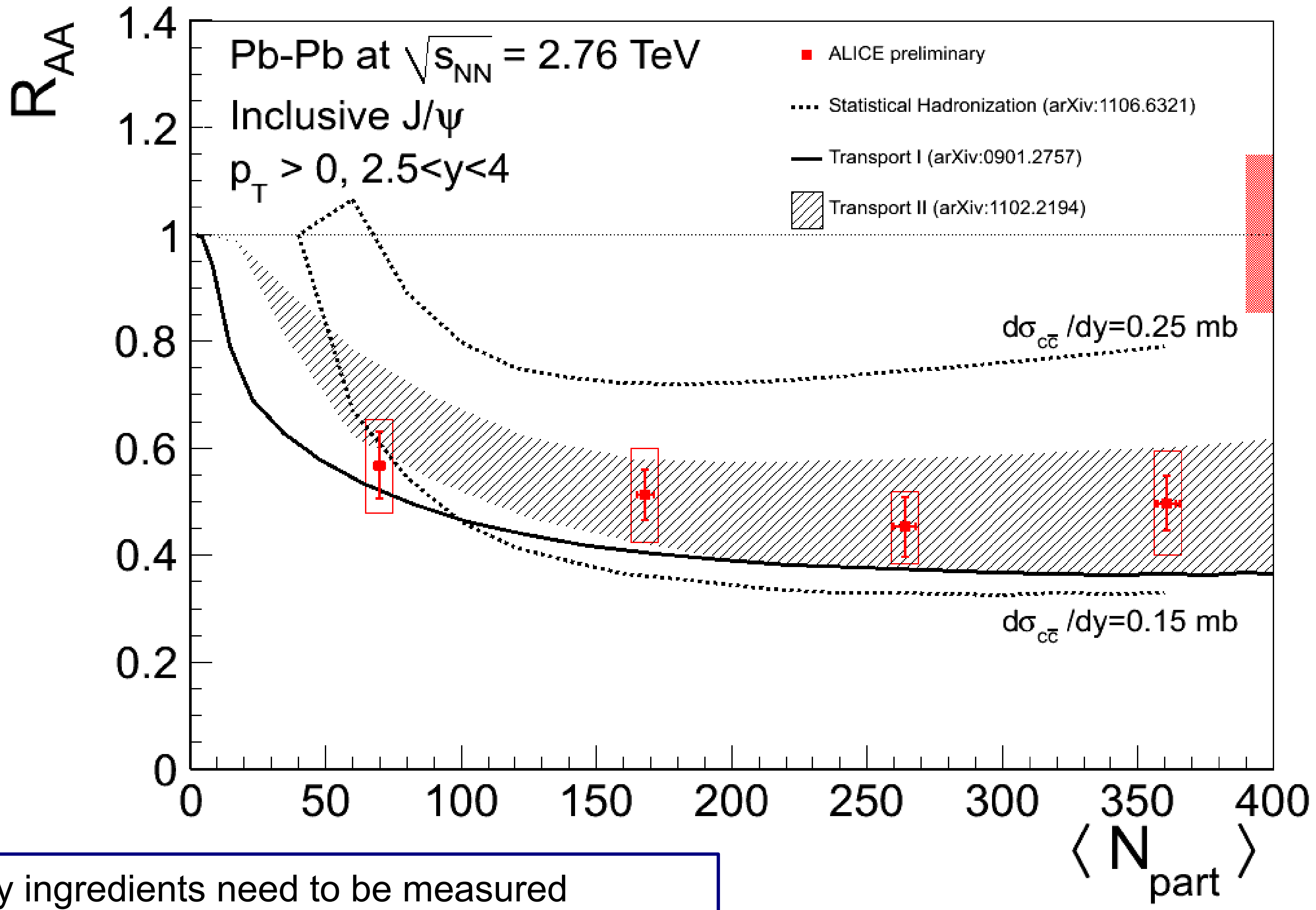
X. Zhu, P. Zhuang, N. Xu, PLB607 (2005) 107
L. Yan, P. Zhuang, N. Xu, PRL97 (2006) 232301
Y. Liu, Z. Qu, N. Xu, P. Zhuang, PLB678 (2009) 72
P. Zhuang @ WE-Heraeus-Seminar 2011.



Statistical hadronization:
→ Screening by QGP of **all** direct J/ψ's
→ CNM (shadowing) on open charm
→ Charmonium production at phase boundary by statistical combination of uncorrelated charm quarks

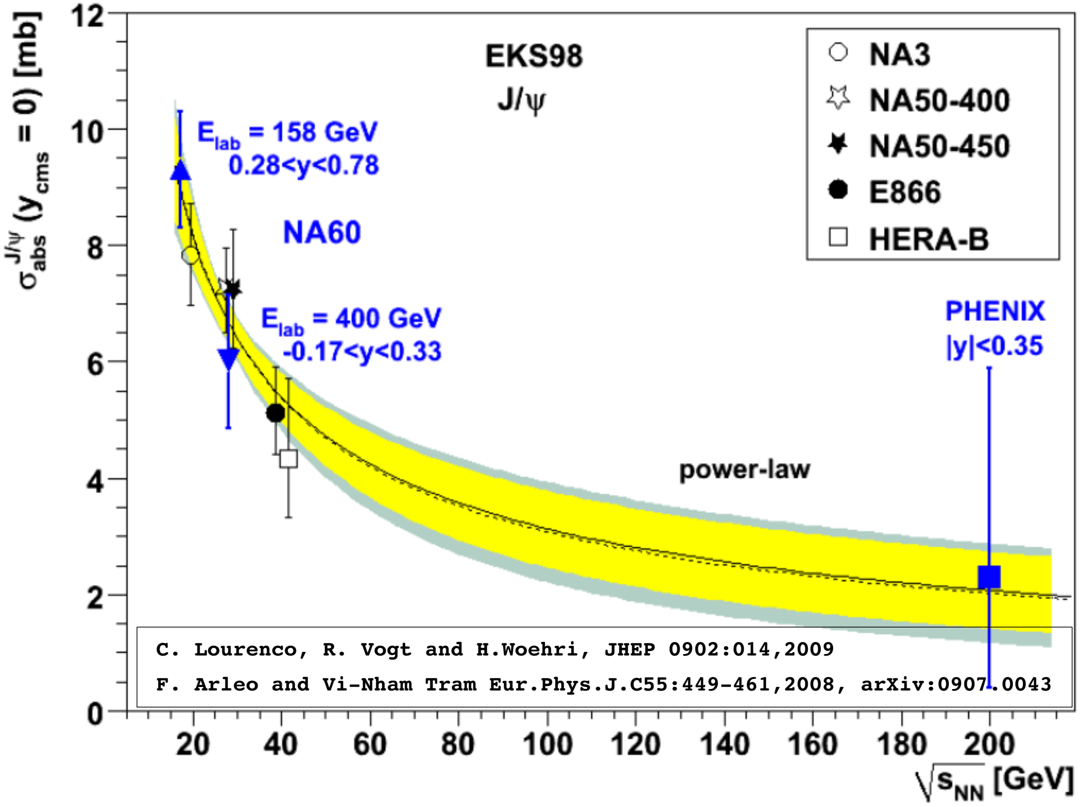
Parton transport Model :
→ Shadowing and Cronin effect
→ prompt J/ψ dissociation in QGP
→ J/ψ regeneration by charm quark pair recombination (detailed balance)
→ Feed-down contributions from B

All models together...



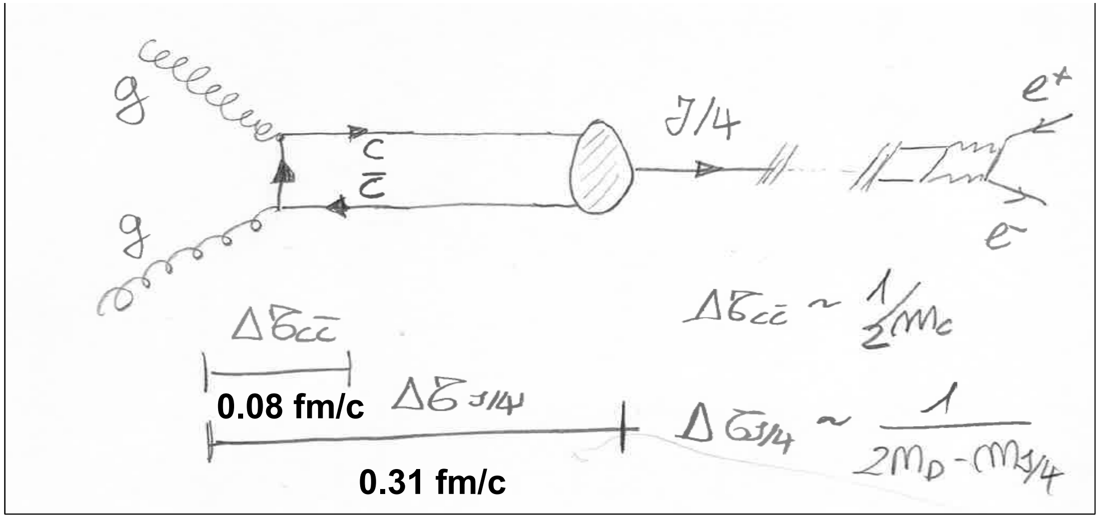
Some key ingredients need to be measured
→ nuclear absorption
→ shadowing in the gluon nuclear PDF
→ $d\sigma_{cc}$/dy

Models ingredients: nuclear absorption



C. Lourenco, R. Vogt and H.Woehri, JHEP 0902:014,2009

F. Arleo and Vi-Nham Tram Eur.Phys.J.C55:449-461,2008, arXiv:0907.0043



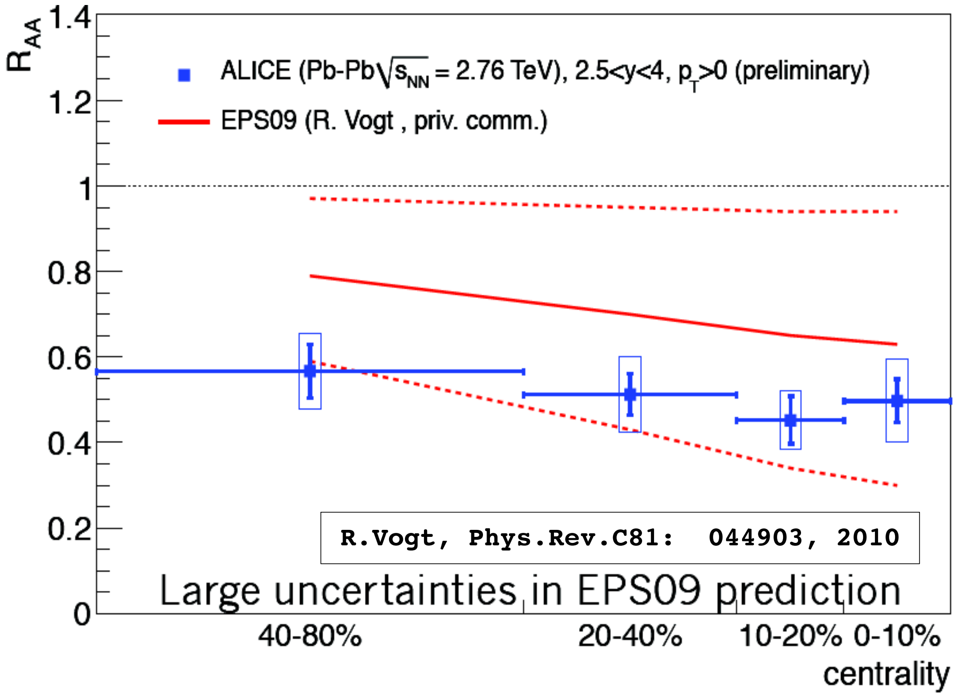
Species	Formation time (fm/c)
c-cbar	0.08
J/ψ	0.31
χ_c	1.0
Ψ′	4.2
b-bar	0.02
Υ(1S)	0.17
Υ(2S)	0.38
Υ(2S)	0.97

i) decreasing σ_{ABS} versus √s

ii) different time-scales

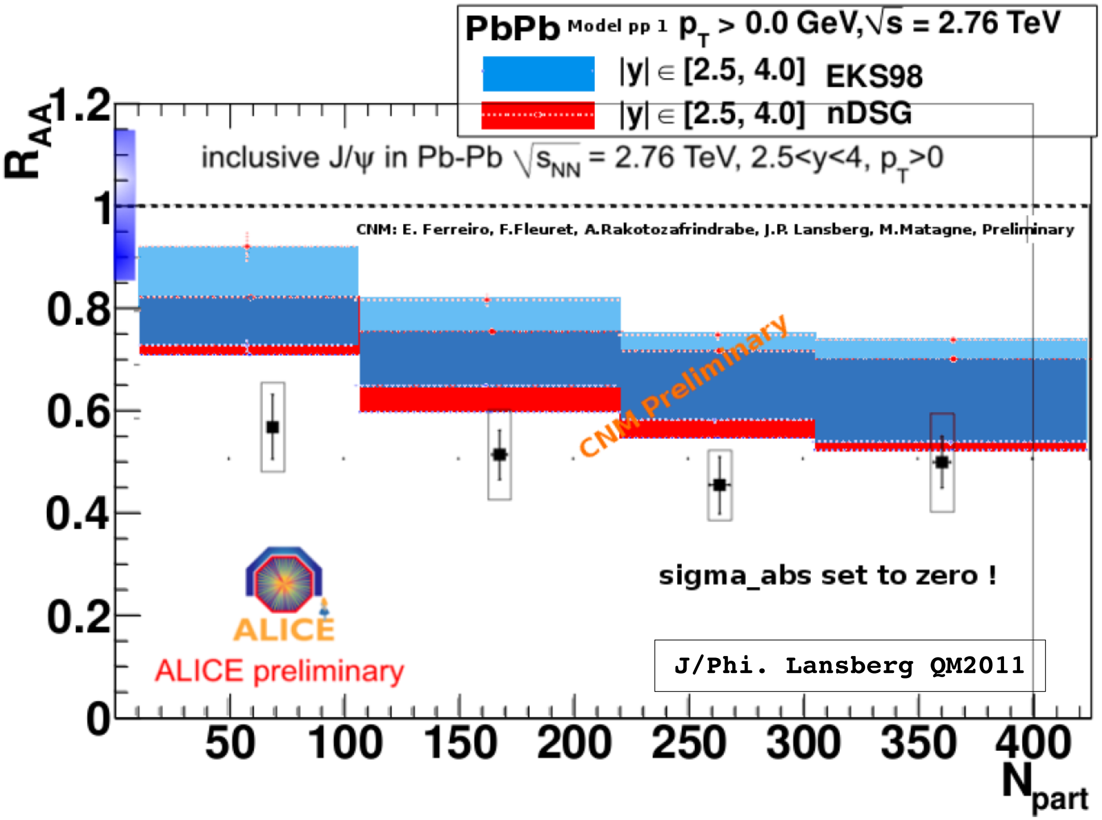
→ everything points to a very low to null nuclear absorption at LHC

Models ingredients: shadowing



R.Vogt, Phys.Rev.C81: 044903, 2010

Large uncertainties in EPS09 prediction



J/Phi. Lansberg QM2011

Shadowing, despite (very) large uncertainties, could almost account for all the suppression seen in central PbPb collisions !

→ σ_{ABS} set to 0 in both models

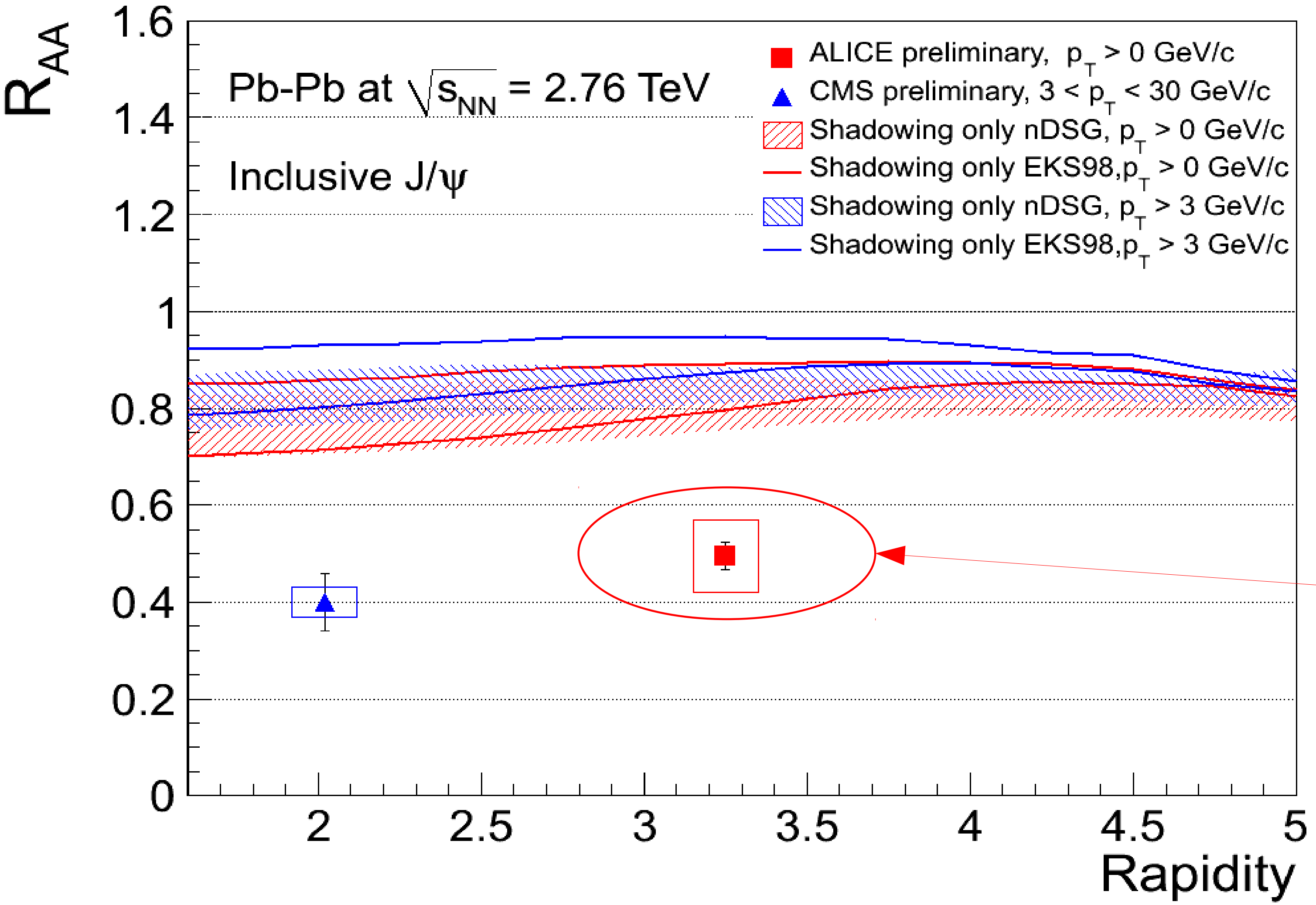
→ different PDFs

→ different J/ψ production mechanism (2 → 1, 2 → 2)

Shadowing contribution is crucial to measure: p-Pb run in 2012

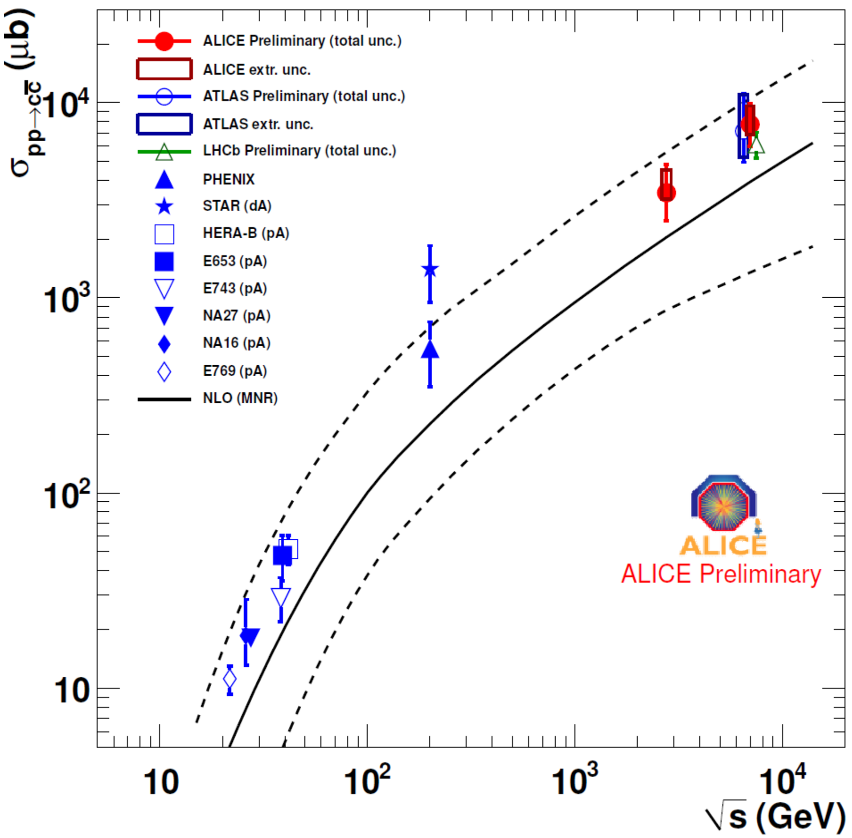
→ maybe few p-Pb collisions in Nov.2011... First measurement at central rapidity feasible ?

Models ingredients: shadowing



Split this point in two rapidity bins ([2.5,3.25] and [3.25,4]) and extract R_{AA} values for p_T > 0 and p_T > 3 GeV/c

Models ingredients: charm cross-section

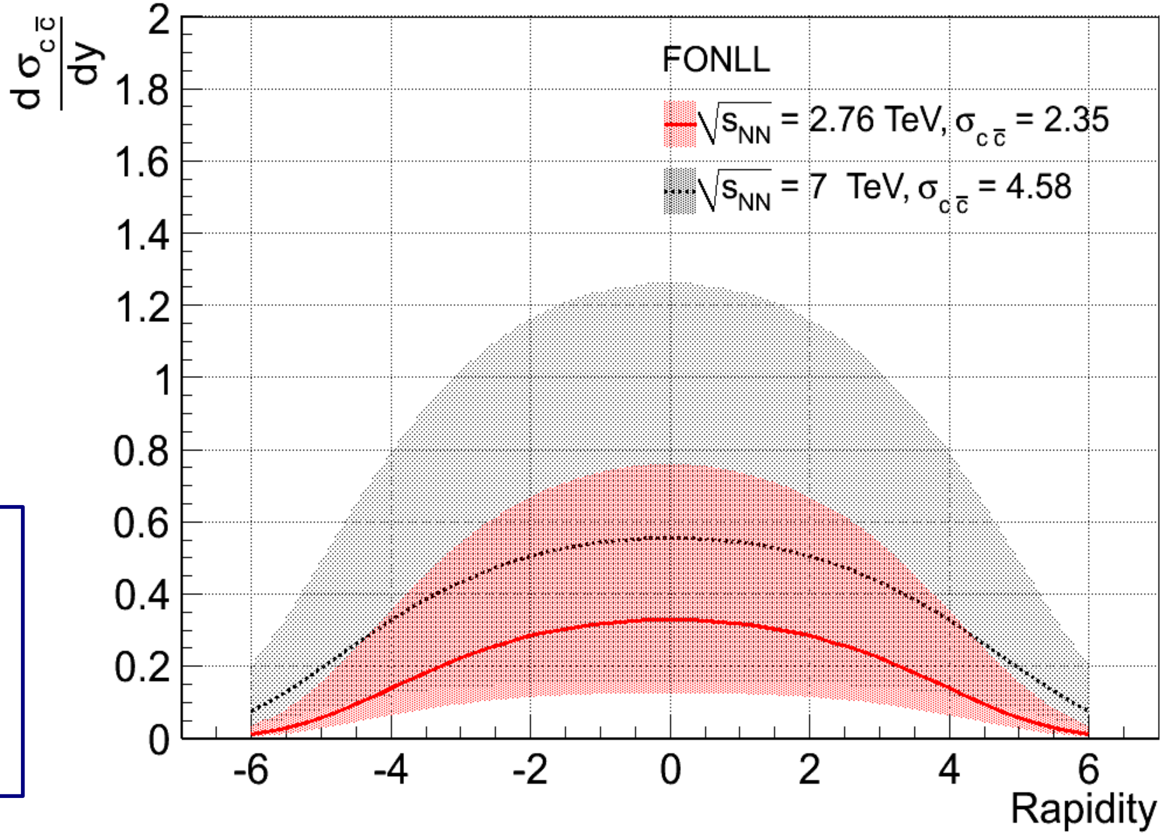


σ(ALICE, 2.76TeV) = 3.45 ± 0.41(stat.) +0.72, -0.84 (syst.) ±0.17(lum.) +1.09, -0.24(extr.) mb

σ(ALICE, 7TeV) = 7.73 ± 0.54 (stat.) +0.74, -1.38 (syst.) ±0.43 (lum.) +1.90, -0.87(extr.) mb

σ(ATLAS, 7TeV) = 7.13 ± 0.28 (stat.) +0.90, -0.66 (syst.) ±0.78(lum.) +3.82, -1.90(extr.) mb

σ(LHCb, 7TeV) = 6.10 ± 0.93 (total) mb



Charm cross-section at LHC lie on the upper-end of model predictions

→ compatible with FONLL
→ crucial input to models

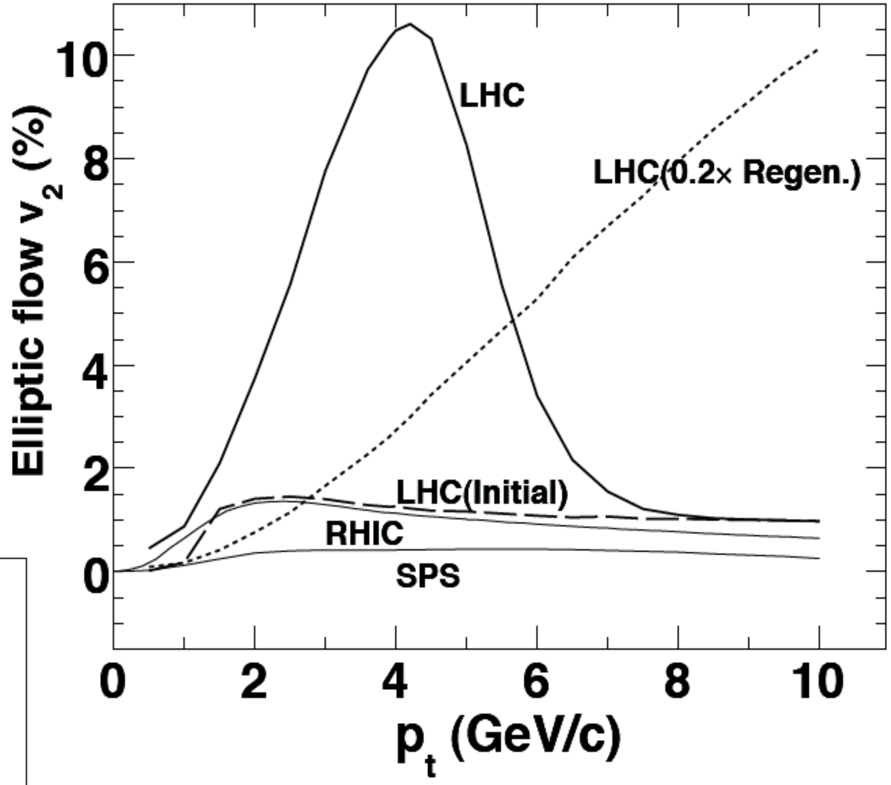
Key measurement to be done....

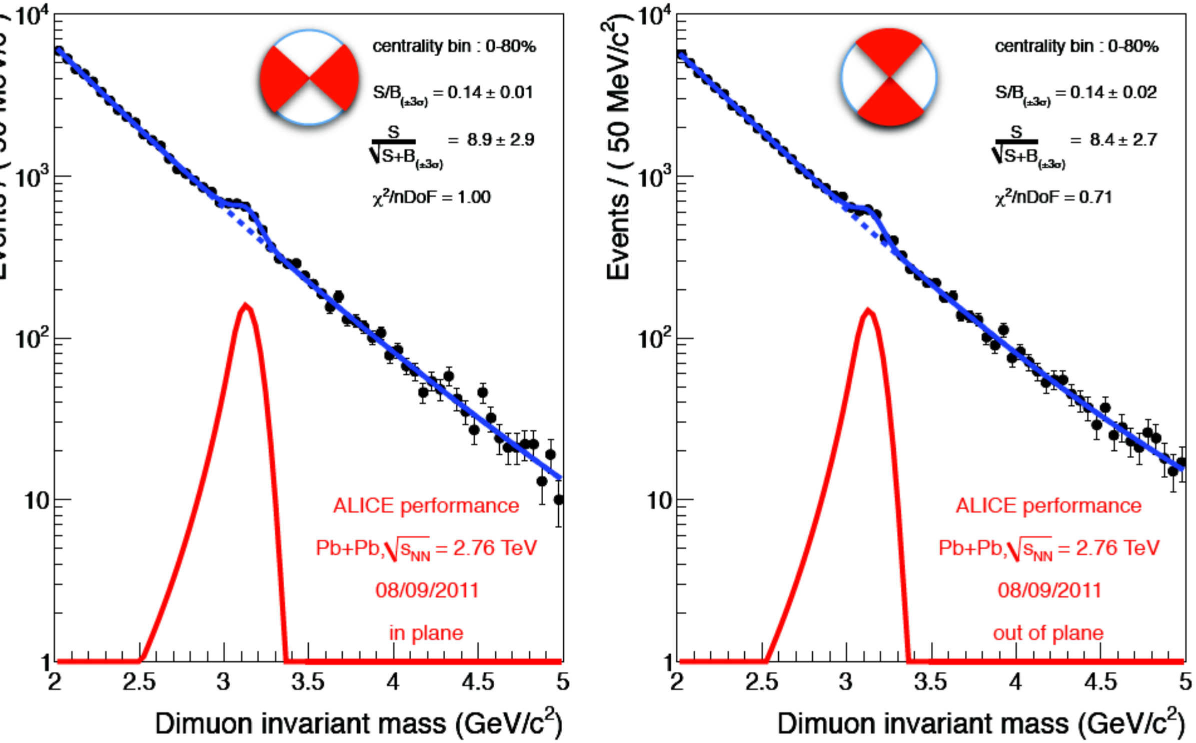
Lower energy measurements do not exhibit any significant v2 (or compatible with 0).

Regeneration or recombination of charm quarks for J/Ψ production will dominate the J/Ψ flow at LHC comparing to that at lower energies.

→ low and mid p_T ranges are crucial

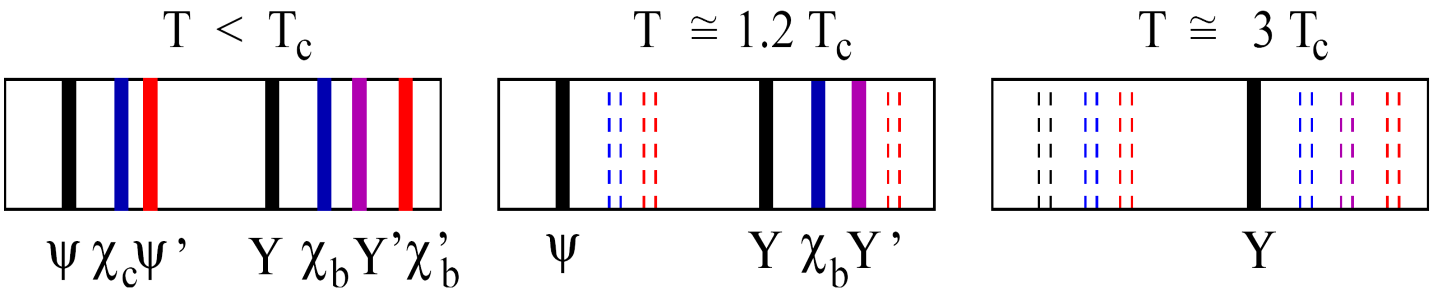
Y. Liu, N. Xu, P. Zhuang, Nucl.Phys.A834 (2010) 317c





Status of the analysis in ALICE : READY
1) event plane with TPC tracks
2) only 2 ΔΦ bins (in and out of plane)
→ to low statistic with 2011 data
→ higher statistic is needed and will be there in a few months !

Summing up...



The suppression pattern is a thermometer of the QCD matter produced : clear advantage to have a measurement of J/ψ and Υ.

$$T_{diss}(\psi') \approx T_{diss}(\chi_c) < T_{diss}(\Upsilon(3S)) < \underline{T_{diss}(J/\psi) \approx T_{diss}(\Upsilon(2S))} < T_{diss}(\Upsilon(1S))$$

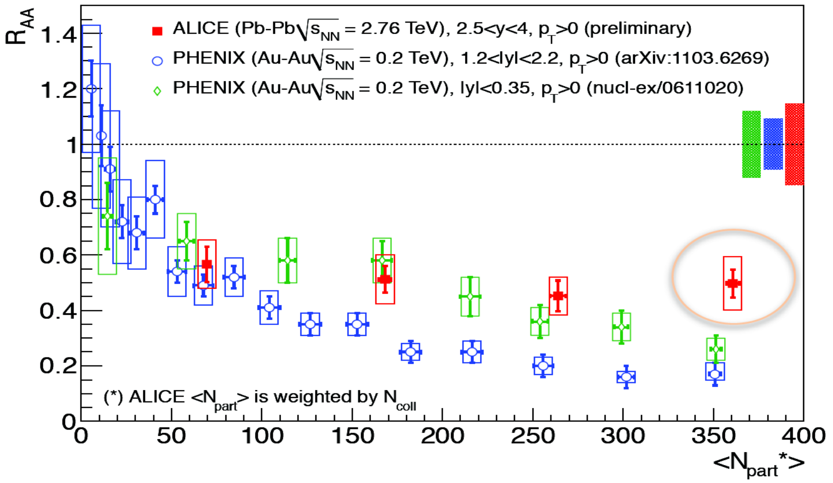
$$\frac{\Upsilon(2S+3S)/\Upsilon(1S)|_{\text{Pb-Pb}}}{\Upsilon(2S+3S)/\Upsilon(1S)|_{pp}} = 0.31^{+0.19}_{-0.15}(\text{stat}) \pm 0.03(\text{syst}),$$

`CMS collaboration Phys. Rev. Lett. 107 (2011) 052302`

CMS results are pointing to (strong) “Indications of Suppression of Excited Υ States in Pb-Pb Collisions" → J/Ψ dissociation temperature reached

i) very likely to have significant melting of J/ψ
ii) very small or null σ_{ABS}
iii) shadowing is poorly constraint.
iv) J/ψ R_{AA} is larger than the one measured at lower energy.

→ Conclusion: make your own.



Conclusions

- ALICE has measured the J/ψ production in Pb-Pb collisions at $\sqrt{s_{NN}}$=2.76 TeV at mid and forward rapidity down to p_T = 0 GeV/c
  - R_{AA} was built using our J/ψ measurement in p-p
    - clear suppression observed $R_{AA}^{0\text{-}80\%} = 0.49 \pm 0.03$ (stat.) ± 0.11 (sys.)
    - value and centrality dependence are significantly different from RHIC

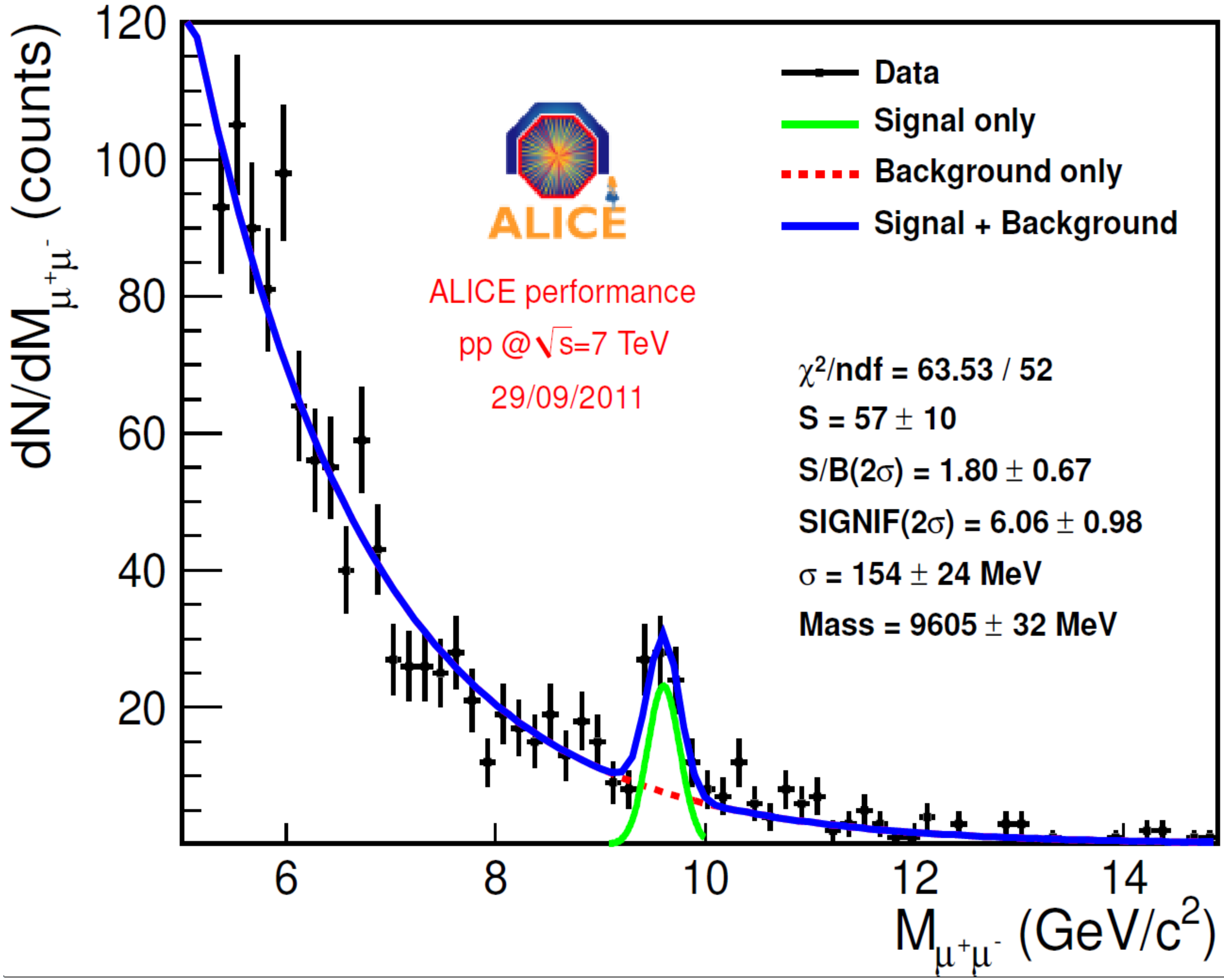
- Models including a J/ψ regeneration component are able to reproduce our data
- Shadowing must be measured at LHC: planned for 2012.
- High statistic measurements like J/ψ flow and p_T dependence of the R_{AA} will shed light on J/ψ re-combination/generation.

→ and also R_{AA} at y=0 down to p_T =0

Backup slides

- Upsilon
- Polarization
- Charm
- Trigger efficiency
- Acc x Eff, embedding, systematics (Raa)
- Raa vs dNch/deta
- LHCb prompts
- Non-prompts in ALICE and others
- Time scale
- Shadowing
- UPC J/Psi

Y in ALICE : p-p collisions



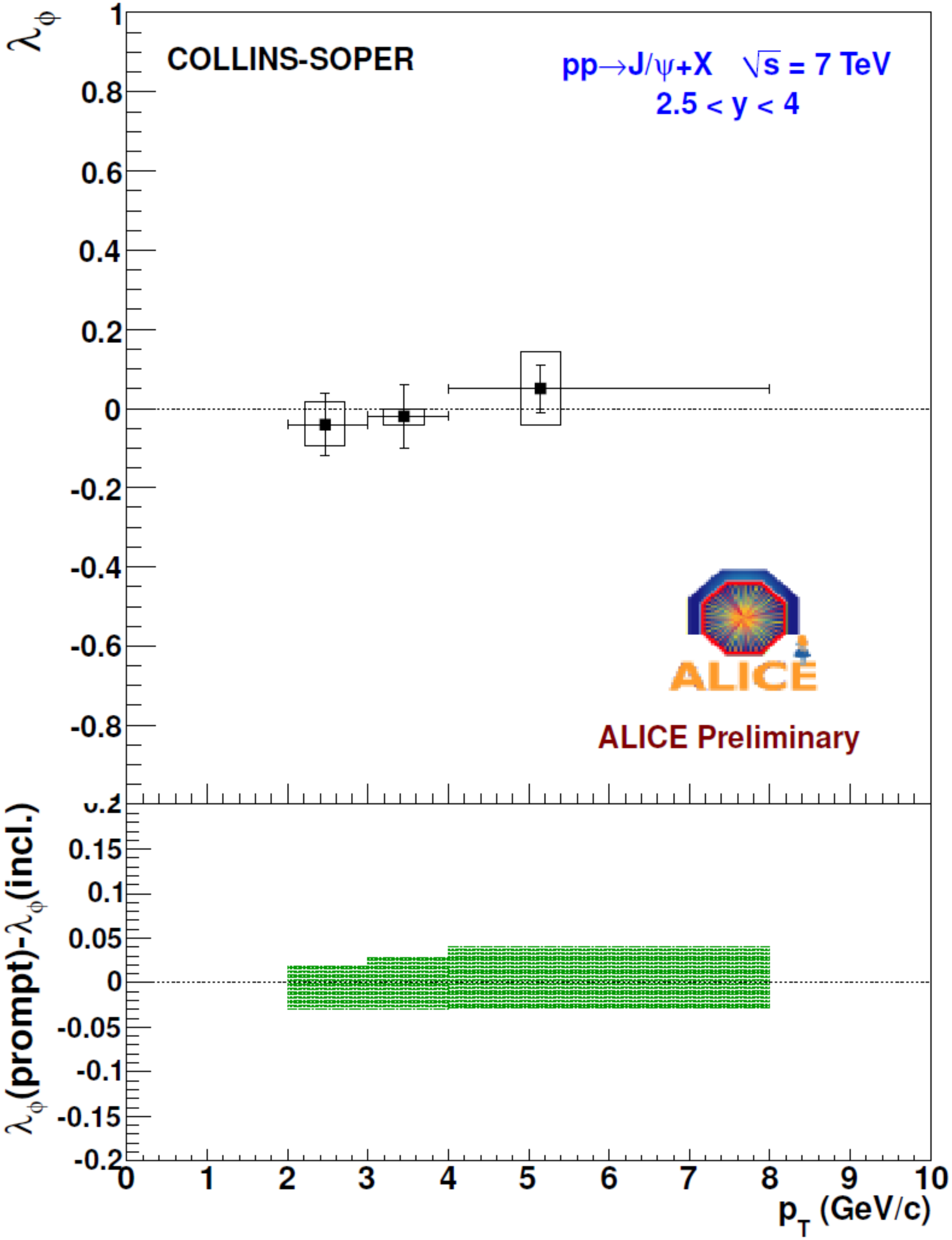
In p-p collisions, ALICE is now having first results on bottomonia

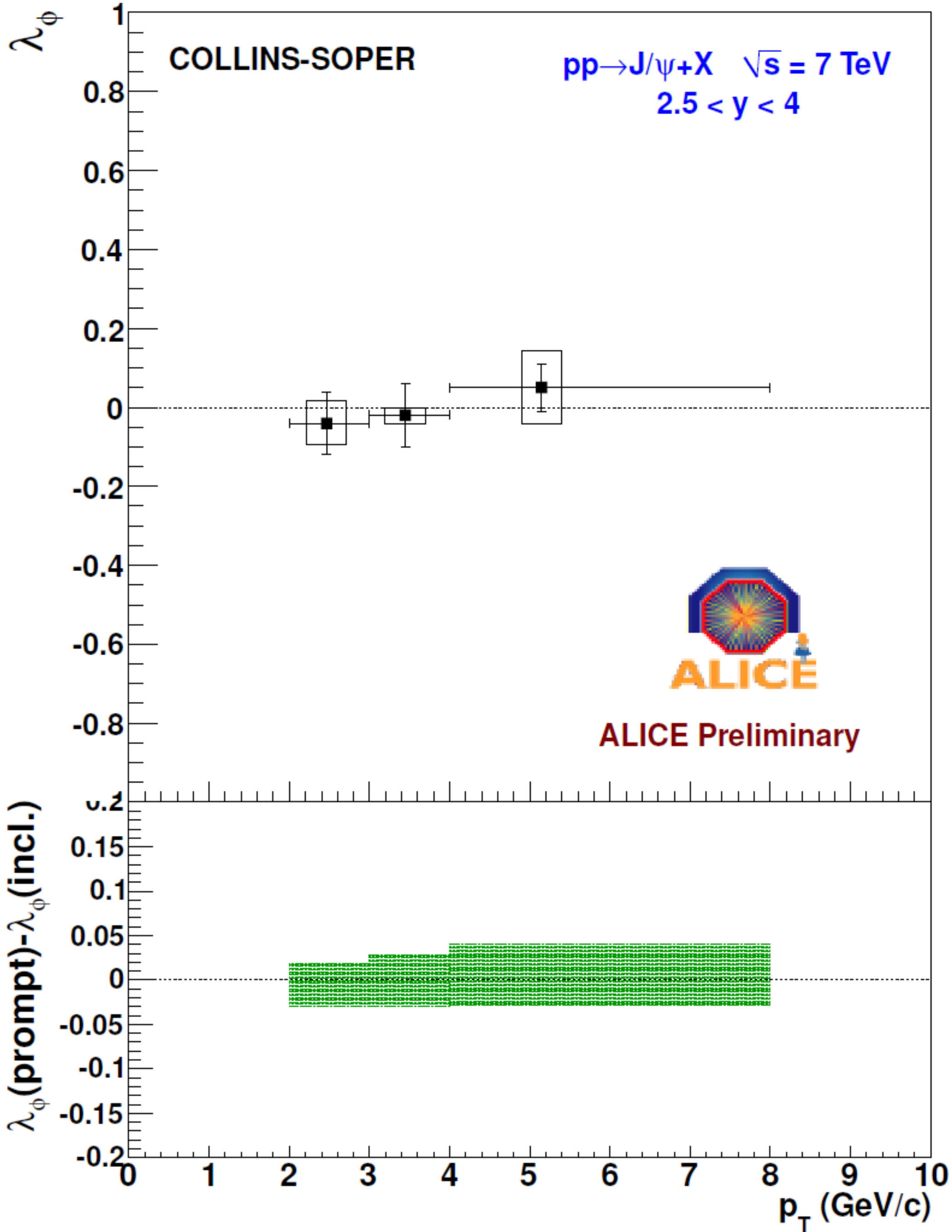
→ at $\sqrt{s_{NN}}$ = 7 TeV

→ in $\mu^+\mu^-$ at y [-4;-2.5]

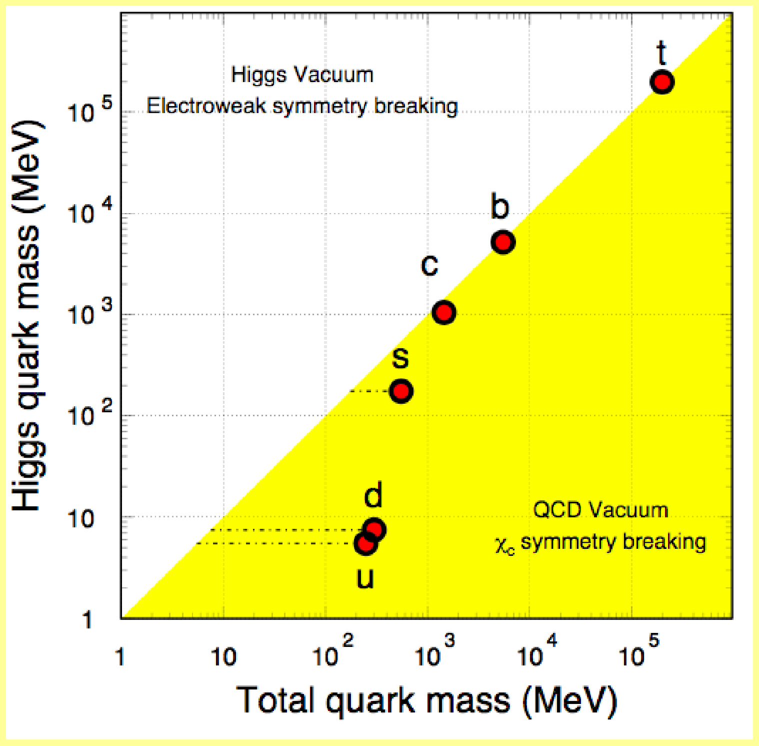
→ down to p_T = 0

Polarization

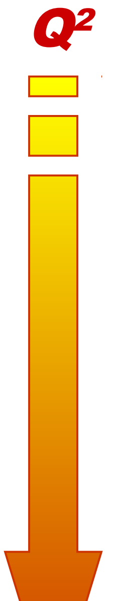


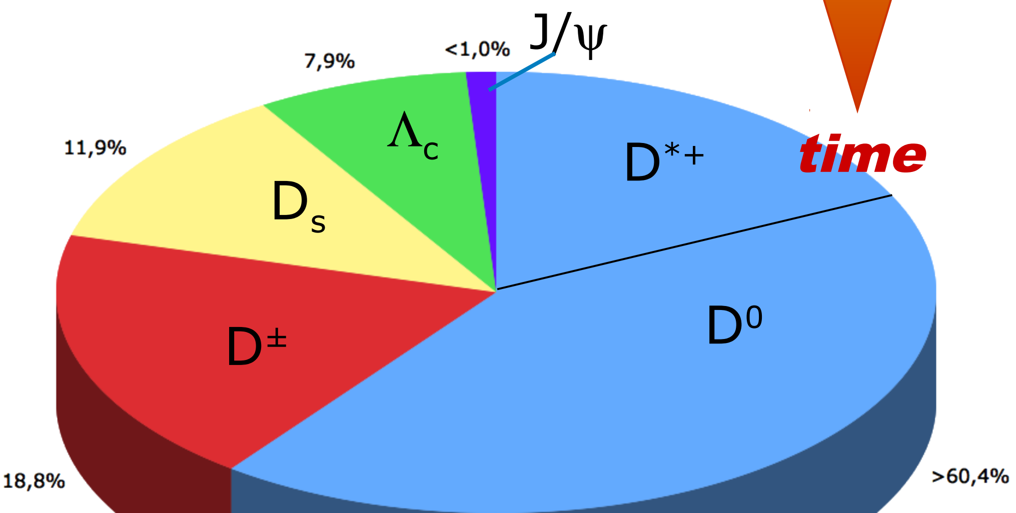


Charming charm...



X. Zhu, M. Bleicher, S.L. Huang, K.S., H. Stöcker, N. Xu, and P. Zhuang, PLB 647 (2007) 366.





$m_{c,b} \gg \Lambda_{QCD}$: new scale

$m_{c,b} \approx$ const., $m_{u,d,s} \neq$ const.

initial conditions:

test pQCD, μ_R, μ_F
probe gluon distribution

early partonic stage:

diffusion (γ), drag (α)
flow, jets, correlations
probe thermalization

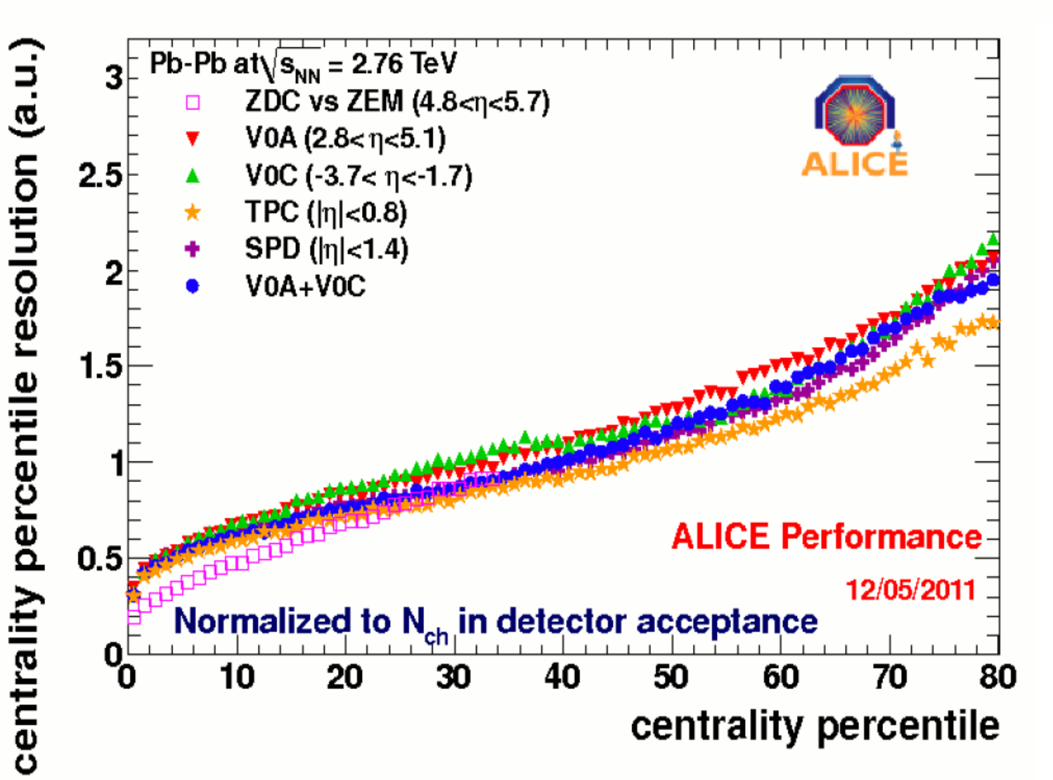
hadronization:

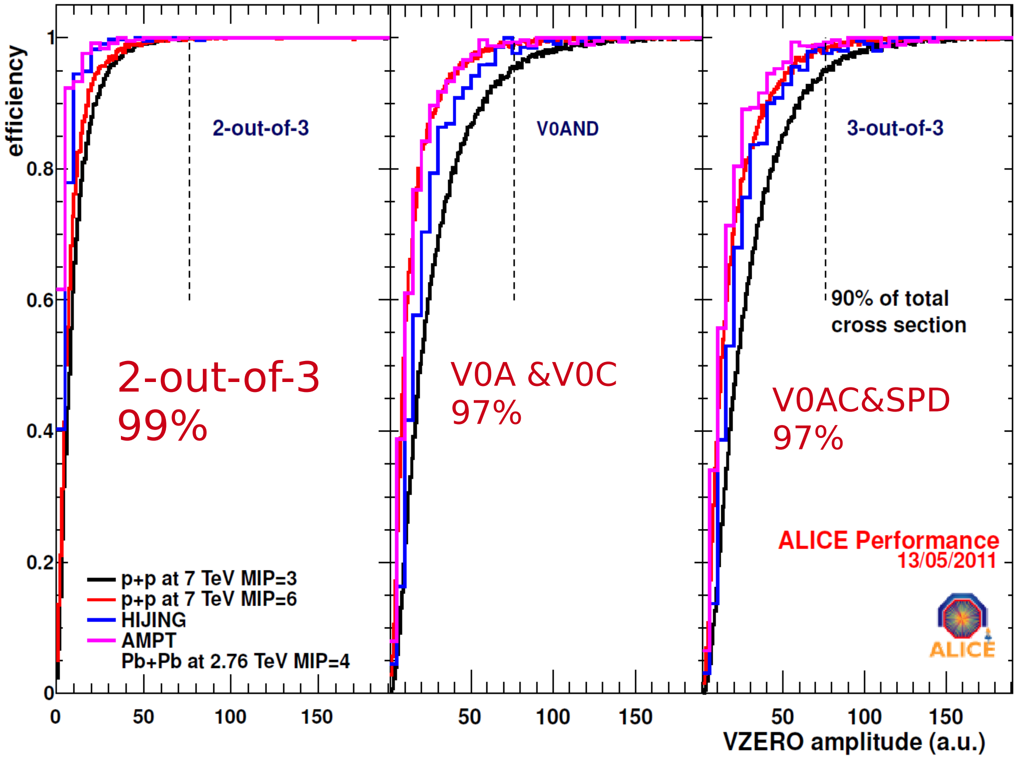
chiral symmetry restoration
confinement
statistical coalescence
J/ψ enhancement / suppression

$J/\Psi\to\mu^+\mu^-$ in Pb+Pb: Trigger

Integrated PbPb luminosity = 2.884 +/- 0.099 μb^{-1} (assuming σ_{PbPb} = 7.65 +/- 0.25 b)

→ MB 3 out of 3 is 100% efficient for V0amp >150 (~ 85%)





V0 amp:
90% ~ 80
80% ~ 240

A.Toia: QM'11

Data set and triggers

System	pp	pp	pp	pp	PbPb
$\sqrt{s_{NN}}$ [TeV]	7	7	2.76	2.76	2.76
trigger	MB	μ-trigger	MB	μ-trigger	MB
N_{events}	up to 298 M	130 M	65 M	~9 M	17 M
L×A1×A2 (nb^{-1})	up to 4.8	16	1.1	20	118

Acceptance x efficiency

- Based on simulations that accounts for the detector conditions and their time dependence

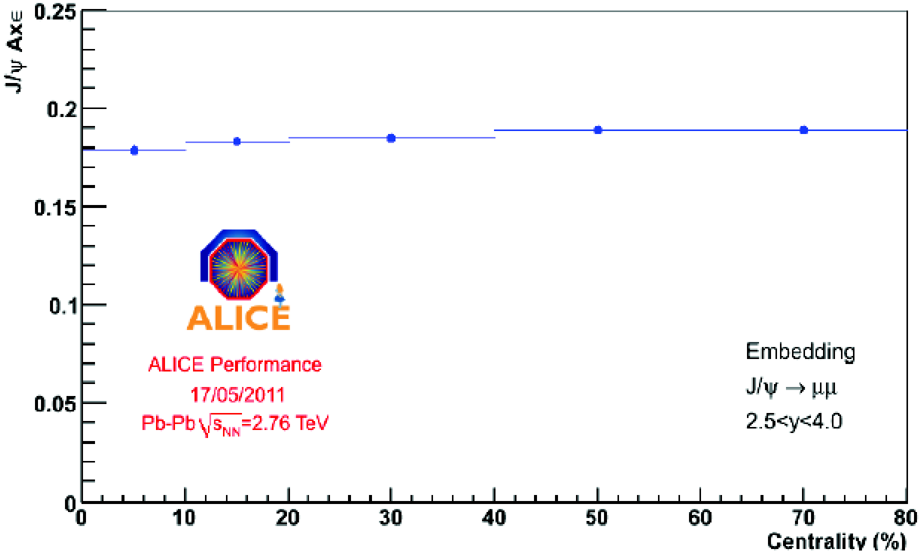
- Realistic J/ψ parameterization:
  - p_T and y interpolated from data (Phenix, CDF, LHC) F. Bossu *et al.*, arXiv:1103.2394
  - Shadowing from EKS98 calculations K.J.Eskola *et al.*, Eur. Phys. J. C9, 61, 1999

→ Integrated Acc×Eff correction with the current track selection = 19.44 ± 0.04 %

- Reconstruction efficiency also measured directly from data:
  - → Poster of A. Lardeux and L. Valencia (#58)
  - → Comparison with simulations gives the systematic uncertainty of Acc×Eff correction
  - → Only 2% decrease in the most central events. Also added in the systematics

Embedding

One J/ψ embedded into each real event. Same reconstruction/selections as for data



- Acc×Eff correction versus centrality

→ Small decreasing of the reconstruction efficiency when increasing centrality

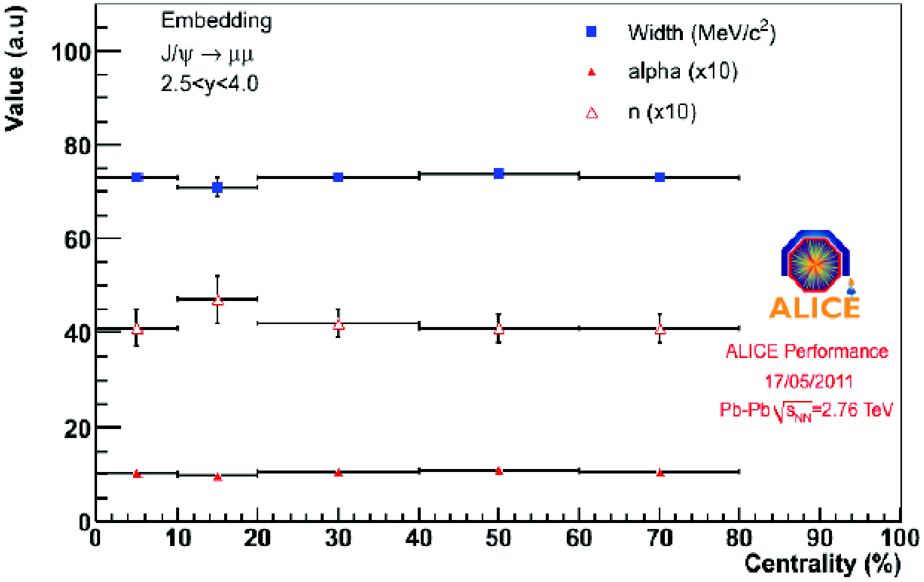
→ Good agreement with the direct measurement from data

→ included in the systematics

- Resolution of the J/ψ (fitted with a Crystal Ball func.) versus centrality

→ No sizable evolution of the parameters versus centrality

→ Good agreement with the measured spectrometer resolution from data

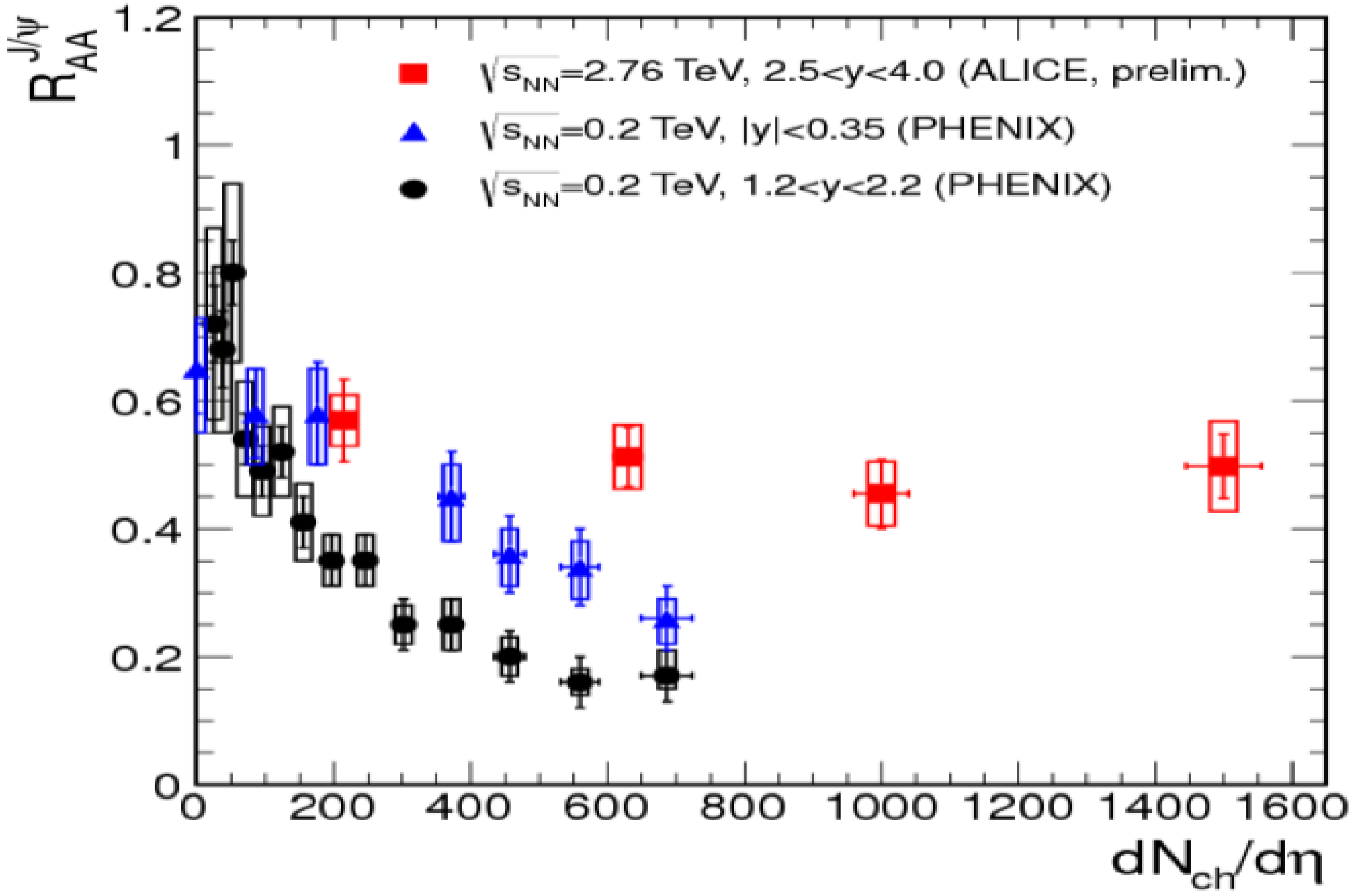


Systematics

Systematic uncertainties depending on the centrality have been separated from the common systematics

centrality	0-10%	10-20%	20-40%	40-80%	Common
$N_{J/\psi}$	19%	14%	17%	14%	-
$N_{J/\psi} / N_{J/\psi}^{40\text{-}80\%}$	12%	8%	7%	-	-
Acceptance	-	-	-	-	3%
Eff. Tracker	4%	2%	1%	0%	5%
Eff. Trigger	-	-	-	-	4%
Reco.	-	-	-	-	2%
B.R.	-	-	-	-	1%
X-section	-	-	-	-	13%
$\langle T_{AA} \rangle$	4%	4%	4%	6%	-
$\langle T_{AA} \rangle^i / \langle T_{AA} \rangle^{40\text{-}80\%}$	6%	5%	4%	-	-
Total for R_{AA}	**20%**	**15%**	**17%**	**15%**	**15%**
Total for R_{CP}	**14%**	**10%**	**8%**	**-**	**-**

R_{AA} in Pb-Pb collisions, ALICE and PHENIX



Bars: statistical uncertainty

Open box: centrality dependent sys. uncertainty

Blue box: common sys. uncertainty (not shown)

Inclusive J/ψ $R_{AA}^{0\text{-}80\%}$ = 0.49 ± 0.03 (stat.) ± 0.11 (sys.)

$dNch/d\eta|_{y=0}$ @ LHC ≈ 2.1 x $dNch/d\eta|_{y=0}$ @ RHIC

Non-prompt/prompt fraction, p-p, 7 TeV

Eur. Phys. J. C71 (2011) 1645 LHCB collaboration

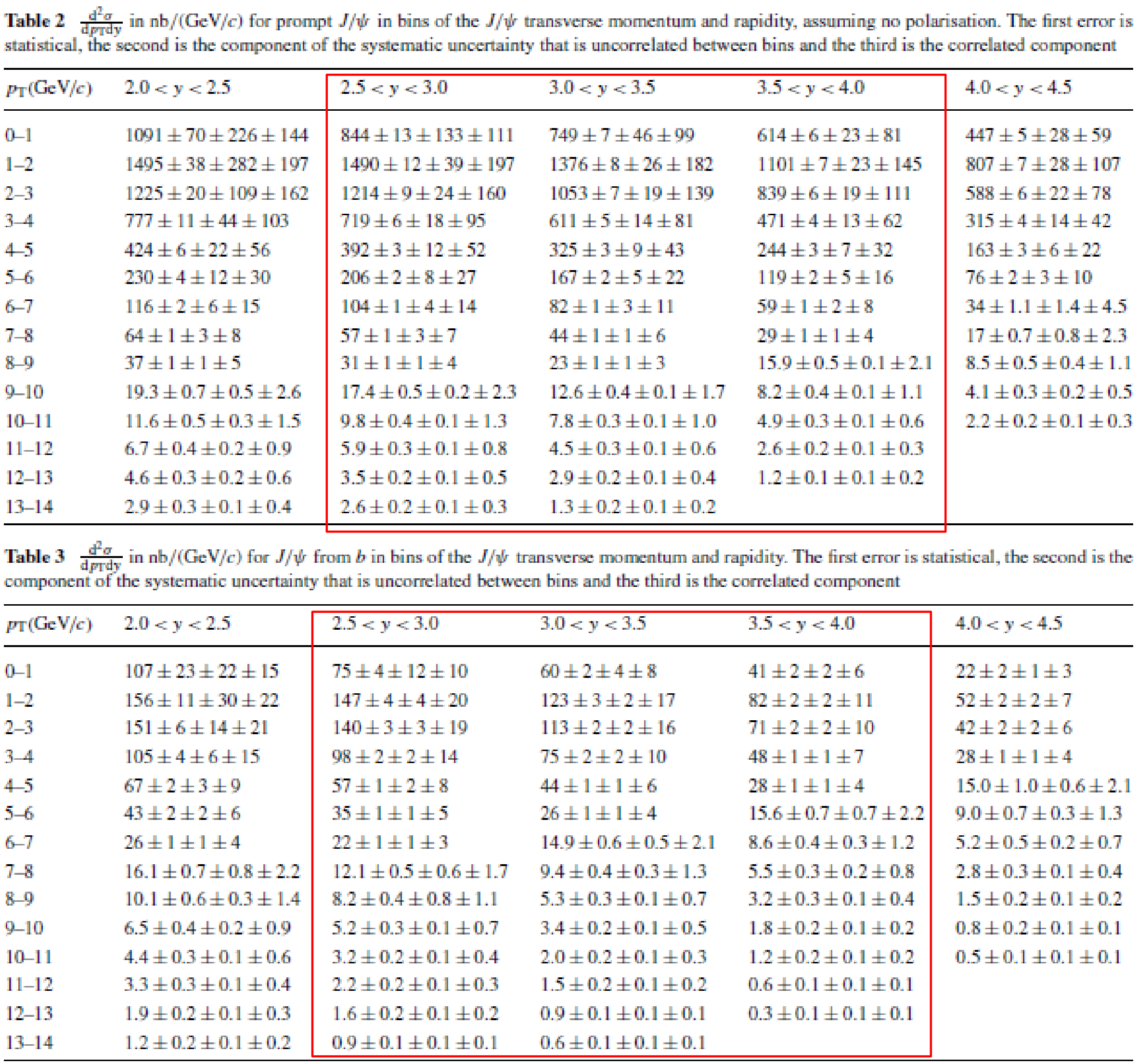


Table 2 $\frac{d^2\sigma}{dp_T dy}$ in nb/(GeV/c) for prompt J/ψ in bins of the J/ψ transverse momentum and rapidity, assuming no polarisation. The first error is statistical, the second is the component of the systematic uncertainty that is uncorrelated between bins and the third is the correlated component

p_T(GeV/c)	$2.0 < y < 2.5$	$2.5 < y < 3.0$	$3.0 < y < 3.5$	$3.5 < y < 4.0$	$4.0 < y < 4.5$
0–1	1091 ± 70 ± 226 ± 144	844 ± 13 ± 133 ± 111	749 ± 7 ± 46 ± 99	614 ± 6 ± 23 ± 81	447 ± 5 ± 28 ± 59
1–2	1495 ± 38 ± 282 ± 197	1490 ± 12 ± 39 ± 197	1376 ± 8 ± 26 ± 182	1101 ± 7 ± 23 ± 145	807 ± 7 ± 28 ± 107
2–3	1225 ± 20 ± 109 ± 162	1214 ± 9 ± 24 ± 160	1053 ± 7 ± 19 ± 139	839 ± 6 ± 19 ± 111	588 ± 6 ± 22 ± 78
3–4	777 ± 11 ± 44 ± 103	719 ± 6 ± 18 ± 95	611 ± 5 ± 14 ± 81	471 ± 4 ± 13 ± 62	315 ± 4 ± 14 ± 42
4–5	424 ± 6 ± 22 ± 56	392 ± 3 ± 12 ± 52	325 ± 3 ± 9 ± 43	244 ± 3 ± 7 ± 32	163 ± 3 ± 6 ± 22
5–6	230 ± 4 ± 12 ± 30	206 ± 2 ± 8 ± 27	167 ± 2 ± 5 ± 22	119 ± 2 ± 5 ± 16	76 ± 2 ± 3 ± 10
6–7	116 ± 2 ± 6 ± 15	104 ± 1 ± 4 ± 14	82 ± 1 ± 3 ± 11	59 ± 1 ± 2 ± 8	34 ± 1.1 ± 1.4 ± 4.5
7–8	64 ± 1 ± 3 ± 8	57 ± 1 ± 3 ± 7	44 ± 1 ± 1 ± 6	29 ± 1 ± 1 ± 4	17 ± 0.7 ± 0.8 ± 2.3
8–9	37 ± 1 ± 1 ± 5	31 ± 1 ± 1 ± 4	23 ± 1 ± 1 ± 3	15.9 ± 0.5 ± 0.1 ± 2.1	8.5 ± 0.5 ± 0.4 ± 1.1
9–10	19.3 ± 0.7 ± 0.5 ± 2.6	17.4 ± 0.5 ± 0.2 ± 2.3	12.6 ± 0.4 ± 0.1 ± 1.7	8.2 ± 0.4 ± 0.1 ± 1.1	4.1 ± 0.3 ± 0.2 ± 0.5
10–11	11.6 ± 0.5 ± 0.3 ± 1.5	9.8 ± 0.4 ± 0.1 ± 1.3	7.8 ± 0.3 ± 0.1 ± 1.0	4.9 ± 0.3 ± 0.1 ± 0.6	2.2 ± 0.2 ± 0.1 ± 0.3
11–12	6.7 ± 0.4 ± 0.2 ± 0.9	5.9 ± 0.3 ± 0.1 ± 0.8	4.5 ± 0.3 ± 0.1 ± 0.6	2.6 ± 0.2 ± 0.1 ± 0.3	
12–13	4.6 ± 0.3 ± 0.2 ± 0.6	3.5 ± 0.2 ± 0.1 ± 0.5	2.9 ± 0.2 ± 0.1 ± 0.4	1.2 ± 0.1 ± 0.1 ± 0.2	
13–14	2.9 ± 0.3 ± 0.1 ± 0.4	2.6 ± 0.2 ± 0.1 ± 0.3	1.3 ± 0.2 ± 0.1 ± 0.2		

Table 3 $\frac{d^2\sigma}{dp_T dy}$ in nb/(GeV/c) for J/ψ from b in bins of the J/ψ transverse momentum and rapidity. The first error is statistical, the second is the component of the systematic uncertainty that is uncorrelated between bins and the third is the correlated component

p_T(GeV/c)	$2.0 < y < 2.5$	$2.5 < y < 3.0$	$3.0 < y < 3.5$	$3.5 < y < 4.0$	$4.0 < y < 4.5$
0–1	107 ± 23 ± 22 ± 15	75 ± 4 ± 12 ± 10	60 ± 2 ± 4 ± 8	41 ± 2 ± 2 ± 6	22 ± 2 ± 1 ± 3
1–2	156 ± 11 ± 30 ± 22	147 ± 4 ± 4 ± 20	123 ± 3 ± 2 ± 17	82 ± 2 ± 2 ± 11	52 ± 2 ± 2 ± 7
2–3	151 ± 6 ± 14 ± 21	140 ± 3 ± 3 ± 19	113 ± 2 ± 2 ± 16	71 ± 2 ± 2 ± 10	42 ± 2 ± 2 ± 6
3–4	105 ± 4 ± 6 ± 15	98 ± 2 ± 2 ± 14	75 ± 2 ± 2 ± 10	48 ± 1 ± 1 ± 7	28 ± 1 ± 1 ± 4
4–5	67 ± 2 ± 3 ± 9	57 ± 1 ± 2 ± 8	44 ± 1 ± 1 ± 6	28 ± 1 ± 1 ± 4	15.0 ± 1.0 ± 0.6 ± 2.1
5–6	43 ± 2 ± 2 ± 6	35 ± 1 ± 1 ± 5	26 ± 1 ± 1 ± 4	15.6 ± 0.7 ± 0.7 ± 2.2	9.0 ± 0.7 ± 0.3 ± 1.3
6–7	26 ± 1 ± 1 ± 4	22 ± 1 ± 1 ± 3	14.9 ± 0.6 ± 0.5 ± 2.1	8.6 ± 0.4 ± 0.3 ± 1.2	5.2 ± 0.5 ± 0.2 ± 0.7
7–8	16.1 ± 0.7 ± 0.8 ± 2.2	12.1 ± 0.5 ± 0.6 ± 1.7	9.4 ± 0.4 ± 0.3 ± 1.3	5.5 ± 0.3 ± 0.2 ± 0.8	2.8 ± 0.3 ± 0.1 ± 0.4
8–9	10.1 ± 0.6 ± 0.3 ± 1.4	8.2 ± 0.4 ± 0.8 ± 1.1	5.3 ± 0.3 ± 0.1 ± 0.7	3.2 ± 0.3 ± 0.1 ± 0.4	1.5 ± 0.2 ± 0.1 ± 0.2
9–10	6.5 ± 0.4 ± 0.2 ± 0.9	5.2 ± 0.3 ± 0.1 ± 0.7	3.4 ± 0.2 ± 0.1 ± 0.5	1.8 ± 0.2 ± 0.1 ± 0.2	0.8 ± 0.2 ± 0.1 ± 0.1
10–11	4.4 ± 0.3 ± 0.1 ± 0.6	3.2 ± 0.2 ± 0.1 ± 0.4	2.0 ± 0.2 ± 0.1 ± 0.3	1.2 ± 0.2 ± 0.1 ± 0.2	0.5 ± 0.1 ± 0.1 ± 0.1
11–12	3.3 ± 0.3 ± 0.1 ± 0.4	2.2 ± 0.2 ± 0.1 ± 0.3	1.5 ± 0.2 ± 0.1 ± 0.2	0.6 ± 0.1 ± 0.1 ± 0.1	
12–13	1.9 ± 0.2 ± 0.1 ± 0.3	1.6 ± 0.2 ± 0.1 ± 0.2	0.9 ± 0.1 ± 0.1 ± 0.1	0.3 ± 0.1 ± 0.1 ± 0.1	
13–14	1.2 ± 0.2 ± 0.1 ± 0.2	0.9 ± 0.1 ± 0.1 ± 0.1	0.6 ± 0.1 ± 0.1 ± 0.1		

Non-prompt/prompt ratio Rnp/n

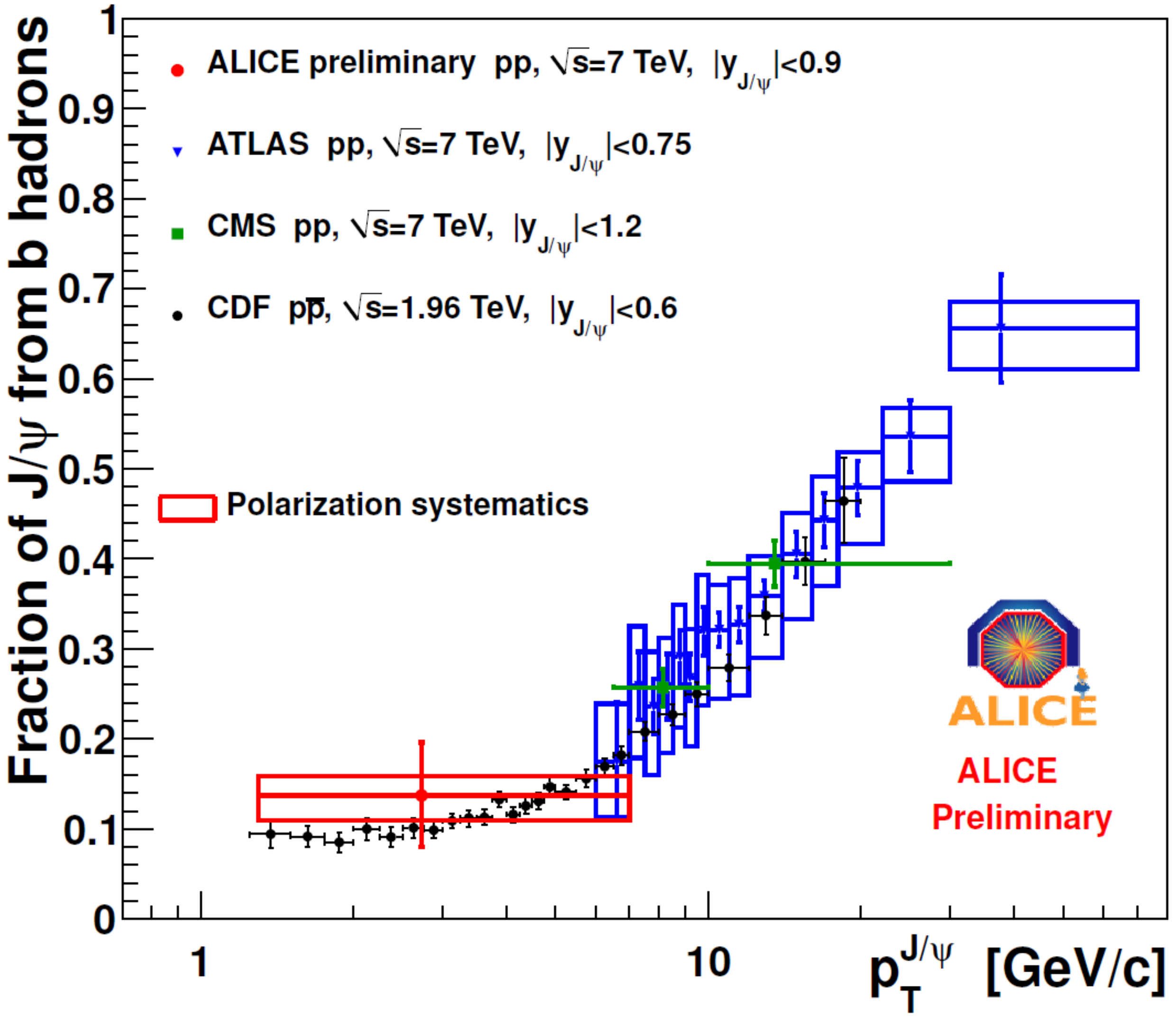
$p_T > 0$, $2.5<y<4$, Rnp/n ≈ 10.7 %

$p_T > 0$, $2.5<y<3$, Rnp/n ≈ 11.9 %
$p_T > 0$, $3.5<y<4$, Rnp/n ≈ 8.7 %

$p_T > 3$, $2.5<y<4$, Rnp/n ≈ 14.3%

$p_T > 3$, $2.5<y<3$, Rnp/n ≈ 15.8 %
$p_T > 3$, $3.5<y<4$, Rnp/n ≈ 11.8%

Non-prompt J/Psi in ALICE

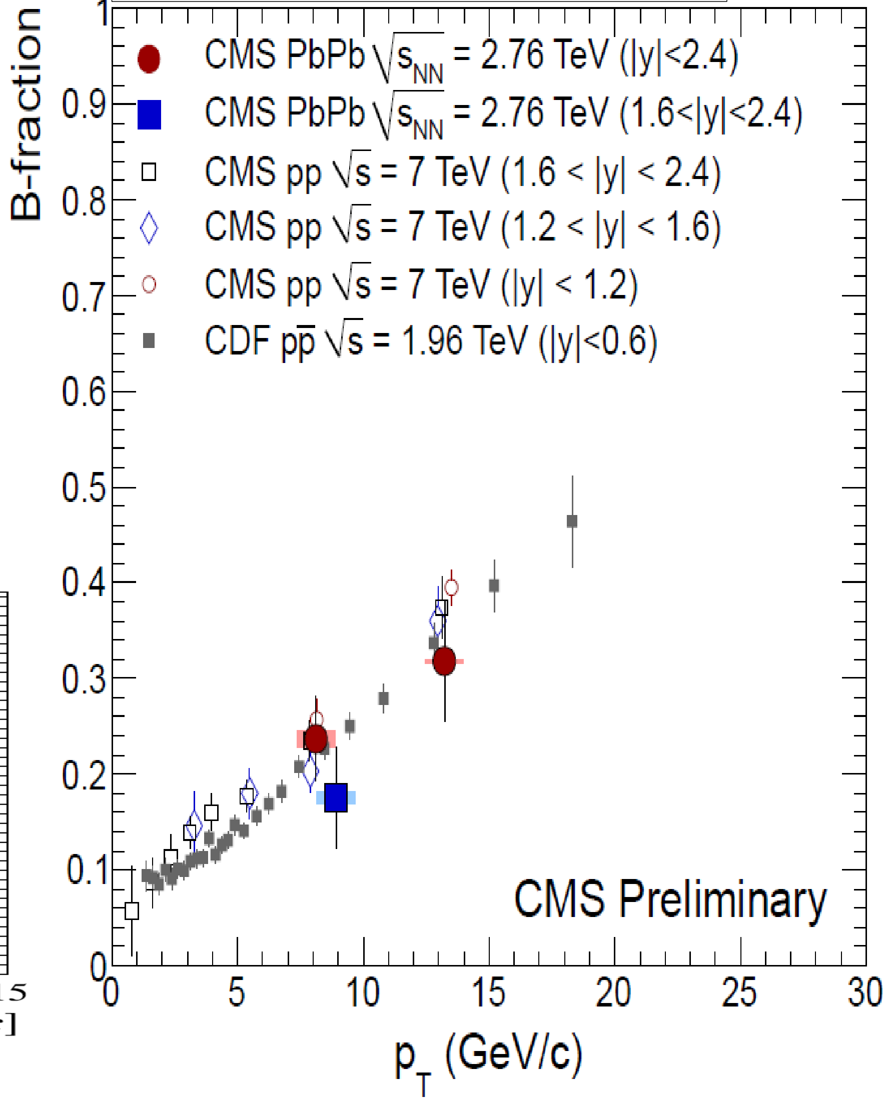


Non-prompt/prompt fraction, p-p, 7 TeV and Pb- Pb 2.76 TeV

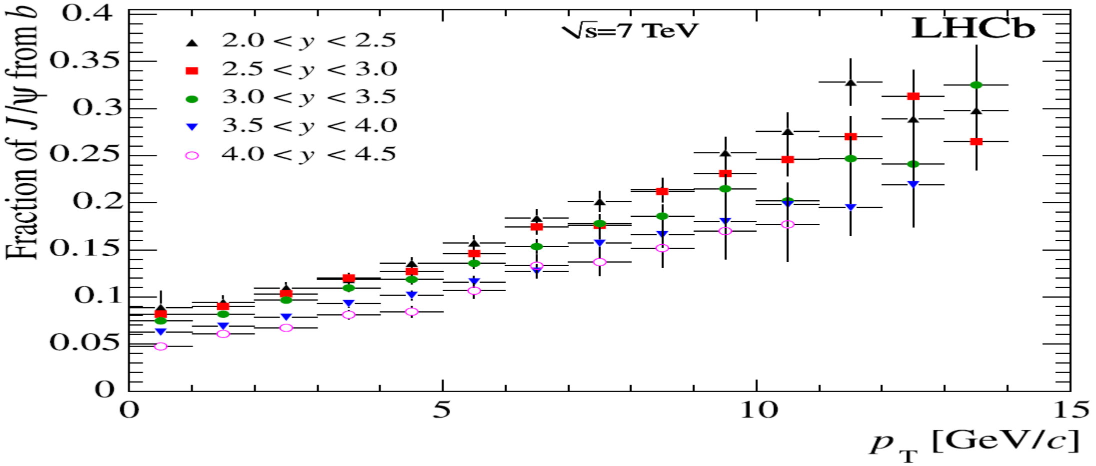
Rapidity dependence of the ratio
non-prompt J/Ψ/prompt J/Ψ

→ in p-p, the ratio decreases with rapidity
→ in Pb-Pb, the ratio might decreases with rapidity

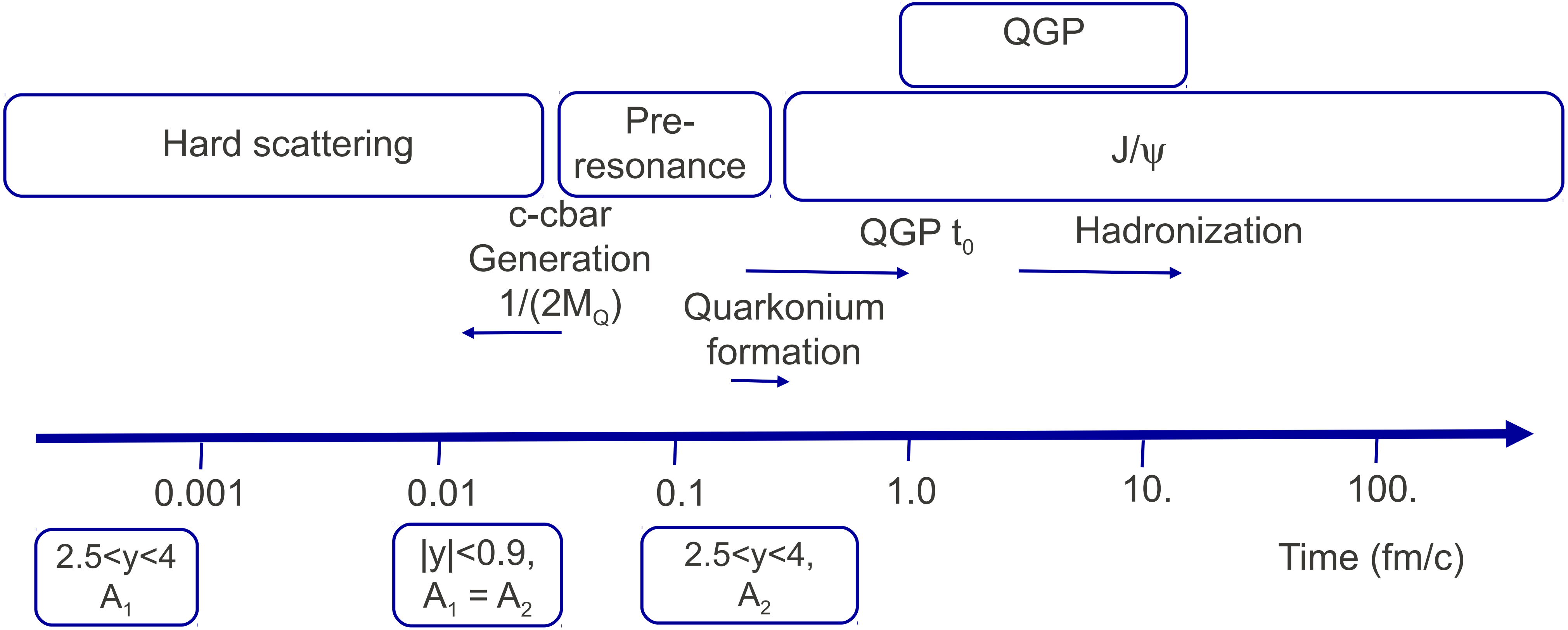
CMS PAS HIN-10-006 CMS collaboration



Eur. Phys. J. C71 (2011) 1645 LHCB collaboration



Time scales at LHC



QGP

Hard scattering

Pre-resonance

J/ψ

c-cbar Generation $1/(2M_Q)$

QGP t_0

Hadronization

Quarkonium formation

0.001

0.01

0.1

1.0

10.

100.

Time (fm/c)

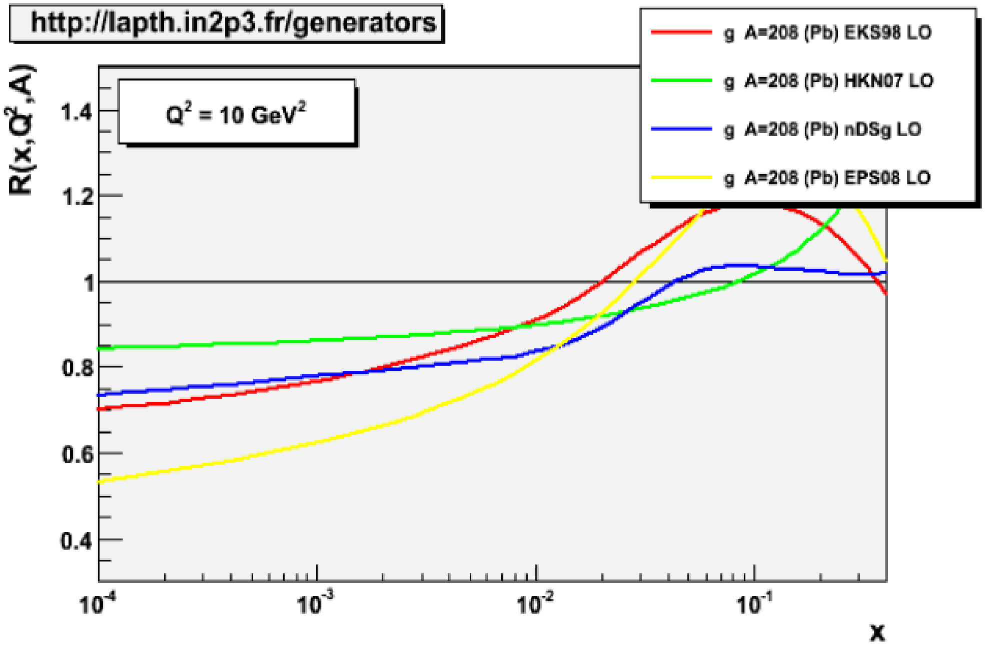
2.5<y<4 A_1

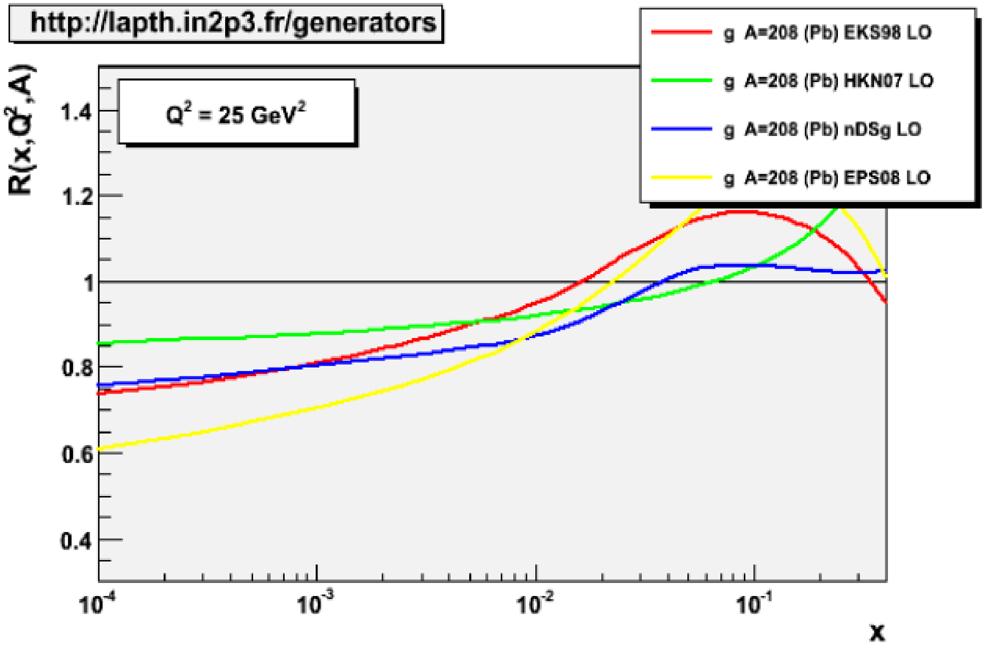
|y|<0.9, $A_1 = A_2$

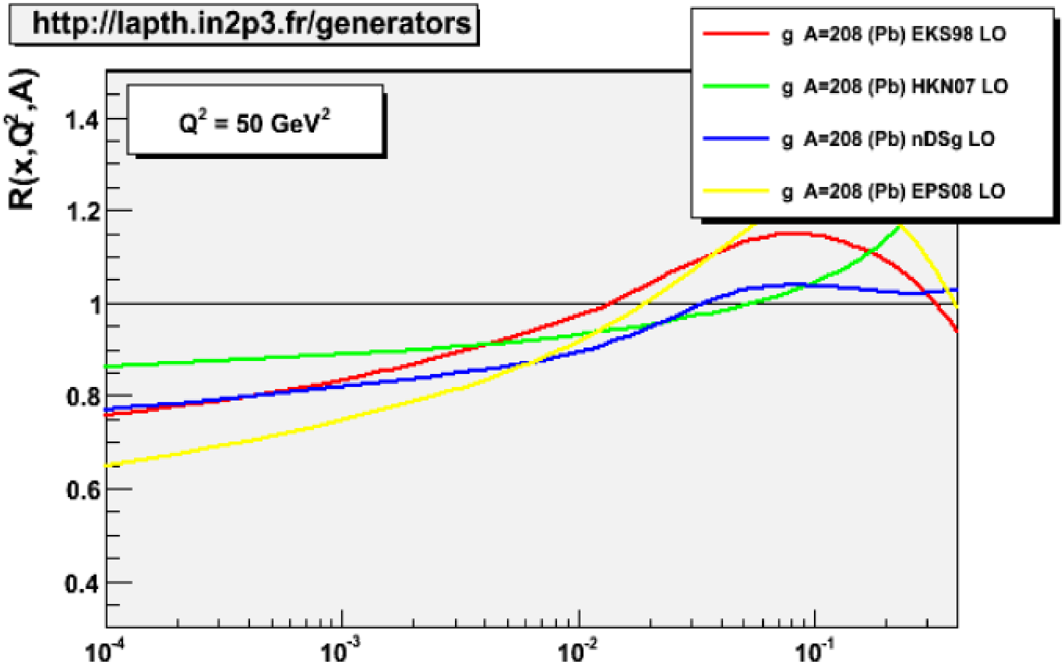
2.5<y<4, A_2

$\tau_{cros} < \tau_{ccbar}$ is a new regime;
Cold nuclear matter effect should affect both quarkonium and HF production;
Coherence of gluon radiation processes in the nucleus;
Needed input from theory (energy loss?)
pA needed at LHC for several nuclei at sqrt(s)=2.76 TeV

Gluon shadowing for Pb ions



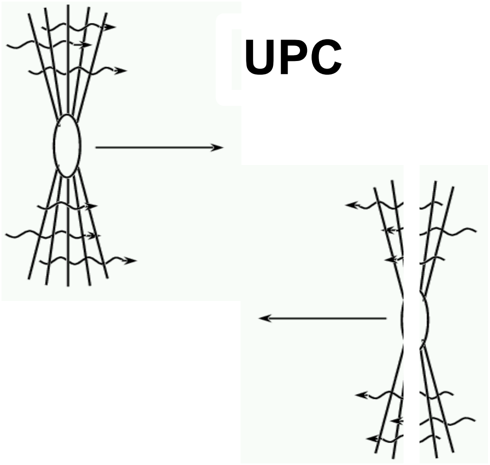




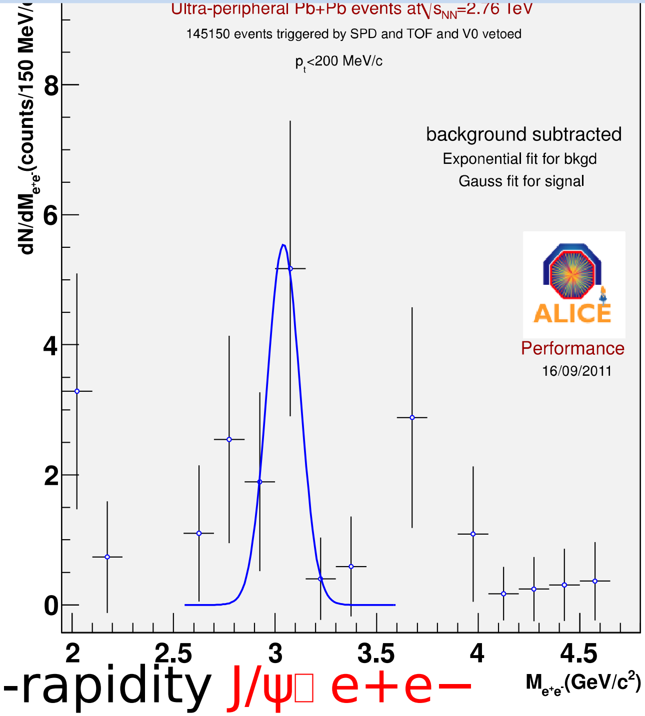
J/ψ production in Ultra-peripheral Pb+Pb collisions

UPC: ultra-peripheral collisions

Probe for nucleon and
nuclear gluon distribution of the nuclei
 Nuclear gluon shadowing



S. Klein and J. Nystrand, PRC60 (1999) 014903
L. Frankfurt, M. Strikman, and M. Zhalov, PLB540 (2002) 220 and PLB537 (2002) 51S
M. Strikman, M. Tverskoy, M. Zhalov, PLB626 (2005) 72



mid-rapidity J/ψ e+e−

Forward rapidity J/ψ μ+μ−