First ReteQuarkonii workshop
25/28 October 2010 Nantes

Charmonium analysis in the ALICE muon spectrometer

B. Boyer for the ALICE collaboration

Outline

- Physics motivation
- The ALICE experiment
- Data sample and cuts
- J/Ψ yield extraction
- Acc x eff
- Normalization
- J/Ψ differential cross section
- Conclusion

Physics motivation

- Need to understand quarkonium production mechanism

⇨ Many models available: COM (NRQCD), CEM, CSM but none is able to predict cross section and polarization at the same time.

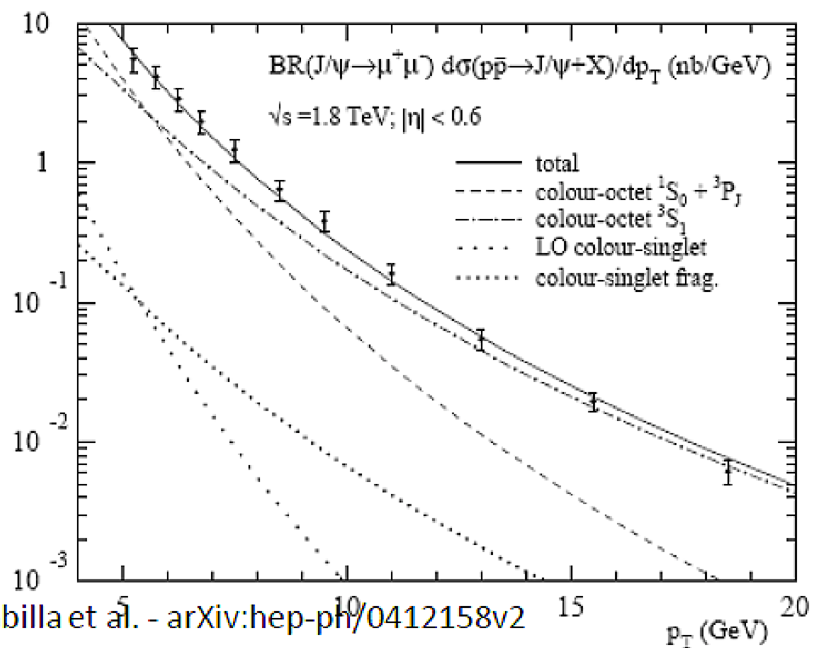
- We need a reference for the future heavy ion collisions

J-P Lansberg arxiv 1003.4319

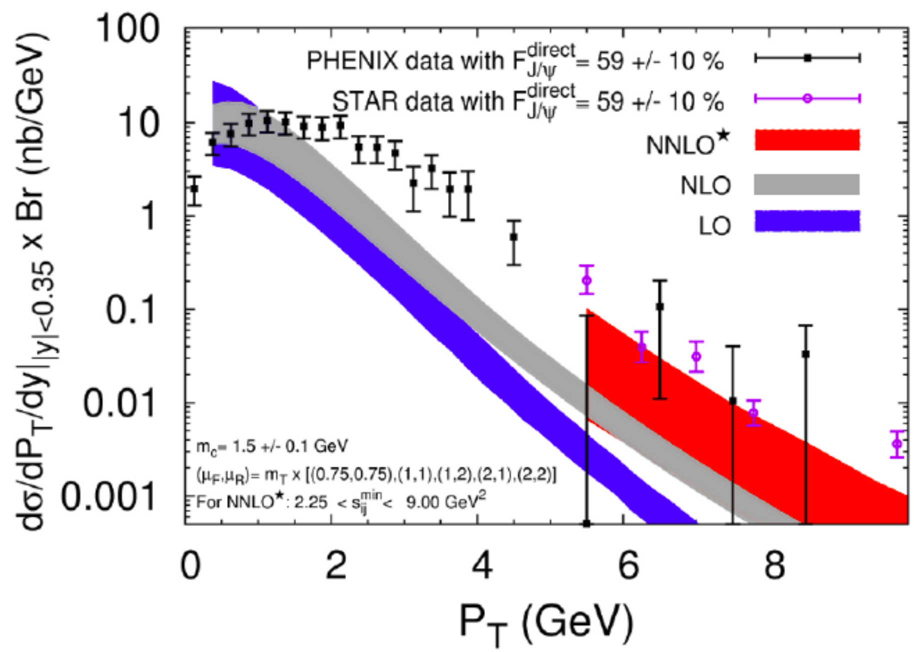
Physics motivation

Cross section

CEM: fit over data, not very predictive
CSM: NLO better than LO (but LO ok for low p_T)
COM (NRQCD): reproduces well the data



N.Brambilla et al. - arXiv:hep-ph/0412158v2



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Physics motivation

Few words about polarization

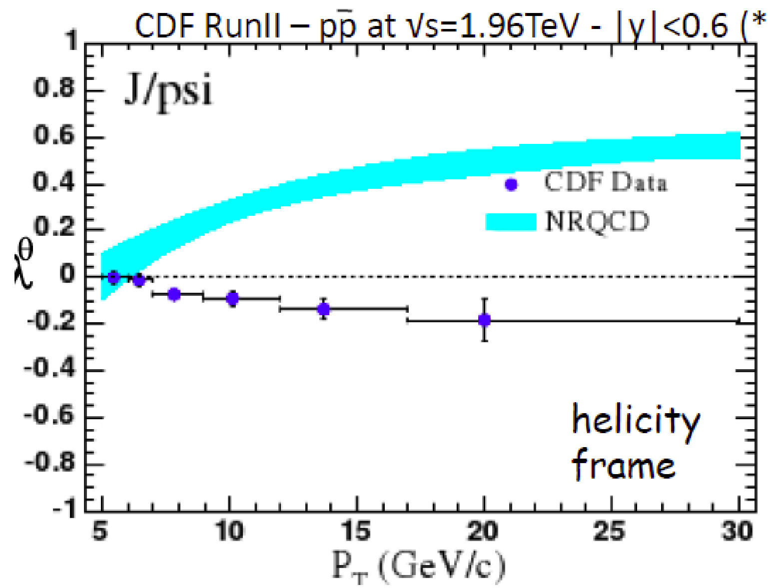
The models make different prediction about the polarization

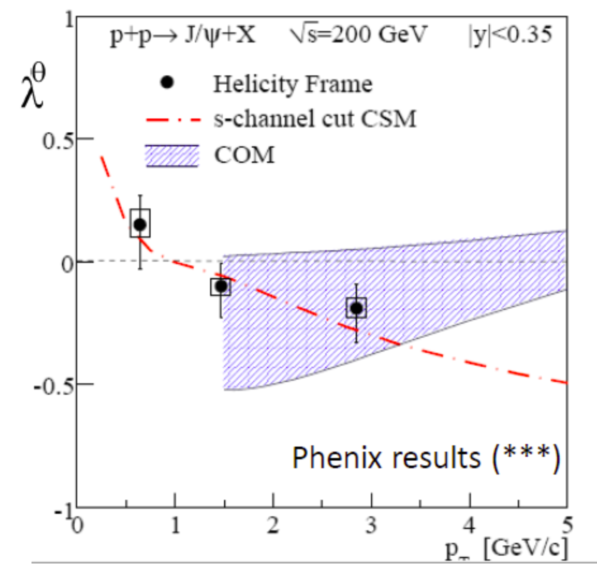
CEM: None

COM (NRQCD): Transverse polarization at high p_T

CSM: Longitudinal at high p_T

The polarization is a good way to discriminate among models





(**) A. Abulencia et al., The CDF Collaboration, Phys. Rev. Lett. 99, 132001 (2007)

(***) Phenix Collaboration, Phys. Rev. D 82, 012001 (2010)

Physics motivation

How ?

- Using the central barrel: $J/\psi \rightarrow e^-e^+$ (BR = 5.94 %)
- With the muon spectrometer: $J/\psi \rightarrow \mu^-\mu^+$ (BR = 5.93 %)

Which J/ψ ?

Inclusive J/ψ

- Prompt J/ψ
  - Direct production: 60 %
  - Feed down (χ_c,ψ') : 30 %
- J/ψ from B
  - b chain decay (10 %)

Difficult in the muon spectrometer
- 3 muon event
- B cross section in single μ

The ALICE detector

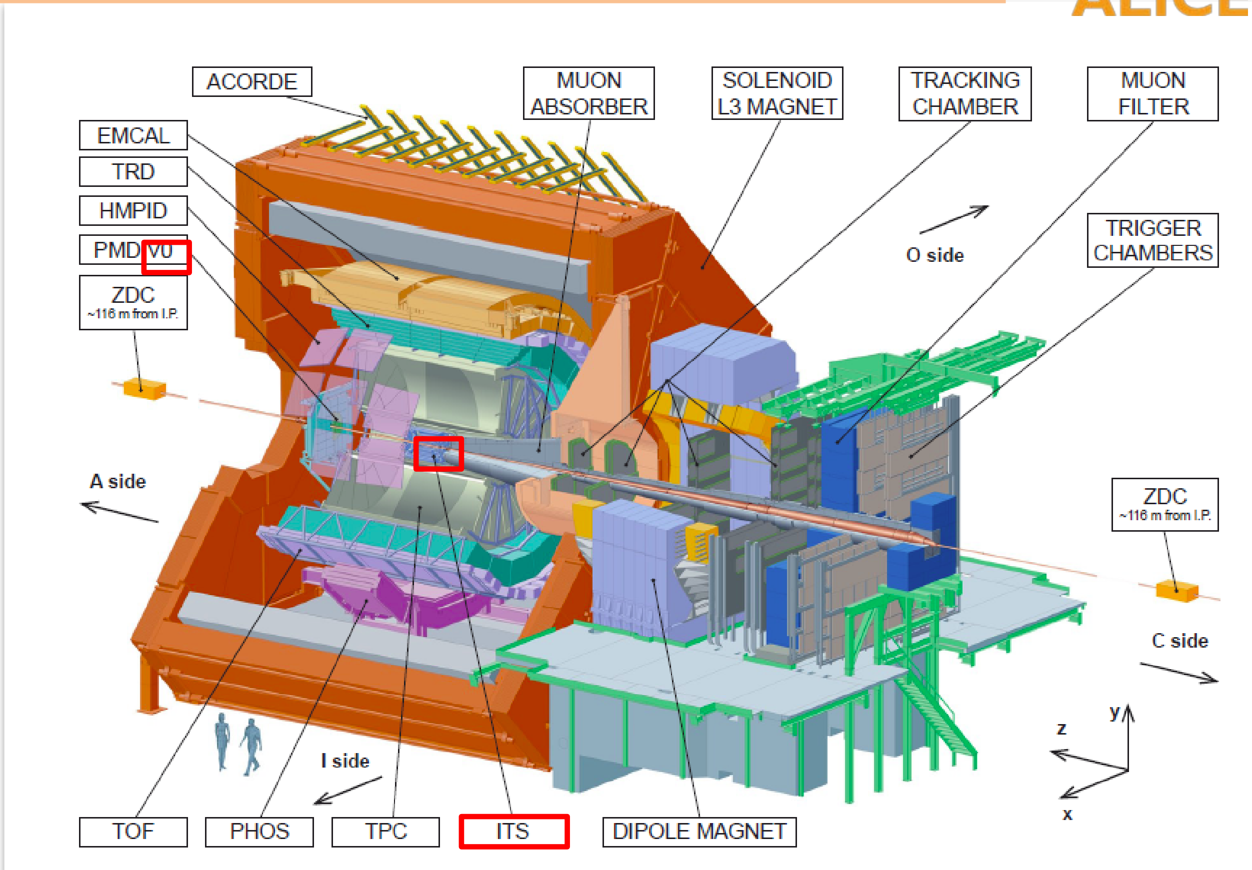
ALICE is the dedicated LHC experiment to heavy-ion studies

p + p collisions

Ref for heavy ion studies
pp physics

Pb + Pb collisions

QGP studies



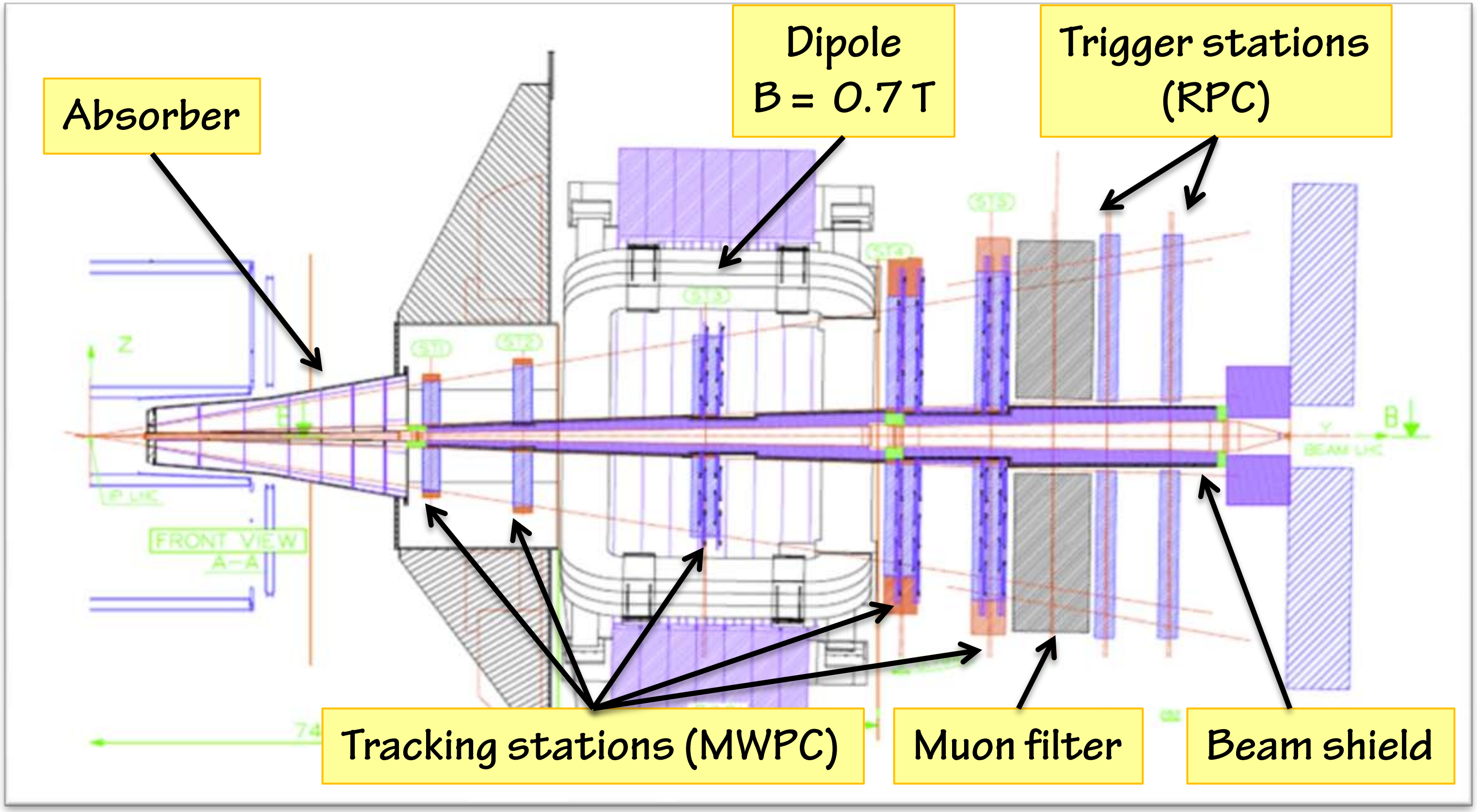
Central barrel
($|\eta| < 0.9$)

→ Quarkonia in dielectrons, jet, strangeness…

Two important detectors for all physics analysis:

- V0 (V0A,V0C) and the SPD → **Min.Bias** trigger signal (**SPD OR V0A OR V0C**).
- SPD → Vertex localisation

The ALICE muon spectrometer



- Heavy flavour (J/ψ,ψ’,Υ,Υ’,Υ’’) and low mass resonance study in dimuon channel.
- Expected resolution of **70 MeV/c²** for the **J/ψ** and **100 MeV/c²** for the **Υ** family.
- Acceptance: - 4 < η < -2.5

Data sample and cuts

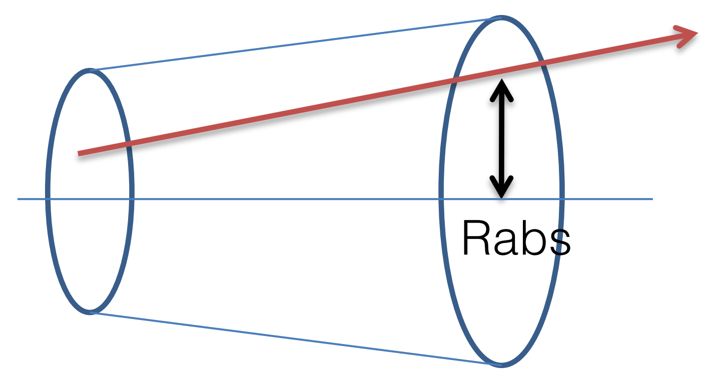
Analysis results are based on the following periods

Period	Time	Integrated luminosity	Comments
LHC10c1	May 2010	2.0 nb^{-1}	• Low beam intensity
LHC10d1	June 2010	6.9 nb^{-1}	• High beam intensity
LHC10d2b	July 2010	4.7 nb^{-1}	• Low beam intensity

Total integrated luminosity: 13. 6 nb^{-1}

<u>Default cuts used for analysis</u>:

1 reconstructed vertex in the SPD
1 muon match the trigger
Cut on $R_{absorber}$

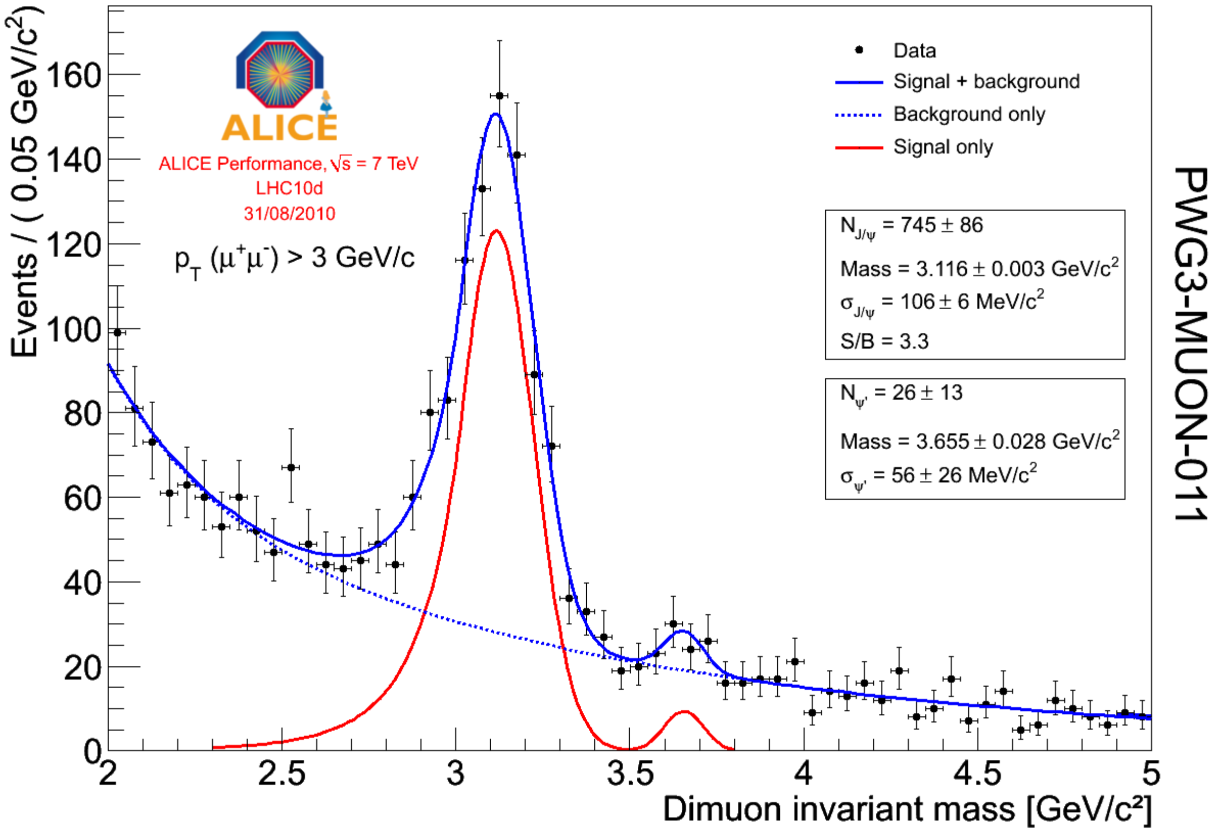


J/ψ yield extraction

- Example of J/ψ invariant mass plot (cuts tuned to enhance the ψ' (2S) signal)

- The fit is a sum of a crystal ball function for the J/ψ and ψ' plus a double exponential for the background.

- Integrated luminosity: 6.9 nb^{-1}

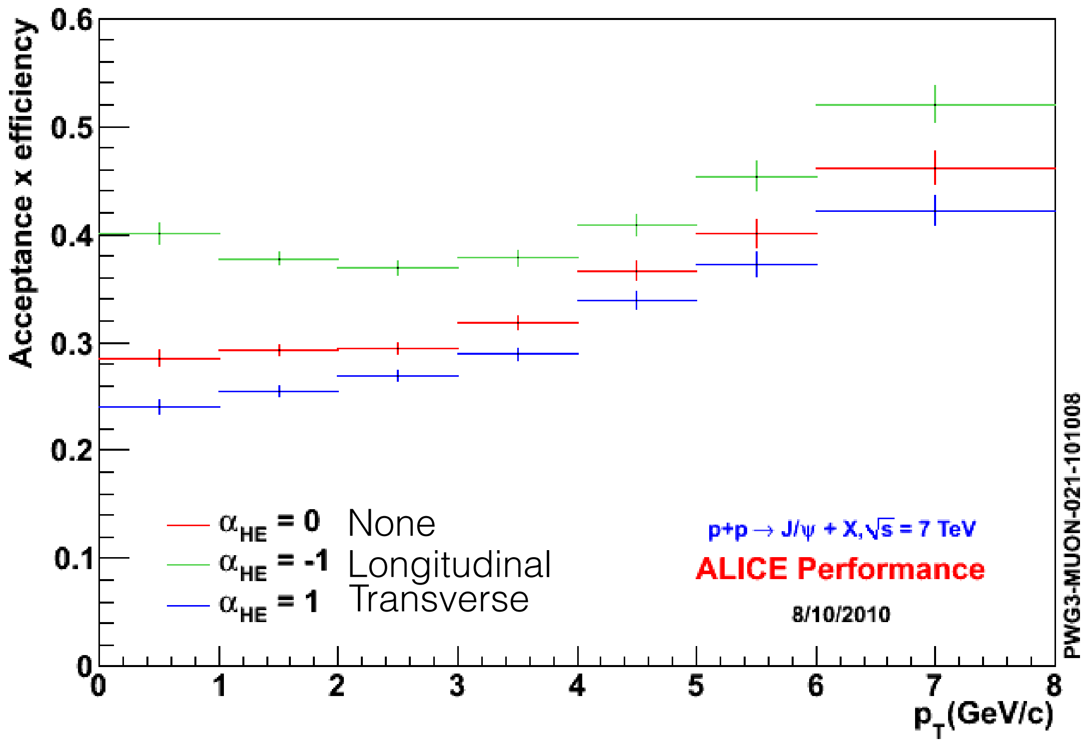


Another fit function « NA60 » (3 gaussians with different sigmas) works well

Crystal Ball + « NA60 » give the J/ψ yield extraction systematical uncertainty

Acc x eff correction

- Correction based on realistic MC simulation for each period
- Simulation performed with realistic inputs: CDFf or p_T, CEM for y
- Polarization taken into account

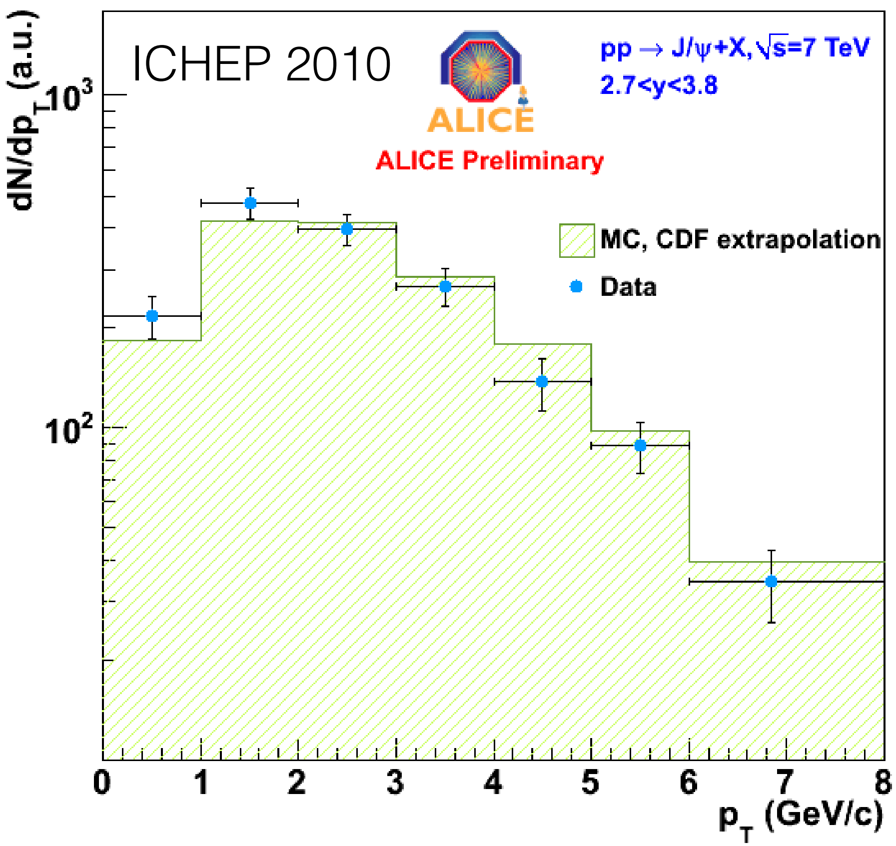


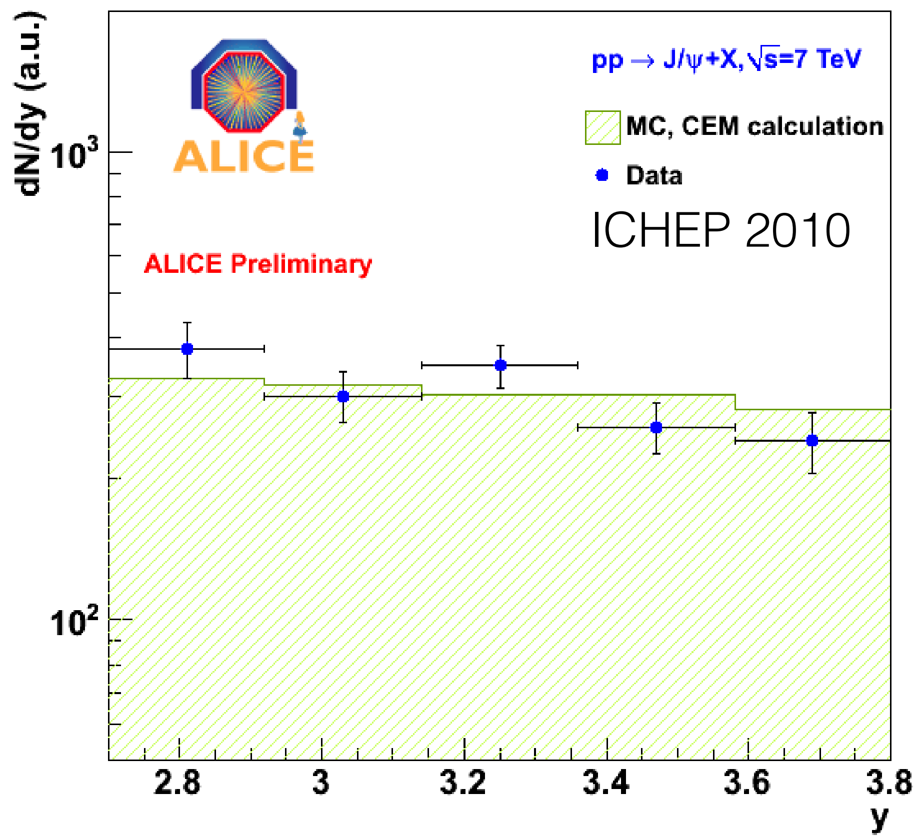
Acceptance x efficiency evaluated for three different polarization scenarios in the helicity frame

Polarization changes the acc x eff

Acc x eff correction

J/ψ p_T and y distributions, corrected for acceptance and efficiency, compared to Monte Carlo simulations (CDF extrapolation).





• p_T distribution: real data are softer than the MC but the difference is negligible so we can apply the correction.

Normalization

- To get an estimation of the luminosity we use the signal from the V0 (V0A and V0C in coincidence → **V0and**).

- Using a Van der Meer scan we get the Luminosity
  → **σ_{V0and} = 62.3 mb** with 10% systematic

- With low intensity runs (to avoid large pile-up) we can extract the ratio V0and/CINT1B
  → **σ_{CINT1B}**= σ_{V0and} / (V0and/CINT1B) **= 71.4 mb**

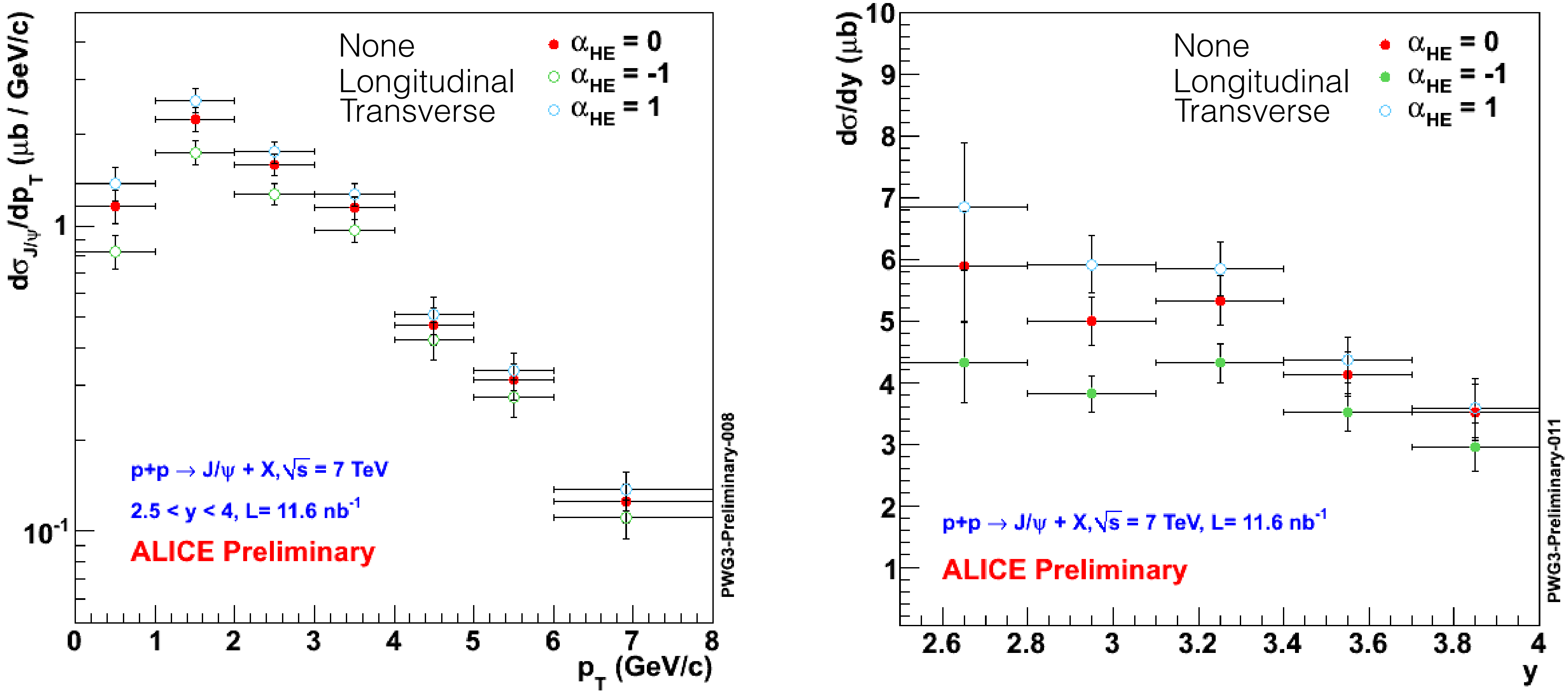
We use σ_{CINT1B} to normalize the cross section with the following formula (most of data come from single μ trigger):

$$\sigma_{J/\psi} = \frac{N_{J/\psi|single\ \mu}}{Acc \times \varepsilon} \times \frac{1}{N_{\mu|single\ \mu}} \times \frac{N_{\mu|CINT1B}}{N_{CINT1B\ (pile\ up\ corr)}} \times \sigma_{CINT1B}$$

Systematic uncertainties on cross section

Origin	Value
Signal extraction	7.5 %
p_T and y shapes used in MC	p_T: +2 % -1.3% Y: + 1.4%, - 1.3%
Trigger efficiency	4 %
Tracking efficiency	2 %
Normalization	10 %
Syst uncertaities combined	**13.5 %**
Polarization	+ 12.0 % - 20.7 %

J/ψ differential cross section



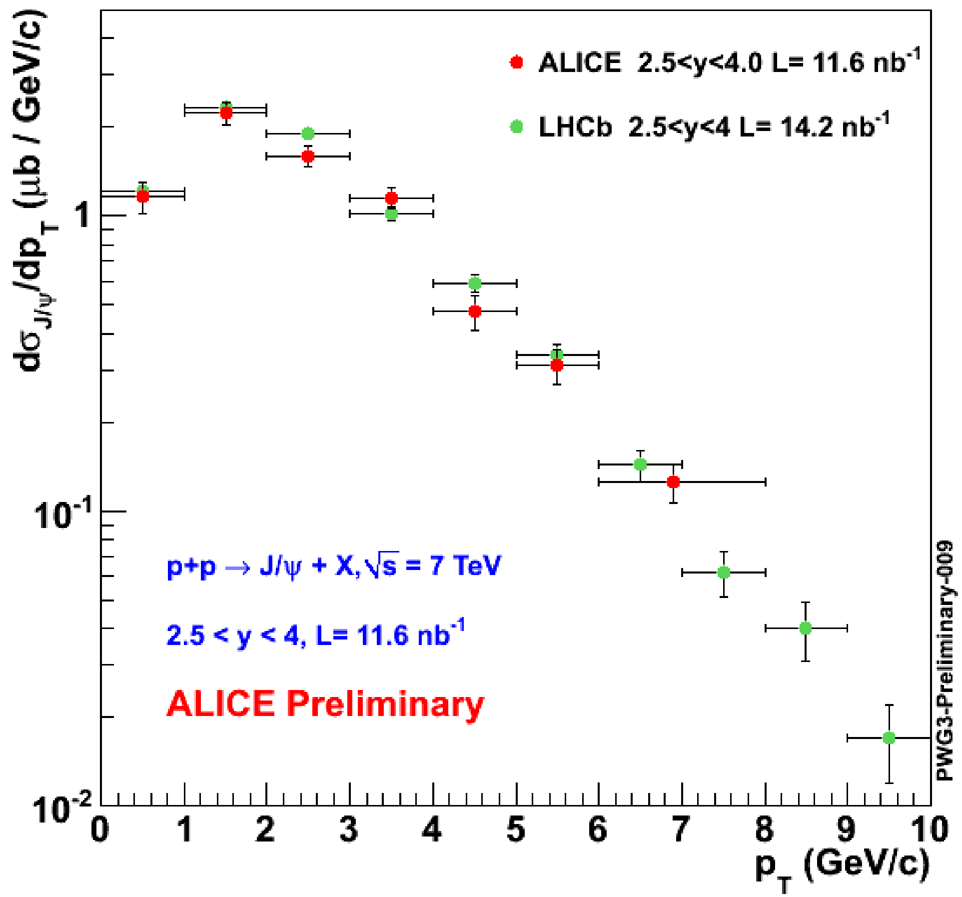
The polarization is an important source of uncertainty

J/ψ differential cross section

ALICE vs LHCb

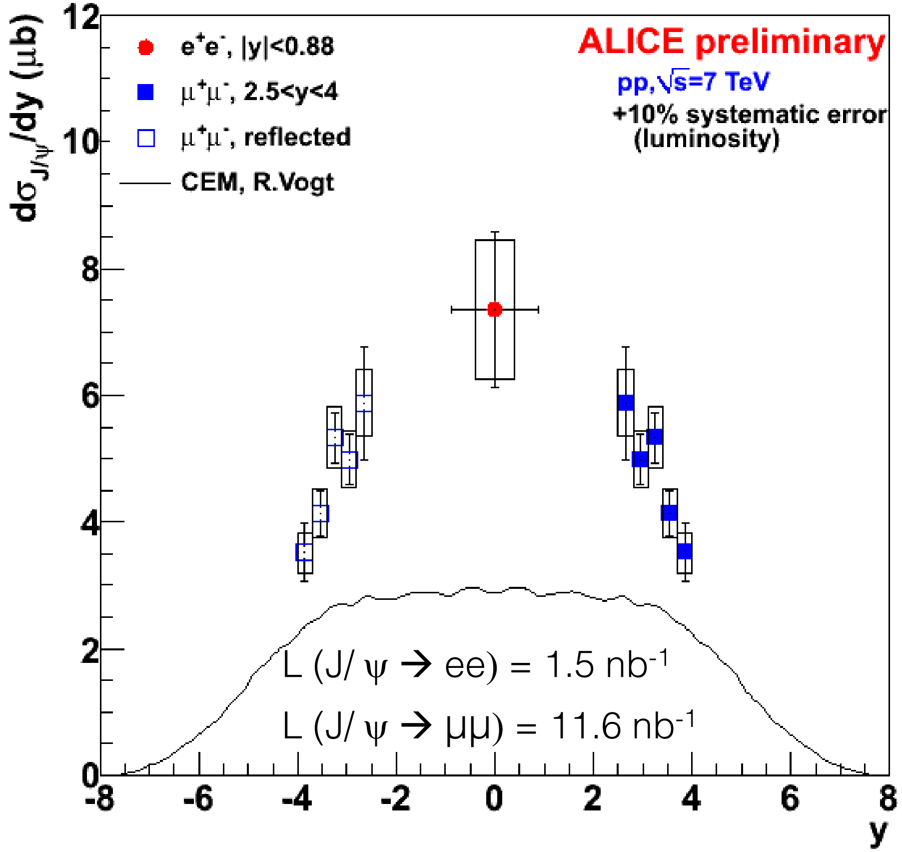
dσ/d p_T J/ψ distribution as above, compared to the result obtained in the same y range (2.5<y<4) by the LHCb experiment (result shown at ICHEP2010)

Our results are in very good agreement with LHCb results in the same rapidity range

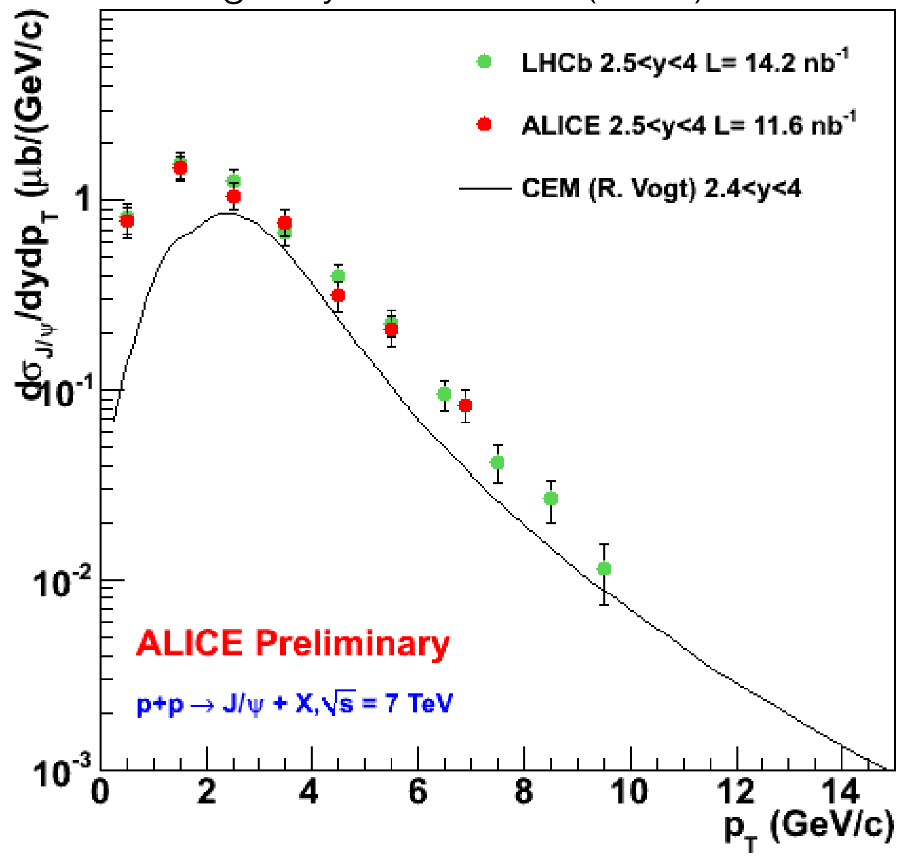


J/ψ differential cross section

Data VS CEM



R.Vogt Phys. Rev. C 81 (2010) 044903



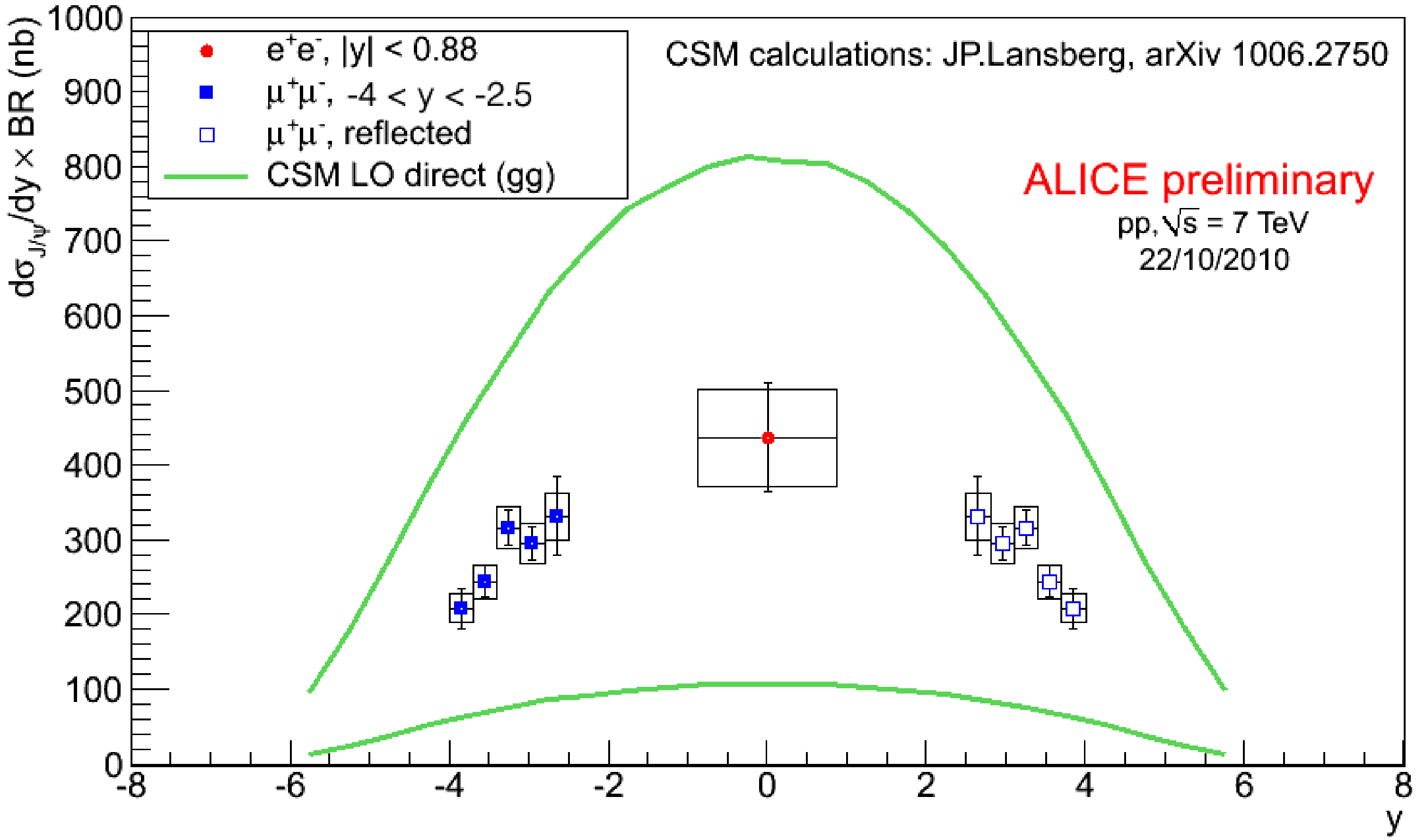
- y dependance: model is flatter than data
- p_T dependance: CEM (prompt J/ ψ) does not reproduce the data at low p_T but the shape is similar for data with p_T > 2 GeV/c

J/ψ differential cross section

Data vs. CSM

L (J/ ψ → ee) = 1.5 nb^{-1}

L (J/ ψ → μμ) = 11.6 nb^{-1}



CSM LO direct (gg) seems to reproduce the y dependence.

Summary and outlook

- We have presented the differential J/ψ cross section in the dimuon channel
  → our results are in very good agreement with LHCb.

- p_T and y dependances seem not to be reproduced by the CEM but theoretical uncertainties are high.
  →cross section does not constraint the model, other observables are needed: polarization.

- y dependence seems to be well reproduced by CSM LO direct(gg)

- A high intensity run is done
  → we expect to have enough J/ψ to study the polarization
  → Reduce the systematic associated

- We are very close to the first heavy ion run !