Heavy ion meeting

26/11/2010

First results on J/ψ production at forward rapidity at ALICE

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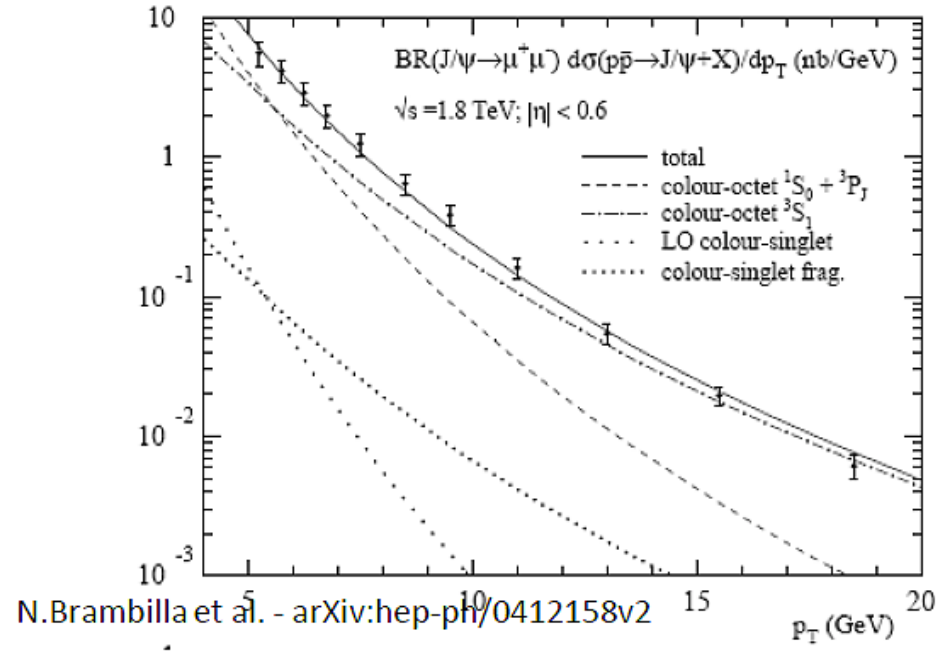
Outline

- Physics motivation
- The ALICE experiment
- Data sample and cuts
- J/ψ analysis
    - Extraction yield
    - Acc x eff correction
    - Normalization
- Results pp @ 7 TeV
- Conclusion

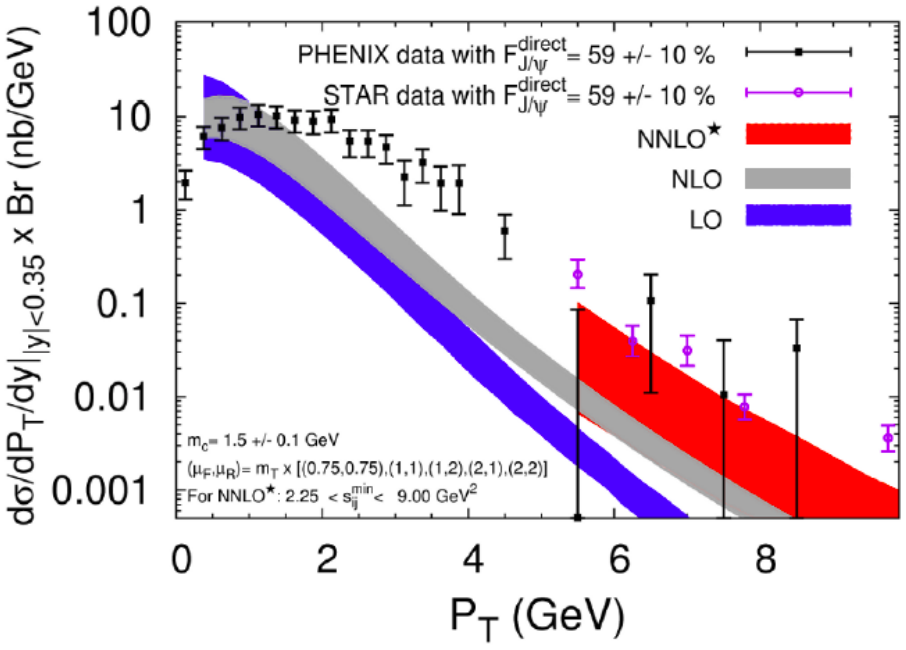
Physics motivation

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



J-P Lansberg arxiv 1003.4319

Physics motivation

Few words about polarization

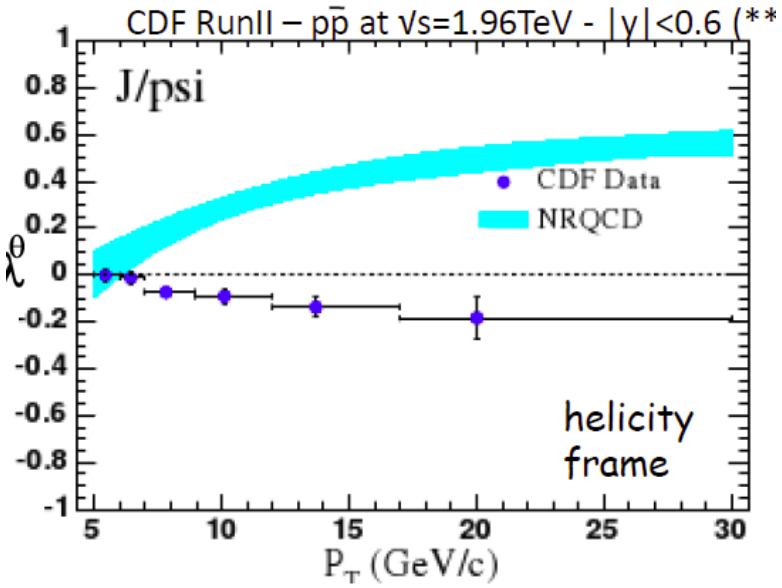
The models make different prediction about the polarization

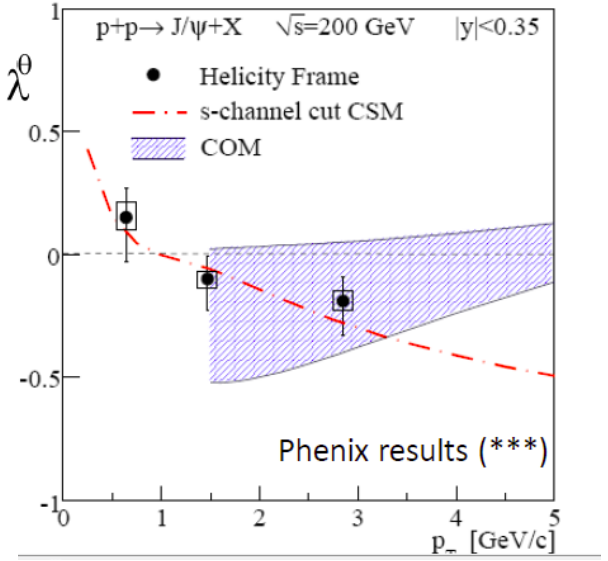
CEM: None

COM: 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)

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 to separate in the muon spectrometer
- 3 muon events
- B cross section in single μ

The ALICE detector

ALICE is the dedicated LHC experiment to heavy-ion studies

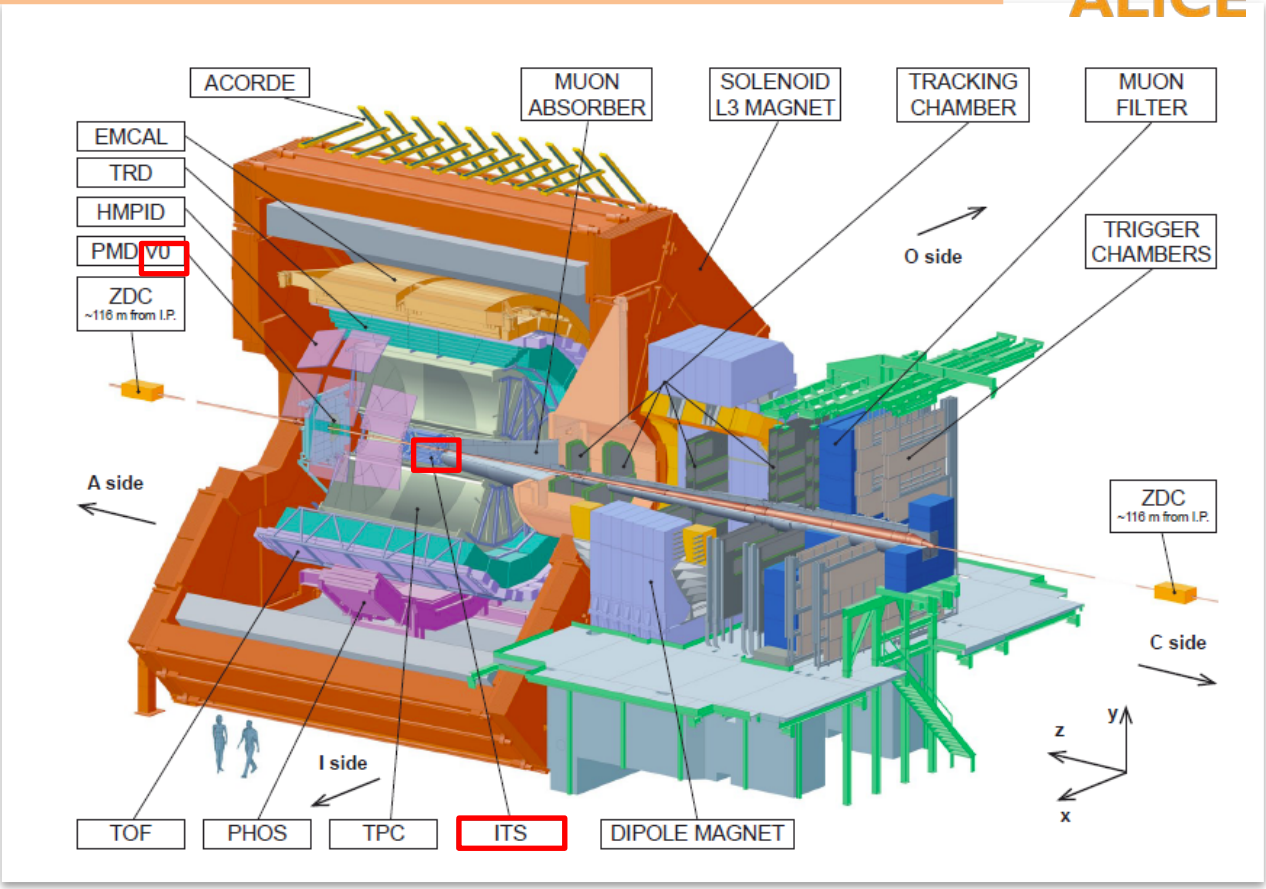
p + p collisions

Ref for heavy ion studies pp physics

Pb + Pb collisions

QGP studies

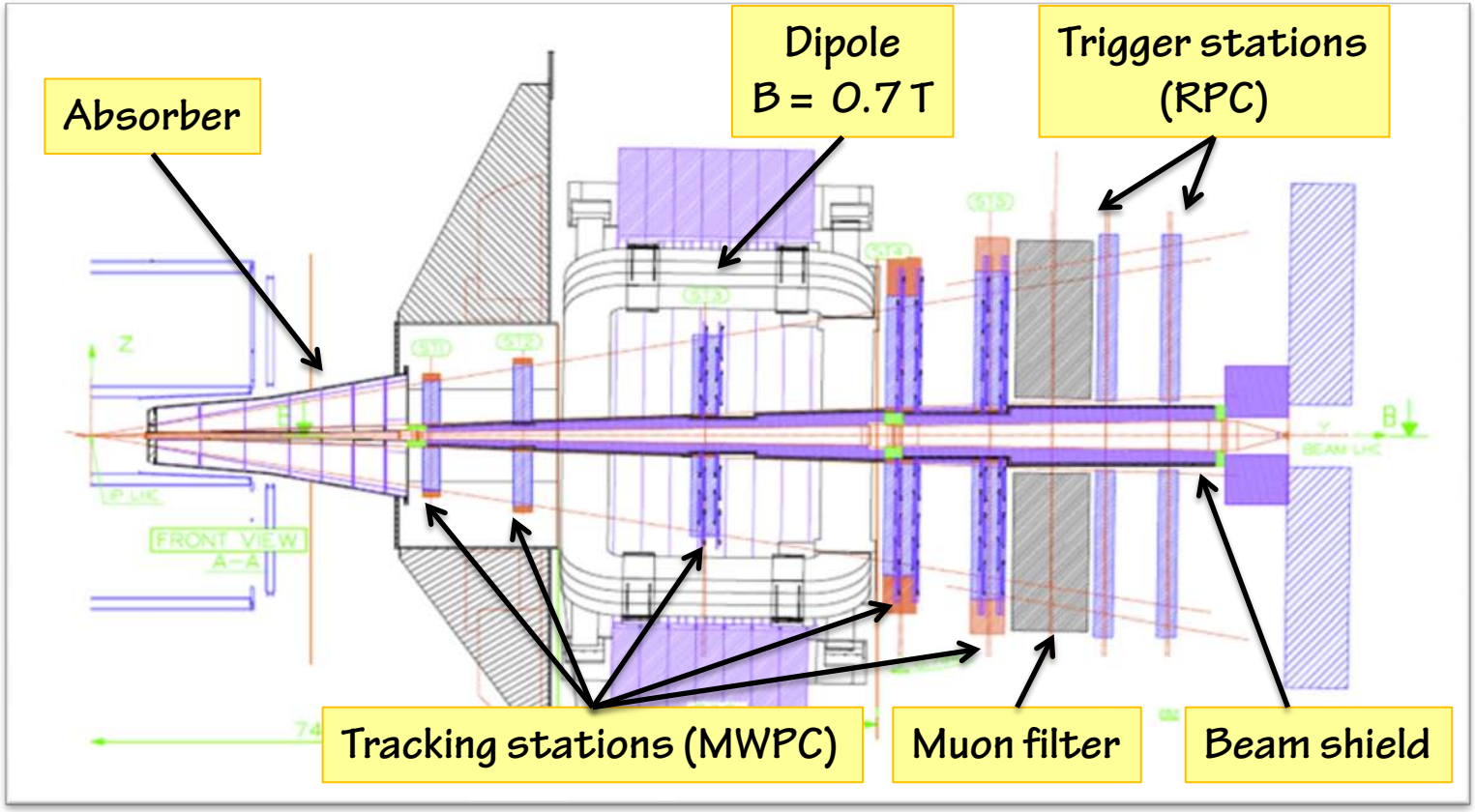
Central barrel ($|\eta| < 0.9$)



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 ($J/\psi, \psi', \Upsilon, \Upsilon', \Upsilon''$) 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: $-4 < \eta < -2.5$

Data sample and cuts

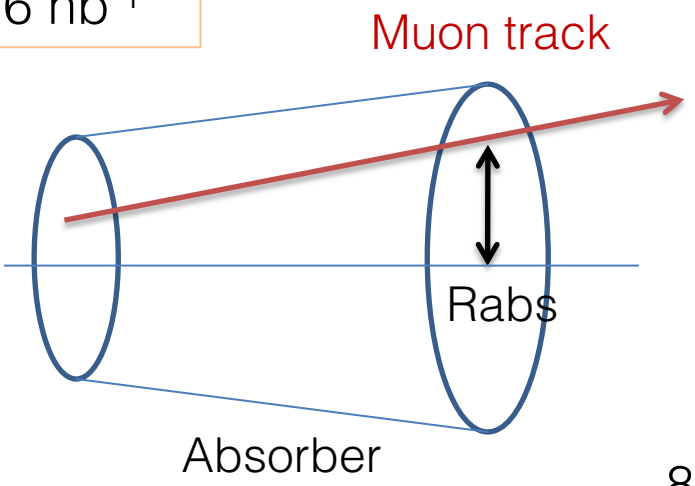
Analysis results are based on the following periods

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 $R_{absorber}$



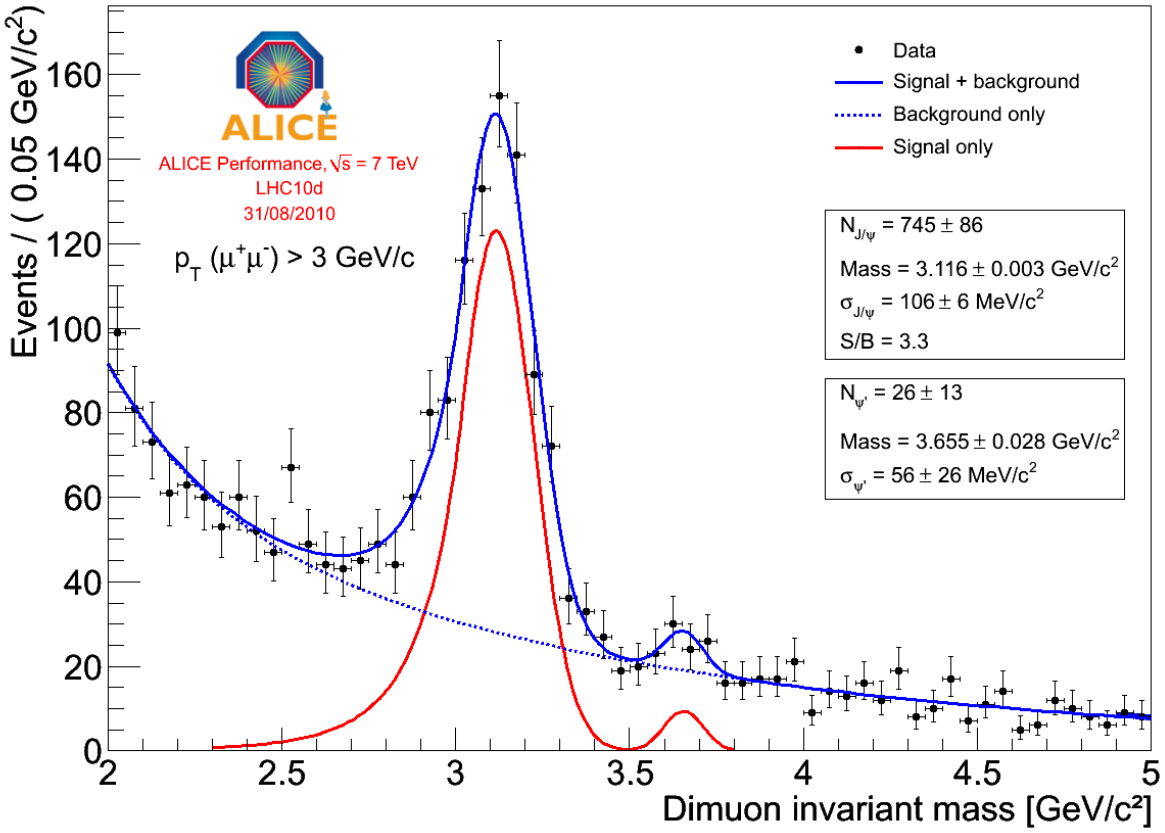
J/ψ yield extraction

pp @ 7 TeV

- 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}



PWG3-MUON-011

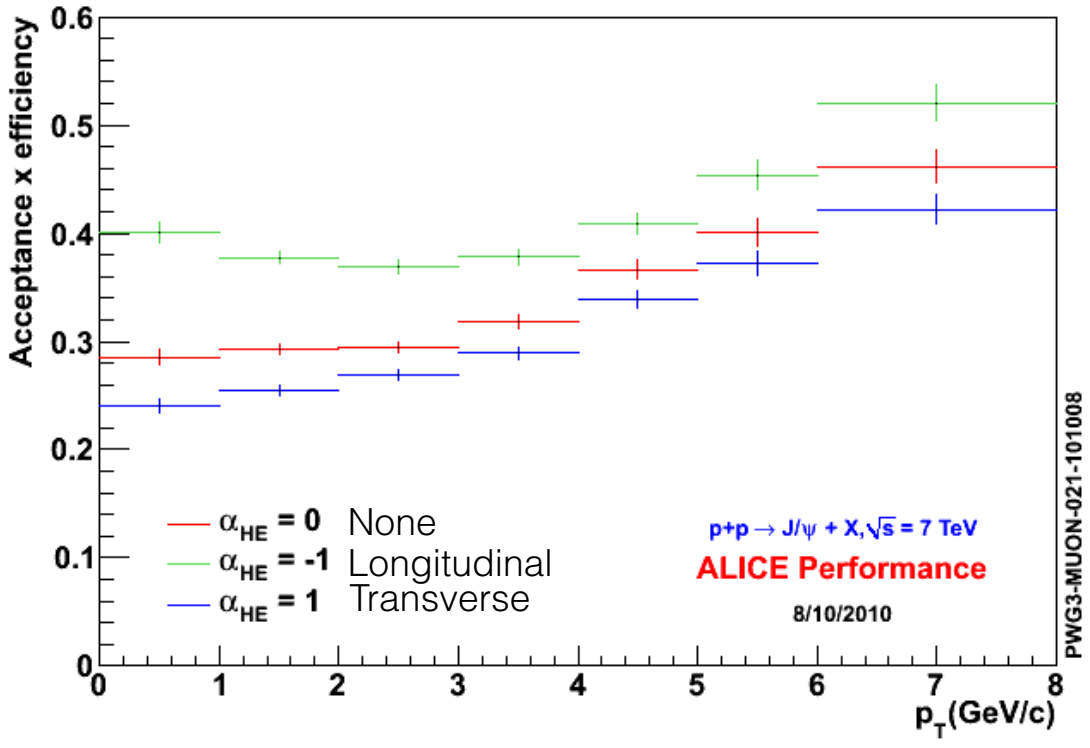
Another fitting function « NA60 » (3 gaussians with different sigmas) works well

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

Acc x eff correction

pp @ 7 TeV

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



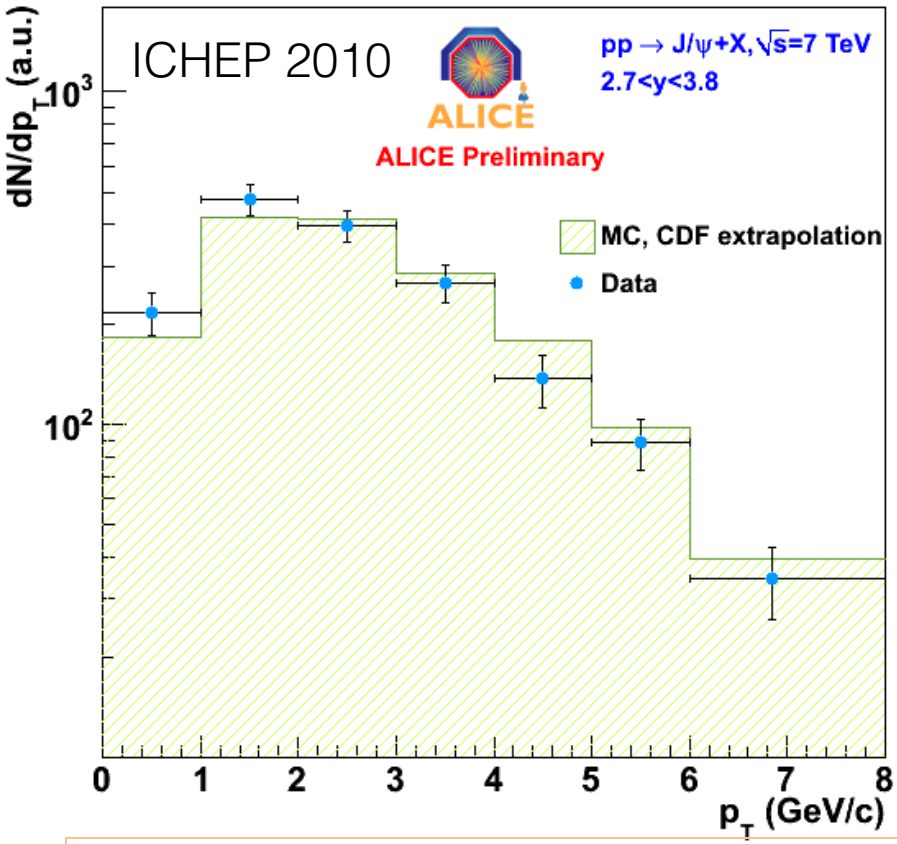
Acceptance x efficiency evaluated for three different polarization scenarios in the helicity frame

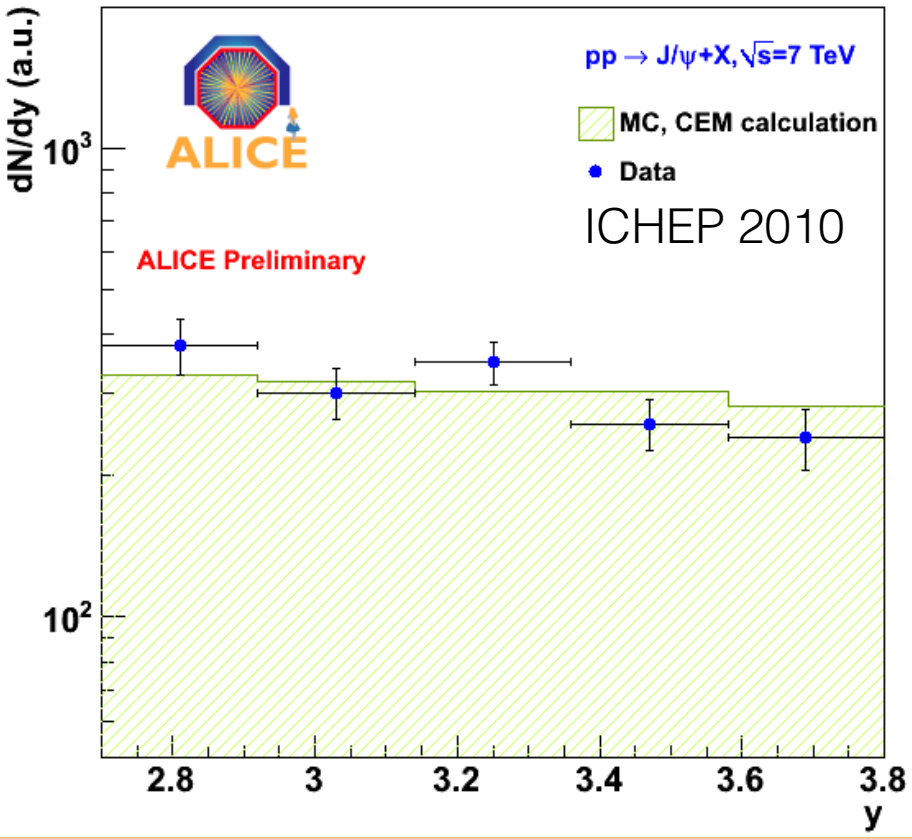
Acc x Eff is sensitive to polarisation

Acc x eff correction

pp @ 7 TeV

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.

- CINT1B is our main MB trigger in pp. CINT1B = V0A or V0C or SMB (a pixel trigger)
  → 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):

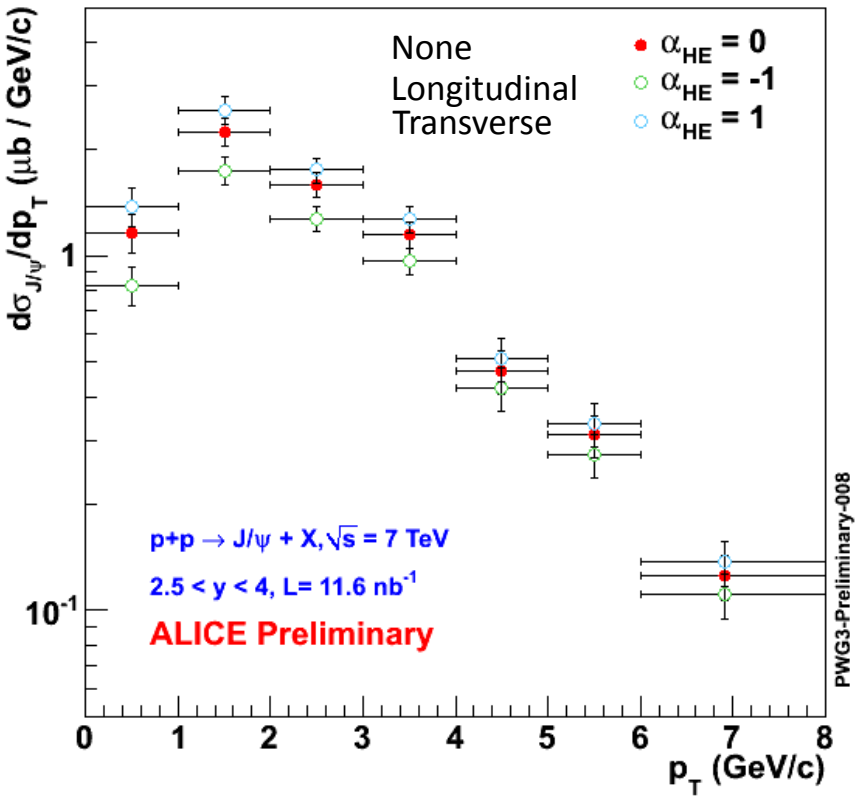
$$\sigma_{J/\psi} = \frac{N_{J/\psi|single\ \mu}}{Acc \times \varepsilon} \times \frac{1}{N_{\mu|single\ \mu}} \times \frac{N_{\mu|CINT1B}}{N_{CINT1B\ (pile\ up\ corr)}} \times \sigma_{CINT1B}$$

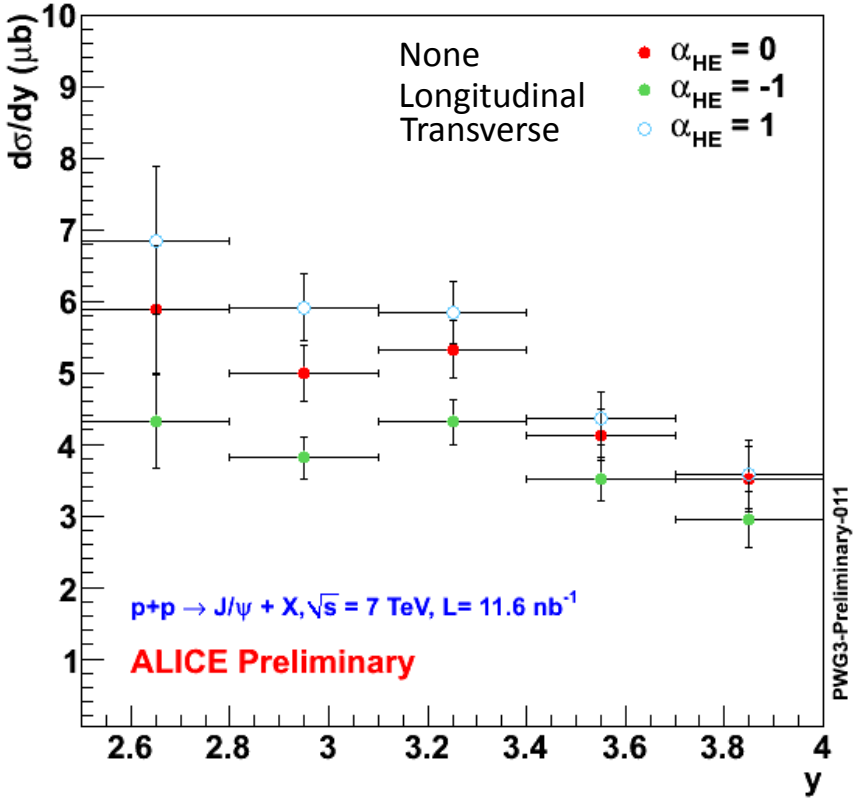
Systematic uncertainties on cross section

Source	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 uncertainties combined	13.5 %
Polarization	+ 12.0 % - 20.7 %

J/ψ differential cross section

pp @ 7 TeV





The polarization is an important source of uncertainty

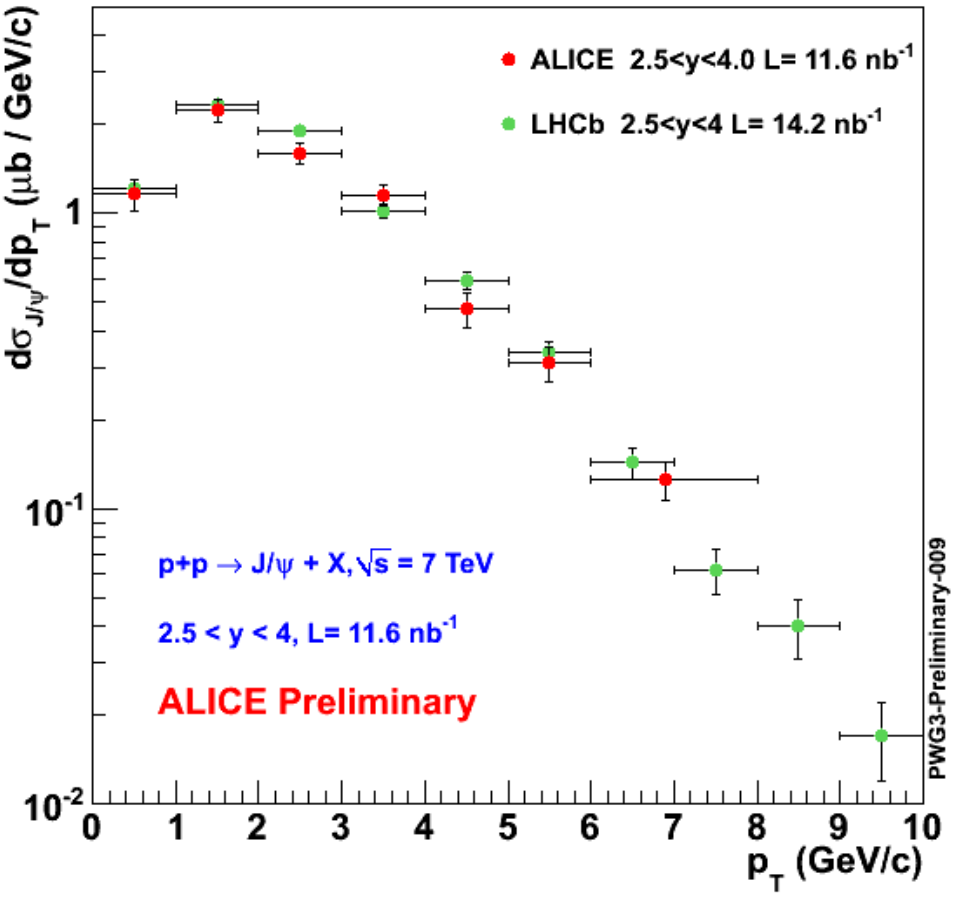
J/ψ differential cross section

pp @ 7 TeV

ALICE vs LHCb

$d\sigma/d\ p_T$ J/ψ distribution as above, compared to the result obtained in the same y range (2.5<y<4) by the LHCb experiment.

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



J/ψ absolute cross section

pp @ 7 TeV

ALICE

$\sigma_{J/\psi}(2.5 < y < 4) = 7.25 \pm 0.29\ (\text{stat}) \pm 0.98\ (\text{syst})\ ^{+1.09}_{-2.25}\ (\text{syst pol})\ \mu b$

LHCb (P. Robbe et al. (LHCb collaboration), LHCb-CONF-2010-010)

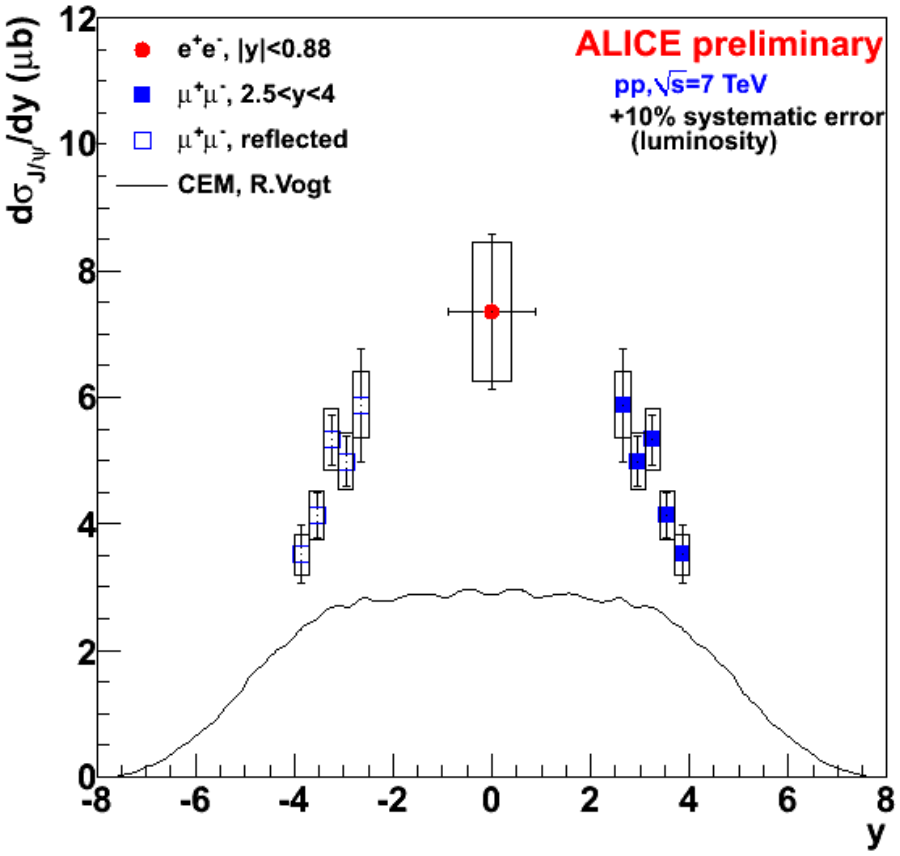
$\sigma_{J/\psi}(2.5 < y < 4) = 7.65 \pm 0.19\ (\text{stat}) \pm 1.10\ (\text{syst})\ ^{+0.87}_{-1.27}\ (\text{syst pol})\ \mu b$

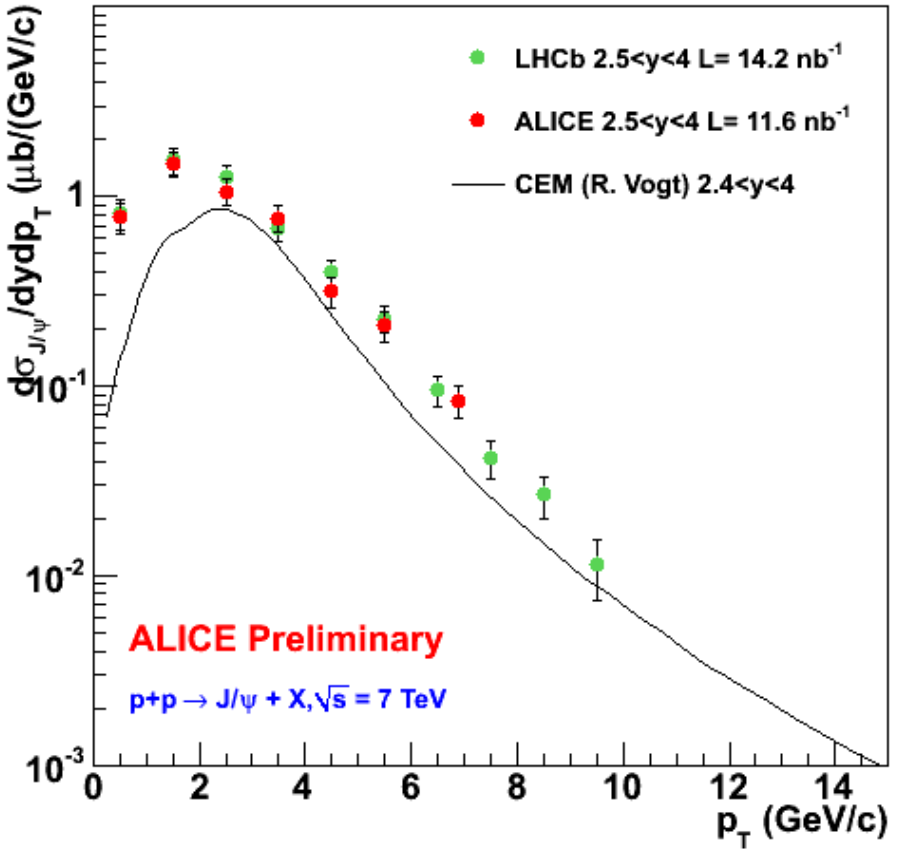
Within the errors, the two measurements are in good agreement.

J/ψ differential cross section

pp @ 7 TeV

Data vs. CEM





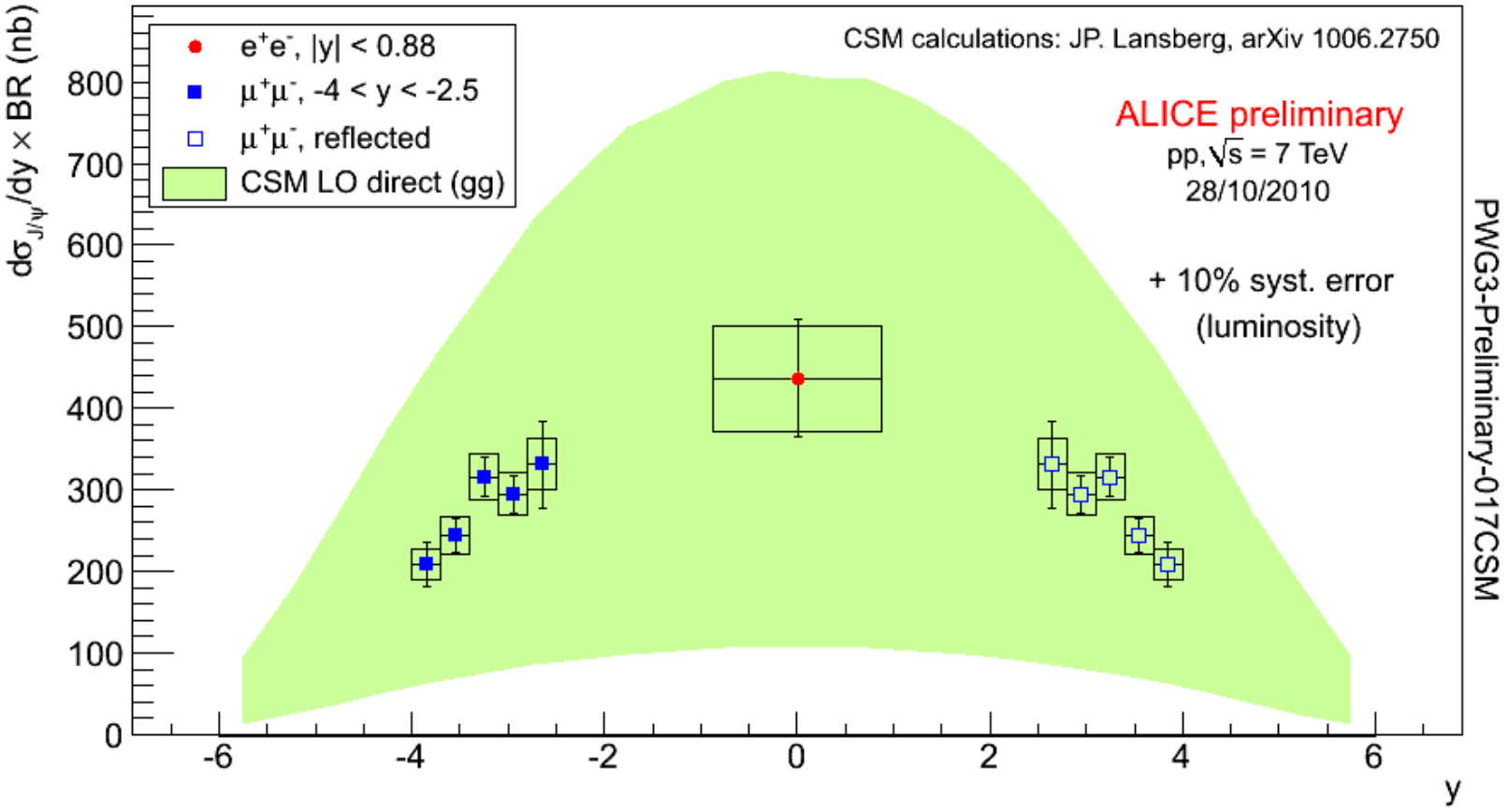
R.Vogt Phys. Rev. C 81 (2010) 044903

- 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

pp @ 7 TeV

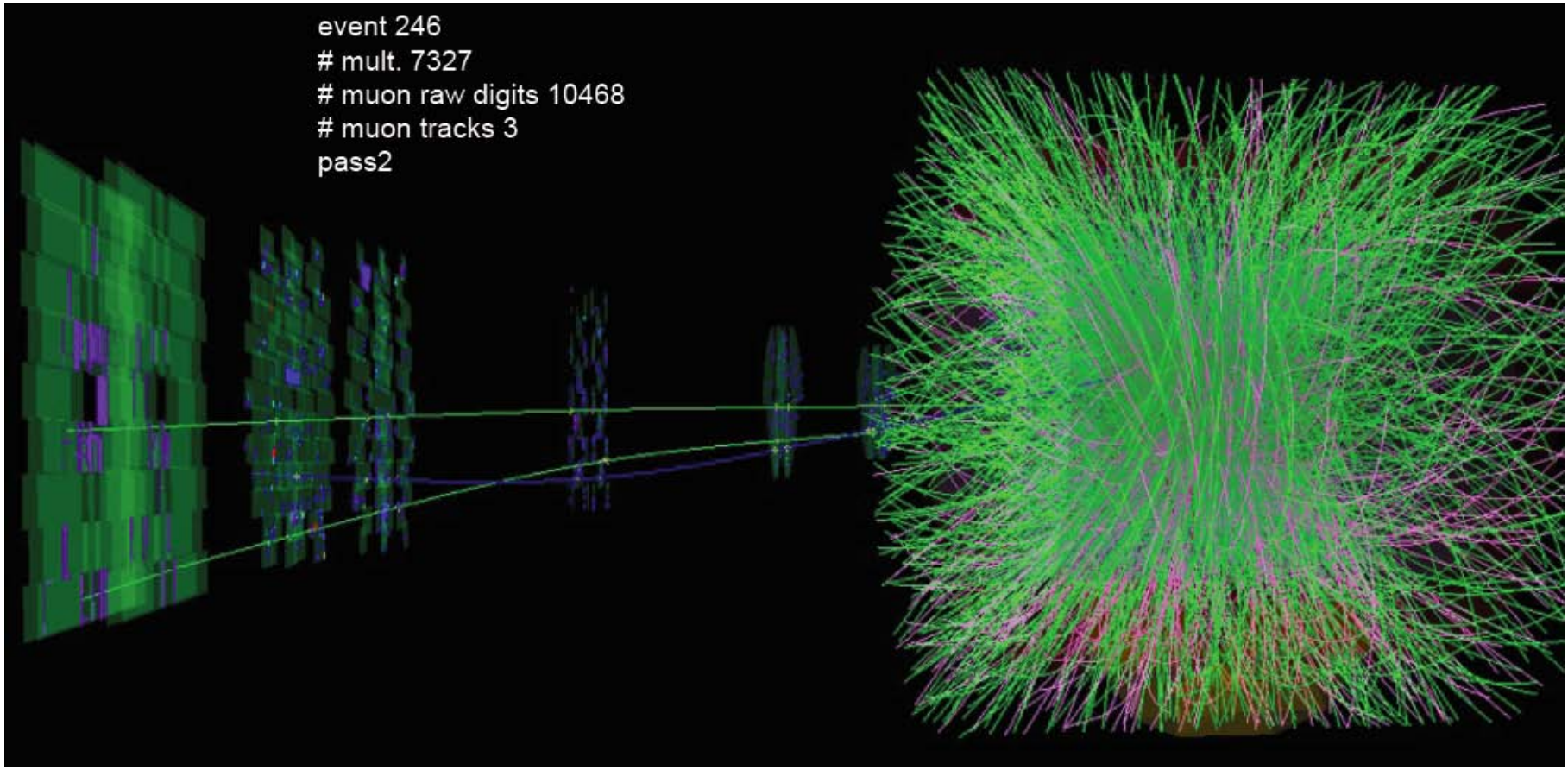
Data vs. CSM



CSM LO direct (gg) reproduce the y dependence.

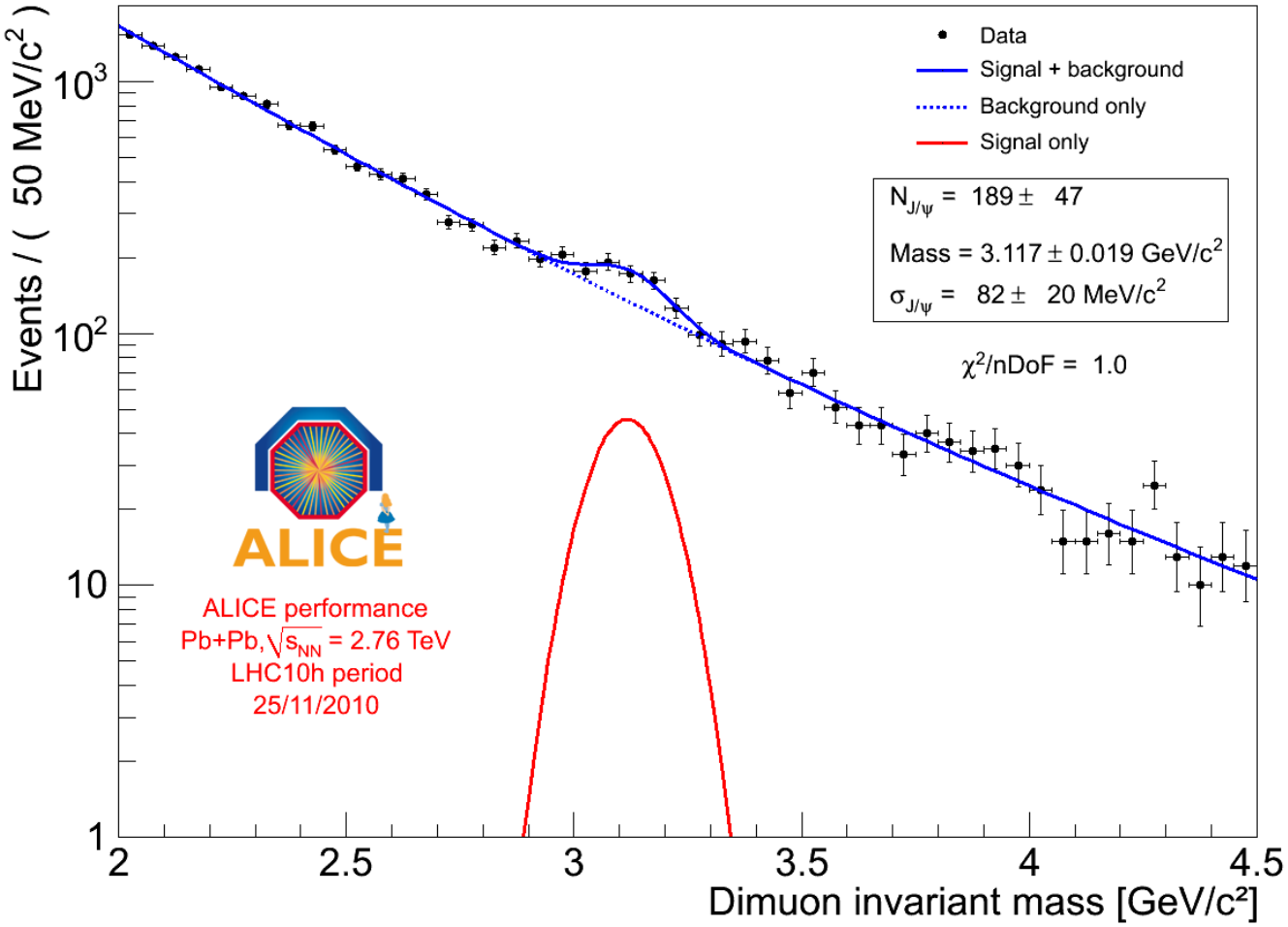
Heavy ion

- LHC is running in heavy ion configuration since November 7th.
- Data taking at $s^{1/2}_{NN}$ = 2.76 TeV is ongoing.



Heavy ions: hunting the J/ψ

J/ψ peak from a sample a runs.



- Triggered events accepted contain V0A + V0C + bunch crossing mask event and/or high multiplicity event
- $17.6 < R_{abs} < 80$ cm
- Rapidity [-4;-2.5] cut on single muon tracks.
- The two tracking tracks match a muon trigger track

Conclusions

• We have presented the differential and absolute J/ψ cross section in pp collisions at 7 TeV 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.

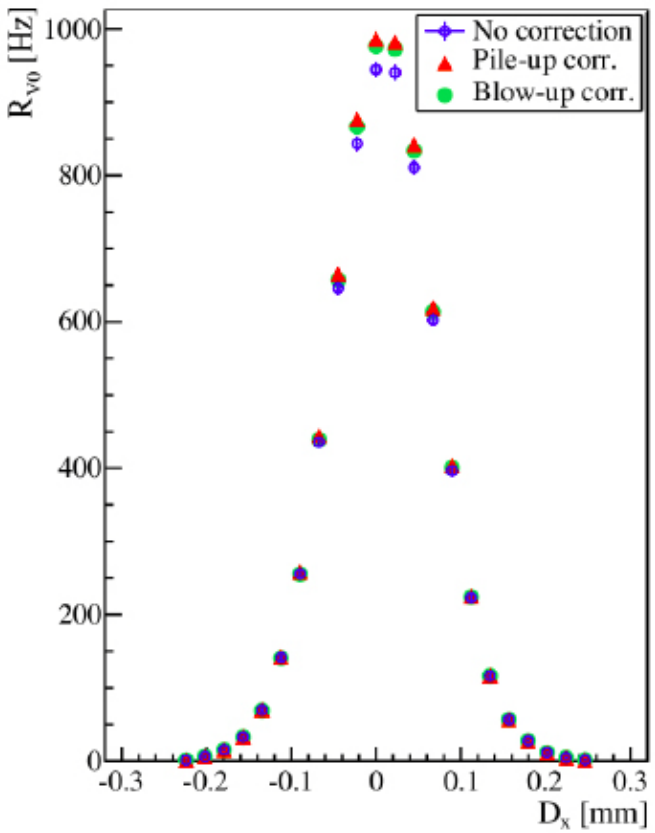
→cross section does not constraint the model, other observables are needed: polarization.

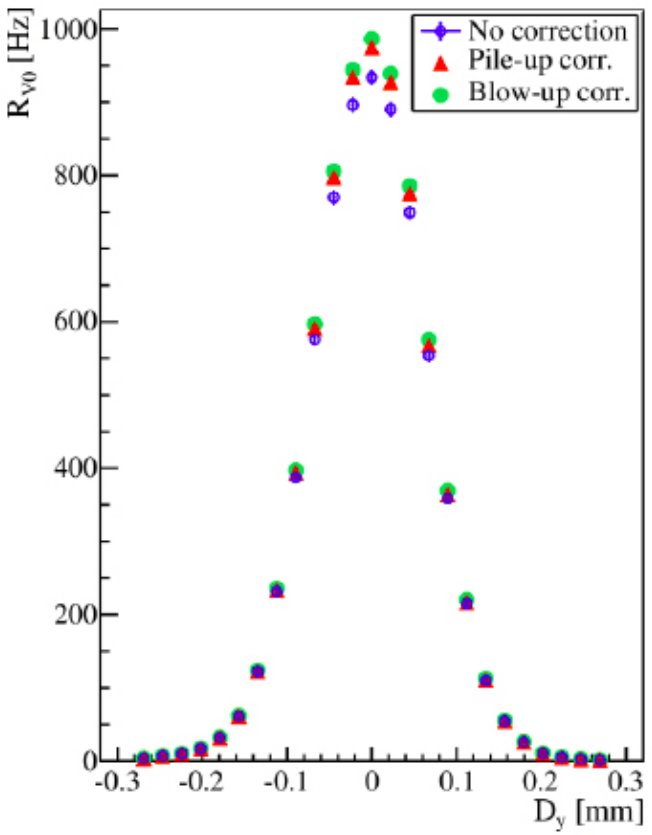
• y dependence seems to be well reproduced by CSM LO direct(gg)

• At midrapidity, the pQCD (NLO) calculations seems to reproduce well the trend of the cross section.

• First heavy ions data are available → the J/ψ is here !

Van der Meer scan

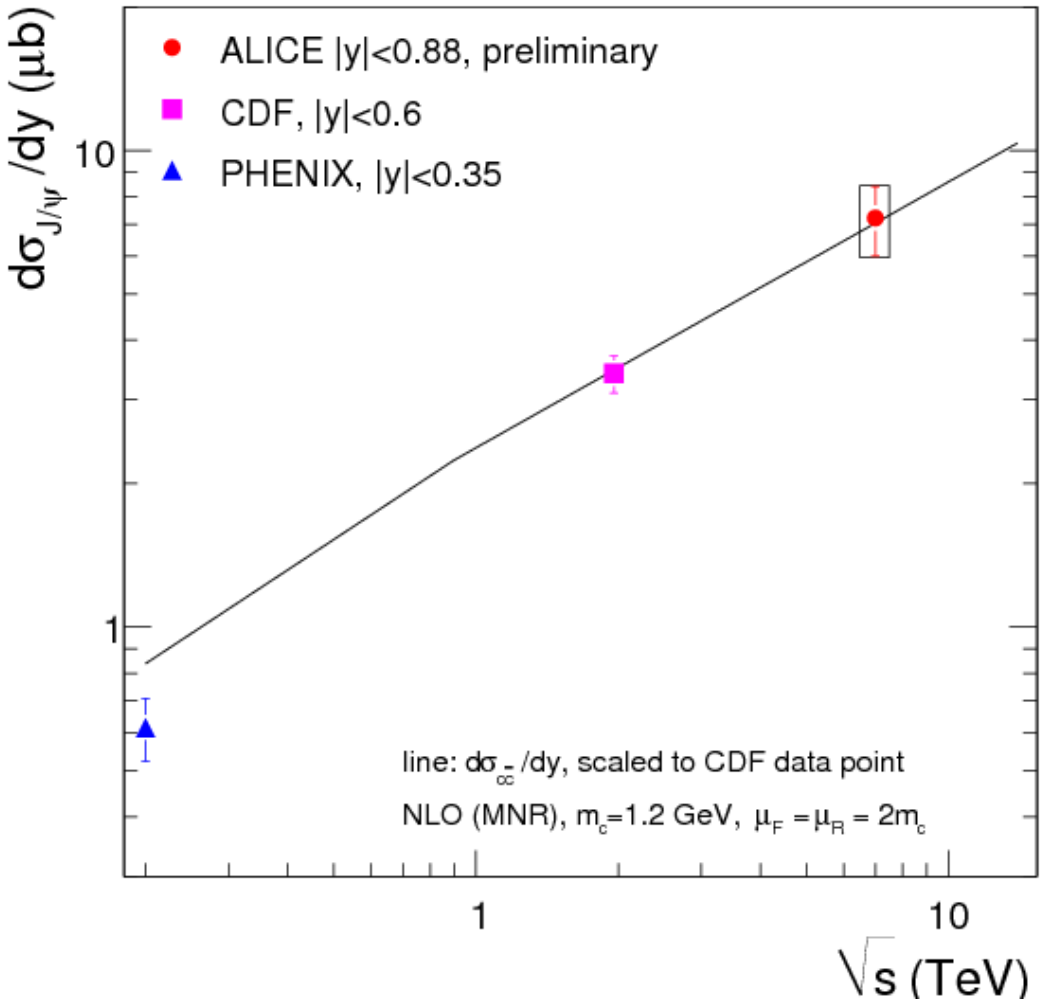




With a double gaussian fit we can extract L and σ_{V0and}

$$L(0,0) = k_b f N_1 N_2 \frac{R^2(0,0)}{S_x S_y} \qquad \sigma_{V0} = \frac{S_x S_y}{k_b f_{rev} \langle R(0,0) \rangle}$$

A midrapidity result



Measured cross section at midrapidity as a function of collisions
energy

the pQCD (NLO) calculations seems to be in good agreement with the data