After the first quarkonium data at $\sqrt{s} = 7$ TeV: where do we stand ?

J.P. Lansberg
Paris Sud XI - IPNO

First Retequarkonii Workshop
October 25th-28th 2010
Nantes France

Outline

What we understand:

1. why QCD corrections do matter at mid- and high-P_T

What we seem to understand:

2. The CSM predictions account correctly for the yield
3. Colour Octet Dominance is challenged at low/mid P_T in pp
4. QCD corrections do matter for the polarisation

What we do not understand:

5. ψ production at very large P_T
6. Other features not understood

What we already have from the LHC

7. LHC data which are public so far
8. Polarisation impact on acceptance
9. First comparisons of theory with LHC data

Part I

What we understand

QCD corrections for Υ at the Tevatron

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J.Campbell, F. Maltoni, F. Tramontano, Phys.Rev.Lett. 98:252002,2007
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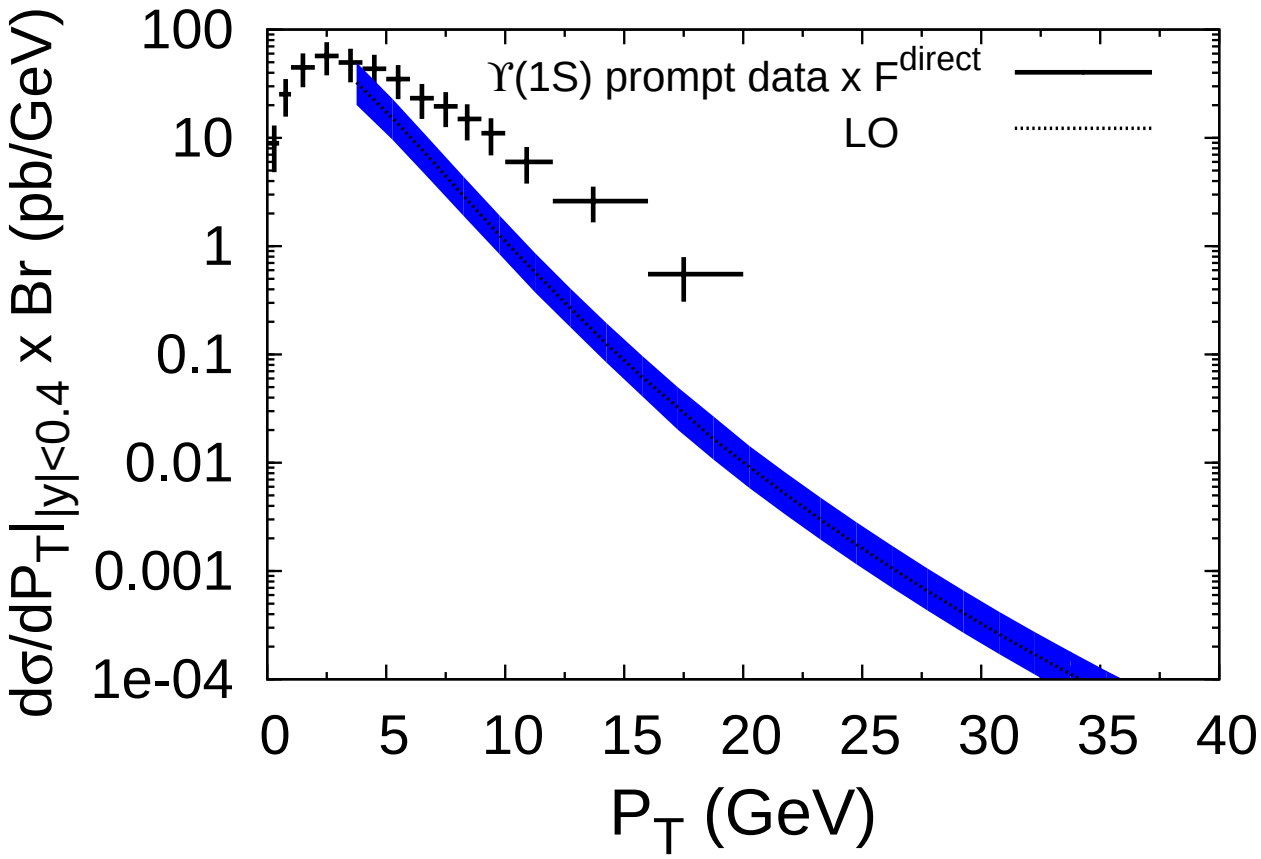

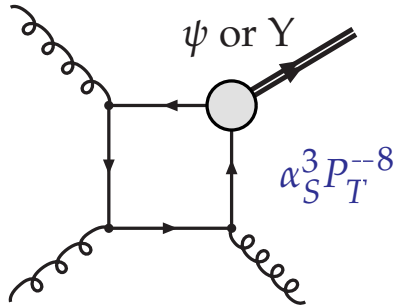

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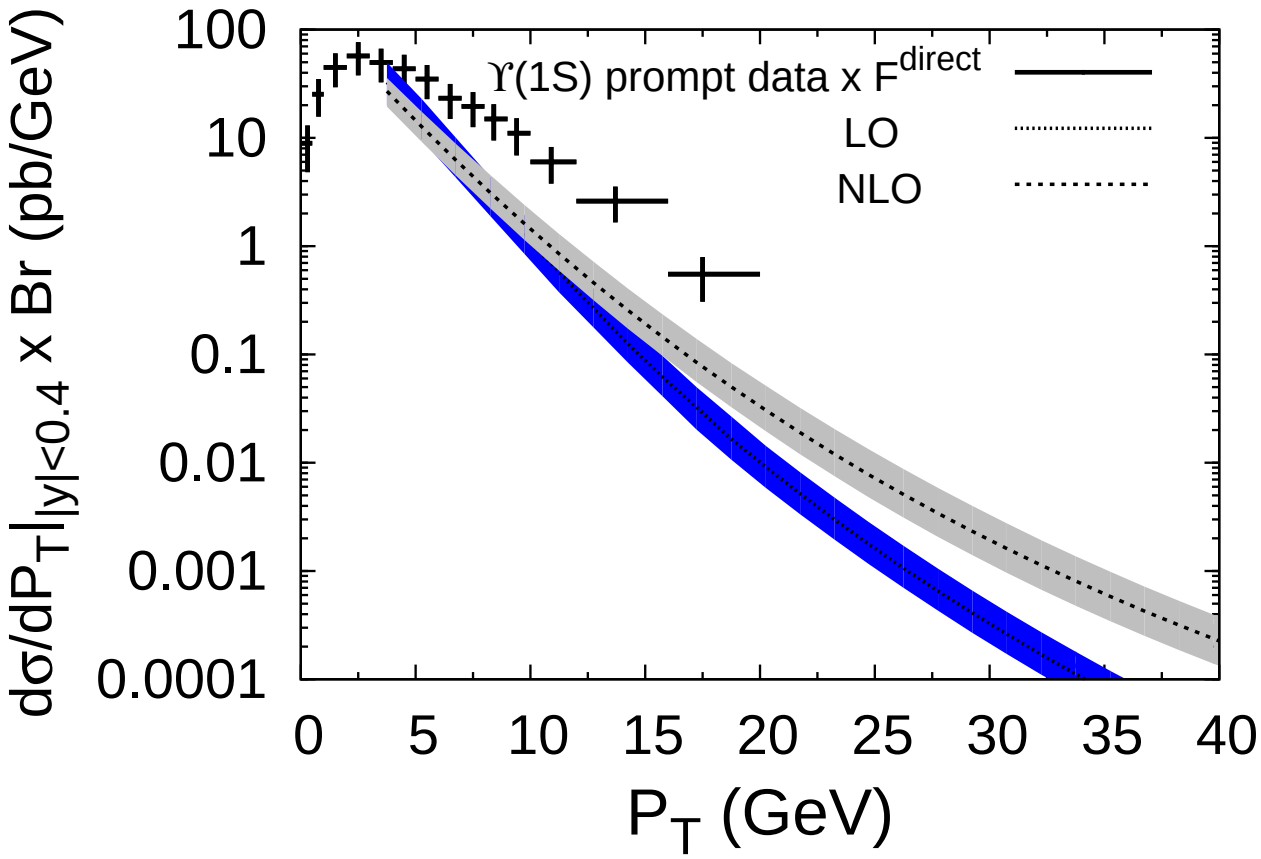

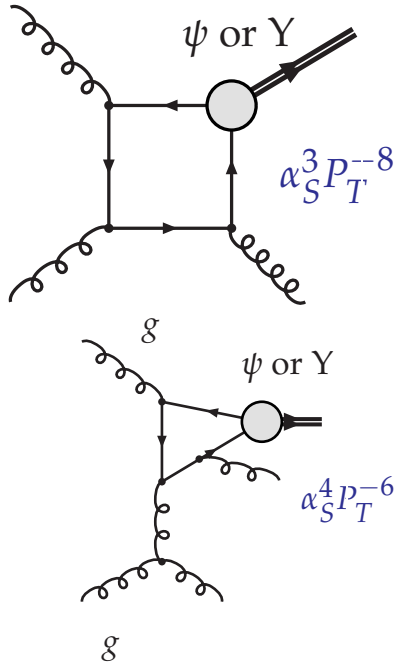

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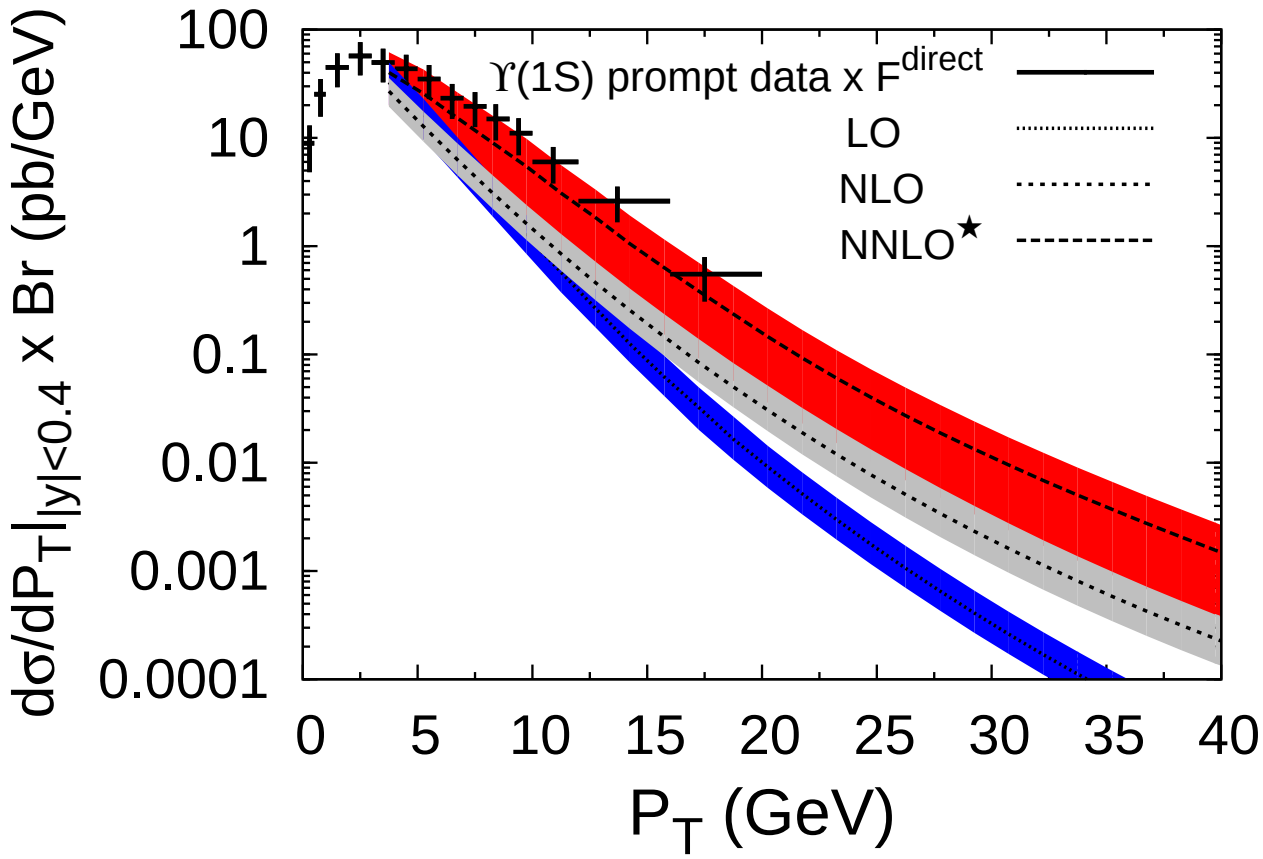

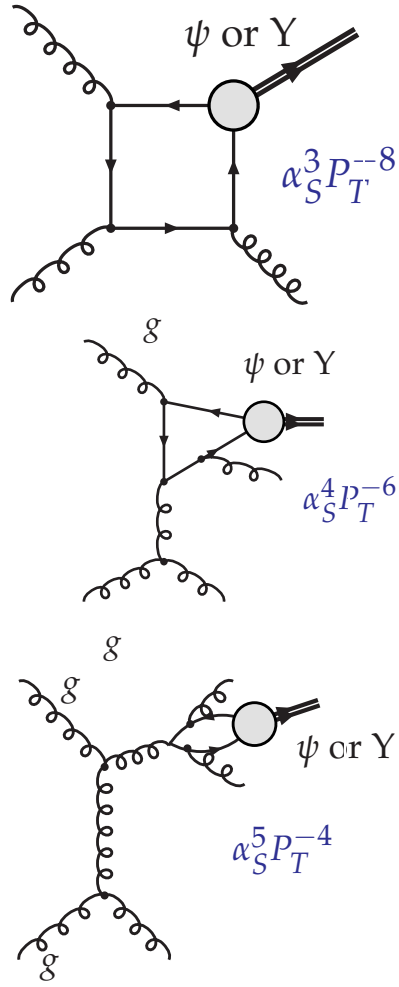

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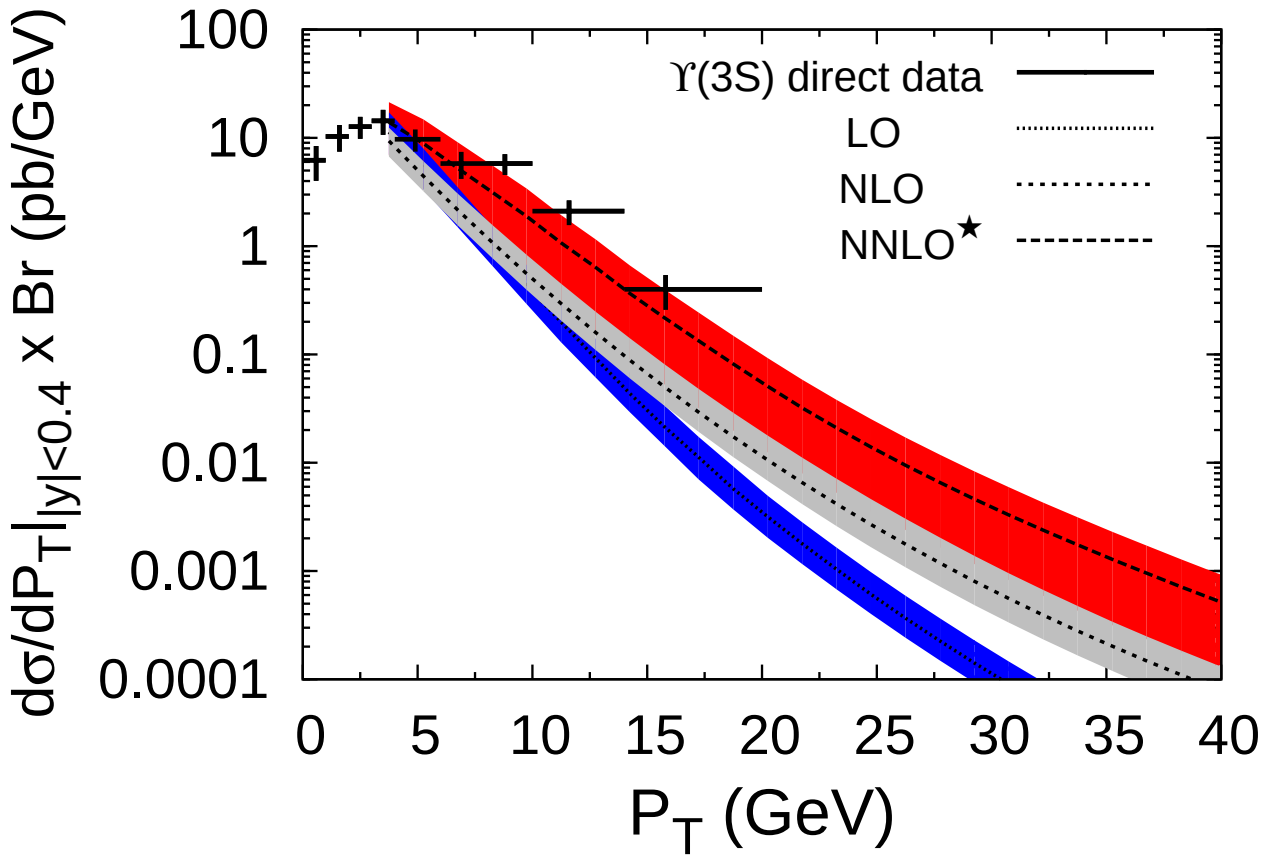

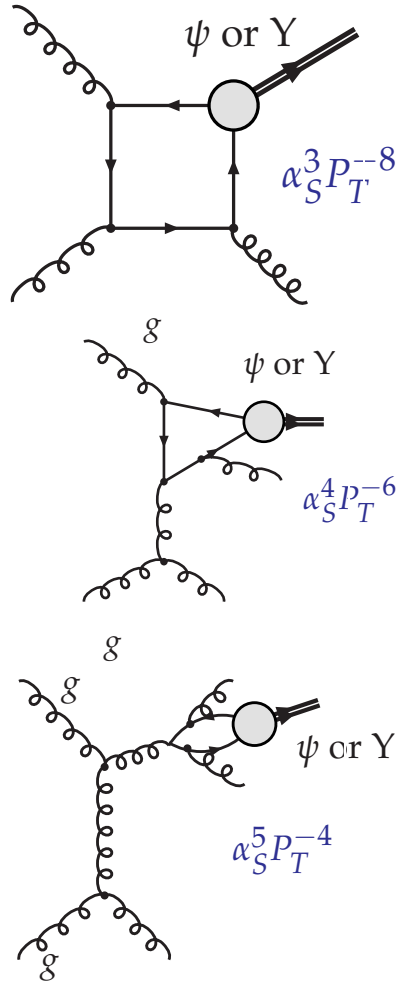

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QCD corrections for J/ψ at RHIC

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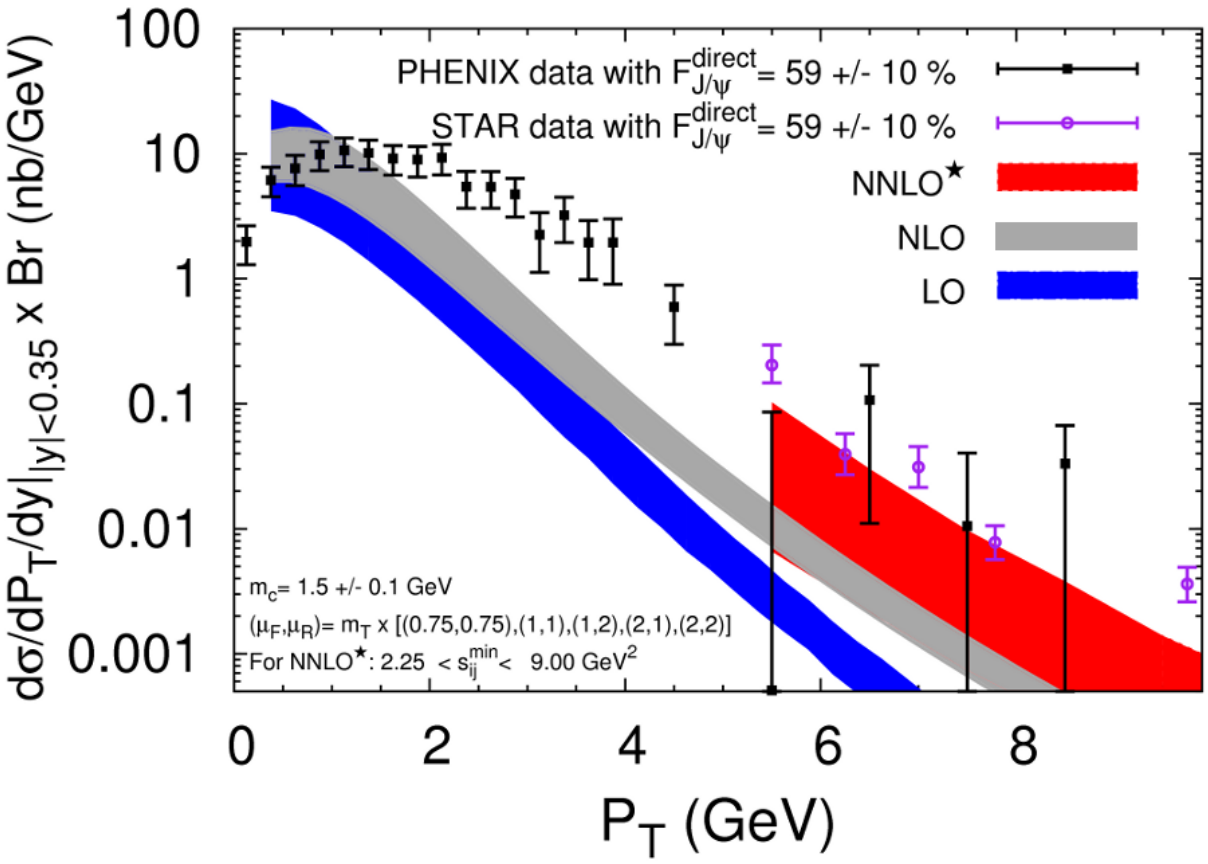

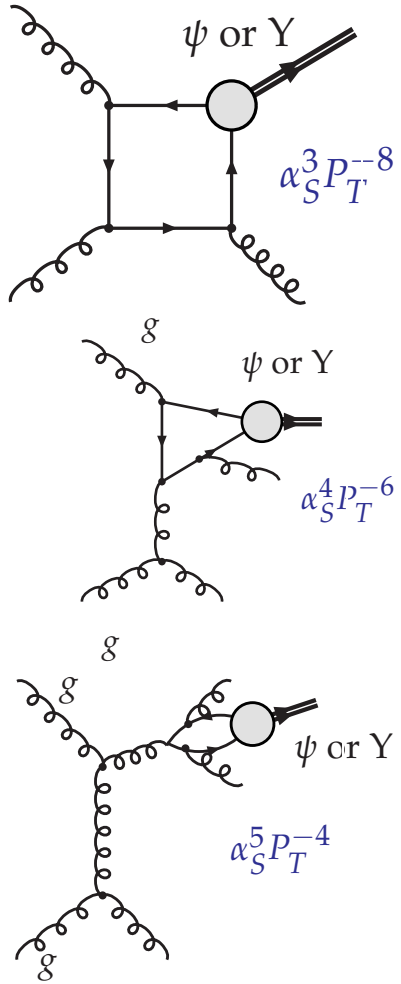

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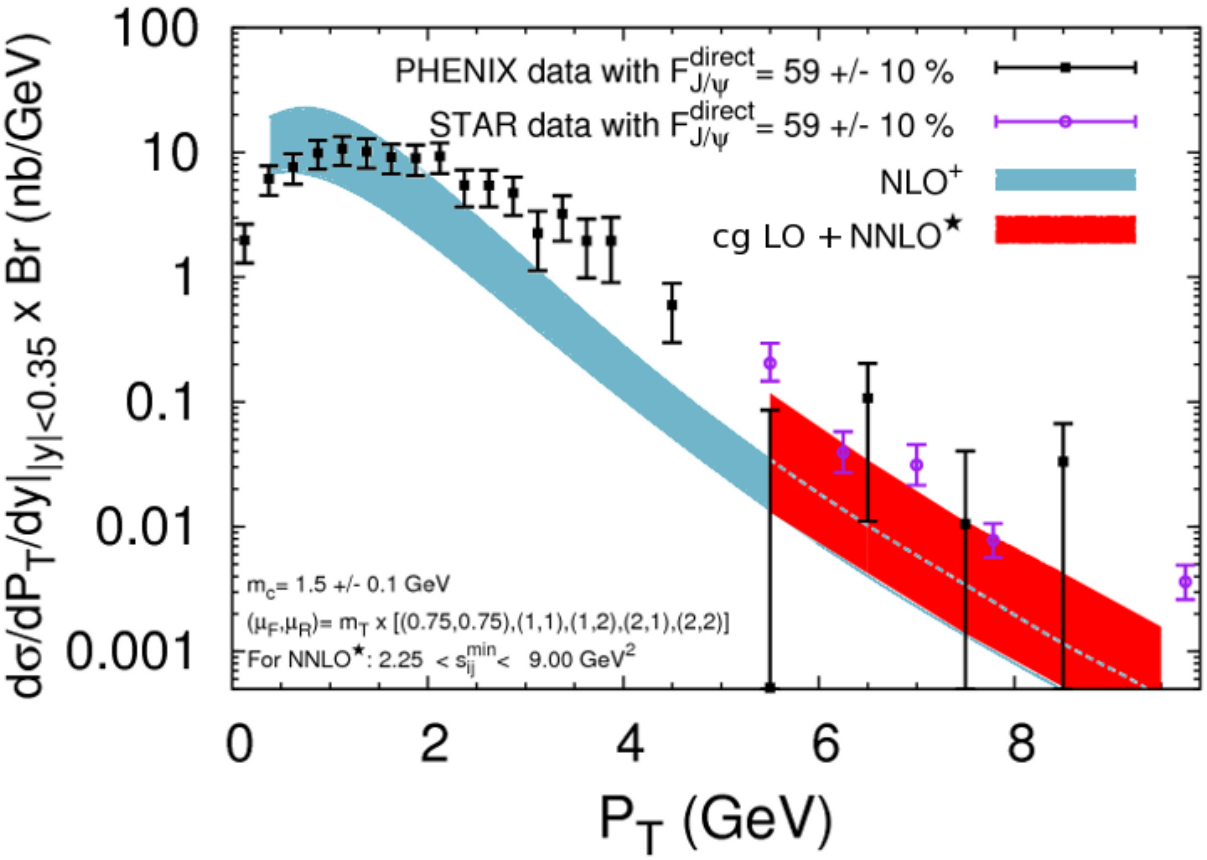

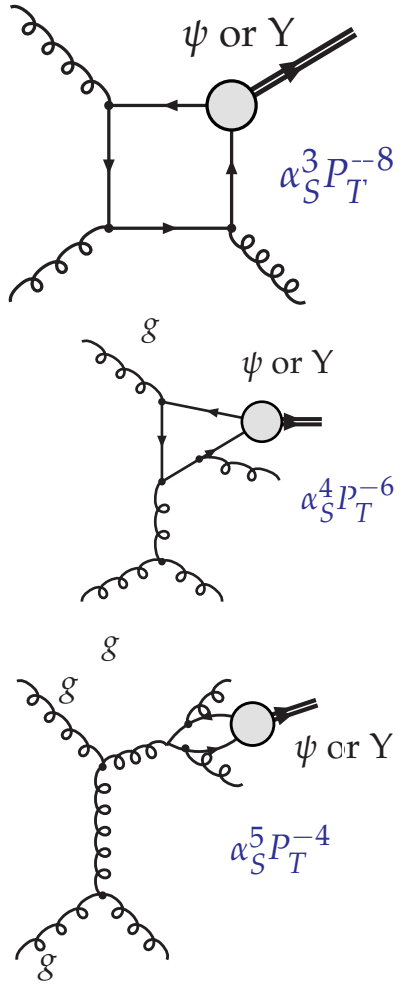

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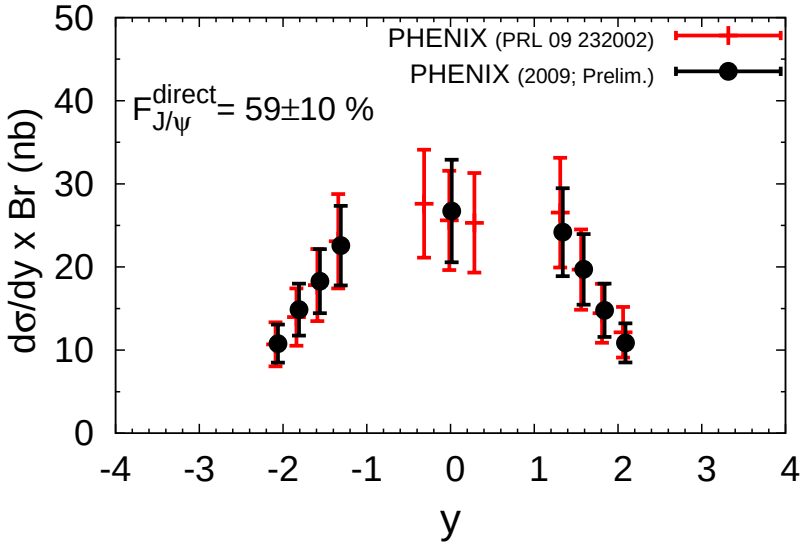
Part II

What we seem to understand

the CSM predictions account correctly for the yield ($\frac{d\sigma}{dy}$)

S. J. Brodsky and JPL, PRD 81 051502 (R), 2010



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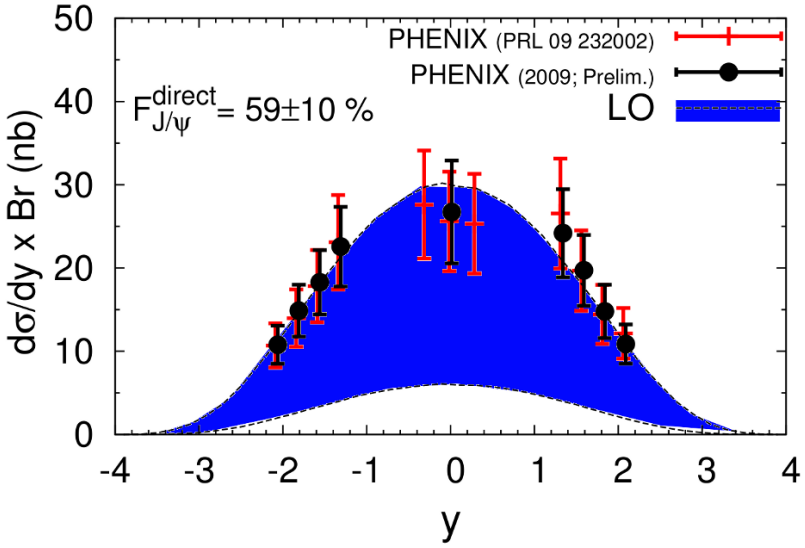

LO: $gg \to J/\psi g$ (nothing new !, back to 1981 !)

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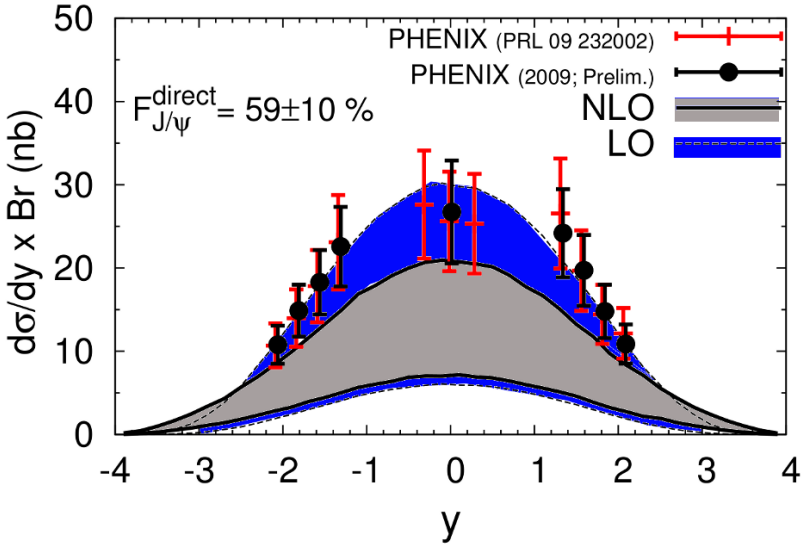

NLO: $gg \to J/\psi$, $gq \to J/\psi gq$, ...

using the matrix elements from J.Campbell, F. Maltoni, F. Tramontano, PRL 98:252002,2007

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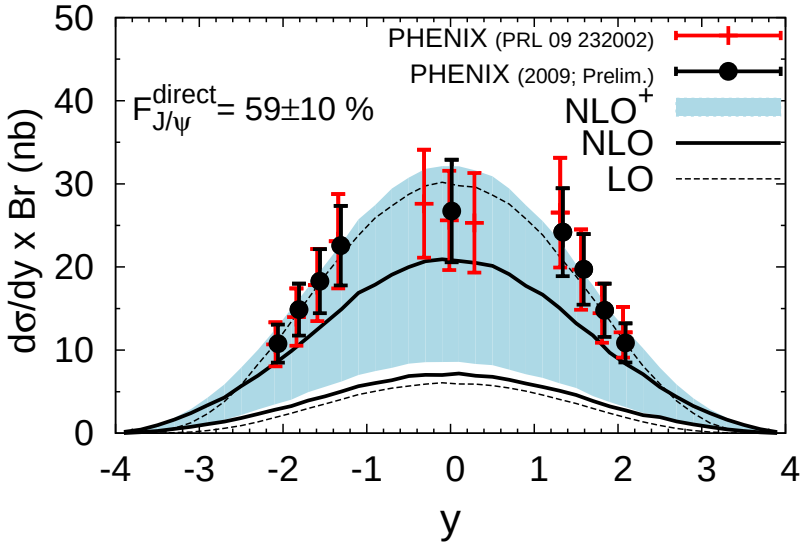

NLO$^+$: adding one new LO contribution $cg \longrightarrow J/\psi c$

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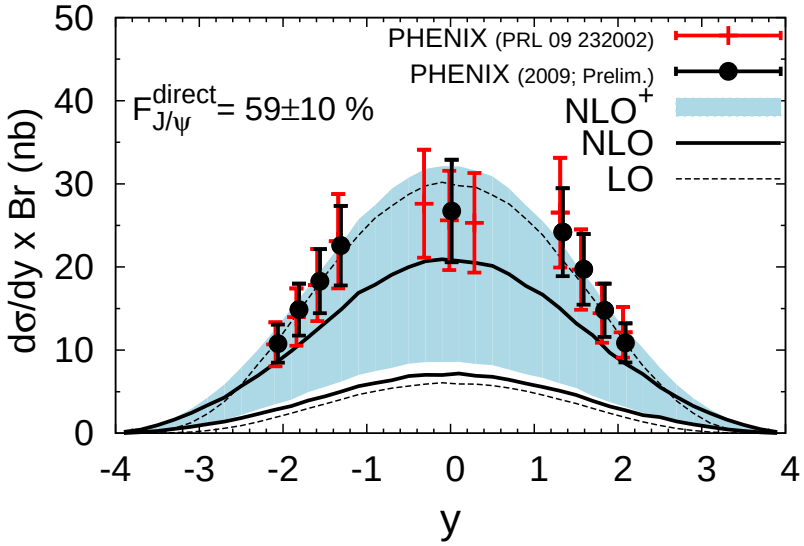

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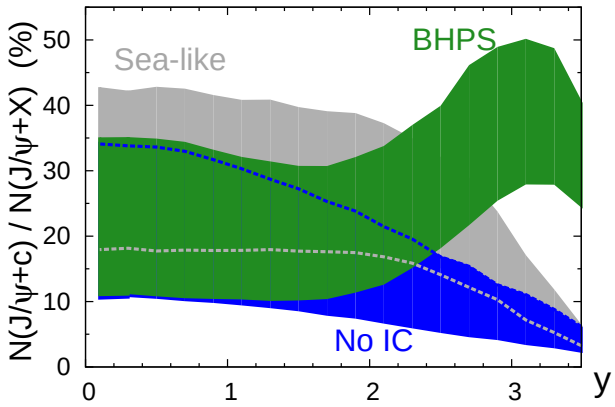
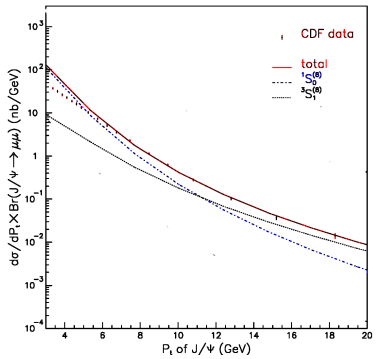


Could be studied via azimuthal correlation $J/\psi + e, \mu$; 10-40% of the direct signal

the Colour Octet Dominance challenged at low/mid P_T in pp ?

- **Constraints from the P_T dependence in pp**
  - Computation at NLO for CO channel: CO predictions overshoot data at low P_T



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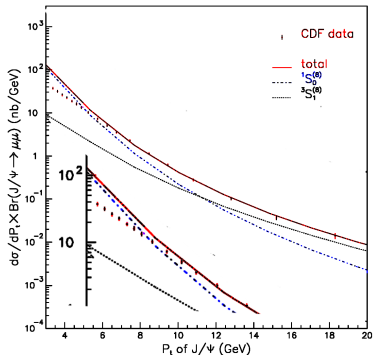

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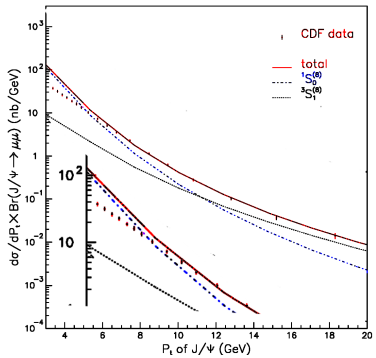

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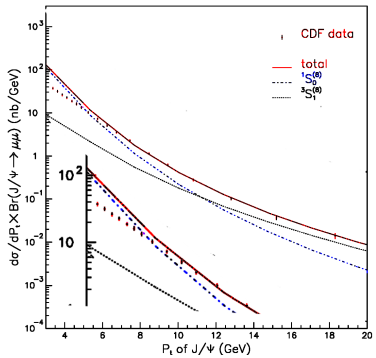

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no space for CO ($^1S_0$ or ^3P_J) in B-factory data

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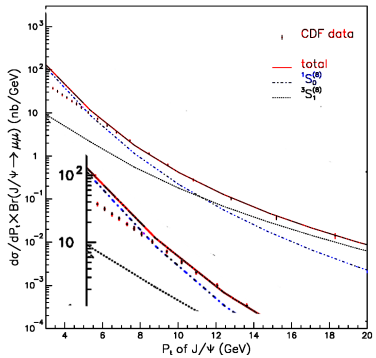

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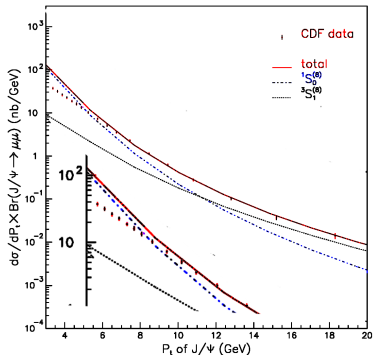

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- Actually, the reduction is much stronger and the CS channel dominates over CO at low/mid P_T in $p-p$ collisions

Υ & ψ polarisation in hadroproduction at $\mathcal{O}(\alpha_S^4)$ & $\mathcal{O}(\alpha_S^5)$

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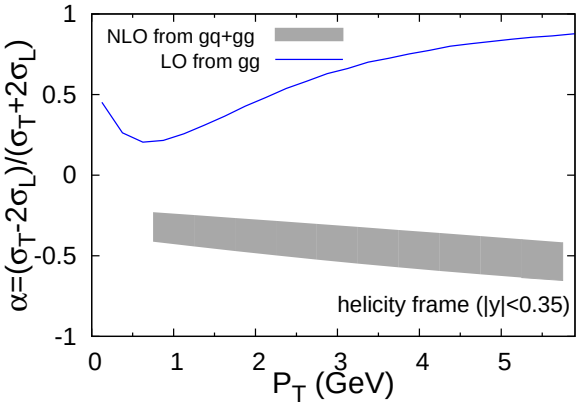

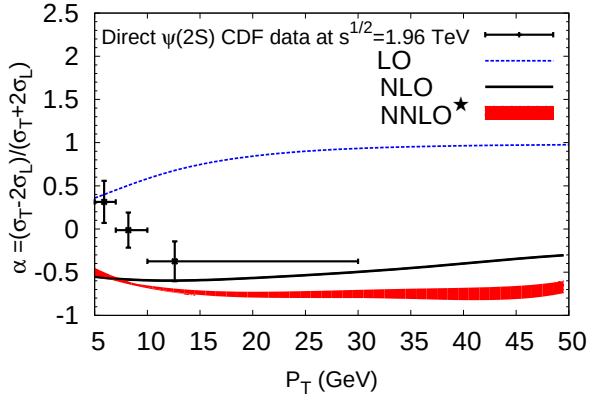

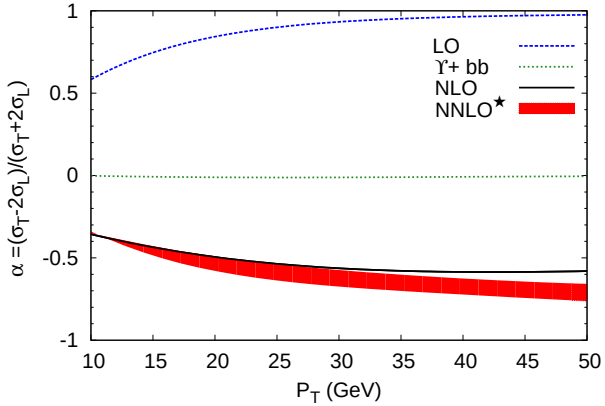

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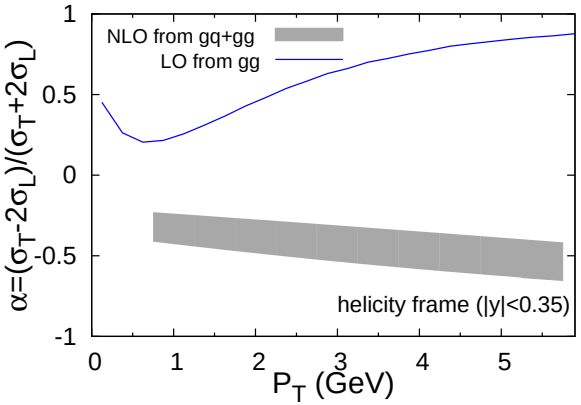
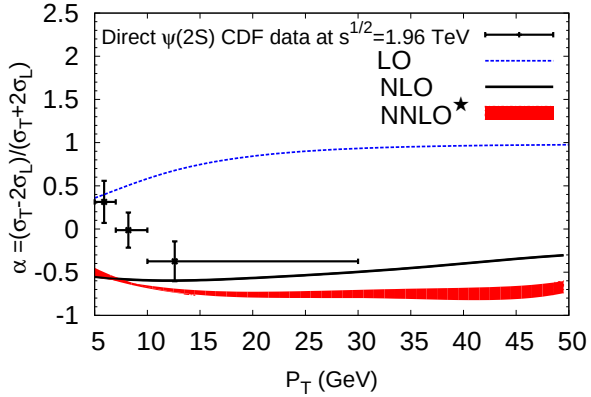
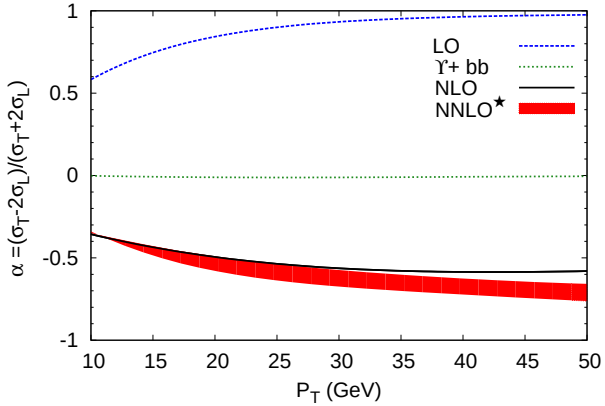






→ Complete modification of the polarisation at NLO (also at NNLO*)

→ Yield from k_T factorisation is also longitudinal (in the helicity frame)

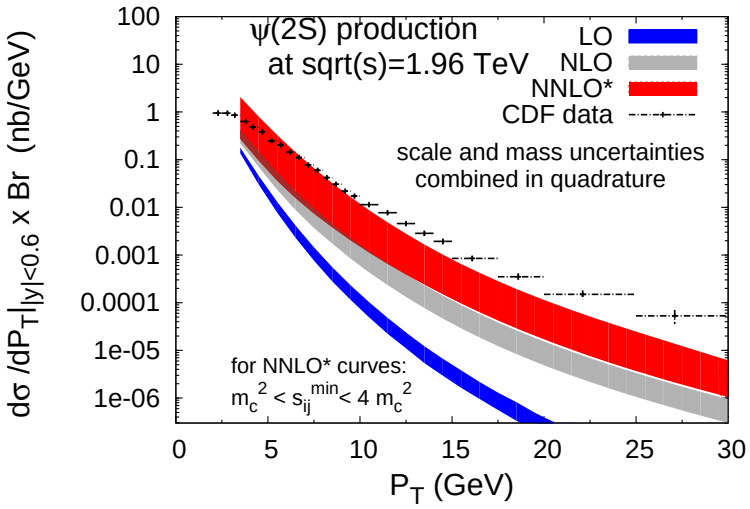
→ **This is not yet explained by simple arguments**

(although reasonable)

Part III

what we do not understand

ψ production at very large P_T



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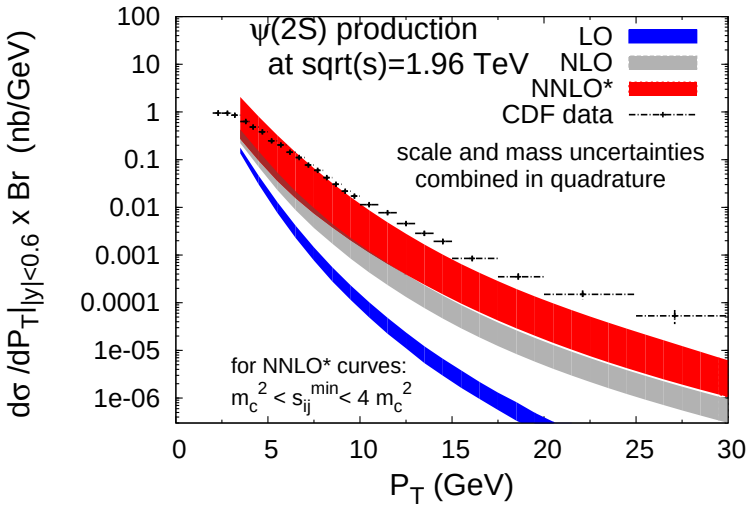

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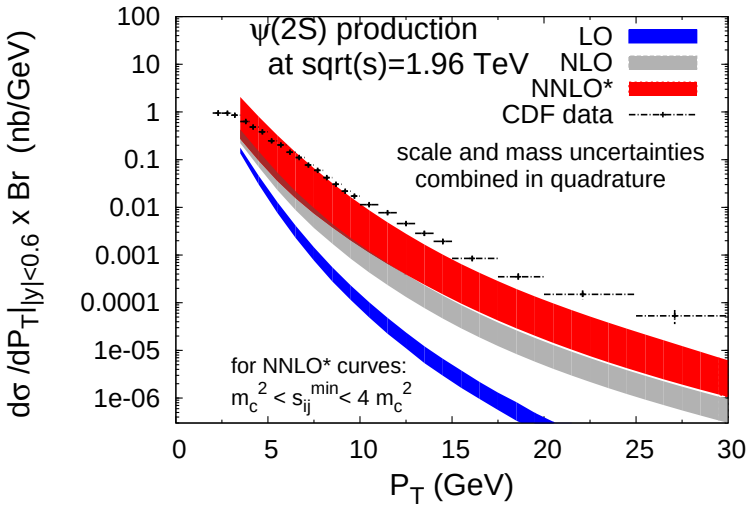

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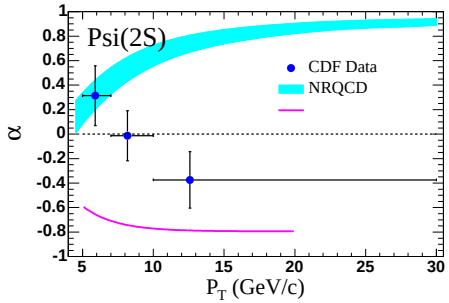

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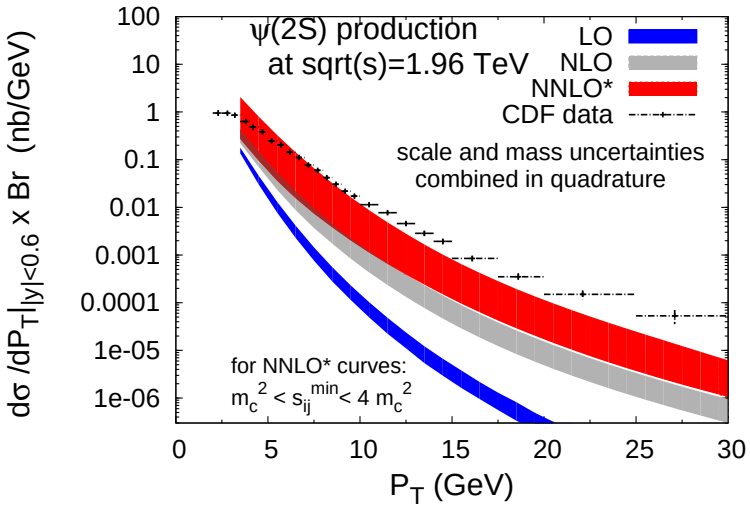

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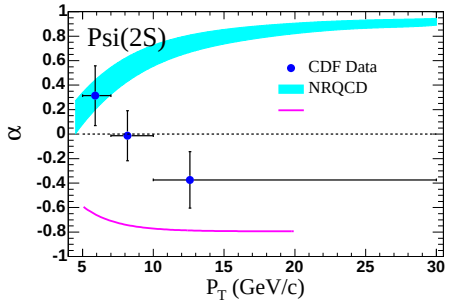

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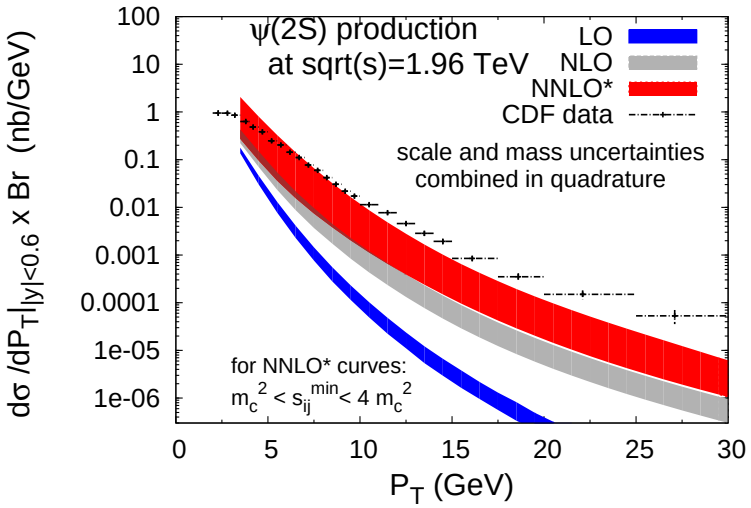

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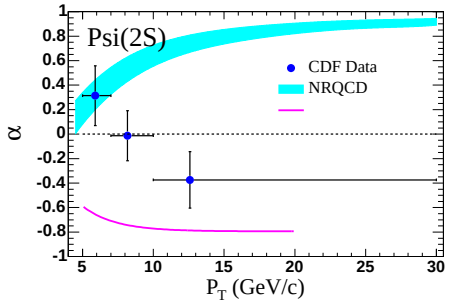

- Could be the data ...
- Let's wait for the LHC data for prompt $\psi(2S)$ or **direct** J/ψ

Other features not understood

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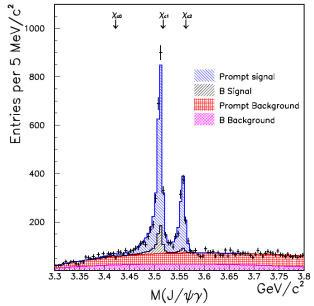

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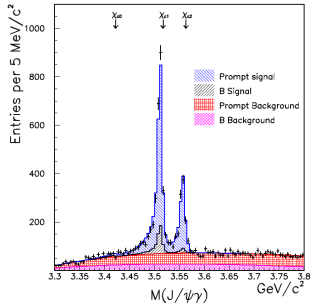

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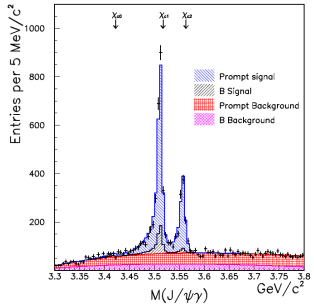

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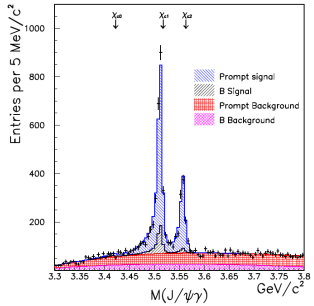

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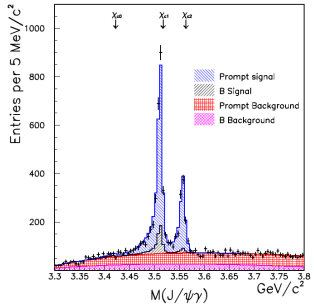

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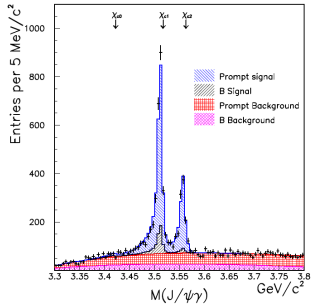

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- Is, in practice, the charmonium family production/suppression suitable to study "sequential suppression" by QGP ?

Part IV

LHC data at $\sqrt{s} = 7$ TeV

LHC data which are public so far

- CMS:
  - J/ψ in two bins in y: $|y| < 1.4$ and $1.4 < |y| < 2.4$
  - Extraction of the prompt signal (*i.e.* excluding B feed down)
  - Υ cross section and ratio (2S+3S) over (1S)

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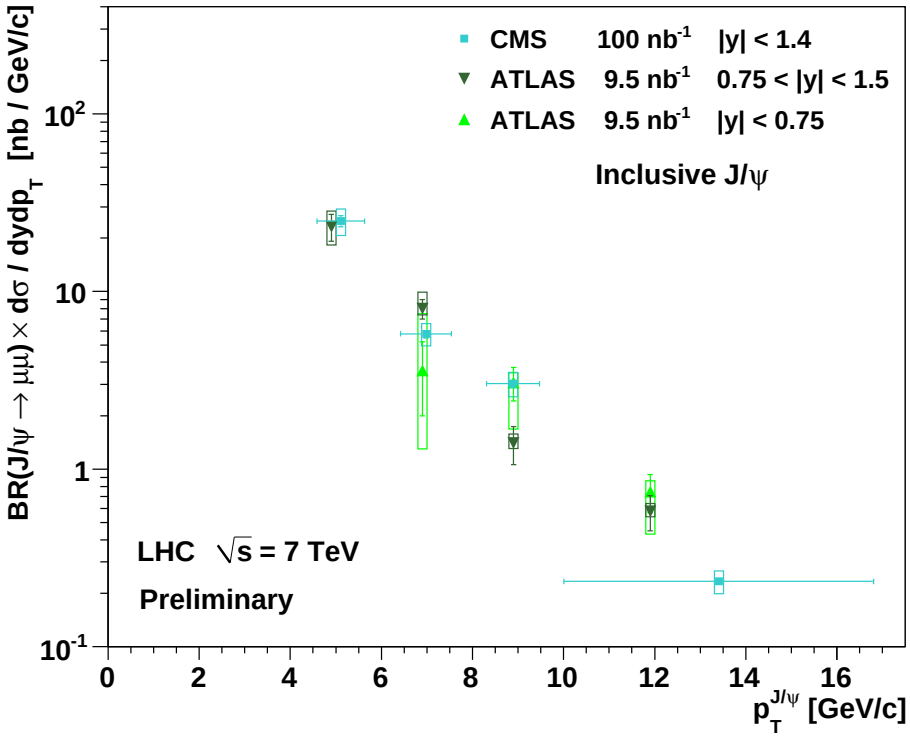
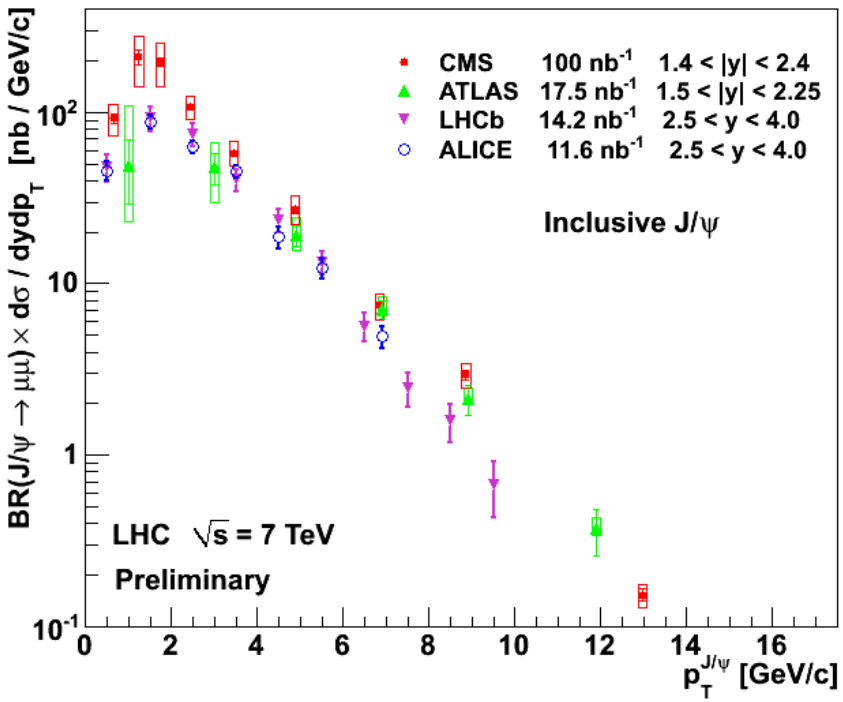
- ALICE:
  - J/ψ spectrum in y in the central region and for $2.7 < |y| < 3.8$
  - J/ψ spectrum in P_T in 1 bin in y: $2.7 < |y| < 3.8$

Comparison data-data

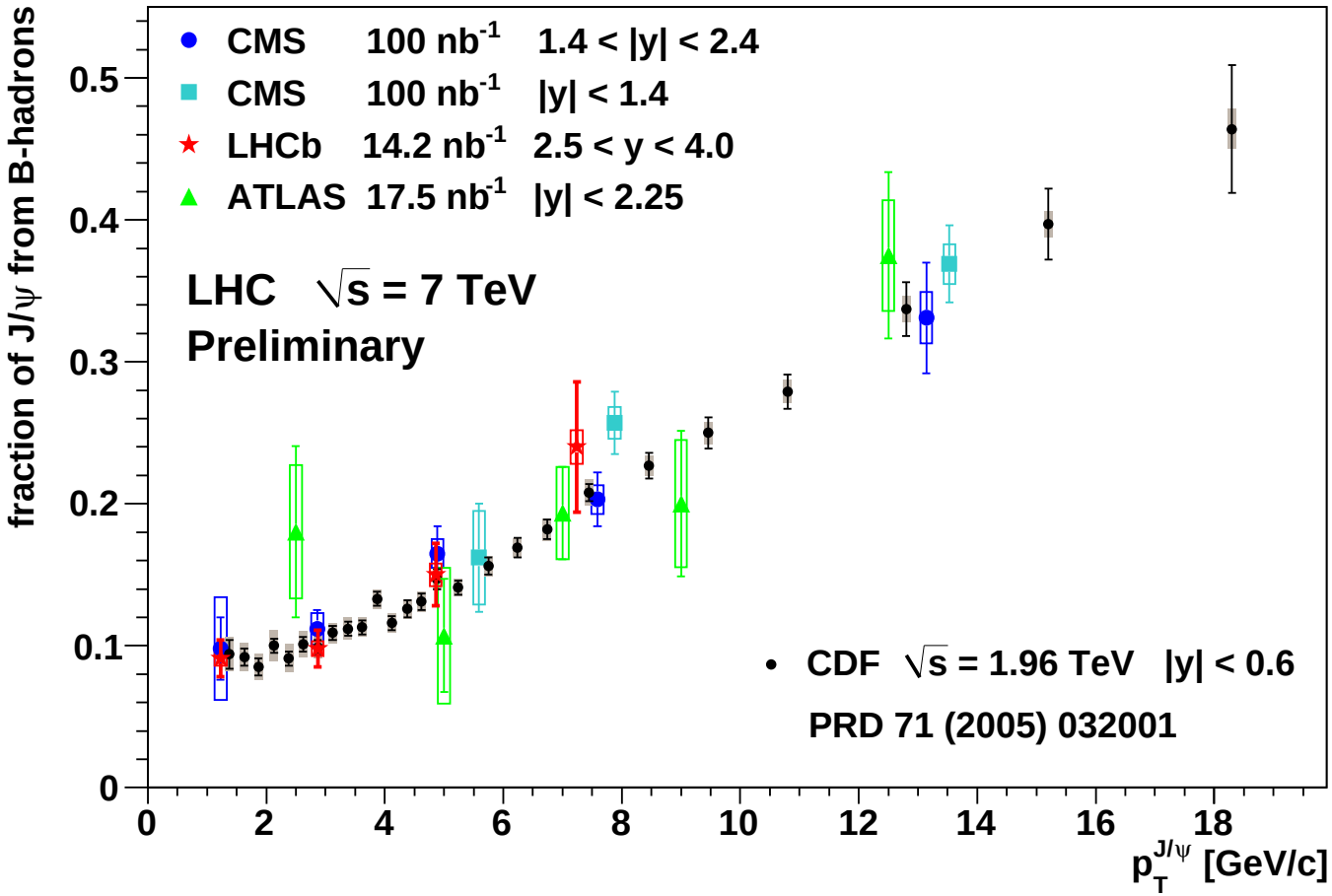
Plots courtesy of H. Woehri,C. Lourenço, collaborative work with colleagues from LHCb, ATLAS and ALICE





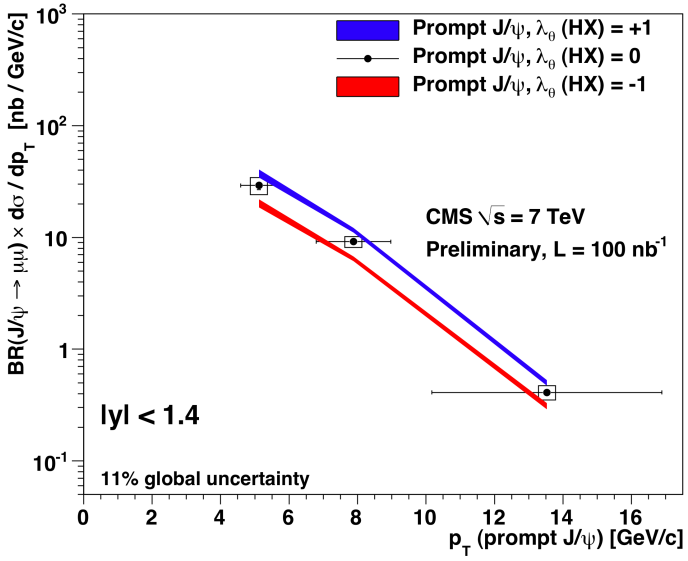
b-feed down extraction

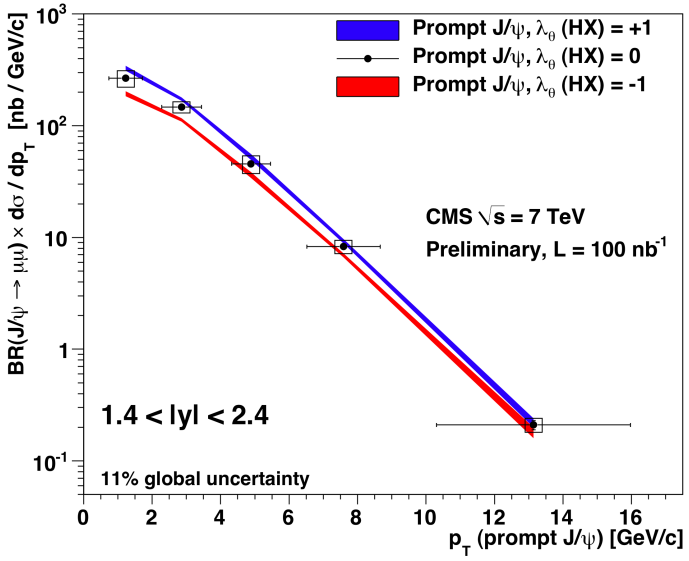
Plot courtesy of H. Woehri, collaborative work with colleagues from LHCb, ATLAS and ALICE shown by C. Lourenço at Quarkonium2010



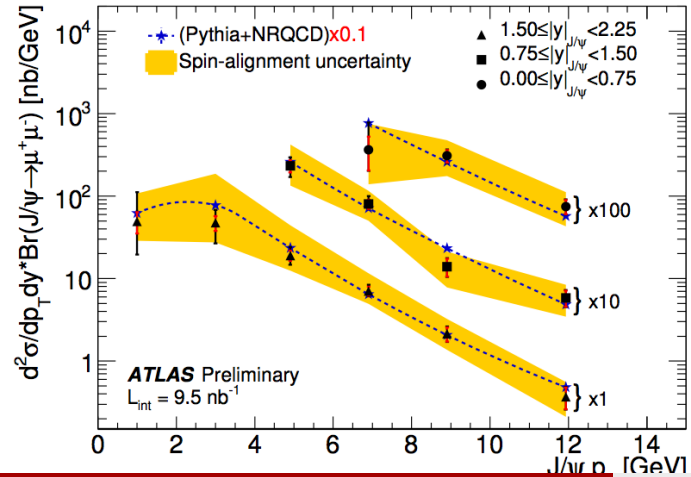
Polarisation impact on acceptance

Plots shown by C. Lourenço at Quarkonium2010

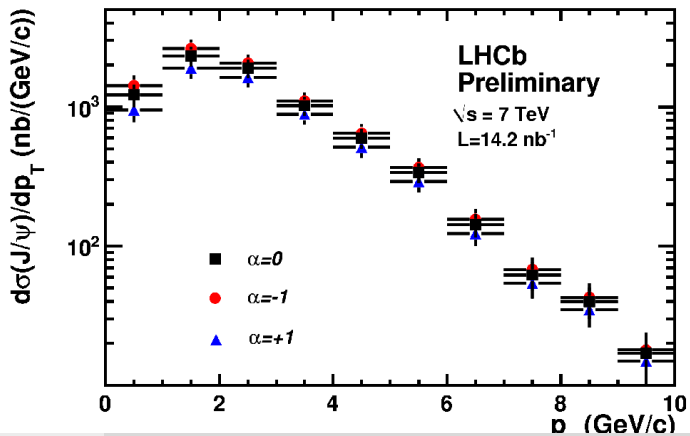




Plot shown by D. Price at Quarkonium2010

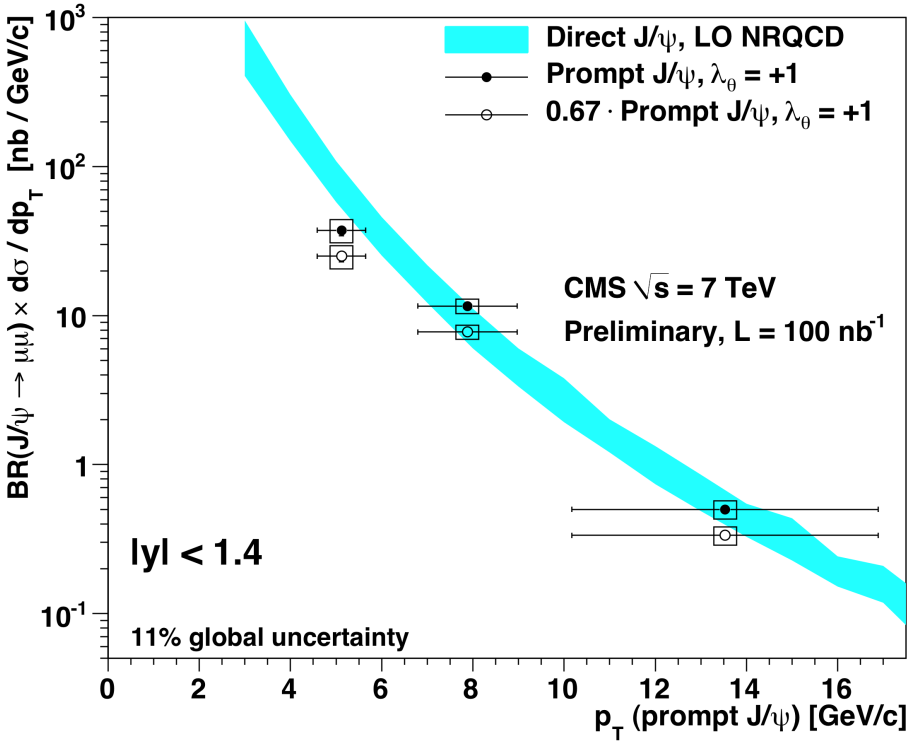


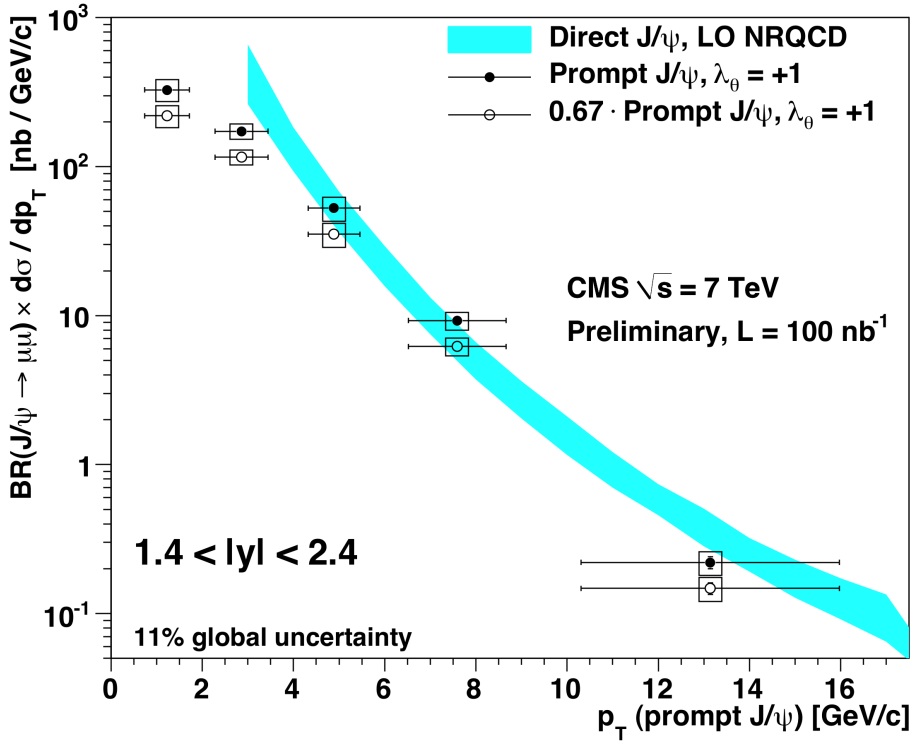
Plot shown by P. Robbe at Quarkonium2010



Comparison of the data with different models: Colour Octet Dominance

Plots by C. Lourenço shown at Quarkonium2010

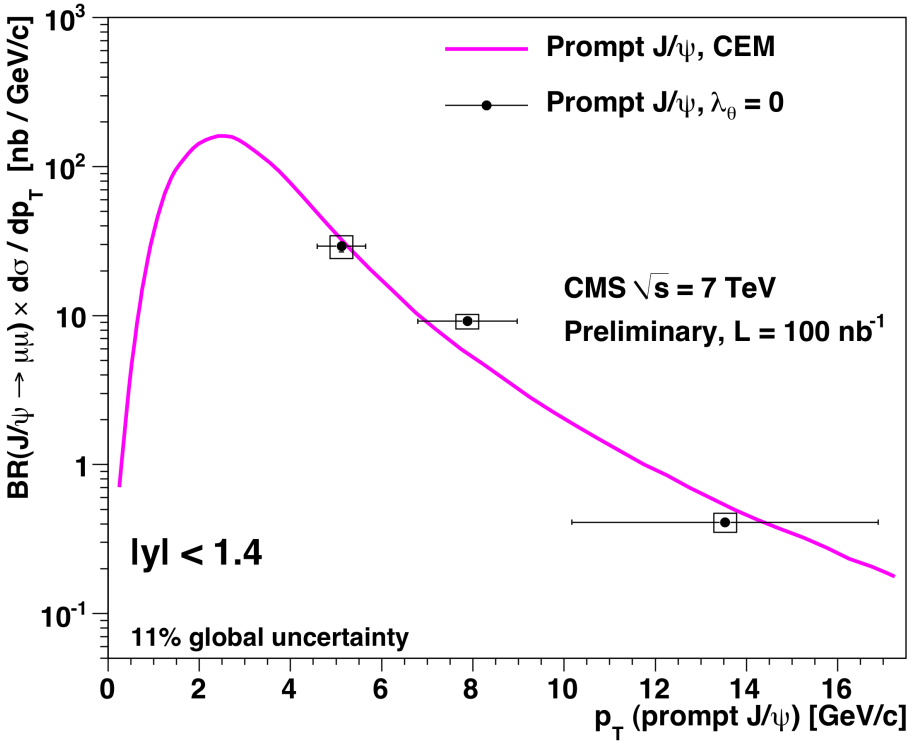


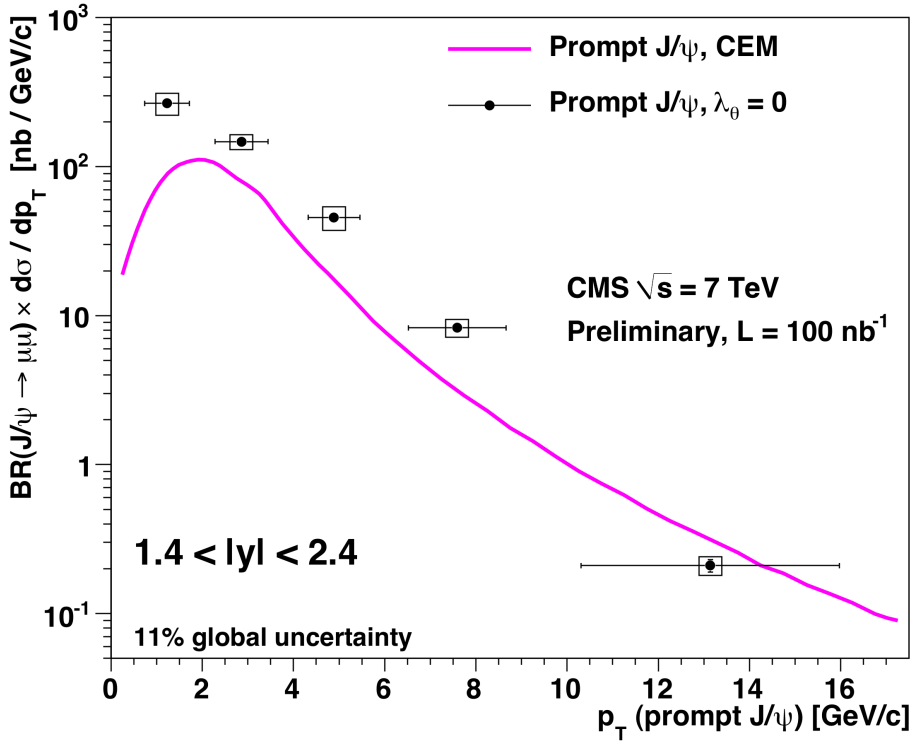


Theory curves by P. Artoisenet.

Comparison of the data with different models: Colour Evaporation Model

Plots shown by C. Lourenço at Quarkonium2010

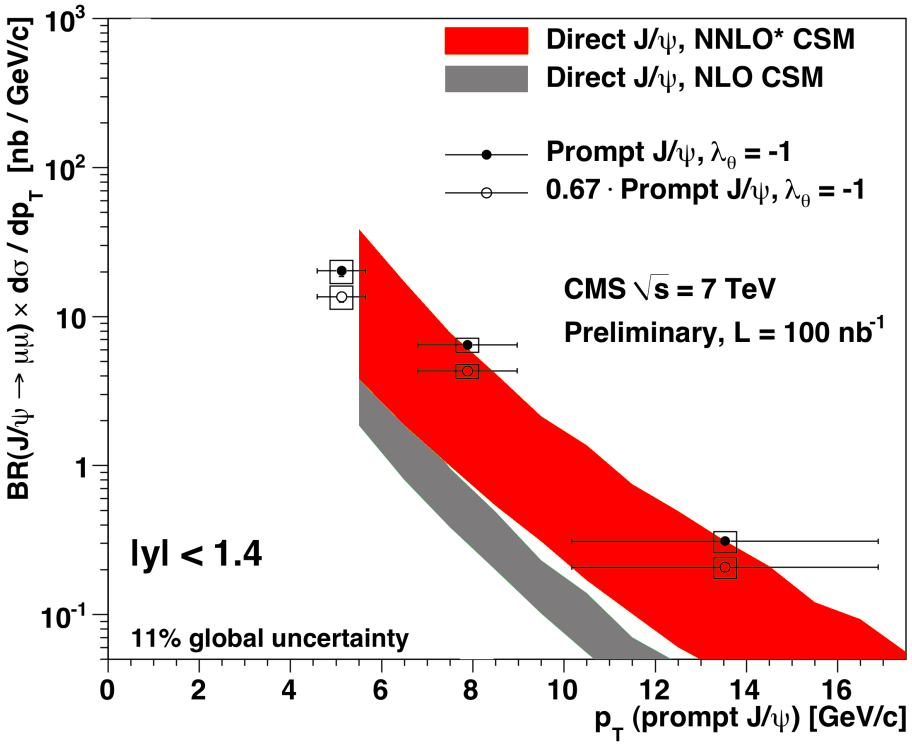


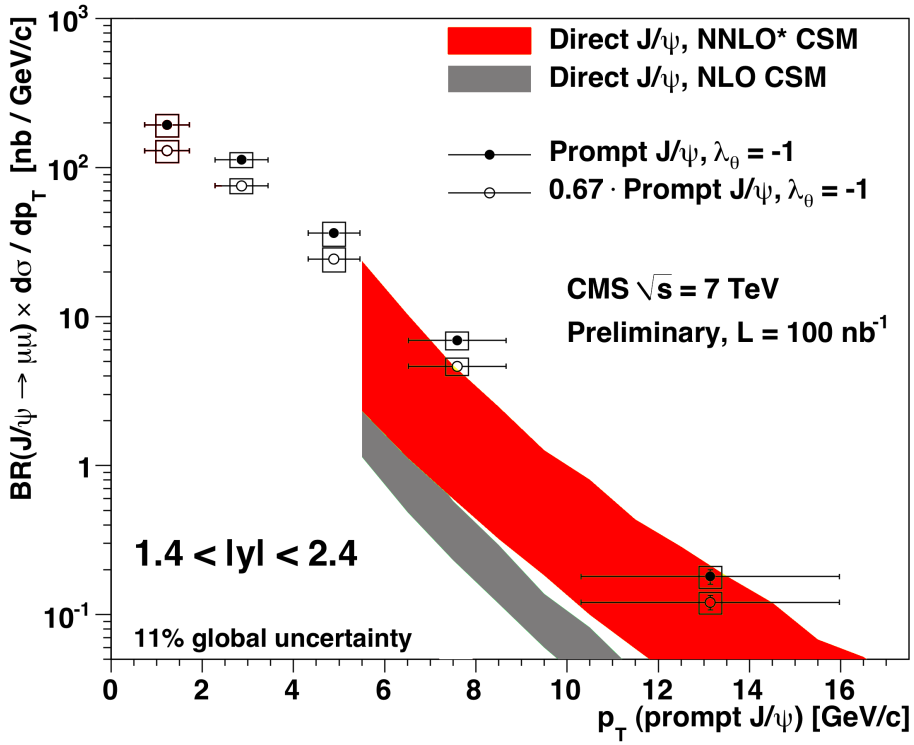


Theory curves by R. Vogt.

Comparison of the data with different models: Colour Singet Model

Plots shown by C. Lourenço at Quarkonium2010

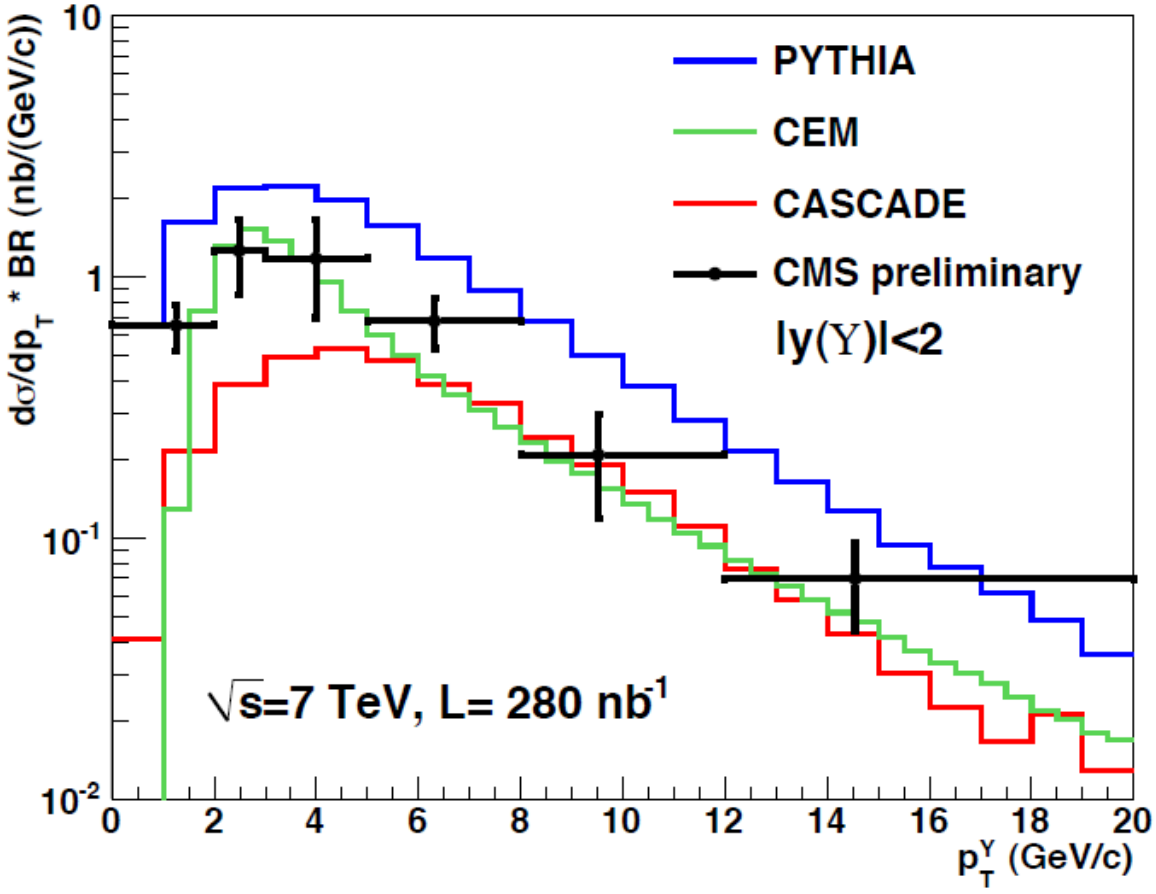




Theory curves by JPL

Comparison of the Υ data with different models

Plot shown by T. Dahms at Quarkonium2010



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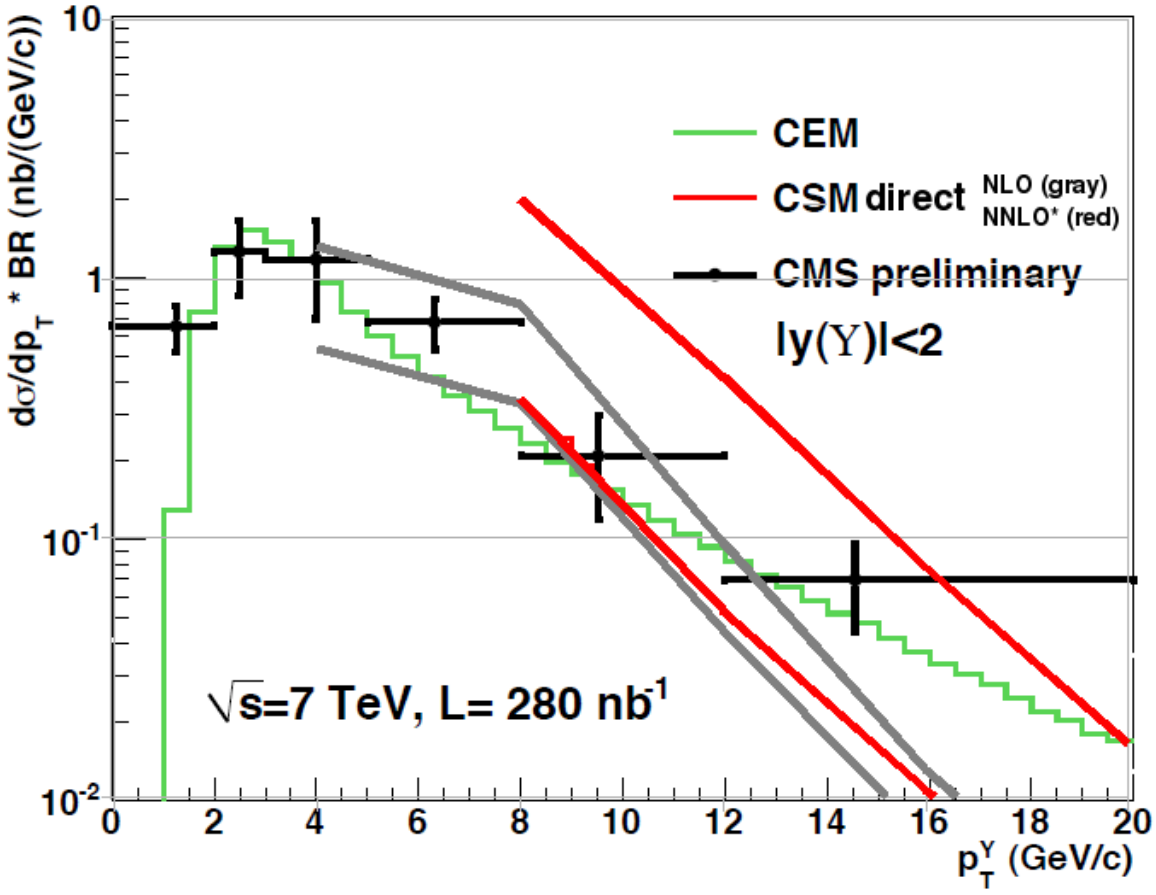


Comparison with Color Singlet Model: NEW !

P.Artoisenet, J.Campbell, JPL, F.Maltoni, F. Tramontano, Phys. Rev. Lett. 101, 152001 (2008)

Part V

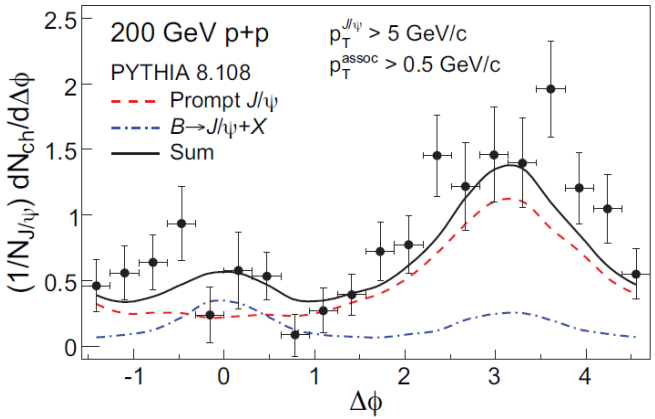
what we expect from the LHC:

Part V

what we expect from the LHC: new measurements

New observables

- $J/\psi+$ hadron azimuthal correlations **STAR Collab., Phys.Rev.C80:041902 (R),2009.**



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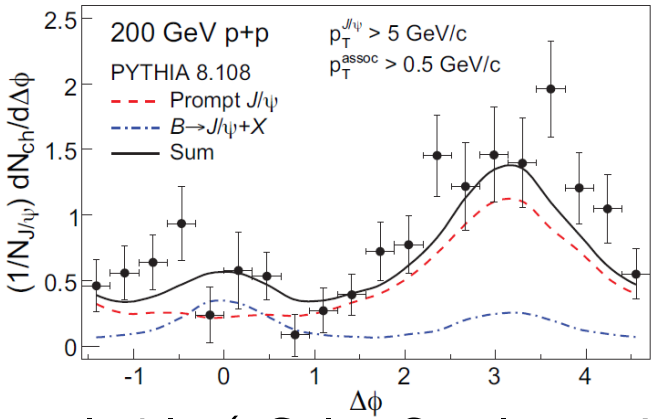

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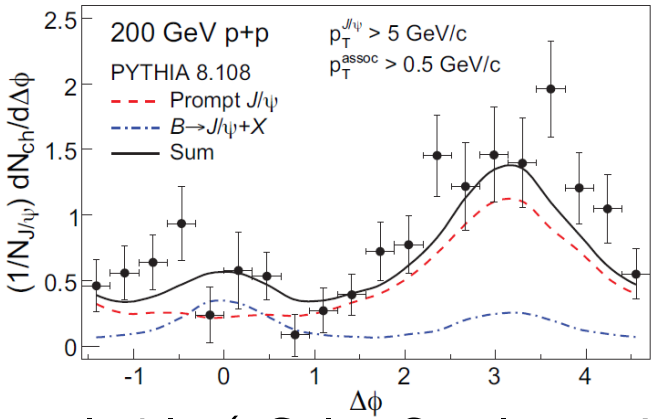

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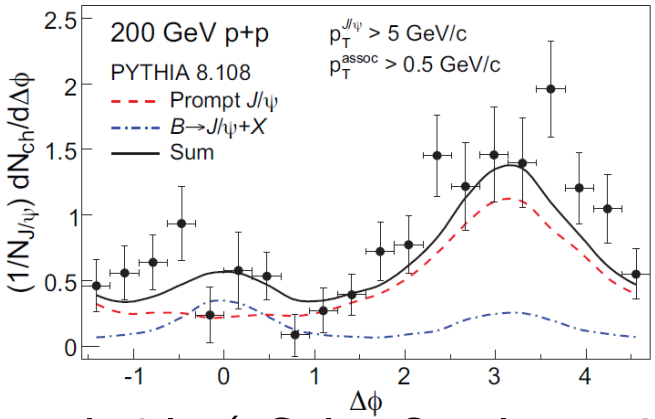

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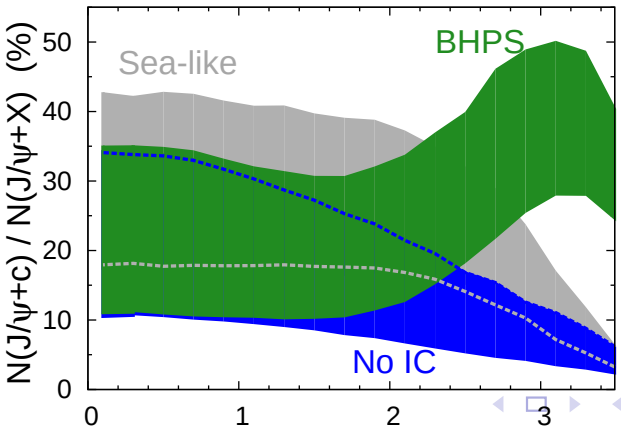
- $J/\psi + D$ or J/ψ+lepton: peak at $\Delta\phi = \pi$ in the yield integrated over P_T

S. J. Brodsky and JPL, PRD 81 051502 (R), 2010



Besides, the rapidity dependence gives info on $c(x)$

plot for RHIC kinematics

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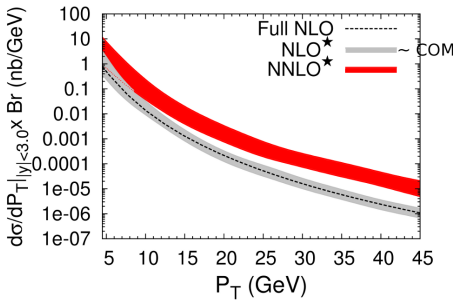

JPL, PLB 679:340,2009.

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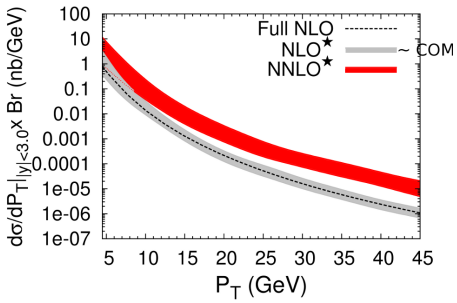

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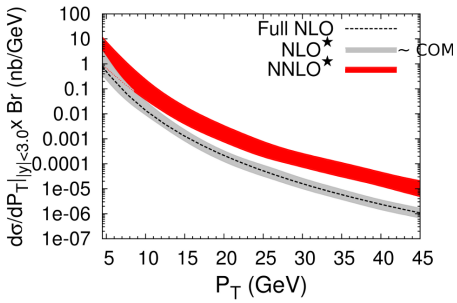

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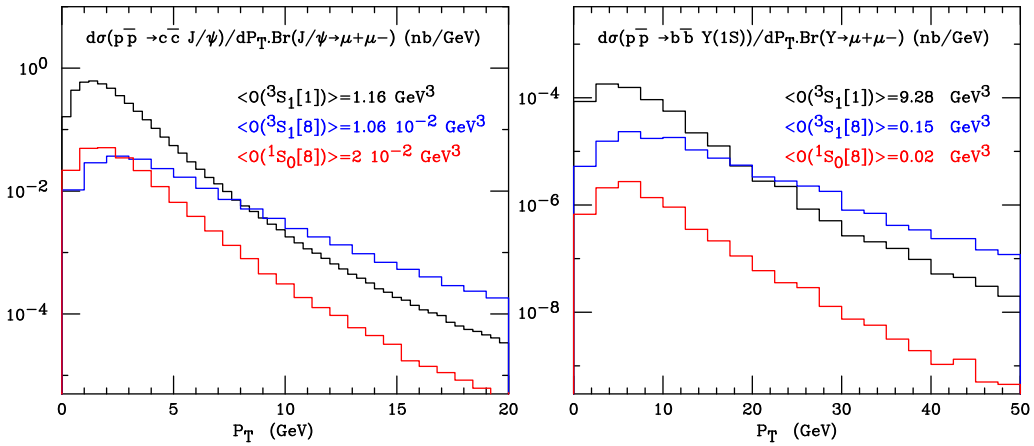

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New observables

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New observables

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  - polarisation of the χ_Q (angular dependence of the γ)

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  - maybe different acceptances, nice cross check

Part VI

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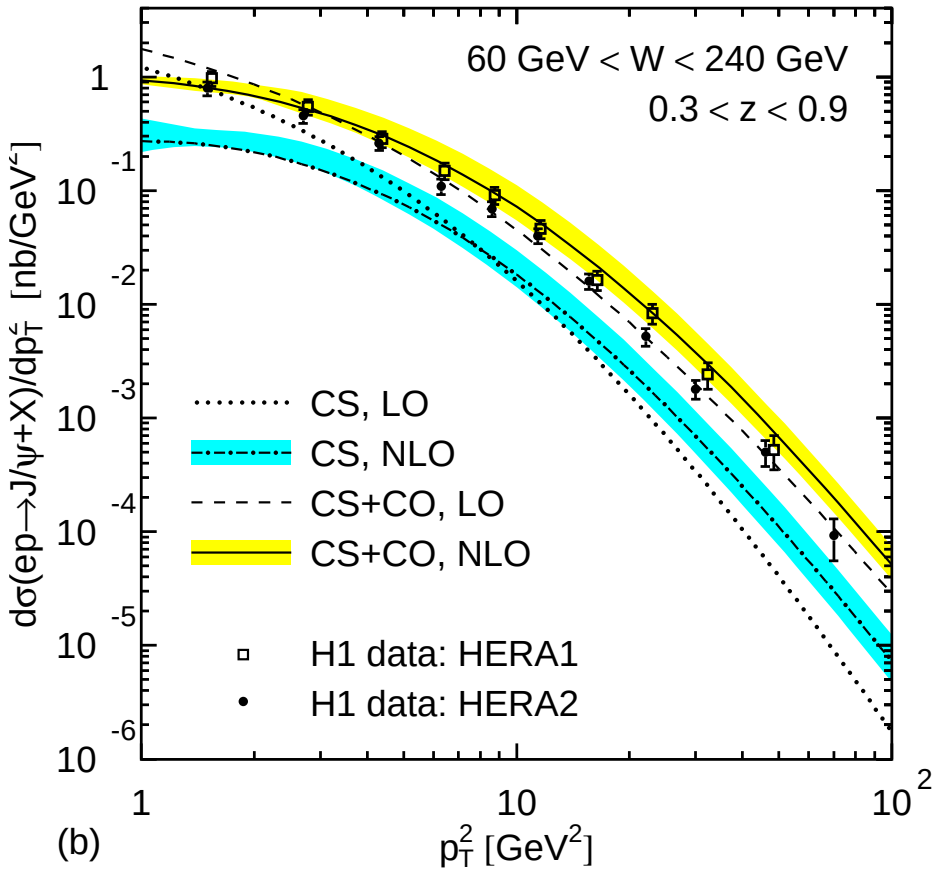
- **Drawback**: large theoretical uncertainties...
- Very soon, the LHC results on inclusive yields will be
  more precise than the theory ...
- The time has come for another look with **new observables**
  at the LHC or elsewhere !

Part VII

Backup

HERA: CSM vs COM at NLO

M. Butenschoen, B. Kniehl, arXiv:1009.5662v1 [hep-ph]



→ Equally good (or ... bad) description of large P_T data.