Perspectives for quarkonium production at the LHC

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École polytechnique – CPHT

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

What we expect from the LHC

6. More observables !

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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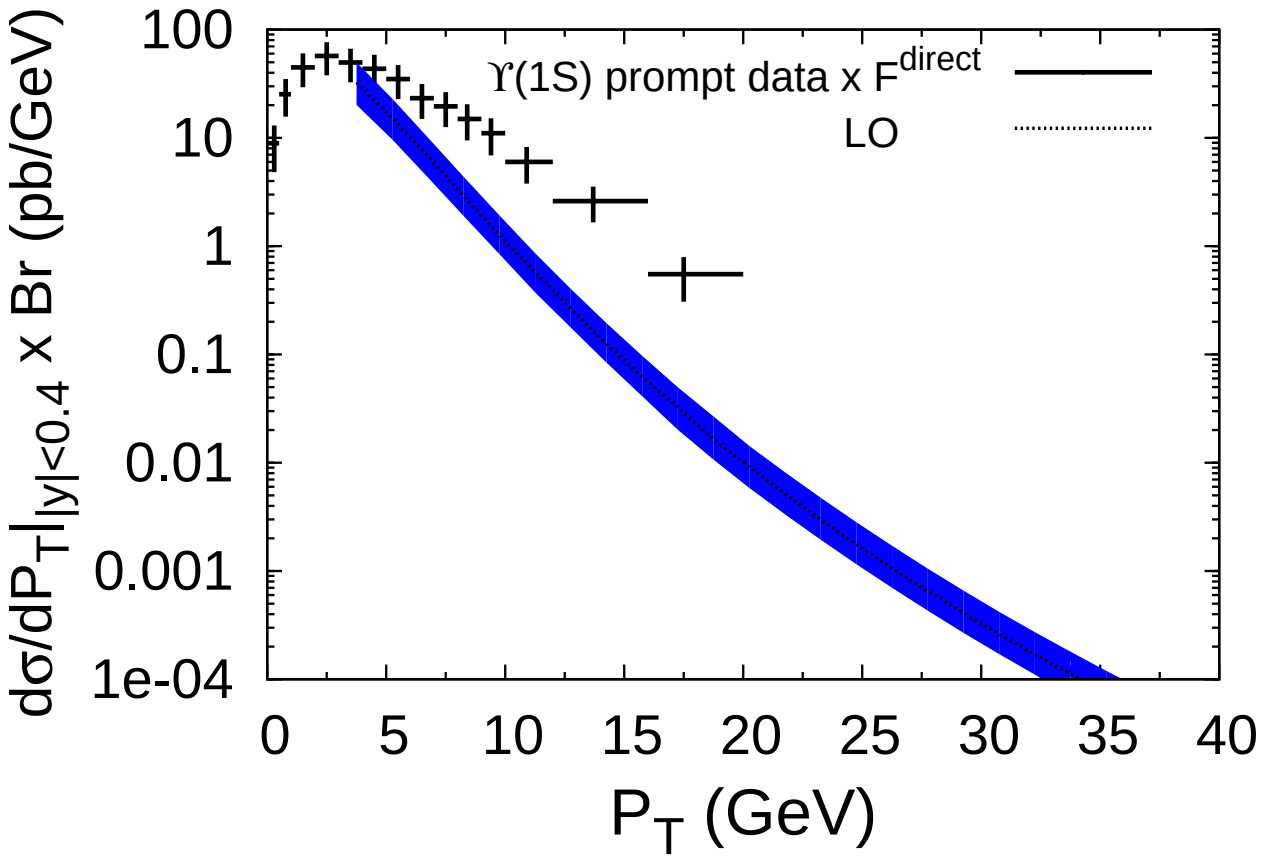

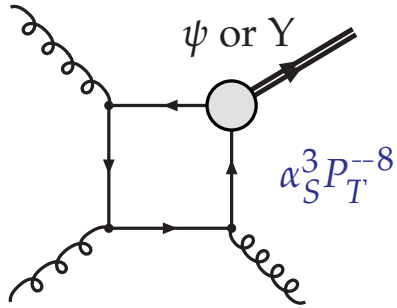

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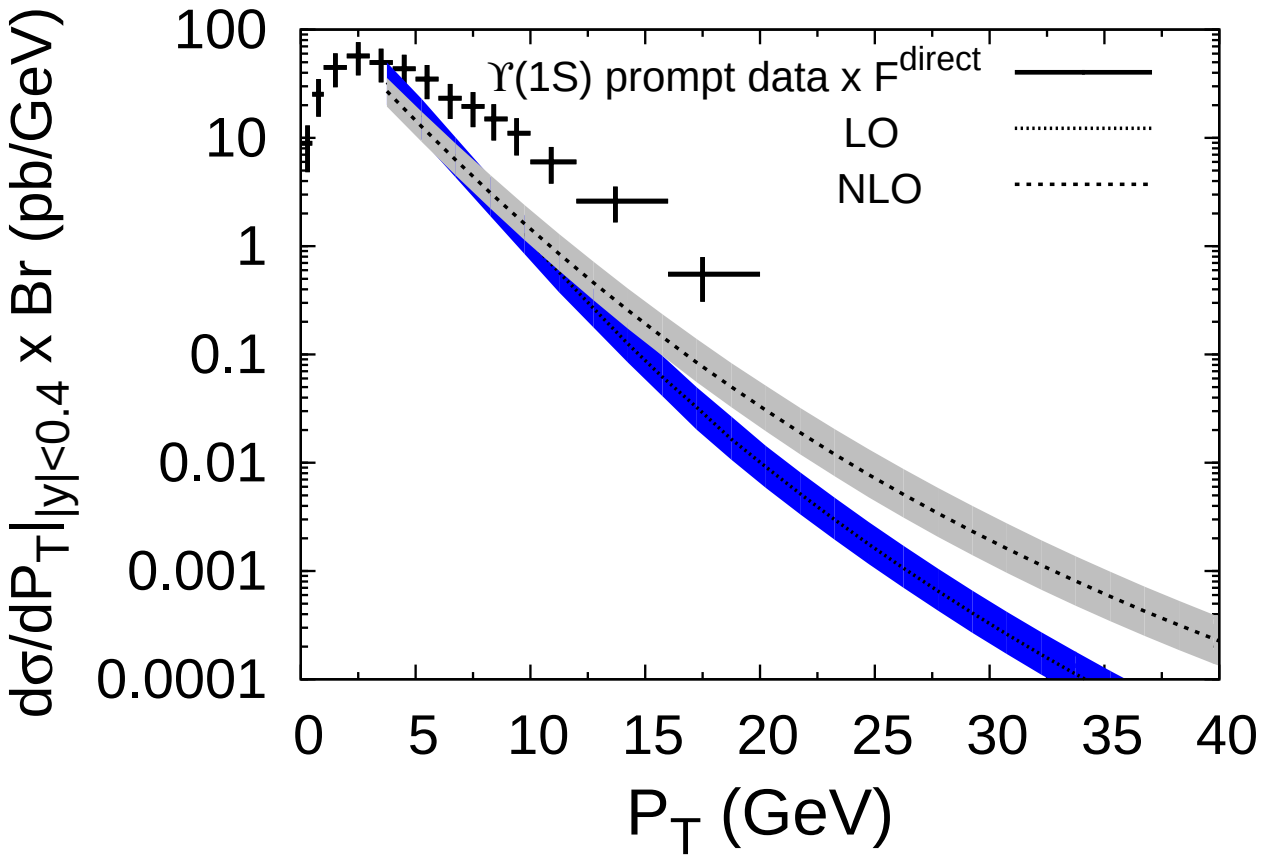

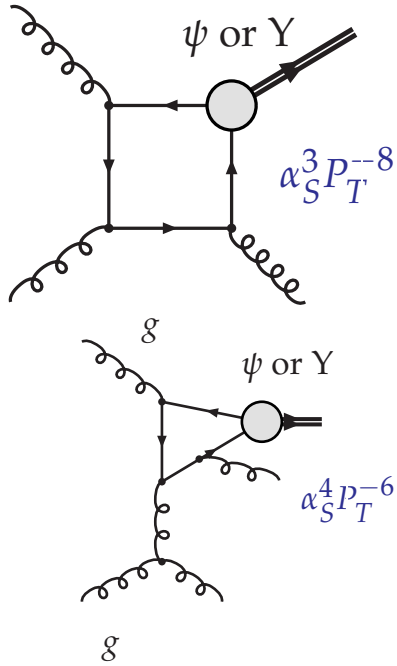

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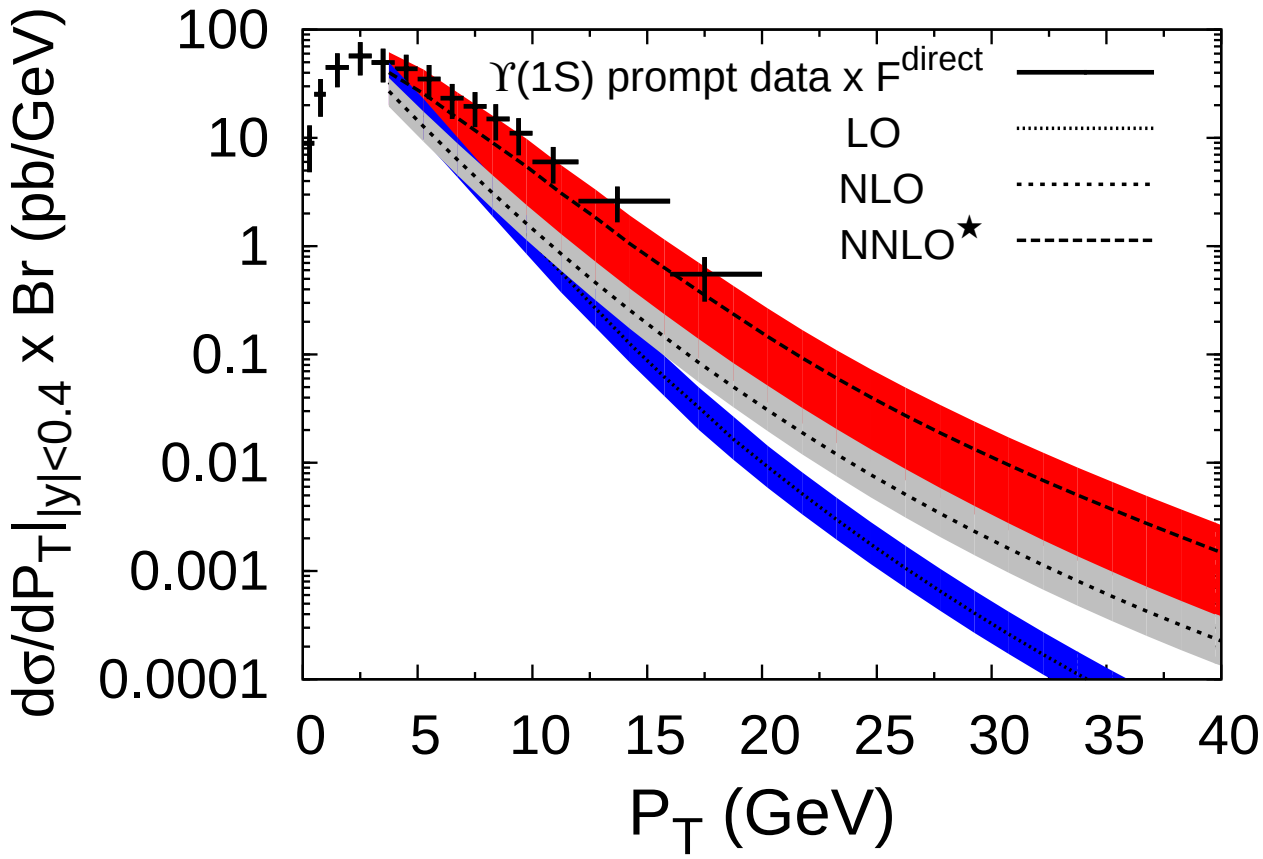

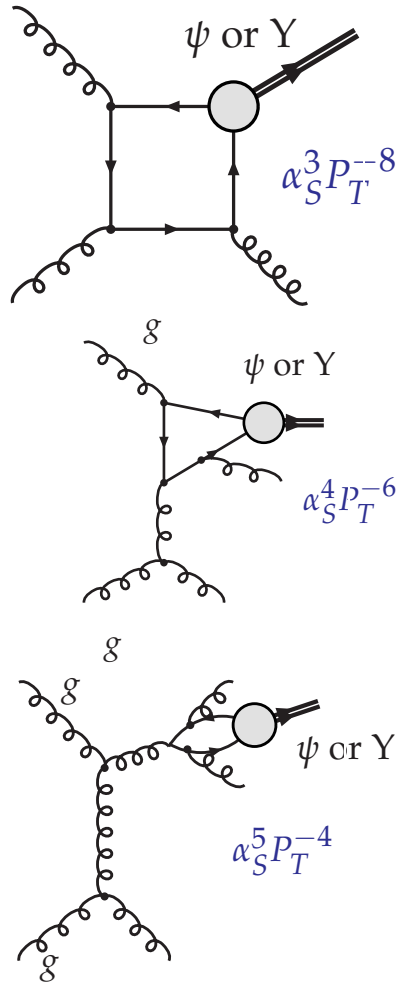

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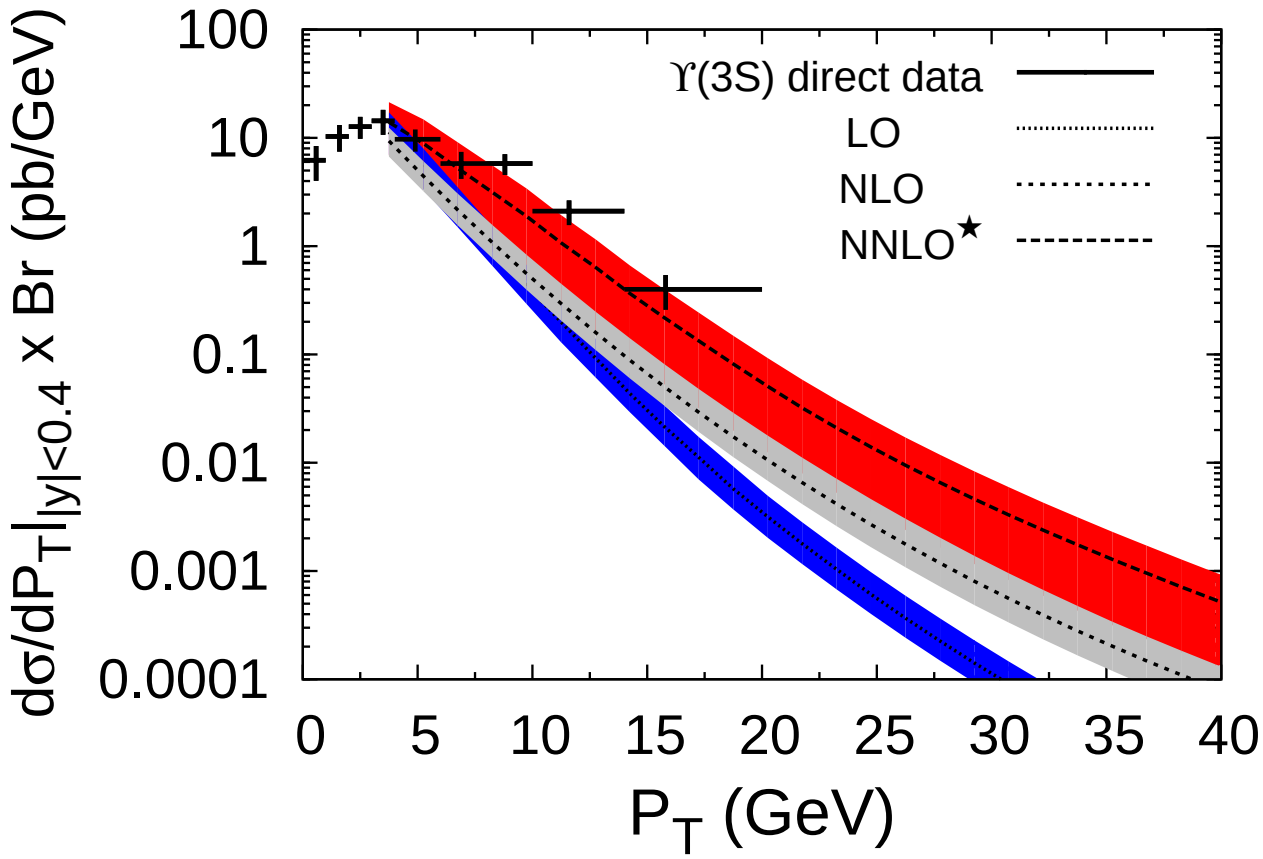

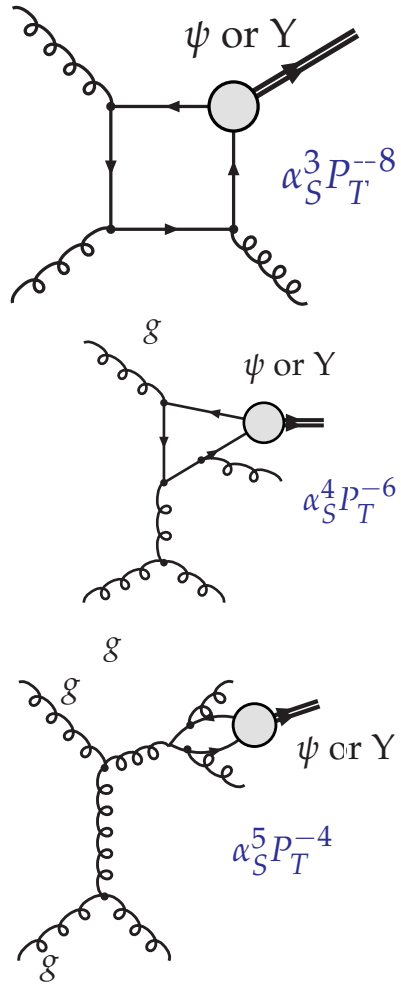

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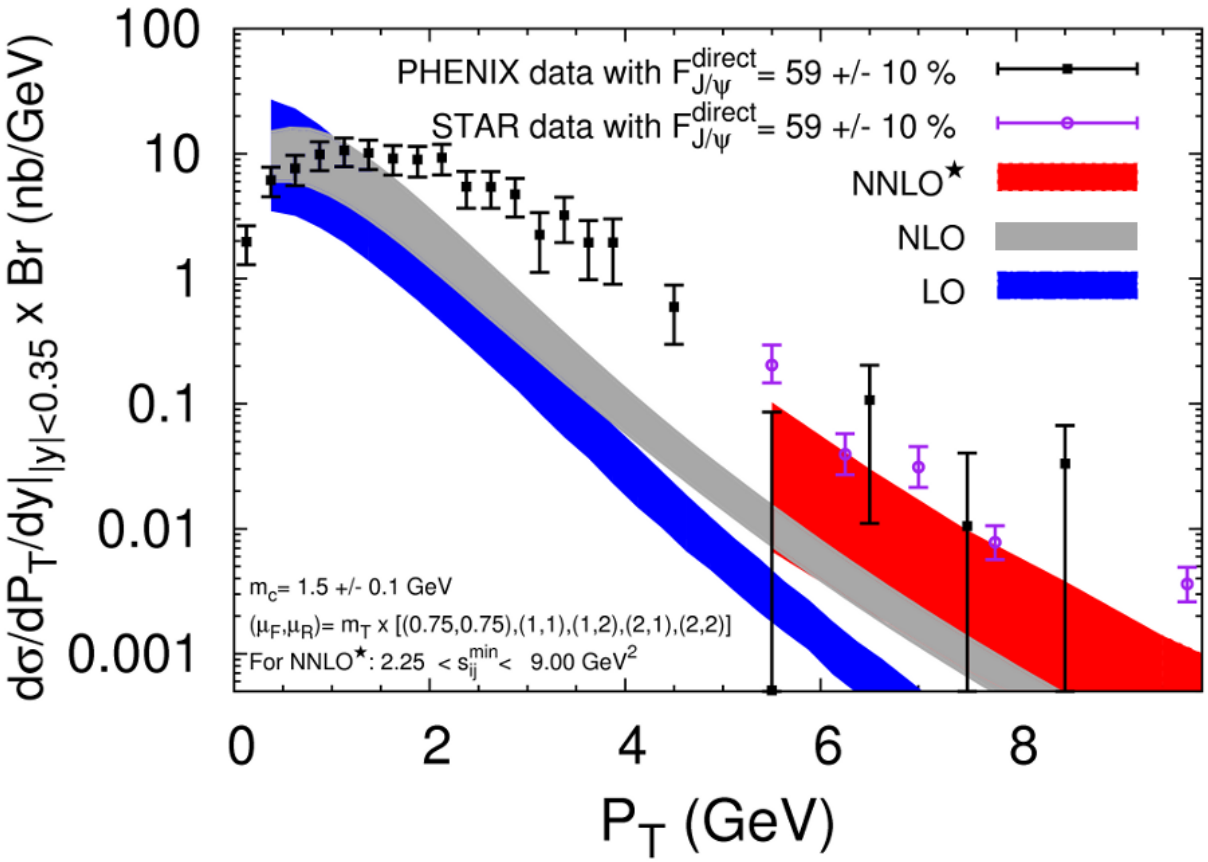

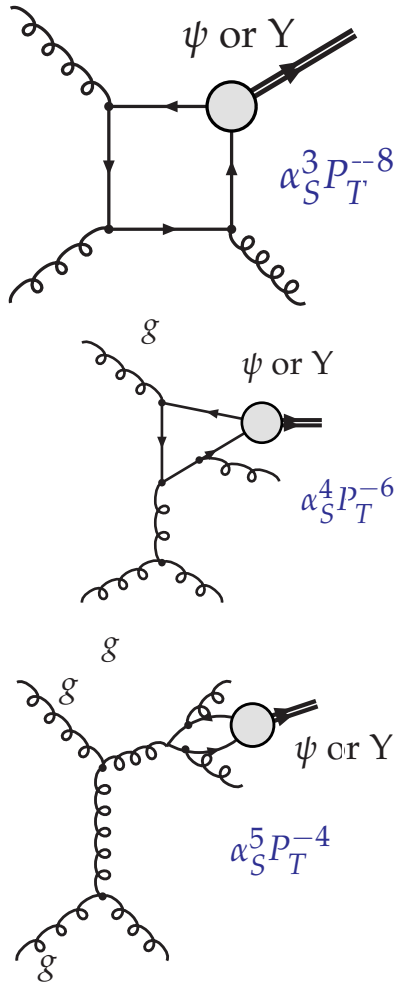

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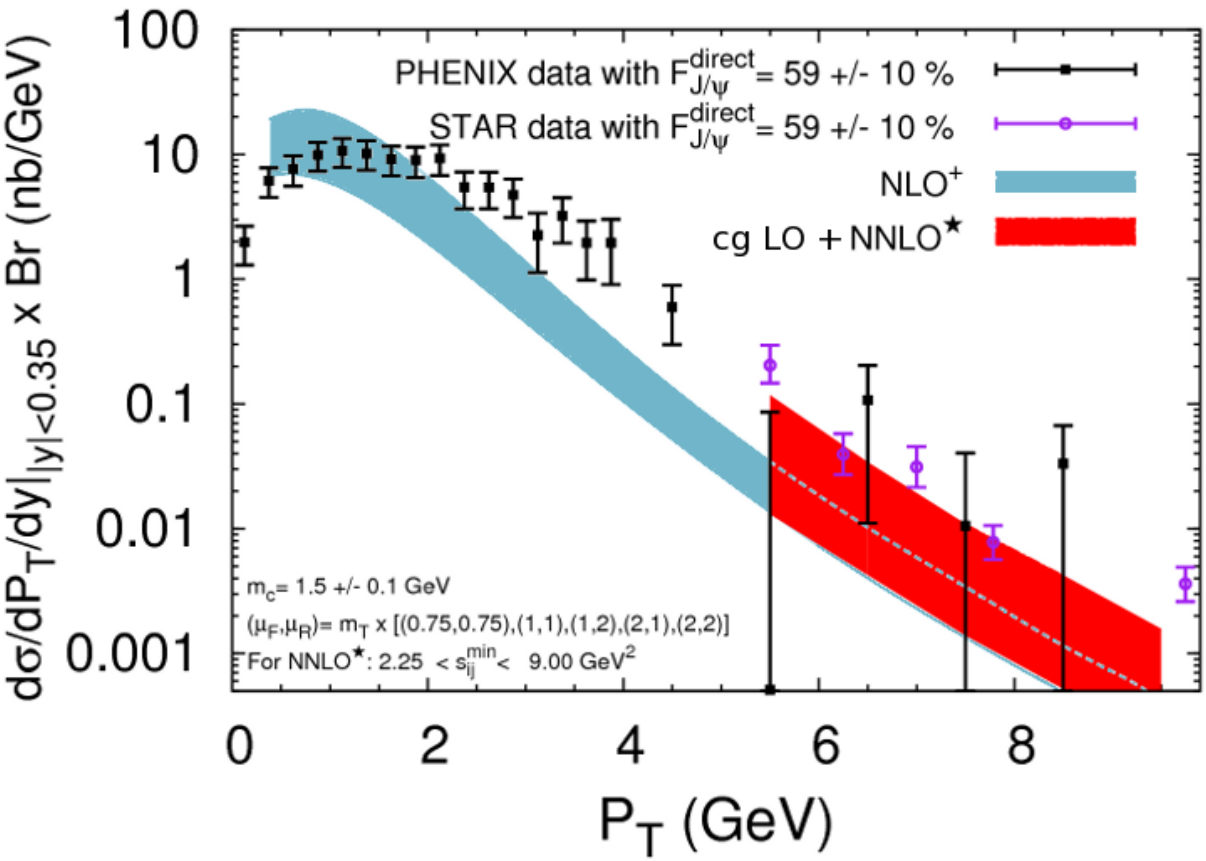

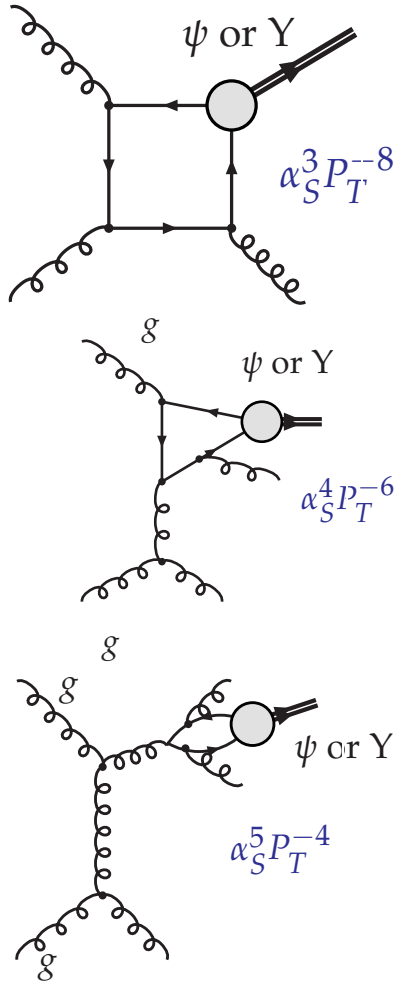

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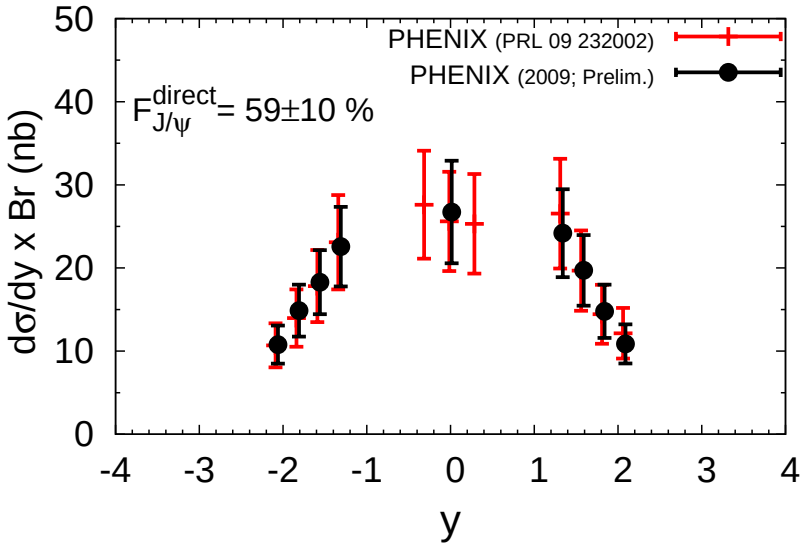
Part II

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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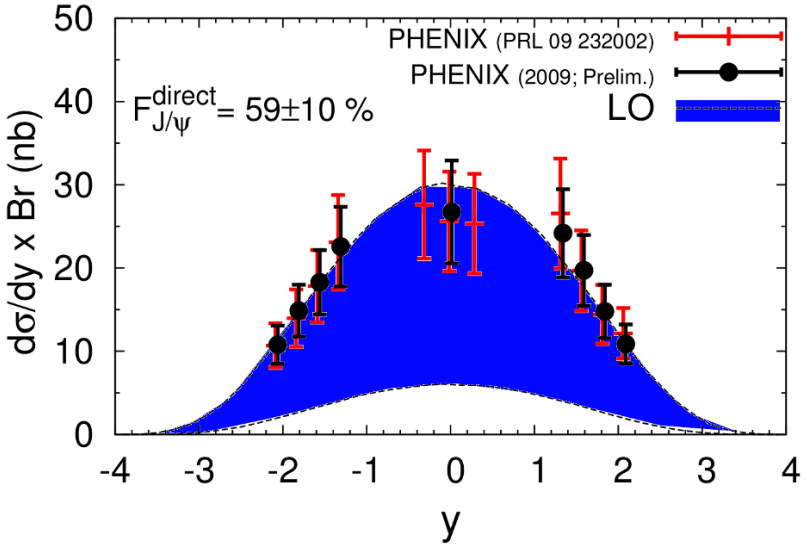

LO: $gg \to J/\psi g$ (nothing new !, back to 1981 !)

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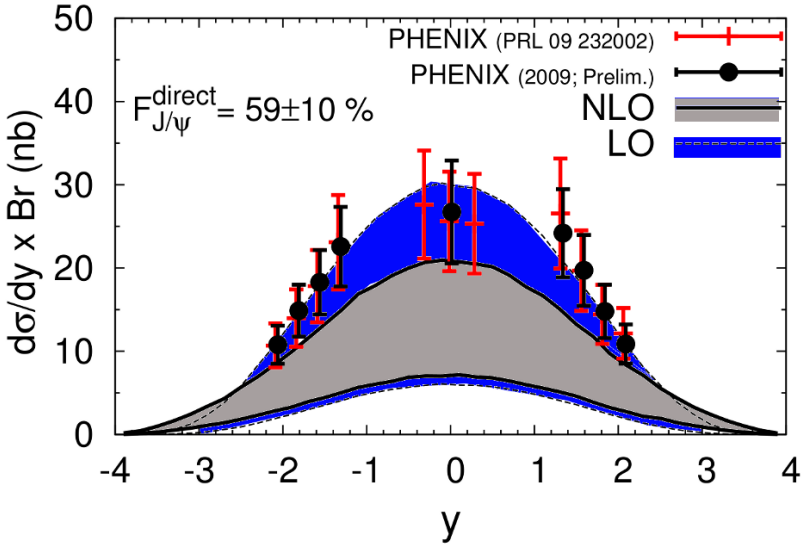

NLO: $gg \to J/\psi$, $gq \to J/\psi gq$, ...

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

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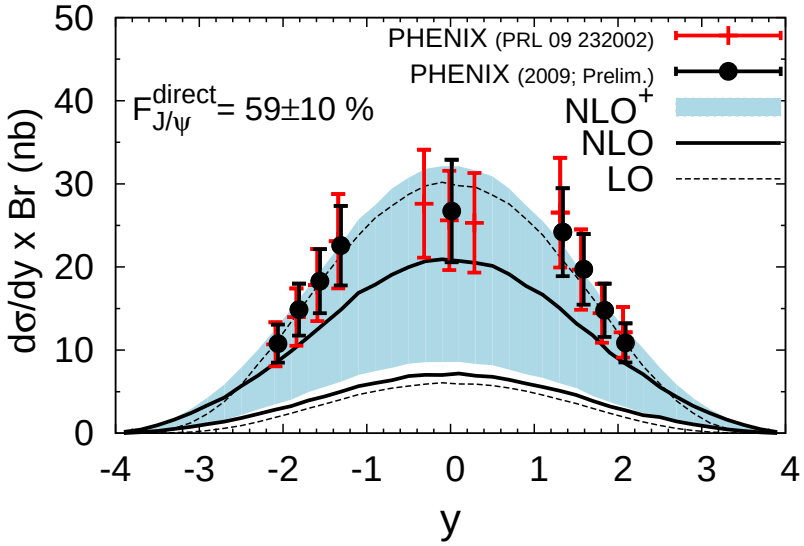

NLO$^+$: adding one new LO contribution $cg \longrightarrow J/\psi c$

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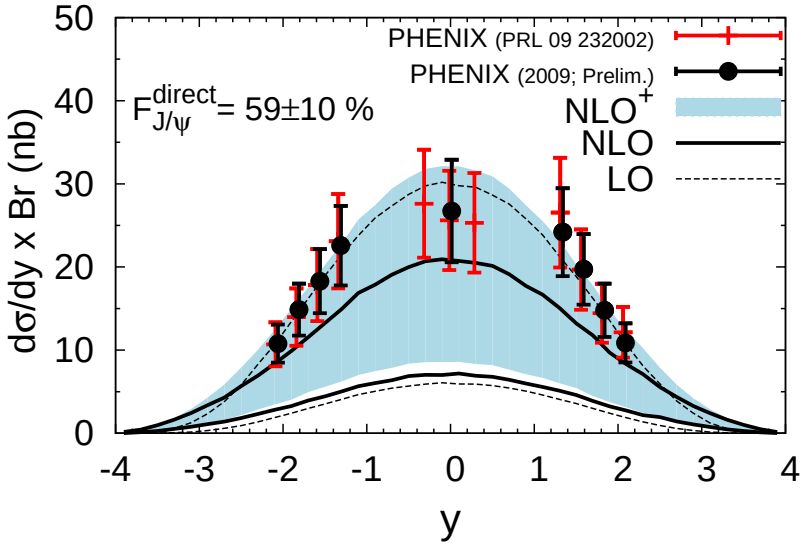

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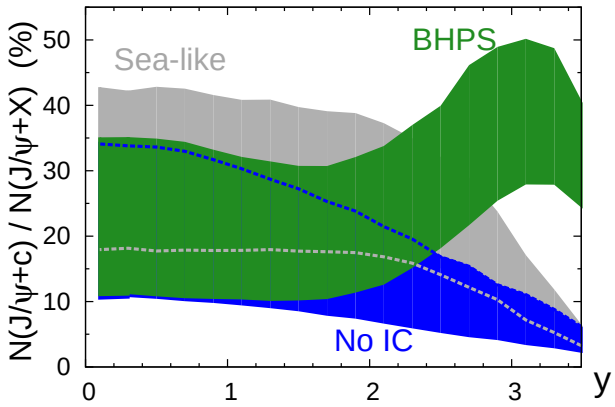

Could be studied via azimuthal correlation $J/\psi + e, \mu$; 10-40% of the direct signal

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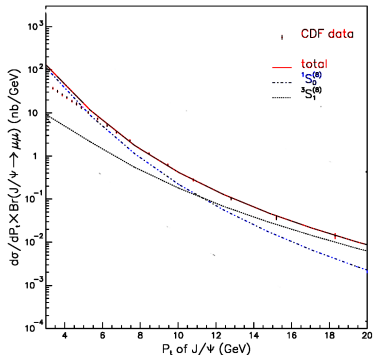
- **Constraints from the P_T dependence in pp**
  - Computation at NLO for CO channel: CO predictions overshoot data at low P_T



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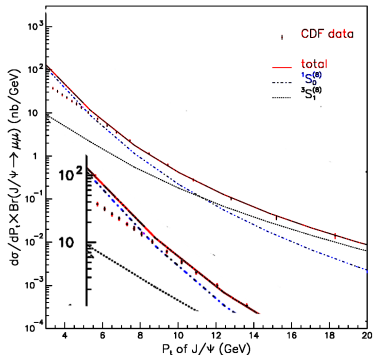

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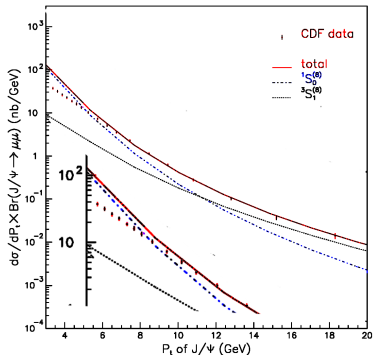

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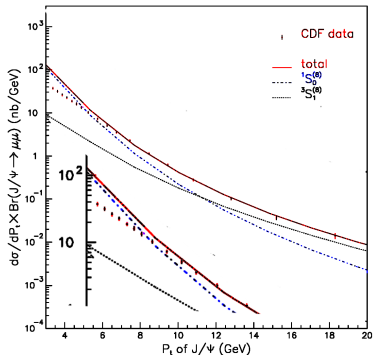

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no space for CO ($^1S_0$ or ^3P_J) in B-factory data

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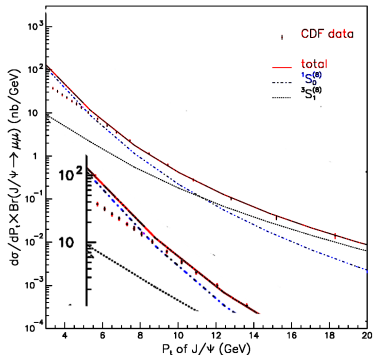

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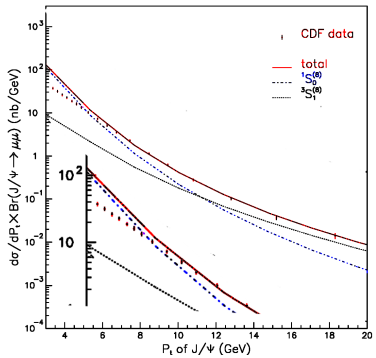

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- Actually, the reduction is much stronger and the CS channel dominates over CO at low/mid P_T in pp

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

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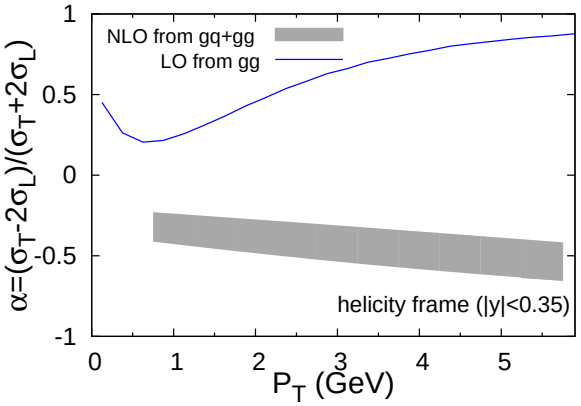

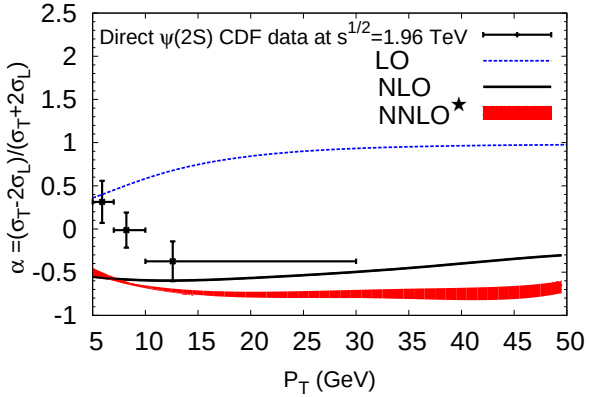

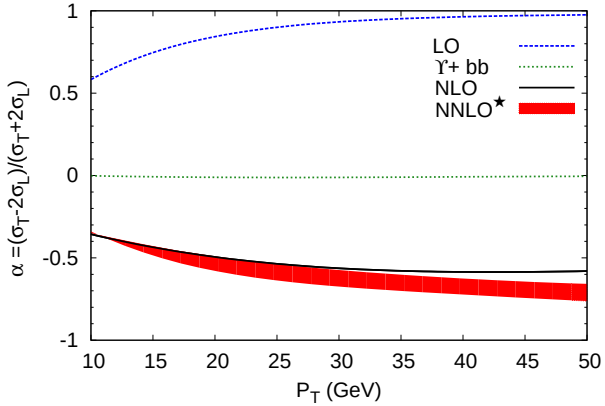

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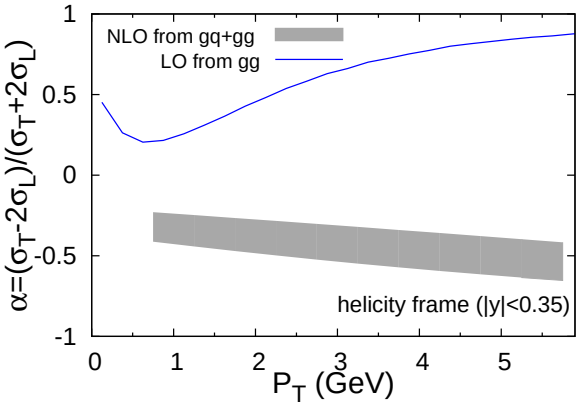
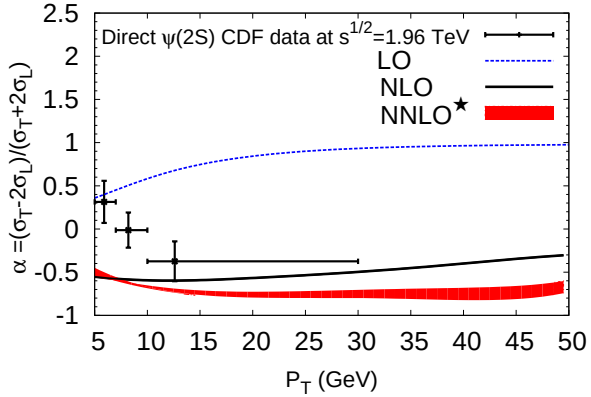
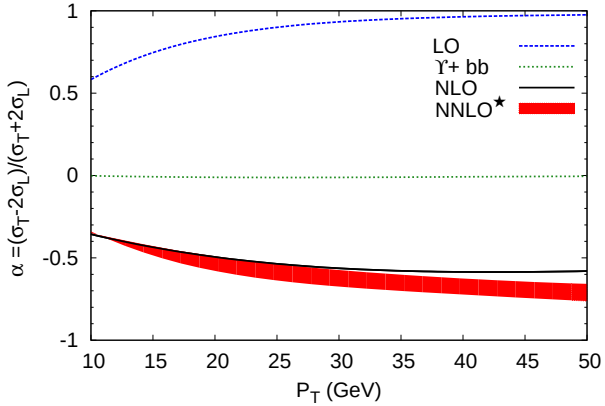






→ Complete modification of the polarisation at NLO (also at NNLO*)

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

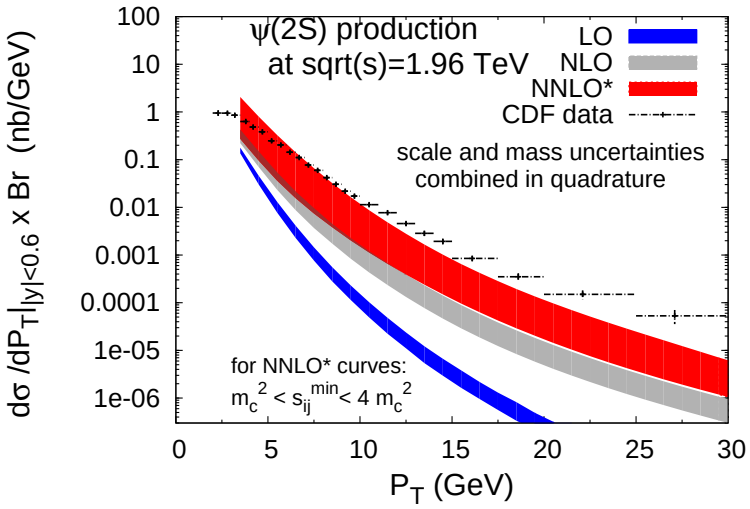
→ **This is not yet explained by simple arguments**

(although reasonable)

Part III

what we do not understand

ψ production at very large P_T



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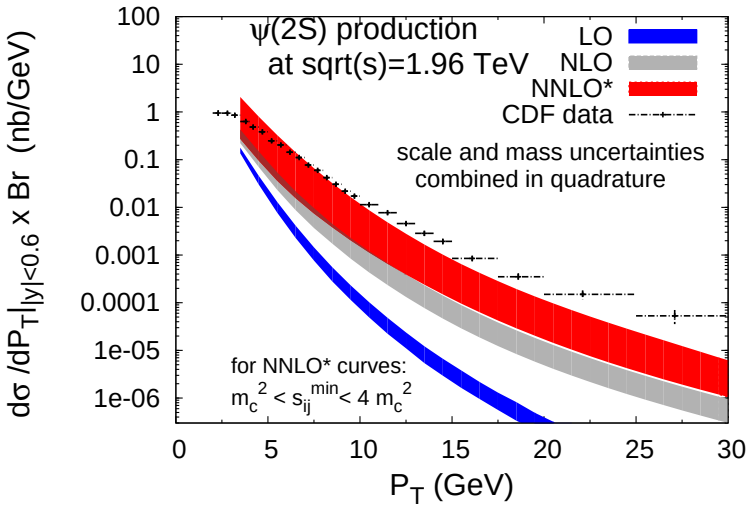

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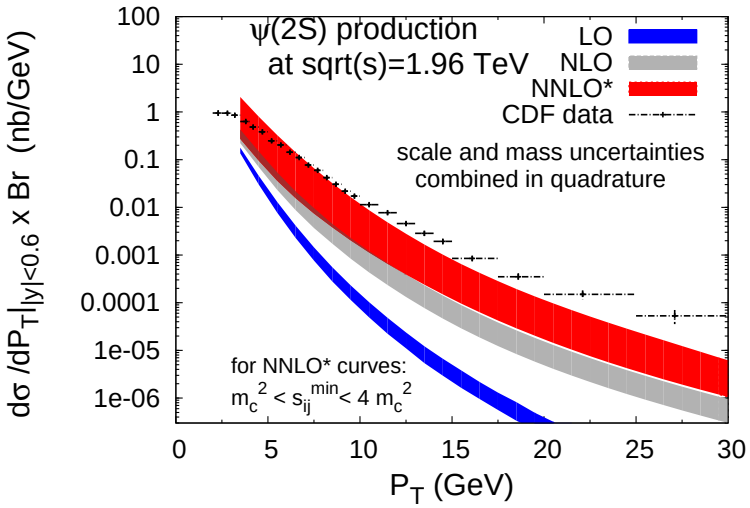

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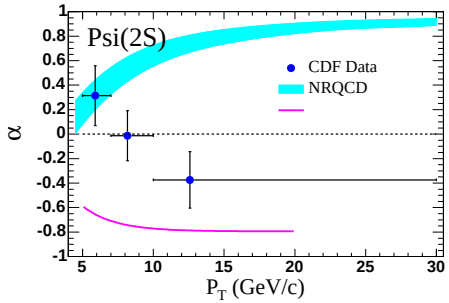

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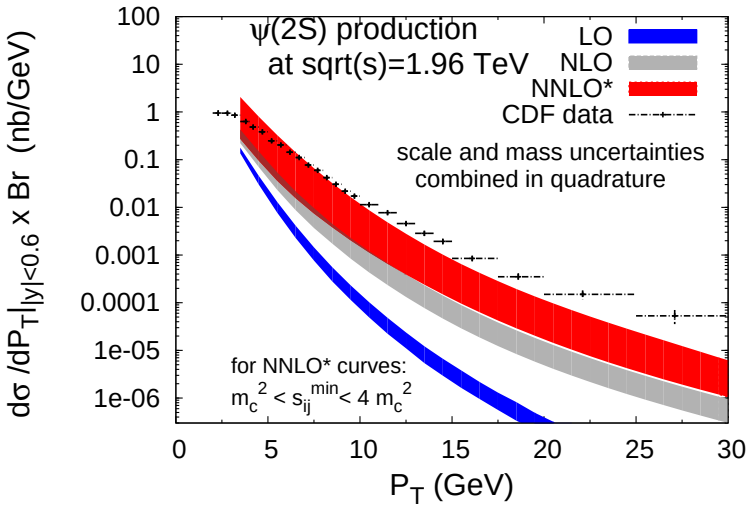

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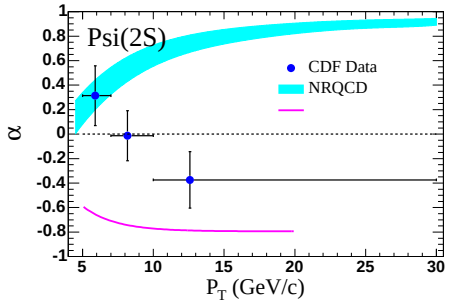

- Could be the data ...

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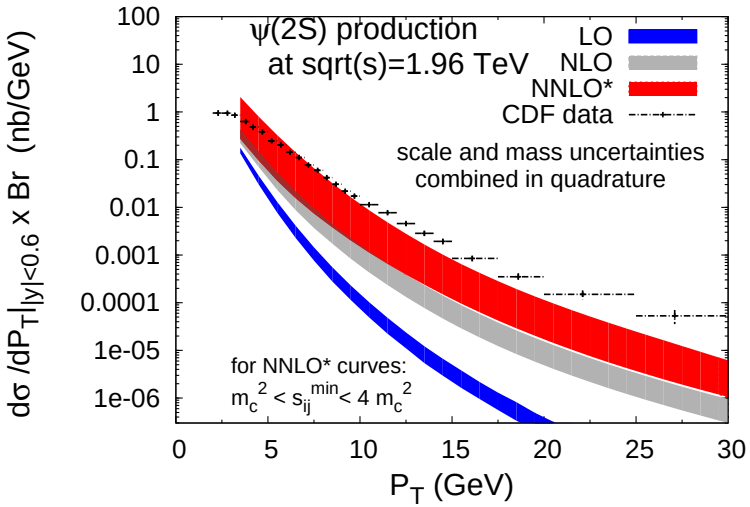

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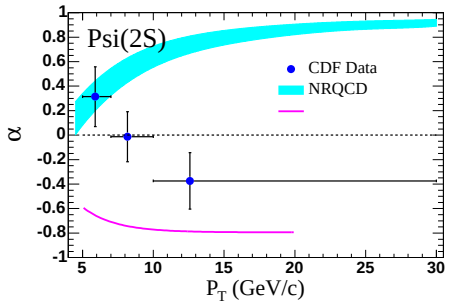

- Could be the data ...
- Let's wait for the LHC data for prompt $\psi(2S)$ or **direct** J/ψ

Part IV

what we expect from the LHC:

Part IV

what we expect from the LHC: new measurements

New observables

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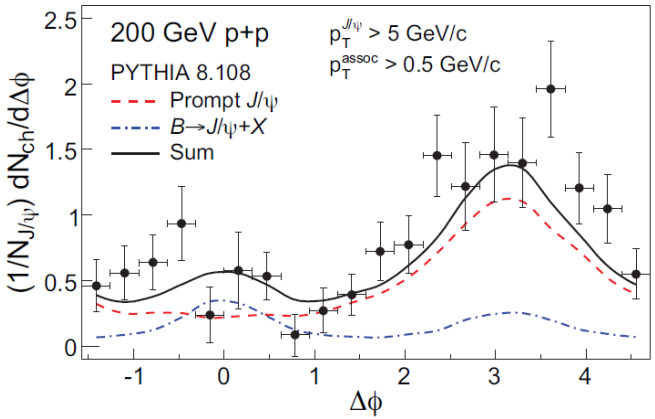

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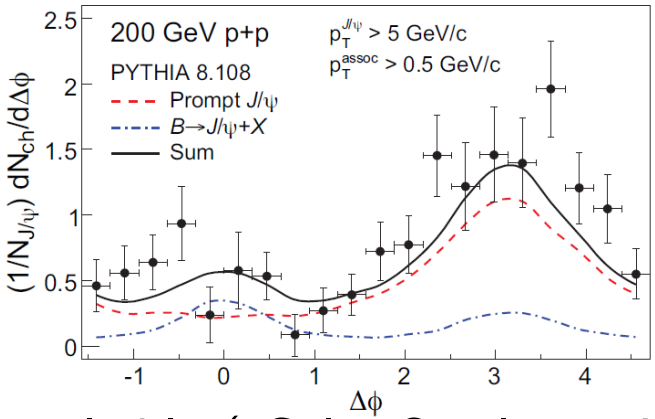

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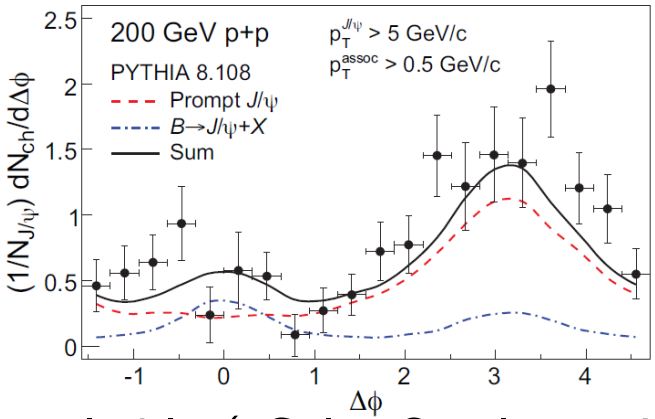

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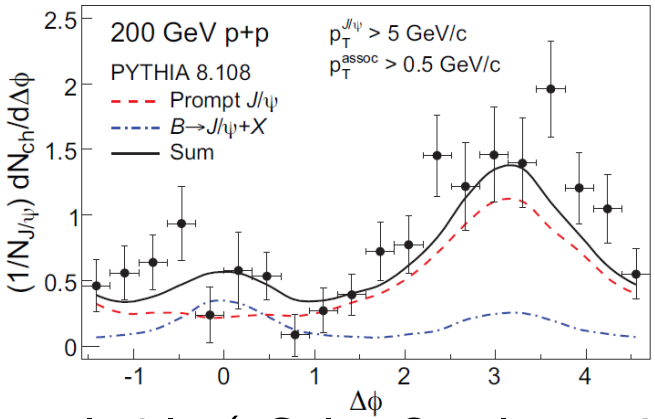

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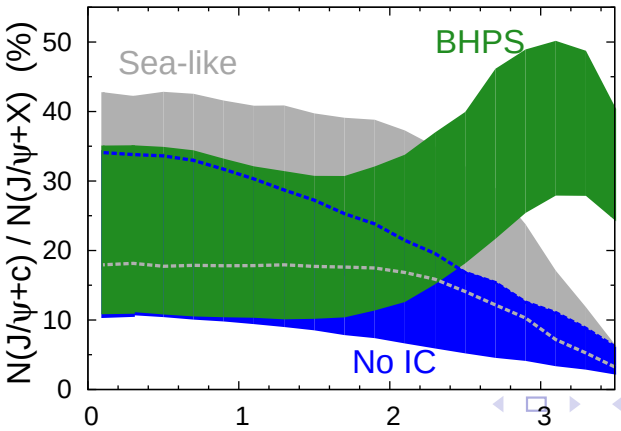
- $J/\psi + D$ or J/ψ+lepton: peak at $\Delta\phi = \pi$ in the yield integrated over P_T

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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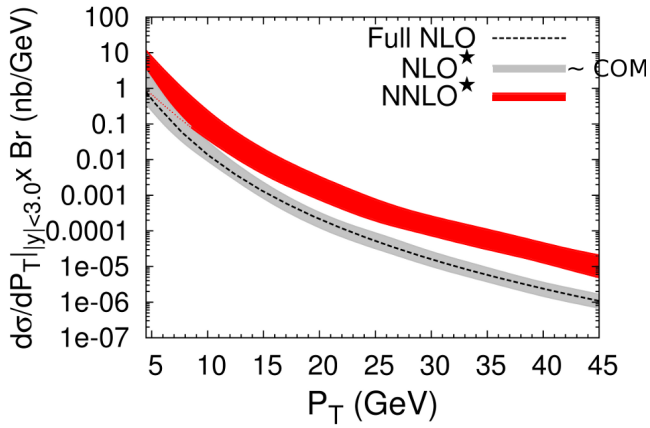

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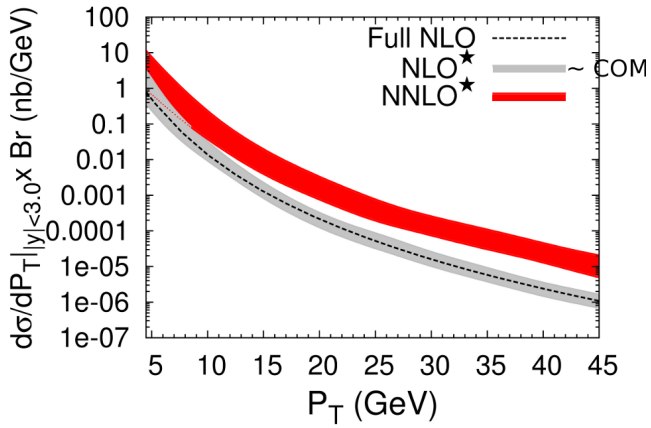

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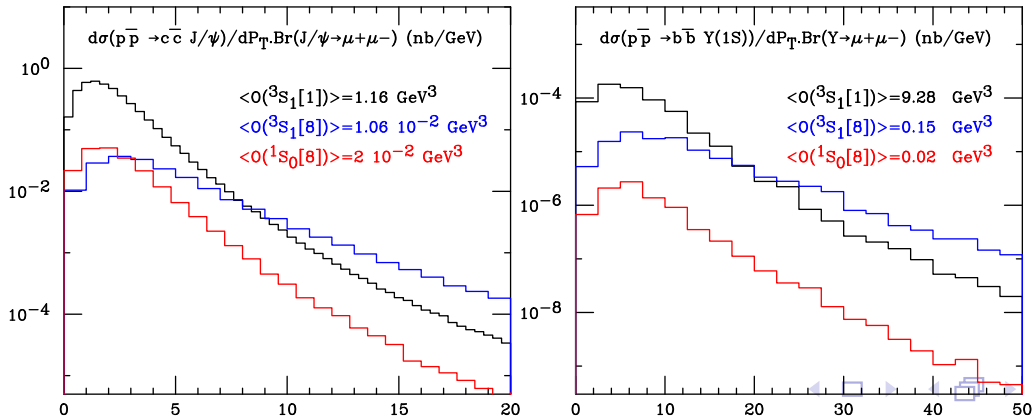

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Part V

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  - pp for ψ (RHIC, Tevatron) (gap at large P_T) — **P.Artoisenet, AIP PC 1038,55,2008. JPL, EPJC 61:693,2009 JPL arXiv:1003.4319 [hep-ph]**
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- **Drawback**: large theoretical uncertainties...
- The time has come for another look with **new observables**
  at the LHC or elsewhere !