Exclusive J/ψ production

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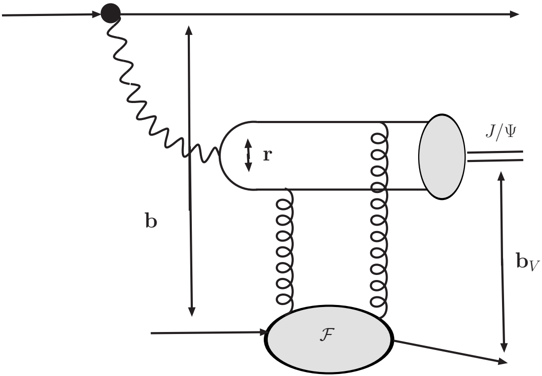
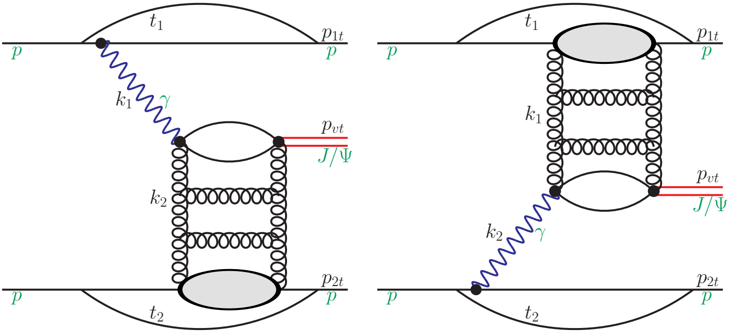
$pp \to ppJ/\psi$



A. Cisek, W. Schäfer and A. Szczurek, JHEP **1504** (2015) 159.

$pp \to ppJ/\psi$



The interference term vanishes for rapidity distributions in Born approximation

see W. Schäfer and A. Szczurek, Phys. Rev. **D76** (2007) 094014.

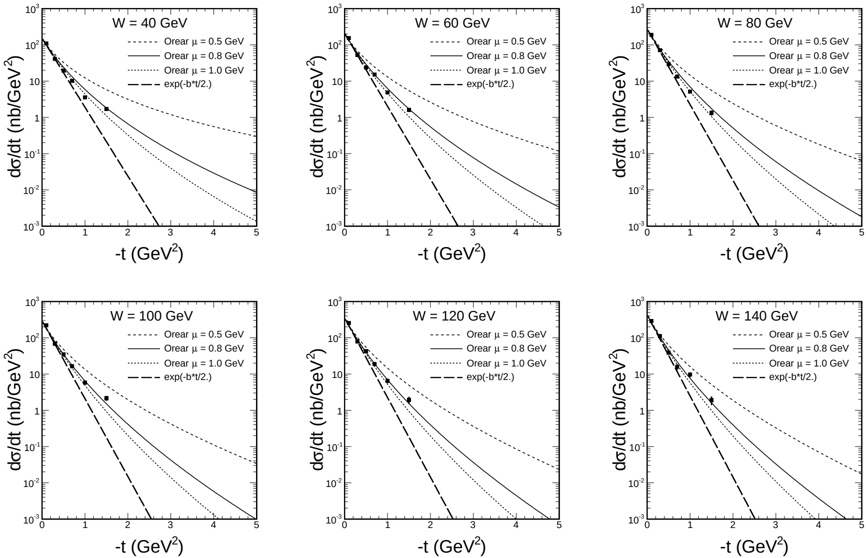
$pp \to ppJ/\psi$

$$\Im m\, \mathcal{M}_T(W, \Delta^2 = 0, Q^2 = 0) = W^2 \frac{c_V \sqrt{4\pi\alpha_{em}}}{4\pi^2}\, 2 \int_0^1 \frac{dz}{z(1-z)} \int_0^\infty \pi dk^2 \psi_V(z, k^2)$$
$$\int_0^\infty \frac{\pi d\kappa^2}{\kappa^4} \alpha_S(q^2) \mathcal{F}(x_{\rm eff}, \kappa^2) \Big(A_0(z, k^2)\; W_0(k^2, \kappa^2) + A_1(z, k^2)\; W_1(k^2, \kappa^2) \Big) .$$

dependence on the meson wave function and UGDF

No wave functions in collinear calculations.

$pp \to ppJ/\psi$


W = 40 GeV
W = 60 GeV
W = 80 GeV
W = 100 GeV
W = 120 GeV
W = 140 GeV
Orear μ = 0.5 GeV
Orear μ = 0.8 GeV
Orear μ = 1.0 GeV
exp(-b*t/2.)
dσ/dt (nb/GeV²)
-t (GeV²)

$pp \to ppJ/\psi$

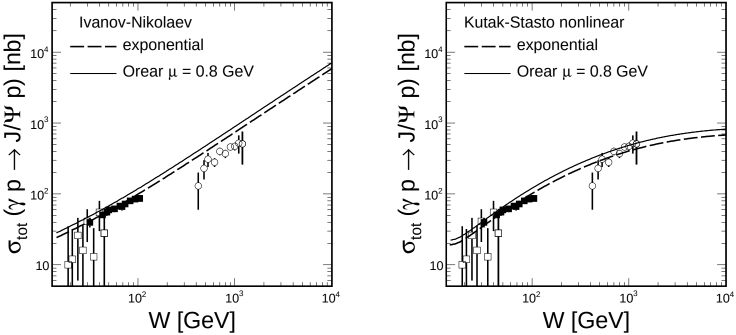
$$
\begin{aligned}
\mathcal{M}^{\lambda_1\lambda_2\to\lambda'_1\lambda'_2\lambda_V}_{h_1h_2\to h_1h_2V}(s,s_1,s_2,t_1,t_2) &= \mathcal{M}_{\gamma\mathbf{P}} + \mathcal{M}_{\mathbf{P}\gamma} \\
= \langle p'_1,\lambda'_1|J_\mu|p_1,\lambda_1\rangle\epsilon^*_\mu(q_1,\lambda_V)\frac{\sqrt{4\pi\alpha_{em}}}{t_1}&\mathcal{M}^{\lambda_{\gamma^*}\lambda_2\to\lambda_V\lambda_2}_{\gamma^*h_2\to Vh_2}(s_2,t_2,Q_1^2) \\
+\langle p'_2,\lambda'_2|J_\mu|p_2,\lambda_2\rangle\epsilon^*_\mu(q_2,\lambda_V)\frac{\sqrt{4\pi\alpha_{em}}}{t_2}&\mathcal{M}^{\lambda_{\gamma^*}\lambda_1\to\lambda_V\lambda_1}_{\gamma^*h_1\to Vh_1}(s_1,t_1,Q_2^2)\,. \qquad (2)
\end{aligned}
$$

$pp \to ppJ/\psi$

Then, the amplitude of Eq. (2) for the emission of a photon of transverse polarization λ_V, and transverse momentum $\boldsymbol{q}_1 = -\boldsymbol{p}_1$ can be written as:

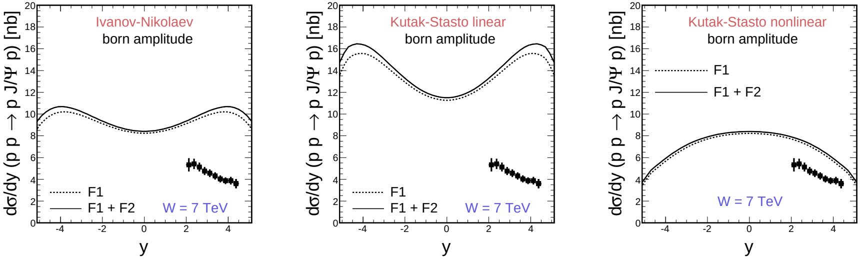
$$\langle p_1', \lambda_1' | J_\mu | p_1, \lambda_1 \rangle \epsilon_\mu^*(q_1, \lambda_V)$$
$$= \frac{(\boldsymbol{e}^{*(\lambda_V)} \boldsymbol{q}_1)}{\sqrt{1 - z_1}} \, \frac{2}{z_1} \, \chi^\dagger_{\lambda'} \Big\{ F_1(Q_1^2) - \frac{i\kappa_p F_2(Q_1^2)}{2m_p} (\sigma_1 \cdot [\boldsymbol{q}_1, \boldsymbol{n}]) \Big\} \chi_\lambda \, . \qquad (3)$$

$pp \to ppJ/\psi$



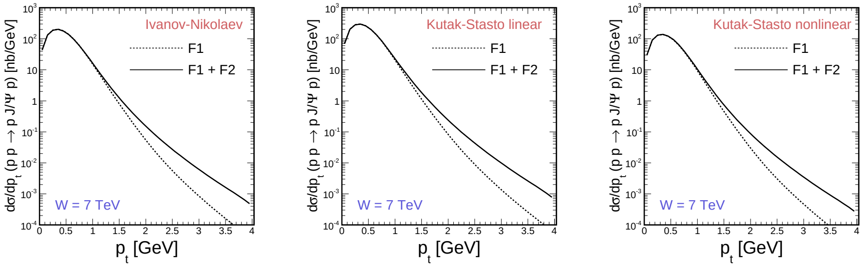
Ivanov-Nikolaev
exponential
Orear μ = 0.8 GeV
σ_tot (γ p → J/Ψ p) [nb]
W [GeV]
Kutak-Stasto nonlinear
exponential
Orear μ = 0.8 GeV
σ_tot (γ p → J/Ψ p) [nb]
W [GeV]

$pp \to ppJ/\psi$



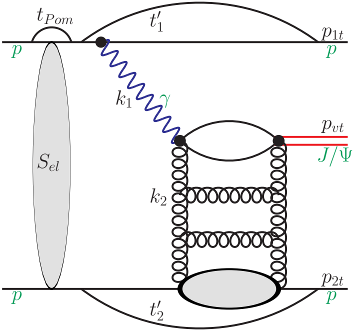
Ivanov-Nikolaev
born amplitude
F1
F1 + F2
W = 7 TeV
Kutak-Stasto linear
born amplitude
F1
F1 + F2
W = 7 TeV
Kutak-Stasto nonlinear
born amplitude
F1
F1 + F2
W = 7 TeV
dσ/dy (p p → p J/Ψ p) [nb]
y

$pp \to ppJ/\psi$



Ivanov-Nikolaev
Kutak-Stasto linear
Kutak-Stasto nonlinear
F1
F1 + F2
W = 7 TeV
dσ/dp_t (p p → p J/Ψ p) [nb/GeV]
p_t [GeV]

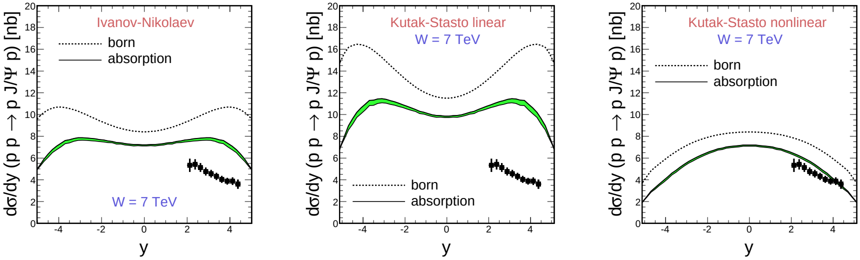
$pp \to ppJ/\psi$



Survival factor depends on the phase space point !

$pp \to ppJ/\psi$

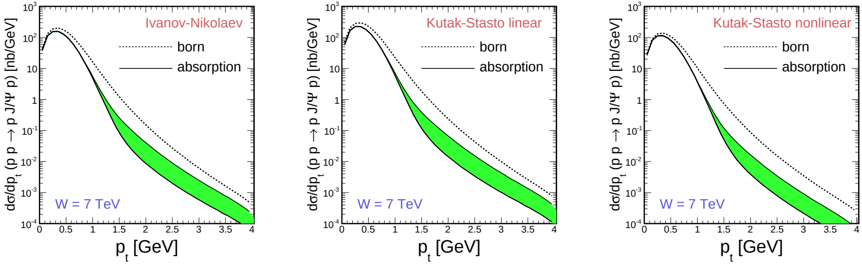
with absorption



similar for ψ'

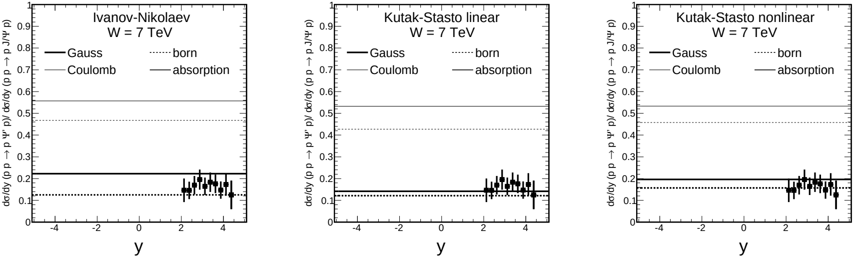
$pp \longrightarrow ppJ/\psi$

with absorption



similar for ψ'

$pp \to ppJ/\psi$



Gauss WF much better than Coulomb WF

$pp \to ppJ/\psi$

There is some model dependent indication of nonlinear effects

Open problems:

- The present experiments are not exclusive.
- So far proton dissociation "extracted" in a model dependent way assuming some functional form in p_t.
- We have some knowledge about diffractive dissociation (HERA).
- Compare to HERA there is also photon dissociation (never discussed, probably bigger).
- Interference effects due to the two diagrams were predicted. It would be nice to see modulation in ϕ_{pp} due to interference effects between the two diagrams.
- CMS+TOTEM and ATLAS+ALFA could measure purely exclusive reaction and study dependences on many more variables.