"Exclusive J/ψ process tamed to probe the low x gluon: power correction"

. **HSQCD-2016**

S.P. Jones, A.D. Martin, M.G. Ryskin and T. Teubner

Exclusive J/ψ production in γp or in ultraperipheral $pp \to p + J/\psi + p$ processes allows to probe gluons at *very* low x.
down to $x = 3 \cdot 10^{-6}$ for LHCb at 13 TeV.

$$\frac{d\sigma}{dt}(\gamma^* p \to J/\psi\ p)\Big|_{t=o} = \frac{\Gamma_{ee} M_\psi^3 \pi^3}{3\alpha^{QED}} \left[\frac{4\alpha_s}{(Q^2 + M_\psi^2)^2} xg(x, \mu_F^2)\right]^2 \left(1 + \frac{Q^2}{M_\psi^2}\right)$$

The problems:

D.Y.Ivanov, A,Schafer, L.Szymanowski, G.Krasnikov EPJ C34 (2004) 297

A. Bad perturbative convergency – $|\text{NLO}_{\text{correct.}}| \;>\; |\text{LO}|$

B. Strong dependence on μ_F **due to:**

i) large $\ln(1/x)$ **in** $(\alpha_s \ln(1/x) \ln \mu_F^2)^n$ **terms**

ii) cancellation between NLO and LO contributions.

(for Υ **situation is better)**

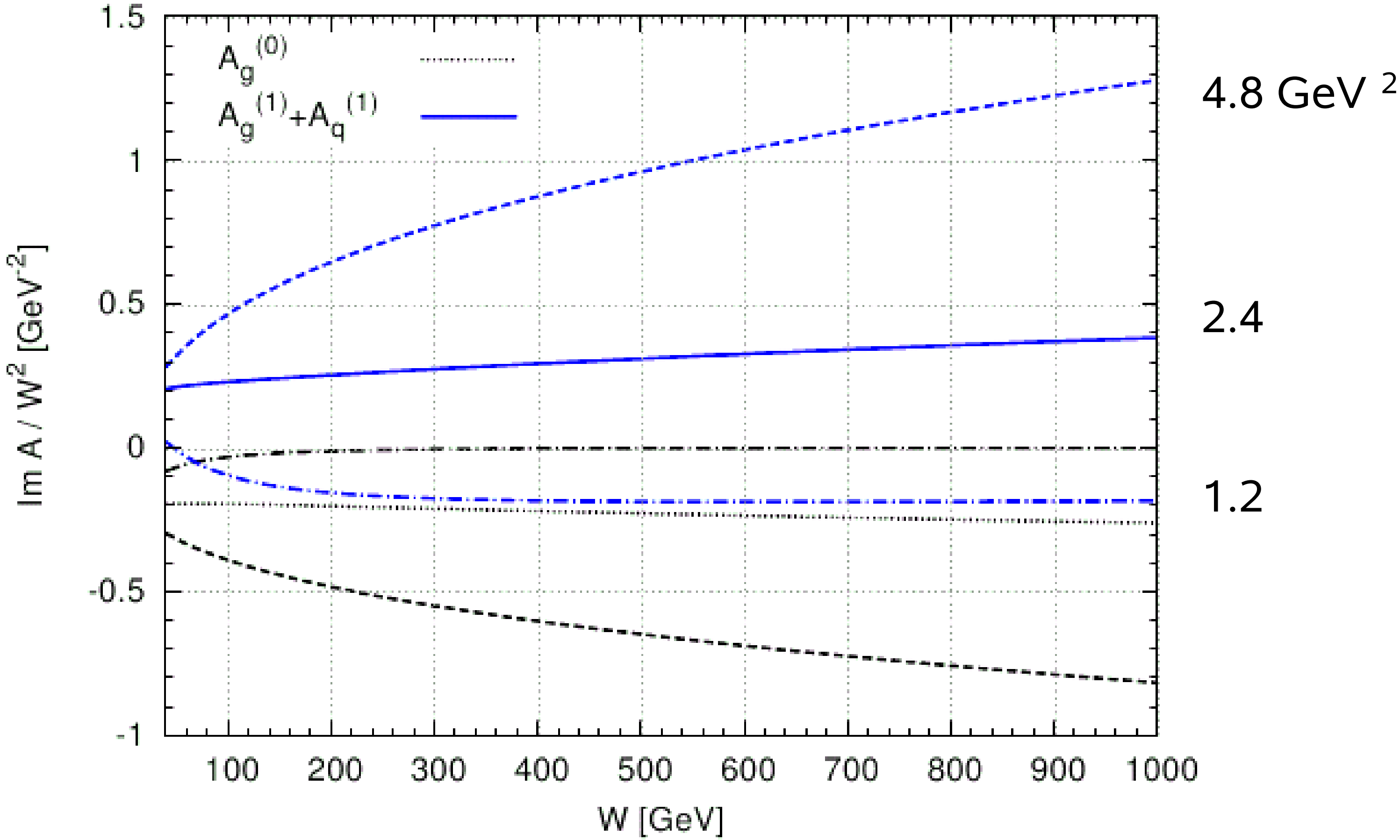


Figure 1: Predictions of $\mathrm{Im}A/W^2$ for $\gamma p \to J/\psi + p$ as a function of the γp centre-of-mass energy W, produced using CTEQ6.6 partons [4] with scales $\mu \equiv \mu_F = \mu_R$. The bottom (top) set of curves corresponds to the Born (1-loop) contribution with the scale variation $\mu^2 = m_c^2/2,\ m_c^2,\ 2m_c^2\ \mathrm{GeV}^2$, where $m_c \equiv M_\psi/2$. The dot-dashed, solid and dashed lines correspond to the low, central and high values of the scale μ, respectively. Note that the bands overlap for energies bigger than about $70\ \mathrm{GeV}$. The figure is taken from Ref. [3]. JMRT J.Phys. G43 (2016) 035002

Power Q_0^2/μ_F^2 correction

We start DGLAP at Q_0.

Everything below Q_0 is included in INPUT $PDF(Q_0)$. NLO contr. from $|q^2| < Q_0^2$ is the double counting.

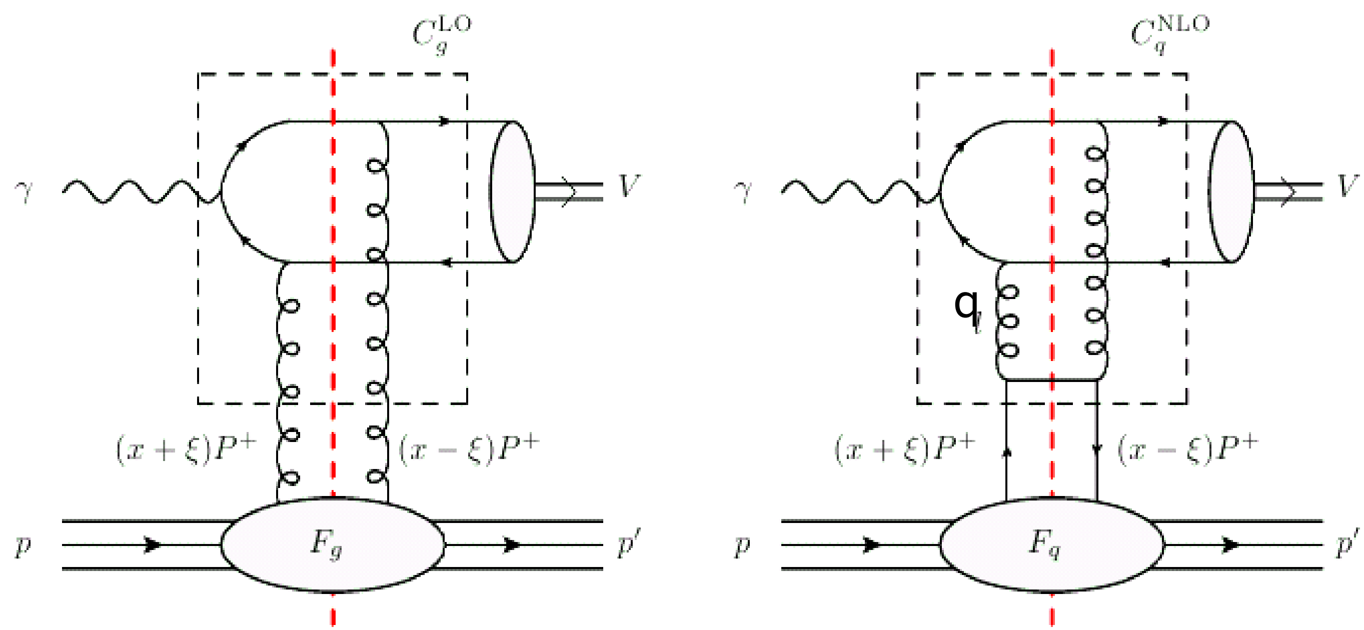


Figure 2: (a) The LO contribution to $\gamma p \to V + p$. (b) The NLO quark contribution. For these graphs all permutations of the parton lines and coupling of the gluon lines to the heavy-quark pair are to be understood. Here $P \equiv (p+p')/2$ and l is the loop momentum.

Solution:

A. to subtract NLO($|q^2| < Q_0^2$) contribution

B. to resum the $(\alpha_s \ln(1/x) \ln \mu_F^2)^n$ double Log.s

by choosing $\mu_F = M_\psi/2$ JMRT, J. Phys. G43 (2016) 035002

$$\mathbf{A}^{(0+1)}(\mu_\mathrm{f}) \equiv \mathbf{C}^{\mathbf{LO}} \otimes \mathbf{GPD}(\mu_\mathbf{F}) + \mathbf{C}^{\mathbf{NLO}}(\mu_\mathbf{F}) \otimes \mathbf{GPD}(\mu_\mathrm{f})$$

. $\mu_R = \mu_F$

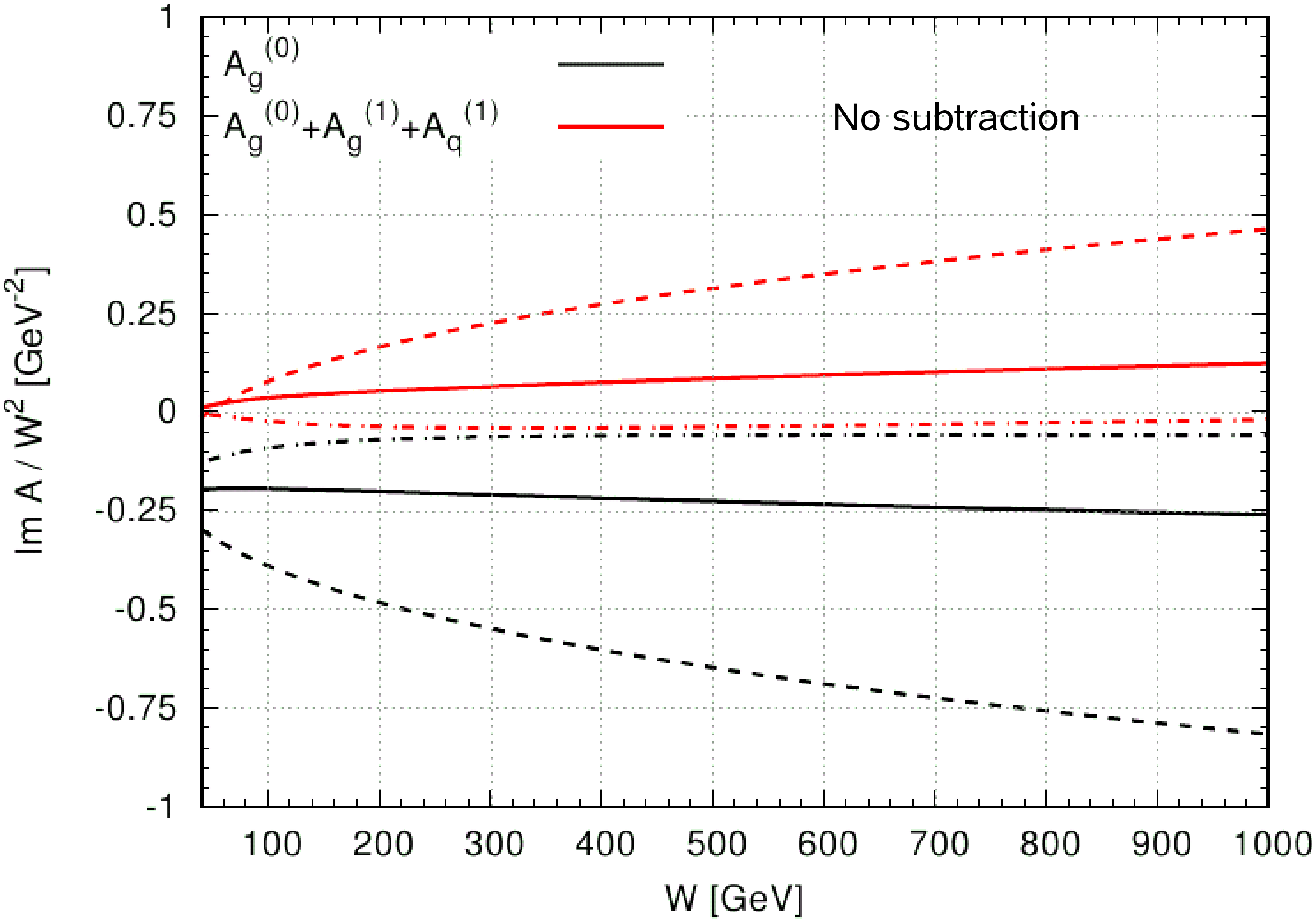
a) BLM prescription – the NLO term $\beta_0 \ln(\mu_R/\mu_F) = 0$

b) Consider the quark loop in gluon propagator.

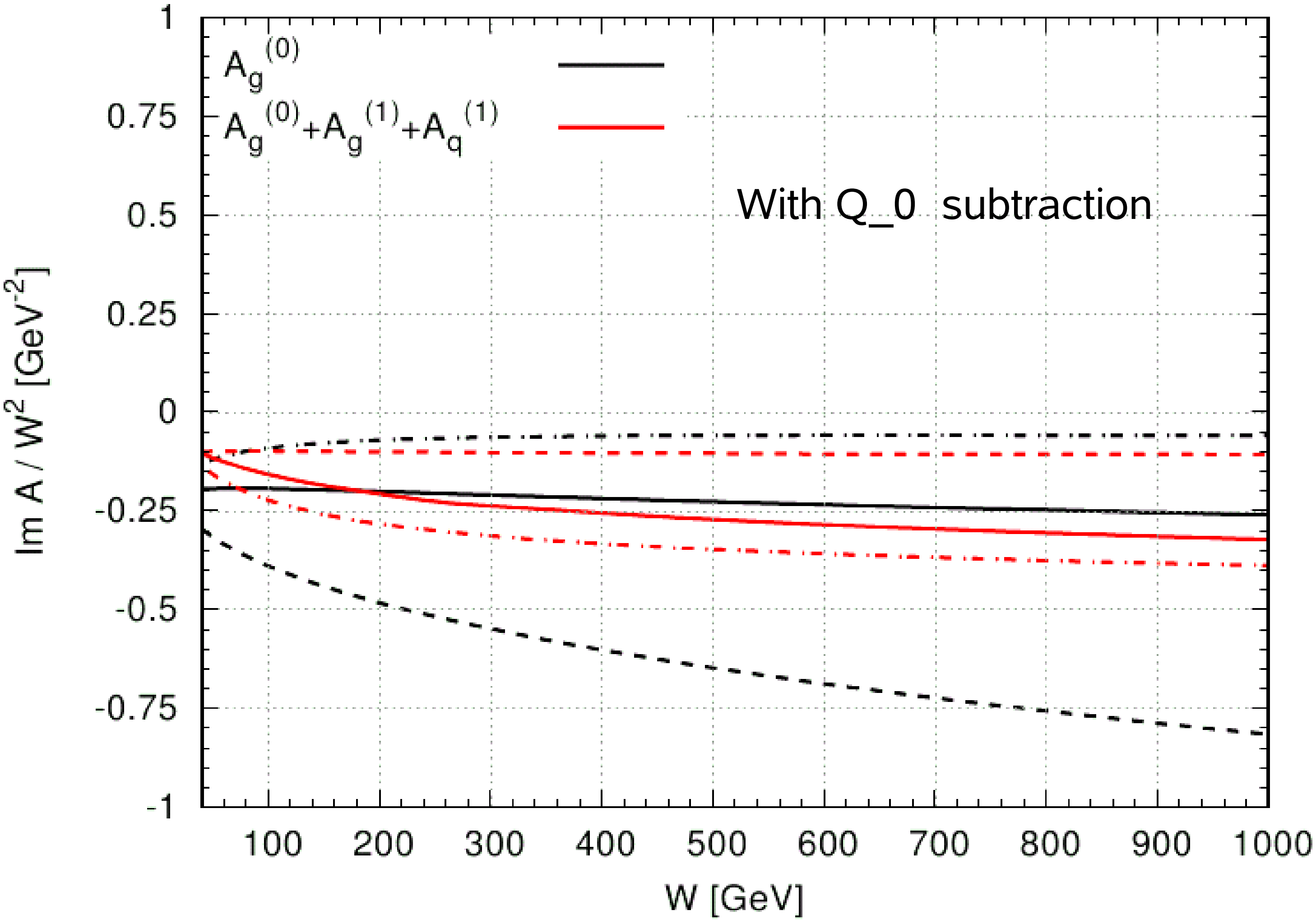
It contains the $\ln(\mu_F/Q_0)$ from DGLAP and

. $\ln(\Lambda_{UV}/\mu_R)$ from $\alpha_s(\mu_R)$

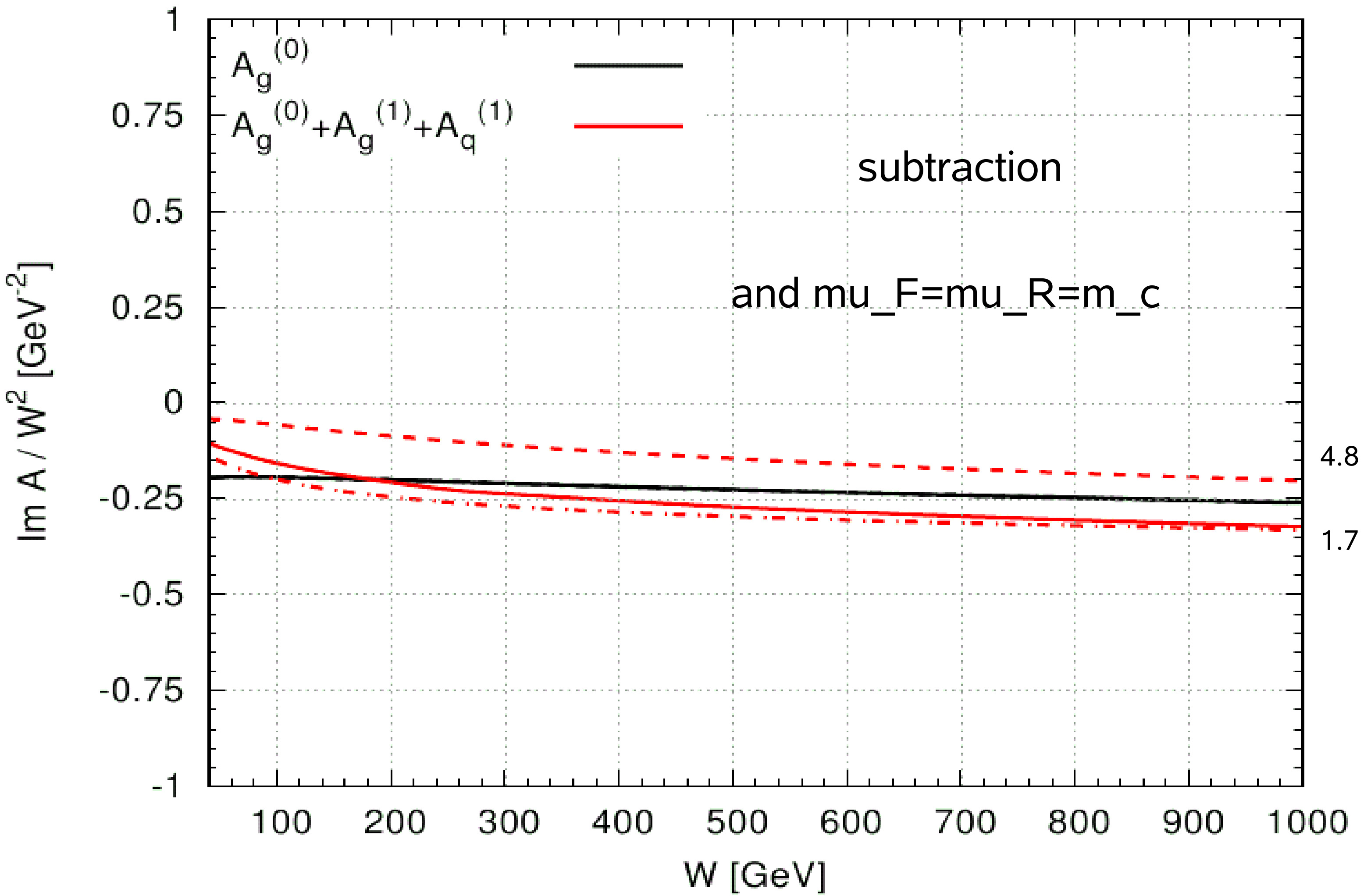
$\mu_R = \mu_F$ provides smooth matching without the double counting.



mu_F=mu_R=1.7, 2.4, 4.8 GeV^2



preliminary



preliminary

Conclusion

Subtraction of $\mathrm{NLO}(q^2| < Q_0^2)$ plus $\mu_\mathrm{F} = \mathrm{M}_\psi/2$ choice

(no double counting) (resum of double Logs)

provide good accuracy for $\gamma \mathrm{p} \to \mathrm{J}/\psi \; + \; \mathrm{p}$ amplitude.

Backup

The SUM of relativistic correct. plus α_s-correct. in J/ψ wave. funct. is small ($\sim$ few %) P.Hoodbhoy PR D56 (1997) 388

For a low x GPD(x) = PDF(x)$\otimes$ Shuvaev transform assuming $\mathrm{H_N} = \mathrm{M_N}$ and no singularity in the right half N-plane in PDF input

Re/Im can be calculated via the dispersion relation for positive signature amplitude.