HIGGS AND HEAVY QUARKS DIFFRACTIVE PRODUCTION

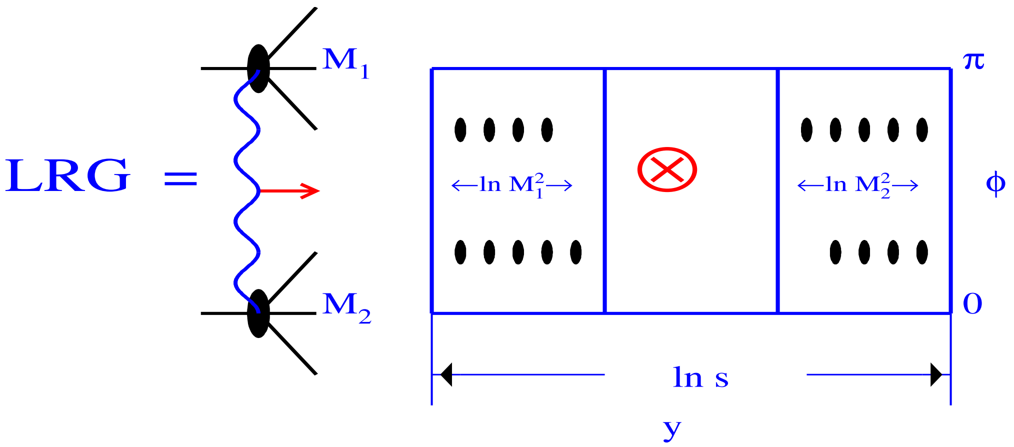
Eugene Levin

Tel Aviv University / BNL

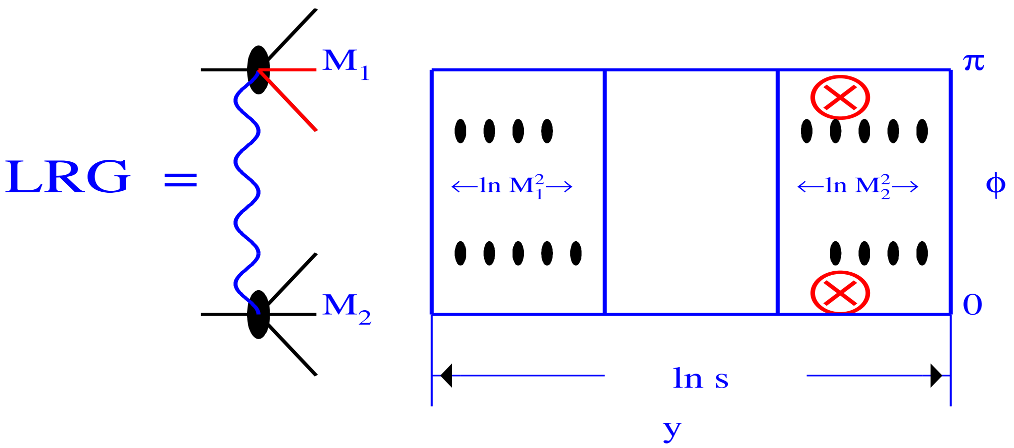
November 4 ,1999

1. **What is the value of cross section for Higgs diffractive production in the central rapidity region?** ?
2. **What is the value of the cross section for diffractive dissociation in heavy quark-antiquark pair** ?
3. **How well can we estimate these cross sections** ?

Double Pomeron Higgs Production:



Diffractive Heavy Quark Production:



Inclusive Higgs production

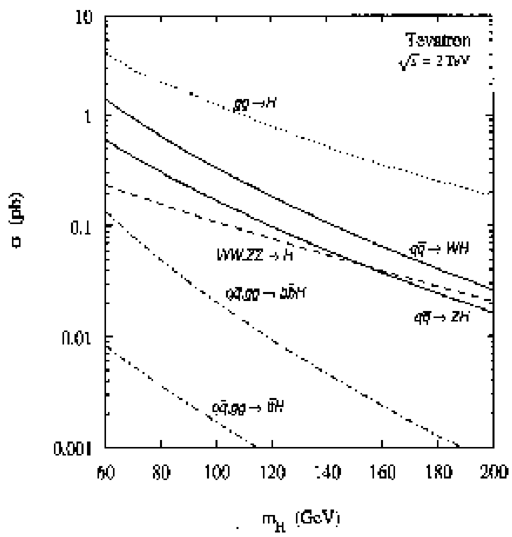
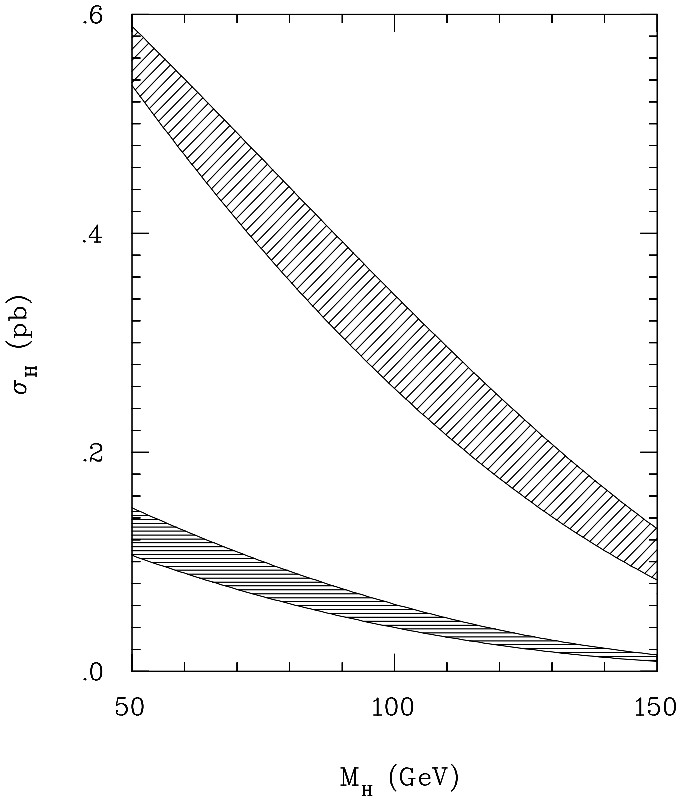


Figure 1

- A.Strange, E. Marciano and S. Willenbrock (1993)

Double Pomeron Higgs production

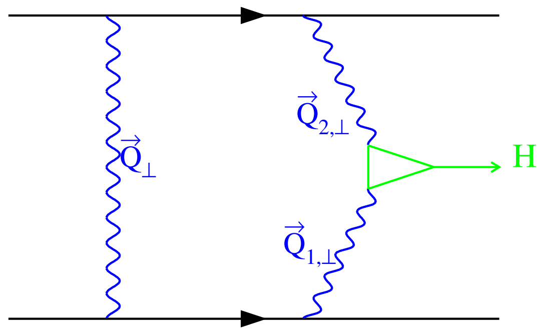
Typical values for cross sections



- A. Bialas and P.V. Landshoff (1991)

- J-R. Cudell and O.F. Hernandez (1995)

Higgs DD production is a "soft" process !!!



$$\mathbf{M(q + q \longrightarrow q + H + q)} \;=$$

$$\frac{2}{9}\, 2\, g_H \int \frac{d^2 Q_\perp}{Q^2_\perp\, Q^2_{1,\perp}\, Q^2_{2,\perp}}\, 4\alpha_S(Q^2_\perp)\, (\vec{Q}_{1,\perp} \cdot \vec{Q}_{2,\perp})$$

They say (S. Dawson (1991)):

$$g^2_H \;=\; \sqrt{2} G_F \alpha^2_S(M^2_H) N^2 / 9\pi^2$$

I think:

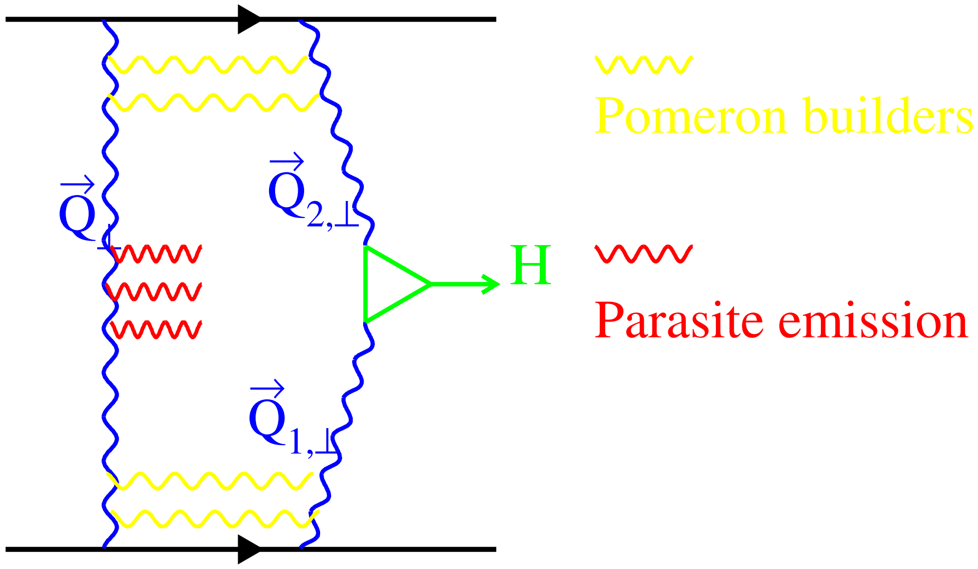
$$g^2_H \;=\; \sqrt{2} G_F \alpha^2_S(Q^2_\perp) N^2 / 9\pi^2$$

$$|\mathbf{t_1}| = |\vec{\mathbf{Q}}_\perp - \vec{\mathbf{Q}}_{\mathbf{1},\perp}| \approx |\mathbf{t_2}| = |\vec{\mathbf{Q}}_\perp - \vec{\mathbf{Q}}_{\mathbf{2},\perp}| \approx \mathbf{2/B_{el}}$$

Therefore:

$$\mathbf{M(q + q \longrightarrow q + H + q)} \propto \int \frac{\mathbf{d^2 Q_\perp}}{\mathbf{Q^4_\perp}}$$

The more the gluons the more the problems



$$\frac{d\sigma_P(pp \to ppH)}{dy}\Big|_{y=0} =$$

$$\frac{4\,g_H^2}{16^2\,\pi^3} \int dt_1 dt_2 g_{Pp}^2 g_{Pp}^2\, e^{\frac{B_{el}(s/M_H^2)}{2}(t_1+t_2)} \left(\frac{s}{M_H^2}\right)^{2\,\Delta_P}$$

$$\begin{aligned}\sigma(GG \to H) &= 1.16\,pb \quad (\alpha_S(M_H^2))\\ &= 20\,pb \quad (\alpha_S(Q_\perp^2))!?\end{aligned}$$

$$\frac{\mathbf{d\sigma_P(pp \to ppH)}}{\mathbf{dy}}|_{\mathbf{y=0}} = \frac{\mathbf{16}}{\pi}\,\sigma(\mathbf{GG} \;\to\; \mathbf{H})\left(\frac{\sigma_{\mathbf{el}}(\mathbf{s/M_H^2})}{\sigma_{\mathbf{tot}}(\mathbf{s/M_H^2})}\right)^{\mathbf{2}}$$

For $M_H = 100GeV$

$$\frac{\mathbf{d\sigma_P(pp \to ppH)}}{\mathbf{dy}}|_{\mathbf{y=0}} = \mathbf{2pb}$$

Not so bad but ...

$$\frac{\mathbf{d\sigma(pp \to ppH)}}{\mathbf{dy}}|_{\mathbf{y=0}} \quad = \quad \mathbf{S^2(no\;\; inel.\;\; int.\; of\; spectators)}$$

$$\cdot \quad \mathbf{S^2(no\;\; parasite\;\; emission)}$$

$$\cdot \quad \frac{\mathbf{d\sigma_P(pp \to ppH)}}{\mathbf{dy}}|_{\mathbf{y=0}}$$

$\langle |\ \mathbf{S^2_{spectator}}|\ |\rangle$
$\approx\ \mathbf{0.07 - 0.13}$

J.D. Bjorken (1993)
E. Gotsman, E. Levin &
Maor (1993 - today)
R.S. Fletcher (1993)

$$\langle |\, \mathbf{S^2(parasite\ \ emission)} |\, |\rangle \;=\; \mathbf{e}^{-\,<\mathbf{N_G(\Delta y = \ln(M_H^2/s_0)}>}$$

In pQCD (Khoze, Martin & Ryskin (1997)):

$$< \mathbf{N_G(\Delta y = \ln(M_H^2/s_0)} > \approx \mathbf{8}$$

My estimate:

$$< \mathbf{N_G(\Delta y = \ln(M_H^2/s_0)} > \;=\; \frac{\mathbf{N_{hadrons}}}{\mathbf{N(one\quad minijet)}} \;\approx\; \mathbf{2-3}$$

$$\langle |\, \mathbf{S^2_{parasite\ \ emission}} |\, |\rangle \;\approx\; \mathbf{0.1}$$

Finally:

$$\frac{d\sigma(pp \to ppH)}{dy}\Big|_{y=0} = 0.02\,pb$$

God loves the brave ! ! !

DD Higgs Production :

$$\frac{d\sigma(pp \to X_1X_2H)}{dy}|_{y=0} = \frac{d\sigma(pp \to ppH)}{dy}|_{y=0}$$

$$\times \left(\frac{\sigma^{SD} \cdot B_{el}(\sqrt{s}/M_H)}{4\,\sigma_{el} \cdot B_{DD}(\sqrt{s}/M_H)}\right)^2$$

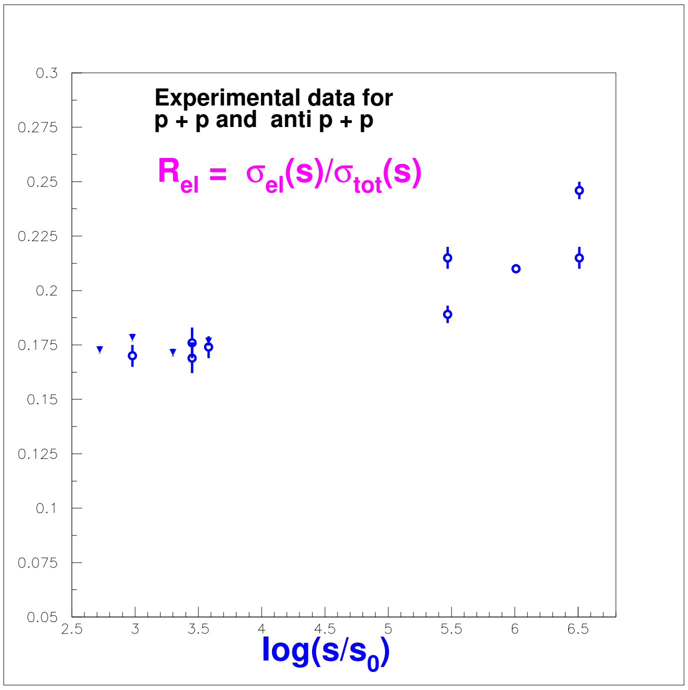
Where

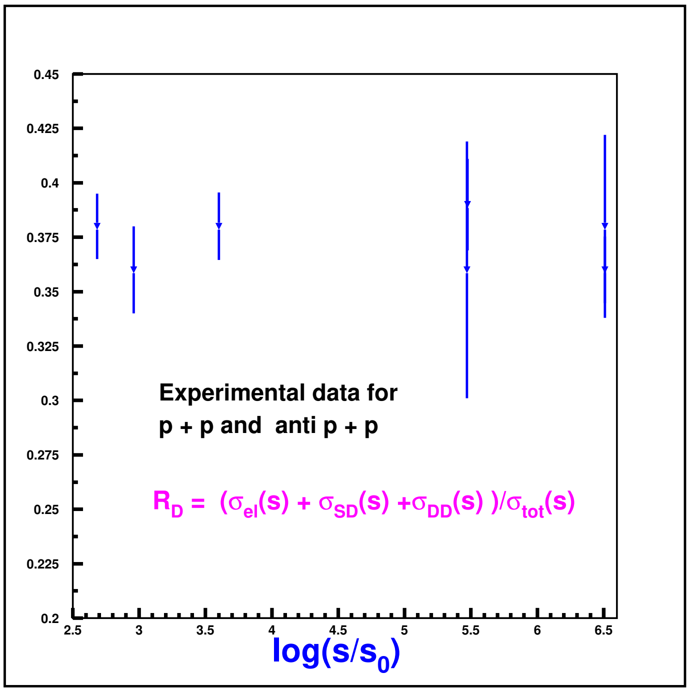
$$B_{DD}(\sqrt{s}/M_H) = 2\,\alpha'_P(0)\ \ln(\sqrt{s}/M_H)$$

Therefore:

$$\frac{d\sigma(pp \to X_1X_2H)}{dy}|_{y=0} = 3 - 4\frac{d\sigma(pp \to ppH)}{dy}|_{y=0}$$

$$= 0.06 - 0.08\mathrm{pb}$$

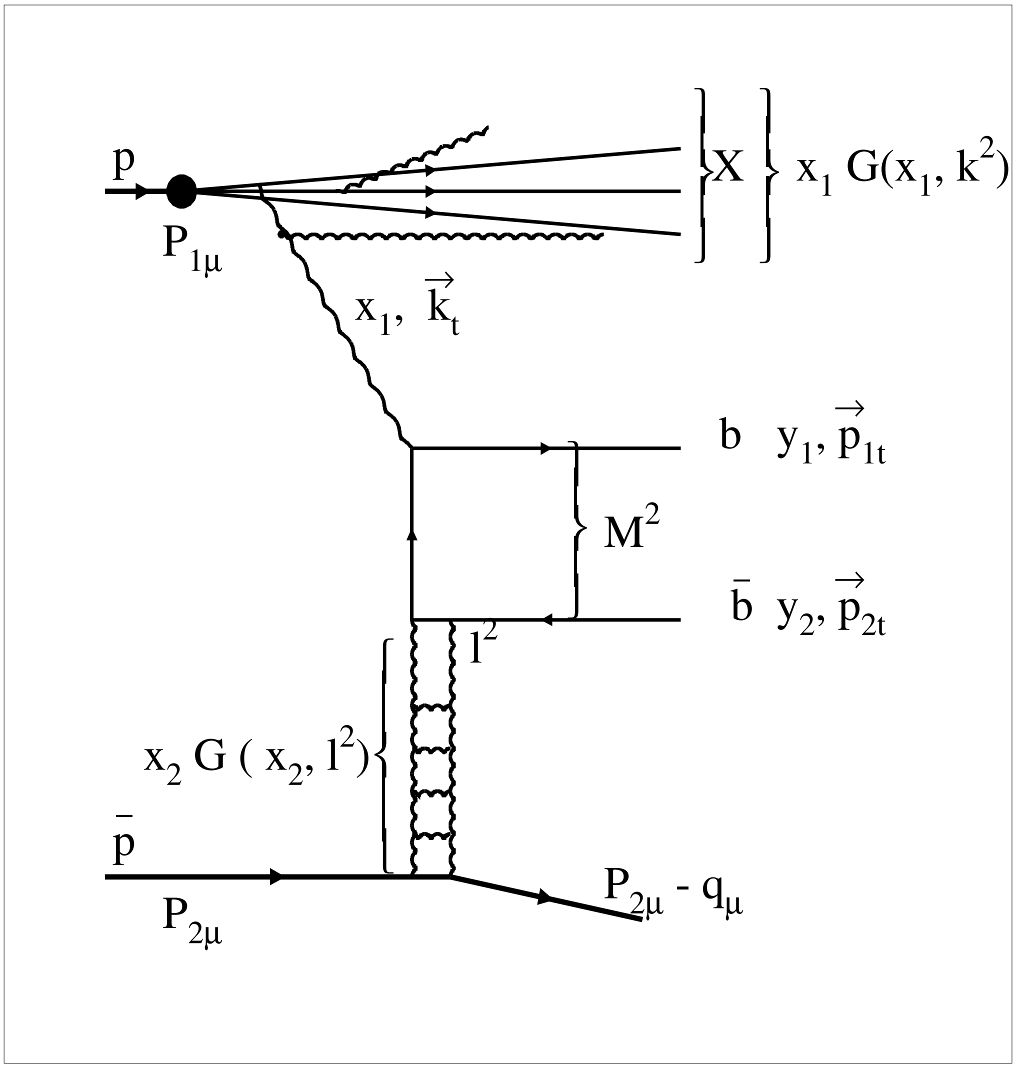

Experimental data for
p + p and anti p + p
$R_{el} = \sigma_{el}(s)/\sigma_{tot}(s)$
$\log(s/s_0)$


Experimental data for
p + p and anti p + p
$R_D = (\sigma_{el}(s) + \sigma_{SD}(s) + \sigma_{DD}(s))/\sigma_{tot}(s)$
$\log(s/s_0)$

SD Q $\bar{\mathrm{Q}}$ Production :

- G. Alves, E.L. and A. Santoro (1996)

Notations and kinematics:



Factorization :

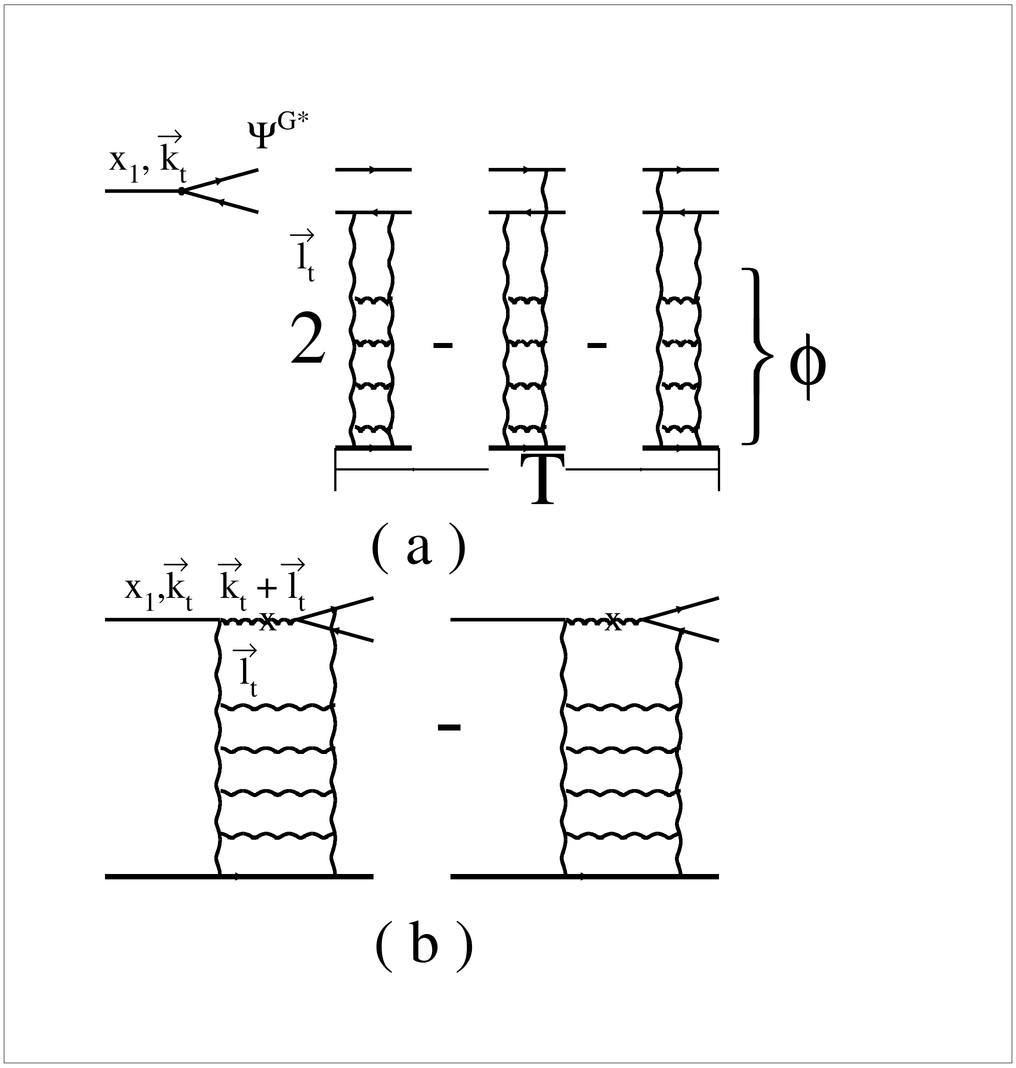
$$\frac{d\sigma}{dY dq_t^2 d\Delta y dp_t^2}\Big|_{q_t^2=0} \;=\; (x_1\, G(x_1,\mu^2)\,)\; \frac{d\sigma^G}{dY dq_t^2 d\Delta y dp_t^2}\Big|_{q_t^2=0}$$

where σ^G **is cross section of**

$$G(x_1,k_t^2) \;+\; \bar{p} \;\rightarrow\; b(y_1) \;+\bar{b}(y_2) \;+\; [LRG(Y)] \;+\; \bar{p}$$

Gluon $\longrightarrow$ **Gluon probe**

Two contributions :



a $\longrightarrow$ Ingelman-Schlein mechanism (IS);

b $\longrightarrow$ Coherent diffraction (CD);

IS:

$$\frac{d\sigma[\mathbf{IS}]}{dY dq_t^2 d\Delta y dp_t^2}\Big|_{q_t^2=0} \propto \Big(x_1\, G(x_1, \mu^2) \Big) \times$$

$$\frac{1}{(m_Q^2 + p_t^2)^3} \cdot \Big(x_2 G(x_2, m_Q^2 + p_t^2)\Big)^2$$

CD:

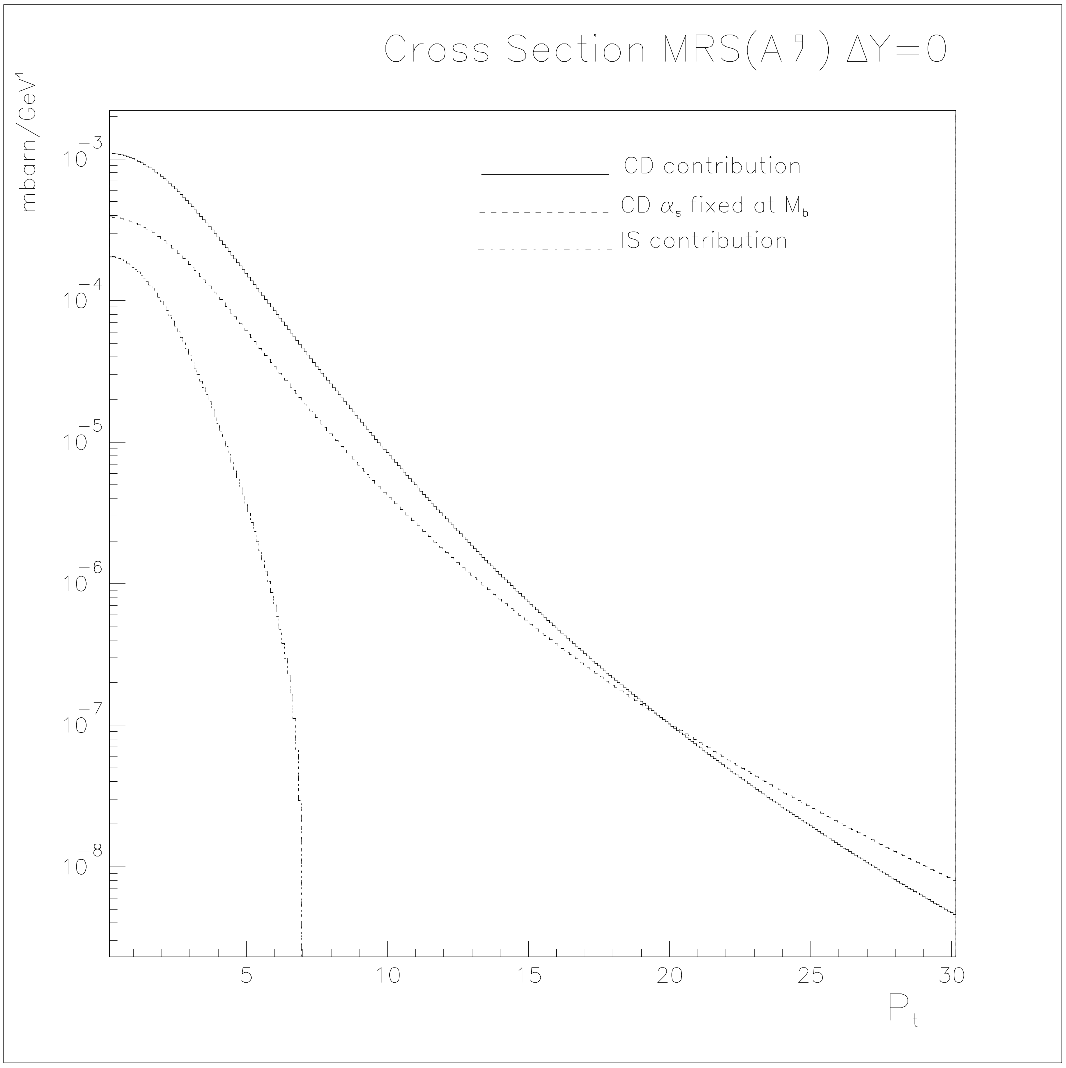
$$\frac{d\sigma[\mathbf{CD}]}{dY dq_t^2 d\Delta y dp_t^2}\Big|_{q_t^2=0} \propto \frac{1}{(m_Q^2 + p_t^2)^2} \times$$

$$\int^{m_{bt}^2} \frac{dk_t^2}{k_t^4} \frac{\partial x_1 G(x_1, k_t^2)}{\partial \ln k_t^2} \Big(x_2 G(x_2, k_t^2) \Big)^2$$

For DIS:

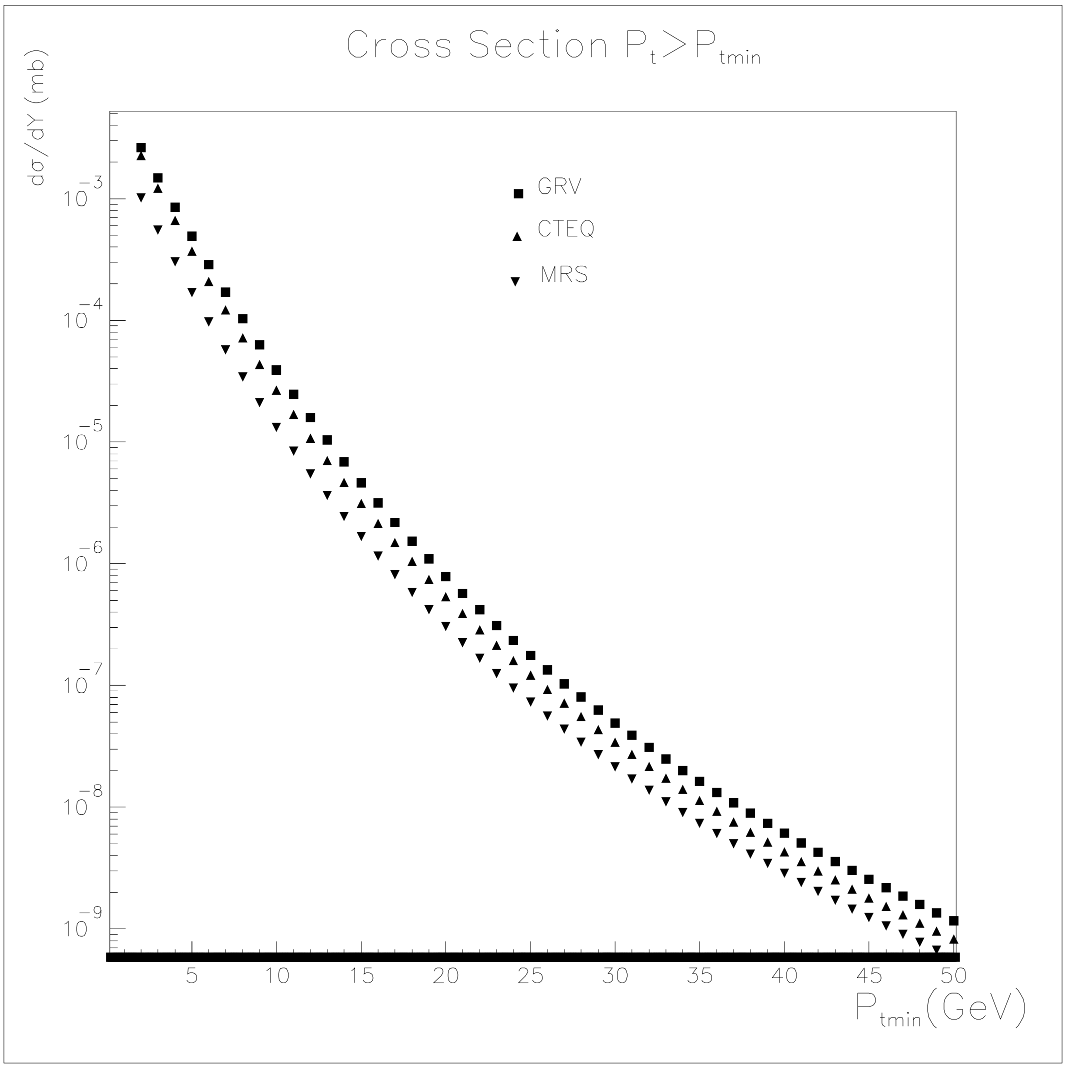
$$\frac{d\sigma[\mathbf{CD}]}{dY dq_t^2 d\Delta y dp_t^2}\Big|_{q_t^2=0} \propto \frac{1}{(m_Q^2 + p_t^2)^2} \times \frac{1}{Q^2}$$

CD ≫ IS for Tevatron :



Prediction:

$$\frac{\mathbf{d}\sigma}{\mathbf{dY}} = \int_{\mathbf{p_t^{min}}}^{\infty} \mathbf{dp_t^2} \int_{-\infty}^{+\infty} \mathbf{d\Delta y} \int_{\mathbf{0}}^{\infty} \mathbf{dq_t^2} \frac{\mathbf{d}\sigma}{\mathbf{dYd\Delta ydq_t^2dp_t^2}}$$



References :

IS:

G. Alves, E.L. & A. Santoro (1996)
F. Yuan & K. Chao (1999)

CD:

G. Alves, E.L. & A. Santoro (1996)
D. Soper (1997)
M. Wüsthoff & A. Martin (1999)

Conclusion:

$$\frac{\mathbf{d}\sigma}{\mathbf{dY}} = < \mathbf{S}^2_{\mathbf{spectators}} > \frac{\mathbf{d}\sigma[\mathbf{CD}]}{\mathbf{dY}} \approx \mathbf{10^{-4} - 10^{-10}\ mbarn}$$

for

$$\mathbf{p_{t,min} = 5 - 50\ GeV}$$

There is a good chance to measure a new contribution to "hard" diffraction which is small in DIS

References:

Higgs DD production:

1. Yu.L. Dokshitzer,V.A. Khoze & T. Sjostrand: *" Rapidity Gaps in Higgs Production,"* CERN-TH 6269/91;
2. Z. Kunszt & W.J. Stirling: *"The Standart Model Higgs at LHC: Branching ratios and Cross -Sections ,"* ETH-TH/90-50;
3. A. Bialas & P.V. Landshoff: *" Higgs production in pp collisions by double-pomeron exchange,"* Phys. Lett.B 256 (1991) 540;
4. B. Muller & Alec J. Schramm: *"Higgs Boson Production in Peripheral Heavy-Ion Collisions,"* Nucl. Phys. A 523 (1991) 677;
5. A.Strange,W. Marciano & S. Willenbrock: *" Higgs Bosons at the Fermilab Tevatron,"* FERMILAB-PUB-93/142-T;
6. V. Barger, R.J.N.Phillips & D.Zeppenfeld: *" Minijet veto: a tool for the heavy Higgs search at the LHC,"* hep-ph/9412276;
7. J-R Cudell & Oscar F. Hernandez: *" Particle Production in a Hadron Collider Rapidity Gap: the Higgs Case,"* hep-ph/9511252;
8. E. Gotsman, E. Levin & U. Maor: *" Effects of Shadowing in Double Pomeron Exchange Processes,"* hep-ph/9503394;
9. V.A. Khoze, A.D. Martin & M.G.Ryskin: *" The rapidity gap Higgs signal at LHC,"* hep-ph/9701419;
10. V.A. Khoze, A.D. Martin & M.G.Ryskin: *" Dijet hadroproduction with rapidity gaps and QCD double lagarithmic effects,"* hep-ph/9705258;

11. E. Gotsman, E. Levin & U. Maor: *" A Two Channel Calculation of Screening Corrections,"* hep-ph/9901416;

Heavy Quarks diffractive production:

1. G. Alves, E. Levin & A. Santoro: *" Diffractive Production of $b\bar{b}$ in Proton - Antiproton Collision at the Tevatron,"* hep-ph/9608443;
2. D.E. Soper: *" Diffraction in DIS and Elsewhere,"* DIS'97 talk, hep-ph/9707384;
3. F. Yuan & K.-T. Chao: *" Diffractive Charm Jet Production at Hadron Colliders in the Two Gluon Exchange Model,"* hep-ph/9810340;
4. F. Yuan & K.-T. Chao: *" Quark Initiated Coherent Diffractive Production of Muon Pair and W boson at Hadron Collider,"* hep-ph/9811285;
5. M. Wusthoff & A.D. Martin: *" Diffractive The QCD description of diffractive processes,"* hep-ph/9909362;