# Isolated jet and photon production in the Regge limit of QCD: from Tevatron to LHC

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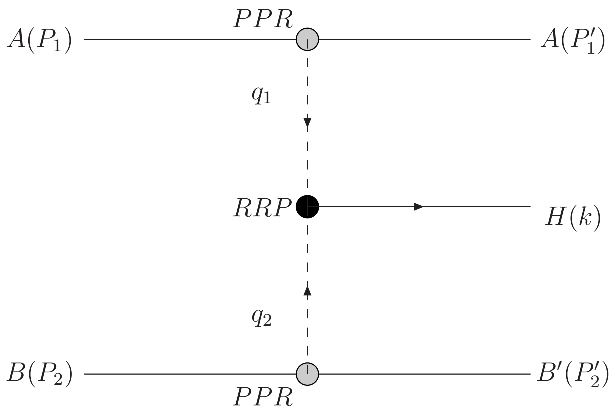
# Multi-Regge Kinematics - I




$$S = (P_1 + P_2)^2, \quad S_1 = (P'_1 + k)^2, \quad S_2 = (P'_2 + k)^2,$$
$$S_1,\ S_2,\ |q_1^2|\ , |q_2^2| \ll S,$$

$$y'_1 \gg y_k \gg y'_2$$

# Multi-Regge Kinematics - II

$$P_1 = E_1(1,0,0,1), \qquad P_2 = E_2(1,0,0,-1), \qquad S = 4E_1E_2$$

$$(n^-)^\mu = P_1^\mu/E_1, \qquad (n^+)^\mu = P_2^\mu/E_2, \qquad k^\pm = k\cdot n^\pm = k^\mu n_\mu^\pm$$

$$q_1 = x_1 P_1 + q_{1T}$$

$$q_2 = x_2 P_2 + q_{2T}$$

$$t_1 = -q_1^2 = -q_{1T}^2, \qquad t_2 = -q_2^2 = -q_{2T}^2$$

$$\alpha_s \ll 1, \qquad x_{1,2} \ll 1$$

# Effective vertice $\mathcal{R}\mathcal{R} \to g$

*Fadin, Kuraev, Lipatov (1976)*

$$C^{g,\mu}_{\mathcal{R}\mathcal{R}}(q_1, q_2) = -g_s f^{abc} \frac{q_1^+ q_2^-}{2\sqrt{t_1 t_2}} \left[ (q_1 - q_2)^\mu + \right.$$

$$\left. + \frac{(n^+)^\mu}{q_1^+} \left( q_2^2 + q_1^+ q_2^- \right) - \frac{(n^-)^\mu}{q_2^-} \left( q_1^2 + q_1^+ q_2^- \right) \right]$$

$$\overline{|\mathcal{M}(\mathcal{R} + \mathcal{R} \to g)|^2} = \frac{3}{2} \pi \alpha_s \mathbf{p}_T^2$$

# Effective vertice $\mathcal{Q}\bar{\mathcal{Q}} \to g(\gamma)$

*Fadin, Sherman (1976)*

$$C^{g,\mu,a}_{\mathcal{Q}\bar{\mathcal{Q}}}(q_1, q_2) = -ig_s T^a \left[\gamma^\mu - \hat{q}_1 \frac{(n^-)^\mu}{q_1^- + q_2^-} - \hat{q}_2 \frac{(n^+)^\mu}{q_1^+ + q_2^+}\right]$$

$$C^{\gamma,\mu}_{\mathcal{Q}\bar{\mathcal{Q}}}(q_1, q_2) = -ieZ_q \left[\gamma^\mu - \hat{q}_1 \frac{(n^-)^\mu}{q_1^- + q_2^-} - \hat{q}_2 \frac{(n^+)^\mu}{q_1^+ + q_2^+}\right]$$

$$\overline{|\mathcal{M}(\mathcal{Q} + \bar{\mathcal{Q}} \to \gamma)|^2} = \frac{4}{3}\pi\alpha Z_q^2 (t_1 + t_2)$$

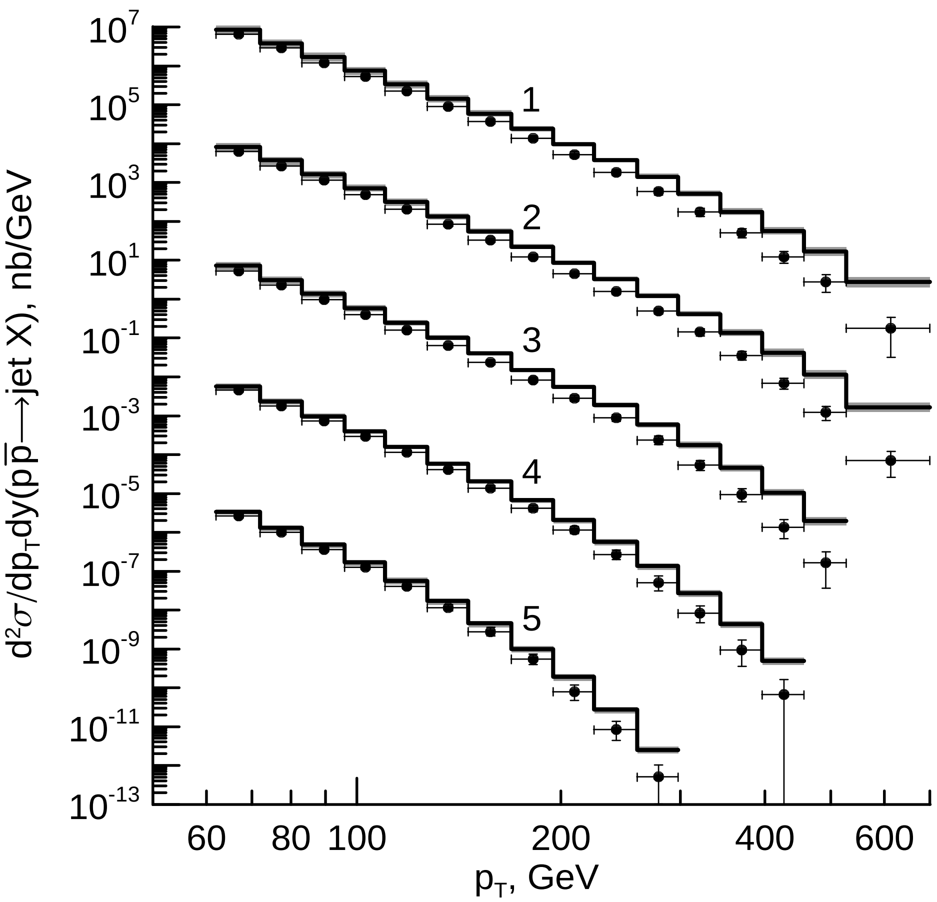
$$d\sigma\left(p\bar{p}(p) \to gX\right) = \int \frac{dx_1}{x_1} \int \frac{d^2 q_{1T}}{\pi} \int \frac{dx_2}{x_2} \int \frac{d^2 q_{2T}}{\pi} \times$$
$$\times \Phi_g^p(x_1, t_1, \mu^2) \Phi_g^{\bar{p}}(x_2, t_2, \mu^2) d\hat{\sigma}\left(\mathcal{R}\mathcal{R} \to g\right)$$

The unintegrated PDFs $\Phi_a^h(x, t, \mu^2)$ are related to their collinear counterparts $F_a^h(x, \mu^2)$ by the normalization condition

$$xF_a^h(x, \mu^2) = \int^{\mu^2} dt\, \Phi_a^h(x, t, \mu^2),$$

In our numerical analysis, we adopt the prescription proposed by *Kimber, Martin, and Ryskin* to obtain unintegrated gluon and quark distribution functions for the proton from the conventional integrated ones, as implemented in *Watt's* **C** code. As input for this procedure, we use the *Martin-Roberts-Stirling-Thorne* proton PDFs.

# Inclusive single jet hadroproduction at Tevatron




*Data by CDF Collaboration,*
$\sqrt{S} = 1.96\ TeV$

*Parton Reggeization*
*Theory predictions:*

1 — $|y| < 0.1$ ($\times 10^6$),

2 — $0.1 < |y| < 0.7$ ($\times 10^3$),

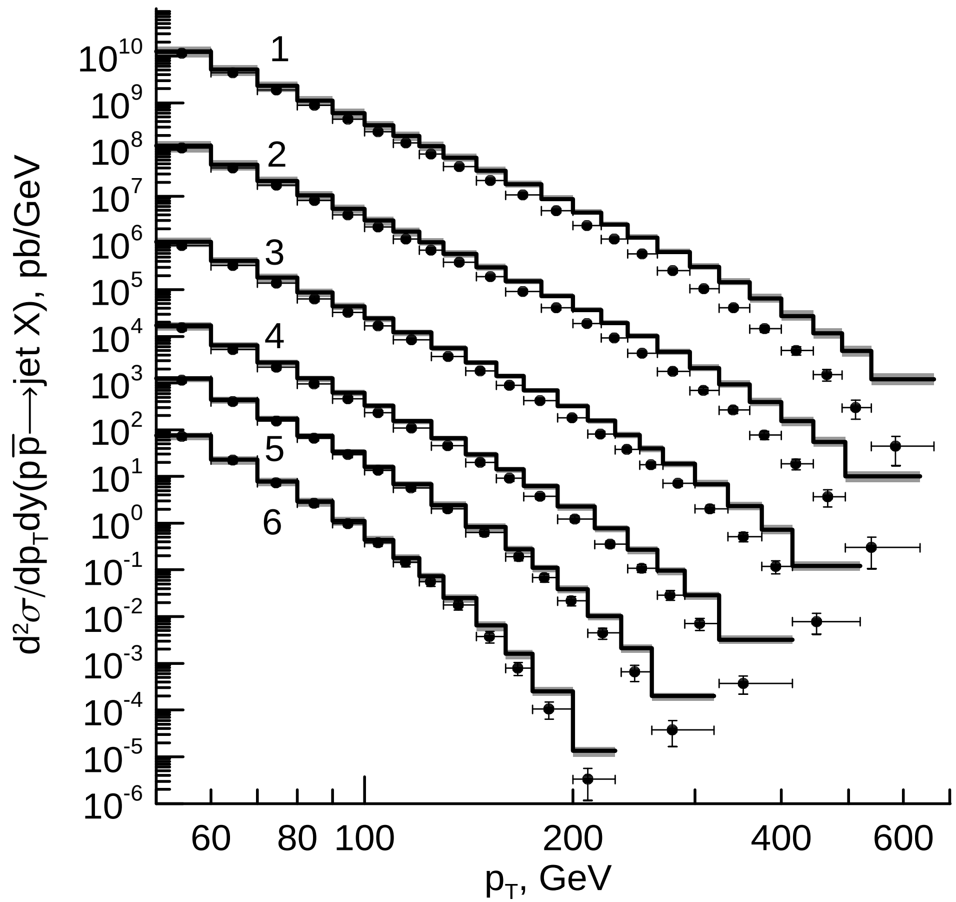
3 — $0.7 < |y| < 1.1$

4 — $1.1 < |y| < 1.6$ ($\times 10^{-3}$)

5 — $1.6 < |y| < 2.1$ ($\times 10^{-6}$)

Shaded bands — theoretical uncertainties $p_T/2 < \mu < 2p_T$

# Inclusive single jet hadroproduction at Tevatron




*Data by D0 Collaboration,* $\sqrt{S} = 1.96\ TeV$

*Parton Reggeization*

*Theory predictions:*

$1$ — $|y| < 0.4$ $(\times 5 \cdot 10^5)$,

$2$ — $0.4 < |y| < 0.8$ $(\times 5 \cdot 10^3)$

$3$ — $0.8 < |y| < 1.2$ $(\times 50)$

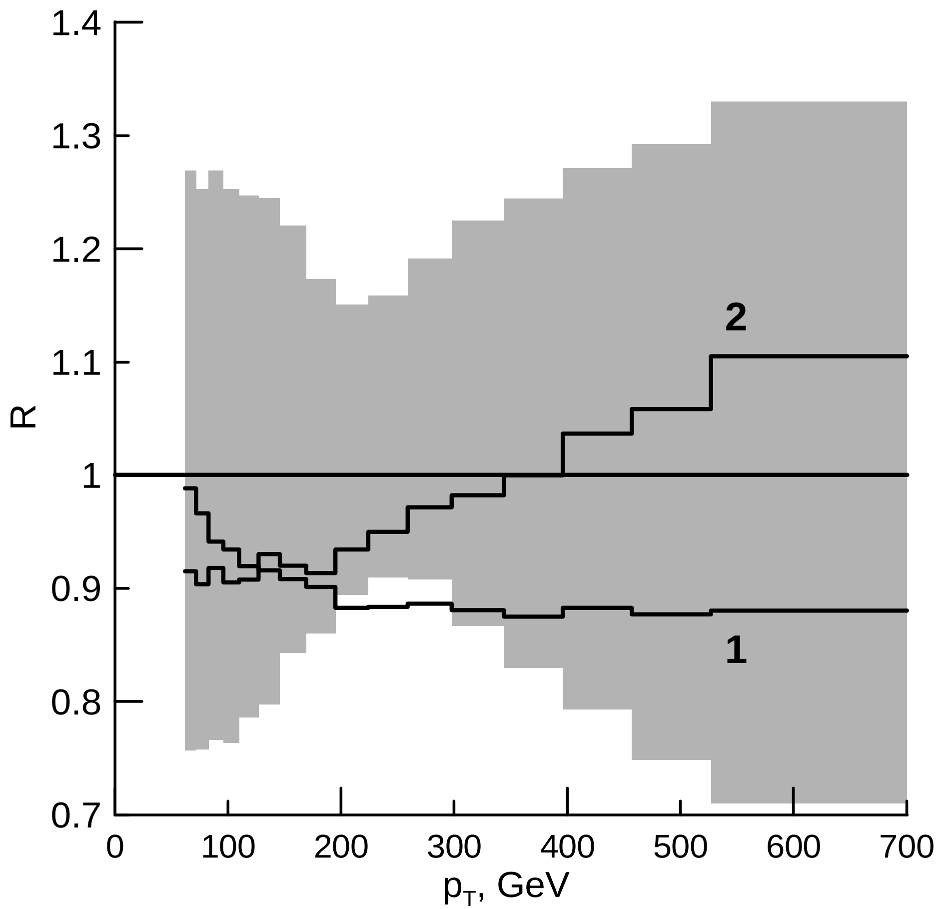
$4$ — $1.2 < |y| < 1.6$

$5$ — $1.6 < |y| < 2.0$ $(\times 0.1)$

$6$ — $2.0 < |y| < 2.4$ $(\times 10^{-2})$

Shaded bands — theoretical uncertainties $p_T/2 < \mu < 2p_T$

# Relative ratio $R$ of single jet production cross sections with different choice of input collinear PDFs




$\sqrt{S} = 1.96\ TeV,\ 0 < |y| < 0.1$

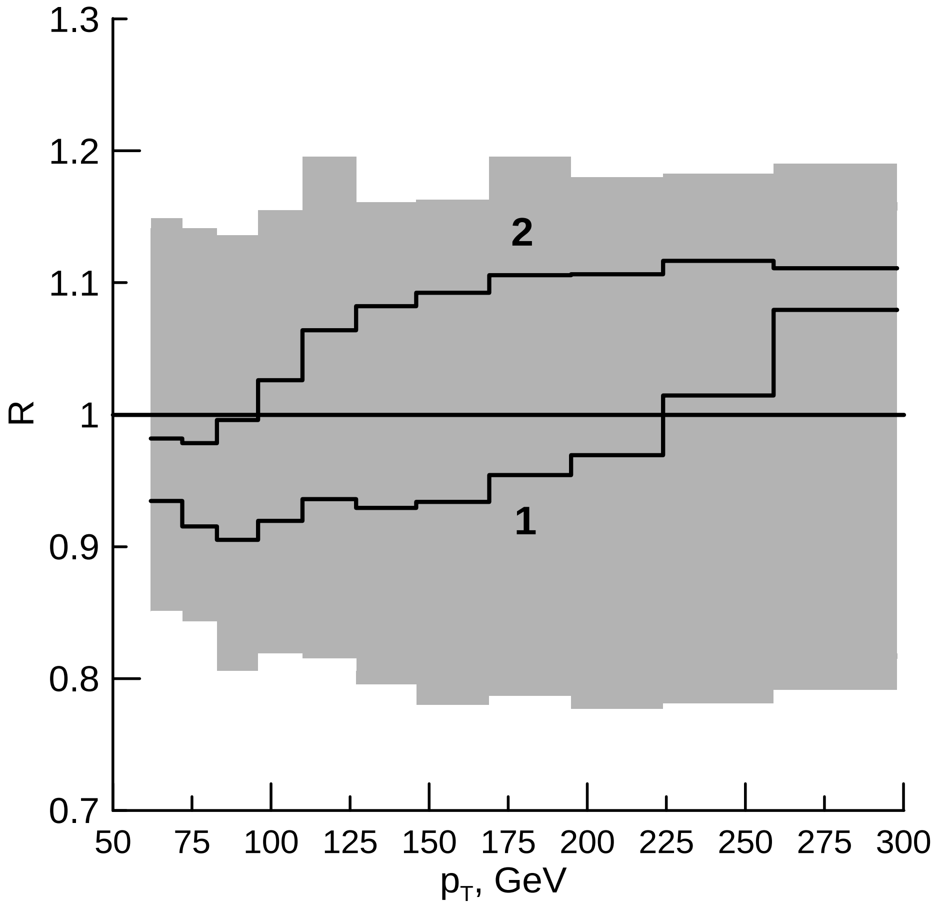
$R = 1$ — MRST input, $\mu = p_T$

shaded area — MRST input, $p_T/2 < \mu < 2p_T$

1 — $R = d^2\sigma_{CTEQ}/d^2\sigma_{MRST}$, $\mu = p_T$

2 — $R = d^2\sigma_{GRV}/d^2\sigma_{MRST}$, $\mu = p_T$

# Relative ratio $R$ of single jet production cross sections with different choice of input collinear PDFs




$\sqrt{S} = 1.96\ TeV,\ 1.6 < |y| < 2.1$

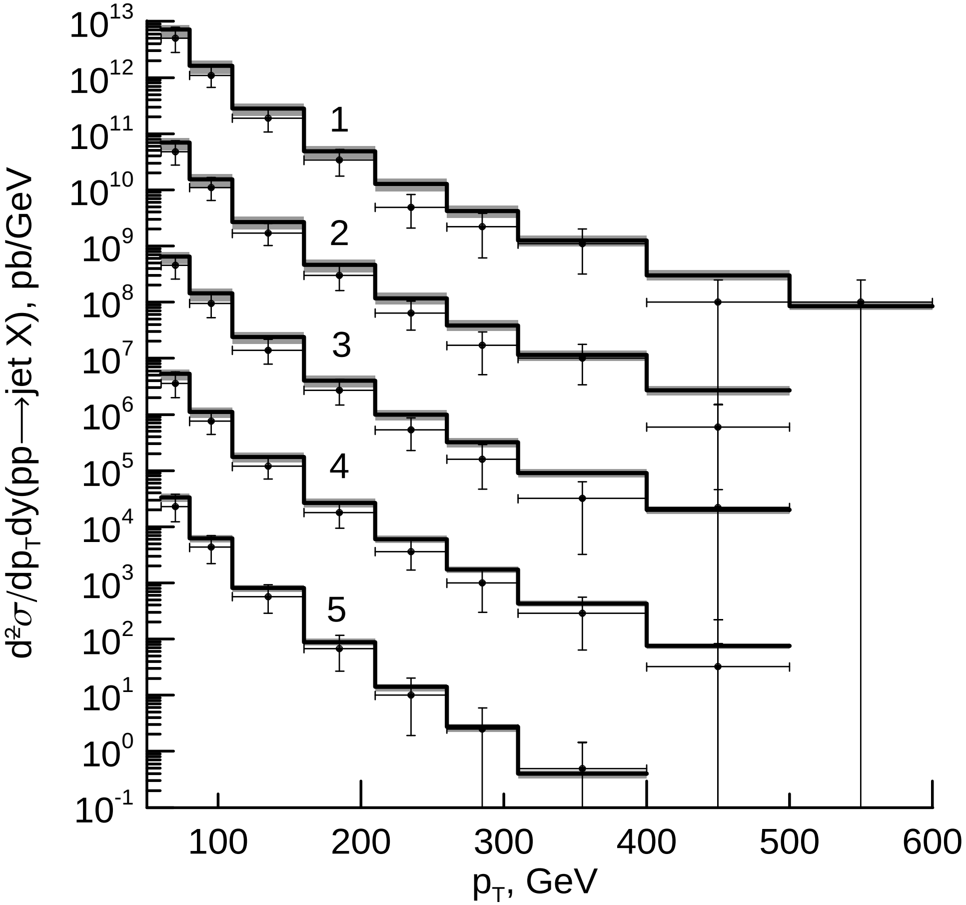
$R = 1$ — MRST input, $\mu = p_T$

shaded area — MRST input, $p_T/2 < \mu < 2p_T$

1 — $R = d^2\sigma_{CTEQ}/d^2\sigma_{MRST}$, $\mu = p_T$

2 — $R = d^2\sigma_{GRV}/d^2\sigma_{MRST}$, $\mu = p_T$

# Inclusive single jet hadroproduction at LHC



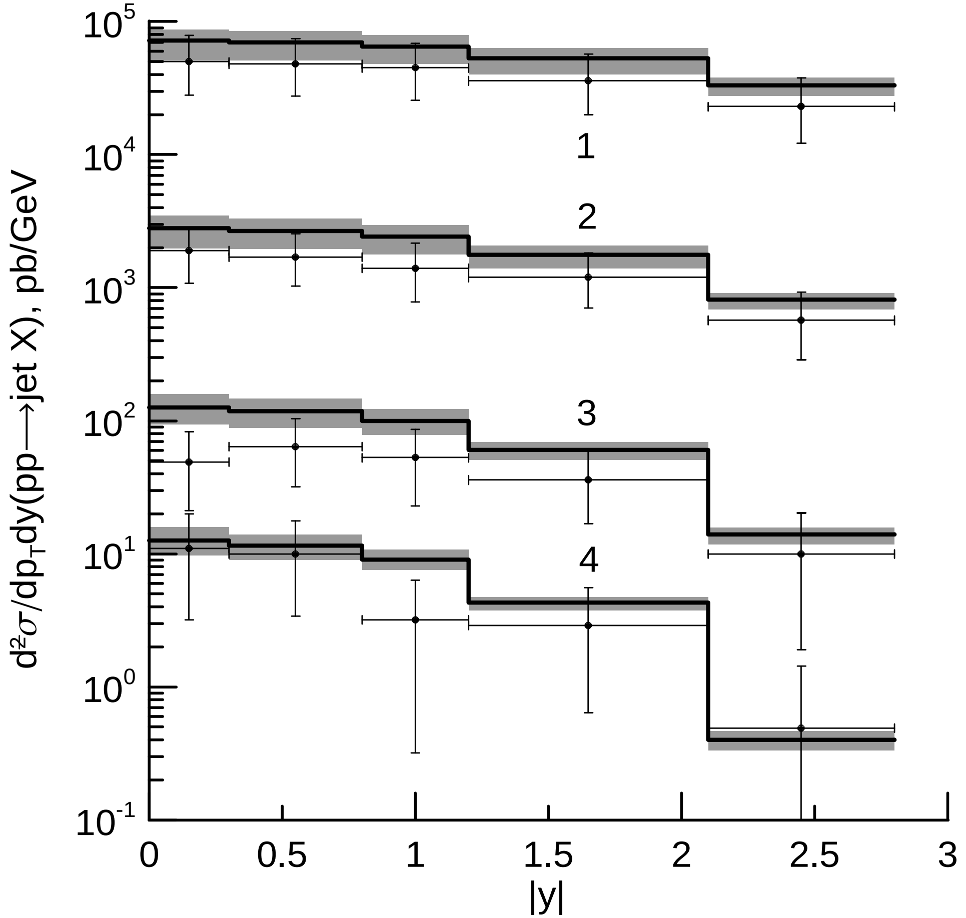

*Data by ATLAS Collaboration,*
$\sqrt{S} = 7\ TeV$

*Parton Reggeization*
*Theory predictions:*

1 — $|y| < 0.3$ $(\times 10^8)$,
2 — $0.3 < |y| < 0.8$ $(\times 10^6)$
3 — $0.8 < |y| < 1.2$ $(\times 10^4)$
4 — $1.2 < |y| < 2.1$ $(\times 10^2)$
5 — $2.1 < |y| < 2.6$

Shaded bands — theoretical uncertainties $p_T/2 < \mu < 2p_T$

# Inclusive single jet hadroproduction at LHC



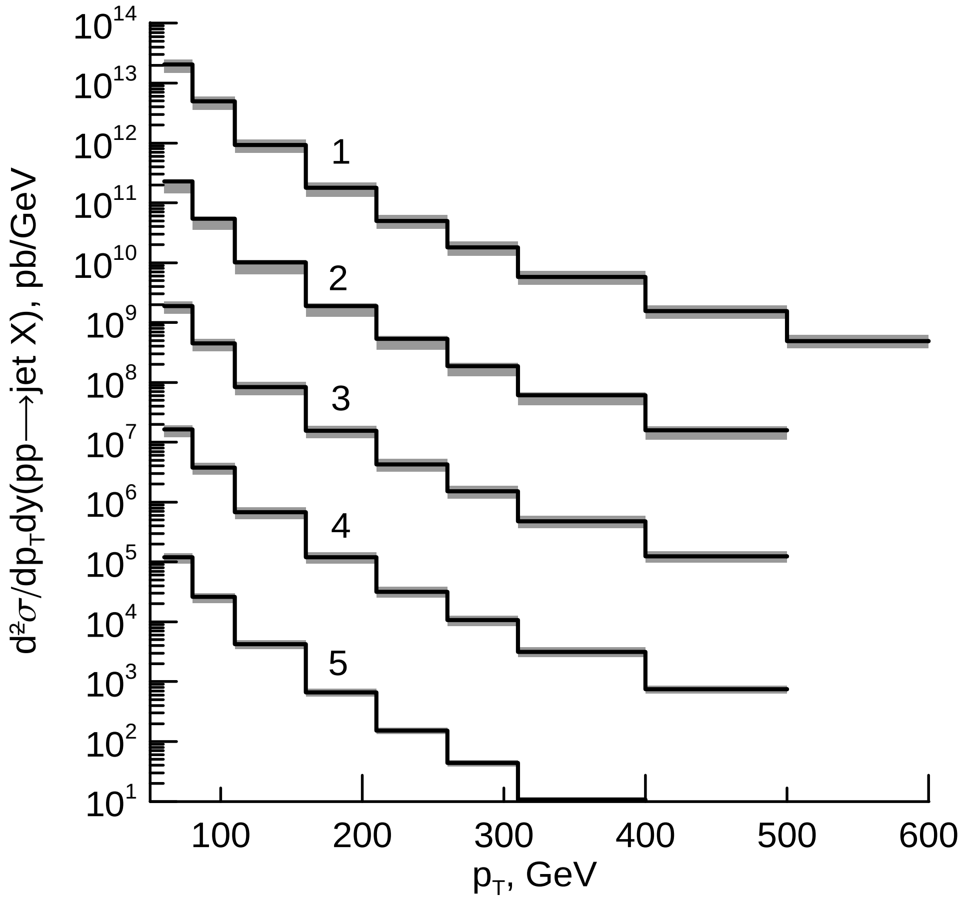

*Data by ATLAS Collaboration,*
$\sqrt{S} = 7$ *TeV*

*Parton Reggeization*
*Theory predictions:*

1 — 60 GeV $< p_T <$ 80 GeV
2 — 110 GeV $< p_T <$ 160 GeV
3 — 210 GeV $< p_T <$ 250 GeV
4 — 310 GeV $< p_T <$ 400 GeV

Shaded bands — theoretical uncertainties $p_T/2 < \mu < 2p_T$

# Inclusive single jet hadroproduction at LHC




$\sqrt{S} = 14\ TeV$

*Parton Reggeization*

*Theory predictions:*

$1 — |y| < 0.3\ (\times 10^8)$,

$2 — 0.3 < |y| < 0.8\ (\times 10^6)$

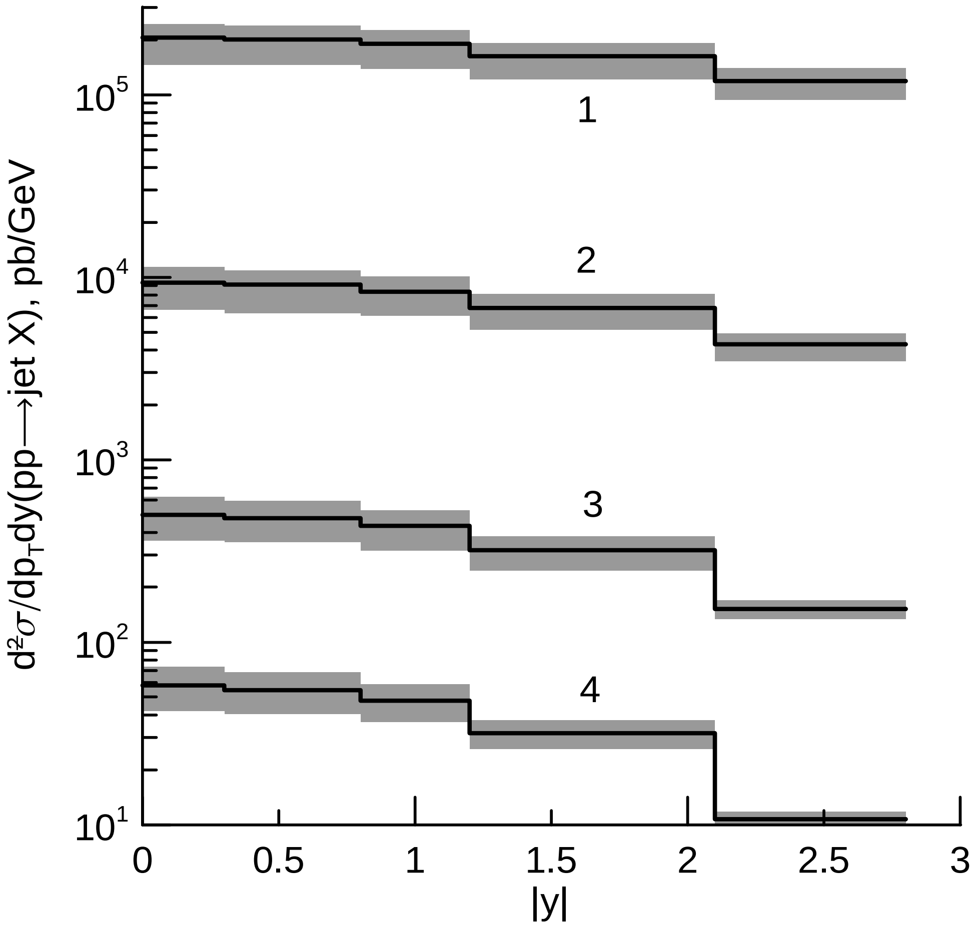
$3 — 0.8 < |y| < 1.2\ (\times 10^4)$

$4 — 1.2 < |y| < 2.1\ (\times 10^2)$

$5 — 2.1 < |y| < 2.6$

Shaded bands — theoretical uncertainties $p_T/2 < \mu < 2p_T$

# Inclusive single jet hadroproduction at LHC




$\sqrt{S} = 14\ TeV$

*Parton Reggeization*
*Theory predictions:*

1 — 60 GeV $< p_T <$ 80 GeV

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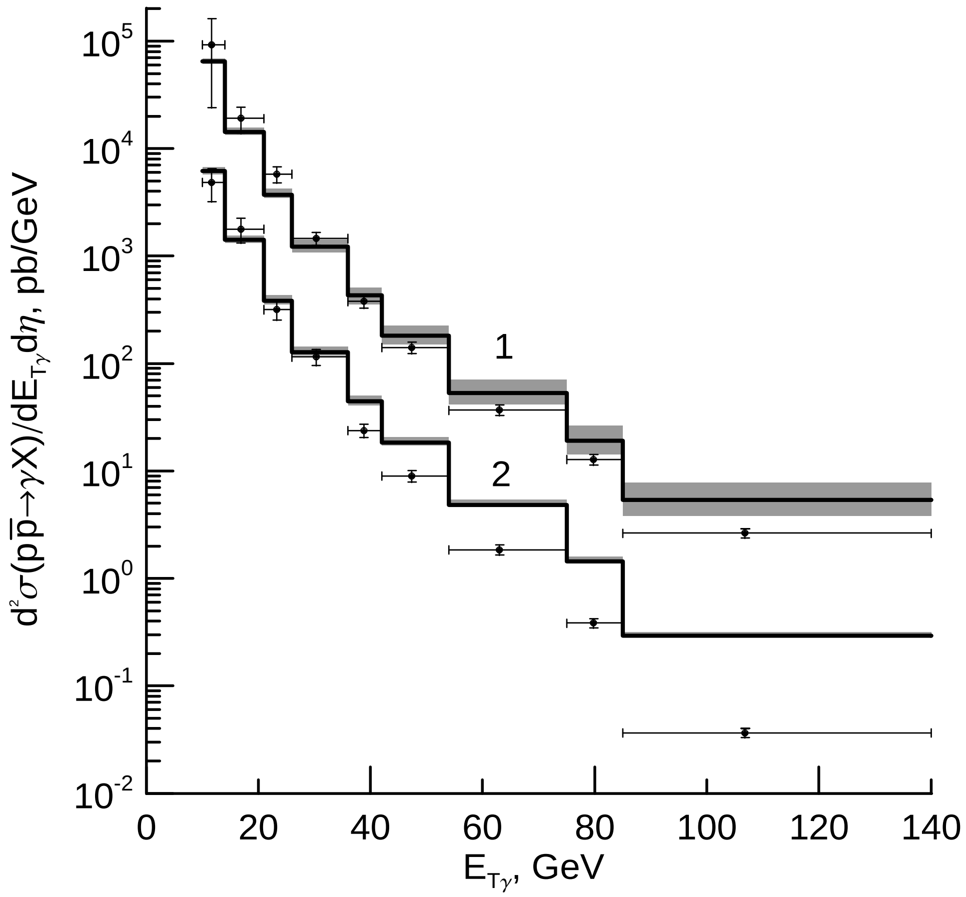
3 — 210 GeV $< p_T <$ 250 GeV

4 — 310 GeV $< p_T <$ 400 GeV

Shaded bands — theoretical uncertainties $p_T/2 < \mu < 2p_T$

# Prompt photon hadroproduction at Tevatron




*Data by D0 Collaboration,* $\sqrt{S} = 1.8\ TeV$

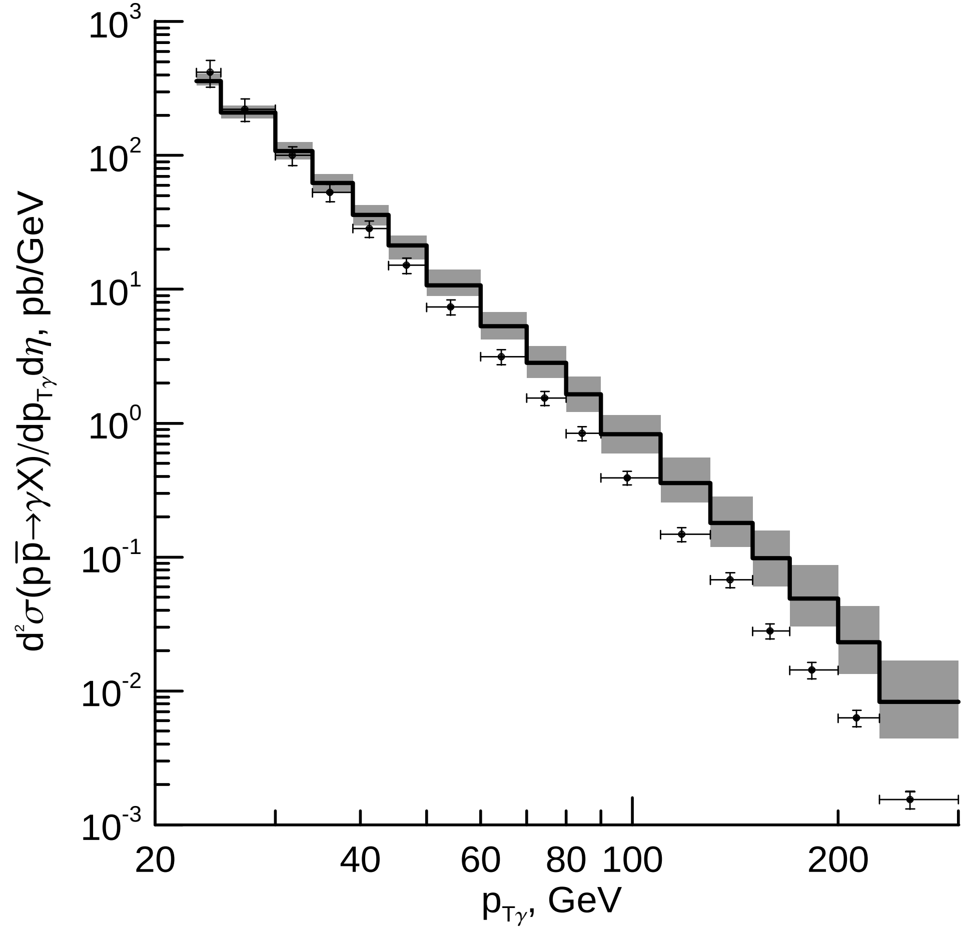
*Parton Reggeization Theory predictions:*

$1$ — $|y| < 0.9$ $(\times 10)$,

$2$ — $1.6 < |y| < 2.5$

Shaded bands — theoretical uncertainties $E_{T\gamma}/2 < \mu < 2E_{T\gamma}$

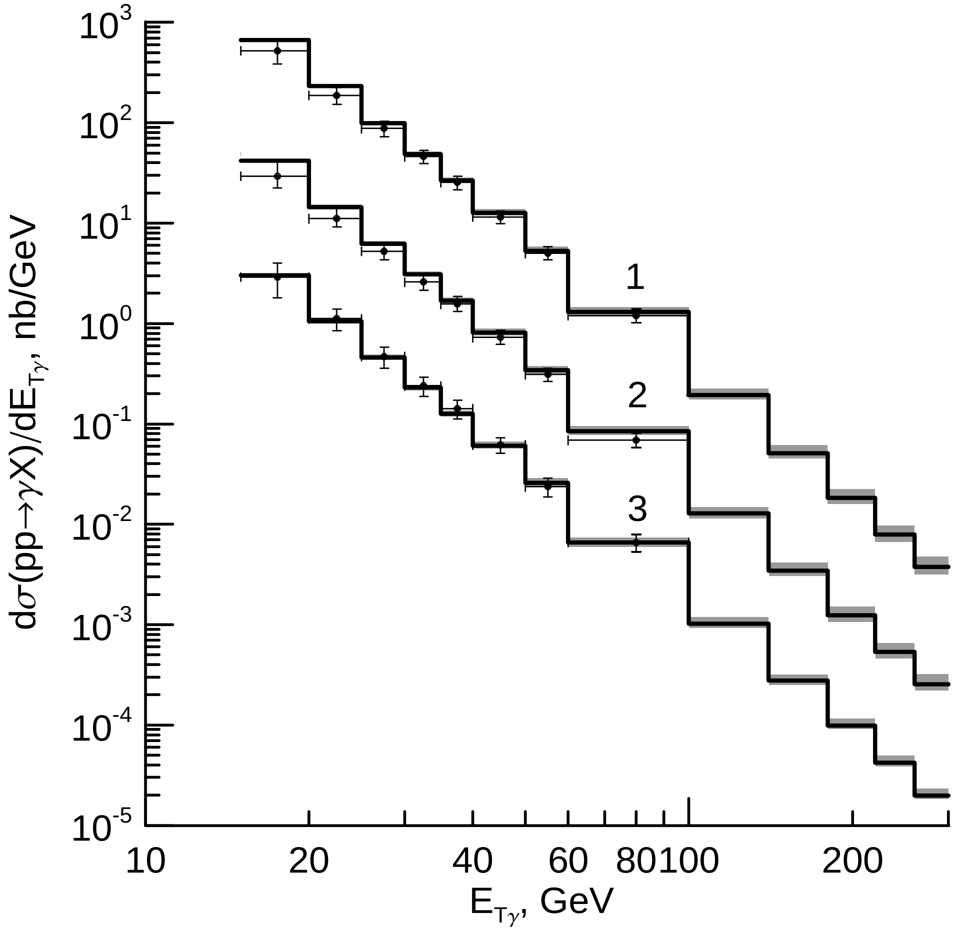
# Prompt photon hadroproduction at Tevatron




*Data by D0 Collaboration,* $\sqrt{S} = 1.96\ TeV$

*Parton Reggeization Theory prediction:* shaded band — theoretical uncertainty $p_{T\gamma}/2 < \mu < 2p_{T\gamma}$

# Prompt photon hadroproduction at LHC




*Data by ATLAS Collaboration,* $\sqrt{S} = 7\ TeV$

*Parton Reggeization Theory predictions:*

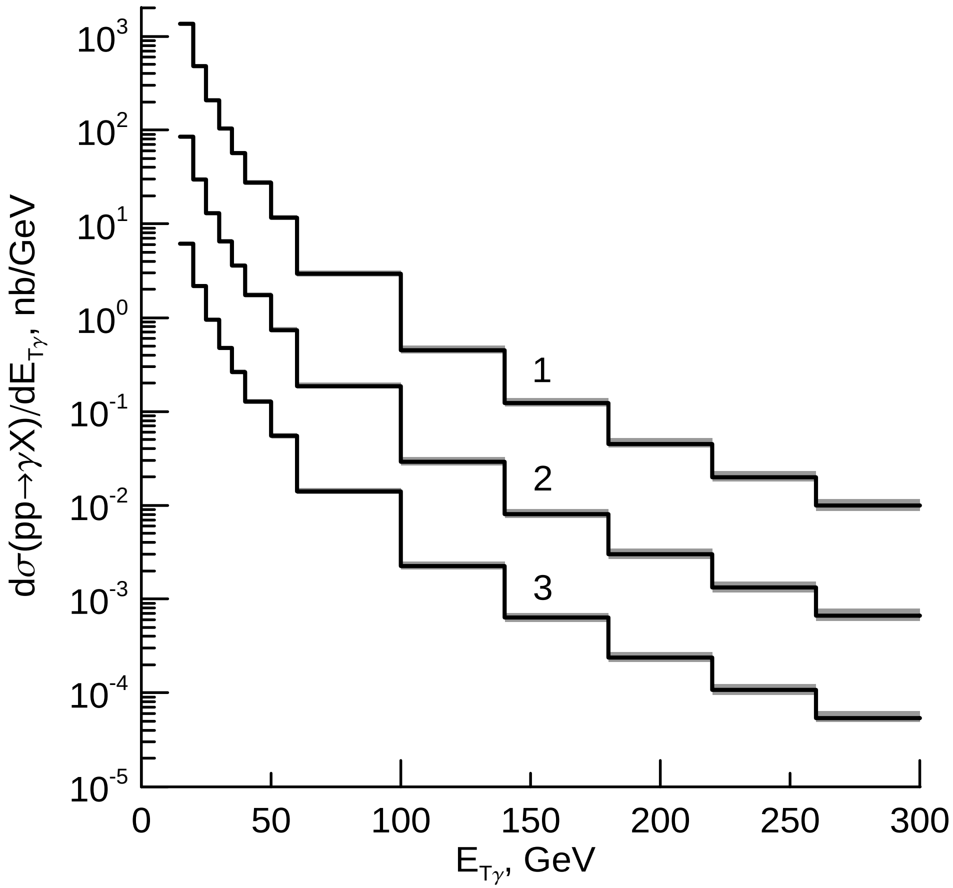
1 — $|y| < 0.6$ ($\times 100$)

2 — $0.6 < |y| < 1.37$ ($\times 5$)

3 — $1.52 < |y| < 1.81$

Shaded bands — theoretical uncertainties $E_{T\gamma}/2 < \mu < 2E_{T\gamma}$

# Prompt photon hadroproduction at LHC




$\sqrt{S} = 14\ TeV$

*Parton Reggeization*

*Theory predictions:*

1 — $|y| < 0.6\ (\times 100)$

2 — $0.6 < |y| < 1.37\ (\times 5)$

3 — $1.52 < |y| < 1.81$

Shaded bands — theoretical uncertainties $E_{T\gamma}/2 < \mu < 2E_{T\gamma}$

## Conclusions

1. Parton Reggeization Approach agrees with data at $x = \frac{2p_T}{\sqrt{S}} \leq 0.1$ ($p_T \leq 100$ GeV for Tevatron and $p_T \leq 350$ GeV for LHC at the 7 TeV). It is demonstrated the dominant role of MRK processes in single jet and photon production at high energy.

2. We predict $p_T$-spectra for single jet and photon for $p_T \leq 700$ GeV for LHC at the 14 TeV.

3. KMR prescription for unintegrated PDF's works well both for gluons and quarks.

# Thank you for attention!