The Influence of Weak Interactions on Inclusive Hadron Spectra At LHC Energies

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Scaling property of pQCD

A robust prediction of pQCD is:

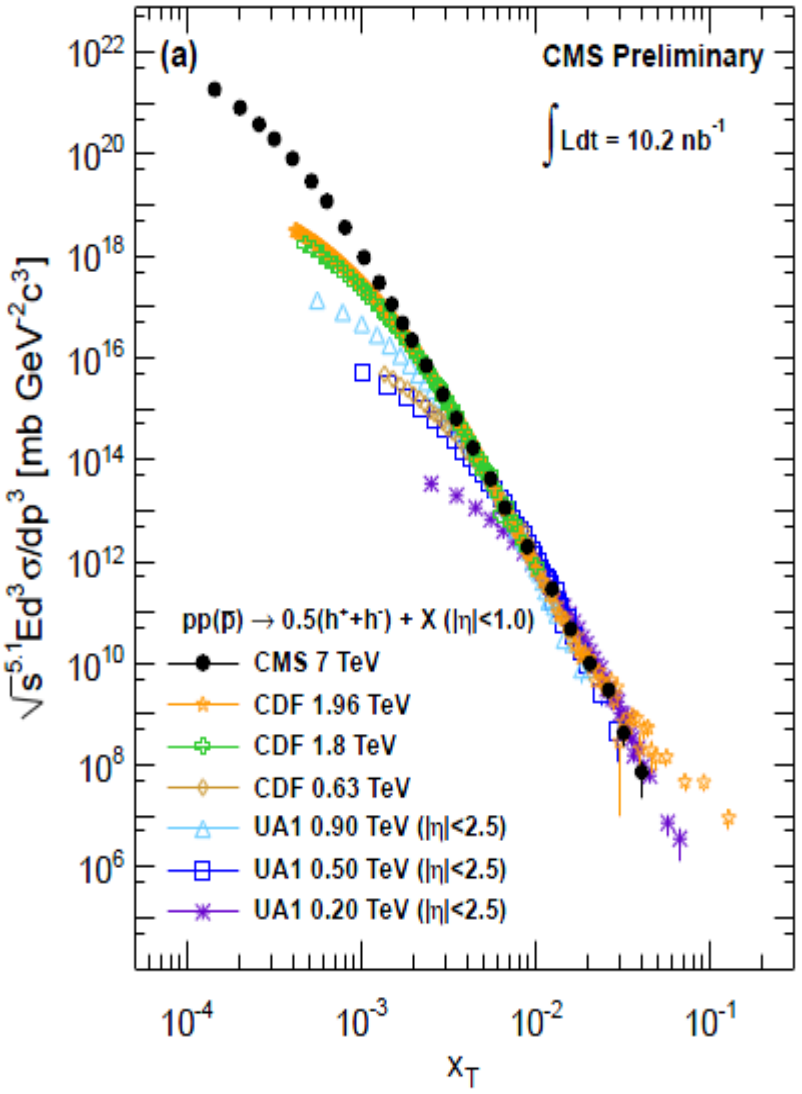
$$E\frac{d\sigma}{d^3p} = \frac{F(x_T)}{p_T^{n(x_T,\sqrt{s})}} = \frac{F'(x_T)}{\sqrt{s}^{n(x_T,\sqrt{s})}}$$

Where $x_T=2p_T/\mathrm{sqrt}(s)$, where n~5

Experimental value: 5.1 +/- 0.2

At high x_T where pQCD is taught to be applicable, every dataset reproduces this scaling property of pQCD, except the CDF data at 1.96TeV.

Plot taken from CMS paper [QCD-10-008-PAS]



If the CDF data are true…

- Possible resolutions:
  - A channel is missing
  - Something is wrong with the PDF fits
  - Something is wrong with the FF fits
  - A production mechanism is missing
  - …
- But CMS data show no deviation from pQCD, so we are looking for an effect that is stronger in ppbar collisions
- And we are looking for something that comes into play at high pT

If the CDF data are true…

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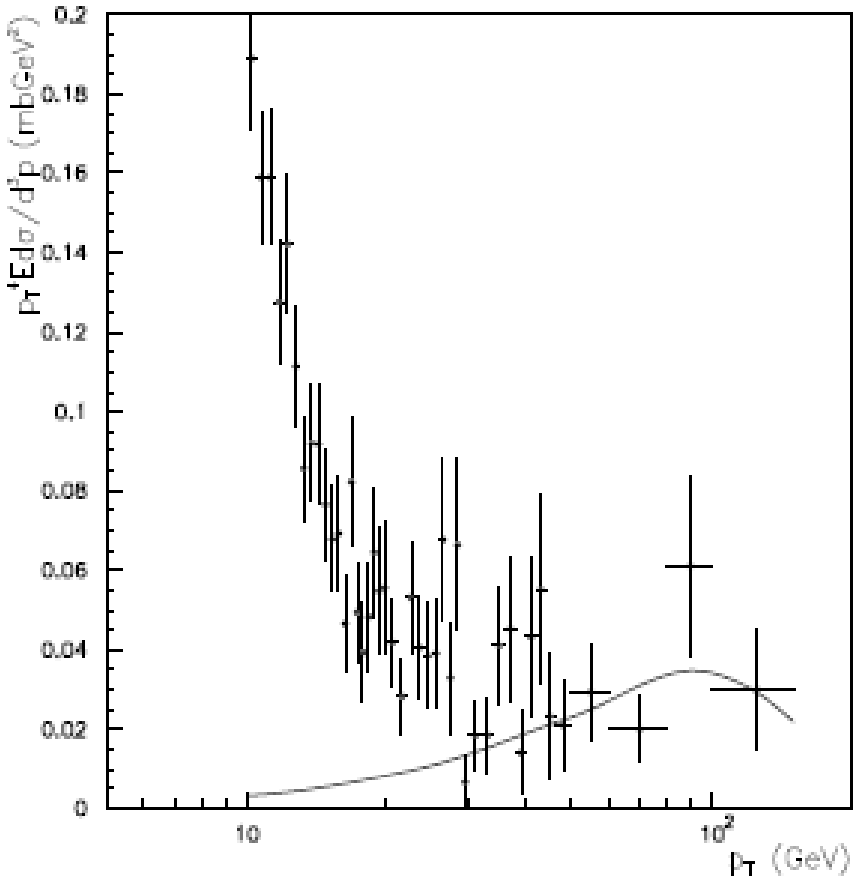
Ioffe: There is a measurable effect



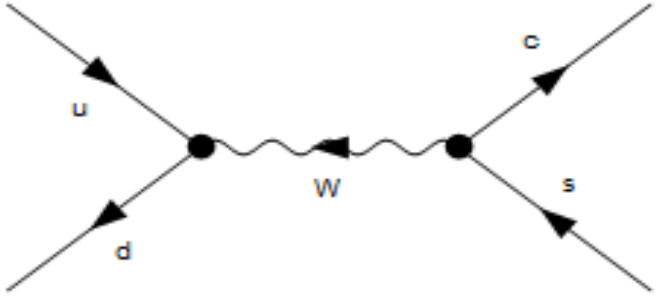
Plot taken form:

2010 Gribov-80 Memorial Workshop: http://cdsagenda5.ictp.trieste.it/full_display.php?ida=a09149

arXiv:1005.1078

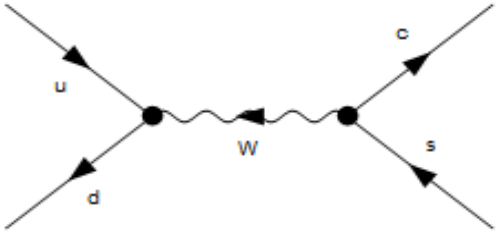
We wanted to check this…

Weak Interaction Contribution



- It is known that less Z mesons are produced at hadron colliders compared to W mesons
- The dominant contribution to W production is the s-channel diagram above, and similar diagrams with different quarks, since s-channel diagrams usually go as $M \sim 1/(s-M^2)$ while t-channel diagrams usually go as $M \sim 1/(t-M^2)$
- This diagram will most likely give a higher XS for ppbar colliders (TEVATRON) than pp colliders(LHC) since in the ppbar case both ongoing partons are both valence quarks
- The resonance is expected to cause a bump at some energies comparable to $M_W \sim 80GeV$, this could violate the usual behaviour at some region

Weak Interaction Contribution



The amplitude for this tree level diagram is:

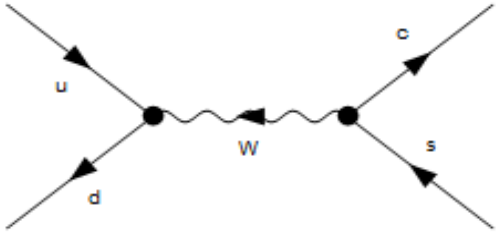
$$iM = V_{ud}V_{cs}\left(\frac{ig}{\sqrt{2}}\bar{v}(p_b)\gamma_\mu\omega_-u(p_a)\right)\left(\frac{-i\left(g^{\mu\nu}-(1-\xi)\frac{q^\mu q^\nu}{q^2-\xi(m_W^2-im_W\Gamma_W)}\right)}{q^2-m_W^2+im_W\Gamma_W}\right)\left(\frac{ig}{\sqrt{2}}\bar{u}(p_c)\gamma_\nu\omega_-v(p_d)\right)$$

1. The W propagator is a renormalized propagator, the width appears. This is necessary to remove the singularity of the cross-section at $s=m_W$
2. For similar diagrams we have a similar amplitude with only the CKM factors different

Neglecting quark masses, summing over fermion spins, taking the traces, contracting indices, we get:

$$\frac{d\sigma}{d\hat{t}}(u\bar{d}\to c\bar{s}) = |V_{ud}|^2|V_{cs}|^2\frac{g_W^4}{16\pi}\frac{\hat{u}^2}{\hat{s}^2((\hat{s}-m_W^2)^2+m_W^2\Gamma_W^2)}$$

Weak Interaction Contribution



$$\frac{d\sigma}{d\hat{t}}(u\bar{d} \to c\bar{s}) = |V_{ud}|^2 |V_{cs}|^2 \frac{g_W^4}{16\pi} \frac{\hat{u}^2}{\hat{s}^2((\hat{s} - m_W^2)^2 + m_W^2 \Gamma_W^2)}$$

This can be plugged in the formula of the parton model:

$$E\frac{d\sigma}{d^3p}(A + B \to H + X) = \sum_{abcd} \int_0^1 dx_a \int_0^1 dx_b \int_0^1 dz_c \, G_{a/A}(x_a, Q^2) G_{b/B}(x_b, Q^2) D_{H/c}(z_c, Q_F^2) \frac{\hat{s}}{\pi z_c^2} \frac{d\sigma}{d\hat{t}}(ab \to cd) \delta^{(3)}(\hat{s} + \hat{t} + \hat{u})$$

We sum for every channel of the form:

$$q_1\overline{q_2} \to W^{+/-} \to q_3\overline{q_4}$$

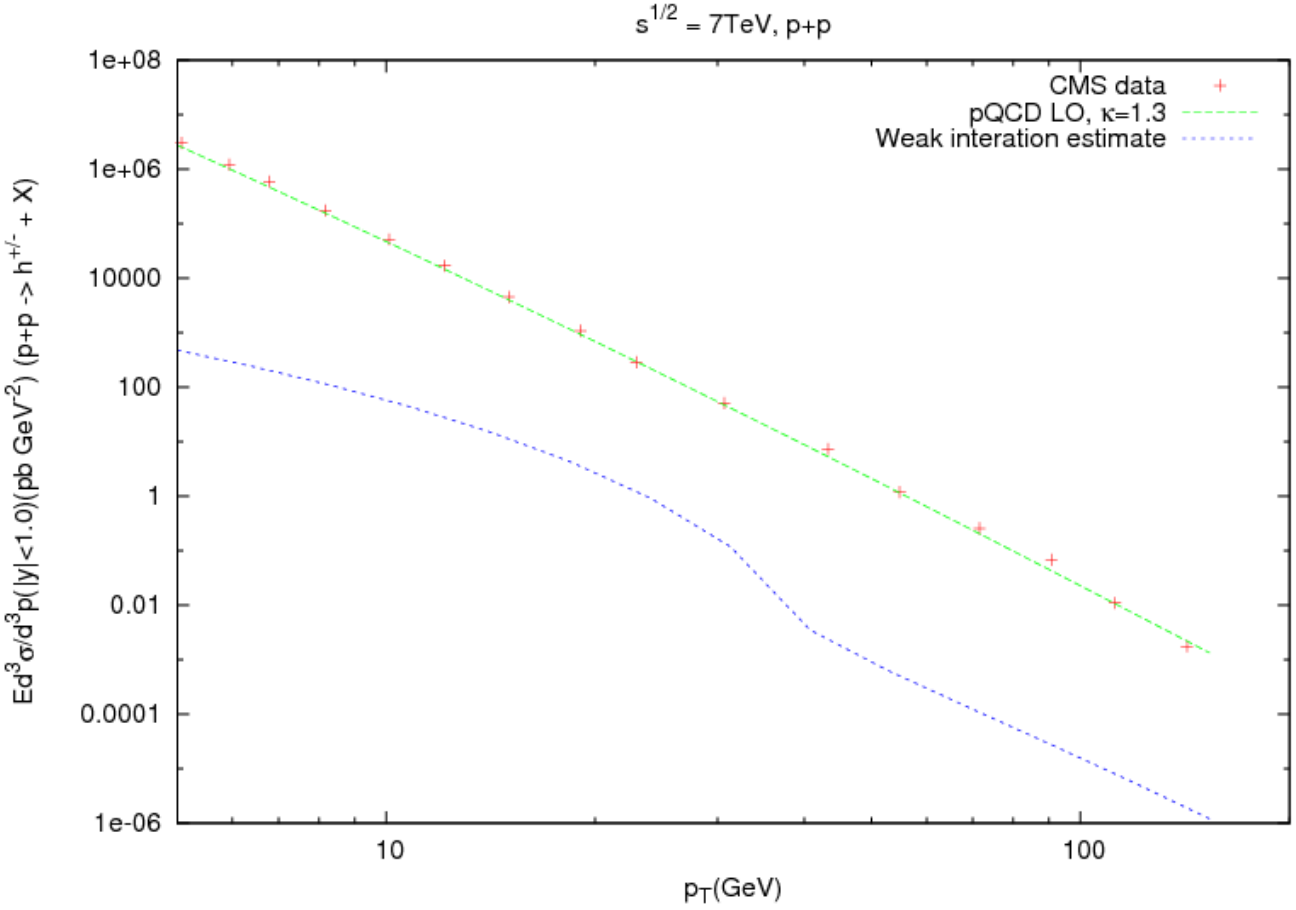
The parton level cross-sections for these differ only in CKM factors and t↔u in some cases.

We neglect interfering t-channel diagrams. For example the t-channel Z exchange scattering udbar→udbar

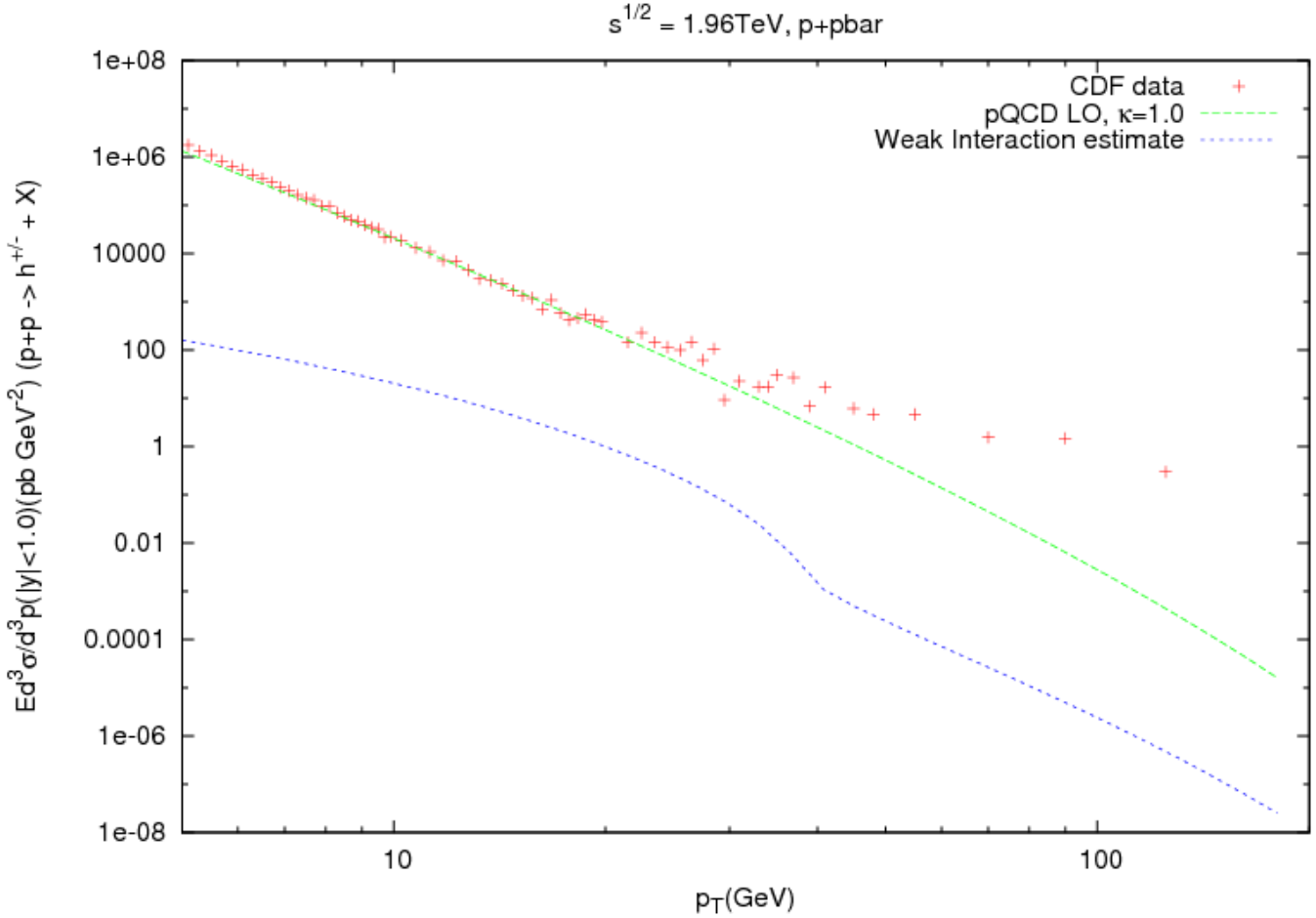
Used PDF: MSTW

Used FF: KKP and/or HKNS

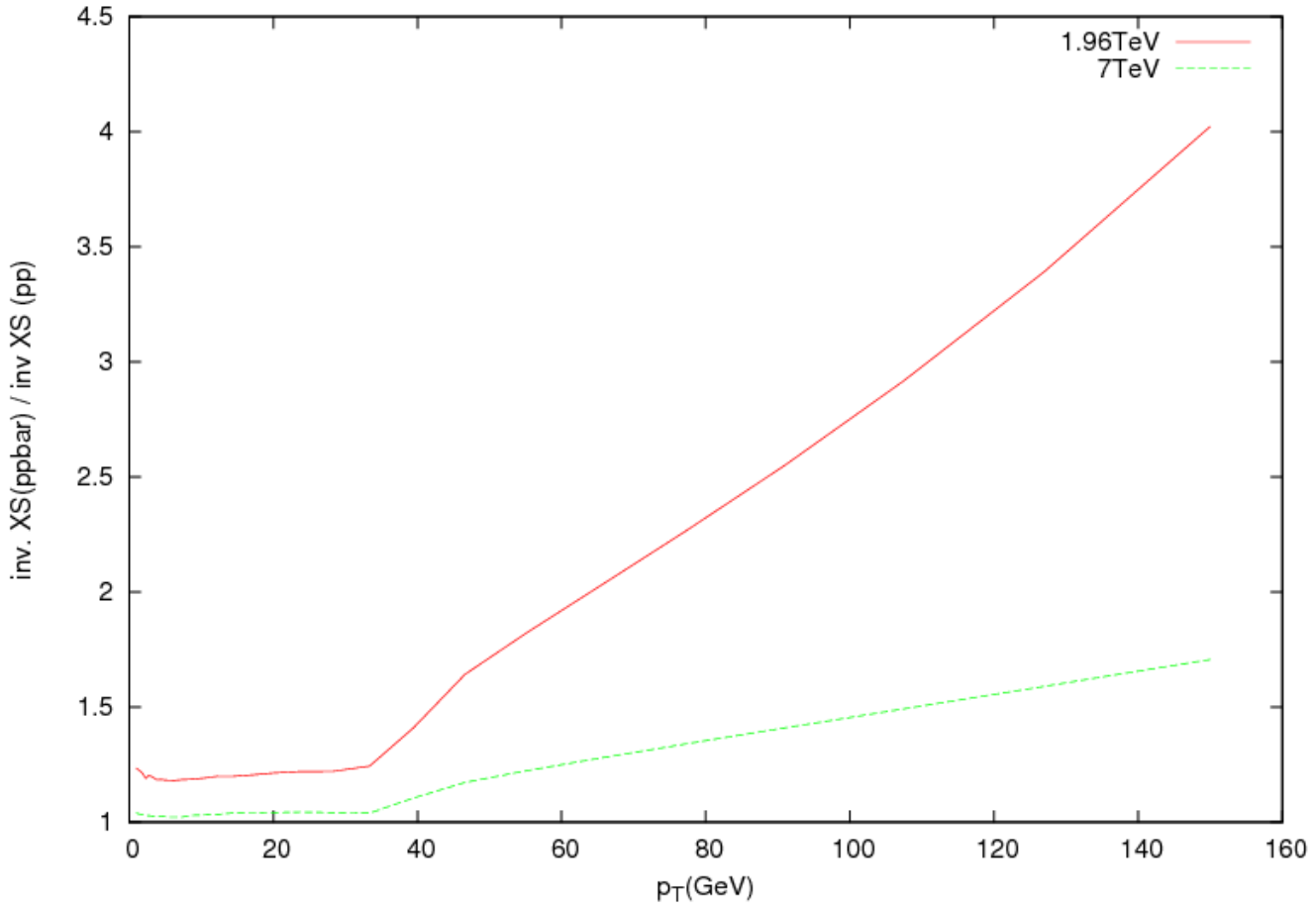
The effect at LHC



The effect at TEVATRON



Comparison between pp and ppbar



Summary

- The effect is indeed bigger in ppbar than in pp
- The s-channel $W^{+/-}$ diagrams create <1% of the QCD contribution
- The effect is way too small to account for inconsistencies with measurements