Large-p_T hadron production in pp-collisions at NICA energies

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Outline

- Large-p_T processes in QCD
- Diquark role in large-p_T hadron and symmetric hadron pairs production
- Summary

Introduction

The QCD parton model demonstrates a good description of mesons over a wide range of energies. But it can't describe an anomalously large yield of protons and, in addition, a strong scaling violation.

Taking into account the two-quark correlation (Diquark) allows us to describe the anomalous proton yield. Laperashvili (1982), Ekelin et al (1984), Kim (1988)

Being a higher-twist, the Diquark contribution can describe the strong scaling violation in deep inelastic scattering of nucleons and the large-p_T baryon production in hard nucleon collisions at **SPD** energies. Kim (1988)

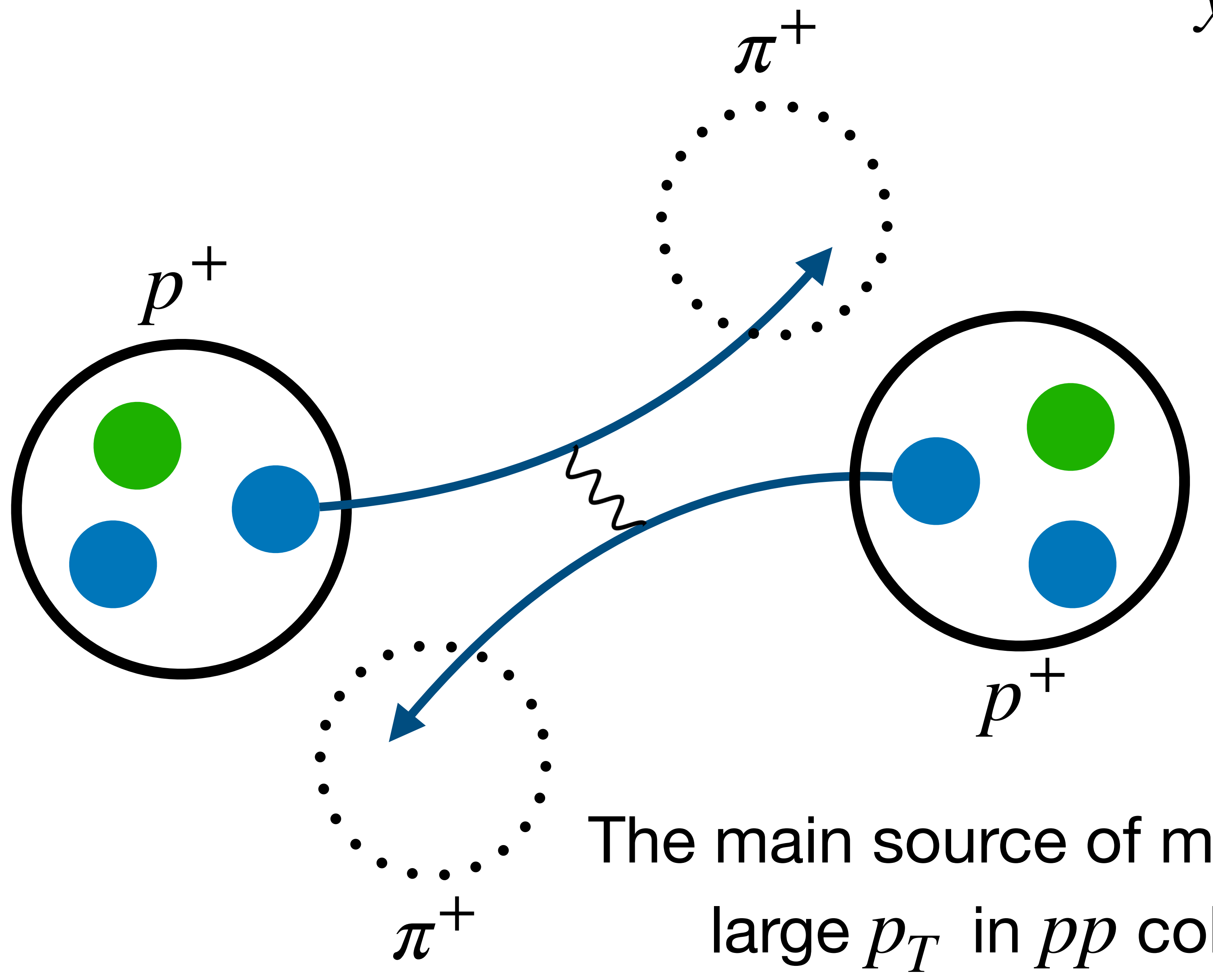
Large-p_T processes in QCD

Colinear factorization

$$\frac{E\,d^3\sigma}{d^3p} = \int_{x_{min}}^{1} dx \int_{y_{min}}^{1} dy\; G_a^A(x)\; G_b^B(y) \left(\frac{d\sigma}{d\hat{t}}\right)_{ab} \frac{D_C^c(z)}{\pi z}$$

$G_a^A(x),\ G_b^B(y)\ \&\ D_C^c(z)$ – **scaling functions**

qq – **scattering**



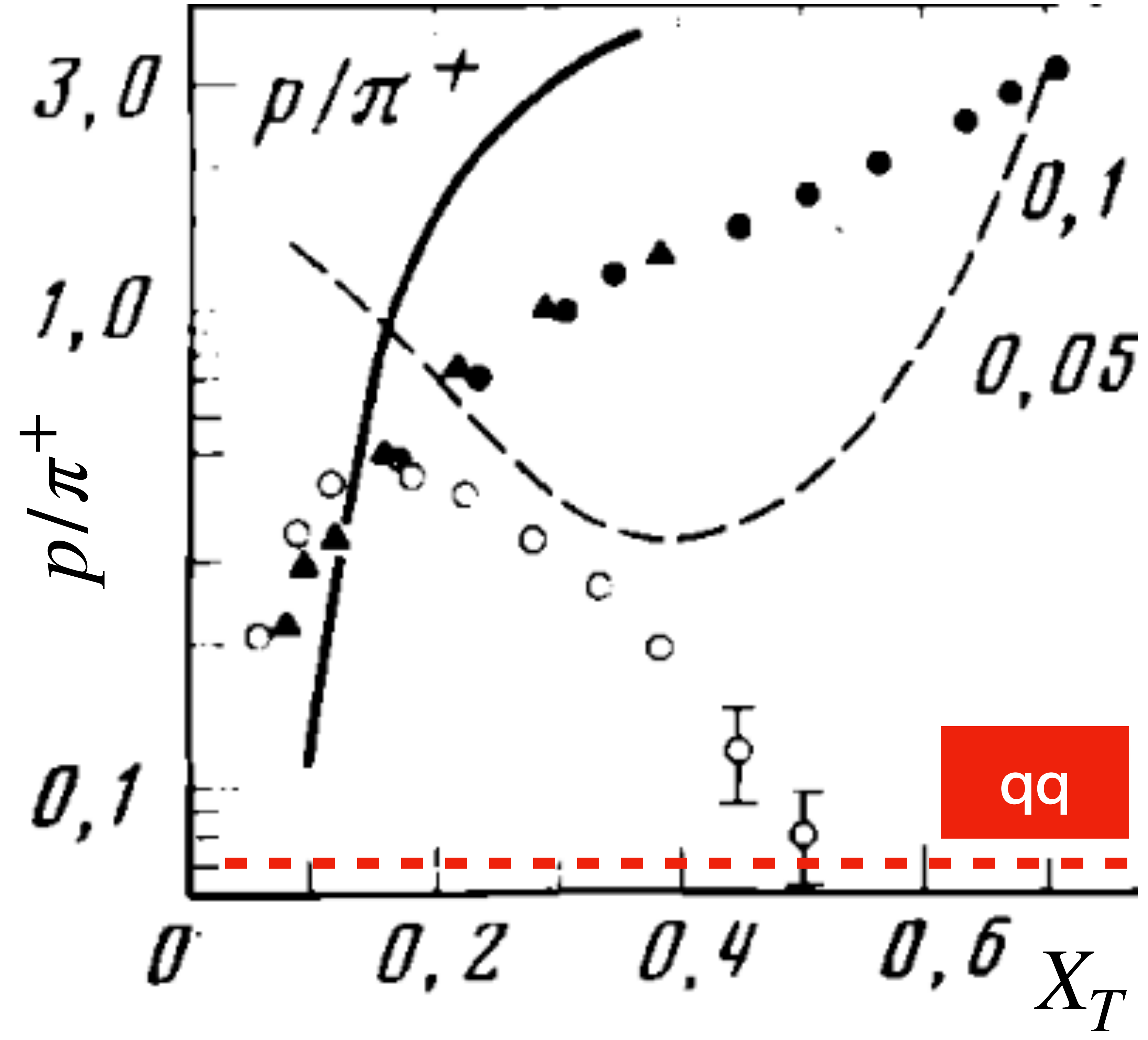
The main source of mesons with large p_T in pp collisions

$$x_T = p_T/p_T^{max} = 2p_T/\sqrt{s}$$

$$\frac{E\,d^3\sigma}{d^3p} \sim \frac{c(x_T, \sqrt{s})}{p_T^4}$$

Weak dependence of $\sqrt{S}$ → scaling

IHEP, Serpukhov ,$\sqrt{s} = 11.5$ GeV
FODS, V.V. Abramov et al. (1985)
FNAL, Batavia, $\sqrt{s} = 23.4$ GeV
D.Antreasyan et al. (1979)

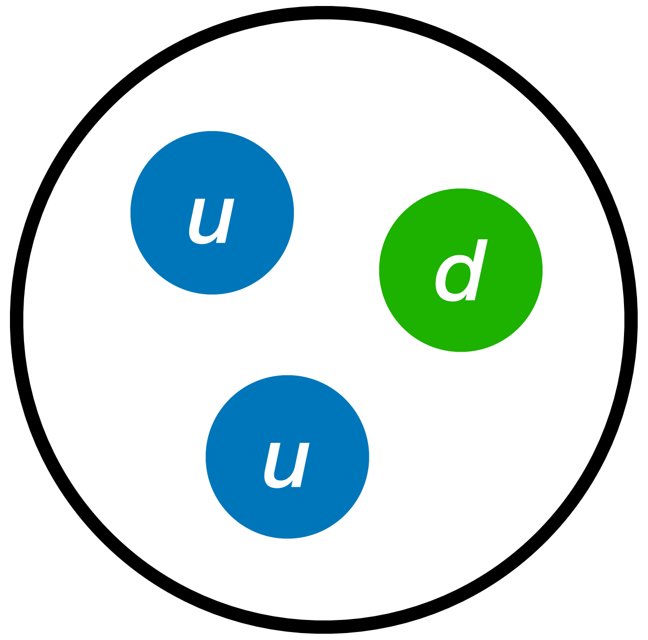


STRONG SCALING VIOLATION

Two-quark correlations: Diquarks

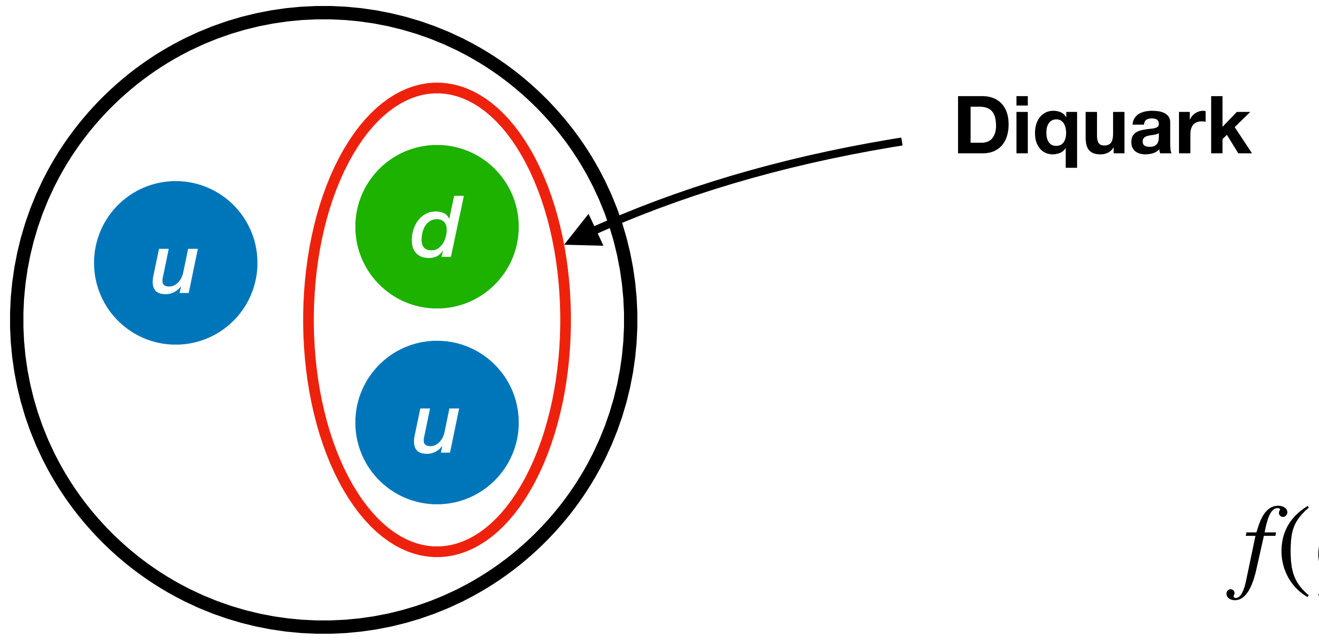
Diquark is a two-quark correlation in baryons.

$p\{uud\}$



Quark model of baryon

$p\{u(ud)\}$



Model of baryon with Diquark

Diquark is not a point-like object!

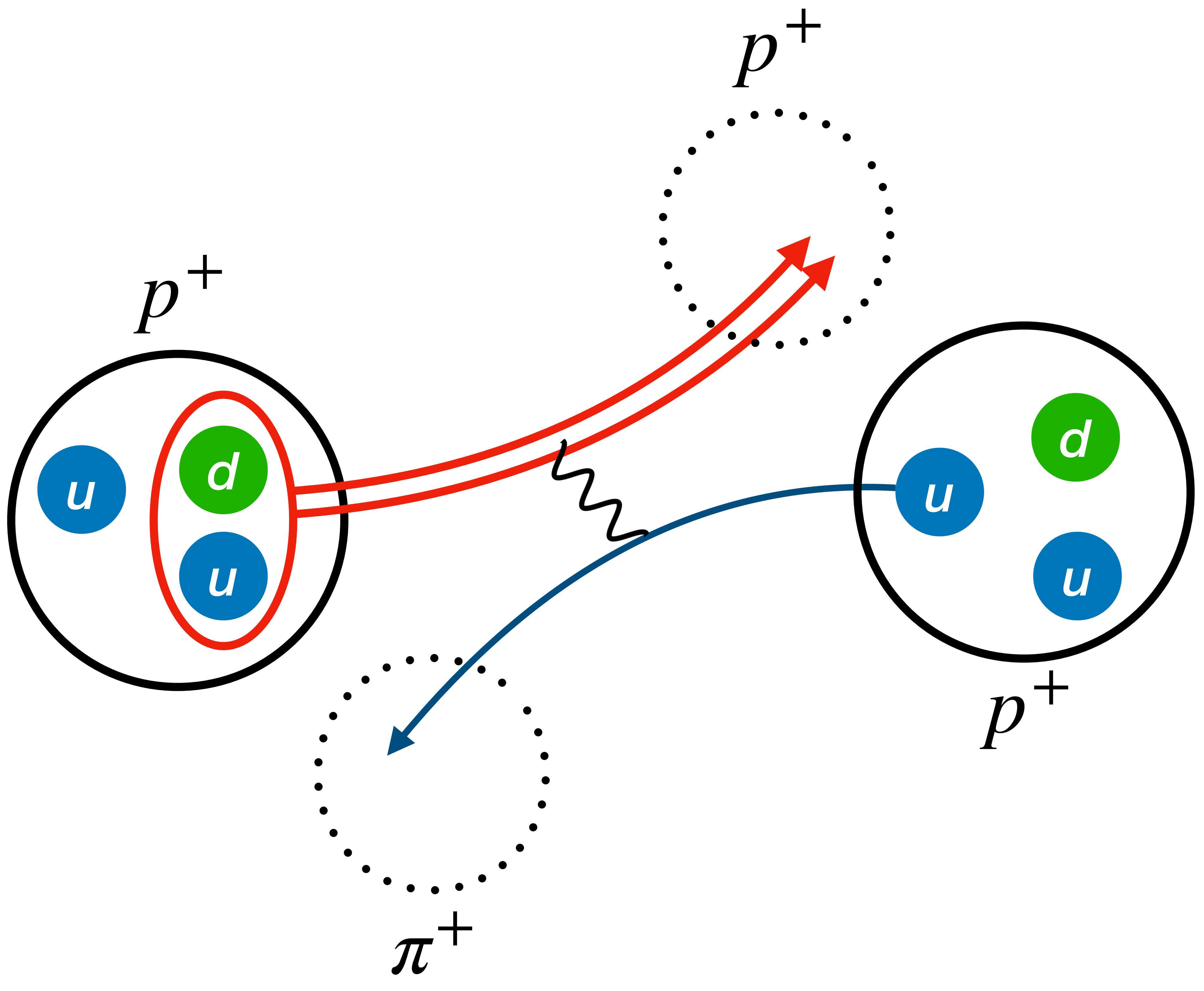
$$f(Q^2) = \frac{1}{1 + \frac{Q^2}{M^2}}$$ – **Diquark form-factor**

M^2 – **Diquark size parameter**

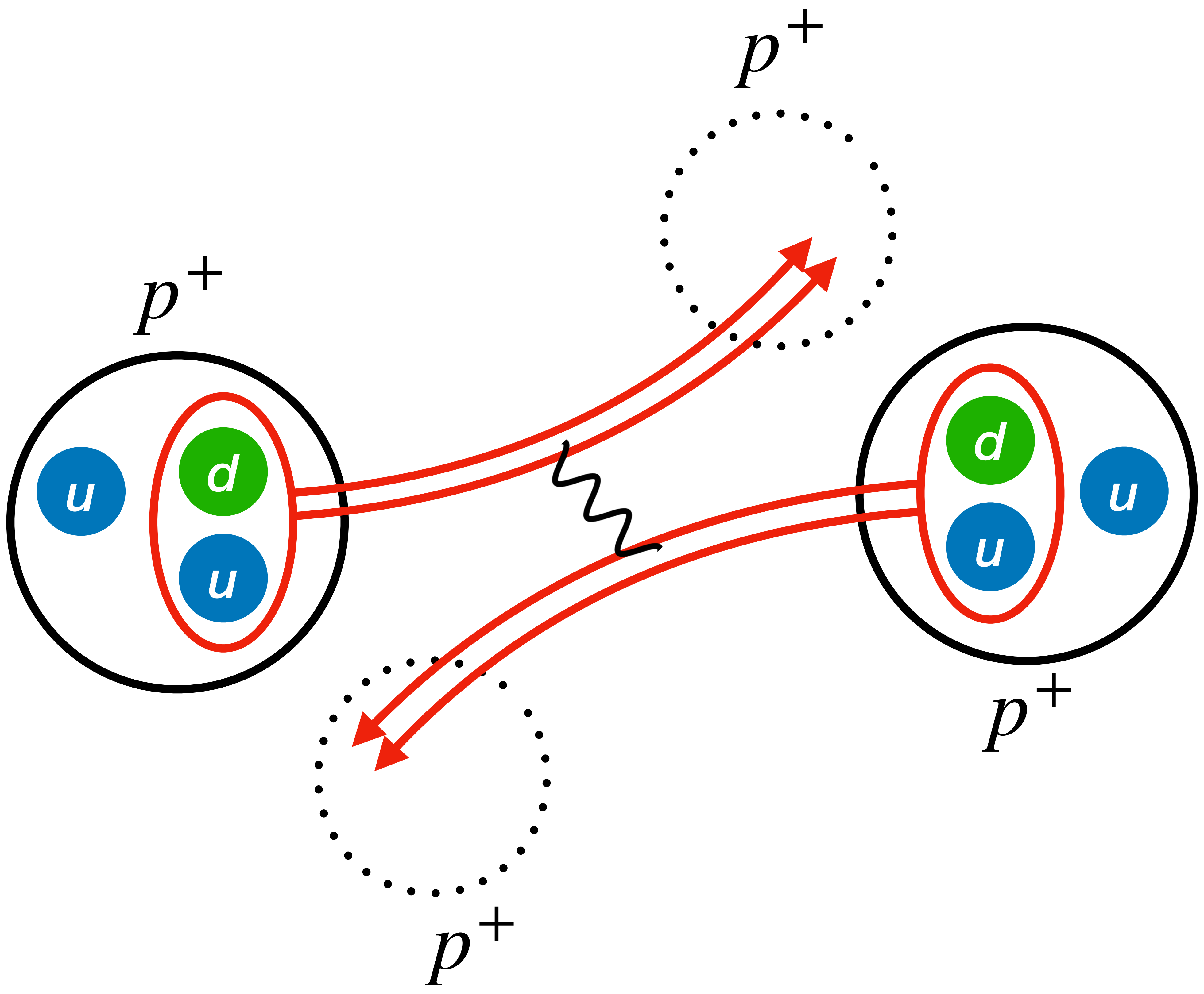
Baryon (proton) is in quark-Diquark state with probability W

Two-quark correlations: Diquarks

(ud) Diquark scatters on u quark



(ud) Diquark scatters on (ud) Diquark



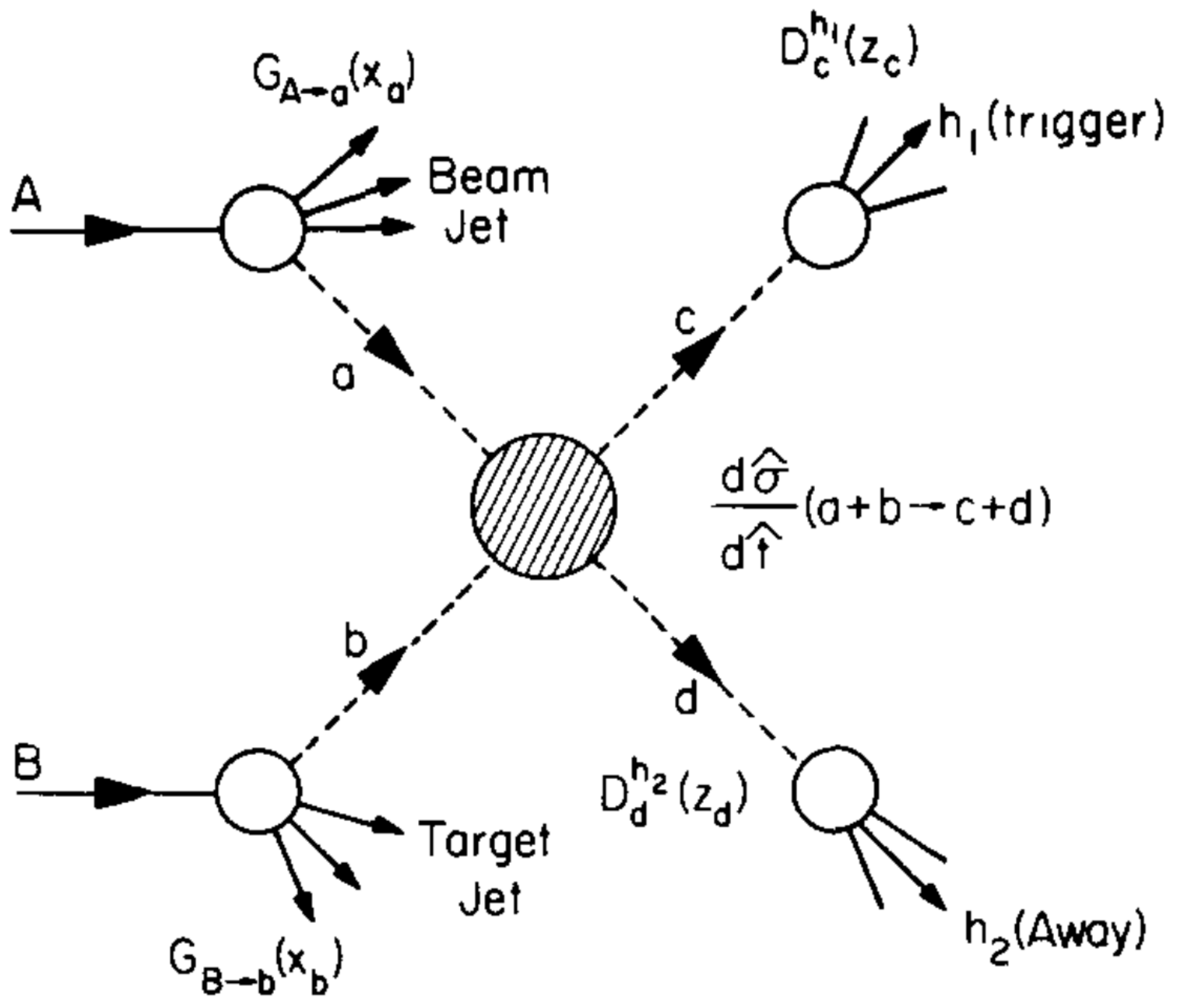
$$\left(\frac{d\hat{\sigma}}{d\hat{t}}\right)_{qD} = \left(\frac{d\hat{\sigma}}{d\hat{t}}\right)_{qq} \cdot f^2(Q^2)$$

The main source of baryons with large p_T in pp collisions

$$\left(\frac{d\hat{\sigma}}{d\hat{t}}\right)_{DD} = \left(\frac{d\hat{\sigma}}{d\hat{t}}\right)_{qq} \cdot f^4(Q^2)$$

Feynman approach: collinear factorization improved by k_T dependence

R.P. FEYNMAN, R.D. FIELD and G.C. FOX
Nuclear Physics B128 (1977) 1-65



$$Ed^3\sigma/d^3p(s,t,u;A+B\to h+X)=$$

$$\int d^2k_{T_a}\int d^2k_{T_b}\int d^2k_{T_c}\int dx_a\int dx_b\, G_{A\to a}(x_a,k_{T_a},Q^2)\; G_{B\to b}(x_b,k_{T_b},Q^2)$$

$$\times\, D_c^h(z_c,k_{T_c},Q^2)\frac{1}{z_c}\frac{1}{\pi}\frac{d\hat{\sigma}}{d\hat{t}}(\hat{s},\hat{t},\hat{u};q_a+q_b\to qc+q_d)$$

Fragmentation Function

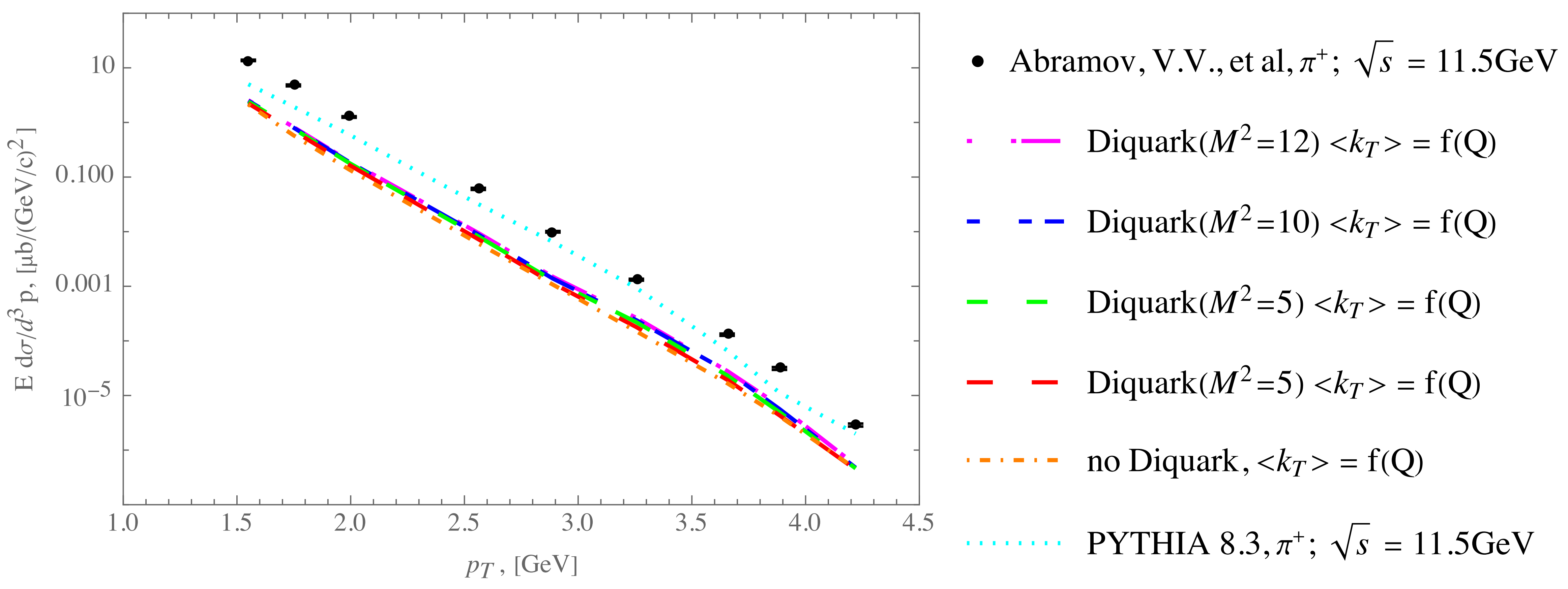
Subprocess cross section

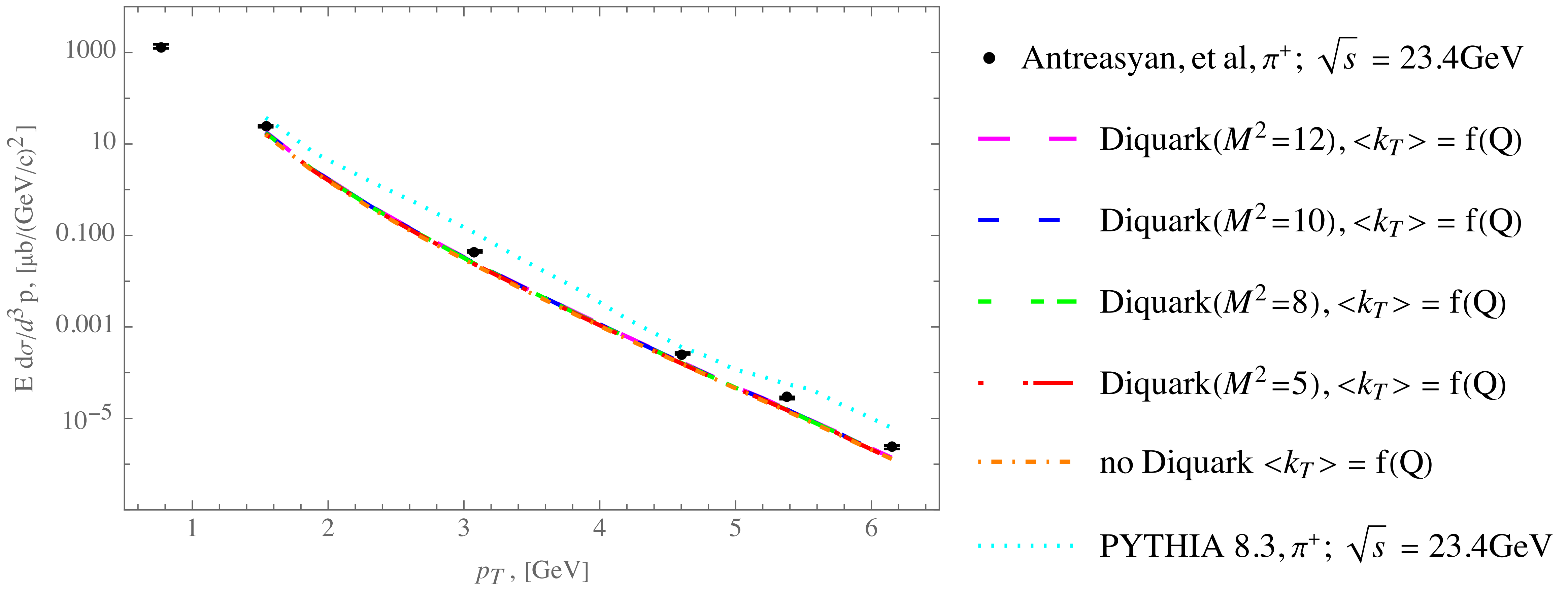
Parton Distribution Function

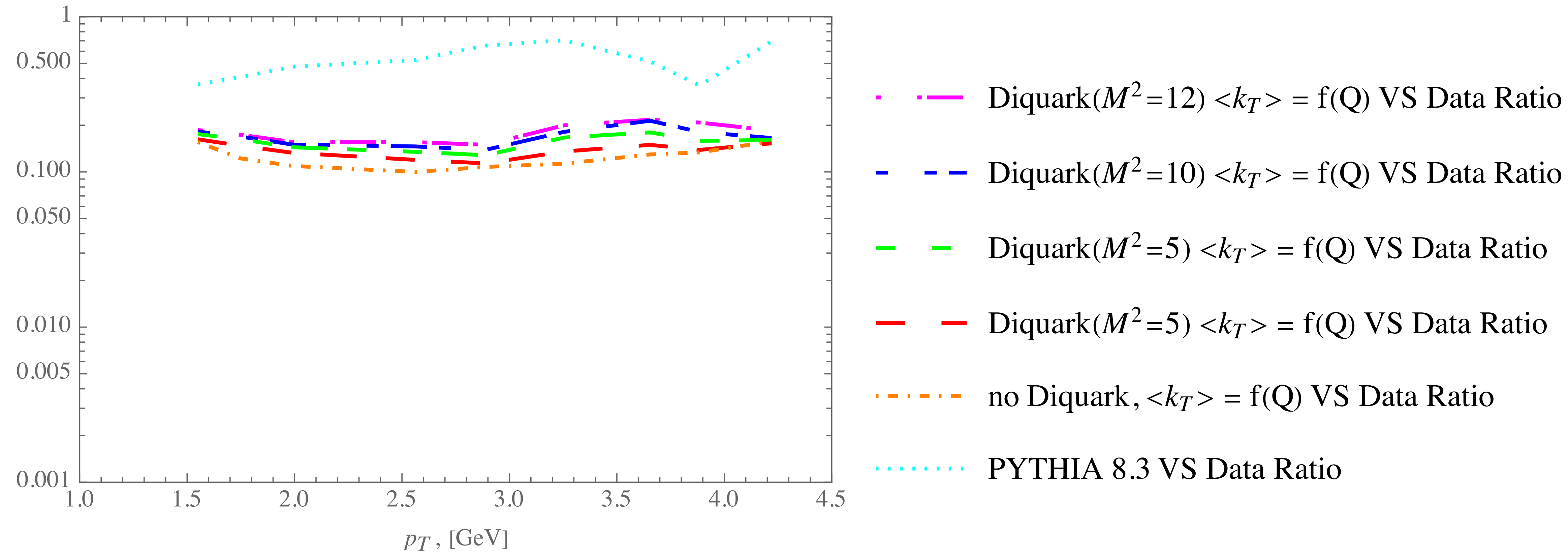
$$F(x,y,k_T)=\hat{F}(x,y)\cdot\tilde{F}(k_T)$$

$\tilde{F}(k_T)=J(k_T,Q^2)\sim e^{k_T^2/\sigma^2(Q^2)}$, where $\sigma^2=\langle k_T^2\rangle$

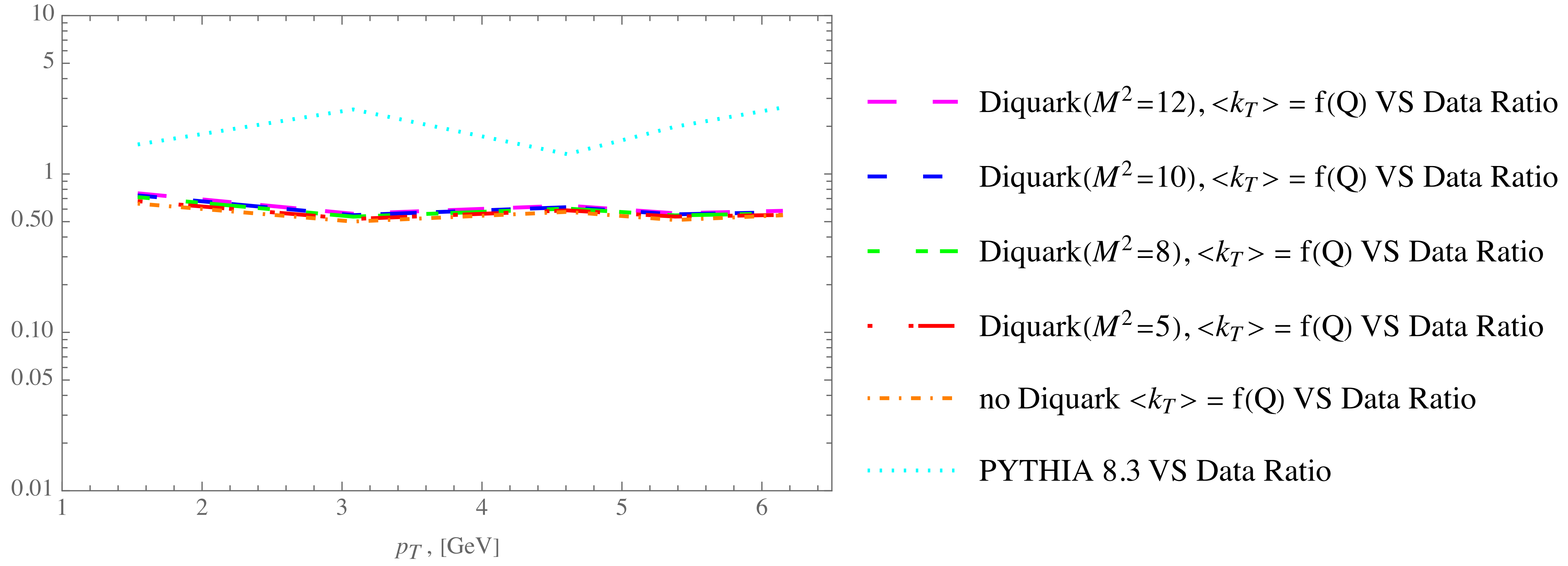
Large-p_T π^+ production







Theory/Data

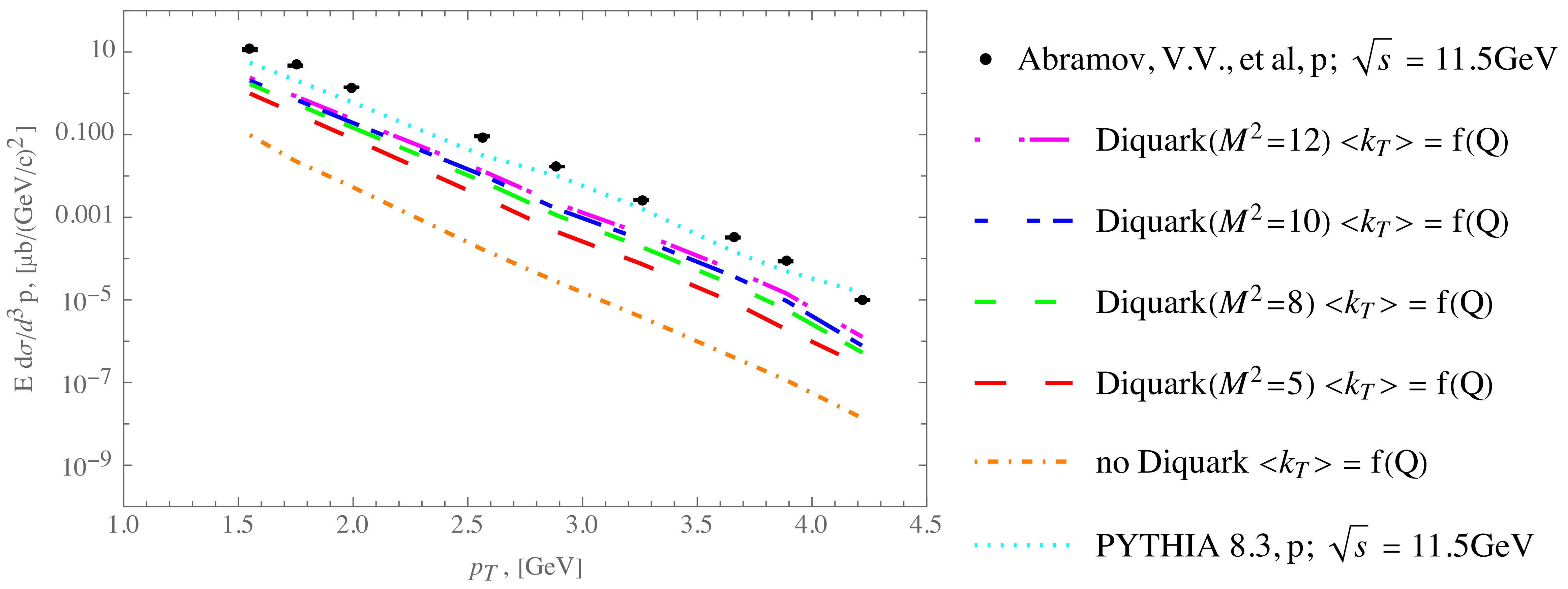


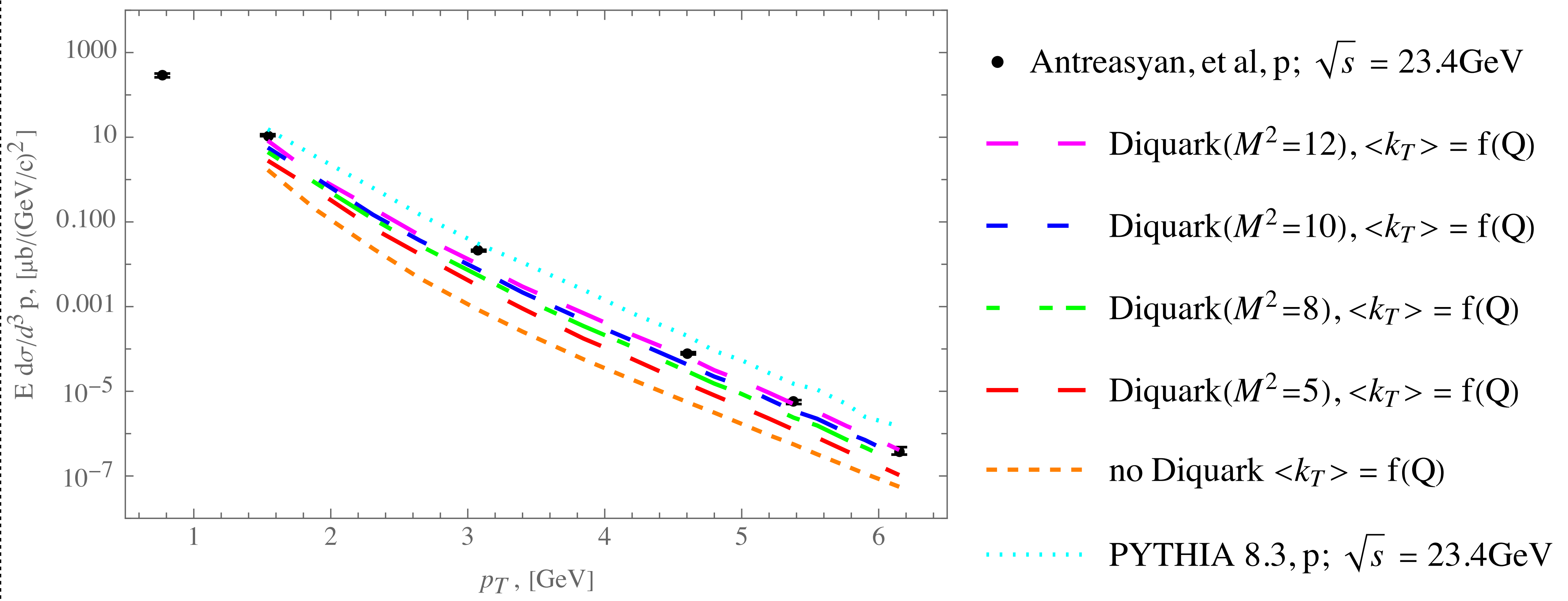
Theory/Data

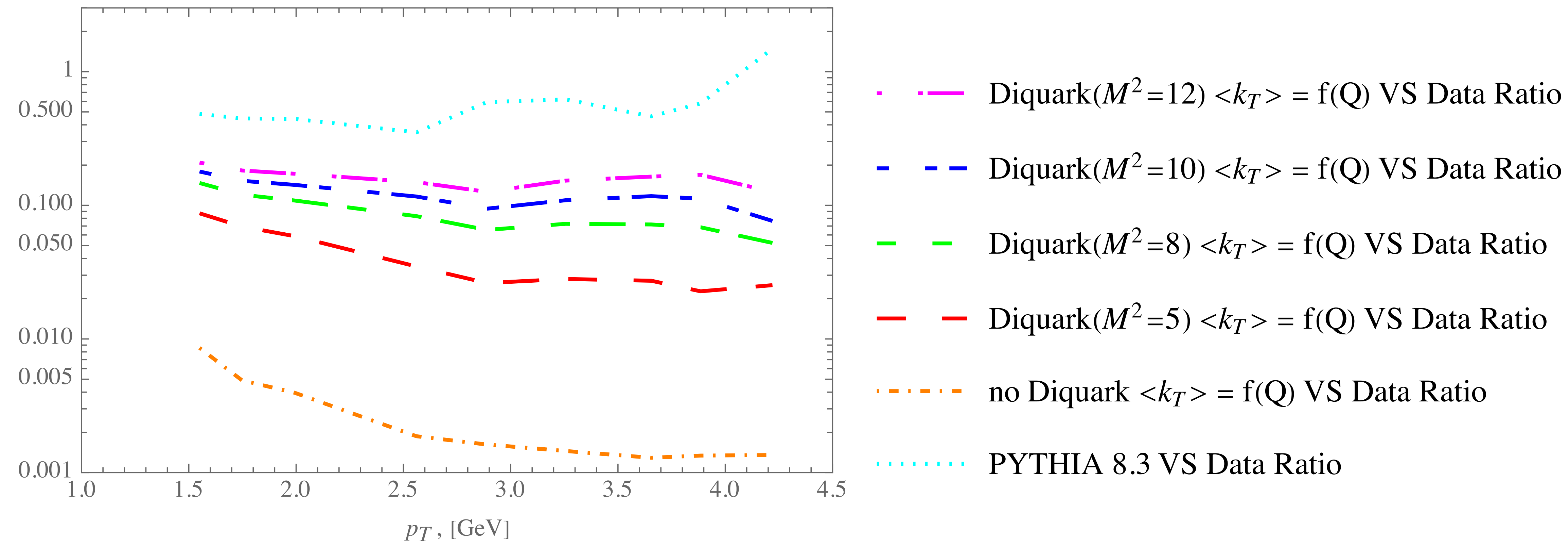
IHEP, Protvino
FODS, V.V. Abramov et al. (1985)

FNAL, Batavia
D.Antreasyan et al. (1979)

Large-p_T p production







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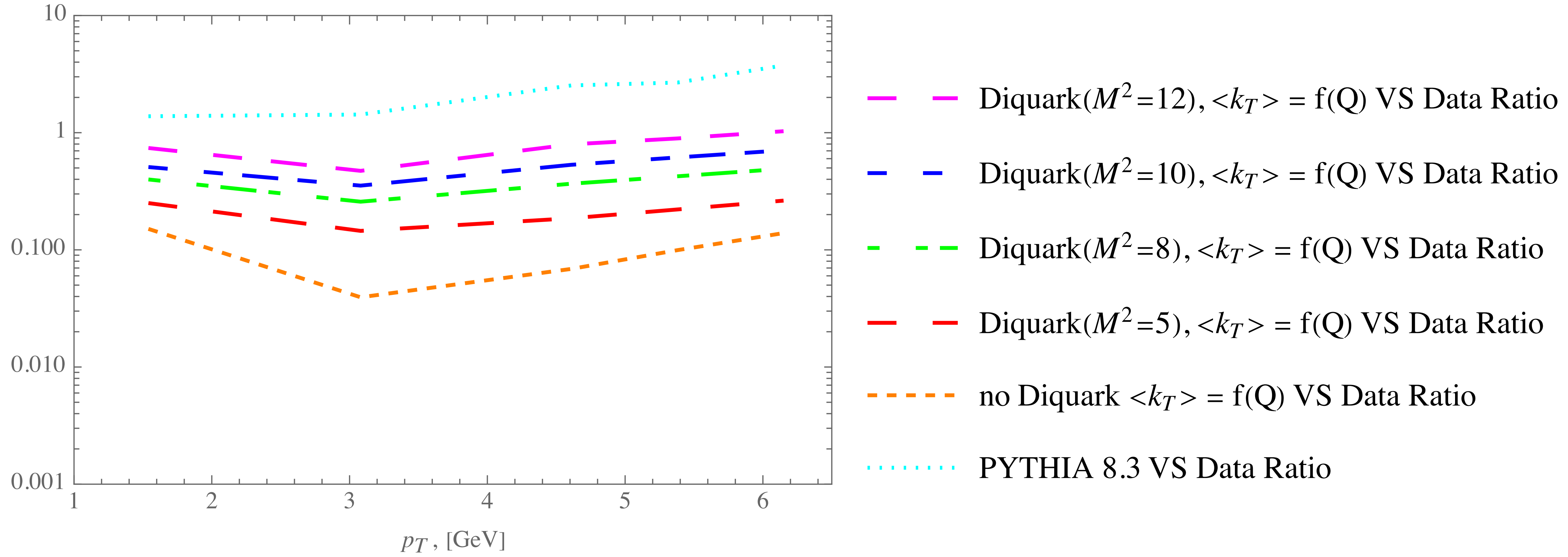

Theory/Data

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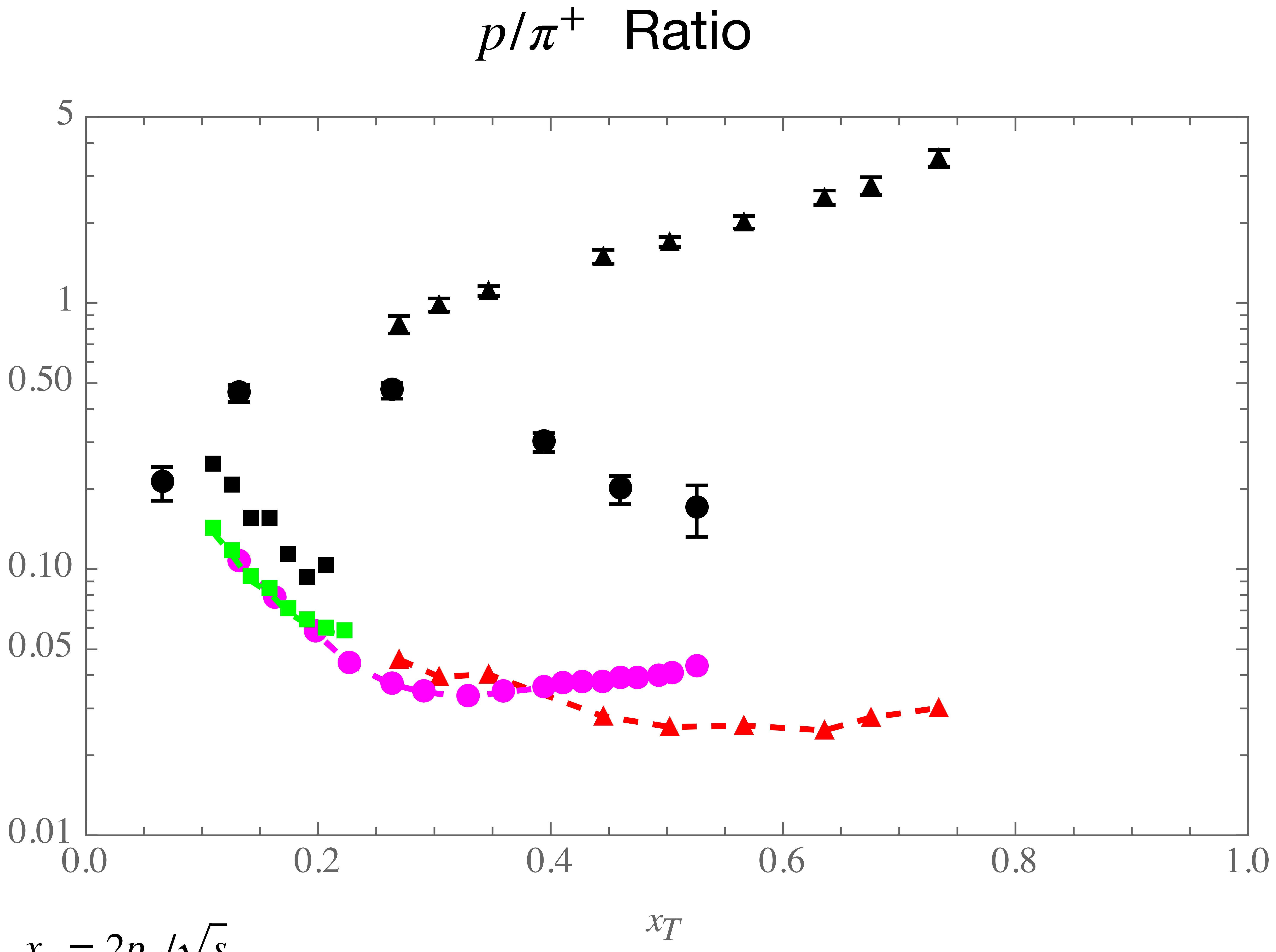
p/π^+ ratio without Diquark



$x_T = 2p_T/\sqrt{s}$

p/π^+ Ratio with $\theta_{cms} = 90^o$ и $\theta_{cms} = 45^o$ (ISR) in pp-collisions and also comparison with data

IHEP, Protvino (▲) для $\sqrt{s} = 11.5$ GeV
FODS, V.V. Abramov et al. (1985)

FNAL, Batavia (•) для $\sqrt{s} = 23.4$ GeV
D.Antreasyan et al. (1979)

ISR, CERN (■) для $\sqrt{s} = 62$ GeV
ABCDHW, A. Breakstone et al. (1985)

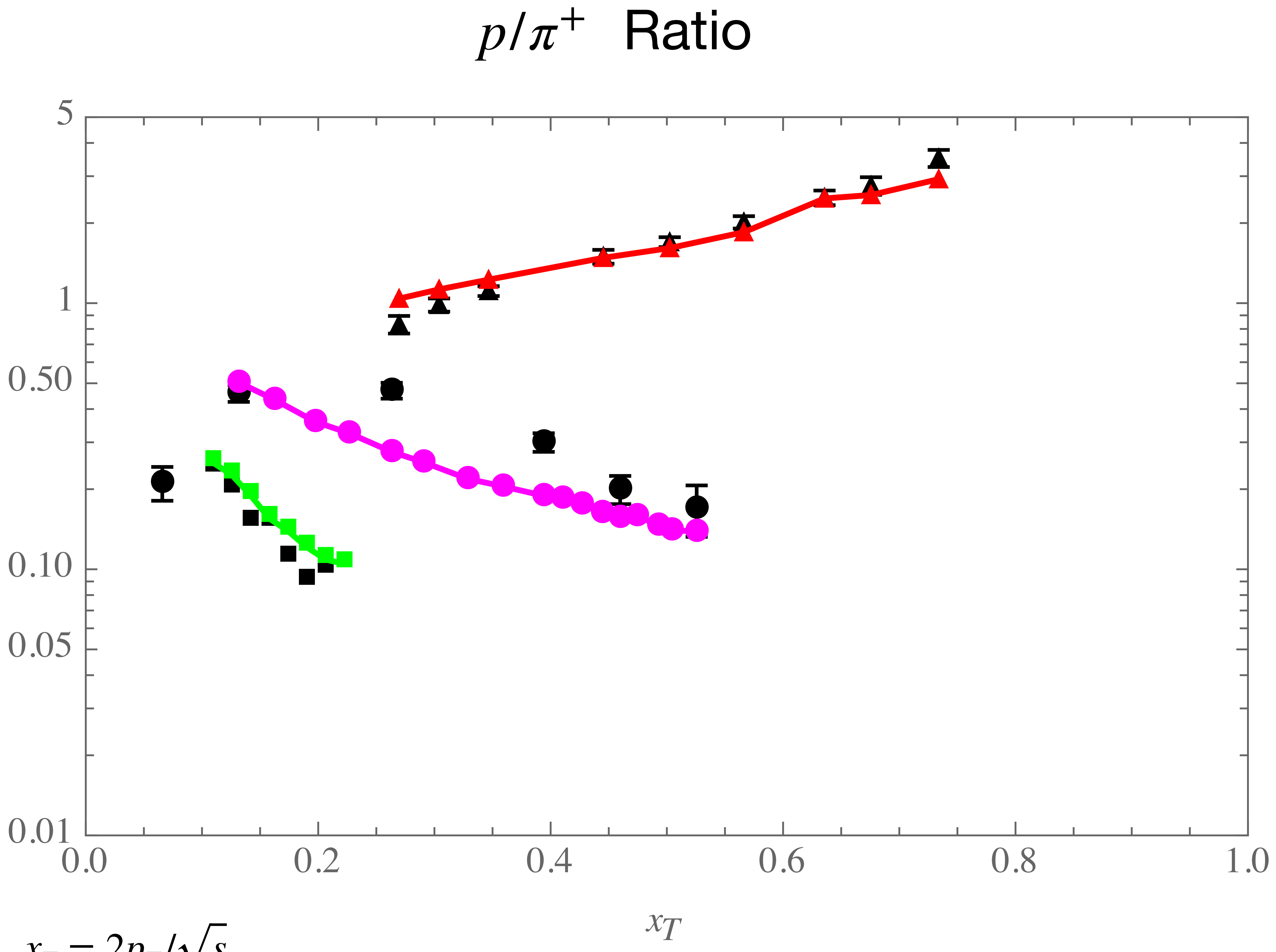
Calculation results**:**

Red line $-\sqrt{s} = 11.5$ GeV,

Magenta $-\sqrt{s} = 23.4$ GeV,

Green $-\sqrt{s} = 62$ GeV

p/π^+ ratio with Diquark



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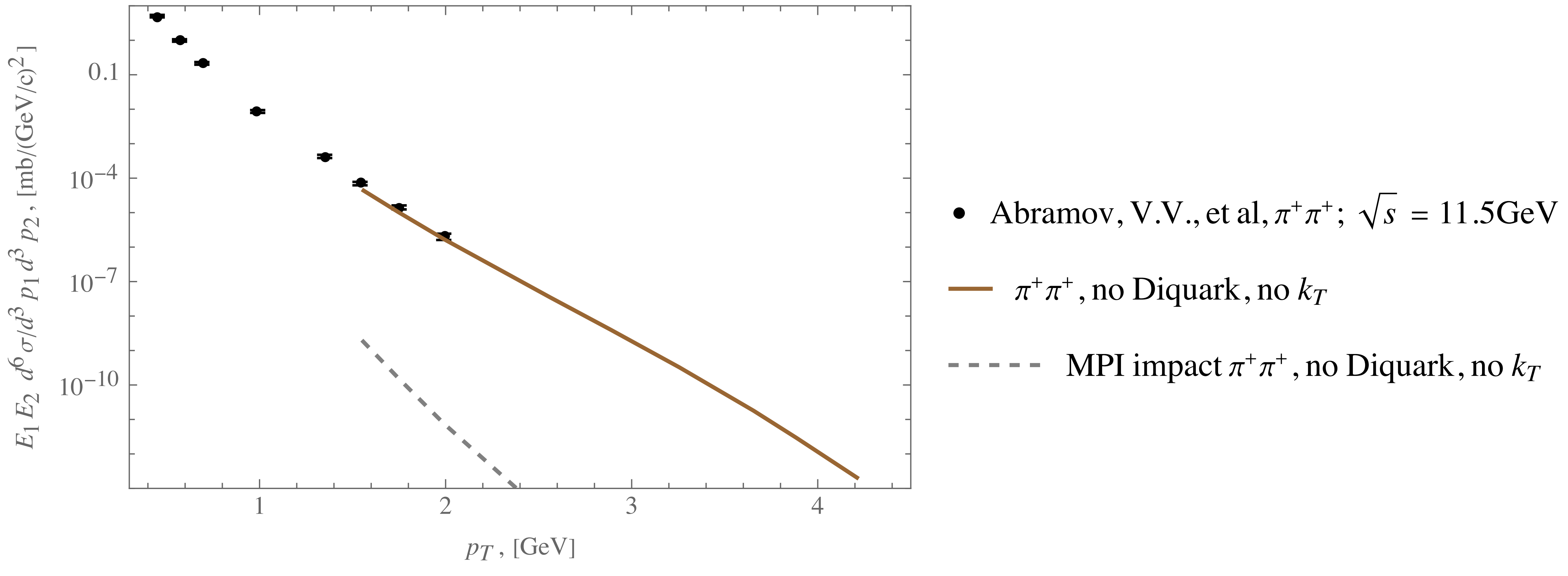
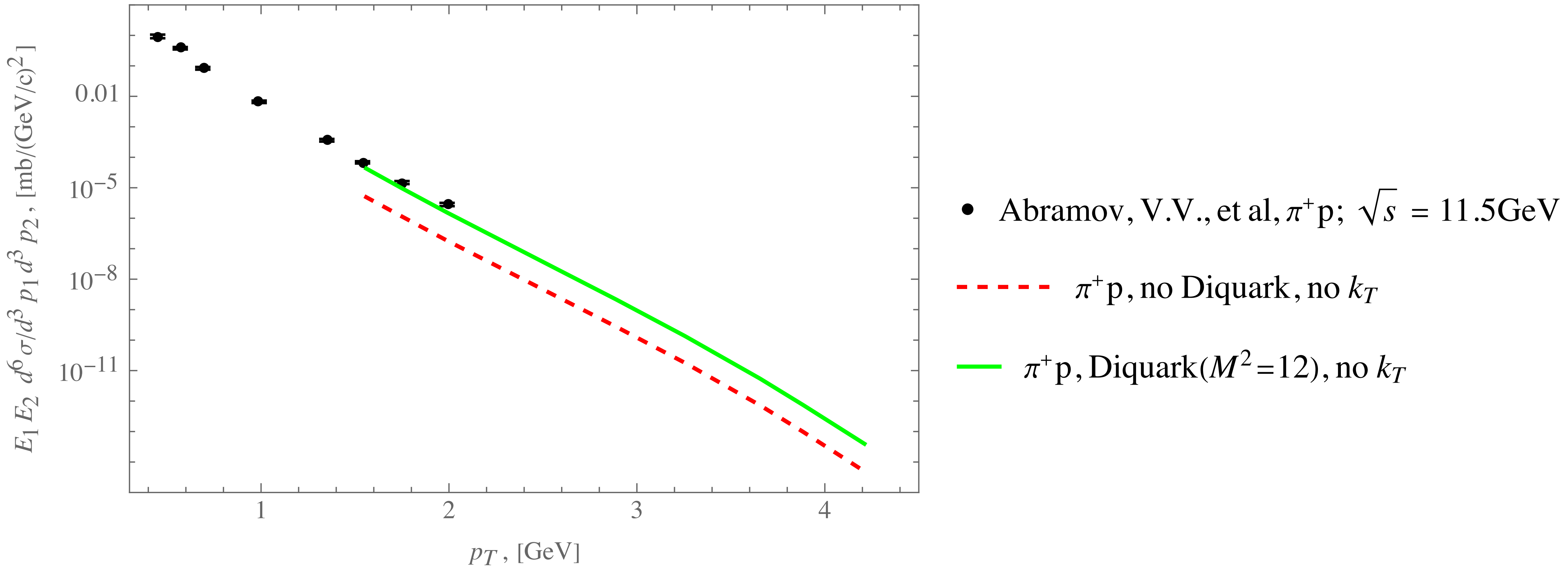
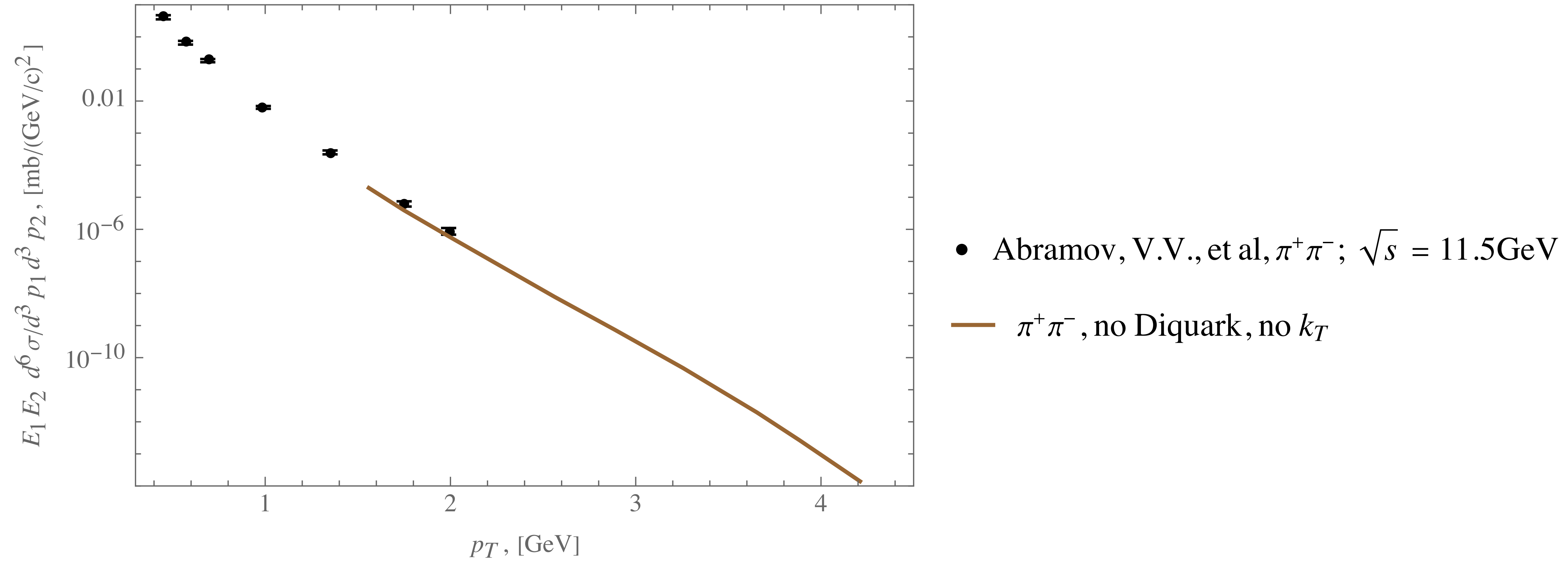
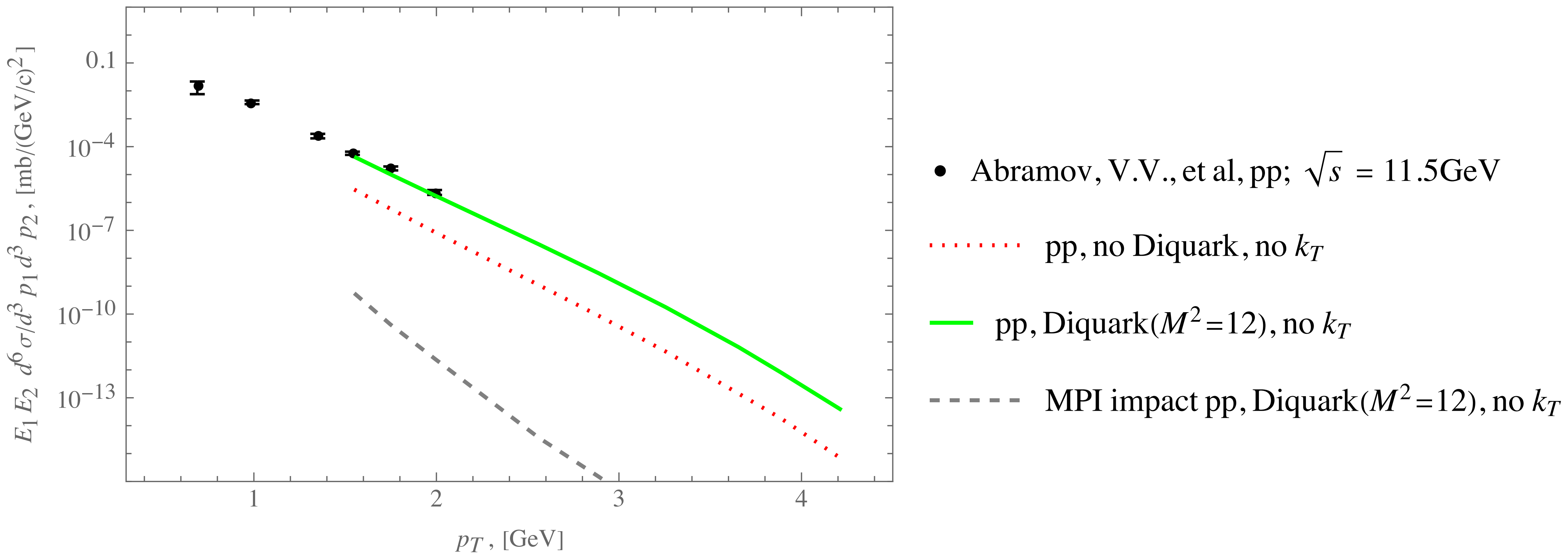
Hadron symmetric pairs production





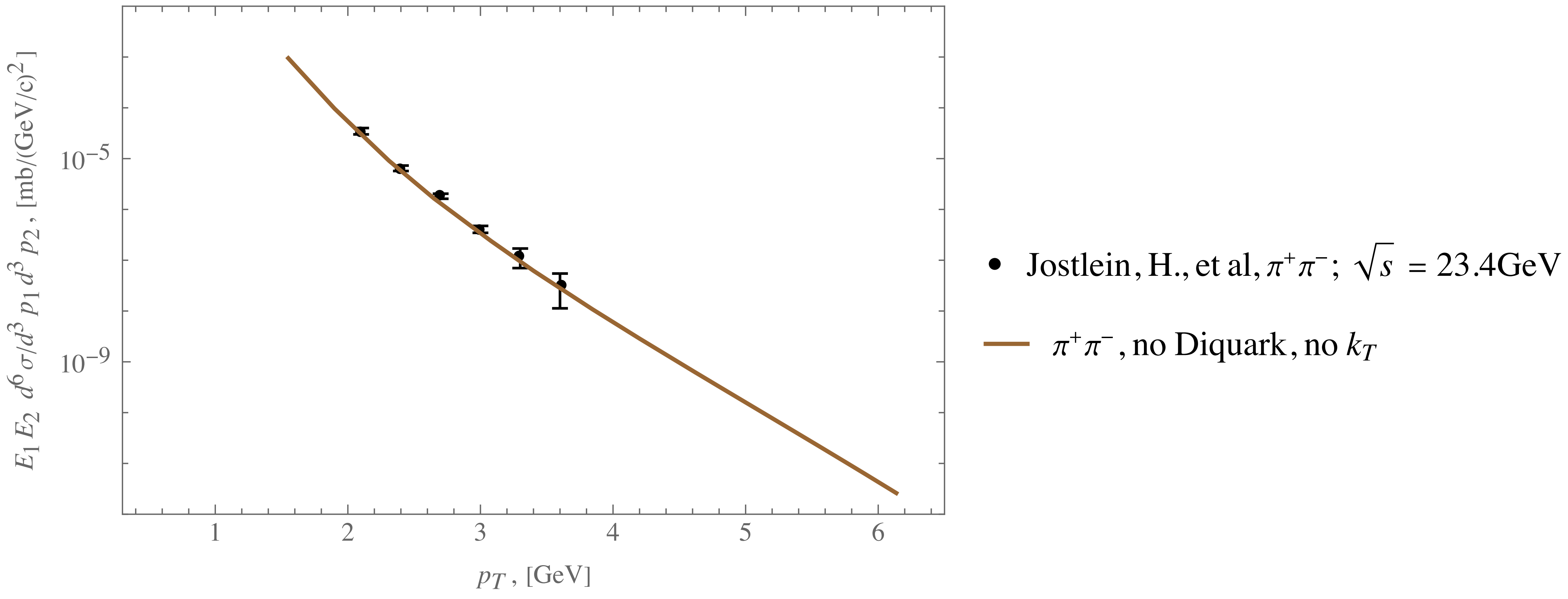


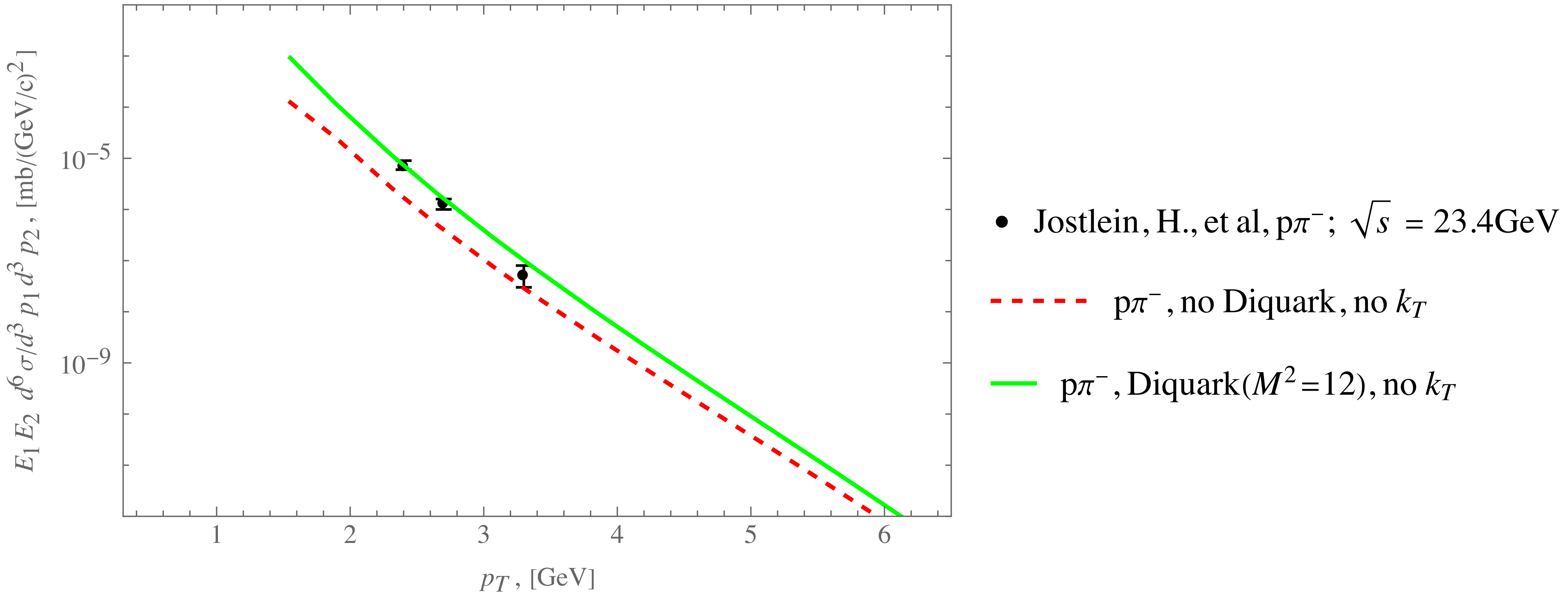


IHEP, Protvino
FODS, V.V. Abramov et al. (1985)

$$\sqrt{s} = 11.5\ \text{GeV}$$

Hadron symmetric pairs production





FNAL, Batavia
H.Jostlein et al. (1979)

$$\sqrt{s} = 23.4 \text{ GeV}$$

Summary

- Two quarks correlations (Diquarks) can describe the strong scaling violation in large-p_T proton production in hard nucleon collisions at **SPD** energies.

- The **SPD** high luminosity at **NICA** collider gives a unique opportunity to study the Diquark distribution in proton in pp-collisions at different energies.

- These results will be used to tune the MC generator **ULYSSES** which is developing in NRC «Kurchatov Institute» - PNPI, Gatchina.