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Gauge Links & Process dependence in Hadronic Reactions

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We study the single transverse spin asymmetries in the single inclusive particle production within the framework of the generalized parton model (GPM). By carefully analyzing the initial- and final-state interactions, we include the process-dependence of the Sivers functions into the GPM formalism. The modified GPM formalism has a close connection with the collinear twist-3 approach. Within the new formalism, we make predictions for inclusive π^0 and direct photon productions at RHIC energies. Also we consider the Sivers asymmetry from the cross section for $p^\uparrow p \longrightarrow h_1 \,\mathrm{jet}\, X$ (w/ D'Iesio, Murgia & Pisano). We find the predictions are opposite to those in the conventional GPM approach.

Spin Dependent Cross Section in GPM $pp \to \pi X$

$$f_{q/A^\uparrow}(x,\vec{k}_T) = f_{q/A}(x,k_T^2) + \tfrac{1}{2}\Delta^N f_{q/A^\uparrow}(x,k_T^2)\vec{S}\cdot(\hat{P}\times\vec{k}_T)$$

A_N is defined by the ratio $\quad A_N \equiv E_h\frac{d\Delta\sigma}{d^3P_h}\Big/ E_h\frac{d\sigma}{d^3P_h}.$

$$E_h\frac{d\Delta\sigma}{d^3P_h} = \frac{\alpha_s^2}{S}\sum_{a,b,c}\int\frac{dx_a}{x_a}d^2k_{aT}\Delta^N f_{a/A}(x_a,k_{aT})\frac{1}{2}S_A\cdot(\hat{P}_A\times\hat{k}_{aT})\int\frac{dx_b}{x_b}d^2k_{bT}f_{b/B}(x_b,k_{bT})$$
$$\times\int\frac{dz_c}{z_c^2}D_{h/c}(z_c)H^U_{ab\to c}(\hat{s},\hat{t},\hat{u})\delta(\hat{s}+\hat{t}+\hat{u}),$$

GPM Anselmino et al.

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$$\times\int\frac{dz_c}{z_c^2}D_{h/c}(z_c)H^U_{ab\to c}(\hat{s},\hat{t},\hat{u})\delta(\hat{s}+\hat{t}+\hat{u}),$$

GPM w/color
LG & Z. Kang
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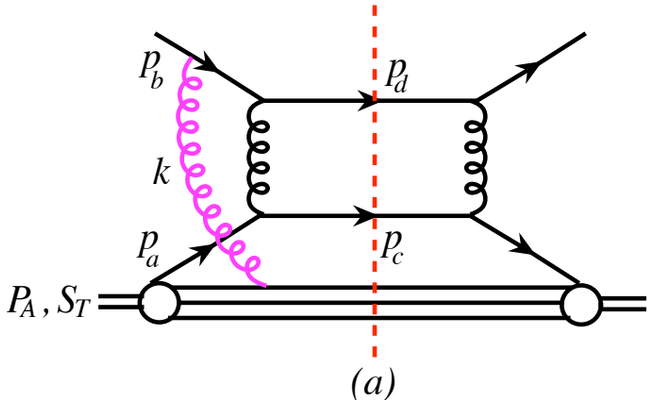
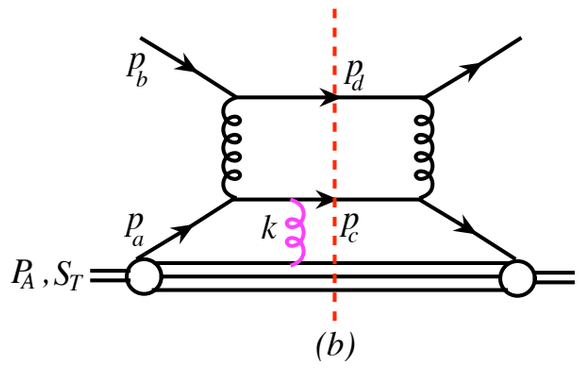
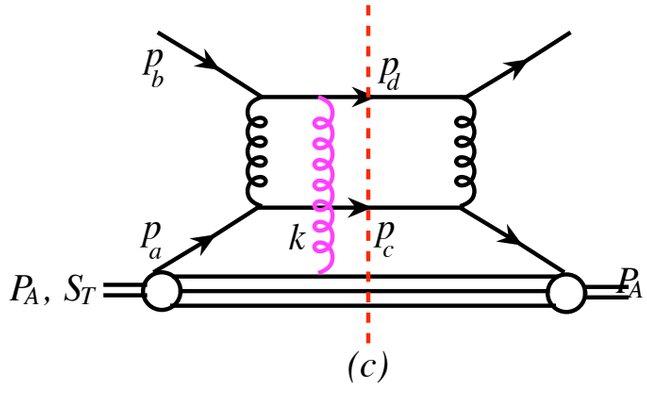
process-dependent Sivers function denoted as $\Delta^N f^{ab\to c}_{a/A}(x_a,k_{aT})$

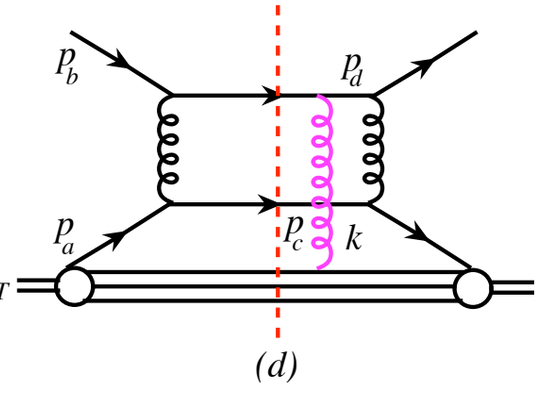
how to get it ?

One gluon exchange approx for ISI and FSI $qq' \to qq'$









$$\left[\frac{-g}{-k^+ - i\epsilon}T^a\right]$$

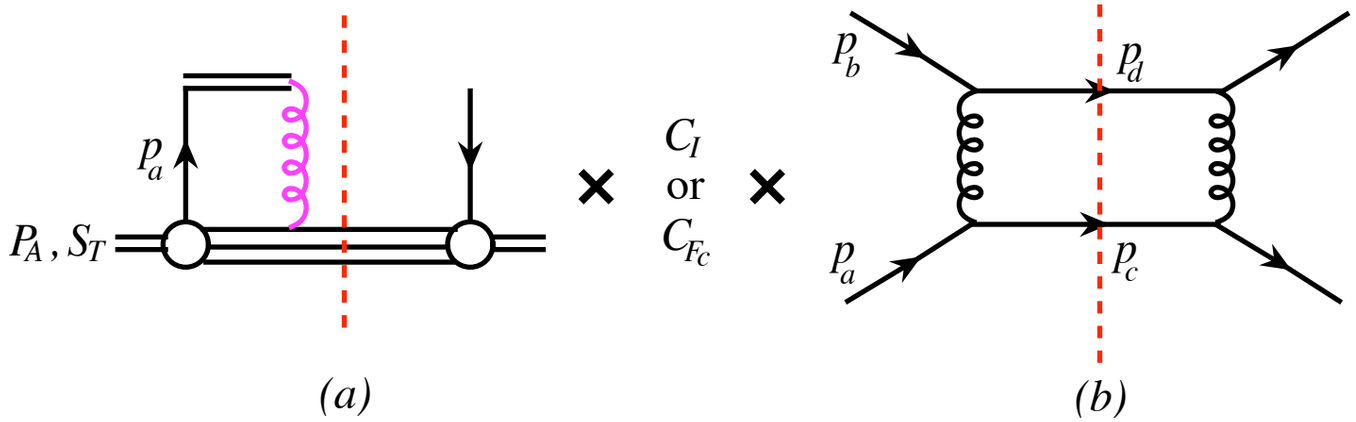
$$\left[\frac{g}{-k^+ + i\epsilon}T^a\right]$$

interaction w/unobserved particle "d" vanishes after summing over both cuts

$$C_I = -\frac{1}{2N_c^2},$$

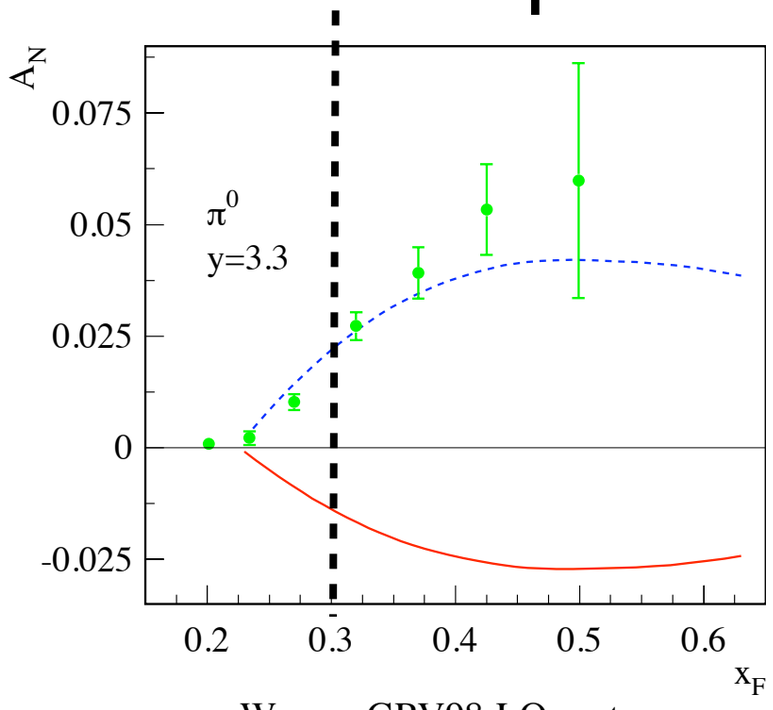
$$C_{F_c} = -\frac{1}{4N_c^2},$$

calculate color factors



Note unpolarized color factor $C_u = \dfrac{N_c^2 - 1}{4N_c^2}$

Based on old parameterization

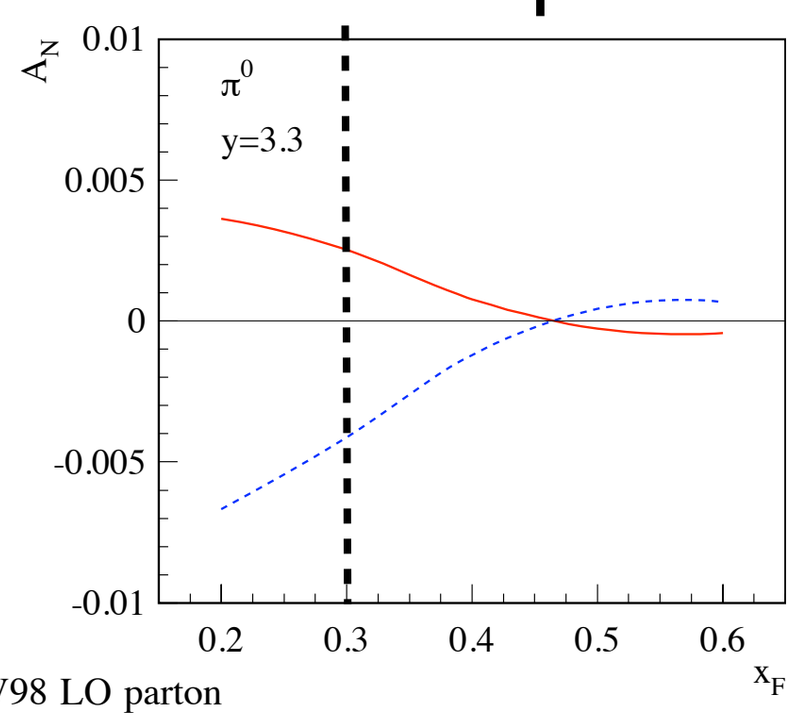


We use GRV98 LO parton

the old Sivers function from [4], and Kretzer fragmentation function [5].

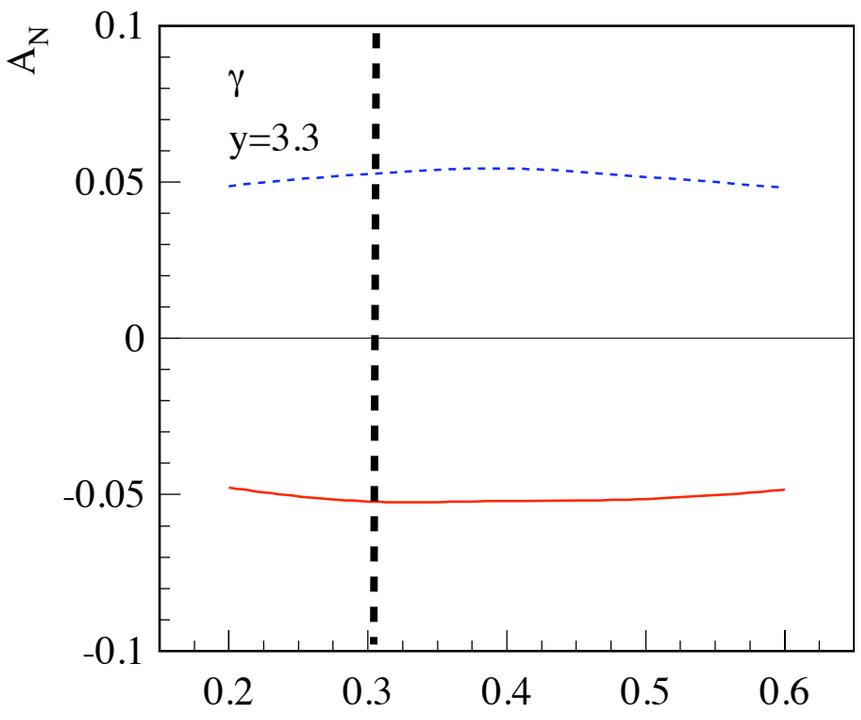
$$pp \to \pi X$$

Based on new parameterization

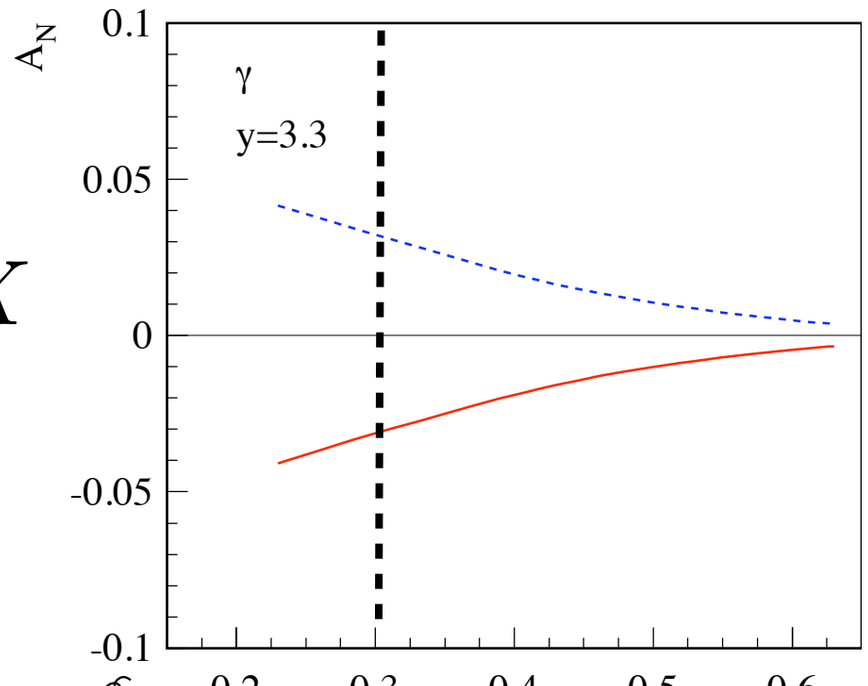


We use GRV98 LO parton

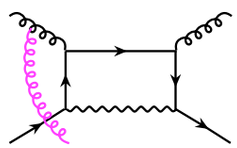
, the latest Sivers function from [2], and DSS fragmentation function [3].



$$pp \to \gamma X$$



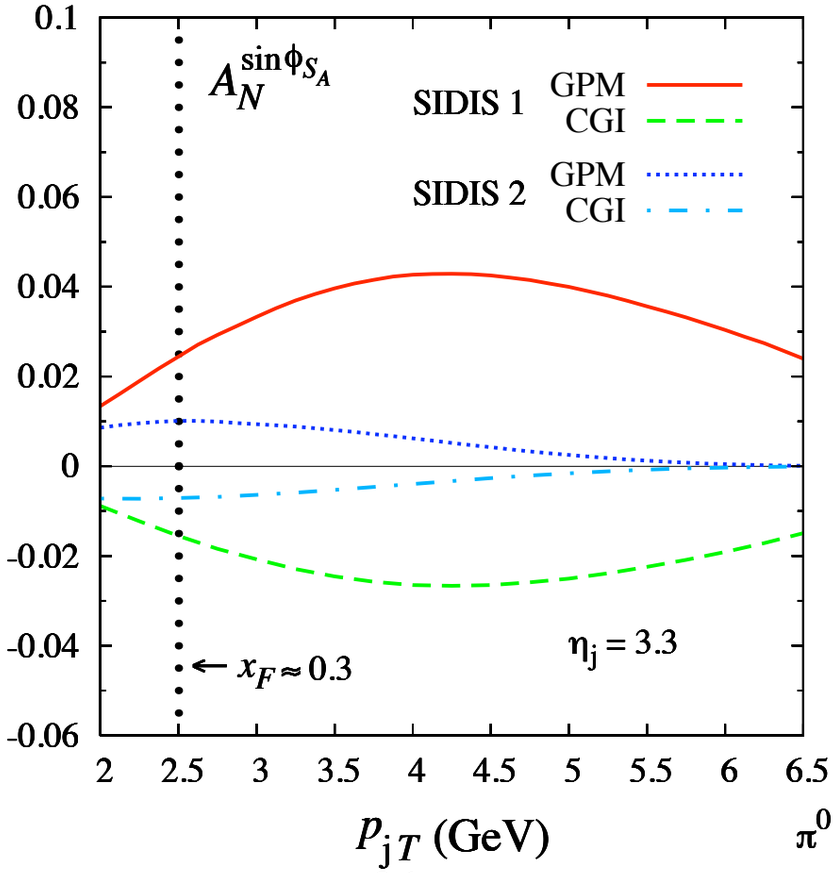
$$H_{qg\to\gamma q}^{\mathrm{Inc}} = -\frac{N_c}{N_c^2-1} e_q^2 \left[-\frac{\hat{t}}{\hat{s}} - \frac{\hat{s}}{\hat{t}} \right]$$



ISI drives result

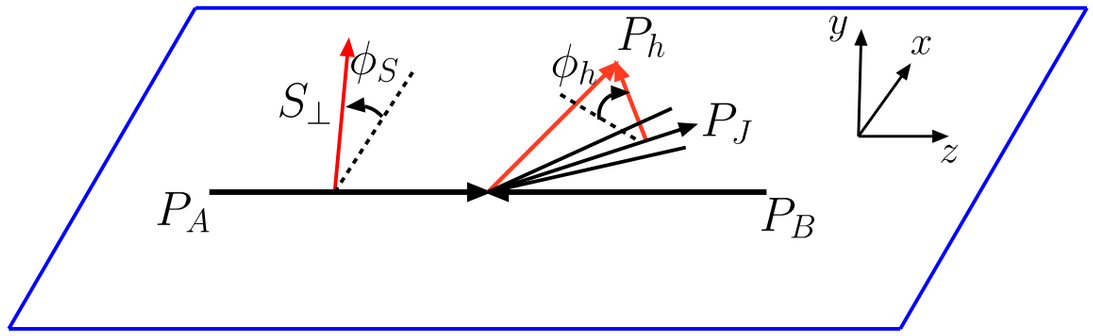
Azimuthal asymmetries for hadron distributions inside a jet in hadronic collisions

π^+



π^0

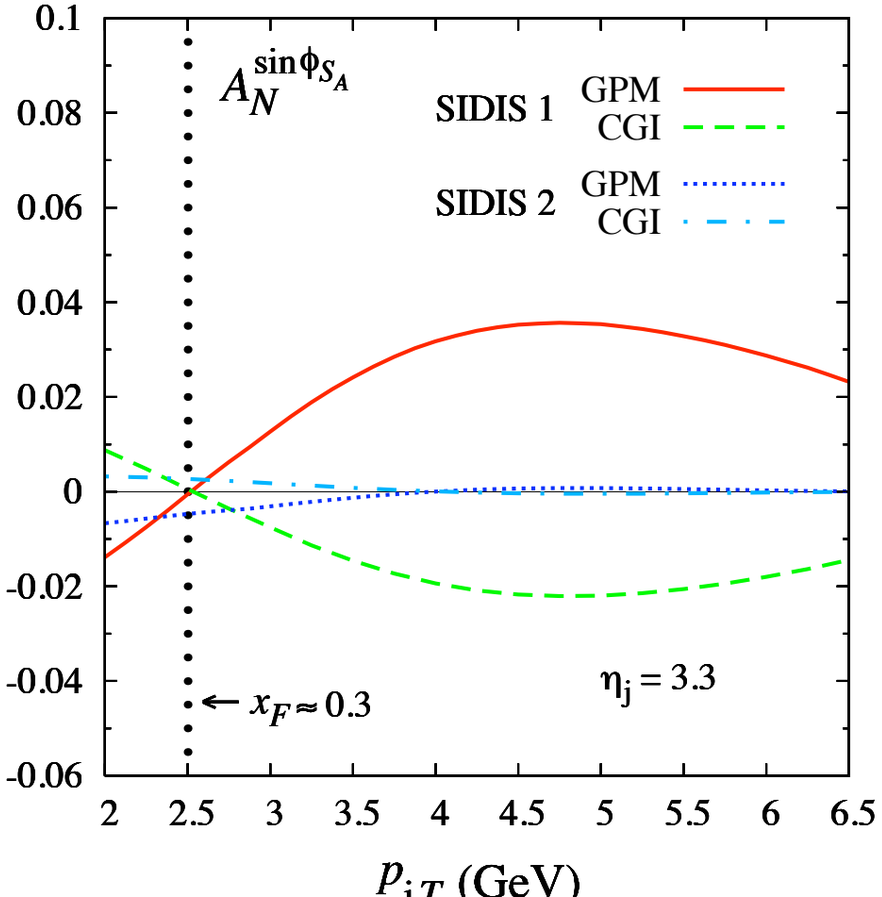
$$\sqrt{s} = 200\,\mathrm{GeV}$$

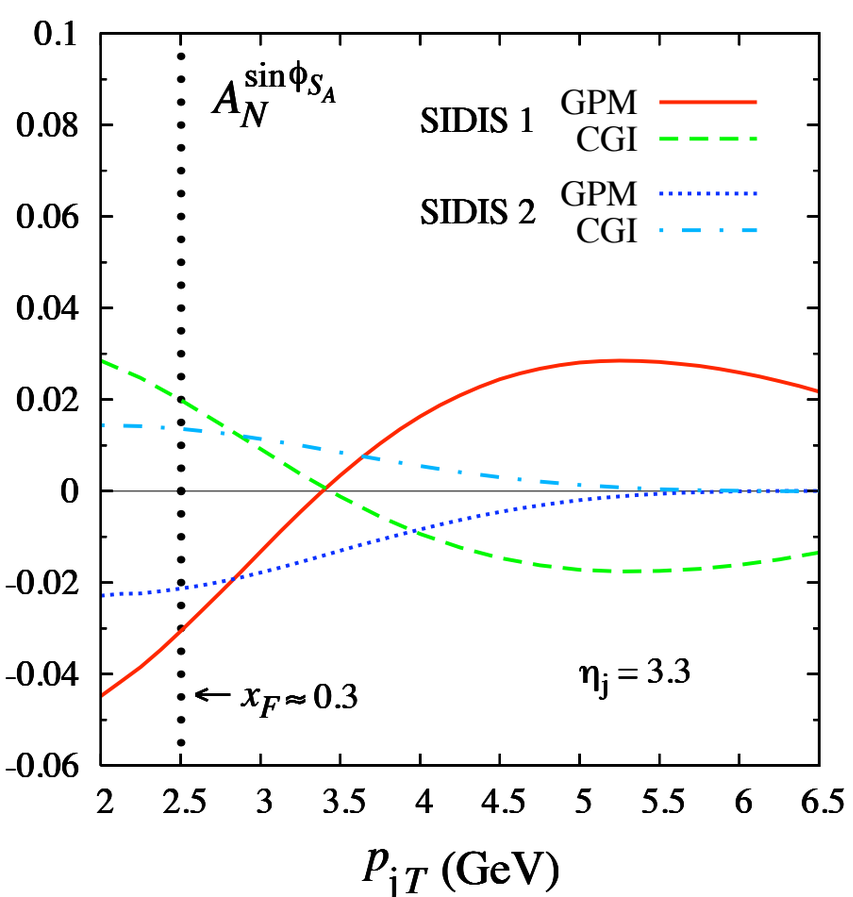


$$x_F = \frac{2P_T}{\sqrt{s}}\sinh(\eta)$$

(w/ D'Iesio, Murgia & Pisano)

π^-





Implementing a k_T expansion collinear twist three expression emerges

$$E_h \frac{d\Delta\sigma}{d^3P_h} = \frac{\alpha_s^2}{s} \sum_{abc} \int \frac{dz_c}{z_c^2} D_{h/c}(z_c) \frac{\epsilon^{P_h S_T n \bar{n}}}{z_c \tilde{u}} \frac{1}{x} (T_F(x,x) - x \frac{d}{dx} T_F(x,x))$$
$$\times \int \frac{dx_b}{x_b} f_{b/B}(x_b) \int H^{\rm Inc}_{ab\to c}(\tilde{s},\tilde{t},\tilde{u}) \frac{1}{x_b s + T/z_c}$$

same as Kouvaris, Qiu , Vogelsang, and Yuan PRD 2006

- Twist 3 and twist 2 approach connection

  we have another term ....comes from $H^{\rm Inc}_{ab\to c}(\hat{s},\hat{t},\hat{u})$

Conclusions

- Generalize GPM w/ color--can then perform global analysis
- Elephant in the room is break down of factorization for these processes
- Appears to be connection between generalized parton model at twist 3 and twist 3 approach
- Estimate mismatch-investigating LG Z. Kang
- TMD fact. is assumed in both GPM and GGPM is this a reasonable pheno. approximation?
- Direct photon driven by same ISI factor as in DY