RHIC Workshop '98

PROBING THE NUCLEON'S TRANSVERSITY VIA TWO-PION PRODUCTION AT RHIC

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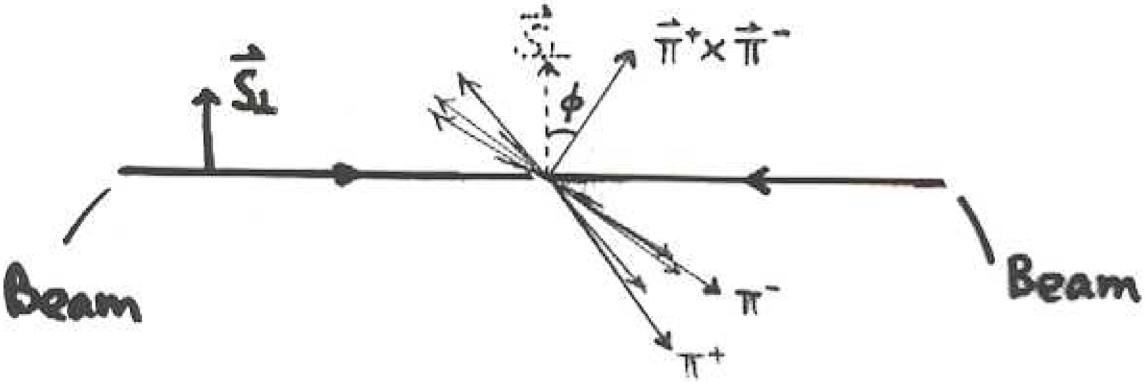
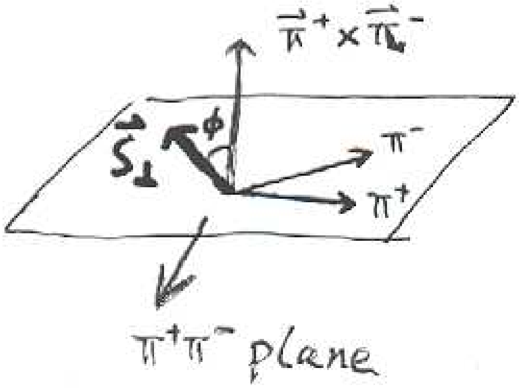
Collaborators: R. L. Jaffe, Xuemin Jin

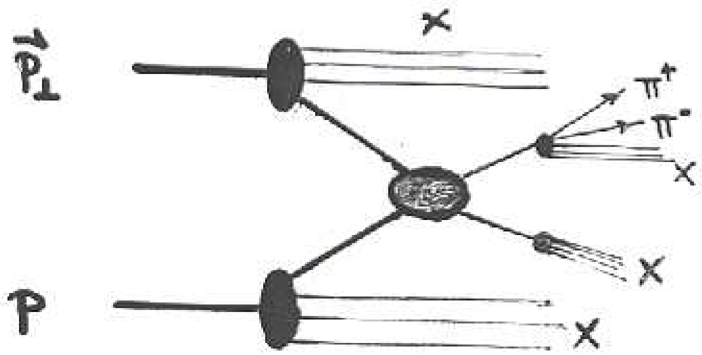
The result

$$\vec{P}_\perp P \longrightarrow \pi^+\pi^- X$$





At partonic level



observable: $\vec{\pi}^+ \times \vec{\pi}^- \cdot \vec{S}_\perp$

Nucleon's polarization

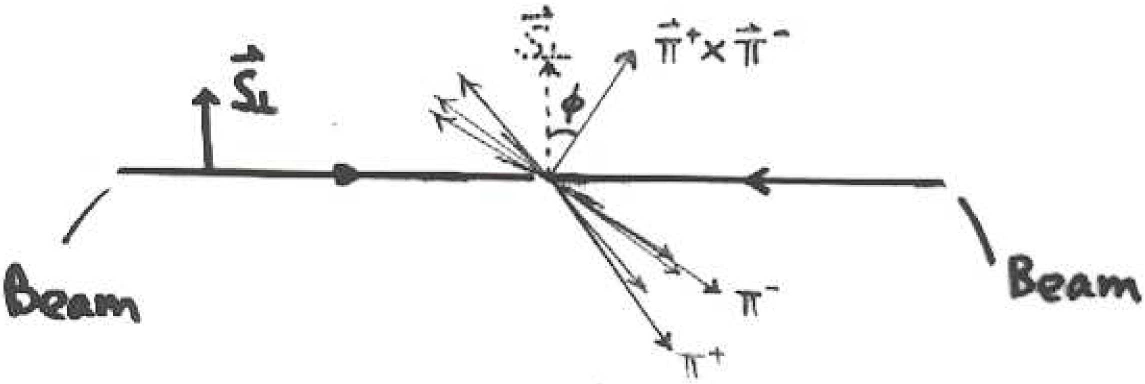
$\propto \cos\phi$

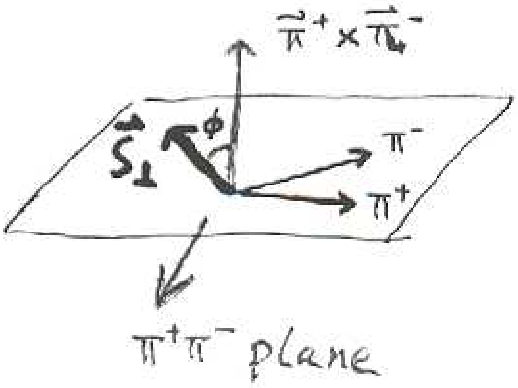
Pion momentum

collins angle

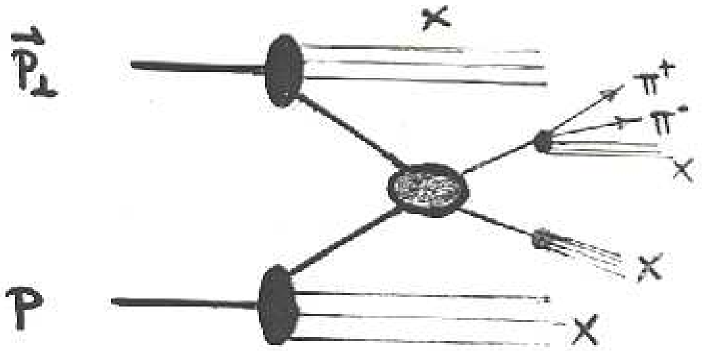
The result

$$\vec{P}_{\perp} P \longrightarrow \pi^+ \pi^- X$$





At partonic level



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An asymmetry

$$A_{\perp T} \equiv \frac{d\sigma_\perp - d\sigma_T}{d\sigma_\perp + d\sigma_T}$$

$$= -\frac{\sqrt{6}}{4}\pi \overbrace{\sin\delta_0 \sin\delta_1 \sin(\delta_0 - \delta_1)}^{\text{FSI phases}} \overbrace{\cos\phi}^{\text{Collins angle } \propto \vec{\pi}^+ \times \vec{\pi}^- \cdot \vec{S}_\perp}$$

$$\times \underbrace{\frac{\delta\hat{\sigma}^{qq}_{qq}}{\hat{\sigma}^{qq}_{qq}}} \frac{\sum_a \delta q^a \, \delta\hat{q}^a_I}{\sum_a q^a (\sin^2\delta_0 \, \hat{q}^a_0 + \sin^2\delta_1 \, \hat{q}^a_1)}$$

Hard process asymmetry $\hat{a}_{\perp T}$ for $qq \to qq$, which is dominant here.

δq^a : Transversity

$\delta\hat{q}^a_I$: unknown interference fragmentation function

q^a : unpolarized quark distribution

$\hat{q}^a_0$: "σ" fragmentation function

$\hat{q}^a_1$: "ρ" fragmentation "

Suppressed dependences

$\delta q \to \delta q(x, Q^2)$, $\delta\hat{q}_I \to \delta\hat{q}_I(z, Q^2, m^2)$

$q \to q(x, Q^2)$, $\hat{q}_0, \hat{q}_1 \to \hat{q}_0(z, Q^2), \hat{q}_1(z, Q^2)$

$\delta_{0,1} \to \delta_{0,1}(m^2)$

<u>Advantages</u>:

- Twist 2
- Abundant pions
- Crucial FSI are known (δ_0, δ_1)

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$$\times \underbrace{\frac{\delta\hat{\sigma}^{qq}_{qq}}{\hat{\sigma}^{qq}_{qq}}}_{} \; \frac{\sum_a \delta q^a \, \delta\hat{q}^a_I}{\sum_a q^a \left(\sin^2\delta_0 \, \hat{q}^a_0 + \sin^2\delta_1 \, \hat{q}^a_1\right)}$$

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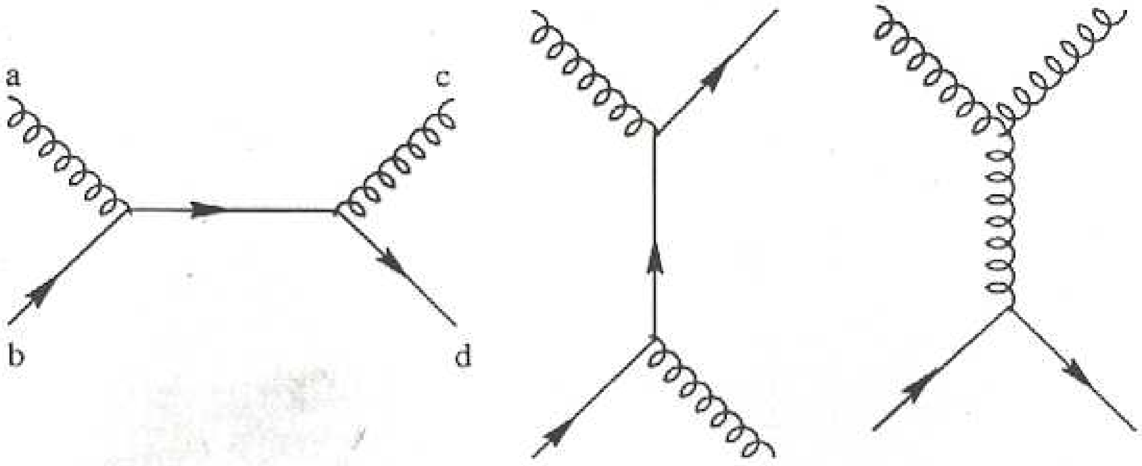
Parton process $ab \to cd$	Spin Average Cross Section—$\hat{\sigma}_{ab}^{cd}$	Transversity Dependent Cross Section—$\delta\hat{\sigma}_{ab}^{cd}$
$qg \to qg$	$\frac{\hat{s}^2+\hat{u}^2}{\hat{t}^2} - \frac{4}{9}\frac{\hat{s}^2+\hat{u}^2}{\hat{s}\hat{u}}$	$\frac{\hat{s}\hat{u}}{\hat{t}^2} - \frac{4}{9}$
$\bar{q}g \to \bar{q}g$	$\frac{\hat{s}^2+\hat{u}^2}{\hat{t}^2} - \frac{4}{9}\frac{\hat{s}^2+\hat{u}^2}{\hat{s}\hat{u}}$	$\frac{\hat{s}\hat{u}}{\hat{t}^2} - \frac{4}{9}$
$qq \to qq$	$\frac{4}{9}\left(\frac{\hat{s}^2+\hat{u}^2}{\hat{t}^2} + \frac{\hat{s}^2+\hat{t}^2}{\hat{u}^2}\right) - \frac{8}{27}\frac{\hat{s}^2}{\hat{u}\hat{t}}$	$\frac{4}{27}\frac{\hat{s}}{\hat{t}} - \frac{4}{9}\frac{\hat{s}\hat{u}}{\hat{t}^2}$
$qq' \to qq'$	$\frac{4}{9}\frac{\hat{s}^2+\hat{u}^2}{\hat{t}^2}$	$-\frac{4}{9}\frac{\hat{s}\hat{u}}{\hat{t}^2}$
$q\bar{q} \to q\bar{q}$	$\frac{4}{9}\frac{\hat{s}^2+\hat{u}^2}{\hat{t}^2} + \frac{\hat{u}^2+\hat{t}^2}{\hat{s}^2} - \frac{8}{27}\frac{\hat{u}^2}{\hat{s}\hat{t}}$	$\frac{8}{27}\frac{\hat{u}}{\hat{t}} - \frac{4}{9}\frac{\hat{s}\hat{u}}{\hat{t}^2}$
$q\bar{q}' \to q\bar{q}'$	$\frac{4}{9}\frac{\hat{s}^2+\hat{u}^2}{\hat{t}^2}$	$-\frac{4}{9}\frac{\hat{s}\hat{u}}{\hat{t}^2}$

Where Each Entries multiplies factor $\pi\alpha_s^2/\hat{s}^2$

For example, $qg \to qg$



(A) (B) (C)

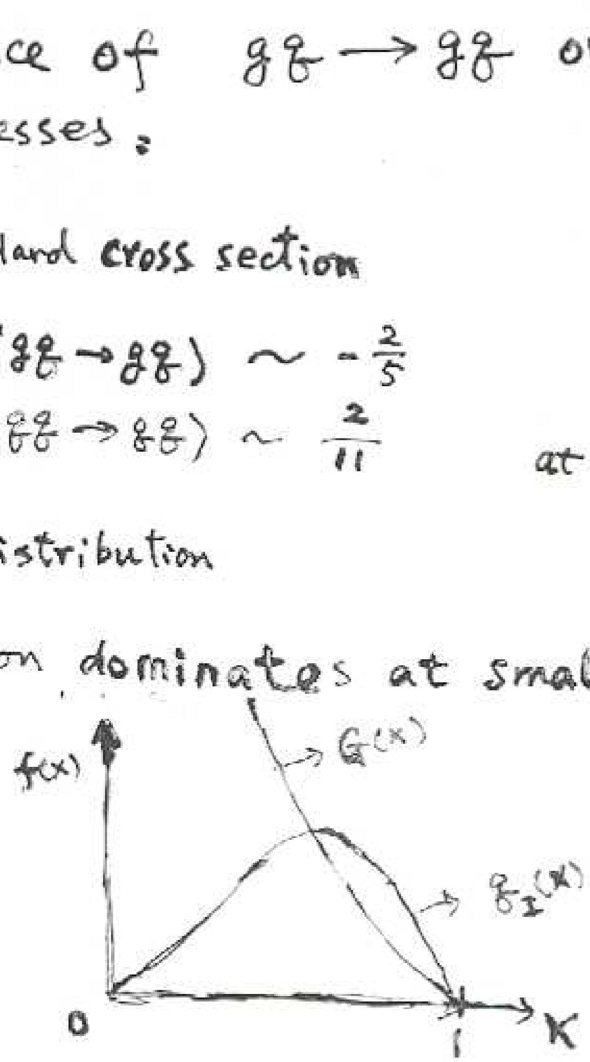
The dominance of $qg \to qg$ over other processes:

- From Hard cross section

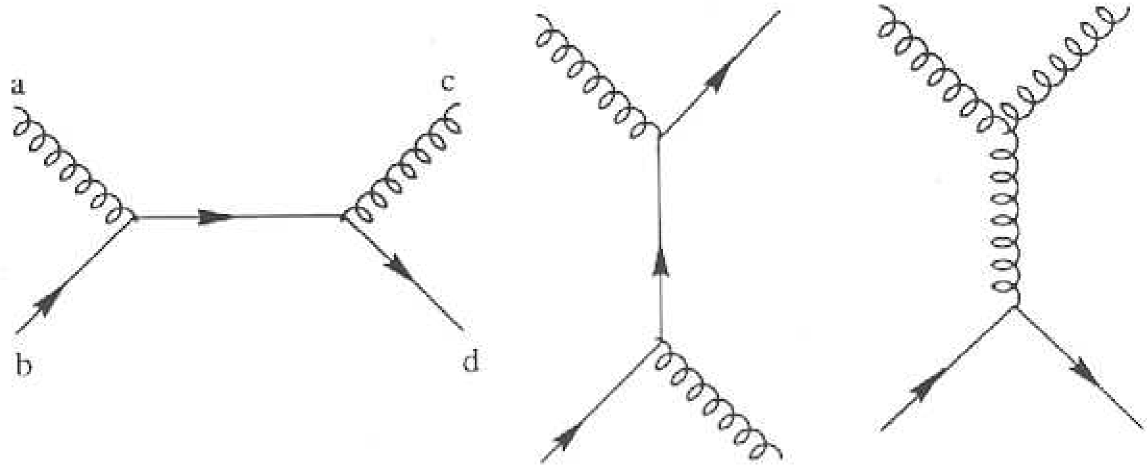
$$\hat{a}_{LT}(qg \to qg) \sim -\frac{2}{5}$$
$$\hat{a}_{LT}(gg \to gg) \sim \frac{2}{11} \qquad \text{at } \theta_{cm} = \frac{\pi}{2}$$

- From distribution

gluon dominates at small x



For example, $qg \to qg$



(A) (B) (C)

The dominance of $gq \to gq$ over other processes:

- From Hard cross section

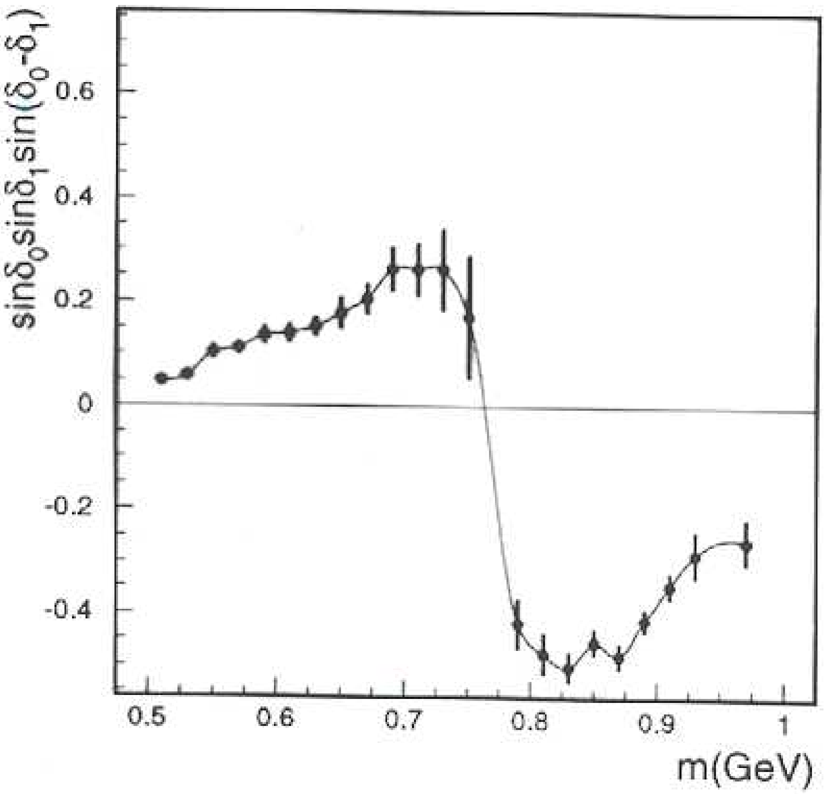
$$\hat{a}_{LT}(gq \to gq) \sim -\frac{2}{5}$$

$$\hat{a}_{LT}(qq \to qq) \sim \frac{2}{11} \quad \text{at } \theta_{cm} = \frac{\pi}{2}$$

- From distribution

gluon dominate at small x

– *Figure of merit*



Data from P. Estabrooks and A. D. Martin, Nucl. Phys. **B79**, 301 (1974)