Transversity and polarized Drell-Yan at RHIC

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The transversity densities $\Delta_T q(x, Q^2)$ are the only completely unknown twist-2 parton distribution functions of the nucleon. In a transversely polarized nucleon they count the number of quarks with spin parallel to the nucleon spin minus the number of quarks with anti-aligned spin. In field theory the transversity distributions are defined in terms of expectation values of chirally-odd operators between nucleon states, which is the reason why they cannot be measured in inclusive DIS. The most promising hard process allowed by this chirality selection rule seems to be Drell-Yan dimuon production, and exactly this reaction will be utilized for attempting a first measurement of the $\Delta_T q(x, Q^2)$ at RHIC via the transverse double spin asymmetry $A_{TT} = d\Delta_T\sigma/d\sigma$. In perturbative QCD, A_{TT} can be expressed in terms of unpolarized parton distributions, the yet unknown transversity densities, and the relevant partonic cross sections. Although the latter have been known to NLO accuracy in the strong coupling for several years by now, consistent NLO calculations of A_{TT} for Drell-Yan became possible only recently, when the two-loop transversity splitting functions became available.

The unpolarized, longitudinally and transversely polarized quark distributions (q, Δq, $\Delta_T q$) of the nucleon are expected to obey an inequality derived by Soffer:

$$2|\Delta_T q(x, Q^2)| \leq q(x, Q^2) + \Delta q(x, Q^2) \, ,$$

which can be used to constrain the $\Delta_T q$ when trying to make predictions for RHIC. We will first show numerically that Soffer's inequality is preserved under NLO QCD evolution to $Q^2 > Q_0^2$ once it is satisfied at the input scale Q_0. Our aim will then be to estimate, within LO and NLO, upper bounds on A_{TT} for the Drell-Yan process at RHIC. To do so, we will assume the validity of Soffer's inequality, which seems reasonable and is corroborated by our finding that NLO evolution preserves the inequality. The maximal asymmetry A_{TT} can then be estimated by further assuming *saturation* of the Soffer bound.

For further details of the work presented here, see: O. Martin, A. Schäfer, M. Stratmann, W. Vogelsang, Soffer's inequality and the transversely polarized Drell-Yan process at next-to-leading order, Phys. Rev. **D57** (1998) 3084.

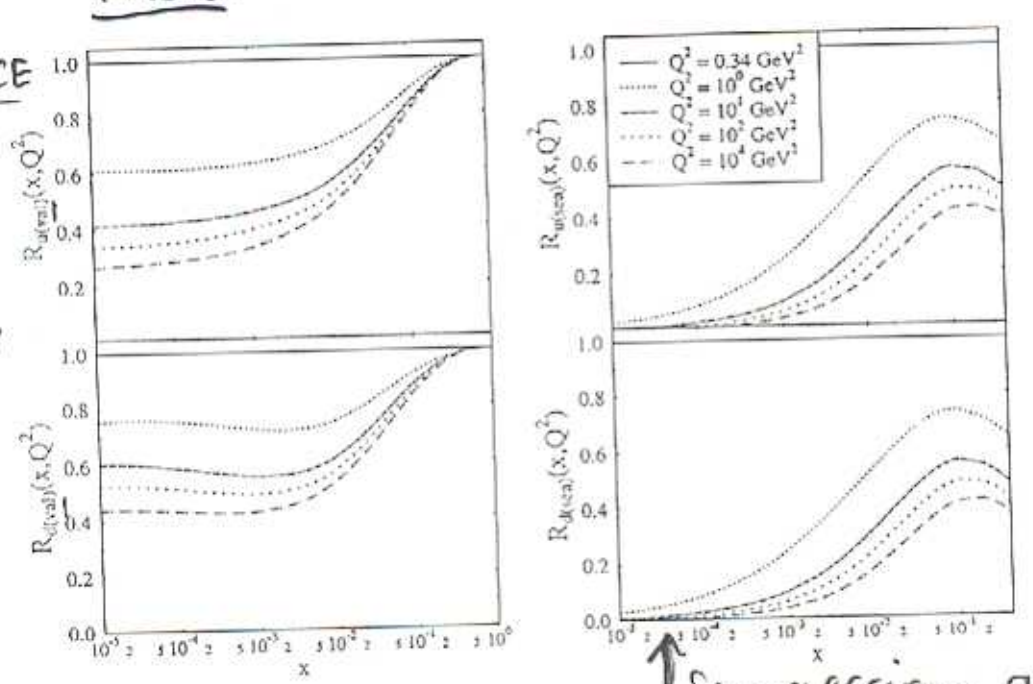
"Radiative Parton Model"

assume

$$\Delta_T q \equiv \frac{1}{2}\left[\underbrace{q}_{\text{GRV}} + \underbrace{\Delta q}_{\text{GRSV}}\right] \quad \text{at } Q = \mu \approx 0.6\ \text{GeV}$$

Then:

VALENCE



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Suppression at small x!

[$\overline{\text{MS}}$]

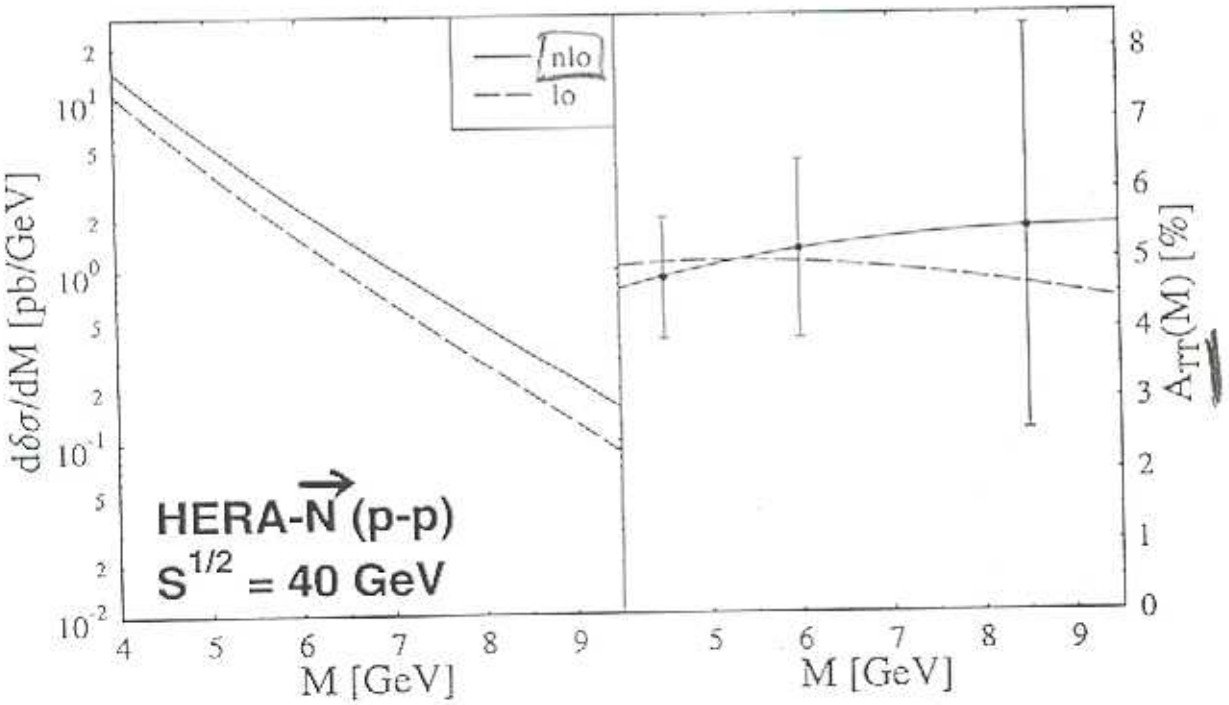
SI remains intact!

$$R_q \equiv \frac{|\Delta_T q(x,Q^2)|}{\frac{1}{2}\left(q(x,Q^2) + \Delta q(x,Q^2)\right)}$$

(→ good constraint for NLO input densities)

$$\Delta_T q(x,\mu^2) \equiv \frac{1}{2}\left[q(x,\mu^2) + \Delta q(x,\mu^2)\right]$$

⇝ "upper bounds" on A_{TT}
(within radiative PM)



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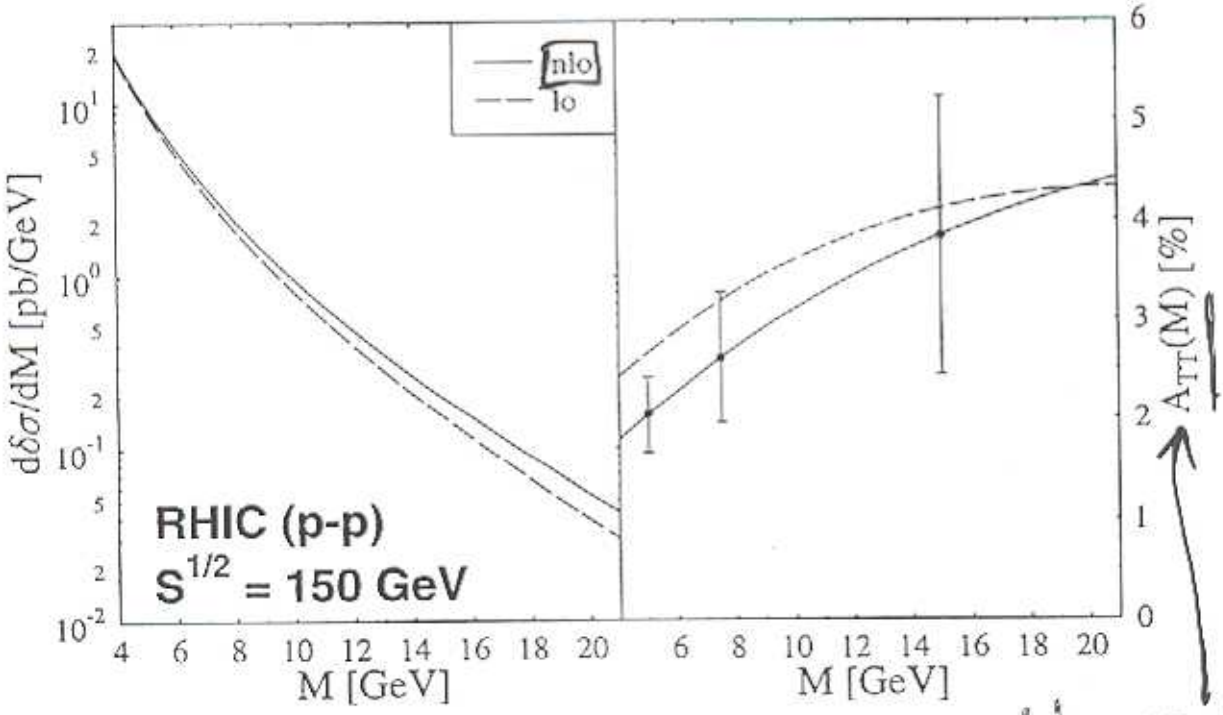
errors for $\mathcal{L} = 240\ \mathrm{Pb}^{-1}$

$\sim \cos(2\phi)$

FOR $\Delta_T \sigma$: INTEGRATE

$$\left[\int_{-\pi/4}^{\pi/4} - \int_{\pi/4}^{3\pi/4} + \int_{3\pi/4}^{5\pi/4} - \int_{5\pi/4}^{7\pi/4}\right] d\phi$$



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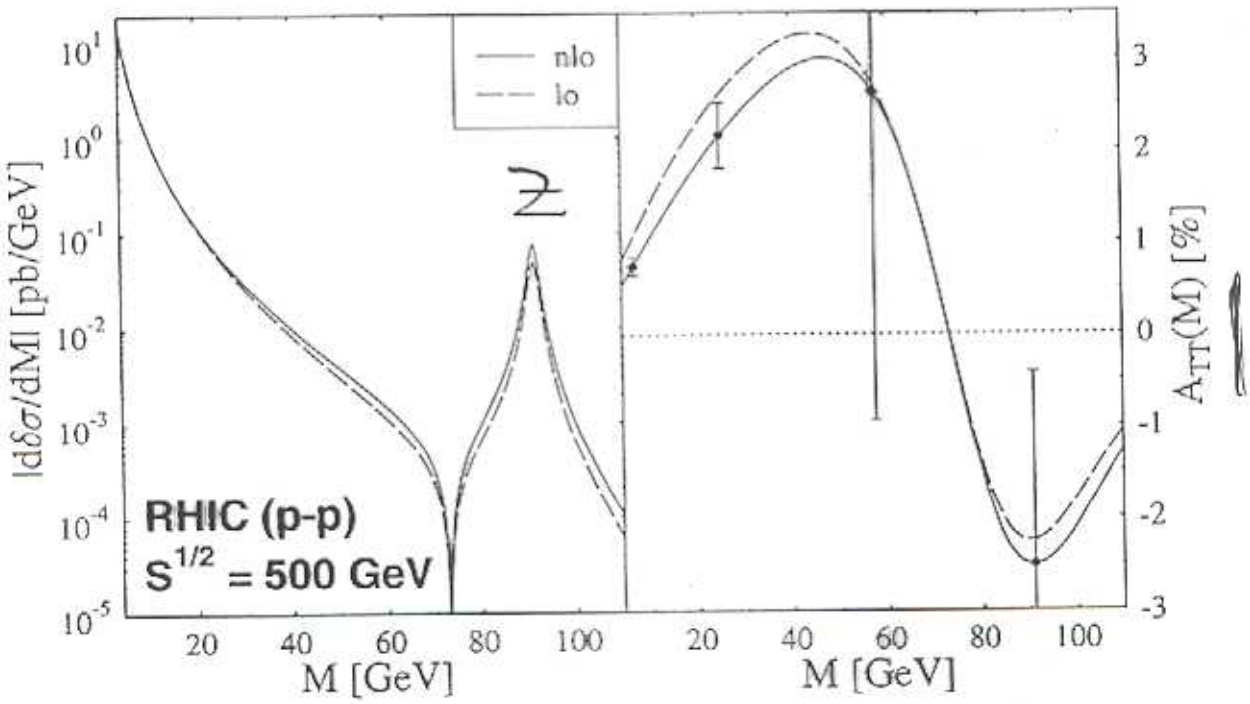
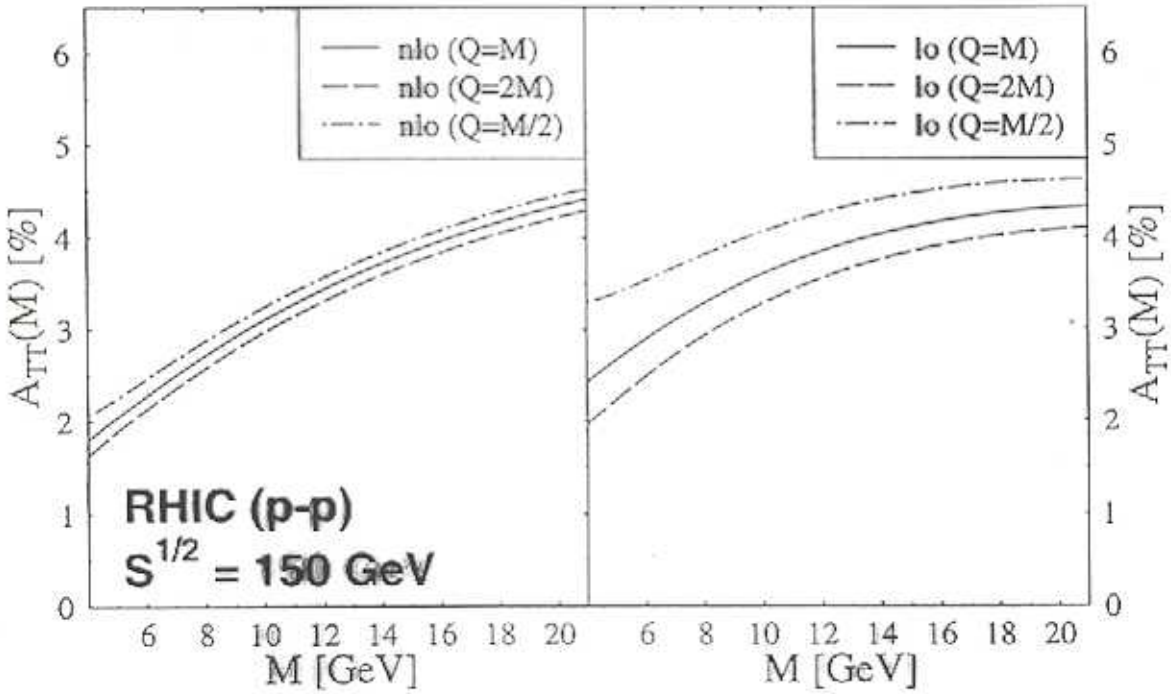
WOULD BE SMALL & NEG. FOR $\Delta q = \Delta_T q$ at μ

$\mathcal{L} = 240 \text{ pb}^{-1}$

→ NLO CORRECTIONS NON-NEGLIGIBLE



$\mathcal{L} = 800\ pb^{-1}$

Scale dependence: LO/NLO