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Future prospects of di-jet production at forward rapidity constraining $\Delta g(x)$ at low x in polarized $\mathfrak{p}+\mathfrak{p}$ collisions at RHIC

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One of the main objectives of the high-energy spin physics program at RHIC at BNL is the precise determination of
the polarized gluon distribution function, $\Delta g(x)$.
Polarized $\vec{p}+\vec{p}$ collisions at
$\sqrt{s}=200$ GeV and at $\sqrt{s}=500$ GeV at RHIC provide a unique way to probe the
proton spin
structure using very well established processes in high-energy
physics, both experimentally and theoretically. Inclusive measurements, such as inclusive
jet production and hadron production, have so far been the prime focus of various released
results at $\sqrt{s}=200$ GeV constraining $\Delta g(x)$ for $0.05<x<0.2$.
A recent global analysis provides
for the first time evidence
of a non-zero value of the gluon polarization
$\int_{0.05}^{0.2}\Delta g(x)\,dx\,(Q^2=10\,\mathrm{GeV}^2)=0.1^{+0.06}_{-0.07}$.
First results of di-jet production at
$\sqrt{s}=200$ GeV by the STAR collaboration will allow a
better constraint of the underlying event kinematics.

Extending the current program to smaller values of x is a key goal
for the future high-energy spin physics program at RHIC. Forward di-jet production at the
STAR experiment beyond the current acceptance of $-1<\eta<+2$, in
particular those carried out at $\sqrt{s}=500$ GeV, provides access to low x values at the level of
10^{-3} where current uncertainties of $\Delta g(x)$ remain very large.

Recent STAR jet results constraining $\Delta g(x)$ will be briefly summarized followed by
a detailed presentation of the physics case of forward di-jet production at $\sqrt{s}=500$ GeV
for $+2.5<\eta<+4$ requiring an upgrade
of the STAR forward detection system. This includes a discussion of the kinematic coverage and
projected uncertainties for different di-jet topological configurations allowing
to optimize the underlying partonic asymmetries to probe $\Delta g(x)$ below the
currently accessible x range as low as 10^{-3} in x. Those measurements will eventually be complemented by a
future Electron-Ion
Collider facility probing $\Delta g(x)$ in polarized $\vec{e}+\vec{p}$ collisions.

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