VTX Upgrade Proposal

September 24, 2003

1 Goals of the VTX upgrade

1.1 Exploring the spin structure of the nucleon

Since deep inelastic scattering (DIS) experiments of polarized leptons from polarized nucleons showed that only 10–30% of the proton spin is carried by the quarks and antiquarks, we have been pursuing origin of the missing spin. In the PHENIX experiment, the gluon polarization, $\Delta g/g$ can be measured over a large range of gluon momentum fraction (x_{gluon}) by using many processes. We pursue the gluon polarization with upgraded detectors at full luminosity. In the full luminosity runs, we will measure A_{LL}:

$$A_{LL} = \frac{1}{P_B \cdot P_Y} \cdot \frac{N_{++} - R \cdot N_{+-}}{N_{++} + R \cdot N_{+-}}$$

of direct photon and heavy flavor production for the gluon polarization measurement.

The current PHENIX baseline detector has capability shown in Fig.1 as blue lines. The different channels cover $0.02 < x_{gluon} < 0.3$, but the coverage of each channel does not have much overlap each other. As shown by red lines, the proposed VTX upgrade detector extends the coverage down to $x \sim 0.01$ and provides significant regions where multiple channels overlap. This overlap will provide vital cross-checks that will improve the reliability of global fits to the gluon polarization.

direct photon + jet The VTX detector will serve as a tracker and provide the jet axis measurement in coincidence with the direct photon. Wide acceptance of the VTX improves determination of the jet axis. This will enable us to reconstruct the kinematics of the event, pin down the x_{gluon}, and make the gluon polarization measurement much more sensitive and clean. It also gives us better isolation cut.

open charm/bottom with displaced vertex We will see the open charm production via electron detection with a displaced vertex. We will have good displaced vertex resolution evaluated with distance of the closest approach (DCA) value smaller than 50 μm at $p_T > 1$ GeV/c. By identifying displaced vertices, we expect much better heavy flavor production measurement.

The VTX detector also extends the upper x_{gluon}-range using hadronic decay channel, $D \to K\pi$, for high-p_T D's. The existing range in x_{gluon} for open charm is made much more robust by requiring displaced tracks from the vertex.

The VTX gives us better S/N ratio to identify those open channels.

Another channel is a bottom pair measurement. This is an extension of the electron–muon coincidence measurement. By detecting a muon (or electron) with the Muon Arms (Central Arm) and a displaced vertex of bottom decay with the VTX detector, we expect much larger statistics than the electron–muon coincidence measurement with the baseline detector.

$B \to J/\psi X$ B-mesons will be identified with J/ψ decays which will be detected as a displaced electron-pair vertex. This process identifies the open bottom production without any charm contribution. It will give us small ambiguity in comparison with theoretical calculation of A_{LL}.

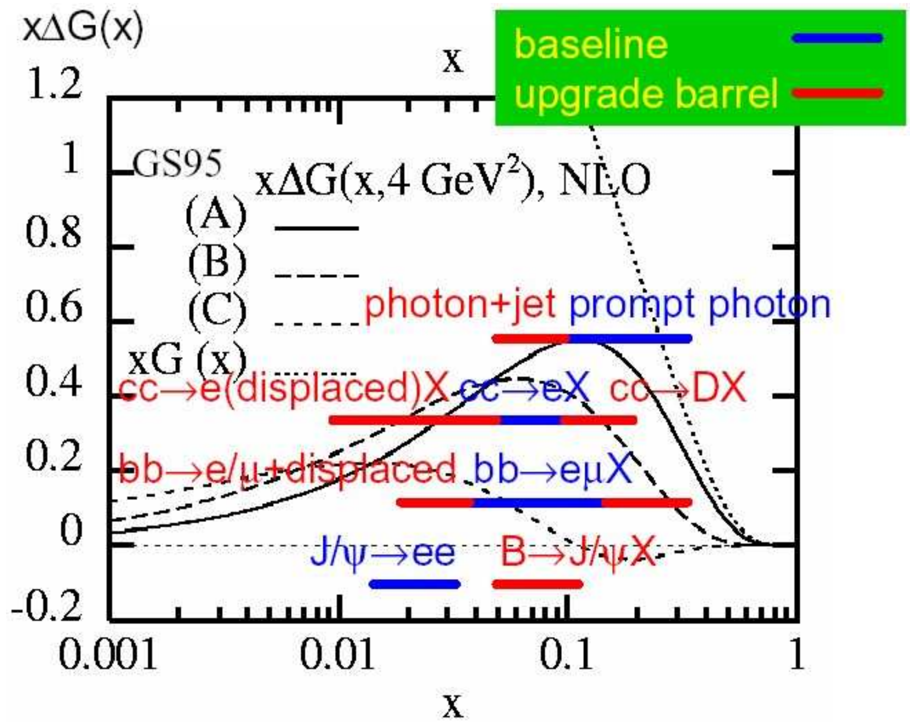

Figure 1: Expected x_{gluon}-ranges for different channels used to extract the gluon polarization. The blue bars indicate PHENIX's existing capability while the red bars indicate the additional coverage provided by the proposed VTX upgrade.

The VTX upgrade also improves weak boson measurement. By applying the isolation cut, background high-p_T electrons can be cleaned from decay electrons by weak bosons. This channel gives us flavor decomposition information of the quark and anti-quark helicity distribution, Δq and $\Delta \bar{q}$ which is another important source of the origin of the missing proton spin.

It also improves correlation measurement between particles. The Collins fragmentation function refers to a correlation between hadron distribution around the jet axis and transverse spin direction of the fragmenting quark. The orientation of dimeson systems inside the jet also shows correlation with the transverse spin of the fragmenting quark which is called interference fragmentation function. Wide acceptance of the VTX improves determination of the jet axis. Through those correlation measurement, we can measure the transversity distribution, δq. The transversity distributions are as fundamental as the longitudinally polarized densities for quarks and gluons, Δq, Δg, but they haven't measured because they decouple from inclusive DIS.