GLUON POLARIZATION MEASUREMENT WITH PHOTON DETECTION AT PHENIX

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At PHENIX, photons are detected by fine segmented EM calorimeters in the central arms. We can investigate the gluon polarization in the proton using polarized pp collisions at RHIC. Prompt photon detection and decay photon detection from π^0 will be discussed.

We will detect photons with EM calorimeters [1] (EMCal) in the central arms of the PHENIX detector. The PHENIX EMCal has a fine granularity which works powerfully to distinguish background particles. The channel size is $\Delta\eta \sim \Delta\phi \sim 0.01$ radian. It enables us to probe the polarized structure of the proton, especially the polarized gluon structure using polarized pp collisions at RHIC.

Prompt photon production in hadronic collisions is a good probe to investigate gluon content in the nucleon because theoretical interpretation of the process is clear-cut. The main contribution comes from the gluon Compton process, $gq \to \gamma q$. For the collision of longitudinally polarized protons, the asymmetry $A_{LL} = 1/P_B^2 \cdot (N_{++} - N_{+-})/(N_{++} + N_{+-})$ is measured, where N_{++} (N_{+-}) is the number of observed prompt photon normalized by luminosity with parallel (anti-parallel) beam polarization. P_B is the polarization magnitude of each beam. For the Compton process, the asymmetry gives;

$$A_{LL} = \frac{\Delta G}{G} \cdot A_1^p \cdot \hat{a}_{LL}(gq \to \gamma q)$$

where A_1^p has been measured by DIS experiments. The asymmetry for elementary process $gq \to \gamma q$, $\hat{a}_{LL}(gq \to \gamma q)$ is calculable. As a result, we can obtain a ratio of polarized to unpolarized distributions of the gluon, $\Delta G/G$. Experimentally, however, it is challenging to identify the prompt photon because of background mainly from two-photon decay of π^0, $\pi^0 \to 2\gamma$. We have to reduce the background by invariant mass reconstruction, isolation cut method [2], etc.

Although π^0 is a background against the prompt photon measurement, it also serves for a gluon polarization measurement. The PHENIX EMCal has a good capability to detect π^0 by the invariant mass reconstruction of $\pi^0 \to 2\gamma$ decay. Because most π^0 originate from QCD jets, the inclusive π^0 measurement

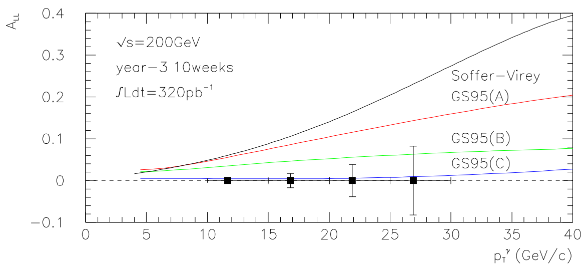

Figure 1: The asymmetry calculations using Soffer–Virey model and three Gehmann–Stirling models are shown. The statistical errors of our asymmetry measurement are also shown.

reflects the initial parton state of the QCD jet production process, i.e. $g+g$, $g+q(\bar{q})$, $q(\bar{q})+q(\bar{q})$. The π^0 asymmetry measurement (A_{LL}) is interpreted by using the polarized parton distribution function, the asymmetry of the elementary processes and the fragmentation function of π^0. We are studying to constrain the gluon polarization from the inclusive π^0 measurement, although it includes more uncertainties than the prompt photon measurement, e.g. uncertainty in the contributing processes and that in the fragmentation process. The advantage of the inclusive π^0 measurement is the abundance of π^0. We will have high statistics for the inclusive π^0 measurement at $\sqrt{s}=200$GeV from the year–2 run (2000–2001), the first year of the polarized proton run at RHIC.

To evaluate sensitivity of these measurements, we performed simulation studies by using PYTHIA with GRV94LO parton distribution function in PDFLIB. We considered acceptance of the PHENIX EMCal and the detector performance.

For the prompt photon measurement, yield for the year–3 run (2001–2002) at $\sqrt{s}=200$GeV was calculated [3] using the full integrated luminosity, 320 pb^{-1}. There is enough yield up to $p_T=30\text{GeV}/c$. We have also studied the isolation cut method to remove background and found that we can identify the prompt photon in the region of $10\text{GeV}/c<p_T<30\text{GeV}/c$. This naively corresponds to the gluon's x_{Bj} region of $0.1<x_{Bj}<0.3$. To evaluate the A_{LL} measurement, four sets of the polarized parton distribution functions with different gluon polarization were compared [4]. Soffer and Virey's model has ΔG value 2.00, and Gehmann and Stirling's three models have ΔG value of 1.71, 1.63 and 1.02. Figure 1 shows the asymmetry calculations using these models and the statistical errors of our asymmetry measurement. In the year–3 run, we will get enough statistics to distinguish these models and we will obtain $\Delta G/G$.

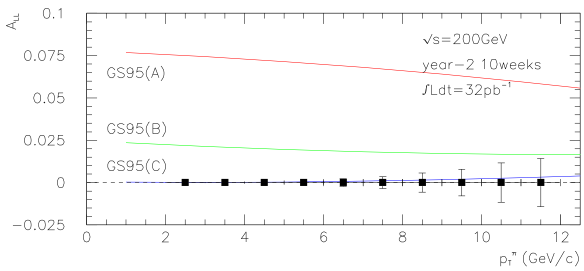

Figure 2: The asymmetry calculations using three Gehmann–Stirling models are shown. The statistical errors of our asymmetry measurement are also shown.

For the π^0 measurement, we have enough yield in year–2. To calculate yield, 10% of the full integrated luminosity value, 32 pb^{-1}, was used. For the asymmetry measurement, Gehmann and Stirling's three models were compared. Figure 2 shows the asymmetry calculations using these models and the statistical errors of our asymmetry measurement. The statistical errors for the year–2 measurement are enough small to distinguish these models. We need further study of the systematic uncertainties.

As a conclusion, we can perform the gluon polarization measurement at PHENIX. In the year–2 run, a π^0 measurement will be done which distinguishes between some models. By using the year–3 run data, prompt photon measurement will be done. In this measurement, we will know $\Delta G/G$ in the gluon's x region $0.1 < x < 0.3$ from $\sqrt{s}$=200GeV run. After the year–4, we will know the x region $0.04 < x < 0.16$ from $\sqrt{s}$=500GeV run. After collecting all these data, we can perform global analysis for the gluon polarization by combining DIS data from other experiments, heavy quark measurement at RHIC and other experiments, etc.

References

1. E. Kistenev *et al.*, Proceedings of the 5th International Conference on Calorimetry in High Energy Physics, edited by H.A. Gordon *et al.*, p.211 (1995).
2. For example, description in G. Sterman *et al.*, *Rev. Mod. Phys.* **67**, 157 (1995).
3. N. Hayashi *et al.*, Proceedings of the 12th International Symposium on High–Energy Spin Physics (SPIN96), edited by C.W. de Jager *et al.*, p.349 (1997).
4. N. Saito, private communications.