Proposal to measure A_{LL} of EM clusters at sPHENIX in 2021

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We propose to measure the double helicity asymmetry (A_{LL}) of electromagnetic (EM) clusters in $\sqrt{s} = 200$ GeV polarized $p + p$ collisions with partially installed sPHENIX detector in 2021. The measurement includes both EM clusters from π^0 decay and the direct photon. The sPHENIX detector will be fully installed in 2022. For the A_{LL} measurement in 2021, we need the EM calorimeter for energy measurement, and minimum number of internal silicon trackers, e.g. inner pixel layers + new 2 or 3 outer layers for charge veto and isolation cut of the EM clusters. In addition, we need a trigger detector that provides the minimum-bias trigger and vertex measurement, and ZDC for relative luminosity measurement. We also need a high-p_T trigger with the EM calorimeter.

In the previous runs of longitudinal polarization at $\sqrt{s} = 200$ GeV in 2005+2006+2009, we've recorded about 20 pb^{-1} integrated luminosity at PHENIX [1]. In 2021, we expect 630 pb^{-1} delivered luminosity and 175 pb^{-1} recorded at sPHENIX (35% 10-cm vertex cut and 80% detector uptime). Since the granularity of the EM calorimeter at sPHENIX $\Delta\eta \times \Delta\phi \sim 0.024 \times 0.024$, we will be able to identify π^0 from two photon decay up to p_T = 8 GeV/c [1]. The sPHENIX acceptance is about 8 times as large as that of the PHENIX EM calorimeter (EMCal). Thus we will be able to measure the A_{LL} of π^0 up to 8 GeV/c with effectively 70 times of the final statistics of the PHENIX measurement. This will provide a very good measurement of the A_{LL} of π^0 as is shown in Fig. 1.

Above $p_T > 8$ GeV/c, it becomes difficult to separate two photons from π^0 decay and single photon of the direct photon [2]. In this p_T range, we can measure the A_{LL} of EM clusters which are mixture of π^0s and direct photons. At higher p_T, direct photon / π^0 ratio is higher. To enhance the

[1] The efficiency to identify π^0 is approximately 50% at $p_T = 8$ GeV/c, and higher at for lower p_T.

[2] We may apply a shape analysis of the EM clusters to distinguish π^0s and direct photons at more than $p_T > 8$ GeV/c.

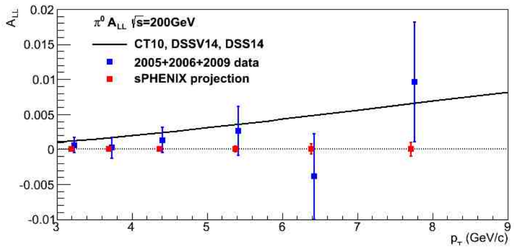

Figure 1: A_{LL} of π^0 measured in 2005+2006+2009 (blue squares) and projection at sPHENIX estimated with an error scale of $1/\sqrt{70}$ of 2005+2006+2009 data (red squares).

fraction of the direct photon, we will apply the isolation cut which requires limited charged particles and other photons around the direct photon [3]. To find the charged particles, we need tracking detectors, e.g. internal silicon trackers with some magnetic field.

By these measurements, we'll be able to obtain high statistics A_{LL} data of π^0 up to $p_T = 8$ GeV/c and that of EM clusters (inclusive or isolated) at higher p_T. High p_T EM cluster data is important because not only it gives an additional statistics to investigate the gluon polarization at high x_T but also systematically different data from existing jet A_{LL} data [2]. Note that isolated EM clusters above 10 GeV/c are dominated by direct photons. The direct photon process is a clean process dominated by the gluon Compton process, so that it is a golden channel for the gluon polarization measurement.

Figure 2 shows projection of the A_{LL} measurement of EM clusters in $\sqrt{s} = 200$ GeV/c polarized $p + p$ collisions at sPHENIX compared with the NLO calculation of direct photon and π^0 by W. Vogelsang. We assumed 175 pb^{-1} luminosity and 60% polarization for the measurement.

In order to estimate the isolation cut, we assumed isolated direct photon ratio of $0.4 + 0.05 \times p_T$ (GeV/c) ($p_T < 10$ GeV/c) or 0.9 ($p_T > 10$ GeV/c) from the all direct photon, and isolated π^0 ratio of 0.4 (p_T independent) from the all π^0 based on PHENIX measurement of the direct photon and π^0 in 2006 [3]. Here we assume the A_{LL} doesn't change after the isolation cut. Figure 3 shows projection of the A_{LL} measurement of EM clusters after the isolation cut compared with the NLO calculation of isolated direct photon

[3] We may also apply the anti-isolation cut to enhance the fraction of π^0.

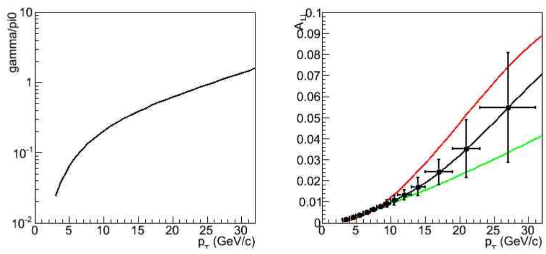

Figure 2: (Left)Cross section ratio of direct photon and π^0. (Right) NLO calculation of A_{LL} of direct photon (red), π^0 (green), and mixture of direct photon and π^0 (black), and projection of the A_{LL} measurement.

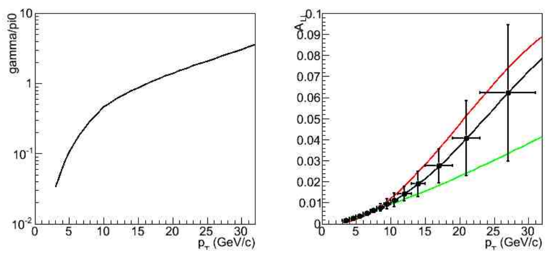

Figure 3: (Left)Cross section ratio of isolated direct photon and isolated π^0. (Right) NLO calculation of A_{LL} of isolated direct photon (red), isolated π^0 (green), and mixture of isolated direct photon and π^0 (black), and projection of the A_{LL} measurement with the isolation cut.

and π^0.

References

[1] A. Adare *et al.* [PHENIX Collaboration], Phys. Rev. D **90**, no. 1, 012007 (2014).

[2] L. Adamczyk *et al.* [STAR Collaboration], Phys. Rev. Lett. **115**, no. 9, 092002 (2015).

[3] A. Adare *et al.* [PHENIX Collaboration], Phys. Rev. D **86**, 072008 (2012).