Transverse single spin asymmetry in charged pion production at midrapidity in polarized $p+p$ collisions at 200 GeV

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One of the main goals of the RHIC spin program is the determination of the transverse-spin structure of the proton, which can in turn provide some insight into the angular-momentum component of partons. For reaching the goal, we measure Transverse Single-Spin Asymmetries (TSSAs) which are left-right asymmetries of final stage particles produced in the transversely polarized $p+p$ collision.[1] The TSSAs (A_N) of pion at midrapidity in $p+p$ collision is expected to be helpful to understand the transversity distributions of quark and gluons, the transverse intrinsic parton momentum, initial and final state effects. In PHENIX the charged pions at mid-rapidity can be measured by the central arm detectors that consist of the Electro-Magnetic Calorimeter (EMCal), Ring-Imaging Cherenkov Detec tor (RICH), Drift Chamber (DC), Pad Chamber (PC). Trigger fired if pions deposited energy over than 1.4 GeV on EMCal and we can detect charged pion's track and energy. In mid-rapidity charged pion measurement, the background is categorized into two sources which are hadron background(kaon and proton) and electron background(electron and positron). Pions with momentum above 5 GeV/c create Cherenkov light in the RICH but kaons and protons can't create Cherenkov light under

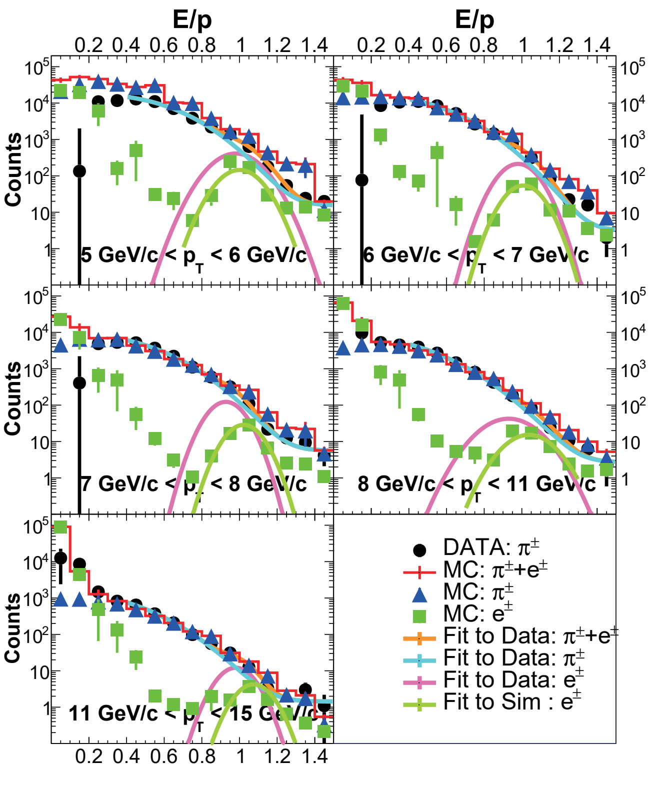

Fig. 1. E/p distribution in pion enhancement sample for five P_T bins.

Table 1. Background fraction of two samples.

particle	p_T bin (GeV/c)	$r_{\pi,e}$
$\pi^{\pm}$	5–6	0.0436
	6–7	0.0688
	7–8	0.1375
	8–11	0.1192
	11–15	0.2154
$e^{\pm}$	5–6	0.00652
	6–7	0.06569
	7–8	0.1646
	8–11	0.8560
	11–15	0.9178

16 GeV/c and 30 GeV/c, respectively. Only electron background remained an object to subtract. In EMCal, electrons lost most of their energy by electromagnetic interactions. Therefore, primary electron's energy/momentum (E/p) distributed around 1. A secondary electron track from photon conversion would be incorrectly reconstructed with large momentum. Therefore secondary electron's energy/momentum would be in the low area. because we can know only background fraction but we can't distinguish electron event from pion event, Eq. (1) is used for background correction of the asymmetries.[2] By using Monte Carlo simulation, we calculated electron background fraction in both pion enhancement sample ($0.2 < E/p < 0.8$) and electron enhancement sample ($E/p < 0.2$ and $0.8 < E/p$).

$$A_N^{\pi} = \frac{A_N^{\pi,\mathrm{Sig}}(1+r_\pi) - A_N^{e,\mathrm{Sig}} r_\pi (1+r_e)}{1 - r_\pi r_e} \qquad (1)$$

$$r_\pi \equiv \frac{N^{\pi,\mathrm{Bg}}}{N^{\pi,\mathrm{Sig}}} = \frac{A^e_{\mathrm{DATA}}}{A^e_{\mathrm{MC_{lumi\_scaled}}}} \times \frac{N^e_{\mathrm{MC_{lumi\_scaled}}}}{N^{\pi+e}_{\mathrm{DATA}}} \qquad (2)$$

$A_N^{\pi,\mathrm{Sig}}$, $A_N^{e,\mathrm{Sig}}$ are asymmetry in the pion and electron enhanced sample, respectively. A^e_{DATA}, $A^e_{\mathrm{MC_{lumi\_scaled}}}$ are amplitude of the Gaussian centered at around one in the data and the luminosity scaled MC simulation, respectively. $N^{\pi,e}_{\mathrm{DATA}}$ and $N^{\pi,e}_{\mathrm{MC_{lumi\_scaled}}}$ are number of entries in the E/p distributions for the data and the luminosity scaled MC simulation in pion enhanced sample, respectively. Figure 1 shows E/p distribution of pion data and distributions of pion and electron in MC, respectively. Background fraction tended to increase with increasing p_T (Table 1). These values are used to calculate corrected A_N for charged pion.

References

1) C. Aidala *et al.* (PHENIX Collaboration), Phys. Rev. D **95**, 112001 (2017).
2) T. B. Moon, Analysis Note No. 1268 in PHENIX Collaboration.

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