Determination of the detector acceptance correction for the PHENIX $W \rightarrow \mu$ analysis

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The cross section and single spin asymmetry of parity violating W production in longitudinally polarized proton collisions have been studied at the Relativistic Heavy Ion Collider as an important probe for sea quark polarization in the proton. At PHENIX, W bosons can be measured via their decays into electrons at midrapidities ($|\eta| < 0.35$) and muons at forward/backward rapidities ($1.2 < |\eta| < 2.4$). Since the preliminary result of the $W \rightarrow \mu$ channel was obtained with the high statistics data sample of 2013[1)], analysis progress has been made towards the publication. One important component is to get the final acceptance correction of the forward muon spectrometer that is applied on the measured W candidates to calculate the total cross section. The total cross section of $W \rightarrow l\nu$ in proton-proton collisions can be written as:

$$\sigma(pp \rightarrow W^{+(-)}X) \times BR(W^{+(-)} \rightarrow l^{+(-)}\nu) = \frac{1}{\mathcal{L}} \frac{(N_{obs} - N_{bg})(1 - f_Z)}{< A \cdot \epsilon >} \quad (1)$$

where $\mathcal{L}$ is total integrated luminosity, $N_{obs(bg)}$ is the number of observed signal (background) events, $A \cdot \epsilon$ is the acceptance and total efficiency correction, and f_Z is the fraction of leptonic decays of Z bosons in the signal.

In order to determine the detector acceptance, Monte-Carlo (MC) simulation samples were produced using the PYTHIA event generator and the PHENIX detector simulation packages based on GEANT3. The MC samples were passed through the same analysis software as the real data. Realistic detector responses such as data driven detector hit efficiency, gain and pedestal calibrations, dead HV modules and readout channels under different beam and detector condition are considered. Figure 1a shows an example of azimuthal distributions of single muon candidates in the north side of the detector for a representative data sample and MC sample.

In this study, we also found that the detector performance varied throughout the data taking periods. This is mainly caused by instability of the readout channels and the number of enabled HV modules of the PHENIX Muon Tracking Chambers[2)]. The number of inactive readout channels and disabled HV modules were scanned for different data taking period in 2013, and we found variations especially in readout channels. The possible causes of the variation in readout channels are problems in gain and pedestal calibrations or detector malfuctions while the HV module status changes typically when the background rate is high. When an output current of a module exceeds a set current, the HV channel in the module becomes disabled to protect the detector. Therefore, we introduced azimuthal angle dependent correction factors between data and MC to include this fluctuation in the simulation. Figure 1b shows the averaged data distribution along with the MC plot for the representative data sample. The averaged data distribution is obtained by summing the entire 2013 data set with a weight of luminosity for different data taking periods. Then, the ratio between the averaged data and MC is taken as the correction factor for each bin. Using the correction factors, $A \cdot \epsilon$ is being estimated including the trigger, reconstruction and analysis cut efficiencies. Currently, the estimation of systematic uncertainty for $A \cdot \epsilon$ is also ongoing and will be finalized in the immediate future.

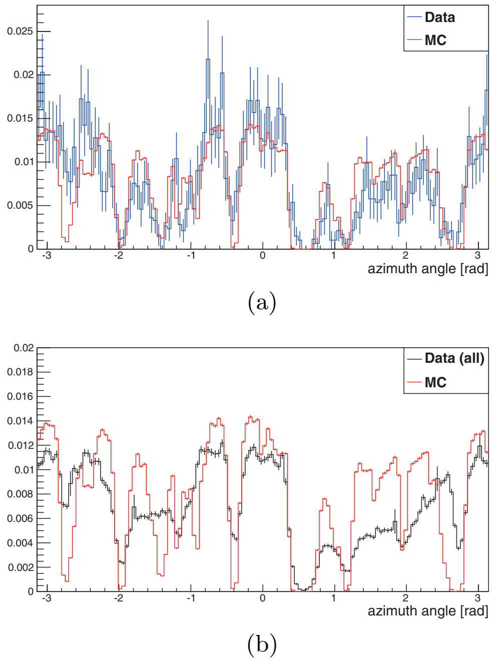

Fig. 1. (a) Azimuthal distributions of a representative data sample (blue) and MC (red). Each bin covers about 0.05 rad. (b) Azimuthal distributions of averaged data (black) and the same MC plot (red) as in (a).

References
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2) H. Akikawa et al.: Nucl. Instr. and Meth. A 499, 537 (2003).

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