Modification of the STAR FMS trigger for Drell-Yan detection

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One of the STAR headline measurements during the 2017 RHIC run is the transverse single-spin asymmetry, A_N, for forward rapidity Drell-Yan di-electron production. It will test the prediction that measurements of the Sivers effect, a correlation between the spin of a proton and the transverse momentum of a quark or gluon within the proton, have opposite signs in Drell-Yan production and semi-inclusive deep-inelastic scattering. This sign change arises because the Sivers effect originates as a repulsive initial-state interaction in Drell-Yan production vs. an attractive final-state interaction in SIDIS. The STAR Drell-Yan measurement will sample the same quark x range, but very different Q^2, as sampled by complementary measurements of W and Z boson A_N that STAR is performing concurrently. In turn, these measurements will also provide crucial information necessary to quantify QCD evolution effects in transverse momentum dependent (TMD) distributions.

During the summer of 2016, we studied the trigger system of the STAR Forward Meson Spectrometer (FMS) to optimize the Drell-Yan detection capability. A large number of Drell-Yan di-electron events were simulated using PYTHIA, and cuts were made to restrict events to those where both the electron and the positron strike the FMS with $p_T > 1.0$ GeV/c. A model of the trigger system was used to identify those simulated events that satisfy the trigger requirements. We found that the existing FMS di-electron trigger had an efficiency of 86% and a spin-dependent Figure-of-Merit of 78.5% for Drell-Yan detection. A detailed investigation found that the reduced Figure-of-Merit arose because the trigger logic

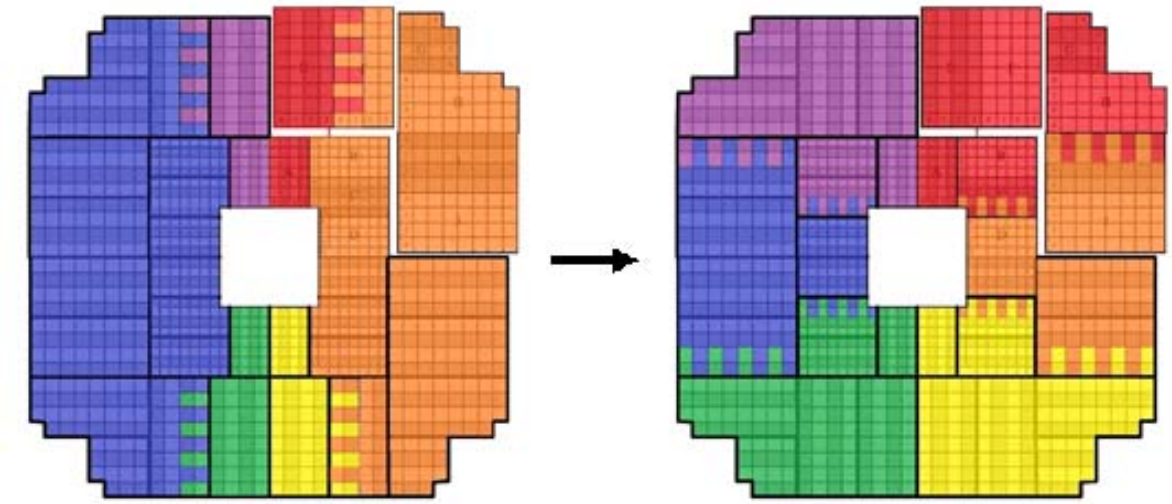

FIG. 1. The left panel shows the original FMS Drell-Yan trigger layout. The right panel shows the revised layout. In both cases, simultaneous hits on non-adjacent colored sections activate the trigger. Hatched sections are shared between sections.

provided very good efficiency for Drell-Yan di-electrons with pair transverse momenta up or down, parallel or anti-parallel to the spin direction, but lower efficiency for pair transverse momenta perpendicular to the spin direction.

Modifications were made to the trigger layout (Fig. 1) and the altered layout was used to analyze the same PYTHIA events. The modified layout was determined to have an efficiency of 94% and a Figure-of-Merit of 93.6% for Drell-Yan detection. The angular distribution of accepted events for each trigger layout can be seen in Fig. 2. The effects of the modification were also tested on similarly generated J/ψ events. The J/ψ efficiency was determined to increase from 76% to 86% and the Figure-of-Merit was determined to increase from 63% to 84%. Our proposed changes to the trigger logic were approved by the FMS group and adopted for the 2017 run of STAR.

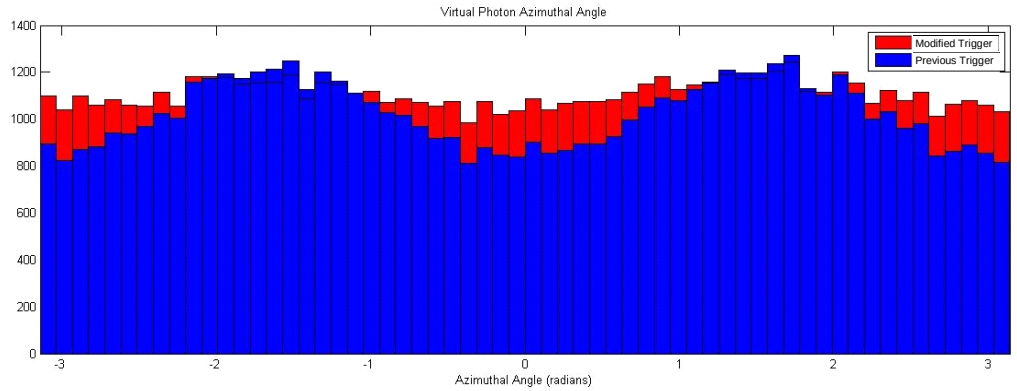

FIG. 2. Comparison of Drell-Yan accepted event angular distribution for each trigger when the p_T-threshold for individual electrons is 1.0 GeV/c.

The p_T-threshold for the individual electrons was initially intended to be set to 1.0 GeV/c. However, it was determined early in the run that the corresponding data rates were higher than acceptable. We reanalyzed the PYTHIA samples using different p_T-thresholds. The resulting Figures-of-Merit are given in Table I. Approximately 2/3 of the 2017 Drell-Yan data was recorded with the threshold at 1.3 GeV/c. This provided a compromise between sampling a large fraction of the delivered luminosity and concurrent acceptance for J/ψ. The J/ψ cross section is much larger than that for Drell-Yan. So for the final 1/3 of the 2017 run, the threshold was raised to 1.4 GeV/c, which allowed the Drell-Yan trigger to sample the full delivered luminosity while sacrificing the ability to collect additional J/ψ data efficiently.

Table I. Figures-of-Merit as a function of the electron trigger threshold.

p_T Threshold (GeV/c)	Drell-Yan Figure-of-Merit	J/ψ Figure-of-Merit
1.0	94%	85%
1.3	82%	42%
1.4	78%	29%