Spin physics with STAR at RHIC

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During the past year, our group efforts in STAR have focused on issues related to the trigger system for the electromagnetic calorimeters and analysis of forward rapidity data that were recorded with the Forward Pion Detector (FPD) and Forward Meson Spectrometer (FMS) during Run 8.

The primary STAR trigger for mid-rapidity jet physics is the "jet patch" (JP) trigger. The JP trigger accepts events where the sum of the transverse energy observed by the STAR Barrel or Endcap Electromagnetic Calorimeters (BEMC/EEMC) over a $\Delta\eta$ x $\Delta\varphi$ ~ 1x1 region surpasses a threshold. Through Run 8, there were 12 non-overlapping JPs in the BEMC, with 6 covering the region $-1 < \eta < 0$ and 6 more covering the region $0 < \eta < 1$. An additional 6 non-overlapping JPs covered the EEMC, $1.09 < \eta < 2$. This led to significant trigger inefficiency when the jet thrust axis fell near a boundary between two JPs. Even more important, this increased the bias in the JP trigger in two ways. Quark jets tend to have their energy more concentrated than gluon jets, which makes them more likely to deposit enough transverse energy within one of the JPs to satisfy the threshold. In a di-jet event, the pseudorapidities of the final-state jets are related to the momentum fractions, x_1 and x_2, of the partons that initiated the collision. Thus, the inefficiency near $\eta = 0$ directly correlates to reduced sensitivity for certain partonic kinematics.

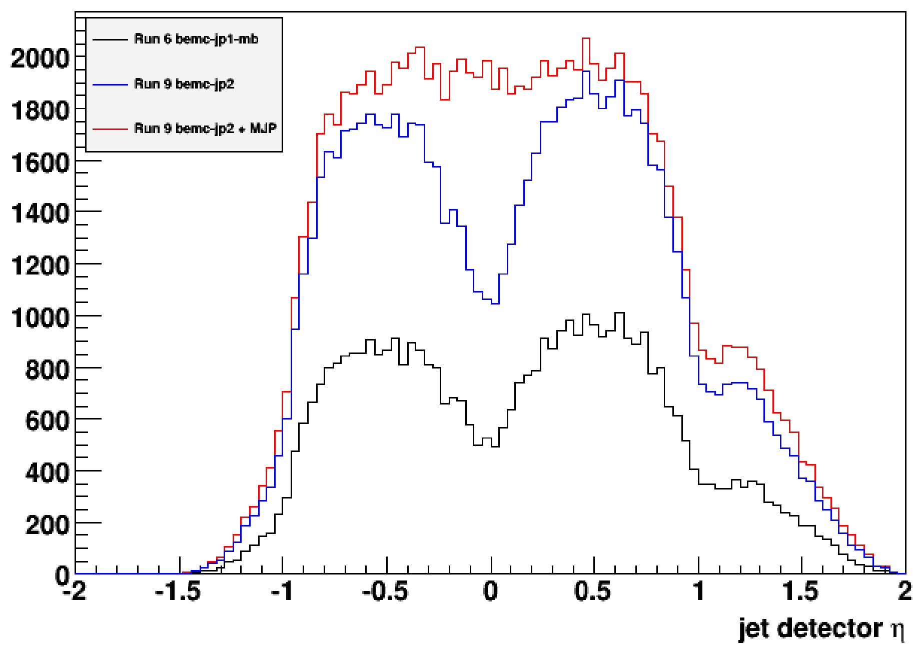

FIG. 1. Impact of the new overlapping jet patch near η=0. The red (blue) curve shows the jet yield for GEANT simulations of 200 GeV p+p PYTHIA events with partonic p_T in the range 11-15 GeV with (without) the new JP.

In April, 2008, we proposed a scheme to rewire and reprogram the BEMC and EEMC trigger electronics in order to provide additional JPs covering the pseudorapidity regions $-0.6 < \eta < +0.4$ and $0.4 < \eta < 1.4$. The changes were implemented last Fall, and have been in routine operation during Run 9. These new JPs reduce the inefficiencies at $\eta = 0$ and $+1$ significantly, as illustrated by the simulation study for the $\eta = 0$ gap in Fig. 1. It was not possible to eliminate the hard boundaries at $\varphi = 0, \pm\pi/3, \pm 2\pi/3$, and π at the same time. However, we have implemented a variation of the "Adjacent Jet Patch" (AJP) trigger that was tested during Run 5. In the new implementation, the AJP trigger requires a pair of JPs, which are next to each other in phi, to exceed a threshold that is set at half of the standard JP threshold. This significantly reduces, but does not eliminate, the inefficiency when jets fall close to the phi boundary between JPs. Trigger studies early in Run 9 indicate that the AJP trigger increased the jet trigger efficiency in 500 GeV p+p collisions by an additional 20-30%.

The simulations illustrated in Fig. 1 required us to enhance some features of the standard STAR trigger simulator code. Since then, we have converted the trigger simulator into a code that can be used to validate the electromagnetic calorimeter trigger performance on-line, in addition to its use to simulate the trigger performance off-line. The first demonstration of the power of this validation process came by running it over p+p data that had been recorded during Run 8. During the run, it had appeared that two JPs were less efficient than the others. Many tests, both by members of the Trigger group and by members of the Spin Physics Working Group, were unable to isolate any problem. Thus, no corrective action was taken during Run 8. In contrast, the new validation program pin-pointed the problem with <20 minute's worth of Run 8 data. It turned out that the problem involved a previously unknown failure mode of certain trigger modules that was not tested by the routine diagnostics. Following this proof of principle, the new validation program was set up to run automatically on the trigger data from every run. Typically, three minutes after the run ends, the validation results are saved to a pdf file that can be browsed over the web. This has given us the ability to isolate and fix problems with the trigger system, including several cases of the Run 8 failure mode, quickly during Run 9.

Members of our group are working toward the goal of reconstructing jets at forward rapidity using the Run 8 transverse spin data from the FMS together with the west Forward Time Projection Chamber. As a first step along this path, the transverse single-spin asymmetry, A_N, has been measured for π^0 production at large x_F and small p_T, using data that were recorded with the east FPD during Run 8. Previous STAR results from Runs 3, 5, and 6 appeared to show a non-monotonic behavior for A_N in the region $1.2 < p_T < 2.5$ GeV/c [1]. It has been suggested [2] that this behavior might indicate that the single-spin asymmetry arises from a combination of the Sivers and Collins effects, with the two processes dominating in different p_T regions. FPD data were recorded during the last few days of Run 8 to explore this possibility. Fig. 2 shows some of the results [3]. The Run 8 data are mostly consistent with results from previous runs. However, in the high-x_F, low-p_T region where the previous data were dominated by low-statistics RHIC Run 3 measurements, the Run 8 data show that A_N is smooth and monotonic. The same conclusion is found when looking at the p_T dependence of the Run 8 data for narrow bins in x_F [3]. These results were presented by J. Drachenberg for the STAR Collaboration at SPIN 2008.

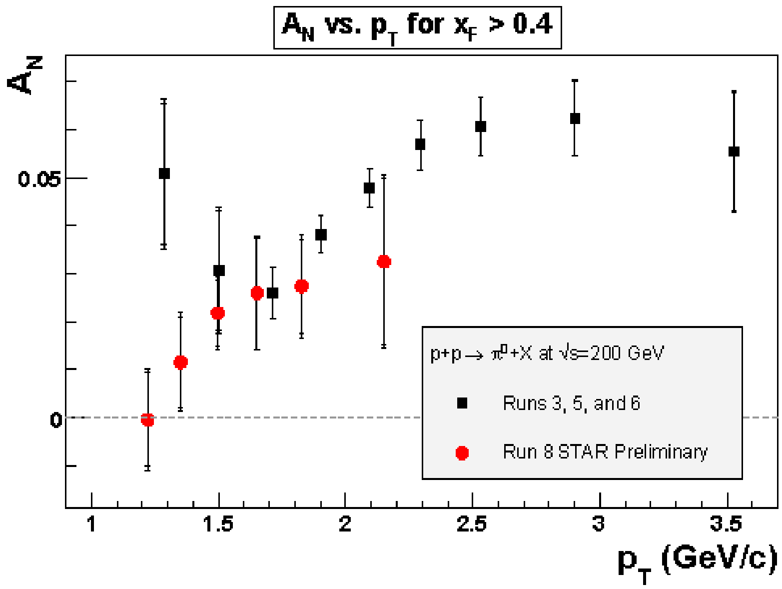

FIG. 2. A_N vs. p_T for inclusive π^0 production at $x_F > 0.4$. The inner error bars are statistical. The outer error bars add statistical and systematic uncertainties in quadrature. This figure is from [3].

Our group continues to handle a variety of administrative responsibilities in STAR. Last June, Dr. Gagliardi was elected to a two-year term as an at-large member of the Advisory Board. This past Fall, the new STAR Spokesperson appointed Dr. Gagliardi chair of the Trigger Board for Run 9. The Trigger Board is charged to ensure that STAR records the data necessary to achieve the Collaboration's stated physics goals. Drs. Gagliardi and Tribble have also participated on several STAR god-parent committees, including chairing three of them.

[1] B. I. Abelev *et al.* (STAR Collaboration), Phys. Rev. Lett. **101**, 222001 (2008).
[2] F. Yuan, Phys. Lett. **B666**, 44 (2008).
[3] J. L. Drachenberg, (for the STAR Collaboration), arXiv:0901.2763 [hep-ex].