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USE OF THE BASE-BAND TUNE METER KICKERS DURING THE FY18 STAR FIXED TARGET RUN AT 3.85 GeV/u*

P. Adams†, N.A. Kling, C. Liu, G.J. Marr, Brookhaven National Laboratory, Upton, NY, USA

Abstract

The base-band tune meter (BBQ) kickers proved to be a useful tool in managing STAR trigger rates during the RHIC FY18 3.85GeV/u[1] Fixed Target Run. The STAR collected over 3 times their original event goal, since it was possible to optimize the STAR trigger rates throughout the length of the physics store.

INTRODUCTION

STAR fixed target experiments are a recent addition to RHIC heavy ion physics program. The purpose of these runs is to study gold-gold collisions at various low energies [1].

The gold fixed target is mounted at the bottom of the RHIC beam pipe 205cm westwards from the middle of the STAR detector, just at the edge of Time Projection Chamber (TPC) subdetector. The beam closed orbit is moved vertically downwards, in order for transversally large emittance particles of the RHIC beam to reach the fixed target and introduce the collisions. Only "Yellow" beam is used as it interacts with the fixed target before it enters the STAR detector, as shown in Fig. 1.

The STAR experiment requested the trigger rate to be kept constant during data taking. This was soundly achieved with help of the BBQ kickers, which are vertical and horizontal kickers normally used for measuring the betatron tune [2]. At 3.85 GeV these kickers are strong enough to excite particles with lower emittance onto the target and hence provide more ideal control of the trigger rate.

OPERATIONAL SETUP

The FY18 fixed target run at 3.85 GeV/u was the first RHIC fixed target physics run. It took place only over a period of few days, 05/30/2018 - 06/04/2018 [3, 4].

The beam fill pattern was 12 evenly spaced bunches with the beam intensity 0.5e9 ions/bunch. At the beginning of each fill the fresh beam was injected into a flat orbit at STAR, then the vertical bump was inserted. The beam closed orbit had to be moved to approximately -13 mm vertically in order to reach the target, given the beam transverse emittance and the STAR beta function equal to 6 m.

STAR decided to keep their detectors on between the fills in order to minimize the down time, especially since the physics stores were only about 30 minutes long. The collimator positions had to be adjusted during the beam dump and fill time as well as during the vertical bump insertion in order to not trip the detectors.

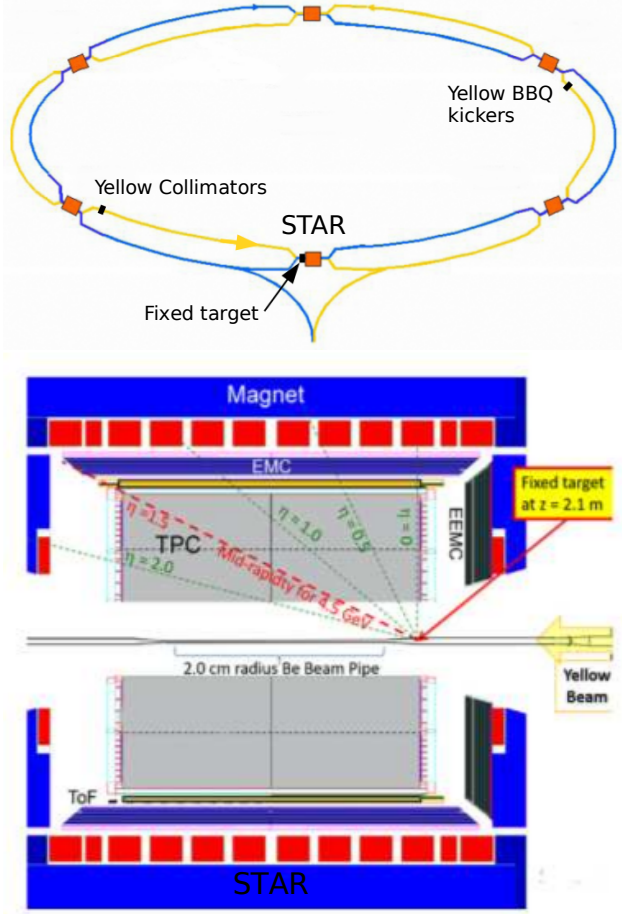

Figure 1: The fixed target layout with respect to the RHIC ring and STAR detector.

The STAR optimal trigger rate was 2000 Hz. It was challenging to maintain this rate throughout the store. Firstly, it was not possible to reach this value at the beginning of each store consistently. Secondarily, the trigger rate was decaying sharply as it is strongly dependent on the bunched beam intensity, as shown in Fig. 2. During FY18 only one 9MHz RF cavity was operational in the Yellow ring, therefore the beam was debunching quickly due to Intra-beam scattering.

Attempts were made to keep the trigger rate leveled by using the orbit control, in other words by changing the size of the STAR vertical orbit bump, as shown in Fig. 3. However, because of the limited control of the corrector power supply setpoints (only 12-bit resolution during FY18), even small orbit changes resulted in large spikes in STAR trigger rate and detector signals (which could cause trips). Additionally the beam position monitors (BPMs), which are needed for the orbit control, would stop reporting data as the bunched beam intensity got too low towards the end of stores (Fig. 4).

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† padams@bnl.gov
[1] 3.85 GeV/u is the particle beam energy

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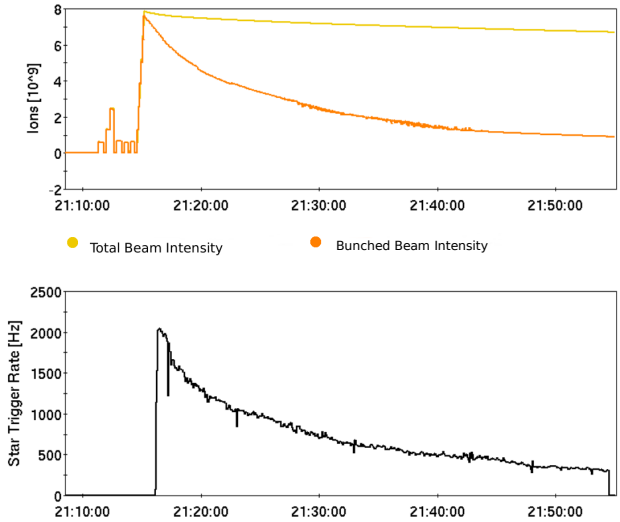

Figure 2: The STAR trigger rate is strongly correlated with the bunched beam intensity.

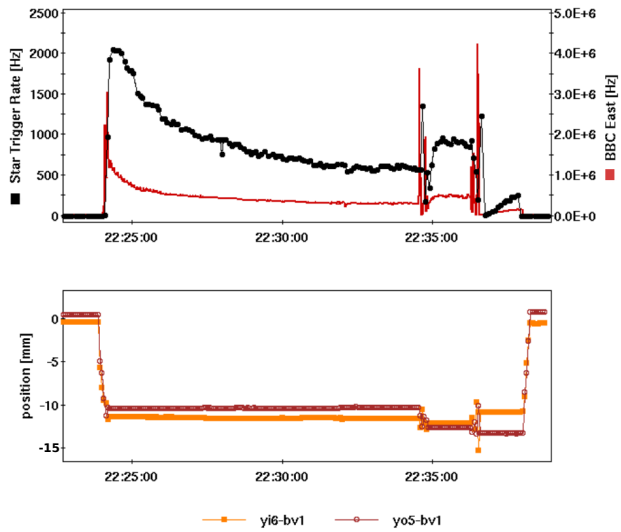

Figure 3: An attempt to control the trigger rates by using the orbit control. Vertical position of the beam is described here by two BPMs, yi6-bv1 and yo5-bv1, which are approximately ±25 m from STAR. Even small changes in orbit lead to spikes in the trigger rate and detector signals (BBC East is one of the STAR sub-detectors).

USE OF THE BBQ KICKERS

The BBQ kickers are normally used to measure the betatron tunes. They act on all circulating bunches when they are on. At typical beam energies, they do not influence the beam transverse profile much at their regular strength. But at 3.85 GeV the beam rigidity is low enough that the particles with the smaller emittance can get enough kick to populate the area of the transverse phase space which overlays the target.

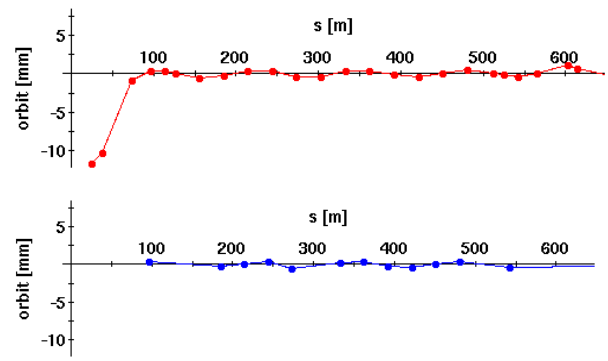

Figure 4: An example of the vertical BPM signal. Horizontal axis is a location around the RHIC ring with s(STAR) = 0 m. Yellow beam travels right-to-left. Top - beginning of the store; Bottom - end of the store (approximately 30 minutes later), some BPMs stop reporting as the beam de-bunches.

The use of the BBQ kickers was crucial in consistently achieving the trigger rate of 2000 Hz within few seconds of physics being declared. The halo of the beam can get scraped by collimators during the vertical bump insertion, but it can be replenished easily with help of the BBQ kickers, as shown in Fig. 5.

And even though the beam de-bunches, the particles with the proper longitudinal and transverse coordinates can be re-introduced and the optimal trigger rate can be maintained throughout the whole fill. Both horizontal and vertical BBQ kickers were used to achieve this. The strength of the kickers was also varied and provided a very fine control of the trigger rate, as shown in Fig. 6. A positive side effect of the BBQ kickers being on during the fills was a continuous betatron tune measurement.

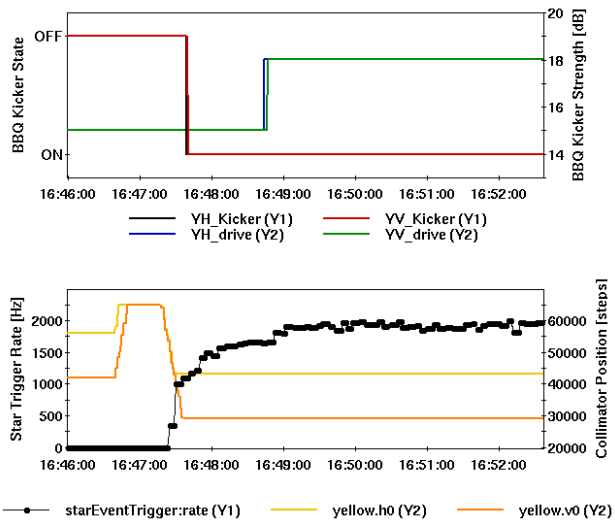

Figure 5: The trigger rate reaches 2000Hz with help of the BBQ kickers shortly after the collimators were pulled out.

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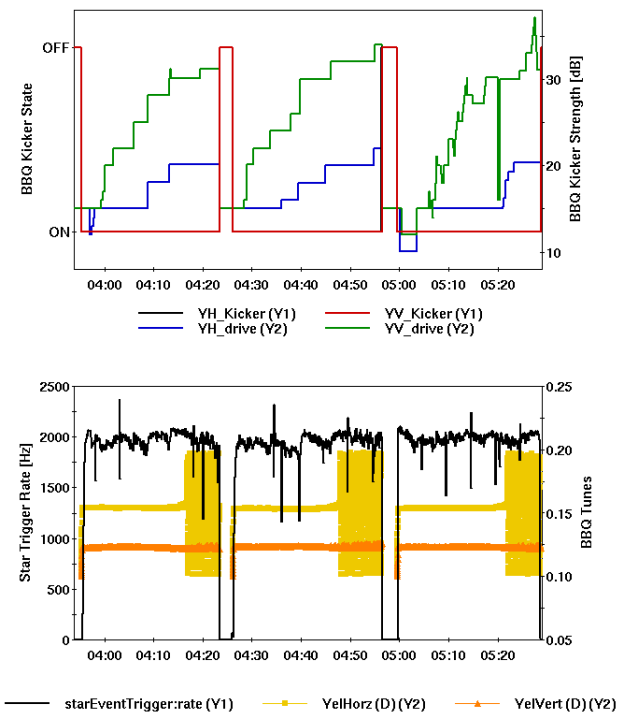

Figure 6: The trigger rate maintained by use of the BBQ kickers. Both horizontal and vertical planes were used and the kicker strength was varied. Allowing almost continuous betatron tune measurement.

LIMIT ON THE DETECTOR RATES

One of the STAR requests for optimal data taking was to limit the detector rates, namely BBC East rate under 1e6 Hz. This channel is a measure of everything that the detector sees (good Au+Au collisions and everything else). As this signal gets high, detectors start to trip, which needs to be avoided.

This put a limit on the effectiveness of using BBQ kickers to keep the STAR trigger rate leveled at 2000Hz as can be seen in Fig. 7.

FY19 FIXED TARGET EXPERIMENTS

The fixed target experiments at energies 4.59, 7.3 and 31.2 GeV/u took place during FY19 run. The RHIC lattices with a larger STAR beta function alleviated the background issues. Additional 9MHz RF cavities helped to suppress the de-bunching of the beam. And the higher resolution (16-bit) controllers for the corrector power supplies allowed for the orbit control to be very effective in maintaining the desired trigger rates [5].

CONCLUSION

The novel approach of using the BBQ kickers for maintaining the optimal trigger rate during the low energy STAR fixed target run proved to be crucial in achieving about 3 times of the initial data set event goal during FY18 [3, 4].

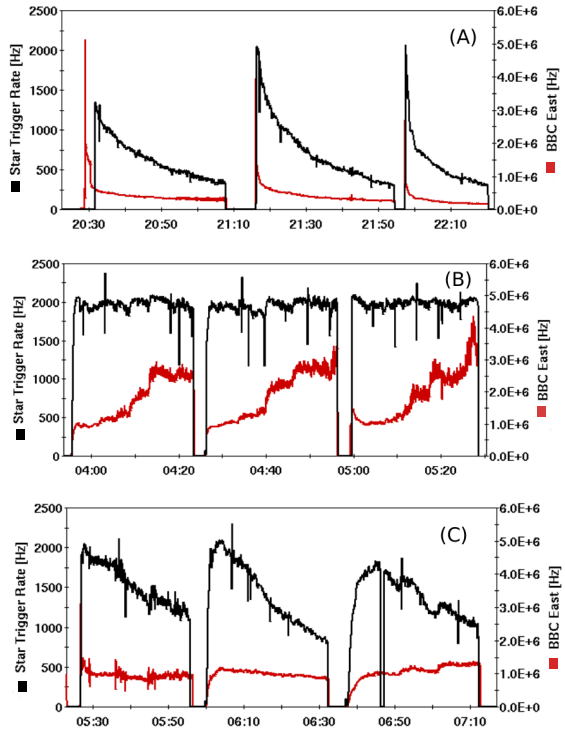

Figure 7: The BBC East rates were the limiting factor in keeping the STAR trigger rate leveled. (A) The trigger rate with the BBQ kickers off. (B) The trigger rate is being leveled at 2000Hz using BBQ without considering the background level. (C) The emphasis is put on keeping the background within limits and thus the 2000Hz trigger rate can not be maintained.

The use of the BBQ kickers for maintaining the trigger rates is a viable backup method in the future fixed target experiments, for cases when the BPM signal is poor and the beam orbit can not be moved and/or if the injectors are not available to provide fresh beam.

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