Development of streaming readout for sPHENIX-INTT detector

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The sPHENIX experiment, which aims to explore the nature of quark-gluon plasma and structure of proton, started taking data in 2023 at RHIC at BNL. INtermediate Tracker (INTT) is one of the sPHENIX tracking detectors. INTT comprises a silicon strip detector covering psuedorapidity $|\eta| < 1.1$ and a full azimuth. In addition to the charged particle tracking, INTT plays a unique role of identifying a single beam crossing where the collision takes place.

sPHENIX is planned for a three-year operation, and 2024 is the only year in which polarized $p + p$ collision experiment is performed. Therefore, it is necessary to collect as much data as possible during the experimental period. At high luminosity such as $p + p$ collisions, the collision rate is higher and traditional data acquisition methods based on trigger lose a lot of data due to its dead time. Streaming readout is a new method that continuously collects data regardless of the trigger. Therefore, more data can be collected than the traditional trigger method. In order to collect as much $p + p$ collision data as possible, we developed the streaming readout method for INTT.

INTT's readout ASIC operates with self-triggering and is capable of keeping time per hit with 7-bit width in the beam clock unit. The time of the hit is called hit-time. The latter circuit, called FELIX, which is responsible for data aggregation, is equipped with a large and high-speed FPGA, and can handle the streaming method. Since no trigger is used, the streaming readout requires that each hit hold a collision time to identify the collision event.

INTT's streaming readout uses 120 beam clocks as one readout cycle. First, the FELIX receives the strobe signal and its time from the sPHENIX timing circuit. Then, the strobe initializes the time counter in the readout ASIC, which allows the readout ASIC to record a collision time relative to the strobe time.

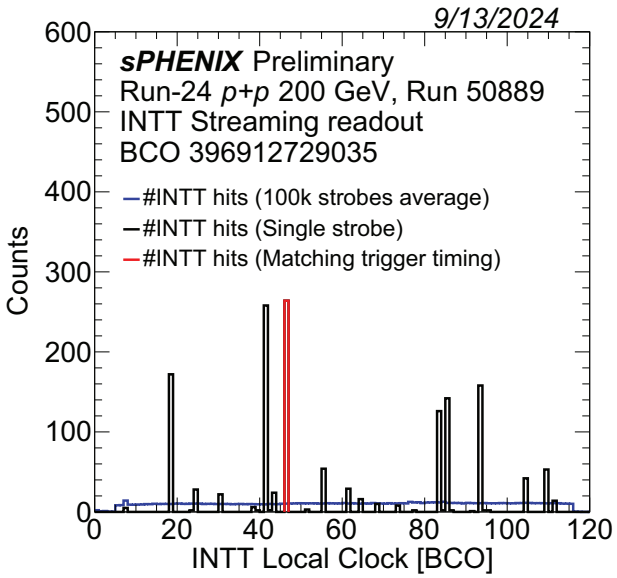

Fig. 1. Number of hits as a function of the hit-time in a readout cycle.

The readout cycle is repeated continuously without the dead time. The collision time is reconstructed by combining the strobe time and hit-time in the readout ASIC for the offline analysis.

Figure **??** shows the number of hits as a function of the hit-time in a readout cycle. Each peak represents a collision that occurred at a different time. The red-line indicates the hits synchronized with the trigger detector. This clearly shows that the time can successfully be determined in the streaming readout. Some small peaks indicate collisions occurring outside of the INTT region.

sPHENIX accumulated large amount of $p + p$ data using the streaming readout in 2024 as summarized in Ref. 1). We are currently developing the software to isolate collision events from data collected in the stream readout using the time information for physics analysis.

Reference

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