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From Analog Inputs to Physics Results: A Case Study in Using Digital Electronics in Physics Research

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Particle collisions at the Relativistic Heavy Ion Collider (RHIC) can range from grazing collisions to head on collisions and can result in a wide range of physical interactions between the colliding particles. Signals from the full detector suite at a collision point cannot be readout quickly enough to record the full 10 MHz crossing rate. Therefore, to make physics conclusions from these collisions, signatures of specific interactions must be identified using a subset of the full detector to reduce the data acquisition rate to a manageable volume. These signatures must be encoded into a real-time digital pattern recognition system to choose the interactions needed to achieve physics results. This is accomplished using custom built electronics arranged in a tree structure to form a digital trigger system composed of analog-to-digital conversion electronics at the tree inputs and digital electronics throughout the rest of the tree. The trigger system developed for the Solenoidal Tracker at RHIC (STAR) is able to identify a wide array of configurable patterns among thousands of individual detectors at a rate of 10 MHz. The system can be easily programmed to identify new patterns and can be used to look for many different patterns simultaneously. The flexibility of this system allows for a wide range of physical interactions to be explored. This system was recently ported for use at a new experiment at RHIC called AnDY, exhibiting the system's general utility as a trigger and data acquisition system for physics experiments.