sPHENIX Report

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Baseline Fluctuation Studies for the sPHENIX TPC Readout

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Abstract

The sPHENIX TPC readout will use an array of quadruple-stacked gas electron multiplier (GEM) modules to amplify signals from the chamber in order to perform precise tracking measurements. The performance of the system may be affected by a shift in the readout baseline due to event-by-event fluctuations. These fluctuations are a result of the common-mode noise generated in the induction gap of the readout as well as the ion tails on the signals caused by capacitive coupling between the bottom GEM and pad plane of each module. It is important for this baseline shift to be well understood and accounted for to avoid degradation in the tracking performance of the TPC. We will present studies done to investigate the baseline shift of the sPHENIX TPC readout along with the methods used to correct for it.

Run Selection

All plots were generated using the prdf files, TPC_ebdc*_beam-00010771-0000.prdf, from collision run 10771. These files were processed using the TPCRawDataTree macros to generate root files with the data stored as TTrees. Run 10771 was a Au+Au $\sqrt{s_{NN}} = 200$ GeV collision run with no magnetic field and 45 kV on the central membrane of the TPC. The GEM modules of the TPC were set to have 4525 V on the top of GEM 1.

Entry Selection

The objective of the entry selection algorithm was to identify all entries from run 10771 with high occupancy or a single hit in the waveform. A hit was defined to be any sample (or string of samples) with a max ADC at least 5σ above the pedestal mean. The pedestal mean and pedestal σ were calculated channel by channel using the first 15 ADC samples of each entry.

The algorithm looped through each entry for a given sector of the TPC and checked if the maximum ADC within the sample was at least 5σ above the pedestal mean. If the entry passed this criterion, the total number of hits in the waveform was found by starting at the max ADC and walking down in both directions to count the total number of times that the waveform dropped below 5σ and then rose back above. If an entry had at least three hits, or a string of more than 10 ADC samples above 5σ, the waveform was stored as a high occupancy entry. These entries were further categorized by their maximum ADC in ranges of 100-200, 200-400, 400-600, and so forth until 1000 ADCs was reached. If the sample had only one hit, and this hit was no more than 10 samples wide, it was stored as a single hit entry. All other entries were ignored.

Waveform Plots

The individual waveforms for the high occupancy entries were filled to separate 1D histograms based on their maximum ADC value. The pedestal mean was subtracted from each ADC sample. An example waveform of the first high occupancy entry for a given ADC range can be seen in Figure 1. These plots help to illustrate the affect of multiple hits, and their maximum ADC value, on the baseline shift of the pedestal.

All single hit entries with the same sector, layer, module number and BCO (event) number were analyzed to identify the pad with the largest ADC value. If the max ADC value lied between sample 20 and 160 (360 total samples in each waveform), The waveform for this pad was filled into two 2D histograms, one that took all single hit entries and a second that was chosen based on the max ADC of the waveform. Once again, the ADC ranges for these secondary histograms were selected to be 100-200, 200-400, and so on. In both histograms, the ADC samples were subtracted by the pedestal mean and shifted so that the maximum ADC value was centered at zero. If the two neighboring pads (left and right of the max pad) also had a single hit entry in the same event, they were filled into their own 2D histograms that followed the same categorization procedure as the ones for the max pads. This process was repeated for all sectors and all distinct events to obtain distributions of the single hit waveforms across the entire run. Figure 2 and Figure 3 show

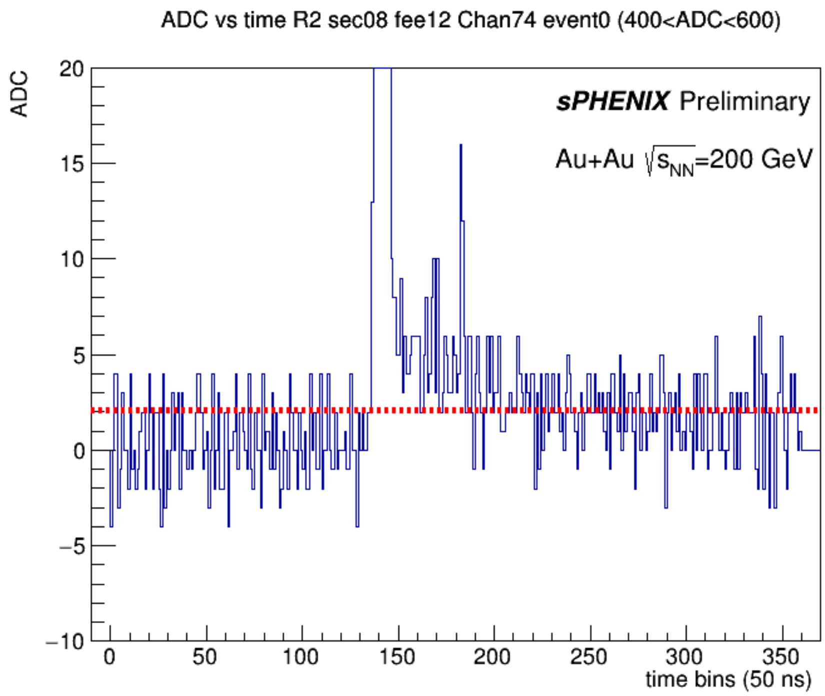

Figure 1: High occupancy waveform with maximum ADC between 400 and 600 ADC. The dashed red line indicates the ADC value 1σ above the pedestal mean.

the single hit waveform distributions of each module type for the max and neighboring pads, respectively.

Profile Plots

The x-axis profiles of the waveform distributions for max and neighboring pads were taken to observe the average waveform shapes. For each profile, the waveform was normalized by the integral under the curve and plotted on a logarithmic scale (see Figure 4). To compare the tail shapes, the profile of each waveform was copied and normalized by the integral only under the tail. The plots for these new waveforms are shown in Figure 5. These plots show that the average single hit waveforms for max and neighboring pads have similar peak and ion tail shapes.

Profile plots were also taken of the 2D histograms divided up by ADC range using the same procedure. Figure 6 and Figure 7 show the profiles for the max pad waveforms and their ion tails, respectively. The neighboring pad waveforms and ion tails are shown in Figure 8 and Figure 9, respectively. These figures show that the peak and ion tail shapes for single hit waveforms may differ as functions of maximum ADC for both the max and neighboring pads.

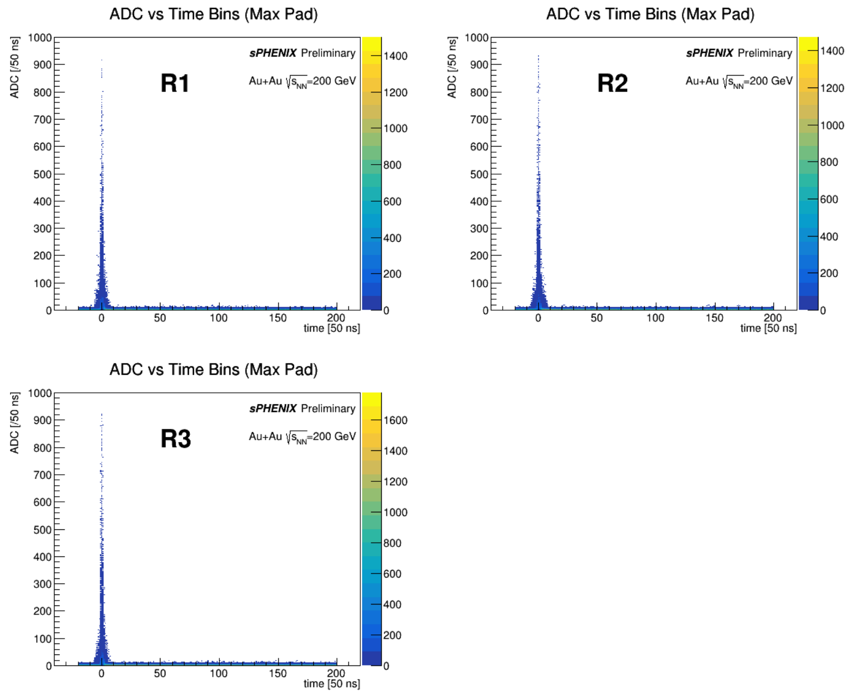

Figure 2: 2D distribution for single hit waveforms from pads with maximum ADC value in a given layer.

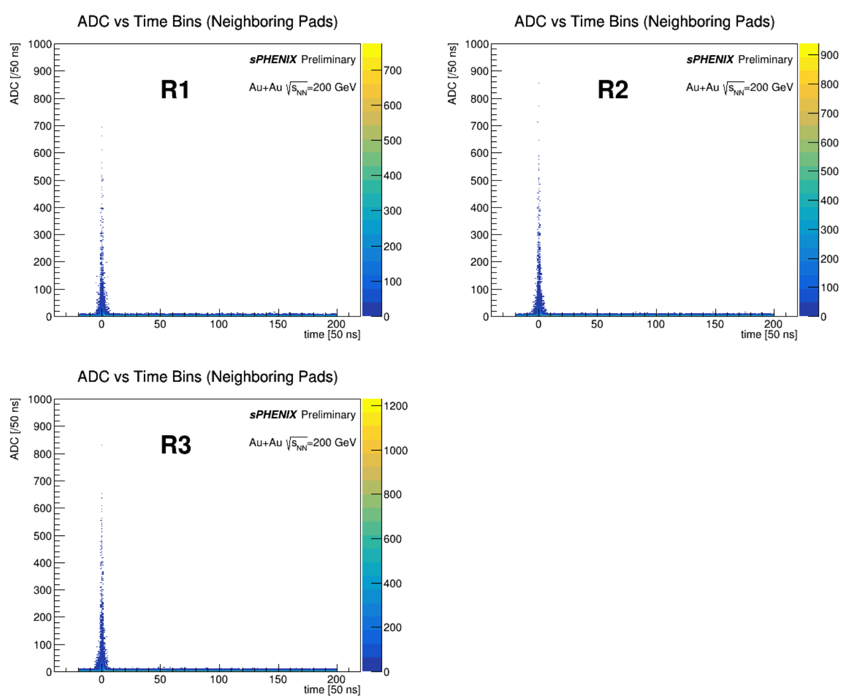

Figure 3: 2D distribution for single hit waveforms from pads neighboring the max pad in a given layer.

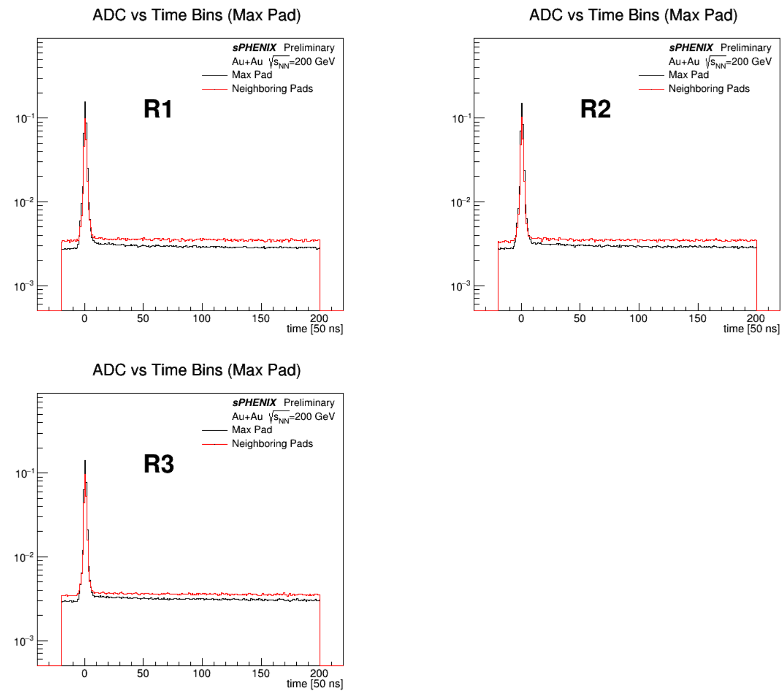

Figure 4: Profiles for single hit waveforms from max and neighboring pads.

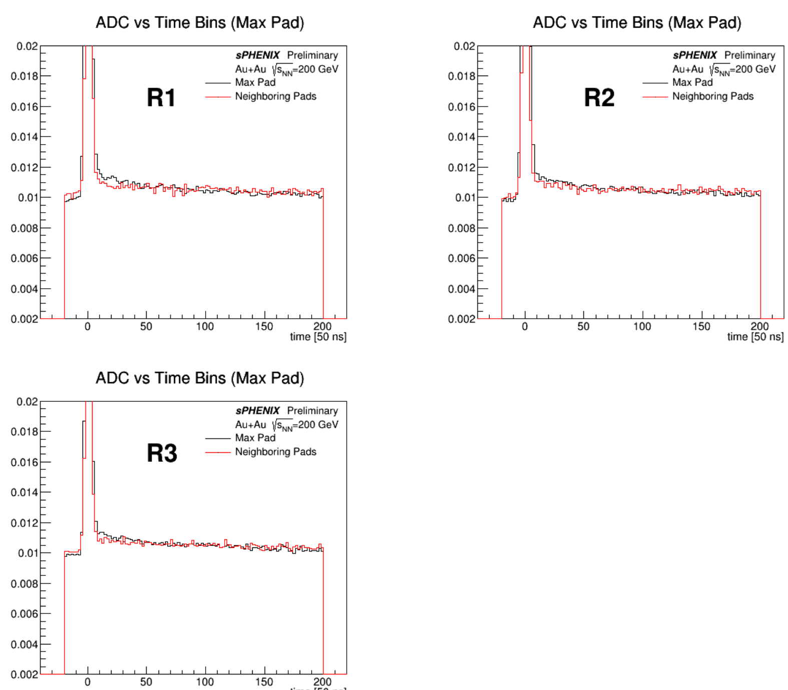

Figure 5: Ion tail profiles for single hit waveforms from max and neighboring pads.

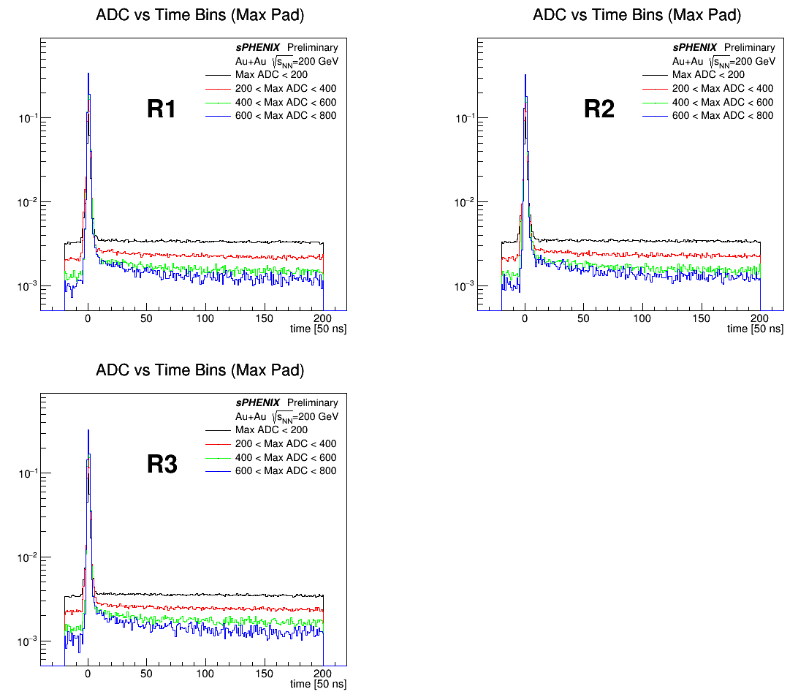

Figure 6: Profiles for single hit waveforms from max pads divided into separate max ADC ranges.

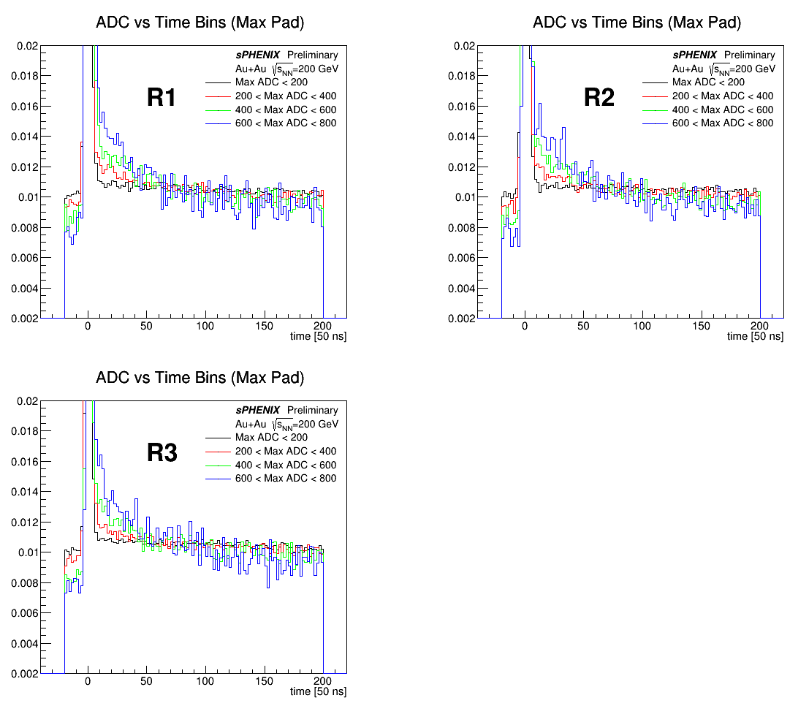

Figure 7: Ion tail profiles for single hit waveforms from max pads separated by max ADC.

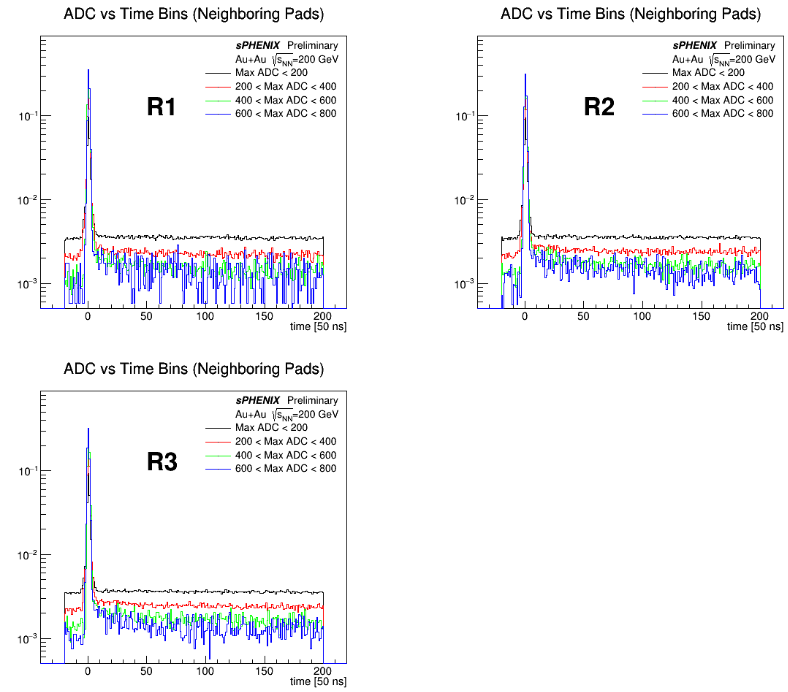

Figure 8: Profiles for single hit waveforms from neighboring pads divided into separate max ADC ranges.

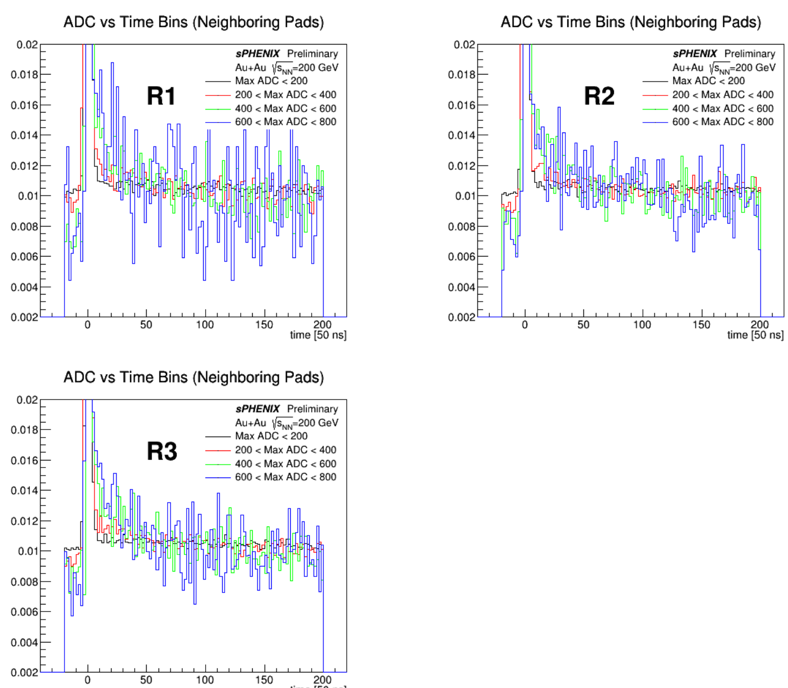

Figure 9: Ion tail profiles for single hit waveforms from neighboring pads separated by max ADC.