Optimizing ICEBERG LArTPC Run Configuration for Data Collection

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Introduction

The ICEBERG project at Fermilab focuses on developing a Liquid Argon Time Projection Chamber (LArTPC) detector to advance neutrino research as part of the DUNE project. To ensure accurate data collection and diagnostics of the ICEBERG electronics, charge injection runs were completed using a pulser to mimic known charge deposition amounts on the LArTPC wires and collect data for analysis and calibration.

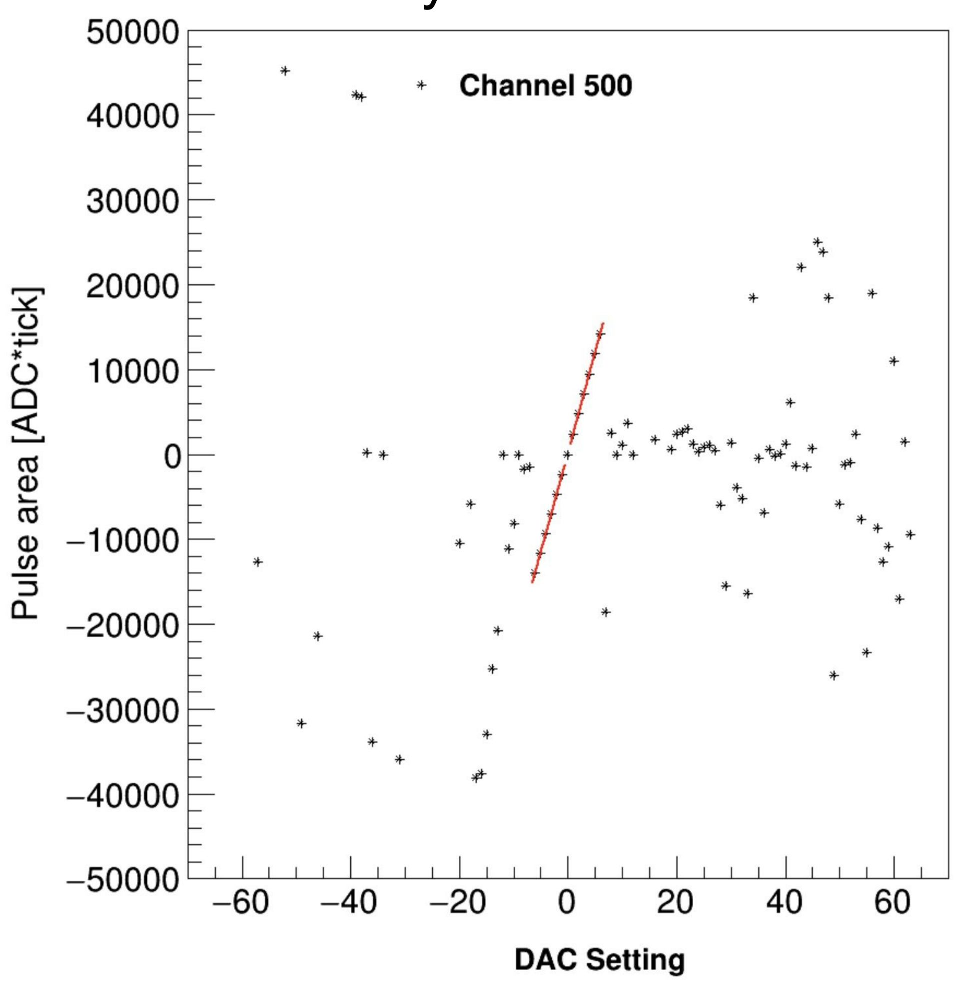

Figure 1. Run Analysis on DAC Setting vs. Pulse Integral Values

The data analysis on the runsets was completed offline using the CERN ROOT software framework. The analysis focused on determining a linear region (similar to Figure 1) in the plotted relation between the Analog-to-Digital Converter (ADC) peaks and different Digital-to-Analog Converter (DAC) values for various run configurations. This analysis is essential for optimizing the detector's performance by identifying the optimal range of DAC values that avoid saturation zones and provide the best experimental results for real non-pulser runs.

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Procedure

The first step involved generating ADC min and max plots for each specific run to understand and collect data on the performance of the detector under various conditions. The graphs referenced in Figure 2 showcase the ADC min and max values for a specific run, along with some statistical properties, such as the mean and standard deviation of the induction plane of wires.

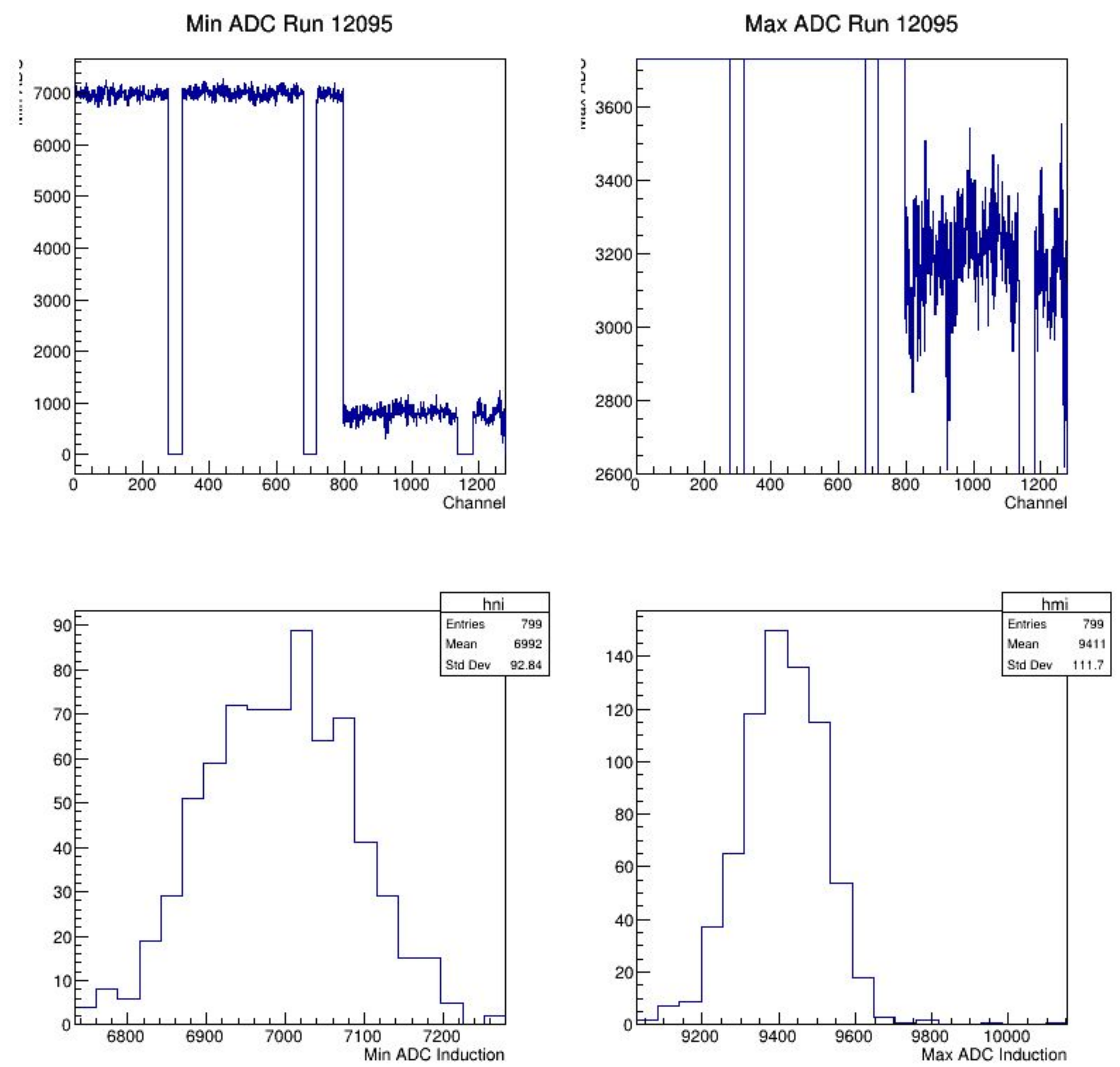

Figure 2. ADC Min/Max Values Plotted by Channel and Mean/Std of Induction

The different run configurations included varying the gain applied to the signal (with values 7.8, 14, and 25 mV/fC), changing the pulse peak times (with values 1, 2, and 3 μs), and modifying the Vref range (with values 1.5, 1.9, and 1.78 V). The baseline value for charge detection was kept at a steady 900/200 mV throughout each experiment, and the data from each set of runs was recorded against 64 evenly spaced DAC values.

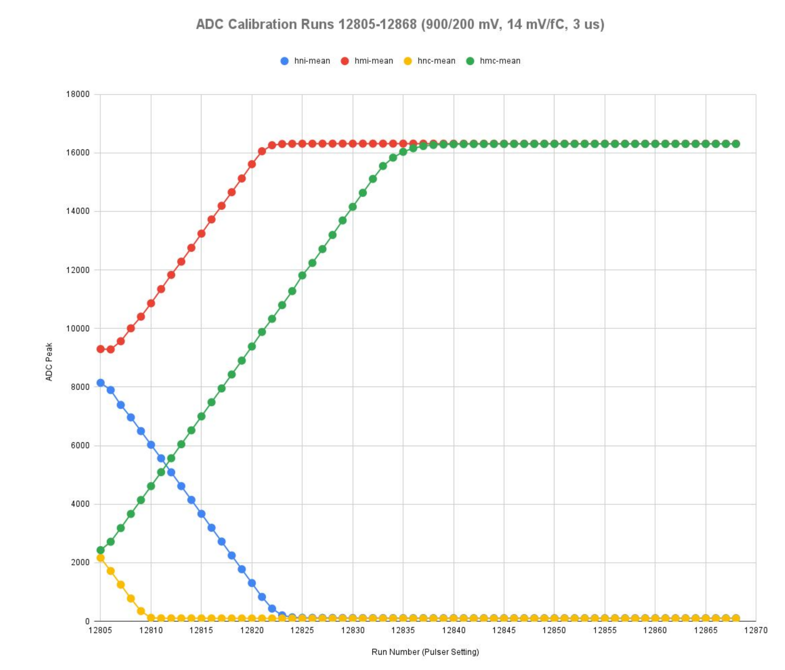

Figure 3. DAC vs. ADC Peaks for Vref = 1.5V

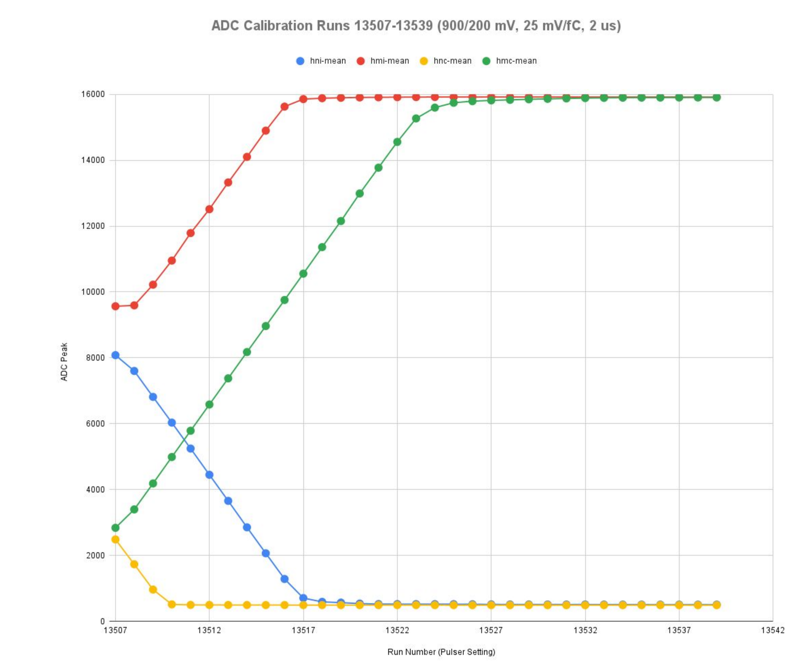

Figure 4. DAC vs. ADC Peaks for Gain = 25 mV/fC

Results

The research results revealed that a Vref of 1.5V led to rapid saturation and a limited linear region (see Figure 3), whereas Vref values of 1.8-1.9V provided an extended linear range. A gain setting of 25 caused the ADC to max out quickly within ~10 DAC values (as in Figure 4), while a gain of 7.8 mV/fC was preferable to 14 due to a higher dynamic ADC range. Based on these measurements and analysis the DUNE-CE Consortium has decided to switch the gain setting for the upcoming ProtoDUNE-II-HD run at CERN from 14 mV/fC to 7.8 mV/fC. The baseline of the collection plane has been adjusted to about 225 mV to move the collection plane pedestal to ~2000 ADC Count.

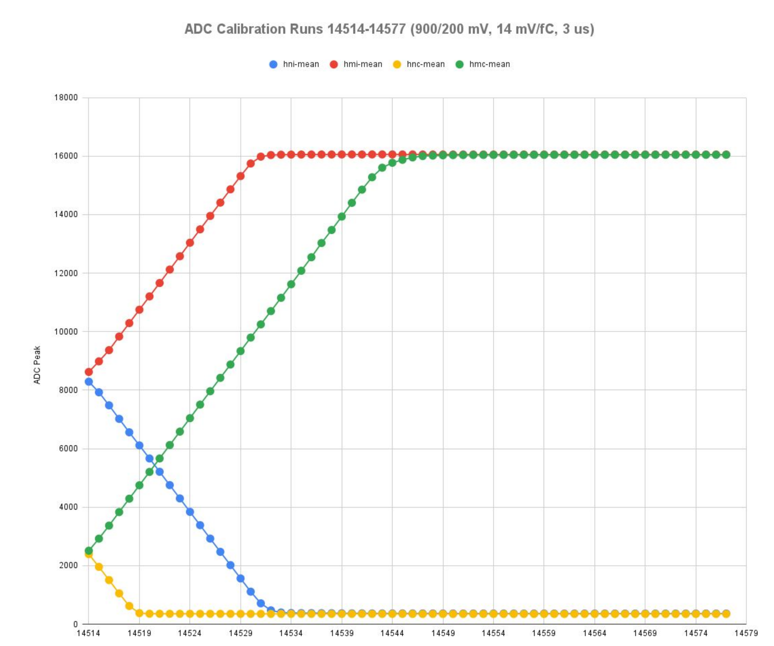

Figure 5. DAC vs. ADC Peaks for Peak Time = 3 μs

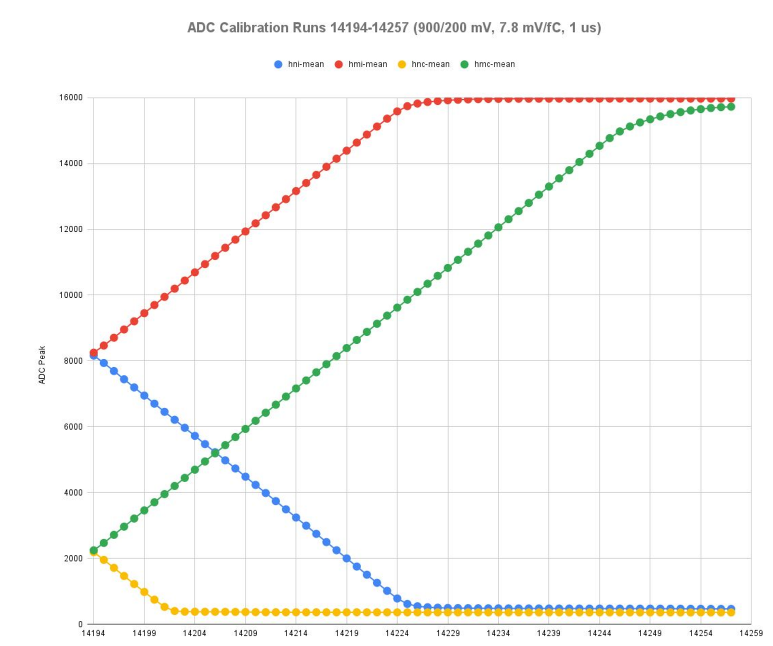

Figure 6. DAC vs. ADC Peaks for Optimal Configuration (Vref = 1.78V, Gain = 7.8 mV/fC, Peak Time = 1 μs)