Impact of Temperature Changes on Drift Properties in a Straw Tube Chamber

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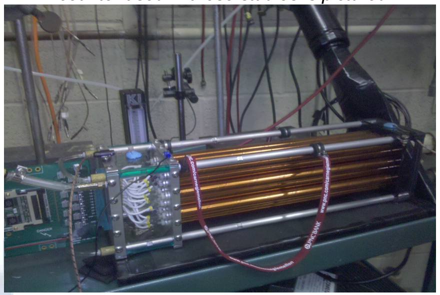

Figure 1: The straw tube multiwire proportional counter used in these studies is pictured.

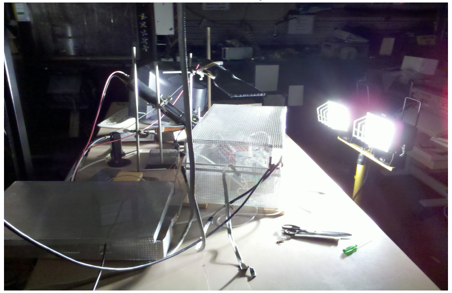

Figure 2: The straw tube chamber inside its noise-reducing Faraday cage and the lamps used to heat the chamber are pictured.

Experimental Setup

In this experiment, a straw tube mulitiwire proportional counter was used and two thermocouple wires were inserted into the gas chambers at each end of the tubes to monitor temperature. The chamber consists of 16 straw tubes in staggered formation with a gold plated tungsten wire strung down the middle of each tube. A gas mixture of 50% argon and 50% carbon dioxide was passed through the tubes, and plastic scintillators were used to trigger the data acquisition system.

As pictured above in Figures 1 and 2, construction lamps were used to heat the chamber up to 34ºC, and a Faraday cage was added around the detector to reduce external noise. The operating voltage was set to 2000V in this experiment, meaning the tungsten wires were held at that voltage.

For each temperature studied, cosmic ray data was collected for at least 24 hours (with about 1 event/sec) while the temperature was checked every minute at both locations on the chamber.

What's Important to Know?

While running experiments with a proportional counter, it is important to know how the gas gain varies with temperature, as this affects the only signal received from the detector, the current on the anode wires. It is also very important to understand how the drift velocity and drift time vary with temperature, as they affect the reconstruction of a particle's track, aka the tracking. The tracking allows one to accurately identify particles based on their energy loss per distance traveled (dE/dx), which is related to the mass and charge of the particle. Without an accurate prediction of drift time, particle identification would fail, as would the experiment.

Background Information

The chamber used in this experiment is a prototype of the Central Drift Chamber (CDC) that will be used in the GlueX experiment in Hall D at Jefferson Lab in Virginia. The CDC is part of the experiment's charged particle tracking package, and its main job is to measure the coordinates of tracks perpendicular to the anode wire with an accuracy of 150 microns. This accuracy can be affected by the drift properties of the gas in the chamber, which are affected by the temperature. So, the purpose of this study is to quantify the changes in the drift properties as a function of temperature.

Results

The data recorded were put into histograms of the pulse height, showing the number of events within a certain range of ADC channels. These histograms were fitted with Landau functions (shown in Figure 3). Using the data for each temperature, it was concluded that the MPV of the Landau fit increased linearly, with a slope of 10 channels/ºC. Similarly, the sigma value, or width of the Landau curve, increased linearly by 4 channels/ºC. This data is shown in Figure 4.

Also, the drift times in the chamber were analyzed. By analyzing the time difference between the signals from the scintillators and the chamber wires, the drift time could be calculated for each temperature. It was determined that the drift time varied linearly with a slope of -3.9 ns/ºC, as shown in Figure 5.

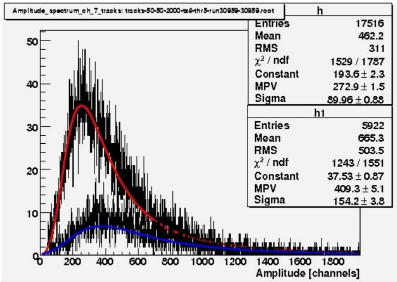

Figure 3: Amplitude histograms fitted with Landau functions. The red fit is for 20ºC and the blue fit is for 34ºC. The blue fit is done with less data.

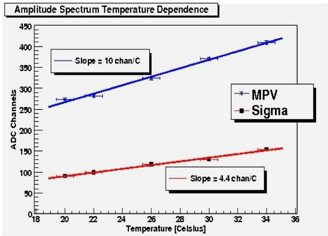

Figure 4: Graph of the amplitude spectrum Temperature dependence for histograms like those in Figure 3. MPV and Sigma are the peak and width values for the Landau fit.

Noise Study

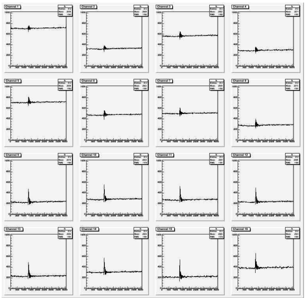

Figure 6: Plots of one noise event for each channel is shown. Peak height indicates proximity to thermocouple. Cosmic ray events are much larger.

It is important to note that noise was picked up from the thermocouple wires. The noise was insignificant and only affected tubes very close to the wires, but it will be monitored in the CDC at Jefferson Lab.

In a small study of this noise, it was found that the thermocouple noise added very little to the background noise. Also, the tracking of the data got rid of this noise almost completely. Plots of one noise event for all the detector wires is shown in Figure 6. The larger pulses are closer to the thermocouple wires. Cosmic ray events are larger by about 5 times, and other noise is about twice as large. In summary, thermocouple noise is not a factor, even though it's measurable.

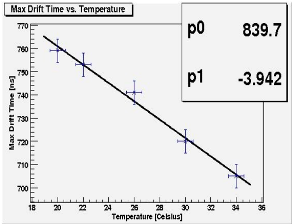

Figure 5: Maximum drift time data is plotted versus temperature and fitted with a straight line.

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