Hall C Reference

SHMS Drift Chambers

M. Eric Christy, Peter Monaghan, Narbe Kalantarians,
Debaditya Biswas, Mahlon Long

December 13, 2016

Abstract

This document describes the design and construction of the tracking drift chambers for the Super High Momentum Spectrometer (SHMS), which is a critical component for the 11 GeV physics program in Jefferson Lab Hall C. The design and construction technique is based on that of previous successful chambers built for the Hall C program, which have been shown to reach the resolutions and particle rate specifications of the SHMS, as outlined in the Hall C 11 GeV pCDR.

1 Mechanical Design

The open layout design consists of a stack of alternating wire and cathode foil planes; each plane consisting of 1/8 inch thick printed circuit board (PCB). These are sandwiched between a pair of aluminum plates on the outside, which provide both the overall structural support and the precise alignment of each board via dowel pins at the corners. Just inside each plates is a fiberlass board with the central area cut out and covered with a vacuum stretched film of aluminized Mylar, which provides the gas window. These are sealed to prevent gas leakage via an o-ring around the gas fitting through-hole on the inside of the plate.

Each chamber consists of two identical half chambers separated by a fiberglass mid-plane, which is utilized for mounting the amplifier discriminator cards required for the sense wire readout. To minimize the production costs, only two

unique PCB types were designed: an X-plane with wires oriented horizontally (Figure 1), and a U-plane with wires oriented at +60 degrees relative the X-plane (Figure 2). All other plane orientations are generated by rotations of these two basic board types. For instance, the boards are designed such that a rotation of 180° in-plane about an axis through the center of the board produces boards with wires of the same orientation, but shifted by 1/2 cell width, thus allowing the resolution of left/right ambiguities. Rotation of Figures 1 and 2 such that the top becomes the bottom produces the X' and U' orientations. The V' and V boards with wire orientation of -60 degrees relative to the X-plane are produced by a rotation of the U and U' boards of 180 degrees into the page about a vertical axis though the center of the board. Each half chamber has three planes with the first half consisting of (U, U', X) and the second half consisting of (X', V, V'). The first chamber is oriented in the SHMS frame such that the board ordering as seen by particle transversing the spectrometer is (U, U', X, X', V, V'). The second chamber is identical to the first chamber, but is rotated 180° about the verticaal axies, giving a plane ordering of (V', V, X', X, U', U). Note that because of this rotation, the U planes in the second chamber are parallel to the V planes in the first chamber and the V planes in the second chamber are parallel to the U planes in the first chamber. A drawing showing the chambers mounted in the frame is presented in Figure 3.

The drift gas (50/50 mixture of Ethane/Argon in production mode) flows across each board through holes in the cathode planes (k-planes) alternating from top to bottom. A technical drawing of a k-plane is presented in Figure 4.

The overall dimensions of the wire chambers are driven by the desired active area for particles at the focal plane of the SHMS; this has been set at 80 cm x 80 cm. The active area of each wire plane consists of alternating 20 μm gold tungsten sense wires and 80 μm copper plated beryllium field wires separated by 0.5 cm. Each wire plane is sandwiched between a pair of cathode planes with the cathode surfaces consisting of 5 mil thick stretched foils of copper plated Kapton.

The mechanical design of the wire chamber was then based on these dimensional constraints. Detailed drawings including dimensions, bolt hole locations, electronics connections, high voltage connections and in the case of the wire planes, signal and high voltage wire traces have been drafted. Detailed wire plane drawings showing the wire traces are shown in Figures 1 and 2.

2 Electrical Design

The copper plated beryllium field wires and the copper plated Kapton foils are held at the same negative potential of $|V| < 3$ kV. A single SHV cable for each chamber supplies this voltage. The high voltage is distributed to each set (plane) of field wires and each foil with a set of short jumpers with polarity keyed locking connectors. (Figure 7)

Each sense wire has its own electronic readout through Nanometrics preamplifier/discriminator cards or LeCroy Corporation LRS 2735DC cards. Each of the cards has 16 inputs which accept negative signals from the sense wires, amplify and then digitize the signals according to whether a user-specified threshold is crossed. This threshold level is set using a low volage (0-10 V) DC power supply.

The Nanometrics and LeCroy amplifier/discriminator cards are powered by +5 V and -5 V low voltage (LV). This LV is provided to each chamber by two model V6PH58AFHM power supplies produced by Accopian Technical Company. (Figure 8) The supplies are connected by a single 6AWG (5) conductor cable to a closed distribution box mounted under each chamber, where they split into two 10AWG cables that connect to block terminals mounted on both the left and right side of the chambers at the bottom of the aluminum plates. The threshold voltage for the discriminator cards is also delivered through the 6AWG cable. The +5 V, -5 V, and ground lines are connected from the terminal block to copper LV rails mounted along the length of the plates. (Figure 9) In-line fuse holders with 10 Amp fuses between these connections on the +5V and -5V lines provide protection from current over draws on the 22AWG jumpers connecting the rails to the amplifier carrier cards. (Figure 10) The circuit diagram of the low voltage distribution is shown in Fig. 11.

For protection against personnel inadvertently shorting the LV rails, the exposed areas of the rails are covered with heat shrink tubing and the entire area of the rails are covered with a protective acrylic cover. The HV connectors at the top and bottom of the chambers are also covered with acrylic covers.

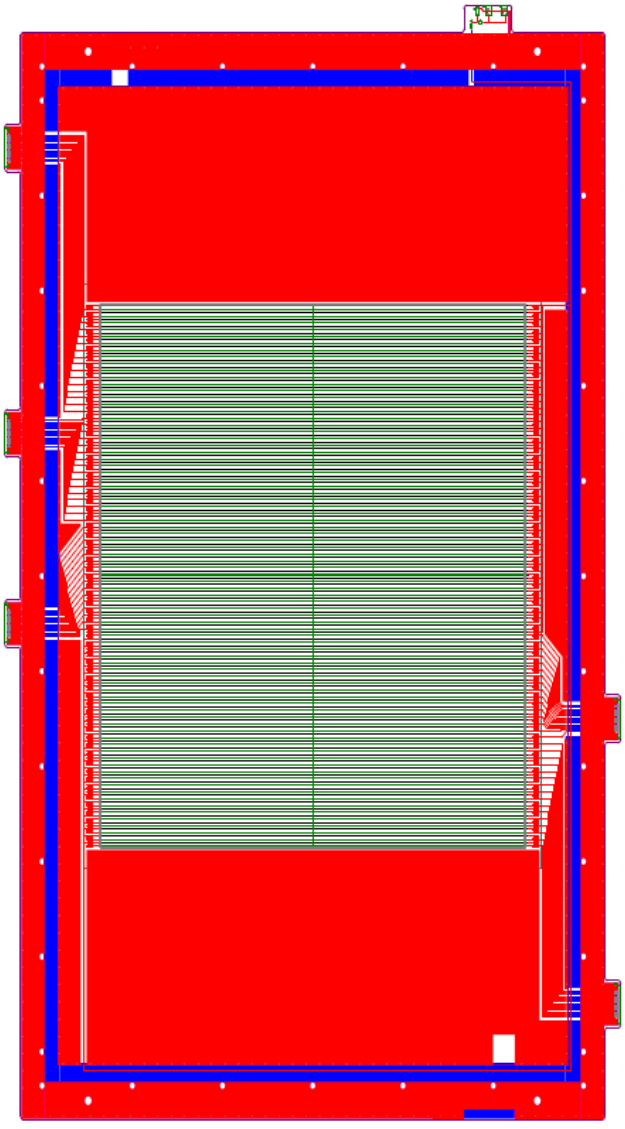

Figure 1: Technical drawing of X-plane PCB.

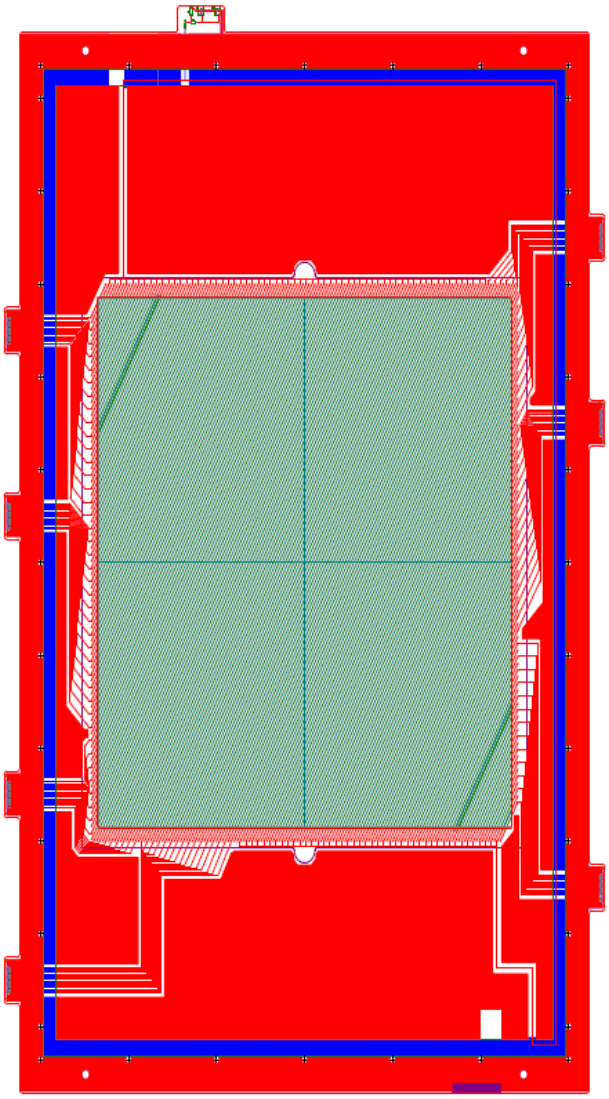

Figure 2: Technical drawing of U-plane PCB.

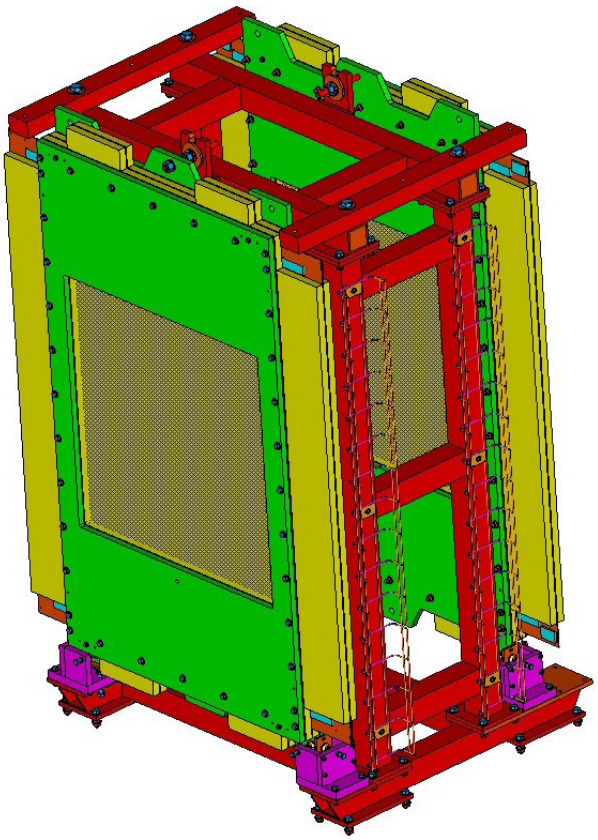

Figure 3: Technical drawing of SHMS drift chambers mounted in detector hut frame.

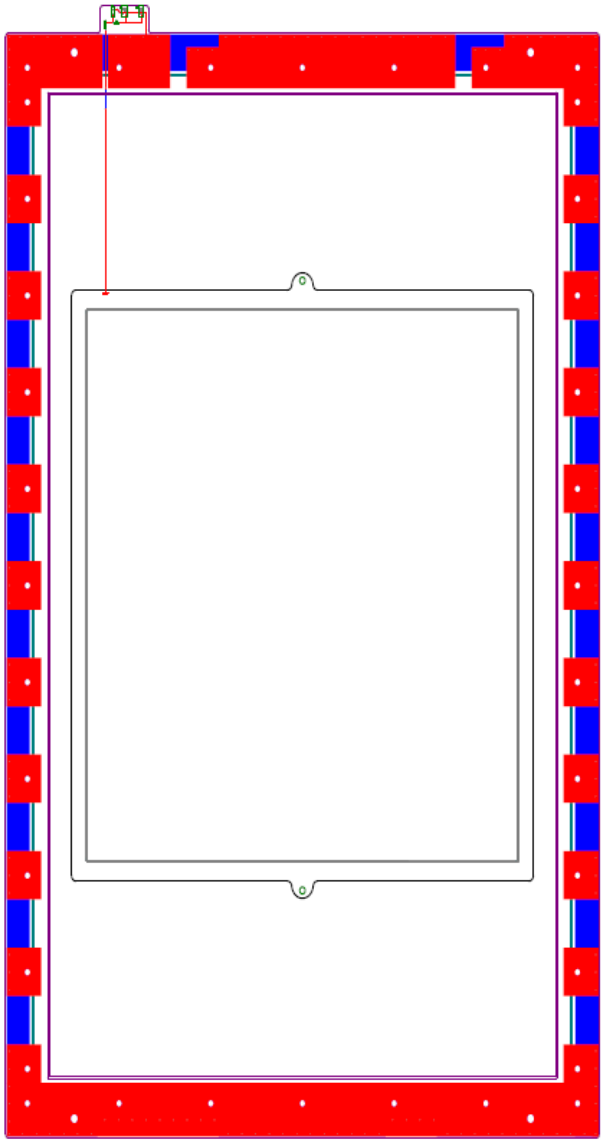

Figure 4: Technical drawing of cathode (k-plane) PCB.

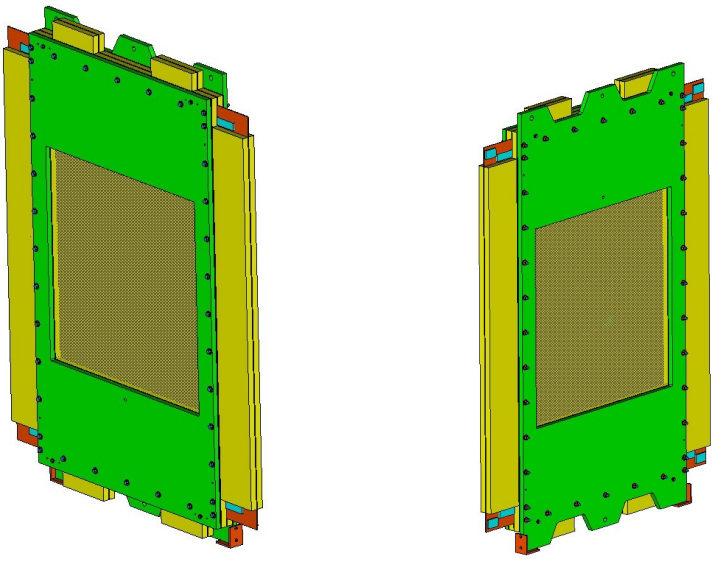

Figure 5: Technical drawing of front (Left panel) and back (Right panel) plates.

Figure 6: **Left:** Checking the wire alignments and resistance for quality assurance of completed wire planes. **Right:** Pairing of a cathode plane with a wire plane. Each completed wire plane is stacked on top of a cathode plane, before moving the pair to the detector stack. The wire plane is stacked on top, in order to ensure that the gas sealing O-ring remains in the groove on the cathode plane. The pair is then flipped with the O-ring facing down and placed onto the detector stack. From left to right is shown: Mr. Bishoy Dongwi, Dr. Pete Monaghan, Mr. Joshua McMahon, Mr. Ian Steele, and Dr. Narbe Kalantarians.

Figure 7: Distribution of high voltage to each plane.

Figure 8: Back side of Acopian power supplies showing connections to five conductor cable.

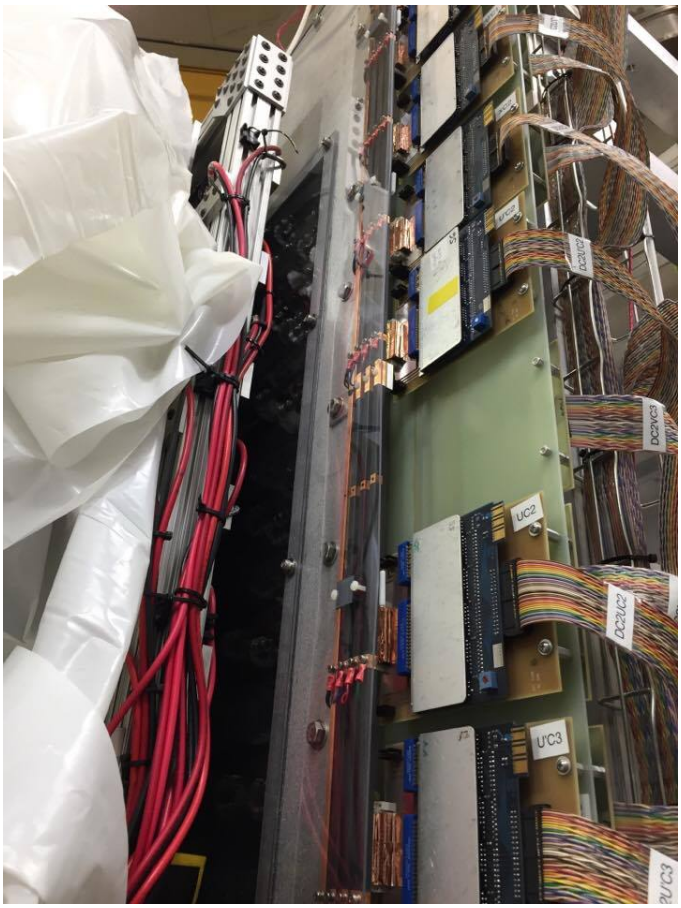

Figure 9: Low voltage distribution rails that supply +5 V and -5 V to the amplifier/discriminator cards.

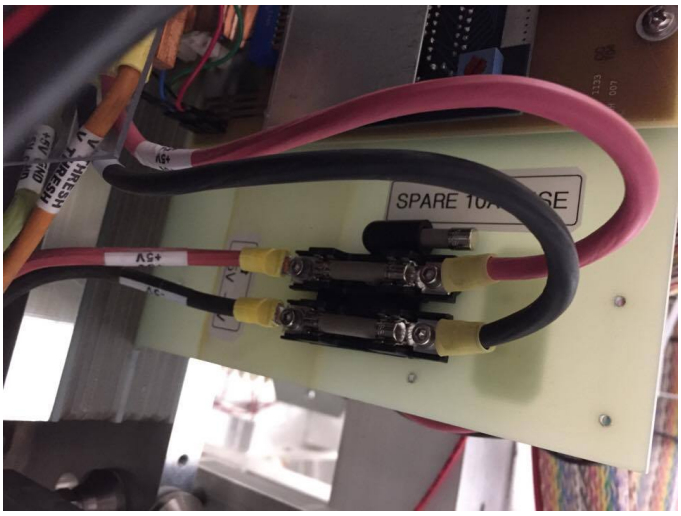

Figure 10: In-line fuses on chamber for +5 V and -5 V.

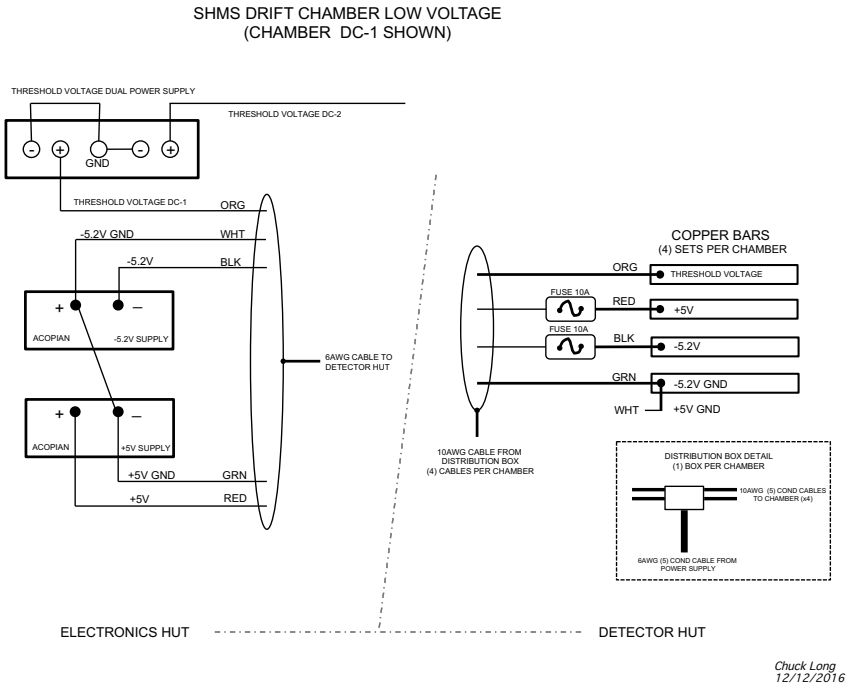

Figure 11: Diagram of low voltage distribution.