Electrical Hazard Review for the FOCUS Straw Tube System

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2. Location and Overview

The FOCUS straw tube system consists of three straw tube chambers which will be referred to as ST0, ST1 and ST2. All three chambers are located between the two analysis magnets (M1 and M2). ST0 and ST1 are located directly upstream of the proportional wire chambers P0 and P1 respectively. ST2 is directly downstream of P2. (see fig. 1) This report will treat the electrical systems in the following order: (1) readout electronics; focusing special attention on the non–commercial electronics, (2) the high voltage system, and (3) power supplies and power distribution.

3. Readout Electronics

The readout electronics for the system can be broken down into three stages. The first stage consists of preamp and discriminator cards located on top of each chamber. The second stage is ECL redriver boards which are located in a relay rack directly east of ST1 (see fig. 2). And the final stage is comprised of LeCroy model 3377 TDC's located in the counting room.

The preamp and discrminator (P/D) cards each handle 6 straw channels. The small chamber (ST0) uses 43 P/D cards and the two larger chambers (ST1 and ST2) each use 79 P/D cards. On the base of each card are sockets which accept pins from the top of two rows

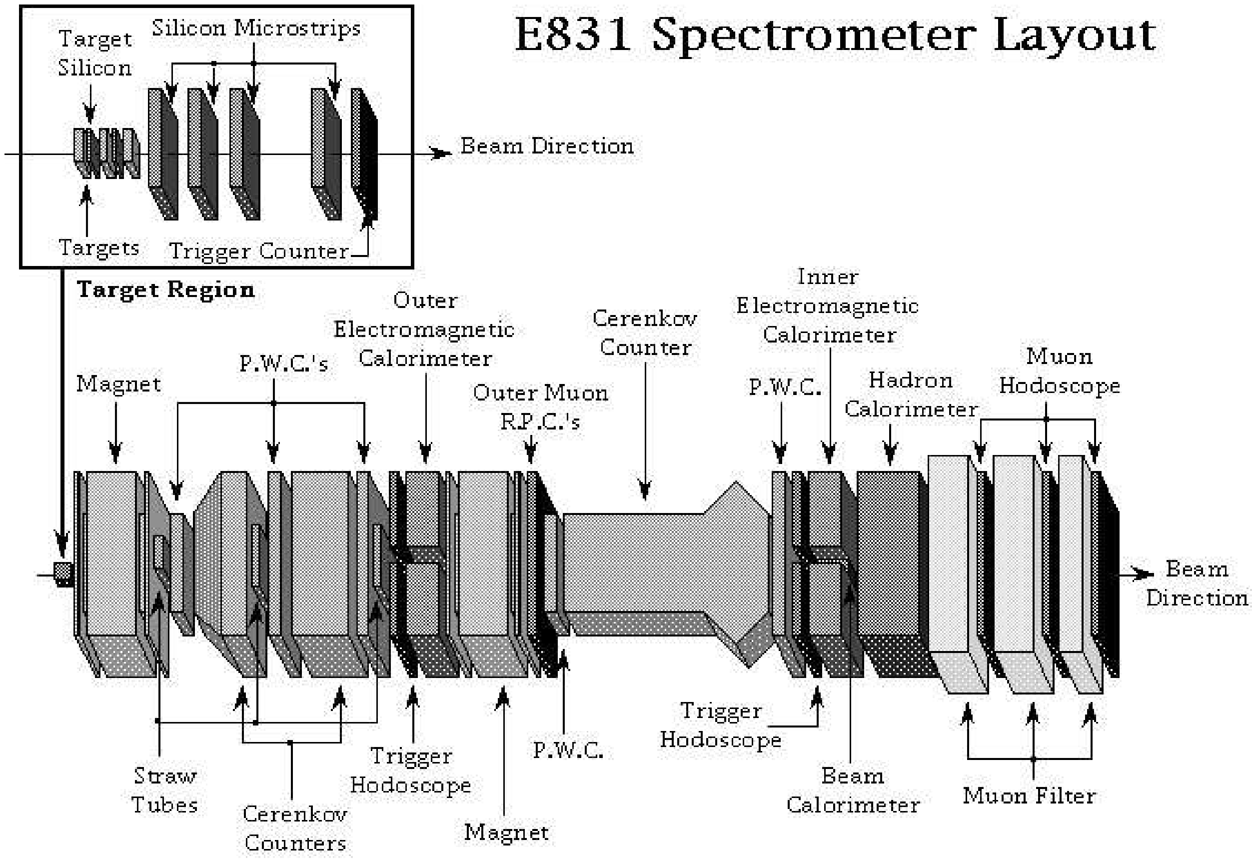

Figure 1: Top view of the FOCUS Spectrometer.

of three straws. Also input at the base of the card, via sockets, are the high voltage supply, preamp power (+6 volts input regulated to +5.0 V and fused at 1/2 amp on each card), and test lines. The base of the card also has two spring loaded ground connections. The high voltage input connection is made via two pin connections, and is distributed to straws through the 6 straw connections. The preamp circuits are coupled to the straw by a 3 kV capacitor which isolates them from the high voltage.

The discriminator portion of the card has its own ground and is coupled to the preamp via a transformer. It requires two separate power voltages (–5.2 V and +5.0 V), a threshold voltage and ground connections. These voltages are connected at the top of each card via an edge connector and each is fused on the card at a half amp. The last connection on the top of the card is the signal output. The signal is differential ECL and the signal cable is flat twisted pair. (See Appendix A for a full schematic of the P/D card.)

Under typical operating conditions one card is expected to draw current from the various voltages as follows: +6 V at 80 mAmps, –5.2 V at 170 mAmps, and +5.0 V at 55 mAmps. The cards are physically separated by about 1 cm and have cooling air flow in between. In ST1 and ST2 the air flow is provided by eleven 12 volt DC fans. Because ST0 sits in the magnetic field of M1, fans mounted on the chamber would not have worked. The cooling air for ST0 is instead provided by AC fans mounted above the support beam. The flowing air is piped down to the chamber and flows past the cards thus drawing out the air from in

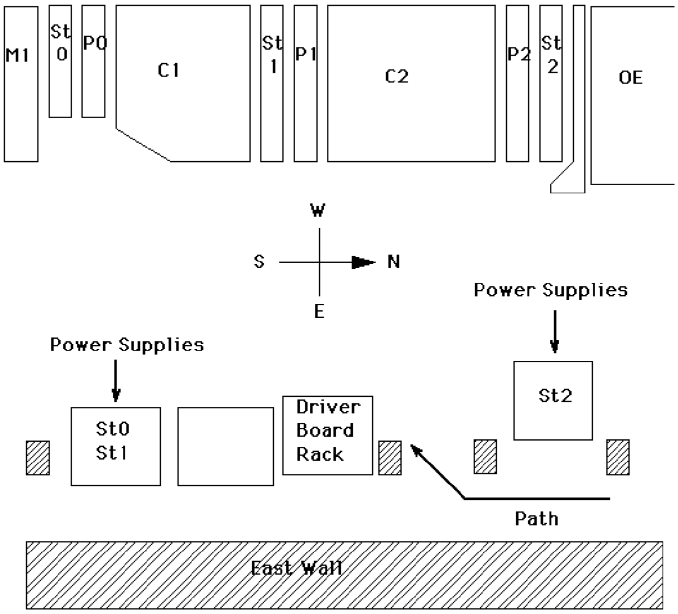

Figure 2: Locations of driver boards and power supplies in the pit.

between.

The signal is then transported via 48 feet of twisted pair cable to the redriver boards. We use 15 redriver boards in 2 VME style crates. Each board can drive up to 96 channels. The driver boards have connectors for 8 inputs each with 12 channels located along the face of the board, and there are three output connectors, each with 32 channels, along the front edge. Also there is a trigger output connector which is not used in this experiment. The power voltage, –5.2 V, and ground are connected though a 64 pin connector. The top 11 pairs of pins are –5.2 V and the bottom eleven pairs are ground. The middle ten pin pairs are for the trigger logic on the redriver board and are not used by us and therefore have no connection to the backplane. The power voltage is fused on each board with a 10 amp fuse. During normal operation each board is expected to draw 6.5 Amps (i.e. each crate will draw 45 to 53 Amps. The boards are about 4 cm apart and are cooled from below by AC fans. (See Appendix B for a full schematic of the redriver boards.)

Both the P/D cards and the redriver boards were designed by a Stanford group for use in Brookhaven experiment 871. They are currently in use there and have experienced no electrical problems.

After the redriver boards the signals travel over another 150 feet of twisted pair cable, which take them up to the south counting room. There they are received by LeCroy model 3377 TDC's in CAMAC crates. The CAMAC crates are located in RR 19 and the crate numbers are 40–42.

4. High Voltage System

The wires iniside the straw operate at a voltage of 1650 volts. That voltage is provided by a LeCroy 1440 mainframe located in the counting room (RR 48). There are 13 separate channels of high voltage, three in ST0 and five in each of ST1 and ST2. The HV is carried down to the pit on 150 foot, standard red RG58 cables with SHV connectors. At the chambers the RG58's are connected to the electronics bulkhead on the top east side of the chamber. At the bulkhead they are grounded to the chamber frame (as are the straws). Inside the bulkhead the HV is transported to a copper bus by single conductor wire rated at 17 KV. The HV is then bussed onto the P/D cards via the copper bus which has been painted with insulating paint to prevent shorts. The LeCroy 1440 is run in a current limiting mode set to trip if there is a current draw of 1 mAmp or more.

5. Power Supplies and Distribution

The low voltage power supplies for the chambers are all previously used fermilab supplies, which are rated to supply 15 Amps or less. Each chamber needs –5.2 V, +5.0 V, +6 V, and a variable threshold (0 to 25 volts). ST1 and ST2 also need +12 V for their DC fans. All voltage supplies are located in the racks indicated in figure 2, with the exception of the threshold. The threshold is located in the south counting room (RR 35). All three chamber thresholds have thier maximum set from the same supply and then individually they are fixed by a turn pot. The threshold voltages are carried down to the pit on standard green RG58 cable and then at the racks their shielding is grounded with the other supplies. The threshold voltage is bussed to the chamber on a single conductor wire.

Each voltaged is carried to the chamber on 14 gauge or larger cable. There is one cable for digital ground (return for –5.2 V, +5.0 V, and threshold) and another ground for the chamber frame (return for +6 V, 12 V and HV). At the chamber the digital voltages are connected brass bus bars that run across the top side of the chamber. Wires that connect the bus bars to the top of the low voltage distribution card are soldered to the buses. The low voltage distribution cards have edge connector for up to eight P/D cards. Each voltage on the distribution card is fused at 3 Amps. At the chamber, the +6 V wire is connected to a terminal block located on the back or the electronics bulkhead. From there individual wires carry the current to the bottom buses. The bottom bus is copper on G10 with pins that plug into the +6 V socket on the P/D cards. The +12 V is distributed to the fan leads via terminal blocks. (See Table I for specific wire gauges and currents.)

Table I: Maximum current in singal conductor wires.

Volts	Gauge	Current (Amps)	Function
–5.2	10	13.6	Supply to chamber
+5.0	10	4.8	Supply to chamber
Threshold	14	≈0	Supply to chamber
Digital ground	10	18.4	Supply to chamber
+6	14	6.4	Supply to chamber
+12	14	1.4	Supply to chamber
Chamber ground	10	7.8	Supply to chamber
+6	22	3.0	Inside bulkhead
+12	22	1.4	Inside bulkhead
–5.2	3/O	52	Supply to crate

The low voltage supplies for the redriver crates are located directly below each crate. They were scavenged from a previous Fermilab experiment. One is a 100 amp supply and the other is a 65 Amp supply. The voltage and ground each connect solid copper strips on the backplane of the crates. The legs of the top and bottom portions of the connectors (the mates of redriver board's power connector) are soldered to the copper strips.

6. Summary

Figure 3 is a schematical layout of the entire system for one chamber.

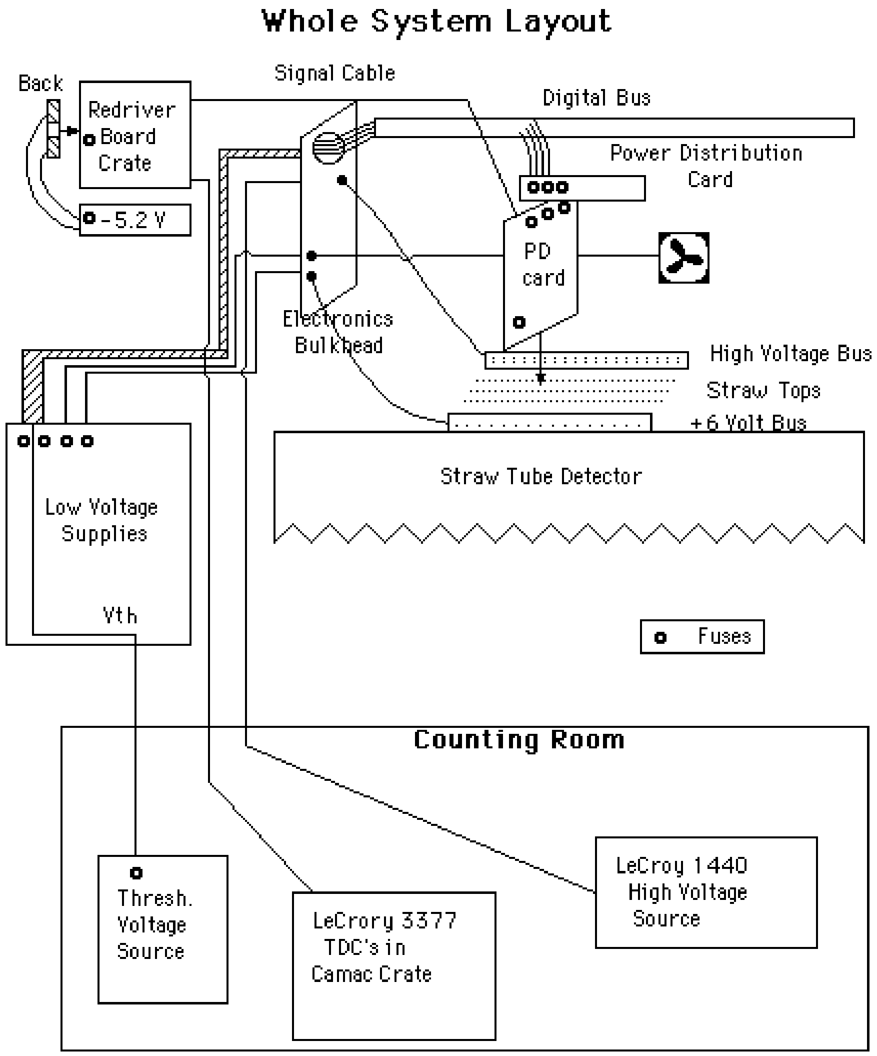

Figure 3: Schematical layout of the straw chamber electrical systems.

Appendix A:

Schematics of the Preamp and Discriminator Card

Appendix B:

Schematics of the Redriver Board