# Safety Document for the CDF Time-of-Flight High Voltage and Low Voltage Systems

**June 14, 2000**

## 1 Introduction

The CDF Time-of-Flight detector consists of 216 bars of Bicron BC-408 scintillator located between the outer can of the COT and the inner diameter of the cryostat of the solenoid. The bars are instrumented with nineteen-stage fine-mesh phototubes (Hamamatsu R7761) at each end of the scintillator for a total of 432 phototubes. The nominal high voltage setting is +2000 V, but the actual high voltage may be set as high as +2500 V for phototubes with significantly lower-than-average gain. These fine-mesh tubes can operate in the 1.4 T field of the CDF solenoid, but the gain is reduced on average by a factor of 500. Due to this reduction in gain, a preamplifier is mounted on the phototube directly behind the base. We must supply, therefore, both high voltage and low voltage to the system using cables that pass through the 30° slots. The base and preamplifiers are both custom designed printed circuit boards with surface mount components. The scintillators are packaged in triplets referred to as "three-packs." Each three-pack has three individual high voltage connections and one low voltage connection on each end of the detector. A complete description of the TOF cables can be found in CDFNOTE 5340.

## 2 TOF High Voltage System

A schematic diagram of the high voltage distribution system is shown in Figure 1. We required a system that would allow us to set individual voltages on all 432 phototubes. We selected a CAEN system that consists of three CAEN HV527 crates filled with CAEN A734P HV supplies. Each crate can accommodate up to ten supplies. Each supply has 16 channels that have been modified to reach a maximum of +3000 V. The output connectors are SHV connectors. At the nominal operating voltage of 2000 V, the current drawn by the phototube base is 200 $\mu$A.

The HV system is located on the first floor in B0 in rack 1RR04C. Red RG58C/U "noncontaminated" cables (the standard Fermilab HV cable) bring the high voltage from this rack down to patch panels located on the detector end walls. These RG58C/U cables are 80 m long and have SHV connectors on both ends.

There are eight patch panels total, each serving 54 HV channels each. The patch panels are 2U high crates and hold PVC boards that have three SHV connectors each as shown in Figure 2. There are 18 PVC boards total in each patch panel crate. The RG58C/U cables hook up on the front of the crate to the SHV connectors on these PVC boards. A custom high voltage co-axial cable manufactured by Habia Corporation is soldered to the other side of these connectors. This custom cable (Habia drawing HPD 9US6194KL-04) is 1.5 mm in diameter and has been designed to operate up to 2500 V. Samples of this cable have been tested to as high as 8000 V, and the rate of micro-discharge in this cable was measured as a function of high voltage from 0 to 5000 V. The Habia cables were selected because their small diameter met our stringent space restrictions in the slots. They were not used to go all the way to the first floor rack because they are too expensive. The Habia cables are 12 m long. They run inside the detector up to the phototubes where they are attached in triplets to an oval printed circuit board that mates with matching boards connected to the phototubes. The solder joints on the oval connector boards are covered either with RTV or with Corona dope. The oval connector boards are located several centimeters further back than the COT end plate and are not easily accessible.

On the patch panel, the solder joints on the PVC boards are covered by heat shrink tubing. There is no open access on the front of the patch panel crate, and plastic sheets cover the sides and the top and bottom of these crates (heat dissipation is not an issue).

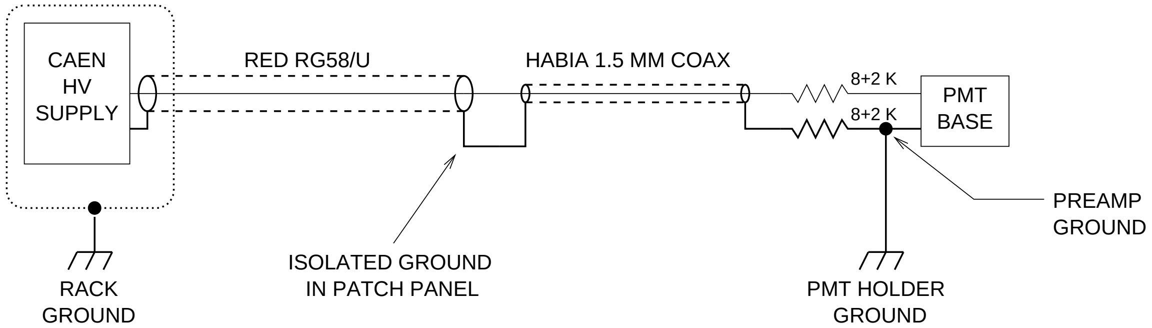


Figure 1: A schematic diagram of the high voltage distribution for the TOF phototubes.

## 3 TOF Low Voltage System

A schematic drawing of the low voltage distribution system for TOF is shown in Figure 3. The preamplifiers are designed to operate with a DC voltage of $\pm 9.5$ V. The low voltage supplies are located in two custom made modules, one on each end wall. Each module contains four 10 V, 20 A Vicor Corporation FlatPAC AC-DC switching supplies (model VI-LUM-EU-CC); two are used for +10 V and two are used for −10 V. The slightly larger voltage (10 V rather than 9.5 V) allows for some voltage drop on the cables that deliver low voltage to the preamplifiers. Each supply provides low voltage for 108 channels or 36 three-packs. There will also be a two printed circuit boards in each module that will provide filtering and fuses for the output, and voltage and current monitoring that will be read by slow controls. The input to the supplies is 115 VAC, and there is a 5 A fuse on the input. The output of the supply is delivered to the end wall by three 10 AWG wires manufactured by Carol Brand (the wires carry +10 V, −10 V, and have common return). The output has 5 A fuses at the supply, so that if cables going to the TOF are crushed causing a short, the maximum power delivered by the output is 50 Watts. On the end wall, the 10 AWG wires are connected to 16 AWG cables, red for positive, blue for negative, and black for return, manufactured by Belden Wire and Cable. This 16 AWG wire passes through the

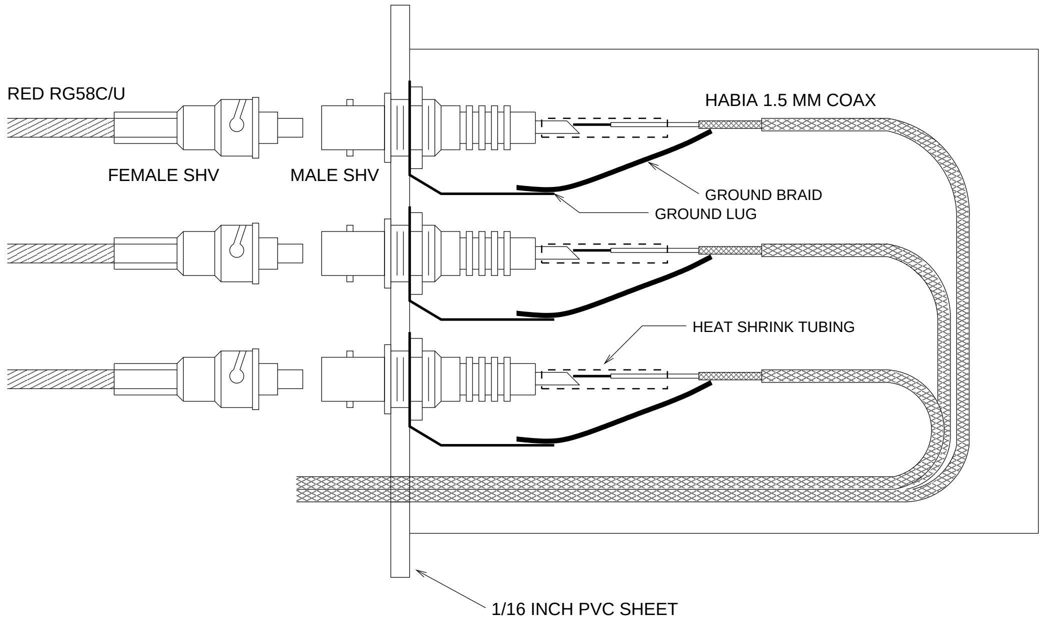


Figure 2: A schematic diagram of the high voltage patch panel PVC board and the connections to the RG58C/U cable and the Habia coaxial cable.

30° slots to the cryostat. This cable is distributed along the circumference of the cryostat and provides power for 36 channels or 12 three-packs. At each three-pack, a short 24 AWG wire assembly (again manufactured by Belden with the same color code for voltage) is spliced to the 16 AWG wire. This assembly connects to the oval board of the three-pack. On the oval board, there are 0.5 A fuses for each voltage so that if a short develops on a particular channel, only that three-pack will lose low voltage. Each preamplifier draws 75 mA of current, so the total power per channel is about 1.5 W.

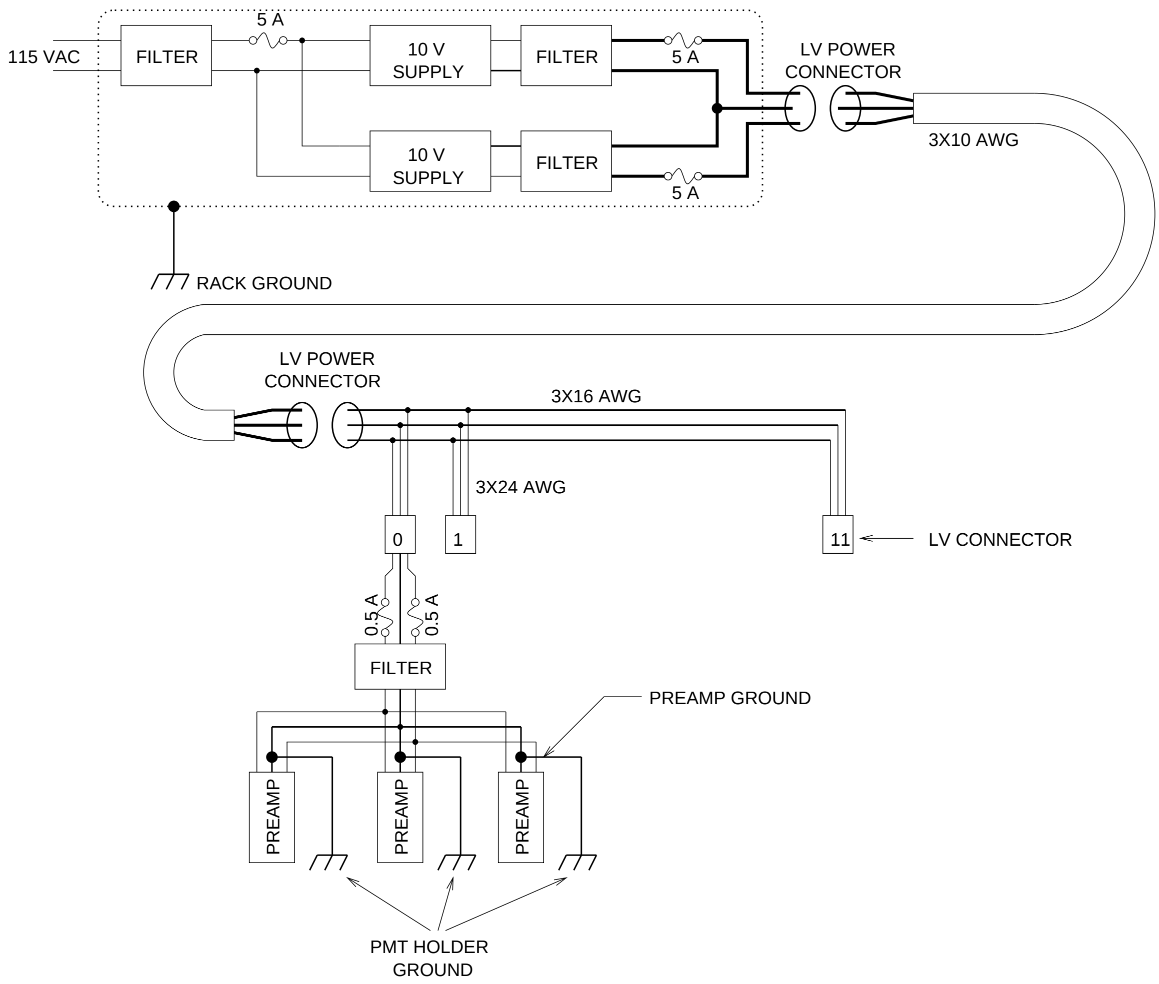


Figure 3: A schematic diagram of the low voltage distribution for the TOF preamplifiers. For simplicity, only two supplies of the four in the low voltage module are shown, and only one of six cables coming from the low voltage module is shown.