# GAIN AND THRESHOLD CONTROL OF SCINTILLATION COUNTERS IN THE CDF MUON UPGRADE FOR RUN II

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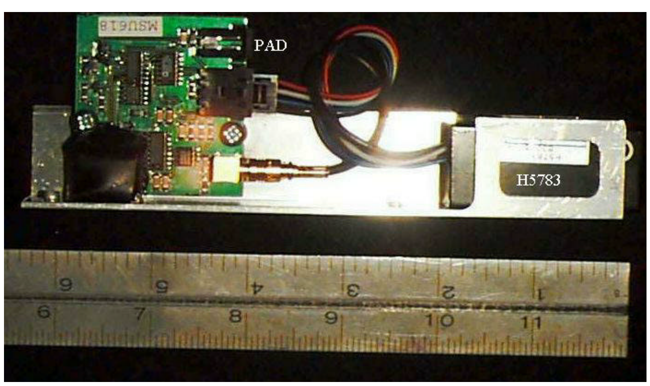
We describe a system for control and readout of scintillation counters in the CDF Muon Upgrade for Run II. In these counters, waveshifting fibers channel light to a commercial module containing a miniature (low gain) photomultiplier tube coupled to a Cockcroft-Walton high voltage generator. On each counter, we mount a small circuit with a fixed gain amplifier, discriminator, pulsed light source driver, and two digital potentiometers to set tube gain and discriminator threshold. A rack-mounted and networked control unit manages up to 48 counters, using twisted pair cables to distribute power, potentiometer settings, light source triggers, and to receive counter signals. The control units stretch and concentrate counter signals for transmission to remote time digitizers. Also, we describe a scintillation counter design that integrates the commercial photomultiplier module and our control circuit into a sturdy package.

## 1 PMT Control and Readout

In the CDF upgrade for Run II, over 700 scintillation counters fill gaps in the Run I muon acceptance and improve the rate capabilities for a forward muon trigger. To capture light in these counters, one edge of the scintillator is covered by waveshifting fibers (1 mm diameter) having one end aluminized and the other terminating on photomuliplier tube (PMT). Expensive and unwieldy light guides, HV power supplies, and HV cables are avoided by using a compact commercial module, Hamamatsu H5783, containing a miniature PMT coupled to a Cockcroft-Walton high voltage (HV) generator. The module uses DC power (+12 V) and a control voltage (0 to 1 V) to adjust high voltage between 0 and 1000 volts. At normal operating voltages (800 V), however, a single photoelectron generates a 2 mV output signal, requiring post-PMT amplification before further signal processing.




To control and readout the PMT module, we designed a small (5x5 cm$^2$) post-PMT amplifier and discriminator (PAD) circuit, mounted in a metal shielded case, or as shown below, mounted along with the PMT module on an aluminum rail. Four control

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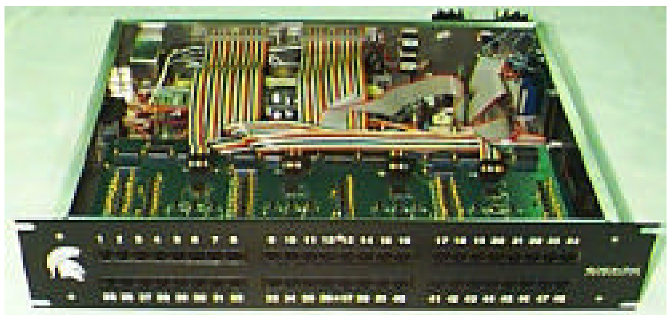
wires and a coaxial signal cable connect the PMT module to the PAD. Counter signals pass through a fixed gain amplifier, AD8015 with a differential gain of 200, and a discriminator, AD96685 with differential inputs and outputs. All communication with a PAD is through one unshielded twisted pair (UTP) cable (4 wire pairs). One pair carries emitter-coupled logic (ECL) outputs of the discriminator, while three pairs carry to the PAD power (two voltages and ground) and three signals (Clock, Select, and Data) setting digital potentiometers (AD8402, dual 8-bit serial) that control PMT high voltage and discriminator threshold. Also on the PAD is a light source driver generating a pulse (10 V, 20 ns) when triggered by the Select signal.



A 48-channel control and concentrator unit (CCU), shown below (top cover removed), supplies power with current limit protection, communicates gain and threshold settings to each PAD, receives, stretches (to 55 ns) and concentrates counter signals onto two 25-pair cables for transmission to remote time digitizers. For diagnostic purposes, a calibration input enables the PAD light source drivers to be pulsed.

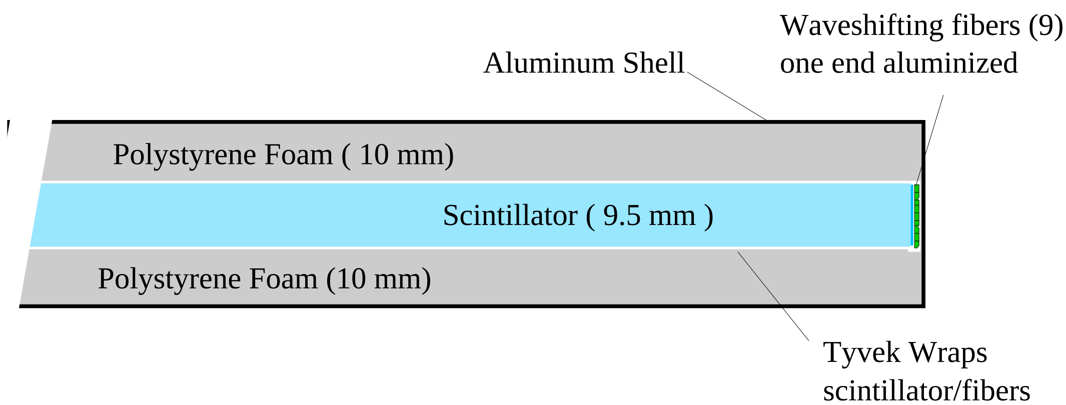
Each CCU has an onboard microprocessor (Z-World, LP3100) with non-volatile memory containing a unique address, and a program to process instructions received from a master computer on an RS485 network. Instructions are coded in a command language containing a CCU address, command, PAD number, and set values. The microprocessor stores set values and continuously compares them with active values for HV and threshold. When the set and active values differ, the new values are sent to the appropriate PAD, and its active value is updated. Thresholds and lowered HV values are transmitted to a PAD immediately, while raised HV values are ramped upward to the set value at an adjustable rate.

Using an analog to digital converter, the CCU microprocessor continuously steps through the channels monitoring the current on the +12 volt power of each PAD. When a PAD is reconnected, the transition of the current from off to on initiates a download of the values for HV and threshold to that PAD. To identify a PAD with intermittent, or out of range current, a history of these transitions is maintained by the microprocessor.

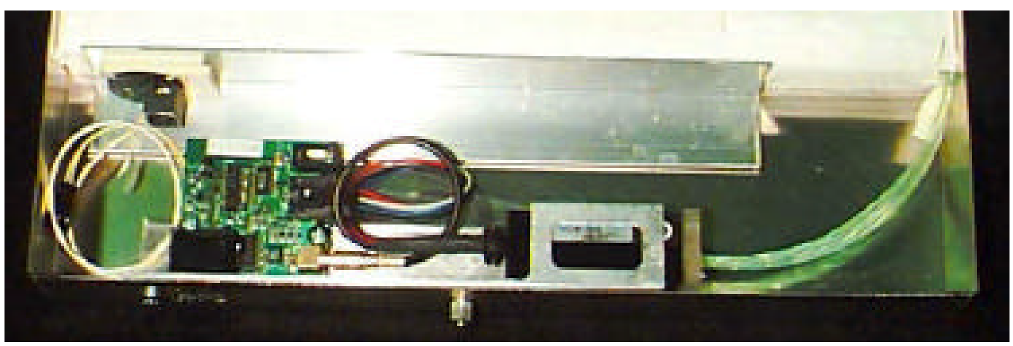
## 2 Integrated Scintillation Counter Design

In plastic scintillation counters, the scintillator is often used as structural element with light guides, photomultipliers, and associated electronics fixed or glued to it. In long counters, thick plastic scintillator is required for mechanical stiffness and for efficient production and propagation of light to a PMT, and must be wrapped with a reflective layer followed by an opaque and protective outer cover. These constraints lead to high counter costs and weight.

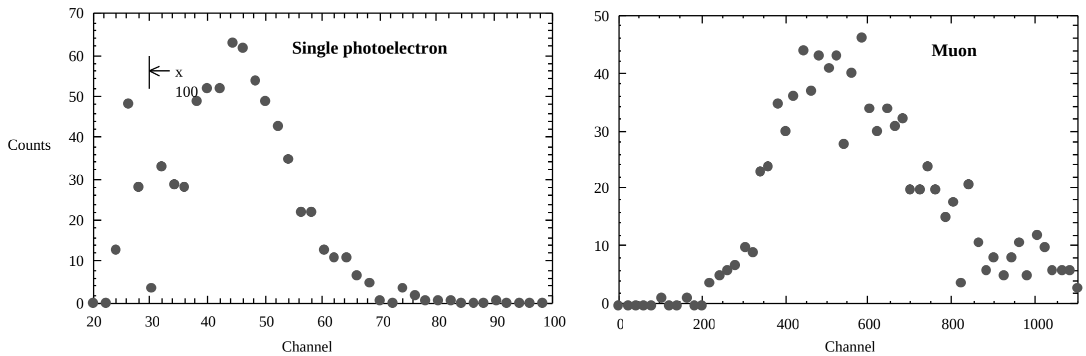
The CDF Toroid Scintillator Upgrade (TSU) counters mount on the face of an iron toroid at each end of the CDF detector, where 72 counters fill an annulus 61 cm wide, with a 365 cm outer radius. For these trapezoid shaped counters, we use fiber readout, a compact PMT, and the digital control circuitry described in the previous section. The scintillator and electronics are housed in a trapezoid shaped case made from an interlocking pan and cover of thin (0.5 mm) aluminum. The aluminum case contains, as shown below, a Tyvek wrapped package holding wavelength shifting fibers against the scintillator, 9.5 mm thick, with edges milled to shape but unpolished. This package is sandwiched between two 10 mm thick layers of polystyrene foam that define the thickness of the case, and stiffen the package.




Shown in the picture below is the last 10 cm of the aluminum case that is made longer than the scintillator to accommodate, the curved waveshifting fibers (on the right) mating with the electronics package. The external connections to the PAD are through a light sealed connector that penetrates through the case. The wrapped scintillator and fiber package is held in place by an aluminum angle that also supports a light emitting diode (on the left).



Test data from a TSU counter is shown in the figure below. The plot on the left shows single photoelectron data (taken with only a few % probability of a signal) where the pedestal region has been reduced by a factor of 100. The plot on the right shows TSU counter data taken with muon trigger using counters of the same size. This counter has a average yield of 29 photoelectrons per muon. The TSU counters have photoelectron yields in a range from 16 to 30.




## 3 Conclusion

A system was described that controls a compact PMT and high voltage generator (Hamamatsu H5783) used on scintillation counters in the muon system upgrade of CDF for Run II. A PAD circuit amplifies and discriminates the PMT signals and provides digital control of the PMT gain and discriminator threshold. A twisted pair cable carries all communication of data and power between a PAD and its CCU controller. Updates of gain and threshold received by a CCU on a slow controls network, initiate a downloaded of new values to the PAD. A CCU continuously monitors the current drawn by each PAD and a download of the most recent gain and threshold values is initiated if a PAD is reconnected. The CCU receives counter signals, stretching and concentrating them onto multi-conductor cables for transmission to remote TDC units. A modular counter design was presented, integrating the scintillator, PMT, and PAD into a sturdy package.