Testing DIRC PMTs

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10/3/2011

1 Background

ETL 9125FLB photomultiplier tubes (PMTs) were obtained from the DIRC detector at SLAC. These PMTs had been submerged in ultra-pure water for an extended period of time, resulting in corrosion of the glass face. Cracks in the face of a PMT would lead to a loss of vacuum, rendering the PMT nonoperational. To ensure the longevity and durability of the DIRC PMTs, small glass circles were glued to the faces. After gluing, the PMTs required testing to guarantee adequate performance.

2 Required Equipment

The following equipment was used to test the PMTs:

- Dark box with high-voltage input and signal outputs
- Power supply
- Amplifier
- Fan in/out
- Attenuator
- Discriminators
- Oscilloscope
- Scalers
- Pulser
- DIRC PMTs with high-voltage bases

3 Setup and Procedure

The setup used for testing is shown in Figure 1. The dark box is designed to supply high-voltage to four PMTs at a time with a single high-voltage input. There are four signal outputs, one for each PMT. The signal travels from the dark box to an amplifier, where it is amplified by a factor of 10. The amplified signal goes directly to the oscilloscope, and also to a fan-in/fan-out module. From the fan-in/fan-out module, three copies of the signal go to an attenuator, where each copy is attenuated by a different amount. The first copy is attenuated by 1.0 (no change), the second by 0.5, and the third by 0.3. The three resulting signals now have amplitudes that have been amplified and attenuated to be a factor of 10, 5, and 3 times higher than the original signal. The 10x and 5x signals travel to a discriminator with a 100 mV threshold, so that the original signal will only be counted if its amplitude is higher than 10 mV and 20 mV respectively. The 3x signal travels to a discriminator with a 10 mV threshold, so that the original signal will only be counted if its amplitude is higher than 3.3 mV. Each signal then goes directly to a scaler. The output of a 10 kHz pulser is used to provide a 10 second gate for the scalers.

The design of the dark box allows one to test four PMTs at a time. Before testing, the face of each PMT is first visually inspected for excessive corrosion and sloppy gluing. Each PMT is connected to a high-voltage base, which is then connected to the high-voltage and signal cables inside of the dark box. After closing the dark box tight, a thick blanket is used to cover the box in order to minimize any light leaks. The high-voltage is switched on and set to 1.0 kV ONLY after the PMTs are submerged in complete darkness (turning on the high-voltage with the PMTs exposed to light will damage them).

When the PMTs are first placed into the dark box, there dark count rate will be relatively high. The dark count rate significantly decreases with time until leveling off after about 1 hour (see Figure 2). So after switching on the high-voltage, one must wait about an hour before obtaining acceptable test results.

To begin testing each PMT, the high-voltage is adjusted so that the amplitude of the single photo electron signal is 40-60 mV (4.0-6.0 mV amplitude for the original, unamplified signal). The oscilloscope is used to observe the average height of the signal. The trigger threshold of the oscilloscope should be set to 10 mV (a 1 mV threshold for the original, unamplified signal). Next, the scalers are used to determine the dark count rate with (original) signal amplitude thresholds set at 3.3 mV, 10 mV, and 20 mV. The output of a 10 kHz pulser is input into the right side of the scalers, and the "predet" is set to 5. As a result, when the"gate" button is pushed the scalers will count until the pulser input reaches 10e5 counts (which will take exactly 10 seconds). During this 10 second gate the scalers will count the number of signal inputs. The dark count rate is determined by dividing the number of counts recorded by 10 seconds. The original signal cable is then switched to the next PMT and the procedure is repeated. During testing the following should be recorded:

- PMT number
- High-voltage setting
- Average amplitude of single photo electron signal
- 3.3 mV dark count rate
- 10 mV dark count rate
- 20 mV dark count rate
- Visual inspection
- Any comments

PMTs are considered to be bad if they have excessive visible damage, or if they have a 3.3 mV dark count rate higher than 2 kHz. In September of 2011, 104 PMTs were tested, 87 of which had adequate performance and acceptable corrosion/gluing.

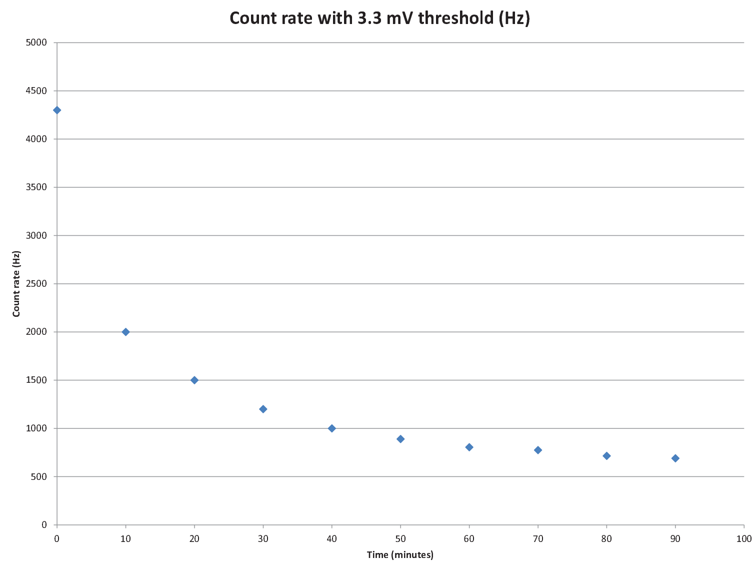

Figure 1: PMT time-dependent dark count rate (3.3 mV threshold)

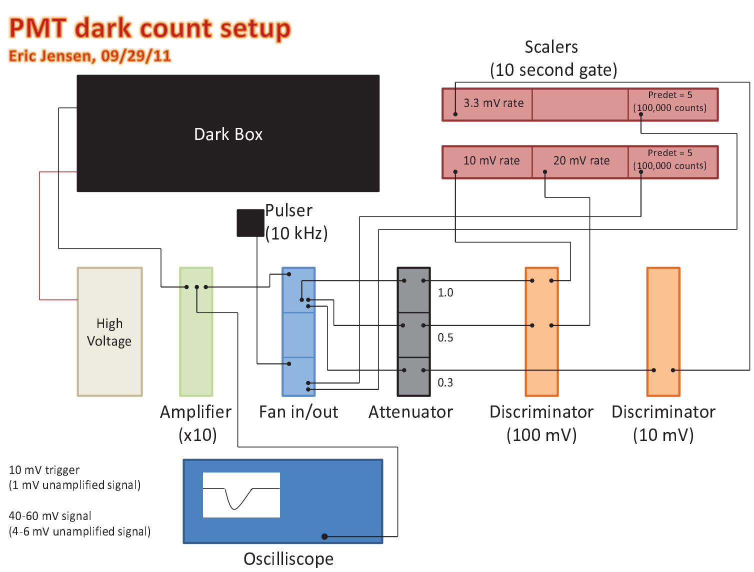

Figure 2: Setup used for testing PMTs