P.16 Dark Aging of the Jefferson Lab Machine Protection Beam Loss Monitors

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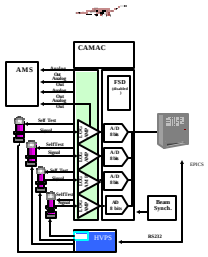
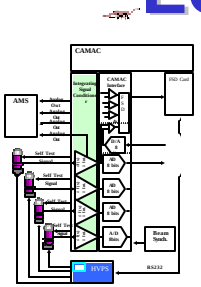


Block Diagram of a typical diagnostic beam loss monitor system.



Block Diagram of a typical machine protection beam loss monitor system.

The Jefferson Lab machine protection beam loss monitors use a photomultiplier based sensor to detect the particle shower that results from prompt ionizing radiaiton due to beam loss.
Trade-offs between sensitivity and false trips are always a concern for such systems. Systematic dark aging of the PMTs allows high sensitivity with little to no degradation in gain characteristics.

The JLab beam loss monitors had the following requirements:

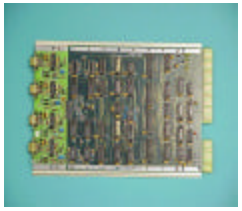
- Fast Response < 10 us
- Low False Trip Rate in a low background radiation environment (< 1Gy) < 1×10^{-3} per day per sensor
- Low Maintenance after installation
- Long Life in rad environment

Experiments both at the Jefferson Lab test lab and the Riverside Hospital oncology accelerator verified the ability to forgo using a mediator such as a scintillator and use the Cerenkov light produced in the PMT glass envelope itself the primary photon source. This greatly simplifies the PMT assembly but raises concerns over the sensitivity of such an arrangement.

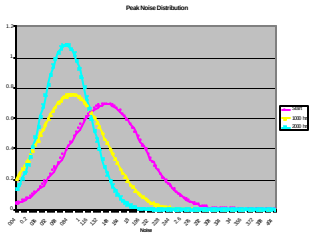
The value of dark Aging photomultipliers has been well established. The Safety Systems Group at JLab set out to establish a program to dark age the over 180 loss monitors in situ. The results, shown in the figures, indicate a significant decrease in noise floor. This has allowed the JLab tubes to be operated at a higher sensitivity while maintaining a low false trip rate.

The dark aging process takes advantage of the programmable high voltage power supplies and the on board analog to digital converter of the BLM system. Tubes are typically processed after installation. They are then periodically checked to verify both noise floor and signal response characteristics.

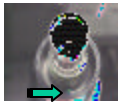
PMT Tube Assembly



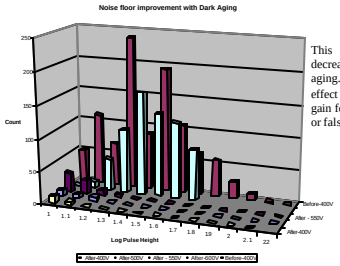
BLM Electronics Signal Processor



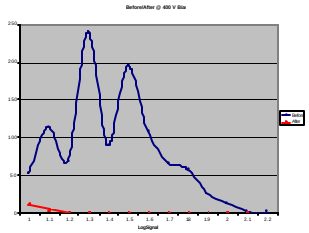
Dark aging naturally occurs in situ. This figure shows the change in the noise floor distribution of 24 tubes which were operated at the nominal operating voltage of 600 Vdc. Over a 3 month time span the average noise floor was reduced while the distribution also decreased.



Tube gain is tested using the built-in self test LED both before and after the aging process

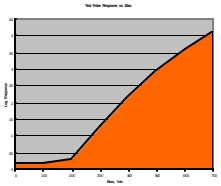


This figure shows the dramatic decrease in noise current after dark aging. The reduction in noise in effect allows operation a higher gain for a given signal to noise ratio or false trip rate.



This figure show the dramatic decrease in noise floor achieved through accelerated dark aging. The data was taken before and after at a bias voltage of 400 Vdc. The aging was performed on the test bench and the performance verified in the accelerator installation. The tubes were aged at 1300Vdc for 72 hours.

Beam Loss Monitor operator screen showing the real-time response of many of the 180 systems. Both diagnostic and machine protection BLMs are shown.



Amplitude response of the LED test pulse vs. Bias voltage.

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