Tri-Main Center
Suite 409
2495 Main Street
Buffalo, NY 14214
716-885-4701

TEACHSPIN
Instruments Designed For Teaching

Muon Physics

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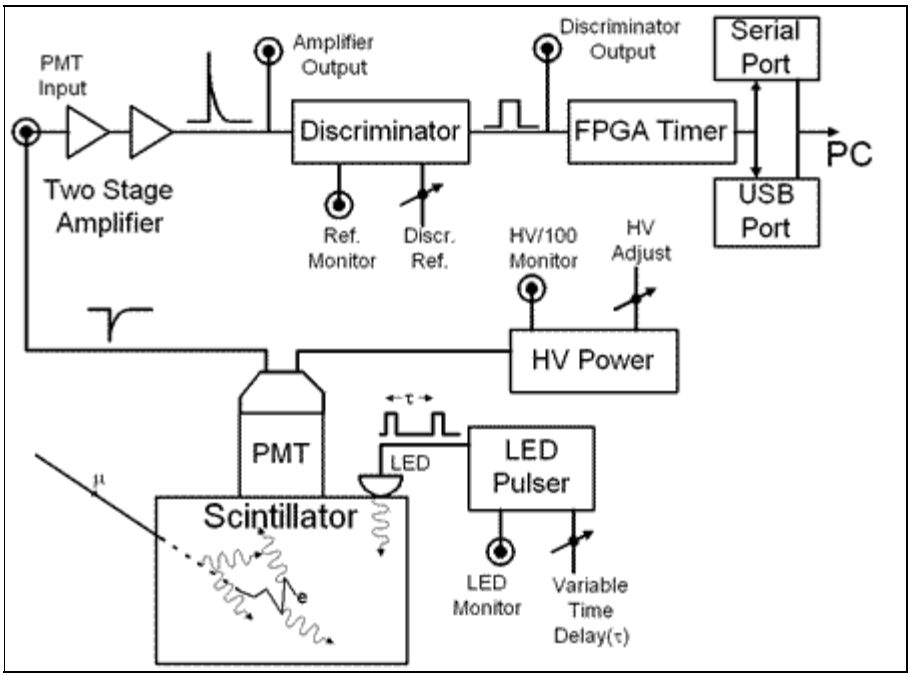
Newsletter 1 – Muons on Parade
Newsletter 2 – More About Muons
Conceptual Introduction – Muon Physics

Block Diagram for Muon Hardware



The Hardware

The complete instrument has three hardware components: a detector, readout electronics and user-supplied personal computer (PC). Control and data acquisition software are also included.

Detector Module

A 16.5 cm diameter by 36 cm tall black anodized aluminum cylinder houses the entire detector module including the plastic scintillator, photomultiplier tube (PMT), and high voltage supply (HV) as well as electronics for an imbedded light emitting diode (LED). The scintillator, a right circular cylinder, is optically coupled to a single 5 cm diameter 10-stage PMT. Because all of the circuitry for the PMT is mounted inside the aluminum cylinder, there are no exposed HV electrodes. The HV is manually controlled and monitored by external controls. The thickness of the scintillator assures that either muon passage through or decay within the scintillator produces a quantity of light well above the PMT threshold. The imbedded LED can be driven by the adjustable pulser to mimic muon decays and to test the readout electronics. Inside the aluminum cylinder, light tight wrapping on both the scintillator and PMT prevent light leaks.

Electronics Module

The electronics module houses all electronics needed to run the experiment. Connections on the front panel allow students not only to examine the PMT signal itself, but also to monitor that signal as it moves along the readout chain.

PMT pulses are first amplified and compared against an adjustable threshold. Pulses above threshold are sent to timing circuitry implemented in a field programmable gate array (FPGA) chip. The first flash of the scintillator starts the timing system. If a second flash occurs within 20 microseconds of the first, the readout electronics measures the time between the two flashes and passes that time to the lifetime display software.

If no second flash occurs within 20 microseconds, the pulse is simply recorded as a charged particle that has passed through the detector. Communication circuitry transfers the data to a PC or laptop through either a serial or USB port.

The Software

Data acquisition of muon decay times is computer controlled to eliminate the tedium of recording numbers and to permit extended data collection times. The decay time histogram is automatically updated with data from the readout electronics. Important display features like the histogram bin size and the logarithmic/linear axis type remain under user control. A password-protected built-in curve fitting algorithm allows for easy determination of the muon lifetime while still maintaining instructor control. Various rate monitors indicate quantities like the instantaneous and time averaged trigger rate, the total number of recorded muon decays and the elapsed time for data acquisition.

Raw data are written to disk files in a compact format so that students can export them to their own software package and not rely on the one provided. Simulation software allows the creation of decay time distributions with a user-adjustable muon lifetime. Source code for data acquisition, plotting and simulation is written in the Tcl/Tk scripting language and is provided free of charge so motivated students can modify the user interface or the built-in lifetime curve fitting algorithm.

The software is distributed on a CD and runs under Microsoft and Linux operating systems. The program requires 100 Mbytes of disc space and 32 Mbytes of memory. It was written to work well with an Intel 133 Mbyte processor. Free updates are available via the World Wide Web.

Detailed technical information and a copy of the user's manual for Muon Physics can be found at www.matphys.com. The website is maintained by Professors Thomas Coan and Jingbo Ye of Southern Methodist University, with whom TeachSpin collaborated in developing this exciting apparatus.

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