IMPORTANT: READ BEFORE STARTING MUON LIFETIME EXPERIMENT

1. Note on Lemo connectors

Most connectors in this experiments are sub-miniature push-pull Lemo coaxial types. **CAUTION** - Handle the Lemo connectors with care – the cables are easily destroyed. To remove a cable, always **grasp the knurled sleeve** close to the panel - NEVER THE CABLE - and gently squeeze the connector free, then pull straight out. When inserting a cable push gently in until you hear, or feel, a click.

2. BNC connectors to scope

Throughout the setup procedure it is essential to use the fast Tektronix oscilloscope to check the signs, amplitudes, occurrence rates and timing relationships of the pulses into and out of each component of the electronic system. Please note that the BNC inputs to the scope are relatively weakly connected to it's internal circuit board and thus are succeptible to damage when attaching and removing cables. Short leads have 'permanently' attached to the inputs on channels 1 and 2. Please do not remove the leads but rather just connect your cables to the ends of these 'pig-tails'.

3. 50 Ohm terminations

Since you are aiming to measure time differences of the order of the travel time of light across the detectors (<10 nanosec), all the circuits up to the MCA must have "rise times" substantially shorter, which means that you must use very high sweep speeds on the oscilloscope in order to perceive whether things are behaving properly. To avoid confusing reflections from the ends of cables, it is essential that all cables carrying fast pulses be terminated at their outputs by their characteristic impedance of 50 ohms, either with a terminating plug on a T-connector, or by an internal termination at the input of a circuit.

4. Coaxial cables: Signals are carried from the detectors to the measuring circuit by coaxial cables which confine the signals and protect them from stray electric and magnetic fields. A coaxial cable consists of a thin inner conductor and a cylindrical, coaxial outer conductor that is usually made of braided wire and is flexible. A coaxial cable can be completely characterized by two parameters -- the inductance per unit length L and the capacitance per unit length C. From L and C you can calculate v the speed of propagation of a signal on the cable and Z_o the characteristic impedance of the cable:

$$v = 1/\sqrt{(LC)} \qquad (1)$$

$$Z_o = \sqrt{(L/C)}. \qquad (2)$$

For the cable most commonly used in a research lab RG58u, a handbook gives $C = 93.5 \times 10^{-12}$ F/m and $Z_o = 50$ ohms. Substituting these values into Eqs. 1 and 2 we find $v = 2.14 \times 10^8$ m/s, about 70% of the speed of light. This gives a transmission delay of 4.7 ns/m.

When using coaxial cables it is usually important to avoid reflections at the end of the cable. If a cable is terminated with an impedance Z , the ratio of the incoming voltage V_i to the reflected voltage V_r is given by

$$V_r/V_i = [Z - Z_o]/[Z + Z_o]. \qquad (B3)$$

The total voltage across the terminating resistance is $V = V_i + V_r$. Three cases are of interest:

1. $Z = 0$: Then $V_i = - V_r$ and $V = 0$, as you would expect for a short circuit.
2. $Z = \infty$: Then $V_i = + V_r$ and $V = 2 V_i$.
3. $Z = R_o$: Then $V_i = 0$ and $V = V_i$.

When $Z = Z_o = 50$ ohms, the cable is properly terminated and there is no reflected signal.

Proper termination is also important for maintaining the lineshape for sharply rising pulses; if the termination is not proper, the rise and fall times for a square pulse will be slowed and the pulse will be broadened.

Try observing the effect of different terminations using the fast scope.