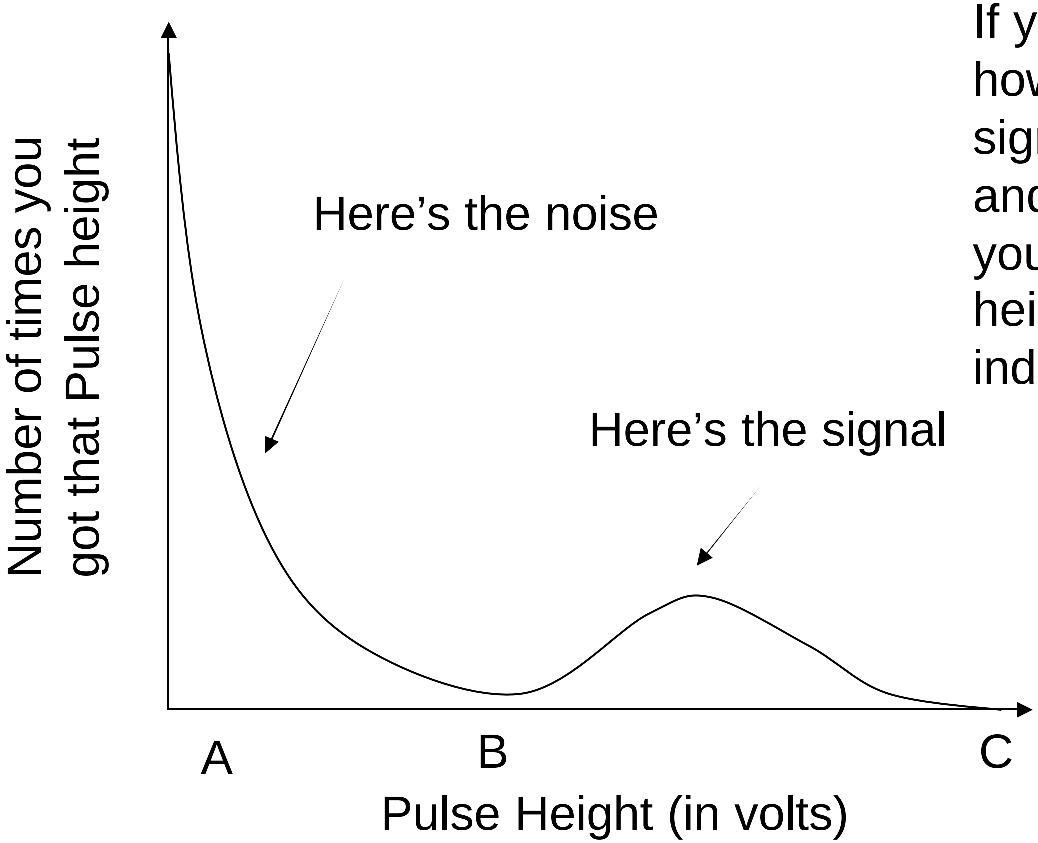
What’s a Counter “Plateau”

An introduction for the muon Lab

Counters have noise and signal

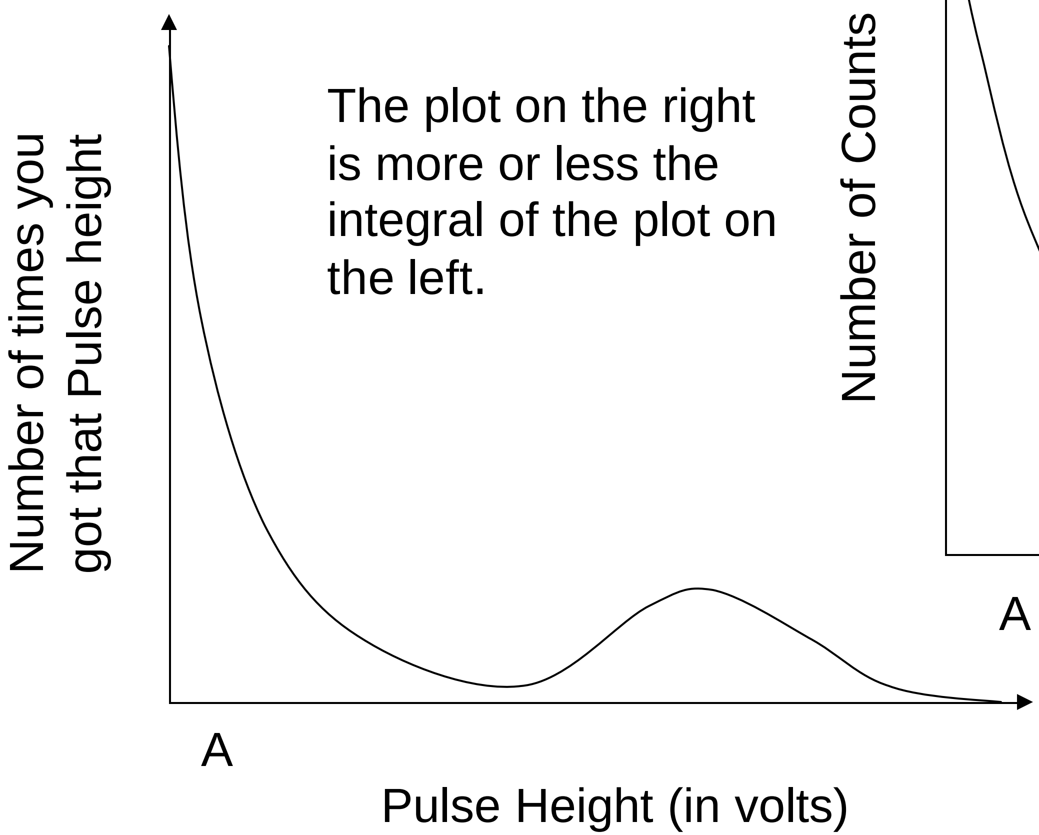
If you are lucky, a histogram of the pulse heights of all the signals coming out of a photomultiplier tube connected to a particle detector may look like:



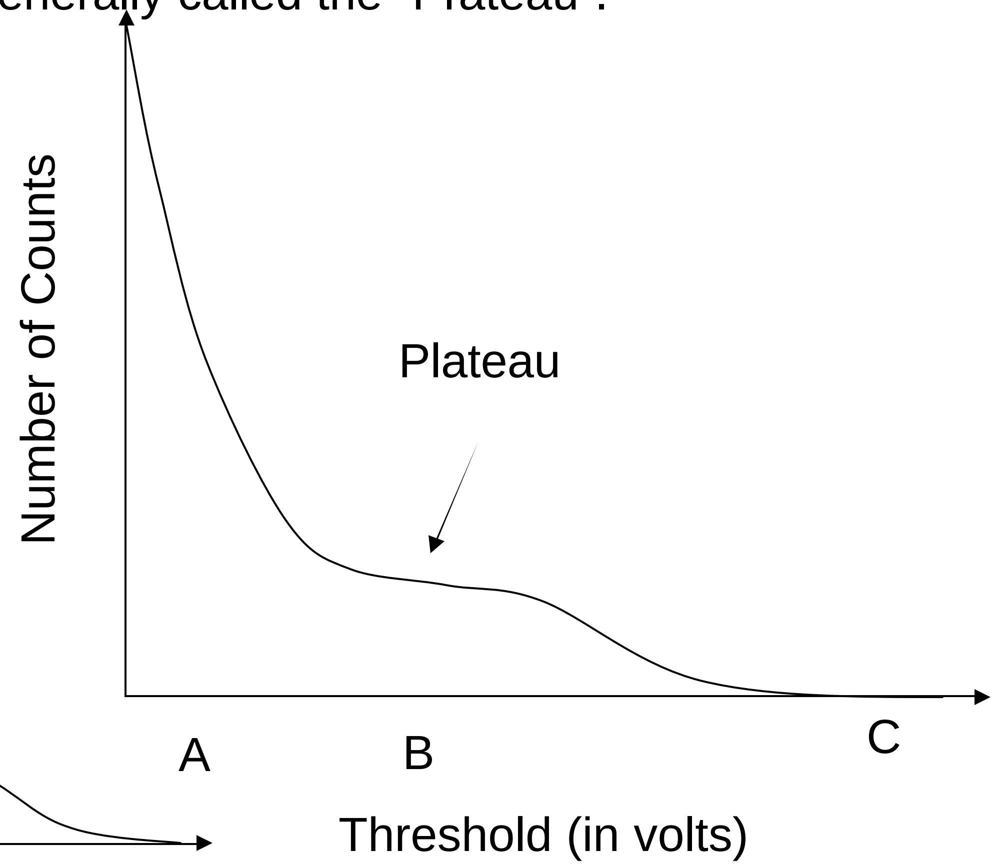
If you were just interested in how many times you got a signal, it makes sense to try and count how many times you got a signal with a pulse height greater than that indicated by "B" on the x axis.

Let's say you do just that. Count all the times there was a pulse with height greater than "B" volts. The point "B" then represents the "threshold" where counting starts.

If you now move this threshold around, and see how many times you get a pulse height greater that a certain value, you may see something like the plot on the right. There is a point around B again, where the number of counts is fairly flat as a function of the threshold you chose. In fact, it looks sort of like a plateau. The area where the number of counts is fairly insensitive to the place where you set a threshold to start counting signals, is generally called the “Plateau”.



The plot on the right is more or less the integral of the plot on the left.



The Muon Lab Plateau

-In the muon lab, you'd like to try and find the correct place to plateau the counter. That's what setting the threshold and the Tube Gain are all about in the set up. You have to set the Tube Gain (This is controlled by a high voltage.) high enough so that the signal is at the very least greater than the minimum threshold of the discriminator (where the tube pulse is converted to a logic signal if the pulse height exceeds the threshold). But……

- -There is a complication! Since you are looking at particles that stop (somewhere!) in the Scintillator part of the detector, the signal is not as pretty as in the idealized picture.
- -There is a complication! You are actually looking at 2 signals: the incoming muon, and the decay electron.

-You need a better way to find the particle plateau. Consider:

- -Noise is supposed to be random. If you plot the time between random pulses, it looks like an exponential that decays as the noise rate.
- -The signature of a muon decay is 2 pulses, on average about 2.2 micro-seconds apart. If you plot the time between pulses from a muon decay,it looks like an exponential that decays as ~1/2.2 microseconds.
- -If you could just plot the noise *rate*, you'd get the number of noise counts in a certain period of time.
- -BUT!!! If you plot just the signal rate, you'd get a few every minute.

What rate is what?

-The rate at which cosmic ray muon’s arrive at the detector is more or less constant.

-The rate at which we detect these muons is adjustable via the tube gain and the threshold voltage. We expect a few a minute.

- But the rate at which muons decay is set by the physics

-The rate at which we get random noise in the detector is adjustable via the tube gain and the threshold voltage. (Though there will be some irreducible (small) accidental noise due to getting more than one muon in the detector.)

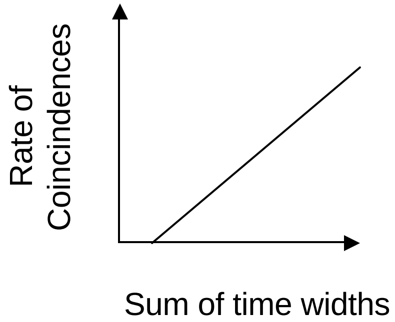
So, what we need to do in the setup, is to make sure the rate of noise and signal in the setup has the following properites:

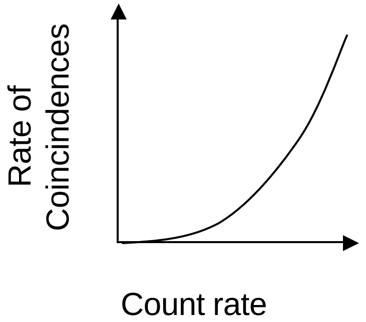
1) Has to have a rate very different that the decay rate of the muon, or we won’t be able to disentangle the the exponential from the noise and the muon decay
2) The noise has to have a rate much lower than the rate at which muon decays are detected. We want our data to be mostly signal!

Bottom line: Get rid of the noise, save the signal.

Now you are ready to set up

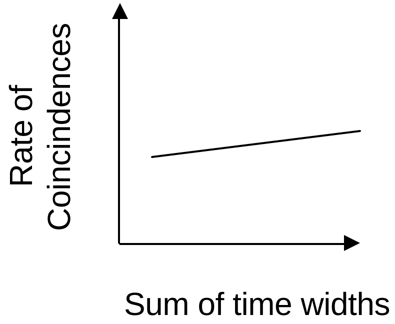
In the express set-up, the method to describe noise is detailed:
Accidental Noise Rate ~
Count Rate*Count Rate (sum of time widths used for coincidence)
And we might expect the following behavior in a detector dominated by accidental coincidences:

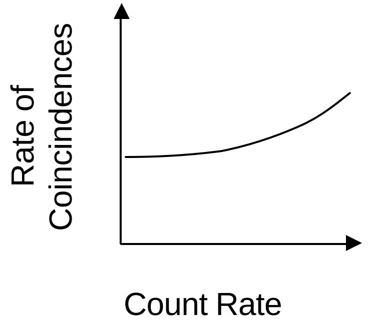




The "count rate" is any time we got a signal above threshold in the discriminator.

While we might expect the following behavior in a detector with muon decays present, where we have tried to reduce the noise





Mathematically, the "Rate of Coincidences" = Rate of Muons that decayed + Accidental Rate