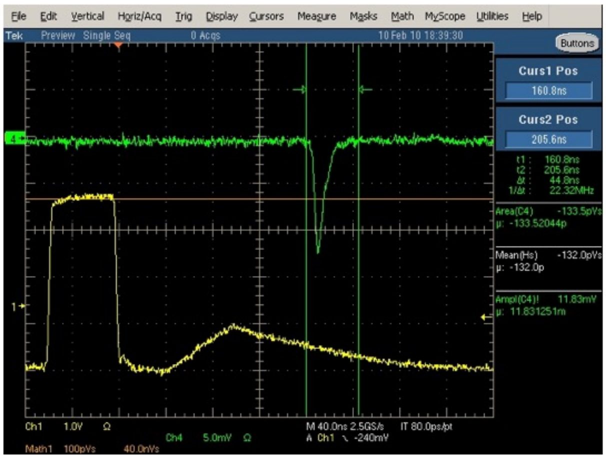
Radiation Detector 2018/19 (SPA6309)

Signal processing

Amplifier



The signal from detectors is an electric pulse, typically few ~ns width and few mV height (either positive or negative). **Amplifier** increases the size of the signal. A larger signal has many benefits, for example, it is more sustainable for biases by transmission of cables, thus **preamplifier** is often located near the detector itself, and not at electronics complex which is sometimes very far from the detector.

Discriminator (Leo, 14.9)

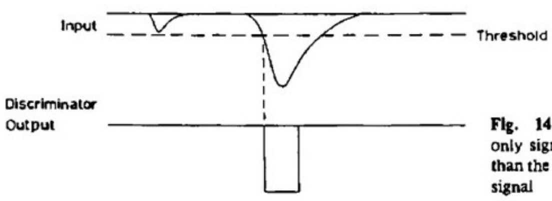
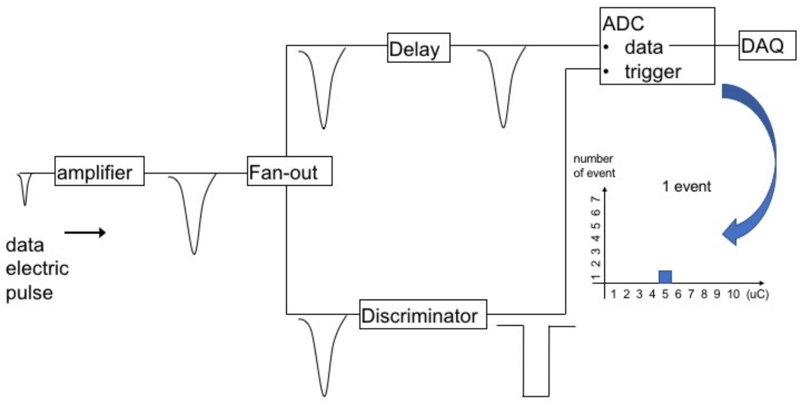


Fig. 14.14. Discriminator operation: only signals whose amplitude is greater than the fixed threshold trigger an output signal

Discriminator makes a block signal (**logic signal**) from an **analog signal.** The height of the outgoing signal and condition to make the signal can be adjustable. These block signals are often used for trigger condition of the detector.

Analog-to-Digital Converter (ADC) and Data acquisition system (DAQ) (Leo, 14.11)

Analog-to-Digital Converter (ADC) is the heart of the electronics complex, which is connected to **data acquisition system (DAQ)**. The **dynamic range** of ADC needs to be set correctly. In the previous example (Lecture 6, Detector concept), Analog input is 5 μC, and data spans 3 to 10 μC. 5 bits ADC can record from 0 to 255. If the 255 of ADC channel corresponds to 3 μC, you don't record anything and all data are **over flow**. On the other hand, if the 1 of the ADC channel corresponds to 10 μC, all data are below 1 and data are **under flow**. Namely, ADC needs to be adjusted so that 3μC to 10μC are nicely fit within 0 to 255 of ADC channel. For example, if one channel is set to 0.1 μC, then the data of 3μC to 10μC will be fit within 30 to 100 of ADC and correctly recorded in DAQ.



Amplifier, **Fan-out**, discriminator, ADC, and DAQ can make a simple data taking system from a detector. A pulsed signal is split to 2 by Fan-out, then one signal is converted to a logic signal by a discriminator, which is used to trigger the ADC. The split signal should experience some **delay** (this can be done simply by adding a long cable) so that it arrives at the same time with the trigger signal (trigger signal is bit slower because it is processed by a discriminator unit).

Concidence unit (Leo, 14.17)

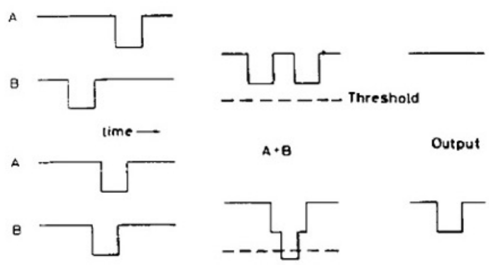
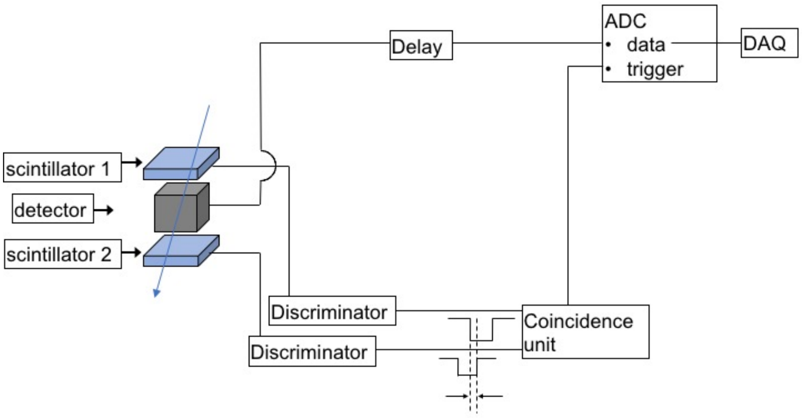


Fig. 14.23. The summing method for determining the coincidence of two signals. The pulses are first summed and then sent through a discriminator set at a level just below twice the logic signal amplitude

Coincidence unit is an essential module for the modern fast physics. It compares the timing of 2 signals and produces a logic signal based on their overlap. This unit works as a logical **AND** operation.

Using a coincidence unit, one can set up a simple detector measurement with cosmic rays. Coincidence signals from scintillators can be used to produce a trigger signal to record the data of the same cosmic ray in the detector.



Electronic logics (Leo, 16)

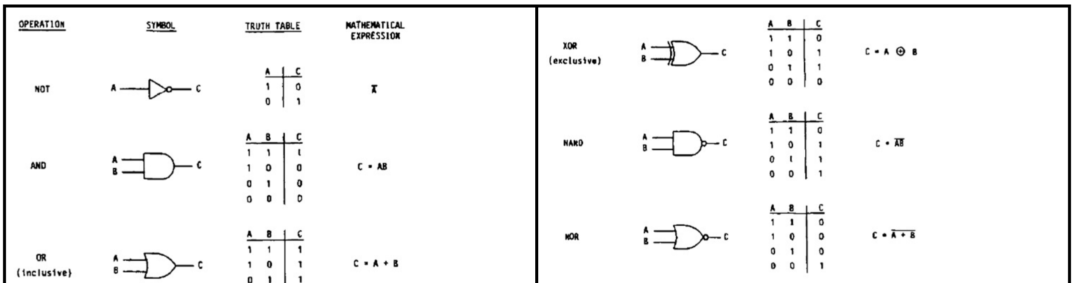
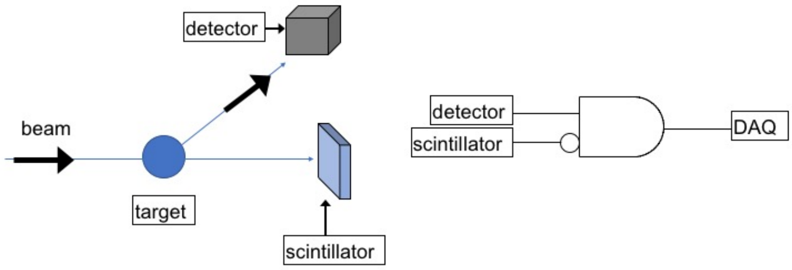


Fig. 16.1. Truth tables and electronic symbols of some common logic gates

Electronic logic symbols are often used for electronics. A simple set up to measure scatterings of beam particles can be done by using a scintillator as an "anti-trigger", namely, data are taken only if the scintillator provides a null signal. This can be simplified by using electronic logic symbols (AND and NOT).



Printed circuit board (PCB) and field-programmable gate array (FPGA)

In modern radiation detectors, all of the electronics are integrated on a circuit board. Once electronic is designed, locations of components are printed on a printed circuit board (**PCB**), and desired electronics scheme is made by combining different circuit boards. However, the latest designs even don't need many circuit boards, but one. Because you can program functions of an amplifier, discriminator, coincidence unit, fan out, etc, on **field-programmable gate array (FPGA)**, sometimes just 1 circuit board with an FPGA can replace all electronics complex!