Lab 2 - Tuesday

Counting Statistics and Signal Processing Electronics Ch. 3
Laboratory Questions

1. A counting standard whose transformation rate is given as 1000 +/- 30/min is used to determine the efficiency of a counting system. The measured count rate is 200 +/- 10/min. What is the efficiency of the counting system and the precision of the measurement?

2. A preliminary measurement made during a short counting time suggested a gross counting rate of 55 cpm. The background counting rate, determined by a 1-h measurement, is 25 cpm. How long should the sample be counted in order to be 96% certain that the measured net counting rate will be within 10% of the true counting rate?

3. What are the models used to describe a sampling distribution? What are the differences between them? Which model(s) is used most often in nuclear decay measurement? Why it is valid to use it in nuclear decay measurement? – Gaussian
   Gaussian, Poisson, Binomial Distribution.

4. What are the types of error propagation? When do we need to include error propagation in measurement and why? Sums or difference of counts, multiplication or division by a constant, mean value of multiple independent counts – the goal is to minimize the associated statistical uncertainty in the final result

5. What do false-positive and false-negative mean? Why do they occur?

6. How does a common detector detect radiation interactions?
   Slide!

7. Draw the general configuration of a pulse mode detector. What quantity information does a pulse mode detector give about the source? $\# = \frac{E_{dep}}{W}$ amplitude total amount of charge $Q = \# \times e$ $V_{max} = \frac{Q}{C}$
   Slide!

8. What is the relationship between absolute and intrinsic detection efficiencies?
   related – $\frac{\Omega}{4\pi}$
   (Slide!) Absolute = All radiation emitted by source + intrinsic is a fraction emitted by source

9. What is the dead time? What we can do to improve the counting loss?

Signal Processing Electronics Laboratory

Important: When using the radioactive sources for your lab, please adhere to these guidelines:

1. Take the whole 8-pack of sources to your lab station. That's why we have 8 packs of sources, one for each lab station.

2. Do not mix and match sources, use and keep the sources to their intended packs. If you look on the cover of the pack, there are identification numbers for each source, which should match the source to its package. This can be important to consistent lab work as each source may be slightly different. This also prevents the need to mix and match sources as each pack has the same types of sources.

3. When taping the sources to a block for this lab, tape the plastic side of the source, not the labeled side. As you can see, quite a few of the Cs-137 and Co-60 source labeled have been damaged from the taping."

Objective:

- Become familiar with the general components required for nuclear counting experiments
- Become familiar with the operation of the counting equipment
- Using a digital oscilloscope, analyze signal pulses from the detector, amplifier, and single-channel analyzer (SCA)

Equipment:

- NIM bin (Canberra model 2100) with the following instruments: (1) HV power supply model 3106D; (2) signal splitter with limiter installed; (3) amplifier model 2022; (4) SCA model 2030; and (5) dual counter/time model 512
- GM detector with source tray
- oscilloscope (Tektronix TDS1001B)
- 3 short BNC-BNC cables; 2 long BNC-BNC cables; 1 SHV/MHV cable; 1 SHV cable from GM
- beta/gamma radiation source (your choice; from the red box of eight sources)
- USB flash drive for data transfer (formatted for Windows PC)

Cable Connections:

To setup the GM counting system, the following connections should be made:

GM detector → signal splitter back panel (GM)
High voltage (OUTPUT) → signal splitter back panel (HV)

Signal splitter front panel (SIGNAL) → amplifer (INPUT)
Amplifier (UNIPOLAR) → Single channel analyzer (INPUT)
Single channel analyzer (OUTPUT) → dual counter/timer (CH2 Input)

In this lab, you will use the oscilloscope to analyze the signal pulses at each step along the signal chain. The pulse should be characterized precisely, varying as many inputs as possible. You should explain all deviations to the signal, at each step, in your lab report.

Oscilloscope (CH1) → to various points in the signal chain

Equipment Settings:

I. **NIM Bin Power → ON**

II. **HV Power Supply:**
Polarity → **(this is fixed internally and should be on POSITIVE)**
High voltage dial → **check fully counter-clock wise (zero)**
High voltage toggle/dial → **ON / 1.5 turns (~0.90 kV)**

III. **Amplifier:**
Course Gain → **100**
Fine Gain → **10.0 (i.e., multiplier of 1X)**
Shaping (μsec) → **2**
Polarity Toggle → **negative (electrons are being collected)**

IV. **Single Channel Analyzer:**
Window (ΔE) → **max (10.0 V)**
Lower Level (E) → **0.10 V**
ΔE Range Toggle → **10 V**

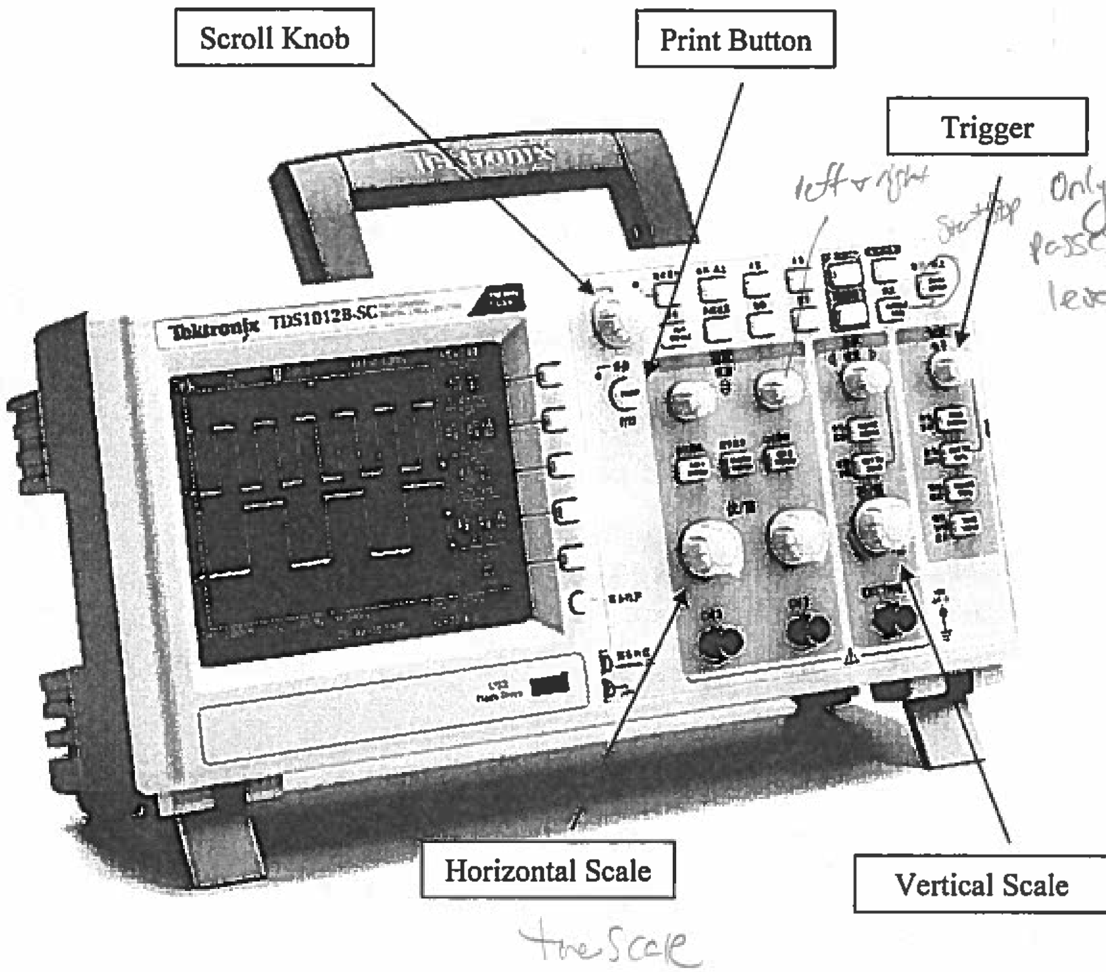
V. **Dual Counter/Timer:**
Begin with all **default** values

At this point, start the counter/timer to be sure that you are collecting counts. If so, remove the radioactive source to be sure that those counts are the result of radioactive decay.

VI. **Oscilloscope (CH1):**
- Turn on the oscilloscope
- Wait until initialized
- Press "Default Setup"
- Press "CH1 Menu"
- On the channel 1 menu, be sure that the probe indicates "1X"; if not, set to "1X"
- Default setup should result in a horizontal setting of **500 μsec/div** and a vertical setting of **1.00 Volts/div**
- Insert USB Flash Drive

* use Software on Computer Program.

lower threshold



Procedure:

I. Analyzing pulses from the detector:

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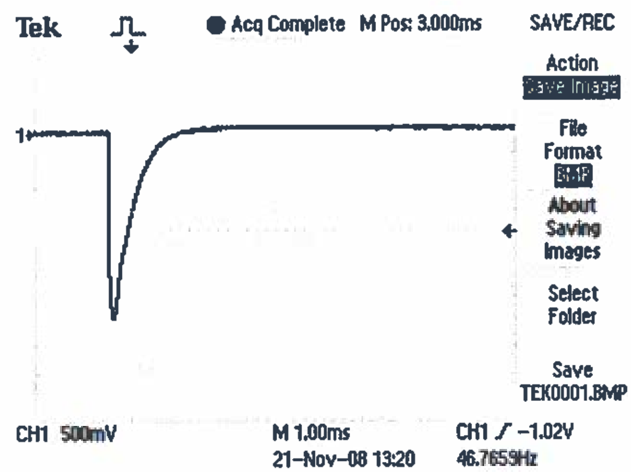
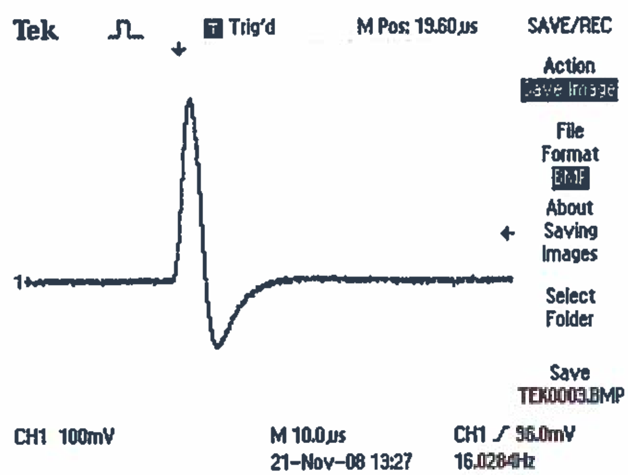
Independent of the oscilloscope, once you're sure the system is operational and responding to the radioactive source, then:

(1) Disconnect the short BNC-BNC cable at the front of the signal splitter and connect the long BNC-BNC cable to the signal splitter at one end and the CH1 input of the oscilloscope at the other end.
(2) Press the "Auto Range" button on the scope and allow it to stabilize.
(3) Press the "CH1 Menu" button.
(4) Ensure that "Probe Voltage" is set to "1X"
(5) Adjust the vertical and horizontal ranges to display the same image as in the figure to the right. Note the 3 marker arrows and the relative size of the pulse (adjust the position of those three arrows by turning the horizontal scale, vertical scale, and trigger knobs. Set the oscilloscope so that you duplicate the figure.
(6) Save the image to your USB drive by hitting the Print Button (be sure to capture time/date on the image).



II. Analyzing the amplifier output pulse:

Connect the oscilloscope cable to the unipolar output of the amplifier, reattach the signal splitter to the amp input, and repeat the above procedures to analyze pulses from the amplifier. Change the amplifier (course and fine) gain, shaping, and polarity settings and describe how this changes the output pulse shape/timing/etc (collect images to support your findings). Change the cable from unipolar to bipolar and describe (collect images) what happens to the output. Analyze the pulses <u>completely</u> and explain your results in detail. Adjust the coarse and fine gains to result in a unipolar output pulse of at least 500 mV (or up to a few volts, if possible) before moving to the next section.

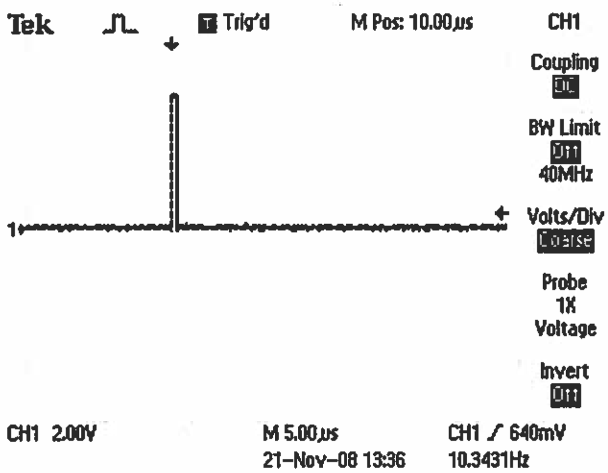


lab2amplifier-SignalSplitter

SCA1

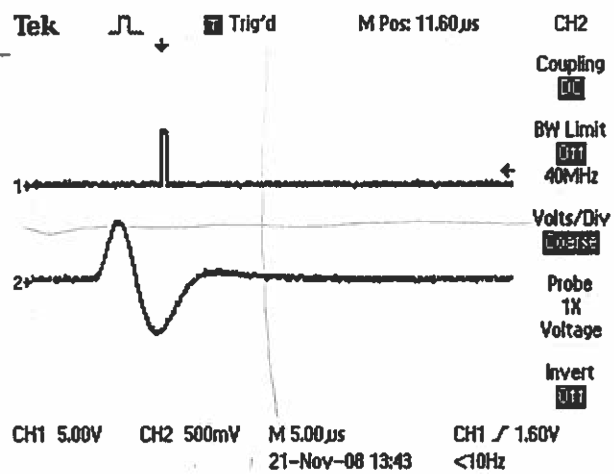
III. Analyzing the SCA output pulse:

Bipolar output



Connect the oscilloscope cable to the output of the SCA, reattach the amplifier unipolar output to the SCA input, and repeat the procedures in Part I to analyze pulses from the SCA. Using the oscilloscope to gather the appropriate information, describe the meaning of the 1V and 10V toggle on the SCA.

While CH1 is connected to the SCA output, and you have the image to the left showing (capture your own duplicate of the image), attach a long BNC-BNC cable between CH2 and the amplifier bipolar output. Activate CH2 by pressing "CH2 Menu". Adjust oscilloscope settings to duplicate the figure to the right (capture your own image). Describe what the display is indicating about the relationship between the two signal pulses being examined.



SCA 2

IV. Learn to use the Dual Counter/Timer:

Disconnect the oscilloscope and reattach the SCA output to the "Ch 2 Input" of the counter/timer. Using the counter/time diagram (located on the side of the cabinet at the front of the lab), learn the functions of the unit and how to change modes, settings, counting times, etc. You'll need to know how to change these settings for future labs.