# Laboratory 5: Lynx Box and Signal Processing

## Objectives

- Place a detector in operation using the Lynx box
- Add a new detector using Prospect
- Determine appropriate filter settings for a MCA

## Equipment

- $BF_3$ detector
- PuBe source
- Lynx box
- Cabling

## Precautions

- ☠ WARNING! HIGH VOLTAGE CAN BE PRESENT ANY TIME! DO NOT TOUCH ENERGIZED CONNECTIONS!
- ☠ Do not connect/disconnect bias cables with the high voltage energized; this can cause damage to the detector and / or electrical shock
- ☠ **Do not energize detector until set up is verified by TA or instructor**
- ☠ Observe proper PuBe source handling techniques

## Reading

- "Lynx Digital Signal Analyzer" pdf
- "ProSpect Gamma Spectroscopy Software" pdf

## Background

This laboratory focuses more heavily on signal processing as it applies to multi-channel analyzers for spectroscopy purposes.

The Lynx is a Multichannel Analyzer that has an integrated signal analyzer based on digital signal processing (DSP) techniques. Using DSP, the detector signal can be converted from an analog signal to a digital signal at the preamplifier output [1]. The direct conversion allows for unique ways to process the signal, including a wide range of shaping times. The Lynx uses a trapezoidal filtering algorithm. Shaping times include rise time, flat top, and fall time [2]. A figure displaying the relationship between the shaping parameters for a trapezoidal pulse waveform is provided in Figure 1.

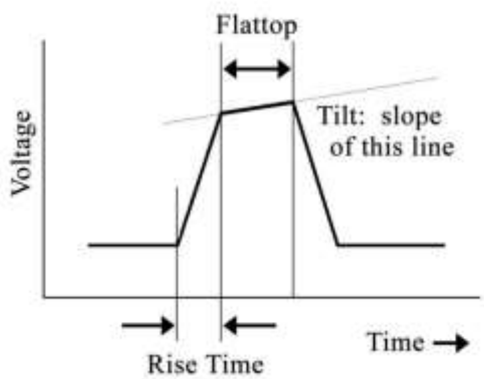


**Figure 1 Shaping Times for Pulses [1]**

The Lynx provides 255 settings for rise time between 0.2 to 51 µs and 33 settings for the flat top between 0 and 3.2 µs [3]. Adjusting rise time is used to optimize noise characteristics. Larger rise times will result in a better signal to noise ratio, whereas shorter rise time can degrade the resolution of the system. The flat top can be adjusted to accommodate variations in rise time, due to charge collection time in the detector. The total processing time can be calculated as follows [2]:

$$T_p = 2T_{Rise} + T_{Flattop}$$

As seen through the equation, if rise time and flat top are set too long this will influence the count rate. Therefore, there is a tradeoff between count rate and resolution.

## Procedure

This laboratory will use a proportional counter that will be used in the subsequent laboratory. The following is a block diagram for the proportional counter system.

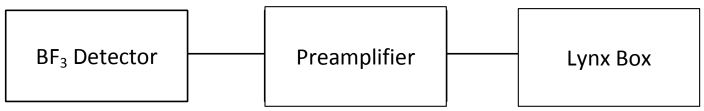


**Figure 2 Block Diagram for $BF_3$ detector**

The following is a description of the connectors used for set up of the proportional counter system.

**Table 1 Description of Connectors for Component**

| Component 1 | Connect with | Component 2 |
|---|---|---|
| $BF_3$ Counter | MHV/C/SHV | Preamplifier |
| Preamplifier (9 pin) | Multipin | Lynx Box |
| Preamplifier (E out) | BNC | Lynx Box (Energy) |
| Preamplifier (HV in) | SHV | Lynx Box (HV +) |

**Comment [JEM1]:** And attenuator

1. Open ProSpect software on the desktop
2. Log in using the technician user
3. Confirm that the high voltage is off under the “High Voltage Settings” on the Prospect software

☠☠☠ *<u>Special precautions are necessary with this counting system</u>. The preamplifier contains a field effect transistor (FET) that is very sensitive to extraneous voltage pulses. <u>Never</u> connect or disconnect the preamplifier until the high voltage power supply has been turned off long enough so that the output potential has decreased to zero. This may take up to a minute after the high voltage power supply has been turned off* ☠☠☠

4. Set up detector system as shown in Figure 2 and Table 1

☠☠☠ *Check set-up with Instructor or TA before proceeding* ☠☠☠

<u>Adding the Detector using Prospect</u>

1. On main detector tab, click “Connect to Device” at the bottom of the screen
2. Under devices and detectors, connect to the **Lynx box** at your station.
3. On detector settings tab, click the green “+” next to the heading; this will add a detector.
4. Name and describe the detector based upon the Serial Number and the type of detector.

**Table 2 Detector Settings**

| Name | Setting |
|---|---|
| Detector type | NaI* |
| Preamp | RC |
| Voltage Range | 5000 V |
| Maximum Voltage | 2200 V |
| Polarity | Positive |

*Note that the Lynx system is designed only to work with NaI and HPGe systems. We have experimented with the settings and are able to make them work well with our $BF_3$ detectors.

<u>Determining MCA Settings: Gain Settings</u>

1. Have the instructor place the $BF_3$ detector in the moderated position of the PuBe source

☠☠☠ *Do <u>not</u> turn on the high voltage until the instructor has checked your setup.* ☠☠☠

2. Connect an oscilloscope to "T out" on the preamplifier
3. Set high voltage in the "High Voltage Settings" to the proper voltage for your detector (see side of detector) using the pencil button
4. Click "on" to energize high voltage
5. Using the oscilloscope, check the polarity of the pulses coming out of the preamplifier (for the gain settings)
    a. Take a screenshot of the pulses
    b. Note the polarity, amplitude, and shape of the pulses
6. Connect the oscilloscope to the "Monitor" output on the Lynx box; this will allow you to monitor the amplifier output waveform
7. Adjust coarse gain and fine gain on the gain settings until the pulses are large, but are not clipping
    a. Take a screenshot of the pulses
8. Set conversion gain to 512
9. Under acquisition tab, set the "preset time" to 100 s
10. Clear the spectrum if one is on the screen
11. Click "start"
12. Export data using excel icon in the upper right corner

<u>Determining MCA Settings: Filter Settings</u>

1. Under the MCA Settings, click "Digital Oscilloscope"; the upper trace is the analog trace and the lower trace is the digital trace
2. Set Analog Trace to "Energy"

3. Take a screen shot of the oscilloscope, and save digital traces using the print feature at the upper right of the screen
4. Vary the flat top and rise time (increase or decrease) under the filter settings
5. Take a 100 s spectrum and export data
6. Inspect changes in the oscilloscope, digital trace, and analog trace. The goal is to have the amplifier output look like the expected pulse shape (~Gaussian).
   a. Take a screen shot of the oscilloscope
7. Save the digital and analog traces
8. Take a 100 s spectrum and export data
9. Repeat steps 4 through 8 for at least 5 different filter settings (including original filter setting)
10. Based on the resulting screen shots and spectra, choose the most appropriate filter setting

**For the Laboratory Report Include:**

Results

- Screenshots of pulses taken in the laboratory and comparison to expected pulses, based on signal pulse laboratory
- Compare oscilloscope, digital traces, and analog traces, and spectra for changing filter settings
- Justify final filter settings chosen
- Calculation of total processing time

Appendix

- Include copies of completed data sheets
- Provide copy of spreadsheets containing calculations

**References**

[1] Ronald Keyser and Timothy Twomey, Optimization of Pulse Processing Parameters for HPGe Gamma-ray Spectroscopy Systems Used in Extreme Count Rate Conditions and Wide Count Rate Ranges.

[2] Canberra, Basic Counting Systems, 2010.

[3] Canberra, Lynx Digital Signal Analyzer, 2012.

[4] Glenn F Knoll, *Radiation Detection and Measurement*. Hobokem: John Wiley & Sons, Inc, 2000.

[5] Herman Cember and Thomas Johnson, *Introduction to Health Physics*.: McGraw-Hill Companies, Inc, 2009.

**Appendix A:** Data

1. Information on sources:

   **PuBe source:**

| Source Characteristic | |
|---|---|
| Source model | PuBe |
| Original activity | 1 Ci |
| Half-Life | |
| Initial n Energy | |

2. **Counting system information:**

   System number: ________________________

   Lynx IP Address: ________________________

3. **Detector settings:**

   Detector name: ________________________

   Detector description: ________________________

   Preamp type: ________________________

   MCA type: ________________________

4. **High voltage settings:**

   Voltage (V): ________________________

   Range (V): ________________________

   Limit (V): ________________________

   Polarity: ________________________

5. **Final Gain Settings:**

Conversion Gain: ________________________

Coarse Gain: ________________________

Fine Gain: ________________________

Polarity: ________________________

6. **Filter Settings:**

| Rise Time | Flat Top |
|---|---|
| | |
| | |
| | |
| | |
| | |

Final Rise Time: ________________________

Final Flat Top: ________________________