Spectrum Techniques

ST365
RADIATION COUNTER
TECHNICAL MANUAL

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WARRANTY AND REPAIR INFORMATION

All products manufactured by Spectrum Techniques are warranted to be free from defects in workmanship and materials for a period of one year from the date of shipment.

Defective products must be returned to our facility at the customer's expense and in turn Spectrum Techniques will cover the cost of returning the products to the customer. This warranty covers the cost of our labor, any replacement parts, and shipment one-way.

Products supplied by Spectrum Techniques but not of our manufacture will be covered by the original manufacturers' warranty, usually one year from date of shipment.

This warranty excludes all GM tube windows which are extremely fragile. These devices cannot be repaired and must be replaced at customer expense.

This warranty does not cover physical damage or misuse.

Warning!

Dangerous voltages can exist at the GM and SCINT connectors. Ensure that the high voltage is set to OFF (LED is not lit) or that the instrument is OFF before connecting or disconnecting a detector.

Caution

Simultaneously connecting a GM tube and a scintillation detector to the ST365 will result in erroneous data. Only connect one at a time.

GM Tube Handling Caution:

GM tubes have extremely thin entrance windows, which require considerable care in handling. Do not remove protective caps unless necessary and never touch the window.

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INTRODUCTION

The ST365 Radiation Counter combines many features into a single inexpensive instrument. We have expanded the classic nuclear scaler design to not only include a preset time function, a digital rate-meter, a digitally controlled high voltage supply, but now with computer interfacing via USB, LAN, and Wi-Fi Direct formats.

The ST365 includes BNC and MHV connectors, as well as a precision high voltage supply that is adjustable from 0 to +1200 volts. This high voltage supply provides 0.2mA at 1200 volts making it suitable for many types of Geiger Mueller (GM) tubes and scintillation detectors.

The preset time function enables the user to acquire radioactive events for a predetermined number of seconds. This is necessary for accurately comparing radioactive sources.

The rate-meter function is ideal for contamination survey work and instantaneously displays the counts per minute (CPM) or counts per second (CPS).

The ST365 comes in two models. The ST365A, with extra-large LED's, provide a digital display that is clear and visible, even under bright ambient light or the ST365B, with a back lit Liquid Crystal Display (LCD), which provides the user with a more interactive interface.

The provided desktop computer software, Spectrum Techniques Ultra, enables classroom demonstrations of nuclear experiments. An instructor or student(s) can run experiments on a wired connection from a PC running Microsoft Windows or from a Mac computer by a USB or LAN interface. If your computer is capable, the user can also connect via Wi-Fi.

The Spectrum Techniques Ultra software saves data in spreadsheet compatible files and can graph the detector results during an experiment.

The Spectrum Techniques Ultra software includes one mode that recycles counting after reaching a preset time and another mode that automatically increments the high voltage after each cycle. The first mode is useful for performing radioactive decay studies while the latter is useful for plotting GM detector plateaus.

Teachers and students can also down load the Spectrum Techniques Ultra software for Android devices to allow instrument control and data display and capture.

IDENTIFYING YOUR MODEL

Model: ST365A

Model: ST365B

SPECIFICATIONS

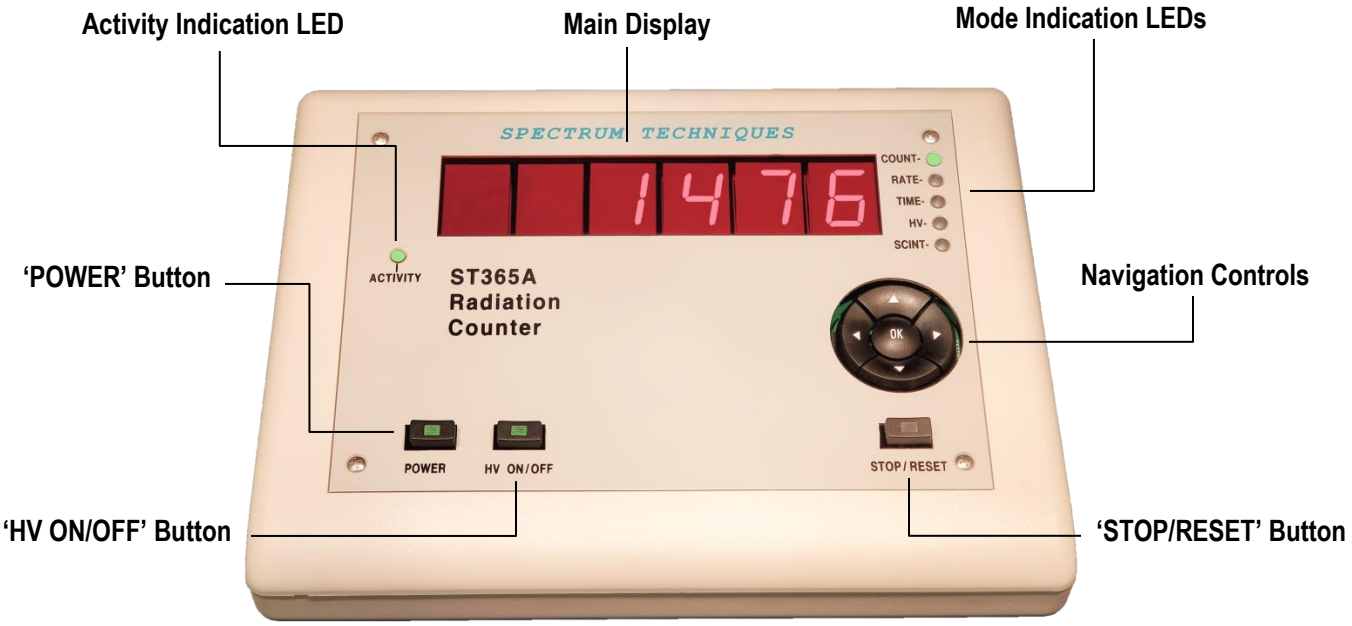
Power:	9 volt DC, at 1200 mA*
High Voltage:	0 to +1200 volts @ 0.2 mA, selectable in 10 volt increments
Inputs/Connectors:	BNC Connector – accepts standard GM detectors MHV Connector – accepts scintillation detectors
Interface:	USB 2.0 LAN (for both PC and Mac) WiFi Direct for Android Device
Model A Display:	6-decade LED – 1 inch numerals
Model B Display:	16 character LCD – Backlight alpha numeric
Modes:	Counts Count Rate (Counts Per Second) Elapsed Time Preset Time High Voltage Level
Software:	Spectrum Techniques Ultra for PC Spectrum Techniques Ultra for Mac Spectrum Techniques Ultra for Android devices
Housing:	Plastic with metal front and rear panel
Dimensions :	7.6 x 22.9 x 17.3 cm (3 x 9 x 6.8 in.) (H x W x D)
Weight:	0.82 kg (1.8 lb)

CAUTION

ONLY USE THE AC ADAPTER INCLUDED WITH THE ST365. USING A DIFFERENT ADAPTER CAN DAMAGE THE UNIT AND VOID THE WARRANTY.

DESCRIPTION OF CONTROLS, FUNCTIONS, AND INDICATORS

Below is a brief description of the ST365's front panel layout. A detailed explanation of the controls can be found in the **STAND ALONE OPERATNG** section.



Model: ST365A

Main Display:	Large digits to show the user set parameters or the measured data.
Mode Indication LEDs:	The LEDs light to indicate the instrument mode selected by the user with the navigation controls.
Activity Indicator:	When the instrument is in counting mode, the *ACTIVITY* LED on the left side of the display will indicate the when the unit is detecting and counting events.
Power Button:	Pressing the *POWER* button toggles the instrument on and off. An LED lights when the unit is powered.
'HV ON/OFF' Button:	Pressing the *HV ON/OFF* button toggles the high voltage on and off. An LED lights in the button to indicate high voltage is on.
'STOP/RESET' Button:	Pressing this button when counting will stop counting. While counting is stopped, pressing the button again resets the time and counts to zero.
Navigation Controls:	The five navigation buttons allow the user to press up / down to select the instrument modes indicated by the LEDs COUNT, RATE, TIME, HV, SCINT and to press left / right to parameter values. Once the parameters have been set, press the center button to begin counting.

STAND ALONE OPERATION

Below is a description of each mode. The 'NAVIGATION CONTROL' buttons allow the user to select up and down through the modes. To the right of the main display is the mode LEDs which indicate the instrument mode. In standalone operation the user can navigate the modes at any time, without affecting the data or interrupting the count, even if the unit is counting.

Main Display:

As the user navigates the modes, the main display changes to reflect the user set parameters or the measured data.

During counting the user can navigate modes and the main display will change without interrupting the count or affecting the count data.

Count Display Mode:
(COUNT LED)

In *COUNT* mode the unit displays the number of radioactive events, or counts. During data acquisition, the display will increment with each event in real time. When in *COUNT* mode the 'COUNT' LED will regularly flash.

Note: that while counting, this LED will flash regardless of the other selected mode displayed on the unit.

Rate Display Mode:
(RATE LED)

In this mode the main display provides the instantaneous count rate in either counts-per-minute (CPM) or counts-per-second (CPS). To choose CPM or CPS, press the 'LEFT' and 'RIGHT' arrow button while in the *RATE* display mode.

Time Set and Display Mode:
(TIME LED)

Preset time: a parameter the user sets for the duration of counting.

Elapsed time: the time since the start of counting.

On entering the *TIME* mode the main display first displays the preset parameter time. It is also used for setting the Preset Time. When selected, the *TIME* mode display shows the elapsed time, to the second, of the most recent data acquisition. If the 'LEFT' or 'RIGHT' arrow button is pressed, the view will switch to the current *Preset Time*.

The *Preset Time* function will allow the user to automatically count radiation events for a predetermined amount of time. To modify the *Preset Time* continue to press the 'LEFT' or 'RIGHT' arrow buttons and observe the change in the *Preset Time*. Pressing the 'LEFT' or 'RIGHT' arrow buttons will modify the preset one second for each key press. Holding the 'LEFT' or 'RIGHT' buttons down will cause the Preset Time to advance rapidly. After 30 seconds the change rate increases again.

Pressing the 'OK' button will cause radioactive events to be counted for the preset time value. Afterwards, counting will automatically stop. Pressing 'OK' button a second time will reset the counts and elapsed time to zero, and again accumulate events until reaching the preset time value. Counting can be interrupted using the 'STOP' button, without losing current data or the time elapsed. Pressing the center navigation 'OK' button will resume data acquisition for the remaining preset time.

To stop the *Preset Time* function for an indefinite count, set the preset time to *zero*.

High Voltage Set and Display Mode:
(HV LED)

This mode is for either displaying or setting the high voltage level. The high voltage can be set to any value between 0 and 1200 volts in 10 volt increments using the 'LEFT' and 'RIGHT' arrow buttons.

Starting a count or pressing the 'STOP/RESET' button do not affect the high voltage setting.

Scintillation/GM Mode Indicator:
(SCINT LED)

When this LED is on, the user can change the input detector type. For correct operation the user must set the ST365 Radiation Counter correctly for the type of detector to which it is connected.

Press the 'LEFT' and 'RIGHT' arrow buttons to set the instrument for either the "Scint" (Scintillation) or "Geiger" (GM) detector. Inside the instrument you are selecting pulse shaping, gain and thresholds appropriate for these different detector types.

BASIC GM SYSTEM SETUP AND OPERATION

Step 1 **CONNECT THE GM DETECTOR TO THE ST365**

Connect one end of the BNC cable to the BNC connector on the detector. Then connect the other end of the BNC cable to the BNC connector on the back of the ST365.

Step 2 **CONNECT THE POWER SUPPLY TO THE ST365**

Connect the power supply to the connector on the back of the ST365 and plug the ST365 into a wall outlet.

Step 3 **POWER ON THE ST365**

Press the 'POWER' button. Use the 'UP' and 'DOWN' arrow buttons, move to the *SCINT* mode. Then use the 'LEFT' and 'RIGHT' arrow buttons to make sure the ST365 is set to 'GEIGER' setting the appropriate thresholds for use with a GM detector.

Step 4 **SET HIGH VOLTAGE**

Use the 'UP' and 'DOWN' arrow buttons, move to the *HV* mode. Then use the 'LEFT' and 'RIGHT' arrow buttons to set the high voltage to the recommended value for the GM detector.

Step 5 **SET PRESET TIME (IF WANTED)**

Use the 'UP' and 'DOWN' arrow buttons, move to the *TIME* mode. Then use the 'LEFT' and 'RIGHT' arrow buttons to set the desired preset time – for an indefinite count, set the preset time to *zero*.

Step 6 **COUNT A RADIOACTIVE SAMPLE**

Place a radioactive source close to the GM detector. Press the 'OK' button to start acquiring data. To stop counting, press the 'STOP/RESET' button once, then to begin counting again, press the 'OK' button. To reset the elapsed time, press the 'STOP/RESET' button twice.

GM Tube Plateau

The standard operating voltage for a GM tube is usually between 800 to 1200 volts. If the manufacturer's recommended operating voltage is not known, the correct operating voltage may be determined experimentally using a radioactive source such as Cs-137.

A properly functioning GM tube will exhibit a "plateau" effect, where the counting rate remains nearly constant while the high voltage is increasing linearly. A GM plateau curve can be created by using a constant preset time to count a source for several runs, while increasing the high voltage by some constant amount after each run. The procedure below describes this process in detail.

Step 1 **POSITION THE RADIOCTIVE SOURCE**

Place the radioactive source in a fixed location close to the window of the GM detector. Once in position, do not move the radioactive source.

Step 2 **BEGIN COUNTING AND INCREASING HIGH VOLTAGE**

Begin counting and slowly increase the high voltage until the activity indication LED begins to occasionally light. This is the starting voltage.

Step 3 **SET A PRESET TIME, COUNT, AND RECORD**

Once the start voltage is determined, set a preset time of 10 seconds and start counting. At the end of the 10 second count, record the results.

Step 4 **INCREASE THE HIGH VOLTAGE AND REPEAT**

Increase the high voltage by 10 or 20 volts, count again, and record the results. Repeat this step until the upper limit voltage of the ST365 is reached.

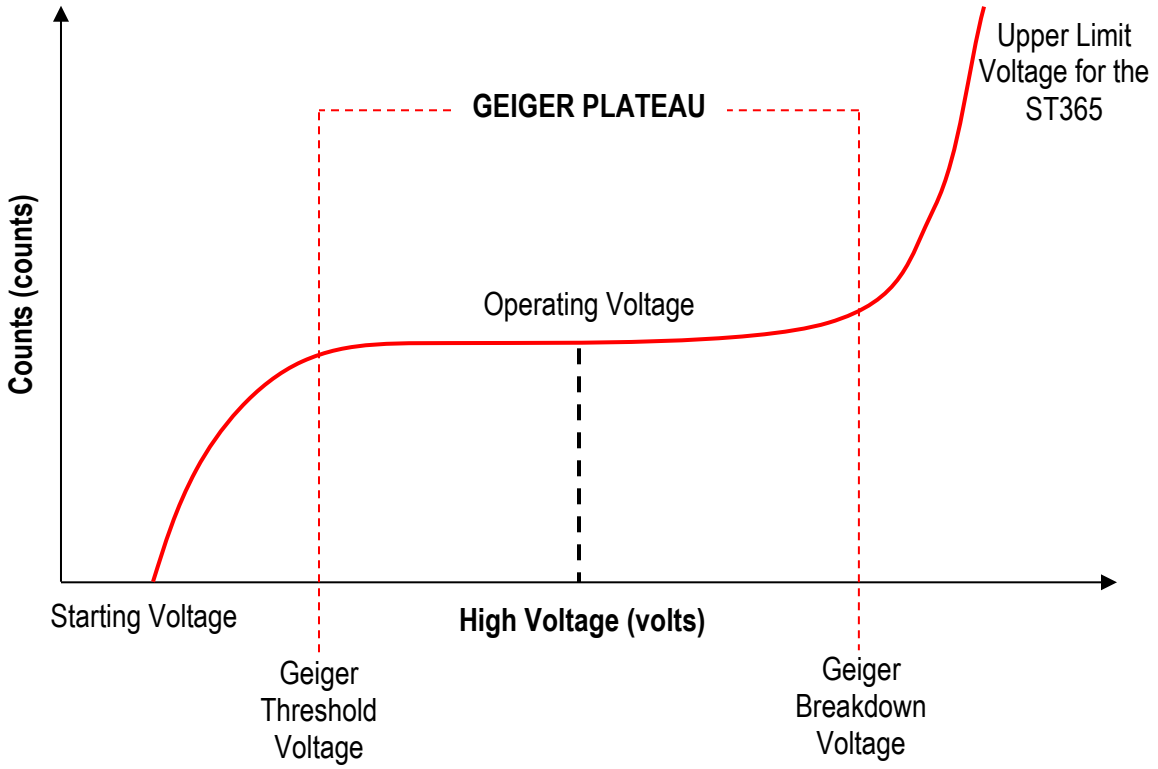
Step 5 **REDUCE HIGH VOLTAGE**

Once finished, reduce the high voltage and power off the ST365.

Step 6 **CREATE THE GM PLATEAU CURVE**

With the collected data, create an X-Y graph with the X-axis being the high voltage (volts) and the Y-axis being the counts (counts). Plot the data points and draw the curve. The plotted data should resemble the graph below.

GEIGER PLATEAU CURVE



Notice the ST365 started counting at a point corresponding to the Geiger Threshold Voltage; from there follows the Geiger Plateau with little change in the counts detected as the voltage increases. Finally, a point is reached where the counts rapidly increase until the ST365/GM tube moves into continuous discharge – This is called the break down region.

A flat, long Geiger Plateau is a desirable characteristic in a counter. In practice, most counters have a slightly sloping Geiger Plateau due to GM tube defects such as gas filling.

The correct operating voltage is calculated roughly as the voltage value corresponding to the middle of the Geiger Plateau region.

Dead Time and Resolving Time

GM tubes exhibit dead time effects due to the recombination time of the internal gas ions after the occurrence of an ionizing event. The actual dead time depends on several factors, including the active volume of the GM tube and the shape of the GM tube. Dead time can range from a few microseconds for smaller tubes, to over 1000 microseconds for larger volume tubes.

When making absolute measurements it is important to compensate for dead time losses at higher counting rates. If the resolving time (T_r) of the detector is known, the true counting rate (R_t) may be calculated from the measured counting rate (R_m) using the following equation:

$$R_t = \frac{R_m}{1 - R_m T_r}$$

If the detector resolving time is unknown, it may be determined experimentally using two radioactive sources. Since maintaining consistent counting geometry is important throughout the experiment, Spectrum Techniques' special split source (Item ID: RSS2) is available for making the measurements.

The procedure below describes this process in detail using Spectrum Techniques' split source.

Step 1 **PLACE THE ST365 INTO RATE MODE**

With the ST365 on, move to the Rate Mode.

Step 2 **POSITION THE RADIOCTIVE SOURCES**

Place the two radioactive sources (a + b) side-by-side close enough to the GM tube window to obtain a count rate of at least 10,000 CPM.

Step 3 **RECORD THE COUNT RATE**

With both sources under the GM tube, record the count rate as $R_{(a+b)}$.

Step 4 **REMOVE SOURCE B, TO COUNT SOURCE A**

Remove source 'b' and replace it with the blank source. Record the count rate as $R_{(a)}$.

Step 5 **REMOVE SOURCE A, TO COUNT SOURCE B**

Remove source 'a' and replace it with the blank source. Record the count rate as $R_{(b)}$.

Step 6 **CALCULATE THE RESOLVING TIME**

Using the equation below, solve for the resolving time:

$$T_r = \frac{R_{(a)} + R_{(b)} - R_{(a+b)}}{2R_{(a)}R_{(b)}}$$

The resolving time for the ST365 is extremely short and not significant when compared to that of the GM tube. Therefore, only the resolving time of the GM tube affects the true count rate.

BASIC SCINTILLATION SYSTEM SETUP AND OPERATION

Step 1 **CONNECT THE SCINTILLATION DETECTOR TO THE ST365**

Connect one end of the BNC cable to the BNC connector on the detector. Then connect the other end of the BNC cable to the BNC connector on the back of the ST365. Connect the HV cable in the same manner.

Step 2 **CONNECT THE POWER SUPPLY TO THE ST365**

Connect the power supply to the connector on the back of the ST365 and plug the ST365 into a wall outlet.

Step 3 **POWER ON THE ST365**

Press the 'POWER' button. Use the 'UP' and 'DOWN' arrow buttons, move to the *SCINT* mode. Then use the 'LEFT' and 'RIGHT' arrow buttons to make sure the ST365 is set to 'SCINT' setting the appropriate thresholds for use with a scintillation detector.

Step 4 **SET HIGH VOLTAGE**

Use the 'UP' and 'DOWN' arrow buttons, move to the *HV* mode. Then use the 'LEFT' and 'RIGHT' arrow buttons to set the high voltage to the recommended value for the Scintillation detector.

Step 5 **SET PRESET TIME (IF WANTED)**

Use the 'UP' and 'DOWN' arrow buttons, move to the *TIME* mode. Then use the 'LEFT' and 'RIGHT' arrow buttons to set the desired preset time – for an indefinite count, set the preset time to *zero*.

Step 6 **COUNT A RADIOACTIVE SAMPLE**

Place a radioactive source close to the scintillation detector. Press the 'OK' button to start acquiring data. To stop counting, press the 'STOP/RESET' button once, then to begin counting again, press the 'OK' button. To reset the elapsed time, press the 'STOP/RESET' button twice.

Sodium Iodide (NaI) Detector High Voltage Sweep

Unlike the Geiger Plateau of GM tubes, there is not an obvious 'correct' operating voltage for a scintillation detector. The ST365 sets the gain of the sodium iodide (NaI) detector by the high voltage it applies to the photo multiplier tube (PMT) – a higher voltage operates the PMT at a higher gain. By performing a 'sweep' of the high voltage using the known energies of different radioactive sources, the user can experimentally determine the voltage threshold for the ST365. The procedure below describes this process in detail.

Step 1 **DETERMINE WHICH RADIOACTIVE SOURCE HAS THE HIGHEST NUMBER OF COUNTS AND SET AN APPROPRIATE PRESET TIME**

Set the ST365 high voltage to the maximum 1200 Volts. Count each source for the same time. Find the sample with the highest count rate. Increase or decrease the count time to give a reading that does not overflow the counter display.

Step 2 PERFORM A BACKGROUND COUNT

Set the High Voltage to the starting voltage, set the Preset Time to the predetermined time, and begin counting. Make sure there are no radioactive sources present. Record the high voltage and total counts. Reset the counts, increase the high voltage by 10 or 20 volts and perform the next count. Repeat this process until the maximum high voltage is reached (1200 volts).

Step 3 BEGIN COUNTING THE FIRST RADIOACTIVE SOURCE AND STEP INCREASE THE HIGH VOLTAGE

Return the high voltage back to the starting voltage and begin counting the first radioactive source. Record the high voltage and total counts. Reset the count, increase the high voltage by 10 or 20 volts and perform the next count. Repeat this process until the maximum high voltage is reached (1200 volts).

Step 4 REPEAT STEP 3 WITH THE REMAINING RADIOACTIVE SOURCES

After the entire sweep using the first radioactive source is completed, repeat the same process using the remaining radioactive sources.

Step 5 REDUCE HIGH VOLTAGE

Once finished, reduce the high voltage and power off the ST365.

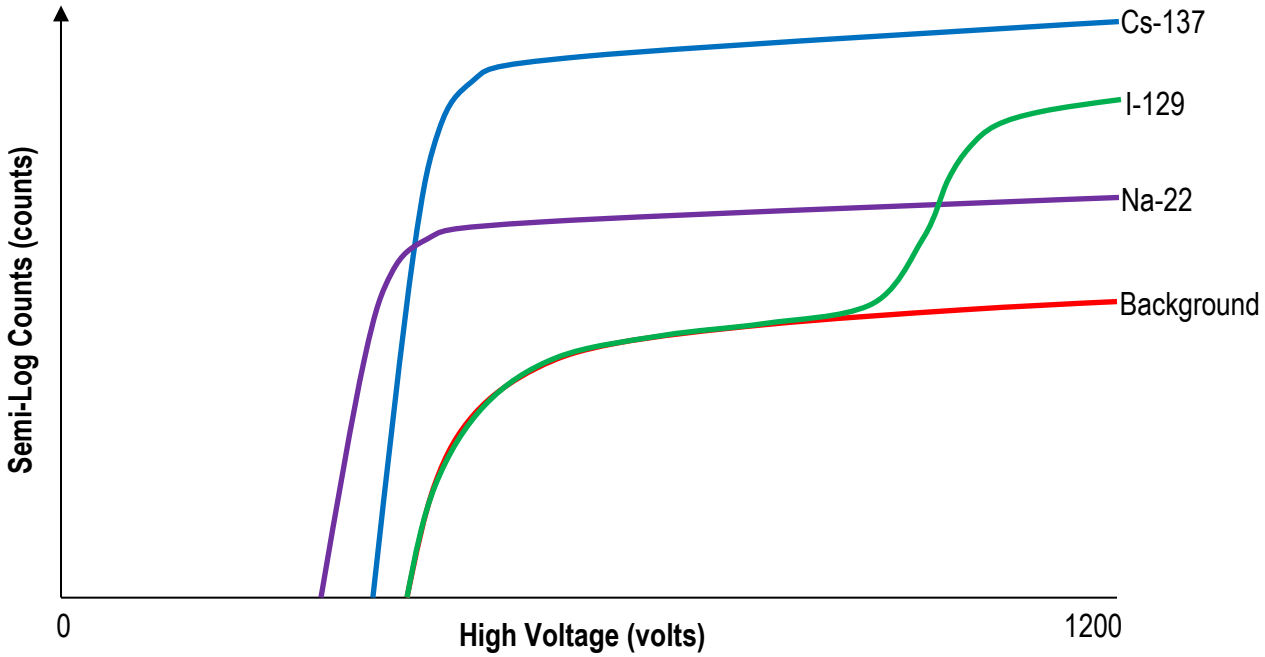
Step 6 CREATE THE CURVE

With the collected data, create a semi-log X-Y graph with the X-axis being the high voltage (volts) and the Y-axis being the counts (counts). Plot the data points for each isotope and draw their respective curves.

The plotted data should bear a resemblance to the graph below which was created using the following isotopes:

ISOTOPE	GAMMA ENERGY (keV)
Na-22	1274.53
Cs-137	661.66
I-129	39.58

SODIUM IODIDE GAIN SWEEP CURVE USING SELECTED ISOTOPES



Notice that at lower high voltages, the ST365 will only count higher energy gammas. Increasing the high voltage brings lower energy gammas above background so that they can be counted.